BS EN 61800-7-1:2016

BSI Standards Publication

Adjustable speed electrical power drive systems

Part 7-1: Generic interface and use of profiles for power drive systems — Interface definition

National foreword

This British Standard is the UK implementation of EN 61800-7-1:2016. It is identical to IEC 61800-7-1:2015. It supersedes BS EN 61800-7-1:2008, which will be withdrawn on 10 October 2018.

The UK participation in its preparation was entrusted to Technical Committee PEL/22, Power electronics.

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

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Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD
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EN 61800-7-1

February 2016

ICS 29.200; 35.100.05

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English Version

Adjustable speed electrical power drive systems - Part 7-1: Generic interface and use of profiles for power drive systems - Interface definition (IEC 61800-7-1:2015)

Entraînements électriques de puissance à vitesse variable - Partie 7-1: Interface générique et utilisation de profils pour les entraînements électriques de puissance - Définition de l'interface
(IEC 61800-7-1:2015)

Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl - Teil 7-1: Generisches Interface und Nutzung von Profilen für Leistungsantriebssysteme (PDS) - Schnittstellendefinition
(IEC 61800-7-1:2015)

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European foreword

The text of document 22G/306/FDIS, future edition 2 of IEC 61800-7-1, prepared by SC 22G “Adjustable speed electric drive systems incorporating semiconductor power converters” of IEC/TC 22 “Power electronic systems and equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61800-7-1:2016.

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)	2016-09-25
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-12-25

This document supersedes EN 61800-7-1:2008.

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Endorsement notice

The text of the International Standard IEC 61800-7-1:2015 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 61131-3	NOTE	Harmonized as EN 61131-3.
IEC 61158 Series	NOTE	Harmonized as EN 61158 Series.
IEC 61158-5-12	NOTE	Harmonized as EN 61158-5-12.
IEC 61158-5-13	NOTE	Harmonized as EN 61158-5-13.
IEC 61158-5-14	NOTE	Harmonized as EN 61158-5-14.
IEC 61158-5-16	NOTE	Harmonized as EN 61158-5-16.
IEC 61158-5-19	NOTE	Harmonized as EN 61158-5-19.
IEC 61158-5-23	NOTE	Harmonized as EN 61158-5-23.
IEC 61158-6-12	NOTE	Harmonized as EN 61158-6-12.
IEC 61158-6-13	NOTE	Harmonized as EN 61158-6-13.
IEC 61158-6-14	NOTE	Harmonized as EN 61158-6-14.
IEC 61158-6-16	NOTE	Harmonized as EN 61158-6-16.
IEC 61158-6-19	NOTE	Harmonized as EN 61158-6-19.
IEC 61158-6-23	NOTE	Harmonized as EN 61158-6-23.
IEC 61499-1:2012	NOTE	Harmonized as EN 61499-1:2013 (not modified).
IEC 61784-1	NOTE	Harmonized as EN 61784-1.
IEC 61784-2	NOTE	Harmonized as EN 61784-2
IEC 61800 Series	NOTE	Harmonized as EN 61800 Series.
IEC 61800-4:2002	NOTE	Harmonized as EN 61800-4:2003 (not modified).
IEC 61800-7-301	NOTE	Harmonized as EN 61800-7-301.
IEC 61800-7-302	NOTE	Harmonized as EN 61800-7-302.
IEC 61800-7-303	NOTE	Harmonized as EN 61800-7-303.
IEC 62026-3	NOTE	Harmonized as EN 62026-3.

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
-	-	Industrial communications subsystem based on ISO 11898 (CAN) for controller-device interfaces - Part 4: CANopen	EN 50325-4	-
IEC 61158-5-2	-	Industrial communication networks - Fieldbus specifications - Part 5-2: Application layer service definition - Type 2 elements	EN 61158-5-2	-
IEC 61158-5-3	-	Industrial communication networks - Fieldbus specifications - Part 5-3: Application layer service definition - Type 3 elements	EN 61158-5-3	-
IEC 61158-5-10	-	Industrial communication networks - Fieldbus specifications - Part 5-10: Application layer service definition - Type 10 elements	EN 61158-5-10	-
IEC 61158-6-2	-	Industrial communication networks - Fieldbus specifications - Part 6-2: Application layer protocol specification - Type 2 elements	EN 61158-6-2	-
IEC 61158-6-3	-	Industrial communication networks - Fieldbus specifications - Part 6-3: Application layer protocol specification - Type 3 elements	EN 61158-6-3	-
IEC 61158-6-10	-	Industrial communication networks - Fieldbus specifications - Part 6-10: Application layer protocol specification - Type 10 elements	EN 61158-6-10	-
IEC 61800-7	Series	Adjustable speed electrical power drive systems - Part 7: Generic interface and use of profiles for power drive systems	EN 61800-7	Series

Publication	Year	Title	EN/HD	Year
IEC 61800-7-201	-	Adjustable speed electrical power drive systems - Part 7-201: Generic interface and use of profiles for power drive systems - Profile type 1 specification	EN 61800-7-201	-
IEC 61800-7-202	2015	Adjustable speed electrical power drive systems - Part 7-202: Generic interface and use of profiles for power drive systems - Profile type 2 specification	EN 61800-7-202	2016
IEC 61800-7-203	-	Adjustable speed electrical power drive systems - Part 7-203: Generic interface and use of profiles for power drive systems - Profile type 3 specification	EN 61800-7-203	-
IEC 61800-7-204	2015	Adjustable speed electrical power drive systems - Part 7-204: Generic interface and use of profiles for power drive systems - Profile type 4 specification	EN 61800-7-204	2016
IEC 61800-7-304	-	Adjustable speed electrical power drive systems - Part 7-304: Generic interface and use of profiles for power drive systems - Mapping of profile type 4 to network technologies	EN 61800-7-304	-
IEC/TR 62390	2005	Common automation device - Profile guideline	-	-

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 7-1: Generic interface and use of profiles for power drive systems – Interface definition

FOREWORD

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International Standard IEC 61800-7-1 has been prepared by subcommittee SC 22G: Adjustable speed electric drive systems incorporating semiconductor power converters, of IEC technical committee TC 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) mapping of drive profile type 1 onto additional network technologies;
b) minor updates in the subclauses for profile types 1, 2 and 4, in relation with corresponding changes in the dedicated IEC 61800-7-20x parts.

The text of this standard is based on the following documents:

FDIS	Report on voting
22G/306/FDIS	22G/321/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61800 series, under the general title *Adjustable speed electrical power drive systems*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The IEC 61800 series is intended to provide a common set of specifications for adjustable speed electrical power drive systems.

IEC 61800-7 specifies profiles for power drive systems (PDS) and their mapping to existing communication systems by use of a generic interface model.

IEC 61800-7 describes a generic interface between control systems and power drive systems. This interface can be embedded in the control system. The control system itself can also be located in the drive (sometimes known as "smart drive" or "intelligent drive").

A variety of physical interfaces is available (analogue and digital inputs and outputs, serial and parallel interfaces, fieldbuses and networks). Profiles based on specific physical interfaces are already defined for some application areas (e.g. motion control) and some device classes (e.g. standard drives, positioner). The implementations of the associated drivers and application programmers interfaces are proprietary and vary widely.

IEC 61800-7 defines a set of common drive control functions, parameters, and state machines or description of sequences of operation to be mapped to the drive profiles.

IEC 61800-7 provides a way to access functions and data of a drive that is independent of the used drive profile and communication interface. The objective is a common drive model with generic functions and objects suitable to be mapped on different communication interfaces. This makes it possible to provide common implementations of motion control (or velocity control or drive control applications) in controllers without any specific knowledge of the drive implementation.

There are several reasons to define a generic interface:

For a drive device manufacturer

– less effort to support system integrators;
– less effort to describe drive functions because of common terminology;
– the selection of drives does not depend on availability of specific support.

For a control device manufacturer

– no influence of bus technology;
– easy device integration;
– independent of a drive supplier.

For a system integrator

– less integration effort for devices;
– only one understandable way of modeling;
– independent of bus technology.

Much effort is needed to design a motion control application with several different drives and a specific control system. The tasks to implement the system software and to understand the functional description of the individual components may exhaust the project resources. In some cases, the drives do not share the same physical interface. Some control devices just support a single interface which will not be supported by a specific drive. On the other hand, the functions and data structures are often specified with incompatibilities. This requires the system integrator to write special interfaces for the application software and this should not be his responsibility.

Some applications need device exchangeability or integration of new devices in an existing configuration. They are faced with different incompatible solutions. The efforts to adapt a solution to a drive profile and to manufacturer specific extensions may be unacceptable. This will reduce the degree of freedom to select a device best suited for this application to the selection of the unit which will be available for a specific physical interface and supported by the controller.

This part of IEC 61800-7 is divided into a generic part and several annexes as shown in Figure 1. The drive profiles types for CiA® 402[1], CIP Motion™[2], PROFIdrive[3] and SERCOS®[4] are mapped to the generic interface in the corresponding annex. The annexes have been submitted by open international network or fieldbus organizations which are responsible for the content of the related annex and use of the related trademarks.

The different profile types 1, 2, 3 and 4 are specified in IEC 61800-7-201, IEC 61800-7-202, IEC 61800-7-203 and IEC 61800-7-204.

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IEC 61800-7-301, IEC 61800-7-302, IEC 61800-7-303 and IEC 61800-7-304 specify how the profile types 1, 2, 3 and 4 are mapped to different network technologies (such as CANopen®[5], CC-Link IE® Field Network[6], EPA™[7], EtherCAT®[8], Ethernet Powerlink™[9], DeviceNet™[10], ControlNet™[11], EtherNet/IP™[12], PROFIBUS[13], PROFINET[14] and SERCOS®).

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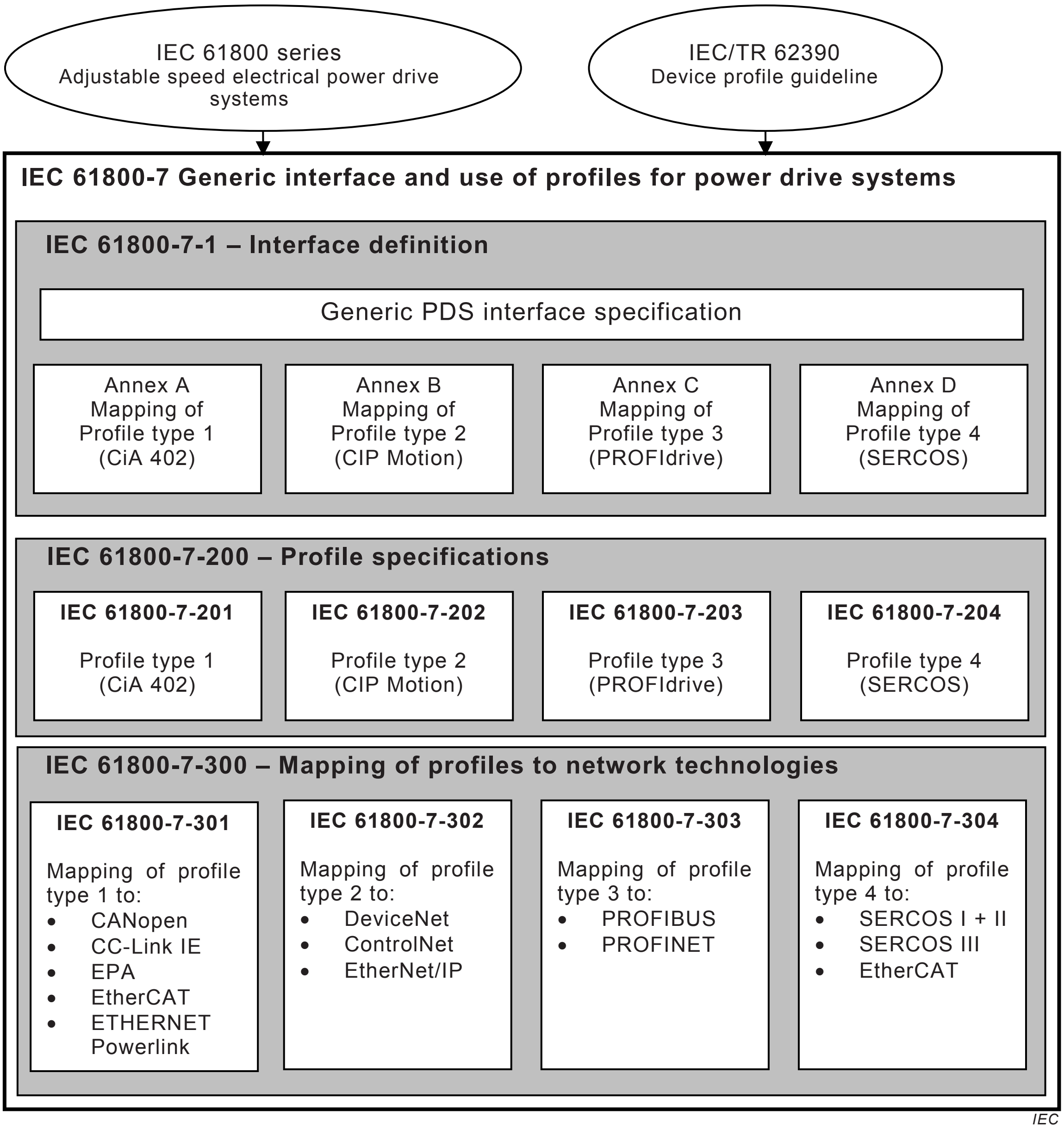

Figure 1 – Structure of IEC 61800-7

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 7-1: Generic interface and use of profiles for power drive systems – Interface definition

1 Scope

This part of IEC 61800 specifies a generic interface between power drive system(s) (PDS) and the application control program in a controller. The generic PDS interface is not specific to any particular communication network technology. Annexes of this part of IEC 61800 specify the mapping of the different drive profiles types onto the generic PDS interface.

The functions specified in this part of IEC 61800 are not intended to ensure functional safety. This requires additional measures according to the relevant standards, agreements and laws.

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.

IEC 61158-5-2, *Industrial communication networks – Fieldbus specifications – Part 5-2: Application layer service definition – Type 2 elements*

IEC 61158-5-3, *Industrial communication networks – Fieldbus specifications – Part 5-3: Application layer service definition – Type 3 elements*

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

IEC 61158-6-2, *Industrial communication networks – Fieldbus specifications – Part 6-2: Application layer protocol specification – Type 2 elements*

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

IEC 61158-6-10, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 61800-7 (all parts), *Adjustable speed electrical power drive systems – Generic interface and use of profiles for power drive systems*

IEC 61800-7-201, *Adjustable speed electrical power drive systems – Part 7-201: Generic interface and use of profiles for power drive systems – Profile type 1 specification*

IEC 61800-7-202:2015, *Adjustable speed electrical power drive systems – Part 7-202: Generic interface and use of profiles for power drive systems – Profile type 2 specification*

IEC 61800-7-203, *Adjustable speed electrical power drive systems – Part 7-203: Generic interface and use of profiles for power drive systems – Profile type 3 specification*

IEC 61800-7-204:2015, *Adjustable speed electrical power drive systems – Part 7-204: Generic interface and use of profiles for power drive systems – Profile type 4 specification*

IEC 61800-7-304, *Adjustable speed electrical power drive systems – Part 7-304: Generic interface and use of profiles for power drive systems – Mapping of profile type 4 to network technologies*

IEC TR 62390:2005, *Common automation device – Profile guideline*

EN 50325-4, *Industrial communications subsystem based on ISO 11898 (CAN) for controller-device interfaces – Part 4: CANopen*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviations apply.

3.1 System definitions

3.1.1
power drive system
PDS
combination of a motor and the Complete Drive Module (CDM)

Note 1 to entry: The complete drive module may include converter, control and self-protection functions and also some auxiliaries (for example ventilation). The PDS does not include the equipment driven by the motor.

Note 2 to entry: A logical power drive system consists of the PDS and an interface (e.g. communication network, fieldbus or software interface) and is accessed by an application control program over the generic PDS interface as described in Figure 3 to Figure 5.

Note 3 to entry: This definition is adapted from specifications in IEC 61800-1, IEC 61800-2, IEC 61800-3 and IEC 61800-4.

Note 4 to entry: The English abbreviation PDS is also used in French.

3.2 General definitions

3.2.1
algorithm
completely determined finite sequence of operations by which the values of the output data can be calculated from the values of the input data

[SOURCE: IEC 60050-351:2013, 351-42-27, modified — The words "instructions" and "variables" are replaced by the words "operations" and "data" and the notes to entry are deleted.]

3.2.2
application
software functional element specific to the solution of a problem in industrial-process measurement and control

Note 1 to entry: An application may be distributed among resources, and may communicate with other applications.

[SOURCE: IEC TR 62390:2005, 3.1.2, modified — The term “application program” has been replaced.]

3.2.3
attribute
property or characteristic of an entity

[SOURCE: IEC TR 62390:2005, 3.1.3]

3.2.4
axis
logical element inside an automation system (e.g. a motion control system) that represents some form of movement

Note 1 to entry: Axes can be rotary or linear, physical or virtual, controlled or simply observed.

3.2.5
class
description of a set of objects that share the same attributes, operations, methods, relationships, and semantics

[SOURCE: ISO/IEC 19501:2005, 0000_121, modified — The second sentence is omitted.]

3.2.6
control
purposeful action on or in a process to meet specified objectives

[SOURCE: IEC 60050-351:2013, 351-42-19, modified — The notes to entry are omitted.]

3.2.7
control device
physical unit that contains – in a module/subassembly or device – an application program to control the PDS

3.2.8
data type
set of values together with a set of permitted operations

[SOURCE: IEC 62390:2005, 3.1.6]

3.2.9
device
field device
<function blocks> networked independent physical entity of an industrial automation system capable of performing specified functions in a particular context and delimited by its interfaces

[SOURCE: IEC 61499-1:2012, 3.29, modified — The note to entry is omitted, “networked” and “of an industrial automation system” are added.]

3.2.10
device
field device
<system integration> entity that performs control, actuating and/or sensing functions and interfaces to other such entities within an automation system

[SOURCE: ISO 15745-1:2003, 3.11]

3.2.11
device profile
representation of a device in terms of its parameters, parameter assemblies and behaviour according to a device model that describes the data and behaviour of the device as viewed through a network, independent from any network technology

[SOURCE: IEC TR 62390:2005, 3.1.9, modified — The notes to entry are omitted.]

3.2.12
feedback variable
variable quantity, which represents the controlled variable and is returned to the comparing element

[SOURCE: IEC 60050-351:2013, 351-48-03, modified — The figure is omitted.]

3.2.13
functional element
entity of software or software combined with hardware, capable of accomplishing a specified function of a device

Note 1 to entry: A functional element has an interface, associations to other functional elements and functions.

Note 2 to entry: A functional element can be made out of function block(s), object(s) or parameter list(s).

[SOURCE: IEC TR 62390:2005, 3.1.12]

3.2.14
input data
data transferred from an external source into a device, resource or functional element

[SOURCE: IEC TR 62390:2005, 3.1.14]

3.2.15
interface
shared boundary between two entities defined by functional characteristics, signal characteristics, or other characteristics as appropriate

[SOURCE: IEC 60050-351:2013, 351-42-25, modified — The words "functional units" are replaced by "entities" and the notes to entry are omitted.]

3.2.16
logical power drive system
model which includes PDS and communication network accessible through the generic PDS interface

3.2.17
model
mathematical or physical representation of a system or a process, based with sufficient precision upon known laws, identification or specified suppositions

[SOURCE: IEC 60050-351:2013, 351-42-26]

3.2.18
operating mode
characterization of the way and the extent to which the human operator intervenes in the control equipment

[SOURCE: IEC 60050-351:2013, 351-55-01, modified – The figure is omitted.]

3.2.19
output data
data originating in a device, resource or functional element and transferred from them to external systems

[SOURCE: IEC TR 62390:2005, 3.1.21]

3.2.20
parameter
data element that represents device information that can be read from or written to a device, for example through the network or a local HMI

Note 1 to entry: A parameter is typically characterized by a parameter name, data type and access direction.

[SOURCE: IEC TR 62390:2005, 3.1.22, modified – The note 1 to entry is omitted.]

3.2.21
profile
representation of a PDS interface in terms of its parameters, parameter assemblies and behavior according to a communication profile and a device profile

Note 1 to entry: Used in this part of IEC 61800 as a synonym for the specifications referenced in the annexes.

3.2.22
reference variable
input variable to a comparing element in a controlling system which sets the desired value of the controlled variable and is deducted from the command variable

[SOURCE: IEC 60050-351:2013, 351-48-02, modified — The figure is omitted.]

3.2.23
type
hardware or software element which specifies the common attributes shared by all instances of the type

[SOURCE: IEC TR 62390:2005, 3.1.25]

3.2.24
use case
class specification of a sequence of actions, including variants, that a system (or other entity) can perform, interacting with actors of the system

[SOURCE: IEC TR 62390:2005, 3.1.26]

3.2.25
variable
software entity that may take different values, one at a time

Note 1 to entry: The values of a variable as well as of a parameter are usually restricted to a certain data type.

[SOURCE: IEC TR 62390:2005, 3.1.27, modified — Note 1 to entry is added.]

3.3 Specific definitions

3.3.1 Common definitions

NOTE The following terms and definitions are mapped by the different profiles to their specific terms.

3.3.1.1
actual value
value of a variable quantity at a given instant

Note 1 to entry: Actual value is used in this document as input data of the application control program to monitor variables of the PDS (e.g. feedback variables).

[SOURCE: IEC 60050-351:2013, 351-41-02, modified – A note to entry is added.]

3.3.1.2
application mode
type of application that can be requested from a PDS

Note 1 to entry: The different application modes reflect the control loop for torque control, velocity control, position control or other applications such as homing.

3.3.1.3
commands
set of commands from the application control program to the PDS to control the behavior of the PDS or functional elements of the PDS

Note 1 to entry: The behavior is reflected by states or operating modes.

Note 2 to entry: The different commands may be represented by one bit each.

3.3.1.4
I/O data
input data and output data that would typically need to be updated on a regular basis (e.g. periodic change of state)

EXAMPLE Commands, set-points, status and actual values

3.3.1.5
set-point
value or variable used as output data of the application control program to control the PDS

3.3.1.6
status
set of information from the PDS to the application control program reflecting the state or mode of the PDS or a functional element of the PDS

Note 1 to entry: The different status information may be coded with one bit each.

3.3.2 Definitions for Annex A

3.3.2.1
CANopen
application layer protocol as defined in EN 50325-4

3.3.2.2
object dictionary
list of objects with unique 16-bit index and 8-bit sub-index as defined in EN 50325-4

3.3.2.3
process data object
communication object with real-time capability

3.3.3 Definitions for Annex B

The terms and definitions given in IEC 61158-5-2 and IEC 61158-6-2 as well as the following also apply for Annex B.

3.3.3.1
CIP Motion™ [15]
extensions to the CIP services and protocol to support motion control over CIP networks

3.3.3.2
CIP Motion™controller
CIP compliant controller containing a Motion Control Axis Object that can interface to a CIP Motion device via a CIP Motion I/O Connection

Note 1 to entry: A description of the Motion Control Axis Object is beyond the scope of IEC 61800-7.

3.3.3.3
CIP Motion™ device
CIP compliant device containing one or more Motion Device Axis Object instances that can communicate to a CIP Motion controller via a CIP Motion I/O Connection

EXAMPLE: A CIP Motion drive is a particular case of a CIP Motion device.

3.3.3.4
CIP Motion™ I/O Connection
CIP Motion™ Connection
periodic bi-directional, class 1, CIP connection between a controller and a drive that is defined as part of the CIP Motion specification

3.3.3.5
CIP Sync™ [15]
extensions to the CIP services and protocol to encapsulate IEC 61588:2009 time synchronization functionality over a CIP Network

Note 1 to entry: See Time Sync Object in IEC 61158-5-2 and IEC 61158-6-2.

3.3.3.6
cyclic data
high priority real-time data that is transferred by a CIP Motion Connection on a periodic basis

Note 1 to entry: This data would be considered I/O data as defined in IEC 61800-7.

3.3.3.7
event data
medium priority real-time data that is transferred by a CIP Motion Connection only after a specified event occurs

Note 1 to entry: Registration and marker input transitions are typical drive events.

3.3.3.8
motion
any aspect of the dynamics of an axis

Note 1 to entry: In the context of this part of IEC 61800-7, it is not limited to servo drives but encompasses all forms of drive based motor control.

3.3.3.9
Motion Device Axis Object
object that defines the attributes, services, and behavior of a motion device based axis according to the CIP Motion specification

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15 CIP Motion™ and CIP Sync™ are trademarks of ODVA, Inc. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trade mark holder or any of its products. Compliance to this profile does not require use of the trade marks CIP Motion™ or CIP Sync™. Use of the trade marks CIP Motion™ or CIP Sync™ requires permission of ODVA, Inc.

Note 1 to entry: This object includes Communications, Device control, and Basic drive FE elements as defined in IEC 61800-7

3.3.3.10
service data
lower priority real-time data associated with a service message from the controller that is transferred by a CIP Motion Connection on a periodic basis

Note 1 to entry: Service data includes service request messages to access Motion Device Axis Object attributes or perform various drive diagnostics.

3.3.3.11
synchronized
condition where the local clock value on the drive is locked onto the master clock of the distributed System Time

Note 1 to entry: When synchronized, the drive and controller devices may utilise time stamps associated with CIP Motion Connection data.

3.3.3.12
System Time
absolute time value as defined in the CIP Sync specification in the context of a distributed time system where all devices have a local clock that is synchronized with a common master clock

Note 1 to entry: In the context of CIP Motion, System Time is a 64-bit integer value in units of nanoseconds with a value of 0 corresponding to the date 1970-01-01.

3.3.3.13
time stamp
System Time stamp value associated with the CIP Motion Connection data that conveys the absolute time when the associated data was captured, or that can also be used to determine when the associated data shall be applied

Note 1 to entry: CIP time stamps are always in the context of a distributed time system where all nodes on the CIP control network have clocks that are synchronized with a master clock source using CIP Sync.

3.3.4 Definitions for Annex C

3.3.4.1
Application Class
configuration of a Drive Object with a set of functional objects and supported by standard telegrams

3.3.4.2
Controller
controlling device which is associated with one or more drives (axes) a host for the overall automation

3.3.4.3
Drive Object
functional element of a Drive Unit

3.3.4.4
Drive Unit
logical device which comprises all functional elements related to one central processing unit

3.3.4.5
host
device that covers the automation functionality of an automation device

3.3.4.6
P-Device
field device and the host for the Drive Objects

3.3.4.7
standard telegram
set of input data and output data for an application mode

3.3.4.8
Supervisor
engineering device which manages provisions of configuration data (parameter sets) and collections of diagnosis data from P-Devices and/or controllers

3.3.5 Definitions for Annex D

3.3.5.1
acknowledge telegram
AT
telegram, in which each slave inserts its data

Note 1 to entry: The English abbreviation AT is also used in French.

