BS EN 61158-6-10:2014

BSI Standards Publication

Industrial communication networks — Fieldbus specifications

Part 6-10: Application layer protocol specification — Type 10 elements

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 61158-6-10:2014. It is identical to IEC 61158-6-10:2014. It supersedes BS EN 61158-6-10:2012 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AMT/7, Industrial communications: process measurement and control, including fieldbus.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2014

ISBN 978 0 580 79473 5
ICS 25.040.40; 35.100.70; 35.110

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2014.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61158-6-10

October 2014

ICS 25.040.40; 35.100.70; 35.110

Supersedes EN 61158-6-10:2012

English Version

Industrial communication networks - Fieldbus specifications - Part 6-10: Application layer protocol specification - Type 10 elements (IEC 61158-6-10:2014)

Réseaux de communication industriels - Spécifications des bus de terrain - Partie 6-10: Spécification du protocole de la couche application - Eléments de type 10 (CEI 61158-6-10:2014)

Industrielle Kommunikationsnetze - Feldbusse - Teil 6-10: Protokollspezifikation des Application Layer (Anwendungsschicht) - Typ 10-Elemente (IEC 61158-6-10:2014)

This European Standard was approved by CENELEC on 2014-09-23. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 65C/764/FDIS, future edition 3 of IEC 61158-6-10, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61158-6-10:2014.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-06-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-09-23

This document supersedes EN 61158-6-10:2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Endorsement notice

The text of the International Standard IEC 61158-6-10:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61784-1	NOTE	Harmonized as EN 61784-1.
IEC 61784-2	NOTE	Harmonized as EN 61784-2.
IEC 61784-3-3	NOTE	Harmonized as EN 61784-3-3.
IEC 60793-2-30	NOTE	Harmonized as EN 60793-2-30.
IEC 60793-2-40	NOTE	Harmonized as EN 60793-2-40.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 61158-1	2014	Industrial communication networks - Fieldbus specifications - Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series	EN 61158-1	2014
IEC 61158-2	2014	Industrial communication networks - Fieldbus specifications - Part 2: Physical layer specification and service definition	EN 61158-2	2014
IEC 61158-5-10	2014	Industrial communication networks - Fieldbus specifications - Part 5-10: Application layer service definition - Type 10 elements	EN 61158-5-10	2014
IEC 61158-6-3	2014	Industrial communication networks - Fieldbus specifications - Part 6-3: Application layer protocol specification - Type 3 elements	EN 61158-6-3	2014
IEC 61588	-	Precision clock synchronization protocol for networked measurement and control systems	-	-
IEC 62439-2	-	Industrial communication networks - High availability automation networks - Part 2: Media Redundancy Protocol (MRP)	EN 62439-2	-
ISO/IEC 646	1991	Information technology - ISO 7-bit coded character set for information interchange	-	-
ISO/IEC 7498-1	-	Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model	-	-
ISO/IEC 8822	-	Information technology - Open Systems Interconnection - Presentation service definition	-	-

Publication	Year	Title	EN/HD	Year
ISO/IEC 8824-1	-	Information technology - Abstract Syntax Notation One (ASN.1): Specification of basic notation	-	-
ISO/IEC 9545	-	Information technology - Open Systems Interconnection - Application layer structure	-	-
ISO/IEC 10731	-	Information technology - Open Systems Interconnection - Basic Reference Model - Conventions for the definition of OSI services	-	-
ISO 8601	-	Data elements and interchange formats - Information interchange - Representation of dates and times	-	-
IEEE 754	-	IEEE Standard for Floating-Point Arithmetic	-	-
IEEE 802	-	IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture	-	-
IEEE 802.1AB	2005	IEEE Standard for Local and metropolitan area networks - Station and Media Access Control Connectivity Discovery	-	-
IEEE 802.1AS	-	IEEE Standard for Local and Metropolitan Area Networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks	-	-
IEEE 802.1D	-	IEEE Standard for local and metropolitan area networks - Media Access Control (MAC) Bridges	-	-
IEEE 802.1Q	-	IEEE Standard for Local and metropolitan area networks - Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks	-	-
IEEE 802.3	-	IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications	-	-
IEEE 802.11	-	IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications	-	-

Publication	Year	Title	EN/HD	Year
IEEE 802.15.1	2005	IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 15.1: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs)	-	-
IETF RFC 768	-	User Datagram Protocol	-	-
IETF RFC 791	-	Internet Protocol	-	-
IETF RFC 792	-	Internet Control Message Protocol	-	-
IETF RFC 826	-	Ethernet Address Resolution Protocol: Or Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware	-	-
IETF RFC 1034	-	Domain names - concepts and facilities	-	-
IETF RFC 1213	-	Management Information Base for Network Management of TCP/IP-based Internets: MIB-II	-	-
IETF RFC 2131	-	Dynamic Host Configuration Protocol	-	-
IETF RFC 2132	-	DHCP Options and BOOTP Vendor Extensions	-	-
IETF RFC 2236	-	Internet Group Management Protocol, Version 2	-	-
IETF RFC 2365	-	Administratively Scoped IP Multicast	-	-
IETF RFC 2474	-	Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers	-	-
IETF RFC 2674	-	Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering and Virtual LAN Extensions	-	-
IETF RFC 2863	-	The Interfaces Group MIB	-	-
IETF RFC 3418	-	Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)	-	-
IETF RFC 3621	-	Power Ethernet MIB	-	-
IETF RFC 4361	-	Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)	-	-
IETF RFC 4363	-	Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions	-	-
IETF RFC 4836	-	Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)	-	-
IETF RFC 5735	-	Special Use IPv4 Addresses	-	-

Publication	Year	Title	EN/HD	Year
IETF RFC 5890	-	Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework	-	-
The Open Group - Publication C706	-	Technical Standard DCE1.1: Remote Procedure Call	-	-

CONTENTS

INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the "three-layer" fieldbus reference model described in IEC 61158-1.

The application protocol provides the application service by making use of the services available from the data-link or other immediately lower layer. The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer application entities (AEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

– as a guide for implementors and designers;
– for use in the testing and procurement of equipment;
– as part of an agreement for the admittance of systems into the open systems environment;
– as a refinement to the understanding of time-critical communications within OSI.

This standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

NOTE Attention is drawn to the fact that use of the associated protocol type(s) is restricted by its (their) intellectual-property-right holder(s). In all cases, the commitment to limited release of intellectual-property-rights made by the holder(s) of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in type combinations as specified explicitly in the IEC 61784 series. Use of the protocol type(s) in other combinations may require permission of their respective intellectual-property-right holder(s).

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Type 10 elements and possibly other types given in this standard as follows:

The following patent rights for Type 10 have been announced by [SI]:

WO publication	Title (WO)
WO 02/043336 EP 1388238	System and method for parallel transfer of real-time critical and non-real-time critical data via switchable data networks, particularly Ethernet
WO 02/076033 EP 1368935	Synchronous clocked communication system with decentralized input/output modules and methods for integrating decentralized input/output modules in such a system
WO 03/028258 EP 1430628	Method for synchronizing nodes of a communication system
WO 03/028259 EP 1430627	Communications system and method for synchronizing a communications cycle
WO 04/030284 EP 1540895	Method for permanent redundant transmission of data telegrams in communication systems
EP 1558002	Method for assigning an IP address to a devic
EP 1318630	Matrices for controlling the device specific data transfer rates on a field bus

IEC takes no position concerning the evidence, validity and scope of these patent rights.

The holders of these patent rights have assured the IEC that they are willing to negotiate licences either free of charge or under reasonable and non-discriminatory terms and

conditions with applicants throughout the world. In this respect, the statement of the holders of these patent rights is registered with IEC. Information may be obtained from:

[SI]: Siemens AG
CT IP L&T
Otto-Hahn-Ring 6
D-81739 Munich
Germany

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

ISO (www.iso.org/patents) and IEC (http://patents.iec.ch) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-10: Application layer protocol specification – Type 10 elements

1 Scope

1.1 General

The Fieldbus Application Layer (FAL) provides user programs with a means to access the fieldbus communication environment. In this respect, the FAL can be viewed as a “window between corresponding application programs.”

This standard provides common elements for basic time-critical and non-time-critical messaging communications between application programs in an automation environment and material specific to Type 10 fieldbus. The term “time-critical” is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

This standard defines in an abstract way the externally visible behavior provided by the Type 10 fieldbus application layer in terms of

a) the abstract syntax defining the application layer protocol data units conveyed between communicating application entities,
b) the transfer syntax defining the application layer protocol data units conveyed between communicating application entities,
c) the application context state machine defining the application service behavior visible between communicating application entities, and
d) the application relationship state machines defining the communication behavior visible between communicating application entities.

The purpose of this standard is to define the protocol provided to

a) define the wire-representation of the service primitives defined in IEC 61158-5-10 and
b) define the externally visible behavior associated with their transfer.

This standard specifies the protocol of the Type 10 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498-1) and the OSI Application Layer Structure (ISO/IEC 9545).

1.2 Specifications

The principal objective of this standard is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-10.

A secondary objective is to provide migration paths from previously-existing industrial communications protocols. It is this latter objective which gives rise to the diversity of protocols standardized in IEC 61158-6.

1.3 Conformance

This standard does not specify individual implementations or products, nor does it constrain the implementations of application layer entities within industrial automation systems. Conformance is achieved through implementation of this application layer protocol specification.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE All parts of the IEC 61158 series, as well as IEC 61784-1 and IEC 61784-2 are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 61158-1:2014, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-2:2014, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-5-10:2014, *Industrial communication networks – Fieldbus specifications – Application layer service definition – Type 10 elements*

IEC 61158-6-3:2014*, Industrial communication networks – Fieldbus specifications – Part 6-3: Application layer protocol specification – Type 3 elements*

IEC 61588, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 62439-2, *Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)*

ISO/IEC 646:1991, *Information technology – ISO 7-bit coded character set for information interchange*

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 8822, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

ISO/IEC 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

IEEE 754, *IEEE Standard for Floating-Point Arithmetic,* available at <http://www.ieee.org>

IEEE 802, *IEEE Standard for Local and metropolitan area networks: Overview and Architecture, available at* <http://www.ieee.org>

IEEE 802.1AB-2005, *IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery,* available at <http://www.ieee.org>

IEEE 802.1AS, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – IEEE standard for Local and metropolitan area networks – Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks,* available at <http://www.ieee.org>

IEEE 802.1D, *IEEE Standard for Local and metropolitan area networks – Media access control (MAC) Bridges,* available at <http://www.ieee.org>

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks,* available at <http://www.ieee.org>

IEEE 802.3, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications,* available at <http://www.ieee.org>

IEEE 802.11, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications,* available at <http://www.ieee.org>

IEEE 802.15.1-2005, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.1: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs),* available at <http://www.ieee.org>

IETF RFC 768, *User Datagram Protocol,* available at <http://www.ietf.org>

IETF RFC 791, *Internet Protocol,* available at <http://www.ietf.org>

IETF RFC 792, *Internet Control Message Protocol,* available at <http://www.ietf.org>

IETF RFC 826, *An Ethernet Address Resolution Protocol or Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware,* available at <http://www.ietf.org>

IETF RFC 1034, *Domain names – concepts and facilities,* available at <http://www.ietf.org>

IETF RFC 1213, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II,* available at <http://www.ietf.org>

IETF RFC 2131, *Dynamic Host Configuration Protocol,* available at <http://www.ietf.org>

IETF RFC 2132, *DHCP Options and BOOTP Vendor Extensions,* available at <http://www.ietf.org>

IETF RFC 2236, *Internet Group Management Protocol, Version 2,* available at <http://www.ietf.org>

IETF RFC 2365, *Administratively Scoped IP Multicast,* available at <http://www.ietf.org>

IETF RFC 2474, *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers,* available at <http://www.ietf.org>

IETF RFC 2674, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering and Virtual LAN Extensions,* available at <http://www.ietf.org>

IETF RFC 2863, *The Interfaces Group MIB,* available at <http://www.ietf.org>

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP),* available at <http://www.ietf.org>

IETF RFC 3621, *Power Ethernet MIB,* available at <http://www.ietf.org>

IETF RFC 4361, *Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4),* available at <http://www.ietf.org>

IETF RFC 4363, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions,* available at <http://www.ietf.org>

IETF RFC 4836, *Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs),* available at <http://www.ietf.org>

IETF RFC 5735, *Special-Use IPv4 Addresses,* available at <http://www.ietf.org>

IETF RFC 5890, *Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework,* available at <http://www.ietf.org>

The Open Group — Publication C706, *Technical standard DCE1.1: Remote Procedure Call,* available at <http://www.opengroup.org/onlinepubs/9629399/toc.htm>

3 Terms, definitions, abbreviations, symbols and conventions

For the purposes of this document, the following terms, definitions, symbols, abbreviations and conventions apply:

3.1 Referenced terms and definitions

3.1.1 ISO/IEC 7498-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 7498-1 apply:

a) application entity
b) application process
c) application protocol data unit
d) application service element
e) application entity invocation
f) application process invocation
g) application transaction
h) real open system

i) transfer syntax

3.1.2 ISO/IEC 8822 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8822 apply:

a) abstract syntax
b) presentation context

3.1.3 ISO/IEC 8824-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8824 apply:

a) object identifier
b) type

3.1.4 ISO/IEC 9545 terms

For the purposes of this document, the following terms as defined in ISO/IEC 9545 apply:

a) application-association
b) application-context
c) application context name
d) application-entity-invocation
e) application-entity-type
f) application-process-invocation
g) application-process-type
h) application-service-element
i) application control service element

3.2 Additional terms and definitions for decentralized periphery

3.2.1
alarm
activation of an event that shows a critical state

3.2.2
alarm ack
acknowledgment of an event that shows a critical state

3.2.3
alarm data object
object(s) which represent critical states referenced by device/API/slot/subslot/alarm type

3.2.4
allocate
take a resource from a common area and assign that resource for the exclusive use of a specific entity

3.2.5
application
function or data structure for which data is consumed or produced

3.2.6
application layer interoperability
capability of application entities to perform coordinated and cooperative operations using the services of the FAL

3.2.7
application objects
multiple object classes that manage and provide a run time exchange of PDUs across the network and within the network device

3.2.8
application process
part of a distributed application on a network, which is located on one device and unambiguously addressed

3.2.9
application process identifier
distinguishes multiple application processes used in a device

3.2.10
application process object
component of an application process that is identifiable and accessible through an FAL application relationship

Note 1 to entry: Application process object definitions are composed of a set of values for the attributes of their class (see the definition for Application Process Object Class Definition). Application process object definitions may be accessed remotely using the services of the FAL Object Management ASE. FAL Object Management services can be used to load or update object definitions, to read object definitions and to dynamically create and delete application objects and their corresponding definitions.

3.2.11
application process object class
class of application process objects defined in terms of the set of their network-accessible attributes and services

3.2.12
application relationship
cooperative association between two or more application-entity-invocations for the purpose of exchange of information and coordination of their joint operation. This relationship is activated either by the exchange of application-protocol-data-units or as a result of preconfiguration activities

3.2.13
application relationship application service element
application-service-element that provides the exclusive means for establishing and terminating all application relationships

3.2.14
application relationship endpoint
context and behavior of an application relationship as seen and maintained by one of the application processes involved in the application relationship

Note 1 to entry: Each application process involved in the application relationship maintains its own application relationship endpoint.

3.2.15
attribute
description of an externally visible characteristic or feature of an object

Note 1 to entry: The attributes of an object contain information about variable portions of an object. Typically, they provide status information or govern the operation of an object. Attributes may also affect the behavior of an object. Attributes are divided into class attributes and instance attributes.

3.2.16
backup
status of the IO AR, which indicates that it, is in the standby state

3.2.17
behavior
indication of how an object responds to particular events

3.2.18
channel
representation of a single physical or logical link of an input or output application object of a server to the process in order to support addressing of diagnosis information

Note 1 to entry: The channel typically represents a single connector or clamp as a real interface of a module or submodule. This reference is used to identify points of failure within diagnosis PDUs.

3.2.19
channel diagnosis
information concerning a specific element of an input or output application object, provided for maintenance purposes

EXAMPLE line break

3.2.20
class
set of objects, all of which represent the same kind of system component

Note 1 to entry: A class is a generalization of an object; a template for defining variables and methods. All objects in a class are identical in form and behavior, but usually contain different data in their attributes.

3.2.21
class attributes
attribute that is shared by all objects within the same class

3.2.22
class code
unique identifier assigned to each object class

3.2.23
class specific service
service defined by a particular object class to perform a required function which is not performed by a common service

Note 1 to entry: A class specific object is unique to the object class which defines it.

3.2.24
clear
status of the IO controller, which indicates that the control algorithm is currently not running

3.2.25
client

a) object which uses the services of another (server) object to perform a task
b) initiator of a PDU to which a server reacts

3.2.26
common profile
collection of device independent information and functionality providing consistency between all devices

3.2.27
communication data object
object(s) which are parameter of communication relationships and referenced by device/ slot/ subslot/ index

3.2.28
configuration check
comparison of the expected IO-Data object structuring of the client with the real IO-Data object structuring to the server in the start-up phase

3.2.29
configuration fault
unacceptable difference between the expected IO-Data object structuring and the real IO-Data object structuring, as detected by the server

3.2.30
configuration identifier
representation of a portion of IO Data of a single input- and/or output-module of a server

3.2.31
consume
act of receiving data from a provider

3.2.32
consumer
node or sink receiving data from a provider

3.2.33
context management
network-accessible information (communication objects) that supports managing the operation of the fieldbus system, including the application layer

Note 1 to entry: Managing includes functions such as controlling, monitoring and diagnosing.

3.2.34
conveyance path
unidirectional flow of APDUs across an application relationship

3.2.35
cyclic
repetitive in a regular manner

3.2.36
data consistency
means for coherent transmission and access of the input- or output-data object between and within client and server

3.2.37
device
physical hardware connected to the link

Note 1 to entry: A device may contain more than one node.

3.2.38
device ID
vendor assigned device type identification

3.2.39
device profile
collection of device dependent information and functionality providing consistency between similar devices of the same device type

3.2.40
diagnosis data object
object(s) which contains diagnosis information referenced by device/API/slot/subslot/index

3.2.41
diagnosis information
all data available at the server for maintenance purposes

3.2.42
dynamic reconfiguration
change of IO data objects without interruption of an established application relationship and continuous updating of non-changed IO data objects

3.2.43
endpoint
one of the communicating entities involved in a connection

3.2.44
engineering
abstract term that characterizes the client application or device responsible for configuring an automation system

3.2.45
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.2.46
error class
general grouping for related error definitions and corresponding error codes

3.2.47
error code
identification of a specific type of error within an error class

3.2.48
event
instance of a change of conditions

3.2.49
extended channel diagnosis
information concerning a specific element of a specific application object, provided for maintenance purposes

EXAMPLE Link Fail

3.2.50
frame
unit of data transfer on a link

3.2.51
identification data object
object(s) that contain information about device, module and submodule manufacturer and type referenced by device/API/slot/subslot/index

3.2.52
implicit AR endpoint
AR endpoint that is defined locally within a device without use of the create service

3.2.53
inbound
input communication relation from IO device to IO controller

3.2.54
index
address of a record data object within an application process

3.2.55
instance
the actual physical occurrence of an object within a class that identifies one of many objects within the same object class

3.2.56
instance attributes
attribute that is unique to an object instance and not shared by the object class

3.2.57
instantiated
object that has been created in a device

3.2.58
invocation
act of using a service or other resource of an application process

Note 1 to entry: Each invocation represents a separate thread of control that may be described by its context. Once the service completes, or use of the resource is released, the invocation ceases to exist. For service invocations, a service that has been initiated but not yet completed is referred to as an outstanding service invocation. Also for service invocations, an Invoke ID may be used to unambiguously identify the service invocation and differentiate it from other outstanding service invocations.

3.2.59
IO controller
controlling device, which acts as client for several IO devices (field devices)

Note 1 to entry: This is usually a programable controller or a distributed control system.

3.2.60
IO data object
object designated to be transferred cyclically for the purpose of processing and referenced by device/API/slot/subslot

3.2.61
IO device
field device which acts as server for IO operation

3.2.62
IO parameter server
server for application parameter of IO devices (client)

Note 1 to entry: This is usually a device to backup parameter data and to log online changes of device parameter.

3.2.63
IO subsystem
subsystem composed of one IO controller and all its associated IO devices

3.2.64
IO supervisor
engineering device which manages commissioning and diagnosis of an IO system

3.2.65
IO system
system composed of all its IO subsystems

Note 1 to entry: As an example a Programable Logic Controller with more than one IO controller (network interface) controls one IO system composed of an IO subsystems for each IO controller.

3.2.66
Isochronous mode
IO system operating tightly synchronized with a jitter of less than 1 μs

3.2.67
member
piece of an attribute that is structured as an element of an array

3.2.68
message
synonym for frame

3.2.69
method
synonym for an operational service which is provided by the server ASE and invoked by a client

3.2.70
module
hardware or logical component of a physical device

3.2.71
network
set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.2.72
object
abstract representation of a particular component within a device, usually a collection of related data (in the form of variables) and methods (procedures) for operating on that data that have clearly defined interface and behavior

3.2.73
object specific service
service unique to the object class which defines it

3.2.74
operate
status of the IO controller that indicates that the control algorithm is currently running

3.2.75
outbound
output communication relation from an IO controller to an IO device

3.2.76
packet
frame

3.2.77
peer
role of an AR endpoint in which it is capable of acting as both client and server

3.2.78
physical device
automation or other network device

3.2.79
point-to-point connection
connection that exists between exactly two application objects

3.2.80
primary
status of the IO AR that indicates that it is in the operating state

Note 1 to entry: Besides a primary IO AR a backup IO AR may exist. In example used for redundancy and dynamic reconfiguration of IO data.

3.2.81
provider
node or source sending data to one or many consumer

3.2.82
PTCP subdomain
certain amount of DTEs with synchronized clocks

3.2.83
qualified channel diagnosis
information concerning a specific element of a specific application object, provided for maintenance purposes with a parameterized severity

EXAMPLE Overload

3.2.84
record data object
object(s) which are already pre-processed and transferred acyclically for the purpose of information or further processing and referenced by device/API/slot/subslot/index

3.2.85
resource
processing or information capability

3.2.86
run
status of the IO controller which indicates that the control algorithm is currently operating

3.2.87
server

a) role of an AREP in which it returns a confirmed service response APDU to the client that initiated the request

b) object which provides services to another (client) object

3.2.88
service
operation or function than an object and/or object class performs upon request from another object and/or object class

3.2.89
slot
address of a structural unit within an IO device

Note 1 to entry: Within a modular device, a slot typically addresses a physical module. Within compact devices, a slot typically addresses a logical function or virtual module.

3.2.90
stop
status of the IO controller which indicates that the control algorithm is currently not running

3.2.91
submodule
hardware or logical component of a module

3.2.92
subslot
address of a structural unit within a slot

Note 1 to entry: A subslot may address a physical interface for submodules within a module. Generally, a subslot is a second level to structure data within a device.

3.2.93
vendor ID
central administrative number used as manufacturer identification

3.3 Abbreviations and symbols

3.3.1 Abbreviations and symbols for media redundancy

MRC	Media Redundancy Client
MRM	Media Redundancy Manager
MRP	Media Redundancy Protocol
MRPD	Media Redundancy with Planned Duplication of frames

NOTE The Media Redundancy with Planned Duplication of frames is done by the sender using different paths for the adjunctive frames.

3.3.2 Abbreviations and symbols for decentralized periphery

AE	Application Entity
AL	Application Layer
ALME	Application Layer Management Entity
ALP	Application Layer Protocol
ALPMI	Alarm Protocol Machine Initiator
ALPMR	Alarm Protocol Machine Responder
AP	Application Process
APDU	Application Protocol Data Unit
API	Application Process Identifier
APM	Acyclic Protocol Machine
APMR	Acyclic Protocol Machine Receiver
APMS	Acyclic Protocol Machine Sender
APO	Application Object
AR	Application Relationship
AREP	Application Relationship End Point
ARP	Address Resolution Protocol
ARPM	Address Resolution Protocol Machine
ASCII	American Standard Code for Information Interchange
ASE	Application Service Element
BLOB	Binary Large OBject
BMA	Best-Master-Algorithm Protocol Machine
BMC	Best Master Clock
CLRPC	Connectionless Remote Procedure Call
CL-RPC	Connectionless Remote Procedure Call
CM	Context Management
CMCTL	Context Management Protocol Machine Controller

CMDEV	Context Management Protocol Machine Device
CMDEV_DA	Context Management Device Access Protocol Machine Device
CMDMC	Discovery Multicast Communication Protocol Machine
CMINA	Context Management IP and Name Assignment Protocol Machine
CMIO	Context Management Input Output Protocol Machine Device
CMPBE	Context Management Prm Begin End Protocol Machine Device
CMRDR	Context Management Read Record Responder Protocol Machine Device
CMRPC	Context Management RPC Device Protocol Machine
CMSM	Context Management Surveillance Protocol Machine Device
CMSU	Context Management Startup Protocol Machine Device
CMWRR	Context Management Write Record Responder Protocol Machine Device
CPM	Consumer protocol machine for cyclic transmitted data
CR	Communication Relationship
CREP	Communication Relationship End Point
CT	Cut Through switching
CTLDINA	Context Management Discovery, IP and Name Assignment
CTLIO	Context Management Input Output Protocol Machine Controller
CTLPBE	Context Management Prm Begin End Protocol Machine Controller
CTLRDI	Context Management Read Record Initiator Protocol Machine Controller
CTLRDR	Context Management Read Record Responder Protocol Machine Controller
CTLRPC	Context Management RPC Protocol Machine Controller
CTLSM	Context Management Surveillance Protocol Machine Controller
CTLSU	Context Management Startup Protocol Machine Controller
CTLWRI	Context Management Write Record Initiator Protocol Machine Controller
CTLWRR	Context Management Write Record Responder Protocol Machine Controller
DCE	OSF Distributed Computing Environment
DCP	Discovery and basic Configuration Protocol
DCPHMCS	DCP Hello Multicast Sender Protocol Machine
DCPHMRC	DCP Hello Multicast Receiver Protocol Machine
DCPMCR	DCP Multicast Receiver Protocol Machine
DCPMCS	DCP Multicast Sender Protocol Machine
DCPUCR	DCP Unicast Receiver Protocol Machine
DCPUCS	DCP Unicast Sender Protocol Machine
DEFRAG	Defragmentation Protocol Machine
DELAY_REQ	Line Delay Request Protocol Machine
DELAY_RSP	Line Delay Response Protocol Machine
DEMUX	Network Access Receiver
DFP	Dynamic Frame Packing
DFP_RELAY	DFP Protocol Machine
DFP_RELAY_IN_STORAGE	DFP Inbound Storage Protocol Machine
DFP_RELAY_INBOUND	DFP Inbound Protocol Machine
DFP_RELAY_OUTBOUND	DFP Outbound Protocol Machine
DHCP	Dynamic Host Configuration Protocol
DIM	Device Interface Module
DLC	Data Link Connection
DLL	Data Link Layer
DLPDU	Data Link-Protocol Data Unit
DLSDU	Data Link-service-data-unit

DMPM	DLL Mapping Protocol Machines
DNS	Domain Name Service
DTE	Date Terminal Equipment
FAL	Fieldbus Application Layer
FDB	Filtering Data Base
FIFO	First In First Out
FRAG	Fragmentation Protocol Machine
FSPM	FAL Service Protocol Machines
FSPMCTL	FSPM Controller
FSPMDEV	FSPM Device
GBSM	Get Best Sync Master Protocol Machine
GSDML	General Station Description Markup Language
I&M	Identification and Maintenance Profile
IANA	Internet Assigned Numbers Authority
ICMP	Internet Control Message Protocol
ID	Identifier
IEC	International Electrotechnical Commission
IFW	RT_CLASS_3 Forwarding Protocol Machine
IOC	Input Output Controller
IOCR	IO Communication Relation
IOCS	Input Output Object Consumer Status
IOD	Input Output Device
IOMCR	IO Multicast Communication Relation
IOPS	Input Output Object Provider Status
IOS	Input Output Supervisor
IP	Internet Protocol
IR	Isochronous Relay
IRT	Isochronous Real Time Protocol
ISO	International Organization for Standardization
IsoM	Isochronous Mode
LED	Light Emitting Diode
LLDP	Link Layer Discovery Protocol
LME	Layer Management Entity
LMPM	Data Link Layer Mapping Protocol Machine
lsb	Least Significant Bit
LT	Length/Type
MAC	Media Access Control
MAC_RELAY	Forwarding Protocol Machine
MCPM	Multicast Consumer protocol machine for cyclic transmitted data
MCR	Multicast communication relation
MPPM	Provider protocol machine for cyclic transmitted data (PPM) using Multicast communication relation
msb	most significant bit
MUX	Network Access Sender
NAP	Network Access Point
NCA	Network Computing Architecture
OSF	Open Software Foundation
OSI	Open Systems Interconnect
PDU	Protocol Data Unit
PL	Physical Layer
PPM	Provider protocol machine for cyclic transmitted data
PTCP	Precision Transparent Clock Protocol
QoS	Quality of Service
RED_RELAY	Realtime Class 3 Forwarding Protocol Machine
RPC	Remote Procedure Call
RSM	Best Remote Sync Master Protocol Machine
RT	Real Time Protocol
RT_CLASS_UDP	Realtime Class UDP (supports Layer 3 transport)
RT_CLASS_1	Realtime Class 1 (Layer 2 tranport)
RT_CLASS_2	Realtime Class 2 (Layer 2 tranport)
RT_CLASS_3	Realtime Class 3 (Layer 2 tranport)

RTA	Real Time Protocol Acyclic
RTC	Real Time Protocol Cyclic
RTC3PSM	Realtime Class 3 Port State Machine
S&F	Store and Forward
SCHEDULER	Scheduler Protocol Machine
SDU	Service Data Unit
SYN_BMA	Best-Master-Algorithm Protocol Machine
SYN_BMA_GBSM	Get Best Sync Master
SYN_BMA_RSM	Best Remote Sync Master
SYN_MPSM	PTCP Master Protocol Machine
SYN_SPSM	PTCP Slave Protocol Machine
SYNC_RELAY	Sync Relay Protocol Machine
TLV	Type Length Value (coding rule)
UDP	User Datagram Protocol
UUID	Universal Unique Identifier
VLAN	Virtual Local Area Network

3.3.3 Abbreviations and symbols for services

cnf	Confirmation
ind	Indication
req	Request
rsp	Response

3.4 Conventions

3.4.1 General concept

The FAL is defined as a set of object-oriented ASEs. Each ASE is specified in a separate clause. Each ASE specification is composed of three parts: its class definitions, its services and its protocol specification. The first two are contained in IEC 61158-5-10. The protocol specification for each of the ASEs is defined in this standard.

The class definitions define the attributes of the classes supported by each ASE. The attributes are accessible from instances of the class using the Management ASE services specified in IEC 61158-5-10 standard. The service specification defines the services that are provided by the ASE.

This standard uses the descriptive conventions given in ISO/IEC 10731.

3.4.2 Conventions for decentralized periphery

3.4.2.1 Abstract syntax conventions

3.4.2.1.1 PDUs are described as octets or groups of octets

a) Groups of octets separated by a comma appear in the order they are transferred If optional octets are not present the following octets appear without a gap

b) If octets or groups of octets are grouped within “{ }” the order is arbitrary

c) If octets or groups of octets are marked with “*” they may appear more than once. If it is used within a “{ }” section they may appear mixed with other octets or group of octets of this section.

d) Octets can be grouped or values can be assigned within “( )”

e) If octets or groups of octets are grouped within “[ ]” the group can be omitted. This doesn’t imply that the support of these octets is optional.

f) Complex APDUs may be built by means of substitutions (sub-structures)

g) Exclusive selections of octets or groups of octets are separated by “^”

NOTE 1 The formal PDU example

AP_PDU = Octet1, OctetGroup1, [Octet2], [Octet3], {[OctGroup2*], OctetGroup3 ^ Octet4}

According to this the following variants are valid on the wire (non exhaustive):

Variant 1: Octet1, OctetGroup1, Octet2, Octet3, OctetGroup2, OctetGroup3

Variant 2: Octet1, OctetGroup1, Octet2, Octet3, OctetGroup2, OctetGroup2, OctetGroup2, OctetGroup3

Variant 3: Octet1, OctetGroup1, OctetGroup2, OctetGroup2, OctetGroup2, OctetGroup3, OctetGroup2

Variant 4: Octet1, OctetGroup1, OctetGroup2, OctetGroup3, OctetGroup2, OctetGroup2, OctetGroup2, OctetGroup2

Variant 5: Octet1, OctetGroup1, Octet3, Octet4

NOTE 2 The arbitrary order implies that groups of octets are characterised by a special header that is described within the coding rules.

NOTE 3 The APDU syntax for RTA- and RTC-PDU implies that according to the maximum DLSDU an APDU does not exceed 1 440 octets in total.

NOTE 4 The APDU syntax for CL-RPC implies that an IO controller supports a minimal ASDU size of 4 096 octets in total and does not exceed 2^{32}-64 octets in total. The minimal ASDU size is derived from the expected size of configuration, parameter and diagnosis data of an enhanced IO device.

3.4.2.2 Convention for the encoding of reserved bits and octets

The term “reserved” may be used to describe bits in octets or whole octets. All bits or octets that are reserved should be set to zero at the sending side and shall not be tested at the receiving side except it is explicitly stated or if the reserved bits or octets are checked by a state machine.

The term “reserved” may also be used to indicate that certain values within the range of a parameter are reserved for future extensions. In this case the reserved values should not be used at the sending side and shall not be tested at the receiving side except it is explicitly stated or if the reserved values are check by a state machine.

3.4.2.3 Conventions for the common codings of specific field octets

APDUs may contain specific fields that carry information in a primitive and condensed way. These fields shall be coded in the order according to Figure 1.

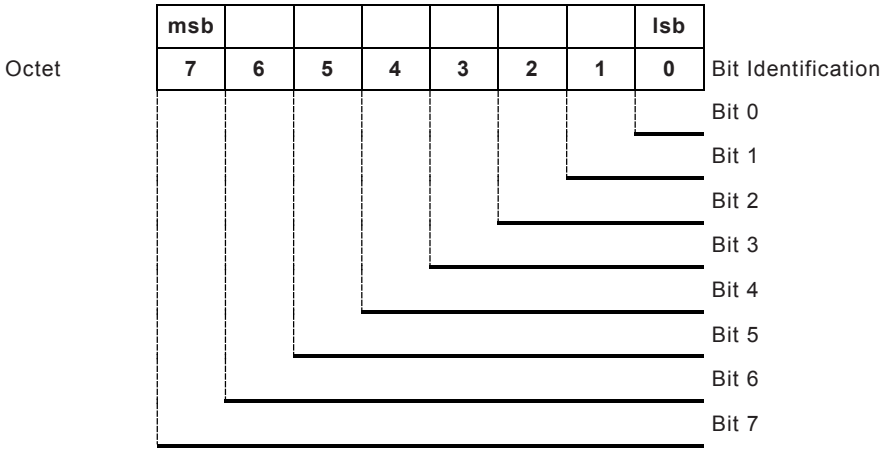


Figure 1 – Common structure of specific fields

Several bit may be grouped as group of bit. Each bit or group of bits shall be addressed by its Bit Identification (e.g. Bit 0, Bit 1 to 4). The position within the octet shall be according to the figure above. Alias names may be used for each bit or group of bits or they may be marked as reserved. The grouping of individual bits shall be in ascending order without gaps. The values for a group of bits may be represented as binary, decimal or hexadecimal values. This value

shall only be valid for the grouped bits and can only represent the whole octet if all 8 bits are grouped. Decimal or hexadecimal values shall be transferred in binary values so that the bit with the highest number of the group represents the msb concerning the grouped bit.

EXAMPLE 1 Description and relation for the specific field octet

Bit 0: reserved.

Bit 1-3: Reason_Code The decimal value 2 for the Reason_Code means general error.

Bit 4-7: shall always set to one.

The octet that is constructed according to the description above looks as follows:

(msb) Bit 7 = 1,
Bit 6 = 1,
Bit 5 = 1,
Bit 4 = 1,
Bit 3 = 0,
Bit 2 = 1,
Bit 1 = 0,
(lsb) Bit 0 = 0.

The bit combination “0-1-0” for Bit 1-3 equals the decimal value 2.

3.4.2.4 Conventions for the common codings of specific field consisting of two subsequent octets

APDUs may contain specific fields that carry information in a primitive and condensed way. These fields shall be coded in the order according to Figure 2 and Figure 3.

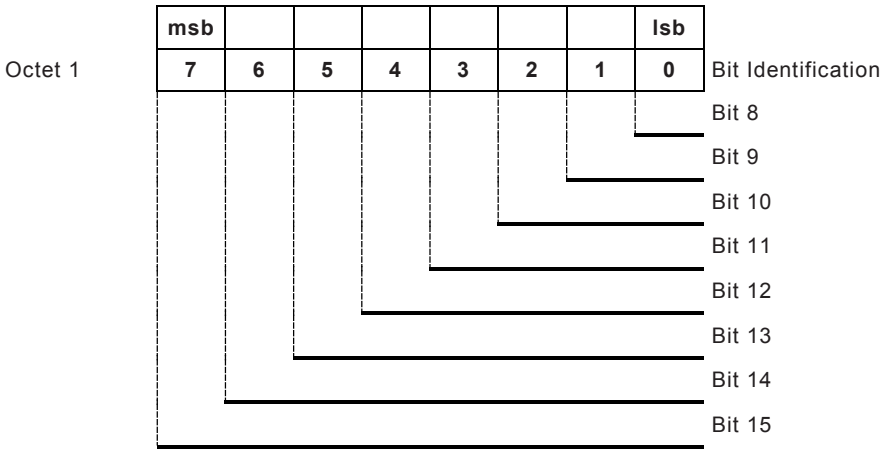


Figure 2 – Common structure of specific fields for octet 1 (high)

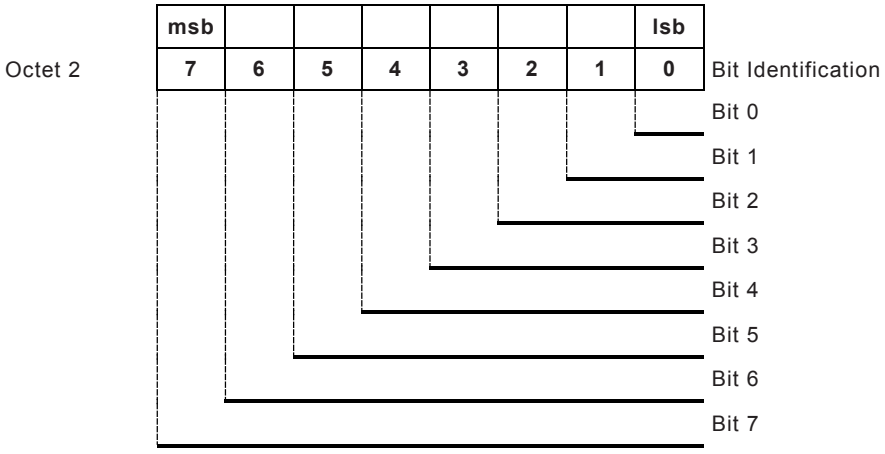


Figure 3 – Common structure of specific fields for octet 2 (low)

Several bits may be grouped as group of bit. Each bit or group of bits shall be addressed by its Bit Identification (e.g. Bit 0, Bit 1 to 4). The position within the octet shall be according to the figure above. Alias names may be used for each bit or group of bits or they may be marked as reserved. The grouping of individual bits shall be in ascending order without gaps. The values for a group of bits may be represented as binary, decimal or hexadecimal values. This value shall only be valid for the grouped bits and can only represent the whole octet if all 16 bits are grouped. Decimal or hexadecimal values shall be transferred in binary values so that the bit with the highest number of the group represents the msb concerning the grouped bit.

3.4.2.5 Conventions for the common coding of specific field consisting of four subsequent octets

APDUs may contain specific fields that carry information in a primitive and condensed way. These fields shall be coded in the order according to Figure 4, Figure 5, Figure 6 and Figure 7.

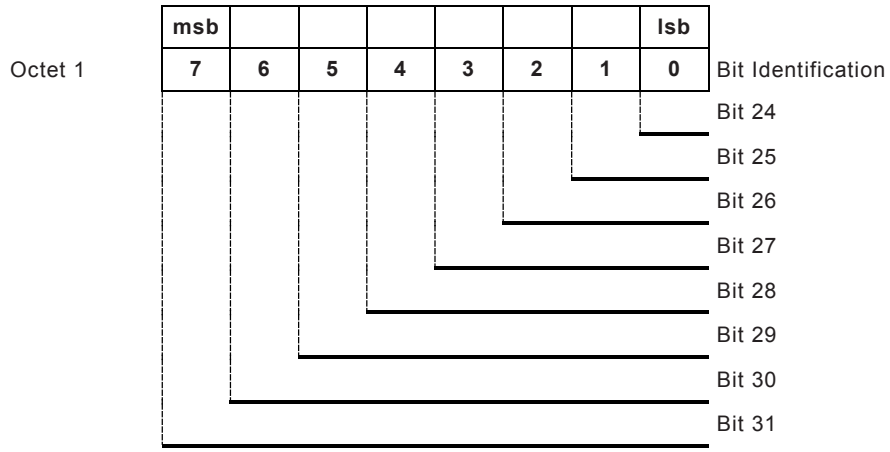


Figure 4 – Common structure of specific fields for octet 1 (high)

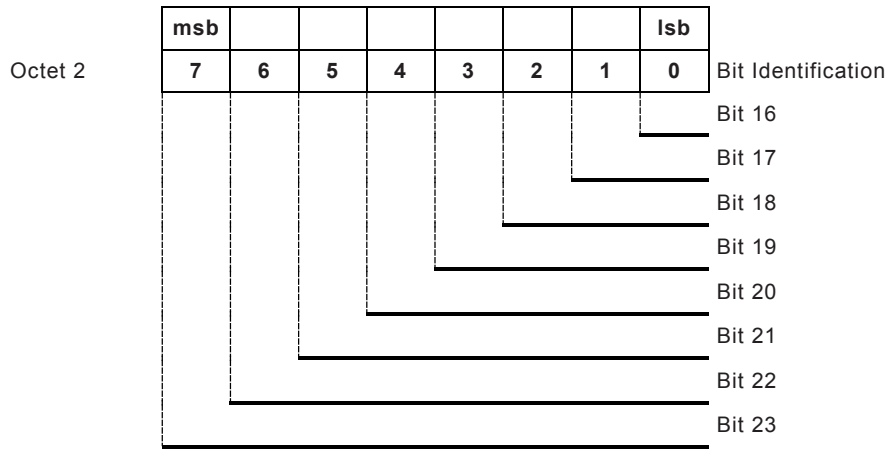


Figure 5 – Common structure of specific fields for octet 2

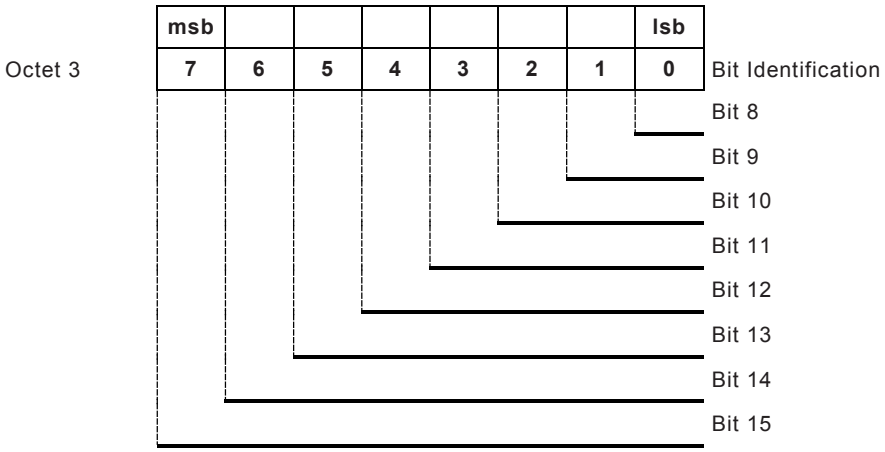


Figure 6 – Common structure of specific fields for octet 3

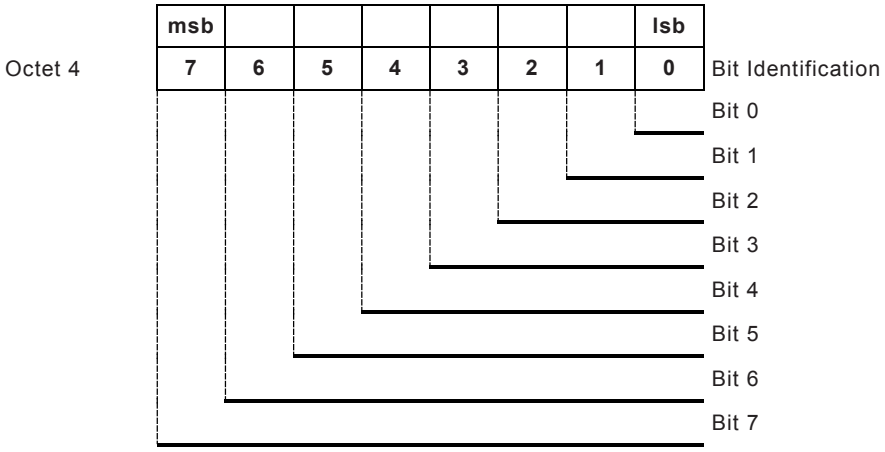


Figure 7 – Common structure of specific fields for octet 4 (low)

Bits may be grouped as group of bits. Each bit or group of bits shall be addressed by its Bit Identification (e.g. Bit 0, Bit 1 to 4). The position within the octet shall be according to the figure above. Alias names may be used for each bit or group of bits or they may be marked as reserved. The grouping of individual bits shall be in ascending order without gaps. The values for a group of bits may be represented as binary, decimal or hexadecimal values. This value shall only be valid for the grouped bits and can only represent the whole octet if all 32 bits are grouped. Decimal or hexadecimal values shall be transferred in binary values so that the bit with the highest number of the group represents the msb concerning the grouped bits.

3.4.3 Conventions used in state machines

The protocol sequences are described by means of State Machines.

In state diagrams states are represented as boxes state transitions are shown as arrows. Names of states and transitions of the state diagram correspond to the names in the textual listing of the state transitions.

The initialization of all parameters (e.g. default values) of a state machine will be realized automatically during the instantiation of the machine (new instance). Implicit transition from POWER-ON to first state calling the INIT service. If it is necessary to have different instances of one machine type, different parameters are set by the INIT service.

The textual listing of the state transitions is structured as follows, see also Table 1.

- The first row contains the name of the transition.
- The second row defines the current state.
- The third row contains an optional event followed by Conditions starting with a "/" as first line character and finally followed by the Actions starting with a "=>" as first line character.
- The last row contains the next state.

If the event occurs and the conditions are fulfilled the transition fires, e.g. the actions are executed and the next state is entered.

The layout of a Machine description is shown in Table 1. The meaning of the elements of a State Machine Description is shown in Table 2.

Table 1 – State machine description elements

#	Current state	Event or condition => action	Next state

Table 2 – Description of state machine elements

Description element	Meaning
Current state Next state	Name of the given states.
#	Name or number of the state transition.
Event	Name or description of the event.
/Condition	Boolean expression. The preceding "/" is not part of the condition.
=> Action	List of assignments and service or function invocations. The preceding "=>" is not part of the action.

The conventions used in the state machines are shown in Table 3.

Table 3 – Conventions used in state machines

Convention	Meaning
:=	Value of an item on the left is replaced by value of an item on the right. If an item on the right is a parameter, it comes from the primitive shown as an input event.
xxx	A parameter name. Example: Identifier := reason means value of a 'reason' parameter is assigned to a parameter called 'Identifier.'
"xxx"	Indicates fixed value. Example: Identifier := "abc" means value "abc" is assigned to a parameter named 'Identifier.'
= or ==	A logical condition to indicate an item on the left is equal to an item on the right.
<	A logical condition to indicate an item on the left is less than the item on the right.
>	A logical condition to indicate an item on the left is greater than the item on the right.
<> or !=	A logical condition to indicate an item on the left is not equal to an item on the right.
>>	A semantic condition with the meaning "newer"

Convention	Meaning
<<	A semantic condition with the meaning “older”
&&	Logical “AND”
||	Logical “OR”
<=	A logical condition to indicate an item on the left is equal or less than the item on the right.
>=	A logical condition to indicate an item on the left is equal or greater than the item on the right.

for (Identifier := start_value to end_value)
actions
endfor
	This construct allows the execution of a sequence of actions in a loop within one transition. The loop is executed for all values from start_value to end_value.

If (condition)
actions
else
actions
	This construct allows the execution of alternative actions depending on some condition (which might be the value of some identifier or the outcome of a previous action) within one transition.
	The parts beginning with “else” can be omitted if there is no action if the condition is not fulfilled.

The conventions used for service in the state machines are shown in Table 4.

Table 4 – Conventions for services used in state machines

Convention	Meaning
xxx.req ()	request according to ISO/IEC 7498-1 invokes the service and passes any required parameter parameters are omitted and listed within the state machine description
xxx.ind ()	indication according to ISO/IEC 7498-1 advices the activation of a requested service
xxx.rsp (+), xxx.cnf (+)	response according to ISO/IEC 7498-1 may positively acknowledge or complete an action previously invoked by a request primitive confirmation according to ISO/IEC 7498-1 primitive returned to the requestor to positively acknowledge or complete an action previously invoked by a request primitive parameters are omitted and listed within the state machine description
xxx.rsp (-), xxx.cnf (-)	response according to ISO/IEC 7498-1 may negatively acknowledge or complete an action previously invoked by a request primitive confirmation according to ISO/IEC 7498-1 primitive returned to the requestor to negatively acknowledge or complete an action previously invoked by a request primitive parameters are omitted and listed within the state machine description
xxx_req (), xxx_cnf (+), xxx_cnf (-)	this construct is used for the description of local and confirmed services, which are transfered between state machines parameters are listed within the state machine description and can be delivered inside the brackets optionally
xxx_ind ()	this construct is used for the description of local services and indicates the reception of this service parameters are listed within the state machine description and can be delivered inside the brackets optionally
xxx ()	this construct is used for the description of state machine internal functions (local) parameters are listed within the state machine description and can be delivered inside the brackets optionally

Convention	Meaning
(), (+), (-)	replacement of the associated parameter list, described in the primitives definition except local services and functions can deliver parameters inside the brackets if the result is not necessary for further executions, the sign + and - can be omitted

Readers are strongly recommended to refer to the clauses for the AREP and CREP attribute definitions, the local functions and the FAL-PDU definitions to understand protocol machines. It is assumed that readers have sufficient knowledge of these definitions and they are used without further explanations.

In addition the following description elements are used:

Wildcard in names
name_XXX: “XXX” is used as wildcard string for all names beginning with “name”.

others: is used as wildcard string for all events which may appear in this state excluding the explicitly stated events.

The typical use of a wildcard is an Event. In this context there are as many state transitions as possible events for this wildcard exists.

Wildcard in state names
“ANY” is used as wildcard string for a current state to indicates all states of this state table.

“SAME” is used as wildcard string for a next state to indicate that the transition remains in the same state. Only to be used in combination with “ANY”.

Conditional Macro
<CONDITIONAL -MACRO-NAME>

<

CONDITION1: macrobody1

CONDITION2: macrobody2

…

>

CONDITION1, CONDITION2, etc. define all possible cases for the conditional macro. The “CONDITIONAL-MACRO-NAME” acts as place holder for the “macrocode” depending on the result of the condition.

Replacement Macro
<REPLACEMENT-MACRO-NAME>

<

XXX= Name1 : macrobody1

XXX= Name2 : macrobody2

…

>

Name1, Name2, etc. define all possible cases for the replacement macro. The “REPLACEMENT-MACRO-NAME” acts as place holder for the “macrocode” depending on the value of the current use of the wildcard XXX.

EXAMPLE

<SERVICE_REQ_PARA>

<

XXX=Read: Para1, Para2

XXX=Write: Para1, Para2, Para3

>

when called in

MSAB_XXX.req(<SERVICE_REQ_PARA>)

will result in

MSAB_Read.req(Para1, Para2) or MSAB_Write.req(Para1, Para2, Para3)

4 Application layer protocol specification for common protocols

4.1 FAL syntax description

4.1.1 DLPDU abstract syntax reference

4.1.1.1 General

Table 5, Table 6 and Table 7 give an outline of the abstract syntax of the DLPDU according to IEEE 802.3, IEEE 802.11 and IEEE 802.15.1.

4.1.1.2 IEEE 802.3

The encoding and decoding of the fields in Table 5 shall be according to IEEE 802.3 for the DLPDU.

Table 5 – IEEE 802.3 DLPDU syntax

DLPDU name	DLPDU structure
DLPDU	Preamble [a], StartFrameDelimiter, DestinationAddress, SourceAddress, DLSDU [b], DLPDU_Padding* [c], FrameCheckSequence
DLSDU	[VLAN] [d], LT, SAPDU ^ FIDAPDU
SAPDU	UDP-RTC-PDU ^ UDP-RTA-PDU ^ CL-RPC-PDU ^ LLDP-PDU [e] ^ ICMP-PDU
FIDAPDU	FrameID, RTC-PDU ^ RTA-PDU ^ DCP-PDU ^ PTCP-PDU [e] ^ FRAG-PDU
VLAN	LT(=0x8100), TagControlInformation
NOTE According to IEEE 802.3 the DLPDUs have a minimum length of 64 octets (excluded Preamble, Start Frame Delimiter).	
[a] The field contains at 7 octets but should be decreased to at least 1 octets according to this standard.	
[b] The minimum DLSDU size is 2 octets.	
[c] The number of padding octets shall be in the range of 0..46 depending on the DLSDU size. See the minimum frame size in IEEE 802.3	
[d] The VLAN field of a RTC DLPDU should be encoded by the sender, but shall be omitted for RT_CLASS_3. It may be omitted by the conveyance of the frame. The RED_RELAY may accept RT_CLASS_3 frames with VLAN. The decoder shall accept DLPDUs with or without VLAN field. Only one VLAN shall be supported, more VLANs may be supported.	
[e] The VLAN field shall be omitted except for the PTCP-AnnouncePDU.	

4.1.1.3 IEEE 802.11

The encoding and decoding of the fields in Table 6 shall be according to IEEE 802.11 for the DLPDU.

Table 6 – IEEE 802.11 DLPDU syntax

DLPDU name	DLPDU structure
DLPDU	DLPDU_1 ^ DLPDU_2 ^ DLPDU_3 ^ DLPDU_4
DLPDU_1	FrameControl, DestinationAddress, SourceAddress, BSSID, SequenceControl, [QoSControl] [b], DLSDU, DLPDU_Padding* [a], FrameCheckSequence
DLPDU_2	FrameControl, DestinationAddress, BSSID, SourceAddress, SequenceControl, [QoSControl] [b], DLSDU, DLPDU_Padding* [a], FrameCheckSequence
DLPDU_3	FrameControl, BSSID, SourceAddress, DestinationAddress, SequenceControl, [QoSControl], DLSDU, DLPDU_Padding* [a], FrameCheckSequence
DLPDU_4	FrameControl, ReceiverAddress, TransmitterAddress, DestinationAddress, SequenceControl, SourceAddress, [QoSControl], DLSDU, DLPDU_Padding* [a], FrameCheckSequence
DLSDU	DSAP(=0xaa), SSAP(=0xaa), CTRL(=0x03), OUI(=0), [VLAN] [b], LT, SAPDU ^ FIDAPDU
SAPDU	UDP-RTC-PDU ^ UDP-RTA-PDU ^ CL-RPC-PDU ^ LLDP-PDU ^ ICMP-PDU
FIDAPDU	FrameID, RTC-PDU ^ RTA-PDU ^ DCP-PDU ^ PTCP-PDU

NOTE 1 For definition of FrameControl see IEEE 802.11

NOTE 2 For definition of BSSID see IEEE 802.11

NOTE 3 For definition of SequenceControl see IEEE 802.11

NOTE 4 For definition of QoSControl see IEEE 802.11

NOTE 5 For definition of ReceiverAddress see IEEE 802.11

NOTE 6 For definition of TransmitterAddress see IEEE 802.11

NOTE 7 The IEEE 802.11 supports the use of VLANs in conjunction with FrameClassifier Type 2. For definition of FrameClassifier see IEEE 802.11

NOTE 8 For definition of DSAP see IEEE 802.11

NOTE 9 For definition of SSAP see IEEE 802.11

NOTE 10 For definition of CTRL see IEEE 802.11

NOTE 11 For definition of OUI in this context see IEEE 802.11

[a] The number of padding octets shall be in the range of 0...46 depending on the DLSDU size. See the minimum frame size in IEEE 802.3.

[b] The VLAN field of a RTC DLPDU should be encoded by the sender, but omitted for RT_CLASS_3. It may be omitted by the conveyance of the frame, but shall be omitted by the RED_RELAY. The decoder shall accept DLPDUs with or without VLAN fields.

4.1.1.4 IEEE 802.15.1

The encoding and decoding of the fields in Table 7 shall be according to IEEE 802.15.1 for the DLPDU.

Table 7 – IEEE 802.15.1 DLPDU syntax

DLPDU name	DLPDU structure
DLPDUHEADER	Access Code, Packet Header, Payload Header, L2CAP Header, BNEPType(0)
DLPDU	DLPDUHEADER, DestinationAddress, SourceAddress, DLSDU [a], FrameCheckSequence
DLSDU	[VLAN] [b], LT, SAPDU ^ FIDAPDU
SAPDU	UDP-RTC-PDU ^ UDP-RTA-PDU ^ CL-RPC-PDU ^ LLDP-PDU [c] ^ ICMP-PDU
FIDAPDU	FrameID, RTC-PDU ^ RTA-PDU ^ DCP-PDU ^ PTCP-PDU [c]
VLAN	LT(=0x8100), TagControlInformation
NOTE 1 For definition of Access Code see IEEE 802.15.1 NOTE 2 For definition of Packet Header see IEEE 802.15.1 NOTE 3 For definition of Payload Header see IEEE 802.15.1 NOTE 4 For definition of L2CAP Header see IEEE 802.15.1 NOTE 5 For definition of BNEPType see IEEE 802.15.1	
[a] The minimum DLSDU size is 2 octets. [b] The VLAN field of a RTC DLPDU should be encoded by the sender, but omitted for RT_CLASS_3. It may be omitted by the conveyance of the frame, but shall be omitted by the RED_RELAY. The decoder shall accept DLPDUs with or without VLAN fields. [c] The VLAN field should be omitted.	

4.1.2 Data types

4.1.2.1 Notation for the Boolean type

Boolean ::= BOOLEAN -- TRUE if the value is non-zero.

-- FALSE if the value is zero.

4.1.2.2 Notation for the Integer type

Integer8 ::= INTEGER (-128..+127) -- range $-2^7 \leq I \leq 2^7-1$

Integer16 ::= INTEGER (-32 768..+32 767) -- range $-2^{15} \leq I \leq 2^{15}-1$

Integer32 ::= INTEGER -- range $-2^{31} \leq I \leq 2^{31}-1$

Integer64 ::= INTEGER -- range $-2^{63} \leq I \leq 2^{63}-1$

4.1.2.3 Notation for the Unsigned type

Unsigned8 ::= INTEGER (0..255) -- range $0 \leq I \leq 2^8-1$

Unsigned16 ::= INTEGER (0..65 535) -- range $0 \leq I \leq 2^{16}-1$

Unsigned32 ::= INTEGER -- range $0 \leq I \leq 2^{32}-1$

Unsigned64 ::= INTEGER -- range $0 \leq I \leq 2^{64}-1$

4.1.2.4 Notation for the Floating Point type

Float32 ::= BIT STRING SIZE (4) -- IEEE 754 Single precision

Float64 ::= BIT STRING SIZE (8) -- IEEE 754 Double precision

4.1.2.5 Notation for the OctetString type

OctetString ::= OCTET STRING -- For generic use

4.1.2.6 Notation for VisibleString type

VisibleString ::= VISIBLE STRING -- ISO/IEC 646 – International Reference Version without the “del” (coding 0x7F) character

4.1.2.7 Notation for BinaryDate type

BinaryDate ::= OCTET STRING SIZE (7) -- ISO 8601 date and time formats are recommended

4.1.2.8 Notation for TimeOfDay type

TimeOfDay with date indication ::= OCTET STRING SIZE (6) -- ISO 8601 date and time formats are recommended

TimeOfDay without date indication ::= OCTET STRING SIZE (4) -- ISO 8601 date and time formats are recommended

4.1.2.9 Notation for TimeDifference type

TimeDifference with date indication ::= OCTET STRING SIZE (6) -- ISO 8601 date and time formats are recommended

TimeDifference without date indication ::= OCTET STRING SIZE (4) -- ISO 8601 date and time formats are recommended

4.2 Transfer syntax

4.2.1 Coding of basic data types

4.2.1.1 General Encoding

– The encoding of values shall be big endian if not explicitly otherwise stated.

4.2.1.2 Encoding of a Boolean value

– The encoding of a Boolean value shall be primitive. The ContentsOctets shall consist of a single octet.

– If the Boolean value is FALSE, the ContentsOctets shall be 0 (zero). If the Boolean value is TRUE, the ContentsOctets shall be 0xff.

4.2.1.3 Encoding of an Integer value

– The encoding of a fixed-length Integer value of Integer8, Integer16, Integer32 and Integer64 types shall be primitive and the ContentsOctets shall consist of exactly one, two, four, or eight octets, respectively.

– The ContentsOctets shall be a two's complement binary number equal to the integer value and consist of bits 7 to 0 of the first octet, followed by bits 7 to 0 of the second octet, followed by bits 7 to 0 of each octet in turn up to and including the last octet of the ContentsOctets.

NOTE The value of a two's complement binary number is derived by numbering the bits in the ContentsOctets, starting with bit 0 of the last octet as bit zero and ending the numbering with bit 7 of the first octet. Each bit is assigned a numerical value of 2^N, where N is its position in the above numbering sequence. The value of the two's complement binary number is obtained by adding the numerical values assigned to each bit for those bits which are set to one, excluding bit 7 of the first octet and then reducing this value by the numerical value assigned to bit 7 of the first octet if that bit is set to one.

4.2.1.4 Encoding of an Unsigned value

– The encoding of a fixed-length Unsigned value of Unsigned8, Unsigned16, Unsigned32 and Unsigned64 types shall be primitive and the ContentsOctets shall consist of exactly one, two, four, or eight octets, respectively.

– The ContentsOctets shall be a binary number equal to the Unsigned value and consist of bits 7 to 0 of the first octet, followed by bits 7 to 0 of the second octet, followed by bits 7 to 0 of each octet in turn up to and including the last octet of the ContentsOctets.

NOTE The value of a binary number is derived by numbering the bits in the ContentsOctets, starting with bit 0 of the last octet as bit zero and ending the numbering with bit 7 of the first octet. Each bit is assigned a numerical value of 2^N, where N is its position in the above numbering sequence. The value of the binary number is obtained by adding the numerical values assigned to each bit for those bits which are set to one.

4.2.1.5 Encoding of a Floating-Point value

– The encoding of a fixed-length floating-point value of Float32 and Float64 types shall be primitive and the ContentsOctets shall consist of exactly four or eight octets, respectively.

– The ContentsOctets shall contain floating-point values defined in conformance with IEEE 754.
For Float32 the sign is encoded in bit 7 of the first octet. It is followed by the exponent starting from bit 6 of the first octet and then the mantissa starting from bit 6 of the second octet.
For Float64 the sign is encoded in bit 7 of the first octet. It is followed by the exponent starting from bit 6 of the first octet and then the mantissa starting from bit 3 of the second octet.

4.2.1.6 Encoding of a VisibleString value

– The encoding of a variable length VisibleString value shall be primitive.

– There is no Length field; the length is encoded implicitly.

– The ContentsOctets shall be a sequence of octets. The leftmost string element is encoded in the first octet, followed by the second octet, followed by each octet in turn up to and including the last octet as rightmost of the ContentsOctets.

4.2.1.7 Encoding of an OctetString value

– The encoding of a variable length OctetString value shall be primitive.

– There is no Length field; the length is encoded implicitly.

– The ContentsOctets shall be a sequence of octets. The leftmost string element is encoded in the first octet, followed by second octet, followed by each octet in turn up to and including the last octet as rightmost of the ContentsOctets.

4.2.1.8 Encoding of a BinaryDate value

– The encoding of a BinaryDate value shall be primitive.

– The Length field shall indicate as a binary number the number of octets in the BinaryDate value.

– The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 8.

bits octets	7	6	5	4	3	2	1	0	
1	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	0…59 999 ms
2	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
3	0	0	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…59 min
4	DST	0	0	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0…23 hours DST: Daylight saving time
	day of week			day of month					1…7 day of week
5	2^{2}	2^{1}	2^{0}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	1…31 day of month
6	0	0	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	1…12 months
7	0	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	0 … 50 years 2000 to 2050 51 … 99 years 1951 to 1999
	msb							lsb	

Figure 8 – Coding of the data type BinaryDate

4.2.1.9 Encoding of a TimeOfDay with and without date indication value

– The encoding of a TimeOfDay with and without date indication value shall be primitive.

– The Length field shall indicate as a binary number the number of octets in the TimeOfDay with and without date indication value.

– The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 9 and Figure 10.

bits octets	7	6	5	4	3	2	1	0	
1	0	0	0	0	2^{27}	2^{26}	2^{25}	2^{24}	Number of Milliseconds since midnight
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	number of days since 1984-01-01 T 00:00 Z only with date indication
6	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	msb							lsb	

Figure 9 – Encoding of TimeOfDay with date indication value

bits octets	7	6	5	4	3	2	1	0	
1	0	0	0	0	2^{27}	2^{26}	2^{25}	2^{24}	Number of Milliseconds since midnight
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	msb							lsb	

Figure 10 – Encoding of TimeOfDay without date indication value

4.2.1.10 Encoding of a TimeDifference with and without date indication value

– The encoding of a TimeDifference with and without date indication value shall be primitive.

– The Length field shall indicate as a binary number the number of octets in the TimeDifference with and without date indication value.

– The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 11 and Figure 12.

bits octets	7	6	5	4	3	2	1	0	
1	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	Milliseconds
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
5	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	Days
6	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	msb							lsb	

Figure 11 – Encoding of TimeDifference with date indication value

bits octets	7	6	5	4	3	2	1	0	
1	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	Milliseconds
2	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
3	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	
4	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	msb							lsb	

Figure 12 – Encoding of TimeDifference without date indication value

4.2.1.11 Encoding of a NULL value

– The encoding of a NULL value shall be primitive.

– The ContentsOctet shall be omitted.

4.2.1.12 Encoding of a NIL value

– The encoding of a NIL value shall be primitive.

– Each ContentsOctet shall be set to zero.

4.2.1.13 Encoding of an UUID

– The encoding of this data type shall be primitive and the ContentsOctets shall consist of exactly sixteen octets.

– For DCE RPC V1.1 the ContentsOctets shall be encoded according to Publication C706 of The Open Group.

4.2.2 Coding section related to common basic fields

4.2.2.1 Overview

The common fields of 4.1.1 are part of the RTC-PDU and RTA-PDU.

4.2.2.2 Coding of the DLPDU field SourceAddress

This field shall be coded as data type OctetString[6]. The value of the field SourceAddress shall be according to the 48-bit universal LAN MAC addresses of IEEE 802, IEEE 802.1D and to Table 8.

Table 8 – SourceAddress

PDU	Meaning
RTC-PDU, RTA-PDU, UDP-RTC-PDU, UDP-RTA-PDU, CL-RPC-PDU, ICMP-PDU, DCP-PDU	The interface MAC address is used
LLDP-PDU, PTCP-PDU	The port MAC address is used

NOTE 1 The port MAC address is used to avoid wrong learning of the Filtering Data Base of the connected devices when ports are in the Port State BLOCKED.

NOTE 2 The port MAC address is named Bridge Port individual MAC address in IEEE 802.1D.

EXAMPLE A device with n ports needs one interface MAC address and n port MAC addresses.

4.2.2.3 Coding of the DLPDU field DestinationAddress

4.2.2.3.1 Overview

This field shall be coded as data type OctetString[6]. The value of the field DestinationAddress shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

NOTE Octet 1 contains the Individual/Group Address Bit (lsb).

4.2.2.3.2 DCP-PDUs

For DCP-Multicast-PDUs, this field shall be coded according to Table 9, Table 10 and Table 11. DCP-Unicast-PDUs shall not use multicast or broadcast addresses.

Table 9 – DCP_MulticastMACAdd for Identify

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-00-00	With FrameID=0xFEFE used for DCP-Identify-ReqPDU

Table 10 – DCP_MulticastMACAdd for Hello

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-00-01	With FrameID=0xFEFC used for DCP-Hello-ReqPDU

Table 11 – DCP_MulticastMACAdd

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-00-02 – 00-00-FF	Reserved for other applications

4.2.2.3.3 PTCP-PDUs

For PTCP-PDUs, the value shall be set according to Table 12, Table 13, Table 14, Table 15, Table 16, Table 17, Table 18 and Table 19.

Table 12 – PTCP_MulticastMACAdd range 1

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-01-00 – 00-03-FF	Reserved for other applications

Table 13 – PTCP_MulticastMACAdd range 2

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-04-00	In conjunction with PTCP-AnnouncePDU and FrameID (=0xFF00) used for clock synchronization
01-0E-CF	00-04-01 – 00-04-1E	Reserved
01-0E-CF	00-04-1F	Reserved

Table 14 – PTCP_MulticastMACAdd range 3

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-04-20	In conjunction with PTCP-RTSyncPDU with follow up and FrameID(=0x0020) used for working clock synchronization
01-0E-CF	00-04-22 – 00-04-3E	Reserved
01-0E-CF	00-04-3F	Reserved

Table 15 – PTCP_MulticastMACAdd range 4

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-04-40	In conjunction with PTCP-FollowUpPDU and FrameID(=0xFF20) used for working clock synchronization
01-0E-CF	00-04-41 – 00-04-5E	Reserved
01-0E-CF	00-04-5F	Reserved

Table 16 – PTCP_MulticastMACAdd range 5

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-04-60 – 00-04-7F	Reserved for other applications

Table 17 – PTCP_MulticastMACAdd range 6

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-04-80	In conjunction with PTCP-RTSyncPDU and FrameID(=0x0080) used for working clock synchronization
01-0E-CF	00-04-81 – 00-04-9E	Reserved
01-0E-CF	00-04-9F	Reserved

Table 18 – PTCP_MulticastMACAdd range 7

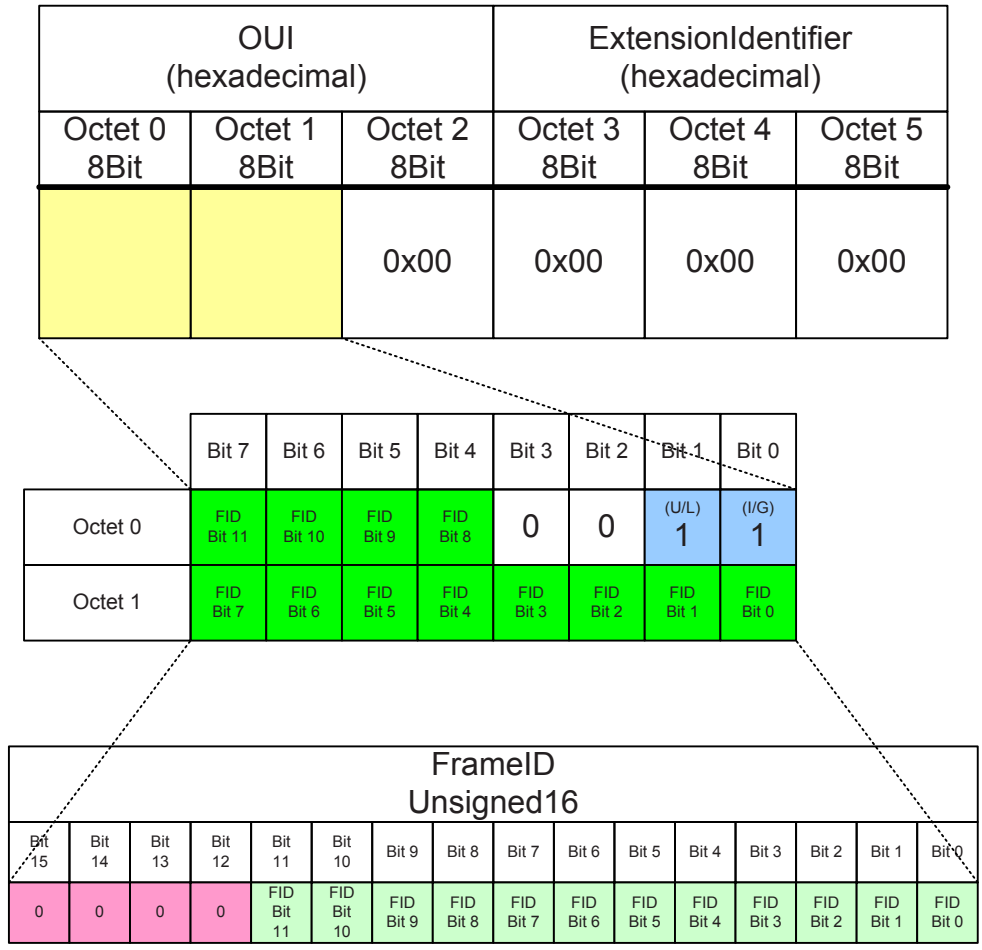
Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-A0	00-04-A0 – FF-FF-FF	Reserved for other applications

Table 19 – PTCP_MulticastMACAdd range 8

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-80-C2	00-00-0E	In conjunction with PTCP-DelayReqPDU and FrameID(=0xFF40), PTCP-DelayResPDU with follow up and FrameID(=0xFF41), PTCP-DelayFuResPDU and FrameID(=0xFF42) and PTCP-DelayResPDU whithout follow up and FrameID (=0xFF43) used for delay measurement

4.2.2.3.4 RTC-PDUs with FastForwarding

For RTC-PDUs with FastForwarding, this field shall be coded according to Figure 13 as a “Locally administered group address” according to the 48-bit universal LAN MAC addresses of IEEE 802.



where
(U/L) means „Universally or Locally administered address“
(I/G) means „Individual/Group address“
FID means FrameID

Figure 13 – FastForwardingMulticastMACAdd

The field DA is used for the forwarding decision and the field FrameID is used for the CPM decision.

4.2.2.3.5 RTC-PDUs with RT_CLASS_3 destination multicast address

For RTC-PDUs with RT_CLASS_3 destination multicast address, this field shall be coded according to Table 20.

Table 20 – RT_CLASS_3 destination multicast address

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-01-01	RT_CLASS_3 destination multicast address

4.2.2.3.6 RTC-PDUs with RT_CLASS_3 invalid frame multicast address

For RTC-PDUs with RT_CLASS_3 invalid frame multicast address, this field shall be coded according to Table 21.

Table 21 – RT_CLASS_3 invalid frame multicast address

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-01-02	RT_CLASS_3 invalid frame multicast address

4.2.2.4 Coding of the field LT

This field shall be coded as data type Unsigned16 with the values according to IEEE 802.3. This specification uses the values according to Table 22.

Table 22 – LT (Length/Type)

Value (hexadecimal)	Meaning
0x0800	IP (UDP, RPC, SNMP, ICMP)
0x0806	ARP
0x8100	Tag Control Information
0x8892	RTC, RTA, DCP, PTCP
0x88f7	IEEE 802.1AS
0x88CC	LLDP

4.2.2.5 Coding of the field TagControlInformation

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 11: TagControlInformation.VLAN_Id
This field shall be coded according to IEEE 802.1Q.

NOTE The VLAN_Id value zero means that no VLANs are used.

Bit 12: TagControlInformation.CanonicalFormatIdentificator
This field shall be coded according to IEEE 802.1Q.

NOTE CFI is constant 0.

Bit 13 – 15: TagControlInformation.Priority
This field shall be coded according to IEEE 802.1Q.

This field shall be coded with the values according to Table 23.

Table 23 – TagControlInformation.Priority

Value (hexadecimal)	Meaning
0x00	IP, DCP
0x01	Reserved
0x02	Reserved
0x03	Reserved
0x04	Reserved
0x05	Low prior RTA_CLASS_1 or RTA_CLASS_UDP
0x06	RT_CLASS_UDP, RT_CLASS_1, RT_CLASS_2, RT_CLASS_3 [a] high prior RTA_CLASS_1 or RTA_CLASS_UDP
0x07	PTCP-AnnouncePDU
[a] RT_CLASS_3 frames uses TagControlInformation.Priority only outside of the RED period.	

NOTE If the used IP implementation does not provide Tag Control Information then the RTA_CLASS_UDP and the RT_CLASS_UDP frames may be without Tag Control Information.

4.2.2.6 Coding of the field FrameID

This field shall be coded as data type Unsigned16 with the values according to Table 24, Table 25, Table 26, Table 27, Table 28, Table 29, Table 30, Table 31, Table 32, Table 33, Table 34, Table 35 and Table 36. This field identifies the structure and the type of the APDU.

Table 24 – FrameID range 1

Value (hexadecimal)	Meaning	Use
0x0000 – 0x001F	Reserved	Reserved
0x0020	PTCP-RTSyncPDU (with follow up)	Precision transparent clock protocol synchronization with follow up Working Clock for Send Clock and Phase Synchronization
0x0021 – 0x007F	Reserved	Reserved

Table 25 – FrameID range 2

Value (hexadecimal)	Meaning	Use
0x0080	PTCP-RTSyncPDU	Precision transparent clock protocol synchronization without follow up Working Clock for Send Clock and Phase Synchronization
0x0081 – 0x009F	Reserved	—
0x00A0 – 0x00FF	Reserved	—

Table 26 – FrameID range 3

Value (hexadecimal)	Meaning	Use
0x0100 – 0x06FF	Dedicated to communication class RT_CLASS_3 (RED) unicast and multicast	RED, non redundant, normal or DFP[a]
0x0700 – 0x0FFF	Dedicated to communication class RT_CLASS_3 (RED) unicast and multicast	RED, redundant[b], normal or DFP
0x1000 – 0x47FF	Reserved	—

[a] A network monitor may sort “normal” and “DFP” frame by using the first SFCRC16 of the frame.

[b] In this case two FrameIDs (e.g. 0xXXX0 and 0xXXX1) are used for one CR. One for each direction in which the frame travels the ring. The pair shall be identified ignoring the least significant bit of the FrameID.

Table 27 – FrameID range 4

Value (hexadecimal)	Meaning	Use
0x4800 – 0x4FFF	Reserved	—
0x5000 – 0x57FF	Reserved	—
0x5800 – 0x5FFF	Reserved	—
0x6000 – 0x67FF	Reserved	—

Table 28 – FrameID range 5

Value (hexadecimal)	Meaning	Use
0x6800 – 0x6FFF	Reserved	—
0x7000 – 0x77FF	Reserved	—
0x7800 – 0x7FFF	Reserved	—

Table 29 – FrameID range 6

Value (hexadecimal)	Meaning	Use
0x8000 – 0xBBFF	Dedicated to communication class RT_CLASS_1 (GREEN) unicast	GREEN, non redundant, normal [a] [b]
0xBC00 – 0xBFFF	Dedicated to RT_CLASS_1 (GREEN) multicast	GREEN, non redundant, normal [a] [b]

[a] Used as substitution for the former communication class RT_CLASS_1(legacy) shown in Table 30.

[b] May be used as RT_CLASS_2 (ORANGE) only in conjunction with ARProperties.StartupMode == Legacy.

Table 30 – FrameID range 7

Value (hexadecimal)	Meaning	Use
0xC000 – 0xF7FF	Dedicated to communication class RT_CLASS_UDP unicast	RT_CLASS_UDP (recommended) and RT_CLASS_1(legacy) [a]; The concurrent use of this range for RT_CLASS_UDP and RT_CLASS_1 shall be rejected.

Value (hexadecimal)	Meaning	Use
0xF800 – 0xFBFF	Dedicated to communication class RT_CLASS_UDP multicast	RT_CLASS_UDP (recommended) and RT_CLASS_1(legacy) [a]; The concurrent use of this range for RT_CLASS_UDP and RT_CLASS_1 shall be rejected.
[a] RT_CLASS_1(legacy) shall be supported by IO controller and IO supervisor. It should not be generated by an IO device.		

Table 31 – FrameID range 8

Value (hexadecimal)	Meaning	Use
0xFC00	Reserved	—
0xFC01	Alarm High	RTA_CLASS_1 and RTA_CLASS_UDP
0xFC02 – 0xFDFF	Reserved	—
0xFE00	Reserved	—
0xFE01	Alarm Low	RTA_CLASS_1 and RTA_CLASS_UDP
0xFE02 – 0xFEFB	Reserved	—
0xFEFC	DCP-Hello-ReqPDU	DCP
0xFEFD	DCP-Get-ReqPDU, DCP-Get-ResPDU, DCP-Set-ReqPDU, DCP-Set-ResPDU	DCP
0xFEFE	DCP-Identify-ReqPDU	DCP
0xFEFF	DCP-Identify-ResPDU	DCP

Table 32 – FrameID range 9

Value (hexadecimal)	Meaning	Use
0xFF00	PTCP-AnnouncePDU (working clock)	Precision transparent clock announce protocol Isochronous application, send clock and phase synchronization
0xFF01 – 0xFF1F	Reserved	—
0xFF20	PTCP-FollowUpPDU (working clock)	Send Clock and phase synchronization (PTCP-FollowUpPDU)
0xFF21 – 0xFF3F	Reserved	—
0xFF40	PTCP-DelayReqPDU	For delay measurement
0xFF41	PTCP-DelayResPDU	For delay measurement with follow up
0xFF42	PTCP-DelayFuResPDU	For delay measurement with follow up
0xFF43	PTCP-DelayResPDU	For delay measurement without follow up
0xFF44 – 0xFF5F	Reserved	—

Table 33 – FrameID range 10

Value (hexadecimal)	Meaning	Use
0xFF60 – 0xFF6F	Reserved	—

Table 34 – FrameID range 11

Value (hexadecimal)	Meaning	Use
0xFF70 – 0xFF7F	Reserved	—

Table 35 – FrameID range 12

Value (hexadecimal)	Meaning	Use
0xFF80 – 0xFF8F	FragmentationFrameID See 4.2.2.7	Peer to peer protocol to enable SendClockFactors less than 5 independent of the frame size of the concurrent used protocols.

NOTE The principle of fragmentation is usable with all SendClockFactors.

Table 36 – FrameID range 13

Value (hexadecimal)	Meaning	Use
0xFF90 – 0xFFFF	Reserved	—

4.2.2.7 Coding of the field FragmentationFrameID

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 3: FragmentationFrameID.FragSequence
This field shall be used to identify the fragmented frame by the receiver and shall be coded according to Table 37.

Table 37 – FragmentationFrameID.FragSequence

Value (hexadecimal)	Meaning
0x00 – 0x0F	Frame number incremented by the sender for each frame which is fragmented.

Bit 4 – 15: FragmentationFrameID.Constant
This field shall be coded with the values according to Table 38.

Table 38 – FragmentationFrameID.Constant

Value (hexadecimal)	Meaning
0xFF8	Upper part of the FrameID according to Table 35

4.3 Discovery and basic configuration

4.3.1 DCP syntax description

4.3.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.3.1.2 DCP APDU abstract syntax

Table 39 defines the abstract syntax of the DCP-PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs.

Table 39 – DCP APDU syntax

APDU name	APDU structure
DCP-PDU	DCP-Multicast-PDU ^ DCP-Unicast-PDU
DCP-Multicast-PDU	DCP-Identify-ReqPDU [g] ^ DCP-Hello-ReqPDU
DCP-Unicast-PDU	DCP-Get-ReqPDU ^ DCP-Set-ReqPDU ^ DCP-Get-ResPDU ^ DCP-Set-ResPDU ^ DCP-Identify-ResPDU
DCP-Identify-ReqPDU	DCP-IdentifyFilter-ReqPDU ^ DCP-IdentifyAll-ReqPDU
DCP-IdentifyFilter-ReqPDU	DCP-MC-Header, [NameOfStationBlock] ^ [AliasNameBlock], IdentifyReqBlock* [a]
DCP-IdentifyAll-ReqPDU	DCP-MC-Header, AllSelectorBlock
DCP-Hello-ReqPDU	DCP-UC-Header, NameOfStationBlockRes, { IPParameterBlockRes, DeviceIDBlockRes, [DeviceOptionsBlockRes] [e], DeviceRoleBlockRes, DeviceInitiativeBlockRes, [DeviceInstanceBlockRes] } [f]
DCP-Identify-ResPDU	DCP-UC-Header, { IdentifyResBlock* [b], NameOfStationBlockRes [c], IPParameterBlockRes [c], DeviceIDBlockRes [c], DeviceVendorBlockRes [c], DeviceOptionsBlockRes [c], DeviceRoleBlockRes [c], [DeviceInitiativeBlockRes] [d], [DeviceInstanceBlockRes] } [f]
DCP-Get-ReqPDU	DCP-UC-Header, GetReqBlock*
DCP-Get-ResPDU	DCP-UC-Header, (GetResBlock ^ GetNegResBlock)*
DCP-Set-ReqPDU	DCP-UC-Header, [StartTransactionBlock, BlockQualifier], [FactoryResetBlock, BlockQualifier] ^ [ResetToFactoryBlock, BlockQualifier] ^ SetReqBlock*, [StopTransactionBlock, BlockQualifier]
DCP-Set-ResPDU	DCP-UC-Header, (SetResBlock ^ SetNegResBlock)*

[a] The content of the field value of the IdentifyReqBlock of the PDU shall be interpreted as a filter at the receiving instance. All included DataBlocks shall be operated with a logical AND and it shall only responded with a DCP-Identify-ResPDU if all filter criteria match.

[b] The content of the field value of the IdentifyResBlock of the PDU shall contain the option and suboption requested in the IdentifyReqBlock. The IdentifyResBlock shall only contain the AliasNameBlock used in the IdentifyReqBlock.

[c] This field shall only be present if it is not already part of the IdentifyResBlock.

[d] This field shall only be present if the usage of DCP-Hello-ReqPDU is activated.

[e] This field should be omitted.

[f] Additional blocks may be appended by the sender.

[g] May be used in conjuntion with interface MAC address.

Table 40 defines structures for substitutions of elements of the APDU structures shown in Table 39.

Table 40 – DCP substitutions

Substitution name	Structure
DCP-MC-Header	ServiceID, ServiceType, Xid, ResponseDelayFactor, DCPDataLength
DCP-UC-Header	ServiceID, ServiceType, Xid, Padding* [a], DCPDataLength [a] Number of Padding octets shall be 2.
IdentifyReqBlock	DeviceRoleBlock ^ DeviceVendorBlock ^ DeviceIDBlock ^ DeviceOptionsBlock ^ MACAddressBlock ^ IPParameterBlock ^ DHCPParameterBlock ^ ManufacturerSpecificParameterBlock

Substitution name	Structure
IdentifyResBlock	NameOfStationBlockRes ^ DeviceRoleBlockRes ^ DeviceVendorBlockRes ^ DeviceIDBlockRes ^ DeviceOptionsBlockRes ^ MACAddressBlockRes ^ IPParameterBlockRes ^ DHCPParameterBlockRes ^ ManufacturerSpecificParameterBlockRes ^ AliasNameBlockRes
GetReqBlock	NameOfStationType ^ DeviceRoleType ^ DeviceVendorType ^ DeviceIDType ^ DeviceOptionsType ^ MACAddressType ^ IPParameterType ^ FullIPSuiteType ^ DHCPParameterType ^ ManufacturerSpecificParameterType ^ DeviceInstanceType ^ AllSelectorType
GetResBlock	NameOfStationBlockRes ^ DeviceRoleBlockRes ^ DeviceVendorBlockRes ^ DeviceIDBlockRes ^ DeviceOptionsBlockRes ^ MACAddressBlockRes ^ IPParameterBlockRes ^ FullIPSuiteBlockRes ^ DHCPParameterBlockRes ^ ManufacturerSpecificParameterBlockRes ^ DeviceInstanceBlockRes
GetNegResBlock	ControlOption, SuboptionResponse, DCPBlockLength, NameOfStationType ^ DeviceRoleType ^ DeviceVendorType ^ DeviceIDType ^ DeviceOptionsType ^ MACAddressType ^ IPParameterType ^ FullIPSuiteType ^ DHCPParameterType ^ ManufacturerSpecificParameterType ^ DeviceInstanceType, BlockError, [AddDataValue]
SetReqBlock	SignalType ^ NameOfStationType ^ DeviceRoleType ^ DeviceVendorType ^ DeviceIDType ^ DeviceOptionsType ^ IPParameterType ^ FullIPSuiteType ^ DHCPParameterType ^ ManufacturerSpecificParameterType, DCPBlockLength, BlockQualifier, SignalValue ^ NameOfStationValue ^ DeviceRoleValue ^ DeviceVendorValue ^ DeviceIDValue ^ DeviceOptionsValue ^ IPParameterValue ^ FullIPSuiteValue ^ DHCPParameterValue ^ ManufacturerSpecificParameterValue Only the adjunctive blocks shall be combined to a SetReqBlock Example SignalType, DCPBlockLength, BlockQualifier, SignalValue
SetResBlock	ControlOption, SuboptionResponse, DCPBlockLength, NameOfStationType ^ DeviceRoleType ^ DeviceVendorType ^ DeviceIDType ^ DeviceOptionsType ^ IPParameterType ^ FullIPSuiteType ^ DHCPParameterType ^ ManufacturerSpecificParameterType ^ SignalType ^ FactoryResetType ^ ResetToFactoryType ^ StartTransactionType ^ StopTransactionType, BlockError(=0), [AddDataValue]
SetNegResBlock	ControlOption, SuboptionResponse, DCPBlockLength, NameOfStationType ^ DeviceRoleType ^ DeviceVendorType ^ DeviceIDType ^ DeviceOptionsType ^ IPParameterType ^ FullIPSuiteType ^ DHCPParameterType ^ ManufacturerSpecificParameterType ^ SignalType ^ FactoryResetType ^ ResetToFactoryType ^ StartTransactionType ^ StopTransactionType, BlockError(<>0), [AddDataValue]
AllSelectorType	AllSelectorOption, SuboptionAllSelector
AllSelectorBlock	AllSelectorType, DCPBlockLength
DeviceInitiativeType	DeviceInitiativeOption, DeviceInitiativeSuboption Only used for the DCP-Hello-ReqPDU and DCP-Identify-ResPDU
DeviceInitiativeBlockRes	DeviceInitiativeType, DCPBlockLength, BlockInfo, DeviceInitiativeValue
StartTransactionType	ControlOption, SuboptionStart
StartTransactionBlock	StartTransactionType, DCPBlockLength
StopTransactionType	ControlOption, SuboptionStop
StopTransactionBlock	StopTransactionType, DCPBlockLength
SignalType	ControlOption, SuboptionSignal

Substitution name	Structure
FactoryResetType	ControlOption, SuboptionFactoryReset
FactoryResetBlock	FactoryResetType, DCPBlockLength
ResetToFactoryType	ControlOption, SuboptionResetToFactory
ResetToFactoryBlock	ResetToFactoryType, DCPBlockLength
NameOfStationType	DevicePropertiesOption, SuboptionNameOfStation
NameOfStationBlock	NameOfStationType, DCPBlockLength, NameOfStationValue
NameOfStationBlockRes	NameOfStationType, DCPBlockLength, BlockInfo, NameOfStationValue
AliasNameType	DevicePropertiesOption, SuboptionAliasName
AliasNameBlock	AliasNameType, DCPBlockLength, AliasNameValue
AliasNameBlockRes	AliasNameType, DCPBlockLength, BlockInfo, AliasNameValue
DeviceRoleType	DevicePropertiesOption, SuboptionDeviceRole
DeviceRoleBlock	DeviceRoleType, DCPBlockLength, DeviceRoleValue
DeviceRoleBlockRes	DeviceRoleType, DCPBlockLength, BlockInfo, DeviceRoleValue
DeviceRoleValue	DeviceRoleDetails, Padding
DeviceVendorType	DevicePropertiesOption, SuboptionDeviceVendor
DeviceVendorBlock	DeviceVendorType, DCPBlockLength, DeviceVendorValue
DeviceVendorBlockRes	DeviceVendorType, DCPBlockLength, BlockInfo, DeviceVendorValue
DeviceIDType	DevicePropertiesOption, SuboptionDeviceID
DeviceIDBlock	DeviceIDType, DCPBlockLength, DeviceIDValue
DeviceIDBlockRes	DeviceIDType, DCPBlockLength, BlockInfo, DeviceIDValue
DeviceIDValue	VendorIDHigh, VendorIDLow, DeviceIDHigh, DeviceIDLow
DeviceOptionsType	DevicePropertiesOption, SuboptionDeviceOptions
DeviceOptionsBlock	DeviceOptionsType, DCPBlocklength, DeviceOptionsValue
DeviceOptionsBlockRes	DeviceOptionsType, DCPBlocklength, BlockInfo, DeviceOptionsValue
DeviceOptionsValue	(Option [a], Suboption [b])* [c] [a] See Table 49 for the values [b] See Table 50, Table 51, Table 52, Table 53, Table 54, Table 55, Table 56, and Table 57 for the values [c] If no entry exists, then omit the DeviceOptionsBlockRes in the DCP-Identify-Res-PDU
DeviceInstanceType	DevicePropertiesOption, SuboptionDeviceInstance Not usable in conjunction with DCP-Set-ReqPDU
DeviceInstanceBlockRes	DeviceInstanceType, DCPBlockLength, BlockInfo, DeviceInstanceValue
DeviceInstanceValue	InstanceHigh, InstanceLow
MACAddressType	IPOption, SuboptionMACAddress
MACAddressBlock	MACAddressType, DCPBlockLength, MACAddressValue
MACAddressBlockRes	MACAddressType, DCPBlockLength, BlockInfo, MACAddressValue
IPParameterType	IPOption, SuboptionIPParameter
IPParameterBlock	IPParameterType, DCPBlockLength, IPParameterValue
IPParameterBlockRes	IPParameterType, DCPBlockLength, BlockInfo, IPParameterValue
IPParameterValue	IPAddress, Subnetmask, StandardGateway
FullIPSuiteType	IPOption, SuboptionFullIPSuite

Substitution name	Structure
FullIPSuiteBlockRes	FullIPSuiteType, DCPBlockLength, BlockInfo, FullIPSuiteValue
FullIPSuiteValue	IPAddress, Subnetmask, StandardGateway, IPAddress[4] [a] [a] This array contains up to four DNS server IP addresses. The value "0.0.0.0" indicates "no address".
DHCPParameterType	DHCPOption, SuboptionDHCP
DHCPParameterBlock	DHCPParameterType, DCPBlockLength, DHCPParameterValue
DHCPParameterBlockRes	DHCPParameterType, DCPBlockLength, BlockInfo, DHCPParameterValue
DHCPParameterValue	SuboptionDHCP, DHCPParameterLength, DHCPParameterData
ManufacturerSpecificParameterType	ManufacturerSpecificOption, SuboptionManufacturerSpecific
ManufacturerSpecificParameterBlock	ManufacturerSpecificParameterType, DCPBlockLength, ManufacturerSpecificParameterValue
ManufacturerSpecificParameterBlock Res	ManufacturerSpecificParameterType, DCPBlockLength, BlockInfo, ManufacturerSpecificParameterValue
ManufacturerSpecificParameterValue	ManufacturerOUI, ManufacturerSpecificString

4.3.1.3 Coding section related to header fields

4.3.1.3.1 Coding of the field ServiceID

This field shall be coded as data type Unsigned8 and shall contain the values as described in Table 41. They shall be set in the appropriate PDU.

Table 41 – ServiceID

Value (hexadecimal)	Meaning
0x00 – 0x02	Reserved
0x03	Get
0x04	Set
0x05	Identify
0x06	Hello
0x07 – 0xFF	Reserved

4.3.1.3.2 Coding of the field ServiceType

4.3.1.3.2.1 Coding of the field ServiceType for request

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0: ServiceType.Selection
This field shall be coded with the values according to Table 42.

Table 42 – ServiceType.Selection

Value (hexadecimal)	Meaning
0x00	Request
0x01	Reserved

Bit 1 – 7: ServiceType.Reserved
This field shall be coded with the values according to Table 43.

Table 43 – ServiceType.Reserved

Value (hexadecimal)	Meaning
0x00	Default
0x01 – 0x7F	Reserved

4.3.1.3.2.2 Coding of the field ServiceType for response

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0: ServiceType.Selection
This field shall be coded with the values according to Table 44.

Table 44 – ServiceType.Selection

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Response

Bit 1: ServiceType.Reserved_1
This field shall be coded with the values according to Table 45.

Table 45 – ServiceType.Reserved_1

Value (hexadecimal)	Meaning
0x00	Default
0x01	Reserved

Bit 2: ServiceType.Response
This field shall be coded with the values according to Table 46.

Table 46 – ServiceType.Response

Value (hexadecimal)	Meaning
0x00	Success Default
0x01	ServiceID not supported Optional, otherwise the request may be ignored.

Bit 3 – 7: ServiceType.Reserved_2
This field shall be coded with the values according to Table 47.

Table 47 – ServiceType.Reserved_2

Value (hexadecimal)	Meaning
0x00	Default
0x01 – 0x1F	Reserved

4.3.1.3.3 Coding of the field Xid

This field shall be coded as data type Unsigned32. It shall contain a transaction identification chosen by the client to associate requests and responses between a client and a server.

4.3.1.3.4 Coding of the field DCPDataLength

This field shall be coded as data type Unsigned16. It shall contain the total length of data followed the DCP-UC-Header or DCP-MC-Header in octets. The maximum length of DCP Data is 1 432 octets.

4.3.1.3.5 Coding of the field ResponseDelayFactor

This field shall be coded as data type Unsigned16 according to Table 48. It shall contain a delay factor that shall be used by the server to calculate its individual response delay time.

Table 48 – ResponseDelayFactor

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001	Allowed value without spread
0x0002 – 0x1900	Allowed value with spread
0x1901 – 0xFFFF	Reserved

The server shall calculate the response delay time (allowed values between 0 ms and 64 s) according to the following formulae.

The last two octets of the MAC address (see the 48-bit universal LAN MAC addresses of IEEE 802) shall be used as random number K. Octet 6 of the MAC address represents the low-order octet and octet 5 the high-order octet.

$$\text{Spread} = K \text{ MOD } \text{ResponseDelayFactor} \quad (1)$$

where

Spread	is the specific spreading factor
K	is the random number, last two octets of the MAC address as random number
ResponseDelayFactor	is the factor for the calculation of an individual response delay

Spread not equal zero:

$$\text{Minimal Response Delay} = 10 \text{ ms} \times \text{Spread} \quad (2)$$

where

Minimal Response Delay	is the minimal response delay

Spread is the specific spreading factor

Spread equal zero:

$$\text{Minimal Response Delay} = 0 \text{ ms} \quad (3)$$

where

Minimal Response Delay is the minimal response delay

The client shall calculate the response delay timeout according to the following formulae.

ResponseDelayFactor equal one:

$$\text{Response delay timeout} = 400 \text{ ms} \quad (4)$$

where

Response delay timeout is the response delay timeout

ResponseDelayFactor greater than one:

$$\text{Intermediate value} = 1 \text{ s} + \text{ResponseDelayFactor} \times 10 \text{ ms} \quad (5)$$

where

Intermediate value is the intermediate value of the response delay

ResponseDelayFactor is the factor for the calculation of an individual response delay

$$\text{Response delay timeout} = \text{Round up to next second (Intermediate value)} \quad (6)$$

where

Response delay timeout is the response delay timeout

Intermediate value is the intermediate value of the response delay

4.3.1.4 Coding section of block fields

4.3.1.4.1 General

The block fields are parted into option, suboption, block length, block info and value. Every block shall assure Unsigned16 alignment. The added padding octets, with the value zero, shall be counted for the DCPDataLength and shall not be counted for the DCPBlockLength. Table 49 shows the list of available options and Table 50, Table 51, Table 52, Table 53, Table 54, Table 55 and Table 56 shows the list of available suboptions.

Table 49 – List of options

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	IPOption
0x02	DevicePropertiesOption
0x03	DHCPOption

Value (hexadecimal)	Meaning
0x04	Reserved
0x05	ControlOption
0x06	DeviceInitiativeOption
0x07 – 0x7F	Reserved
0x80 – 0xFE	ManufacturerSpecificOption
0xFF	AllSelectorOption

Table 50 – List of suboptions for option IPOption

Value (hexadecimal)	Meaning	Accessible
0x01	SuboptionMACAddress	Read
0x02	SuboptionIPParameter	Read / Write
0x03	SuboptionFullIPSuite	Read / Write Optional
Other	Reserved	—

Table 51 – List of suboptions for option DevicePropertiesOption

Value (hexadecimal)	Meaning	Accessible
0x01	SuboptionDeviceVendor	Read
0x02	SuboptionNameOfStation	Read / Write
0x03	SuboptionDeviceID	Read
0x04	SuboptionDeviceRole	Read
0x05	SuboptionDeviceOptions	Read
0x06	SuboptionAliasName	Used as filter only
0x07	SuboptionDeviceInstance	Read Optional
Other	Reserved	—

Table 52 – List of suboptions for option DHCPOption

Value (hexadecimal)	Meaning	Accessible
See Table 57	SuboptionDHCP	Read / Write

Table 53 – List of suboptions for option ControlOption

Value (hexadecimal)	Meaning	Accessible
0x01	SuboptionStart	Write
0x02	SuboptionStop	Write
0x03	SuboptionSignal	Write
0x04	SuboptionResponse	—

Value (hexadecimal)	Meaning	Accessible
0x05	SuboptionFactoryReset	Write
0x06	SuboptionResetToFactory	Write
Other	Reserved	—

Table 54 – List of suboptions for option DeviceInitiativeOption

Value (hexadecimal)	Meaning	Accessible
0x01	SuboptionDeviceInitiative	Read
Other	Reserved	—

Table 55 – List of suboptions for option AllSelectorOption

Value (hexadecimal)	Meaning	Accessible
0xFF	SuboptionAllSelector	Used as filter only
Other	Reserved	—

Table 56 – List of suboptions for option ManufacturerSpecificOption

Value (hexadecimal)	Meaning	Accessible
0x00 – 0xFF	SuboptionManufacturerSpecific	Manufacturer specific

4.3.1.4.2 Coding section related to IPOption

4.3.1.4.2.1 Coding of the field IPOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.2.2 Coding of the field SuboptionMACAddress

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.2.3 Coding of the field SuboptionIPParameter

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.3 Coding section related to DevicePropertiesOption

4.3.1.4.3.1 Coding of the field DevicePropertiesOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.3.2 Coding of the field SuboptionDeviceVendor

This field shall be coded as data type Unsigned8 according to Table 51.

4.3.1.4.3.3 Coding of the field SuboptionNameOfStation

This field shall be coded as data type Unsigned8 according to Table 51.

4.3.1.4.3.4 Coding of the field SuboptionDeviceID

This field shall be coded as data type Unsigned8 according to Table 51.

4.3.1.4.3.5 Coding of the field SuboptionDeviceRole

This field shall be coded as data type Unsigned8 according to Table 51.

4.3.1.4.3.6 Coding of the field SuboptionDeviceOptions

This field shall be coded as data type Unsigned8 according to Table 51.

This option/suboption combination should be used to convey a list of the supported options and suboptions which are defined as optional and could be used for all options and suboptions.

4.3.1.4.3.7 Coding of the field SuboptionAliasName

This field shall be coded as data type Unsigned8 according to Table 51.

4.3.1.4.3.8 Coding of the field SuboptionDeviceInstance

This field shall be coded as data type Unsigned8 according to Table 51.

4.3.1.4.4 Coding section related to DHCPOption

4.3.1.4.4.1 Coding of the field DHCPOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.4.2 Coding of the field SuboptionDHCP

This field shall be coded as data type Unsigned8. The allowed values shall be according to Table 57.

Table 57 – SuboptionDHCP

Value (decimal)	Data Length	Description	References
0 – 11	—	Reserved [a]	—
12	1 +	Host Name [d]	RFC 2132
13 – 42	—	Reserved [a]	—
43	1 +	Vendor specific information	RFC 2132
44 – 53	—	Reserved [a]	—
54	4	Server identifier	RFC 2132
55	1 +	Parameter request list [c]	RFC 2132
56 – 59	—	Reserved [a]	—
60	1 +	Class-identifier	RFC 2132
61	2 +	DHCP client identifier	RFC 2132, RFC 4361, and RFC 4363
62 – 80	—	Reserved [a]	—
81	1 +	FQDN, Fully Qualified Domain Name [d]	—
82 – 96	—	Reserved [a]	—

Value (decimal)	Data Length	Description	References
97	Variable	UUID-based Client (=addressed Station) Identifier	—
98 – 254	—	Reserved [a]	—
255 [b]	1	See 4.3.1.4.24	—

[a] The reserved options should be used in the same meaning as they are defined in the corresponding RFCs for DHCP.

[b] By RFC 2132 defined as “END” but handled internally. Thus this key is overloaded as DHCP control in this standard.

[c] In this option, at least the parameters 1 (subnet mask) and 3 (router) should be requested.

[d] The use of these suboptions is still not fixed and subject to change in later revisions.

4.3.1.4.5 Coding section related to ControlOption

4.3.1.4.5.1 Coding of the field ControlOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.5.2 Coding of the field SuboptionStart

This field shall be coded as data type Unsigned8 according to Table 53 and with a DCPBlockLength according to Table 58.

Table 58 – Coding of DCPBlockLength in conjunction with SuboptionStart

Value (hexadecimal)	Meaning
0x0000 – 0x0001	Reserved
0x0002	Default
0x0003 – 0xFFFF	Reserved

There are no additional data for this suboption.

4.3.1.4.5.3 Coding of the field SuboptionStop

This field shall be coded as data type Unsigned8 according to Table 53 and with a DCPBlockLength according to Table 59.

Table 59 – Coding of DCPBlockLength in conjunction with SuboptionStop

Value (hexadecimal)	Meaning
0x0000 – 0x0001	Reserved
0x0002	Default
0x0003 – 0xFFFF	Reserved

There are no additional data for this suboption.

4.3.1.4.5.4 Coding of the field SuboptionSignal

This field shall be coded as data type Unsigned8 according to Table 53 and with a DCPBlockLength according to Table 60.

Table 60 – Coding of DCPBlockLength in conjunction with SuboptionSignal

Value (hexadecimal)	Meaning
0x0000 – 0x0003	Reserved
0x0004	Default
0x0005 – 0xFFFF	Reserved

4.3.1.4.5.5 Coding of the field SuboptionResponse

This field shall be coded as data type Unsigned8 according to Table 53.

4.3.1.4.5.6 Coding of the field SuboptionFactoryReset

This field shall be coded as data type Unsigned8 according to Table 53 and with a DCPBlockLength according to Table 61.

Table 61 – Coding of DCPBlockLength in conjunction with SuboptionFactoryReset

Value (hexadecimal)	Meaning
0x0000 – 0x0001	Reserved
0x0002	Default
0x0003 – 0xFFFF	Reserved

There are no additional data for this suboption.

Factory Reset shall permanently set

- The NameOfStation to “”
- The IP address, the subnet mask and the standard gateway to 0.0.0.0
- All other parameters to the manufacturers default value.

NOTE All stored parameters of the physical device like, PDIRData, PDPortDataAdjust, … are set to default as manufacturers default value.

Every device should support a possibility to execute “reset to factory” without an engineering device. This could be done with a switch or by other means.

The execution of Factory Reset should not influence the switching of a node.

4.3.1.4.5.7 Coding of the field SuboptionResetToFactory

This field shall be coded as data type Unsigned8 according to Table 53 and with a DCPBlockLength according to Table 62.

Table 62 – Coding of DCPBlockLength in conjunction with SuboptionResetToFactory

Value (hexadecimal)	Meaning
0x0000 – 0x0001	Reserved
0x0002	Default
0x0003 – 0xFFFF	Reserved

There are no additional data for this suboption.

This Suboption offers different modes coded by the BlockQualifier.

4.3.1.4.6 Coding section related to DeviceInitiativeOption

4.3.1.4.6.1 Coding of the field DeviceInitiativeOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.6.2 Coding of the field SuboptionDeviceInitiative

This field shall be coded as data type Unsigned8 according to Table 54 and with a DCPBlockLength according to Table 63.

Table 63 – Coding of DCPBlockLength in conjunction with SuboptionDeviceInitiative

Value (hexadecimal)	Meaning
0x0000 – 0x0003	Reserved
0x0004	Default
0x0005 – 0xFFFF	Reserved

4.3.1.4.7 Coding section related to AllSelectorOption

4.3.1.4.7.1 Coding of the field AllSelectorOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.7.2 Coding of the field SuboptionAllSelector

This field shall be coded as data type Unsigned8 according to Table 55.

4.3.1.4.8 Coding section related to ManufacturerSpecificOption

4.3.1.4.8.1 Coding of the field ManufacturerSpecificOption

This field shall be coded as data type Unsigned8 according to Table 49.

4.3.1.4.8.2 Coding of the field SuboptionManufacturerSpecific

This field shall be coded as data type Unsigned8 according to Table 56.

4.3.1.4.9 Coding of the field DCPBlockLength

This field shall be coded as data type Unsigned16 and shall contain the length of the specific data of the suboption without DCPBlockLength itself and without counting padding octets.

4.3.1.4.10 Coding of the field BlockQualifier

This field shall be coded as data type Unsigned16.

Allowed values with the option IPOption, DevicePropertiesOption, DHCPOption and ManufacturerSpecificOption shall be according to Table 64.

Table 64 – BlockQualifier with options IPOption, DevicePropertiesOption, DHCPOption and ManufacturerSpecificOption

Bit	Value (binary)	Meaning
Bit 0	0	Store the value of the option/suboption and its attribute “temporary” in the DCP ASE and use the value subsequently. The attribute temporary means that the value shall be reset to its default value after a power off / power on cycle.
	1	Store the value of the option/suboption and its attribute “permanent” in the DCP ASE and use the value subsequently. The attribute permanent means that the value shall be available after a power off / power on cycle.
Bit 1 – 15	—	Reserved

Allowed values with the option ControlOption and suboption SuboptionResetToFactory shall be according to Table 65.

Table 65 – BlockQualifier with option ControlOption and suboption SuboptionResetToFactory

Bit	Value (decimal)	Meaning	Range
Bit 0	0	Reserved	—
	1		
Bit 1 – 15	0	Reserved	—
	1	Recommended Reset application data Reset data which have been stored permanent in submodules and modules to factory values.	Interface
	2	Mandatory Reset communication parameter All parameters active for the interface or the ports and the ARs shall be set to the default values and if permanently stored reset. This mode is intended to set the addressed communication interface of a device into a state which almost similar to the “out of the box” state.	
	3	Recommended Reset engineering parameter Reset engineering parameters which have been stored permanent in the IOC or IOD to factory values.	
	4	Recommended Resets all stored data Resets all stored data in the IOD or IOC to its factory default values.	

Bit	Value (decimal)	Meaning	Range
	5 – 7	Reserved	
	8	Recommended Resets all stored data in the IOD or IOC to its factory values. This service shall reset the communication parameters of all interfaces of the device and should reset all parameters of the device. This mode is intended to set the device into a state which is similar to the “out of the box” state.	Device
	9	Optional Reset and restore data Reset installed software revisions to factory images.	
	10 – 15	Reserved	
	other	Reserved	—
The applicative behavior shall be defined by profiles and/or the local application.			

In all other cases the field BlockQualifier shall be set according to Table 66.

Table 66 – BlockQualifier with all other options and suboptions

Bit	Value (binary)	Meaning
Bit 0 – 15	0	Default
Bit 0 – 15	other	Reserved

4.3.1.4.11 Coding of the field BlockError

This field shall be coded as data type Unsigned8 and shall be set according to Table 67.

Table 67 – BlockError

Value (hexadecimal)	Meaning	Usage
0x00	No error	Positive response Parameter delivered and accepted
0x01	Option not supported	If optional option is not supported
0x02	Suboption not supported or no DataSet available or BlockQualifier not supported	If optional suboption is not supported
0x03	Suboption not set	If suboption could not be set for local reasons
0x04	Resource error	If there is a temporary resource error within the server
0x05	SET not possible by local reasons	If Set service is not possible for local reasons
0x06	In operation, SET not possible	If Set service is not possible because of application operation
0x07 – 0xFF	Reserved	Shall not be used.

4.3.1.4.12 Coding of the field BlockInfo

This field shall be coded as data type Unsigned16. The allowed values shall be set according to Table 68, Table 69, Table 70 and Table 71.

Table 68 – BlockInfo for SuboptionIPParameter

Bit	Meaning
Bit 0 – 1	See Table 69
Bit 2 – 6	Reserved
Bit 7	See Table 70
Bit 8 – 15	Reserved

Table 69 – Bit 1 and Bit 0 of BlockInfo for SuboptionIPParameter

Bit 1	Bit 0	Meaning for SuboptionIPParameter
0	0	No IP parameter
0	1	IP parameter set
1	0	IP parameter set via DHCP
1	1	Reserved

Table 70 – Bit 7 of BlockInfo for SuboptionIPParameter

Bit 7	Meaning for SuboptionIPParameter
0	No IP address conflict detected [a] IP address active
1	IP address conflict detected [a] IP address not active
[a] An optional local defined test shows that the requested IP address is already in use by a different device. The device is not able to activate the delivered IP address.	

Table 71 – BlockInfo for all other suboptions

Bit	Meaning
Bit 0 – 15	Reserved

4.3.1.4.13 Coding of the field DeviceInitiativeValue

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0: DeviceInitiativeValue.Hello
This field shall be set according to Table 72.

Table 72 – DeviceInitiativeValue

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Device does not issue a DCP-Hello-ReqPDU after power on.
0x01	ON	Device does issue a DCP-Hello-ReqPDU after power on.

Bit 1 – 15: DeviceInitiativeValue.reserved
This field shall be set according to 3.4.2.2.

4.3.1.4.14 Coding of the field SignalValue

This field shall be coded as data type Unsigned16 according to Table 73.

Table 73 – SignalValue

Value (hexadecimal)	Meaning	Usage
0x0100	Flash Once	Flash a LED (e.g. the Ethernet LINK LED) or an alternative signalization with duration of 3 s with a frequency of 1 Hz (500 ms on, 500 ms off).

4.3.1.4.15 Coding of the field NameOfStationValue

4.3.1.4.15.1 General

Each NameOfStation shall be unique in case a device is equipped with more than one interface submodule.

4.3.1.4.15.2 Encoding

This field shall be coded as data type OctetString with 1 to 240 octets. The definition of RFC 5890 and the following syntax applies:

- 1 or more labels, separated by [.]
- Total length is 1 to 240
- Label length is 1 to 63
- Labels consist of [a-z0-9-]
- Labels do not start with [-]
- Labels do not end with [-]
- The first label does not have the form “port-xyz” or “port-xyz-abcde” with a, b, c, d, e, x, y, z = 0…9, to avoid wrong similarity with the field AliasNameValue
- Station-names do not have the form n.n.n.n, n = 0...999

NOTE 1 Labels do only start with ‘xn–‘ if the original string contains characters other than [a-z0-9-].

EXAMPLE 1 “device-1.machine-1.plant-1.vendor”

EXAMPLE 2 “mühle1.ölmühle1.plant.com“ is coded as “xn–mhle1-kva.xn–lmhle1-vxa4c.plant.com“

NOTE 2 The field NameOfStationValue is not terminated by zero.

NOTE 3 Devices with more than one Ethernet interface need more than one unique NameOfStation. In this case the name of station is a name of interface. Because most devices own only one interface, the name of interface is also the name of station.

4.3.1.4.15.3 Semantics with Identify service

The following rules shall be applied:

- Name of station with length 1 to 240 octets:
  Only the device shall answer which has exactly got this name. In the comparison of the two names on equality the DNS conventions shall be considered.
- Name of station with length == 0:
  Only those devices shall answer, which have not received a station name yet.

The network representation of the NameOfStation shall be according to 4.3.1.4.15.2.

4.3.1.4.15.4 Semantics with Set service

The following rules shall be applied:

– Name of station with length 1 to 240 octets:
The station shall set its name according to the NameOfStationValue.

– Name of station with length == 0:
The station shall delete its stored name.

The network representation of the NameOfStation shall be according to 4.3.1.4.15.2.

4.3.1.4.16 Coding of the field NameOfPort

This field shall be coded as OctetString[8] or OctetString[14] as “port-xyz” or “port-xyz-rstuv” where x, y, z is in the range “0”-“9” from 001 up to 255 and r, s, t, u, v is in the range “0”-“9” from 00000 up to 65535. The values x, y, z shall be used to identify the port number. The values r, s, t, u, v shall be used to identify the slot which contains the port.

The values “port-001-00000” shall be used for the first port submodule for an interface within slot 0 if any other slot may contain another port submodule.

The values “port-001” shall be used for the first port submodule for an interface if no other slot may contain another port submodule.

Furthermore, the definition of RFC 5890 shall be applied.

4.3.1.4.17 Coding of the field AliasNameValue

4.3.1.4.17.1 Encoding

This field shall be coded as OctetString. The content shall be the concatenation of the content of the fields NameOfPort and NameOfStation.

AliasNameValue = NameOfPort + ”.” + NameOfStation (7)

where

AliasNameValue	is an additional name of a node. It addresses one particular interface of this node.
NameOfPort	is the neighbor’s name of port
NameOfStation	is the neighbor’s name of station

4.3.1.4.17.2 Semantics with Identify service

The following rules shall be applied:

– Alias name with length != 0:
Only the device shall answer which has exactly got this additional alias name. In the comparison of the two names on equality the DNS conventions shall be considered. The device shall not answer with the AliasName. Instead it shall use the current NameOfStation (even if the NameOfStation is not set).

– Name of the station with length == 0:
Not allowed in a request.

NOTE The AliasName is an unique alternative name for a device or an interface of a device. The alias name is derived from topology or neighborhood information. The alias name of station cannot be set or get through means of DCP.

4.3.1.4.18 Coding of the field DeviceRoleDetails

This field shall be coded as data type Unsigned8 with the values according to Table 74.

Table 74 – DeviceRoleDetails

Bit	Meaning	Usage
Bit 0	PNIO Device	The device contains an IO device interface.
Bit 1	PNIO Controller	The device contains an IO controller interface.
Bit 2	PNIO Multidevice	The device contains multiple IO device interfaces.
Bit 3	PNIO Supervisor	The device contains an IO supervisor interface.
Bit 4 – 7	Reserved	—

4.3.1.4.19 Coding of the field MACAddressValue

This field shall be coded as data type OctetString[6]. The value of the field shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

4.3.1.4.20 Coding of the field IPAddress

This field shall be coded as data type OctetString[4]. The encoding of the fields shall be according to RFC 791, RFC 5735 and to Table 75.

The value zero in all octets shall be used to delete a currently set IP address.

Table 75 – IPAddress

Value (CIDR [a])	Meaning
0.0.0.0 / 8	No IP address assigned
127.0.0.0 / 8	Reserved Loopback
224.0.0.0 / 4	Reserved Multicast
Other	IP address assigned
Reserved	If a subnet is used, the top most IPAddress of this subnet is used as a subnet broadcast address. The assignment of this IPAddress should be rejected.
[a] Notation according to classless inter domain routing defined in RFC 4632	

NOTE The object IP suite (IPAddress, Subnetmask and StandardGateway) exist only one time. The flag “store permanently” is an attribute of the object and changed in conjunction with every write access.

4.3.1.4.21 Coding of the field Subnetmask

This field shall be coded as data type OctetString[4]. The encoding of the fields shall be according to RFC 791, RFC 5735 and to Table 76.

Table 76 – Subnetmask

Value	Number of hosts	Meaning
255.255.255.255	1	Subnet mask assigned
255.255.255.254	2	
255.255.255.252	4	
255.255.255.248	8	
255.255.255.240	16	
255.255.255.224	32	

Value	Number of hosts	Meaning
255.255.255.192	64	
255.255.255.128	128	
255.255.255.000	256	
255.255.254.000	512	
255.255.252.000	1 024	
255.255.248.000	2 048	
255.255.240.000	4 096	
255.255.224.000	8 192	
255.255.192.000	16 384	
255.255.128.000	32 768	
255.255.000.000	65 536	
255.254.000.000	131 072	
255.252.000.000	262 144	
255.248.000.000	524 288	
255.240.000.000	1 048 576	
255.224.000.000	2 097 152	
255.192.000.000	4 194 304	
255.128.000.000	8 388 608	
255.000.000.000	16 777 216	
254.000.000.000	33 554 432	Subnet mask valid, support optional according to the rules of IANA
252.000.000.000	67 108 864	
248.000.000.000	134 217 728	
240.000.000.000	268 435 456	
224.000.000.000	536 870 912	Subnet mask valid, but rejected according to the rules of IANA
192.000.000.000	1 073 741 824	
128.000.000.000	2 147 483 648	
000.000.000.000	4 294 967 296	Subnet mask valid, but rejected according to the rules of IANA if a StandardGateway is assigned. Subnet mask valid and assigned if no StandardGateway is assigned.
Other	Reserved	Invalid subnet mask

4.3.1.4.22 Coding of the field StandardGateway

This field shall be coded as data type OctetString[4]. The encoding of the field shall be according to RFC 791, RFC 5735, Table 75 and Table 77.

If no IPAddress is assigned, the values of IPAddress, Subnetmask and StandardGateway shall be set to zero.

Table 77 – StandardGateway

Value (CIDR [a])	Meaning
0.0.0.0 / 32	No standard gateway assigned The application shall set up the local IP implementation to avoid IP routing
Own IPAddress / 32	No standard gateway assigned The application shall set up the local IP implementation to avoid IP routing
Other [b]	Standard gateway assigned Should be checked against the field subnetmask
Reserved [c]	No standard gateway assigned
[a] Notation according to classless inter domain routing defined in RFC 1518 and RFC 1519 [b] Valid according to Table 75 and Table 76 [c] Invalid according to Table 75 and Table 76	

The checking rules for the StandardGateway depends on the existence of more than one interface. For more interfaces, only one StandardGateway (only one object) shall exist. This means that every manipulation of the StandardGateway from any interface has an impact on all other interfaces. Thus, the checking in this case shall be done by local means and local rules.

4.3.1.4.23 Coding of the fields DHCPParameterValue using DHCP Option 61

The client identifier can be used by a DHCP client to request its IP parameters from a DHCP server. A device shall be able to use the client identifier from the data set in the following way:

4.3.1.4.23.1 Coding of the field DHCPParameterLength

This field shall be coded as data type Unsigned16 and shall contain the length of the specific subsequent data.

4.3.1.4.23.2 Use of MACAddress as client identifier

If the device shall obtain its IP parameters using the DHCP protocol and use the MAC address as a client identifier, then the option 61 shall have the following values:

SuboptionDHCP = 61

DHCPParameterLength = 1

DHCPParameterData = 1

4.3.1.4.23.3 Use of NameOfStation as client identifier

If the device shall obtain its IP parameters using the DHCP protocol and use the NameOfStation as client identifier the option 61 shall have the following values (in addition to RFC 2132):

SuboptionDHCP = 61

DHCPParameterLength = 1

DHCPParameterData = 0

If the name of station of the device has been changed the DHCP request shall automatically use the new NameOfStation in the next DHCP request.

4.3.1.4.23.4 Use of arbitrary client identifier

If the device shall obtain its IP parameters using the DHCP protocol and use an arbitrary string as client identifier the option 61 shall have the following values:

SuboptionDHCP	= 61
DHCPParameterLength	=> 1
DHCPParameterData[first octet]	= 0
DHCPParameterData[second octet …n]	= either ”NameOfStation” or “AliasName”

4.3.1.4.24 Coding of the fields DHCPParameterValue using DHCP Option 255

The DHCP option 255 is defined as END by RFC 2131. It is used automatically by the DHCP client or server. Thus this option is overloaded by DCP and shall be used in the following way:

SuboptionDHCP	= 255
DHCPParameterLength	= 1
DHCPParameterData	= 0: Don’t use DHCP (Default)
	= 1: Don’t use DHCP but set all DHCPOptions to their “Reset to factory” value
	= 2: Use DHCP with the given set of DHCPOptions

NOTE If DHCP is enabled, than all earlier set IPAddress, Subnetmask and StandardGateway values are deleted. These fields are now controlled by DHCP.

This option should be the last one in a list of DHCP options in a set request.

4.3.1.4.25 Coding of the field ManufacturerOUI

This field shall be coded as OctetString[3] with the Organizationally unique identifier (OUI) as defined by IEEE 802.

NOTE The value of this central administrative number is given by the IEEE Registration Authority Committee. Available at <http://standards.ieee.org/regauth>

4.3.1.4.26 Coding of the field ManufacturerSpecificString

This field shall be coded as data type OctetString and shall contain the values of the related option and suboptions. If the BlockValue has an odd length a padding octet shall be added at the end in order to be Unsigned16 aligned. The padding octet shall have the value 0.

4.3.1.4.27 Coding of the field DeviceVendorValue

This field shall be coded as data type VisibleString and shall contain the same content as the field DeviceType without the trailing blanks.

4.3.1.4.28 Coding of the field DHCPParameterData

This field shall be coded as data type OctetString and shall contain the values of the related option and suboptions. If the BlockValue has an odd length a padding octet shall be added at the end in order to be Unsigned16 aligned. The padding octet shall have the value 0.

4.3.1.4.29 Coding of the field AddDataValue

This field shall be coded as data type OctetString and shall contain the values of the related option and suboptions. If the BlockValue has an odd length a padding octet shall be added at the end in order to be Unsigned16 aligned. The padding octet shall have the value 0.

4.3.2 DCP protocol state machines

4.3.2.1 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.3.2.2 Application Relationship Protocol Machines

4.3.2.2.1 DCP Unicast Sender

4.3.2.2.1.1 Primitive definitions

####### 4.3.2.2.1.1.1 Primitives exchanged between remote machines

The remote service primitives including their associated parameters issued or received by DCPUCS are described in the service definition and shown in Table 78.

Table 78 – Remote primitives issued or received by DCPUCS

Primitive	Source	Destination	Associated parameters	Functions
DCP_Get.req	local means	DCPUCS	CREP, DA, ListOfOptions	This service is used to fetch data from the remote DCP ASE. The parameter DA contains the Layer2 address of the server and the parameter ListOfOptions the requested information.
DCP_Set.req	CTLDINA	DCPUCS	CREP, DA, ListOfData, ListOfControlCommands	This service is used to convey data to the remote DCP ASE. The parameter DA contains the Layer2 address of the server and the parameter ListOfData the requested information. The ListOfControlCommand contains steering information.
LMPM_A_Data.cnf (-)	LMPM	DCPUCS	CREP, LMPM_status	—
LMPM_A_Data.cnf (+)	LMPM	DCPUCS	CREP, LMPM_status	—
LMPM_A_Data.ind	LMPM	DCPUCS	CREP, DA, SA, Prio, A_SDU	—
DCP_Get.cnf (-)	DCPUCS	local means	ERRCLS, ERRCODE	—
DCP_Get.cnf (+)	DCPUCS	local means	ListOfData	—
DCP_Set.cnf (-)	DCPUCS	CTLDINA	ERRCLS, ERRCODE	—
DCP_Set.cnf (+)	DCPUCS	CTLDINA	CREP, ListOfResponse	This service conveys the data and the execution info.

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.req	DCPUCS	LMPM	CREP, DA, SA, Prio, A_SDU	—

4.3.2.2.1.1.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DCPUCS are described in the service definition and shown in Table 79.

Table 79 – Local primitives issued or received by DCPUCS

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.3.2.2.1.2 State transition diagram

The state transition diagram of the DCPUCS is shown in Figure 14.

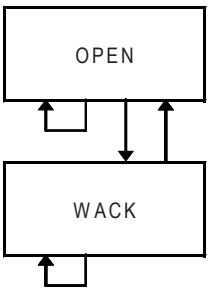


Figure 14 – State transition diagram of DCPUCS

States of the DCPUCS

OPEN	Wait for a DCP_Get or DCP_Set request from the application and send it to the server. Then change to state WACK and wait for the response.
WACK	Wait for a DCP_Get or DCP_Set response from the server and create a DCP_Get or DCP_Set confirmation. If the server doesn't respond, retry the request and after the retry limit is expired create a negative confirmation.

4.3.2.2.1.3 State machine description

The state machine gets its initial values from the DCP ASE attributes. Within the OPEN state, DCP Get and Set service requests issued by the DCP user are transformed to Data Link Layer services. After issuing the transmission of data, the WACK state is used to wait for the Response-PDU causing a confirmation primitive to the DCP user.

4.3.2.2.1.4 DCPUCS state table

Table 80 contains the complete description of the DCPUCS state table.

Table 80 – DCPUCS state table

#	Current State	Event /Condition =>Action	Next State
1	OPEN	**DCP_Get.req ()** => Pending:= GET DA := From instance identified by CREP XID := SXID A_SDU := DCP-GetReqPDU with parameters from the request Store A_SDU Retry:= Max Retry Limit StartTimer (UC Client Timeout) LMPM_A_Data.req ()	WACK
2	OPEN	**DCP_Set.req ()** => Pending:= SET DA := From instance identified by CREP XID := SXID A_SDU := DCP-SetReqPDU with parameters from the request Store A_SDU Retry:= Max Retry Limit StartTimer (UC Client Timeout) LMPM_A_Data.req ()	WACK
3	OPEN	LMPM_A_Data.ind () => ignore	OPEN
4	OPEN	LMPM_A_Data.cnf () => ignore	OPEN
5	OPEN	TimerExpired (UC Client Timeout) => ignore	OPEN
6	WACK	**DCP_Get.req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE DCP_Get.cnf (-)	WACK
7	WACK	**DCP_Set.req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE DCP_Set.cnf (-)	WACK
8	WACK	**LMPM_A_Data.ind ()** /DCP-Get-ResPDU && Pending == GET && XID == SXID => SXID := SXID+1 StopTimer (UC Client Timeout) DCP_Get.cnf (+)	OPEN
9	WACK	**LMPM_A_Data.ind ()** /DCP-Get-ResPDU && (Pending != GET || XID != SXID) => ignore	WACK

#	Current State	Event /Condition =>Action	Next State
10	WACK	**LMPM_A_Data.ind ()** /DCP-Set-ResPDU && Pending == SET && XID == SXID => SXID:= SXID+1 StopTimer (UC Client Timeout) DCP_Set.cnf (+)	OPEN
11	WACK	**LMPM_A_Data.ind ()** /DCP-Set-ResPDU && (Pending != SET || XID != SXID) => ignore	WACK
12	WACK	**LMPM_A_Data.cnf (+)** /LMPM_status == OK => ignore	WACK
13	WACK	**LMPM_A_Data.cnf (-)** /LMPM_status != OK && Pending == GET => ERRCLS := PROTOCOL ERRCODE := LMPM StopTimer (UC Client Timeout) DCP_Get.cnf (-)	OPEN
14	WACK	**LMPM_A_Data.cnf (-)** /LMPM_status != OK && Pending == SET => ERRCLS := PROTOCOL ERRCODE := LMPM StopTimer (UC Client Timeout) DCP_Set.cnf (-)	OPEN
15	WACK	**TimerExpired (UC Client Timeout)** /Retry != 0 => A_SDU:=from Stored A_SDU Retry:= Retry-1 StartTimer (UC Client Timeout) LMPM_A_Data.req ()	WACK
16	WACK	**TimerExpired (UC Client Timeout)** /Retry == 0 && Pending == GET => ERRCLS := PROTOCOL ERRCODE := TIMEOUT DCP_Get.cnf (-)	OPEN
17	WACK	**TimerExpired (UC Client Timeout)** /Retry == 0 && Pending == SET => ERRCLS := PROTOCOL ERRCODE := TIMEOUT DCP_Set.cnf (-)	OPEN

#	Current State	Event /Condition =>Action	Next State
18	WACK	**LMPM_A_Data.ind ()** /!(DCP-Set-ResPDU || DCP-Get-ResPDU) => ignore	WACK

4.3.2.2.1.5 Functions, Macros, Timers and Variables

Table 81 contains the functions, macros, timers and variables used by the DCPUCS and their arguments and their descriptions.

Table 81 – Functions, Macros, Timers and Variables used by the DCPUCS

Name	Type	Function/Meaning
StartTimer	Function	This function is used to start or restart a timer.
StopTimer	Function	This function is used to stop a timer.
TimerExpired	Function	This function signals that a timer is expired.
UC Client Timer	Timer	This Timer, restarted on the requestor when sending an unicast request, will terminate waiting for an response.
ERRCLS	Variable	This local variable contains the entity signaling the error.
ERRCODE	Variable	This local variable contains the error reason in the context of the ERRCLS.
Max Retry Limit	Variable	This local variable contains the retry limit.
Pending	Variable	This local variable holds the information whether a Set or Get service is pending.
Retry	Variable	This local variable contains the retry counter. The maximum value shall be taken from the appropriate DCP ASE attribute.
SXID	Variable	This local variable contains the Transaction ID XID used to identify services uniquely. The initial value shall be derived from a random number generator.
UC Client Timeout	Variable	The value of this local variable shall be taken from the appropriate DCP ASE attribute. The default value is 1 s.

4.3.2.2 DCP Unicast Receiver

4.3.2.2.1 Primitive definitions

4.3.2.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DCPUCR are described in the service definition and shown in Table 82.

Table 82 – Remote primitives issued or received by DCPUCR

Primitive	Source	Destination	Associated parameters	Functions
DCP_Set.rsp	CMINA	DCPUCR	CREP, ListOfResponse	—
LMPM_A_Data.cnf	LMPM	DCPUCR	CREP, LMPM_status	—

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.ind	LMPM	DCPUCR	CREP, DA, SA, Prio, A_SDU	—
DCP_Set.ind	DCPUCR	CMINA	CREP, ListOfData, ListOfControlCommands	—
LMPM_A_Data.req	DCPUCR	LMPM	CREP, DA, SA, Prio, A_SDU	—

4.3.2.2.2.1.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DCPUCR are described in the service definition and shown in Table 83.

Table 83 – Local primitives issued or received by DCPUCR

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.3.2.2.2.2 State transition diagram

The state transition diagram of the DCPUCR is shown in Figure 15.

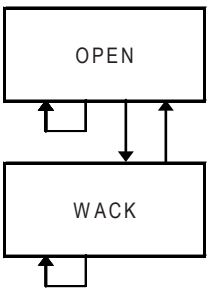


Figure 15 – State transition diagram of DCPUCR

States of the DCPUCR

OPEN	Wait for a DCP Get or Set service and prepare the response for GET
WACK	Wait for the application response for SET to create the DCP set response

4.3.2.2.2.3 State machine description

Within the OPEN state, the state machine is waiting for the first LMPM_A_Data service indication. After passing the indication to the user the WACK state is entered. A response service will activate an LMPM_A_Data request and bring the machine back to the OPEN state.

4.3.2.2.2.4 DCPUCR state table

Table 84 contains the complete description of the DCPUCR state table. A LMPM_A_Data.ind primitive will be accepted if type is DCP-Get-ResPDU or DCP-Set-ResPDU.

Table 84 – DCPUCR state table

#	Current State	Event /Condition =>Action	Next State
1	OPEN	DCP_Set.rsp () => ignore	OPEN
2	OPEN	**LMPM_A_Data.ind ()** /DCP-Get-ReqPDU && (SAM == NIL || SAM == SA) && (DA != Multicast) && ValidSelectors => SAM := SA SXID := XID SDA := SA DA := SDA XID := SXID A_SDU := Create DCP-Get-ResPDU with ListOfData taken from the DCP ASE according the ListOfData of the DCP-Get-ReqPDU StartTimer (Client Hold Time) LMPM_A_Data.req ()	OPEN
3	OPEN	**LMPM_A_Data.ind ()** /DCP-Get-ReqPDU && (SAM == NIL || SAM == SA) && (DA != Multicast) && !ValidSelectors => SAM := SA SXID := XID SDA := SA DA := SDA XID := SXID ERRCLS := Invalid_Parameter ERRCODE := Invalid_DataSet A_SDU := Create DCP-Get-ResPDU with error information StartTimer (Client Hold Time) LMPM_A_Data.req ()	OPEN
4	OPEN	**LMPM_A_Data.ind ()** /DCP-Set-ReqPDU && (SAM == NIL || SAM == SA) && (DA != Multicast) => SAM:= SA SXID := XID SDA := SA DCP_Set.ind (CREP, ListOfData)	WACK
5	OPEN	**LMPM_A_Data.ind ()** /DCP-Get-ReqPDU && (SAM != NIL && SAM != SA) => ignore	OPEN
6	OPEN	**LMPM_A_Data.ind ()** /DCP-Set-ReqPDU && (SAM != NIL && SAM != SA) => ignore	OPEN

#	Current State	Event /Condition =>Action	Next State
7	OPEN	LMPM_A_Data.cnf () => ignore	OPEN
8	OPEN	TimerExpired (Client Hold Time) => SAM:= NIL	OPEN
9	WACK	**DCP_Set.rsp ()** => DA := SDA XID := SXID A_SDU := DCP-Set-ResPDU containing the response from the application StartTimer (Client Hold Time) LMPM_A_Data.req ()	OPEN
10	WACK	LMPM_A_Data.ind () => ignore	WACK
11	WACK	LMPM_A_Data.cnf () => ignore	WACK

4.3.2.2.2.5 Functions, Macros, Timers and Variables

Table 85 contains the functions, macros, timers and variables used by the DCPUCR and their arguments and their descriptions.

Table 85 – Functions, Macros, Timers and Variables used by the DCPUCR

Name	Type	Function/Meaning
StartTimer	Function	This function is used to start or restart a timer
StopTimer	Function	This function is used to stop a timer
TimerExpired	Function	This function is issued if a timer expires
ValidSelectors	Macro	Check the PDU against the DCP definition and the DCP ASE
Client Hold Timer	Timer	This timer is used to protect the server from multiple client access during state OPEN. It protects the client reaction time for the next request and is independent from the server reaction time.
Client Hold Time	Variable	The value of this time is by default 3 s
SAM	Variable	This local variable contains the SA of the client which is at the moment “owner” of the server.
SDA	Variable	This local variable contains the last valid SA conveyed with a LMPM_A_Data indication with valid data and is used for the generating of a response
SXID	Variable	This local variable contains the Transaction ID XID used to identify services uniquely in the context of the client. The value shall be taken from the request PDU.

4.3.2.2.3 DCP Multicast Sender

4.3.2.2.3.1 Primitive definitions

4.3.2.2.3.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DCPMCS are described in the service definition and shown in Table 86.

Table 86 – Remote primitives issued or received by DCPMCS

Primitive	Source	Destination	Associated parameters	Functions
DCP_Identify.req	CTLDINA	DCPMCS	ListOfFilter, ResponseDelayFactor	—
LMPM_A_Data.cnf (-)	LMPM	DCPMCS	CREP, LMPM_status	—
LMPM_A_Data.cnf (+)	LMPM	DCPMCS	CREP, LMPM_status	—
LMPM_A_Data.ind	LMPM	DCPMCS	CREP, DA, SA, Prio, A_SDU	—
DCP_Identify.cnf (-)	DCPMCS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCP_Identify.cnf (+)	DCPMCS	CTLDINA	ListOfDevices	—
LMPM_A_Data.req	DCPMCS	LMPM	CREP, DA, SA, Prio, A_SDU	—

4.3.2.2.3.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DCPMCS are described in the service definition and shown in Table 87.

Table 87 – Local primitives issued or received by DCPMCS

Primitive	Source	Destination	Associated parameters	Functions
DCP_Identify_ind	DCPMCS	CTLDINA	SA, ListOfDevices	—

4.3.2.2.3.2 State transition diagram

The state transition diagram of the DCPMCS is shown in Figure 16.

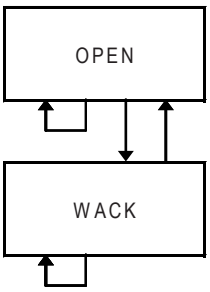


Figure 16 – State transition diagram of DCPMCS

States of the DCPMCS

OPEN	Wait for an Identify service request.
WACK	Wait for all responses until a certain time.

4.3.2.2.3.3 State machine description

The machine waits in the OPEN state for an Identify service request. After issuing the transmission of the data the WACK state is used to wait for all responses until a certain time. The timeout causes to issue the Identify confirmation service primitive with all received responses to the DCP user and sets the state machine to the OPEN state.

4.3.2.2.3.4 DCPMCS state table

Table 88 contains the complete description of the DCPMCS state machine. A LMPM_A_Data.ind primitive shall be accepted if type is DCP-IdentifyResPDU.

Table 88 – DCPMCS state table

#	Current State	Event /Condition =>Action	Next State
1	OPEN	**DCP_Identify.req ()** => XID := SXID DA := DCP_MulticastMACAdd A_SDU := DCP-Identify-ReqPDU First := TRUE StartTimer (Response delay timeout) LMPM_A_Data.req ( )	WACK
2	OPEN	LMPM_A_Data.ind () => ignore	OPEN
3	OPEN	LMPM_A_Data.cnf () => ignore	OPEN
4	OPEN	TimerExpired (Response delay timeout) => ignore	OPEN
5	WACK	**DCP_Identify.req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE DCP_Identify.cnf (-)	WACK
6	WACK	**LMPM_A_Data.ind ()** /(DCP-Identify-ResPDU && XID == SXID) && FIRST == FALSE => ListOfDevices.SA += SA ListOfDevices.ListOfData += A_SDU	WACK
7	WACK	**LMPM_A_Data.ind ()** /(DCP-Identify-ResPDU && XID == SXID) && First == TRUE => ListOfDevices.SA += SA ListOfDevices.ListOfData += A_SDU First := FALSE DCP_Identify_ind (SA, ListOfDevices)	WACK

#	Current State	Event /Condition =>Action	Next State
8	WACK	**LMPM_A_Data.ind ()** /!(DCP-Identify-ResPDU && XID == SXID) => ignore	WACK
9	WACK	LMPM_A_Data.cnf (+) => ignore	WACK
10	WACK	**LMPM_A_Data.cnf (-)** => ERRCLS := PROTOCOL ERRCODE := LMPM StopTimer (Response delay timeout) DCP_Identify.cnf (-)	OPEN
11	WACK	**TimerExpired (Response delay timeout)** => ListOfDevices := Stored ListOfDevices SXID := SXID + 1 DCP_Identify.cnf (+)	OPEN

4.3.2.2.3.5 Functions, Macros, Timers and Variables

Table 89 contains the functions, macros, timers and variables used by the DCPMCS and their arguments and their descriptions.

Table 89 – Functions used by the DCPMCS

Name	Type	Function/Meaning
SXID	Variable	This local variable contains the Transaction ID XID used to Identify services uniquely. It shall be changed with every request.
First	Variable	This variable is used for the speed up of the connection establishing.
Response delay timer	Timer	This timer is used to build a timeout for the DCP Identify response
Response delay timeout	Variable	The value is derived from the ResponseDelayFactor
TimerExpired	Function	This function is issued if a timer expires
StartTimer	Function	This function is used to start or restart a timer
StopTimer	Function	This function is used to stop a timer

4.3.2.2.4 DCP Multicast Receiver

4.3.2.2.4.1 Primitive definitions

4.3.2.2.4.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DCPMCR are described in the service definition and shown in Table 90.

Table 90 – Remote primitives issued or received by DCPMCR

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.cnf	LMPM	DCPMCR	CREP, LMPM_status	—
LMPM_A_Data.ind	LMPM	DCPMCR	CREP, DA, SA, Prio, A_SDU	—
LMPM_A_Data.req	DCPMCR	LMPM	CREP, DA, SA, Prio, A_SDU	—

4.3.2.2.4.1.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DCPMCR are described in the service definition and shown in Table 91.

Table 91 – Local primitives issued or received by DCPMCR

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.3.2.2.4.2 State transition diagram

The state transition diagram of the DCPMCR is shown in Figure 17.

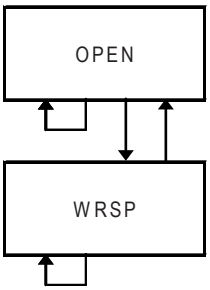


Figure 17 – State transition diagram of DCPMCR

States of the DCPMCR

OPEN	Waiting for DCP-IdentifyReqPDUs and compare the local data with the ListOfFilter. If a hit is detected start the response delay and change to the next state.
WRSP	Waits the response delay to send the response in case the DCP user has recognized a match with local data.

4.3.2.2.4.3 State machine description

The state machine is waiting for DCP-IdentifyReqPDUs in the OPEN state. The filter list shall be passed to the DCP user to check the filter criteria. The state machine waits in the state WRSP a certain time calculated by means of the clients Response Delay Factor to send the

response in case the DCP user has recognized a match with local data. Otherwise, nothing shall be sent.

4.3.2.2.4.4 DCPMCR state table

Table 92 contains the complete description of the DCPMCR state machine. A LMPM_A_Data.ind primitive shall be accepted if Type is DCP-IdentifyReqPDU.

Table 92 – DCPMCR state table

#	Current State	Event /Condition =>Action	Next State
1	OPEN	**LMPM_A_Data.ind ()** /DCP-Identify-ReqPDU && Successful comparison with ListOfFilters => SAM := SA SXID := XID ResponseDelay :=CalculateResponseDelay(ResponseDelayFactor, MACAddress) StartTimer (ResponseDelay)	WRSP
2	OPEN	**LMPM_A_Data.ind ()** /DCP-Identify-ReqPDU && ! Successful comparison with ListOfFilters => ignore	OPEN
3	OPEN	**LMPM_A_Data.ind ()** /!DCP-Identify-ReqPDU => ignore	OPEN
4	OPEN	LMPM_A_Data.cnf () => ignore	OPEN
5	WRSP	**TimerExpired (ResponseDelay)** => DA := SAM XID := SXID A_SDU := Create DCP-Identify-ResPDU with ListOfData taken from the DCP ASE according the ListOfFilters of the DCP-Identify-ReqPDU LMPM_A_Data.req ()	OPEN
6	WRSP	LMPM_A_Data.ind () => ignore	WRSP
7	WRSP	LMPM_A_Data.cnf () => ignore	WRSP

4.3.2.2.4.5 Functions, Macros, Timers and Variables

Table 93 contains the functions or macros used by the DCPMCR and their arguments and their descriptions.

Table 93 – Functions, Macros, Timers and Variables used by the DCPMCR

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or restarts a timer
StopTimer	Function	This local function stops a timer
TimerExpired	Function	This local function is issued if a timer expires

Name	Type	Function/Meaning
CalculateResponseDelay	Macro	This local macro calculates the ResponseDelay according the rules of this standard using the ResponseDelayFactor and the interface MACAddress.
Successful comparison with ListOfFilters	Macro	Checks the PDU against the parameters stored in the DCP ASE
ResponseDelayTimer	Timer	This timer is used to create the response delay
ResponseDelay	Variable	This variable contains the value according the calculation rules stated in this standard.
SAM	Variable	This local variable contains the SourceAddress of the requester used for the response.
SXID	Variable	This local variable contains the Transaction ID XID used to Identify services uniquely.

4.3.2.2.5 DCP Hello Multicast Sender

4.3.2.2.5.1 Primitive definitions

4.3.2.2.5.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DCPHMCS are described in the service definition and shown in Table 94.

Table 94 – Remote primitives issued or received by DCPHMCS

Primitive	Source	Destination	Associated parameters	Functions
DCP_Hello.req	CMINA	DCPHMCS	ListOfData	—
LMPM_A_Data.cnf (-)	LMPM	DCPHMCS	CREP, LMPM_status	—
LMPM_A_Data.cnf (+)	LMPM	DCPHMCS	CREP, LMPM_status	—
LMPM_A_Data.ind	LMPM	DCPHMCS	CREP, DA, SA, Prio, A_SDU	—
DCP_Hello.cnf (-)	DCPHMCS	CMINA	ERRCLS, ERRCODE	—
DCP_Hello.cnf (+)	DCPHMCS	CMINA	—	—
LMPM_A_Data.req	DCPHMCS	LMPM	CREP, DA, SA, Prio, A_SDU	—

4.3.2.2.5.1.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DCPHMCS are described in the service definition and shown in Table 95.

Table 95 – Local primitives issued or received by DCPHMCS

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.3.2.2.5.2 State transition diagram

The state transition diagram of the DCPHMCS is shown in Figure 18.

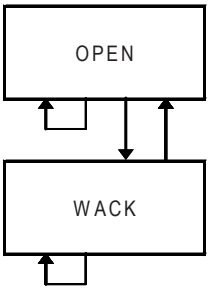


Figure 18 – State transition diagram of DCPHMCS

States of the DCPHMCS

OPEN	Wait for a Hello service request from the upper layer
WACK	Wait for the Hello confirmation from the lower layer

4.3.2.2.5.3 State machine description

The machine waits in the OPEN state for an Hello service request. After issuing the transmission of the data the WACK state is used to wait for the transmit confirmation.

4.3.2.2.5.4 DCPHMCS state table

Table 96 contains the complete description of the DCPHMCS state machine.

Table 96 – DCPHMCS state table

#	Current State	Event /Condition =>Action	Next State
1	OPEN	**DCP_Hello.req ()** => DA := DCP_MulticastMACAdd for Hello A_SDU := DCP-Hello-ReqPDU LMPM_A_Data.req ()	WACK
2	OPEN	LMPM_A_Data.ind () => ignore	OPEN
3	OPEN	LMPM_A_Data.cnf () => ignore	OPEN
4	WACK	LMPM_A_Data.ind () => ignore	WACK
5	WACK	**LMPM_A_Data.cnf (+)** => DCP_Hello.cnf (+)	OPEN
6	WACK	**LMPM_A_Data.cnf (-)** => ERRCLS := PROTOCOL ERRCODE := LMPM DCP_Hello.cnf (-)	OPEN

4.3.2.2.5.5 Functions, Macros, Timers and Variables

Table 97 contains the functions, macros, timers and variables used by the DCPHMCS and their arguments and their descriptions.

Table 97 – Functions, Macros, Timers and Variables used by the DCPHMCS

Name	Type	Function/Meaning
SXID	Variable	The XID shall be ignored by the Hello receiver. It may be incremented by the sender.

4.3.2.2.6 DCP Hello Multicast Receiver

4.3.2.2.6.1 Primitive definitions

4.3.2.2.6.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DCPHMCR are described in the service definition and shown in Table 98.

Table 98 – Remote primitives issued or received by DCPHMCR

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.cnf	LMPM	DCPHMCR	CREP, LMPM_status	—
LMPM_A_Data.ind	LMPM	DCPHMCR	CREP, DA, SA, Prio, A_SDU	—
DCP_Hello.ind	DCPHMCR	CTLDINA	ListOfData	—

4.3.2.2.6.1.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DCPHMCR are described in the service definition and shown in Table 99.

Table 99 – Local primitives issued or received by DCPHMCR

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.3.2.2.6.2 State transition diagram

The state transition diagram of the DCPHMCR is shown in Figure 19.

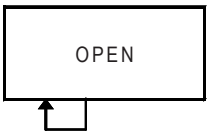


Figure 19 – State transition diagram of DCPHMCR

States of the DCPHMCR

OPEN waiting for DCP-Hello-ReqPDUs

4.3.2.2.6.3 State machine description

The state machine is waiting for DCP-Hello-ReqPDUs in the OPEN state.

4.3.2.2.6.4 DCPHMCR state table

Table 100 contains the complete description of the DCPHMCR state machine. A LMPM_A_Data.ind primitive will be accepted if Type is DCP-Hello-ReqPDU.

Table 100 – DCPHMCR state table

#	Current State	Event /Condition =>Action	Next State
1	OPEN	**LMPM_A_Data.ind ()** /DCP-Hello-ReqPDU && Successful comparison with ListOfData => DCP_Hello.ind ()	OPEN
2	OPEN	**LMPM_A_Data.ind ()** /!DCP-Hello-ReqPDU => ignore	OPEN
3	OPEN	LMPM_A_Data.cnf () => ignore	OPEN

4.3.2.2.6.5 Functions, Macros, Timers and Variables

Table 101 contains the functions, macros, timers and variables used by the DCPHMCR and their arguments and their descriptions.

Table 101 – Functions, Macros, Timers and Variables used by the DCPHMCR

Name	Type	Function/Meaning
Successful comparison with ListOfData	Macro	Compare the PDU content with the local stored information and return TRUE if it fits.

4.3.3 DLL Mapping Protocol Machines

There is no DLL Mapping Protocol Machine (DMPM) defined for this Protocol.

4.4 Precision working time control

4.4.1 FAL syntax description

4.4.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.4.1.2 APDU abstract syntax

Table 102 defines the abstract syntax of the PTCP PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs.

Table 102 – PTCP APDU syntax

APDU name	APDU structure
PTCP-PDU	PTCP-SYNC-PDU ^ PTCP-FUP-PDU ^ PTCP-ANNOUNCE-PDU ^ PTCP-DELAY-REQ-PDU ^ PTCP-DELAY-RSP-PDU ^ PTCP-DELAY-FU-RSP-PDU
PTCP-FUP-PDU	PTCP-Header-FUP, PTCP-FollowUpPDU
PTCP-SYNC-PDU	PTCP-Header-Sync, PTCP-RTSyncPDU
PTCP-ANNOUNCE-PDU	PTCP-Header-Announce, PTCP-AnnouncePDU
PTCP-DELAY-REQ-PDU	PTCP-Header-Delay, PTCP-DelayReqPDU
PTCP-DELAY-RSP-PDU	PTCP-Header-Delay, PTCP-DelayResPDU
PTCP-DELAY-FU-RSP-PDU	PTCP-Header-Delay, PTCP-DelayFuResPDU
PTCP-RTSyncPDU	PTCPSubdomain, PTCPTime, PTCPTimeExtension, PTCPMaster, [PTCPOption], PTCPEnd, [APDU_Status] [a]
PTCP-AnnouncePDU	PTCPSubdomain, PTCPMaster, [PTCPOption], PTCPEnd
PTCP-FollowUpPDU	PTCPSubdomain, PTCPTime, [PTCPOption], PTCPEnd
PTCP-DelayReqPDU	PTCPDelayParameter, [PTCPOption], PTCPEnd
PTCP-DelayResPDU	PTCPDelayParameter, PTCPPortParameter, PTCPPortTime, [PTCPOption], PTCPEnd
PTCP-DelayFuResPDU	PTCPDelayParameter, [PTCPOption], PTCPEnd
[a] Legacy support	

Table 103 defines structures for substitutions of elements of the APDU structures.

Table 103 – PTCP substitutions

Substitution name	Structure
PTCP-Header-Sync	PTCP_reserved_1, PTCP_reserved_2, PTCP_Delay10ns, PTCP_SequenceID, PTCP_Delay1ns_Byte [d], Padding [a], PTCP_Delay1ns
PTCP-Header-FUP	[HWPadding*] [b], PTCP_SequenceID, [Padding*] [c], PTCP_Delay1ns_FUP
PTCP-Header-Announce	[HWPadding*] [b], PTCP_SequenceID, [Padding*] [e]
PTCP-Header-Delay	[HWPadding*] [b], PTCP_SequenceID, [Padding*] [c], PTCP_Delay1ns
PTCPSubdomain	PTCP_TLVHeader, PTCP_MasterSourceAddress, PTCP_SubdomainUUID
PTCPTime	PTCP_TLVHeader, PTCP_EpochNumber, PTCP_Seconds, PTCP_NanoSeconds
PTCPTimeExtension	PTCP_TLVHeader, PTCP_Flags, PTCP_CurrentUTCOffset, [Padding*] [a]
PTCPMaster	PTCP_TLVHeader, PTCP_MasterPriority1, PTCP_MasterPriority2, PTCP_ClockClass, PTCP_ClockAccuracy, PTCP_ClockVariance, [Padding*] [a]
PTCPDelayParameter	PTCP_TLVHeader, PTCP_PortMACAddress
PTCPPortParameter	PTCP_TLVHeader, [Padding*] [a], PTCP_T2PortRxDelay, PTCP_T3PortTxDelay
PTCPPortTime	PTCP_TLVHeader, [Padding*] [a], PTCP_T2TimeStamp
PTCPOption	PTCP_TLVHeader, PTCP_OUI, PTCP_SubType, Data*, [Padding*] [a]
PTCPEnd	PTCP_TLVHeader(0)
[a] 32 bit alignment shall be ensured [b] 12 octets padding [c] 2 octets padding [d] Legacy to cover hardware needs [e] 6 octets padding	

4.4.1.3 Coding section related to common basic fields

4.4.1.3.1 Coding of the field PTCP_reserved_1

This field shall be coded as data type Unsigned32.

4.4.1.3.2 Coding of the field PTCP_reserved_2

This field shall be coded as data type Unsigned32.

4.4.1.3.3 Coding of the field HWPadding

This field shall be coded as data type Unsigned8.

4.4.1.3.4 Coding of the field PTCP_TLVHeader

The coding of this field shall be according to 3.4.2.4. and the individual bits shall have the following meaning:

Bit 0 – 8: PTCP_TLVHeader.Length
The value contains the sum of subsequent octets of the according block.

Bit 9 – 15: PTCP_TLVHeader.Type
This field shall be coded with the values according to Table 104.

Table 104 – PTCP_TLVHeader.Type

Value (hexadecimal)	Meaning	Use
0x00	PTCPEnd	Mandatory
0x01	PTCPSubdomain	Mandatory
0x02	PTCPTime	Mandatory
0x03	PTCPTimeExtension	Mandatory
0x04	PTCPMaster	Mandatory
0x05	PTCPPortParameter	Mandatory
0x06	PTCPDelayParameter	Mandatory
0x07	PTCPPortTime	Mandatory
0x08 – 0x7E	Reserved	—
0x7F	PTCPOption Organizationally specific	Optional

4.4.1.3.5 Coding section related to PTCP-Header

These fields contains the propagation delay time in nanoseconds. It is parted into a field for the 10 ns part and a field for the 1 ns part. All delay fields are only relevant for Sync-, FollowUp-, DelayRes- without DelayFuRes- and DelayFuRes-Messages.

4.4.1.3.5.1 Coding of the field PTCP_Delay10ns

This field shall be coded as data type Unsigned32 and contains the 10 ns part of the propagation delay time. This field shall be coded with the values according to Table 105.

Table 105 – PTCP_Delay10ns

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFE	Valid 10 nanosecond part of the propagation delay time
0xFFFFFFFF	Invalid This value indicates an overflow and marks the delay fields as invalid

4.4.1.3.5.2 Coding of the field PTCP_Delay1ns_Byte

The field contains the 1 ns part of the propagation delay time.

NOTE Legacy to cover hardware needs

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0 – 3: PTCP_Delay1ns_Byte.Value
The value contains the 1 ns part of the propagation delay time. This field shall be coded with the values according to Table 106.

Table 106 – PTCP_Delay1ns_Byte.Value

Value (hexadecimal)	Meaning
0x00 – 0x09	Number of ns
0x0A – 0x0F	Reserved

Bit 4 – 7: PTCP_Delay1ns_Byte.Reserved
This field shall be set according to 3.4.2.2.

Instead of this field only the field PTCP_Delay1ns may be used.

4.4.1.3.5.3 Coding of the field PTCP_Delay1ns

This field shall be coded as data type Unsigned32 and contains the 1 ns part of the propagation delay time. This field shall be coded with the values according to Table 107.

Table 107 – PTCP_Delay1ns

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFE	Valid 1 nanosecond part of the propagation delay time
0xFFFFFFFF	Invalid This value indicates an overflow and marks the delay fields as invalid

4.4.1.3.5.4 Coding of the field PTCP_Delay1ns_FUP

This field shall be coded as data type Integer32 and contains the correction of the propagation delay time in 1 ns. This field shall be coded with the values according to Table 108.

Table 108 – PTCP_Delay1ns_FUP

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFF	Nanosecond part of the propagation delay time

4.4.1.3.5.5 Coding of the field PTCP_SequenceID

This field shall be coded as data type Unsigned16 with the values according to Table 109.

Table 109 – PTCP_SequenceID

Meaning	Usage
Sync frame	The PTCP master increments this field for every sync frame.
Follow up frame	The PTCP master or a follow up injecting PTCP forwarder mirrors the value from the Sync frame.
Delay request frame	The PTCP delay measurement requester increments this field for every measurement.
Delay response frame	The responder mirrors the value from the Delay request frame.
Delay response follow up frame	The responder uses the value from the Delay response frame.

The receiver of the PTCP frames shall use this field to detect repetitions, loss of frames and timeliness of data. For this reason the PTCP_SequenceID value range shall be divided in the ratio 15/16 for valid and 1/16 for invalid as shown in Figure 20.

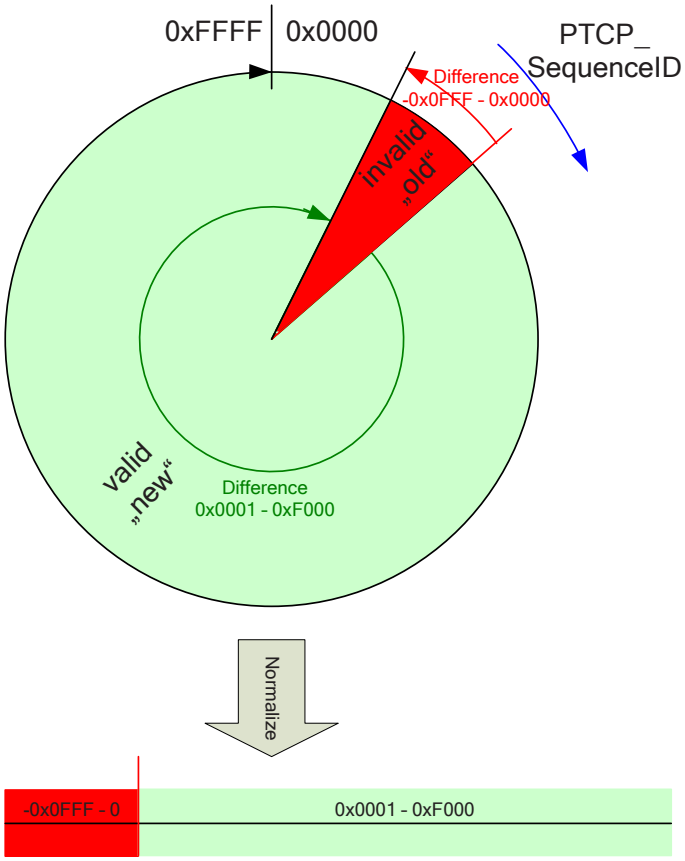


Figure 20 – PTCP_SequenceID value range

4.4.1.3.6 Coding of the field PTCP_OUI

This field shall be coded as OctetString[3] with the Organizationally unique identifier (OUI) as defined in IEEE 802.

NOTE The value of this central administrative number is given by the IEEE Registration Authority Committee. Available at <http://standards.ieee.org/regauth>

4.4.1.3.7 Coding of the field PTCP_SubType

This field shall be coded as Unsigned8. The value is organizationally specific. For the OUI the parameter PTCP_SubType shall be coded as in Table 110.

Table 110 – PTCP_SubType for OUI (=00-0E-CF)

Value (hexadecimal)	Meaning	Usage
0x00 – 0xFF	Reserved	—

4.4.1.3.8 Coding of the field PTCP_Seconds

This field shall be coded as data type Unsigned32 with the values according to Table 111. The resolution of this field is 1 s.

Table 111 – PTCP_Seconds

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFF	Time in s

4.4.1.3.9 Coding of the field PTCP_NanoSeconds

This field shall be coded as data type Unsigned32 with the values according to Table 112. The resolution of this field is 1 ns.

Table 112 – PTCP_NanoSeconds

Value (hexadecimal)	Meaning
0x00000000 – 0x3B9AC9FF	Time in ns
0x3B9ACA00 – 0xFFFFFFFF	Reserved

4.4.1.4 Coding section of PTCP-PDU specific fields

4.4.1.4.1 Coding of the field PTCP_MasterSourceAddress

This field shall be coded as data type OctetString[6]. The value of the field Destination Address shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

4.4.1.4.2 Coding of the field PTCP_SubdomainUUID

This field shall be coded as data type UUID.

NOTE The value NIL indicates no synchronization within the Read Real Sync Data service.

4.4.1.4.3 Coding of the field PTCP_Flags

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 7: PTCP_Flags.reserved_1
This field shall be set according to 3.4.2.2.

Bit 8 – 9: PTCP_Flags.LeapSecond
This field shall be set according to Table 113.

Table 113 – PTCP_Flags.LeapSecond

Value (hexadecimal)	Meaning
0x00	No leap second
0x01	Last minute has 61 s
0x02	Last minute has 59 s
0x03	Reserved

Bit 10 – 15: PTCP_Flags.reserved_2
This field shall be set to zero.

4.4.1.4.4 Coding of the field PTCP_EpochNumber

This field shall be coded as data type Unsigned16 and contain the 0x100000000 s part of the time. The value of the PTCP_EpochNumber field shall be the value of epoch number of the global time properties data set of the clock issuing this message according to Table 114 and Table 115. The starting point of time is similar to the IEC 61588 the 1970-01-01 T 00:00:00 Z.

Table 114 – Timescale correspondence between MJD, UTC and PTCP_EpochNumber

MJD (Modified Julian Day)	UTC (Universal Time Coordinated)	UTC Offset (Leap seconds)	Value PTCP_Seconds	Value PTCP_Epoch-Number
0:00:00 15 020	1900-01-01 T 00:00:00 Z	—	—	—
0:00:00 40 587	1970-01-01 T 00:00:00 Z	—	0	0
0:00:00 41 317	1972-01-01 T 00:00:00 Z	10	63 072 000 + 10	0
16:57:44 51 357	1999-06-28 T 16:57:44 Z	32	930 589 064 + 32	0
—	2006-01-01 T 00:00:00 Z	33	—	0

NOTE The coding YYYY-MM-DD T HH:MM:SS Z is according ISO 8601, where 'T' signals that a time follows the date and 'Z' signals that the time is UTC.

Table 115 – Timescale correspondence between PTCP_EpochNumber, PTCP_Second, PTCP_Nanosecond, CycleCounter and SendClockFactor

CycleCounter value (hexadecimal)	PTCP_EpochNumber value (decimal)	PTCP_Second value (decimal)	PTCP_Nanosecond value (decimal)	SendClockFactor value (decimal)
0x0000000000000000	0	0	0	32
0x0000000000010000	0	65	536 000 000	32
0x0000000100000000	0	4 294 967	296 000 000	32
0x0001000000000000	65	2 302 102 470	656 000 000	32

$$PTCP\_Epoch = PTCP\_EpochNumber \times 0x100000000 \quad (8)$$

where

PTCP_Epoch is the helper variable for the calculation of seconds

PTCP_EpochNumber is the epoch number

$$PTCP\_Time = PTCP\_Epoch + PTCP\_Second + PTCP\_Nanosecond \quad (9)$$

where

PTCP_Time is the PTCP time

PTCP_Epoch is the helper variable for the calculation of seconds

PTCP_Second is the PTCP second value

PTCP_Nanosecond is the PTCP nanosecond value

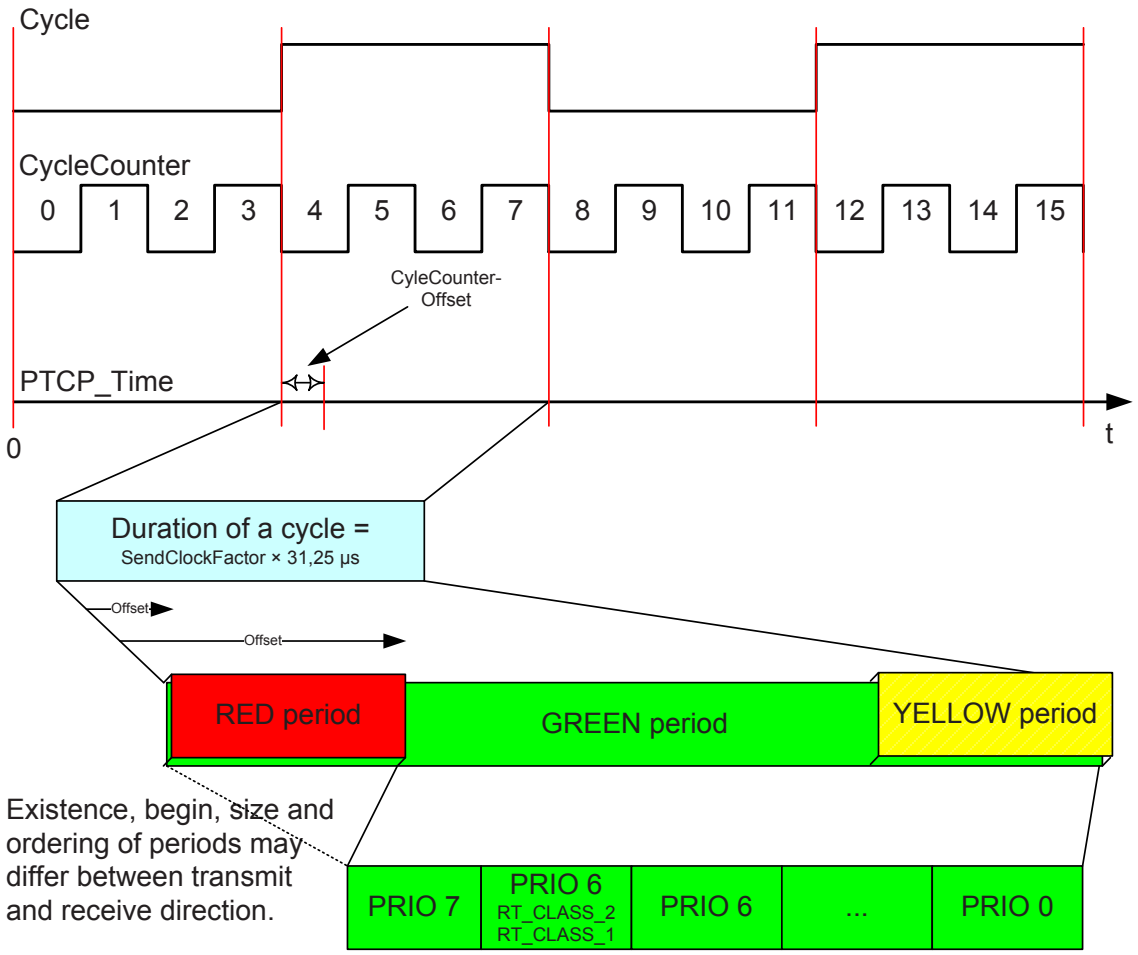


Figure 21 – Timescale correspondence between PTCP_Time and CycleCounter

For the synchronization of the CycleCounter as shown in Figure 21, the calculation shall accept PTCP_Time values with an offset to the cycle begin.

$$\text{Cycle} = \text{PTCP\_Time } \mathit{DIV} \text{ (SendClockFactor} \times 31{,}25\ \mu\text{s)} \quad (10)$$

where

Cycle	is the cycle
PTCP_Time	is the PTCP time
SendClockFactor	is the factor of the send clock, the length of one phase

$$\text{CycleCounter} = \text{Cycle} \times \text{SendClockFactor} \quad (11)$$

where

CycleCounter	is the counter of cycles
Cycle	is the cycle
SendClockFactor	is the factor of the send clock, the length of one phase

$$\text{CycleCounterOffset} = \text{PTCP\_Time } \mathit{MOD} \text{ (SendClockFactor} \times 31{,}25\ \mu\text{s)} \quad (12)$$

where

CycleCounterOffset	is the offset of the cycle counter

PTCP_Time	is the PTCP time
SendClockFactor	is the factor of the send clock, the length of one phase

NOTE 1 DIV does an integer division and delivers the quotient.

