
**Information technology —
Telecommunications and information
exchange between systems — PHY/MAC
specifications for short-range wireless
low-rate applications in the ISM band**

*Technologies de l'information — Téléinformatique — Spécifications
PHY/MAC pour applications à bas débit sans fil à courte portée
dans la bande ISM*

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/IEC JTC 1, *Information technology, SC 6, Telecommunications and information exchange between systems*.

This second edition cancels and replaces the first edition (ISO/IEC 29157:2010), which has been technically revised.

Introduction

This International Standard is the revision of ISO/IEC 29157. This International Standard was established to provide a unified platform for services of data rates up to 1 Mbps: control data, voice, audio, and video. The purpose of the revision is to accommodate the advancement of technology for higher-quality services in the mobile applications.

The direction of the revision is three-fold: to enhance throughput, to facilitate co-existence with other technologies such as time-division LTE (long term evolution) and WiMAX II, and to increase data rate. For the higher throughput, the length of the preamble of the payload frames is made variable up to the user's need (see [9.2.2](#)). For the co-existence, the duration of the middle frames is reduced to 4 ms from 16 ms to make align with those of the other technologies (see [8.3](#)). With the shorter middleframes, the International Standard does not only harmonise with other technologies, but also attains advantages of shorter communication delay and less paring time. To increase the data rate, the message part of the payload frames may be modulated with QPSK. The modulation format is indicated by the 'PHY version' of the header (see [Clause 7](#) and [9.3](#)). With the addition of the new option, the data rate can be increased to 2 Mbps. In addition, to protect communications against security challenges due to the loss of protection provided by wires, this International Standard provides the optional security mechanism (See [9.3.2](#) and [Annex A](#)).

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Information technology — Telecommunications and information exchange between systems — PHY/MAC specifications for short-range wireless low-rate applications in the ISM band

1 Scope

This International Standard specifies the PHY characteristics and MAC procedures used for short-range, low-data-rate, wireless communications with very low latency and point-to-multipoint connection capability.

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 9798-3, *Information technology — Security techniques — Entity authentication — Part 3: Mechanisms using digital signature techniques*

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3 Terms and definitions (standards.iteh.ai)

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

3.1

pico-net

small operational range for wireless transmissions within about 10 meters in radius from the user or his/her device

3.2

group

total of devices interoperable within a Pico-net, with their usage of the same group code separating them from other devices in different groups

3.3

master

device transmitting the reference synchronisation signal within a group

3.4

slave

device that is not a master

3.5

scan

process performed by slaves to search for the synchronising signal from the master

3.6

middleframe

basic unit of frame operation, consisting of one control frame and one or more payload frames

Note 1 to entry: Sixteen middleframes constitute a superframe.

3.7

superframe

bigger frame consisting of sixteen middleframes

Note 1 to entry: The superframe is the overall operational unit of pico-net MAC operations.

3.8

scan code

7-bit seed to generate one of the 127 gold codes which has a value between 1 and 127

3.9

open code

code used for broadcasting

3.10

closed code

code used exclusively for a specific communication group or purpose

3.11

group code

code to discriminate among communication groups

Note 1 to entry: Either an open or a closed code may be applied.

3.12

security code

code applied to message data to enhance security or privacy of the communication

Note 1 to entry: Either an open or a closed code may be applied.

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4 Abbreviated terms

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The following acronyms are used in this International Standard.

AARQF	authentication access request frame
AARSF	authentication access response frame
ACCF	authentication capabilities announcement frame
ADDM	address mode
BF	beacon frame
BPSK	binary phase shift keying
DME	device management entity
FBF	fast beacon frame
FSK	frequency shift keying
GAPF	general authentication process frame
GFSK	Gaussian frequency shift keying
GKAP	group key authentication protocol
GTK	group temporal key
ISM	industrial, scientific, and medical
LSAP	light-weight shared-key authentication protocol

MAC	medium access control
MACF	MCF acknowledge control frame
MCF	master control frame
MLME	MAC sublayer management entity
MLME-SAP	MAC sublayer management entity-service access point
MPDU	MAC protocol data unit
MSDU	MAC service data unit
PD-SAP	PHY data service access point
PDU	protocol data unit
PF	payload frame
PHY	physical layer
PLAS	pico-net light-weight architecture security
PLME	physical layer management entity
PLME-SAP	physical layer management entity - service access point
PPDU	physical layer protocol data unit
PSDU	physical layer service data unit
PTK	pairwise temporal key ISO/IEC 29157:2015
QPSK	quadrature phase shift keying
RACF	RCF acknowledge control frame
RCF	request control frame
RF	radio frequency
RSSI	received signal strength indication
SAP	service access point
SDU	service data unit

5 Overview

There may be many applications in the ISM band. Such applications that require a short-range wireless communication channel can be listed as follows in the order of data rates; video, audio, voice, control, sensor, and so on. A different platform for a different application may be an ineffective way in light of cost, time-to-market, compatibility, etc. It would be beneficial to have a single platform which is capable of accommodating all these applications with the least overhead.

