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## Proposed Text Changes for Clause 12

### **1. 2.4 GHz ISM Band Direct Sequence Spread Spectrum Physical Layer Specification**

#### **1.1. Introduction**

This section 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 must provide a processing gain of at least 10 dB. This is accomplished by chipping the baseband signal at 11 MHz with an 11-chip Barker sequence. 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.

~~Key characteristics resulting from spreading of DSSS systems are the low radiated power per spectral band, robustness against interference, processing gain, and insensitiveness to multipath effects of the channel.~~

##### **1.1.1. Scope**

This section 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 is 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 shown in Figure 12-1. 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 subsections.

The DSSS Physical Layer service is provided to the Media Access Control through the physical layer service primitives described in Section 9.

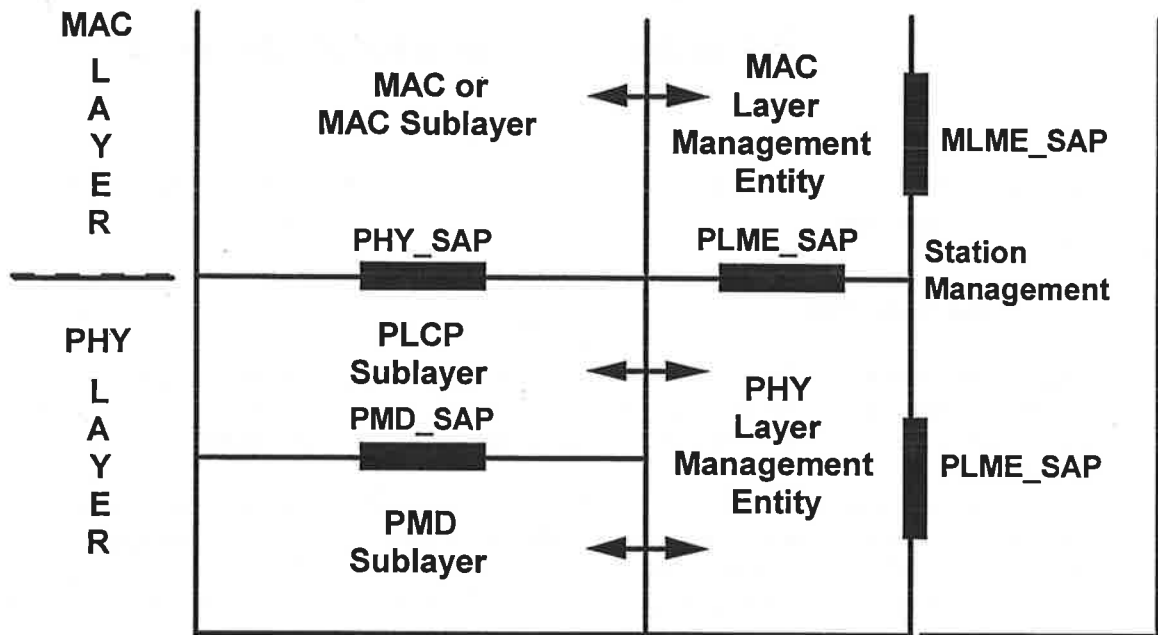


Figure 12-1: Protocol Reference Model

#### 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 section 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 section provides a convergence procedure in which MPDUs are converted to and from PPDU. During transmission, the MPDU is 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 12-2 shows the format for the PPDU including the PLCP preamble, the 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 shall be described in detail in section 12.2.3.

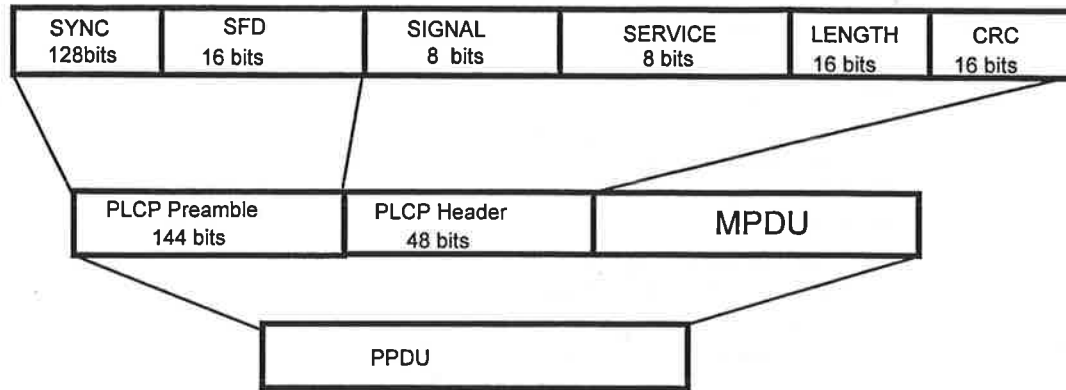


Figure 12-2: PLCP Frame Format

### 1.2.3. PLCP Field Definitions

The entire PLCP preamble and header shall be transmitted using the 1 Mb/s DBPSK modulation described in section 12.4.7. All transmitted bits shall be scrambled using the feedthrough scrambler described in section 12.2.4.

#### 1.2.3.1. PLCP Synchronization (SYNC)

The synchronization field shall consist of 128 bits of scrambled 1 bits. This field is 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 is provided to indicate the start of PHY dependent parameters within the PLCP preamble. The SFD is 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 will be used for transmission (and reception) of the MPDU. The data rate is 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 is 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 section 12.2.5. This field is protected by the CCITT CRC-16 frame check sequence described in section 12.2.3.6.

#### 1.2.3.4. PLCP 802.11 Service Field (SERVICE)

The 8 bit 802.11 service field is reserved for future use. The value of h00 signifies 802.11 device compliance. The LSB shall be transmitted first in time. This field is protected by the CCITT CRC-16 frame check sequence described in section 12.2.3.6.

**1.2.3.5. PLCP Length Field (LENGTH)**

The PLCP length field is an unsigned 16 bit integer which indicates the number of octets (4 to  $2^{16}$  as defined by aMPDU\_Max\_Lngth\_1M or aMPDU\_Max\_Lngth\_2M~~maximum~~ [per 10.1.1.24.23]) to be transmitted in the MPDU. The transmitted value is provided by the LENGTH parameter in the TXVECTOR issued with the PHY\_TXSTARTDATA.request primitive described in section 9. The LSB (least significant bit) shall transmitted first in time. This field is protected by the CCITT CRC-16 frame check sequence described in section 12.2.3.6.

**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 is 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 will 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 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 12-3 depicts this example.

