IEEE P802.22
Wireless RANs

Preliminary (Unapproved) Draft Standard for P802.22.1

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Abstract

This document is a Preliminary (Unapproved) Draft of the P802.22.1 Standard.

IEEE Standard for
Information technology—
Telecommunications and information exchange between systems—
Local and metropolitan area networks—
Specific requirements—

Part 22.1: Enhanced Protection for Low-Power, Licensed Devices Operating in Television Broadcast Bands

Sponsor

LAN/MAN Standards Committee
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IEEE Computer Society

Abstract: This standard defines the protocol and data formats for communication devices used to protect low-power, licensed devices operating in television broadcast bands from harmful interference generated by license-exempt devices operating in the same bands.
Keywords: ad hoc network, beacons, TV white space, WRAN

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Introduction

This introduction is not part of IEEE Std 802.22.1/D1, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 22.1: Enhanced Protection for Low-Power, Licensed Devices Operating in Television Broadcast Bands.

This standard defines the protocol and data formats for communication devices offering enhanced protection for low-power, licensed devices operating in television broadcast bands. Protection is provided through the use of a beacon, which contains information relevant to the licensed device, including its physical location and estimated duration of channel occupancy. The standard uses the ALOHA medium access mechanism, and all transmissions are broadcast.

The physical layer uses direct sequence spread spectrum (DSSS) with differential quadrature phase-shift keying (DQPSK). A synchronization word and countdown mechanism (i.e., time until the next beacon transmission) is transmitted continuously on the I channel, while beacons and inter-device communications are transmitted on the Q channel. Frequency, modulation rate, and transmit power vary from region to region and must adhere to local regulations.

Notice to users

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Participants

At the time the draft of this standard was sent to sponsor ballot, the IEEE P802.22 Working Group had the following voting members:

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William J. Rose, *Task Group 1 Chair*
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Monique Bourgeois Brown, *Task Group 1 Editor-in-Chief*
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<insert list of voters here>

Major contributions were received from the following individuals: *<insert names here>*

The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention. *<insert names here>*

When the IEEE-SA Standards Board approved this standard on DD MM 2007, it had the following membership: *<insert names here>*

,

Also included are the following nonvoting IEEE-SA Standards Board liaisons: *<insert names here>*

IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements—

Part 22.1: Enhanced Protection for Low-Power, Licensed Devices Operating in Television Broadcast Bands

1. Overview

1.1 General

The Federal Communications Commission (FCC) in the United States of America has proposed to allow license-exempt devices to operate within portions of the television (TV) white space not used for broadcasts. Although this “unused” portion is not used for broadcasts, low-power, licensed devices, such as wireless microphones, do use this spectrum, and it is important to protect those devices from interference to avoid disrupting incumbent services.

This standard defines a method of protection that will enable continued interference-free operation of the licensed, incumbent services and promote spectrum sharing with the license-exempt devices, benefitting both the incumbent licensees and equipment manufacturers.

1.2 Scope

The scope of this standard is to specify a method to provide enhanced protection for licensed devices, such as those used in the production and transmission of broadcast programs (e.g. devices licensed as secondary under FCC Part 74 in the USA and equivalent devices in other regulatory domains), from harmful interference caused by license-exempt devices (e.g. IEEE 802.22) which are also intended to operate in the television broadcast bands.

1.3 Purpose

The purpose of this standard is to define an efficient method for license-exempt devices to provide enhanced protection to low-power, licensed devices which are entitled to protection from harmful interference and that share the same spectrum. This standard may be applicable in global regulatory environments.

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 or corrigenda) applies.

FIPS Pub 197, Advanced Encryption Standard (AES).[1]

IEEE Std 802®, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture.[2]

ISO/IEC 8802-2 (IEEE Std 802.2™), Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 2: Logical link control.[3]

ISO/IEC 9646-7 (ITU-T Rec. X.296), Information technology — Open systems interconnection — Conformance testing methodology and framework — Part 7: Implementation conformance statements.

[1]FIPS publications are available from the National Technical Information Service (NTIS), U. S. Dept. of Commerce, 5285 Port Royal Rd., Springfield, VA 22161 (http://www.ntis.org/).

[2]IEEE Publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org).

[3]ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO/IEC publications are also available in the United States from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/). Electronic copies are available in the United States from the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

3. Definitions

For the purposes of this standard, the following terms and definitions apply. Terms not defined in this clause can be found in the *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B1].[4]

3.1 Channel: A portion of spectrum within the television broadcast bands, which may be 6, 7 or 8 MHz wide, depending on its geographic location.

3.2 FCC Part 74 device: Low power auxiliary stations as defined in §74, Subpart H.

3.3 Primary protecting device (PPD): A device that uses periodic beacons to protect its corresponding licensed device, and its protection may be extended to other licensed devices in the area. ~~There is only one PPD in a given area.~~ *[Editor's note: Since we don't mandate aggregation, we should remove this text.]*

3.4 Protected device: A low-power, licensed device that is being protected by a beaconing device.

3.5 Protecting device: A beaconing device that is protecting a low-power, licensed device. The protecting device may be either the primary protecting device (PPD) or a secondary protecting device (SPD).

3.6 Secondary protecting device (SPD): A device that shares the responsibility of protecting its corresponding licensed device with the PPD. An SPD occasionally sends beacons for the sole purpose of communicating with the PPD. ~~There may be numerous SPDs in a given area.~~ *[Editor's note: I don't think the last line is necessary.]*

3.7 Slot: A period of time equal to 24 symbol times, or the duration of one sync burst.

3.8 Subchannel: A 200 kHz-wide portion of a channel. The lowest frequency subchannel is centered 100 kHz above the lower edge of the channel, and the highest frequency subchannel is centered 100 kHz below the upper edge of the channel. The number of subchannels within a given channel depends on the width of the channel.

3.9 Television white space: Spectrum traditionally allocated for VHF and UHF TV broadcast that is made available for unlicensed use on a regional basis conditioned on the requirement that the unlicensed devices not cause harmful interference to licensed TV reception, wireless microphones or other protected devices.

[4]The numbers in brackets correspond to the numbers of the bibliography in Annex A.

4. Acronyms and abbreviations

ACK	Acknowledgement
ANP	Acknowledgement/No Acknowledgement Period
ARIB	Association of Radio Industries and Businesses
ATSC	Advanced Television Systems Committee
DSSS	Direct Sequence Spread Spectrum
DQPSK	Differential Quadrature Phase-Shift Keying
ED	Energy Detection
EIRP	Effective Isotropic Radiated Power
ETSI	European Telecommunications Standards Institute
EVM	Error Vector Magnitude
FCC	Federal Communications Commission
HDTV	High Definition Television
IC	Industry Canada
LQI	Link Quality Indicator
LSB	Least Significant Bit
MFR	MAC Footer
MHR	MAC Header
MIB	MAC Information Base
MIC	Message Integrity Code
MLME	MAC Sublayer Management Entity
MLME-SAP	MAC Sublayer Management Entity Service Access Point
MPDU	MAC Protocol Data Unit
MSB	Most Significant Bit
NACK	No Acknowledgement
NHL	Next Higher Layer
PD-SAP	PHY Data Service Access Point
PER	Packet Error Rate
PHR	PHY Header
PIB	PHY Information Base
PLME	PHY Layer Management Entity
PLME-SAP	PHY Layer Management Entity Service Access Point
PN	Pseudo-random Noise
PPD	Primary Protecting Device
PPDU	PHY Protocol Data Unit
PSDU	PHY Service Data Unit
RATSC	symbol Rate defined by the Advanced Television Systems Committee
RTS	Request To Send
SAP	Service Access Point
SHR	Synchronization Header
SPD	Secondary Protecting Device

5. Functional overview

5.1 Introduction

This standard defines the protocol and data formats for communication devices offering enhanced protection for low-power, licensed devices operating in television broadcast bands.

A brief overview of the general functions of a beaconing network is given in 5.1 through 5.6, and includes information on the frame structure, the data transfer model, and security.

As described in greater detail in 7.4.2, upon initialization each device monitors its channel for a random number of slots to determine the presence or absence of other beaconing devices. If none are heard, the device determines that it shall act as the primary protecting device (PPD), and begins beaconing; if one or more beaconing devices are heard, under control of an upper layer, the device may determine either to act as the PPD and initiate its own beacon, or as a secondary protecting device (SPD) and attempt to contact a beaconing device.

5.2 Superframe structure

IEEE P802.22.1/D1 employs the superframe structure shown in Figure 1.

The superframe structure consists of a succession of slots, in which two logical channels are continuously transmitted in parallel. The first logical channel is the synchronization channel. The second logical channel is the beacon channel (7.2). The synchronization channel consists of a succession of synchronization bursts (6.3.1). Each slot contains one synchronization burst, as well as a fixed number of bits from the beacon channel. Under control of an upper layer, a receive period (6.5), and an acknowledgement/no acknowledgement period (ANP) may also be included (6.6). This format repeats without interruption while the protecting device is in operation.

The synchronization bursts, each of which consists of a synchronization word followed by a decrementing index value, enable a receiver asynchronously sampling the beacon channel to quickly determine when the next beacon will be sent.

The beacon contains information relevant to the device protected by the protecting device, including its physical location and estimated duration of channel occupancy. The beacon includes an initialization subfield, which indicates whether the device is in its initial transmission period on a channel.

Following the beacon, there is an optional receive period, during which the PPD pauses to monitor the channel for a request to send (RTS) burst transmitted by a SPD. Finally, there is an optional ANP, reflecting whether or not an RTS burst was detected. During the initial transmission period, no receive period or ANP will follow.

If the optional receive period and ANP are to be included, the final index value in the series of synchronization bursts will be one, indicating that the next superframe starts after the receive period and corresponding ANP (as illustrated in Figure 1 (a)). If they are not included, the final index value will be zero, indicating that the next superframe starts immediately (as illustrated in Figure 1 (b)). While this final synchronization burst with index zero is being transmitted on the I channel, the Q channel will transmit all zeros. *[Editor's note: This text is needed to explain how the countdown sequence works for initialization mode (this is separate from the SPD superframe discussion). I expanded it slightly and added a figure 1 (b) to try and clarify things.]*

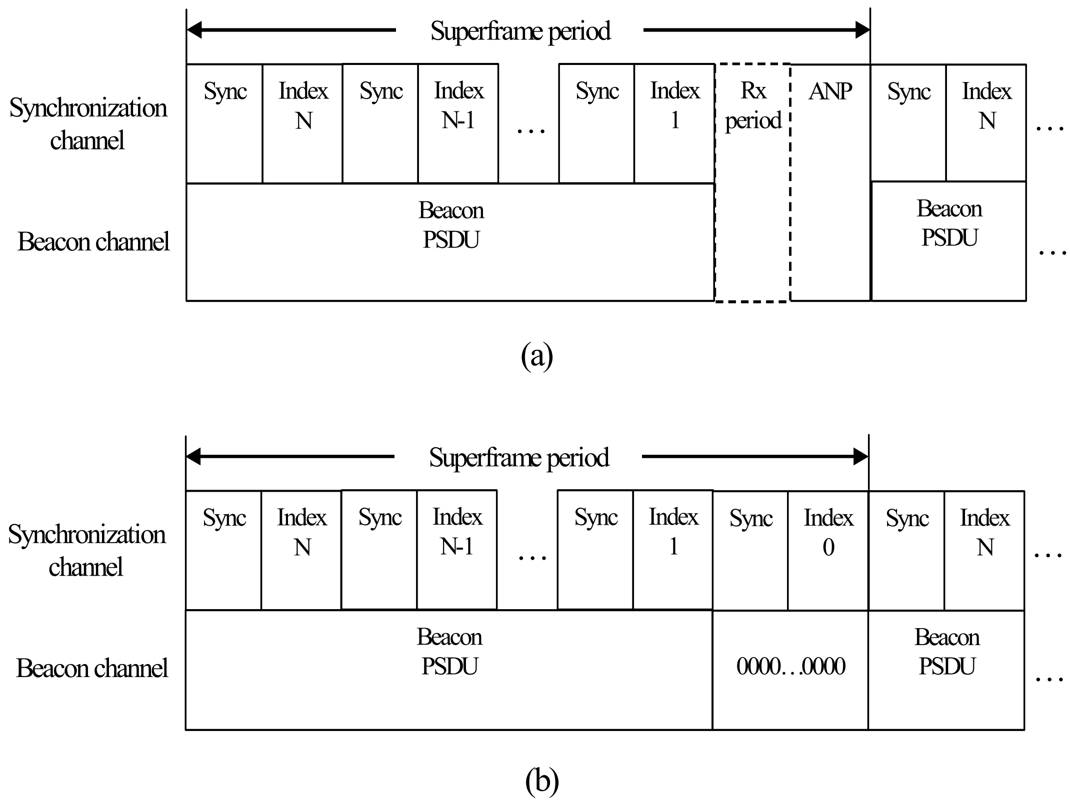


Figure 1—Superframe logical format

5.3 Data transfer model

All transmissions are broadcast. Transmitted data may be received and processed by any device in the area (e.g., WRAN), including other IEEE 802.22.1-compliant devices.

If the receiving device is an IEEE 802.22.1-compliant device, two types of data transfer transactions exist. The first type is the data transfer from the PPD to an SPD, in which the PPD transmits the data. The second type is the data transfer from an SPD to the PPD, in which the SPD transmits the data.

When the PPD desires to send data to a SPD, it does so by placing the information in its beacon PSDU. The SPD, of which there may be many in range of the PPD, monitors the beacon PSDU of the PPD, and decodes its address and recovers the message. No acknowledgement of data reception is provided at the MAC level. See Figure 2.

When an SPD desires to send data to the PPD, it sends an RTS burst to the PPD during the receive period of the superframe, then ensures that an ACK, as opposed to a NACK, was transmitted during the ANP. The PPD then yields the following superframe to the SPD, which then transmits its own superframe, containing its data and the synchronization channel, during this time. Following the transmission by the SPD, the PPD continues the superframe by monitoring the channel during the receive period. See Figure 3.

