PD CLC/TS 50568-4:2015

BSI Standards Publication

Electricity metering data exchange

Part 4: Lower layer PLC profile using SMITP B-PSK modulation

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/13, Electricity Meters.

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

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Electricity metering data exchange - Part 4: Lower layer PLC profile using SMITP B-PSK modulation

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Foreword

This document (CLC/TS 50568-4:2015) has been prepared by CLC/TC 13, "Electrical energy measurement and control".

The following date is fixed:

- latest date by which the existence of this document has to be announced at national level (doa) 2015-07-24

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Introduction

This Technical Specification is based on the results of the European OPEN Meter project, Topic Energy 2008.7.1.1, Project no.: 226369, www.openmeter.com.

According to the structure of the CLC/TS 50568 documentation, this document is positioned as highlighted in the following figure:

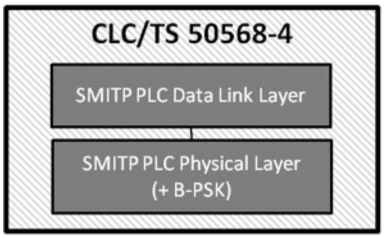

Figure 1 – Document structure of CLC/TS 50568-4

1 Scope

This Technical Specification specifies the characteristics of the profile related to Physical and Data Link Layers for communications on LV distribution network between a Concentrator (master node) and one or more slave nodes.

The following prescriptions are applied to groups of devices that communicate using low voltage network. Each section of the network is composed by one Concentrator (acting as the master of the section), and one or more primary nodes (A-Nodes). Every A-Node can optionally be associated to one secondary node (B-Node).

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.

EN 50065-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 1: General requirements, frequency band and electromagnetic disturbances*

3 Terms, definitions, acronyms and notations

3.1 Terms and definitions

For the purpose of this document, the following terms and definitions apply:

3.1.1
concentrator section
identification code of the network managed by the concentrator

3.1.2
node subsection
identification code of the sub network within the network identified by concentrator section

3.1.3
node progressive
unique node ID within the node sub section

3.1.4
upper layers
every communication stack layer except PHY, MAC and LLC

3.2 Acronyms

For the purpose of this document, the following acronyms apply:

ACA: Absolute Communication Address

B-PSK: Binary Phase Shift Keying

CRC: Cyclic Redundancy Check

D-L: Data-Link

ECC: Encryption Coding Control

ECTL: Extended Control

HDLC: High-level data link control procedures

LLC: Logical Link Control

LSb: Least Significant bit

LSB: Least Significant Byte

LSDU: LLC Service Data Unit

LV: Low Voltage

MAC: Medium Access Control

MAU: Mains Attachment Unit

MSb: Most Significant bit

MSB: Most Significant Byte

NDM: Normal disconnect mode, one of the non-operational data link mode of HDLC

NM: Network Management

Ph: Physical

PLS: Physical Signalling

PRE: Preamble

PSK: Phase Shift Keying

SAP: Service Access Point

SCA: Section Communication Address

UL: Upper Layer

UW: Unique Word

3.3 Notations

For the purpose of this document, the following notations apply:

– 1 byte = 8 bits (or octet);

– byte/field name representation: capital letters;

– bit name representation: small letters;

– bits transmission sequence related to their representation: first bit on the left = first transmitted bit;

– bit transmission order related to their weight: least significant bit = first transmitted bit;

– bytes transmission sequence related to their representation: first byte on the left = first transmitted byte;

– bytes transmission order related to their weight: least significant byte = first transmitted byte;

– fields transmission sequence related to their representation: first field on the left = first transmitted field;

– fields transmission order related to their weight: least significant field= first transmitted field;

– a frame/message is “upstream” if it is logically sent from centre to periphery;

– a frame/message is “downstream” if it is logically sent from periphery to centre.

4 Overview

4.1 Communication characterization on LV network

The Physical Layer configuration on LV network is considered as a multi-point connection of nodes operating in half-duplex mode. So, access rules are required in order to avoid nodes transmission collisions.

Furthermore, it has to be considered that LV network cannot be treated as a normal broadcast medium, because standing-waves phenomena and most of all signal attenuation may make direct communication between couple of nodes impossible.

In order to obtain a virtually direct communication, between any couple of nodes, the protocol functionalities shall foresee the repetition technique. Figure 2 shows the reference scheme of a LV line portion, which is identified as communication section. A LV network controlled by a Concentrator is composed by a set of branch-connected sections of this kind:

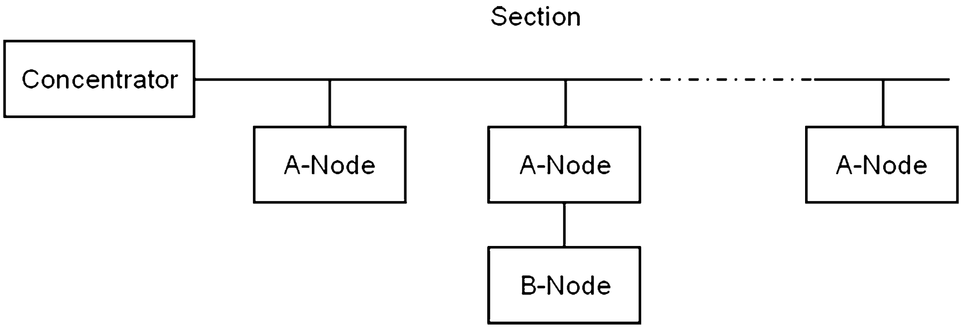

Figure 2 – Communication section in a LV line

where:

– information exchanging is required either between Concentrator and any node, or between an A-Node and the associated B-Node;

– message transferring shall always happen on the A-Node electric connection phase. In case of polyphase meter, communication shall always happen through one of the three phases, the same one for all communications;

– each A-Node and B-Node has its own unique address.

There are the following two types of sub-nets. Each one is unbalanced (the initiation of transmission procedure is limited to a master or a sub-net master station), with one or more slave nodes.

A sub-net

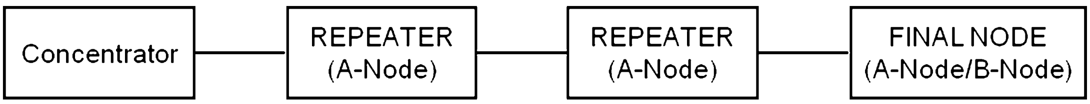

Figure 3 – A sub-net

Within A sub-net, communications between Concentrator (master station for this sub-net) and any node (slave), with single or group addressing, are defined. This sub-net can use repetition.

B sub-net

Figure 4 – B sub-net

Within B sub-net, communications between A-Node (master station for this sub-net) and the associated B-Node (slave) are defined. This sub-net does not foresee repetition.

The profile of protocols to be used has to reach the following objectives:

– to satisfy application requirements in terms of efficiency and effectiveness;

– to reduce data amount to supply to equipment during network configuration stage as much as possible;

– to make efficient use of the channel;

– to support all the group addressing performances, according with what is required by applications, also in presence of a network with repetitions.

4.2 Communication architecture

4.2.1 Overview

This document describes a lower layer profile that includes the Logical Link Control, the Medium Access Control and the Physical Layers.

The repetition functionality is inserted in the MAC sub-layer, in order to guarantee to LLC sub-layer the direct exchange between Concentrator master node and each of the slave nodes.

4.2.2 LLC sub-layer

LLC sub-layer interfaces the Upper Layers on the upper side and the MAC sub-layer on the lower side. It is required to support the following functions:

– it is responsible about the execution of end-to-end exchange procedures to guarantee a correct access procedure that avoids any possible collision on the network (in any moment a single node can ask a transmission request on MAC level); it manages access times to the LV communication on the master node;

– it operates end-to-end between master nodes and all the slave nodes; it offers a connectionless-type service to equipment applications, according with the kind of exchange procedure required;

– in master nodes, it indicates to Upper Layer the network availability; the transmission of another message can be requested, upon reception of this indication;

– in master nodes, it manages re-transmissions (retry) on exchanges with expected answer.

The mechanisms to provide the above listed features are left to the implementers of the Master node without any limitation on interoperability.

LLC sub-layer does not check the correctness of the used disciplines (see 4.4); it’s up to the upper layer to select it properly.

4.2.3 MAC sub-layer

In this sub-layer, the repetition functionalities (MACre) are distinguished from the physical interfacing functionalities (MACph).

MACre functions:

– it operates end-to-end between master node and all the network slave nodes offering a connectionless service;
– it uses the services supplied by MACph to transfer frames with the limited goal to provide necessary functions for the packet transfer between a master node and a slave final node on a multi-point Data-Link with hidden stations (slave nodes that need one or more repeaters to communicate with the master node);
– it manages the timers of busy network condition in master nodes and repeaters.

MACph functions:

– frames encapsulation;
– received frames filtering, on the basis of a single or grouped address;
– frame errors detection.

The access mode to the physical medium is half duplex. MACph is capable to distinguish correct frames from not correct ones, but it does not handle error recovery. A wrong frame is rejected.

MACph also handles connection electric phase detection of LV: the correlation between frame and LV phase shall happen:

– in transmitting mode on Concentrator and on A-Node repeater;
– in receiving mode on all the A-Nodes;

while the correlation shall happen in both mode types on B-Nodes.

NOTE The phase detection algorithm depends on the specific implementation adopted by manufacturers.

4.2.4 Physical Layer

4.2.4.1 Introduction

The Physical Layer (PHY) defines the method used to transfer data over the physical medium (power line), by performing:

– encapsulation of data in a physical frame;
– modulation / demodulation of the physical frame using B-PSK scheme.

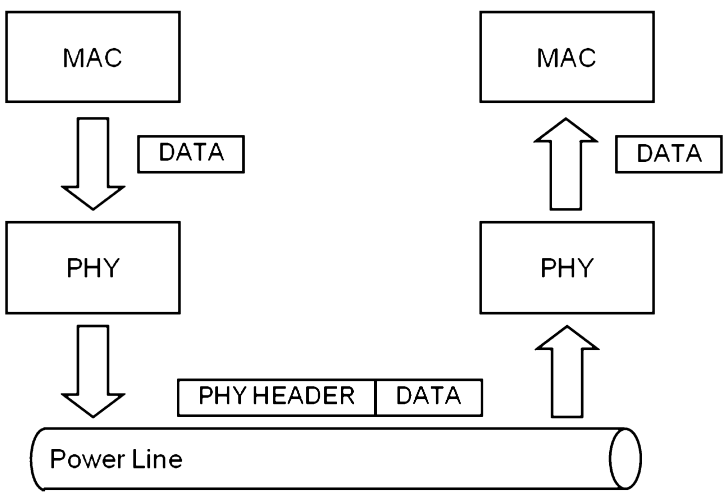

Figure 5 – Data transfer on power line

Additionally, the Physical Layer provides following services:

– bit and byte synchronization;

– Signal to noise ratio (SNR) estimation. When implemented, this functionality may be used for Network Management purposes (out of the scope of this document).

4.2.4.2 Modulation and modes

The modulation is a B-PSK (Binary Phase Shift Keying) with a symbol rate equal to 9600 symbol/s. To improve the robustness of the communication in noisy environments, an error correction technique is implemented through the use of a convolutional code with rate ½ and an interleaver. Therefore, the resulting bit-rate is 4800 bps.

