

Updated New Text for Clause 15

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 Direct Sequence Spread Spectrum (DSSS) system. The Radio Frequency LAN system is initially aimed for the 2.4 GHz ISM band as provided in the USA according to Document FCC 15.247 and in Europe by ETS 300-328. Other countries have similar regulations.

The DSSS system provides a wireless LAN with both a 1 Mb/s and a 2 Mb/s data payload communication capability. According to the FCC regulations, the DSSS system shall provide a processing gain of at least 10 dB. This shall be accomplished by chipping the baseband signal at 11 MHz with an 11-chip PN code. The DSSS system uses baseband modulations of Differential Binary Phase Shift Keying (DBPSK) and Differential Quadrature Phase Shift Keying (DQPSK) to provide the 1 and 2 Mb/s data rates, respectively.

1.1.1 Scope

This clause describes the physical layer services provided to the 802.11 wireless LAN MAC by the 2.4 GHz Direct Sequence Spread Spectrum system. The DSSS PHY layer consists of two protocol functions:

- a) A physical layer convergence function which adapts the capabilities of the physical medium dependent system into the Physical Layer service. This function shall be supported by the Physical Layer Convergence Procedure (PLCP) which defines a method of mapping the 802.11 MAC layer Protocol Data Units (MPDU) into a framing format suitable for sending and receiving user data and management information between two or more stations using the associated physical medium dependent system.
- b) A Physical Medium Dependent (PMD) system whose function defines the characteristics and method of transmitting and receiving data via wireless media between two or more nodes.

Each physical medium dependent sublayer for the DSSS PMD may require the definition of a unique PLCP. If the PMD sublayer already provides the defined Physical Layer services, the physical layer convergence function might be null.

1.1.2 DSSS Physical Layer Functions

The 2.4 GHz DSSS PHY architecture is depicted in the reference model shown in **Error! Reference source not found.** The DSSS physical layer contains three functional entities: the physical medium dependent function, the physical layer convergence function, and the layer management function. Each of these functions is described in detail in the following subclauses.

The DSSS Physical Layer service shall be provided to the Media Access Control through the physical layer service primitives described in clause **Error! Reference source not found.**

1.1.2.1 Physical Layer Convergence Procedure Sublayer

In order to allow the 802.11 MAC to operate with minimum dependence on the PMD sublayer, a physical layer convergence sublayer is defined. This function simplifies the physical layer service interface to the 802.11 MAC services.

1.1.2.2 Physical Medium Dependent Sublayer

The physical medium dependent sublayer provides a means to send and receive data between two or more stations. This clause is concerned with the 2.4 GHz ISM bands using Direct Sequence modulation.

1.1.2.3 Physical Layer Management Entity (LME)

The Physical LME performs management of the local Physical Layer Functions in conjunction with the MAC Management entity.

1.1.3 Acronyms

CCA	Clear Channel Assessment
CRC	Cyclic Redundancy Check
DBPSK	Differential Binary Phase Shift Key
DQPSK	Differential Quadrature Phase Shift Key
DSSS	Direct Sequence Spread Spectrum
ED	Energy Detection
FCS	Frame Check Sequence
FER	Frame Error Rate
LME	Layer Management Entity
LSB	Least Significant Bit
MAC	Media Access Control
MIB	Management Information Base
MPDU	MAC Protocol Data Unit
MSB	Most Significant Bit
PHY_SAP	Physical Layer Service Access Point
PLCP	Physical Layer Convergence Procedure
PLME	PHY Layer Management Entity
PMD	Physical Medium Dependent
PMD_SAP	Physical Medium Dependent Service Access Point
PN	Pseudo Noise (PN code sequence)
PPDU	PHY Protocol Data Unit
RSSI	Received Signal Strength Indication
SAP	Service Access Point
SFD	Start Frame Delimiter
SQ	Signal Quality (PN code correlation strength)
TXE	Transmit Enable

1.1.4 Service Specification Method and Notation

The models represented by figures and state diagrams are intended to be illustrations of functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation, the actual method of implementation is left to the discretion of the 802.11 DSSS PHY compliant developer.

The service of a layer or sublayer is a set of capabilities that it offers to a user in the next higher layer (or sublayer). Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

1.2 DSSS Physical Layer Convergence Procedure Sublayer

1.2.1 Introduction

This clause provides a convergence procedure in which MPDUs are converted to and from PPDU. During transmission, the MPDU shall be prepended with a PLCP preamble and 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. The PLCP preamble contains the following fields: synchronization (SYNC) and Start Frame Delimiter (SFD). The PLCP header contains the following fields: 802.11 signaling (SIGNAL), 802.11 service (SERVICE), length (LENGTH), and CCITT CRC-16. Each of these fields are described in detail in clause 1.2.3.

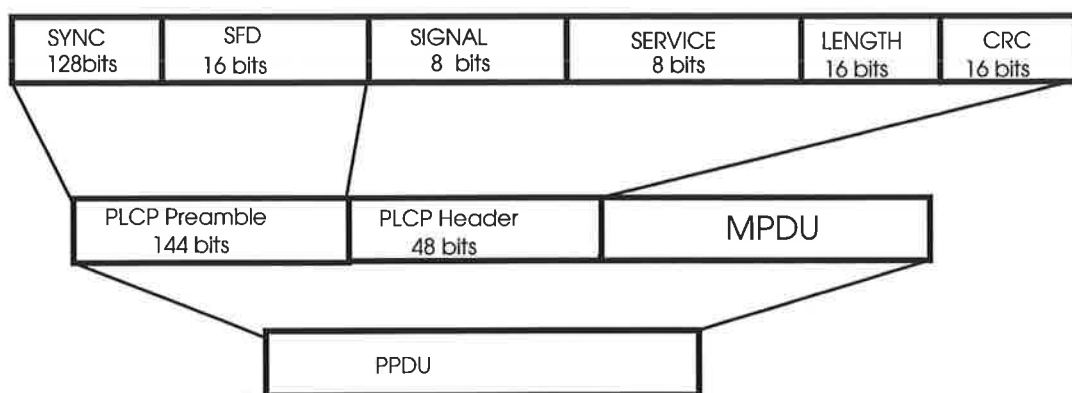


Figure 1, PLCP Frame Format

1.2.3 PLCP Field Definitions

The entire PLCP preamble and header shall be transmitted using the 1 Mb/s DBPSK modulation described in clause 1.4.7. All transmitted bits shall be scrambled using the feedthrough scrambler described in clause 1.2.4.

1.2.3.1 PLCP Synchronization (SYNC)

The synchronization field shall consist of 128 bits of scrambled 1 bits. This field shall be provided so that the receiver can perform the necessary operations for synchronization.

1.2.3.2 PLCP Start Frame Delimiter (SFD)

The Start Frame Delimiter shall be provided to indicate the start of PHY dependent parameters within the PLCP preamble. The SFD shall be a 16 bit field, hF3A0 (MSB to LSB). The LSB shall be transmitted first in time.

1.2.3.3 PLCP 802.11 Signal Field (SIGNAL)

The 8 bit 802.11 signal field indicates to the PHY the modulation which shall be used for transmission (and reception) of the MPDU. The data rate shall be equal to the Signal Field value multiplied by 100Kb/s. The DSSS PHY currently supports two mandatory modulation services given by the following 8 bit words, where the LSB shall be transmitted first in time:

- a) h0A (MSB to LSB) for 1 Mb/s DBPSK
- b) h14 (MSB to LSB) for 2 Mb/s DQPSK

The DSSS PHY rate change capability is described in clause 1.2.5. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause 1.2.3.6.

1.2.3.4 PLCP 802.11 Service Field (SERVICE)

The 8 bit 802.11 service field shall be reserved for future use. The value of h00 signifies 802.11 device compliance. The LSB shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause 1.2.3.6.

1.2.3.5 PLCP Length Field (LENGTH)

The PLCP length field shall be an unsigned 16 bit integer which indicates the number of microseconds ~~octets~~ (164 to $2^{16}-1$ ~~as defined by aMPDU_Max_Lngth~~) ~~required to be transmitted in the MPDU~~. The transmitted value shall be ~~determined from~~ provided by the LENGTH parameter in the TXVECTOR issued with the PHY_TXSTART.request primitive described in clause **Error! Reference source not found.** The length field provided in the TXVECTOR is in bytes and is converted to microseconds for inclusion in the PLCP LENGTH field. The LSB (least significant bit) shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause 1.2.3.6.

