

**Verteilungsautomatisierung mit Hilfe von Trägersystemen auf
Verteilungsleitungen**Teil 5-1: Profile der unteren Schichten – Profil für erweiterte Frequenzsprungmodulation (S-FSK)
(IEC 61334-5-1:2001) Deutsche Fassung EN 61334-5-1:2001, Text Englisch**DIN****EN 61334-5-1**

ICS 29.240.99; 33.040.40 ;35.100.05

Distribution automation using distribution line carrier systems –

Part 5-1: Lower layer profiles –

The spread frequency shift keying (S-FSK) profile

(IEC 61334-5-1:2001); German version EN 61334-5-1:2001, Text in English

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

Partie 5-1: Profils des couches basses –

Profil S-FSK (modulation par saut de fréquences étalées)

(CEI 61334-5-1:2001); Version allemande EN 61334-5-1:2001, texte en anglais

Die Europäische Norm EN 61334-5-1:2001 hat den Status einer Deutschen Norm.**Beginn der Gültigkeit**

Die EN 61334-5-1 wurde 2001-06-01 angenommen.

Nationales Vorwort

Für die vorliegende Norm ist das nationale Arbeitsgremium K 461 „Elektrizitätszähler“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE zuständig.

Die der EN 61334-5-1 zugrunde liegende internationale Norm IEC 61334-5-1 hat das Technische Komitee 57 „Power systems control and associated communications“ (Netzleittechnik und zugehörige Kommunikationstechnik) der Internationalen Elektrotechnischen Kommission (IEC) unter Mitwirkung des als nationales Arbeitsgremium zuständigen Komitees 461 „Elektrizitätszähler“ der DKE erarbeitet. Die Federführung lag beim AK 461.0.14 „Datenübertragung“.

Die internationale Norm IEC 61334-5-1:2001 „Distribution automation using distribution line carrier systems – Part 5-1: Lower layer profiles – The spread frequency shift keying (S-FSK) profile“ ist unverändert von CENELEC als Europäische Norm EN 61334-5-1:2001-07 und somit in das Deutsche Nationale Normenwerk übernommen worden (in der vorliegenden Norm mit veränderten Seitenzahlen).

Der Norm-Inhalt war veröffentlicht als E DIN IEC 57(Sec)199:1995-02. Demgegenüber ist die vorliegende Norm redaktionell überarbeitet und sachlich ergänzt.

Die enthaltene IEC-Publikation wurde vom TC 57 „Power system control and associated communications“ erarbeitet.

Das IEC-Komitee hat entschieden, dass der Inhalt dieser Publikation bis zum Jahr 2010 unverändert bleiben soll. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees die Publikation

- bestätigt,
- zurückgezogen,
- durch eine Folgeausgabe ersetzt oder
- geändert.

Fortsetzung Seite 2 bis 4
und 63 Seiten EN

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird mit der Deutschen Fassung der von CENELEC für EN 61334-5-1 beschlossenen ergänzenden Festlegungen die Englische Fassung der IEC 61334-5-1 veröffentlicht. Hinzu kommt, dass die meisten Internationalen Normen, auf die darin verwiesen wird, in ihren englischen Originaltexten als Europäische Normen übernommen und dann ebenso als Deutsche Normen veröffentlicht wurden, z. B. alle Normen, die sich auf das Basis-Referenzmodell für die Kommunikation Offener Systeme (OSI-Referenzmodell) [en: Open Systems Interconnection] nach DIN EN ISO/IEC 7498-1 beziehen. Um die Anwendung der vorliegenden Norm zu erleichtern, wurden die nachfolgenden einführenden Vorbemerkungen und Erläuterungen vorangestellt.

Das Präsidium des DIN hat mit Präsidialbeschluss 13/1983 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Einführung

Dieser Teil der Reihe IEC 61334 beschreibt die Anforderungen der erweiterten Frequenzsprungmodulation (S-FSK) (Spread Frequency Shift Keying modulation) im Zusammenhang mit den Diensten, die von der Instanz der Bitübertragungsschicht und der MAC-Teilschicht zur Verfügung gestellt werden. Als Übertragungsmedium wird das Verteilungsnetz auf Mittelspannungs-(MV) oder Niederspannungs-(LV) Ebene vorausgesetzt. Die in dieser Norm beschriebene MAC-Teilschicht ist an die in IEC 61334-4-32 beschriebene Steuerungsschicht der logischen Verbindung gekoppelt.