3.3.5.2
communication cycle
accumulation of all telegrams between two master synchronization telegrams

3.3.5.3
control unit
control device

3.3.5.4
control word
two adjacent bytes inside the master data telegram containing commands for the addressed drive

3.3.5.5
cycle time
time span between two consecutive cyclically recurring events

3.3.5.6
cyclic data
part of the message which does not change its meaning during cyclic operation of the interface

3.3.5.7
data exchange
demand dependent, non-cyclic transmission of information after request was sent by the master (service channel)

3.3.5.8
feed forward
command value used to compensate the lag in the control loop

3.3.5.9
identification number
IDN
designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

Note 1 to entry: The English abbreviation IDN is also used in French.

3.3.5.10
master
node, which assigns the other nodes the right to transmit

3.3.5.11
master data telegram
MDT
telegram, in which the master inserts its data

Note 1 to entry: The English abbreviation MDT is also used in French.

3.3.5.12
operating cycle
period of the control loop within the drive or the control unit

3.3.5.13
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.3.5.14
slave
node, which is assigned the right to transmit by the master

3.3.5.15
status word
two adjacent bytes inside the drive telegram containing status information

3.3.5.16
telegram
message
dataset

3.3.5.17
topology
physical network architecture with respect to the connection between the stations of the communication system

3.4 Abbreviated terms

3.4.1 Common abbreviations

CDM	complete drive module
DCS	distributed control system
ERP	enterprise resource planning
FE	functional element
HMI	human machine interface
I/O	input/output
ID	identifier
MES	manufacturing execution system
NC	numerical control system with a numeric control command set
PDS	power drive system
PLC	programmable logic controller without a motion control command set

SCADA	supervisory control and data acquisition
URL	universal resource locator

3.4.2 Abbreviations for Annex A

CiA	CAN in Automation
FSA	finite state automaton
NMT	network management
PDO	process data object

3.4.3 Abbreviations for Annex B

Attr ID	attribute identifier
CIP™	Common Industrial Protocol (see IEC 61158 Type 2, IEC 61784-1 and IEC 61784-2 Communication Profile Family 2)

3.4.4 Abbreviations for Annex C

AC x	Application Class x, where x is the number of the AC
DO	Drive Object
DU	Drive Unit
I&M	identification and maintenance functions
P-Device	Peripheral Device
PROFIdrive	PROcess FIeldbus for drives
STW	control word
ZSW	status word

3.4.5 Abbreviations for Annex D

AT	acknowledge telegram
C1D	class 1 diagnostic
C2D	class 2 diagnostic
C3D	class 3 diagnostic
CP	communication phase (CP0 … to CP6 – communication phases 0 … 6)
IDN	identification number
MDT	master data telegram
SERCOS	SErial Real time COmmunication System
SVC	service channel

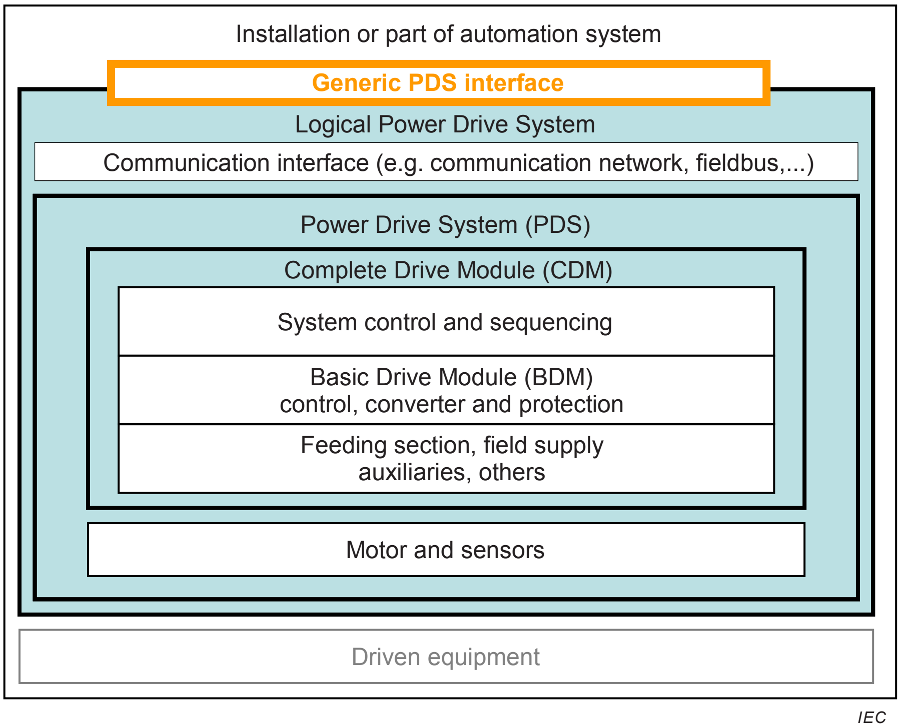
3.5 Conventions

Hexadecimal numbers shall be represented by 0xnn, nn_{hex} or nn_h.

4 General architecture

4.1 Generic PDS interface

This part of IEC 61800-7 specifies a generic interface between power drive systems (PDS) and the application control program in a controller. The generic PDS interface is not specific to any particular communication network technologies. The generic PDS interface supports only single axis control. Any functions for coordination of multiple axis are outside the scope of this part of IEC 61800-7. This might be a part of the logical controller.



NOTE In this part of IEC 61800-7, the drive device corresponds to the Complete Drive Module (CDM).

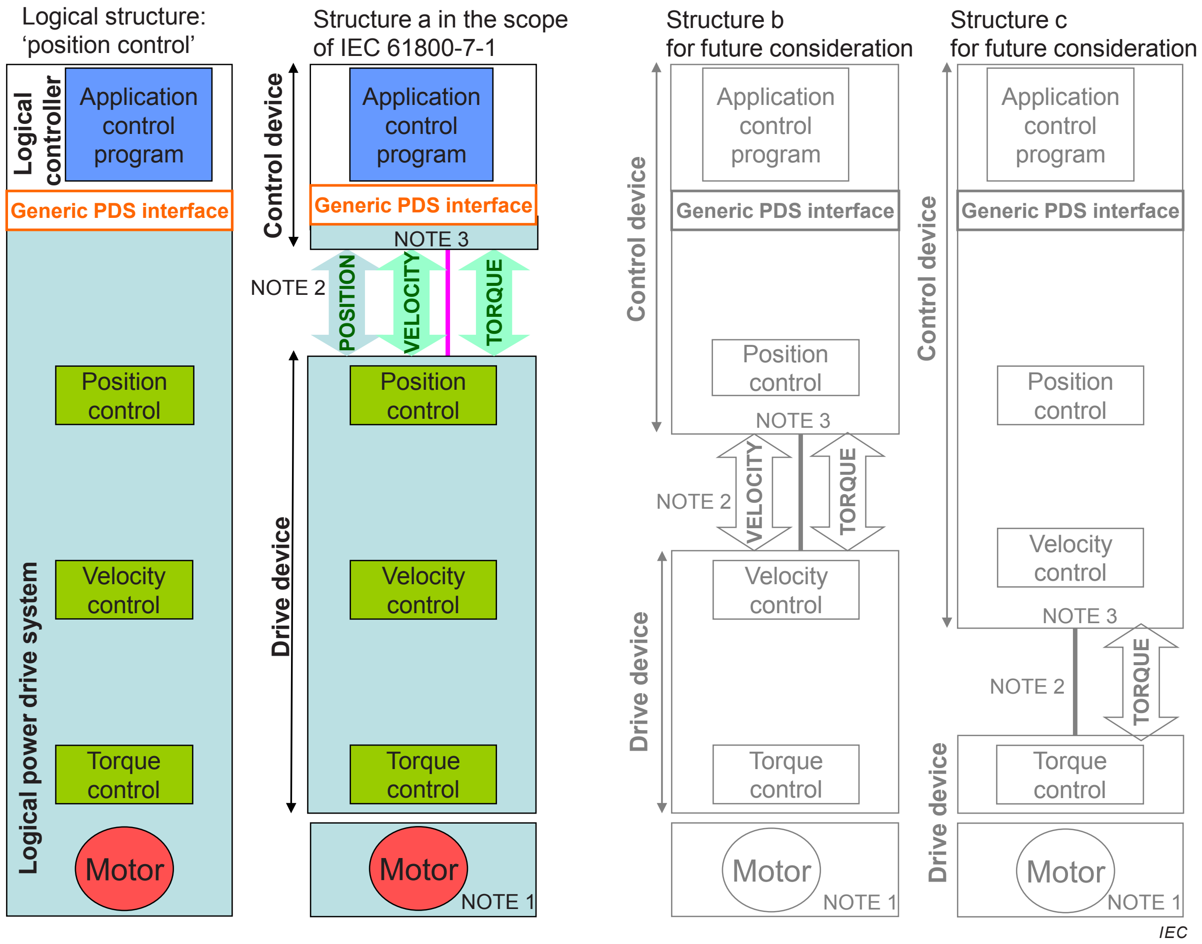
Figure 2 – Definition of power drive system

The PDS includes the drive device (or complete drive module) and the motor and sensors as shown in Figure 2.

The logical PDS is controlled by one or more logical controllers. The functions of the logical controller are performed by the application control program. The functionality of the logical PDS may be differentiated by position-control, velocity-control and torque-control applications. Figure 3 shows a subset of possible structures for position-control, Figure 4 shows a subset of possible structures for velocity-control and Figure 5 shows a subset of possible structures for torque-control applications.

NOTE 1 Possible velocity control types are listed in IEC 61800-4:2002, Annex B, and not covered by this part of IEC 61800-7.

NOTE 2 "Velocity" is used throughout this part of IEC 61800 to mean speed (e.g. movement of a motor) as well as velocity (e.g. movement of mechanical equipment). However "speed" is retained in the title to be consistent with common usage.



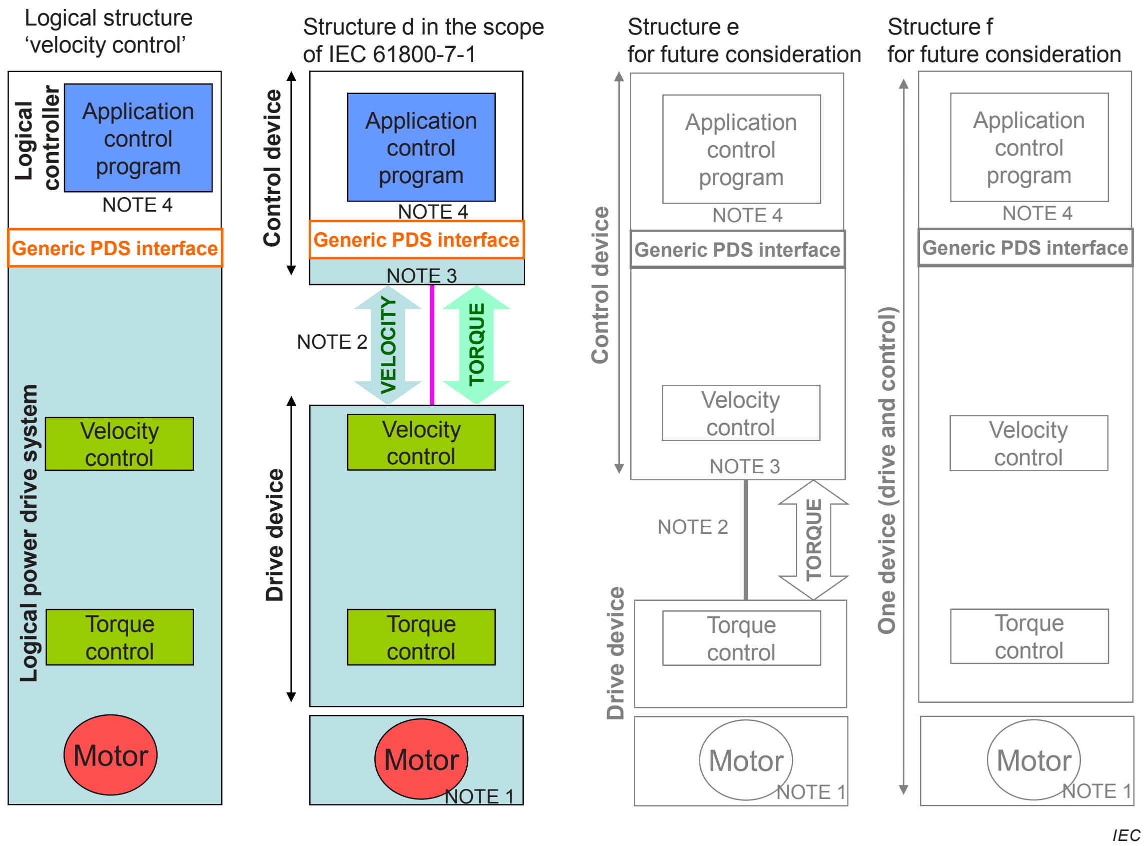
NOTE 1 In general, the PDS model includes the motor.

NOTE 2 Between the control device and the drive device is a network or fieldbus to transmit the data values such as position, velocity and torque.

NOTE 3 Mapping or adaptation as needed for specific network or fieldbus technology.

Figure 3 – Example of system structures for position-control applications

Structure a in Figure 3 shows a position-control application where all three control loops are implemented inside the drive device. In structure b, the velocity- and torque-control loops are inside the drive device and the position-control loop is in the control device. In structure c, only the torque-control is inside the drive device and the other control loops of the complete logical PDS are implemented inside the control device. In all three examples, the generic PDS interface is identical.



NOTE 1 In general, the PDS model includes the motor.

NOTE 2 Between the control device and the drive device is a network or fieldbus to transmit the data values like velocity and torque.

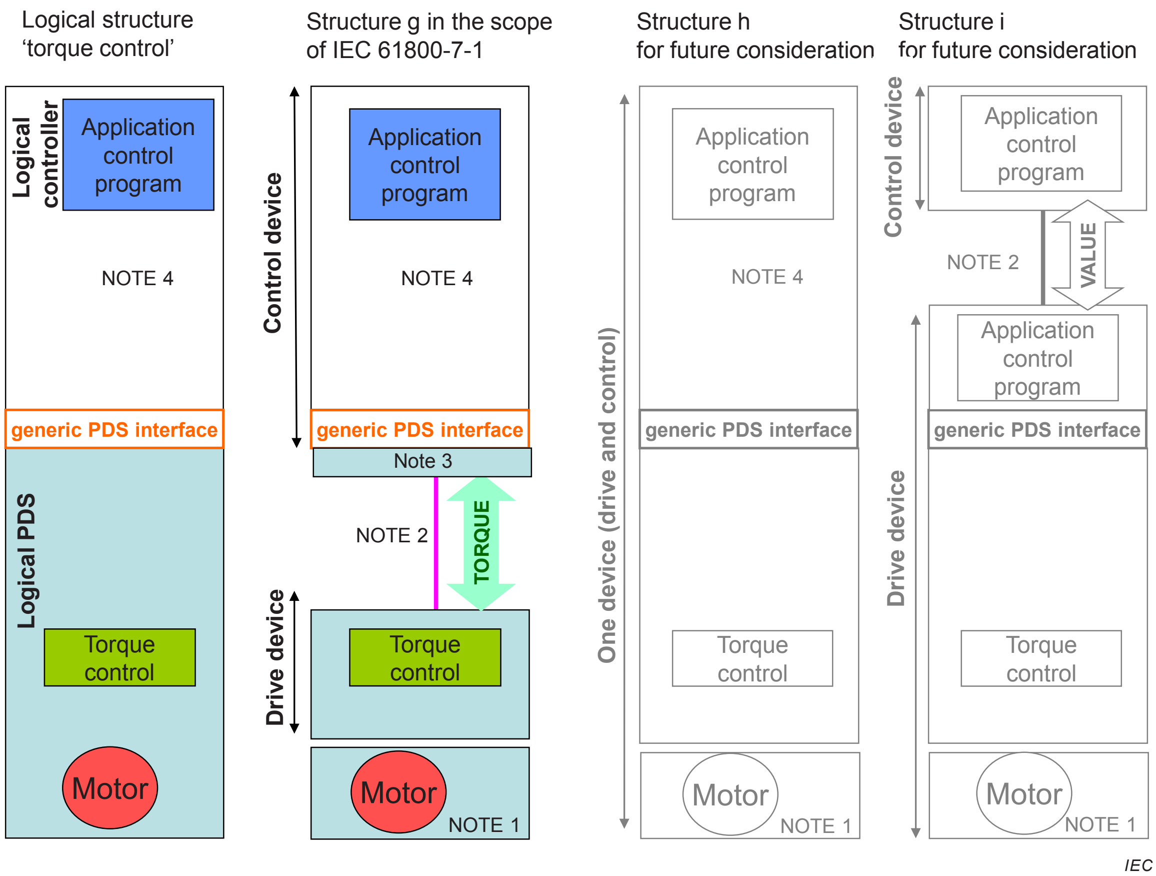
NOTE 3 Mapping or adaptation as needed for specific network or fieldbus technology.

NOTE 4 The application control program can also include position control.

Figure 4 – Examples of system structures for velocity-control applications

Structure d in Figure 4 shows a velocity-control application where all the control loops are implemented in the drive device. In structure e, the velocity-control loop is implemented in the control device and the torque-control in the drive device. Structure f shows an implementation where all the functionality is implemented in one single device. In fact, in structure f, the network or fieldbus is missing. In all three structures of Figure 4, the generic PDS interface is identical.

It is possible that the generic PDS interface be used in velocity-control and the application control program includes also position-control functionality.



NOTE 1 In general, the PDS model includes the motor.

NOTE 2 Between the control device and the drive device is a network or fieldbus to transmit the data values for torque.

NOTE 3 Mapping or adaptation as needed for specific network or fieldbus technology.

NOTE 4 The application control program can also include position control and velocity control functionality.

Figure 5 – Examples of system structures for torque-control applications

In Figure 5, possible implementations of torque-control applications are listed. The torque-control may be in the control device as in structure g. In structure h, all the functionality is in one device and the network or fieldbus is missing. It is always possible that the generic PDS interface be used for torque-control and the application program includes velocity-control and position-control functionality. In structure i, this generic interface is inside the "smart" drive device.

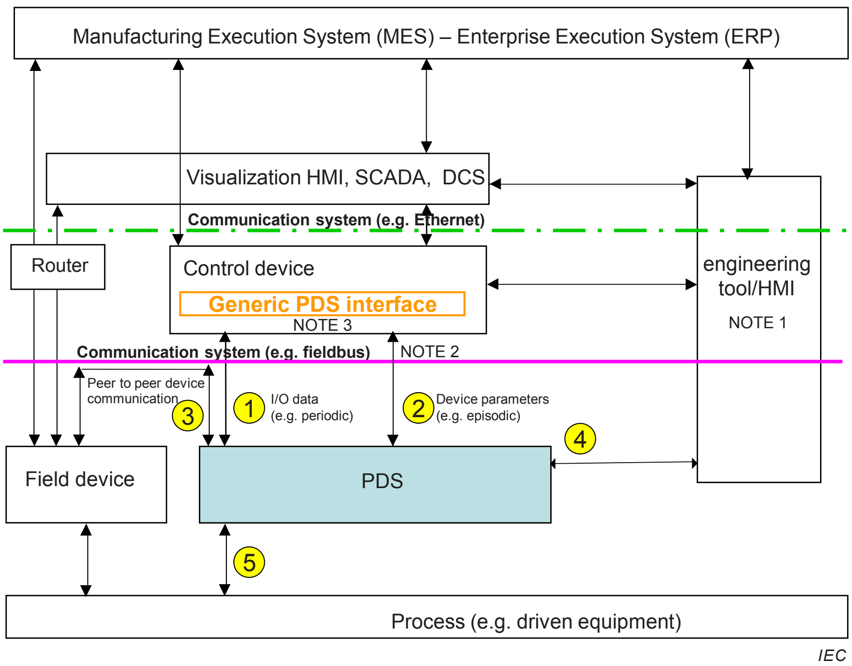
The specification of functionalities for the control device is beyond the scope of this part of IEC 61800-7. Table 1 lists the structures within the scope of this part of IEC 61800-7.

Table 1 – Structures within the scope of this part of IEC 61800-7

Structure	Application	In the scope of the document
a	Position control	**Yes**
b	Position control	No, for future consideration
c	Position control	No, for future consideration
d	Velocity control	**Yes**
e	Velocity control	No, for future consideration
f	Velocity control	No, for future consideration
g	Torque control	**Yes**
h	Torque control	No, for future consideration
i	Torque control	No, for future consideration

4.2 Typical structure of automation systems

The modelling of a device is done according to IEC device profile guideline (see IEC TR 62390). An automation system including PDS typically has the structure defined in Figure 6.



NOTE 1 The engineering tool can be one tool connected to one of the different communication networks or three different tools depending on the type of communication network connected to.

NOTE 2 Communication systems can be redundant as required; this has no influence to the generic PDS interface.

NOTE 3 Mapping or adaptation as needed for specific network or fieldbus technology.

Figure 6 – Typical structure of automation systems (adapted from IEC TR 62390)

The PDS has different logical interfaces to the outside world numbered 1) to 5) in Figure 6.

1) I/O data (generic PDS interface)

This interface is part of the generic PDS interface. It provides the control and monitoring interface between the control device and the PDS (see 3.3.1.4).

2) Device parameters (generic PDS interface)

This interface provides parameter access to the control device and remote engineering tools for identification, configuration, adjustment, monitoring or data logging. The device parameters are available for transfer via the communication system through the generic PDS interface.

3) Peer to peer device communication

The use of peer to peer communication service among other devices is a function of specific fieldbus technology and is not covered by the generic PDS interface.

4) Device parameters (local or other interface)

The local access and interface of an engineering tool or HMI to the PDS is not covered in this part of IEC 61800-7.

NOTE HMI or engineering tools can use the generic PDS interface or the fieldbus communication services which support the PDS interface. However, HMI sharing of the fieldbus could result in changes to performance of PDS data, this could be notified to the application.

5) Interface to the process

The interface to the process – the driven equipment – is not covered by this part of IEC 61800-7.

4.3 Structure of the logical PDS

A logical PDS is composed of different functional elements (FE) according to Figure 7.

Each FE has parameters and algorithms or functions to describe the behavior.

The parameters are used to define

- a unique name and identifier,
- state of operation,
- one or several inputs and output variables, and
- the behavior on algorithms and/or functions

of the FE.

The relation of the different states is described in a state-chart diagram.

Parameters may be structured in additional parameter lists depending on the operating mode of the FE or the application mode of the PDS.

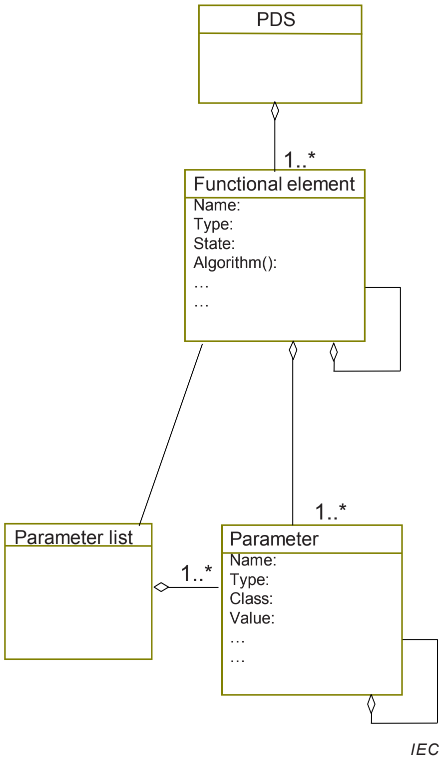


Figure 7 – Structure of the PDS with functional elements

For a logical PDS, the following FEs are recognized (see Figure 8):

Device identification FE

The Device identification FE contains the parameters needed to identify the physical device(s). Possible devices are drive device and control device according to Clause 1.

The Device identification FE is defined in 5.1.

Device control FE

The Device control FE includes the state machine for the control of the drive device.

The Device control FE is defined in 5.2.

Communication FE

The Communication FE of the logical PDS is composed of the communication specific parameters of the network between the control device and the drive device. It includes the communication state machine of the connected devices.

NOTE 1 Most of these parameters and states of the Communication FE are network or fieldbus specific.

NOTE 2 One profile can use different Communication FEs.

The generic Communication FE is defined in 5.3.

Basic drive FE

The different control loop functions like position-control, velocity-control and torque-control are the basic drive functions.

The Basic drive FE's are defined in 5.4.

Optional application FE

The possibility exists for the logical PDS to include additional – optional – application functions. A typical Optional application FE is the management of additional inputs or outputs for example the connections to a separated encoder device, brake control, limit switch etc. These functions are not further specified in this part of IEC 61800-7.

Other interface FE

The possibility exists for the logical PDS to have local interfaces or to support other protocols over the network to HMI or tools. These functions are not further specified in this part of IEC 61800-7.

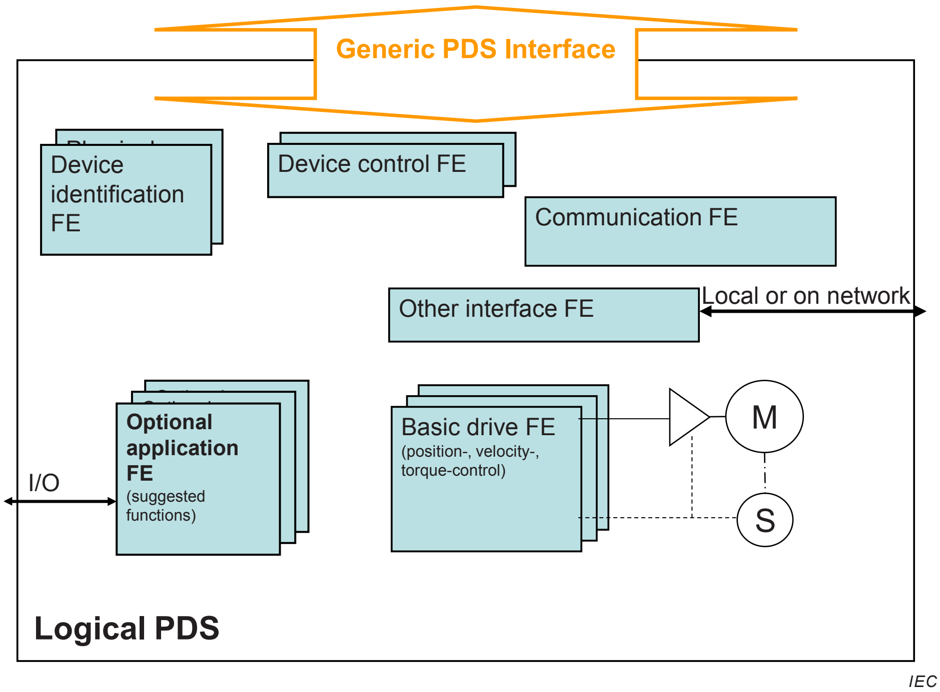


Figure 8 – Functional elements (FE) in the logical PDS

The detailed characteristics of the parameters in the different FE's in the PDS should be described according to IEC TR 62390:2005, Annex B.