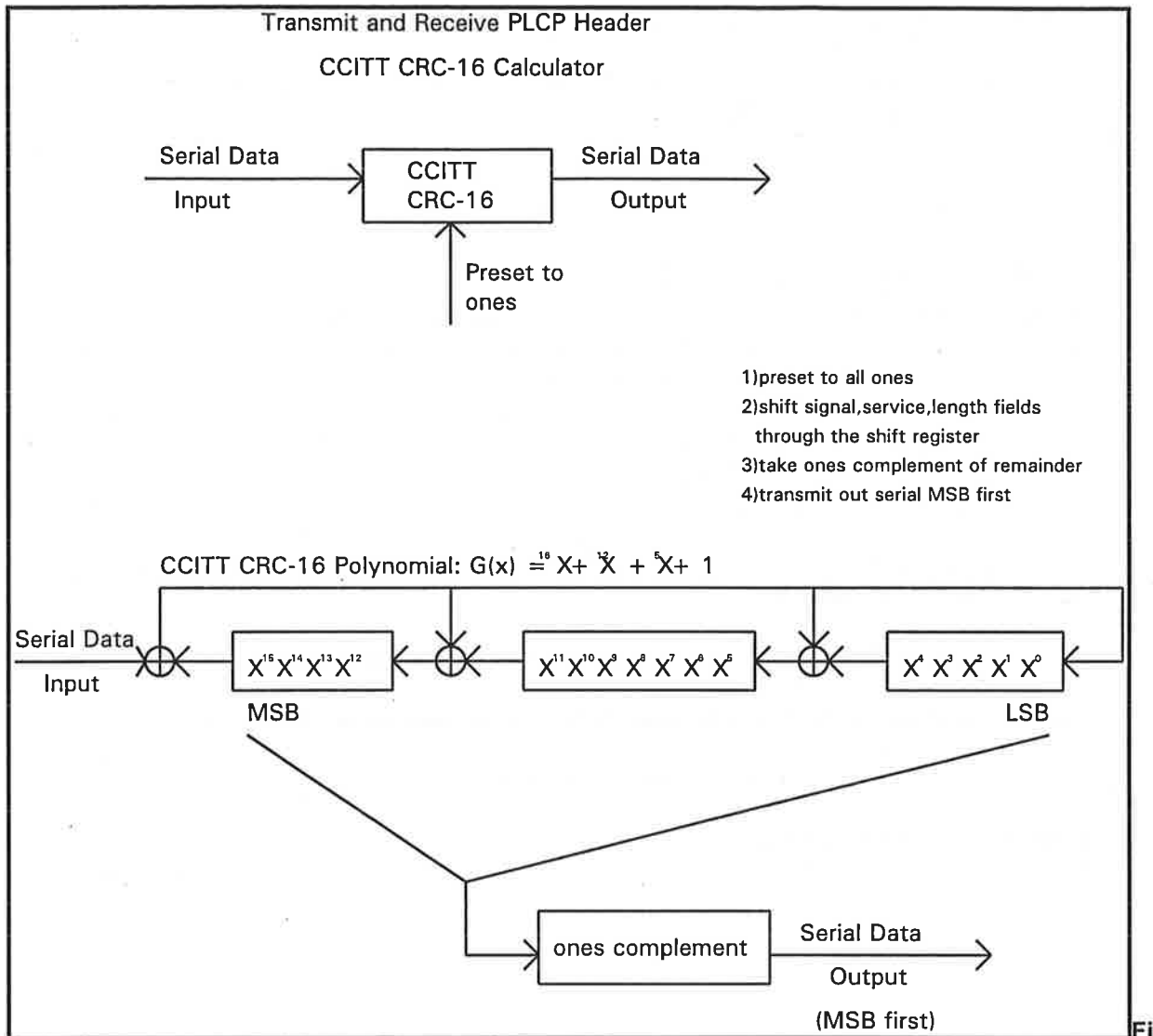


Figure 12-3: CCITT CRC-16 implementation

An illustrative example of the CCITT CRC-16 FCS using the above information follows:

Data	CRC Registers	
	MSB	LSB
	1111111111111111	; Initialize Preset to 1's
0	1110111110111111	
1	1101111110111110	
0	10101111101011101	
1	0101111010111010	
0	1011110101110100	
0	0110101011001001	
0	1101010110010010	
0	1011101100000101	
0	0110011000101011	

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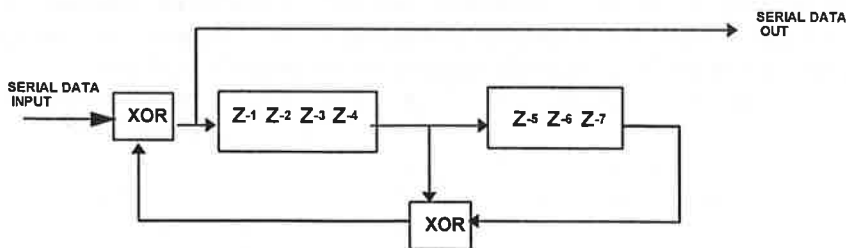
0      1100110001010110
0      1000100010001101
0      0000000100111011
0      0000001001110110
0      0000010011101100
0      0000100111011000
0      0001001110110000
0      0010011101100000
0      0010011101100000
0      0100111011000000
0      0100111011000000
0      1001110110000000
0      0010101100100001
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
    