1.2.3.6 PLCP CRC Field (CCITT CRC-16)

The 802.11 SIGNAL, 802.11 SERVICE, and LENGTH fields shall be protected with a CCITT CRC-16 FCS (frame check sequence). The CCITT CRC-16 FCS shall be the ones complement of the remainder generated by the modulo 2 division of the protected PLCP fields by the polynomial:

$$x^{16} + x^{12} + x^5 + 1$$

The protected bits shall be processed in transmit order. All FCS calculations shall be made prior to data scrambling.

As an example, the SIGNAL, SERVICE, and LENGTH fields for a DBPSK signal with a packet length of 192 microseconds (32 bytes) would be given by the following:

0101 0000 0000 0000 0000 0011 0000 0000 (left most bit transmitted first in time)

The ones complement FCS for these protected PLCP preamble bits would be the following:

0101 1011 0101 0111 (left most bit transmitted first in time)

Figure 2 depicts this example.

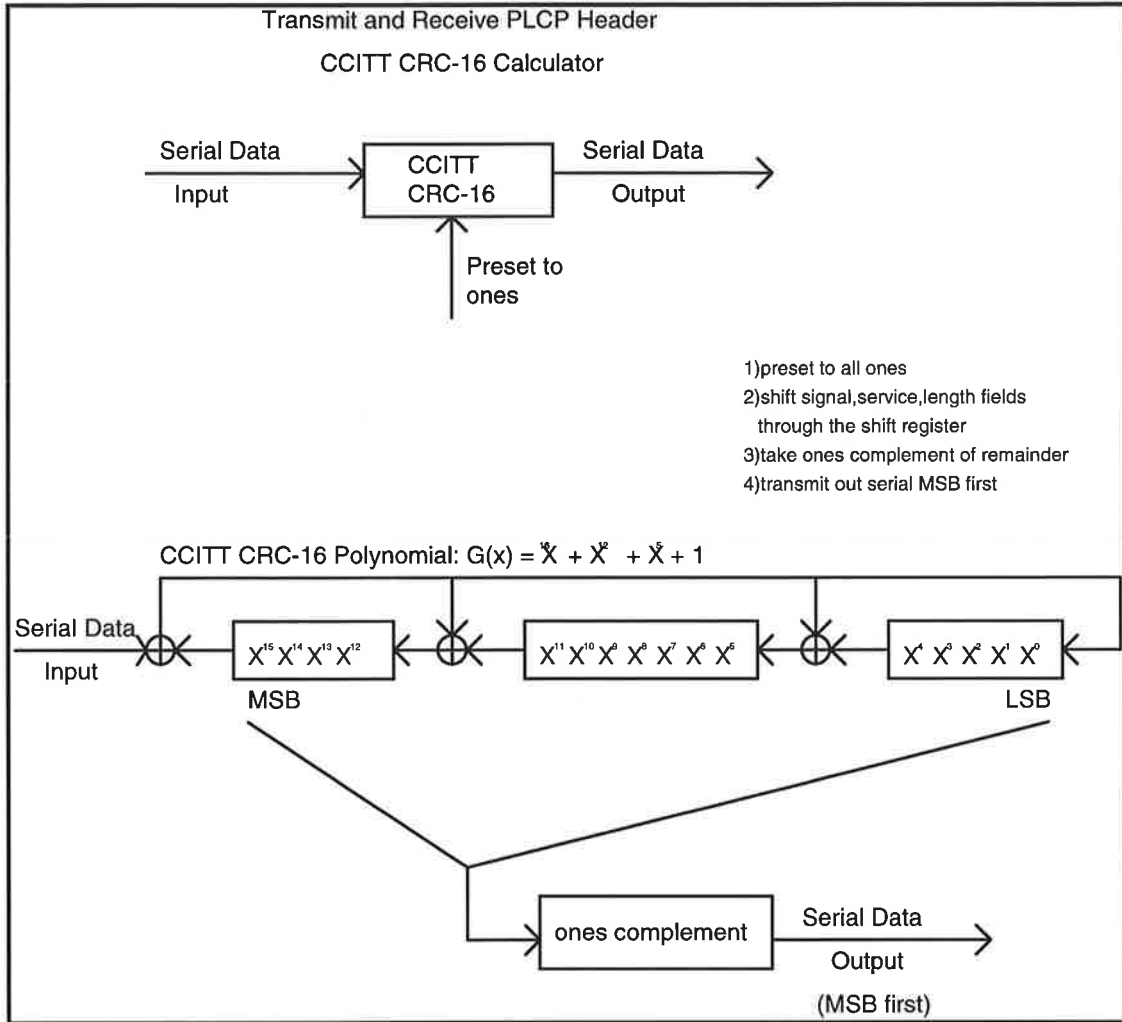


Figure 2, CCITT CRC-16 Implementation

An illustrative example of the CCITT CRC-16 FCS using the above information follows in Figure 3.

Data	CRC Registers	
	MSB	LSB
	1111111111111111	; Initialize Preset to 1's
0	1110111111011111	
1	1101111110111110	
0	1010111101011101	
1	0101111010111010	
0	1011110101110100	
0	0110101011001001	
0	1101010110010010	
0	101110110000101	
0	0110011000101011	
0	1100110001010110	
0	1000100010001101	
0	000000100111011	
0	000001001110110	
0	000010011101100	
0	000100111011000	
0	001001110110000	
0	010011101100000	
0	100111011000000	
0	0010101100100001	
0	0101011001000010	
0	1010110010000100	
1	0101100100001000	
1	1010001000110001	
0	0101010001000011	
0	1010100010000110	
0	0100000100101101	
0	1000001001011010	
0	0001010010010101	
0	0010100100101010	
0	0101001001010100	
0	1010010010101000	
	0101101101010111	; 1's Complement, Result = CRC FCS Parity

Figure 3, Example CRC Calculation

1.2.4 PLCP / DSSS PHY Data Scrambler and Descrambler

The polynomial $G(z) = z^{-7} + z^{-4} + 1$ shall be used to scramble ALL bits transmitted by the DSSS PHY. The feedthrough configuration of the scrambler shall be self synchronizing requiring no prior knowledge of the transmitter initialization of the scrambler shall be required for receive processing. Figure 4 and Figure 5 show typical implementations of the data scrambler and descrambler. Other implementations are possible.

The scrambler should be initialized to any state except all ones when transmitting.

Scrambler Polynomial; $G(z)=Z^{-7} +Z^{-4} +1$

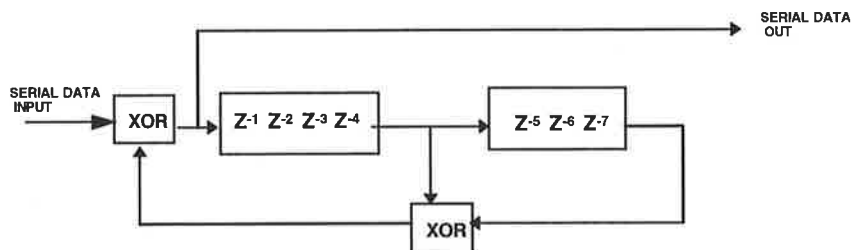


Figure 4, Data Scrambler

Descrambler Polynomial; $G(z)=Z^{-7}Z^{-4} +1$

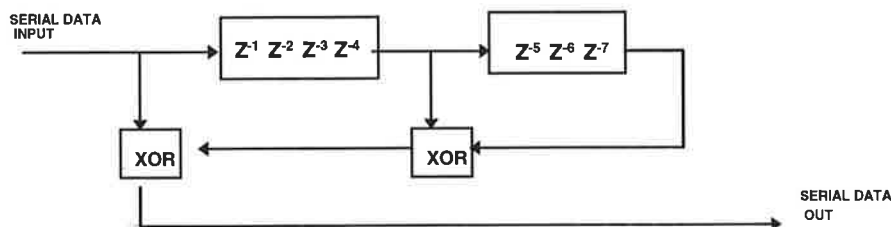


Figure 5, Data Descrambler

1.2.5 PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mb/s DBPSK modulation. The 802.11 SIGNAL field shall indicate the modulation which shall be used to transmit the MPDU. The transmitter and receiver shall initiate the modulation indicated by the 802.11 SIGNAL field starting with the first symbol (1bit for DBPSK or 2 bits for DQPSK) of the MPDU. The MPDU transmission rate shall be set by the SIGNAL parameter in the TXVECTOR issued with the PHY_TXSTART.request primitive described in clause **Error! Reference source not found.**

1.2.6 PLCP Transmit Procedure

The PLCP transmit procedure is shown in Figure 6.