Data flow and timing

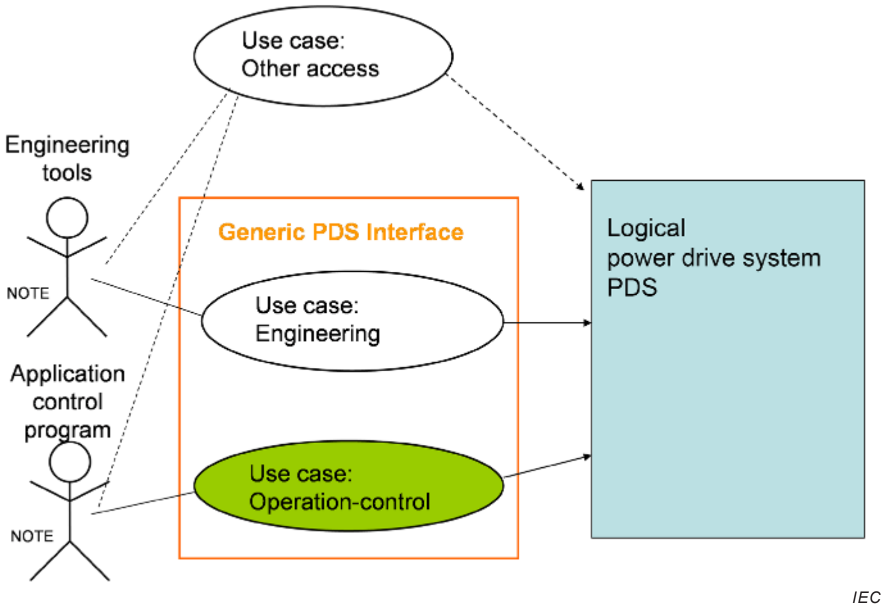
Commands and set-points are outputs from an application program and inputs to a logical PDS. Status information and actual values are outputs from a logical PDS and inputs to an application program.

One of the characteristics of a parameter or a parameters list is the access timing (see IEC TR 62390:2005, Annex B). This access timing depends on the need of the application program and the capabilities of the technology solutions.

4.4 Use cases of the PDS

4.4.1 General

The generic PDS interface is used by two different actors: the access by an application control program and the access by an engineering tool. The application control program uses the PDS for control-operation and the engineering tool uses the PDS for engineering. Local or other access methods to the PDS are beyond the scope of this part of IEC 61800-7. This relation is shown in Figure 9.



NOTE This symbol represents an “actor“. It can be an operator or a device.

Figure 9 – Use case for the generic PDS interface

4.4.2 Use case Engineering

The use case Engineering occurs in different phases of the life cycle of the system:

- commissioning;
- maintenance.

In this use case, different types of operation are needed:

- identification;
- configuration;
- adjustment;
- command;
- give set-point(s);
- monitoring;
- read data logging.

4.4.3 Use case Operation-control

In the use case Operation-control, the generic PDS interface for I/O data is used as follows.

- The application control program issues the commands (see 3.3.1.3) to the PDS.
- The application control program sets the set-point(s) (see 3.3.1.5) to the PDS.
- The PDS signals its status (see 3.3.1.6) to the application control program.
- The PDS may signal actual values (see 3.3.1.1) to the application control program.

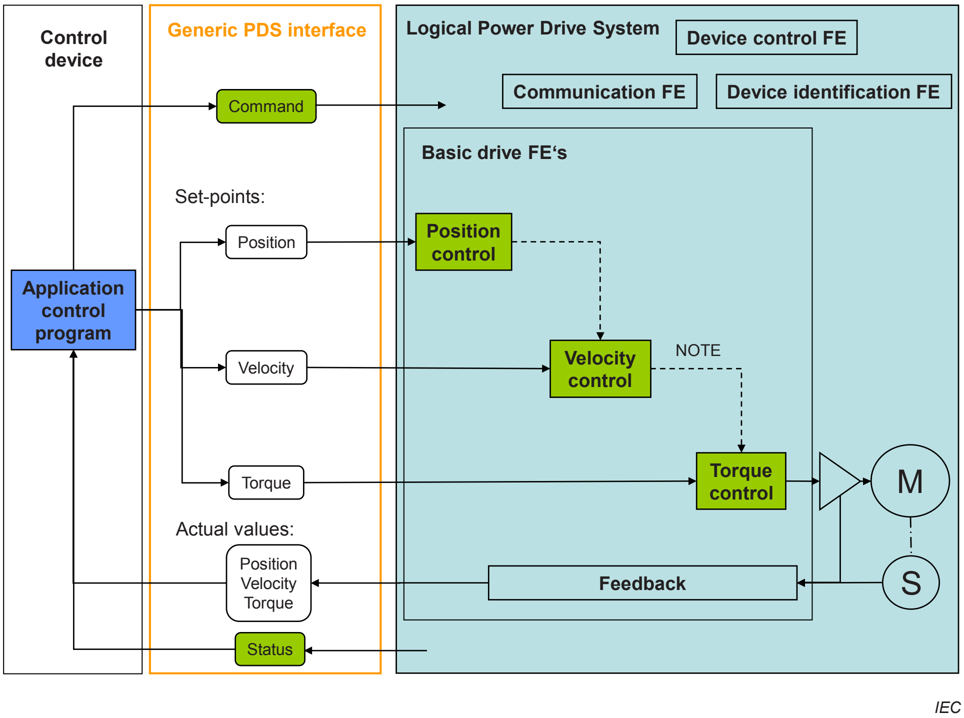
The commands, the set-points, the status and the actual values form the I/O data of the PDS.

The use case Operation-control may also use the generic PDS interface for device parameters for monitoring or modification of parameters (see 3.2.20).

The use case Operation-control can be in different application modes. Depending on the PDS Basic drive FE used inside the PDS and the possible set-point values, the application mode may be torque control, velocity control, position control or others for example homing.

Instead of set-point values, it is also possible to have one or several set-point values preset inside the PDS in a data array. The set-point is, in this case, a pointer to an element of the array. The pointer itself may be an index into the array or a bit pattern in a command word.

Depending on the application mode, different possible interfaces, parameters and state machines exist to describe the behavior of the PDS. Possible set-point values and actual values for all application modes are presented in a schematic way in Figure 10.



NOTE Additional relations between the different FE's can exist in the logical power drive system.

Figure 10 – The generic interface in the use case Operation

5 Functional elements

5.1 Device identification FE

5.1.1 General

In the Device identification FE are the parameters defined to identify the PDS, the versions of hardware and software and its manufacturer. An indication may be given about the identification and location of the PDS in a plant or installation.

5.1.2 Parameters

Possible parameters are listed in Table 2.

Table 2 – Parameters in the Device identification FE

Name	Meaning
Profile ID	Identification of the profile.
Manufacturer ID	Identification of the manufacturer or vendor of the device.
Product ID	Identification of the device type and model.
Serial number	A serial number is a unique production number of the device manufacturer even for devices with the same hardware, software or firmware version.
Hardware revision	The content of this parameter characterizes the edition of the hardware only.
Software revision	The content of this parameter characterizes the edition of the software or firmware of the device.
Tag	For each device within a plant, a unique label is necessary for the identification of its function. This label is set by the user but stored in the device.
Location	For each device within a plant, a unique label is necessary for the identification of its location.
Profile defined	Additional profile specific parameters.
This table is given for reference purposes. It is not necessary for all the parameters of this table to be implemented. Additional parameters not listed in this table may also be implemented.	

The type and size of these parameters are network dependent.

5.2 Device control FE

5.2.1 General

In the Device control FE, the state machine of the PDS is defined.

In this generic PDS interface, only a simple state machine to control the fault handling is defined. If the PDS is not able to provide the required services, it stays in the *faulted* state. A reset command from the controller device or a local interface is required to go to the *no fault* state. In the *no fault* state, the PDS is able to provide the required services.

The PDS may also signal a warning message to signal an error, which does not influence the services that the PDS is able to provide. These warnings may not require an acknowledgement and may therefore not be part of the state machine.

In a profile, more states may be provided, which means that one state defined in this generic PDS profile may be represented by several states in a PDS.

This state machine of the Device control FE is related to the other state machines in the other FEs of the PDS.

NOTE In the general architecture of the logical PDS system, the controller device can also have state machines. These state machines are not in the scope of this part of IEC 61800-7.

5.2.2 I/O data

With the status values listed in Table 3, the PDS signals the actual state of the Device control FE.

Table 3 – Status values for the Device control FE

Name	Meaning
Faulted	Set if the PDS is in the *faulted* state
Warning	Set if a warning condition is available
NOTE 1 Warning conditions do not necessarily need a reset action from the control device. NOTE 2 Additional information on the type of fault or warning can be provided in parameters.	

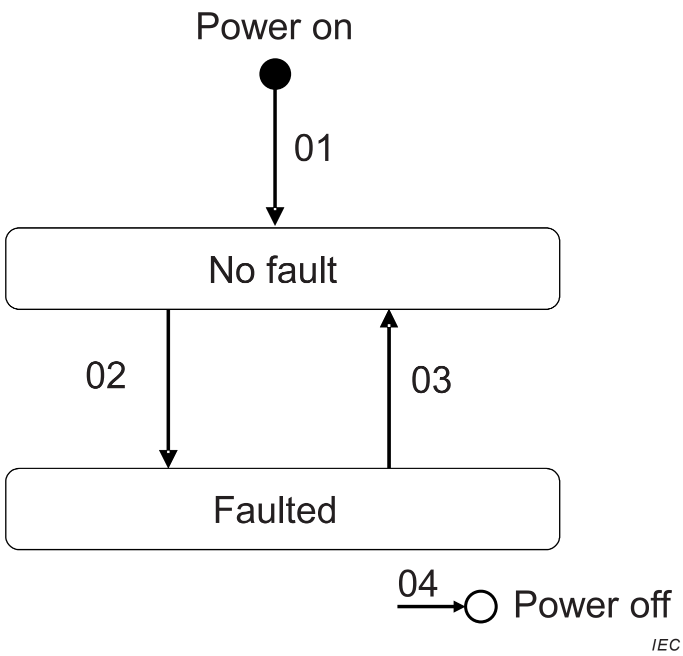
To control the state machine in the Device control FE, one message or command is used (see Table 4). Additional commands may be defined in the profile.

Table 4 – Command values for the Device control FE

Name	Meaning
Reset Fault	If the fault condition is eliminated, the PDS is requested to change state to *no fault*.

5.2.3 States

The Device control FE may be in the states described in Figure 11 and Figure 12. After the power on initialization, the Device control FE goes to the *no fault* state. If there exists a fault condition in the drive, a change to the *faulted* state shall be executed. A fault reaction may be performed before transiting to the *faulted* state.



NOTE The TRANSITION number corresponds to the number next to the arrow in the state-chart diagram.

Figure 11 – Device control FE state-chart diagram

STATE NAME	STATE DESCRIPTION
No fault	The PDS is able to provide the required services
Faulted	The PDS is not able to provide the required services and needs a reset

TRANSITION	SOURCE STATE	TARGET STATE	EVENT / ACTION
01	Power on	No fault	Automatic transition / Initialization of the PDS.
02	No fault	Faulted	Fault condition in the drive / Signal new state. This is typically an event which is generated by the internal, device dependent functions of the PDS.
03	Faulted	No fault	The *reset fault* command is issued / Signal new state. This event may be generated by a command from the control device or from a local interface depending on the state of the Communication FE.
04	Any state	Power off	Power off / Shut down the PDS.

IEC

Figure 12 – Device control FE state transition table

5.2.4 Parameters

In addition to the I/O data, the parameters in Table 5 are part of the Device control FE.

Table 5 – Parameters in the Device control FE

Name	Meaning
Fault	Identification of the fault which caused the *faulted* state
Warning	Identification of the condition which caused the warning status
Profile defined	Additional profile specific parameters
NOTE The exact coding and representation of this information is profile specific.	

5.3 Communication FE

5.3.1 General

The Communication FE includes all the state machines and parameters for the network or fieldbus interface. Multiple instances of the Communication FE are possible if a profile supports different networks or fieldbus interfaces.

The PDS may be in the *limited communication* or *normal communication* state.

Typically in the *limited communication* state the connection or functions of the network or fieldbus interface may be available in a read only mode, but the PDS does not accept commands and does not execute the set-points from the control device. In the *limited communication* state, the commands to the PDS are accepted only through the local interface.

In the *normal communication* state, the PDS is controlled by the control device over the network or fieldbus.

There is the possibility that different levels of access exist, which means that local or remote access may be separated for I/O data, reading of parameters and read/write of parameters. This may be represented by additional sub-states in the profiles.

There may be an additional state machine in the Communication FE reflecting the state of the network or fieldbus connection. This additional state machine is only needed, if a synchronous communication is required by the control application. In this case, the Communication FE may be in one of the states *synchronized* or *not synchronized*. The profiles may define additional sub-states for this state machine.

Synchronized operation means that the control device and the PDS use the same time base. This may be achieved for example by a local timer synchronization mechanism distributed via the network or external global time resources. These mechanisms allow synchronizing of application cycles in the control device and the PDS.

These state machines of the Communication FE are related to the other state machines in the other FEs of the PDS.

5.3.2 I/O data

With the status values listed in Table 6, the PDS signals the actual state of the Communication FE.

Table 6 – Status values for the Communication FE (see Figure 13)

Name	Meaning
Normal communication	Set if the PDS accepts commands and set-points over the communication interface

To control the state machine in the Communication FE the following messages or commands are used (see Table 7). In the profile additional commands may be defined.

Table 7 – Command values for the Communication FE (see Figure 13)

Name	Meaning
Stop communication	The control device requests the PDS to go to *limited communication* state
Run communication	The control device requests the PDS to go to the *normal communication* state

One optional communication function is the possibility to execute the PDS control loop in synchronous mode with the communication network or fieldbus. If this optional communication function is used, it is recommended to signal this status (see Table 8) and use the commands of Table 9.

Table 8 – Status values for the optional Communication FE (see Figure 15)

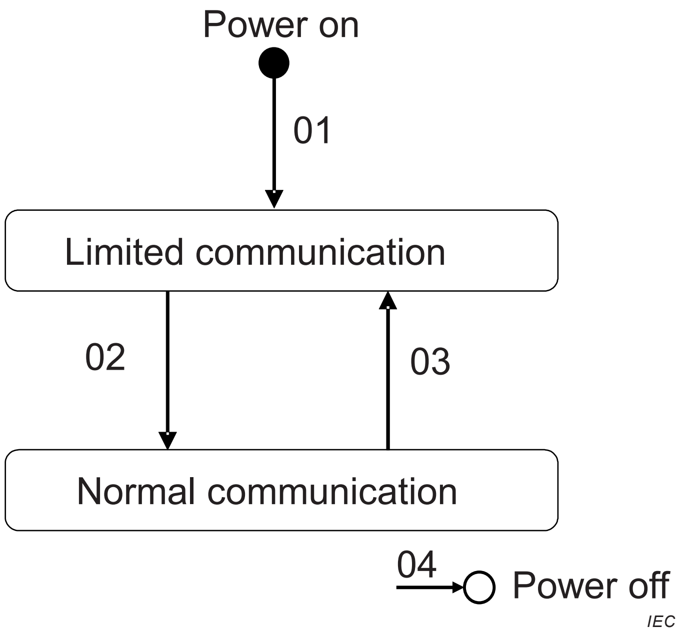
Name	Meaning
Synchronized	The local time of the PDS runs synchronous with the network and the control device

Table 9 – Command values for the optional Communication FE (see Figure 15)

Name	Meaning
Synchronize	Synchronization is requested to be switched on
Do not synchronize	Synchronization is requested to be switched off

5.3.3 States

The Communication FE may be in the states described in Figure 13 and Figure 14.



NOTE The TRANSITION number corresponds to the number next to the arrow in the state-chart diagram.

Figure 13 – Communication FE state-chart diagram

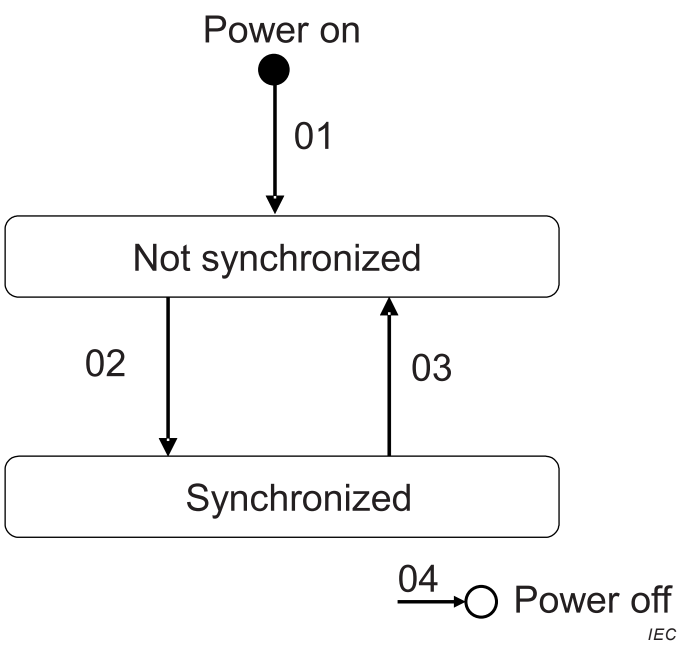
STATE NAME	STATE DESCRIPTION
Normal communication	The PDS communicates over the communication interface
Limited communication	The PDS does not communicate over the communication interface

TRANSITION	SOURCE STATE	TARGET STATE	EVENT / ACTION
01	Power on	Limited communication	Automatic transition / the network interface is initialized
02	Limited communication	Normal communication	The *run communication* command is set by the control device or a local command to start communication is invoked / signal new state
03	Normal communication	Limited communication	The *stop communication* command is set by the control device or a local command is invoked / signal new state
04	Any	Power off	Power off / shut down the PDS
NOTE Possible conflicts of *run communication* and *stop communication* commands are handled by the profiles.			

IEC

Figure 14 – Communication FE state transition table

In addition, the Communication FE can be in the states described in Figure 15 and Figure 16.



NOTE The TRANSITION number corresponds to the number next to the arrow in the state-chart diagram.

Figure 15 – Optional Communication FE state-chart diagram

STATE NAME	STATE DESCRIPTION		
Synchronized	The local time of the PDS is synchronous with the communication network and the control device		
Not synchronized	The local time of the PDS is not synchronous with the communication network and the control device		
TRANSITION	**SOURCE STATE**	**TARGET STATE**	**EVENT / ACTION**
01	Power on	Not synchronized	Automatic transition / initialization of the FE
02	Not synchronized	Synchronized	The command *synchronize* is requested by the control device and achieved by the PDS / signal state
03	Synchronized	Not synchronized	The synchronization is lost or the command *do not synchronize* is requested / signal state
04	All	Power off	Power off / shut down the PDS
NOTE In most implementations, there are additional states defined and used to implement the synchronization mechanism.			

IEC

Figure 16 – Optional Communication FE state transition table

5.3.4 Parameters

In the Communication FE, there are the parameters defined to identify the communication interface and network type. These parameters are profile-dependent.

5.4 Basic drive FE

5.4.1 General

In the Basic drive FE, there are defined the state machines and the parameters to provide the basic drive functions.

In the generic interface, simple state machines with the states *operating* and *not operating* and *local control* and *remote control* are defined. Depending on the application mode, additional states and state machines may be defined by the profiles.

In the state *operating,* the PDS reacts on the commands and the set-point(s) provided by the remote or local interface and provides the status values and required actual values.

In the state *not operating,* the PDS does not react on the set-point(s) provided by the local or remote interface. The commands however are still valid and handled by the PDS.

In the state *local control*, the PDS reacts on the commands and the set-point(s) provided by local interface and provides the status values and required actual values.

In the state *remote control*, the PDS reacts on the commands and the set-point(s) provided by the remote interface and provides the status values and required actual values.

These state machines of the Basic drive FE may be related to the state machines in the other FE's of the PDS.

5.4.2 I/O data

With the status values listed in Table 10, the PDS signals the actual state of the Basic drive FE. Additional commands may be defined by the profiles. These commands may also be dependent on the application mode.

Table 10 – Status values of the Basic drive FE

Name	Meaning
Operating	The PDS is attempting to follow the set-point values

One optional basic drive function is the possibility to execute the PDS control loop in remote or local control mode. If this optional basic drive function is used, it is recommended to signal this status (see Table 11 and Figure 15).

Table 11 – Optional status values for the Basic drive FE

Name	Meaning
Remote control	Set if the PDS accepts commands and set-points over the communication interface

To control the state machine of the Basic drive FE, at least the command defined in Table 12 shall be defined. Depending on the additional states defined by the application mode, the profile may define additional commands.

Table 12 – Command values for Basic drive FE

Name	Meaning
Operate	The PDS should start action on the provided set point data

Depending on the application mode, the set-point and actual values are defined to control the PDS. These possible values are defined in Clause 6.

To control the optional state machine in the Basic drive FE, one message or command is used (see Table 13). In the profile, additional commands may be defined.

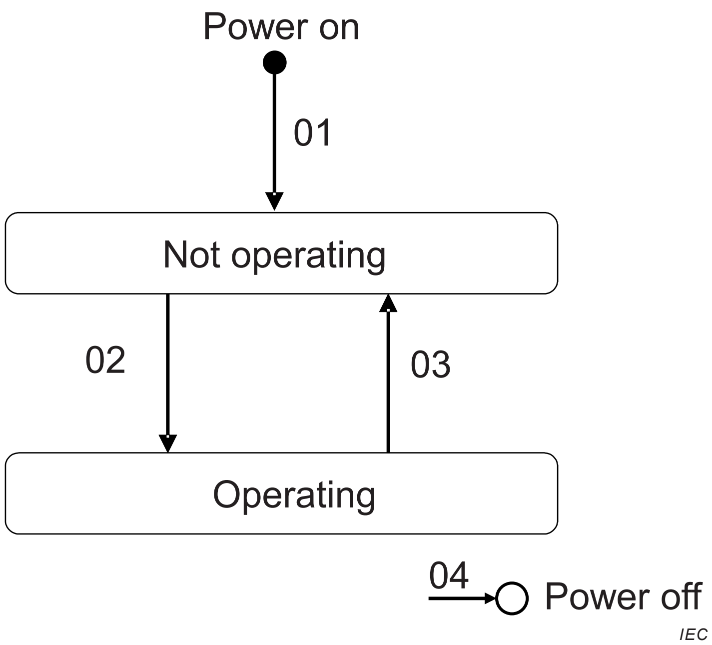
Table 13 – Optional command values for the Basic drive FE

Name	Meaning
Local	The control device releases the control over the PDS
Remote	The control device requests the control over the PDS

5.4.3 States

The PDS basic drive functions may be in the states as described in Figure 17 and Figure 18.

The different states may be split in sub-states by the profiles.



NOTE The TRANSITION number corresponds to the number next to the arrow in the state-chart diagram.

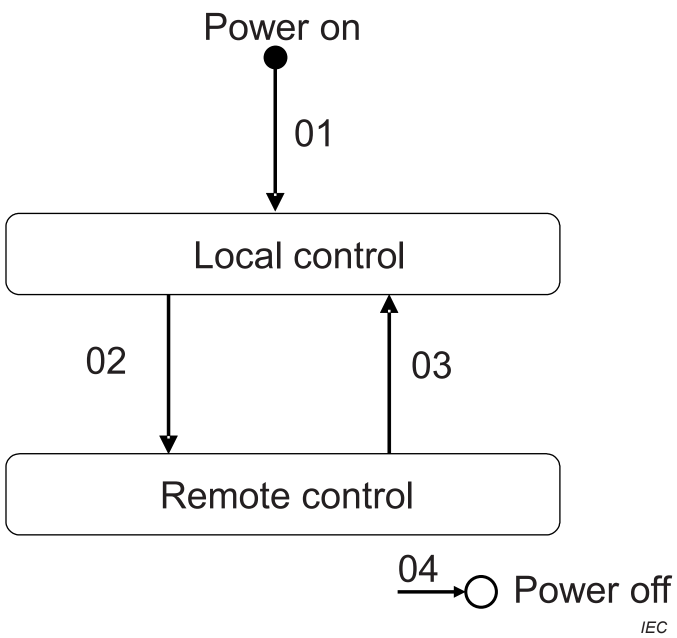
Figure 17 – Basic drive FE state-chart diagram

STATE NAME	STATE DESCRIPTION		
Operating	The PDS reacts on the requested set-points and commands		
Not operating	The PDS does not deal with the set-point values – but reacts on the commands		
TRANSITION	**SOURCE STATE**	**TARGET STATE**	**EVENT / ACTION**
01	Power on	Not operate	Automatic transition / initialization of the Basic drive FE
02	Not operating	Operating	The *operate* command from a local or remote interface is invoked / signal state
03	Operating	Not operating	The *operate* command is removed / signal state
04	All	Power off	Power off / shut down

IEC

Figure 18 – Basic drive FE state transition table

In addition, the Basic drive FE may be in the states described in Figure 19 and Figure 20.



NOTE The TRANSITION number corresponds to the number next to the arrow in the state-chart diagram.

Figure 19 – Optional Basic drive FE state-chart diagram

STATE NAME	STATE DESCRIPTION
Remote control	The PDS accepts commands and set-points over the communication interface
Local control	The PDS does not accept set-points and accepts only reduced set of commands over the communication interface

TRANSITION	SOURCE STATE	TARGET STATE	EVENT / ACTION
01	Power on	Local control	Automatic transition / the function is initialized
02	Local control	Remote control	The *remote* command is set by the control device or a local command to permit remote control is invoked / signal the state
03	Remote control	Local control	The *local* command is set by the control device or a local command to take local control is invoked / signal the state
04	All	Power off	Power off / shut down

NOTE Possible conflicts of *local* and *remote* commands are handled by the profiles.

IEC

Figure 20 – Optional Basic drive FE state transition table

5.4.4 Parameters

In the Basic drive FE, the parameters “mode command” and “mode status” are defined to

- define the actual application mode used,
- to define the set of I/O data, and
- to specify the behavior of the FE depending on the application mode.

