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INTERNATIONAL
STANDARD

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inside

**Information technology – Home electronic system (HES) architecture –
Part 3-11: Frequency modulated wireless short-packet (FMWSP) protocol
optimised for energy harvesting – Architecture and lower layer protocols**

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**INFORMATION TECHNOLOGY –
HOME ELECTRONIC SYSTEM (HES) ARCHITECTURE –**

**Part 3-11: Frequency modulated wireless short-packet (FMWSP)
protocol optimised for energy harvesting –
Architecture and lower layer protocols**

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International Standard ISO/IEC 14543-3-11 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

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 and ISO 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 title page.

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

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INTRODUCTION

Various electrically controlled sensors and switches are used in homes and similar environments for many different applications. Examples of such applications are lighting, heating, energy management, blinds control, different forms of security control and entertainment (audio and video).

In most cases the device, e.g., a switch initiating an action, and the device, e.g., a lamp, are installed at different places. The distance can be bridged by wires, infrared or radio transmission. Presently equipment at both ends of a wireless transmission link needs to be powered by line or battery.

While wireless transmissions are especially attractive to retrofit homes, power maintenance of battery-driven devices is a burden. In addition, these batteries require scarce materials. Since the command and control messages sent by control and sensor devices in homes are very short, they can be powered using new techniques for energy harvesting, provided they use a wireless protocol that operates on relatively low power. Energy available in the environment of a device is captured and stored (harvested) to power operation of the device. Examples of energy sources are mechanical actuation, solar radiation, temperature differences, etc. If this is executed at least one device in the link neither needs a battery nor a wire. Energy harvesting devices need very limited power and use an energy efficient radio protocol to send data to other conventionally powered devices in the home. In order to ensure interoperability of such devices from different sources within a home, an international standard for a protocol is required that uses the little power that energy harvested devices can provide and at the same time spans distances to be bridged within a home environment.

Several such devices used within a home may come from different sources. They are required to interwork with each other using a common internal network (in this standard called a home network) and supporting a home automation system. When a home automation system meets ISO/IEC HES standards, it is called a Home Electronic System (HES).

Two alternative technologies are supported by the ISO/IEC 14543 series of standards. The two standards, ISO/IEC 14543-3-10 and ISO/IEC 14543-3-11, are optimised for energy harvesting based on similar techniques, but with different modulation schemes. ISO/IEC 14543-3-10 and ISO/IEC 14543-3-11 specify two lower layer wireless short-packet protocols, where the former uses an amplitude modulated signal and ISO/IEC 14543-3-11 a frequency modulated signal.

Amplitude modulated wireless communications are more energy efficient but less adapted to mobile devices. This is due to the fact that the impedance of a mobile antenna is affected by the environment of the mobile device, e.g., when the device is held in the hand or moved to metal surface. Changes in impedance affect the amplitude linearity of the radio frequency output amplifier, but have no impact on the frequency itself. Thus, an AM wireless system is more sensitive to changes in environment than a FM wireless system. Also frequencies above 800 MHz are better suited for mobile devices, since they require smaller antennas. Thus, the frequency 315 MHz is not used in this standard, which together makes the FM wireless system more efficient for mobile devices.

Compared to the AM wireless system, the FM wireless system provides more flexibility in the size of various pieces of information that can be transmitted. This includes the possibility to have larger payloads, different lengths of the identifiers of originators and destinations, and greater variability of structures and lengths of the telegram types. In addition, the number of steps a telegram can be repeated is increased from 2 to 15.

AM and FM wireless system are efficient enough to

• support energy harvested products for sensors and switches that do not require cables and batteries, and

• extend the life of battery-operated devices.

Both an AM and a FM system can be active at the same time, since each system is so constructed that only permitted messages are accepted. Collisions can be avoided by listen-before-talk (LBT) technology or overcome by redundant transmissions.

**INFORMATION TECHNOLOGY –
HOME ELECTRONIC SYSTEM (HES) ARCHITECTURE –**

**Part 3-11: Frequency modulated wireless short-packet (FMWSP)
protocol optimised for energy harvesting –
Architecture and lower layer protocols**

1 Scope

This part of ISO/IEC 14543 specifies a frequency modulated wireless protocol for low-powered devices such as energy harvested devices in a home environment. This wireless protocol is specifically designed to keep the energy consumption of such sensors and switches extremely low.

The design is characterised by

- keeping the communications very short, infrequent and mostly unidirectional, and

- using communication frequencies that provide a good range even at low transmit power and avoid collisions from disturbers.

