

IEEE P802.11

Wireless Access Method and Physical Layer Specification

**Proposed text for section 11**  
**Based on responses to Draft D1 Letter Ballot processed**  
**at May 1995 Meeting.**

Abstract: This paper presents the changes to section 11 in the Draft Standard P802.11/D1 as a result of the Response to Draft D1 Letter Ballot processed at the May 1995 Meeting as shown in the companion document P802.11-95/72A

All Letter Ballot comments were processed at the May meeting.

ACTION: Adopt the changes in this paper to replace the portions in section 11 of P802.11/D1.

## 11. 2.4 GHz ISM Band Direct Sequence Spread Spectrum Physical Layer Specification

### 11.1 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 the like similar regulations.

The DSSS system provides a 1 and 2 Mb/s wireless LAN. 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 ~~signal is spreaded with a 11-chip Barker sequence, thus providing a 11 times wider spectrum band. A coding gain of 10 dB can be established.~~ The DSSS system uses baseband modulations of Differential Binary Phase Shift Keying (DBPSK) and Differential Quadrature Phase Shift Keying (DQPSK) to provide for 1 and 2 Mb/s data rates respectively.

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

#### 11.1.1 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 (DS) system. The DS PHY layer consists of two protocol functions as follows:

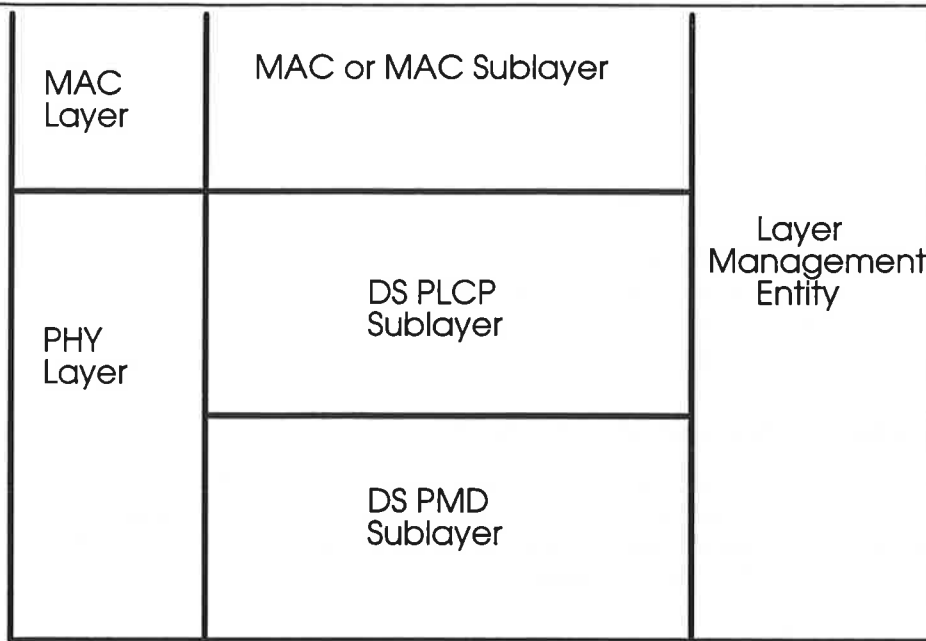
- a) A physical layer convergence function which adapts the capabilities of the physical medium dependent system into the Physical Layer service. This function is supported by the Physical Layer Convergence Procedure (PLCP) which defines a method of mapping the 802.11 MAC layer Protocol Data Units (MPDU) 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 DS 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.

#### 11.1.2 DSSS Physical Layer Functions

The 2.4 GHz DS PHY architecture is shown in Figure 11-1. The DS 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 DS Physical Layer service is provided to the Media Access Control through the physical layer service primitives described in Section 8.



**Figure 11-1: Protocol Reference Model**

#### 11.1.2.1 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.

#### 11.1.2.2 Physical Medium Dependent Sublayer

The physical medium dependent sublayer provides a means to send or receive data between two or more stations. ~~In this case, This section is concerned with the 2.4 GHz ISM bands using Direct Sequence modulation are used.~~

#### 11.1.2.3 Physical Layer Management Entity (LME)

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

#### 11.1.3 Acronyms

PPDU	PHY Protocol Data Unit
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
LME	Layer Management Entity
<u>LSB</u>	<u>Least Significant Bit</u>
MAC	Media Access Control
MIB	Management Information Base

MPDU	MAC Protocol Data Unit
MSB	Most Significant Bit
PPDU	PHY Protocol Data Unit
PHY_SAP	Physical Layer Service Access Point
PLCP	Physical Layer Convergence Procedure
PMD	Physical Medium Dependent
PMD_SAP	Physical Medium Dependent Service Access Point
PN	Pseudo Noise (PN code sequence)
RSSI	Received Signal Strength Indication
SQ	Signal Quality (PN code correlation strength)
SAP	Service Access Point
TXE	Transmit Enable

**11.1.4 Service Specification Method and Notation**

The models represented by figures and state diagrams are intended as the 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 DS 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.