These parameters are profile and application mode dependent.

5.5 Optional application FE

In the PDS, additional functionality may be introduced. This could be for example additional I/O connections for limit switches or additional sensors to measure the values of for example velocity or position.

These optional application FEs are not further specified in this generic PDS interface.

The profiles may use other profile specifications for these application FEs.

6 Application modes

6.1 General

The logical PDS can be in different application modes depending on the hardware and software functions available on the PDS. Table 14 shows the possible control loops and extensions.

Table 14 – Possible generic application modes

Control loop	**Set-points**		
	Torque control (see 6.2)	Velocity control (see 6.3)	Position control (see 6.4)
Preset	Normally not used	See Figure 23	See Figure 26
Control	See Figure 21	See Figure 24	See Figure 27
Control with mandatory feedback of the next control level	See Figure 22	See Figure 25	Higher control level such as multi-axis are not in the scope of this part of IEC 61800

In Table 15, the possible set-point values for the reference variables for these generic application modes are listed.

Table 15 – Set-point values for generic application modes

Application mode	Set-point	Functions in the PDS	Related figure
Torque preset	Torque-index or just On/Off	Open loop torque control.	Normally not used
Torque control	Torque	Open torque control loop. Additionally, a measured or estimated feedback value(s) is (are) provided.	Figure 21
Torque control with velocity feedback	Torque	Closed Torque control loop. Additionally, a measured or estimated feedback value(s) is (are) provided.	Figure 22
Velocity preset	Velocity-index or just On/Off	Drive can run on one or several fixed velocities with internal control of torque and velocity.	Figure 23
Velocity control	Velocity	Open velocity and torque control loop. Additionally, a measured or estimated feedback value is provided.	Figure 24
Velocity control with position feedback	Velocity	Closed velocity and torque control loop. Additionally, a measured or estimated feedback value is provided.	Figure 25
Position preset	Position-index or just On/Off	Drive can go to fixed positions with closed loop control with (or without) sensor feedback, using (optionally) defined trajectories.	Figure 26
Position control	Position	Open or closed torque, velocity and position control loop in the drive with (or without) sensor feedback.	Figure 27

NOTE 1 Speed, velocity and frequency are considered as similar functionalities. In fact they are not the same, but there is a constant factor in the relation between the different meanings of the variables.

There is one mandatory set-point and one or a set of actual values specified for each application mode. Additional set-points and additional actual values are possible.

NOTE 2 In all cases, the state of the FE basic drive functions in the PDS is controlled with the commands and monitored with the status.

6.2 Torque control

In the torque control application mode, the application control program gives a set-point value for the torque to the PDS. The PDS may provide the calculated or measured (estimated) actual torque value in the feedback variable.

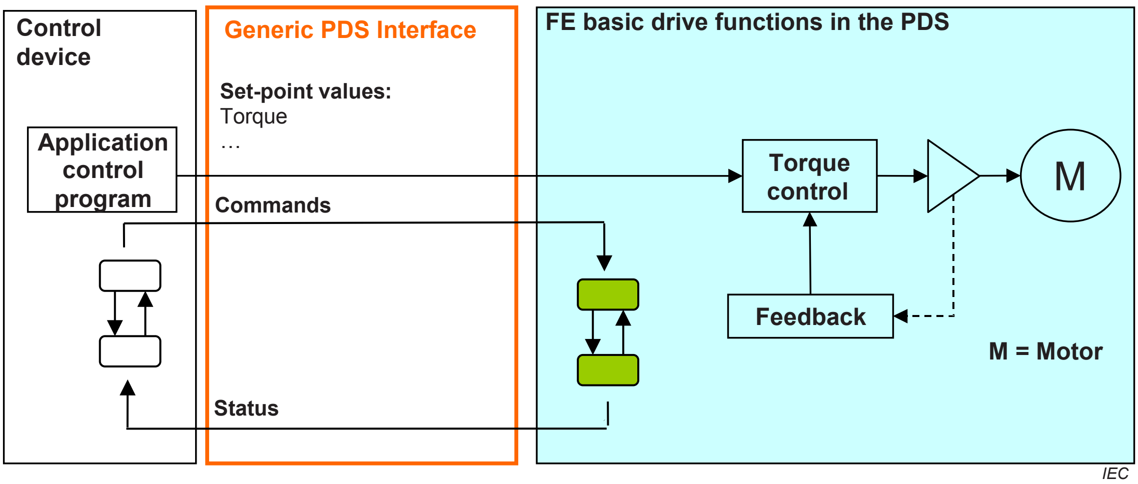


Figure 21 – Torque control application mode

In the torque control with velocity feedback application mode, the application control program gives a set-point value for the torque to the PDS as input data. The actual velocity can be estimated or measured by the PDS depending on the hardware possibilities of the PDS.

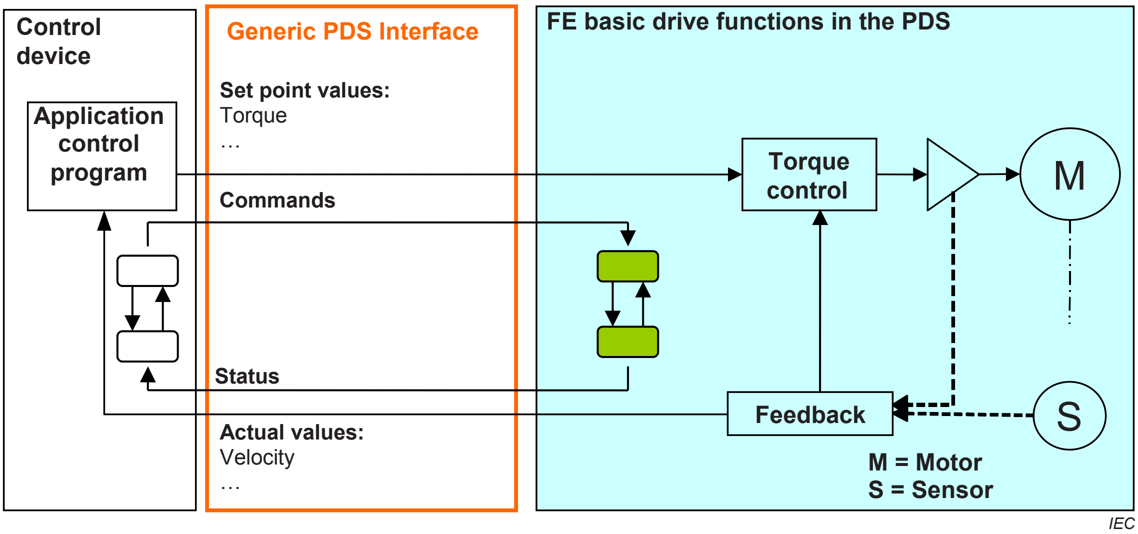


Figure 22 – Torque control with velocity feedback application mode

6.3 Velocity control

In the velocity preset application mode the velocity data holds the possible velocity values of the PDS. In the simplest case, this has two values: ON/OFF. In a more sophisticated PDS, there is the possibility of a selection of two or more different – fixed – velocities.

NOTE 1 The set-point data is only an index into the list of possible velocity values stored in the velocity data record inside the PDS.

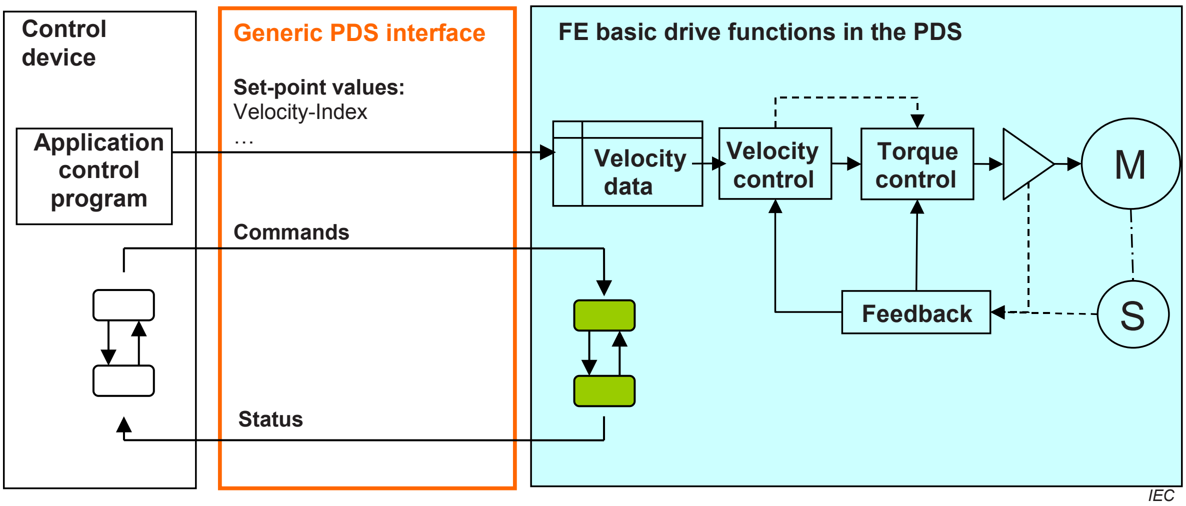


Figure 23 – Velocity preset application mode

The velocity control application mode is probably the most used application mode. The application control program gives the set-point value for velocity, and optionally the torque if forward control is also used. The PDS may optionally return the actual velocity and also the actual torque value. The feedback values may be calculated (estimated) or measured.

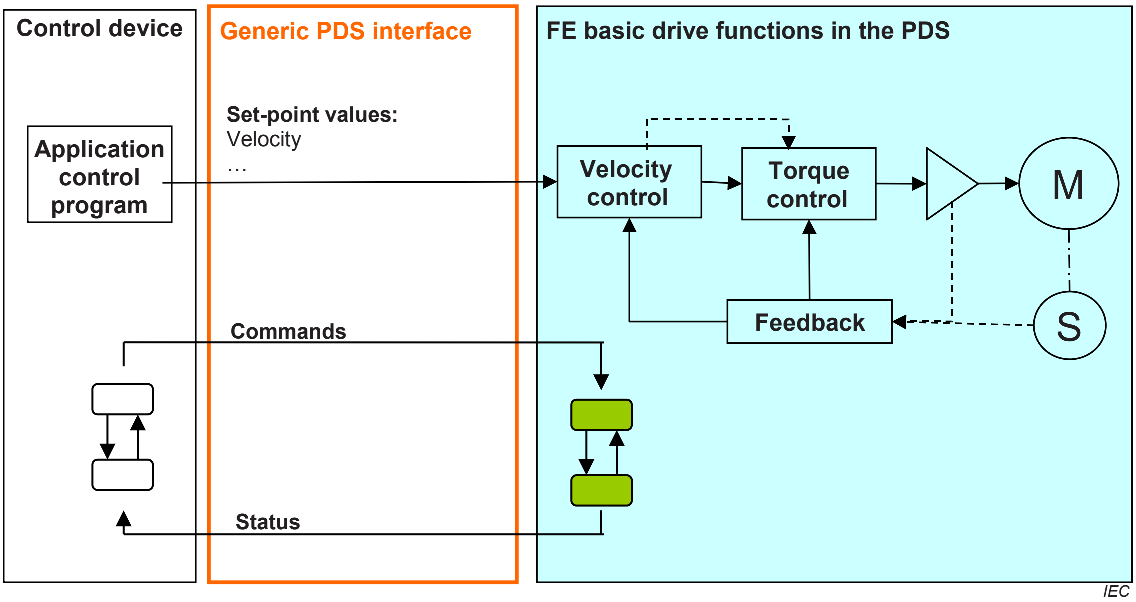


Figure 24 – Velocity control application mode

If the measurement possibilities exist, it may make sense to also feedback the actual position from the PDS. This allows the construction of a simple position control in the control device.

NOTE 2 In most implementations today, this position feedback is realized independently from the PDS in an additional device.

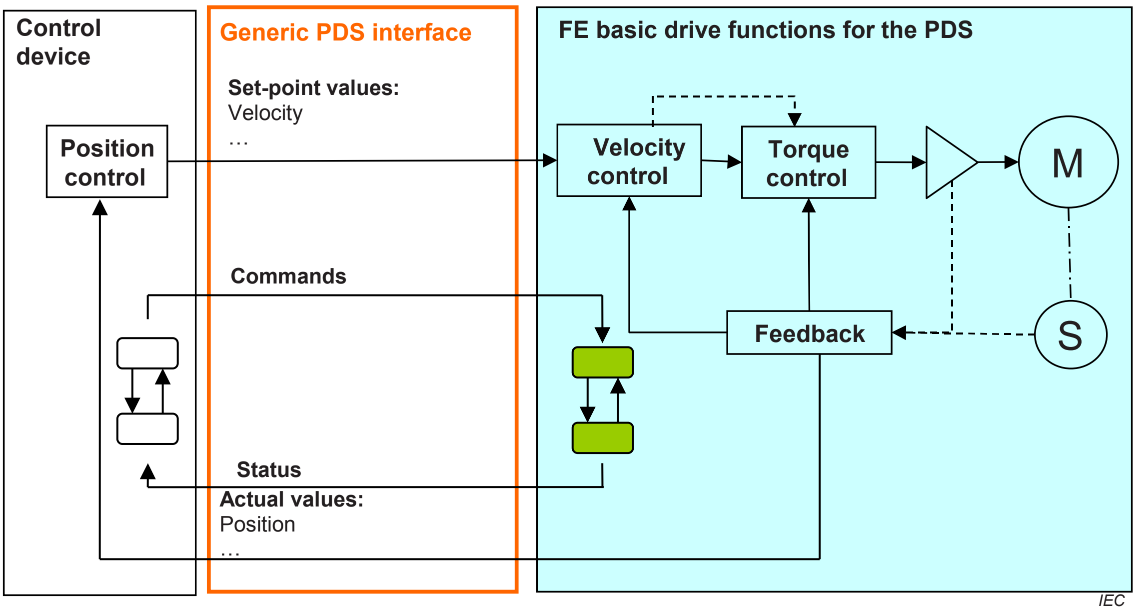


Figure 25 – Velocity control with position feedback application mode

6.4 Position control

In position data, a set of possible positions is stored in the PDS. Options may exist to define the trajectory to be followed between these positions.

NOTE The set-point data is only an index to the list of possible position values stored in the position data record inside the PDS.

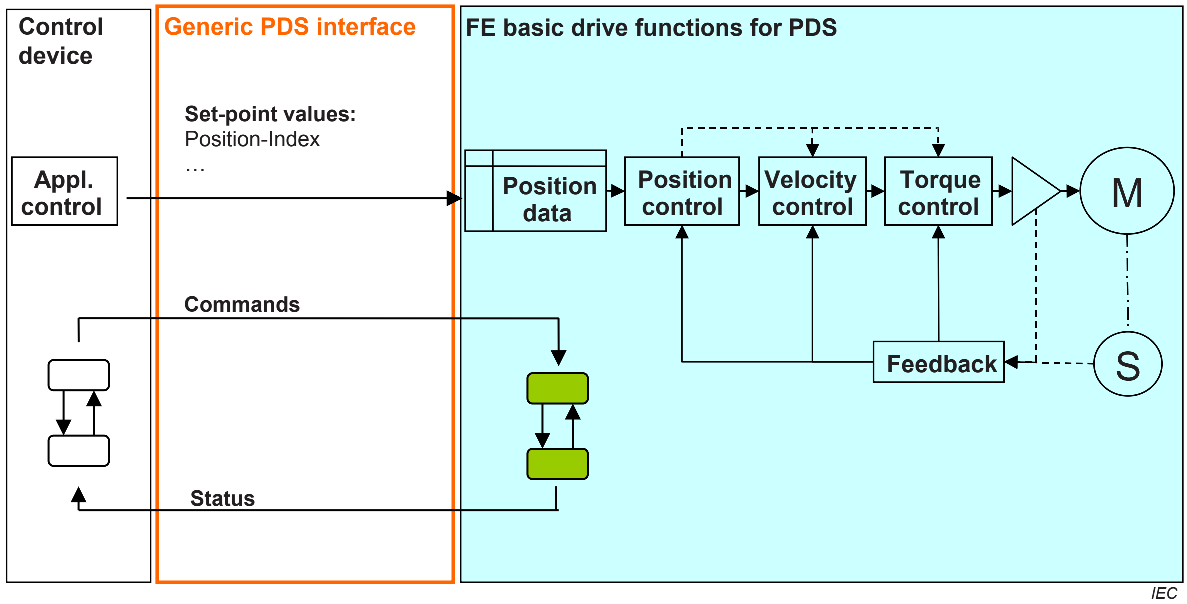


Figure 26 – Position preset application mode

The almost complete application mode is the position control mode. The application control program sends the set-point position values to the PDS. If forward control is needed, additional set-points for torque and velocity are possible. The PDS may signal that the set-point value has been reached using status information. Additionally, it is possible that the PDS gives the actual position, velocity and/or torque.

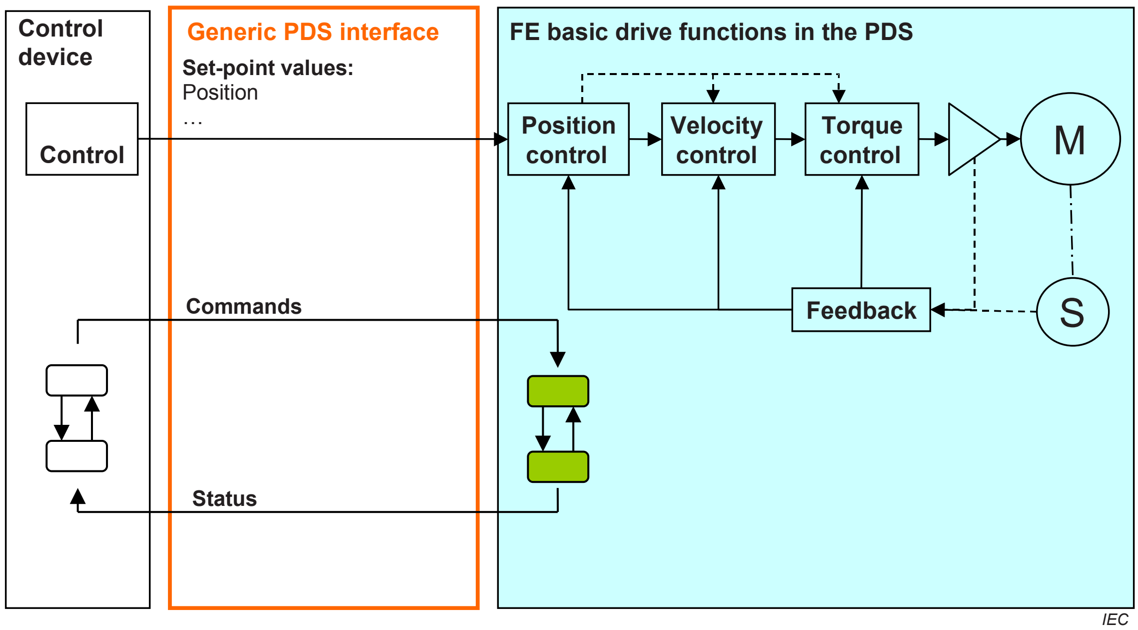


Figure 27 – Position control application mode

7 Profile specific extensions

Profiles to be mapped may specify additional functionalities which extend the functions of the generic interface.

8 Structure for annexes

8.1 General

The annexes provide the mapping of drive profiles onto the generic PDS interface.

Each annex has its own subclause for definitions and abbreviations in Clause 3. Only definitions used in the mapping are listed.

The structure of the annexes is fixed in 8.2. For each clause, the heading and the required mapping is defined.

Most mapping tables in the annexes are structured according to Table 16.

Table 16 – Mapping of names to profiles

Name	Profile name	Details	Reference
Generic name[a]	Profile name[b]	Identification[c]	See document xyz[d]

[a] Name of the item in the generic PDS interface.

[b] Name of the item with the corresponding meaning in the profile.

[c] Detailed identification of the item in the profile.

[d] Detailed reference to standards.

8.2 Structure of the annexes

The structure of the annexes is defined in Table 17. The template subclauses are given as template for Annex "x".

Table 17 – Structure of annexes

Subclause	Title	Explanation
x.1	Overview	The scope of the profile and boundary conditions are described in one or several sentences. These definitions shall be mapped to the definitions of the drive profile if they are relevant using the format of Table 18.
x.2	Mapping of general architecture	--
x.2.1	Typical structure of automation systems	Indicate the typical structure of the automation system assumed by the specific drive profile.
x.2.2	Structure of the logical PDS	Give here the structure of the PDS used in profile *x*. The general structure of the drive profile is described here with several sentences. This description should give a general understanding of the concepts used.
x.2.3	Use cases of the PDS	--
x.2.3.1	General	Explain in several sentences the mapping of the use cases.
x.2.3.2	Use case Engineering	How is the engineering handled in profile *x*? Explain in several sentences.
x.2.3.3	Use case Operation-control	How is the operation-control handled in profile *x*? Explain in several sentences.
x.3	Functional elements	---
x.3.1	Device identification FE	---
x.3.1.1	General	Explain mapping of device identification of the drive profile.
x.3.1.2	Parameters	Provide mappings for parameters listed in Table 2 using the format of Table 16.
x.3.2	Device control FE	---
x.3.2.1	General	Explain mapping of device control of the profile.
x.3.2.2	I/O data	Provide mappings for status values and command values listed in Table 3 and Table 4 using the format of Table 16.
x.3.2.3	States	References to the profile specific state machines may be added.
x.3.2.4	Parameters	Provide mappings for parameters listed in Table 5 using the format of Table 16.
x.3.3	Communication FE	---
x.3.3.1	General	Explain mapping of Communication FE of the profile.
x.3.3.2	I/O data	Provide mappings for status values and command values listed in Table 6, Table 7, Table 8 and Table 9 using the format of Table 16.
x.3.3.3	States	References to the profile specific state machines may be added.
x.3.3.4	Parameters	Indication where in the profile the parameters for the Communication FE are defined.
x.3.4	Basic drive FE	---
x.3.4.1	General	Explain mapping of Basic drive FE of the profile.
x.3.4.2	I/O data	Provide mappings for status values and command values listed in Table 10, Table 11, Table 12 and Table 13 using the format of Table 16.
x.3.4.3	States	References to the profile specific state machines may be added.
x.3.4.4	Parameters	Indication where in the profile specification the parameters mode command and mode status and others are defined.
x.3.5	Optional application functions FE	Reference and mapping to other or additional functions may be done here.
x.4	Application modes	---

Subclause	Title	Explanation
x.4.1	General	List of the application modes available in the profile is given here as the template of Table 19.
x.4.2	Torque control	Mapping of I/O data identified in the generic PDS interface onto the drive profile terminology is described here. Each supported torque application mode shall be documented separately using the template of Table 20. Additional information may be given here.
x.4.3	Velocity control	Mapping of I/O data identified in the generic PDS interface onto the drive profile terminology is described here. Each supported velocity application mode shall be documented separately using the template of Table 21. Additional information may be given here.
x.4.4	Position control	Mapping of I/O data identified in the generic PDS interface onto the drive profile terminology is described here. Each supported position application mode shall be documented separately using the template of Table 22. Additional information may be given here.
x.5	Profile specific extensions	Profile specific extensions (e.g. additional application modes) shall be listed here.

Names and layout of the tables referred to in Table 17 shall be as specified in Table 18 to Table 22.

Table 18 – Profile specific terms

IEC 61800-7 term	Profile *x* term	Reference
I/O data	e.g. cyclic data e.g. PDO	Is the same
Command	e.g. Controlword	Is the same
Set-point		
Status	e.g. Statusword	
Actual value		

Table 19 – Supported application modes

IEC 61800-7 application mode	Equivalent profile *x* terminology
Application modes as listed in Table 15.	Corresponding term of the profile *x*

Table 20 – I/O data for profile torque mode

IEC 61800-7 I/O data	Equivalent profile *x* terminology
Command	Corresponding term of the profile *x*
Status	Corresponding term of the profile *x*
Set-point torque	Corresponding term of the profile *x*
Actual torque	Corresponding term of the profile *x*

Table 21 – I/O data for profile velocity mode

IEC 61800-7 I/O data	Equivalent profile x terminology
Command	Corresponding term of the profile x
Status	Corresponding term of the profile x
Set-point velocity	Corresponding term of the profile x
Actual velocity	Corresponding term of the profile x

Table 22 – I/O data for profile position mode

IEC 61800-7 I/O data	Equivalent profile x terminology
Command	Corresponding term of the profile x
Status	Corresponding term of the profile x
Set-point position	Corresponding term of the profile x
Actual position	Corresponding term of the profile x

Annex A
(normative)

Mapping to profile CiA 402 drive and motion control

A.1 Overview

This annex specifies the mapping of the CiA 402 drive and motion control profile onto the generic power drive system (PDS) interface.

Terms of the CiA drive profile are mapped to IEC 61800-7-1 terms as specified in Table A.1.

Table A.1 – Profile specific terms

IEC 61800-7 term	CiA 402 term	Reference
I/O data	Process data	See IEC 61800-7-201
Command	Controlword	See IEC 61800-7-201
Set-point	Target value	See IEC 61800-7-201
Status	Statusword	See IEC 61800-7-201
Actual value	Actual value	See IEC 61800-7-201
NOTE These communication objects are network technology dependent.		

A.2 Mapping of general architecture

A.2.1 Typical structure of automation system

The typical structure of automation system and the structure of the logical PDS given in Clause 4 apply to this annex. The control device featuring the generic PDS interface controls the drive devices via the communication network.

The network technology may provide different communication services for control and monitoring respectively configuration and diagnostic purposes. The drive device and the control device may produce specific emergency messages in case of the detection of several device-internal failures.

All process data, communication and application objects are listed in the object dictionary of the drive device. The object dictionary entries are accessible by means of specific communication services. The entries are uniquely addressed by the 16-bit index and the 8-bit sub-index.

A.2.2 Structure of the logical PDS

The drive device shall support one of the modes of operation and may support several of them. The CiA 402 logical power drive system is modelled as shown in Figure A.1.