4.2.5 Protocol’s architecture for LV nodes communication

Referring to LV sub-nets, the following figures show the protocol stack in each equipment:

in A sub-net:

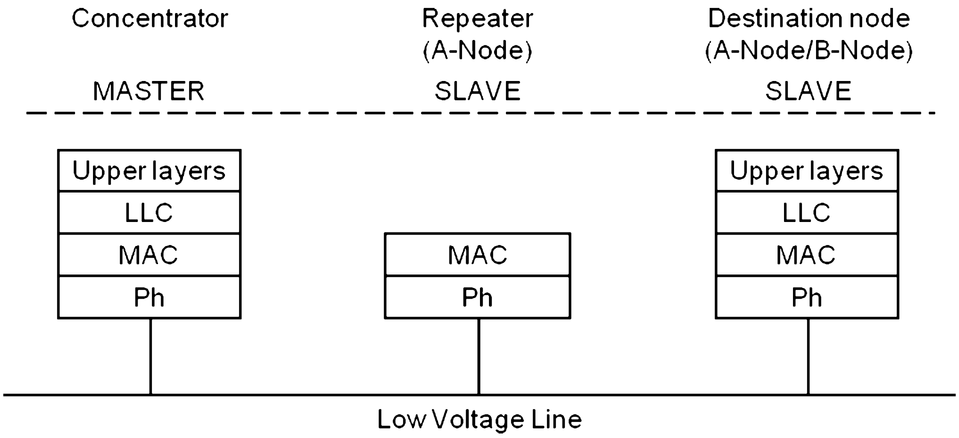

Figure 6 – Protocol’s architecture in the A sub-net

in B sub-net:

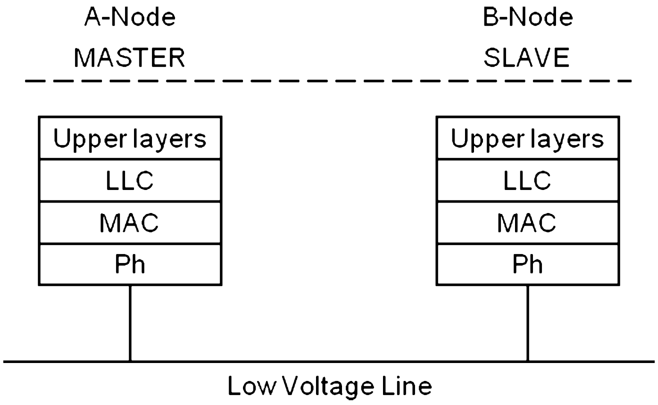

Figure 7 – Protocol’s architecture in the B sub-net

Each node type shall own a protocol profile including all the sub-layers required by the sub-nets in which the node works.

Sub-layers required to Concentrator:

– LLC manages LLC services as master for A sub-net;

– MAC manages MAC services as master for A sub-net.

Sub-layers required to a A-Node:

– LLC manages LLC services as slave for A sub-net, and LLC services as master for B sub-net;

– MAC manages MAC services as slave for A sub-net, and MAC services as master (without repetition) for B sub-net.

These are the sub-layers requested to B-Node:

– LLC manages LLC services as slave for B sub-net;

– MAC manages MAC services as slave (without phase detection and repetition) for B sub-net.

4.3 Requests priority and slave nodes scanning

The LLC sublayer of concentrator receives and processes requests coming from UL in FIFO order without priority handling.

NOTE Manufacturers can also implement procedures within concentrator in order to differently manage requests from central system and messages towards slave nodes.

4.4 Communication disciplines

4.4.1 Service classes

The communication on LV network shall happen within the following three classes of basic services:

– S Class – Send/Noreply (Sxx):

  message transmission without either response or acknowledge requiring.

– RA Class – Request/Respond (RAx):

  message transmission requiring a response from an A Node. The layers above Data-Link that receive a message belonging to this class shall always generate a response. The response is never generated by remote node Data-Link Layer.

– RB Class – Request/Respond (RBx):

  message transmission requiring a response from an B Node. The layers above Data-Link that receive a message belonging to this class shall always generate a response. The response is never generated by remote node Data-Link Layer.

– RC Class – Request/MultiRespond (RCx):

  message transmission accepting several responses. The layers above Data-Link that receive a message belonging to this class, if enabled, shall always generate a response. The response will be delayed as defined in 4.4.2. So the sender having multiple addressed targets (multicast address, or several targets which are entitled to answer to the same command), can receive several responses.

Table 1 – Service classes in communication disciplines

Class	Function	Description
S	Send/Noreplay	Send message without response/ack
RA	Request/Respond	Send message with response to a node in A subnetwork.
RB	Request/Respond	Send message with response to a node in B subnetwork.
RC	Request/MultiRespond	Send message with (multiple) response

The communication disciplines are defined for each service class on the basis of service type requested by Upper Layer to LLC, and then by LLC to MAC; these disciplines are further on subdivided in sub-disciplines (see 4.4.3). Since the type of the request coming from the UL shall be known to choose the proper communication discipline and so to compute the right value of the timers, it is Upper Layer care to configure the discipline in the LLC and MAC sub layers (see 5.1.1 and 6.1.1).

Supervision timers (T) within master node and intermediate repeaters are defined for each class, concerning:

– about master: maximum waiting time to recover the network access in case of no response (because not expected or lost);

– about repeaters: response frame (when expected) waiting time.

Supervision timers are managed at MAC level, as soon as the supervision timer expires the information is propagated by the MAC sublayer itself, along the repetition chain of the message, to the Master node, which shall issue a MA_EVENT.indication primitive. At the reception of the MA_EVENT.indication the Master node LLC sublayer shall generate an appropriate DL_DATA.confirm with negative result.

Meaning of parameters that are in T function expressions is illustrated in the next subclause.

4.4.2 Timers

The next subclauses will use the parameters described below to define the timers:

$$T = Ta + Tb$$

where:

T is the total transaction time;

Ta is the A sub-net utilization time;

Tb is the B sub-net utilization time.

Ta and Tb take a different value according with procedure type.

The following variables are defined:

$nbTXa$ is the number of bits to transmit on A sub-net;

$nbRXa$ is the number of bits to receive on A sub-net;

nbTXb is the number of bits to transmit on B sub-net;

nbRXb is the number of bits to receive on B sub-net;

tbit is the one bit time;

nbadd is the address field bit number;

r is the number of subsequent repeaters.

In order to calculate the supervision timer, the node (Master or repeater) shall use as nbRXa and nbRXb the maximum number of bytes allowed by the used discipline, as described in Tables B.1 and B.2.

An additional value shall be added to *Ta* and *Tb*; this value depends on processing time of every device involved in the transmission (*Tel*) and on other delays that are typical of particular scenario. This additional value is needed to provide a safety margin to avoid collision in network accessing.

Tel is the processing time;

delay is the further delay for specific reasons.

The estimate of above-mentioned time shall also consider next hypothesis:

– *nbadd* parameter value can be equal to 12 or 48, depending on the adopted addressing policy (see 6.2.5.2);

– Concentrator and repeaters know the size of all the messages involved in a transaction, or however their maximum size;

– in case of a request with one or more possible response (by different sizes), the maximum size is considered;

– in case of requests to a node that do not foresee response, the repeaters shall not activate timers after the frame has been sent;

– delay introduced by each device for internal processing shall not be greater than 10 ms.

The repeaters shall be provided with a *Tb* and *nbRXa* value associated to current transaction.

The information about transaction type (or adopted discipline) is transmitted in the MAC frame control field. For the adopted discipline coding, refer to Annex B.

Since a known maximum size for the reply message corresponds to each activity, also the maximum waiting time for the busy network is known. So, the A-Node repeater is able to calculate its own timer.

4.4.3 Discipline types

4.4.3.1 Disciplines of class S

SAx discipline.

This discipline involves the A sub-net:

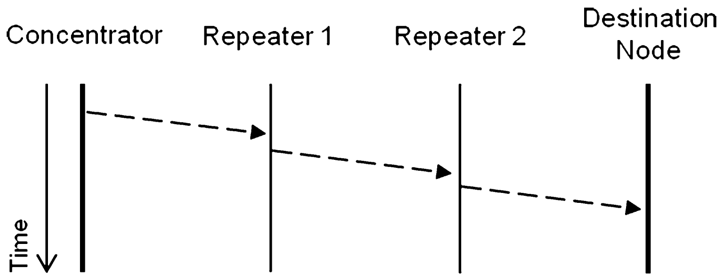

Figure 8 – Messages exchange in the SAx discipline

The total transaction time has the following value:

$$T = [nbTX \cdot (r+1) + nbadd \cdot r \cdot (r+1)/2] \cdot tbit + Tel \cdot r$$

Since no response is expected, repeaters do not have to activate a response-waiting timer.

This procedure foresees a supervision timeout T on the Concentrator. LLC notifies timeout expiry to the Upper Layer and only at T expiry accepts the request to send a new message.

LLC of the involved A-Node delivers received message toUL, and refuses further transmission requests.

4.4.3.2 Disciplines of class R

RAx Discipline

This discipline involves only A sub-net:

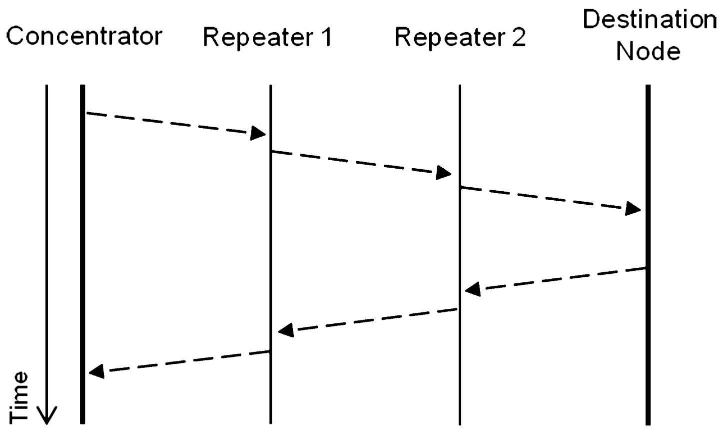

Figure 9 – Messages exchange in the RAx discipline

The total transaction time has the following value:

$$T = [(nbTX + nbRX) \cdot (r+1) + nbadd \cdot r \cdot (r+1)/2] \cdot tbit + (2r+1) \cdot Tel + delay$$

This procedure foresees a Concentrator supervision timeout T, which shall consider the response by slave final node; so LLC accepts a new message from Upper Layer only at reception of reply frame by slave final node or at temporization expiry. The temporization expiry is notified to the Upper Layers through DL-DATA.confirm service, as explained in 5.1.2.

The duty of LLC is to pass over to UL the response message or the eventual signalling of expired supervision timeout T.

The duty of MAC is to manage supervision timeout T.

LLC sub-layers of eventual repeaters are not involved.

MAC of repeaters will follow the procedures that are foreseen by repetition within this discipline, by activating a supervision timer on repetition according with the defined expression.

LLC in slave final nodes delivers the received message to Upper Layer and prepares itself to satisfy a request, from UL, to send a response on the network.

RBx Discipline

It involves A and B sub-nets.

Within B sub-net the discipline is Request/Respond type:

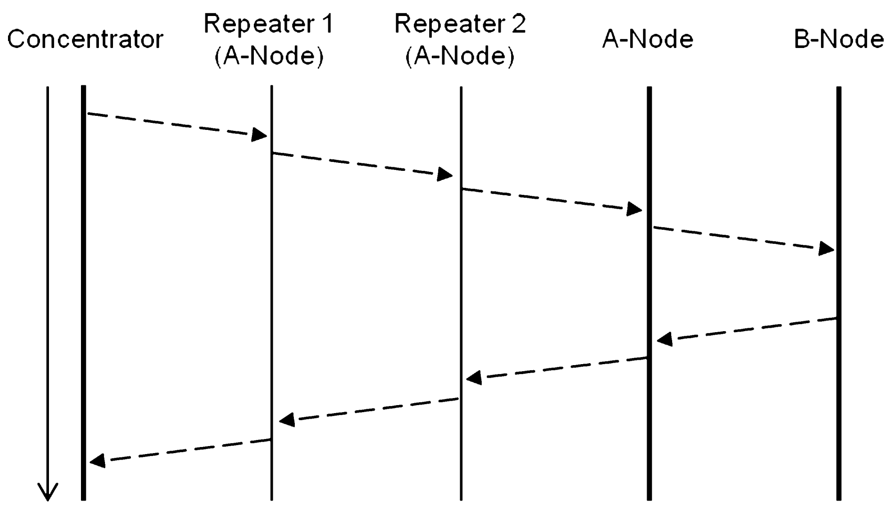

Figure 10 – Messages exchange in the RBx discipline

The total transaction time has the following value:

$$T = [(nbTXa + nbRXa)\cdot(r+1) + nbadd \cdot r \cdot (r+1)/2 + (nbTXb + nbRXb)]\cdot tbit + (2r+1)\cdot Tel + 2\cdot Tel + delay$$

The master supervision timeout T shall consider the message propagation, the response on B sub-net and the response of A-Node to Concentrator.

LLC on Concentrator has the task to give UL the response or the eventual indication of supervision timeout T expiry. It can accept a new message from Upper Layer only at reception of slave final node LLC response frame or at T temporization expiry.

The LLC of eventual repeaters are not involved.

The repeaters MAC will follow the procedures foreseen by repetition within this discipline, by activating a repetition supervision timer according with the defined expression.