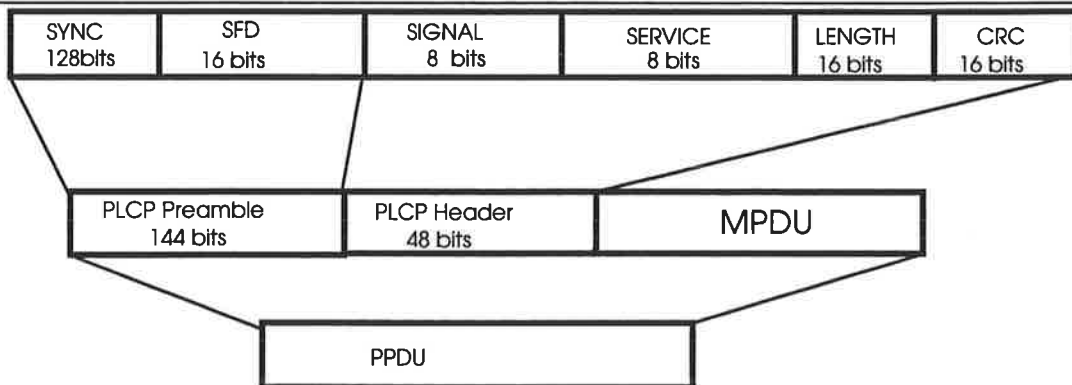
**11.2 DSSS Physical Layer Convergence Procedure Sublayer**

**11.2.1 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.

**11.2.2 Physical Layer Convergence Procedure Frame Format**

Figure 11-2 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), CRC. Each of these fields shall be described in detail in section 11.2.3.



**Figure 11-2: PLCP Frame Format**

### 11.2.3 PLCP Field Definitions

The entire PLCP preamble and header shall be transmitted using the 1 MBPS DBPSK modulation described in section 11.4.7. All the transmitted data bits shall be scrambled using the feedthrough scrambler described in section 11.4.

#### 11.2.3.1 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.

#### 11.2.3.2 PLCP Start Frame Delimiter (SFD)

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

#### 11.2.3.3 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 or (and reception) of the MPDU. The data rate is equal to the Signal Field value multiplied by 100Kb/s. The DS 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 MBPS DBPSK
- b) h14 (MSB to LSB) for 2 MBPS DQPSK

The DS PHY rate change capability will be described in section 11.2.5. This field is protected by the CRC frame check sequence described in section 11.2.3.6

#### 11.2.3.4 PLCP 802.11 Service Field (SERVICE)

The 8 bit 802.11 service field is reserved for future use. This field must be set to h00. The LSB shall be transmitted first in time. This field is protected by the CRC frame check sequence described in section 11.2.3.6.

#### 11.2.3.5 PLCP Length Field (LENGTH)

The PLCP length field is an unsigned 16 bit integer which indicates the number of octets (1 up to  $2^{16}$  as defined by aMPDU\_maximum [per 9.1.4.23]) to be transmitted in the MPDU. The transmitted value is provided by the LENGTH parameter in the PHY\_DATA.request primitive described in section 8. The LSB (least significant bit) shall be transmitted first in time. The bits shall be transmitted in increasing sequential order with the MSB (most significant bit) being transmitted last. This field is protected by the CRC frame check sequence described in section 11.2.3.6.

#### 11.2.3.6 PLCP CRC Field (CRC)

The 802.11 signal, 802.11 service, and length fields shall be protected with a CRC CCITT-FCS (frame check sequence). The CRC CCITT-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, PLCP service, and Length fields for a DQPSK signal with a packet length of 192 would be given by the following:

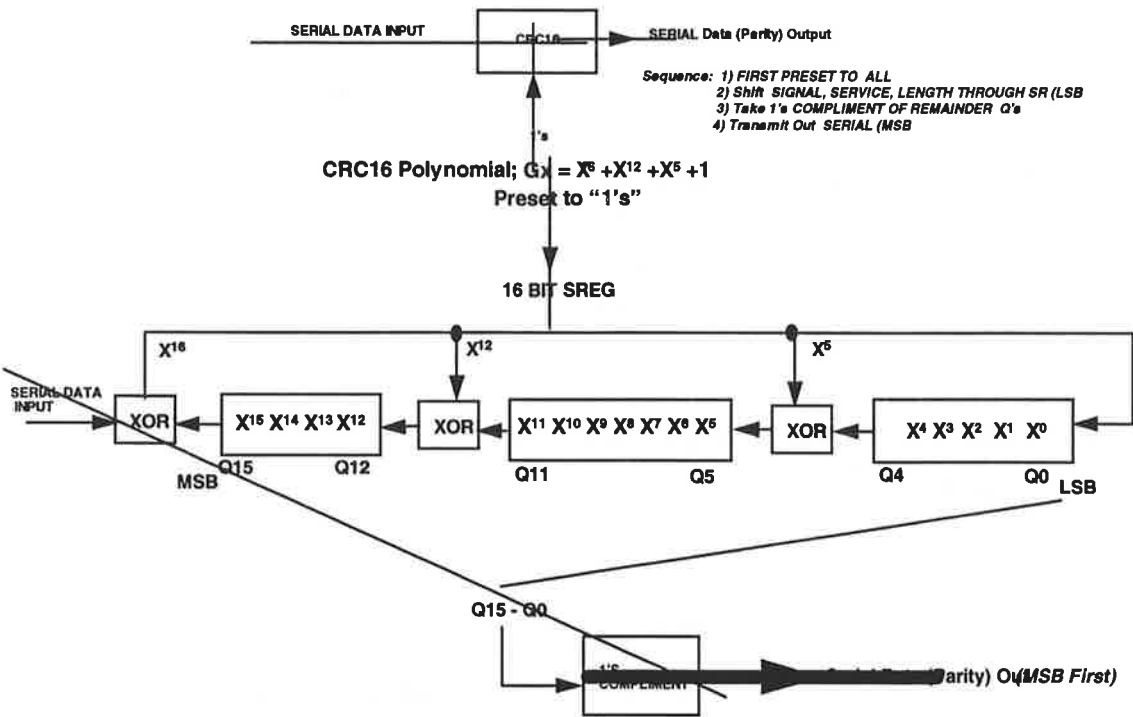
0101 0000 0000 0000 0000 0011 0000 0000 (left most bit transmitted first in time)

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

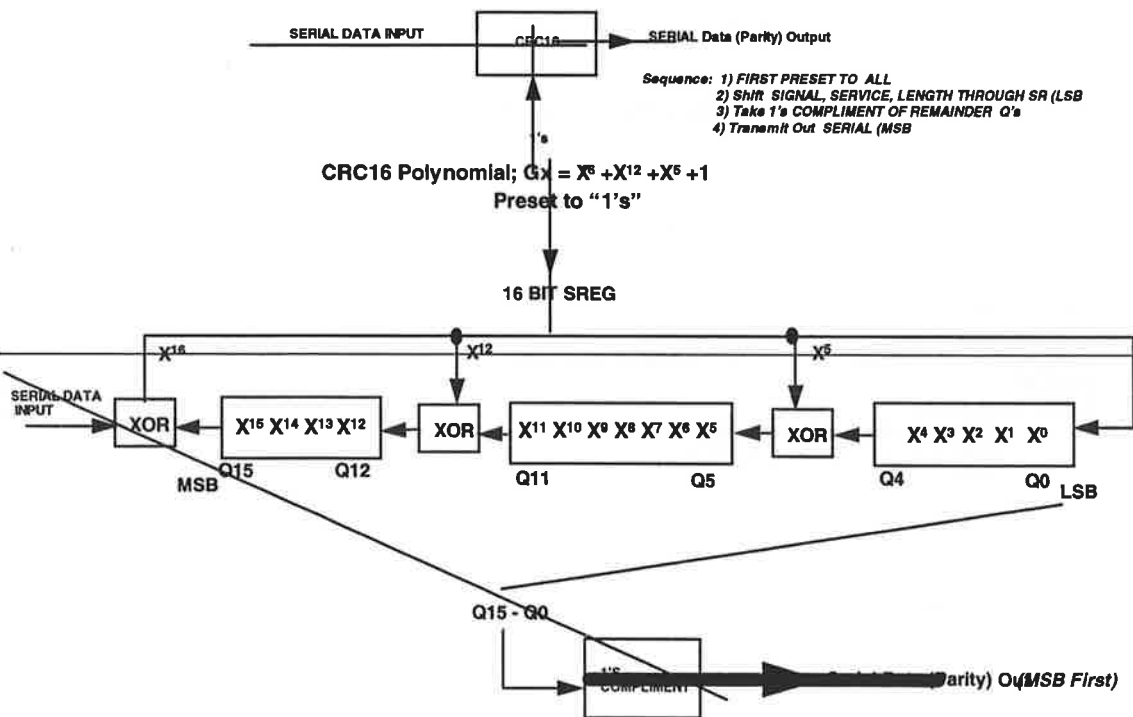
0101 1011 0101 0111 (left most bit transmitted first in time)

Figure 11-3 depicts this example ~~is depicted~~.