Die drei Teile – Modulation, Bitübertragungsschicht und MAC-Teilschicht – werden so aneinander angepasst, dass ein optimales Verhältnis Kosten/Leistungsfähigkeit erreicht werden kann.

Das in dieser Norm beschriebene Profil ist eines von mehreren Profilen (der Reihe IEC 61334-5), die alle für die Datenübertragung über ein Verteilungsnetz entwickelt wurden. Unter Berücksichtigung der laufenden technischen Entwicklung auf diesem Gebiet wurden die Profile zunächst als Technische Fachberichte veröffentlicht, mit dem Ziel, diejenigen Profile, die in der Praxis erfolgreich sind, in Normen umzuwandeln.

Nationaler Anhang NA (informativ)

Zusammenhang mit Europäischen und Internationalen Normen

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe der Norm.

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen ist nachstehend wiedergegeben. Zum Zeitpunkt der Veröffentlichung dieser Norm waren die angegebenen Ausgaben gültig.

IEC hat 1997 die Benummerung der IEC-Publikationen geändert. Zu den bisher verwendeten Normnummern wird jeweils 60000 addiert. So ist zum Beispiel aus IEC 68 nun IEC 60068 geworden.

Tabelle NA.1

Europäische Norm	Internationale Norm	Deutsche Norm	Klassifikation im VDE-Vorschriftenwerk
–	IEC/TR 61334-1-4:1995	–	–
EN 61334-4-1:1996	IEC 61334-4-1:1996	DIN EN 61334-4-1:1998-01	–
EN 61334-4-32:1996	IEC 61334-4-32:1996	DIN EN 61334-4-32:1997-09	–
EN 61334-4-41:1996	IEC 61334-4-41:1996 ¹⁾	DIN EN 61334-4-41:1997-09	–
EN 61334-4-42:1996	IEC 61334-4-42:1996 ²⁾	DIN EN 61334-4-42:1997-09	–
EN 61334-4-511:2000	IEC 61334-4-511:2000	DIN EN 61334-4-511:2001-05	–
–	IEC 61334-4-512	–	–
–	ISO/IEC 7498-1:1994	–	–
–	ISO/IEC 7498-3:1987	–	–
–	ISO/IEC/TR 8509:1987	–	–
–	ISO/IEC 8824:1990	–	–
EN 50065:1991 + A1:1992 + A2:1995 + A3:1996	–	DIN EN 50065-1 (VDE 0808 Teil 1):1996-11	–

¹⁾ ANMERKUNG Harmonisiert als EN 61334-4-41:1996 (nicht modifiziert).

²⁾ ANMERKUNG Harmonisiert als EN 61334-4-42:1996 (nicht modifiziert).

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN EN 50065-1 (VDE 0808 Teil 1), *Signalübertragung auf elektrischen Niederspannungsnetzen im Frequenzbereich 3 kHz bis 148,5 kHz – Teil 1: Allgemeine Anforderungen, Frequenzbänder und elektromagnetische Verträglichkeit; Deutsche Fassung EN 50065-1:1991 + A1:1992 + A2:1995 + A3:1996.*

DIN EN 61334-4-1, *Verteilungsautomatisierung mit Hilfe von Trägersystemen auf Verteilungsleitungen – Teil 4: Datenkommunikationsprotokolle; Hauptabschnitt 1: Referenzmodell für ein Kommunikationssystem (IEC 61334-4-1:1996); Deutsche Fassung EN 61334-4-1:1996.*

DIN EN 61334-4-32, *Verteilungsautomatisierung mit Hilfe von Trägersystemen auf Verteilungsleitungen – Teil 4: Datenkommunikationsprotokolle; Hauptabschnitt 32: Sicherungsschicht; Steuerung logischer Verbindungen (LLC) (IEC 61334-4-32:1996); Deutsche Fassung EN 61334-4-32:1996.*

DIN EN 61334-4-41, *Verteilungsautomatisierung mit Hilfe von Trägersystemen auf Verteilungsleitungen – Teil 4: Datenkommunikationsprotokolle; Hauptabschnitt 41: Anwendungsprotokolle; Verteilungsleitungs-Nachrichtenspezifikation (IEC 61334-4-41:1996); Deutsche Fassung EN 61334-4-41:1996.*

DIN EN 61334-4-42, *Verteilungsautomatisierung mit Hilfe von Trägersystemen auf Verteilungsleitungen – Teil 4: Datenkommunikationsprotokolle; Hauptabschnitt 42: Anwendungsprotokolle; Anwendungsschicht (IEC 61334-4-42:1996); Deutsche Fassung EN 61334-4-42:1996.*

