SLOVENSKI STANDARD
SIST-TS CLC/TS 50590:2015

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Izmenjava podatkov pri merjenju električne energije - Nižjenivojski PLC-profil, ki uporablja adaptivni razpršeni spekter za omrežja CX1 z več nosilc

Electricity metering data exchange - Lower layer PLC profile using adaptive multi-carrier spread spectrum for CX1 networks

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Electricity metering data exchange - Lower layer PLC profile using Adaptive Multi Carrier Spread-Spectrum (AMC-SS) modulation

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

This document (CLC/TS 50590:2015) 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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1 Scope

This Technical Specification specifies the physical layer, medium access control layer and logical link control layer for communication on an electrical distribution network between a master node and one or more slave nodes using a compatibly extendable form (CX1) of Adaptive Multi-Carrier Spread Spectrum (AMC-SS) technique. The adaptive cellular communication network technology provided in this specification may be used for automated meter reading as well as for other distribution network applications.

The[GK1] physical layer provides a modulation technique that efficiently utilizes the allowed bandwidth within the CENELEC A band (3 kHz – 95 kHz), offering a very robust communication in the presence of narrowband interference, impulsive noise, and frequency selective attenuation. The physical layer of AMC-SS is defined in Clause 5 of CLC/TS 50590:2015[GK2].

The data link (DL) layer consists of three parts, the ‘Medium Access Control’ (MAC) sub-layer, the Logical Link Control (LLC) sub-layer and the ‘Convergence’ sub-layer. The data link layer allows the transmission of data frames through the use of the power line physical channel. It provides data services, frame integrity control, routing, registration, multiple access, and cell change functionality. The MAC sub-layer and the LLC sub-layer of AMC-SS are defined in Clause 6 of CLC/TS 50590:2015. The Convergence sub-layer is defined in this document.

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

DIN 43863–5:2012-04, *Identification number for measuring devices applying for all manufacturers*

3 Terms, definitions and acronyms

3.1 Terms and definitions

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

3.1.1
device identifier
property that universally identifies a node

3.1.2
frame forwarding
procedure of PHY frame retransmission by a slave node or simultaneously by several slave nodes

3.1.3
higher layer entity
entity of the layer or sub-layer in OSI model, which is situated above the layer or sub-layer of the entity offering the services. A possible convergence sub-layer between the higher layer entity and the entity offering the services may be a null layer, which is as simple as possible without a special convergence capability

3.1.4
MAC frame
MAC sub-layer Protocol Data Unit (MPDU)

3.1.5
master node
node which controls and manages the resources of a network cell

3.1.6
message
LLC sub-layer Protocol Data Unit (MPDU)

3.1.7
network
set of network nodes that can communicate by complying with this specification and are identified by the same value of N_NIN

3.1.8
network cell
set of network nodes that can communicate by complying with this specification and share a single master node, which is identified by the CIN

3.1.9
node
any one element of a network cell which is able to transmit to and receive from other network elements

3.1.10
slave node
any node of a network cell which is not operating as a master node

3.1.11
PHY frame
a PHY Layer Protocol Data Unit (PPDU)

3.1.12
registration
procedure of master node assignment to a slave node

3.1.13
slave node registration
assignment of dynamic address information to a slave node

3.1.14
symbol
waveform used in the communication channel that persists for a fixed period of time