```

**1.2.4. PLCP / DS 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 is self initializing. No prior initialization of the scrambler is required for receive processing. Figures 12-3 and 12-4 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 12-3: Data Scrambler**

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

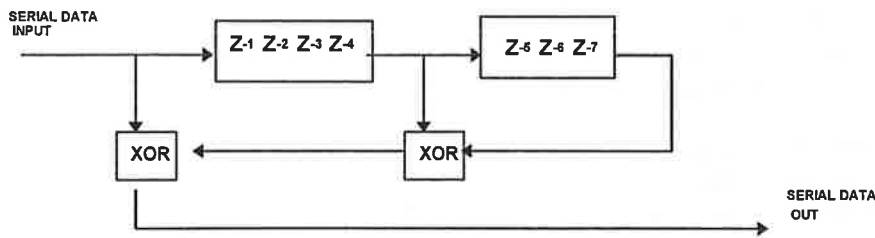


Figure 12-4: Data Descrambler

### 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 will indicate the modulation which will be used to transmit the MPDU. The transmitter and receiver will initiate the modulation indicated by the 802.11 SIGNAL field starting with the first symbol (1 bit for DBPSK or 2 bits for DQPSK) of the MPDU. The MPDU transmission rate is set by the SIGNALRATE parameter in the TXVECTOR issued with the PHY\_TXSTART.request primitive described in section 9, PHY\_DATA.request primitive.

### 1.2.6. PLCP Transmit Procedure

The PLCP transmit procedure is shown in Figure 12-5.

In order to transmit data, PHY\_TXSTART.request must be enabled so that the PHY entity is in the transmit state. Further, the PHY must 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.

Based on the status of CCA indicated by PHY\_CCA.indicate, the MAC will assess that the channel is clear. A clear channel is indicated by PHY\_CCADATA.indicate(IDLEEND-OF-ACTIVITY). If the channel is clear, transmission of the MPDU is initiated by issuing the PHY\_TXSTARTDATA.request (TXVECTORSTART-OF-ACTIVITY) primitive. The TXVECTOR elements for the PHY\_TXSTARTDATA.request(START-OF-ACTIVITY) are the PLCP header parameters SIGNAL, SERVICE and LENGTH and the PMD parameters of ANT\_STATE, CHNL\_ID, and TXPWR\_LEVEL.

The PLCP will issue PHY\_ANTSEL, PHY\_RATE, PHY\_CHANNEL, and PHY\_TXPWRLVL primitives to configure the PHY. The PLCP will then issue a PHY\_TXSTART.request and the PHY entity will immediately initiate data scrambling and transmission of the PLCP preamble based on the parameters passed in the PHY\_TXSTARTDATA.request primitive. The time required for TX power on ramp described in section 12.4.7 is included in the PLCP synchronization field. Once the PLCP preamble transmission is completed, data is exchanged between the MAC and the PHY by a series of PHY\_DATA.request(DATA-octet) primitives issued by the MAC. The modulation rate change, if any, is initiated with the first data symbol of the MPDU as described in section 12.2.5. 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 PHY\_DATA.request primitives. Transmission can be prematurely is terminated by the MAC through the primitive PHY\_TXENDDATA.request(END-OF-DATA). PHY\_TXSTART is disabled by with the end-of-activity and the issuance of the PHY\_TXEND.request. Normal The termination occurs after the transmission of the final bit of the last MPDU octet according to. The number of octets transmitted must equal the number supplied in the DSSS PHY preamble LENGTH field. The packet transmission is completed and the PHY entity enters the receive state (i.e. PHY\_TXSTART is disabled). It is recommended that chipping continue during power down.



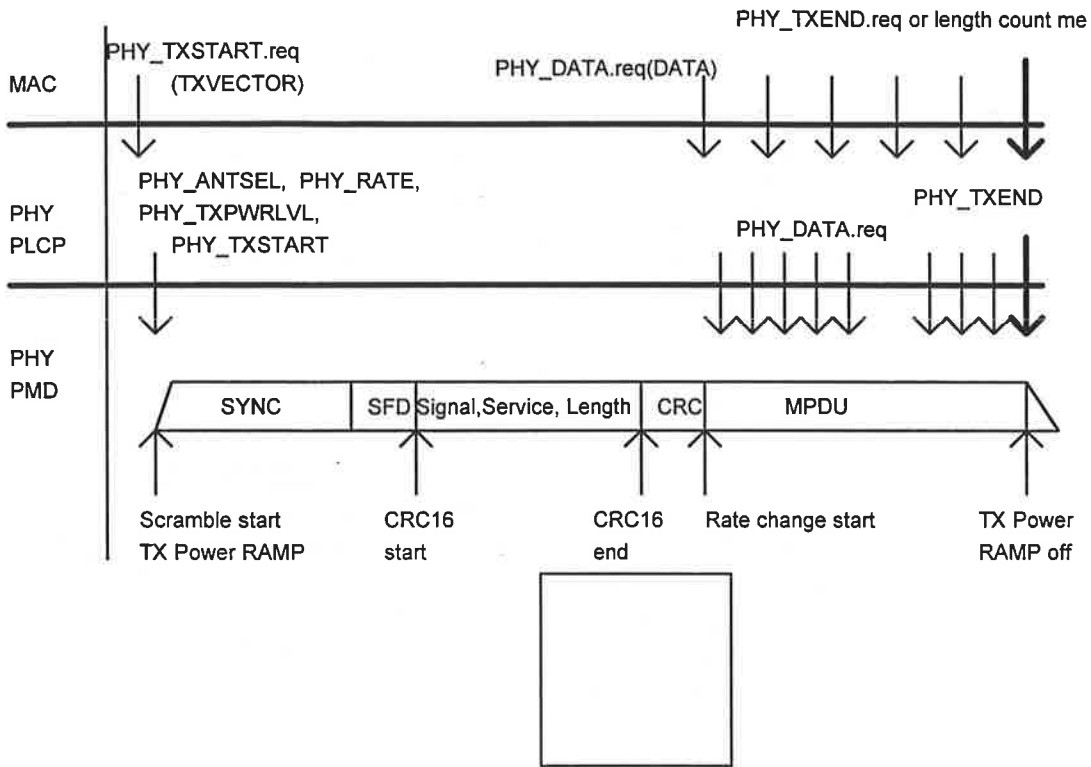


Figure 12-5: PLCP Transmit Procedure

4.2.6.1. Transmit State Machine

A typical state machine implementation of the PLCP transmit procedure is provided in Figure 12-6.

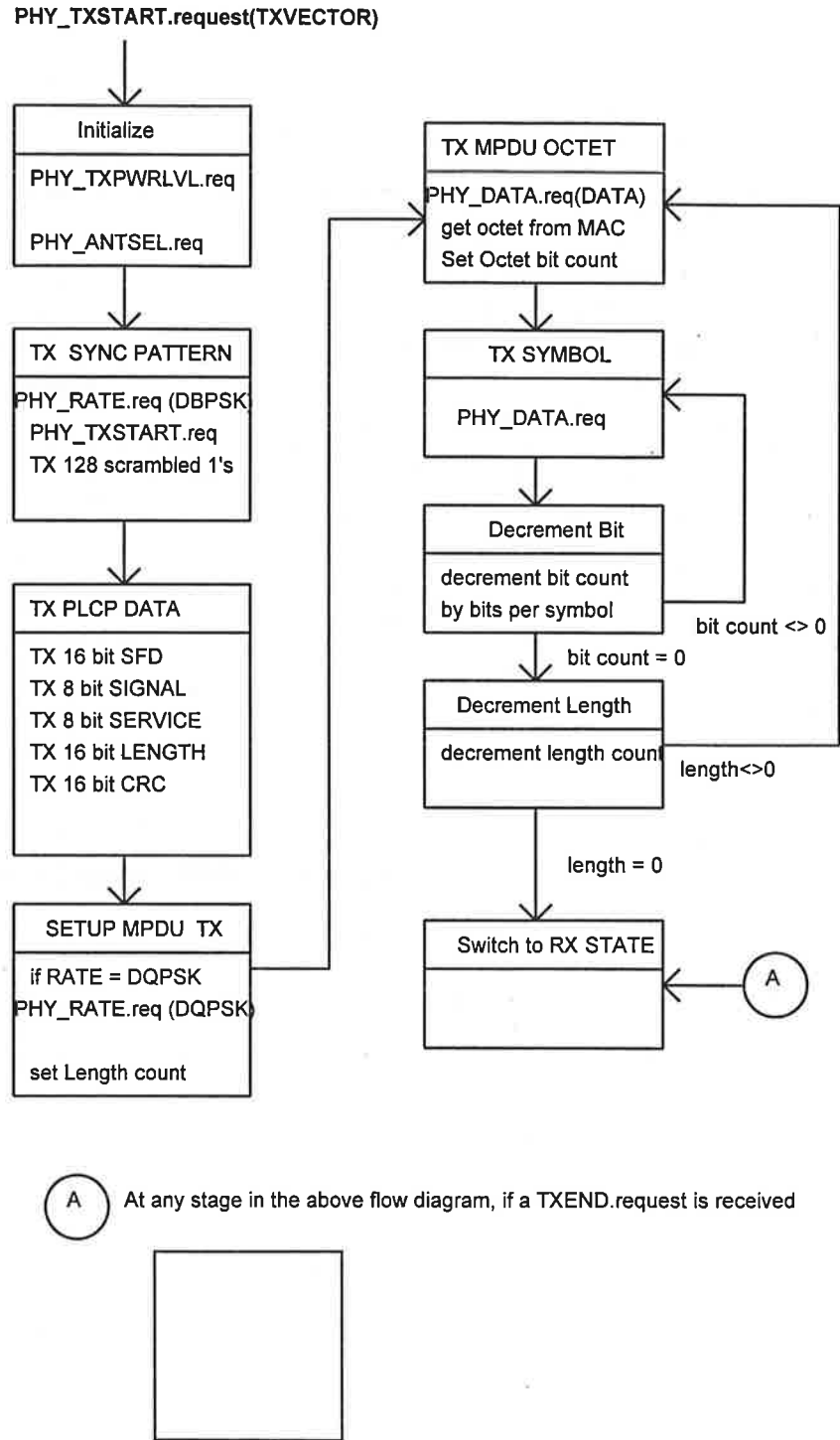


Figure 12-6: PLCP Transmit State Machine

1.2.7. PLCP Receive Procedure

The PLCP receive procedure is shown in Figure 12-7.

In order to receive data, PHY\_TXSTART\_request must be disabled so that the PHY entity is in the receive state. Further, ~~the PHY must be set to operate at the appropriate CHNL\_ID through Station Management via the PLME,~~ the PHY is set to the appropriate CHNL\_ID and the CCA method is chosen Layer Management Service Access Point (LMSAP). Other receive parameters such as RSSI, SQ (signal quality), and indicated RATE may also be accessed via the PHY-SAP/LMSAP.

Upon receiving the transmitted energy, according to the selected CCA mode, the PHY\_ED will be enabled (according to section 12.4.8.4) as the RSSI strength reaches the ED\_THRESHOLD and/or PHY\_CS will be enabled after code lock is established. ~~If the transmitted energy is associated with a DSSS PHY PLCP and if the PHY entity acquires PN code lock based on the SQ\_THRESHOLD, then PHY\_CS will be enabled. Based on the CCA (see section 12.4.8.4) these conditions are~~ can be used to indicate activity to the MAC via PHY\_CCA.indicate according to section 12.4.8.4. PHY\_CCA-DATA.indicate(BUSYSTART\_OF\_ACTIVITY) is issued for energy detection or code lock prior to correct reception of the PLCP frame. The PMD primitives PHY\_SQ and PHY\_RSSI are issued to update the- RSSI and SQ parameters reported to the MAC.

~~After PHY\_CCA.indicate is issued, the PHY entity begins searching for the SFD field. Once the SFD field is detected, CCITT CRC-16 processing is initiated and the PLCP 802.11 SIGNAL, 802.11 SERVICE, and LENGTH fields are received. The CCITT CRC-16 FCS will be processed. If the CCITT CRC-16 FCS check fails, the PHY receiver will return to the RX Idle state as depicted in Figure 12-8. Should the status of CCA return to the IDLE state code lock be lost during reception prior to completion of the full PLCPMPDU processing, the PHY receiver will return to the RX Idle state, as indicated by the LENGTH field, the PLCP will issue a PHY-DATA.indicate(~~ After PHY\_CCA.indicate is issued, the PHY entity begins searching for the SFD field. Once the SFD field is detected, CCITT CRC-16 processing is initiated and the PLCP 802.11 SIGNAL, 802.11 SERVICE, and LENGTH fields are received. The CCITT CRC-16 FCS will be processed. If the CCITT CRC-16 FCS check fails, the PHY receiver will return to the RX Idle state as depicted in Figure 12-8. Should the status of CCA return to the IDLE state code lock be lost during reception prior to completion of the full PLCPMPDU processing, the PHY receiver will return to the RX Idle state, as indicated by the LENGTH field, the PLCP will issue a PHY- DATA.indicate( ~~END\_OF\_DATA, carrier\_lost).~~

