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Wireless LANs

Proposed Text for Offset Quadrature Bi-Orthogonal (OQBO) Modulation for 2.4 GHz High Speed PHY Specification

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1 High-Rate Direct-Sequence Spread Spectrum Physical Layer Specification for the 2.4 GHz ISM Band

1.1 Introduction

This clause describes the physical layer for the High Data Rate (HDR) Direct Sequence Spread Spectrum (DSSS) system. The HDR DSSS system provides a wireless LAN with both a 6.875 and a 11.00 Mb/s payload.

1.1.1 Scope

This clause describes the physical layer services provided to the 802.11 wireless LAN MAC by the 2.4 GHz HDR DSSS system. The HDR DSSS PHY layer consists of the same two protocol functions described in clause 15.1.1.

1.1.2 High-Rate DSSS Physical Layer Functions

The 2.4 GHz HDR DSSS PHY architecture is the same as described in clause 15.1.2

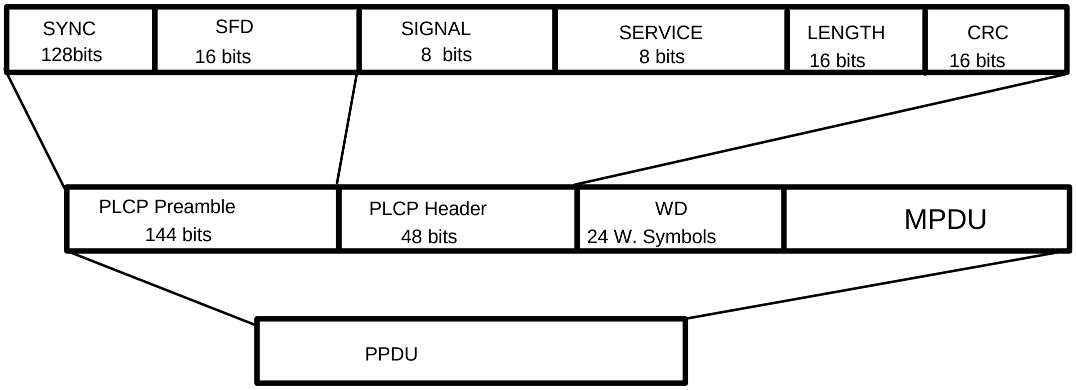
1.2 DSSS Physical Layer Convergence Procedure Sub-Layer

1.2.1 Introduction

During transmission the MPDU shall be prepended with a PLCP Preamble and PLCP Header to create the PPDU.
At the receiver the PLCP Preamble and Header are processed to aid in demodulation and delivery of the MPDU.

1.2.2 Physical Layer Convergence Procedure Frame Format

Figure 1 shows the format for the PPDU, including the DSSS PLCP preamble, the DSSS PLCP header and the MPDU frame. The PLCP Preamble contains the Synchronization (SYNC) and Start Frame Delimiter (SFD) fields.
The PLCP Header contains the 802.11 signalling (SIGNAL) and length (LENGTH) fields. Each of these is described in clause 1.2.3.



Details of **WD** Walsh Diversity High Rate Field Format (24 8-ary Walsh Symbols):

(Time flows from top to bottom.)

High-Rate 8-ary Walsh	Current Antenna	8 Symbols
Guard Time	Change Antenna	1 Symbol
Timing and Carrier Phase	Other Antenna	3 Symbols
High-Rate 8-ary Walsh	Other Antenna	8 Symbols
Guard Time	Change Antenna (If Required)	1 Symbol
Timing and Carrier	Selected Antenna	3 Symbols

Figure 1 - PLCP Frame Format

1.2.3 PLCP Field Definitions

1.2.3.1 PLCP Preamble and PLCP Header

The PLCP preamble, and the PLCP header, shall be transmitted using the 1 Mb/s DBPDK described in clause 15.4.7 (part of the Low Data Rate Direct Sequence Spread Spectrum Physical Layer for the 2.4 GHz ISM band.)

The preamble and header are always transmitted at 1 Mb/s and the SIGNAL field is used to define the data rate for the Frame Body.

In addition: the following two signal fields shall be used for the High-rate modes:

a) 45h (MSB to LSB) for 6.875 Mb/s **(MDR)**
b) 6Eh (MSB to LSB) for 11.00 Mb/s **(HRD)**

1.2.3.2 Walsh Diversity High Rate Field Format

The Walsh Diversity High Rate Field shall be transmitted using the 11 Mb/s 8-ary Walsh Offset Quadrature Bi-Orthogonal (OQBO) method described in clause 1.4.6.4.2 (11.00 Mb/s mode.)

1.2.4 PLCP/DSSS PHY Data Scrambler and Descrambler

All PHY data shall be scrambled and descrambled by the means described in clause 15.2.4.

1.2.5 PLCP Data Modulation and Modulation Rate Change

The PLCP preamble and header shall be transmitted using the 1 Mb/s DBPSK modulation described in clause 15 and its sub-clauses. The 802.11 SIGNAL field shall indicate the if the data in the MPDU is to be low rate (1 or 2 Mb/s) or high rate (6.875 or 11 Mb/s.) If the data is low rate, the modulation rate change shall occur in accordance with clause 15.2.5.

If the modulation is high rate, the additional Walsh Diversity High Rate Field shall be transmitted after the header CRC. The last bit of the header CRC shall be used as a phase reference at +45°. The Walsh Diversity High Rate Field shall be transmitted using the 8-ary 11 Mb/s mode. The transmitter and receiver shall initiate the modulation indicated by the 802.11 signal field starting with the first chip of the first Walsh symbol of the MPDU. The MPDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR issued with the PHY-TXSTART. Request primitive described in clause 1.4.4.1.

If the MPDU uses MDR, the 6.875 Mb/s data is transmitted after the 11.00 Mb/s Walsh Diversity High Rate Field .

1.2.6 PLCP Transmit Procedure

The PLCP transmit procedure is shown in Figure 1a.

In order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate channel through Station Management via the PLME. Other transmit parameters such as DATARATE, TX antenna, and TX power are set via the PHY-SAP with the PHY_TXSTART.request(TXVECTOR) as described in clause 1.4.4.2.

Based on the status of CCA indicated by PHY-CCA.indicate, the MAC will assess that the channel is clear. A clear channel shall be indicated by PHY-CCA.indicate(IDLE). If the channel is clear, transmission of the PPDU shall be initiated by issuing the PHY-TXSTART.request (TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are the PLCP header parameters SIGNAL (DATARATE), SERVICE and LENGTH and the PMD parameters of TX_ANTENNA and TXPWR_LEVEL. The PLCP header parameter LENGTH is calculated from the TXVECTOR element by multiplying by 2 for 6.875 Mb/s and by 1 for 11.0 Mb/s.