The LLC sub-layer in slave final node delivers received message to Upper Layer, waits for response message from Upper Layer and sends it on network.

Since B-Node should send a response, this discipline foresees a supervision timeout T even on A-Node. If the response arrives, LLC (A-Node is master of B sub-net) delivers the response to UL, otherwise it indicates timeout expiry.

4.4.3.3 Disciplines of class RC

RCx Discipline without repeaters

The sender sending a message with RCx discipline waits several responses. Typically the sender sends a request to a multicast address.

To avoid that responses by several responders will collide, the target will respond in delayed mode. The target calculates a random number between 1 and N and responds in the slot time identified by the random number. The max number of the slots is N. The time of a slot ($TSlot$) is defined by a parameter inside the target (starting default by manufacturer: 250 ms).

In this case the time out calculation is simpler. Assuming that $TSlot$ is correctly calculated:

$$T = ExT = (N+1) \cdot TSlot$$

where:

ExT is the ExtraTime;

N is the max number of the slots (as defined in Annex B: 8, 16, 32, 64);

$TSlot$ is the time of a slot.

$TSlot$ shall be:

$$TSlot > (nbTX + nbRX) \cdot tbit + Tel + ST$$

where:

ST is the safe time.

EXAMPLE:

First default value used is 250 ms, considering that the used message is a short one (less than 20 bytes payload).

That time gives a 100 ms margin (ST) at 2400 baud.

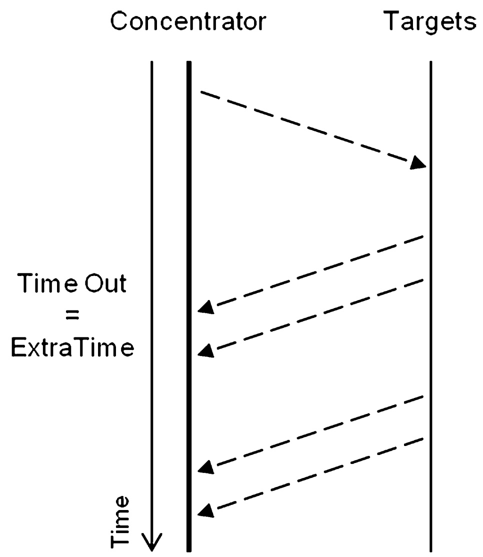

Figure 11 – Messages exchange in the RCx discipline without repeaters

RCx discipline with repeaters

The target of the message sent by concentrator is a A node that has to send the message using the above defined “Request/MultiRespond” discipline toward the meters below in the A subnet and sends the response to the concentrator when the time out expires. During the time out expiring time, it receives some responses by final targets.

To define the correct time out, the following disciplines are used:

– the discipline defined in the field dddd of CTL byte from the first until the last repeater;

– Request/MultiRespond discipline further down the last repeater.

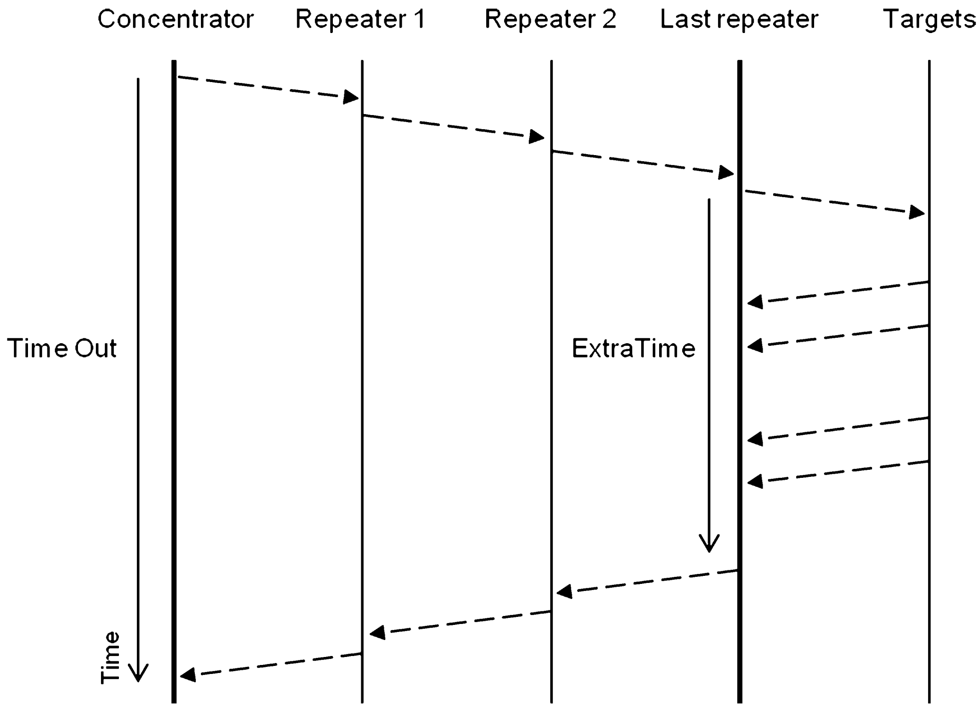

Figure 12 – Messages exchange in the RCx discipline with repeaters

The total transaction time has the following value:

$$T = [(nbTXa + nbRXa)\cdot(r+1) + nbadd \cdot r \cdot (r+1)/2]\cdot tbit + ExT + (2r+1)\cdot Tel + 2\cdot Tel + delay$$

5 LLC sub layer

NOTE This section covers the SMITP Logical Link Control services, which are specified by describing the information flow between the Upper Layers and the MAC sub layer, which is describing the service primitives and parameters which characterize each service, the SDU format and the associated procedures.

5.1 Primitives and services

5.1.1 DL_Data.request

5.1.1.1 Function

The DL_Data.request primitive is passed to the LLC sub layer entity to request that an L_SDU be sent to a remote LLC sub layer entity or entities using the LLC transmission procedures.

5.1.1.2 Structure

The semantics of the primitive are as follows:

– DL_Data.request (ECTL, Destination_address, Service_class, Max_resp_len, Tslot_num, L_SDU)

– DL_Data.request (ECTL, LSDU)

The first one is used by the master node, the second one by the slave node responding to a request.

The ECTL parameter is formatted as specified in D.2. It carries information about the entity which requests the service (sub field DSAP) and the requested level of security (sub field ECC).

The Destination_address parameter specifies the address of the remote station involved in the data unit transmission, and the ordered list of the addresses of the involved repeaters.

The Service_class parameter specifies which service class is requested to the LLC, available service classes are described in 4.4.1 and coded as indicated above, the usage of this parameter by the MAC sub layer is described in detail in 6.1.2.

– 0x00 = S
– 0x01 = RA
– 0x02 = RB
– 0x03 = RC

The Max_resp_len parameter is the maximum number of bytes (calculated at MAC level) expected on the response from the slave station. It is used, only in association with Request/Respond service classes, to calculate the proper discipline for the MAC sublayer as showed in Annex B.

The Tslot_num is the number of time slots allocated in a data request with Service_class RC. It is used to calculate the proper discipline for the MAC sublayer as explained in Annex B.

The L_SDU parameter specifies the link data unit to be transferred by the LLC sub layer entity to the peer LLC sub layer entity or entities.

The Service_class and Discipline parameters have meaning only if the entity invoking the primitive is a Master node.

5.1.1.3 Use

This primitive is generated by the UL entity whenever data is transmitted to a peer UL entity.

The receipt of this primitive will cause the LLC sublayer entity to append all LLC specific fields and pass the properly formed L_PDU to the lower layers of protocol for transfer to the peer LLC sublayer entity or entities.

The receipt of this primitive will generate a MA_Data.request for transfer to the MAC sublayer entity.

5.1.2 DL_Data.confirm

5.1.2.1 Function

The DL_Data.confirm issues a local confirmation of the transmission of the L_PDU. This primitive has only local significance and provides an appropriate response to the UL entity which initiated a DL_Data.request primitive indicating the local success or failure of the request, as specified by the lower levels.

5.1.2.2 Structure

The semantics of the primitive are as follows:

– DL_Data.confirm (ECTL, Destination_address, Transmission_status)

The ECTL parameter is formatted as specified in D.2

The Destination_address parameter specifies the address of the remote station involved in the data unit transmission.

The Transmission_Status parameter is used to pass status information back to the local requesting UL entity. It is used to indicate the success or failure of the previous associated DL_Data.request primitive.

- 0x00 = positive result;
- 0x01 = negative result.

5.1.2.3 Use

This primitive is generated in response to a DL_Data.request primitive back to the local UL entity. This primitive is generated on an incoming MA_Data.confirm service issued by the local MAC sub layer entity.

It is assumed that sufficient information is available to the UL entity to associate the response with the appropriate request.

5.1.3 DL_DATA.indication

5.1.3.1 Function

The DL_Data.indication primitive is passed from the LLC sub layer to the UL entity to indicate the arrival of a L_PDU. This primitive defines the transfer of data from the LLC sub layer entity to the UL entity.

5.1.3.2 Structure

The semantics of the primitive are as follows:

– DL_Data.indication (ECTL, Source_address, L_SDU)

The ECTL parameter is formatted as specified in D.2

The Source_address parameter specifies the MAC address or SCA of the remote station involved in the data unit transmission.

The L_SDU parameter specifies the link service data unit which has been received by the LLC sub layer entity.

5.1.3.3 Use

The DL_Data.indication is passed from the LLC sub layer entity to the UL entity to indicate the arrival of a MA_Data.indication from a remote data link user entity to the local LLC sublayer entity.

ECTLBasing on DSAP subfield of the ECTL field, the LPDU is dispatched to the appropriate Upper Layer entity (Upper layer data or Network Management/Discovery and Registration) as described in D.2.

5.2 LLC protocol data unit structure

5.2.1 LLC_PDU format

All LLC_PDUs shall conform to the following format:

- Control field
- ECTL field
- Data

Control field and ECTL field consist in one byte each. The data field is and integer number of bytes between 0 and MAX_LPDU_Length (see 5.3.4).

Control	ECTL	DATA

Figure 13 – LLC frame structure

5.2.2 Control field

The control field consists of one byte which is used to define the type of the received L_PDU. The control field is formatted as indicated in Figure 14:

First bit transmitted
↓

0	1	2	3	4	5	6	7
1	1	0	0	P/F	0	0	0

Figure 14 – Control Field format

Poll/Final (P/F) has different meaning depending on the Service Class requested to the LLC.

In case the sender is the master station this bit has the meaning of Poll, in this case it can assumes two values:

- P=0 in command frames which require Send/Noreply services (S service class).
- P=1 in command frames which require Request/Respond services (RA, RB and RC service classes).

In case the sender is the Slave station this bit always assumes the same value:

- F=1 in response frames using the Request/Respond services (P=1)

5.2.3 Address field

The ECTL field is formatted as described in D.2.

5.2.4 Invalid L_PDU

An invalid L_PDU is one which doesn’t contain properly formatted Control, ECTL and Data fields.

5.3 LLC procedures

5.3.1 Procedure for addressing

The pairing between the sender and the receiver is managed through the MAC address or SCA, which is passed as an argument in the DL_Data procedures.

5.3.2 Information transmission

Information transfer from an master station to a slave station is accomplished by sending a properly formatted L_SDU, the value of the control field depends on the discipline and the address specified in the DL_Data.request primitive.

Information transfer from a slave station to a master station is accomplished by sending a properly formatted L_SDU, and only if the P/F control field specifies the use of the Request/Respond services.

5.3.3 Information Reception

If a valid L_PDU is received (see 5.2.4), the LLC sub layer entity issues the appropriate DL_Data.indication primitive to the proper Upper Layer entity (see 5.1.3.3).

5.3.4 Length of an PDU

The maximum length of the data field of an L_PDU (MAX_LPDU_Length) is 128 bytes.

6 MAC sub layer

6.1 Primitives and services

6.1.1 Primitives

The following primitives are provided by MAC sub layer on interface with LLC sub layer:

– MA_DATA.request

– MA_DATA.indication

– MA_DATA.confirm

The following primitive is provided by MAC sub layer on the interface with Network Management (NM):

– MA_EVENT.indication

The MA_DATA.request is defined as follows for master node and slave node respectively:

– MA_DATA.request (Destination_address, MA_sdu, Service_Class)

– MA_DATA.request (MA_sdu, Service_Class)

in which the parameter:

- *Destination_address* indicates destination node address (single or group); and the ordered list of the addresses of the involved repeaters;
- *MA_sdu* is data unit to be sent;
- *Service_Class* defines service type requested to MAC by LLC.

