TECHNICAL SPECIFICATION

IEC TS 61334-5-5

First edition
2001-09

Distribution automation using distribution line carrier systems –

**Part 5-5:
Lower layer profiles –
Spread spectrum-fast frequency hopping (SS-FFH) profile**

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FOREWORD

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IEC 61334-5-5, which is a technical specification, has been prepared by IEC technical committee 57: Power system control and associated communications.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
57/489/CDV	57/518/RVC

Full information on the voting for the approval of this technical specification 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 3.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

- transformed into an International Standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This technical specification describes a new physical layer variant with respect to the already defined modulation techniques FSK and S-FSK within the IEC 61334 series (IEC 61334-5-1 and IEC 61334-5-2 [1])).

The SS-FFH profile outlined in this technical specification basically incorporates spread spectrum modulation techniques. It offers the main advantages of very high robustness and improved EMI characteristics without sharing classical spread spectrum drawbacks such as exaggerated bandwidth demand or impractical realization.

The profile specifies the physical layer including the transmission methods and the services provided by both the physical layer and medium access sublayer entities.

[1]) IEC 61334-5-1, *Distribution automation using distribution line carrier systems – Part 5-1: Lower layer profiles – The spread frequency shift keying (S-FSK) profile*

IEC 61334-5-2, *Distribution automation using distribution line carrier systems – Part 5-2: Lower layer profiles – Frequency shift keying (FSK) profile*

DISTRIBUTION AUTOMATION USING DISTRIBUTION LINE CARRIER SYSTEMS –

Part 5-5: Lower layer profiles – Spread spectrum-fast frequency hopping (SS-FFH) profile

1 Scope and object

This technical specification describes the requirements of the spread spectrum-fast frequency hopping (SS-FFH) approach for distribution line carrier communication systems. It incorporates the primitives provided by the physical and MAC layer entities as well as the modulation and transmission methods.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61334. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61334 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 61000-3-8, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 8: Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels*

IEC 61334-4-1, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 1: Reference model of the communication system*

IEC 61334-4-32, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 32: Data link layer – Logical Link Control (UC)*

ITU-T Recommendation V.42, *Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion*

3 Abbreviations and definitions

For the purpose of this technical specification, the following abbreviations and definitions apply.

3.1 Abbreviations

DA	Destination_address
DLC	Distribution Line Carrier
FFH	Fast Frequency Hopping
LV	Low Voltage
M_PDU	MAC Layer Protocol Data Unit
M_SDU	MAC Layer Service Data Unit
MAC, M, MA	Medium Access Control
MV	Medium Voltage
P_PDU	Physical Layer Protocol Data Unit
P_SDU	Physical Layer Service Data Unit
SC	Service_class
SDU	Service Data Unit
SS	Spread Spectrum

3.2 Definitions

3.2.1
chip
sinusoidal carrier waveform of limited time duration. Sequences of four chips form one symbol

3.2.2
domain
logical section of a DLC network

3.2.3
hops
number of routing repetitions required for communication between the master and a specific station

3.2.4
preamble
modulated signal sequence that precedes a data frame for synchronization purpose

3.2.5
routing repetition
re-sending a PDU with a modified protocol information field because the destination station can not be reached directly by the source station. The routing repetition procedure concerns only the protocol information field and is handled by the MAC sublayer

3.2.6
symbol
modulated signal that encodes two transmitted bits

4 Physical layer

4.1 Purpose

This clause details the transmission method to transport data frames provided by the MAC sublayer to and from peer MAC entities using the electrical low-voltage distribution network. It also specifies the requirements for the logical interface between the physical layer and the MAC sublayer.

4.2 Electrical characteristics

The physical layer interfaces directly with the low-voltage distribution wiring as transport medium. The electrical characteristics of the distribution network are AC, 230 V, 50/60 Hz. Network coupling may be either single- or three-phase.

4.3 Modulation principle

The modulation method is spread spectrum fast frequency hopping (SS-FFH) modulation. The basis of SS-FFH are time-limited sinusoidal carrier waveforms of a certain time duration T_C and different frequencies f_i i = 1 ... M. These carrier bursts are called chips. The reciprocal of the chip time duration T_C is called chip rate R_C. An information symbol is encoded by a sequence of subsequential chips as seen in figure 1.