DIN EN 61334-4-511, *Verteilungsautomatisierung mit Hilfe von Trägersystemen auf Verteilungsleitungen – Teil 4-511: Datenkommunikationsprotokolle; Systemverwaltung; CIASE-Protokoll (IEC 61334-4-511:2000); Deutsche Fassung EN 61334-4-511:2000, Text Englisch.*

Deutsche Fassung

Verteilungsautomatisierung mit Hilfe von Trägersystemen auf
Verteilungsleitungen

Teil 5-1: Profile der unteren Schichten – Profil für erweiterte Frequenzsprungmodulation (S-FSK)
(IEC 61334-5-1:2001)

Distribution automation using distribution line
carrier systems
Part 5-1: Lower layer profiles
The spread frequency shift keying (S-FSK)
profile
(IEC 61334-5-1:2001)

Automatisation de la distribution à l'aide de
systèmes de communication à courants
porteurs
Partie 5-1: Profils des couches basses
Profil S-FSK (modulation par saut de
fréquences étalées)
(CEI 61334-5-1:2001)

Diese Europäische Norm wurde von CENELEC am 2001-06-01 angenommen. Die CENELEC-Mitglieder sind gehalten, die CEN/CENELEC-Geschäftsordnung zu erfüllen, in der die Bedingungen festgelegt sind, unter denen dieser Europäischen Norm ohne jede Änderung der Status einer nationalen Norm zu geben ist.

Auf dem letzten Stand befindliche Listen dieser nationalen Normen mit ihren bibliographischen Angaben sind beim Zentralsekretariat oder bei jedem CENELEC-Mitglied auf Anfrage erhältlich.

Diese Europäische Norm besteht in drei offiziellen Fassungen (Deutsch, Englisch, Französisch). Eine Fassung in einer anderen Sprache, die von einem CENELEC-Mitglied in eigener Verantwortung durch Übersetzung in seine Landessprache gemacht und dem Zentralsekretariat mitgeteilt worden ist, hat den gleichen Status wie die offiziellen Fassungen.

CENELEC-Mitglieder sind die nationalen elektrotechnischen Komitees von Belgien, Dänemark, Deutschland, Finnland, Frankreich, Griechenland, Irland, Island, Italien, Luxemburg, Niederlande, Norwegen, Österreich, Portugal, Schweden, Schweiz, Spanien, der Tschechischen Republik und dem Vereinigten Königreich.

CENELEC

Europäisches Komitee für Elektrotechnische Normung
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique

Zentralsekretariat: rue de Stassart 35, B-1050 Brüssel

Vorwort

Der Text des Schriftstücks 57/512/FDIS, zukünftige 2. Ausgabe von IEC 61334-5-1, ausgearbeitet von dem IEC TC 57 „Power system control and associated communications“, wurde der IEC-CENELEC Parallelen Abstimmung unterworfen und von CENELEC am 2001-06-01 als EN 61334-5-1 angenommen.

Nachstehende Daten wurden festgelegt:

- spätestes Datum, zu dem die EN auf nationaler Ebene durch Veröffentlichung einer identischen nationalen Norm oder durch Anerkennung übernommen werden muss (dop): 2002-03-01
- spätestes Datum, zu dem nationale Normen, die der EN entgegenstehen, zurückgezogen werden müssen (dow): 2004-06-01

Anhänge, die als „normativ“ bezeichnet sind, gehören zum Norminhalt.

In dieser Norm sind die Anhänge A und ZA normativ.

Der Anhang ZA wurde von CENELEC hinzugefügt.

Anerkennungsnotiz

Der Text der Internationalen Norm IEC 61334-5-1:2001 wurde von CENELEC ohne irgendeine Abänderung als Europäische Norm angenommen.

In der offiziellen Fassung sind unter „Literaturhinweise“ zu den aufgelisteten Normen die nachstehenden Anmerkungen einzutragen:

IEC 61334-4-41:1996	ANMERKUNG	Harmonisiert als EN 61334-4-41:1996 (nicht modifiziert).
IEC 61334-4-42:1996	ANMERKUNG	Harmonisiert als EN 61334-4-42:1996 (nicht modifiziert).

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DISTRIBUTION AUTOMATION USING DISTRIBUTION LINE CARRIER SYSTEMS –

Part 5-1: Lower layer profiles – The spread frequency shift keying (S-FSK) profile

1 General

1.1 Scope and object

This part of IEC 61334 describes the requirements of S-SFK (frequency shift keying modulation) in conjunction with the services provided by the physical layer entity and 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 standard interfaces with the logical link control layer described in IEC 61334-4-32.