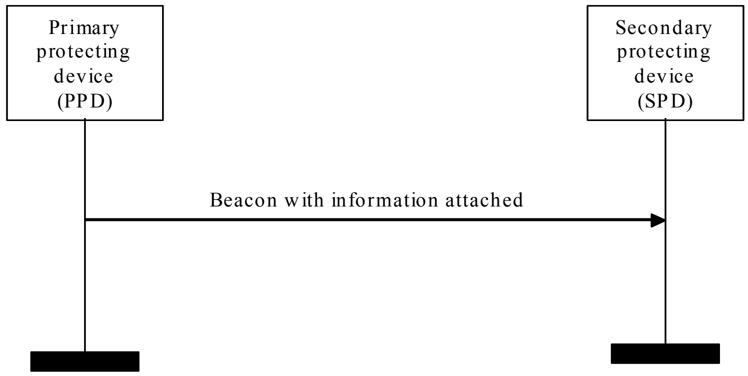


Figure 2—Communication from primary to secondary protecting devices

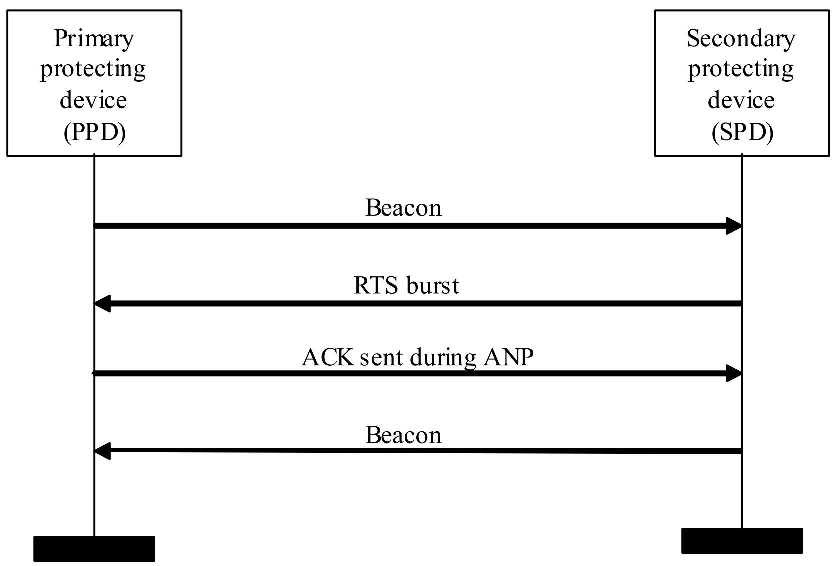


Figure 3—Communication from secondary to primary protecting devices

5.4 Synchronization burst structure

Figure 4 shows the structure of the synchronization burst sequence, which originates from within the PHY layer of the PPD. Each synchronization burst contains a 15-bit synchronization word, plus a 9-bit index value that decrements with each burst transmission. The synchronization burst sequence enables fast detection of the PPD, while the decrementing index value identifies the start time of the next superframe transmission in multiples of slots (1 slot = 24 bits/9609.1 Hz = 2.497632… ms).

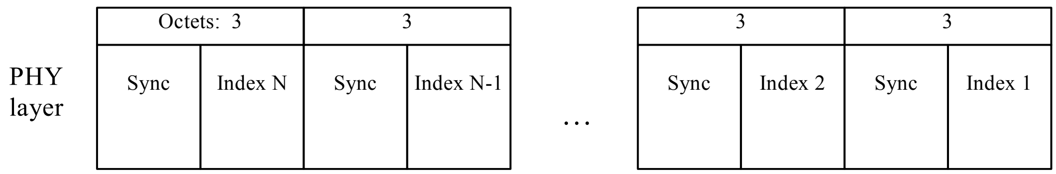


Figure 4—Schematic view of synchronization burst sequence

[Comment from Steve on the length of the index: I thought this got reduced since the packet will be much shorter than 512 sync bursts (1536 bytes) now; 5 bits ought to do. Could use longer sync word or shorter sync burst or parity bit on 5-bit index (use 21 bits total).

Comment from editor: leave it as is for now until we know the outcome of the error detection/correction and security discussions.]

5.5 Beacon frame structure

Figure 5 shows the structure of the beacon frame, which originates from within the MAC sublayer of either the PPD or an SPD. The beacon frame contains a MAC header (MHR) and a MAC footer (MFR). The MHR contains the three MAC parameter fields and the source address, location and a channel/subchannel map field. The MFR contains a *TBD*-octet message integrity code (MIC). The MHR and MFR together form the MAC protocol data unit (MPDU), which has the same contents as the PHY service data unit (PSDU). The PSDU and PHR together form the beacon frame.

The MAC beacon frame is passed to the PHY as the PSDU, which becomes the PHY payload. The PHY payload is prefixed with a PHY header (PHR), containing the initialization bit. The PHR and PHY payload together form the PHY protocol data unit (PPDU) (i.e., the PHY packet).

5.6 Security

TBD

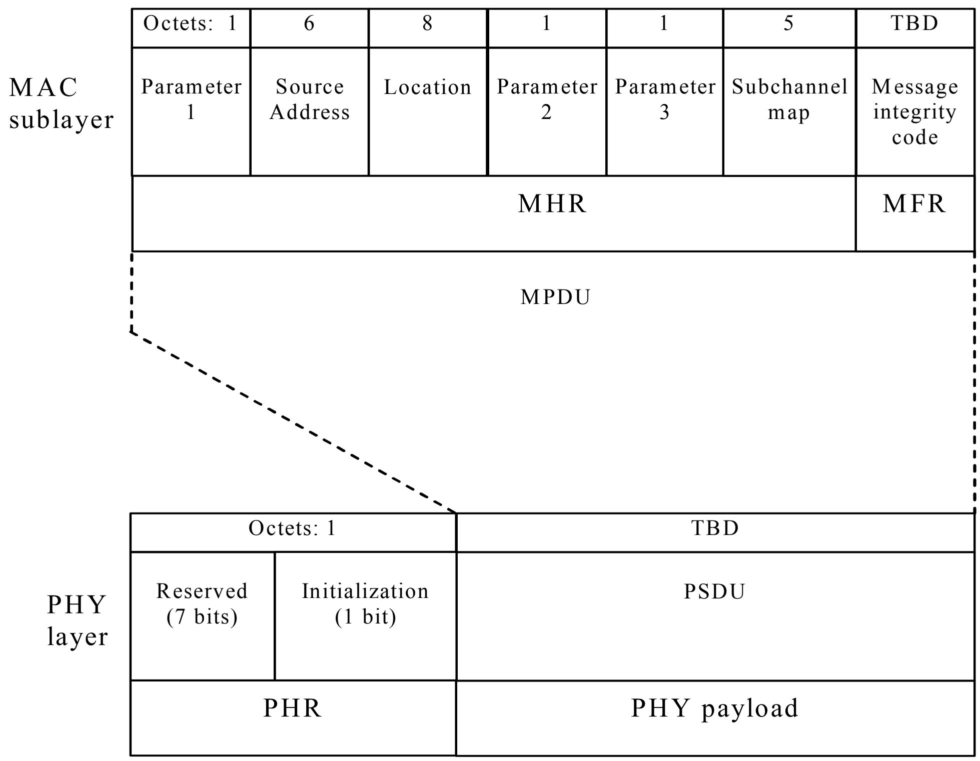


Figure 5—Schematic view of the beacon frame and the PHY packet (PPDU)

6. PHY specification

6.1 General requirements and definitions

The PHY is responsible for the following tasks:

— Activation and deactivation of the radio transceiver

— Link quality indicator (LQI) for received packets

— Channel frequency selection

— Data transmission and reception

Constants and attributes that are specified and maintained by the PHY are written in the text of this clause in italics. Constants have a general prefix of "a", e.g., *aRegion*, and are listed in Table 19. Attributes have a general prefix of "phy", e.g., *phyCurrentChannel*, and are listed in Table 20.

6.1.1 Operating frequency range

A compliant device shall operate in one of several frequency bands using the modulation and spreading formats summarized in Table 1.

Table 1—Frequency bands and modulation rates

Country/ Region	Frequency band (MHz)	Offset from lower channel edge (kHz)	Chip rate (kchips/s)	Symbol rate (kBaud)
US/Canada/ Mexico Region 2 (DTV)	54-72, 76-88, 174-216, 470-698	309.4406	76.873	9.6091
EU/Africa Region 1 (DVB)	174-230, 470-852	*TBD*	*TBD*	*TBD*
Japan/Asia Region 3	90-108, 170-222, 470-770	*TBD*	*TBD*	*TBD*
Australia Region 3	45-70, 85-108, 175-222, 526-820	*TBD*	*TBD*	*TBD*

While this standard is intended to conform to relevant local regulations in many jurisdictions around the world, the reader is encouraged to confirm compliance with applicable local regulatory bodies.

Here are several such local regulatory bodies:

— Europe: European Telecommunications Standards Institute (ETSI)

— Japan: Association of Radio Industries and Businesses (ARIB)

— United States: Federal Communications Commission (FCC)

— Canada: Industry Canada (IC)

6.1.2 Channel information

The region of operation determines the width of the protected channels. Protected channels may be 6 MHz wide, 7 MHz wide, or 8 MHz wide. Each channel is divided into 200 kHz-wide subchannels, with the lowest frequency subchannel being centered 100 kHz above the lower edge of the channel and the highest frequency subchannel being centered 100 kHz below the upper edge of the channel. A 6 MHz-wide channel has 30 subchannels, while a 7 MHz-wide and an 8 MHz-wide channel have 35 and 40 subchannels, respectively.

6.1.3 RF power measurement

Unless otherwise stated, all RF power measurements, either transmit or receive, shall be made at the appropriate transceiver to antenna connector. The measurements shall be made with equipment that is either 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 for the antenna gain in the implementation.

6.1.4 Receiver sensitivity definitions

The definitions in Table 2 are referenced by subclauses elsewhere in this standard.

Table 2—Receiver sensitivity definitions

Term	Definition of term	Conditions
Packet error rate (PER)	Average fraction of transmitted packets that are not correctly received.	Average measured over random PSDU data.
Sensitivity	Threshold input signal power that yields a specified PER.	– PSDU length = 47 octets. – PER < 1%. – Power measured at antenna terminals. – Interference not present.

6.2 PHY service specifications

The PHY provides an interface between the MAC sublayer and the physical radio channel. The PHY conceptually includes a management entity called the PHY Layer Management Entity (PLME). The PLME provides a means of passing information between the MAC sublayer and the physical radio channel (but not across the radio channel). The PLME is also responsible for maintaining a database of variables pertaining to the PHY, which is called the PHY Information Base (PIB).

Figure 6 depicts the components and interfaces of the PHY.

The PHY provides two services, accessed through two service access points (SAPs): the PHY data service, accessed through the PHY data SAP (PD-SAP), and the PHY management service, accessed through the PLME-SAP.

6.2.1 PHY data service

The PD-SAP is an interface that supports the transport of MPDUs between peer MAC sublayer entities. In the case of this standard, the MPDU always contains a beacon frame. Table 3 lists the primitives supported by the PD-SAP. These primitives are discussed in the subclauses referenced in the table.

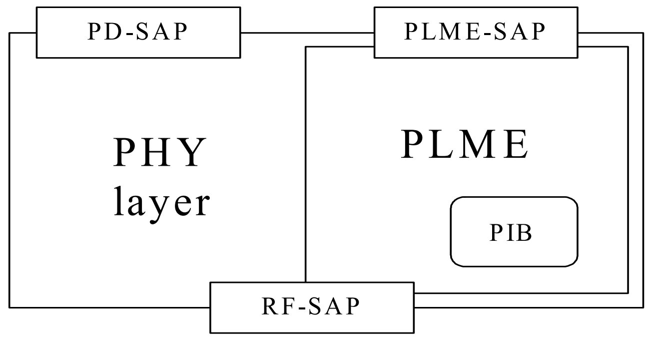


Figure 6—The PHY reference model

Table 3—PD-SAP primitives

PD-SAP primitive	Request	Confirm	Indication
PD-DATA	6.2.1.1	6.2.1.2	6.2.1.3

6.2.1.1 PD-DATA.request

The PD-DATA.request primitive is generated by a MAC sublayer entity and issued to its PHY entity to request the transfer of an MPDU (i.e., PSDU). Table 4 specifies the parameters for the PD-DATA.request primitive.

Table 4—PD-DATA.request parameters

Name	Type	Valid range	Description
~~psduLength~~	~~Unsigned integer~~	~~≤ *aMaxPHYPacketSize*~~	~~The number of octets contained in the PSDU to be transmitted by the PHY entity.~~
psdu	Set of octets	—	The set of octets forming the PSDU to be transmitted by the PHY entity.

On receipt of the PD-DATA.request primitive by the PHY entity, the PHY will attempt to transmit the supplied PSDU. Provided the transmitter is enabled, the PHY will first construct a PPDU, containing the supplied PSDU, and then transmit the PPDU. When the PHY entity has completed the transmission, it will issue the PD-DATA.confirm primitive with a status of SUCCESS.

If the PD-DATA.request primitive is received while the receiver is enabled, the transceiver is disabled, or the transmitter is already busy transmitting, the PHY entity will discard the PSDU and issue the PD-DATA.confirm with the appropriate error status (6.2.1.2).

6.2.1.2 PD-DATA.confirm

The PD-DATA.confirm primitive is generated by the PHY entity and issued to its MAC sublayer entity in response to a PD-DATA.request primitive, in order to confirm the end of the transmission attempt of an MPDU (i.e., PSDU) from a local PHY layer entity to a peer PHY layer entity. Table 5 specifies the parameters for the PD-DATA.confirm primitive.

Table 5—PD-DATA.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS, RX_ON, TRX_OFF, or TX_BUSY	The result of the request to transmit a packet.

On receipt of the PD-DATA.confirm primitive, the MAC sublayer entity is notified of the result of its request to transmit. If the transmission attempt was successful, the Status parameter is set to SUCCESS.