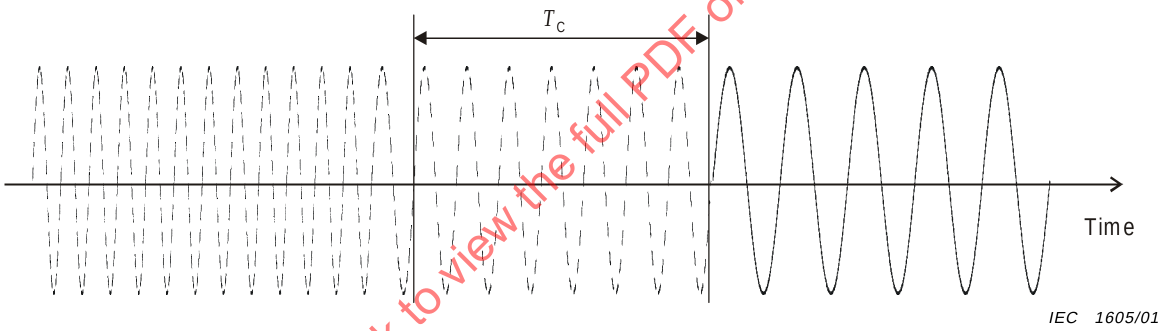

Figure 1 – Time representation of M = 3 SS-FFH symbol

Each frequency is used only once per sequence. For this reason, the number of symbols that can be encoded this way is M.

An example for M = 4 is given in the following.

Symbol	Bitmapping
S_1	00
S_2	01
S_3	10
S_4	11

Chip 1	Chip 2	Chip 3	Chip 4
f_1	f_2	f_3	f_4
f_2	f_3	f_4	f_1
f_3	f_4	f_1	f_2
f_4	f_1	f_2	f_3

IEC 1606/01

Figure 2 – Coding of information symbols in sequence of carrier chips

The mapping of symbols into two bit patterns is also shown in figure 2. The maximum number of bits that can be encoded with M different symbols is ld M. Thus the data rate R_D given the chip rate R_C is

$$R_D = \frac{R_C}{M} \times \text{ld}\,(M)$$

Spreading the information in the described way on numerous carriers has several advantages. First-symbol detection is possible with only one carrier present which makes SS-FFH very robust against interference. Second EMI regulations can be met more easily through the fact that the signalling energy is not confined to a narrow spectral segment.

SS-FFH provides the robustness unique to spread spectrum systems without sharing the drawbacks such as complicated synchronization or expensive system implementation.

4.4 Receiver principle

Demodulation and detection of symbols follows a soft decision algorithm. This means that quasi-analogue values for the presence or non-presence of each chip of a symbol are used for detection.

Four demodulated signals, one for each frequency j = 1 ... 4, are used for symbol detection for each of the subsequent chips k = 1 ... 4. As an example of a receiver architecture the receiver sums up the demodulated signals d_{jk} for four possible symbols.

$$DS_1 = d_{11} + d_{22} + d_{33} + d_{44}$$

$$DS_2 = d_{21} + d_{32} + d_{43} + d_{14}$$

$$DS_3 = d_{31} + d_{42} + d_{13} + d_{24}$$

$$DS_4 = d_{41} + d_{12} + d_{23} + d_{34}$$

Finally the symbol i with the largest sum DS_i is chosen.

NOTE Actual receiver realization has no influence on interoperability.

4.5 Synchronization

4.5.1 Bit timing

The basic timing unit is

$$t_B = 1/(6f_N)$$

where f_N denotes the mains frequency, for example, 50 Hz or 60 Hz.

Shorter intervals for bit timing may be generated by subdividing the basic unit. The basic unit itself is generated by dividing the time period between two voltage zero crossings of one phase by three. The beginning of a basic timing unit is demarked by basic timing markers. This procedure ensures synchronization of the basic timing units of any transmitter and receiver within a three-phase low-voltage network.

NOTE 1 Transmission delays are negligible for the data rates and typical distances considered in this document.

NOTE 2 Without violating the synchronization condition, fixed phase shifts between zero crossings and basic timing markers may be introduced. This phase shift must not be time variant and must be constant for the overall system.

4.5.2 Chip timing

The beginning of a chip sequence is demarked by the aforementioned bit timing.

Given a chip rate R_C, the symbol rate R_S is an integer multiple of R_C:

$$R_S = K \times R_C$$

4.5.3 Frame synchronization

Synchronization of frames is accomplished by preambles preceding the data frame. A pre-defined sequence of eight symbols is used for this purpose. Acknowledging that accurate preamble detection is mandatory for good overall system performance, two principles are deployed:

- preamble chip rate is substantially lower than data chip rate;
- a soft decision preamble detection algorithm is used. [1)]

The following binary sequence is used as a preamble.

Bit	1	0	0	1	0	1	1	1	0	0	1	0	0	0	1	1
Symbol	S_3		S_2		S_2		S_4		S_1		S_3		S_1		S_4	

The suggested preamble chip rate is half the data chip rate, resulting in a signalling energy which is two times higher for each transmitted symbol.

4.5.4 Enhanced bit synchronization

Synchronization may be enhanced by additionally using the preamble sequence for fine tuning of the chip timing.

4.6 Frequency sets

Any frequency in the range 9 kHz to 95 kHz, which is a multiple of 2,4 kHz may be chosen for signalling. Due to heavy interference at lower frequencies the upper end of this band is preferable. Suggested frequencies are 52,8 kHz, 62,4 kHz, 72 kHz and 86,4 kHz.