This International Standard is intended to provide a unified yet efficient and versatile platform for low-power, low-data-rate, short-range wireless communication applications. It is possible to accommodate diverse services of different nature in a single platform.

For mobile applications, low power consumption is one of the most important factors. To save power, data rate should be traded-off. This International Standard aims for the applications of 2 Mbps or less. To minimise implementation effort, it assumes the use of off-the-shelf RF components for the ISM band.

The International Standard makes use of frequency hopping, time-division multiple access, and time/frequency hybrid diversity. Frequency hopping is adopted to render immunity to the channel variations and to provide independent simultaneous communication channels. Time-division multiple access provides one with the control of interference of strong adjacent signals which otherwise should be avoided using an elaborate manipulation. The diversity technology is the means to maintain quality-of-service in the ISM band where channel fading is of serious concern.

Each device in the pico-net formed by this International Standard is either a master or a slave. In the pico-net, there exists only one single master which transmits a beacon signal to which all the other devices (slaves) are synchronised. The beacon signal contains the time synchronisation information and the frequency hopping pattern table. The frequency hopping pattern table contains the 16 best frequencies which are selected by sounding algorithms (see 7.4.5).

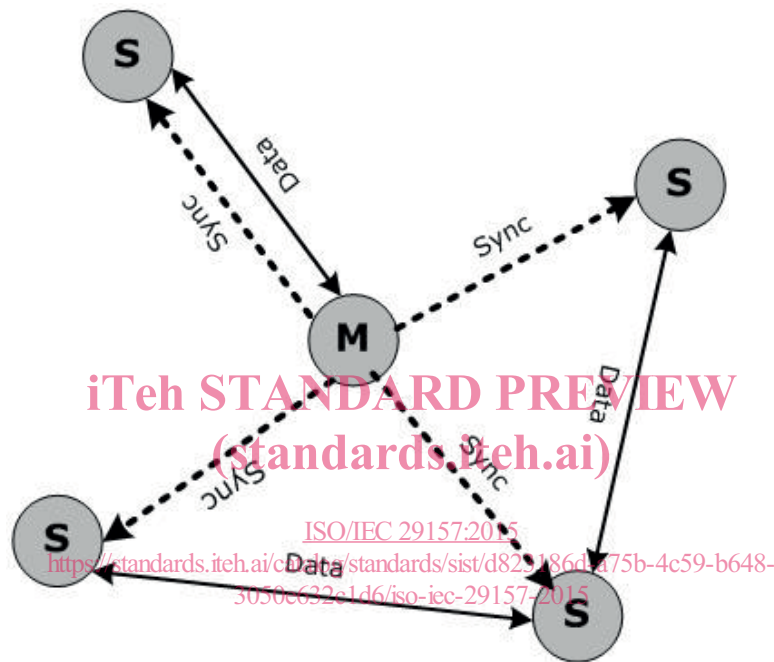


Figure 1 — A group communication example

At start-up, the master checks the frequency channels and selects the best 16 channels out of 80 to form a table of sixteen orthogonal frequency hopping patterns (see 8.4.2). Each frequency hopping pattern corresponds to a channel. The master assigns a communication channel (or channels) using the MCF (Master Control Frame) to be described below (see 7.4). Within each communication channel which is specified by a unique frequency-hopping pattern, the devices communicate with each other using time-division multiple access without any other intervention of the master.

The pico-net may have up to sixteen independent simultaneous communication channels. Within each communication channel, point-to-multipoint communication (broadcasting) is possible not to mention one-to-one communications. Moreover, each device may switch to another communication channel other than the current one if permitted by the master. Figure 1 shows an example of group communication in the pico-net. The master (M) transmits a beacon signal and is communicating with only one slave (S). The other slaves are communicating with another via other channels independently of the master.

Data are encased into the well-tailored standard units of a frame, a middleframe, and a superframe (see 8.3). Figure 2 shows the relationship between these units. These data formats are synchronised to the master beacon signal. To accommodate different applications in a single framework, this International Standard fixes the length of protocol frames to 4 ms which gives a permissible level of latency in most applications. A middleframe consists of frames. Sixteen middleframes constitute a superframe.