If the PLCP ~~header/preamble~~ reception is successful, a PHY\_RXSTARTDATA.indicate(RXVECTORSTART\_OF\_DATA) will be issued. The RXVECTOR associated with this primitive includes the SIGNAL field, the SERVICE field, the 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, octet) primitive exchanges. The rate change indicated in the 802.11 SIGNAL field is initiated with the first symbol of the MPDU as described in section 12.2.5. 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 is returned to the ~~RX~~ Idle state as shown in Figure 12-8. A PHY\_RXENDDATA.indicate( ~~END\_OF\_DATA, No\_Error)~~ primitive is issued. A PHY\_CCADATA.indicate( ~~IDLEEND\_OF\_ACTIVITY)~~ primitive is 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, ~~Should code lock / synchronization be lost prior to the end of the MPDU as indicated in the PLCP LENGTH field,~~ the error condition PHY\_RXENDDATA.indicate( ~~END\_OF\_DATA, carrier\_lost)~~ will be reported to the MAC. The DSSS PHY shall ensure that the CCA will indicate a busy medium for the intended duration of the transmitted packet.

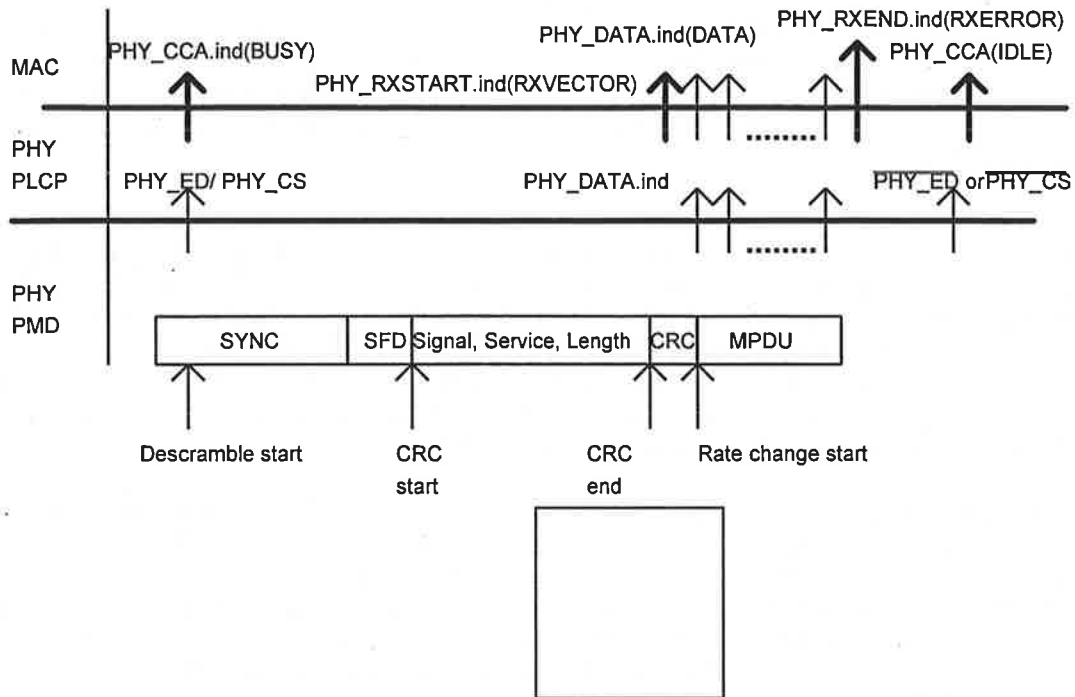


Figure 12-7: PLCP Receive Procedure

4.2.7.1. Receive State Machine

A typical state machine implementation of the PLCP ~~receive~~<sup>transmit</sup> procedure is provided in Figure 12-8.

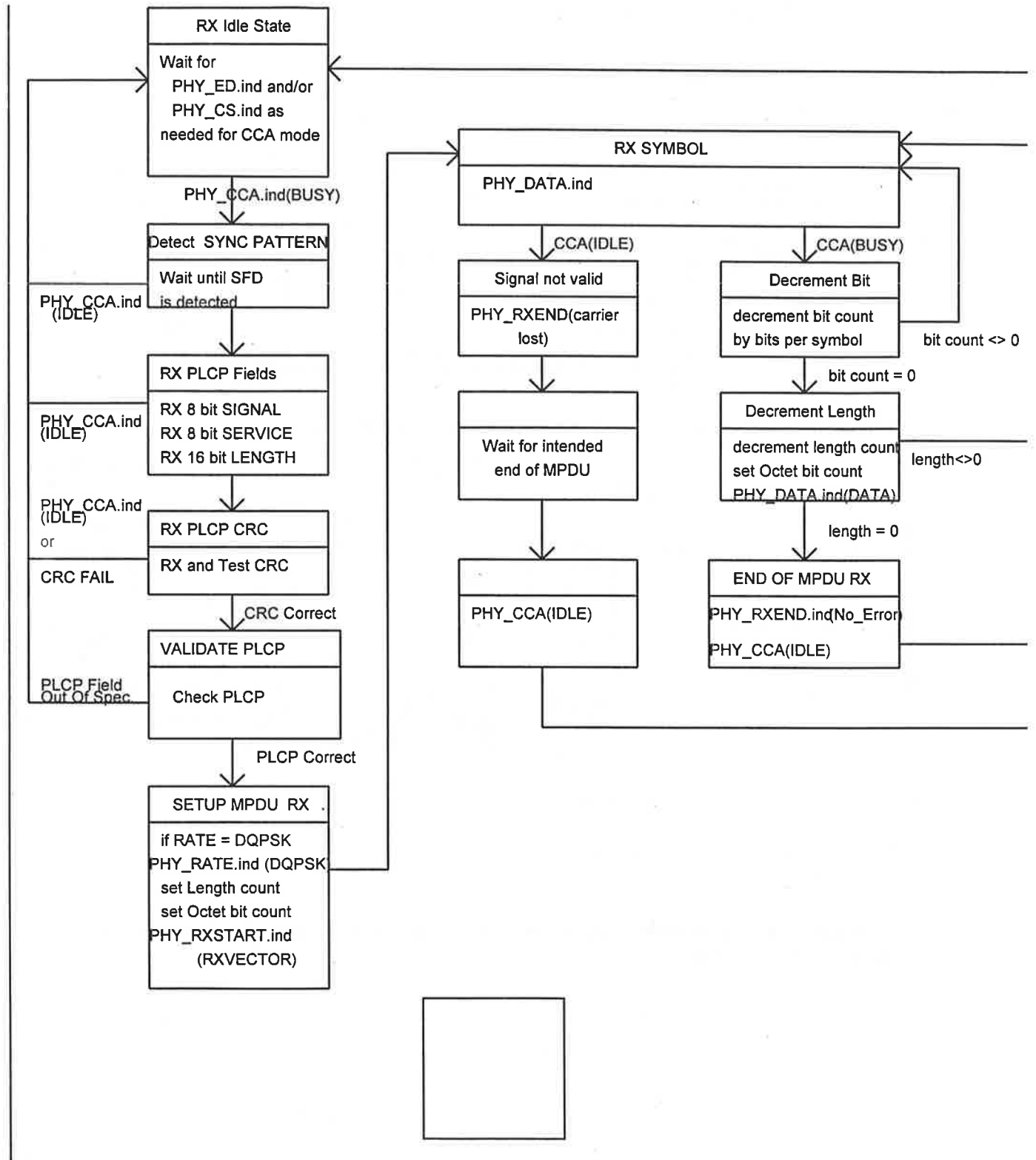


Figure 12-8: PLCP Receive State Machine

### 1.3. DSSS Physical Layer Management Entity (PLME)

#### 1.3.1. PLME\_SAP Sublayer Management primitives

The following message may be sent between the PHY sublayer entities and intra layer of higher Layer Management Entities (LME).

Primitive	Request	Indicate	Confirm	Response
<u>PLME_CCA_MODE</u>	X			
<u>PLME_CHNL_ID</u>	X			
<u>PLME_DIVERSITY</u>	X			
<u>PLME_DOZE</u>	X			
<u>PLME_SLEEP</u>	X			
<u>PLME_RESET</u>	X		✗	

Table 12-1: PLME\_SAP Sublayer Management Primitives

#### 1.3.2. PLME\_SAP Management Service Primitive Parameters

There are currently no parameters associated with the PLME\_SAP service primitives. Table 12-2 shows the parameters used by the PLME\_SAP primitives.

Parameter	Associated Primitive	Value
<u>CCA_MODE</u>	<u>PLME_CCA_MODE.request</u>	<u>ED Only, CS Only, ED+CS</u>
<u>ED_THRESHOLD</u>	<u>PLME_CCA_MODE.request</u>	<u>ED Threshold if required for CCA operation</u>
<u>CHNL_ID</u>	<u>PLME_CHNL_ID.request</u>	<u>1-11 for FCC, 3-11 for ETSI, 12 for Japan</u>
<u>ANT_LIST</u>	<u>PLME_DIVERSITY.request</u>	<u>list of valid antennas to search</u>
<u>DIV_MODE</u>	<u>PLME_DIVERSITY.request</u>	<u>Enabled or Disabled</u>

Table 12-2: PLME\_SAP Primitive Parameters

#### 1.3.3. PLME\_SAP Detailed Service Specification

##### 1.3.3.1. PLME\_RESET.request

###### Function

This primitive is a request by the LME to reset the PHY. The PHY is 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 is generated at any time to reset the PHY.

**Effect of Receipt**

Receipt of this primitive by the PHY sublayer will 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 is 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 is generated at any time to change the CCA mode used by the PHY.

**Effect of Receipt**

Receipt of this primitive by the PHY sublayer will 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 is 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 will be 1-11 for FCC, 3-11 for ETSI, or 12 for Japan.

**When Generated**

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

**Effect of Receipt**

Receipt of this primitive by the PHY sublayer will 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 is 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 is generated at any time to place the PHY into the DOZE state.

##### Effect of Receipt

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

#### **1.3.3.5. PLME\_SLEEP.request**

##### Function

This primitive is a request by the LME to place the PHY into a SLEEP state.

##### Semantics of the Service Primitive

The primitive shall provide the following parameters:

PLME\_SLEEP.request

There are no parameters associated with this primitive.

##### When Generated

This primitive is generated at any time to place the PHY into the SLEEP state.

##### Effect of Receipt

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



**1.3.3.6. PLME\_DIVERSITY.request****Function**

This primitive is 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 will cause the diversity function to be enabled or disabled. ANT\_LIST will contain the antenna numbers which are valid to search.

**When Generated**

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

**Effect of Receipt**

Receipt of this primitive by the PHY sublayer will cause the PHY entity to change the operating state of the antenna diversity function according to the parameters DIV\_MODE and ANT\_LIST.

**1.3.3.7. PLME\_RESET.confirm****Function**

This primitive is a confirmation of request by the LME to reset the PHY.

**Semantics of the Service Primitive**

The primitive shall provide the following parameters:

PLME\_RESET.confirm