4.7 Physical frame encapsulation (see table 1 and figure 3)

Each physical layer data frame (P_PDU) consists of the physical layer data unit (P_SDU) and a preceding preamble (see 4.5.3).

Table 1 – P_PDU fields and rates

	Preamble	**P_SDU**
Length	8 symbols	26 octets
Chip rate	0,5 R_C	R_C

1) The actual preamble detection algorithm does not affect compatibility.

To ease implementation of the preamble detection algorithm, the very first symbol of the data unit (P_SDU) has the time duration of a preamble symbol. Thus, the P_SDU has the following actual structure.

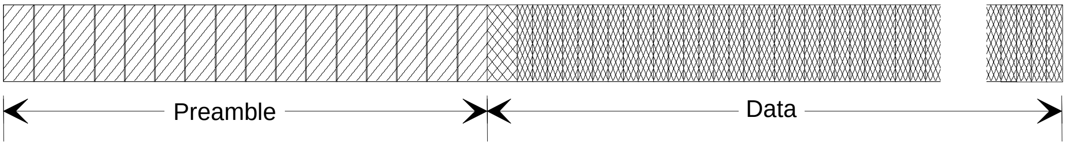

Figure 3 – Actual P_PDU representation

4.8 Symbol, bit and byte encoding

One byte is transmitted as a sequence of four symbols, each containing 2 bits (dibits). The LSB (rightmost) dibit of a byte is transmitted first.

4.9 Important parameters

In order to achieve compatibility, the values of the parameters of the physical layer must be agreed upon. Suggested parameters are

Signalling frequencies:	52,8 kHz, 62,4 kHz, 72 kHz and 86,4 kHz
Preamble symbols:	8
Preamble chip rate:	1 200 chip/s
Preamble bit sequence:	1001 0111 0010 0011
Data symbols:	13
Data chip rate:	2 400 chip/s
Gross bit rate:	1 200 bit/s
Phase shift zero crossing/basic timing markers:	90°

Transmitting signal voltage amplitude follows IEC 61000-3-8. Actual transmitting power is strongly influenced by the input impedance of the power grid for the signalling frequencies. For typical system implementation, amplitudes should be held stable in the range from under 1 Ω up to 10 Ω.

4.10 Physical layer data services

The physical layer data service primitives enable the MAC sublayers to transmit and receive M_PDUs to and from peer MAC sublayers.

There are three basic service primitives:

- P_Data.request
- P_Data.confirm
- P_Data.indication

4.10.1 Interface data units

The data units used by Phy primitives are P_SDUs. Each P_SDU has a fixed length of 26 bytes.

4.10.2 P_Data.request

4.10.2.1 Function

This primitive is used to request sending a P_SDU from the local Phy entity to one or several peer Phy entities.

4.10.2.2 Structure

The semantics of the primitive are as follows:

P_Data.request(
    P_SDU,
    tscl
)

P_SDU is the data unit passed to the Phy layer interface.

tscl defines three different transmitter synchronization classes:

s_sync: physical frame transmission starts with basic timing marker
z_sync: physical frame transmission starts with zero crossing
no_sync: physical frame is sent out immediately

4.10.2.3 Use

The primitive is generated by the MAC sublayer entity.

Reception of a P_Data.request causes the physical layer entity to wait for the proper synchronization moment (as defined by tscl), send out the preamble and the P_SDU.

4.10.3 P_Data.confirm

4.10.3.1 Function

The P_Data.confirm primitive provides an appropriate response to a P_Data.request primitive. It indicates proper transmission of a P_SDU by the Phy layer entity.

4.10.3.2 Structure

The semantics are as follows:

P_Data.confirm(Transmission_Status)

Transmission_Status specifies whether the previously issued Phy_Data.request primitive was executed successfully or not. The possible returned values are

P_OK: P_PDU was transmitted successfully
P_TU: Transmission failed due to temporarily unavailable resources at physical layer
P_HF: Hardware failure at the physical layer
P_SE: Syntax error

4.10.3.3 Use

The primitive is generated in response to a previously issued P_Data.request.

It is assumed that the MAC sublayer has sufficient information to associate the confirmation with the corresponding request.

4.10.4 P_Data.indication

4.10.4.1 Function

The primitive defines the transfer of data from the physical layer entity to the MAC sublayer entity.

4.10.4.2 Structure

The semantics of the primitive are as follows:

```
P_Data.indication(
        P_SDU
        )
```

4.10.4.3 Use

The P_Data.indication primitive is used to indicate reception and transfer the contents of a valid frame by the Phy layer entity to the MAC sublayer entity.

4.11 Physical layer management interface

The physical layer management interface gives means to access and modify certain variables of the physical sublayer to a local management entity.

4.11.1 Physical layer management variables

The following physical layer management variables are used to control and monitor physical layer functions. They can be read and written by local management entities.