3.2 Acronyms

AC	Alternating Current
ACK	Acknowledgement
AGC	Automatic Gain Control
AMC-SS	Adaptive Multi-Carrier Spread-Spectrum
BNC	Backbone Network Connection
BTO	Beacon Time-Out Period
CCV	Code Connection Vector
CENELEC	European Committee for Electrotechnical Standardization
CFL	Carrier Frequency List
CIN	Channel Identification Number
CL	Convergence Sub-Layer
CONV	Convolutional Code
COSEM	Companion Specification for Energy Metering
CRC	Cyclic Redundancy Check
CRCINITVAL	CRC Initialization Value
CWD	Contention Window Duration
CX1	Compatibly extendable form [JK3]of AMC-SS PLC
D_ACK	Data Acknowledgement
DB	Data Block
DBL	Data Block Length
DFC	Data Flow Control
D8PSK	Differential Eight Phase Shift Keying
DBPSK	Differential Binary Phase Shift Keying
DID	Device Identifier
DL	Data Link
DLL	Data Link Layer
DLMS	Device Language Message Specification
DLS	Data Link Services
DP	Data Priority
DPSK	Differential Phase Shift Keying
DQPSK	Differential Quadrature Phase Shift Keying
FCB	Frame Count Bit
FCS	Frame Check Sequence
FCV	Frame Count Bit Valid
FEC	Forward Error Correction
FH	Frequency Hopping
FHCS	Frame Header Check Sequence
FMS	Frequency mapping schemes
FX	Frame Forwarding
FXDC	Frame Forwarding Down-Counter
FXS	Frame Forwarding Sector Address
FXT	Total Number of Frame Retransmissions
HLE	Higher Layer Entity
HTB	Header Tail Bits
Hz	Hertz
IEC	International Electrotechnical Commission
IFI	Interframe Interval
ITD	Initial Transmission Delay
kHz	kilo Hertz
L_FC	Link Function Code
L_NIN	Lower Byte of Network Identification Number
LA	Link Address
LCN	Link Channel Number
LLC	Logical Link Control
LLCF	Logical Link Control Field
LPDU	LLC Sub-Layer Protocol Data Unit
LSB	Least Significant Byte
LTS	Length of Training Sequence

N_NIN	Node Network Identification Number
M_CIN	Master Channel Identification Number
MAC	Medium Access Control
MA	Multicast Link-Address
MCN	Multicast Number
MN	Master Node
MPDU	MAC Protocol Data Unit
MSB	Most Significant Byte
NIN	Network Identification Number
NLA	New Link Address
NMAx	New Multicast Addresses
NSC	Network with Spreading/Shrinking Cells
p-MN	Primary Master Node
OSI	Open System Interconnection
PDDTH	Power-Down Duration Threshold
PDS	PHY Data Symbol
PDU	Protocol Data Unit
PDZ	PHY Data Zero Symbol
PHS	PHY Header Symbol
PHY	Physical Layer
PHZ	PHY Header Zero Symbol
PPDU	PHY Protocol Data Unit
PRM	Primary Bit
PRMB	Preamble
PSDU	PHY Service Data Unit
PSK	Phase Shift Keying
RC	Repetition Code
RES	Reserved
RN	Relaying Node
RZCO	Reference Zero-Crossing Offset
s-MN	Secondary Master Node
SCA	Scrambling Code Array
SCL	Scrambling Code Length
SN	Slave Node
SYNC	Synchronization Sequence
SYNCR	Synchronization Sequence Reference Symbols
SYNCS	Synchronization Sequence Symbols
S_CIN	Slave Channel Identification Number
S_FXENA	Slave Frame Forwarding Enable
S_FXS	Slave Frame Forwarding Sector
S_MAx	Slave Multicast Addresses
S_LA	Slave Link-Address
TB	Tail Bits
TLA	Temporary Link Address
TM	Transmit Mode
TNCW	Total Number of Contention Windows
TNS	Total Number of Symbols
TS	Training Sequence
TSS	Training Sequence Symbol
TSA	Training Sequence Array
TSL	Training Sequence Length

4 General description

Layers 1 and 2 transport the higher layer messages between the nodes of a low voltage distribution network. Layer 1 (physical layer, PHY) generates a physical signal that is sent over the medium. The data link layer (DLL, layer 2) is split up into three sub-layers: medium access control sub-layer (MAC, sub-layer 2a), logical link control sub-layer

(LLC, sub-layer 2b) and convergence sub-layer (CL, sub-layer 2c). The first two sub-layers of the data link layer perform the formatting of the frames, handle channel access and frame forwarding procedures, provide data integrity checks and are responsible for addressing, segmentation and message retransmission. The convergence layer provides adaptation to the specific higher layer protocol and may be transparent. The convergence layer is not part of this document but is defined in the profile specification. The convergence sub-layer provides a mapping between the primitives that are used by the higher layer entity, and the primitives of the logical link control sub-layer. Layer 2 also provides functionality of multiplexing and prioritization between different higher layer entities or applications (within a network node) and layer-2 networking. Furthermore, multiplexing of different protocol elements with DLMS/COSEM elements is specified herein. The structure of the lower layer PLC profile is shown in Figure 1.