NOTE 2 MOD does an integer division and delivers the remainder.

4.4.1.4.5 Coding of the field PTCP_CurrentUTCOffset

This field shall be coded as data type Integer16. The value of the current PTCP_CurrentUTCOffset field shall be the value of current_utc_offset of the global time properties data set of the clock issuing this message according to Table 114.

4.4.1.4.6 Coding of the field PTCP_MasterPriority1

PTCP_MasterPriority1 is used in the execution of the best master clock algorithm. Lower values take precedence. The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0 – 2: PTCP_MasterPriority1.Priority
This field shall be set according to Table 116 and Table 117.

Table 116 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 2

Value (hexadecimal)	Usage	Meaning
0x00	Reserved	—
0x01	Primary synchronization master	Clock synchronization (primary master)
0x02	Secondary synchronization master	Clock synchronization (secondary master)
0x03 – 0x07	Reserved	—

Table 117 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 1

Value (hexadecimal)	Usage	Meaning
0x00	Sync slave	Clock synchronization (slave)
0x01 – 0x07	Reserved	—

Bit 3 – 5: PTCP_MasterPriority1.Level
This field shall be set according to Table 118.

Table 118 – PTCP_MasterPriority1.Level

Value (hexadecimal)	Usage	Meaning
0x00	Level 0 (highest)	See Annex J
0x01	Level 1	
0x02 – 0x06	…	
0x07	Level 7 (lowest)	

Bit 6: PTCP_MasterPriority1.Reserved
This field shall be set zero.

Bit 7: PTCP_MasterPriority1.Active
This field shall be set zero for the PDSyncData.

This field shall be set zero for the PTCP-ANNOUNCE-PDU if the sync master doesn't convey PTCP-SYNC-PDU's and shall be set to one if the sync master conveys PTCP-SYNC-PDU's.

Thus this field shall be set to one for the PTCP-SYNC-PDU after the best master selection is done.

4.4.1.4.7 Coding of the field PTCP_MasterPriority2

This field shall be coded as Unsigned8. PTCP_MasterPriority2 is used in the execution of the best master clock algorithm. Lower values take precedence. The value of PTCP_MasterPriority2 shall be configurable according to Table 119.

Table 119 – PTCP_MasterPriority2

Value (hexadecimal)	Usage	Meaning
0x00 – 0xFE	Reserved	—
0xFF	Default	Default

4.4.1.4.8 Coding of the field PTCP_ClockClass

This field shall be coded as data type Unsigned8 with the values according to Table 120. For working clock synchronization the arbitrary timescale (ARB) shall be used.

Table 120 – PTCP_ClockClass for SyncID == 0 (working clock synchronization)

Value (hexadecimal)	Usage	Meaning
0x00 – 0x0C	Reserved	—
0x0D	Shall designate a PTCP clock as a primary reference that is synchronized to an application specific source of time. The timescale distributed shall be ARBITRARY. A clock class 0x0D clock shall not be a slave to another clock in the PTCP domain.	Default
0x0E	Shall designate a PTCP clock that has previously been designated as clock class 0x0D but that has lost the ability to synchronize to an application specific source of time and is in holdover mode and within holdover specifications. The timescale distributed shall be ARBITRARY. A clock class 0x0E clock shall not be a slave to another clock in the PTCP domain	—
0x0F – 0xBA	Reserved	—
0xBB	Degradation alternative B for a PTCP clock of clock class 0x07 that is not within holdover specification. A clock of clock class 0xBB may be a slave to another clock in the PTCP domain.	—
0xBC – 0xC0	Reserved	—
0xC1	Degradation alternative B for a PTCP clock of clock class 0x0E that is not within holdover specification. A clock of clock class 0xC1 may be a slave to another clock in the PTCP domain.	—
0xC2 – 0xFE	Reserved	—
0xFF	Shall be the clock class of a slave-only clock.	—

4.4.1.4.9 Coding of the field PTCP_ClockAccuracy

This field shall be coded as data type Unsigned8 with the values according to Table 121. The PTCP_ClockAccuracy indicates the expected accuracy of a clock when it is master. The value of PTCP_ClockAccuracy shall represent its current status.

Table 121 – PTCP_ClockAccuracy

Value (hexadecimal)	Usage	Meaning
0x00 – 0x1F	Reserved	—
0x20	The time is accurate to within 25 ns	—
0x21	The time is accurate to within 100 ns	Default for working clock synchronization
0x22	The time is accurate to within 250 ns	—
0x23	The time is accurate to within 1 μs	—
0x24	The time is accurate to within 2,5 μs	—
0x25	The time is accurate to within 10 μs	—
0x26	The time is accurate to within 25 μs	—
0x27	The time is accurate to within 100 μs	—
0x28	The time is accurate to within 250 μs	—
0x29	The time is accurate to within 1 ms	—
0x30 – 0xFD	Reserved	—
0xFE	Unknown	—
0xFF	Reserved	—

4.4.1.4.10 Coding of the field PTCP_ClockVariance

This field shall be coded as data type Unsigned16 with the values according to Table 122. The value characterizes the quality of a clock. Each master clock shall maintain an estimate of its inherent precsision. This is the precision of the timestamps included in the sync-frames issued by the PTCP synchronization master when it is not synchronized to another PTCP synchronization master using the PTCP protocol.

Table 122 – PTCP_ClockVariance

Value (hexadecimal)	Usage	Meaning
0x0000	Reserved	Default
0x0001 – 0xFFFF	Reserved	—

4.4.1.4.11 Coding of the field PTCP_T2PortRxDelay

This field shall be coded as data type Unsigned32 with the values according to Table 123.

Table 123 – PTCP_T2PortRxDelay

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFF	Port receive delay (MDI to SHIM) in nanoseconds.

4.4.1.4.12 Coding of the field PTCP_T3PortTxDelay

This field shall be coded as data type Unsigned32 with the values according to Table 124.

Table 124 – PTCP_T3PortTxDelay

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFF	Port transmit delay (SHIM to MDI) in nanoseconds.

4.4.1.4.13 Coding of the field PTCP_PortMACAddress

This field shall be coded as data type OctetString[6]. The value of the field PTCP_PortMACAddress shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

4.4.1.4.14 Coding of the field PTCP_T2TimeStamp

This field shall be coded as data type Unsigned32 with the values according to Table 125.

Table 125 – PTCP_T2TimeStamp

Value (hexadecimal)	Meaning
0x00000000 – 0xFFFFFFFF	TimeStamp in nanoseconds

4.4.2 AP-Context state machine

There is no AP-Context State Machine defined for this Protocol.

4.4.3 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.4.4 Application Relationship Protocol Machines

4.4.4.1 Generic Synchronization with PTCP

4.4.4.1.1 Timestamp

The PTCP message timestamp point for a transmitted or received frame shall correspond to the leading edge of the first bit of the octet immediately following the Start Frame Delimiter octet of an IEEE 802.3 frame as shown in Figure 22.

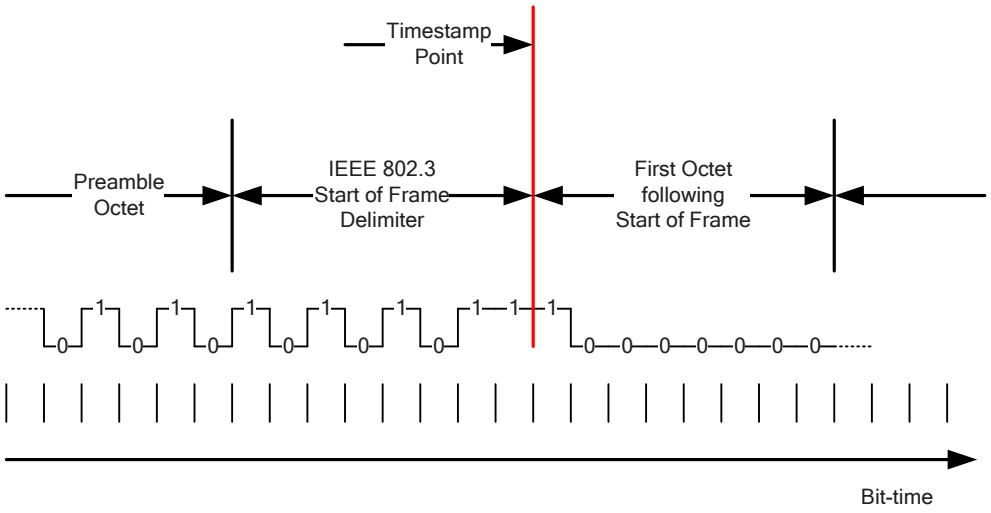


Figure 22 – Message timestamp point

4.4.4.1.2 Timer model

PTCP uses a the timer model shown in Figure 23.

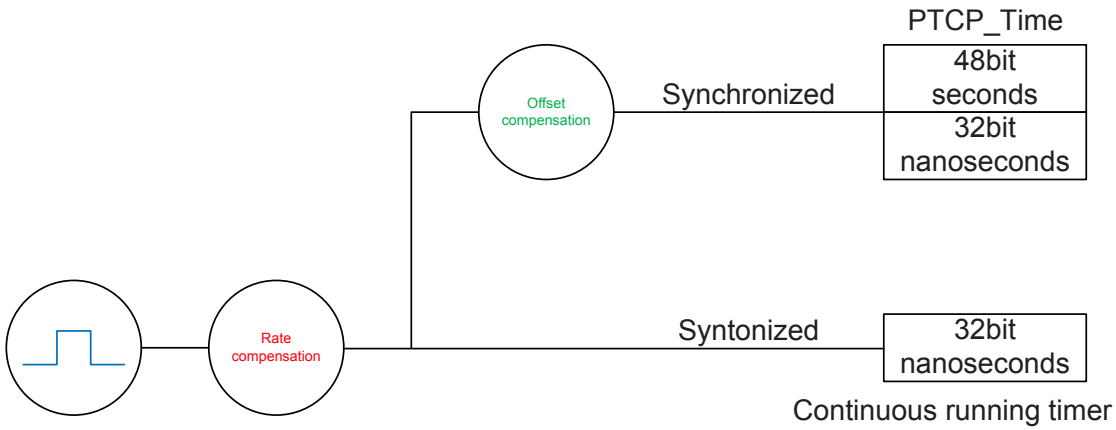


Figure 23 – Timer model

It consist of two timers. The first, at least 32 bit wide syntonized continuous running timer with a resolution of one nanosecond, is used for the line delay and bridge delay measurement, the second 80 bit wide synchronized timer with a resolution of one nanosecond ist used for the PTCP_Time of master or slave.

4.4.4.1.3 Generic model

For each received and transmitted sync, delay request or delay response message a time stamping unit shall generate a time stamp. Figure 24 shows the four timestamps used for synchronization.

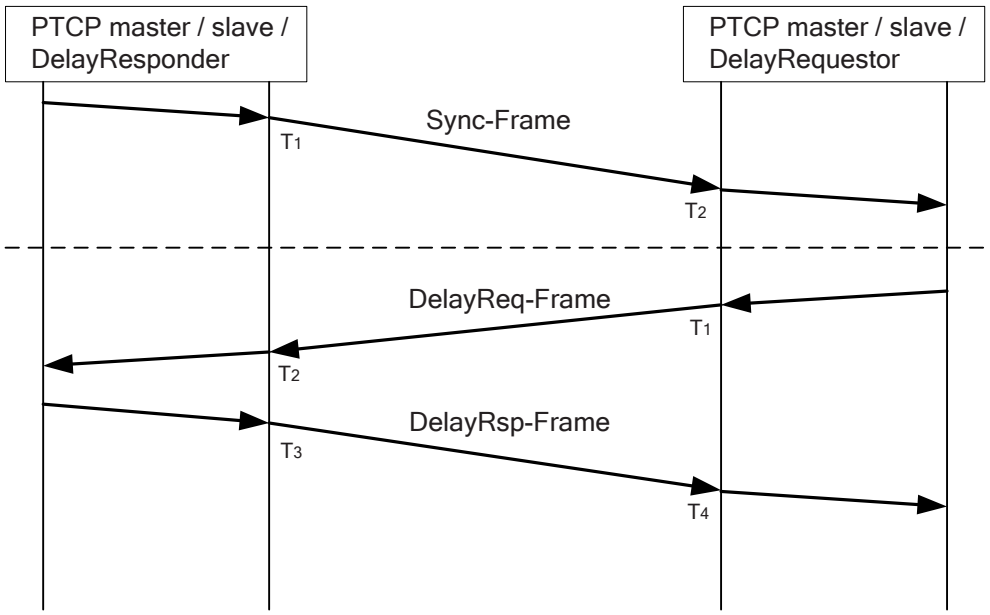


Figure 24 – Four message timestamps

The generic model uses the following formulae.

$$\text{SendTimeStamp} = T_1 \quad (13)$$

$$\text{ReceiptTimeStamp} = T_2 \quad (14)$$

$$\text{SendTimeStamp} = T_3 \quad (15)$$

$$\text{ReceiptTimeStamp} = T_4 \quad (16)$$

where

T_1 is measured by the local clock of the port which sends a Sync- or a DelayReq-Frame

T_2 is measured by the local clock of the port which receives a Sync- or a DelayReq-Frame

T_3 is measured by the local clock of the port which sends a DelayRes-Frame

T_4 is measured by the local clock of the port which receives a DelayRes-Frame

4.4.4.1.4 Line delay measurement and peer rate compensation

The line delay measurement and the peer rate compensation calculation between DelayRequestor and DelayResponder are described in Figure 25. DelayReq-, DelayRes and DelayFuRes-Messages shall be used for delay measurement and shall not be propagated. The DelayFuRes-Frame is used to transmit the value of ResDelay to the DelayRequestor.

DelayResponder which are not able to measure the line delay but want to receive the Sync-Frame shall use a DelayRes.req with a ResDelay value of zero.

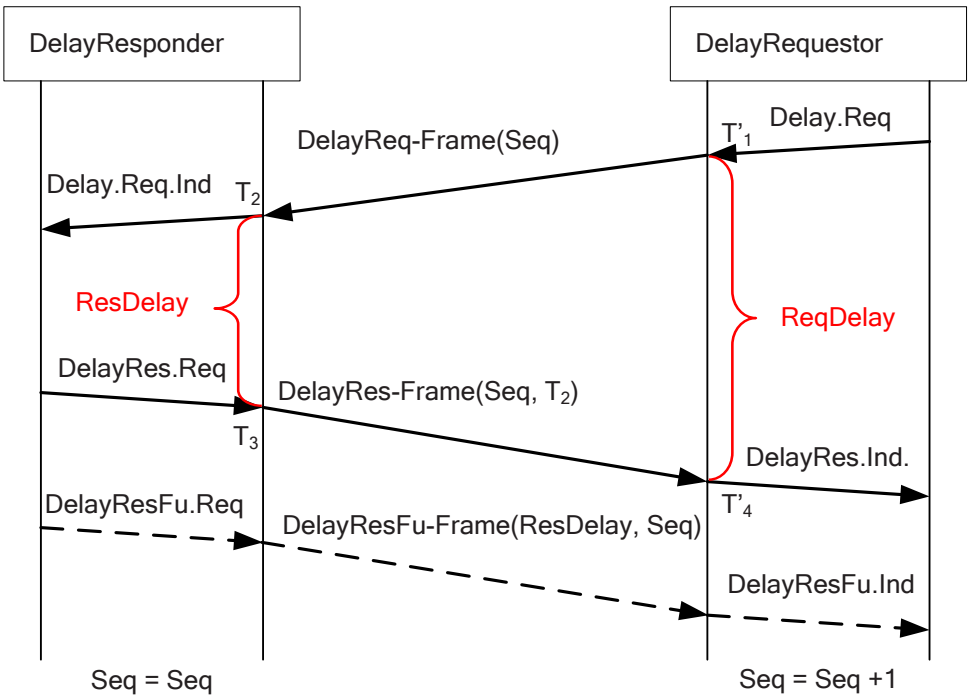


Figure 25 – Line delay protocol with follow up

If a time stamping unit is capable to calculate the response delay time on the fly and insert the response time in the delay response frame no delay follow up message is necessary.

The line delay measurement without DelayFuRes-message between DelayRequestor and DelayResponder is described in Figure 26.

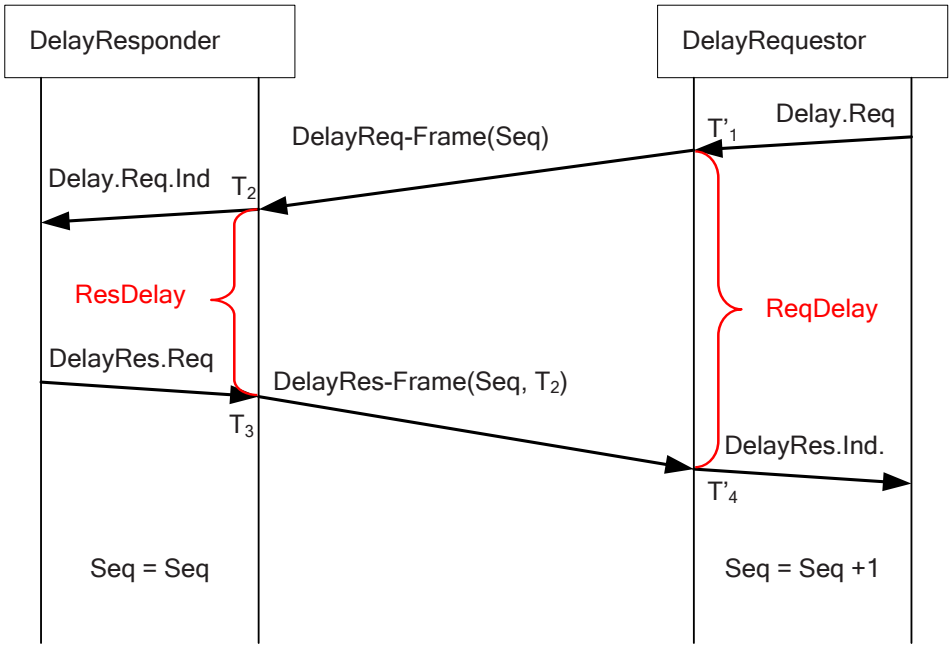


Figure 26 – Line delay protocol without follow up

The calculation of line delay and peer rate compensation factor is shown in following formulae. If the DelayRes-PDU contains the field T_2, the Formula (19) shall be used, if the ResDelay is zero, RCF_{peer}.shall be set to one.

$$ResDelay = T_3 - T_2 \quad (17)$$

where

ResDelay	is the delay at responder side
T_3	is the time stamp of sending DelayRes-Frame as DelayResponder
T_2	is the time stamp of receiving DelayReq-Frame as DelayResponder

$$ReqDelay = T'_4 - T'_1 \quad (18)$$

where

ReqDelay	delay requestor
T'_4	is the time stamp of receiving DelayRes-Frame as DelayRequestor
T'_1	is the time stamp of sending DelayReq-Frame as DelayRequestor

$$RCF_{peer} = \frac{T_2(Seq) - T_2(Seq-1)}{T'_1(Seq) - T'_1(Seq-1)} \quad (19)$$

where

RCF_{peer}	is the peer rate compensation factor
T_2	is the time stamp of receiving DelayReq-Frame as DelayResponder and transmitted using the DelayRes-Frame to the DelayRequestor
T'_1	is the time stamp of sending DelayReq-Frame as DelayRequestor
Seq	is the sequence variable

$$ResDelay_{peer} = \frac{ResDelay}{RCF_{peer}} \quad (20)$$

where

$ResDelay_{peer}$	is the delay responder at this peer
ResDelay	is the delay responder
RCF_{peer}	is the peer rate compensation factor

The delay measurement shall be repeated in cycles.

4.4.4.1.5 Line delay calculation

The line delay between two devices supporting PTCP is determined as described in Figure 27.

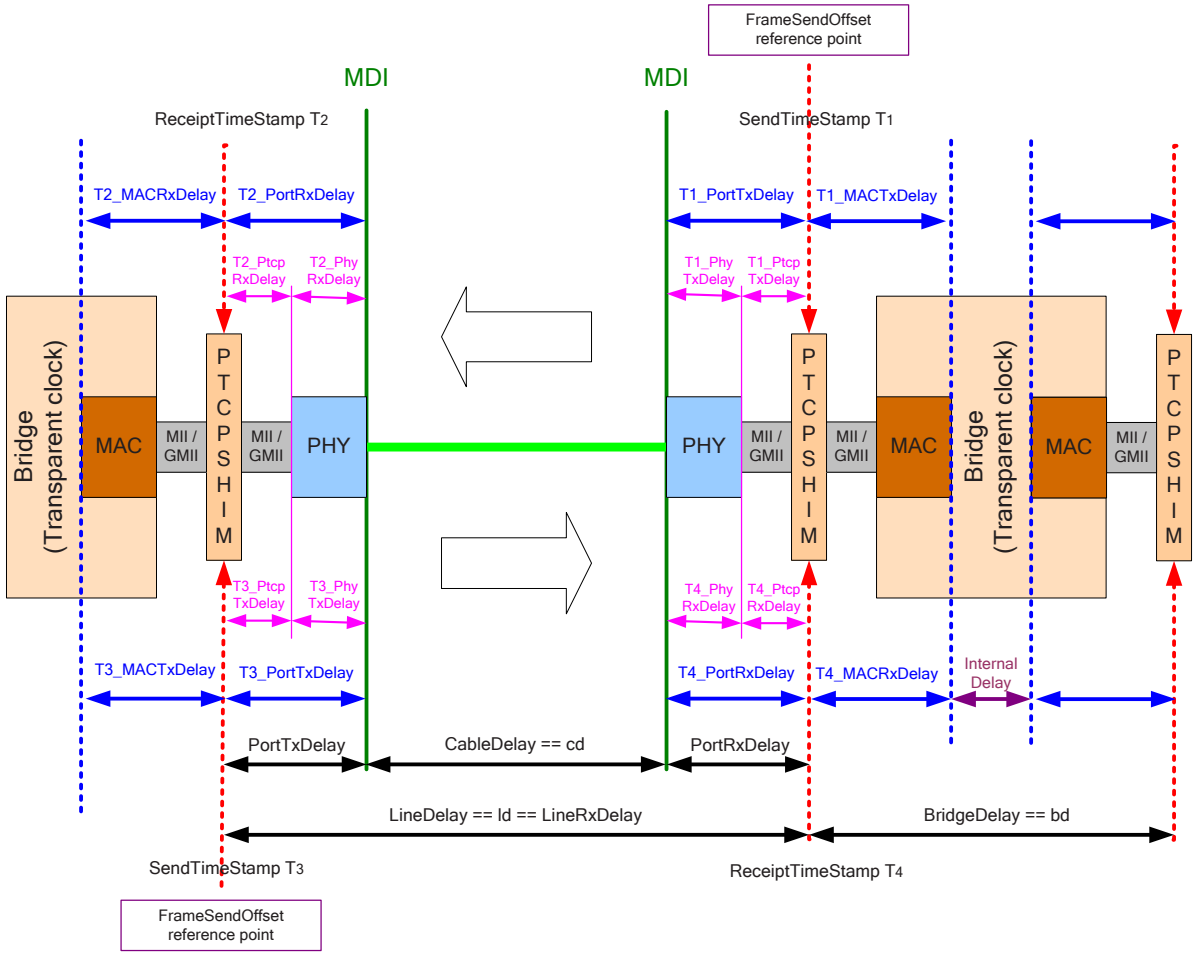


Figure 27 – Line delay measurement

NOTE 1 The Reduced Media Independent Interface (RMII) synchronisates its internal 50 MHz clock with the 25 MHz clock of the PHY. It results in a quantization error of 20 ns. This jitter cannot be compensated. The Media Independent Interface (MII) is using the PHY clock without this error.

NOTE 2 The cable type Class D has a maximal delay skew of 45 ns for 100 m cable length. It results in a 45 ns offset error which cannot be compensated. A selection of better cable reduces this error.

A port receive/transmit delay (example: T1_PortTxDelay) contains the line delay of the used PHY component and the deviation from the reference time stamp.

$$T1\_PortTxDelay = T1\_PhyTxDelay + T1\_PtcpTxDelay \quad (21)$$

where

T1_PortTxDelay	is the port transmit delay
T1_PhyTxDelay	is the delay of the used PHY component
T1_PtcpTxDelay	is the deviation from the reference time stamp

$$T3\_PortTxDelay = T3\_PhyTxDelay + T3\_PtcpTxDelay \quad (22)$$

where

T3_PortTxDelay	is the port transmit delay
T3_PhyTxDelay	is the delay of the used PHY component
T3_PtcpTxDelay	is the deviation from the reference time stamp

$$T2\_PortRxDelay = T2\_PhyRxDelay + T2\_PtcpRxDelay \quad (23)$$

where

T2_PortRxDelay	is the port receive delay
T2_PhyRxDelay	is the delay of the used PHY component
T2_PtcpRxDelay	is the deviation from the reference time stamp

$$T4\_PortRxDelay = T4\_PhyRxDelay + T4\_PtcpRxDelay \quad (24)$$

where

T4_PortRxDelay	is the port receive delay
T4_PhyRxDelay	is the delay of the used PHY component
T4_PtcpRxDelay	is the deviation from the reference time stamp

$$CableDelay = (ReqDelay - ResDelay_{peer} - T1\_PortTxDelay - T2\_PortRxDelay - T3\_PortTxDelay - T4\_PortRxDelay) / 2 \quad (25)$$

where

CableDelay	is the delay of the cable
ReqDelay	is the delay requestor
$ResDelay_{peer}$	is the delay responder
T1_PortTxDelay	is the port transmit delay
T2_PortRxDelay	is the port receive delay
T3_PortTxDelay	is the port transmit delay
T4_PortRxDelay	is the port receive delay

$$LineDelay = CableDelay + T3\_PortTxDelay + T4\_PortRxDelay \quad (26)$$

where

LineDelay	is the delay between both PTCPSHIMs for received frames
CableDelay	is the delay of the cable
T3_PortTxDelay	is the port receive/transmit delay
T4_PortRxDelay	is the port receive/transmit delay

$$LineDelay_{SyncMaster} = LineDelay \times RCF_{SyncMaster} \quad (27)$$

where

$LineDelay_{SyncMaster}$	is the compensated time needed to forward a frame
LineDelay	is the measured value between two peers
$RCF_{SyncMaster}$	is the factor between the frequency of the SyncMaster and the frequency of the SyncSlave

NOTE 3 Formua (27) is only informative if the LineDelay is measured with the syntonized timer.

A DelayRes.req with a ResDelay value of zero indicates that the CableDelay and the LineDelay are not measureable, but the responding peer wants to receive the Sync-Frame.

LineSyncDelay is the line delay of the Sync-Frame. Due to the asymmetry of the involved communication path and due to the resolution of the time stamps it is basically impossible to determine the line delay exactly.

A PTCP clock can detect non PTCP neighbors by checking the line delay between nodes. As a switch delay is in the range of several (>2) μs, the delay between two nodes connected with 100 m Twisted Pair cabling (100 Base TX) is about 500 ns.

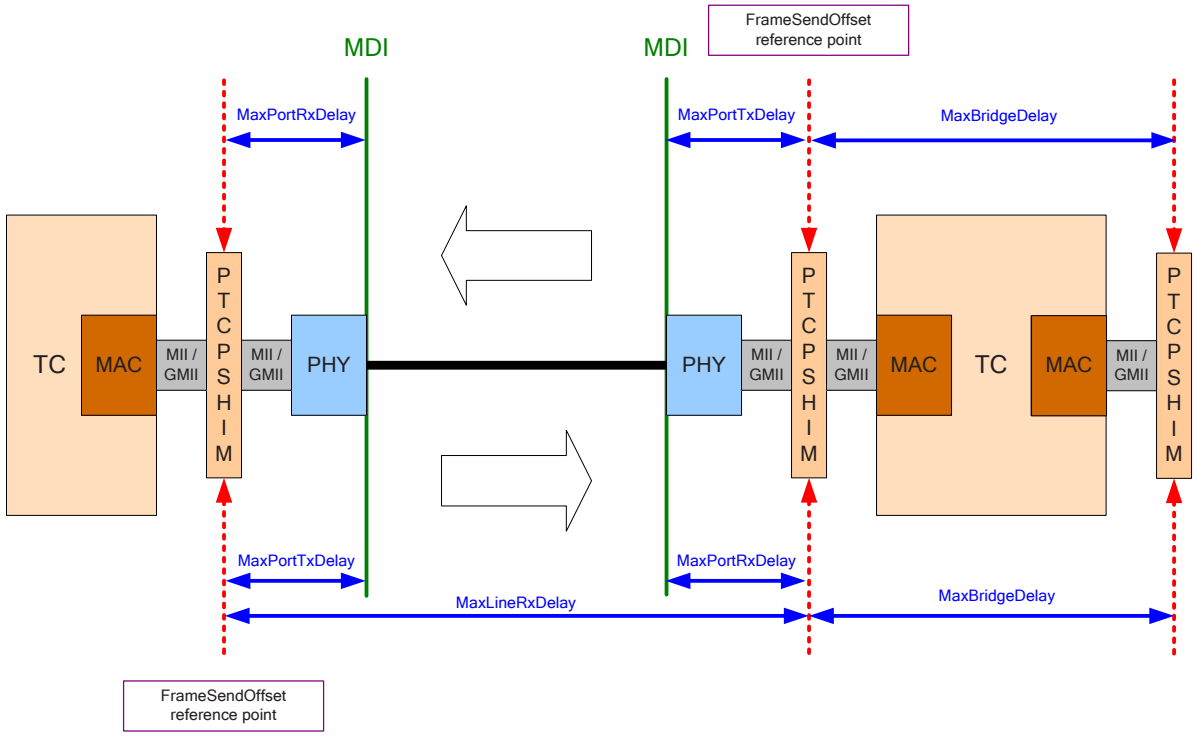


Figure 28 – Model parameter for GSDML usage

Figure 28 shows the model parameter for GSDML usage. The parameter MaxBridgeDelay, MaxPortTxDelay and MaxPortRxDelay offers engineering tools a calculation basis for RT_CLASS_3.

The to be used MaxBridgeDelay depends on the bridging mode like normal forwarding, fast forwarding and DFP concatenated forwarding.

4.4.4.1.6 Sync-Frame forwarding

A device which forwards PTCP sync messages measures the bridge delay as shown in Figure 29 and adds this time to the delay field in the sync or follow up message.

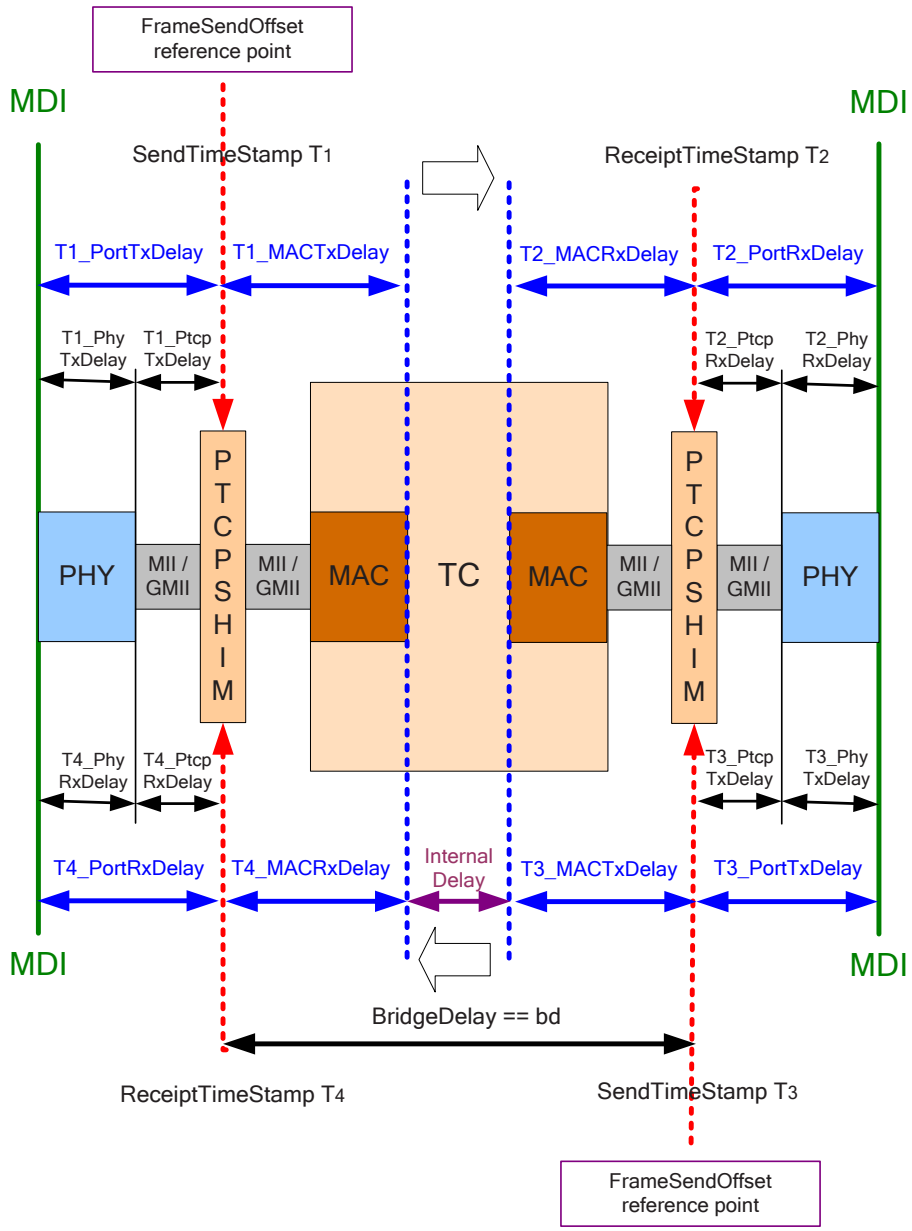


Figure 29 – Bridge delay measurement

The calculation of the bridge delay is shown in following formulae.

$$BridgeDelay = T_3 - T_4 \quad (28)$$

where

BridgeDelay	is the time needed to forward a frame
T3	is the point in time when the first bit of the SD of a frame is transmitted
T4	is the point in time when the first bit of the SD of a frame is received

$$BridgeDelay_{SyncMaster} = BridgeDelay \times RCF_{SyncMaster} \quad (29)$$

where

$BridgeDelay_{SyncMaster}$	is the compensated time needed to forward a frame
BridgeDelay	is the time needed to forward a frame

$RCF_{SyncMaster}$	is the factor between the frequency of the SyncMaster and the frequency of the SyncSlave

NOTE Formua (29) is only informative if the LineDelay is measured with the syntonized timer.

$$RCF_{SyncMaster} = \Delta t_{SyncMaster} / \Delta t_{SyncSlave} \quad (30)$$

where

$RCF_{SyncMaster}$	is the ratio between the clock of the SyncMaster and the SyncSlave calculated by the SyncSlave
$\Delta t_{SyncMaster}$	is a time interval of at least 200 ms from the SyncMaster point of view
$\Delta t_{SyncSlave}$	is a time interval measured at the SyncSlave for the given $\Delta t_{SyncMaster}$

The principle of synchronization through a sequence of devices can be seen in Figure 30. The node emitting the time frames for synchronization in the network is known as PTCP master. All other nodes that receive and/or pass on these frames are known as PTCP slave. A PTCP master uses a reference to a local time system or a global time source.

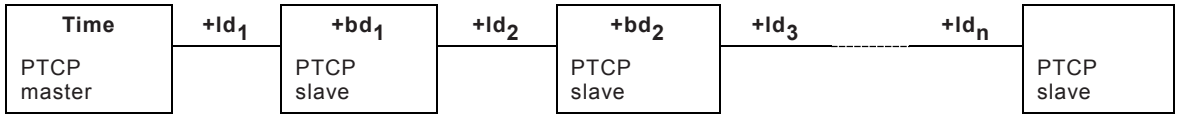


Figure 30 – Delay accumulation

The Sync-Frames are forwarded as peer to peer frames. Every device shall adjust the Sync-Frame by

– adding its bridge delay bd_x (bridge delay measurement is shown in Figure 29)
– adding the line delay ld_x (line delay measurement is shown in Figure 27),

to the delay field of the Sync-Frame as it passes through. Each PTCP slave knows the propagation delay of the sync frame. When the time of arrival T_2 is known, the drift compared to the PTCP master can also be determined.

4.4.4.1.7 Rate compensation

4.4.4.1.7.1 Bridge delay

The bridge delay should be measured with a timer syntonized / rate compensated to the SyncMaster in order to achieve high precision synchronization.

4.4.4.1.7.2 Line delay measurement

The line delay should be measured with a timer syntonized / rate compensated to the SyncMaster in order to achieve high precision synchronization.

4.4.4.1.8 Time deviation measurement

To achieve the measurement of the deviation, see Figure 31, hardware signaling is necessary. For every supported PTCP_SyncID a signal shall be generated. It may only be accessible in test lab environment.

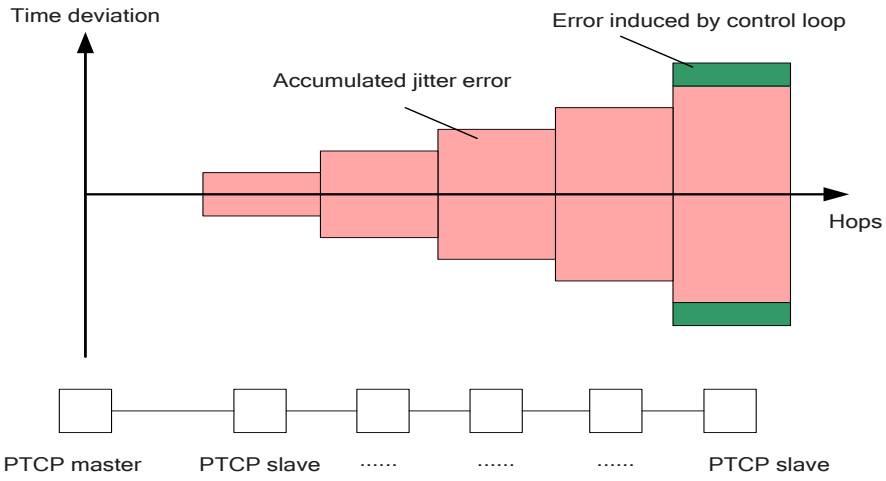


Figure 31 – Worst case accumulated time deviation of synchronization

Figure 32 and Figure 33 show in principle the measurement of the deviation.

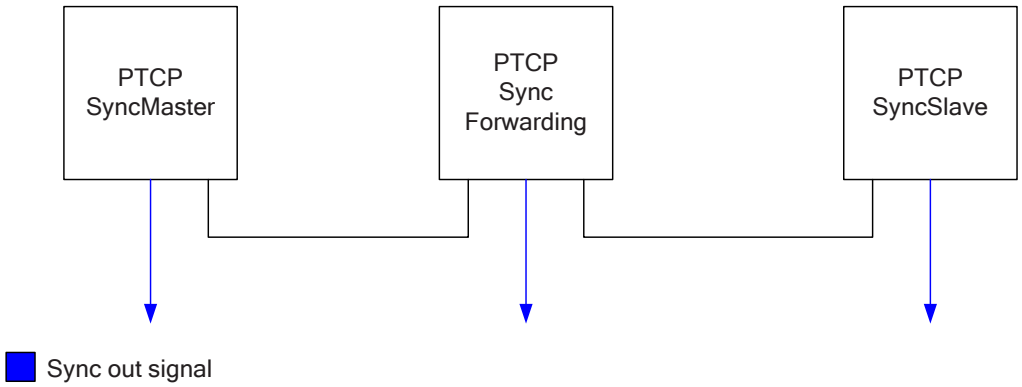


Figure 32 – Scheme for measurement of deviation

Every cycle as shown in Figure 21 shall be signaled for clock synchronization. Every second shall be signaled for time synchronization.

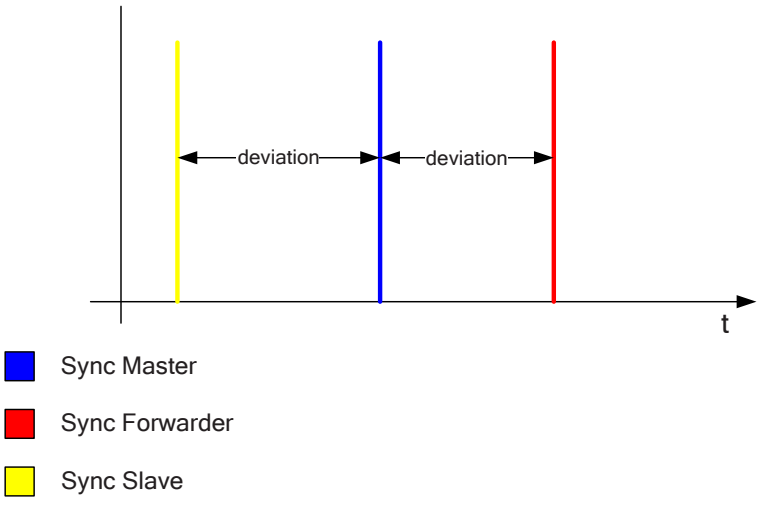


Figure 33 – Measurement of deviation

4.4.4.1.9 Synchronization Protocol

4.4.4.1.9.1 General

PTCP masters are sending Sync-Frames periodically. The sync frame has an original sending time (T_{ORG}).

A PTCP master

- sets the PTCPTime field of the sync frame to T_{ORG}, and
- sets the PTCP_Delay fields of the sync frame to its internal handling time; i.e. the time which passed between T_{ORG} and sending the sync frame.

A PTCP slave adds to the content of the corresponding PTCP_Delay field in the PTCP-Header-Sync the following terms:

- the line delay (T_{LD}) of the port where the sync frame was received, and
- the bridge delay (T_{BD}); i.e. the time to forward the sync frame.

Special case: If the PTCP master or some PTCP slave is not able to directly add the delay times into the sync frame PTCP_Delay fields, it shall generate a so called Follow-Up frame (FU) and add there its bridge delay to the PTCP_Delay field. The line delay is always added to the PTCP_Delay fields of the sync frame.

All times are always related to the measurement time stamp point; see Figure 22 for details.

Each PTCP slave compares its local clock with the sum of PTCPTime, PTCP_Delay out of the sync frame and (if applicable) PTCP_Delay out of the Follow-Up frame. The offset between T_{Slave} and T_{Master} can thus be determined. The PTCP slave follows the time of the PTCP master.

4.4.4.1.9.2 PTCP Master Synchronization with Sync-Frame

PTCP masters are sending Sync-Frames periodically. The synchronization scheme as described in Figure 34 requires transferring the exact sending time of the Sync-Frame as initial value of the delay.

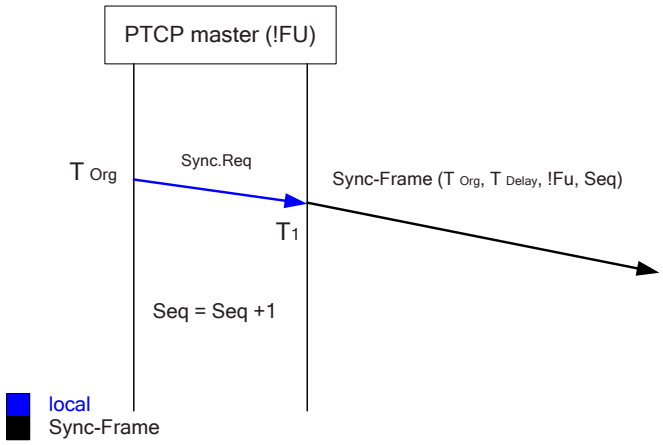


Figure 34 – PTCP master sending Sync-Frame without Follow Up-Frame

$$T_{Delay} = T_1 - T_{Org} \quad (31)$$

where

T_{Delay}	is the internal handling time of the sync frame within the PTCP master; it is the value of the PTCP_Delay field within the sync frame send by the PTCP Master
T_1	is the time stamp of sending the Sync-Frame by the PTCP master
T_{Org}	is the original time of the PTCP master clock

4.4.4.1.9.3 PTCP Master Synchronization with Sync- and FollowUp-Frame

Figure 35 shows a PTCP master which cannot modify a frame before transmission. A PTCP master who is not able to enter the internal handling time into the Sync-Frame directly will use a FollowUp-Frame.

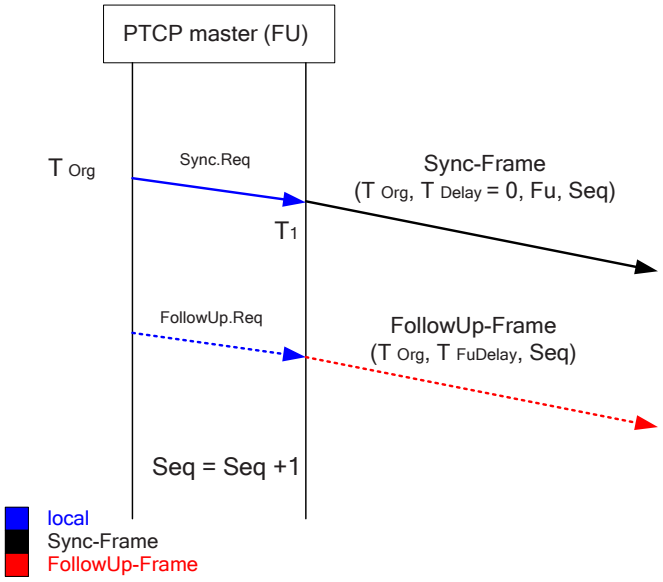


Figure 35 – PTCP master sending Sync-Frame with FollowUp-Frame

The delay field in the Sync-Frame shall be set to 0 by the PTCP master. The delay ($T_{FuDelay}$) in the associated FollowUp-Frame contains the initial value of the sync frame's delay.

$$T_{FuDelay} = T_1 - T_{Org} \quad (32)$$

where

$T_{fuDelay}$	is the internal handling time of the sync frame within the PTCP master; it is the value of the PTCP_Delay field within the **FollowUp** frame send by the PTCP Master.
T_{org}	is the original time of the PTCP master clock
T_1	is the time stamp of sending the Sync-Frame by the PTCP master

4.4.4.1.9.4 PTCP Slave Synchronization (!FU)

A PTCP slave as shown in Figure 36 that can modify a frame before transmission (!FU node) adds its internal bridge delay and the line delay to the delay value in the Sync-Frame as it passes through.

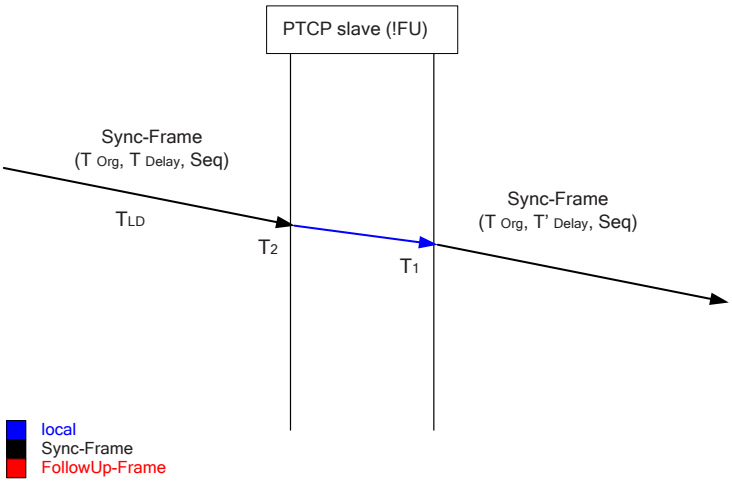


Figure 36 – !FU Sync Slave Forwarding Sync-Frame

$$T'_{Delay} = T_{Delay} + T_{LD} + (T_1 - T_2) \quad (33)$$

where

T'_{Delay}	is the value of the PTCP_Delay field within the sync frame send by the PTCP slave
T_{Delay}	is the delay time as being received by the PTCP slave
T_{LD}	is the line delay time of the receiving port
T_1	is the send time stamp of the Sync-Frame by the PTCP slave
T_2	is the receive time stamp of the Sync-Frame by the PTCP slave

If the sync frame has a FollowUp frame, it is forwarded without any modification by a !FU node.

4.4.4.1.9.5 PTCP Slave Synchronization (FU)

Some implementations of IEEE 802.3 do not allow modifying a frame during transmission.

Such as PTCP slave (FU-Node) still adds the line delay to the delay value in the sync frame, but adds its internal bridge delay to the delay value in the FollowUp-Frame.

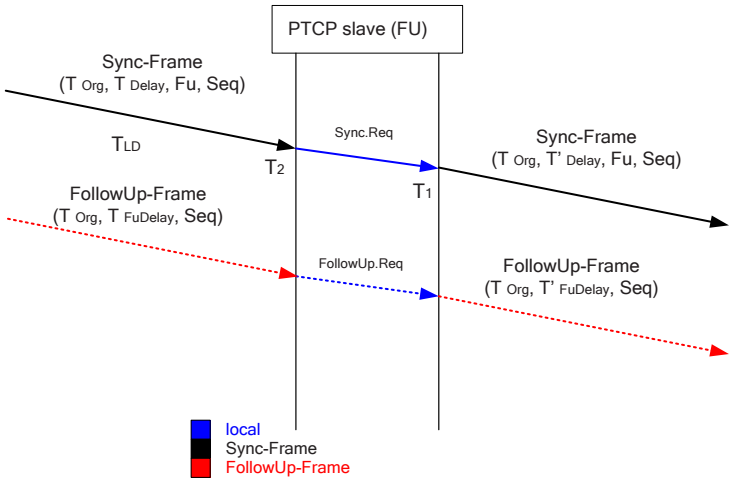


Figure 37 – FU Sync Slave Forwarding Sync- and FollowUp-Frame

$$T'_{Delay} = T_{Delay} + T_{LD} \quad (34)$$

where

T'_{Delay}	is the value of the PTCP_Delay field within the sync frame send by the PTCP slave
T_{Delay}	is the delay time within the sync frame as being received by the PTCP slave
T_{LD}	is the line delay of the receiving port

$$T'_{FuDelay} = T_{FuDelay} + (T_1 - T_2) \quad (35)$$

where

$T'_{FuDelay}$	is the value of the PTCP_Delay field within the FollowUp frame send by the PTCP slave
$T_{FuDelay}$	is the delay time within the FollowUp frame as being received by the PTCP slave
T_{LD}	is the line delay of the receiving port
T_1	is the send time stamp of the Sync-Frame by the PTCP slave
T_2	is the receive time stamp of the Sync-Frame by the PTCP slave

If no FollowUp frame exists it is generated by an FU PTCP slave. This principle is shown in Figure 38.

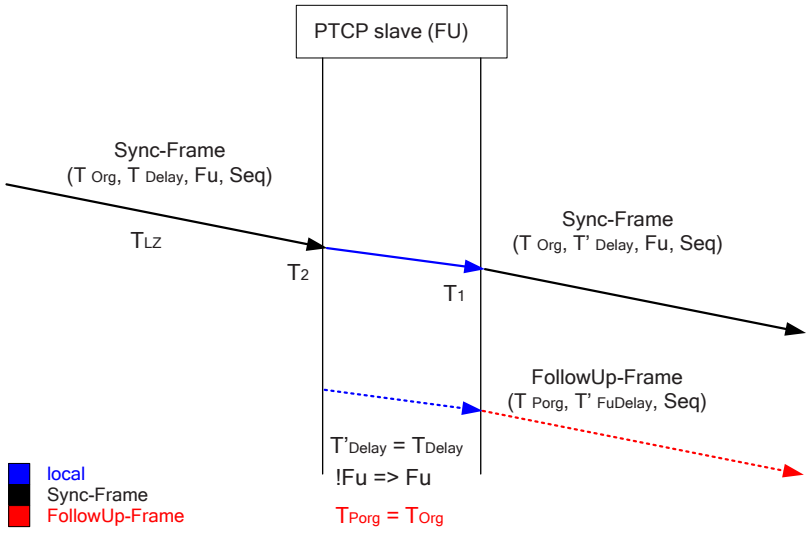


Figure 38 – FU Sync Slave Forwarding Sync- and Generating FollowUp-Frame

$$T'_{Delay} = T_{Delay} + T_{LD} \quad (36)$$

where

T'_{Delay}	is the value of the PTCP_Delay field within the sync frame send by the PTCP slave
T_{Delay}	is the delay time within the sync frame as being received by the PTCP slave
T_{LD}	is the line delay of the receiving port

$$T'_{FuDelay} = (T_1 - T_2) \quad (37)$$

where

$T'_{FuDelay}$	is the value of the PTCP_Delay field within the FollowUp frame send by the PTCP slave
T_{LD}	is the line delay of the receiving port
T_1	is the send time stamp of the Sync-Frame by the PTCP slave
T_2	is the receive time stamp of the Sync-Frame by the PTCP slave

4.4.4.1.10 Error recovery

A link down will delete the line delay. A line delay measurement error will stop the forwarding of all sync messages.

To deal with redundancy switchover in case of redundant paths, a Sync-Frame shall be forward only if the sequence number difference to the previous forwarded message is positive. This prevents duplicates which may corrupt the follow up sequence.

The use of an alternate path is possible as long as there is a valid line delay measurement available.

There are 2 timeouts:

– Delay measurement:
  Allowed time between delay request and delay response
– Monitoring of sync:
  Allowed time between two subsequent sync frames

The timeout of the line delay measurement shall be higher as the timeout of the time master and is calculated independently at every update of the line delay.

For resource limitations the size of the master data base can be limited. Two masters shall be possible at any time. This is possible as the BMA algorithm will cancel the activities of a Sync master.

The line delay values can be restricted for some technologies (e.g. 100 Base TX have delay values below 1 μs). Error shall be reported but the reaction is beyond the scope of this specification.

4.4.4.2 Line delay measurement

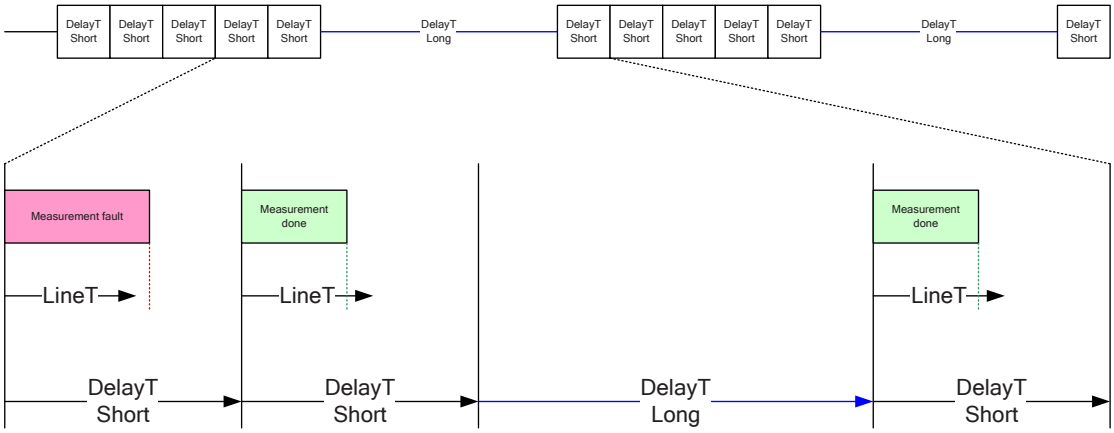
4.4.4.2.1 Line Delay Request Protocol Machine

4.4.4.2.1.1 General

4.4.4.2.1.1.1 General

Figure 39 shows that the line delay is monitored by the LineT und the DelayT timers. Each time the DelayT expires a line delay measurement starts. If the LineT expires before the line delay measurement is done, an error counter is increased.

If the current measurement cycle (5 times) is finished a break for DelayT (long) is made.



Key:
DelayT (Short) is the delay between two measurements
DelayT(Long) is the delay between measurement bursts
LineT is the monitoring time for one measurement

Figure 39 – Principle of the monitoring of the line delay measurement

LineT may be substituted by the checking of the ResDelay value in combination with the DelayT(Short).

4.4.4.2.1.2 Primitive definitions

4.4.4.2.1.2.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Line delay request Protocol Machine (DELAY_REQ) are described in the service definition and shown in Table 126.

Table 126 – Remote primitives issued or received by DELAY_REQ

Primitive	Source	Destination	Associated parameters	Functions
MAUType_Change_ind	IEEE802.3	DELAY_REQ	PortID, MAU_Type, LINK_Status	—
LMPM_P_Data.ind	LMPM	DELAY_REQ	CREP, S_Port, Tstamp, DA, SA, A_SDU	The LMPM indicates a received delay response or delay followup response.
LMPM_P_Data.cnf ()	LMPM	DELAY_REQ	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_P_Data.req	DELAY_REQ	LMPM	CREP, D_Port, Tstamp, DA, SA, A_SDU	The DELAY_REQ issues a delay request.

4.4.4.2.1.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DELAY_REQ are described in the service definition and shown in Table 127.

Table 127 – Local primitives issued or received by DELAY_REQ

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.4.4.2.1.3 State transition diagram

The state transition diagram of the DELAY_REQ is shown in Figure 40.

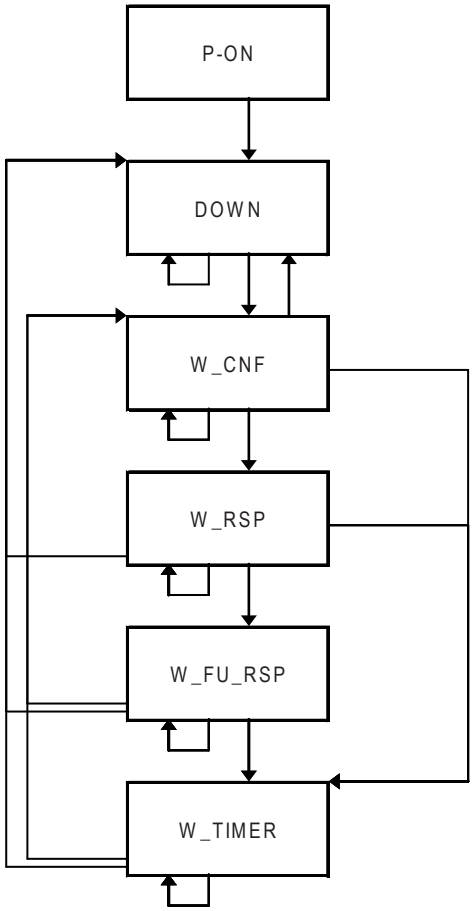


Figure 40 – State transition diagram of DELAY_REQ

States of the DELAY_REQ

P-ON	Initialization of local data.
DOWN	Link of port is down. The line delay measurement shall be initiated after link up by sending a delay request frame.
W_CNF	Wait for confirmation of delay request and store the transmit timestamp of the delay request message.
W_RSP	Wait for delay response frame from the DelayResponder.
W_FU_RSP	Wait for delay response follow up frame and calculate line delay.
W_TIMER	Wait for timeout to repeat the line delay measurement.

4.4.4.2.1.4 State machine description

The line delay measurement shall be initiated by each port and should be repeated in intervals of 8 s. The state machine which sends a delay request frame is called DelayRequestor.

4.4.4.2.1.5 DELAY_REQ state table

Table 128 contains the state table used by DELAY_REQ.

Table 128 – DELAY_REQ state table

#	Current State	Event /Condition =>Action	Next State
1	P-ON	=> Nrepeat := 0 SequenceID := 0 ErrorCounter := 0 RESET_RCF_PEER RESET_LINE_DELAY	DOWN
2	DOWN	MAUType_Change_ind () /!LINK_OK => ignore	DOWN
3	DOWN	MAUType_Change_ind () /LINK_OK => A_PDU := PTCP_DELAY_REQ_PDU StartTimer (DelayT, DELAY_REQ_SHORT_INTERVAL) StartTimer (LineT, TIMEOUT_LINE_DELAY) DelayReq_Req ()	W_CNF
4	W_CNF	DelayReq_Cnf () /Status == !OK => SequenceID++	W_TIMER
5	W_CNF	DelayReq_Cnf () /Status == OK => Tx_Tstamp_T1 := Tstamp	W_RSP
6	W_CNF	MAUType_Change_ind () /!LINK_OK => Nrepeat := 0 ErrorCounter := 0 SequenceID++ StopTimer (DelayT) StopTimer (LineT) RESET_RCF_PEER RESET_LINE_DELAY	DOWN
7	W_CNF	MAUType_Change_ind () /LINK_OK => ignore	W_CNF
8	W_CNF	TimerExpired (DelayT) => A_PDU := PTCP_DELAY_REQ_PDU SequenceID++ StartTimer (DelayT, DELAY_REQ_SHORT_INTERVAL) StartTimer (LineT, TIMEOUT_LINE_DELAY) DelayReq_Req ()	W_CNF
9	W_CNF	TimerExpired (LineT) /MAX_ERROR_COUNT > ErrorCounter => ErrorCounter++	W_TIMER
10	W_CNF	TimerExpired (LineT) /MAX_ERROR_COUNT <= ErrorCounter => ErrorCounter := 0 RESET_LINE_DELAY	W_TIMER

#	Current State	Event /Condition =>Action	Next State
11	W_RSP	DelayResp_Ind () /!CHECK_DELAY_RSP_VALID => ignore	W_RSP
12	W_RSP	DelayResp_Ind () /CHECK_DELAY_RSP_VALID && CHECK_DELAY_RSP_WITH_FU_RSP => Rx_Tstamp2_T2 := Rx_Tstamp1_T2 Rx_Tstamp1_T2 := PTCP_DELAY_RES_PDU.T2TimeStamp Delay := PTCP_DELAY_RES_PDU.Delay Rx_Tstamp_T4 := Tstamp if (Nrepeat > 0) CALC_RCF_PEER	W_FU_RSP
13	W_RSP	DelayResp_Ind () /CHECK_DELAY_RSP_VALID && !CHECK_DELAY_RSP_WITH_FU_RSP && CHECK_DELAY_VALID => Rx_Tstamp2_T2 := Rx_Tstamp1_T2 Rx_Tstamp1_T2 := PTCP_DELAY_RES_PDU.T2TimeStamp Rx_Tstamp_T4 := Tstamp Delay := PTCP_DELAY_RES_PDU.Delay if (Nrepeat > 0) CALC_RCF_PEER CALC_LINE_DELAY Nrepeat++ ErrorCounter := 0	W_TIMER
14	W_RSP	DelayResp_Ind () /CHECK_DELAY_RSP_VALID && !CHECK_DELAY_RSP_WITH_FU_RSP && !CHECK_DELAY_VALID => SET_DUMMY_LINE_DELAY StartTimer (DelayT, DELAY_REQ_SHORT_INTERVAL)	W_TIMER
15	W_RSP	DelayFuResp_Ind () => ignore	W_RSP
16	W_RSP	MAUType_Change_ind () /!LINK_OK => Nrepeat := 0 ErrorCounter := 0 SequenceID++ StopTimer (DelayT) StopTimer (LineT) RESET_RCF_PEER RESET_LINE_DELAY	DOWN
17	W_RSP	MAUType_Change_ind () /LINK_OK => ignore	W_RSP
18	W_RSP	TimerExpired (DelayT) => SequenceID++ Nrepeat := 0 RESET_RCF_PEER StartTimer (DelayT, DELAY_REQ_LONG_INTERVAL)	W_TIMER
19	W_RSP	TimerExpired (LineT) /MAX_ERROR_COUNT > ErrorCounter => ErrorCounter++	W_TIMER

#	Current State	Event /Condition =>Action	Next State
20	W_RSP	TimerExpired (LineT) /MAX_ERROR_COUNT <= ErrorCounter => ErrorCounter := 0 RESET_LINE_DELAY	W_TIMER
21	W_FU_RSP	DelayResp_Ind () /!CHECK_DELAY_RSP_VALID => ignore	W_FU_RSP
22	W_FU_RSP	DelayResp_Ind () /CHECK_DELAY_RSP_VALID => Nrepeat := 0 StopTimer (DelayT) StartTimer (DelayT, DELAY_REQ_LONG_INTERVAL) RESET_LINE_DELAY	W_TIMER
23	W_FU_RSP	DelayFuResp_Ind () /!CHECK_DELAY_FU_RSP_VALID => ignore	W_FU_RSP
24	W_FU_RSP	DelayFuResp_Ind () /CHECK_DELAY_FU_RSP_VALID => Delay := Delay + PTCP_DELAY_FURES_PDU.Delay if (Nrepeat > 0) CALC_LINE_DELAY Nrepeat++ ErrorCounter := 0	W_TIMER
25	W_FU_RSP	MAUType_Change_ind () /!LINK_OK => Nrepeat := 0 ErrorCounter := 0 SequenceID++ StopTimer (DelayT) StopTimer (LineT) RESET_RCF_PEER RESET_LINE_DELAY	DOWN
26	W_FU_RSP	MAUType_Change_ind () /LINK_OK => ignore	W_FU_RSP
27	W_FU_RSP	TimerExpired (DelayT) => A_PDU := PTCP_DELAY_REQ_PDU SequenceID++ StartTimer (DelayT, DELAY_REQ_SHORT_INTERVAL) StartTimer (LineT, TIMEOUT_LINE_DELAY) DelayReq_Req ()	W_CNF
28	W_FU_RSP	TimerExpired (LineT) /MAX_ERROR_COUNT > ErrorCounter => ErrorCounter++	W_TIMER
29	W_FU_RSP	TimerExpired (LineT) /MAX_ERROR_COUNT <= ErrorCounter => ErrorCounter := 0 RESET_LINE_DELAY	W_TIMER

#	Current State	Event /Condition =>Action	Next State
30	W_TIMER	DelayResp_Ind () => ignore	W_TIMER
31	W_TIMER	DelayFuResp_Ind () => ignore	W_TIMER
32	W_TIMER	MAUType_Change_ind () /!LINK_OK => Nrepeat := 0 ErrorCounter := 0 SequenceID++ StopTimer (DelayT) StopTimer (LineT) RESET_RCF_PEER RESET_LINE_DELAY	DOWN
33	W_TIMER	MAUType_Change_ind () /LINK_OK => ignore	W_TIMER
34	W_TIMER	TimerExpired (DelayT) /Nrepeat < MAX_DELAY_REQ_REPEAT => A_PDU := PTCP_DELAY_REQ_PDU SequenceID++ StartTimer (DelayT, DELAY_REQ_SHORT_INTERVAL) StartTimer (LineT, TIMEOUT_LINE_DELAY) DelayReq_Req ()	W_CNF
35	W_TIMER	TimerExpired (DelayT) /Nrepeat >= MAX_DELAY_REQ_REPEAT => Nrepeat := 0 RESET_RCF_PEER StartTimer (DelayT, DELAY_REQ_LONG_INTERVAL)	W_TIMER
36	W_TIMER	TimerExpired (LineT) => ignore	W_TIMER

4.4.4.2.1.6 Parameters

4.4.4.2.1.7 Functions, Macros, Timers and Variables

Table 129 contains the functions, macros, timers and variables used by the DELAY_REQ and their arguments and their descriptions.

Table 129 – Functions, macros, timers and variables used by the DELAY_REQ

Name	Type	Function/Meaning
CALC_LINE_DELAY	Function	Line delay for the arithmetical average value of at least the last 7 delay measurements
CALC_RCF_PEER	Function	Calculation of the frequency deviation to the neighbor
CHECK_DELAY_RSP_VALID	Function	Check whether the delay response is valid according to the coding rules
CHECK_DELAY_RSP_WITH_FU_RSP	Function	Check if delay response type is with or without delay response followup frame. TRUE := Wait for the delay response followup FALSE := Without delay response followup

Name	Type	Function/Meaning
CHECK_DELAY_VALID	Function	Check parameter of PTCP_DELAY_RSP_PDU TRUE := The line delay measurement is supported. FALSE := „Special case“; the connected node doesn’t support line delay measurement but wants to receive the sync messages. This case is signaled by PTCP_DELAY_RSP_PDU.Delay1ns := 0x00
LINK_OK	Function	Check link MAU_Type == FULL_DUPLEX LINK_Status == Up || LINK_Status == UP_CLOSED
RESET_LINE_DELAY	Function	Set line delay to zero
RESET_RCF_PEER	Function	Set RCF_PEER to one
SET_DUMMY_LINE_DELAY	Function	Set line delay to one
StartTimer	Function	This local function is used to start or restart a timer
StopTimer	Function	This local function is used to stop a timer
TimerExpired	Function	This local function is issued if a timer expires
DelayFuResp_Ind (S_Port, Tstamp, PTCP_DELAY_FU_RSP_PDU)	Macro	Receive PTCP-PDU according PTCP_DELAY_FU_RSP_PDU LMPM_P_Data.ind (CREP, D_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_DELAY_FU_RSP_PDU := A_SDU without LT and FrameID
DelayReq_Cnf (D_Port, Tstamp, Status)	Macro	LMPM_P_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status
DelayReq_Req (Port, PTCP_DELAY_REQ_PDU)	Macro	Create PTCP-PDU according PTCP_DELAY_REQ_PDU Assignments: D_Port := Port DA :=PTCP_MulticastMACadd for PTCP_DELAY_REQ_PDU SA := local port address PTCP_DELAY_REQ_PDU.SequenceID := SequenceID PTCP_DELAY_REQ_PDU.PortMACAddress := local port address A_SDU := LT, FrameID, PTCP_DELAY_REQ_PDU LMPM_P_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU)
DelayResp_Ind (S_Port, Tstamp, PTCP_DELAY_RSP_PDU)	Macro	Receive PTCP-PDU according PTCP_DELAY_RSP_PDU LMPM_P_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_DELAY_RSP_PDU := A_SDU without LT and FrameID
DelayT	Timer	This local timer is used control the start of a line delay measurement
LineT	Timer	This local timer is used to monitor the timely correct reception of a DelayResponse indication
DELAY_REQ_LONG_INTERVAL	Variable	This local variable contains the time of the pause of line delay measurement. Default value: 8 s
DELAY_REQ_SHORT_INTERVAL	Variable	This local variable contains the time between two line delay measurement. Default value: 200 ms
ErrorCounter	Variable	This local variable contains the actual error count.

Name	Type	Function/Meaning
MAX_DELAY_REQ_REPEAT	Variable	This local variable contains the number of line delay measurements between a pause. Default value: 5
MAX_ERROR_COUNT	Variable	This local variable contains the number of allowed erroneous line delay measurements before the line delay is reset. Default value: 3
Rx_Tstamp_T4	Variable	This local variable contains the receive timestamp of the delay response frame.
Rx_Tstamp1_T2	Variable	This local variable contains a receive timestamp of the delay request frame by the delay responder.
Rx_Tstamp2_T2	Variable	This local variable contains a receive timestamp of the delay request frame by the delay responder.
SequenceID	Variable	This local variable contains the sequence number of the delay request message. It shall be incremented with every delay measurement.
TIMEOUT_LINE_DELAY	Variable	This local variable contains the timeout for the line delay measurement response. Default value: 100 ms
Tx_Tstamp_T1	Variable	This local variable contains the transmit timestamp of the delay request frame.

4.4.4.2.2 Line Delay Response Protocol Machine

4.4.4.2.2.1 Primitive definitions

4.4.4.2.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Line delay Response Protocol Machine (DELAY_RSP) are described in the service definition and shown in Table 130.

Table 130 – Remote primitives issued or received by DELAY_RSP

Primitive	Source	Destination	Associated parameters	Functions
MAUType_Change_ind	IEEE802.3	DELAY_RSP	PortID, MAU_Type, LINK_Status	—
LMPM_P_Data.ind	LMPM	DELAY_RSP	CREP, S_Port, Tstamp, DA, SA, A_SDU	—
LMPM_P_Data.cnf ()	LMPM	DELAY_RSP	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_P_Data.req	DELAY_RSP	LMPM	CREP, D_Port, Tstamp, DA, SA, A_SDU	—

4.4.4.2.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DELAY_RSP are described in the service definition and shown in Table 131.

Table 131 – Local primitives issued or received by DELAY_RSP

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.4.4.2.2.2 State transition diagram

The state transition diagram of the DELAY_RSP is shown in Figure 41.

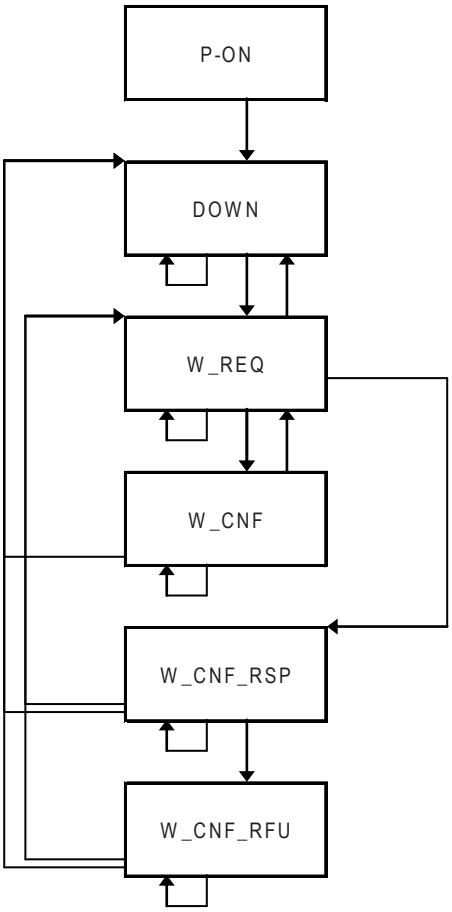


Figure 41 – State transition diagram of DELAY_RSP

States of the DELAY_RSP

P-ON	Data initialization.
DOWN	Link of port is down. Wait for link up.
W_REQ	If a delay request message is received the receive time stamp will be stored and the DelayResonder sends a delay response message.
W_CNF	Wait for the confirmation of the delay response request.
W_CNF_RSP	Wait for the confirmation of the delay response message, calculate the delay response time and send a delay response follow up message.
W_CNF_RFU	Wait for the confirmation of the delay response follow up message.

4.4.4.2.2.3 State machine description

The DelayResponder state machine handles the responder functionality of the line delay measurement. It receives the line delay measurement request and responses with a line delay measurement response.

The DelayResponder shall respond with the DelayResponse without FollowUp if supported. Otherwise it shall use the DelayResponse with FollowUp.

Each delay request message shall be immediately responded with a delay response message.

4.4.4.2.2.4 DELAY_RSP state table

Table 132 contains the state table used by DELAY_RSP.

Table 132 – DELAY_RSP state table

#	Current State	Event /Condition =>Action	Next State
1	P-ON	 =>	DOWN
2	DOWN	MAUType_Change_ind () /! LINK_OK => ignore	DOWN
3	DOWN	MAUType_Change_ind () /LINK_OK => ignore	W_REQ
4	W_REQ	**DelayReq_Ind ()** /FU_RES => store PTCP_DELAY_REQ_PDU A_PDU := PTCP_DELAY_RES_PDU Rx_Tstamp_T2 := Tstamp PTCP_DELAY_RES_PDU.T2TimeStamp := Rx_Tstamp_T2 DelayResp_Req ()	W_CNF_RSP
5	W_REQ	**DelayReq_Ind ()** /!FU_RES => store PTCP_DELAY_REQ_PDU A_PDU := PTCP_DELAY_RES_PDU Rx_Tstamp_T2 := Tstamp PTCP_DELAY_RES_PDU.T2TimeStamp := Rx_Tstamp_T2 DelayResp_Req ()	W_CNF
6	W_REQ	**DelayReq_Ind ()** /!FU_TIMESTAMP => store PTCP_DELAY_REQ_PDU A_PDU := PTCP_DELAY_RES_PDU PTCP_DELAY_RES_PDU.Delay := 0 DelayResp_Req ()	W_CNF
7	W_REQ	MAUType_Change_ind () /! LINK_OK => ignore	DOWN
8	W_REQ	MAUType_Change_ind () /LINK_OK => ignore	W_REQ

#	Current State	Event /Condition =>Action	Next State
9	W_CNF	DelayResp_Cnf () => ignore	W_REQ
10	W_CNF	MAUType_Change_ind () /! LINK_OK => ignore	DOWN
11	W_CNF	MAUType_Change_ind () /LINK_OK => ignore	W_CNF
12	W_CNF_RSP	**DelayResp_Cnf ()** /Status != OK => ignore	W_REQ
13	W_CNF_RSP	**DelayResp_Cnf ()** /Status == OK => Tx_Tstamp_T3 := Tstamp A_PDU := PTCP_DELAY_FU_RES_PDU PTCP_DELAY_FU_RES_PDU.Delay := CALC_RESIDENTIAL_TIME DelayFuResp_Req ()	W_CNF_RFU
14	W_CNF_RSP	MAUType_Change_ind () /! LINK_OK => ignore	DOWN
15	W_CNF_RSP	MAUType_Change_ind () /LINK_OK => ignore	W_CNF_RSP
16	W_CNF_RFU	DelayFuResp_Cnf () => ignore	W_REQ
17	W_CNF_RFU	MAUType_Change_ind () /! LINK_OK => ignore	DOWN
18	W_CNF_RFU	MAUType_Change_ind () /LINK_OK => ignore	W_CNF_RFU

4.4.4.2.2.5 Functions, Macros, Timers and Variables

Table 133 contains the functions, macros, timers and variables used by the DELAY_RSP and their arguments and their descriptions.

Table 133 – Functions, Macros, Timers and Variables used by the DELAY_RSP

Name	Type	Function/Meaning
DelayResp_Req (Port, PTCP_DELAY_RSP_PDU)	Macro	Create PTCP-PDU according PTCP_DELAY_RSP_PDU Assignments: D_Port := Port DA := Multicast-MAC-Address for PTCP_DELAY_RSP_PDU SA := local port address PTCP_DELAY_RSP_PDU.SequenceID := PTCP_DELAY_REQ_PDU.SequenceID PTCP_DELAY_RSP_PDU.PortMACAddress := PTCP_DELAY_REQ_PDU.PortMACAddress PTCP_DELAY_REQ_PDU.T2PortRxDelay := T2_PortRxDelay PTCP_DELAY_REQ_PDU.T3PortTxDelay := T3_PortTxDelay PTCP_DELAY_REQ_PDU.T2TimeStamp := T2_TimeStamp A_SDU := LT, FrameID, PTCP_DELAY_RSP_PDU LMPM_P_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU)
DelayFuResp_Req (Port, ResTime, PTCP_DELAY_FU_RSP_PDU)	Macro	Create PTCP-PDU according PTCP_DELAY_FU_RSP_PDU Assignments: D_Port := Port DA := Multicast-MAC-Address for PTCP_DELAY_FU_RSP_PDU SA := local source address PTCP_Delay := ResTime A_SDU := LT, FrameID, PTCP_DELAY_FU_RSP_PDU LMPM_P_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU)
DelayResp_Cnf (D_Port, Tstamp, Status)	Macro	LMPM_P_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status
DelayFuResp_Cnf (D_Port, Tstamp, Status)	Macro	LMPM_P_Data.cnf (CREP, D_Port, Tstamp, LMPM_Status) Assignments: Status := LMPM_status
DelayReq_Ind (S_Port, Tstamp, PTCP_DELAY_REQ_PDU)	Macro	Receive PTCP-PDU according PTCP_DELAY_REQ_PDU LMPM_P_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_DELAY_REQ_PDU := A_SDU without LT and FrameID
Rx_Tstamp_T2	Variable	This local variable contains the receive time stamp of the delay request message.
Tx_Tstamp_T3	Variable	This local variable contains the transmit time stamp of the delay response message.
LINK_OK	Macro	Check whether the MAU_Type is FULL_DUPLEX and the LINK_Status is UP or BLOCKED.
CALC_RESIDENTIAL_TIME	Macro	Calculate the residential time ResTime := (Tx_Stamp_T3 – Rx_Stamp_T2)

4.4.4.3 Overview for master slave state tables

Figure 42 shows an overview of the interaction between the PTCP state tables. For devices without PTCP support or for PTCP slaves without an active PTCP master, the reference time sink is generated by local means.

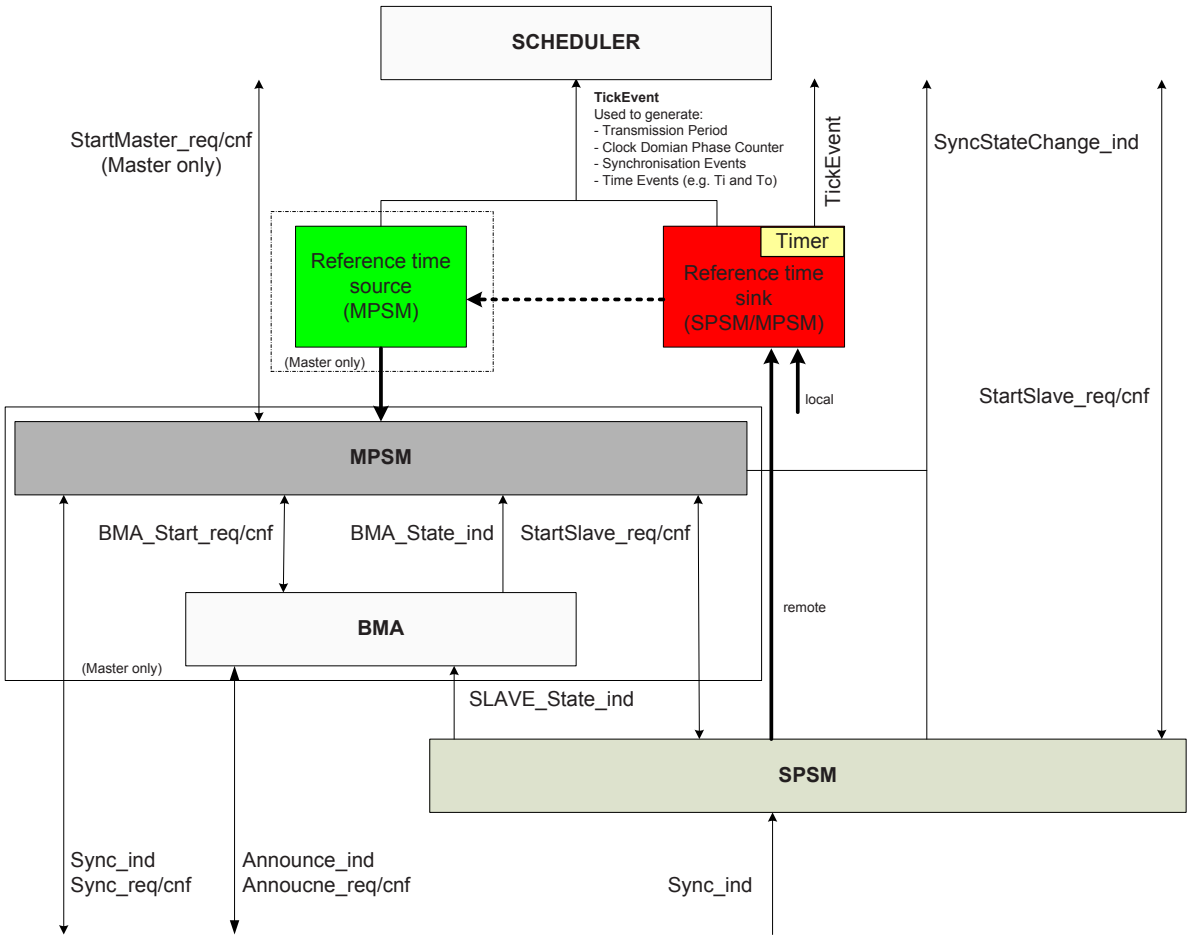


Figure 42 – Overview of PTCP

For the use a PTCP in conjunction with wireless the principles of IEEE 802.1AS should be used.

4.4.4.4 Best-Master-Algorithm

4.4.4.4.1 Best-Master-Algorithm Protocol Machine

4.4.4.4.1.1 Primitive definitions

####### 4.4.4.4.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Best-Master-Algorithm Protocol Machine (SYN_BMA) are described in the service definition and shown in Table 134.

Table 134 – Remote primitives issued or received by SYN_BMA

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.req	BMA	LMPM	CREP, D_Port, Tstamp, DA, SA, A_SDU	—

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.cnf	LMPM	BMA	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_A_Data.ind	LMPM	BMA	CREP, S_Port, Tstamp, DA, SA, A_SDU	—

4.4.4.4.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by SYN_BMA are described in the service definition and shown in Table 135.

Table 135 – Local primitives issued or received by SYN_BMA

Primitive	Source	Destination	Associated parameters	Functions
BMA_Start_req	MPSM	BMA	—	Activate best master function
BMA_Start_cnf (+/-)	BMA	MPSM	—	Confirmation for best master function start
BMA_Stop_req	MPSM	BMA	—	Deactivates best master function
BMA_Stop_cnf (+/-)	BMA	MPSM	—	Confirmation for stop best master function
BMA_State_ind	BMA	MPSM	Role	During the startup period the BMA elects the best sync master. Allowed value for Role: - MASTER - SLAVE
SLAVE_State_ind	SPSM	BMA	State	Indication for master lost. The event is generated by the SLAVE. - MASTER_LOST
Announce_req	BMA	LMPM	PTCP_ANNOUNCE_PDU	Create PTCP-PDU according PTCP_ANNOUNCE_PDU Assignments: D_Port := AUTO DA :=PTCP_MulticastMACadd for PTCP_ANNOUNCE_PDU SA := local source address PTCP_ANNOUNCE_PDU.SequenceID := SequenceID PTCP_ANNOUNCE_PDU.DomainUUID := DomainUUID PTCP_ANNOUNCE_PDU.MasterSourceAddress := local master address PTCP_ANNOUNCE_PDU.MasterPriority1 := Priority PTCP_ANNOUNCE_PDU.ClockClass := Class PTCP_ANNOUNCE_PDU.ClockAccuracy := Accuracy PTCP_ANNOUNCE_PDU.ClockVariance := Variance PTCP_ANNOUNCE_PDU.MasterPriority2 := 0xFF A_SDU := LT, FrameID, PTCP_ANNOUNCE_PDU LMPM_A_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU)

Primitive	Source	Destination	Associated parameters	Functions
Announce_cnf (+/-)	LMPM	BMA	State	LMPM_A_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status
Annouce_ind	LMPM	BMA	PTCP_ANNOUNCE_PDU	Receive PTCP-PDU according PTCP_SYNC_PDU LMPM_A_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_SYNC_PDU := A_SDU without LT and FrameID

4.4.4.4.1.2 State transition diagram

The state transition diagram of the SYN_BMA is shown in Figure 43:

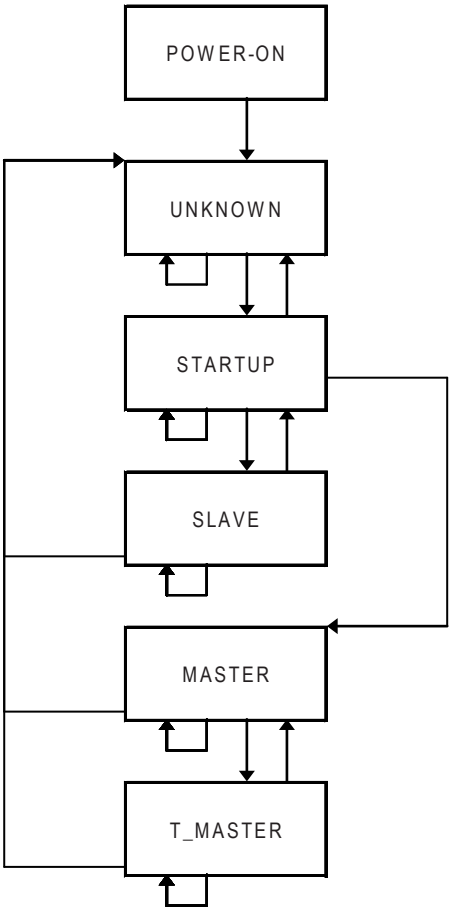


Figure 43 – State transition diagram of SYN_BMA

States of the SYN_BMA

POWER-ON	Data initialization
UNKNOWN	The synchronization role is unknown. A role shall be set via PTCP services.
STARTUP	The role set via PTCP services. The potential master starts

	sending announce messages.
SLAVE	The potential master in state SLAVE shall be synchronized by using the synchronization messages from the active master in the sync domain.
MASTER	At this state the device is, due to its synchronization attributes, elected as the best master.
T_MASTER	This is a transition state which indicates the receiving of announce messages from another potential master in the sync domain.

4.4.4.4.1.3 State machine description

The BMA-state-machine shall elect the best master from all announced master-capable devices during the start up period. These decisions are made local by every master. An instance of the state machine exists for every PTCP SyncID.

Due to the fact, that not every device is able to be master or should be master, the behavior of the state machine depends on his role. The role is set by PTCP services. Roles are master, secondary master and slave. A master also needs slave functionality.

Whether a device with the role master becomes master or secondary master will be decided during the start up period by the best master algorithm. Every potential master shall send announce messages to take part in master and secondary master election.

The master election will be made in two steps. With the first received announce the potentially master will be stored in a master list. With the next announce the SYN_BMA elects this master, if it’s the best known master.

During master competition all potentially masters will be collected in master list. After election they drop out via altering.

If the decision to be master is dropped, the best master starts sending sync messages. The remaining potential masters stop to send announce messages and have to be slaves. If the active master fails, the backup masters restart sending sync and announce messages.

4.4.4.4.1.4 SYN_BMA state table

Table 136 contains the state table used by SYN_BMA.

Table 136 – SYN_BMA state table

#	Current State	Event /Condition =>Action	Next State
1	POWER-ON	=> init MasterList SequenceID := 0 BestMaster := FALSE ACTIVE_MASTER_FLAG := FALSE AGING_MASTER_LIST StartTimer (MasterListAgingTimer, MasterAgingTime)	UNKNOWN

#	Current State	Event /Condition =>Action	Next State
2	UNKNOWN	**BMA_Start_req ()** => Status := OK A_PDU := PTCP_ANNOUNCE_PDU StartTimer (AnnTimer, MasterAnnounceTime) StartTimer (StartupTimer, MasterStartupTime) BMA_Start_cnf (+) for i := all op. D_Ports do if (TRANSMIT_PORT_VALID) Announce_req (i, PTCP_ANNOUNCE_PDU)	STARTUP
3	UNKNOWN	**BMA_Stop_req ()** => StopTimer (AnnTimer) Status := OK BMA_Stop_cnf (+)	UNKNOWN
4	UNKNOWN	**TimerExpired (MasterListAgingTimer)** => AGING_MASTER_LIST StartTimer (MasterListAgingTimer, MasterAgingTime)	UNKNOWN
5	STARTUP	**BMA_Start_req ()** => Status := WRONG_SEQUENCE BMA_Start_cnf (-)	STARTUP
6	STARTUP	**BMA_Stop_req ()** => StopTimer (AnnTimer) StopTimer (StartupTimer) Status := OK BMA_Stop_cnf (+)	UNKNOWN
7	STARTUP	Announce_cnf () => ignore	STARTUP
8	STARTUP	SLAVE_State_ind (State) => ignore	STARTUP
9	STARTUP	**Announce_ind ()** /!VALID_SYNC_MASTER => ignore	STARTUP
10	STARTUP	**Announce_ind ()** /VALID_SYNC_MASTER && !CHECK_IN_MASTER_LIST => ADD_TO_MASTER_LIST	STARTUP
11	STARTUP	**Announce_ind ()** /VALID_SYNC_MASTER && CHECK_IN_MASTER_LIST => UPDATE_MASTER_ENTRY	STARTUP
12	STARTUP	**TimerExpired (AnnTimer)** /!LOCAL_IS_BEST_MASTER => BestMaster := FALSE StopTimer (StartupTimer) StartTimer (AnnTimer, MasterAnnounceTime) BMA_State_ind (SLAVE)	SLAVE

#	Current State	Event /Condition =>Action	Next State
13	STARTUP	**TimerExpired (AnnTimer)** /LOCAL_IS_BEST_MASTER => BestMaster := TRUE SequenceID++ A_PDU := PTCP_ANNOUNCE_PDU StartTimer (AnnTimer, MasterAnnounceTime) BMA_State_ind (MASTER) for i := all op. D_Ports do if (TRANSMIT_PORT_VALID) Announce_req (i, PTCP_ANNOUNCE_PDU)	STARTUP
14	STARTUP	**TimerExpired (StartupTimer)** => ACTIVE_MASTER_FLAG := TRUE	MASTER
15	STARTUP	**TimerExpired (MasterListAgingTimer)** => AGING_MASTER_LIST StartTimer (MasterListAgingTimer, MasterAgingTime)	STARTUP
16	SLAVE	**BMA_Start_req ()** => Status := WRONG_SEQUENCE BMA_Start_cnf (-)	SLAVE
17	SLAVE	**BMA_Stop_req ()** => StopTimer (AnnTimer) Status := OK BMA_Stop_cnf (+)	UNKNOWN
18	SLAVE	Announce_cnf ( ) => ignore	SLAVE
19	SLAVE	**SLAVE_State_ind (State)** /State != MASTER_LOST => ignore	SLAVE
20	SLAVE	**SLAVE_State_ind (State)** /State == MASTER_LOST && !BestMaster => ignore	SLAVE
21	SLAVE	**SLAVE_State_ind (State)** /State == MASTER_LOST && BestMaster => SequenceID++ A_PDU:= PTCP_ANNOUNCE_PDU StartTimer (StartupTimer, MasterStartupTime) BMA_State_ind (MASTER) for i := all op. D_Ports do if (TRANSMIT_PORT_VALID) Announce_req (i, PTCP_ANNOUNCE_PDU)	STARTUP
22	SLAVE	**Announce_ind ()** /!VALID_SYNC_MASTER => ignore	SLAVE
23	SLAVE	**Announce_ind ()** /VALID_SYNC_MASTER && !CHECK_IN_MASTER_LIST => ADD_TO_MASTER_LIST	SLAVE

#	Current State	Event /Condition =>Action	Next State
24	SLAVE	**Announce_ind ()** /VALID_SYNC_MASTER && CHECK_IN_MASTER_LIST => UPDATE_MASTER_ENTRY	SLAVE
25	SLAVE	**TimerExpired (AnnTimer)** /!LOCAL_IS_BEST_MASTER => BestMaster := FALSE StartTimer (AnnTimer, MasterAnnounceTime)	SLAVE
26	SLAVE	**TimerExpired (AnnTimer)** /LOCAL_IS_BEST_MASTER => BestMaster := TRUE StartTimer (AnnTimer, MasterAnnounceTime)	SLAVE
27	SLAVE	**TimerExpired (MasterListAgingTimer)** => AGING_MASTER_LIST StartTimer (MasterListAgingTimer, MasterAgingTime)	SLAVE
28	MASTER	**BMA_Start_req ()** => Status := WRONG_SEQUENCE BMA_Start_cnf (-)	MASTER
29	MASTER	**BMA_Stop_req ()** => StopTimer (AnnTimer) Status := OK BMA_Stop_cnf (+)	UNKNOWN
30	MASTER	Announce_cnf ( ) => ignore	MASTER
31	MASTER	SLAVE_State_ind (State) => ignore	MASTER
32	MASTER	**Announce_ind ()** /!VALID_SYNC_MASTER => ignore	MASTER
33	MASTER	**Announce_ind ()** /VALID_SYNC_MASTER && !CHECK_IN_MASTER_LIST => ADD_TO_MASTER_LIST	MASTER
34	MASTER	**Announce_ind ()** /VALID_SYNC_MASTER && CHECK_IN_MASTER_LIST => UPDATE_MASTER_ENTRY	MASTER

35	MASTER	**TimerExpired (AnnTimer)**
		/!MASTER_LIST_EMPTY
		=>
		SequenceID++
		A_PDU := PTCP_ANNOUNCE_PDU
		StartTimer (AnnTimer, MasterAnnounceTime)
		StartTimer (StartupTimer, MasterStartupTime)
		for i := all op. D_Ports
		do
		  if (TRANSMIT_PORT_VALID)
		  Announce_req (i, PTCP_ANNOUNCE_PDU)
			T_MASTER

36	MASTER	**TimerExpired (AnnTimer)** /MASTER_LIST_EMPTY => StartTimer (AnnTimer, MasterAnnounceTime)	MASTER

#	Current State	Event /Condition =>Action	Next State
37	MASTER	**TimerExpired (MasterListAgingTimer)** => AGING_MASTER_LIST StartTimer (MasterListAgingTimer, MasterAgingTime)	MASTER
38	T_MASTER	**BMA_Start_req ()** => Status := WRONG_SEQUENCE BMA_Start_cnf (-)	T_MASTER
39	T_MASTER	**BMA_Stop_req ()** => StopTimer (AnnTimer) Status := OK BMA_Stop_cnf (+)	UNKNOWN
40	T_MASTER	Announce_cnf () => ignore	T_MASTER
41	T_MASTER	SLAVE_State_ind (State) => ignore	T_MASTER
42	T_MASTER	**Announce_ind ()** /!VALID_SYNC_MASTER => ignore	T_MASTER
43	T_MASTER	**Announce_ind ()** /VALID_SYNC_MASTER && !CHECK_IN_MASTER_LIST => ADD_TO_MASTER_LIST StartTimer (StartupTimer, MasterStartupTime)	T_MASTER
44	T_MASTER	**Announce_ind ()** /VALID_SYNC_MASTER && CHECK_IN_MASTER_LIST => UPDATE_MASTER_ENTRY StartTimer (StartupTimer, MasterStartupTime)	T_MASTER

45	T_MASTER	**TimerExpired (AnnTimer)**
		/!MASTER_LIST_EMPTY
		=>
		SequenceID++
		A_PDU := PTCP_ANNOUNCE_PDU
		StartTimer (AnnTimer, MasterAnnounceTime)
		StartTimer (StartupTimer, MasterStartupTime)
		for i := all op. D_Ports
		do
		  if (TRANSMIT_PORT_VALID)
		  Announce_req (i, PTCP_ANNOUNCE_PDU)
			T_MASTER

46	T_MASTER	**TimerExpired (AnnTimer)**
		/MASTER_LIST_EMPTY
		=>
		SequenceID++
		A_PDU := PTCP_ANNOUNCE_PDU
		StartTimer (AnnTimer, MasterAnnounceTime)
		for i := all op. D_Ports
		do
		  if (TRANSMIT_PORT_VALID)
		  Announce_req (i, PTCP_ANNOUNCE_PDU)
			T_MASTER

47	T_MASTER	TimerExpired (StartupTimer) => ignore	MASTER
48	T_MASTER	**TimerExpired (MasterListAgingTimer)** => AGING_MASTER_LIST StartTimer (MasterListAgingTimer, MasterAgingTime)	T_MASTER

4.4.4.4.1.5 Functions, Macros, Timers and Variables

Table 137 contains the functions, macros, timers and variables used by the SYN_BMA and their arguments and their descriptions.

Table 137 – Functions, Macros, Timers and Variables used by the SYN_BMA

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or restarts a timer
StopTimer	Function	This local function stops a timer
TimerExpired	Function	This local function is issued if a timer expires
ADD_TO_MASTER_LIST	Macro	Insert sync master in remote sync master list sm_sa := PTCP_ANNOUNCE_PDU.MasterSourceAddress if (MasterList.Num_entry < MAX_CNT_REMOTE_MASTER) MasterList.Insert(sm_sa) MasterList.Entry{sm_sa}.Priority1 := PTCP_ANNOUNCE_PDU.Priority1 MasterList.Entry{sm_sa}.Accuracy := PTCP_ANNOUNCE_PDU.Accuracy MasterList.Entry{sm_sa}.Variance := PTCP_ANNOUNCE_PDU.Variance MasterList.Entry{sm_sa}.Priority2 := PTCP_ANNOUNCE_PDU.Priority2 MasterList.Entry{sm_sa}.SA := sm_sa MasterList.Entry{sm_sa}.Receipt := 1 MasterList.Num_entry++
AGING_MASTER_LIST	Macro	Aging of entries in remote sync master list for m := 0 to MasterList.Num_entry if (MasterList.Entry[m].Receipt == 0) MasterList.Num_entry-- MasterList.Remove(sm_sa)
Announce_cnf (+/-) (State)	Macro	LMPM_A_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status
Announce_ind (PTCP_ANNOUNCE_PDU)	Macro	Receive PTCP-PDU according PTCP_ANNOUNCE_PDU LMPM_A_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_ANNOUNCE_PDU := A_SDU without LT and FrameID
Announce_req (Port, PTCP_ANNOUNCE_PDU)	Macro	Create PTCP-PDU according PTCP_ANNOUNCE_PDU Assignments: D_Port := Port DA :=PTCP_MulticastMACadd for PTCP_ANNOUNCE_PDU SA := local source address PTCP_ANNOUNCE_PDU.SequenceID := SequenceID PTCP_ANNOUNCE_PDU.DomainUUID := DomainUUID PTCP_ANNOUNCE_PDU.MasterSourceAddress := local master address PTCP_ANNOUNCE_PDU.MasterPriority1 := Priority PTCP_ANNOUNCE_PDU.ClockClass := Class PTCP_ANNOUNCE_PDU.ClockAccuracy := Accuracy PTCP_ANNOUNCE_PDU.ClockVariance := Variance PTCP_ANNOUNCE_PDU.MasterPriority2 := 0xFF A_SDU := LT, FrameID, PTCP_ANNOUNCE_PDU LMPM_A_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU)
CHECK_IN_MASTER_LIST	Macro	Master in PTCP_SubDomainUUID master list sm_sa := PTCP_ANNOUNCE_PDU.MasterSourceAddress sm_sa in MasterList
init MasterList	Macro	initialize data set for remote master MasterList.Num_entry := 0
LOCAL_IS_BEST_MASTER	Macro	Executes comparison according 4.4.4.4.1.6 and return TRUE if the local master is found, else FALSE.

Name	Type	Function/Meaning
TRANSMIT_PORT_VALID	Macro	Table 152 shall be applied.
UPDATE_MASTER_ENTRY	Macro	Update entry in remote sync master list MasterList.Entry{sm_sa}.Priority1 := PTCP_ANNOUNCE_PDU.Priority1 MasterList.Entry{sm_sa}.Accuracy := PTCP_ANNOUNCE_PDU.Accuracy MasterList.Entry{sm_sa}.Variance := PTCP_ANNOUNCE_PDU.Variance MasterList.Entry{sm_sa}.Priority2 := PTCP_ANNOUNCE_PDU.Priority2 MasterList.Entry{sm_sa}.Receipt += 1
VALID_SYNC_MASTER	Macro	Domain is supported PTCP_ANNOUNCE_PDU.DomainUUID == DomainUUID
AnnTimer	Timer	This local timer is used to create the interval for the sending of announce frames
MasterListAgingTimer	Timer	This local timer is used to create the interval for the aging of the entries of the master list.
StartupTimer	Timer	This local timer is used to create the interval for the checking of announce frames.
MasterAgingTime	Variable	Time for the aging of the master list Default value: „2 x PTCP Takeover Timeout“
MasterAnnounceTime	Variable	An announce frame shall be sent every MasterAnnounceTime until MasterStartupTime. Default value: 100 ms
MasterStartupTime	Variable	Time for the receiving check of announce frames. Default value: 10 s

4.4.4.4.1.6 Finding the Best Sync Master

PTCP contains the support of multiple sync masters. The filtering of the stored sync masters to found the “to be used” sync master is done by the BMA using the keys attributes SyncID and PTCP_SubdomainUUID and the following checking rules:

NOTE 1 The PTCP_ClockClass is not used.

NOTE 2 Lower values take precedence.

1) Checking whether a PTCP_MasterPriority1.Active == TRUE sync master exists

The BMA checks whether an ACTIVE sync master exists. If another sync master is active the checking master changes to the sync slave mode.

If no ACTIVE sync master exists it continuous with the next check.

NOTE 3 If the local sync master is active, it stays active until the application decides otherwise.

2) Find the sync master with the best PTCP_MasterPriority1.Level

The BMA searches for the sync masters with the best value, taking its own value into account.

If more than one sync master exists in residual list then continue with the next check else use the found one.

3) Find the sync master with the best PTCP_MasterPriority1.Priority

The BMA searches for the sync masters with the best value of the residual list.

If more than one sync master exists in residual list then continue with the next check else use the found one.

4) Find the sync master with the best PTCP_MasterPriority2

The BMA searches for the sync masters with the best value of the residual list.

If more than one sync master exists in residual list then continue with the next check else use the found one.

5) Find the sync master with the best PTCP_ClockVariance

The BMA searches for the sync masters with the best value of the residual list.

If more than one sync master exists in residual list then continue with the next check else use the found one.

6) Find the sync master with the best PTCP_ClockAccuracy

The BMA searches for the sync masters with the best value of the residual list.

If more than one sync master exists in residual list then continue with the next check else use the found one.

7) Find the sync master with the best PTCP_MasterSourceAddress

The BMA searches for the sync masters with the lowest value (comparing octet zero to five) of the PTCP_MasterSourceAddress of the residual list.

Use the found one.

NOTE 4 The PTCP_MasterSourceAddress is used as “tie breaker”.

4.4.4.5 PTCP Master Protocol Machine

4.4.4.5.1 Primitive definitions

4.4.4.5.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by PTCP Master Protocol Machine (SYN_MPSM) are described in the service definition and shown in Table 138.

Table 138 – Remote primitives issued or received by SYN_MPSM

Primitive	Source	Destination	Associated parameters	Functions
LMPM_P_Data.req	MPSM	LMPM	CREP, D_Port, Tstamp, DA, SA, A_SDU	—
LMPM_P_Data.cnf	LMPM	MPSM	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_P_Data.ind	LMPM	MPSM	CREP, S_Port, Tstamp, DA, SA, A_SDU	—

4.4.4.5.1.1.1 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by SYN_MPSM are described in the service definition and shown in Table 139.

Table 139 – Local primitives issued or received by SYN_MPSM

Primitive	Source	Destination	Associated parameters	Functions
StartMaster_req	PTCP ASE	MPSM	—	Activate master function
StartMaster_cnf	MPSM	PTCP ASE	Status	Confirmation for master start
StopMaster_req	PTCP ASE	MPSM	—	Deactivates master function
StopMaster_cnf	MPSM	PTCP ASE	Status	Confirmation for master stop
StartSlave_req	MPSM	SPSM	—	Activate slave function
StartSlave_cnf	SPSM	MPSM	—	Confirmation for start slave
StopSlave_req	MPSM	SPSM	—	Deactivates slave function
StopSlave_cnf	SPSM	MPSM	—	Confirmation for stop slave
BMA_Start_req	MPSM	BMA	—	Activate best master function
BMA_Start_cnf	BMA	MPSM	—	Confirmation for best master function start
BMA_Stop_req	MPSM	BMA	—	Deactivates best master function
BMA_Stop_cnf	BMA	MPSM	—	Confirmation for stop best master function
BMA_State_ind	BMA	MPSM	Role	During the startup period the BMA elects the best sync master. Allowed value for Role: - MASTER - SLAVE
SyncStateChange_ind	MSPM	FSPM	Status	Indication for events - SINGLE_MASTER - MULTIPLE_MASTER

4.4.4.5.2 State transition diagram

The state transition diagram of the SYN_MPSM is shown in Figure 44:

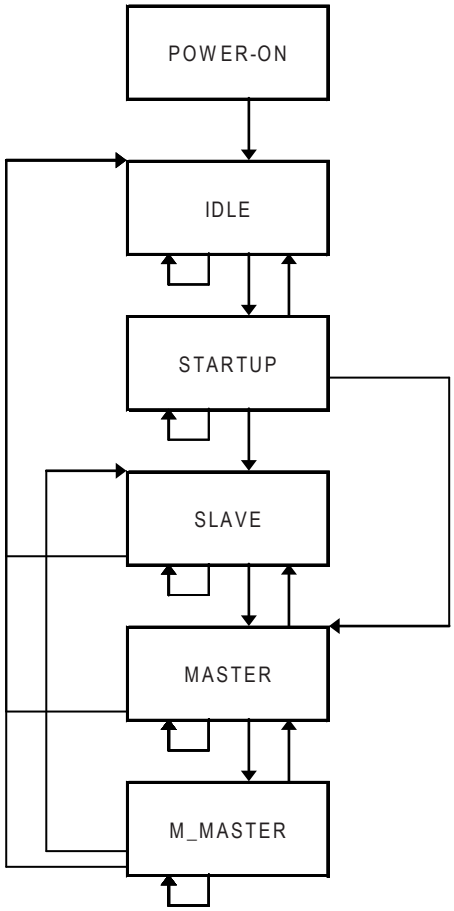


Figure 44 – State transition diagram of SYN_MPSM

States of the SYN_MPSM

POWER-ON	After start up the data management shall be initialized (POWER-ON) and the synchronization role shall be set (IDLE).
IDLE	The master role is set by PTCP services. After this the MPSM goes from state IDLE to state STARTUP and starts the BMA state machine.
STARTUP	During the start up period the MPSM is in state STARTUP.
SLAVE	The master is synchronized by sync messages from another master in the sync domain.
MASTER	This is the active primary master. Therefore it sends synchronization messages.
M_MASTER	This state handles the multiple master issues.

4.4.4.5.3 State machine description

The master protocol state machine controls the transition between the roles master and slave. The transitions are made local by every master for every supported PTCP SyncID and the engineering assigned PTCP SubDomainUUID. Therefore an instance of the state machine exists for every SyncID with the key attribute SubDomainUUID. To achieve these transitions the MPSM shall initiate synchronization and announce messages. Announce messages shall be sent by the SYN_BMA to advertise master capabilities and grant that only one master is active.

Multiple active primary masters shall be prevented by the state STARTUP and the best master algorithm. Therefore the decision to go from state STARTUP to state MASTER

(primary sync master) will be made by the SYN_BMA with extensive knowledge of concurrent masters.

If an active master (with fewer capabilities) already exists and after the start up period a new master comes along, the new master needs to synchronize to the active master. For synchronization the MPSM goes to state SLAVE.

4.4.4.5.4 SYN_MPSM state table

Table 140 contains the state table used by SYN_MPSM.

Table 140 – SYN_MPSM state table

#	Current State	Event /Condition =>Action	Next State
1	POWER-ON	=> SequenceID := 0 MultipleMaster := FALSE	IDLE
2	IDLE	**StartMaster_req ()** => Status := OK BMA_Start_req () StartMaster_cnf (Status)	STARTUP
3	IDLE	**StopMaster_req ()** => Status := OK StopMaster_cnf (Status)	IDLE
4	IDLE	Sync_cnf () => ignore	IDLE
5	IDLE	BMA_Stop_cnf () => ignore	IDLE
6	STARTUP	**StartMaster_req ()** => Status := WRONG_SEQUENCE StartMaster_cnf (Status)	STARTUP
7	STARTUP	**StopMaster_req ()** => Status := OK StopMaster_cnf (Status) BMA_Stop_req ()	IDLE
8	STARTUP	Sync_cnf () => ignore	STARTUP
9	STARTUP	**BMA_State_ind (State)** /State == SLAVE => Status := OK StartSlave_req ()	SLAVE
10	STARTUP	**BMA_State_ind (State)** /State == MASTER => State := SINGLE_MASTER SequenceID++ StartTimer (SyncTimer, SyncInterval) StartTimer (TimeoutT, SyncTimeOut) for i := all op. D_Ports do if (TRANSMIT_PORT_VALID) Sync_req (i, PTCP_SYNC_PDU)	MASTER

#	Current State	Event /Condition =>Action	Next State
11	SLAVE	**StartMaster_req ()** => Status := WRONG_SEQUENCE StartMaster_cnf (Status) BMA_Start_req ()	SLAVE
12	SLAVE	**StopMaster_req ()** => Status := OK BMA_Stop_req () StopMaster_cnf (Status)	IDLE
13	SLAVE	Sync_cnf () => ignore	SLAVE
14	SLAVE	**BMA_State_ind (State)** /State == SLAVE => ignore	SLAVE

15	SLAVE	**BMA_State_ind (State)**
		/State == MASTER
		=>
		State := SINGLE_MASTER
		SequenceID++
		
		StartTimer (SyncTimer, SyncInterval)
		StartTimer (TimeoutT, SyncTimeOut)
		StopSlave_req ()
		
		for i := all op. D_Ports
		do
		  if (TRANSMIT_PORT_VALID)
		  Sync_req (i, PTCP_SYNC_PDU)
			MASTER

16	MASTER	**StartMaster_req ()** => Status := WRONG_SEQUENCE StartMaster_cnf (Status)	MASTER
17	MASTER	**StopMaster_req ()** => Status := OK StopTimer (SyncTimer) StopTimer (TimeoutT) BMA_Stop_req () StopMaster_cnf (Status)	IDLE
18	MASTER	**BMA_State_ind (State)** /State == SLAVE => StopTimer (SyncTimer) StopTimer (TimeoutT) StartSlave_req ()	SLAVE
19	MASTER	**BMA_State_ind (State)** /State == MASTER => ignore	MASTER
20	MASTER	**Sync_ind ()** /!RECEIVE_PORT_VALID => ignore	MASTER
21	MASTER	**Sync_ind ()** /RECEIVE_PORT_VALID && !NEW_SYNC_FRAME => ignore	MASTER

#	Current State	Event /Condition =>Action	Next State
22	MASTER	**Sync_ind ()** /RECEIVE_PORT_VALID && NEW_SYNC_FRAME => MultipleMaster := TRUE	MASTER
23	MASTER	Sync_cnf () => ignore	MASTER

24	MASTER	**TimerExpired (SyncTimer)**
		=>
		SequenceID++
		
		StartTimer (SyncTimer, SyncInterval)
		for i := all op. D_Ports
		do
		  if (TRANSMIT_PORT_VALID)
		  Sync_req (i, PTCP_SYNC_PDU)
			MASTER

25	MASTER	**TimerExpired (TimeoutT)** /!MultipleMaster => StartTimer (TimeoutT, SyncTimeOut)	MASTER
26	MASTER	**TimerExpired (TimeoutT)** /MultipleMaster => MultipleMaster := FALSE StartTimer (TimeoutT, SyncTimeOut) SyncStateChange_ind (MULTIPLE_MASTER)	M_MASTER
27	M_MASTER	**StartMaster_req ()** => Status := WRONG_SEQUENCE StartMaster_cnf (Status)	M_MASTER
28	M_MASTER	**StopMaster_req ()** => Status := OK StopTimer (SyncTimer) StopTimer (TimeoutT) BMA_Stop_req () StopMaster_cnf (Status)	IDLE
29	M_MASTER	**BMA_State_ind (State)** /State == SLAVE => StopTimer (SyncTimer) StopTimer (TimeoutT) StartSlave_req ()	SLAVE
30	M_MASTER	**BMA_State_ind (State)** /State == MASTER => ignore	M_MASTER
31	M_MASTER	**Sync_ind ()** /!RECEIVE_PORT_VALID => ignore	M_MASTER
32	M_MASTER	**Sync_ind ()** /RECEIVE_PORT_VALID && !NEW_SYNC_FRAME => ignore	M_MASTER
33	M_MASTER	**Sync_ind ()** /RECEIVE_PORT_VALID && NEW_SYNC_FRAME => MultipleMaster := TRUE	M_MASTER

#	Current State	Event /Condition =>Action	Next State
34	M_MASTER	Sync_cnf () => ignore	M_MASTER
35	M_MASTER	**TimerExpired (SyncTimer)** => SequenceID++ StartTimer (SyncTimer, SyncInterval) for i := all op. D_Ports do if (TRANSMIT_PORT_VALID) Sync_req (i, PTCP_SYNC_PDU)	M_MASTER
36	M_MASTER	**TimerExpired (TimeoutT)** /!MultipleMaster => StartTimer (TimeoutT, SyncTimeOut) SyncStateChange_ind (SINGLE_MASTER)	MASTER
37	M_MASTER	**TimerExpired (TimeoutT)** /MultipleMaster => MultipleMaster := FALSE StartTimer (TimeoutT, SyncTimeOut)	M_MASTER

4.4.4.5.5 Functions, Macros, Timers and Variables

Table 141 contains the functions, macros, timers and variables used by the SYN_MPSM and their arguments and their descriptions.

Table 141 – Functions, Macros, Timers and Variables used by the SYN_MPSM

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or restarts a timer
StopTimer	Function	This local function stops a timer
TimerExpired	Function	This local function is issued if a timer expires
NEW_SYNC_FRAME	Macro	Check if the PTCP_SYNC frame is valid, the sequence number is newer and from the stored MasterMACAddress.
RECEIVE_PORT_VALID	Macro	Table 151 shall be applied.
Sync_cnf (+/-) (D_Port)	Macro	LMPM_P_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status
Sync_ind (S_Port, PTCP_SYNC_PDU)	Macro	Receive PTCP-PDU according PTCP_SYNC_PDU LMPM_P_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_SYNC_PDU := A_SDU without LT and FrameID

Name	Type	Function/Meaning
Sync_req (D_Port, PTCP_SYNC_PDU)	Macro	Create PTCP-PDU according PTCP_SYNC_PDU Assignments: D_Port := D_Port DA := Multicast Address for PTCP_SYNC_PDU and corresponding SyncID SA := port source address PTCP_SYNC_PDU.SequenceID := SequenceID PTCP_SYNC_PDU.DomainUUID := DomainUUID PTCP_SYNC_PDU.MasterSourceAddress := local master address PTCP_SYNC_PDU.Time := local time from source PTCP_SYNC_PDU.TimeExtension := CurrentUTCOffset := Current UTC Offset PTCP_SYNC_PDU.MasterPriority1 := Priority PTCP_SYNC_PDU.ClockClass := Class PTCP_SYNC_PDU.ClockAccuracy := Accuracy PTCP_SYNC_PDU.ClockVariance := Variance PTCP_SYNC_PDU.MasterPriority2 := 0xFF A_SDU := LT, FrameID, PTCP_SYNC_PDU LMPM_P_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU)
TRANSMIT_PORT_VALID	Macro	Table 152 shall be applied.

4.4.4.6 PTCP Slave Protocol Machine

4.4.4.6.1 Primitive definitions

4.4.4.6.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by PTCP Slave Protocol Machine (SYN_SPSM) are described in the service definition and shown in Table 142.

Table 142 – Remote primitives issued or received by SYN_SPSM

Primitive	Source	Destination	Associated parameters	Functions
LMPM_P_Data.ind	LMPM	SPSM	CREP, S_Port, Tstamp, DA, SA, A_SDU	—

4.4.4.6.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by SYN_SPSM are described in the service definition and shown in Table 143.

Table 143 – Local primitives issued or received by SYN_SPSM

Primitive	Source	Destination	Associated parameters	Functions
StartSlave_req	MPSM	SPSM	—	Activate slave function
StartSlave_cnf	SPSM	MPSM	Status	Confirmation for start slave
StopSlave_req	MPSM	SPSM	—	Deactivates slave function
StopSlave_cnf	SPSM	MPSM	Status	Confirmation for stop slave
SyncStateChange_ind	SPSM	FSPM	Status	Indication for events - JITTER_OUT_OF_BOUNDARY - NO_SYNC_MESSAGE_RECEIVED
SLAVE_State_ind	SPSM	BMA	Status	Indication for events used by the best master algorithms - MASTER_LOST

4.4.4.6.2 State transition diagram

The state transition diagram of the SYN_SPSM is shown in Figure 45.

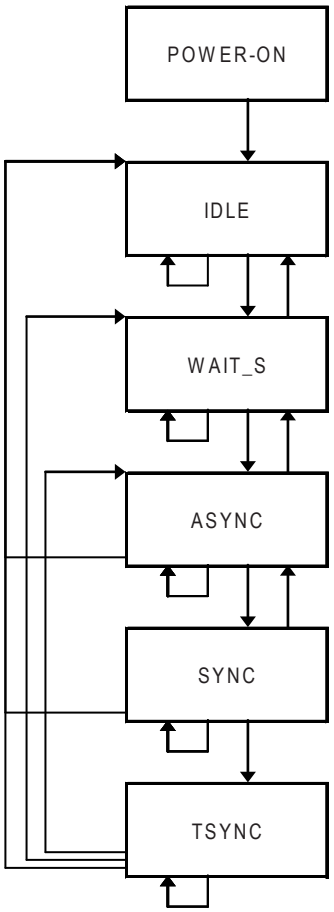


Figure 45 – State transition diagram of SYN_SPSM

States of the SYN_SPSM

POWER-ON	Data initialization
IDLE	The ASE service “StartSlave_req” shall start the slave function of the device.
WAIT_S	The slave is waiting for receiving sync messages in state WAIT_S.
ASYNC	The slave is not synchronized to the active master of the sync domain.
SYNC	The slave has achieved synchronicity with the active master of the sync domain.
TSYNC	The slave is still waiting for new sync messages.

4.4.4.6.3 State machine description

The slave protocol machine controls the transition of a sync slave device. Therefore an instance of the state machine exists for every SyncID with the key attribute PTCP_SubDomainUUID.

After start up the data management shall be initialized (POWER-ON) and the synchronization role shall be set (IDLE). The role is set by PTCP services. After this the SPSM goes from state IDLE to state WAIT_S. In state WAIT_S the slave waits for sync messages to synchronize to an active master. When receiving sync messages the SPSM goes from state WAIT_S to state ASYNC. If the slave is synchronized the SPSM shall switch to state SYNC. If in state SYNC no sync message will be received the SPSM shall switch to state TSYNC.

4.4.4.6.4 SYN_SPSM state table

Table 144 contains the state table used by SYN_SPSM.

Table 144 – SYN_SPSM state table

#	Current State	Event /Condition =>Action	Next State
1	POWER-ON	=> Stored PTCP_MasterSourceAddress := NIL	IDLE
2	IDLE	**StartSlave_req ()** => store Parameter Status := OK StartTimer (TakeoverTimeoutT, MasterTimeOut) StartSlave_cnf (Status)	WAIT_S
3	IDLE	**StopSlave_req ()** => Status := OK StopSlave_cnf (Status)	IDLE
4	WAIT_S	**StartSlave_req ()** => Status := WRONG_SEQUENCE StartSlave_cnf (Status)	WAIT_S
5	WAIT_S	**StopSlave_req ()** => Status := OK StopTimer (TakeoverTimeoutT) StopSlave_cnf (Status)	IDLE
6	WAIT_S	**Sync_ind ()** /!VALID_SYNC_FRAME => ignore	WAIT_S
7	WAIT_S	**Sync_ind ()** /VALID_SYNC_FRAME => L_Time := LocalTime M_Time := PTCP_SYNC_DATA.Time OFFSET_CTRL_START (L_Time, M_Time) StartTimer (OffsetContLoopT, SyncInterval) StartTimer (TakeoverTimeoutT, MasterTimeOut) StartTimer (SyncTimeoutT, SyncTimeOut) SyncStateChange_ind (JITTER_OUT_OF_BOUNDARY)	ASYNC
8	WAIT_S	**TimerExpired (TakeoverTimeoutT)** => Stored PTCP_MasterSourceAddress := NIL SLAVE_State_ind (MASTER_LOST)	WAIT_S
9	ASYNC	**StartSlave_req ()** => Status := WRONG_SEQUENCE StartSlave_cnf (Status)	ASYNC

#	Current State	Event /Condition =>Action	Next State
10	ASYNC	**StopSlave_req ()** => OFFSET_CTRL_STOP Status := OK StopTimer (OffsetContLoopT) StopTimer (TakeoverTimeoutT) StopTimer (SyncTimeoutT) StopSlave_cnf (Status)	IDLE
11	ASYNC	**Sync_ind ()** /!VALID_SYNC_FRAME => ignore	ASYNC
12	ASYNC	**Sync_ind ()** /VALID_SYNC_FRAME => L_Time := LocalTime M_Time := PTCP_SYNC_DATA.Time StartTimer (TakeoverTimeoutT, MasterTimeOut) StartTimer (SyncTimeoutT, SyncTimeOut) SyncStateChange_ind (INFO, M_Time, L_Time)	ASYNC
13	ASYNC	**TimerExpired (OffsetContLoopT)** /!OFFSET_CTRL_IS_SYNC => OFFSET_CTRL_CALC (L_Time, M_Time) StartTimer (OffsetContLoopT, SyncInterval)	ASYNC
14	ASYNC	**TimerExpired (OffsetContLoopT)** /OFFSET_CTRL_IS_SYNC => OFFSET_CTRL_CALC (L_Time, M_Time) StartTimer (OffsetContLoopT, SyncInterval) SyncStateChange_ind (SYNC)	SYNC
15	ASYNC	**TimerExpired (TakeoverTimeoutT)** => Stored PTCP_MasterSourceAddress := NIL StopTimer (SyncTimeoutT) SLAVE_State_ind (MASTER_LOST)	WAIT_S
16	SYNC	**StartSlave_req ()** => Status := WRONG_SEQUENCE StartSlave_cnf (Status)	SYNC
17	SYNC	**StopSlave_req ()** => OFFSET_CTRL_STOP Status := OK StopTimer (OffsetContLoopT) StopTimer (TakeoverTimeoutT) StopTimer (SyncTimeoutT) StopSlave_cnf (Status)	IDLE
18	SYNC	**Sync_ind ()** /!VALID_SYNC_FRAME => ignore	SYNC

#	Current State	Event /Condition =>Action	Next State
19	SYNC	**Sync_ind ()** /VALID_SYNC_FRAME => L_Time := LocalTime M_Time := PTCP_SYNC_DATA.Time StartTimer (TakeoverTimeoutT, MasterTimeOut) StartTimer (SyncTimeoutT, SyncTimeOut) SyncStateChange_ind (INFO, M_Time, L_Time)	SYNC
20	SYNC	**TimerExpired (OffsetContLoopT)** /OFFSET_CTRL_IS_SYNC => OFFSET_CTRL_CALC (L_Time, M_Time) StartTimer (OffsetContLoopT, SyncInterval)	SYNC
21	SYNC	**TimerExpired (OffsetContLoopT)** /!OFFSET_CTRL_IS_SYNC => OFFSET_CTRL_CALC (L_Time, M_Time) StartTimer (OffsetContLoopT, SyncInterval) SyncStateChange_ind (JITTER_OUT_OF_BOUNDARY)	ASYNC
22	SYNC	**TimerExpired (TakeoverTimeoutT)** => Stored PTCP_MasterSourceAddress := NIL SLAVE_State_ind (MASTER_LOST)	TSYNC
23	TSYNC	**StartSlave_req ()** => Status := WRONG_SEQUENCE StartSlave_cnf (Status)	TSYNC
24	TSYNC	**StopSlave_req ()** => OFFSET_CTRL_STOP Status := OK StopTimer (OffsetContLoopT) StopTimer (TakeoverTimeoutT) StopTimer (SyncTimeoutT) StopSlave_cnf (Status)	IDLE
25	TSYNC	**Sync_ind ()** /!VALID_SYNC_FRAME => ignore	TSYNC
26	TSYNC	**Sync_ind ()** /VALID_SYNC_FRAME => L_Time := LocalTime M_Time := PTCP_SYNC_DATA.Time StartTimer (TakeoverTimeoutT, MasterTimeOut) StartTimer (SyncTimeoutT, SyncTimeOut) SyncStateChange_ind (INFO, M_Time, L_Time)	ASYNC
27	TSYNC	**TimerExpired (OffsetContLoopT)** => StartTimer (OffsetContLoopT, SyncInterval) //NOTE The control loop should try to keep the clock stable	TSYNC
28	TSYNC	**TimerExpired (SyncTimeoutT)** => OFFSET_CTRL_STOP StopTimer (OffsetContLoopT) SyncStateChange_ind (NO_SYNC_MESSAGE_RECEIVED)	WAIT_S

4.4.4.6.5 Functions, Macros, Timers and Variables

Table 145 contains the functions, macros, timers and variables used by the SYN_SPSM and their arguments and their descriptions.

Table 145 – Functions, Macros, Timers and Variables used by the SYN_SPSM

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or restarts a timer
StopTimer	Function	This local function stops a timer
TimerExpired	Function	This local function is issued if a timer expires
OFFSET_CTRL_CALC	Macro	This local macro makes the offset compensation Parameters: - LocalTime - MasterTime
OFFSET_CTRL_IS_SYNC	Macro	This local macro measured the sync error in PLL Window //NOTE The detection of a fault depends on the filter algorithm of the selected control loop because the decision is made with local informations only.
OFFSET_CTRL_START	Macro	This local macro initialize the control loop for offset compenstation Parameters: - LocalTime - MasterTime
OFFSET_CTRL_STOP	Macro	This local macro stops the offset compensation

Sync_ind	Macro	Receive PTCP-PDU according PTCP_SYNC_PDU
		
		LMPM_P_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU)
		if A_SDU.FrameID == WITHOUT_FUP_PDU
		  PTCP_SYNC_DATA := PTCP_SYNC_PDU
		else
		  wait for valid PTCP_FUP_PDU from active Master
		  LMPM_P_Data.ind (CREP, S_Port, DA, SA, A_SDU)
		  PTCP_SYNC_DATA.Delay += PTCP_FUP_PDU.Delay
		
		Assignments:
		PTCP_SYNC_PDU := A_SDU without LT and FrameID
		PTCP_FUP_PDU := A_SDU without LT and FrameID
		
		Parameters:
		- SourcePort
		- LocalTime
		- PTCP_SYNC_DATA

VALID_SYNC_FRAME	Macro	See Table 146
OffsetContLoopT	Timer	This local timer is used for the offset checking between LocalTime and MasterTime. It shall be aligned to the SyncInterval for best control loop results.
SyncTimeoutT	Timer	This local timer is used to monitor the existence of the sync master. If this time expires the sync master is lost.
TakeoverTimeoutT	Timer	This local timer is used to monitor the existence of the sync master. If this time expires the preparation for a master switchover is done. This time shall always be lesser than SyncTimoutT.
MasterTimeout	Variable	This local variable contains the value for the warning / preparation level master timeout. Default value: 3 x SyncInterval //NOTE This value is derived from the PTCPTakeoverTimeoutFactor.
PTCP_MasterSourceAddress	Variable	This shared variable contains the MasterSourceAddress of the actual SyncMaster. It is additional changed by the SYNC_RELAY.
Status	Variable	This local variable is used to store the status for further use.

Name	Type	Function/Meaning
SyncInterval	Variable	This local variable contains the value of the sync indication receiving interval. Default value: SyncInterval //NOTE This value is derived from the SyncSendFactor
SyncTimeout	Variable	This local variable contains the value fault level master timeout. Default value: 6 x SyncInterval //NOTE This value is derived from the PTCPTimeoutFactor

4.4.4.6.6 Sync receiving rules truth table for one SyncID

Table 146 contains the truth table used by the SPSM.

Table 146 – Truth table for one SyncID for receiving sync and follow up frames

Input								Output
Condition of the receive port [b]								Local
Port-State [d]	MAU-Type [f]	Line-Delay	Ingress Filter	Sub-domain-UUID	Master-MAC-Address	PTCP_-Sequence ID	PTCP_Delay1ns / PTCP_Delay10ns	Frame from port valid
Disabled	—	—	—	—	—	—	—	No
!Disabled	Wrong	—	—	—	—	—	—	No
!Disabled	Ok	No	—	—	—	—	—	No
!Disabled	Ok	Yes	Yes	—	—	—	—	No
!Disabled	Ok	Yes	No	Wrong	—	—	—	No
!Disabled	Ok	Yes	No	Equal [a]	Wrong	—	—	No
!Disabled	Ok	Yes	No	Equal [a]	Equal [a]	Older	—	No
!Disabled	Ok	Yes	No	Equal [a]	Equal [a]	Newer [c]	Invalid [e]	No
!Disabled	Ok	Yes	No	Equal [a]	Equal [a]	Newer [c]	Valid [e]	Yes

[a] If the own PTCP_SubdomainUUID and/or the MasterMACAddress is unknown (coded as zero), the compare with the values of the PTCP sync frame may return “equal” to optimize the startup of the synchronization.

[b] At the receive port, the local PTCP_SubdomainUUID and/or the MasterMACAddress is checked against the PTCP frame.

[c] If the own MasterMACAddress is unknown (coded as zero), a PTCP sync frame with the local PTCP_SubdomainUUID is defined as ‘newer’. The PTCP_SequenceID is bound to the MasterMACAddress.

[d] According to IEEE 802.3 the PortStates are Disabled, Discarding, Learning and Forwarding. Only the PortState Disabled allows no forwarding or receiving of frames.

[e] See the definition of the fields PTCP_Delay10ns and PTCP_Delay1ns for details.

[f] MAUType is full duplex and a link exists.

4.4.4.7 Sync Relay Protocol Machine

4.4.4.7.1 Primitive definitions

4.4.4.7.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Sync Relay Protocol Machine (SYNC_RELAY) are described in the service definition and shown in Table 147.

Table 147 – Remote primitives issued or received by SYNC_RELAY

Primitive	Source	Destination	Associated parameters	Functions
LMPM_P_Data.req ()	SYNC_RELAY	LMPM	CREP, D_Port, Tstamp, DA, SA, A_SDU	—
LMPM_P_Data.cnf ()	LMPM	SYNC_RELAY	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_P_Data.ind ()	LMPM	SYNC_RELAY	CREP, D_Port, Tstamp, DA, SA, A_SDU	—

4.4.4.7.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by SYNC_RELAY are described in the service definition and shown in Table 148.

Table 148 – Local primitives issued or received by SYNC_RELAY

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.4.4.7.2 State transition diagram

The state transition diagram of the SYNC_RELAY is shown in Figure 46.

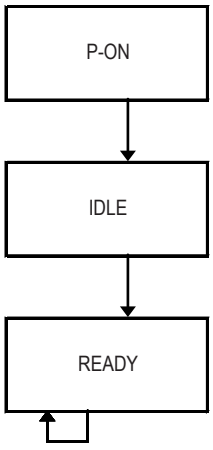


Figure 46 – State transition diagram of SYNC_RELAY

States of the SYNC_RELAY

P-ON	Initialization of the filtering data base for sync frames.
IDLE	Start of the receipt timer for aging the entries in the filtering data base.
READY	The state READY describes the rules for forwarding sync and followup messages.

4.4.4.7.3 State machine description

The SYNC_RELAY protocol machine describes the sync and followup forwarding rules for bridges.

Each time stamp unit of the bridge shall correct the delay field of sync frames on the fly. The time correction (bridge and line delay) is done by adding the delay while transmitting a sync frame.

The SYNC_RELAY protocol machine is necessary to avoid circulating sync messages in the network.

For a high precision the bridge delay of the sync and the follow up frame should be small and stable.

Announce frames shall be handled by the MAC_RELAY. Additional to the MAC_RELAY rules an implicit egress and ingress boundary should be activated for every port which does not support line delay measurement.

4.4.4.7.4 SYNC_RELAY state table

Table 149 contains the state table used by SYNC_RELAY. Only the PTCP frames from one master and one PTCP_SubdomainUUID for one SyncID shall be forwarded. After the selection of a master, the PTCP frames of the others shall be dropped. Table 151 and Table 152 show at a glance the conditions.

Table 149 – SYNC_RELAY state table

#	Current State	Event /Condition =>Action	Next State
1	P-ON	=> Init RelayTable	IDLE
2	IDLE	=> StartTimer (PTCP_Timeout) StartTimer (PTCP_TakeoverTimeout)	READY
3	READY	**TimerExpired (PTCP_Timeout)** => AGING_OF_FWSM_LIST(PT) StartTimer (PTCP_Timeout)	READY
4	READY	**TimerExpired (PTCP_TakeoverTimeout)** => AGING_OF_FWSM_LIST(PTT) StartTimer (PTCP_TakeoverTimeout)	READY
5	READY	Sync_Ind (S_Port, PTCP_SYNC_PDU) /!RECEIVE_PORT_VALID => ignore	READY
6	READY	**Sync_Ind (S_Port, PTCP_SYNC_PDU)** /RECEIVE_PORT_VALID && !NEW_SYNC_FRAME => ignore	READY
7	READY	**Sync_Ind (S_Port, PTCP_SYNC_PDU)** /RECEIVE_PORT_VALID && NEW_SYNC_FRAME && !RATE_VALID => UPDATE_MASTER_ENTRY CalculateMasterRCF	READY

#	Current State	Event /Condition =>Action	Next State

8	READY	**Sync_Ind (S_Port, PTCP_SYNC_PDU)**
		/RECEIVE_PORT_VALID
		&& NEW_SYNC_FRAME
		&& RATE_VALID
		=>
		UPDATE_MASTER_ENTRY
		CalculateMasterRCF
		for i := all op. D_Ports \ S_Port
		do
		if (TRANSMIT_PORT_VALID)
		Sync_Req (i, PTCP_SYNC_PDU)
		
		//NOTE If the hardware does not support “sync request only forwarding” then a sync frame and a followup frame are conveyed.
			READY

9	READY	**Sync_Cnf ()** => ignore	READY
10	READY	Followup_Ind (S_Port, PTCP_FUP_PDU) /!RECEIVE_PORT_VALID => ignore	READY
11	READY	**Followup_Ind (S_Port, PTCP_FUP_PDU)** /RECEIVE_PORT_VALID && !VALID_FU_FRAME => ignore	READY
12	READY	**Followup_Ind (S_Port, PTCP_FUP_PDU)** /RECEIVE_PORT_VALID && VALID_FU_FRAME && RATE_VALID => SET_FU_RECEIVED for i := all op. D_Ports \ S_Port do if (TRANSMIT_PORT_VALID) Followup_Req (i, PTCP_FUP_PDU)	READY
13	READY	Followup_Cnf () => ignore	READY

4.4.4.7.5 Functions, Macros, Timers and Variables

Table 150 contains the functions, macros, timers and variables used by the SYNC_RELAY and their arguments and their descriptions.

Table 150 – Functions, Macros, Timers and Variables used by the SYNC_RELAY

Name	Type	Function/Meaning
CalculateMasterRCF	Function	This local function calculates and updates the rate ($RCF_{SyncMaster}$)
AGING_OF_FWSM_LIST	Macro	This local macro shall handle the entry in the RelayTable. In normal condition only none or one entry exists. PTCP_Timeout expired (PT): Delete the stored MasterMACAddress to enable the receiving of the sync frame from a primary/secondary master PTCP_TakeoverTimeout expired (PTT): Delete the stored MasterMACAddress, the stored PTCP_SubdomainUUID (if not defined locally) and set the rate invalid RelayTableEntry[SyncID, DomainUUID]: - MasterAddress - SequenceID - RxPort - FuFrame
Followup_Cnf	Macro	LMPM_P_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status Parameters: - DestinationPort - Status
Followup_Ind	Macro	Receive PTCP-PDU according PTCP_FUP_PDU LMPM_P_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_FUP_PDU := A_SDU without LT and FrameID Parameters: - SourcePort - PTCP_FUP_PDU
Followup_Req	Macro	Create PTCP-PDU according PTCP_FUP_PDU Assignments: D_Port := Port DA := multicast address for PTCP_FUP_PDU SA := local port address A_SDU := LT, FrameID, PTCP_FUP_PDU LMPM_P_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU) Parameters: - DestinationPort - PTCP_FUP_PDU
NEW_SYNC_FRAME	Macro	This local macro check as a second check after RECEIVE_PORT_VALID if the PTCP_SYNC frame is valid. It checks the semantics and the values of the delay fields.
RATE_VALID	Macro	This local macro checks if the rate ($RCF_{SyncMaster}$) is calculated and valid in the range of a $\pm 100 \frac{\mu Hz}{Hz}$ $\left(\pm 250 \frac{\mu Hz}{Hz}\right)$ clock.
RECEIVE_PORT_VALID	Macro	Table 151 shall be applied.
SET_FU_RECEIVED	Macro	Update entry in RelayTable[SyncID, DomainUUID] FuFrame := TRUE

Name	Type	Function/Meaning
Sync_Cnf	Macro	LMPM_P_Data.cnf (CREP, D_Port, Tstamp, LMPM_status) Assignments: Status := LMPM_status Parameters: - DestinationPort - Status
Sync_Ind	Macro	Receive PTCP-PDU according PTCP_SYNC_PDU LMPM_P_Data.ind (CREP, S_Port, Tstamp, DA, SA, A_SDU) Assignments: PTCP_SYNC_PDU := A_SDU without LT and FrameID Parameters: - SourcePort - PTCP_SYNC_PDU
Sync_Req	Macro	Create PTCP-PDU according PTCP_SYNC_PDU Assignments: D_Port := Port DA := multicast address for PTCP_SYNC_PDU SA := local port address A_SDU := LT, FrameID, PTCP_SYNC_PDU LMPM_P_Data.req (CREP, D_Port, Tstamp, DA, SA, A_SDU) Parameters: - DestinationPort - PTCP_SYNC_PDU
TRANSMIT_PORT_VALID	Macro	Table 152 shall be applied.
UPDATE_MASTER_ENTRY	Macro	Update entry in RelayTable[SyncID, DomainUUID] for sync master MasterAddress := PTCP_SYNC_PDU.MasterSourceAddress SequenceID := PTCP_SYNC_PDU.SequenceID RxPort := S_Port FuFrame := FALSE
VALID_FU_FRAME	Macro	Check RelayTable[SyncID, DomainUUID] for receive port and sequence number is valid MasterAddress == PTCP_FUP_PDU.MasterSourceAddress SequenceID == PTCP_FUP_PDU.SequenceID RxPort == S_Port FuFrame == FALSE
PTCP_TakeoverTimeout	Timer	This local variable contains the value for the warning / preparation level master timeout. Default value: 3 x SyncInterval //NOTE This value is derived from the PTCPTakeoverTimeoutFactor
PTCP_Timeout	Timer	This local variable contains the value fault level master timeout. Default value: 6 x SyncInterval //NOTE This value is derived from the PTCPTimeoutFactor

4.4.4.7.6 Sync forwarding rules for bridges truth table for one SyncID

Table 151 and Table 152 contain the truth table used by the SYNC_RELAY.

Table 151 – Truth table for one SyncID for receiving

Input						Output
Condition of the receive port [b]						Local
PortState [c]	MAUType	LineDelay	Ingress-Filter	Subdomain-UUID	MasterMACAddress	Frame from port valid
Disabled	—	—	—	—	—	No
!Disabled	Wrong	—	—	—	—	No
!Disabled	Ok	No	—	—	—	No
!Disabled	Ok	Yes	Yes	—	—	No
!Disabled	Ok	Yes	No	Wrong	—	No
!Disabled	Ok	Yes	No	Equal [a]	Wrong	No
!Disabled	Ok	Yes	No	Equal [a]	Equal [a]	Yes [d]

[a] If the own PTCP_SubdomainUUID and/or the MasterMACAddress is unknown (coded as zero), the compare with the values of the PTCP sync frame may return “equal” to optimize the startup of the synchronization.

[b] At the receive port, the local PTCP_SubdomainUUID and/or the MasterMACAddress is checked against the PTCP frame.

[c] According to IEEE 802.3 the PortStates are Disabled, Discarding, Learning and Forwarding. Only the PortState Disabled allows no forwarding or receiving of frames.

[d] An optional filter should be used to discard frames with invalid content of the PTCP_Delay1ns / PTCP_Delay10ns fields.

Table 152 – Truth table for one SyncID for transmitting

Input							Output
Local	Conditions of a transmit port [b]						Local
Rate known	Subdomain-UUID	MasterMAC-Address	PortState	MAU-Type	Line-Delay	Egress-Filter	Port for frame valid
No	—	—	—	—	—	—	No
Yes	Wrong	—	—	—	—	—	No
Yes	Equal [a]	Wrong	—	—	—	—	No
Yes	Equal [a]	Equal [a]	Discarding	—	—	—	No
Yes	Equal [a]	Equal [a]	!Discarding	Wrong	—	—	No
Yes	Equal [a]	Equal [a]	!Discarding	Ok	No	—	No
Yes	Equal [a]	Equal [a]	!Discarding	Ok	Yes	Yes	No
Yes	Equal [a]	Equal [a]	!Discarding	Ok	Yes	No	Yes

[a] If the own PTCP_SubdomainUUID and/or the MasterMACAddress is unknown (coded as zero), the compare with the values of the PTCP frame may return “equal” to optimize the startup of the synchronization.

[b] At the transmit port, the remote PTCP_SubdomainUUID and/or the MasterMACAddress is checked against the PTCP frame.

4.4.4.8 Scheduler Protocol Machine

4.4.4.8.1 Primitive definitions

4.4.4.8.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by SCHEDULER are described in the service definition and shown in Table 153.

Table 153 – Remote primitives issued or received by SCHEDULER

Primitive	Source	Destination	Associated parameters	Functions
LMPM_C_Data.req	SCHEDULER	LMPM	CREP, PortList, DA, SA, Prio, C_SDU, APDU_Status	—
UDP_C_Data.req	SCHEDULER	IP	IPPort, CREP, DA, SA, Prio, C_SDU, APDU_Status	—
LMPM_C_Data.cnf	LMPM	SCHEDULER	CREP, PortList, DA, SA, Prio, C_SDU, APDU_Status	—
UDP_C_Data.cnf	IP	SCHEDULER	IPPort, CREP, DA, SA, Prio, C_SDU, APDU_Status	—

4.4.4.8.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by SCHEDULER are described in the service definition and shown in Table 154.

Table 154 – Local primitives issued or received by SCHEDULER

Primitive	Source	Destination	Associated parameters	Functions
DMUX_Schedule_cnf	DEMUX	SCHEDULER	—	—
MUX_Schedule_cnf	MUX	SCHEDULER	—	—
DMUX_Schedule_req	SCHEDULER	DEMUX	CycleCounter, Rx_Period	—
DMUX_Schedule_req	SCHEDULER	DEMUX	Rx_Period	—
MUX_Schedule_req	SCHEDULER	MUX	CycleCounter, Tx_Period	—
MUX_Schedule_req	SCHEDULER	MUX	Tx_Period	—
SCHEDULER_add_req	PPM	SCHEDULER	CREP, ReductionRatio, Phase, Sequence, TxOptions	Add a PPM to the scheduler
SCHEDULER_remove_req	PPM	SCHEDULER	CREP	Remove a PPM from the scheduler
SCHEDULER_error_ind	SCHEDULER	CMSU CTLSU	CREP, ErrorCode	Signal an overload. In this case the NEXT phase shall be skipped
SCHEDULER_add_cnf	SCHEDULER	PPM	CREP	Add a PPM to the scheduler
SCHEDULER_remove_cnf	SCHEDULER	PPM	CREP	Remove a PPM from the scheduler

4.4.4.8.2 State transition diagram

The state transition diagram of the SCHEDULER is shown in Figure 47.

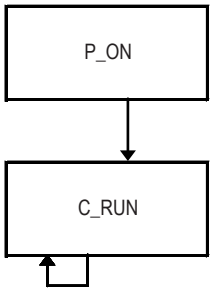


Figure 47 – State transition diagram of SCHEDULER

States of the SCHEDULER

P_ON	Data initialization
C_RUN	Scheduler is active and running

4.4.4.8.3 State machine description

The SCHEDULER generates the signals for the local handling of time events. The TickEvent is additionaly used to trigger the timely correct forwarding of RT_CLASS_3 frames.

4.4.4.8.4 SCHEDULER state table

Table 155 contains the state table used by SCHEDULER.

Table 155 – SCHEDULER state table

#	Current State	Event /Condition =>Action	Next State
1	P_ON	**Scheduler_Init_req ()** => TxPeriod := GREEN RxPeriod := GREEN MUX_Schedule_req(TxPeriod) DMUX_Schedule_req(RxPeriod)	C_RUN
2	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /TxPeriod == GREEN && TxPeriodChecker () == GREEN => ignore	C_RUN
3	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /TxPeriod == RED && TxPeriodChecker () == GREEN => TxPeriod := GREEN MUX_Schedule_req(CycleCounter, TxPeriod)	C_RUN
4	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /TxPeriod == RED && TxPeriodChecker () == RED => ignore	C_RUN

#	Current State	Event /Condition =>Action	Next State
5	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /TxPeriod == GREEN && TxPeriodChecker () == RED => TxPeriod := RED MUX_Schedule_req(CycleCounter, TxPeriod)	C_RUN
6	C_RUN	MUX_Schedule_cnf() => ignore	C_RUN
7	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /RxPeriod == GREEN && RxPeriodChecker () == GREEN => ignore	C_RUN
8	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /RxPeriod == RED && RxPeriodChecker () == GREEN => RxPeriod := GREEN DMUX_Schedule_req(CycleCounter, RxPeriod)	C_RUN
9	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /RxPeriod == RED && RxPeriodChecker () == RED => ignore	C_RUN
10	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /RxPeriod == GREEN && RxPeriodChecker () == RED => RxPeriod := RED DMUX_Schedule_req(CycleCounter, RxPeriod)	C_RUN
11	C_RUN	DMUX_Schedule_cnf() => ignore	C_RUN
12	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /for each active PPM check whether CycleCounter, CycleOffset fits to FrameSendOffset and ReductionRatio check if PPM ready to schedule and frame not already at the LMPM => C_Data_req()	C_RUN
13	C_RUN	**TickEvent (CycleCounter, CycleOffset)** /for each active PPM check whether CycleCounter, CycleOffset fits to FrameSendOffset and ReductionRatio check if PPM ready to schedule and frame already at the LMPM => SCHEDULER_error.ind (ErrorCode = Overload)	C_RUN
14	C_RUN	C_Data_cnf() => ignore	C_RUN
15	C_RUN	SCHEDULER_add.req (CREP, ReductionRatio, Phase, Sequence) => Add PPM to list SCHEDULER_add.cnf (CREP)	C_RUN
16	C_RUN	**SCHEDULER_remove.req (CREP)** => Remove PPM from list SCHEDULER_remove.cnf (CREP)	C_RUN

4.4.4.8.5 Functions, Macros, Timers and Variables

Table 156 contains the functions, macros, timers and variables used by the SCHEDULER and their arguments and their descriptions.

Table 156 – Functions, Macros, Timers and Variables used by the SCHEDULER

Name	Type	Function/Meaning
RxPeriodChecker	Function	This local function checks the active RxPeriod and returns it.
TickEvent	Function	Local generated event from a timer. The timer shall be controlled by the PTCP master or slave in case of synchronization or free running without synchronization. Parameter: - CycleCounter - CycleOffset
TxPeriodChecker	Function	This local function checks the active TxPeriod and returns it.
C_Data_cnf	Macro	if (txOption == RTC) LMPM_C_Data.cnf (CREP, LMPM_status) if (txOption == UDP) UDP_C_Data.cnf (IPPort, CREP, LMPM_status)
C_Data_req	Macro	if (txOption == RTC) LMPM_C_Data.req (CREP, Port, DA, SA, Prio, C_SDU, APDU_Status) if (txOption == UDP) UDP_C_Data.req (IPPort, CREP, DA, SA, Prio, C_SDU, APDU_Status)
RxPeriod	Variable	This variable contains the values: RED and GREEN
TxPeriod	Variable	This variable contains the values: RED and GREEN

4.4.4.8.6 Truth tables

4.4.4.8.6.1 PeriodChecker rules truth table

Table 157 and Table 158 contains the truth table used by the SCHEDULER to detect the requiered period per port.

Table 157 – Truth table for RxPeriodChecker of one port

Input		Output
RTC3PSM port state	**CycleOffset inside RED period**	**RxPeriod**
OFF	—	GREEN
—	Outside	GREEN
UP	Inside	GREEN
RUN	Inside	RED

Table 158 – Truth table for TxPeriodChecker of one port

Input		Output
RTC3PSM port state	**CycleOffset inside RED period**	**TxPeriod**
OFF	—	GREEN
—	Outside	GREEN
UP	Inside	RED
RUN	Inside	RED

4.4.5 DLL Mapping Protocol Machines

There is no DLL Mapping Protocol Machine (DMPM) defined for this protocol.

4.5 Time synchronization

For time synchronization the IEEE 802.1AS applies. The support of the IEEE 802.1AS Management Information Base (MIB) is optional.

4.6 Media redundancy

4.6.1 Media redundancy and loop prevention

For media redundancy the IEC 62439-2 applies. The support of the MRP Management Information Base (MIB) is optional.

4.6.2 Seamless media redundancy

For seamless media redundancy MRPD applies. This shall be done by using the PPM, CPM and the RED_RELAY.

MRPD shall only be operated in conjunction with MRP.

4.7 Real time cyclic

4.7.1 FAL syntax description

4.7.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.7.1.2 RTC APDU abstract syntax

Table 159 defines the abstract syntax of the Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 159 shall represent the content of the DLSDU in Table 5.

Table 159 – RTC APDU syntax

APDU name	APDU structure
RTC-PDU	C_SDU ^ CSF_SDU, [RTCPadding*] [a] [b], APDU_Status
UDP-RTC-PDU	IPHeader, UDPHeader, FrameID, RTC-PDU

[a] In case of RTC-PDU the number of padding octets shall be in the range of 0...40 depending on the DataItem size. In case of UDP-RTC-PDU the number of padding octets shall be in the range of 0…12 depending on the DataItem size.

[b] In case of RT_CLASS_3 transportation the number of padding octets is given by the engineering system.

Table 160 defines structures for substitutions of elements of the APDU structures shown in Table 159.

Table 160 – RTC substitutions

Substitution name	Structure
C_SDU	{[DataItem], [GAP*]}* [a]
DataItem	{[IOCS*], [DataObjectElement*]}*
SubstituteDataItem	{[IOCS*] [b], [SubstituteDataObjectElement*]}*

Substitution name	Structure
DataObjectElement	[Data*], IOPS
SubstituteDataObjectElement	[Data*], SubstituteDataValid
CSF_SDU	SFCRC16, SUBFRAME*, SFEndDelimiter [a]
SUBFRAME	SFPosition, SFDataLength, SFCycleCounter, DataStatus, C_SDU, SFCRC16
SFEndDelimiter	SFPosition(=0), SFDataLength(=0)
APDU_Status	CycleCounter, DataStatus, TransferStatus
[a] The maximum size of a C_SDU or CSF_SDU shall be not larger than 1 440 octets. [b] The value shall contain the same value as the field DataItem.IOCS.	

4.7.2 FAL transfer syntax

4.7.2.1 Coding section of Data-RTC-PDU specific fields

4.7.2.1.1 Overview

The field Data and IOxS shall also be used to encode user data for all other PDU types.

4.7.2.1.2 Coding of the field CycleCounter

This field shall be coded as data type Unsigned16. One increment represents a time value of 31,25 μs for RTC-PDU and 1 ms for UDP-RTC-PDU. Each RTC-PDU or UDP-RTC-PDU contains its CycleCounter created according to Figure 49 by the sender.

The receiver of the RTC-PDU or UDP-RTC-PDU shall use this field to detect repetitions, loss of frames and timeliness of data. For this reason the CycleCounter value range shall be divided in the ratio 15/16 for valid and 1/16 for invalid as shown in Figure 48.

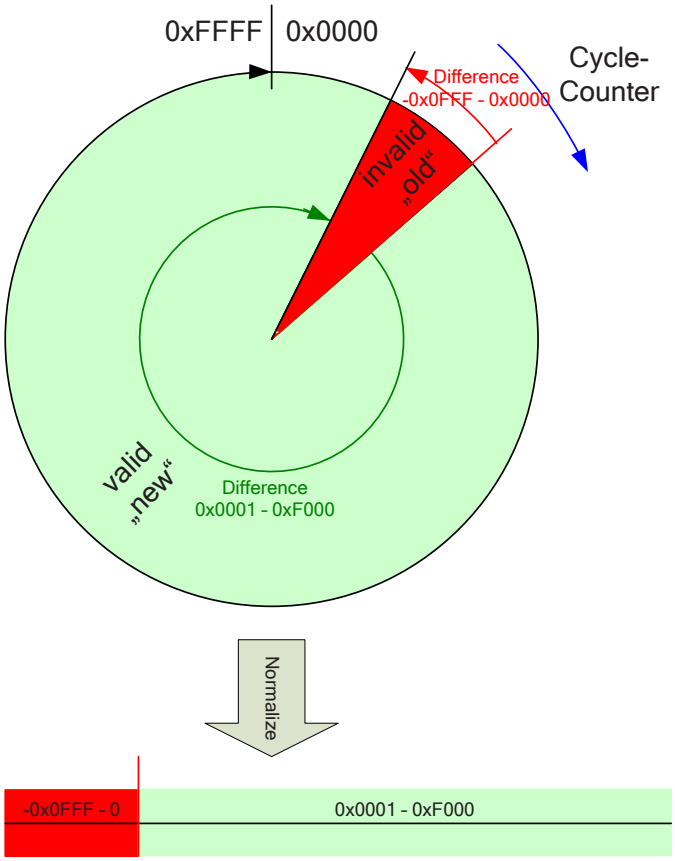


Figure 48 – CycleCounter value range

NOTE The normalization can be done using the following formula:
CycleCounter(Normalized) := ((((CycleCounter(NEW) + (0x10000 – CycleCounter(STORED)) – 1) & 0xFFFF) – 0xF000) × (-1)).

Table 161 defines a maximum time window between the old and the new frame and the action of the consumer according to the difference between the CycleCounter of the last received RTC-PDU or UDP-RTC-PDU and the value of the current received PDU.

Table 161 – CycleCounter Difference

Value (hexadecimal)	Time range RTC-PDU [s]	Time range UDP-RTC-PDU [s]	Meaning	Use
-0x0FFF – 0x0000	0,128	4,096	Red sector according to Figure 48 1/16 of the CycleCounter range The consumer votes the received frame as older than the stored frame	Frame is dropped
0x0001 – 0xF000	1,92	61,44	Green sector according to Figure 48 15/16 of the CycleCounter range The consumer votes the received frame as newer than the stored frame	Frame is processed

If MRPD is used, the CycleCounter of the adjunctive frames shall be set identical by the sender.

A device shall maintain a local 64 bit counter with an increment of 31,25 µs as shown in Figure 49.

The bits 0 to 14 shall be used identically for the CycleCounter of the RTC-PDUs. The bit 15 of the 16 bit CycleCounter of the RTC-PDUs may also be identically to bit 15 of the 64 bit local counter.

The bits 5 to 19 shall be used as bit 0 to 14 identically for the CycleCounter of the UDP-RTC-PDUs. The bit 15 of the 16 bit CycleCounter of the UDP-RTC-PDUs may also be identically to bit 20 of the 64 bit local counter.

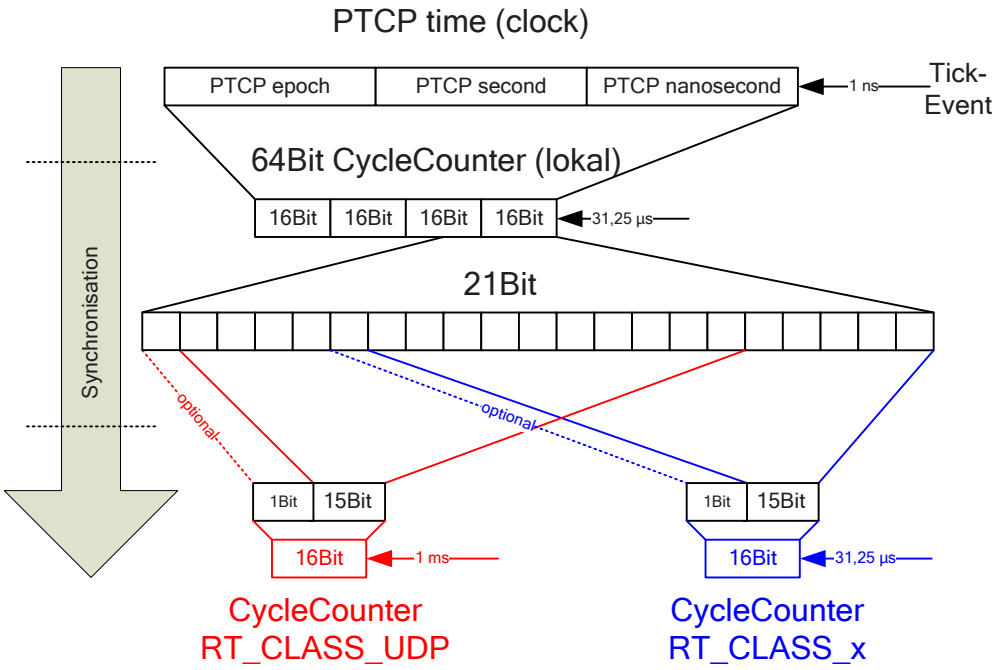


Figure 49 – Structure of the CycleCounter

In case of a global synchronization of the nodes, the bit 15 of the CycleCounter base for RTC-PDUs and the bit 20 of the CycleCounter base for UDP-RTC-PDUs shall be set according to Figure 49 and Figure 50 to avoid a false “older” detection by the receiver.

The CycleCounter shall be set due to synchronization according to the model shown in Figure 50.

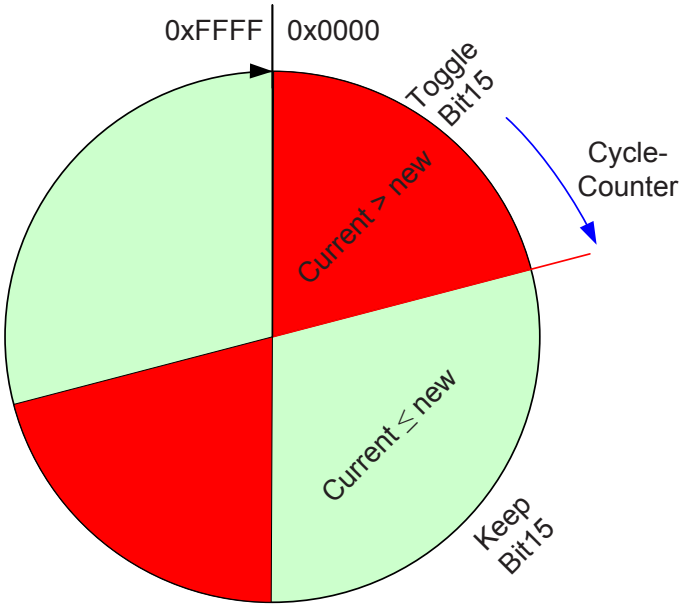


Figure 50 – Optimized CycleCounter setting

CycleCounter(current)
This means the value of the CycleCounter used by the sender before executing the synchronization.

CycleCounter(next)
This means the value of the CycleCounter needed by the sender according to the synchronization information

if CycleCounter(current)[0..14] <= CycleCounter(next)[0..14]

then /* current ≤ next */

SET CycleCounter[0..14] with CycleCounter(next)[0..14] and keep CycleCounter[15]

else /* current > next */

SET CycleCounter[0..14] with CycleCounter(next)[0..14] and toggle CycleCounter[15]

4.7.2.1.3 Coding of the field DataStatus

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0: DataStatus.State

This field shall be coded with the values according to Table 162 and evaluated after the AR is in state InDATA.

Table 162 – DataStatus.State

Value (hexadecimal)	Meaning
0x00	IOCR state is backup
0x01	IOCR state is primary

Bit 1: DataStatus.Redundancy

This field shall be coded with the values according to Table 163 and evaluated after the AR is in state InDATA.

Table 163 – DataStatus.Redundancy

Value (hexadecimal)	Meaning
0x00	Default One primary AR of a given AR-set is present
0x01	None primary AR of a given AR-set is present

NOTE An IO controller set this flag independent from the ARType to the Default value.

Bit 2: DataStatus.DataValid

This field shall be coded with the values according to Table 164.

Table 164 – DataStatus.DataValid

Value (hexadecimal)	Meaning
0x00	DataItem invalid
0x01	DataItem valid

It is recommended to use DataStatus.DataValid == 'DataItem invalid' for DFP only in conjunction with IOxS.DataState == 'Bad' for all DataItems.

Bit 3: DataStatus.Reserved_1

This field shall be set to zero but not checked by the receiver

Bit 4: DataStatus.ProviderState

This field shall be coded with the values according to Table 165.

Table 165 – DataStatus.ProviderState

Value (hexadecimal)	Meaning
0x00	Stop
0x01	Run

Bit 5: DataStatus.StationProblemIndicator

This field shall be coded with the values according to Table 166.

Table 166 – DataStatus.StationProblemIndicator

Value (hexadecimal)	Meaning
0x00	Problem detected
0x01	Normal Operation

Bit 6: DataStatus.Reserved_2

This field shall be set according to 3.4.2.2.

Bit 7: DataStatus.Ignore

This field shall be coded with the values according to Table 167 and Table 168.

Table 167 – DataStatus.Ignore of a frame

Value (hexadecimal)	Meaning
0x00	Evaluate the DataStatus
0x01	Ignore the DataStatus Shall only be set for a frame containing sub frames with SFIOCRProperties.SFCRC16 := 1

Table 168 – DataStatus.Ignore of a sub frame

Value (hexadecimal)	Meaning
0x00	Evaluate the sub frame
0x01	Ignore the sub frame; it is a surrogate sub frame. The CPM threads this subframe as invalid.

4.7.2.1.4 Coding of the field TransferStatus

This field shall be coded as data type Unsigned8. This field shall be set to zero for RT_CLASS_UDP, RT_CLASS_1 and RT_CLASS_2 frames. For RT_CLASS_3 the value shall be set according to Table 169.

Table 169 – TransferStatus for RT_CLASS_3

Bit position	Name	Value	Meaning
0	AlignmentOrFrameChecksumError	0	No frame checksum error or alignment error
		1	A frame checksum error or alignment error and no MAC receive buffer overflow has appeared
1	WrongLengthError	0	No length error
		1	A length error has appeared
2	MACReceiveBufferOverflow	0	No MAC receive buffer overflow
		1	A MAC receive buffer overflow has appeared
3	RT_CLASS_3 Error	0	No RT_CLASS_3 error
		1	RT_CLASS_3 error E.g. the frame has not been received in time or has not had the expected frame type or has not had the expected frame ID or has not had the expected Source MAC address (this is optionally checked) or in case of an underrun, e.g. the bridge received a header, but the data have not arrived on time
Other	—	Reserved	Reserved

4.7.2.1.5 Coding section related to decentralized periphery

4.7.2.1.5.1 Coding of the field Data

The data types defined in IEC 61158-5-10, Clause 5 shall be used for Data.

4.7.2.1.5.2 Coding section related to Subframe

4.7.2.1.5.2.1 Coding of the field SFCRC16

This field shall be coded as data type Unsigned16.

The SFCRC16 is generated by Formula (38) as a 16 Bit-polynominal.

$$SFCRC16 = 1 + x^2 + x^{15} + x^{16} \quad (38)$$

where

x	is the content of the octet
SFCRC16	16 Bit-polynominal

Each SFCRC16 starts with value 0 and calculates all octets beginning with first octet of destination MAC address up to the SFCRC16.

The 16 bit value representation in a frame is little endian (which ensures that the value of CRC is 0 after the SFCRC16 octets of the previous Subframe).

NOTE The design could be checked with http://www.easics.be/webtools/crctool.

The generation of the first SFCRC16 starts with the first octet of the destination MAC address, ignores the VLAN tag (and other tags) and ends with the last octet of the FrameID.

The generation of the Subframe SFCRC16, as shown in Figure 51 starts with the first octet of the SFPosition and ends with the last octet of the field C_SDU.

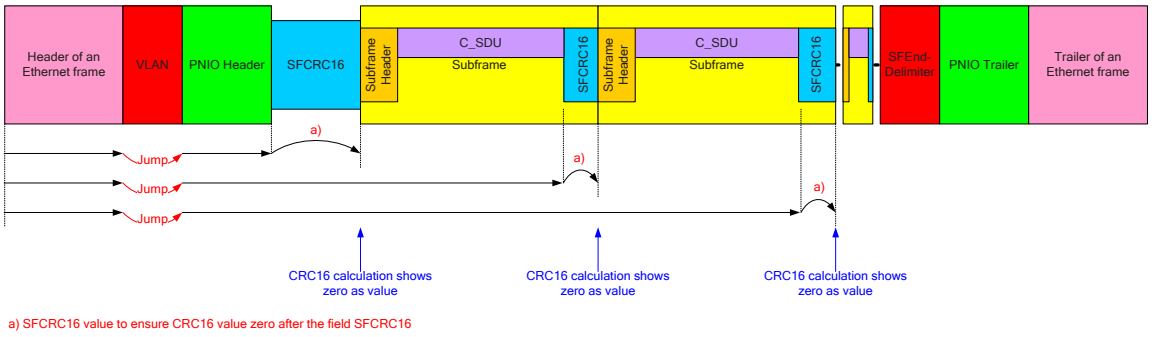


Figure 51 – SFCRC16 generation rule

4.7.2.1.5.2.2 Coding of the field SFPosition

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0-6: SFPosition.Position

This field shall be coded with the values according to Table 170.

Table 170 – SFPosition.Position

Value (hexadecimal)	Meaning
0x00	End of Subframe coding
0x01 – 0x3F	Useable for packetizing and unpacking of Subframes during transport and end to end
0x40 – 0x7F	Useable for packetizing and unpacking of Subframes end to end

NOTE End to end means, that the source of data creates and concatenates the Subframes for a frame. The conveyance is done without any change on the frame. The sink of the data unpacks the Subframes and uses the data.

Bit 7: SFPosition.Reserved

This field shall be coded with the values according to Table 171.

Table 171 – SFPosition.Reserved

Value (hexadecimal)	Meaning
0x00	Reserved

4.7.2.1.5.2.3 Coding of the field SFDataLength

This field shall be coded as data type Unsigned8 with the values according to Table 172.

Table 172 – SFDataLength

Value (hexadecimal)	Meaning
0x00	End of Subframe coding
0x01 – 0xFF	Number of octets of the C_SDU

4.7.2.1.5.2.4 Coding of the field SFCycleCounter

This field shall be coded as data type Unsigned8. Each Subframe contains its SFCycleCounter incremented by one for each transmission from the PPM.

The receiver of the Subframe shall use this field to detect repetitions, loss of Subframes and timeliness of data. For this reason the SFCycleCounter value range shall be divided in the ratio 15/16 for valid and 1/16 for invalid as shown in Figure 52.

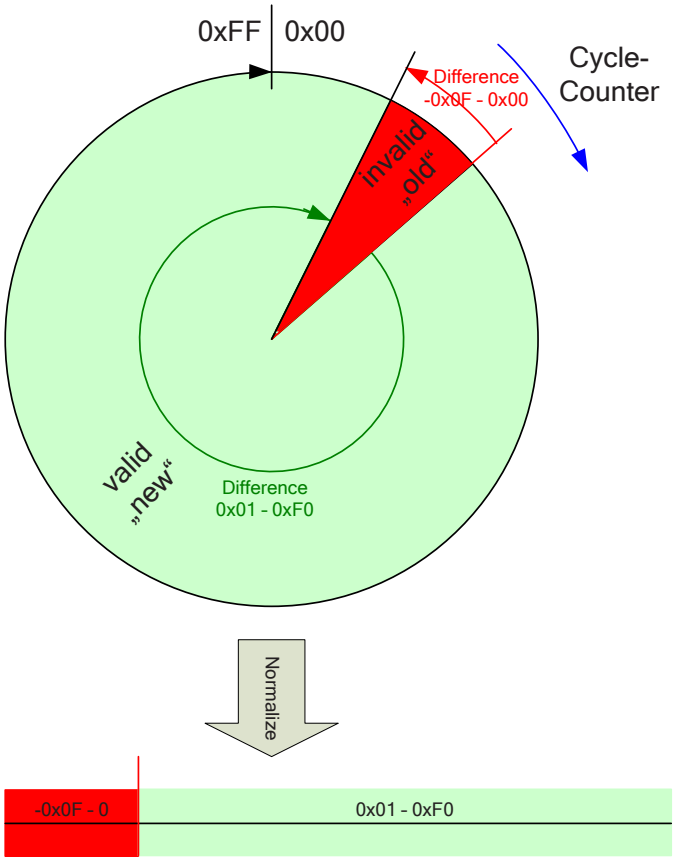


Figure 52 – SFCycleCounter value range

Table 173 defines a maximum time window between the old and the new SFCycleCounter and the action of the consumer according to the difference between the SFCycleCounter of the last received Subframe and the value of the current received Subframe.