This primitive is passed to MAC sub-layer and it is invoked by LLC sub-layer to request a MA_sdu transmission to final node with address Destination_address.

This primitive is present on LLC/MAC interface in a master station, within A sub-net. In this case (Concentrator), if the communication between Concentrator and the target A-Node involves some repeaters, Destination Address shall indicate the entire repetition path as specified in 6.2.5

This primitive is present on LLC/MAC interface in a master station, within B sub-net.

This primitive is present also in LLC/MAC interface in a slave station (both within A sub-net and B sub-net), but in this case *Service_Class* contains the same value as indicated by master station's request and *Destination_address* is not present because, in master-slave network downstream messages, the address of the sender is specified.

The MA_DATA.indication is defined as follows for master node and slave node respectively:

– MA_DATA.indication (Destination_address, MA_sdu)

– MA_DATA.indication (Source_address, MA_sdu)

in which the parameter:

- *Destination_address* indicates destination node address (single or group). This parameter makes sense only in the case of a message sent by the concentrator to a meter (or a group of meters); in case of message sent by a meter to a concentrator this field is not present.

- *Source_address* indicates source node address. This parameter make sense only in the case of a message sent by a meter to the concentrator; in case of message sent by a concentrator to a meter this field is not present.
- *MA_sdu* is data unit to be sent.

This primitive is passed from MAC sub-layer to LLC sub-layer to transfer a received MA_sdu.

This primitive is present on LLC/MAC interface either in a master station or in a slave station.

The MA_DATA.confirm is defined as follows:

– MA_DATA.confirm (Status)

in which the parameter *Status* indicates the positive or negative result of a MA_sdu sending to the node:

- 0x25 = positive result;
- 0x27 = negative result.

This primitive is passed to LLC sub-layer from MAC sub-layer to confirm if sending of MA_sdu previously passed from LLC sub-layer with a MA_DATA request has been done positively or negatively.

It always ends a MA_DATA.request and it notifies to LLC sub-layer that MAC sub-layer is available to satisfy a new request.

It is followed by a MA_DATA.indication if data for LLC sub-layer are present.

It notifies to master LLC sub-layer a positive result when:

- the waited response has arrived from slave final node;
- no response has arrived from slave final node, because it was not foreseen by the discipline, and T time of MAC protocol has expired.

It notifies to master LLC sub-layer a negative result when:

- no response has arrived from slave final node, when a response was foreseen by the discipline, and T time of MAC protocol has expired.

It notifies to slave LLC sub-layer the transmission result of the response frame.

It is present on LLC/MAC interface either in a master station or in a slave station within all the sub-nets.

The MA_EVENT.indication is defined as follows:

– MA_EVENT.indication (Event_identifier, Event_value)

in which the parameter:

- *Event_identifier* specifies the occurred event;
- *Event_value* specifies additional information concerning the occurred event.

This primitive is present only on master node and MAC passes it to NM to notify events that are important for communication management.

In the following table values of MA_EVENT.indication parameters are described:

Table 2 – MA_EVENT.indication parameters

Event_identifier	Event_value	Description
0	ACA	Timer expiration. Repeater node, whose supervision timer has expired, generates a CRP frame back to the master node. *Event_value* contains the ACA of the node has generated the CRP frame.
1 ÷ 255	-	Reserved

6.1.2 Service classes

The basic services provided by MAC are those that can be managed by the Service_Class parameter:

Sxx: service with "postponed confirmation": confirmation is given when the channel gets free from eventual repetitions on the A sub-net (see Figure 15).

Rxx: service with "round-trip delayed confirmation": confirmation is given by the time used by both the upstream frame and the waited downstream one, including eventual repetitions on A sub-net, and eventual activities (delays) on B sub-net (see Figure 16).

Sxx service is used when the LLC has been requested a Send/Noreply service class, while Rxx service is used when the LLC has been requested a Request/respond or a Request/Multirespond service class.

These fundamental services have effects on the generation of MA_DATA.confirm only at master side; at slave side the MA_DATA.confirm is issued at the end of the transmission regardless of the used service.

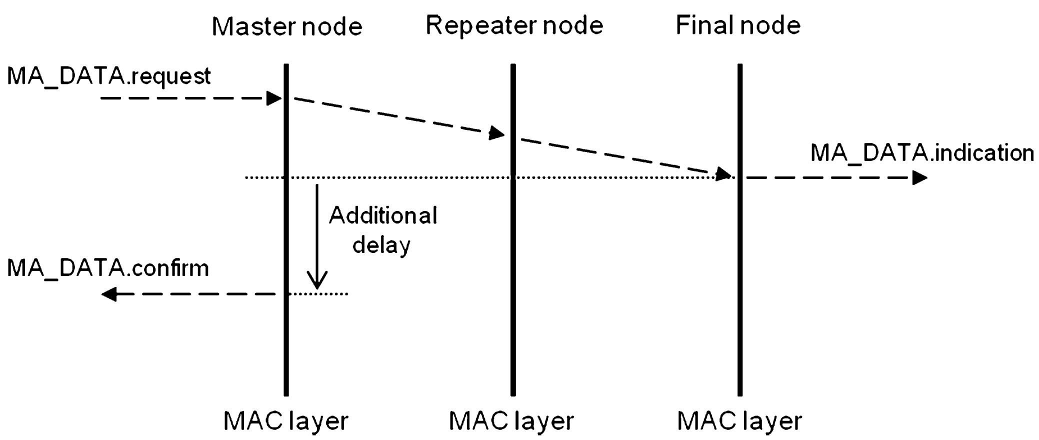

Figure 15 – Messages exchange in the Sxx service class

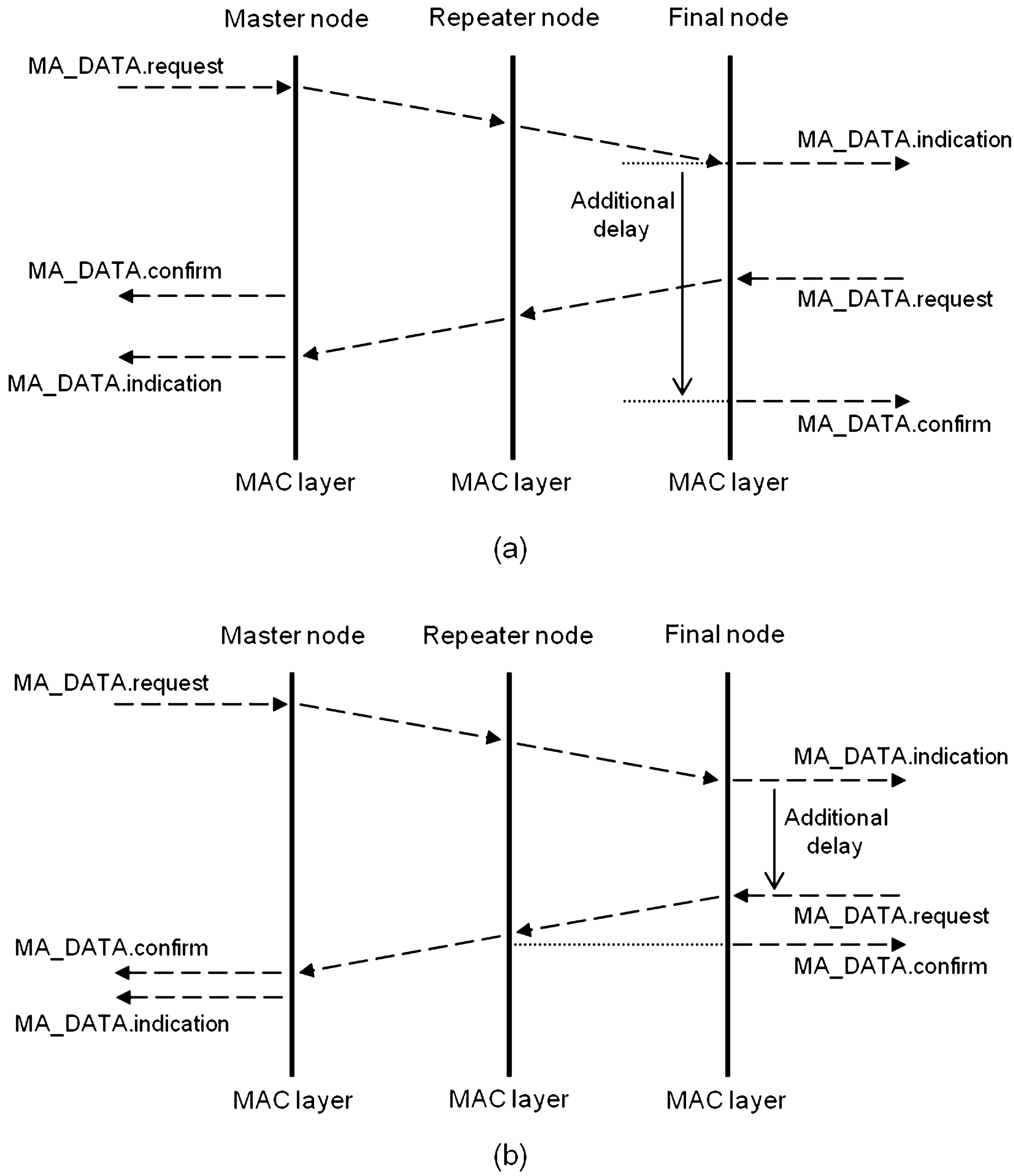

Figure 16 – Messages exchange in the Rxx service class with (b) or without (a) timeout expiration along the chain,

The dotted line on Figure 16 (a) does not represent a data flow between two nodes; it is the graphical representation of a time passage that is able to release the final node.

6.2 Frame Structure

6.2.1 General

The transmitted MAC frame is composed by the following fields:

LT	ADDR	CTL	RP	NB	INF	SVT

Figure 17 – MAC frame structure

where:

LT: Frame Length

ADDR: MAC address or SCA

CTL: Control

RP: Repetition Parameters

NB: 1 byte field (not used)

INF: Information (MAC-sdu or LLC-PDU)

SVT: Frame checking sequence (CRC)

6.2.2 Frame length (LT)

This field is composed by 1 byte and it indicates the number of bytes contained in frame delimiters, LT excluded, SVT included.

6.2.3 Address (ADDR)

The field is composed by 6 bytes and contains:

– the address of destination node (repeater or final node) in the upstream frames;

– the address of source node (final node or repeater) in the downstream frames.

The address can be either the MAC address (Absolute Communication Address, ACA) or the Section Communication Address (SCA) defined in A.1.

6.2.4 Control (CTL)

Control field is composed by 1 byte and its configuration is tied to the frame function in the following way:

Table 3 – CTL field coding in MAC frame

Frame type	CTL								Frame function
RIP	0	r	r	r	d	d	d	d	Repetition (upstream)
NOR1	1	0	0	0	d	d	d	d	Normal 1 (upstream)
NOR2	1	0	1	0	d	d	d	d	Normal 2 (downstream)
CRP	1	1	0	0	d	d	d	d	Repetition control (downstream)

where:

rrr: 3 bits that indicate the number of involved repeaters (from 1 to 8) after whom transmits:

000 = one repeater

100 = two repeaters

010 = three repeaters

110 = four repeaters

… = …

111 = eight repeaters;

dddd: 4 bits that indicate exchange discipline (see B.1).

From the functional point of view, the following three types of frame are defined:

– RIP frames manage repetition till last involved repeater;

– NOR1 type frames manage connection between the last involved repeater and the final node or the direct connection (without repeaters) between master node and final slave node;

– NOR2 type frames manage either backwards repetition or backwards direct connection (without repeaters) between slave node and master node;

– CRP type frames are generated by repeater node with expired T timer in the Request/Respond discipline.

In case of backward repetition (which uses NOR2 type frames) the number of repeaters is not relevant, since RP field is empty and every repeater in the chain is made aware of its direct peers by the corresponding downstream message.

Details on how the above frames are used are explained in 6.2.8 and 6.3.3.

6.2.5 Repetition Parameters (RP)

6.2.5.1 General

This field is always present in RIP and CRP type frames while it is always empty in NOR1 and NOR2 type frames. The Concentrator works with fixed repetition chains and manages by itself the repetition path configuration.

6.2.5.2 RP field in RIP frames

There are two different cases, depending on the addressing mode used by Concentrator.