This allows the use of small and low cost energy harvesters that can compete with similar batteries-powered devices. The messages sent by energy harvested devices are received and processed mainly by line-powered devices such as relay switch actuators, repeaters or gateways. Together these form part of a home automation system, which, when conforming to the ISO/IEC 14543 series of standards, is defined as a Home Electronic System.

This part of ISO/IEC 14543 specifies OSI Layers 1 to 3 of the Frequency Modulated Wireless Short-Packet (FMWSP) protocol. It makes use of a frequency modulated signal well adapted to mobile devices and also supports high frequency wireless communications.

The FMWSP protocol system consists of two, and optionally three types of components that are specified in this standard. These are the transmitter, the receiver and optionally the repeater. Repeaters are needed when the transmitter and the receiver are located such that no good direct communication between them can be established. By direct communications the functional distance of the system is up to 300 m line-of-sight including the Fresnel zone and up to 30 m in buildings.

Since wireless communications may be overheard by receivers outside the intended environment, users should be aware of the risks this might cause before installing any wireless system. In contrast to listening devices, however, protection against malicious attacks for the technology in this standard can partly be handled in the upper layers, and is thus not treated here.

2 Normative references

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

ISO/IEC 7498-1, *Information technology – Open systems interconnection – Basic Reference Model – Part 1: The Basic Model*

3   Terms, definitions and abbreviations

3.1   Terms and definitions

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

3.1.1
byte
represented by 8 bit

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.4]

3.1.2
centre frequency
mean frequency between the mark and space frequency of the transmitter

Note 1 to entry: See Figure 1.

3.1.3
collision
two wireless transmitters using the same wireless channel and transmitting data at the same time

3.1.4
cyclic redundancy check
CRC
integrity hash algorithm based on a polynomial division

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.6]

3.1.5
DATA_DL
field in the telegram containing the payload data of the link layer

3.1.6
DATA_PL
field in the packet containing the payload data of the physical layer

3.1.7
data rate
number of bits per second

3.1.8
data rate error
difference between the actual data rate and the specified data rate divided by the specified data rate

3.1.9
energy harvesting
energy available in the environment of a device that is captured and stored (harvested) to power operation of the device

Note 1 to entry: Examples of energy sources are mechanical actuation, solar radiation, temperature differences etc.

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.8]

3.1.10
frequency deviation
FDEV
half the magnitude between the mark frequency and the space frequency

Note 1 to entry: See Figure 1.

3.1.11
frequency error
difference between the centre frequency and the operating frequency

Note 1 to entry: See Figure 1.

3.1.12
frequency modulation
representation of logical 1 and logical 0 by mark and space frequencies

Note 1 to entry: See Figure 1.

3.1.13
frequency shift keying
FSK
transmission representing digital data by means of frequency modulation

3.1.14
HASH
field in which the hash value for the data integrity control of a transmitted telegram is specified

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.10, modified – "Subtelegram" has been removed in the definition.]

3.1.15
identity of destination
DESTID
unique identity of the destination device of a FMWSP telegram

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.14, modified – Both the term and the definition have been modified, not, however, the abbreviation.]

3.1.16
identity of source
ORIGID
unique identity of the device from which the telegram originates

Note 1 to entry: See Figure 1.

3.1.17
LENGTH
field in a packet or a telegram specifying the number of remaining bytes in the packet respectively the telegram

3.1.18
listen before talk
LBT
technique of checking the occupancy of the wireless channel before transmitting any packets

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.17, modified – "Frames" has been replaced by "packets" in the definition.]

3.1.19
mark frequency
frequency in a frequency modulated transmission representing a logical 1

Note 1 to entry: See Figure 1.

3.1.20
maximum tolerated signal
maximum input level power a receiver is able to cope with

3.1.21
non-return-to-zero
NRZ
code used for transmission of digital data

3.1.22
operating frequency
frequency claimed by the system specification

3.1.23
optimum sampling point
middle of the transmitted bit

Note 1 to entry: See Figure 1.

3.1.24
out of band spurious emissions
frequencies not deliberately created by the system

3.1.25
packet
set of data to be transmitted as a complete unit on the physical layer

3.1.26
packet error rate
average fraction of transmitted packets that has not been correctly received, where each packet contains arbitrary data

3.1.27
power amplifier ramp-off time
PA Ramp-Off Time
time between the end of the last symbol of the packet and the time the transmitter is powered down

Note 1 to entry: See Figure 1.