Table 173 – SFCycleCounter Difference

Value (hexadecimal)	Time range RTC-PDU [s]	Time range UDP-RTC-PDU [s]	Meaning	Use
-0x0F– 0x00	—	—	Red sector according to Figure 52 1/16 of the SFCycleCounter range The consumer votes the received Subframe as older than the stored Subframe	Subframe is dropped
0x01 – 0xF0	—	—	Green sector according to Figure 52 15/16 of the SFCycleCounter range The consumer votes the received Subframe as newer than the stored Subframe	Subframe is processed

NOTE The same SFCycleCounter value, which means the difference is zero, is assigned to older.

If MRPD is used, the SFCycleCounter of the adjunctive subframes shall be set identical by the sender.

4.7.2.1.5.3 Coding section related to IOxS (IOPS, IOCS, SubstituteDataValid)

4.7.2.1.5.3.1 Coding of the field IOPS

The coding of these fields shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0: IOxS.Extension
This field shall be coded with the values according to Table 174.

Table 174 – IOxS.Extension

Value (hexadecimal)	Meaning
0x00	No IOxS octet follows
0x01	One more IOxS octet follows

Bit 1 to 4: IOxS.reserved
This field shall be set according to 3.4.2.2.

Bit 5 to 6: IOxS.Instance
This field shall be coded with the values according to Table 175 if the IOxS.DataState bit is set to bad. If this bit is set to good the IOxS instance bits are don't care and shall be set to zero.

Table 175 – IOxS.Instance

Value (hexadecimal)	Meaning
0x00	Detected by subslot
0x01	Detected by slot
0x02	Detected by IO device
0x03	Detected by IO controller

Bit 7: IOxS.DataState
This field shall be coded with the values according to Table 176.

Table 176 – IOxS.DataState

Value (hexadecimal)	Meaning
0x00	Bad Data field may not contain valid user data – the receiver shall use its pre-configured values (zero, last valid value, or default value) instead of transmitted data field values SubstituteDataValid = FALSE
0x01	Good Data field shall contain valid user data SubstituteDataValid = TRUE

4.7.2.1.5.3.2 Coding of the field IOCS

The coding of these fields shall be according to 4.7.2.1.5.3.1.

4.7.2.1.5.3.3 Coding of the field SubstituteDataValid

The coding of these fields shall be according to 4.7.2.1.5.3.1.

4.7.3 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.7.4 Application Relationship Protocol Machines

4.7.4.1 Provider protocol machine

4.7.4.1.1 General

Figure 53 and Figure 54 shows the basic structure of the Provider protocol machine (PPM).

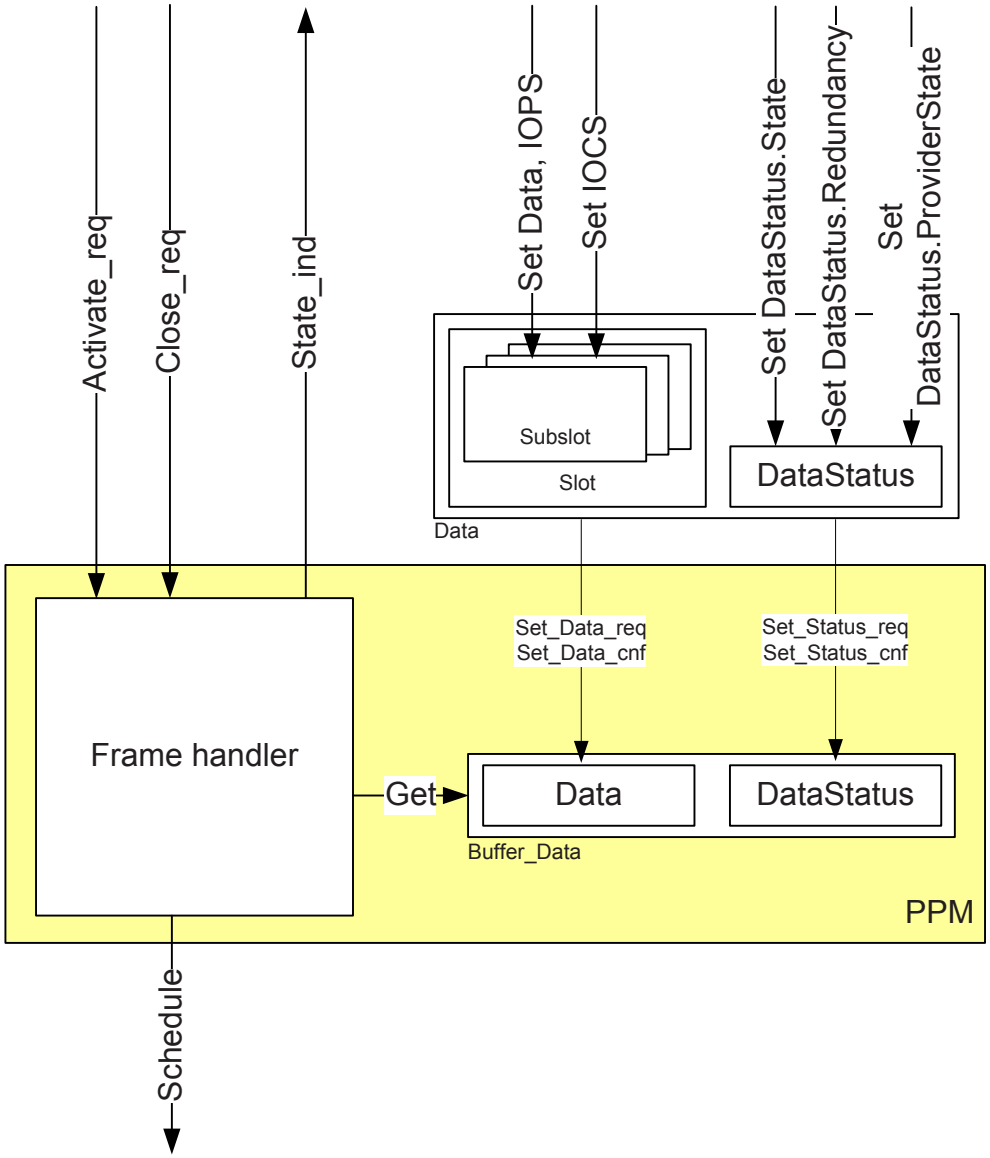


Figure 53 – Basic structure of a PPM with frame structure

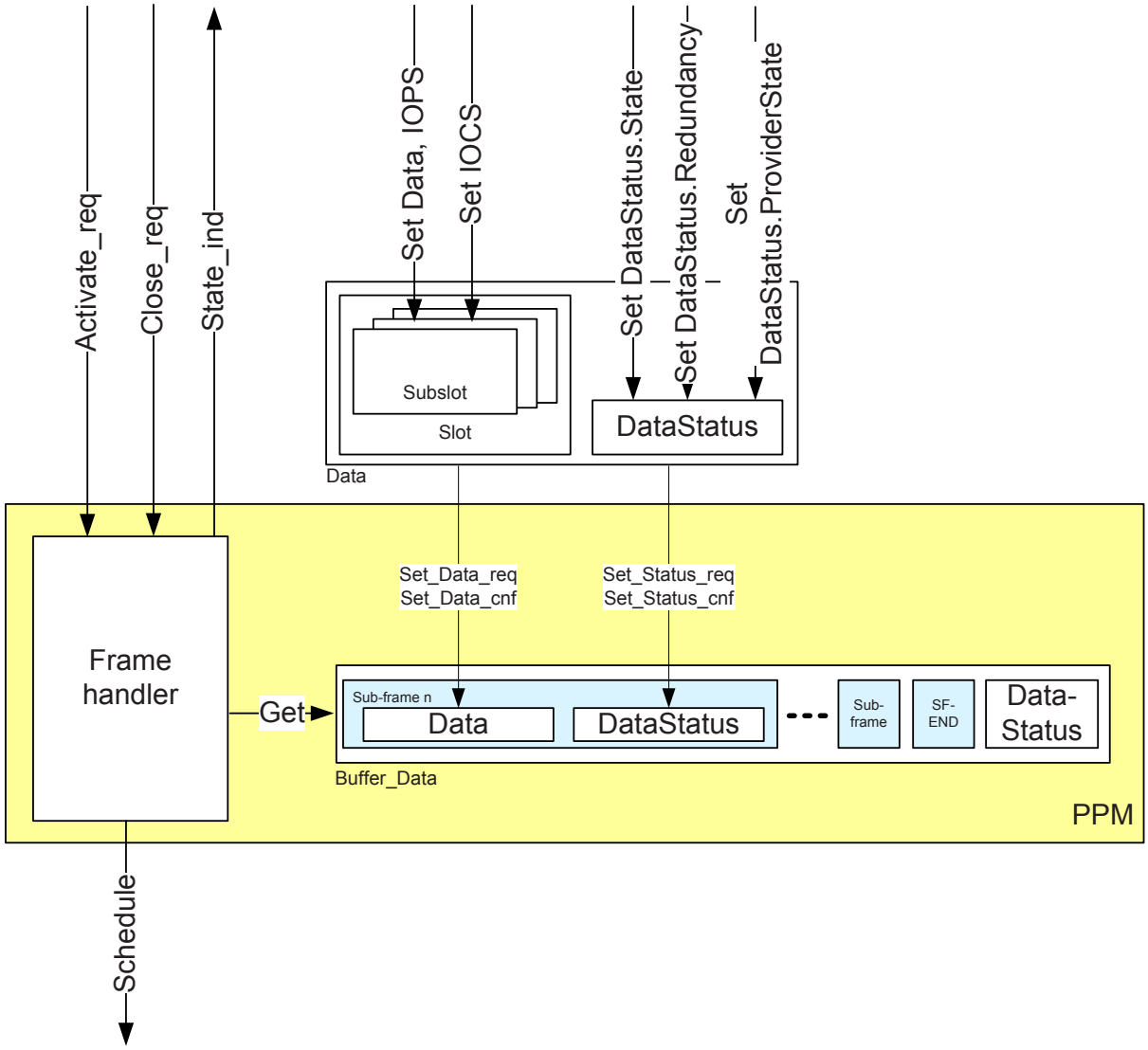


Figure 54 – Basic structure of a PPM with subframe structure

4.7.4.1.2 Primitive definitions

4.7.4.1.2.1 Primitives exchanged between remote machines

The remote service primitives including their associated parameters issued or received by PPM are described in the service definition and shown in Table 177.

Table 177 – Remote primitives issued or received by PPM

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.7.4.1.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by PPM are described in the service definition and shown in Table 178.

Table 178 – Local primitives issued or received by PPM

Primitive	Source	Destination	Associated parameters	Functions
PPM_Activate_cnf (-)	PPM	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—
PPM_Activate_cnf (+)	PPM	CMSU CTLSU	CREP	—
PPM_Activate_req	CMSU CTLSU	PPM	CREP, DA, SA, FrameID, Prio, TxOption, ReductionRatio, Phase, Sequence, Default_Values, Default_Status	—
PPM_Close_cnf (-)	PPM	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—
PPM_Close_cnf (+)	PPM	CMSU CTLSU	CREP	—
PPM_Close_req	CMSU CTLSU	PPM	CREP	—
PPM_Error_ind	PPM	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—
PPM_Set_Data_cnf (-)	PPM	FSPMDEV FSPMCTL	CREP, ERRCLS, ERRCODE	—
PPM_Set_Data_cnf (+)	PPM	FSPMDEV FSPMCTL	CREP	—
PPM_Set_Data_req	FSPMDEV FSPMCTL	PPM	CREP, Data	—
PPM_Set_Status_cnf (-)	PPM	FSPMDEV FSPMCTL	CREP, ERRCLS, ERRCODE	—
PPM_Set_Status_cnf (+)	PPM	FSPMDEV FSPMCTL	CREP	—
PPM_Set_Status_req	FSPMDEV FSPMCTL	PPM	CREP, Status	—
PPM_State_ind	PPM	local matter	CREP, State	—
Scheduler_add_cnf (-)	SCHEDULER	PPM	CREP	—
Scheduler_add_cnf (+)	SCHEDULER	PPM	CREP	—
SCHEDULER_add_req	PPM	SCHEDULER	CREP, ReductionRatio, Phase, Sequence, TxOption	—
Scheduler_remove_cnf (-)	SCHEDULER	PPM	CREP	—
Scheduler_remove_cnf (+)	SCHEDULER	PPM	CREP	—
SCHEDULER_remove_req	PPM	SCHEDULER	CREP	—
Scheduler_transmit_ind	SCHEDULER	PPM	CREP	—

4.7.4.1.3 State transition diagram

The state transition diagram of the PPM is shown in Figure 55.

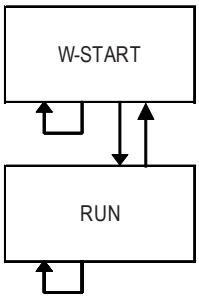


Figure 55 – State transition diagram of PPM

States of the PPM

W-START	Waiting for initialization and add the frame to the SCHEDULER
RUN	Running

4.7.4.1.4 State machine description

The W-START state indicates that an initialization is needed. The Activate service sets the machine in the RUN state waiting for Provider Data service requests and Time events. Receiving the confirmation will bring back the machine to the RUN state. An error or a Close service request is needed to re-enter the W-START state.

Each PPM handles up to two frames with one or two FrameIDs. For RTC3 compatibility two frames with the same FrameID and for MRPD two frames with two FrameIDs (FrameID and FrameID+1) are handled.

It is used to setup the frames which are transmitted by the Scheduler. The content (Buffer_Data) contains the local data if "frame structure" is used or the local data and the stored subframes (DFP_STORAGE) if "subframe structure" is used.

The Buffer_Data is fetched first from the INBOUND DFP frame and if this frame is too late from the DFP_STORAGE. If the concurrently received and transmitted subframe is detected as invalid, the frame should be shortened adding a TX-error (see Annex S) at the transmitting port.

NOTE The TagControlInformation.VLAN_Id is set to zero by the PPM but can be set different elsewhere according to IEEE 802.1Q.

4.7.4.1.5 PPM state table

Table 179 contains the description of the PPM state table.

Table 179 – PPM state table

#	Current State	Event /Condition =>Action	Next State
1	W-START	**PPM_Activate_req ()** => FirstTransmit := FALSE Buffer_Data := Default_Values Buffer_Status := Default_Status SCHEDULER_add.req () PPM_Activate_cnf (+)	RUN
2	W-START	**PPM_Set_Data_req (Data)** => ERRCLS := CTXT ERRCODE := INVALID_STATE PPM_Set_Data_cnf (-)	W-START
3	W-START	**PPM_Set_Status_req (Status)** => ERRCLS := CTXT ERRCODE := INVALID_STATE PPM_Set_Status_cnf (-)	W-START
4	W-START	**PPM_Close_req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE PPM_Close_cnf (-)	W-START
5	W-START	Scheduler_transmit.ind () => ignore	W-START
6	W-START	Scheduler_add.cnf (+) => ignore	W-START
7	W-START	Scheduler_remove.cnf (+) => ignore	W-START
8	W-START	Scheduler_add.cnf (-) => ignore	W-START
9	W-START	Scheduler_remove.cnf (-) => ignore	W-START
10	RUN	**PPM_Activate_req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE PPM_Activate_cnf (-)	RUN
11	RUN	**PPM_Set_Data_req (Data)** => Buffer_Data := Data PPM_Set_Data_cnf (+)	RUN
12	RUN	**PPM_Set_Status_req (Status)** => Buffer_Status := Status PPM_Set_Status_cnf (+)	RUN
13	RUN	**PPM_Close_req ()** => SCHEDULER_remove.req () PPM_Close_cnf (+)	W-START
14	RUN	**Scheduler_transmit.ind ()** /FirstTransmit == FALSE => FirstTransmit := TRUE PPM_State_ind (Start)	RUN

#	Current State	Event /Condition =>Action	Next State
15	RUN	**Scheduler_transmit.ind ()** /FirstTransmit == TRUE => ignore	RUN
16	RUN	Scheduler_add.cnf (+) => ignore	RUN
17	RUN	Scheduler_remove.cnf (+) => ignore	RUN
18	RUN	**Scheduler_add.cnf (-)** => ERRCLS := CTXT ERRCODE := INVALID PPM_State_ind (Error) PPM_Error_ind (Error)	W-START
19	RUN	Scheduler_remove.cnf (-) => ignore	RUN

4.7.4.1.6 Functions, Macros, Timers and Variables

Table 180 contains the functions, macros, timers and variables used by the PPM and their arguments and their descriptions.

Table 180 – Functions, Macros, Timers and Variables used by the PPM

Name	Type	Function/Meaning
FirstTransmit	Variable	This local variable contains the information whether the frame was at least one time conveyed.
Buffer_Data	Variable	This local variable contains the data (encoded as DataItem*) which shall be used as storage of the data dedicated for conveyance of the next Data-RTC-PDU or UDP-RTC-PDU.
Buffer_Status	Variable	This local variable contains the status (encoded as APDU_Status.DataStatus) which shall be used as storage of the status dedicated for conveyance of the next Data-RTC-PDU or UDP-RTC-PDU.
NOTE DataItem* includes all DataItems for the dedicated PDU.		

4.7.4.1.7 Truth tables

Table 181 contains the valid combinations, their meaning and their description of TxOption.

Table 181 – Truth table used by the PPM for TxOption

RT_CLASS_X	ARProperties. StartupMode	IRT	MRPD	DFP	Description
		FrameSendOffset, Port	FrameID, FrameSendOffset, Port	SFPosition	
RT_CLASS_1, RT_CLASS_2, RT_CLASS_UDP	—	—	—	—	PPM shall create one frame
RT_CLASS_3	Legacy	Values given	—	—	PPM shall create two frames. During startup (see Annex B) one frame with the given values from the connect service and one frame with RR=128 only send in the GREEN PERIOD. After ReadyForRTC3 the additional (GREEN) frame shall be deleted.
RT_CLASS_3	Legacy	Values given	Values given	—	Not supported
RT_CLASS_3	Legacy	Values given	—	Values given	Not supported
RT_CLASS_3	Legacy	Values given	Values given	Values given	Not supported
RT_CLASS_3	Advanced	Values given	—	—	PPM shall create one frame (see Annex A)
RT_CLASS_3	Advanced	Values given	Values given	—	PPM shall create two frames (see Annex A and Annex Q)
RT_CLASS_3	Advanced	Values given	—	Values given	PPM shall create one frame (see Annex A)
RT_CLASS_3	Advanced	Values given	Values given	Values given	PPM shall create two frames (see Annex A and Annex Q)

4.7.4.2 Consumer protocol machine

4.7.4.2.1 General

Figure 56 shows the basic structure of the Consumer protocol machine (CPM).

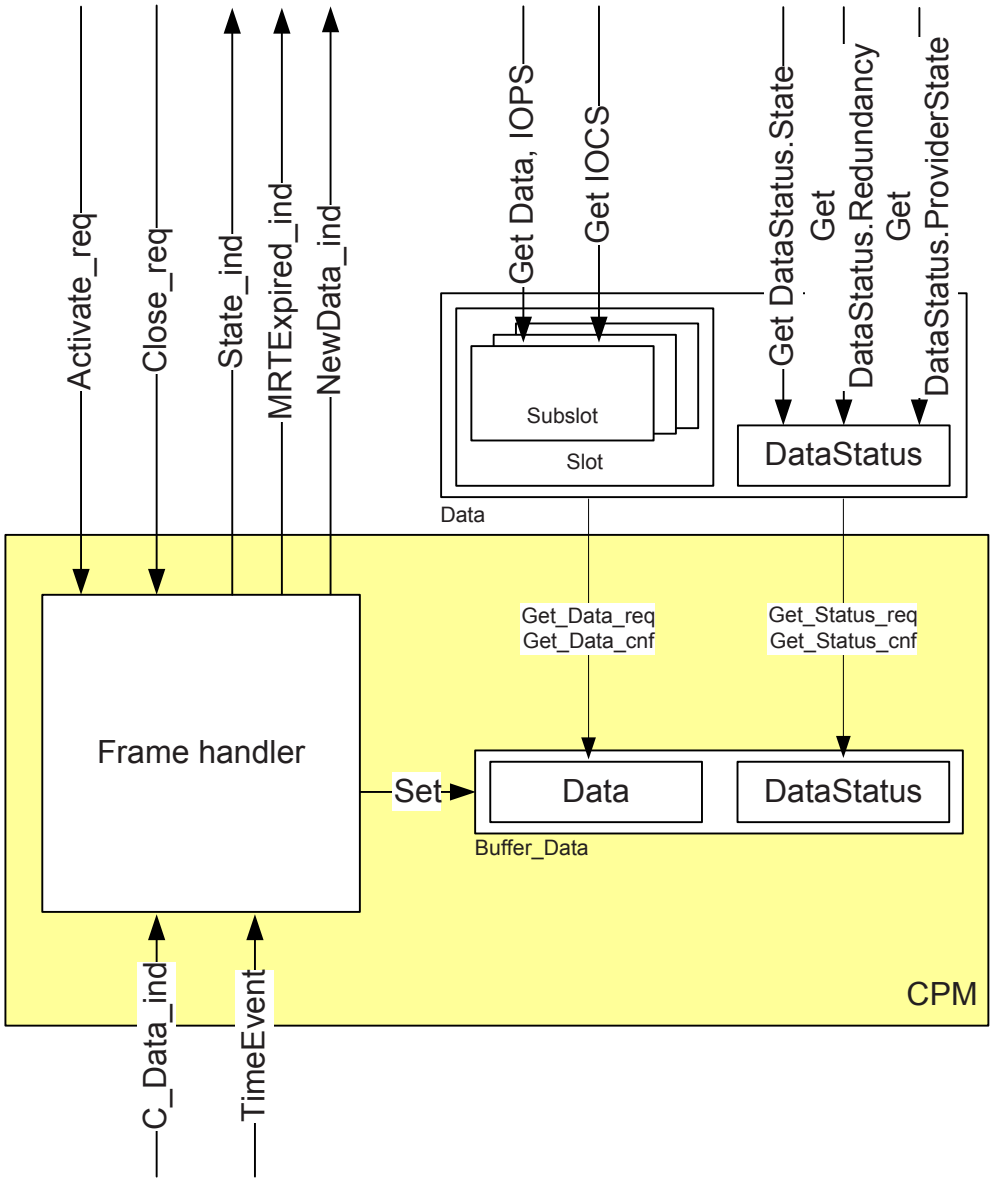


Figure 56 – Basic structure of a CPM

4.7.4.2.2 Primitive definitions

4.7.4.2.2.1 Primitives exchanged between remote machines

The remote service primitives including their associated parameters issued or received by CPM are described in the service definition and shown in Table 182.

Table 182 – Remote primitives issued or received by CPM

Primitive	Source	Destination	Associated parameters	Functions
LMPM_C_Data.ind	LMPM	CPM	CREP, Port, DA, SA, Prio, C_SDU, APDU_Status	—

Primitive	Source	Destination	Associated parameters	Functions
UDP_C_Data.ind	IP	CPM	CREP, IPPort, DA, SA, Prio, C_SDU, APDU_Status	—

4.7.4.2.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CPM are described in the service definition and shown in Table 185.

Table 183 – Local primitives issued or received by CPM

Primitive	Source	Destination	Associated parameters	Functions
CPM_Activate_cnf (-)	CPM	CMSU CMDMC CTLSU	CREP, ERRCLS, ERRCODE	—
CPM_Activate_cnf (+)	CPM	CMSU CMDMC CTLSU	CREP	—
CPM_Activate_req	CMSU CMDMC CTLSU	CPM	CREP, DA, SA, FrameID, RxOption, Exp_Length, DataHoldFactor, Default_Value, Default_Status	—
CPM_Close_cnf (+)	CPM	CMSU CMDMC CTLSU	CREP	—
CPM_Close_req	CMSU CMDMC CTLSU	CPM	CREP	—
CPM_Error_ind	CPM	CMSU CTLSU	CREP, ERRCLS, ERRCODE	Locally generated event if something strange happens
CPM_Get_Data_cnf (-)	CPM	FSPMDEV FSPMCTL	CREP, ERRCLS, ERRCODE	—
CPM_Get_Data_cnf (+)	CPM	FSPMDEV FSPMCTL	CREP, Data, New_Flag	—
CPM_Get_Data_req	FSPMDEV FSPMCTL	CPM	CREP	—
CPM_Get_Status_cnf (-)	CPM	FSPMDEV FSPMCTL	CREP, ERRCLS, ERRCODE	—
CPM_Get_Status_cnf (+)	CPM	FSPMDEV FSPMCTL	CREP, Status, RecvCounter	—
CPM_Get_Status_req	FSPMDEV FSPMCTL	CPM	CREP	—
CPM_MRTExpired_ind	CPM	Diagnosis Module	info	—

Primitive	Source	Destination	Associated parameters	Functions
CPM_NewData_ind	CPM	FSPMDEV FSPMCTL CMIO CTLIO CMDMC	AREP, CREP, APDU_Status, data {Data, NoData}	—
CPM_State_ind	CPM	CMIO CTLIO CMDMC	state {Start, Stop}	—

4.7.4.2.3 State transition diagram

The state transition diagram of the CPM is shown in Figure 57.

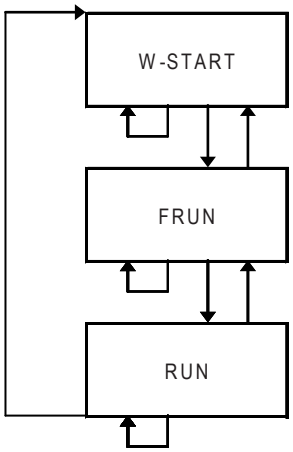


Figure 57 – State transition diagram of CPM

States of the CPM

W-START	The W-START state indicates that the initialization is needed. The Activate service sets the machine in the RUN state or in the FRUN (first run) state.
FRUN	The state machine is waiting for the first C_Data_ind service indication in these states. The DataHoldTime is ignored in this state. After passing the Start indication to the user the RUN state is entered.
RUN	In this state the monitoring using the DataHoldtime is active. A timeout will force a state transition back to FRUN (combined with a Stop indication). A Close service request is needed to reenter the W-START state.

4.7.4.2.4 State machine description

The W-START state indicates that the initialization is needed. The Activate service sets the machine in the RUN state or in the FRUN (first run) state. The state machine is waiting for the first LMPM_C_Data service indication in these states. After passing the Start indication to the user the RUN state is entered.

A timeout will force a state transition back to FRUN (combined with a Stop indication). A Close service request is needed to reenter the W-START state.

Each time receiving valid C_Data.ind the time is read and stored in a local variable together with a flag.

Each CPM handles up to two frames with one or two FrameIDs. For RTC3 compatibility two frames with the same FrameID and for MRPD two frames with two FrameIDs (FrameID and FrameID+1) are handled.

4.7.4.2.5 CPM state table

Table 184 contains the complete description of the CPM state table.

Table 184 – CPM state table

#	Current State	Event /Condition =>Action	Next State
1	W-START	**CPM_Activate_req ()** => Store DA, SA, FrameID, RxOption, DataHoldFactor, Default_Value, Default_Status New_Data := FALSE for all ports of interface do: RxA(Port, FrameID) := Invalid DHt := 0 Cycle := 0 RecvCnt := 0 Buffer_Data := Default_Value Buffer_Status := Default_Status Primary := TRUE ControlInterval := SendClockFactor x ReductionRatio x 31,25 μs StartTimer (ControlInterval) CPM_Activate_cnf (+)	FRUN
2	W-START	**CPM_Close_req ()** => StopTimer (ControlInterval) CPM_Close_cnf (+)	W-START
3	W-START	**CPM_Get_Status_req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE CPM_Get_Status_cnf (-)	W-START
4	W-START	**CPM_Get_Data_req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE CPM_Get_Data_cnf (-)	W-START
5	W-START	C_Data_ind => ignore	W-START
6	FRUN	**CPM_Activate_req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE CPM_Activate_cnf (-)	FRUN
7	FRUN	**CPM_Close_req ()** => StopTimer () CPM_Close_cnf (+)	W-START
8	FRUN	**CPM_Get_Status_req ()** => Status := Cycle, Buffer_Status RecvCounter := RecvCnt RecvCnt := 0 CPM_Get_Status_cnf (+)	FRUN
9	FRUN	**CPM_Get_Data_req ()** => Data := Buffer_Data New_Flag := New_Data New_Data := FALSE	FRUN

#	Current State	Event /Condition =>Action	Next State
		CPM_Get_Data_cnf (+)	
10	FRUN	**C_Data_ind** /FrameGuard () == INVALID => ignore	FRUN

11	FRUN	**C_Data_ind**
		/FrameGuard () == VALID, DHTReload, UpdateData
		=>
		New_Data := TRUE
		RxA(Port, FrameID) := APDU_Status.Cycle_Counter
		DHt := 0
		Cycle := APDU_Status.Cycle_Counter
		Buffer_Data := Filter (Data)
		Buffer_Status := APDU_Status
		RecvCnt := RecvCnt + 1
		CPM_State_ind (Start)
		CPM_NewData_ind (Data)
		If MRPD active then
		  StartTimer (MRPDt)
		
		//NOTE DataStatus.State == don't care and DataStatus.DataValid == Valid
			RUN

12	FRUN	**C_Data_ind**
		/FrameGuard () == VALID, DHTReload
		=>
		RxA(Port, FrameID) := APDU_Status.Cycle_Counter
		DHt := 0
		Cycle := APDU_Status.Cycle_Counter
		Buffer_Status := APDU_Status
		RecvCnt := RecvCnt + 1
		CPM_State_ind (Start)
		CPM_NewData_ind (NoData)
		
		If MRPD active then
		  StartTimer (MRPDt)
		
		//NOTE DataStatus.State == Backup
			RUN

13	FRUN	TimerExpired (ControlInterval) => ignore	FRUN
14	FRUN	TimerExpired (MRWDt) => ignore	FRUN
15	RUN	**CPM_Activate_req ()** => ERRCLS := CTXT ERRCODE := INVALID_STATE CPM_Activate_cnf (-)	RUN
16	RUN	**CPM_Close_req ()** => StopTimer (ControlInterval) CPM_Close_cnf (+)	W-START
17	RUN	**CPM_Get_Status_req ()** => Status := Cycle, Buffer_Status, RecvCounter := RecvCnt, RecvCnt := 0 CPM_Get_Status_cnf (+)	RUN
18	RUN	**CPM_Get_Data_req ()** => Data := Buffer_Data, New_Flag := New_Data New_Data := FALSE CPM_Get_Data_cnf (+)	RUN
19	RUN	**C_Data_ind** /FrameGuard () == INVALID =>	RUN

#	Current State	Event /Condition =>Action	Next State
		ignore	
20	RUN	**C_Data_ind** /FrameGuard () == VALID, DHTReload, UpdateData => New_Data := TRUE, RxA(Port, FrameID) := APDU_Status.Cycle_Counter DHt := 0 Cycle := APDU_Status.Cycle_Counter Buffer_Data := Filter (Data) Buffer_Status := APDU_Status RecvCnt := RecvCnt + 1 CPM_NewData_ind (Data) //NOTE DataStatus.State == don't care and DataStatus.DataValid == Valid	RUN
21	RUN	**C_Data_ind** /FrameGuard () == VALID, DHTReload => RxA(Port, FrameID) := APDU_Status.Cycle_Counter DHt := 0 Cycle := APDU_Status.Cycle_Counter Buffer_Status := APDU_Status RecvCnt := RecvCnt + 1 CPM_NewData_ind (NoData) //NOTE DataStatus.State == Backup	RUN
22	RUN	**TimerExpired (ControlInterval)** /DHt > (DataHoldFactor-1) => DHt := 0 CPM_State_ind (Stop) //NOTE DHt expired	FRUN
23	RUN	**TimerExpired (ControlInterval)** /DHt < (DataHoldFactor) => DHt := DHt +1	RUN
24	RUN	**TimerExpired (MRWDt)** /MRPD active && MRWDt expired => CPM_MRTExpired_ind (Fault)	RUN
25	RUN	**TimerExpired (MRWDt)** /MRPD active && MRPDGuard () == Adjunctive frame received => for all ports, FrameIDs RxA(Port, FrameID) := Invalid StopTimer (MRWDt) CPM_MRTExpired_ind (Ok)	RUN
26	RUN	**TimerExpired (MRWDt)** /MRPD active && MRPDGuard () == No adjunctive frame received => for all ports, FrameIDs RxA(Port, FrameID) := Invalid StartTimer (MRWDt)	RUN

4.7.4.2.6 Functions, Macros, Timers and Variables

Table 185 contains the functions, macros, timers and variables used by the CPM and their arguments and their descriptions.

Table 185 – Functions, Macros, Timers and Variables used by the CPM

Name	Type	Function/Meaning
Filter	Function	This local function filters from the received data the to be stored portion for the Buffer_Data.
FrameGuard	Function	This local function checks the received frame against the expected structure and semantics according the coding and the truth tables. VALID / INVALID: This flag shows whether the received frame is valid. DHTReload: This flag shows, that the DataHoldTimer shall be retriggered. UpdateData: This flag shows, that Buffer_Data and Buffer_Status shall be updated with the received data.
MRPDGuard	Function	This local function checks whether the adjunctive frame defined by the activation of MRPD is received or not. It uses the local variable RxA as database.
StartTimer	Function	This local function starts or restarts a timer.
StopTimer	Function	This local function stops a timer.
TimerExpired	Function	This local function is issued if a timer expires.

C_Data_ind	Macro	if (RxOption == RTC)
		LMPM_C_Data.ind (CREP, Port, DA, SA, Prio, C_SDU, APDU_Status)
		
		if (RxOption == UDP)
		UDP_C_Data.ind (IPPort, CREP, DA, SA, Prio, C_SDU, APDU_Status)

RxOption	Macro	Contains the - RT_CLASS_x - FrameID, - if MRPD - FrameID (redundant path), - Media redundancy watchdog (MRPD active) - if DFP - subaddress SFPosition
ControlInterval	Timer	This local timer contains the monitoring interval for the DataHoldFactor. ControlInterval := SendClockFactor x ReductionRatio x 31,25 μs This timer shall use a autoreload function to start itself after it expires. It shall be aligned to the PTCP or local driven SendClock.
MRWDt	Timer	This local timer contains the monitoring interval for the Media Redundancy WatchDog time. It is used to monitor the receiving of the adjunctive frames defined by MRPD and issue an event if expired.
Buffer_Data	Variable	This local variable contains the last valid service data unit conveyed with a LMPM_C_Data indication.
Buffer_Status	Variable	This local variable contains the last valid APDU_Status conveyed with a LMPM_C_Data indication.
Cycle	Variable	This local variable contains the last valid Cycle Counter conveyed with a LMPM_C_Data indication with valid data.
Default_Status	Variable	The CycleCounter is set to invalid, the TransferStatus and the DataStatus is set to zero.
Default_Value	Variable	The Data is set to zero and the IOxS to BAD.
DHt	Variable	This local variable contains the DataHoldFactor counter value of the time events since last LMPM_C_Data indication.
ERRCLS	Variable	This local variable contains the entity signaling the error.
ERRCODE	Variable	This local variable contains the error reason in the context of the ERRCLS.
New_Data	Variable	This local variable signals the receipt of a valid LMPM_C_Data indication (set to FALSE by a GetData request).
RecvCnt	Variable	This local variable contains the counter value of the received cyclic PDU since last GetStatus request.

Name	Type	Function/Meaning

RxA	Variable	This local variable contains the stored information about the received frames for the MRPD checking.
		
		Principle:
		RxA(m, n) == RxA(o, n+1)
		// Stored APDU_Status.CycleCounter are equal
		// m, o element {1..MaxPort}
		// n, n+1 element {FrameID, FrameID+1}

Table 186 contains the valid combinations, their meaning and their description for RxOption.

Table 186 – Truth table used by the CPM for RxOption

RT_CLASS_X	ARProperties. StartupMode	MRPD	DFP	Description
		FrameID, Redundancy watchdog	SFPosition	
RT_CLASS_1, RT_CLASS_2, RT_CLASS_UDP	—	—	—	CPM shall create one consumer for one frame
RT_CLASS_3	FALSE	—	—	CPM shall create one consumer for one frame. During startup (see Annex B) the DHT values are for RR=256 and after ReadyForRTC3 as given during the connect service.
RT_CLASS_3	FALSE	Values given	—	Not supported
RT_CLASS_3	FALSE	—	Values given	Not supported
RT_CLASS_3	FALSE	Values given	Values given	Not supported
RT_CLASS_3	TRUE	—	—	CPM shall create one consumer for one frame (see Annex A)
RT_CLASS_3	TRUE	Values given	—	CPM shall create one consumer for two frames (see Annex A and Annex Q)
RT_CLASS_3	TRUE	—	Values given	CPM shall create one consumer for one frame (see Annex A)
RT_CLASS_3	TRUE	Values given	Values given	CPM shall create one consumer for two frames (see Annex A and Annex Q)

4.7.4.2.7 Truth tables

4.7.4.2.7.1 CPM checking rules for one frame

Table 187, Table 188, Table 189 and Table 190 contains the truth table used by the CPM for frames.

Table 187 – Truth table for one frame using RT_CLASS_x

Input					Output
Received frame					Local
Received-InRED [c]	APDU_Status. TransferStatus	SourceMAC-Address [b]	FrameID, redundant FrameID [a]	C_SDU. Length	Frame structure
FALSE	—	—	—	—	Invalid

Input					Output
Received frame					Local
TRUE	InValid	—	—	—	Invalid
TRUE	Valid	Wrong	—	—	Invalid
TRUE	Valid	Ok	Wrong	—	Invalid
TRUE	Valid	Ok	Ok	Wrong	Invalid
TRUE	Valid	Ok	Ok	Ok	Valid
[a] The SFPosition.Position (different frame layout) is managed by the DFP_RELAY. [b] For frames using DFP optional. [c] Only checked for RT_CLASS_3.					

Table 188 – Truth table for one frame using RT_CLASS_UDP

Input					Output
Received frame					Local
APDU_Status. TransferStatus	SourceIP-Address	SourceIPPort	FrameID, redundant FrameID	C_SDU. Length	Frame structure
Invalid	—	—	—	—	Invalid
Valid	Wrong	—	—	—	Invalid
Valid	Ok	Wrong	—	—	Invalid
Valid	Ok	Ok	Wrong	—	Invalid
Valid	Ok	Ok	Ok	Wrong	Invalid
Valid	Ok	Ok	Ok	Ok	Valid

Table 189 – Truth table for the C_SDU

Input	Output
Received frame	Local
APDU_Status.CycleCounter	C_SDU structure
Older [a]	Invalid
Newer [b]	Valid
[a] See 4.7.2.1.2 and Table 161. When activating a CPM, the stored CycleCounterValue is set to invalid to make the next received frame in all cases “Newer”. [b] See 4.7.2.1.2 and Table 161.	

Table 190 – Truth table for arranging DHt and data

Input				Output		
Received frame				Local		
Frame structure	C_SDU structure	APDU_Status. DataStatus. DataValid	APDU_Status. DataStatus. State	Datahold timer	Update data	FrameGuard
Invalid	—	—	—	—	No	Invalid
Valid	Invalid	—	—	—	No	Invalid
Valid	Valid	Invalid	Primary	—	No	Invalid
Valid	Valid	Invalid	Backup	Reload	No	Valid
Valid	Valid	Valid	Primary	Reload	Yes	Valid
Valid	Valid	Valid	Backup	Reload	Yes	Valid

4.7.4.2.7.2 CPM checking rules for one subframe

Table 191, Table 192, Table 193 and Table 194 contains the truth table used by the CPM for subframes.

Table 191 – Truth table for the subframe – frame check

Input			Output
FrameID	SourceMAC-address	Header Subframe. SFCRC16	Frame check
FALSE	—	—	Invalid
TRUE	FALSE	—	Invalid
TRUE	TRUE	Invalid	Invalid
TRUE	TRUE	Valid	Valid
TRUE	TRUE	Don’t care	Valid

Table 192 – Truth table for the subframe – sub frame check

Input			Output
Subframe. Position	Subframe. Length	Subframe. SFCRC16	Sub frame check
FALSE	—	—	Invalid
TRUE	FALSE	—	Invalid
TRUE	TRUE	Invalid	Invalid
TRUE	TRUE	Valid	Valid
TRUE	TRUE	Don’t care	Valid

Table 193 – Truth table for the subframe – sub frame data check

Input		Output
Subframe. DataStatus. Ignore	Subframe. SFCycleCounter	Sub frame data check
Ignore	—	Invalid
Ok	OLD	Invalid
Ok	NEW	Valid

Table 194 – Truth table for the subframe – DHt and data

Input					Output		
Received frame					Local		
Frame check	Sub frame check	Sub frame data check	Subframe. DataStatus. Valid	Subframe. DataStatus. State	Datahold timer	Update data	Frame-Guard
Invalid	—	—	—	—	—	No	Invalid
Valid	Invalid	—	—	—	—	No	Invalid
Valid	Valid	Invalid	—	—	—	No	Invalid
Valid	Valid	Valid	Invalid	Backup	Reload	No	Valid
Valid	Valid	Valid	Valid	Primary	Reload	Yes	Valid
Valid	Valid	Valid	Valid	Backup	Reload	Yes	Valid

4.7.5 DLL Mapping Protocol Machines

There is no DLL Mapping Protocol Machine (DMPM) defined for this Protocol.

4.8 Real time acyclic

4.8.1 RTA syntax description

4.8.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.8.1.2 RTA APDU abstract syntax

Table 195 defines the abstract syntax of the Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 195 shall represent the content of the DLSDU in Table 5.

Table 195 – RTA APDU syntax

APDU name	APDU structure
RTA-PDU	DATA-RTA-PDU ^ ACK-RTA-PDU ^ NACK-RTA-PDU ^ ERR-RTA-PDU
UDP-RTA-PDU	IPHeader, UDPHeader, FrameID, RTA-PDU
NOTE The DLPDU_Padding applies for the RTA-PDU and the UDP-RTA-PDU.	

Table 196 defines structures for substitutions of elements of the APDU structures shown in Table 195.

Table 196 – RTA substitutions

Substitution name	Structure
Reference	DestinationServiceAccessPoint, SourceServiceAccessPoint
Destination-ServiceAccess-Point	AlarmEndpoint
Source-ServiceAccess-Point	AlarmEndpoint
FlagsSequence	AddFlags, SendSeqNum, AckSeqNum
VendorDevice-ErrorInfo	VendorID, DeviceID, Data*
DATA-RTA-PDU	Reference, PDUType (=1), FlagsSequence, VarPartLen (1 – 1 432) [a], RTA-SDU
ACK-RTA-PDU	Reference, PDUType (=3), FlagsSequence, VarPartLen (=0)
NACK-RTA-PDU	Reference, PDUType (=2), FlagsSequence, VarPartLen (=0)
ERR-RTA-PDU	Reference, PDUType (=4), FlagsSequence, VarPartLen (=4), PNIOStatus, [VendorDeviceErrorInfo] [b]

[a] The maximum VarPartLen is calculated to fit in the RTA-PDU and in the UDP-RTA-PDU.

[b] The number of octets of this substitution shall not exceed the DLPDU_Padding. See minimum frame size in IEEE 802.3

4.8.2 RTA transfer syntax

4.8.2.1 Coding section related to RTA-PDUs specific fields

4.8.2.1.1 Coding of the field AlarmEndpoint

This field shall be coded as data type Unsigned16. It identifies, in combination with the Host-Address, the service access points of a bidirectional connection as shown in Figure 58. The values for source and destination shall be exchanged during a context management operation.

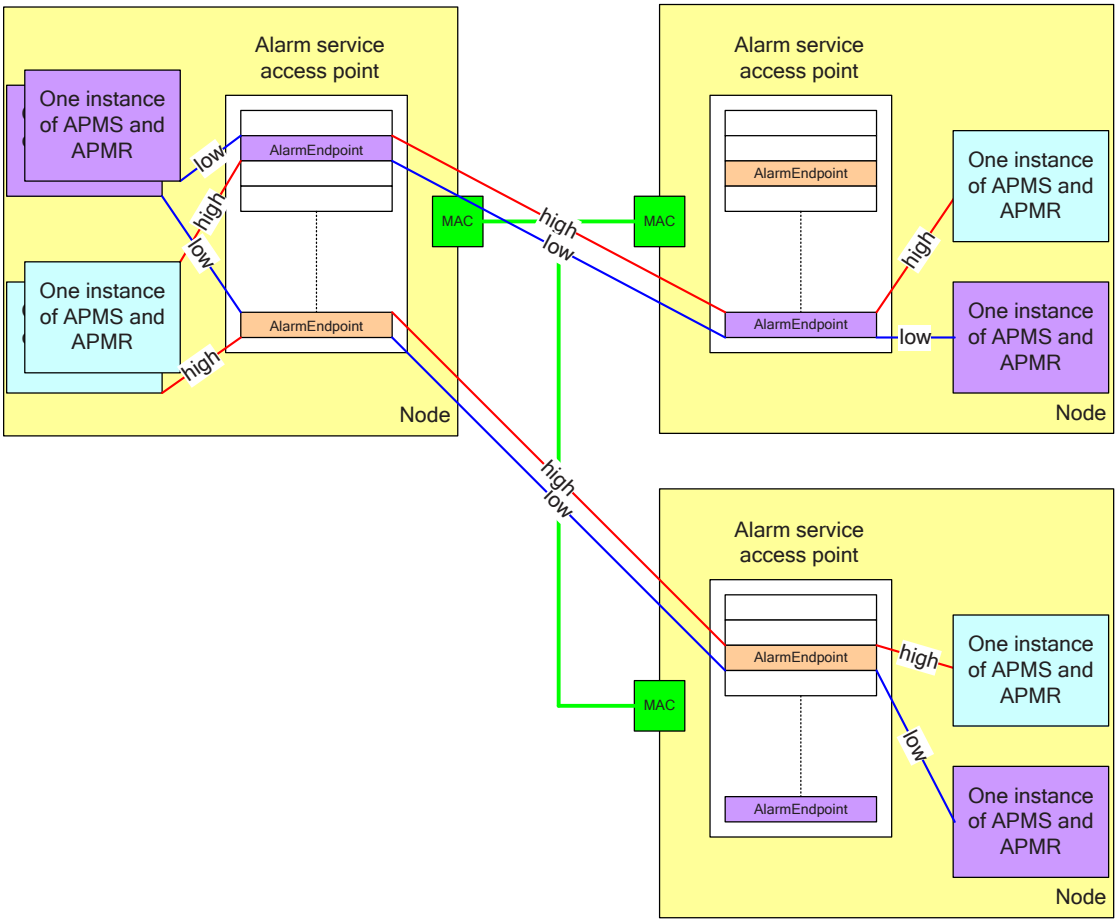


Figure 58 – Addressing scheme of RTA

NOTE The IO controller send its AlarmEndpoint during the connect to the IO device using the field LocalAlarmReference in the AlarmCRBlockReq. The IO device responds with its AlarmEndpoint using the field LocalAlarmReference in the AlarmCRBlockRes.

The IO controller uses its AlarmEndpoint as SourceServiceAccessPoint and the AlarmEndpoint of the IO devices as DestinationServiceAccessPoint. The IO device uses its AlarmEndpoint as SourceServiceAccessPoint and the AlarmEndpoint of the IO controller as DestinationServiceAccessPoint.

4.8.2.1.2 Coding of the field PDUType

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0 – 3: PDUType.Type
This field shall be coded with the values according to Table 197.

Table 197 – PDUType.Type

Value (hexadecimal)	Meaning	Usage
0x00	Reserved	—
0x01	RTA_TYPE_DATA	Shall only be used to encode the DATA-RTA-PDU
0x02	RTA_TYPE_NACK	Shall only be used to encode the NACK-RTA-PDU
0x03	RTA_TYPE_ACK	Shall only be used to encode the ACK-RTA-PDU

Value (hexadecimal)	Meaning	Usage
0x04	RTA_TYPE_ERR	Shall only be used to encode the ERR-RTA-PDU
0x05 – 0x0F	Reserved	—

Bit 4 – 7: PDUType.Version
This field shall be coded with the values according to Table 198.

Table 198 – PDUType.Version

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Version 1 of the protocol
0x02 – 0x0F	Reserved

4.8.2.1.3 Coding of the field AddFlags

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0 – 3: AddFlags.WindowSize
This field shall be coded with the values according to Table 199.

Table 199 – AddFlags.WindowSize

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Window size one
0x02 – 0x07	Reserved

Bit 4: AddFlags.TACK
This field shall be coded with the values according to Table 200 by the sender within a RTA-PDU to control the acknowledge behavior of the receiver.

Table 200 – AddFlags.TACK

Value (hexadecimal)	Meaning	Usage
0x00	No immediate acknowledge	Shall be set for ERR-RTA-PDU, ACK-RTA-PDU and NACK-RTA-PDU and not checked by the receiver.
0x01	Immediate acknowledge	Shall be set for immediate acknowledge for DATA-RTA-PDU.

Bit 5 – 7: AddFlags.reserved
This field shall be set according to 3.4.2.2.

4.8.2.1.4 Coding of the field SendSeqNum

This field shall be coded as data type Unsigned16 with values according to Table 201.

Table 201 – SendSeqNum

Value (hexadecimal)	Usage
0x0000 – 0x7FFF	The first issued DATA-RTA-PDU shall contain the value zero.
other	Reserved
0xFFFE	This value shall be used to synchronize sender and receiver after establishment of the application relationship. This value indicates that there was no reception of a DATA-RTA-PDU before.
0xFFFF	This value shall be used to synchronize sender and receiver after establishment of the application relationship. This value indicates the first DATA-RTA-PDU.

This field contains the number of the DATA-RTA-PDU. The incrementing and comparison of this number is done using modulo 2^{15} operations.

NOTE The first DATA-RTA-PDU sets SendSeqNum=0xFFFF and AckSeqNum=0xFFFE. It is acknowledged with SendSeqNum=0xFFFE and AckSeqNum=0xFFFF. The second DATA-RTA-PDU sets SendSeqNum=0 and AckSeqNum=0xFFFE. The synchronization is necessary because the acyclic protocol does not define any connection monitoring.

4.8.2.1.5 Coding of the field AckSeqNum

This field shall be coded as data type Unsigned16 with values according to Table 202.

Table 202 – AckSeqNum

Value (hexadecimal)	Usage
0x0000 – 0x7FFF	The first issued DATA-RTA-PDU shall contain the value zero.
other	Reserved
0xFFFE	This value shall be used to synchronize sender and receiver after establishment of the application relationship. This value indicates that there was no DATA-RTA-PDU received before.
0xFFFF	This value shall be used to synchronize sender and receiver after establishment of the application relationship. This value acknowledges the reception of the first DATA-RTA-PDU.

This field contains the number of the DATA-RTA-PDU that is expected to be acknowledged or which is acknowledged.

4.8.2.1.6 Coding of the field VarPartLen

This field shall be coded as data type Unsigned16 according to Table 203. The VarPartLen shall not contain the DLPDU_Padding.

Table 203 – VarPartLen

Value (hexadecimal)	Meaning
0x0000	No RTA-SDU exists
0x0001 – 0x0598	A RTA-SDU with VarPartLen octets exists
0x0599 – 0xFFFF	Reserved

4.8.3 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.8.4 Application Relationship Protocol Machines

4.8.4.1 General

The symmetrical RTA transport is used by the symmetrical Acyclic Protocol Machine (APM). The APM is built as shown in Figure 59. An ALPMI / ALPMR channel is addressed by Source-Node, Destination-Node, Source-SAP, Destination-SAP and FrameID high or low.

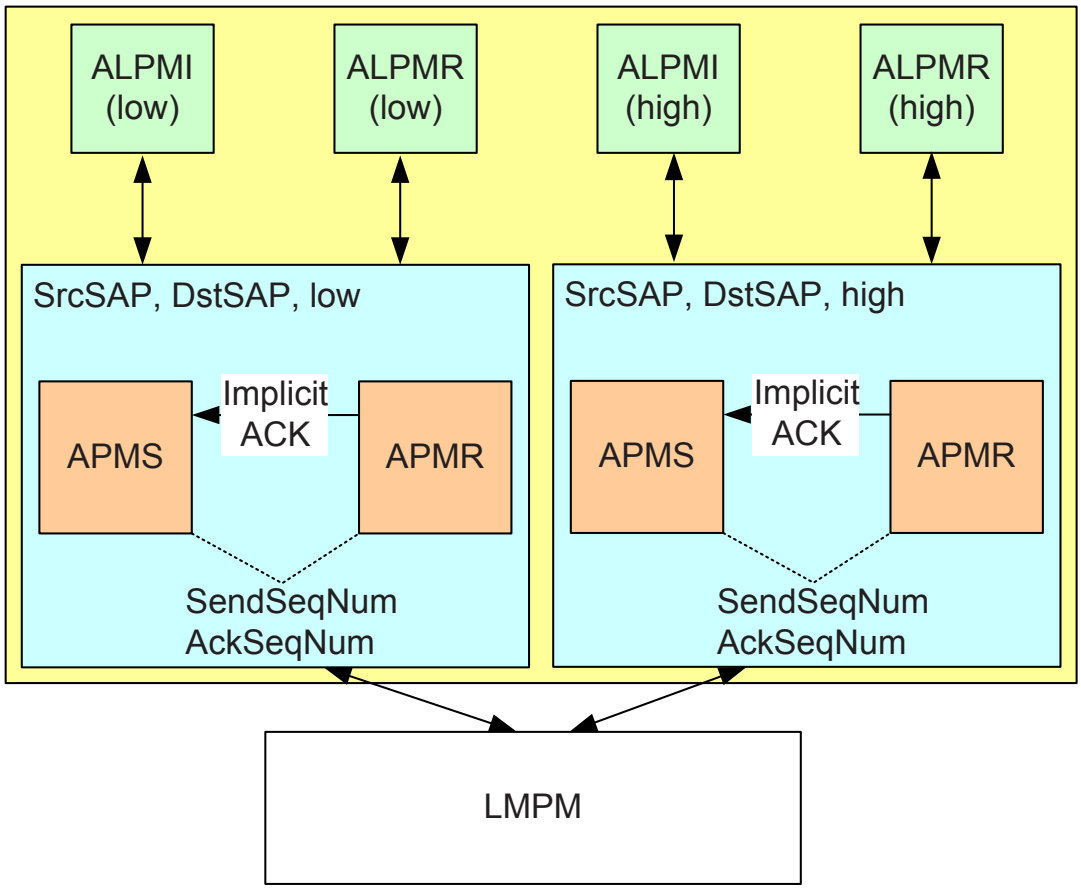


Figure 59 – Structure of the APM

4.8.4.2 Acyclic Protocol Machine Sender

4.8.4.2.1 General

In the following the structure of the Acyclic Protocol Machine Sender (APMS) is shown (see Figure 60).

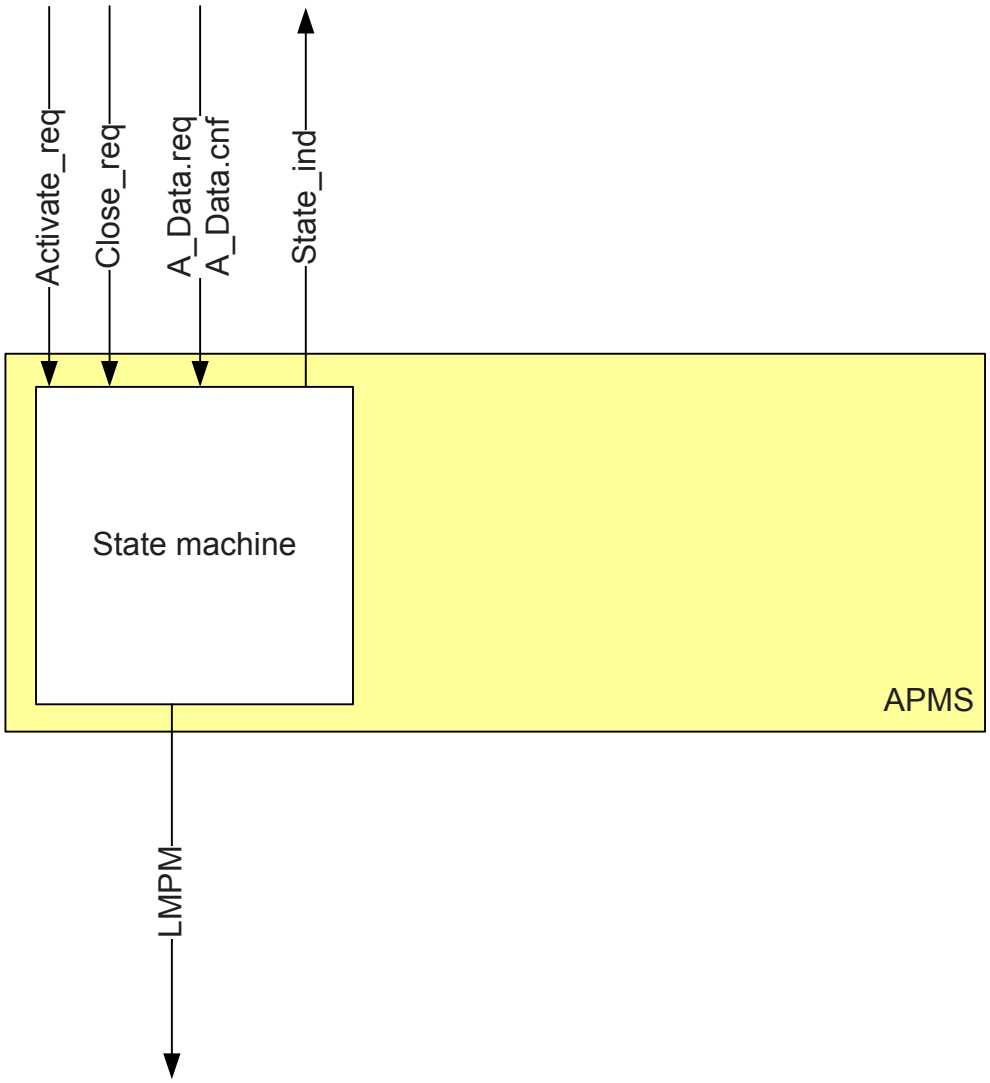


Figure 60 – Structure of the APMS

4.8.4.2.2 Primitive definitions

4.8.4.2.2.1 Primitives exchanged between remote machines

The remote service primitives including their associated parameters issued or received by APMS are described in the service definition and shown in Table 204.

Table 204 – Remote primitives issued or received by APMS

Primitive	Source	Destination	Associated parameters	Functions
APMS_A_Data.cnf (-)	APMS	ALPMI ALPMR	CREP, ERRCLS, ERRCODE	—
APMS_A_Data.cnf (+)	APMS	ALPMI ALPMR	CREP	—
APMS_A_Data.req	ALPMI ALPMR	APMS	CREP, Data	—
LMPM_A_Data.cnf	LMPM	APMS	CREP, LMPM_status	

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.ind	LMPM	APMS	CREP, S_Port, Tstamp, DA, SA, VLANPrio, VLANID, A_SDU	—
LMPM_N_Data.cnf	LMPM	APMS	CREP, LMPM_status	—
LMPM_N_Data.ind	LMPM	APMS	CREP, DA, SA, VLANPrio, VLANId, N_SDU	—
LMPM_A_Data.req	APMS	LMPM	CREP, S_Port, Tstamp, DA, SA, VLANPrio, VLANID, A_SDU	—
LMPM_N_Data.req	APMS	LMPM	CREP, DA, SA, VLANPrio, VLANId, N_SDU	—

4.8.4.2.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by APMS are described in the service definition and shown in Table 205.

Table 205 – Local primitives issued or received by APMS

Primitive	Source	Destination	Associated parameters	Functions
APMS_Activate_req	ALPMI ALPMR	APMS	CREP, DA, SA, FrameID, VLANPrio, VLANID, RTATimeoutFactor, RTARetries, Transport, DstIP, SrcIP	—
APMS_Close_req	ALPMI ALPMR	APMS	CREP, ErrCode	—
APMS_Close_cnf	APMS	ALPMI ALPMR	CREP	—
APMS_Activate_cnf (-)	APMS	ALPMI ALPMR	CREP, ERRCLS, ERRCODE	—
APMS_Activate_cnf (+)	APMS	ALPMI ALPMR	CREP	—
APMS_Error_ind	APMS	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—

4.8.4.2.3 State transition diagram

The state transition diagram of the APMS is shown in Figure 61.

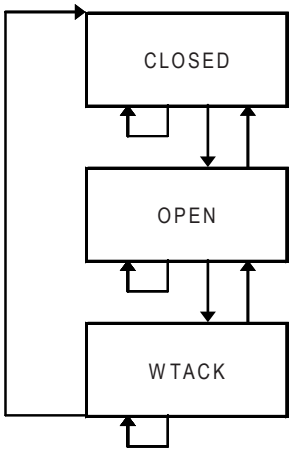


Figure 61 – State transition diagram of APMS

States of the APMS

CLOSED	The CLOSED state indicates that an initialization is needed. Activate service sets the machine in the OPEN state.
OPEN	Waiting for A-Data service request
WTACK	After issuing the transmission of data the WTACK state is used to wait for a transport acknowledge. Receiving the acknowledge will set back the machine to the OPEN state.

4.8.4.2.4 State machine description

This state machine, addressed by Source-Host, Source-ServiceAccessPoint, Destination-Host, DestinationAccessPoint and Priority, handles the A-Data service. Each priority (High and Low) is handled independent. This state machine is part of the APMS and APMR pair which is used as sender and responder for the transport acknowledge A-Data services. The A-Data service are used for the Alarm transport.

4.8.4.2.5 APMS state table

Table 206 contains the complete description of the APMS state machine. A LMPM_A_Data.ind primitive will be accepted if the value of the PDUType.Type field is DATA-RTA-PDU, ACK-RTA-PDU or NACK-RTA-PDU and the PDUType. Version is RTA_VERS=1.

The APMS state machine specify the abort sequence and shows the corresponding ERR-RTA-PDU. These PDU shall only be sent from the APMS for low priority alarms from both sides of the connection.

Table 206 – APMS state table

#	Current State	Event /Condition =>Action	Next State
1	CLOSED	**APMS_Activate.req ()** => AlarmInstance[SrcSAP, DstSAP, Prio] := DA, RTATimeoutFactor, RTARetries, … // NOTE Information used for ALPMI, ALPMR, APMS and APMR Send_Seq_Count:=0xffff Send_Seq_CountO:=0xfffe Use CREP to identify the AlarmInstance APMS_Activate.cnf (+)	OPEN
2	CLOSED	**APMS_Close.req ()** => APMS_Close.cnf ()	CLOSED
3	CLOSED	**APMS_A_Data.req ()** => ERRCLS := APMS ERRCODE := INVALID_STATE APMS_A_Data.cnf (-)	CLOSED
4	CLOSED	A_Data_ind => ignore	CLOSED
5	CLOSED	A_Data_cnf => ignore	CLOSED
6	OPEN	**APMS_Activate.req ()** => ERRCLS := APMS ERRCODE := INVALID_STATE APMS_Activate.cnf (-)	OPEN
7	OPEN	**APMS_Close.req ()** /VLANPrio == Low => PDU.Version:=1 PDU.PDUType:=ERR PDU.AddFlags.TACK:=0 PDU.AddFlags.WindowSize:=1 PDU.SendSeqNum:=Send_Seq_Count PDU.AckSeqNum:=Expected_Seq_CountO (from APMR) PDU.PNIOStatus.ErrorCode = 0xCF PDU.PNIOStatus.ErrorDecode = 0x81 PDU.PNIOStatus.ErrorCode1 = 0xFD PDU.PNIOStatus.ErrorCode2 = ErrCode from APMS_Close request A_Data_req StopTimer (RTATimeout) APMS_Close.cnf ()	CLOSED
8	OPEN	**APMS_Close.req ()** /VLANPrio == High => //NOTE Error PDU only for the APMS instance “low” StopTimer (RTATimeout) APMS_Close.cnf ()	CLOSED
9	OPEN	**APMS_A_Data.req ()** => PDU.Version:=1 PDU.PDUType:=DATA PDU.AddFlags.TACK:=Tack PDU.AddFlags.WindowSize:=1 PDU.SendSeqNum:=Send_Seq_Count PDU.AckSeqNum:=Expected_Seq_CountO (from APMR) PDU.RTA-SDU:=Data Store PDU.Flags, PDU.RTA-SDU Retry:= RTARetries A_Data_req	WTACK

#	Current State	Event /Condition =>Action	Next State
10	OPEN	**A_Data_ind** /PDU.PDUType == DATA || PDU.PDUType == NAK || PDU.PDUType == ACK => ignore	OPEN
11	OPEN	**A_Data_ind** /PDU.Type == ERR => ERRCLS := PDU.PNIOStatus.ErrorCode1 ERRCODE := PDU.PNIOStatus.ErrorCode2 APMS_Error_ind ()	OPEN
12	OPEN	A_Data_cnf => ignore	OPEN
13	OPEN	TimerExpired => ignore	OPEN
14	WTACK	**APMS_Activate.req ()** => ERRCLS := APMS ERRCODE := INVALID_STATE APMS_Activate.cnf (-)	WTACK
15	WTACK	**APMS_Close.req ()** /VLANPrio == Low => PDU.Version:=1 PDU.PDUType:=ERR PDU.AddFlags:=0 PDU.Window:=1 PDU.SendSeqNum:=Send_Seq_Count PDU.AckSeqNum:=Expected_Seq_CountO (from APMR) PDU.PNIOStatus.ErrorCode = 0xCF PDU.PNIOStatus.ErrorDecode = 0x81 PDU.PNIOStatus.ErrorCode1 = 0xFD PDU.PNIOStatus.ErrorCode2 = ErrCode from APMS_Close request A_Data_req StopTimer (RTATimeout) APMS_Close.cnf ()	CLOSED
16	WTACK	**APMS_Close.req ()** /VLANPrio == High => StopTimer (RTATimeout) APMS_Close.cnf ()	CLOSED
17	WTACK	**APMS_A_Data.req ()** => ERRCLS := APMS ERRCODE := INVALID_STATE APMS_A_Data.cnf (-)	WTACK
18	WTACK	**A_Data_ind** /(PDU.PDUType == DATA || PDU.PDUType == ACK) && PDU.AckSeqNum == Send_Seq_Count => Send_Seq_CountO:=Send_Seq_Count Send_Seq_Count:= (Send_Seq_Count+1) & 0x7fff //NOTE TACK shall be done by ACK or DATA APMS_A_Data.cnf (+)	OPEN
19	WTACK	**A_Data_ind** /(PDU.PDUType == DATA || PDU.PDUType == ACK) && PDU.AckSeqNum != Send_Seq_Count => ignore	WTACK
21	WTACK	**A_Data_ind** /PDU.Type == ERR => APMS_Error_ind ()	WTACK

#	Current State	Event /Condition =>Action	Next State
21	WTACK	**A_Data_ind** /PDU.PDUType == NAK => ignore	WTACK
22	WTACK	**A_Data_cnf** => StartTimer (RTATimeout)	WTACK
23	WTACK	**TimerExpired** / Retry != 0 => PDU.Version:=1 PDU.PDUType:=DATA PDU.AddFlags.TACK:=from Stored PDU.AddFlags PDU.AddFlags.WindowSize:=1 PDU.SendSeqNum:=Send_Seq_Count PDU.AckSeqNum:=Expected_Seq_CountO (from APMR) PDU.RTA-SDU:=from Stored PDU.RTA-SDU Retry:= Retry-1 A_Data_req	WTACK
24	WTACK	**TimerExpired** /Retry == 0 => ERRCLS := APMS ERRCODE := TIMEOUT APMS_Error_ind () APMS_A_Data.cnf (-)	OPEN

4.8.4.2.6 Functions, Macros, Timers and Variables

Table 207 contains the functions, macros, timers and variables used by the APMS, their arguments and their descriptions.

Table 207 – Functions, Macros, Timers and Variables used by the APMS

Name	Type	Function/Meaning
StartTimer	Function	This function is used to start or restart a timer.
StopTimer	Function	This function is used to stop a timer.
TimerExpired	Function	This function signals that a timer is expired.

A_Data_cnf	Macro	if (Transport == RTC)
		LMPM_A_Data.cnf (CREP, D_Port, Tstamp, LMPM_status)
		
		if (Transport == UDP)
		LMPM_N_Data.cnf (CREP, D_Port, Tstamp, LMPM_status)

A_Data_ind	Macro	if (Transport == RTC)
		LMPM_A_Data.ind (CREP, S_Port, Tstamp, DA, SA, VLANPrio, VLANID, A_SDU)
		PDU := A_SDU
		
		if (Transport == UDP)
		LMPM_N_Data.ind (CREP, DA, SA, VLANPrio, VLANId, N_SDU)
		PDU := N_SDU

A_Data_req	Macro	if (Transport == RTC)
		A_SDU := PDU
		LMPM_A_Data.req (CREP, D_Port := AUTO, DA, SA, VLANPrio, VLANID, A_SDU)
		
		if (Transport == UDP)
		N_SDU := PDU
		LMPM_N_Data.req (CREP, D_Port := AUTO, DA, SA, VLANPrio, VLANID, N_SDU)

Name	Type	Function/Meaning
RTATimeout	Timer	This timer monitors the transport acknowledge from the responder
ERRCLS	Variable	This local variable contains the entity signaling the error.
ERRCODE	Variable	This local variable contains the error reason in the context of the ERRCLS.
Expected_Seq_CountO	Variable	This local variable contains the previous counter value of the Seq_Count variable.
RTARetries	Variable	This local variable contains the maximum retry factor from RTA ASE. The default value is 3.
Retry	Variable	This local variable is used as a working counter for the retry.
RTATimeoutFactor	Variable	This local variable contains the value from the RTA ASE. The default value is 100 ms.
Send_Seq_Count	Variable	This local variable contains the counter value which shall be used at the conveyance of the next DATA-RTA-PDU.

4.8.4.3 Acyclic Protocol Machine Receiver

4.8.4.3.1 General

In the following the structure of the Acyclic Protocol Machine Receiver (APMR) is shown (see Figure 62).

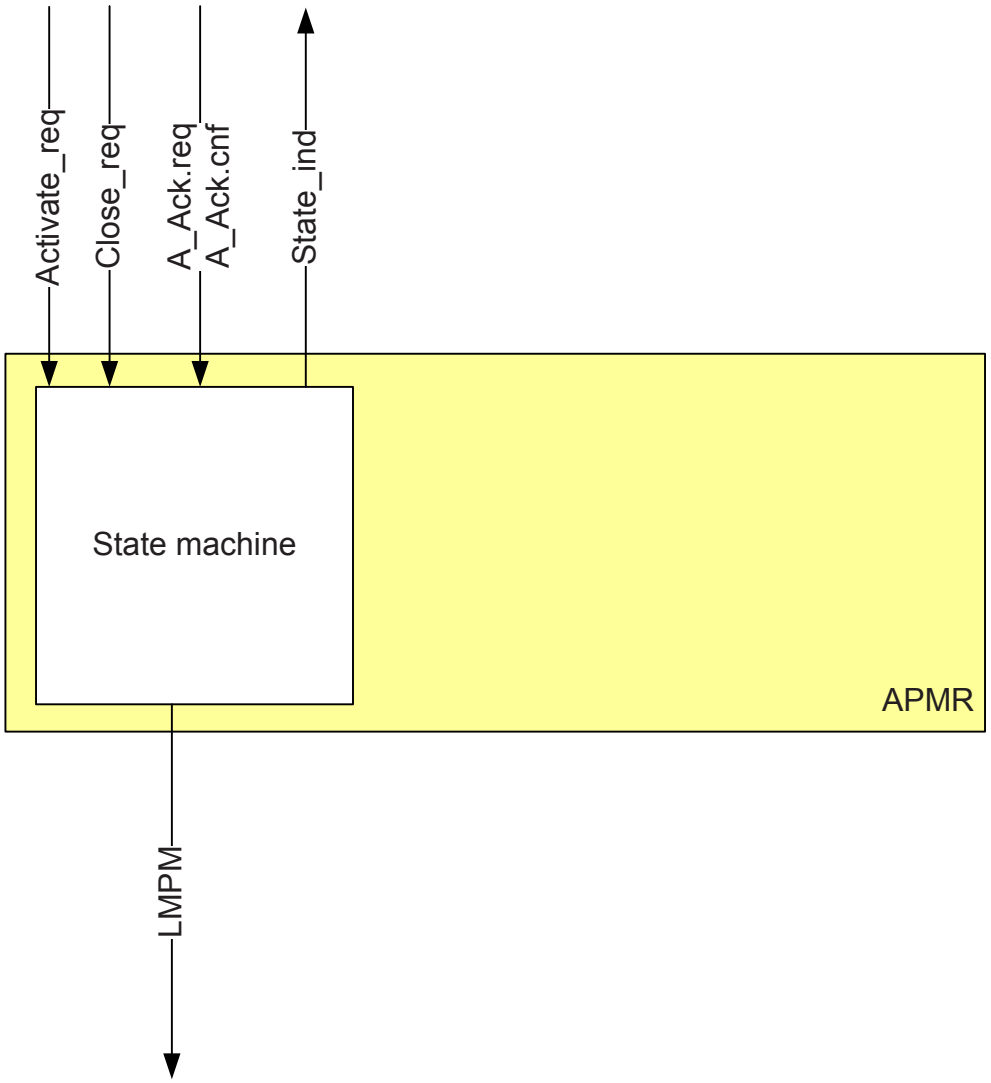


Figure 62 – Structure of the APMR

4.8.4.3.2 Primitive definitions

4.8.4.3.2.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by APMR are described in the service definition and shown in Table 209.

Table 208 – Remote primitives issued or received by APMR

Primitive	Source	Destination	Associated parameters	Functions
APMR_A_Data.ind	APMR	ALPMR	CREP, Data	Destination used if Data == AlarmNofication-PDU || Data == unknown
APMR_A_Data.ind	APMR	ALPMI	CREP, Data	Destination used if Data == Alarm-Ack-PDU || Data == unknown
LMPM_A_Data.cnf	APMR	LMPM	CREP, D_Port, Tstamp, LMPM_status	—

Primitive	Source	Destination	Associated parameters	Functions
LMPM_A_Data.ind	APMR	LMPM	CREP, S_Port, Tstamp, DA, SA, VLANPrio, VLANID, A_SDU	—
LMPM_A_Data.req	APMR	LMPM	CREP, D_Port:=AUTO, DA, SA, VLANPrio, VLANID, A_SDU	—
LMPM_N_Data.cnf	APMR	LMPM	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_N_Data.ind	APMR	LMPM	CREP, DA, SA, VLANPrio, VLANId, N_SDU	—
LMPM_N_Data.req	APMR	LMPM	CREP, D_Port:=AUTO, DA, SA, VLANPrio, VLANID, N_SDU	—

4.8.4.3.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CPM are described in the service definition and shown in Table 209.

Table 209 – Local primitives issued or received by APMR

Primitive	Source	Destination	Associated parameters	Functions
APMR_Activate_req	ALPMI	APMR	CREP, DA, SA, FrameID, VLANPrio, VLANID, Transport, DstIP, SrcIP	—
APMR_Close_req	ALPMI	APMR	CREP	—
APMR_Activate_cnf (-)	APMR	ALPMI	CREP, ERRCLS, ERRCODE	—
APMR_Activate_cnf (+)	APMR	ALPMI	CREP	—
APMR_Close_cnf (+)	APMR	ALPMI	CREP	—
APMR_Error_ind	APMR	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—

4.8.4.3.3 State transition diagram

The state transition diagram of the APMR is shown in Figure 63.

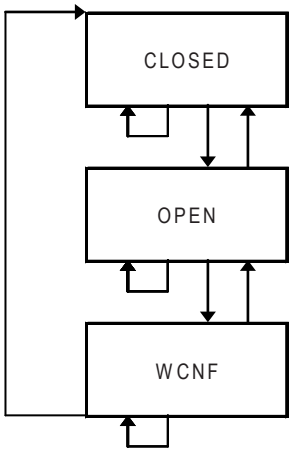


Figure 63 – State transition diagram of APMR

States of the APMR

CLOSED	The CLOSED state indicates that an initialization is needed. The Activate service sets the machine in the OPEN state.
OPEN	Waiting for LMPM_A_Data or a UDP_A_Data service indication and convey a transport acknowledge.
WCNF	Wait for the confirmation of the transport acknowledge and issue a APMR_Data indication.

4.8.4.3.4 State machine description

This state machine, addressed by Source-Host, Source-ServiceAccessPoint, Destination-Host, DestinationAccessPoint and Priority, handles the A-Data service. Each priority (High and Low) is handled independent. This state machine is part of the APMS and APMR pair which is used as sender and responder for the transport acknowledge A-Data services. The A-Data service are used for the Alarm transport.

4.8.4.3.5 APMR state table

Table 210 contains the complete description of the APMR state machine. A LMPM_A_Data.ind primitive will be accepted:

– If PDUType.Type field is DATA-RTA-PDU and the PDUType.Version field is one and the VarPartLen is greater than zero and the AddFlagsWindow is one.

– If PDUType.Type field is ERR-RTA-PDU and the PDUType.Version field is one and the VarPartLen is 4.

Table 210 – APMR state table

#	Current State	Event /Condition =>Action	Next State
1	CLOSED	**APMR_Activate.req ()** => AlarmInstance[SrcSAP, DstSAP, Prio] := DA, RTATimeoutFactor, RTARetries, … // NOTE Information used for ALPMI, ALPMR, APMS and APMR Expected_Seq_Count:=0xffff Expected_Seq_CountO:=0xfffe Use CREP to identify the AlarmInstance APMR_Activate.cnf (+)	OPEN
2	CLOSED	**APMR_Close.req ()** => APMR_Close.cnf (+)	CLOSED
3	CLOSED	A_Data_ind => ignore	CLOSED
4	CLOSED	A_Data_cnf => ignore	CLOSED
5	OPEN	**APMR_Activate.req ()** => ERRCLS := APMR ERRCODE :=INVALID_STATE APMR_Activate.cnf (-)	OPEN
6	OPEN	**APMR_Close.req ()** => APMR_Close.cnf (+)	CLOSED
7	OPEN	**A_Data_ind** /PDU.Type == DATA && PDU.AddFlags.Tack && PDU.SendSeqNum == Expected_Seq_Count => Store Data := PDU.RTA-SDU Expected_Seq_CountO :=Expected_Seq_Count Expected_Seq_Count := (Expected_Seq_Count+1) & 0x7fff PDU.Version :=1 PDU.Type := ACK PDU.AddFlags.TACK :=0 PDU.AddFlags.WindowSize :=1 PDU.SendSeqNum := Send_Seq_CountO (from the APMS) PDU.AckSeqNum := Expected_Seq_CountO //NOTE The PDU.SendSeqNum shall be set with the value from the corresponding APMS A_Data_req	WCNF
8	OPEN	**A_Data_ind** /PDU.Type == DATA && PDU.AddFlags.Tack && PDU.SendSeqNum == Expected_Seq_CountO => PDU.Version:=1 PDU.Type:= ACK PDU.AddFlags.TACK:=0 PDU.AddFlags.WindowSize:=1 PDU.SendSeqNum:=Send_Seq_CountO (from the APMS) PDU.AckSeqNum:=Expected_Seq_CountO A_Data_req	OPEN

#	Current State	Event /Condition =>Action	Next State
9	OPEN	**A_Data_ind** /PDU.Type == DATA && PDU.AddFlags.Tack && PDU.SendSeqNum != Expected_Seq_Count && PDU.SendSeqNum != Expected_Seq_CountO => ERRCLS := RTA_ERR_CLS_PROTOCOL ERRCODE := RTA_ERR_CODE_SEQ PDU.Version:=1 PDU.Type:= NAK PDU.AddFlags.TACK:=0 PDU.AddFlags.Window:=1 PDU.SendSeqNum:=Send_Seq_CountO (from the APMS) PDU.AckSeqNum:=Expected_Seq_CountO A_Data_req	OPEN
10	OPEN	**A_Data_ind** /PDU.Type == ERR => ERRCLS := PDU.PNIOStatus.ErrorCode1 ERRCODE := PDU.PNIOStatus.ErrorCode2 APMR_Error_ind ()	OPEN
11	OPEN	**A_Data_ind** /(PDU.Type == DATA && !PDU.AddFlags.Tack) => ignore	OPEN
12	OPEN	**A_Data_ind** /PDU.Type == ACK || PDU.Type == NAK => ignore	OPEN
13	OPEN	A_Data_cnf => ignore	OPEN
14	WCNF	**APMR_Activate.req ()** => ERRCLS := APMR ERRCODE :=INVALID_STATE APMR_Activate.cnf (-)	WCNF
15	WCNF	**APMR_Close.req ()** => APMR_Close.cnf (+)	CLOSED
16	WCNF	**A_Data_cnf** => Retrieve Data := PDU.RTA-SDU APMR_A_Data.ind ()	OPEN
17	WCNF	**A_Data_ind** /PDU.Type != ERR => ignore	WCNF
18	WCNF	**A_Data_ind** /PDU.Type == ERR => APMR_Error_ind ()	WCNF

4.8.4.3.6 Functions, Macros, Timers and Variables

Table 211 contains the functions, macros, timers and variables used by the APMR and their arguments and their descriptions.

Table 211 – Functions, Macros, Timers and Variables used by the APMR

Name	Type	Meaning

A_Data_ind	Macro	if (Transport == RTC)
		LMPM_A_Data.ind(CREP, S_Port, Tstamp, DA, SA, VLANPrio, VLANID, A_SDU)
		PDU := A_SDU
		
		if (Transport == UDP)
		LMPM_N_Data.ind(CREP, DA, SA, VLANPrio, VLANId, N_SDU)
		PDU := N_SDU

A_Data_cnf	Macro	if (Transport == RTC) LMPM_A_Data.cnf (CREP, D_Port, Tstamp,LMPM_status) if (Transport == UDP) LMPM_N_Data.cnf (CREP, D_Port, Tstamp, LMPM_status)

A_Data_req	Macro	if (Transport == RTC)
		A_SDU := PDU
		LMPM_A_Data.req (CREP, D_Port := AUTO, DA, SA, VLANPrio, VLANID, A_SDU)
		
		if (Transport == UDP)
		N_SDU := PDU
		LMPM_N_Data.req (CREP, D_Port := AUTO, DA, SA, VLANPrio, VLANID, N_SDU)

PDU	Variable	Local variable representing the UDP-RTA-PDU or RTA-PDU depending on transport. Used to show the protocol specific setup and validation of RTA fields. The setup and validation of additional PDU-Parameters (e.g. IP-header) is not shown. The PDUType is shown in Table 202.
Expected_Seq_Count	Variable	This local variable contains the counter value which shall be used at the receipt of the next DATA PDU.
Expected_Seq_CountO	Variable	This local variable contains the previous counter value of the Seq_Count variable.

4.8.5 DLL Mapping Protocol Machines

There is no DLL Mapping Protocol Machine (DMPM) defined for this Protocol.

4.9 Fragmentation

4.9.1 General

The LengthOfPeriod is limited on the lower end by the maximum size of an Ethernet frame. The fragmentation reduces, with a peer to peer approach, the conveyed size of an Ethernet frame and allows to use a LengthOfPeriod down to 31,25 μs.

It uses the IEEE 802.1Q defined TagControlInformation.Priority to encode and decode up to 8 (at least one shall be supported) parallel fragmentation streams. Because of the bundling to the IEEE 802.1Q the granularity of the supported streams shall be one, two, four, or eight and the assignment to the TagControlInformation.Priority is shown in Table 212.

Table 212 – TagControlInformation.Priority vs. streams

Priority	One stream	Two streams	Four streams	Eight streams
7	Default All priorities are assigned to one stream	The upper four priorities are assigned to one stream	Two priorities are assigned to one stream	One priority is one stream
6				One priority is one stream
5			Two priorities are assigned to one stream	One priority is one stream
4				One priority is one stream
3		The lower four	Two priorities are	One priority is one stream

Priority	One stream	Two streams	Four streams	Eight streams
2		priorities are assigned to one stream	assigned to one stream	One priority is one stream
1			Two priorities are assigned to one stream	One priority is one stream
0				One priority is one stream

Even for the frames, generated by the fragmentation the lower frame size limit of the IEEE 802.3 applies. Thus limits the use of the principle of fragmentation according to Figure O.2, Formula (39), Formula (40), Formula (41) and Formula (42) as shown in Table 213.

The following Formula (39) shows the calculation for a single frame which is fragmented into a first and a last fragment.

NOTE The LowestFractionizeableFrameSize has two different values for frames with or without VLAN. Thus the fragmentation payload is defined and used as a simplification.

$$\text{LowestFractionizeableFrameSize} = \text{FrameDataFromFirstFragment} + \text{FrameDataFromLastFragment} + \text{ProtocolOverhead} \quad (39)$$

With VLAN

$$\text{LowestFractionizeableFrameSize} = 40 \text{ octets} + 38 \text{ octets} + 20 \text{ octets}$$

$$\text{LowestFractionizeableFrameSize} = 98 \text{ octets}$$

Without VLAN

$$\text{LowestFractionizeableFrameSize} = 48 \text{ octets} + 42 \text{ octets} + 16 \text{ octets}$$

$$\text{LowestFractionizeableFrameSize} = 106 \text{ octets}$$

where

LowestFractionizeableFrameSize	is the minimum length of frame to be able to be fractionized
FrameDataFromFirstFragment	is the amount of data of the original frame which is conveyed by the first fragment
FrameDataFromLastFragment	is the amount of data of the original frame which is conveyed by the last fragment
ProtocolOverhead	is the amount of data of the ethernet protocol frame

The following Formula (40) shows the calculation for the minimum leftover payload of a frame which is fragmented into a middle and a last fragment.

NOTE The LowestFractionizeableFrameSize has two different values for frames with or without VLAN. For simplification only the value with VLAN is used.

$$\text{LowestFractionizeableFrameSize} = \text{FrameDataFromMiddleFragment} + \text{FrameDataFromLastFragment} + \text{ProtocolOverhead} \quad (40)$$

With VLAN

$$\text{LowestFractionizeableFrameSize} = 40 \text{ octets} + 38 \text{ octets} + 26 \text{ octets}$$

$$\text{LowestFractionizeableFrameSize} = 104 \text{ octets}$$

Without VLAN

LowestFractionizeableFrameSize = 48 octets + 42 octets + 22 octets

LowestFractionizeableFrameSize = 112 octets

where

LowestFractionizeableFrameSize	is the minimum length of frame to be able to be fractionized
FrameDataFromMiddleFragment	is the amount of residual data of the original frame which is conveyed by a middle fragment
FrameDataFromLastFragment	is the amount of residual data of the original frame which is conveyed by the last fragment
ProtocolOverhead	is the amount of data of the ethernet protocol frame

Formula (41) shows a frame used for the first, middle or a last fragment with a VLAN tag.

Lowest frame size(with VLAN) = DestinationMAC + SourceMAC + VLAN + FragmentationHeader + Payload + FCS (41)

Payload(with VLAN) = Lowest frame size – (DestinationMAC + SourceMAC + VLAN + FragmentationHeader + FCS)

Payload(with VLAN) = 64 – (6 + 6 + 4 + 6 + 4)

Payload(with VLAN) = 38

according the rules for FragStatus.MoreFollows:=More fragments follows

Payload(with VLAN) = 40

according the rules for FragStatus.MoreFollows:=Last fragment

Payload(with VLAN) = 38

where

Lowest frame size	is the allowed minimum length of a frame (64 octets)
DestinationMAC	is the length of the MAC address (6 octets)
SourceMAC	is the length of the MAC address (6 octets)
VLAN	is the length of the VLAN tag (4 octets)
FragmentationHeader	is the length of the fragmentation header (6 octets)
Payload	is the length of the payload
FCS	is the length of the FCS (4 octets)

Formula (42) shows a frame used for the first, middle or a last fragment with a VLAN tag.

Lowest frame size(without VLAN) = DestinationMAC + SourceMAC + FragmentationHeader + Payload + FCS (42)

Payload(without VLAN) = Lowest frame size – (DestinationMAC + SourceMAC + FragmentationHeader + FCS)

Payload(without VLAN) = 64 – (6 + 6 + 6 + 4)

Payload(without VLAN) = 42

according the rules for FragStatus.MoreFollows:=More fragments follows

Payload(without VLAN) = 48

according the rules for FragStatus.MoreFollows:=Last fragment

Payload(without VLAN) = 42

where

Lowest frame size	is the allowed minimum length of a frame (64 octets)
DestinationMAC	is the length of the MAC address (6 octets)
SourceMAC	is the length of the MAC address (6 octets)
VLAN	is the length of the VLAN tag (4 octets)
FragmentationHeader	is the length of the fragmentation header (6 octets)
Payload	is the length of the payload
FCS	is the length of the FCS (4 octets)

Table 213 – Lower limit of fragments

Case	VLAN	Payload size of the fragments	Meaning
First + last	With	Payload first fragment := 40 octets Payload last fragment := 38 octets Protocol part := 20 octets	Smallest fragment able frame size := DA + SA + VLAN + Payload + FCS := 98 octets
	Without	Payload first fragment := 48 octets Payload last fragment := 42 octets Protocol part := 16 octets	Smallest fragment able frame size := DA + SA + Payload + FCS := 106 octets
Middle + last	With	Payload middle fragment := 40 octets Payload last fragment := 38 octets Protocol part := 26 octets	Smallest fragment able residual payload size := DA + SA + VLAN + FragHeader + Payload + FCS := 104 octets
	Without	Payload middle fragment := 48 octets Payload last fragment := 42 octets Protocol part := 22 octets	Smallest fragment able residual payload size := DA + SA + FragHeader + Payload + FCS := 112 octets

A fragmentation payload of 90 octets for all kind of frames (with and without VLAN) may be used to simplify the implementation of fragmentation. Thus the lowest frame size which could still be fragmented shall be 110 octets with VLAN and 106 octets without VLAN and the lowest residual fragmentation payload which could still be fragmented shall be 116 octets with VLAN and 112 octets without VLAN.

4.9.2 FRAG syntax description

4.9.2.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.9.2.2 FRAG APDU abstract syntax

Table 214 defines the abstract syntax of the Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 214 shall represent the content of the DLSDU in Table 5.

Table 214 – FRAG APDU syntax

APDU name	APDU structure
FRAG-PDU	FRAG-DATA-PDU

Table 215 defines structures for substitutions of elements of the APDU structures shown in Table 214.

Table 215 – FRAG substitutions

Substitution name	Structure
FRAG-DATA-PDU	FragDataLength, FragStatus, FragData

4.9.3 FRAG transfer syntax

4.9.3.1 Coding section related to FRAG-PDUs specific fields

4.9.3.1.1 Coding of the field FragDataLength

The field FragDataLength is coded as an Unsigned8 and contains the number of 8 octet portions of the fragment data. For the last fragment (FragStatus.MoreFollows := 0) up to 7 “leftover” octets may be added.

FragDataLength shall be calculated according to Formula (43).

$$\text{FragDataLength} = (\text{Length of FragData } DIV\ 8) \tag{43}$$

where

FragDataLength	is the length of the field FragData in 8 octet portions
Length of FragData	is the length of the field FragData in octets
8	is the defined value of an increment of FragData

If the fragmentation of a frame into multiples of 8 octet portions has any leftover, then the size of the last fragment containing the FragData shall be the rest, containing the leftover octets.

The receiver shall accept a fragmented frame with this kind of FragData if FragStatus.MoreFollows := 0.

This field shall be coded as Unsigned8 with the values according to Table 216.

Table 216 – FragDataLength

Value (hexadecimal)	Meaning	Usage
0x00, …, 0x04	—	Reserved
0x05 or 0x06 [a]	Minimum If the FragStatus.MoreFollows := 1, then the length of FragData is 0x30 octets If the FragStatus.MoreFollows := 0, then the length of FragData is 0x30 to 0x37 octets (up to 7 leftover octets)	Mandatory
0x08, …, 0xBE	…	Mandatory
0xBF [b]	Maximum If the FragStatus.MoreFollows := 1, then the length of FragData is 0x5CF octets If the FragStatus.MoreFollows := 0, then the length of FragData is 0x5F8 to 0x5FF octets	Mandatory
0xC0, …, 0xFF	Maximum length of FragData is 0x7FF	Optional

[a] The minimum FragDataLength which shall be supported by the DEFRAG is 0x05 with VLAN and 0x06 without VLAN.

[b] The maximum FragDataLength which shall be supported by the DEFRAG is defined by the use of at least two fragments for a maximum IEEE 802.3 frame. The support of one fragment fragmentation is not intended.

4.9.3.1.2 Coding of the field FragStatus

The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0 – 5: FragStatus.FragmentNumber
This field contains the fragment number and shall be coded according to Table 217.

Table 217 – FragStatus.FragmentNumber

Value (hexadecimal)	Meaning
0x00	First fragment of a frame
0x01	Second fragment of a frame
…	…
0x3F	64th fragment of a frame

Bit 6: FragStatus.Reserved
This field shall be coded according to Table 218.

Table 218 – FragStatus.Reserved

Value (hexadecimal)	Meaning
0x00	Reserved

Bit 7: FragStatus.MoreFollows
This field shall be coded according to Table 219.

Table 219 – FragStatus.MoreFollows

Value (hexadecimal)	Meaning
0x00	Last fragment
0x01	More fragments follows

4.9.3.1.3 Coding of the field FragData

This field shall be coded as data type OctetString and shall contain the transmitted portion of data of the fragmented frame.

4.9.4 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.9.5 Application Relationship Protocol Machines

There is no Application Relationship Protocol Machine (ARPM) defined for this Protocol.

4.9.6 DLL Mapping Protocol Machines

4.9.6.1 Fragmentation

4.9.6.1.1 Fragmentation dynamic

4.9.6.1.1.1 Primitive definitions

4.9.6.1.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by FRAG_D are described in the service definition and shown in Table 220.

Table 220 – Remote primitives issued or received by FRAG_D

Primitive	Source	Destination	Associated parameters	Functions
QueueHandler.req	FRAG_D	QueueHandler	Queue, Frame	—

4.9.6.1.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by FRAG_D are described in the service definition and shown in Table 221.

Table 221 – Local primitives issued or received by FRAG_D

Primitive	Source	Destination	Associated parameters	Functions
SCHEDULER_StartOfPeriod	SCHEDULER	FRAG	—	This local function is issued if a new communication cycle starts.

4.9.6.1.2 State transition diagram

The state transition diagram of the FRAG_D is shown in Figure 64.

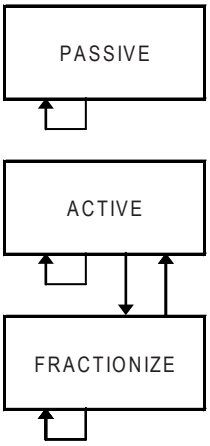


Figure 64 – State transition diagram of FRAG_D

States of the FRAG_D

PASSIVE	The FRAG unit is not used. Frames passes unaffected.
ACTIVE	The FRAG unit for the defined stream is active and waits for frames to fractionize them if needed.
FRACTIONIZE	A frame is fragmented and conveyed. High priority frames which do not need fragmentation may overtake the fragments. After the last fragment is sent, the state ACTIVE is reached. If residential time is available the fragmentation starts immediately with the next frame.

4.9.6.1.1.3 State machine description

The FRAG is responsible for fragmentation of frames according to the residual GREEN period. It gets the frames from the QueueHandler, breaks them into fragments, if necessary and allowed for the protocol, and stores the fragments in the lower queues of the QueueHandler.

In the inactive state FRAG shall be bypassed by the QueueHandler.

The fragmentation may be done by two different strategies. The first one is the dynamic fragmentation, which uses the residential GREEN phase and the second one is the static fragmentation, which uses a predefined fragment size.

4.9.6.1.1.4 FRAG_D state table (dynamic fragmentation)

Table 222 contains the FRAG_D state table.

Table 222 – FRAG_D state table (dynamic)

#	Current State	Event /Condition =>Action	Next State
1	PASSIVE	 => ignore	PASSIVE
2	ACTIVE	**QueuesNotEmpty ()** /Period == RED => ignore	ACTIVE

#	Current State	Event /Condition =>Action	Next State
3	ACTIVE	**QueuesNotEmpty ()** /Period == GREEN => GetFrameFromQueue () StartFragStream ()	FRACTIONIZE
4	FRACTIONIZE	QueuesNotEmpty () => ignore	FRACTIONIZE
5	FRACTIONIZE	**StartFragStream ()** /Period == GREEN && FrameFitsIntoResidualPeriod == TRUE => QueueHandler.req () //NOTE Send frame	ACTIVE
6	FRACTIONIZE	**StartFragStream ()** /Period == GREEN && FrameFitsIntoResidualPeriod == FALSE && FrameSizeAllowsFragmentation == TRUE && ResidualPeriodShorterThanMin == TRUE => ignore //NOTE Wait until the next GREEN period starts	FRACTIONIZE
7	FRACTIONIZE	**SCHEDULER_StartOfPeriod ()** /Period == GREEN && ResidualPeriodShorterThanMin == TRUE => ignore	FRACTIONIZE
8	FRACTIONIZE	**StartFragStream ()** /Period == GREEN && FrameFitsIntoResidualPeriod == FALSE && FrameSizeAllowsFragmentation == TRUE && ResidualPeriodShorterThanMin == FALSE && LastFragment == FALSE => CalculateFragSize () CreateFrag () QueueHandler.req () //NOTE Send frame fragment	FRACTIONIZE
9	FRACTIONIZE	**SCHEDULER_StartOfPeriod ()** /Period == GREEN && ResidualPeriodShorterThanMin == FALSE && LastFragment == TRUE => CalculateFragSize () CreateFrag () QueueHandler.req () //NOTE Send frame fragment	ACTIVE

#	Current State	Event /Condition =>Action	Next State
10	FRACTIONIZE	**QueuesNotEmpty ()** /CheckForFrameWithHigherPriority () == EXISTS && FrameFitsIntoResidualPeriod == TRUE => GetFrameFromQueue () QueueHandler.req ()	FRACTIONIZE
11	FRACTIONIZE	**QueuesNotEmpty ()** /CheckForFrameWithHigherPriority () == EXISTS && FrameFitsIntoResidualPeriod == FALSE => ignore	FRACTIONIZE

4.9.6.1.1.5 Functions, Macros, Timers and Variables

Table 223 contains the functions, macros, timers and variables used by the FRAG_D and their arguments and their descriptions.

Table 223 – Functions, Macros, Timers and Variables used by the FRAG_D (dynamic)

Name	Type	Function/Meaning
CalculateFragSize	Function	This local function calculates the fragment size due to the residual GREEN period and the fragmentation rules. If dynamic fragmentation is not supported, use a default length given by the engineering according the minimal GREEN period of all phases.
CheckForFrameWithHigherPriority	Function	This local function tests whether any frame with a higher priority than the fragmented one is stored in the queues.
CreateFrag	Function	This local function creates a fragment according the coding and the fragmentation rules. Either first, next or last. Keep in mind, that the minimum and the maximum frame size of a IEEE 802.3 frame are still valid, even for fragments.
FrameFitsIntoResidualPeriod	Function	This local function checks whether the residual GREEN period is longer than the frame needs for conveyance
FrameSizeAllowsFragmentation	Function	This local function checks whether the frame is big enough for fragmentation
GetFrameFromQueue	Function	This local function fetches the next frame according the amount of FRAG streams and priorities.
QueuesNotEmpty	Function	This local function is issued if any entry is stored in the queues.
ResidualPeriodShorterThanMin	Function	This local function checks whether the residual GREEN period is shorter than an minimum frame needs for conveyance
StartFragStream	Function	This local function triggers the fragment creation of FRAG.
LastFragment	Macro	This local macro contains information whether the actual fragment is the last fragment. With the conveyance of the last fragment ends the FRAG stream
Period	Macro	This local macro contains the information what period (RED or GREEN) is active.

4.9.6.1.2 Fragmentation static

4.9.6.1.2.1 Primitive definitions

4.9.6.1.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by FRAG_S are described in the service definition and shown in Table 224.

Table 224 – Remote primitives issued or received by FRAG_S

Primitive	Source	Destination	Associated parameters	Functions
QueueHandler.req	FRAG_S	QueueHandler	Queue, Frame	—

4.9.6.1.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by FRAG_S are described in the service definition and shown in Table 225.

Table 225 – Local primitives issued or received by FRAG_S

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.9.6.1.2.2 State transition diagram

The state transition diagram of the FRAG_S is shown in Figure 65.

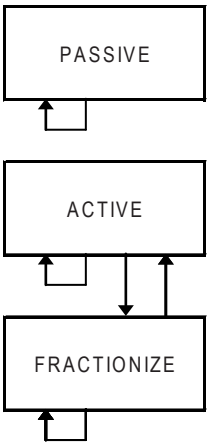


Figure 65 – State transition diagram of FRAG_S

States of the FRAG_S

PASSIVE	The FRAG unit is not used. Frames passes unaffected.
ACTIVE	The FRAG unit for the defined stream is active and waits for frames to fractionize them if needed.
FRACTIONIZE	A frame is fragmented and conveyed. High priority frames which do not need fragmentation may overtake the fragments. After the last fragment is sent, the state ACTIVE is reached. If residential time is available the fragmentation starts immediately with the next frame.

4.9.6.1.2.3 State machine description

The FRAG is responsible for fragmentation of frames according to the residual GREEN period. It gets the frames from the QueueHandler, breaks them into fragments, if necessary and allowed for the protocol, and stores the fragments in the lower queues of the QueueHandler.

In the inactive state FRAG shall be bypassed by the QueueHandler.

The fragmentation may be done by two different strategies. The first one is the dynamic fragmentation, which uses the residential GREEN phase and the second one is the static fragmentation, which uses a predefined fragment size.

4.9.6.1.2.4 FRAG_S state table (static fragmentation)

Table 226 contains the FRAG_S state table.

Table 226 – FRAG_S state table (static)

#	Current State	Event /Condition =>Action	Next State
1	PASSIVE	 => ignore	PASSIVE
2	ACTIVE	**QueuesNotEmpty ()** /Period == RED => ignore	ACTIVE

3	ACTIVE	**QueuesNotEmpty ()**
		/Period == GREEN
		&&
		FrameSizeAllowsFragmentation == FALSE
		=>
		GetFrameFromQueue ()
		
		// Adapt the assigned queues if more than one Frag stream exists
		QueueHandler.req ()
		
		//NOTE Send frame
			ACTIVE

4	ACTIVE	**QueuesNotEmpty ()** /Period == GREEN && FrameSizeAllowsFragmentation == TRUE => GetFrameFromQueue () // Adapt the assigned queues if more than one Frag stream exists StartFragStream ()	FRACTIONIZE
5	FRACTIONIZE	QueuesNotEmpty () => ignore	FRACTIONIZE
6	FRACTIONIZE	**StartFragStream ()** => CalculateFragSize () CreateAllFrags () For all fragment frames QueueHandler.req () //NOTE Send fragment frame	FRACTIONIZE
7	FRACTIONIZE	LastFragmentTransmitted () =>	ACTIVE

#	Current State	Event /Condition =>Action	Next State

8	FRACTIONIZE	**QueuesNotEmpty ()**
		/CheckForFrameWithHigherPriority () == EXISTS
		&&
		FrameSizeAllowsFragmentation == FALSE
		=>
		GetFrameFromQueue ()
		
		// Adapt the assigned queues if more than one Frag stream exists
		QueueHandler.req ()
		
		//NOTE Send frame
			FRACTIONIZE

9	FRACTIONIZE	**QueuesNotEmpty ()** /CheckForFrameWithHigherPriority () == EXISTS && FrameSizeAllowsFragmentation == TRUE => ignore	FRACTIONIZE

4.9.6.1.2.5 Functions, Macros, Timers and Variables

Table 227 contains the functions, macros, timers and variables used by the FRAG_S and their arguments and their descriptions.

Table 227 – Functions, Macros, Timers and Variables used by the FRAG_S (static)

Name	Type	Function/Meaning
CalculateFragSize	Function	This local function calculates the fragment size due to the given expected fragment size and the fragmentation rules. The default length is given by the engineering according the minimal GREEN period of all phases.
CheckForFrameWithHigherPriority	Function	This local function tests whether any frame with a higher priority than the fragmented one is stored in the queues.
CreateAllFrags	Function	This local function creates all fragments according the coding and the fragmentation rules. Either first, next or last. Keep in mind, that the minimum and the maximum frame size of a IEEE 802.3 frame are still valid, even for fragments.
FrameSizeAllowsFragmentation	Function	This local function checks whether the frame is big enough for fragmentation
GetFrameFromQueue	Function	This local function fetches the next frame according the amount of FRAG streams and priorities.
QueuesNotEmpty	Function	This local function is issued if any entry is stored in the queues.
StartFragStream	Function	This local function triggers the fragment creation of FRAG.
LastFragmentTransmitted	Function	This local function is issued if the last fragment is conveyed.
Period	Macro	This local macro contains the information what period (RED or GREEN) is active.

4.9.6.2 Defragmentation

4.9.6.2.1 Primitive definitions

4.9.6.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DEFRAG are described in the service definition and shown in Table 228.

Table 228 – Remote primitives issued or received by DEFRAG

Primitive	Source	Destination	Associated parameters	Functions
DMUX_DEFRAG.ind	DEMUX	DEFRAG	Port, Tstamp, DA, SA, VLAN, N_SDU	—
DMUX_MAC_RELAY.ind	DEFRAG	MAC_RELAY	Port, Tstamp, DA, SA, N_SDU	—

4.9.6.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DEFRAG are described in the service definition and shown in Table 229.

Table 229 – Local primitives issued or received by DEFRAG

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.9.6.2.2 State transition diagram

The state transition diagram of the DEFRAG is shown in Figure 66.

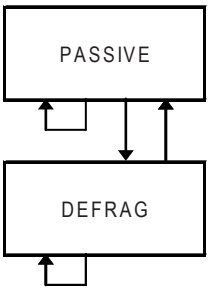


Figure 66 – State transition diagram of DEFRAG

States of the DEFRAG

PASSIVE	Waiting for the first fragment of a stream. For each supported steam exists a DEFRAG unit.
DEFRAG	A stream was started by the first fragment. After receiving the last fragment of the current stream, the machine reaches PASSIVE again. If the amount of data received during DEFRAG exceeds the maximum frame size according to the IEEE 802.3, the defragmentation is

aborted and the state PASSIVE entered.

4.9.6.2.3 State machine description

A DEFRAG state machine shall exist for every supported steam. At least one stream shall be supported, if fragmentation is supported. In this case the DEFRAG is waiting for a FRAGMENT after the link is active.

4.9.6.2.4 DEFRAG state table

Table 230 contains the DEFRAG state table which exists for each port.

Table 230 – DEFRAG state table

#	Current State	Event /Condition =>Action	Next State
1	PASSIVE	**DMUX_DEFRAG.ind ()** /DefragGuard () == FirstFragment => Store fragment	DEFRAG
2	PASSIVE	**DMUX_DEFRAG.ind ()** /DefragGuard () == Invalid => ignore	PASSIVE
3	DEFRAG	**DMUX_DEFRAG.ind ()** /DefragGuard () == NextFragment && FrameLimitReached => Delete stored fragments	PASSIVE
4	DEFRAG	**DMUX_DEFRAG.ind ()** /DefragGuard () == NextFragment && ! FrameLimitReached => Store fragment	DEFRAG
5	DEFRAG	**DMUX_DEFRAG.ind ()** /DefragGuard () == LastFragment && FrameLimitReached => Delete stored fragments	PASSIVE
6	DEFRAG	**DMUX_DEFRAG.ind ()** /DefragGuard () == LastFragment && ! FrameLimitReached => Create frame Delete stored fragments DMUX_MAC_RELAY.ind ()	PASSIVE
7	DEFRAG	**DMUX_DEFRAG.ind ()** /DefragGuard () == FirstFragment => Delete stored fragments Store fragment	DEFRAG
8	DEFRAG	**DMUX_DEFRAG.ind ()** /DefragGuard () == Invalid => Delete stored fragments	PASSIVE

4.9.6.2.5 Functions, Macros, Timers and Variables

Table 231 contains the functions used by the DEFRAG, their arguments and their descriptions.

Table 231 – Functions, Macros, Timers and Variables used by the DEFRAG

Name	Type	Function/Meaning
DefragGuard	Function	This local function checks the fragments against truth tables.
Store fragment	Macro	This local macro store the fragment for further defragmentation
Delete stored fragment	Macro	This local macro deletes the previous stored fragments
Create frame	Macro	This local macro creates a frame out of the stored fragments
FrameLimitReached	Macro	This local macro checks whether the IEEE 802.3 frame limits are exceeded.

4.9.6.2.6 DefragGuard

The DefragGuard checks the received frame against Table 232, Table 233 and Table 234. The used table depends on the local supported functionality.

The defragmentation shall accept a frame independent from the value of FrameID.FragSequence in combination with FragStatus.FragmentNumber:=0 as start of a new defragmentation sequence.

Table 232 – Truth table for the DefragGuard – first fragment

Input				Output
FragmentationFrameID. FragSequence	FragStatus. FragmentNumber	FragStatus. MoreFollows	FragDataLength	Local
Invalid	—	—	—	Invalid
Valid	Invalid	—	—	Invalid
Valid	Valid	FALSE [a]	—	Invalid
Valid	Valid	TRUE	Invalid	Invalid
Valid	Valid	TRUE	Valid	Valid
[a] The MoreFollows for the first fragment shall never be set to FALSE by the sender.				

Table 233 – Truth table for the DefragGuard – next fragment

Input				Output
FragmentationFrameID. FragSequence	FragStatus. FragmentNumber	FragStatus. MoreFollows	FragDataLength	Local
Invalid	—	—	—	Invalid
Valid [a]	Invalid	—	—	Invalid
Valid	Valid [b]	FALSE	—	Invalid
Valid	Valid [b]	TRUE	Invalid	Invalid
Valid	Valid	TRUE	Valid	Valid
[a] Identical to the store one from the first fragment.				
[b] The stored one from the last received fragment of this FraqSequence (FragmentNumber =+ 1).				

Table 234 – Truth table for the DefragGuard – last fragment

Input				Output
FragmentationFrameID. FragSequence	FragStatus. FragmentNumber	FragStatus. MoreFollows	FragDataLength	Local
Invalid	—	—	—	Invalid
Valid	Invalid	—	—	Invalid
Valid	Valid	TRUE	—	Invalid
Valid	Valid	FALSE [a]	Invalid	Invalid
Valid	Valid	FALSE [a]	Valid	Valid
[a] The MoreFollows for the last fragment shall be set to FALSE by the sender.				

4.10 Remote procedure call

4.10.1 RPC syntax description

4.10.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.10.1.2 RPC APDU abstract syntax

Table 235 shows the utilization of the Publication C706 of The Open Group and defines the abstract syntax of the Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 235 shall represent the content of the DLSDU in Table 5.

Table 235 – RPC APDU syntax

APDU name	APDU structure
CL-RPC-PDU	IPHeader, UDPHeader, RPCHeader, NDRData
NDRData	NDRDataRequest ^ NDRDataResponse ^ NDREPMapLookupReq ^ NDREPMapLookupRes ^ NDREPMapLookupFreeReq ^ NDREPMapLookupFreeRes ^ NDRAck ^ NDRQuAck ^ NDRQuit ^ NDRFack ^ NDRFault ^ NDRNoCall ^ NDRWorking ^ NDRPing ^ NDRReject

Table 236 defines structures for substitutions of elements of the APDU structures shown in Table 235.

Table 236 – RPC substitutions

Substitution name	Structure
RPCHeader	RPCVersion (4), RPCPacketType, RPCFlags, RPCFlags2, RPCDRep, RPCSerialHigh, RPCObjectUUID [a], RPCInterfaceUUID [b], RPCActivityUUID, RPCServerBootTime, RPCInterfaceVersion, RPCSequenceNmb, RPCOperationNmb [c], RPCInterfaceHint, RPCActivityHint, RPCLengthOfBody, RPCFragmentNmb, RPCAuthenticationProtocol, RPCSerialLow
NDRDataRequest	ArgsMaximum, ArgsLength, MaximumCount, Offset(0), ActualCount, PROFINETIOServiceReqPDU
NDRDataResponse	PNIOStatus, ArgsLength, MaximumCount, Offset(0), ActualCount, [PROFINETIOServiceResPDU]
NDRFault	RPCNCAFaultStatus
NDRAck	NULL
NDRQuAck	NULL ^ (RPCCancelVersion(0), RPCCancelID, RPCServerIsAccepting)

Substitution name	Structure
NDRQuit	NULL ^ (RPCCancelVersion(0), RPCCancelID)
NDRFack	NULL ^ (RPCVersionFack(0), RPCPad1, RPCWindowSize, RPCMaxTsdu, RPCMaxFragSize, RPCSerialNumber, RPCSelAckLen, RPCArrayOfSelAck*)
NDRNoCall	NULL ^ NDRFack
NDRWorking	NULL
NDRPing	NULL
NDRReject	RPCNCARejectStatus
NDREPMapLookupReq	RPCInquiryType, RPCObjectReference(1), RPCObjectUUID, RPCInterfaceReference(2), RPCInterfaceUUID, RPCInterfaceVersionMajor, RPCInterfaceVersionMinor, RPCVersionOption(1), RPCEntryHandleAttribute(0), RPCEntryHandleUUID, RPCMaxEntries
NDREPMapLookupRes	RPCEntryHandleAttribute(0), RPCEntryHandleUUID, RPCNumberOfEntries, RPCMaxEntries, RPCEntriesOffset, RPCEntriesCount, [(RPCObjectUUID, RPCTowerReference, RPCAnnotationOffset, RPCAnnotationLength, RPCAnnotation, [RPCGap*], RPCTowerLength, RPCTowerOctetStringLength, [RPCTowerOctetString*], [RPCGap*])*], RPCEPMapStatus
RPCTowerOctetString	RPCFloorCount, [RPCFloor*]
RPCFloor	RPCLHSByteCount, [RPCProtocolIdentifierString*], RPCRHSByteCount, [RPCRelatedData*]
RPCProtocolIdentifier-String	(RPCID, RPCInterfaceUUID [a], RPCInterfaceVersionMajor [a]) ^ (RPCID, RPCDataRepresentationUUID [a], RPCInterfaceVersionMajor) ^ RPCProtocolIdentifier ^ RPCServerUDPPort ^ RPCHostAddress [a] Shall be coded in little endian format
RPCRelatedData	RPCInterfaceVersionMinor [a] ^ RPCPortNumber ^ RPCIPAddress [a] Shall be coded in little endian format
NDREPMapLookupFree Req	RPCEntryHandleAttribute, RPCEntryHandleUUID
NDREPMapLookupFree Res	RPCEntryHandleAttribute, RPCEntryHandleUUID, RPCEPMapStatus
RPCAnnotation	DeviceType, Blank, OrderID, Blank, HWRevision, Blank, SWRevisionPrefix, SWRevision, EndTerm
[a] To identify IO device, IO controller, IO supervisor. [b] To identify PNIO interface type. [c] To identify the service type e.g. Connect, Release, Read, Write, Control.	

4.10.2 RPC Transfer syntax

4.10.2.1 Coding section related to CL-RPC-PDU

4.10.2.1.1 Coding of the field RPCVersion

This field shall be coded as data type Unsigned8 with values according to Table 237.

Table 237 – RPCVersion

Value (hexadecimal)	Meaning
0x04	Used RPC version
Other	Reserved

4.10.2.1.2 Coding of the field RPCPacketType

This field shall be coded as data type Unsigned8 with values according to Table 238.

Table 238 – RPCPacketType

Value (hexadecimal)	Meaning
0x00	Request
0x01	Ping
0x02	Response
0x03	Fault
0x04	Working
0x05	No call, response to ping
0x06	Reject
0x07	Acknowledge
0x08	Connectionless cancel
0x09	Fragment acknowledge (FACK-PDU)
0x0A	Cancel acknowledge
0x0B – 0xFF	Reserved

The decoder shall only check the 5 least significant bits.

4.10.2.1.3 Coding of the field RPCFlags

This field shall be coded as data type according to 3.4.2.3 with values according to Table 239.

Table 239 – RPCFlags

Bit	Meaning if set to 1
Bit 0	Implementation specific, shall be set to zero
Bit 1	Last fragment
Bit 2	Fragment
Bit 3	No fragment acknowledge requested
Bit 4	Maybe
Bit 5	Idempotent
Bit 6	Broadcast
Bit 7	Implementation specific, shall be set to zero

4.10.2.1.4 Coding of the field RPCFlags2

This field shall be coded as data type according to 3.4.2.3 with values according to Table 240.

Table 240 – RPCFlags2

Bit	Meaning if set to 1
Bit 0	Implementation specific, shall be set to 0
Bit 1	Cancel was pending at call end
Bit 2	Reserved
Bit 3	Reserved
Bit 4	Reserved
Bit 5	Reserved

Bit	Meaning if set to 1
Bit 6	Reserved
Bit 7	Reserved

4.10.2.1.5 Coding of the field RPCDRep

This field shall be coded as data type OctetString[3].

RPCDRep Octet 1
The coding of the first octet shall be according to 3.4.2.3 and the individual bits shall have the meaning defined in Table 241.

Table 241 – RPCDRep.Character- and IntegerEncoding

Bit	Field Name	Value	Meaning
0 – 3	RPCDRep.CharacterEncoding [a]	0	ASCII
		1	EBCDIC
4 – 7	RPCDRep.IntegerEncoding [b]	0	Big endian [c]
		1	Little endian [c]

[a] Not used within Type 10.

[b] As an exception to 3.4.2.5 the RPC encoding rules are applied to the RPCHeader, NDR substitutions and NDREPMap substitutions within Type 10. It only uses Unsigned8, Unsigned16, or Unsigned32 there. The user data of the Type 10 service definitions are not influenced because everything is an opaque OctetString there.

[c] See The Open Group — Publication C706.

RPCDRep Octet 2
The values of the second octet shall be encoded according to Table 242.

Table 242 – RPCDRep Octet 2 – Floating Point Representation

Value (hexadecimal)	Meaning
0x00	IEEE
0x01	VAX
0x02	CRAY
0x03	IBM
0x04 – 0xFF	Reserved

RPCDRep Octet 3
The value of the third octet shall be zero.

4.10.2.1.6 Coding of the field RPCSerialHigh

This field shall be coded as data type Unsigned8. The value contains the high octet of the fragment number of the call.

4.10.2.1.7 Coding of the field RPCSerialLow

This field shall be coded as data type Unsigned8. The value contains the low octet of the fragment number of the call.

NOTE The value of the field RPCSerial is incremented which each transmission even with a transmission repetition in distinction to the field FragmentNmb.

4.10.2.1.8 Coding of the field RPCObjectUUID

This field shall be coded as data type structure containing the following elements:

- Data1 as Unsigned32
- Data2 as Unsigned16
- Data3 as Unsigned16
- Data4 as array of eight Unsigned8 (Octet 1 to Octet 8)

The octet ordering shall be according to the value of the field RPCDRep (little endian or big endian).

The ordering of octets of Data4 is shown in Table 243.

Table 243 – RPCObjectUUID.Data4

Octet	Meaning
1	Values see Table 244
2	
3	Instance High
4	Instance Low
5	DeviceID High
6	DeviceID Low
7	VendorID High
8	VendorID Low

Defined values for PNIO items are shown in Table 244 and Table 245. These values shall be used in conjunction with the values from Table 246.

Table 244 – RPCObjectUUID for PNIO

Value	Description	
UUID_IO_ObjectInstance_XYZ DEA00000-6C97-11D1-8271-{xxxxyyyyzzzz}	Identifies an object instance within a physical device in case there are more than one instance, where	
	xxxx	Represents the instance or node number See Table 245
	yyyy	Identify the Device ID as a vendor specific number for the device class
	zzzz	Represents the Vendor ID as a central administrative number assigned by the responsible user organisation

Table 245 – RPCObjectUUID for PNIO with multiple interfaces

Value	Description	
xxxx	Identifies an object instance within a physical device in case there are more than one instance, where	
	Bit 0 – Bit 11	Represents the instance or node number
	Bit 12 – Bit 15	Identify the interface 0x0: Interface 0 (Default) … 0xF: Interface 15 See “I” within Formula (45)

4.10.2.1.9 Coding of the field RPCInterfaceUUID

This field shall be coded as data type structure containing the following elements:

– Data1 as Unsigned32
– Data2 as Unsigned16
– Data3 as Unsigned16
– Data4 as array of eight Unsigned8

The octet ordering shall be according to the value of the field RPCDRep (little endian or big endian).

Defined values for PNIO items are shown in Table 246.

Table 246 – RPCInterfaceUUID for PNIO

Value	Description
UUID_IO_DeviceInterface DEA00001-6C97-11D1-8271-00A02442DF7D	Identifies the interface of an IO device uniquely. RPCInterfaceVersion shall be: Major version: 1 Minor version: 0
UUID_IO_ControllerInterface DEA00002-6C97-11D1-8271-00A02442DF7D	Identifies the interface of an IO controller uniquely. RPCInterfaceVersion shall be: Major version: 1 Minor version: 0
UUID_IO_SupervisorInterface DEA00003-6C97-11D1-8271-00A02442DF7D	Identifies the interface of an IO supervisor uniquely. RPCInterfaceVersion shall be: Major version: 1 Minor version: 0
UUID_IO_ParameterServerInterface DEA00004-6C97-11D1-8271-00A02442DF7D	Identifies the interface of an IO parameter server uniquely. RPCInterfaceVersion shall be: Major version: 1 Minor version: 0

Defined values for the RPC end point mapper are shown in Table 247.

Table 247 – RPCInterfaceUUID for the RPC end point mapper

Value	Description
UUID_EPMap_Interface E1AF8308-5D1F-11C9-91A4-08002B14A0FA UUID_EPMap_Object 00000000-0000-0000-0000-000000000000	Identifies the interface of the endpoint mapper. The RPCInterfaceVersion shall be: Major version: 3 Minor version: 0

4.10.2.1.10 Coding of the field RPCActivityUUID

This field shall be coded as data type structure containing the following elements:

- Data1 as Unsigned32
- Data2 as Unsigned16
- Data3 as Unsigned16
- Data4 as array of eight Unsigned8

NOTE The response mirrors the content of the field of the request.

The endianess is according to the value in the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The IOC and the IOD generates an RPCActivityUUID for each AR and use them as long as the AR exist.

4.10.2.1.11 Coding of the field RPCServerBootTime

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

NOTE Idempotent functions do not need to maintain this value. Only the endpointmapper is allowed to answer with zero.

4.10.2.1.12 Coding of the field RPCInterfaceVersion

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 15: RPCInterfaceVersion.Major
This field shall be set according to Table 248.

Table 248 – RPCInterfaceVersion.Major

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001 – 0xFFFF	Valid version information

Bit 16 – 31: RPCInterfaceVersion.Minor
This field shall be set according to Table 249.

Table 249 – RPCInterfaceVersion.Minor

Value (hexadecimal)	Meaning
0x0000 – 0xFFFF	Valid version information

The endianess is according to the value in the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.13 Coding of the field RPCSequenceNmb

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.14 Coding of the field RPCOperationNmb

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The RPCOperationNmb identifies the PNIO service supported by the PNIO interfaces

– IO device,
– IO controller and
– IO supervisor.

The values for PNIO services are defined in Table 250.

Table 250 – RPCOperationNmb (IO device, controller and supervisor)

Value (decimal)	Service	Usage
0	Connect	—
1	Release	—
2	Read	Only valid with ARUUID<>0
3	Write	Only valid with ARUUID<>0
4	Control	—
5	Read Implicit	Only valid with ARUUID=0
6 – 65 535	Reserved	—

The values for endpoint mapper services according to Table 251 shall be used.

Table 251 – RPCOperationNmb for endpoint mapper

Value (decimal)	Usage	Service
0	Optional	Insert
1	Optional	Delete
2	Mandatory	Lookup
3	Optional	Map
4	Mandatory	LookupHandleFree
5	Optional	InqObject
6	Optional	MgmtDelete

Value (decimal)	Usage	Service
7 – 65 535	Reserved	—

4.10.2.1.15 Coding of the field RPCInterfaceHint

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value should be set to no hint (0xFFFF) for this version.

The client shall start with “no hint” for the first call and should use the server response for the following calls to allow a server optimization.

4.10.2.1.16 Coding of the field RPCActivityHint

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value should be set to no hint (0xFFFF) for this version.

The client shall start with “no hint” for the first call and should use the server response for the following calls to allow a server optimization.

4.10.2.1.17 Coding of the field RPCLengthOfBody

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to the number of octets of NDRData of the current frame.

The conveyance of NDRData may require more than one frame. In this case RPCLengthOfBody contains only the number of octets for the current frame.

4.10.2.1.18 Coding of the field RPCFragmentNmb

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to the number of the current fragment.

4.10.2.1.19 Coding of the field RPCAuthenticationProtocol

This field shall be coded as data type Unsigned8.

The value shall be set to zero for no authentication.

4.10.2.1.20 Coding of the field RPCCancelVersion

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to zero.

4.10.2.1.21 Coding of the field RPCCancelID

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.22 Coding of the field RPCServerIsAccepting

This field shall be coded as data type Unsigned8.

4.10.2.1.23 Coding of the field RPCVersionFack

This field shall be coded as data type Unsigned8.

The value shall be set to zero.

4.10.2.1.24 Coding of the field RPCPad1

This field shall be coded as data type Unsigned8.

4.10.2.1.25 Coding of the field RPCWindowSize

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field RPCDRep (little endian or big endian).

4.10.2.1.26 Coding of the field RPCMaxTsdu

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.27 Coding of the field RPCMaxFragSize

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.28 Coding of the field RPCSerialNumber

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.29 Coding of the field RPCSelAckLen

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.30 Coding of the field RPCArrayOfSelAck

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.1.31 Coding of the field RPCDataRepresentationUUID

This field shall be coded as data type structure containing the following elements:

- Data1 as Unsigned32
- Data2 as Unsigned16
- Data3 as Unsigned16
- Data4 as array of eight Unsigned8

The octet ordering shall be little endian with the value according to Table 252.

Table 252 – RPCDataRepresentationUUID – defined values

Value [UUID]	Value	Description
8A885D04-1CEB-11C9-9FE8-08002B104860	Data representation	Identifies the RPC data representation uniquely.

4.10.2.2 Coding section related to NDREPMapPDU

4.10.2.2.1 Coding of the field DeviceType

This field shall be coded as data type VisibleString[25]. The value shall be set manufacturer specific and shall be filled with blanks if it is shorter than 25 octets.

NOTE See also the field DeviceVendorValue.

4.10.2.2.2 Coding of the field OrderID

This field shall be coded as data type VisibleString[20]. The value shall be set manufacturer specific and shall be filled with blanks if it is shorter than 20 octets.

4.10.2.2.3 Coding of the field HWRevision

This field shall be coded as data type VisibleString[5]. The value shall be set manufacturer specific using the character “0”-“9” and “<Blank>”. The range is from “<Blank><Blank><Blank><Blank>0” to “99999”.

NOTE As an example HWRevision could be “<Blank><Blank><Blank><Blank>2”, “<Blank>5714”, or “61214”.

This field shall show the same revision than the field IM_Hardware_Revision.

4.10.2.2.4 Coding of the field SWRevisionPrefix

This field shall be coded as data type VisibleString[1]. The value shall be set manufacturer specific using the character:

– “V” for an officially released version
– “R” for Revision
– “P” for Prototype
– “U” for Under Test (Field Test)
– “T” for Test Device

It is recommended to use “V” in conjunction with the field SWRevision containing “<Blank><Blank>0<Blank><Blank>0<Blank><Blank>0” if a submodule contains no software / firmware.

4.10.2.2.5 Coding of the field SWRevision

This field shall be coded as data type VisibleString[9]. The value shall be set manufacturer specific using the character “0”-“9” and “<Blank>”. The range is from “<Blank><Blank>0<Blank><Blank>0<Blank><Blank>0” to “999999999”.

As an example SWRevision could be “<Blank><Blank>1<Blank><Blank>0<Blank><Blank>0”. The presentation layer may insert a “.” after each group of three octets for better visualization.

4.10.2.2.6 Coding of the field Blank

This field shall be coded as data type OctetString with 1 octet.

The value shall be set to 0x20.

4.10.2.2.7 Coding of the field RPCInquiryType

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The coding shall be according to Table 253.

Table 253 – RPCInquiryType

Value (hexadecimal)	Meaning	Using
0x00000000	Read all registered interfaces with objects.	Mandatory
0x00000001	Read all objects for one registered interface.	Optional
0x00000002	Read all interfaces including a dedicated object.	Optional
0x00000003	Read one dedicated interface with one dedicated object.	Optional
0x00000004 – 0xFFFFFFFF	Reserved	—

4.10.2.2.8 Coding of the field RPCObjectReference

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to 1.

4.10.2.2.9 Coding of the field RPCInterfaceReference

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field RPCDRep (little endian or big endian).

The value shall be set to 2.

4.10.2.2.10 Coding of the field RPCInterfaceVersionMajor

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.11 Coding of the field RPCInterfaceVersionMinor

This field shall be coded as data type Unsigned16. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.12 Coding of the field RPCVersionOption

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to 1.

4.10.2.2.13 Coding of the field RPCEntryHandleAttribute

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to 0.

4.10.2.2.14 Coding of the field RPCEntryHandleUUID

This field shall be coded as data type UUID. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.15 Coding of the field RPCMaxEntries

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set at least to 1.

4.10.2.2.16 Coding of the field RPCNumberOfEntries

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.17 Coding of the field RPCEntriesOffset

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to 0.

4.10.2.2.18 Coding of the field RPCEntriesCount

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.19 Coding of the field RPCTowerReference

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to 3.

4.10.2.2.20 Coding of the field RPCAnnotationOffset

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to 0.

4.10.2.2.21 Coding of the field RPCAnnotationLength

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set from 0 to 64.

4.10.2.2.22 Coding of the field EndTerm

This field shall be coded as data type Unsigned8. The value shall be set to 0.

4.10.2.2.23 Coding of the field RPCGap

This field shall be coded as data type Unsigned8.

4.10.2.2.24 Coding of the field RPCTowerLength

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.25 Coding of the field RPCTowerOctetStringLength

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

4.10.2.2.26 Coding of the field RPCEPMapStatus

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The coding shall be according to Table 254.

Table 254 – RPCEPMapStatus

Value (hexadecimal)	Meaning
0x00000000	RPC okay
0x16C9A0D6	Endpoint not registered
others	Reserved

4.10.2.2.27 Coding of the field RPCFloorCount

This field shall be coded as data type Unsigned16. The encoding shall be independently of the field RPCDRep always little endian.

The value shall be set to 5.

4.10.2.2.28 Coding of the field RPCLHSByteCount

This field shall be coded as data type Unsigned16. The encoding shall be independently of the field RPCDRep always little endian.

4.10.2.2.29 Coding of the field RPCRHSByteCount

This field shall be coded as data type Unsigned16. The encoding shall be independently of the field RPCDRep always little endian.

4.10.2.2.30 Coding of the field RPCID

This field shall be coded as data type Unsigned8.

The value shall be set to 0x0D.

4.10.2.2.31 Coding of the field RPCProtocolIdentifier

This field shall be coded as data type Unsigned8.

The value shall be set to 0x0A.

4.10.2.2.32 Coding of the field RPCServerUDPPort

This field shall be coded as data type Unsigned8.

The value shall be set to 0x08.

4.10.2.2.33 Coding of the field RPCHostAddress

This field shall be coded as data type Unsigned8.

The value shall be set to 0x09.

4.10.2.2.34 Coding of the field RPCPortNumber

This field shall be coded as data type Unsigned16. The encoding shall be independently of the field RPCDRep always big endian.

4.10.2.2.35 Coding of the field RPCIPAddress

This field shall be coded as data type Unsigned32. The encoding shall be independently of the field RPCDRep always big endian.

The value may be zero.

4.10.2.3 Coding section related to NDRData

4.10.2.3.1 Coding of the field ArgsMaximum

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to the maximum buffer size available for the response.

4.10.2.3.2 Coding of the field ArgsLength

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to the number of octets within the PROFINETIOServiceReqPDU or PROFINETIOServiceResPDU.

4.10.2.3.3 Coding of the field MaximumCount

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

In case of a request the value shall be set to the same value as in the field ArgsMaximum. Within the response the value shall be taken from the field ArgsMaximum of the appropriate request.

In case of an inconsistency in the coding of the “Uni-dimensional Conformant-varying Array” the packet should be rejected on the server side and an error should be reported locally on the client side, as stated in The Open Group — Publication C706.

4.10.2.3.4 Coding of the field Offset

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to zero.

4.10.2.3.5 Coding of the field ActualCount

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The value shall be set to the same value as in the field ArgsLength.

4.10.2.3.6 Coding of the field PNIOStatus

This field shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian) within the first field of the NDRDataResponse. In all other cases the octet ordering shall be big endian.

The content is defined in 5.2.6. The PNIOStatus shall be calculated according to the following formula.

$$\begin{aligned} \text{PNIOStatus} = {} & \text{ErrorCode} \times 16\,777\,216 + \\ & \text{ErrorDecode} \times 65\,536 + \\ & \text{ErrorCode1} \times 256 + \\ & \text{ErrorCode2} \end{aligned} \tag{44}$$

where

ErrorCode	is the error code value
ErrorDecode	is the error decode value
ErrorCode1	is the error code1 value
ErrorCode2	is the error code2 value

4.10.2.4 Coding section related to RPC (NCA Codes)

4.10.2.4.1 Coding of the field RPCNCAFaultStatus

The RPC specific NCA error codes shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The values shall be according to Table 255.

Table 255 – Values of NCAFaultStatus

Value (hexadecimal)	Definition
0x1C000001	NCA_s_fault_int_div_by_zero
0x1C000002	NCA_s_fault_addr_error
0x1C000003	NCA_s_fault_fp_div_zero
0x1C000004	NCA_s_fault_fp_underflow
0x1C000005	NCA_s_fault_fp_overflow
0x1C000006	NCA_s_fault_invalid_tag
0x1C000007	NCA_s_fault_invalid_bound
0x1C000008	NCA_s_rpc_version_mismatch
0x1C000009	NCA_s_unspec_reject
0x1C00000A	NCA_s_bad_actid

Value (hexadecimal)	Definition
0x1C00000B	NCA_s_who_are_you_failed
0x1C00000C	NCA_s_manager_not_entered
0x1C00000D	NCA_s_fault_chancel
0x1C00000E	NCA_s_fault_ill_inst
0x1C00000F	NCA_s_fault_fp_error
0x1C000010	NCA_s_fault_int_overflow
0x1C000012	NCA_s_fault_unspec
0x1C000013	NCA_s_fault_remote_comm_failure
0x1C000014	NCA_s_fault_pipe_empty
0x1C000015	NCA_s_fault_pipe_closed
0x1C000016	NCA_s_fault_pipe_order
0x1C000017	NCA_s_fault_pipe_discipline
0x1C000018	NCA_s_fault_pipe_comm_error
0x1C000019	NCA_s_fault_pipe_memory
0x1C00001A	NCA_s_fault_context_mismatch
0x1C00001B	NCA_s_fault_remote_no_memory
0x1C00001C	NCA_s_invalid_pres_context_id
0x1C00001D	NCA_s_unsupported_authn_level
0x1C00001F	NCA_s_invalid_checksum
0x1C000020	NCA_s_invalid_crc
0x1C000021	NCA_s_fault_user_defined
0x1C000022	NCA_s_fault_tx_open_failed
0x1C000023	NCA_s_fault_codeset_conv_error
0x1C010001	NCA_s_comm_failure
0x1C010015	NCA_s_fault_string_too_long

4.10.2.4.2 Coding of the field RPCNCARejectStatus

The RPC specific NCA error codes shall be coded as data type Unsigned32. The octet ordering shall be according to the value of the field “RPCDRep.IntegerEncoding” (little endian or big endian).

The values shall be according to Table 256.

Table 256 – Values of NCARejectStatus

Value (hexadecimal)	Definition
0x1C000008	NCA_rpc_version_mismatch
0x1C000009	NCA_unspec_reject
0x1C00000A	NCA_s_bad_actid
0x1C00000B	NCA_who_are_you_failed
0x1C00000C	NCA_manager_not_entered
0x1C010002	NCA_op_rng_error
0x1C010003	NCA_unk_if

Value (hexadecimal)	Definition
0x1C010006	NCA_wrong_boot_time
0x1C010009	NCA_s_you_crashed
0x1C01000B	NCA_proto_error
0x1C010013	NCA_out_args_too_big
0x1C010014	NCA_server_too_busy
0x1C010017	NCA_unsupported_type
0x1C00001D	NCA_unsupported_authn_level
0x1C00001F	NCA_invalid_checksum
0x1C000020	NCA_invalid_crc

4.10.3 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.10.4 Application Relationship Protocol Machines

4.10.4.1 RPC Protocol Machine

4.10.4.1.1 Primitive definitions

4.10.4.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by RPC are described in the service definition and shown in Table 257.

Table 257 – Remote primitives issued or received by RPC

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.10.4.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by RPC are described in the service definition and shown in Table 258.

Table 258 – Local primitives issued or received by RPC

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.10.4.1.2 State transition diagram

The state transition diagram of RPC is defined in the Technical standard DCE1.1.

4.10.4.1.3 State machine description

The state machine description is defined in the Technical standard DCE1.1.

4.10.4.1.4 RPC state table

The state table is defined in the Technical standard DCE1.1.

4.10.4.1.5 Functions, Macros, Timers and Variables

The functions are defined in the Technical standard DCE1.1.

4.10.4.2 Monitoring of services

The Ping service initiated by a service requester is called to monitor the health of the responder. The Cancel service may be repeated up to three times.

Timeout Ping
The value shall be 2 s.

NOTE 1 The ping service is used if the request is completely sent and the response is still pending.

Timeout FRAG
The value shall be 2 s.

NOTE 2 The transmission of a fragment will be repeated up to three times after 2 s if there is no acknowledge.

Timeout Cancel
The value shall be 1 s.

NOTE 3 The Cancel service will be repeated up to three times after 1 s if there is no reaction.

Timeout Resend, Timeout Ack, Timeout Broadcast, Timeout IDLE, Timeout WAIT
The values don't care.

NOTE 4 The above described parameters are defined with their values in DCE RPC.

4.10.5 DLL Mapping Protocol Machines

There is no DLL Mapping Protocol Machine (DMPM) defined for this Protocol.

4.11 Link layer discovery

4.11.1 FAL common syntax description

4.11.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.11.1.2 LLDP APDU abstract syntax

Table 259 defines the abstract syntax of the LLDP PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 259 shall represent the content of the DLSDU in Table 5.

Table 259 – LLDP APDU syntax

APDU name	APDU structure
LLDP-PDU	LLDPChassis, LLDPPort, LLDPTTL, LLDP-PNIO-PDU, LLDPEnd
LLDP-PNIO-PDU	{ LLDP_PNIO_DELAY [a], LLDP_PNIO_PORTSTATUS, [LLDP_PNIO_ALIAS], LLDP_PNIO_MRPPORTSTATUS [b], LLDP_PNIO_CHASSIS_MAC, LLDP8023MACPHY [d], LLDPManagement, LLDP_PNIO_PTCPSTATUS [c], [LLDPOption*] [e], [LLDP8021*], [LLDP8023*] }

[a] Shall only exist, if LineDelay measurement is supported.

[b] Shall only exist, if MRP is activated for this port.

[c] Shall only exist, if PTCP is activated by means of the PDSyncData Record.

[d] Shall only exist, if IEEE 802.3 is used.

[e] Other LLDP options may be used concurrently.

Table 260 defines structures for substitutions of elements of the APDU structures shown in Table 259.

Table 260 – LLDP substitutions

Substitution name	Structure
LLDPChassis with MultipleInterfaceMode.-NameOfDevice:=0	LLDPChassisStationName ^ LLDPChassisMacAddress [a]
LLDPChassis with MultipleInterfaceMode.-NameOfDevice:=1	LLDPChassisStationName ^ LLDPChassisMacAddress [c]
LLDPChassisStationName	LLDP_TLVHeader [b], LLDP_ChassisIDSubType(7) [b], LLDP_ChassisID
LLDPChassisMacAddress	LLDP_TLVHeader [b], LLDP_ChassisIDSubType(4) [b], (CMResponderMacAdd ^ CMInitiatorMacAdd) [d]
LLDPPort	LLDP_TLVHeader [b], LLDP_PortIDSubType(7) [b], LLDP_PortID
LLDPTTL	LLDP_TLVHeader [b], LLDP_TimeToLive(20) [b]
LLDP_PNIO_Header	LLDP_TLVHeader [b], LLDP_OUI(00-0E-CF)
LLDP_PNIO_DELAY	LLDP_PNIO_Header, LLDP_PNIO_SubType(0x01), PTCP_PortRxDelayLocal, PTCP_PortRxDelayRemote PTCP_PortTxDelayLocal, PTCP_PortTxDelayRemote, CableDelayLocal
LLDP_PNIO_PORTSTATUS	LLDP_PNIO_Header, LLDP_PNIO_SubType(0x02), RTClass2_PortStatus, RTClass3_PortStatus
LLDP_PNIO_ALIAS	LLDP_PNIO_Header, LLDP_PNIO_SubType(0x03), AliasNameValue
LLDP_PNIO_MRPPORTSTATUS	LLDP_PNIO_Header, LLDP_PNIO_SubType(0x04), MRP_DomainUUID, MRRT_PortStatus
LLDP_PNIO_CHASSIS_MAC	LLDP_PNIO_Header, LLDP_PNIO_SubType(0x05), (CMResponderMacAdd ^ CMInitiatorMacAdd) [d]
LLDP_PNIO_PTCPSTATUS	LLDP_PNIO_Header, LLDP_PNIO_SubType(0x06), PTCP_MasterSourceAddress [e], PTCP_SubdomainUUID [f], IRDataUUID [g], LLDP_LengthOfPeriod [g], LLDP_RedOrangePeriodBegin [g], LLDP_OrangePeriodBegin [g], LLDP_GreenPeriodBegin [g]
LLDPEnd	LLDP_TLVHeader [b](0)
LLDP8021	LLDP_TLVHeader [b], LLDP_OUI(00-80-C2) [h], LLDP_8021_SubType [h], Data [h]
LLDP8023	LLDP_TLVHeader [b], LLDP_OUI(00-12-0F) [i], LLDP_8023_SubType [i], Data [i]
LLDP8023MACPHY	LLDP_TLVHeader [b], LLDP_OUI(00-12-0F) [i], LLDP_8023_SubType(1) [i], LLDP_8023_AUTONEG [i], LLDP_8023_PMDCAP [i], LLDP_8023_OPMAU [i]
LLDPManagement	LLDP_TLVHeader [b], LLDP_ManagementData [j]

[a] LLDPChassisMacAddress shall be used if no NameOfStation is assigned.

[b] The encoding of the fields shall be according to IEEE 802.1AB-2005.

[c] LLDPChassisMacAddress shall only be used if the NameOfDevice is equal to the NameOfStation and no NameOfStation is assigned.

[d] Shall be the interface MAC address of the transmitting node.

[e] Shall be set zero, if unknown.

[f] Shall be PTCP_SubdomainUUID of PTCP_SyncID := 0. Otherwise the value shall be zero.

[g] Shall be set zero, if unknown.

[h] Shall be set according to IEEE 802.1AB-2005 Annex F.

[i] Shall be set according to IEEE 802.1AB-2005 Annex G.

[j] Shall be set according to IEEE 802.1AB-2005, 9.5.9. It is recommended to set the object identifier according to 4.17.2.

NOTE There are different kinds of MAC addresses. The port MAC address used as SourceAddress and the interface MAC address used as CMResponderMacAdd or CMInitiatorMacAdd.

4.11.2 LLDP transfer syntax

4.11.2.1 General

As an extension to IEEE 802.1AB-2005, 10.5.3.1 this standard defines that value of the LLDP field txDelayWhile shall be zero. In this case, every node transmits LLDP PDUs on data change.

4.11.2.2 Coding of the field LLDP_ChassisID

This field shall be coded as data type OctetString according to Table 261.

NOTE The field LLDP_ChassisID is not terminated by zero.

Table 261 – LLDP_ChassisID in conjunction with MultipleInterfaceMode.NameOfDevice and NameOfStation

Multiple-InterfaceMode. NameOfDevice	NameOfStation exist	Data type	Meaning	
0	Yes	OctetString[]	This field shall be coded with 1 to 240 octets according to 4.3.1.4.15.	
0	No	—	—	
1	Yes	OctetString[]	Mandatory [a]	This field should be coded with “DeviceType, Blank, OrderID, Blank, IM_Serial_Number, Blank, HWRevision, Blank, SWRevisionPrefix, SWRevision”
			Optional [b]	This field shall be coded with 1 to 240 octets according to 4.3.1.4.15.
1	No	OctetString[]	Mandatory [a]	This field should be coded with “DeviceType, Blank, OrderID, Blank, IM_Serial_Number, Blank, HWRevision, Blank, SWRevisionPrefix, SWRevision”
			—	—

[a] Mandatory for nodes with multiple interfaces and recommended for all other nodes.

[b] Optional for nodes with single interface which will never have multiple interfaces.

4.11.2.3 Coding of the field LLDP_PortID

This field shall be coded as data type OctetString according to Table 262.

NOTE The field LLDP_PortID is not terminated by zero.

Table 262 – LLDP_PortID in conjunction with MultipleInterfaceMode.NameOfDevice

Multiple-InterfaceMode. NameOfDevice	Data type	Meaning
0	OctetString[8] or OctetString[14]	The field LLDP_PortID shall be coded according to 4.3.1.4.16
1	OctetString[]	The field LLDP_PortID shall be coded according to 4.3.1.4.17.1

4.11.2.4 Coding of the field LLDP_PNIO_SubType

This field shall be coded as data type Unsigned8 and shall be set according to Table 263.

Table 263 – LLDP_PNIO_SubType

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Measured delay values
0x02	Port Status
0x03	Alias
0x04	MRP Port Status
0x05	Interface MAC address
0x06	PTCP Status
0x07 – 0xFF	Reserved

4.11.2.5 Coding of the field PTCP_PortRxDelayLocal

This field shall be coded as data type Unsigned32, the time base shall be 1 ns and shall be set according to Table 264.

Table 264 – PTCP_PortRxDelayLocal

Value (hexadecimal)	Meaning
0x00	Unknown
0x01 – 0x00000FFF	Local RX port delay
0x00001000 – 0xFFFFFFFF	Reserved

4.11.2.6 Coding of the field PTCP_PortRxDelayRemote

This field shall be coded as data type Unsigned32, the time base shall be 1 ns and shall be set according to Table 265.

Table 265 – PTCP_PortRxDelayRemote

Value (hexadecimal)	Meaning
0x00	Unknown
0x01 – 0x00000FFF	Remote RX port delay
0x00001000 – 0xFFFFFFFF	Reserved

4.11.2.7 Coding of the field PTCP_PortTxDelayLocal

This field shall be coded as data type Unsigned32, the time base shall be 1 ns and shall be set according to Table 266.

Table 266 – PTCP_PortTxDelayLocal

Value (hexadecimal)	Meaning
0x00	Unknown
0x01 – 0x00000FFF	Local TX port delay
0x00001000 – 0xFFFFFFFF	Reserved

4.11.2.8 Coding of the field PTCP_PortTxDelayRemote

This field shall be coded as data type Unsigned32, the time base shall be 1 ns and shall be set according to Table 267.

Table 267 – PTCP_PortTxDelayRemote

Value (hexadecimal)	Meaning
0x00	Unknown
0x01 – 0x00000FFF	Remote TX port delay
0x00001000 – 0xFFFFFFFF	Reserved

4.11.2.9 Coding of the field CableDelayLocal

This field shall be coded as data type Unsigned32, the time base shall be 1 ns and shall be set according to Table 268.

Table 268 – CableDelayLocal

Value (hexadecimal)	Meaning
0x00	Unknown
0x01 – 0x000FFFFF	Measured cable delay
0x00100000 – 0xFFFFFFFF	Reserved

4.11.2.10 Coding of the field RTClass2_PortStatus

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 1: RTClass2_PortStatus.State
This field shall be set according to Table 269 or Table 270.

Table 269 – RTClass2_PortStatus.State with ARProperties.StartupMode == Legacy

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Not used or configured if LLDP_OrangePeriodBegin.Valid is equal one.
0x01	Reserved	—
0x02	RTCLASS2_RUN	ORANGE Phase activated for transmission and reception of RTClass2 Frames
0x03	Reserved	—

Table 270 – RTClass2_PortStatus.State with ARProperties.StartupMode == Advanced

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Not used
other	Reserved	—

Bit 2 – 15: RTClass2_PortStatus.reserved
This field shall be set according to 3.4.2.2.

4.11.2.11 Coding of the field RTClass3_PortStatus

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 2: RTClass3_PortStatus.State
This field shall be set according to Table 271.

Table 271 – RTClass3_PortStatus.State

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Not used or configured if LLDP_RedOrangePeriodBegin.Valid is equal one. RED period is deactivated.
0x01	Reserved	—
0x02	RTCLASS3_UP	RED period activated for transmission of RTClass3 Frames. Expected next state: RTCLASS3_RUN
0x03	Reserved	—
0x04	RTCLASS3_RUN	RED period activated for transmission and reception of RTClass3 Frames
0x05 – 0x07	Reserved	—

Bit 3 – 11: RTClass3_PortStatus.reserved
This field shall be set according to 3.4.2.2.

Bit 12: RTClass3_PortStatus.Fragmentation
This field shall be set according to Table 272.

Table 272 – RTClass3_PortStatus.Fragmentation

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Default The fragmentation mode for this port is disabled.
0x01	ON	The fragmentation mode for this port is enabled.

The information whether the fragmentation is activated, shall be derived from the PDIRGlobalData and the SendClockFactor.

Bit 13: RTClass3_PortStatus.PreambleLength
This field shall be set according to Table 273.

Table 273 – RTClass3_PortStatus.PreambleLength

Value (hexadecimal)	Meaning	Usage
0x00	Seven octets	Default The PHY uses seven octets preamble when transmitting
0x01	One octet	The PHY uses one octet preamble when transmitting

It is recommended, that a PHY / MAC supports one octet preamble length when sending using the MAUType 100BASETXFD.

A PHY / MAC should support one octet preamble length when receiving using the MAUType 100BASETXFD.

Table 274 contains the truth table used for the shortening of the preamble.

Table 274 – Truth table for shortening of the preamble

Input		Output
RTC3PSM	**AdjustPreambleLength.** **PreambleLength.Length**	**RTClass3_PortStatus.** **PreambleLength**
EXPECTED_REMOTE(LLDP_ChassisID) == REMOTE(LLDP_ChassisID) AND EXPECTED_REMOTE(LLDP_PortID) == REMOTE(LLDP_PortID) AND EXPECTED_REMOTE(IRDataUUID) == REMOTE(LLDP_IRDataUUID) AND EXPECTED_LOCAL(MAUType) == LOCAL(MAUType)	Seven Octets	Seven Octets
	One Octet	One Octet
! (EXPECTED_REMOTE(LLDP_ChassisID) == REMOTE(LLDP_ChassisID) AND EXPECTED_REMOTE(LLDP_PortID) == REMOTE(LLDP_PortID) AND EXPECTED_REMOTE(IRDataUUID) == REMOTE(LLDP_IRDataUUID) AND EXPECTED_LOCAL(MAUType) == LOCAL(MAUType))	—	Seven Octets

Bit 14: RTClass3_PortStatus.reserved
This field shall be set according to 3.4.2.2.

Bit 15: RTClass3_PortStatus.Optimized
This field shall be set according to Table 275.

Table 275 – RTClass3_PortStatus.Optimized

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Default
0x01	ON	Reserved

4.11.2.12 Coding of the field MRRT_PortStatus

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 1: MRRT_PortStatus.State
This field shall be set according to Table 276.

Table 276 – MRRT_PortStatus.State

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Not used / not configured
0x01 – 0x03	Reserved	—

Bit 2 – 15: MRRT_PortStatus.reserved
This field shall be set according to 3.4.2.2.

4.11.2.13 Coding of the field IRDataUUID

This field shall be coded as data type UUID according to Table 277.

Table 277 – IRDataUUID

Value (UUID)	Meaning	Usage
00000000-0000-0000-0000-000000000000	No RT_CLASS_3 domain	Initial value
00000000-0000-0000-0000-000000000001 – FFFFFFFF-FFFF-FFFF-FFFF-FFFFFFFFFFFE	UUID for a RT_CLASS_3 domain	Generated by engineering and used by IO controller and IO device to identify a RT_CLASS_3 domain

4.11.2.14 Coding of the field LLDP_RedOrangePeriodBegin

As defined for RT_CLASS_3 the usage of a port is divided into different time periods. Also the usage of a port is divided into transmit and receive direction. The coding of this field shall be according to 3.4.2.5 and to Figure 21. The individual bits shall have the following meaning:

Bit 0 – 30: LLDP_RedOrangePeriodBegin.Offset
This field shall be set according to Table 278.

Table 278 – LLDP_RedOrangePeriodBegin.Offset

Value (hexadecimal)	Meaning	Usage
0x00000000 – 0x003D08FF	Offset relative to the begin of the cycle in nanoseconds	Begin of the RT_CLASS_3 period of the transmit direction of the port. If a RedPeriod is defined, the value shall be derived from the minimum of RedOrangePeriodBegin, else the value shall be derived from ReservedIntervalBegin.
0x003D0900 – 0x7FFFFFFF	Reserved	—

Bit 31: LLDP_RedOrangePeriodBegin.Valid
This field shall be set according to Table 279.

Table 279 – LLDP_RedOrangePeriodBegin.Valid

Value (hexadecimal)	Meaning	Usage
0x00	Invalid	The value of LLDP_RedOrangePeriodBegin.Offset is not valid. It shall be set to zero.
0x01	Valid	The value of LLDP_RedOrangePeriodBegin.Offset is valid.

4.11.2.15 Coding of the field LLDP_OrangePeriodBegin

NOTE Used only with ARProperties.StartupMode == Legacy.

The coding of this field shall be according to 3.4.2.5 and to Figure 21. The individual bits shall have the following meaning:

Bit 0 – 30: LLDP_OrangePeriodBegin.Offset
This field shall be set according to Table 280.

Table 280 – LLDP_OrangePeriodBegin.Offset

Value (hexadecimal)	Meaning	Usage
0x00000000 – 0x003D08FF	Offset relative to the begin of the cycle in nanoseconds	Begin of the RT_CLASS_2 period of the transmit direction of the port. If a RedPeriod is defined, the value shall be derived from the maximum of OrangePeriodBegin, else the value shall be derived from ReservedIntervalBegin.
0x003D0900 – 0x7FFFFFFF	Reserved	—

Bit 31: LLDP_OrangePeriodBegin.Valid
This field shall be set according to Table 281 or Table 282.

Table 281 – LLDP_OrangePeriodBegin.Valid with ARProperties.StartupMode == Legacy

Value (hexadecimal)	Meaning	Usage
0x00	Invalid	The value of LLDP_OrangePeriodBegin.Offset is not valid. It shall be set to zero.
0x01	Valid	The value of LLDP_OrangePeriodBegin.Offset is valid.

Table 282 – LLDP_OrangePeriodBegin.Valid with ARProperties.StartupMode == Advanced

Value (hexadecimal)	Meaning	Usage
0x00	Invalid	LLDP_OrangePeriodBegin.Offset is not valid. It shall be set to zero.
other	—	Reserved

4.11.2.16 Coding of the field LLDP_GreenPeriodBegin

As defined for RT_CLASS_1, RT_CLASS_2, RT_CLASS_UDP and the other protocols the usage of a port is divided into different time periods. Also the usage of a port is divided into

transmit and receive. The coding of this field shall be according to 3.4.2.5 and to Figure 21. The individual bits shall have the following meaning:

Bit 0 – 30: LLDP_GreenPeriodBegin.Offset
This field shall be set according to Table 283.

Table 283 – LLDP_GreenPeriodBegin.Offset

Value (hexadecimal)	Meaning	Usage
0x00000000 – 0x003D08FF	Offset relative to the begin of the cycle in nanoseconds	Begin of the unrestricted period of the transmit direction of the port. The value shall be derived from ReservedIntervalEnd.
0x003D0900 – 0x7FFFFFFF	Reserved	—

Bit 31: LLDP_GreenPeriodBegin.Valid
This optional field shall be set according to Table 284.

Table 284 – LLDP_GreenPeriodBegin.Valid

Value (hexadecimal)	Meaning	Usage
0x00	Invalid	The value of LLDP_GreenPeriodBegin.Offset is not valid. It shall be set to zero.
0x01	Valid	The value of LLDP_GreenPeriodBegin.Offset is valid.

4.11.2.17 Coding of the field LLDP_LengthOfPeriod

A port is divided into different time periods. The duration of all periods is shown by this field. The coding of this field shall be according to 3.4.2.5 and to Figure 21. The individual bits shall have the following meaning:

Bit 0 – 30: LLDP_LengthOfPeriod.Length
This field shall be set according to Table 285.

Table 285 – LLDP_LengthOfPeriod.Length

Value (hexadecimal)	Meaning	Usage
0x00007A12 – 0x003D0900	Duration of a cycle in nanoseconds	The value shall be a multiple of 31 250 ns. See 5.2.4.62
0x003D0900 – 0x7FFFFFFF	Reserved	—

Bit 31: LLDP_LengthOfPeriod.Valid
This optional field shall be set according to Table 286.

Table 286 – LLDP_LengthOfPeriod.Valid

Value (hexadecimal)	Meaning	Usage
0x00	Invalid	LLDP_LengthOfPeriod.Length is not valid. It shall be set to zero.
0x01	Valid	LLDP_LengthOfPeriod.Length is valid.

4.11.2.18 Coding of the field LLDP_POINT

This field shall be coded as data type OctetString with one octet. The value shall be ".".

NOTE The field LLDP_POINT is not terminated by zero.

4.11.2.19 Coding of the field LLDP_TimeToLive

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.20 Coding of the field LLDP_TLVHeader

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.21 Coding of the field LLDP_ChassisIDSubType

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.22 Coding of the field LLDP_PortIDSubType

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.23 Coding of the field LLDPOption

This field shall be coded according to IEEE 802.1AB-2005, 9.4.

4.11.2.24 Coding of the field LLDP_OUI

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.25 Coding of the field LLDP_8021_SubType

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.26 Coding section related to LLDP_Management

4.11.2.26.1 Coding of the field LLDP_ManagementData

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.27 Coding section related to LLDP_8023

4.11.2.27.1 Coding of the field LLDP_8023_SubType

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.27.2 Coding of the field LLDP_8023_AUTONEG

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.27.3 Coding of the field LLDP_8023_PMDCAP

This field shall be coded according to IEEE 802.1AB-2005.

4.11.2.27.4 Coding of the field LLDP_8023_OPMAU

This field shall be coded according to IEEE 802.1AB-2005.

4.11.3 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.11.4 Application Relation Protocol Machines

There is no Application Relation Protocol Machine (ARPM) defined for this Protocol.

4.11.5 DLL Mapping Protocol Machines

There is no DLL Mapping Protocol Machine (DMPM) defined for this Protocol.

4.12 MAC Bridges

4.12.1 Overview

The concepts according to IEEE 802.1D standard shall be applied.

According to this concept, every MAC Bridge shall not forward frames where the SourceMACAddress is its own one and shall support wire speed forwarding of frames.

Apart from IEEE 802.1D behavior, this protocol specification defines the following protocol machines to provide special forwarding actions:

- RT_CLASS_3 Forwarding Protocol Machine (RED_RELAY)
- DFP Forwarding Protocol Machine (DFP_RELAY)
- Time Synchronization Forwarding Protocol Machine (SYNC_RELAY)

Additionally the learning mechanisms of IEEE 802.1D shall be disabled according to Table 287, Table 288 and Table 289. As an optimization a previous learned entry of the FDB may be refreshed.

The using of the “Cut through” principle for the forwarding of frames needs a late error handling to avoid frame fragments in a switched network. Thus, whenever an invalid (by FCS or SFCRC16) frame is detected which is already partial forwarded, it should be shortened adding a TX-error (see Annex S) at the transmitting port.

4.12.2 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.12.3 Application Relation Protocol Machines

There is no Application Relation Protocol Machine (ARPM) defined for this Protocol.

4.12.4 DLL Mapping Protocol Machines

4.12.4.1 Forwarding Protocol Machine

4.12.4.1.1 Filtering database

According to IEEE 802 and this standard a switch contains a filtering data base (FDB) to optimize the bridging. Table 287, Table 288 and Table 289 show the list of entries.

The row ORG with an entry “YES” indicates whether this protocol is able to be received or transmitted, even if a port is excluded from the active topology by MRP or RSTP.

NOTE IEC 62439-2 if supported adds further entries in the FDB.

Table 287 – Unicast FDB entries

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Application	Bridge	ORG	Learning	Meaning
Vendor	n	Receive [a]	Filter	No	Enabled	Interface MAC address
Vendor	n+1 – n+m	Receive [a]	Filter	No	Enabled	Port MAC addresses
Others	Others	—	—	—	—	
[a] If applicable						

Table 288 – Multicast FDB entries

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Application	Bridge	ORG	Learning	Meaning
01-0E-CF	00-00-00	Receive [a]	Forward	No	Enabled	With FrameID=0xFEFE used for DCP-Identify-ReqPDU
01-0E-CF	00-00-01	Receive [a]	Forward	No	Enabled	With FrameID=0xFEFC used for DCP-Hello-ReqPDU
01-0E-CF	00-01-01	Receive [a]	Filter [b]	No	Disabled	RT_CLASS_3 destination multicast address
01-0E-CF	00-01-02	Receive [a]	Filter [b]	No	Disabled	RT_CLASS_3 invalid frame multicast address
01-0E-CF	00-02-00 – 00-02-1F	Receive [a]	Forward [c]	No	Enabled	RT_CLASS_2 multicast communication address
01-0E-CF	00-02-20 – 00-02-FF	Receive [a]	Forward	No	Enabled	RT_CLASS_2 multicast communication address
01-0E-CF	00-04-00	Receive [a]	Forward	No	Disabled	In conjunction with PTCP-AnnouncePDU and FrameID (=0xFF00) used for working clock synchronization
01-0E-CF	00-04-20	Receive [a]	Filter	Yes	Disabled	In conjunction with PTCP-RTSyncPDU with follow up and FrameID(=0x0020) used for working clock synchronization
01-0E-CF	00-04-40	Receive [a]	Filter	Yes	Disabled	In conjunction with PTCP-FollowUpPDU and FrameID(=0xFF20) used for working clock synchronization
01-0E-CF	00-04-80	Receive [a]	Filter	Yes	Disabled	In conjunction with PTCP-RTSyncPDU and FrameID(=0x0080) used for working clock synchronization
X3-XX-00	00-00-00	Receive [a]	Filter [b]	No	Disabled	Fast forwarding RT_CLASS_3 destination multicast address
01-80-C2	00-00-00	Receive [a]	Filter [d]	Yes	Disabled	IEEE 802.1D Rapid spanning tree protocol (RSTP)
01-80-C2	00-00-01 – 00-00-0D	Receive [a]	Filter	Yes	Disabled	IEEE 802.1D

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Application	Bridge	ORG	Learning	Meaning
01-80-C2	00-00-0E	Receive [a]	Filter	Yes	Disabled	IEEE 802.1D, IEEE 802.1AS, IEEE 802.1AB (LLDP), and PTCP In conjunction with PTCP-DelayReqPDU and FrameID(=0xFF40), PTCP-DelayResPDU with follow up and FrameID(=0xFF41), PTCP-DelayFuResPDU and FrameID(=0xFF42) and PTCP-DelayResPDU whithout follow up and FrameID (=0xFF43) used for delay measurement
01-80-C2	00-00-0F	Receive [a]	Filter	Yes	Disabled	IEEE 802.1D
01-80-C2	00-00-10	Receive [a]	Filter	Yes	Disabled	IEEE 802.1D All LANs bridge management group address
01-00-5E	40-F8-00 – 40-FB-FF	Receive [a]	— [e]	No	Enabled	Used for multicast communication relations in conjunction with RT_CLASS_UDP
Others	Others	—	—	—	—	—

[a] If applicable

[b] This frames shall be discarded by the MAC Relay if RT_CLASS_3 is supported, otherwise should be discarded

[c] Forwarding depends on the setting of MulticastBoundary

[d] It is recommended to forward Rapid Spanning Tree Protocol (RSTP) frames in switches without RSTP support or switches with alternative media redundancy protocols like MRP

[e] It is recommended to forward these frames unless RFC 4604 (IGMPv3) is supported

Table 289 – Broadcast FDB entry

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Application	Bridge	ORG	Learn-ing	Meaning
FF-FF-FF	FF-FF-FF	Receive [a]	Forward	No	Enabled	Broadcast
Others	Others	—	—	—	—	—

[a] If applicable

4.12.4.1.2 Primitive definitions

The service primitives including their associated parameters issued by MAC_RELAY user received by MAC_RELAY and vice versa are described in the MAC bridges ASE in the service definition.

4.12.4.1.2.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by MAC_RELAY are described in the service definition and shown in Table 290.

Table 290 – Remote primitives issued or received by MAC_RELAY

Primitive	Source	Destination	Associated parameters	Functions
MAC_RELAY_Data.req	LMPM	MAC_RELAY	Frame	—
MAC_RELAY_Data.cnf	LMPM	MAC_RELAY	Frame, Status	—
MAC_RELAY_Data.ind	MAC_RELAY	LMPM	Port, Frame, Timestamp	—
DEMUX_MAC_RELAY.ind	DEMUX	MAC_RELAY	Port, Frame	—
QueueHandler.req	MAC_RELAY	QueueHandler	Queue, Frame	—

4.12.4.1.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by MAC_RELAY are described in the service definition and shown in Table 291.

Table 291 – Local primitives issued or received by MAC_RELAY

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.12.4.1.3 State transition diagram

The state transition diagram of the MAC_RELAY shall be according to IEEE 802.1D.

4.12.4.1.4 State machine description

The state machine shall of the MAC_RELAY be according to IEEE 802.1D.

4.12.4.1.5 MAC_RELAY state table

The state table shall be according to IEEE 802.1D.

4.12.4.1.6 Functions, Macros, Timers and Variables

Table 292 contains the functions, macros, timers and variables used by the MAC_RELAY and their arguments and their descriptions.

Table 292 – Functions, Macros, Timers and Variables used by the MAC_RELAY

Name	Type	Function/Meaning
—	—	—

4.12.4.2 RT_CLASS_3 port state machine

4.12.4.2.1 General

This part of the specification defines the utilization of the IEEE 802.1D standard.

It includes extensions for RT_CLASS_3 phase regarding forwarding of frames.

The routing mechanisms of IEEE 802.1D shall be temporarily disabled within the RT_CLASS_3 phase. In this case, the routing of RT_CLASS_3 frames shall be done according to the attributes defined by the appropriate ASE. The values of the attributes define a special routing table, which is used.

4.12.4.2.2 Primitive definitions

4.12.4.2.2.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Realtime Class 3 Port State Machine (RTC3PSM) are described in the service definition and shown in Table 293.

Table 293 – Remote primitives issued or received by RTC3PSM

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.12.4.2.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by RTC3PSM are described in the service definition and shown in Table 294.

Table 294 – Local primitives issued or received by RTC3PSM

Primitive	Source	Destination	Associated parameters	Functions
Remote_Systems_Data_Change_ind	LLDP	RTC3PSM	Local Port ID, List of Neighbors	—
MAU_Type_Change_ind	IEEE 802.3	RTC3PSM	Local Port ID, Local MAU Type, Local Link Status	—
Port_State_Change_ind	IEEE 802.1D	RTC3PSM	Local PortState	—
Sync_State_Change_ind	PTCP	RTC3PSM	Sync State	—
SetPortState	RTC3PSM	IEEE 802.1D	Local PortState	—

4.12.4.2.3 State transition diagram

The state transition diagram of the RTC3PSM is shown in Figure 67.

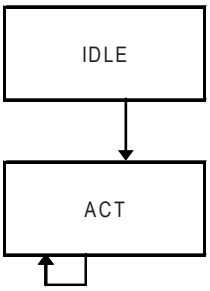


Figure 67 – State transition diagram of RTC3PSM

States of the RT3PSM

IDLE Idle state

ACT Active state

4.12.4.2.4 State machine description

The Realtime Class 3 Port State Machine (RTC3PSM) arranges the port states of realtime class 3.

4.12.4.2.5 RTC3PSM state table

The RTC3PSM state table is shown in Table 295 and shall exist for each port. The bandwidth allocation using the TXBeginEndAssignment and the RXBeginEndAssignment shall be coupled with the RTC3PSM port states.

Table 295 – RTC3PSM state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	=> EvaluateTruthTable() SetPortState ()	ACT
2	ACT	**Remote_Systems_Data_Change_ind ()** => REMOTEPORTSTATE NEIGHBOR ENGINEERING EvaluateTruthTable() SetPortState ()	ACT
3	ACT	**MAU_Type_Change_ind ()** => PORT EvaluateTruthTable() SetPortState ()	ACT
4	ACT	**Sync_State_Change_ind ()** => SYNC EvaluateTruthTable() SetPortState ()	ACT
5	ACT	**Port_ State_Change_ind ()** => PORT EvaluateTruthTable() SetPortState ()	ACT

4.12.4.2.6 Functions, Macros, Timers and Variables

Table 296 contains the functions, macros, timers and variables used by the RTC3PSM and their arguments and their descriptions.

Table 296 – Functions, Macros, Timers and Variables used by the RTC3PSM

Name	Type	Function/Meaning
EvaluateTruthTable	Function	This function is used as a trigger to evaluate the corresponding truth table.
If activated	Function	This check is activated by a sub block of the PDPortDataCheck record.
CHECK_DATA	Macro	This function delivers an information whether the local stored data is valid.

Name	Type	Function/Meaning
DIFFERENCE_FAULT	Macro	This function checks whether the difference between the local and remote measured CableDelay is less than 50 ns.
EXPECTED_LOCAL	Macro	This function delivers the local stored information which is expected to be achieved from local.
EXPECTED_REMOTE	Macro	This function delivers the local stored information which is expected to be delivered from remote.
GET_DOMAIN_BOUNDARY_VALUE	Macro	This function delivers the local information, stored in PDIRGlobalData and PDIRBeginEndData, whether this port is used as a RT_CLASS_3 port or not.
LOCAL	Macro	This function delivers the local information.
NEIGHBOR	Macro	! (// physical if activated: EXPECTED_REMOTE(LLDP_ChassisID) != REMOTE(LLDP_ChassisID) OR if activated: EXPECTED_REMOTE(LLDP_PortID) != REMOTE(LLDP_PortID) OR REMOTE(MAUType) != VALID [a] OR if activated: (EXPECTED_REMOTE(MAUType) != LOCAL(MAUType)) OR if activated: (LOCAL(LineDelay) > EXPECTED_LOCAL(LineDelay)) OR if activated: (EXPECTED_REMOTE(PreambleLength) != REMOTE(PreambleLength)) OR if activated: (EXPECTED_REMOTE(Fragmentation) != REMOTE(Fragmentation))) [a] This function returns for the parameter MAUType the value VALID, if the speed is greater or equal 100 Mbit/s and the duplexity is full according to 6.2.12.7.

PORT	Macro	! (
		// physical
		LOCAL(MAUType) != VALID a
		OR
		if activated: (EXPECTED_LOCAL(MAUType) != LOCAL(MAUType))
		OR
		LOCAL(PortState) == DISCARDING
		OR
		LOCAL(LinkStatus) != UP
		OR
		// logical
		LOCAL(GET_DOMAIN_BOUNDARY_VALUE()) == TRUE
		)
		
		[a] This function returns for the parameter MAUType the value VALID, if the speed is greater or equal 100 Mbit/s and the duplexity is full according to Table 551.