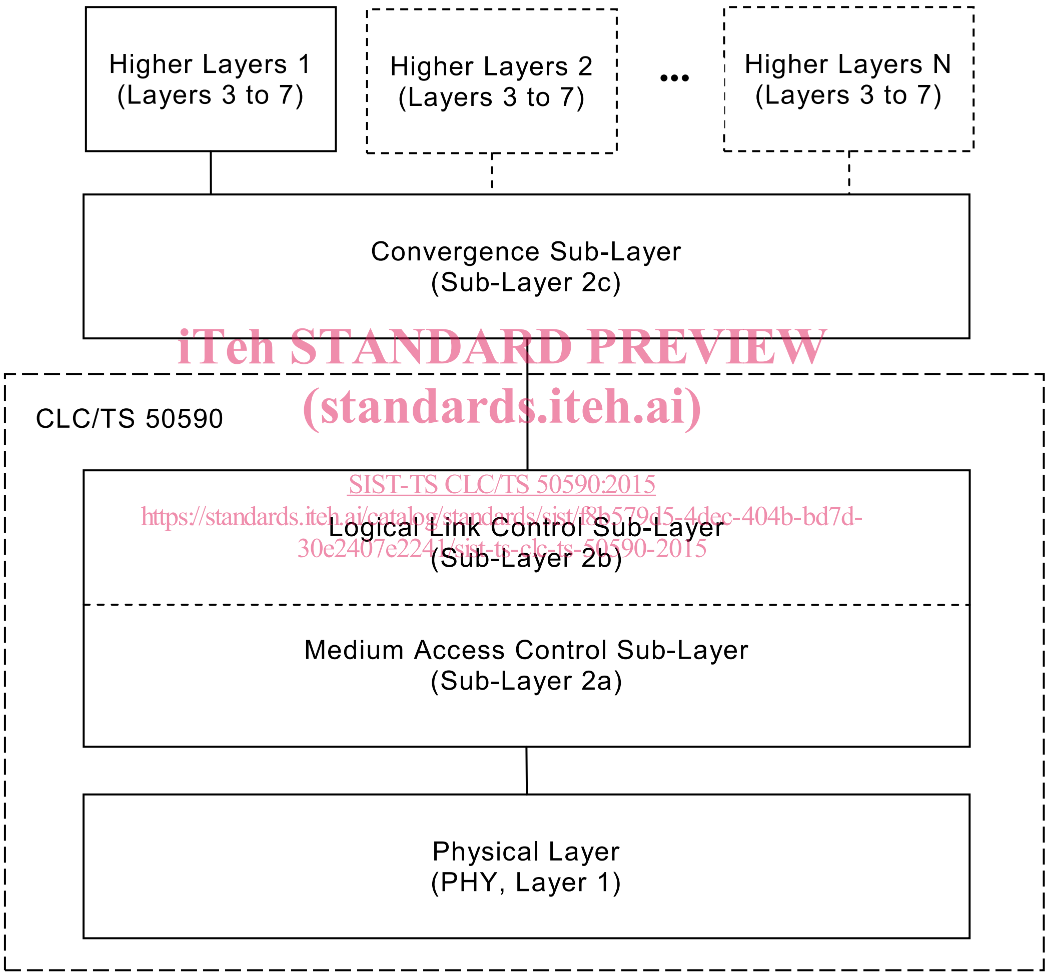

Figure 1 – Layers of AMC-SS profile

Information between layers is exchanged via primitives (see Figure 2). The following primitives are used for the communication between the logical link control sub-layer and the convergence sub-layer: DL_data.request, DL_data_identifier.confirm, DL_data.indication, DL_data.response, DL_data.confirm, DL_data_ack.response, DL_data_ack.confirm and DL_control.indication. For communication between the data link layer (LLC + MAC) and the physical layer the primitives P_data.request and P_data.indication are used.