A frame is categorised into one of the seven kinds depending on its use: (1) a beacon frame (BF), (2) a fast beacon frame (FBF), (3) a request control frame (RCF), (4) a master control frame (MCF), (5) an RCF

acknowledge control frame (RACF), (6) an MCF acknowledge control frame (MACF), and (7) a payload frame (PF). All the frames except the payload frame (PF) are control frames. All the control frames have an identical format consisting of Lock Time, Preamble, Header, Message, and EoF Delimiter (see 8.2). The payload frame is used to carry user's data. Unlike the control frames whose preambles are fixed, the length of the preamble of the payload frame is variable to enhance the data throughput (see 9.2.2). Header is used to identify the kind of the frame. The message field is used to convey information and data necessary for communications (see 7.1 to 7.7).

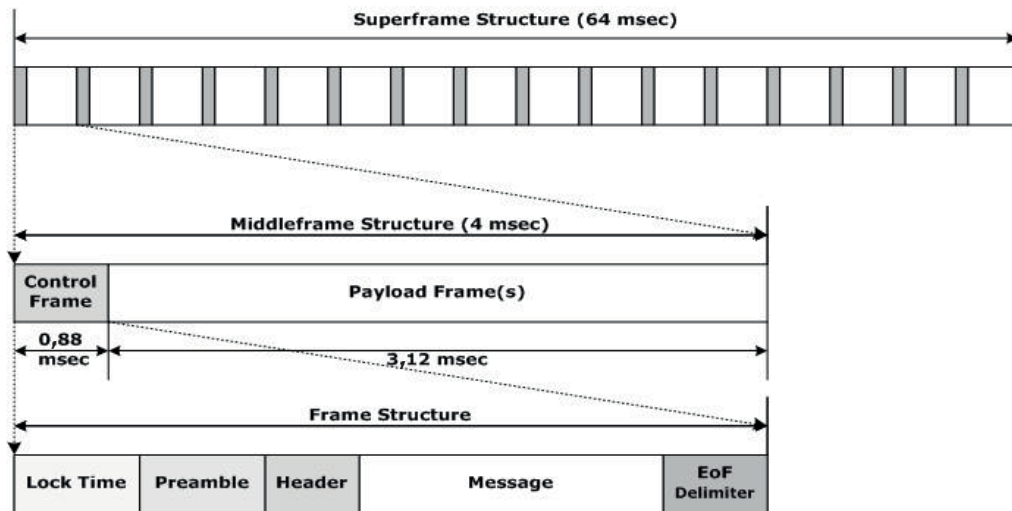


Figure 2 — Data formats: a frame, a middleframe, and a superframe
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A middleframe consists of one control frame and one or more payload frames (PF's). The middleframe starts with a control frame whose length is fixed to 0,88 ms. The length of the middleframe is fixed to 4 ms. The length of the payload frames varies depending on applications. Carrier frequencies hop in harmony with the middleframes.

A superframe consists of sixteen middleframes and is of 64 ms. Superframes have two modes: a normal mode and a fast synchronisation mode (see 8.3.2). A fast synchronisation mode is used for robust synchronisation. In a fast synchronisation mode, a frame called 'fast beacon frame (FBF)' is used instead of 'beacon frame (BF)'. Two modes may be interchangeably adopted by the unit of a superframe.

For security reasons, the preamble in the frame uses Gold codes for group identification. The message field data are also encrypted with security codes (see 9.3.2).

The MAC/PHY services and primitives will be defined and described in [Clause 6](#).

This International Standard uses the 2,4 GHz band and offers two classes of power transmission levels. Class one is up to 100 mW and class two is up to 10 mW. As a modulation scheme, the International Standard uses (G)FSK and QPSK (see 9.3).

In addition, this International Standard protects the communications from the security challenges due to the lack of protecting wires. Eavesdroppers may overhear data exchanges not intended for them, whereas imposters may send forged data not using its own identity, may replay previously transmitted data, and may transmit modified data captured from a previous transmission. In order to solve these issues, This International Standard also provides the security mechanism which the user can choose to implement (See 9.3.2 and [Annex A](#)).

6 Interlayer service specification

This Clause defines the interface between the MAC and PHY layers, and between the MAC layer and the upper layer.

6.1 Overview

Both MAC and PHY layers conceptually have management entities, called the MLME (MAC Layer Management Entity) and the PLME (PHY Layer Management Entity), respectively. These entities provide a service interfaces for the layer management functions.

The PHY provides data and management services through two SAPs (Service Access Points). The PHY data services are provided through the PD-SAP (PHY Data SAP), and PHY management services are provided through the PLME-SAP. The DME-PLME_SAP is equivalent to MLME-PLME-SAP except that it operates through DME rather than MLME.

The MAC provides data and management services through two SAPs (Service Access Points). The MAC data services are provided through the MAC-SAP, and MAC management services are provided through the MLME-SAP.