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 CHNL_ID through Station Management via the PLME. Other transmit parameters such as RATE, TX antenna, and TX power are set via the PHY-SAP with the TXSTART.request(TXVECTOR) as described in clause **Error! Reference source not found.**

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 MPDU 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, 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 8 for 1 Mb/s and by 4 for 2 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. 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.

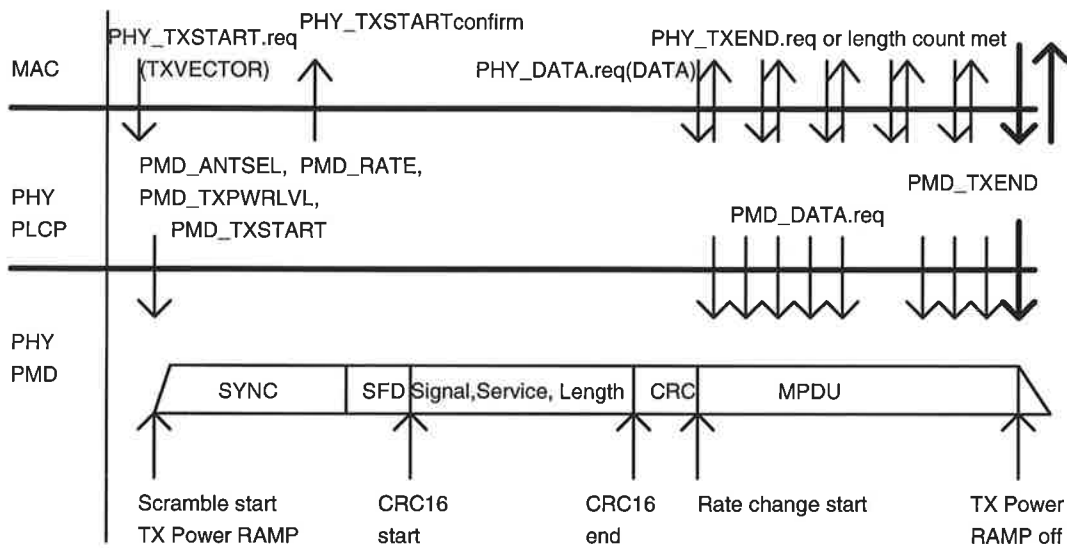


Figure 6, PLCP Transmit Procedure

A typical state machine implementation of the PLCP transmit procedure is provided in Figure 7.

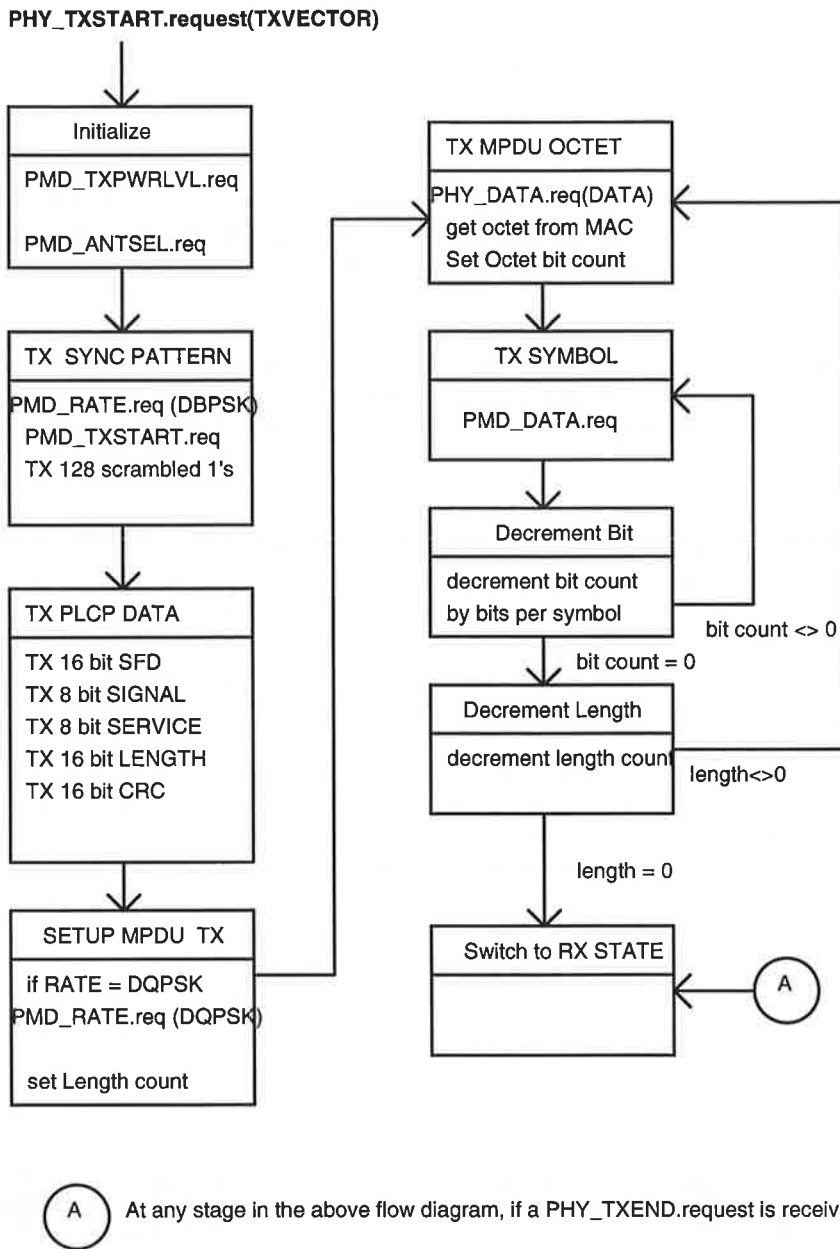


Figure 7, PLCP Transmit State Machine

1.2.7 PLCP Receive Procedure

The PLCP receive procedure is shown in Figure 8.

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 CHNL_ID and the CCA method is chosen. Other receive parameters such as RSSI, SQ (signal quality), and indicated RATE 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 9. 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)LENGTH field, the antenna used for receive, PHY_RSSI, and PHY_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 initiated with the first symbol of the MPDU 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 9. A PHY_RXEND.indicate(No_Error) primitive shall be issued. A PHY_CCA.indicate(IDLE) primitive shall be issued following a change in PHY_CS and/or PHY_ED according to the selected CCA method.

In the event that a change in PHY_CS or PHY_ED 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(carrier_lost) shall be reported to the MAC. The DSSS PHY shall ensure that the CCA shall 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 out of 802.11 DS specification, a PHY_RXSTART.indicate will not be issued. But the DSSS PHY shall ensure that the CCA shall indicate a busy medium for the intended duration of the transmitted packet. The intended duration is indicated by the LENGTH field (length * 1 microseconds). The PHY shall issue the error condition PHY_RXSTART.indicate(PLCP out of spec).

