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INTERNATIONAL STANDARD

Information technology – Home electronic system (HES) architecture – Part 3-5: Media and media dependent layers – Powerline for network based control of HES Class 1

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FOREWORD

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This International Standard is a product family standard. It shall be used in conjunction with ISO/IEC 14543-2-1, 14543-3-1, 14543-3-2, 14543-3-3, 14543-3-4, 14543-3-6 and 14543-3-7.

The list of all currently available parts of the ISO/IEC 14543 series, under the general title *Information technology – Home electronic system (HES) architecture,* can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

INTRODUCTION

The Reference model for Open System Interconnection (OSI), specified in ISO/IEC 7498, assigns the functions that are needed for communications between two entities that are connected by a medium to seven logical layers. This International Standard specifies interconnection of entities used for home and building control via the medium powerline. It specifies the medium dependent functions, that is the mains characteristics and the transmission technology in terms of the Physical Layer and the Data Link Layer, according to ISO/IEC 7498.

Currently, ISO/IEC 14543, *Information technology – Home Electronic System (HES) architecture*, consists of the following parts:

Part 2-1: *Introduction and device modularity*
Part 3-1: *Communication layers – Application layer for network based control of HES Class 1*
Part 3-2: *Communication layers – Transport, network and general parts of data link layer for network based control of HES Class 1*
Part 3-3: *User process for network based control of HES Class 1*
Part 3-4: *System management – Management procedures for network based control of HES Class 1*
Part 3-5: *Media and media dependent layers – Powerline for network based control of HES Class 1*
Part 3-6: *Media and media dependent layers – Twisted pair for network based control of HES Class 1*
Part 3-7: *Media and media dependent layers – Radio frequency for network based control of HES Class 1*
Part 4: *Home and building automation in a mixed-use building (technical report)*
Part 5-1: *Intelligent grouping and resource sharing for HES Class 2 and Class 3 – Core protocol (under consideration)*
Part 5-2: *Intelligent grouping and resource sharing for HES Class 2 and Class 3 – Device certification (under consideration)*

Additional parts may be added at a later date.

INFORMATION TECHNOLOGY – HOME ELECTRONIC SYSTEM (HES) ARCHITECTURE –

Part 3-5: Media and media dependent layers – Powerline for network based control of HES Class 1

1 Scope

This part of ISO/IEC 14543 defines the mandatory and optional requirements for the medium specific Physical and Data Link Layer of Powerline Class 1 in its two variations PL110 and PL132.

NOTE Data Link Layer interface and general definitions, which are medium independent, are given in ISO/IEC 14543-3-1.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 14543-2-1, *Information technology – Home Electronic System (HES) architecture – Part 2-1: Introduction and device modularity*

ISO/IEC 14543-3-1, *Information technology – Home Electronic System (HES) architecture – Part 3-1: Communication layers – Application layer for network based control of HES Class 1*

ISO/IEC 14543-3-2, *Information technology – Home Electronic System (HES) architecture – Part 3-2: Communication layers – Transport, network and general parts of data link layer for network based control of HES Class 1*

ISO/IEC 14543-3-3, *Information technology – Home Electronic System (HES) architecture – Part 3-3: User process for network based control of HES Class 1*

ISO/IEC 14543-3-4, *Information technology – Home Electronic System (HES) architecture – Part 3-4: System management – Management procedures for network based control of HES Class 1*

ISO/IEC 14543-3-6, *Information technology – Home Electronic System (HES) architecture – Part 3-6: Media and media dependent layers – Twisted pair for network based control of HES Class 1*

ISO/IEC 14543-3-7, *Information technology – Home Electronic System (HES) architecture – Part 3-6: Media and media dependent layers – Radio frequency for network based control of HES Class 1*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

EN 50065-1, *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*

EN 50065-7, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 7: Equipment impedance*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this International Standard the definitions given in ISO/IEC 14543-2-1 (some of which are repeated below for convenience) and the following apply.