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

The profile described in this standard is one of several profiles (described in series IEC 61334-5) which are all designed for data transmission via the distribution network. Considering the ongoing technical development in this field, the profiles are published first as technical specifications with the intention to transform into standards those profiles which are successful in practice.

1.2 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/TR 61334-1-4:1995, *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 61334-4-1:1996, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 1: Reference model of the communication system*

IEC 61334-4-32:1996, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 32: Data link layer – Logical link control (LLC)*

IEC 61334-4-511:2000, *Distribution automation using distribution line carrier systems – Part 4-511: Data communication protocols – Systems management – CIASE protocol*

IEC 61334-4-512, *Distribution automation using distribution line carrier systems – Part 4-512: Data communication protocols – Systems management using profile 61334-5-1 MIB ¹⁾*

ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model – The Basic Model*

ISO/IEC 7498-3:1997, *Information technology – Open Systems Interconnection – Basic Reference Model – 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 part of IEC 61334, the definitions of ISO/IEC 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 (for example, immunity against narrowband interferers) with the advantages of a classical FSK system (low-complexity, well-investigated implementations).

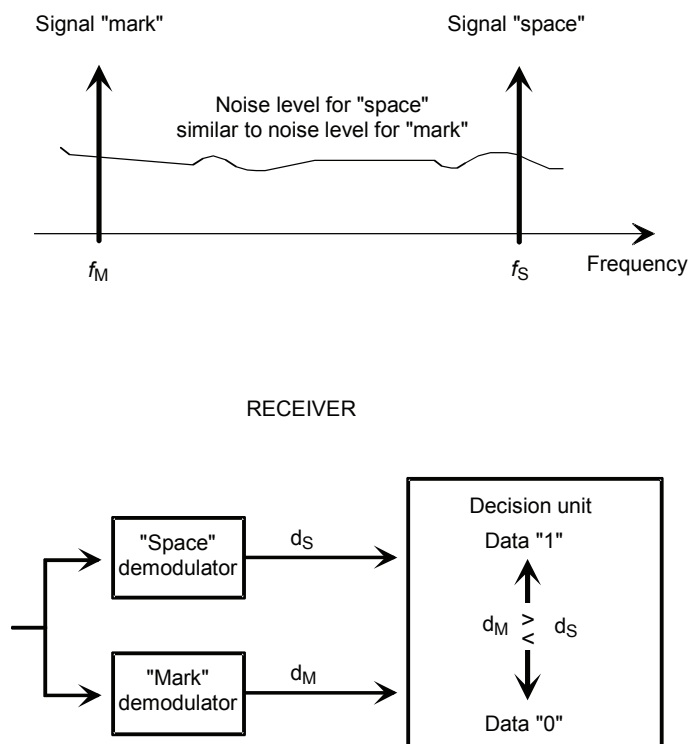
2.2 Spread frequency shift keying (S-FSK) principle

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).

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.

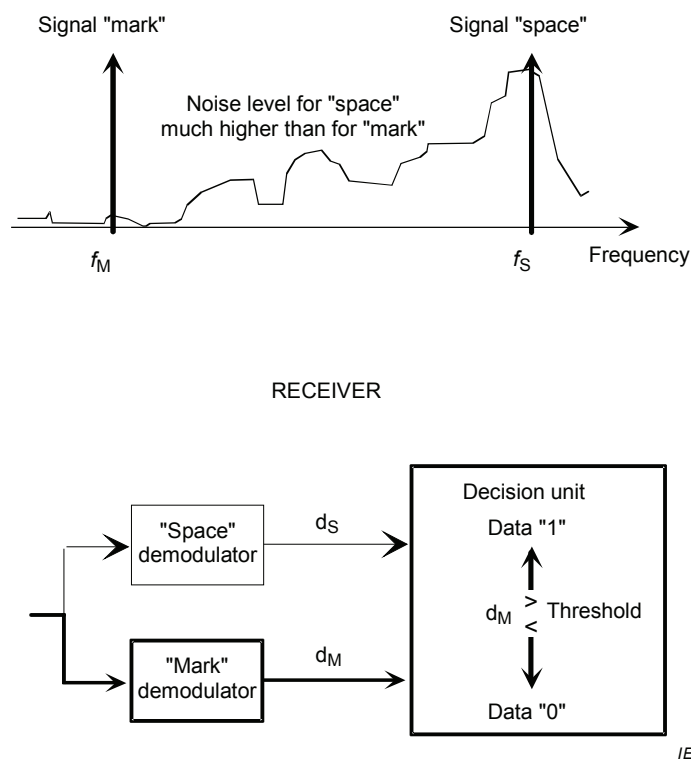
The quality measurements and the threshold computation may be based on a predefined preamble which precedes the transmission of the actual data frame.