If Concentrator is addressing nodes using ACA, in the RIP type frames this field contains the ordered sequence of MAC addresses (ACA):

– of the repeater nodes between source node (Concentrator or repeater) and final node, excluded the address of destination node (first repeater of the sequence) put in the ADDR field of the same frame;

– of the final node.

It is composed by m sub-fields, each one consisting of 6 bytes, where m is the number of involved repeaters after frame transmitter (m is codified in the rrr bits, which are contained in the concerning CTL field). These sub-fields are organized as follows:

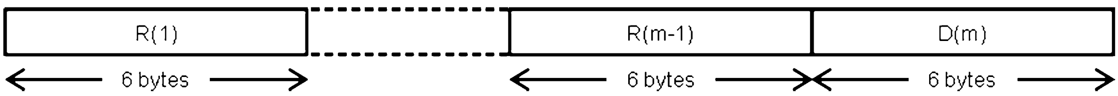

Figure 18 – RP field in MAC frame (ACA addresses)

where:

R(i): repeater MAC address of order (i+1) [with i=1,.., (m-1)] after frame transmitter;

D: MAC address of final node;

while MAC address of the first repeater after the frame transmitter is put in the ADDR field of the same frame.

If Concentrator is addressing nodes using SCA, in the RIP type frame this field contains the ordered sequence of Node Subsection and Node Progressive fields (see Figure A.1) of SCA addresses (2 byte short form SCA address as described in Annex A):

– of the repeater nodes between source node (Concentrator or repeater) and final node, excluded address of destination node (first repeater of the sequence) put in the ADDR field of the same frame;

– of the final node.

It is composed by m sub-fields, each one consisting of 2 bytes, where m is the number of involved repeaters after frame transmitter (m is codified in the rrr bits, which are contained in the concerning CTL field). These sub-fields are organized as follows:

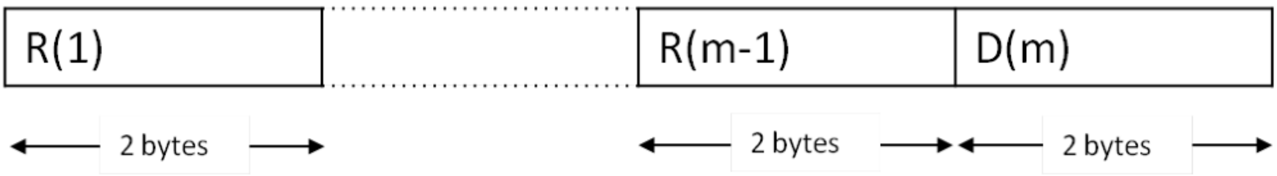

Figure 19 – RP field in MAC frame (short form SCA addresses)

where:

R(i): repeater short form SCA address of order (i+1) [with i=1,.., (m-1)] after frame transmitter;

D: short form SCA address of final node (Node subsection, Node progressive);

while the entire SCA address (6 bytes, see A.1) of the first repeater after the frame transmitter is put in the ADDR field of the same frame.

In both cases (ACA or SCA addressing mode) the reorganization of the message performed by each repeater is detailed in 6.3.3.

NOTE How the concentrator select the repeaters to build the repetition chain is an implementation issue and is out of the scope of this document.

6.2.5.3 RP field in CRP frames

In these frames the RP field contains only the address (ACA or SCA) of the repeater node whose timeout expired and that started repetition control procedure (Request/Respond disciplines). CRP frames are described in details in 6.3.3.3.

6.2.6 Information (INF)

This field is composed by a variable integer number of bytes. These bytes contain the information (MAC-sdu) that has been exchanged end-to-end between master and slave.

It is always present in RIP, NOR1 and NOR2 frames; it is always empty in CRP frames.

The maximum number of information bytes contained is 130; the minimum is 4.

The INF structure is detailed in Figure 13.

6.2.7 Frame checking sequence (SVT)

This field contains the remainder (CRC of 32 bit), complemented to ones, of the division (modulo 2) of the bits sequence contained between the fields LT and INF (both included, considering, in this sequence, the first 32 bits starting from LT as complemented to ones) for the following generator polynomial:

$$g(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1$$

6.2.8 Example of frame types

The following figures represent examples of the four types of MAC frame taking account the following conditions:

– the sub-net A is involved;

– the final destination node is an A-Node;

– two repeaters are involved;

– the communication discipline is Request/Respond (RA2).

The bit values of the CTL field and the contents of the ADDR, RP and INF fields are showed.

LT	1st repeater ADDR	0 100 1100	2nd repeater ADDR + final node ADDR	NB	MAC-sdu	SVT

Figure 20 – RIP MAC frame

The RIP MAC frame is sent by the Concentrator to the first repeater of the repetition chain. In the RP field there are the addresses of the second repeater and the final destination A-Node.

LT	final node ADDR	1 000 1100	NB	MAC-sdu	SVT

Figure 21 – NOR1 MAC frame

The NOR1 MAC frame is sent by the last repeater (the second one) to the final destination A-Node. The RP field is empty.

LT	final node ADDR	1 010 1100	NB	MAC-sdu	SVT

Figure 22 – NOR2 MAC frame

The NOR2 MAC frame is sent by the final destination A-Node to the last repeater. The RP field is empty. This is a downstream frame, so in the ADDR field there is the address of the node is sending the frame, in this example the final destination A-Node address.

LT	1st repeater ADDR	1 100 1100	2nd repeater ADDR	NB	SVT

Figure 23 – CRP MAC frame

The CRP MAC frame is sent from the first repeater to the Concentrator. The RP field contains always (also in all the other CRP frames) the address of the repeater that has started the repetition control procedure because its timeout expired, in this example the last repeater. The INF field is empty. This is a downstream frame, so in the ADDR field there is the address of the node is sending the frame, in this example the first repeater address.

6.3 Procedures

6.3.1 Frame filtering

MAC functions in the context of transmission and reception service, carry out procedures that allow to check correctness of frames that are physically exchanged on the network.

On reception, it selects frames directed to that node through ADDR field filtering and on the entire frame it carries out the following checks:

– congruence of the integer number of bytes contained between delimiters, with the value of LT field;

– SVT congruence;

– congruence of INF bytes number within predetermined limits.

In this way it is possible for a node to reject spurious frames received from the network, generated by noise during intra-frame pauses.

6.3.2 Phase detection

The phase detection procedure requires that Concentrator and any possible repeating Nodes correlate frame transmission to the first coincidence with zero crossing (positive slope) of the voltage of the LV phase involved in that communication.

This implies that the concentrator is aware of the phase connection of every repeater in the chain and that all the repeaters shall be connected to the phase used by the concentrator."

6.3.3 Repetition

6.3.3.1 General

In the nodes that handle repetition, MAC uses CTL and RP frame fields to discipline information transmission from master node to indicated final node or vice versa.

A repeater that can directly communicate with the final node, is considered as final repeater.

Between final repeater and final node only NOR1 frames (with empty RP field) are exchanged; also the downstream NOR2 frames have always an empty RP field.

Between A-Node and B-Node only NOR1 and NOR2 frames are used, since no repetitions are foreseen on B sub-net.

6.3.3.2 Example of repetition procedures

A repetition example to transmit an LLC-pdu from LLC entity on master node, to the respective slave final node entity, and vice versa, during a single transaction with Rax discipline is given below.

It is assumed that this transaction involves two intermediate repeaters, R1 and R2. Following figures show respectively the case of ACA addressing mode (Figure 24) and the case of SCA addressing mode (Figure 25). The SCA address format is described in Annex A.

The CTL field shows frame type (RIP frame, NOR1 frame or NOR2 frame), the number of next involved repeaters and type of discipline considered.