The PLCP shall issue PMD_ANTSEL, PMD_RATE, and PMD_TXPWRLVL primitives to configure the PHY. The PLCP shall then issue a PMD_TXSTART.request and the PHY entity shall immediately initiate data scrambling and transmission of the PLCP preamble based on the parameters passed in the PHY-TXSTART.request primitive. The time required for TX power on ramp described in clause 1.4.7.7 shall be included in the PLCP synchronization field. Once the PLCP preamble transmission is complete, data shall be exchanged between the MAC and the PHY by a series of PHY_DATA.request(DATA) primitives issued by the MAC and PHY_DATA.confirm primitives issued by the PHY. The modulation rate change, if any, shall be initiated with the first data symbol of the MPDU as described in clause 1.2.5. The PHY proceeds with MPDU transmission through a series of data octet transfers from the MAC. At the PMD layer, the data octets are sent in LSB to MSB order and presented to the PHY layer through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY_TXEND.request. PHY-TXSTART shall be disabled by the issuance of the PHY_TXEND.request. Normal termination occurs after the transmission of the final bit of the last MPDU octet according to the number supplied in the DSSS PHY preamble LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e. PHY-TXSTART shall be disabled). It is recommended that chipping continue during power down. Each PHY-TXEND.request is acknowledged with a PHY_TXEND.confirm primitive from the PHY.

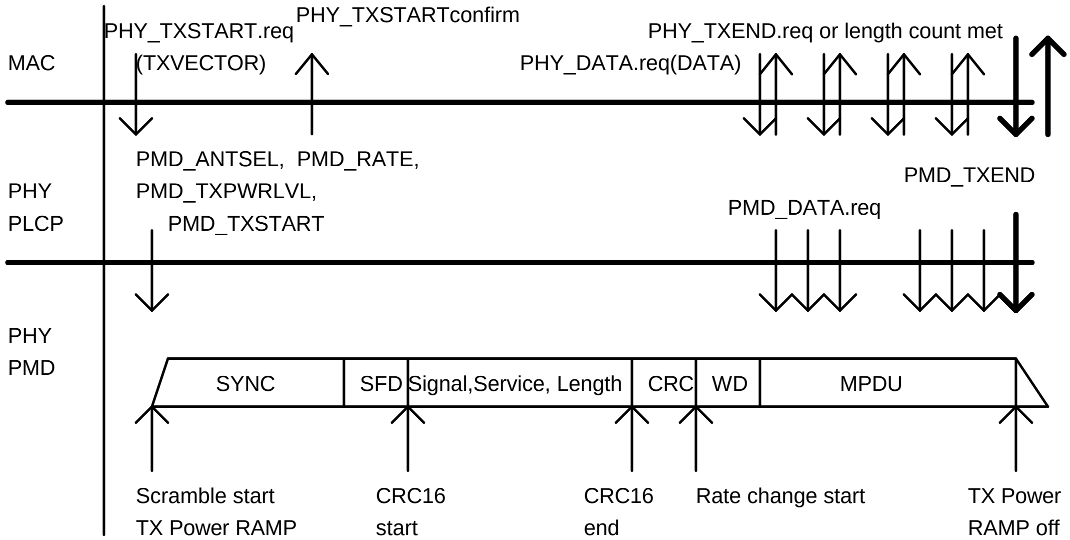


Figure 1A, PLCP Transmit Procedure

A typical state machine implementation of the PLCP transmit procedure is provided in Figure 2.

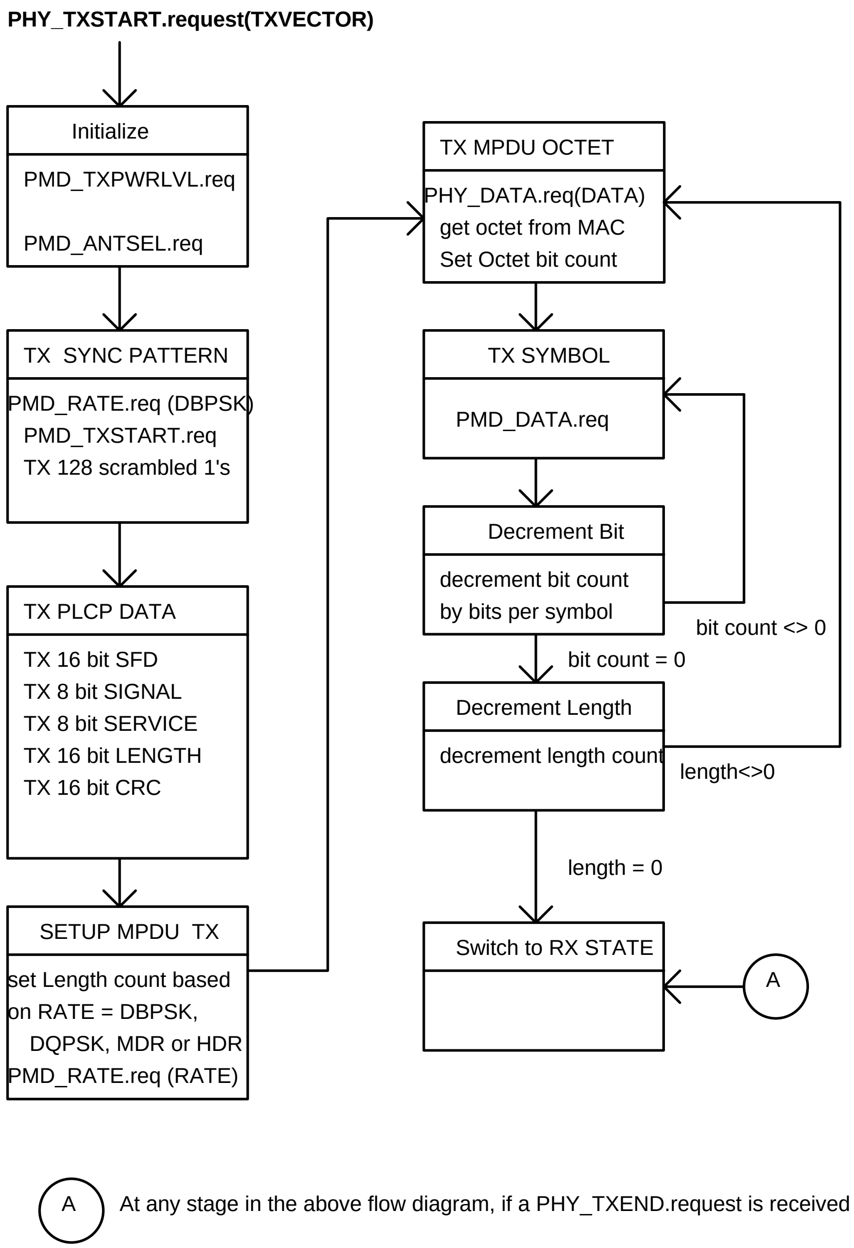


Figure 2A, PLCP Transmit State Machine

1.2.7 PLCP Receive Procedure

The PLCP receive procedure is shown in Figure 3A.

In order to receive data, PHY-TXSTART.request shall be disabled so that the PHY entity is in the receive state. Further, through Station Management via the PLME, the PHY is set to the appropriate channel and the CCA method is chosen. Other receive parameters such as RSSI, SQ (signal quality) and indicated DATARATE may be accessed via the PHY-SAP.

Upon receiving the transmitted energy, according to the selected CCA mode, the PMD_ED shall be enabled (according to clause 1.4.8.4) as the RSSI strength reaches the ED_THRESHOLD and/or PMD_CS shall be enabled after code lock is established. These conditions are used to indicate activity to the MAC via PHY-CCA.indicate according to clause 1.4.8.4. PHY-CCA.indicate(BUSY) shall be issued for energy detection and/or code lock prior to correct reception of the PLCP frame. The PMD primitives PMD_SQ and PMD_RSSI are issued to update the RSSI and SQ parameters reported to the MAC.