3.1.28
power amplifier ramp-on time
PA Ramp-On Time
time between the transmitter has been powered on and the start of the first symbol of the preamble (PRE)

Note 1 to entry: See Figure 1.

3.1.29
preamble
PRE
alternating sequence of bits in the beginning of a packet used for threshold generation and bit synchronisation

3.1.30
pulse shape
shape of the symbol

Note 1 to entry: See Figure 1.

3.1.31
radio frequency power
RF power
strength of the transmitter

3.1.32
rated transmission power
transmission power claimed by the specification of the transmitter

3.1.33
receiver sensitivity
minimum input power level for which the specified packet error rate has been fulfilled

3.1.34
repeated telegrams
telegrams transmitted by a repeater

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.28]

3.1.35
repeater
receives telegrams and sends refreshed signals to any FMWSP receiver

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.29]

3.1.36
space frequency
frequency in a frequency modulated transmission representing a logical 0

Note 1 to entry: See Figure 1.

3.1.37
symbol
bit transmitted by the sender representing either a logical 0 or a logical 1

Note 1 to entry: See Figure 1.

3.1.38
synchronisation word
SYNCWD
word transmitted in the packet to identify the FMWSP protocol and also used to synchronize the receiver to the incoming signal

3.1.39
telegram
data unit of the network and data link layers

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.34, modified – The definition has been changed and the note has been removed.]

3.1.40
telegram type
identifies the type of a telegram transmitted in the FMWSP protocol

Note 1 to entry: There are several types of telegrams that can be transmitted in the FMWSP protocol. Telegram types are used and defined by applications and chosen such that a minimum amount of energy is consumed. This standard specifies the syntax of the telegram types, but the semantics and which fields are supported are specified by the applications.

[SOURCE: ISO/IEC 14543-3-10:2012, 3.1.35, modified – The abbreviation has been deleted, the definition has been modified and Notes 1 and 2 have been replaced by a new Note 1.]

3.1.41
transmission power
power of the emission during transmission

Note 1 to entry: See Figure 1.

3.2   Abbreviations

ADDATA	Additional Data
CRC	Cyclic Redundancy Check
DATA_DL	Payload Data of the data link and network layers
DATA_PL	Payload Data of the physical layer
DESTID	Destination device IDentity
EIRP	Effective Isotropic Radiated Power
ERP	Effective Radiated Power
ETELTYP	Extended Telegram Type
EXHDR	Extension Header
FDEV	Frequency deviation
FMWSP	Frequency Modulated Wireless Short-Packet Protocol
FSK	Frequency Shift Keying
HDR	Header
LBT	Listen Before Talk
LSB	Least Significant Bit
MSB	Most Significant Bit
NRZ	Non-Return-to-Zero
ORIGID	Transmitting device Identity
PRE	Preamble
RF	Radio Frequency
SYNCWD	Synchronisation Word

4   Conformance

The three components of the FMWSP protocol system specified in this standard are the transmitter, the receiver and the repeaters. The repeaters shall be able to both transmit and receive telegrams and shall thus support the requirements for both the transmitters and receivers.

To conform to this International Standard the components shall support at least one of the three wireless frequencies 868,300 MHz, 902,875 MHz or 928,350 MHz unless another frequency is mandated by local regulations. For the frequency chosen, the transmitter shall support all the transmitter requirements that are not explicitly listed as optional, and the receiver shall support all the receiver requirements that are not explicitly listed as optional. These requirements are specified in Clauses 6, 7 and 8. The repeater shall, in addition to the requirements for a transmitter and for a receiver, also support the specifications in 8.3.

5   Architecture

5.1   Generic protocol description

5.1.1   Overview

This subclause provides a comprehensive overview of the Frequency Modulated Wireless Short-Packet (FMWSP) protocol stack (see Table 1). The FMWSP is a lightweight layered protocol designed to minimise both energy demand and the probability of a transmission collision. The FMWSP protocol stack accommodates the structure of the OSI reference model (see ISO/IEC 7498-1).