In order to provide correct MAC operation, each device must possess a DME (Device Management Entity). The DME is a layer-independent entity and act under the direction of a higher-level management application. Figure below depicts the relationships between the various management entities.

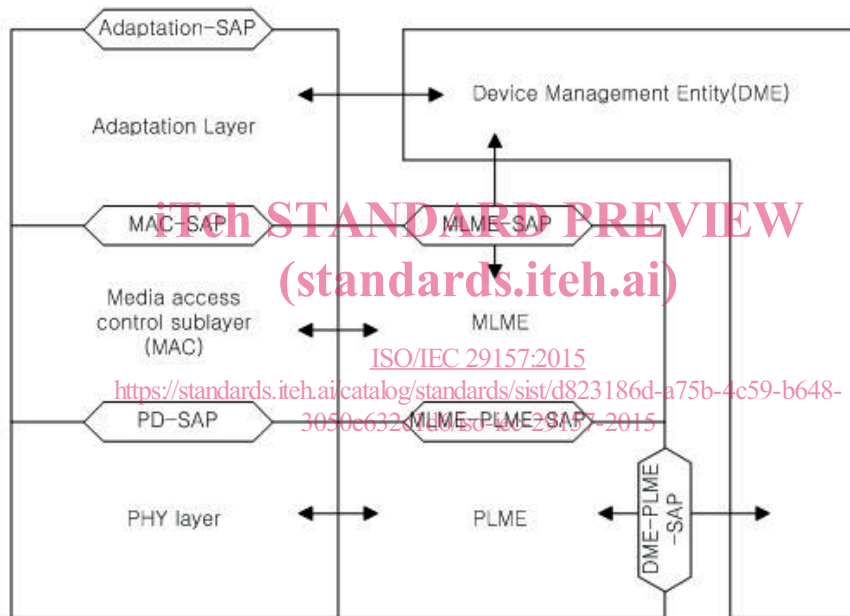


Figure 3 — The protocol model used in this International Standard

6.2 General format of management primitives

Each sublayer’s specific management information is organised into the relevant Management Information Base (MIB). Corresponding to the MIB of the PAN, the LAN/MAN contains the MIB that operates according to the Simple Network Management Protocol (SNMP). However, since management within network is restricted to an individual network (i.e. one network does not interfere in the management of another) the MIB is used to define the specifications of each sublayer.

MLME and PLME are assumed to have a MIB for each sublayer, and the management primitives of the MIB are exchanged by means of management SAPs. The manager can “GET” or “SET” the value of the MIB attribute via the primitives. The “SET” request primitive can also trigger certain actions within the relevant layer.

A “GET” or “SET” primitive may be expressed in the form of a request accompanying a confirm primitive. Such primitives have the prefix MLME or PLME depending on whether the point of exchange is the MAC SAP or the PHY SAP. DME utilizes the services provided by MLME through the MLME SAP.

In [Table 1](#), “XX” stands for “MLME” or “PLME”, and the parameters of the primitives are defined in [Table 2](#).

Table 1 — General management primitive overview

Name	Request	Confirm
XX-GET	6.2.1	6.2.2
XX-SET	6.2.3	6.2.4

Table 2 — MLME/PLME general management primitive parameters

Name	Type	Valid range	Description
MIBattribute	Octet string	Any MIB attribute	MIB attribute name
MIBvalue	Variable		MIB value
ResultCode	Enumeration	SUCCESS, INVALID_MIB_ATTRIBUTE, READ_ONLY_MIB_ATTRIBUTE, WRITE_ONLY_MIB_ATTRIBUTE	Result of MLME or PLME request

6.2.1 MLME-GET.request and PLME-GET.request

This primitive requests information about the relevant MAC MIB or PHY MIB. The semantics of these primitives are as follows.

XX-GET.request (

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MIBattribute [ISO/IEC 29157:2015](https://standards.iteh.ai/catalog/standards/sist/d823186d-a75b-4c59-b648-3050e632c1d6/iso-iec-29157-2015)

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The primitive parameters are defined in [Table 2](#).

6.2.1.1 When generated

DME and MLME (in the case of a PLME-GET.request) create these primitives to retrieve information from the MAC or PHY MIB.

6.2.1.2 Effect of receipt

The relevant management entity fetches the requested MIB attribute from the database and returns the value as the result of XX-GET.confirm.

6.2.2 MLME-GET.confirm and PLME-GET.confirm

This primitive returns the result of an information request to the relevant MAC MIB or PHY MIB. The semantics of these primitives are as follows.

XX-GET.confirm (

Status,

MIBattribute,

MIBattributevalue

)