After PHY-CCA.indicate is issued, the PHY entity shall begin searching for the SFD field. Once the SFD field is detected, CCITT CRC-16 processing shall be initiated and the PLCP 802.11 SIGNAL, 802.11 SERVICE and LENGTH fields are received. The CCITT CRC-16 FCS shall be processed. If the CCITT CRC-16 FCS check fails, the PHY receiver shall return to the RX Idle state as depicted in Figure 4A. Should the status of CCA return to the IDLE state during reception prior to completion of the full PLCP processing, the PHY receiver shall return to the RX Idle state.

If the PLCP header reception is successful (and the SIGNAL field is completely recognizable and supported), a PHY_RXSTART.indicate(RXVECTOR) shall be issued. The RXVECTOR associated with this primitive includes the SIGNAL field, the SERVICE field, the MPDU length in bytes (calculated from the LENGTH field in microseconds), the antenna used for receive (RX_ANTENNA), RSSI and SQ.

The received MPDU bits are assembled into octets and presented to the MAC using a series of PHY_DATA.indicate(DATA) primitive exchanges. The rate change indicated in the 802.11 SIGNAL field shall be implemented as described in clause 1.2.5. The PHY proceeds with MPDU reception. After the reception of the final bit of the last MPDU octet indicated by the PLCP preamble LENGTH field, the receiver shall be returned to the RX Idle state as shown in Figure 4A. A PHY_RXEND.indicate (NoError) primitive shall be issued. A PHY-CCA.indicate(IDLE) primitive shall be issued following a change in PHYCS and/or PHYED according to the selected CCA method.

In the event that a change in PHYCS or PHYED would cause the status of CCA to return to the IDLE state before the complete reception of the MPDU as indicated by the PLCP LENGTH field, the error condition PHY_RXEND.indicate(CarrierLost) shall be reported to the MAC. The DSSS PHY will ensure that the CCA will indicate a busy medium for the intended duration of the transmitted packet.

If the PLCP header is successful, but the indicated rate in the SIGNAL field is not receivable, a PHY_RXSTART.indicate will not be issued. The PHY shall issue the error condition PHY_RXEND.indicate(UnsupportedRate). If the PLCP header is successful, but the SERVICE field is out of 802.11 DSSS specification, a PHY_RXSTART.indicate will not be issued. The PHY shall issue the error condition PHY_RXEND.indicate(FormatViolation). Also, in both cases, the DSSS PHY will ensure that the CCA shall indicate a busy medium for the intended duration of the transmitted frame as indicated by the LENGTH field. The intended duration is calculated using the LENGTH and RATE fields.

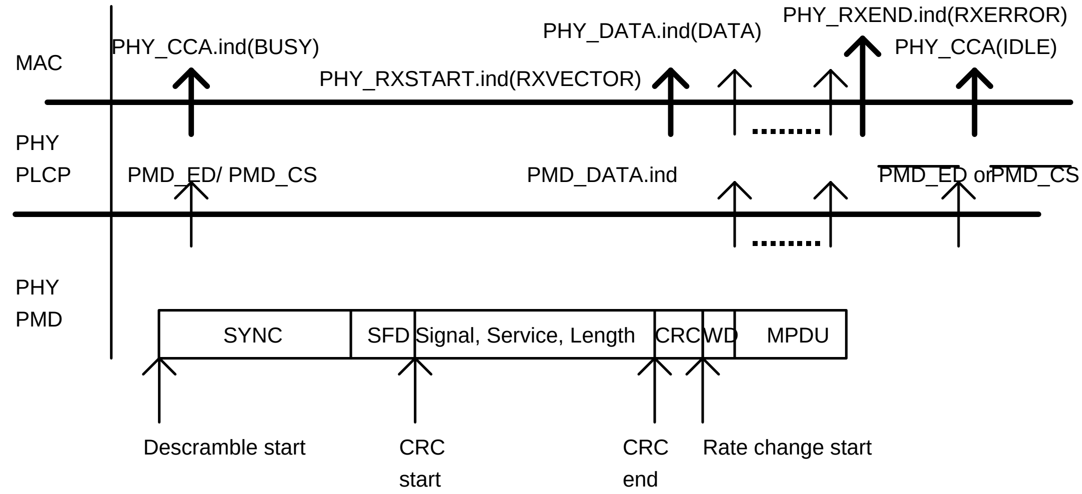


Figure 3A, PLCP Receive Procedure

A typical state machine implementation of the PLCP receive procedure is provided in Figure 4A.