There are no parameters associated with this primitive.

**When Generated**

This primitive is generated as a response to the PLME\_RESET.request once the PHY has successfully completed the reset.

**Effect of Receipt**

The effect of the receipt of this primitive by the LME is unspecified.

**1.3.4. DSSS Physical Layer Management Information Base**

All DSSS Physical Layer Management Information Base variables are defined in Section 10 with specific values defined in Table 12-32.

Managed Object	Default Value / Range	Operational Semantics
<b>agPhyOperation_grp</b>		
aPHY_Type	DSSS-2.4 (02)	Static
aReg_Domains_Suprt	implementation dependent	Static
aCurrent_Reg_Domain	implementation dependent	Static
aSlot_Time	20 usec	Static
aCCA_Asmnt_Time	≤ 15 usec	Static
aRxTx_Turnaround_Time	≤ 5 usec	Static
aTx_PLCP_Delay	implementation dependent	Static
aRxTx_Switch_Time	≤ 5 usec	Static
aTxRamp_On_Time	implementation dependent	Static
aTx_RF_Delay	implementation dependent	Static
aSIFS_Time	10 usec	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
<b>agPhyRate_grp</b>		
aSuprt_Data_Rates	00,01,02	Static
aMPDU_Max_Lngth_1M	$4 \leq x \leq (2^{16} - 1)$	Static
aMPDU_Max_Lngth_2M	$4 \leq x \leq (2^{16} - 1)$	Static
<b>agPhyAntenna_grp</b>		
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
<b>agPhyTxPwr_grp</b>		
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
<b>agPhyStatus_grp</b>		
aSynthesizer_Locked	implementation dependent not applicable	Dynamic/n/a
<b>agPhyDSSS_grp</b>		

aRadio_Type	type1, type2 implementation dependent	Static
aCurrent_Channel	implementation dependent	Dynamic
aCCA_Mode_Suprt	implementation dependent	Static
aCurrent_CCA_Mode	implementation dependent	Dynamic
aED_Threshold	implementation dependent	Dynamic
<b>agPowerSaving_grp</b>		
aSleep_Turnon_Time	implementation dependent	Static
aDoze_Turnon_Time	implementation dependent	Static

Table 12-32: MIB Variable Parameters

### 1.4. DSSS Physical Medium Dependent Sublayer

#### 1.4.1. Scope and Field of Application

This section describes the PMD services provided to the PLCP for the DSSS Physical Layer. Also defined in this section 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 12-9.

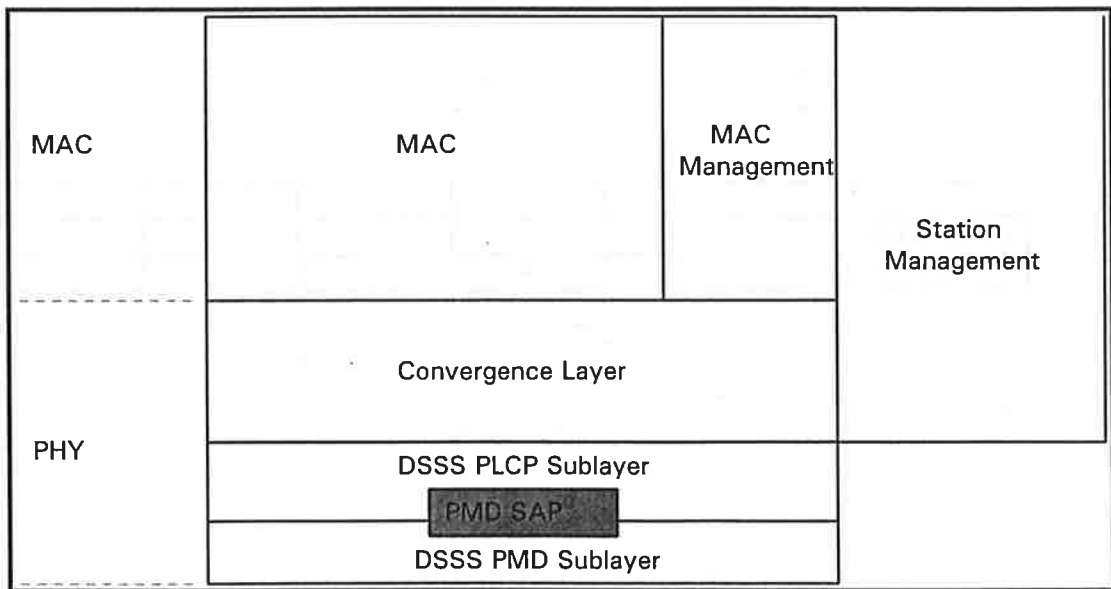


Figure 12-9 PMD Layer Reference Model

### 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 is 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 is 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 section are considered mandatory unless otherwise specified.

#### 1.4.4.1. PMD\_SAP Peer-to-Peer Service Primitives

The following table 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			
PHY_TXEND	X			
PHY_DATA	X	X		

Table 12-43: PMD\_SAP Peer-to-Peer Service Primitives

#### 1.4.4.2. PMD\_SAP Sublayer-to-Sublayer Service Primitives

Primitive	Request	Indicate	Confirm	Response
PHY_TXSTART	X			
PHY_TXEND	X			
PHY_ANTSEL	X	X		
PHY_DIVERSITY	X			
PHY_TXPWRLVL	X			
PHY_CHANNEL	X			
PHY_RATE	X	X		
PHY_RSSI/PHY_RSSI		XX		
PHY_SQ		X		
PHY_CS		X		
PHY_ED	X	X		
PHY_CCA		X		

Table 12-54: PMD\_SAP Sublayer-to-Sublayer Service Primitives

**1.4.4.3. 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	PHY_DATA.request	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK
RXD_UNIT	PHY_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK
RF_STATE	PHY_TXE.request	Receive, Transmit
ANT_STATE	PHY_ANTSEL.indicate PHY_ANTSEL.request	1 to 256
DIV_CONTROL	PHY_DIVERSITY.request	On, Off
TXPWR_LEVEL	PHY_TXPWRLVL	0,1,2,3 (max of 4 levels)
CHNL_ID	PHY_CHANNEL.request	1 to 12
RATE	PHY_RATE.indicate PHY_RATE.request	h0A for 1 Mb/s DBPSK h14 for 2 Mb/s DQPSK
RSSI	PHY_RSSI.indicate	0-78 bits of RSSI
SQ	PHY_SQ.indicate	0-87 bits of Signal Quality

**Table 12-65: List of Parameters for the PMD Primitives****1.4.5. PMD\_SAP Detailed Service Specification**

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

**1.4.5.1. PHY\_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:

PHY\_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 is used by the PHY to be differentially encoded into a DBPSK or DQPSK transmitted symbol. The symbol itself is spread by the PN code prior to transmission.

**When Generated**

This primitive is generated by the PLCP sublayer to request transmission of a symbol. The data clock for this primitive is 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. PHY\_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:

PHY\_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 is 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. PHY\_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:

PHY\_TXSTART.request

##### **When Generated**

This primitive is generated by the PLCP sublayer to initiate the PMD layer transmission of the PPDU. The PHY\_DATA.request primitive must be provided to the PLCP sublayer prior to issuing the PHY\_TXSTART command.

##### **Effect of Receipt**

PHY\_TXSTART initiates transmission of a PPDU by the PMD sublayer.

#### **1.4.5.4. PHY\_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:

PHY\_TXEND.request

#### **When Generated**

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

#### **Effect of Receipt**

PHY\_TXEND terminates transmission of a PPDU by the PMD sublayer.

### **1.4.5.5. PHY\_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:

PHY\_ANTSEL.request(ANT\_STATE)

ANT\_STATE selects which of the available antennas should be used for transmit. The number of available antennas is determined from the MIB table by the PHY\_??? parameter aSuprt\_Rx\_Antennass-NO\_ANT.

#### **When Generated**

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