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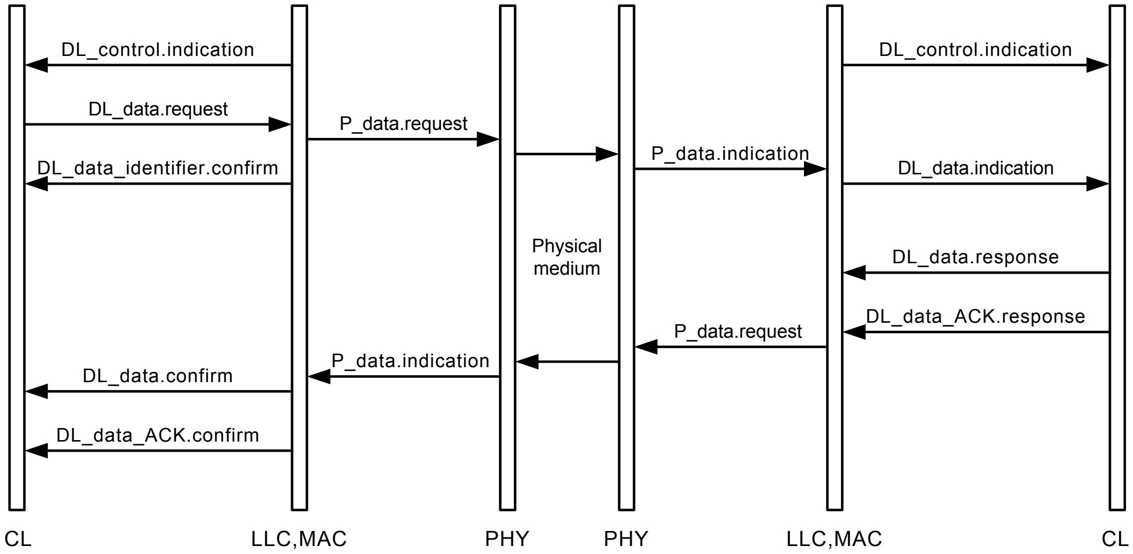

Figure 2 – Primitives

5 PHY layer specification

5.1 Overview

To generate physical signals, the AMC-SS physical layer uses a multi-carrier spread spectrum technique in combination with Differential Phase Shift Keying (DPSK) and forward-error-correction (FEC) coding.

This technique provides the following advantages:

- Robustness against time–frequency-selective fading;
- Robustness against pulse and narrowband interference, pulsating non-gaussian noise and combinations of them;
- Robustness against unwanted intermodulation effects;
- Lower linearity requirements for the analogue front end;
- High power efficiency as a result of low peak-to-average power ratio of the transmitted signal;
- Good electromagnetic compatibility between neighbouring systems.

The Figure 3 shows the block diagram of different data processing steps performed by the physical layer during the transmission of a PHY protocol data unit (PPDU).