Table 1 – The FMWSP protocol stack structure (OSI)

Frequency Modulated Wireless Short-Packet protocol (FMWSP) stack			
Standard	**Layer**	**Services**	**Data units**
Not defined in this standard	Application		
	Presentation		
	Session		
	Transport		
ISO/IEC 14543-3-11	Network	Media access Listen Before Talk (LBT)	TELEGRAM
	Data link layer	Data integrity	TELEGRAM
	Physical	Frequency modulation Preamble (PRE) Synchronisation word (SYNCWD)	BITS / PACKET

5.1.2   Physical layer

At the physical layer the data are transmitted on the 868,3 MHz, the 902,875 MHz or the 928,35 MHz frequency band with 125 kbit/s data rate using Frequency Shift Keying (FSK). This may be subject to national regulations. One bit duration is 8 μs. The data are transmitted in packets. A packet consists of the preamble (PRE), the synchronisation word (SYNCWD), followed by a byte describing the length of the data message (LENGTH) and the actual data (DATA_PL).

The protocol is working plesiochronous. In a plesiochronous system the different parts of the system are almost, but not quite, synchronized. Within the limits of the maximum packet length the system can be considered as mesochronous (clocks have same frequency but different phase). After synchronisation based on the synchronisation word (SYNCWD) the system is considered synchronous. Thereby one can use a very energy efficient coding, namely the Non-Return-to-Zero (NRZ) coding.

For further details, see Clause 6.

5.1.3   Data link layer

A telegram is the part of a packet from which the preamble (PRE) and the synchronisation word (SYNCWD) have been removed. At the receiving end the telegram is transferred to the data link layer where the data integrity of the telegram is checked. If the data integrity check fails, the telegram is discarded.

5.1.4 Network layer

The network layer is responsible for routing, in this case primarily a repeating process, which is needed when the sender and recipient cannot communicate directly. This requires the existence of installed repeaters between them (see 8.3).

Another task of the network layer is to manage the timing of the received/transmitted telegrams. When possible, a listen-before-talk (LBT) technique is used to ensure that no transmission is initiated when the wireless channel is occupied.

5.1.5 Transport layer

This layer is not described in this standard.

5.1.6 Session layer

This layer is not described in this standard.

5.1.7 Presentation layer

This layer is not described in this standard.

5.1.8 Application layer

This layer is not described in this standard.

5.2 Data unit description

The communication protocol is based on units of data. The structure of the data units for each layer is described in Clause 6 (Physical layer), Clause 7 (Data link layer), and Clause 8 (Network layer).

A packet is the representation of the encoded data on the physical layer. It includes control and synchronisation information for the receiver. A packet is transmitted as a bit by bit serial sequence. At the receiving end, a telegram is the result of a decoding process, in which the fields preamble (PRE) and synchronisation word (SYNCWD) have been removed from the packet. At the transmitter side a packet is constructed by adding these two fields to the telegram.

6 Layer 1 – Physical layer

6.1 Overview

The physical parameters that shall be supported by the FMWSP protocol are described in this clause. The next subclause defines and illustrates the physical parameters that are specified in this standard. The requirements that a FMWSP transmitter shall fulfil are described in 6.3 and those for a FMWSP receiver in 6.4.

The physical layer is also responsible for the transformation between the transmitted data units in the physical layer, packets, and the transmitted data units in the link layer, telegrams. The structure and encoding of the FMWSP protocol packets are found in 6.5.

