

# Distribution automation using distribution line carrier systems —

## Part 5: Lower layer profiles —

### Section 1: Guide to Spread Frequency Shift Keying (S-FSK) profile

ICS 33.200; 35.100.05

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# National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power system control and associated communications, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the IEC title page, pages ii to iv, pages 1 to 35 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

### Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------|----------|
|          |      |          |
|          |      |          |
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|          |      |          |

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**RAPPORT  
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**Automatisation de la distribution à l'aide  
de systèmes de communication à courants  
porteurs –**

**Partie 5:  
Profils des couches basses –  
Section 1: Profil S-FSK  
(Spread Frequency Shift Keying)**

**Distribution automation using  
distribution line carrier systems –**

**Part 5:  
Lower layer profiles –  
Section 1: Spread Frequency  
Shift Keying (S-FSK) profile**



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

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Foreword

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- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example “state of the art”.

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 1334-5-1, which is a technical report of type 2, has been prepared by IEC technical committee 57: Power system control and associated communications.

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

| Committee draft | Report on voting |
|-----------------|------------------|
| 57(SEC) 199     | 57/243/RVC       |

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

This document is issued in the type 2 technical report series of publications (according to G.3.2.2 of part 1 of the IEC/ISO Directives) as a “prospective standard for provisional application” in the field of Spread Frequency Shift Keying (S-FSK) profile for distribution automation using distribution line carrier systems because there is an urgent requirement for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this type 2 Technical Report will be carried out not later than three years after its publication, with the options of either extension for a further three years or conversion to an International Standard or withdrawal.

Annex A and Annex B form an integral part of this technical report.

## 1 General

### 1.1 Scope and object

This Technical Report of type 2 describes the requirements of Spread Frequency Shift Keying modulation in conjunction with the services provided by the Physical Layer Entity and of the MAC sublayer. The transmission medium is assumed to be the distribution network on both MV or LV level. The MAC sublayer described in this document interfaces to the Logical Link Control layer described in IEC 1334-4-32.

The three parts: modulation, physical layer and MAC sublayer are matched to each other such that an optimum cost-performance relation can be achieved.

The profile described in this report is one of several profiles (of the IEC 1334-5 series) which are all designed for data transmission via the distribution network. Considering the ongoing technical development in this field the profiles are published as Technical Reports of type 2 with the intention to transform those profiles which are successful in practice into standards.

### 1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 1334-1-4:1995, *Distribution automation using distribution line carrier systems — Part 1: General considerations — Section 4: Identification of data transmission parameters concerning medium and low-voltage distribution mains*.

IEC/FDIS 1334-4-32, *Distribution automation using distribution line carrier systems — Part 4: Data communication protocols — Section 32: Data link layer — Logical link control*<sup>1)</sup>.

ISO 7498-1:1994, *Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model*.

ISO 7498-3:1989, *Information processing systems — Open Systems Interconnection — Basic Reference Model — Part 3: Naming and addressing*.

EN 50065-1:1991, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz — Part 1: General requirements, frequency bands and electromagnetic disturbances*.

### 1.3 Definitions

For the purpose of this Technical Report, the definitions of ISO 7498-1 and EN 50065-1 apply.

## 2 Modulation

### 2.1 Purpose

S-FSK is a modulation and demodulation technique which combines some of the advantages of a classical spread spectrum system (e.g. immunity against narrow band interferers) with the advantages of a classical FSK system (low complexity, well-investigated implementations).

