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INTERNATIONAL STANDARD

colour 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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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

FOREWORD

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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.

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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

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.