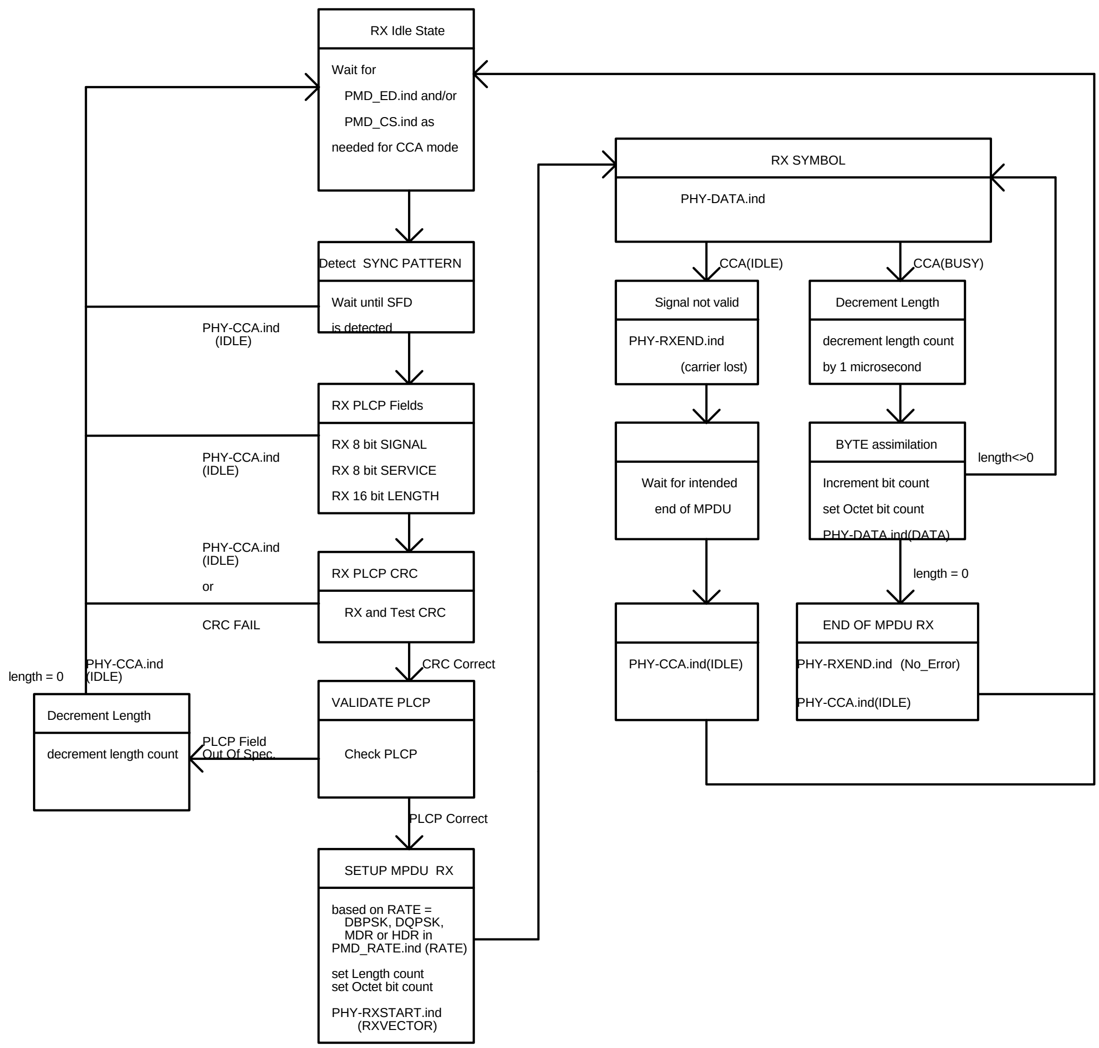


Figure 4A, PLCP Receive State Machine

1.3 High Data Rate DSSS Physical Layer Management Entity

1.3.1 PLME_SAP Sublayer Management primitives

Table 1 lists the MIB attributes which may be accessed by the PHY sublayer entities and intra layer of higher Layer Management Entities (LME). These attributes are accessed via the PLME-GET, PLME-SET and PLME-RESET primitives defined in clause 10.

1.3.2 DSSS Physical Layer Management Information Base

All DSSS Physical Layer Management Information Base attributes are defined in clause 12 with specific values defined in Table 1.

Managed Object	**Default Value / Range**	**Operational Semantics**
agPhyOperationGroup		
aPHYType	DSSS-2.4 (02)	Static
aTempType	implementation dependent	Static
aCWmin	31	Static
aCWmax	1023	Static
aRegDomainsSupported	implementation dependent	Static
aCurrentRegDomain	implementation dependent	Static
aSlotTime	20 µs	Static
aCCATime	≤ 15 µs	Static
aRxTxTurnaroundTime	≤ 5 µs	Static
aTxPLCPDelay	implementation dependent	Static
aRxTxSwitchTime	≤ 5 µs	Static
aTxRampOnTime	implementation dependent	Static
aTxRFDelay	implementation dependent	Static
aSIFSTime	10 µs	Static
aRxRFDelay	implementation dependent	Static
aRxPLCPDelay	implementation dependent	Static
aMACProcessingDelay	not applicable	n/a
aTxRampOffTime	implementation dependent	Static
aPreambleLength	144 bits	Static
aPLCPHeaderLength	48 bits	Static
agPhyRateGroup		
aSupportedDataRatesTx	02h, 04h	Static
aSupportedDataRatesRx	02h, 04h	Static
aMPDUMaxLength	4 ≤ x ≤ (2^13 - 1)	Static
agPhyAntennaGroup		
aCurrentTxAntenna	implementation dependent	Dynamic
aDiversitySupport	implementation dependent	Static
agPhyTxPowerGroup		
aNumberSupportedPowerLevels	implementation dependent	Static
aTxPowerLevel1	implementation dependent	Static
aTxPowerLevel2	implementation dependent	Static
aTxPowerLevel3	implementation dependent	Static
aTxPowerLevel4	implementation dependent	Static
aTxPowerLevel5	implementation dependent	Static
aTxPowerLevel6	implementation dependent	Static

aTxPowerLevel7	implementation dependent	Static
aTxPowerLevel8	implementation dependent	Static
aCurrentTxPowerLevel	implementation dependent	Dynamic
agPhyStatusGroup		
aSynthesizerLocked	implementation dependent	Dynamic
agPhyDSSSGroup		
aCurrentChannel	implementation dependent	Dynamic
aCCAModeSupport	implementation dependent	Static
aCurrentCCAMode	implementation dependent	Dynamic
aEDThreshold	implementation dependent	Dynamic
agPhyPwrSavingGroup		
aDozeTurnonTime	implementation dependent	Static
aCurrentPowerState	implementation dependent	Dynamic
agAntennasListGroup		
aSupportTxAntennas	implementation dependent	Static
aSupportRxAntennas	implementation dependent	Static
aDiversitySelectRx	implementation dependent	Dynamic

Table 1, MIB Attribute Default Values / Ranges

Notes: The column titled Operational Semantics contains two types: static and dynamic. Static MIB attributes are fixed and cannot be modified for a given PHY implementation. MIB Attributes defined as dynamic can be modified by some management entity.

1.4 High Data Rate DSSS Physical Medium Dependent Sublayer

1.4.1 Scope and Field of Application

Scope and Field of Application

This clause describes the PMD services provided to the PLCP for the DSSS Physical Layer. Also defined in this clause are the functional, electrical and RF characteristics required for interoperability of implementations conforming to this specification. The relationship of this specification to the entire DSSS PHY Layer is shown in Figure 5.

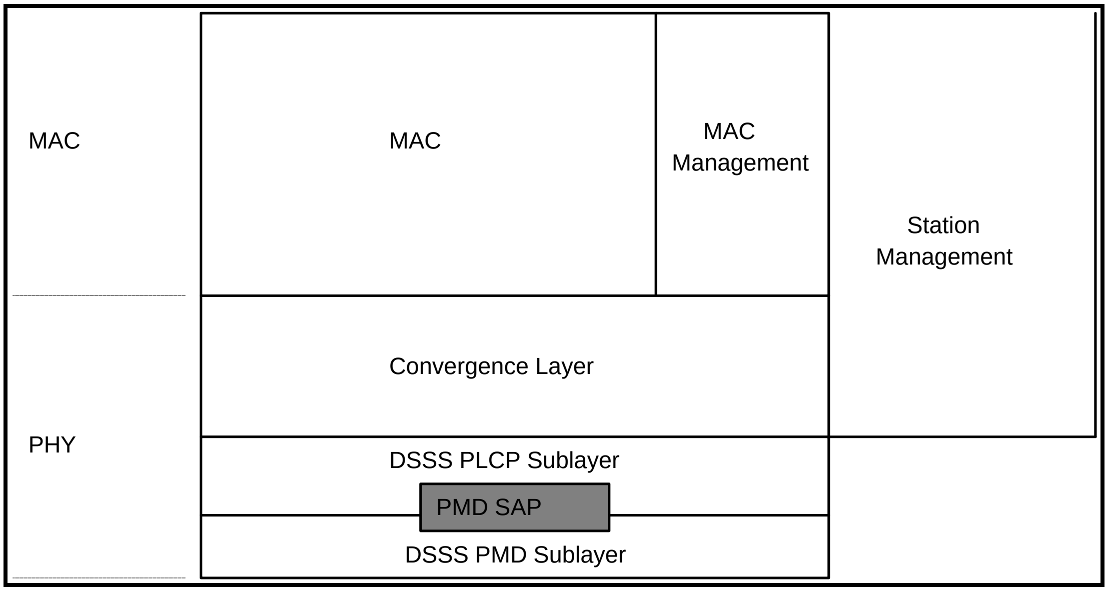


Figure 5, PMD Layer Reference Model

1.4.2 Overview of Service

The DSSS Physical Medium Dependent Sublayer accepts Physical Layer Convergence Procedure sublayer service primitives and provides the actual means by which data shall be transmitted or received from the medium. The combined function of DSSS PMD sublayer primitives and parameters for the receive function results in a data stream, timing information, and associated received signal parameters being delivered to the PLCP sublayer. A similar functionality shall be provided for data transmission.