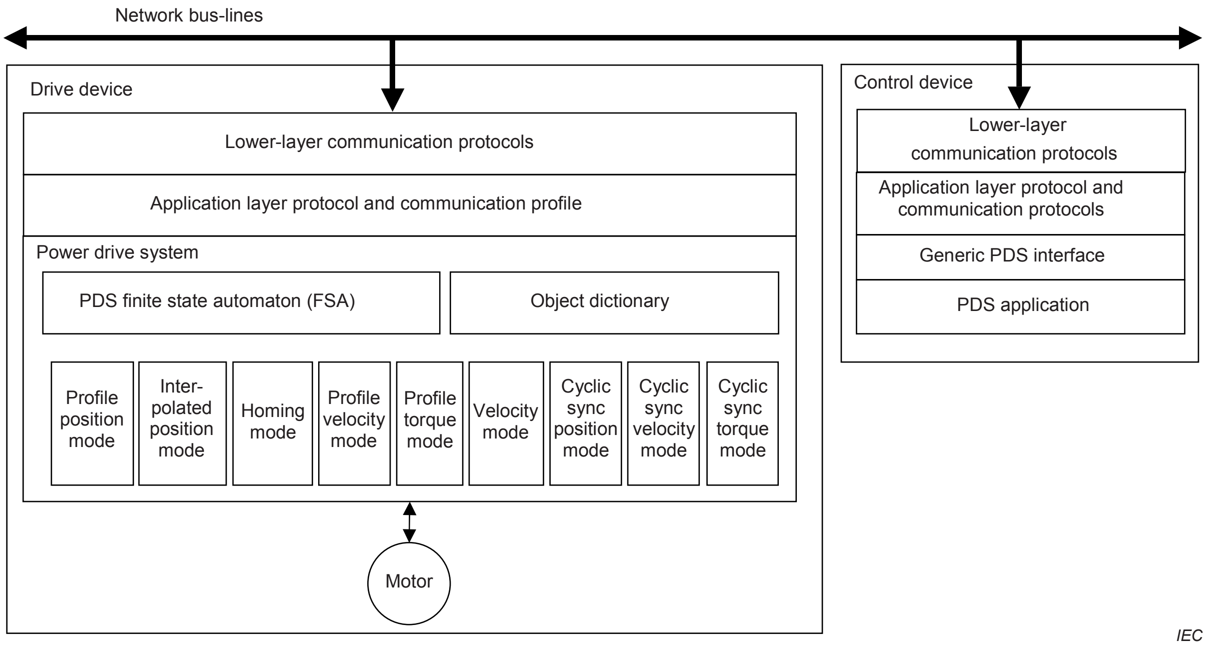


Figure A.1 – CiA 402 logical power drive system model

A.2.3 Use cases of the PDS

A.2.3.1 General

The CiA 402 compliant drive device may be configured and operated by means of dedicated communication services by the control device. The implementation of process data and configuration objects depends on the supported modes of operation.

A.2.3.2 Use case Engineering

The configuration may be performed by the control device or by a dedicated tool device. The tool device may reside in the control device. The control device and the tool device use the same communication services to configure the drive device.

A.2.3.3 Use case Operation-control

The drive device is normally operated by the control device implementing the generic PDS by means of controlword and target values. The kind of target value depends on the currently selected mode of operation. The drive device is monitored by the control device by means of the statusword and actual values. The kind of actual values depends on the currently selected mode of operation.

A.3 Functional elements

A.3.1 Device identification FE

A.3.1.1 General

In addition to the parameters defined in this part of IEC 61800-7, the CiA 402 profile defines some more identification parameters for the drive device and the motor. These identification parameters are available by means of communication services.

A.3.1.2 Parameters

The identification parameters used by this drive profile are given in Table A.2.

Table A.2 – Drive device identification parameters

Name	Profile name	Details	Reference
Manufacturer ID	Vendor ID	Object 1018 01_h	See EN 50325-4
Order ID	Product code	Object 1018 02_h	See EN 50325-4
Serial number	Serial number	Object 1018 04_h	See EN 50325-4
Hardware revision	Manufacturer hardware version	Object 1009 00_h (see Note)	See EN 50325-4
Software revision	Manufacturer software version	Object 100A 00_h (see Note)	See EN 50325-4
–	Motor type	Object 6402 00_h	See IEC 61800-7-201
–	Motor catalog number	Object 6403 00_h	See IEC 61800-7-201
–	Motor manufacturer	Object 6404 00_h	See IEC 61800-7-201
–	http motor catalog address	Object 6405 00_h	See IEC 61800-7-201
–	Motor calibration date	Object 6406 00_h	See IEC 61800-7-201
–	Motor service period	Object 6407 00_h	See IEC 61800-7-201
–	Supported drive modes	Object 6502 00_h	See IEC 61800-7-201
–	Drive catalog number	Object 6503 00_h	See IEC 61800-7-201
–	http drive catalog address	Object 6505 00_h	See IEC 61800-7-201
	Version number	Object 67FE 00_h	See IEC 61800-7-201
NOTE These object entries are network technology dependent; the given indices and sub-indices are CANopen-specific.			

A.3.2 Device control FE

A.3.2.1 General

The Device control FE of the drive device shall provide information on fault situations by means of the statusword. The fault shall be reset by means of the controlword.

A.3.2.2 I/O data

The fault state of the Device control FE shall be signalled by setting the bit 4 of statusword to 1. The fault reset shall be command by setting the bit 7 from 0 to 1. The status values are given in Table A.3. The command values are given in Table A.4.

Table A.3 – Status values for the Device control FE

Name	Profile name	Details	Reference
Faulted	Fault and fault reaction active	Object 6041_h	See IEC 61800-7-201
No fault	Not ready to switch on, switch on disabled, ready to switch on, switched on, operation enabled, quick stop active	Object 6041_h	See IEC 61800-7-201

Table A.4 – Command values for the Device control FE

Name	Profile Name	Details	Reference
Reset fault	Fault reset bit 0 to 1	Object 6040_h	See IEC 61800-7-201

A.3.2.3 States

The fault reaction active and fault state is equivalent to the device control FE *faulted* state. If no fault is indicated in the statusword, this is equivalent to the device control FE *no fault* state.

A.3.2.4 Parameters

The occurrence of a failure shall be indicated as defined in Table A.5. The reset shall be commanded as defined in Table A.5.

Table A.5 – Parameters in the Device control FE

Name	Profile name	Details	Reference
Fault	Fault bit	Object 6041_h	See IEC 61800-7-201
Warning	Fault reaction code	Object $605E_h$	See IEC 61800-7-201

A.3.3 Communication FE

A.3.3.1 General

The Communication FE of the drive device includes the network management slave FSA controlled by the network management master device. The network management is network technology dependent.

A.3.3.2 I/O data

The network management master controls the PDS communication FSA by means of NMT messages. The drive device provides its communication status by means of network technology specific mechanism (e.g. CANopen defines the node/life guarding function and the heartbeat function). The status values are given in Table A.6. The command values are given in Table A.7.

Table A.6 – Status values for the Communication FE

Name	Profile name	Details	Reference
Communication running	Operational	5_d (see Note)	See EN 50325-4
Communication stopped	Pre-operational or Stopped	127_d or 4_d (see Note)	See EN 50325-4
NOTE These values are network technology dependent; the given examples are CANopen-specific.			

Table A.7 – Command values for the Communication FE

Name	Profile name	Details	Reference
Stop communication	Enter pre-operational or Stop remote node	CS = 128_d or 2_d (see Note)	See EN 50325-4
Run communication	Start remote node	CS = 1_d (see Note)	See EN 50325-4
NOTE These command specifiers are network technology dependent; the given examples are CANopen-specific.			

If the drive device and the control device want to exchange process data synchronously, the used network technology is responsible for achieving synchronous transmission.

A.3.3.3 States

The Communication stopped state is equivalent to the NMT pre-operational or NMT stopped state. The Communication running state is equivalent to the NMT operational state.

The synchronization is network technology dependent. In CANopen, each Process Data Object (PDO) may be configured individually to be transmitted or to be received synchronously. If synchronization is lost, the drive device may send an Emergency message. Another possibility is to use a global time base.

A.3.3.4 Parameters

The parameters are network technology specific.

A.3.4 Basic drive FE

A.3.4.1 General

This profile defines a PDS FSA that is controlled by the controlword received from the control device. This FSA provides sub-states, which are defined in detail in IEC 61800-7-201. The drive device provides the statusword, which is consumed by the control device.

A.3.4.2 I/O data

The status values are given in Table A.8. The command values are given in Table A.9.

Table A.8 – Status values for the Basic drive FE

Name	Profile name	Details	Reference
Operating	Operation enabled	Bits 0 to 6 in Object 6041 00_h	See IEC 61800-7-201

Table A.9 – Command values for the Basic drive FE

Name	Profile name	Details	Reference
Operate	Start (reset) command	Bits 0 to 3 and bit 7 in Object 6040 00_h	See IEC 61800-7-201

A.3.4.3 States

The PDS FSA defined in detail in IEC 61800-7-201 specifies the possible control sequence of the drive device. A single state represents a special behavior. The state also determines, which commands are accepted; for example it is only possible to start a point-to-point move when the drive is in the operation-enable state. States may be changed using the controlword and/or according to internal events.

A.3.4.4 Parameters

The drive device's behavior may be configured by means of parameters via the network. The CiA 402 profile defines parameters to select the mode of operations among many others. Table A.10 shows some of these parameters defined in IEC 61800-7-201.

Table A.10 – Basic drive FE parameters

Name	Profile name	Details	Reference
Mode command	Modes of operation	Object 6060 00_h	See IEC 61800-7-201
Mode status	Modes of operation display	Object 6061 00_h	See IEC 61800-7-201
–	Abort connection option code	Object 6007 00_h	See IEC 61800-7-201
–	Quick stop option code	Object 605A 00_h	See IEC 61800-7-201
–	Shutdown option code	Object 605B 00_h	See IEC 61800-7-201
–	Disable operation mode code	Object 605C 00_h	See IEC 61800-7-201
–	Halt option code	Object 605D 00_h	See IEC 61800-7-201
–	Fault reaction option code	Object 605E 00_h	See IEC 61800-7-201

A.3.5 Optional application functions FE

A.3.5.1 General

The CiA 402 profile defines optionally a position feedback interface. The position feedback information is accessible via the network interface.

The drive device may provide digital inputs and outputs readable respectively writable via the network.

A.3.5.2 I/O data

The used communication services for transmitting the position feedback information as well as the digital inputs and outputs are network technology dependent.

A.3.5.3 Parameters

The parameters of the optional application functions FE are listed in Table A.11.

Table A.11 – Optional application functions FE parameters

Profile name	Details	Reference
Position actual internal value	Object 6063 00_h	See IEC 61800-7-201
Velocity sensor actual value	Object 6069 00_h	See IEC 61800-7-201
Sensor selection code	Object 606A 00_h	See IEC 61800-7-201
Position encoder resolution	Object 608F 00_h	See IEC 61800-7-201
Velocity encoder resolution	Object 6090 00_h	See IEC 61800-7-201
Digital inputs	Object 60FD 00_h	See IEC 61800-7-201
Digital outputs	Object 60FE 00_h	See IEC 61800-7-201

A.4 Application modes

A.4.1 General

The drive device compliant to the CiA 402 profile defined in IEC 61800-7-201 may function as servo controller, frequency converter, or stepper motor. It shall support one, and may support several or all of the defined modes of operation. Besides those pre-defined modes of operation, the user may configure other application behavior.

The application modes supported are listed in Table A.12.

Table A.12 – Supported application modes

IEC 61800-7 application mode	Equivalent CiA 402 profile terminology
Torque control with optional feedback	Profile torque mode, Cyclic sync torque mode
Velocity preset	Velocity mode
Velocity control with optional feedback	Profile velocity mode, Cyclic sync velocity mode
Position preset	Profile position mode
Position control with optional feedback	Interpolated position mode, Cyclic sync position mode

The network communication messages used for the transmission of process data are network technology dependent. They may be different for servo controller, frequency inverter, and stepper motors.

A.4.2 Torque control

A drive device in CiA 402 profile torque mode may use the process data given in Table A.13 and the configuration parameters given in Table A.14.

Table A.13 – I/O data for profile torque mode

IEC 61800-7 I/O data	Equivalent CiA 402 profile terminology
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Torque set-point	Target torque (6071 00_h)
Actual torque	Torque actual value (6077 00_h)

Table A.14 – Parameter for profile torque mode

Index and sub-index	CiA 402 configuration object
6072 00_h	Max torque
6073 00_h	Max current
6074 00_h	Torque demand value
6075 00_h	Motor rated current
6076 00_h	Motor rated torque
6078 00_h	Current actual value
6079 00_h	DC link circuit voltage
6087 00_h	Torque slope
6088 00_h	Torque profile type
60E0 00_h	Positive torque limit value
60E1 00_h	Negative torque limit value
60F8 00_h	Max slippage

A drive device in CiA 402 cyclic sync torque mode may use the process data given in Table A.15 and the configuration parameters given in Table A.16.

Table A.15 – I/O data for cyclic sync torque mode

IEC 61800-7 I/O data	Equivalent CiA 402 process data
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Torque set-point	Target torque (6071 00_h)
Actual torque	Torque actual value (6077 00_h)

Table A.16 – Parameter for cyclic sync torque mode

Index and sub-index	CiA 402 configuration object
6072 00_h	Max torque
6076 00_h	Motor rated torque
6080 00_h	Max motor speed
60EA 00_h	Commutation angle
60B2 00_h	Torque offset
60C2 XX_h	Interpolation time period

A.4.3 Velocity control

A drive device in CiA 402 velocity mode may use the process data given in Table A.17 and the configuration parameters given in Table A.18.

Table A.17 – I/O data for velocity mode

IEC 61800-7 I/O data	Equivalent CiA 402 profile terminology
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Velocity set-point	Target velocity (vl) (6042 00_h)
Actual velocity	vl velocity actual value (6044 00_h)

Table A.18 – Parameter for velocity mode

Index and sub-index	CiA 402 configuration object
6043 00_h	vl velocity demand
6048 XX_h	vl velocity acceleration
6049 XX_h	vl velocity deceleration
604A XX_h	vl velocity quick stop
604B XX_h	vl set-point factor
604C XX_h	vl dimension factor
6050 00_h	vl slow down time
6051 00_h	vl quick stop time

A drive device in CiA 402 profile velocity mode may use the process data given in Table A.19 and the configuration parameters given in Table A.20.

Table A.19 – I/O data for profile velocity mode

IEC 61800-7 I/O data	Equivalent CiA 402 process data
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Velocity set-point	Target velocity (pv) (60FF 00_h)
Actual velocity	Velocity actual value (606C 00_h)

Table A.20 – Parameter for profile velocity mode

Index and sub-index	CiA 402 configuration object
6069 00_h	Velocity sensor actual value
606A 00_h	Sensor selection mode
606B 00_h	Velocity demand value
606D 00_h	Velocity window
606E 00_h	Velocity window time
606F 00_h	Velocity threshold time
60F8 00_h	Max slippage
6071 00_h	Target torque
6072 00_h	Max torque
607E 00_h	Polarity
607F 00_h	Max motor velocity
6080 00_h	Max motor speed
6083 00_h	Profile acceleration
6084 00_h	Profile deceleration
6085 00_h	Quick stop deceleration
6086 00_h	Motion profile type

A drive device in CiA 402 cyclic sync velocity mode may use the process data given in Table A.21 and the configuration parameters given in Table A.22.

Table A.21 – I/O data for cyclic sync velocity mode

IEC 61800-7 I/O data	Equivalent CiA 402 process data
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Velocity set-point	Target velocity (pv) (60FF 00_h)
Actual velocity	Velocity actual value (606C 00_h)

Table A.22 – Parameter for cyclic sync velocity mode

Index and sub-index	CiA 402 configuration object
605A 00_h	Quick stop option code
6069 00_h	Velocity sensor actual value
6062 00_h	Position demand value
6063 00_h	Position actual internal value
6072 00_h	Max torque
6076 00_h	Motor rated torque
6077 00_h	Torque actual value
607E 00_h	Polarity
6080 00_h	Max motor speed
6085 00_h	Quick stop deceleration
6086 00_h	Motion profile type
60B1 00_h	Velocity offset
60B2 00_h	Torque offset
60C2 XX_h	Interpolation time period

A.4.4 Position control

A drive device in CiA 402 profile position mode may use the process data given in Table A.23 and the configuration parameters given in Table A.24.

Table A.23 – I/O data for profile position mode

IEC 61800-7 I/O data	Equivalent CiA 402 profile terminology
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Position set-point	Target position (607A 00_h)
Actual position	Position actual value (6064 00_h)

Table A.24 – Parameter for profile position mode

Index and sub-index	CiA 402 configuration object
607B XX_h	Position range limit
607D XX_h	Software position limit
607E 00_h	Polarity
607F 00_h	Max profile velocity
6080 00_h	Max motor speed
6081 00_h	Profile velocity
6082 00_h	End velocity
6083 00_h	Profile acceleration
6084 00_h	Profile deceleration
6085 00_h	Quick stop deceleration
6086 00_h	Motion profile type
60C5 00_h	Max acceleration
60C6 00_h	Max deceleration

A drive device in CiA 402 interpolated position mode may use the process data given in Table A.25 and the configuration parameters given in Table A.26.

Table A.25 – I/O data for interpolated position mode

IEC 61800-7 I/O data	Equivalent CiA 402 object
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Position set-point	Position demand value (6062 00_h)
Actual position	Position actual internal value (6063 00_h)

Table A.26 – Parameter for interpolated position mode

Index and sub-index	CiA 402 configuration object
606A 00_h	Sensor selection code
607F 00_h	Max profile velocity
608F XX_h	Position encoder resolution
6090 XX_h	Velocity encoder resolution
6091 XX_h	Gear ratio
6092 XX_h	Feed constant
60C0 00_h	Interpolation sub mode select
60C1 XX_h	Interpolation data record
60C2 XX_h	Interpolation time period
60C3 XX_h	Interpolation sync definition
60C4 XX_h	Interpolation data configuration
60C5 00_h	Max acceleration
60C6 00_h	Max deceleration

A drive device in CiA 402 cyclic sync position mode may use the process data given in Table A.27 and the configuration parameters given in Table A.28.

Table A.27 – I/O data for cyclic sync position mode

IEC 61800-7 I/O data	Equivalent CiA 402 object
Command	Controlword (6040 00_h)
Status	Statusword (6041 00_h)
Position set-point	Target position (607A 00_h)
Actual position	Position actual value (6064 00_h)

Table A.28 – Parameter for cyclic sync position mode

Index and sub-index	CiA 402 configuration object
605A 00_h	Quick stop option code
6063 00_h	Position actual internal value
6065 00_h	Following error window
6066 00_h	Following error time out
6069 00_h	Velocity sensor actual value
606C 00_h	Velocity actual value
6072 00_h	Max torque
6076 00_h	Motor rated torque
6077 00_h	Torque actual value
607B XX_h	Position range limit
607D XX_h	Software position limit
607E 00_h	Polarity
6080 00_h	Max motor speed
6085 00_h	Quick stop deceleration
6086 00_h	Motion profile type
60B0 00_h	Position offset
60B1 00_h	Velocity offset
60B2 00_h	Torque offset
60C2 XX_h	Interpolation time period
60F4 00_h	Following error actual value
60FA 00_h	Control effort

Annex B
(normative)

Mapping to profile CIP Motion™

B.1 Overview

This annex describes the mapping of CIP Motion drive profile attributes to the generic power drive system (PDS) interface.

Terms and definitions of the CIP Motion drive profile are mapped to IEC 61800-7 terms as specified in Table B.1.

Table B.1 – Profile specific terms

IEC 61800-7 term	CIP Motion term	Reference
I/O data	Cyclic Data [a]	See IEC 61800-7-202
Command	Axis Control	See IEC 61800-7-202
Set-point	Command Data	See IEC 61800-7-202
Status	Axis State (+ Axis Status)	See IEC 61800-7-202
Actual value	Actual Data	See IEC 61800-7-202
[a] Both synchronized or unsynchronized.		

B.2 Mapping of general architecture

B.2.1 Typical structure of automation systems

The CIP Motion device profile is an extension of the CIP services and protocol, providing a common application level interface to a wide variety of motion control devices that are common to industrial automation.

The behavior of a CIP Motion compliant drive is controlled through a single cyclic bi-directional CIP Motion I/O Connection between a controller and the drive. The connection data structure is flexible in both size and content, which is solely determined by information resident in the packet header. The CIP Motion I/O Connection data structure consists of a high priority Cyclic Data Channel, a medium priority Event Data Channel, and a low priority service channel (see Figure B.1). Drive diagnostics, commissioning operations, and parameter configuration are all handled by the service channel, registration and homing events are handled by the event channel, and real time critical data, such as Command Data and Actual Data, is exchanged between the drive and controller via the Cyclic Data Channel.

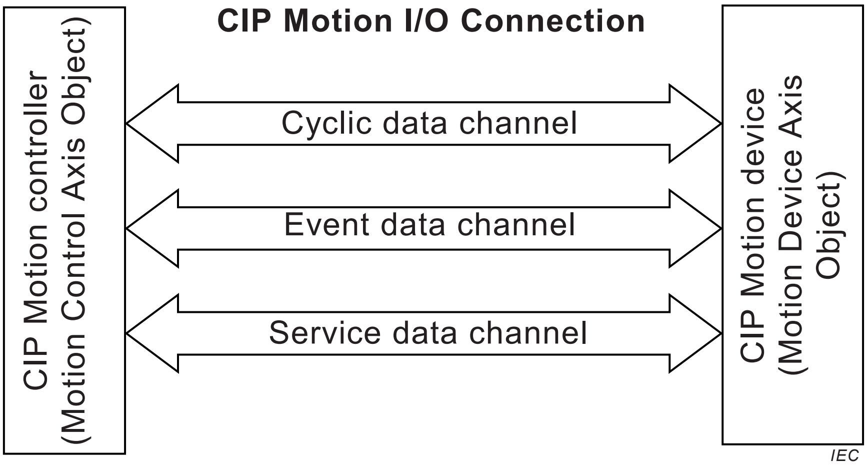


Figure B.1 – CIP Motion I/O Connection data structure

B.2.2 Structure of the logical PDS

The object structure of the logical PDS used in the CIP Motion drive profile is shown in Figure B.2.

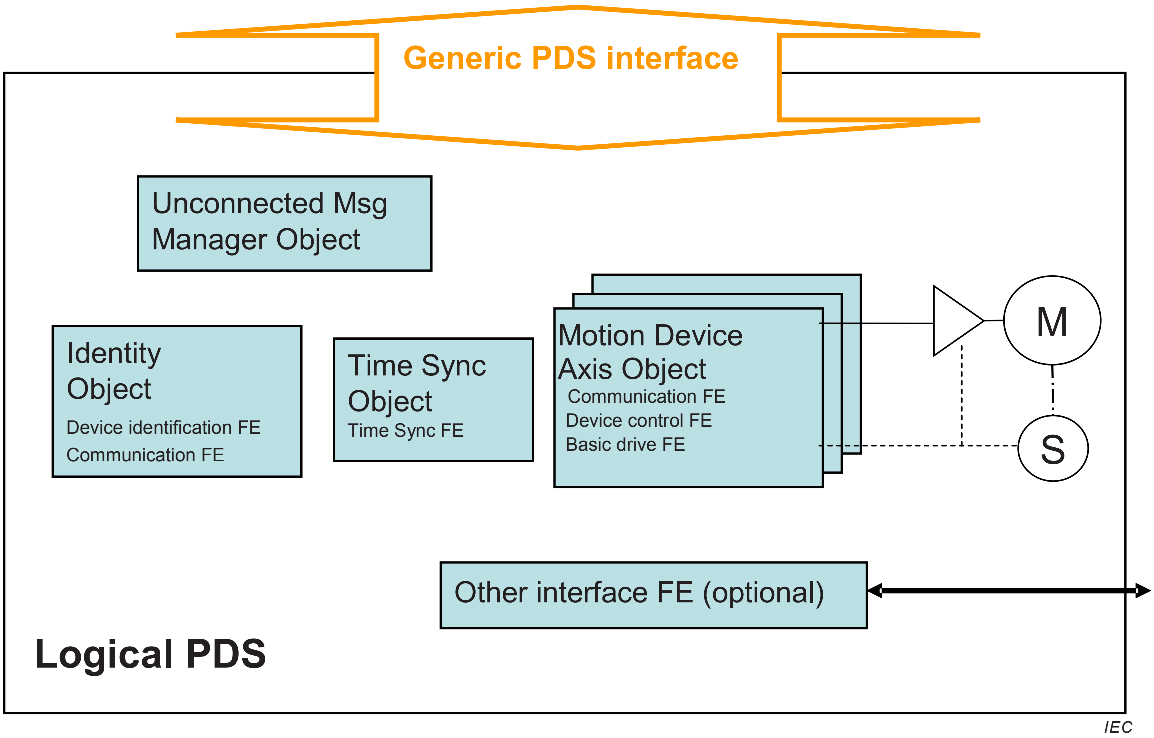


Figure B.2 – Object structure of the logical PDS

The Unconnected Message Manager is responsible for routing all unconnected CIP service requests to the targeted object in the PDS. These common CIP services include, but are not limited to, Get_Attribute, Reset, and Forward_Open services.

The Identity Object contains all pertinent information about the physical drive, including the Device ID, Product ID, and firmware revision.

The Time Sync Object (see IEC 61158-5-2 and IEC 61158-6-2) embodies the time synchronization functionality of the drive that allows the drive's local clock to be accurately synchronized with a distributed System Clock. Different levels of time synchronization precision are supported by the communication protocol depending on the implementation. This includes the case where there is no time synchronization capability within the drive.

The Motion Device Axis Object includes the Communication FE, Device control FE, and Basic drive FE behavior. A unique Motion Device Axis Object instance is created for each physical axis associated with a given drive network node and only one CIP Motion I/O Connection is created for each drive node. This means that the CIP Motion I/O Connection shall contain a block of data for each axis instance in a multi-axis drive.

The Other interface FE could be any additional non-CIP interface protocol to the drive, typically included to support a drive specific engineering tool. Such an interface is optional and not within the scope of this part of IEC 61800-7.

B.2.3 Use cases of the PDS

B.2.3.1 General

With the CIP Motion drive profile, use case actors performing engineering tasks (configuration and diagnostics) and operation-control (real-time control, command, actual, and status data) utilize the same CIP Motion I/O Connection. While the connection itself is cyclic in nature, the two data channels within the connection data structure have different priority levels.

B.2.3.2 Use case Engineering

The commissioning, configuration, diagnostic, and maintenance tasks associated with the engineering use case typically use the service channel of the CIP Motion I/O Connection. This is a lower priority data channel where CIP service requests and responses are exchanged between the controller and the targeted drive. Lower priority implies that the drive is not obligated to process the service request within one cyclic update period.

The Motion Device Axis Object supports a variety of CIP services that allow engineering use case actors to read and write object parameters and initiate commissioning operations. The CIP Motion drive profile defines these CIP services in detail and also provides the semantics of all parameters (attributes) contained in the Motion Device Axis Object.