6.2 General description

This subclause describes the physical parameters for the FMWSP protocol, which shall be supported by the WSP signalling system. This includes all electrical parameters and associated tolerances for the transmitter and the receiver.
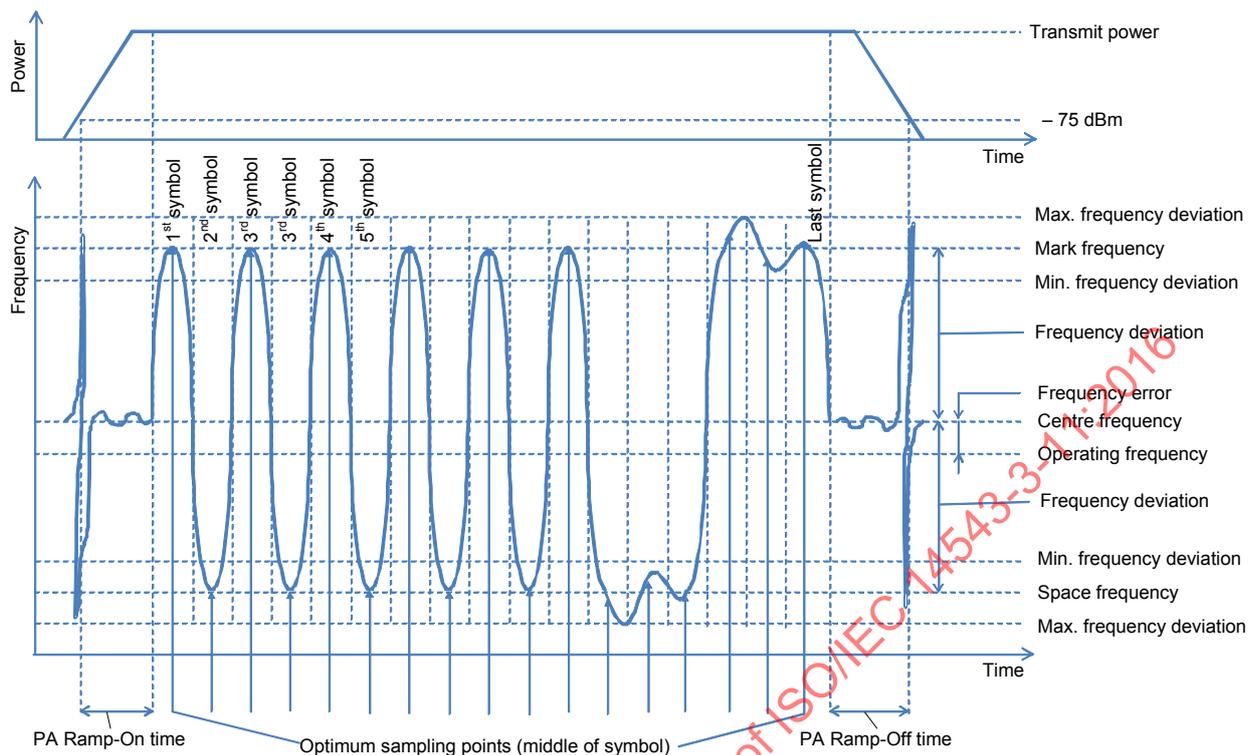
**Figure 1 – Illustration of a frequency modulated signal and
various associated physical parameters**

Figure 1 shows an FSK envelope. It also illustrates various physical parameters that are defined below. These are needed for the understanding of how the FMWSP protocol is defined.

Centre frequency is the mean frequency between the mark frequency and space frequency of the transmitter (see Figure 1).

Data rate error specifies the difference between the actual data rate and the specified data rate divided by the specified data rate. The shorter the telegram the larger the allowed data rate error.

Data rate is the number of bits per second.

Frequency deviation (FDEV) is half the magnitude between the mark frequency and the space frequency. It has a maximum and a minimum value between which the peaks of the symbols have to lie (see Figure 1).

Frequency error is the difference between the centre frequency and the operating frequency (see Figure 1). It is positive when the centre frequency is larger than the operating frequency and negative when the centre frequency is smaller than the operating frequency.

Frequency modulation is done such that a logical 1 and logical 0 are represented by the mark frequency and the space frequency, respectively (see Figure 1).

Mark frequency is representing the logical 1 and has the value of the centre frequency added by the frequency deviation (see Figure 1).

Maximum tolerated signal is the maximum input level power a receiver shall be able to cope with.

Operating frequency is the frequency claimed by the system specification (see Figure 1).

Optimum sampling points are in the middle of the transmitted bit (see Figure 1).

Out of band spurious emissions are the frequencies not deliberately created by the system and these shall conform to the local regulations.

Packet Error Rate is the average fraction of transmitted packets that has not been correctly received, where each packet contains arbitrary data.

PA Ramp Off-Time is the time between the end of the last symbol of the packet and the time the transmitter is powered down (see Figure 1).

PA Ramp On-Time is the time between the transmitter has been powered on and the start of the first symbol of the preamble (PRE) (see Figure 1).

Pulse shape is the shape of the symbol. It can have an arbitrary form, but shall have its peaks located between the maximum and minimum frequency deviation values (see Figure 1).

Radio Frequency (RF) power is the strength of the transmitter measured at the antenna connector, if present. It should be made with equipment that has either been matched to the impedance of the antenna connector or corrected for any mismatch. For devices without an antenna connector, the measurements shall be interpreted as effective isotropic radiated power (EIRP) (i.e. a 0 dBi gain antenna), and any radiated measurements shall be corrected to compensate gain in the implementation.

Rated transmission power is the transmission power specified for the transmitter.

Receiver sensitivity is the minimum input power level for which the specified packet error rate under the conditions specified in 6.4 has been fulfilled.

Space frequency is representing the logical 0 and has the value of the centre frequency subtracted by the frequency deviation (see Figure 1).