1.4.3 Overview of Interactions

The primitives associated with the 802.11 PLCP sublayer to the DSSS PMD falls into two basic categories:

a) Service primitives that support PLCP peer-to-peer interactions.
b) Service primitives that have local significance and support sublayer-to-sublayer interactions.

1.4.4 Basic Service and Options

All of the service primitives described in this clause are considered mandatory unless otherwise specified.

PMD_SAP Peer-to-Peer Service Primitives

Table 2 indicates the primitives for peer-to-peer interactions.

Primitive	**Request**	**Indicate**	**Confirm**	**Response**

PHY-RXSTART		X		
PHY-RXEND		X		
PHY-CCA		X		
PHY-TXSTART	X		X	
PHY-TXEND	X		X	
PHY-DATA	X	X	X	

Table 2, PMD_SAP Peer-to-Peer Service Primitives

PMD_SAP Peer-to-Peer Service Primitive Parameters

Several service primitives include a parameter vector. This vector shall be actually a list of parameters which may vary depending on PHY type. Table 3 indicates the parameters required by the MAC or DSSS PHY in each of the parameter vectors used for peer-to-peer interactions.

Parameter	Associated Primitive	Value
LENGTH	RXVECTOR, TXVECTOR	4 to 2^16-1
DATARATE	RXVECTOR, TXVECTOR	PHY dependent
SERVICE	RXVECTOR, TXVECTOR	PHY dependent
TXPWR_LEVEL	TXVECTOR	PHY dependent
TX_ANTENNA	TXVECTOR	PHY dependent
RSSI	RXVECTOR	PHY dependent
SQ	RXVECTOR	PHY dependent
RX_ANTENNA	RXVECTOR	PHY dependent

Table 3, DSSS PMD_SAP Peer-to-Peer Service Primitives

PMD_SAP Sublayer-to-Sublayer Service Primitives

Primitive	Request	Indicate	Confirm	Response
PMD_TXSTART	X			
PMD_TXEND	X			
PMD_ANTSEL	X	X		
PMD_TXPWRLVL	X			
PMD_RATE	X	X		
PMD_RSSI		X		
PMD_SQ		X		
PMD_CS		X		
PMD_ED	X	X		

Table 4, PMD_SAP Sublayer-to-Sublayer Service Primitives

PMD_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
DATA	PHY_DATA.request PHY_DATA.indicate	octet value: 00h-FFh
TXVECTOR	PHY_DATA.request	a set of parameters

RXVECTOR	PHY_DATA.indicate	a set of parameters
TXD_UNIT	PMD_DATA.request	One(1), Zero(0): DBPSK; di bit combinations 00,01,11,10: DQPSK; 10 bit combinations: 6.875 Mb/s mode; 8 bit combinations 11.00 Mb/s mode.
RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK; 10 bit combinations: 6.875 Mb/s mode; 8 bit combinations; 11.00 Mb/s mode.
RF_STATE	PMD_TXE.request	Receive, Transmit
ANT_STATE	PMD_ANTSEL.indicate PMD_ANTSEL.request	1 to 256
TXPWR_LEVEL	PHY_TXSTART	0,1,2,3 (max. of 4 levels)
RATE	PMD_RATE.indicate PMD_RATE.request	0Ah for 1 Mb/s DBPSK; 14h for 2 Mb/s DQPSK; 45h for 6.875 Mb/s 16-ary Walsh; 6Eh for 11.00 Mb/s 8-ary Walsh.
RSSI	PMD_RSSI.indicate	0-8 bits of RSSI
SQ	PMD_SQ.indicate	0-8 bits of Signal Quality

Table 5, List of Parameters for the PMD Primitives

1.4.5 PMD_SAP Detailed Service Specification

The following clause describes the services provided by each PMD primitive.

PMD_DATA.request

Function

This primitive defines the transfer of data from the PLCP sublayer to the PMD entity.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_DATA.request(TXD_UNIT)

The TXD_UNIT parameter takes on the value of either ONE(1) or ZERO(0) for DBPSK modulation or the di-bit combination 00, 01, 11, or 10 for DQPSK modulation; 10 bit combinations for Mb/s mode; 8 bit combinations for11.00 Mb/s mode.. This parameter represents a single block of data which in turn shall be used by the PHY to be differentially encoded into a DBPSK or DQPSK transmitted symbol. The symbol itself shall be spread by the PN code prior to transmission.

When Generated

This primitive shall be generated by the PLCP sublayer to request transmission of a symbol. The data clock for this primitive shall be supplied by PMD layer based on the PN code repetition.

Effect of Receipt

The PMD performs the differential encoding, PN code modulation and transmission of the data.

PMD_DATA.indicate

Function

This primitive defines the transfer of data from the PMD entity to the PLCP sublayer.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_DATA.indicate(RXD_UNIT)

The RXD_UNIT parameter takes on the value of ONE(1) or ZERO(0) for DBPSK modulation or as the di-bit 00, 01, 11, or 10 for DQPSK modulation; 10 bit combinations for Mb/s mode; 8 bit combinations for 11.00 Mb/s mode. This parameter represents a single symbol which has been demodulated by the PMD entity.

When Generated

This primitive generated by the PMD entity, forwards received data to the PLCP sublayer. The data clock for this primitive shall be supplied by PMD layer based on the PN code repetition.

Effect of Receipt

The PLCP sublayer either interprets the bit or bits which are recovered as part of the PLCP convergence procedure or passes the data to the MAC sublayer as part of the MPDU.

PMD_TXSTART.request

Function

This primitive, generated by the PHY PLCP sublayer, initiates PPDU transmission by the PMD layer.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_TXSTART.request

When Generated

This primitive shall be generated by the PLCP sublayer to initiate the PMD layer transmission of the PPDU. The PHY_DATA.request primitive shall be provided to the PLCP sublayer prior to issuing the PMD_TXSTART command.

Effect of Receipt

PMD_TXSTART initiates transmission of a PPDU by the PMD sublayer.

PMD_TXEND.request

Function

This primitive, generated by the PHY PLCP sublayer, ends PPDU transmission by the PMD layer.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_TXEND.request

When Generated

This primitive shall be generated by the PLCP sublayer to terminate the PMD layer transmission of the PPDU.

Effect of Receipt

PMD_TXEND terminates transmission of a PPDU by the PMD sublayer.

PMD_ANTSEL.request

Function

This primitive, generated by the PHY PLCP sublayer, selects the antenna used by the PHY for transmission or reception (when diversity is disabled).

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_ANTSEL.request(ANT_STATE)

ANT_STATE selects which of the available antennas should be used for transmit. The number of available antennas shall be determined from the MIB table parameters aSupportRxAntennas and aSupportTxAntennas.

When Generated

This primitive shall be generated by the PLCP sublayer to select a specific antenna for transmission (or reception when diversity is disabled).