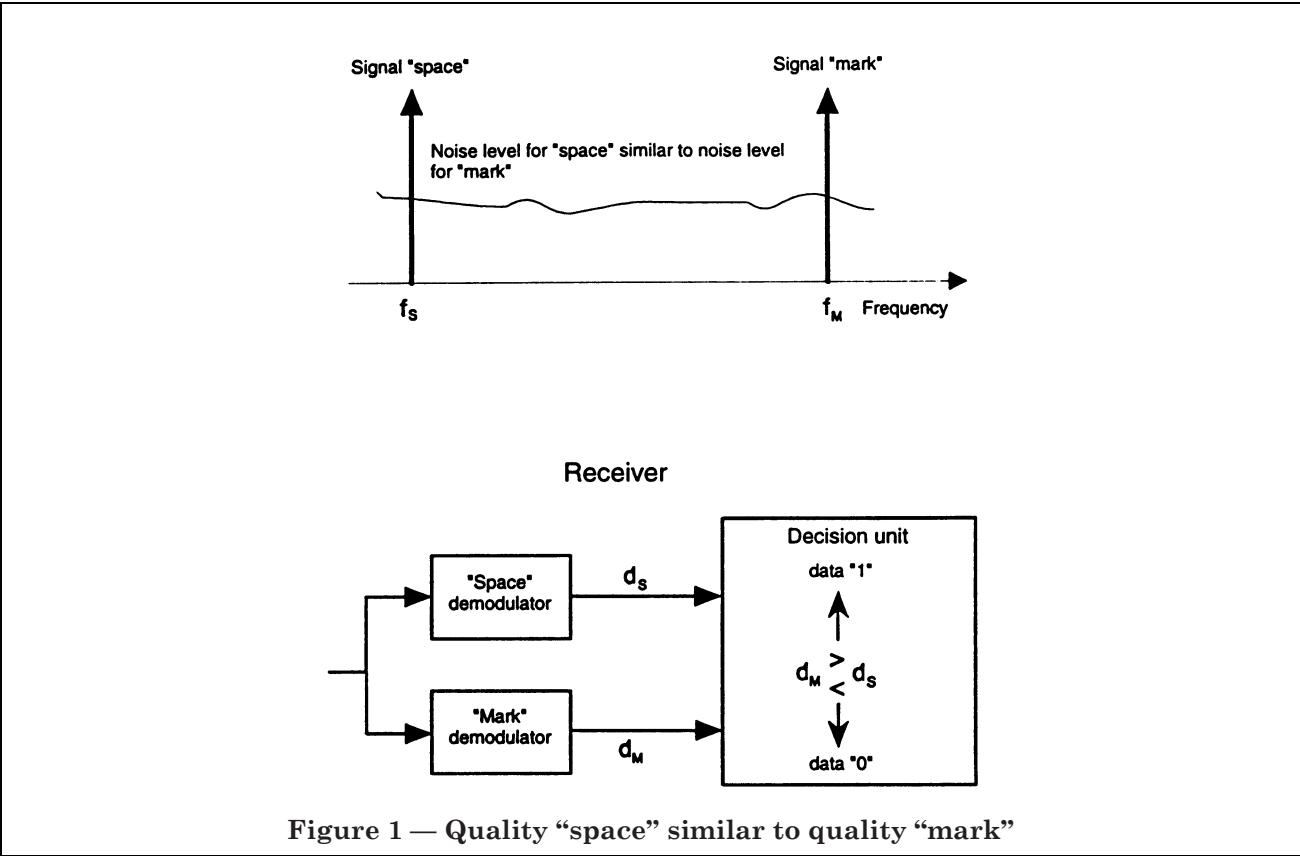
### 2.2 The Spread Frequency Shift Keying (S-FSK) principle

The transmitter assigns the Space frequency  $F_s$  to “data 0” and the Mark frequency  $F_M$  to “data 1”. The difference between S-FSK and the classical FSK lies in the fact that  $F_s$  and  $F_M$  are now placed far from each other (spreading). By placing the signal for “space” far from the signal for “mark” their transmission quality becomes independent (the strengths of the small band interferences and the signal attenuations are both independent at the two frequencies).

<sup>1)</sup> At present at the stage of Final Draft International Standard (57/266/FDIS).

The receiver performs conventional FSK demodulation at the two possible frequencies (the half-channels) resulting in two demodulated signals  $d_s$  and  $d_m$ . If the average reception quality of the two half-channels is similar (see Figure 1), then the decision unit decides on the higher of the two demodulated channels (“data 0” if  $d_s > d_m$ , “data 1” if  $d_s < d_m$ ). If, however, the average reception quality of one half-channel is significantly better than the quality of the other half-channel (see Figure 2), then the decision unit compares the demodulated signal of the better channel with a threshold  $T$ , thus ignoring the worse channel.