If the PD-DATA.request primitive was received while the receiver was enabled, the PHY entity discards the PSDU and issues the PD-DATA.confirm primitive with the Status parameter set to RX_ON. If the PD-DATA.request primitive was received while the transceiver was disabled, the PHY entity discards the PSDU and issues the PD-DATA.confirm primitive with the Status parameter set to TRX_OFF. If the PD-DATA. request primitive was received while the transmitter was already busy transmitting, the PHY entity discards the PSDU and issues the PD-DATA.confirm primitive with the Status parameter set to TX_BUSY.

6.2.1.3 PD-DATA.indication

The PD-DATA.indication primitive is generated by the PHY entity and issued to its MAC sublayer entity to transfer a received MPDU (i.e., PSDU). Table 6 specifies the parameters for the PD-DATA.indication primitive.

Table 6—PD-DATA.indication parameters

Name	Type	Valid range	Description
~~psduLength~~	~~Unsigned Integer~~	~~≤ *aMaxPHYPacketSize*~~	~~The number of octets contained in the PSDU received by the PHY entity.~~
psdu	Set of octets	—	The set of octets forming the PSDU received by the PHY entity.
ppduLinkQuality	Integer	0x00–0xff	The LQI value measured during reception of the PPDU.

~~This primitive will not be generated if the psduLength field received by the PHY entity is either zero or greater than *aMaxPHYPacketSize*.~~

6.2.2 PHY management service

The PLME-SAP is an interface that provides a means of passing information between the MAC sublayer and the physical radio channel (but not across the radio channel) via the MLME and the PLME. Table 7 lists the primitives supported by the PLME-SAP. These primitives are discussed in the clauses referenced in the table.

6.2.2.1 PLME-GET.request

The PLME-GET.request primitive is generated by the MLME and issued to its PLME to obtain information from the PIB about a given PIB attribute. Table 8 specifies the parameters for the PLME-GET.request primitive.

Table 7—PLME-SAP primitives

PLME-SAP primitive	Request	Confirm
PLME-GET	6.2.2.1	6.2.2.2
PLME-INITIATE-RTS-BURST	6.2.2.3	6.2.2.4
PLME-SET	6.2.2.5	6.2.2.6
PLME-SET-TRX-STATE	6.2.2.7	6.2.2.8

Table 8—PLME-GET.request parameters

Name	Type	Valid range	Description
PIBAttribute	Enumeration	See Table 20	The identifier of the PIB attribute being requested.

On receipt of the PLME-GET.request primitive, the PLME will attempt to retrieve the requested PIB attribute from its database. If the requested PIB attribute is successfully retrieved, the PLME will issue the PLME-GET.confirm primitive with a status of SUCCESS.

If the identifier of the PIB attribute is not found in the database, the PLME will issue the PLME-GET.confirm primitive with the appropriate error status (6.2.2.2).

6.2.2.2 PLME-GET.confirm

The PLME-GET.confirm primitive is generated by the PLME and issued to its MLME in response to a PLME-GET.request primitive, and it reports the results of an information request from the PIB. Table 9 specifies the parameters for the PLME-GET.confirm primitive.

Table 9—PLME-GET.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS or ATTRIBUTE_NOT_FOUND	The result of the request for PIB attribute information.
PIBAttribute	Enumeration	See Table 20	The identifier of the PIB attribute that was requested.
PIBAttributeValue	Various	Attribute specific	The value of the indicated PIB attribute that was requested. This parameter has zero length when the Status parameter is set to ATTRIBUTE_NOT_FOUND.

On receipt of the PLME-GET.confirm primitive, the MLME is notified of the results of its request to read a PIB attribute. If the request to read a PIB attribute was successful, the Status parameter is set to SUCCESS. If the identifier of the PIB attribute was not found in the database, the Status parameter is set to ATTRIBUTE_NOT_FOUND.

6.2.2.3 PLME-INITIATE-RTS-BURST.request

The PLME-INITIATE-RTS-BURST.request primitive is generated by the MLME of a secondary protecting device and issued to its PLME to request that the PHY entity generate an RTS burst packet. The PLME-INITIATE-RTS-BURST.request primitive has no parameters.

Once the burst packet is transmitted, the PLME will issue the PLME-INITIATE-RTS-BURST.confirm primitive with a status of COMPLETE (6.2.2.4).

6.2.2.4 PLME-INITIATE-RTS-BURST.confirm

The PLME-INITIATE-RTS-BURST.confirm primitive is generated by the PLME of a secondary protecting device and issued to its MLME in response to a PLME-INITIATE-RTS-BURST.request primitive, and it confirms that an RTS burst packet was sent by the PHY entity. Table 10 specifies the parameters for the PLME-INITIATE-RTS-BURST.confirm primitive.

Table 10—PLME-INITIATE-RTS-BURST.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	COMPLETE	The result of the request to send an RTS burst packet.

On receipt of the PLME-INITIATE-RTS-BURST.confirm primitive, the MLME is notified that its request to send an RTS burst packet was accepted. A Status parameter equal to COMPLETE indicates that the packet was sent.

6.2.2.5 PLME-SET.request

The PLME-SET.request primitive is generated by the MLME and issued to its PLME to attempt to set the indicated PIB attribute to the given value. Table 11 specifies the parameters for the PLME-SET.request primitive.

Table 11—PLME-SET.request parameters

Name	Type	Valid range	Description
PIBAttribute	Enumeration	See Table 20	The identifier of the PIB attribute to set.
PIBAttributeValue	Various	Attribute specific	The value of the indicated PIB attribute to set.

On receipt of the PLME-SET.request primitive, the PLME will attempt to write the given value to the indicated PIB attribute in its database.

If the requested PIB attribute is successfully written, the PLME will issue the PLME-SET.confirm primitive with a status of SUCCESS.

If the PIBAttribute parameter specifies an attribute that is not found in the database or if the specified value is out of the valid range for the given attribute, the PLME will issue the PLME-SET.confirm primitive with the appropriate error status (6.2.2.6).

6.2.2.6 PLME-SET.confirm

The PLME-SET.confirm primitive is generated by the PLME and issued to its MLME in response to a PLME-SET.request primitive, and it reports the results of the attempt to set a PIB attribute. Table 12 specifies the parameters for the PLME-SET.confirm primitive.

Table 12—PLME-SET.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS, ATTRIBUTE_NOT_FOUND, or INVALID_PARAMETER	The status of the attempt to set the requested PIB attribute.
PIBAttribute	Enumeration	See Table 20	The identifier of the PIB attribute being confirmed.

On receipt of the PLME-SET.confirm primitive, the MLME is notified of the result of its request to set the value of a PIB attribute. If the requested value was successfully written to the indicated PIB attribute, the Status parameter is set to SUCCESS.

If the PIBAttribute parameter specified an attribute that was not found in the database, the Status parameter is set to ATTRIBUTE_NOT_FOUND. If the PIBAttibuteValue parameter specified a value that is out of the valid range for the given attribute, the PLME Status parameter is set to INVALID_PARAMETER.

6.2.2.7 PLME-SET-TRX-STATE.request

The PLME-SET-TRX-STATE.request primitive is generated by the MLME and issued to its PLME to request that the PHY entity change the internal operating state of the transceiver. Table 13 specifies the parameters for the PLME-SET-TRX-STATE.request primitive.

Table 13—PLME-SET-TRX-STATE.request parameters

Name	Type	Valid range	Description
TRX_State	Enumeration	RX_ON, TX_ON, or TRX_OFF	The new state in which to configure the transceiver.

The transceiver has three main states:

— Transceiver disabled (TRX_OFF)
— Transmitter enabled (TX_ON)
— Receiver enabled (RX_ON).

On receipt of the PLME-SET-TRX-STATE.request primitive, the PLME will immediately cause the PHY to change to the requested state. Once the state change is accepted, the PLME will issue the PLME-SET-TRX-STATE.confirm primitive with a status of COMPLETE.

6.2.2.8 PLME-SET-TRX-STATE.confirm

The PLME-SET-TRX-STATE.confirm primitive is generated by the PLME and issued to its MLME in response to a PLME-SET_TRX_STATE.request primitive, and it reports the result of a request to change the internal operating state of the transceiver. Table 14 specifies the parameters for the PLME-SET-TRX-STATE.confirm primitive.

Table 14—PLME-SET-TRX-STATE.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	COMPLETE	The result of the request to change the state of the transceiver.

On receipt of the PLME-SET-TRX-STATE.confirm primitive, the MLME is notified that its request to change the internal operating state of the transceiver was accepted. A Status parameter equal to COMPLETE indicates that the internal operating state of the transceiver was changed to the requested state.

6.2.3 PHY enumerations description

The enumeration values used by the PHY data and management primitives are given in Table 33.

6.3 Synchronization burst

A synchronization burst is composed of two fields, the sync field and the index field.

Octets: 3	
Sync (15 bits)	Index (9 bits)
Synchronization burst	

Figure 7—Format of the PPDU

The sync field is used by the transceiver to obtain chip and symbol synchronization with incoming data. The sync field shall have the value shown in Table 15.

Table 15—Format of the sync field

Bits	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Name	s_0	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}	s_{11}	s_{12}	s_{13}	s_{14}
Value	1	1	1	1	0	1	0	1	1	0	0	1	0	0	0

The index field is used to obtain frame synchronization with an incoming beacon. It contains a numerical value equal to the number of synchronization bursts remaining (not including the present burst) before the start of the next superframe. The index field shall be decremented by one each time a synchronization burst is transmitted until the index reaches either zero or one, depending on whether the PPDU will be followed by a receive period (6.5) and a corresponding acknowledgement/no acknowledgement period (ANP) burst (6.6).

If the PPDU will not be followed by a receive period and a corresponding ANP, the final index shall be zero, indicating that the next superframe shall start immediately. If the PPDU is to be followed by a receive period (6.5) and an ANP, the final index shall be one, indicating that the next superframe shall start after the receive period and corresponding ANP.

6.4 PPDU format

Each PPDU packet consists of a constant length payload of length *TBD* octets, which carries the MAC sublayer frame.

For the PPDU packet structure, the multiple octet field shall be transmitted or received least significant octet first and each octet shall be transmitted or received least significant bit (LSB) first.

6.5 Receive period and request to send (RTS) burst

This subclause specifies the format of the receive period and RTS burst.

For convenience, the RTS burst structure is presented so that the leftmost field as written in this standard shall be transmitted or received first. All multiple octet fields shall be transmitted or received least significant octet first and each octet shall be transmitted or received LSB first.

The RTS burst is used by an SPD to reserve a superframe to transmit to the PPD. Each RTS burst consists of an RTS codeword field, which is built from the 15-bit sync field of Table 15 (6.3). The RTS codeword field is twelve bits long, and it consists of the first twelve bits of the sync field cyclically shifted to the right by three.

Let c denote the right cyclic shift applied to the sync field, s denote the sync field bit, and r_i denote the i-th bit in the RTS codeword field. Then,

$$r_i = s_{(i+c) mod 15} \tag{1}$$

where $i = (0, ..., 15)$.

A cyclic shift of three guarantees a low rate of falsing on a sync field, since two consecutive sync fields can never be transmitted on the logical I channel. Moreover, since the length of the RTS burst is 6 symbols, and it is surrounded by two silent periods of length 5 symbols each, it is unlikely that a receiver will mistake an RTS burst for a sync field.

The RTS burst structure shall be formatted as illustrated in Table 16.

The RTS is transmitted within the receive period immediately following the beacon frame. The receive period is 16 symbols in duration, corresponding to the first 16 symbols of the slot immediately following the beacon frame. The order of symbols within the receive period is as follows: 5 symbols of turnaround time, 6 symbols for the RTS, 5 symbols of turnaround time. The remaining 8 symbols of the slot consist of 3 symbols for the ANP burst, and another 5 symbols of turnaround time, bringing the total slot length to 24 symbols. Figure 8 illustrates the receive period structure.

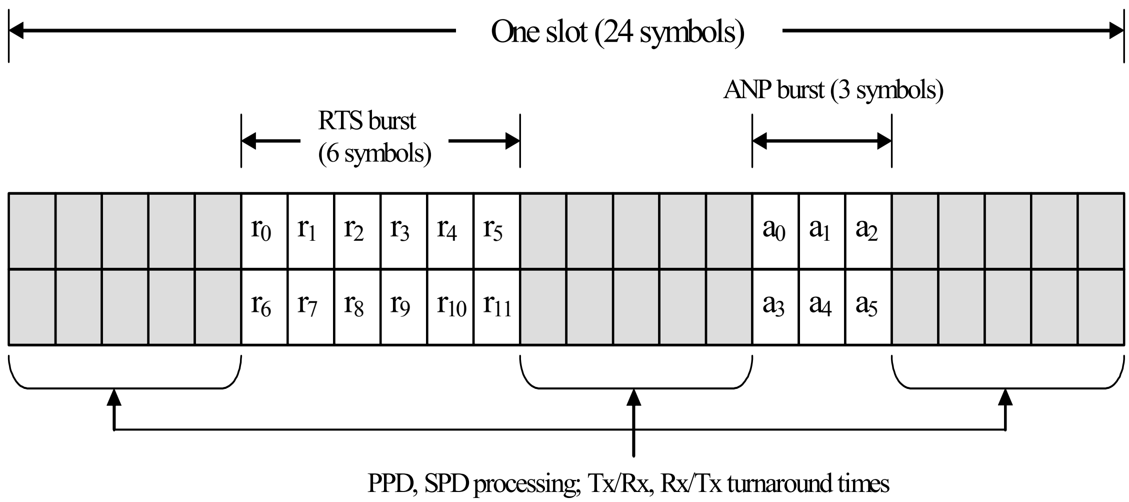


Figure 8—Receive period structure

Table 16—Format of the RTS codeword field

(DQPSK) Symbol number		**0**	**1**	2	**3**	**4**	**5**
Physical I channel (dI)	Name	r_0	r_1	r_2	r_3	r_4	r_5
	Value	0	0	0	1	1	1
Physical Q channel (dQ)	Name	r_6	r_7	r_8	r_9	r_{10}	r_{11}
	Value	1	0	1	0	1	1

6.6 Acknowledgement/no acknowledgement period (ANP) burst

This subclause specifies the format of the ANP burst.

For convenience, the ANP burst structure is presented so that the leftmost (least significant) bit as written in this standard shall be transmitted or received first.