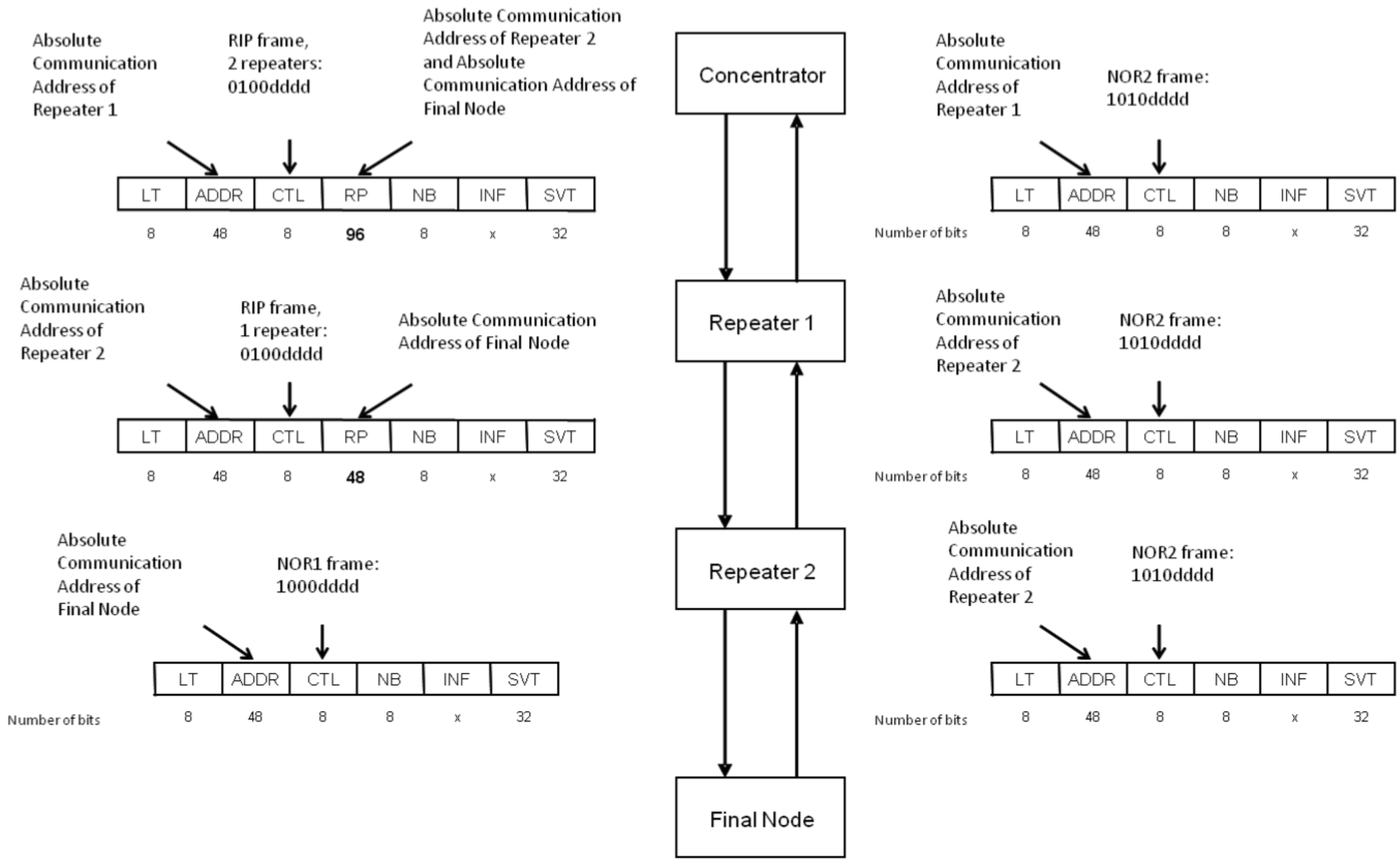

Figure 24 – Example of repetition procedure using ACA address

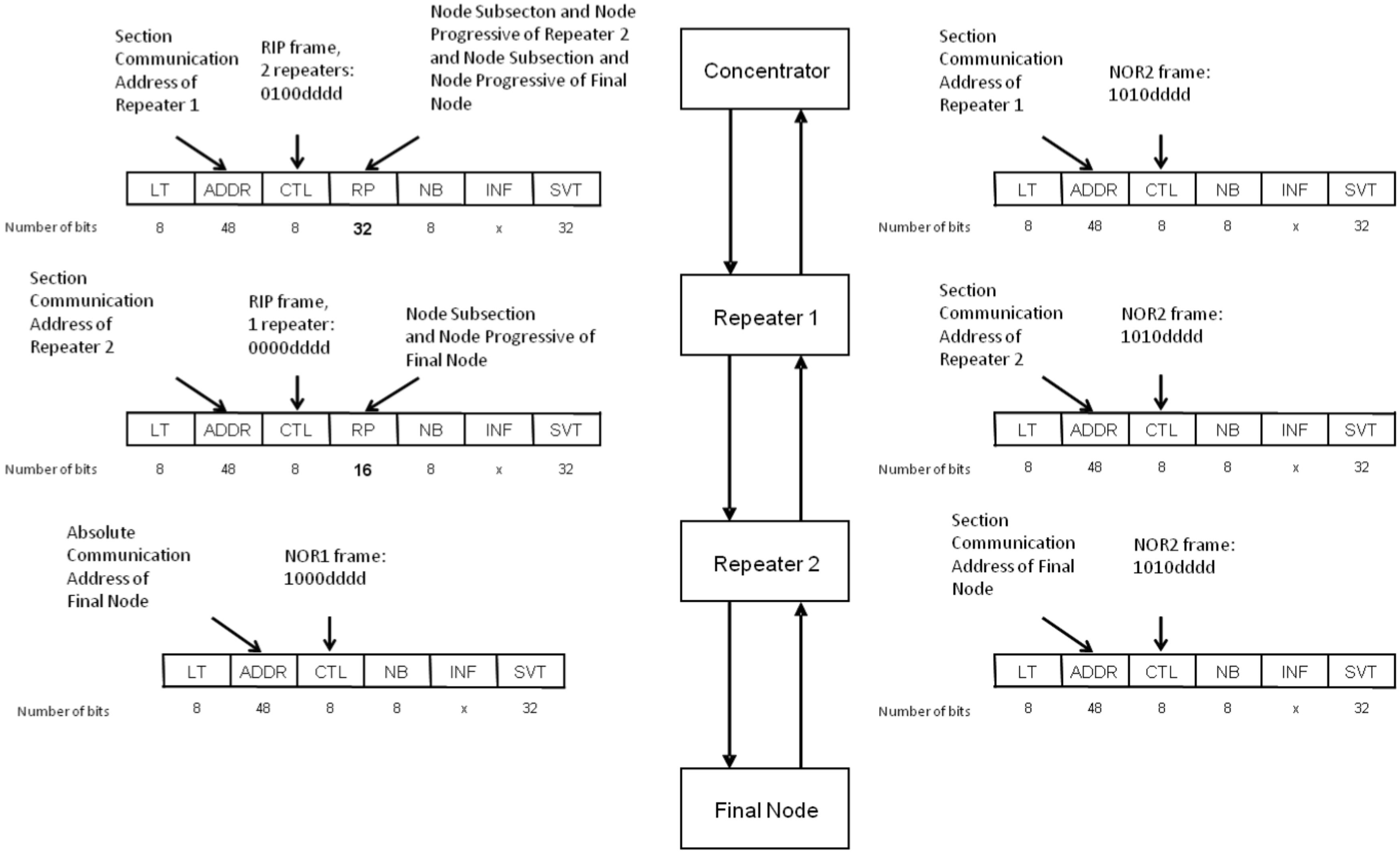

Figure 25 – Example of repetition procedure using SCA address

Previous figures describe the following steps:

a) LLC master entity prepares its pdu (generated on request of application level that is expecting a response) and delivers it to MAC layer that sends the pdu to final node with address indicated on request.

b) Master MAC deduces from Destination_address parameter received from LLC/MAC interface MA_Data.Request primitive that communication with indicated slave final node is impossible directly. However, it is possible through repeaters with R1 and R2 addresses; so it creates a RIP frame that has:

   – as final address the one of desired slave final node;

   – as repeaters addresses the ones of all the intermediate nodes (R2);

   containing LLC-pdu and sends the frame to node R1.

   If LLC master entity uses SCA addressing mode, all the addresses in RP field are composed by only 2 bytes (Node subsection and Node progressive, see A.1).

   Once transfer has been completed, and a reply is foreseen, MAC of master goes on receiving mode with R1 address (ACA or SCA); in fact Master node is not provided with an individual address, since in upstream messages the address is the one of the final node, while in downstream messages the address is the one of the sender (final node or repeater) as explained in 6.2.3.

   How to distinguish between ACA and SCA address is described in Annex A.

c) The MAC of R1 repeater receives the frame, sees by CTL and RP fields which is the addressed slave final node and that the communication is possible through repeater with R2 address; so it properly reorganizes the LT, CTL, RP fields, calculates new SVT value and sends RIP frame towards the R2 node.

   Then, MAC of R1 goes on receiving mode with R2 address and keeps this receiving state for a certain time; the supervision timer value on R1 shall be smaller than the value of the timer on master node and bigger than that on R2 repeater, so that the timer activated in the R2 expires before the one in R1.

d) The MAC of R2 repeater receives the frame and from fields CTL and RP, sees which is the addressed slave final node; it understands that direct communication with desired slave final node is possible, so it properly reorganizes the LT, CTL fields, calculates new SVT value and sends NOR1 frame to Final Node (this is valid also for a group address).

   Therefore, the MAC of R2 goes for a certain period on receiving mode, using the slave Final Node address.

e) The MAC of slave Final Node receives the frame NOR1 with its own address (or with group address), and, since it is the final node, it passes LLC-pdu to LLC sub-layer.

   The LLC sub-layer passes the message to the upper layer, obtaining a response message; it generates LLC-pdu and passes it to MAC that transmits it with Final Node address a NOR2 frame.

f) MAC of R2 node is now waiting from an downstream message coming from the final node, and it is the only node allowed to forward this message to the next repeater (R1). Then the MAC of R2 node clears the supervision timer.

g) MAC of R1 node is now waiting from an downstream message coming from R2 node (a message with R2 address in the ADDR field), and it is the only node allowed to forward this message to the master node. Then the MAC of R1 node clears the supervision timer.

h) Master node was waiting for a downstream message coming from R1 node (a message with R1 address in the ADDR field); the MAC master that was expecting a reply from slave Final Node, obtains LLC-pdu contained in INF and passes it to LLC master as coming from the LLC of the inquired slave Final Node; it clears supervision timer previously activated.

It is pointed out, thanks to the state information present on intermediate repeaters that:

– each repeater is in receiving mode with address of the next node (repeater or final);

– each repeater knows it is expecting a response frame from next repeater node of the chain;

– it can execute downstream repetition using its own node address;

and thanks to the fact that the MAC on master node has kept the notion of the inquired slave Final Node address, the downstream frames can have a normal format (NOR2) with empty RP.

The supervision timer T associated with each Request/Respond class discipline on A sub-net is also in function of repeaters on the end-to-end path; it is calculated by the MAC function in master and in the repeater nodes; it is activated by frame transmission.

On master node the LLC sub-layer receives the timeout expiry indication by MAC (using the MA_DATA.confirm primitive with negative result) and, if it has ended retransmissions, it passes it to upper layer (see LLC sub layer, Clause 5).

In an intermediate repeater node, the T timer expiry causes the return to reception mode with its own address and with emission of a CRP frame, as explained in 6.3.3.3.

6.3.3.3 Repetition control

The repeaters do CRP repetition control to inform the master node if errors occurred in interacting with the next nodes during a transaction between master node and slave final node that is passing through them (e.g. no response from slave final node within a predefined time, see Figure 26).

CRP frames have the following characteristics:

– they are sent by repeater nodes only in case of Request/Respond type services;

– they are all downstream; the ADDR field carry the address of the sender as the NOR2 type frames;

– it is originated by a repeater node which experienced a supervision timer expiration;

– they have the INF field empty and the address of the node where the supervision timer has expired, in RP field;

– they are destined to master node MAC.

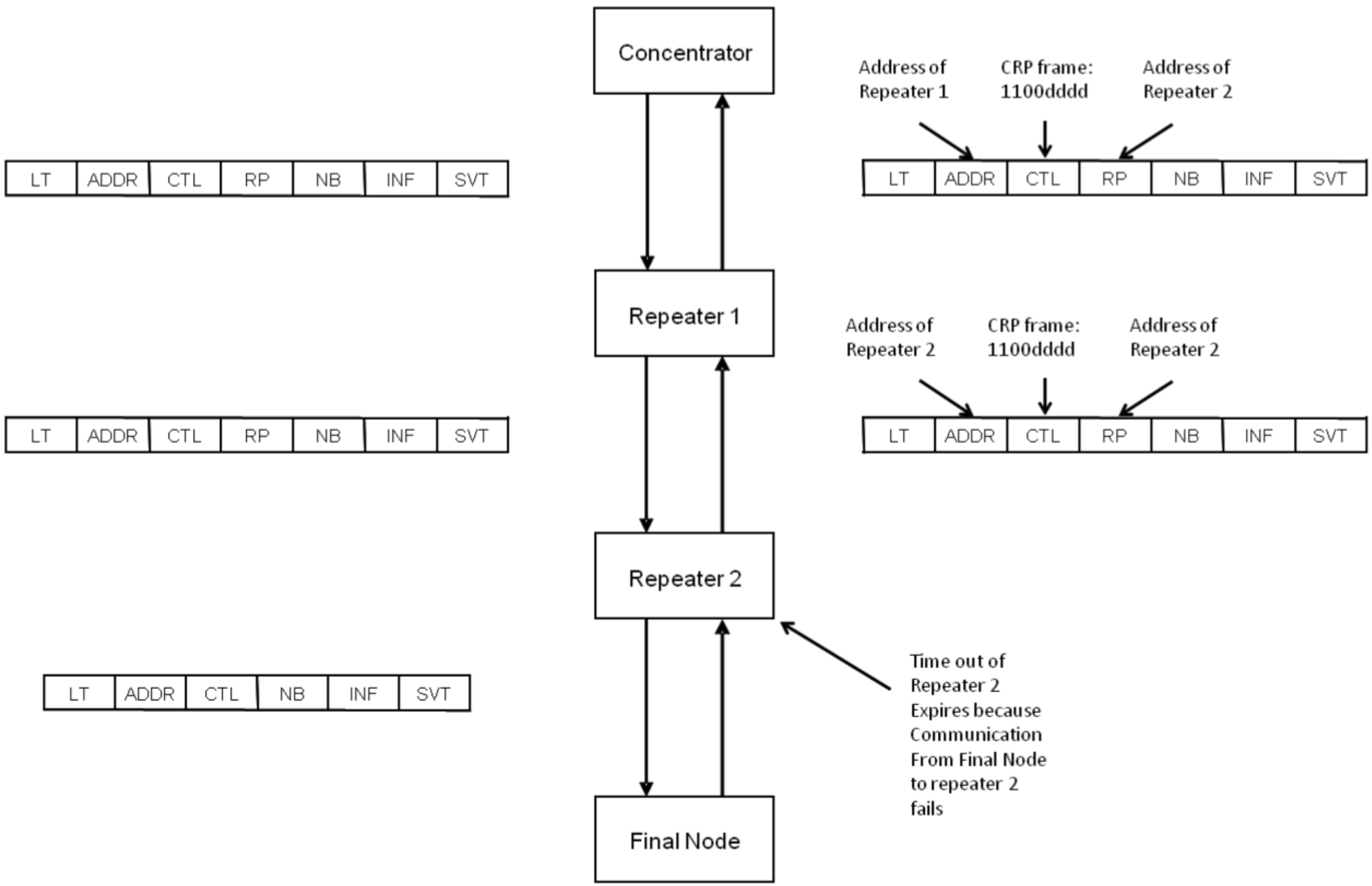

Figure 26 – Example of CRP repetition control procedure

Examining Figure 26, in case R2 has not received response from Final Node, the anomalous condition - notified by the repeater node MAC with R2 address through a CRP frame - indicates that the supervision timer T of R2 repeater transaction is expired; in this case the RP field contains the address of the Node that has generated the CRP frame (R2), and the INF field is empty.

7 Physical Layer

7.1 Overview

The Physical Layer (PHY) defines the method used to transfer data over the physical medium.

In transmission the PHY layer performs:

– coding and encapsulation of the MAC data unit (MA_sdu) into a Physical frame (P_frame);

– modulation of the P_frame using Binary Phase Shift Keying (B-PSK);

while in reception the PHY layer performs:

– frame and byte synchronization on the received PHY stream;

– demodulation of the P_frame using Binary Phase Shift Keying (B-PSK);

– de-coding of the PHY payload (P_payload) and extraction of the MAC data unit (MA_sdu).