B.2.3.3 Use case Operation-control

The critical real-time data exchange associated with the operation-control use case is handled by the high priority cyclic channel of the CIP Motion I/O Connection. Higher priority implies that the drive and controller devices are obligated to process the cyclic channel data within one cyclic update period. Failure to do so could eventually lead to a connection fault.

The state of a drive axis is controlled via bits in the Axis Control data element and monitored via bits in the Axis State data element that are standard elements of the cyclic data channel. One or more Command and Actual values can be included in the associated cyclic data channel to control and monitor axis motion. The specific Command and Actual values passed are determined by the Command Data Set and Actual Data Set parameters passed as part of the cyclic data connection header. This allows the contents of the real-time data to be altered on-the-fly and synchronously with changes to the drive's control mode.

B.3 Functional elements

B.3.1 Device identification FE

B.3.1.1 General

Parameters of the Device identification FE are defined as part of the CIP Identity Object.

B.3.1.2 Parameters

Parameters of the Device identification FE in the CIP Motion drive profile are mapped to IEC 61800-7 parameters as specified in Table B.2.

Table B.2 – Mapping of parameters for the Device identification FE

Name	Profile name	Details	Reference
Profile ID	–	–	–
Manufacturer ID	Vendor ID	Identity Object, Attr ID = 1	See IEC 61800-7-202, IEC 61158-5-2,IEC 61158-6-2
Product ID	Device Type	Identity Object, Attr ID = 2	See IEC 61800-7-202, IEC 61158-5-2,IEC 61158-6-2
	Product Code	Identity Object, Attr ID = 3	See IEC 61800-7-202, IEC 61158-5-2,IEC 61158-6-2
Serial number	Serial Number	Identity Object, Attr ID = 6	See IEC 61800-7-202, IEC 61158-5-2,IEC 61158-6-2
Hardware revision	–	–	–
Software revision	–	–	–
Tag	–	–	–
Location	–	–	–
Revision counter	Revision Major Revision Minor Revision	Identity Object, Attr ID = 4	See IEC 61800-7-202, IEC 61158-5-2,IEC 61158-6-2
–	Product Name	Identity Object, Attr ID = 7	See IEC 61800-7-202, IEC 61158-5-2,IEC 61158-6-2

B.3.2 Device control FE

B.3.2.1 General

The Motion Device Axis Object state machine follows the basic principles of operation outlined in the generic PDS Device control FE.

B.3.2.2 I/O data

The state of the drive axis is indicated by the Axis State attribute and by bits defined in the Axis Status attribute (see Table B.3). It is controlled the Axis Control element of the Cyclic Data Header (see Table B.4). These data are passed via the cyclic data channel of the CIP Motion I/O Connection.

Table B.3 – Mapping of status values for the Device control FE

Name	Profile name	Details	Reference
Faulted	Major Faulted	Axis State, value 8	See IEC 61800-7-202:2015, 7.3.13.1
Warning	Alarm (minor fault)	Axis Status, bit 1	See IEC 61800-7-202:2015, 7.3.13.2.1

Table B.4 – Mapping of command values for the Device control FE

Name	Profile name	Details	Reference
Reset Fault	Fault Reset Request	Axis Control, value 6	See IEC 61800-7-202:2015, 6.4.3.3.3

B.3.2.3 States

The basic state model of a drive axis is shown in Figure B.3.

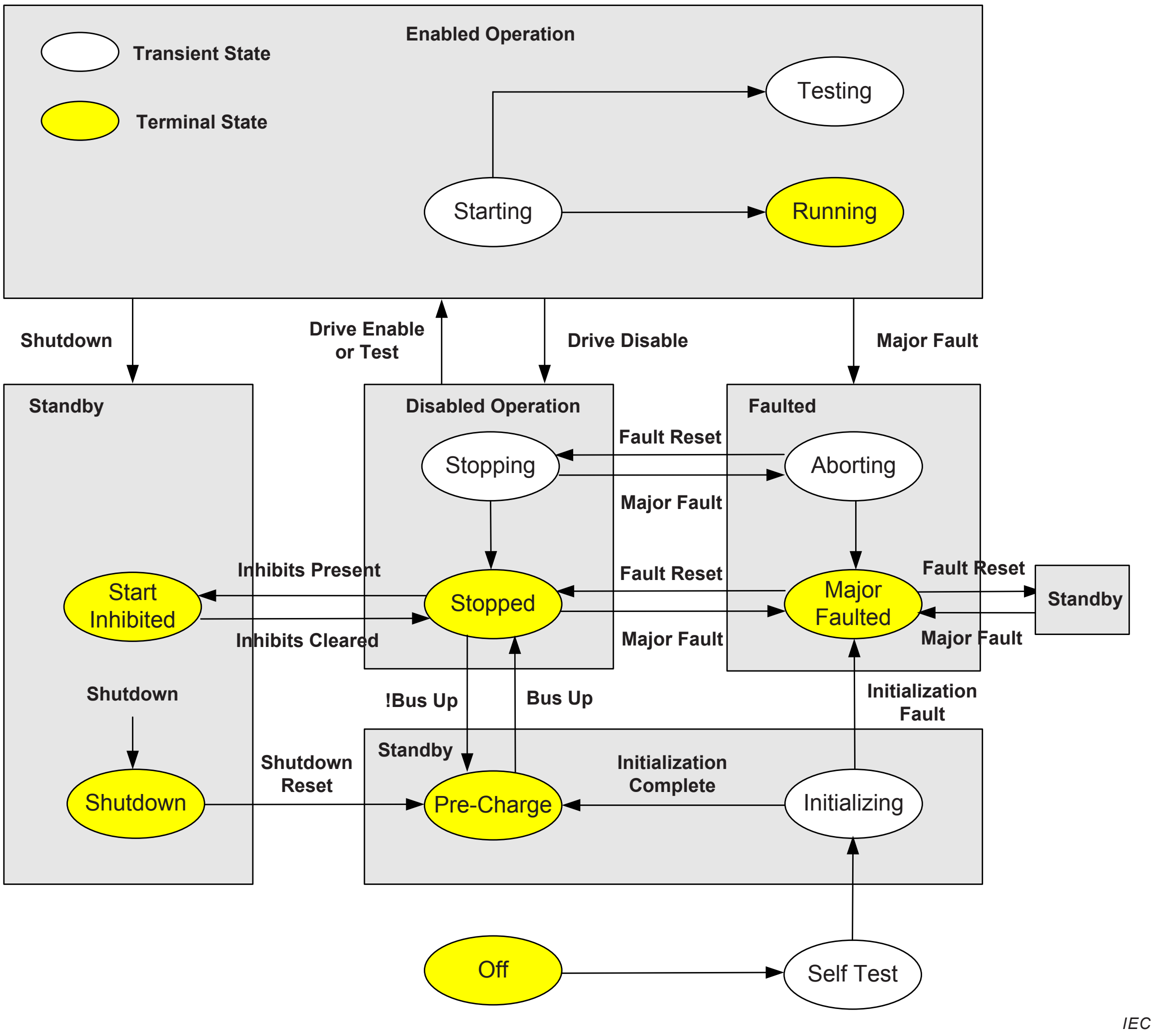


Figure B.3 – Motion Device Axis Object state machine

When a drive axis experiences a major or minor fault condition, a configurable fault action is applied by the drive (major fault) or the controller (minor fault) to stop the axis. This transitional state of the axis is called the Aborting state. Once the stopping process is complete, the axis enters the Faulted state and remains in that state until an explicit Fault Reset command is given. After execution of a Fault Reset, assuming there are no persistent fault conditions, the axis transitions to one of the Standby states.

In the CIP Motion drive profile, warnings are called alarms. Unlike faults, alarms do not directly initiate any action; alarm bits automatically clear when the alarm condition is eliminated. Conditions within the drive, called exceptions, can be configured to generate either a fault, or an alarm, or ignored completely.

A more detailed description of the drive axis states can be found in IEC 61800-7-202.

B.3.2.4 Parameters

Additional attributes are defined in the CIP Motion drive profile to further diagnose the fault or alarm condition. The most common of these are specified in Table B.5.

Table B.5 – Mapping of parameters for the Device control FE

Name	Profile name	Details	Reference
Fault	Axis Fault Type	Enumeration that specifies the source of a fault condition or a fault clearing event in an axis fault log record	See IEC 61800-7-202:2015, 7.3.15
	Axis Fault Code	When the Axis Fault Type is non-zero, enumeration that specifies the bit number of a fault condition in an axis fault log record. When the Axis Fault Type is zero, enumeration that indicates the source of a fault clearing event	See IEC 61800-7-202:2015, 7.3.15
	Axis Fault Sub Code	Enumeration that provides additional detail for some fault conditions in an axis fault log record	See IEC 61800-7-202:2015, 7.3.15
Warning	Axis Alarm Type	Enumeration that specifies the source of an alarm condition in an axis alarm log record	See IEC 61800-7-202:2015, 7.3.15
	Axis Alarm Code	Enumeration that specifies the bit number of an alarm condition in an axis alarm log record	See IEC 61800-7-202:2015, 7.3.15
	Axis Alarm Sub Code	Enumeration that provides additional detail for some alarm conditions in an axis alarm log record	See IEC 61800-7-202:2015, 7.3.15

B.3.3 Communication FE

B.3.3.1 General

Generic PDS states of *limited communication* and *normal communication* map directly to CIP Motion drive profile states Remote Control and Local Control. The CIP Remote Mode bit is used to transition the drive communications node between the remote and local states. CIP Motion drive profile also supports the *synchronized* state and a command bit to request drive node synchronization if it is required.

B.3.3.2 I/O data

The state of the drive axis Communication FE is indicated by bits defined in the Node Status attribute (see Table B.6 and Table B.8). This attribute is passed in the CIP Device-to-Controller Connection Header.

The state of the drive axis Communication FE is controlled by bits defined in the Node Control attribute (see Table B.7 and Table B.9). This attribute is also passed in the CIP Controller-to-Device Connection Header.

NOTE CIP Motion uses the concept of Remote/Local Control at the Communication FE level to determine which interface is in control of the drive. For multi-axis drive platforms with one Communication FE, this is preferred over a per axis drive FE Remote/Local implementation. Other than the name, CIP Remote/Local behavior is identical to *normal/limited communication* as defined in 5.3.

Table B.6 – Mapping of status values for the Communication FE

Name	Profile name	Details	Reference
Normal communication	Remote Mode[a]	Node Status, bit 0 set	See IEC 61800-7-202:2015, 7.2.2.2
[a] See Note in this subclause.			

Table B.7 – Mapping of command values for the Communication FE

Name	Profile name	Details	Reference
Stop communication	Mode Control (Local Mode Request)[a]	Node Control, bit 0 clear	See IEC 61800-7-202:2015, 7.2.2.1
Run communication	Mode Control (Remote Mode Request)[a]	Node Control, bit 0 set	See IEC 61800-7-202:2015, 7.2.2.1
[a] See Note in this subclause.			

Table B.8 – Mapping of status values for the optional Communication FE

Name	Profile name	Details	Reference
Synchronized	Sync Mode	Node Status, bit 1 set	See IEC 61800-7-202:2015, 7.2.2.2

Table B.9 – Mapping of command values for the optional Communication FE

Name	Profile name	Details	Reference
Synchronize	Sync Control (Synchronous Mode Request)	Node Control, bit 1 set	See IEC 61800-7-202:2015, 7.2.2.1
Do not synchronize	Sync Control (Asynchronous Mode Request)	Node Control, bit 1 clear	See IEC 61800-7-202:2015, 7.2.2.1

B.3.3.3 States

When beginning the connection initialization process the CIP Motion I/O Connection state as indicated by the Node Status attribute is Remote Mode and Asynchronous Mode. When the Time Sync Object has determined that the PDS clock has been fully synchronized, the connection state can transition from Asynchronous Mode to Synchronous Mode when requested by the controller via the Node Control element.

If the state of the connection state transitions from Remote Mode to Local Mode, the Synchronous/Asynchronous Mode state machine is no longer applicable.

If Synchronization is requested via the Node Control element, and the drive cannot successfully transition to the Synchronized state, a Node Fault is generated.

B.3.3.4 Parameters

No specific timing parameters are required to establish the CIP Motion I/O Connection other than the update period of the connection, as established by the Controller Update Period. This attribute value is embedded in the connection data structure itself allowing the connection update period to be changed during operation.

Communication node addressing is network specific and handled by the applicable network specific Link Object defined by the CIP services and protocol.

B.3.4 Basic drive FE

B.3.4.1 General

As noted above, the Basic drive FE behavior is governed by the Motion Device Axis state model of the Motion Device Axis Object as shown in Figure B.3.

B.3.4.2 I/O data

The axis state is controlled by the Axis Control word in the CIP Motion controller-to-device connection (see Table B.11) and indicated by the Axis State word in the CIP Motion device-to-controller connection (see Table B.10). The optional generic PDS states of “local control/remote control” are not explicitly supported by the drive state model. When the CIP Motion I/O Connection is established and in the Remote Control communications state, all axis instances associated with the drive node are exclusively controlled via the CIP Motion I/O Connection and NOT the local interface. There is no mechanism for the CIP controller to force the drive FE to relinquish control of a specific Motion Device Axis Object instance to a local drive interface.

In Table B.10 and Table B.11, only the attributes that map to the states defined in IEC 61800-7 are listed.

Table B.10 – Status values for the Basic drive FE

Name	Profile name	Details	Reference
Operating	Running	Axis State, value 4	See IEC 61800-7-202:2015, 7.3.13.1
	Control Mode	Indicates the current drive Application Mode.	See IEC 61800-7-202:2015, 7.3.2.2.1

Table B.11 – Command values for the Basic drive FE

Name	Profile name	Details	Reference
Operate	Enable Request	Axis Control, value 1	See IEC 61800-7-202:2015, 6.4.3.3.3
	Control Mode	Determines the drive Application Mode	See IEC 61800-7-202:2015, 7.3.2.2.1

B.3.4.3 States

In general, Motion Device Axis Object state changes are initiated by setting bits in the Axis Control element of the CIP Motion controller-to-device connection. For more details on the various states comprising the Motion Device Axis Object state model, refer to the Motion Device Axis Object specification (see IEC 61800-7-202).

B.3.4.4 Parameters

Within the Running state, the drive's behavior is governed by the Control Mode attribute that is passed as part of the CIP Motion I/O Connection data. The enumerated Control Modes line up closely with the Application Modes defined in IEC 61800-7-1. Values for the Control Mode attribute are specified in Table B.12.

Table B.12 – Drive Control Mode values for the Basic drive FE

Attribute name	Description of attribute	Semantics of values
Axis Control Mode	Enumerated code that determines the specific dynamic behavior of the motor that the drive is to control. These control modes are further specified in IEC 61800-7-202.	0 = no control 1 = position control 2 = velocity control 3 = acceleration control 4 = torque control 5 to 15 = (reserved)

Unlike many drive profiles, the contents of the I/O data exchanged between the controller and the drive, i.e. cyclic data, is not implicitly determined by the application mode or operating mode of the drive, but rather explicitly determined by Command Data Set, Actual Data Set, and Status Data Set attributes. These attributes are established by the controller and passed as part of the CIP Motion I/O Connection header. Using this mechanism, the contents of the various data sets may be changed at any time during drive operation.

The Command Data Set attribute found in the controller-to-device connection data header identifies the set-points that are contained in the connection's Cyclic Data Block. This bit mapped value has a bit defined for each possible real-time command reference (see Table B.13). Command Data appears in the same order in the Command Data Set as the bit numbers.

NOTE 1 Command Position would appear before Command Torque in the real-time data structure if both bits were set.

When multiple Command Data values are provided in the connection's Cyclic Data Block, inner loop Command Data values are used as input for feed forward operations

Table B.13 – Command Data Set values for the Basic drive FE

Bit	Command Data element produced
0	Command Position
1	Command Velocity
2	Command Acceleration
3	Command Torque
4	(Reserved)
5	(Reserved)
6	Unwind Cycle Count
7	Position Displacement

The Actual Data Set attribute found in the device-to-controller connection data header identifies the Actual Data values that are contained in the connection's Cyclic Data Block. This bit mapped value has a bit defined for each possible real-time Actual Data attribute that is to be included in the Actual Data Set of the device-to-controller connection's Cyclic Data Block for the next update (see Table B.14). Actual data appears in the same order as the bit numbers.

NOTE 2 Actual Position would appear before Actual Acceleration in the real-time data structure if both bits were set.

Table B.14 – Actual Data Set values for the Basic drive FE

Bit	Actual Data element produced
0	Actual Position
1	Actual Velocity
2	Actual Acceleration
3	(Reserved)
4	(Reserved)
5	(Reserved)
6	Unwind Cycle Count
7	Position Displacement

This bit-mapped Status Data Set contains bits that determine the contents of the Status Data Set of the device-to-controller connection's Instance Data Block in the next update (see Table B.15). Status data appears in the same order as the bit numbers.

NOTE 3 Drive Status would appear before, for example, Fault History data in the cyclic data structure after the Actual Data Set.

The definitions of each of these Status Data Elements can be found by looking up the corresponding Motion Device Axis Object attribute specification (see IEC 61800-7-202).

Table B.15 – Status Data Set values for the Basic drive FE

Bit	Status Data Element produced
0	Axis Fault Type Axis Fault Code Axis Fault Sub Code Axis Fault Action Axis Fault Time Stamp
1	Axis Alarm Type Axis Alarm Code Axis Alarm Sub Code Axis Alarm State Axis Alarm Time Stamp
2	Axis Status Axis Status – Mfg
3	Axis I/O Status Axis I/O Status – Mfg
4	Axis Safety Status Axis Safety Status – Mfg Axis Safety State Pad
5	(Reserved)
6	(Vendor specific)
7	(Vendor specific)

It is the responsibility of the controller to provide the correct data set configuration based on the selected Control Mode.

Obviously if position control mode was selected, the controller should send the position command reference and set the corresponding Command Position bit in the Command Data Set attribute.

For more detail on the parameters associated with the CIP Motion Device Axis Object state model, refer to the CIP Motion Device Axis Object specification (see IEC 61800-7-202).

B.4 Application modes

B.4.1 General

CIP Motion defines a set of control modes that define the equivalent of a PDS application mode and have similar behavior (see Table B.16).

Relevant CIP Motion control modes for the PDS are: Position Control, Velocity Control, and Torque Control. The PDS Application modes that specify a preset, or index into a drive based data table, are handled in CIP via explicit service requests over Service Data Channel to a drive based motion planner. Since this is not indexing *per se*, this application mode is marked as not used in Table B.16.

Table B.16 – Supported application modes

IEC 61800-7 application mode	Equivalent CIP Motion profile terminology
Torque preset	Not used
Torque control	Torque Control
Torque control with velocity feedback	Torque Control
Velocity preset	Not used
Velocity control	Velocity Control
Velocity control with position feedback	Velocity Control
Position preset	Not used
Position control	Position Control

Table B.17 summarizes the generic PDS Application Modes available in the CIP Motion drive profile and the equivalent CIP Motion Control Mode settings and Set-points.

Table B.17 – Set-point values for the generic application modes

Generic PDS Application Mode	CIP Motion Control Mode	CIP Motion Set-point	Functions in the PDS
Torque control	Torque	Command Torque	Open torque control loop. Additionally, a measured or estimated feedback value(s) is (are) provided.
Torque control with velocity feedback	Torque	Command Torque	Closed torque control loop. Additionally, a measured or estimated feedback value(s) is (are) provided.
Velocity preset	Not used	Not used	–
Velocity control	Velocity	Command Velocity	Open velocity and torque control loop. Additionally, a measured or estimated feedback value is provided.
Velocity control with position feedback	Velocity	Command Velocity	Closed velocity and torque control loop. Additionally, a measured or estimated feedback value is provided.
Position preset	Not used	Not used	–
Position control	Position	Command Position	Open or closed torque, velocity and position control loop in the drive with (or without) sensor feedback.

The CIP Motion drive profile does not support the concept of standard messages, with fixed set-point and actual data content based on the application mode. Instead, the content of CIP Motion I/O Connection data structure is freely configurable and established by the controller (see B.3.4.4).

B.4.2 Torque control

The torque control specific I/O data is given in Table B.18.

Table B.18 – I/O data for profile torque mode

IEC 61800-7 I/O data	Equivalent CIP Motion profile terminology
Command	Axis Control
Status	Axis State (+ Axis Status)
Set-point torque	Command Torque
Actual torque	Not applicable

A complete list of CIP Motion drive profile parameters for Torque control may be found in the Motion Device Axis Object specification (see IEC 61800-7-202).

B.4.3 Velocity control

The velocity control specific I/O data is given in Table B.19.

Table B.19 – I/O data for profile velocity mode

IEC 61800-7 I/O data	Equivalent CIP Motion profile terminology
Command	Axis Control
Status	Axis State (+ Axis Status)
Set-point velocity	Command Velocity
Actual velocity	Actual Velocity

A complete list of CIP Motion drive profile parameters for Velocity control may be found in the Motion Device Axis Object specification (see IEC 61800-7-202).

B.4.4 Position control

The position control specific I/O data is given in Table B.20.

Table B.20 – I/O data for profile position mode

IEC 61800-7 I/O data	Equivalent CIP Motion profile terminology
Command	Axis Control
Status	Axis State (+ Axis Status)
Set-point position	Command Position
Actual position	Actual Position

A complete list of CIP Motion drive profile parameters for Position control may be found in the Motion Device Axis Object specification (see IEC 61800-7-202).

B.5 Profile specific extensions

No profile specific extensions are defined.

Annex C
(normative)

Mapping to profile PROFIdrive

C.1 Overview

This annex describes the mapping of the PROFIdrive – Profile Drive Technology to the generic power drive system (PDS) interface.

Terms and definitions of the PROFIdrive profile are mapped to IEC 61800-7-1 terms as specified in Table C.1.

Table C.1 – Profile specific terms

IEC 61800-7 term	PROFIdrive term	Reference
I/O data	IO Data	See IEC 61800-7-203
Command	Control word (STW)	See IEC 61800-7-203
Set-point	Setpoint value	See IEC 61800-7-203
Status	Status word (ZSW)	See IEC 61800-7-203
Actual value	Actual value	See IEC 61800-7-203

C.2 Mapping of general architecture

C.2.1 Typical structure of automation systems

The PROFIdrive base model defines as basic elements the following three classes of devices.

The Controller is a controlling device which is associated with one or more drives (axes). Related to the automation system, the Controller is the host for the overall automation.

The P-Device is a field device and the host for the drive (closed loop control, inverter). The P-Device typically is associated with one or more Controller devices.

The Supervisor typically is an engineering device which manages provisions of configuration data (parameter sets) and collections of diagnosis data from P-Devices and/or Controllers.

Figure C.1 shows the different communication channels which are available between the P-Device and the other Devices. The Clock Synchronous Operation as well as IO Data transfer is available between P-Device and Controller and between P-Devices itself. Parameter access to the P-Device is available from all other Controller and Supervisor devices.

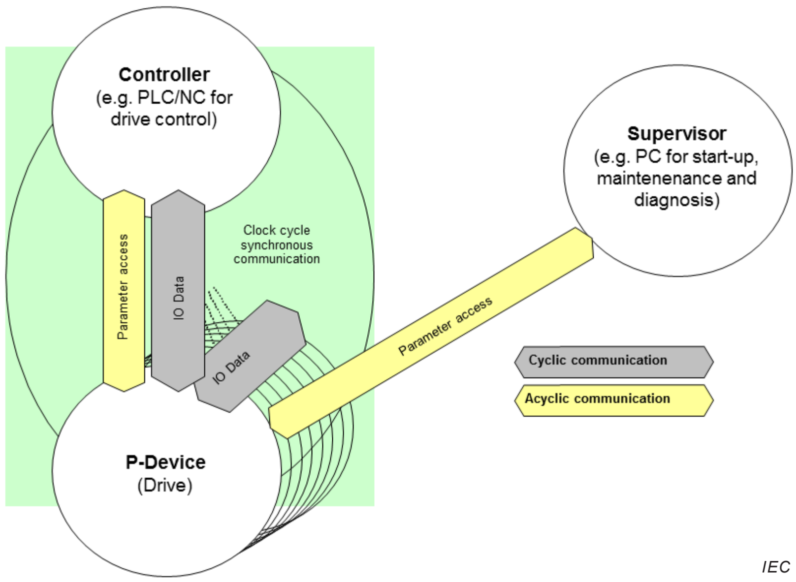


Figure C.1 – Overview of communication devices and services in PROFIdrive

The PROFIdrive Base Model defines the following communication services. The communication services are provided from the Device and are used from the Functional Object.

Cyclic Data Exchange

Cyclic communication means the simple transfer of IO Data of predefined size in a reserved time slot. With cyclic communication, the IO Data that is critical with respect to time is exchanged between the controller and device or between devices. Typically, such data contains setpoint values and actual values, control- and status information. The Cyclic Data Exchange service is assigned to the Controller – P-Device and the P-Device – P-Device relationship.

Acyclic Data Exchange

Compared to cyclic communication, data is exchanged acyclically only if necessary. Via acyclic communication, not time-critical data is transferred, for example the download of firmware or parameter data. The Acyclic Data Exchange service is assigned to the Controller – P-Device and the Supervisor – P-Device relationship.

Alarm Mechanism

With the Alarm Mechanism service, alarm information and exception situations are signalled to the controlling device in a real time manner. The service works in a demand-oriented way to keep the exception status image of the Functional Object in the controller up to date. With this service, the controller is able to respond on an occurring event in the drive as fast as possible without polling the drive status information permanently on its own. The Alarm Mechanism service is assigned to the Controller – P-Device relationship.

Clock Synchronous Operation

The Clock Synchronous Operation service guaranties the start of tasks on different communication devices or Functional Objects at the same time with minimum (specified) jitter (for example input sampling and output processes). Also this service implies that dedicated cyclic data packages are definitely transmitted until a certain moment in the communication cycle. For drive technology, clock cycle synchronous communication is the basis for drive synchronization. Such basic functionality is described in IEC 61158-5-3 and IEC 61158-6-3 or IEC 61158-5-10 and IEC 61158-6-10. The used communication system has to provide the basic functionality for Clock Synchronous Operation. This means that not only message interchange on the bus system has to be scheduled, but also that the application control algorithms – such as closed loop speed and current controllers in the drive, or the control processes in the higher level automation system – are synchronized.

C.2.2 Structure of the logical PDS

The PROFIdrive Device consists out of one or more Functional Objects. The Functional Objects are logical objects which represent functionality inside the automation system.

If the Device is of the type P-Device, the Functional Objects inside the P-Device are of the type Drive Object.

Based on the objects defined in the Base Model the hierarchical order and dependencies between them are shown in the Object Model (see Figure C.2).