The quality measurements and the threshold computation may be based on a predefined preamble which precedes the transmission of the actual data frame.



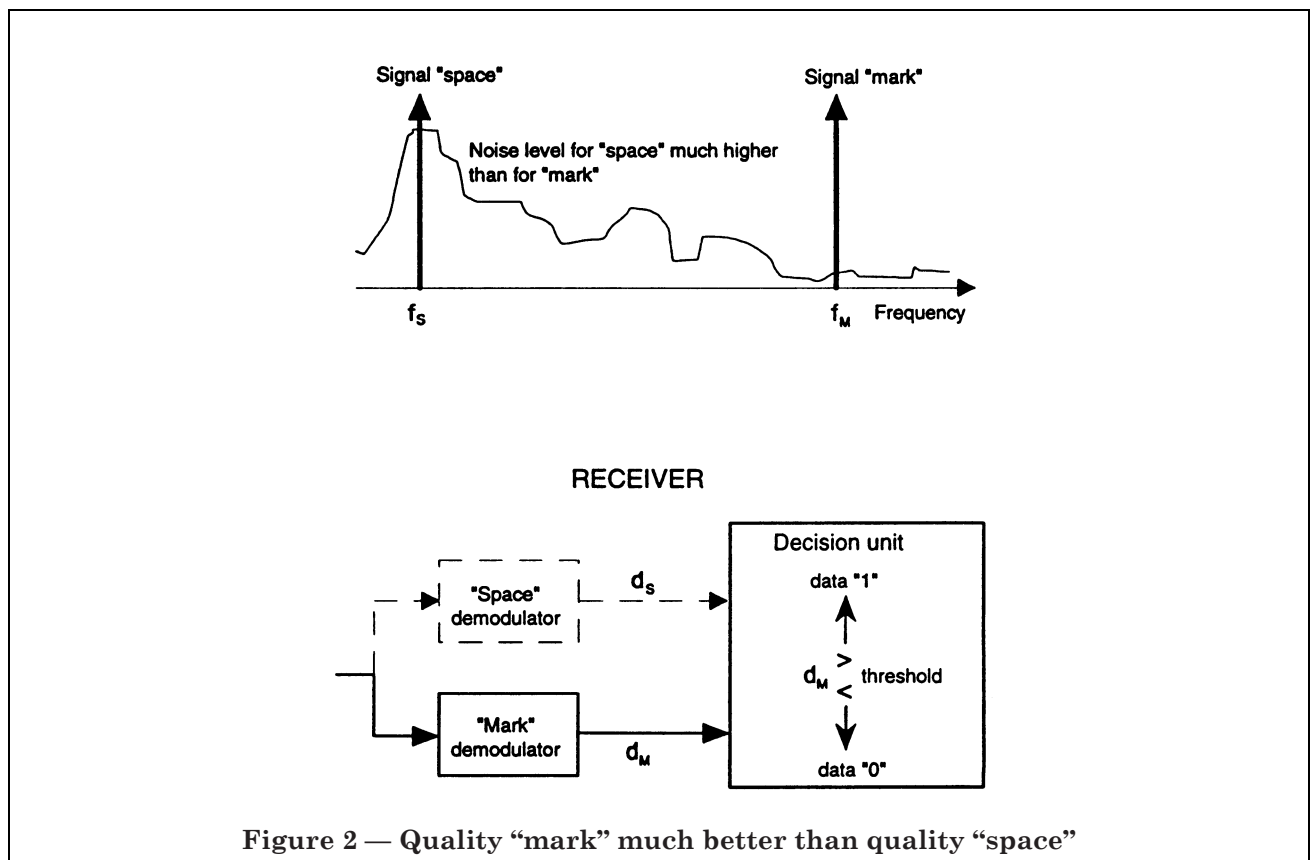


Figure 2 — Quality “mark” much better than quality “space”

The ratio between the two signal energy levels is denoted as energy ratio  $x$ , where  $x = E_{b1}/E_{b0}$ . The following  $E_b/N_0$  values Shall not be exceeded while achieving the given BERs.