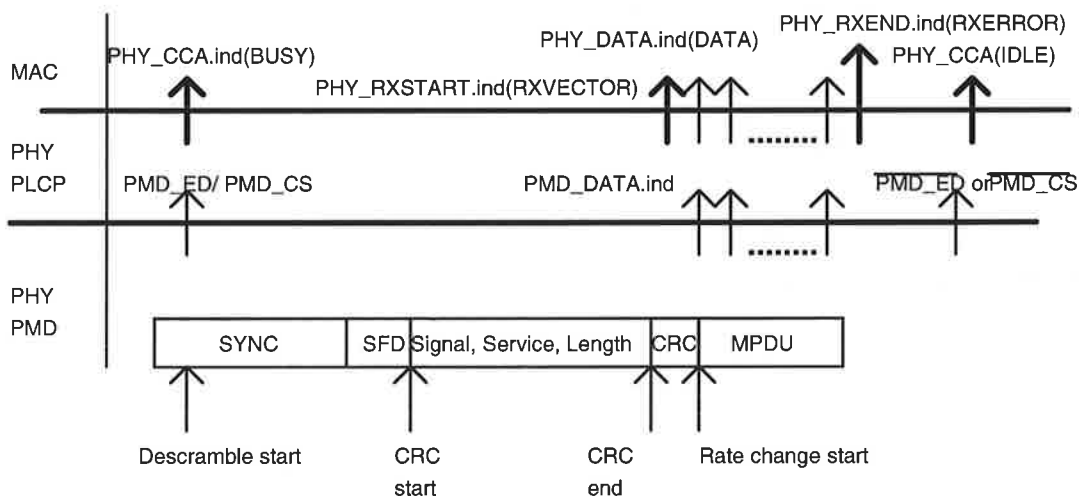


Figure 8, PLCP Receive Procedure

A typical state machine implementation of the PLCP receive procedure is provided in Figure 9.

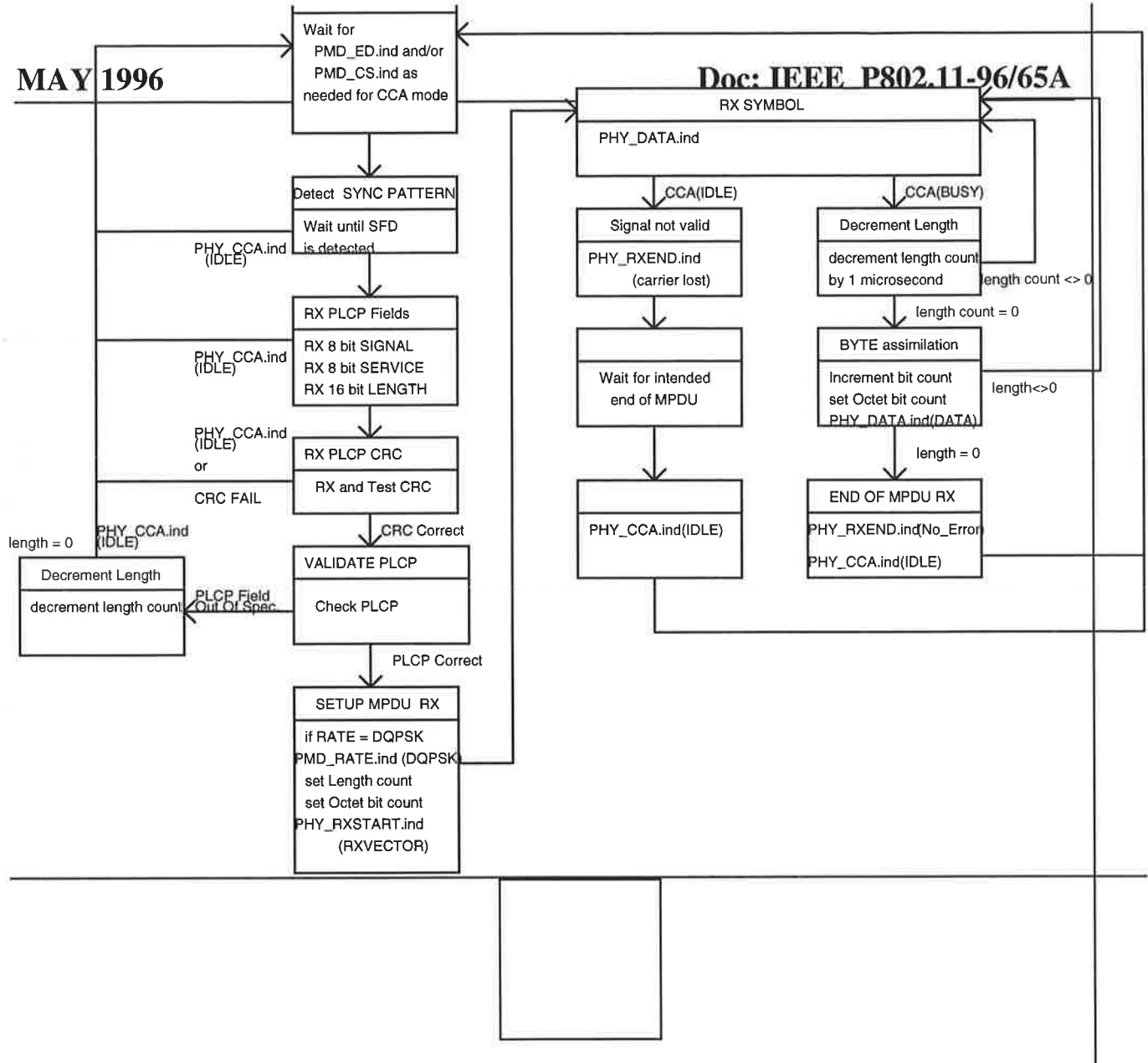


Figure 9, PLCP Receive State Machine

1.3 DSSS Physical Layer Management Entity (PLME)

1.3.1 PLME_SAP Sublayer Management primitives

Table 1 lists the primitives which may be sent between the PHY sublayer entities and intra layer of higher Layer Management Entities (LME).

Primitive	Request	Indicate	Confirm	Response
PLME_CCA_MODE	X			
PLME_CHNL_ID	X			
PLME_DIVERSITY	X			
PLME_DOZE	X			
PLME_RESET	X			
PLME_TEST_MODE	X			
PLME_TEST_OUTPUTRESET	X			

Table 1, PLME_SAP Sublayer Management Primitives

1.3.2 PLME_SAP Management Service Primitive Parameters

Table 2 shows the parameters used by the PLME_SAP primitives.

Parameter	Associated Primitive	Value
CCA_MODE	PLME_CCA_MODE.request	ED_Only, CS_Only, ED+CS
ED_THRESHOLD	PLME_CCA_MODE.request	ED Threshold if required for CCA operation
CHNL_ID	PLME_CHNL_ID.request	1-11 for FCC, 3-11 for ETSI, 12 for Japan
ANT_LIST	PLME_DIVERSITY.request	list of valid antennas to search
DIV_MODE	PLME_DIVERSITY.request	Enabled or Disabled
TEST_ENABLE	PLME_TEST_MODE.request	Enabled or Disabled
TEST_MODE	PLME_TEST_MODE.request	Continuous TX, Transparent RX, 50% TX/RX
SCRAMBLE STATE	PLME_TEST_MODE.request	Enabled or Disabled
SPREADING STATE	PLME_TEST_MODE.request	Enabled or Disabled
DATA_TYPE	PLME_TEST_MODE.request	Ones, Zeros, Revs
DATA RATE	PLME_TEST_MODE.request	1 Mbps or 2 Mbps
DIV_MODE TEST OUTPUT	PLME_TEST_OUTPUT.request PLME_DIVERSITY.request	Enabled or Disabled Enabled or Disabled

Table 2, PLME_SAP Primitive Parameters

1.3.3 PLME_SAP Detailed Service Specification

1.3.3.1 PLME_RESET.request

Function

This primitive shall be a request by the LME to reset the PHY. The PHY shall be always reset to the receive state to avoid accidental data transmission.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME_RESET.request

There are no parameters associated with this primitive.

When Generated

This primitive shall be generated at any time to reset the PHY.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to reset both the transmit and the receive state machines and place the PHY into the receive state.

1.3.3.2 PLME_CCA_MODE.request

Function

This primitive shall be a request by the LME to establish a particular CCA mode operation for the PHY.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME_CCA_MODE.request(CCA_MODE, ED_THRESHOLD)

CCA_MODE shall indicate one of three CCA operational modes of energy detect only, carrier sense only, or a combination of energy detect and carrier sense.

When Generated

This primitive shall be generated at any time to change the CCA mode used by the PHY.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to use the specified CCA_MODE with the ED Threshold set as appropriate for the mode of operation.

1.3.3.3 PLME_CHNL_ID.request

Function

This primitive shall be a request by the LME to set the operational frequency of the PHY.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME_CHNL_ID.request(CHNL_ID)

The CHNL_ID parameter shall be 1-11 for FCC, 3-11 for ETSI, or 12 for Japan.