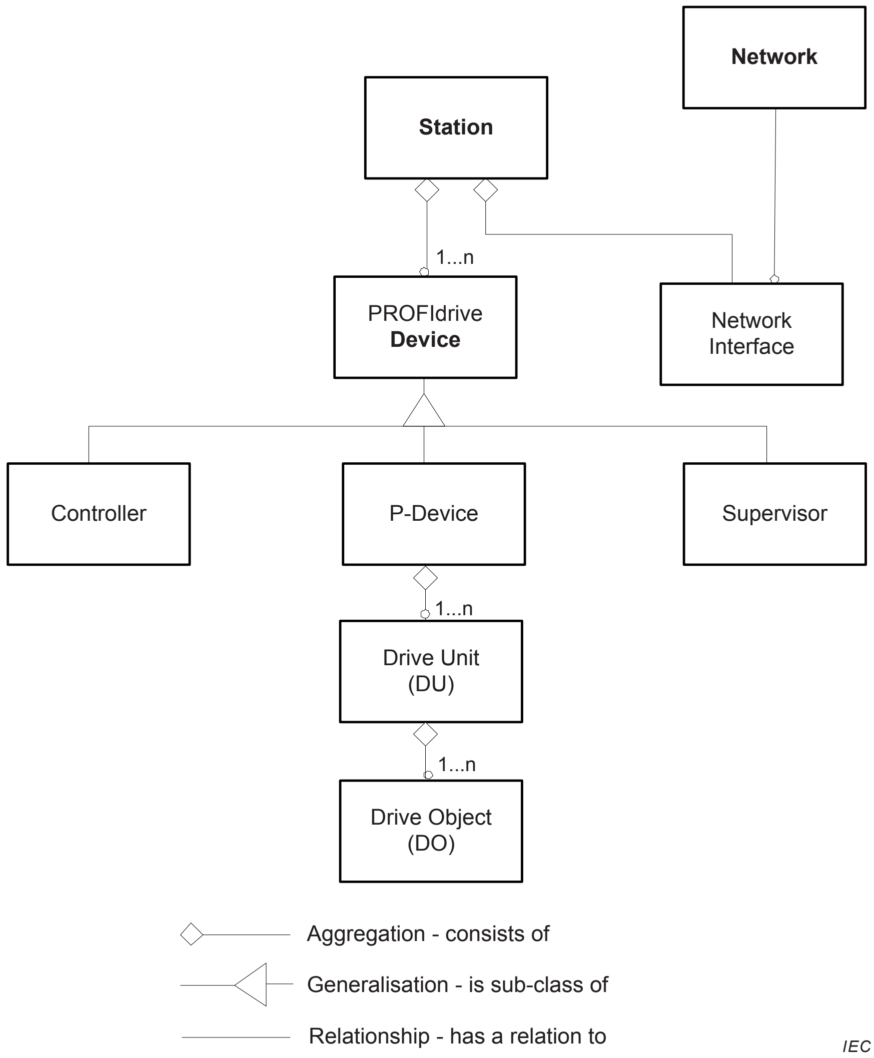


Figure C.2 – Structure of the PROFIdrive device

Every P-Device contains exactly one or multiple Drive Units (DU), which contains one or more Drive Objects (DO). The DOs may be of different type. One dedicated type of general importance in the PROFIdrive profile is the Axis type DO, which is typically related to a motor and specified in detail in IEC 61800-7-203. The Drive Object (DO) of Axis type is mapped to the generic PDS interface.

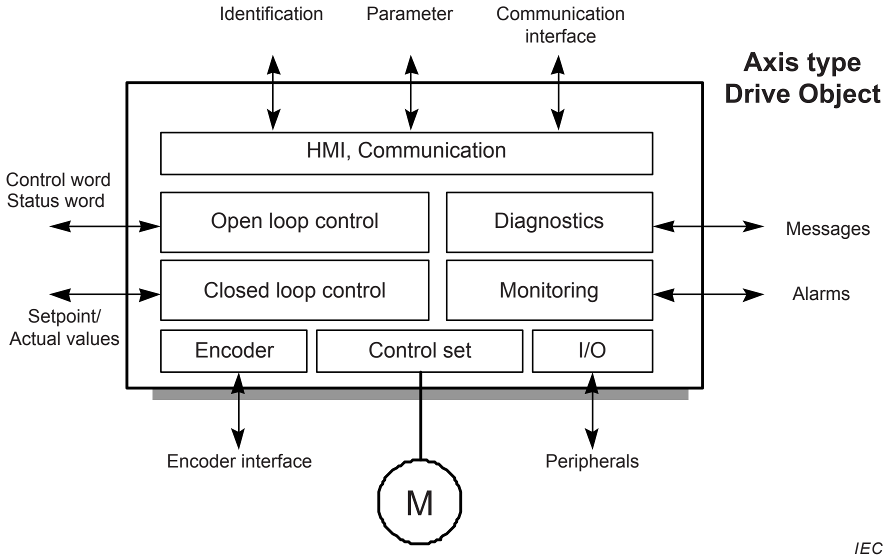


Figure C.3 – PROFIdrive Axis type Drive Object

The following objects are included in the PROFIdrive Axis type Drive Object (see Figure C.3):

- objects for device identification;
- parameters for accessing information and settings of the individual function modules;
- objects for setting the communication interface;
- objects for drive control (for example, control words and status words);
- objects for setpoint processing (for example, setpoint values and actual values);
- objects for diagnostics and monitoring (for example, messages, alarms, faults);
- objects for integrated sensor interface(s);
- objects for integrated peripheral functions (integrated I/O).

C.2.3 Use cases of the PDS

C.2.3.1 General

The PROFIdrive profile defines a unified device behavior and access technique to the drive data. Figure C.4 shows the relation between the different communication services of the P-Device and the internal structure of the DO.

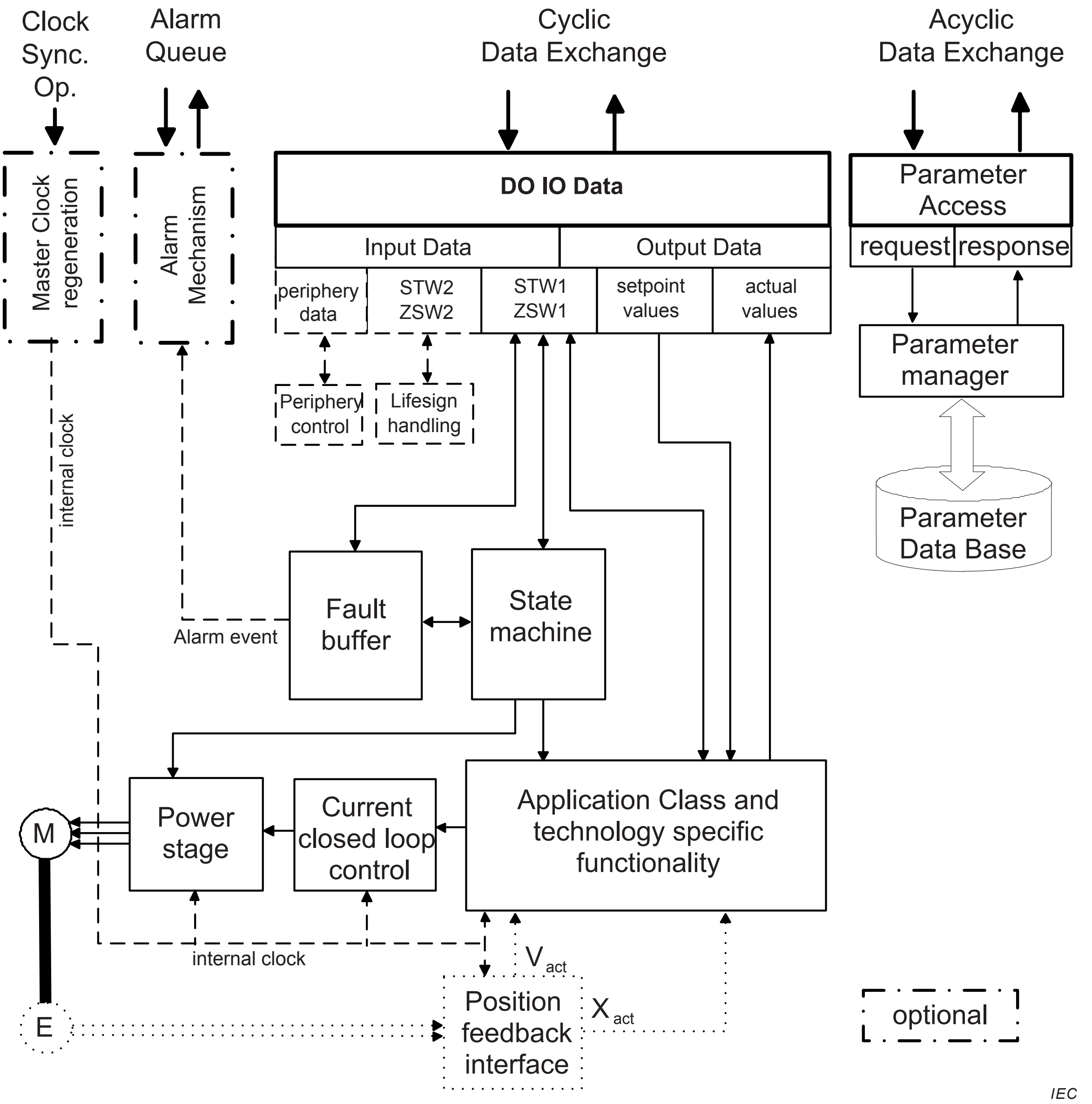


Figure C.4 – Functional block diagram of the PROFIdrive Axis type DO

C.2.3.2 Use case Engineering

Parameters are accessed over the Acyclic Data Exchange service. The profile defines the access mechanism, the representation of possible values and the parameter description mechanism. Only the semantics of parameters describing the device, the communication interface and general services are defined in the profile. All other parameters are drive technology dependant and not defined in the profile.

C.2.3.3 Use case Operation-control

The behavior of the drive is controlled with the Cyclic Data Exchange service. The state machine of the drive is controlled with the control word(s) STW and monitored with the status word(s) ZSW. The IO Data includes one or several signals assigned to setpoints and actual values to control and monitor the drive. Possible combinations of signals are composed in predefined standard telegrams.

Optionally, the Alarm Mechanism may be used for the monitoring of the alarm and diagnostics information and the Clock Synchronous Operation service is used to synchronize the clocks of the tasks of the application processes.

C.3 Functional elements

C.3.1 Device identification FE

C.3.1.1 General

In PROFIdrive, there is one parameter with subindexes to identify the Drive Unit. This parameter shall be accessible by the acyclic communication interface.

C.3.1.2 Parameters

There are two possibilities for Drive Unit identification in the PROFIdrive profile. One uses an identification parameter defined in the PROFIdrive profile, and the other is based on the generic device identification and maintenance functions (I&M, see PNO/3.502). Both are represented in Table C.2.

Table C.2 – Parameters for device identification

Name	Profile name	Details	Reference
Profile ID	PROFILE_ID	Block I&M0	See IEC 61800-7-203
Manufacturer ID	Manufacturer	Parameter 964 subindex 0	See IEC 61800-7-203
	MANUFACTURER_ID	Block I&M0	See IEC 61800-7-203
Product ID	Drive Unit type	Parameter 964 subindex 1	See IEC 61800-7-203
	ORDER_ID	Block I&M0	See IEC 61800-7-203
Serial number	SERIAL_NUMBER	Block I&M0	See IEC 61800-7-203
Hardware revision	Version [a]	Parameter 964 subindex 2	See IEC 61800-7-203
	HARDWARE_REVISION	Block I&M0	See IEC 61800-7-203
Software revision	Firmware date	Parameter 964 subindex 3&4	See IEC 61800-7-203
	SOFTWARE_REVISION	Block I&M0	See IEC 61800-7-203
Tag	TAG_FUNCTION [b]	Block I&M0	See IEC 61800-7-203
Location	TAG_LOCATION [b]	Block I&M0	See IEC 61800-7-203
	INSTALLATION_DATE [b]	Block I&M0	See IEC 61800-7-203

[a] At present, this is the firmware version.

[b] Optional.

C.3.2 Device control FE

C.3.2.1 General

A drive fault situation, which causes one or several fault messages, generates a device-specific fault reaction. It may cause the power converter to be powered-down. The presence of faults and warnings is signalled in the I/O data.

Dedicated parameters related to the fault buffer and the warning mechanism are available to enable access to more detailed information about the actual fault and warning situation and about the fault history without any disturbances on the cyclic data exchange and the operation of the drive.

C.3.2.2 I/O data

The actual state of the Device control FE is signalled in the status word 1 and is controlled with the control word 1 of the I/O data (see Table C.3 and Table C.4).

Table C.3 – Status values for the Device control FE

Name	Profile name	Details	Reference
Faulted	Fault Present / No Fault	Status word 1, Bit 3	See IEC 61800-7-203
Warning	Warning Present / No Warning	Status word 1, Bit 7	See IEC 61800-7-203

Table C.4 – Command values for the Device control FE

Name	Profile name	Details	Reference
Reset Fault	Fault Acknowledge	Control word 1, Bit 7	See IEC 61800-7-203

C.3.2.3 States

The fault reaction in PROFIdrive is fault-specific and device-specific. After the fault has been acknowledged, the fault disappears if the reason for the fault does not exist anymore. The device specific fault numbers are in the fault parameters.

C.3.2.4 Parameters

Parameters 953 to 960 (warning words) (see Table C.5) are reserved for warnings. Every bit of a warning word is assigned a warning (device specific). Bit value "0" signifies "warning not present", bit value "1" signifies "warning present". The warning words are only changed locally from the power converter. If at least one warning is present, then additionally bit 7 "warning" is set in status word 1.

A fault tracking system is defined to save the fault messages. This fault tracking system consists of the fault buffer and the fault code list. The fault buffer contains a list of fault messages which have been generated if a fault occurs (device specific fault code), The optional fault number list contains an assignment of alternative fault codes (application specific fault code) to the device specific fault codes. The mechanism how the fault tracking system can be read is described in IEC 61800-7-203.

Table C.5 – Device control parameters

Name	Profile name	Details	Reference
Fault	Fault number	Parameter 947	See IEC 61800-7-203
	Fault message counter	Parameter 944	See IEC 61800-7-203
	Fault code	Parameter 945	See IEC 61800-7-203
	Fault code list	Parameter 946	See IEC 61800-7-203
	Fault time	Parameter 948	See IEC 61800-7-203
	Fault value	Parameter 949	See IEC 61800-7-203
	Scaling of the fault buffer	Parameter 950	See IEC 61800-7-203
	Fault number list	Parameter 951	See IEC 61800-7-203
	Fault situation counter	Parameter 952	See IEC 61800-7-203
Warning	Warning words	Parameter 953 to 960	See IEC 61800-7-203

C.3.3 Communication FE

C.3.3.1 General

For the PROFIdrive Base Model the following states, related to the Communication FE are defined.

- Offline: There is generally no communication service working.
- Preparation: In this state, the Acyclic Data Exchange service and the Alarm Mechanism is working. This means that configuration information may be passed from the Controller to the P-Device and parameter access is possible. Alarms will also be forwarded. There may be no Cyclic Data Exchange service or the transmitted IO Data is not valid. For Clock Synchronous Operation, the communication system tries to synchronize all Slave Clocks to the Clock Master.
- Synchronization: In this state, the Acyclic Data Exchange, the Cyclic Data Exchange and the Alarm Mechanism are working and the transmitted cyclic data is valid. The application processes try to synchronize their tasks to each other (synchronize to the local Slave Clock and synchronize the data streams via the cyclic communication channels).
- Operation: In this state, all application processes are synchronized and the whole application is ready to operate (productive work).

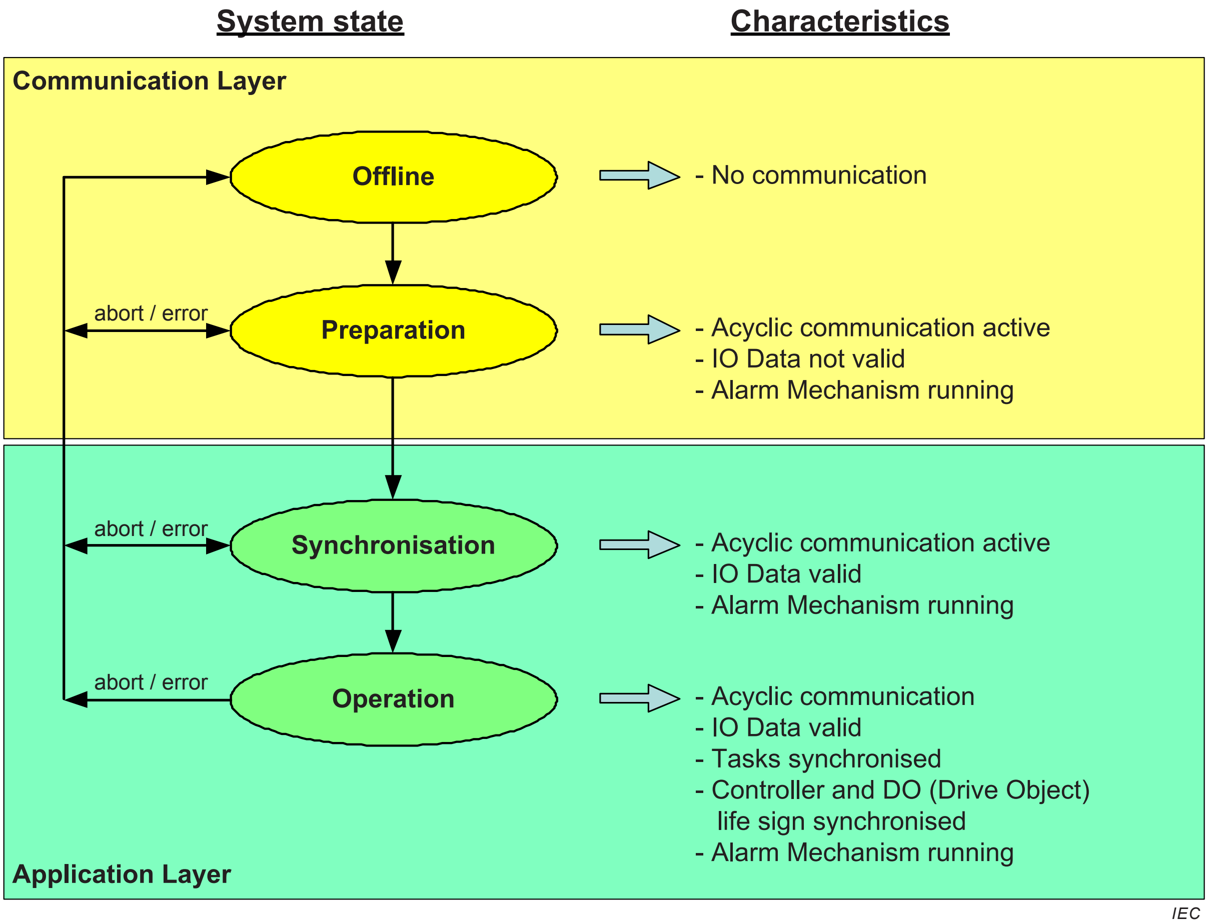


Figure C.5 – Mapping of Communication FE states

The states Preparation and Synchronization correspond to the generic state *limited communication* and *not synchronized*. The state Operation corresponds to the state *normal operation* and *synchronized* of the generic PDS interface as represented in Figure C.5.

C.3.3.2 I/O data

The signalling of the states of the Communication FE in the I/O data is communication profile specific.

C.3.3.3 States

The number of sub-states and implementation is communication profile specific.

C.3.3.4 Parameters

The number and meaning of the Communication FE parameters is communication profile specific.

C.3.4 Basic drive FE

C.3.4.1 General

The PROFIdrive profile for drive technology defines state machines which are controlled by the control word received from the controlling device. These state machines are more complex than the state machine given in this standard.

C.3.4.2 I/O data

The drive state machines are controlled with the control words. The status words reflect the actual state of the drive.

In Table C.6 and Table C.7, only the bits used to control the states defined in this standard are listed.

Table C.6 – Status values of the Basic drive FE

Name	Profile name	Details	Reference
Operating	Operation Enabled / Operation Disabled	Status word 1, Bit 2	See IEC 61800-7-203

Table C.7 – Command values of the Basic drive FE

Name	Profile name	Details	Reference
Operate	Enable Operation / Disable Operation	Control word 1, Bit 3	See IEC 61800-7-203
NOTE Additional status information is also transferred in the Status word. The state machine defines how the corresponding bits are handled.			

The controller can only control the PDS if the following conditions are fulfilled.

1) The Communication FE is in the *normal communication* state.
2) The PDS signals “Control Requested” in the status word to the controller. This is only the case if the related parameter permits the remote control of the PDS over the communication interface.
3) The controller sends the command “Control By PLC” to the PDS to signal that he is ready to take over the control and his IO Data are valid.
4) The controller sends the command “On” to switch on the PDS.
5) The PDS signals “Ready To Operate” in the status word to the controller.

These states are signalled by the values listed in Table C.8 and controlled as described in Table C.9.

Table C.8 – Status values for the optional Basic drive FE

Name	Profile name	Details	Reference
Remote control	Control Requested / No Control Requested	Status word 1, Bit 9	See IEC 61800-7-203

Table C.9 – Command values for the optional Basic drive FE

Name	Profile name	Details	Reference
Remote	Control By PLC	Control word 1, Bit 10	See IEC 61800-7-203
Local	No Control By PLC	Control word 1, Bit 10	See IEC 61800-7-203
NOTE In the “Local control” state, the controller still is able to monitor the state of the Basic drive FE of the PDS over the network.			

C.3.4.3 States

The general state machine is defined in IEC 61800-7-203. The state machine describes the possible control sequence of the drive. Every state represents a special behavior. The state also determines which commands are accepted. States may be changed using the control words and/or according to internal events.

In the PROFIdrive general state machine, the generic *operating* state is the state Operation, and the generic *not operating* state comprises the sub-states (Switching On Inhibited, Ready for Switching On, Switched On).

C.3.4.4 Parameters

The parameters “Telegram selection” and “Operating mode” shows the coding of the interface mode which is related to the “Application Class”. In PROFIdrive, the application mode is divided in different Application Classes and telegram types. This specifies the exact meaning of the control and status words and the state machine used (see Table C.10).

Table C.10 – Device control parameters

Name	Profile name	Reference	Details
Mode command	Telegram selection Operating mode	Parameter 922 Parameter 930	See IEC 61800-7-203
Mode status	Telegram selection Operating mode	Parameter 922 Parameter 930	See IEC 61800-7-203

C.3.5 Optional application functions FE

C.3.5.1 General

The PROFIdrive profile includes the option to have a position feedback interface included in the drive. It is an interface defined between the drive and a higher level control. The interface gives the possibility for the control device to get position feedback information over the communication interface, taken from the sensors connected to the drive. The functionality described in the position feedback interface is implemented in the drive, not in the sensor itself.

C.3.5.2 I/O data

To control and monitor this position feedback sensor, a special sensor control word and sensor status word is defined in IEC 61800-7-203. The proposed combinations of sensor feedbacks and application modes are listed in the standard telegrams.

C.3.5.3 Parameters

The parameter with number 979 and several indexes is used to specify the number and exact behavior of the position feedback sensors and the exact behavior of the position feedback interface. The exact definitions are in IEC 61800-7-203.

C.4 Application modes

C.4.1 General

The PROFIdrive profile specifies two basic modes called operating modes and defines related state machines.

By use of the standard telegrams and the possibility of free configurable telegrams, it is possible to specify other application modes, as described in Table C.11. A series of signals is defined to configure the optional IO Data (setpoint values, actual values).

Table C.11 – Supported application modes

IEC 61800-7 application mode	Equivalent PROFIdrive profile terminology
Torque preset	Torque control (AC 1) (free configurable telegram)
Torque control	Torque control (AC 1) (free configurable telegram)
Torque control with velocity feedback	Torque control (AC 1) (free configurable telegram)
Velocity preset	Speed control mode (AC 1) (free configurable telegram)
Velocity control	Speed control mode (AC 1) (standard telegram 1 / 2)
	Process technology mode (AC 1) (standard telegram 20)
Velocity control with position feedback	Speed control mode with one or two sensors (AC 4) (standard telegram 3 / 4 / 5 / 6)
Position preset	Positioning mode with motion commands (AC 3) (standard telegram 7 / 9)
Position control	Position control with position setpoint interface (AC 5) (standard telegram 8)

C.4.2 Torque control

There is no explicit mode torque control defined in the PROFIdrive profile. It is always possible that free configurable telegrams be used.

C.4.3 Velocity control

In the velocity control mode, PROFIdrive may support a simple set of IO Data with or without sensors (see Table C.12).

Table C.12 – I/O data for profile velocity mode

IEC 61800-7 I/O data	Equivalent PROFIdrive profile terminology
Command	Control word 1 (STW1) Control word 2 (STW2) optional
Status	Status word 1 (ZSW1) Status word 2 (ZSW2) optional
Set-point velocity	Speed setpoint A (NSOLL_A, signed16) or Speed setpoint B (NSOLL_B, signed32)
Actual velocity	Speed actual value A (NIST_A, signed16) or Speed actual value B (NIST_B, signed32)

For the velocity control with position feedback mode, a special standard telegram with one or several sensor(s) feedback is defined (see Table C.13).

Table C.13 – I/O data for profile velocity control mode with position feedback

IEC 61800-7 I/O data	Equivalent PROFIdrive profile terminology
Command	Control word 1 (STW1) Control word 2 (STW2) Sensor 1 control word (G1_STW) Sensor 2 control word (G2_STW) [a] Sensor 3 control word (G3_STW) [a]
Status	Status word 1 (ZSW1) Status word 2 (ZSW2) Sensor 1 status word (G1_ZSW) Sensor 2 status word (G2_ZSW) [a] Sensor 3 status word (G3_ZSW) [a]
Set-point velocity	Speed setpoint B (NSOLL_B, signed32)
Actual velocity	Speed actual value B (NIST_B, signed32)
Actual position	Sensor 1 position actual value (G1_XIST) Sensor 2 position actual value (G2_XIST) [a] Sensor 3 position actual value (G3_XIST) [a]
[a] The second and third sensors are optional.	

For special applications in process control applications, additional torque feedback is also defined in the standard telegrams (see Table C.14).

Table C.14 – I/O data for profile velocity control mode (process technology)

IEC 61800-7 I/O data	Equivalent PROFIdrive profile terminology
Command	Control word 1 (STW1)
Status	Status word 1 (ZSW1)
Set-point velocity	Speed setpoint A (NSOLL_A, signed16)
Actual velocity	Speed actual value A (NIST_A, signed16)
Actual torque	Torque actual value (MIST_GLATT)
Actual value	Output current (IAIST_GLATT) Active power (PIST_GLATT) Drive status/fault word (MELD_NAMUR)

For advanced velocity control special standard telegrams are defined.