Table 1 — Maximum  $E_b/N_0$  allowed to achieve a given BER

| BER               | $-5 \text{ dB} < x < 5 \text{ dB}$ | $x = \pm 10 \text{ dB}$   | $x = \pm 20 \text{ dB}$   |
|-------------------|------------------------------------|---------------------------|---------------------------|
| $10^{-5}$         | $E_b/N_0 < 21 \text{ dB}$          | $E_b/N_0 < 17 \text{ dB}$ | $E_b/N_0 < 7 \text{ dB}$  |
| $10^{-4}$         | $E_b/N_0 < 19 \text{ dB}$          | $E_b/N_0 < 15 \text{ dB}$ | $E_b/N_0 < 5 \text{ dB}$  |
| $10^{-3}$         | $E_b/N_0 < 17 \text{ dB}$          | $E_b/N_0 < 13 \text{ dB}$ | $E_b/N_0 < 3 \text{ dB}$  |
| $10^{-2}$         | $E_b/N_0 < 14 \text{ dB}$          | $E_b/N_0 < 11 \text{ dB}$ | $E_b/N_0 < 1 \text{ dB}$  |
| $10^{-1}$         | $E_b/N_0 < 10 \text{ dB}$          | $E_b/N_0 < 7 \text{ dB}$  | $E_b/N_0 < -3 \text{ dB}$ |
| $2 \cdot 10^{-1}$ | $E_b/N_0 < 8 \text{ dB}$           | $E_b/N_0 < 4 \text{ dB}$  | $E_b/N_0 < -5 \text{ dB}$ |

NOTE The  $E_b/N_0$  limits should serve as guidelines. They are at least 3 dB above the theoretically achievable values.

## 2.3 The spreading

The values for the absolute frequency deviation  $|F_M - F_S|$  should be such that the signal transmission qualities at  $F_M$  and at  $F_S$  are independent of each other. Taking into account the measurements presented in IEC 1334-1-4 it is recommended to use  $|F_M - F_S| > 10 \text{ kHz}$ .

## 2.4 Performance tests

### 2.4.1 Purpose

The quality of the implementation is guaranteed by different performance tests. The tests can be performed under laboratory conditions and shall be reproducible.

The BER (bit error rate) measurements are made by transmitting a preamble, a frame delimiter followed by a block of 38 bytes of data. It is assumed that no frame synchronization errors are encountered. The BER is measured by counting the errors in the block of data.

The tests which will be described in the following shall be accomplished for receiver input signals in the range of  $2 \text{ mV}_{\text{rms}}$  to  $2 \text{ V}_{\text{rms}}$ .

Different kinds of interferer are added to the transmitted signal.

#### 2.4.2 White noise BER tests

White Gaussian Noise is added to the transmitted signal.

$N_0$  [W/Hz] denotes the noise power spectral density measured at the input of the receiver at frequencies  $f_c - f_d$ ,  $f_c$  and  $f_c + f_d$ . It shall be ensured that the noise spectrum is flat between  $f_c - f_d$  and  $f_c + f_d$ .

$E_b$  [Ws] denotes the received signal energy per bit.  $E_b = V_{\text{signal}}^2 (\text{r.m.s.}) \cdot 3,333 \cdot 10^{-3} \text{ s}$ , where  $V_{\text{signal}} (\text{r.m.s.})$  is the true r.m.s. (root mean square) value of the transmitted signal at the receiver input. The bandwidth of the r.m.s. voltmeter shall be such that the entire frequency range of the signal is considered.

Because the channel may behave differently for the two transmitted frequencies (different noise levels and/or different attenuations) the AWGN (additive white Gaussian noise) tests are made using different signal levels.  $E_{b1}$  is the energy of the received signal if “logical 1” is transmitted,  $E_{b0}$  is the energy of the received signal if “logical 0” is transmitted. The average energy per bit then becomes  $E_b = (E_{b1} + E_{b0})/2$ .

#### 2.4.3 Narrowband interferer BER tests

One sinusoidal interferer of frequency  $f_N$  is added to the transmitted signal. The average interferer power is  $S_N = V_{\text{interferer}}^2 (\text{r.m.s.})$ . The average signal power is  $S_s = V_{\text{signal}}^2 (\text{r.m.s.})$ .