The ANP burst is used by the PPD to indicate whether or not it has received a request to transmit (i.e., an RTS burst) from an SPD in the receive period immediately preceding the ANP. If it has received a request, the PPD shall transmit an ACK. Note that the received request must be error-free in order to transmit an ACK. Otherwise, it shall transmit a NACK.

The ACK and NACK transmissions shall be formatted as illustrated in Table 17 and Table 18, respectively.

6.7 PHY constants and PIB attributes

This subclause specifies the constants and attributes required by the PHY layer.

Table 17—Format of the ANP burst for an ACK

(DQPSK) Symbol number		0	1	2
Physical I channel (dI)	Name	a_0	a_1	a_2
	Value	0	1	0
Physical Q channel (dQ)	Name	a_3	a_4	a_5
	Value	1	0	1

Table 18—Format of the ANP burst for a NACK

(DQPSK) Symbol number		0	1	2
Physical I channel (dI)	Name	a_0	a_1	a_2
	Value	1	0	1
Physical Q channel (dQ)	Name	a_3	a_4	a_5
	Value	0	1	0

6.7.1 PHY constants

The constants that define the characteristics of the PHY layer are presented in Table 19.

Table 19—PHY constants

Constant	Description	Value
aBand	The frequency band of operation. A value of zero represents the VHF band, while a value of one represents the UHF band.	Implementation specific
~~*aMaxPHYPacketSize*~~	~~The maximum PSDU size the PHY layer shall be able to receive.~~	~~*TBD* octets~~
aRegion	The geographical region of operation.	Dependent on physical location (no units)
~~*aTurnaroundTime*~~ *[Editor's note: This constant does not seem necessary.]*	~~The RX-to-TX or TX-to-RX maximum turnaround time (see 6.9.9 and 6.9.10).~~	~~2 symbols~~

6.7.2 PHY PIB attributes

The PIB attributes required to manage the PHY layer of are presented in Table 20.

Table 20—PHY PIB attributes

Attribute	Identifier	Type	Range	Description
phyCurrentChannel	0x00	Integer	Band and region dependent. See Table 1 for allowable channels.	The RF channel to use for all following transmissions and receptions. The channel specified shall be a valid channel for the geographic region specified by *aRegion*.
~~*phyTransmitPower*~~	~~0x02~~	~~*TBD*~~	~~Band and region dependent.~~	~~The maximum transmitter power allowed that complies with regional requirements. The power specified shall depend on the band, specified by *aBand*, and the geographic region, specified by *aRegion*.~~

6.8 PHY specifications

6.8.1 Modulation and spreading

The IEEE P802.22.1/D1 PHY shall employ direct sequence spread spectrum (DSSS) with differential quadrature phase-shift keying (DQPSK).

6.8.1.1 Reference modulator diagram

The functional block diagram in Figure 9 is provided as a reference for specifying the PHY modulation and spreading functions. The number in each block refers to a subclause that describes that function. Each bit in the synchronization burst and beacon PPDU shall be processed through the differential encoding, bit-to-chip mapping and modulation functions in octet-wise order. Within each octet, the LSB, b_0, is processed first and the most significant bit (MSB), b_7, is processed last.

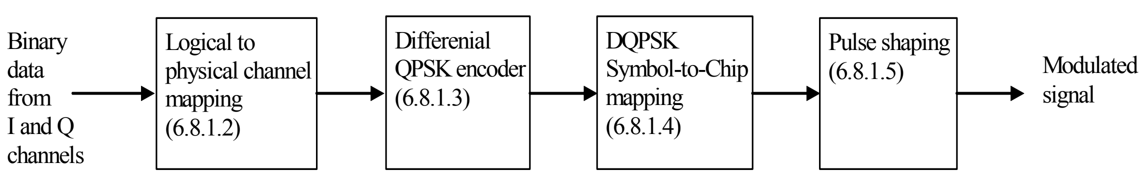


Figure 9—Modulation and spreading functions

6.8.1.2 Mapping of logical channels to physical channels

Data bits passed by the MAC to the PHY either belong to the synchronization logical channel, the beacon frame logical channel, the RTS burst, or the ANP burst. These bits are parsed between the physical I channel and the physical Q channel, which are used as input for DQPSK encoding (6.8.1.3).

Parsing of the RTS burst bits to the I and Q channels is described in Table 16. Parsing of the ANP burst bits to the I and Q channels is described in Table 17 and Table 18.

Bits of the beacon frame belong to the beacon frame logical channel and shall first be parsed into consecutive 3-octet words in the same order as they have been passed from the MAC. Bits of the synchronization burst belong to the synchronization logical channel and are naturally parsed into consecutive 3-octet synchronization bursts in the same order as they have been passed from the MAC.

The bits of the beacon frame logical channel shall directly be mapped to the bits of the physical Q channel. The bits of the synchronization logical channel shall directly be mapped to the bits of the physical I channel. Both physical channels shall be referenced to a common time reference, meaning that they are simultaneous channels, and as such one bit *dI* from the I channel and one bit *dQ* from the Q channel shall be transmitted simultaneously in a single modulation symbol.

6.8.1.3 Differential QPSK encoding

Differential QPSK encoding is a phase change applied to the previous DQPSK symbol according to the two raw data bits from the I and Q channels being encoded. The DQPSK symbols belong to the constellation (1+j, -1+j, -1+j, -1-j). DQPSK encoding is performed by the transmitter and can be described by Table 21.

Table 21—DQPSK encoding table

Input bits (dI, dQ)	Phase change (φ)
0 0	0
1 0	$\pi/2$
0 1	π
1 1	$(3\pi)/2\ \ (-\pi/2)$

Differential QPSK encoding can equivalently be performed with a complex multiplication, and it is described by Equation (2):

$$E_n = E_{n-1} \times e^{j\varphi_n} \tag{2}$$

where

φ_n is the phase change according to the two raw data bits being encoded,

E_n is the corresponding differentially encoded symbol,

E_{n-1} is the previous differentially encoded symbol.

For each packet transmitted, φ_1 corresponds to the first two raw data bits to be encoded and E_0 is assumed to be $1+j$.

Conversely, for each packet received, φ_1 corresponds to the first two raw data bits to be decoded, and E_0 is assumed to be $1+j$.

6.8.1.4 Bit-to-chip mapping

Each DQPSK symbol shall be mapped into an 8-chip, complex, pseudo-random noise (PN) sequence as specified in Table 22. During each symbol period, the least significant chip, c_0, is transmitted first, and the most significant chip, c_7, is transmitted last.

Table 22—DQPSK symbol-to-chip mapping

Input		Chip values							
DQPSK symbol	DQPSK symbol phase	c_0	c_1	c_2	c_3	c_4	c_5	c_6	c_7
1 + j	$\pi/4$	-j	-j	-j	j	j	-j	j	-j
-1 + j	$3\pi/4$	1	1	1	-1	-1	1	-1	1
1 - j	$-\pi/4$	-1	-1	-1	1	1	-1	1	-1
-1 - j	$-3\pi/4$	j	j	j	-j	-j	j	-j	j

The DQPSK symbol-to-chip mapping operation can be equivalently viewed as the complex multiplication of the DQPSK symbol with the complex spreading sequence (-1-j,-1-j,-1-j,1+j,1+j,-1-j,1+j,-1-j), followed by a division by two.

For ease of implementation, the DQPSK chips are rotated by $\pi/4$ before being transmitted, so that the transmitted chips belong to the constellation (0.707+0.707j, -0.707+0.707j, -0.707+0.707j, -0.707-0.707j).

The despreading of the complex signal is performed, after synchronization with the chip pulses and rotation of the chips by $-\pi/4$, by summing the element-wise product of the eight consecutive received chips with the complex conjugate of the spreading sequence, and then dividing by the processing gain of eight.

6.8.1.5 Pulse shaping

The chip sequence is modulated onto the carrier with square-root-raised-cosine pulse shaping (roll-off factor = 0.5) applied separately to the in-phase and quadrature components of the complex modulation chips.

6.8.1.6 Chip and bit rates

Both chip rate and bit rate are related to the Advanced Television Systems Committee (ATSC) high definition television (HDTV) symbol rate (RATSC = 10.7622378 MHz). The chip rate, R_c, shall be equal to RATSC/140 ± 2 ppm (approximately 76.873 kchip/s), and the bit rate, R_b, shall be equal to $R_c/8$ (approximately 9.6091 kbit/s).

6.9 Radio specifications

6.9.1 Transmit center frequency tolerance

The transmitted center frequency tolerance shall be ± 2 ppm maximum.

6.9.2 Transmit power

The maximum transmit power shall conform to local regulations and shall depend on the band, specified by *aBand*, and the geographic region, specified by *aRegion*.

6.9.3 Transmit PSD mask

The spectral density of the transmitted signal shall comply with applicable local regulations.

6.9.4 Modulation accuracy

[Editor's note: This subclause was originally called "pulse shape quality."]

An error vector magnitude (EVM) measurement is used to determine modulation accuracy. In order to calculate the EVM measurement, a time record of N received signal coordinate pairs $(\tilde{I}_j, \tilde{Q}_j)$ is captured. For each received chip, a decision is made as to which chip was transmitted. The ideal position of the chosen chip is represented by the vector (I_j, Q_j) . The error vector $(\delta I_j, \delta Q_j)$ is defined as the distance from this ideal position to the actual position of the received chip.

Thus, the received vector is the sum of the ideal vector and the error vector.

$$(\tilde{I}_j, \tilde{Q}_j) = (I_j, Q_j) + (\delta I_j, \delta Q_j) \quad (3)$$

The EVM for this standard is defined as

$$EVM = \sqrt{\frac{\frac{1}{N}\sum_{j=1}^{N}(\delta I_j^2 + \delta Q_j^2)}{S^2_{max}}} \times 100\,\% \quad (4)$$

where S_{max} is the magnitude of the vector to the outermost constellation point and $(\delta I_j, \delta Q_j)$ is the error vector.

The EVM measurement shall be made on baseband I and Q data after recovery through an ideal reference receiver system. The ideal reference receiver shall perform carrier lock, chip timing recovery, and amplitude adjustment while making the measurements. The ideal reference receiver shall have a data filter impulse response that approximates that of an ideal root raised cosine filter with 50% excess bandwidth.

6.9.5 Out-of-band spurious emission

The out-of-band spurious emissions shall conform to local regulations.

6.9.6 Receiver sensitivity

Under the conditions specified in 6.1.4, a compliant device shall be capable of achieving a sensitivity of *TBD* dBm or better.

6.9.7 Receiver jamming resistance

[To be added]

6.9.8 Receiver maximum input level of desired signal (blocking)

A compliant device shall be capable of receiving a desired signal of 0 dBm or better.

~~6.9.9 Tx-to-Rx turnaround time~~

~~The TX-to-RX turnaround time shall be less than *aTurnaroundTime* (6.7.1). The TX-to-RX turnaround time shall be measured at the air interface from the center of the last chip (of the last symbol) transmitted until the receiver is ready to begin the reception.~~

~~6.9.10 Rx-to-Tx turnaround time~~

~~The RX-to-TX turnaround time shall be less than *aTurnaroundTime*. The RX-to-TX turnaround time shall be measured at the air interface from the center of the last chip (of the last symbol) of a received packet until the transmitter is ready to begin transmission. Actual transmission start times are specified by the MAC sublayer (7.4.7).~~

[Editor's note: There is an inconsistency between these subclauses and 7.4.7 in the MAC. It looks like 7.4.7 includes processing time, but the PHY sections don't. Figure 8 gives all the information needed in a simple format. Recommend removing 6.9.9, 6.9.10 and 7.4.7. We can expand the text surrounding figure 8 if necessary.]

6.9.11 Link quality indicator (LQI)

The LQI measurement is a characterization of the strength and/or quality of a received beacon frame. The measurement may be implemented using receiver energy detection (ED), a signal-to-noise ratio estimation, or a combination of these methods. The use of the LQI result by the higher layers is not specified in this standard.

The LQI measurement shall be performed for each received beacon frame, and the result shall be reported to the MAC sublayer using the PD-DATA.indication primitive (6.2.1.3) as an integer ranging from 0x00 to 0xff. The minimum and maximum LQI values (0x00 and 0xff) should be associated with the lowest and highest quality beacon signals detectable by the receiver, and LQI values in between should be uniformly distributed between these two limits. At least eight unique values of LQI shall be used.

7. MAC sublayer specification

This clause specifies the MAC sublayer of IEEE P802.22.1/D1. The MAC sublayer handles all access to the physical radio channel and is responsible for the following tasks:

— Generating sync bursts and beacons
— Synchronizing to other beacons
— Supporting message authentication and integrity
— Employing the channel access mechanism
— Providing a reliable link between two peer MAC entities

Constants and attributes that are specified and maintained by the MAC sublayer are written in the text of this clause in italics. Constants have a general prefix of "a", e.g., *aMaxBeaconOverhead*, and are listed in Table 35. Attributes have a general prefix of "mac", e.g., *macNumSyncBursts*, and are listed in Table 36, while the security attributes are listed in Table *TBD*.

7.1 MAC sublayer service specification

The MAC sublayer provides an interface between the next higher layer and the PHY. The MAC sublayer conceptually includes a management entity called the MAC Sublayer Management Entity (MLME). The MLME provides a means of passing information between the next higher layer and the MAC sublayer. The MLME is also responsible for maintaining a database of variables pertaining to the MAC sublayer, which is called the MAC Information Base (MIB).

Figure 10 depicts the components and interfaces of the MAC sublayer.

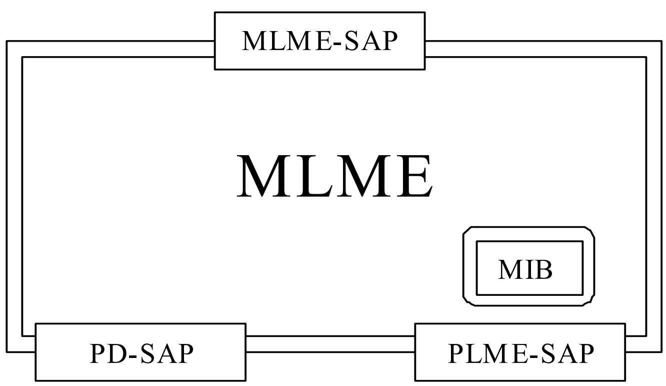


Figure 10—The MAC sublayer reference model

The MAC sublayer provides a MAC management service, accessed through the MLME-SAP.