When Generated

This primitive shall be generated at any time to alter the frequency of operation of the PHY.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to change the frequency of operation according to the CHNL_ID parameter.

1.3.3.4 PLME_DOZE.request

Function

This primitive shall be a request by the LME to place the PHY into the DOZE state.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME_DOZE.request

There are no parameters associated with this primitive.

When Generated

This primitive shall be generated at any time to place the PHY into the DOZE state.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to place itself into the DOZE state.

1.3.3.5 PLME_DIVERSITY.request

Function

This primitive shall be a request by the LME to enable or disable the PHY from using antenna diversity.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME_DIVERSITY.request(DIV_MODE,ANT_LIST)

DIV_MODE shall cause the diversity function to be enabled or disabled. ANT_LIST shall contain the antenna numbers which are valid to search.

When Generated

This primitive shall be generated at any time to change the operating mode of antenna diversity.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to change the operating state of the antenna diversity function according to the parameters DIV_MODE and ANT_LIST.

1.3.3.6 PLME TEST MODE.request

Function

This primitive shall be a request by the LME to establish a test mode operation for the PHY. The parameters associated with this primitive are considered as recommendations and are optional in any particular implementation.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME TEST MODE.request(TEST_ENABLE, TEST_MODE, SCRAMBLE_STATE, SPREADING_STATE, DATA_TYPE, DATA_RATE)

TEST_ENABLE enables and disables the PHY test mode according to the remaining parameters; TEST_MODE selects one of three operational states: transparent receive, continuous transmit, 50 percent duty cycle TX/RX; SCRAMBLE_STATE sets the operational state of the of the scrambler; SPREADING_STATE selects the operational state of the chipping; DATA_TYPE selects one of three data patterns to be used for the transmit portions of the tests; DATA_RATE selects between 1 and 2 Mbps operation.

When Generated

This primitive shall be generated at any time to enter the PHY test mode.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to enter the test mode of operation.

1.3.3.7 PLME TEST OUTPUT.request

Function

This optional primitive shall be a request by the LME to enable selected test signals from the PHY. The parameters associated with this primitive are considered as recommendations and are optional in any particular implementation.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME TEST OUTPUT.request(TEST_OUTPUT)

TEST_OUTPUT enables and disables selected signals for debugging and testing the PHY. Some signals which may be available for output are PHY_TXSTART.request, PHY_RXSTART.indicate(RXVECTOR), CCA_INDICATE.indicate, the chipping clock, the data clock, the symbol clock, TX data, RX data.

When Generated

This primitive shall be generated at any time to enable the test outputs when in the PHY test mode.

Effect of Receipt

Receipt of this primitive by the PHY sublayer shall cause the PHY entity to enabled the test outputs.

1.3.4 DSSS Physical Layer Management Information Base

All DSSS Physical Layer Management Information Base attributes are defined in clause **Error! Reference source not found.** with specific values defined in Table 3.

Managed Object	Default Value / Range	Operational Semantics
agPhyOperation_grp		
aPHY_Type	DSSS-2.4 (02)	Static
aTemp_Type	type1, type2 implementation dependent	Static
aReg_Domains_Suprt	implementation dependent	Static
aCurrent_Reg_Domain	implementation dependent	Static
aSlot_Time	20 μ s	Static
aCCA_Asmnt_Time	$\leq 15 \mu$ s	Static
aRxTx_Turnaround_Time	$\leq 5 \mu$ s	Static
aTx_PLCP_Delay	implementation dependent	Static
aRxTx_Switch_Time	$\leq 5 \mu$ s	Static
aTxRamp_On_Time	implementation dependent	Static
aTx_RF_Delay	implementation dependent	Static
aSIFS_Time	10 μ s	Static
aRx_RF_Delay	implementation dependent	Static
aRx_PLCP_Delay	implementation dependent	Static
aMAC_prc_Delay	not applicable	n/a
aTxRamp_Off_Time	implementation dependent	Static
aPreamble_Length	144 bits	Static
aPLCP_Header_Length	48 bits	Static
agPhyRate_grp		
aSuprt_Data_Rates	01,02	Static
aMPDU_Max_Lngth	$44 \leq x \leq (2^{13} - 1)$	Static
agPhyAntenna_grp		
aSuprt_Tx_Antennas	implementation dependent	Static
aCurrent_Tx_Antenna	implementation dependent	Dynamic
aSuprt_Rx_Antennas	implementation dependent	Static
aDiversity_Suprt	implementation dependent	Static
aDiversity_Slct_Rx	implementation dependent	Dynamic
agPhyTxPwr_grp		
aNbr_Suprtd_Pwr_Lvls	implementation dependent	Static
aTx_Pwr_Lvl1	implementation dependent	Static
aTx_Pwr_Lvl2	implementation dependent	Static

aTx_Pwr_Lvl3	implementation dependent	Static
aTx_Pwr_Lvl4	implementation dependent	Static
aTx_Pwr_Lvl5	implementation dependent	Static
aTx_Pwr_Lvl6	implementation dependent	Static
aTx_Pwr_Lvl7	implementation dependent	Static
aTx_Pwr_Lvl8	implementation dependent	Static
aCurrent_Tx_PwrLvl	implementation dependent	Dynamic
agPhyStatus_grp		
aSynthesizer_Locked	implementation dependent	Dynamic
agPhyDSSS_grp		
aCurrent_Channel	implementation dependent	Dynamic
aCCA_Mode_Suprt	implementation dependent	Static
aCurrent_CCA_Mode	implementation dependent	Dynamic
aED_Threshold	implementation dependent	Dynamic
agPowerSaving_grp		
aDoze_Turnon_Time	implementation dependent	Static
aCurrent_Power_State	implementation dependent	Dynamic

Table 3, MIB Variable Parameters

1.4 DSSS Physical Medium Dependent Sublayer

1.4.1 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 10.

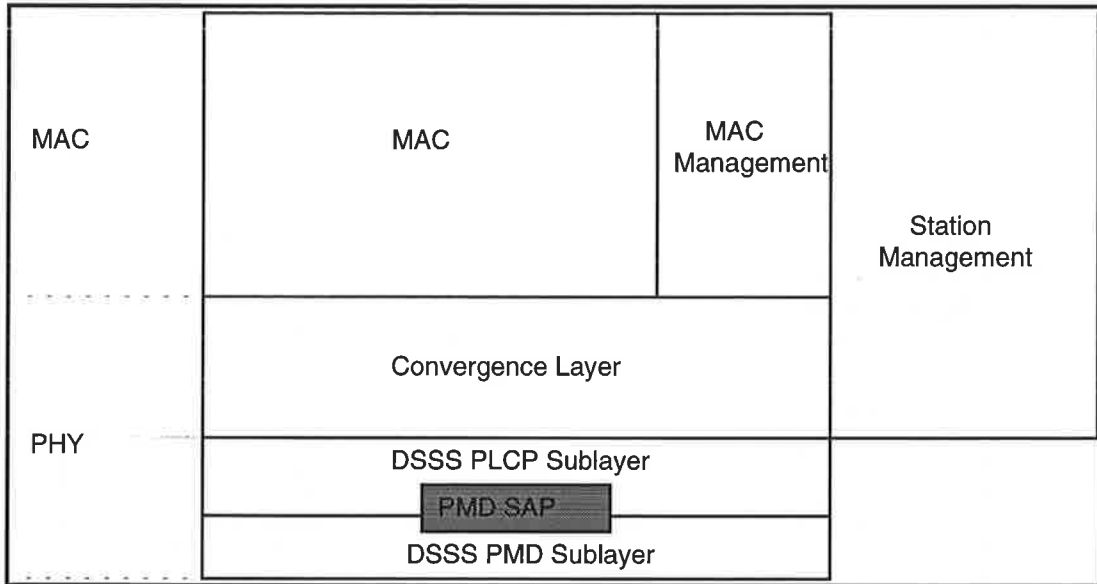


Figure 10, PMD Layer Reference Model

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 media. 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.