3.1.1
differential mode
PL signals are injected between phase and neutral

3.1.2
router
connects one sub-network to another sub-network

3.1.3
PL110
powerline signalling operating in a frequency band of 95 kHz to 125 kHz according to EN 50065-1

3.1.4
PL132
powerline signalling operating in a frequency band of 125 kHz to 140 kHz according to EN 50065-1

3.2 Abbreviations

ACK	acknowledgement
APDU	Application Layer Protocol Data Unit
CS	Check Sequence
CSMA	Carrier Sense Multiple Access protocol
CTRL	Control field
DAF	Destination Address Flag
DOA	Domain Address
FCS	Frame Check Sequence
FEC	Forward Error Correction
FSK	Frequency Shift Keying
HES Class 1	refers to simple control and command
HES Class 2	refers to Class 1 plus simple voice and stable picture transmission
HES Class 3	refers to Class 2 plus complex video transfers
LPDU	Link Layer Protocol Data Unit
MAU	Medium Attachment Unit
MSK	Minimum Shift Keying
NACK	Not acknowledge
NPCI	Network Protocol Control Information
NRZ	No Return to Zero
PL	Powerline
SPD	Surge Protection Devices
TPDU	Transport Layer Protocol Data Unit
SFSK	Spread Frequency Shift Keying

4 Conformance

A device conforming to this International Standard shall support the physical medium as specified in clause 5 or clause 7, and it shall provide transmission capability as specified in clause 6.

5 Requirements for HES Class 1, PL110

5.1 Physical Layer PL110

5.1.1 General

This clause describes the physical layer characteristics of the PL110 powerline signalling which operates in the frequency band (95 to 125) kHz band as described in EN 50065-1 and which has a nominal centre frequency of 110 kHz.

The main characteristics of PL110 physical layer are:

- a spread frequency shift keying signalling;
- asynchronous transmission of data packets;
- symbols globally synchronised to the mains frequency;
- half duplex bi-directional communication.

Electrical wiring in the building/home shall be in compliance with the current national regulations. Powerline communication is described in EN 50065-1.

The electric power distribution network normally determines the physical topology of the powerline network. The structure of this network may be single phase or three phase. The rated voltage between one phase and neutral shall be 110 V and 230 V, respectively. PL110 signals are injected between phase and neutral.

General requirements for the physical layer type PL110 are given in Table 1.

Table 1 – General requirements for physical layer PL110

Characteristics	Description
Medium	Electrical power distribution network
Topology	Installation dependant (e.g., linear, star, tree)
Bit rate	1 200 bit/s
Mains frequency	50 Hz and 60 Hz, respectively
Number of Domain Addresses	255
Number of Individual Addresses	32 767
Modulation type	Spread frequency shift keying (SFSK)
Frequency for logical 0	105,6 kHz ± 0,1%
Frequency for logical 1	115,2 kHz ± 0,1%
Bit duration	833,3 µs
Maximum output level	122 dB µV [a]
Input sensitivity	≤60 dB µV [b]
Device class	Class 122[c]
Compliance to standards	EN 50065-1

[a] Measurement according to EN 50065-1.

[b] With artificial network according to CISPR 16-1-1 [(50 µH + 5 Ω) / 50 Ω].

[c] Equipment manufactured in accordance with class 116 according to EN 50065-1 will now meet the requirements of Class 122 and may be marked Class 116 provided that its output complies with the previous standard.

The logical structure of the physical layer PL110 entity is shown in Figure 1. Each PL110-device includes one physical layer PL110 entity.

The PL110 entity shall consist of three blocks:

- connector;
- medium attachment unit (MAU);
- error correction.