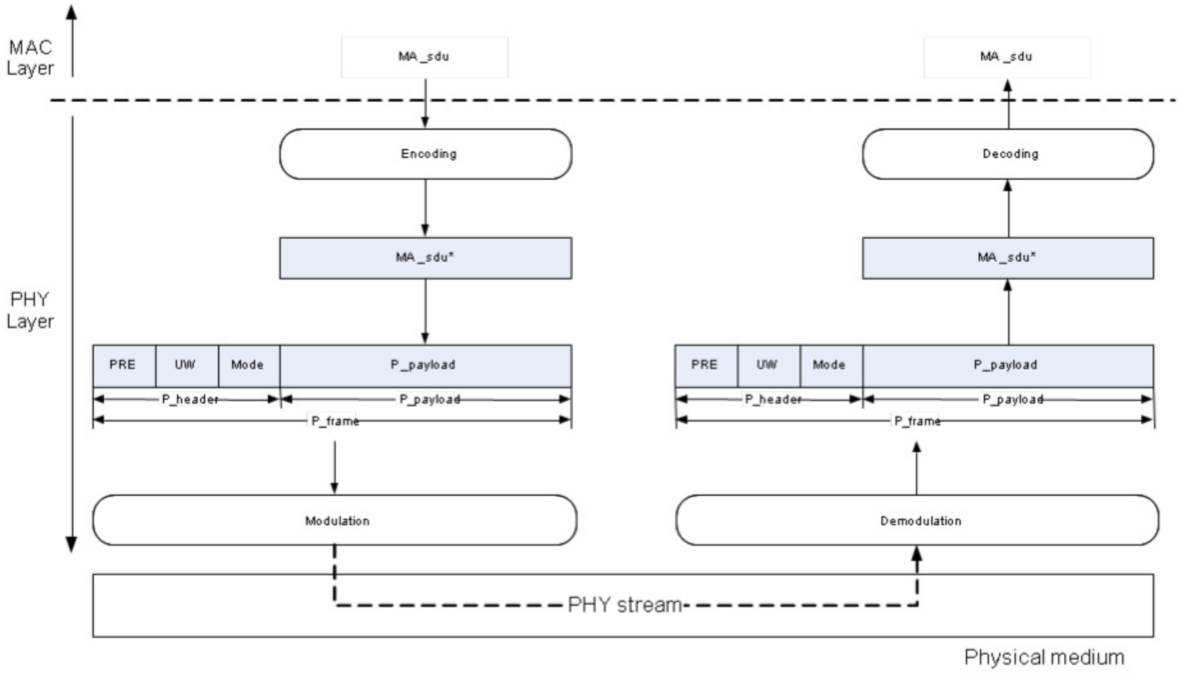

Figure 27 – Data transfer in Physical Layer

7.2 P_frame Structure

7.2.1 General

The MAC data unit (MA_sdu) exchanged with the MAC layer is first coded through a convolutional encoder and interleaver to improve the robustness of the communication. The resulting coded message (MA_sdu*) is used as Physical payload (P_payload) to build a Physical frame (P_frame), consisting of a P_header and a P_payload, with sub-fields as shown in Figure 28.

P_header			P_payload
PREAMBLE (PRE)	UNIQUE WORD (UW)	MODE	MA_sdu* *(coded)*
2 … 5 bytes	4 bytes	1 byte	M_size bytes (0 … 251)

Figure 28 – Physical frame (P_frame) structure

The convolutional encoder and interleaver are used on the MAC data unit (MA_sdu) only. The P_payload is always coded, while the P_header is left not coded.

7.2.2 Preamble (PRE)

A sequence of alternating 1 and 0 symbols required by the receiver PLL to lock on the best sampling time. Its length should be programmable using one of the following values: 16, 24, 32, 40 bits.

The pattern value is 0xAAAA, 0xAAAAAA, 0xAAAAAAAA, 0xAAAAAAAAAA depending on the chosen length. The length of this field has no impact in the interoperability among different implementation choices.

The bits of the preamble pattern are sent from the least significant (rightmost) bit (LSb) to the most significant (leftmost) bit (MSb).

7.2.3 Unique word (UW)

32 bits pattern on which the receiver performs:

– frame synchronization: only after Unique Word identification, the incoming data are considered a valid message and then demodulated;

– byte synchronization.

The pattern value is 0x014AE326.

The bits of the 32-bit pattern are sent from the least significant (rightmost) bit (LSb) to the most significant (leftmost) bit (MSb).

7.2.4 Mode

8 bits pattern delimiting the start of the convolutional coding used on the PHY payload (P_payload).

The pattern value is 0x33.

The bits of the 8-bit pattern are sent from the least significant (rightmost) bit (LSb) to the most significant (leftmost) bit (MSb).

7.2.5 P_payload

The Physical payload (P_payload) is composed by the MAC data unit coded through the convolutional encoder and interleaver (MA_sdu*).

Each byte of the P_payload is sent starting from its least significant (rightmost) bit (LSb) to the most significant (leftmost) bit (MSb).

7.3 Modulation

The modulation is a B-PSK (binary phase shift keying) with a symbol rate equal to 9600 symbol/s. The phase encoding scheme is:

– not differential on P_header: the binary ‘1’ and ‘0’ are coded with two phases separated by 180°. It does not matter where the constellation points are positioned;

– differential on P_payload: a binary ‘1’ is transmitted by adding 180° to the current phase and a binary ‘0’ by adding 0° to the current phase.

One B-PSK channel with a carrier frequency centred at 86 kHz shall be used. The maximum signal transmission level shall be in accordance with EN 50065-1.

7.4 Encoder

7.4.1 General

The Encoder consists of two blocks:

– convolutional Encoder;

– convolutional Interleaver.

The coding is applied on the P_payload only, while the P_header is left not coded (Figure 29).

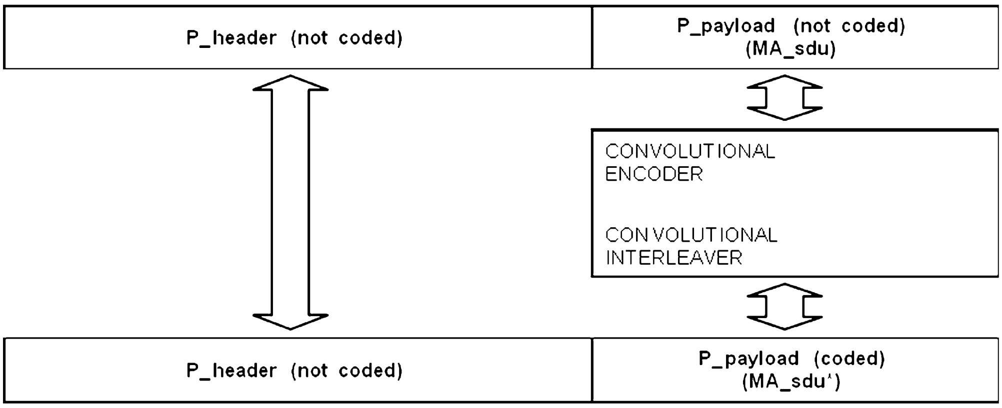

Figure 29 – Convolutional encoding of the P_payload

7.4.2 Convolutional Encoder

The encoder is a rate 1/2 convolutional encoder with constraint length K = 7. At the beginning, the encoder state is set to zero. At the end of transmission of the payload, zeroes shall be inserted to flush the encoder. The bit generated by the first code generator is first output. The block diagram of the encoder is shown in Figure 30.

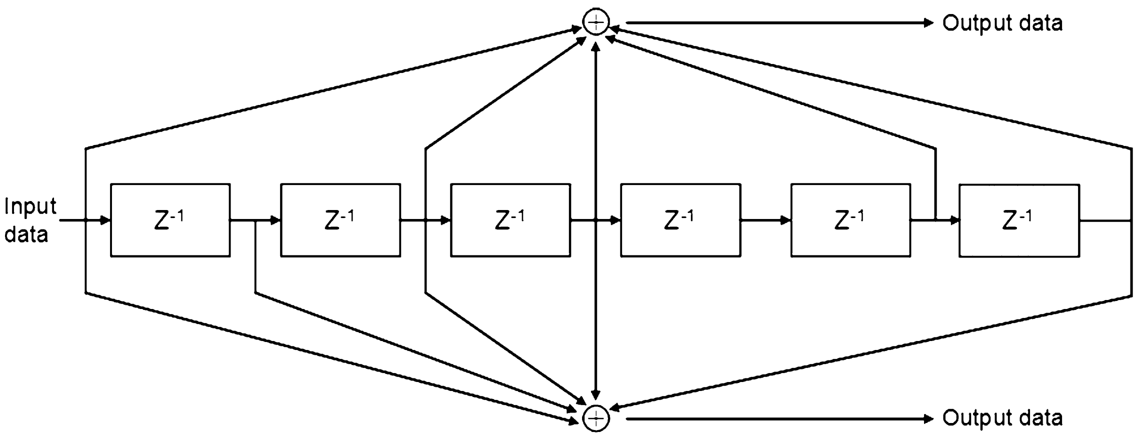

Figure 30 – Convolutional Encoder

7.4.3 Convolutional Interleaver

The interleaver is composed of multiplexer/demultiplexer selecting among 8 paths, each with a shift registers with a register length ranging from 0 to 7 bits as shown in Figure 31.

Both the multiplexer/demultiplexer and the shift-registers are clocked at the bit-stream sample rate.

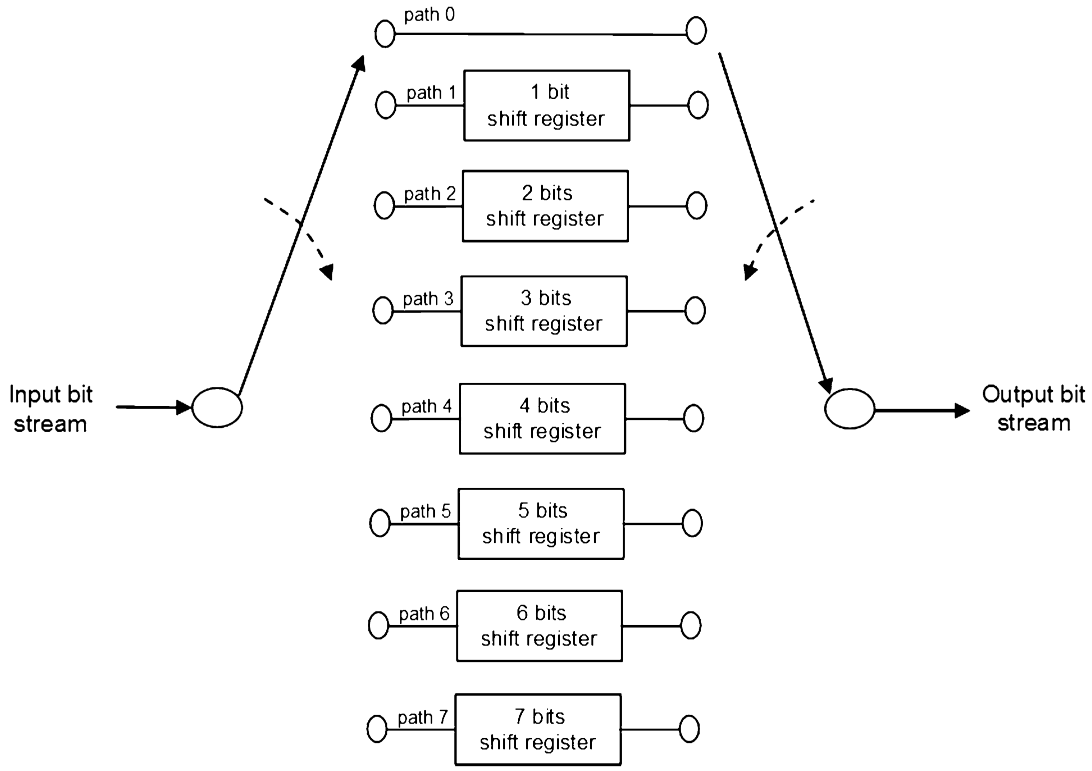

Figure 31 – Convolutional Interleaver

Example of interleaving

Table 4 shows an example of interleaving performed on an input stream bit of 24 bit, assuming Table 5 as initial condition for the shift registers.