#### **Effect of Receipt**

PHY\_ANTSEL immediately selects the antenna specified by ANT\_STATE.

### **1.4.5.6. PHY\_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:

PHY\_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 is generated by the PLCP sublayer to report the antenna used for the most recent packet reception.

#### **Effect of Receipt**

PHY\_ANTSEL immediately reports the antenna specified by ANT\_STATE.

### **1.4.5.7. PHY\_DIVERSITY.request**

#### **Function**

This primitive, generated by the PHY PLCP sublayer, selects whether antenna diversity is enabled or disabled during reception.

#### **Semantic of the Service Primitive**

The primitive shall provide the following parameters:

PHY\_DIVERSITY.request(DIV\_CONTROL)

DIV\_CONTROL selects whether the diversity function is enabled or not.

#### **When Generated**

This primitive is 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**

PHY\_DIVERSITY immediately alters the receive state machine to operate according to the DIV\_CONTROL parameter.

### **1.4.5.8. PHY\_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:

PHY\_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 is determined by the MIB parameter NO\_TXPWRLVLS. Section 12.4.7.3 provides further information on the optional DSSS PHY power level control capabilities.

#### **When Generated**



This primitive is generated by the PLCP sublayer to select a specific transmit power. This primitive is applied prior to setting PHY\_TXSTART into the transmit state.

#### **Effect of Receipt**

PHY\_TXPWRLVL immediately sets the transmit power level given by TXPWR\_LEVEL.

### **1.4.5.9. PHY\_CHANNEL.request**

#### **Function**

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

#### **Semantics of the Service Primitive**

The primitive shall provide the following parameters:

PHY\_CHANNEL.request(CHNL\_ID)

CHNL\_ID selects which of the DSSS PHY channel frequencies will be used for transmission or reception. Section 12.4.6.2 provides further information on the DSSS PHY channel plan.

#### **When Generated**

This primitive is generated by the PLCP sublayer to change or set the current DSSS PHY channel.

#### **Effect of Receipt**

The receipt of PHY\_CHANNEL immediately changes the operating channel as set by the CHNL\_ID parameter.

### **1.4.5.10. PHY\_RATE.request**

#### **Function**

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

#### **Semantic of the Service Primitive**

The primitive shall provide the following parameters:

PHY\_RATE.request(RATE)

RATE selects which of the DSSS PHY data rates will be used for MPDU transmission. Section 12.4.6.4 provides further information on the DSSS PHY modulation rates. The DSSS PHY rate change capability is fully described in section 12.2.

#### **When Generated**

This primitive is 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 will be used for all MPDU transmissions. This rate will be used for transmission only. The DSSS PHY will still be capable of receiving all the required DSSS PHY modulation rates.

#### **1.4.5.11. PHY\_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 is indicated in the PLCP preamble 802.11 SIGNALING field.

##### **Semantic of the Service Primitive**

The primitive shall provide the following parameters:

PHY\_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. Section 12.4.6.4 provides further information on the DSSS PHY modulation rates. The DSSS PHY rate change capability is fully described in section 12.2.

##### **When Generated**

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

##### **Effect of Receipt**

This parameter is provided to the PLCP layer for information only.

#### **1.4.5.12. PHY\_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:

PHY\_RSSI.indicate(RSSI)

The RSSI is 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 is generated by the PMD when the DSSS PHY is in the receive state. It is continuously available to the PLCP which in turn provides the parameter to the MAC entity.

##### **Effect of Receipt**

This parameter is 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. PHY\_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 is 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:

PHY\_SQ.indicate(SQ)

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

##### Effect of Receipt

This parameter is 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. ~~SQ may also be used as a code lock indication based on the SQ\_THRESHOLD parameter in section 12.4.5.11.~~

#### 1.4.5.14. PHY\_CS.indicate

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

##### Semantic of the Service Primitive

The PHY\_CS (Carrier Sense) primitive in conjunction with PHY\_ED provide CCA status through the PLCP layer PHY\_CCA primitive. PHY\_CS indicates a binary status of ENABLED or DISABLED. PHY\_CS is ENABLED when the correlator signals quality indicated in PHY\_SQ is greater than the CS\_THRESHOLD parameter. PHY\_CS is DISABLED when the PHY\_SQ falls below the correlation threshold.

##### When Generated

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

##### Effect of Receipt

This indicator is provided to the PLCP for forwarding to the MAC entity for information purposes through the PHY\_CS indicator. This parameter indicates 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 PHY\_CS is ENABLED.

#### **1.4.5.15. PHY\_ED.indicate**

##### **Function**

This optional primitive, generated by the PMD, indicates to the PLCP layer that the receiver has detected RF energy indicated by the PHY\_RSSI primitive which is above a predefined threshold.