REMOTE	Macro	This function delivers the remote information stored locally.
REMOTEPORTSTATE	Macro	(// physical Does the remote RT_CLASS_3_Port_State exist and contain a value out of the following list {OFF, RTCLASS3_UP, RTCLASS3_RUN})

Name	Type	Function/Meaning

SYNC	Macro	! (
		// physical
		LOCAL(SYNC) == FALSE
		OR
		// logical
		if activated: (DIFFERENCE_FAULT(LOCAL(CableDelayLocal), REMOTE(CableDelayRemote)))
		)

4.12.4.2.7 Truth table

Table 297 and Table 298 contain the truth table used by the RTC3PSM.

Table 297 – Truth table for the RTC3PSM

Input						Output
Conditions of the transmit port				Remote port state	Local port state	Next local port state
PORT	NEIGHBOR	SYNC	ENGINEERING [b]	—	—	—
FALSE	—	—	—	—	—	OFF
TRUE	FALSE	—	—	—	—	OFF
TRUE	TRUE	FALSE	—	—	—	OFF
TRUE	TRUE	TRUE	FALSE	—	—	OFF
TRUE	TRUE	TRUE	TRUE	OFF	—	UP
TRUE	TRUE	TRUE	TRUE	UP	—	RUN
TRUE	TRUE	TRUE	TRUE	RUN	— [a]	RUN

[a] The local state “OFF” in combination with remote port state “RUN” is not suitable, but possible as a transient state. Even in this case, the next local state should be “RUN”.

[b] PDIRData and if needed PDIRSubframeData exist and is valid.

Table 298 – RXBeginEndAssignment and TXBeginEndAssignment

Input		Output	
Local port state	Remote port state	Local RXBeginEndAssignment	Local TXBeginEndAssignment
OFF	—	OFF	OFF
UP	—	OFF	ON [a]
RUN	UP	ON	ON [a]
RUN	RUN	ON	ON [b]

[a] To protect the installation of a remote RXBeginEndAssignment the local TXBeginEndAssignment should start with the RedOrangePeriodBegin:= 0, even if the PDIRBeginEndData stated otherwise.

[b] After the installation of a remote RXBeginEndAssignment the local TXBeginEndAssignment should start with the RedOrangePeriodBegin from the PDIRBeginEndData.

4.12.4.2.8 Generating of events

The RTC3PSM shows the state changes required to establish a RT_CLASS_3 peer to peer communication. Additional Figure 68 shows the diagnostic events, generated according to the state changes of the RTC3PSM. Table 299 defines the coding of the associated events.

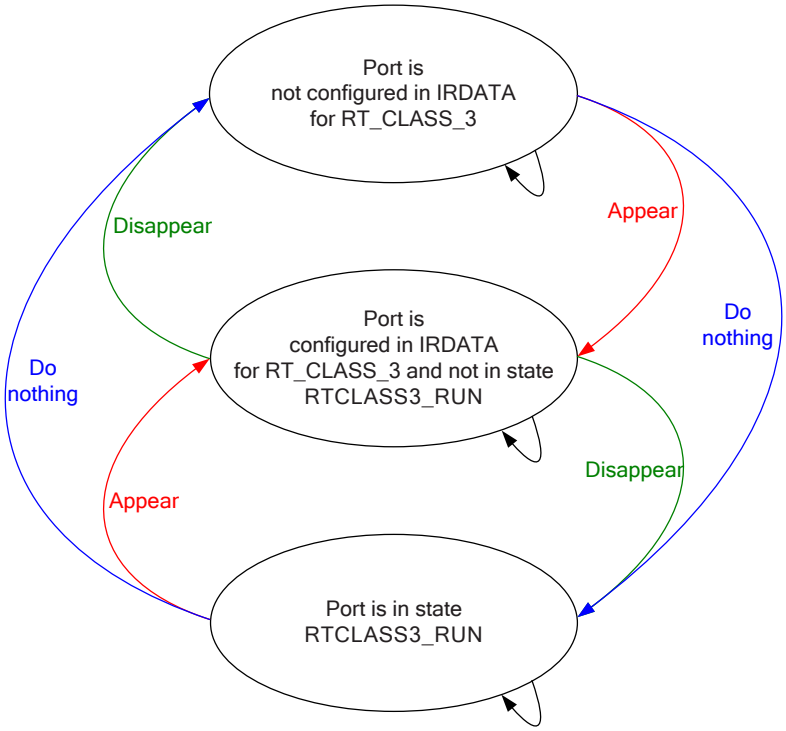


Figure 68 – State transition diagram for generating events

Table 299 – Event function table

Function name	Operations
Appear	Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:=Port Data Change Notification Alarm User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Appears ChannelErrorType := “Remote Mismatch” ExtChannelErrorType := “RT Class3 mismatch” Alarm Notification.req(AREP, API, Alarm Priority, Alarm Type, Slot Number, Subslot Number, Alarm Specifier, Module Ident Number, Submodule Ident Number, Alarm Item)
Disappear	Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:=Port Data Change Notification Alarm User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Disappears ChannelErrorType := “Remote Mismatch” ExtChannelErrorType := “RT Class3 mismatch” Alarm Notification.req(AREP, API, Alarm Priority, Alarm Type, Slot Number, Subslot Number, Alarm Specifier, Module Ident Number, Submodule Ident Number, Alarm Item)
Do nothing	This state change shall not indicate an event

4.12.4.3 RT_CLASS_3 Forwarding Protocol Machine

4.12.4.3.1 Primitive definitions

4.12.4.3.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Realtime Class 3 Forwarding Protocol Machine (RED_RELAY) are described in the service definition and shown in Table 300.

Table 300 – Remote primitives issued or received by RED_RELAY

Primitive	Source	Destination	Associated parameters	Functions
DMUX_RED_RELAY.ind	DFP_RELAY, DEMUX	RED_RELAY	Port, Tstamp, DA, SA, N_SDU, ReceivedInRED	—
RED_RELAY_Data.ind	RED_RELAY	LMPM	Port, Tstamp, DA, SA, N_SDU, ReceivedInRED	—
QueueHandler.req	RED_RELAY	QueueHandler	RED	This function puts the frame in the RED queue of the QueueHandler. The MUX dequeues the frame and conveys it to the MAC.

4.12.4.3.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by RED_RELAY are described in the service definition and shown in Table 301.

Table 301 – Local primitives issued or received by RED_RELAY

Primitive	Source	Destination	Associated parameters	Functions
RED_RELAY_Error_Ind	RED_RELAY	Local matter	CREP, ErrorCode	—
SyncStateChange_ind	PTCP	RED_RELAY	SYNC	—

4.12.4.3.2 State transition diagram

The state transition diagram of the RED_RELAY is shown in Figure 69.

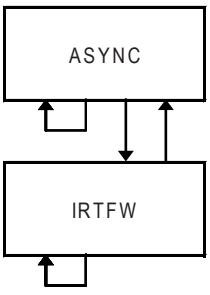


Figure 69 – State transition diagram of RED_RELAY

States of the RED_RELAY

ASYNC	The node shall be synchronized, either local as a sync master or remote as a sync slave for the RED forwarding
IRTFW	If the node is synchronized, the forwarding and local reception for RED frames using the PDIRFrameData or the PDIRGlobalData and PDIRBeginEndData shall be done

4.12.4.3.3 State machine description

The Realtime Class 3 Forwarding Protocol Machine (RED_RELAY) arranges the forwarding and local reception of RED frames.

4.12.4.3.4 RED_RELAY state table

The RED_RELAY shall ensure that the forwarding of the RT_CLASS_3 frames is done in a timely correct way. This means that the frame shall be forwarded according to the given FrameSendOffset (see Figure 29 for the FrameSendOffset reference point), to work with all kinds of RedGuards.

Devices supporting the RedGuard with full check may generate surrogate frames (see Table 169 for the used values of APDU_Status.TransferStatus), if a RED_RELAY_Error_Ind is detected or a frame is missing.

The necessary data for the RED_RELAY is given by the PDIRFrameData or locally generated out of the PDIRGlobalData.

The RED_RELAY state table is shown in Table 302.

Table 302 – RED_RELAY state table

#	Current State	Event /Condition =>Action	Next State
1	ASYNC	SyncStateChange_ind () /SYNC => ignore	IRTFW
2	ASYNC	SyncStateChange_ind () /!SYNC => ignore	ASYNC
3	ASYNC	TickEvent () => ignore	ASYNC
4	ASYNC	DMUX_RED_RELAY.ind () => ignore	ASYNC
5	IRTFW	SyncStateChange_ind () /SYNC => ignore	IRTFW
6	IRTFW	SyncStateChange_ind () /!SYNC => ignore	ASYNC
7	IRTFW	**TickEvent (CycleCounter, CycleOffset)** => Calculate Local_Phase as input for the RedGuard Calculate Local_FrameSendOffset as input for the RedGuard	IRTFW
8	IRTFW	**DMUX_RED_RELAY.ind ()** /RedGuard () == DISCARD, Reason == WrongTxPortState => ErrorCode := WRONG_TX_STATE RED_RELAY_Error_Ind (CREP, ErrorCode)	IRTFW

#	Current State	Event /Condition =>Action	Next State
9	IRTFW	**DMUX_RED_RELAY.ind ()** /RedGuard () == DISCARD, Reason == Data length => ErrorCode := WRONG_LENGTH RED_RELAY_Error_Ind (CREP, ErrorCode)	IRTFW
10	IRTFW	**DMUX_RED_RELAY.ind ()** /RedGuard () == DISCARD, Reason == FrameID OR Reason == Receive Port OR Reason == Phase => ErrorCode := WRONG_FRAMEID RED_RELAY_Error_Ind (CREP, ErrorCode)	IRTFW
11	IRTFW	**DMUX_RED_RELAY.ind ()** /RedGuard () == DISCARD, Reason == FrameSendOffset => ErrorCode := WRONG_FrameSendOffset RED_RELAY_Error_Ind (CREP, ErrorCode)	IRTFW

12	IRTFW	**DMUX_RED_RELAY.ind ()**
		/RedGuard () == FORWARD, List of TX Ports
		=>
		StartTimer (IRT, Expected FrameSendOffset)
		For (TimerExpired (IRT), List of TX ports)
		if TX Port == 0
		RED_RELAY_Data.ind ()
		else
		QueueHandler.req ()
			IRTFW

4.12.4.3.5 Functions, Macros, Timers and Variables

Table 303 contains the functions, macros, timers and variables used by the RED_RELAY and their arguments and their descriptions.

Table 303 – Functions, Macros, Timers and Variables used by the RED_RELAY

Name	Type	Function/Meaning
RedGuard	Function	This function checks the received frame against the local information.
StartTimer	Function	Starts the IRT Timer which controls the timely correct transmission of a frame
TickEvent	Function	CycleCounter, CycleOffset
TimerExpired	Function	Controls the timely correct transmission of a frame
Calculate Local_FrameSendOffset as input for the RedGuard	Macro	Calculate the input parameter Local_FrameSendOffset for the RedGuard
Calculate Local_Phase as input for the RedGuard	Macro	Calculate the input parameter Local_Phase for the RedGuard
IRT_Timer	Timer	Timer which is used to controls the timely correct transmission of a frame by generating the FrameSendOffset event
Expected FrameSendOffset	Variable	Expected or calculated FrameSendOffset of the frame
Local_FrameSendOffset	Variable	This local variable contains the actual value of the FrameSendOffset driven by TickEvent
Local_Phase	Variable	This local variable contains the actual value of the Phase driven by TickEvent

4.12.4.3.6 RedGuard

The RedGuard checks the received frame (which is “Received in RED” due to the DEMUX) against Table 304, Table 305 or Table 306. The used table depends on the local supported functionality.

Table 304 – Truth table for the RedGuard with full check

Input					Output		
Conditions of the receive port					Conditions of the transmit port		Local
FrameID [a]	Receive port	Phase	Data length	FrameSend Offset [c]	List of TX ports	Remote RTC3PSM	RED relay
FALSE	—	—	—	—	—	—	Discard [b]
TRUE	FALSE	—	—	—	—	—	Discard [b]
TRUE	TRUE	FALSE	—	—	—	—	Discard [b]
TRUE	TRUE	TRUE	FALSE	—	—	—	Discard [b]
TRUE	TRUE	TRUE	TRUE	FALSE	—	—	Discard [b]
TRUE	TRUE	TRUE	TRUE	TRUE	—	! RUN	Discard [b]
TRUE	TRUE	TRUE	TRUE	TRUE	Yes	RUN	Forward

[a] The FrameID shall be checked against the PDIRFrameData and PDIRBeginEndData.

[b] The bridge should discard the frame.

[c] The forwarding of the frame could be done keeping its given FrameSendOffset (TRUE) or not (FALSE).

Table 305 – Truth table for the RedGuard with reduced check

Input		Output		
Conditions of the receive port		Conditions of the transmit port		Local
FrameID [a]	FrameSend Offset [c]	List of TX ports	Remote RTC3PSM	RED relay
FALSE	—	—	—	Discard [b]
TRUE	FALSE	—	—	Discard [b]
TRUE	TRUE	—	! RUN	Discard [b]
TRUE	TRUE	Yes	RUN	Forward

[a] The FrameID shall be checked against PDIRFrameData and PDIRBeginEndData.

[b] The bridge should discard the frame.

[c] The forwarding of the frame could be done keeping its given FrameSendOffset (TRUE) or not (FALSE).

Table 306 – Truth table for the RedGuard with minimal check

Input	Output		
Conditions of the receive port	Conditions of the transmit port		Local
FrameID [a]	List of TX ports	Remote RTC3PSM	RED relay
FALSE	—	—	Discard [b]
TRUE	—	! RUN	Discard [b]

Input	Output		
Conditions of the receive port	**Conditions of the transmit port**		**Local**
FrameID [a]	**List of TX ports**	**Remote RTC3PSM**	**RED relay**
TRUE	Yes	RUN	Forward
[a] The FrameID shall be checked against PDIRFrameData (for local received and not forwarded frames) and PDIRBeginEndData. [b] The bridge should discard the frame.			

4.12.4.4 DFP Forwarding Protocol Machine

4.12.4.4.1 General

The DFP_RELAY arranges frames with the attribute DFP. A DFP frame is a special form of an RT_CLASS_3 frame.

DFP offers two different principles, inbound and outbound, for the handling of this kind of frames. Figure 70, Figure 71 and Figure 72 shows the integration of DFP.

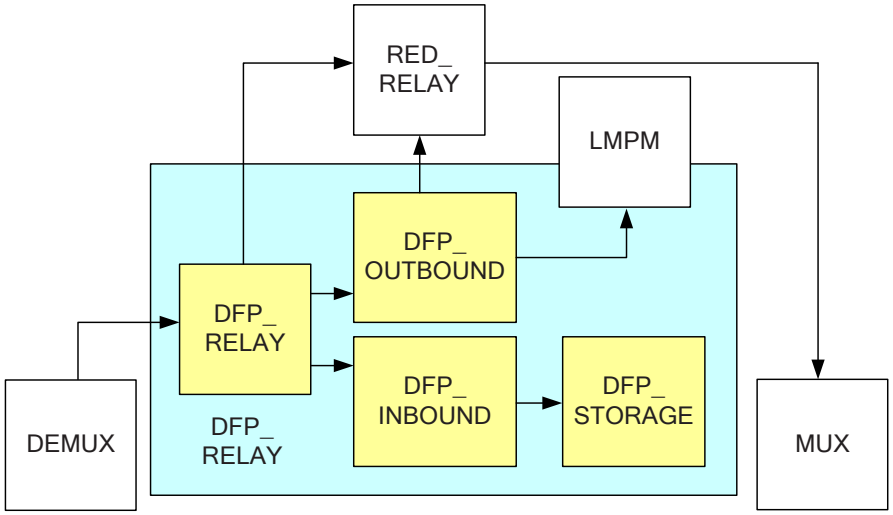


Figure 70 – Scheme of the DFP_RELAY

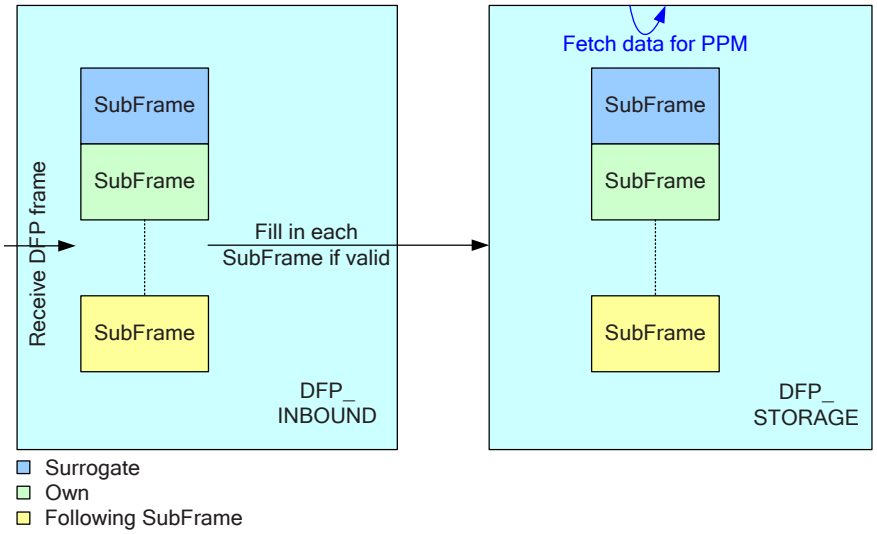


Figure 71 – Scheme of the DFP_INBOUND and DFP_STORAGE

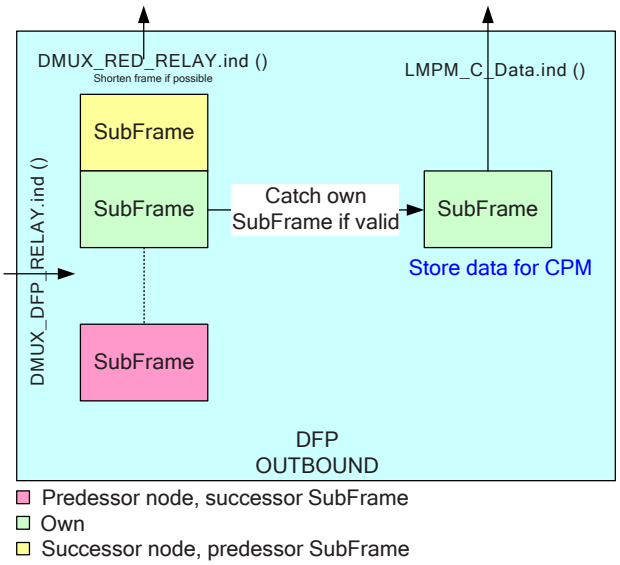


Figure 72 – Scheme of the DFP_OUTBOUND

4.12.4.4.2 DFP Protocol Machine

4.12.4.4.2.1 Primitive definitions

4.12.4.4.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DFP Protocol Machine (DFP_RELAY) are described in the service definition and shown in Table 307.

Table 307 – Remote primitives issued or received by DFP_RELAY

Primitive	Source	Destination	Associated parameters	Functions
DMUX_DFP_RELAY.ind	DEMUX	DFP_RELAY	Port, Tstamp, DA, SA, C_SDU, ReceivedInRED	—
DFP_INBOUND.ind	DFP_RELAY	DFP_INBOUND	Port, Tstamp, DA, SA, C_SDU, ReceivedInRED	—
DFP_OUTBOUND.ind	DFP_RELAY	DFP_OUTBOUND	Port, Tstamp, DA, SA, C_SDU, ReceivedInRED	—
DMUX_RED_RELAY.ind	DFP_RELAY	RED_RELAY	Port, Tstamp, DA, SA, C_SDU, ReceivedInRED	—

4.12.4.4.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DFP_RELAY are described in the service definition and shown in Table 308.

Table 308 – Local primitives issued or received by DFP_RELAY

Primitive	Source	Destination	Associated parameters	Functions
SyncStateChange_ind	PTCP	DFP_RELAY	state {SYNC, ASYNC}	—

4.12.4.4.2.2 State transition diagram

The state transition diagram of the DFP_RELAY is shown in Figure 73.

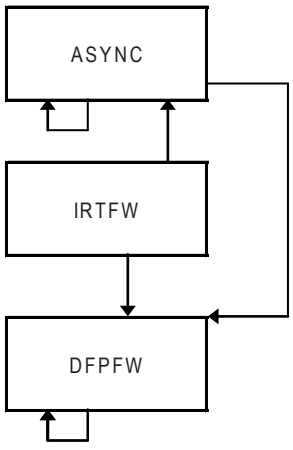


Figure 73 – State transition diagram of DFP_RELAY

States of the DFP_RELAY

ASYNC	The node shall be synchronized, either local as a sync master or remote as a sync slave for the DFP forwarding which is based on the RED forwarding
DFPFW	DFP forwarding active

4.12.4.4.2.3 State machine description

This state machine receives the possible DFP frames from the DEMUX and forwards them to the assigned state machine.

Unknown RT_CLASS_3 frames are forwarded to the RED_RELAY.

4.12.4.4.2.4 DFP_RELAY state table

The DFP_RELAY checks the received frame (which is “Received in RED” due to the DEMUX) against the state table shown in Table 309.

Table 309 – DFP_RELAY state table

#	Current State	Event /Condition =>Action	Next State
1	ASYNC	SyncStateChange_ind () /SYNC => ignore	DFPFW
2	ASYNC	SyncStateChange_ind () /!SYNC => ignore	ASYNC
3	DFPFW	SyncStateChange_ind () /SYNC => ignore	DFPFW
4	DFPFW	SyncStateChange_ind () /!SYNC => ignore	ASYNC
5	DFPFW	**DMUX_DFP_RELAY.ind ()** /DFPGuard () == OUTBOUND => DFP_OUTBOUND.ind ()	DFPFW
6	DFPFW	**DMUX_DFP_RELAY.ind ()** /DFPGuard () == INBOUND => DFP_INBOUND.ind ()	DFPFW
7	DFPFW	**DMUX_DFP_RELAY.ind ()** /DFPGuard () == RED_RELAY => DMUX_RED_RELAY.ind ()	DFPFW

4.12.4.4.2.5 Functions, Macros, Timers and Variables

Table 310 contains the functions, macros, timers and variables used by the DFP_RELAY and their arguments and their descriptions.

Table 310 – Functions, Macros, Timers and Variables used by the DFP_RELAY

Name	Type	Function/Meaning
DFPGuard	Function	This function checks the received frame against the local information.

4.12.4.4.2.6 DFPGuard

The DFPGuard checks the received frame against Table 311.

Table 311 – Truth table for the DFPGuard

Input			Output		
Local			Local		
FrameID [a]	Outbound	Inbound	RED_RELAY	OUTBOUND	INBOUND
FALSE	—	—	TRUE	—	—
TRUE	—	—	TRUE	—	—
TRUE	TRUE	FALSE	FALSE	TRUE	FALSE
TRUE	FALSE	TRUE	FALSE	FALSE	TRUE
TRUE	FALSE	FALSE	TRUE	FALSE	FALSE
TRUE	TRUE [b]	TRUE [b]	—	—	—

[a] Checked against the PDIRSubframeData.

[b] Avoided by local checks.

4.12.4.4.3 DFP Inbound Protocol Machine

4.12.4.4.3.1 Primitive definitions

4.12.4.4.3.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DFP Protocol Machine (DFP_RELAY_INBOUND) are described in the service definition and shown in Table 312.

Table 312 – Remote primitives issued or received by DFP_RELAY_INBOUND

Primitive	Source	Destination	Associated parameters	Functions
DFP_INBOUND.ind	DFP_RELAY	DFP_RELAY_INBOUND	Port, Tstamp, DA, SA, N_SDU, ReceivedInRED	—

4.12.4.4.3.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DFP_RELAY_INBOUND are described in the service definition and shown in Table 313.

Table 313 – Local primitives issued or received by DFP_RELAY_INBOUND

Primitive	Source	Destination	Associated parameters	Functions
DFP_Activate_req	CMSU	DFP_RELAY_INBOUND	CREP	—
DFP_Close_req	CMSU	DFP_RELAY_INBOUND	CREP	—
DFP_Activate_cnf (+)	DFP_RELAY_INBOUND	CMSU	CREP	—
DFP_Close_cnf (+)	DFP_RELAY_INBOUND	CMSU	CREP	—
StoreSubframe_ind	DFP_RELAY_INBOUND	DFP_RELAY_IN_STORAGE	CREP, Subframe	Trigger the DFP STORAGE for further handling of the sub frame.

4.12.4.4.3.2 State transition diagram

The state transition diagram of the DFP_RELAY_INBOUND is shown in Figure 74.

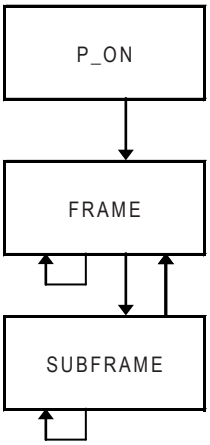


Figure 74 – State transition diagram of DFP_RELAY_INBOUND

States of the DFP_RELAY_INBOUND

P_ON	Data initialization
FRAME	Check DFP frame
SUBFRAME	Check DFP sub frame

4.12.4.4.3.3 State machine description

This state machine receives the INBOUND DFP frames, identified by it's FrameID, checks them against the protocol definition supporting the two modes DistributedWatchDog active and passive.

For MRPD, two DFP layouts exist, identified by the FrameID.

4.12.4.4.3.4 DFP_RELAY_INBOUND state table

The DFP_RELAY_INBOUND shall ensure that the reception of a DFP frames is done in a correct way and the state table is shown in Table 314.

Table 314 – DFP_RELAY_INBOUND state table

#	Current State	Event /Condition =>Action	Next State
1	P_ON	**DFP_Activate_req ()** => DFP_Activate_cnf (+)	FRAME
2	FRAME	**DFP_INBOUND.ind ()** /InboundGuard () == FrameStructureValid => DFP_Check_SubFrame ()	SUBFRAME
3	FRAME	**DFP_INBOUND.ind ()** /InboundGuard () == INVALID => ignore	FRAME
4	SUBFRAME	**DFP_Check_SubFrame()** /InboundGuard () == SubFrameStructureValid, SubFrameValid => StoreSubFrame_ind () DFP_Check_SubFrame ()	SUBFRAME
5	SUBFRAME	**DFP_Check_SubFrame()** /InboundGuard () == SubFrameStructureValid, SubFrameValid, EndOfSubFrame => ignore	FRAME
6	SUBFRAME	**DFP_Check_SubFrame()** /InboundGuard () == SubFrameStructureValid, SubFrameDataInvalid => DFP_Check_SubFrame ()	FRAME
7	SUBFRAME	**DFP_Check_SubFrame()** /InboundGuard () == INVALID => ignore	FRAME
8	ANY	**DFP_Close_req ()** => DFP_Close_cnf (+)	P_ON

4.12.4.4.3.5 Functions, Macros, Timers and Variables

Table 315 contains the functions, macros, timers and variables used by the DFP_RELAY_INBOUND and their arguments and their descriptions.

Table 315 – Functions, Macros, Timers and Variables used by the DFP_RELAY_INBOUND

Name	Type	Function/Meaning
InboundGuard	Function	This function checks the received frame against the local information.
DFP_Check_SubFrame	Function	Trigger for further frame parsing. The subframes are checked according to their sequence in the frame; each call of the function checks a particular subframe.

4.12.4.4.3.6 InboundGuard

The InboundGuard checks the received frame against Table 316, Table 317, Table 318 and Table 319.

Table 316 – Truth table for the InboundGuard – frame check

Input	Output
Header Subframe. SFCRC16	**Frame check**
Invalid	Invalid
Valid	Valid

Table 317 – Truth table for the InboundGuard – sub frame check

Input			Output
Subframe. Position [a]	**Subframe. Length** [b]	**Subframe. SFCRC16** [c]	**Sub frame check**
Not found	—	—	Invalid
Found	FALSE	—	Invalid
Found	TRUE	Invalid	Invalid
Found	TRUE	Valid	Valid

[a] Checks whether the next expected subframe is received

[b] Checks whether the subframe has the expected length

[c] Checks whether the SFCRC16 is valid

Table 318 – Truth table for the InboundGuard – sub frame data check

Input				Output
RestartFor-DistributedWDTime [a]	**Distributed-WatchDog-Factor** [b]	**Subframe. DataStatus. Valid** [c]	**Subframe. SFCycleCounter** [d]	**Sub frame data check**
OFF	OFF	—	—	Valid
Running	—	—	—	Invalid
Expired / OFF	ON	Invalid	—	Invalid
Expired / OFF	ON	Valid	Old	Invalid
Expired / OFF	ON	Valid	New	Valid

[a] A running RestartForDistríbutedWDTime stops the storage of the subframe.

[b] The check of the subframe data is done by the endpoint if the distributed watchdog is disabled.

[c] The data is only stored, if it is valid.

[d] Only newer subframes are stored.

Table 319 – Truth table for the InboundGuard – full check

Input			Output		
Frame check	**Sub frame check**	**Sub frame data check**	**Frame-StructureValid**	**Subframe-StructureValid**	**Subframe-DataValid**
Invalid	—	—	Invalid	—	—
Valid	Invalid	—	Valid	Invalid	—
Valid	Valid	Invalid	Valid	Valid	Invalid
Valid	Valid	Valid	Valid	Valid	Valid

4.12.4.4.4 DFP Inbound Storage Protocol Machine

4.12.4.4.4.1 General

From the consistency point of view there exists no difference between the rules for a frame or a subframe. The conveyance system shall insure that a frame is transported with frame consistency and a subframe is transported with subframe consistency.

4.12.4.4.4.2 Primitive definitions

4.12.4.4.4.2.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DFP Inbound Storage Protocol Machine (DFP_RELAY_IN_STORAGE) are described in the service definition and shown in Table 320.

Table 320 – Remote primitives issued or received by DFP_RELAY_IN_STORAGE

Primitive	Source	Destination	Associated parameters	Functions
AlarmNotification.ind	DFP_RELAY_IN_STORAGE	FAL	AREP, API, AlarmPriority, AlarmType, SlotNumber, SubslotNumber, AlarmSpecifier, ModuleIdentNumber, SubmoduleIdentNumber, AlarmItem	Inform the application that a concatenation fault takes place.

4.12.4.4.4.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DFP_RELAY_IN_STORAGE are described in the service definition and shown in Table 321.

Table 321 – Local primitives issued or received by DFP_RELAY_IN_STORAGE

Primitive	Source	Destination	Associated parameters	Functions
DFP_Activate_req	CMSU	DFP_RELAY_IN_STORAGE	CREP	—
DFP_Close_req	CMSU	DFP_RELAY_IN_STORAGE	CREP	—
DFP_Activate_cnf(+)	DFP_RELAY_IN_STORAGE	CMSU	CREP	—
DFP_Close_cnf	DFP_RELAY_IN_STORAGE	CMSU	CREP	—
DFP_Error_ind	DFP_RELAY_IN_STORAGE	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—
StoreSubFrame_ind	DFP_RELAY_INBOUND	DFP_RELAY_IN_STORAGE	CREP, Subframe	Stores a received subframe on its storage

4.12.4.4.4.3 State transition diagram

The state transition diagram of the DFP_RELAY_IN_STORAGE is shown in Figure 75.

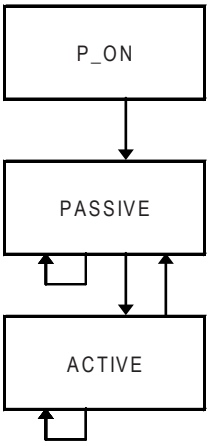


Figure 75 – State transition diagram of DFP_RELAY_IN_STORAGE

States of the DFP_RELAY_IN_STORAGE

P_ON	Data initialization
PASSIVE	Wait for first receive or for the timeout of the RestartForDistributedWDTime.
ACTIVE	Check receive of a DFP sub frame with distributed watchdog if activated. Additional check the concatenation of the subframes against the associated PPM time constraints and generate indications if necessary.

4.12.4.4.4.4 DFP_RELAY_IN_STORAGE state machine description

This state machine receives subframe and stores them for further use. The concatenation of the subframes to the local generated frame is done in parallel to the storing of the data.

If a fault is detected, then the transmission of the frame shall be aborted with a corresponding TX-error. In this case the last stored data of the subframe is still valid and useable.

4.12.4.4.4.5 DFP_RELAY_IN_STORAGE state table

The DFP_RELAY_IN_STORAGE shall control the reception of DFP frames. The corresponding state table is shown in Table 322.

Table 322 – DFP_RELAY_IN_STORAGE state table

#	Current State	Event /Condition =>Action	Next State
1	P_ON	**DFP_Activate_req ()** => Create list of sub frames in surrogate state List of successors If activated List of distributed watchdogs DFP_Activate_cnf(+)	PASSIVE
2	PASSIVE	**StoreSubFrame_ind ()** /RestartForDistributedWDTime (Position) != Running => Update content of the stored sub frame (Position) If activated StartTimer (Distributed WDT (Position))	ACTIVE

#	Current State	Event /Condition =>Action	Next State
3	PASSIVE	**StoreSubFrame_ind ()** /RestartForDistributedWDTime (Position) == Running =>	PASSIVE
4	PASSIVE	TimerExpired (RestartForDistributedWDTime (Position)) => ignore	PASSIVE
5	PASSIVE	TimerExpired (Distributed WDT (Position)) => ignore	PASSIVE
6	ACTIVE	**StoreSubFrame_ind ()** => Update content of the stored sub frame (Position) If activated StartTimer (Distributed WDT (Position))	ACTIVE
7	ACTIVE	**TimerExpired (Distributed WDT (Position))** => Set stored sub frame in surrogate state (Position) StartTimer (RestartForDistributedWDTime (Position))	PASSIVE
8	ACTIVE	TimerExpired (RestartForDistributedWDTime (Position)) => ignore	ACTIVE
9	ACTIVE	**TickEvent ()** /Phase and FrameSendOffset of the associated PPM && Sub frames updated in this Phase && !Appear sent => ignore	ACTIVE
10	ACTIVE	**TickEvent ()** /Phase and FrameSendOffset of the associated PPM && !Sub frames updated in this Phase && Appear sent => ignore	ACTIVE
11	ACTIVE	**TickEvent ()** /Phase and FrameSendOffset of the associated PPM && Sub frames updated in this Phase && Appear sent => Appear sent := FALSE Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:= Dynamic Frame Packing problem notification User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Disappears ChannelErrorType := “Dynamic frame packing function mismatch” ExtChannelErrorType := “Frame late error” AlarmNotification.ind ()	ACTIVE
12	ACTIVE	**TickEvent ()** /Phase and FrameSendOffset of the associated PPM && !Sub frames updated in this Phase && !Appear sent => Appear sent := TRUE Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:= Dynamic Frame Packing problem notification User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Appears ChannelErrorType := “Dynamic frame packing function mismatch” ExtChannelErrorType := “Frame late error” AlarmNotification.ind ()	ACTIVE

#	Current State	Event /Condition =>Action	Next State
13	ANY	**DFP_Close_req ()** => Remove list of sub frames Remove stored diagnosis from Diagnosis ASE DFP_Close_cnf ()	P_ON

4.12.4.4.4.6 Functions, Macros, Timers and Variables

Table 323 contains the functions, macros, timers and variables used by the DFP_RELAY_IN_STORAGE and their arguments and their descriptions.

Table 323 – Functions, Macros, Timers and Variables used by the DFP_RELAY_IN_STORAGE

Name	Type	Function/Meaning
Set stored sub frame in surrogate state	Function	This local function shall set the C_SDU of the sub frame to zero and the DataStatus.Ignore of the sub frame to TRUE; the other flags of the DataStatus and the SFCycleCounter should be zero.
StartTimer	Function	This local function is used to start or restart a timer.
TickEvent	Function	Local generated event from a timer. The timer shall be controlled by the PTCP master or slave in case of synchronization or free running without synchronization. Parameters: CycleCounter, CycleOffset
TimerExpired	Function	This local function is issued if a timer expires.
Update content of the stored sub frame	Function	This local function updated the C_SDU, DataStatus and the SFCycleCounter of the sub frame
Phase and FrameSendOffset of the associated PPM	Macro	This local macro uses the timing information of the associated PPM for a check against the information from TickEvent.
Sub frames updated in this Phase	Macro	This local macro checks whether the sub frame was received in time to be concatenated to the local injected frame.
Distributed Watchdog Time	Timer	This timer is used to control the correct reception of valid data if activated.
RestartForDistributedWDTime	Timer	This timer is used to protect a surrogate sub frame for the detection of a fault by the IO controller. It is only active if the distributed watchdog is requested by the engineering.
Appear sent	Variable	This local variable is used to store the information whether an alarm request was already given or not.

4.12.4.4.5 DFP Outbound Protocol Machine

4.12.4.4.5.1 Primitive definitions

4.12.4.4.5.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by DFP Inbound Protocol Machine (DFP_RELAY_OUTBOUND) are described in the service definition and shown in Table 324.

Table 324 – Remote primitives issued or received by DFP_RELAY_OUTBOUND

Primitive	Source	Destination	Associated parameters	Functions
DFP_OUTBOUND.ind	DFP_RELAY	DFP_RELAY_OUTBOUND	Port, Tstamp, DA, SA, C_SDU, ReceivedInRED	—
LMPM_C_Data.ind	DFP_RELAY_OUTBOUND	—	CREP, DA, SA, VLANPrio, VLANID, C_SDU, APDU_Status, ReceivedInRED	Convey the own sub frame to the local interface for further handling in the associated CPM.
DMUX_RED_RELAY.ind	DFP_RELAY_OUTBOUND	RED_RELAY	Port, Tstamp, DA, SA, N_SDU, ReceivedInRED	—

4.12.4.4.5.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DFP_RELAY_OUTBOUND are described in the service definition and shown in Table 325.

Table 325 – Local primitives issued or received by DFP_RELAY_OUTBOUND

Primitive	Source	Destination	Associated parameters	Functions
DFP_Activate_cnf (+)	DFP_RELAY_OUTBOUND	CMSU	CREP	—
DFP_Close_cnf (+)	DFP_RELAY_OUTBOUND	CMSU	CREP	—
DFP_Activate_req	CMSU	DFP_RELAY_OUTBOUND	CREP	—
DFP_Close_req	CMSU	DFP_RELAY_OUTBOUND	CREP	—

4.12.4.4.5.2 State transition diagram

The state transition diagram of the DFP_RELAY_OUTBOUND is shown in Figure 76.

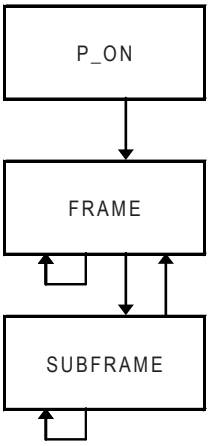


Figure 76 – State transition diagram of DFP_RELAY_OUTBOUND

States of the DFP_RELAY_OUTBOUND

P_ON	Data initialization
FRAME	Check the frame whether it has a valid structure and shall be shortened.
SUBFRAME	Search for the own subframe and shorten the frame if the structure is valid.

4.12.4.4.5.3 DFP_RELAY_OUTBOUND state machine description

This state machine receives a frame identified by the FrameID, checks whether the shortening is possible. If possible, the frame will be shortened before the own subframe and forwarded. The own subframe will be conveyed to the CPM. If not possible, the frame is forwarded to the RED_RELAY.

The DFP_RELAY_OUTBOUND shall ensure that the local portion of the DFP frames is given to the LMPM and the, if applicable, shortened frame is given to the RED_RELAY.

The frame should be shortened if SFIOCRProperties.SFCRC16 is set to one and the assigned subframe locally received after checking its SFCRC16.

The shortening shall be done by replacing the locally received subframe with a SFEndDelimiter, if needed Padding and an APDU_Status (CycleCounter:=actual local value, TransferStatus:=0, DataStatus.Ignore:=1, DataStatus.State:=1, DataStatus.DataValid:=1, DataStatus.StationProblemIndicator:=1, DataStatus.ProviderState:=1).

A locally assigned subframe shall be received after checking the FCS of the conveying frame if SFIOCRProperties.SFCRC16 is set to zero.

4.12.4.4.5.4 DFP_RELAY_OUTBOUND state table

The DFP_OUTBOUND state table is shown in Table 326.

Table 326 – DFP_RELAY_OUTBOUND state table

#	Current State	Event /Condition =>Action	Next State
1	P_ON	**DFP_Activate_req ()** => DFP_Activate_cnf (+)	FRAME
2	FRAME	**DFP_OUTBOUND.ind ()** /OutboundGuard () == FrameStructureValid, FrameShortenImpossible => DMUX_RED_RELAY.ind ()	FRAME
3	FRAME	**DFP_OUTBOUND.ind ()** /OutboundGuard () == FrameStructureValid, FrameShortenPossible && FirstSubframeInFrame == OWN => DMUX_RED_RELAY.ind ()	FRAME
4	FRAME	**DFP_OUTBOUND.ind ()** /OutboundGuard () == FrameStructureValid, FrameShortenPossible && ! FirstSubframeInFrame == OWN => DFP_Check_SubFrame ()	SUBFRAME
5	FRAME	**DFP_OUTBOUND.ind ()** /OutboundGuard () == INVALID => ignore //NOTE The frame shall be shorten after the last valid subframe by the MUX using the appropriate TX-error	FRAME
6	SUBFRAME	**DFP_Check_SubFrame ()** /OutboundGuard () == SubFrameStructureValid && SFPosition.Position == OWN => N_SDU := ShortenFrame (N_SDU) LMPM_C_Data.ind () DMUX_RED_RELAY.ind ()	SUBFRAME
7	SUBFRAME	**DFP_Check_SubFrame ()** /OutboundGuard () == SubFrameStructureValid && SFPosition.Position != OWN => DFP_Check_SubFrame ()	SUBFRAME
8	SUBFRAME	**DFP_Check_SubFrame ()** /OutboundGuard () == INVALID => ignore //NOTE The frame shall be shorten after the last valid subframe by the MUX using the appropriate TX-error	FRAME
9	ANY	**DFP_Close_req ()** => DFP_Close_cnf (+)	P_ON

4.12.4.4.5.5 Functions, Macros, Timers and Variables

Table 327 contains the functions, macros, timers and variables used by the DFP_RELAY_OUTBOUND and their arguments and their descriptions.

Table 327 – Functions, Macros, Timers and Variables used by the DFP_RELAY_OUTBOUND

Name	Type	Function/Meaning
DFP_Check_SubFrame	Function	Trigger for further frame parsing. The subframes are checked according to their sequence in the frame; each call of the function checks a particular subframe.
OutboundGuard	Function	This local function checks the received frame against the local information.
ShortenFrame	Function	This local function shortens the N_SDU if the sequence of valid SFCRC16 is not broken.
FirstSubframeInFrame	Macro	This local macro returns the information of the first subframe in the frame. This information is needed to avoid shortening of a frame which contains only one subframe.
OWN	Variable	This local variable contains the information about the own subframe.

4.12.4.4.5.6 OutboundGuard

The OutboundGuard checks the received frame against Table 328 and Table 329.

Table 328 – Truth table for the OutboundGuard – frame check

Input			Output	
SFIOCRProperties. SFCRC16 [a]	**Header Subframe. SFCRC16** [b]	**Structure before own Subframe** [c]	**Frame structure**	**Frame shorten**
FALSE	—	—	Valid	Impossible
TRUE	Invalid	—	Invalid	—
TRUE	Valid	Invalid	Invalid	Impossible
TRUE	Valid	Valid	Valid	Possible

[a] The shortening of a frame is only possible if the SFCRC16 is valid. Thus, the subframes are only checked if the SFCRC16 shall exist.

[b] The header SFCRC16 is check before the subframe checking starts.

[c] The shortening is only possible if a consistent structure is found before the own subframe.

Table 329 – Truth table for the OutboundGuard – sub frame check

Input				Output
Frame structure	**Subframe. Position** [a]	**Subframe. Length** [b]	**Subframe. SFCRC16**	**Sub frame structure**
Invalid	—	—	—	Invalid
Valid	Invalid	—	—	Invalid
Valid	Valid	Invalid	—	Invalid
Valid	Valid	Valid	Invalid	Invalid
Valid	Valid	Valid	Valid	Valid

[a] Check against the protocol definition, optional against the structure from the PDIRSubframeData.

[b] Check against the protocol definition, optional against the structure from the PDIRSubframeData.

4.13 Virtual bridges

4.13.1 Overview

The concepts according to IEEE 802.1Q standard shall be applied. This part of the specification defines the utilization of the IEEE 802.1Q standard. It includes extensions for RT_CLASS_3 phase regarding forwarding of frames. The routing mechanisms of IEEE 802.1Q shall be temporary disabled within the RT_CLASS_3 phase. In this case, the routing of RT_CLASS_3 frames shall be done according to the attributes defined by the appropriate ASE. The values of the attributes define a special routing table, which is used.

Apart from IEEE 802.1Q standard behavior, this protocol specification defines the following protocol machines to provide special MAC actions:

– Queue handler Protocol Machine (QueueHandler)
– Multiplex MAC Protocol Machine (MUX)
– Demultiplex MAC Protocol Machine (DEMUX)

4.13.2 QueueHandler

The QueueHandler manages the priority queues of a port. It offers service primitives for en queuing and dequeuing of frames. Additionally information of the content of a queue is available.

4.13.3 FAL Service Protocol Machines

There is no FAL Service Protocol Machine (FSPM) defined for this Protocol.

4.13.4 Application Relation Protocol Machines

There is no Application Relation Protocol Machine (ARPM) defined for this Protocol.

4.13.5 DLL Mapping Protocol Machines

4.13.5.1 Network Access Sender protocol Machine

4.13.5.1.1 Primitive definitions

####### 4.13.5.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Network Access Sender (MUX) are described in the service definition and shown in Table 330.

Table 330 – Remote primitives issued or received by MUX

Primitive	Source	Destination	Associated parameters	Functions
M_UNITDATA.req	MUX	MAC	frame_type, mac_action, destination_address, source_address, mac_service_data_unit, user_priority, access_priority, frame_check_sequence, canonical_format_indicator, vlan_classification, rif_information (optional), include_tag	—
M_UNITDATA.ind	MAC	MUX	time_stamp	—
LinkStateChange.ind	MAC	MUX	Port, Link_State	—

Primitive	Source	Destination	Associated parameters	Functions
PortStateChange.ind	Virtual Bridge	MUX	Port, Port_State	—

4.13.5.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by MUX are described in the service definition and shown in Table 331.

Table 331 – Local primitives issued or received by MUX

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.13.5.1.2 State transition diagram

The state transition diagram of the MUX is shown in Figure 77.

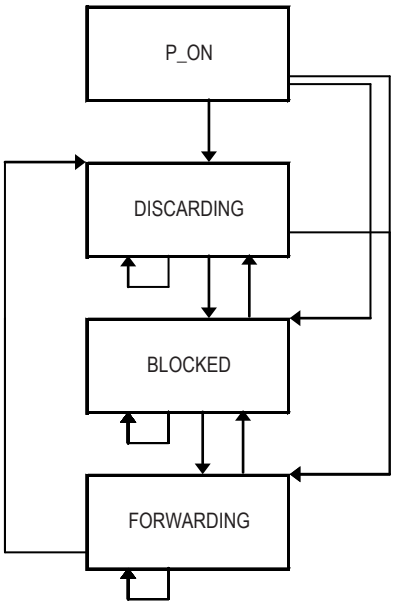


Figure 77 – State transition diagram of MUX

States of the MUX

P-ON	Wait for the startup Link and Port state and jump to the appropriate state
DISCARDING	All frames are discarded in this state
BLOCKED	Only network control or RT_CLASS_3 frames are forwarded in this state
FORWARDING	All frames are forwarded

4.13.5.1.3 State machine description

The MUX is responsible for mapping LMPM, RED_RELAY and MAC_RELAY(IEEE 802.1D) services to MAC according to IEEE 802.3.

Additional the Queue handler shown in Figure 79 is used to manage the priority queues.

4.13.5.1.4 MUX state table

The MUX state table is shown in Table 332.

Table 332 – MUX state table

#	Current State	Event /Condition =>Action	Next State
1	P_ON	/StateChecker () == FORWARDING => Period := GREEN	FORWARDING
2	P_ON	/StateChecker () == BLOCKED => Period := GREEN	BLOCKED
3	P_ON	/StateChecker () == DISCARDING => Period := GREEN	DISCARDING
4	P_ON	M_UNITDATA.cnf () => ignore	P_ON
5	DISCARDING	MUX_Schedule_req (CycleCounter, Tx_Period) => ignore	DISCARDING
6	DISCARDING	**QueuesNotEmpty ()** => GET_FRAME_FROM_QUEUE(NwC_Hi, NwC_Lo, PRIO7, RED, PRIO6, …, PRIOR2-1) DISCARD_FRAME()	DISCARDING
7	DISCARDING	M_UNITDATA.cnf () => ignore	DISCARDING
8	BLOCKED	**QueuesNotEmpty ()** /Period == GREEN && FrameSizeFits (NwC_Hi, NwC_Lo) => GET_FRAME_FROM_QUEUE(NwC_Hi, NwC_Lo) M_UNITDATA.req ()	BLOCKED
9	BLOCKED	**QueuesNotEmpty ()** /Period == GREEN && !FrameSizeFits (NwC_Hi, NwC_Lo) => ignore	BLOCKED
10	BLOCKED	M_UNITDATA.cnf () => ignore	BLOCKED
11	BLOCKED / FORWARDING	MUX_Schedule_req (CycleCounter, Tx_Period) => Period := Tx_Period	BLOCKED / FORWARDING
12	BLOCKED / FORWARDING	**QueuesNotEmpty ()** /Period == RED => GET_FRAME_FROM_QUEUE(RED) M_UNITDATA.req ()	BLOCKED / FORWARDING
13	FORWARDING	**QueuesNotEmpty ()** /Period == GREEN && FrameSizeFits (NwC_Hi, NwC_Lo, PRIO7, PRIO6, …, PRIOR2-1) => GET_FRAME_FROM_QUEUE(NwC_Hi, NwC_Lo, PRIO7, PRIO6, …, PRIOR2-1)	FORWARDING

#	Current State	Event /Condition =>Action	Next State
		M_UNITDATA.req ()	
14	FORWARDING	**QueuesNotEmpty ()** /Period == GREEN && !FrameSizeFits (NwC_Hi, NwC_Lo, PRIO7, PRIO6, …, PRIOR2-1) => ignore	FORWARDING
15	FORWARDING	M_UNITDATA.cnf () => ignore	FORWARDING
16	BLOCKED / FORWARDING	**QueuesNotEmpty ()** /Period != RED && FrameEgressFilter () => GET_FRAME_FROM_QUEUE() DISCARD_FRAME()	BLOCKED / FORWARDING
17	ANY	**LinkStateChange ()** /StateChecker () == DISCARDING => Period := GREEN	DISCARDING
18	ANY	**PortStateChange ()** /StateChecker () == DISCARDING => Period := GREEN	DISCARDING
19	ANY	**LinkStateChange ()** /StateChecker () == BLOCKED => ignore	BLOCKED
20	ANY	**PortStateChange ()** /StateChecker () == BLOCKED => ignore	BLOCKED
21	ANY	**LinkStateChange ()** /StateChecker () == FORWARDING => ignore	FORWARDING
22	ANY	**PortStateChange ()** /StateChecker () == FORWARDING => ignore	FORWARDING

4.13.5.1.5 Functions, Macros, Timers and Variables

Table 333 contains the functions, macros, timers and variables used by the MUX and their arguments and their descriptions.

Table 333 – Functions, Macros, Timers and Variables used by MUX

Name	Type	Function/Meaning
FrameEgressFilter	Function	This local function checks whether the frame should be transmitted or dropped according to the IEEE 802.1D egress filtering
FrameSizeFits	Function	This local function checks if the found frame fits into the remaining period till the next StartOfRED. It was only searched in the (…) queues from highest to lowest priority. The first non fitting frame stops the search and FALSE was returned. The check includes the requirements of the corresponding truth table.

Name	Type	Function/Meaning
QueuesNotEmpty	Function	This local event is issued if an entry in any queue exists. An entry exists after a frame receive is detected and the CT or S&F switching has the transmit queue assigned.
StateChecker	Function	This local function checks the Link_State and Port_State for the possible next state and returns the result.
DISCARD_FRAME	Macro	Discards the selected frame
GET_FRAME_FROM_QUEUE	Macro	Delivers a frame out of (...) queues. This dequeuing always works from highest to lowest priority of the queues.
Period	Variable	This local variable stores the actual period for further use

4.13.5.1.6 Truth tables

4.13.5.1.6.1 FrameSizeFits rules truth table

Table 334 contains the truth table used by the MUX.

Table 334 – Truth table for FrameSizeFits

Input						Output
Period	**Distance greater than MaxFrameSize**	**Distance greater than YellowTime**	**Well known protocols**	**Other protocols**	**Frame size**	**FrameSizeFits**
GREEN	True	True	CT / S&F	CT / S&F	—	True
GREEN	False	True	CT / S&F	—	—	True
GREEN	False	True	—	S&F	Fits	True
GREEN	False	True	—	S&F	Too big	False
GREEN	False	False	S&F	S&F	Fits	True
GREEN	False	False	S&F	S&F	Too big	False
GREEN	False	False	CT	CT	—	False
RED	—	—	—	—	—	—

4.13.5.1.6.2 StateChecker truth table

Table 335 contains the truth table used by the MUX.

Table 335 – Truth table for StateChecker

Input		Output
Link_State	**Port_State**	**StateChecker**
DOWN	DISCARDING	DISCARDING
DOWN	BLOCKED	DISCARDING
DOWN	FORWARDING	DISCARDING
UP	DISCARDING	DISCARDING
UP	BLOCKED	BLOCKED
UP	FORWARDING	FORWARDING

4.13.5.2 Network Access Receiver Protocol Machine

4.13.5.2.1 Primitive definitions

4.13.5.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Network Access Sender (DEMUX) are described in the service definition and shown in Table 336.

Table 336 – Remote primitives issued or received by DEMUX

Primitive	Source	Destination	Associated parameters	Functions
M_UNITDATA.ind	MAC	DEMUX	Port, frame_type, mac_action, destination_address, source_address, mac_service_data_unit, user_priority, frame_check_sequence, canonical_format_indicator, vlan_identifier	—
DMUX_DEFRAG.ind	DEMUX	DEFRAG	Port, Tstamp, DA, SA, VLAN, N_SDU	—
DMUX_DFP_RELAY.ind	DEMUX	DFP_RELAY	Port, Tstamp, DA, SA, N_SDU, ReceivedInRED	—
DMUX_MAC_RELAY.ind	DEMUX		Port, Tstamp, DA, SA, N_SDU	—
DMUX_P_Data.ind	DEMUX	LMPM	Port, Tstamp, DA, SA, N_SDU	—
DMUX_RED_RELAY.ind	DEMUX	RED_RELAY	Port, Tstamp, DA, SA, N_SDU, ReceivedInRED	—

4.13.5.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by DEMUX are described in the service definition and shown in Table 337.

Table 337 – Local primitives issued or received by DEMUX

Primitive	Source	Destination	Associated parameters	Functions
DMUX_Schedule_req	SCHEDULER	DEMUX	Rx_Period	—
DMUX_Schedule_cnf	DEMUX	SCHEDULER	—	—

4.13.5.2.2 State transition diagram

The state transition diagram of the DEMUX is shown in Figure 78.

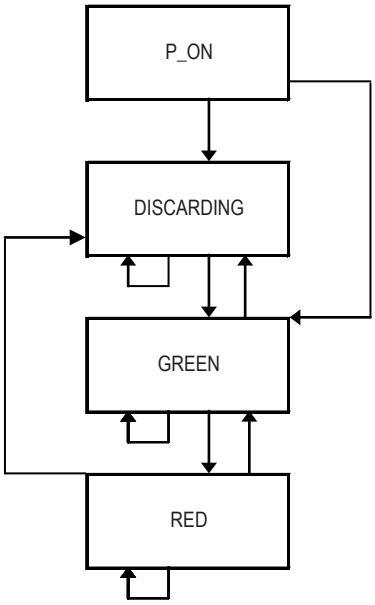


Figure 78 – State transition diagram of DEMUX

States of the DEMUX

P_ON	Power on
DISCARDING	port state discarding
GREEN	green period
RED	red period

4.13.5.2.3 State machine description

The DEMUX is responsible for mapping MAC services according to IEEE 802.3 to LMPM, RED_RELAY and MAC_RELAY (IEEE 802.1D).

The generation of the flag ReceivedInRED shall be done by checking the receive TimeStamp made by the SHIM. If the value of the ReceiveTimeStamp is equal or greater the RedOrangePeriodBegin and less or equal the GreenPeriodBegin point in time, then the ReceivedInRED shall be set to TRUE, otherwise to FALSE.

4.13.5.2.4 DEMUX state table

The DEMUX state table is shown in Table 338.

Table 338 – DEMUX state table

#	Current State	Event /Condition =>Action	Next State
1	P_ON	/Port_State != Discarding => ignore	GREEN
2	P_ON	/Port_State == Discarding => ignore	DISCARDING
3	DISCARDING	**DMUX_Schedule_req ()** => DMUX_Schedule_cnf ()	DISCARDING
4	DISCARDING	M_UNITDATA.ind () => ignore	DISCARDING
5	DISCARDING	**PortStateChange ()** /Port_State == Discarding => ignore	DISCARDING
6	DISCARDING	**PortStateChange ()** /Port_State != Discarding => ignore	GREEN
7	GREEN	**PortStateChange ()** /Port_State != Discarding => ignore	GREEN
8	GREEN	**PortStateChange ()** /Port_State == Discarding => ignore	DISCARDING
9	GREEN	**DMUX_Schedule_req ()** /Rx_Period == GREEN => DMUX_Schedule_cnf ()	GREEN
10	GREEN	**DMUX_Schedule_req ()** /Rx_Period == RED => DMUX_Schedule_cnf ()	RED
11	GREEN	**M_UNITDATA.ind ()** /FrameIngressFilter // Checking the ingress filter is always the first check! => ignore	GREEN
12	GREEN	**M_UNITDATA.ind ()** /FRAGMENT => DMUX_DEFRAG.ind ()	GREEN
13	GREEN	**M_UNITDATA.ind ()** /OTHER OR RED OR DFP => DMUX_MAC_RELAY.ind ()	GREEN
14	GREEN	**M_UNITDATA.ind ()** /CTRL => Get_Receive_TimeStamp () DMUX_P_Data.ind ()	GREEN

#	Current State	Event /Condition =>Action	Next State
15	RED	**PortStateChange ()** /Port_State != Discarding => ignore	RED
16	RED	**PortStateChange ()** /Port_State == Discarding => ignore	DISCARDING
17	RED	**DMUX_Schedule_req ()** /Rx_Period == GREEN => DMUX_Schedule_cnf ()	GREEN
18	RED	**DMUX_Schedule_req ()** /Rx_Period == RED => DMUX_Schedule_cnf ()	RED
19	RED	**M_UNITDATA.ind ()** /RED => ReceivedInRED := TRUE DMUX_RED_RELAY.ind ()	RED
20	RED	**M_UNITDATA.ind ()** /DFP => ReceivedInRED := TRUE DMUX_DFP_RELAY.ind ()	RED
21	RED	**M_UNITDATA.ind ()** /FRAGMENT => DMUX_DEFRAG.ind ()	RED
22	RED	**M_UNITDATA.ind ()** /OTHER => DMUX_MAC_RELAY.ind ()	RED
23	RED	**M_UNITDATA.ind ()** /CTRL => Get_Receive_TimeStamp () DMUX_P_Data.ind ()	RED

4.13.5.2.5 Functions, Macros, Timers and Variables

Table 339 contains the functions, macros, timers and variables used by the DEMUX and their arguments and their descriptions.

Table 339 – Functions, Macros, Timers and Variables used by the DEMUX

Name	Type	Function/Meaning
Get_Receive_TimeStamp	Function	Get the receive time stamp frame the Timestamp Shim for this frame
CTRL	Macro	Network control/management e.g. PTCP synchronization frames without “RT_CLASS_3 attribute”, LLDP, PTCP Line delay measurement, PTCP announce, media redundancy, …
DFP	Macro	RT_CLASS_3 frames with “DFP attribute” EtherType == 0x8892 FrameID == 0x0100…0x0FFF
FRAGMENT	Macro	Frame using the fragmentation protocol. EtherType == 0x8892 FrameID == Fragmentation
FrameIngressFilter	Macro	Checks whether this frame is filtered by an ingress rule.

Name	Type	Function/Meaning
OTHER	Macro	Any other frame.
RED	Macro	RT_CLASS_3 frames EtherType == 0x8892 FrameID == 0x0100 …0x0FFF Special case: PTCP synchronization frames with “RT_CLASS_3 attribute” EtherType == 0x8892 FrameID == 0x0080
PortStateChange	Function	Conveys the info about the port state

4.14 IP suite

4.14.1 Overview

The utilization of the RFC 768 (UDP), RFC 791 (IP), RFC 792 (ICMP), RFC 826 (ARP), RFC 2236 (IP Multicasting), RFC 2474 (IP Extensions) standards are defined for this specification. It includes definitions for UDP ports and IP multicast addresses and utilization of IP header fields for RT_CLASS_UDP.

4.14.2 IP/UDP syntax description

4.14.2.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

4.14.2.2 IP/UDP APDU abstract syntax

Table 340 defines the abstract syntax of the Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 340 shall represent the content of the DLSDU in Table 5.

Table 340 – IP/UDP APDU syntax

APDU name	APDU structure
ICMP-PDU	IPHeader [a], ICMPHeader, Data*
[a] The value of IPHeader.IP_Protocol shall be set to 1 to indicate ICMP.	

Table 341 defines structures for substitutions of elements of the APDU structures shown in Table 340.

Table 341 – IP/UDP substitutions

Substitution name	Structure
IPHeader	IP_VersionIHL(0x45), IP_TypeOfService, IP_TotalLength, IP_Identification, IP_Flags_FragOffset [a], IP_TTL, IP_Protocol, IP_HeaderChecksum, IP_SrcIPAddress, IP_DstIPAddress, [IP_Options] [b] The encoding of the fields shall be according to RFC 791.
ICMPHeader	ICMP_Type, ICMP_Code, ICMP_HeaderChecksum
UDPHeader	UDP_SrcPort, UDP_DstPort, UDP_DataLength, UDP_Checksum [c]
[a] For UDP-RTC-PDU and UDP-RTA-PDU IP fragmentation shall not be used. [b] The field IP_Options shall be omitted for UDP-RTC-PDU and UDP-RTA-PDU. [c] The UDP_Checksum should be set to zero for RT_CLASS_UDP and RTA_CLASS_UDP to improve performance. It is not required for the receiver to check the UDP_Checksum for UDP-RTC-PDU and UDP-RTA-PDU.	

4.14.3 IP/UDP transfer syntax

4.14.3.1 Coding section related to IP, ICMP and UDP

4.14.3.1.1 Coding section related to ICMP

####### 4.14.3.1.1.1 Coding of the field ICMP_Type

The encoding of the fields shall be according to RFC 792.

####### 4.14.3.1.1.2 Coding of the field ICMP_Code

The encoding of the fields shall be according to RFC 792.

####### 4.14.3.1.1.3 Coding of the field ICMP_HeaderChecksum

The encoding of the fields shall be according to RFC 792.

4.14.3.1.2 Coding section related to UDP

####### 4.14.3.1.2.1 Coding of the field UDP_DataLength

The encoding of the fields shall be according to RFC 768.

####### 4.14.3.1.2.2 Coding of the field UDP_Checksum

The encoding of the fields shall be according to RFC 768.

####### 4.14.3.1.2.3 Coding of the field UDP_SrcPort

The encoding of the fields shall be according to RFC 768. Defined values are shown in Table 342.

Table 342 – UDP_SrcPort

Value (hexadecimal)	Meaning	Usage
0x8892	IANA_PNIO_UDP_UNICAST_PORT	UDP-RTC-PDU and UDP-RTA-PDU
0x8893	IANA_PNIO_UDP_MULTICAST_PORT	Reserved
0x8894	IANA_PNIO_EPM_PORT	NDREPMapLookupReq or NDREPMapLookupFreeReq
0xC000 – 0xFFFF	IANA_FREE_PORT Is used as dynamic and/or private port	PROFINETIOServiceReqPDU and PROFINETIOServiceResPDU

####### 4.14.3.1.2.4 Coding of the field UDP_DstPort

The encoding of the fields shall be according to RFC 768. Defined values are shown in Table 343.

Table 343 – UDP_DstPort

Value (hexadecimal)	Meaning	Usage
0x8892	IANA_PNIO_UDP_UNICAST_PORT	UDP-RTC-PDU and UDP-RTA-PDU
0x8893	IANA_PNIO_UDP_MULTICAST_PORT	Reserved
0x8894	IANA_PNIO_EPM_PORT	NDREPMapLookupReq or NDREPMapLookupFreeReq, also possible for each RPC call

Value (hexadecimal)	Meaning	Usage
0xC000 – 0xFFFF	IANA_FREE_PORT Is used as dynamic and/or private port	PROFINETIOServiceReqPDU and PROFINETIOServiceResPDU

4.14.3.1.3 Coding section related to IP

4.14.3.1.3.1 Coding of the field IP_DstIPAddress

The encoding of the fields shall be according to RFC 791, RFC 2236 and RFC 2365. Defined values are shown in Table 344 and Table 345.

Table 344 – IP_DstIPAddress

IP address	Range	Meaning
224.0.0.34	subnet	SUBNET_MULTICAST_IP_ADDRESS_FOR_DISCOVERY
—	site	SITE_MULTICAST_IP_ADDRESS_FOR_DISCOVERY

Table 345 – IP Multicast DstIPAddress according to RFC 2365

Multicast IP address	Associated Multicast MAC address	Associated FrameID	Usage
239.0.0.0 – 239.192.247.255	—	—	not used
239.192.248.0	01-00-5E-40-F8-00	0xF800	Used for multicast communication relations in conjunction with RT_CLASS_UDP
239.192.248.1 – 239.192.251.254	01-00-5E-40-F8-01 – 01-00-5E-40-FB-FE	0xF801 – 0xFBFE	Used for multicast communication relations in conjunction with RT_CLASS_UDP
239.192.251.255	01-00-5E-40-FB-FF	0xFBFF	Used for multicast communication relations in conjunction with RT_CLASS_UDP
239.193.252.0 – 239.255.255.255	—	—	not used

4.14.3.1.3.2 Coding of the field IP_VersionIHL

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.3 Coding of the field IP_TypeOfService

The encoding of the fields shall be according to RFC 791 and RFC 2474.

4.14.3.1.3.4 Coding of the field IP_TotalLength

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.5 Coding of the field IP_Identification

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.6 Coding of the field IP_Flags_FragOffset

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.7 Coding of the field IP_TTL

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.8 Coding of the field IP_Protocol

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.9 Coding of the field IP_HeaderChecksum

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.10 Coding of the field IP_SrcIPAddress

The encoding of the fields shall be according to RFC 791.

4.14.3.1.3.11 Coding of the field IP_Options

The encoding of the fields shall be according to RFC 791.

4.14.4 ARP cache

The utilization of the RFC 826 (ARP) and the control of the ARP cache may be optimized to reduce the switchover time between two nodes using the same IP address at different times. Thus may be done by deleting the ARP cache entry of an IP address every time the AR is released or aborted.

4.15 Domain name system

4.15.1 General

The utilization of the RFC 1034 (DNS) standard is defined for this specification. It includes the usage and the content syntax of domain name.

4.15.2 Primitive definitions

4.15.2.1 Primitives exchanged between remote machines

The remote service primitives including their associated parameters issued or received by DNS are described in the service definition and shown in Table 346.

Table 346 – Remote primitives issued or received by DNS

Primitive name	Source	Destination	Associated parameters	Functions
DNS_QueryName.req	DNS	DNS client	QNAME := StationName.RealStationName or StationName.AliasStationName, QCLASS, QTYPE	Resolve name with IP address
DNS_QueryName.cnf	DNS server	DNS	QNAME := StationName.RealStationName or StationName.AliasStationName, QCLASS, QTYPE, Answer := IPAddress	Resolve name with IP address

NOTE High level interfaces may offer a GetHostByName service instead of the QNAME service.

4.15.2.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DNS are described in the service definition and shown in Table 347.

Table 347 – Local primitives issued or received by DNS

Primitive name	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.15.3 DNS state transition diagram

See RFC 1034 (DNS).

4.15.4 State machine description

See RFC 1034 (DNS).

4.15.5 DNS state table

See RFC 1034 (DNS).

4.15.6 Functions, Macros, Timers and Variables

Table 348 contains the functions, macros, timers and variables used by the DNS and their arguments and their descriptions.

Table 348 – Functions, Macros, Timers and Variables used by the DNS

Name	Type	Function/Meaning
—	—	—

4.16 Dynamic host configuration

4.16.1 General

The utilization of the RFC 2131 (DHCP) standard is defined for this specification. It includes the usage and the content syntax of Client ID.

NOTE A tight coupling between DNS and DHCP server prevents Name vs. IP address mismatch.

4.16.2 Primitive definitions

4.16.2.1 Primitives exchanged between remote machines

The remote service primitives including their associated parameters issued or received by DHCP are described in the service definition and shown in Table 349.

Table 349 – Remote primitives issued or received by DHCP

Primitive name	Source	Destination	Associated parameters	Functions
DHCP offer	DHCP	DHCP server	OP, HTYPE, HLEN, HOPS, XID, SECS, FLAGS, CIADDR, YIADDR, SIADDR, GIADDR, CHADDR , DHCPOptions (53, 1, 3, 51, 54, 6, …)	Second service in a sequence to offer the DHCP client a parameter set.
DHCP acknowledgement	DHCP	DHCP server	OP, HTYPE, HLEN, HOPS, XID, SECS, FLAGS, CIADDR, YIADDR, SIADDR, GIADDR, CHADDR, DHCPOptions (53, 1, 3, 51, 54, 6, …)	Fourth service in a sequence to deliver the agreed parameter set.
DHCP discovery	DHCP client	DHCP	OP, HTYPE, HLEN, HOPS, XID, SECS, FLAGS, CIADDR, YIADDR, SIADDR, GIADDR, CHADDR, DHCPOptions (53, 50, 55, …)	First service in a sequence to find a DHCP server.

Primitive name	Source	Destination	Associated parameters	Functions
DHCP request	DHCP client	DHCP	OP, HTYPE, HLEN, HOPS, XID, SECS, FLAGS, CIADDR, YIADDR, SIADDR, GIADDR, CHADDR, DHCPOptions (53, 50, 54, …)	Third service in a sequence which is used by the client to select a server.

4.16.2.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by DHCP are described in the service definition and shown in Table 350.

Table 350 – Local primitives issued or received by machines

Primitive name	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.16.3 DHCP state transition diagram

See RFC 2131 (DHCP).

4.16.4 State machine description

See RFC 2131 (DHCP).

4.16.5 DHCP state table

See RFC 2131 (DHCP).

4.16.6 Functions, Macros, Timers and Variables

Table 351 contains the functions, macros, timers and variables used by the DHCP and their arguments and their descriptions.

Table 351 – Functions, Macros, Timers and Variables used by the DHCP

Name	Type	Function/Meaning
—	—	—

4.17 Simple network management

4.17.1 Overview

The utilization of the RFC 1213 (MIB 2), RFC 2674 (Bridges with traffic classes), RFC 2863 (IF MIB), RFC 3418 (SNMP), RFC 3621 (Power over Ethernet MIB), RFC 4836 (MAU MIB) and IEEE 802.1AB (LLDP MIB) standards are defined for this specification. Furthermore, the PNIO MIB is specified in 4.17.2 and LLDP EXT MIB is specified in 4.17.4.

4.17.2 Enterprise number for PNIO MIB

The coding of the field enterprise number shall be according to Table 352.

Table 352 – Enterprise number

Value (decimal)	Meaning
24 686	Enterprise number for the PNIO MIB

4.17.3 MIB cross reference

It is recommended that each (LLDP-MIB.)“lldpLocPortDesc” is defined disjunct to make a cross reference to the MIB2 possible.

The link between the MIB2 and the LLDP MIB may be done by the rule (LLDP-MIB.)“lldpLocPortDesc” == (MIB2.)”ifDescr”.

4.17.4 LLDP EXT MIB

See Annex W

4.18 Common DLL Mapping Protocol Machines

4.18.1 Overview

The DLL Mapping Protocol Machines (DMPM) consists of several protocol machines:

– Handling of the services invoked by other Application Layer entities (LMPM)
– Forwarding for RT_CLASS_3 (RED_Relay)
– Forwarding for DFP (DFP_Relay)

NOTE 1 Forwarding of standard frames is according to IEEE 802.1D and therefore not specified here.

– Mapping to Media Access Control interface (MAC) and send/receive functions for synchronization messages

NOTE 2 Invoking of MAC is according to IEEE 802.3 and therefore not specified here.

– Fragmentation and reassemblation (FRAG and DEFRAG)
– SYNC_SHIMP to add precise time stamps for synchronization

The Interface between the service handler (LMPM), forwarding machines and Mapping to Media Access Control (MAC) consists of a set of queues and global data.

Figure 79 illustrates the structuring of the protocol machines for the DMPM for a device and Annex H describes the upper protocol layers.

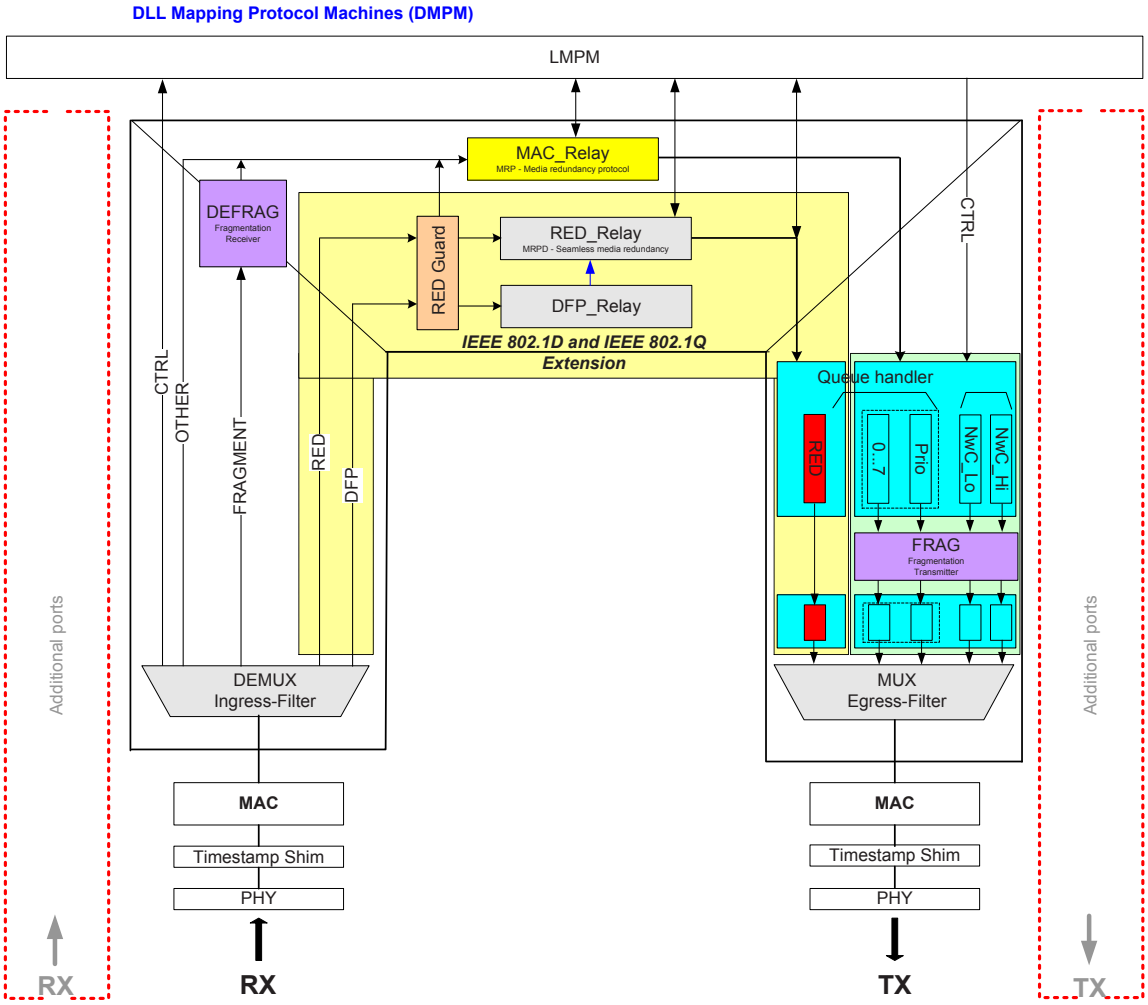


Figure 79 – Structuring of the protocol machines within the DMPM (bridge)

NOTE 3 This picture is often called baggy pants model.

4.18.2 Data Link Layer Mapping Protocol Machine

4.18.2.1 Primitive definitions

4.18.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Data Link Layer Mapping Protocol Machine (LMPM) are described in the service definition and shown in Table 353.

Table 353 – Remote primitives issued or received by LMPM

Primitive	Source	Destination	Associated parameters	Functions
DMUX_P_Data.ind	DEMUX	LMPM	CREP, S_Port, Tstamp, DA, SA, N_SDU	Network management protocols are issued direct to the LMPM.
LMPM_A_Data.cnf	LMPM	APMS APMR DCPUCS DCPUCR	CREP, LMPM_status	—

Primitive	Source	Destination	Associated parameters	Functions
		DCPMCS DCPMCR DCPHMCS DCPHMCR		
LMPM_A_Data.ind	LMPM	APMS APMR DCPUCS DCPUCR DCPMCS DCPMCR DCPHMCS DCPHMCR	CREP, DA, SA, VLANPrio, VLANID, A_SDU	—
LMPM_A_Data.req	APMS APMR DCPUCS DCPUCR DCPMCS DCPMCR DCPHMCS DCPHMCR	LMPM	CREP, DA, SA, VLANPrio, VLANID, A_SDU	—
LMPM_C_Data.cnf	LMPM	SCHEDULER	CREP, LMPM_status	—
LMPM_C_Data.ind	LMPM	CPM	CREP, DA, SA, VLANPrio, VLANID, C_SDU, APDU_Status	—
LMPM_C_Data.req	SCHEDULER PPM	LMPM	CREP, DA, SA, VLANPrio, VLANID, C_SDU, APDU_Status	—
LMPM_N_Data.cnf	LMPM	APMS APMR IP	CREP, LMPM_status	The placeholder IP is used for other protocol machines.
LMPM_N_Data.ind	LMPM	APMS APMR IP	CREP, DA, SA, VLANPrio, VLANID, N_SDU	The placeholder IP is used for other protocol machines.
LMPM_N_Data.req	APMS APMR IP	LMPM	CREP, DA, SA, VLANPrio, VLANID, N_SDU	The placeholder IP is used for other protocol machines.
LMPM_P_Data.cnf	LMPM	PTCP	CREP, D_Port, Tstamp, LMPM_status	—
LMPM_P_Data.ind	LMPM	PTCP	CREP, S_Port, Tstamp, DA, SA, N_SDU	—
LMPM_P_Data.req	DelayReq DelayRsp MPSM	LMPM	CREP, D_Port, Tstamp, DA, SA,	—

Primitive	Source	Destination	Associated parameters	Functions
			N_SDU	
MAC_RelayData.cnf	MAC_RELAY	LMPM	CREP, Status	—
MAC_RelayData.ind	MAC_RELAY	LMPM	CREP, DA, SA, LT, VLANPrio, VLANID, C_SDU, APDU_status	—
MAC_RelayData.req	LMPM	MAC_RELAY	CREP, DA, SA, VLANPrio, VLANID, C_SDU, APDU_Status	This function is provided by the IEEE 802.1D. It searches the filtering database and executes for each found destination port the M_UNITDATA.req.
MUX_Data.ind	MUX	LMPM	CREP, D_Port, Tstamp, Status	Due to the definition of a M_UNITDATA.req a indication is needed the deliver the transmit time stamp if needed.
QueueHandler.req	LMPM	QueueHandler	CREP, D_Port, Tstamp, N_SDU	For network management protocols or protocols which do not use the filtering database the LMPM accesses the MUX via the QueueHandler.req.

4.18.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by LMPM are described in the service definition and shown in Table 354.

Table 354 – Local primitives issued or received by LMPM

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

4.18.2.2 State transition diagram

The state transition diagram of the LMPM is shown in Figure 80.

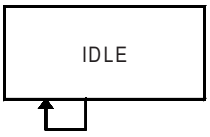


Figure 80 – State transition diagram of LMPM

States of the LMPM

IDLE	The LMPM is the interface between the bridges or the MAC and the local state machines.

4.18.2.3 State machine description

The LMPM forms the interface between MAC and LMPM-User for various data and management services. The services are all handled in the IDLE-State.

The service request will be validated first. A negative validation will result in a negative confirmation. Otherwise the service will be put into the appropriate priority service queue. Services executed by MAC will be moved from the request queues to the confirmation queues. All valid incoming services will be put into the indication queue.

4.18.2.4 LMPM state table

The LMPM state table is shown in Table 355.

Table 355 – LMPM state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**LMPM_P_Data.req ()** /CheckPDUType () == TimeStamped => QueueHandler.req () //NOTE After the dequeuing and transmitting a MUX_Data.ind () is generated from MUX and issued to the LMPM to convey the transmit Tstamp for the frame	IDLE
2	IDLE	**MUX_Data.ind ()** => ignore LMPM_P_Data.cnf ()	IDLE
3	IDLE	**LMPM_N_Data.req ()** /CheckPDUType () == other //NOTE Other includes RT_CLASS_UDP and RTA_CLASS_UDP => LMPM_N_Data.cnf () MAC_RELAY_Data.req ()	IDLE
4	IDLE	MAC_RELAY_Data.cnf () => ignore	IDLE
5	IDLE	**LMPM_A_Data.req ()** /CheckPDUType () == RTA_CLASS_1 => LMPM_A_Data.cnf () MAC_RELAY_Data.req ()	IDLE
6	IDLE	**LMPM_C_Data.req ()** /CheckPDUType () == RT_CLASS_1 => LMPM_C_Data.cnf () MAC_RELAY_Data.req ()	IDLE
7	IDLE	**LMPM_C_Data.req ()** /CheckPDUType () == RT_CLASS_2 => LMPM_C_Data.cnf () MAC_RELAY_Data.req ()	IDLE
8	IDLE	**LMPM_C_Data.req ()** /CheckPDUType () == RT_CLASS_3 => LMPM_C_Data.cnf () QueueHandler.req ()	IDLE

#	Current State	Event /Condition =>Action	Next State
9	IDLE	**DMUX_P_Data.ind ()** /CheckPDUType () == TimeStamped => LMPM_P_Data.ind ()	IDLE
10	IDLE	**RED_RELAY_Data.ind ()** /CheckPDUType () == RT_CLASS_3 => LMPM_C_Data.ind ()	IDLE
11	IDLE	**MAC_RELAY_Data.ind ()** /CheckPDUType () == RT_CLASS_2 => LMPM_C_Data.ind ()	IDLE
12	IDLE	**MAC_RELAY_Data.ind ()** /CheckPDUType () == RT_CLASS_1 => LMPM_C_Data.ind ()	IDLE
13	IDLE	**MAC_RELAY_Data.ind ()** /CheckPDUType () == RTA_CLASS_1 => LMPM_A_Data.ind ()	IDLE
14	IDLE	**MAC_RELAY_Data.ind ()** /CheckPDUType () == other => LMPM_N_Data.ind ()	IDLE

4.18.2.5 Functions, Macros, Timers and Variables

Table 356 contains the functions, macros, timers and variables used by the LMPM and their arguments and their descriptions.

Table 356 – Functions, Macros, Timers and Variables used by the LMPM

Name	Type	Function/Meaning
CheckPDUType	Function	This local function check the PDU type and returns the values - RT_CLASS_1 - RT_CLASS_2 - RT_CLASS_3 - RTA_CLASS_1 - Other - TimeStamped

5 Application layer protocol specification for decentralized periphery

5.1 FAL syntax description

5.1.1 DLPDU abstract syntax reference

The DLPDU abstract syntax from 4.1.1 shall be applied.

5.1.2 APDU abstract syntax

Table 357 defines the abstract syntax of the Application Layer PDUs referred to as APDUs. The defined order of octets shall be used to convey the APDUs. The APDUs of Table 357 shall represent the content of the DLSDU in Table 5.

Table 357 – IO APDU substitutions

Substitution name	Structure
RTA-SDU	AlarmNotification-PDU ^ AlarmAck-PDU
BlockHeader	BlockType, BlockLength, BlockVersionHigh, BlockVersionLow
AlarmNotification-PDU	BlockHeader, AlarmType, API [a], SlotNumber [a], SubslotNumber [a], ModuleIdentNumber, SubmoduleIdentNumber, AlarmSpecifier, AlarmPayload [a] These fields addresses the submodule which may be source or sink of an alarm. They contains the source if the IO device issues an alarm and the sink if the IO controller issues an alarm. The BlockType field within the BlockHeader shall be set to AlarmNotification high or low according to Table 358.
AlarmAck-PDU	BlockHeader, AlarmType, API, SlotNumber, SubslotNumber, AlarmSpecifier, PNIOStatus The BlockType field within the BlockHeader shall be set to AlarmAck high or low according to Table 358. Special case “No Error”: PNIOStatus(=0x00, 0x00, 0x00, 0x00) Special case “Alarm Type Not Supported” or if a reserved Alarm Type is used: PNIOStatus(=0xDA, 0x81, 0x3C, 0x00) Special case “Wrong Submodule State”: PNIOStatus(=0xDA, 0x81, 0x3C, 0x01) Special case “IOCARSR: Backup - Alarm not executed”: PNIOStatus(=0xDA, 0x81, 0x3C, 0x02)
AlarmPayload	[MaintenanceItem], [DiagnosisItem] ^ [AlarmItem] ^ [Upload&RetrievalItem] ^ [iParameterItem] See Table 361
MaintenanceItem	UserStructureIdentifier, BlockHeader, Padding, Padding, MaintenanceStatus
Upload&RetrievalItem	UserStructureIdentifier, BlockHeader, Padding, Padding, (URRecordIndex, URRecordLength)* Special case “Retrieve all stored records”: UserStructureIdentifier, BlockHeader(=0x0F04), Padding, Padding, URRecordIndex(=0), URRecordLength(=0)
iParameterItem	UserStructureIdentifier, BlockHeader, Padding, Padding, iPar_Req_Header, Max_Segm_Size, Transfer_Index, Total_iPar_Size

Substitution name	Structure
DiagnosisItem	UserStructureIdentifier, ChannelDiagnosisData* ^ ExtChannelDiagnosisData* ^ QualifiedChannelDiagnosisData* ^ DiagnosisData* Special case ChannelDiagnosisData: UserStructureIdentifier(=0x8000), ChannelDiagnosisData* Special case ExtChannelDiagnosisData: UserStructureIdentifier(=0x8002), ExtChannelDiagnosisData* Special case QualifiedChannelDiagnosisData: UserStructureIdentifier(=0x8003), QualifiedChannelDiagnosisData* Special case DiagnosisData with ManufacturerSpecificDiagnosis: UserStructureIdentifier(=0x0000 – 0x7FFF), (BlockHeader, API, ManufacturerSpecific-Diagnosis)*
AlarmItem	UserStructureIdentifier, Data*
PROFINETIO-ServiceReqPDU	IODConnectReq ^ IODWriteReq ^ IODWriteMultipleReq ^ IODReadReq ^ IODControlReq ^ IODReleaseReq ^ IOXControlReq
PROFINETIO-ServiceResPDU	IODConnectRes ^ IODWriteRes ^ IODWriteMultipleRes ^ IODReadRes ^ IODControlRes ^ IODReleaseRes ^ IOXControlRes
IODConnectReq with StartupMode:=1	ARBlockReq, {[IOCRBlockReq*], [AlarmCRBlockReq], [ExpectedSubmoduleBlockReq*] [b], [PrmServerBlock], [MCRBlockReq*] [a], [ARRPCBlockReq], [IRInfoBlock], [SRInfoBlock], [ARVendorBlockReq*], [ARFSUBlock] } Special case: “IOCARSingle” or “IOSAR”: ARBlockReq, {IOCRBlockReq*, AlarmCRBlockReq, ExpectedSubmoduleBlockReq*, [PrmServerBlock], [MCRBlockReq*] [a], [ARRPCBlockReq], [IRInfoBlock], [ARVendorBlockReq*], [ARFSUBlock] } Special case: “IOSAR with ARProperties.DeviceAccess:=1”: ARBlockReq [c] Special case: “IOCARSR”: ARBlockReq, {IOCRBlockReq*, AlarmCRBlockReq, ExpectedSubmoduleBlockReq*, [PrmServerBlock], [MCRBlockReq*] [a], [ARRPCBlockReq], [IRInfoBlock], SRInfoBlock, [ARVendorBlockReq*], [ARFSUBlock] } [a] The field MCRBlockReq shall only be present if at least one IOCRBlockReq contains the value MULTICAST_CONSUMER_CR as an IO CR Type. [b] The field ExpectedSubmoduleBlockReq shall only contain submodules which are referred in at least one IOCRBlockReq. [c] The field CMInitiatorActivityTimeoutFactor specifies the watchdog time.

Substitution name	Structure
IODConnectRes with StartupMode:=1	ARBlockRes, {[IOCRBlockRes*], [AlarmCRBlockRes], [ModuleDiffBlock], [ARRPCBlockRes] [a], ARServerBlockRes, [ARVendorBlockRes*] [b] } Special case: “IOCARSingle” or “IOSAR”: ARBlockRes, {IOCRBlockRes*, AlarmCRBlockRes, [ModuleDiffBlock], [ARRPCBlockRes] [a], ARServerBlockRes, [ARVendorBlockRes*] [b] } Special case: “IOSAR with ARProperties.DeviceAccess=1”: ARBlockRes, ARServerBlockRes [a] The field ARRPCBlockRes shall only be present if IODConnectReq contains an ARRPCBlockReq. [b] The number of ARVendorBlockRes entries shall be equal to the number of ARVendorBlockReq entries in the IODConnectReq.
IODConnectReq with StartupMode:=0	ARBlockReq, {[IOCRBlockReq*], [AlarmCRBlockReq], [ExpectedSubmoduleBlockReq*] [b], [PrmServerBlock], [MCRBlockReq*] [a], [ARRPCBlockReq] } Special case: “IOCARSingle” or “IOSAR”: ARBlockReq, {IOCRBlockReq*, AlarmCRBlockReq, ExpectedSubmoduleBlockReq*, [PrmServerBlock], [MCRBlockReq*] [a], [ARRPCBlockReq] } Special case: “IOSAR with ARProperties.DeviceAccess:=1”: ARBlockReq [c] Special case: “IOCARSingle using RT_CLASS_3: ARBlockReq, {IOCRBlockReq* [d], AlarmCRBlockReq, ExpectedSubmoduleBlockReq*, [PrmServerBlock], [MCRBlockReq*][a], [ARRPCBlockReq] } [a] The field MCRBlockReq shall only be present if at least one IOCRBlockReq contains the value MULTICAST_CONSUMER_CR as an IO CR Type. [b] The field ExpectedSubmoduleBlockReq shall only contain submodules which are referred in at least one IOCRBlockReq. [c] The field CMInitiatorActivityTimeoutFactor specifies the watchdog time. [d] To establish an “IOCARSingle using RT_CLASS_3” with RT_CLASS_3 input and output communication relations, one input and one output communication relation, shall exist.
IODConnectRes with StartupMode:=0	ARBlockRes, {[IOCRBlockRes*], [AlarmCRBlockRes], [ModuleDiffBlock], [ARRPCBlockRes] [a]} Special case: “IOCARSingle” or “IOSAR”: ARBlockRes, {IOCRBlockRes*, AlarmCRBlockRes, [ModuleDiffBlock], [ARRPCBlockRes] [a]} Special case: “IOSAR with ARProperties.DeviceAccess=1”: ARBlockRes [a] The field ARRPCBlockRes shall only be present if IODConnectReq contains an ARRPCBlockReq.

Substitution name	Structure
IODWriteMultipleReq	IODWriteReqHeader [a], (IODWriteReqHeader, RecordDataWrite, [Padding*] [b])* [a] The value of the parameter index shall be 0xE040. [b] The number of padding octets (value=0) shall be 0,1,2,3 to have 32 bit alignment to the next IODWriteReqHeader.
IODWriteReq	IODWriteReqHeader, RecordDataWrite
IODWriteReqHeader	BlockHeader, SeqNumber, ARUUID, API, SlotNumber, SubslotNumber, Padding* [a], Index, RecordDataLength, RWPadding* [b] [a] The number of padding octets (value=0) in the write request is 2. [b] The number of padding octets (value=0) in the write request is 24.
IODWriteRes	IODWriteResHeader [a] [a] The value of the parameter PNIOStatus shall be (0,0,0,0) or a duplicate of the PNIOStatus from the NDRDataResponse.
IODWriteMultipleRes	IODWriteResHeader [a] [b], (IODWriteResHeader)* [c] [a] The value of the parameter index shall be 0xE040. [b] The value of the parameter PNIOStatus shall be (0,0,0,0) or a duplicate of the PNIOStatus from the NDRDataResponse. [c] The value of the parameter PNIOStatus contains the result of the particular write.
IODWriteResHeader	BlockHeader, SeqNumber, ARUUID, API, SlotNumber, SubslotNumber, Padding* [a], Index, RecordDataLength, AdditionalValue1, AdditionalValue2, PNIOStatus, RWPadding* [b] [a] The number of padding octets (value=0) in the write response is 2. [b] The number of padding octets (value=0) in the write response is 16.
IODReadReq	IODReadReqHeader, RecordDataReadQuery
IODReadReqHeader	BlockHeader, SeqNumber, ARUUID, API, SlotNumber, SubslotNumber, Padding* [a], Index, RecordDataLength, [TargetARUUID] [b], RWPadding* [c] [a] The number of padding octets (value=0) in the read request is 2. [b] The optional field TargetARUUID shall only be used in conjunction with the value 0 of ARUUID (Implicit AR). [c] The number of padding octets (value=0) in the read request is 24 or 8.
RecordDataReadQuery	UploadBLOBQuery ^ (BlockHeader, Data* [a]) ^ NULL [a] The usage, structure and values shall be defined for a) Manufacturer specific index range by the manufacturer b) Profile specific index ranges by the profiles c) All other index ranges by this standard
IODReadRes	IODReadResHeader, RecordDataRead
IODReadResHeader	BlockHeader, SeqNumber, ARUUID, API, SlotNumber, SubslotNumber, Padding* [a], Index, RecordDataLength, AdditionalValue1, AdditionalValue2, RWPadding* [b] [a] The number of padding octets (value=0) in the read res is 2. [b] The number of padding octets (value=0) in the read res is 20.

Substitution name	Structure
IODControlReq	ControlBlockConnect [a] ^ (ControlBlockConnect, SubmoduleListBlock) [b] ^ ControlBlockPlug [c] [a] Shall be used in the context of a connect or a PrmBegin/PrmEnd sequence for ControlCommand.PrmEnd [b] Shall be used in the context of a PrmBegin/PrmEnd sequence for ControlCommand.PrmBegin with SubmoduleListBlock [c] Shall be used in the context of a plug/release for ControlCommand.PrmEnd
IODControlRes	ControlBlockConnect [a] ^ (ControlBlockConnect, [ModuleDiffBlock]) [b] ^ ControlBlockPlug [c] ^ NULL [d] [a] Shall be used in the context of a connect or a PrmBegin/PrmEnd sequence for ControlCommand.PrmEnd [b] Shall be used in the context of a PrmBegin/PrmEnd sequence for ControlCommand.PrmBegin if the checking of the SubmoduleListBlock leads to a ModuleDiffBlock [c] Shall be used in the context of a plug/release for ControlCommand.PrmEnd [d] In case of a negative response NULL shall be transmitted.
IODReleaseReq	ReleaseBlock
IODReleaseRes	ReleaseBlock ^ NULL [a] [a] In case of a negative response NULL shall be transmitted.
IOXControlReq with StartupMode:=1	(ControlBlockConnect, [ModuleDiffBlock]) [a] ^ (ControlBlockPlug, [ModuleDiffBlock])] [b] [a] Shall be used in the context of a connect or a PrmBegin/PrmEnd sequence for ControlCommand.ApplicationReady with ModuleDiffBlock if needed. [b] Shall be used in the context of a plug/release for ControlCommand.ApplicationReady with ModuleDiffBlock if needed. The field ModuleDiffBlock shall only be present if it contains entries. An empty ModuleDiffBlock shall be omitted.
IOXControlRes with StartupMode:=1	ControlBlockConnect [a] ^ ControlBlockPlug [b] ^ NULL [c] [a] Shall be used in the context of a connect or a PrmBegin/PrmEnd sequence for ControlCommand.ApplicationReady [b] Shall be used in the context of a plug/release for ControlCommand.ApplicationReady [c] In case of a negative response NULL shall be transmitted.
IOXControlReq with StartupMode:=0	(ControlBlockConnect, [ModuleDiffBlock]) [a] ^ (ControlBlockPlug, [ModuleDiffBlock])] [b] ^ ControlBlockRFC [c] ^ ControlBlockRTC [d] [a] Shall be used in the context of a connect for ControlCommand.ApplicationReady with ModuleDiffBlock if needed. [b] Shall be used in the context of a plug/release for ControlCommand.ApplicationReady with ModuleDiffBlock if needed. [c] Shall be used for ControlCommand.ReadyForCompanion [d] Shall be used for ControlCommand.ReadyForRT_CLASS_3 The field ModuleDiffBlock shall only be present if it contains entries. An empty ModuleDiffBlock shall be omitted.

Substitution name	Structure
IOXControlRes with StartupMode:=0	ControlBlockConnect [a] ^ ControlBlockPlug [b] ^ ControlBlockRFC [c] ^ ControlBlockRTC [d] ^ NULL [e] [a] Shall be used in the context of a connect for ControlCommand.ApplicationReady [b] Shall be used in the context of a plug/release for ControlCommand.ApplicationReady [c] Shall be used for ControlCommand.ReadyForCompanion [d] Shall be used for ControlCommand.ReadyForRT_CLASS_3 [e] In case of a negative response NULL shall be transmitted.
ARBlockReq	BlockHeader, ARType, ARUUID, SessionKey, CMInitiatorMacAdd, CMInitiatorObjectUUID, ARProperties, CMInitiatorActivityTimeoutFactor, InitiatorUDPRTPort [a], StationNameLength, CMInitiatorStationName [b] [a] If no RT_CLASS_UDP CR is used, the value for InitiatorUDPRTPort shall be set to 0x8892. [b] This coding leads to a misalignment if the length of CMInitiatorStationName is uneven. An IO device should support a [Padding*] behind to ensure Unsigned32 alignment. The BlockType field within the BlockHeader shall be set to ARBlockReq according to Table 358.
ARBlockRes	BlockHeader, ARType, ARUUID, SessionKey, CMResponderMacAdd, ResponderUDPRTPort [a] If no RT_CLASS_UDP CR is used, the value for ResponderUDPRTPort shall be set to 0x8892. The BlockType field within the BlockHeader shall be set to ARBlockRes according to Table 358.
IOCRBlockReq	BlockHeader, IOCRType, IOCRReference, LT, IOCRProperties, DataLength, FrameID, SendClockFactor, ReductionRatio, Phase, Sequence, FrameSendOffset, DataHoldFactor [a], DataHoldFactor, IOCRTagHeader, IOCRMulticastMACAdd, NumberOfAPIs, (API, NumberOfIODataObjects, (SlotNumber, SubslotNumber, IODataObjectFrameOffset)*, NumberOfIOCS, (SlotNumber, SubslotNumber, IOCSFrameOffset)*)* [a] This field exists due to legacy reasons and was formerly called WatchDogFactor. The BlockType field within the BlockHeader shall be set to IOCRBlockReq according to Table 358. Special Case IOCRType == OUTPUT_CR not using RT_CLASS_3 The field FrameID shall not be evaluated. Special Case IOCRType == OUTPUT_CR using RT_CLASS_3 The field FrameID shall contain the FrameID used in the corresponding PDIRData. Special Case IOCRType == MULTICAST_CONSUMER_CR The field FrameID shall contain a FrameID from the defined multicast range. The configuration tool shall guarantee that this FrameID is unique within the project context.
MCRBlockReq	BlockHeader, IOCRReference, AddressResolutionProperties, MCITimeoutFactor, StationNameLength, ProviderStationName, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.

Substitution name	Structure
IOCRBlockRes	BlockHeader, IOCRType, IOCRReference, FrameID The BlockType field within the BlockHeader shall be set to IOCRBlockRes according to Table 358.
ExpectedSubmodule-BlockReq	BlockHeader, NumberOfAPIs, (API, SlotNumber [a], ModuleIdentNumber, ModuleProperties, NumberOfSubmodules, (SubslotNumber, SubmoduleIdentNumber, SubmoduleProperties [b], (DataDescription, SubmoduleDataLength, LengthIOPS, LengthIOCS)*)*)* [a] This parameter is constant for one ExpectedSubmoduleBlockReq because each contains the data for only one slot. [b] The field SubmoduleProperties.Type determines the number of subsequent data description blocks. The BlockType field within the BlockHeader shall be set to ExpectedSubmoduleBlockReq according to Table 358.
ModuleDiffBlock	BlockHeader, NumberOfAPIs, (API, NumberOfModules, (SlotNumber, ModuleIdentNumber [a], ModuleState [b], NumberOfSubmodules, [(SubslotNumber, SubmoduleIdentNumber [a], SubmoduleState)*])*)* [a] Real identification data [b] If ModuleState=NO_MODUL then NumberOfSubmodules shall be zero. The subsequent part shall be omitted. For all other ModuleState only the SubmoduleState shall be used to decide whether the submodule shall be parameterized. The BlockType field within the BlockHeader shall be set to ModuleDiffBlock according to Table 358.
AlarmCRBlockReq	BlockHeader, AlarmCRType, LT, AlarmCRProperties, RTATimeoutFactor, RTARetries, LocalAlarmReference, MaxAlarmDataLength, AlarmCRTagHeaderHigh, AlarmCRTagHeaderLow The BlockType field within the BlockHeader shall be set to AlarmCRBlockReq according to Table 358.
AlarmCRBlockRes	BlockHeader, AlarmCRType, LocalAlarmReference, MaxAlarmDataLength The BlockType field within the BlockHeader shall be set to AlarmCRBlockRes according to Table 358.
PrmServerBlock	BlockHeader, ParameterServerObjectUUID, ParameterServerProperties, CMInitiatorActivityTimeoutFactor, StationNameLength, ParameterServerStationName [a] [a] An IO device should support a [Padding*] behind to ensure Unsigned32 alignment. The BlockType field within the BlockHeader shall be set to PrmServerBlock according to Table 358.
ARRPCBlockReq	BlockHeader, InitiatorRPCServerPort The BlockType field within the BlockHeader shall be set to ARRPCBlockReq according to Table 358.
ARRPCBlockRes	BlockHeader, ResponderRPCServerPort The BlockType field within the BlockHeader shall be set to ARRPCBlockRes according to Table 358.

Substitution name	Structure
ARServerBlockRes	BlockHeader, StationNameLength, CMResponderStationName, [Padding* [a]] [a] The number of Padding octets shall ensure Unsigned32 alignment. The BlockType field within the BlockHeader shall be set to ARServerBlockRes according to Table 358.
IRInfoBlock	BlockHeader, Padding* [a], IRDataUUID, Padding*[a], NumberOfIOCRs [b], [(IOCRReference, SubframeOffset, SubframeData)*] [a] The number of Padding octets shall be 2. [b] This field shall be coded as zero if no DFP is used. The BlockType field within the BlockHeader shall be set to IRInfoBlock according to Table 358.
SRInfoBlock	BlockHeader, RedundancyDataHoldFactor, SRProperties The BlockType field within the BlockHeader shall be set to SRInfoBlock according to Table 358.
ARFSUBlock	ARFSUDataAdjust The BlockType field within the BlockHeader shall be set to ARFSUBlock according to Table 358.
ARVendorBlockReq	BlockHeader, APStructureIdentifier, API, [Data*], [Padding* [a]] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. The BlockType field within the BlockHeader shall be set to ARVendorBlockReq according to Table 358. Special case “Extended identification rules” BlockHeader, APStructureIdentifier (:=0x8000), API (:=0), ExpectedExtendedIdentification-Info, [Padding* [a]]
ARVendorBlockRes	BlockHeader, APStructureIdentifier, API, [Data*], [Padding* [a]] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. The BlockType field within the BlockHeader shall be set to ARVendorBlockRes according to Table 358. Special case “Extended identification rules” BlockHeader, APStructureIdentifier (:=0x8000), API (:=0), RealExtendedIdentificationInfo, [Padding* [a]]
ExpectedExtended-IdentificationInfo	ExtendedIdentificationInfo
RealExtended-IdentificationInfo	ExtendedIdentificationInfo
ExtendedIdentification-Info	ExtendedIdentificationUUID, ExtendedIdentificationVersionHigh, ExtendedIdentificationVersionLow

Substitution name	Structure
SubframeBlock	BlockHeader, FrameID [a], SFIOCRProperties, SubframeData* [b] [a] For MRPD only the SubframeBlock for the FrameID with the least significant bit set to zero shall be created. [b] The ordering of SubframeData octets shall be used for the non redundant path The BlockType field within the BlockHeader shall be set to SubframeBlock according to Table 358.
PDIRSubframeData	BlockHeader, NumberOfSubframeBlocks, SubframeBlock* The BlockType field within the BlockHeader shall be set to PDIRSubframeBlock according to Table 358.
ControlBlockConnect	BlockHeader, Padding* [a], ARUUID, SessionKey, Padding* [a], ControlCommand, ControlBlockProperties [a] The number of Padding octets shall be 2. The BlockType field within the BlockHeader shall be set to IODBlockReq, IODBlockRes, IOXBlockReq and IOXBlockRes according to Table 358.
ControlBlockPlug	BlockHeader, Padding* [a], ARUUID, SessionKey, AlarmSequenceNumber, ControlCommand, ControlBlockProperties [a] The number of Padding octets shall be 2. The BlockType field within the BlockHeader shall be set to IOXBlockReq, IOXBlockRes according to Table 358. The field AlarmSequenceNumber shall contain the value of the sub-field AlarmSpecifier.SequenceNumber of the corresponding AlarmNotification-PDU.
ControlBlockRFC	BlockHeader, Padding* [a], ARUUID, SessionKey, Padding* [a], ControlCommand, ControlBlockProperties [a] The number of Padding octets shall be 2. The BlockType field within the BlockHeader shall be set to ReadyForCompanionBlock according to Table 358.
ControlBlockRTC	BlockHeader, Padding* [a], ARUUID, SessionKey, Padding* [a], ControlCommand, ControlBlockProperties [a] The number of Padding octets shall be 2. The BlockType field within the BlockHeader shall be set to ReadyForRTCLASS3Block according to Table 358.
ReleaseBlock	BlockHeader, Padding* [a], ARUUID, SessionKey, Padding* [a], ControlCommand, ControlBlockProperties [a] The number of Padding octets shall be 2. The BlockType field within the BlockHeader shall be set to ReleaseBlock according to Table 358.

Substitution name	Structure
SubmoduleListBlock	BlockHeader, NumberOfEntries, (API, SlotNumber, SubslotNumber)* The BlockType field within the BlockHeader shall be set to SubmoduleListBlock according to Table 358.
RecordDataRead	DiagnosisData* ^ ExpectedIdentificationData* ^ RealIdentificationData* ^ SubstituteValue ^ RecordInputDataObjectElement ^ RecordOutputDataObjectElement ^ Data* ^ ARData ^ IMData ^ LogBookData ^ ModuleDiffBlock ^ APIData ^ PDPortDataAdjust* ^ PDPortDataCheck* ^ PDPortDataReal* ^ PDIRData ^ PDSyncData* ^ PdevData ^ IsochronousModeData* ^ PDInterfaceAdjust ^ PDInterfaceMrpDataAdjust* ^ PDInterfaceMrpDataCheck* ^ PDInterfaceMrpDataReal* ^ PDPortMrpDataAdjust ^ PDPortMrpDataReal ^ PDPortFODataReal ^ PDPortFODataAdjust ^ PDPortFODataCheck ^ PDRealData* ^ PDExpectedData* ^ PDNCDataCheck ^ PDPortStatistic ^ I&M0FilterData ^ ARFSUDataAdjust ^ PDInterfaceFSUDataAdjust ^ PDInterfaceDataReal ^ AutoConfiguration ^ PDIRSubframeData ^ NestedDiagnosisInfo ^ UploadBLOB ^ NULL [a] [a] NULL shall be used if a requested well-known data record is empty (e.g. Diagnosis, ModuleDiffBlock, ARData, ...).
RecordDataWrite	SubstituteValue ^ Data* ^ IMDataWrite ^ PDPortDataAdjust ^ PDPortDataCheck ^ PDIRData ^ PDSyncData ^ IsochronousModeData ^ PDInterfaceMrpDataAdjust ^ PDInterfaceMrpDataCheck ^ PDPortMrpDataAdjust ^ PDPortFODataAdjust ^ PDPortFODataCheck ^ PDNCDataCheck ^ ARFSUDataAdjust ^ PDInterfaceFSUDataAdjust ^ PDIRSubframeData ^ PDInterfaceAdjust ^ CombinedObjectContainer
DiagnosisData with BlockVersionLow=0	BlockHeader, ChannelDiagnosis ^ ManufacturerSpecificDiagnosis ^ ExtChannelDiagnosis BlockVersionLow=0 shall be supported by IO controller and IO supervisor. It shall not be generated by IO device.
DiagnosisData with BlockVersionLow=1	BlockHeader, API, ChannelDiagnosis ^ ManufacturerSpecificDiagnosis ^ ExtChannelDiagnosis ^ QualifiedChannelDiagnosis BlockVersionLow=1 shall be generated by IO device and support by IO controller and IO supervisor.
ChannelDiagnosis	SlotNumber, SubslotNumber, ChannelNumber(0x8000), ChannelProperties [a], UserStructureIdentifier(0x8000), ChannelDiagnosisData* [a] The field ChannelProperties.Type, the field ChannelProperties.Direction, the field ChannelProperties.Maintenance shall be set to zero. The field ChannelProperties.Specifier shall be set to appear if at least one ChannelProperties.Specifier in the ChannelDiagnosisData is set to appear in conjunction with ChannelProperties.Maintenance(=diagnosis). Else, the field ChannelProperties.Specifier shall be set to disappear.
ChannelDiagnosisData	ChannelNumber, ChannelProperties, ChannelErrorType
Manufacturer-SpecificDiagnosis	SlotNumber, SubslotNumber, ChannelNumber, ChannelProperties, UserStructureIdentifier, Data*
ExtChannelDiagnosis	SlotNumber, SubslotNumber, ChannelNumber(0x8000), ChannelProperties [a], UserStructureIdentifier(0x8002), ExtChannelDiagnosisData* [a] The field ChannelProperties.Type, the field ChannelProperties.Direction, the field ChannelProperties.Maintenance shall be set to zero. The field ChannelProperties.Specifier shall be set to appear if at least one ChannelProperties.Specifier in the ExtChannelDiagnosisData is set to appear in conjunction with ChannelProperties.Maintenance(=diagnosis). Else, the field ChannelProperties.Specifier shall be set to disappear.
ExtChannel-DiagnosisData	ChannelNumber, ChannelProperties, ChannelErrorType, ExtChannelErrorType, ExtChannelAddValue

Substitution name	Structure
QualifiedChannel-Diagnosis	SlotNumber, SubslotNumber, ChannelNumber(0x8000), ChannelProperties [a], UserStructureIdentifier(0x8003), QualifiedChannelDiagnosisData* [a] The field ChannelProperties.Type, the field ChannelProperties.Direction, the field ChannelProperties.Maintenance shall be set to zero. The field ChannelProperties.Specifier shall be set to appear if at least one ChannelProperties.Specifier in the QualifiedChannelDiagnosisData is set to appear in conjunction with ChannelProperties.Maintenance(=diagnosis). Else, the field ChannelProperties.Specifier shall be set to disappear.
QualifiedChannel-DiagnosisData	ChannelNumber, ChannelProperties, ChannelErrorType, ExtChannelErrorType, ExtChannelAddValue, QualifiedChannelQualifier
ExpectedIdentification-Data with BlockVersionLow = 0 Legacy	BlockHeader, NumberOfSlots, (SlotNumber, ModuleIdentNumber, NumberOfSubslots, (SubslotNumber, SubmoduleIdentNumber)*)*
ExpectedIdentification-Data with BlockVersionLow =1	BlockHeader, NumberOfAPIs, (API, NumberOfSlots, (SlotNumber, ModuleIdentNumber, NumberOfSubslots, (SubslotNumber, SubmoduleIdentNumber)*)*)*
RealIdentificationData with BlockVersionLow = 0	BlockHeader, NumberOfSlots, (SlotNumber, ModuleIdentNumber, NumberOfSubslots, (SubslotNumber, SubmoduleIdentNumber)*)*
RealIdentificationData with BlockVersionLow = 1	BlockHeader, NumberOfAPIs, (API, NumberOfSlots, (SlotNumber, ModuleIdentNumber, NumberOfSubslots, (SubslotNumber, SubmoduleIdentNumber)*)*)*
PDIRData with BlockVersionLow = 1	BlockHeader, Padding, Padding, SlotNumber, SubslotNumber, PDIRGlobalData, PDIRFrameData [a] [b], PDIRBeginEndData [a] This block may contain information about receiving, transmitting and forwarding, or receiving and transmitting only. [b] If this block exists, the DFP frames shall be integrated.
PDSyncData with BlockVersionLow = 2	BlockHeader, Padding, Padding, PTCP_SubdomainUUID, ReservedIntervalBegin, ReservedIntervalEnd, PLLWindow, SyncSendFactor, SendClockFactor, PTCPTimeoutFactor, PTCPTakeoverTimeoutFactor, PTCPMasterStartupTime, SyncProperties, PTCP_MasterPriority1, PTCP_MasterPriority2, PTCPLengthSubdomainName, PTCPSubdomainName, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PDTimeData	BlockHeader, TimeMasterPriority1, TimeMasterPriority2, TimePLLWindow, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PdevData	BlockHeader, Padding, Padding, [PDIRData], [PDSyncData], [PDIRSubframeData], [PDTimeData]
PDRealData	MultipleBlockHeader, { [PDPortDataReal] [b], [PDInterfaceMrpDataReal], [PDPortMrpDataReal], [PDPortFODataReal] [a], [PDInterfaceDataReal], [PDPortStatistic] } [c] [a] There shall be no FiberOpticManufacturerSpecific information [b] The fields SlotNumber and SubslotNumber shall be ignored [c] Each submodule's data (e.g. interface or port) need its own MultipleBlockHeader

Substitution name	Structure
PDExpectedData	MultipleBlockHeader, { [PDPortDataCheck] [a], [PDPortDataAdjust] [a], [PDInterfaceMrpDataAdjust], [PDInterfaceMrpDataCheck], [PDPortMrpDataAdjust], [PDPortFODataAdjust], [PDPortFODataCheck], [PDNCDataCheck], [PDInterface-FSUDataAdjust], [PDInterfaceAdjust] } [b] [a] The fields SlotNumber and SubslotNumber shall be ignored [b] Each submodule's data (e.g. interface or port) need its own MultipleBlockHeader
PDPortDataReal	BlockHeader, Padding, Padding, SlotNumber, SubslotNumber, LengthOwnPortName, OwnPortName, NumberOfPeers, [Padding*] [a], [LengthPeerPortName, PeerPortName, LengthPeerStationName, PeerStationName, [Padding*] [a], LineDelay, PeerMACAddress [b], [Padding*] [a]]*, MAUType [c], [Padding*] [a], Reserved [d], RTClass3_PortStatus, MulticastBoundary, LinkState, [Padding*] [a], MediaType [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. b This field contains the interface MAC address of the peer [c] See Table 552 [d] The number of reserved octets shall be 2.
PDInterfaceDataReal	BlockHeader, LengthOwnStationName, OwnStationName, [Padding*] [a], MACAddressValue [b], [Padding*] [a], IPParameterValue, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. [b] This field contains the interface MAC address
TxPortGroup	NumberOfTxPortGroups, TxPortGroupArray
SubstituteValue	BlockHeader, SubstitutionMode, SubstituteDataItem
RecordInputData-ObjectElement	BlockHeader, LengthIOCS, IOCS, LengthIOPS, IOPS, LengthData, Data Special case: Response for an output submodule PNIOStatus(=0xDE, 0x80, 0xB0, 0x00)
RecordOutputData-ObjectElement	BlockHeader [c], SubstituteActiveFlag, LengthIOCS, LengthIOPS, LengthData, DataItem [a], SubstituteValue [b] Special case: Response for an input submodule PNIOStatus(=0xDE, 0x80, 0xB0, 0x00) [a] For this record DataItem shall be coded as IOCS, Data, IOPS [b] The IOPS of the SubstituteDataItem inherited by the SubstituteValue contains the valid information [c] The BlockLength shall include the SubstituteValue

Substitution name	Structure
ARData with BlockVersionLow = 0 Legacy May only be used with StartupMode:=0	BlockHeader, NumberOfARs, (ARUUID, ARType, ARProperties, CMInitiatorObjectUUID, StationNameLength, CMInitiatorStationName, NumberOfIOCRs, (IOCRType, IOCRProperties, FrameID, APDU_Status [a], InitiatorUDPRTPort, ResponderUDPRTPort)*, AlarmCRType, LocalAlarmReference, RemoteAlarmReference, ParameterServerObjectUUID [b], StationNameLength [c], [ParameterServerStationName], NumberOfAPIs, API*)* Special case: “IOSAR with ARProperties.DeviceAccess=1”: NumberOfIOCRs := 0 AlarmCRType := 0 NumberOfAPIs := 0 [a] The APDU_Status.CycleCounter and APDU_Status.TransferStatus can be zero [b] The ParameterServerObjectUUID shall be NIL if not used [c] The StationNameLength shall be 0 if not used. In this case the field ParameterServerStationName shall be omitted
ARData with BlockVersionLow = 1	BlockHeader, NumberOfARs, (ARUUID, CMInitiatorObjectUUID, ParameterServerObjectUUID [b], ARProperties, ARType, AlarmCRType, LocalAlarmReference, RemoteAlarmReference, InitiatorUDPRTPort, ResponderUDPRTPort, StationNameLength, CMInitiatorStationName, [Padding*] [d], StationNameLength [c], [ParameterServerStationName], [Padding*] [d], NumberOfIOCRs, [Padding*] [d], (IOCRProperties, IOCRType, FrameID, APDU_Status [a])*, NumberOfAPIs, [Padding*] [d], API*, ARDataInfo)* Special case: “IOSAR with ARProperties.DeviceAccess=1”: NumberOfIOCRs := 0 AlarmCRType := 0 NumberOfAPIs := 0 [a] The APDU_Status.CycleCounter and APDU_Status.TransferStatus can be zero [b] The ParameterServerObjectUUID shall be NIL if not used [c] The StationNameLength shall be 0 if not used. In this case the field ParameterServer-StationName shall be omitted [d] The number of padding octets shall be adapted to make the following field Unsigned32 aligned.
ARDataInfo	NumberOfEntries, [Padding*] [a], { [IRInfoBlock], [SRInfoBlock], [ARVendorBlockReq *], [ARVendorBlockRes *], [ARFSUBlock], [SRLData] [b] } [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. [b] The SRLData block shall be used if a redundant network access point exists.
SRLData	BlockHeader, RedundancyInfo, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
APIData	BlockHeader, NumberOfAPIs, API*
LogBookData	BlockHeader, ActualLocalTimeStamp, NumberOfLogEntries, (LocalTimeStamp, ARUUID, PNIOStatus, EntryDetail)*
CMInitiatorObjectUUID	PROFINETIOConstantValue, InstanceHigh, InstanceLow, DeviceIdentNumber
ParameterServer-ObjectUUID	PROFINETIOConstantValue, InstanceHigh, InstanceLow, DeviceIdentNumber
DeviceIdentNumber	DeviceIDHigh, DeviceIDLow, VendorIDHigh, VendorIDLow
IMDataWrite	[I&M1] ^ [I&M2] ^ [I&M3] ^ [I&M4]
IMData	I&M0 ^ [I&M1] ^ [I&M2] ^ [I&M3] ^ [I&M4]

Substitution name	Structure
I&M0	BlockHeader, VendorIDHigh, VendorIDLow, OrderID, IM_Serial_Number, IM_Hardware_Revision, IM_Software_Revision, IM_Revision_Counter, IM_Profile_ID, IM_Profile_Specific_Type, IM_Version, IM_Supported
I&M1	BlockHeader, IM_Tag_Function, IM_Tag_Location
I&M2	BlockHeader, IM_Date
I&M3	BlockHeader, IM_Descriptor
I&M4	BlockHeader, IM_Signature
I&M0FilterData	{I&M0FilterDataSubmodule [a], [I&M0FilterDataModule] [b], I&M0FilterDataDevice [c]} [a] Shall contain all submodules with discrete IMData [b] Shall, if exists, contain only the module reference [c] Shall contain the device reference (e.g. the interface submodule) which shall support writing of I&M1, I&M2, I&M3, and I&M4
I&M0FilterDataInfo	NumberOfAPIs, (API, NumberOfModules, (SlotNumber, ModuleIdentNumber, NumberOfSubmodules, (SubslotNumber, SubmoduleIdentNumber)*)*)*
I&M0FilterData-Submodule	BlockHeader, I&M0FilterDataInfo
I&M0FilterDataModule	BlockHeader, I&M0FilterDataInfo
I&M0FilterDataDevice	BlockHeader, I&M0FilterDataInfo
IM_Version	IM_Version_Major, IM_Version_Minor
IM_Software_Revision	SWRevisionPrefix, IM_SWRevision_Functional_Enhancement, IM_SWRevision_Bug_Fix, IM_SWRevision_Internal_Change
MultipleBlockHeader	BlockHeader, Padding, Padding, API, SlotNumber, SubslotNumber
PDIRGlobalData with BlockVersionLow = 1	BlockHeader, Padding, Padding, IRDataUUID, MaxBridgeDelay, NumberOfPorts, (MaxPortTxDelay, MaxPortRxDelay)*
PDIRGlobalData with BlockVersionLow = 2	BlockHeader, Padding, Padding, IRDataUUID, MaxBridgeDelay, NumberOfPorts, (MaxPortTxDelay, MaxPortRxDelay, MaxLineRxDelay, YellowTime)*
PDIRBeginEndData	BlockHeader, Padding, Padding, RedGuard, NumberOfPorts, (NumberOfAssignments, (TXBeginEndAssignment, RXBeginEndAssignment)*, NumberOfPhases, (TXPhaseAssignment, RXPhaseAssignment)*)*
RedGuard	StartOfRedFrameID, EndOfRedFrameID
TXBeginEndAssignment	RedOrangePeriodBegin, OrangePeriodBegin [a], GreenPeriodBegin [a] Shall be set to GreenPeriodBegin
RXBeginEndAssignment	RedOrangePeriodBegin, OrangePeriodBegin [a], GreenPeriodBegin [b] [a] Shall be set to GreenPeriodBegin [b] GreenPeriodBegin shall be set to the end of the red period.
TXPhaseAssignment	PhaseAssignment
RXPhaseAssignment	PhaseAssignment
PDIRFrameData with BlockVersionLow = 0	BlockHeader, Padding, Padding, (FrameSendOffset, DataLength, ReductionRatio, Phase, FrameID, EtherType, RxPort, FrameDetails, TxPortGroup, [Padding*] [a])* [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.

Substitution name	Structure
PDIRFrameData with BlockVersionLow = 1	BlockHeader, Padding, Padding, FrameDataProperties, [(FrameSendOffset, DataLength, ReductionRatio, Phase, FrameID [a] [b] [c], EtherType, RxPort, FrameDetails, TxPortGroup, [Padding*] [d])*] [a] This block shall contain all FrameIDs which are locally received (node is sink) or locally injected (node is source) into the network. It may contain the FrameIDs which are only forwarded by the node. [b] With DFP: This block shall contain two entries for the same FrameID if this node contains a DFP_INBOUND or a DFP_OUTBOUND state machine which is a receiver of this frame. One entry contain the receive path and one the transmit path. If the transmit path doesn't exist (outbound frame is fully consumed by this node) the corresponding entry shall be skipped. [c] With MRPD: A consumer shall exist two times (FrameID and FrameID+1) and a provider shall exist two times (FrameID and FrameID+1) in case of IOCR and may exist more than two times in case of MCR. [d] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
IsochronousModeData	BlockHeader, Padding, Padding, SlotNumber, SubslotNumber, ControllerApplicationCycleFactor, TimeDataCycle, TimeIOInput, TimeIOOutput, TimeIOInputValid, TimeIOOutputValid
PDPortDataAdjust	BlockHeader, Padding, Padding, SlotNumber, SubslotNumber, { [AdjustDomainBoundary], [AdjustMulticastBoundary], [AdjustMAUType ^ AdjustLinkState], [AdjustPeerToPeerBoundary], [AdjustDCPBoundary], [AdjustPreambleLength] }
PDPortDataCheck	BlockHeader, Padding, Padding, SlotNumber, SubslotNumber, { [CheckPeers], [CheckLineDelay], [CheckMAUType], [CheckLinkState], [CheckSyncDifference], [CheckMAUTypeDifference] }
AdjustDomainBoundary with BlockVersionLow = 1	BlockHeader, Padding, Padding, DomainBoundaryIngress, DomainBoundaryEgress, AdjustProperties, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
AdjustMulticast-Boundary	BlockHeader, Padding, Padding, MulticastBoundary, AdjustProperties, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
AdjustMAUType	BlockHeader, Padding, Padding, MAUType, AdjustProperties
AdjustLinkState	BlockHeader, Padding, Padding, LinkState, AdjustProperties
AdjustPeerToPeer-Boundary	BlockHeader, Padding, Padding, PeerToPeerBoundary, AdjustProperties, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
AdjustDCPBoundary	BlockHeader, Padding, Padding, DCPBoundary, AdjustProperties, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
AdjustPreambleLength	BlockHeader, Padding, Padding, PreambleLength, AdjustProperties, [Padding*] a a The number of padding octets shall be adapted to make the block Unsigned32 aligned.
CheckPeers	BlockHeader, NumberOfPeers, (LengthPeerPortName, PeerPortName, LengthPeerStationName, PeerStationName)*, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
CheckLineDelay	BlockHeader, Padding, Padding, LineDelay
CheckMAUType	BlockHeader, MAUType
CheckLinkState	BlockHeader, LinkState
CheckSyncDifference	BlockHeader, CheckSyncMode

Substitution name	Structure
CheckMAUType-Difference	BlockHeader, MAUTypeMode
PDInterfaceAdjust	BlockHeader, Padding, Padding, MultipleInterfaceMode, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PDInterface-MrpDataAdjust	BlockHeader, Padding, Padding, MRP_DomainUUID, MRP_Role, [Padding*] [a], MRP_LengthDomainName, MRP_DomainName, [Padding*] [a], { [(MrpManagerParams) ^ (MrpClientParams)] } [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PDInterface-MrpDataReal with BlockVersionLow = 0	BlockHeader, Padding, Padding, MRP_DomainUUID, MRP_Role, MRP_LengthDomainName, MRP_DomainName, [Padding*] [a], MRP_Version, { [(MrpManagerParams) ^ (MrpClientParams)], [MrpRingStateData] }, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PDInterface-MrpDataReal with BlockVersionLow = 1	BlockHeader, Padding, Padding, MRP_DomainUUID, MRP_Role, MRP_Version, MRP_LengthDomainName, MRP_DomainName, [Padding*] [a], { [(MrpManagerParams) ^ (MrpClientParams)], [MrpRingStateData] }, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PDInterface-MrpDataCheck	BlockHeader, Padding, Padding, MRP_DomainUUID, MRP_Check
PDPortMrpDataAdjust	BlockHeader, Padding, Padding, MRP_DomainUUID
PDPortMrpDataReal	BlockHeader, Padding, Padding, MRP_DomainUUID
MrpManagerParams	BlockHeader, MRP_Prio, MRP_TOPchgT, MRP_TOPNRmax, MRP_TSTshortT, MRP_TSTdefaultT, MRP_TSTNRmax, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
MrpClientParams	BlockHeader, MRP_LNKdownT, MRP_LNKupT, MRP_LNKNRmax
MrpRingStateData	BlockHeader, MRP_RingState
PDPortFODataReal	BlockHeader, Padding, Padding, FiberOpticType, FiberOpticCableType, [FiberOpticManufacturerSpecific*] [a], [FiberOpticDiagnosisInfo] [a] Only used by legacy nodes.
FiberOpticManufacturer Specific	BlockHeader, VendorIDHigh, VendorIDLow, VendorBlockType, Data*, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
FiberOpticDiagnosisInfo	BlockHeader, Padding, Padding, FiberOpticPowerBudgetReal, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
FiberOpticPowerBudget Real	FiberOpticPowerBudgetType [a] [a] FiberOpticPowerBudgetType.CheckEnable shall be set to zero. It has no meaning in this usage.
PDPortFODataAdjust	BlockHeader, Padding, Padding, FiberOpticType, FiberOpticCableType
PDPortFODataCheck	BlockHeader, Padding, Padding, MaintenanceRequiredPowerBudget, MaintenanceDemandedPowerBudget, ErrorPowerBudget
MaintenanceRequired-PowerBudget	FiberOpticPowerBudgetType

Substitution name	Structure
MaintenanceDemanded-PowerBudget	FiberOpticPowerBudgetType
ErrorPowerBudget	FiberOpticPowerBudgetType
PDNCDataCheck	BlockHeader, Padding, Padding, MaintenanceRequiredDropBudget, MaintenanceDemandedDropBudget, ErrorDropBudget
MaintenanceRequired-DropBudget	NCDropBudgetType
MaintenanceDemanded-DropBudget	NCDropBudgetType
ErrorDropBudget	NCDropBudgetType
PDPortStatistic	BlockHeader, Padding, Padding, ifInOctets, ifOutOctets, ifInDiscards, ifOutDiscards, ifInErrors, ifOutErrors, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
PDInterface-FSUDataAdjust	BlockHeader, [Padding*] [a], { [FSHelloBlock], [FastStartUpBlock] } [b] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. [b] At least one optional block shall be existing.
ARFSUDataAdjust	BlockHeader, [Padding*] [a], { [FSParameterBlock], [FastStartUpBlock] } [b] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. [b] At least one optional block shall be existing.
FSHelloBlock	BlockHeader, [Padding*] [a], FSHelloMode, FSHelloInterval, FSHelloRetry, FSHelloDelay, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
FSParameterBlock	BlockHeader, [Padding*] [a], FSParameterMode, FSParameterUUID, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
FastStartUpBlock	BlockHeader, [Padding*] [a], Data*, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
AutoConfiguration	BlockHeader, [Padding*] [a], ACCommunication, ACConfiguration, [ACIsochronous], [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
ACCommunication	BlockHeader, [Padding*] [a], ACMinDeviceInterval, ACCommunicationProperties, SendClockFactorArray, [Padding*] [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
SubmoduleInputData-Length	SubmoduleDataLength
SubmoduleOutputData-Length	SubmoduleDataLength
ACConfiguration	BlockHeader, [Padding*] [a], (API, SlotNumber, SubslotNumber, ModuleIdentNumber, SubmoduleIdentNumber, SubmoduleInputDataLength, SubmoduleOutputDataLength)* [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.

Substitution name	Structure
ACIsochronous	BlockHeader, [Padding*] [a], (API, SlotNumber, SubslotNumber, TimeIOBase [b], TimeIOInput [c], TimeIOOutput [d])* [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned. [b] Minimum value according to the GSDML keyword T_IO_Base [c] Minimum value according to the GSDML keyword T_IO_InputMin [d] Minimum value according to the GSDML keyword T_IO_OutputMin
CombinedObject-Container	{ COContainerContent* }
COContainerContent	BlockHeader, Padding, Padding, API, Slot, Subslot, Padding, Padding, Index, COContainerBlock, [Padding]* [a] [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.
COContainerBlock	Data* Special case “PhysicalDevice” (combined object access point is the interface submodule): [PDPortDataAdjust] ^ [PDPortDataCheck] ^ [PDIRData] ^ [PDSyncData] ^ [PDInterfaceMrpDataAdjust] ^ [PDInterfaceMrpDataCheck] ^ [PDPortMrpDataAdjust] ^ [PDPortFODataAdjust] ^ [PDPortFODataCheck] ^ [PDNCDataCheck] ^ [PDInterfaceFSUDataAdjust] ^ [PDIRSubframeData] ^ [PDInterfaceAdjust] ^ [PDTimeData]
UploadBLOBQuery	BlockHeader, Padding, Padding, FromOffsetData
UploadBLOB	BlockHeader, Padding, Padding, FromOffsetData, NextOffsetData, TotalSize, Data*
NestedDiagnosisInfo	BlockHeader, NumberOfEntries, (IPaddress, StationNameLength, NameOfStationValue, [Padding]* [a])* [a] The number of padding octets shall be adapted to make the block Unsigned32 aligned.

5.2 Transfer syntax

5.2.1 Coding section related to BlockHeader specific fields

5.2.1.1 Coding of the field BlockType

This field shall be coded as data type Unsigned16 with the values according to Table 358. This field identifies the PDU or data block type.

Table 358 – BlockType

Value (hexadecimal)	Used for	Used by
0x0000	Reserved	—
0x0001	AlarmNotification High	RTA-SDU.AlarmNotification-PDU
0x0002	AlarmNotification Low	RTA-SDU.AlarmNotification-PDU
0x0003 – 0x0007	Reserved	—
0x0008	IODWriteReqHeader	PROFINETIO-ServiceReqPDU.IODWriteReq
0x0009	IODReadReqHeader	PROFINETIO-ServiceReqPDU.IODReadReq
0x000A – 0x000F	Reserved	—
0x0010	DiagnosisData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.DiagnosisData RTA-SDU.AlarmNotification-PDU.AlarmPayload.DiagnosisItem.DiagnosisData
0x0011	Reserved	—

Value (hexadecimal)	Used for	Used by
0x0012	ExpectedIdentificationData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.ExpectedIdentificationData
0x0013	RealIdentificationData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.RealIdentificationData
0x0014	SubstituteValue	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.SubstituteValue PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.SubstituteValue
0x0015	RecordInputDataObjectElement	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.RecordInputDataObjectElement
0x0016	RecordOutputDataObjectElement	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.RecordOutputDataObjectElement
0x0017	Reserved	—
0x0018	ARData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.ARData
0x0019	LogBookData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.LogBookData
0x001A	APIData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.APIData
0x001B	SRLData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.ARDataInfo.SRLData
0x001C – 0x001F	Reserved	—
0x0020	I&M0	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.IMData.I&M0
0x0021	I&M1	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.IMData.I&M1 PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.IMDataWrite.I&M1
0x0022	I&M2	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.IMData.I&M2 PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.IMDataWrite.I&M2
0x0023	I&M3	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.IMData.I&M3 PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.IMDataWrite.I&M3

Value (hexadecimal)	Used for	Used by
0x0024	I&M4	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.IMData.I&M4 PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.IMDataWrite.I&M4
0x0025 – 0x002F	I&M5 – 15 [a] [a] Reserved for additional identification and maintenance data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite
0x0030	I&M0FilterDataSubmodule	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.I&M0FilterData.I&M0FilterDataSubmodule
0x0031	I&M0FilterDataModule	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.I&M0FilterData.I&M0FilterDataModule
0x0032	I&M0FilterDataDevice	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.I&M0FilterData.I&M0FilterDataDevice
0x0033 – 0x0100	Reserved	—
0x0101	ARBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.ARBlockReq
0x0102	IOCRBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.IOCRBlockReq
0x0103	AlarmCRBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.AlarmCRBlockReq
0x0104	ExpectedSubmoduleBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.ExpectedSubmoduleBlockReq
0x0105	PrmServerBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.PrmServerBlockReq
0x0106	MCRBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.MCRBlockReq
0x0107	ARRPCBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.ARRPCBlockReq
0x0108	ARVendorBlockReq	PROFINETIO-ServiceReqPDU.IODConnectReq.ARVendorBlockReq
0x0109	IRInfoBlock	PROFINETIO-ServiceReqPDU.IODConnectReq.IRInfoBlock
0x010A	SRInfoBlock	PROFINETIO-ServiceReqPDU.IODConnectReq.SRInfoBlock
0x010B	ARFSUBlock	PROFINETIO-ServiceReqPDU.IODConnectReq.ARFSUBlock
0x010C – 0x010F	Reserved	—
0x0110	IODBlockReq, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceReqPDU.IODControlReq.ControlBlockConnect (PrmEnd.req)
0x0111	IODBlockReq, shall only be used in conjunction with a plug alarm event	PROFINETIO-ServiceReqPDU.IODControlReq.ControlBlockPlug (PrmEnd.req)
0x0112	IOXBlockReq, shall be used in conjunction within the connection establishment phase or a PrmBegin/PrmEnd sequence	PROFINETIO-ServiceReqPDU.IOXControlReq.ControlBlockConnect (ApplicationReady.req)

Value (hexadecimal)	Used for	Used by
0x0113	IOXBlockReq, shall only be used in conjunction with a plug alarm event	PROFINETIO-ServiceReqPDU.IOXControlReq.ControlBlockPlug (ApplicationReady.req)
0x0114	ReleaseBlockReq	PROFINETIO-ServiceReqPDU.IODReleaseReq.ReleaseBlock
0x0115	Reserved	—
0x0116	IOXBlockReq, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceReqPDU.IOXControlReq.ControlBlockConnect (ReadyForCompanion.req)
0x0117	IOXBlockReq, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceReqPDU.IOXControlReq.ControlBlockConnect (ReadyForRT_CLASS_3.req)
0x0118	IODBlockReq	PROFINETIO-ServiceReqPDU.IODControlReq.ControlBlockConnect (PrmBegin.req)
0x0119	SubmoduleListBlock	PROFINETIO-ServiceReqPDU.IODControlReq.SubmoduleListBlock (PrmBegin.req)
0x0118 – 0x01FF	Reserved	—
0x0200	PDPortDataCheck	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataCheck
0x0201	PdevData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PdevData
0x0202	PDPortDataAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust
0x0203	PDSyncData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDSyncData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDSyncData
0x0204	IsochronousModeData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.IsochronousModeData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.IsochronousModeData
0x0205	PDIRData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDIRData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDIRData

Value (hexadecimal)	Used for	Used by
0x0206	PDIRGlobalData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDIRGlobalData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDIRGlobalData
0x0207	PDIRFrameData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDIRFrameData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDIRFrameData
0x0208	PDIRBeginEndData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDIRBeginEndData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDIRBeginEndData
0x0209	AdjustDomainBoundary Sub block for adjusting DomainBoundary	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustDomainBoundary PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust. AdjustDomainBoundary
0x020A	Sub block for checking Peers	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck.CheckPeers PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.CheckPeers
0x020B	Sub block for checking LineDelay	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck.CheckLineDelay PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataCheck.CheckLineDelay
0x020C	Sub block for checking MAUType	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck.CheckMAUType PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataCheck.CheckMAUType
0x020E	AdjustMAUType Sub block for adjusting MAUType	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustMAUType PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.AdjustMAUType
0x020F	PDPortDataReal	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataReal PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDPortDataReal

Value (hexadecimal)	Used for	Used by
0x0210	AdjustMulticastBoundary Sub block for adjusting MulticastBoundary	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustMulticastBoundary PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.AdjustMulticastBoundary
0x0211	PDInterfaceMrpDataAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceMrpDataAdjust
0x0212	PDInterfaceMrpDataReal	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataReal PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDInterfaceMrpDataReal
0x0213	PDInterfaceMrpDataCheck	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataCheck PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceMrpDataCheck PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDInterfaceMrpDataCheck
0x0214	PDPortMrpDataAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortMrpDataAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortMrpDataAdjust PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDPortMrpDataAdjust
0x0215	PDPortMrpDataReal	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortMrpDataReal PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDPortMrpDataReal
0x0216	MrpManagerParams Sub block for media redundancy manager parameters	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataAdjust.MrpManagerParams PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceMrpDataAdjust.MrpManagerParams PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataReal.MrpManagerParams

Value (hexadecimal)	Used for	Used by
0x0217	MrpClientParams Sub block for media redundancy client parameters	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataAdjust.MrpClientParams PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceMrpDataAdjust.MrpClientParams PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataReal.MrpClientParams
0x0219	MrpRingStateData Sub block for media redundancy ring state data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceMrpDataReal.MrpRingStateData
0x021B	AdjustLinkState Sub block for adjusting LinkState	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustLinkState PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.AdjustLinkState
0x021C	CheckLinkState Sub block for checking LinkState	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck.CheckLinkState PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.CheckLinkState
0x021E	CheckSyncDifference Sub block for checking local and remote CableDelay detected by LLDP to discover a sync difference	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck.CheckSyncDifference PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataCheck.CheckSyncDifference
0x021F	CheckMAUTypeDifference Sub block for checking local and remote MAUTypes detected by LLDP	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataCheck.CheckMAUTypeDifference PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataCheck.CheckMAUTypeDifference
0x0220	PDPortFODataReal	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortFODataReal PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDPortFODataReal
0x0221	FiberOpticManufacturerSpecific Sub block for reading real fiber optic manufacturerspecific data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortFODataReal.FiberOpticManufacturerSpecific PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDPortFODataReal.FiberOpticManufacturerSpecific
0x0222	PDPortFODataAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortFODataAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortFODataAdjust PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDPortFODataAdjust

Value (hexadecimal)	Used for	Used by
0x0223	PDPortFODataCheck	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortFODataCheck PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortFODataCheck PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDPortFODataCheck
0x0224	AdjustPeerToPeerBoundary Sub block for adjusting the peer to peer boundary	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustPeerToPeerBoundary PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.AdjustPeerToPeerBoundary
0x0225	AdjustDCPBoundary Sub block for adjusting the DCP boundary	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustDCPBoundary PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.AdjustDCPBoundary
0x0226	AdjustPreambleLength Sub block for adjusting the used length of preamble	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortDataAdjust.AdjustPreambleLength PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDPortDataAdjust.AdjustPreambleLength
0x0227	Reserved	—
0x0228	FiberOpticDiagnosisInfo Sub block for reading real fiber optic diagnosis data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortFODataReal.FiberOpticDiagnosisInfo PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.FiberOpticDiagnosisInfo
0x0229	Reserved	—
0x022A	PDIRSubframeData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDIRSubframeData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDIRSubframeData PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PdevData.PDIRSubframeData
0x022B	SubframeBlock Sub block for the persistent portion of DFP	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDIRSubframeData.SubframeBlock PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDIRSubframeData.SubframeBlock PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PdevData.PDIRSubframeData.SubframeBlock
0x022C	Reserved	—

Value (hexadecimal)	Used for	Used by
0x022D	PDTimeData	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.COContainerContent.COContainerBlock.PDTimeData PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.COContainerContent.COContainerBlock.PDTimeData
0x022E – 0x22F	Reserved	—
0x0230	PDNCDataCheck	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDNCDataCheck PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDNCDataCheck PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDNCDataCheck
0x0231 – 0x23F	Reserved	—
0x0240	PDInterfaceDataReal	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceDataReal PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDInterfaceDataReal
0x0241 – 0x024F	Reserved	—
0x0250	PDInterfaceAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceAdjust PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDInterfaceDataAdjust
0x0251	PDPortStatistic	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDPortStatistic PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.PDPortStatistic
0x0252 – 0x03FF	Reserved	—
0x0400	MultipleBlockHeader	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDRealData.MultipleBlockHeader PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData. MultipleBlockHeader
0x0401	COContainerContent	PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.CombinedObjectContainer.COContainerContent
0x0402 – 0x04FF	Reserved	—
0x0500	RecordDataReadQuery	PROFINETIO-ServiceResPDU.IODReadReq.RecordDataReadQuery
0x0501 – 0x05FF	Reserved	—

Value (hexadecimal)	Used for	Used by
0x0600	FSHelloBlock	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceFSUDataAdjust.FSHelloBlock PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceFSUDataAdjust.FSHelloBlock PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDInterfaceFSUDataAdjust.FSHelloBlock
0x0601	FSParameterBlock	PROFINETIO-ServiceReqPDU.IODConnectReq.IOCRBlockReq.ARFSUBlock.ARFSUDataAdjust.FSParameterBlock
0x0602 – 0x607	Reserved for FastStartUp	—
0x0608	PDInterfaceFSUDataAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDInterfaceFSUDataAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.PDInterfaceFSUDataAdjust PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.PDExpectedData.PDInterfaceFSUDataAdjust
0x0609	ARFSUDataAdjust	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.ARFSUDataAdjust PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite.ARFSUDataAdjust PROFINETIO-ServiceReqPDU.IODConnectReq.ARFSUBlock.ARFSUDataAdjust
0x060A – 0x60F	Reserved for FastStartUp	—
0x0610 – 0x06FF	Reserved	—
0x0700	AutoConfiguration Auto configuration data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.AutoConfiguration
0x0701	AutoConfiguration Auto configuration communication data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.AutoConfiguration.ACCommunication
0x0702	AutoConfiguration Auto configuration configuration data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.AutoConfiguration.ACConfiguration
0x0703	AutoConfiguration Auto configuration isochronous data	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.AutoConfiguration.ACIsochronous
0x0704 – 0x07FF	Reserved	—
0x0800	Reserved for profiles covering energy saving BlockType for request service	PROFINETIO-ServiceReqPDU.IODWriteReq.RecordDataWrite
0x0801	Reserved for profiles covering energy saving BlockType for response service	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead
0x0800 – 0x08FF	Reserved for profiles covering energy saving	—

Value (hexadecimal)	Used for	Used by
0x0900 – 0x09FF	Reserved for profiles covering sequence of events	—
0x0A00	Controller to controller communication Upload BLOB Query	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.UploadBLOBQuery
0x0A01	Controller to controller communication Upload BLOB	PROFINETIO-ServiceResPDU.IODReadRes.RecordDataRead.UploadBLOB
0x0A02	Controller to controller communication Nested diagnosis info	PROFINETIO-ServiceReqPDU.IODReadReq.RecordDataRead.NestedDiagnosisInfo
0x0A03 – 0x0AFF	Reserved for profiles covering controller to controller communication	—
0x0B00 – 0x0EFF	Reserved	—
0x0F00	MaintenanceItem	RTA-SDU.Alarmnotification-PDU.AlarmPayload.MaintenanceItem
0x0F01	Upload selected records within Upload&RetrievalItem	RTA-SDU.Alarmnotification-PDU.AlarmPayload.Upload&RetrievalItem
0x0F02	iParameterItem	RTA-SDU.Alarmnotification-PDU.AlarmPayload.iParameterItem
0x0F03	Retrieve selected records within Upload&RetrievalItem	RTA-SDU.Alarmnotification-PDU.AlarmPayload.Upload&RetrievalItem
0x0F04	Retrieve all stored records within Upload&RetrievalItem	RTA-SDU.Alarmnotification-PDU.AlarmPayload.Upload&RetrievalItem
0x0F05 – 0x6FFF	Reserved	—
0x7000 – 0x7FFF	Reserved for user specific data objects	—
0x8000	Reserved	—
0x8001	Alarm Ack High	RTA-SDU.AlarmAck-PDU
0x8002	Alarm Ack Low	RTA-SDU.AlarmAck-PDU
0x8008	IODWriteResHeader	PROFINETIO-ServiceResPDU.IODWriteRes
0x8009	IODReadResHeader	PROFINETIO-ServiceReqPDU.IODReadRes
0x800A – 0x8100	Reserved	—
0x8101	ARBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.ARBlockRes
0x8102	IOCRBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.IOCRBlockRes
0x8103	AlarmCRBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.AlarmCRBlockRes
0x8104	ModuleDiffBlock	PROFINETIO-ServiceResPDU.IODConnectRes.ModuleDiffBlock PROFINETIO-ServiceResPDU.IODWriteRes.RecordDataRead.ModuleDiffBlock PROFINETIO-ServiceReqPDU.IOXControlReq.ModuleDiffBlock
0x8105	PrmServerBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.PrmServerBlockRes
0x8106	ARServerBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.ARServerBlockRes
0x8107	ARRPCBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.ARRPCBlockRes

Value (hexadecimal)	Used for	Used by
0x8108	ARVendorBlockRes	PROFINETIO-ServiceResPDU.IODConnectRes.ARVendorBlockRes
0x8109 – 0x810F	Reserved	—
0x8110	IODBlockRes, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceResPDU.IODControlRes.ControlBlockConnect (Prm End.rsp)
0x8111	IODBlockRes, shall only be used in conjunction with a plug alarm event	PROFINETIO-ServiceResPDU.IODControlRes.ControlBlockPlug (Prm End.rsp)
0x8112	IOXBlockRes, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceResPDU.IOXControlRes.ControlBlockConnect (Application Ready.rsp)
0x8113	IOXBlockRes, shall only be used in conjunction with a plug alarm event	PROFINETIO-ServiceResPDU.IOXControlRes.ControlBlockPlug (Application Ready.rsp)
0x8114	ReleaseBlockRes	PROFINETIO-ServiceResPDU.IODReleaseRes.ReleaseBlock
0x8115	Reserved	—
0x8116	IOXBlockRes, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceResPDU.IOXControlRes.ControlBlockConnect (ReadyForCompanion.rsp)
0x8117	IOXBlockRes, shall only be used in conjunction with connection establishment phase	PROFINETIO-ServiceResPDU.IOXControlRes.ControlBlockConnect (ReadyForRT_CLASS_3.rsp)
0x8118	IODBlockRes	PROFINETIO-ServiceResPDU.IODControlRes.ControlBlockConnect (PrmBegin.rsp)
Other	Reserved	—

5.2.1.2 Coding of the field BlockLength

This field shall be coded as data type Unsigned16. This field shall contain the number of octets without counting the fields BlockType and BlockLength.

5.2.1.3 Coding of the field BlockVersionHigh

This field shall be coded as data type Unsigned8 with the values according to Table 359.

Table 359 – BlockVersionHigh

Value (hexadecimal)	Meaning	Use
0x00	Reserved	—
0x01	Version 1	Indicates Version 1
0x02 – 0xFF	Reserved	—

5.2.1.4 Coding of the field BlockVersionLow

This field shall be coded as data type Unsigned8 with the values according to Table 360.

Table 360 – BlockVersionLow

Value (hexadecimal)	Meaning	Use
0x00	Version 0	Indicates version 0
0x01	Version 1	Indicates version 1
0x02 – 0xFF	Version 2 to version 255	Indicates version 2 to 255

5.2.2 Coding section related to RTA-SDU specific fields

5.2.2.1 Coding of the field AlarmType

This field shall be coded as data type Unsigned16 with the values according to Table 361.

Table 361 – AlarmType

Value (hexadecimal)	Meaning	Attached to the Diagnosis ASE	USI structured AlarmPayload	AlarmPayload required	Alarm priority [e]
0x0000	Reserved	—	—	—	—
0x0001	Diagnosis	Yes	Yes	Yes [d]	Low
0x0002	Process	No	Yes	Optional	High
0x0003	Pull [a]	No	Yes	Optional	Low
0x0004	Plug	No	Yes	Optional	Low
0x0005	Status	No	Recommended	Optional	Low
0x0006	Update	No	Recommended	Optional	Low
0x0007	Media Redundancy	Yes	Yes	Yes [d]	Low
0x0008	Controlled by supervisor Logical “Pull” of a submodule to withdraw ownership	No	Yes	Optional	Low
0x0009	Released Logical “Plug” of a submodule to return ownership or trigger a reparameterization	No	Yes	Optional	Low
0x000A	Plug Wrong Submodule [c]	No	Yes	Optional	Low
0x000B	Return of Submodule [f]	No	Yes	Optional	Low
0x000C	Diagnosis disappears	Yes	Yes	Optional	Low
0x000D	Multicast communication mismatch notification	Yes	Yes	Yes [d]	Low
0x000E	Port data change notification	Yes	Yes	Yes [d]	Low
0x000F	Sync data changed notification	Yes	Yes	Yes [d]	Low
0x0010	Isochronous mode problem notification	Yes	Yes	Yes [d]	Low
0x0011	Network component problem notification	Yes	Yes	Yes [d]	Low
0x0012	Time data changed notification	Yes	Yes	Yes [d]	Low
0x0013	Dynamic Frame Packing problem notification	Yes	Yes	Yes [d]	Low
0x0014	MRPD problem notification	Yes	Yes	Yes [d]	Low
0x0015	System Redundancy notification	Yes	Yes	Yes [d]	Low

Value (hexadecimal)	Meaning	Attached to the Diagnosis ASE	USI structured AlarmPayload	AlarmPayload required	Alarm priority [e]
0x0016	Multiple interface mismatch notification	Yes	Yes	Yes [d]	Low
0x0017 – 0x001D	Reserved	—	—	—	—
0x001E	Upload and retrieval notification	No	Yes	Yes	Low
0x001F	Pull module [b]	No	Yes	Optional	Low
0x0020 – 0x007F	Manufacturer specific	No	Recommended	Optional	Low
0x0080 – 0x00FF	Reserved for profiles	No	YES	Optional	Low
0x0100 – 0xFFFF	Reserved	—	—	—	—

[a] With ARProperties.PullModuleAlarmAllowed(=0) subslot number 0x0001 – 0x8FFF used as “Pull submodule” and subslot number 0 used as “Pull module”.

[b] With ARProperties.PullModuleAlarmAllowed(=1) AlarmType(Pull) shall signal pulling of submodule and AlarmType(Pull module) shall signal pulling of module.

[c] Only an information for the application of the CMCTL.

[d] An AlarmPayload may not exist if a diagnosis disappears.

[e] Recommended assignment.

[f] Only this AlarmType is used for SharedInput submodules, too.

5.2.2.2 Coding of the field AlarmSpecifier

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 10: AlarmSpecifier.SequenceNumber
This field shall be coded according to Table 362. By means of the SequenceNumber the receiver detects duplications and reflects the value of the field in the AlarmAck.

Each alarm priority (HIGH or LOW) administrates its own SequenceNumber. It should start with zero and shall be incremented with every AlarmNotification. The Alarm receiver shall accept an arbitrary value as start value.

NOTE The SequenceNumber may start for each AR of an AR set with every switchover with an arbitrary value.

Whenever an Alarm is repeated over different ARs of an ARset the same SequenceNumber shall be used.

For the System Redundancy notification the SequenceNumber is without a meaning and shall be set to zero.

Table 362 – AlarmSpecifier.SequenceNumber

Value (hexadecimal)	Meaning
0x0000 – 0x07FF	Allowed value range

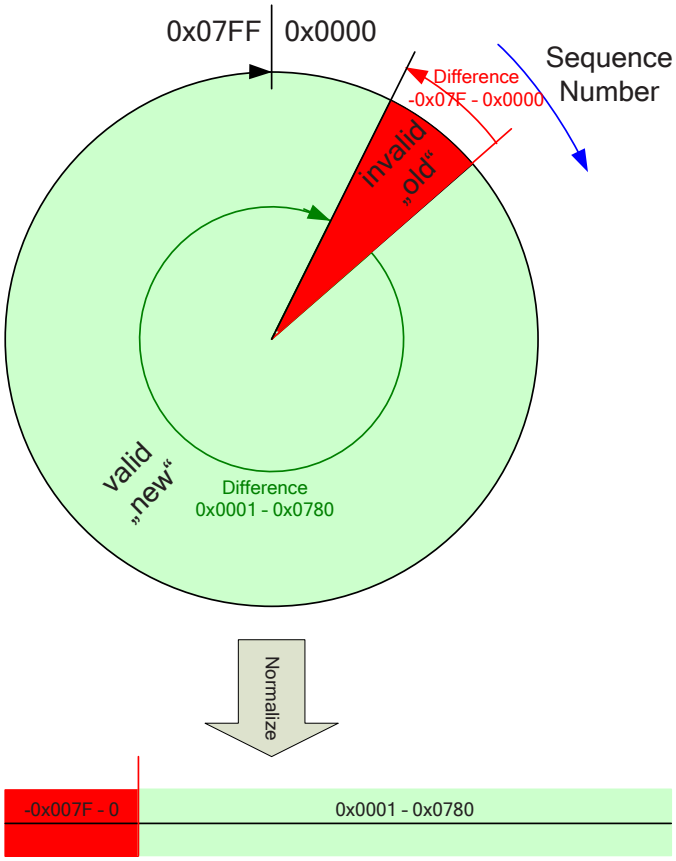


Figure 81 – AlarmSpecifier.SequenceNumber value range

Table 363 defines a maximum SequenceNumber window between an old and a new alarm.

Table 363 – AlarmSpecifier.SequenceNumber Difference

Value (hexadecimal)	Meaning	Use
-0x007F – 0x0000	Red sector according to Figure 81 1/16 of the SequenceNumber range The alarm sink votes the received alarm as older	Alarm is dropped
0x0001 – 0x0780	Green sector according to Figure 81 15/16 of the SequenceNumber range The alarm sink votes the received alarm as newer	Alarm is processed

Bit 11: AlarmSpecifier.ChannelDiagnosis
This field shall be coded with the values according to Table 364. For all other AlarmTypes this field shall be set to zero.

Table 364 – AlarmSpecifier.ChannelDiagnosis

Value (hexadecimal)	Meaning	Usage within AlarmType
0x00	Means that the Submodule (alarm source) contains no ChannelDiagnosis, ExtChannelDiagnosis or QualifiedChannelDiagnosis with Channel-Properties.Maintenance (=diagnosis) and Channel-Properties.Specifier (=appear)	All Diagnosis ASE attached AlarmTypes
0x01	Means that the Submodule (alarm source) contains at least one ChannelDiagnosis, ExtChannelDiagnosis or QualifiedChannelDiagnosis with Channel-Properties.Maintenance (=diagnosis) and Channel-Properties.Specifier (=appear)	

Bit 12: AlarmSpecifier.ManufacturerSpecificDiagnosis
This field shall be coded with the values according to Table 365. For all other AlarmTypes this field shall be set to zero.

Table 365 – AlarmSpecifier.ManufacturerSpecificDiagnosis

Value (hexadecimal)	Meaning	Usage within AlarmType
0x00	Means that the Submodule (alarm source) contains no ManufacturerSpecificDiagnosis with Channel-Properties.Maintenance (=diagnosis) and Channel-Properties.Specifier (=appear or disappear)	All Diagnosis ASE attached AlarmTypes
0x01	Means that the Submodule (alarm source) contains at least one ManufacturerSpecificDiagnosis with ChannelProperties.Maintenance (=diagnosis) and ChannelProperties.Specifier (=appear or disappear)	

Bit 13: AlarmSpecifier.SubmoduleDiagnosisState
This field shall be coded with the values according to Table 366. For all other AlarmTypes this field shall be set to zero.

Table 366 – AlarmSpecifier.SubmoduleDiagnosisState

Value (hexadecimal)	Meaning	Usage within AlarmType
0x00	Error free No DiagnosisData with ChannelProperties.Maintenance (=diagnosis) and ChannelProperties.Specifier (=appear) exists at the submodule. Furthermore, it indicates that all reported diagnosis has been cleared. An individual “disappears” notification can be omitted. However, even in this case a Manufacturer Specific Diagnosis with ChannelProperties.Maintenance (=diagnosis) and ChannelProperties.Specifier (=disappear) may be present.	All Diagnosis ASE attached AlarmTypes
0x01	At least one DiagnosisData with Channel-Properties.Maintenance (=diagnosis) and Channel-Properties.Specifier (=appear) exists at the submodule.	

Bit 14: AlarmSpecifier.reserved
This field shall be set to zero.

Bit 15: AlarmSpecifier.ARDiagnosisState
This field shall be coded with the values according to Table 367. For all other AlarmTypes this field shall be set to zero.

Table 367 – AlarmSpecifier.ARDiagnosisState

Value (hexadecimal)	Meaning	Usage within AlarmType
0x00	Error free No DiagnosisData with ChannelProperties.Maintenance(=diagnosis) and ChannelProperties.Specifier(=appear) exists at the AR. Furthermore, it indicates that all reported diagnosis has been cleared. An individual “disappears” notification can be omitted. However, even in this case a Manufacturer Specific Diagnosis with ChannelProperties.Maintenance(=diagnosis) and ChannelProperties.Specifier(=disappear) may be present.	All Diagnosis ASE attached AlarmTypes
0x01	At least one DiagnosisData with ChannelProperties.Maintenance(=diagnosis) and ChannelProperties.Specifier(=appear) exists at the AR.	

5.2.3 Coding section related to common address fields

5.2.3.1 Coding of the field API

This field, defined as an administrative number, shall be coded as data type Unsigned32 according to Table 368.

Table 368 – API

Value (hexadecimal)	Meaning of API
0	Default
0x00000001 – 0x0000FFFF	Used for profile definitions fitting for 5.2.7.8
0x00010000 – 0xFFFFFFFF	Used for profile definitions beyond 5.2.7.8

NOTE API means Application Process Identifier.

5.2.3.2 Coding of the field SlotNumber

This field shall be coded as data type Unsigned16 according to Table 369.

Table 369 – SlotNumber

Value (hexadecimal)	Meaning of SlotNumber
0 – 0x7FFF	The first usable slot for modules is zero. The last usable slot for modules is 0x7FFF. It may contain gaps.
0x8000 – 0xFFFF	Reserved

5.2.3.3 Coding of the field SubslotNumber

This field shall be coded as data type Unsigned16 according to Table 370.

Table 370 – SubslotNumber

Value (hexadecimal)	Meaning of SubslotNumber	
0x0000	ARProperties.PullModuleAlarmAllowed (=0)	Shall be used to code “Pull module” in conjunction with AlarmType (Pull).
	ARProperties.PullModuleAlarmAllowed (=1)	Useable subslot. The first usable subslot for submodules is zero.
0x0001 – 0x7FFF	The last usable subslot for submodules is 0x7FFF. There may be gaps.	
0x8000 – 0x8FFF	Default Used for 16 interface submodules with up to 255 ports. There may be gaps. See Formula (45) If used by system redundancy, the interface submodule mounted left or down into the rack.	
0x9000 – 0x9FFF	Used for 16 interface submodules with up to 255 ports. There may be gaps. See Formula (45) Used by system redundancy with redundant interface for the interface submodule mounted right or up into the rack.	
0xA000 – 0xFFFF	Reserved	

The subslotnumber shall be evaluated with 0xLIPP with I counting interfaces (PP := 00 means interface itself) and PP counting ports as shown in Formula (45).

$$\text{SubslotNumber} = 0xL000 + 0x0I00 + 0x00PP \quad (45)$$

where

SubslotNumber	is the corresponding value
L	is the basic value for this formula 0x8000 or 0x9000
I	is the number of the interface starting with zero
PP	is the number of the port of the interface starting with one. The value zero means no port.

5.2.3.4 Coding of the field Index

5.2.3.4.1 General

This field shall be coded as data type Unsigned16. The range from zero to 0x7FFF shall be used to address user specific record data objects. The range from 0x8000 to 0xFFFF shall be used for protocol specific function or further protocol extensions. The range from 0x8000 to 0xFFFF is divided into four sections. It is defined for each section whether the fields ARUUID, SlotNumber and SubslotNumber shall be ignored or used. The optional field TargetARUUID shall only be present and evaluated in conjunction with the defined indices.

Furthermore, all services with write access shall only use the valid address space of the established AR context. Read services may address record data beyond this context.

5.2.3.4.2 Usage of the address parameters

The following expressions show the evaluating of the address parameters according to the index range.

The rules to evaluate the address parameter shown in Table 371, Table 372, Table 373, Table 374, Table 375 shall be applied.

NOTE Implicit means from outside an existing AR. Explicit means from inside the existing AR.

Table 371 – Expression 1 (subslot specific)

RPCOperationNmb	ARUUID	Target ARUUID	Validity
Implicit Read	NIL (implicit AR)	Evaluated if needed by the index	API, Slot Number, Subslot Number, Index shall be evaluated
Implicit Read	Not NIL (explicit AR)	—	Not allowed
Explicit Read/Write	NIL (implicit AR)	—	Not allowed
Explicit Read/Write	Not NIL (established AR)	Ignore	API, Slot Number, Subslot Number, Index shall be evaluated

Table 372 – Expression 2 (slot specific)

RPCOperationNmb	ARUUID	Target ARUUID	Validity
Implicit Read	NIL (implicit AR)	Evaluated if needed by the index	API, Slot Number, Index shall be evaluated
Implicit Read	Not NIL (explicit AR)	—	Not allowed
Explicit Read/Write	NIL (implicit AR)	—	Not allowed
Explicit Read/Write	Not NIL (established AR)	Ignore	API, Slot Number, Index shall be evaluated

Table 373 – Expression 3 (AR specific)

RPCOperationNmb	ARUUID	Target ARUUID	Validity
Implicit Read	NIL (implicit AR)	Evaluated if needed by the index	Index shall be evaluated
Implicit Read	Not NIL (explicit AR)	—	Not allowed
Explicit Read/Write	NIL (implicit AR)	—	Not allowed
Explicit Read/Write	Not NIL (established AR)	Ignore	Index shall be evaluated

Table 374 – Expression 4 (API specific)

RPCOperationNmb	ARUUID	Target ARUUID	Validity
Implicit Read	NIL (implicit AR)	Ignore	API, Index shall be evaluated
Implicit Read	Not NIL (explicit AR)	—	Not allowed
Explicit Read/Write	NIL (implicit AR)	—	Not allowed
Explicit Read/Write	Not NIL (established AR)	Ignore	API, Index shall be evaluated

Table 375 – Expression 5 (device specific)

RPCOperationNmb	ARUUID	Target ARUUID	Validity
Implicit Read	NIL (implicit AR)	Ignore	Index shall be evaluated
Implicit Read	Not NIL (explicit AR)	—	Not allowed
Explicit Read/Write	NIL (implicit AR)	—	Not allowed
Explicit Read/Write	Not NIL (established AR)	Ignore	Index shall be evaluated

5.2.3.4.3 Grouping of DiagnosisData for the diagnosis records

The diagnosis records contain different data dependent on the index. The grouping shall be according to Table 376. The identifier is used in Table 378, Table 379, Table 380, Table 381 and Table 382.

Table 376 – Grouping of DiagnosisData

Identifier	Meaning
Diagnosis in channel coding	ChannelDiagnosis, ExtChannelDiagnosis and QualifiedChannelDiagnosis with ChannelProperties.Maintenance(=diagnosis) and ChannelProperties.Specifier(=appear)
Diagnosis in all codings	ChannelDiagnosis, ExtChannelDiagnosis, QualifiedChannelDiagnosis and ManufacturerSpecificDiagnosis with ChannelProperties.Maintenance(=diagnosis) and ChannelProperties.Specifier(=appear)
Maintenance required in channel coding	ChannelDiagnosis, ExtChannelDiagnosis and QualifiedChannelDiagnosis with ChannelProperties.Maintenance(=MaintenanceRequired) and ChannelProperties.Specifier(=appear)
Maintenance required in all codings	ChannelDiagnosis, ExtChannelDiagnosis, QualifiedChannelDiagnosis and ManufacturerSpecificDiagnosis with ChannelProperties.Maintenance(=MaintenanceRequired) and ChannelProperties.Specifier(=appear)
Maintenance demanded in channel coding	ChannelDiagnosis, ExtChannelDiagnosis and QualifiedChannelDiagnosis with ChannelProperties.Maintenance(=MaintenanceDemanded) and ChannelProperties.Specifier(=appear)
Maintenance demanded in all codings	ChannelDiagnosis, ExtChannelDiagnosis, QualifiedChannelDiagnosis and ManufacturerSpecificDiagnosis with ChannelProperties.Maintenance(=MaintenanceDemanded) and ChannelProperties.Specifier(=appear)
Diagnosis, Maintenance, Qualified and Status	ChannelDiagnosis, ExtChannelDiagnosis, QualifiedChannelDiagnosis, ManufacturerSpecificDiagnosis with ChannelProperties.Maintenance(=any) and ChannelProperties.Specifier(=appear), and ManufacturerSpecificDiagnosis with ChannelProperties.Maintenance(=diagnosis) and ChannelProperties.Specifier(=disappear)

5.2.3.4.4 Assigned numbers

The coding for user specific record data shall be according to Table 377.

Table 377 – Index (user specific)

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0 – 0x7FFF	User specific RecordData	Expression 1 applies.

The coding for submodule specific defined record data shall be according to Table 378.

Table 378 – Index (subslot specific)

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0x8000	ExpectedIdentificationData for one subslot	Expression 1 applies.
0x8001	RealIdentificationData for one subslot	Expression 1 applies.
0x8002 – 0x8009	Reserved	Reserved
0x800A	Diagnosis in channel coding for one subslot	Expression 1 applies.
0x800B	Diagnosis in all codings for one subslot	Expression 1 applies.
0x800C	Diagnosis, Maintenance, Qualified and Status for one subslot	Expression 1 applies.
0x800D – 0x800F	Reserved	Reserved
0x8010	Maintenance required in channel coding for one subslot	Expression 1 applies.
0x8011	Maintenance demanded in channel coding for one subslot	Expression 1 applies.
0x8012	Maintenance required in all codings for one subslot	Expression 1 applies.
0x8013	Maintenance demanded in all codings for one subslot	Expression 1 applies.
0x8014 – 0x801D	Reserved	Reserved
0x801E	SubstituteValues for one subslot	Expression 1 applies.
0x801F	Reserved	Reserved
0x8020	PDIRSubframeData for one subslot	Expression 1 applies.
0x8021 – 0x8027	Reserved	Reserved
0x8028	RecordInputDataObjectElement for one subslot	Expression 1 applies.
0x8029	RecordOutputDataObjectElement for one subslot	Expression 1 applies.
0x802A	PDPortDataReal for one subslot	Expression 1 applies.
0x802B	PDPortDataCheck for one subslot	Expression 1 applies.
0x802C	PDIRData for one subslot	Expression 1 applies.
0x802D	Expected PDSyncData for one subslot with SyncID value 0	Expression 1 applies.
0x802E	Reserved (legacy)	Reserved
0x802F	PDPortDataAdjust for one subslot	Expression 1 applies.
0x8030	IsochronousModeData for one subslot	Expression 1 applies.
0x8031	Expected PDTimeData for one subslot	Expression 1 applies.
0x8032 – 0x804F	Reserved	Reserved
0x8050	PDInterfaceMrpDataReal for one subslot	Expression 1 applies.
0x8051	PDInterfaceMrpDataCheck for one subslot	Expression 1 applies.
0x8052	PDInterfaceMrpDataAdjust for one subslot	Expression 1 applies.
0x8053	PDPortMrpDataAdjust for one subslot	Expression 1 applies.
0x8054	PDPortMrpDataReal for one subslot	Expression 1 applies.
0x8055 – 0x805F	Reserved	Reserved
0x8060	PDPortFODataReal for one subslot	Expression 1 applies.