7.1.1 MAC management service

The MLME-SAP is an interface that provides a means of passing information between the next higher layer and MAC sublayer (using the MLME). Table 23 summarizes the primitives supported by the MLME through the MLME-SAP interface. The primitives are discussed in the subclauses referenced in the table.

Table 23—Primitives supported by the MLME-SAP

Name	Request	Indication	Confirm
MLME-BEACON-LOST		7.1.1.1	
MLME-GET	7.1.1.2		7.1.1.3
MLME-INCOMING-BEACON		7.1.1.4	
MLME-SCAN	7.1.1.7		7.1.1.8
MLME-SET	7.1.1.9		7.1.1.10
MLME-START-BEACON	7.1.1.11		7.1.1.12

7.1.1.1 MLME-BEACON-LOST.indication

The MLME-BEACON-LOST.indication primitive is generated by the MLME of an SPD and issued to its next higher layer as a notification that the last *aMaxMissedBeacons* beacons of the PPD were not heard. This primitive is only issued by an SPD and has no parameters.

7.1.1.2 MLME-GET.request

The MLME-GET.request primitive is generated by the next higher layer and issued to its MLME to request information about a given MIB attribute. Table 24 specifies the parameters for the MLME-GET.request primitive.

Table 24—MLME-GET.request parameters

Name	Type	Valid range	Description
MIBAttribute	Integer	See Table 36	The identifier of the MIB attribute to read.

On receipt of the MLME-GET.request primitive, the MLME attempts to retrieve the requested MIB attribute from its database. If the requested MIB attribute is successfully retrieved, the MLME will issue the MLME-GET.confirm primitive with a status of SUCCESS. Otherwise, the MLME will issue the MLME-GET.confirm primitive with the appropriate error status (see 7.1.1.3).

7.1.1.3 MLME-GET.confirm

The MLME-GET.confirm primitive is generated by the MLME and issued to its next higher layer in response to an MLME-GET.request primitive, and it reports the results of an information request from the MIB. Table 25 specifies the parameters for the MLME-GET.confirm primitive.

On receipt of the MLME-GET.confirm primitive, the next higher layer is notified of the results of its request to read a MIB attribute. If the request to read a MIB attribute was successful, the Status parameter is set to SUCCESS. If the identifier of the MIB attribute was not found in the database, the Status parameter is set to ATTRIBUTE_NOT_FOUND.

Table 25—MLME-GET.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS or ATTRIBUTE_NOT_FOUND	The result of the request for MIB attribute information.
MIBAttribute	Integer	See Table 36	The identifier of the MIB attribute that was read.
MIBAttributeValue	Various	Attribute specific; see Table 36	The value of the indicated MIB attribute that was read. This parameter has zero length when the Status parameter is set to ATTRIBUTE_NOT_FOUND.

7.1.1.4 MLME-INCOMING-BEACON.indication

The MLME-INCOMING-BEACON.indication primitive is generated by the MLME and issued to its next higher layer in order to transfer the parameters contained within a received beacon frame. The primitive also transfers a measure of the LQI, the time the beacon frame was received, and the number of the channel on which it was received. Table 26 specifies the parameters for the MLME-INCOMING-BEACON.indication primitive.

On receipt of the MLME-INCOMING-BEACON.indication primitive, the next higher layer is notified of the arrival of a beacon frame at the MAC sublayer.

7.1.1.5 ~~MLME-NEW-BEACON-DATA.request~~

[Editor's note: Removed. The purpose of this primitive was to provide the next higher layer with a way to change the payload and also to send down a new subchannel map. Since the payload has been removed and the subchannel map is already in the MIB (Table 36), I have removed the primitive entirely. If the next higher layer wants to change any parameter(s) in the beacon, it should do so by updating the appropriate MIB parameter via the MLME-SET.request primitive.]

~~7.1.1.6 MLME-NEW-BEACON-DATA.confirm~~

[Editor's note: Removed. See note above.]

7.1.1.7 MLME-SCAN.request

The MLME-SCAN.request primitive is generated by the next higher layer and issued to its MLME to initiate a listening period on a given channel or channels. Table 27 specifies the parameters for the MLME-SCAN.request primitive.

On receipt of the MLME-SCAN.request primitive, the MLME enables the receiver and listens to each channel specified by the ChannelList parameter for a finite amount of time, as specified by the Duration parameter.

Once the scan operation has finished, the MLME will issue the MLME-SCAN.confirm primitive with a status of COMPLETE.

Table 26—MLME-INCOMING-BEACON.indication parameters

Name	Type	Valid range	Description
Parameter1	Integer	See 7.2.1	The parameter contains the information from the MHR field of the same name (i.e., frame version number, priority level, antenna height, and device rank).
Parameter2	Integer	See 7.2.4	The parameter contains the information from the MHR field of the same name (i.e., channel width, cease tx, keep out zone data).
Parameter3	Integer	See 7.2.5	The parameter contains the information from the MHR field of the same name (i.e., antenna location, required need data timer).
Address	IEEE address	A valid 48-bit IEEE address	The address of the originator of the beacon frame.
Location	*TBD*	*TBD*	The location of the originator of the beacon frame.
SubchannelMap	Bitmap	40-bit field	The subchannels of the occupied channel that are protected by the device that transmitted the beacon.
Channel	Integer	Region dependent. See Table 1 in 6.1.1.	The channel on which the beacon was received.
~~IncomingTimestamp~~ *[Editor's note: This is from original proposal, but I can't think of a reason to keep it]*	~~Integer~~		~~The time the beacon frame was received relative to the clock of the receiving device.~~
LinkQuality	Integer	0x00–0xff	The LQI at which the beacon frame was received. Lower values represent lower LQI (6.9.11).

Table 27—MLME-SCAN.request parameters

Name	Type	Valid range	Description
ChannelList	Bitmap	69-bit field	The list of channels to be scanned. The 69 bits (b_0, b_1,... b_{69}) indicate which channels are to be scanned (1 = scan, 0 = do not scan).
Duration	Integer	0–100	A value used to calculate the length of time to spend scanning each channel. The length of time spent scanning each channel is $2 + 0.01m$ seconds, where m is the value of the Duration parameter.

7.1.1.8 MLME-SCAN.confirm

The MLME-SCAN.confirm primitive is generated by the MLME and issued to its next higher layer when the channel scanning operation initiated with the MLME-SCAN.request primitive has completed. Table 28 specifies the parameters for the MLME-SCAN.confirm primitive.

Table 28—MLME-SCAN.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	COMPLETE	The result of the attempt to scan the channel list.
ChannelsScanned	Bitmap	69-bit field	Indicates which channels given in the request were scanned (1 = scanned, 0 = not scanned or not requested).
ChannelsIdle	Bitmap	69-bit field	Indicates which channels given in the request were idle (1 = idle, 0 = occupied or not requested).

On receipt of the MLME-SCAN.confirm primitive, the MLME is notified that its request to scan the specified list of channels was accepted. A Status parameter equal to COMPLETE indicates that the scan is complete.

7.1.1.9 MLME-SET.request

The MLME-SET.request primitive is generated by the next higher layer and issued to its MLME, and it attempts to write the given value to the indicated MIB attribute. Table 29 specifies the parameters for the MLME-SET.request primitive.

Table 29—MLME-SET.request parameters

Name	Type	Valid range	Description
MIBAttribute	Integer	See Table 36	The identifier of the MIB attribute to write.
MIBAttributeValue	Various	Attribute specific; see Table 36	The value to write to the indicated MIB attribute.

On receipt of the MLME-SET.request primitive, the MLME attempts to write the given value to the indicated MIB attribute in its database. If the requested MIB attribute is successfully written, the MLME will issue the MLME-SET.confirm primitive with a status of SUCCESS. Otherwise, the MLME will issue the MLME-SET.confirm primitive with the appropriate error status (see 7.1.1.8).

7.1.1.10 MLME-SET.confirm

The MLME-SET.confirm primitive is generated by the MLME and issued to its next higher layer in response to an MLME-SET.request primitive, and it reports the results of an attempt to write a value to a MIB attribute. Table 30 specifies the parameters for the MLME-SET.confirm primitive.

Table 30—MLME-SET.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS, ATTRIBUTE_NOT_FOUND, or INVALID_PARAMETER	The result of the request to write the MIB attribute.
MIBAttribute	Integer	See Table 36	The identifier of the MIB attribute that was written.

On receipt of the MLME-SET.confirm primitive, the next higher layer is notified of the result of its request to set the value of a MIB attribute. If the requested value was written to the indicated MIB attribute, the Status parameter is set to SUCCESS.

If the MIBAttribute parameter specifies an attribute that is not found in the database, the Status parameter is set to ATTRIBUTE_NOT_FOUND. If the MIBAttributeValue parameter specifies a value that is out of the valid range for the given attribute, the Status parameter is set to INVALID_PARAMETER.

7.1.1.11 MLME-START-BEACON.request

The MLME-START-BEACON.request primitive is generated by the next higher layer and issued to its MLME to initiate either a single beacon transmission or periodic beacon transmissions or to stop periodic beacon transmissions. Table 31 specifies the parameters for the MLME-START-BEACON.request primitive.

Table 31—MLME-START-BEACON.request parameters

Name	Type	Valid range	Description
Parameter1	Integer	See 7.2.1	The parameter contains the information from the MHR field of the same name (i.e., frame version number, priority level, antenna height, and device rank).
Parameter2	Integer	See 7.2.4	The parameter contains the information from the MHR field of the same name (i.e., channel width, cease tx, keep out zone data).
Parameter3	Integer	See 7.2.5	The parameter contains the information from the MHR field of the same name (i.e., antenna location, required need data timer).
Address	IEEE address	A valid 48-bit IEEE address	The address of the originator of the beacon frame.
Location	*TBD*	*TBD*	The location of the originator of the beacon frame.
SubchannelMap	Bitmap	40-bit field	The subchannels of the occupied channel that are to be protected.
Channel	Integer	Region dependent. See Table 1 in 6.1.1.	The channel on which to transmit the beacon(s).

Table 31—MLME-START-BEACON.request parameters *(continued)*

Name	Type	Valid range	Description
Start	Boolean	TRUE or FALSE	If this parameter is TRUE, the device is to begin beacon transmission. Otherwise, the device is to stop beacon transmissions.
Periodic	Boolean	TRUE or FALSE	If this parameter is TRUE, the device transmits periodic beacons. Otherwise, the device transmits one beacon. This parameter is ignored if the Start parameter is FALSE.

On receipt of the MLME-START-BEACON.request primitive, the MLME attempts to either start or stop the transmission of a beacon(s). If the requested action was successfully executed, the MLME will issue the MLME-START-BEACON.confirm primitive with a status of SUCCESS. Otherwise, the MLME will issue the MLME-START-BEACON.confirm primitive with the appropriate error status (see 7.1.1.12).

7.1.1.12 MLME-START-BEACON.confirm

The MLME-START-BEACON.confirm primitive is generated by the MLME and issued to its next higher layer in response to an MLME-START-BEACON.request primitive, and it reports the results of the attempt to start or stop the transmission of a beacon(s). Table 32 specifies the parameters for the MLME-START-BEACON.confirm primitive.

Table 32—MLME-START-BEACON.confirm parameters

Name	Type	Valid range	Description
Status	Enumeration	SUCCESS or NACK	The result of the attempt to either start or stop the transmission of a beacon(s).

On receipt of the MLME-START-BEACON.confirm primitive, the next higher layer is notified of the results of its request to either start or stop beacon transmissions. If the request was successful, the Status parameter is set to SUCCESS. If the primitive was issued by the next higher layer of an SPD and the beacon was not transmitted due to the reception of a NACK, the Status parameter is set to NACK.

7.1.2 Enumeration description

The enumeration values used by the MAC management primitives, as well as by the PHY data and management primitives, are given in Table 33.

7.2 MAC beacon frame

This subclause specifies the format of the MAC beacon frame (MPDU).

The beacon frame is described as a sequence of fields in a specific order. The beacon frame format is depicted in the order in which it is transmitted by the PHY, from left to right, where the leftmost bit is transmitted first in time. Bits within each field are numbered from *0* (leftmost and least significant) to *k - 1*

Table 33—Enumerations values

Enumeration	Value	Description
SUCCESS	0x00	The requested operation was completed successfully.
ATTRIBUTE_NOT_FOUND	0x01	A SET/GET request was issued with the identifier of a MIB or PIB attribute that is not supported.
COMPLETE	0x02	The requested operation is complete.
INVALID_PARAMETER	0x03	A parameter in the primitive is either not supported or is out of the valid range.
RX_ON	0x04	The transceiver is either already in or requested to change to the received enabled state.
TRX_OFF	0x05	The transceiver is either already in or requested to change to the transceiver disabled state.
TX_BUSY	0x06	A request to transmit a packet was made while the transceiver was in the process of transmitting a previously requested packet.
TX_ON	0x07	The transceiver is in the transmitter enabled state.

(rightmost and most significant), where the length of the field is *k* bits. Fields that are longer than a single octet are sent to the PHY in the order from the octet containing the lowest numbered bits to the octet containing the highest numbered bits.

All reserved bits shall be set to zero upon transmission and shall be ignored upon receipt.

The beacon frame format is composed of a MHR and a MFR. The fields of the MHR appear in a fixed order. The beacon frame shall be formatted as illustrated in Figure 11.

Octets: 1	6	8	1	1	5	*TBD*
Parameter 1	Source Address	Location	Parameter 2	Parameter 3	Channel/ Subchannel Map	Message Integrity Code
MHR						MFR

Figure 11— MAC beacon frame format (MPDU)

7.2.1 Parameter 1 field

The Parameter 1 field includes the Frame Version Number, Priority Level, Antenna Height, and Rank subfields. The Parameter 1 field shall be formatted as illustrated in Figure 12.