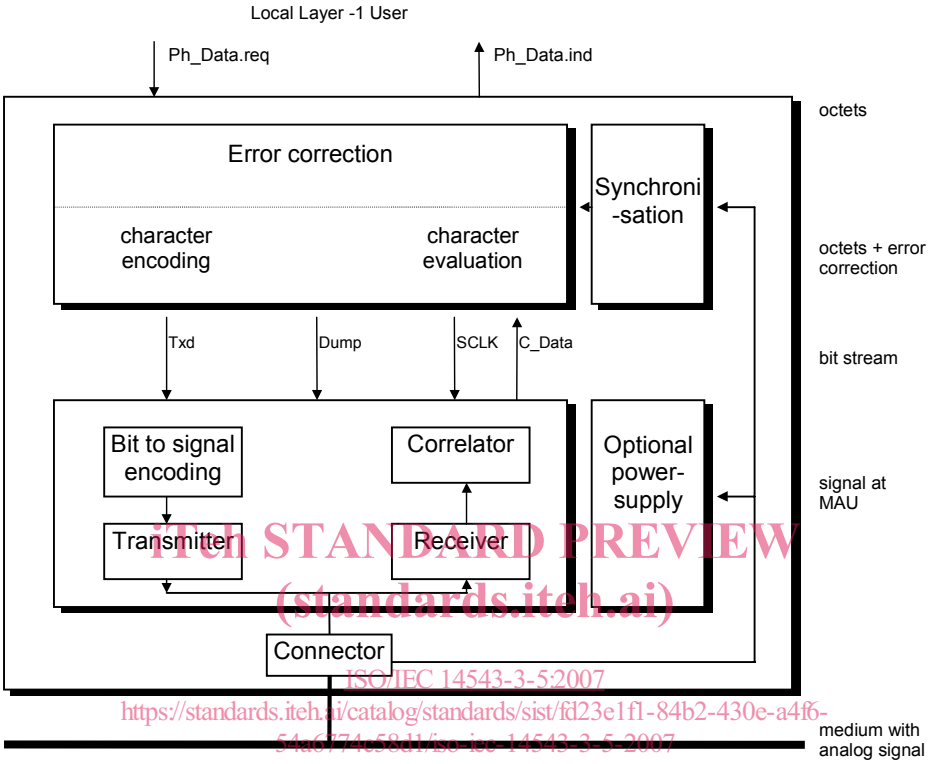


Figure 1 – Structure of the MAU (example)

5.1.2 Transmission medium

5.1.2.1 Requirements for protection against electric shocks and connectors

The PL110 devices are connected to the mains installation network. The requirements for protection against electric shocks for human beings (and animals) and connectors shall be considered within the assembled device. They are not subject to the physical layer description.

These requirements are specified in the installation and equipment standards (safety standards).

5.1.2.2 Powerline cables

The requirements for powerline cables are defined by the use as installation wires according to national regulations. Normally, the type of cable, the connected loads and the topology of the network is not known. In contrast to the theoretical values of typical cable characteristics, for example as specified in IEC 60227-4 and IEC 60502-1, the impedance at one network access point is determined more by the connected load than by the cabling.

Typical cables for fixed electrical installation are “thermoplastic-insulated and sheathed cable”, “PC insulated flat cable, overall covering vulcanised rubber” or “sheathed metal-clad wiring cable with PVC insulated cores sheet-zinc cover with additional PVC jacket”.

NOTE The use of shielded power cables and of cables with cross-sections greater than 35 mm^2 can influence PL110 signalling significantly!

5.1.3 Medium attachment unit (MAU)

The Medium Attachment Unit converts the frequency-coded signals into values representing logical ones and zeroes and vice versa. In parallel, a power supply circuit may be connected to the medium. Signal converter and power supply shall be independent from each other. The power supply shall meet the requirements specified in Table 2.

Table 2 – Power supply of the MAU

Power supply	Nominal values
Receiving mode	5 V at 30 mA / 24 V at 1 mA
Transmitting mode	5 V at 30 mA / 24 V at 10 mA – 50 mA (dependent on impedance)

Compliance is checked by measurement.

The power supply of the MAU may be internal or external.

5.1.3.1 Signal encoding

A signal of 105,6 kHz for a period of 833,3 µs shall correspond to a logical 0, a signal of 115,2 kHz for a period of 833,3 µs to a logical 1. See Figure 2.