1.4.4.1 PMD_SAP Peer-to-Peer Service Primitives

Table 4 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 4, PMD_SAP Peer-to-Peer Service Primitives

1.4.4.2 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 4 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
SIGNAL	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 5, PMD_SAP Peer-to-Peer Service Primitives

1.4.4.3 PMD_SAP Sublayer-to-Sublayer Service Primitives

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

Table 6, PMD_SAP Sublayer-to-Sublayer Service Primitives

1.4.4.4 PMD_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
DATA	PHY_DATA.request PHY_DATA.indicate	octet value: 00-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
RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK
RF_STATE	PMD_TXE.request	Receive, Transmit

ANT_STATE	PMD_ANTSEL.indicate PMD_ANTSEL.request	1 to 256
DIV_CONTROL	PLME_DIVERSITY.request	On, Off
TXPWR_LEVEL	PHY_TXSTART	0,1,2,3 (max of 4 levels)
CHNL_ID	PLME_CHANNEL.request	1 to 12
RATE	PMD_RATE.indicate PMD_RATE.request	h0A for 1 Mb/s DBPSK h14 for 2 Mb/s DQPSK
RSSI	PMD_RSSI.indicate	0-8 bits of RSSI
SQ	PMD_SQ.indicate	0-8 bits of Signal Quality

Table 7, 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.

1.4.5.1 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. 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.

1.4.5.2 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. 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 pass the data to the MAC layer as part of the MPDU.

1.4.5.3 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.

1.4.5.4 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.

1.4.5.5 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 aSuprt_Rx_Antennas and aSuprt_Tx_Antennas.

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.

1.4.5.6 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.

1.4.5.7 PLME_DIVERSITY.request

Function

This primitive, generated by the PHY PLME sublayer, selects whether antenna diversity shall be enabled or disabled during reception.

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PLME_DIVERSITY.request(DIV_CONTROL)

DIV_CONTROL selects whether the diversity function shall be enabled or not.

When Generated

This primitive shall be generated by the PLCP sublayer to change the operating state of the receive state machine to select a specific antenna for reception or to allow diversity function.

Effect of Receipt

PLME_DIVERSITY immediately alters the receive state machine according to the DIV_CONTROL parameter.

1.4.5.8 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 NO_TXPWRLVLS. 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.

1.4.5.9 PLME_CHANNEL.request

Function

This primitive, generated by the PHY PLME sublayer, selects the channel frequency which shall be used by the DSSS PHY for transmission or reception.

Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME_CHANNEL.request(CHNL_ID)

CHNL_ID selects which of the DSSS PHY channel frequencies shall be used for transmission or reception. Clause 1.4.6.2 provides further information on the DSSS PHY channel plan.

When Generated

This primitive shall be generated by the PLME sublayer to change or set the current DSSS PHY channel.

Effect of Receipt

The receipt of PLME_CHANNEL immediately changes the operating channel as set by the CHNL_ID parameter.

1.4.5.10 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 PHY_RATE selects the rate which shall be used for all 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.

1.4.5.11 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.

1.4.5.12 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.

1.4.5.13 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.

1.4.5.14 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 PHY_CCA primitive. PMD_CS indicates a binary status of ENABLED or DISABLED. PMD_CS shall be ENABLED when the correlator signals 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 PHY is receiving 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 PHY_CCA indicator. This parameter shall indicate that the RF media 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.

1.4.5.15 PMD_ED.indicate

Function

This optional primitive, generated by the PMD, may 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 PHY_CCA 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 media 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.

1.4.5.16 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.

1.4.5.17 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 DS-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 media 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 DSSS Physical Medium Dependent sublayer. These specifications apply to both the receive and the transmit functions and general operation of a 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 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 Channels

For the 2.4 to 2.4835 GHz frequency band, 11 channels are specified. The channel center frequencies and CHNL_ID numbers shall be as shown in Table 8 for FCC (North America) and ETSI (Europe). For Japan, operation shall be specified as 2.471 to 2.497 GHz. CHNL_ID 12 shall be specified for operation in Japan. For the FCC domain all channels 1-11 shall be supported and for the ETSI domain channels 3-11 shall be supported.

CHNL_ID	FCC Channel Frequencies	ETSI Channel Frequencies	Japan Frequency
1	2412 MHz	N/A	N/A
2	2417 MHz	N/A	N/A
3	2422 MHz	2422 MHz	N/A
4	2427 MHz	2427 MHz	N/A
5	2432 MHz	2432 MHz	N/A
6	2437 MHz	2437 MHz	N/A
7	2442 MHz	2442 MHz	N/A
8	2447 MHz	2447 MHz	N/A
9	2452 MHz	2452 MHz	N/A
10	2457 MHz	2457 MHz	N/A
11	2462 MHz	2462 MHz	N/A
12	N/A	N/A	2484 MHz

Table 8, DSSS PHY Frequency Channel Plan

In a multiple cell network topology, overlapping and/or adjacent cells using different channels can operate simultaneously without interference if the distance between the center frequencies is at least 30 MHz. Channel 12 shall be designated specifically for operation in Japan.

1.4.6.3 Spreading Sequence

The following 11 chip Barker sequence shall be used as the PN code sequence:

+1, -1,+1,+1, -1,+1, +1, +1, -1, -1, -1

The left most chip shall be output first in time. The first chip shall be aligned at the start of a transmitted symbol. The symbol duration shall be exactly 11chips long.

1.4.6.4 Modulation and Channel Data Rates

Two modulation formats and data rates are specified for the DSSS PHY: a Basic Access Rate and an Enhanced Access Rate. The Basic Access Rate shall be based on 1 Mb/s DBPSK modulation. The DBPSK encoder is specified in Table 9. The Enhanced Access Rate shall be based on 2 Mb/s DQPSK. The DQPSK encoder is specified in Table 10. (In the tables, $+j\omega$ shall be defined as counterclockwise rotation.)

Bit Input	Phase Change ($+j\omega$)
0	0
1	π

Table 9, 1 Mb/s DBPSK Encoding Table

Dibit pattern (d0,d1) d0 is first in time	Phase Change ($+j\omega$)
00	0
01	$\pi/2$
11	π
10	$3\pi/2$ ($-\pi/2$)

Table 10, 2 Mb/s DQPSK Encoding Table

1.4.6.5 Transmit and Receive In Band and Out of Band Spurious Emissions

The 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, 15.205, and 15.209. For Europe, refer to ETS 300-328.

1.4.6.6 Transmit to Receive Turnaround Time

The TX to RX turnaround time shall be less than 10 μ s including the power down ramp specified in clause 1.4.7.7.

The TX to RX turnaround time shall be measured at the air interface from the trailing edge of the last transmitted symbol to valid CCA detection of incoming signal. The CCA should occur within 25 μ s (10 μ s for turnaround time plus 15 μ s for energy detect) or by the next slot boundary occurring after the 25 μ s has elapsed (refer to clause 1.4.8.4). A receiver input signal 3dB above the ED threshold described in clause 1.4.8.4 shall be present at the receiver.

1.4.6.7 Receive to Transmit Turnaround Time

The RX to TX turnaround time shall be measured at the MAC/PHY interface, using ~~PHY_TXSTART.request~~~~PHY_DATA.request~~(START OF DATA) and shall be less than or equal to 5 μ s. This includes the transmit power up ramp described in clause 1.4.7.7.

1.4.6.8 Slot Time

The slot time for the DSSS PHY shall be the sum of the RX to TX turnaround time (5 μ s) and the energy detect time (15 μ s specified in clause 1.4.8.4). The propagation delay shall be regarded to be included in the energy detect time.

1.4.6.9 Transmit and Receive Antenna Port Impedance

The transmit and receive antenna port(s) impedance shall be 50 Ω if the port is exposed.

1.4.6.10 Transmit and Receive Operating Temperature Range

Two temperature ranges for full operation compliance to the DSSS PHY are specified. Type 1 shall be defined as 0 $^{\circ}$ C to 40 $^{\circ}$ C is designated for office environments. Type 2 shall be defined as -30 $^{\circ}$ C to +70 $^{\circ}$ C and is designated for industrial environments.

1.4.7 PMD Transmit Specifications

The following clauses describe the transmit functions and parameters associated with the Physical Medium Dependent sublayer.