4.11.1.1 delta_electrical_phase

Phase difference between mains voltage zero crossings provided to peer physical sublayers.

4.11.1.2 preamble_threshold

Controls the sensitivity of the preamble detection algorithm

4.11.1.3 max_receiving_gain

Sets the maximum gain of the automatic gain control of the receiver front end.

4.11.2 Physical layer management services

Services are provided for

- reading and writing of management variables;
- starting and stopping of processes;
- notification of events.

4.12 Physical layer states

The physical layer is at any time in one of the following states.

STARTUP: while waiting for hardware being initialized

PAQ: preamble acquisition

SNDF_E: await synchronization, send preamble, send data

SNDF_X: terminate sending

RCVF: receive frame

Initial state	Event	Action	Next state
STARTUP	initialized()=TRUE	none	PAQ
PAQ	P_Data.request(P_SDU) and check_Dreq(P_SDU)=OK	build_frame(P_SDU)	SNDF_E
PAQ	P_Data.request(P_PSDU) and check_Dreq(P_SDU)<>OK	P_Data.confirm(result=check_Dreq(P_SDU))	PAQ
PAQ	Prea_found()	recv_data(P_SDU)	RCVF
PAQ	PMread(PM_Variable) and check_PMreq()=OK	PMgetvalue(PM_Variable) PMconfirm(OK)	PAQ
PAQ	PMwrite(PM_Variable,PM_Value) and check_PMreq()=OK	PMsetvalue(PM_Variable,PM_Value) PMconfirm(OK)	PAQ
PAQ	PMread(PM_Variable) and check_PMreq()<>OK	PMconfirm(check_PMreq())	PAQ
PAQ	PMwrite(PM_Variable,PM_Value) and check_PMreq()<>OK	PMconfirm(check_PMreq())	PAQ
SNDF_E	sync()	snd_frame	SNDF_X
SNDF_X	fsent()	P_Data.confirm(result=OK)	PAQ
RCV	frcvd()	build_PSDU P_Data.indication(P_SDU)	PAQ

4.12.1 State functions and events

4.12.1.1 Prea_found()

This event indicates reception of a valid preamble.

TRUE: valid preamble is detected, next received symbol is data

FALSE: no valid preamble detected

4.12.1.2 check_Dreq(P_SDU)

This function checks the validity of a P_SDU for any physical layer service requests. Defined values are

P_OK: P_PDU was transmitted successfully

P_NI: Requested service is not implemented

P_ER: Transmission failed due to temporarily unavailable resources at physical layer

P_HF: Hardware failure at the physical layer

P_SE: Syntax error

4.12.1.3 check_PMreq()

This function checks requests to the physical layer management interface. Allowed return values are

P_OK: Request can be processed

P_NI: Requested service is not implemented

P_ER: Request will not be processed due to temporarily unavailable resources at physical layer

P_HF: Hardware failure at the physical layer

P_SE: Syntax error

4.12.1.4 sync()

The event is generated by physical layer according to the specified synchronization class tscl.

Three transmitter synchronization classes are defined:

s_sync: event occurs at each basic timing marker

z_sync: event occurs each zero crossing

no_sync: sync() always TRUE

4.12.1.5 fsent()

Event is generated by physical layer when entire frame has been sent.

4.12.1.6 initialized()

Monitors the initialization sequence of physical layer hardware. Returned values are

TRUE: initialization finished

FALSE: initialization in progress

4.12.1.7 frcvd()

Indicates the reception of a complete physical frame.

4.12.1.8 PMread()

Generated by local system management entity to read physical layer variables.

4.12.1.9 PMwrite()

Generated by local system management entity to write physical layer variables.

4.12.2 Actions

4.12.2.1 build_frame(P_SDU)

Builds up physical frame ready for transmission. Append P_SDU to preamble.

4.12.2.2 snd_frame

Sends out physical frame immediately.

4.12.2.3 recv_data

Receives data segment of frame immediately after preamble detection.

4.12.2.4 build_PSDU

Builds P_SDU from received physical frame.

4.12.2.5 PMgetvalue

Returns value of physical layer management variable.

4.12.2.6 PMsetvalue

Sets value of physical layer management variable.

4.12.2.7 PMconfirm

Generates primitive to indicate the processing result of management variable read or write requests.

5 Medium access control sublayer

5.1 Outline

The MAC/DLL sublayer provides unconfirmed data transfer primitives for exchange of variable length M_SDUs to and from peer MAC/DLL entities. This implies functions for

- reliable detection of transmission errors;
- composition and decomposition of variable length M_SDUs into M_PDUs;
- repeater capabilities.

Figure 4 illustrates communications between a local MAC entity and a remote MAC entity with a repeating MAC entity involved.