##### **Semantic of the Service Primitive**

The PHY\_ED (Energy Detect) primitive along with the PHY\_SQ provide CCA status at the PLCP layer through the PHY\_CCA primitive. PHY\_ED indicates a binary status of ENABLED or DISABLED. PHY\_ED is ENABLED when the RSSI indicated in PHY\_RSSI is greater than the ED\_THRESHOLD parameter. PMD\_ED is DISABLED when the PHY\_RSSI falls below the energy detect threshold.

##### **When Generated**

This primitive is 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 is provided to the PLCP for forwarding to the MAC entity for information purposes through the PHY\_ED indicator. This parameter indicates 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 PHY\_CS function will be enabled shortly after the PHY\_ED function is enabled.

#### **1.4.5.16. PHY\_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:

PHY\_ED.request(ED\_THRESHOLD)

ED\_THRESHOLD sets the threshold which the RSSI indicated must be greater than in order for PHY\_ED to be enabled.

##### **When Generated**

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

##### **Effect of Receipt**

The receipt of PHY\_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 is generated by the PHY sublayer when the PHY is receiving RF energy from any source which exceeds the ED\_THRESHOLD parameter (PHY\_ED is active) and optionally is a valid correlated DS-PHY signal whereby PHY\_CS would also be active.

**Effect of Receipt**

This indicator is 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 PHY\_CS function will be enabled shortly after the PHY\_ED function is enabled.

**1.4.6. PMD Operating Specifications General**

The following sections 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 and in the 2.471 to 2.497 GHz frequency band has been 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 12.75 for FCC (North America) and ETSI (Europe). For Japan, operation is specified as 2.471 to 2.497 GHz. CHNL\_ID 12 is specified for operation in Japan. For the FCC domain all channels 1-11 must be supported and for the ETSI domain channels 3-11 must 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 12-76: 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 is 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 is output first in time. The first chip is aligned at the start of a transmitted symbol. The symbol duration is exactly 11 chips 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 is based on 1 Mb/s DBPSK modulation. The DBPSK encoder is specified in Table 12.86. The Enhanced Access Rate is based on 2 Mb/s DQPSK. The DQPSK encoder is specified in Table 12.97. (In the tables,  $+j\omega$  is defined as counterclockwise rotation.)

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

Table 12-87: 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	$\pi$
10	$3\pi/2$ ( $-\pi/2$ )

Table 12-98: 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 in the USA and Europe. 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 usec including the power down ramp specified in section 12.4.7.7.

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 usec (10 usec for turnaround time plus 15 usec for energy detect) or by the next slot boundary occurring after the 25 usec has elapsed (refer to 12.4.8.4). A receiver input signal 3dB above the ED threshold described in section 12.4.8.4 shall be present at the receiver.

**1.4.6.7. Receive to Transmit Turnaround Time**

The RX to TX turnaround time is measured at the MAC/PHY interface, using PHY\_DATA.request(START-OF-DATA) and shall be less than or equal to 5 usec. This includes the transmit power up ramp described in section 12.4.8.6.

**1.4.6.8. Slottime**

The slot time for the DSSS PHY is the sum of the RX to TX turnaround time (5 usec) and the energy detect time (15 usec specified in section 12.4.8.4). The propagation delay, which is in the order of 1 usec, is 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 50Ω 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 is defined as 0°C to 40° C is designated for office environments. Type 2 is defined as -30° C to +70°C and is designated for industrial environments.

**1.4.7. PMD Transmit Specifications**

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

**1.4.7.1. Transmit Power Levels**

The maximum allowable output Equivalent-Isotropically Radiated Power (EIRP) as measured in accordance with practices specified by the regulatory bodies is shown in Table 12-109. In the USA, the radiated emissions should also conform with the ANSI uncontrolled radiation emission standards (ANSI document C95.1 published in 1991).

Maximum Output Power EIRP	Geographic Location	Compliance Document
1000 mW	USA	FCC 15.247
100 mW (EIRP)	EUROPE	ETS 300-328
10 mW/MHz	JAPAN	MPT ordinance 78

Table 12-109: 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 dB (dB relative to the  $\text{SINx/x}$  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 dB 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 12-10. The measurements shall be made using 100 KHz resolution bandwidth.

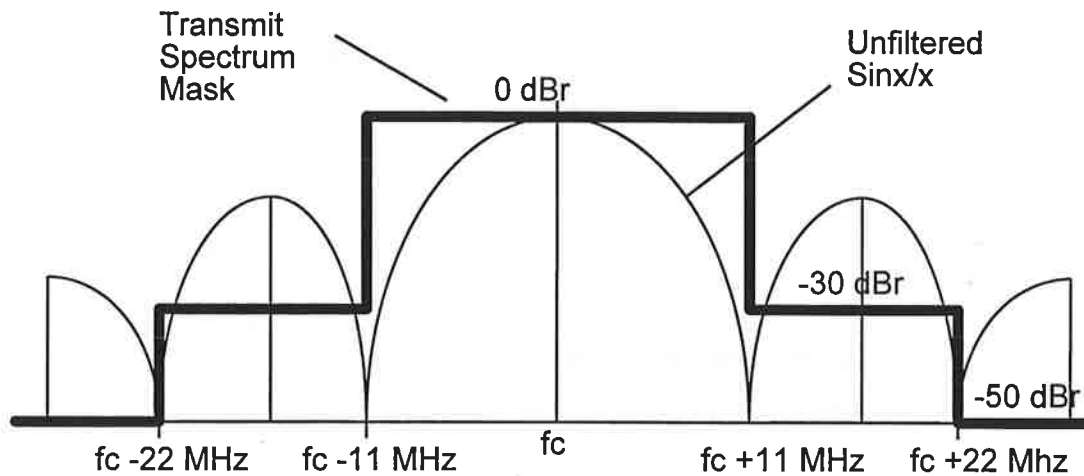


Figure 12-10: Transmit Spectrum Mask

#### 1.4.7.5. Transmit Center Frequency Tolerance

The transmitted center frequency tolerance is +/- 25 ppm maximum.

#### 1.4.7.6. Chip Clock Frequency Tolerance

The PN code chip clock frequency tolerance shall be better than +/- 25ppm 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 usec. The transmit power on -ramp is shown in figure 12-11.



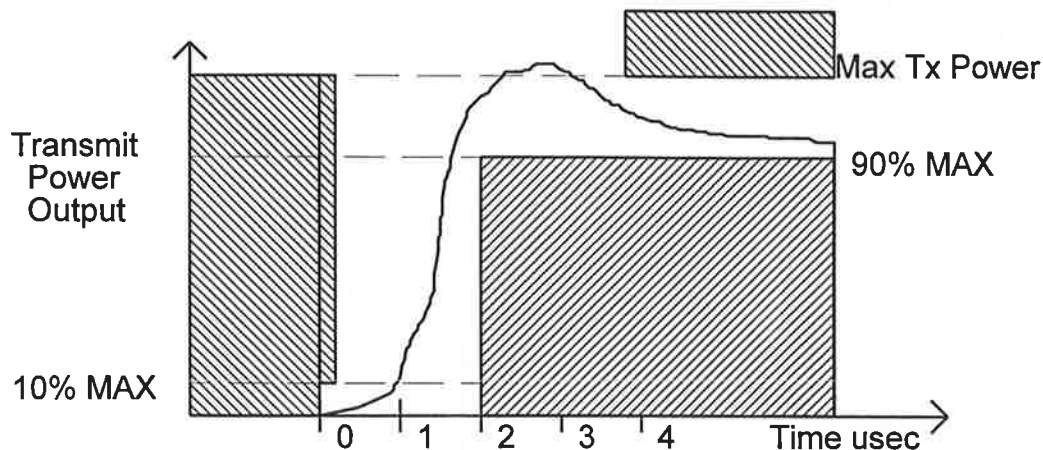


Figure 12-11: Transmit Power On Ramp