1.4.7.1 Transmit Power Levels

The maximum allowable output power as measured in accordance with practices specified by the regulatory bodies is shown in Table 11. In the USA, the radiated emissions should also conform with the ANSI uncontrolled radiation emission standards (ANSI/IEEE C95.1-1992 or IEEE C95.1-1991).

Maximum Output Power	Geographic Location	Compliance Document
1000 mW	USA	FCC 15.247
100 mW (EIRP)	EUROPE	ETS 300-328
10 mW/MHz	JAPAN	MPT ordinance 79

Table 11, Transmit Power Levels

1.4.7.2 Minimum Transmitted Power Level

The minimum transmitted 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. At a minimum, a radio capable of transmission greater than 100 mW shall be capable of switching power back to 100 mW or less.

1.4.7.4 Transmit Spectrum Mask

The transmitted spectral products shall be less than -30 dBr (dB relative to the SINx/x peak) for $f_c - 22 \text{ MHz} < f < f_c - 11 \text{ MHz}$ and $f_c + 11 \text{ MHz} < f < f_c + 22 \text{ MHz}$ and -50 dBr for $f < f_c - 22 \text{ MHz}$ and $f > f_c + 22 \text{ MHz}$ where f_c is the channel center frequency. The transmit spectral mask is shown in Figure 11. The measurements shall be made using 100 KHz resolution bandwidth and a 30 KHz video bandwidth.

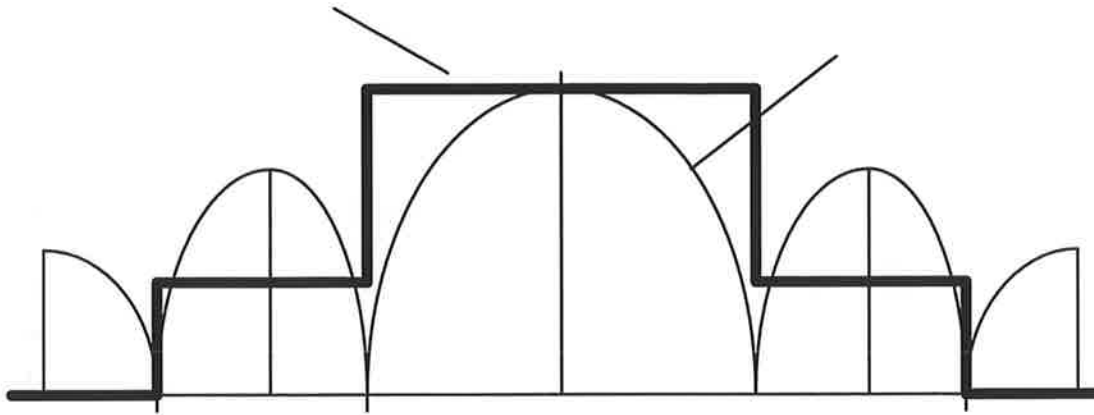


Figure 11, Transmit Spectrum Mask

1.4.7.5 Transmit Center Frequency Tolerance

The transmitted center frequency tolerance shall be ± 25 ppm maximum.

1.4.7.6 Chip Clock Frequency Tolerance

The PN code chip clock frequency tolerance shall be better than ± 25 ppm maximum.

1.4.7.7 Transmit Power On and Power Down Ramp

The transmit power on ramp for 10% to 90% of maximum power shall be no greater than $2 \mu\text{s}$. The transmit power on ramp is shown in Figure 12.

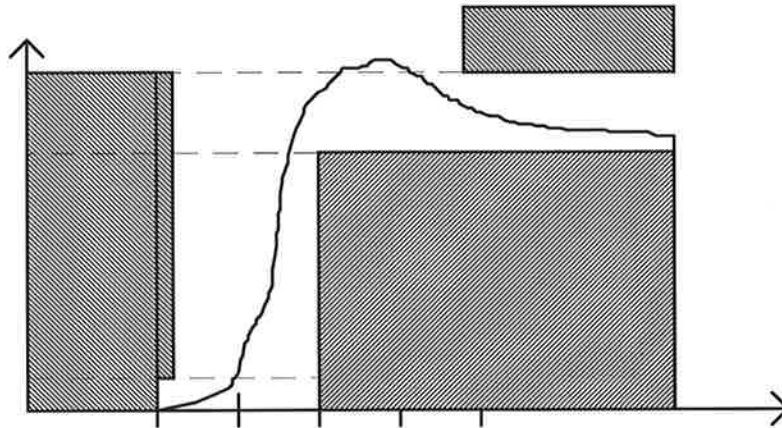


Figure 12, Transmit Power On Ramp

The transmit power down ramp for 90% to 10% maximum power shall be no greater than $2 \mu\text{s}$. The transmit power down ramp is shown in Figure 13.

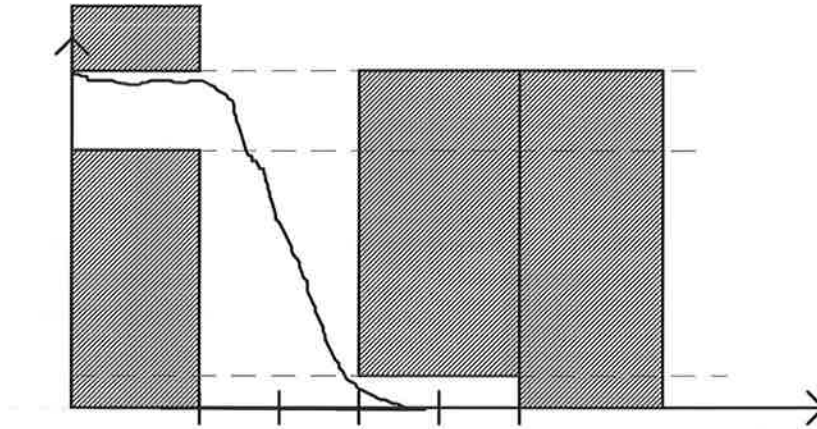


Figure 13, Transmit Power Down Ramp

The transmit power ramps shall be constructed such that the DSSS PHY emissions conform with spurious frequency product specification defined 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 15 dB below the peak $\text{SIN}(x)/x$ power spectrum. The RF carrier suppression shall be measured while transmitting a repetitive 01 data sequence with the scrambler disabled using DQPSK modulation. A 100 kHz resolution bandwidth shall be used to perform this measurement.

1.4.7.9 Transmit Modulation Accuracy

The transmit modulation accuracy requirement for the DSSS PHY shall be based on the difference between the actual transmitted waveform and the ideal signal waveform. Modulation accuracy shall be determined by measuring the peak vector error magnitude measured during each chip period. Worst case vector error magnitude shall not exceed 0.35 for the normalized sampled chip data. The ideal complex I and Q constellation points associated with DQPSK modulation $(0.707, 0.707)$, $(0.707, -0.707)$, $(-0.707, 0.707)$, $(-0.707, -0.707)$ shall be used as the reference. These measurements shall be from baseband I and Q sampled data after recovery through a reference receiver system.

Figure 14 illustrates the ideal DQPSK constellation points and range of worst case error specified for modulation accuracy.

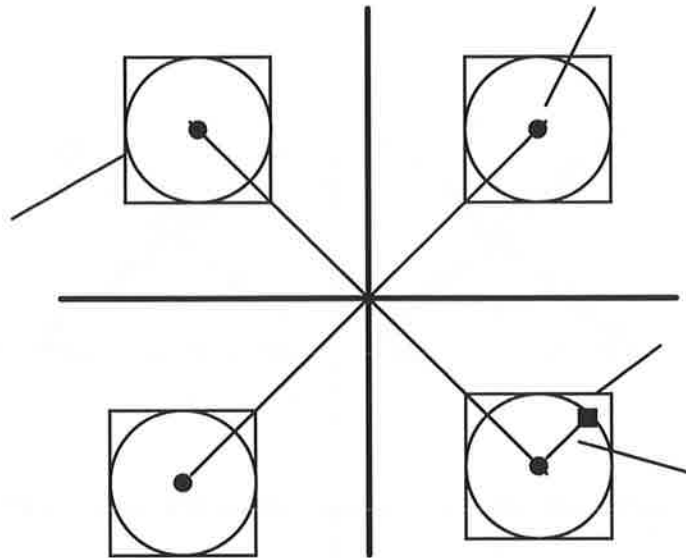


Figure 14, Modulation Accuracy Measurement Example

Error vector measurement requires a reference receiver capable of carrier lock. All measurements shall be made under carrier lock conditions. The distortion induced in the constellation by the reference receiver shall be calibrated and measured. The test data error vectors described below shall be corrected to compensate for the reference receiver distortion.