Symbol is the bit transmitted by the sender representing either a logical 0 or a logical 1.

Transmission power is the power of the emission during transmission (see Figure 1).

6.3 Physical specifications for a FMWSP transmitter

This subclause provides the requirements for a FMWSP transmitter. Table 2 lists all required parameter values that shall be supported for both a transmitter and a repeater. These parameters have all been described in 6.2 above.

Table 2 – Requirements for a FMWSP transmitter

Parameter	Minimum value	Typical value	Maximum value
Operating frequency for 868 MHz systems		868,300 MHz	
Operating frequency for 902 MHz systems		902,875 MHz	
Operating frequency for 928 MHz systems		928,350 MHz	
Frequency error (all operating frequencies)	−18 kHz		+18 kHz
Data rate (intended)		125 kbit/s	
Data rate error	$-7\,680 \times 10^{-6}$ / telegram length in bytes (-30×10^{-6} for maximum telegram length of 256 B)		$+7\,680 \times 10^{-6}$ / telegram length in bytes ($+30 \times 10^{-6}$ for maximum telegram length of 256 B)
Modulation type		FSK	
Coding		NRZ	
Frequency deviation (FDEV)	55,0 kHz	62,5 kHz	70,0 kHz
logical '0' (from centre frequency)		− FDEV	
logical '1' (from centre frequency)		+ FDEV	
Rated transmission power	0 dBm		Limited by national regulations
PA Ramp-On Time	0 µs		40 µs
PA Ramp-Off Time	0 µs		40 µs

6.4 Physical specifications for a FMWSP receiver

This subclause provides the requirements for a FMWSP receiver. A FMWSP receiver shall be able to cope with the transmitted signals within the tolerances given in 6.3. It shall also fulfil the requirements in Table 3. These parameters have all been described in 6.2 above.

Table 3 – Requirements for a FMWSP receiver

Parameter	Value
Receiver sensitivity	< −95 dBm
Maximum tolerated signal	> −20 dBm
Packet error rate Conditions: − packet with the value of field LENGTH = 10 B − no interference − power measured at the terminals of the receiving antenna	<0,1 %

6.5 Packet structure

This subclause specifies the structure of a packet, i.e. the telegram as transmitted in the physical layer. Details for various aspects of the data encoding in the packet are described. The mode of transmission is with the most significant bit (MSB) first. The maximum length of a packet is 260 B.

PRE	SYNCWD	LENGTH	DATA_PL

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Figure 2 – The packet structure for the FMWSP protocol

The complete packet consists of the preamble (PRE), the synchronisation word (SYNCWD), the length (LENGTH) of the field DATA_PL followed by the payload DATA_PL as illustrated in
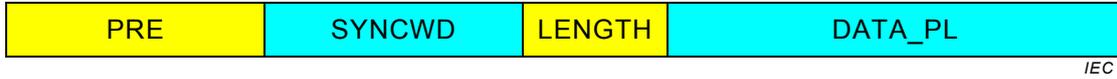
PRE	SYNCWD	LENGTH	DATA_PL

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Figure 2 above and described in Table 4.

Table 4 – Packet field values of the FMWSP protocol

Field	Value	Bit / Byte order
PRE (Preamble) (16 bit)	bit sequence "1010101010101010" (0xAAAA)	MSB transmitted first
SYNCWD (Synchronisation word) (16 bit)	bit sequence "1010100100111100" (0xA93C)	Byte transmission order from left to right
LENGTH (8 bit)	1 – 255	
DATA_PL (1 B to 255 B)	Payload data	

Every packet starts with the preamble (PRE) of length 16 bit (see Table 4).

PRE: This field, the preamble of length 2 B, is the start of packet and is used for threshold generation and bit synchronisation. Its value is seen in Table 4.

SYNCWD: This field is the synchronisation word, of length 2 B, serves to identify the FMWSP protocol and also used to synchronize the receiver to the incoming signal. Its value is seen in Table 4.

LENGTH: This field, of length 1 B, specifies the remaining number of bytes of the packet, which coincides with the length of the field DATA_PL.

DATA_PL: This field contains the payload data of the physical layer and will be described in detail in Clause 7. Its number of bytes is determined by the field LENGTH.

The relationship between a packet in the physical layer and a telegram in the link layer is described in 6.6.

6.6   Relationship between a packet and a telegram

A receiver needs to deduce the telegram from the packet, whereas a transmitter needs to create a packet out of a telegram. The relationship between them is seen in

LENGTH	DATA_PL

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Figure 3.