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0x8061	PDPortFODataCheck for one subslot	Expression 1 applies.
0x8062	PDPortFODataAdjust for one subslot	Expression 1 applies.
0x8063 – 0x806F	Reserved	Reserved
0x8070	PDNCDataCheck for one subslot	Expression 1 applies.
0x8071	PDInterfaceAdjust for one subslot	Expression 1 applies.
0x8072	PDPortStatistic for one subslot	Expression 1 applies.
0x8073 – 0x807F	Reserved	Reserved
0x8080	PDInterfaceDataReal for one subslot	Expression 1 applies.
0x8081 – 0x808F	Reserved	Reserved
0x8090	Expected PDInterfaceFSUDataAdjust	Expression 1 applies.
0x8091 – 0x809F	Reserved	Reserved
0x80A0	Profiles covering energy saving – Record_0	Expression 1 applies.
0x80A1 – 0x80AF	Reserved for profiles covering energy saving	Expression 1 applies.
0x80B0	CombinedObjectContainer	Expression 1 applies.
0x80B1 – 0x80BF	Reserved	Reserved
0x80C0	Profiles covering sequence of events – Record_0	Expression 1 applies.
0x80C1 – 0x80CF	Reserved for profiles covering sequence of events	Expression 1 applies.
0x80D0 – 0xAFEF	Reserved	Reserved
0xAFF0	I&M0	Expression 1 applies.
0xAFF1	I&M1	Expression 1 applies.
0xAFF2	I&M2	Expression 1 applies.
0xAFF3	I&M3	Expression 1 applies.
0xAFF4	I&M4	Expression 1 applies.
0xAFF5 – 0xAFFF	I&M5 – I&M15 [a] [a] Reserved for additional identification and maintenance data	Expression 1 applies.
0xB000 – 0xBFFF	Reserved for profiles	Expression 1 applies.

The coding for module specific defined record data shall be according to Table 379.

Table 379 – Index (slot specific)

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0xC000	ExpectedIdentificationData for one slot	Expression 2 applies.
0xC001	RealIdentificationData for one slot	Expression 2 applies.
0xC002 – 0xC009	Reserved	Reserved
0xC00A	Diagnosis in channel coding for one slot	Expression 2 applies.
0xC00B	Diagnosis in all codings for one slot	Expression 2 applies.

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0xC00C	Diagnosis, Maintenance, Qualified and Status for one slot	Expression 2 applies.
0xC00D – 0xC00F	Reserved	Reserved
0xC010	Maintenance required in channel coding for one slot	Expression 2 applies.
0xC011	Maintenance demanded in channel coding for one slot	Expression 2 applies.
0xC012	Maintenance required in all codings for one slot	Expression 2 applies.
0xC013	Maintenance demanded in all codings for one slot	Expression 2 applies.
0xC014 – 0xCFFF	Reserved	Reserved
0xD000 – 0xDFFF	Reserved for profiles	Expression 2 applies.

The coding for AR specific defined record data shall be according to Table 380.

Table 380 – Index (AR specific)

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0xE000	ExpectedIdentificationData for one AR	Expression 3 applies.
0xE001	RealIdentificationData for one AR	Expression 3 applies.
0xE002	ModuleDiffBlock for one AR	Expression 3 applies.
0xE003 – 0xE009	Reserved	Reserved
0xE00A	Diagnosis in channel coding for one AR	Expression 3 applies.
0xE00B	Diagnosis in all codings for one AR	Expression 3 applies.
0xE00C	Diagnosis, Maintenance, Qualified and Status for one AR	Expression 3 applies.
0xE00D – 0xE00F	Reserved	Reserved
0xE010	Maintenance required in channel coding for one AR	Expression 3 applies.
0xE011	Maintenance demanded in channel coding for one AR	Expression 3 applies.
0xE012	Maintenance required in all codings for one AR	Expression 3 applies.
0xE013	Maintenance demanded in all codings for one AR	Expression 3 applies.
0xE014 – 0xE02F	Reserved	Reserved
0xE030	Reserved	Reserved
0xE031 – 0xE03F	Reserved	Reserved
0xE040	WriteMultiple	Expression 3 applies.
0xE041 – 0xE04F	Reserved	Reserved

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0xE050	ARFSUDataAdjust data for one AR Legacy, used only for ARProperties.StartupMode == Legacy	Expression 3 applies.
0xE051 – 0xE05F	Reserved for FastStartUp	Expression 3 applies.
0xE060 – 0xEBFF	Reserved	Reserved
0xEC00 – 0xEFFF	Reserved for profiles	Expression 3 applies.

The coding for API specific defined record data shall be according to Table 381 if no AR has been established.

Table 381 – Index (API specific)

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0xF000	RealIdentificationData for one API	Expression 4 applies.
0xF001 – 0xF009	Reserved	Reserved
0xF00A	Diagnosis in channel coding for one API	Expression 4 applies.
0xF00B	Diagnosis in all codings for one API	Expression 4 applies.
0xF00C	Diagnosis, Maintenance, Qualified and Status for one API	Expression 4 applies.
0xF00D – 0xF00F	Reserved	Reserved
0xF010	Maintenance required in channel coding for one API	Expression 4 applies.
0xF011	Maintenance demanded in channel coding for one API	Expression 4 applies.
0xF012	Maintenance required in all codings for one API	Expression 4 applies.
0xF013	Maintenance demanded in all codings for one API	Expression 4 applies.
0xF014 – 0xF01F	Reserved	Reserved
0xF020	ARData for one API	Expression 4 applies.
0xF021 – 0xF3FF	Reserved	Reserved
0xF400 – 0xF7FF	Reserved for profiles	Expression 4 applies.

The coding for device specific defined record data shall be according to Table 382.

Table 382 – Index (device specific)

Value (hexadecimal)	Meaning of index	Meaning of fields ARUUID, API, SlotNumber, SubslotNumber and TargetARUUID
0xF800 – 0xF80B	Reserved	Reserved
0xF80C	Diagnosis, Maintenance, Qualified and Status for one device	Expression 5 applies.
0xF80D – 0xF81F	Reserved	Reserved
0xF820	ARData	Expression 5 applies.
0xF821	APIData	Expression 5 applies.
0xF822 – 0xF82F	Reserved	Reserved
0xF830	LogBookData	Expression 5 applies.
0xF831	PdevData	Expression 5 applies.
0xF832 – 0xF83F	Reserved	Reserved
0xF840	I&M0FilterData	Expression 5 applies.
0xF841	PDRealData	Expression 5 applies.
0xF842	PDExpectedData	Expression 5 applies.
0xF843 – 0xF84F	Reserved	Reserved
0xF850	AutoConfiguration	Expression 5 applies.
0xF851 – F85F	Reserved	Reserved
0xF860	Controller to controller communication GSD upload using UploadBLOBQuery and UploadBLOB	Expression 5 applies.
0xF861	Controller to controller communication Nested diagnosis info	Expression 5 applies.
0xF862 – 0xF86F	Reserved for controller to controller communication	Reserved
0xF870 – 0xFBFE	Reserved	Reserved
0xFBFF	Trigger index for the RPC connection monitoring inside the CMSM	Expression 5 applies.
0xFC00 – 0xFFFF	Reserved for profiles [a]	Expression 5 applies.
[a] The index is defined as an administrative number.		

5.2.4 Coding section related to AL services

5.2.4.1 Coding of the field RecordDataLength

This field shall be coded as data type Unsigned32. The field RecordDataLength shall only contain the number of user octets.

5.2.4.2 Coding of the field SeqNumber

This field shall be coded as data type Unsigned16 and shall be incremented for each IODWriteReq and IODReadReq by the requestor and mirrored by the responder; the protocol layer shall not check the SeqNumber.

The check for the correct SeqNumber should be done by the application.

The SeqNumber is valid in the context of a SessionKey and starts with zero.

NOTE The SeqNumber and the SessionKey allows detection of sequence errors.

This field shall contain the value 0 for an implicit AR.

5.2.4.3 Coding of the field ARType

This field shall be coded as data type Unsigned16 with the values according to Table 383.

Table 383 – ARType

Value (hexadecimal)	Meaning	Use
0x0000	Reserved	—
0x0001	IOCARSingle	—
0x0002 – 0x0005	Reserved	—
0x0006	IOSAR	The supervisor AR is a special form of the IOCARSingle allowing takeover of the ownership of a submodule
0x0007 – 0x000F	Reserved	—
0x0010	IOCARSingle using RT_CLASS_3	This is a special form of the IOCARSingle indicating RT_CLASS_3 communication
0x0011 – 0x001F	Reserved	—
0x0020	IOCARSR	The SR AR is a special form of the IOCARSingle indicating system redundancy or configure in run usage
0x0021 – 0xFFFF	Reserved	—

5.2.4.4 Coding of the field SessionKey

This field shall be coded as data type Unsigned16 and shall be increased by one for each connect by the CMInitiator. The CMResponder shall use this value for each subsequent PROFINETIOServiceReq- and PROFINETIOServiceResPDU within this session.

NOTE The SessionKey allows the CMInitiator to detect sequence errors during the establishment and release phase of an AR.

This field shall contain the value zero for the implicit AR.

5.2.4.5 Coding of the field CMInitiatorMacAdd

This field shall be coded as data type OctetString[6]. The value of the field CMInitiatorMacAdd shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

5.2.4.6 Coding of the field IOCRMulticastMACAdd

This field shall be coded as data type OctetString[6]. The value of the field IOCRMulticastMACAdd shall be set according to the 48-bit universal LAN MAC addresses of IEEE 802, to Table 384 and Table 385.

The IP Multicast address used for multicast communication relation using RT_CLASS_UDP shall be set according RFC 2365.

Table 384 – IOCRMulticastMACAdd using RT_CLASS_UDP

IP multicast address	Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Associated FrameID	Usage
239.192.248.0	01-00-5E	40-F8-00	0xF800	Used for multicast communication relations in conjunction with RT_CLASS_UDP
239.192.248.1 – 239.192.251.254	01-00-5E	40-F8-01 to 40-FB-FE	0xF801 – 0xFBFE	Used for multicast communication relations in conjunction with RT_CLASS_UDP
239.192.251.255	01-00-5E	40-FB-FF	0xFBFF	Used for multicast communication relations in conjunction with RT_CLASS_UDP

Table 385 – IOCRMulticastMACAdd using RT_CLASS_2 or RT_CLASS_3

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-0E-CF	00-00-00 to 00-00-FF	Reserved for other applications
01-0E-CF	00-01-00	Reserved for further multicast addresses within the Type 10 context
01-0E-CF	00-01-01	RT_CLASS_3 destination multicast address
01-0E-CF	00-01-02	RT_CLASS_3 invalid frame multicast address
01-0E-CF	00-01-03 to 00-01-FF	Reserved for further multicast addresses within the Type 10 context
01-0E-CF	00-02-00 to 00-02-FF	RT_CLASS_2 multicast communication address
01-0E-CF	00-03-00 to 00-03-FF	Reserved for further multicast addresses within the Type 10 context
01-0E-CF	00-04-00 to FF-FF-FF	Reserved for other applications
03-00-00 to FF-FF-00	00-00-00	Fast Forwarding local administered multicast address range

NOTE Octet 1 contains the Individual/Group Address Bit (lsb).

The Organizationally Unique Identifier (OUI) as defined by IEEE 802 for Type 10 is 00-0E-CF and shall be set according to Table 386.

Table 386 – Type 10 OUI

Value (hexadecimal)	Meaning
00-0E-CF	Global administered individual unicast
01-0E-CF	Global administered group (multicast) address
02-0E-CF	Local administered individual unicast
03-0E-CF	Local administered group (multicast) address

5.2.4.7 Coding of the field CMResponderMacAdd

This field shall be coded as data type OctetString[6]. The value of the field CMResponderMacAdd shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

NOTE Octet 1 contains the Individual/Group Address Bit (lsb).

5.2.4.8 Coding of the field ARProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 2: ARProperties.State
This field shall be set according to Table 387.

Table 387 – ARProperties.State

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Active
0x02 – 0x07	Reserved

Bit 3: ARProperties.SupervisorTakeoverAllowed
This field shall be set according to Table 388.

Table 388 – ARProperties.SupervisorTakeoverAllowed

Value (hexadecimal)	Meaning
0x00	Not allowed
0x01	Allowed

Bit 4: ARProperties.ParameterizationServer
This field shall be set according to Table 389.

Table 389 – ARProperties.ParameterizationServer

Value (hexadecimal)	Meaning
0x00	External PrmServer
0x01	CM Initiator

Bit 5 – 7: ARProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 8: ARProperties.DeviceAccess
This field shall be set according to Table 390.

Table 390 – ARProperties.DeviceAccess

Value (hexadecimal)	Meaning
0x00	Only the submodules from the ExpectedSubmoduleBlock are accessible
0x01	Submodule access is controlled by IO device application

Bit 9-10: ARProperties.CompanionAR
This field shall be set according to Table 391.

Table 391 – ARProperties.CompanionAR

Value (hexadecimal)	Meaning	Use
0x00	Single AR	RT_CLASS_1, RT_CLASS_2, RT_CLASS_3, or RT_CLASS_UDP connection establishment
0x01	First AR of a companion pair and a companion AR shall follow	For future use
0x02	Companion AR	For future use
0x03	Reserved	—

Bit 11: ARProperties.AcknowledgeCompanionAR
This field shall be set according to Table 392.

Table 392 – ARProperties.AcknowledgeCompanionAR

Value (hexadecimal)	Meaning	Use
0x00	No companion AR or no acknowledge for the companion AR required	RT_CLASS_1, RT_CLASS_2, RT_CLASS_3, or RT_CLASS_UDP connection establishment
0x01	Companion AR with acknowledge	For future use

Bit 12 – 23: ARProperties.reserved_2
This field shall be set according to 3.4.2.2.

Bit 24 – 29: ARProperties.reserved_3
This field shall be set to zero.

Bit 30: ARProperties.StartupMode
This field shall be set according to Table 393.

Table 393 – ARProperties.StartupMode

Value (hexadecimal)	Meaning	Use
0x00	Legacy	Recommended Compatibility mode for legacy nodes. The two provider mode for the RT_CLASS_3 startup is required
0x01	Advanced	Mandatory for this standard.

Bit 31: ARProperties.PullModuleAlarmAllowed
This field shall be set according to Table 394.

Table 394 – ARProperties.PullModuleAlarmAllowed

Value (hexadecimal)	Meaning	Use
0x00	The AlarmType(=Pull) shall signal pulling of submodule and module. The subslot number zero shall code pulling of module in conjunction with AlarmType(=Pull).	Mandatory
0x01	The AlarmType(=Pull) shall signal pulling of submodule. The AlarmType(=Pull module) shall signal pulling of module. The subslot number 0 – 0x8FFF shall code pulling of submodule in conjunction with AlarmType(=Pull).	Optional

5.2.4.9 Coding of the field IOCRProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 3: IOCRProperties.RTClass
This field shall be set according to Table 395.

Table 395 – IOCRProperties.RTClass

Value (hexadecimal)	Meaning	Use
0x00	Reserved	—
0x01	Use FrameID range 7 for the IOCRs See Table 30	Data-RTC-PDU IOCRProperties.RTClass == 0x02 shall be used as substitution by the engineering tool. Shall be supported for legacy IO devices by IO controller and IO supervisor. It should not be generated by an IO device.
0x02	Use FrameID range 6 for the IOCRs See Table 29	Data-RTC-PDU
0x03	Use FrameID range 3 for the IOCRs See Table 26	Data-RTC-PDU
0x04	Use FrameID range 7 for the IOCRs See Table 30	UDP-RTC-PDU
0x05 – 0x07	Reserved	—

Bit 4 – 12: IOCRProperties.reserved_1
This field shall be set to zero.

Bit 13 – 23: IOCRProperties.reserved_2
This field shall be set according to 3.4.2.2.

Bit 24 – 31: IOCRProperties.reserved_3
This field shall be set to zero.

5.2.4.10 Coding of the field NumberOfIODataObjects

This field shall be coded as data type Unsigned16.

5.2.4.11 Coding of the field NumberOfIOCS

This field shall be coded as data type Unsigned16.

5.2.4.12 Coding of the field IOCRReference

This field shall be coded as data type Unsigned16. It is an identification tag for the CR and is used within the IOCBlockReq and IOCBlockRes to reference the DataItem. Furthermore, it is used in PDIRData of the Physical Device ASE.

5.2.4.13 Coding of the field IOCRTagHeader

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0-11: IOCRTagHeader.IOCRVLANID
This field shall be set according to Table 396.

Table 396 – IOCRTagHeader.IOCRVLANID

Value (hexadecimal)	Meaning
0x000	No VLAN
0x001	Default VLAN
0x002 – 0xFFF	According IEEE 802.1Q

Bit 12: IOCRTagHeader.reserved
This field shall be set to zero.

Bit 13 – 15: IOCRTagHeader.IOUserPriority
This field shall be set according to Table 397.

Table 397 – IOCRTagHeader.IOUserPriority

Value (hexadecimal)	Meaning
0x00 – 0x05	Reserved
0x06	IO CR Priority
0x07	Reserved

5.2.4.14 Coding of the field IOCRType

This field shall be coded as data type Unsigned16 with the values according to Table 398.

Table 398 – IOCRType

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001	Input CR
0x0002	Output CR
0x0003	Multicast Provider CR
0x0004	Multicast Consumer CR
0x0005 – 0xFFFF	Reserved

5.2.4.15 Coding of the field CMInitiatorActivityTimeoutFactor

This field shall be coded as data type Unsigned16 with the values according to Table 399 and Table 400.

Table 399 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess:=0

Value (decimal)	Meaning	Use
0	Reserved	—
1 – 1 000	With a time base of 100 ms	The IO device monitors the time between Connect response and the subsequent first activity of the IO controller
1 001 – 65 535	Reserved	—

Table 400 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess:=1 or ARProperties.StartupMode:=1

Value (decimal)	Meaning	Use
0 – 99	Reserved	—
100 – 1 000	With a time base of 100 ms	Default value: 200 The IO device monitors the time between Connect response and the subsequent Read and Write record activity of the IO controller
1 001 – 65 535	Reserved	—

This field shall be used from the CMDEV for the calculation of the CMInitiatorActivityTimeout according to Formula (46).

$$\text{CMInitiatorActivityTimeout} = \text{CMInitiatorActivityTimeoutFactor} \times 100\ \text{ms} \quad (46)$$

where

CMInitiatorActivityTimeout is the CM initiator activity timeout

CMInitiatorActivityTimeoutFactor is the CM initiator activity timeout factor

This field shall be used from the CMCTL for the calculation of the CMInitiatorTriggerTimeout-Factor which is used for the AR establishing with the values according to Formula (47) and Table 401.

$$\text{CMInitiatorTriggerTimeoutFactor} = \text{CMInitiatorActivityTimeoutFactor}\ \mathit{DIV}\ 3 \quad (47)$$

where

CMInitiatorActivityTimeoutFactor is the CM initiator activity timeout factor

CMInitiatorTriggerTimeoutFactor is the CM initiator trigger timeout factor

Table 401 – CMInitiatorTriggerTimeoutFactor

Value (decimal)	Meaning	Use
0 – 32	Reserved	—
33 – 333	With a time base of 100 ms	Used for the connection monitoring during startup until the PPM / CPM connection monitoring takes place.
334 – 65 535	Reserved	—

The value of the CMInitiatorTriggerTimeout shall be calculated according to Formula (48).

$$\text{CMInitiatorTriggerTimeout} = \text{CMInitiatorTriggerTimeoutFactor} \times 100\ \text{ms} \quad (48)$$

where

CMInitiatorTriggerTimeout is the CM initiator trigger timeout

CMInitiatorTriggerTimeoutFactor is the CM initiator trigger timeout factor

5.2.4.16 Coding of the field StationNameLength

This field shall be coded as data type Unsigned16.

5.2.4.17 Coding of the field CMInitiatorStationName

This field shall be coded according to the rules of 4.3.1.4.15.1.

5.2.4.18 Coding of the field CMResponderStationName

This field shall be coded according to the rules of 4.3.1.4.15.1.

5.2.4.19 Coding of the field ParameterServerStationName

This field shall be coded according to the rules of 4.3.1.4.15.1.

5.2.4.20 Coding of the field ProviderStationName

This field shall be coded according to the rules of 4.3.1.4.15.1.

5.2.4.21 Coding of the field IODataObjectFrameOffset

This field shall be coded as data type Unsigned16. It is used within the IOCRBlockReq to reference the offset of the DataItem. It shall be in a range off 0 to 1 439. The maximum number of used octets shall not exceed the maximum C_SDU size.

5.2.4.22 Coding of the field IOCSFrameOffset

This field shall be coded as data type Unsigned16. It is used within the IOCRBlockReq to reference the offset of the IOCS. It shall be in a range off 0 to 1 439. The maximum number of used octets shall not exceed the maximum C_SDU size.

5.2.4.23 Coding of the field LengthIOCS

This field shall be coded as data type Unsigned8 and shall be set according to Table 402.

Table 402 – LengthIOCS

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	One octet for IOCS
0x02 – 0xFF	Reserved

5.2.4.24 Coding of the field LengthIOPS

This field shall be coded as data type Unsigned8 and shall be set according to Table 403.

Table 403 – LengthIOPS

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	One octet for IOPS
0x02 – 0xFF	Reserved

5.2.4.25 Coding of the field LengthData

This field shall be coded as data type Unsigned16. The values shall be in the range from 0 to 1 439.

5.2.4.26 Coding of the field NumberOfAPIs

This field shall be coded as data type Unsigned16.

NOTE The value 0 is only used in conjunction with ARProperties.DeviceAccess =1.

5.2.4.27 Coding of the field AlarmCRProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0: AlarmCRProperties.Priority
This field shall be set according to Table 404.

Table 404 – AlarmCRProperties.Priority

Value (hexadecimal)	Meaning
0x00	User priority (default) The priority given by the user is used and two alarm resources are available
0x01	Fixed priority Use only low priority, user priority is ignored and only one alarm resource is available

An IO device as alarm sink shall always support AlarmCRProperties.Priority:=”User priority” and the IO controller as alarm source may choose whether it limits itself to one resource or not.

Bit 1: AlarmCRProperties.Transport
This field shall be set according to Table 405.

Table 405 – AlarmCRProperties.Transport

Value (hexadecimal)	Meaning	Usage
0x00	RTA_CLASS_1	Alarm CR uses DATA-RTA-PDU
0x01	RTA_CLASS_UDP	Alarm CR uses UDP-RTA-PDU

Bit 2 – 23: AlarmCRProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 24 – 31: AlarmCRProperties.reserved_2
This field shall be set to zero.

5.2.4.28 Coding of the field AlarmCRTagHeaderHigh

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0-11: AlarmCRTagHeaderHigh.AlarmCRVLANID
This field shall be set according to Table 406.

Table 406 – AlarmCRTagHeaderHigh.AlarmCRVLANID

Value (hexadecimal)	Meaning
0x000	No VLAN
0x001	Default VLAN
0x002 – 0xFFF	According IEEE 802.1Q

Bit 12: AlarmCRTagHeaderHigh.reserved
This field shall be set to zero.

Bit 13 – 15: AlarmCRTagHeaderHigh.AlarmUserPriority
This field shall be set according to Table 407.

Table 407 – AlarmCRTagHeaderHigh.AlarmUserPriority

Value (hexadecimal)	Meaning
0x00 – 0x05	Reserved
0x06	Alarm CR Priority High
0x07	Reserved

5.2.4.29 Coding of the field AlarmCRTagHeaderLow

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0-11: AlarmCRTagHeaderLow.AlarmCRVLANID
This field shall be set according to Table 408.

Table 408 – AlarmCRTagHeaderLow.AlarmCRVLANID

Value (hexadecimal)	Meaning
0x000	No VLAN
0x001	Default VLAN
0x002 – 0xFFF	According IEEE 802.1Q

Bit 12: AlarmCRTagHeaderLow.reserved
This field shall be set to zero.

Bit 13 – 15: AlarmCRTagHeaderLow.AlarmUserPriority
This field shall be set according to Table 409.

Table 409 – AlarmCRTagHeaderLow.AlarmUserPriority

Value (hexadecimal)	Meaning
0x00 – 0x04	Reserved
0x05	Alarm CR Priority Low
0x06 – 0x07	Reserved

5.2.4.30 Coding of the field AlarmSequenceNumber

This field shall be coded as data type Unsigned16 with the values according to Table 410.

Table 410 – AlarmSequenceNumber

Value (hexadecimal)	Meaning	Use
0x000 – 0x7FF	Mirrors the sequence number of the plug alarm notification	It provides the relation between Plug Alarm notification and the ControlBlockPlug within Application Ready
0x800 – 0xFFFF	Reserved	—

5.2.4.31 Coding of the field AlarmCRType

This field shall be coded as data type Unsigned16 with the values according to Table 411.

Table 411 – AlarmCRType

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001	Alarm CR
0x0002 – 0xFFFF	Reserved

5.2.4.32 Coding of the field RTATimeoutFactor

This field shall be coded as data type Unsigned16 with the values according to Table 412. The time base is 100 ms.

The RTATimeout shall be calculated according to Formula (49).

$$\text{RTATimeout} = \text{RTATimeoutFactor} \times 100\ \text{ms} \tag{49}$$

where

RTATimeout is the RTA timeout

RTATimeoutFactor is the RTA timeout factor

Table 412 – RTATimeoutFactor

Value (hexadecimal)	Meaning	Use
0x0000	Reserved	—
0x0001	Mandatory	Default DATA-RTA-PDU or UDP-RTA-PDU acknowledge monitoring
0x0002 – 0x0064	Mandatory	DATA-RTA-PDU or UDP-RTA-PDU acknowledge monitoring
0x0065 – 0xFFFF	Optional	DATA-RTA-PDU or UDP-RTA-PDU acknowledge monitoring

NOTE The value of the RTATimeoutFactor depends on the conveyance time of the DATA-RTA-PDU or UDP-RTA-PDU between two peers.

5.2.4.33 Coding of the field RTARetries

This field shall be coded as data type Unsigned16 with the values according to Table 413.

Table 413 – RTARetries

Value (hexadecimal)	Meaning	Meaning
0x0000 – 0x0002	Reserved	Reserved
0x0003	Mandatory	Default
0x0004 – 0x000F	Mandatory	—
0x0010 – 0xFFFF	Reserved	Reserved

5.2.4.34 Coding of the field PROFINETIOConstantValue

This field shall be coded as data type structure containing the following elements:

- Data1 as Unsigned32 (0xDEA00000)
- Data2 as Unsigned16 (0x6C97)
- Data3 as Unsigned16 (0x11D1)
- Data4 as array of two Unsigned8, Octet 1 (0x82) to Octet 2 (0x71)

NOTE The ordering of transmission of the Unsigned32 or Unsigned16 values is according to the RPC Flag Drep (Little Endian or Big Endian) if it is part of the RPCHeader or NDREPMapPDU. If it is part of the NDRDataxxx PDUs then only Big Endian Format is used.

The value of the field PROFINETIOConstantValue shall be DEA00000-6C97-11D1-8271.

5.2.4.35 Coding of the field AddressResolutionProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 2: AddressResolutionProperties.Protocol
This field shall be set according to Table 414.

Table 414 – AddressResolutionProperties.Protocol

Value (hexadecimal)	Meaning	Use
0x00	Reserved	—
0x01	DNS	Multicast consumer uses DNS to resolve the multicast provider source MAC address.
0x02	DCP	Multicast consumer uses DCP to resolve the multicast provider source MAC address.
0x03 – 0x07	Reserved	—

Bit 3 – 7: AddressResolutionProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 8 – 15: AddressResolutionProperties.reserved_2
This field shall be set to zero.

Bit 16 – 31: AddressResolutionProperties.Factor
This field shall be coded with the values according to Table 415. The time base is one second. The AddressResolutionInterval shall be calculated according to Formula (50).

Table 415 – AddressResolutionProperties.Factor

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001 – 0x0064	Mandatory
0x0065 – 0xFFFF	Optional

$$\text{AddressResolutionInterval} = \text{AddressResolutionProperties.Factor} \times 1\ \text{s} \quad (50)$$

where

AddressResolutionInterval is the address resolution interval

AddressResolutionProperties.Factor is the factor for the calculation of the address resolution interval

5.2.4.36 Coding of the field MCITimeoutFactor

This field shall be coded as data type Unsigned16 with the values according to Table 416. The time base shall be 100 ms. The MCIMonitoringInterval shall be calculated according to Formula (51).

Table 416 – MCITimeoutFactor

Value (hexadecimal)	Meaning
0x0000 – 0x0064	Mandatory
0x0065 – 0xFFFF	Reserved

$$\text{MCIMonitoringInterval} = \text{MCITimeoutFactor} \times 100\ \text{ms} \quad (51)$$

where

MCIMonitoringInterval is the MCI monitoring interval

MCITimeoutFactor is the factor for the calculation of the MCI monitoring interval

5.2.4.37 Coding of fields related to Instance, DeviceID, VendorID

5.2.4.37.1 General

The Unsigned16 fields Instance, DeviceID and VendorID are divided into two Unsigned8 fields to define the order of the octets inside the ObjectUUID OctetString.

5.2.4.37.2 Coding of the field InstanceLow

This field shall be coded as data type Unsigned8.

5.2.4.37.3 Coding of the field InstanceHigh

This field shall be coded as data type Unsigned8.

The value zero for both InstanceHigh and InstanceLow is recommended for single instance devices.

5.2.4.37.4 Coding of the field DeviceIDLow

This field, defined as an administrative number, shall be coded as data type Unsigned8 by the manufacturer of the device.

The value zero for both DeviceIDHigh and DeviceIDLow is reserved.

5.2.4.37.5 Coding of the field DeviceIDHigh

This field, defined as an administrative number, shall be coded as data type Unsigned8 by the manufacturer of the device.

The value zero for both DeviceIDHigh and DeviceIDLow is reserved.

5.2.4.37.6 Coding of the field VendorIDLow

This field, defined as an administrative number, shall be coded as data type Unsigned8 with the values according to Table 417.

Table 417 – VendorIDLow

Value (hexadecimal)	Meaning
0x00	The value zero for both VendorIDHigh and VendorIDLow is reserved for IEC 61158-6-3 devices.
0x01 – 0xFF	Administrative number

5.2.4.37.7 Coding of the field VendorIDHigh

This field, defined as an administrative number, shall be coded as data type Unsigned8 with the values according to Table 418.

Table 418 – VendorIDHigh

Value (hexadecimal)	Meaning
0x00	The value 0 for both VendorIDHigh and VendorIDLow is reserved for IEC 61158-6-3 devices.
0x01 – 0xEF	Administrative number
0xFF	The value 0xFF is reserved for profiles.

5.2.4.38 Coding of the field ModuleIdentNumber

This field shall be coded as data type Unsigned32. This field shall be coded with the values according to Table 419.

Table 419 – ModuleIdentNumber

Value (hexadecimal)	Meaning
0x00000000	Reserved
0x00000001 – 0xFFFFFFFF	Manufacturer specific

5.2.4.39 Coding of the field SubmoduleIdentNumber

This field shall be coded as data type Unsigned32. This field shall be coded with the values according to Table 420.

Table 420 – SubmoduleIdentNumber

Value (hexadecimal)	Meaning ARProperties.PullModuleAlarm-Allowed := 0	Meaning ARProperties.PullModuleAlarm-Allowed := 1
0x00000000	Assigned to the subslot zero only in conjunction with Pull alarm and SubslotNumber := 0 as identification for the function pull module. Manufacturer specific for subslots > 0	Manufacturer specific for all other subslots
0x00000001 – 0xFFFFFFFF	Manufacturer specific for all other subslots	

The numbering for device identification is hierarchical. The toplevel is the DeviceIdentNumber which contains an administrative uniquely assigned number. The second level is the ModuleIdentNumber that is unique in the scope of the DeviceIdentNumber. The third level is the SubmoduleIdentNumber that is unique in the scope of the ModuleIdentNumber.

NOTE 1 Unique means, that the associated submodule properties, e.g. data structure, diagnosis and parameterization, defined in this standard are identified.

NOTE 2 The hardware of a submodule is identified by the VendorID and the OrderID.

5.2.4.40 Coding of the field NumberOfARs

This field shall be coded as data type Unsigned16.

5.2.4.41 Coding of the field NumberOfIOCRs

This field shall be coded as data type Unsigned16.

5.2.4.42 Coding of the field SubmoduleDataLength

This field shall be coded as data type Unsigned16. The range shall be between 0 and 1 439.

5.2.4.43 Coding of the field NumberOfModules

This field shall be coded as data type Unsigned16.

5.2.4.44 Coding of the field NumberOfSlots

This field shall be coded as data type Unsigned16.

5.2.4.45 Coding of the field NumberOfSubmodules

This field shall be coded as data type Unsigned16.

5.2.4.46 Coding of the field NumberOfSubslots

This field shall be coded as data type Unsigned16.

5.2.4.47 Coding of the field ARUUID

This field shall be coded as data type UUID according to Table 421 and Table 422.

Table 421 – ARUUID

Value (UUID)	Meaning	Use
00000000-0000-0000-0000-000000000000	Reserved	The value NIL indicates the usage of the implicit AR.
Other	Valid for an AR	Unambiguous values which identifies an ARs. See Table 422 for IOCARSR

Table 422 – ARUUID in conjunction with ARType:= IOCARSR

<table>
<tr><th>Value</th><th colspan="3">Description</th></tr>
<tr><td rowspan="5">aaaaaaaa-bbbb-cccc-dddd-eeeeeeeezzzz</td><td colspan="3">Identifies an application relation where</td></tr>
<tr><td>aaaaaaaa
bbbb
(6 octets)</td><td colspan="2">Is similar to the standard ARUUID</td></tr>
<tr><td>cccc
dddd
eeeeeeee
(8 octets)</td><td colspan="2">Is used as a configuration info covering the content of the Connect.req.</td></tr>
<tr><td rowspan="3">zzzz
(2 octets)</td><td>Bit 0-2:</td><td>01: 1st AR of an AR-set
02: 2nd AR of an AR-set
03: 3rd AR of an AR-set
04: 4th AR of an AR-set

Others: Reserved</td></tr>
<tr><td>Bit 3-4:</td><td>02: Communication endpoint shall allocate two ARs for the AR-set

Others: Reserved</td></tr>
<tr><td>Bit 5-15:</td><td>Reserved</td></tr>
<tr><td colspan="4">The ARUUID of an IOCARSR differs only in Bit 0-2.</td></tr>
</table>

5.2.4.48 Coding of the field TargetARUUID

This field shall be coded as data type UUID according to Table 423.

Table 423 – TargetARUUID

Value (UUID)	Meaning	Use
00000000-0000-0000-0000-000000000000	Reserved	The value NIL indicates the usage of the implicit AR.
other	Valid for an AR	All other values identify established Ars.

5.2.4.49 Coding of the field ActualLocalTimeStamp

This field shall be coded as data type Unsigned64 according to Table 424.

Table 424 – ActualLocalTimeStamp

Value (hexadecimal)	Meaning	Use
0x0000000000000000 – 0xFFFFFFFFFFFFFFFF	Contains the current cycle count value when reading the log book.	—

5.2.4.50 Coding of the field LocalTimeStamp

This field shall be coded as data type Unsigned64 according to Table 425.

Table 425 – LocalTimeStamp

Value (hexadecimal)	Meaning	Use
0x0000000000000000 – 0xFFFFFFFFFFFFFFFF	Contains the current cycle count when storing the entry to the log book.	—

5.2.4.51 Coding of the field NumberOfLogEntries

This field shall be coded as data type Unsigned16 according to Table 426.

Table 426 – NumberOfLogEntries

Value	Meaning	Use
0	Reserved	—
16	Minimum number shall be 16 for an IO device	—
128	Minimum number shall be 128 for an IO controller	—
other	Number of log entries	—

5.2.4.52 Coding of the field EntryDetail

This field shall be coded as data type Unsigned32 according to protocol machine behavior and Table 427.

Table 427 – EntryDetail

Value (hexadecimal)	Meaning	Use
0x00000000	No detail	—
other	Value derived from the signaling protocol machine	—

5.2.4.53 Coding of the field AdditionalValue1 and AdditionalValue2

This field shall be coded as data type Unsigned16 according to Table 428.

Table 428 – AdditionalValue1 and AdditionalValue2

Value (hexadecimal)	Meaning	Use
0x0000	No further information or positive response	IODReadRes, IODWriteRes, IODWriteMultipleRes
other	Additional user information within negative response	IODReadRes, IODWriteRes, IODWriteMultipleRes

5.2.4.54 Coding of the field ControlBlockProperties

The coding of this field shall be according to 3.4.2.4, Table 429, Table 430 and Table 431.

Table 429 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady with ARProperties.StartupMode:=1

Bitposition	Value (hexadecimal)	Meaning
Bit 0 – 15	—	Shall be set according to 3.4.2.2.

Table 430 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady with ARProperties.StartupMode:=0

Bitposition	Value (hexadecimal)	Meaning
Bit 0	0x00	Wait for explicit ControlCommand.ReadyForCompanion
	0x01	Implicit ControlCommand.ReadyForCompanion
Bit 1	0x00	Wait for explicit ControlCommand.ReadyForRT_CLASS_3
	0x01	Implicit ControlCommand.ReadyForRT_CLASS_3
Bit 2 – 15	—	Shall be set according to 3.4.2.2.

Table 431 – ControlBlockProperties in conjunction with the other values of the field ControlCommand

Bitposition	Value (hexadecimal)	Meaning
Bit 0 – 15	—	Shall be set according to 3.4.2.2.

5.2.4.55 Coding of the field ControlCommand

The coding of this field shall be according to 3.4.2.4. Only one of the following bits shall be set. The individual bits shall have the following meaning:

Bit 0: ControlCommand.PrmEnd
This field shall be set according to Table 432.

Table 432 – ControlCommand.PrmEnd

Value (hexadecimal)	Meaning	Use
0x00	No PrmEnd	—
0x01	The IO controller has finished the transmission of the stored start-up parameter.	IODControlReq

Bit 1: ControlCommand.ApplicationReady
This field shall be set according to Table 433.

Table 433 – ControlCommand.ApplicationReady

Value (hexadecimal)	Meaning	Use
0x00	No Application Ready	—
0x01	The IO device has finished the start-up of its application or a new module or submodule was plugged and is ready to operate.	IOXControlReq

Bit 2: ControlCommand.Release
This field shall be set according to Table 434.

Table 434 – ControlCommand.Release

Value (hexadecimal)	Meaning	Use
0x00	No Release	—
0x01	The IO controller terminates the AR.	IODReleaseReq

Bit 3: ControlCommand.Done
This field shall be set according to Table 435.

Table 435 – ControlCommand.Done

Value (hexadecimal)	Meaning	Use
0x00	No Done	—
0x01	Acknowledge is sent.	IODReleaseRes, IOXControlRes, IODControlRes

Bit 4: ControlCommand.ReadyForCompanion
This field shall be set according to Table 436.

Table 436 – ControlCommand.ReadyForCompanion

Value (hexadecimal)	Meaning	Use
0x00	Not ready for companion	—
0x01	The IO device has finished the start-up of its application and is ready for the companion AR.	IOXControlReq

Bit 5: ControlCommand.ReadyForRT_CLASS_3
This field shall be set according to Table 437.

Table 437 – ControlCommand.ReadyForRT_CLASS_3

Value (hexadecimal)	Meaning	Use
0x00	Not ready for RT_CLASS_3	—
0x01	The IO device has finished the start-up of its application and is ready for RT_CLASS_3 communication.	IOXControlReq

Bit 6: ControlCommand.PrmBegin
This field shall be set according to Table 438.

Table 438 – ControlCommand.PrmBegin

Value (hexadecimal)	Meaning	Use
0x00	No PrmBegin	—
0x01	The IO controller starts the transmission of the stored start-up parameter.	IODControlReq

Bit 7 to 15: ControlCommand.reserved
This field shall be set to zero.

5.2.4.56 Coding of the field DataDescription

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 1: DataDescription.Type
This field shall be set according to Table 439.

Table 439 – DataDescription.Type

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Input
0x02	Output
0x03	Reserved

Bit 2-15: DataDescription.reserved
This field shall be set to zero.

5.2.4.57 Coding of the field DataLength

This field shall be coded as data type Unsigned16. The values shall contain the length of the C_SDU or the CSF_SDU according to Table 440.

NOTE The field DataLength is in minimum the sum of all DataItems. It can be larger.

Table 440 – Values of DataLength

Value (decimal)	Domain	Meaning
40 – 1 440	RT_CLASS_1, RT_CLASS_2 and RT_CLASS_3	Valid range
12 – 1 440	RT_CLASS_UDP	Valid range
other	—	Reserved

5.2.4.58 Coding of the field GAP

This field shall be coded as data type Unsigned8. The values shall be set to zero.

5.2.4.59 Coding of the field Padding

This field shall be coded as data type Unsigned8. The values shall be set to zero.

5.2.4.60 Coding of the field RTCPadding

This field shall be coded as data type Unsigned8.

5.2.4.61 Coding of the field RWPadding

This field shall be coded as data type Unsigned8. The values shall be set to zero.

5.2.4.62 Coding of the field SendClockFactor

These fields shall be coded as data type Unsigned16 according to Table 441. The time base is 31,25 μs.

Table 441 – Values of SendClockFactor

Value (decimal)	LengthOfPeriod	Meaning
0	—	Reserved
1	31,25 μs	Optional
2	62,5 μs	Optional
3	93,75 μs	Optional
4	125 μs	Optional
5 – 7	—	Optional
8	250 μs	Optional
9 – 15	—	Optional
16	500 μs	Optional
17 – 31	—	Optional
32	1 ms	Mandatory
33 – 63	—	Optional
64	2 ms	Optional
65 – 127	—	Optional
128	4 ms	Optional
129 – 65 535	—	Reserved

Valid combinations of the SendClockFactor with ReductionRatio are shown in Table 442.

The LengthOfPeriod corresponds with a value range from 31,25 μs to 4 000 μs. A maximum Ethernet frame contains 1 518 or 1 522 octets. To transfer this kind of frame at a data rate of 100 Mbit/s the LengthOfPeriod should be greater than 122,24 μs and at a data rate of 1 Gbit/s the LengthOfPeriod should be greater than 12,224 μs.

The value of the LengthOfPeriod shall be calculated according to Formula (52).

$$\text{LengthOfPeriod} = \text{SendClockFactor} \times 31{,}25\ \mu\text{s} \tag{52}$$

where

LengthOfPeriod is the length of the period

SendClockFactor factor of the send clock, the length of one phase

Used within the PDSyncData block, this field shall only be valid if the field SyncProperties.SyncID contains the value 0.

5.2.4.63 Coding of the field ReductionRatio

These fields shall be coded as data type Unsigned16 with the values according to Table 442, Table 443 and Table 444.

The allowed value shall be calculated in conjunction with Table 441 according Formula (53).

Table 442 – Values of ReductionRatio for RT_CLASS_1 and RT_CLASS_2

Value (decimal)	Meaning	Use
1	Mandatory	Transmit and receive every send clock
2	Mandatory	Transmit and receive every second send clock
4	Mandatory	Transmit and receive every forth send clock
8	Mandatory	Transmit and receive every eighth send clock
16	Mandatory	Transmit and receive every sixteenth send clock
32	Mandatory	Transmit and receive every 32 send clock
64	Mandatory	Transmit and receive every 64 send clock
128	Mandatory	Transmit and receive every 128 send clock
256	Mandatory	Transmit and receive every 256 send clock
512	Mandatory	Transmit and receive every 512 send clock
16 385 – 65 535	Reserved	—
other	Optional	—

Table 443 – Values of ReductionRatio for RT_CLASS_3

Value (decimal)	Meaning	Use
1	Mandatory	Transmit and receive every send clock
2	Mandatory	Transmit and receive every second send clock
4	Mandatory	Transmit and receive every forth send clock
8	Mandatory	Transmit and receive every eighth send clock
16	Mandatory	Transmit and receive every sixteenth send clock
16 385 – 65 535	Reserved	—
other	Optional	—

Table 444 – Values of ReductionRatio for RT_CLASS_UDP

Value (decimal)	Meaning	Use
1	Optional	Transmit and receive every send clock
2	Optional	Transmit and receive every second send clock
4	Optional	Transmit and receive every forth send clock
8	Optional	Transmit and receive every eighth send clock
16	Optional	Transmit and receive every sixteenth send clock
32	Optional	Transmit and receive every 32 send clock
64	Optional	Transmit and receive every 64 send clock
128	Mandatory	Transmit and receive every 128 send clock
256	Mandatory	Transmit and receive every 256 send clock
512	Mandatory	Transmit and receive every 512 send clock
1 024	Mandatory	Transmit and receive every 1 024 send clock
2 048	Mandatory	Transmit and receive every 2 048 send clock
4 096	Mandatory	Transmit and receive every 4 096 send clock

Value (decimal)	Meaning	Use
8 192	Mandatory	Transmit and receive every 8 192 send clock
16 384	Mandatory	Transmit and receive every 16 384 send clock
16 385 – 65 535	Reserved	—
other	Optional	—

5.2.4.64 Coding of the field Phase

These fields shall be coded as data type Unsigned16 according to Table 445. It shall be less or equal to the related ReductionRatio.

Table 445 – Values of Phase

Value (decimal)	Meaning	Use
0	Reserved	—
1 – 16 384	Mandatory	But shall not exceed the value of ReductionRatio
16 385 – 65 535	Reserved	—

5.2.4.65 Coding of the field Sequence

These fields shall be coded as data type Unsigned16 according to Table 446.

Table 446 – Values of Sequence

Value (hexadecimal)	Meaning	Use
0	Mandatory, sequence undefined	The PPMs uses a random sequence for each phase
0x0001 – 0xFFFF	Optional, sequence defined	The PPMs uses the given sequence for each phase

NOTE For RT_CLASS_3 is a given sequence used, even if the parameter Sequence is set to zero.

5.2.4.66 Coding of the field DataHoldFactor

These fields shall be coded as data type Unsigned16. The time base is SendClockFactor multiplied with ReductionRatio of the monitored consumer.

The DataHoldTime shall be calculated according to Formula (53).

$$\text{DataHoldTime} = \text{DataHoldFactor} \times \text{SendClockFactor} \times \text{ReductionRatio} \times 31{,}25\ \mu\text{s} \quad (53)$$

where

DataHoldTime is the data hold time
DataHoldFactor is the data hold factor
SendClockFactor is the send clock factor
ReductionRatio is the reduction ratio

The value range for Data-RTC-PDUs is from 0x0003 to 0x1E00. The DataHoldTime shall equal or less than 1,92 s.

The value range for UDP-RTC-PDUs is from 0x0003 to 0xF000. The DataHoldTime shall equal or less than 61,44 s.

For a frame, the usage of the DataHoldFactor is defined in Table 447.

Table 447 – DataHoldFactor of a frame

Value (hexadecimal)	Meaning	Description
0x0000	Reserved	—
0x0001 – 0x0002	Optional	A value “1” leads to an AR termination for one missed frame, a value “2” leads to an AR termination for two missed frames.
0x0003 – 0x00FF	Mandatory	An expiration of the time leads to an AR termination.
0x0100 – 0x1E00	Optional	An expiration of the time leads to an AR termination.
0x1E01 – 0xFFFF	Reserved	—

For a Subframe, the usage of the DataHoldFactor is defined in Table 448.

Table 448 – DataHoldFactor of a Subframe

Value (hexadecimal)	Meaning	Description
0x0000	Reserved	—
0x0001 – 0x0002	Optional	A value “1” leads to an AR termination for one missed frame, a value “2” leads to an AR termination for two missed frames.
0x0003 – 0x001F	Mandatory	An expiration of the time leads to an AR termination.
0x0020 – 0x1E00	Optional	An expiration of the time leads to an AR termination.
0x1E01 – 0xFFFF	Reserved	—

5.2.4.67 Coding of the field FrameSendOffset

This field shall be coded as data type Unsigned32 and set according to Table 449, Figure 82 and Formula (54). The time base is 1 ns.

NOTE The minimal planned gap between two RT_CLASS_3 frames is 1 120 ns.

Table 449 – Values of FrameSendOffset

Value (decimal)	Meaning	Use
0 – 0x00001388	Relative send offset to the start of the related cycle	Optional
0x00001389 – 0x003B28FF	Relative send offset to the start of the related cycle	Mandatory for RT_CLASS_3 Optional for RT_CLASS_1, RT_CLASS_2 and RT_CLASS_UDP
0x003B2900 – 0x003D08FF	Relative send offset to the start of the related cycle Only useable if the frame size fulfill Formula (54)	Mandatory for RT_CLASS_3 Optional for RT_CLASS_1, RT_CLASS_2 and RT_CLASS_UDP

Value (decimal)	Meaning	Use
0x003D0900 – 0xFFFFFFFE	Reserved	Not used
0xFFFFFFFF	Best effort Provider protocol machines sends the frame as soon as possible	Mandatory Not used for PDIRFRameData

$$\text{FrameSendOffset[Frame]} + \text{Duration[Frame]} < \text{SendClockFactor} \times 31{,}25\ \mu\text{s} \quad (54)$$

where

FrameSendOffset is the frame send offset

Frame is the current frame

Duration is the duration

SendClockFactor is the factor of the send clock, the length of one phase

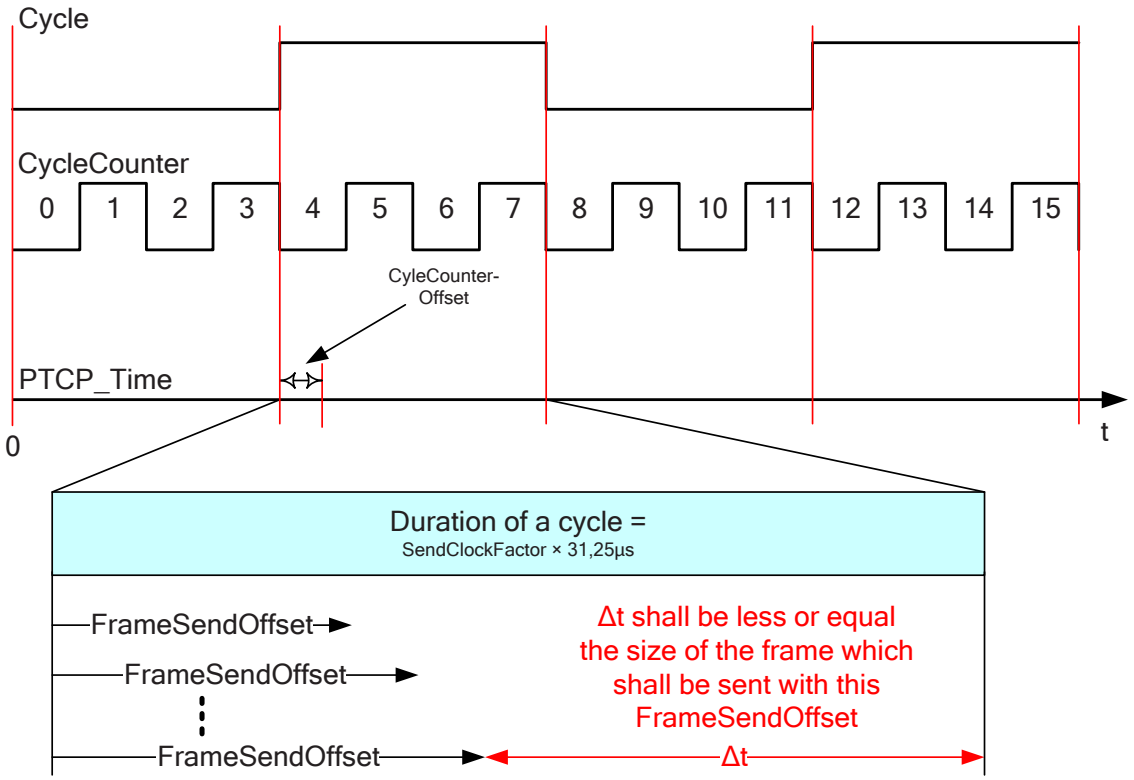


Figure 82 – FrameSendOffset vs. duration of a cycle

5.2.4.68 Coding of the field ModuleState

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 450.

Table 450 – ModuleState

Value (hexadecimal)	Meaning	Use
0x0000	No module	E.g. module not plugged
0x0001	Wrong module [a]	E.g. ModuleIdentNumber wrong
0x0002	Proper module	Module is okay but at least one submodule is locked, wrong or missing
0x0003	Substitute [b]	Module is not the same as requested – but the IO device was able to adapt by its own knowledge
0x0004 – 0xFFFF	Reserved	—

[a] This coding should be avoided if possible. The substitution may be “Substitute” for the module and “Wrong (WR)” for each submodule. See Table 457 for valid combinations.

[b] This coding may be used in combination with “SubmoduleState.IdentInfo := Wrong (WR)”.

5.2.4.69 Coding of the field SubmoduleState

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

5.2.4.69.1 Coding if SubmoduleState.FormatIndicator == 1

Bit 0 – 2: SubmoduleState.AddInfo
This field shall be set according to Table 451.

Table 451 – SubmoduleState.AddInfo

Value (hexadecimal)	Meaning	Description
0x00	None	—
0x01	Takeover is not allowed	This Submodule is not available for takeover by IOSAR.
0x02 – 0x07	Reserved	—

Bit 3: SubmoduleState.QualifiedInfo
This field shall be set according to Table 452.

Table 452 – SubmoduleState.QualifiedInfo

Value (hexadecimal)	Meaning	Description
0x00	No QualifiedInfo available	No Channel of the Submodule contains QualifiedChannelDiagnosis
0x01	QualifiedInfo available	At least one Channel of the Submodule contains QualifiedChannelDiagnosis

Bit 4: SubmoduleState.MaintenanceRequired
This field shall be set according to Table 453.

Table 453 – SubmoduleState.MaintenanceRequired

Value (hexadecimal)	Meaning	Description
0x00	No MaintenanceRequired available	No Channel of the Submodule requires maintenance
0x01	MaintenanceRequired available	At least one Channel of the Submodule requires maintenance

Bit 5: SubmoduleState.MaintenanceDemanded
This field shall be set according to Table 454.

Table 454 – SubmoduleState.MaintenanceDemanded

Value (hexadecimal)	Meaning	Description
0x00	No MaintenanceDemanded available	No Channel of the Submodule demandes maintenance
0x01	MaintenanceDemanded available	At least one Channel of the Submodule demandes maintenance

Bit 6: SubmoduleState.DiagInfo
This field shall be set according to Table 455.

Table 455 – SubmoduleState.DiagInfo

Value (hexadecimal)	Meaning	Description
0x00	No DiagnosisData available	There is no DiagnosisData available/stored for this submodule.
0x01	DiagnosisData available	There is DiagnosisData (with ChannelProperties.Specifier := Appears) available for this submodule: It can be read with the corresponding records.

Bit 7 – 10: SubmoduleState.ARInfo
This field shall be set according to Table 456.

Table 456 – SubmoduleState.ARInfo

Value (hexadecimal)	Meaning	Description
0x00	Own	This AR is owner of the submodule
0x01	ApplicationReadyPending (ARP)	This AR is owner of the submodule but it is blocked. E.g. parameter checking pending
0x02	Superordinated Locked (SO)	This AR is not owner of the submodule. It is blocked by superordinated means
0x03	Locked By IO Controller (IOC)	This AR is not owner of the submodule. It is owned by another IOAR
0x04	Locked By IO Supervisor (IOS)	This AR is not owner of the submodule. It is owned by another IOSAR
0x05 – 0x0F	Reserved	—

Bit 11 – 14: SubmoduleState.IdentInfo
This field shall be set according to Table 457.

Table 457 – SubmoduleState.IdentInfo

Value (hexadecimal)	Meaning	Usable in conjunction with ModuleState "Wrong module"
0x00	OK	No
0x01	Substitute (SU)	No
0x02	Wrong (WR)	Yes
0x03	NoSubmodule (NO)	Yes
0x04 – 0x0F	Reserved	—

Bit 15: SubmoduleState.FormatIndicator

This field shall be set according to Table 458.

Table 458 – SubmoduleState.FormatIndicator

Value (hexadecimal)	Meaning	Use
0x00	Coding uses SubmoduleState.Detail	Shall be supported by an IO controller and IO supervisor.
0x01	Coding uses SubmoduleState.IdentInfo, .ARInfo and .AddInfo	Shall be used by an IO device, IO controller and IO supervisor.

5.2.4.69.2 Coding if SubmoduleState.FormatIndicator == 0

Bit 0 – 14: SubmoduleState.Detail

This field shall be set according to Table 459.

Table 459 – SubmoduleState.Detail

Value (hexadecimal)	Meaning	Use
0x0000	No submodule	—
0x0001	Wrong submodule	—
0x0002	Locked by IO controller	—
0x0003	Reserved	—
0x0004	Application ready pending	Shall only be used in conjunction with IOXControl request (application ready)
0x0005	Reserved	—
0x0006	Reserved	—
0x0007	Substitute	Submodule is not the same as requested – but the IO device was able to adapt In this case the IO device should adapt (e.g. to new input or output length)
0x0008 – 0x7FFF	Reserved	—

NOTE The field SubmoduleState is only responded if there is a difference between expected and real configuration data. SubmoduleState "GOOD" is not defined because for such submodules no status is reported within the ModuleDiffBlock.

Bit 15: SubmoduleState.FormatIndicator

This field shall be set according to Table 458.

5.2.4.70 Coding of the field SubmoduleProperties

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 1: SubmoduleProperties.Type
This field shall be set according to Table 460.

Table 460 – SubmoduleProperties.Type

Value (hexadecimal)	Meaning	Use
0x00	No input and no output data	Submodule without IO data, treated as input without data (for IOCS/IOPS), one Input DataDescription Block follows
0x01	Input data	Submodule with input data, one Input DataDescription Block follows
0x02	Output data	Submodule with output data, one Output DataDescription Block follows
0x03	Input and output data	Submodule with input and output data, one Input and one Output DataDescription Block follows

Bit 2: SubmoduleProperties.SharedInput
This field shall be set according to Table 461.

Table 461 – SubmoduleProperties.SharedInput

Value (hexadecimal)	Meaning	Use
0x00	IO controller	IO controller Can be used together with all possible values of SubmoduleProperties.Type.
0x01	IO controller shared	Only the shared IO controller shall use this value. The shared IO controller does not receive alarms and is restricted to read access. The value shall not be used together with SubmoduleProperties.Type==0x02.

Bit 3: SubmoduleProperties.ReduceInputSubmoduleDataLength
This field shall be set according to Table 462.

Table 462 – SubmoduleProperties.ReduceInputSubmoduleDataLength

Value (hexadecimal)	Meaning	Use
0x00	Expected	Use expected input SubmoduleDataLength for I-CR
0x01	Zero	Reduce input SubmoduleDataLength to zero for I-CR

Bit 4: SubmoduleProperties.ReduceOutputSubmoduleDataLength
This field shall be set according to Table 463.

Table 463 – SubmoduleProperties.ReduceOutputSubmoduleDataLength

Value (hexadecimal)	Meaning	Use
0x00	Expected	Use expected output SubmoduleDatalength for O-CR
0x01	Zero	Reduce output SubmoduleDatalength to zero for O-CR

Bit 5: SubmoduleProperties.DiscardIOXS
This field shall be set according to Table 464.

Table 464 – SubmoduleProperties.DiscardIOXS

Value (hexadecimal)	Meaning	Use
0x00	Expected	Merge all expected IOXS for this submodule in the frames of the corresponding CRs
0x01	Zero	Discard all expected IOXS for this submodule in the frames of the corresponding CRs

Bit 6 – 7: SubmoduleProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 8 – 15: SubmoduleProperties.reserved_2
This field shall be set to zero.

5.2.4.71 Coding of the field ModuleProperties

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 7: ModuleProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 8 – 15: ModuleProperties.reserved_2
This field shall be set to zero.

5.2.4.72 Coding of the field SubstitutionMode

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 465.

Table 465 – SubstitutionMode

Value (hexadecimal)	Meaning	Use
0x0000	ZERO	The outputs are set to zero or inactive
0x0001	Last value	Hold the last valid application value
0x0002	Replacement value	Set the output to the configured replacement value
0x0003 – 0x00FF	Reserved	—
0x0100 – 0x01FF	Reserved for profiles	Shall be used for profiles
0x0200 – 0xFFFF	Reserved	—

5.2.4.73 Coding of the field SubstituteActiveFlag

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 466.

Table 466 – SubstituteActiveFlag

Value (hexadecimal)	Meaning	Use
0x0000	Operation	The outputs are set according to normal control process (substitute inactive)
0x0001	Substitute	The outputs are set according to substitute function (substitute active)
0x0002 – 0xFFFF	Reserved	—

5.2.4.74 Coding of the field InitiatorUDPRTPort

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 467.

Table 467 – InitiatorUDPRTPort

Value (hexadecimal)	Meaning	Use
0x0000 – 0x03FF	IANA_WELL_KNOWN_PORT	Optional Port may be blocked by other protocols
0x0400 – 0xBFFF	IANA_DEFINED_PORT	Usable
0x8892	Default for unicast IANA_PNIO_UDP_UNICAST_PORT	Recommended
0x8893	Default for multicast IANA_PNIO_UDP_MULTICAST_PORT	Recommended
0xC000 – 0xFFFF	IANA_FREE_PORT is used as dynamic and/or private port	Usable

5.2.4.75 Coding of the field ResponderUDPRTPort

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 468.

Table 468 – ResponderUDPRTPort

Value (hexadecimal)	Meaning	Use
0x0000 – 0x03FF	IANA_WELL_KNOWN_PORT	Optional Port may be blocked by other protocols
0x0400 – 0xBFFF	IANA_DEFINED_PORT	Usable
0x8892	Default for unicast IANA_PNIO_UDP_UNICAST_PORT	Recommended
0x8893	Default for multicast IANA_PNIO_UDP_MULTICAST_PORT	Recommended
0xC000 – 0xFFFF	IANA_FREE_PORT is used as dynamic and/or private port	Usable

5.2.4.76 Coding of the field InitiatorRPCServerPort

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 469.

Table 469 – InitiatorRPCServerPort

Value (hexadecimal)	Meaning	Use
0x0000 – 0x03FF	IANA_WELL_KNOWN_PORT	Reserved
0x0400 – 0xBFFF	IANA_DEFINED_PORT	Useable
0xC000 – 0xFFFF	IANA_FREE_PORT is used as dynamic and/or private port	Recommended

5.2.4.77 Coding of the field ResponderRPCServerPort

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 470.

Table 470 – ResponderRPCServerPort

Value (hexadecimal)	Meaning	Use
0x0000 – 0x03FF	IANA_WELL_KNOWN_PORT	Reserved
0x0400 – 0xBFFF	IANA_DEFINED_PORT	Useable
0xC000 – 0xFFFF	IANA_FREE_PORT is used as dynamic and/or private port	Recommended

5.2.4.78 Coding of the field LocalAlarmReference

This field shall be coded as data type Unsigned16. This field shall contain the value of the reference of the IO controller within AlarmCRBlockReq and shall contain the value of the reference of the IO device within AlarmCRBlockRes.

In the ARData, this field contains the reference of the IO controller received by the AlarmCRBlockReq.

5.2.4.79 Coding of the field RemoteAlarmReference

This field shall be coded as data type Unsigned16. This field shall contain the value of the reference of the IO device, transmitted within AlarmCRBlockRes to the IO controller, within ARData.

5.2.4.80 Coding of the field MaxAlarmDataLength

This field shall be coded as data type Unsigned16 with values according to Table 471.

Table 471 – MaxAlarmDataLength

Value (hexadecimal)	Meaning
0x00C8	Mandatory Maximal size of the AlarmNotification-PDU accepted by the AlarmEndpoint.
0x00C9 – 0x0598	Optional Maximal size of the AlarmNotification-PDU accepted by the AlarmEndpoint.
other	Reserved

An AlarmEndpoint shall not create larger AlarmNotification-PDUs than negotiated during AR establishment.

5.2.4.81 Coding of the field ParameterServerProperties

This field shall be coded as data type Unsigned32. This field is reserved for future use.

5.2.5 Coding section related to ARVendorBlock

5.2.5.1 Coding of the field APStructureIdentifier

This field, defined as an administrative number, shall be coded as data type Unsigned16 according to Table 472 and Table 473.

Table 472 – APStructureIdentifier with API := 0

Value (hexadecimal)	Meaning
0 – 0x7FFF	Vendor specific This key defines in combination with the key API the structure of Data in ARVendorBlockReq and ARVendorBlockRes.
0x8000	Extended identification rules Used for common profile “Controller to controller communication”
0x8001 – 0xFFFF	Administrative number This key defines in combination with the key API the structure of Data in ARVendorBlockReq and ARVendorBlockRes.

Table 473 – APStructureIdentifier with API != 0

Value (hexadecimal)	Meaning
0 – 0xFFFF	Administrative number for application profiles This key defines in combination with the key API the structure of Data in ARVendorBlockReq and ARVendorBlockRes.

5.2.5.2 Coding of the field ExtendedIdentificationUUID

This field shall be coded as data type UUID.

5.2.5.3 Coding of the field ExtendedIdentificationVersionHigh

This field shall be coded as data type Unsigned8 with the values according to Table 474.

Table 474 – ExtendedIdentificationVersionHigh

Value (hexadecimal)	Meaning	Use
0x00	Reserved	—
0x01	Version 1	Indicates Version 1
0x02 – 0xFF	Version 2 to version 255	Indicates version 2 to 255

5.2.5.4 Coding of the field ExtendedIdentificationVersionLow

This field shall be coded as data type Unsigned8 with the values according to Table 475.

Table 475 – ExtendedIdentificationVersionLow

Value (hexadecimal)	Meaning	Use
0x00	Version 0	Indicates version 0
0x01	Version 1	Indicates version 1
0x02 – 0xFF	Version 2 to version 255	Indicates version 2 to 255

5.2.6 Coding section related to PNIOStatus

5.2.6.1 General

In general, the value ErrorCode=0, ErrorDecode=0, ErrorCode1=0 and ErrorCode2=0 shall be used to indicate “okay”.

Furthermore, in case of an illegal combination of address parameters within an IODReadReq the value ErrorCode=“IODReadRes”, ErrorDecode=“PNIORW”, ErrorCode1=“access-invalid area” and ErrorCode2 may be used to indicate the faulty parameter.

NOTE An illegal address combination is for example TargetARUUID==zero and ARUUID==zero in ReadExpectedIdentification service.

5.2.6.2 Coding of the field ErrorCode

This field shall be coded as data type Unsigned8. The usage is defined in Table 476.

Table 476 – Values of ErrorCode for negative responses

Value (hexadecimal)	Meaning	Use
0x00	Reserved	Special case “No Error”: ErrorCode = 0, ErrorDecode = 0, ErrorCode1 = 0, ErrorCode2 = 0
0x01 – 0x1F	Reserved	—
0x20 – 0x3F	Manufacturer specific	Within the LogBookData
0x40 – 0x80	Reserved	—
0x81	PNIO	Used for all errors not covered elsewhere.
0x82 – 0xCE	Reserved	—
0xCF	RTA error	Within the ERR-RTA-PDU and UDP-RTA-PDU
0xD0 – 0xD9	Reserved	—

Value (hexadecimal)	Meaning	Use
0xDA	AlarmAck	Within the DATA-RTA-PDU and UDP-RTA-PDU
0xDB	IODConnectRes	Within the CL-RPC-PDU
0xDC	IODReleaseRes	Within the CL-RPC-PDU
0xDD	IODControlRes, IOXControlRes	Within the CL-RPC-PDU
0xDE	IODReadRes	Within the CL-RPC-PDU only used with ErrorDecode=PNIORW
0xDF	IODWriteRes	Within the CL-RPC-PDU only used with ErrorDecode=PNIORW
0xE0 – 0xEF	Reserved	—
0xF0 – 0xFF	Reserved	—

5.2.6.3 Coding of the field ErrorDecode

This field shall be coded as data type Unsigned8. The usage is defined in Table 477.

Table 477 – Values of ErrorDecode

Value (hexadecimal)	Meaning	Use
0x00	Reserved	See Table 476
0x01 – 0x7F	Reserved	—
0x80	PNIORW [a]	Used in context with user error codes of the services Read and Write
0x81	PNIO	Used in context with other services or internal e.g. RPC errors
0x82	Manufacturer Specific	Used only in context of LogBookData
0x83 – 0xFF	Reserved	—
[a] Equivalent to IEC 61158-6-3 (DPV1)		

5.2.6.4 Coding of the field ErrorCode1 and ErrorCode2

5.2.6.4.1 General

These fields shall be coded as data type Unsigned8.

The field ErrorDecode defines the coding and meaning of ErrorCode1 and ErrorCode2.

5.2.6.4.2 ErrorDecode value PNIORW

The ErrorDecode value PNIORW indicate that the parameters ErrorCode1 shall be set according to Table 478. The ErrorCode1 consists of ErrorClass and ErrorDecode.

Table 478 – Coding of ErrorCode1 with ErrorDecode PNIORW

ErrorCode1		
ErrorClass (decimal) **Bit7 – 4**	**Meaning**	**ErrorCode (decimal)** **Bit3 – 0**
0 to 9	Not specified	Reserved
10	Application	0 = read error 1 = write error 2 = module failure 3 = not specified 4 = not specified 5 = not specified 6 = not specified 7 = busy 8 = version conflict 9 = feature not supported 10 = User specific 1 11 = User specific 2 12 = User specific 3 13 = User specific 4 14 = User specific 5 15 = User specific 6
11	Access	0 = invalid index 1 = write length error 2 = invalid slot / subslot 3 = type conflict 4 = invalid area / API 5 = state conflict 6 = access denied 7 = invalid range 8 = invalid parameter 9 = invalid type 10= backup 11 = User specific 7 12 = User specific 8 13 = User specific 9 14 = User specific 10 15 = User specific 11
12	Resource	0 = read constrain conflict 1 = write constrain conflict 2 = resource busy 3 = resource unavailable 4 = not specified 5 = not specified 6 = not specified 7 = not specified 8 = User specific 12 9 = User specific 13 10 = User specific 14 11 = User specific 15 12 = User specific 16 13 = User specific 17 14 = User specific 18 15 = User specific 19
13 to 15	User specific	User specific
NOTE Not specified values are used to serve legacy codes and are intended to be passed unchanged to the application.		

The ErrorDecode value PNIORW indicates that the parameter ErrorCode2 shall be set according to Table 479.

Table 479 – Coding of ErrorCode2 with ErrorDecode PNIORW

ErrorCode2 (hexadecimal)	Meaning	Usage
0x00 – 0xFF	User specific	—

5.2.6.4.3 ErrorDecode value PNIO

The ErrorDecode value PNIO indicates that the parameter ErrorCode1 shall be set according to Table 480, Table 481, Table 482, Table 483, Table 484, Table 485, Table 486 and the definitions of 4.10.2.3.6.

Table 480 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 1)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
0	Reserved	0 – 255	Reserved
1	Connect Parameter Error Faulty ARBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		13	Error in Parameter NameOfStation
		14 – 255	Reserved
2	Connect Parameter Error Faulty IOCRBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		28	Error in Parameter IOCSFrameOffset production
		29 – 255	Reserved
3	Connect Parameter Error Faulty ExpectedSubmoduleBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		16	Error in Parameter LengthIOCS production
		17 – 255	Reserved
4	Connect Parameter Error Faulty AlarmCRBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		15	Error in Parameter AlarmCRTagHeaderLow
		16 – 255	Reserved
5	Connect Parameter Error Faulty PrmServerBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		8	Error in Parameter ParameterServerStationName
		9 – 255	Reserved
6	Connect Parameter Error Faulty MCRBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
		…	…
		8	Error in Parameter ProviderStationName
		9 – 255	Reserved
7	Connect Parameter Error Faulty ARRPCBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		4	Error in Parameter InitiatorRPCServerPort
		5 – 255	Reserved
8	Read Write Record Parameter Error Faulty Record	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		12	Error in Parameter TargetARUUID
		13 – 255	Reserved
9	Connect Parameter Error Faulty IRInfoBlock	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		5	Error in Parameter IRDataUUID
		6 – 255	Reserved
10	Connect Parameter Error Faulty SRInfoBlock	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		5	Error in Parameter SRProperties
		6 – 255	Reserved
11	Connect Parameter Error Faulty ARFSUBlock	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		5	FastStartUpBlock
		6 – 255	Reserved
12	Connect Parameter Error Faulty ARVendorBlockReq	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		5	Error in Parameter API
		6	Error in Parameter Data*
		7 – 255	Reserved
13 – 19	Reserved	0 – 255	Reserved
20	IODControl Parameter Error Faulty ControlBlockConnect	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		9	Error in Parameter ControlBlockProperties
		10 – 255	Reserved

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
21	IODControl Parameter Error Faulty ControlBlockPlug	0	Error in Parameter BlockType
		…	…
		9	Error in Parameter ControlBlockProperties
		10 – 255	Reserved
22	IOXControl Parameter Error Faulty ControlBlockConnect after a connection establishment	0	Error in Parameter BlockType
		…	…
		7	Error in Parameter ControlBlockProperties
		8 – 255	Reserved
23	IOXControl Parameter Error Faulty ControlBlockPlug after a plug alarm	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		7	Error in Parameter ControlBlockProperties
		8 – 255	Reserved
24	IODControl Parameter Error Faulty ControlBlockPrmBegin	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		9	Error in Parameter ControlBlockProperties
		10 – 255	Reserved
25	IODControl Parameter Error Faulty SubmoduleListBlock	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		7	Error in Parameter SubslotNumber
		8 – 255	Reserved
26 – 39	Reserved	0 – 255	Reserved
40	Release Parameter Error Faulty ReleaseBlock	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		7	Error in Parameter ControlBlockProperties
		8 – 255	Reserved
41 – 49	Reserved	0 – 255	Reserved
50	Response Parameter Error Faulty ARBlockRes	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		8	Error in Parameter ResponderUDPRTPort
		9 – 255	Reserved
51	Response Parameter Error Faulty IOCRBlockRes	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		6	Error in Parameter FrameID

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
		7 – 255	Reserved
52	Response Parameter Error Faulty AlarmCRBlockRes	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		6	Error in Parameter MaxAlarmDataLength
		7 – 255	Reserved
53	Response Parameter Error Faulty ModuleDiffBlock	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		13	Error in Parameter SubmoduleState
		14 – 255	Reserved
54	Response Parameter Error Faulty ARRPCBlockRes	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		4	Error in Parameter ResponderRPCServerPort
		5 – 255	Reserved
55	Response Parameter Error Faulty ARServerBlockRes	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		4	Error in Parameter CMResponderStationName
		5 – 255	Reserved
56	Response Parameter Error Faulty ARVendorBlockRes	0	Error in Parameter BlockType
		1	Error in Parameter Length
		…	…
		5	Error in Parameter API
		6	Error in Parameter Data*
		7 – 255	Reserved
57 – 59	Reserved	0 – 255	Reserved

Table 481 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 2 – alarm acknowledge)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
60	AlarmAck Error Codes	0	Alarm Type Not Supported
		1	Wrong Submodule State
		2	IOCARSR Backup - Alarm not executed
		3 – 255	Reserved

Table 482 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 3 – machines)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
65	ALPMI	0	Invalid state
		1	Wrong ACK-PDU
		2	Invalid
		3	Wrong state
		4 – 255	Reserved
66	ALPMR	0	Invalid state
		1	Wrong Notification PDU
		2	Invalid
		3	Wrong state
		4 – 255	Reserved
67	LMPM	0 – 255	Usage see protocol machines and stored as LogBook entries
68	MAC	0 – 255	Usage see protocol machines and stored as LogBook entries
69	RPC	0 – 255	see Table 486
70	APMR	0	Invalid state
		1	LMPM signaled an error
		2 – 255	Reserved
71	APMS	0	Invalid state
		1	LMPM signaled an error
		2	Timeout
		3 – 255	Reserved
72	CPM	0	Invalid state
		1 – 255	Reserved
73	PPM	0	Invalid state
		1 – 255	Reserved
74	Used by DCPUCS	0	Invalid state
		1	LMPM signaled an error
		2	Timeout
		3 – 255	Reserved
75	Used by DCPUCR	0	Invalid state
		1	LMPM signaled an error
		2 – 255	Reserved
76	Used by DCPMCS	0	Invalid state
		1	LMPM signaled an error
		2 – 255	Reserved
77	Used by DCPMCR	0	Invalid state
		1	LMPM signaled an error
		2 – 255	Reserved
78	FSPM	0 – 255	Usage see protocol machines and stored as LogBook entries

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
79 – 99	Reserved	0 – 255	Reserved
121 – 199	Reserved	0 – 255	Reserved
221 – 252	Reserved	0 – 255	Reserved

Table 483 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 4 – IO controller)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
62	CMCTL	0	State conflict
		1	Timeout
		2	No data send
		3	Out of resource
		4 – 255	Reserved
63	CTLDINA (successor of the NRPM)	0	No DCP active / No Link
		1	DNS unknown RealStationName
		2	DCP no RealStationName
		3	DCP multiple RealStationName
		4	DCP no StationName
		5	No IP address
		6	DCP set error
		7 – 255	Reserved
100	CTLSM	0	Invalid state
		1	CTLSM signaled an error
		2 – 255	Reserved
101	CTLRDI	0	Invalid state
		1	CTLRDI signaled an error
		2 – 255	Reserved
102	CTLRDR	0	Invalid state
		1	CTLRDR signaled an error
		2 – 255	Reserved
103	CTLWRI	0	Invalid state
		1	CTLWRI signaled an error
		2 – 255	Reserved
104	CTLWRR	0	Invalid state
		1	CTLWRR signaled an error
		2 – 255	Reserved
105	CTLIO	0	Invalid state
		1	CTLIO signaled an error
		2 – 255	Reserved
106	CTLSU	0	Invalid state
		1	AR add provider or consumer failed

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
		2	AR alarm-open failed
		3	AR alarm-ack-send
		4	AR alarm-send
		5	AR alarm-ind
		6 – 255	Reserved
107	CTLRPC	0	Invalid state
		1	CTLRPC signaled an error
		2 – 255	Reserved
108	CTLPBE	0	Invalid state
		1	CTLPBE signaled an error
		2 – 255	Reserved
109 – 120	Reserved	0 – 255	Reserved

Table 484 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 5 – IO device)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
61	CMDEV	0	State conflict
		1	Resource
		2 – 255	Usage see protocol machines and stored as LogBook entries
64	CMRPC (successor of the RMPM)	0	ArgsLength invalid
		1	Unknown blocks
		2	IOCR missing
		3	Wrong block count (e.g. wrong AlarmCRBlock count)
		4	Out of AR resources
		5	AR UUID unknown
		6	State conflict
		7	Out of Provider, Consumer, or Alarm Resources
		8	Out of memory
		9	Pdev already owned
		10	ARset State conflict during connection establishment
		11	ARset Parameter conflict during connection establishment
		12 – 255	Reserved
200	CMSM	0	Invalid state
		1	CMSM signaled an error
		2 – 255	Reserved
201	Reserved	0 – 255	Reserved

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
202	CMRDR	0	Invalid state
		1	CMRDR signaled an error
		2 – 255	Reserved
203	Reserved	0 – 255	Reserved
204	CMWRR	0	Invalid state
		1	AR is not in state Primary. In this case the write of a record is not allowed.
		2	CMWRR signaled an error
		3 – 255	Reserved
205	CMIO	0	Invalid state
		1	CMIO signaled an error
		2 – 255	Reserved
206	CMSU	0	Invalid state
		1	AR add provider or consumer failed
		2	AR alarm-open failed
		3	AR alarm-send
		4	AR alarm-ack-send
		5	AR alarm-ind
		6 – 255	Reserved
207	Reserved	0 – 255	Reserved
208	CMINA	0	Invalid state
		1	CMINA signaled an error
		2 – 255	Reserved
209	CMPBE	0	Invalid state
		1	CMPBE signaled an error
		2 – 255	Reserved
210	CMDMC	0	Invalid state
		1	CMDMC signaled an error
		2 – 255	Reserved
211 – 220	Reserved	0 – 255	Reserved

Table 485 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 6 – abort reasons)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
253	Used by RTA for protocol error (RTA_ERR_CLS_PROTOCOL)	0	Reserved
		1	Error within the coordination of sequence numbers (RTA_ERR_CODE_SEQ) error
		2	Instance closed (RTA_ERR_ABORT)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
		3	AR out of memory (RTA_ERR_ABORT)
		4	AR add provider or consumer failed (RTA_ERR_ABORT)
		5	AR consumer DHT expired (RTA_ERR_ABORT)
		6	AR cmi timeout (RTA_ERR_ABORT)
		7	AR alarm-open failed (RTA_ERR_ABORT)
		8	AR alarm-send.cnf(-) (RTA_ERR_ABORT)
		9	AR alarm-ack-send.cnf(-) (RTA_ERR_ABORT)
		10	AR alarm data too long (RTA_ERR_ABORT)
		11	AR alarm.ind(err) (RTA_ERR_ABORT)
		12	AR rpc-client call.cnf(-) (RTA_ERR_ABORT)
		13	AR abort.req (RTA_ERR_ABORT)
		14	AR re-run aborts existing (RTA_ERR_ABORT)
		15	AR release.ind received (RTA_ERR_ABORT)
		16	AR device deactivated (RTA_ERR_ABORT)
		17	AR removed (RTA_ERR_ABORT)
		18	AR protocol violation (RTA_ERR_ABORT)
		19	AR name resolution error (RTA_ERR_ABORT)
		20	AR RPC-Bind error (RTA_ERR_ABORT)
		21	AR RPC-Connect error (RTA_ERR_ABORT)
		22	AR RPC-Read error (RTA_ERR_ABORT)
		23	AR RPC-Write error (RTA_ERR_ABORT)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
		24	AR RPC-Control error (RTA_ERR_ABORT)
		25	AR forbidden pull or plug after check.rsp and before in-data.ind (RTA_ERR_ABORT)
		26	AR AP removed (RTA_ERR_ABORT)
		27	AR link down (RTA_ERR_ABORT)
		28	AR could not register multicast-mac address (RTA_ERR_ABORT)
		29	Not synchronized (cannot start companion-ar) (RTA_ERR_ABORT)
		30	Wrong topology (cannot start companion-ar) (RTA_ERR_ABORT)
		31	DCP, station-name changed (RTA_ERR_ABORT)
		32	DCP, reset to factory or factory reset (RTA_ERR_ABORT)
		33	Can’t start companion-AR because a 0xLIPP submodule in the first AR... (RTA_ERR_ABORT)
		34	No IRDATA record yet (RTA_ERR_ABORT)
		35	Pdev, owner is leaving (RTA_ERROR_ABORT)
		36	Pdev, no port offers required speed/duplexity (RTA_ERROR_ABORT)
		37	IP-Suite [of the IOC] changed by means of DCP_set(IPParameter) or local engineering (RTA_ERROR_ABORT)
		38	IOCARSR RDHT expired (RTA_ERROR_ABORT)
		39	IOCARSR Pdev, parametrization impossible (RTA_ERROR_ABORT)
		40	Remote application ready timeout expired (RTA_ERROR_ABORT)

Value ErrorCode1 (decimal)	Meaning	Value ErrorCode2 (decimal)	Meaning/Usage
		41	IOCARSR Redundant interface lost or access to the peripherals impossible (RTA_ERROR_ABORT)
		42 – 200	Reserved
		201 – 255	Manufacturer specific
254	Reserved	0 – 255	Reserved
255	User specific	0 – 254	User specific
		255	Recommended for “User abort” without further detail

Table 486 – Values of ErrorCode2 for ErrorCode1 = RPC

Value (decimal)	Definition	Meaning
0	Reserved	—
1	CLRPC_ERR_REJECTED	Endpoint mapper or server did reject the call. For further details see Table 255 and Table 256.
2	CLRPC_ERR_FAULTED	Server had a fault while executing the call. For further details see Table 255 and Table 256.
3	CLRPC_ERR_TIMEOUT	Endpoint mapper or server did not respond
4	CLRPC_ERR_IN_ARGS	Broadcast or maybe “ndr_data” too large
5	CLRPC_ERR_OUT_ARGS	Server sent back more than “alloc_len”
6	CLRPC_ERR_DECODE	Result of endpoint mapper “lookup” could not be decoded
7	CLRPC_ERR_PNIO_OUT_ARGS	Out-args not “PN IO signature”, too short or inconsistent
8	CLRPC_ERR_PNIO_APP_TIMEOUT	RPC call was terminated after RPC application timeout
9 to 255	Reserved	—

5.2.6.4.4 ErrorDecode value ManufacturerSpecific

The ErrorDecode value ManufacturerSpecific indicates that the parameter ErrorCode1 and ErrorCode2 shall be set according to Table 487 and Table 488.

Table 487 – Coding of ErrorCode1 for ErrorDecode with the value ManufacturerSpecific

ErrorCode1 (hexadecimal)	Meaning	Usage
0x00 – 0xFF	Manufacturer specific	—

Table 488 – Coding of ErrorCode2 for ErrorDecode with the value ManufacturerSpecific

ErrorCode2 (hexadecimal)	Meaning	Usage
0x00 – 0xFF	Manufacturer specific	—

5.2.7 Coding section related to I&M Records

5.2.7.1 General

All data with type VisibleString shall be left justified. If the text is shorter than the defined string length, the gap shall be filled with blanks.

5.2.7.2 Coding of the field IM_Serial_Number

This field shall be coded as data type VisibleString[16]. The value shall be set manufacturer specific and shall be filled with blanks if it is shorter than 16 octets.

It uniquely identifies one produced entity and is thus an extension of VendorID, DeviceID, ModuleIdentNumber, and SubmoduleIdentNumber.

5.2.7.3 Coding of the field IM_Hardware_Revision

This field shall be coded as data type Unsigned16 with the values according to Table 489.

Table 489 – IM_Hardware_Revision

Value (hexadecimal)	Meaning
0x0000 – 0xFFFF	Hardware revision

5.2.7.4 Coding of the field IM_SWRevision_Functional_Enhancement

This field shall be coded as data type Unsigned8 with the values according to Table 490.

Table 490 – IM_SWRevision_Functional_Enhancement

Value (hexadecimal)	Meaning
0x00 – 0xFF	Functional Enhancement

5.2.7.5 Coding of the field IM_SWRevision_Bug_Fix

This field shall be coded as data type Unsigned8 with the values according to Table 491.

Table 491 – IM_SWRevision_Bug_Fix

Value (hexadecimal)	Meaning
0x00 – 0xFF	Bug Fix

5.2.7.6 Coding of the field IM_SWRevision_Internal_Change

This field shall be coded as data type Unsigned8 with the values according to Table 492.

Table 492 – IM_SWRevision_Internal_Change

Value (hexadecimal)	Meaning
0x00 – 0xFF	Internal Change

5.2.7.7 Coding of the field IM_Revision_Counter

This field shall be coded as data type Unsigned16 with the values according to Table 493.

Table 493 – IM_Revision_Counter

Value (hexadecimal)	Meaning	Usage
0x0000	Revision Counter	Mandatory
0x0001 – 0xFFFF	Revision Counter	Optional

5.2.7.8 Coding of the field IM_Profile_ID

This field, defined as an administrative number, shall be coded as data type Unsigned16 with the values according to Table 494.

Table 494 – IM_Profile_ID

Value (hexadecimal)	Meaning
0x0000	Non profile device
0x0001 – 0xF6FF	Administrative number
0xF700 – 0xFFFE	Reserved for profiles
0xFFFF	Reserved

NOTE 1 Depends on 5.2.3.1.

NOTE 2 In the future this standard may extend this field to Unsigned32.

5.2.7.9 Coding of the field IM_Profile_Specific_Type

This field, defined as an administrative number, shall be coded as data type Unsigned16 with the values according to Table 495 and Table 496.

Table 495 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID := 0x0000

Value (hexadecimal)	Meaning
0x0000	Unspecified
0x0001	Standard Controller, e.g. Programable Logic Controller
0x0002	PC-based Station
0x0003	IO-Module
0x0004	Communication Module
0x0005	Interface Module
0x0006	Active Network Infrastructure Component
other	—

Table 496 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID range 0x0001 – 0xF6FF

Value (hexadecimal)	Meaning
0x0000	Unspecified, if not defined otherwise by the profile
0x0001 – 0xFFFF	Using shall be defined by profiles and will be treated as a subversion of the profile

5.2.7.10 Coding of the field IM_Version_Major

This field shall be coded as data type Unsigned8 with the values according to Table 497.

Table 497 – IM_Version_Major

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Shall set in this version
0x02 – 0xFF	Reserved

5.2.7.11 Coding of the field IM_Version_Minor

This field shall be coded as data type Unsigned8 with the values according to Table 498.

Table 498 – IM_Version_Minor

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	Shall set in this version
0x02 – 0xFF	Reserved

5.2.7.12 Coding of the field IM_Supported

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0: IM_Supported.Profile_specific
This field should be set to zero.

NOTE An application profile can define a different behavior.

Bit 1: IM_Supported.I&M1
This field shall be set according to Table 499.

Table 499 – IM_Supported.I&M1

Value (hexadecimal)	Meaning
0x00	Not supported
0x01	The record allows read and write access.

A write access may by denied by the application.

Bit 2: IM_Supported.I&M2
This field shall be set according to Table 499.

Bit 3: IM_Supported.I&M3
This field shall be set according to Table 499.

Bit 4: IM_Supported.I&M4
This field shall be set according to Table 499.

Bit 5: IM_Supported.I&M5
This field shall be set according to Table 499.

Bit 6: IM_Supported.I&M6
This field shall be set according to Table 499.

Bit 7: IM_Supported.I&M7
This field shall be set according to Table 499.

Bit 8: IM_Supported.I&M8
This field shall be set according to Table 499.

Bit 9: IM_Supported.I&M9
This field shall be set according to Table 499.

Bit 10: IM_Supported.I&M10
This field shall be set according to Table 499.

Bit 11: IM_Supported.I&M11
This field shall be set according to Table 499.

Bit 12: IM_Supported.I&M12
This field shall be set according to Table 499.

Bit 13: IM_Supported.I&M13
This field shall be set according to Table 499.

Bit 14: IM_Supported.I&M14
This field shall be set according to Table 499.

Bit 15: IM_Supported.I&M15
This field shall be set according to Table 499.

5.2.7.13 Coding of the field IM_Tag_Function

This field shall be coded as data type VisibleString[32]. The value shall be set manufacturer specific and shall be filled with blanks if it is shorter than 32 octets.

NOTE The VisibleString[32] filled with the character blank ‘ ‘ is the reset to factory value.

5.2.7.14 Coding of the field IM_Tag_Location

This field shall be coded as data type VisibleString[22]. The value shall be set manufacturer specific and shall be filled with blanks if it is shorter than 22 octets.

NOTE The VisibleString[22] filled with the character blank ‘ ‘ is the reset to factory value.

5.2.7.15 Coding of the field IM_Date

This field shall be coded as data type VisibleString[16] with the values according to Table 500.

The string format “YYYY-MM-DD’T’HH:MM’Z’” or “YYYY-MM-DD’T’HH:MM’±HH:MM’” is in accordance with ISO 8601.

The letter ‘T’ indicates, that a time value follows after the date and the letter ‘Z’ indicates, that the time value is a UTC time.

For legacy reasons the ‘T’ is replaced by “ “ and the time zone information ‘Z’ or ’±HH:MM’ is discarded.

Table 500 – IM_Date

Octet	Meaning	Usage
0 – 3	YYYY	Year with four digits
4	“–“	Character dash ‘–‘ as separator
5 – 6	MM	Month with two digits
7	“–“	Character dash ‘–‘ as separator
8 – 9	DD	Day with two digits
10	“ “	Character blank ‘ ‘ as separator
11 – 12	HH	Hour with two digits
13	“:”	Character colon ‘:‘ as separator
14 – 15	MM	Minute with two digits

NOTE The VisibleString[16] filled with the character blank ‘ ‘ is the reset to factory value.

5.2.7.16 Coding of the field IM_Descriptor

This field shall be coded as data type VisibleString[54]. The value shall be set manufacturer specific and shall be filled with blanks if it is shorter than 54 octets.

NOTE The VisibleString[54] filled with the character blank ‘ ‘ is the reset to factory value.

5.2.7.17 Coding of the field IM_Signature

This field shall be coded as data type OctetString[54]. The value shall be set manufacturer specific and shall be filled with zero if it is shorter than 54 octets.

NOTE The OctetString[54] filled with zero or an application default is the reset to factory value.

5.2.8 Coding section related to Alarm and Diagnosis PDUs

5.2.8.1 Coding of the field UserStructureIdentifier

This field shall be coded as data type Unsigned16 with the values according to Table 501. This field identifies the structure of the field Data of the AlarmNotification and structure of the field Data of the alarm data.

Table 501 – UserStructureIdentifier

Value (hexadecimal)	Meaning	Usage
0x0000 – 0x7FFF	ManufacturerSpecific	ManufacturerSpecific Diagnosis shall be used in conjunction with following AlarmTypes: All Diagnosis ASE attached AlarmTypes ManufacturerSpecific Diagnosis shall be used in conjunction with following records: All records containing Diagnosis Data In conjunction with other alarm types the usage is manufacturer specific.
0x8000	ChannelDiagnosis	ChannelDiagnosis shall be used in conjunction with following AlarmTypes: All Diagnosis ASE attached AlarmTypes ChannelDiagnosis shall be used in conjunction with following Records: All records containing Diagnosis Data
0x8001	Multiple	Reserved
0x8002	ExtChannelDiagnosis	ExtChannelDiagnosis shall be used in conjunction with following AlarmTypes: All Diagnosis ASE attached AlarmTypes ExtChannelDiagnosis shall be used in conjunction with following Records: All records containing Diagnosis Data
0x8003	QualifiedChannel-Diagnosis	QualifiedChannelDiagnosis shall be used in conjunction with following AlarmTypes: All Diagnosis ASE attached AlarmTypes QualifiedChannelDiagnosis shall be used in conjunction with following Records: All records containing Diagnosis Data
0x8004 – 0x80FF	Reserved	—
0x8100	Maintenance	Maintenance shall be used in conjunction with following AlarmTypes: All Diagnosis ASE attached AlarmTypes Furthermore, the AlarmNotification shall only convey this block if the alarm source contains at least one Maintenance Required entry, or one Maintenance Demanded entry, or one Qualifier_x entry. Otherwise the block shall be omitted.
0x8101 – 0x81FF	Reserved	—
0x8200	Upload&Retrieval	Upload&Retrieval shall be used in conjunction with upload and retrieval notification.
0x8201	iParameter	iParameter shall be used in conjunction with upload and retrieval notification.
0x8202 – 0x8FFF	Reserved	—

Value (hexadecimal)	Meaning	Usage
0x8300	Sequence of events	Sequence of events shall be used in conjunction with following AlarmTypes: Process alarm
0x8301 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	—
0xA000 – 0xFFFF	Reserved	—

5.2.8.2 Coding of the field ChannelErrorType

This field shall be coded as data type Unsigned16 with the values according to Table 502.

Table 502 – ChannelErrorType

Value (hexadecimal)	Meaning	Assigned text
0x0000	Reserved	Unknown error
0x0001	Short circuit	Short circuit
0x0002	Undervoltage	Undervoltage
0x0003	Overvoltage	Overvoltage
0x0004	Overload	Overload
0x0005	Overtemperature	Overtemperature
0x0006	Line break	Line break
0x0007	Upper limit value exceeded	Upper limit value exceeded
0x0008	Lower limit value exceeded	Lower limit value exceeded
0x0009	Error	Error
0x000A	Simulation active	Simulation active
0x000B	Reserved	Unknown error
0x000C	Reserved	Unknown error
0x000D	Reserved	Unknown error
0x000E	Reserved	Unknown error
0x000F	Default for “parameter missing” [b]	The channel needs (additional) parameters. No or too less parameters are written
0x0010	Default for “parameterization fault” [b]	Parameterization fault. Wrong or too many parameters are written
0x0011	Default for “power supply fault” [b]	Power supply fault
0x0012	Default for “fuse blown / open” [b]	Fuse blown / open
0x0013	Default for “communication fault” [b]	Communication fault. Sequence number wrong / sequence wrong
0x0014	Default for “ground fault” [b]	Ground fault
0x0015	Default for “reference point lost” [b]	Reference point lost
0x0016	Default for “process event lost / sampling error” [b]	Process event lost / sampling error
0x0017	Default for “threshold warning” [b]	Threshold warning
0x0018	Default for “output disabled” [b]	Output disabled
0x0019	Default for “safety event” [b]	Safety event
0x001A	Default for “external fault” [b]	External fault

Value (hexadecimal)	Meaning	Assigned text
0x001B	Manufacturer specific	Manufacturer specific
0x001C	Manufacturer specific	Manufacturer specific
0x001D	Manufacturer specific	Manufacturer specific
0x001E	Manufacturer specific	Manufacturer specific
0x001F	Default for “temporary fault” [b]	Temporary fault
0x0020 – 0x00FF	Reserved for common profiles [a]	Central administrative number to unambiguously distinguish between common profiles
0x0100 – 0x7FFF	Manufacturer specific	Manufacturer specific
0x8000	Data transmission impossible	Data Transmission Impossible
0x8001	Remote mismatch	Remote Mismatch
0x8002	Media redundancy mismatch	Media Redundancy Mismatch
0x8003	Sync mismatch	Sync Mismatch
0x8004	IsochronousMode mismatch	IsochronousMode Mismatch
0x8005	Multicast CR mismatch	Multicast CR Mismatch
0x8006	Reserved	Reserved
0x8007	Fiber optic mismatch	Information for fiber optic links
0x8008	Network component function mismatch	Network functionality problems occur
0x8009	Time mismatch	Time master not existent or precision problems
0x800A	Dynamic frame packing function mismatch	DFP problems occur
0x800B	Media redundancy with planned duplication mismatch	MRPD problems occur
0x800C	System redundancy mismatch	System Redundancy Mismatch
0x800D	Multiple interface mismatch	Information about multiple interface problems
0x800E	Nested diagnosis indication	Controller to controller communication Used for propagation of diagnosis in hierachical structures
0x800F	Reserved	Unknown error
0x8010 – 0x8FFF	Reserved	Unknown error
0x9000 – 0x9FFF	Reserved for profiles [a]	Profile specific
0xA000 – 0xFFFF	Reserved	Unknown error

[a] Central administrative number to unambiguously distinguish between profiles

[b] For legacy devices “Manufacturer specific”

5.2.8.3 Coding of the field ChannelNumber

This field shall be coded as data type Unsigned16 with the values according to Table 503.

Table 503 – ChannelNumber

Value (hexadecimal)	Meaning
0x0000 – 0x7FFF	Manufacturer specific

Value (hexadecimal)	Meaning
0x8000	Submodule Only one coding for ChannelProperties.Direction shall be used.
0x8001 – 0xFFFF	Reserved

NOTE The ChannelNumber 0x8000 references the submodule itself.

A distinct channel is addressed by the ChannelNumber in addition with the ChannelProperties.Direction.

In dependence with the field ChannelProperties.Accumulative the following meaning shall be applied:

– ChannelProperties.Accumulative=1 then the field ChannelNumber shall contain the number of the smallest channel of the effected group
– ChannelProperties.Accumulative=0 then the field ChannelNumber shall contain the number of the effected channel

5.2.8.4 Coding of the field ChannelProperties

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 7: ChannelProperties.Type
This field shall be set according to Table 504.

Table 504 – ChannelProperties.Type

Value (hexadecimal)	Meaning	Usage
0x00	—	Shall be used if the field ChannelNumber contains the value 0x8000 (submodule) Furthermore, it shall be used if none of the below defined types are appropriate.
0x01	1 Bit	The data length of this channel is 1 Bit.
0x02	2 Bit	The data length of this channel is 2 Bit.
0x03	4 Bit	The data length of this channel is 4 Bit.
0x04	8 Bit	The data length of this channel is 8 Bit.
0x05	16 Bit	The data length of this channel is 16 Bit.
0x06	32 Bit	The data length of this channel is 32 Bit.
0x07	64 Bit	The data length of this channel is 64 Bit.
0x08 – 0xFF	Reserved	—

Bit 8: ChannelProperties.Accumulative
This field shall be set to one if it is an accumulative diagnosis from more than one channel. Otherwise it shall be set to zero.

Bit 9 – 10: ChannelProperties.Maintenance
This field shall be set according to Table 505, Table 506 and Table 507.

The dependencies with elements of the field ChannelProperties are specified in Table 506 and the dependencies with Alarmnotification and RecordDataRead(DiagnosisData) in Table 507.

Table 505 – ChannelProperties.Maintenance

MaintenanceRequired Bit 9	MaintenanceDemanded Bit 10:	Usage
0x00	0x00	Diagnosis
0x01	0x00	Maintenance required
0x00	0x01	Maintenance demanded
0x01	0x01	QualifiedChannelQualifier [a]
[a] This indicates that the severity is coded in the field QualifiedChannelQualifier (see Figure 83). All values of the ChannelProperties.Maintenance could be used in combination with Qualified Diagnosis.		

Table 506 – Valid combinations within ChannelProperties

Maintenance	Specifier	Meaning	Valid with
Diagnosis	0x00	All subsequent [a] Diagnosis, MaintenanceRequired, MaintenanceDemanded and QualifiedDiagnosis disappear	ChannelDiagnosis
	0x01	Diagnosis appears	ChannelDiagnosis, ManufacturerSpecificDiagnosis, ExtChannelDiagnosis
	0x02	Diagnosis disappears	
	0x03	Diagnosis disappears but other remain	
Maintenance required	0x00	Reserved	ChannelDiagnosis, ManufacturerSpecificDiagnosis, ExtChannelDiagnosis
	0x01	MaintenanceRequired appears	
	0x02	MaintenanceRequired disappears	
	0x03	MaintenanceRequired disappears but other remain	
Maintenance demanded	0x00	Reserved	ChannelDiagnosis, ManufacturerSpecificDiagnosis, ExtChannelDiagnosis
	0x01	MaintenanceDemanded appears	
	0x02	MaintenanceDemanded disappears	
	0x03	MaintenanceDemanded disappears but other remain	
Qualified-Channel-Qualifier	0x00	Reserved	QualifiedChannelDiagnosis
	0x01	QualifiedDiagnosisQualifier appears	
	0x02	QualifiedDiagnosisQualifier disappears	
	0x03	QualifiedDiagnosisQualifier disappears but other remain	
[a] Subsequent means, all ExtChannelErrorTypes for the delivered ChannelErrorType and also the ChannelErrorType itself disappears. Shall be used in AlarmNotification only.			

Table 507 – Valid combinations for Alarmnotification and Record-DataRead(DiagnosisData)

Maintenance	Specifier	Meaning	Valid with
Diagnosis	0x00	All subsequent [a] Diagnosis, MaintenanceRequired, MaintenanceDemanded and QualifiedDiagnosis disappear	Alarmnotification
	0x01	Diagnosis appears	Alarmnotification and Record-DataRead(DiagnosisData)
	0x02	Diagnosis disappears	Alarmnotification RecordDataRead(DiagnosisData) shall only be used in conjunction with ManufacturerSpecific-Diagnosis
	0x03	Diagnosis disappears but other remain	Alarmnotification
Maintenance required	0x00	Reserved	—
	0x01	MaintenanceRequired appears	Alarmnotification and Record-DataRead(DiagnosisData)
	0x02	MaintenanceRequired disappears	Alarmnotification
	0x03	MaintenanceRequired disappears but other remain	
Maintenance demanded	0x00	Reserved	—
	0x01	MaintenanceDemanded appears	Alarmnotification and Record-DataRead(DiagnosisData)
	0x02	MaintenanceDemanded disappears	Alarmnotification
	0x03	MaintenanceDemanded disappears but other remain	
Qualified diagnosis	0x00	Reserved	—
	0x01	QualifiedDiagnosis appears	Alarmnotification and Record-DataRead(DiagnosisData)
	0x02	QualifiedDiagnosis disappears	Alarmnotification
	0x03	QualifiedDiagnosis disappears but other remain	

[a] Subsequent means, all ExtChannelErrorTypes for the delivered ChannelErrorType and also the ChannelErrorType itself disappears.

Bit 11 – 12: ChannelProperties.Specifier
This field shall be coded with the values according to Table 508. The field ChannelProperties.Specifier is related to the addressed channel and severity (diagnosis, maintenance or qualified). The dependencies with elements of the field ChannelProperties are specified in Table 506.

Table 508 – ChannelProperties.Specifier

Value (hexadecimal)	Meaning	Usage
0x00	All subsequent disappears	See Table 506 The Diagnosis ASE contains no longer any entries (of any severity) for this channel
0x01	Appears	An event appears and/or exists further The Diagnosis ASE contains this and possible other entries for this channel.
0x02	Disappears	An event disappears and/or exists no longer The Diagnosis ASE contains no longer any entries of the same severity for this channel
0x03	Disappears but other remain	An event disappears The Diagnosis ASE still contains other entries of the same severity for this channel

NOTE The conveyed data of the AlarmNotification depends on the creation time and can differ from the actual content of the Diagnosis ASE. The AlarmNotification is used to convey the changes and the Diagnosis ASE to contain the actual status.

Bit 13 – 15: ChannelProperties.Direction
This field shall be set according to Table 509.

Table 509 – ChannelProperties.Direction

Value (hexadecimal)	Meaning
0x00	Manufacturer specific
0x01	Input
0x02	Output
0x03	Input/Output
0x04 – 0x07	Reserved

5.2.8.5 Coding of the field ExtChannelErrorType

This field shall be coded as data type Unsigned16. The value of this field depends on the field ChannelErrorType. The values shall be set according to Table 510.

Table 510 – ExtChannelErrorType

Value (hexadecimal)	Meaning
0x0000 – 0xFFFF	Definition is depending on the ChannelErrorType (see tables below).

In conjunction with defined ChannelErrorTypes the ExtChannelErrorType shall be set according to Table 512, Table 513, Table 514, Table 515, Table 516, Table 517, Table 518, Table 519, Table 520, Table 521, Table 522, Table 523, Table 524, Table 525, and Table 526.

Additional an ExtChannelErrorType value range is bound to the type of the ChannelErrorType according to Table 511.

Table 511 – Allowed combinations of ChannelErrorType, ExtChannelErrorType, and ExtChannelAddValue

ChannelErrorType	ExtChannelErrorType	ExtChannelAddValue	Usage
Normative	Normative	Normative	Allowed
Normative	Vendor specific	Vendor specific	Allowed
Normative	Profile specific	Profile specific	Allowed
Profile specific	Profile specific	Profile specific	Allowed
Profile specific	Vendor specific	Vendor specific	Allowed
Profile specific	Normative	Normative	Prohibited
Vendor specific	Vendor specific	Vendor specific	Allowed
Vendor specific	Normative	Normative	Prohibited
Vendor specific	Profile specific	Profile specific	Prohibited

Table 512 – ExtChannelErrorType for ChannelErrorType 0 – 0xFF

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Accumulative Info	Alarm/diagnosis
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 513 – ExtChannelErrorType for ChannelErrorType 0x0100 – 0x7FFF

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Accumulative Info	Alarm/diagnosis
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 514 – ExtChannelErrorType for ChannelErrorType “Data transmission impossible”

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Link State mismatch – Link down	Alarm/diagnosis
0x8001	MAUType mismatch	Alarm/diagnosis
0x8002	Line Delay mismatch	Alarm/diagnosis
0x8003 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis

Value (hexadecimal)	Meaning	Usage
0xA000 – 0xFFFF	Reserved	—

Table 515 – ExtChannelErrorType for ChannelErrorType "Remote mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Peer name of station mismatch	Alarm/diagnosis
0x8001	Peer name of port mismatch	Alarm/diagnosis
0x8002	Peer RT_CLASS_3 mismatch [a]	Alarm/diagnosis
0x8003	Peer MAUType mismatch	Alarm/diagnosis
0x8004	Peer MRP domain mismatch	Alarm/diagnosis
0x8005	No peer detected	Alarm/diagnosis
0x8006	Reserved	—
0x8007	Peer Line Delay mismatch	Alarm/diagnosis
0x8008	Peer PTCP mismatch [b]	Alarm/diagnosis
0x8009	Peer Preamble Length mismatch	Alarm/diagnosis
0x800A	Peer Fragmentation mismatch	Alarm/diagnosis
0x800B – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

[a] This events occurs, if the remote RTClass3_PortStatus.State is not RTCLASS3_RUN. This could also happen, if the remote IRDATAUUID is not equal to the local IRDATAUUID.

[b] This events occurs, if the remote PTCP_SubdomainUUID is equal to the local PTCP_SubdomainUUID and the remote PTCP_MasterSourceAddress is not equal to the local PTCP_MasterSourceAddress.

Table 516 – ExtChannelErrorType for ChannelErrorType "Media redundancy mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Manager role fail	Alarm/diagnosis
0x8001	MRP ring open	Alarm/diagnosis
0x8002	Reserved	—
0x8003	Multiple manager	Alarm/diagnosis
0x8004 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

The source of a "Media redundancy mismatch" is always a port. If two ports are affected, the one with the lesser number shall be used.

Table 517 – ExtChannelErrorType for ChannelErrorType "Sync mismatch" and for ChannelErrorType "Time mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	No sync message received	Alarm/diagnosis
0x8001 – 0x8002	Reserved	—
0x8003	Jitter out of boundary	Alarm/diagnosis
0x8004 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 518 – ExtChannelErrorType for ChannelErrorType "Isochronous mode mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Output Time Failure – Output update missing or out of order	Alarm/diagnosis
0x8001	Input Time Failure	Alarm/diagnosis
0x8002	Master Life Sign Failure – Error in MLS update detected	Alarm/diagnosis
0x8003 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 519 – ExtChannelErrorType for ChannelErrorType "Multicast CR mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Multicast Consumer CR timed out	Alarm/diagnosis
0x8001	Address resolution failed	Alarm/diagnosis
0x8002 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 520 – ExtChannelErrorType for ChannelErrorType "Fiber optic mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Power Budget	Alarm/diagnosis

Value (hexadecimal)	Meaning	Usage
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 521 – ExtChannelErrorType for ChannelErrorType "Network component function mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Frame dropped – no resource	Alarm/diagnosis
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 522 – ExtChannelErrorType for ChannelErrorType "Dynamic Frame Packing function mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000 – 0x80FF	Reserved	—
0x8100	Frame late error for FrameID "0x0100"	Alarm/diagnosis
0x8101 + 0x8FFE	See Formula (55)	Alarm/diagnosis
0x8FFF	Frame late error for FrameID "0x0FFF"	Alarm/diagnosis
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

The source of a "Dynamic Frame Packing function mismatch" is the interface submodule using the DFP packing function.

The used ExtChannelErrorType shall be calculated according Formula (55).

$$\text{ExtChannelErrorType} = 0x8000 + \text{FrameID} \quad (55)$$

where

ExtChannelErrorType	is the ExtChannelErrorType used for the signaling of an event
0x8000	is the base value of the ChannelNumber
FrameID	is the FrameID of the frame issuing the event

Table 523 – ExtChannelErrorType for ChannelErrorType “Media redundancy with planned duplication mismatch”

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000 – 0x86FF	Reserved	—
0x8700	MRPD duplication void for FrameID “0x0700”	Alarm/diagnosis
0x8701 + 0x8FFE	See Formula (56)	Alarm/diagnosis
0x8FFF	MRPD duplication void for FrameID “0x0FFF”	Alarm/diagnosis
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

The source of a “Media redundancy with planned duplication mismatch” is the interface submodule using the MRPD function.

NOTE Searching for the smallest SlotNumber and then for the smallest SubslotNumber of this slot identifies the least SlotNumber/SubslotNumber combination.

The used ExtChannelErrorType shall be calculated according Formula (56).

$$\text{ExtChannelErrorType} = 0x8000 + \text{FrameID} \quad (56)$$

where

ExtChannelErrorType	is the ExtChannelErrorType used for the signaling of an event
0x8000	is the base value of the ChannelNumber
FrameID	is the FrameID of the frame issuing the event

Table 524 – ExtChannelErrorType for ChannelErrorType “System redundancy mismatch”

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	System redundancy event	Alarm/diagnosis
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

The source of a “System redundancy mismatch” is the submodule with the lowest API/SlotNumber/SubslotNumber combination, which is part of the AR.

Table 525 – ExtChannelErrorType for ChannelErrorType "Multiple interface mismatch"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	StandardGateway mismatch	Alarm/diagnosis
0x8001	NameOfStation of the interface is not unambiguous	Alarm/diagnosis
0x8002	IPAddress range of the interface is not unambiguous	Alarm/diagnosis
0x8003	Conflicting MultipleInterfaceMode.NameOfDevice mode	Alarm/diagnosis
0x8004 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

Table 526 – ExtChannelErrorType for ChannelErrorType "Nested diagnosis indication"

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved	—
0x0001 – 0x7FFF	Manufacturer specific	Alarm/diagnosis
0x8000	Subordinated entity information	Alarm/diagnosis
0x8001 – 0x8FFF	Reserved	—
0x9000 – 0x9FFF	Reserved for profiles	Alarm/diagnosis
0xA000 – 0xFFFF	Reserved	—

5.2.8.6 Coding of the field ExtChannelAddValue

This field shall be coded as data type Unsigned32 with the values according to Table 527.

Table 527 – Values for ExtChannelAddValue

Value (hexadecimal)	Meaning
0x00000000	No additional information
0x00000001 – 0xFFFFFFFF	Definition depending on ChannelError and ExtChannelErrorType

5.2.8.6.1 Coding of the field ExtChannelAddValue for ChannelErrorType = 0 – 0x7FFF

This field shall be coded with the values according to Table 528 if the field ExtChannelErrorType contains the value 0x8000 and the field ChannelErrorType contains the value 0 – 0x7FFF.

Table 528 – Values for Accumulative Info

Bitposition	Value (hexadecimal)	Meaning
Bit 0	0x00	ChannelNumber is not effected
	0x01	ChannelNumber is effected
Bit 1	0x00	ChannelNumber + 1 is not effected
	0x01	ChannelNumber + 1 is effected
Bit 2	0x00	ChannelNumber + 2 is not effected
	0x01	ChannelNumber + 2 is effected
…	…	…
Bit30	0x00	ChannelNumber + 30 is not effected
	0x01	ChannelNumber + 30 is effected
Bit31	0x00	ChannelNumber + 31 is not effected
	0x01	ChannelNumber + 31 is effected

5.2.8.6.2 Coding of the field ExtChannelAddValue for ChannelErrorType “Fiber optic mismatch”

This field shall be coded with the values according to Table 529 if the field ExtChannelErrorType contains the value 0x8000 and the field ChannelErrorType contains the value 0x8007.

Table 529 – Values for “Fiber optic mismatch” – “Power Budget”

Value (hexadecimal)	Meaning
0x00 – 0x3E7	PowerBudget in 0,1 dB steps [0..99,9 dB]
0x03E8 – 0xFFFFFFFE	Reserved
0xFFFFFFFF	Unknown

5.2.8.6.3 Coding of the field ExtChannelAddValue for ChannelErrorType “Network component function mismatch”

This field shall be coded with the values according to Table 530 if the field ExtChannelErrorType contains the value 0x8000 and the field ChannelErrorType contains the value 0x8008.

Table 530 – Values for “Network component function mismatch” – “Frame dropped”

Value (hexadecimal)	Meaning
0x00000000 – 0x00FFFFFF	Number of dropped frames in case of no resource
0x01000000 – 0xFFFFFFFF	Reserved

5.2.8.6.4 Coding of the field ExtChannelAddValue for ChannelErrorType “Remote mismatch”

This field shall be coded with the values according to Table 531 if the field ExtChannelErrorType contains the value 0x8007 and the field ChannelErrorType contains the value 0x8001.

Table 531 – Values for “Remote mismatch” – ”Peer CableDelay mismatch”

Value (hexadecimal)	Meaning	Usage
0x00 – 0x32	Error of measurement	No signaling
0x33 – 0x3B9ACA00	CableDelay difference between peers	Signal deviation
0x3B9ACA01 – 0xFFFFFFFF	Reserved	—

5.2.8.6.5 Coding of the field ExtChannelAddValue for ChannelErrorType “Multiple interface mismatch”

This field shall be coded with the values according to Table 532 if the field ExtChannelErrorType contains the value 0x8003 and the field ChannelErrorType contains the value 0x800D.

Table 532 – Values for “Multiple interface mismatch” – ”Conflicting MultipleInterfaceMode.NameOfDevice mode”

Value (hexadecimal)	Meaning	Usage
0x00	Reserved	—
0x01	MultipleInterfaceMode.NameOfDevice for this interface is set to zero but one other interface is set to one.	Inconsistency
0x02	MultipleInterfaceMode.NameOfDevice for this interface is set to one but one other interface is set to zero.	Inconsistency
other	Reserved	—

5.2.8.7 Coding of the field QualifiedChannelQualifier

This field shall be coded as data type Unsigned32. The values shall be set according to Table 533. There shall only one bit be set in one QualifiedChannelDiagnosis.

Table 533 – Values for QualifiedChannelQualifier

Bitposition	Value (hexadecimal)	Meaning	Usage
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	0x00	Qualifier_2 not set	Profile specific
	0x01	Qualifier_2 is set	
Bit 3	0x00	Qualifier_3 not set	
	0x01	Qualifier_3 is set	
…		…	
Bit 30	0x00	Qualifier_30 not set	
	0x01	Qualifier_30 is set	
Bit 31	0x00	Qualifier_31 not set	
	0x01	Qualifier_31 is set	

5.2.8.8 Coding of the field MaintenanceStatus

This field shall be coded as data type Unsigned32. At least one of the bits below shall be set to one in order to convey this alarm block according to Table 534. Otherwise this block shall be omitted.

Table 534 – Values for MaintenanceStatus

Bitposition	Bit name	Value (hexadecimal)	Meaning
Bit 0	MaintenanceRequired	0x00	No maintenance required information available
		0x01	Maintenance required information available
Bit 1	MaintenanceDemanded	0x00	No maintenance demanded information available
		0x01	Maintenance demanded information available
Bit 2	Qualifier_2	0x00	No information available
		0x01	Information available
Bit 3	Qualifier_3	0x00	No information available
		0x01	Information available
…	—	—	…
Bit 30	Qualifier_30	0x00	No information available
		0x01	Information available
Bit 31	Qualifier_31	0x00	No information available
		0x01	Information available

The classification of diagnosis, maintenance and qualified according to their severity is shown in Figure 83.

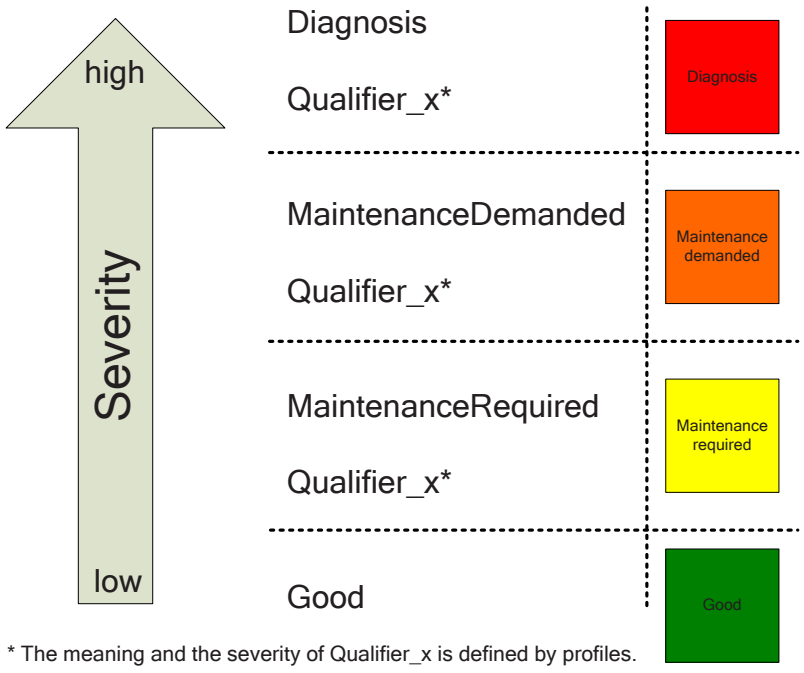


Figure 83 – Severity classification of diagnosis, maintenance and qualified

The meaning and the severity of Qualifier_x shall be defined by a profile.

5.2.9 Coding section related to upload and retrieval

5.2.9.1 Coding of the field URRecordIndex

This field shall be coded as data type Unsigned32 with the values according to Table 535.

Table 535 – URRecordIndex

Value (hexadecimal)	Meaning
0x00000000 – 0x0000FFFF	Index of the used record
0x00010000 – 0xFFFFFFFF	Reserved

5.2.9.2 Coding of the field URRecordLength

This field shall be coded as data type Unsigned32 with the values according to Table 536.

Table 536 – URRecordLength

Value (hexadecimal)	Meaning
0x00000000	Write stored records to the IO device.
0x00000001 – 0xFFFFFFFF	Write stored records to the IO device, if the length of each selected record is less or equal URRecordLength.

5.2.10 Coding section related to iParameter

5.2.10.1 Coding of the field iPar_Req_Header

This field shall be coded as data type Unsigned32 with the values according to IEC 61784-3-3.

5.2.10.2 Coding of the field Max_Segm_Size

This field shall be coded as data type Unsigned32 with the values according to IEC 61784-3-3.

5.2.10.3 Coding of the field Transfer_Index

This field shall be coded as data type Unsigned32 with the values according to IEC 61784-3-3.

5.2.10.4 Coding of the field Total_iPar_Size

This field shall be coded as data type Unsigned32 with the values according to IEC 61784-3-3.

5.2.11 Coding section related to Physical Device Interface Data

5.2.11.1 Coding of the field MultipleInterfaceMode

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0: MultipleInterfaceMode.NameOfDevice
This field shall be set according to Table 537.

Table 537 – MultipleInterfaceMode.NameOfDevice

Value (hexadecimal)	Meaning
0x00	Default The field LLDPChassis contains the NameOfStation and the field PortID of LLDP contains the name of the port.
0x01	The field LLDPChassis contains the NameOfDevice and is defined by local means. The field PortID of LLDP contains the name of the port and the NameOfStation.

Bit 1 – 15: MultipleInterfaceMode.reserved_1
This field shall be set to zero.

Bit 16 – 31: MultipleInterfaceMode.reserved_2
This field shall be set according to 3.4.2.2.

5.2.12 Coding section related to Physical Device Port Data

5.2.12.1 Coding of the field OwnPortName

This field shall be coded as data type OctetString[] according to 4.3.1.4.16.

5.2.12.2 Coding of the field LengthOwnPortName

This field shall be coded as data type Unsigned8 according to 4.3.1.4.16.

5.2.12.3 Coding of the field NumberOfPeers

This field shall be coded as data type Unsigned8.

5.2.12.4 Coding of the field LengthPeerPortName

This field shall be coded as data type Unsigned8.

5.2.12.5 Coding of the field PeerPortName

5.2.12.5.1 Usage in conjunction with PDPortDataCheck.CheckPeers

This field shall be coded according to 4.3.1.4.16.

5.2.12.5.2 Usage in conjunction with PDPortDataReal

This field shall be coded according to 4.3.1.4.16. It shall contain the NameOfPort part of the received LLDP_PortID, if coded according to 4.3.1.4.16. Otherwise the LengthPeerPortName shall be zero.

5.2.12.6 Coding of the field LengthPeerStationName

This field shall be coded as data type Unsigned8.

5.2.12.7 Coding of the field PeerStationName

5.2.12.7.1 General

This field shall be coded as data type OctetString[] with 1 to 255 octets.

5.2.12.7.2 Usage in conjunction with PDPortDataCheck.CheckPeers

This field shall be coded according to 4.3.1.4.15.

5.2.12.7.3 Usage in conjunction with PDPortDataReal

This field shall be coded according to 4.3.1.4.15. It shall contain the NameOfStation part of the received LLDP_PortID or LLDP_ChassisID, if coded according to 4.3.1.4.15. Otherwise the LengthPeerStationName shall be zero.

5.2.12.8 Coding of the field LengthOwnStationName

This field shall be coded as data type Unsigned8 according to 4.3.1.4.15.

5.2.12.9 Coding of the field OwnStationName

This field shall be coded as data type OctetString[] according to 4.3.1.4.15.

5.2.12.10 Coding of the field LineDelay

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 30: LineDelay.Value
This field shall be set according to Table 538, Table 539, Figure 27 and Formula (26).

Table 538 – LineDelay.Value with LineDelay.FormatIndicator == 0

Value (hexadecimal)	Meaning
0x00000000	Line delay and cable delay unknown
0x00000001 – 0x7FFFFFFF	Line delay in nanoseconds

Table 539 – LineDelay.Value with LineDelay.FormatIndicator == 1

Value (hexadecimal)	Meaning
0x00000000	Reserved
0x00000001 – 0x7FFFFFFF	Cable delay in nanoseconds

Bit 31: LineDelay.FormatIndicator
This field shall be set according to Table 540.

Table 540 – LineDelay.FormatIndicator

Value (hexadecimal)	Meaning	Usage
0x00	LineDelay.Value is coded as line delay	Default, if line delay or cable delay is unknown Shall be used in conjunction with PDPortDataCheck
0x01	LineDelay.Value is coded as cable delay	Default, if cable delay is known Shall be used in conjunction with PDPortDataReal

5.2.12.11 Coding of the field PeerMACAddress

This field shall be coded as data type OctetString[6]. The value of the field PeerMACAddress shall be according to the 48-bit universal LAN MAC addresses of IEEE 802.

NOTE Octet 1 contains the Individual/Group Address Bit (lsb).

5.2.13 Coding section related to Physical Device IR Data

5.2.13.1 Coding of the field RxPort

This field shall be coded as data type Unsigned8.This field shall be coded with the values according to Table 541.

Table 541 – RxPort

Value (hexadecimal)	Meaning
0x00	Local interface
0x01	Port 1
0x02	Port 2
…	…
0xFF	Port 255

5.2.13.2 Coding of the field NumberOfTxPortGroups

This field shall be coded as data type Unsigned8 and shall be set according to Table 542. This field shall only count the successing TxPortGroupArray entries.

Table 542 – NumberOfTxPortGroups

Value (hexadecimal)	Meaning
0x01, 0x03, 0x05, 0x07, 0x09, 0x0A, 0x0C, 0x0F	Allowed values
0x11, 0x13, 0x15, 0x17, 0x19, 0x1A, 0x1C, 0x1F	Allowed values
0x21	Allowed values
other	Reserved

5.2.13.3 Coding of the field TxPortGroupArray

The field TxPortGroupArray is an array of octets that shall contain at least one and at most 33 octets referred to as TxPortGroup octet. A TxPortGroup octet shall consist of at least one and at most 8 TxPort entries referred to as TxPortGroup entry 0 to TxPortGroup entry 7. Therefore, the number of TxPortGroup octet corresponds to the number of ports within a device and shall be calculated as follows

$$N = M_{highest} \text{ DIV } 8 + 1 \quad (57)$$

where

N	is the number of TxPortGroup octets or the number of array elements
$M_{highest}$	is the highest number of TxPorts within a device (maximum 255)
8	is the bit size of a octet

$$G = m \text{ DIV } 8 + 1 \quad (58)$$

where

G	is the number of the TxPortGroup octet containing the TxPort
m	is the number of the current TxPort with $1 \leq m \leq M$
8	is the bit size of a octet

$$B = m \text{ MOD } 8 \quad (59)$$

where

B	is the number of the bit in the TxPortGroup octet containing the TxPort
m	is the number of the current TxPort with $1 \leq m \leq M$
8	is the bit size of a octet

NOTE The term DIV stands for division without remainder. The term MOD stands for the remainder of the division.

The last TxPortGroup octet (octet N) may not contain all 8 TxPort entries. If $M_{highest}$ MOD 8 ≠ 7 the octet N is not fully filled and the remaining bits shall be set to zero referred to as Padding Bits.

The TxPortGroup of the devices TxPorts shall be structured in ascending order without gaps. The coding of this field shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0: TxPortEntry_0
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 0 is present. A padding bit shall be used if no TxPort is present.

Table 543 – TxPortEntry

Value (hexadecimal)	Meaning
0x00	Transmission off
0x01	Transmission on

The TxPort of local injection is always placed in TxPortEntry_0 of the TxPortGroup octet number one.

Bit 1: TxPortEntry_1
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 1 is present. A padding bit shall be used if no TxPort is present.

Bit 2: TxPortEntry_2
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 2 is present. A padding bit shall be used if no TxPort is present.

Bit 3: TxPortEntry_3
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 3 is present. A padding bit shall be used if no TxPort is present.

Bit 4: TxPortEntry_4
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 4 is present. A padding bit shall be used if no TxPort is present.

Bit 5: TxPortEntry_5
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 5 is present. A padding bit shall be used if no TxPort is present.

Bit 6: TxPortEntry_6
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 6 is present. A padding bit shall be used if no TxPort is present.

Bit 7: TxPortEntry_7
This bit shall be set with the values according to Table 543 if the TxPort with the number that meets m MOD 8 = 7 is present. A padding bit shall be used if no TxPort is present.

5.2.13.4 Coding of the field FrameDetails

This field shall be coded according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0 – 1: FrameDetails.SyncFrame
This field shall be coded with the values according to Table 544 and Table 545.

Table 544 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode := "Absolute mode"

Value (hexadecimal)	Meaning	Description
0x00	No sync frame	Mandatory
0x01	Primary sync frame	Legacy
0x02	Secondary sync frame	Primary and secondary sync frame use the same FrameID. At one time only one frame shall be valid.
0x03	Reserved	—

Table 545 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode := "Relative mode"

Value (hexadecimal)	Meaning	Description
0x00	No sync frame	Mandatory
Other	Reserved	—

Bit 2 – 3: FrameDetails.MeaningFrameSendOffset
This field shall be coded with the values according to Table 546.

Table 546 – FrameDetails.MeaningFrameSendOffset

Value (hexadecimal)	Meaning	Usage
0x00	The content of the field FrameSendOffset specifies the point of time for transmitting a frame. For the receiver the content of the field specifies the point of time for receiving a frame.	Mandatory
other	Reserved	—

Bit 4 – 6: FrameDetails.reserved
This field shall be set to zero.

Bit 7: FrameDetails.MediaRedundancyWatchDog
This field shall be set according to Table 547.

Table 547 – FrameDetails.MediaRedundancyWatchDog

Value (hexadecimal)	Meaning	Meaning
0x00	Disable	Do not monitor the quality of a MRPD connection
0x01	Enable	Monitor the quality of a MRPD connection and signal a change

5.2.13.5 Coding of the field FrameDataProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0: FrameDataProperties.ForwardingMode
This field shall be set according to Table 548.

Table 548 – FrameDataProperties.ForwardingMode

Value (hexadecimal)	Meaning
0x00	Absolute mode The FrameSendOffset contains the sending time for a forwarded frame
0x01	Relative mode The FrameSendOffset shall contain the sending time of a forwarded frame or the “Best effort” value.

Bit 1 – 2: FrameDataProperties.FastForwardingMulticastMACAdd
This field shall be set according to Table 549.

Table 549 – FrameDataProperties.FastForwardingMulticastMACAdd

Value (hexadecimal)	Meaning
0x00	Legacy Use interface MAC destination unicast address
0x01	Use RT_CLASS_3 destination multicast address
0x02	Use FastForwardingMulticastMACAdd
0x03	Reserved

Bit 3 – 4: FrameDataProperties.FragmentationMode
This field shall be coded with the values according to Table 550.

Table 550 – FrameDataProperties.FragmentationMode

Value (hexadecimal)	Meaning	Usage
0x00	No fragmentation	Mandatory
0x01	Fragmentation enabled Maximum fragment size for static fragmentation 128 Bytes	Optional
0x02	Fragmentation enabled Maximum fragment size for static fragmentation 256 Bytes	Optional
0x03	Reserved	—

Bit 5 – 15: FrameDataProperties.reserved_1
This field shall be set to zero.

Bit 16 – 31: FrameDataProperties.reserved_2
This field shall be set according to 3.4.2.2.

5.2.13.6 Coding of the field AdjustProperties

This field shall be coded as data type Unsigned16 with the value zero.

5.2.13.7 Coding of the field MAUType

This field shall be coded as data type Unsigned16 with the values according to RFC 4836, Table 551 and Table 552.

Table 551 – MAUType

Value (hexadecimal)	Meaning	Usage
0x0000	Reserved for MediaType “Copper cable” and “Fiber optic cable”	Default for LinkState.Link != “UP”
	Used for MediaType “Radio communication”	Default for radio communication
0x0005	10BaseT	PDPortDataReal
0x000A	10BaseTXHD	PDPortDataReal
0x000B	10BaseTXFD	PDPortDataReal
0x000C	10BaseFLHD	PDPortDataReal
0x000D	10BaseFLFD	PDPortDataReal
0x000F	100BaseTXHD	PDPortDataReal
0x0010	Default (MediaType Copper) 100BaseTXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0011	100BaseFXHD	PDPortDataReal
0x0012	Default (MediaType Fiber optic) 100BaseFXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0015	1000BaseXHD	PDPortDataReal
0x0016	1000BaseXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0017	1000BaseLXHD	PDPortDataReal
0x0018	1000BaseLXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0019	1000BaseSXHD	PDPortDataReal
0x001A	1000BaseSXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x001D	1000BaseTHD	PDPortDataReal
0x001E	1000BaseTFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x001F	10GbaseFX	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0020	10GbaseLX4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0021	10GbaseR	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck

Value (hexadecimal)	Meaning	Usage
0x0022	10GbaseER	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0023	10GbaseLR	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0024	10GbaseSR	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0025	10GbaseW	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0026	10GbaseEW	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0027	10GbaseLW	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0028	10GbaseSW	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0029	10GbaseCX4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x002A	2BaseTL	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x002B	10PassTS	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x002C	100BaseBX10D	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x002D	100BaseBX10U	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x002E	100BaseLX10	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x002F	1000BaseBX10D	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0030	1000BaseBX10U	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0031	1000BaseLX10	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0032	1000BasePX10D	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0033	1000BasePX10U	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0034	1000BasePX20D	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0035	1000BasePX20U	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0036	10GBaseT or 100BasePXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0037	10GBaseLRM	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0038	1000BaseKX	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0039	1000BaseKX4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x003A	1000BaseKR	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x003B	10G1GBasePRXD1	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck

Value (hexadecimal)	Meaning	Usage
0x003C	10G1GBasePRXD2	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x003D	10G1GBasePRXD3	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x003E	10G1GBasePRXU1	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x003F	10G1GBasePRXU2	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0040	10G1GBasePRXU3	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0041	10GBasePRD1	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0042	10GBasePRD2	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0043	10GBasePRD3	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0044	10GBasePRU1	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0045	10GBasePRU3	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0046	40GbaseKR4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0047	40GbaseCR4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0048	40GbaseSR4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x0049	40GbaseFR	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x004A	40GbaseLR4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x004B	100GbaseCR10	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x004C	100GbaseSR10	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x004D	100GbaseLR4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
0x004E	100GbaseER4	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
IANA dependent	100BasePXFD	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
Useable well known numbers	Speed of 100 Mbit/s (and more) and duplexity full	PDPortDataReal, PDPortDataAdjust, PDPortDataCheck
Unuseable well known numbers	Speed less than 100 Mbit/s or duplexity half	PDPortDataReal
other	Reserved	—

NOTE The MAUType 100BasePXFD has two codings due to legacy reasons.

Table 552 – Valid combinations between MAUType and LinkState

LinkState.Port	LinkState.Link	MAUType	Usage
Unknown Disabled / Discarding Blocking Listening Learning Forwarding Broken	Up (ready to pass packets)	10BaseT	PDPortDataReal
		10BaseTXHD	
		10BaseTXFD	
		10BaseFLHD	
		10BaseFLFD	
		100BaseTXHD	
		100BaseTXFD (Default)	
		100BaseFXHD	
		100BaseFXFD	
		1000BaseXHD	
		1000BaseXFD	
		1000BaseLXHD	
		1000BaseLXFD	
		1000BaseSXHD	
		1000BaseSXFD	
		1000BaseTHD	
		1000BaseTFD	
		10GigBaseFX	
		100BaseLX10	
		100BasePXFD	
		Useable well known numbers	
		Unuseable well known numbers	
	Down	Reserved	
	Testing (in some test mode)		
	Unknown (status cannot determined)		
Reserved	Reserved		

5.2.13.8 Coding of the field CheckSyncMode

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0: CheckSyncMode.CableDelay
This field shall be set according to Table 553.

Table 553 – CheckSyncMode.CableDelay

Value (hexadecimal)	Meaning	Usage
0x00	OFF	No check
0x01	ON	Check cable delay difference between local and remote measured cable delay versus 50 ns.

Bit 1: CheckSyncMode.SyncMaster
This field shall be set according to Table 554.

Table 554 – CheckSyncMode.SyncMaster

Value (hexadecimal)	Meaning	Usage
0x00	OFF	No check
0x01	ON	Check PTCP_MasterSourceAddress between local and remote using LLDP_PNIO_PTCPSTATUS.

Bit 2 – 15: CheckSyncMode.reserved
This field shall be set according to 3.4.2.2.

5.2.13.9 Coding of the field MAUTypeMode

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0: MAUTypeMode.Check
This field shall be set according to Table 555.

Table 555 – MAUTypeMode.Check

Value (hexadecimal)	Meaning	Usage
0x00	OFF	No check
0x01	ON	Check MAU type difference between local and remote detected value.

Bit 1 – 15: MAUTypeMode.reserved
This field shall be set according to 3.4.2.2.

5.2.13.10 Coding of the field DomainBoundaryIngress

The coding of this field shall be according to 3.4.2.5 and the individual bits shall be coded with the values according to Table 556.

Table 556 – DomainBoundaryIngress

Bit	Value	Meaning
0	1	Block an incoming frame with the multicast MAC address 01-0E-CF-00-04-20, 01-0E-CF-00-04-40 and 01-0E-CF-00-04-80
	0	Do not block an incoming frame with the multicast MAC address 01-0E-CF-00-04-20, 01-0E-CF-00-04-40 and 01-0E-CF-00-04-80
1..31	reserved	

5.2.13.11 Coding of the field DomainBoundaryEgress

The coding of this field shall be according to 3.4.2.5 and the individual bits shall be coded with the values according to Table 557.

Table 557 – DomainBoundaryEgress

Bit	Value	Meaning
0	1	Block an outgoing frame with the multicast MAC address 01-0E-CF-00-04-20, 01-0E-CF-00-04-40 and 01-0E-CF-00-04-80
	0	Do not block an outgoing frame with the multicast MAC address 01-0E-CF-00-04-20, 01-0E-CF-00-04-40 and 01-0E-CF-00-04-80
1..31	reserved	

For the PTCP-AnnoucePDU Table 556 and Table 557 shall be combined according to Table 558 to decode the domain boundary.

Table 558 – DomainBoundaryAnnounce

—	Domain-Boundary-Ingress	Domain-Boundary-Egress	Meaning
Bit	**Value**	**Value**	**—**
0	1	1	Discard frames with the multicast MAC address 01-0E-CF-00-04-00
	0	1	Do not block a frame with the multicast MAC address 01-0E-CF-00-04-00
	1	0	
	0	0	
1..31	reserved		

5.2.13.12 Coding of the field MulticastBoundary

This field shall be coded as data type Unsigned32. The individual bits shall be coded with the values according to Table 559.

Table 559 – MulticastBoundary

Bit	Value	Meaning
0	1	Block the multicast MAC address 01-0E-CF-00-02-00
	0	Do not block the multicast MAC address 01-0E-CF-00-02-00
…	1	Block the multicast MAC address 01-0E-CF-00-02-xx
	0	Do not block the multicast MAC address 01-0E-CF-00-02-xx
31	1	Block the multicast MAC address 01-0E-CF-00-02-1F
	0	Do not block the multicast MAC address 01-0E-CF-00-02-1F

This shall be applied for the first 32 RT_CLASS_2 multicast addresses from 01-0E-CF-00-02-00 to 01-0E-CF-00-02-1F.

5.2.13.13 Coding of the field PeerToPeerBoundary

This field shall be coded as data type Unsigned32. The individual bits shall be coded with the values according to Table 560.

Table 560 – PeerToPeerBoundary

Bit	Value	Meaning
0	1	The LLDP agent shall not send LLDP frames (egress filter).
	0	The LLDP agent shall send LLDP frames for this port.
1	1	The PTCP ASE shall not send PTCP_DELAY request frames (egress filter).
	0	The PTCP ASE shall send PTCP_DELAY request frames for this port.
2	1	The Time ASE shall not send PATH_DELAY request frames (egress filter).
	0	The Time ASE shall send PATH_DELAY request frames for this port.
…	0	Reserved
31	0	Reserved

5.2.13.14 Coding of the field DCPBoundary

This field shall be coded as data type Unsigned32. The individual bits shall be coded with the values according to Table 561.

Table 561 – DCPBoundary

Bit	Value	Meaning
0	1	Block an outgoing DCP_Identify frame (egress filter) with the multicast MAC address 01-0E-CF-00-00-00
	0	Do not block the multicast MAC address 01-0E-CF-00-00-00
1	1	Block an outgoing DCP_Hello frame (egress filter) with the multicast MAC address 01-0E-CF-00-00-01
	0	Do not block the multicast MAC address 01-0E-CF-00-00-01
…	0	Reserved
31	0	Reserved

5.2.13.15 Coding of the field PreambleLength

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0: PreambleLength.Length
This field shall be set according to Table 562.

Table 562 – PreambleLength.Length

Value (hexadecimal)	Meaning	Usage
0x00	Seven octets Preamble shall be used	Default For the Ethernet frames the PHY shall use seven octets preamble before the start delimiter (SD)
0x01	One octet Preamble shall be used	For the Ethernet frames the PHY shall use one octet preamble before the start delimiter (SD)

Bit 1 – 15: PreambleLength.reserved
This field shall be set according to 3.4.2.2.

5.2.13.16 Coding of the field LinkState

The coding of this field shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 7: LinkState.Link
This field shall be set according to Table 563.

Table 563 – LinkState.Link

Value (hexadecimal)	Meaning	Usage
0x00	Reserved	—
0x01	Up (ready to pass packets)	PDPortDataReal, CheckLinkState
0x02	Down	PDPortDataReal, AdjustLinkState
0x03	Testing (in some test mode)	PDPortDataReal
0x04	Unknown (status cannot be determined)	PDPortDataReal
0x05	Dormant	PDPortDataReal
0x06	NotPresent	PDPortDataReal
0x07	LowerLayerDown	PDPortDataReal
0x08 – 0xFF	Reserved	—

Bit 8 – 15: LinkState.Port
This field shall be set according to Table 564.

Table 564 – LinkState.Port

Value (hexadecimal)	Meaning	Usage
0x00	Unknown	Default Mandatory PDPortDataReal
0x01	Disabled / Discarding	Optional PDPortDataReal
0x02	Blocking	Optional PDPortDataReal
0x03	Listening	Optional PDPortDataReal
0x04	Learning	Optional PDPortDataReal

Value (hexadecimal)	Meaning	Usage
0x05	Forwarding	Optional PDPortDataReal
0x06	Broken	Optional PDPortDataReal
0x07 – 0xFF	Reserved	—

5.2.13.17 Coding of the field MediaType

This field shall be coded as data type Unsigned32 with the values according to Table 565.

Table 565 – MediaType

Value (hexadecimal)	Meaning	Usage
0x00	Unknown	PDPortDataReal
0x01	Copper cable	PDPortDataReal
0x02	Fiber optic cable	PDPortDataReal
0x03	Radio communication	PDPortDataReal
0x04 – 0xFFFFFFFF	Reserved	—

5.2.13.18 Coding of the field MaxBridgeDelay

This field shall be coded as data type Unsigned32 according to Table 566 in nanoseconds. Figure 28 shows the meaning of MaxBridgeDelay.

Table 566 – MaxBridgeDelay

Value (hexadecimal)	Meaning
0x00000000	Unknown
0x00000001 – 0x0000FFFF	From engineering used bridge delay for RT_CLASS_3 calculation
0x00010000 – 0xFFFFFFFF	Reserved

5.2.13.19 Coding of the field NumberOfPorts

This field shall be coded as data type Unsigned32 with values according to Table 567.

Table 567 – NumberOfPorts

Value (hexadecimal)	Meaning
0x00000000	Reserved
0x00000001 – 0x000000FF	Number of following port entries
0x00000100 – 0xFFFFFFFF	Reserved

5.2.13.20 Coding of the field MaxPortTxDelay

This field shall be coded as data type Unsigned32 according to Table 568 in nanoseconds. Figure 28 shows the meaning of MaxPortTxDelay.

Table 568 – MaxPortTxDelay

Value (hexadecimal)	Meaning
0x00000000	Unknown
0x00000001 – 0x0000FFFF	From engineering used port transmit delay for RT_CLASS_3 calculation
0x00010000 – 0xFFFFFFFF	Reserved

5.2.13.21 Coding of the field MaxPortRxDelay

This field shall be coded as data type Unsigned32 according to Table 569 in nanoseconds. Figure 28 shows the meaning of MaxPortRxDelay.

Table 569 – MaxPortRxDelay

Value (hexadecimal)	Meaning
0x00000000	Unknown
0x00000001 – 0x0000FFFF	From engineering used port receive delay for RT_CLASS_3 calculation
0x00010000 – 0xFFFFFFFF	Reserved

5.2.13.22 Coding of the field MaxLineRxDelay

This field shall be coded as data type Unsigned32 according to Table 570 in nanoseconds. Figure 28 shows the meaning of MaxLineRxDelay.

Table 570 – MaxLineRxDelay

Value (hexadecimal)	Meaning
0x00000000	Unknown No delay, forward as soon as possible
0x00000001 – 0x3B9AC9FF	From engineering used line delay for RT_CLASS_3 calculation
0x3B9ACA00 – 0xFFFFFFFF	Reserved

5.2.13.23 Coding of the field YellowTime

This field shall be coded as data type Unsigned32 according to Table 571 in nanoseconds. Figure 84 and Figure 86 shows the meaning and Figure 85 the calculation principle of YellowTime.

The YELLOW period allows a bridge to optimize the forwarding of frames as shown in Figure 85.

If the YellowTime, calculated according Formula (60) and (61), is less than the maximum Ethernet frame, the fragmentation shall be enabled.

NOTE The YellowTime is 125 μs if running without fragmentation.

$$\text{YellowTime} = (\text{InterFrameGAP} + \text{PreambleLength} + \text{StartFrameDelimiter} + \text{MAX}(\text{Selected Protocols})) \times 80\ \text{ns} + \text{REDBeginSafetyMargin} \quad (60)$$

where

YellowTime	is the minimum time between two reserved periods
InterFrameGAP	is the minimum distance between two frames
PreambleLength	is the length of the Preamble
StartFrameDelimiter	is the time used to transmit the SFD
MAX(Selected Protocols)	is the length of the frames of the selected protocols
REDBeginSafetyMargin	is the time which covers internal delays of a switch

MAX(Selected Protocols) = Maximum (PTCP, MRP, RT, IEEE 802.1AS) (61)

where

MAX(Selected Protocols)	is the maximum frame size of the protocol list
PTCP	is the maximum size of a frame used by the PTCP protocol Fragmentable protocol elements are ignored
MRP	is the maximum size of a frame used by the MRP protocol
RT	is the maximum frame length of a RT_CLASS_1/_2 frame used in this specific environment
IEEE 802.1AS	is the maximum size of a frame used by the IEEE 802.1AS protocol Fragmentable protocol elements are ignored

Table 571 – YellowTime

Value (hexadecimal)	Meaning	Usage
0x00 – 0x1ABF	Reserved	—
0x1AE0	Yellow time in Nanoseconds Equal to 86 Octets at 100 Mbit/s	Fragmentation is supported. In this case Formula (61) may return the value 64 Octets.
0x1AE1 – 0x1E847	—	Fragmentation is supported. The frame length of RT is between 65 and 1521 Octets.
0x1E848	Default Yellow time in Nanoseconds Equal to 1562,5 Octets at 100 Mbit/s	Fragmentation is *not* supported. In this case Formula (61) returns the value 1522 Octets.
0x0x1E849 – 0xFFFFFFFF	Reserved	—

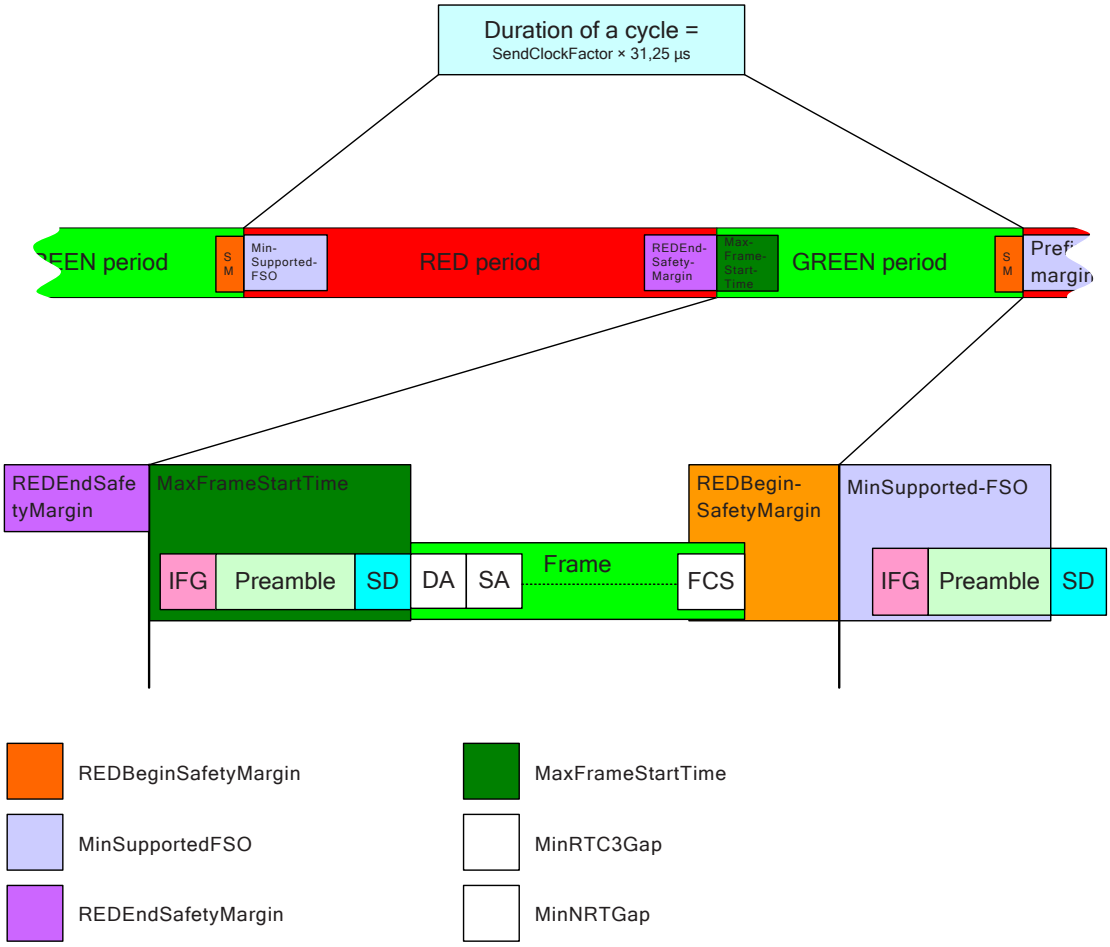


Figure 84 – Calculation principle for a cycle

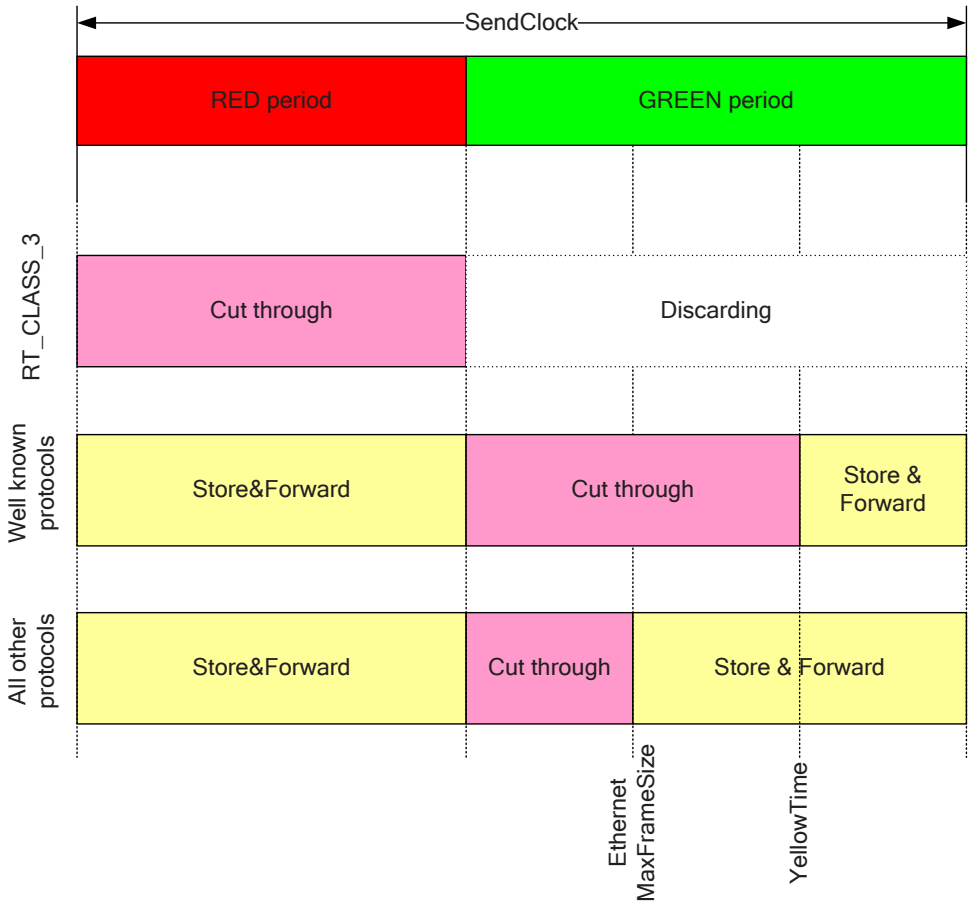


Figure 85 – Calculation principle for the minimum YellowTime

5.2.13.24 Coding of the field StartOfRedFrameID

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 572 and Table 574.

Table 572 – StartOfRedFrameID

Value (hexadecimal)	Meaning
0x0000 – 0x007F	Reserved
0x0080	Reserved Shall be accepted in case of legacy support for PTCP in RED
0x0081 – 0x00FF	Reserved
0x0100 – 0x0FFF	Mandatory 0x0100 is the default value
0x1000 – 0xFFFF	Reserved

5.2.13.25 Coding of the field EndOfRedFrameID

This field shall be coded as data type Unsigned16. This field shall be coded with the values according to Table 573 and Table 574.

Table 573 – EndOfRedFrameID

Value (hexadecimal)	Meaning
0x0000 – 0x00FF	Reserved
0x0100 – 0x0FFF	Mandatory 0x0FFF is the default value
0x1000 – 0xFFFF	Reserved

Table 574 – Dependencies of StartOfRedFrameID and EndOfRedFrameID

Value (hexadecimal)	Meaning
StartOfRedFrameID < EndOfRedFrameID	Valid
StartOfRedFrameID ≥ EndOfRedFrameID	Not used

5.2.13.26 Coding of the field NumberOfAssignments

This field shall be coded as data type Unsigned32. This field shall be coded with the values according to Table 575.

Table 575 – NumberOfAssignments

Value (hexadecimal)	Meaning
0x00000000	Reserved
0x00000001 – 0x00000004	Mandatory, if only phases with reserved periods (RED) exist, four entries shall be supported. Number of following assignment entries
0x00000005	Mandatory, if phases without reserved periods (RED) exist, five entries shall be supported. Number of following assignment entries
0x00000006 – 0x000000010	Optional Number of following assignment entries
0x00000011 – 0xFFFFFFFF	Reserved

If there is no reserved period for a port, than the NumberOfAssignments shall be coded with one and RedOrangePeriodBegin, OrangePeriodBegin and GreenPeriodBegin shall be coded with zero. Furthermore, the NumberOfPhases shall be coded with one and AssignedValueForReservedBegin, AssignedValueForOrangeBegin and AssignedValueForReservedEnd shall be coded with zero.

5.2.13.27 Coding of the field NumberOfPhases

This field shall be coded as data type Unsigned32. This field shall be coded with the values according to Table 576.

Table 576 – NumberOfPhases

Value (hexadecimal)	Meaning
Other	Reserved
0x00000001	Mandatory One following phase assignment entry
0x00000002	Mandatory Two following phase assignment entries
0x00000004	Mandatory Four following phase assignment entries
0x00000008	Mandatory Eight following phase assignment entries
0x00000010	Mandatory Sixteen following phase assignment entries

NOTE If more than 16 phases exist due to a ReductionRatio greater sixteen, the engineering shall logically reduce the amount of begin and end values to fit again in this structure.

5.2.13.28 Coding of the field PhaseAssignment

The field PhaseAssignment shall be according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 3: AssignedValueForReservedBegin
This bit shall be set with the values according to Table 577.

Table 577 – AssignedValueForReservedBegin

Value (hexadecimal)	Meaning
0x00	RedOrangePeriodBegin of entry one of the XXBeginEndAssignment shall be used
0x01 – 0x0E	…
0x0F	RedOrangePeriodBegin of entry sixteen of the XXBeginEndAssignment shall be used

Bit 4 – 7: AssignedValueForOrangeBegin
This bit shall be set with the values according to Table 578.

Table 578 – AssignedValueForOrangeBegin

Value (hexadecimal)	Meaning
0x00	OrangePeriodBegin of entry one of the XXBeginEndAssignment shall be used
0x01 – 0x0E	…
0x0F	OrangePeriodBegin of entry sixteen of the XXBeginEndAssignment shall be used

Bit 8 – 11: AssignedValueForReservedEnd
This bit shall be set with the values according to Table 579.

Table 579 – AssignedValueForReservedEnd

Value (hexadecimal)	Meaning
0x00	GreenPeriodBegin of entry one of the XXBeginEndAssignment shall be used
0x01 – 0x0E	…
0x0F	GreenPeriodBegin of entry sixteen of the XXBeginEndAssignment shall be used

Bit 12 – 15: Reserved
This bit shall be set to zero.

5.2.13.29 Coding of the field RedOrangePeriodBegin

This field shall be coded as data type Unsigned32 with values according to Table 580 and Table 581. The time base is 1 ns.

Table 580 – Values of RedOrangePeriodBegin

Value (hexadecimal)	Meaning	Use
0	Relative offset to the start of the related cycle	Mandatory
1 – 0x003D08FF	Relative offset to the start of the related cycle	Optional Use not intended
0x003D0900 – 0xFFFFFFFF	Reserved	—

Table 581 – Dependencies of RedOrangePeriodBegin, OrangePeriodBegin and GreenPeriodBegin

Value (hexadecimal)	Meaning	Usage
RedOrangePeriodBegin < OrangePeriodBegin < GreenPeriodBegin	Not used	—
RedOrangePeriodBegin = OrangePeriodBegin < GreenPeriodBegin	Not used	—
RedOrangePeriodBegin < OrangePeriodBegin = GreenPeriodBegin	Only a RED period is defined	Mandatory
RedOrangePeriodBegin = OrangePeriodBegin = GreenPeriodBegin = 0	No reserved period is defined	Mandatory
RedOrangePeriodBegin > OrangePeriodBegin	Not used	—
RedOrangePeriodBegin > GreenPeriodBegin	Not used	—
OrangePeriodBegin > GreenPeriodBegin	Not used	—

5.2.13.30 Coding of the field OrangePeriodBegin

This field shall be coded as data type Unsigned32 with values according to Table 581, Table 582, and Table 583. The time base is 1 ns.

Table 582 – Values of OrangePeriodBegin with ARProperties.StartupMode == Legacy

Value (hexadecimal)	Meaning	Use
0 – 0x003D08FF	Relative offset to the start of the related cycle	Optional
0x003D0900 – 0xFFFFFFFF	Reserved	—

Table 583 – Values of OrangePeriodBegin with ARProperties.StartupMode == Advanced

Value (hexadecimal)	Meaning	Use
GreenPeriodBegin	OrangePeriodBegin shall be equal to GreenPeriodBegin	—
other	Reserved	—

5.2.13.31 Coding of the field GreenPeriodBegin

This field shall be coded as data type Unsigned32 with values according to Table 581 and Table 584. The time base is 1 ns.

Table 584 – Values of GreenPeriodBegin

Value (hexadecimal)	Meaning	Use
0 – 0x0007A120	Relative offset to the start of the related cycle	Mandatory
0x0007A121 – 0x003D08FF	Relative offset to the start of the related cycle	Optional
0x003D0900 – 0xFFFFFFFF	Reserved	—

5.2.13.32 Coding of the field EtherType

This field shall be coded as Unsigned16 as described for the field LT in Table 22. This specification uses the value according to Table 585.

Table 585 – EtherType

Value (hexadecimal)	Meaning
0x8892	This standard

5.2.14 Coding section related to Physical Sync Data

5.2.14.1 Coding of the field PTCPLengthSubdomainName

This field shall be coded as data type Unsigned8.

5.2.14.2 Coding of the field PTCPSubdomainName

This field shall be coded as data type OctetString with 1 to 240 octets according to 4.3.1.4.15.1.

NOTE The field PTCPSubdomainName is not terminated by zero.

5.2.14.3 Coding of the field SyncProperties

This field shall be coded according to 3.4.2.4 and the individual bits shall have the following meaning:

Bit 0 – 1: SyncProperties.Role
This field shall be coded with the values according to Table 586.

Table 586 – SyncProperties.Role

Value (hexadecimal)	Meaning	Usage
0x00	Reserved	—
0x01	External sync	Working Clock Slave
0x02	Internal sync	Working Clock Master
0x03	Reserved	—

Bit 2 – 7: SyncProperties.reserved
This field shall be set to zero.

Bit 8 – 12: SyncProperties.SyncID
This field shall be coded according to Table 587.

Table 587 – SyncProperties.SyncID

Value (hexadecimal)	Meaning	Usage
0x00	SyncID 0	Working Clock synchronization
other	reserved	—

Bit 13 – 15: SyncProperties.reserved
This field shall be set to zero.

5.2.14.4 Coding of the field ReservedIntervalBegin

This field shall be coded as data type Unsigned32 with values according to Table 588, Table 589, Table 592, and Figure 86. The time base is one nanosecond.

Table 588 – ReservedIntervalBegin with ARProperties.StartupMode == Legacy

Value (hexadecimal)	Meaning
0x00000000	Begin of ORANGE period
other	Reserved

Table 589 – ReservedIntervalBegin with ARProperties.StartupMode == Advanced

Value (hexadecimal)	Meaning
0x00000000	Mandatory
other	Reserved

5.2.14.5 Coding of the field ReservedIntervalEnd

This field shall be coded as data type Unsigned32 with values according to Table 590, Table 591, Table 592, and Figure 86. The time base is one nanosecond.

Table 590 – ReservedIntervalEnd with ARProperties.StartupMode == Legacy

Value (hexadecimal)	Meaning
0x00000001 – 50% SendClock	End of ORANGE period
other	Reserved

Table 591 – ReservedIntervalEnd with ARProperties.StartupMode == Advanced

Value (hexadecimal)	Meaning
0x00000000	Mandatory
other	Reserved

The dependencies between the field ReservedIntervalBegin and the field ReservedIntervalEnd are shown in Table 592.

Table 592 – Dependencies of ReservedIntervalBegin and ReservedIntervalEnd

Value (hexadecimal)	Meaning
ReservedIntervalBegin < ReservedIntervalEnd	An ORANGE period is defined
ReservedIntervalBegin = ReservedIntervalEnd = 0	Default
ReservedIntervalBegin > ReservedIntervalEnd	Not used

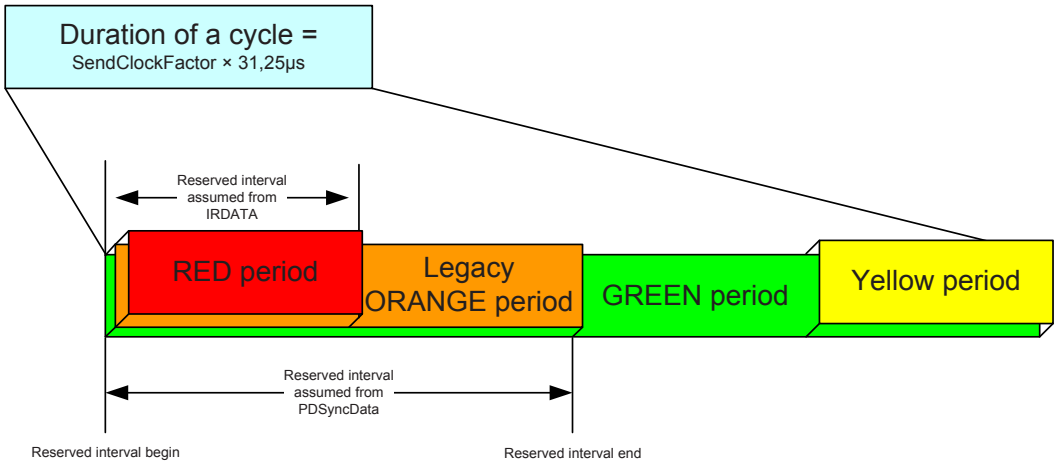


Figure 86 – Definition of the reserved interval

5.2.14.6 Coding of the field SyncSendFactor

This field shall be coded as data type Unsigned32 with values according to Table 593. The time base is 31,25 µs.

Table 593 – SyncSendFactor

Value (hexadecimal)	Meaning	SyncID (Clock)	SyncID (Time)
0x0000	Reserved	—	—
0x0001 – 0x03FF	Optional	—	—
0x03C0	Default	Mandatory (30 ms)	Optional (30 ms)
0x03C1 – 0x0C7F	Optional	—	—
0x0C80	Optional	—	Optional (100 ms)
0x0C81 – 0x176FF	Optional	—	—
0x17700	Default	—	Optional (3 s)
0x17701 – 0x4E1FF	Optional	—	—
0x4E200	Optional	—	Optional (10 s)
0x4E200 – 0xEA5FF	Optional	—	—
0xEA600	Default	—	Mandatory (30 s)
0x000EA601 – 0xA4CB7FFF	Optional	—	—
0xA4CB8000	Default	—	Optional (24 h)
0xA4CB8001 – 0xFFFFFFFF	Reserved	—	—

The SyncSendFactor may be rounded to full 10 ms before usage.

Each SyncProperties.SyncID shall require its own SyncSendFactor. The SyncSendInterval shall be calculated according to Formula (62).

$$\text{SyncSendInterval} = \text{SyncSendFactor} \times 31{,}25\ \mu\text{s} \quad (62)$$

where

SyncSendInterval is the sync send interval

SyncSendFactor is the factor for the calculation of the sync send interval

5.2.14.7 Coding of the field PTCPTimeoutFactor

This field shall be coded as data type Unsigned16. The time base is the value of the field SyncSendFactor. The value range shall be according to Table 594.

Table 594 – PTCPTimeoutFactor

Value (hexadecimal)	Meaning
0x0000	Disabled
0x0001 – 0x0002	Optional
0x0003 – 0x0005	Mandatory
0x0006	Default, mandatory
0x0007 – 0x000F	Mandatory
0x0010 – 0x01FF	Optional
0x0200 – 0xFFFF	Reserved

Each SyncProperties.SyncID shall require its own PTCPTimeoutFactor. The Timeout shall be calculated according to Formula (63).

$$\text{Timeout} = \text{PTCPTimeoutFactor} \times \text{SyncSendFactor} \times 31{,}25\ \mu\text{s} \quad (63)$$

where

Timeout	is the time out
PTCPTimeoutFactor	is the PTCP timeout factor for the calculation of the time out
SyncSendFactor	is the factor for the calculation of the sync send interval

5.2.14.8 Coding of the field PTCPTakeoverTimeoutFactor

This field shall be coded as data type Unsigned16 with the values according to Table 595. The time base is the value of the field SyncSendFactor.

Table 595 – PTCPTakeoverTimeoutFactor

Value (hexadecimal)	Meaning
0x0000	Disabled
0x0001	Optional
0x0002	Mandatory Default for sync slaves
0x0003	Mandatory Default for sync masters
0x0004 – 0x000F	Mandatory
0x0010 – 0x01FF	Optional
0x0200 – 0xFFFF	Reserved

Each SyncProperties.SyncID shall require its own PTCPTakeoverTimeoutFactor. The Timeout shall be calculated according to Formula (64).

$$\text{Timeout} = \text{PTCPTakeoverTimeoutFactor} \times \text{SyncSendFactor} \times 31{,}25\ \mu\text{s} \quad (64)$$

where

Timeout	is the time out
PTCPTakeoverTimeoutFactor	is the PTCP takeover factor for the calculation of the time out
SyncSendFactor	is the factor for the calculation of the sync send interval
31,25 μs	is the time base for the calculation

5.2.14.9 Coding of the field PTCPMasterStartupTime

This field shall be coded as data type Unsigned16 with the values according to Table 596. The time base is one second.

Table 596 – PTCPMasterStartupTime

Value (hexadecimal)	Meaning
0x0000	Disabled
0x0001 – 0x0004	Optional
0x0005 – 0x003B	Mandatory
0x003C	Default, mandatory
0x003D – 0x012C	Optional
0x012D – 0xFFFF	Reserved

Each SyncProperties.SyncID shall require its own PTCPMasterStartupTime.

5.2.14.10 Coding of the field PLLWindow

This field shall be coded as data type Unsigned32 with the values according to Table 597. The time base shall be one nanosecond.

Table 597 – PLLWindow

Value (hexadecimal)	Meaning	SyncID := 0 (Working Clock)
0x00	Disabled	—
0x0001 – 0x03E7	Optional	—
0x03E8	Default	Mandatory (1 μs)
0x03E9 – 0x270F	Optional	—
0x2710	Default	Optional (10 μs)
0x2710 – 0x000F423F	Optional	—
0x000F4240	Default	Optional (1 ms)
0x000F423F – 0x98967F	Optional	—
0x989680	Default	Optional (10 ms)
0x989681 – 0xFFFFFFFF	Reserved	—

Each SyncProperties.SyncID shall require its own PLLWindow.

The definition of the PLLWindow is shown in Figure 87 and Figure 88.

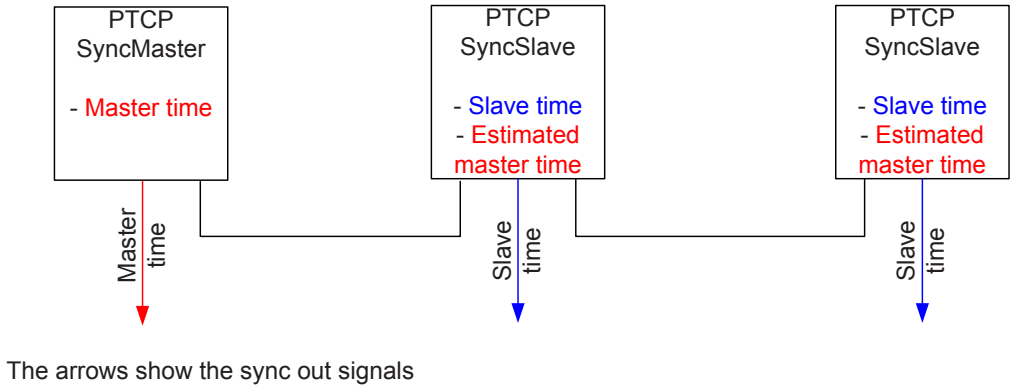


Figure 87 – Toplevel view to the PLL window

NOTE 1 The SyncSlaves estimates the master time by means of PTCP. It control its slave time to follow the master time, but in real life it follows the estimated master time. Because of the noisy environment the estimated master time is more or less equal to the master time.

NOTE 2 The external measurement of the PLLWindow is done between master time and slave time. The internal measurement of a SyncSlave is done between estimated master time and slave time.