¹⁾ To be published.



IEC 463/01

Figure 1 – Quality "space" similar to quality "mark"



IEC 464/01

Figure 2 – Quality "mark" much better than quality "space"

2.3 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 61334-1-4, it is recommended that $|f_M - f_S| > 10$ kHz be used.

f_M and f_S shall be situated in the frequency band defined in EN 50065-1.

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 subclauses shall be accomplished for receiver input signals in the range of $2 \text{ mV}_{\text{rms}}$ to 2 V_{rms} .

Different kinds of interferences 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. $E_b = V_{\text{signal}}^2(\text{r.m.s.})$, 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 attenuation) 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 $E_b = (E_{b1} + E_{b0})/2$.

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}	$E_b/N_0 < 10 \text{ dB}$	$E_b/N_0 < 7 \text{ dB}$	$E_b/N_0 < -3 \text{ dB}$
2×10^{-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.			

2.4.3 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 mV_{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 three-phase;
- b) 50 Hz or 60 Hz $\pm 10 \%$;
- c) 230 V_{rms} (190 V_{rms} min., 250 V_{rms} max.).

3.2.1 Coding

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

3.2.2 Bit timing

At 50 Hz, 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/s at 50 Hz, and 360 bits/s at 60 Hz.

At the minimum transmission speed (300 bits/s or 360 bits/s), the duration of three data bits might correspond to the time interval between two succeeding zero crossings of one of the three phases of the mains. When mains-synchronized, the data bits are placed in time so 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 for 50 Hz mains signal (600 bits/s, 900 bits/s, 1 200 bits/s, etc.) are possible.

3.2.3 Frame timing

The PHY_frames (consisting of a preamble, a start subframe delimiter, a MAC-subframe, and a pause) are transmitted during predefined time slots (see figure 3); this means 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

For the remote station (server), the system wide synchronization of the slot indicators is achieved by means of any subframe received using the preamble and the start delimiter.

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 P_sdu (38 bytes) equal to the M_pdu transmitted by the MAC sublayer;
- a P_pci encapsulating the P_sdu with a preceding preamble (2 bytes) followed by the subframe delimiter (2 bytes) and a succeeding pause (3 bytes).

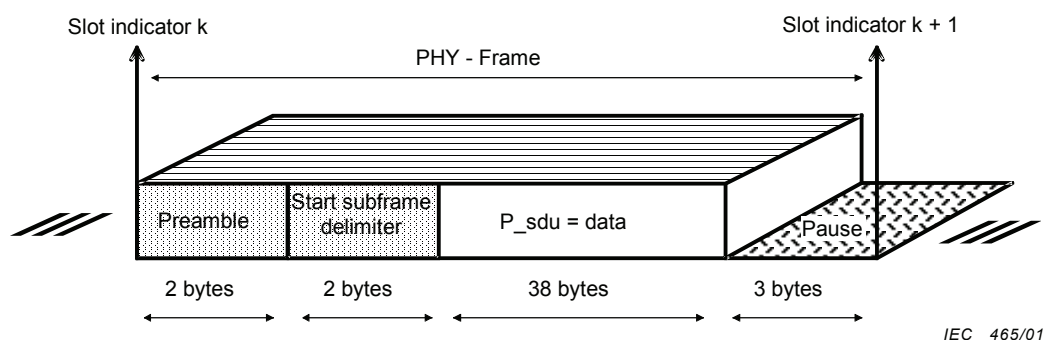


Figure 3 – Time slot and physical frame structure

3.3.2 Byte and bit ordering

The bytes are sent from the most significant byte (MSB) to the least significant byte (LSB). By convention, the most significant byte corresponds to the leftmost byte.

Bit fields are packed with the same convention as byte fields. That is, the first bit in an octet is the most significant (leftmost) bit.

3.3.3 Preamble and start subframe delimiter

The preamble is a 16-bit field equal to: AAAA (hex).

The start subframe delimiter is a 16-bit field equal to: 54C7 (hex) which follows the preamble.

The preamble and the start subframe delimiter form a set of four bytes which serves the following purposes:

- a) adaptation of the automatic gain control (AGC);
- b) quality measurement and threshold computation (determination of the demodulation method);
- c) fine tuning of the bit synchronization (if necessary);
- d) frame checking: the aim is to verify that the received demodulated signal structure corresponds to an extract of a physical frame. The checking is carried out on a part of the preamble and start subframe delimiter fields;
- e) slot indicator resynchronization (if necessary).

