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IEEE Standard for
Local and metropolitan area networks—

Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)

Amendment 4: Alternative Physical Layer Extension to Support Medical Body Area Network (MBAN) Services Operating in the 2360 MHz – 2400 MHz Band

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
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IEEE Std 802.15.4j™-2013
(Amendment to
IEEE Std 802.15.4™-2011
as amended by IEEE Std 802.15.4e™-2012,
IEEE Std 802.15.4f™-2012,
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IEEE-SA Standards Board

Abstract: In this amendment to IEEE Std 802.15.4™-2011, a physical layer for IEEE 802.15.4 in the 2360 MHz to 2400 MHz band which complies with Federal Communications Commission (FCC) MBAN rules is defined. Modifications to the MAC needed to support this new physical layer are also defined in this amendment.

Keywords: IEEE 802.15.4™, IEEE 802.15.4j™, MBAN, medical body area network

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When the IEEE-SA Standards Board approved this standard on 23 January 2013, it had the following membership:

Introduction

This introduction is not part of IEEE Std 802.15.4j™-2013, IEEE Standard for Local and metropolitan area networks—Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)—Amendment 4: Alternative Physical Layer Extension to Support Medical Body Area Network (MBAN) Services Operating in the 2360 MHz – 2400 MHz band .

This amendment specifies an alternate PHY in addition to those of the IEEE Std 802.15.4-2011, IEEE Std 802.15.4e™-2012, IEEE Std 802.15.4f™-2012, and IEEE Std 802.15.4g™-2012. This alternate PHY is specified for the 2360 MHz - 2400 MHz band MBAN band. In addition to the new PHY, the amendment also defines those MAC modifications that may be used to support the PHY implementation.

The US Federal Communications Commission has allocated spectrum in the range of 2360 MHz – 2400 MHz for use on a secondary basis for MBAN services. One of the major benefits of this spectrum is the ability to extend mature and low-cost IEEE 802.15.4™ solutions to this new spectrum and this amendment adapts the O-QPSK PHY for this purpose. Consideration has been given during the standardization process to keep the channelization scheme flexible, assisted by the use of new PHY parameter change features, to accommodate harmonized coexistence with in-band primary/MBAN services and to enable MBAN low-power implementations.

Contents

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Local and metropolitan area networks—

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NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and <u>underscore</u> (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Deletions and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.[1]

[1]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

3. Definitions, acronyms, and abbreviations

3.2 Acronyms and abbreviations

Insert the following acronyms alphabetically into 3.2:

FCC	Federal Communications Commission
MBAN	medical body area network

4. General description

Insert the following new subclause (4.1b) after 4.1a:

4.1b Introduction to medical body area network (MBAN) services

The US Federal Communications Commission (FCC) has allocated spectrum in the range of 2360 MHz to 2400 MHz for use on a secondary basis for MBAN services. MBAN devices operating within this band conform to a set of rules specified in a Report and Order (FCC 12-54, ET Docket No. 08-59) issued by the FCC, which restrict use of the band to only medical, non-voice use under direction of a healthcare practitioner, among other requirements. As a secondary user in this band, MBAN devices are required to protect all primary users and accept possible interference from those users. When a primary user is making use of a portion of the band MBAN devices vacate that portion of the band. Use of the band by the primary user is, in general, scheduled well in advance allowing MBAN users to share the band in an orderly manner.

Insert the following new subclause (4.2d) after 4.2c:

4.2d MBAN channel and/or band switch

An MBAN band coordinator may require devices to switch their operating channel and/or band at a specific time. The PHY Parameter Change IE is used by a device to notify another device to change operating channel and/or band at a certain time. This situation can arise, for example, for MBAN devices when a primary user is scheduled to use part of the band covering the MBAN device's operating channel at a scheduled time. The device is then required to vacate the channel at the scheduled time and move to another channel and/or band that does not interfere with the primary user.

5. MAC protocol

5.2 MAC frame formats

5.2.4 Information element

5.2.4.5 MLME information elements

Delete and insert the following new entries at the end of Table 4d:

Table 4d—Sub-ID allocation for short form

Sub-ID value	Content length	Name	Description
~~0x25-0x3f~~	—	~~Reserved~~	—
0x25	6	PHY Parameter Change IE	Defines time of parameter change
0x26	2	O-QPSK PHY Specific Parameter Change IE	Selects band and channel index
0x27-0x3f	—	Reserved	—

Insert the following new subclauses after 5.2.4.22:

5.2.4.23 PHY Parameter Change IE

The PHY Parameter Change IE is used by a device to notify a peer device or devices to switch operating band, channel, or other PHY specific operational parameters. This IE may be used in a directed frame to initiate a change between specific peers, or may be used in periodic beacons to affect a coordinated change among members of a PAN. The specific procedures for affecting a change are outside the scope of this standard.

The content of the PHY Parameter Change IE shall be formatted as illustrated in Figure 48uu.

Octets: 4	4
Effective Time of Change	Notification Time

Figure 48uu—PHY Parameter Change IE

The Effective Time of Change field shall contain a time in the future, in microseconds, when the change should occur. This time shall be decremented accordingly every time the PHY Parameter Change IE is transmitted.