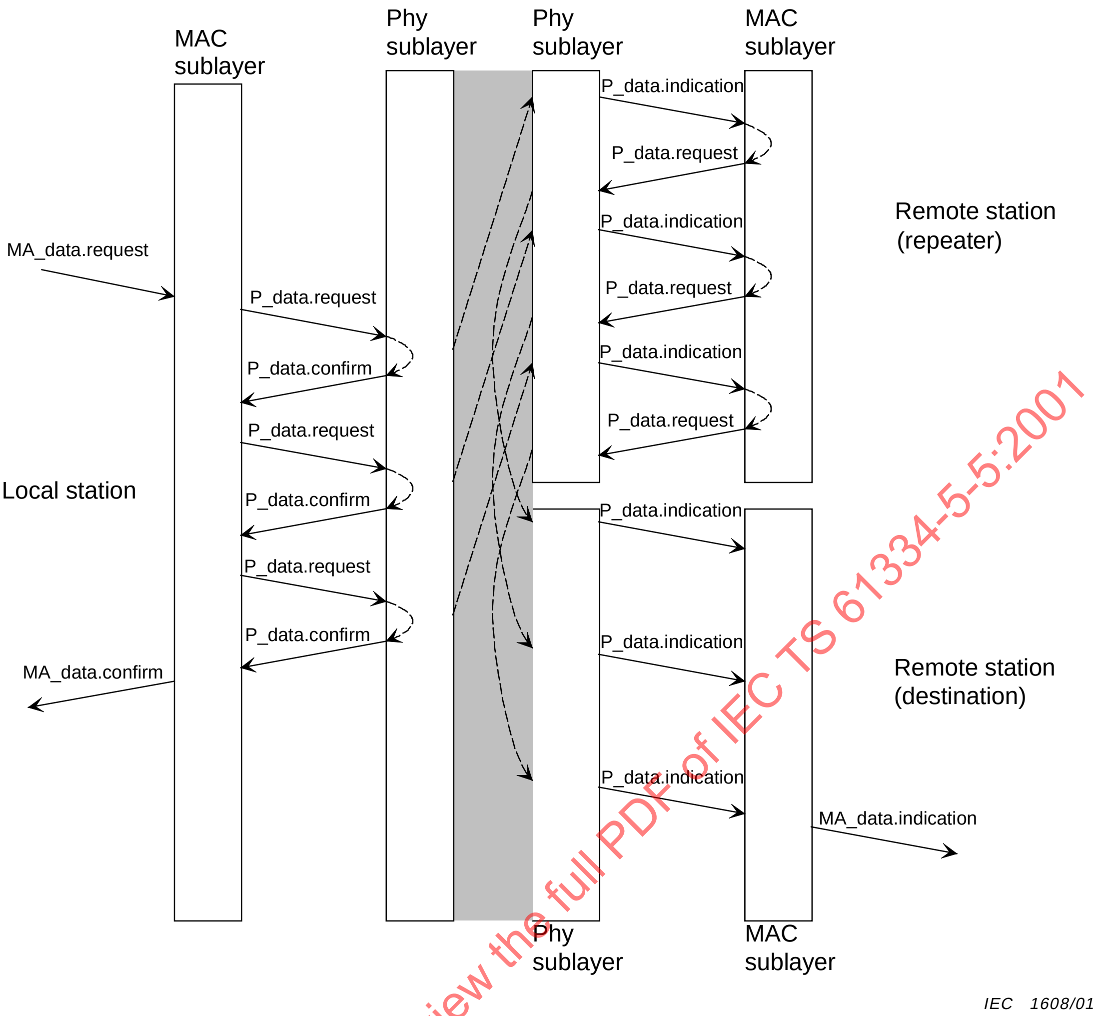

Figure 4 – MAC services

In the example given, the MAC sublayer of the local station decomposes the M_SDU into three P_SDUs (subframes). These are sent using the P_Data.request primitive.

The MAC entity of the repeater remote station synchronously resends all received P_SDUs as the received P_SDU is not addressed to this station.

The MAC entity of the addressed remote station rebuilds a M_SDU out of the received P_SDUs and provides it to a higher layer using the MA_Data.indication primitive.

5.1.1 Frame format

This subclause details the structure of data units used in the MAC sublayer entity.

Regardless of the frame format of the M_SDUs actually provided to the MAC sublayer from the LLC sublayer the MAC sublayer will construct MAC sublayer protocol data units M_PDUs. Each M_PDU has the following structure.

M_PDU			
Address	Protocol info	Data	Frame check
MADR	MPCI	M_SDU	MFCS
2 octets	16 bit	20 octets	16 bit

The field contents are outlined in the following.

5.1.1.1 MAC Address (MADR)

A structured address is used for MAC addressing. It carries only a destination address and is composed of two fields:

LV node (MADR.N): specifies the node or group of nodes within a domain

LV domain (MADR.D): specifies the low-voltage network domain or group of domains

MAC address (MADR)															
LV domain (MADR.D)								**LV_node (MADR.N)**							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
NOTE LV domains are not unique. They may be reused when absence of crosstalk between the reused domains is guaranteed.															