Effect of Receipt

PMD_ANTSEL immediately selects the antenna specified by ANT_STATE.

PMD_ANTSEL.indicate

Function

This primitive, generated by the PHY PLCP sublayer, reports the antenna used by the PHY for reception of the most recent packet.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_ANTSEL.indicate(ANT_STATE)

ANT_STATE reports which of the available antennas was used for reception of the most recent packet.

When Generated

This primitive shall be generated by the PLCP sublayer to report the antenna used for the most recent packet reception.

Effect of Receipt

PMD_ANTSEL immediately reports the antenna specified by ANT_STATE.

PMD_TXPWRLVL.request

Function

This primitive, generated by the PHY PLCP sublayer, selects the power level used by the PHY for transmission.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_TXPWRLVL.request(TXPWR_LEVEL)

TXPWR_LEVEL selects which of the optional transmit power levels should be used for the current packet transmission. The number of available power levels shall be determined by the MIB parameter aNumberSupportedPowerLevels. Clause 1.4.7.3 provides further information on the optional DSSS PHY power level control capabilities.

When Generated

This primitive shall be generated by the PLCP sublayer to select a specific transmit power. This primitive shall be applied prior to setting PMD_TXSTART into the transmit state.

Effect of Receipt

PMD_TXPWRLVL immediately sets the transmit power level given by TXPWR_LEVEL.

PMD_RATE.request

Function

This primitive, generated by the PHY PLCP sublayer, selects the modulation rate which shall be used by the DSSS PHY for transmission.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_RATE.request(RATE)

RATE selects which of the DSSS PHY data rates shall be used for MPDU transmission. Clause 1.4.6.4 provides further information on the DSSS PHY modulation rates. The DSSS PHY rate change capability is fully described in clause 1.2.

When Generated

This primitive shall be generated by the PLCP sublayer to change or set the current DSSS PHY modulation rate used for the MPDU portion of a PPDU.

Effect of Receipt

The receipt of PMD_RATE selects the rate which shall be used for all subsequent MPDU transmissions. This rate shall be used for transmission only. The DSSS PHY shall still be capable of receiving all the required DSSS PHY modulation rates.

PMD_RATE.indicate

Function

This primitive, generated by the PMD sublayer, indicates which modulation rate was used to receive the MPDU portion of the PPDU. The modulation shall be indicated in the PLCP preamble 802.11 SIGNALING field.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_RATE.indicate(RATE)

In receive mode, the RATE parameter informs the PLCP layer which of the DSSS PHY data rates was used to process the MPDU portion of the PPDU. Clause 1.4.6.4 provides further information on the DSSS PHY modulation rates. The DSSS PHY rate change capability is fully described in clause 1.2.

When Generated

This primitive shall be generated by the PMD sublayer when the PLCP preamble 802.11 SIGNALING field has been properly detected.

Effect of Receipt

This parameter shall be provided to the PLCP layer for information only.

PMD_RSSI.indicate

Function

This optional primitive, generated by the PMD sublayer, provides to the PLCP and MAC entity the Received Signal Strength.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_RSSI.indicate(RSSI)

The RSSI shall be a measure of the RF energy received by the DSSS PHY. RSSI indications of up to 8 bits (256 levels) are supported.

When Generated

This primitive shall be generated by the PMD when the DSSS PHY is in the receive state. It shall be continuously available to the PLCP which in turn provides the parameter to the MAC entity.

Effect of Receipt

This parameter shall be provided to the PLCP layer for information only. The RSSI may be used in conjunction with SQ as part of a Clear Channel Assessment scheme.

PMD_SQ.indicate

Function

This optional primitive, generated by the PMD sublayer, provides to the PLCP and MAC entity the Signal Quality of the DSSS PHY PN code correlation. The signal quality shall be sampled when the DSSS PHY achieves code lock and held until the next code lock acquisition.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_SQ.indicate(SQ)

The SQ shall be a measure of the PN code correlation quality received by the DSSS PHY. SQ indications of up to 8 bits (256 levels) are supported.

When Generated

This primitive shall be generated by the PMD when the DSSS PHY is in the receive state and code lock is achieved. It shall be continuously available to the PLCP which in turn provides the parameter to the MAC entity.

Effect of Receipt

This parameter shall be provided to the PLCP layer for information only. The SQ may be used in conjunction with RSSI as part of a Clear Channel Assessment scheme.

PMD_CS.indicate

This primitive, generated by the PMD, shall indicate to the PLCP layer that the receiver has acquired (locked) the PN code and data is being demodulated.

Function

This primitive, generated by the PMD, shall indicate to the PLCP layer that the receiver has acquired (locked) the PN code and data is being demodulated.

Semantic of the Service Primitive

The PMD_CS (Carrier Sense) primitive in conjunction with PMD_ED provide CCA status through the PLCP layer PHYCCA primitive. PMD_CS indicates a binary status of ENABLED or DISABLED. PMD_CS shall be ENABLED when the correlator signal quality indicated in PMD_SQ is greater than the CS_THRESHOLD parameter. PMD_CS shall be DISABLED when the PMD_SQ falls below the correlation threshold.

When Generated

This primitive shall be generated by the PHY sublayer when the DSSS PHY is receiving a PPDU and the PN code has been acquired.

Effect of Receipt

This indicator shall be provided to the PLCP for forwarding to the MAC entity for information purposes through the PHYCCA indicator. This parameter shall indicate that the RF medium is busy and occupied by a DSSS PHY signal. The DSSS PHY should not be placed into the transmit state when PMD_CS is ENABLED.

PMD_ED.indicate

Function

This optional primitive, generated by the PMD, shall indicate to the PLCP layer that the receiver has detected RF energy indicated by the PMD_RSSI primitive which is above a predefined threshold.

Semantic of the Service Primitive

The PMD_ED (Energy Detect) primitive along with the PMD_SQ provide CCA status at the PLCP layer through the PHYCCA primitive. PMD_ED indicates a binary status of ENABLED or DISABLED. PMD_ED shall be ENABLED when the RSSI indicated in PMD_RSSI is greater than the ED_THRESHOLD parameter. PMD_ED shall be DISABLED when the PMD_RSSI falls below the energy detect threshold.

When Generated

This primitive shall be generated by the PHY sublayer when the PHY is receiving RF energy from any source which exceeds the ED_THRESHOLD parameter.

Effect of Receipt

This indicator shall be provided to the PLCP for forwarding to the MAC entity for information purposes through the PMD_ED indicator. This parameter shall indicate that the RF medium may be busy with an RF energy source which is not DSSS PHY compliant. If a DSSS PHY source is being received, the PMD_CS function shall be enabled shortly after the PMD_ED function is enabled.

PMD_ED.request

Function

This optional primitive, generated by the PHY PLCP, sets the energy detect ED THRESHOLD value.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PMD_ED.request(ED_THRESHOLD)

ED_THRESHOLD sets the threshold which the RSSI indicated shall be greater than in order for PMD_ED to be enabled.

When Generated

This primitive shall be generated by the PLCP sublayer to change or set the current DSSS PHY energy detect threshold.

Effect of Receipt

The receipt of PMD_ED immediately changes the energy detection threshold as set by the ED_THRESHOLD parameter.