NOTE The receiving gain (determined when receiving the preamble and start subframe delimiter field) can be bounded to a maximum value. This value is memorized in the max-receiving-gain physical management variable.

3.3.4 Pause

Twenty-four-bit field of no transmission.

The purpose of the pause is to give the receiver time to perform decoding and data processing before it has to be ready for the next frame.

3.4 Physical layer services definitions

3.4.1 General description

3.4.1.1 The P_Data services

The P_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 general P_Data service primitives and two specific P_Sync service primitives for local synchronization management purposes.

The three general P_Data service primitives are:

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

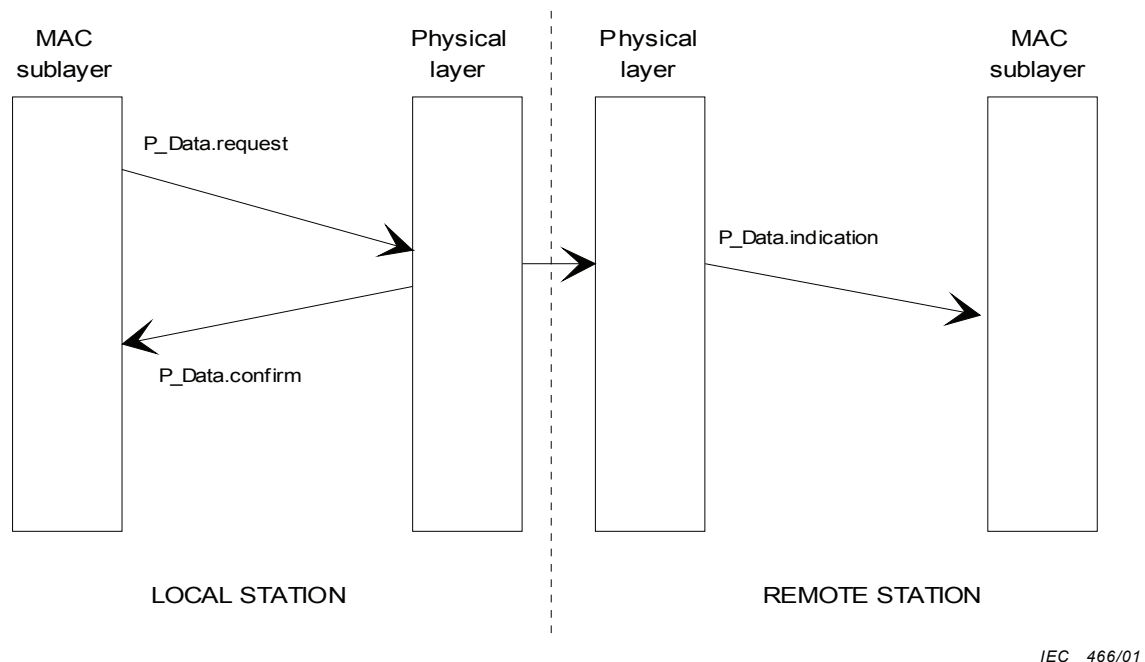


Figure 4 – P_Data services

3.4.1.2 The P_Sync services

The P_Sync services provided by the physical layer allow the MAC sublayer entity to:

- ask for a new synchronization,
- be informed of a change in the synchronization state of the physical layer.

There are two P_Sync primitives which are used locally by the MAC sublayer:

- P_Sync.request;
- P_Sync.indication.

3.4.2 P_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:

```
P_Data.request (  
    P_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 reception 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 P_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 P_Data.request primitive. The P_Data.confirm primitive tells the MAC sublayer entity how the PHY_frame of the previous P_Data.request has been transmitted on the medium.

3.4.3.2 Structure

The semantics of this primitive are as follows:

```
P_Data.confirm (  
    Transmission_status)
```

The Transmission_status parameter is used to pass status information back to the local requesting MAC sublayer entity. It is used to indicate the success or failure of the previous associated P_Data.request. It may also indicate that the physical layer has lost its frame synchronization.

The possible returned value of the Transmission_status is one of the following:

- OK: no error has been found;
- LP-TU: resources temporally unavailable at the PHY sublayer;
- LP-NI: resources not implemented or inactivated at the physical layer;
- LP-HF: hardware failure at the PHY sublayer;
- LP-NS: physical layer not synchronized;
- LP-SE: syntax error on the P_sdu transmitted by the MAC sublayer (length of the P_sdu different from 38 bytes).

3.4.3.3 Use

This primitive is generated in response to a P_Data.request from the local MAC sublayer entity.

It is assumed that sufficient information is available to the MAC sublayer to associate the confirm with the appropriate request.

3.4.4 P_Data.indication

3.4.4.1 Function

This primitive defines the transfer of data from the PHY sublayer entity to the MAC sublayer entity.

3.4.4.2 Structure

The semantics of this primitive are as follows