The 802.11 vendor compatible radio shall provide an exposed TX chip clock which shall be used to sample the I and Q outputs of the reference receiver.

The measurement shall be made under the conditions of continuous DQPSK transmission using scrambled all 1's.

The EYE pattern of the I channel shall be used to determine the I and Q sampling point. The chip clock provided by the vendor radio shall be time delayed such that the samples fall at a 1/2 chip period offset from the mean of the zero crossing positions of the EYE (see Figure 15 below). This is the ideal center of the EYE and may not be the point of maximum EYE OPENING.

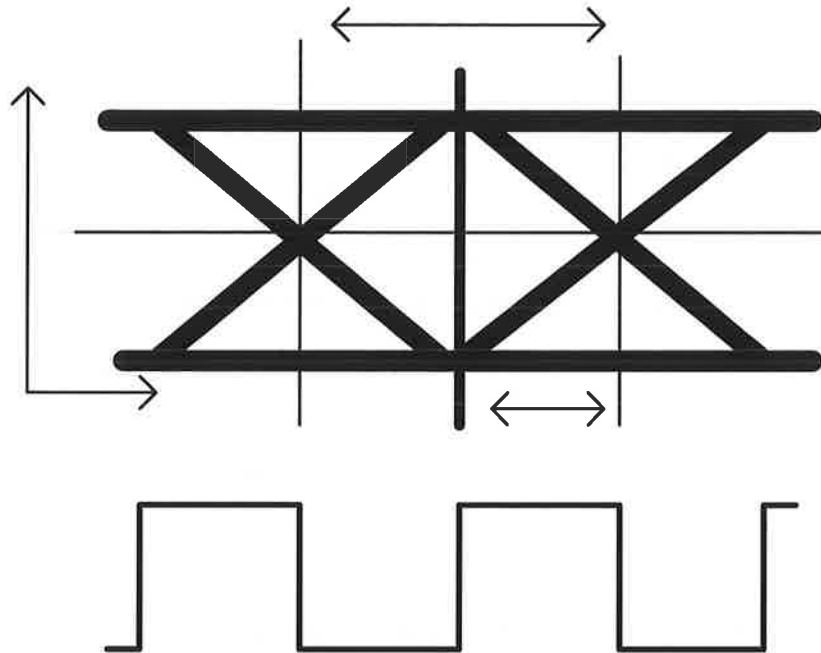


Figure 15, Chip Clock Alignment with Baseband Eye Pattern

Using the aligned chip clock, 1000 samples of the I and Q baseband outputs from the reference receiver are captured. The vector error magnitudes shall be calculated as follows:

Calculate the DC offsets for I and Q samples.

$$I_{\text{mean}} = \sum_{n=0}^{1000} I(n)/1000$$

$$Q_{\text{mean}} = \sum_{n=0}^{1000} Q(n)/1000$$

Calculate the DC corrected I and Q samples for all N = 1000 sample pairs.

$$I_{\text{DC}}(n) = I(n) - I_{\text{mean}}$$

$$Q_{\text{DC}}(n) = Q(n) - Q_{\text{mean}}$$

Calculate the average magnitude of I and Q samples.

$$I_{\text{mag}} = \sum_{n=0}^{1000} |I_{\text{DC}}(n)|/1000$$

$$Q_{\text{mag}} = \sum_{n=0}^{1000} |Q_{\text{DC}}(n)|/1000$$

Calculate the normalized error vector magnitude for the $I_{\text{DC}}(n)/Q_{\text{DC}}(n)$ pairs.

$$V_{\text{ERR}}(n) = \text{sqrt}[1/2 \times ((|I_{\text{DC}}(n)|/ I_{\text{mag}})^2 + (|Q_{\text{DC}}(n)|/ Q_{\text{mag}})^2)] - V_{\text{CORRECTION}}$$

with $V_{\text{CORRECTION}}$ = error induced by the reference receiver system.

A vendor DSSS PHY implementation shall be compliant if for all N = 1000 samples the following condition is met:

$$V_{ERR(n)} < 0.35$$

1.4.8 PMD Receiver Specifications

The following clauses describe the receive functions and parameters associated with the Physical Medium Dependent sublayer.

1.4.8.1 Receiver Minimum Input Level Sensitivity

The Frame Error Rate (FER) shall be less than 8×10^{-2} at an MPDUFrame length of 1024 bytes for an input level of -80 dBm measured at the antenna connector. This FER shall be specified for 2 Mb/s DQPSK modulation. The test for the minimum input level sensitivity shall be conducted with the energy detection threshold set less than or equal to -80 dBm.

1.4.8.2 Receiver Maximum Input Level

The receiver shall provide a maximum FER of 8×10^{-2} at an MPDU length of 1024 bytes for a maximum input level of -4 dBm measured at the antenna. This FER shall be specified for 2 Mb/s DQPSK modulation.

1.4.8.3 Receiver Adjacent Channel Rejection

Adjacent channel rejection is defined between the two channels in each channel group defined in clause 1.4.6.2.

The adjacent channel rejection shall be equal to or better than 35 dB with a FER of 8×10^{-2} using 2 Mb/s DQPSK modulation described in clause 1.4.6.4 and an MPDU length of 1024 bytes.

The adjacent channel rejection shall be measured using the following method:

Input a 2 Mb/s DQPSK modulated signal at a level 6 dB greater than specified in clause 1.4.8.1. In an adjacent channel (greater than 30 MHz separation as defined by the channel numbering), input a signal modulated in a similar fashion which adheres to the transmit mask specified in clause 1.4.7.4 to a level 41 dB above the level specified in clause 1.4.8.1. The adjacent channel signal shall be derived from a separate signal source. It cannot be a frequency shifted version of the reference channel. Under these conditions, the FER shall be no worse than 8×10^{-2} .

1.4.8.4 Clear Channel Assessment

The DSSS PHY shall provide the capability to perform Clear Channel Assessment (CCA) according to at least one of the following three methods:

CCA Mode 1: Energy above threshold. CCA shall report a busy medium upon detecting any energy above the ED threshold.

CCA Mode 2: Carrier sense only. CCA shall report a busy medium only upon the detection of a DSSS signal. This signal may be above or below the ED threshold.

CCA Mode 3: Carrier sense with energy above threshold. CCA shall report a busy medium upon the detection of a DSSS signal with energy above the ED threshold.

The energy detection status shall be given by the PMD primitive, PMD_ED. The carrier sense status shall be given by PMD_CS. The status of PMD_ED and PMD_CS are used in the PLCP convergence procedure to indicate activity to the MAC through the PHY interface primitive PHY_CCA.indicate.

A Busy channel shall be indicated by PHY_CCA.indicate of class BUSY.

Clear Channel shall be indicated by PHY_CCA.indicate of class IDLE.

The PHY MIB attribute aCCA_Mode_Suprt shall indicate the appropriate operation modes. The PHY shall be configured through the PHY MIB attribute aCurrent_CCA_Mode.

The CCA shall be TRUE if there is no energy detect or carrier sense. The CCA parameters are subject to the following criteria:

- a) The energy detection threshold shall be less than or equal to -80 dBm for TX power > 100 mW, -76 dBm for 50 mW < TX power <= 100 mW, and -70 dBm for TX power <= 50 mW.
- b) With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 μ s from a slot boundary, the CCA indicator shall report channel busy before the end of the slot time. This implies that the CCA signal is available as an exposed test point.
- c) In the event that a correct PLCP Header is received, the DSSS PHY shall hold the CCA signal inactive (channel busy) for the full duration as indicated by the PLCP LENGTH field. Should a loss of carrier sense occur in the middle of reception, the CCA shall indicate a busy medium for the intended duration of the transmitted packet.

Conformance to DSSS PHY CCA shall be demonstrated by applying a DSSS compliant signal, above the appropriate ED threshold (a), such that all conditions described in (b) and (c) above are demonstrated.