Pre-defined domain addresses	
LV domain MADR.D	**Use**
NoDomainMADR.D	Not used for any domain
AllDomainsMADR.D	To address all present domains

Mapping to IEC 61334-4-32 predefined MAC addresses	
IEC 61334-4-32	**SS-FFH MAC addresses**
"To All"	AllDomainsMADR.D, ToAllConfMADR.N
"New"	AllDomainsMADR.D, NewMADR.N
"To All Physical Systems"	AllDomainsMADR.D, ToAllPhyMADR.N
"NO-BODY"	NoDomainMADR.D, NoBodyMADR.N
Individual address	MADR.D, MADR.N

5.1.1.2 Protocol control field (MPCI)

MPCI carries additional protocol information fields, namely

- the subframe number (MPCI.SFC) that uniquely marks each subframe of a transmission;
- the first subframe flag (MPCI.FSF) that marks the very first subframe of a transmission;
- the total number of unsegmented payload bytes (MPCI.SLEN) of the M_SDU;
- the number of remaining routing repetitions (MPCI.HC) of the subframe.

The control field has the following structure.

MPCI															
MPCI. FSF	**MPCI.SFC**					**HC**		**MPCI.SLEN**							
0	4	3	2	1	0	1	0	7	6	5	4	3	2	1	0

5.1.1.3 Frame check sequence MFCS

A cyclic redundancy code (CRC) is used to create the frame check sequence. The entire frame consisting of address, PCI and data is protected against undetectable transmission errors.

The CRC is defined by its generator polynomial g(x) of degree 16:

$$g(x) = x^{16} + x^{14} + x^{12} + x^{11} + x^{8} + x^{5} + x^{4} + x^{2} + 1$$

or 15935 in hexadecimal notation.

Compared to the ITU-T CRC polynomial 11021hex, this code guarantees a higher hamming distance (5) for the used frame lengths of up to 257 bit/32 byte. Assuming a bit error rate of 10^{-3} for the physical layer the probability of undetected errors after CRC checking is better than 10^{-10}.

5.1.2 M_SDU Frame decomposition

In order to transfer variable length M_SDUs from and to peer LLC entities, data is segmented into one or more subframes as depicted in figure 5.

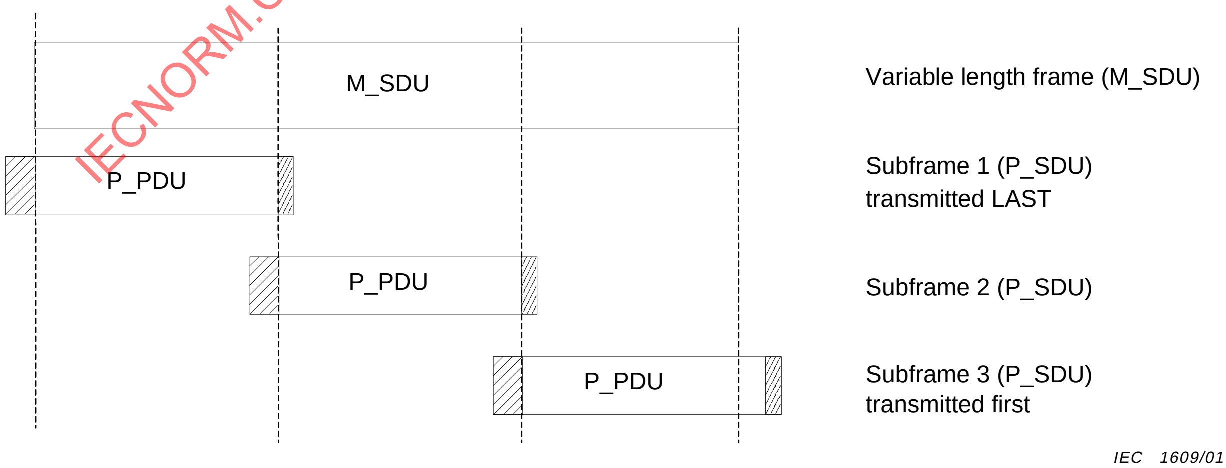

Figure 5 – Frame decomposition

5.1.2.1 Subframe order

The subframes are transmitted in reverse order, i.e. the first bits of the M_SDU are transmitted in the last subframe and vice versa.

5.1.2.2 MPCI values

Rules for the MPCI fields subframe counter, first subframe flag, are

- the first decomposed and transmitted subframe has

  MPCI.SFC = total number of subframes – 1

  MPCI.FSF = 1
- the relevant MPCI fields of the n-th subframe are

  MPCI.SFC = total number of subframes – n

  MPCI.FSF = 0
- the relevant MPCI fields of the last subframe are

  MPCI.SFC = 0

  MPCI.FSF = 0

5.2 Repeater principle

A flooding store forward repeater principle is used to overcome physical distance limitations of the powerline channel. Each MAC subframe carries a counter for the number of remaining routing repetitions (MPCI.HC). Upon reception of a M_PDU with non-zero repetition counter each MAC sublayer entity generates routing repetition M_PDUs. The routing repetition M_PDU differs from the originally received M_PDU only by the repetition counter that is decremented by one.