```
P_Data.indication(  
    P_sdu  
)
```

3.4.4.3 Use

The P_Data.indication is passed from the PHY sublayer entity to the MAC sublayer entity to indicate the arrival of a frame to the local PHY sublayer entity. Such frames are reported only if they are properly synchronized and written in a valid format.

3.4.5 P_Sync.request

3.4.5.1 Function

This primitive has only local significance. It provides the MAC sublayer with a means to ask for a resynchronization of the physical layer.

3.4.5.2 Structure

The semantics of the primitive are as follows:

P_Sync.request (state)

The state parameter takes only one value: state=rejected. This information is submitted to ask for a new synchronization.

3.4.5.3 Use

This primitive is generated by the MAC sublayer each time a new synchronization is needed (for more details, see 4.3.6).

3.4.6 P_Sync.indication

3.4.6.1 Function

This primitive has only local significance. It informs the MAC sublayer of a synchronization state change at the physical layer level.

3.4.6.2 Structure

The semantics of the primitive are as follows:

P_Sync.indication (
 New Synchronization State
)

The New Synchronization State parameter indicates the new synchronization state of the physical layer. It takes only one value:

- SYNCHRO_FOUND: the physical layer entity has found a synchronization reference.

3.4.6.3 Use

This primitive is generated by the physical sublayer entity each time a new synchronization reference is found. No P_Sync.indication() service is returned when the synchronization loss is required by the MAC sublayer through the P_Sync.request (State=Rejected) primitive.

3.5 Sending and receiving physical sublayer

The functional model is analysed from a client or server point of view. The model allows writing and reading of the physical management variables (see 3.5.5.3) through management primitives.

3.5.1 Sending

3.5.1.1 Client sending

The client is the master of the DLC communication. He must transmit physical frames during predefined time slots. The beginning of a time slot starts at time instances called slot indicators. These indicators correspond to a zero crossing of one of the three phases of the mains. Each time the client physical layer finds a new slot indicator reference, it notifies it to the MAC sublayer by providing a P_Sync.indication(SYNCHRO_FOUND) primitive.

NOTE The MAC sublayer is able to order the search of a new time slot reference thanks to the P_Sync.request (state=rejected) primitive.

When the physical layer receives a P_data.request primitive from the MAC sublayer, it first checks the length of the received P_sdu. If this length is different from 38 bytes, a negative P_Data.confirm is immediately returned to the MAC sublayer.

If the length of the P_sdu is equal to 38 bytes, the physical layer waits for the occurrence of a time slot indicator to start the transmission. When this event appears, the physical layer first transmits the preamble (2 bytes equal to AAAA H) followed by the start subframe delimiter (2 bytes equal to 54C7 H) and the 38 bytes of the P_sdu issued from the MAC sublayer.

Once the transmission of these 42 bytes is over, the physical layer resumes an idle state when it is ready for processing incoming physical frames or P_Data.request primitives.

3.5.1.2 Server sending

The server is the slave of the DLC communication. To transmit a physical frame, the server shall be synchronized with a client.

If the server is synchronized with the client, the sending procedure is identical to that of the client.

3.5.2 Receiving

3.5.2.1 Client receiving

If the physical layer has not received any P_Data.request primitive in the current time slot, it automatically enters the reception mode for the next time slot indicator occurrence.

The physical layer uses the first four bytes of the received data to

- stabilize the gain;
- measure the quality on each half-channel and determine the decision threshold to be used for the reception process;
- check the received demodulated signal structure.

If the received demodulated signal structure corresponds to the beginning of a physical frame, the physical layer carries on the demodulation of the next 38 bytes. A P_Data.indication primitive is then issued to the upper MAC sublayer. It then enters the idle state, waiting for the next time slot indicator occurrence.

If the received demodulated signal structure does not correspond to the beginning of a physical frame, it is deduced that it is noise. The physical layer immediately enters the idle state.

3.5.2.2 Server receiving