PHY-CCA.indicate

Function

This primitive, generated by the PMD, indicates to the PLCP layer that the receiver has detected RF energy which adheres to the CCA algorithm.

Semantic of the Service Primitive

The PHY-CCA primitive provides CCA status at the PLCP layer to the MAC.

When Generated

This primitive shall be generated by the PHY sublayer when the PHY is receiving RF energy from any source which exceeds the ED_THRESHOLD parameter (PMD_ED is active) and optionally is a valid correlated DSSS PHY signal whereby PMD_CS would also be active.

Effect of Receipt

This indicator shall be provided to the PLCP for forwarding to the MAC entity for information purposes through the PHY-CCA indicator. This parameter indicates that the RF medium may be busy with an RF energy source which may or may not be DSSS PHY compliant. If a DSSS PHY source is being received, the PMD_CS function shall be enabled shortly after the PMD_ED function is enabled.

1.4.6 PMD Operating Specifications General

The following clauses provide general specifications for the high-rate DSSS Physical Medium Dependent sub-layer. These specifications apply to both transmit and receive functions and general operation of the high-rate DSSS PHY.

1.4.6.1 Operating Frequency Range

The DSSS PHY shall operate in the frequency range of 2.4 to 2.4835 GHz as allocated by regulatory bodies in the USA, Canada and Europe or in the 2.471 to 2.497 GHz frequency band as allocated by regulatory authority in Japan.

1.4.6.2 Number of Operating Frequency Channels

The channel center frequencies and CHNL_ID numbers shall be the same as for the lower-rate DSSS PHY standard, as shown in Table 63, in clause 15.4.6.2.

1.4.6.3 Spreading Sequence

The following spreading sequences shall be used:

a) For 6.875 Mb/s mode: {16 chip sequence Hex: 131F; Binary:0001001100011111 }
b) For 11.00 Mb/s mode: {8 chip sequence *same 8 chip sequence proposed by Harris*}.

1.4.6.4 Modulation and Channel Data Rates

1.4.6.4.1 6.875 Mb/s mode.

Data out the scrambler at 6.875 Mb/s shall be first de-multiplexed, 10 bits at a time, into 5 bits for the I channel, then 5 bits for the Q channel. The first 4 I channel bits shall be used to determine one of sixteen Walsh functions. The 4 bit binary word (LSB first) shall determine which Walsh function {W(0) through W(16)} shall be used. If the last I channel bit is a “0”, no change shall occur to this Walsh function. If the last I channel bit is a “1”, the bits of the Walsh function shall be inverted. The processing of the 5 Q channel bits shall be used to find another Walsh function, with or without inversion, using the same method described for the 5 I channel bits.

Both the I and Q channel functions so determined shall have a Walsh symbol rate of 0.6875 Msymbols/sec. This corresponds to a Walsh chipping rate of 11 Mchips/sec. Both the I and Q channels shall be exclusive-or’ed with the spreading sequence specified in clause 1.4.6.3 a. The Q channel shall then be delayed by (1.0/22.0) ns with respect to the I channel. The accuracy of this delay time shall be in accordance with the chip clock frequency tolerance specified in clause 1.4.7.6. The digital I and Q data thus derived shall be translated into I and Q analog signals by the transformation:

data 0 translates into positive voltage
data 1 translated into negative voltage.

The I analog voltage shall modulate the in-phase carrier.
The Q analog voltage shall modulate quadrature phase carrier.

1.4.6.4.2 11.00 Mb/s mode
Data out the scrambler at 11 Mb/s shall be first de-multiplexed, 8 bits at a time, into 4 bits for the I channel, then 4 bits for the Q channel. The first 3 I channel bits shall be used to determine one of eight Walsh functions. The 3 bit binary word (LSB first) shall determine which Walsh function {W(0) through W(7)} shall be used. If the last I channel bit is a "0", no change shall occur to this Walsh function. If the last I channel bit is a "1", the bits of the Walsh function shall be inverted. The processing of the 4 Q channel bits shall be used to find another Walsh function, with or without inversion, using the same method described for the 4 I channel bits.

Both the I and Q channel functions so determined shall have a Walsh symbol rate of 1.375 Msymbols/sec. This corresponds to a Walsh chipping rate of 11 Mchips/sec. Both the I and Q channels shall be exclusive-or'ed with the spreading sequence specified in clause 1.4.6.3 b. The Q channel shall then be delayed by (1.0/22.0) ns with respect to the I channel. The accuracy of this delay time shall be in accordance with the chip clock frequency tolerance specified in clause 1.4.7.6. The digital I and Q data thus derived shall be translated into I and Q analog signals by the transformation:

data 0 translates into positive voltage
data 1 translated into negative voltage.

The I analog voltage shall modulate the in-phase carrier.
The Q analog voltage shall modulate quadrature phase carrier.

1.4.6.5 Transmit and Receive In-Band and Out-of-Band Spurious Emissions
The high-rate DSSS PHY shall conform with in-band and out-of-band spurious emissions as set by regulatory bodies. For the USA, refer to FCC 15.247, 15.202, and 15.209. For Europe, refer to ETS 300-328.

1.4.6.6 Transmit to Receive Turnaround Time
The transmit-to-receive turn-around time shall be less than 10 μs, including the power-down ramp specified in clause Transmit Power On and Power Down Ramp. This time shall be measured as described in clause 15.4.6.6

1.4.6.7 Receive to Transmit Turnaround Time
The receive-to-transmit turn-around time shall be less than 5 μs, including the power-up ramp specified in clause Transmit Power On and Power Down Ramp. This time shall be measured as described in clause 15.4.6.7.

1.4.6.8 Slot Time
The slot time for the high-rate DSSS PHY shall be the sum of the carrier-detect time specified in clause Clear Channel Assessment and twice the receive-to-transmit turn-around time specified in clause Receive to Transmit Turnaround Time.

1.4.6.9 Transmit and Receive Antenna Port Impedance
If exposed, the transmitter and receiver antenna port(s) shall be of nominal impedance 50 ohms.

1.4.6.10 Transmit and Receive Operating Temperature
The operating temperature range shall be 0°C to 40°C.

1.4.7 PMD Transmit Specifications
The following clauses describe the transmit functions and parameters associated with the Physical Medium Dependent sub-layer.

1.4.7.1 Maximum Transmit Power Levels
The maximum allowable output power, as measured in accordance with practices specified by the regulatory bodies, is shown in Table 1. In the USA, the radiated emissions should also conform to the ANSI uncontrolled radiation emission standards (ANSI/IEEE C95.1-1992).

Table 1 - Maximum Transmit Power Levels

Maximum output power	**Geographic location**	**Compliance Document**
1000 mW (GT <6 dBi)	USA	FCC 15.247
100 mW (EIRP)	Europe	ETS 300-328
≈10 mW/MHz	Japan MPT	ordinance 79

1.4.7.2 Minimum Transmitted Power level
The minimum transmit power shall be no less than 1 mW.

1.4.7.3 Transmit Power Level Control
Power control shall be provided for transmitted power greater than 100 mW. A maximum of 4 power levels may be provided. A radio capable of transmitting more than 100 mW shall at least be capable of switching down to 100mW.