Bits: 0–2	3-5	6	7
Frame Version Number	Priority Level	Antenna Height	Rank

Figure 12—Format of the Parameter 1 field

The Frame Version Number subfield specifies the version number of the transmitted frame. This subfield shall be set to 0x00 to indicate a frame compliant with this standard. All other subfield values shall be reserved for future use.

The Priority Level subfield specifies the priority of the service protected by the beacon frame transmission. The value of the Priority Level subfield shall be numeric, in which the value 0x07 shall be defined as highest priority and the value 0x00 as lowest priority.

The Antenna Height subfield specifies the height above ground level of the antenna transmitting the beacon frame. It shall be set to one if this height is greater than 30 meters. It shall be set to zero if this height is less than or equal to 30 meters. *[Editor's note: Is 30 meters the correct height? or is it 30 feet (i.e., 10 meters)?]*

The Rank subfield shall be set to one if the beaconing device is the PPD or zero if it is an SPD.

7.2.2 Source Address field

The Source Address field is 6 octets in length and specifies the address of the originator of the beacon frame.

7.2.3 Location field

The Location field is 8 octets in length and specifies the location of the originator of the beacon frame. *[Editor's note: Insert location encoding description here.]*

7.2.4 Parameter 2 field

The Parameter 2 field includes the Channel Width, Cease Tx and Keep Out Zone subfields. The Parameter 2 field shall be formatted as illustrated in Figure 13.

Bits: 0-1	2	3-6	7
Channel Width	Cease Tx	Reserved	Keep Out Zone

Figure 13—Format of the Parameter 2 field

The Channel Width subfield specifies the width of the occupied channel being protected by the transmitting device. The subfield shall be set to 0x00 if the occupied channel is 6 MHz wide, 0x01 if it is 7 MHz wide, or 0x02 if it is 8 MHz wide. The value 0x03 shall be reserved for future use.

The Cease Tx subfield specifies whether the transmitting device is planning to cease transmission. The subfield shall be set to one to indicate that the device plans to stop transmitting and shall be set to zero otherwise.

The Keep Out Zone subfield specifies the size of the protected radius. If the protected radius is greater than 500 m, it shall be set to one. It shall be set to zero if the protected radius is less than or equal to 500 meters. *[Comment from editor: Making this a 2-bit field was discussed at the Melbourne meeting. Need meeting details before making any changes.]*

All other bits are reserved.

7.2.5 Parameter 3 field

The Parameter 3 field includes the Indoor/Outdoor and Required Need Timer subfields. The Parameter 3 field shall be formatted as illustrated in Figure 14.

Bits: 0	1-7
Indoor/Outdoor	Required Need Timer

Figure 14—Format of the Parameter 3 field

The Indoor/Outdoor subfield indicates the location of the receiver antenna of the protected device. It shall be set to one if the antenna is indoors and shall be set to zero if the antenna is outdoors. Zero (outdoors) shall be the default.

The Required Need Timer subfield shall be a numeric value indicating the estimated time remaining, in hours, that the channel will be occupied. A value of 0x00 indicates that the channel will be occupied for an indeterminate amount of time.

7.2.6 Channel/Subchannel Map field

The Channel/Subchannel Map field is five octets in length and is a bitmap identifying either a list of occupied channels being protected by the transmitting device or a list of the 200 kHz-wide subchannels within an occupied channel being protected.

The LSB (bit 0) of the bitmap designates whether the remaining 39 bits are used to identify protected channels or subchannels. If bit 0 is zero, the remaining bits identify protected channels. If bit 0 is one, the remaining bits identify protected subchannels.

7.2.6.1 Channel mapping

Figure 15 illustrates the bit assignment for the case when bit 0 of the Channel/Subchannel Map field is set to zero, indicating that the field is to be used as a channel map.

Bit: 0	1	2–6	7–12	13–18	19–24	25–30	31–36	37–39
Channel/ Subchannel	Reserved	Region/ Sub-group	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Reserved

Figure 15—Field as a channel map (bit 0 set to zero)

Bit 1 is reserved for future use and shall be set to zero.

Bits 2-6 specify the Region/Sub-group subfield, which is the geographical region of operation. Only fourteen region designators are necessary for channel mapping worldwide due to common sharing of band plans of the VHF and UHF segments among various countries, and in some cases, entire continents. For example, most of Western Europe utilizes a formalized band plan for UHF allocations, and this allocation plan is also utilized by most of Africa. In addition to these fourteen region designators, five values are used to describe the UHF sub-groups in the United States. These sub-group designators are only specified in the event that channel aggregation is employed. Reserved values are included in the list and can be used in the event of future changes to band plans and allocations. See Table 34 for the list of region and sub-group designators.

Table 34—Region and sub-group designators for protected channels

Bit: 3 4 5 6 7	Region
0 0 0 0 0	United States of America with less than 64 channels (UHF and VHF)
0 0 0 0 1	The Americas (excluding USA) VHF
0 0 0 1 0	The Americas (excluding USA), Korea, Taiwan, Philippines, certain Pacific Islands UHF
0 0 0 1 1	Ireland VHF
0 0 1 0 0	Australia VHF
0 0 1 0 1	Australia UHF
0 0 1 1 0	Western Europe, Africa, Asia, Pacific Islands (excluding French Territories) UHF
0 0 1 1 1	France VHF
0 1 0 0 0	New Zealand UHF
0 1 0 0 1	Morocco
0 1 0 1 0	Eastern Europe / Russia VHF
0 1 0 1 1	South Africa VHF
0 1 1 0 0	French Overseas Territories
0 1 1 0 1	China
0 1 1 1 0–0 1 1 11	Reserved
1 0 0 0 0	United States UHF Sub-group 1* (television channels 14-20)
1 0 0 0 1	United States UHF Sub-group 2* (television channels 21-28)
1 0 0 1 0	United States UHF Sub-group 3* (television channels 29-36)
1 0 0 1 1	United States UHF Sub-group 4* (television channels 38-44)
1 0 1 0 0	United States UHF Sub-group 5* (television channels 45 - 51)
1 0 1 0 1–1 1 1 11	Reserved

*Sub-groups may be specified in the event that channel aggregation is employed.

The five Channel subfields allow explicit entry of up to 5 protected channels. Each Channel subfield is six bits long. If the number of channels in a given region is less than 64, the channel number shall simply be converted to a 6-bit binary number before inserting it into the subfield. If the number of channels in a given region exceeds 64, a re-mapping procedure is needed in order to utilize the 6-bit subfield. The channel designations for these regions shall be re-mapped to a sequential numbering system, starting with "1". This shall be accomplished by the following equation:

$$C_m = C_a - C_1$$

where C_m is the mapped channel number to be inserted into the Channel subfield, C_a is the actual television channel number to be protected, and C_1 is the channel number assigned to the first (lowest) channel designation for the region to be mapped.

For example, if the actual television channel to be protected is 68 and the first channel number assigned in the local region is 14, then the mapped channel number to be inserted into the Channel subfield is 68 - 14 = 54.

Bits 37-39 are reserved for future use and shall be set to zero.

7.2.6.2 Subchannel mapping

A total of thirty 200 kHz subchannels can be defined in a 6 MHz-wide channel, thirty-five 200 kHz subchannels can be defined in a 7 MHz-wide channel, and forty 200 kHz subchannels can be defined in an 8 MHz-wide channel. An 8 MHz-wide channel requires 40 bits to map all 40 available subchannels, but only 39 bits are available. Therefore, in this case, the 200 kHz subchannel utilized by the beacon shall not be mapped, thus allowing all other subchannels to be mapped.

Figure 16 illustrates the bit assignment for the case when bit 0 of the Channel/Subchannel Map field is set to one, indicating that the field is to be used as a subchannel map. Bit 1 represents the 200 kHz subchannel centered 100 kHz above the lower edge of the channel. The subchannel centered 100 kHz below the upper edge of the channel corresponds to bit 30 for 6 MHz-wide channels, bit 35 for 7 MHz-wide channels, or bit 39 for 8 MHz-wide channels. See 6.1.2 for more information on channels and subchannels.

Bit: 0	**1**	**2**	**...**	**29**	**30**
Channel/ Subchannel	Subchannel 1	Subchannel 2	...	Subchannel 29	Subchannel 30

Figure 16—Field as a subchannel map (bit 0 set to one) for a 6 MHz channel

If the center frequency of one or more protected devices falls within a 200 kHz subchannel, the bit representing that subchannel is set to a 1. If no protected device center frequency falls within a subchannel, the bit is set to 0. If the occupied channel width is such that not all of the 40 bits are needed, the remaining MSBs (9 bits for a 6 MHz-wide channel and 4 bits for a 7 MHz-wide channel) shall be set to zero but shall not indicate unused subchannels. The Channel Width subfield in the Parameter 2 field (7.2.4) indicates occupied channel width.

7.2.7 Message Integrity Code (MIC) field

The Message Integrity Code field is 16 octets in length and is used to cryptographically authenticate the beacon frame. It also ensures that the beacon frame contents have not been modified or corrupted since their transmission. The algorithm used to calculate the value of the MIC field is defined in *Annex TBD*.

7.3 MAC constants and MIB attributes

This subclause specifies the constants and attributes required by the MAC sublayer.

7.3.1 MAC constants

The constants that define the characteristics of the MAC sublayer are presented in Table 35.

Table 35—MAC sublayer constants

Constant	Description	Value
aAddress	The 48-bit IEEE address assigned to the device.	Device specific
~~*aMaxBeaconOverhead*~~ *[Editor's note: without the MAC payload field, this seems pointless to keep]*	~~The maximum number of octets contained in the combined MHR and MFR.~~	
aMaxMissedBeacons	The number of consecutive missed beacons that will cause an SPD to send a notification to the next higher layer. If the device is operating as the PPD, this constant shall not apply.	*TBD*

7.3.2 MIB attributes

The MIB attributes required to manage the MAC sublayer of are presented in Table 36.

Table 36—MIB attributes

Attribute	Identi fier	Type	Range	Description	Default
macAntennaHeight		Boolean	Zero or one	The height above ground level of the antenna transmitting the beacon frame. Zero indicates a height of less than or equal to 30 meters, and one indicates a height greater than 30 meters.	Zero
macIndoorOutdoor *[Editor's note: changed name from* macAntennaLocation *to match 7.2.5.]*		Boolean	Zero or one	The location of the receiver antenna of the protected device. Zero indicates that the antenna is outdoors, and one indicates that it is indoors.	Zero
macBeaconLocation		*TBD*	*TBD*	The location of the originator of the beacon frame.	*TBD*
macCeaseTx		Boolean	Zero or one	An indication of whether the device plans to cease transmission. One indicates that the device plans to stop transmitting. Zero indicates the device will continue to transmit.	Zero

Table 36—MIB attributes *(continued)*

Attribute	Identi fier	Type	Range	Description	Default
macChannelWidth		Integer	0x00-0x02	The width of the occupied channel being protected by the transmitting device.	Region-dependent
macFrameVersionNumber		Integer	0x00–0x07	The version number to be included in transmitted frames.	0x00
macKeepOutZone		Boolean	Zero or one	The size, in meters, of the radius of the physical area protected by the beacon frame. Zero indicates that the protected radius is less than or equal to 500 m, and one indicates that it is greater than 500 meters.	Zero
macNumSyncBursts		Integer	*TBD* –*TBD*	The number of synchronization bursts to be sent prior to transmitting the beacon frame.	*TBD*
macPPDAddress		IEEE address	A valid 48-bit IEEE address	The 48-bit address of the PPD.	—
macPriorityLevel		Integer	0x00–0x07	The priority of the service protected by the beacon frame transmission.	0x00
macProtectingDeviceRank		Boolean	Zero or one	The rank of the protecting device. Zero indicates an SPD, and one indicates a PPD.	Zero
macRequiredNeedTimer		Integer	0x00–0x7f	A numeric value indicating the estimated time remaining, in hours, that the channel will be occupied. A value of 0x00 indicates that the channel will be occupied for an indeterminate amount of time.	0x00
macSubchannelMap		Bitmap	40-bit field	The subchannels of the occupied channel being protected by the transmitting device (7.2.6).	Device-dependent

7.4 MAC functional description

This subclause provides a detailed description of the MAC functionality.

7.4.1 Superframe structure

The superframe structure repeats without interruption on a given occupied channel. The superframe format is shown in Figure 17.

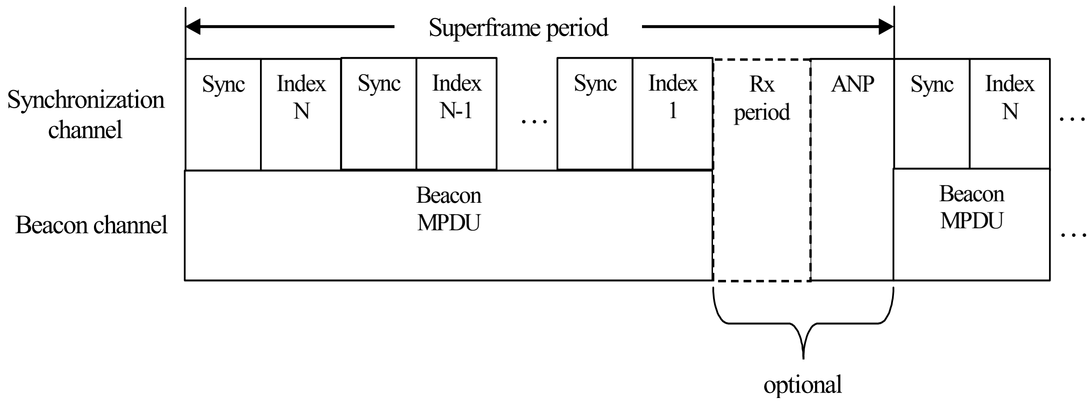


Figure 17—Superframe format

A large portion of the superframe structure is divided over two logical channels, which are transmitted in parallel. The synchronization logical channel consists of a plurality of synchronization bursts (6.5), and the beacon logical channel consists of the beacon MSDU (7.2). Under control of the next higher layer, a receive period (6.5), and an acknowledgement/non-acknowledgement period (ANP) may optionally be included (6.6). This format repeats without interruption while the protecting device is in operation.