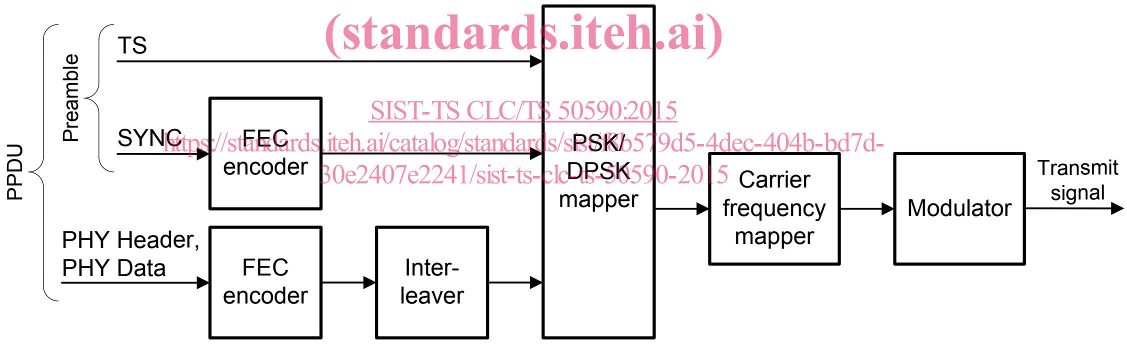

Figure 3 – PHY layer processing steps during PPDU transmission

Neither FEC-encoding nor interleaving is performed on the training sequence (TS). The bits of the synchronisation sequence (SYNC), the PHY header and PHY data are encoded with a FEC code. Encoded bit-sequences of the PHY header and PHY data are additionally interleaved. The training sequence and the encoded and interleaved bit sequences are mapped to the carrier phase angels depending on a PSK or a DPSK scheme and then to the carrier frequencies. The result of the PSK/DPSK and carrier frequency mapping is a sequence of unmodulated symbols containing modulation parameter. In the modulator these symbols are modulated and combined to a transmit signal, which is coupled into the physical channel – power-line.

The PHY layer processing steps during the reception of the PPDU are implementation specific and out of scope of this specification.

5.2 PHY protocol data unit

5.2.1 PPDU structure

5.2.1.1 General

The PPDU (i. e. PHY frame) consists of the preamble, the PHY header and the PHY data field. The preamble contains a training sequence (TS) and the synchronisation sequence SYNC. The PSK encoded elements of the TS are defined by the parameter TSL and the parameter array TSA (see Annex D).

Figure 4 below shows the bit-oriented structure of the PPDU (except training sequence), which is defined in Table 1 below.

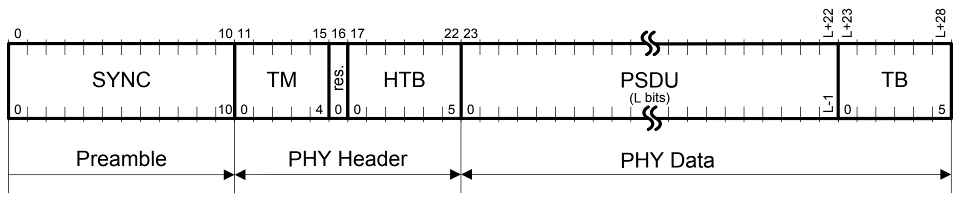

Figure 4 – Bit-oriented PPDU structure without TS

The bits of the PPDU (except TS) are numbered from 0 to L+28, where L is the length of PSDU in bits. In the following these bits are denoted as d_0, d_1, ..., d_k, ..., d_{L+28} .

Table 1 – PPDU structure without TS

Part of PPDU		Field	Bit number	Bits	Name	Value
Part of PPDU	Preamble	SYNC	10 to 0	11	Synchronisation bit sequence	0x247 - allowed value; 0x000 to 0x246 - unused; 0x248 to 0x7FF - unused.
	PHY Header	TM [a]	15 to 11	5	PHY data transmit mode number [a]	0x00 to. 0x14 - TM0 to TM20; 0x15 to 0x1F – reserved for future use.
		res.	16	1	Reserved bit for future use	0x0 - allowed value; 0x1 - not allowed.
		HTB	22 to 17	6	PHY header tail bits	0x00 - allowed value; 0x01 to 0x3F - not allowed.
	PHY Data	PSDU	23 to L+22	L [a]	PHY service data unit	PSDU = MPDU (cf. Table 9).
		TB [b]	L+23 to L+28	6	PHY data tail bits [b]	0x00 - allowed value; 0x01 to 0x3F - not allowed.

[a] L is the length of PSDU in bits. The value of L is handed over to the PHY layer from MAC sub-layer together with MPDU = PSDU and the value of TM using the primitive P_data.request defined in Sub-section 5.5.

[b] PPDU does not contain TB if TM = 16 to 20

For the transmission of the TS, SYNC, PHY header and PHY data different transmit modes are used (see Table 2 below).

Figure 5 shows symbolically the transmit signal (corresponding transmitted PHY frame) consisting of overlapped modulated symbols at the output of the modulator (cf. Figure 7 and Figure 8). The detailed PHY frame structure is described in the following sub-sections.