The Notification time field shall contain the local time value in the generating device at the time the frame containing the PHY Parameter Change IE is generated.

The PHY Parameter Change IE shall always be followed in the frame by a valid Operating Mode Description IE.

5.2.4.24 O-QPSK PHY Operating Mode Description IE

An encoding for representing an operating mode for the O-QPSK PHY defined in Clause 10 is shown in Figure 48vv.

Octets: 1	**1**
Band Selector	Channel Index

Figure 48vv—O-QPSK PHY Operating Mode Description IE

The Band Selector field identifies the band for the operating mode and shall take one of the values in Table 4s.

Table 4s—Band Selector frequency bands

Band Selector value	Corresponding band
1	779 MHz – 787 MHz
2	868.0 MHz – 868.6 MHz
3	902 MHz – 928 MHz
4	2360 MHz – 2400 MHz
5	2400.0 MHz – 2483.5 MHz

The Channel Index field shall contain a valid channel number as defined in 8.1.2.1, 8.1.2.2, or 8.1.2.11 as appropriate to the band selector value.

8. General PHY requirements

8.1 General requirements and definitions

Change the following items at the end of the second dashed list in 8.1 as shown:

— **O-QPSK PHY:** direct sequence spread spectrum (DSSS) PHY employing offset quadrature phase¬shift keying (O-QPSK) modulation, operating in the 780 MHz bands, 868 MHz, 915 MHz, 2380 MHz, and 2450 MHz, as defined in Clause 10.

8.1.1 Operating frequency range

Insert the following new row before 2450 DSSS as shown in Table 66:

Table 66—Frequency bands and data rates

PHY (MHz)	Frequency band (MHz)	Spreading parameters		Data parameters		
		Chip rate (kchip/s)	Modulation	Bit rate (kb/s)	Symbol rate (ksymbol/s)	Symbols
2380 DSSS	2360 – 2400	2000	O-QPSK	250	62.5	16-ary orthogonal

8.1.2 Channel assignments

Insert the following new subclause (8.1.2.11) after 8.1.2.10.2:

8.1.2.11 Channel numbering for 2380 MHz band

For channel page eleven, 15 channels numbered zero to fourteen are available across the 2380 MHz band. The center frequencies of these channels are defined as follows:

$F_c = 2363 + 5\,k$ in megahertz, for $k = 0, 1, \ldots, 6$

$F_c = 2367 + 5\,(k - 7)$ in megahertz, for $k = 7, 8, \ldots, 13$

and $F_c = 2395$ in megahertz, for $k = 14$

where

k is the channel number.

10. O-QPSK PHY

10.2 Modulation and spreading

10.2.1 Data rate

Change the first paragraph of 10.2.1 as shown:

The data rate of the O-QPSK PHY shall be 250 kb/s when operating in the 2450 MHz, 915 MHz, ~~or~~ 780 MHz, or 2380 MHz bands and shall be 100 kb/s when operating in the 868 MHz band.

Insert after the second paragraph in 10.2.1:

Support for the 2380 MHz O-QPSK PHY is mandatory when operating in the 2380 MHz band.

10.2.4 Symbol-to-chip mapping

Change the first paragraph of 10.2.4 as shown:

In the 2450 MHz and 2380 MHz bands, each data symbol shall be mapped into a 32-chip PN sequence as specified in Table 73. The PN sequences are related to each other through cyclic shifts and/or conjugation (i.e., inversion of odd-indexed chip values).

Change the title of Table 73 as shown:

Table 73—Symbol-to-chip mapping for the 2450 MHz and 2380 MHz bands

10.2.5 O-QPSK modulation

Change the first paragraph of 10.2.5 as shown:

The chip sequences representing each data symbol are modulated onto the carrier using O-QPSK with half-sine pulse shaping. Even-indexed chips are modulated onto the in-phase (I) carrier, and odd-indexed chips are modulated onto the quadrature-phase (Q) carrier. In the 2450 MHz and 2380 MHz bands, each data symbol is represented by a 32-chip sequence, and so the chip rate is 32 times the symbol rate. In the 915 MHz, 868 MHz, and 780 MHz bands, each data symbol is represented by a 16-chip sequence, and so the chip rate is 16 times the symbol rate. To form the offset between I-phase and Q-phase chip modulation, the Q-phase chips shall be delayed by T_c with respect to the I-phase chips, as illustrated in Figure 70, where T_c is the inverse of the chip rate.

10.2.6 Pulse shape

Change the first paragraph of 10.2.6 as shown:

In the 2450 MHz, 915 MHz, ~~and~~ 868 MHz, and 2380 MHz bands, the half-sine pulse shape is used to represent each baseband chip and is given by:

10.2.7 Chip transmission order

Change the first paragraph of 10.2.7 as shown:

During each symbol period, the least significant chip, c_0, is transmitted first and the most significant chip, either c_{31}, for the 2450 MHz<u> and 2380 MHz</u> band<u>s</u>, or c_{15}, for the 915 MHz, 868 MHz, and 780 MHz bands, is transmitted last.