The synchronization bursts, which consist of a synchronization word followed by a decrementing index value, enable a receiver asynchronously sampling the channel to quickly determine when the beacon will be sent. The beacon itself contains information relevant to the device protected by the protecting device, including its physical location and estimated duration of channel occupancy. Following the beacon, there is an optional receive period, during which the primary protecting device pauses to monitor the channel for an RTS burst transmitted by a secondary protecting device. Finally, there is an optional ANP, reflecting whether or not an RTS burst was detected.

If the optional receive period and ANP are included, the final index value in the series of synchronization bursts shall be one, indicating that the next superframe shall start after the receive period and corresponding ANP. If they are not included, the final index value shall be zero, indicating that the next superframe shall start immediately.

7.4.2 Transmission protocol

All transmissions shall be made using the ALOHA protocol. Only the PPD shall transmit beacon frames unless an SPD has been granted permission to do so in place of the PPD. In order to gain permission to transmit a beacon, an SPD transmits an RTS burst without first sampling the channel. In the event that two SPDs transmit an RTS burst simultaneously, at best only one will be received by the PPD. If neither is received, the PPD will transmit a NACK during the ANP and then continue to transmit its own beacon frame. If one is received, both SPDs will hear an ACK from the PPD and proceed to transmit a beacon frame. These beacon frames are transmitted without first sampling the channel. An SPD will know whether the PPD received its beacon by examining the contents of the PPD's subsequent beacon frames. The PPD's beacon shall only contain the data from an SPD if it correctly received the SPD's beacon.

7.4.3 Device initialization procedure

Upon initialization, a protecting device shall identify the channel it is to monitor, then monitor that channel for a period of $2 + 0.01m$ continuous seconds, where m is an integer selected at random from the set [0, 1, 2, …, 98, 99, 100], to determine the presence or absence of a PPD. A PPD is determined to be present on the channel if the protecting device receives a beacon frame.

The monitoring operation may be initiated by the next higher layer of the protecting device via the MLME-SCAN.request primitive. Any beacon frame received during the scan shall be passed to the next higher layer via the MLME-INCOMING-BEACON.indication primitive.

At the conclusion of this initial monitoring period, if the protecting device determines that there is no PPD already present on the channel (i.e., no beacon frame was detected), the protecting device may, at the discretion of the next higher layer, promote itself to PPD and begin transmitting periodic beacons. Beacon transmission is initiated by the next higher layer via the MLME-START-BEACON.request primitive with the Periodic parameter set to TRUE, indicating that periodic beacons are to be transmitted.

During this initial transmission period, the new PPD shall set the initialization bit in the PHR to one and transmit a continuous series of superframes, which shall not include receive periods or ANPs, for a period of 30 seconds. Each superframe shall be composed of 383 synchronization bursts followed by a minimum-length beacon (51 octets), and have a period of 8*(383*3 + 51)/9609 = 0.999063 s. *[Editor's note: the numbers in this paragraph are now different.]*

Following the initial transmission period, superframe transmission shall continue; however, the receive period and ANP shall be inserted immediately following the beacon frame. Since the receive period and ANP together have a duration of one slot time, the ~~maximum~~ number of synchronization bursts in a superframe following the initial transmission period is *TBD*.

At the conclusion of the initial monitoring period, if the protecting device determines that there is a PPD on the channel (i.e., a beacon frame was detected), the protecting device may, at the discretion of the upper layer, send its information to the PPD for inclusion in the PPD's beacon rather than begin its own superframe transmissions (i.e., opt to become an SPD). This may be accomplished by the protecting device synchronizing to the superframe of the PPD, transmitting an RTS burst during the receive period, and then transmitting its own beacon frame containing the information it wishes the PPD to include in future beacons. For more details, see 7.4.4.

7.4.4 Inter-device communications

[Editor's note: this subclause was formerly called "Interrupting the PPD."]

7.4.4.1 Data aggregation

A PPD may aggregate data received by one or more SPDs, as long as these SPDs operate on the same channel as the PPD. The SPD transfers data to the PPD by sending a beacon frame, which the PPD passes to its next higher layer. The received data may be aggregated with that of the PPD at the discretion of the next higher layer.

7.4.4.2 SPD behavior

An SPD may interrupt the PPD in order to transmit its own beacon frame. To initiate this option, the next higher layer sends an MLME-START-BEACON.request primitive to the MAC sublayer with the Periodic parameter set to FALSE, indicating that only one beacon is to be transmitted. Upon receipt of the primitive, the MAC sublayer shall request that the PHY layer transmit an RTS burst during the receive period of the superframe by issuing the PLME-INITIATE-RTS-BURST.request primitive instructing the PHY layer to start the transmission. If, in response to the RTS burst, the SPD receives an ACK from the PPD during the ANP, the SPD shall transmit its beacon frame in place of the normally-transmitted beacon frame of the PPD during the following superframe. If the SPD received a NACK during the ANP, it shall not transmit a beacon frame. If a NACK is received, the next higher layer of the SPD is notified of the inability to transmit its beacon via the MLME-START-BEACON.confirm primitive with the Status parameter set to NACK. The action taken by the next higher layer on receipt of this primitive is out of the scope of this standard.

[Editor's note: Re-worded the paragraph for clarity. The new text is in red; the omitted text has been struck through.] One situation that may cause the SPD to receive a NACK during the ANP is if two or more SPDs transmitted RTS bursts in the receive period of the same superframe and those RTS bursts collided. If the PPD does not receive an RTS burst, each SPD will receive a NACK. If the PPD receives one of the RTS bursts, any SPD that did not get through on the channel will not immediately realize there was a collision, because it will receive the ACK meant for the second SPD. However, once the SPD receives subsequent beacon frames from the PPD, it should notice that the beacon does not contain its data. In this case or in the case when the SPD receives a NACK, one option for the next higher layer of the SPD is to use a random backoff time before requesting to send another RTS burst. ~~Note, however, that this scenario is unlikely due to the direct sequence capture effect.~~

7.4.4.3 PPD behavior

If the PPD detects an RTS burst from an SPD, the PPD shall transmit an ACK during the ANP. The PPD shall continue the transmission of synchronization bursts in the following superframe; however, the PPD shall not send a beacon frame. Instead, it shall enable its receiver for a period of one slot. If, during this time, the beacon of the SPD is detected, the receiver shall remain on, and the beacon shall be received and passed to the higher layer via the MLME-INCOMING-BEACON.indication primitive. Immediately following the beacon reception (and following the one-slot period, if a beacon is not detected), the receiver shall remain enabled through the receive period, where the PPD again monitors for an RTS burst. *[Editor's note: this is what we may want to change to prevent a denial of service attack on the PPD.]* The following ANP shall then be transmitted accordingly.

Any response from the PPD generated by the beacon of the interrupting SPD may be placed in the next beacon frame transmitted by the PPD. The PPD may, at the discretion of the next higher layer, aggregate the data received by an SPD(s) with its own data. This could include combining the subchannels protected by the SPD with those protected by the PPD and transmitting this combined list in the Subchannel Map field of the PPD's beacon frame.

If the PPD does not detect an RTS burst during its receive period, it shall transmit a NACK during the ANP and continue superframe transmissions without interruption.

7.4.4.4 Illustrations

Figure 18 illustrates the scenarios described in the preceding text. In (a), the PPD transmits the synchronization bursts and the beacon frame. The PPD then enables its receiver to listen for an RTS burst from a SPD. In this case, the PPD does receive an RTS burst, and consequently, the PPD transmits an ACK. In (b), the SPD transmits the synchronization bursts and the beacon frame. The PPD then enables its receiver to listen for an RTS burst from a SPD. In this case, the PPD does not receive an RTS burst, and consequently, the PPD transmits a NACK. *[Editor's comment: The previous sentence will need to be modified once we reach a conclusion on the SPD superframe discussion.]* In (c), the PPD transmits the synchronization bursts and the beacon frame. The PPD then enables its receiver to listen for an RTS burst from a SPD. In this case, the PPD does not receive an RTS burst, and consequently, the PPD transmits a NACK. The scenario in (c) repeats until another RTS burst is received, as in (b).

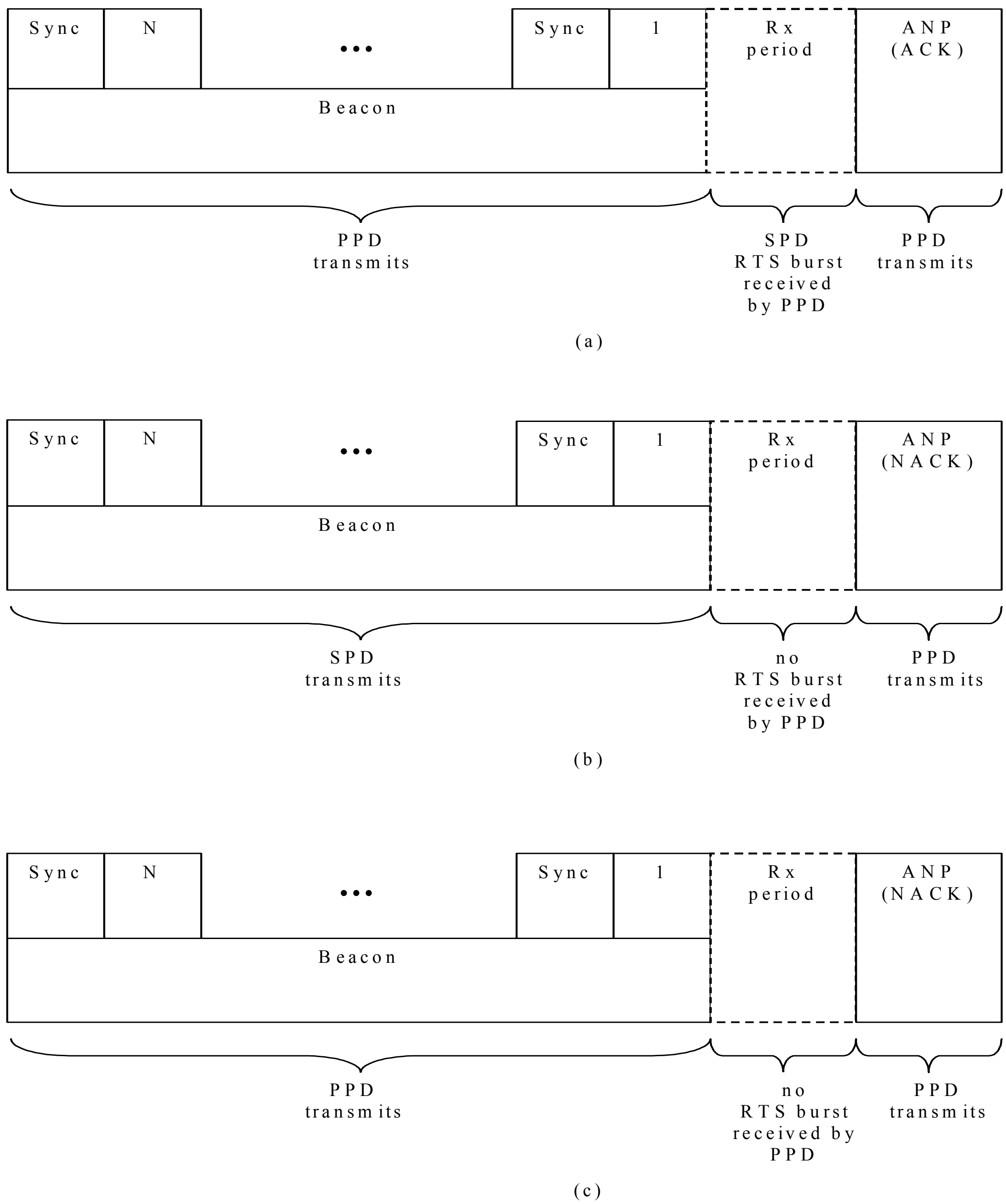


Figure 18—SPD interruption of the PPD in order to transmit a beacon frame

7.4.5 Beaconing

7.4.5.1 Primary protecting device (PPD)

The PPD shall transmit a beacon frame in every superframe unless it has been interrupted by an SPD wishing to send its own beacon frame (7.4.4). If the next higher layer wants to change any beacon parameter, it should do so by issuing the MLME-SET.request primitive to the MAC sublayer.

If the PPD does not transmit a beacon frame due to an interrupt by an SPD, the PPD shall listen for the beacon frame of the SPD and pass it to the next higher layer via the MLME-INCOMING-BEACON.indication primitive.

7.4.5.2 Secondary protecting device (SPD)

Every SPD shall be responsible for verifying that its protection needs remain satisfied by continuously monitoring the PPD. Every received beacon frame shall be passed to the next higher layer via the MLME-INCOMING-BEACON.indication primitive. If the SPD misses *aMaxMissedBeacons* consecutive beacon frames, the MAC sublayer shall notify the next higher layer that it no longer detects the PPD's beacon via the MLME-BEACON-LOST.indication primitive. The action taken by the next higher layer on receipt of this primitive is out of the scope of this standard.

If the SPD wishes to transmit its own beacon frame by interrupting the PPD, it shall follow the procedure described in 7.4.4.

7.4.6 Ceasing transmissions

7.4.6.1 Primary protecting device (PPD)

A probable scenario is that the PPD will cease transmission abruptly. Because the SPD is continuously monitoring the channel, the MAC sublayer of the SPD shall issue an MLME-BEACON-LOST.indication primitive to the next higher layer once *aMaxMissedBeacons* consecutive beacon frames are missed, thus alerting the next higher layer that the device it is protecting is no longer protected by the PPD's beacon. The action taken by the next higher layer on receipt of this primitive is out of the scope of this standard. One option, however, is for the SPD to promote itself to PPD and begin transmitting periodic beacons.

If the PPD is aware that it is about to cease transmission, it shall set the Cease Tx subfield in the beacon header to one upon sending its last beacon. The next higher layer of the SPD shall be notified through the MLME-INCOMING-BEACON.indication primitive. Again, the action taken by the next higher layer on receipt of this primitive is out of the scope of this standard.

If an SPD does promote itself to PPD, this new PPD shall not be required to set the initialization bit in the PHR to one for a period of thirty seconds, as is required for a PPD following the device initialization procedure (7.4.3). The new PPD shall initially continue to transmit the same beacon parameters as the original PPD. However, the following update procedure should be followed such that the PPD will eventually have the most current information.