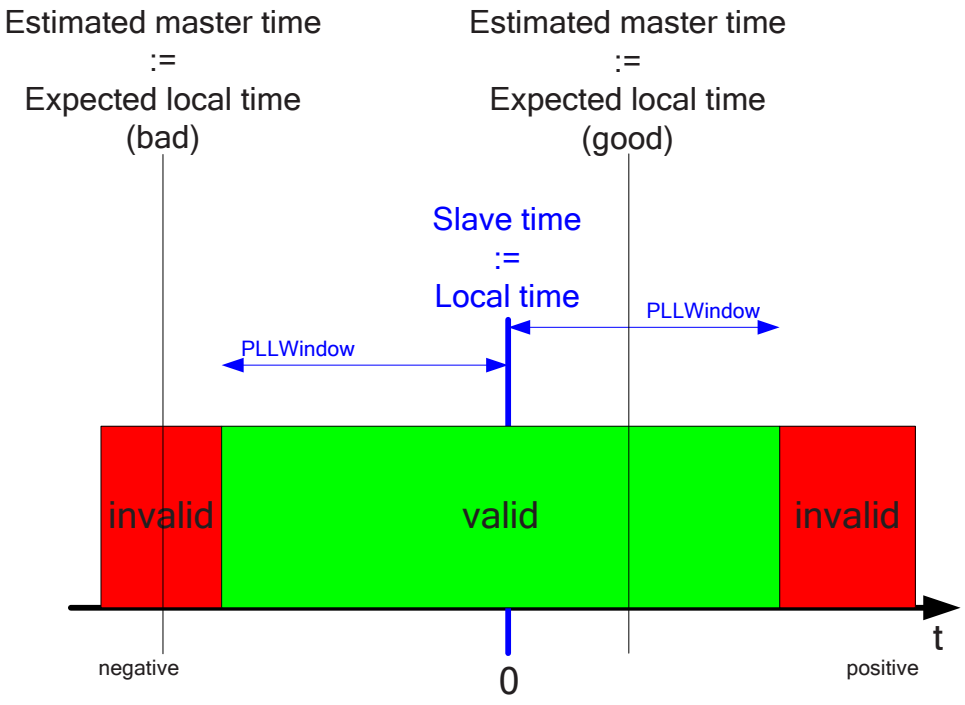


Figure 88 – Definition of PLL window

5.2.15 Coding section related to Isochrone Mode Data

5.2.15.1 Coding of the field TimeIObase

This field shall be coded as data type Unsigned32 with values according to Table 598. The time base is ns.

Table 598 – TimeIObase

Value (decimal)	Meaning
1 – 32 000 000	Optional
other	Reserved

5.2.15.2 Coding of the field TimeDataCycle

This field shall be coded as data type Unsigned16 with values according to Table 599. The time base is 31,25 μs.

Table 599 – TimeDataCycle

Value (hexadecimal)	Meaning	Comment
0x00	Reserved	—
0x01	Optional	Minimum time of 31,25 μs
0x02 – 0x03FF	Optional	…
0x0400	Optional	Maximum time of 32 ms.
0x401 – 0xFFFF	Reserved	—

The calculation of the TimeDC shall be done by Formula (65).

$$\text{TimeDC} = \text{TimeDataCycle} \times 31{,}25\ \mu\text{s} \tag{65}$$

where

TimeDC	is the time for the isochronous data cycle
TimeDataCycle	is the factor for the TimeDC
31,25 μs	is the time base for the calculation

5.2.15.3 Coding of the field TimeIOInput

This field shall be coded as data type Unsigned32 with values according to Table 600. The time base is ns.

Table 600 – TimeIOInput

Value (decimal)	Meaning
0 – 32 000 000	Optional
Other	Reserved

5.2.15.4 Coding of the field TimeIOOutput

This field shall be coded as data type Unsigned32 with values according to Table 601. The time base is ns.

Table 601 – TimeIOOutput

Value (decimal)	Meaning
0 – 32 000 000	Optional
other	Reserved

5.2.15.5 Coding of the field TimeIOInputValid

This field shall be coded as data type Unsigned32 with values according to Table 602. The time base is ns.

Table 602 – TimeIOInputValid

Value (decimal)	Meaning
0 – 32 000 000	Optional
other	Reserved

5.2.15.6 Coding of the field TimeIOOutputValid

This field shall be coded as data type Unsigned32 with values according to Table 603. The time base is ns.

Table 603 – TimeIOOutputValid

Value (decimal)	Meaning
0 – 32 000 000	Optional
other	Reserved

5.2.15.7 Coding of the field ControllerApplicationCycleFactor

This field shall be coded as data type Unsigned16 with values according to Table 604.

Table 604 – ControllerApplicationCycleFactor

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001 – 0x0400	Optional
0x0401 – 0xFFFF	Reserved

5.2.16 Coding section related to Physical Time Data

5.2.16.1 Coding of the field TimePLLWindow

This field shall be coded as data type Unsigned32 with the values according to Table 605. The time base shall be one nanosecond.

Table 605 – TimePLLWindow

Value (hexadecimal)	Meaning	SyncID (Time)
0x0000	Disabled	—
0x03E8	Default	Optional (1 μs)
0x2710	Default	Optional (10 μs)
0x000186A0	Default	Mandatory (100 μs)
0x000F4240	Default	Optional (1 ms)
0x00989680	Default	Optional (10 ms)
other	Reserved	—

The definition of the TimePLLWindow is shown in Figure 89 and Figure 90.

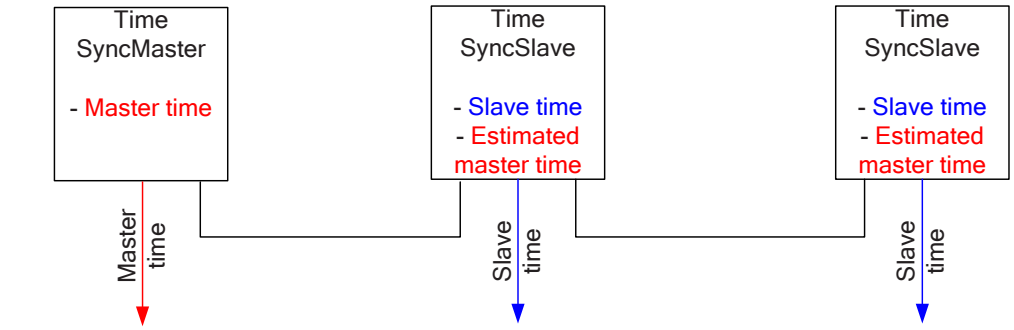


Figure 89 – Toplevel view to the time PLL window

NOTE 1 The SyncSlaves estimates the master time by means of IEEE 802.1AS. It control its slave time to follow the master time, but in real life it follows the estimated master time. Because of the noisy environment the estimated master time is more or less equal to the master time.

NOTE 2 The external measurement of the TimePLLWindow is done between master time and slave time. The internal measurement of a SyncSlave is done between estimated master time and slave time.

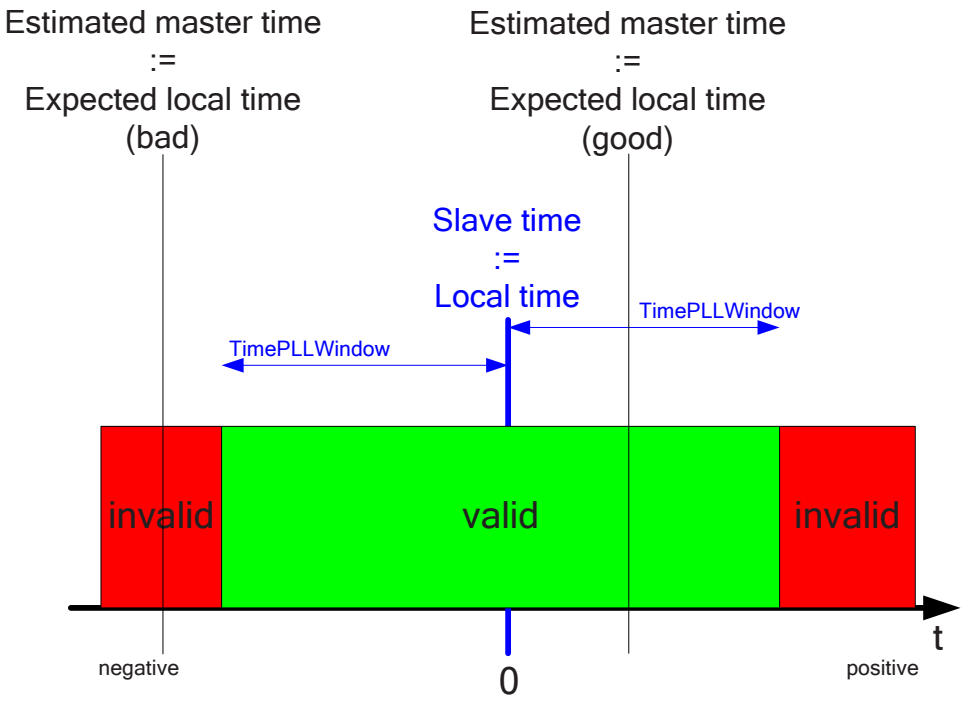


Figure 90 – Definition of time PLL window

5.2.16.2 Coding of the field TimeMasterPriority1

This field shall be coded as Unsigned8 with the value according to Table 606.

Table 606 – TimeMasterPriority1

Value (hexadecimal)	Usage	Meaning
0x00	Reserved	—
0x01 – 0x7F	Master	Optional
0x80	Master	Default for the role Time Master
0x81 – 0xFE	Master	Optional
0xFF	Slave	Default for the role Time slave

5.2.16.3 Coding of the field TimeMasterPriority2

This field shall be coded as Unsigned8 with the value according to Table 607.

Table 607 – TimeMasterPriority2

Value (hexadecimal)	Usage	Meaning
0x00 – 0xF7	Reserved	—
0xF8	Default	Default
0xF9 – 0xFF	Reserved	—

5.2.17 Coding section related to Media Redundancy

5.2.17.1 Coding of the field MRP_RingState

This field shall be coded as Unsigned16 with the values according to Table 608.

Table 608 – MRP_RingState

Value (hexadecimal)	Meaning	Usage
0x0000	Ring open	Redundancy manager in Ring open state
0x0001	Ring closed	Redundancy manager in Ring closed state
0x0002 – 0xFFFF	Reserved	—

5.2.17.2 Coding of the field MRP_DomainUUID

This field shall be coded as UUID with the values according to Table 609.

Table 609 – MRP_DomainUUID

Value (UUID)	Meaning	Usage
00000000-0000-0000-0000-000000000000	—	Reserved
00000000-0000-0000-0000-000000000001 – FFFFFFFF-FFFF-FFFF-FFFF-FFFFFFFFFFFE	UUID for media redundancy domain	Optional
FFFFFFFF-FFFF-FFFF-FFFF-FFFFFFFFFFFF	Default UUID for media redundancy domain	Mandatory

5.2.17.3 Coding of the field MRP_LengthDomainName

This field shall be coded as data type Unsigned8 and shall be set according to Table 611.

Table 610 – MRP_LengthDomainName

Value (hexadecimal)	Meaning
0x00	Reserved
0x01 – 0xF0	Allowed values
0xF1 – 0xFF	Reserved

5.2.17.4 Coding of the field MRP_DomainName

This field shall be coded as data type OctetString with 1 to 240 octets according to 4.3.1.4.15.1.

NOTE The field MRP_DomainName is not terminated by zero.

5.2.17.5 Coding of the field MRP_Role

This field shall be coded as data type Unsigned16 and shall be set according to Table 611.

Table 611 – MRP_Role

Value (hexadecimal)	Meaning
0x0000	Media Redundancy disabled
0x0001	Media Redundancy Client
0x0002	Media Redundancy Manager
0x0003 – 0xFFFF	Reserved

5.2.17.6 Coding of the field MRP_Version

This field shall be coded as data type Unsigned16 and set according to Table 612.

Table 612 – MRP_Version

Value (hexadecimal)	Meaning
0x0001	Version 1
other	Reserved

5.2.17.7 Coding of the field MRP_Prio

This field shall be coded as Unsigned16 and set according to Table 613.

Table 613 – MRP_Prio

Value (hexadecimal)	Meaning
0x0000	Highest priority redundancy manager
0x1000 – 0x7000	High priorities
0x8000	Default priority for redundancy manager
0x9000 – 0xE000	Low priorities
0xF000	Lowest priority redundancy manager
other	Reserved

5.2.17.8 Coding of the field MRP_TOPchgT

This field defines the common point of time that shall be used to invoke the Flush Filtering Data base service and shall be coded as data type Unsigned16. The value shall be set according to Table 614 with a time base of 10 ms.

Table 614 – MRP_TOPchgT

Value (decimal)	Meaning	Usage
0	0 ms	Clear filtering database (FDB table) immediately
1	10 ms	Mandatory
2 – 100	20 ms – 1 s	Optional
101 – 65 535	Reserved	—

5.2.17.9 Coding of the field MRP_TOPNRmax

This field shall be coded as data type Unsigned16 and set according to Table 615.

Table 615 – MRP_TOPNRmax

Value (decimal)	Meaning	Usage
0	Reserved	—
1	1 iteration	Optional
2	2 iterations	Optional
3	3 iterations	Mandatory (200 ms reconfiguration time)
4	4 iterations	Optional
5	5 iterations	Optional
6 – 65 535	Reserved	—

5.2.17.10 Coding of the field MRP_TSTshortT

This field shall be coded as data type Unsigned16 and set according to Table 616.

Table 616 – MRP_TSTshortT

Value (decimal)	Meaning	Usage
0	Reserved	—
1 – 9	1 – 9 ms	Optional (short test interval)
10	10 ms	Mandatory (200 ms reconfiguration time)
10 – 500	10 – 500 ms	Optional (short test interval)
501 – 65 535	Reserved	—

5.2.17.11 Coding of the field MRP_TSTdefaultT

This field shall be coded as data type Unsigned16 and set according to Table 617.

Table 617 – MRP_TSTdefaultT

Value (decimal)	Meaning	Usage
0	Reserved	—
1 – 19	1 – 19 ms	Optional (default test interval)
20	20 ms	Mandatory (200 ms reconfiguration time)
21 – 1 000	21 ms – 1 s	Optional (default test interval)
1 001 – 65 535	Reserved	—

5.2.17.12 Coding of the field MRP_TSTNRmax

This field shall be coded as data type Unsigned16 and set according to Table 618.

Table 618 – MRP_TSTNRmax

Value (decimal)	Meaning	Usage
0 – 1	Reserved	—
2	2 outstanding test indications cause ring failure	Optional
3	3 outstanding test indications cause ring failure	Mandatory (200 ms reconfiguration time)
4 – 10	4 – 10 outstanding test indications cause ring failure	Optional
11 – 65 535	Reserved	—

5.2.17.13 Coding of the field MRP_LNKdownT

This field shall be coded as data type Unsigned16. The coding shall be according to Table 619.

Table 619 – MRP_LNKdownT

Value (decimal)	Meaning	Usage
0	Reserved	—
1 – 19	1 – 19 ms Link Down interval	Optional
20	20 ms Link Down interval	Mandatory
21 – 1 000	21 – 1 000 ms Link Down interval	Optional
1 001 – 65 535	Reserved	—

5.2.17.14 Coding of the field MRP_LNKupT

This field shall be coded as data type Unsigned16 according to Table 620.

Table 620 – MRP_LNKupT

Value (decimal)	Meaning	Usage
0	Reserved	—
1 – 19	1 – 19 ms Link Up interval	Optional
20	20 ms Link Up interval	Mandatory
21 – 1 000	21 – 1 000 ms Link Up interval	Optional
1 001 – 65 535	Reserved	—

5.2.17.15 Coding of the field MRP_LNKNRmax

This field shall be coded as data type Unsigned16 according to Table 621.

Table 621 – MRP_LNKNRmax

Value (decimal)	Meaning	Usage
0	Reserved	—
1	1 iteration	Optional
2	2 iterations	Optional
3	3 iterations	Optional
4	4 iterations	Mandatory
5	5 iterations	Optional
6 – 65 535	Reserved	—

5.2.17.16 Coding of the field MRP_Check

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0: MRP_Check.MediaRedundancyManager
This field shall be set according to Table 622.

Table 622 – MRP_Check.MediaRedundancyManager

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Disable MediaRedundancyManager diagnosis
0x01	ON	Enable MediaRedundancyManager diagnosis (see Table 516)

Bit 1: MRP_Check.MRP_DomainUUID
This field shall be set according to Table 623.

Table 623 – MRP_Check.MRP_DomainUUID

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Disable the check of the MRP_DomainUUID vs. LLDP_PNIO_MRPPORTSTATUS
0x01	ON	Enable the check of the MRP_DomainUUID vs. LLDP_PNIO_MRPPORTSTATUS and the generation of “Peer MRP domain mismatch” (see Table 515)

Bit 2 – 23: MRP_Check.reserved_1
This field shall be set according to 3.4.2.2.

Bit 24 – 31: MRP_Check.reserved_2
This field shall be set to zero.

5.2.18 Coding section related to fiber optics

5.2.18.1 Coding of the field VendorBlockType

This field shall be coded as data type Unsigned16 and set according to Table 624.

Table 624 – VendorBlockType

Value (hexadecimal)	Meaning
0x0000 – 0xFFFF	Vendor specific

5.2.18.2 Coding of the field FiberOpticType

This field shall be coded as data type Unsigned32 and set according to Table 625.

Table 625 – FiberOpticType

Value (hexadecimal)	Meaning
0x00000000	No fiber type adjusted
0x00000001	9 μm single mode fiber
0x00000002	50 μm multi mode fiber
0x00000003	62,5 μm multi mode fiber
0x00000004	SI-POF [a], NA = 0,5
0x00000005	SI-PCF [a], NA = 0,36
0x00000006	LowNA-POF [a], NA = 0,3
0x00000007	GI-POF [a]
0x00000008	GI-PCF [a]
0x00000009 – 0x0000007F	Reserved
0x00000080 – 0x000000FF	Vendor specific
0x00000100 – 0xFFFFFFFF	Reserved
[a] See IEC 61158-2.	

5.2.18.3 Coding of the field FiberOpticCableType

This field shall be coded as data type Unsigned32. The coding shall be according to Table 626.

Table 626 – FiberOpticCableType

Value (hexadecimal)	Meaning
0x0000	No cable specified
0x0001	Inside/outside cable, fixed installation
0x0002	Inside/outside cable, flexible installation
0x0003	Outdoor cable, fixed installation
0x0004 – 0xFFFFFFFF	Reserved

5.2.18.4 Coding of the field FiberOpticPowerBudgetType

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 30: FiberOpticPowerBudgetType.Value
This field shall be set according to Table 627.

Table 627 – FiberOpticPowerBudgetType.Value

Value (hexadecimal)	Meaning	Usage
0	0 dB	Mandatory for maintenance demanded
0x0001 – 0x0013	0,1 dB to 1,9 dB	Optional
0x0014	2 dB	Mandatory for maintenance required
0x0015 – 0x03E7	2,1 dB to 99,9 dB	Optional
0x03E8 – 0x7FFFFFFF	Reserved	—

Bit 31: FiberOpticPowerBudgetType.CheckEnable
This field shall be set according to Table 628.

Table 628 – FiberOpticPowerBudgetType.CheckEnable

Value (hexadecimal)	Meaning
0x0	OFF
0x1	ON Comparison value is FiberOpticPowerBudgetType.Value

5.2.18.5 Coding of the field FiberOpticManufacturerSpecific

This field shall be coded as data type OctetString.

5.2.19 Coding section related network components

5.2.19.1 Coding of the field NCDropBudgetType

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 30: NCDropBudgetType.Value
This field shall be set according to Table 629.

Table 629 – NCDropBudgetType.Value

Value (hexadecimal)	Meaning	Usage
0	Reserved	—
0x0001 – 0x0002	Number of dropped frames	Optional
0x0003	Number of dropped frames	Mandatory for maintenance required
0x0004 – 0x0009	Number of dropped frames	Optional
0x000A	Number of dropped frames	Mandatory for maintenance demanded
0x000B – 0x03E7	Number of dropped frames	Optional
0x03E8 – 0x7FFFFFFF	Reserved	—

Bit 31: NCDropBudgetType.CheckEnable
This field shall be set according to Table 630.

Table 630 – NCDropBudgetType.CheckEnable

Value (hexadecimal)	Meaning
0x0	OFF
0x1	ON Comparison value is NCDropBudgetType.Value

The checking of the dropped frames shall be done according to Figure 91 and Figure 92.

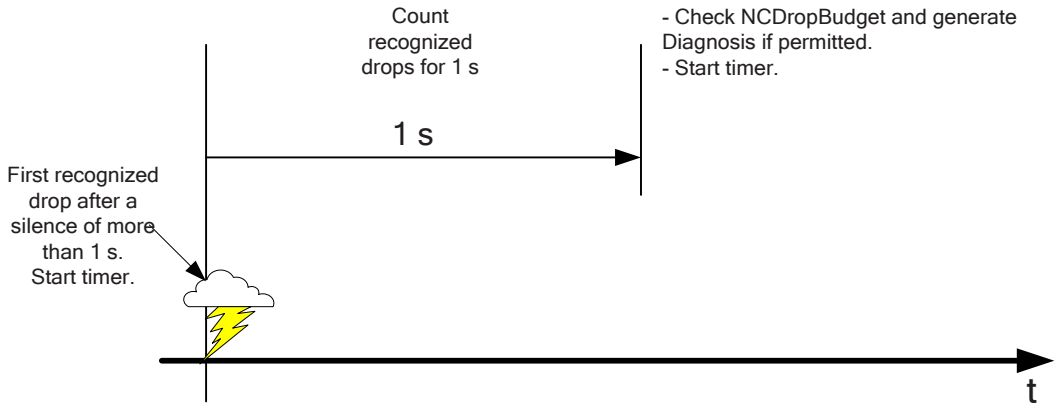


Figure 91 – Detection of dropped frames — appear

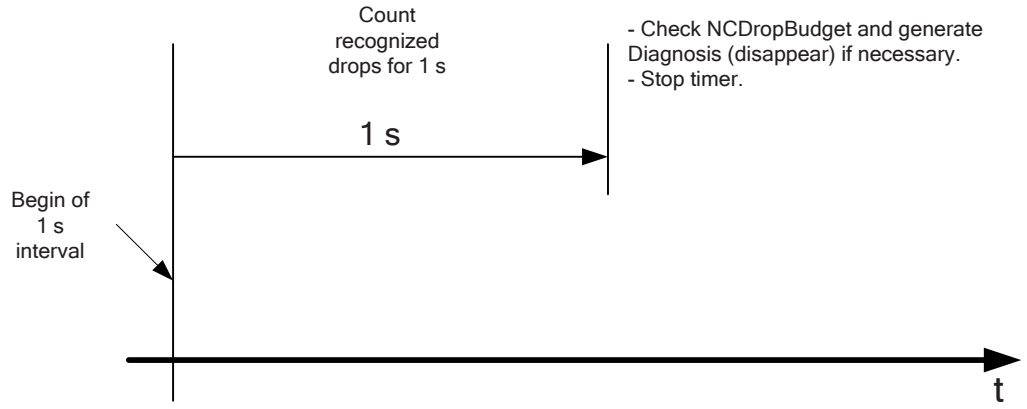


Figure 92 – Detection of dropped frames — disappear

5.2.20 Coding section related port statistic

5.2.20.1 Coding of the field ifInOctets

This field shall be coded as data type Unsigned32 with the values according to IETF RFC 1213. The value zero shall be used if not supported.

5.2.20.2 Coding of the field ifOutOctets

This field shall be coded as data type Unsigned32 with the values according to IETF RFC 1213. The value zero shall be used if not supported.

5.2.20.3 Coding of the field ifInDiscards

This field shall be coded as data type Unsigned32 with the values according to IETF RFC 1213. The value zero shall be used if not supported.

5.2.20.4 Coding of the field ifOutDiscards

This field shall be coded as data type Unsigned32 with the values according to IETF RFC 1213. The value zero shall be used if not supported.

5.2.20.5 Coding of the field ifInErrors

This field shall be coded as data type Unsigned32 with the values according to IETF RFC 1213. The value zero shall be used if not supported.

5.2.20.6 Coding of the field ifOutErrors

This field shall be coded as data type Unsigned32 with the values according to IETF RFC 1213. The value zero shall be used if not supported.

5.2.21 Coding section related to fast start up

5.2.21.1 Coding of the field FSHelloMode

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 1: FSHelloMode.Mode
This field shall be set according to Table 631.

Table 631 – FSHelloMode.Mode

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Default
0x01	Send DCP_Hello.req on LinkUp	—
0x02	Send DCP_Hello.req on LinkUp after HelloDelay	—
0x03	Reserved	Reserved

Bit 2 – 23: FSHelloMode.reserved_1
This field shall be set according to 3.4.2.2.

Bit 24 – 31: FSHelloMode.reserved_2
This field shall be set to zero.

5.2.21.2 Coding of the field FSHelloInterval

This field shall be coded as data type Unsigned32. The coding shall be according to Table 632.

Table 632 – FSHelloInterval

Value (hexadecimal)	Meaning	Usage
0x00000001E	30 ms Wait this time after the first DCP_Hello.req before conveying a second DCP_Hello.req	Default
0x000000032	50 ms Wait this time after the first DCP_Hello.req before conveying a second DCP_Hello.req	—
0x000000064	100 ms Wait this time after the first DCP_Hello.req before conveying a second DCP_Hello.req	—
0x00000012C	300 ms Wait this time after the first DCP_Hello.req before conveying a second DCP_Hello.req	—
0x0000001F4	500 ms Wait this time after the first DCP_Hello.req before conveying a second DCP_Hello.req	—
0x0000003E8	1 000 ms Wait this time after the first DCP_Hello.req before conveying a second DCP_Hello.req	—
other	Reserved	—

5.2.21.3 Coding of the field FSHelloRetry

This field shall be coded as data type Unsigned32. The coding shall be according to Table 633.

Table 633 – FSHelloRetry

Value (hexadecimal)	Meaning	Usage
0x00000000	Reserved	—
0x00000001 – 0x00000002	Number of retransmission of the Hello.req	—
0x00000003	Number of retransmission of the Hello.req	Default
0x00000004 – 0x0000000F	Number of retransmission of the Hello.req	—
0x00000010 – 0xFFFFFFFF	Reserved	—

5.2.21.4 Coding of the field FSHelloDelay

This field shall be coded as data type Unsigned32. The coding shall be according to Table 634.

Table 634 – FSHelloDelay

Value (hexadecimal)	Meaning	Usage
0x000000000	OFF	Default
0x000000032	50 ms Wait this time after the first LinkUp.ind before conveying a DCP_Hello.req	—
0x000000064	100 ms Wait this time after the first LinkUp.ind before conveying a DCP_Hello.req	—
0x0000001F4	500 ms Wait this time after the first LinkUp.ind before conveying a DCP_Hello.req	—

Value (hexadecimal)	Meaning	Usage
0x0000003E8	1 000 ms Wait this time after the first LinkUp.ind before conveying a DCP_Hello.req	—
other	Reserved	—

5.2.21.5 Coding of the field FSParameterMode

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 1: FSParameterMode.Mode
This field shall be set according to Table 635.

Table 635 – FSParameterMode.Mode

Value (hexadecimal)	Meaning	Usage
0x00	OFF	Default
0x01	ON	—
0x02	Reserved	—
0x03	Reserved	—

Bit 2 – 23: FSParameterMode.reserved_1
This field shall be set according to 3.4.2.2.

Bit 24 – 31: FSParameterMode.reserved_2
This field shall be set to zero.

5.2.21.6 Coding of the field FSParameterUUID

This field shall be coded as data type UUID with values according to Table 636.

Table 636 – FSParameterUUID

Value (UUID)	Meaning
00000000-0000-0000-0000-000000000000	Reserved
00000000-0000-0000-0000-000000000001 – FFFFFFFF-FFFF-FFFF-FFFF-FFFFFFFFFFFF	UUID for the record data (including physical device data, ...) delivered between IODConnectRes and IODControlReq.

5.2.22 Coding section related to DFP

5.2.22.1 Coding of the field NumberOfSubframeBlocks

This field shall be coded as data type Unsigned16 with values according to Table 637.

Table 637 – NumberOfSubframeBlocks

Value (hexadecimal)	Meaning
0x0000	Reserved
0x0001 – 0x00FF	Number of the following SubframeBlocks
0x0100 – 0xFFFF	Reserved

5.2.22.2 Coding of the field SFIOCRProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0 – 7: SFIOCRProperties.DistributedWatchDogFactor
This field shall be set according to Table 638.

Table 638 – SFIOCRProperties.DistributedWatchDogFactor

Value (hexadecimal)	Meaning	Description
0x00	Optional	Distributed WatchDog shall be disabled
0x01 – 0x02	Optional	A value “1” leads to an AR termination for one missed frame, a value “2” leads to an AR termination for two missed frames.
0x03 – 0x1F	Mandatory	An expiration should be signaled to the application as a hint for a possible communication disturbance.
0x20 – 0xFF	Optional	An expiration should be signaled to the application as a hint for a possible communication disturbance.

The time base is the SendClockFactor multiplied with ReductionRatio of the monitored provider.

The DistributedWatchDogTime shall be calculated according to Formula (66).

$$\text{Distributed-WatchDogTime} = \text{Distributed-WatchDogFactor} \times \text{SendClockFactor} \times \text{ReductionRatio} \times 31{,}25\ \mu s \quad (66)$$

where

DistributedWatchDogTime	is the distributed watch dog time
DistributedWatchDogFactor	is the factor for the calculation of the distributed watch dog
SendClockFactor	is the send clock factor
ReductionRatio	is the reduction ratio

Bit 8 – 15: SFIOCRProperties.RestartFactorForDistributedWD
This field shall be set according to Table 639.

Table 639 – SFIOCRProperties.RestartFactorForDistributedWD

Value (hexadecimal)	Meaning	Description
0x00	Mandatory	No restart delay necessary
0x01 – 0x09	Optional	Less than 1 s restart delay
0x0A – 0x50	Mandatory	1 s to 8 s restart delay
0x51 – 0xFF	Optional	More than 8 s restart delay

The time base is 100 ms. The RestartForDistributedWDTime shall be calculated according to Formula (67).

$$\text{RestartForDistributed-WDTime} = \text{RestartFactorFor-DistributedWDFactor} \times 100\ ms \quad (67)$$

where

RestartForDistributedWDTime	is the restart for distributed watch dog time
RestartFactorForDistributedWDFactor	is the factor for the calculation of the restart for distributed watch dog time

The RestartFactorForDistributedWD shall only be used if the SFIOCRProperties.DistributedWatchDogFactor is not set to zero.

NOTE The RestartForDistributedWDTime is defined as minimum time having an accuracy between '-0' and '+1 s'.

Bit 16 – 23: SFIOCRProperties.DFPMode
This field shall be set according to Table 640.

Table 640 – SFIOCRProperties.DFPMode

Value (hexadecimal)	Meaning	Description
0x00	Mandatory	End node mode
0x01 – 0x3F	Mandatory	Concatenating mode Own Subframe position
0x40 – 0xFF	Optional	Concatenating mode Own Subframe position

Bit 24 – 27: SFIOCRProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 28: SFIOCRProperties.reserved_2
This field shall be set to zero.

Bit 29: SFIOCRProperties.DFPDirection
This field shall be set according to Table 641.

Table 641 – SFIOCRProperties.DFPDirection

Value (hexadecimal)	Meaning	Description
0x00	Mandatory	This Frame is intended to be handled by the DFP_INBOUND state machine.
0x01	Mandatory	This Frame is intended to be handled by the DFP_OUTBOUND state machine.

Bit 30: SFIOCRProperties.DFPRedundantPathLayout
This field shall be set according to Table 642.

Table 642 – SFIOCRProperties.DFPRedundantPathLayout

Value (hexadecimal)	Meaning	Description
0x00	Mandatory	The Frame for the redundant path, coded by the FrameID with the least significant bit set to one, shall contain the ordering shown by SubframeData.
0x01	Mandatory	The Frame for the redundant path, coded by the FrameID with the least significant bit set to one, shall contain the inverse ordering of the SubframeData.

Bit 31: SFIOCRProperties.SFCRC16
This field shall be set according to Table 643.

Table 643 – SFIOCRProperties.SFCRC16

Value (hexadecimal)	Description
0x00	SFCRC16 and SFCycleCounter shall be created or set to zero by the sender and not checked by the receiver.
0x01	SFCRC16 and SFCycleCounter shall be created by the sender and checked by the receiver.

5.2.22.3 Coding of the field SubframeData

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

NOTE The SFCRC16 of the frame header and the SFEndDelimiter are implicit. See CSF_SDU.

Bit 0 – 6: SubframeData.Position
This field shall be set according to Table 644.

Table 644 – SubframeData.Position

Value (hexadecimal)	Meaning
0x00	Reserved
0x01 – 0x7F	SFPosition.Position of the Subframe

Bit 7: SubframeData.reserved_1
This field shall be set according to 3.4.2.2.

Bit 8 – 15: SubframeData.DataLength
This field shall be set according to Table 645.

Table 645 – SubframeData.DataLength

Value (hexadecimal)	Meaning
0x00	Reserved
0x01 – 0xFF	Number of octets of the C_SDU of the SUBFRAME

Bit 16 – 31: SubframeData.reserved_2
This field shall be set according to 3.4.2.2.

5.2.22.4 Frame late error

The checking of the DFP frame late error shall be done according to Figure 93.

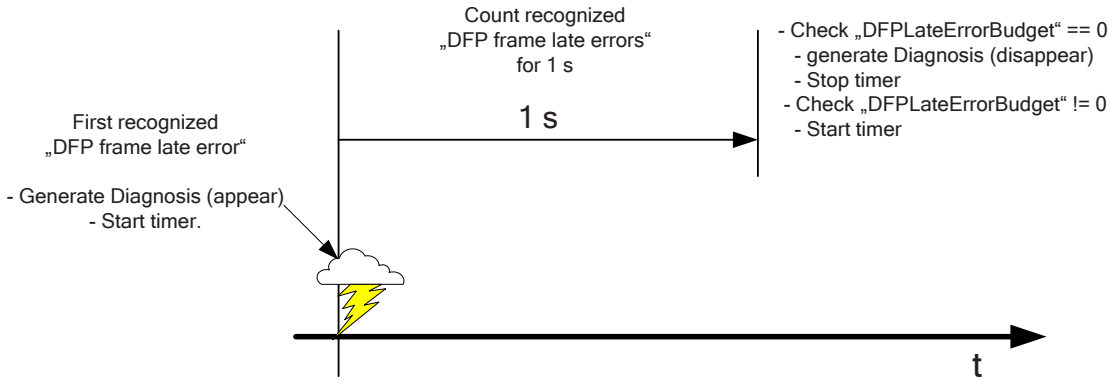


Figure 93 – Detection of DFP late error — appear and disappear

Table 646 – Event function table

Function name	Operations
Appear	Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:= Dynamic Frame Packing problem notification User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Appears ChannelProperties.Maintenance := MaintenanceDemanded ChannelErrorType := “Dynamic frame packing function mismatch” ExtChannelErrorType := “Frame late error” (see Formula (55)) Alarm Notification.req(AREP, API, Alarm Priority, Alarm Type, Slot Number, Subslot Number, Alarm Specifier, Module Ident Number, Submodule Ident Number, Alarm Item)
Disappear	Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:= Dynamic Frame Packing problem notification User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Disappears ChannelProperties.Maintenance := MaintenanceDemanded ChannelErrorType := “Dynamic frame packing function mismatch” ExtChannelErrorType := “Frame late error” (see Formula (55)) Alarm Notification.req(AREP, API, Alarm Priority, Alarm Type, Slot Number, Subslot Number, Alarm Specifier, Module Ident Number, Submodule Ident Number, Alarm Item)
Do nothing	This state change shall not indicate an event

5.2.22.5 Coding of the field SubframeOffset

This field shall be coded as data type Unsigned16 with values according to Table 647.

Table 647 – SubframeOffset

Value (hexadecimal)	Meaning
0x0000 – 0x0005	Reserved
0x0006 – 0x059B	Number of octets from the begin of the frame C_SDU to the begin of the according subframe C_SDU
0x059C – 0xFFFF	Reserved

5.2.23 Coding section related to MRPD

5.2.23.1 Overview

The following rules shall be applied for the MediaRedundancyWatchDog of MRPD. The time value (e.g. 8 s) of the MediaRedundancyWatchDog shall be defined locally to avoid “false positive” events in case of frame errors. It shall be activated if MRPD is used.

5.2.23.2 MediaRedundancyWatchDog expired

The checking whether the MediaRedundancyWatchDog (as an example with the time value 1 s) is expired shall be done according to Figure 94.

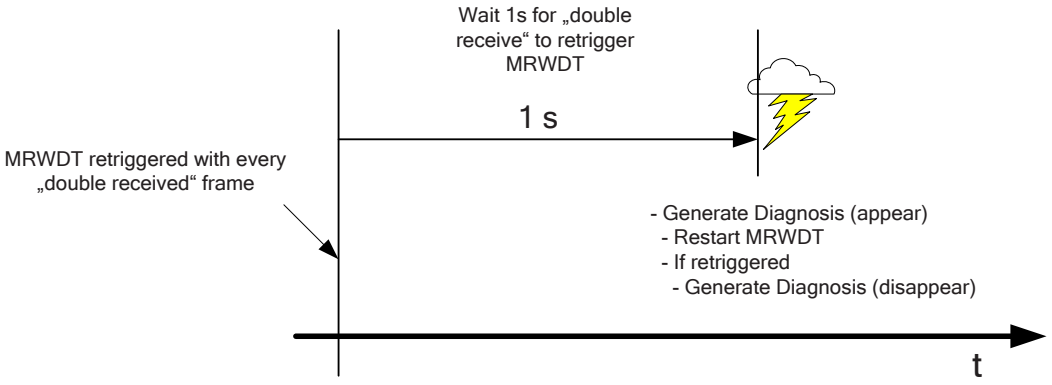


Figure 94 – MediaRedundancyWatchDog expired — appear and disappear

Table 648 – Event function table

Function name	Operations
Appear	Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:= MRPD problem notification User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Appears ChannelProperties.Maintenance :=MaintenanceDemanded ChannelErrorType := “Media redundancy with planned duplication mismatch” ExtChannelErrorType := “MRPD duplication void” (see Formula (56)) Alarm Notification.req(AREP, API, Alarm Priority, Alarm Type, Slot Number, Subslot Number, Alarm Specifier, Module Ident Number, Submodule Ident Number, Alarm Item)
Disappear	Alarm Priority := ALARM_HIGH or ALARM_LOW Alarm Type:= MRPD problem notification User Structure Identifier := 0x8002 ChannelNumber := 0x8000 ChannelProperties.Specifier := Disappears ChannelProperties.Maintenance :=MaintenanceDemanded ChannelErrorType := “Media redundancy mismatch” ExtChannelErrorType := “MRPD duplication void” (see Formula (56)) Alarm Notification.req(AREP, API, Alarm Priority, Alarm Type, Slot Number, Subslot Number, Alarm Specifier, Module Ident Number, Submodule Ident Number, Alarm Item)
Do nothing	This state change shall not indicate an event

5.2.24 Coding section related to auto configuration

5.2.24.1 Overview

The following coding section applies for the auto configuration functionality.

5.2.24.2 Coding of the field SendClockFactorArray

The field SendClockFactorArray is an array of 16 SCFEntry octets. It shall be used to code the supported SendClockFactors. Each bit of the array corresponds with one SendClockFactor and shall be calculated as shown in Formula (68) and (69).

$$N = (SendClockFactor - 1)\ DIV\ 8 \quad (68)$$

where

N	is the number of the octet
SendClockFactor	is the supported SendClockFactor
8	is the bit size of a octet

$$M = (SendClockFactor - 1)\ MOD\ 8 \quad (69)$$

where

M	is the number of the bit within the octet
SendClockFactor	is the supported SendClockFactor
8	is the bit size of a octet

NOTE The term DIV stands for division without remainder. The term MOD stands for the remainder of the division.

The SendClockFactorArray shall be structured in ascending order without gaps.

The coding of the SCFEntry shall be according to 3.4.2.3 and the individual bits shall have the following meaning:

Bit 0: SCFEntry_0
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Table 649 – SCFEntry

Value (hexadecimal)	Meaning
0x00	SendClockFactor not supported
0x01	SendClockFactor supported

Bit 1: SCFEntry_1
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Bit 2: SCFEntry_2
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Bit 3: SCFEntry_3
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Bit 4: SCFEntry_4
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Bit 5: SCFEntry_5
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Bit 6: SCFEntry_6
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

Bit 7: SCFEntry_7
This bit shall be set with the values according to Table 649 if the SendClockFactor with the number that meets Formula (68) and (69) is present.

5.2.24.3 Coding of the field ACCommunicationProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0: ACCommunicationProperties.DFP
This field shall be set according to Table 650.

Table 650 – ACCommunicationProperties.DFP

Value (hexadecimal)	Meaning
0x00	Not supported
0x01	Supported

Bit 1 – 2: ACCommunicationProperties.RTC3
This field shall be set according to Table 651.

Table 651 – ACCommunicationProperties.RTC3

Value (hexadecimal)	Meaning
0x00	Not supported
0x01	PDIRFrameData with local and forwarding (including the FrameSendOffset) information needed
0x02	PDIRFrameData with local information needed
0x03	Reserved

Bit 3: ACCommunicationProperties.RTCUDP
This field shall be set according to Table 652.

Table 652 – ACCommunicationProperties.RTCUDP

Value (hexadecimal)	Meaning
0x00	RT_CLASS_UDP not supported
0x01	RT_CLASS_UDP supported

Bit 3 – 15: ACCommunicationProperties.reserved_1
This field shall be set according to 3.4.2.2.

Bit 16 – 31: ACCommunicationProperties.reserved_2
This field shall be set to zero.

5.2.24.4 Coding of the field ACMinDeviceInterval

This field shall be coded as data type Unsigned16 according to Table 653.

Table 653 – ACMinDeviceInterval

Value (hexadecimal)	Meaning
0x00	Reserved
0x01	31,25 μs MinDeviceInterval as a factor of 31,25 μs.
…	…
0x1000	128 ms MinDeviceInterval as a factor of 31,25 μs.
0x1001 – 0xFFFF	Reserved

5.2.25 Coding section related to controller to controller communication

5.2.25.1 Overview

The following coding section applies for the controller to controller communication.

5.2.25.2 Coding of the field FromOffsetData

This field shall be coded as data type Unsigned32 according to Table 654.

Table 654 – FromOffsetData

Value (hexadecimal)	Meaning	Description
0x00000000 – 0xFFFFFFFF	Mandatory	Contains the offset in octets as base offset for the request and the delivered chunk of data in the response.

5.2.25.3 Coding of the field NextOffsetData

This field shall be coded as data type Unsigned32 according to Table 655.

Table 655 – NextOffsetData

Value (hexadecimal)	Meaning	Description
0x00000000	Mandatory	The last chunk of data is read.
Other	Mandatory	Delivers the next to be used offset value for convenience. More data is available.

5.2.25.4 Coding of the field TotalSize

This field shall be coded as data type Unsigned32 according to Table 656.

Table 656 – TotalSize

Value (hexadecimal)	Meaning	Description
0x00000000	Reserved	—
Other	Mandatory	Contains the total size in octets of the requested object.

5.2.26 Coding section related to system redundancy

5.2.26.1 Overview

The following coding section applies for the system redundancy functionality.

5.2.26.2 Coding of the field RedundancyInfo

The coding of this field shall be according to 3.7.3.4 and the individual bits shall have the following meaning:

Bit 0: RedundancyInfo.EndPoint1
This field shall be coded according to Table 657.

Table 657 – RedundancyInfo.EndPoint1

Value (hexadecimal)	Meaning
0x00	The position of the delivering node in a rack is not the left or below one.
0x01	The delivering node is the left or below one.

Bit 1: RedundancyInfo.EndPoint2
This field shall be coded according to Table 658.

Table 658 – RedundancyInfo.EndPoint2

Value (hexadecimal)	Meaning
0x00	The delivering node is not the right or above one.
0x01	The delivering node is the right or above one.

Valid combinations of RedundancyInfo.EndPoint1 and RedundancyInfo.EndPoint2 are shown in Table 659.

Table 659 – Valid combination of RedundancyInfo.EndPoint1 and RedundancyInfo.EndPoint2

RedundancyInfo. EndPoint1	RedundancyInfo. EndPoint2	Meaning
0x00	0x00	Reserved
0x00	0x01	Valid combination
0x01	0x00	Valid combination
0x01	0x01	Reserved

Bit 2 – 15: RedundancyInfo.reserved
This field shall be set to zero.

5.2.26.3 Coding of the field SRProperties

The coding of this field shall be according to 3.4.2.5 and the individual bits shall have the following meaning:

Bit 0: SRProperties.InputValidOnBackupAR
This field shall be coded according to Table 660.

Table 660 – SRProperties.InputValidOnBackupAR

Value (hexadecimal)	Meaning
0x00	The device may deliver valid input data
0x01	The device shall deliver valid input data

Bit 1: SRProperties.ActivateRedundancyAlarm
This field shall be coded according to Table 661.

Table 661 – SRProperties.ActivateRedundancyAlarm

Value (hexadecimal)	Meaning
0x00	The device shall not send Redundancy alarm
0x01	The device shall send Redundancy alarm

Bit 2 – 15: SRProperties.Reserved_1
This field shall be set to zero.

Bit 16 – 31: SRProperties.Reserved_2
This field shall be set according to 3.4.2.2.

5.2.26.4 Coding of the field RedundancyDataHoldFactor

This field shall be coded as data type Unsigned16 according to Table 662. The time base shall be 1 ms.

Table 662 – RedundancyDataHoldFactor

Value (hexadecimal)	Meaning	Description
0x0000 – 0x0002	Reserved	—
0x0003 – 0x00C7	Optional	An expiration of the time leads to an AR termination.
0x00C8 – 0xFFFF	Mandatory	An expiration of the time leads to an AR termination.

The RedundancyDataHoldTime is calculated according to Formula (70).

$$RDHT = RedundancyDataHoldFactor \times 1\ ms \quad (70)$$

where

RDHT is the redundancy data hold

RedundancyDataHoldFactor is the factor for the calculation of the redundancy data hold time

5.2.26.5 Coding of the field NumberOfEntries

This field shall be coded as data type Unsigned16 according to Table 663.

Table 663 – NumberOfEntries

Value (hexadecimal)	Meaning	Use
0x0000 – 0xFFFF	Number of entries	—

5.2.27 PDU checking rules

5.2.27.1 General

5.2.27.1.1 Overview

The following rules shall be applied to check FAL PDUs at the receiver. PDU code checking rules provide redundant information in a condensed way. In case of a contradiction of PDU code checking rules with other parts of the specification, other parts of the specification shall have precedence.

NOTE A PDU is structured with blocks which are identified by their BlockType. Unknown or unexpected blocks lead to a structure fault.

5.2.27.1.2 Additional checking rules, given by profiles

Application profiles like system redundancy define addition PDU code checking rules. Thus, a parameter shown as valid in the following condensed way of the PDU code checking rules may be signaled as invalid in their context.

5.2.27.2 IODConnectReq

5.2.27.2.1 ArgsLength

This field shall be checked according to Table 664.

Table 664 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	Okay, check IODConnectReq-PDU
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataRequest	ArgsLength	!= Sum of all BlockLength + Number of Blocks × 4	CMRPC/CMINA: ArgsLength invalid
IODConnectReq	ARBlockReq	Not first block	RSP-, 0xDB, 0x81, 0x01, 0
IODConnectReq		Case ARProperties.DeviceAccess == 1: other blocks than ARBlockReq	CMRPC/CMINA: Unknown blocks

	Parameter	Checking rules	Behavior on match
IODConnectReq	IOCRBlockReq	Case ARProperties.Device-Access == 0: Number of IOCRBlockReq with CRType == “Input CR” == 0 OR Number of IOCRBlockReq with CRType == “Output CR” == 0	CMRPC/CMINA: IOCR missing
IODConnectReq	AlarmCRBlockReq	Case ARProperties.Device-Access == 0: Number of AlarmCRBBlockReq != 1	CMRPC/CMINA: Wrong AlarmCRBlock count

5.2.27.2.2 ARBlockReq

This field shall be checked according to Table 665.

Table 665 – ARBlockReq – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0101	RSP-, 0xDB, 0x81, 0x01, 0
BlockLength	!= 54 + StationNameLength	RSP-, 0xDB, 0x81, 0x01, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x01, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x01, 3
ARType	== reserved OR not supported	RSP-, 0xDB, 0x81, 0x01, 4
ARUUID	== NIL	RSP-, 0xDB, 0x81, 0x01, 5
CMInitiatorMacAdd	If (IOCRProperties.RTClass == RT_CLASS_UDP) AND (CMInitiatorMacAdd != zero)	RSP-, 0xDB, 0x81, 0x01, 7
CMInitiatorMacAdd	== multicast address	RSP-, 0xDB, 0x81, 0x01, 7
CMInitiatorObjectUUID	<see next 5 lines>	
.. time low	!= 0xDEA00000	RSP-, 0xDB, 0x81, 0x01, 8
.. time mid	!= 0x6C97	RSP-, 0xDB, 0x81, 0x01, 8
.. time high version	!= 0x11D1	RSP-, 0xDB, 0x81, 0x01, 8
.. Clock[2]	!= 0x82, 0x71	RSP-, 0xDB, 0x81, 0x01, 8
.. Node[6] (contains instance, device, vendor)	Not checked	—
ARProperties.State	ARProperties.State != Active	RSP-, 0xDB, 0x81, 0x01, 9
ARProperties.Supervisor-TakeoverAllowed	Don’t care	—
ARProperties.Parameterization Server	== External PrmServer	RSP-, 0xDB, 0x81, 0x01, 9
ARProperties.reserved_1	Not checked	—
ARProperties.DeviceAccess	== 1 AND ARType != IOSAR	RSP-, 0xDB, 0x81, 0x01, 9
ARProperties.CompanionAR	== 3	RSP-, 0xDB, 0x81, 0x01, 9

Parameter	Checking rules	Behavior on match
CMInitiatorActivityTimeoutFactor	!= 1 to 1 000 (base 100 ms)	RSP-, 0xDB, 0x81, 0x01, 10

InitiatorUDPRTPort	If (IOCRProperties.RTClass == RT_CLASS_UDP)
	== 0 to 0x03FF
	else
	ignore
		RSP-, 0xDB, 0x81, 0x01, 11

StationNameLength	== 0 OR > 240	RSP-, 0xDB, 0x81, 0x01, 12
CMInitiatorStationName	NOT (VisibleString, according to RFC 5890)	RSP-, 0xDB, 0x81, 0x01, 13

5.2.27.2.3 IOCRBlockReq

This field shall be checked according to Table 666.

Table 666 – IOCRBlockReq – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0102	—
BlockLength	!= 42 + NumberOfAPI × (8 + NumberOfIODataObjects × 6 + NumberOfIOCS × 6)	RSP-, 0xDB, 0x81, 0x02, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x02, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x02, 3
IOCRType	!= 0x01 to 0x04	RSP-, 0xDB, 0x81, 0x02, 4
IOCRReference	Is not unique OR (IOCRType == 0x4 AND no corresponding MCRBlock)	RSP-, 0xDB, 0x81, 0x02, 5
LT	Case IOCRProperties.RTClass != 0x04: != 0x8892 Case IOCRProperties.RTClass == 0x04: != 0x0800	RSP-, 0xDB, 0x81, 0x02, 6
IOCRProperties.RTClass	!= 0x01 to 0x04 OR not supported in GSDML	RSP-, 0xDB, 0x81, 0x02, 7
IOCRProperties.reserved_1	!= 0x0	RSP-, 0xDB, 0x81, 0x02, 7
IOCRProperties.reserved_2	!= 0x0	RSP-, 0xDB, 0x81, 0x02, 7
DataLength	If (IOCRProperties.RTClass == 0x04 AND DataLength != 12 to 1 440) OR ((IOCRProperties.RTClass == 0x01 OR IOCRProperties.RTClass == 0x02 OR IOCRProperties.RTClass == 0x03) AND DataLength != 40 to 1 440)	RSP-, 0xDB, 0x81, 0x02, 8

Parameter	Checking rules	Behavior on match
FrameID	If (IOCRType==(MULTICAST_CONSUMER_CR OR MULTICAST_PROVIDER_CR)) AND (IOCRProperties.RTClass == 0x01 AND FrameID!=0xF800 to 0xFBFF) OR (IOCRProperties.RTClass == 0x02 AND FrameID!=0xBC00 to 0xBFFF) OR (IOCRProperties.RTClass == 0x03 AND FrameID!=0x0100 to 0x7FFF) OR (IOCRProperties.RTClass == 0x04 AND FrameID!=0xF800 to 0xFBFF)	RSP-, 0xDB, 0x81, 0x02, 9
FrameID	If IOCRType==INPUT_CR AND ((IOCRProperties.RTClass == 0x01 AND FrameID!=0xC000 to 0xF7FF) OR (IOCRProperties.RTClass == 0x02 AND FrameID!=0x8000 to 0xBBFF) OR (IOCRProperties.RTClass == 0x03 AND FrameID!=0x0100 to 0x7FFF) OR (IOCRProperties.RTClass == 0x04 AND FrameID!=0xC000 to 0xF7FF))	RSP-, 0xDB, 0x81, 0x02, 9
SendClockFactor	!=1 to 128 OR not supported in GSDML OR (IOCRProperties.RTClass == 0x3 AND SendClockFactor != LocalClock) OR (IOCRProperties.RTClass == 0x3 AND SendClockFactor × ReducationRatio < LocalClock)	RSP-, 0xDB, 0x81, 0x02, 10
ReductionRatio	If IOCRProperties.RTClass == 0x01 to 0x03 AND (ReductionRatio != 1 to 512 OR not supported in GSDML) OR (ReductionRatio ≥ 256 AND SendClockFactor > 64) OR (ReductionRatio == 512 AND SendClockFactor > 32)	RSP-, 0xDB, 0x81, 0x02, 11

Parameter	Checking rules	Behavior on match
ReductionRatio	If IOCRProperties.RTClass == 0x04 AND (ReductionRatio != 1 to 16 384 OR not supported in GSDML) OR (ReductionRatio ≥ 8 192 AND SendClockFactor > 64) OR (ReductionRatio == 16 384 AND SendClockFactor > 32))	RSP-, 0xDB, 0x81, 0x02, 11
Phase	If Phase == 0x0 OR Phase > ReductionRatio	RSP-, 0xDB, 0x81, 0x02, 12
Sequence	not checked	—
FrameSendOffset	If (FrameSendOffset ≥ SendClockFactor × 31 250 ns) OR ((FrameSendOffset >= 0x003D0900) AND (FrameSendOffset <= 0xFFFFFFFE))	RSP-, 0xDB, 0x81, 0x02, 14
DataHoldFactor (legacy)	if DataHoldFactor (legacy) != DataHoldFactor	RSP-, 0xDB, 0x81, 0x02, 15
DataHoldFactor	If DataHoldFactor != 0x0001 to 0x1E00 OR (IOCRProperties.RTClass == 0x04 AND DataHoldFactor × ReductionRatio × SendClockFactor × 31,25 > 61 440 000) OR (IOCRProperties.RTClass == 0x01 to 0x03 AND DataHoldFactor × ReductionRatio × SendClockFactor × 31,25 > 1 920 000)	RSP-, 0xDB, 0x81, 0x02, 16
IOCRTagHeader.IOCRVLANID	Not checked	—
IOCRTagHeader.IOUserPriority	!= IO CR Priority	RSP-, 0xDB, 0x81, 0x02, 17
IOCRMulticastMACAdd	Case IOCRType == 0x03 or 0x04: Is not multicast address	RSP-, 0xDB, 0x81, 0x02, 18
NumberOfAPI	NumberOfAPI == 0	RSP-, 0xDB, 0x81, 0x02, 19
API	API not in corresponding ExpectedSubmoduleBlockReq	RSP-, 0xDB, 0x81, 0x02, 20
NumberOfIODataObjects	== 0x0 AND NumberOfIOCS = 0x0	RSP-, 0xDB, 0x81, 0x02, 21
SlotNumber	Not in corresponding ExpectedSubmoduleBlockReq	RSP-, 0xDB, 0x81, 0x02, 22

Parameter	Checking rules	Behavior on match
SubslotNumber	Is not unique (in conjunction with SlotNumber) OR Not in corresponding ExpectedSubmoduleBlockReq OR ((corresponding SubmoduleProperties.Type == 0x0 to 0x1) AND (IOCRType == 0x2 OR 0x4)) OR ((corresponding SubmoduleProperties.Type == 0x2) AND (IOCRType == 0x1 OR 0x3))	RSP-, 0xDB, 0x81, 0x02, 23
IODataObjectFrameOffset	>= DataLength OR (IODataObjectFrameOffset + (effective SubmoduleDataLength + effective LengthIOPS of corresponding submodule) >= DataLength) OR (IOCRType != “multicast consumer CR” AND (IODataObjectFrameOffset + (effective SubmoduleDataLength + effective LengthIOPS of corresponding submodule) overlap with other IODataObjects or IOCSes))	RSP-, 0xDB, 0x81, 0x02, 24
NumberOfIOCS	== 0x0 AND NumberOfIODataObjects == 0x0	RSP-, 0xDB, 0x81, 0x02, 25
SlotNumber	Not in corresponding ExpectedSubmoduleBlockReq	RSP-, 0xDB, 0x81, 0x02, 26
SubslotNumber	Is not unique (in conjunction with SlotNumber) OR Not in corresponding ExpectedSubmoduleBlockReq OR ((corresponding SubmoduleProperties.Type == 0x0 to 0x1) AND (IOCRType == 0x1)) OR ((corresponding SubmoduleProperties.Type == 0x2) AND (IOCRType == 0x2))	RSP-, 0xDB, 0x81, 0x02, 27
IOCSFrameOffset	>= DataLength OR not unique OR (IOCSFrameOffset + (effective LengthIOCS of corresponding submodule) >= DataLength) OR (IOCSFrameOffset + (effective LengthIOCS of corresponding submodule) overlap with other IODataObjects or IOCSes)	RSP-, 0xDB, 0x81, 0x02, 28

5.2.27.2.4 AlarmCRBlockReq

This field shall be checked according to Table 667.

Table 667 – AlarmCRBlockReq – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0103	—
BlockLength	!= 22	RSP-, 0xDB, 0x81, 0x04, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x04, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x04, 3
AlarmCRType	!= 0x0001	RSP-, 0xDB, 0x81, 0x04, 4
LT	Case AlarmCRProperties.Transport == 0x00: != 0x8892 Case AlarmCRProperties.Transport == 0x01: != 0x0800	RSP-, 0xDB, 0x81, 0x04, 5
AlarmCRProperties.Priority	Not checked	—
AlarmCRProperties.Transport	Not checked	—
AlarmCRProperties.reserved	!= 0x0	RSP-, 0xDB, 0x81, 0x04, 6
RTATimeoutFactor	!= 0x0001 to 0x0064 optional: AND != 0x0065 to 0xFFFF	RSP-, 0xDB, 0x81, 0x04, 7
RTARetries	!= 3 to 15	RSP-, 0xDB, 0x81, 0x04, 8
LocalAlarmReference	Not checked	—
MaxAlarmDataLength	!= 200 to 1 432	RSP-, 0xDB, 0x81, 0x04, 10
AlarmCRTagHeaderHigh. AlarmCRVLANID	Not checked	—
AlarmCRTagHeaderHigh. AlarmUserPriority	!= Alarm CR Priority High	RSP-, 0xDB, 0x81, 0x04, 11
AlarmCRTagHeaderLow. AlarmCRVLANID	Not checked	—
AlarmCRTagHeaderLow. AlarmUserPriority	!= Alarm CR Priority Low	RSP-, 0xDB, 0x81, 0x04, 12

5.2.27.2.5 ExpectedSubmoduleBlockReq

This field shall be checked according to Table 668.

Table 668 – ExpectedSubmoduleBlockReq – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0104	—
BlockLength	!= 4 + NumberOfAPI × (14 + NumberOfSubmodules × (8 + NumberOfSubsequentDataDescriptionBlocks × 6)	RSP-, 0xDB, 0x81, 0x03, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x03, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x03, 3
NumberOfAPI	== 0	RSP-, 0xDB, 0x81, 0x03, 4
API	> 0x0 AND not supported in GSDML	RSP-, 0xDB, 0x81, 0x03, 5
SlotNumber	!= 0x0 to 0x7FFF OR not supported in GSDML OR not unique	RSP-, 0xDB, 0x81, 0x03, 6

Parameter	Checking rules	Behavior on match
ModuleIdentNumber	== 0x00000000	RSP-, 0xDB, 0x81, 0x03, 7
ModuleProperties.reserved	!= 0x0	RSP-, 0xDB, 0x81, 0x03, 8
NumberOfSubmodules	== 0	RSP-, 0xDB, 0x81, 0x03, 9
SubslotNumber	Case ARProperties.PullModuleAlarmAllowed (=0): != 0x0001 to 0x7FFF OR not supported in GSDML OR not unique OR not used in at least one IOCR OR == 0x8000 to 0x8FFF AND API != 0 Case ARProperties.PullModuleAlarmAllowed (=1): != 0x0000 to 0x7FFF OR not supported in GSDML OR not unique OR not used in at least one IOCR OR == 0x8000 to 0x8FFF AND API != 0	RSP-, 0xDB, 0x81, 0x03, 10
SubmoduleProperties.Type	== (NO_IO OR INPUT) AND !(input description block follows) OR == (OUTPUT) AND !(output description block follows) OR == (IO) AND !(input description block follows AND output description block follows)	RSP-, 0xDB, 0x81, 0x03, 12
SubmoduleProperties. SharedInput	If SubmoduleProperties.Type == (OUTPUT DATA) AND SubmoduleProperties.SharedInput == 0x1	RSP-, 0xDB, 0x81, 0x03, 12
SubmoduleProperties. ReduceInputSubmoduleDataLength	Not checked	—
SubmoduleProperties. ReduceOutputSubmoduleDataLength	Not checked	—
SubmoduleProperties. DiscardIOXS	Not checked	—
SubmoduleProperties. reserved	!= 0x0	RSP-, 0xDB, 0x81, 0x03, 12
DataDescription.Type	If DataDescription.Type == (0x00 OR 0x03) OR DataDescription.Type == 0x01 AND SubmoduleProperties.Type == 0x02 OR DataDescription.Type == 0x02 AND SubmoduleProperties.Type != (0x02 OR 0x03)	RSP-, 0xDB, 0x81, 0x03, 13
DataDescription.reserved	!= 0x0	RSP-, 0xDB, 0x81, 0x03, 13
SubmoduleDataLength	!= 0 to 1 439	RSP-, 0xDB, 0x81, 0x03, 14
LengthIOPS	!= 0x01	RSP-, 0xDB, 0x81, 0x03, 15
LengthIOCS	!= 0x01	RSP-, 0xDB, 0x81, 0x03, 16

5.2.27.2.6 PrmServerBlock

This field shall be checked according to Table 669.

Table 669 – PrmServerBlock – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0105	—
BlockLength	!= 26 + StationNameLength	RSP-, 0xDB, 0x81, 0x05, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x05, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x05, 3
ParameterServerObjectUUID	Not checked	—
ParameterServerProperties	Not checked	—
CMInitiatorActivityTimeoutFactor	!= 1 to 1 000	RSP-, 0xDB, 0x81, 0x05, 6
StationNameLength	!= 1 to 240	RSP-, 0xDB, 0x81, 0x05, 7
ParameterServerStationName	Not visible string according to RFC 5890	RSP-, 0xDB, 0x81, 0x05, 8

5.2.27.2.7 MCRBlock

This field shall be checked according to Table 670.

Table 670 – MCRBlockReq – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0106	—
BlockLength	!= (12 + StationNameLength + Padding) AND (BlockLength mod 4 == 0)	RSP-, 0xDB, 0x81, 0x06, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x06, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x06, 3
IOCRReference	Is not unique OR Corresponding IOCRType != 0x4	RSP-, 0xDB, 0x81, 0x06, 4
AddressResolutionProperties. Protocol	!= 0x01 OR 0x02	RSP-, 0xDB, 0x81, 0x06, 5
AddressResolutionProperties. Reserved	!= 0x0	RSP-, 0xDB, 0x81, 0x06, 5
AddressResolutionProperties. Factor	!= 0x0001 to 0x0064 optional: AND != 0x0065 to 0xFFFF	RSP-, 0xDB, 0x81, 0x06, 5
MCITimeoutFactor	> 100	RSP-, 0xDB, 0x81, 0x06, 6
StationNameLength	!= 1 to 240	RSP-, 0xDB, 0x81, 0x06, 7
ProviderStationName	Not visible string according to RFC 5890	RSP-, 0xDB, 0x81, 0x06, 8
Padding	Not checked	—

5.2.27.2.8 ARRPCBlockReq

This field shall be checked according to Table 671.

Table 671 – ARRPCBlockReq – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0107	—
BlockLength	!= 4	RSP-, 0xDB, 0x81, 0x07, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x07, 2
BlockVersionLow	!= 0x01	RSP-, 0xDB, 0x81, 0x07, 3
InitiatorRPCServerPort	!= 0x0400 to 0xFFFF	RSP-, 0xDB, 0x81, 0x07, 4

5.2.27.2.9 ARVendorBlockReq

This field shall be checked regarding definitions to BlockType 0x0108. No detailed checking rules are defined.

5.2.27.2.10 IRInfoBlock

This field shall be checked according to Table 672.

Table 672 – IRInfoBlock – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0109	—
BlockLength	!= 1 + 1 + 2(Padding) + 16 + 2(Padding) + 2 + NumberOfIOCRs * (2 + 2 + 4)	RSP-, 0xDB, 0x81, 0x09, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x09, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x09, 3
Padding	Not checked	—
IRDataUUID	== 0	RSP-, 0xDB, 0x81, 0x09, 5
Padding	Not checked	—
NumberOfIOCRs	!= 0 OR 2	RSP-, 0xDB, 0x81, 0x09, 7
IOCRReference	no matching IOCRBlockReq or not unique	RSP-, 0xDB, 0x81, 0x09, 8
SubframeOffset	>= DataLength – (2 + 2)	RSP-, 0xDB, 0x81, 0x09, 9
SubframeData	(SubframeData.Position == 0) OR (SubframeData.DataLength == 0) OR (SubframeOffset + SubframeData.DataLength > DataLength – (2 + 2))	RSP-, 0xDB, 0x81, 0x09, 10

5.2.27.2.11 SRInfoBlock

This field shall be checked according to Table 673.

Table 673 – SRInfoBlock – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x010A	—
BlockLength	!= 2 + 2 + 4	RSP-, 0xDB, 0x81, 0x0A, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDB, 0x81, 0x0A, 2
BlockVersionLow	!= 0x00	RSP-, 0xDB, 0x81, 0x0A, 3
RedundancyDataHoldFactor	(== 0 to 2 OR not supported in GSDML)	RSP-, 0xDB, 0x81, 0x0A, 4
SRProperties. InputValidOnBackupAR	Not checked	—
SRProperties. ActivateRedundancyAlarm	Not checked	—
SRProperties. Reserved_1	!= 0	RSP-, 0xDB, 0x81, 0x0A, 5
SRProperties. Reserved_2	Not checked	—

5.2.27.2.12 ARFSUBlock

This field shall be checked regarding definitions to BlockType 0x010B. No detailed checking rules are defined.

5.2.27.3 IODConnectRes

5.2.27.3.1 ArgsLength

This field shall be checked according to Table 674.

Table 674 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	Okay, check IODConnectRes-PDU
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRData-Response	ArgsLength	!= Sum of all BlockLength + Number of Blocks × 4	CMCTL: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the response	CMCTL: Unknown blocks
IODConnectRes	—	—	—

5.2.27.3.2 ARBlockRes

This field shall be checked according to Table 675.

Table 675 – ARBlockRes – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8101	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 30	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARType	!= ARBlockReq.ARType	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARUUID	!= ARBlockReq.ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	== ARBlockReq.SessionKey	n. a.
SessionKey	!= ARBlockReq.SessionKey	ignore
CMResponderMacAdd	Is not unicast	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

ResponderUDPRTPort	If (IOCRProperties.RTClass == RT_CLASS_UDP)
	== 0 to 0x03FF
	else
	ignore
		ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.3.3 IOCRBlockRes

This field shall be checked according to Table 676.

Table 676 – IOCRBlockRes – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8102	n. a.
BlockLength	!= 8	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
IOCRType	!= IOCRBlockReq.IOCRType	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
IOCRReference	!= IOCRBlockReq.IOCRReference	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

Parameter	Checking rules	Behavior on match
FrameID	If (IOCRBlockReq.IOCRType == “Input CR” OR IOCRBlockReq.IOCRType == “Multicast Consumer CR”) AND IOCRBlockReq.FrameID != FrameID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
FrameID	If (IOCRBlockReq.IOCRType == “Output CR”) AND ((IOCRProperties.RTClass == 0x01 AND FrameID!=0xC000 to 0xF7FF) OR (IOCRProperties.RTClass == 0x02 AND FrameID!=0x8000 to 0xBBFF) OR (IOCRProperties.RTClass == 0x03 AND FrameID!=0x0100 to 0x7FFF AND IOCRBlockReq.FrameID != FrameID) OR (IOCRProperties.RTClass == 0x04 AND FrameID!=0xC000 to 0xF7FF))	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.3.4 AlarmCRBlockRes

This field shall be checked according to Table 677.

Table 677 – AlarmCRBlockRes – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8103	—
BlockLength	!= 8	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
AlarmCRType	!= 0x0001	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
LocalAlarmReference	Not checked	—
MaxAlarmDataLength	!= 200 to 1 432	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.3.5 ModuleDiffBlock

This field shall be checked according to Table 678.

NOTE For legacy reasons, a ModuleDiffBlock containing NumberOfAPIs == 1, API == 0 and NumberOfModules == 0, may be seen in Connect.rsp or ApplRdy.req.

Table 678 – ModuleDiffBlock – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8104	—
BlockLength	!= 4 + NumberOfAPI × (6 + NumberOfModules × (10 + NumberOfSubmodules × 8))	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
NumberOfAPIs	== 0	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
API	!= ExpectedSubmoduleBlockReq.API	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
NumberOfModules	== 0	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SlotNumber	!= ExpectedSubmoduleBlockReq.SlotNumber	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ModuleState	== 0x0 to 0x0003	—
ModuleState	!= 0x0 to 0x0003	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
NumberOfSubmodules	Not checked	—
SubslotNumber	!= ExpectedSubmoduleBlockReq.SubslotNumber	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SubmoduleIdentNumber	Not checked	—
SubmoduleState.AddInfo	Not checked	—
SubmoduleState.QualifiedInfo	Not checked	—
SubmoduleState.Maintenance-Required	Not checked	—
SubmoduleState.Maintenance-Demanded	Not checked	—
SubmoduleState.DiagInfo	Not checked	—
SubmoduleState.ARInfo	If SubmoduleState.FormatIndicator == 1 != 0x0 to 0x04	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SubmoduleState.IdentInfo	If SubmoduleState.FormatIndicator == 1 != 0x0 to 0x03 and Table 457	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SubmoduleState. FormatIndicator	Not checked	—
SubmoduleState.Detail	If SubmoduleState.FormatIndicator == 0 != (0x0 to 0x02 OR 0x04 OR 0x07)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.3.6 PrmServerBlockRes

This field shall be checked regarding definitions to BlockType 0x8105. No additional checking rules are defined.

5.2.27.3.7 ARServerBlockRes

This field shall be checked according to Table 679.

Table 679 – ARServerBlockRes – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8106	—
BlockLength	!= Calculated length	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
StationNameLength	!= Length of the CMResponderStationName	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
CMResponderStationName	!= Local strored / expected CMResponderStationName	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.3.8 RRPCBlockRes

This field shall be checked regarding definitions to BlockType 0x8107. No additional checking rules are defined.

5.2.27.3.9 ARVendorBlockRes

This field shall be checked regarding definitions to BlockType 0x8108. No additional checking rules are defined.

5.2.27.4 IODControlReq

5.2.27.4.1 ArgsLength

This field shall be checked according to Table 680.

Table 680 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	Okay, check IODControlReq-PDU
	RPCOperationNmb	== 5 (Read Implicit)	—

	Parameter	Checking rules	Behavior on match
NDRDataRequest	ArgsLength	!= Sum of all BlockLength + Number of Blocks × 4	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the response	CMRPC/CMINA: Unknown blocks
IODControlReq	—	—	—

5.2.27.4.2 ControlBlockConnect request

This field shall be checked according to Table 681.

Table 681 – ControlBlockConnect(PrmEnd) – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0110	RSP-, 0xDD, 0x81, 0x14, 0
BlockLength	!= 28	RSP-, 0xDD, 0x81, 0x14, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDD, 0x81, 0x14, 2
BlockVersionLow	!= 0x00	RSP-, 0xDD, 0x81, 0x14, 3
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x14, 4
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
SessionKey	!= ARBlockReq.SessionKey	RSP-, 0xDD, 0x81, 0x14, 6
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x14, 7
ControlCommand	!= 0x0001 (PrmEnd)	RSP-, 0xDD, 0x81, 0x14, 8
ControlBlockProperties.reserved	!= 0x0000	RSP-, 0xDD, 0x81, 0x14, 9

5.2.27.4.3 ControlBlockPlug

This field shall be checked according to Table 682.

Table 682 – ControlBlockPlug(PrmEnd) – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0111	RSP-, 0xDD, 0x81, 0x15, 0
BlockLength	!= 28	RSP-, 0xDD, 0x81, 0x15, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDD, 0x81, 0x15, 2
BlockVersionLow	!= 0x00	RSP-, 0xDD, 0x81, 0x15, 3
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x15, 4
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
SessionKey	!= ARBlockReq.SessionKey	RSP-, 0xDD, 0x81, 0x15, 6
AlarmSequenceNumber	!= AlarmSpecifier.SequenceNumber of corresponding AlarmNotification-PDU	RSP-, 0xDD, 0x81, 0x15, 7
ControlCommand	!= 0x0001 (PrmEnd)	RSP-, 0xDD, 0x81, 0x15, 8
ControlBlockProperties.reserved	!= 0x0000	RSP-, 0xDD, 0x81, 0x15, 9

5.2.27.4.4 ControlBlockConnect request

This field shall be checked according to Table 683.

Table 683 – ControlBlockConnect(PrmBegin) – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0118	RSP-, 0xDD, 0x81, 0x18, 0
BlockLength	!= 28	RSP-, 0xDD, 0x81, 0x18, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDD, 0x81, 0x18, 2
BlockVersionLow	!= 0x00	RSP-, 0xDD, 0x81, 0x18, 3
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x18, 4
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
SessionKey	!= ARBlockReq.SessionKey	RSP-, 0xDD, 0x81, 0x18, 6
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x18, 7
ControlCommand	!= 0x0040 (PrmBegin)	RSP-, 0xDD, 0x81, 0x18, 8
ControlBlockProperties.reserved	!= 0x0000	RSP-, 0xDD, 0x81, 0x18, 9

5.2.27.4.5 SubmoduleListBlock

This field shall be checked according to Table 684.

Table 684 – SubmoduleListBlock – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0119	RSP-, 0xDD, 0x81, 0x19, 0
BlockLength	!= Calculated length	RSP-, 0xDD, 0x81, 0x19, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDD, 0x81, 0x19, 2
BlockVersionLow	!= 0x00	RSP-, 0xDD, 0x81, 0x19, 3
NumberOfEntries	!= Fitting to the BlockLength	RSP-, 0xDD, 0x81, 0x19, 4
API	!= Fitting to the ExpectedIdentification	RSP-, 0xDD, 0x81, 0x19, 5
SlotNumber	!= Fitting to the ExpectedIdentification	RSP-, 0xDD, 0x81, 0x19, 6
SubslotNumber	!= Fitting to the ExpectedIdentification	RSP-, 0xDD, 0x81, 0x19, 7

5.2.27.5 IODControlRes

5.2.27.5.1 ArgsLength

This field shall be checked according to Table 685.

Table 685 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—

	Parameter	Checking rules	Behavior on match
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	Okay, check IODControlRes-PDU
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataResponse	ArgsLength	!= Sum of all BlockLength + Number of Blocks × 4	CMCTL: ArgsLength invalid
	ArgsLength	General: If one OR more unknown blocks are contained in the response	CMCTL: Unknown blocks
IODControlRes	—	—	—

5.2.27.5.2 ControlBlockConnect

This field shall be checked according to Table 686.

Table 686 – ControlBlockConnect – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8110	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 28	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARUUID	!= IODControlReq.ControlBlockConnect. ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	!= IODControlReq.ControlBlockConnect. SessionKey	Ignore
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlCommand	!= 0x0008 (Done)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlBlockProperties.reserved	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.5.3 ControlBlockPlug

This field shall be checked according to Table 687.

Table 687 – ControlBlockPlug – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8111	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 28	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARUUID	!= IODControlReq.ControlBlockPlug. ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	!= IODControlReq.ControlBlockPlug. SessionKey	Ignore
AlarmSequenceNumber	!= AlarmSpecifier.SequenceNumber of corresponding AlarmNotification-PDU	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlCommand	!= 0x0008 (Done)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlBlockProperties.reserved	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.5.4 ControlBlockConnect

This field shall be checked according to Table 688.

Table 688 – ControlBlockConnect(PrmBegin) – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8118	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 28	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

Parameter	Checking rules	Behavior on match
ARUUID	!= IODControlReq.ControlBlockConnect.PrmBegin.ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	!= IODControlReq.ControlBlockConnect.PrmBegin.SessionKey	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlCommand	!= 0x0008 (Done)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlBlockProperties.reserved	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.6 IOXControlReq

5.2.27.6.1 ArgsLength

This field shall be checked according to Table 689.

Table 689 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	Okay, check IOXControlReq-PDU
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataRequest	ArgsLength	!= Sum of all BlockLength + Number of Blocks × 4	CMRPC / CTLRPC: ArgsLength invalid
	ArgsLength	General: If one OR more unknown blocks are contained in the request	CMRPC / CTLRPC: Unknown blocks
IOXControlReq	—	—	—

5.2.27.6.2 ControlBlockConnect

This field shall be checked according to Table 690.

Table 690 – ControlBlockConnect(ApplRdy) – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0112	RSP-, 0xDD, 0x81, 0x16, 0
BlockLength	!= 28	RSP-, 0xDD, 0x81, 0x16, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDD, 0x81, 0x16, 2
BlockVersionLow	!= 0x00	RSP-, 0xDD, 0x81, 0x16, 3
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x16, 4

Parameter	Checking rules	Behavior on match
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
SessionKey	!= ARBlockReq.SessionKey	RSP-, 0xDD, 0x81, 0x16, 6
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x16, 7
ControlCommand	!= 0x0002 (ApplicationReady)	RSP-, 0xDD, 0x81, 0x16, 8
ControlBlockProperties.reserved	!= 0x0000	RSP-, 0xDD, 0x81, 0x16, 9

5.2.27.6.3 ControlBlockPlug

This field shall be checked according to Table 691.

Table 691 – ControlBlockPlug(ApplRdy) – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0113	RSP-, 0xDD, 0x81, 0x17, 0
BlockLength	!= 28	RSP-, 0xDD, 0x81, 0x17, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDD, 0x81, 0x17, 2
BlockVersionLow	!= 0x00	RSP-, 0xDD, 0x81, 0x17, 3
Padding	!= 0x00	RSP-, 0xDD, 0x81, 0x17, 4
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
SessionKey	!= ARBlockReq.SessionKey	RSP-, 0xDD, 0x81, 0x17, 6
AlarmSequenceNumber	!= AlarmSpecifier.SequenceNumber of corresponding AlarmNotification-PDU	RSP-, 0xDD, 0x81, 0x17, 7
ControlCommand	!= 0x0002 (ApplicationReady)	RSP-, 0xDD, 0x81, 0x17, 8
ControlBlockProperties.reserved	!= 0x0000	RSP-, 0xDD, 0x81, 0x17, 9

5.2.27.6.4 ExpectedSubmoduleBlockReq

This field shall be checked according to Table 668.

5.2.27.6.5 ModuleDiffBlock

This field shall be checked according to Table 678 using the ErrorCodes from Table 480 row “Faulty ModuleDiffBlock”.

5.2.27.7 IOXControlRes

5.2.27.7.1 ArgsLength

This field shall be checked according to Table 692.

Table 692 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—

	Parameter	Checking rules	Behavior on match
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	Okay, check IOXControlRes-PDU
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataRespons e	ArgsLength	!= Sum of all BlockLength + Number of Blocks × 4	CMRPC/CMINA: ArgsLength invalid
	ArgsLength	General: If one OR more unknown blocks are contained in the response	CMRPC/CMINA: Unknown blocks
IOXControlRes	—	—	—

5.2.27.7.2 ControlBlockConnect

This field shall be checked according to Table 693.

Table 693 – ControlBlockConnect – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8112	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 28	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARUUID	!= IOXControlReq.ControlBlockConnect. ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	!= IOXControlReq.ControlBlockConnect. SessionKey	ignore
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlCommand	!= 0x0008 (Done)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlBlockProperties.reserved	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.7.3 ControlBlockPlug

This field shall be checked according to Table 694.

Table 694 – ControlBlockPlug – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8113	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 28	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARUUID	!= IOXControlReq.ControlBlockPlug. ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	!= IOXControlReq.ControlBlockPlug. SessionKey	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
AlarmSequenceNumber	!= AlarmSpecifier.SequenceNumber of corresponding AlarmNotification-PDU	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlCommand	!= 0x0008 (Done)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlBlockProperties.reserved	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.8 IODReleaseReq

5.2.27.8.1 ArgsLength

This field shall be checked according to Table 695.

Table 695 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	Okay, check IODReleaseReq-PDU
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataRequest	ArgsLength	!= ReleaseBlock.BlockLength + 4	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the request	CMRPC/CMINA: Unknown blocks
IODReleaseReq	—	—	—

5.2.27.8.2 ReleaseBlock

This field shall be checked according to Table 696.

Table 696 – ReleaseBlock – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0114	RSP-, 0xDC, 0x81, 0x28, 0
BlockLength	!= 28	RSP-, 0xDC, 0x81, 0x28, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDC, 0x81, 0x28, 2
BlockVersionLow	!= 0x00	RSP-, 0xDC, 0x81, 0x28, 3
Padding	!= 0x00	RSP-, 0xDC, 0x81, 0x28, 4
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
SessionKey	!= ARBlockReq.SessionKey	RSP-, 0xDC, 0x81, 0x28, 6
Padding	!= 0x00	RSP-, 0xDC, 0x81, 0x28, 7
ControlCommand	!= 0x0004 (Release)	RSP-, 0xDC, 0x81, 0x28, 8
ControlBlockProperties.reserved	!= 0x0000	RSP-, 0xDC, 0x81, 0x28, 9

5.2.27.9 IODReleaseRes

5.2.27.9.1 ArgsLength

This field shall be checked according to Table 697.

Table 697 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	Okay, check IODReleaseRes-PDU
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataResponse	ArgsLength	!= ReleaseBlock.BlockLength + 4	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the response	CMRPC/CMINA: Unknown blocks
IODReleaseRes	—	—	—

5.2.27.9.2 ReleaseBlock

This field shall be checked according to Table 698.

Table 698 – ReleaseBlock – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8114	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 28	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ARUUID	!= IODReleaseReq.ReleaseBlock.ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SessionKey	!= IODReleaseReq.ReleaseBlock. SessionKey	ignore
Padding	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlCommand	!= 0x0008 (Done)	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
ControlBlockProperties.reserved	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT

5.2.27.10 IODWriteReq

5.2.27.10.1 ArgsLength

This field shall be checked according to Table 699.

Table 699 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	Okay, check IODWriteReq-PDU
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRDataRequest	ArgsLength	!= (IODWriteReqHeader. BlockLength + 4 + IODWriteReqHeader. RecordDataLength)	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the request	CMRPC/CMINA: Unknown blocks
IODWriteReq	—	—	—

5.2.27.10.2 IODWriteReqHeader

This field shall be checked according to Table 700.

Table 700 – IODWriteReqHeader – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0008	RSP-, 0xDF, 0x81, 0x08, 0
BlockLength	!= 60	RSP-, 0xDF, 0x81, 0x08, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDF, 0x81, 0x08, 2
BlockVersionLow	!= 0x00	RSP-, 0xDF, 0x81, 0x08, 3
SeqNumber	Not checked	—
ARUUID	!= ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown
API	> 0x0 AND not supported in GSDML	RSP-, 0xDF, 0x80, 0xB4, 6
SlotNumber	!= 0x0 to 0x7FFF OR not supported in GSDML	RSP-, 0xDF, 0x80, 0xB2, 7
SubslotNumber	!= 0x0 to 0x8FFF OR not supported in GSDML	RSP-, 0xDF, 0x80, 0xB2, 8
Padding	!= 0x0000	RSP-, 0xDF, 0x80, 0xB7, 9
Index	Not supported by application	RSP-, 0xDF, 0x80, 0xB0, 10
RecordDataLength	!= consistent with ArgsLength	RSP-, 0xDF, 0x81, 0x08, 11
RWPadding	Not checked	—

5.2.27.10.3 RecordDataWrite

This field shall be not checked.

5.2.27.11 IODWriteRes

5.2.27.11.1 ArgsLength

This field shall be checked according to Table 701.

Table 701 – ArgsLength check

	Parameter	Checking rules	Behavior on match
NDRDataResponse	ArgsLength	!= IODWriteResHeader.BlockLength + 4	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
	—	General: If one OR more unknown blocks are contained in the response	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
IODReleaseRes	—	—	—

5.2.27.11.2 IODWriteResHeader

This field shall be checked according to Table 702.

Table 702 – IODWriteResHeader – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8008	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 60	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SeqNumber	Not checked	—
ARUUID	!= IODWriteReq.IODWriteReqHeader. ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
API	!= IODWriteReq.IODWriteReqHeader.API	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SlotNumber	!= IODWriteReq.IODWriteReqHeader.SlotNumber	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SubslotNumber	!= IODWriteReq.IODWriteReqHeader.SubslotNumber	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Index	!= IODWriteReq.IODWriteReqHeader.Index	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
RecordDataLength	Not checked	—
AdditionalValue1	Not checked	—
AdditionalValue2	Not checked	—
PNIOStatus	Not checked	—
RWPadding	Not checked	—

5.2.27.12 IODWriteMultipleReq

5.2.27.12.1 ArgsLength

This field shall be checked according to Table 703.

Table 703 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	Okay, check IODWriteMultipleReq-PDU
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—

	Parameter	Checking rules	Behavior on match
NDRDataRequest	ArgsLength	!= IODWriteReqHeader. BlockLength + 4 + Sum of all IODWriteReqHeader.BlockLength + Number of WriteBlocks × 4	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the request	CMRPC/CMINA: Unknown blocks
IODWriteReq	—	—	—

5.2.27.12.2 IODWriteReqHeader (multiple)

This field shall be checked according to Table 700. The value of the parameter index shall be 0xE040.

5.2.27.12.3 IODWriteReqHeader

This field shall be checked according to Table 700.

5.2.27.12.4 RecordDataWrite

This field shall be not checked.

5.2.27.12.5 Padding

The number of padding octets shall be 0, 1, 2 and 3 to have 32 bit alignment to the next IODWriteReqHeader. The value of the padding octets is not checked.

5.2.27.13 IODWriteMultipleRes

5.2.27.13.1 ArgsLength

This field shall be checked according to Table 704.

Table 704 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	—
	RPCOperationNmb	== 3 (Write)	Okay, check IODWriteMultipleRes-PDU
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	—
NDRData-Response	ArgsLength	!= IODWriteResHeader. BlockLength + 4 + Sum of all IODWriteResHeader.BlockLength + Number of IODWriteResHeaderBlocks × 4	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the response	CMRPC/CMINA: Unknown blocks
IODWriteMultiple-Res	—	—	—

5.2.27.13.2 IODWriteResHeader (multiple)

This field shall be checked according to Table 702. The value of the parameter index shall be 0xE040.

5.2.27.13.3 IODWriteResHeader

This field shall be checked according to Table 702.

5.2.27.14 IODReadReq

5.2.27.14.1 ArgsLength

This field shall be checked according to Table 705.

Table 705 – ArgsLength check

	Parameter	Checking rules	Behavior on match
RPCHeader	RPCOperationNmb	== 0 (Connect)	—
	RPCOperationNmb	== 1 (Release)	—
	RPCOperationNmb	== 2 (Read)	Okay, check IODReadReq-PDU
	RPCOperationNmb	== 3 (Write)	—
	RPCOperationNmb	== 4 (Control)	—
	RPCOperationNmb	== 5 (Read Implicit)	Okay, check IODReadReq-PDU
NDRDataRequest	ArgsLength	!= IODReadReqHeader.BlockLength + 4 OR != IODReadReqHeader.BlockLength + 4 + RecordDataReadQuery.BlockLength + 4	CMRPC/CMINA: ArgsLength invalid
	—	General: If one OR more unknown blocks are contained in the request	CMRPC/CMINA: Unknown blocks
IOReadReq	—	—	—

5.2.27.14.2 IODReadReqHeader

This field shall be checked according to Table 706.

Table 706 – IODReadReqHeader – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0009	RSP-, 0xDE, 0x81, 0x08, 0
BlockLength	!= 60	RSP-, 0xDE, 0x81, 0x08, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDE, 0x81, 0x08, 2
BlockVersionLow	!= 0x00	RSP-, 0xDE, 0x81, 0x08, 3
SeqNumber	Not checked	—
ARUUID	Case RPCOperationNmb == 2 (Read): != ARBlockReq.ARUUID	CMRPC/CMINA: AR UUID unknown

Parameter	Checking rules	Behavior on match
ARUUID	Case RPCOperationNmb == 5 (Read Implicit): != NIL	RSP-, 0xDE, 0x81, 0x08, 5
API	> 0x0 AND not supported in GSDML	RSP-, 0xDE, 0x80, 0xB4, 6
SlotNumber	!= 0x0 to 0x7FFF OR not supported in GSDML	RSP-, 0xDE, 0x80, 0xB2, 7
SubslotNumber	!= 0x0 to 0x8FFF OR not supported in GSDML	RSP-, 0xDE, 0x80, 0xB2, 8
Padding	!= 0x0000	RSP-, 0xDE, 0x80, 0xB7, 9
Index	Not supported by application	RSP-, 0xDE, 0x80, 0xB0, 10
RecordDataLength	Not consistent with ArgsMaximum	RSP-, 0xDE, 0x81, 0x08, 11
TargetARUUID	Case RPCOperationNmb == 2 (Read): TargetARUUID != NIL	RSP-, 0xDE, 0x81, 0x08, 12
RWPadding	Not checked	—

5.2.27.14.3 RecordDataReadQuery

This field shall be checked according to Table 707.

Table 707 – RecordDataReadQuery – request check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x0500 OR not supported in GSDML	CMRPC/CMINA: Unknown blocks
BlockLength	< 0x3 OR not consistent with ArgsLength	RSP-, 0xDE, 0x81, 0x08, 1
BlockVersionHigh	!= 0x01	RSP-, 0xDE, 0x81, 0x08, 2
BlockVersionLow	!= 0x00	RSP-, 0xDE, 0x81, 0x08, 3
Data	Not checked	—

5.2.27.15 IODReadRes

5.2.27.15.1 ArgsLength

This field shall be checked according to Table 708.

Table 708 – ArgsLength check

	Parameter	Checking rules	Behavior on match
NDRDataResponse	ArgsLength	!= IODReadResHeader.BlockLength + 4 + IODReadResHeader.RecordDataLength	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
	—	General: If one OR more unknown blocks are contained in the response	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
IODReadRes	—	—	—

5.2.27.15.2 IODReadResHeader

This field shall be checked according to Table 709.

Table 709 – IODReadResHeader – response check

Parameter	Checking rules	Behavior on match
BlockType	!= 0x8009	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockLength	!= 60	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionHigh	!= 0x01	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
BlockVersionLow	!= 0x00	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SeqNumber	Not checked	—
ARUUID	!= IODReadReqHeader.ARUUID	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
API	!= IODReadReqHeader.API	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SlotNumber	!= IODReadReqHeader.SlotNumber	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
SubslotNumber	!= IODReadReqHeader.SubslotNumber	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Padding	!= 0x0000	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
Index	!= IODReadReqHeader.Index	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
RecordDataLength	Not consistent with ArgsLength	ERR-RTA, RTA_ERR_CLS_PROTOCOL, RTA_ERR_ABORT
AdditionalValue1	Not checked	—
AdditionalValue2	Not checked	—
RWPadding	Not checked	—

5.2.27.15.3 RecordDataRead

This field shall be not checked.

5.3 FAL protocol state machines

5.3.1 Overall structure

5.3.1.1 Overview

The FAL protocol state machine structure is as defined in Figure 66. The general structure is according to the IEC 61158-6 series protocol machine model.

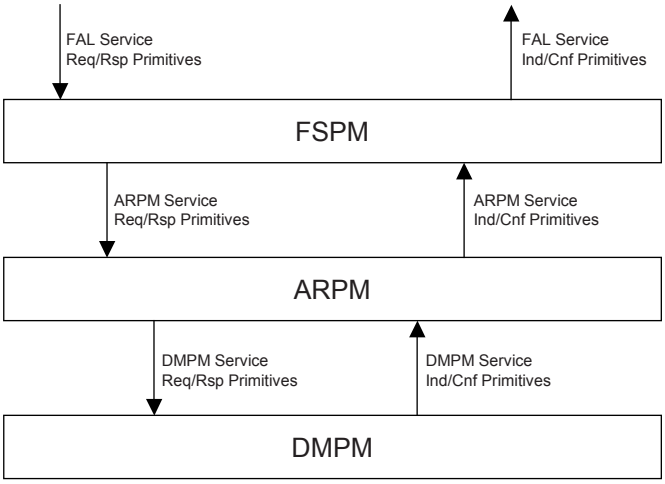


Figure 95 – Relationship among Protocol Machines

The behavior of the FAL is specified by three integrated protocol machines. The FSPM is the service interface between the FAL services that are part of the FAL Class specification and the particular AREP.

The FAL provides two kinds of protocol machine architectures, one for IO controller and one for IO devices.

The FSPM is responsible for the following activities:

- To accept service primitives from the FAL service user and convert them into FAL internal primitives.
- To select the ARPM state machine based on the implicit addressing mechanism and send FAL internal primitives with the service parameters to the ARPM.
- To accept FAL internal primitives from the ARPM and convert them into service primitives for the FAL service user.
- To deliver the FAL service primitives to the FAL user.

The ARPM specifies the conveyance type for the application relation.

The DMPM specifies the mapping to the Data Link Layer. The DMPM defines therefore two protocol machines, the LMPM and the MAC protocol machines.

5.3.1.2 FAL Service Protocol Machines

The FSPM State Machines co-ordinate the underlying state machines used for processing of the various services and application relations.

The FSPM basically is a mapping protocol machine. The main task is to pass the service to the protocol machine responsible for that service and forward confirmations and responses to the user. In addition a basic redundancy control scheme is included that allow to collaborate two or four AR into a single entity with higher availability.

For this task, the following support shall be offered by an FSPM:

- Support of an AR set (only for redundant devices)
- Coordination of the Primary / Backup APDU_Status.DataStatus.State (information)
- Coordination of the Primary / Backup failure situation using APDU_Status.DataStatus.Redundancy (information)

- Issuing switchover procedures (signal Primary request in case of an IO-Device)
- Collaboration of the set and get data services of the AR set

5.3.1.3 IO controller to IO device

The PPM, CPM, ALPMI, ALPMR, APMR, APMS, CMDEV, CMCTL, CMRPC, CMINA, CTLRPC, CTLDINA State Machines are responsible for the cyclic, acyclic and alarm data transfer between an IO controller and an IO device. These are used to establish an IO AR.

5.3.1.4 IO supervisor to IO device

The PPM, CPM, ALPMI, ALPMR, APMR, APMS, CMDEV, CMCTL, CMRPC, CMINA, CTLRPC, CTLDINA State Machines are responsible for the cyclic, acyclic and alarm data transfer between an IO supervisor and an IO device. These are used to establish a Supervisor AR.

5.3.1.5 DLL Mapping Protocol Machines

The DL Mapping Protocol Machines (DMPM) connects the other State machines and Layer 2. DMPM provides the coordination of all state machines concerning the configuration and error handling of the Data Link Layer Usage. The functions are mapped by the DMPM to the DLL services of Layer 2. The DMPM generates the necessary Layer 2 parameters of the service, receives the confirmations and indications from Layer 2 and passes them to the appropriate DMPM-User.

The DMPM is directly put upon the DLL User – DLL interface as described in Data Link Layer Service Definitions (Refer to Enhanced Internal Sublayer Services IEEE 802.3).

The DMPM uses for the mapping of the DMPM functions on the Layer 2 the following services:

- MA_UNITDATA.req
- MA_UNITDATA.ind

For the purpose of this specification there is an explicit confirmation for the MA_UNITDATA request service primitive indicating that the DLPDU has been transmitted.

5.4 AP-Context state machine

There is no AP-Context State Machine defined for this Protocol.

5.5 FAL Service Protocol Machines

5.5.1 Overview

This type specifies one FAL Service Protocol Machine (FSPM) state machine to transfer the FAL user service primitives into FAL internal service primitives and vice versa. There are two kinds of FSPM defined, one for the IO device (FSPMDEV) and one for the IO controller (FSPMCTL).

5.5.2 FAL Service Protocol Machine Device

5.5.2.1 Overview

The FSPMDEV is responsible for the startup of the underlying protocol machines (LMPM, LLDP, DHCP/DCP, IP, UDP, RPC, CMDEV, CMCTL, DCP, PTCP, ALPM, PPM, CPM…).

5.5.2.2 Primitive definitions

Table 710 shows the service primitives including their associated parameters issued by the AP-Context (FAL user) and received by the FSPMDEV with the mapping to underlying services.

Table 710 – Primitives issued by AP-Context (FAL user) to FSPMDEV

Primitive name	Associated parameters	Primitive mapped to	Parameter mapped to
local AR Abort.req	AREP	CM_Abort_req (AREP)	AREP=AREP
local Create LogBook Entry	info	CreateLogBookEntry (info)	info = info
local Get Input IOCS.req	AREP CREP Slot Number Subslot Number	CPM_Get_Data_req (CREP)	MAP_GINIOCS_REQ
local Get Output.req	AREP CREP Slot Number Subslot Number	CPM_Get_Data_req (CREP), CPM_Get_Status_req (CREP)	CREP=CREP
local Set AR State.req	AREP ARState	Set_Variable (Arstate)	AREP=AREP ARState=ARState
local Set Command.rsp (+)	List Of Response	DCP_Set.rsp (+)	CREP DA ListOfResponse = List Of Response
local Set Command.rsp (-)	ERRCLS ERRCODE	DCP_Set.rsp (-)	CREP DA ERRCLS = ERRCLS ERRCODE = ERRCODE
local Set Input.req	AREP CREP Slot Number Subslot Number IOPS Subslot Input Data	PPM_Set_Data_req (CREP, Data)	MAP_SIN_REQ
local Set Output IOCS.req	AREP CREP Slot Number Subslot Number IOCS	PPM_Set_Data_req (CREP, Data)	MAP_OIOCS_REQ
local Set Provider State.req	AREP ProviderState Flag	PPM_Set_Status_req (CREP, D_Status)	MAP_SPS_REQ
local Set Redundancy.req	AREP Redundancy Flag	PPM_Set_Status_req (CREP, D_Status)	MAP_SRS_REQ
local Set State.req	AREP State Flag	PPM_Set_Status_req (CREP, D_Status)	MAP_SSS_REQ
Application Ready.req	AREP Session Key Alarm Sequence Number Module Diff Block	CM_Ccontrol.req (AREP, ControlBlock, ModuleDiffBlock)	MAP_AREADY_REQ
Connect.rsp (-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Connect.rsp (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_CON_RSP-

Primitive name	Associated parameters	Primitive mapped to	Parameter mapped to
Connect.rsp (+)	AREP AR Response Block List of IO CR Response Blocks Alarm CR Response Block Module Diff Block AR RPC Block AR Vendor Block	CM_Connect.rsp (+)(AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock, ARRPCBlock, ARVendorBlock)	MAP_CON_RSP+
Prm Begin.rsp (-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Dcontrol.rsp (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_BOP_RSP-
Prm Begin.rsp (+)	AREP Session Key	CM_Dcontrol.rsp (+) (AREP, ControlBlock)	MAP_BOP_RSP+
Prm End.rsp (-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Dcontrol.rsp (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_EOP_RSP-
Prm End.rsp (+)	AREP Session Key Alarm Sequence Number	CM_Dcontrol.rsp (+) (AREP, ControlBlock)	MAP_EOP_RSP+
Read.rsp (-)	AREP Seq Number Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Read.rsp (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_READ_RSP-
Read.rsp (+)	AREP Seq Number Length Data	CM_Read.rsp (+)(AREP, Seq Number, AddData1, AddData2, Length, Data)	MAP_READ_RSP+
Write.rsp (-)	AREP Seq Number Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Write.rsp (-) (AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_WRITE_RSP-
Write.rsp (+)	AREP Seq Number	CM_Write.rsp (+) (AREP, Seq Number, AddData1, AddData2)	MAP_WRITE_RSP+
Alarm.req	AREP API Alarm Priority Alarm Type Slot Number Subslot Number Alarm Specifier Module Ident Number Submodule Ident Number	ALPMI_Alarm_Notification.req (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, Alarm_User_Data_Structure_Identifier,	MAP_AN_REQ

Primitive name	Associated parameters	Primitive mapped to	Parameter mapped to
	Alarm Item	Alarm_User_Data)	
Alarm.rsp (-)	AREP API Alarm Type Slot Number Subslot Number Alarm Specifier PNIO Status	ALPMR_Alarm_Ack.req (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, PNIO_Status)	MAP_ALARM_RSP-
Alarm.rsp (+)	AREP API Alarm Type Slot Number Subslot Number Alarm Specifier PNIO Status	ALPMR_Alarm_Ack.req (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, PNIO_Status)	MAP_ALARM_RSP+

Table 711 shows the service primitives including their associated parameters issued by the FSPMDEV and received by the AP-Context (FAL user).

Table 711 – Primitives issued by FSPMDEV to AP-Context (FAL user)

Primitive mapped from	Parameter mapped from	Primitive name	Associated parameters
CM_Abort_cnf (-)	AREP=AREP	local AR Abort.cnf (-)	AREP
CM_Abort_cnf (+)	AREP=AREP	local AR Abort.cnf (+)	AREP
CMDEV_state_ind (state, SessionKey)	if (state == ABORT) then AREP=AREP Session Key=SessionKey else ignore	local AR Abort.ind	AREP, Session Key
CM_Release.ind (AREP, ReleaseBlock)	MAP_REL_IND	local AR Abort.ind	AREP Session Key
CMDEV_state_ind (state)	if (state == DATA) then AREP=AREP else ignore	local AR In Data.ind	AREP
CPM_NewData_Ind (AREP, CREP, APDU_Status)	MAP_NEWSTATUS_IND	local Data State Changed.ind	AREP CREP DataValid Flag State Flag Redundancy Flag ProviderState Flag ProblemIndicator Flag
DiagnosisEvent (AREP, CREP, API, Diagnosis Data)	MAP_DIAGEVT_IND	local Diagnosis Event	AREP CREP Alarm Item
CPM_Get_Status_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_GINIOCS_CNF-	local Get Input IOCS.cnf (-)	AREP
CPM_Get_Status_cnf (+) (CREP, Status, RecvCounter)	MAP_GINIOCS_CNF+	local Get Input IOCS.cnf (+)	AREP IOCS
CPM_Get_Data_cnf (-) (	MAP_GOUTD_CNF-	local Get	AREP

Primitive mapped from	Parameter mapped from	Primitive name	Associated parameters
CREP, ERRCLS, ERRCODE)		Output.cnf (-)	
CPM_Get_Data_cnf (+) (CREP, Data, New_Flag)	MAP_GOUTD_CNF+	local Get Output.cnf (+)	AREP IOPS Subslot Output Data New Flag IOCS
CPM_NewData_Ind (AREP, CREP, APDU_Status, data)	MAP_NEWDATA_IND	local New Output.ind	AREP CREP Slot Number Subslot Number InData Flag
if (Set_Variable (Arstate)) == FALSE	AREP=AREP	local Set AR State.cnf (-)	AREP
if (Set_Variable (Arstate)) == TRUE	AREP=AREP	local Set AR State.cnf (+)	AREP
DCP_Set.ind	CREP, ListOfData, ListOfControlCommands	local Set Command.ind	DA List Of Data = ListOfData List Of Control Commands = ListOfControlCommands
PPM_Set_Data_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_SIN_CNF	local Set Input.cnf (-)	AREP
PPM_Set_Data_cnf (+) (CREP)	MAP_SIN_CNF	local Set Input.cnf (+)	AREP
PPM_Set_Data_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_OIOCS_CNF	local Set Output IOCS.cnf (-)	AREP
PPM_Set_Data_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_OIOCS_CNF	local Set Output IOCS.cnf (+)	AREP
PPM_Set_Status_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_SPS_CNF	local Set Provider State.cnf (-)	AREP
PPM_Set_Status_cnf (+) (CREP)	MAP_SPS_CNF	local Set Provider State.cnf (+)	AREP
PPM_Set_Status_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_SPS_CNF	local Set Redundancy.cnf (-)	AREP
PPM_Set_Status_cnf (+) (CREP)	MAP_SPS_CNF	local Set Redundancy.cnf (+)	AREP
PPM_Set_Status_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_SPS_CNF	local Set State.cnf (-)	AREP
PPM_Set_Status_cnf (+) (CREP)	MAP_SPS_CNF	local Set State.cnf (+)	AREP
SyncStateChange_ind (Status)	MAP_SYSTI_IND	local Sync State Info.ind	Sync Data Sync Error Status
TickEvent (CycleCounter, CycleOffset)	MAP_SYNCH_IND	local SYNCH Event.ind	Slot Subslot Global Cycle Counter

Primitive mapped from	Parameter mapped from	Primitive name	Associated parameters
			Phase Status
CM_Ccontrol.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_AREADY_CNF-	Application Ready.cnf (-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Ccontrol.cnf (+)(AREP, ControlBlock)	MAP_AREADY_CNF+	Application Ready.cnf (+)	AREP Session Key Alarm Sequence Number
CM_Connect.ind (AREP ARBlockReq ListOfIOCRBlockReq ListOfExpectedSubmoduleBlockReq AlarmCRBlockReq ParameterServerBlock ListOfMulticastCRBlock ARRPCBlock IRInfosBlock SRInfoBlock ARVendorBlock ARServerBlock ARFSUBlock)	MAP_CON_IND	Connect.ind	AREP AR Parameter Block List of IO CR Parameter Blocks List of Expected Submodule Blocks Alarm CR Parameter Block Parameter Server Block List of Multicast CR Block AR RPC Block IR Info Block SR Info Block AR Vendor Block AR Server Block AR FSU Block
CM_Dcontrol.ind (AREP, ControlBlock, ListOfSubmodules)	MAP_BOP_IND	Prm Begin.ind	AREP Session Key List of Submodules
CM_Dcontrol.ind (AREP, ControlBlock)	MAP_EOP_IND	Prm End.ind	AREP Session Key Alarm Sequence Number
CM_Read.ind (AREP, API, TargetARUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length)	MAP_READ_IND	Read.ind	AREP API Target ARUUID Slot Number Subslot Number Index Seq Number Length
CM_Write.ind (AREP, SlotNumber, SubslotNumber, Index, PrmFlag, SeqNumber, Length, Data)	MAP_WRITE_IND	Write.ind	AREP API Slot Number Subslot Number Index Prm Flag Seq Number Length Data
ALPMI_Alarm_Notification.cnf (+)(CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, Alarm_User_Data_Structure_Identifier, Alarm_User_Data, PNIO_Status)	MAP_AA_IND+	Alarm.cnf (+)	AREP API Alarm Type Slot Number Subslot Number Alarm Specifier PNIO Status

Primitive mapped from	Parameter mapped from	Primitive name	Associated parameters
ALPMI_Alarm_Notification.cnf (-)(CREP, ERRCLS, ERRCODE)	MAP_AN_CNF-	Alarm.cnf (-)	AREP Status
ALPMR_Alarm_Notification.ind (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, User_Structure_Identifier, User_Data)	MAP_AN_IND	Alarm.ind	AREP API Alarm Priority Alarm Type Slot Number Subslot Number Alarm Specifier Module Ident Number Submodule Ident Number Alarm Item

5.5.2.3 State transition diagram

The FSPMDEV defines no state machine. Therefore no states are described.

5.5.2.4 State machine description

The FSPMDEV defines no state machine. Therefore no state machine description exists.

5.5.2.5 FSPMDEV state table

The FSPMDEV defines no state machine because all services are transferred to the underlying protocol machines.

5.5.2.6 Functions, Macros, Timers and Variables

Table 712 shows the functions, macros, timers and variables defined for FSPMDEV, which are used by service primitives issued by the FAL user.

Table 712 – Functions, Macros, Timers and Variables used by the AP-Context (FAL user) to FSPMDEV

Name	Function
MAP_ALARM_RSP-	if (PNIO Status != GOOD) then CREP=AREP.CREP API Alarm_Type=Alarm Type Slot_Number=Slot Number Subslot_Number=Subslot Number Alarm_Specifier=Alarm Specifier Sequence_Number PNIO_Status=PNIO Status
MAP_ALARM_RSP+	if (PNIO Status == GOOD) then CREP=AREP.CREP API Alarm_Type=Alarm Type Slot_Number=Slot Number Subslot_Number=Subslot Number Alarm_Specifier=Alarm Specifier Sequence_Number PNIO_Status=PNIO Status
MAP_AN_REQ	map service parameter 1:1 (=)

Name	Function
MAP_AREADY_REQ	AREP=AREP ControlBlockConnect.SessionKey=Session Key^(ControlBlockPlug.SessionKey=Session Key,ControlBlockPlug.AlarmSequenceNumber=Alarm Sequence Number) ModuleDiffBlock=Module Diff Block
MAP_BOP_RSP-	map service parameter 1:1 (=)
MAP_BOP_RSP+	AREP=AREP ControlBlockConnect.SessionKey=Session Key
MAP_CON_RSP-	map service parameter 1:1 (=)
MAP_CON_RSP+	AREP=AREP ARBlockRes=AR Response Block ListOfIOCRBlockRes=List of IO CR Response Blocks AlarmCRBlockRes=Alarm CR Response Block ModuleDiffBlock=Module Diff Block ARRPCBlock=AR RPC Block ARVendorBlock=AR Vendor Block
MAP_EOP_RSP-	map service parameter 1:1 (=)
MAP_EOP_RSP+	AREP=AREP ControlBlockConnect.SessionKey=Session Key^(ControlBlockPlug.SessionKey=Session Key,ControlBlockPlug.AlarmSequenceNumber=Alarm Sequence Number)
MAP_GINIOCS_REQ	CREP=CREP
MAP_OIOCS_REQ	CREP=CREP Data=IOCS
MAP_READ_RSP-	map service parameter 1:1 (=)
MAP_READ_RSP+	map service parameter 1:1 (=)
MAP_SIN_REQ	CREP=CREP Data={IOPS, Subslot Input Data}
MAP_SPS_REQ	CREP=AREP.CREP DataStatus={ProviderState=ProviderState Flag}
MAP_SRS_REQ	CREP=AREP.CREP DataStatus={Redundancy=Redundancy Flag}
MAP_SSS_REQ	CREP=AREP.CREP DataStatus={State=State Flag}
MAP_WRITE_RSP-	map service parameter 1:1 (=)
MAP_WRITE_RSP+	map service parameter 1:1 (=)

Table 713 shows the functions, macros, timers and variables defined for FSPMDEV, which are used by services primitives issued by the FSPMDEV.

Table 713 – Functions, Macros, Timers and Variables used by the FSPMDEV to AP-Context (FAL user)

Name	Function
MAP_AA_IND-	if (PNIO_Status != GOOD) then AREP=CREP.AREP API Alarm Type=Alarm_Type Slot Number=Slot_Number Subslot Number=Subslot_Number Alarm Specifier=Alarm_Specifier PNIO Status=PNIO_Status

Name	Function
MAP_AA_IND+	if (PNIO_Status == GOOD) then AREP=CREP.AREP API Alarm Type=Alarm_Type Slot Number=Slot_Number Subslot Number=Subslot_Number Alarm Specifier=Alarm_Specifier PNIO Status=PNIO_Status
MAP_AN_CNF-	AREP=CREP.AREP Status=(ERRCLS, ERRCODE)
MAP_AN_CNF+	AREP=CREP.AREP
MAP_AN_IND	AREP=CREP.AREP API Alarm Priority Alarm Type =Alarm_Type Slot Number =Slot_Number Subslot Number =Subslot_Number Alarm Specifier=Alarm_Specifier Module Ident Number=Module_Ident_Number Submodule Ident Number=Submodule_Ident_Number Alarm Item = {User_Structure_Identifier, User_Data}
MAP_AREADY_CNF-	map service parameter 1:1 (=)
MAP_AREADY_CNF+	AREP=AREP Session Key=ControlBlockPlug.SessionKey^ControlConnectPlug.SessionKey
MAP_BOP_IND	if (ControlBlockConnect.PrmEnd=TRUE) then AREP=AREP.CREP Session Key Alarm Sequence Number ControlCommand.PrmBegin=PrmBegin
MAP_CON_IND	AREP=AREP AR Parameter Block=ARBlockReq List of IO CR Parameter Blocks=ListOfIOCRBlockReq List of Expected Submodule Blocks=ListOfExpectedSubmoduleBlockReq Alarm CR Parameter Block=AlarmCRBlockReq Parameter Server Block=ParameterServerBlock List of Multicast CR Block=ListOfMulticastCRBlock AR RPC Block=ARRPCBlock IR Info Block=IRInfoBlock SR Info Block=SRInfoBlock AR Vendor Block=ARVendorBlock AR Server Block=ARServerBlock AR FSU Block=ARFSUBlock
MAP_DIAGEVT_IND	AREP =AREP CREP=CREP Alarm Item = Diagnosis Data
MAP_EOP_IND	if (List of Submodules=ListOfSubmodules) then AREP=AREP Session Key=ControlBlockConnect.SessionKey^ControlBlockPlug.SessionKey Alarm Sequence Number=ControlBlockPlug.AlarmSequenceNumber
MAP_GINIOCS_CNF-	AREP=AREP.CREP IOCS=Status RevCounter
MAP_GINIOCS_CNF+	AREP=AREP.CREP
MAP_GOUTD_CNF-	AREP=CREP.AREP other ignore
MAP_GOUTD_CNF+	AREP=CREP IOPS=Data Subslot Output Data=Data New Flag=New_Flag IOCS=Data

Name	Function
MAP_INDATA_IND	AREP=CREP.AREP CREP=CREP Slot Number =0 Subslot Number =0 InData Flag=TRUE
MAP_NEWDATA_IND	for each Slot/Subslot AREP=CREP.AREP CREP=CREP Slot Number=AREP.SlotNumber Subslot Number=AREP.SubSlotnumber InData Flag=data local New Output.ind(AREP, CREP, Slot Number, Subslot Number, InData Flag)if (data != NoData) AREP=CREP.AREP CREP=CREP
MAP_NEWSTATUS_IND	if (APDU_Status has been changed) AREP=CREP.AREP CREP=CREP DataValid Flag=APDU_Status.DataStatus.DataValid State Flag=APDU_Status.DataStatus.State Redundancy Flag=APDU_Status.DataStatus.Redundancy ProviderState Flag=APDU_Status.DataStatus.ProviderState ProblemIndicator Flag=APDU_Status.DataStatus.ProblemIndicator
MAP_NODATA_IND	AREP=CREP.AREP CREP=CREP Slot Number =0 Subslot Number =0 Watchdog Flag=TRUE
MAP_OIOCS_CNF	AREP=CREP.AREP other ignore

MAP_READ_IND	if ((Index < =0x7FFF) OR (0xAFF0<=Index<=0xAFFF)) then
	AREP=AREP
	API=API
	Target ARUUID = TargetARUUID
	Slot Number = SlotNumber
	Subslot Number =SubslotNumber
	Index =Index
	Seq Number =SeqNumber
	Length=Length
	else
	map to special FAL user Read service primitive

MAP_REL_IND	AREP=AREP Session Key=ReleaseBlock.SessionKey
MAP_SIN_CNF	AREP=CREP.AREP other ignore
MAP_SPS_CNF	AREP=CREP.AREP other ignore
MAP_SYNCH_IND	Slot Subslot Global Cycle Counter=CycleCounter Phase Status
MAP_SYSTI_IND	Sync Data Sync Error Status=Status

MAP_WRITE_IND	if ((Index < =0x7FFF) OR (0xAFF0<=Index<=0xAFFF)) then
	AREP=AREP
	API=API
	Slot Number = SlotNumber
	Subslot Number =SubslotNumber
	Index =Index
	Multiple = Multiple
	Seq Number =SeqNumber
	Length=Length
	Data=Data
	else
	map to special FAL user Write service primitive

5.5.3 FAL Service Protocol Machine Controller

5.5.3.1 Overview

The FSPMCTL is responsible for the startup of the underlying protocol machines (LMPM, LLDP, DHCP/DCP, IP, UDP, RPC, CMDEV, CMCTL, DCP, PTCP, ALPM, PPM, CPM…).

5.5.3.2 Primitive definitions

Table 714 shows the service primitives including their associated parameters issued by the AP-Context (FAL user) and received by the FSPMCTL with the mapping to underlying services.

Table 714 – Primitives issued by AP-Context (FAL user) to FSPMCTL

Primitive name	Associated parameters	Primitive mapped to	Parameter mapped to
local AR Abort.req	AREP Session Key	CM_Release.req(AREP, ControlBlock)	MAP_REL_REQ
local Create LogBook Entry	info	CreateLogBookEntry (info)	info = info
local Get Input.req	AREP CREP Slot Number Subslot Number	CPM_Get_Data_req (CREP)	MAP_GIN_REQ
local Get Output IOCS.req	AREP CREP Slot Number Subslot Number	CPM_Get_Status_req (CREP)	MAP_GOUTIOCS_REQ
local Set AR State.req	AREP ARState	Set_Variable (Arstate)	AREP=AREP ARState=ARState
local Set Input IOCS.req	AREP CREP Slot Number Subslot Number IOCS	PPM_Set_Data_req (CREP, Data)	MAP_SINIOCS_REQ
local Set Output.req	AREP CREP Slot Number Subslot Number IOPS Subslot Output Data	PPM_Set_Data_req (CREP, Data)	MAP_SOUT_REQ
local Set Provider State.req	AREP Provider State Flag	PPM_Set_Status_req (CREP, D_Status)	MAP_SPS_REQ
local Set Redundancy.req	AREP Redundancy Flag	PPM_Set_Status_req (CREP, D_Status)	MAP_SRS_REQ
local Set State.req	AREP State Flag	PPM_Set_Status_req (CREP, D_Status)	MAP_SSS_REQ
Application Ready.rsp(-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Ccontrol.rsp (-)(AREP, ControlBlock)	MAP_AREADY_RES-
Application Ready.rsp(+)	AREP Session Key Alarm Sequence Number	CM_Ccontrol.rsp (+)(AREP, ControlBlock)	MAP_AREADY_RES+

Primitive name	Associated parameters	Primitive mapped to	Parameter mapped to
Connect.req	AREP AR Parameter Block List of IO CR Parameter Blocks List of Expected Submodule Blocks Alarm CR Parameter Block Parameter Server Block List of Multicast CR Blocks AR RPC Block IR Info Block SR Info Block AR Vendor Block AR Server Block AR FSU Block	CM_Connect.req (AREP ARBlockReq ListOfIOCRBlockReq ListOfExpectedSubmoduleBlockReq AlarmCRBlockReq ParameterServerBlock ListOfMulticastCRBlock ARRPCBlock IRInfosBlock SRInfoBlock ARVendorBlock ARServerBlock ARFSUBlock)	MAP_CON_REQ
Prm Begin.req	AREP Session Key Alarm Sequence Number List Of Submodules	CM_Dcontrol.req (AREP, ControlBlock, ListOfSubmodules)	MAP_PB_REQ
Prm End.req	AREP Session Key Alarm Sequence Number	CM_Dcontrol.req (AREP, ControlBlock)	MAP_EOP_REQ
Read.req	AREP API Target ARUUID Slot Number Subslot Number Index Seq Number Length	CM_Read.req (AREP, API, TargetARUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length)	MAP_READ_REQ
Read.rsp (-)	AREP Seq Number Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Read.rsp (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_READ_RSP-
Read.rsp (+)	AREP Seq Number Length Data	CM_Read.rsp (+)(AREP, Seq Number, AddData1, AddData2, Length, Data)	MAP_READ_RSP+
Write.req	AREP API Slot Number Subslot Number Index Seq Number Length Data	CM_Write.req (AREP, SlotNumber, SubslotNumber, Index, SeqNumber, Length, Data)	MAP_WRITE_REQ
Write.rsp (-)	AREP Seq Number Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2	CM_Write.rsp (-)(AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_WRITE_RSP-

Primitive name	Associated parameters	Primitive mapped to	Parameter mapped to
Write.rsp (+)	AREP Seq Number	CM_Write.rsp (+) (AREP, Seq Number, AddData1, AddData2)	MAP_WRITE_RSP+
Alarm.req	AREP API Alarm Priority Alarm Type Slot Number Subslot Number Alarm Specifier Module Ident Number Submodule Ident Number Alarm Item	ALPMI_Alarm_Notification.req (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, Alarm_User_Data_Structure_Identifier, Alarm_User_Data)	MAP_AN_REQ
Alarm.rsp (-)	AREP API Alarm Type Slot Number Subslot Number Alarm Specifier PNIO Status	ALPMR_Alarm_Ack.req (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, PNIO_Status)	MAP_ALARM_RSP-
Alarm.rsp (+)	AREP API Alarm Type Slot Number Subslot Number Alarm Specifier PNIO Status	ALPMR_Alarm_Ack.req (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, PNIO_Status)	MAP_ALARM_RSP+

Table 715 shows the service primitives including their associated parameters issued by the FSPMCTL and received by the AP-Context (FAL user).

Table 715 – Primitives issued by FSPMCTL to AP-Context (FAL user)

Primitive mapped to	Parameter mapped from	Primitive name	Associated parameters
CM_Abort.cnf (-)	AREP=AREP	local AR Abort.cnf (-)	AREP
CM_Abort.cnf (+)	AREP=AREP	local AR Abort.cnf (+)	AREP
CM_Abort.ind	AREP	local AR Abort.ind	AREP
CMCTL_state_ind (AREP, state)	if (state == DATA) then AREP=AREP else ignore	local AR In Data.ind	AREP
CPM_NewData_Ind (AREP, CREP, APDU_Status)	MAP_NEWSTATUS_IND	local Data State Changed.ind	AREP CREP DataValid Flag State Flag Redundancy Primary State Flag ProviderState Flag ProblemIndicator Flag
DiagnosisEvent (AREP, CREP, API, Diagnosis Data)	MAP_DIAGEVT_IND	local Diagnosis Event.ind	AREP CREP Alarm Item

Primitive mapped to	Parameter mapped from	Primitive name	Associated parameters
CPM_Get_Data_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_GIND_CNF-	local Get Input.cnf(-)	AREP
CPM_Get_Data_cnf (+) (CREP, Data, New_Flag)	MAP_GIND_CNF+	local Get Input.cnf(+)	AREP IOPS Subslot Input Data New Flag IOCS
CPM_Get_Status_cnf (-) (CREP, ERRCLS, ERRCODE)	MAP_GOUTIOCS_CNF-	local Get Output IOCS.cnf(-)	AREP
CPM_Get_Status_cnf (+) (CREP, Status, RecvCounter)	MAP_GOUTIOCS_CNF+	local Get Output IOCS.cnf(+)	AREP IOCS
CPM_NewData_Ind (AREP, CREP, APDU_Status)	MAP_NEWDATA_IND	local New Input.ind	AREP CREP Slot Number Subslot Number InData Flag
if (Set_Variable (Arstate)) == FALSE	AREP=AREP	local Set AR State.cnf (-)	AREP
if (Set_Variable (Arstate)) == TRUE	AREP=AREP	local Set AR State.cnf (+)	AREP
PPM_Set_Data_cnf(-) (CREP, ERRCLS, ERRCODE)	MAP_IIOCS_CNF	local Set Input IOCS.cnf(-)	AREP
PPM_Set_Data_cnf(+) (CREP)	MAP_IIOCS_CNF	local Set Input IOCS.cnf(+)	AREP
PPM_Set_Data_cnf(-) (CREP, ERRCLS, ERRCODE)	MAP_IIOCS_CNF	local Set Output.cnf(-)	AREP
PPM_Set_Data_cnf(+) (CREP)	MAP_IIOCS_CNF	local Set Output.cnf(+)	AREP
PPM_Set_Status_cnf(-) (CREP, ERRCLS, ERRCODE)	MAP_SPS_CNF	local Set Provider State.cnf(-)	AREP
PPM_Set_Status_cnf(+) (CREP)	MAP_SPS_CNF	local Set Provider State.cnf(+)	AREP
PPM_Set_Status_cnf(-) (CREP, ERRCLS, ERRCODE)	MAP_SRS_CNF	local Set Redundancy.cnf(-)	AREP
PPM_Set_Status_cnf(+) (CREP)	MAP_SRS_CNF	local Set Redundancy.cnf(+)	AREP
PPM_Set_Status_cnf(-) (CREP, ERRCLS, ERRCODE)	MAP_SPS_CNF	local Set State.cnf(-)	AREP
PPM_Set_Status_cnf(+) (CREP)	MAP_SPS_CNF	local Set State.cnf(+)	AREP
SyncStateChange_ind (Status)	MAP_SYSTI_IND	local Sync State Info.ind	Sync Data Sync Error Status
TickEvent (CycleCounter, CycleOffset)	MAP_SYNCH_IND	local SYNCH Event.ind	Slot Subslot Global Cycle

Primitive mapped to	Parameter mapped from	Primitive name	Associated parameters
			Counter Phase Status
CM_Ccontrol.ind (AREP, ControlBlock, ModuleDiffBlock)	MAP_AREADY_IND	Application Ready.ind	AREP Session Key Alarm Sequence Number Module Diff Block
CM_Connect.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_CON_CNF-	Connect.cnf(-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Connect.cnf (+) (AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock, ARRPCBlock, ARVendorBlock)	MAP_CON_CNF+	Connect.cnf(+)	AREP AR Response Block List of IO CR Response Blocks Alarm CR Response Block Module Diff Block AR RPC Block AR Vendor Block
CM_Release.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_REL_CNF-	local AR Abort.cnf (-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Release.cnf (+)(AREP, ControlBlock)	MAP_REL_CNF+	local AR Abort.cnf (+)	AREP Session Key
CM_Dcontrol.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	AREP	Prm Begin.cnf(-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Dcontrol.cnf (+) (AREP, ControlBlock)	AREP	Prm Begin.cnf(+)	AREP Session Key
CM_Dcontrol.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_EOP_CNF-	Prm End.cnf(-)	AREP Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Dcontrol.cnf (+) (AREP, ControlBlock)	MAP_EOP_CNF+	Prm End.cnf(+)	AREP Session Key Alarm Sequence Number
CM_Read.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_READ_CNF-	Read.cnf(-)	AREP Seq Number Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Read.cnf (+)(AREP, Seq Number,	MAP_READ_CNF+	Read.cnf(+)	AREP Seq Number Length

Primitive mapped to	Parameter mapped from	Primitive name	Associated parameters
Length, Data)			Data
CM_Read.ind (AREP, API, TargetARUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length)	MAP_READ_IND	Read.ind	AREP API Target ARUUID Slot Number Subslot Number Index Seq Number Length
CM_Write.cnf (-)(AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2)	MAP_WRITE_CNF-	Write.cnf(-)	AREP Seq Number Error Decode Error Code 1 Error Code 2 Add Data 1 Add Data 2
CM_Write.cnf (+)(AREP, Seq Number)	MAP_WRITE_CNF+	Write.cnf(+)	AREP Seq Number
CM_Write.ind (AREP, SlotNumber, SubslotNumber, Index, PrmFlag, SeqNumber, Length, Data)	MAP_WRITE_IND	Write.ind	AREP API Slot Number Subslot Number Index Prm Flag Seq Number Length Data
ALPMI_Alarm_Notification.cnf (+)(CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, Alarm_User_Data_Structure_Identifier, Alarm_User_Data, PNIO_Status)	MAP_AA_IND+	Alarm.cnf (+)	AREP API Alarm Type Slot Number Subslot Number Alarm Specifier PNIO Status
ALPMI_Alarm_Notification.cnf (-)(CREP, ERRCLS, ERRCODE)	MAP_AN_CNF	Alarm.cnf(-)	AREP Status
ALPMR_Alarm_Notification.ind (CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, User_Structure_Identifier, User_Data)	MAP_AN_IND	Alarm.ind	AREP API Alarm Priority Alarm Type Slot Number Subslot Number Alarm Specifier Module Ident Number Submodule Ident Number Alarm Item

5.5.3.3 State transition diagram

The FSPMCTL defines no state machine. Therefore no states are described.

5.5.3.4 State machine description

The FSPMCTL defines no state machine. Therefore no state machine description exists.

5.5.3.5 FSPMCTL state table

The FSPMCTL defines no state machine because all services are transfered to the underlying protocol machines.

5.5.3.6 Functions, Macros, Timers and Variables

Table 716 shows the functions, macros, timers and variables defined for FSPMCTL, which are used by services primitives issued by the FAL user.

Table 716 – Functions, Macros, Timers and Variables used by AP-Context (FAL user) to FSPMCTL

Name	Function
MAP_ALARM_RSP-	if (PNIO Status != GOOD) then CREP=AREP.CREP API Alarm_Type=Alarm Type Slot_Number=Slot Number Subslot_Number=Subslot Number Alarm_Specifier=Alarm Specifier Sequence_Number PNIO_Status=PNIO Status
MAP_ALARM_RSP+	if (PNIO Status == GOOD) CREP=AREP.CREP API Alarm_Type=Alarm Type Slot_Number=Slot Number Subslot_Number=Subslot Number Alarm_Specifier=Alarm Specifier Sequence_Number PNIO_Status=PNIO Status
MAP_AN_REQ	CREP=AREP.CREP API Alarm Priority Alarm_Type=Alarm Type Slot_Number=Slot Number Subslot_Number=Subslot Number Alarm_Specifier=Alarm Specifier Module_Ident_Number=Module Ident Number Submodule_Ident_Number=Submodule Ident Number Alarm_User_Data_Structure_Identifier=User Structure Identifier Alarm_User_Data=User Structure Identifier.User Data
MAP_AREADY_RES-	AREP=AREP Error Decode Error Code 1 Error Code 2
MAP_AREADY_RES+	AREP=AREP ControlBlockConnect.SessionKey=Session Key^(ControlBlockPlug.SessionKey=Session Key,ControlBlockPlug.AlarmSequenceNumber=Alarm Sequence Number)
MAP_CON_REQ	AREP=AREP ARBlockReq=AR Parameter Block ListOfIOCRBlockReq=List of IO CR Parameter Blocks ListOfExpectedSubmoduleBlockReq=List of Expected Submodule Blocks AlarmCRBlockReq=Alarm CR Parameter Block ParameterServerBlock=Parameter Server Block ListOfMulticastCRBlock=List of Multicast CR Block ARRPCBlock=AR RPC Block IRInfoBlock=IR Info Block SRInfoBlock=SR Info Block ARVendorBlock=AR Vendor Block ARServerBlock=AR Server Block AR FSU Block=AR FSU Block

Name	Function
MAP_EOP_REQ	AREP=AREP ControlBlockConnect.SessionKey=Session Key^(ControlBlockPlug.SessionKey=Session Key,ControlBlockPlug.AlarmSequenceNumber=Alarm Sequence Number) ControlBlockConnect.PrmEnd=TRUE
MAP_GIN_REQ	CREP=CREP
MAP_GOUTIOCS_REQ	CREP=CREP
MAP_PB_REQ	AREP=AREP ControlBlockConnect.SessionKey=Session Key ControlCommand.PrmBegin=PrmBegin ListOfSubmodules=List Of Submodules
MAP_READ_REQ	map service parameter 1:1 (=)
MAP_READ_RSP-	map service parameter 1:1 (=)
MAP_READ_RSP+	map service parameter 1:1 (=)
MAP_REL_REQ	AREP=AREP ReleaseBlock.SessionKey=SessionKey
MAP_SINIOCS_REQ	CREP=CREP Data=IOCS
MAP_SOUT_REQ	CREP=CREP Data={IOPS,Subslot Output Data}
MAP_SPS_REQ	CREP=AREP.CREP DataStatus={ProviderState=ProviderState Flag}
MAP_SRS_REQ	CREP=AREP.CREP DataStatus={Redundancy=Redundancy Flag}
MAP_SSS_REQ	CREP=AREP.CREP DataStatus={State=State Flag}
MAP_WRITE_REQ	AREP=AREP API SlotNumber=Slot Number SubslotNumber=Subslot Number Index=Index Multiple=Multiple SeqNumber=Seq Number Length=Length Data=Data
MAP_WRITE_RSP-	map service parameter 1:1 (=)
MAP_WRITE_RSP+	map service parameter 1:1 (=)

Table 717 shows the functions, macros, timers and variables defined for FSPMCTL, which are used by services primitives issued by the FSPMCTL.

Table 717 – Functions, Macros, Timers and Variables used by FSPMCTL to AP-Context (FAL user)

Name	Function
MAP_AA_CNF	AREP=CREP.AREP other ignore
MAP_AA_IND-	if (PNIO_Status != GOOD) then AREP=CREP.AREP API Alarm Type=Alarm_Type Slot Number=Slot_Number Subslot Number=Subslot_Number Alarm Specifier=Alarm_Specifier PNIO Status=PNIO_Status

Name	Function
MAP_AA_IND+	if (PNIO_Status == GOOD) then AREP=CREP.AREP API Alarm Type=Alarm_Type Slot Number=Slot_Number Subslot Number=Subslot_Number Alarm Specifier=Alarm_Specifier PNIO Status=PNIO_Status
MAP_AN_CNF	AREP=CREP.AREP Status
MAP_AN_IND	AREP=CREP.AREP API Alarm Priority Alarm Type =Alarm_Type Slot Number =Slot_Number Subslot Number =Subslot_Number Alarm Specifier=Alarm_Specifier Module Ident Number=Module_Ident_Number Submodule Ident Number=Submodule_Ident_Number Alarm Item = {User_Structure_Identifier, User_Data}
MAP_AREADY_IND	AREP=AREP Session Key=ControlBlockPlug.SessionKey^ControlConnectPlug.SessionKey Module Diff Block=ModuleDiffBlock
MAP_CON_CNF-	AREP =AREP Error Decode =ErrorDecode Error Code 1 =ErrorCode1 Error Code 2 =ErrorCode2 Add Data 1=AddData1 Add Data 2=AddData2
MAP_CON_CNF+	AREP =AREP AR Response Block=ARBlockRes List of IO CR Response Blocks=ListOfIOCRBlockRes Alarm CR Response Block=AlarmCRBlockRes Module Diff Block=ModuleDiffBlock AR RPC Block=ARRPCBlock AR Vendor Block=ARVendorBlock
MAP_DIAGEVT_IND	AREP =AREP CREP=CREP Alarm Item = Diagnosis Data
MAP_EOP_CNF-	AREP =AREP Error Decode =ErrorDecode Error Code 1 =ErrorCode1 Error Code 2 =ErrorCode2 Add Data 1=AddData1 Add Data 2=AddData2
MAP_EOP_CNF+	AREP=AREP Session Key= ControlBlockConnect.SessionKey^ControlBlockPlug.SessionKey Alarm Sequence Number=ControlBlockPlug.AlarmSequenceNumber
MAP_GIND_CNF-	AREP=CREP.AREP other ignore
MAP_GIND_CNF+	AREP=CREP IOPS=Data Subslot Input Data=Data New Flag=New_Flag IOCS=Data
MAP_GOUTIOCS_CNF-	AREP=CREP.AREP ERRCLS ERRCODE
MAP_GOUTIOCS_CNF+	AREP=CREP.AREP IOCS=Status RevCounter
MAP_IIOCS_CNF	AREP=CREP.AREP other ignore

Name	Function
MAP_INDATA_IND	AREP=CREP.AREP CREP=CREP Slot Number =0 Subslot Number =0 InData Flag=TRUE
MAP_NEWDATA_IND	if (Data has been changed) then AREP=AREP CREP=CREP Slot Number Subslot Number
MAP_NEWSTATUS_IND	if (APDU_Status has been changed) AREP=CREP.AREP CREP=CREP DataValid Flag=APDU_Status.DataStatus.DataValid State Flag=APDU_Status.DataStatus.State Redundancy Flag=APDU_Status.DataStatus.Redundancy ProviderState Flag=APDU_Status.DataStatus.ProviderState ProblemIndicator Flag=APDU_Status.DataStatus.ProblemIndicator
MAP_NODATA_IND	AREP=CREP.AREP CREP=CREP Slot Number =0 Subslot Number =0 Watchdog Flag=TRUE
MAP_READ_CNF-	if (ServiceReqWasRead(AREP, Seq Number) == TRUE) then AREP = AREP Seq Number = Seq Number Error Decode = ErrorDecode Error Code 1 = ErrorCode1 Error Code 2 = ErrorCode2 Add Data 1 = AddData1 Add Data 2 =AddData2
MAP_READ_CNF+	if (ServiceReqWasRead(AREP, Seq Number) == TRUE) then AREP = AREP Seq Number = Seq Number Length = Length Data = Data

MAP_READ_IND	if ((Index < =0x7FFF) OR (0xAFF0<=Index<=0xAFFF)) then
	AREP=AREP
	API=API
	Target ARUUID = TargetARUUID
	Slot Number = SlotNumber
	Subslot Number =SubslotNumber
	Index =Index
	Seq Number =SeqNumber
	Length=Length
	else
	map to special FAL user Read service primitive

MAP_REL_CNF-	AREP =AREP Error Decode =ErrorDecode Error Code 1 =ErrorCode1 Error Code 2 =ErrorCode2
MAP_REL_CNF+	AREP=AREP Session Key=ReleaseBlock.SessionKey
MAP_SPS_CNF	AREP=CREP.AREP other ignore
MAP_SRS_CNF	AREP=CREP.AREP other ignore
MAP_SYNCH_IND	Slot Subslot Global Cycle Counter=CycleCounter Phase Status
MAP_SYSTI_IND	Sync Data Sync Error Status=Status

Name	Function
MAP_WRITE_CNF-	if (ServiceReqWasWrite(AREP, Seq Number) == TRUE) then AREP=AREP Multiple Seq Number Error Decode =ErrorDecode Error Code 1 =ErrorCode1 Error Code 2 =ErrorCode2 Add Data 1=AddData1 Add Data 2=AddData2
MAP_WRITE_CNF+	if (ServiceReqWasWrite(AREP, Seq Number) == TRUE) then AREP=AREP Multiple Seq Number =SeqNumber

MAP_WRITE_IND	if ((Index < =0x7FFF) OR (0xAFF0<=Index<=0xAFFF)) then
	AREP=AREP
	API=API
	Slot Number = SlotNumber
	Subslot Number =SubslotNumber
	Index =Index
	Multiple = Multiple
	Seq Number =SeqNumber
	Length=Length
	Data=Data}
	else
	map to special FAL user Write service primitive

5.6 Application Relationship Protocol Machines

5.6.1 Alarm Protocol Machine Initiator

5.6.1.1 Primitive definitions

5.6.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Alarm Protocol Machine Initiator (ALPMI) are described in the service definition and shown in Table 718.

Table 718 – Remote primitives issued or received by ALPMI

Primitive	Source	Destination	Associated parameters	Functions
APMR_A_Data.ind	APMR	ALPMI	CREP, Data	—
APMS_A_Data.cnf (-)	APMS	ALPMI	CREP, ERRCLS, ERRCODE	—
APMS_A_Data.cnf (+)	APMS	ALPMI	CREP	—
ALPMI_Alarm_Notification.req	FSPMDEV FSPMCTL	ALPMI	CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, Alarm_User_Data_Structure_Identifier, Alarm_User_Data	The service Alarm_Notification conveys alarm data.
APMS_A_Data.req	ALPMI	APMS	CREP, Data	—

Primitive	Source	Destination	Associated parameters	Functions
ALPMI_Alarm_Notification.cnf (-)	ALPMI	FSPMDEV FSPMCTL	CREP, ERRCLS, ERRCODE	This service primitive indicates that the Alarm_Notification service failed.
ALPMI_Alarm_Notification.cnf (+)	ALPMI	FSPMDEV FSPMCTL	CREP	This service primitive indicates that the Alarm_Notification service succeeded.

5.6.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by ALPMI are described in the service definition and shown in Table 719.

Table 719 – Local primitives issued or received by ALPMI

Primitive	Source	Destination	Associated parameters	Functions
ALPMI_Activate_req	CMSU CTLSU	ALPMI	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	The service Activate initializes the ALPMI and requests the initialization of the APMS and APMR protocol machines.
ALPMI_Close_req	CMSU CTLSU	ALPMI	CREP	The service Close deinitializes the ALPMI and closes the APMR and APMS protocol machines.
ALPMI_Activate_cnf (-)	ALPMI	CMSU CTLSU	CREP, ERRCLS, ERRCODE	—
ALPMI_Activate_cnf (+)	ALPMI	CMSU CTLSU	CREP	—
ALPMI_Close_cnf (+)	ALPMI	CMSU CTLSU	CREP	—
ALPMI_Error_ind	ALPMI	CMSU CTLSU	CREP, ERRCLS, ERRCODE	This service primitive indicates a failure during transmission of alarm data.

5.6.1.2 State transition diagram

The state transition diagram of the ALPMI is shown in Figure 96.

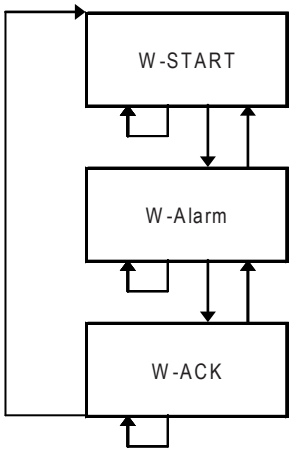


Figure 96 – State transition diagram of ALPMI

States of the ALPMI

W-START	The W-START state indicates that the initialization is needed. The Activate service sets the machine in the W-Alarm state.
W-Alarm	Indicates a successful initialization and the state machine is waiting for Alarm Notification requests
W-ACK	Wait for an Alarm Acknowledge and generate the Alarm Notification confirmation.

5.6.1.3 State machine description

This state machine handles the Alarm Notification. Each priority (High and Low) is handled independent. An application issues an Alarm.req which is conveyed by the ALPMI and the APMS to the APMR and the ALPMR. The ALPMR indicates the Alarm.ind to the remote application.

The remote application issues an Alarm.rsp to the ALPMR and the APMS which is conveyed to the APMR and the ALPMI. The ALPMI issues an Alarm.cnf to the application.

5.6.1.4 ALPMI state table

Table 720 contains the complete description of the ALPMI state machine.

Table 720 – ALPMI state table

#	Current State	Event /Condition =>Action	Next State
1	W-START	**ALPMI_Activate_req ()** => AlarmInstance[SrcSAP, DstSAP, Prio] := DA, RTATimeoutFactor, RTARetries, … // NOTE Information used for ALPMI, ALPMR, APMS and APMR Use CREP to identify the AlarmInstance ALPMI_Activate_cnf (+)	W-Alarm
2	W-START	**ALPMI_Close_req ()** => ALPMI_Close_cnf ()	W-START

#	Current State	Event /Condition =>Action	Next State
3	W-START	APMS_A_Data.cnf (+) => ignore	W-START
4	W-START	**APMS_A_Data.cnf (-)** => ERRCLS := ALPMI ERRCODE := Invalid ALPMI_Error_ind ()	W-START
5	W-START	**ALPMI_Alarm_Notification.req ()** => ALPMI_Alarm_Notification.cnf (-)	W-START
6	W-START	APMR_A_Data.ind () => ignore	W-START
7	W-Alarm	**ALPMI_Alarm_Notification.req ()** => Select the addressed / associated APMS and combine data for the alarm notification request APMS_A_Data.req ()	W-ACK
8	W-Alarm	**ALPMI_Activate_req ()** => ERRCLS:= ALPMI ERRCODE:= WRONG-STATE ALPMI_Activate_cnf (-)	W-Alarm
9	W-Alarm	**ALPMI_Close_req ()** => ALPMI_Close_cnf ()	W-START
10	W-Alarm	APMS_A_Data.cnf (+) => ignore	W-Alarm
11	W-Alarm	**APMS_A_Data.cnf (-)** => ERRCLS := ALPMI ERRCODE := Invalid ALPMI_Error_ind ()	W-Alarm
12	W-Alarm	APMR_A_Data.ind () => ignore	W-Alarm
13	W-ACK	**APMR_A_Data.ind ()** /Data == Alarm-Ack-PDU => ALPMI_Alarm_Notification.cnf (+)	W-Alarm
14	W-ACK	**ALPMI_Activate_req ()** => ERRCLS:= ALPMI ERRCODE:= WRONG-STATE ALPMI_Activate_cnf (-)	W-ACK
15	W-ACK	**ALPMI_Alarm_Notification.req ()** => ALPMI_Alarm_Notification.cnf (-)	W-ACK
16	W-ACK	**ALPMI_Close_req ()** => ALPMI_Close_cnf ()	W-START
17	W-ACK	APMS_A_Data.cnf (+) => ignore	W-ACK
18	W-ACK	**APMS_A_Data.cnf (-)** => ERRCLS := ALPMI ERRCODE := Invalid ALPMI_Error_ind ()	W-ACK

#	Current State	Event /Condition =>Action	Next State
19	W-ACK	**APMR_A_Data.ind ()** /Data != Alarm-Ack-PDU => ERRCLS:= ALPMI ERRCODE:= WRONG-ACK-PDU ALPMI_Error_ind ()	W-Alarm

5.6.1.5 Functions, Macros, Timers and Variables

Table 721 contains the functions, macros, timers and variables used by the ALPMI and their arguments and their descriptions.

Table 721 – Functions, Macros, Timers and Variables used by ALPMI

Name	Type	Meaning
AlarmInstance	Variable	This AR global variable contains the required information for this protocol machine instance.
ERRCLS	Variable	This local variable contains the entity signaling the error.
ERRCODE	Variable	This local variable contains the error reason in the context of the ERRCLS.

5.6.2 Alarm Protocol Machine Responder

5.6.2.1 Primitive definitions

5.6.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Alarm Protocol Machine Responder (ALPMR) are described in the service definition and shown in Table 722.

Table 722 – Remote primitives issued or received by ALPMR

Primitive	Source	Destination	Associated parameters	Functions
APMR_A_Data.ind	APMR	ALPMR	CREP.APMR, Data	—
APMS_A_Data.cnf (-)	APMS	ALPMR	CREP.APMS, ERRCLS, ERRCODE	—
APMS_A_Data.cnf (+)	APMS	ALPMR	CREP	—
ALPMR_Alarm_Ack.req	FSPMCTL FSPMDEV	ALPMR	CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, PNIO_Status	The service Alarm_Ack conveys the alarm acknowledgement.
ALPMR_Alarm_Ack.cnf (-)	ALPMR	FSPMCTL FSPMDEV	CREP, ERRCLS, ERRCODE	This service primitive indicates that the Alarm_Ack service failed.
ALPMR_Alarm_Ack.cnf (+)	ALPMR	FSPMCTL FSPMDEV	CREP	This service primitive indicates that the Alarm_Ack service succeeded.

Primitive	Source	Destination	Associated parameters	Functions
ALPMR_Alarm_Notification.ind	ALPMR	FSPMCTL FSPMDEV	CREP, Alarm_Type, Slot_Number, Subslot_Number, Alarm_Specifier, Sequence_Number, Module_Ident_Number, Submodule_Ident_Number, User_Structure_Identifier, User_Data	The service Alarm_Notification indicates alarm data.

5.6.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by ALPMR are described in the service definition and shown in Table 723.

Table 723 – Local primitives issued or received by ALPMR

Primitive	Source	Destination	Associated parameters	Functions
ALPMR_Activate_req	CMSU CTLSU	ALPMR	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	The service Activate initializes the ALPMR and requests the initialization of the APMS and APMR protocol machines.
ALPMR_Close_req	CMSU CTLSU	ALPMR	CREP	The service Close deinitializes the ALPMI and closes the APMR and APMS protocol machines.
ALPMR_Activate_cnf (-)	ALPMR	CMSU CTLSU	CREP, ERRCLS, ERRCODE	This service primitive indicates that the Activate service failed.
ALPMR_Activate_cnf (+)	ALPMR	CMSU CTLSU	CREP	This service primitive indicates that the Activate service succeeded.
ALPMR_Close_cnf (+)	ALPMR	CMSU CTLSU	CREP	This service primitive indicates that the Close service succeeded.
ALPMR_Error_ind	ALPMR	CMSU CTLSU	CREP, ERRCLS, ERRCODE	This service primitive indicates a failure during transmission of alarm data.

5.6.2.2 State transition diagram

The state transition diagram of the ALPMR is shown in Figure 97.

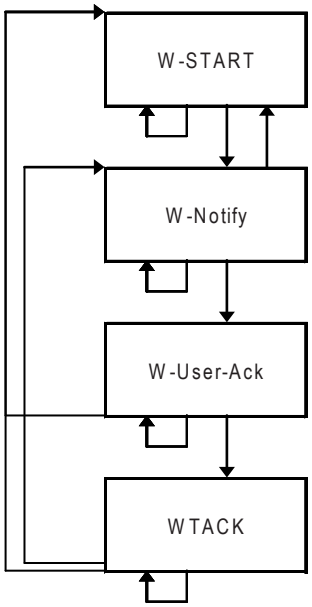


Figure 97 – State transition diagram of ALPMR

States of the ALPMR

W-START	The W-START state indicates that the initialization is needed. The Activate service sets the machine in the W-Notify state.
W-Notify	After successful initialization the state machine is waiting for Alarm Notification PDUs in the state W-Notify and enters afterwards the W-User-Ack state waiting for an Alarm Ack from the application.
W-User-Ack	Waiting for an Alarm Ack from the application.
WTACK	Wait for the confirmation of the transport acknowledge.

5.6.2.3 State machine description

This state machine handles the responder for an Alarm Notification. Each priority (High and Low) is handled independent.

A remote application issues an Alarm.req which is conveyed by the ALPMI and the APMS to the APMR and the ALPMR. The ALPMR indicates the Alarm.ind to the application.

The application issues an Alarm.rsp to the ALPMR and the APMS which is conveyed to the APMR and the ALPMI. The ALPMI issues an Alarm.cnf to the remote application.

5.6.2.4 ALPMR state table

Table 724 contains the complete description of the ALPMR state machine.

Table 724 – ALPMR state table

#	Current State	Event /Condition =>Action	Next State
1	W-START	**ALPMR_Activate_req ()** => AlarmInstance[SrcSAP, DstSAP, Prio] := DA, RTATimeoutFactor, RTARetries, … // NOTE Information used for ALPMI, ALPMR, APMS and APMR Use CREP to identify the AlarmInstance ALPMR_Activate_cnf (+)	W-Notify
2	W-START	**ALPMR_Close_req ()** => ALPMR_Close_cnf ()	W-START
3	W-START	**ALPMR_Alarm_Ack.req ()** => ERRCLS:= ALPMR ERRCODE:= WRONG-STATE ALPMR_Alarm_Ack.cnf (-)	W-START
4	W-START	APMR_A_Data.ind () => ignore	W-START
5	W-START	APMS_A_Data.cnf () => ignore	W-START
6	W-Notify	**ALPMR_Activate_req ()** => ERRCLS:= ALPMR ERRCODE:= WRONG-STATE ALPMR_Activate_cnf (-)	W-Notify
7	W-Notify	**ALPMR_Alarm_Ack.req ()** => ERRCLS:= ALPMR ERRCODE:= WRONG-STATE ALPMR_Alarm_Ack.cnf (-)	W-Notify
8	W-Notify	**ALPMR_Close_req ()** => ALPMR_Close_cnf () ALPMR_Error_ind ()	W-START
9	W-Notify	**APMR_A_Data.ind ()** /Data != Alarm-Notification-PDU => ERRCLS:= ALPMR ERRCODE:= WRONG-NOTIFICATION-PDU ALPMR_Error_ind ()	W-Notify
10	W-Notify	**APMR_A_Data.ind ()** /Data = Alarm-Notification-PDU => Combine data for the alarm notification indication ALPMR_Alarm_Notification.ind ()	W-User-Ack
11	W-Notify	APMS_A_Data.cnf (+) => ignore	W-Notify
12	W-Notify	**APMS_A_Data.cnf (-)** => ERRCLS:= ALPMR ERRCODE:= Invalid ALPMR_Error_ind ()	W-Notify
13	W-User-Ack	**ALPMR_Activate_req ()** => ERRCLS:= ALPMR ERRCODE:= WRONG-STATE ALPMR_Activate_cnf (-)	W-User-Ack

#	Current State	Event /Condition =>Action	Next State
14	W-User-Ack	**ALPMR_Alarm_Ack.req ()** => Select the addressed / associated APMS and combine data for the alarm ack request APMS_A_Data.req ()	WTACK
15	W-User-Ack	**ALPMR_Close_req ()** => ALPMR_Close_cnf () ALPMR_Error_ind ()	W-START
16	W-User-Ack	**APMR_A_Data.ind ()** => ERRCLS:= RTA_ERR_CLS_PROTOCOL ERRCODE:= AR protocol violation Combine data for the RTA error request ALPMR_Error_ind ()	W-User-Ack
17	W-User-Ack	APMS_A_Data.cnf (+) => ignore	W-User-Ack
18	W-User-Ack	**APMS_A_Data.cnf (-)** => ERRCLS:= ALPMR ERRCODE:= Invalid ALPMR_Error_ind ()	W-User-Ack
19	WTACK	**APMS_A_Data.cnf (+)** => ALPMR_Alarm_Ack.cnf (+)	W-Notify
20	WTACK	**ALPMR_Activate_req ()** => ERRCLS:= ALPMR ERRCODE:= WRONG-STATE ALPMR_Activate_cnf (-)	WTACK
21	WTACK	**ALPMR_Alarm_Ack.req ()** => ERRCLS:= ALPMR ERRCODE:= WRONG-STATE ALPMR_Alarm_Ack.cnf (-)	WTACK
22	WTACK	**ALPMR_Close_req ()** => ALPMR_Close_cnf () ALPMR_Error_ind ()	W-START
23	WTACK	**APMR_A_Data.ind ()** => ERRCLS:= RTA_ERR_CLS_PROTOCOL ERRCODE:= AR protocol violation ALPMR_Error_ind ()	WTACK
24	WTACK	**APMS_A_Data.cnf (-)** => ERRCLS:= ALPMR ERRCODE:= Invalid ALPMR_Error_ind ()	WTACK

5.6.2.5 Functions, Macros, Timers and Variables

Table 725 contains the functions, macros, timers and variables used by the ALPMR and their arguments and their descriptions.

Table 725 – Functions, Macros, Timers and Variables used by ALPMR

Name	Type	Meaning
AlarmInstance	Variable	This AR global variable contains the required information for this protocol machine instance.
ERRCLS	Variable	This local variable contains the entity signaling the error.
ERRCODE	Variable	This local variable contains the error reason in the context of the ERRCLS.

5.6.3 Device

5.6.3.1 General

5.6.3.1.1 General

The CMDEV arranges the connection establishment of an IO device. Figure 98 shows the integration of the IO device CM.

The following definition shall be used for ARBlockReq.ARProperties.StartupMode:=Advanced. For ARBlockReq.ARProperties.StartupMode:=Legacy the definitions of the version V2.2 and the Annex B applies.

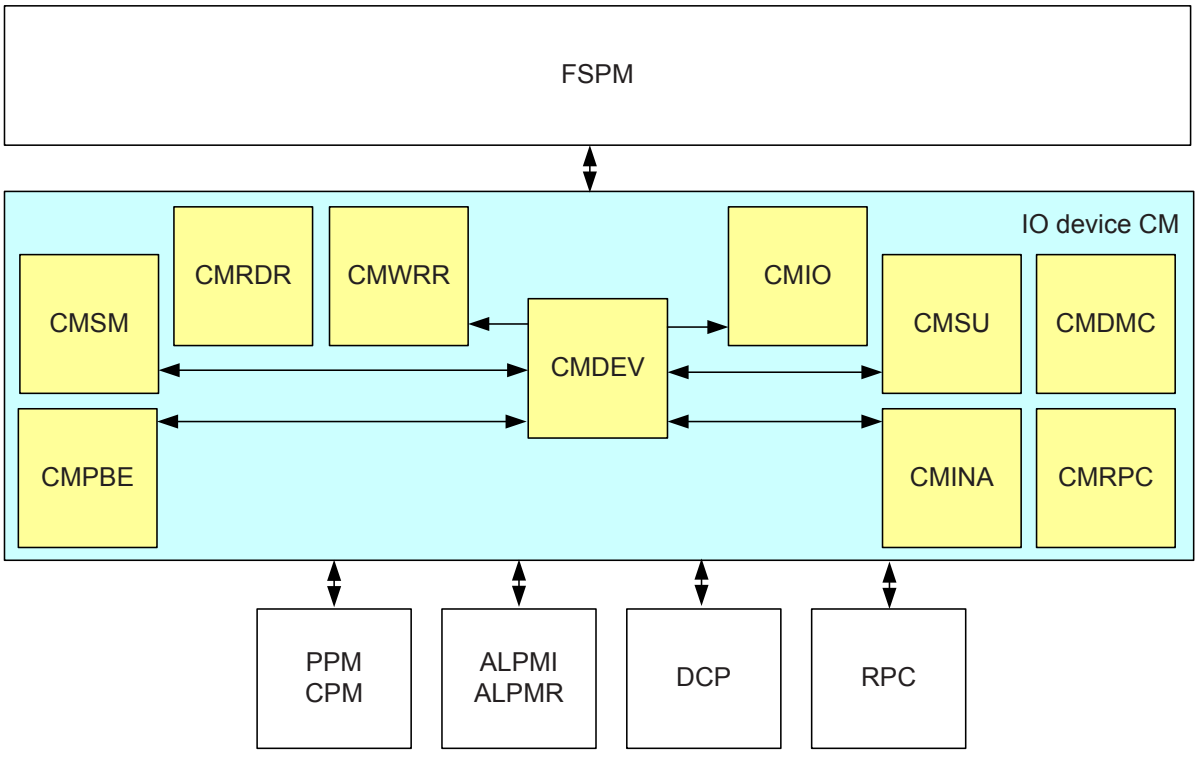


Figure 98 – Scheme of the IO device CM

CMDEV
This state machine handles the context management of the IO device.

CMWRR
This state machine handles the responder functionality of the write service.

CMRDR
This state machine handles the responder functionality of the read service.

CMSM
This state machine handles the connection monitoring during the startup.

CMPBE
This optional state machine handles the PrmBegin, PrmEnd and ApplRdy sequence for system redundancy and configure in run.

CMSU
This state machine handles the startup of the different state machines during startup and shut down.

CMIO
This state machine handles the IO data services.

CMDMC
This state machine handles the startup of the multicast communication relations.

CMRPC
This state machine handles the translation of RPC services.

CMINA
This state machine handles IP and Name assignment.

5.6.3.1.2 State transition diagram

The state transition diagram of the IO device CM is shown in Figure 99.

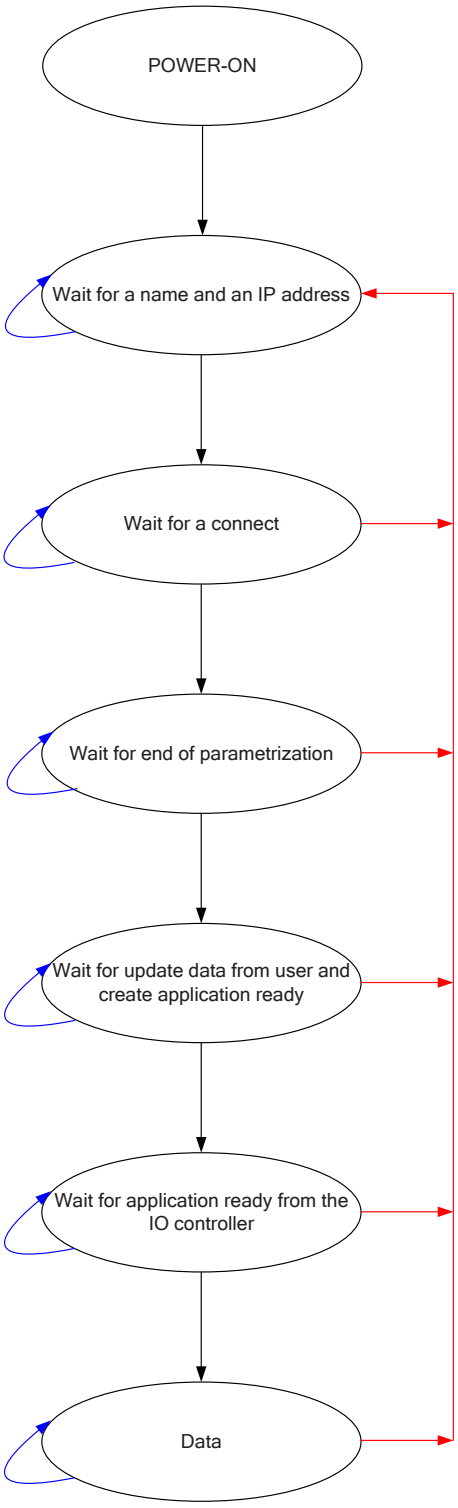


Figure 99 – State transition diagram of the IO device CM

States of the IO device CM

POWER-ON	Startup the IO device and initialize all necessary resources
Wait for a name and an IP address	A name and an IP address is needed for the communication to the IO controller
Wait for connect	The IO device is the responder for the application relation to the IO controller. The connect establishes an application relation between the IO controller and the IO device. Part of this AR are the required communication resources and the requested submodules.

Wait for end of parameterization	The IO controller parameterizes all submodules of the AR and informs the application of the IO device when the last startup record is conveyed. The application uses this signal to evaluate the parameters and executes them.
Wait for update from user and create application ready	The submodules generate interpretable data after the parameterization. This data shall be updated in the PPM buffer before the application ready is signaled to the IO controller.
Wait for application ready from IO controller	The IO controller has received the application ready from the IO device executes it locally. After that, the confirmation of the application ready shall be given to the IO device.
	Cyclic exchange data of the submodules between the IO controller and IO devices starts, with the first NewData_ind after the reception of the application ready confirmation from the IO controller.
Data	See Annex A for the special case isochronous application

5.6.3.2 Context Management Device

5.6.3.2.1 CMDEV state machine

5.6.3.2.1.1 Primitive definitions

####### 5.6.3.2.1.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Device (CMDEV) are described in the service definition and shown in Table 726.

Table 726 – Remote primitives issued or received by CMDEV

Primitive	Source	Destination	Associated parameters	Functions
CM_Ccontrol.req	FSPMDEV	CMDEV	AREP, ControlBlock, ModuleDiffBlock	The service Ccontrol conveys the application ready flag.
CM_Connect.rsp (-)	FSPMDEV	CMDEV	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	This service primitive is a positive response to establish an application relationship.
CM_Connect.rsp (+)	FSPMDEV	CMDEV	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock	This service primitive is a negative response and the requested application relationship is not established.
CM_Dcontrol.rsp (-)	FSPMDEV	CMDEV	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	This service primitive is a response to end of parameter signal.
CM_Dcontrol.rsp (+)	FSPMDEV	CMDEV	AREP, ControlBlock	This service primitive is a response to end of parameter signal.
RM_Ccontrol.cnf (-)	CMRPC	CMDEV	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Ccontrol.cnf (+)	CMRPC	CMDEV	AREP, ControlBlock	—

Primitive	Source	Destination	Associated parameters	Functions
RM_Connect.ind	CMRPC	CMDEV	AREP, ARBlockReq, ListOfIOCRBlockReq, AlarmCRBlockReq, ListOfExpectedSubmoduleBlockReq, ListOfMCRBlockReq, ListOfSubFrameBlockReq	—
RM_Dcontrol.ind	CMRPC	CMDEV	AREP, ControlBlock	—
RM_Release.ind	CMRPC	CMDEV	AREP, ControlBlock	—
CM_Ccontrol.cnf (-)	CMDEV	FSPMDEV	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	This service primitive confirms the Ccontrol service.
CM_Ccontrol.cnf (+)	CMDEV	FSPMDEV	AREP, ControlBlock	This service primitive confirms the Ccontrol service.
CM_Connect.ind	CMDEV	FSPMDEV	AREP, ARBlockReq, ListOfIOCRBlockReq, AlarmCRBlockReq, ListOfExpectedSubmoduleBlockReq, ListOfMCRBlockReq, ListOfSubFrameBlockReq	This service primitive indicates a request to establish an application relationship.
CM_Dcontrol.ind	CMDEV	FSPMDEV	AREP, ControlBlock	This service primitive indicates the end of parameter.
CM_Release.ind	CMDEV	FSPMDEV	AREP, ReleaseBlock	This service primitive indicates that the application relationship should be released.
RM_Ccontrol.req	CMDEV	CMRPC	AREP, ControlBlock, ModuleDiffBlock	—
RM_Connect.rsp (-)	CMDEV	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2	—
RM_Connect.rsp (+)	CMDEV	CMRPC	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock	—
RM_Dcontrol.rsp (+)	CMDEV	CMRPC	AREP, ControlBlock	—
RM_Release.rsp (+)	CMDEV	CMRPC	AREP, ControlBlock	—

5.6.3.2.1.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMDEV are described in the service definition and shown in Table 727.

Table 727 – Local primitives issued or received by CMDEV

Primitive	Source	Destination	Associated parameters	Functions
CMIO_info_ind	CMIO	CMDEV	—	—
CMSU_start_cnf (-)	CMSU	CMDEV	ListofCREPs, ListofErrors	This service primitive confirms the start service.
CMSU_start_cnf (+)	CMSU	CMDEV	ListofCREPs	This service primitive confirms the start service.
CM_Abort_req	FSPMDEV	CMDEV	AREP	The service Abort removes the stored AREP from the list of AREPs.
CM_Init_req	FSPMDEV	CMDEV	—	—
CMSU_start_req	CMDEV	CMSU	—	This service primitive confirms the start service.
CM_Abort_cnf	CMDEV	FSPMDEV	AREP	The service Abort removes the stored AREP from the list of AREPs.
CM_Init_cnf	CMDEV	FSPMDEV	—	—
CMDEV_state_ind	CMDEV	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	state {ABORT, STARTUP, PRMEND, APPLRDY, DATA}	This service primitive controls the state of the AR establishment.

5.6.3.2.1.2 State transition diagram

The state transition diagram of the CMDEV is shown in Figure 100.

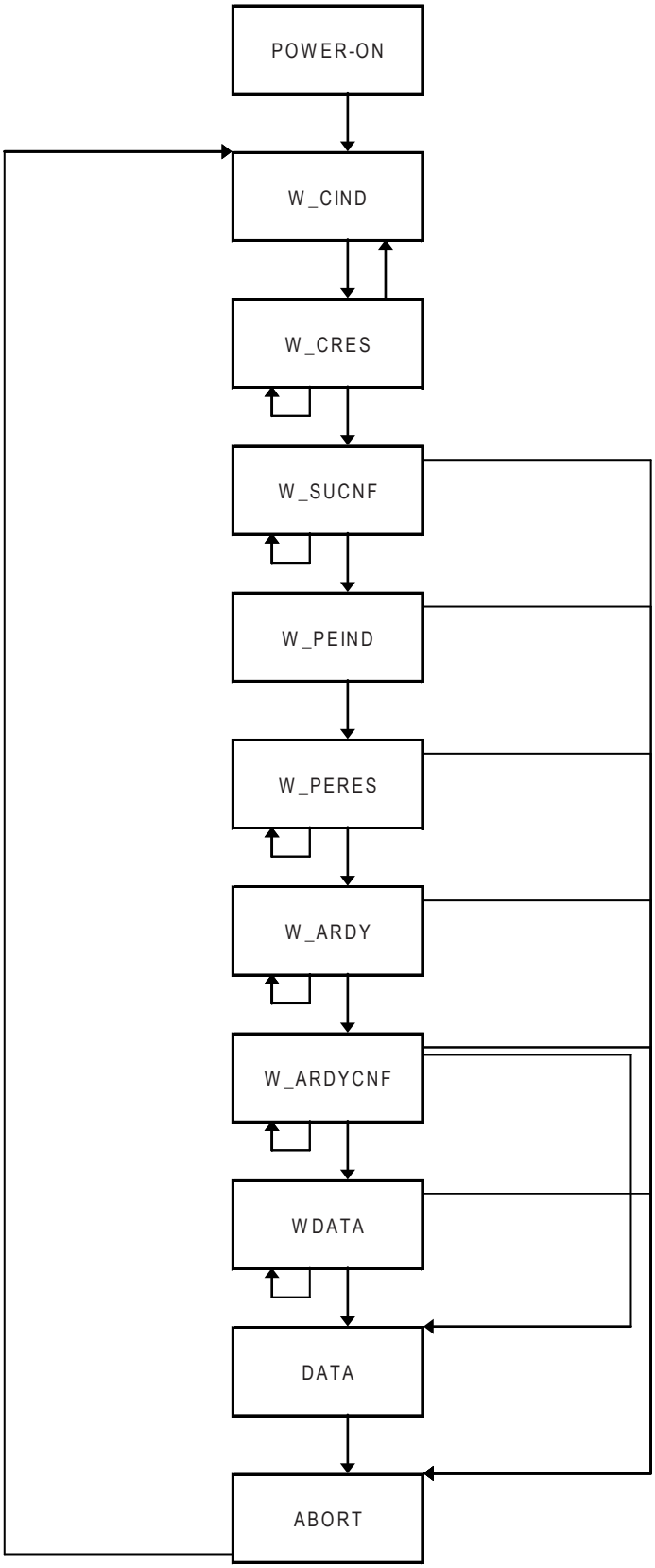


Figure 100 – State transition diagram of CMDEV

States of the CMDEV

POWER-ON	Data initialization

W_CIND	Wait for connect indication
W_CRES	Wait for connect response from the application and start the CMSU
W_SUCNF	Wait for CMSU confirmation and convay the connect response
W_PEIND	Wait for PrmEnd indication
W_PERES	Wait for PrmEnd response from the application
W_ARDY	Wait for ARDY request from the application
W_ARDYCNF	Wait for ARDY confirmation
WDATA	Wait for the established cyclic data exchange to start the CPM / PPM connection monitoring. The ALPMI is now able to issue an alam.
DATA	Data exchange and connection monitoring using the CPM / PPM. The ALPMI is now able to issue an alam.
ABORT	Abort application relation

5.6.3.2.1.3 State machine description

The CM Device protocol machine (CMDEV) is present for each AR of an IO Device.

Two kinds of Ars, selected by the attribute ARProperties.DeviceAccess, handled by CMDEV and CMDEV_DA exists.

Furthermore, if a multicast communication relation (MCR) is selected, the MCITimeoutFactor shall be used to optimize the diagnosis. If a MCR is not running and the MCITimeoutFactor is not expired, the ApplRdy.req shall be delayed until the MCITimeoutFactor expires or if earlier, all MCRs are running.