Sending out the routing repetition frame synchronously for all modem units of a domain is guaranteed by the corresponding physical sublayer entities. However, looking on a large number of repeating units, theoretical impairments due to synchronization uncertainties or wave propagation effects, can be neglected.

5.3 MAC layer data service definition

The MAC data service primitives are used to transfer data to and from peer MAC sublayer entities.

5.3.1 MA_Data.request

5.3.1.1 Function

This primitive defines the transfer of a M_SDU from the local MAC entity to one or multiple peer MAC entities in case of group addressing.

5.3.1.2 Structure

The semantics of the primitive are as follows:

MA_Data.request (
Destination_address,
M_SDU,
Service_class
)

Destination_address (DA) specifies either an individual or group MAC destination address. Corresponding to IEC 61334-4-1 (reference model) predefined group addresses are "To All", "New", "To All Physical Systems", "Masters" and "NO-BODY" (see 5.1.1.1).

M_SDU (MAC service data unit) specifies the data unit to be transferred by the MAC sublayer entity.

Service_class (SC) specifies the service class. Only service class 0 "confirm after transmission" is supported.

5.3.1.3 Use

The primitive is generated by the LLC sublayer entity.

Reception of this primitive will cause the MAC entity to decompose the provided M_SDU into one or more subframes, add appropriate protocol information and send the so formed M_PDUs to the lower protocol layer entities.

5.3.2 MA_Data.confirm

5.3.2.1 Function

The MA_Data.confirm primitive provides an appropriate response to a MA_Data.request primitive. It indicates successful or failed transmission of a M_SDU by the MAC sublayer entity.

5.3.2.2 Structure

The semantics are as follows:

MA_Data.confirm(Transmission_Status)

Transmission_Status (Tstat) specifies whether the previously issued MA_Data.request primitive was executed successfully or not. The possible returned values are

OK: Parameter fields successfully processed and resources available.

MA_TU: Transmission failed due to temporarily unavailable resources at MAC sublayer

MA_NI: Requested service or service class is not supported

MA_HF: Hardware failure at the MAC sublayer

MA_SE: Syntax error at MAC sublayer

5.3.2.3 Use

The primitive is generated in response to a previously issued MA_Data.request.

It is assumed that the LLC sublayer has sufficient information to associate the confirmation with the corresponding request.

5.3.3 MA_Data.indication

5.3.3.1 Function

The primitive defines the transfer of data from the MAC sublayer entity to the LLC sublayer entity.

5.3.3.2 Structure

The semantics of the primitive are as follows:

MA_Data.indication(
    Destination_address,
    Source_address,
    M_SDU
)

Destination_address (DA) specifies either a individual or group MAC destination address of the received frame.

Source_address (SA) specifies the individual MAC address of the originator of the received frame.

NOTE As source addresses are not supported by the physical sublayer, SA is replaced with the DA of a previously issued MA_Data.request.

M_SDU (MAC service data unit) specifies the data unit received by the MAC sublayer entity.

5.3.3.3 Use

The MA_Data.indication primitive is used to indicate reception of a valid frame by the MAC sublayer entity to the LLC sublayer entity.

5.4 MAC layer timeout values

5.4.1 Roundtrip delay

The maximum roundtrip time of a MAC request-response cycle includes the transmission time to the remote LLC entity including repeaters, remote LLC processing time and the transmission back to the local entity. It is calculated using the following terms.

T_{response}	The maximum response delay of a remote station
T_{rep}	The maximum processing delay of a repeating station
$N_{\mathrm{rep\_com}}$	The configured number of network hops in command direction
$N_{\mathrm{rep\_mon}}$	The configured number of network hops in monitor direction
T_{command}	Transmission time in command direction (without repeaters)
T_{monitor}	Transmission time in monitor direction (without repeaters)

$$T_{\mathrm{rmax}} = T_{\mathrm{command}} + (N_{\mathrm{rep\_com}} - 1) \times (T_{\mathrm{rep}} + T_{\mathrm{command}}) + T_{\mathrm{response}} + T_{\mathrm{monitor}} + (N_{\mathrm{rep\_mon}} - 1) \times (T_{\mathrm{rep}} + T_{\mathrm{monitor}})$$

The transmission times can be calculated using:

M_{data} Length in bits of the P_PDU data field

M_{prea} Length in bits of the P_PDU preamble

R_{data} Data bit rate

R_{prea} Preamble bit rate

$$T_{command} = T_{monitor} = \frac{1}{R_{prea}} \times (M_{prea} + 1) + \frac{1}{R_{data}} \times (M_{data} - 1)$$

Using the values given in 4.9, the one-way transmission time is

$$T_{command} = T_{monitor} < 200 \text{ ms.}$$

5.5 MAC sublayer management services

The MAC sublayer management service primitives provide the following functions to a local management entity.