The server is the slave of the DLC communication. To receive a physical frame, the server shall be synchronized with a client.

The maximum gain used by the server in the receiving mode can be controlled by the client system through the max-receiving-gain MIB object (see IEC 61334-4-512).

If the server is synchronized with the client, the receiving procedure is identical to that of the client.

3.5.3 Synchronization – desynchronization of a server

An unsynchronized server always analyses the transmission channel to discover data corresponding to the preamble (AAAAH) and the start subframe delimiter (54C7H) fields. When the physical layer finds a sequence true to the path, it notifies it to the MAC sublayer by providing a P_Sync.indication(SYNCHRO_FOUND) primitive. It then enters the reception mode and acquires the next 38 data bytes. A P_sdu is formed from this packet of bytes and is submitted to the MAC sublayer.

The server is supposed to have found a synchronization reference as soon as the MAC sublayer receives a SYNCHRO_FOUND notification. Nevertheless, this reference is kept by the system only if the MAC sublayer is able to observe the reception of a valid MAC frame during a limited period called synchronization-confirmation-time-out.

If no valid MAC frame is received by the MAC sublayer during this period, it is supposed that the system found its synchronization reference on parasite signal. The MAC sublayer then orders a desynchronization of the physical layer by sending a P_Sync.request(State=Rejected) primitive. If a valid MAC frame is received, the system considers that the synchronization reference is correct. This reference is kept.

Besides desynchronizations due to the expiration of the specific synchronization-confirmation-time-out counter, other events controlled by the MAC sublayer may cause a desynchronization of the system. These are:

- the expiration of the time-out-frame-not-OK counter: no valid frame has been received during a period of time equal to time-out-frame-not-OK seconds;
- the expiration of the time-out-not-addressed counter: no personally addressed frame has been received by the system during a period of time equal to time-out-not-addressed minutes;
- the identification of a wrong initiator: the MAC sublayer has identified a MAC frame transmitted or designated to an unauthorized client system. The system should not be synchronized on such frames: desynchronization is then ordered;

NOTE Such an event can only occur if the system is configured in the so-called locked state. In the locked state, the server system only accepts synchronization on frames which are issued by, or designated to, a specific client system called the initiator. The initiator is identified by its MAC address contained in the initiator-mac-address MAC management variable. If this variable is set to the NO-BODY value, the server system works in an unlocked state.

- the writing of the new-synchronization MAC management variable;
- the writing of the mac-address MAC management variable (only if set to NEW).

3.5.4 Physical state transition tables

Table 2 – Server physical layer transition table

Initial state	Events	Actions	Final state
Config	Local_Status() = OK and Is_server()=TRUE	None	LFS
LFS or S_IDL	Write_Request() and Check_Write()<>OK	Write_Conf(P_Tstat=Check_Write())	Unchanged state
LFS or S_IDL	Read_Request() and Check_Read()<>OK	Read_Conf(P_Tstat=Check_Read())	Unchanged state
LFS or S_IDL	Write_Request(max-receiving-gain) and Check_Write()=OK	Set_Value(max-receiving-gain) Write_Conf(P_Tstat=OK)	Unchanged state
LFS or S_IDL	Read_Request(Server-Physical- Management-Variable) and Check_Read()=OK	Read_Conf(Server-Physical-Management- Variable)	Unchanged state
LFS or S_IDL	P_Data.request (P_sdu) and Check()<>OK	P_Data.confirm (P_Tstat = Check())	LFS
LFS	P_Sync.request(State)	None	LFS
LFS	Synchro_Found(Delta_Phase)	Init_Time_slot() Init_Counter(synchronisation- confirmation-time-out) Set_Delta_Electrical_Phase(Delta_Phase) P_Sync.indication(SYNCHRO_FOUND)	S_RPF.R
S_IDL	P_Sync.request (State=Rejected)	None	LFS
S_IDL	Time_Slot()	None	S_RPF.C
S_IDL	P_Data.request (P_sdu) and Check()<>OK	P_Data.confirm(P_Tstat= Check())	S_IDL
S_IDL	P_Data.request (P_sdu) and Check()=OK	Build_P_Frame (preamble = AAAAH SSD = 54C7H P_sdu)	SPF.W
S_RPF.C	Preamble_SSD() = OK	None	S_RPF.R
S_RPF.C	Preamble_SSD() <> OK	None	S_IDL
S_RPF.R	End_Receiving() and Sync_Conf = FALSE	P_Data.indication(P_sdu)	S_IDL
SPF.W	Time_Slot()	None	SPF.S
SPF.S	End_Sending()	P_Data.confirm (P_Tstat= OK)	S_IDL