The possible RPC reruns are handled at the CMRPC.

5.6.3.2.1.4 CMDEV state table

Table 728 contains the complete description of the CMDEV state machine.

Table 728 – CMDEV state table

#	Current State	Event /Condition =>Action	Next State
1	POWER-ON	**CM_Init_req ()** => CM_Init_cnf ()	W_CIND
2	W_CIND	**RM_Connect.ind ()** /CheckAPDU () == OK => Ready4DATA:=FALSE CM_Connect.ind ()	W_CRES
3	W_CIND	**RM_Connect.ind ()** /CheckAPDU () == ErrorDecode, ErrorCode1, ErrorCode2 => RM_Connect.rsp (-)	W_CIND
4	W_CRES	**CM_Connect.rsp (+)** => CMSU_start_req () //NOTE Start all required protocol machines	W_SUCNF

#	Current State	Event /Condition =>Action	Next State
5	W_CRES	**CM_Connect.rsp (-)** => CreateLogBookEntry () RM_Connect.rsp (-)	W_CIND
6	W_CRES	RM_Dcontrol.ind () => ignore	W_CRES
7	W_CRES	RM_Release.ind () => ignore	W_CRES
8	W_SUCNF	**CMSU_start_cnf (+)** => CMDEV_state_ind (STARTUP) RM_Connect.rsp (+)	W_PEIND
9	W_SUCNF	**CMSU_start_cnf (-)** => ErrorDecode := PNIO ErrorCode1 := CMDEV ErrorCode2 := state conflict CreateLogBookEntry () RM_Connect.rsp (-)	ABORT
10	W_SUCNF	RM_Dcontrol.ind () => ignore	W_SUCNF
11	W_SUCNF	RM_Release.ind () => ignore	W_SUCNF
12	W_PEIND	**RM_Dcontrol.ind ()** /PRMEND => CM_Dcontrol.ind ()	W_PERES
13	W_PEIND	**RM_Release.ind ()** => CM_Release.ind () RM_Release.rsp ()	ABORT
14	W_PERES	**CM_Dcontrol.rsp (+)** => CMDEV_state_ind (PRMEND) RM_Dcontrol.rsp (+)	W_ARDY
15	W_PERES	**CM_Dcontrol.rsp (-)** => RM_Dcontrol.rsp (-)	ABORT
16	W_PERES	RM_Dcontrol.ind () => ignore	W_PERES
17	W_PERES	RM_Release.ind () => ignore	W_PERES
18	W_ARDY	**CMIO_info_ind ()** /state == DATA_POSSIBLE => Ready4DATA:=TRUE	W_ARDY
19	W_ARDY	**CMIO_info_ind ()** /state == DATA_IMPOSSIBLE => Ready4DATA:=FALSE	W_ARDY
20	W_ARDY	**CM_Ccontrol.req ()** /APPLRDY && All PPM buffers are updated and valid => CMDEV_state_ind (APPLRDY)	W_ARDYCNF

#	Current State	Event /Condition =>Action	Next State
		RM_Ccontrol.req (APPL_RDY)	
21	W_ARDY	**CM_Ccontrol.req ()** /APPLRDY && ! All PPM buffers are updated and valid => CM_Ccontrol.cnf (-)	W_ARDY
22	W_ARDY	**RM_Release.ind ()** => CM_Release.ind () RM_Release.rsp ()	ABORT
23	W_ARDYCNF	**CMIO_info_ind ()** /state == DATA_POSSIBLE => Ready4DATA:=TRUE	W_ARDYCNF
24	W_ARDYCNF	**CMIO_info_ind ()** /state == DATA_IMPOSSIBLE => Ready4DATA:=FALSE	W_ARDYCNF
25	W_ARDYCNF	**RM_Ccontrol.cnf (+)** /Ready4DATA == TRUE => CMDEV_state_ind (DATA) CM_Ccontrol.cnf (+) //NOTE The next NewData_ind () after the „Local AR In Data.ind“ contains the first valid data from the IO controller	DATA
26	W_ARDYCNF	**RM_Ccontrol.cnf (+)** /Ready4DATA == FALSE => CM_Ccontrol.cnf (+)	WDATA
27	W_ARDYCNF	**RM_Ccontrol.cnf (-)** => CreateLogBookEntry () CM_Ccontrol.cnf (-)	ABORT
28	W_ARDYCNF	**RM_Release.ind ()** => CM_Release.ind () RM_Release.rsp ()	ABORT
29	WDATA	**CMIO_info_ind ()** /state == DATA_POSSIBLE => Ready4DATA:=TRUE CMDEV_state_ind (DATA)	DATA
30	WDATA	**CMIO_info_ind ()** /state == DATA_IMPOSSIBLE => Ready4DATA:=FALSE	WDATA
31	WDATA	**RM_Release.ind ()** => CM_Release.ind () RM_Release.rsp ()	ABORT
32	DATA	**RM_Release.ind ()** => CM_Release.ind () RM_Release.rsp ()	ABORT
33	ABORT	 => CMDEV_state_ind (ABORT)	W_CIND
34	ANY	**CMDEV_state_ind ()** /state == ABORT => ignore	W_CIND

#	Current State	Event /Condition =>Action	Next State
35	ANY	**CM_Abort_req ()** => CMDEV_state_ind (ABORT)	W_CIND

5.6.3.2.1.5 Functions, Macros, Timers and Variables

Table 729 contains the functions, macros, timers and variables used by the CMDEV and their arguments and their descriptions.

Table 729 – Functions, Macros, Timers and Variables used by CMDEV

Name	Type	Function/Meaning
CheckAPDU	Function	This local function checks the semantics of the connect.
Ready4Data	Variable	This local variable is used to store state informations during AR establishment.
All PPM buffer are updated and valid	Macro	This local macro return TRUE if the user has updated the Data_Buffer of the PPMs.

5.6.3.2.2 CMDEV Device Access state machine

5.6.3.2.2.1 General

The CMDEV_DA arranges the device access connection establishment of an IO device. Figure 101 shows the integration of the IO device CM – device access.

The following definition shall be used for ARBlockReq.ARProperties.StartupMode:=Advanced. For ARBlockReq.ARProperties.StartupMode:=Legacy the definitions of the version V2.2 and the Annex B applies.

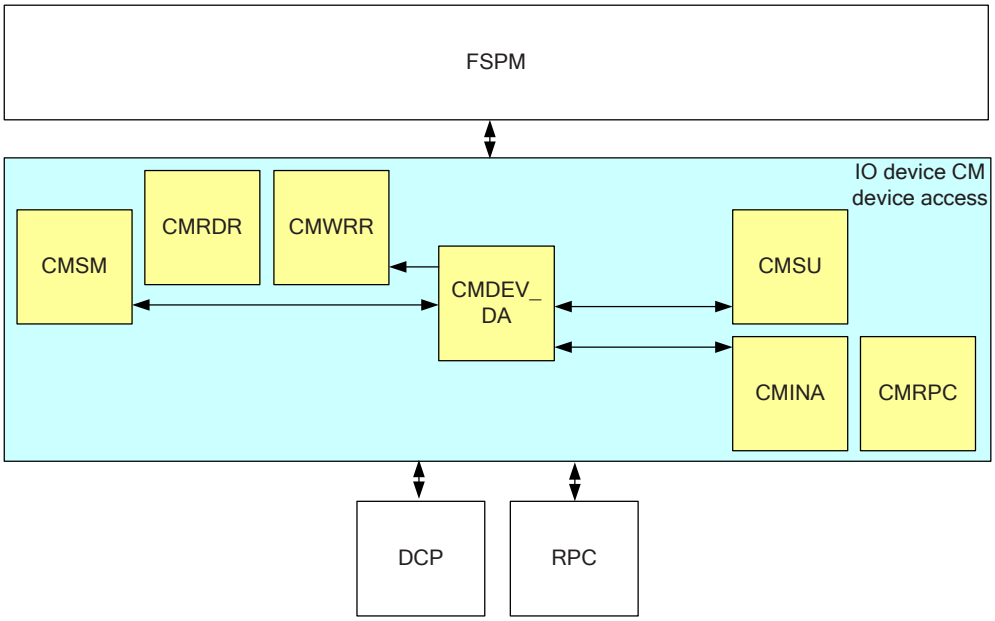


Figure 101 – Scheme of the IO device CM – device access

CMDEV
This state machine handles the context management of the IO device.

CMWRR
This state machine handles the responder functionality of the write service.

CMRDR
This state machine handles the responder functionality of the read service.

CMSM
This state machine handles the connection monitoring during the startup.

CMSU
This state machine handles the startup of the different state machines during startup and shut down.

CMRPC
This machine handles the RPC communication and therefore all issued and received RPC services.

CMINA
This machine handles the IP and Name assignment.

5.6.3.2.2.2 Primitive definitions

5.6.3.2.2.2.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Device Device Access (CMDEV_DA) are described in the service definition and shown in Table 730.

Table 730 – Remote primitives issued or received by CMDEV_DA

Primitive	Source	Destination	Associated parameters	Functions
CM_Connect.ind	CMDEV_DA	FSPMDEV	AREP, ARBlockReq	—
RM_Connect.rsp(-)	CMDEV_DA	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2	—
RM_Connect.rsp(+)	CMDEV_DA	CMRPC	AREP, ARBlockRes	—
RM_Release.rsp(-)	CMDEV_DA	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2	—
RM_Release.rsp(+)	CMDEV_DA	CMRPC	AREP, IODReleaseRes	—
CM_Connect.rsp (-)	FSPMDEV	CMDEV_DA	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Connect.rsp (+)	FSPMDEV	CMDEV_DA	AREP, ARBlockRes	—
RM_Connect.ind	CMRPC	CMDEV_DA	AREP, ARBlockReq	—
RM_Release.ind	CMRPC	CMDEV_DA	AREP, IODReleaseReq	—

5.6.3.2.2.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMDEV_DA are described in the service definition and shown in Table 731.

Table 731 – Local primitives issued or received by CMDEV_DA

Primitive	Source	Destination	Associated parameters	Functions
CMDEV_state_ind	CMDEV_DA	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	AREP, state {STARTUP, ABORT}	—
CM_Abort_req	FSPMDEV	CMDEV_DA	AREP	—
CM_Abort_cnf	CMDEV_DA	FSPMDEV	AREP	—
CM_Init_req	FSPMDEV	CMDEV_DA	AREP	—
CM_Init_cnf	CMDEV_DA	FSPMDEV	AREP	—

5.6.3.2.3 State transition diagram

The state transition diagram of the CMDEV_DA is shown in Figure 100.

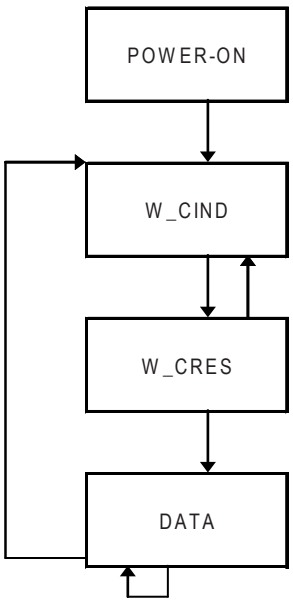


Figure 102 – State transition diagram of CMDEV_DA

States of the CMDEV_DA

POWER-ON	Data initialization
W_CIND	Wait for connect indication
W_CRES	Wait for connect response from the application
DATA	Data exchange monitored by CMSM

5.6.3.2.2.4 State machine description

The CM Device protocol machine for device access (CMDEV_DA) is present for each AR of an IO Device. The selection is done by the attribute ARProperties.DeviceAccess.

The device access is used if only a record service channel to the application is needed. The connection monitoring for this kind of an IOCAR is done by the CMSM using read and write record services.

The CMDEV_DA signals the CMSM only STARTUP when switching to DATA to keep the monitoring using read and write services active.

5.6.3.2.2.5 CMDEV_DA (device access) state table

Table 732 contains the complete description of the CMDEV_DA state machine.

Table 732 – CMDEV_DA state table

#	Current State	Event /Condition =>Action	Next State
1	POWER-ON	**CM_Init_req ()** => CM_Init_cnf ()	W_CIND
2	W_CIND	**RM_Connect.ind ()** /CheckAPDU () == OK => CM_Connect.ind ()	W_CRES
3	W_CIND	**RM_Connect.ind ()** /CheckAPDU () == ErrorDecode, ErrorCode1, ErrorCode2 => RM_Connect.rsp (-)	W_CIND
4	W_CRES	**CM_Abort_req ()** => RM_Connect.rsp (-) CMDEV_state_ind (ABORT) CM_Abort_cnf ()	W_CIND
5	W_CRES	**CM_Connect.rsp (+)** => RM_Connect.rsp (+) CMDEV_state_ind (STARTUP)	DATA
6	W_CRES	**CM_Connect.rsp (-)** => RM_Connect.rsp (-)	W_CIND
7	DATA	**CM_Abort_req ()** => CMDEV_state_ind (ABORT) CM_Abort_cnf ()	W_CIND
8	DATA	**RM_Release.ind ()** => RM_Release.rsp () CMDEV_state_ind (ABORT)	W_CIND
9	DATA	CM_Connect.rsp () => ignore	DATA

5.6.3.2.2.6 Functions, Macros, Timers and Variables

Table 733 contains the functions, macros, timers and variables used by the CMDEV(DA) and their arguments and their descriptions.

Table 733 – Functions, Macros, Timers and Variables used by CMDEV(DA)

Name	Type	Function/Meaning
CheckAPDU	Function	This local function checks the semantics of the connect.

5.6.3.3 Context Management Startup Device

5.6.3.3.1 Primitive definitions

5.6.3.3.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Startup Protocol Machine Device (CMSU) are described in the service definition and shown in Table 734.

Table 734 – Remote primitives issued or received by CMSU

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.3.3.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMSU are described in the service definition and shown in Table 735.

Table 735 – Local primitives issued or received by CMSU

Primitive	Source	Destination	Associated parameters	Functions
ALPMI_Activate_req	CMSU	ALPMI	CREP	—
ALPMR_Activate_req	CMSU	ALPMR	CREP	—
APMR_Activate_req	CMSU	APMR	CREP	—
APMS_Activate_req	CMSU	APMS	CREP	—
CMSU_start_cnf (-)	CMSU	CMDEV	ErrorList {ListOfPPM, ListOfCPM, ListOfMCR, ALPMI, ALPMR, DFP}	This service primitive starts the underlying protocol ressources.
CMSU_start_cnf (+)	CMSU	CMDEV	—	—
CMDMC_Activate_req	CMSU	CMDMC	CREP.CMDMC, ProviderStationName, CR_Parameter	—
CMDMC_Close_req	CMSU	CMDMC	CREP	—
ALPMI_Activate_cnf (-)	ALPMI	CMSU	—	—
ALPMI_Error_ind	ALPMI	CMSU	CREP, ERRCLS, ERRCODE	—
ALPMR_Activate_cnf (-)	ALPMR	CMSU	—	—

Primitive	Source	Destination	Associated parameters	Functions
ALPMR_Error_ind	ALPMR	CMSU	CREP, ERRCLS, ERRCODE	—
APMR_Activate_cnf (-)	APMR	CMSU	—	—
APMR_Error_ind	APMR	CMSU	CREP, ERRCLS, ERRCODE	—
APMS_Activate_cnf (-)	APMS	CMSU	—	—
APMS_Error_ind	APMS	CMSU	CREP, ERRCLS, ERRCODE	—
CMSU_start_req	CMDEV	CMSU	AREP, ARBlockReq, ListOfIOCRBlockReq, AlarmCRBlockReq, ListOfExpectedSubmoduleBlockReq, ListOfMCRBlockReq, ListOfSubFrameBlockReq, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes	This service primitive starts the underlying protocol ressources.
CMDMC_Activate_cnf (-)	CMDMC	CMSU	—	—
CMDMC_Error_ind ()	CMDMC	CMSU	ErrorCode1, ErrorCode2	—
CPM_Activate_cnf (-)	CPM	CMSU	—	—
CPM_Error_ind	CPM	CMSU	ErrorCode1, ErrorCode2	—
DFP_Activate_cnf (-)	DFP	CMSU	—	—
PPM_Activate_cnf (-)	PPM	CMSU	—	—
PPM_Error_ind	PPM	CMSU	ErrorCode1, ErrorCode2	—
XXX_Activate_cnf (+)	xxx	CMSU	CREP	—
XXX_Close_cnf (+)	xxx	CMSU	CREP	—
CPM_Activate_req	CMSU	CPM	CREP, DA, SA, FrameID, RxOption, ARProperties.StartupMode, …	—
CPM_Close_req	CMSU	CPM	CREP	—
DFP_Activate_req	CMSU	DFP	CREP	—
DFP_Close_req	CMSU	DFP	CREP	—
CMDEV_state_ind	CMDEV CMSU	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	State {ABORT, STARTUP, PRMEND, APPLRDY, DATA}	This service primitive controls the state of the CMSU.

Primitive	Source	Destination	Associated parameters	Functions
PPM_Activate_req	CMSU	PPM	CREP, DA, SA, FrameID, TxOption, ARProperties.StartupMode, …	—
PPM_Close_req	CMSU	PPM	CREP	—

5.6.3.3.2 State transition diagram

The state transition diagram of the CMSU is shown in Figure 103.

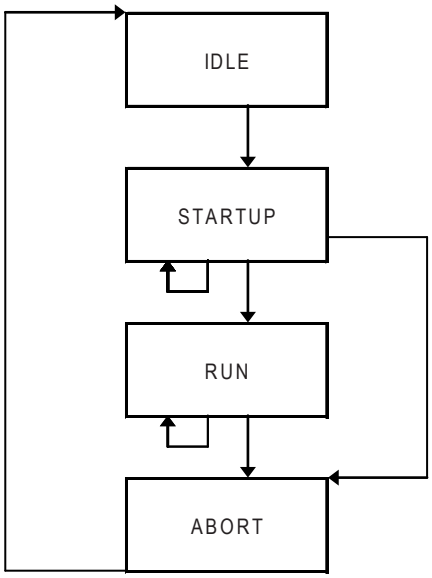


Figure 103 – State transition diagram of CMSU

States of the CMSU

IDLE	Wait for the start command and start the associated state machines.
STARTUP	Check the response of the started machines and continue in state RUN.
RUN	Startup of the state machines is done, wait for shut down or fault.
ABORT	Termination sequence

5.6.3.3.3 State machine description

The Context Management Startup Protocol Machine Device (CMSU) of an IO device arranges the start of the underlying protocol machines.

The startup of the CPM and PPM state machines shall be done between receiving the connect request service and the Application ready service. The startup shall be finish before issuing the Application ready request service.

5.6.3.3.4 CMSU state table

Table 736 contains the description of the CMSU state machine. The difference between ARProperties.StartupMode=Legacy and ARProperties.StartupMode=Advanced is handled by the CMSU, the PPM and the CPM.

Table 736 – CMSU state table

#	Current State	Event /Condition =>Action	Next State

1	IDLE	**CMSU_start_req ()**
		=>
		CREP.PPM := create (PPM)
		CREP.CPM := create (CPM)
		
		CREP.ALPMI := create (ALPMI)
		CREP.ALPMR := create (ALPMR)
		
		CREP.APMS := create (APMS)
		CREP.APMR := create (APMR)
		
		if exist:
		CREP.MPPM := create (PPM)
		CREP.CMDMC := create (CMDMC)
		CREP.DFP := create (DFP)
		
		//NOTE Create high and low alarm machine instances
		PPM_Activate_req ()
		CPM_Activate_req ()
		
		if applicable
		CMDMC_Activate_req ()
		if applicable
		DFP_Activate_req ()
		
		ALPMI_Activate_req ()
		ALPMR_Activate_req ()
		APMS_Activate_req ()
		APMR_Activate_req ()
			STARTUP

2	STARTUP	**XXX_Activate_cnf (+)** /if last confirmation is received => CMSU_start_cnf (+)	STARTUP
3	STARTUP	**PPM_Activate_cnf (-)** => ErrorCode2 = AR add provider or consumer failed CMSU_start_cnf (-)	STARTUP
4	STARTUP	**CPM_Activate_cnf (-)** => ErrorCode2 = AR add provider or consumer failed CMSU_start_cnf (-)	STARTUP
5	STARTUP	**ALPMI_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMSU_start_cnf (-)	STARTUP
6	STARTUP	**ALPMR_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMSU_start_cnf (-)	STARTUP
7	STARTUP	**APMS_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMSU_start_cnf (-)	STARTUP
8	STARTUP	**APMR_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMSU_start_cnf (-)	STARTUP

#	Current State	Event /Condition =>Action	Next State
9	STARTUP	**CMDMC_Activate_cnf (-)** => ErrorCode1 := CMDEV ErrorCode2 := state conflict CMSU_start_cnf (-)	STARTUP
10	STARTUP	**DFP_Activate_cnf (-)** => ErrorCode2 = AR add provider or consumer failed CMSU_start_cnf (-)	STARTUP
11	STARTUP	**CMSU_start_req ()** => ErrorCode1 := CMDEV ErrorCode2 := state conflict CMSU_start_cnf (-)	STARTUP
12	STARTUP	**CMDEV_state_ind ()** /state != ABORT => ignore	RUN

13	STARTUP	**CMDEV_state_ind ()**
		/state == ABORT
		=>
		PPM_Close_req ()
		CPM_Close_req ()
		
		if applicable
		  CMDMC_Close_req ()
		if applicable
		  DFP_Close_req ()
		
		ALPMI_Close_req ()
		ALPMR_Close_req ()
		APMS_Close_req ()
		APMR_Close_req ()
			ABORT

14	RUN	**CMDEV_state_ind ()** /state != ABORT => ignore	RUN

15	RUN	**CMDEV_state_ind ()**
		/state == ABORT
		=>
		PPM_Close_req ()
		CPM_Close_req ()
		
		if applicable
		  CMDMC_Close_req ()
		if applicable
		  DFP_Close_req ()
		
		ALPMI_Close_req ()
		ALPMR_Close_req ()
		APMS_Close_req ()
		APMR_Close_req ()
			ABORT

16	RUN	**CMSU_start_req ()** => ErrorCode1 := CMDEV ErrorCode2 := state conflict CMSU_start_cnf (-)	RUN

#	Current State	Event /Condition =>Action	Next State

17	ABORT	**XXX_Close_cnf (+)**
		/if last confirmation is received
		=>
		Delete (PPM)
		Delete (CPM)
		
		Delete (ALPMI)
		Delete (ALPMR)
		
		Delete (APMS)
		Delete (APMR)
		
		if exist:
		Delete (DFP)
		
		if exist:
		Delete (CMDMC)
		
		//NOTE Delete all created PPMs and CPMs
			IDLE

18	ANY	**PPM_Error_ind ()** => CMDEV_state_ind (ABORT)	SAME
19	ANY	**CPM_Error_ind ()** => CMDEV_state_ind (ABORT)	SAME
20	ANY	**ALPMI_Error_ind ()** => ErrorCode2 := AR alarm-send or ErrorCode2 := AR alarm-ack-send CMDEV_state_ind (ABORT)	SAME
21	ANY	**ALPMR_Error_ind ()** => ErrorCode2 := AR alarm-ind CMDEV_state_ind (ABORT)	SAME
22	ANY	**APMS_Error_ind ()** => ErrorCode2 := AR alarm-send or ErrorCode2 := AR alarm-ack-send CMDEV_state_ind (ABORT)	SAME
23	ANY	**APMR_Error_ind ()** => ErrorCode2 := AR alarm-ind CMDEV_state_ind (ABORT)	SAME
24	ANY	**CMDMC_Error_ind ()** => CMDEV_state_ind (ABORT)	SAME

5.6.3.3.5 Functions, Macros, Timers and Functions

Table 737 contains the functions, macros, timers and variables used by the CMSU and their arguments and their descriptions.

Table 737 – Functions, Macros, Timers and Variables used by the CMSU

Name	Type	Function/Meaning
Delete	Function	This local function frees or unbounds the machines from the CMCTL instance if the AR is aborted.
If last confirmation is received	Macro	This local macro collects all the confirmations and returns TRUE if all receive with xxx_cnf (+).

5.6.3.4 Context Management Input Output Device

5.6.3.4.1 Primitive definitions

5.6.3.4.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Input Output Protocol Machine Device (CMIO) are described in the service definition and shown in Table 738.

Table 738 – Remote primitives issued or received by CMIO

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.3.4.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by Context Management Input Output Protocol Machine Device (CMIO) are described in the service definition and shown in Table 739.

Table 739 – Local primitives issued or received by CMIO

Primitive	Source	Destination	Associated parameters	Functions
CMIO_info_ind	CMIO	CMDEV	info	—
CPM_State_ind	CPM	CMIO	—	—
CPM_NewData_ind	CPM	CMIO FSPMDEV CMDMC CTLIO	AREP, CREP, APDU_Status, data {Data, NoData}	This service primitive indicates an update of a receive buffer.
CMDEV_state_ind	CMDEV	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	State {ABORT, STARTUP, PRMEND, APPLRDY}	This service primitive controls the state of the CMIO.

5.6.3.4.2 State transition diagram

The state transition diagram of the CMIO is shown in Figure 104.

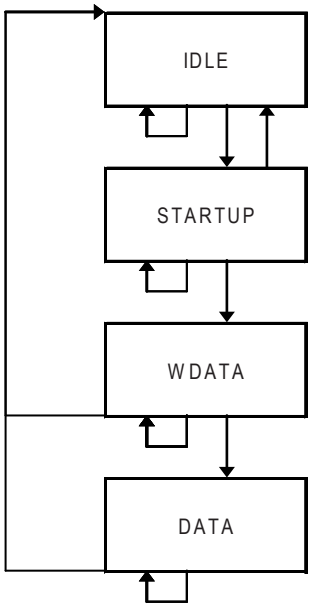


Figure 104 – State transition diagram of CMIO

States of the CMIO

IDLE	No AR context exists
STARTUP	Initial parameterization phase
WDATA	Wait until the AR is ready to switch to the DATA state due to all associated CPMs are receiving frames.
DATA	Data exchange phase. Monitoring the DataHoldTime.

5.6.3.4.3 State machine description

The CM Input Output protocol machine (CMIO) arranges the access to the DataStatus and NewData indication.

5.6.3.4.4 CMIO state table

Table 740 contains the complete description of the CMIO state machine.

Table 740 – CMIO state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	CPM_NewData_ind () => ignore	IDLE
2	IDLE	CPM_State_ind () => ignore	IDLE
3	IDLE	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE

#	Current State	Event /Condition =>Action	Next State
4	IDLE	**CMDEV_state_ind ()** /state == STARTUP => For all CPMs CmInstance[CREP.CPM]:=Stop	STARTUP
5	STARTUP	CPM_NewData_ind () => ignore	STARTUP
6	STARTUP	CPM_State_ind () => ignore	STARTUP
7	STARTUP	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
8	STARTUP	**CMDEV_state_ind ()** /state == PRMEND => StartTimer ()	WDATA
9	WDATA	**CPM_NewData_ind ()** => CmInstance[CREP.CPM]:=Start	WDATA
10	WDATA	**CPM_State_ind ()** /state == STOP => CmInstance[CREP.CPM]:=Stop	WDATA
11	WDATA	**CPM_State_ind ()** /state == START => CmInstance[CREP.CPM]:=Start	WDATA
12	WDATA	**TimerExpired ()** /All CPM of CmInstance[CREP.CPM] contain the value “Start” => StartTimer () CMIO_info_ind (DATA_POSSIBLE)	WDATA
13	WDATA	**TimerExpired ()** /One CPM of CmInstance[CREP.CPM] contains the value “Stop” => StartTimer () CMIO_info_ind (DATA_IMPOSSIBLE)	WDATA
14	WDATA	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
15	WDATA	**CMDEV_state_ind ()** /state == APPLRDY => ignore	WDATA
16	WDATA	**CMDEV_state_ind ()** /state == DATA => StopTimer ()	DATA
17	DATA	CPM_NewData_ind () => ignore	DATA
18	DATA	**CPM_State_ind ()** /state == STOP && CREP != CREP.MCPM => CMDEV_state_ind (ABORT)	DATA

#	Current State	Event /Condition =>Action	Next State
19	DATA	**CPM_State_ind ()** /state == START => ignore	DATA
20	DATA	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE

5.6.3.4.5 Functions, Macros, Timers and Variables

Table 741 contains the functions, macros, timers and variables used by the CMIO and their arguments and their descriptions.

Table 741 – Functions used by the CMIO

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or restarts a timer. The time for this timer may be 100 ms. NOTE An implementation can use “change” events instead of this timer.
StopTimer	Function	This local functions stops a timer
TimerExpired	Function	This local function is issued if a timer expires
CmInstance	Variable	This AR global variable contains the informations about the AR.

5.6.3.5 Context Management Write Record Device

5.6.3.5.1 Primitive definitions

5.6.3.5.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Write Record Responder Protocol Machine Device (CMWRR) are described in the service definition and shown in Table 742.

Table 742 – Remote primitives issued or received by CMWRR

Primitive	Source	Destination	Associated parameters	Functions
CM_Write.rsp (-)	FSPMDEV	CMWRR	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Write.rsp (+)	FSPMDEV	CMWRR	AREP, SeqNumber, AddData1, AddData2	—
RM_Write.ind	CMRPC	CMWRR	AREP, API, SlotNumber, SubslotNumber, Index, SeqNumber, Length, Data	—

Primitive	Source	Destination	Associated parameters	Functions
CM_Write.ind	CMWRR	FSPMDEV	AREP, API, SlotNumber, SubslotNumber, Index, PrmFlag, SeqNumber, Length, Data	—
RM_Write.rsp (-)	CMWRR	CMRPC	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Write.rsp (+)	CMWRR	CMRPC	AREP, SeqNumber	—

5.6.3.5.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMWRR are described in the service definition and shown in Table 743.

Table 743 – Local primitives issued or received by CMWRR

Primitive	Source	Destination	Associated parameters	Functions
CMDEV_state_ind	CMDEV	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	state	—

5.6.3.5.2 State transition diagram

The state transition diagram of the CMWRR is shown in Figure 105.

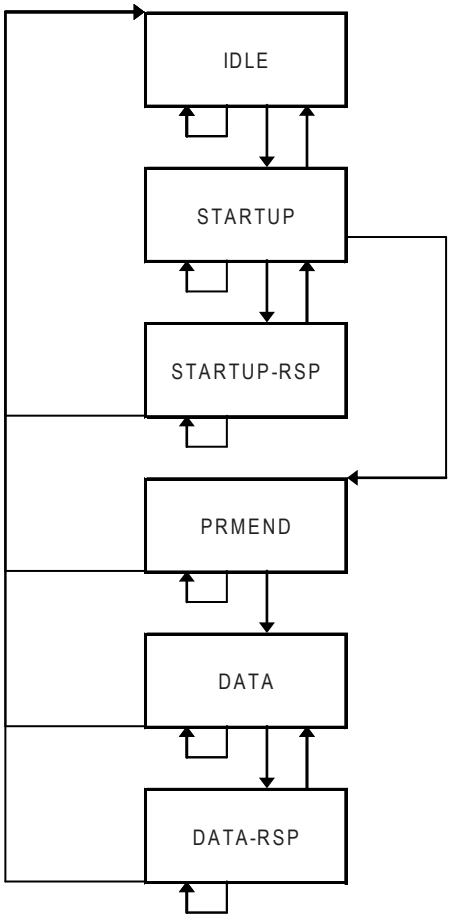


Figure 105 – State transition diagram of CMWRR

States of the CMWRR

IDLE	No AR context exists
STARTUP	The associated AR reaches the internal state STARTUP. Write services handled during this state.
STARTUP-RSP	Wait for the user response and convey it to the requester.
PRMEND	The associated AR reaches the internal state PRMEND. Write services rejected during this state.
DATA	The associated AR reaches the internal state DATA. Write services handled during this state.
DATA-RSP	Wait for the user response and convey it to the requester.

5.6.3.5.3 State machine description

The CM Write Record protocol machine (CMWRR) arranges the write record service.

5.6.3.5.4 CMWRR state table

Table 744 contains the complete description of the CMWRR state machine. The CMWRR checks whether the ARUUID exists.

Table 744 – CMWRR state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**RM_Write.ind ()** => ErrorDecode := PNIORW ErrorCode1 := state conflict RM_Write.rsp (-)	IDLE
2	IDLE	CM_Write.rsp () => ignore	IDLE
3	IDLE	**CMDEV_state_ind ()** /state == STARTUP => ignore	STARTUP
4	IDLE	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
5	STARTUP	**RM_Write.ind ()** /Arstate != Backup => CM_Write.ind ()	STARTUP-RSP
6	STARTUP	**RM_Write.ind ()** /Arstate == Backup => ErrorDecode := PNIORW ErrorCode1 := backup RM_Write.rsp (-)	STARTUP
7	STARTUP-RSP	**CM_Write.rsp (+)** => RM_Write.rsp (+)	STARTUP
8	STARTUP-RSP	**CM_Write.rsp (-)** => RM_Write.rsp (-)	STARTUP
9	STARTUP-RSP	RM_Write.ind () => ignore	STARTUP-RSP
10	STARTUP-RSP	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
11	STARTUP	**CMDEV_state_ind ()** /state == PRMEND => ignore	PRMEND
12	STARTUP	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
13	PRMEND	**RM_Write.ind ()** => ErrorDecode := PNIORW ErrorCode1 := state conflict RM_Write.rsp (-)	PRMEND
14	PRMEND	**CMDEV_state_ind ()** /state == APPLRDY => ignore	DATA
15	PRMEND	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE

#	Current State	Event /Condition =>Action	Next State
16	DATA	**CMDEV_state_ind ()** /state == DATA => ignore	DATA
17	DATA	**RM_Write.ind ()** /Arstate != Backup => CM_Write.ind ()	DATA-RSP
18	DATA	**RM_Write.ind ()** /Arstate == Backup => ErrorDecode := PNIORW ErrorCode1 := backup RM_Write.rsp (-)	DATA
19	DATA	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
20	DATA-RSP	**CM_Write.rsp (+)** => RM_Write.rsp (+)	DATA
21	DATA-RSP	**CM_Write.rsp (-)** => RM_Write.rsp (-)	DATA
22	DATA-RSP	RM_Write.ind () => ignore	DATA-RSP
23	DATA-RSP	**CMDEV_state_ind ()** /state == DATA => ignore	DATA-RSP
24	DATA-RSP	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE

5.6.3.5.5 Functions, Macros, Timers and Variables

Table 745 contains the functions, macros, timers and variables used by the CMWRR and their arguments and their descriptions.

Table 745 – Functions, Macros, Timers and Variables used by CMWRR

Name	Type	Function/Meaning
Arstate	Variable	This AR global variable contains the current state of the AR. Possible values are: First, Primary, Backup Initial value of this variable is Primary

5.6.3.6 Context Management Read Record Device

5.6.3.6.1 Primitive definitions

5.6.3.6.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Read Record Responder Protocol Machine Device (CMRDR) are described in the service definition and shown in Table 746.

Table 746 – Remote primitives issued or received by CMRDR

Primitive	Source	Destination	Associated parameters	Functions
CM_Read.rsp (-)	FSPMDEV	CMRDR	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Read.rsp (+)	FSPMDEV	CMRDR	AREP, SeqNumber, Length, Data	—
RM_Read.ind	CMRPC	CMRDR	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Read.ind	CMRDR	FSPMDEV	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Read.rsp (-)	CMRDR	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.rsp (+)	CMRDR	CMRPC	AREP, SeqNumber, Length, Data	—

5.6.3.6.1.2 Primitives exchanged between local machines

The local primitives including their associated parameters issued or received by CMRDR are described in the service definition and shown in Table 747.

Table 747 – Local primitives issued or received by CMRDR

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.3.6.2 State transition diagram

The state transition diagram of the CMRDR is shown in Figure 106.

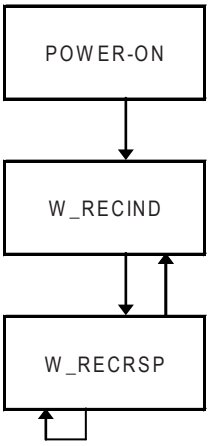


Figure 106 – State transition diagram of CMRDR

States of the CMRDR

POWER-ON	Data initialization
W_RECIND	Wait for read record indication
W_RECRSP	Wait for read record response

5.6.3.6.3 State machine description

The CM Read Record protocol machine (CMRDR) arranges the read record service.

5.6.3.6.4 CMRDR state table

Table 748 contains the complete description of the CMRDR state machine. The CMRPC checks whether the ARUUID exists.

Table 748 – CMRDR state table

#	Current State	Event /Condition =>Action	Next State
1	POWER-ON	=> Init	W_RECIND
2	W_RECIND	**RM_Read.ind ()** => CM_Read.ind ()	W_RECRSP
3	W_RECRSP	**CM_Read.rsp (+)** => RM_Read.rsp (+)	W_RECIND
4	W_RECRSP	**CM_Read.rsp (-)** => RM_Read.rsp (-)	W_RECIND
5	W_RECRSP	RM_Read.ind () => ignore	W_RECRSP

The serialization of the “Read” RPC calls for one AR is done by the RPC layer. Thus, it is not necessary to check the serialization again in the CMRDR.

5.6.3.6.5 Functions, Macros, Timers and Variables

Table 749 contains the functions, macros, timers and variables used by the CMRDR and their arguments and their descriptions.

Table 749 – Functions, Macros, Timers and Variables used by CMRDR

Name	Type	Function/Meaning
—	—	—

5.6.3.7 Context Management Surveillance Device

5.6.3.7.1 Primitive definitions

5.6.3.7.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Surveillance Protocol Machine Device (CMSM) are described in the service definition and shown in Table 750.

Table 750 – Remote primitives issued or received by CMSM

Primitive	Source	Destination	Associated parameters	Functions
CM_Read.ind	CMRDR	CMSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Read.rsp	CMRDR	CMSM	AREP, SeqNumber	—
CM_Write.ind	CMWRR	CMSM	AREP, API, SlotNumber, SubslotNumber, Index, PrmFlag, SeqNumber, Length, Data	—
CM_Write.rsp	CMWRR	CMSM	AREP, SeqNumber	—
RM_Read.ind	CMRPC	CMSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	Trigger record indication This service primitive is the indication of the Read service.
CM_Abort.req	FSPMDEV CMSU CMIO CMSM	CMDEV	AREP	Abort current AR establishing

Primitive	Source	Destination	Associated parameters	Functions
RM_Read.rsp (+)	CMSM	CMRPC	AREP, API, TargetUUID, SeqNumber, Length, Data	Trigger record response This service primitive is the response to the Read service.

5.6.3.7.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMSM are described in the service definition and shown in Table 751.

Table 751 – Local primitives issued or received by CMSM

Primitive	Source	Destination	Associated parameters	Functions
CMDEV_state_ind	CMDEV	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	state	State “PRMEND” start CMI timeout State “DATA” start CMI timeout

5.6.3.7.2 State transition diagram

The state transition diagram of the CMSM is shown in Figure 107.

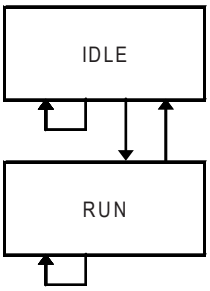


Figure 107 – State transition diagram of CMSM

States of the CMSM

IDLE	Wait for the start of the connection monitoring
RUN	Connection monitoring running

5.6.3.7.3 State machine description

The CM server protocol machine (CMSM) arranges the connection monitoring between the connect response and the start of the PPM / CPM connection monitoring.

The CMSM uses Read, Write and Dcontrol indication and response for the triggering of the connection monitoring.

5.6.3.7.4 CMSM state table

Table 752 contains the complete description of the CMSM state machine.

Table 752 – CMSM state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CMDEV_state_ind ()** /state == STARTUP => StartTimer (CMI, CMInitiatorActivityTimeout)	RUN
2	IDLE	**CMDEV_state_ind ()** /state != STARTUP => ignore	IDLE
3	IDLE	TimerExpired (CMI) => ignore	IDLE
4	IDLE	**RM_Read.ind ()** /Index == Trigger => RM_Read.rsp (+)	IDLE
5	IDLE	**RM_Read.ind ()** /Index != Trigger => ignore	IDLE
6	IDLE	CM_Read.ind () => ignore	IDLE
7	IDLE	CM_Read.rsp () => ignore	IDLE
8	IDLE	CM_Write.ind () => ignore	IDLE
9	IDLE	CM_Write.rsp () => ignore	IDLE
10	RUN	TimerExpired (CMI) => CM_Abort.req ()	IDLE
11	RUN	**CMDEV_state_ind ()** /state == DATA || state == ABORT => StopTimer (CMI)	IDLE
12	RUN	**CMDEV_state_ind ()** /state != DATA && state != ABORT => ignore	RUN
13	RUN	**RM_Read.ind ()** /Index == Trigger => StopTimer (CMI) StartTimer (CMI, CMInitiatorActivityTimeout) RM_Read.rsp (+)	RUN
14	RUN	**CM_Read.rsp ()** => StartTimer (CMI, CMInitiatorActivityTimeout)	RUN
15	RUN	**CM_Write.rsp ()** => StartTimer (CMI, CMInitiatorActivityTimeout)	RUN

#	Current State	Event /Condition =>Action	Next State
16	RUN	**CM_Read.ind ()** => StopTimer (CMI)	RUN
17	RUN	**CM_Write.ind ()** => StopTimer (CMI)	RUN

5.6.3.7.5 Functions, Macros, Timers and Variables

Table 753 contains the functions, macros, timers and variables used by the CMSM and their arguments and their descriptions.

Table 753 – Functions, Macros, Timers and Variables used by the CMSM

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or restarts a timer.
StopTimer	Function	This local function stops a timer.
TimerExpired	Function	This local function is issued if a timer expires.
Trigger	Macro	This local Macro represents the Trigger record.
CMI	Timer	This local timer shall be loaded with the CMInitiatorActivityTimeout and is used for the connection montinoring during startup.

5.6.3.8 Context Management Prm Begin End Device

5.6.3.8.1 Primitive definitions

5.6.3.8.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Prm Begin End Protocol Machine Device (CMPBE) are described in the service definition and shown in Table 754.

Table 754 – Remote primitives received by CMPBE

Primitive	Source	Destination	Associated parameters	Functions
CM_Ccontrol.req	FSPMDEV	CMPBE	AREP, ControlBlock, ModuleDiffBlock	—
CM_Dcontrol.rsp	FSPMDEV	CMPBE	AREP, ControlBlock	—
RM_Ccontrol.cnf	CMRPC	CMPBE	AREP, ControlBlock	—
RM_Dcontrol.ind	CMRPC	CMPBE	AREP, ControlBlock	—
CM_Ccontrol.cnf	CMPBE	FSPMDEV	AREP, ControlBlock	—
CM_Dcontrol.ind	CMPBE	FSPMDEV	AREP, ControlBlock	—
RM_Ccontrol.req	CMPBE	CMRPC	AREP, ControlBlock, ModuleDiffBlock	—
RM_Dcontrol.rsp (-)	CMPBE	CMRPC	AREP, ErrorDecode, ErrorCode1,	—

Primitive	Source	Destination	Associated parameters	Functions
			ErrorCode2, AddData1, AddData2	
RM_Dcontrol.rsp (+)	CMPBE	CMRPC	AREP, ControlBlock	—

5.6.3.8.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMPBE are described in the service definition and shown in Table 755.

Table 755 – Local primitives issued or received by CMPBE

Primitive	Source	Destination	Associated parameters	Functions
CMDEV_state_ind	CMDEV	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	state	—
CM_Abort_req	CMPBE	FSPMDEV CMSU CMIO CMSM	AREP	—

5.6.3.8.2 State transition diagram

The state transition diagram of the CMPBE is shown in Figure 108.

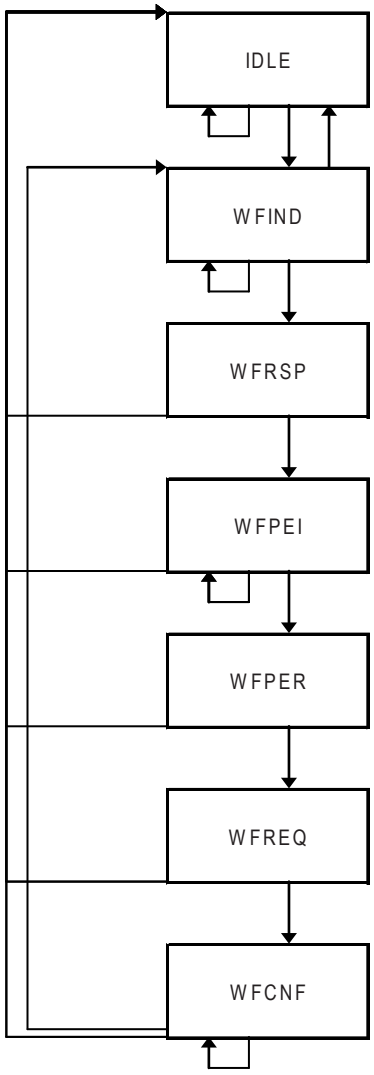


Figure 108 – State transition diagram of CMPBE

States of the CMPBE

IDLE	Wait for the start of DATA
WFIND	Wait for a PrmBegin command
WFRSP	Wait for a PrmBegin response from the application
WFPEI	Wait for the records from the IO controller and the PrmEnd request
WFPER	Wait for a PrmEnd response from the application
WFREQ	Wait for an update of the IO data of the affected submodules before issuing the ApplRdy service.
	Wait for the application ready request from the application
WFCNF	Wait for an application ready confirmation and after that, for the next CPM_NewData_ind from the affected Submodules / IOCR for valid data.

5.6.3.8.3 State machine description

The PrmBegin PrmEnd ApplRdy sequence is used to make a consistent update of the parameters of submodules using the wellknown ApplRdy model. The IO device handles this sequence by the CMPBE.

The IO device stores all Alarms from the involved submoduls during the PrmBegin PrmEnd ApplRdy sequence.

Any overlapping Alarm, except the Plug or Release, shall be proceed and acknowledged by the IO controller before the IO device issues the ApplRdy. Overlapping Plug and Release Alarms shall be stored by the IO controller and processed after the PrmBegin PrmEnd ApplRdy sequence.

The IO device rates all stored Alarms from the involved submoduls and removes all dispensable Alarms before issuing ApplRdy.

5.6.3.8.4 CMPBE state table

Table 756 contains the complete description of the CMPBE state machine.

Table 756 – CMPBE state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CMDEV_state_ind ()** /state == DATA => ignore	WFIND
2	IDLE	**CMDEV_state_ind ()** /state =! DATA => ignore	IDLE
3	WFIND	**RM_Dcontrol.ind ()** /Stored request exists => Retrieve stored request CM_Dcontrol.ind ()	WFRSP
4	WFIND	**RM_Dcontrol.ind ()** /ControlBlock == PrmBegin => AlarmProceedingBlocked //NOTE Do not proceed any Alarm of an involved submodule CM_Dcontrol.ind ()	WFRSP
5	WFIND	**RM_Dcontrol.ind ()** /ControlBlock =! PrmBegin => ignore	WFIND
6	WFIND	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
7	WFRSP	**CM_Dcontrol.rsp ()** /ControlBlock == PrmBegin => RM_Dcontrol.rsp (+)	WFPEI
8	WFRSP	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
9	WFPEI	**RM_Dcontrol.ind ()** /ControlBlock == PrmEnd => CM_Dcontrol.ind ()	WFPER
10	WFPEI	**RM_Dcontrol.ind ()** /ControlBlock =! PrmEnd =>	WFPEI

#	Current State	Event /Condition =>Action	Next State
		ignore	
11	WFPEI	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
12	WFPER	**CM_Dcontrol.rsp ()** /ControlBlock == PrmEnd => RM_Dcontrol.rsp (+)	WFREQ
13	WFPER	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
14	WFREQ	**CM_Ccontrol.req ()** /ControlBlock == ApplRdy && AlarmAckPending == TRUE => CM_Ccontrol.cnf (-)	WFREQ
15	WFREQ	**CM_Ccontrol.req ()** /ControlBlock == ApplRdy && AlarmAckPending == FALSE => RM_Ccontrol.req ()	WFCNF
16	WFREQ	**RM_Dcontrol.ind ()** /ControlBlock == PrmBegin //NOTE PrmEnd is handled by CMRPC as RPC Rerun => RM_Dcontrol.rsp (-) CMDEV_state_ind (ABORT)	IDLE
17	WFREQ	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE
18	WFCNF	**RM_Ccontrol.cnf ()** /ControlBlock == ApplRdy => AlarmProceedingAllowed //NOTE Continue with the proceeding of Alarms CM_Ccontrol.cnf ()	WFIND
19	WFCNF	**RM_Dcontrol.ind ()** /ControlBlock == PrmBegin => Store request //NOTE Execute the stored request after ApplRdy.cnf to make the PBE sequence robust	WFCNF
20	WFCNF	**CMDEV_state_ind ()** /state == ABORT => ignore	IDLE

5.6.3.8.5 Functions, Macros, Timers and Variables

Table 757 contains the functions, macros, timers and variables used by the CMPBE and their arguments and their descriptions.

Table 757 – Functions, Macros, Timers and Variables used by the CMPBE

Name	Type	Function/Meaning
AlarmAckPending	Macro	This local macro checks whether an involved submodule (list given by the PrmBegin.req) has an outstanding Alarm acknowledge for any Alarm except Plug or Release. TRUE := an outstanding Alarm acknowledge exists FALSE := no outstanding Alarm acknowledge exists
AlarmProceedingAllowed	Macro	This local macro continues the proceeding of all kind of Alarms for any involved submodule (list given by the PrmBegin).
AlarmProceedingBlocked	Macro	This local macro stops the proceeding of all kind of Alarms for any involved submodule (list given by the PrmBegin).
Retrieve stored request	Macro	This local macro retrieves the stored request.
Store request	Macro	This local macro stores the request for later use.
Stored request exists	Macro	This local macro checks whether a request is stored.

5.6.3.9 Context Management Discovery Multicast Communication

5.6.3.9.1 Primitive definitions

5.6.3.9.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Discovery Multicast Communication Protocol Machine (CMDMC) are described in the service definition and shown in Table 758.

Table 758 – Remote primitives issued or received by CMDMC

Primitive	Source	Destination	Associated parameters	Functions
DCP_Identify.cnf (-)	DCPMCS	CMDMC	CREP, ERRCLS, ERRCODE	This service primitive indicates that the address resolution of a M-Provider station name has failed.
DCP_Identify.cnf (+)	DCPMCS	CMDMC	CREP	This service primitive indicates that the address resolution of a M-Provider station name has succeeded.
DCP_Identify.req	CMDMC	DCPMCS	CREP, DA, ListOfFilter, ResponseDelay	The service Identify starts the address resolution of the station name of a M-Provider

5.6.3.9.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMDMC are described in the service definition and shown in Table 759.

Table 759 – Local primitives issued or received by CMDMC

Primitive	Source	Destination	Associated parameters	Functions
CMDMC_Activate_req	CMSU	CMDMC	CREP, ProviderStationName, CR_Parameter	The service activate initializes the CMDMC state machine.
CMDMC_Close_req	CMSU	CMDMC	CREP	The service close deinitializes the CMDMC state machine.

Primitive	Source	Destination	Associated parameters	Functions
CPM_Activate_cnf (-)	CPM	CMDMC	CREP, ERRCLS, ERRCODE	This service primitive indicates that the Activate service failed.
CPM_Activate_cnf (+)	CPM	CMDMC	CREP	This service primitive indicates that the Activate service succeeded.
CPM_Close_cnf	CPM	CMDMC	CREP	This service primitive indicates that the Close service succeeded.
CPM_NewData_ind	CPM	CMDMC FSPMDEV FSPMCTL CMIO CTLIO	AREP, CREP, APDU_Status, data {Data, NoData}	This service primitive indicates that new Multicast Consumer Data have been received.
CPM_State_ind	CPM	CMDMC FSPMDEV FSPMCTL CMIO CTLIO	CREP	This service primitive indicates that Data Hold Time has expired.
CMDMC_Error_ind ()	CMDMC	CMSU	CREP, ERRCLS, ERRCODE	This service primitive indicates that a problem exists.
CMDMC_Activate_cnf (-)	CMDMC	CMSU	CREP, ERRCLS, ERRCODE	This service primitive indicates that the Activate service failed.
CMDMC_Activate_cnf (+)	CMDMC	CMSU	CREP	This service primitive indicates that the Activate service succeeded.
CMDMC_Close_cnf	CMDMC	CMSU	CREP	This service primitive indicates that the Close service succeeded.
CPM_Close_req	CMSU	CPM	CREP	The service Activate deinitializes the CPM and stops the transmission of data. The schedule is cleared.
CPM_Activate_req	CMDMC	CPM	CREP, DA, SA, FrameId, Prio, VLAN, Exp_Lenth, DataHoldTime, Default_Value, Default_Status	The service Activate initializes the CPM and loads the schedule to the DMPM.

5.6.3.9.2 State transition diagram

The state transition diagram of the CMDMC is shown in Figure 109.

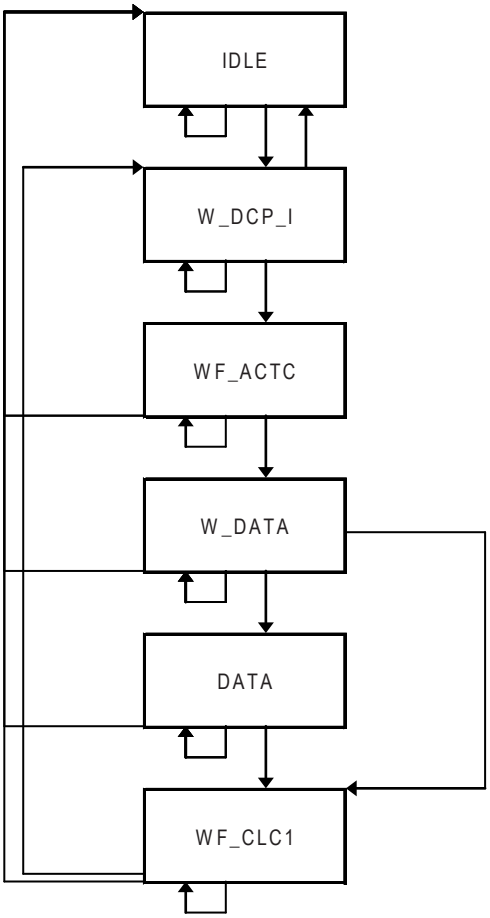


Figure 109 – State transition diagram of CMDMC

States of the CMDMC

IDLE	Wait for the start command
W_DCP_I	Wait for the DCP Identify service response
WF_ACTC	Wait for the activation of the CPM
W_DATA	Wait for the NewData_ind of the CPM
DATA	Working state
WF_CLC1	Wait for the shut down of former started state machines

5.6.3.9.3 State machine description

The Discovery Multicast Communication Protocol Machine (CMDMC) arranges the multicast communication between IO devices. This is done by discovering the communication partners and starting of the assosiated CPMs. The discovery uses the DCP Identify service.

5.6.3.9.4 CMDMC state table

Table 760 contains the complete description of the CMDMC state machine.

Table 760 – CMDMC state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CMDMC_Activate_req ()** => MCName := ProviderStationName DA := DCPMC_add ListofFilter := DeviceProperties, NameOfStation, MCName ResponseDelay := 1 For all Submodules within M-Consumer-CRs do: Add entry to the diagnosis ASE: Submodule ChannelNumber := 0x8000 ChannelProperties.Type := 0x00 ChannelProperties.Specifier := 0x01 ChannelErrorType := Multicast CR Mismatch ExtChannelErrorType := Multicast Consumer CR timed out CMDMC_Activate_cnf (+) DCP_Identify.req ()	W_DCP_I
2	IDLE	**CMDMC_Close_req ()** => CMDMC_Close_cnf ()	IDLE
3	IDLE	**OTHERS** => ignore	IDLE
4	W_DCP_I	**DCP_Identify.cnf ()** /No device found => DA := DCPMC_add ListofFilter := DeviceProperties, NameOfStation, MCName ResponseDelay := 1 For all Submodules within M-Consumer-CRs do: Add entry to the diagnosis ASE: ChannelNumber := 0x8000 ChannelProperties.Type := 0x00 ChannelProperties.Specifier := 0x01 ChannelErrorType := Multicast CR Mismatch ExtChannelErrorType := AddressResolutionFailed DCP_Identify.req () DiagnosisEvent ()	W_DCP_I
5	W_DCP_I	**DCP_Identify.cnf ()** /Device found => CREP := create(CPM) MC_InData(CREP) := FALSE CPM_Activate_req ()	WF_ACTC
6	W_DCP_I	**CMDMC_Close_req ()** => CMDMC_Close_cnf ()	IDLE
7	W_DCP_I	**OTHERS** => ignore	W_DCP_I
8	WF_ACTC	CPM_Activate_cnf (+) => ignore	W_DATA
9	WF_ACTC	**CPM_Activate_cnf (-)** => CMDMC_Error_ind () CPM_Close_req ()	IDLE
10	WF_ACTC	**CMDMC_Close_req ()** => CMDMC_Close_cnf ()	IDLE

#	Current State	Event /Condition =>Action	Next State
11	WF_ACTC	**OTHERS** => ignore	WF_ACTC
12	W_DATA	**CPM_NewData_ind ()** /CMDEV_ApplRdy == FALSE => MC_InData(CREP) := TRUE For all Submodule within M-Consumer-CRs do: Delete M-Consumer “Multicast CR Mismatch” from the diagnosis ASE	W_DATA
13	W_DATA	**CPM_NewData_ind ()** /CMDEV_ApplRdy == TRUE => MC_InData(CREP) := TRUE For all Submodule within M-Consumer-CRs do: Delete M-Consumer “Multicast CR Mismatch” from the diagnosis ASE	DATA
14	W_DATA	**CPM_State_ind ()** /state==stop => MC_InData(CREP) := FALSE For all Submodules within M-Consumer-CRs do: Add entry to the diagnosis ASE: Submodule ChannelNumber := 0x8000 ChannelProperties.Type := 0x00 ChannelProperties.Specifier := 0x01 ChannelErrorType := Multicast CR Mismatch ExtChannelErrorType := Multicast Consumer CR timed out DiagnosisEvent () CPM_Close_req ()	WF_CLC1
15	W_DATA	**CPM_State_ind ()** /state!=stop => ignore	W_DATA
16	W_DATA	**CMDMC_Close_req ()** => CMDMC_Close_cnf ()	IDLE
17	W_DATA	**OTHERS** => ignore	W_DATA
18	DATA	**CPM_State_ind ()** /state==stop => MC_InData(CREP) := FALSE For all Submodules within M-Consumer-CRs do: Add entry to the diagnosis ASE: Submodule ChannelNumber := 0x8000 ChannelProperties.Type := 0x00 ChannelProperties.Specifier := 0x01 ChannelErrorType := Multicast CR Mismatch ExtChannelErrorType := Multicast Consumer CR timed out DiagnosisEvent () CPM_Close_req ()	WF_CLC1
19	DATA	**CPM_State_ind ()** /state!=stop => ignore	DATA
20	DATA	**CMDMC_Close_req ()** => CMDMC_Close_cnf ()	IDLE
21	DATA	CPM_NewData_ind () => ignore	DATA

#	Current State	Event /Condition =>Action	Next State
22	DATA	**OTHERS** => ignore	DATA
23	WF_CLC1	**CPM_Close_cnf ()** => DCP_Identify.req ()	W_DCP_I
24	WF_CLC1	**CMDMC_Close_req ()** => CMDMC_Close_cnf ()	IDLE
25	WF_CLC1	**OTHERS** => ignore	WF_CLC1

5.6.3.9.5 Functions, Macros, Timers and Variables

Table 761 contains the functions, macros, timers and variables used by the CMDMC and their arguments and their descriptions.

Table 761 – Functions, Macros, Timers and Variables used by the CMDMC

Name	Type	Function/Meaning
CMDEV_ApplRdy	Variable	This local variable shows whether the AR is in state DATA or not
MC_InData	Variable	This local variable stores the information whether the CPM is in state RUN or not
DiagnosisEvent	Function	This funcrion issues an entry to the diagnosis ASE
OTHERS	Macro	This local macro contains all other possible events, not shown explicitly, in this state.

5.6.3.10 Context Management IP and Name Assignment

5.6.3.10.1 Primitive definitions

5.6.3.10.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management IP and Name Assignment Protocol Machine (CMINA) are described in the service definition and shown in Table 772.

Table 762 – Remote primitives issued or received by CMINA

Primitive	Source	Destination	Associated parameters	Functions
DCP_Set.ind	DCP	CMINA	CREP, SA, ListOfData, ListOfControlCommands	—
DHCPOFFER.ind	DHCP	CMINA	IP_Para, ListOfData	—
DCP_Set.rsp (-)	CMINA	DCP	CREP, DA, ERRCLS, ERRCODE	—
DCP_Set.rsp (+)	CMINA	DCP	CREP, DA, ListOfResponse	—

Primitive	Source	Destination	Associated parameters	Functions
DCP_HELLO.req	CMINA	DCPHMCS	CREP, ListOfData	—
DCP_HELLO.cnf ()	DCP	CMINA	—	—
DHCPDISCOVER.req	CMINA	DHCP	Options	—

5.6.3.10.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMINA are described in the service definition and shown in Table 763.

Table 763 – Local primitives issued or received by CMINA

Primitive	Source	Destination	Associated parameters	Functions
CMDEV_state_ind	CMINA	CM*	—	Cancelation information for the AR to release resources

5.6.3.10.2 State transition diagram

The state transition diagram of the CMINA is shown in Figure 110.

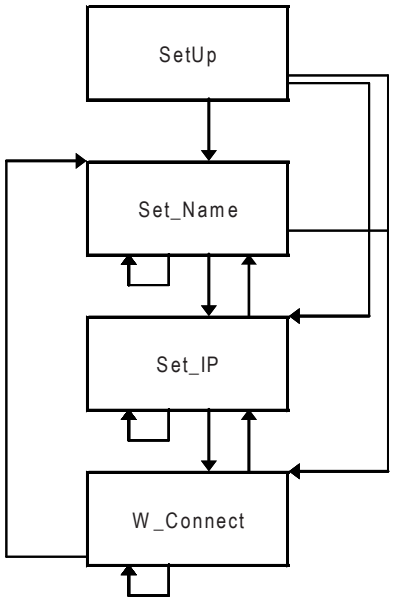


Figure 110 – State transition diagram of CMINA

States of the CMINA

SetUp	Wait for NameOfStation and IP-suite and start the discovery according to the stored values of the DCP ASE
Set_Name	Wait for a NameOfStation
Set_IP	Wait for a IP-suite
W_Connect	Wait for the AR establishment

5.6.3.10.3 State machine description

The Context Management IP and Name Assignment Protocol Machine (CMINA) arranges the IP and station name assignment and handles the DCP Set, DHCPOFFER, DCP HELLO and the DHCPDISCOVER services.

The FSHelloDelay shall be handled independent from this state machine.

5.6.3.10.4 CMINA state table

Table 764 contains the complete description of the CMINA state machine.

Table 764 – CMINA state table

#	Current State	Event /Condition =>Action	Next State
1	SetUp	/LocalNameOfStation == NIL && LocalDHCPenable => StartTimer (DHCP_RetryTime) DHCPDISCOVER.req ()	Set_Name
2	SetUp	/LocalNameOfStation == NIL && !LocalDHCPenable => ignore	Set_Name
3	SetUp	/LocalNameOfStation != NIL && LocalIPsuite == NIL && LocalDHCPenable => StartTimer (DHCP_RetryTime) DHCPDISCOVER.req ()	Set_IP
4	SetUp	/LocalNameOfStation != NIL && LocalIPsuite == NIL && LocalHELLOenable => StartTimer (HelloIntervalTime) HelloCount := FSHelloRetry DCP_HELLO.req ()	Set_IP
5	SetUp	/LocalNameOfStation != NIL && LocalIPsuite != NIL && LocalHELLOenable => StartIP () StartTimer (HelloIntervalTime) HelloCount := FSHelloRetry DCP_HELLO.req ()	W_Connect
6	SetUp	/LocalNameOfStation != NIL && LocalIPsuite == NIL &&	Set_IP

#	Current State	Event /Condition =>Action	Next State
		!LocalDHCPenable => ignore	
7	SetUp	 /LocalNameOfStation != NIL && LocalIPsuite != NIL && !LocalHELLOenable => StartIP ()	W_Connect
8	Set_Name	**DHCPOFFER.ind ()** /CheckAPDU () == Valid, Name, IP => StopTimer (DHCP_RetryTime) Store Data in DCP ASE StartIP ()	W_Connect
9	Set_Name	**DHCPOFFER.ind ()** /CheckAPDU () == Valid => Store Data in DCP ASE	Set_Name
10	Set_Name	**DHCPOFFER.ind ()** /CheckAPDU () == InValid => ignore	Set_Name
11	Set_Name	**DCP_Set.ind ()** /CheckAPDU () == Valid, Name, IP => StopTimer (DHCP_RetryTime) Store Data in DCP ASE StartIP () DCP_Set.rsp (+)	W_Connect
12	Set_Name	**DCP_Set.ind ()** /CheckAPDU () == Valid, Name, DHCP => StartTimer (DHCP_RetryTime) Store Data in DCP ASE Reset IP suite in DCP ASE DCP_Set.rsp (+) DHCPDISCOVER.req ()	Set_IP
13	Set_Name	**DCP_Set.ind ()** /CheckAPDU () == Valid, Name && LocalIPsuite == NIL => Store Data in DCP ASE DCP_Set.rsp (+)	Set_IP
14	Set_Name	**DCP_Set.ind ()** /CheckAPDU () == Valid, Name && LocalIPsuite != NIL => Store Data in DCP ASE DCP_Set.rsp (+)	W_Connect
15	Set_Name	**DCP_Set.ind ()** /CheckAPDU () == Valid || CheckAPDU () == Valid, ResetIP => Store Data in DCP ASE DCP_Set.rsp (+)	Set_Name
16	Set_Name	**DCP_Set.ind ()**	Set_Name

#	Current State	Event /Condition =>Action	Next State
		/CheckAPDU () == Valid, Unknown => ERRCLS := Invalid_Parameter ERRCODE := Invalid_DataSet DCP_Set.rsp (-)	
17	Set_Name	**DCP_Set.ind ()** /CheckAPDU () == InValid => ignore	Set_Name
18	Set_Name	**TimerExpired (DHCP_RetryTime)** => ExponentialBackOff (DHCP_RetryTime) StartTimer (DHCP_RetryTime) DHCPDISCOVER.req ()	Set_Name
19	Set_Name	DCP_Hello.cnf () => ignore	Set_Name
20	Set_IP	**DHCPOFFER.ind ()** /CheckAPDU () == Valid, IP => StopTimer (DHCP_RetryTime) Store Data in DCP ASE StartIP ()	W_Connect
21	Set_IP	**DHCPOFFER.ind ()** /CheckAPDU () == Valid || CheckAPDU () == Valid, ResetIP => Store Data in DCP ASE	Set_IP
22	Set_IP	**DHCPOFFER.ind ()** /CheckAPDU () == InValid => ignore	Set_IP
23	Set_IP	**DCP_Set.ind ()** /CheckAPDU () == Valid, IP => StopTimer (DHCP_RetryTime) Store Data in DCP ASE StartIP () DCP_Set.rsp (+)	W_Connect
24	Set_IP	**DCP_Set.ind ()** /CheckAPDU () == Valid, ResetName || CheckAPDU () == Valid, ResetToFactory => Reset assigned Data in DCP ASE DCP_Set.rsp (+)	Set_Name
25	Set_IP	**DCP_Set.ind ()** /CheckAPDU () == Valid => Store Data in DCP ASE DCP_Set.rsp (+)	Set_IP
26	Set_IP	**DCP_Set.ind ()** /CheckAPDU () == Valid, Unknown => ERRCLS := Invalid_Parameter ERRCODE := Invalid_DataSet DCP_Set.rsp (-)	Set_IP
27	Set_IP	**DCP_Set.ind ()** /CheckAPDU () == InValid =>	Set_IP

#	Current State	Event /Condition =>Action	Next State
		ignore	
28	Set_IP	**TimerExpired (DHCP_RetryTime)** => ExponentialBackOff (DHCP_RetryTime) StartTimer (DHCP_RetryTime) DHCPDISCOVER.req ()	Set_IP
29	Set_IP	**TimerExpired (HelloIntervalTime)** /HelloCount != 0 => StartTimer (HelloIntervalTime) HelloCount := HelloCount – 1 DCP_HELLO.req ()	Set_IP
30	Set_IP	TimerExpired (HelloIntervalTime) /HelloCount == 0 => ignore	Set_IP
31	Set_IP	DCP_Hello.cnf () => ignore	Set_IP
32	W_Connect	**DHCPOFFER.ind ()** /CheckAPDU () == Valid, ChangeIP && CheckARActive () == None => StopIP () Store Data in DCP ASE StartIP ()	W_Connect
33	W_Connect	**DHCPOFFER.ind ()** /CheckAPDU () == Valid, ChangeIP && CheckARActive () == Aractive => ignore	W_Connect
34	W_Connect	**DCP_Set.ind ()** /CheckAPDU () == Valid => Store Data in DCP ASE DCP_Set.rsp (+)	W_Connect
35	W_Connect	**DCP_Set.ind ()** /(CheckAPDU () == Valid, ResetName || CheckAPDU () == Valid, ResetToFactory) && CheckARActive () == None => StopIP () Reset assigned Data in DCP ASE DCP_Set.rsp (+)	Set_Name
36	W_Connect	**DCP_Set.ind ()** /(CheckAPDU () == Valid, ResetName || CheckAPDU () == Valid, ResetToFactory) && CheckARActive () == Aractive => StopIP () Reset assigned Data in DCP ASE DCP_Set.rsp (+) For all active Ars CMDEV_state_ind (ABORT)	Set_Name
37	W_Connect	**DCP_Set.ind ()** /(	Set_IP

#	Current State	Event /Condition =>Action	Next State
		CheckAPDU () == Valid, ChangeName || CheckAPDU () == Valid, ResetIP) && CheckARActive () == None => StopIP () Store Data in DCP ASE Reset IP suite in DCP ASE DCP_Set.rsp (+)	
38	W_Connect	**DCP_Set.ind ()** /(CheckAPDU () == Valid, ChangeName || CheckAPDU () == Valid, ResetIP) && CheckARActive () == Aractive => StopIP () Store Data in DCP ASE Reset IP suite in DCP ASE DCP_Set.rsp (+) For all active Ars CMDEV_state_ind (ABORT)	Set_IP
39	W_Connect	**DCP_Set.ind ()** /CheckAPDU () == Valid, ChangeIP && CheckARActive () == None => StopIP () Store Data in DCP ASE StartIP () DCP_Set.rsp (+)	W_Connect
40	W_Connect	**DCP_Set.ind ()** /CheckAPDU () == Valid, ChangeIP && CheckARActive () == Aractive => ERRCLS := Invalid_Parameter ERRCODE := Invalid_State DCP_Set.rsp (-)	W_Connect
41	W_Connect	**DCP_Set.ind ()** /CheckAPDU () == Valid, Unknown => ERRCLS := Invalid_Parameter ERRCODE := Invalid_DataSet DCP_Set.rsp (-)	W_Connect
42	W_Connect	**DCP_Set.ind ()** /CheckAPDU () == InValid => ignore	W_Connect
43	W_Connect	**TimerExpired (HelloIntervalTime)** /HelloCount != 0 => StartTimer (HelloIntervalTime) HelloCount := HelloCount – 1 DCP_HELLO.req ()	W_Connect
44	W_Connect	TimerExpired (HelloIntervalTime) /HelloCount == 0 => ignore	W_Connect
45	W_Connect	DCP_Hello.cnf () => ignore	W_Connect

5.6.3.10.5 Functions, Macros, Timers and Variables

Table 765 and Table 766 contains the functions, macros, timers and variables used by the CMINA and their arguments and their descriptions.

Table 765 – Functions, Macros, Timers and Variables used by the CMINA

Name	Type	Function/Meaning
CheckAPDU	Function	This local function checks the block structure and the parameters according to the coding and checking rules.
CheckARactive	Function	This local function checks whether an AR is active.
ExponentialBackOff	Function	This local function changes the DHCP_RetryTime according to the DHCP specification.
StartIP	Function	This local function assigns an IP suite to the IP stack.
StartTimer	Function	This local function starts or restarts a timer
StopIP	Function	This local function withdraws the IP suite from the IP stack.
StopTimer	Function	This local function stops a timer
TimerExpired	Function	This local function is executed if a timer expires
LocalHELLOenable	Macro	This local macro request the HELLO state from the DCP ASE and returns NIL if it not exists
LocalIPsuite	Macro	This local macro request the IP-suite from the DCP ASE and returns NIL if it not exists
LocalNameOfStation	Macro	This local macro request the NameOfStation from the DCP ASE and returns NIL if it not exists
DHCP_RetryTime	Timer	This timer controls the interval between two DHCP requests
HelloIntervalTime	Timer	This timer controls the interval between two HELLO requests given by the FSHelloInterval.
ERRCLS	Variable	This local variable stores the error class for the error PDU.
ERRCODE	Variable	This local variable stores the error code for the error PDU.
HelloCount	Variable	This local variable count down the conveyed Hello request from the initial value FSHelloRetry

Table 766 – Return values of CheckAPDU

Name	Function/Meaning
ChangeIP	ChangeIP states that the frame contains an IP-suite and an IP-suite is already stored.
ChangeName	ChangeName states that the frame contains a NameOfStation and a NameOfStation is already stored.
DHCP	DHCP states that the frame contains DHCP enable.
InValid	InValid states that the frame is malformed according this standard.
IP	IP states that the frame contains an IP-suite.
Name	Name states that the frame contains the NameOfStation.
ResetIP	ResetIP states that the frame contains a delete IP-suite command.
ResetName	ResetName states that the frame contains a delete NameOfStation command.
ResetToFactory	ResetToFactory states that the frame contains a delete NameOfStation command.
Unknown	Unknown states that the frame contains unknown options or suboptions.
Valid	Valid states that the frame is correct according this standard.

5.6.3.11 Context Management RPC Device

5.6.3.11.1 Primitive definitions

5.6.3.11.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management RPC Device Protocol Machine (CMRPC) are described in the service definition and shown in Table 767.

Table 767 – Remote primitives issued or received by CMRPC

Primitive	Source	Destination	Associated parameters	Functions
RM_Ccontrol.req	CMDEV	CMRPC	AREP, ControlBlock, ModuleDiffBlock	—
RM_Connect.rsp (-)	CMDEV	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Connect.rsp (+)	CMDEV	CMRPC	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock	—
RM_Dcontrol.rsp (-)	CMDEV	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Dcontrol.rsp (+)	CMDEV	CMRPC	AREP, ControlBlock	—
RM_Read.rsp (-)	CMDEV	CMRPC	AREP, Multiple, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.rsp (+)	CMDEV	CMRPC	AREP, SeqNumber, AddData1, AddData2	—
RM_Release.rsp (-)	CMDEV	CMRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Release.rsp (+)	CMDEV	CMRPC	AREP, ControlBlock	—
RM_Write.rsp (-)	CMDEV	CMRPC	AREP, Multiple, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—

Primitive	Source	Destination	Associated parameters	Functions
RM_Write.rsp (+)	CMDEV	CMRPC	AREP, SeqNumber, AddData1, AddData2	—
RM_Ccontrol.cnf (-)	CMRPC	CMDEV	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Ccontrol.cnf (+)	CMRPC	CMDEV, CMPBE	AREP, ControlBlock	—
RM_Connect.ind	CMRPC	CMDEV, CMPBE	AREP, ARBlockReq, ListOfIOCRBlockReq, AlarmCRBlockReq, ListOfExpectedSubmoduleBlockReq	—
RM_Dcontrol.ind	CMRPC	CMDEV, CMDEV_DA	AREP, ControlBlock	—
RM_Read.ind	CMRPC	CMDEV, CMRDR, CMSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Release.ind	CMRPC	CMDEV, CMDEV_DA	AREP, ControlBlock	—
RM_Write.ind	CMRPC	CMDEV, CMWRR	AREP, API, SlotNumber, SubslotNumber, Index, Multiple, SeqNumber, Length, Data	—
RPC_Ccontrol.req	CMRPC	RPC	Arg	—
RPC_Connect.rsp (-)	CMRPC	RPC	Arg	—
RPC_Connect.rsp (+)	CMRPC	RPC	Arg	—
RPC_Dcontrol.rsp (-)	CMRPC	RPC	Arg	—
RPC_Dcontrol.rsp (+)	CMRPC	RPC	Arg	—
RPC_Read.rsp (-)	CMRPC	RPC	Arg	—
RPC_Read.rsp (+)	CMRPC	RPC	Arg	—
RPC_Release.rsp (-)	CMRPC	RPC	Arg	—
RPC_Release.rsp (+)	CMRPC	RPC	Arg	—
RPC_Write.rsp (-)	CMRPC	RPC	Arg	—
RPC_Write.rsp (+)	CMRPC	RPC	Arg	—
RPC_Ccontrol.cnf (-)	RPC	CMRPC	Arg	—
RPC_Ccontrol.cnf (+)	RPC	CMRPC	Arg	—
RPC_Connect.ind	RPC	CMRPC	Arg	—
RPC_Dcontrol.ind	RPC	CMRPC	Arg	—
RPC_Read.ind	RPC	CMRPC	Arg	—
RPC_Release.ind	RPC	CMRPC	Arg	—
RPC_Write.ind	RPC	CMRPC	Arg	—

5.6.3.11.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMRPC are described in the service definition and shown in Table 768.

Table 768 – Local primitives issued or received by CMRPC

Primitive	Source	Destination	Associated parameters	Functions
CMDEV_state_ind	CMDEV	FSPMDEV CMSU CMIO CMWRR CMSM CMPBE CMRPC	AREP, state	Cancelation information for the AR to release resources

5.6.3.11.2 State transition diagram

The state transition diagram of the CMRPC is shown in Figure 111.

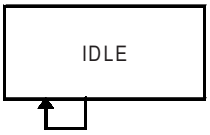


Figure 111 – State transition diagram of CMRPC

States of the CMRPC

IDLE Wait for a RPC call, check its integrity, the resources and for idempotent rerun

5.6.3.11.3 State machine description

The Context Management RPC Device Protocol Machine (CMRPC) arranges the RPC communication and handles all issued and received RPC services.

5.6.3.11.4 CMRPC state table

Table 769 contains the complete description of the CMRPC state machine.

Table 769 – CMRPC state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**RM_Ccontrol.req ()** => encode RPC PDU RPC_Ccontrol.req ()	IDLE
2	IDLE	**RPC_Ccontrol.cnf (-)** /CheckRPC () == Valid => AREP := LocateAR () RM_Ccontrol.cnf (-)	IDLE

#	Current State	Event /Condition =>Action	Next State
3	IDLE	**RPC_Ccontrol.cnf (+)** /CheckRPC () == Valid => AREP := LocateAR () RM_Ccontrol.cnf (+)	IDLE
4	IDLE	**RPC_Ccontrol.cnf ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => AREP := LocateAR () RM_Ccontrol.cnf (-)	IDLE
5	IDLE	**RPC_Dcontrol.ind ()** /CheckRPC () == Rerun => Retrieve stored response encode RPC PDU RPC_Dcontrol.rsp ()	IDLE
6	IDLE	**RPC_Dcontrol.ind ()** /CheckRPC () == Valid, ExplicitAR => AREP := LocateAR () RM_Dcontrol.ind ()	IDLE
7	IDLE	**RPC_Dcontrol.ind ()** /CheckRPC () == Valid, UnknownAR => ErrorCode2 := ARUUID_Unknown encode RPC Error PDU RPC_Dcontrol.rsp (-)	IDLE
8	IDLE	**RPC_Dcontrol.ind ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode RPC Error PDU RPC_Dcontrol.rsp (-)	IDLE
9	IDLE	**RM_Dcontrol.rsp (+)** => encode RPC PDU Store response RPC_Dcontrol.rsp (+)	IDLE
10	IDLE	**RM_Dcontrol.rsp (-)** => encode Error PDU Store response RPC_Dcontrol.rsp (-)	IDLE
11	IDLE	**RPC_Write.ind ()** /CheckRPC () == Valid, ExplicitAR => AREP := LocateAR () RM_Write.ind ()	IDLE
12	IDLE	**RPC_Write.ind ()** /CheckRPC () == Valid, UnknownAR => ErrorCode2 := ARUUID_Unknown encode Error PDU RPC_Write.rsp (-)	IDLE
13	IDLE	**RPC_Write.ind ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode RPC Error PDU RPC_Write.rsp (-)	IDLE
14	IDLE	**RM_Write.rsp (+)** => encode RPC PDU RPC_Write.rsp (+)	IDLE

#	Current State	Event /Condition =>Action	Next State
15	IDLE	**RM_Write.rsp (-)** => encode Error PDU RPC_Write.rsp (-)	IDLE
16	IDLE	**RPC_Read.ind ()** /CheckRPC () == Valid, ImplicitAR => AREP := NIL RM_Read.ind ()	IDLE
17	IDLE	**RPC_Read.ind ()** /CheckRPC () == Valid, ExplicitAR => AREP := LocateAR () RM_Read.ind ()	IDLE
18	IDLE	**RPC_Read.ind ()** /CheckRPC () == Valid, UnknownAR => ErrorCode2 := ARUUID_Unknown encode Error PDU RPC_Read.rsp (-)	IDLE
19	IDLE	**RPC_Read.ind ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode RPC Error PDU RPC_Read.rsp (-)	IDLE
20	IDLE	**RM_Read.rsp (+)** => encode RPC PDU RPC_Read.rsp (+)	IDLE
21	IDLE	**RM_Read.rsp (-)** => encode Error PDU RPC_Read.rsp (-)	IDLE
22	IDLE	**RPC_Connect.ind ()** /CheckRPC () == Valid, UnknownAR && CheckResource () == Unavailable => ErrorCode2 := NO_AR_RESOURCE encode RPC Error PDU RPC_Connect.rsp (-)	IDLE
23	IDLE	**RPC_Connect.ind ()** /CheckRPC () == Valid, UnknownAR, UnknownARset && CheckResource () == Available => AllocateResource () RM_Connect.ind ()	IDLE
24	IDLE	**RPC_Connect.ind ()** /CheckRPC () == Valid, UnknownAR, ExplicitARset //NOTE Preallocated resources by the first AR of a AR set => RM_Connect.ind ()	IDLE
25	IDLE	**RPC_Connect.ind ()** /CheckRPC () == Valid, UnknownAR, NoARset && CheckResource () == Available => AllocateResource () RM_Connect.ind ()	IDLE

#	Current State	Event /Condition =>Action	Next State
26	IDLE	**RPC_Connect.ind ()** /CheckRPC () == Valid, ExplicitAR => ErrorCode2 := StateConflict encode RPC Error PDU RPC_Connect.rsp (-) CMDEV_state_ind (ABORT)	IDLE
27	IDLE	**RPC_Connect.ind ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode RPC Error PDU RPC_Connect.rsp (-)	IDLE
28	IDLE	**RM_Connect.rsp (+)** => encode RPC PDU RPC_Connect.rsp (+)	IDLE
29	IDLE	**RM_Connect.rsp (-)** => FreeResource () encode Error PDU RPC_Connect.rsp (-)	IDLE
30	IDLE	**RPC_Release.ind ()** /CheckRPC () == Valid, ExplicitAR => AREP := LocateAR () RM_Release.ind ()	IDLE
31	IDLE	**RPC_Release.ind ()** /CheckRPC () == Valid, UnknownAR => ErrorCode2 := ARUUID_Unknown encode RPC Error PDU RPC_Release.rsp (-)	IDLE
32	IDLE	**RPC_Release.ind ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode RPC Error PDU RPC_Release.rsp (-)	IDLE
33	IDLE	**RM_Release.rsp (+)** => FreeResource () encode RPC PDU RPC_Release.rsp (+)	IDLE
34	IDLE	**RM_Release.rsp (-)** => FreeResource () encode Error PDU RPC_Release.rsp (-)	IDLE
35	IDLE	**CMDEV_state_ind ()** /state == ABORT && CheckAREP () == Known => FreeResource ()	IDLE
36	IDLE	**CMDEV_state_ind ()** /state == ABORT && CheckAREP () == Unknown => ignore	IDLE
37	IDLE	**CMDEV_state_ind ()** /state != ABORT => ignore	IDLE

5.6.3.11.5 Functions, Macros, Timers and Variables

Table 770 and Table 771 contains the functions, macros, timers and variables used by the CMRPC and their arguments and their descriptions.

Table 770 – Functions, Macros, Timers and Variables used by the CMRPC

Name	Type	Function/Meaning
AllocateResource	Function	This local function allocates the necessary resources for the AR using ARType, number of IOCRs and amount of IO data. An AR of the ARType IOCARSR allocates the resources for the complete AR set.
CheckAREP	Function	This local function checks whether the AREP exists.
CheckResource	Function	This local function checks the availability of the necessary resources for the connect indication using ARType, number of IOCRs and amount of IO data. Special case “Out of ARset resources” For the first application relation having ARType IOCARSR and belonging to a new ARSet (as indicated by the ARUUID) the resources of the complete ARSet are allocated; i.e. for all Ars of the complete ARSet. The resources of an application relation belonging to the same ARSet established at some later point are assigned from this allocated memory. The resources of the ARSet are freed when the last application relation of the ARSet is terminated. Special case “ARType specific resource handling” The resource checking shall cover the resource model shown in the GSD which optimizes the usage of the existing resources of a IO device.
CheckRPC	Function	This local functions checks the block structure and parameters against the definitions of this standard. Special case "Shared IO device" The first established AR defines the SendClockFactor of the physical device. If a succeeding AR owns an unreachable SendClockFactor, this function returns InValid and a parameter error for the SendClockFactor or the ReductionRatio shall be created in the connect response negative. Unreachable may be a different SendClockFactor or a not representable combination of SendClockFactor and ReductionRatio. Special case “Shared IO device with RT_CLASS_3” The first established AR defines the IRDataUUID of the physical device. If a succeeding AR owns a different IRDataUUID, this function returns InValid and a parameter error for the IRDataUUID shall be created in the connect response negative. Special case “Startup of the ARs of an ARset” If the CMDEV already establishes one AR of the set, then the CMRPC rejects a new AR connection request until ApplReady.cnf is reached. Also an AR connection request of a new AR of the set is rejected if the last AR of set is shutting down. Used ErrorCode2 := “ARset – State conflict during connection establishment”
FreeResource	Function	This local function frees the allocated resources of the AR.
Encode Error PDU	Macro	This local macro generates the appropriate PDU with the detected errors from the PDU checking rules.
Encode RPC Error PDU	Macro	This local macro generates the appropriate PDU with the detected errors from the PDU checking rules. A RPC error PDU consists only out of the RPC NDR header.
Encode RPC PDU	Macro	This local macro generates the appropriate PDU.
LocateAR	Macro	This local macro retrieves the associated AREP
Retrieve stored response	Macro	This local macro retrieves the previously stored parameter in case of a detected RPC rerun.

Name	Type	Function/Meaning
Store response	Macro	This local macro stores the parameters of the RPC response to be retrievable in case of a RPC rerun
AREP	Variable	This local variable stores the application relation end point for further use

Table 771 – Return values of CheckRPC

Name	Function/Meaning
Valid	Valid states that the frame is correct according this standard.
InValid	InValid states that the frame is incorrect.
ExplicitAR	This AR, identified by the ARUUID, already exists.
UnknownAR	This AR, identified by the ARUUID, doesn't exist.
ImplicitAR	This services uses the implicit access to the device.
UnknownARset	This AR, identified by the ARUUID, is part of an ARset which doesn't exist.
ExplicitARset	This AR, identified by the ARUUID, is part of an ARset which already exists.
NoARset	This AR, identified by the ARUUID, is not part of an ARset.

5.6.4 Controller

5.6.4.1 General

5.6.4.1.1 General

The CMCTL arrange the connection establishment of an IO controller. Figure 112 shows the integration of the IO controller CM.

The following definition shall be used for ARBlockReq.ARProperties.StartupMode:=Advanced. For ARBlockReq.ARProperties.StartupMode:=Legacy the definitions of the version V2.2 and the Annex B applies.

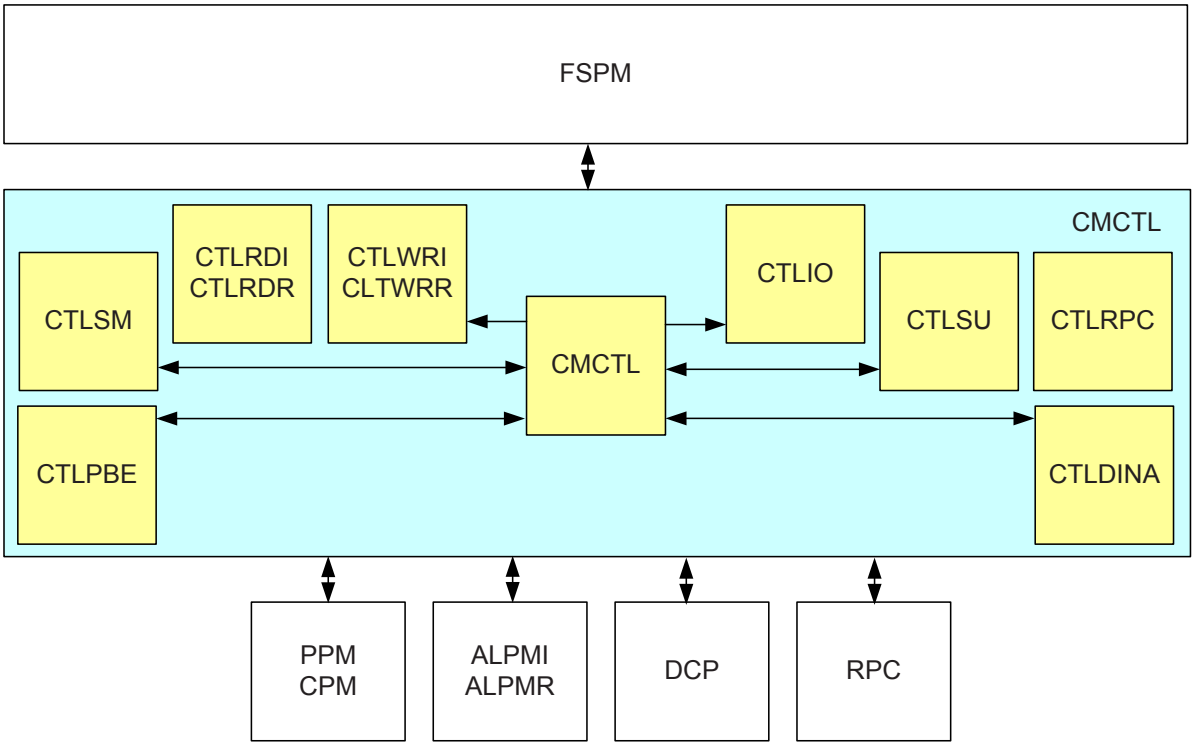


Figure 112 – Scheme of the IO controller CM

CMCTL
This state machine handles the context management of the IO controller.

CTLWRI
This state machine handles the initiator functionality of the write service.

CTLWRR
This optional state machine handles the responder functionality of the write service.

CTLRDI
This state machine handles the initiator functionality of the read service.

CTLRDR
This optional state machine handles the responder functionality of the read service.

CTLSM
This state machine handles the connection monitoring during the startup.

CTLPBE
This optional state machine handles the PrmBegin, PrmEnd and ApplRdy sequence for system redundancy and configure in run.

CTLSU
This state machine handles the startup of the different state machines during startup and shut down.

CTLRPC
This state machine handles the translation of RPC services.

CTLIO
This state machine handles the IO data services.

CTLDINA
This machine handles the discovery, IP and station name assignment.

5.6.4.1.2 State transition diagram

The state transition diagram of the CMCTL is shown in Figure 113.

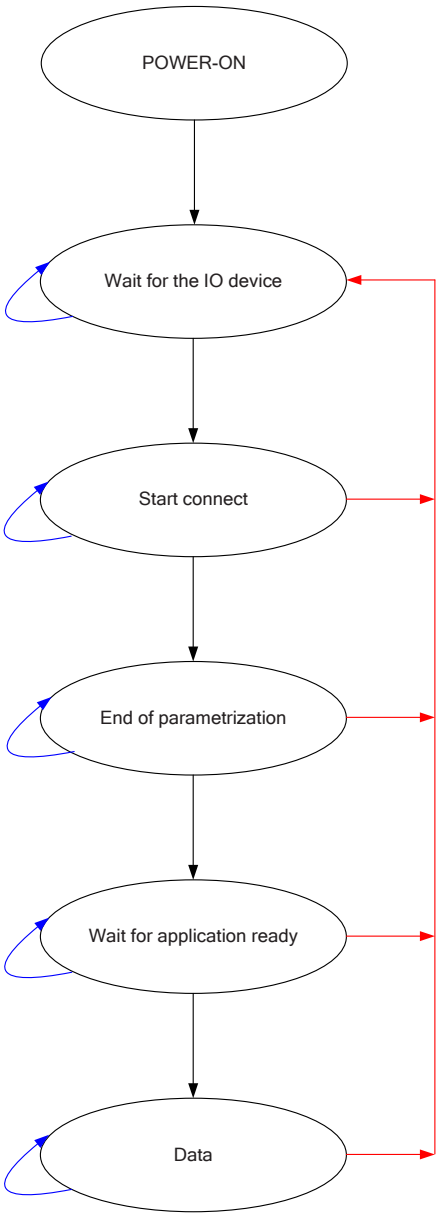


Figure 113 – State transition diagram of the IO controller CM

States of the IO controller CM

POWER-ON	Startup the IO controller and initialize all necessary resources
Wait for the IO device	Search for the expected IO device and prepare it, if necessary of the connection establishing
Start connect	Connect to the IO device by exchanging the communication parameters and the expected submodules to be exchanged in Data
End of parametrization	Convey the parameters for the expected submodules to be exchanged in Data and inform the IO device of the end of the startup parameterization
Wait for application ready	Give the IO device and the parameterized submodules time to adapt to the

	previous conveyed parameters
Data	Cyclic exchange data of the submodules between the IO controller and IO devices

5.6.4.2 Context Management Controller

5.6.4.2.1 Primitive definitions

5.6.4.2.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by CMCTL are described in the service definition and shown in Table 772.

Table 772 – Remote primitives issued or received by CMCTL

Primitive	Source	Destination	Associated parameters	Functions
RM_Ccontrol.ind	CTLRPC	CMCTL	AREP, ControlBlock, ModuleDiffBlock	—
RM_Connect.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Connect.cnf (+)	CTLRPC	CMCTL	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock, ARRPCBlockRes	—
RM_Dcontrol.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Dcontrol.cnf (+)	CTLRPC	CMCTL	AREP, ControlBlock	—
RM_Release.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Release.cnf (+)	CTLRPC	CMCTL	AREP, ControlBlock	—
CM_Connect.req	FSPMCTL	CMCTL	AREP, ARBlockReq, ListOfIOCRBlockReq, ListOfExpectedSubmoduleBlockReq, AlarmCRBlockReq, ParameterServerBlock, ListOfMulticastCRBlock, ARRPCBlock, IRInfosBlock, SRInfoBlock, ARVendorBlock	The service Connect opens an application relationship.
RM_Ccontrol.rsp (+)	CMCTL	CTLRPC	AREP, ControlBlock	—

Primitive	Source	Destination	Associated parameters	Functions
RM_Ccontrol.rsp(-)	CMCTL	CTLRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Connect.req	CMCTL	CTLRPC	AREP, ARBlockReq, ListOfIOCRBlockReq, AlarmCRBlockReq, ListOfExpectedSubmodul eBlockReq, ARRPCBlockReq	—
RM_Dcontrol.req	CMCTL	CTLRPC	AREP, ControlBlock	—
RM_Release.req	CMCTL	CTLRPC	AREP, ControlBlock	—
CM_Connect.cnf (-)	CMCTL	FSPMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	This service primitive is a negative confirmation and the requested application relationship is not established.
CM_Connect.cnf (+)	CMCTL	FSPMCTL	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock, ARRPCBlock	This service primitive is a positive confirmation to establish an application relationship.

5.6.4.2.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CMCTL are described in the service definition and shown in Table 773.

Table 773 – Local primitives issued or received by CMCTL

Primitive	Source	Destination	Associated parameters	Functions
CTLDINA_Discover_cnf (-)	CTLDINA	CMCTL	ErrorClass, ErrorCode	—
CTLDINA_Discover_cnf (+)	CTLDINA	CMCTL	—	—
CTLIO_info_ind	CTLIO	CMCTL	AREP	—
CMCTL_start_cnf (-)	CTLSU	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CMCTL_start_cnf (+)	CTLSU	CMCTL	AREP	—
CMCTL_PrmDone_ind	CTLWRI	CMCTL	AREP	—
CM_Abort_req	FSPMCTL	CMCTL	AREP	The service Abort terminates the AR.
CTLDINA_Discover_req ()	CMCTL	CTLDINA	AddressResolution, StationName, Dev_IP_Parameter, DCP_Parameter	—
CTLSM_start_req	CMCTL	CTLSM	AREP	—
CMCTL_start_req	CMCTL	CTLSU	AREP	—

Primitive	Source	Destination	Associated parameters	Functions
CM_Abort_cnf	CMCTL	FSPMCTL	AREP	—
CMCTL_state_ind	CMCTL	FSPMCTL CTLSU CTLWRI CTLWRR CTLPBE CTLIO CTLRDI	AREP, state {STARTUP, APPLRDY, WDATA, DATA, ABORT}	—

5.6.4.2.2 State transition diagram

The state transition diagram of the CMCTL is shown in Figure 114.

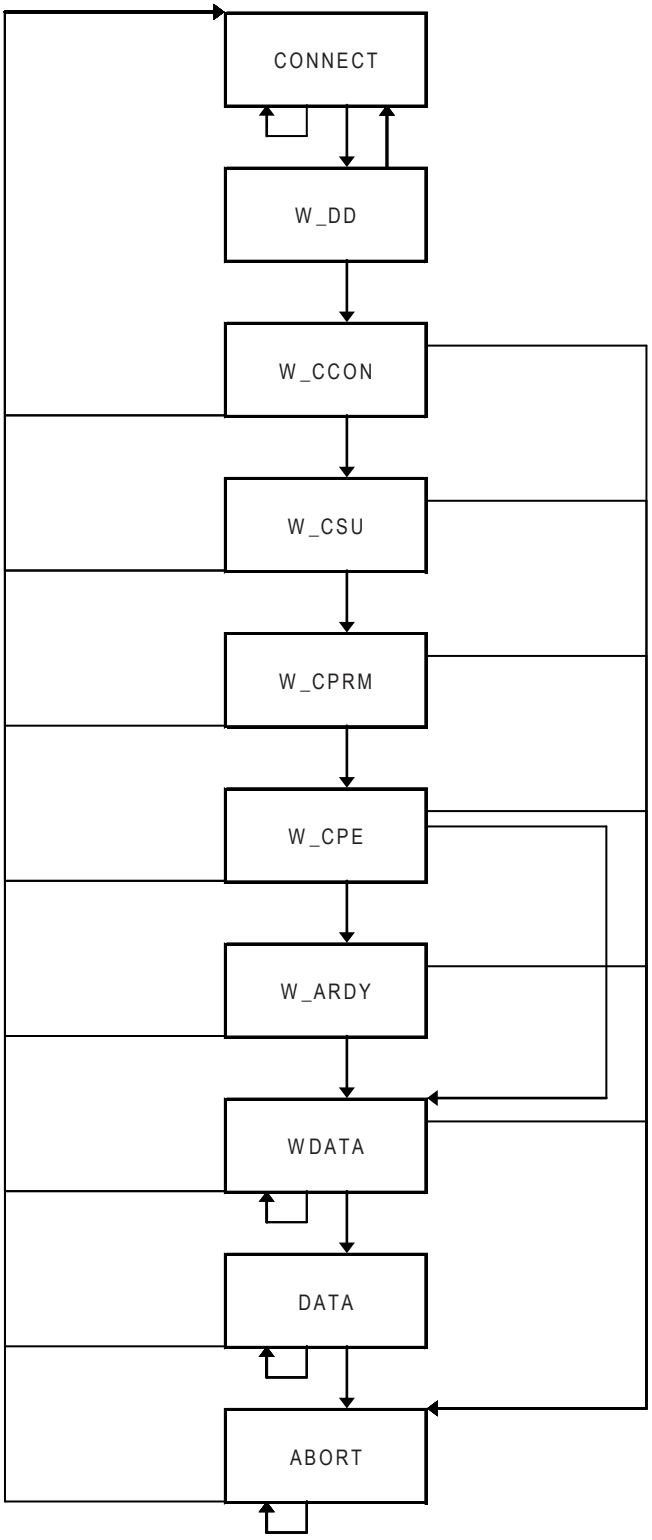


Figure 114 – State transition diagram of CMCTL

States of the CMCTL

CONNECT	Wait for a connect service from the FAL
W_DD	Wait for successful device discovery and start the AR
W_CCON	Wait for the confirmation of the connect request and start the necessary machines

W_CSU	Wait for the confirmation of the start of the necessary machines
W_CPRM	Wait for the end of the startup parameterization to issue the PrmEnd command
W_CPE	Wait for the confirmation of the PrmEnd command and change to the next state
W_ARDY	Wait for the ApplRdy command from the IO device
WDATA	Wait for data exchange using CPM and PPM and the termination of the RPC connect monitoring. The ALPMI is now able to issue an alam.
DATA	Data exchange and connection monitoring using the CPM / PPM. The ALPMI is now able to issue an alam.
ABORT	Do the shutdown in case of application command. An erroneous shutdown is handled by all machines concurrently initiated by the CMCTL_state_ind (ABORT).

5.6.4.2.3 State machine description

The CM Controller protocol machine exists for every AR of an IO controller. The CM Connect request service primitive may be used to address either the endpoint mapper port or the Responder RPC Server port directly. It is necessary to get the port number of the Responder RPC Server port by local means or by querying the responders endpoint mapper.

An implementation of the CMCTL shall handle the oustanding confirmations in case of an ABORT itself before a new connect service is issued.

NOTE The direct addressing of the Responder Server RPC Port is used to avoid personal firewall conflicts on PC based systems. The direct addressing of the Initiator Server RPC Port is used to support multiple engineering tools hosted on one PC.

5.6.4.2.4 CMCTL state table

Table 774 contains the complete description of the CMCTL state machine.

Table 774 – CMCTL state table

#	Current State	Event /Condition =>Action	Next State
1	CONNECT	**CM_Connect.req ()** => Store Args CTLDINA_Discover_req ()	W_DD
2	CONNECT	**CM_Abort_req ()** => CM_Abort_cnf ()	CONNECT
3	W_DD	**CTLDINA_Discover_cnf (+)** => Use stored Args RM_Connect.req ()	W_CCON
4	W_DD	CTLDINA_Discover_cnf (-) => CM_Connect.cnf (-)	CONNECT
5	W_DD	**CM_Abort_req ()** => CM_Abort_cnf ()	CONNECT
6	W_DD	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT

#	Current State	Event /Condition =>Action	Next State
7	W_CCON	**RM_Connect.cnf (+)** => Store Result CMCTL_start_req () CTLSM_start_req ()	W_CSU
8	W_CCON	**RM_Connect.cnf (-)** => CM_Connect.cnf (-)	CONNECT
9	W_CCON	**CM_Abort_req ()** => CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
10	W_CCON	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT
11	W_CSU	**CMCTL_start_cnf (+)** => LocalState := STARTUP CMCTL_state_ind (STARTUP)	W_CPRM
12	W_CSU	**CMCTL_start_cnf (-)** => CMCTL_state_ind (ABORT)	CONNECT
13	W_CSU	**CM_Abort_req ()** => CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
14	W_CSU	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT
15	W_CPRM	**CMCTL_PrmDone_ind ()** => Create PDU ControlBlockConnect.PrmEnd := TRUE RM_Dcontrol.req ()	W_CPE
16	W_CPRM	**CM_Abort_req ()** => CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
17	W_CPRM	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT
18	W_CPE	**RM_Dcontrol.cnf (+)** /ControlBlockConnect.PrmEnd == TRUE => LocalState := APPLRDY StartTimer (RemoteApplicationReadyTimeout) CMCTL_state_ind (APPLRDY)	W_ARDY
19	W_CPE	**RM_Dcontrol.cnf (-)** /ControlBlockConnect.PrmEnd == TRUE => CMCTL_state_ind (ABORT)	CONNECT
20	W_CPE	**CM_Abort_req ()** => CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
21	W_CPE	**RM_Ccontrol.ind ()** /ControlCommand.ApplicationReady == TRUE => Store Result LocalState := WDATA	WDATA

#	Current State	Event /Condition =>Action	Next State
		CMCTL_state_ind (WDATA) RM_Ccontrol.rsp (+)	
22	W_CPE	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT
23	W_ARDY	TimerExpired (RemoteApplicationReadyTimeout) => CMCTL_state_ind (ABORT)	CONNECT
24	W_ARDY	**RM_Ccontrol.ind ()** /ControlCommand.ApplicationReady == TRUE => Store Result LocalState := WDATA StopTimer (RemoteApplicationReadyTimeout) CMCTL_state_ind (WDATA) RM_Ccontrol.rsp (+)	WDATA
25	W_ARDY	**CM_Abort_req ()** => StopTimer (RemoteApplicationReadyTimeout) CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
26	W_ARDY	**CMCTL_state_ind ()** /state == ABORT => StopTimer (RemoteApplicationReadyTimeout)	CONNECT
27	WDATA	**RM_Dcontrol.cnf (+)** /ControlBlockConnect.PrmEnd == TRUE => ignore	WDATA
28	WDATA	**RM_Dcontrol.cnf (-)** /ControlBlockConnect.PrmEnd == TRUE => CMCTL_state_ind (ABORT)	CONNECT
29	WDATA	**CM_Abort_req ()** => CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
30	WDATA	**CTLIO_info_ind ()** /state == DATA_IMPOSSIBLE => ignore	WDATA
31	WDATA	**CTLIO_info_ind ()** /state == DATA_POSSIBLE => LocalState := DATA CMCTL_state_ind (DATA) CM_Connect.cnf (+)	DATA
32	WDATA	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT
33	DATA	**CMCTL_state_ind ()** /state == ABORT => ignore	CONNECT
34	DATA	**CM_Abort_req ()** => CMCTL_state_ind (ABORT) RM_Release.req ()	ABORT
35	DATA	CTLIO_info_ind () => ignore	DATA

#	Current State	Event /Condition =>Action	Next State
36	DATA	RM_Connect.cnf () => ignore	DATA
37	DATA	RM_Dcontrol.cnf () => ignore	DATA
38	DATA	RM_Ccontrol.ind () => ignore	DATA
39	ABORT	**RM_Release.cnf ()** => CM_Abort_cnf ()	CONNECT
40	ABORT	**CM_Abort_req ()** => CM_Abort_cnf ()	ABORT
41	ABORT	RM_Connect.cnf () => ignore	ABORT
42	ABORT	RM_Dcontrol.cnf () => ignore	ABORT
43	ABORT	RM_Ccontrol.ind () => ignore	ABORT
44	ABORT	CMCTL_state_ind () => ignore	ABORT

5.6.4.2.5 Functions, Macros, Timers and Variables

Table 775 contains the functions, macros, timers and variables used by the CMCTL and their arguments and their descriptions.

Table 775 – Functions, Macros, Timers and Variables used by the CMCTL

Name	Type	Function/Meaning
StartTimer	Function	This local function is used to start or restart a timer
StopTimer	Function	This local function is used to stop a timer
TimerExpired	Function	This local function is issued if a timer expires
Create PDU	Macro	This local macro creates the corresponding PDU
Store Args	Macro	This local macros stores the parameters of the request for further use
Store Results	Macro	This local macro stores the result for a possible RPC rerun
Use stored Args	Macro	This local macro retrieve the stored parameters
RAR	Timer	This local timer is loaded with the RemoteApplicationReadyTimeout and used for the monitoring of the time between PrmEnd and ApplicationReady.
LocalState	Variable	This local variable contains the current state

5.6.4.3 Context Management Surveillance Controller

5.6.4.3.1 Primitive definitions

5.6.4.3.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by CTLSM are described in the service definition and shown in Table 776.

Table 776 – Remote primitives issued or received by CTLSM

Primitive	Source	Destination	Associated parameters	Functions
RM_Read.req	CTLSM	CTLRPC	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Read.cnf	CTLRDI	CTLSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Read.cnf (-)	CTLRPC	CTLSM	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.cnf (+)	CTLRPC	CTLSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Write.cnf	CTLWRI	CTLSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Read.req	FSPMCTL	CTLSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Write.req	FSPMCTL	CTLSM	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—

5.6.4.3.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLSM are described in the service definition and shown in Table 777.

Table 777 – Local primitives issued or received by CTLSM

Primitive	Source	Destination	Associated parameters	Functions
CTLSM_Start_req	CMCTL	CTLSM	Timeout	—
CTLIO_info_ind	CTLIO	CTLSM	info {DATA_POSSIBLE}	—
CTLSM_Start_cnf	CTLSM	CMCTL	—	—
CMCTL_state_ind	CTLSM	CMCTL	state {ABORT}	—

5.6.4.3.2 State transition diagram

The state transition diagram of the CTLSM is shown in Figure 115.

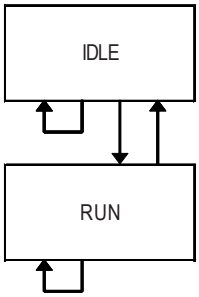


Figure 115 – State transition diagram of CTLSM

States of the CTLSM

IDLE Wait for the start of the connection monitoring

RUN Connection monitoring running

5.6.4.3.3 State machine description

The CM client protocol machine (CTLSM) arranges the condition monitoring between PRM_END and the PPM/CPM connection monitoring.

5.6.4.3.4 CTLSM state table

Table 778 contains the complete description of the CTLSM state machine.

Table 778 – CTLSM state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CTLSM_Start_req (CMInitiatorTriggerTimeout)** => StartTimer (CMI, CMInitiatorTriggerTimeout) CTLSM_Start_cnf ()	RUN
2	IDLE	CTLIO_info_ind () => ignore	IDLE

#	Current State	Event /Condition =>Action	Next State
3	IDLE	CMCTL_state_ind () => ignore	IDLE
4	IDLE	TimeExpired (CMI) => ignore	IDLE
5	IDLE	**RM_Read.cnf ()** /Index == Trigger => ignore	IDLE
6	RUN	TimerExpired (CMI) => RM_Read.req ()	RUN
7	RUN	CTLSM_Start_req (CMInitiatorTriggerTimeout) => ignore	RUN
8	RUN	**CTLIO_info_ind ()** /info == DATA_POSSIBLE => StopTimer (CMI)	IDLE
9	RUN	**CMCTL_state_ind ()** /state == ABORT => StopTimer (CMI)	IDLE
10	RUN	**RM_Read.cnf (+)** /Index == Trigger => StartTimer (CMI, CMInitiatorTriggerTimeout)	RUN
11	RUN	**RM_Read.cnf (-)** /Index == Trigger => StopTimer (CMI) CMCTL_state_ind (ABORT)	IDLE
12	RUN	**CM_Read.req** => StopTimer (CMI)	RUN
13	RUN	**CM_Write.req** => StopTimer (CMI)	RUN
14	RUN	**CM_Read.cnf** => StartTimer (CMI, CMInitiatorTriggerTimeout)	RUN
15	RUN	**CM_Write.cnf** => StartTimer (CMI, CMInitiatorTriggerTimeout)	RUN

5.6.4.3.5 Functions, Macros, Timers and Variables

Table 779 contains the functions, macros, timers and variables used by the CTLSM and their arguments and their descriptions.

Table 779 – Functions, Macros, Timers and Variables used by the CTLSM

Name	Type	Function/Meaning
TimerExpired	Function	This local function is issued if a timer expires.
StartTimer	Function	This local function starts or restarts a timer.
StopTimer	Function	This local function stops a timer.

Name	Type	Function/Meaning
CMI	Timer	This local timer is loaded with the CMInitiatorTriggerTimeout and used for the connection monitoring before the CPM / PPM monitoring is activated.

5.6.4.4 Context Management Input Output Controller

5.6.4.4.1 Primitive definitions

5.6.4.4.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by CTLIO are described in the service definition and shown in Table 780.

Table 780 – Remote primitives issued or received by CTLIO

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.4.4.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLIO are described in the service definition and shown in Table 781.

Table 781 – Local primitives issued or received by CTLIO

Primitive	Source	Destination	Associated parameters	Functions
CMCTL_state_ind	CMCTL CTLIO	CTLIO CMCTL	state {ABORT, …}	—
CPM_NewData_ind	CPM	CMIO FSPMDEV CMDMC CTLIO	AREP, CREP, APDU_Status, data {Data, NoData}	—
CPM_State_ind	CPM	CTLIO	CREP	—
CTLIO_info_ind	CTLIO	CMCTL	info {DATA_POSSIBLE, DATA_IMPOSSIBLE}	—

5.6.4.4.2 State transition diagram

The state transition diagram of the CTLIO is shown in Figure 116.

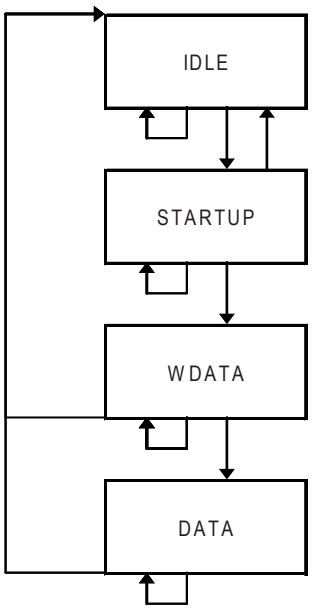


Figure 116 – State transition diagram of CTLIO

States of the CTLIO

IDLE	Wait for the start of a connection to a IO device
STARTUP	Wait for the CMCTL state PRMEND
WDATA	Wait for the established PPM / CPM data exchange
DATA	Monitor the PPM / CPM data exchange

5.6.4.4.3 State machine description

The Context Management Input Output Protocol Machine Controller (CTLIO) arranges the access to the DataStatus and NewData indication. It also handles the switchover between RPC connection monitoring and CPM / PPM connection monitoring.

5.6.4.4.4 CTLIO state table

Table 782 contains the complete description of the CTLIO state machine.

Table 782 – CTLIO state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	CPM_NewData_ind () => ignore	IDLE
2	IDLE	CPM_State_ind () => ignore	IDLE
3	IDLE	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE

#	Current State	Event /Condition =>Action	Next State
4	IDLE	**CMCTL_state_ind ()** /state == STARTUP => For all CPMs CmInstance[CREP.CPM]:=Stop	STARTUP
5	STARTUP	CPM_NewData_ind () => ignore	STARTUP
6	STARTUP	CPM_State_ind () => ignore	STARTUP
7	STARTUP	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
8	STARTUP	**CMCTL_state_ind ()** /state == APPLRDY => StartTimer ()	WDATA
9	WDATA	**CPM_NewData_ind ()** => CmInstance[CREP.CPM]:=Start	WDATA
10	WDATA	**CPM_State_ind ()** /state == STOP => CmInstance[CREP.CPM]:=Stop	WDATA
11	WDATA	**CPM_State_ind ()** /state == START => CmInstance[CREP.CPM]:=Start	WDATA
12	WDATA	**TimerExpired ()** /All CPM of CmInstance[CREP.CPM] contain the value “Start” => StartTimer () CTLIO_info_ind (DATA_POSSIBLE)	WDATA
13	WDATA	**TimerExpired ()** /One CPM of CmInstance[CREP.CPM] contains the value “Stop” => StartTimer () CTLIO_info_ind (DATA_IMPOSSIBLE)	WDATA
14	WDATA	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
15	WDATA	**CMCTL_state_ind ()** /state == WDATA => ignore	WDATA
16	WDATA	**CMCTL_state_ind ()** /state == DATA => StopTimer ()	DATA
17	DATA	CPM_NewData_ind () => ignore	DATA
18	DATA	**CPM_State_ind ()** /state == STOP && CREP != CREP.MCPM => CMCTL_state_ind (ABORT)	IDLE

#	Current State	Event /Condition =>Action	Next State
19	DATA	**CPM_State_ind ()** /state == START => ignore	DATA
20	DATA	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE

5.6.4.4.5 Functions, Macros, Timers and Variables

Table 783 contains the functions, macros, timers and variables used by the CTLIO and their arguments and their descriptions.

Table 783 – Functions, Macros, Timers and Variables used by the CTLIO

Name	Type	Function/Meaning
TimerExpired	Function	This local function is issued if a timer expires.
StartTimer	Function	This local function is used to start or restart a timer.
StopTimer	Function	This local function is used to stop a timer.
CmInstance	Variable	This AR global variable contains the information about the used CRs and their states.

5.6.4.5 Context Management Read Record Initiator Controller

5.6.4.5.1 Primitive definitions

5.6.4.5.1.1 Primitives exchanged between remote machines

Table 784 shows the service primitives including their associated parameters received by Context Management Read Record Initiator Protocol Machine Controller (CTLRDI).

Table 784 – Remote primitives received by CTLRDI

Primitive	Source	Destination	Associated parameters	Functions
CM_Read.cnf (-)	CTLRDI	FSPMCTL	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Read.cnf (+)	CTLRDI	FSPMCTL	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length, Data	—
RM_Read.cnf (-)	CTLRPC	CTLRDI	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.cnf (+)	CTLRPC	CTLRDI	AREP,	—

Primitive	Source	Destination	Associated parameters	Functions
			SeqNumber, Length, Data	
CM_Read.req	FSPMCTL	CTLRDI	AREP, API, TargetARUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Read.req	CTLRDI	CTLRPC	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—

5.6.4.5.1.2 Primitives exchanged between local machines

Table 785 shows the service primitives including their associated parameters issued or received by the CTLRDI.

Table 785 – Local primitives issued or received by CTLRDI

Primitive	Source	Destination	Associated parameters	Functions
CMCTL_state_ind	CMCTL	FSPMCTL CTLSU CTLWRI CTLWRR CTLPBE CTLIO CTLRDI	state {ABORT, ...}	—

5.6.4.5.2 State transition diagram

The state transition diagram of the CTLRDI is shown in Figure 117.

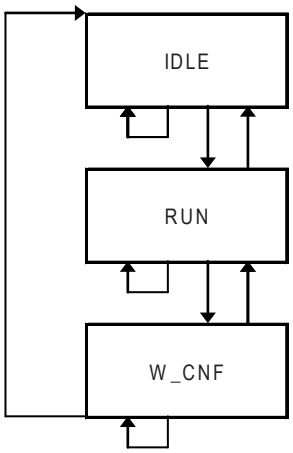


Figure 117 – State transition diagram of CTLRDI

States of the CTLRDI

IDLE	Idle state. Read explizit not supported.
RUN	Active state, handle read service
W_CNF	Wait for read confirmation

5.6.4.5.3 State machine description

The Context Management Read Record Initiator Protocol Machine Controller (CTLRDI) arranges the initiator side of the read record service.

5.6.4.5.4 CTLRDI state table

Table 786 contains the complete description of the CTLRDI state machine.

Table 786 – CTLRDI state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CM_Read.req ()** => ErrorCode:= wrong state CM_Read.cnf (-)	IDLE
2	IDLE	RM_Read.cnf () => ignore	IDLE
3	IDLE	**CMCTL_state_ind ()** /state != ABORT => ignore	RUN
4	IDLE	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
5	RUN	**CM_Read.req ()** => RM_Read.req ()	W_CNF
6	RUN	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
7	RUN	**CMCTL_state_ind ()** /state != ABORT => ignore	RUN
8	W_CNF	**RM_Read.cnf (+)** => CM_Read.cnf (+)	RUN
9	W_CNF	**RM_Read.cnf (-)** => CM_Read.cnf (-)	RUN
10	W_CNF	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
11	W_CNF	**CMCTL_state_ind ()** /state != ABORT => ignore	W_CNF

5.6.4.5.5 Functions, Macros, Timers and Variables

Table 787 contains the functions, macros, timers and variables used by the CTLRDI and their arguments and their descriptions.

Table 787 – Functions, Macros, Timers and Variables used by CTLRDI

Name	Type	Function/Meaning
—	—	—

5.6.4.6 Context Management Read Record Responder Controller

5.6.4.6.1 Primitive definitions

5.6.4.6.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Read Record Responder Protocol Machine Controller (CTLRDR) are described in the service definition and shown in Table 788.

Table 788 – Remote Primitives received by CTLRDR

Primitive	Source	Destination	Associated parameters	Functions
CM_Read.ind	CTLRDR	FSPMCTL	AREP, API, TargetARUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
CM_Read.rsp (-)	FSPMCTL	CTLRDR	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Read.rsp (+)	FSPMCTL	CTLRDR	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length, Data	—
RM_Read.ind	CTLRPC	CTLRDR	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Read.rsp (-)	CTLRDR	CTLRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.rsp (+)	CTLRDR	CTLRPC	AREP, SeqNumber, Length, Data	—

5.6.4.6.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLRDR are described in the service definition and shown in Table 789.

Table 789 – Local primitives issued or received by CTLRDR

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.4.6.2 State transition diagram

The state transition diagram of the CTLRDR is shown in Figure 118.

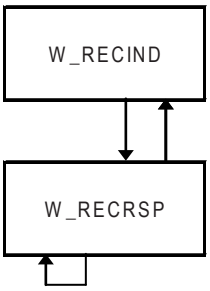


Figure 118 – State transition diagram of CTLRDR

States of the CTLRDR

W_RECIND	Wait for read record indication
W_RECRSP	Wait for read record response

5.6.4.6.3 State machine description

The CM Read Record protocol machine (CTLRDR) arranges the read record service.

5.6.4.6.4 CTLRDR state table

Table 790 contains the complete description of the CTLRDR state machine.

Table 790 – CTLRDR state table

#	Current State	Event /Condition =>Action	Next State
1	W_RECIND	**RM_Read.ind ()** => CM_Read.ind ()	W_RECRSP
2	W_RECRSP	**CM_Read.rsp (+)** => RM_Read.rsp (+)	W_RECIND
3	W_RECRSP	**CM_Read.rsp (-)** => RM_Read.rsp (-)	W_RECIND

#	Current State	Event /Condition =>Action	Next State
4	W_RECRSP	RM_Read.ind () => ignore	W_RECRSP

5.6.4.6.5 Functions, Macros, Timers and Variables

Table 791 contains the functions, macros, timers and variables used by the CTLRDR and their arguments and their descriptions.

Table 791 – Functions, Macros, Timers and Variables used by CTLRDR

Name	Type	Function/Meaning
—	—	—

5.6.4.7 Context Management RPC Controller

5.6.4.7.1 Primitive definitions

5.6.4.7.1.1 Primitives exchanged between remote machines

Table 792 shows the service primitives including their associated parameters received by Context Management RPC Protocol Machine Controller (CTLRPC).

Table 792 – Remote primitives received by CTLRPC

Primitive	Source	Destination	Associated parameters	Functions
RM_Ccontrol.rsp (-)	CMCTL	CTLRPC	AREP, ControlBlock	—
RM_Ccontrol.rsp (+)	CMCTL	CTLRPC	AREP, ControlBlock, ModuleDiffBlock	—
RM_Connect.req	CMCTL	CTLRPC	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock	—
RM_Dcontrol.req	CMCTL	CTLRPC	AREP, ControlBlock	—
RM_Read.req	CMCTL	CTLRPC	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Read.rsp (-)	CMCTL	CTLRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.rsp (+)	CMCTL	CTLRPC	AREP, SeqNumber, Length, Data	—
RM_Release.req	CMCTL	CTLRPC	AREP, ControlBlock	—

Primitive	Source	Destination	Associated parameters	Functions
RM_Release.rsp (-)	CMCTL	CTLRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Release.rsp (+)	CMCTL	CTLRPC	AREP, ControlBlock	—
RM_Write.req	CMCTL	CTLRPC	AREP, API, SlotNumber, SubslotNumber, Index, Multiple, SeqNumber, Length, Data	—
RM_Write.rsp (-)	CMCTL	CTLRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Write.rsp (+)	CMCTL	CTLRPC	AREP, SeqNumber	—
RM_Ccontrol.ind	CTLRPC	CMCTL	AREP, ControlBlock, ModuleDiffBlock	—
RM_Connect.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Connect.cnf (+)	CTLRPC	CMCTL	AREP, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes, ModuleDiffBlock, ARRPCBlockRes	—
RM_Dcontrol.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Dcontrol.cnf (+)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Read.cnf (+)	CTLRPC	CMCTL	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—

Primitive	Source	Destination	Associated parameters	Functions
RM_Read.ind	CTLRPC	CMCTL	AREP, API, TargetUUID, SlotNumber, SubslotNumber, Index, SeqNumber, Length	—
RM_Release.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Release.cnf (+)	CTLRPC	CMCTL	AREP, ControlBlock	—
RM_Release.ind	CTLRPC	CMCTL	AREP, ControlBlock	—
RM_Write.cnf (-)	CTLRPC	CMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Write.cnf (+)	CTLRPC	CMCTL	AREP, SeqNumber	—
RM_Write.ind	CTLRPC	CMCTL	AREP, API, SlotNumber, SubslotNumber, Index, Multiple, SeqNumber, Length, Data	—
RPC_Ccontrol.rsp (-)	CTLRPC	RPC	Arg	—
RPC_Ccontrol.rsp (+)	CTLRPC	RPC	Arg	—
RPC_Connect.req	CTLRPC	RPC	Arg	—
RPC_Dcontrol.req	CTLRPC	RPC	Arg	—
RPC_Read.req	CTLRPC	RPC	Arg	—
RPC_Read.rsp (-)	CTLRPC	RPC	Arg	—
RPC_Read.rsp (+)	CTLRPC	RPC	Arg	—
RPC_Release.req	CTLRPC	RPC	Arg	—
RPC_Release.rsp (-)	CTLRPC	RPC	Arg	—
RPC_Release.rsp (+)	CTLRPC	RPC	Arg	—
RPC_Write.req	CTLRPC	RPC	Arg	—
RPC_Write.rsp (-)	CTLRPC	RPC	Arg	—
RPC_Write.rsp (+)	CTLRPC	RPC	Arg	—
RPC_Ccontrol.ind	RPC	CTLRPC	Arg	—
RPC_Connect.cnf (-)	RPC	CTLRPC	Arg	—
RPC_Connect.cnf (+)	RPC	CTLRPC	Arg	—
RPC_Dcontrol.cnf (-)	RPC	CTLRPC	Arg	—
RPC_Dcontrol.cnf (+)	RPC	CTLRPC	Arg	—
RPC_Read.cnf (-)	RPC	CTLRPC	Arg	—
RPC_Read.cnf (+)	RPC	CTLRPC	Arg	—

Primitive	Source	Destination	Associated parameters	Functions
RPC_Read.ind	RPC	CTLRPC	Arg	—
RPC_Release.cnf (-)	RPC	CTLRPC	Arg	—
RPC_Release.cnf (+)	RPC	CTLRPC	Arg	—
RPC_Release.ind	RPC	CTLRPC	Arg	—
RPC_Write.cnf (-)	RPC	CTLRPC	Arg	—
RPC_Write.cnf (+)	RPC	CTLRPC	Arg	—
RPC_Write.ind	RPC	CTLRPC	Arg	—

5.6.4.7.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLRPC are described in the service definition and shown in Table 793.

Table 793 – Local primitives issued or received by CTLRPC

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.4.7.2 State transition diagram

The state transition diagram of the CTLRPC is shown in Figure 119.

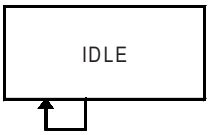


Figure 119 – State transition diagram of CTLRPC

States of the CTLRPC

IDLE Wait for an RPC or an RM call, check its integrity and for idempotent rerun

5.6.4.7.3 State machine description

The Context Management RPC Controller Protocol Machine (CTLRPC) arranges the RPC communication and handles all issued and received RPC services.

5.6.4.7.4 CTLRPC state table

Table 794 contains the complete description of the CTLRPC state machine.

Table 794 – CTLRPC state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**RPC_Ccontrol.ind ()** /CheckRPC () == Rerun => Retrieve stored response encode RPC PDU RPC_Ccontrol.rsp ()	IDLE
2	IDLE	**RPC_Ccontrol.ind ()** /CheckRPC () == Valid => AREP := LocateAR () RM_Ccontrol.ind ()	IDLE
3	IDLE	**RPC_Ccontrol.ind ()** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode Error PDU RPC_Ccontrol.rsp (-)	IDLE
4	IDLE	**RM_Ccontrol.rsp (-)** => encode Error PDU Store response RPC_Ccontrol.rsp (-)	IDLE
5	IDLE	**RM_Ccontrol.rsp (+)** => encode RPC PDU Store response RPC_Ccontrol.rsp (+)	IDLE
6	IDLE	**RM_Dcontrol.req ()** => encode RPC PDU RPC_Dcontrol.req ()	IDLE
7	IDLE	**RPC_Dcontrol.cnf (-)** => RM_Dcontrol.cnf (-)	IDLE
8	IDLE	**RPC_Dcontrol.cnf (+)** /CheckRPC () == Valid => AREP := LocateAR () RM_Dcontrol.cnf (+)	IDLE
9	IDLE	**RPC_Dcontrol.cnf (+)** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode Error PDU RM_Dcontrol.cnf (-)	IDLE
10	IDLE	**RM_Write.rsp (-)** => encode Error PDU RPC_Write.rsp (-)	IDLE
11	IDLE	**RM_Write.rsp (+)** => encode RPC PDU RPC_Write.rsp (+)	IDLE
12	IDLE	**RM_Write.req ()** => encode RPC PDU RPC_Write.req ()	IDLE
13	IDLE	**RPC_Write.ind ()** => AREP := LocateAR () RM_Write.ind ()	IDLE

#	Current State	Event /Condition =>Action	Next State
14	IDLE	**RPC_Write.cnf (-)** => RM_Write.cnf (-)	IDLE
15	IDLE	**RPC_Write.cnf (+)** /CheckRPC () == Valid => AREP := LocateAR () RM_Write.cnf (+)	IDLE
16	IDLE	**RPC_Write.cnf (+)** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode Error PDU RM_Write.cnf (-)	IDLE
17	IDLE	**RM_Read.rsp (-)** => encode Error PDU RPC_Read.rsp (-)	IDLE
18	IDLE	**RM_Read.rsp (+)** => encode RPC PDU RPC_Read.rsp (+)	IDLE
19	IDLE	**RM_Read.req ()** => encode RPC PDU RPC_Read.req ()	IDLE
20	IDLE	**RPC_Read.ind ()** => AREP := LocateAR () RM_Read.ind ()	IDLE
21	IDLE	**RPC_Read.cnf (-)** => RM_Read.cnf (-)	IDLE
22	IDLE	**RPC_Read.cnf (+)** /CheckRPC () == Valid => AREP := LocateAR () RM_Read.cnf (+)	IDLE
23	IDLE	**RPC_Read.cnf (+)** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode Error PDU RM_Read.cnf (-)	IDLE
24	IDLE	**RM_Connect.req ()** => encode RPC PDU RPC_Connect.req ()	IDLE
25	IDLE	**RPC_Connect.cnf (-)** => RM_Connect.cnf (-)	IDLE
26	IDLE	**RPC_Connect.cnf (+)** /CheckRPC () == Valid //NOTE The CMResponderName shall be checked to avaid wrong connections => AREP := LocateAR () RM_Connect.cnf (+)	IDLE
27	IDLE	**RPC_Connect.cnf (+)** /CheckRPC () == InValid, ErrorDecode, ErrorCode1, ErrorCode2 => encode Error PDU RM_Connect.cnf (-)	IDLE

#	Current State	Event /Condition =>Action	Next State
28	IDLE	**RM_Release.req ()** => encode RPC PDU RPC_Release.req ()	IDLE
29	IDLE	**RPC_Release.cnf ()** => RM_Release.cnf ()	IDLE
30	IDLE	**RPC_Release.ind ()** => encode Error PDU RPC_Release.rsp (-)	IDLE
31	IDLE	**RPC_Connect.ind ()** => encode Error PDU RPC_Connect.rsp (-)	IDLE

5.6.4.7.5 Functions, Macros, Timers and Variables

Table 795 contains the functions, macros, timers and variables used by the CTLRPC and their arguments and their descriptions.

Table 795 – Functions, Macros, Timers and Variables used by the CTLRPC

Name	Type	Function/Meaning
CheckRPC	Function	This local functions checks the block structure and parameters against the definitions of this standard.
Encode Error PDU	Macro	This local macro generates the appropriate PDU with the detected errors from the PDU checking rules. An error PDU consists only out of the RPC NDR header.
Encode RPC PDU	Macro	This local macro generates the appropriate PDU.
LocateAR	Macro	This local macro retrieves the assosiated AREP.
Retrieve stored response	Macro	This local macro retrieves the previously stored parameter in case of a detected RPC rerun.
Store response	Macro	This local macro stores the parameters of the RPC response to be retrievable in case of a RPC rerun
AREP	Variable	This local variable stores the application relation end point for further use

5.6.4.8 Context Management Startup Controller

5.6.4.8.1 Primitive definitions

5.6.4.8.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Startup Protocol Machine Controller (CTLSU) are described in the service definition and shown in Table 796.

Table 796 – Remote primitives issued or received by CTLSU

Primitive	Source	Destination	Associated parameters	Functions
—	—	—	—	—

5.6.4.8.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLSU are described in the service definition and shown in Table 797.

Table 797 – Local Primitives issued or received by CTLSU

Primitive	Source	Destination	Associated parameters	Functions
ALPMI_Activate_req	CTLSU	ALPMI	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	—
ALPMI_Close_req	CTLSU	ALPMI	CREP	—
APMR_Activate_req	CTLSU	APMR	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	—
APMR_Close_req	CTLSU	APMR	CREP	—
APMS_Activate_req	CTLSU	APMS	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	—
APMS_Close_req	CTLSU	APMS	CREP	—
CMCTL_start_cnf (-)	CTLSU	CMCTL	—	—
CMCTL_start_cnf (+)	CTLSU	CMCTL	—	—
CPM_Activate_req	CTLSU	CPM	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	—
CPM_Close_req	CTLSU	CPM	CREP	—
ALPMI_Activate_cnf (-)	ALPMI	CTLSU	—	—
ALPMI_Error_ind	ALPMI	CTLSU	ErrorCode1, ErrorCode2	—
ALPMR_Activate_cnf (-)	ALPMR	CTLSU	—	—
ALPMR_Error_ind	ALPMR	CTLSU	—	—
APMR_Error_ind	APMR	CTLSU	ErrorCode1, ErrorCode2	—
APMS_Error_ind	APMS	CTLSU	ErrorCode1, ErrorCode2	—
CMCTL_start_req	CMCTL	CTLSU	AREP, ARBlockReq, ListOfIOCRBlockReq, AlarmCRBlockReq, ListOfExpectedSubmoduleBlockReq, ListOfMCRBlockReq, ListOfSubFrameBlockReq, ARBlockRes, ListOfIOCRBlockRes, AlarmCRBlockRes	—
CPM_Activate_cnf (-)	CPM	CTLSU	—	—
CPM_Error_ind	CPM	CTLSU	ErrorCode1, ErrorCode2	—

Primitive	Source	Destination	Associated parameters	Functions
DFP_Activate_cnf (-)	DFP	CTLSU	—	—
PPM_Activate_cnf (-)	PPM	CTLSU	—	—
PPM_Error_ind	PPM	CTLSU	ErrorCode1, ErrorCode2	—
XXX_Activate_cnf (+)	xxx	CTLSU	CREP	—
XXX_Close_cnf (+)	xxx	CTLSU	CREP	—
CMCTL_state_ind	CMCTL	FSPMCTL CTLSU CTLWRI CTLWRR CTLPBE CTLIO CTLRDI	state {ABORT}	—
PPM_Activate_req	CTLSU	PPM	CREP, DA, SA, VLAN, RTATimeoutFactor, RTARetries	—
PPM_Close_req	CTLSU	PPM	CREP	—

5.6.4.8.2 State transition diagram

The state transition diagram of the CTLSU is shown in Figure 120.

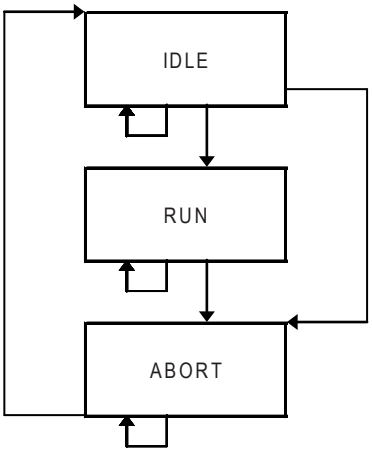


Figure 120 – State transition diagram of CTLSU

States of the CTLSU

IDLE	No AR context exists
RUN	The lower machines are started or bound to the AR. This state is kept during startup and data exchange.
ABORT	Termination sequence

5.6.4.8.3 State machine description

The IO controller startup protocol machine (CTLSU) arranges the start of the underlying protocol machines.

The startup of the CPM and PPM state machines shall be done between receiving the connect confirmation service and the Parameterization end confirmation service. The startup shall be finish before issuing the Application ready response service.

5.6.4.8.4 CTLSU state table

Table 798 contains the complete description of the CTLSU state machine.

Table 798 – CTLSU state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CMCTL_start_req ()** => CREP.PPM := create (PPM) CREP.CPM := create (CPM) CREP.ALPMI := create (ALPMI) CREP.ALPMR := create (ALPMR) CREP.APMS := create (APMS) CREP.APMR := create (APMR) //NOTE Create high and low instance of the Alarm machines PPM_Activate_req () CPM_Activate_req () ALPMI_Activate_req () ALPMR_Activate_req () APMS_Activate_req () APMR_Activate_req ()	IDLE
2	IDLE	**XXX_Activate_cnf (+)** /if last confirmation is received => CMCTL_start_cnf (+)	IDLE
3	IDLE	**PPM_Activate_cnf (-)** => ErrorCode2 = AR add provider or consumer failed CMCTL_start_cnf (-)	IDLE
4	IDLE	**CPM_Activate_cnf (-)** => ErrorCode2 = AR add provider or consumer failed CMCTL_start_cnf (-)	IDLE
5	IDLE	**ALPMI_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMCTL_start_cnf (-)	IDLE
6	IDLE	**ALPMR_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMCTL_start_cnf (-)	IDLE
7	IDLE	**APMS_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMCTL_start_cnf (-)	IDLE
8	IDLE	**APMR_Activate_cnf (-)** => ErrorCode2 = AR alarm-open failed CMCTL_start_cnf (-)	IDLE
9	IDLE	**CMCTL_state_ind ()** /state == !ABORT => ignore	RUN

#	Current State	Event /Condition =>Action	Next State
10	IDLE	**CMCTL_state_ind ()** /state == ABORT => PPM_Close_req () CPM_Close_req () ALPMI_Close_req () ALPMR_Close_req () APMS_Close_req () APMR_Close_req ()	ABORT
11	IDLE	**PPM_Error_ind ()** => CMCTL_state_ind (ABORT)	IDLE
12	IDLE	**CPM_Error_ind ()** => CMCTL_state_ind (ABORT)	IDLE
13	IDLE	**ALPMI_Error_ind ()** => CMCTL_state_ind (ABORT)	IDLE
14	IDLE	**ALPMR_Error_ind ()** => CMCTL_state_ind (ABORT)	IDLE
15	IDLE	**APMS_Error_ind ()** => CMCTL_state_ind (ABORT)	IDLE
16	IDLE	**APMR_Error_ind ()** => CMCTL_state_ind (ABORT)	IDLE
17	RUN	**CMCTL_state_ind ()** /state == !ABORT => ignore	RUN
18	RUN	**CMCTL_state_ind ()** /state == ABORT => PPM_Close_req () CPM_Close_req () ALPMI_Close_req () ALPMR_Close_req () APMS_Close_req () APMR_Close_req ()	ABORT
19	RUN	**CMCTL_start_req ( )** => ErrorCode1 := CMCTL ErrorCode2 := state conflict CMCTL_start_cnf (-)	RUN
20	RUN	**PPM_Error_ind ()** => CMCTL_state_ind (ABORT)	RUN
21	RUN	**CPM_Error_ind ()** => CMCTL_state_ind (ABORT)	RUN
22	RUN	**ALPMI_Error_ind ()** => CMCTL_state_ind (ABORT)	RUN
23	RUN	**ALPMR_Error_ind ()** => CMCTL_state_ind (ABORT)	RUN

#	Current State	Event /Condition =>Action	Next State
24	RUN	**APMS_Error_ind ()** => CMCTL_state_ind (ABORT)	RUN
25	RUN	**APMR_Error_ind ()** => CMCTL_state_ind (ABORT)	RUN
26	ABORT	**XXX_Close_cnf (+)** /if last confirmation is received => Delete (PPM) Delete (CPM) Delete (ALPMI) Delete (ALPMR) Delete (APMS) Delete (APMR)	IDLE
27	ABORT	PPM_Error_ind () => ignore	ABORT
28	ABORT	CPM_Error_ind () => ignore	ABORT
29	ABORT	ALPMI_Error_ind () => ignore	ABORT
30	ABORT	ALPMR_Error_ind () => ignore	ABORT
31	ABORT	APMS_Error_ind () => ignore	ABORT
32	ABORT	APMR_Error_ind () => ignore	ABORT

5.6.4.8.5 Functions, Macros, Timers and Variables

Table 799 contains the functions, macros, timers and variables used by the CTLSU and their arguments and their descriptions.

Table 799 – Functions, Macros, Timers and Variables used by the CTLSU

Name	Type	Function/Meaning
Delete	Function	This local function frees or unbounds the machines from the CMCTL instance if the AR is aborted.
If last confirmation is received	Macro	This local macro collects all the confirmations and returns TRUE if all receive with xxx_cnf (+).

5.6.4.9 Context Management Write Record Initiator Controller

5.6.4.9.1 Primitive definitions

5.6.4.9.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Write Record Initiator Protocol Machine Controller (CTLWRI) are described in the service definition and shown in Table 800.

Table 800 – Remote primitives issued or received by CTLWRI

Primitive	Source	Destination	Associated parameters	Functions
CM_Write.cnf (-)	CTLWRI	FSPMCTL	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Write.cnf (+)	CTLWRI	FSPMCTL	AREP, SeqNumber	—
RM_Write.req	CTLWRI	CTLRPC	AREP, API, SlotNumber, SubslotNumber, Index, Multiple, SeqNumber, Length, Data	—
CM_Write.req	FSPMCTL	CTLWRI	AREP, SlotNumber, SubslotNumber, Index, SeqNumber, Length, Data	—
RM_Write.cnf (-)	CTLRPC	CTLWRI	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Write.cnf (+)	CTLRPC	CTLWRI	AREP, SeqNumber	—

5.6.4.9.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLWRI are described in the service definition and shown in Table 801.

Table 801 – Local primitives issued or received by CTLWRI

Primitive	Source	Destination	Associated parameters	Functions
CMCTL_state_ind	CMCTL	CTLWRI	state {ABORT, …}	—
CMCTL_PrmDone_ind	CTLWRI	CMCTL	—	—

5.6.4.9.2 State transition diagram

The state transition diagram of the CTLWRI is shown in Figure 121.

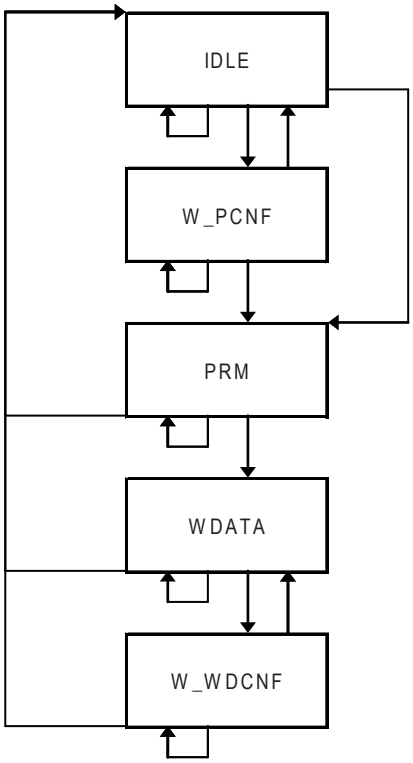


Figure 121 – State transition diagram of CTLWRI

States of the CTLWRI

IDLE	No AR context exists
PRM	Do the startup parameterization.
W_PCNF	Wait for the write record confirmation during startup parameterization.
WDATA	An application process may issue a write record request after the CMCTL enters the WDATA state. This is monitored by the CTLWRI.
W_WDCNF	After a write record is conveyed, the CTLWRI waits for the confirmation.

5.6.4.9.3 State machine description

The Context Management Write Record Initiator Protocol Machine Controller (CTLWRI) arranges initiator side of the read record service.

5.6.4.9.4 CTLWRI state table

Table 802 contains the complete description of the CTLWRI state machine.

Table 802 – CTLWRI state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CM_Write.req ()** => ErrorCode:= wrong state CM_Write.cnf (-)	IDLE
2	IDLE	RM_Write.cnf () => ignore	IDLE
3	IDLE	**CMCTL_state_ind ()** /state == STARTUP && List of Startup Records is empty => ignore CMCTL_PrmDone_ind ()	PRM
4	IDLE	**CMCTL_state_ind ()** /state == STARTUP && ! List of Startup Records is empty => Get first entry RM_Write.req ()	W_PCNF
5	W_PCNF	**RM_Write.cnf ()** /! List of Startup Records is empty => Get next entry RM_Write.req ()	W_PCNF
6	W_PCNF	**RM_Write.cnf ()** /List of Startup Records is empty => CMCTL_PrmDone_ind ()	PRM
7	W_PCNF	**CM_Write.req ()** => ErrorCode:= wrong state CM_Write.cnf (-)	W_PCNF
8	W_PCNF	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
9	W_PCNF	**CMCTL_state_ind ()** /state != ABORT => ignore	W_PCNF
10	PRM	**CM_Write.req ()** => ErrorCode:= wrong state CM_Write.cnf (-)	PRM
11	PRM	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
12	PRM	**CMCTL_state_ind ()** /state == APPLRDY || state == STARTUP => ignore	PRM
13	PRM	**CMCTL_state_ind ()** /state == WDATA || state == DATA => ignore	WDATA

#	Current State	Event /Condition =>Action	Next State
14	WDATA	**CM_Write.req ()** => RM_Write.req ()	W_WDCNF
15	WDATA	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
16	WDATA	**CMCTL_state_ind ()** /state != ABORT => ignore	WDATA
17	W_WDCNF	**RM_Write.cnf (+)** => CM_Write.cnf (+)	WDATA
18	W_WDCNF	**RM_Write.cnf (-)** => CM_Write.cnf (-)	WDATA
19	W_WDCNF	**CM_Write.req ()** => ErrorCode:= wrong state CM_Write.cnf (-)	W_WDCNF
20	W_WDCNF	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
21	W_WDCNF	**CMCTL_state_ind ()** /state != ABORT => ignore	W_WDCNF

5.6.4.9.5 Functions, Macros, Timers and Variables

Table 803 contains the functions, macros, timers and variables used by the CTLWRI and their arguments and their descriptions.

Table 803 – Functions, Macros, Timers and Variables used by CTLWRI

Name	Type	Function/Meaning
—	—	—

5.6.4.10 Context Management Write Record Responder Controller

5.6.4.10.1 Primitive definitions

5.6.4.10.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Write Record Responder Protocol Machine Controller (CTLWRR) are described in the service definition and shown in Table 804.

Table 804 – Remote primitives issued or received by CTLWRR

Primitive	Source	Destination	Associated parameters	Functions
CM_Write.ind	CTLWRR	FSPMCTL	AREP, SlotNumber, SubslotNumber, Index, SeqNumber, Length, Data	—
RM_Write.rsp (-)	CTLWRR	CTLRPC	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
RM_Write.rsp (+)	CTLWRR	CTLRPC	AREP, SeqNumber	—
CM_Write.rsp (-)	FSPMCTL	CTLWRR	AREP, SeqNumber, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	—
CM_Write.rsp (+)	FSPMCTL	CTLWRR	AREP, SeqNumber	—
RM_Write.ind	CTLRPC	CTLWRR	AREP, API, SlotNumber, SubslotNumber, Index, Multiple, SeqNumber, Length, Data	—

5.6.4.10.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLWRR are described in the service definition and shown in Table 805.

Table 805 – Local primitives issued or received by CTLWRR

Primitive	Source	Destination	Associated parameters	Functions
CMCTL_state_ind	CMCTL	CTLWRR	state {ABORT, …}	—

5.6.4.10.2 State transition diagram

The state transition diagram of the CTLWRR is shown in Figure 122.

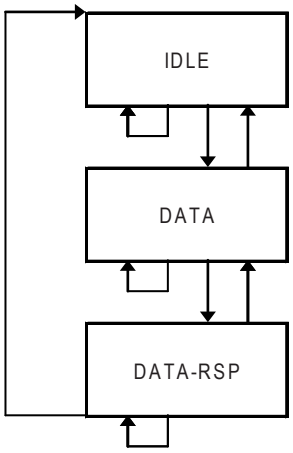


Figure 122 – State transition diagram of CTLWRR

States of the CTLWRR

IDLE	No AR context exists
DATA	The associated AR reaches an internal state in which write services are handled.
DATA-RSP	Wait for the user response and convey it to the requester.

5.6.4.10.3 State machine description

The Context Management Write Record Responder Protocol Machine Controller (CTLWRR) arranges the read record service.

5.6.4.10.4 CTLWRR state table

Table 806 contains the complete description of the CTLWRR state machine.

Table 806 – CTLWRR state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**RM_Write.ind ()** => ErrorDecode := PNIORW ErrorCode1 := state conflict RM_Write.rsp (-)	IDLE
2	IDLE	CM_Write.rsp () => ignore	IDLE
3	IDLE	**CMCTL_state_ind ()** /state == STARTUP =>	DATA
4	IDLE	**CMCTL_state_ind ()** /state != STARTUP =>	IDLE
5	DATA	**CMCTL_state_ind ()** /state != ABORT => ignore	DATA

#	Current State	Event /Condition =>Action	Next State
6	DATA	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
7	DATA	**RM_Write.ind ()** => CM_Write.ind ()	DATA-RSP
8	DATA-RSP	**CM_Write.rsp (+)** => RM_Write.rsp (+)	DATA
9	DATA-RSP	**CM_Write.rsp (-)** => RM_Write.rsp (-)	DATA
10	DATA-RSP	RM_Write.ind () => ignore	DATA-RSP
11	DATA-RSP	**CMCTL_state_ind ()** /state != ABORT => ignore	DATA-RSP
12	DATA-RSP	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE

5.6.4.10.5 Functions, Macros, Timers and Variables

Table 807 contains the functions, macros, timers and variables used by the CTLWRR and their arguments and their descriptions.

Table 807 – Functions, Macros, Timers and Variables used by CTLWRR

Name	Type	Function/Meaning
—	—	—

5.6.4.11 Context Management Prm Begin End Controller

5.6.4.11.1 Primitive definitions

5.6.4.11.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Prm Begin End Controller (CTLPBE) are described in the service definition and shown in Table 808.

Table 808 – Remote primitives issued or received by CTLPBE

Primitive	Source	Destination	Associated parameters	Functions
RM_Ccontrol.ind	CTLRPC	CTLPBE	AREP, ControlBlock, ModuleDiffBlock	ApplRdy
RM_Dcontrol.cnf (-)	CTLRPC	CTLPBE	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	PrmBegin or PrmEnd

Primitive	Source	Destination	Associated parameters	Functions
RM_Dcontrol.cnf (+)	CTLRPC	CTLPBE	AREP, ControlBlock	PrmBegin or PrmEnd
CM_Ccontrol.rsp (-)	FSPMCTL	CTLPBE	AREP, ControlBlock	ApplRdy
CM_Ccontrol.rsp (+)	FSPMCTL	CTLPBE	AREP, ControlBlock	ApplRdy
CM_Dcontrol.req	FSPMCTL	CTLPBE	AREP, ControlBlock, ListOfSubmodules	PrmBegin or PrmEnd
RM_Ccontrol.rsp (-)	CTLBE	CTLRPC	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	ApplRdy
RM_Ccontrol.rsp (+)	CTLBE	CTLRPC	AREP, ControlBlock	ApplRdy
RM_Dcontrol.req	CTLBE	CTLRPC	AREP, ControlBlock	PrmBegin or PrmEnd
CM_Ccontrol.ind	CTLBE	FSPMCTL	AREP, ControlBlock, ModuleDiffBlock	ApplRdy
CM_Dcontrol.cnf (-)	CTLBE	FSPMCTL	AREP, ErrorDecode, ErrorCode1, ErrorCode2, AddData1, AddData2	PrmBegin or PrmEnd
CM_Dcontrol.cnf (+)	CTLBE	FSPMCTL	AREP, ControlBlock, ModuleDiffBlock	PrmBegin or PrmEnd

5.6.4.11.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLPBE are described in the service definition and shown in Table 809.

Table 809 – Local primitives issued or received by CTLPBE

Primitive	Source	Destination	Associated parameters	Functions
CMCTL_state_ind	CMCTL CTLPBE	CTLPBE CMCTL	AREP, state {STARTUP, APPLRDY, WDATA, DATA, ABORT}	—

5.6.4.11.2 State transition diagram

The state transition diagram of the CTLPBE is shown in Figure 123.

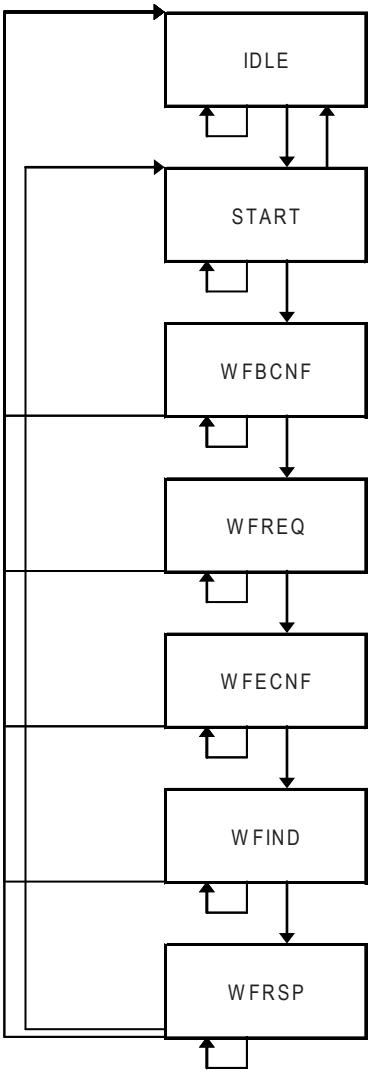


Figure 123 – State transition diagram of CTLPBE

States of the CTLPBE

IDLE	Wait for the start of DATA
START	Wait for a PrmBegin command
WFBCNF	Wait for a PrmBegin confirmation from the IO device
WFREQ	The application shall convey the records to the IO device using the CTLWRI. This machine waits for the PrmEnd command to continue.
WFECNF	Wait for a PrmEnd confirmation from the IO device
WFIND	Wait for an application ready indication from the IO device
WFRSP	Wait for an application ready confirmation from the application and convey it to the IO device. A possible RPC rerun is handled by the CTLRPC.

5.6.4.11.3 State machine description

The CTLPBE arranges a consistent parameterization for a given amount of submodules and their startup parameters in state DATA.

The IO controller shall proceed all Alarms from the involved submoduls during the PrmBegin PrmEnd ApplRdy sequence, except the Plug or Release. Overlapping Plug and Release

Alarms shall be stored by the IO controller and processed after the PrmBegin PrmEnd ApplRdy sequence.

5.6.4.11.4 CTLPBE state table

Table 810 contains the complete description of the CTLPBE state machine.

Table 810 – CTLPBE state table

#	Current State	Event /Condition =>Action	Next State
1	IDLE	**CMCTL_state_ind ()** /state == DATA => ignore	START
2	IDLE	**CMCTL_state_ind ()** /state =! DATA => ignore	IDLE
3	START	**CM_Dcontrol.req ()** /ControlBlock == PrmBegin => RM_Dcontrol.req ()	WFBCNF
4	START	**CM_Dcontrol.req ()** /ControlBlock =! PrmBegin => ignore	START
5	START	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
6	WFBCNF	**RM_Dcontrol.cnf (+)** /ControlBlock == PrmBegin => CM_Dcontrol.cnf (+)	WFREQ
7	WFBCNF	**RM_Dcontrol.cnf (-)** /ControlBlock == PrmBegin => CM_Dcontrol.cnf (-) CMCTL_state_ind (ABORT)	IDLE
8	WFBCNF	**CM_Dcontrol.req ()** => ignore CM_Dcontrol.cnf (-)	WFBCNF
9	WFBCNF	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
10	WFBCNF	**CMCTL_state_ind ()** /state != ABORT => ignore	WFBCNF
11	WFREQ	**CM_Dcontrol.req ()** /ControlBlock == PrmEnd => RM_Dcontrol.req ()	WFECNF
12	WFREQ	**CM_Dcontrol.req ()** /ControlBlock =! PrmEnd => ignore	IDLE

#	Current State	Event /Condition =>Action	Next State
13	WFREQ	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
14	WFREQ	**CMCTL_state_ind ()** /state != ABORT => ignore	WFREQ
15	WFECNF	**RM_Dcontrol.cnf (+)** /ControlBlock == PrmEnd => CM_Dcontrol.cnf (+)	WFIND
16	WFECNF	**RM_Dcontrol.cnf (-)** /ControlBlock == PrmEnd => CM_Dcontrol.cnf (-) CMCTL_state_ind (ABORT)	IDLE
17	WFECNF	**CM_Dcontrol.req ()** => ignore CM_Dcontrol.cnf (-)	WFECNF
18	WFECNF	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
19	WFECNF	**CMCTL_state_ind ()** /state != ABORT => ignore	WFECNF
20	WFIND	**RM_Ccontrol.ind ()** /ControlBlock == ApplRdy => CM_Ccontrol.ind ()	WFRSP
21	WFIND	**CM_Dcontrol.req ()** => ignore CM_Dcontrol.cnf (-)	WFIND
22	WFIND	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE
23	WFIND	**CMCTL_state_ind ()** /state != ABORT => ignore	WFIND
24	WFRSP	**CM_Ccontrol.rsp (+)** /ControlBlock == ApplRdy => RM_Ccontrol.rsp (+)	START
25	WFRSP	**CM_Ccontrol.rsp (-)** /ControlBlock == ApplRdy => RM_Ccontrol.rsp (-)	IDLE
26	WFRSP	**CM_Dcontrol.req ()** => ignore CM_Dcontrol.cnf (-)	WFRSP
27	WFRSP	**CMCTL_state_ind ()** /state == ABORT => ignore	IDLE

#	Current State	Event /Condition =>Action	Next State
28	WFRSP	**CMCTL_state_ind ()** /state != ABORT => ignore	WFRSP

5.6.4.11.5 Functions, Macros, Timers and Variables

Table 811 contains the functions, macros, timers and variables used by the CTLPBE and their arguments and their descriptions.

Table 811 – Functions, Macros, Timers and Variables used by CTLPBE

Name	Type	Function/Meaning
—	—	—

5.6.4.12 Context Management Discovery, IP and Name Assignment

5.6.4.12.1 Primitive definitions

5.6.4.12.1.1 Primitives exchanged between remote machines

The service primitives including their associated parameters issued or received by Context Management Discovery, IP and Name Assignment (CTLDINA) are described in the service definition and shown in Table 812.

Table 812 – Remote primitives issued or received by CTLDINA

Primitive	Source	Destination	Associated parameters	Functions
ARP_getMACQ.ind	ARP	CTLDINA	MAC_Address, IP_Address	—
ARP_getMAC.req	CTLDINA	ARP	IP_Address	—
DCPHMCR_Activate.req	CTLDINA	DCPHMCR	CREP, VLAN-Prio, VLAN-ID, DCPHMC_Timeout	—
DCPMCS_Activate.req	CTLDINA	DCPMCS	CREP, VLAN-Prio, VLAN-ID, DCPMC_Timeout	—
DCP_Identify.req	CTLDINA	DCPMCS	CREP, ListofFilter, ResponseDelay, DCP_Para.isASU	—
DCP_Set.req	CTLDINA	DCPUCS	CREP, DA, DataSet, Dev_IP_Para, SetCmd	—
DCPUCS_Activate.req	CTLDINA	DCPUCS	CREP, VLAN-Prio, VLAN-ID, DCPUC_Timeout	—
DNS_QueryName.req	CTLDINA	DNS	StationName.RealStationName	—
DCP_Hello.ind	DCPHMCR	CTLDINA	CREP, ListOfData	—

Primitive	Source	Destination	Associated parameters	Functions
DCPHMCR_Activate.cnf (-)	DCPHMCR	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCPHMCR_Activate.cnf (+)	DCPHMCR	CTLDINA	CREP	—
DCPHMCR_Close.cnf (-)	DCPHMCR	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCPHMCR_Close.cnf (+)	DCPHMCR	CTLDINA	CREP	—
DCP_Identify.cnf (-)	DCPMCS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCP_Identify.cnf (+)	DCPMCS	CTLDINA	CREP, ListOfData	—
DCPMCS_Activate.cnf (-)	DCPMCS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCPMCS_Activate.cnf (+)	DCPMCS	CTLDINA	CREP	—
DCPMCS_Close.cnf (-)	DCPMCS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCPMCS_Close.cnf (+)	DCPMCS	CTLDINA	CREP	—
DCP_Set.cnf (-)	DCPUCS	CTLDINA	CREP, DA, ERRCLS, ERRCODE	—
DCP_Set.cnf (+)	DCPUCS	CTLDINA	CREP, DA, ListOfResponse	—
DCPUCS_Activate.cnf (-)	DCPUCS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCPUCS_Activate.cnf (+)	DCPUCS	CTLDINA	CREP	—
DCPUCS_Close.cnf (-)	DCPUCS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DCPUCS_Close.cnf (+)	DCPUCS	CTLDINA	CREP	—
DNS_QueryName.cnf (-)	DNS	CTLDINA	CREP, ERRCLS, ERRCODE	—
DNS_QueryName.cnf (+)	DNS	CTLDINA	IP_Add	—

5.6.4.12.1.2 Primitives exchanged between local machines

The local service primitives including their associated parameters issued or received by CTLDINA are described in the service definition and shown in Table 813.

Table 813 – Local primitives issued or received by CTLDINA

Primitive	Source	Destination	Associated parameters	Functions
CTLDINA_Discover_req	CMCTL	CTLDINA	Add_resolution, StationName, Dev_IP_Para, DCP_Para	This service starts the device discovery and name resolution process.

Primitive	Source	Destination	Associated parameters	Functions
CTLDINA_Discover_cnf (-)	CTLDINA	CMCTL	ErrorClass, ErrorCode	This service primitive indicates that the address and name resolution service failed. The error parameter contains the reason for the failure (e.g. no device, multiple devices)
CTLDINA_Discover_cnf (+)	CTLDINA	CMCTL	Dev_MAC_Addr	This service primitive indicates that the Activate service succeeded and delivers the MAC Address of the IO device.
DCP_Identify_ind	DCP	CTLDINA	—	—
CMCTL_state_ind	CTLDINA	CMCTL	state {ABORT}	This service shut down the AR connection establishment.

5.6.4.12.2 State transition diagram

The state transition diagram of the CTLDINA is shown in Figure 124.

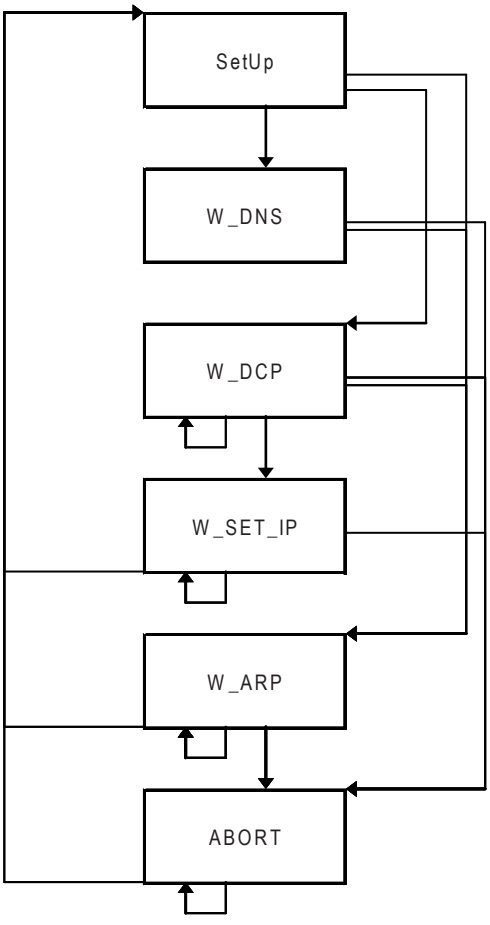


Figure 124 – State transition diagram of CTLDINA

States of the CTLDINA

SetUp	Start the appropriate discovery process and change to the correct next state
W_DNS	Wait for the response of the DNS service and evaluate the result
W_DCP	Wair for the response of the DCP service and evaluate the result
W_SET_IP	Wait for the response of the DCP set service and evaluate the result

W_ARP	Wait for the response of the ARP service and evaluate the result
ABORT	A fault or a late error is detected and signaled

5.6.4.12.3 State machine description

The Context Management Discovery, IP and Name Assignment (CTLDINA) arranges the discovery, IP and station name assignment.

5.6.4.12.4 CTLDINA state table

Table 814 contains the complete description of the CTLDINA state machine.

Table 814 – CTLDINA state table

#	Current State	Event /Condition =>Action	Next State
1	SetUp	**CTLDINA_Discover_req ()** /Add_resolution == DNS => Query := StationName.RealStationName DNS_QueryName.req ()	W_DNS
2	SetUp	**CTLDINA_Discover_req ()** /Add_resolution == DCP => LateError := FALSE ListofFilter := Filter with StationName.RealStationName ResponseDelay := 1 DCP_Identify.req ()	W_DCP
3	SetUp	**CTLDINA_Discover_req ()** /Add_resolution == none => NumberOfARP:=0 IP_Addr := Dev_IP_Para.IP StartTimer (ARP_Timer) ARP_getMAC.req ()	W_ARP
4	W_DNS	**DNS_QueryName.cnf (+)** => NumberOfARP:=0 IP_Addr := Query_IP_Add StartTimer (ARP_Timer) ARP_getMAC.req ()	W_ARP
5	W_DNS	**DNS_QueryName.cnf (-)** / Reason == Time-Out => ErrorClass := CTLDINA ErrorCode := Unknown_RealStationName	ABORT
6	W_DCP	**DCP_Identify_ind ()** /Length(ListOfFoundDevices) == 1 && ListOfFoundDevices.IP-Suite == Dev_IP_Para.IP-Suite => LateError:=TRUE NumberOfARP:=0 IP_Addr := ListOfFoundDevices.IP MAC_Addr := ListOfFoundDevices.SA StartTimer (ARP_Timer) //NOTE Late error handling ARP_getMAC.req () CMDINA_Init_cnf (+)	W_ARP
7	W_DCP	**DCP_Identify.cnf (+)** /Length(ListOfFoundDevices) == 1 && ListOfFoundDevices.IP-Suite == Dev_IP_Para.IP-Suite	W_DCP

#	Current State	Event /Condition =>Action	Next State
		=> ignore	
8	W_DCP	**DCP_Identify.cnf (+)** /Length(ListOfFoundDevices) == 1 && ! (ListOfFoundDevices.IP-Suite == Dev_IP_Para.IP-Suite) => IP_Addr := Dev_IP_Para.IP MAC_Addr := ListOfFoundDevices.SA SetCmd=IP-Suite DCP_Set.req ()	W_SET_IP
9	W_DCP	**DCP_Identify.cnf (+)** /Length(ListOfFoundDevices) > 1 => ErrorClass := CTLDINA ErrorCode := Multiple_RealStationName	ABORT
10	W_DCP	**DCP_Identify.cnf (+)** /Length(ListOfFoundDevices) == 0 => ErrorClass := CTLDINA ErrorCode := No_RealStationName	ABORT
11	W_DCP	**DCP_Identify.cnf (-)** => ErrorClass := CTLDINA ErrorCode := No_StationName	ABORT
12	W_DCP	**DCP_Hello.ind ()** /ListOfFoundDevices.StationName == StationName.RealStationName && ListOfFoundDevices.IP == VALID => LateError:=TRUE NumberOfARP:=0 IP_Addr := ListOfFoundDevices.IP MAC_Addr := ListOfFoundDevices.SA StartTimer (ARP_Timer) //NOTE Late error handling ARP_getMAC.req () CMDINA_Init_cnf (+)	W_ARP
13	W_DCP	**DCP_Hello.ind ()** /ListOfFoundDevices.StationName != StationName.RealStationName || ListOfFoundDevices.IP != VALID => ignore	W_DCP
14	W_SET_IP	**DCP_Set.cnf (+)** => Dev_MAC_Addr := MAC_Addr CTLDINA_Discover_cnf (+)	SetUp
15	W_SET_IP	**DCP_Set.cnf (-)** => ErrorClass := CTLDINA ErrorCode := DCP_Error	ABORT
16	W_SET_IP	DCP_Hello.ind () => ignore	W_SET_IP
17	W_SET_IP	DCP_Identify.cnf () => ignore	W_SET_IP
18	W_SET_IP	DCP_Identify_ind () => ignore	W_SET_IP

#	Current State	Event /Condition =>Action	Next State
19	W_ARP	**ARP_getMACQ.ind ()** /IP_Address == Dev_IP_Para.IP && DifferentMacAddress => NumberOfARPs:= NumberOfARPs + 1 Dev_MAC_Addr := MAC_Address	W_ARP
20	W_ARP	**ARP_getMACQ.ind ()** /IP_Address != Dev_IP_Para.IP || (IP_Address == Dev_IP_Para.IP && !DifferentMacAddress) => ignore	W_ARP
21	W_ARP	**TimerExpired (ARP_Timer)** /NumberOfARPs == 0 => ErrorClass := CTLDINA ErrorCode := No_IP_Addr	ABORT
22	W_ARP	**TimerExpired (ARP_Timer)** /NumberOfARPs > 1 => ErrorClass := CTLDINA ErrorCode := Multiple_IP_Addr	ABORT
23	W_ARP	**TimerExpired (ARP_Timer)** /NumberOfARPs == 1 && LateError == FALSE => CTLDINA_Discover_cnf (+)	SetUp
24	W_ARP	**TimerExpired (ARP_Timer)** /NumberOfARPs == 1 && LateError == TRUE => ignore	SetUp
25	W_ARP	**DCP_Identify.cnf ()** /LateError == FALSE => ignore	W_ARP
26	W_ARP	**DCP_Identify.cnf (+)** /LateError == TRUE && Length(ListOfFoundDevices) > 1 => ErrorClass := CTLDINA ErrorCode := Multiple_RealStationName	ABORT
27	W_ARP	**DCP_Identify.cnf (+)** /LateError == TRUE && Length(ListOfFoundDevices) == 0 => ErrorClass := CTLDINA ErrorCode := No_RealStationName	ABORT
28	W_ARP	**DCP_Identify.cnf (+)** /LateError == TRUE && Length(ListOfFoundDevices) == 1 => ignore	W_ARP
29	W_ARP	DCP_Hello.ind () => ignore	W_ARP
30	W_ARP	DCP_Identify_ind () => ignore	W_ARP
31	ABORT		SetUp

#	Current State	Event /Condition =>Action	Next State
		/LateError == FALSE => Close all open underlaying state machines CTLDINA_Discover_cnf (-)	
32	ABORT	 /LateError == TRUE => Close all open underlaying state machines CMCTL_state_ind (ABORT)	SetUp
33	ABORT	DCP_Hello.ind () => ignore	ABORT
34	ABORT	DCP_Identify.cnf () => ignore	ABORT
35	ABORT	DCP_Identify_ind () => ignore	ABORT

5.6.4.12.5 Functions, Macros, Timers and Variables

Table 815 contains the functions, macros, timers and variables used by the CTLDINA and their arguments and their descriptions.