C.4.4 Position control

For the position preset mode, the position index selection is defined in a standard telegram. In this case, the storage and the format of the traversing block is device specific (see Table C.15).

Table C.15 – I/O data for profile position preset

IEC 61800-7 I/O data	Equivalent PROFIdrive profile terminology
Command	Control word 1 (STW1)
Status	Status word 1 (ZSW1)
Set-point position-index	Traversing block selection (SATZANW)
Actual position-index	Actual traversing block (AKTSATZ)

In the position control mode, a special standard telegram with one sensor feedback is defined (see Table C.16).

Table C.16 – I/O data for profile position mode

IEC 61800-7 I/O data	Equivalent PROFIdrive profile terminology
Command	Control word 1 (STW1) Control word 2 (STW2)
Status	Status word 1 (ZSW1) Status word 2 (ZSW2)
Set-point position	Position setpoint value A (XSOLL_A, signed32)
Actual position	Position actual value A (XIST_A, signed32)

C.5 Profile specific extensions

The PROFIdrive profile supports the following additional functions:

– multiple axis in one device;
– exchange of cyclic data between P-Devices (peer-to-peer communication).

Annex D
(normative)

Mapping to profile SERCOS

D.1 Overview

This annex describes the mapping of the SERCOS profile for drives and motion control devices to the generic power drive system (PDS) interface.

Terms and definitions of the SERCOS profile are mapped to IEC 61800-7-1 terms as specified in Table D.1.

Table D.1 – Profile specific terms

IEC 61800-7 term	SERCOS term	Reference
I/O data	Cyclic data	See IEC 61800-7-204 [a]
Command	Control word	See IEC 61800-7-204
Set-point	Command value	See IEC 61800-7-204
Status	Status word	See IEC 61800-7-204
Actual value	Feedback value	See IEC 61800-7-204

[a] I/O data is the part of the SERCOS telegrams which does not change its meaning during operation of the interface. Most of SERCOS cyclic data is I/O data as defined in IEC 61800-7-1, but the possibility of transmitting device parameters on an unscheduled time base also exists.

D.2 Mapping of general architecture

D.2.1 Typical structure of automation systems

Figure D.1 shows PDS interface examples. The system may have one or more control device interfaces depending on configuration. Each control device interface shall handle only one network on the physical layer as well as in the overlying protocol layers.

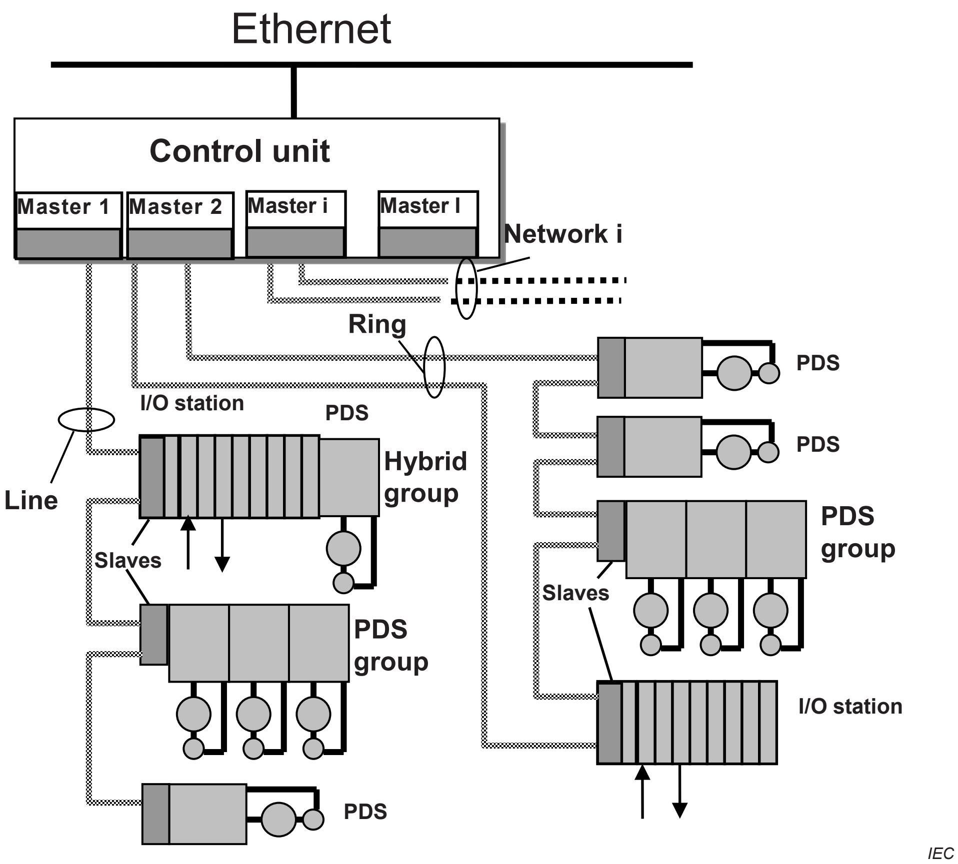


Figure D.1 – Topology example

Application specific terms are used in this figure. Although not relevant in this part of IEC 61800, they may be useful as they illustrate typical uses of SERCOS for PDS. They refer to features that may lie beyond the scope of this part of IEC 61800-7 (see Clause 1). These terms are:

- PDS group – group of several PDS that communicate through a network using one slave;
- hybrid group – group of one or several PDS and an I/O station that communicate by a network using one slave;
- I/O station – connection point of sensors and actuators that are managed by the control unit.

In some applications, a PDS may communicate directly with another PDS for providing proper motion coordination. This is called cross communication and may be provided for by SERCOS, although it lies beyond the scope of this standard.

SERCOS provides a large number of data and procedure commands which can be used for the operation of machines. All data, procedure commands, and all supplementary information are summarized in data blocks, which contain each an identification number (IDN), a name, attributes, units, minimum and maximum input values as well as the data itself.

SERCOS requires synchronization during cyclic data transmission. The operating cycle of the master shall be synchronized with the communication cycle and with the operating cycle of the slave devices. In that way, beats between individual cycles are prevented and latency delays are reduced to a minimum. Slave output signals shall become active and slave input signals shall be sampled concurrently in all devices.

D.2.2 Structure of the logical PDS

The typical structure of automation system and the structure of the logical PDS given in Clause 4 apply to this annex. PDS devices compliant to the SERCOS device profile are controlled by the control device or by other PDS devices in the following ways.

- I/O data shall be cyclically transmitted during a so-called real-time channel (RTC). The transmitted information shall be selected once during system initialization, depending upon configuration and mode of operation.
- Strictly specified device control and status information shall be transmitted together with the I/O data during the RTC.
- Device parameters that are transmitted on an unscheduled time-base are transmitted during a so-called service channel (SVC) which shall be part of the RTC. Additionally, these device parameters may also be transmitted within the Unified Communication Channel (UCC) using IP communication. This transmission shall occur in such a way that cyclic I/O data transmission is not affected and that all PDS continuously have the same data throughput at their disposal.

All communication and application parameters are listed in the IDN dictionary of the SERCOS device. This dictionary is used both for selecting the cyclically transmitted I/O data and for interfacing device parameters within the SVC.

D.2.3 Use cases of the PDS

D.2.3.1 General

It shall be possible to configure the PDS during normal operation as well as during automatic system initialization.

D.2.3.2 Use case Engineering

Use case engineering shall be realized using the service channel (SVC) or the unified communication channel (UCC).

D.2.3.3 Use case Operation-control

Use case Operation-control shall be realized using the service channel (SVC) and the real-time channel (RTC). During initialization, the control device automatically lets the whole system pass through a sequence of communication phases (CP). As long as the last phase (CP 4) has not been reached, only parts of the PDS operation modes are available (see Clause D.3).

D.3 Functional elements

D.3.1 Device identification FE

D.3.1.1 General

In addition to the parameters defined in 5.1, SERCOS defines some more identification parameters for the drive device and the motor. These identification parameters are available by calling the corresponding IDN using the service channel (SVC).

D.3.1.2 Parameters

Table D.2 lists the device identification parameters.

Table D.2 – Device identification parameters

Name	Profile name	Reference	Details
Profile ID	Profile identification	IDN S-0-0449	See IEC 61800-7-204
Manufacturer ID	Vendor name Vendor code	IDN S-0-0438 IDN S-0-0439	See IEC 61800-7-204
Product ID	Controller type Motor type	IDN S-0-0140 IDN S-0-0141	See IEC 61800-7-204
Serial number	Serial number drive control Serial number power stage Serial number motor	IDN S-0-0432 IDN S-0-0433 IDN S-0-0434	See IEC 61800-7-204
Hardware revision	Hardware version	IDN S-0-0031	See IEC 61800-7-204
Software revision	Manufacturer version	IDN S-0-0030	See IEC 61800-7-204

D.3.2 Device control FE

D.3.2.1 General

During the real-time channel, just before control device data is sent to the PDS's or before PDS data is sent back to the control device, a few bits of information shall be transmitted for exchanging control, status and error information. This shall occur at each cycle in such a way that it does not require any communication extra time.

Getting more detailed fault information and fault resetting shall be done using the service channel (SVC) and the appropriate IDN.

In that way, depending upon the application, the control device may react to a PDS fault without affecting in any way the synchronization accuracy and stop the whole machine or the machine part that is concerned by the faulty PDS.

D.3.2.2 I/O data

Table D.3 shows the different error flags that SERCOS shall make available, as well as the IDN's for getting the corresponding detailed information as well as for resetting the fault condition.

Table D.3 – Status values for the Device control FE

Name	Profile name	Reference	Details
Faulted	Drive shut-down error C1D	1 bit in status word of PDS	TRUE = Fault present FALSE = No fault
Warning	Drive shut-down warning C2D	1 bit in status word of PDS	TRUE = New change FALSE = Change has been acknowledged
	Drive operation status flag C3D	1 bit in status word of PDS	TRUE = New change FALSE = Change has been acknowledged
	Error in service channel	1 bit in status word of PDS	TRUE = Fault present FALSE = No fault

Table D.4 shows the mechanism for resetting a PDS fault. Resetting PDS warnings and operation status flags shall be automatic while reading the corresponding IDN's, as described in Table D.5.

Table D.4 – Command values for the Device control FE

Name	Profile name	Reference	Details
Reset Fault	Reset C1D	IDN S-0-0099	Acknowledged by setting a bit in PDS status word

D.3.2.3 States

The SERCOS fault state machine is equivalent to the Device control FE state machine as per 5.2.3, whereas "Error situation" is used instead of *faulted*.

The fault reaction in SERCOS is fault-specific and may be application-specific. After the fault has been acknowledged and if it is no longer present, the fault information disappears.

The SERCOS warning and operation state machines are similar to the fault state machine, whereas resetting occurs automatically as soon as the control device reads the warning details using the proper IDN in the service channel (SVC).

D.3.2.4 Parameters

Further details on a fault origin shall be made available via service channel (SVC), using the appropriate IDN, which is mentioned in Table D.5.

Table D.5 – Parameters for the Device control FE

Name	Profile name	Reference	Details
Fault	Drive shut-down error C1D	IDN S-0-0011	Reading IDN gives details
Warning	Drive shut-down warning C2D	IDN S-0-0012	Reading IDN resets and gives details
	Drive operation status flag C3D	IDN S-0-0013	Reading IDN resets and gives details
Common	Diagnostic number	IDN S-0-0390	Manufacturer specific
	Diagnostic	IDN S-0-0095	

D.3.3 Communication FE

D.3.3.1 General

The SERCOS communication shall include the transmission of a synchronization message from the control device to all PDS. This message shall not be a specific telegram and may be part of a data-transmitting telegram. It shall be transmitted once at the beginning of each communication cycle.

This synchronization information is used for triggering all connected PDS internal timers so that they are able to operate synchronously, as described at the end of D.2.1.

The SERCOS communication cycle time shall be defined as multiples and submultiples of 250 μs, whereas:

– cycle time = $n \times 250$ µs (n is an integer between 1 and 260)

– cycle time = 250 µs / 2^n (n is then an integer of 1, 2, or more)

This means that the cycle time may be selected between 31,25 µs and 65 ms, depending on application. It may be shorter, but shall not be longer.

The synchronization message shall be sent by the control device and shall be handled by the Communication FE of the PDS with a jitter that should not exceed a maximum value, as specified in the mapping to communication profiles (see IEC 61800-7-304).

A major role of this procedure is measuring all communication delays and setting all PDS internal clocks for synchronization purposes.

As soon as the initialization starts and as long as it is not finished, the Communication FE shall lock the Basic drive FE in *not operating* status.

D.3.3.2 I/O data

SERCOS communication may be either initialising, or running in normal state, or not running. In normal state, communication is automatically synchronized. Should it stop running while in “Communication running” state, then it sets the “communication error” bit in the “Faulted“ diagnostic. I/O data for Communication FE is combined with I/O data for Basic drive FE. Command values for the Communication FE belong to the system initialization, which is communication profile specific.

D.3.3.3 States

Communication profile specific.

D.3.3.4 Parameters

Communication profile specific.

D.3.4 Basic drive FE

D.3.4.1 General

The SERCOS profile defines a PDS state machine that shall be as shown in Figure D.2. It is controlled by the control unit using the control word, depending on the PDS status word.

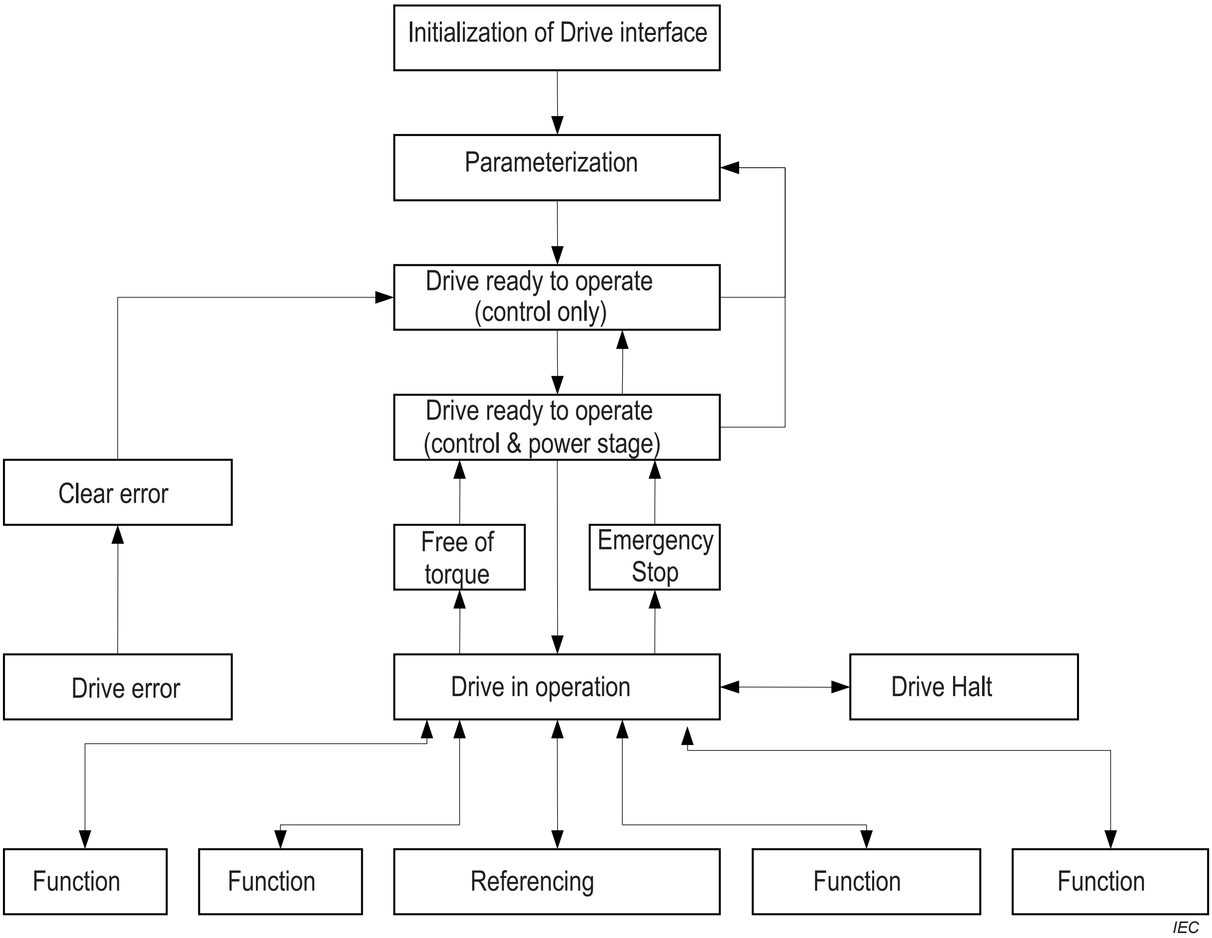


Figure D.2 – State machine of Basic drive FE

During the initialization sequence, the Device control FE shall prevent the Basic drive FE to operate the motor.

D.3.4.2 I/O data

The status values are given in Table D.6, and the command values in Table D.7.

Table D.6 – Status values for the Basic drive and Communication FEs

Name	Profile name	Reference	Details
Operating	Ready to operate	2 bits in PDS status word	00 = PDS not ready, internal checks not concluded 01 = PDS logic ready 10 = PDS power supply on 11 = PDS ready to operate
	Actual operation mode	3 bits in PDS status word	000... 111 = operation mode #0 to #7

Table D.7 – Command values for the Basic drive and Communication FEs

Name	Profile name	Reference	Details
Operate	Enable drive	3 bits in PDS control word	See IEC 61800-7-204
	Operation mode	3 bits in PDS control word	000... 111 = operation mode #0... 7

D.3.4.3 States

The state machine defined in detail in IEC 61800-7-204:2015, 7.2, describes the possible control sequence of the PDS Basic drive FE.

D.3.4.4 Parameters

The Basic drive FE behavior may be configured by means of parameters using the service channel (SVC). They shall be set depending upon the application if the corresponding control loop is used in the selected operating modes. More details and further parameters are shown in detail in IEC 61800-7-204:2015, Clauses 11 and 12.

D.3.5 Optional application functions FE

A PDS with SERCOS profile may provide Optional application FE. These FEs are further described in IEC 61800-7-204:2015, Clause 11.

D.4 Application modes

D.4.1 General

In the SERCOS profile, the term operation mode is used instead of application mode.

It provides a way to define several operation modes and a procedure for switching from a mode to another one. Each operation mode is defined in detail using the appropriate IDN.

The PDS operation mode is set by the control word, which is transmitted at each communication cycle. The control word allows the system to choose between one primary mode of operation and up to 7 secondary modes of operation. The response to the active mode appears in the status word of the PDS, which is also transmitted at each communication cycle.

All operation modes are individually defined in separate IDN, as shown in Table D.8.

Table D.8 – IDN for operation modes

IDN for operation mode definitions	Description
S-0-0032	Primary operation mode
S-0-0033	Secondary operation mode 1
S-0-0034	Secondary operation mode 2
S-0-0035	Secondary operation mode 3
S-0-0284	Secondary operation mode 4
S-0-0285	Secondary operation mode 5
S-0-0286	Secondary operation mode 6
S-0-0287	Secondary operation mode 7
S-0-0292	List of supported operation modes

The operation modes are shown in the following list:

- no mode of operation defined;
- torque control;
- velocity control;
- position control;
- interpolation;
- positioning;
- operating mode without control loops.

NOTE Position control, interpolation and positioning can be used, depending upon configuration, with:

- feedback value 1, or
- feedback value 2, or
- feedback values 1 and 2,
- with following error, or
- without following error (lag-less).

SERCOS defines six different standard telegrams (see Table D.9 and Table D.10) which can be used for typical modes of operation. In addition, an application telegram (telegram number 7) can be configured by the user.

Table D.9 – Supported application modes

IEC 61800-7 application mode	Equivalent SERCOS profile terminology
Torque control	Control word Bit 15 to 9 = 00xxx xxx, Bit 8 to 0 = 0 0000 0001 Torque control operation mode in the drive, standard telegram 1 (S-0-0080 in MDT) or telegram 7
Torque control with velocity feedback	Configurable application telegram (telegram 7)
Velocity preset	Configurable application telegram (telegram 7)
Velocity control	Control word Bit 15 to 9 = 00xxx xxx, Bit 8 to 0 = 0 0000 0010 Velocity control operation mode in the drive. The position feedback acquisition and the closing of the position loop takes place in the control unit, standard telegram 6 (S-0-0036 in MDT) or telegram 7
Velocity control with position feedback	Velocity control operation mode in the drive. The position feedback acquisition takes place in the drive. The position loop is closed in the control unit, standard telegram 3 (S-0-0036 in MDT, S-0-0051/53 in AT) or telegram 7
Position preset	Configurable application telegram (telegram 7)
Position control	Position control operation mode in the drive. The position feedback acquisition takes place in the drive as well as the closing of the position loop, standard telegram 4 (S-0-0047 in MDT, S-0-0051/53 in AT) or telegram 7

Table D.10 – Additional application modes

SERCOS application mode	Details
Velocity control with velocity feedback	Velocity control operation mode in the drive. The velocity feedback acquisition and the closing of the velocity loop takes place in the PDS, S-0-0036 in MDT, S-0-0040 in AT
Position and velocity switchable control	Velocity and position control operation mode in the PDS. Switching modes between velocity and position control is possible, S-0-0036/S-0-0047 in MDT, S-0-0040/S-0-0051/S-0-0053 in AT
User configurable	By using the configurable telegram 7, any combination of I/O data can be configured, others can be added on a vendor specific basis.

D.4.2 Torque control

The torque specific I/O data and device parameters are given in Table D.11 and Table D.12. More details and further parameters are shown in detail in IEC 61800-7-204.

Table D.11 – I/O data for profile torque mode

IEC 61800-7-1 I/O data	Equivalent SERCOS profile terminology
Command	Control word
Status	Status word
Set-point torque	Torque command value (S-0-0080) Additive torque command value (S-0-0081)
Actual torque	Torque feedback value (S-0-0084)

Other application modes that are vendor specific may be added.

Table D.12 – Configuration data for torque control

SERCOS IDN number	SERCOS IDN name
S-0-0085	Torque polarity parameter
S-0-0086	Torque/force data scaling type
S-0-0093	Torque/force data scaling factor
S-0-0094	Torque/force data scaling exponent
S-0-0013	Class 3 diagnostic
S-0-0082	Positive torque limit value
S-0-0083	Negative torque limit value
S-0-0092	Bipolar torque limit value
S-0-0334	Status "$T \geq T_{limit}$"
S-0-0106	Current loop proportional gain 1
S-0-0107	Current loop integral action time 1
S-0-0119	Current loop proportional gain 2
S-0-0120	Current loop integral action time 2
S-0-0155	Friction torque compensation
S-0-0163	Weight counterbalance

D.4.3 Velocity control

The velocity specific I/O data and device parameters are given in Table D.13 and Table D.14. More details and further parameters are shown in detail in IEC 61800-7-204.

Table D.13 – I/O data for profile velocity mode

IEC 61800-7-1 I/O data	Equivalent SERCOS profile terminology
Command	PDS control word
Status	PDS status word
Set-point velocity	Velocity command value (S-0-0036) Additive velocity command value (S-0-0037)
Actual velocity	Velocity feedback value 1 (S-0-0040) Velocity feedback value 2 (S-0-0156)

Table D.14 – Configuration data for velocity control

SERCOS IDN number	SERCOS IDN name
S-0-0043	Velocity polarity parameter
S-0-0044	Velocity data scaling type
S-0-0045	Velocity data scaling factor
S-0-0046	Velocity data scaling exponent
S-0-0038	Positive velocity limit value
S-0-0039	Negative velocity limit value
S-0-0091	Bipolar velocity limit value
S-0-0100	Velocity loop proportional gain
S-0-0101	Velocity loop integral action time
S-0-0102	Velocity loop differential time
S-0-0347	Velocity error
S-0-0377	Velocity feedback monitoring window
S-0-0392	Velocity feedback filter
S-0-0013	Class 3 diagnostic
S-0-0038	Positive velocity limit value
S-0-0039	Negative velocity limit value
S-0-0091	Bipolar velocity limit value
S-0-0335	Status "$n_{command} > n_{limit}$"
S-0-0339	Status "$n_{feedback} \leq$ Minimum spindle speed"
S-0-0340	Status " $n_{feedback} \geq$ Maximum spindle speed"
S-0-0377	Velocity feedback monitoring window
Acceleration and jerk specific values	
S-0-0136	Positive acceleration limit value
S-0-0137	Negative acceleration limit value
S-0-0138	Bipolar acceleration limit value
S-0-0349	Bipolar jerk limit

D.4.4 Position control

The position specific I/O data and device parameters are given in Table D.15 and Table D.16. More details and further parameters are shown in detail in IEC 61800-7-204.

Table D.15 – I/O data for profile position mode

IEC 61800-7-1 I/O data	Equivalent SERCOS profile terminology
Command	PDS control word
Status	PDS status word
Set-point position	Position command value (S-0-0047) Additive position command value (S-0-0048)
Actual position	Position feedback value 1 (Motor feedback, S-0-0051) Position feedback value 2 (External feedback, S-0-0053) Following distance (S-0-0189)

Table D.16 – Configuration data for position control

SERCOS IDN number	SERCOS IDN name
S-0-0055	Position polarity parameter
S-0-0076	Position data scaling type
S-0-0077	Linear position data scaling factor
S-0-0078	Linear position data scaling exponent
S-0-0079	Rotational position resolution
S-0-0011	Class 1 diagnostic
S-0-0049	Positive position limit value
S-0-0050	Negative position limit value
S-0-0055	Position polarity parameter
S-0-0159	Monitoring window
S-0-0278	Maximum travel range
S-0-0058	Reversal clearance
S-0-0104	Position loop *K*v-factor
S-0-0105	Position loop integral action time
S-0-0296	Velocity feed forward gain
S-0-0348	Acceleration feed forward gain
S-0-0391	Position feedback monitoring window
S-0-0392	Velocity feedback filter
S-0-0052	Reference distance 1
S-0-0054	Reference distance 2

D.5 Profile specific extensions

SERCOS defines several additional functions that may be provided by a PDS device. These functions include:

a) additional mode of operations, for example
   1) interpolation mode,
   2) positioning mode,
   3) spindle synchronous mode;
b) homing procedures (drive-controlled, NC-controlled, absolute homing);
c) probing;
d) modulo.

More details and additional parameters are described in IEC 61800-7-204.

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