Any SPD in the area shall receive the beacon, note that the Source Address field in the beacon frame has changed (i.e., the Source Address field is different from the value of *macPPDAddress*) and set the value of *macPPDAddress* to the value of the Source Address field. The SPD should then interrupt the PPD to send its own beacon frame (see 7.4.4.2). Eventually every SPD should interrupt the PPD to send a beacon frame, ensuring that the PPD has the most current information.

7.4.6.2 Secondary protecting device (SPD)

If an SPD is aware that it is about to cease transmission, it should interrupt the PPD to send its own beacon frame (see 7.4.4.2). If the RTS is acknowledged, the SPD shall set the Cease Tx subfield in the beacon header to one before sending. The next higher layer of the PPD shall be notified through the MLME-INCOMING-BEACON.indication primitive and should remove all information corresponding to the SPD from its own beacons. If the RTS is not acknowledged, the next higher layer of the SPD shall be notified and will decide how to proceed. The action taken by the next higher layer of any device is out of the scope of this standard.

If the SPD leaves the radio space without notifying the PPD, the PPD shall continue to transmit beacons containing the information corresponding to the SPD until the time the PPD itself ceases transmission.

7.4.7 ~~Tx-Rx and Rx-Tx turnaround time~~

~~The MAC sublayer needs a finite amount of time to process data received by the PHY. To allow for this, the separation between a transmitted beacon and an RTS, and between an RTS and the ANP, shall be *aTurnaroundTime*.~~

[Editor's note: There is an inconsistency between this subclause and 6.9.10, 6.9.11 in the PHY. It looks like 7.4.7 includes processing time, but the PHY sections don't. Figure 8 gives all the information needed in a simple format. Recommend removing 6.9.9, 6.9.10 and 7.4.7. We can expand the text surrounding figure 8 if necessary.]

7.5 Security suite specifications

TBD

7.6 Message sequence charts (MSC) illustrating MAC-PHY interaction

Figure 19 illustrates the initialization period for the PPD. Figure 20 and Figure 21 illustrate inter-device communications.

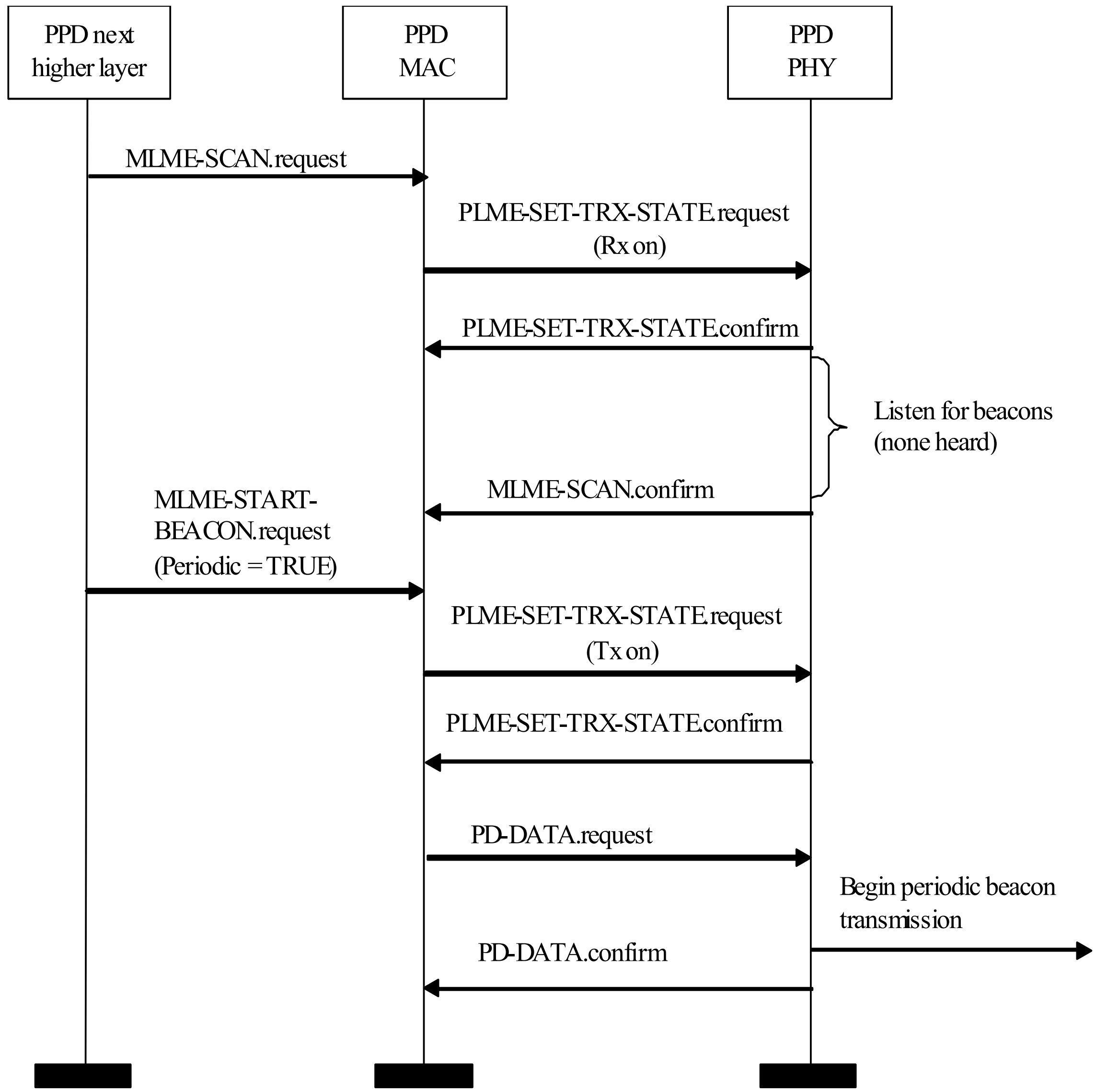


Figure 19—Initialization of the PPD

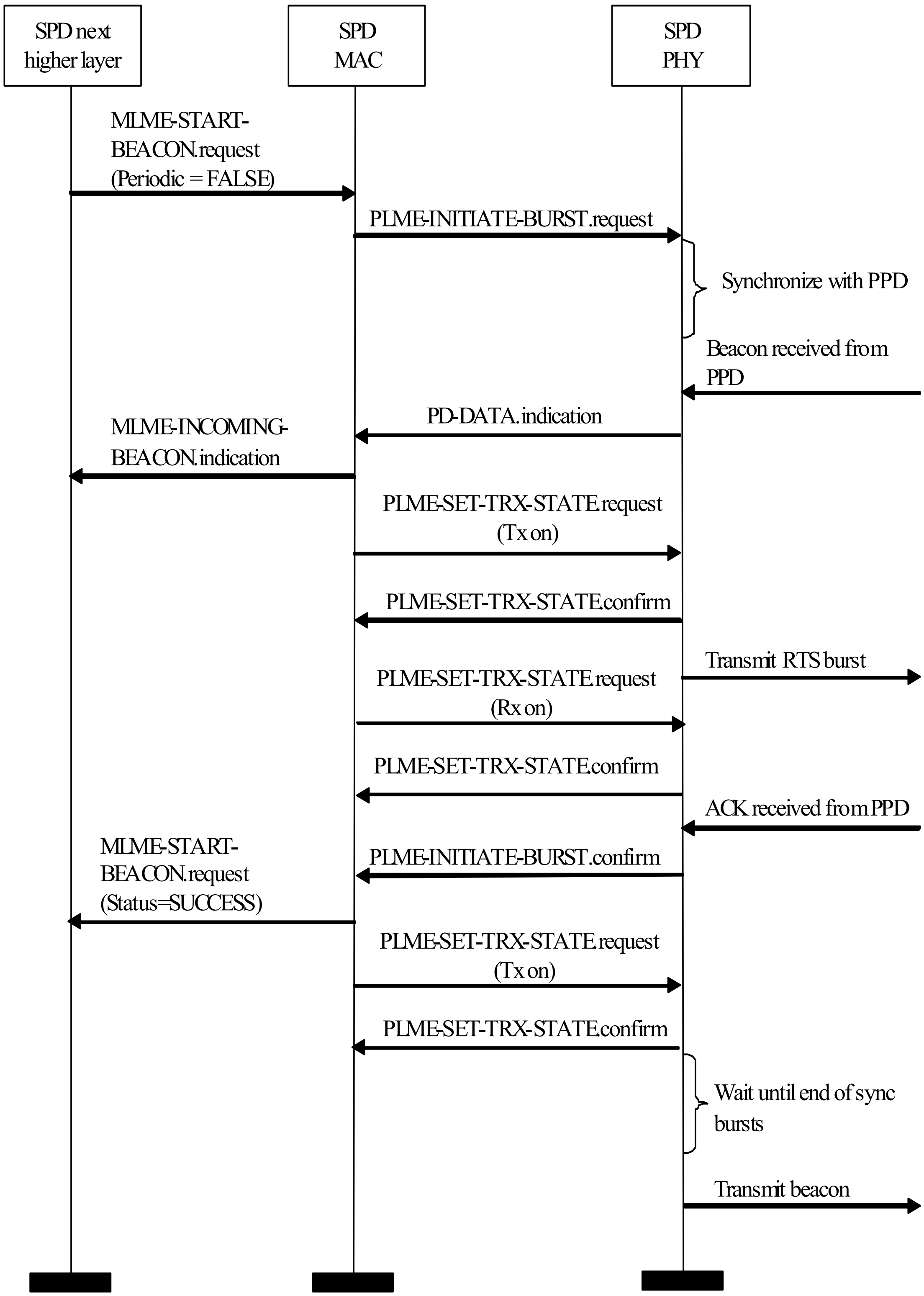
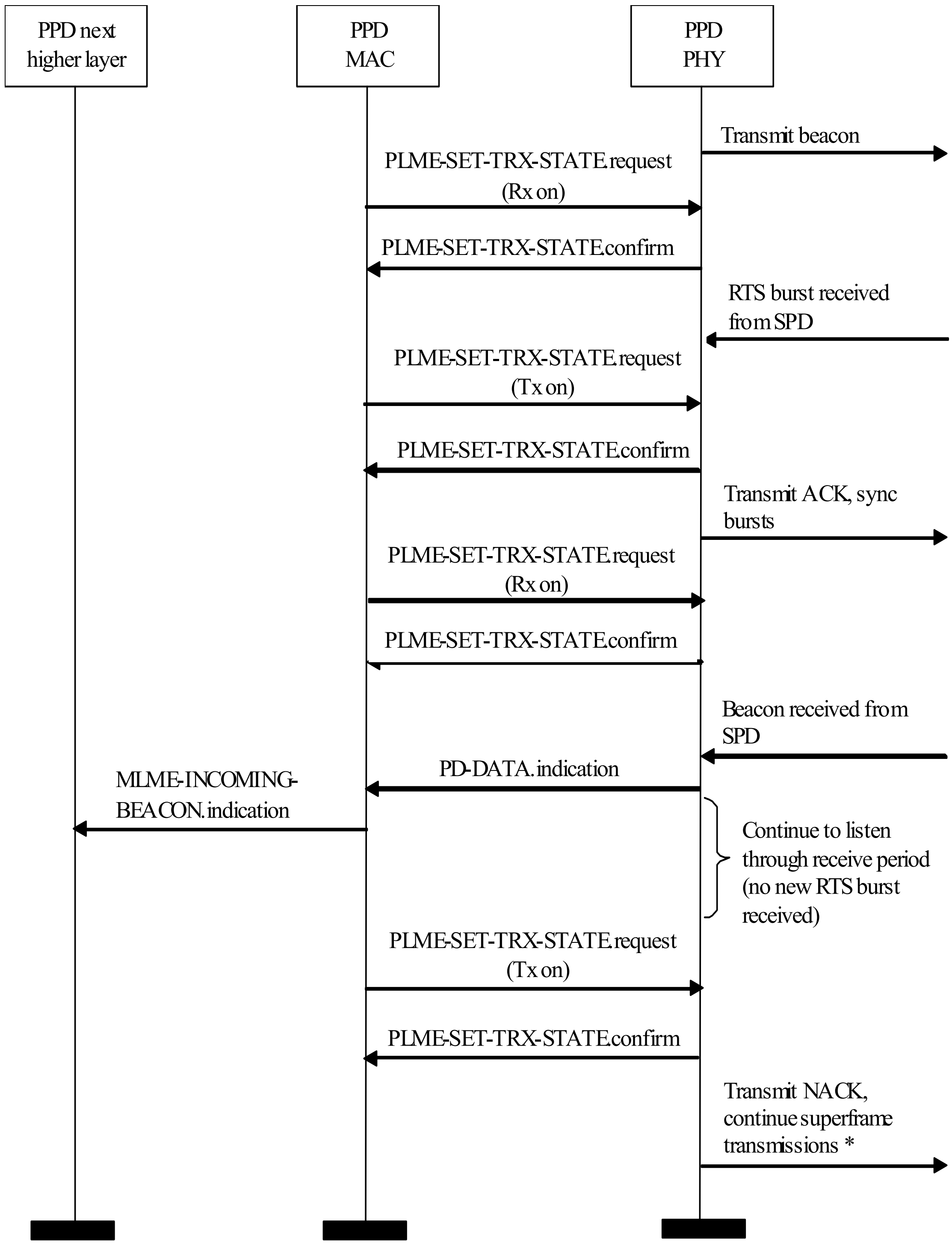


Figure 20—SPD interrupting the PPD (for inter-device communications)



* The next higher layer may choose to combine the data received in the SPD's beacon with its own and then send the MLME-NEW-BEACON-DATA.request primitive to the MAC to change the beacon content.

Figure 21—PPD being interrupted by an SPD (for inter-device communications)

Annex A

(informative)

Bibliography

A.1 General

[B1] IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition.[5]

[B2] ISO/IEC 7498-1:1994, Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model.[6]

[TBD]

A.2 Regulatory documents

[TBD]

[5]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

[6]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).