Table 815 – Functions, Macros, Timers and Variables used by the CTLDINA

Name	Type	Function/Meaning
StartTimer	Function	This local function starts or retriggers a timer
StopTimer	Function	This local function stops a timer
TimerExpired	Function	This local function is executed if a timer expires
DifferentMacAddress	Macro	This local macro checks whether the MAC address of the sender of the ARP response is equal or different to the already stored MAC address. The first received ARP is always different.
Length (ListOfFoundDevices)	Macro	This local macro calculates the number of elements of the ListOfFoundDevices list
Store parameters	Macro	This local macro stores parameters in the context of the CTLDINA
ARP_Timer	Timer	This timer is used to monitor the response for the ARP service
ErrorClass	Variable	This local variable contains the error location
ErrorCode	Variable	This local variable contains the error code in the context of the ErrorClass
LateError	Variable	This local variable is used for the late error handling to speed up the startup during normal operation.
ListOfFilters	Variable	This local variable contains the list of DCP options/suboptions which are used for the DCP_Identify service
ListOfFoundDevices	Variable	This local variable contains the list of DCP options/suboptions which are delivered by the DCP_Identify service
NumberOfARP	Variable	This local variable contains amount of received ARP responses
Query	Variable	This local variable contains the list of parameters which are used for the DNS service

5.6.4.12.6 Automatic NameOfStation assignment

The CTLDINA should be extended for automatic NameOfStation assignment. The principle state transition diagram is shown in Figure 125.

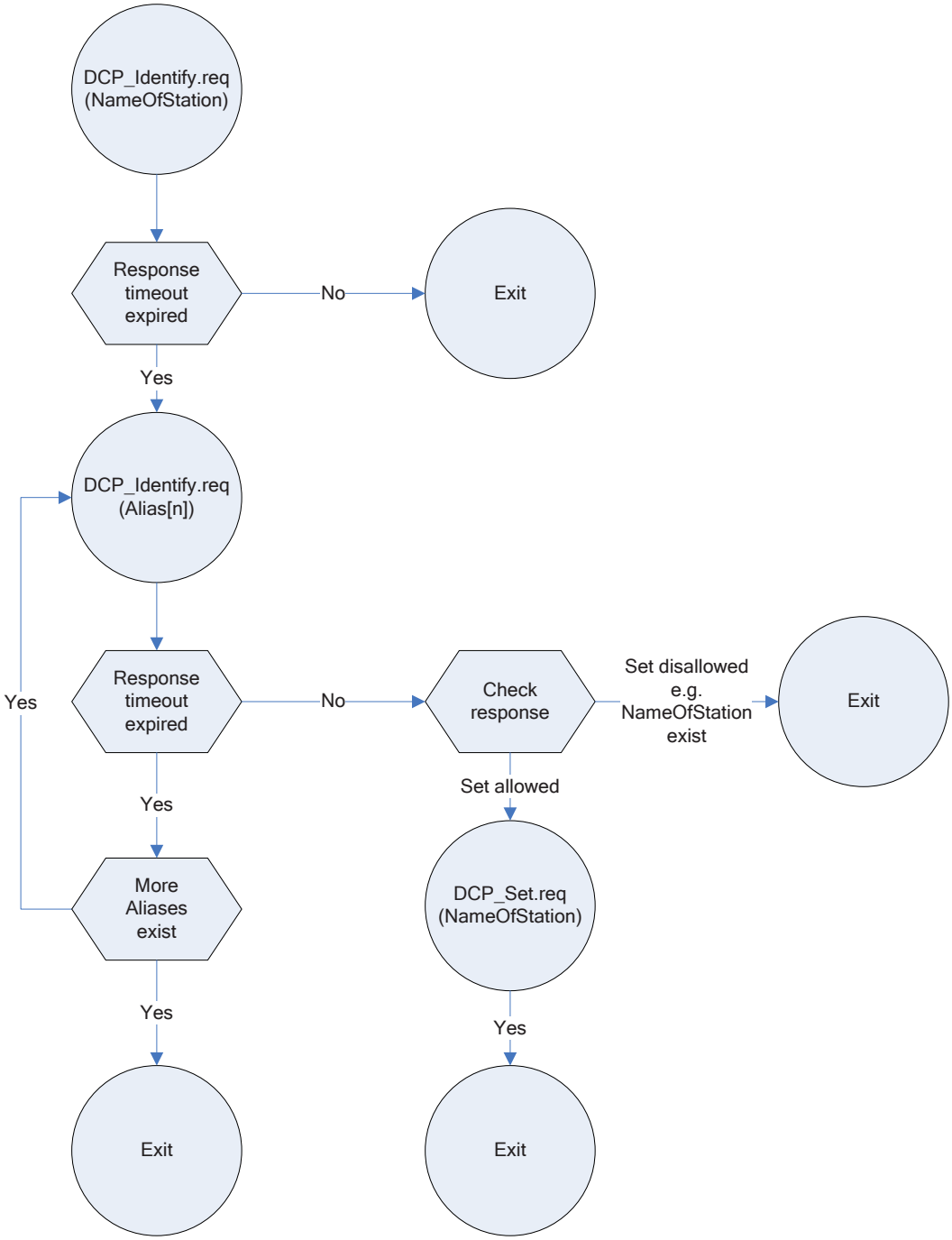


Figure 125 – Automatic NameOfStation assignment

5.7 DLL Mapping Protocol Machines

The DLL Mapping Protocol Machines (DMPM) mapping shall be according to 4.18.2.

Annex A
(normative)

Unified establishing of an AR for all RT classes

This standard offers a unified AR establishment for all kinds of CRs. For this reason, the software effort may be reduced.

The AR establishing is parted into period “A” between Connect and PrmEnd and period “B” after PrmEnd.

During “A” the connection monitoring is done locally by the IOD using CMInitiatorTimeout and by the IOC using the given RPC monitoring. Additionally a defined “Application timeout” of 300 s is used by the IOC.

During “B” the connection monitoring is switched from the model in period “A” to a connection monitoring using the WDT / DHT of the RT_CLASS_1 / RT_CLASS_2 (GREEN) or RT_CLASS_3 (RED) IOCRs.

NOTE The IOD (acting as RPC server) needs no additional timeout, because it activates the CMInitiatorTimeout again, after the RPC response was sent.

Table A.1 shows the attributes of the examples.

Table A.1 – Examples for the AR establishing

Figure	Traffic mode	Meaning
Figure A.1, Figure A.2, Figure A.3, Figure A.4 and Figure A.5	GREEN or RED	All kinds of RT and IRT communication The connection monitoring is done in parallel with RPC and RT. As long as the GREEN / RED monitoring isn’t established, the monitoring is done by RPC. This figure shows the RPC communication thread which is synchronized with the RT communication thread. For interoperability with previous versions see Table B.1.

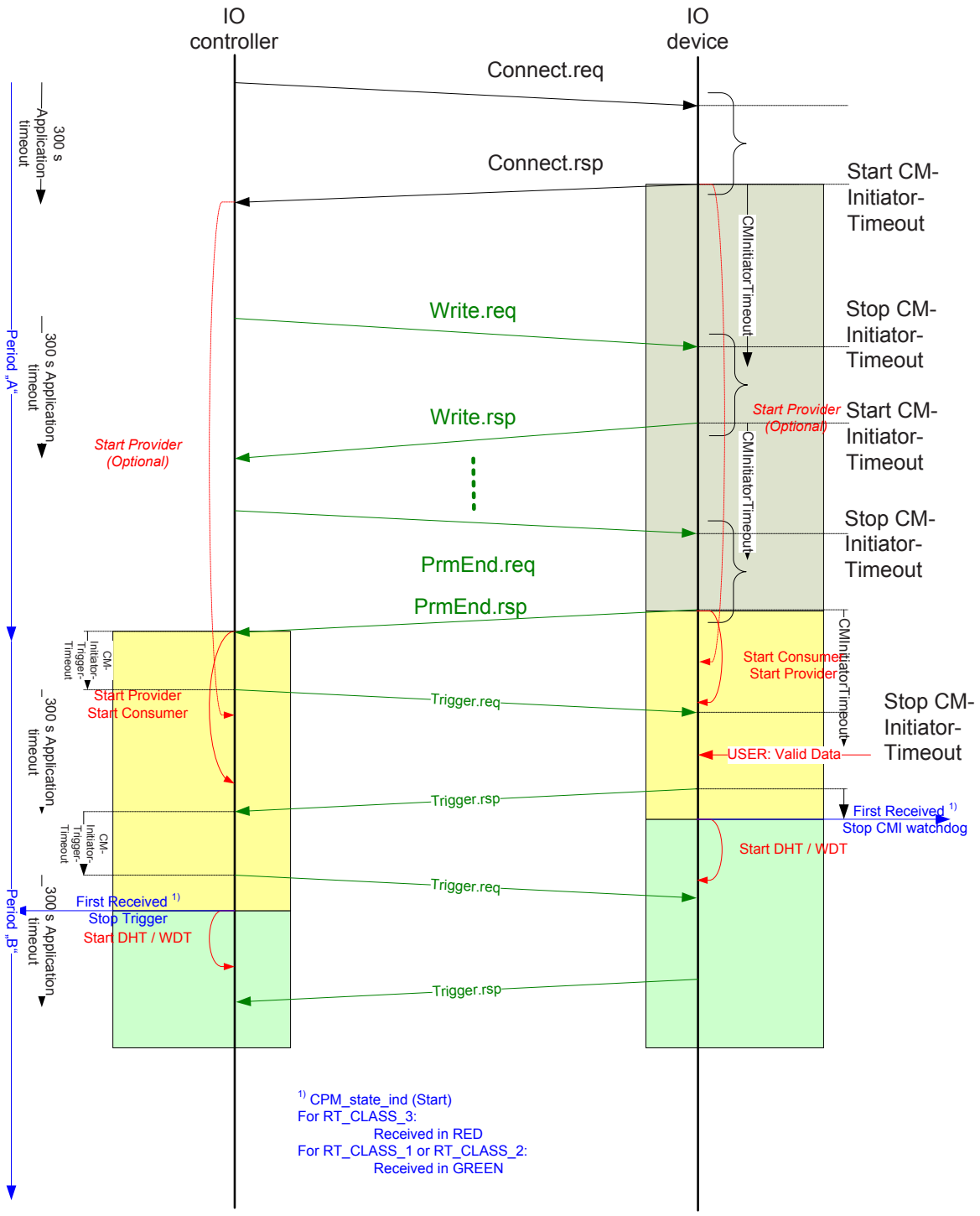


Figure A.1 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Initial connection monitoring w/o RT)

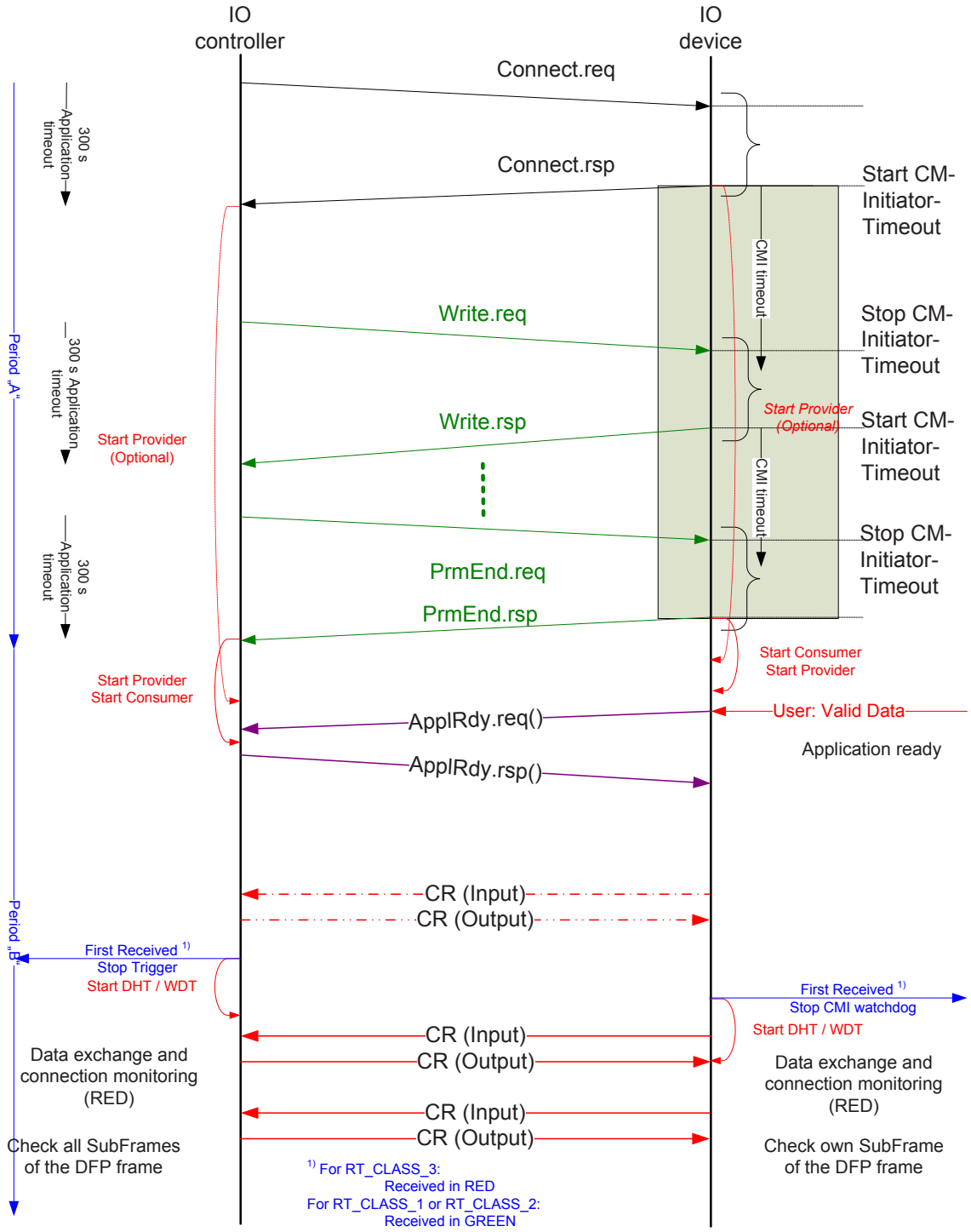


Figure A.2 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Connection monitoring with RT)

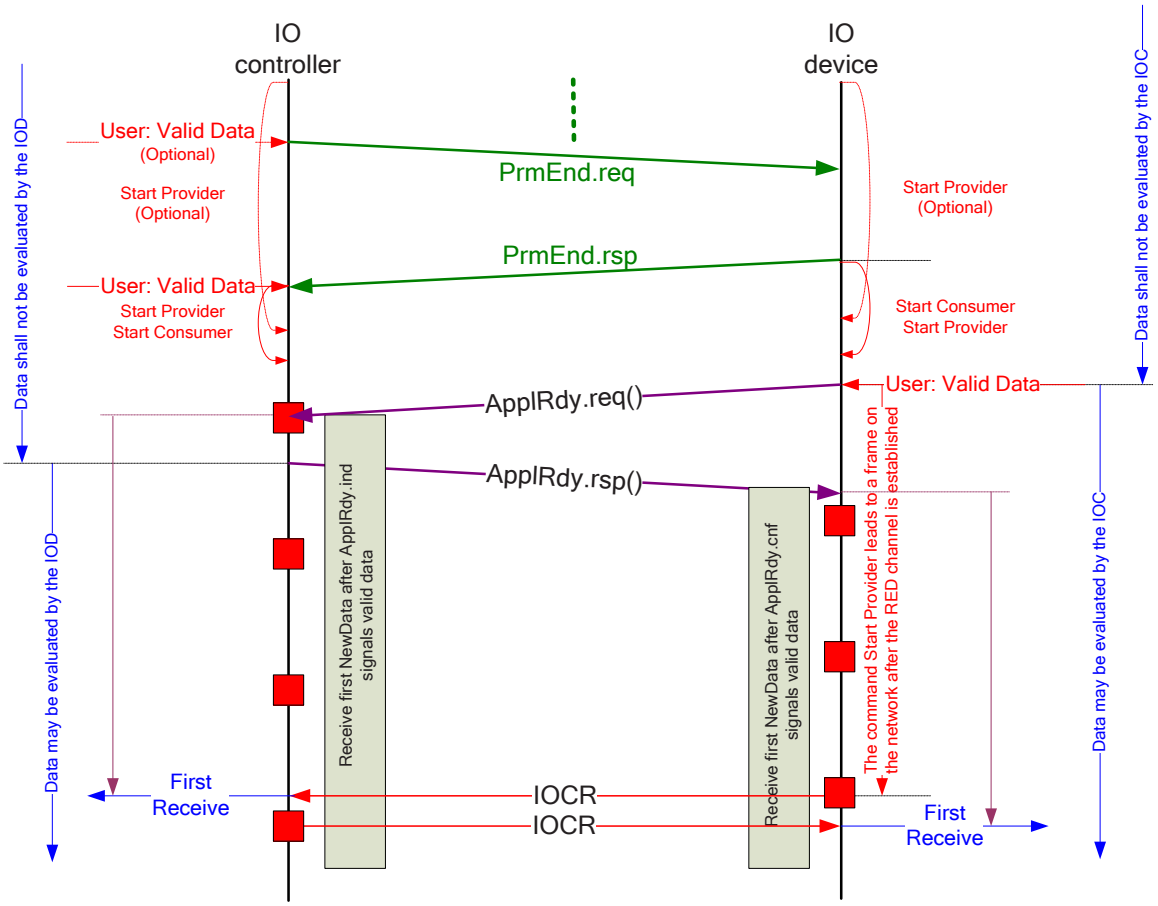


Figure A.3 – Principle of the data evaluation during startup (RED channel establishment delayed)

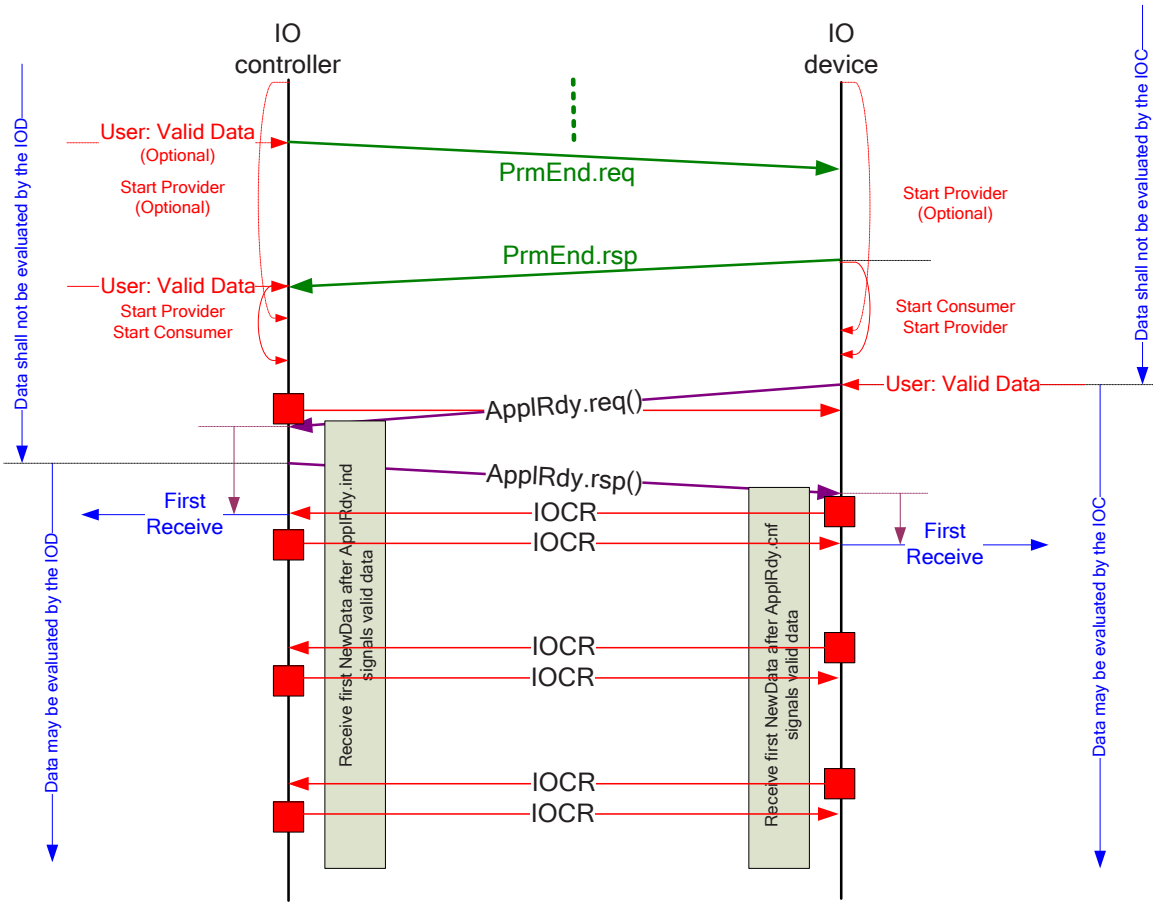


Figure A.4 – Principle of the data evaluation during startup (RED channel establishment early)

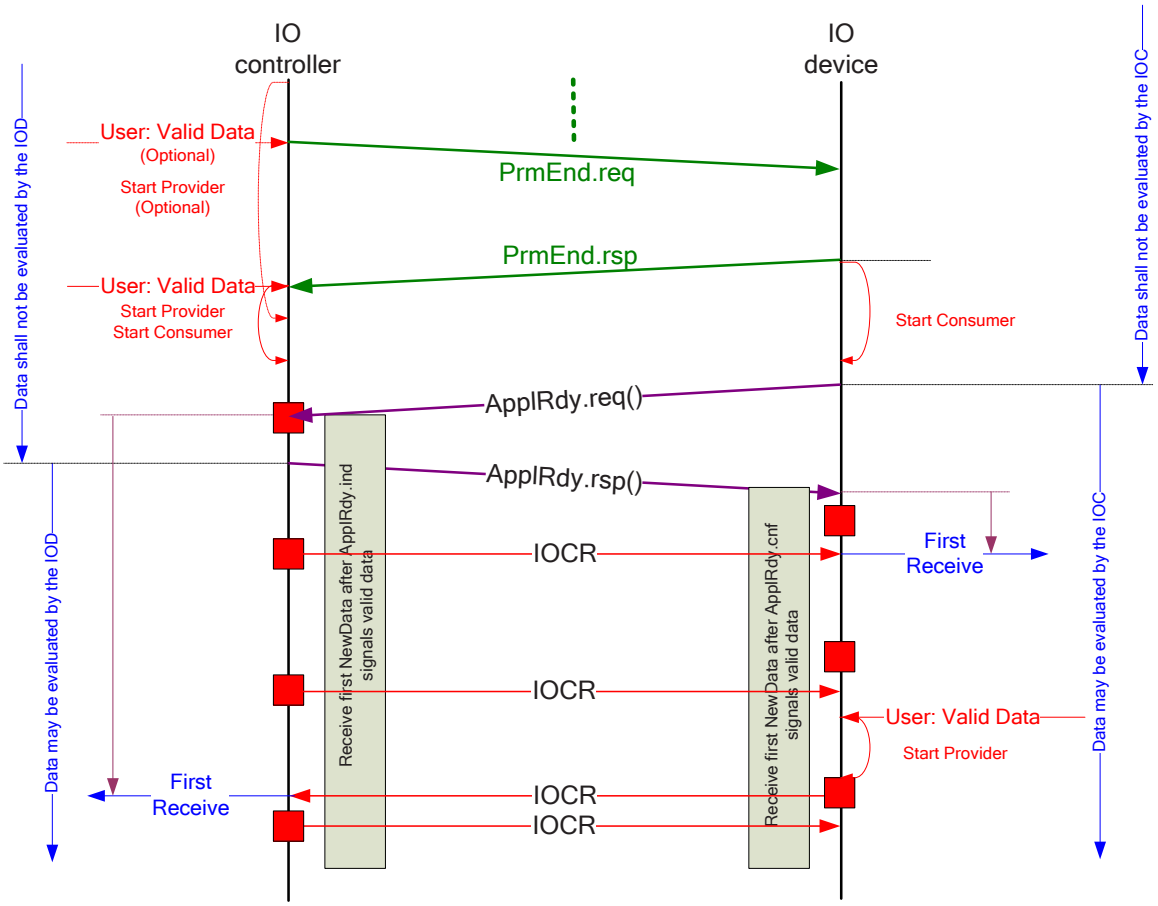


Figure A.5 – Principle of the data evaluation during startup (Special case: Isochronous mode application)

An isochronous mode application needs to be isochronous at application level. This may delay the existence of valid data. The device may start later with its then valid data, to avoid a prolongation of Application Ready.

Annex B
(normative)

Compatible establishing of an AR

This standard offers compatibility, encoded by ARProperties.StartUpMode == Legacy, for all kind of ARs. Table B.1 shows the attributes of the examples. The IO device defines the speed of the establishing.

Table B.1 – Examples for compatible AR establishing

Figure	Mode	Meaning
Figure B.1	ARProperties.StartupMode == Legacy	IRT communication with SendClock greater or equal 250 μs This compatible mode ensures interoperability with the earlier versions of this standard.
Figure B.2	ARProperties.StartupMode == Legacy	RT communication with SendClock greater or equal 250 μs This compatible mode ensures interoperability with the earlier versions of this standard.

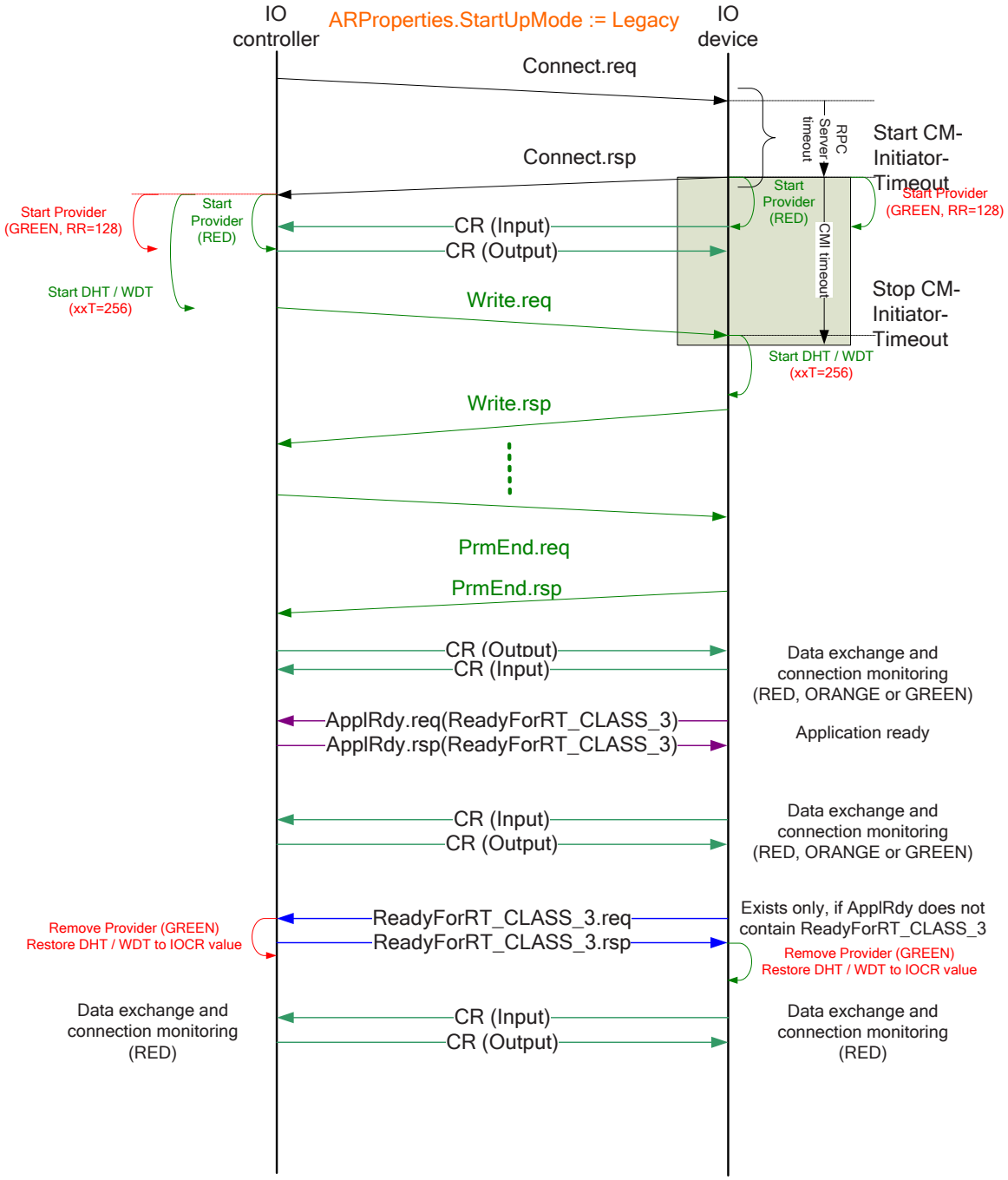


Figure B.1 – Establishing of an AR using RT_CLASS_3 AR with startup mode “Legacy”

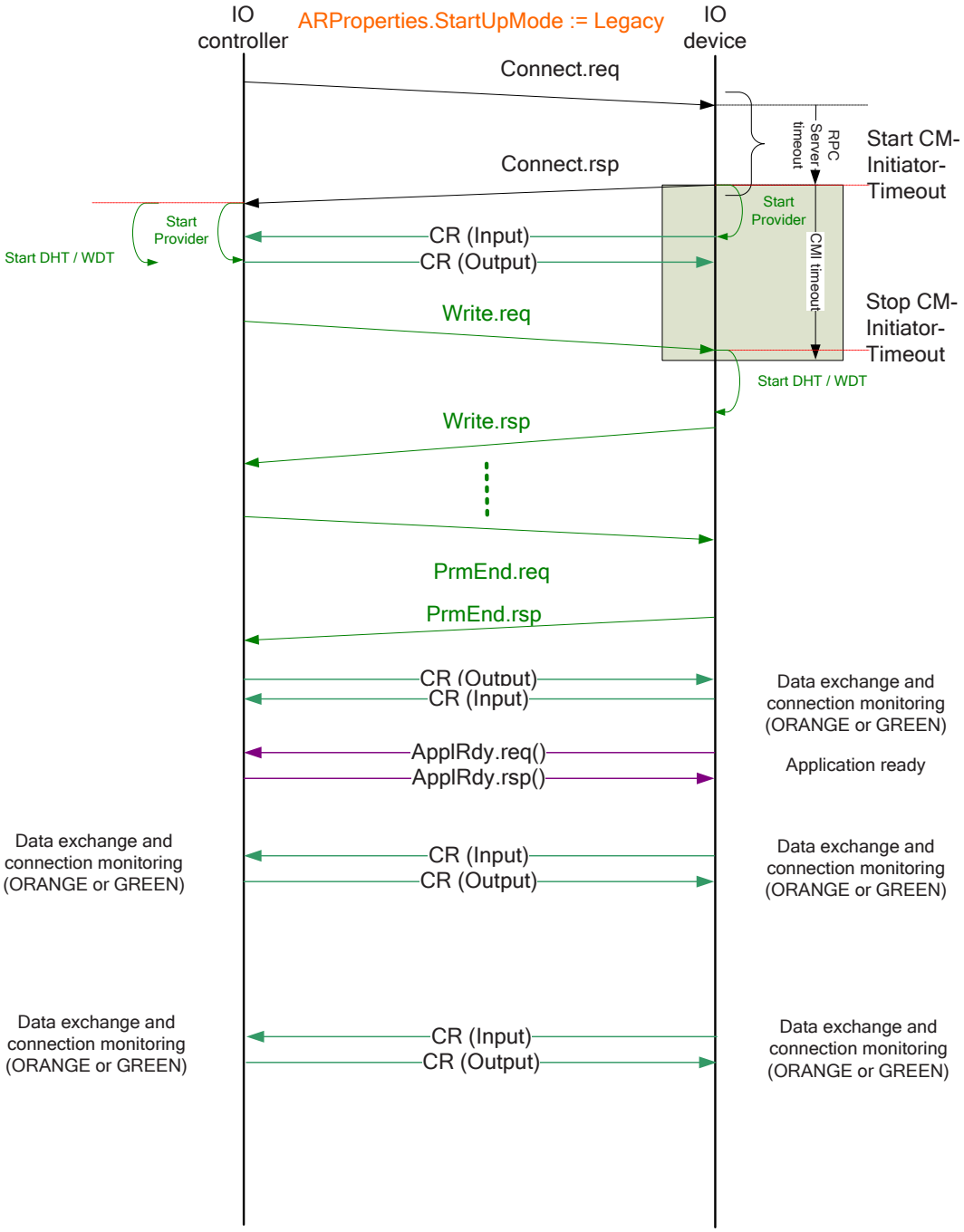


Figure B.2 – Establishing of an AR using RT_CLASS_1, 2 or UDP AR with startup mode “Legacy”

Annex C
(informative)

Establishing of a device access AR

As an example of a device access AR see Figure C.1. Only Connectionless RPC is used to drive this kind of AR.

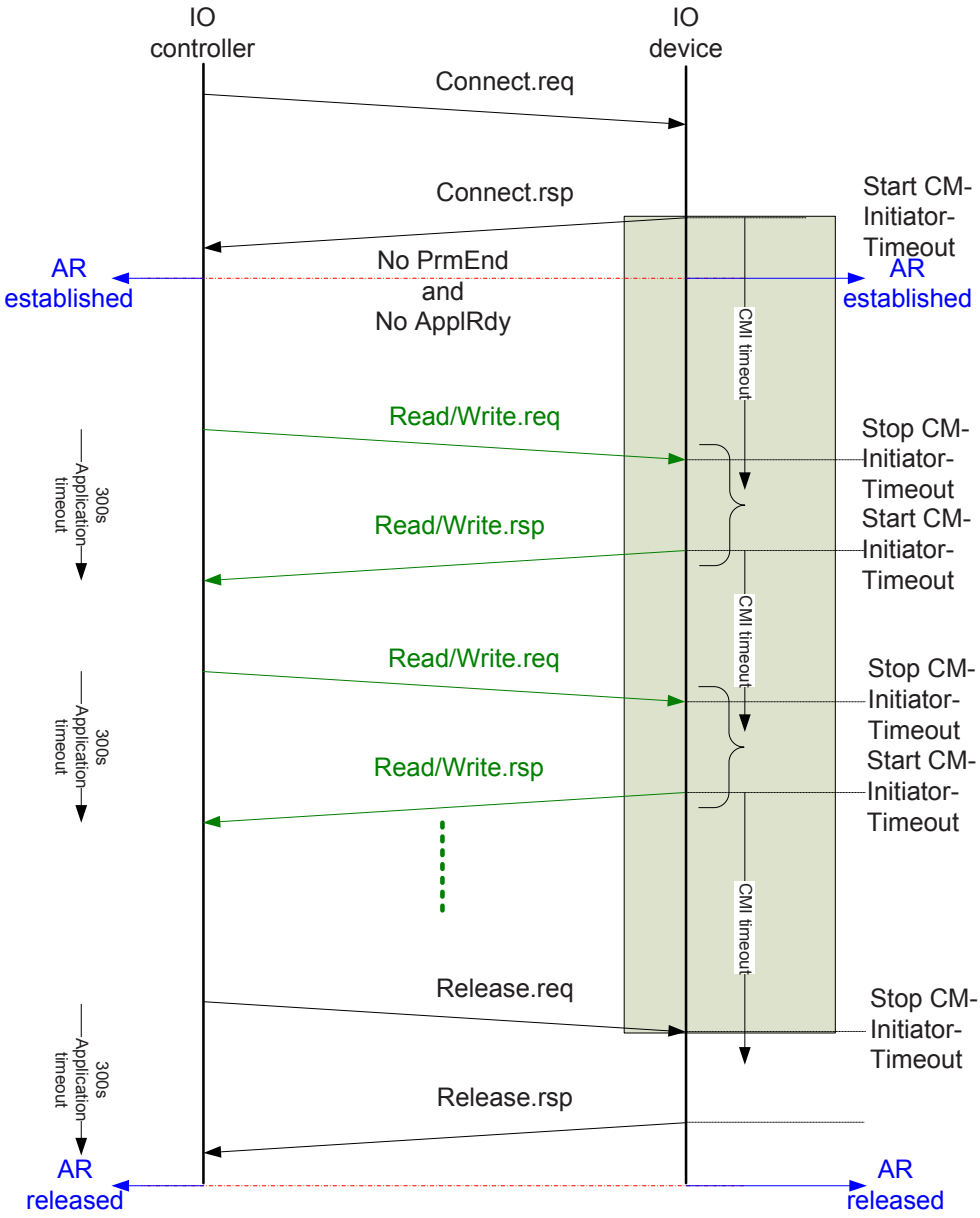


Figure C.1 – Establishing of a device access AR

Annex D
(informative)

Establishing of an AR (accelerated procedure)

As an example of an accelerated startup see Figure D.1. The timeout/response control for an accelerated startup is done by concurrent running timers. After the response the state machine of the IO controller go immediate to the next state. This model replaces the cascading of three timers (Identify timeout, Set timeout and ARP timeout) as shown in Formula (D.1) by a model which cascades only $\Delta t\ IOD_x$ and $\Delta t\ IOC_y$ as shown in Formula (D.2).

$$\text{Startup Delay before Connect} = \Delta t\ IOC_1 + \text{Identify timeout(1 s)} + \Delta t\ IOC_2 + \Delta t\ IOC_3 + \text{ARP timeout(2 s)} + \Delta t\ IOC_4 \quad \text{(D.1)}$$

where

Startup Delay before Connect	is the startup before connect variable
$\Delta t\ IOC_1$	is the time between IO controller startup and first received hello
Identify timeout	is the identify timeout variable
$\Delta t\ IOC_2$	is the time between sending the ARP request after identification
$\Delta t\ IOC_3$	is the time between sending the set request after address resolution
$\Delta t\ IOC_4$	is the time between sending the connect request after setting the IP address
ARP timeout	is the ARP timeout variable

$$\text{Startup Delay before Connect} = \Delta t\ IOC_1 + \Delta t\ IOD_1 + \Delta t\ IOC_2 + \Delta t\ IOD_2 + \Delta t\ IOC_3 + \Delta t\ IOD_3 + \Delta t\ IOC_4 \quad \text{(D.2)}$$

where

Startup Delay before Connect	is the startup before connect variable
$\Delta t\ IOC_1$	is the time between IO controller startup and first received hello
$\Delta t\ IOD_1$	is the time between responding the identify request
$\Delta t\ IOC_2$	is the time between sending the ARP request after identification
$\Delta t\ IOD_2$	is the time between responding the ARP request
$\Delta t\ IOC_3$	is the time between sending the set request after address resolution
$\Delta t\ IOD_3$	is the time between responding the set request
$\Delta t\ IOC_4$	is the time between sending the connect request after setting the IP address

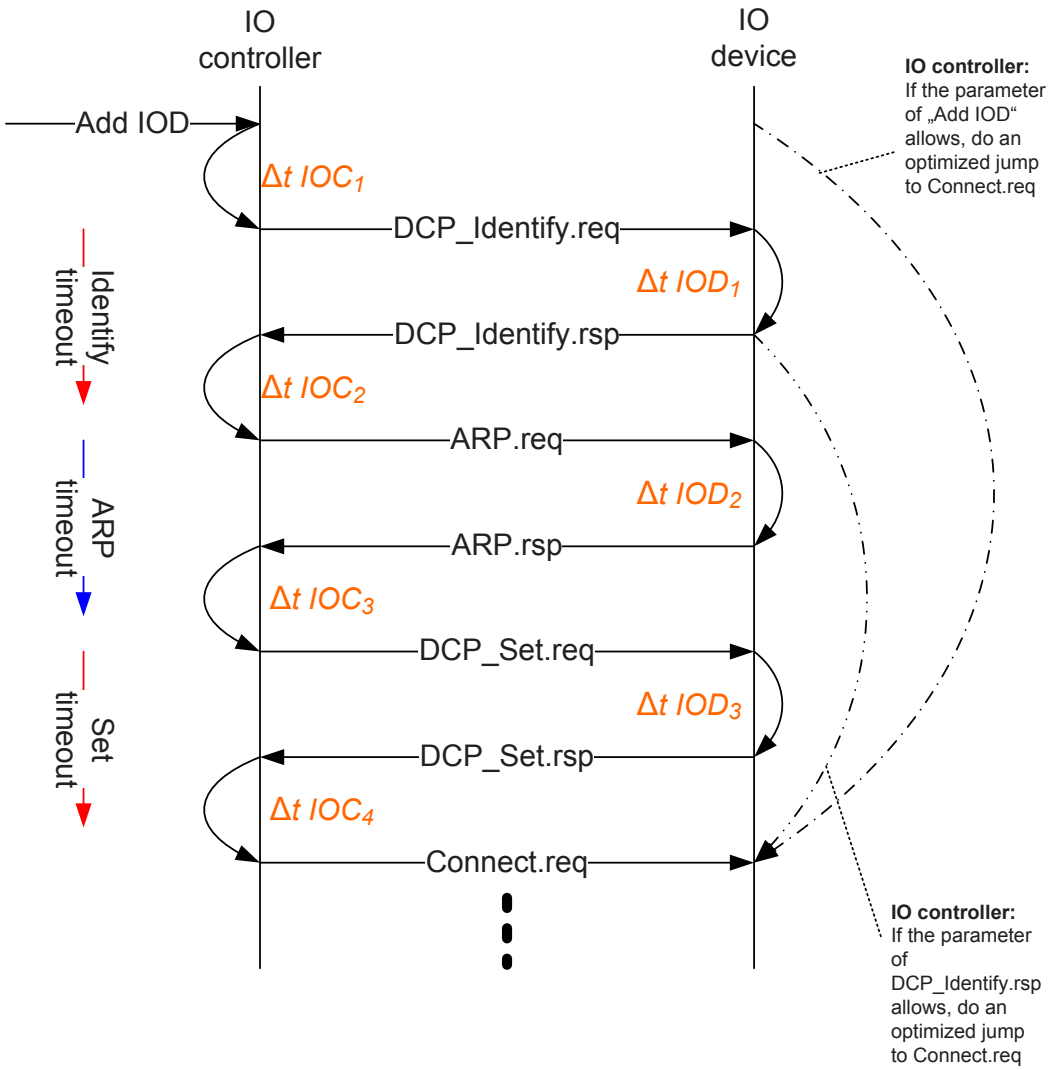
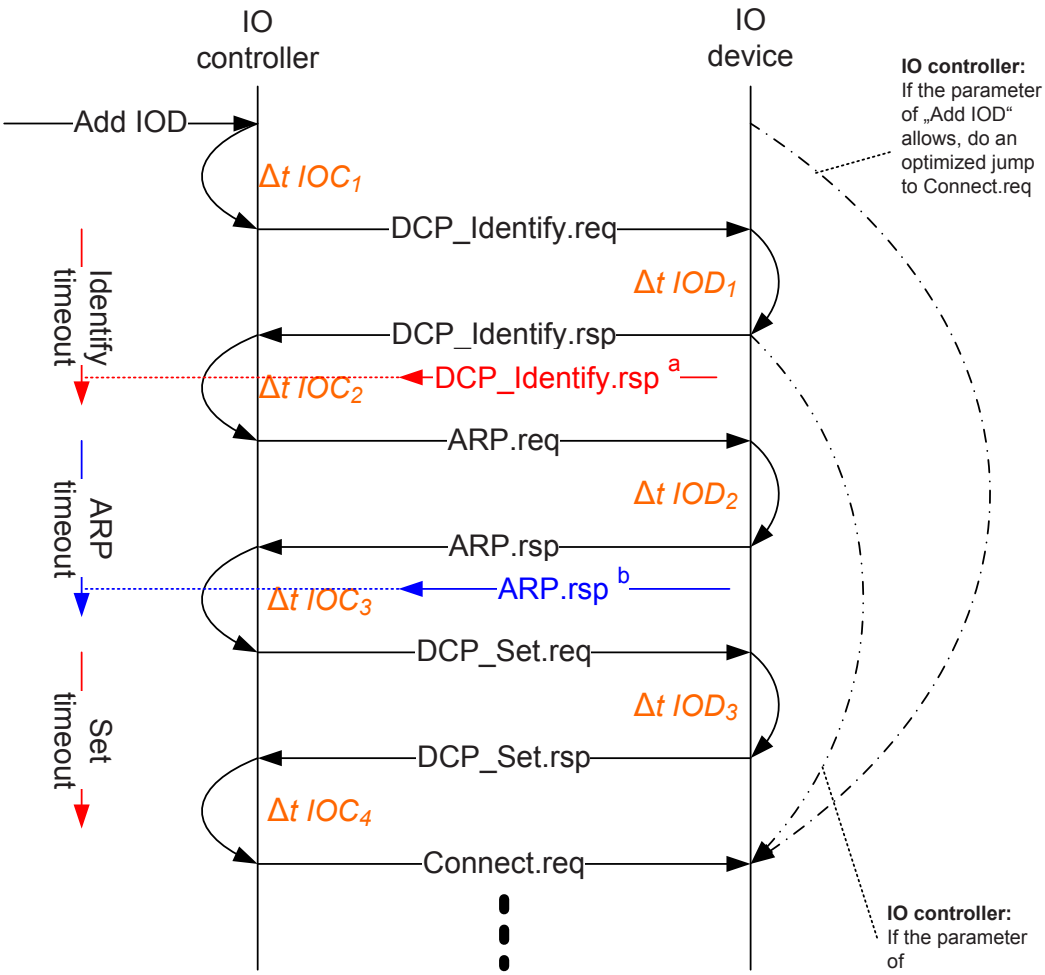


Figure D.1 – Accelerated establishing of an IOAR without error

Figure D.2 shows an example of an accelerated startup with a “late” error. In this case the connect procedure shall be abort according to the state machine of the IO controller.



[a] The late fault detection stops the establishing of an IO AR
[b] The late fault detection stops the establishing of an IO AR

Figure D.2 – Accelerated establishing of an IOAR with “late” error

Annex E
(informative)

Establishing of an AR (fast startup procedure)

The accelerated startup shown in Annex D offers a fair ability for faster systems. For systems which produce with different tools e.g. robots with toolkits, the accelerated startup needs additional enhancements. This so called fast startup is shown in Figure E.1. In this case the IO device offers the IO controller with a DCP_Hello.req all required information to directly jump to the Connect service. The required delay is decrease as shown in Formula (E.1) and (E.2).

$$\text{Startup Delay before Connect} = \Delta t\ IOC_1 + \Delta t\ IOC_2 \quad \text{(E.1)}$$

where

Startup Delay before Connect	is the startup before connect variable
$\Delta t\ IOC_1$	is the time between IO controller startup and first received hello
$\Delta t\ IOC_2$	is the time between first received hello and connect service

If the startup state machine of the IO controller is active before the IO device is switched on, then Formula (E.2) can be assumed.

$$\text{Startup Delay before Connect} = \Delta t\ IOC_2 \quad \text{(E.2)}$$

where

Startup Delay before Connect	is the startup before connect variable
$\Delta t\ IOC_2$	is the time between first received hello and connect service

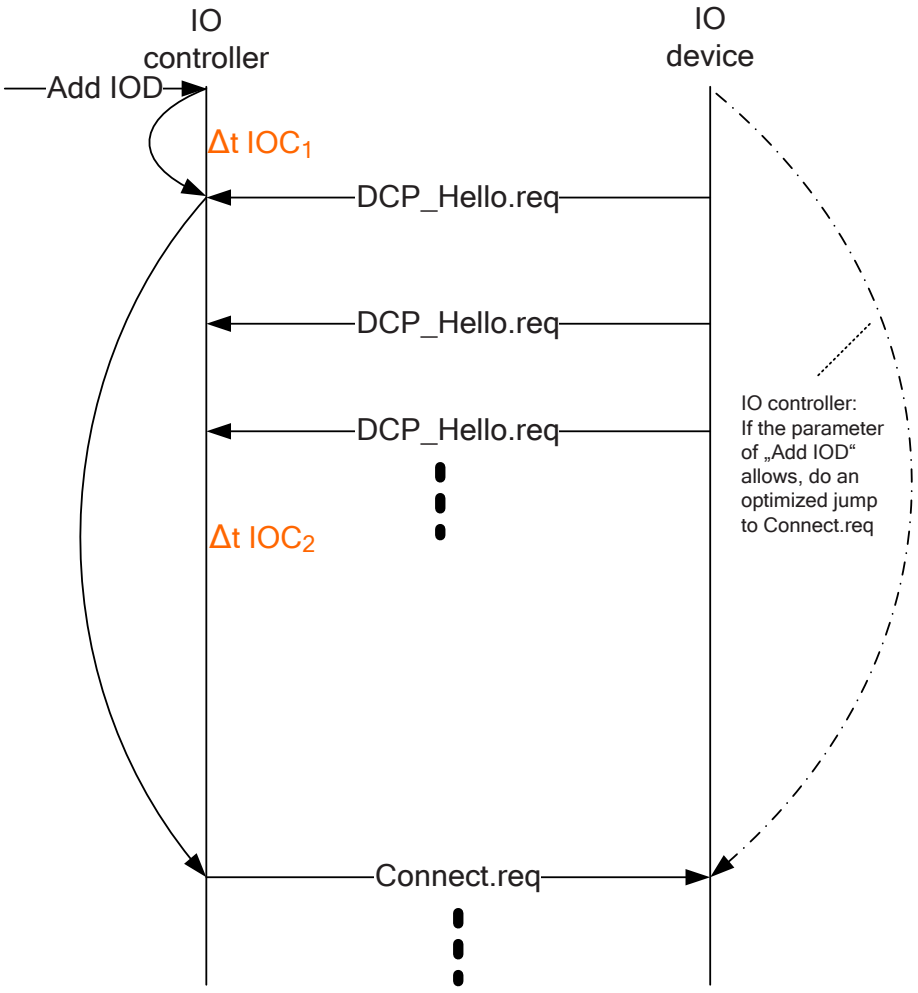


Figure E.1 – Establishing of an IOAR using fast startup

Annex F
(informative)

Example of the upload, storage and retrieval procedure

More and more IO devices need commissioning before they can do their task. Sensors, robots and light shields need to be taught. This work, done by a commissioning engineer, leads to parameters which only exist in the IO device.

These commissioning or teaching parameters are stored persistently in the IO device, to keep them available after a power cycle.

To cover a malfunction of the IO device, these parameters should also be stored outside of the IO device. This external storage may be any kind of non-volatile media like a removable memory card. It also could be the memory of the host of the IO controller.

The upload and retrieval alarm notification offers in combination with read and write record the ability to do an upload with storage and a retrieval of these parameters.

Figure F.1 shows an example of upload with storage and Figure F.2 shows an example of retrieval of parameters.

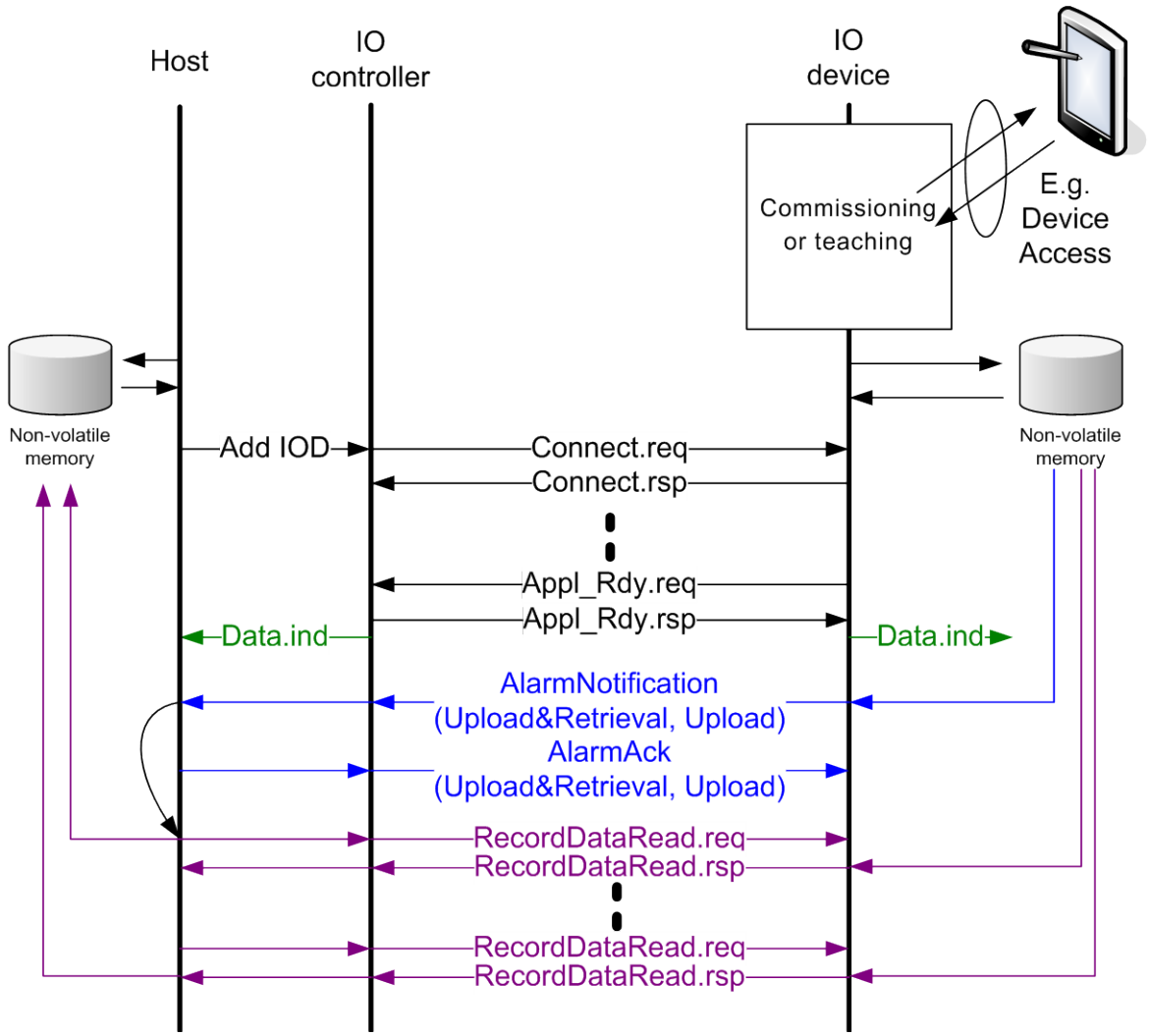


Figure F.1 – Example of upload with storage

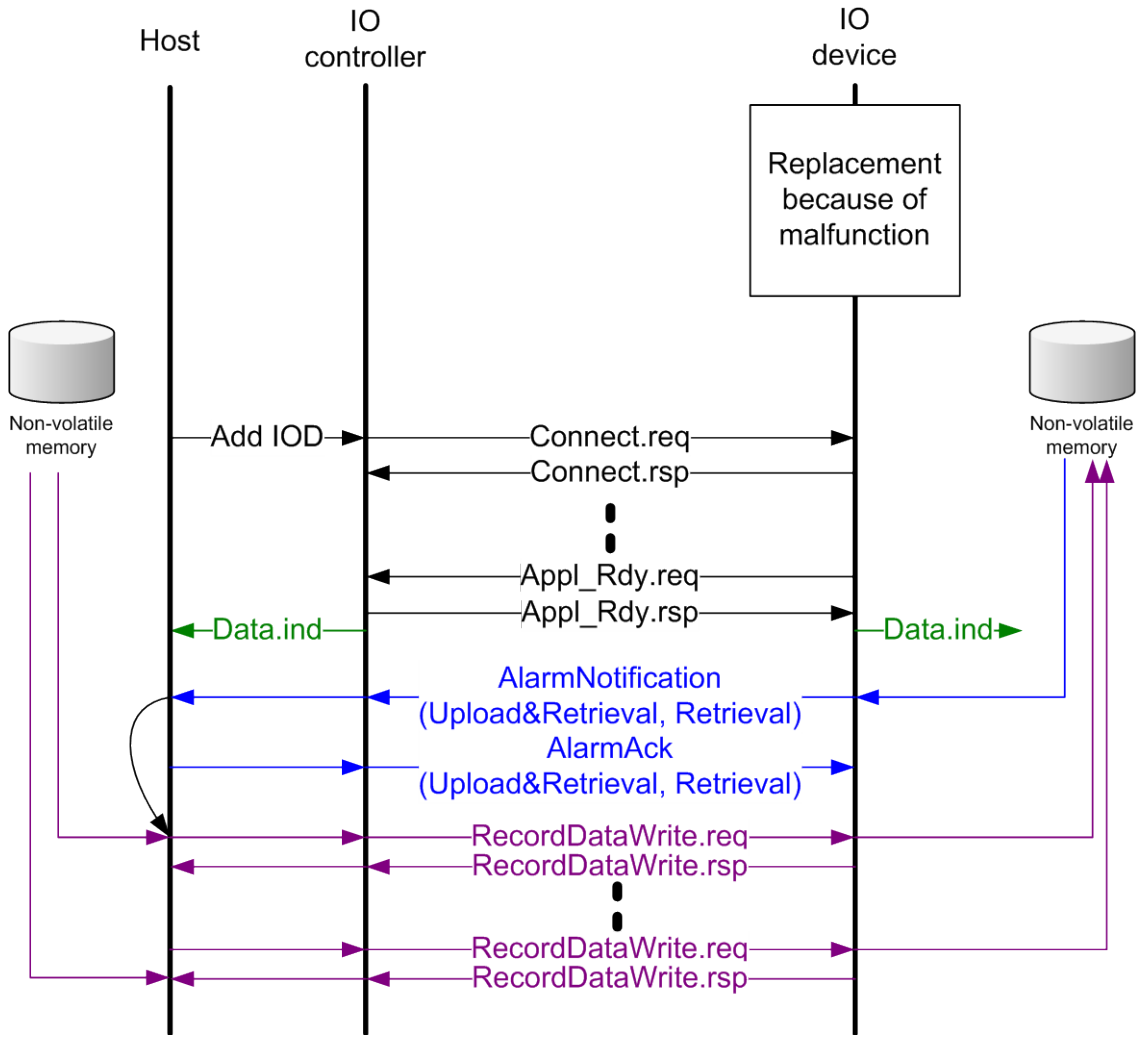


Figure F.2 – Example of retrieval with storage

Annex G
(informative)

OSI reference model layers

Figure G.1 shows the assignment of used protocols to the OSI reference model layers.

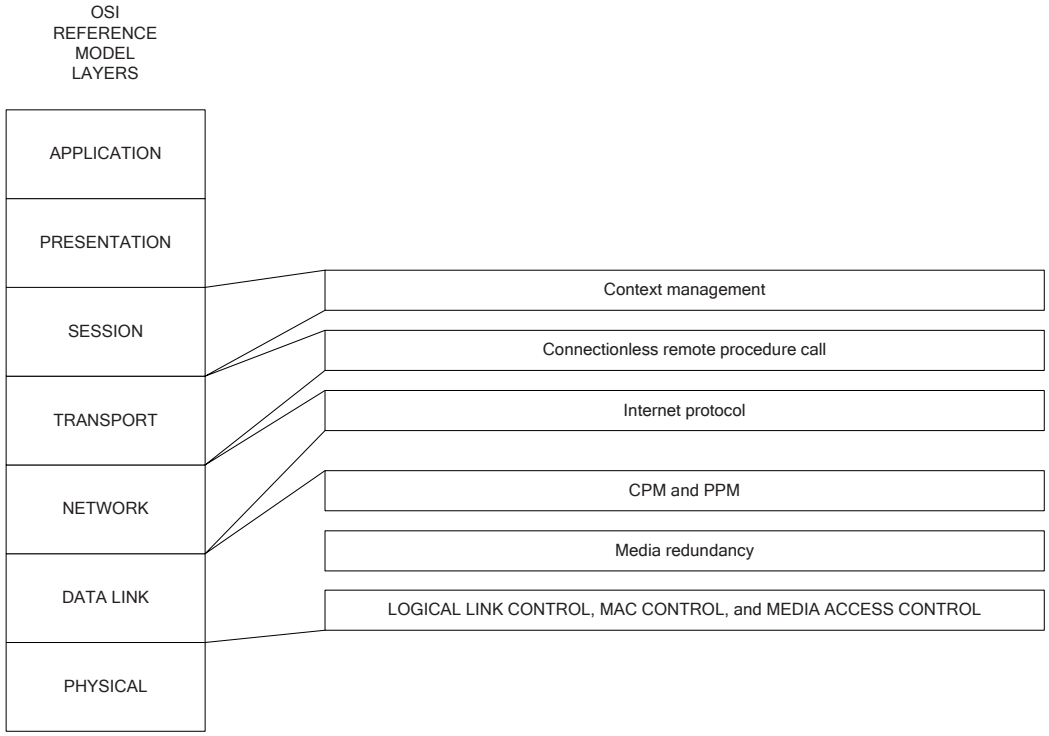


Figure G.1 – Assignment of the OSI reference model layers

Annex H
(informative)

Overview of the IO controller and the IO device state machines

Figure H.1 illustrates the general structure of the AL of an IO controller by showing its state machines and the services used by them.

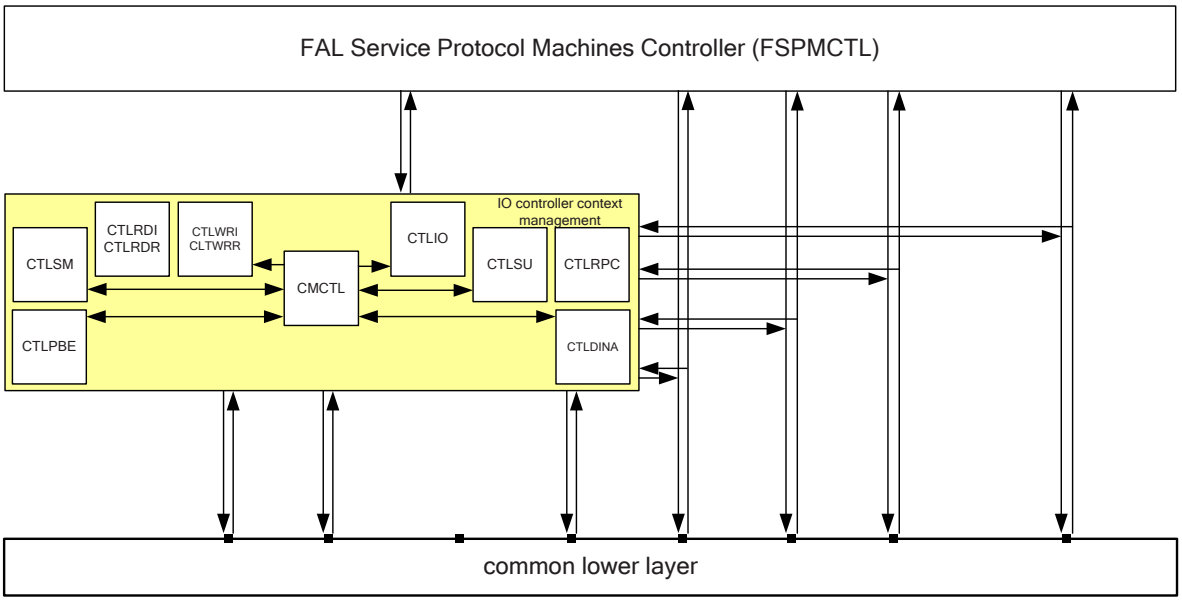


Figure H.1 – Overview of the IO controller state machines

Figure H.2 illustrates the general structure of the AL of an IO device by showing its state machines and the services used by them.

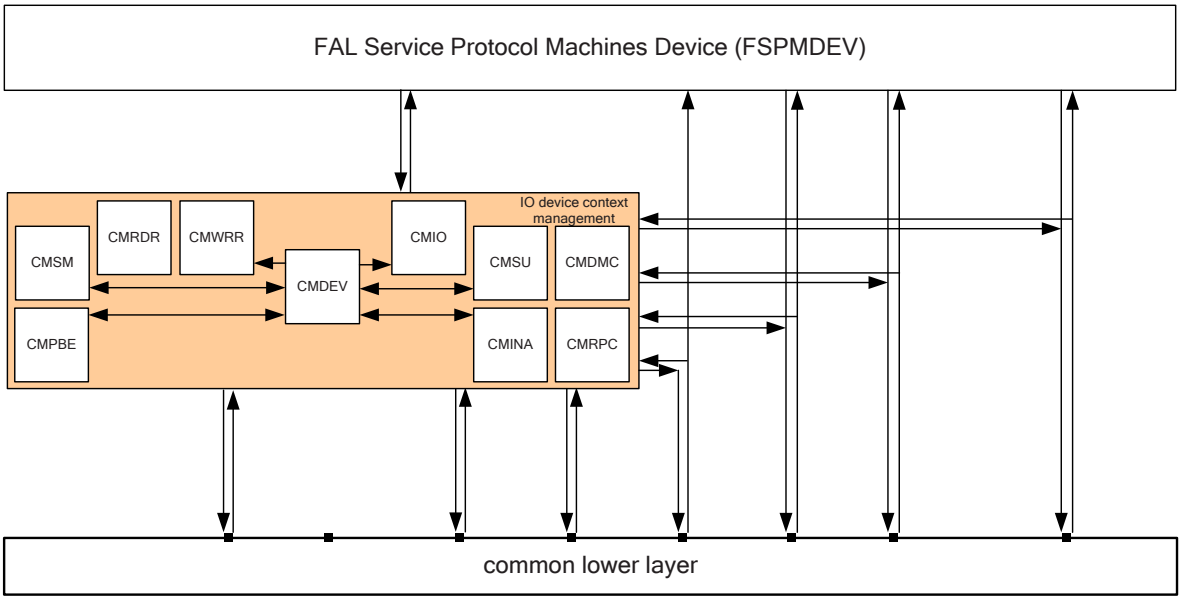


Figure H.2 – Overview of the IO device state machines

Figure H.3 illustrates the general structure of the common AL by showing its state machines.

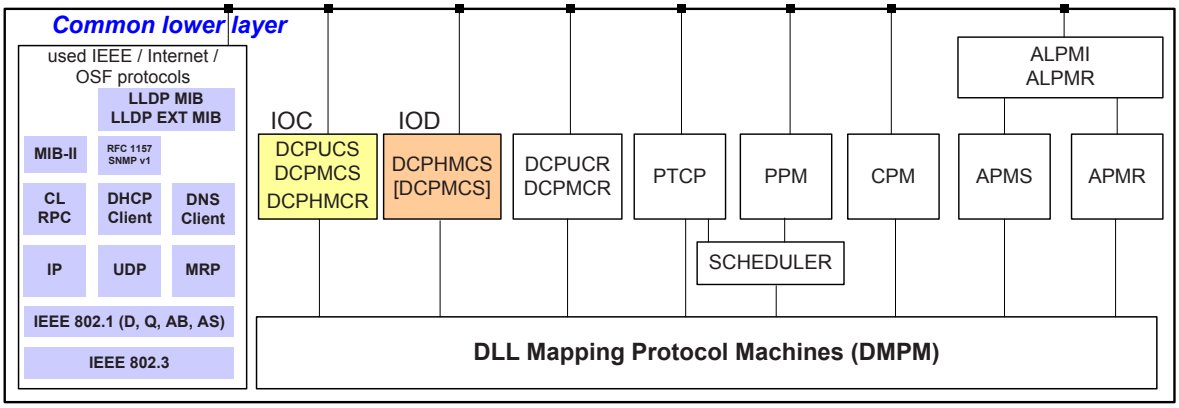


Figure H.3 – Overview of the common state machines

Annex I
(informative)

Priority regeneration

According to IEEE 802.1Q and this standard Table I.1 shows the priority regeneration for a transmit port. The priority decreases from row “Network control high” to row “2, 1”.

Table I.1 – Priority regeneration and queue usage

Priority	Criteria	GREEN PERIOD	RED PERIOD	Meaning
Network control high (IEEE 802.1D)	PTCP synchronization frames	Transmit	Store	Network management PTCP synchronization
Network control low (IEEE 802.1D)	Other management protocols	Transmit	Store	Network management LLDP, PTCP Line delay measurement, media redundancy, …
7 (IEEE 802.1Q)	VLAN priority	Transmit	Store	PTCP announce
6.2 Red queue “planned forwarding” (IEEE 802.1Q)	RT_CLASS_3 frames	Discard [a]	Transmit	Exists only if RED period is established No frames shall be in the red queue, if the RTC3 port state machine is not in state RTCLASS3_RUN. In this case all RT_CLASS_3 frames are received “outside” of the RED PERIOD
6.1 (IEEE 802.1Q)	RT_CLASS_1 and RT_CLASS_2 (GREEN) frames	Transmit	Store	RT_CLASS_1 frames and RT_CLASS_2 frames
6.0 (IEEE 802.1Q)	VLAN priority	Transmit	Store	Alarm high
5 (IEEE 802.1Q)	VLAN priority	Transmit	Store	Alarm low
4 (IEEE 802.1Q)	VLAN priority	Transmit	Store	—
3 – 0 (IEEE 802.1Q)	See Table I.2 or Table I.3. This standard recommends Table I.3.			

[a] RED frames are always transmitted before the end of the RED period if stored in the red queue. This queue shall be discarded, if the RTC3PSM state is no longer RTCLASS3_RUN and any frame is stored.

Table I.2 – Priority regeneration – variant 1

Priority	Criteria	GREEN PERIOD	RED PERIOD	Meaning
3, 0 (IEEE 802.1Q)	VLAN priority	Transmit	Store	Other frames without VLAN TAG
2, 1 (IEEE 802.1Q)	VLAN priority	Transmit	Store	—

Table I.3 – Priority regeneration – variant 2

Priority	Criteria	GREEN PERIOD	RED PERIOD	Meaning
3, 2 (IEEE 802.1Q)	VLAN priority	Transmit	Store	—
0, 1 (IEEE 802.1Q)	VLAN priority	Transmit	Store	Other frames without VLAN TAG

NOTE For further information see IEEE 802.1Q.

Annex J
(informative)

Overview of the PTCP synchronization master hierarchy

Figure J.1 and Figure J.2 illustrates the general structure of the hierarchy of synchronization masters. The top level masters may synchronize all lower levels, but a lower level master shall never synchronize a higher level.

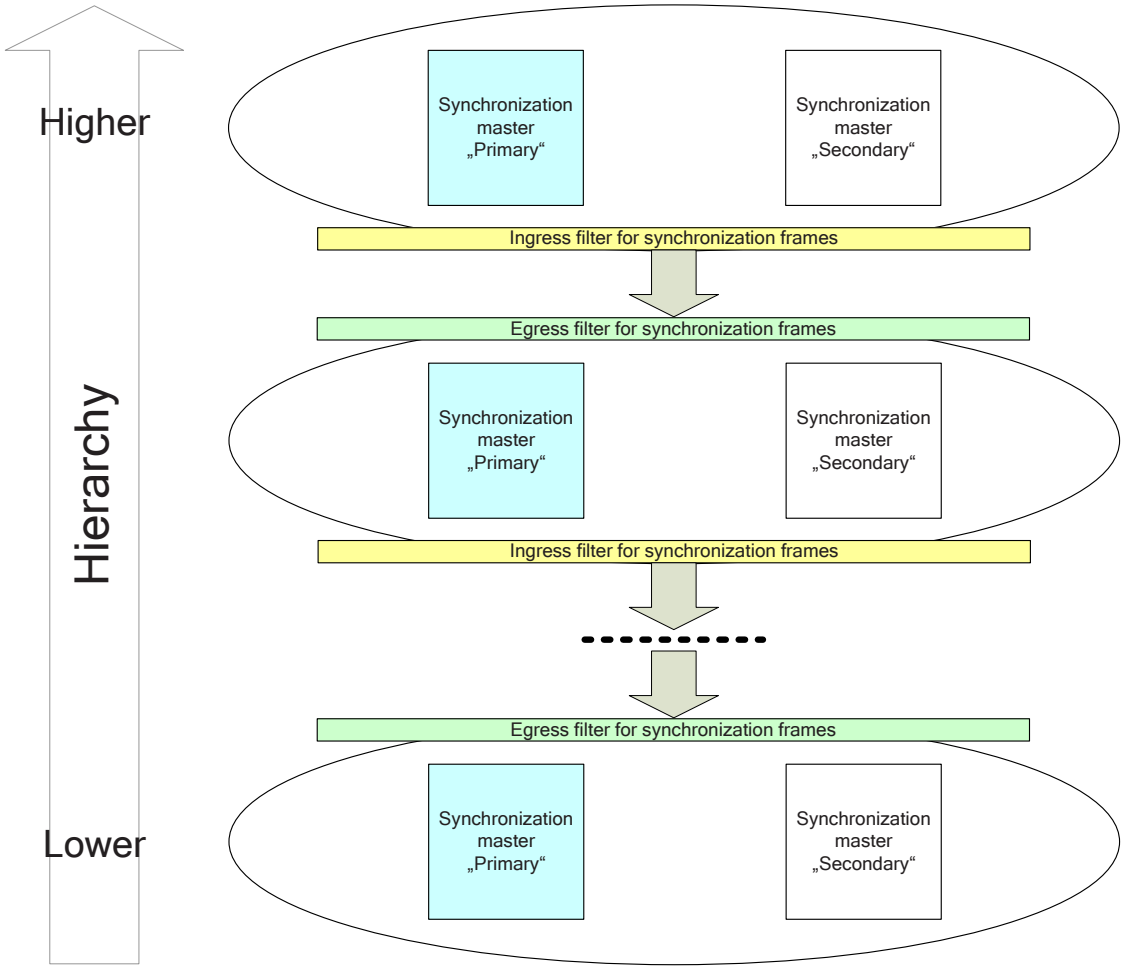


Figure J.1 – Level model for synchronization master hierarchy

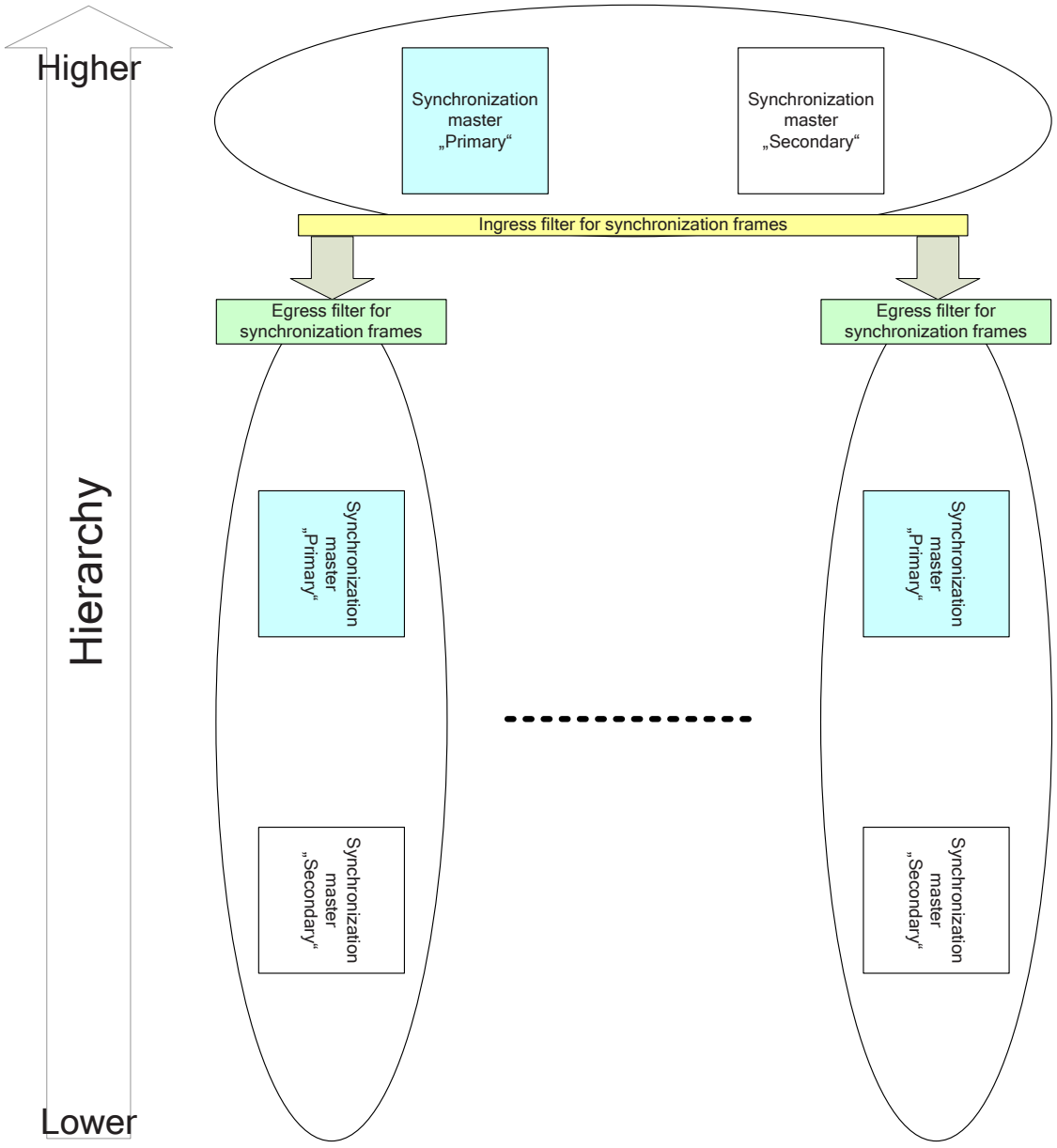


Figure J.2 – Two level variant of the synchronization master hierarchy

Annex K
(informative)

Optimization of bandwidth usage

Figure K.1 illustrates the structure of a linear network. When transmitting frames through this network the line delay and the bridge delay delays them in each node. From the IOC point of view, Figure K.2 shows the transmit and Figure K.3 shows the receive direction in a full duplex network.

When reducing the RED period in each node to the required time, additional bandwidth will be available.

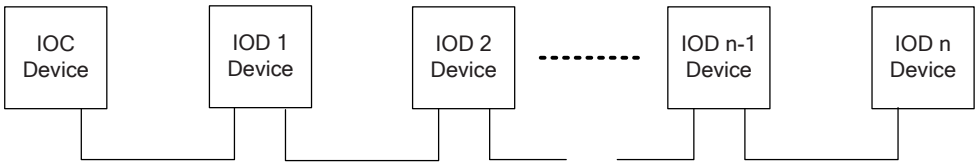


Figure K.1 – Devices build up in a linear structure

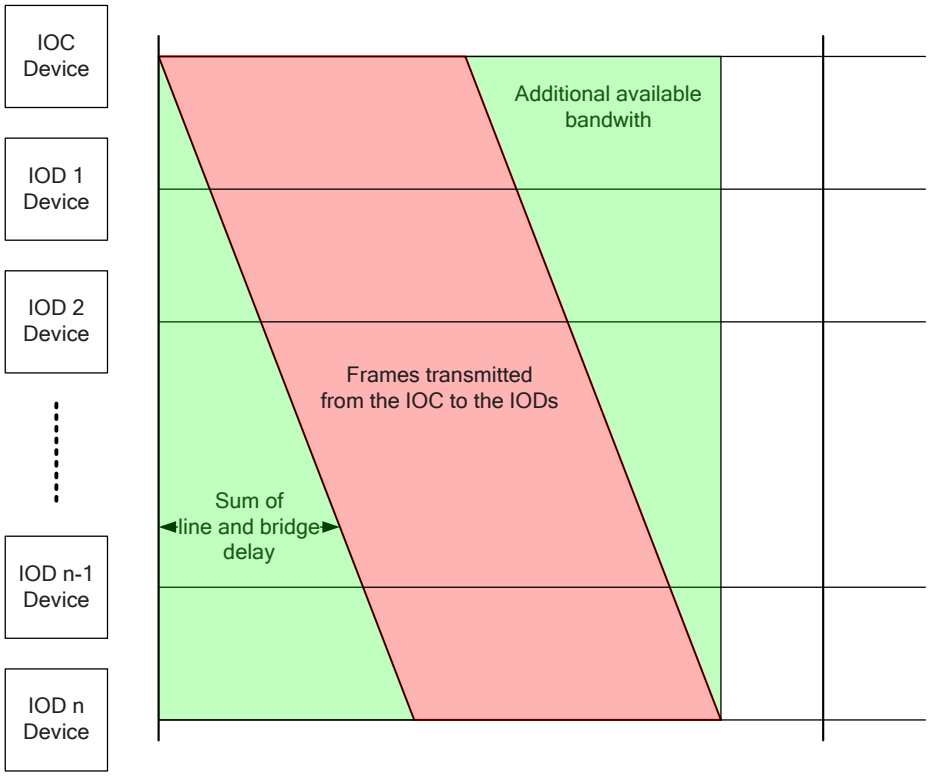


Figure K.2 – Propagation of frames in linear transmit direction

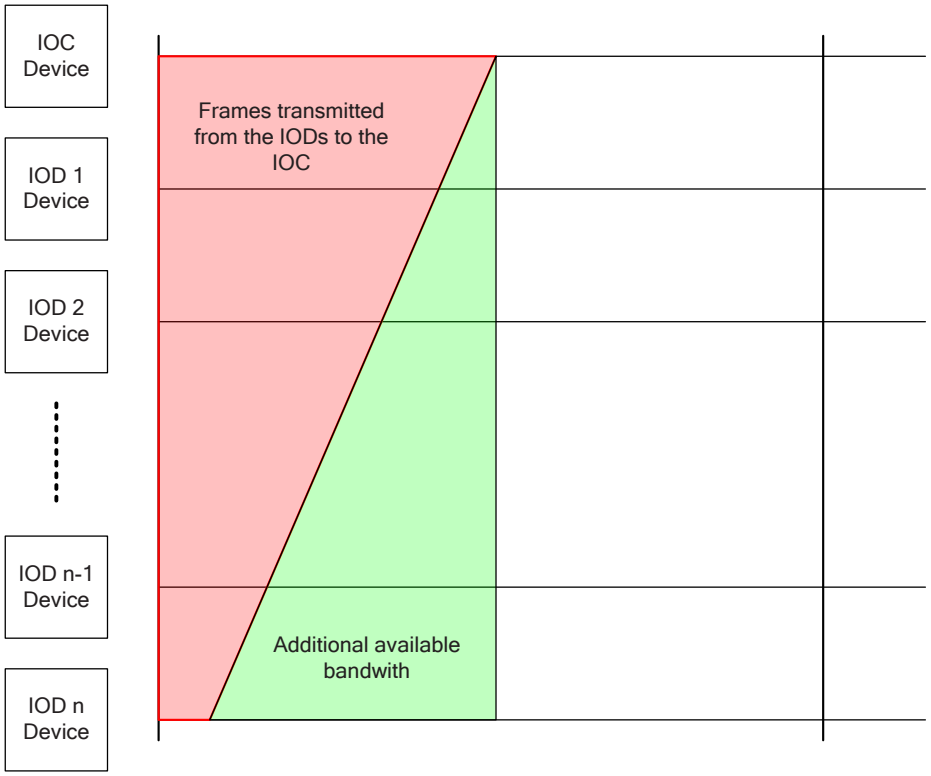


Figure K.3 – Propagation of a frames in receive direction

Annex L
(informative)

Time constraints for bandwidth allocation

Figure L.1 illustrates the association between the begin and end of the RED phase of the transmitting and the begin and end of the RED phase of the receiving port.

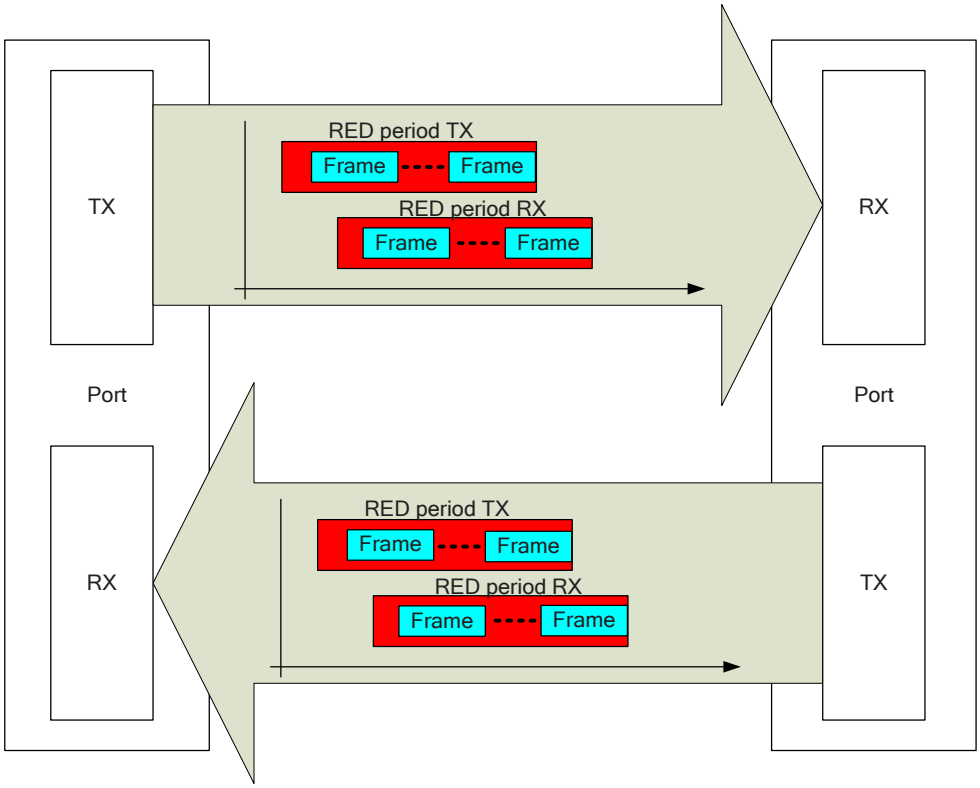


Figure L.1 – Overview of time constraints for bandwidth allocation

Figure L.2 illustrates the calculation of a RED period and Figure L.3 illustrates the calculation of a GREEN period for a port. This calculation uses the engineered payload, the MinSupportedFSO and the REDEndSafetyMargin for the length of RED period.

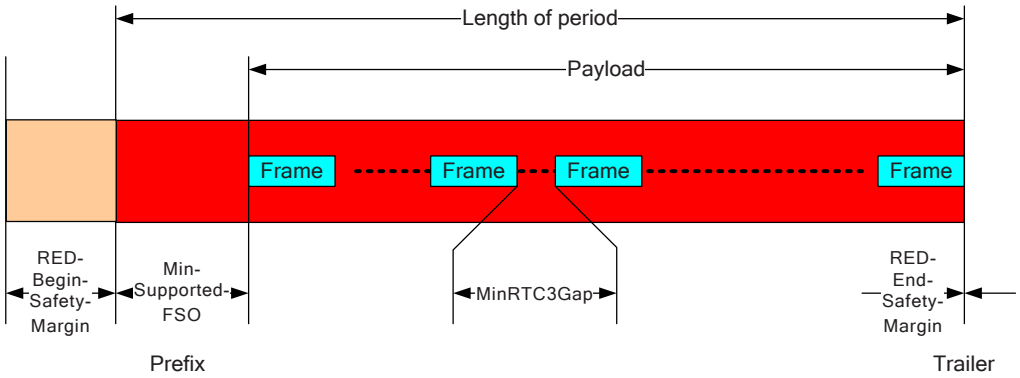


Figure L.2 – Calculation of the length of a RED period

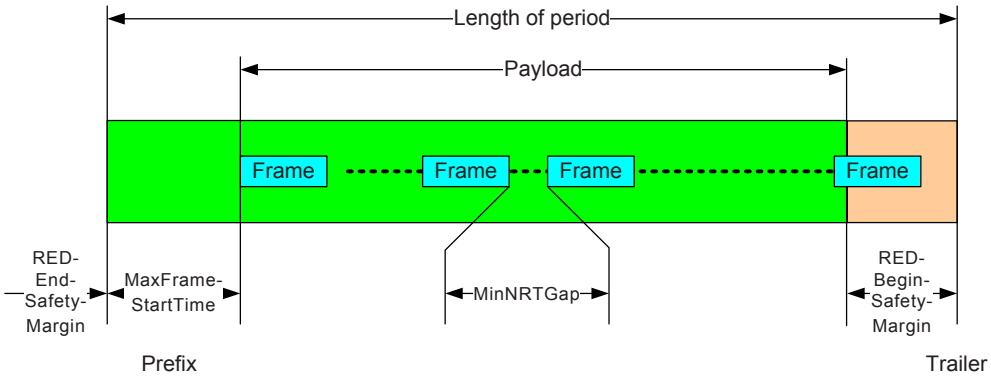


Figure L.3 – Calculation of the length of a GREEN period

Formula (L.1) shows the calculation of a RED period for a port.

$$\text{Length of period} = \text{MinSupportedFSO} + \text{payload} + \text{REDEndSafetyMargin} \quad \text{(L.1)}$$

where

MinSupportedFSO	is the time the period shall start before the first frame is sent or expected to be received
payload	is the time which is necessary to transfer all frames of this period
REDEndSafetyMargin	is the time the period shall be prolonged after the last frame is sent or expected to be received

Formula (L.2) and (L.3) shows the calculation of the start of period for a port in principle. Both, TX start of period and RX start of period shall never be negative.

$$\text{TX start of period} = 0 \quad \text{(L.2)}$$

$$\text{RX start of period} = 0 \quad \text{(L.3)}$$

The engineering shall use the LineDelay (or the MaxLineDelay) by planning the FrameSendOffset. Because the LineDelay and the jitter of synchronization is always less than the MinSupportedFSO, every frame will be transmitted and received inside the calculated period.

The YellowTime, always active before RED, ensures that in the above defined environment, only RT_CLASS_3 frames are transmitted and received in the RED.

Annex M
(informative)

Time constraints for the forwarding of a frame

The forwarding of a frame in a network depends on the bridge and the line delay. The line delay cumulates the cable and the port delay.

The minimum bridge delay (see Figure 27) depends on the needed octets for the forwarding decision. For this standard the reception of a frame until the FrameID is necessary.

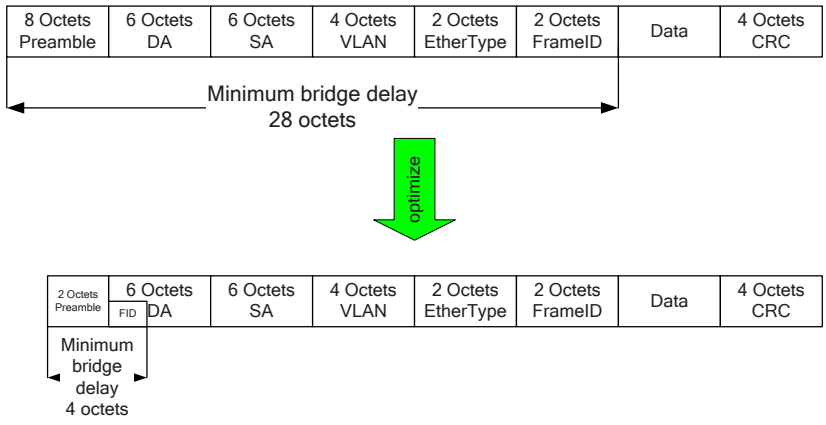


Figure M.1 – Minimization of bridge delay

Figure M.1 shows the optimization. The first step optimize the bridge delay to the minimum is a hardware that add no additional delay to the theoretical minimum Ethernet bridge delay. The second step uses a different strategy to make the forwarding decision by means of a different coding of the DA field. The third step reduces the received octets without a change of the required octets for the forwarding decision.

An optimization of the line delay (see Figure 27) is only possible by a reduction of the PortRxDelay and PortTxDelay values, which depends on the MAU.

Annex N
(informative)

Principle of dynamic frame packing

The protocol vs. data ratio for IO devices with a small amount of data could be optimized using dynamic frame packing.

The dynamic frame packing may be used for input and output data as shown in Figure N.1, Figure N.2 and Figure N.3.

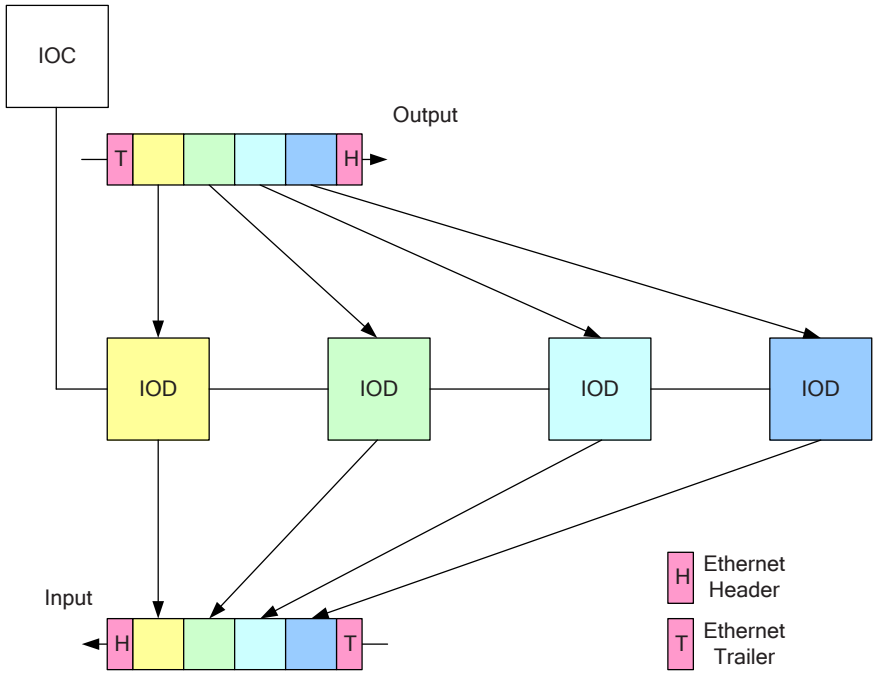


Figure N.1 – Dynamic frame packing

As an additional optimization the output frame (Provider from the IO controller point of view) shall be truncated as shown in Figure N.2.

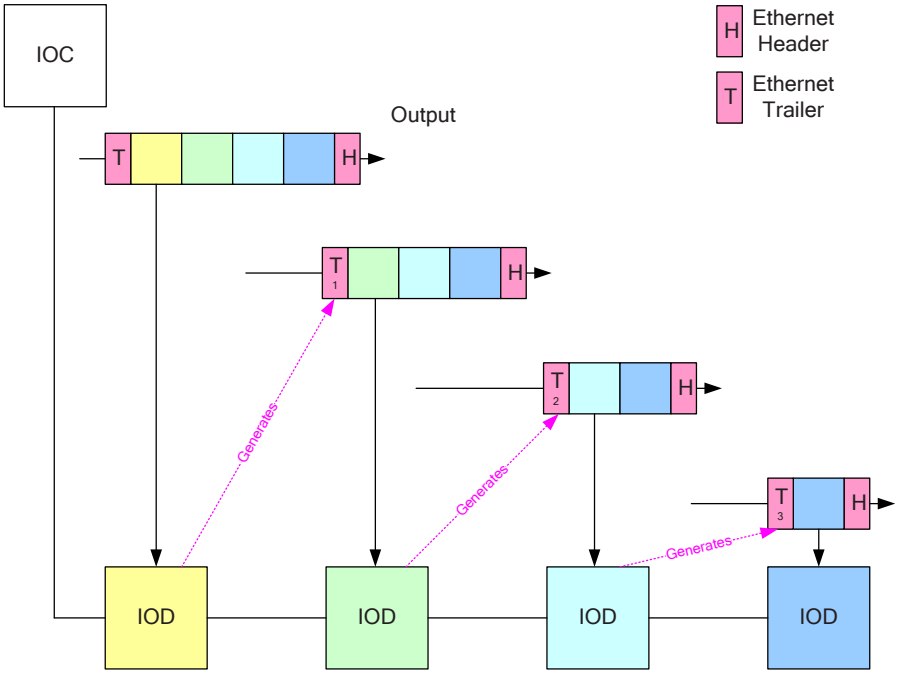


Figure N.2 – Dynamic frame packing – truncation of outputs

The input frame (Consumer from the IO controller point of view) shall be concatenated as shown in Figure N.3 for optimization.

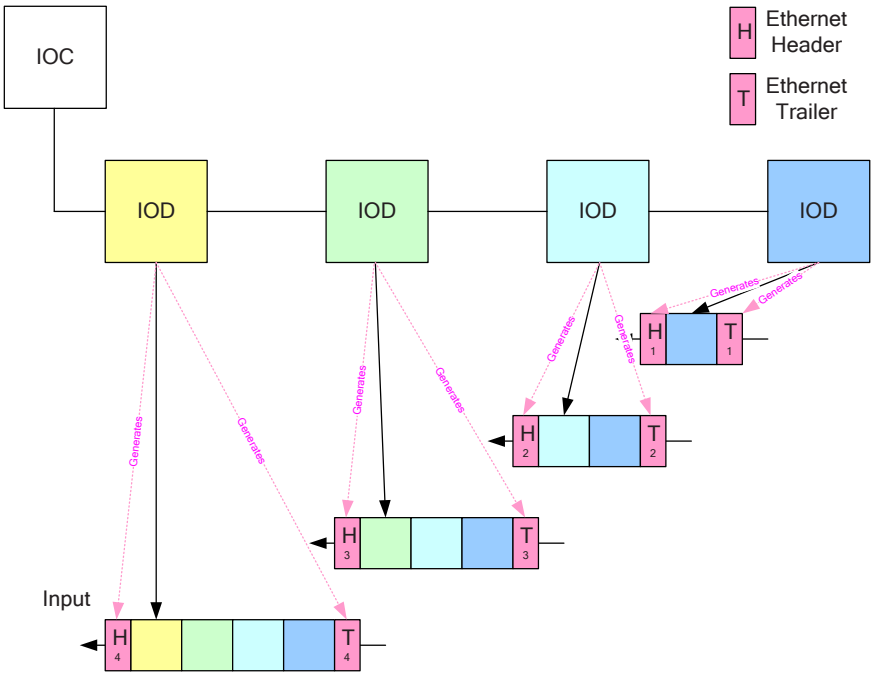


Figure N.3 – Dynamic frame packing – concatenation of inputs

The model of dynamic frame packing offers two variants. The first, the “pack on transport” variant is shown before. The second, the end node variant is shown in Figure N.4. In this case, all Subframes are generated by one IOC and one IOD.

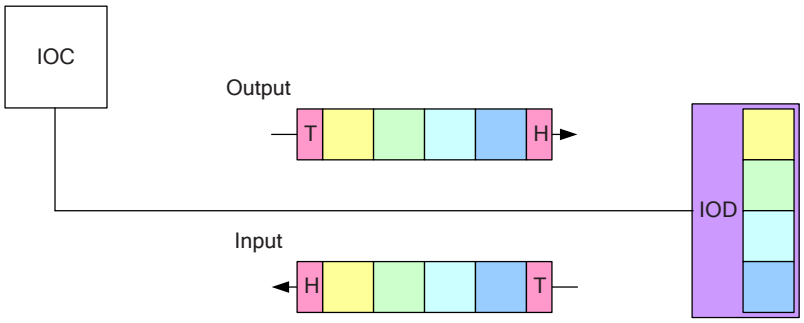


Figure N.4 – End node mode

The concatenation of inputs could not be done in zero time. Thus, an internal delay called DFPFeed exists. The parameter MaxDFPFeed is used to calculate the delay (DFPFeed) of the implementation, as shown in Figure Figure N.5.

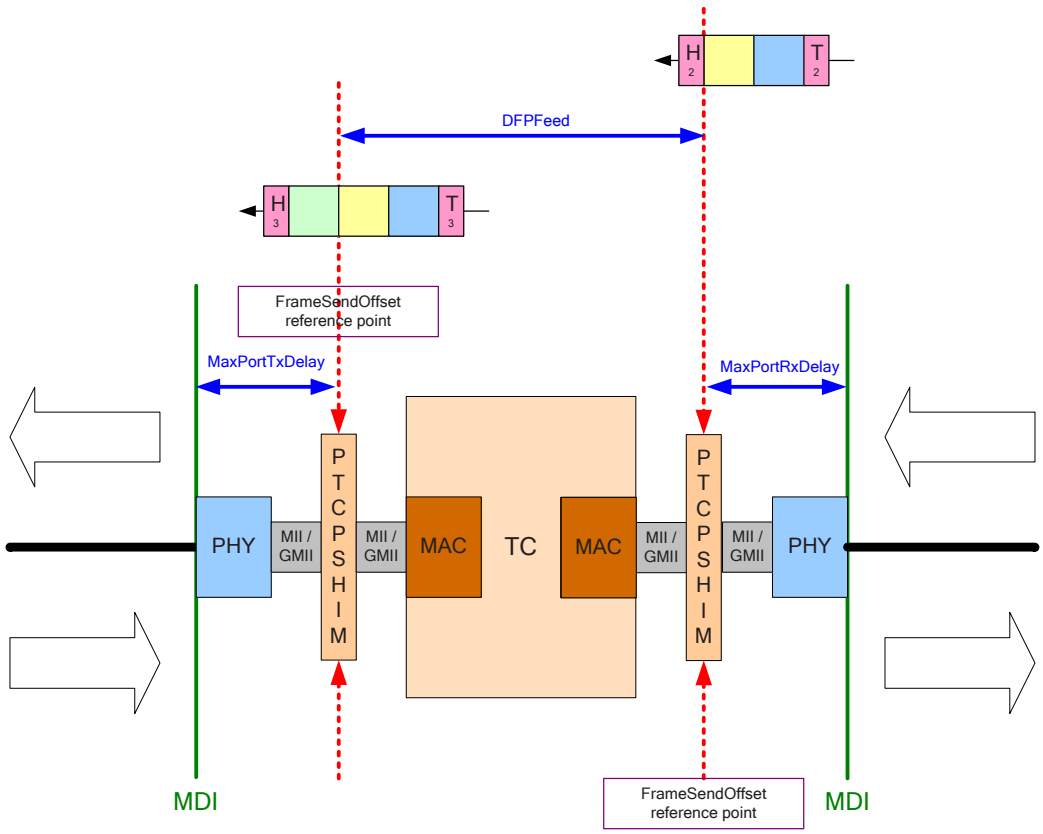


Figure N.5 – DFPFeed definition

The calculation of the DFPFeed shall be done by Formula (N.1). The engineering parameter MaxDFPFeed shall cover the maximum value of an implementation.

$$DFPFeed = FrameSendOffset(Subframe, TxPort) - ReceiveTimeStamp(Subframe, RxPort) \quad (N.1)$$

where

DFPFeed	is the internal delay to concatenate a subframe to another
FrameSendOffset(Subframe, TxPort)	is the point in time when the subframe shall be transmitted
ReceiveTimeStamp(Subframe, RxPort)	is the point in time when the subframe is received

Annex O
(informative)

Principle of Fragmentation

The concept of peer to peer fragmentation offers the possibility to reduce the SendClock to 31,25 μs or to enhance the RED bandwidth for a SendClock over 50 %.

Example The RED period for a SendClock of 1 ms may be 900 μs and the GREEN period 100 μs.

Figure O.1 shows the principle of the fragmentation and Figure O.2 the protocol elements of fragmentation as an example for one frame.

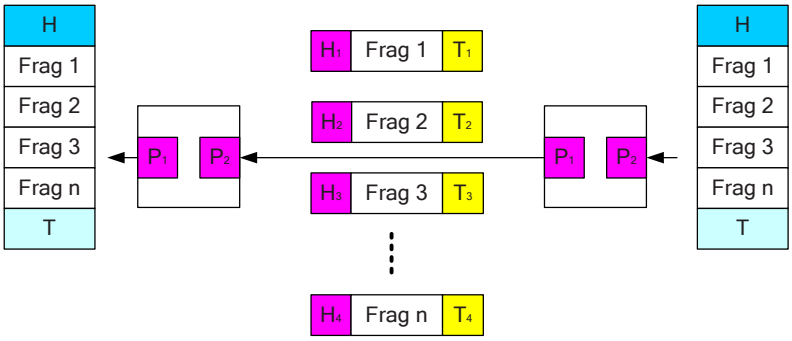


Figure O.1 – Principle of fragmentation

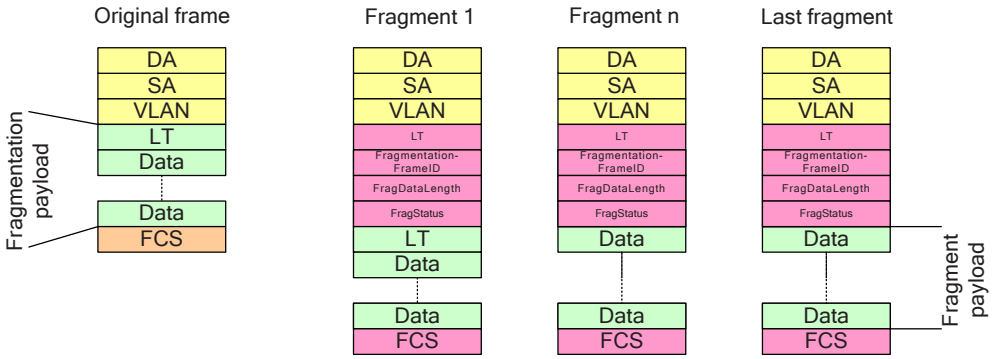


Figure O.2 – Protocol elements of fragments

The generation of fragments shall ensure that a fragment is small enough to be transmitted during GREEN and big enough to make a good usage of the bandwidth. In best case the transmitter generates fragments which are as long as the residual GREEN part of the period. The performance in this case is equivalent to 250 μs length of period.

Figure O.3 shows the principle of bandwidth allocation when using fragmentation. In this case the bandwidth is parted into a RT_CLASS_3 period, a RT_CLASS_2 / _1 communication period and a NRT communication period.

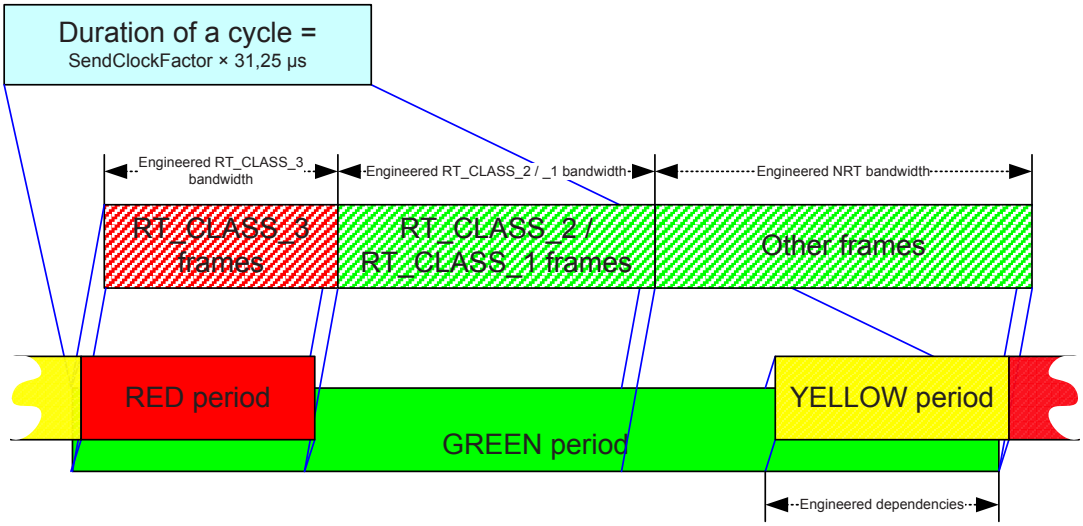


Figure O.3 – Bandwidth allocation using fragmentation

NOTE RED and YELLOW are bound together. Thus it exist always both or none.

The engineering shall check the needed bandwidth for all periods and also keep in mind, that RT_CLASS_2 / _1 frames are never fragmented and that this kind of frames are forwarded in the cut-through mode.

Thus, the YELLOW period shall cover the longest RT_CLASS_2 / _1 or any other non-fragmentable frame to avoid destroyed frames.

The RT_CLASS_2 / _1 communication period and NRT communication period may be combined for cases which need a minimum SendClockFactor. In these cases, the principle of the ReductionRatio is used to guarantee bandwidth for the NRT communication.

Figure O.4 shows the combination of a fragmentation and a non fragmentation domain. The rules for the forwarding of RT_CLASS_2 / _1 frames and the protection of the RED period makes a fragmentation domain delicate for unexpected too long RT_CLASS_2 / _1 frames.

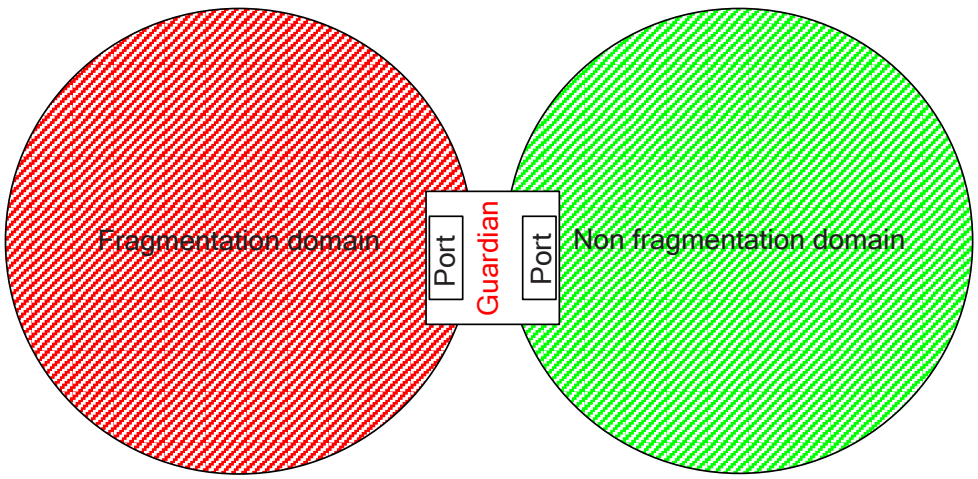


Figure O.4 – Guardian for a fragmentation domain

Thus, a guardian which checks whether the to be forwarded RT_CLASS_2 / _1 frames are valid for the fragmentation domain is useful. Only RT_CLASS_2 / _1 frames which comply to the Yellow period rule should be forwarded.

Annex P
(informative)

MRPD – Principle of seamless media redundancy

The concept seamless media redundancy offers a reliable network infrastructure in case of fault. Figure P.1, Figure P.2 and Figure P.3 shows the concept in principle.

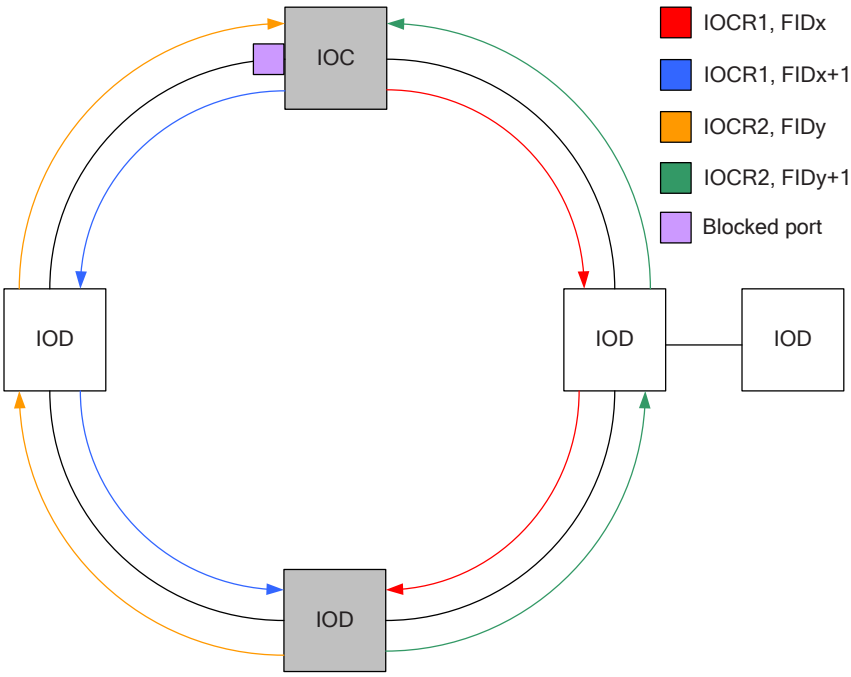


Figure P.1 – Principle of seamless media redundancy – I/OCR

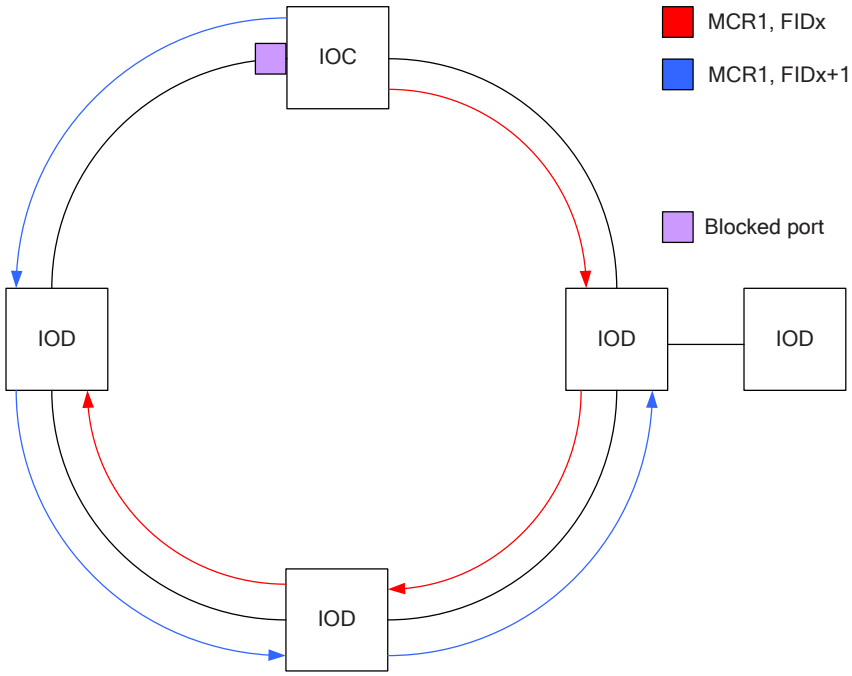


Figure P.2 – Principle of seamless media redundancy – MCR

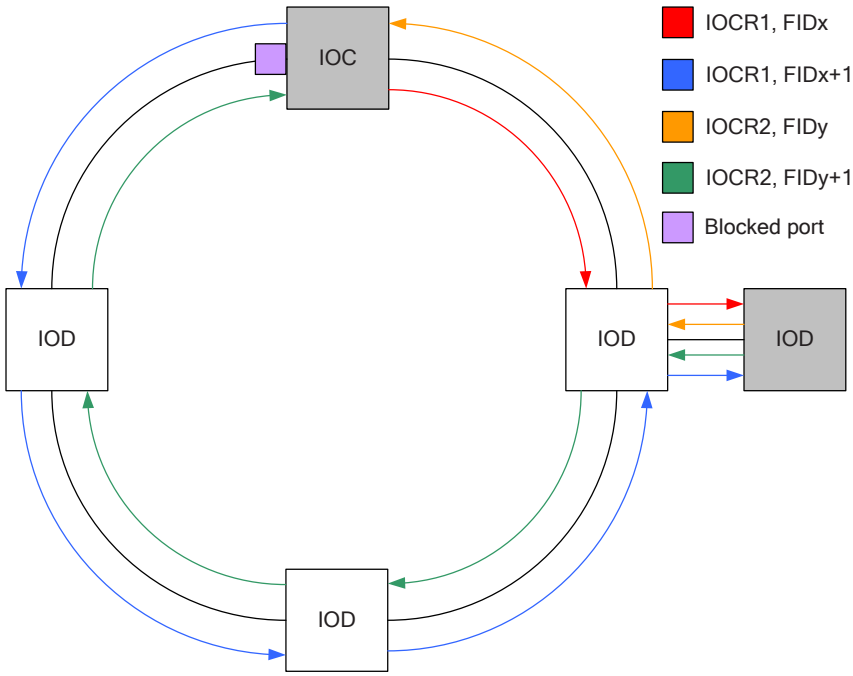


Figure P.3 – Principle of seamless media redundancy – Line

Annex Q
(normative)

Principle of a RED_RELAY without forwarding information in PDIRFrameData

The RED_RELAY needs information about the forwarding port and the sending time of a frame. This information is given by the PDIRFrameData. As an optimization the necessary information for the RED_RELAY may be calculated using the PDIRGlobalData. Figure Q.1 shows the concept.

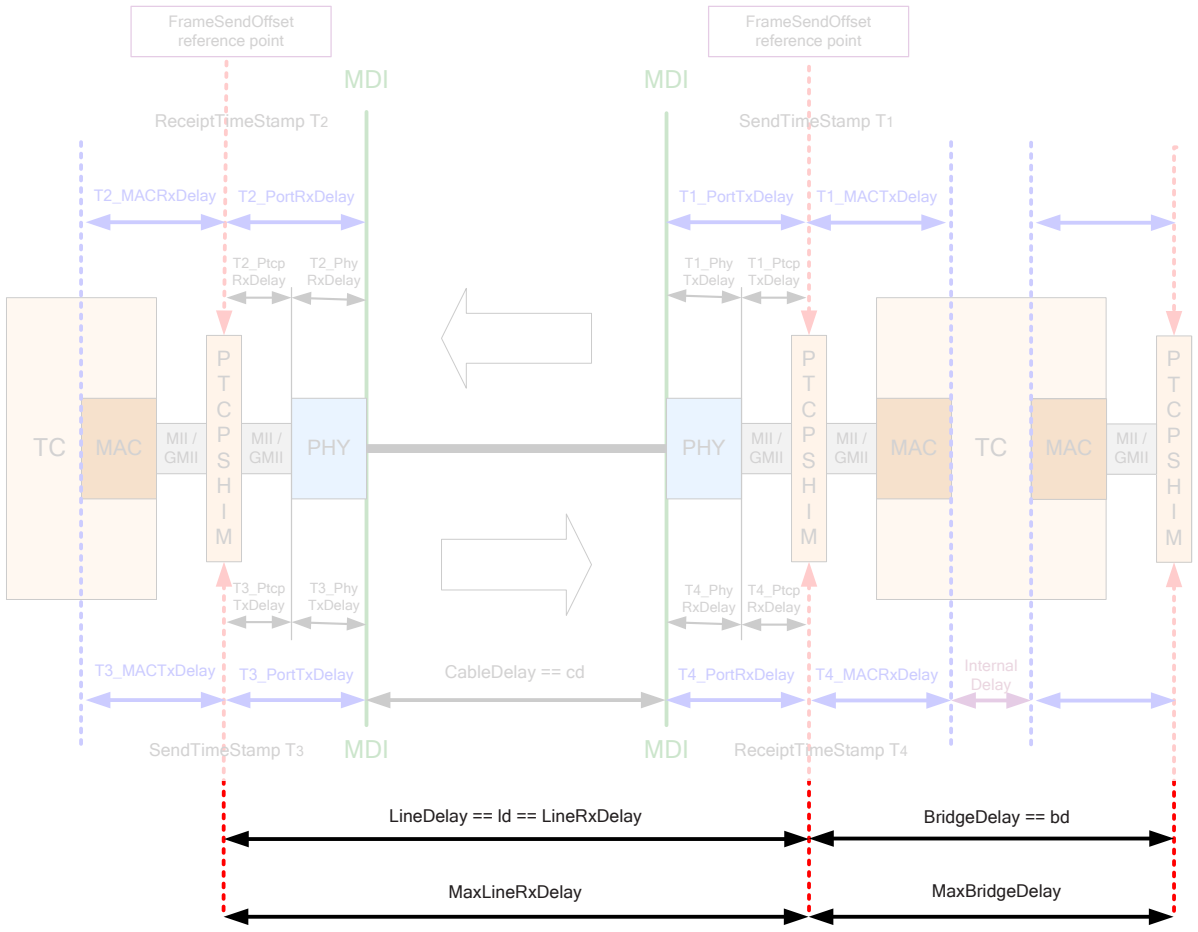


Figure Q.1 – Generating the FrameSendOffset for a RED_RELAY without forwarding information in PDIRFrameData

NOTE Figure Q.1 is formated partial as transparent to highlight the important part for this annex.

The calculation of the required FrameSendOffset for each frame shall be done by Formula (Q.1).

$$\begin{aligned} \text{FrameSendOffset}(\text{Frame}, \text{TxPort}) = {} & \text{ReceiveTimeStamp}(\text{Frame}, \text{RxPort}) \\ & + (\text{PDIRGlobalData.MaxLineRxDelay} - \text{LineRxDelay}) \\ & + (\text{PDIRGlobalData.MaxBridgeDelay}) \\ & - \text{SafetyMargin} \end{aligned} \quad \text{(Q.1)}$$

where

FrameSendOffset(Frame, TxPort)	is the point in time when the frame shall be transmitted
ReceiveTimeStamp(Frame, RxPort)	is the point in time when the frame is received
PDIRGlobalData.MaxLineRxDelay	is the time which is used by the engineering as LineDelay
LineRxDelay	is the time which is measured by the node
PDIRGlobalData.MaxBridgeDelay	is the time which is used by the engineering as BridgeDelay. The BridgeDelay given by the node shall be less than MaxBridgeDelay.
SafetyMargin	is the time which covers measurement errors (e.g. 100 ns)

For nodes with two ports an assumption for the forwarding port is done. For nodes with more than two ports additional information, at least which TxPort shall be used, is needed.

The calculation of the RetentionTime for each frame shall be done by Formula (Q.2).

$$\text{FrameSendOffset(Frame, TxPort)} = \text{ReceiveTimeStamp(Frame, RxPort)} + \text{RetentionTime(Frame)} \quad \text{(Q.2)}$$

where

FrameSendOffset(Frame, TxPort)	is the calculated point in time when the frame shall be transmitted
ReceiveTimeStamp(Frame, RxPort)	is the point in time when the frame is received
RetentionTime(Frame)	is the time where a frame is hold up in the bridge

The calculation of the required RetentionTime and MaxRetentionTime for each frame shall be done by Formula (Q.3) and (Q.4).

$$\begin{aligned}\text{RetentionTime(Frame)} &= (\text{MaxLineRxDelay}(T_{n+1}) - \text{RealLineRxDelay}(T_{n+1})) + (\text{MaxBridgeDelay}(T_{n+1}) - \text{RealBridgeDelay}(T_{n+1})) \quad \text{(Q.3)}\\ &= (\text{MaxPortTxDelay}(T_n) - \text{RealPortTxDelay}(T_n)) + (\text{MaxCableDelay} - \text{RealCableDelay}) + (\text{MaxPortRxDelay}(T_{n+1}) - \text{RealPortRxDelay}(T_{n+1})) + (\text{MaxBridgeDelay}(T_{n+1}) - \text{RealBridgeDelay}(T_{n+1}))\end{aligned}$$

$$\text{MaxRetentionTime(Frame)} = (\text{MaxLineRxDelay}(T_{n+1}) - 0) + (\text{MaxBridgeDelay}(T_{n+1}) - \text{RealBridgeDelay}(T_{n+1})) \quad \text{(Q.4)}$$

where

RetentionTime(Frame)	is the difference between the engineered and the real value of the line delay and bridge delay which shall be compensated by the node
MaxRetentionTime(Frame)	is the maximum difference between the engineered and the real value of the line delay and bridge delay which shall be compensated by the node
MaxLineRxDelay	is the engineered value of the line delay
RealLineRxDelay	is the real value of the line delay
MaxBridgeDelay	is the engineered value of the bridge delay
RealBridgeDelay	is the real value of the bridge delay
MaxPortTxDelay	is the engineered delay of the port transmitting a frame
RealPortTxDelay	is the real delay of the port transmitting a frame
MaxPortRxDelay	is the engineered delay of the port receiving a frame
RealPortRxDelay	is the real delay of the port receiving a frame
MaxCableDelay	is the engineered delay of the cable
RealCableDelay	is the real delay of the cable
T_n	is the node transmitting the frame
T_{n+1}	is the node receiving the frame and ensuring the Retention Time for the transmitting of the frame

Annex R
(informative)

Optimization for fast startup without autonegotiation

To increase the startup time of an Ethernet connection the auto negotiation time shall be avoided. To do this, the wiring of one port shall have the required crossover to avoid the usage of crossover cables, as shown in Figure R.1.

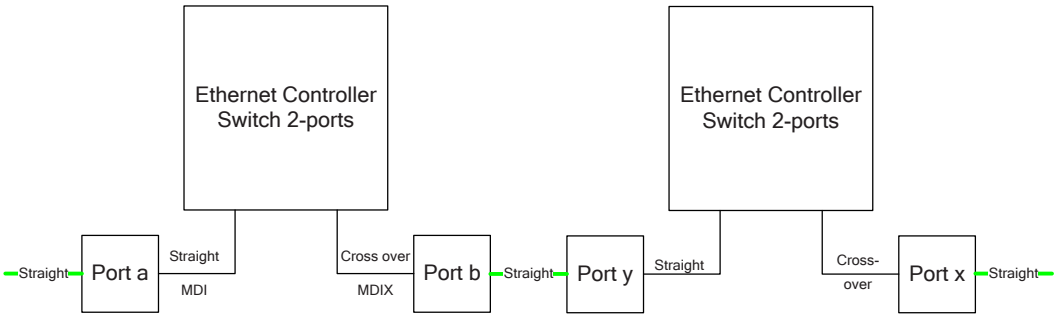


Figure R.1 – Scheme of a 2-port switch

NOTE 1 The MDI interface is intended to be used by end stations and routers (single port per interface devices).

NOTE 2 The MDIX interface is intended to be used by hubs and switches (multiple port per interface devices) to enable the usage of straight-through cables for end stations.

NOTE 3 Up to date components use auto MDI/MDIX (autonegotiation) to automatically switch to the proper configuration once a cable is connected.

NOTE 4 Nodes with more than two ports may provide one straight and many cross over ports.

The behavior of the possible combinations of PHY / MAC modes is shown in Figure R.2 and Table R.1

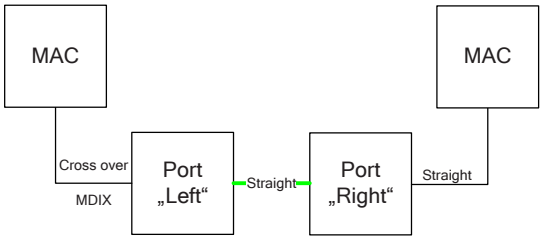


Figure R.2 – Scheme of 2-ports

Table R.1 – Truth table

Parameterized mode of Port "Left"	Negotiate mode of Port "Left"	Negotiate mode of Port "Right"	Parameterized mode of Port "Right"
AutoNegotiation	100BASETXFD	100BASETXFD	AutoNegotiation
100BASETXFD	100BASETXFD	100BASETXHD → 100BASETXFD [a]	AutoNegotiation
100BASETXFD	100BASETXFD	100BASETXFD [b]	AutoNegotiation
100BASETXFD	100BASETXFD	100BASETXFD	100BASETXFD

[a] This standard requires at least 100 Mbit/s. If the negotiation process signals 100BASETXHD the application should change it to 100BASETXFD.

[b] A PHY / MAC combination may optimize the negotiation for this standard.

Annex S
(informative)

TX-error handling

The IEEE 802 offers the possibility to encode errors during the transmission of a frame in the MAC. The recommended coding is shown in Table S.1.

Table S.1 – TX-error

Error-Code (hexadecimal)	Meaning
0x0	Transmission aborted due to receive error (RX_ERR := ’1’)
0x1	Transmission aborted due to receive error (frame FCS error)
0x2	Transmission aborted due to receive error (frame to long)
0x3	Transmission aborted due to receive error (frame to short)
0x4	Transmission aborted due to receive error (subframe CRC16 error)
0x5	Transmission aborted due to receive error (unexpected end of a DFP frame)
0x6	Transmission aborted due to receive error (unexpected subframe of a DFP frame)
0x7	Transmission aborted due to resource error
0x8	Transmission aborted due to MAC error
0x9	Transmission aborted due to SA := own MAC address error
0xA	Transmission aborted due to disable port or disable MAC
0xB	Transmission aborted due to unexpected structure of a DFP frame
0xC	Transmission aborted due to unexpected structure of a PTCP frame
0xD	Reserved
0xE	Reserved
0xF	Reserved

Annex T
(informative)

Example of a PrmBegin, PrmEnd and ApplRdy sequence

This standard introduces the PrmBegin, PrmEnd and ApplRdy procedure as a basic feature for system redundancy and configure in run.

Figure T.1 shows an example of this procedure.

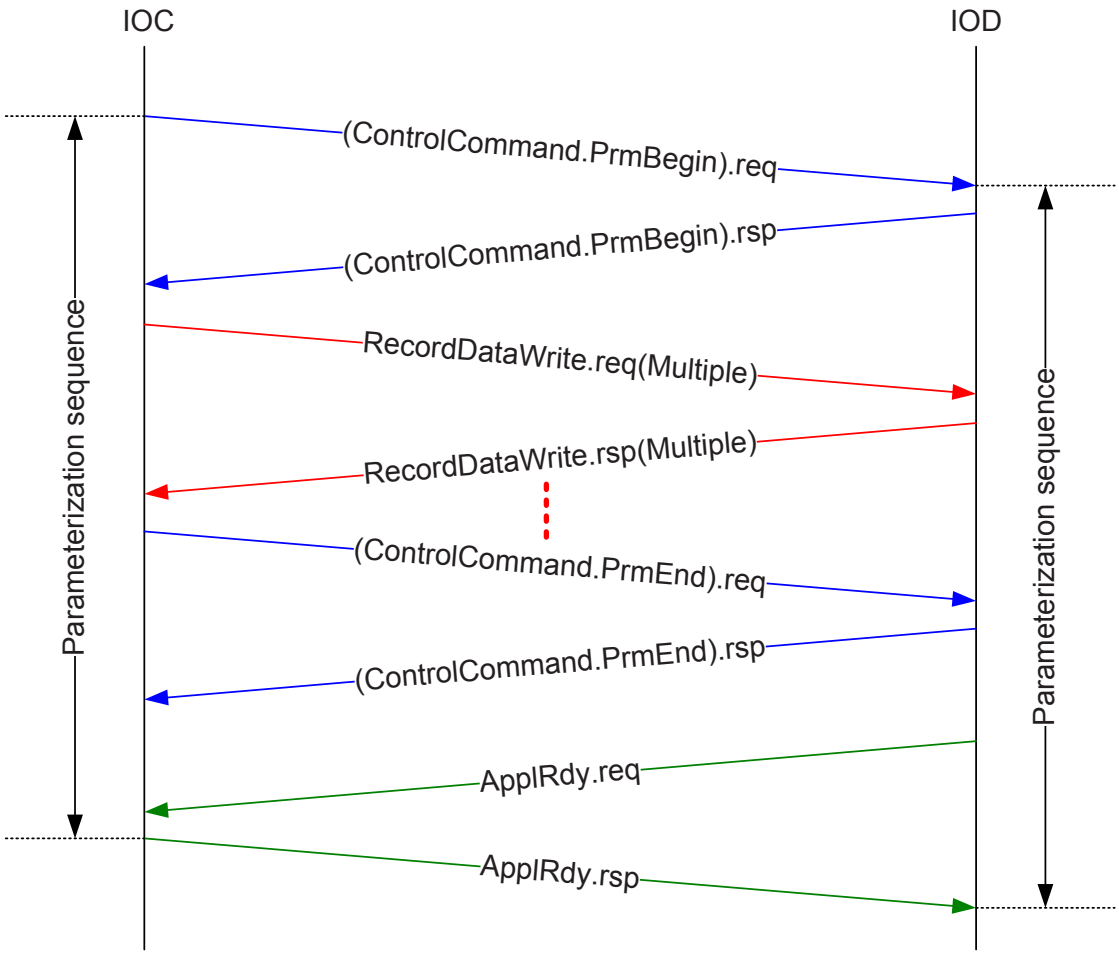


Figure T.1 – PrmBegin, PrmEnd and ApplRdy procedure

Annex U
(informative)

List of supported MIBs

This standard defines a list of supported MIBs for the devices. Table U.1 shows the defined or referenced MIBs.

Table U.1 – List of supported MIBs

Name	Meaning
MIB II	MIB from IETF RFC 1213
Interface Group MIB	MIB from IETF RFC 2863 NOTE This MIB supports interface and port mapping. It is used by newer MIBs to provide an overall view to the interfaces and ports.
LLDP-MIB	MIB from IEEE 802.1AB
LLDP-EXT-DOT1-MIB	Extension of the IEEE 802.1AB MIB by IEEE 802.1
LLDP-EXT-DOT3-MIB	Extension of the IEEE 802.1AB MIB by IEEE 802.3
LLDP-EXT-PNIO-MIB	Extension of the IEEE 802.1AB MIB by this standard
PI-MIB	MIB from this standard
IEEE8021-AS-MIB	MIB from IEEE 802.1AS
MRP-MIB	MIB from IEC 62439-2

Annex V
(informative)

Structure and content of BLOB

The BLOB used for the GSD contains the binary respresentation of the result of a Lempel-Ziv-Markow-Algorithm compression of a directory structure shown in Table V.1.

The compression should be done by using i.e. the program 7zip. The BLOB is the binary content of the created archive file.

Table V.1 – Content of archive

Directory	Meaning
Icons	Containing the icons used for the GSD. May be empty or non existent.
Interface	Containing the interface specification for the provided controller to controller communication interface. May be empty or non existent.
GSD	Contains GSD file.
Other	Additional information not fitting into the other directories. May be empty or non existent.

Annex W
(normative)

LLDP EXT MIB

This standard defines an extension to the IEEE 802.1AB-2005 MIB which is shown below.

```
LLDP-EXT-PNO-MIB DEFINITIONS ::= BEGIN

IMPORTS
    SnmpAdminString                 FROM SNMP-FRAMEWORK-MIB
    Unsigned32,
    MODULE-IDENTITY,
    OBJECT-TYPE                     FROM SNMPv2-SMI
    MacAddress,
    DisplayString,
    TruthValue                      FROM SNMPv2-TC
    MODULE-COMPLIANCE,
    OBJECT-GROUP                    FROM SNMPv2-CONF
    lldpExtensions,
    lldpRemTimeMark,
    lldpRemLocalPortNum,
    lldpRemIndex,
    lldpPortConfigEntry,
    lldpLocPortNum                  FROM LLDP-MIB;

lldpXPnoMIB                         MODULE-IDENTITY
    LAST-UPDATED                    "201003010000Z" - March 1, 2010
    ORGANIZATION                    "PROFIBUS & PROFINET INTERNATIONAL (PI)"
    CONTACT-INFO                    "
                                    URL:    http://www.profibus.com
                                    email:  info@profibus.com

                                    Postal: Haid-und-Neu-Strasse 7
                                            D-76131 Karlsruhe

                                    Tel:    ++49 721 9658 - 590
                                    "
    DESCRIPTION                     "
                                    The LLDP Management Information base extension
module for
                                    PROFINET organizationally defined discovery
information.

                                    Copyright © PROFIBUS Nutzerorganisation e.V.
(2005).
                                    "
    REVISION                        "200602280000Z" - February 28, 2006
    DESCRIPTION                     "
                                    added MRP UUID information, port status values and
                                    naming of tables changed
                                    "
    REVISION                        "200508310000Z" - August 31, 2005
    DESCRIPTION                     "added RT port status"
    REVISION                        "200505300000Z" - May 30, 2005
    DESCRIPTION                     "initial version"
                            OUI for PNO 3791 (00-0E-CF)
    ::= { lldpExtensions 3791 }


Organizationally Defined Information Extension - PNO

lldpXPnoObjects                     OBJECT IDENTIFIER ::= { lldpXPnoMIB 1 }

                            LLDP PNO extension MIB groups
lldpXPnoConfig                      OBJECT IDENTIFIER ::= { lldpXPnoObjects 1 }
lldpXPnoLocalData                   OBJECT IDENTIFIER ::= { lldpXPnoObjects 2 }
lldpXPnoRemoteData                  OBJECT IDENTIFIER ::= { lldpXPnoObjects 3 }

PNO - Configuration

lldpXPnoConfigTable                 OBJECT-TYPE
    SYNTAX                          SEQUENCE OF LldpXPnoConfigEntry
    MAX-ACCESS                      not-accessible
```

```
    STATUS                          current
    DESCRIPTION                     "
                                    A table that controls selection of LLDP
                                    TLVs to be transmitted on individual ports.
                                    "
    ::= { lldpXPnoConfig 1 }

lldpXPnoConfigEntry                 OBJECT-TYPE
    SYNTAX                          LldpXPnoConfigEntry
    MAX-ACCESS                      not-accessible
    STATUS                          current
    DESCRIPTION                     "
                                    LLDP configuration information that controls the
                                    transmission of PNO organizationally defined TLVs
                                    on LLDP transmission capable ports.

                                    This configuration object augments the
                                    lldpPortConfigEntry of the LLDP-MIB, therefore it
                                    is only present along with the port configuration
                                    defined by the associated lldpPortConfigEntry
entry.

                                    Each active lldpXPnoConfigEntry must be restored
                                    from non-volatile storage (along with the
corresponding
                                    lldpPortConfigEntry) after a re-initialization of
the
                                    management system.
                                    "
    AUGMENTS                        { lldpPortConfigEntry}
    ::= { lldpXPnoConfigTable 1 }

LldpXPnoConfigEntry ::=             SEQUENCE {
    lldpXPnoConfigSPDTxEnable       TruthValue,
    lldpXPnoConfigPortStatusTxEnable TruthValue,
    lldpXPnoConfigAliasTxEnable     TruthValue,
    lldpXPnoConfigMrpTxEnable       TruthValue,
    lldpXPnoConfigPtcpTxEnable      TruthValue
}

lldpXPnoConfigSPDTxEnable           OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-write
    STATUS                          current
    DESCRIPTION                     "
                                    The lldpXPnoConfigSPDTxEnable, which is defined as
                                    a truth value and configured by the network
management,
                                    determines whether the PNO organizationally defined
                                    signal propagation delay TLV transmission is
allowed on
                                    a given LLDP transmission capable port.

                                    The signal propagation delay is composed of the
port
                                    transmission delay, the port receiving delay and
the line
                                    delay. These values can't be transmitted
independently of
                                    each other.

                                    The value of this object must be restored from non-
volatile
                                    storage after a re-initialization of the management
system.
                                    "
    DEFVAL                          { true }
    ::= { lldpXPnoConfigEntry 1 }

lldpXPnoConfigPortStatusTxEnable    OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-write
    STATUS                          current
    DESCRIPTION                     "
                                    The lldpXPnoConfigPortStatusTxEnable, which is
defined as
                                    a truth value and configured by the network
management,
```

```
                                determines whether the PNO organizationally defined
                                RT port status TLV transmission is allowed on a
given
                                LLDP transmission capable port.

                                The value of this object must be restored from non-
volatile
                                storage after a re-initialization of the management
system.
                                "
    DEFVAL                      { true }
    ::= { lldpXPnoConfigEntry 2 }

lldpXPnoConfigAliasTxEnable     OBJECT-TYPE
    SYNTAX                      TruthValue
    MAX-ACCESS                  read-write
    STATUS                      current
    DESCRIPTION                 "
                                The lldpXPnoConfigAliasTxEnable, which is defined
as
                                a truth value and configured by the network
management,
                                determines whether the PNO organizationally defined
                                alias TLV (chassisId) transmission is allowed on a
given
                                LLDP transmission capable port.

                                The value of this object must be restored from non-
volatile
                                storage after a re-initialization of the management
system.
                                "
    DEFVAL                      { true }
    ::= { lldpXPnoConfigEntry 3 }

lldpXPnoConfigMrpTxEnable       OBJECT-TYPE
    SYNTAX                      TruthValue
    MAX-ACCESS                  read-write
    STATUS                      current
    DESCRIPTION                 "
                                The lldpXPnoConfigMrpTxEnable, which is defined as
                                a truth value and configured by the network
management,
                                determines whether the PNO organizationally defined
                                MRP TLV transmission is allowed on a given
                                LLDP transmission capable port.

                                The value of this object must be restored from non-
volatile
                                storage after a re-initialization of the management
system.
                                "
    DEFVAL                      { true }
    ::= { lldpXPnoConfigEntry 4 }

lldpXPnoConfigPtcpTxEnable      OBJECT-TYPE
    SYNTAX                      TruthValue
    MAX-ACCESS                  read-write
    STATUS                      current
    DESCRIPTION                 "
                                The lldpXPnoConfigPtcpTxEnable, which is defined as
                                a truth value and configured by the network
management,
                                determines whether the PNO organizationally defined
                                PTCP TLV transmission is allowed on a given
                                LLDP transmission capable port.

                                The value of this object must be restored from non-
volatile
                                storage after a re-initialization of the management
system.
                                "
    DEFVAL                      { true }
    ::= { lldpXPnoConfigEntry 5 }

PNO - Local System Information

lldpXPnoLocTable                OBJECT-TYPE
```

```
    SYNTAX                          SEQUENCE OF LldpXPnoLocEntry
    MAX-ACCESS                      not-accessible
    STATUS                          current
    DESCRIPTION                     "
                                    This table contains one row per port for PNO
                                    organizationally defined LLDP extension on the
                                    local system known to this agent.
                                    "
    ::= { lldpXPnoLocalData 1 }

lldpXPnoLocEntry                    OBJECT-TYPE
    SYNTAX                          LldpXPnoLocEntry
    MAX-ACCESS                      not-accessible
    STATUS                          current
    DESCRIPTION                     "
                                    Additional information about a particular port
                                    component.

                                    This object is indexed by the lldpLocPortNum
                                    of the LLDP-MIB, therefore it is only present
                                    along with the port entry defined by the
                                    associated lldpLocPortEntry entry.

                                    Each active lldpXPnoLocEntry must be restored
                                    from non-volatile storage (along with the
                                    corresponding lldpLocPortEntry) after a
                                    re-initialization of the management system.
                                    "
    INDEX                           { lldpLocPortNum  }
    ::= { lldpXPnoLocTable 1 }

LldpXPnoLocEntry ::=                SEQUENCE {
    lldpXPnoLocLPDValue             Unsigned32,
    lldpXPnoLocPortTxDValue         Unsigned32,
    lldpXPnoLocPortRxDValue         Unsigned32,
    lldpXPnoLocPortStatusRT2        INTEGER,
    lldpXPnoLocPortStatusRT3        INTEGER,
    lldpXPnoLocPortNoS              DisplayString,
    lldpXPnoLocPortMrpUuId          OCTET STRING,
    lldpXPnoLocPortMrrtStatus       INTEGER,
    lldpXPnoLocPortPtcpMaster       MacAddress,
    lldpXPnoLocPortPtcpSubdomainUUID OCTET STRING,
    lldpXPnoLocPortPtcpIRDataUUID   OCTET STRING,
    lldpXPnoLocPortModeRT3          INTEGER,
    lldpXPnoLocPortPeriodLength     Unsigned32,
    lldpXPnoLocPortPeriodValidity   TruthValue,
    lldpXPnoLocPortRedOffset        Unsigned32,
    lldpXPnoLocPortRedValidity      TruthValue,
    lldpXPnoLocPortOrangeOffset     Unsigned32,
    lldpXPnoLocPortOrangeValidity   TruthValue,
    lldpXPnoLocPortGreenOffset      Unsigned32,
    lldpXPnoLocPortGreenValidity    TruthValue,
    lldpXPnoLocPortStatusRT3OptimizationSupported   TruthValue,
    lldpXPnoLocPortStatusRT3PreambleShorteningSupported TruthValue,
    lldpXPnoLocPortStatusRT3PreambleShortening  TruthValue,
    lldpXPnoLocPortStatusRT3FragmentationSupported  TruthValue,
    lldpXPnoLocPortStatusRT3Fragmentation   TruthValue
}

lldpXPnoLocLPDValue                 OBJECT-TYPE
    SYNTAX                          Unsigned32
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the line propagation
                                    delay in nanoseconds which was measured by the
local
                                    system on the corresponding port.

                                    A value of zero shall be used if the system either
                                    could not accomplish the measurement or does not
support
                                    such a measurement.
                                    "
    DEFVAL                          { 0 }
    ::= { lldpXPnoLocEntry 1 }
```

```
lldpXPnoLocPortTxDValue             OBJECT-TYPE
    SYNTAX                          Unsigned32
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the PortTxDelay
                                    in nanoseconds which was measured by the local
                                    system on the corresponding port.

                                    A value of zero shall be used if the system either
                                    could not accomplish the measurement or does not
                                    support such a measurement.
                                    "
    DEFVAL                          { 0 }
    ::= { lldpXPnoLocEntry 2 }

lldpXPnoLocPortRxDValue             OBJECT-TYPE
    SYNTAX                          Unsigned32
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the PortRxDelay
                                    in nanoseconds which was measured by the local
                                    system on the corresponding port.

                                    A value of zero shall be used if the system either
                                    could not accomplish the measurement or does not
                                    support such a measurement.
                                    "
    DEFVAL                          { 0 }
    ::= { lldpXPnoLocEntry 3 }

lldpXPnoLocPortStatusRT2            OBJECT-TYPE
    SYNTAX                          INTEGER {
                                        off(0),
                                        configured(1),
                                        running(2)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the local system according to RT class 2.

                                    A value of off(0) means that there isn't any RT2
                                    capability available for this port. When the port
is
                                    configured for RT2 mode, but the mode isn't active
yet
                                    the value will be configured(1). If the RT2 mode is
                                    configured for this port and the mode is active,
the
                                    value will be running(2).
                                    "
    ::= { lldpXPnoLocEntry 4 }

lldpXPnoLocPortStatusRT3            OBJECT-TYPE
    SYNTAX                          INTEGER {
                                        off(0),
                                        configured(1),
                                        up(2),
                                        down(3),
                                        running(4)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the local system according to RT class 3.

                                    A value of off(0) means that there isn't any RT3
                                    capability available for this port. When the port
is
```

```
                                    configured for RT3 mode, but the mode isn't active
yet
                                    the value will be configured(1).
                                    When the port is ready for transmission and
reception
                                    of RT3 traffic, the port status will be running(4).
                                    "
    ::= { lldpXPnoLocEntry 5 }

lldpXPnoLocPortNoS                  OBJECT-TYPE
    SYNTAX                          DisplayString
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The local PROFINET NameofStation. If the station
isn't
                                    configured yet, the value of this object will be
the
                                    MAC address of the device as a string.
                                    "
    ::= { lldpXPnoLocEntry 6 }

lldpXPnoLocPortMrpUuId              OBJECT-TYPE
    SYNTAX                          OCTET STRING (SIZE (16))
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The UUID of the MRP domain to which this port
belongs
                                    to. If the port doesn't belong to a MRP domain, the
value
                                    must be NIL ('0000000000000000').
                                    "
    ::= { lldpXPnoLocEntry 7 }

lldpXPnoLocPortMrrtStatus           OBJECT-TYPE
    SYNTAX                          INTEGER {
                                        off(0),
                                        configured(1),
                                        up(2)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This object reports the status of the MRRT entity
of the
                                    corresponding port.

                                    A value of off(0) means that there isn't any MRRT
                                    capability available for this port or it is
switched off.
                                    The value configured(1) indicates that MRRT is
configured
                                    for the port. When MRRT is active on the port, the
value
                                    will be up(2).
                                    "
    ::= { lldpXPnoLocEntry 8 }

lldpXPnoLocPortPtcpMaster           OBJECT-TYPE
    SYNTAX                          MacAddress
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The interface MAC address of the PTCP sync master
device
                                    of the PTCP subdomain. If unknown it shall be set
to zero.
                                    "
    ::= { lldpXPnoLocEntry 9 }

lldpXPnoLocPortPtcpSubdomainUUID    OBJECT-TYPE
    SYNTAX                          OCTET STRING (SIZE (16))
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The UUID of the PTCP subdomain to which this port
belongs
```

```
                                    to. If the port doesn’t belong to a PTCP subdomain
or the subdomain
                                    is invalid or unknown the value of this object must
be
                                    NIL (‘0000000000000000’).
                                    “
    ::= { lldpXPnoLocEntry 10 }

lldpXPnoLocPortPtcpIRDataUUID       OBJECT-TYPE
    SYNTAX                          OCTET STRING (SIZE (16))
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     “
                                    The UUID of the IR data domain to which this port
belongs
                                    to. If the port doesn’t belong to a IR data domain
or the domain
                                    is invalid or unknown the value of this object must
be
                                    NIL (‘0000000000000000’).
                                    “
    ::= { lldpXPnoLocEntry 11 }

lldpXPnoLocPortModeRT3              OBJECT-TYPE
    SYNTAX                          INTEGER
                                    {
                                        standard(1),
                                        optimized(0)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     “
                                    The mode in which the RT3 status is given. If the
object is
                                    in standard mode all five values of RT3 status are
valid, else only
                                    …
                                    “
    ::= { lldpXPnoLocEntry 12 }

lldpXPnoLocPortPeriodLength         OBJECT-TYPE
    SYNTAX                          Unsigned32 (31250..4000000)
    UNITS                           “ns”
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     “
                                    This integer value represents the duration of a
cycle
                                    in nanoseconds on the corresponding port.
                                    The value shall be a multiple of 31250 nanoseconds.
                                    “
    ::= { lldpXPnoLocEntry 13 }

lldpXPnoLocPortPeriodValidity       OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     “
                                    The value of this object indicates whether the
value of
                                    lldpXPnoLocPortPeriodLength of the according table
entry is
                                    valid or not.
                                    “
    ::= { lldpXPnoLocEntry 14 }

lldpXPnoLocPortRedOffset            OBJECT-TYPE
    SYNTAX                          Unsigned32 (0..3999999)
    UNITS                           “ns”
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     “
                                    This integer value represents the begin of the
RT_CLASS_3 period
                                    of the cycle of the receive direction on the
corresponding port
                                    as an offset relative to the begin of the cycle in
nanoseconds.
```

```
                                    "
    ::= { lldpXPnoLocEntry 15 }

lldpXPnoLocPortRedValidity          OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoLocPortRedOffset of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoLocEntry 16 }

lldpXPnoLocPortOrangeOffset         OBJECT-TYPE
    SYNTAX                          Unsigned32 (0..3999999)
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the begin of the
RT_CLASS_2 period
                                    of the cycle of the receive direction on the
corresponding port
                                    as an offset relative to the begin of the cycle in
nanoseconds.
                                    "
    ::= { lldpXPnoLocEntry 17 }

lldpXPnoLocPortOrangeValidity       OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoLocPortOrangeOffset of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoLocEntry 18 }

lldpXPnoLocPortGreenOffset          OBJECT-TYPE
    SYNTAX                          Unsigned32 (0..3999999)
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the begin of the
unrestricted period
                                    of the cycle of the receive direction on the
corresponding port
                                    as an offset relative to the begin of the cycle in
nanoseconds.
                                    "
    ::= { lldpXPnoLocEntry 19 }

lldpXPnoLocPortGreenValidity        OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoLocPortGreenOffset of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoLocEntry 20 }

lldpXPnoLocPortStatusRT3OptimizationSupported OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
```

```
                                    This value represents the status of the
corresponding
                                    port of the local system according to the optimized
RTC3PSM.
                                    The value true(1) indicates the support, the value
                                    false(2) indicates no support of the optimized
RTC3PSM.
                                    "
    ::= { lldpXPnoLocEntry 21 }

lldpXPnoLocPortStatusRT3PreambleShorteningSupported OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the local system according to the
shortening of the Preamble.
                                    The value true(1) indicates the support, the value
                                    false(2) indicates no support of the shortening of
the Preamble.
                                    "
    ::= { lldpXPnoLocEntry 22 }

lldpXPnoLocPortStatusRT3PreambleShortening OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the local system according to the Preamble
lenghts.
                                    The value true(1) indicates a Preamble length of
one octet,
                                    the value false(2) indicates a Preamble length of
seven octets.
                                    "
    ::= { lldpXPnoLocEntry 23 }

lldpXPnoLocPortStatusRT3FragmentationSupported OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the local system according to the
fragmentation.
                                    The value true(1) indicates the support, the value
                                    false(2) indicates no support of fragmentation.
                                    "
    ::= { lldpXPnoLocEntry 24 }

lldpXPnoLocPortStatusRT3Fragmentation OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the local system according to the
fragmentation.
                                    The value true(1) indicates the activation, the
value
                                    false(2) indicates the deactivation.
                                    "
    ::= { lldpXPnoLocEntry 25 }

PNO - Remote System Information

lldpXPnoRemTable                    OBJECT-TYPE
    SYNTAX                          SEQUENCE OF LldpXPnoRemEntry
    MAX-ACCESS                      not-accessible
    STATUS                          current
    DESCRIPTION                     "
```

```
                                    This table contains one or more rows per physical
network
                                    connection known to this agent. The agent may wish
to
                                    ensure that only one lldpXPnoRemEntry is present
for
                                    each local port, or it may choose to maintain
multiple
                                    lldpXPnoRemEntries for the same local port.
                                    "
    ::= { lldpXPnoRemoteData 1 }

lldpXPnoRemEntry                    OBJECT-TYPE
    SYNTAX                          LldpXPnoRemEntry
    MAX-ACCESS                      not-accessible
    STATUS                          current
    DESCRIPTION                     "
                                    Each entry represents the received information of
the
                                    communication partner on this physical connection.

                                    The entries feature multiple indices from the
                                    lldpRemEntry of the LLDP-MIB, therefore it is
                                    only present along with the description defined
                                    by the associated lldpRemEntry entry.
                                    "
    INDEX                           { lldpRemTimeMark, lldpRemLocalPortNum,
lldpRemIndex }
    ::= { lldpXPnoRemTable 1 }

LldpXPnoRemEntry ::=                SEQUENCE {
    lldpXPnoRemLPDValue             Unsigned32,
    lldpXPnoRemPortTxDValue         Unsigned32,
    lldpXPnoRemPortRxDValue         Unsigned32,
    lldpXPnoRemPortStatusRT2        INTEGER,
    lldpXPnoRemPortStatusRT3        INTEGER,
    lldpXPnoRemPortNoS              DisplayString,
    lldpXPnoRemPortMrpUuId          OCTET STRING,
    lldpXPnoRemPortMrrtStatus       INTEGER,
    lldpXPnoRemPortPtcpMaster       MacAddress,
    lldpXPnoRemPortPtcpSubdomainUUID OCTET STRING,
    lldpXPnoRemPortPtcpIRDataUUID   OCTET STRING,
    lldpXPnoRemPortModeRT3          INTEGER,
    lldpXPnoRemPortPeriodLength     Unsigned32,
    lldpXPnoRemPortPeriodValidity   TruthValue,
    lldpXPnoRemPortRedOffset        Unsigned32,
    lldpXPnoRemPortRedValidity      TruthValue,
    lldpXPnoRemPortOrangeOffset     Unsigned32,
    lldpXPnoRemPortOrangeValidity   TruthValue,
    lldpXPnoRemPortGreenOffset      Unsigned32,
    lldpXPnoRemPortGreenValidity    TruthValue,
    lldpXPnoRemPortStatusRT3PreambleShortening  TruthValue,
    lldpXPnoRemPortStatusRT3Fragmentation   TruthValue
}

lldpXPnoRemLPDValue                 OBJECT-TYPE
    SYNTAX                          Unsigned32
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the line propagation
                                    delay in nanoseconds which was measured by the
remote
                                    system on the corresponding port.

                                    A value of zero shall be used if the remote system
either
                                    could not accomplish the measurement or does not
support
                                    such a measurement.
                                    "
    ::= { lldpXPnoRemEntry 1 }

lldpXPnoRemPortTxDValue             OBJECT-TYPE
    SYNTAX                          Unsigned32
    UNITS                           "ns"
    MAX-ACCESS                      read-only
```

```
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the PortTxDelay in
                                    nanoseconds which was measured by the remote
                                    system on the corresponding port.

                                    A value of zero shall be used if the remote system
either
                                    could not accomplish the measurement or does not
support
                                    such a measurement.
                                    "
    ::= { lldpXPnoRemEntry 2 }

lldpXPnoRemPortRxDValue             OBJECT-TYPE
    SYNTAX                          Unsigned32
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the PortRxDelay in
                                    nanoseconds which was measured by the remote
                                    system on the corresponding port.

                                    A value of zero shall be used if the remote system
either
                                    could not accomplish the measurement or does not
support
                                    such a measurement.
                                    "
    ::= { lldpXPnoRemEntry 3 }

lldpXPnoRemPortStatusRT2            OBJECT-TYPE
    SYNTAX                          INTEGER {
                                        off(0),
                                        configured(1),
                                        running(2)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the remote system according to RT class 2.

                                    A value of off(0) means that there isn't any RT2
                                    capability available for this port. When the port
is
                                    configured for RT2 mode, but the mode isn't active
yet
                                    the value will be configured(1). If the RT2 mode is
                                    configured for this port and the mode is active,
the
                                    value will be running(2).
                                    "
    ::= { lldpXPnoRemEntry 4 }

lldpXPnoRemPortStatusRT3            OBJECT-TYPE
    SYNTAX                          INTEGER {
                                        off(0),
                                        configured(1),
                                        up(2),
                                        down(3),
                                        running(4)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the remote system according to RT class 3.

                                    A value of off(0) means that there isn't any RT3
                                    capability available for this port. When the port
is
                                    configured for RT3 mode, but the mode isn't active
yet
                                    the value will be configured(1).
```

```
                                    When the port is ready for transmission and
reception
                                    of RT3 traffic, the port status will be running(4).
                                    "
    ::= { lldpXPnoRemEntry 5 }

lldpXPnoRemPortNoS                  OBJECT-TYPE
    SYNTAX                          DisplayString
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The PROFINET NameofStation of the remote partner.
If the
                                    station isn't configured yet, the value of this
object
                                    will be the MAC address of the device as a string.
                                    "
    ::= { lldpXPnoRemEntry 6 }

lldpXPnoRemPortMrpUuId              OBJECT-TYPE
    SYNTAX                          OCTET STRING (SIZE (16))
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The UUID of the MRP domain to which the
corresponding port
                                    of the remote system belongs to. If the port
doesn't belong
                                    to a MRP domain, the value must be NIL
('0000000000000000').
                                    "
    ::= { lldpXPnoRemEntry 7 }

lldpXPnoRemPortMrrtStatus           OBJECT-TYPE
    SYNTAX                          INTEGER {
                                        off(0),
                                        configured(1),
                                        up(2)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This object reports the status of the MRRT entity
of the
                                    corresponding port.

                                    A value of off(0) means that there isn't any MRRT
                                    capability available for this port or it is
switched off.
                                    The value configured(1) indicates that MRRT is
configured
                                    for the port. When MRRT is active on the port, the
value
                                    will be up(2).
                                    "
    ::= { lldpXPnoRemEntry 8 }

lldpXPnoRemPortPtcpMaster           OBJECT-TYPE
    SYNTAX                          MacAddress
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The interface MAC address of the PTCP sync master
device
                                    of the PTCP subdomain. If unknown it shall be set
to zero.
                                    "
    ::= { lldpXPnoRemEntry 9 }

lldpXPnoRemPortPtcpSubdomainUUID    OBJECT-TYPE
    SYNTAX                          OCTET STRING (SIZE (16))
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The UUID of the PTCP subdomain to which this port
belongs
                                    to. If the port doesn't belong to a PTCP subdomain
or the subdomain
```

```
                                    is invalid or unknown the value of this object must
be
                                    NIL ('0000000000000000').
                                    "
    ::= { lldpXPnoRemEntry 10 }

lldpXPnoRemPortPtcpIRDataUUID       OBJECT-TYPE
    SYNTAX                          OCTET STRING (SIZE (16))
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The UUID of the IR data domain to which this port
belongs
                                    to. If the port doesn't belong to a IR data domain
or the domain
                                    is invalid or unknown the value of this object must
be
                                    NIL ('0000000000000000').
                                    "
    ::= { lldpXPnoRemEntry 11 }

lldpXPnoRemPortModeRT3              OBJECT-TYPE
    SYNTAX                          INTEGER
                                    {
                                        standard(1),
                                        optimized(0)
                                    }
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The mode in which the RT3 status is given. If the
object is
                                    in standard mode all five values of RT3 status are
valid, else only
                                    …
                                    "
    ::= { lldpXPnoRemEntry 12 }

lldpXPnoRemPortPeriodLength         OBJECT-TYPE
    SYNTAX                          Unsigned32 (31250..4000000)
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the duration of a
cycle
                                    in nanoseconds on the corresponding port.
                                    The value shall be a multiple of 31250 nanoseconds.
                                    "
    ::= { lldpXPnoRemEntry 13 }

lldpXPnoRemPortPeriodValidity       OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoRemPortPeriodLength of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoRemEntry 14 }

lldpXPnoRemPortRedOffset            OBJECT-TYPE
    SYNTAX                          Unsigned32 (0..3999999)
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the begin of the
RT_CLASS_3 period
                                    of the cycle of the receive direction on the
corresponding port
                                    as an offset relative to the begin of the cycle in
nanoseconds.
                                    "
    ::= { lldpXPnoRemEntry 15 }
```

```
lldpXPnoRemPortRedValidity          OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoRemPortRedOffset of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoRemEntry 16 }

lldpXPnoRemPortOrangeOffset         OBJECT-TYPE
    SYNTAX                          Unsigned32 (0..3999999)
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the begin of the
RT_CLASS_2 period
                                    of the cycle of the receive direction on the
corresponding port
                                    as an offset relative to the begin of the cycle in
nanoseconds.
                                    "
    ::= { lldpXPnoRemEntry 17 }

lldpXPnoRemPortOrangeValidity       OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoRemPortOrangeOffset of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoRemEntry 18 }

lldpXPnoRemPortGreenOffset          OBJECT-TYPE
    SYNTAX                          Unsigned32 (0..3999999)
    UNITS                           "ns"
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This integer value represents the begin of the
unrestricted period
                                    of the cycle of the receive direction on the
corresponding port
                                    as an offset relative to the begin of the cycle in
nanoseconds.
                                    "
    ::= { lldpXPnoRemEntry 19 }

lldpXPnoRemPortGreenValidity        OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    The value of this object indicates whether the
value of
                                    lldpXPnoRemPortGreenOffset of the according table
entry is
                                    valid or not.
                                    "
    ::= { lldpXPnoRemEntry 20 }

lldpXPnoRemPortStatusRT3PreambleShortening OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
```

```
                                    port of the remote system according to the Preamble
lenghts.
                                    The value true(1) indicates a Preamble length of
one octet,
                                    the value false(2) indicates a Preamble length of
seven octets.
                                    "
    ::= { lldpXPnoRemEntry 21 }

lldpXPnoRemPortStatusRT3Fragmentation OBJECT-TYPE
    SYNTAX                          TruthValue
    MAX-ACCESS                      read-only
    STATUS                          current
    DESCRIPTION                     "
                                    This value represents the status of the
corresponding
                                    port of the remote system according to the
fragmentation.
                                    The value true(1) indicates the activation, the
value
                                    false(2) indicates the deactivation.
                                    "
    ::= { lldpXPnoRemEntry 22 }

Conformance Information

lldpXPnoConformance                 OBJECT IDENTIFIER ::= { lldpXPnoMIB 2 }
lldpXPnoCompliances                 OBJECT IDENTIFIER ::= { lldpXPnoConformance 1 }
lldpXPnoGroups                      OBJECT IDENTIFIER ::= { lldpXPnoConformance 2 }

compliance statements

lldpXPnoCompliance                  MODULE-COMPLIANCE
    STATUS                          current
    DESCRIPTION                     "
                                    The compliance statement for SNMP entities which
                                    implement the PNO organizationally defined LLDP
                                    extension MIB.
                                    "
    MODULE                          -- compliant to this module
    MANDATORY-GROUPS                { lldpXPnoConfigGroup, lldpXPnoLocGroup,
lldpXPnoRemGroup }
    GROUP                           lldpXPnoMrpGroup
    DESCRIPTION                     "Required if the system provides MRP."
    GROUP                           lldpXPnoPtcpGroup
    DESCRIPTION                     "Required if the system provides PTCP."
    ::= { lldpXPnoCompliances 1 }

MIB groupings

lldpXPnoConfigGroup                 OBJECT-GROUP
    OBJECTS                         {
                                    lldpXPnoConfigSPDTxEnable,
                                    lldpXPnoConfigPortStatusTxEnable,
                                    lldpXPnoConfigAliasTxEnable
                                    }
    STATUS                          current
    DESCRIPTION                     "
                                    The collection of objects which are used to
configure the
                                    PNO organizationally defined LLDP extension
implementation behavior.

                                    This group is mandatory for agents which implement
the PNO
                                    organizationally defined LLDP extension, because
the information
                                    about the signal propagation delay is necessary to
configure
                                    PROFINET domains.
                                    "
    ::= { lldpXPnoGroups 1 }

lldpXPnoLocGroup                    OBJECT-GROUP
    OBJECTS                         { lldpXPnoLocLPDValue,
                                      lldpXPnoLocPortTxDValue,
                                      lldpXPnoLocPortRxDValue,
                                      lldpXPnoLocPortStatusRT2,
```

```
                                    lldpXPnoLocPortStatusRT3,
                                    lldpXPnoLocPortNoS,
                                    lldpXPnoLocPortModeRT3,
                                    lldpXPnoLocPortPeriodLength,
                                    lldpXPnoLocPortPeriodValidity,
                                    lldpXPnoLocPortRedOffset,
                                    lldpXPnoLocPortRedValidity,
                                    lldpXPnoLocPortOrangeOffset,
                                    lldpXPnoLocPortOrangeValidity,
                                    lldpXPnoLocPortGreenOffset,
                                    lldpXPnoLocPortGreenValidity,
                                    lldpXPnoLocPortStatusRT3OptimizationSupported,
lldpXPnoLocPortStatusRT3PreambleShorteningSupported,
                                    lldpXPnoLocPortStatusRT3PreambleShortening,
                                    lldpXPnoLocPortStatusRT3FragmentationSupported,
                                    lldpXPnoLocPortStatusRT3Fragmentation
                                  }
    STATUS                        current
    DESCRIPTION                   "
                                  The collection of objects which are used to
configure the
                                  PNO organizationally defined LLDP extension
implementation behavior.

                                  This group is mandatory for agents which implement
the PNO
                                  organizationally defined LLDP extension, because
the information
                                  about the signal propagation delay is necessary to
configure
                                  PROFINET domains.
                                  "
    ::= { lldpXPnoGroups 2 }

lldpXPnoRemGroup                  OBJECT-GROUP
    OBJECTS                       { lldpXPnoRemLPDValue,
                                    lldpXPnoRemPortTxDValue,
                                    lldpXPnoRemPortRxDValue,
                                    lldpXPnoRemPortStatusRT2,
                                    lldpXPnoRemPortStatusRT3,
                                    lldpXPnoRemPortNoS,
                                    lldpXPnoRemPortModeRT3,
                                    lldpXPnoRemPortPeriodLength,
                                    lldpXPnoRemPortPeriodValidity,
                                    lldpXPnoRemPortRedOffset,
                                    lldpXPnoRemPortRedValidity,
                                    lldpXPnoRemPortOrangeOffset,
                                    lldpXPnoRemPortOrangeValidity,
                                    lldpXPnoRemPortGreenOffset,
                                    lldpXPnoRemPortGreenValidity,
                                    lldpXPnoRemPortStatusRT3PreambleShortening,
                                    lldpXPnoRemPortStatusRT3Fragmentation
                                  }
    STATUS                        current
    DESCRIPTION                   "
                                  The collection of objects which are used to
configure the
                                  PNO organizationally defined LLDP extension
implementation behavior.

                                  This group is mandatory for agents which implement
the PNO
                                  organizationally defined LLDP extension, because
the information
                                  about the signal propagation delay is necessary to
configure
                                  PROFINET domains.
                                  "
    ::= { lldpXPnoGroups 3 }

lldpXPnoMrpGroup                  OBJECT-GROUP
    OBJECTS                       { lldpXPnoConfigMrpTxEnable,
                                    lldpXPnoLocPortMrpUuId,
                                    lldpXPnoLocPortMrrtStatus,
                                    lldpXPnoRemPortMrpUuId,
                                    lldpXPnoRemPortMrrtStatus
                                  }
```

```
    STATUS                          current
    DESCRIPTION                     "
                                    The collection of objects which are used to
configure the
                                    PNO organizationally defined LLDP extension
implementation behavior.

                                    This group is mandatory for agents which implement
the PNO
                                    organizationally defined LLDP extension, because
the information
                                    about the signal propagation delay is necessary to
configure
                                    PROFINET domains.
                                    "
    ::= { lldpXPnoGroups 4 }

lldpXPnoPtcpGroup                   OBJECT-GROUP
    OBJECTS                         { lldpXPnoConfigPtcpTxEnable,
                                      lldpXPnoLocPortPtcpMaster,
                                      lldpXPnoLocPortPtcpSubdomainUUID,
                                      lldpXPnoLocPortPtcpIRDataUUID,
                                      lldpXPnoRemPortPtcpMaster,
                                      lldpXPnoRemPortPtcpSubdomainUUID,
                                      lldpXPnoRemPortPtcpIRDataUUID
                                    }
    STATUS                          current
    DESCRIPTION                     "
                                    The collection of objects which are used to
configure the
                                    PNO organizationally defined LLDP extension
implementation behavior.

                                    This group is mandatory for agents which implement
the PNO
                                    organizationally defined LLDP extension, because
the information
                                    about the signal propagation delay is necessary to
configure
                                    PROFINET domains.
                                    "
    ::= { lldpXPnoGroups 5 }

END
```

Bibliography

IEC 61784-1, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61784-2, *Industrial communication networks – Profiles – Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3*

IEC 61784-3-3, *Industrial communication networks – Profiles – Part 3-3: Functional safety fieldbuses – Additional specifications for CPF 3*

IEC 60793-2-30, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres*

IEC 60793-2-40, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres*

ISO/IEC 8859-1, *Information technology – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No. 1*

ISO 15745-4:2003, *Industrial automation systems and integration – Open systems application integration framework – Part 4: Reference description for Ethernet-based control systems* Amendment 1:2006, PROFINET profiles

IEEE 802.11n, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications – Amendment 5: Enhancements for Higher Throughput,* available at <http://www.ieee.org>

IETF RFC 2737, *Entity MIB (Version 2),* available at <http://www.ietf.org>

IETF RFC 3376, *Internet Group Management Protocol – Version 3,* available at <http://www.ietf.org>

IETF RFC 4133, *Entity MIB (Version 3)*, available at <http://www.ietf.org>

IETF RFC 4604, *Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast*, available at <http://www.ietf.org>

IETF RFC 4632, *Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan*, available at <http://www.ietf.org>

IETF RFC 5494, *IANA Allocation Guidelines for the Address Resolution Protocol (ARP),* available at <http://www.ietf.org>

IETF RFC 5891, *Internationalized Domain Names in Applications (IDNA): Protocol,* available at <http://www.ietf.org>

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™