Table 4 – Example of interleaving

INPUT BIT STREAM	Shift registers content								OUTPUT BIT STREAM
b0	b0								b0
b1	b1	i0							i0
b2	b2	i1	i2						i2
b3	b3	i3	i4	i5					i5
b4	b4	i6	i7	i8	i9				i9
b5	b5	i10	i11	i12	i13	i14			i14
b6	b6	i15	i16	i17	i18	i19	i20		i20
b7	b7	i21	i22	i23	i24	i25	i26	i27	i27
b8	b8	b0							b8
b9	b9	b1	i0						b1
b10	b10	b2	i1	i2					i1
b11	b11	b3	i3	i4	i5				i4
b12	b12	b4	i6	i7	i8	i9			i8
b13	b13	b5	i10	i11	i12	i13	i14		i13
b14	b14	b6	i15	i16	i17	i18	i19	i20	i19
b15	b15	b7	i21	i22	i23	i24	i25	i26	i26
b16	b16	b8	b0						b16
b17	b17	b9	b1	i0					b9
b18	b18	b10	b2	i1	i2				b2
b19	b19	b11	b3	i3	i4	i5			i3
b20	b20	b12	b4	i6	i7	i8	i9		i7
b21	b21	b13	b5	i10	i11	i12	i13	i14	i12
b22	b22	b14	b6	i15	i16	i17	i18	i19	i18
b23	b23	b15	b7	i21	i22	i23	i24	i25	i25

Table 5 – Shift registers initial condition

Path 1		i0					
Path 2		i1	i2				
Path 3		i3	i4	i5			
Path 4		i6	i7	i8	i9		
Path 5		i10	i11	i12	i13	i14	
Path 6		i15	i16	i17	i18	i19	i20	
Path 7		i21	i22	i23	i24	i25	i26	i27

7.5 P_Data services

7.5.1 General

The P_Data services provided by the PHY layer allow MAC to transmit or receive a payload (M_payload).

Three general P_Data primitives are available:

- P_Data.Request
- P_Data.Confirm
- P_Data.Indication

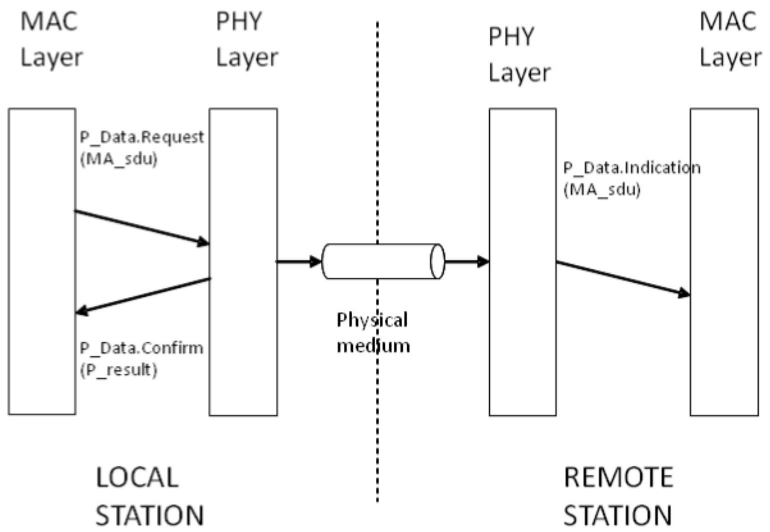

Figure 32 – P_Data services

7.5.2 P_Data.request

Requests for the transmission of the MAC data unit (MA_sdu) on the physical medium.

7.5.3 P_Data.confirm

The local confirmation in response to a previous P_Data.request.

Possible results (P_result):

- OK (00h): the transmission has been performed;
- NOK (01h): the transmission has not been performed.

7.5.4 P_Data.indication

Unsolicited indication to notify the arrival of a frame containing data MA_sdu.

Annex A
(informative)

SCA address configuration

A.1 Structure of the SCA and ACA addresses

The structure of the Section Communication Address (SCA) is specified as follows:

LSB

Meter address					Length
Concentrator section			Node subsection	Node progressive	Concentrator section length
			Values: from 0 to 255	Values: from 0 to 255	**Fixed bits**: **1 1** .. ..
LSb	LSb	LSb	LSb	LSb	LSb
First trans. bit	First trans. bit	First trans. bit	First trans. bit	First trans. bit	First trans. bit
First transmitted byte	2nd byte	3rd byte	4th byte	5th byte	Last transmitted byte

Figure A.1 – SCA address structure

When Node progressive and Node subsection bits are all set =1, broadcast addressing mode is enabled.

As long as SCA address format is used, the RP field of the MAC frames contains an ordered list of SCA addresses in short form, which means only Node Subsection and Node progressive fields (byte 4 and 5 in the above picture) are sent.

A node without a valid SCA can be addressed only through its ACA until the concentrator assigns to it a valid SCA. The structure of the Absolute Communication Address (ACA) is specified as follows:

LSB

Meter Serial Number			Year	Manufacturer	Apparatus Type
			Fixed bit: **0**	**Fixed bit:** **0**	**Fixed bits:** **0 0** .. ..
LSb	LSb	LSb	LSb	LSb	LSb
First trans. bit	First trans. bit	First trans. bit	First trans. bit	First trans. bit	First trans. bit
First transmitted byte	2nd byte	3rd byte	4th byte	5th byte	Last transmitted byte

Figure A.2 – ACA address structure

The two most significant bits of the last transmitted byte of the address allow to distinguish between SCA and ACA. It is an unique worldwide identifier defined during manufacturing process, composed by 6 bytes.

Annex B
(informative)

Disciplines

B.1 Discipline timers configuration

The four bit sub field dddd in MAC CTL field is chosen depending on the number of bytes received within the sub net A when the final node is an A-Node (discipline RA) and within the sub nets A and B when the final node is a B-Node (discipline RB).

In the following table seven thresholds for RA and three thresholds for RB indicating the maximum number of bytes of the response message are associated to the values of sub field dddd.

The master node knows a priori the length of a response message upon its request and properly sets the corresponding value of bits dddd into the MAC frame.

Using this information and the associated maximum number of receiving bytes, every repeater involved in a transmission activity is able to calculate its supervisor timer.

Table B.1 – Subfield dddd and maximum number of received bytes in A and B subnets for disciplines S, RA and RB.

Procedure		Maximum number of RX bytes on A sub-net	Maximum number of RX bytes on B sub-net	Bits dddd in MAC CTL field
S	-	-	-	0000
	A1	0	0	1000
R	A1	21	-	0100
	A2	41	-	1100
	A3	61	-	0010
	A4	81	-	1010
	A5	101	-	0110
	A6	121	-	1110
	A7	142	-	0001
	B1	30	20	1001
	B2	110	30	0101
	B3	150	50	1101

Table B.2 – Subfield ddd and number of time slots for RC disciplines.

Procedure		TimeSlotsNumber (N)	Maximum number of RX bytes on A sub-net	Maximum number of RX bytes on B sub-net	Bits dddd in MAC CTL field
RC	C1	8	90	40	0011
	C2	16	90	40	1011
	C3	32	90	40	0111
	C4	64	90	40	1111

In case of discipline RC the master node chooses the number of time slots to be used by final nodes for the response message, and sets the associated value of bits dddd in the MAC frame.

Using this information, the ExtraTime value is computed using the following formula:

$ExT = (N+1) * TSlot$

and then it is used by involved repeaters in the computation of the RC discipline timers as described in 4.4.2.

Annex C
(informative)

Details on message bit coding

C.1 Example of bit coding

In the following example the way a PLC application message is coded from the LSDU (Upper Layer Data) to the Physical Layer is showed. This message is sent by the Concentrator without authentication, not encrypted and in the Request/Respond discipline. Two repeaters are involved and the SCA addressing mode is used.

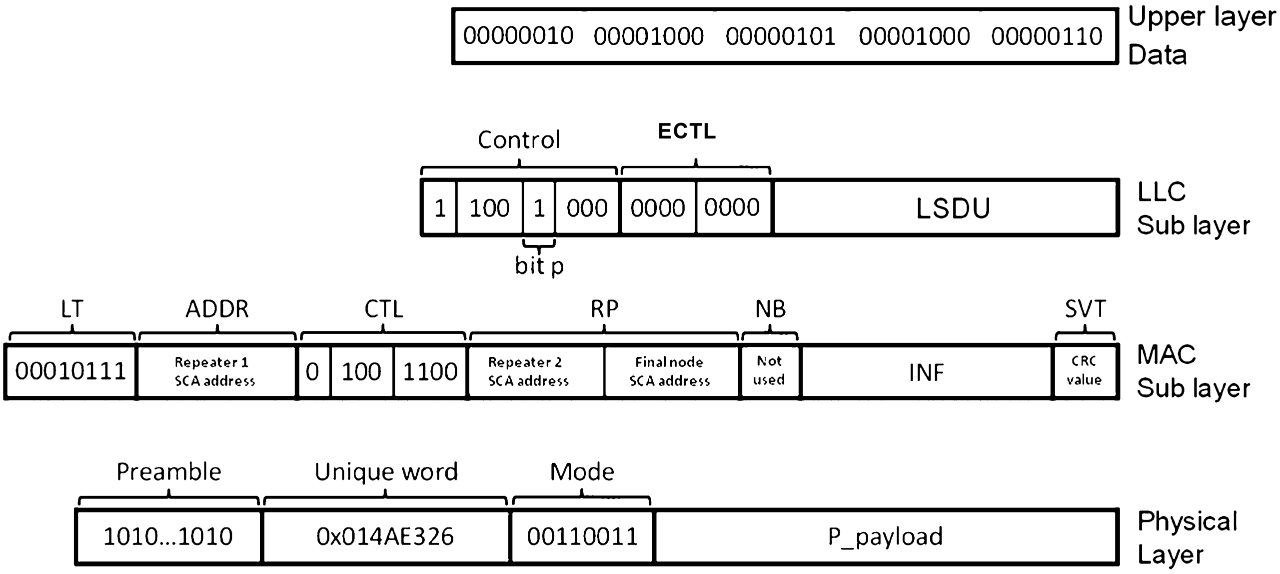

Figure C.1 – Frames encapsulation example

In Figure C.1 data from the upper layer (e.g. a message requiring a Read with concerning info) and bit values in the frames of Data Link and Physical Layers are showed.

At LLC sub layer, the field Control has bit p is set to 1 to indicate a command frame (see 5.2.1). According to D.2, the four most significant bits of field ECTL are set to 0000 to specify that such a frame is an application management frame, and the four least significant bits are set to 0000 to specify that the encryption is disabled. The field LSDU contains the application message.

At MAC sub layer, the field LT indicates the length (23 bytes) of the MAC frame, LT excepted, and ADDR contains the 6 bytes SCA address of the first repeater (see 6.2.3). As described in 6.2.4, the most significant bit of the CTL field indicates that the frame is a repetition one (0 = RIP frame); next three bits specify that two repeaters are involved in the communication and last four bits indicate that a Request/Respond discipline is used. In the field RP the 2 bytes short form SCA addresses of the second repeater and the final destination node are contained (see 6.2.5.2) and the field INF contains the 7 bytes LLC PDU. In the field SVT the CRC of the first 32 bits starting from LT is computed.

At Physical Layer, the fields Preamble, Unique word and Mode contain the values defined in 7.2.2, 7.2.3 and 7.2.4. The field P_payload contains the 24 bytes MA_sdu.

Annex D
(normative)

SMITP-BPSK specific definitions

D.1 Management of reserved elements

The management of the following elements of the technical specification described in this document is reserved to Meters and More Association:

- bit 2 and bit 3 of sub field DSAP in the LLC frame, see following D.2.

D.2 ECTL (Extended control) structure

ECTL consists of 1 byte divided in two Nibbles, identified as DSAP and ECC (2 * 4 bits):

- DSAP (Destination Service Access Point):
  - Bit 0-1 used to identify Upper Layer data or Network Management/Discovery and Registration:
    - 00 Upper Layer data;
    - 01 Network management/Discovery and Registration;
  - Bit 2-3 reserved.
- ECC (Encryption Coding Control):

it is used to discriminate what kind of encryption method is used to protect the payload field. The encryption functionality is available in both directions.

- 0000 Encryption disabled (default)
- xx10 reserved
- xx01 reserved
- x0xx reserved
- x1xx reserved

Bibliography

CLC/TS 50568-8:2015, *Electricity metering data exchange — The DLMS/COSEM suite – Part 8: PLC profile based on SMITP B-PSK modulation Including:The Original-SMITP PLC profile based on SMITP B-PSK modulation,The Original-SMITP Local data exchange profile and The Original-SMITP IP profile*

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