For  $S_N/S_s < 30 \text{ dB}$  no errors shall be encountered ( $\text{BER} < 10^{-5}$ ) for any frequency  $20 \text{ kHz} < f_N < 95 \text{ kHz}$ .

#### 2.4.4 Impulsive noise BER tests

Periodic impulsive noise with an amplitude of 5 V peak-to-peak, a frequency  $F$  and duty cycles between 10 % and 50 % is used. The signal amplitude is set to  $20 \text{ mV}_{\text{rms}}$ . The BER shall be lower than  $10^{-5}$  for  $F=100 \text{ Hz}$  and  $F=1\,000 \text{ Hz}$ .

### 3 Physical layer

#### 3.1 Purpose

This clause covers the services required of the DCP Physical Layer Entity at the logical interfaces with the MAC sublayer. It also defines the transmission methods which are used to provide the information flow through the physical channel (LV power distribution network).

#### 3.2 Transmission method

Distribution line signalling equipment will interface with distribution power-line wiring systems with the following characteristics:

- a) AC single-phase or 3-phase;
- b) 50 Hz or 60 Hz  $\pm 10\%$ ;
- c)  $230 \text{ V}_{\text{rms}}$  (min.  $190 \text{ V}_{\text{rms}}$ , max.  $250 \text{ V}_{\text{rms}}$ ) or  $110 \text{ V}_{\text{rms}}$  (min.  $90 \text{ V}_{\text{rms}}$ , max.  $130 \text{ V}_{\text{rms}}$ ).

##### 3.2.1 Coding

Non-return-to-zero (NRZ) coding is used.

##### 3.2.2 Bit timing

The maximum duration of a data (transmission moment) is 3,333 ms. The defined bit duration corresponds to a minimum transmission speed of 300 bits per second.

The duration of 3 data bits might correspond to the time interval between two succeeding zero crossings of one of the three phases of the mains. When mains are synchronized to the mains, the data bits are placed in time such that the start of every third bit corresponds to the zero crossing of one phase. This means that bit synchronization can be achieved by dividing the interval between two zero crossings of one of the three phases by three. Other transmission speeds which are multiples of 300 bits/s (600 bits/s, 900 bits/s, 1 200 bits/s, etc.) are possible.

### 3.2.3 Frame timing

The **PHY\_frames** (consisting of: preamble, start subframe delimiter, MAC-subframe, pause) are transmitted during predefined time slots (see Figure 3); meaning that the PHY\_frames will always start at integer multiples of the **basic time slot duration**. These time instances are called **slot indicators**. After slot synchronization is achieved, the physical layer of each unit will keep track of the slot indicators independently by means of its internal clock.

### 3.2.4 Slot timing

The system-wide synchronization of the slot indicators is achieved by means of the **PHY\_sync\_frame**. The synchronization procedure is initiated from the application layer.

The MAC\_frame corresponding to the **PHY\_sync\_frame** has the following structure.

Frame indicator:

FI:= long frame

Number of subframes:

NS:= 1

Initial and current credit:

IC:= 7 (hex), CC:= -

Source and destination addresses:

SA:= INITIATOR, DA:= NOBODY

Pad length:

PL:= 00 (hex)

Data field:= L\_PDU:= ( DSAP:=FF, SSAP:=INITIATOR, CF:=B0, [20 times AA][55 93 96])

Frame check sequence:

FCS:= according to DATA

## 3.3 Packet encapsulation

### 3.3.1 Purpose

In order to ensure optimum robustness against synchronization errors at the physical level a PHY\_frame consists of a PHY\_SDU (38 bytes) which is encapsulated with a preceding preamble (2 bytes) followed by the subframe delimiter (2 bytes) and a succeeding pause (3 bytes).

### 3.3.2 Preamble

16 bit field: AAAA (hex).

The preamble serves the following purposes: fine tuning of the bit synchronization (if necessary), adaptation of the thresholds for the demodulator, adaptation of the automatic gain control (AGC).