The transmit power down ramp for 90% to 10% maximum power shall be no greater than 2 usec. The transmit power down ramp is shown in figure 12-12.

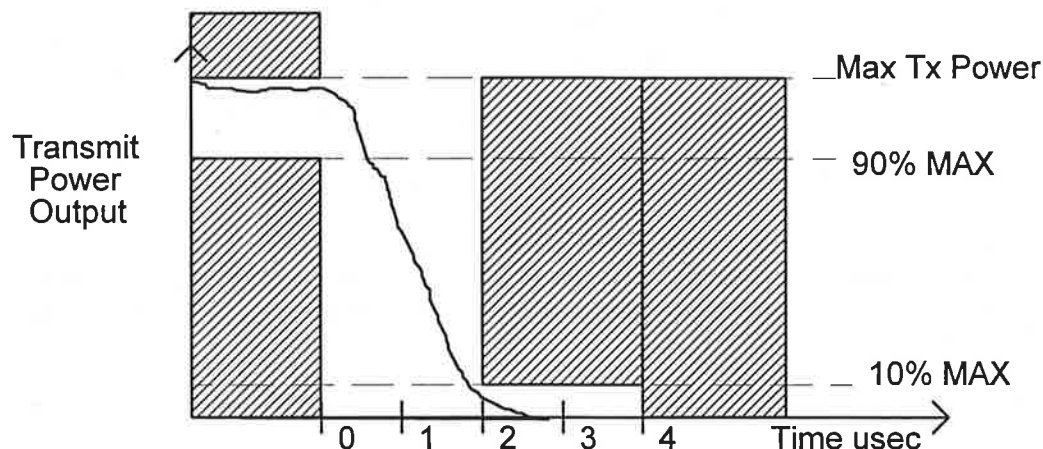


Figure 12-12: Transmit Power Down Ramp

The transmit power ramps shall be constructed such that the DSSS PHY emissions conform with spurious frequency product specification defined in section 12.4.6.5.

**1.4.7.8. RF Carrier Suppression**

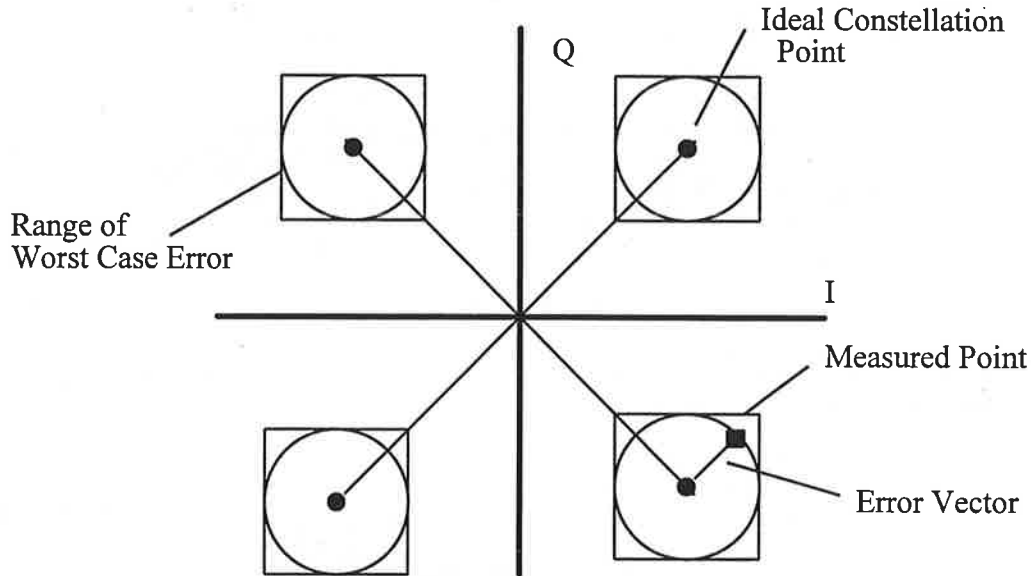
The RF carrier suppression, measured at the channel center frequency, shall be at least 15 dB below the peak  $SIN(x)/x$  power spectrum. The RF carrier suppression shall be measured while transmitting a repetitive 01 data sequence with the scrambler disabled using DQPSK modulation. A 100 KHz resolution bandwidth shall be used to perform this measurement.

**1.4.7.9. Transmit Modulation Accuracy**

The transmit modulation accuracy requirement for the DSSS PHY is 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 exceeded 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 12-13 illustrates the ideal DQPSK constellation points and range of worst case error specified for modulation accuracy.



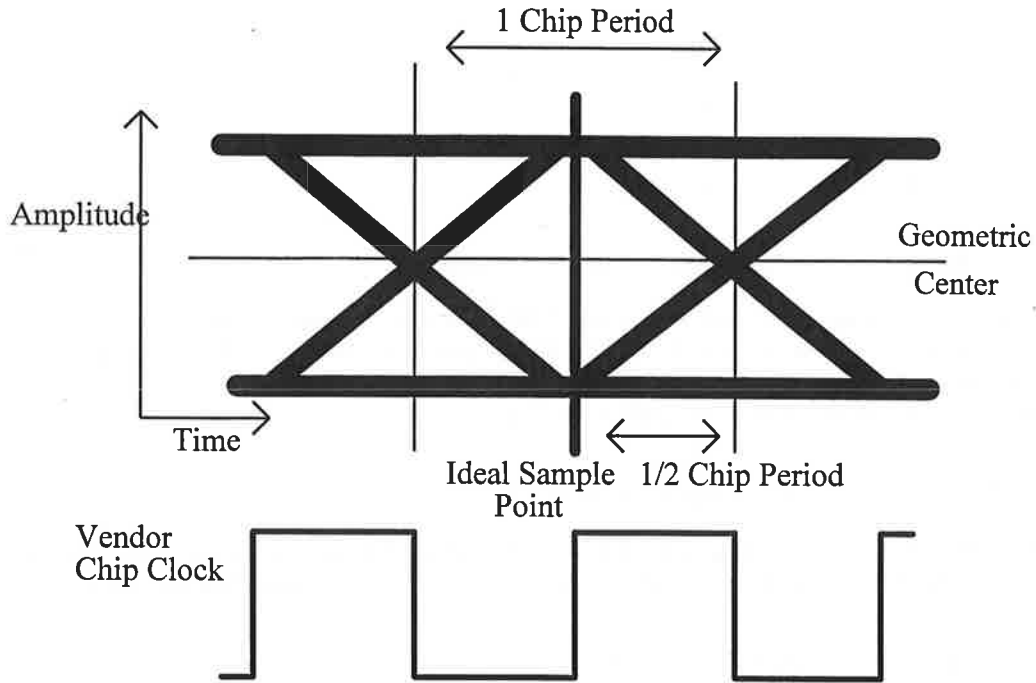
**Figure 12-13: Modulation Accuracy Measurement Example**

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 will be corrected to compensate for the reference receiver distortion.

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

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

The EYE pattern of the I channel will be used to determine the I and Q sampling point. The chip clock provided by the vendor radio will 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 12-14 below). This is the ideal center of the EYE and may not be the point of maximum EYE OPENING.



**Figure 12-14: 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.

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

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 sections 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  $8 \cdot 10^{-23}$  at a Frame length of 1024 bytes for an input level of -80 dBm measured at the antenna connector. This FER is specified for 2 Mb/s DQPSK modulation ~~ed with the 11 chip Barker spreading sequence.~~ 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  $8 \cdot 10^{-23}$  at a maximum input level of -4 dBm measured at the antenna. This FER is specified for 2 Mb/s DQPSK modulation ~~ed with the 11 chip Barker spreading sequence.~~

##### 1.4.8.3. Receiver Adjacent Channel Rejection

Adjacent channel rejection is defined between the two channels in each channel group defined in section 12.4.6.2.

The adjacent channel rejection shall be equal to or better than 35 dB with a FER of  $8 \cdot 10^{-23}$  using 2 Mb/s DQPSK modulation ~~ed with the 11 chip Barker spreading code described in section 12.4.6.3.~~

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

Input a 2 Mb/s DQPSK ~~modulated signal spread with the 11 chip Barker spreading code~~ at a level 6 dB greater than specified in section 12.4.8.1. 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 section 12.4.7.43 to a level 41 dB above the level specified in 12.4.8.1. The adjacent channel signal must 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  $8 \cdot 10^{-23}$ .

##### 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 will report a busy medium upon detecting any energy above the ED threshold.

CCA Mode 2: Carrier sense only. CCA will 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 will report a busy medium upon the detection of a DSSS signal with energy above the ED threshold.

~~The CCA shall be based on the status of energy detection above a given threshold and by detection of code lock based on correlation quality (i.e. carrier sense).~~ The energy detection status is given by the PMD primitive, PHY\_ED. The carrier sense status is given by PHY\_CS. The status of PHY\_ED and PHY\_CS are used in the

PLCP convergence procedure to indicate activity to the MAC through the PHY interface primitive PHY\_CCA.indicate. ~~The primitive class indicates the CCA status.~~

A Busy channel is indicated by PHY\_DATA.indicate of class START-OF-ACTIVITY, END-OF-DATA, or DATA.

Clear Channel is indicated by PHY\_DATA.indicate of class END-OF-DATA-AND-ACTIVITY or END-OF-ACTIVITY.

The PHY MIB variable aCCA\_Mode\_Suprt will indicate the appropriate operation modes. The PHY will be configured through the PHY MIB variable aCurrent\_CCA\_Mode.

~~The CCA shall be TRUE if there is no energy detect or carrier sense. If ED is active without carrier sense being active, then CCA is allowed to go TRUE.~~ ~~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) The worst case latency With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 usec from a slot boundary, the CCA indicator shall report channel busy before the end of the slot time, of the detection of an energy change across the ED threshold incident on the receiver antenna to the reporting of channel busy shall be less than or equal to 15 usec or by the next slot boundary occurring after the 15 usec has elapsed. ~~This implies that the CCA signal is available as an exposed test point.~~
- e) ~~The CCA state machine shall be reset upon transition from the TX state to the RX state.~~
- 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 will 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 and below the appropriate ED energy detect threshold (a),~~ such that all conditions described in (b) and (c) above are demonstrated.