1.4.7.4 Transmit Spectrum Mask
The peak of the transmitter power spectrum in taken to be 0 dBr. The transmit power spectral density PT(f) (including spurious products) shall be:

Where fc is the carrier frequency and f is the spectral variable, both in MHz. The transmitter spectrum shall be contained within the spectral mask shown in Figure 6. The measurements shall be made using 100 kHz resolution bandwidth and 30 kHz video bandwidth.

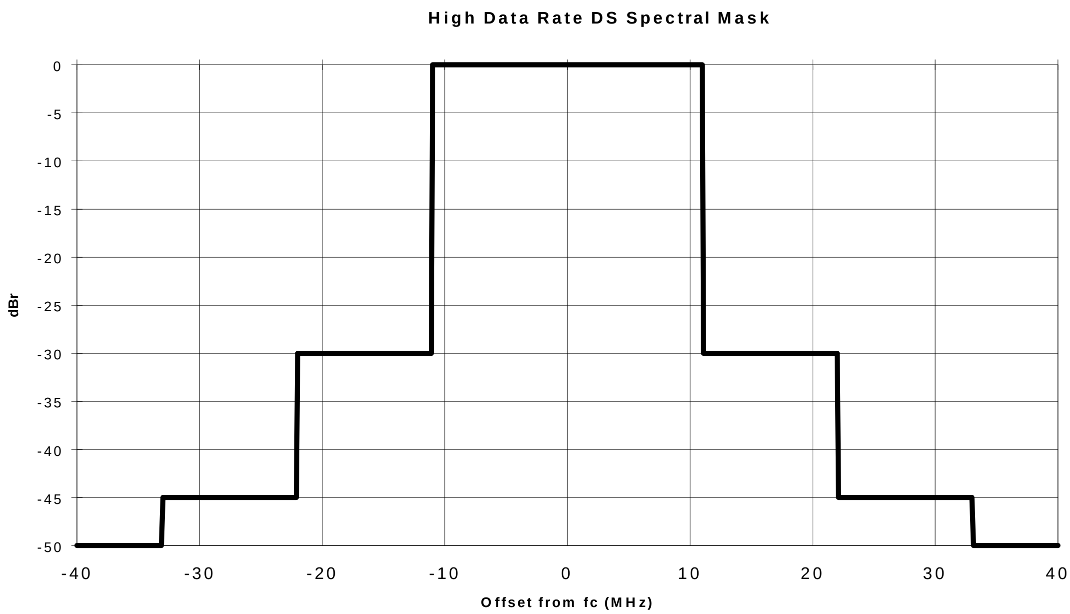


Figure 6 Transmit Spectrum Mask

1.4.7.5 Transmit Center Frequency Tolerance
The transmit center-frequency tolerance shall be ±10 ppm.

1.4.7.6 Chip Clock Frequency Tolerance
The chip-clock-frequency tolerance shall be ±10 ppm.

1.4.7.7 Transmit Power On and Power Down Ramp
The transmitter power-on and power-off, measured from 10%-to-90% and 90%-to-10% of steady-state power, respectively, shall not exceed 2 µs. The transmit power ramps must be consistent with the out-of-band emissions as specified in clause 1.4.6.5

1.4.7.8 RF Carrier Suppression
The RF carrier suppression, measured at the channel center frequency, shall be at least 10 dB below the peak of the power spectrum. The RF carrier suppression shall be measured while transmitting randomized data. The peak of the spectrum shall be referenced to 100-kHz resolution.

1.4.7.9 Transmit Modulation Accuracy
Transmit Modulation Accuracy shall be determined using the methods specified in clause 15.4.7.9, except Q channel samples shall be taken ½ chip delayed from the clock used to sample the I channel.

1.4.8 PMD Receiver Specifications

1.4.8.1 Receiver Minimum Input Level Sensitivity

1.4.8.1.1 6.875 Mb/s mode.
The frame error rate (FER) shall be less than $8x10^{-2}$ at an MPDU length of 1024 bytes for an input level of -83 dBm measured at the antenna connector (or equivalent specification, if antenna is built-in). This FER shall be exclusive of frame retransmission protocol(s).
1.4.8.1.2 11.00 Mb/s mode.

The frame error rate (FER) shall be less than $8x10^{-2}$ at an MPDU length of 1024 bytes for an input level of -80 dBm measured at the antenna connector (or equivalent specification, if antenna is built-in). This FER shall be exclusive of frame retransmission protocol(s).

1.4.8.2 Receiver Maximum Input Level

The frame error rate (FER) shall be less than $8x10^{-2}$ at an MPDU length of 1024 bytes for an input level of -4 dBm measured at the antenna connector (or equivalent specification, if antenna is built-in). This FER shall pertain to the 11-Mbps modulation, and shall be exclusive of frame retransmission protocol(s).

1.4.8.3 Receiver Adjacent Channel Rejection

Adjacent channel rejection is defined between two channels as specified in clause Number of Operating Frequency Channels. The adjacent-channel-rejection specification applies to a pair channels, of either data rate, separated by 25 MHz. The adjacent rejection shall be 35 dB, or greater, at a FER of $8x10^{-2}$.

1.4.6.6 Modulation and Channel Data Rates and an MPDU length of 1024 bytes. The adjacent channel rejection shall be measured as follows: The input signal shall use the 6.875 Mb/s or 11.00 Mb/s. at a level 6-dB greater than that specified in clause 1.4.8.1. Receiver Minimum Input Level Sensitivity for the data rate of that signal. The adjacent-channel signal shall use the same data rate as the desired signal at a level 41-dB greater than that specified in clause 1.4.8.1. Receiver Minimum Input Level Sensitivity for the data rate of that signal. The adjacent channel signal shall be derived from a separate signal source. The FER shall be no worse than $8x10^{-2}$.

1.4.8.4 Clear Channel Assessment

The high-rate DSSS PHY shall provide the capability to perform Clear channel Assessment (CCA) according to the following Carrier-Sense methods:

Mode 1 (required): DSSS under 802.11-18. CCA shall report a busy medium upon detecting the preamble portion of a DSSS transmission specified under 802.11-18, using the search code in effect within the BSA.

Mode 2 (optional): DSSS under 802.11-15. CCA shall report a busy medium upon detecting any portion of a 1- or 2-Mbps DSSS transmission using 11-Mchip/s PSK spreading and the Barker code specified in 802.11-15.

Mode 3 (optional): FH under 802.11-14. CCA shall report a busy medium upon detecting any portion of a 1- or 2-Mbps FHSS transmission using 1-symbol/s on center frequencies and with modulation specified in 802.11-14.

Modes 2 and 3, if implemented, must be maskable.

The CCA shall be TRUE if none of the un-masked modes indicates carrier sense condition. CCA operation is subject to the following criteria:

a) Carrier sense must occur for signals above the minimum receive signal level indicated in clause Receiver Minimum Input Level Sensitivity;

b) Carrier sense must occur within the CCA carrier-sense time of 10 μs after initiation of signal;

c) If an 802.11-18 PLCP Header is received, then the high-rate DSSS PHY shall hold the CCA signal inactive (channel busy) for the full duration as indicated by the PLCP LENGTH field, even if loss of carrier sense should occur before the end of reception;

d) If an optional (Mode 2 or Mode 3) carrier sense occurs, then the CCA signal inactive (channel busy) shall persist until the signal is no longer detectable.