PHYSICAL LAYER

PRE	SYNCWD	LENGTH	DATA_PL

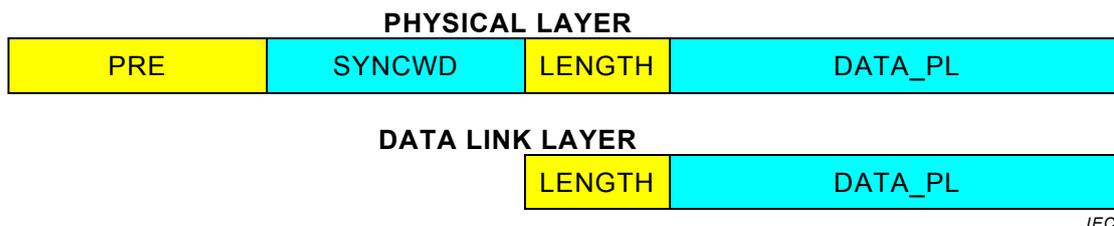**DATA LINK LAYER**

LENGTH	DATA_PL

IEC

Figure 3 – Relationship between a packet and a telegram

The difference between a packet and a telegram is that the fields PRE and SYNCWD of the packet are missing in the telegram, which consists of the fields LENGTH and DATA_PL.

7 Layer 2 – Data link layer

7.1 Overview

The structure of the transmitted data at the link layer, a telegram, exists in two different forms. One is for extremely short telegrams with a length of less than 8 B (see 7.2). The other telegrams can have a length between 8 B and 256 B (see 7.3). The data link layer is also responsible for the data integrity service, which is described in 7.4 below.

7.2 Structure of a telegram of length less than 8 B

A telegram of a length less than 8 B is a telegram in which the value of the field LENGTH is less than or equal to 6 B. Its structure is shown in

LENGTH	ORIGID	DATA_DL

IEC

Figure 4.

LENGTH	ORIGID	DATA_DL

IEC

Figure 4 – Structure of a telegram length of less than 8 B

The various fields in the telegram are:

LENGTH: This field specifies not only the number of bytes following this field in the telegram, but also the type of the telegram as shown in Table 5. The length of this field is 1 B.

ORIGID: This field specifies the identity of the source of the telegram. The length of the field depends on the telegram type as seen in Table 5.

DATA_DL: This field contains the payload of the telegram. The length of the field depends on the telegram type a seen in Table 5.

Table 5 – Field values and meaning of a telegram with less than 8 B of length

Value of LENGTH	Length of field ORIGID bit	Length of field DATA_DL bit	Meaning Telegram type
0000 0001	8	0	1
0000 0010	8	8	2
0000 0011	16	8	3
0000 0100	24	8	4

| 0000 0101 | 32 | 8 | 5 |
| 0000 0110 | 32 | 16 | 6 |

Since there is neither any information about either repetition (see 8.3) nor for data integrity (see 7.4), these types of telegrams shall never be repeated. Also the upper layers are responsible for data integrity.

The semantics of a telegram type is specified by the application and not by this standard. This standard specifies the syntax, which addresses structure and properties of the telegram.

7.3　Structure of a telegram length of more than 7 B

A telegram with more than 7 B length has a field LENGTH larger than 6 B. It has a different structure and is able to transfer more information. It includes a data integrity checksum, and it can be repeated. Its structure is shown in

| LENGTH | HDR | EXHDR | ETELTYP | ORIGID | DESTID | DATA_DL | ADDATA | HASH |

IEC

Figure 5.

| LENGTH | HDR | EXHDR | ETELTYP | ORIGID | DESTID | DATA_DL | ADDATA | HASH |

IEC

Figure 5 – Structure of a telegram length of more than 7 B

The various fields in the telegram are:

LENGTH: This is the first field of the telegram and specifies the number of bytes of the telegram that follows this field. Its length is 1 B.

HDR: This field, the header, with a length 1 B, specifies (see Table 6)

- the type of telegram,

- if the field Extended Telegram Type (ETELTYP) is present,

- if the field Extension Header (EXHDR) is present,

- the length in bytes of the field source identity (ORIGID), and

- if the field Destination Identity (DESTID) is present as well as its length in bytes.

EXHDR: This field, the Extension Header, of a length 1 B, specifies (see Table 7)

- if the telegram is the original telegram,

- if the telegram is a repeated telegram and then which order of repetition it is (maximum 15), and

- if the telegram contains the field Additional Data (ADDATA) and then its length in bytes.