Transmit and Receive PLCP Header CRC16 Calculator



Transmit and Receive PLCP Header CRC16 Calculator



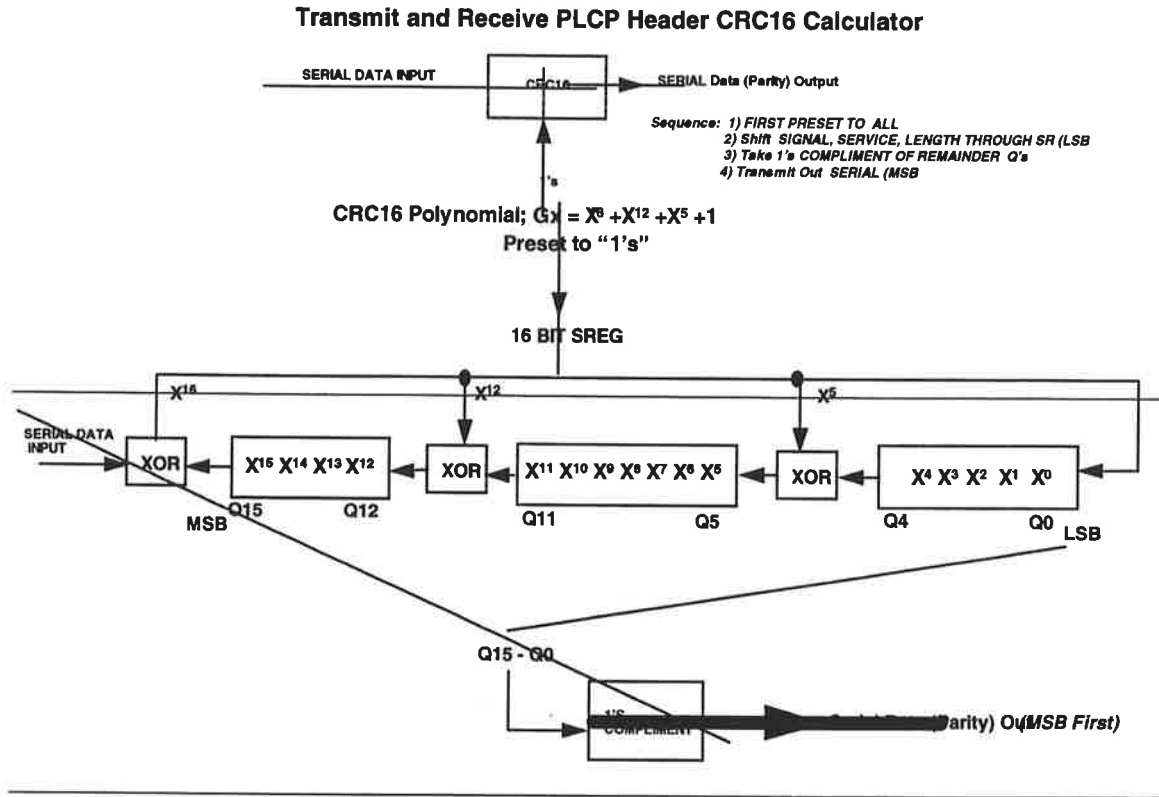


Figure 11-3: CRC implementation

An illustrative programming example using the above of the CRC FCS follows:

```
#include <stdio.h>

int data {32}          {0,1,0,1, 0,0,0,0, 0,0,0,0, 0,0,0,0,
                       0,0,0,0 0,0,1,1, 0,0,0,0, 0,0,0,0};

main() {
  int i, residue, fdbk;
  residue = 0xFFFF;
  printf(" ");
  fprintf(stdout, residue, 16);          :binary print function
  printf("\n");
  for i=0; i<32; i++) {
    fdbk = (residue >> 15) ^ data[i];
    residue = (2 * residue) & 0xFFFF;
    if (fdbk) residue ^= 0x1021;
    printf ("%d", data[i]);
    fprintf (stdout, residue, 16);
    printf ("\n"); }
  residue ^= 0xFFFF;
  printf ("CRC parity ");
  fprintf (stdout, residue, 16);
  printf ("\n"); }
```