### 3.3.3 Start subframe delimiter

16 bit field: 54 C7 (hex).

The purpose of the frame delimiter is to check the frame timing and to resynchronize its slot indicators if necessary.

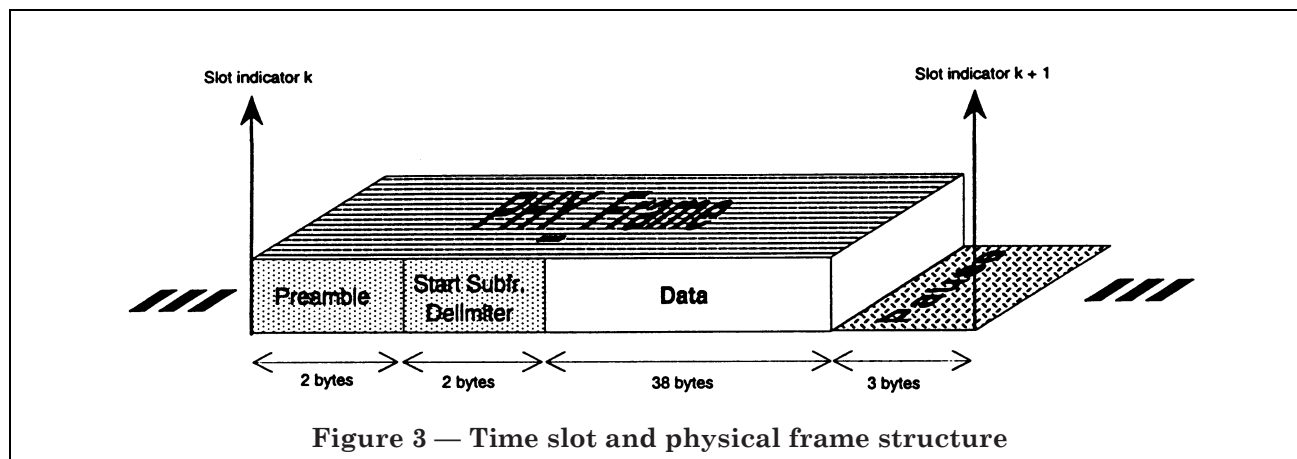
### 3.3.4 Pause

24 bit (for non-multiplexed systems) field of no transmission.

The purpose of the pause is twofold:

- a) to give the receiver time to perform demodulation, decoding and data processing before it has to be ready for the next frame;
- b) if the length of the pause is longer than 42 bytes, then time multiplexing of different systems becomes possible.

This last feature becomes particularly important when the DCP system has to operate in a meshed distribution network where the stations have access to several initiators. In this case slot synchronization between the initiators is necessary.



## 3.4 Physical layer services definitions

### 3.4.1 General description

The PHY\_Data services provided by the physical layer allow the MAC sublayer entity to transfer a single M\_PDU to a peer MAC sublayer entity or entities using the low-voltage distribution network as the transport medium.

There are three service primitives.

- PHY\_Data.request
- PHY\_Data.confirm
- PHY\_Data.indication

### 3.4.2 PHY\_Data.request

#### 3.4.2.1 Function

This primitive defines the transfer of data from a local MAC sublayer entity to a single peer MAC entity or multiple peer MAC entities in the case of a group address.

#### 3.4.2.2 Structure

The semantics of the primitive are as follows.

```
PHY_Data.request (
    PHY_SDU
)
```

#### 3.4.2.3 Use

This primitive is generated by the MAC sublayer entity whenever data shall be transmitted to a peer MAC entity or entities. This can be in response to a request from higher layers of protocol.

The receipt of this primitive will cause the PHY entity to construct a PHY\_frame as described in Figure 3 and the transfer to the peer PHY layer entity or entities.

### 3.4.3 PHY\_Data.confirm

#### 3.4.3.1 Function

This primitive has only local significance and provides an appropriate response to the MAC sublayer entity which initiated a PHY\_Data.request primitive. The PHY\_Data.confirm primitive tells the MAC sublayer entity whether the PHY\_frame of the previous PHY\_Data.request has unsuccessfully been transmitted on the medium.