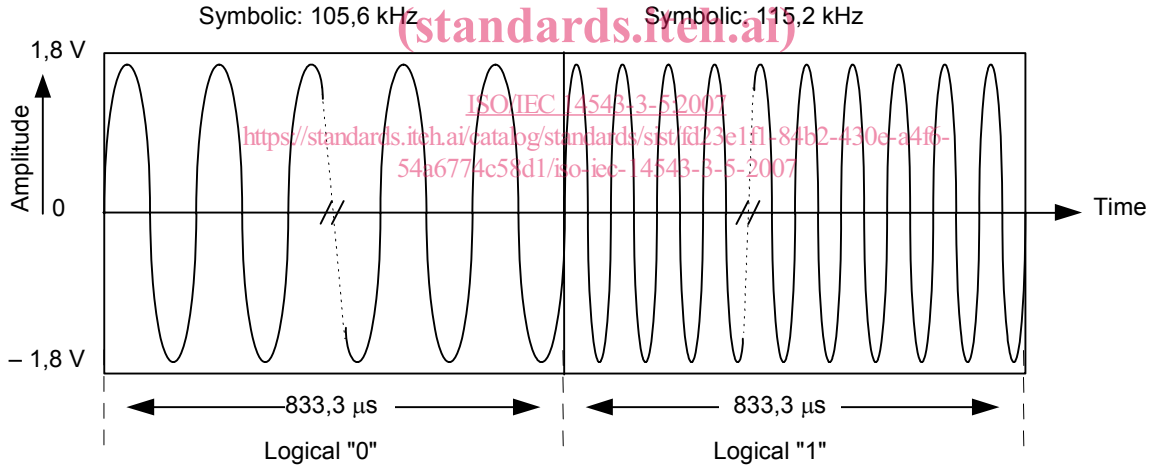


Figure 2 – Signal encoding

These NRZ signals are superimposed on the AC voltage of the mains at 50 Hz and 60 Hz, respectively. The maximum amplitude of the signal shall be limited to 122 dBµV, measured according to EN 50065-1 by using an artificial mains network as specified in CISPR 16-1-1. The sensitivity of the receiver shall exceed 60 dBµV.

For minimal disturbance, the change between adjacent symbols shall be phase continuous, as shown in Figure 2.

Compliance is checked by measurement.

5.1.3.2 Overlapping of logical 0 or 1

Overlapping of logical 0 or 1 symbols, for example, the simultaneous transmission of equal information at the same time from several MAUs (e.g., common ACK), results in fade-in / fade-out effects. Due to slight frequency deviations between several MAUs, the signal fades

periodically with the difference of the MAU frequencies. In PL110 powerline communication this case can be avoided by setting a unique group response flag to each assigned group address.

5.1.3.3 Overlapping of logical 0 and 1

Overlapping of logical 0 and 1 symbols, for example, the simultaneous transmission of different information at the same time from several MAUs, results in a collision. While there is no indication of collision for any MAU, the probability of this state is minimised by a special bus access mechanism.