10.3 O-QPSK PHY RF requirements

10.3.1 Operating frequency range

Change the dashed list in 10.3.1 as shown:

— 779 – 787 MHz
— 868.0 – 868.6 MHz
— 902 – 928 MHz
<u>— 2360 – 2400 MHz</u>
— 2400.0 – 2483.5 MHz

10.3.2 Transmit power spectral density (PSD) mask

Change the third paragraph of 10.3.2 as shown:

When operating in the <u>2380 MHz and </u>2450 MHz band<u>s</u>, the transmitted spectral products shall be less than the limits specified in Table 76. For both relative and absolute limits, average spectral power shall be measured using a 100 kHz resolution bandwidth. For the relative limit, the reference level shall be the highest average spectral power measured within ±1 MHz of the carrier frequency.

Change the title of Table 76 as shown:

Table 76—<u>2380 MHz and </u>2450 MHz band<u>s</u> O-QPSK transmit PSD limits

10.3.3 Symbol rate

Change the first paragraph of 10.3.3 as shown:

The O-QPSK PHY symbol rate shall be 25 ksymbol/s when operating in the 868 MHz band and 62.5 ksymbol/s when operating in the 780 MHz, 915 MHz, <u>2380 MHz, </u>or 2450 MHz bands with an accuracy of ±40 ppm.

10.3.5 Receiver interface rejection

Change the first paragraph of 10.3.5 as shown:

This subclause applies only to the 780 MHz, 915 MHz, <u>2380 MHz, </u>and 2450 MHz bands as there is only one channel available in the 868 MHz band.

Change the title of Table 77 as shown:

Table 77—Minimum receiver interface rejection requirements for the 780 MHz, 915 MHz, 2380 MHz, and 2450 MHz bands.

Annex A

(informative)

Bibliography

Insert the following new references alphanumerically in Annex A:

[B24] IEEE Std 802.1D, IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges.[1]

[1] IEEE publications are available from The Institute of Electrical and Electronics Engineers (http://standards.ieee.org/). This document is available at https://mentor.ieee.org/802.15/documents.

Annex D

(informative)

Protocol implementation conformance statement (PICS) proforma[1]

D.7 PICS proforma tables

D.7.2.2 PHY functions

Insert new row after RF9 in Table D.3 (the rest of the table is not shown) as indicated:

Table D.3—Radio frequency (RF)

Item number	Item description	Reference	Status	Support		
				N/A	Yes	No
RF10	2380 MHz O-QPSK PHY	Table 66, Clause 10	O.3			

[1]Copyright release for PICS proformas: Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

Insert after new Annex O the following new annex (Annex P):

Annex P

(informative)

Features to assist MBAN devices

This annex describes two features that could be used to assist the operation of MBAN devices.

P.1 Coordinator switching

There are several MBAN usage scenarios where the devices that are associated with one coordinator may need to be moved to another coordinator. For example, a patient with an array of sensors is in transportation from an operating room to a recovery room and monitored by a portable monitor to provide continuous care services. The patient is then moved back to his/her patient room in which a bedside monitor is available. Switching the sensor devices from the portable monitor to the bedside monitor would provide better data processing and display and save the battery life of the portable device. It is important that an orderly switching of the devices from the coordinator in the portable monitor to the desired coordinator in the bedside monitor takes place. Since the switching is instigated and controlled by a clinician and the procedure to enable this resides in the higher layer of the coordinators, a detailed description of how this is done will not be described here, though some of the steps that could be used are noted here.

First, the coordinator sends a message to the associated devices informing the devices of the identity of the coordinator with which they should associate after they have been disassociated from their existing coordinator. This identity information is supplied to the coordinator by the clinician. On receipt of this information the devices should then cease further data transmission and await notification from the coordinator that they have been disassociated. Upon disassociation, the devices then commence a scanning procedure to find the new coordinator whose identity is being broadcast within the beacon to determine the channel number that the coordinator is using, its PAN ID and MAC extended address. Once this information is obtained the devices can begin association and then communication between the devices and the new coordinator can commence. This description does not necessarily include all of the steps that need to be taken and it only gives an indication of what may be required.

P.2 Channel bitmap

To assist with coexistence to the primary users of the 2360 MHz – 2390 MHz band, MBAN devices may be excluded from using some of the channels in this band (Channels 0 – 5 and 7 – 12). The channels that are excluded may change over time. Regulations require that the operation of MBAN hub devices have access to a mechanism that provides information on the portions of the band that cannot be used. The description of this mechanism is beyond the scope of this standard. To assist other MBAN devices, such as those connected to sensors, that do not have direct access to this mechanism, a bitmap may be used by a hub device to indicate the channels that are allowed to be used by the MBAN devices.

The bitmap can be conveyed as an Encapsulated Service Data Unit (ESDU) Information Element (IE) described in 5.2.4.4 that can be used to encapsulate a higher layer payload. The definition of the format of this payload is beyond of the scope of this standard.