- indication of events occurring in the MAC sublayer entity
- reading and writing of MAC parameters.

Figure 6 illustrates the MAC management primitives.

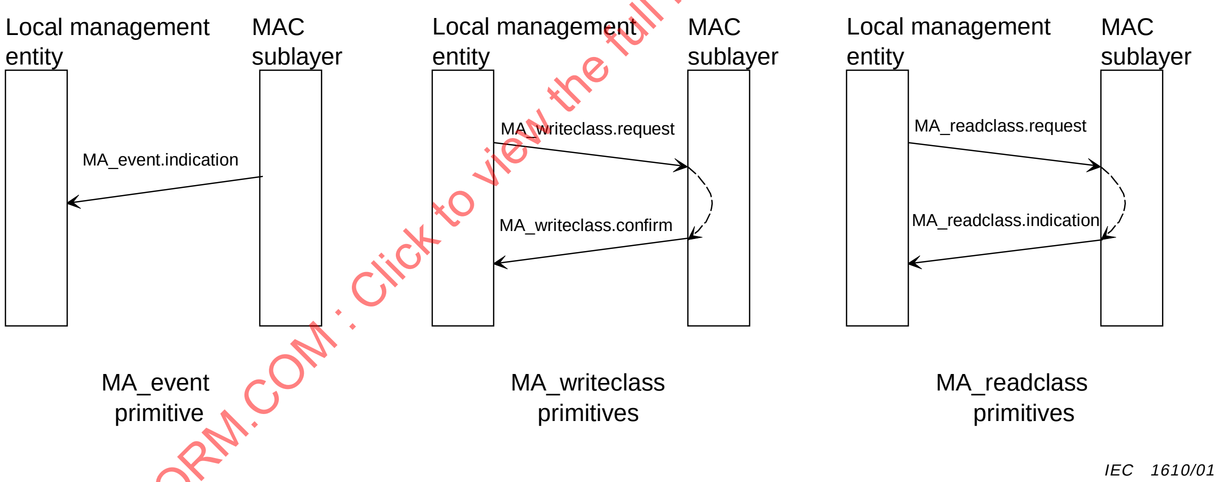

Figure 6 – MAC management services

5.5.1 MA_event.indication

5.5.1.1 Function

This primitive defines the transfer of information on events occurred in the MAC sublayer.

5.5.1.2 Structure

The semantics of the primitive are

MA_event.indication(
    Event_class,
    Event_value1,
    Event_value2,
    Event_value3,
    Event_value4,
    Event_value5,
    Event_value6,
    Event_value7,
    Event_value8,
)

Event_class specifies the type of the event occurred.
Event_value specifies additional values, depending on the event_class.

5.5.1.3 Use

MA_event.indication indicates the occurrence of various events in the MAC sublayer entity.

5.5.2 MA_writeclass.request

5.5.2.1 Function

This primitive defines the writing of MIB objects in the MAC sublayer entity.

5.5.2.2 Structure

The semantics of the primitive are

MA_writeclass.request(
    Parameter_class,
    Parameter_value1,
    Parameter_value2,
    Parameter_value3,
    Parameter_value4,
    Parameter_value5,
    Parameter_value6,
    Parameter_value7,
    Parameter_value8,
)

Parameter_class specifies the specific parameter class of the MAC sublayer entity to be written.

Parameter_value specifies the value of the parameters to be written.

5.5.2.3 Use

MA_writeclass.request is used to write a parameter class consisting of up to eight parameter values in the MAC sublayer entity.

5.5.3 MA_writeclass.confirm

5.5.3.1 Function

This primitive corresponds to the MA_writeclass.request and defines transmission of status data from the MAC sublayer entity to the local management entity.

5.5.3.2 Structure

The semantics of this primitive are as follows:

MA_writeclass.confirm(Status)

Status specifies whether the previously issued MA_writeclass.request was executed correctly or not. Status may have the following values.

OK: Request to write was executed successfully

MA_NI: Write to requested class not implemented or denied

MA_SE: Syntax error

MA_HF: Hardware failure at MAC sublayer.

5.5.3.3 Use

MA_writeclass.confirm informs the local management entity about the success of previously issued MA_writeclass.request.

5.5.4 MA_readclass.request

5.5.4.1 Function

This primitive defines the reading of internal MAC sublayer parameters.

5.5.4.2 Structure

The semantics of the primitive are

MA_readclass.request(
    Parameter_class,
)

Parameter_class specifies the set of eight parameters to be read.

5.5.4.3 Use

MA_readclass.request is used to read parameters from the MAC sublayer entity to a local management entity. It causes the MAC sublayer entity to read the desired parameters and send them to the management entity using the MA_readclass.indication primitive.