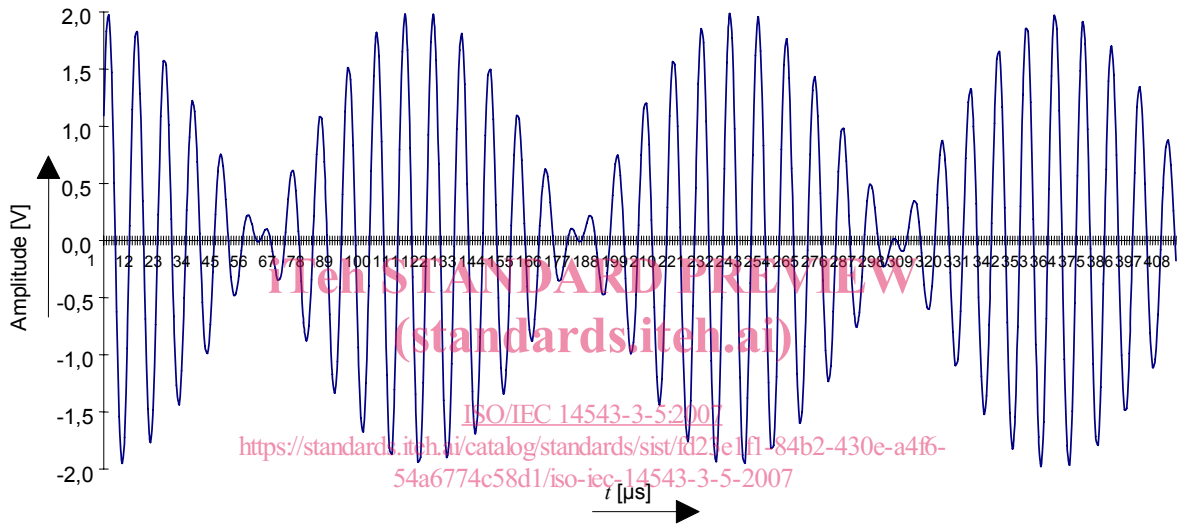


Figure 3 – Idealised overlapping of 105,6 kHz and 115,2 kHz

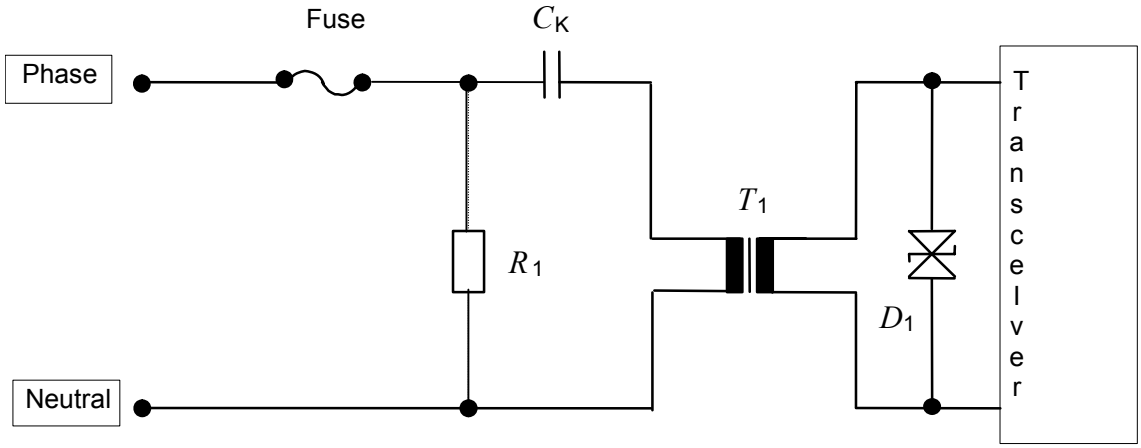
5.1.3.4 Impedance of the MAU

To limit the influence of connected MAUs on the characteristic of the powerline bus the impedance in receiving mode shall be high. For signal injection with minimum losses, the impedance in transmitting mode shall be low. When tested according to EN 50065-7, the limits for PL110 shall be:

Table 3 – Requirements for the impedance of the MAU

Impedance on	Requirements
Receiving mode	$\lvert Z_{in} \rvert \geq 80\ \Omega$ at 100 kHz to 125 kHz
Transmitting mode	$\lvert Z_{out} \rvert \leq 20\ \Omega$ at 100 kHz to 125 kHz

5.1.3.5 PL bus coupling



Legend:

C_k: coupling capacitor, X2-type
T_1: coupling transformer
D_1: transient voltage protection diode
R_1: resistor for discharging C_k (optional)

Figure 4 – Example of a PL inductive coupling circuit

Electrical coupling of signals to the powerline is done by special circuits. In general, capacitive or inductive coupling may be used. Inductive coupling may be or may not be combined with electrical insulation.

5.1.4 Installation topology

The structure of an electrical installation is either linear, star, ring, tree, or any combination thereof. Referring to the electrical distribution board as the centre, the topology normally has a star structure. Each branch of the electrical distribution network may have its own different structure.

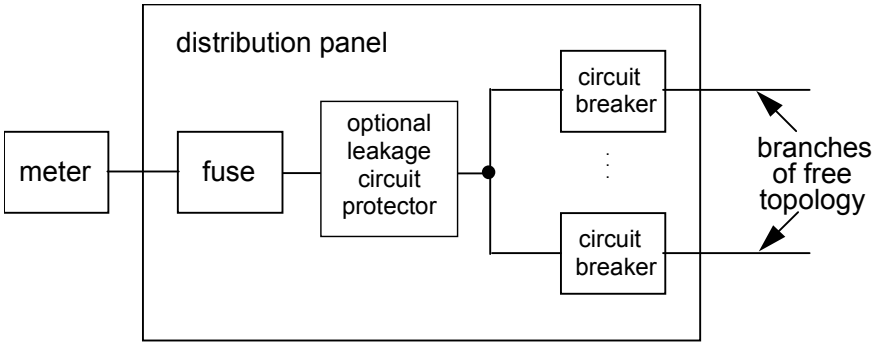


Figure 5 – Example of a typical PL topology

5.1.5 Installation requirements

The installation of the powerline network is subject to national and international regulations and standards. Additional instructions about the communication aspects of the network may be given in the manufacturer's instruction sheet.