ETELTYP: This field, the extended telegram type, of a length 1 B, specifies additional types of telegram not included among those found in HDR (see Table 6).

ORIGID: This field specifies the identity of the source of the telegram. The length of this field is specified in the field HDR.

DESTID: This field specifies the identity of the device for which this telegram is intended. Its presence and length is specified in the field HDR (see Table 6).

DATA_DL: This field contains the payload of the data link layer. The length of this field has to be deduced from the value specified in the field LENGTH and presence and lengths of all the other fields in the telegram.

ADDATA: This field contains additional data, which can be used for testing and installation purposes. Its presence and length in bytes are specified in the field EXHDR (see Table 7).

HASH: This field, of length 1 B, contains the integrity check value. The algorithm is specified in 7.4.

Table 6 – Header (HDR) description

HDR	Value	Meaning
bit 7...5	000	ORIGID 24 bit (3 B), No DESTID
	001	ORIGID 32 bit (4 B), No DESTID
	010	ORIGID 32 bit (4 B), DESTID 32 bit (4 B)
	011	ORIGID 48 bit (6 B), No DESTID
	100	ORIGID 128 bit (16 B), No DESTID
	101	ORIGID 128 bit (16 B), DESTID 128 bit (16 B)
	110	ORIGID 16 bit (2 B), No DESTID
	111	ORIGID 48 bit (6 B), DESTID 48 bit (6 B)
bit 4	0	No EXHDR
	1	EXHDR present
bit 3....0	0000	Telegram Type 7
	0001	Telegram Type 8
	0010	Telegram Type 9
	0011	Telegram Type 10
	0100	Telegram Type 11
	0101	Telegram Type 12
	0110	Telegram Type 13
	0111	Telegram Type 14
	1000	Telegram Type 15
	1001	Telegram Type 16
	1010	Telegram Type 17
	1011	Telegram Type 18
	1100	Telegram Type 19
	1101	Telegram Type 20
	1110	Telegram Type 21
	1111	ETELTYP present

The first 3 bits of the header (HDR) specify the length and presence of the source identity (ORIGID) and of the destination identity (DESTID) of the telegram (see Table 6).

The 4th bit specifies if the Extended Header (EXHDR) is present.

The last 4 bits of HDR specify the type of telegram or if the field ETELTYP is present (see Table 8). The semantics of a telegram type are specified by the application and not by this standard. This standard specifies the syntax, which addresses structure and properties of the telegram.

Table 7 – Extended header (EXHDR) description

EXHDR	Value	Meaning
bit 7...4	0000	Original telegram
	0001--1111	Telegram repetition number (1, ... ,154)
		1111 also means that this telegram is not permitted to be repeated by any repeater receiving it
bit 3....0	0000	No ADDATA present
	0001--1111	Length of ADDATA field in bytes (1 B to 15 B)

The first four bits of the extended header (EXHDR) specify if the telegram is permitted to be repeated or not. The value '0 0 0 0' means that it is the original telegram and that it is permitted to be repeated. The value '1 1 1 1' means it is either the original telegram that is not permitted to be repeated or a repeated telegram that has reached its maximum repetition number (15) and is no longer permitted to be repeated.

The last four bits of EXHDR specify the length in bytes of the field Additional Data (ADDATA). In case the value is 0, no such field is present.

Table 8 – Extended telegram type (ETELTYP) description

ETELTYP	Value	Meaning
bit 7...0	00000000	Telegram Type 22
	00000001	Telegram Type 23
	...	...
	11111110	Telegram Type 276
	11111111	Telegram Type 277

ETELTYP specifies the telegram types 22 to 277. The semantics of a telegram type are specified by the application and not by this standard. This standard specifies the syntax, which addresses structure and properties of the telegram.

7.4 Data integrity

Data integrity is only provided for telegrams containing the field HASH, i.e. telegrams longer than 7 B. In order to check that one of these longer telegrams has arrived intact, a hash of the telegram is calculated by the transmitting device, i.e. a transmitter or a repeater, before transmission and attached to the telegram (field HASH). The attached hash value is not protected and thus only serves to detect transmission failures and not protection against malicious intent. The verification is done by the device receiving the telegram, i.e. a receiver or a repeater. The algorithm supported is an 8-bit long Cyclic Redundancy Check (CRC) algorithm. All receivers and repeaters are required to support this hash function.