Data	Register	
MSB		LSB
	1111111111111111	: Initialize Preset to 1's
0	1110111111011111	
1	1101111111011110	
0	10101111101011101	
1	01011111010111010	



0	1011110101110100
0	0110101011001001
0	1101010110010010
0	1011101100000101
0	0110011000101011
0	1100110001010110
0	1000100010001101
0	0000000100111011
0	000001001110110
0	0000010011101100
0	0000100111011000
0	0001001110110000
0	0010011101100000
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
	<b>0101101101010111 ; 1's Complement, Result = CRC FCS Parity</b>

**11.2.4 PLCP / DS PHY Data Scrambler and Descrambler**

The polynomial  $1 + xz^{-4} + xz^{-7}$  shall be used to scramble ALL bits transmitted by the DS PHY. The feedthrough configuration of the scrambler is self initializing. No prior initialization of the scrambler is required for either transmit or receive processing. Figures 11-3 and 11-4 shows typical implementations of the data scrambler and descrambler. Other implementations are possible.

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

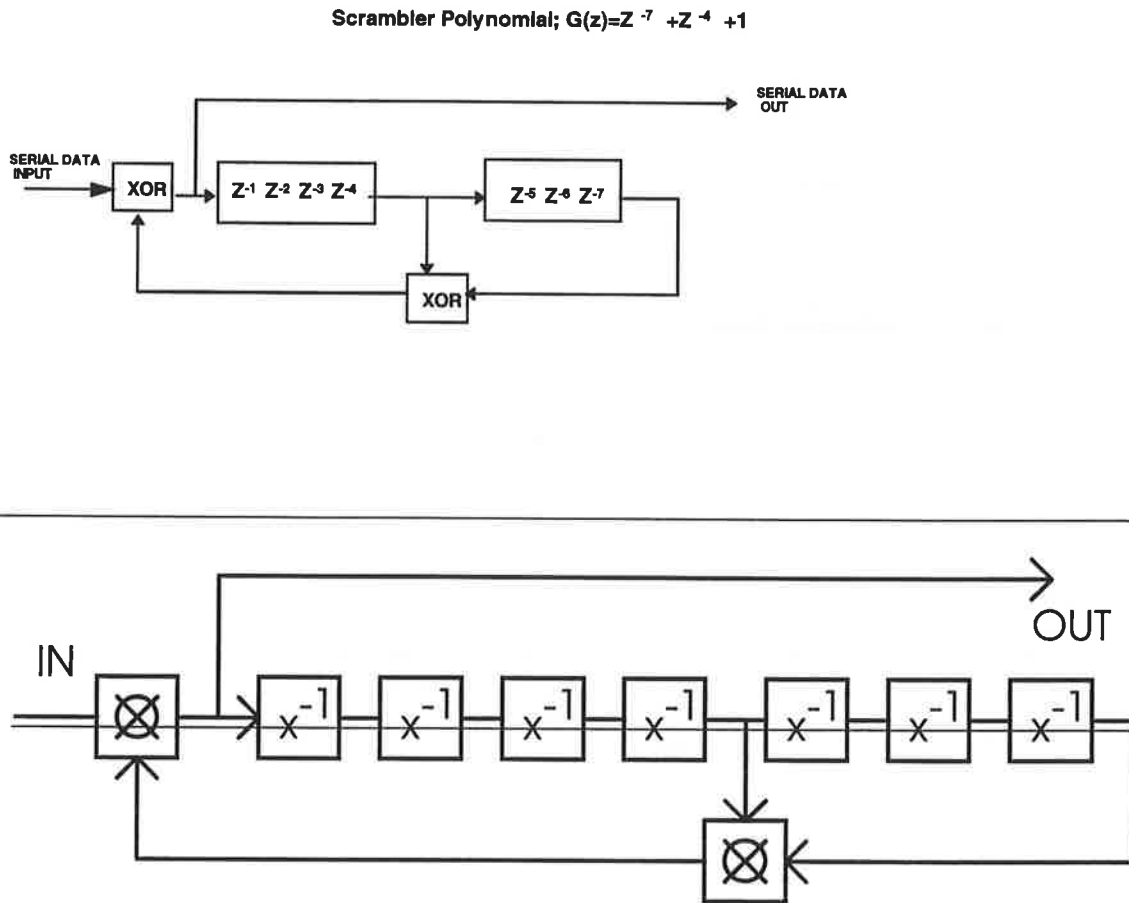
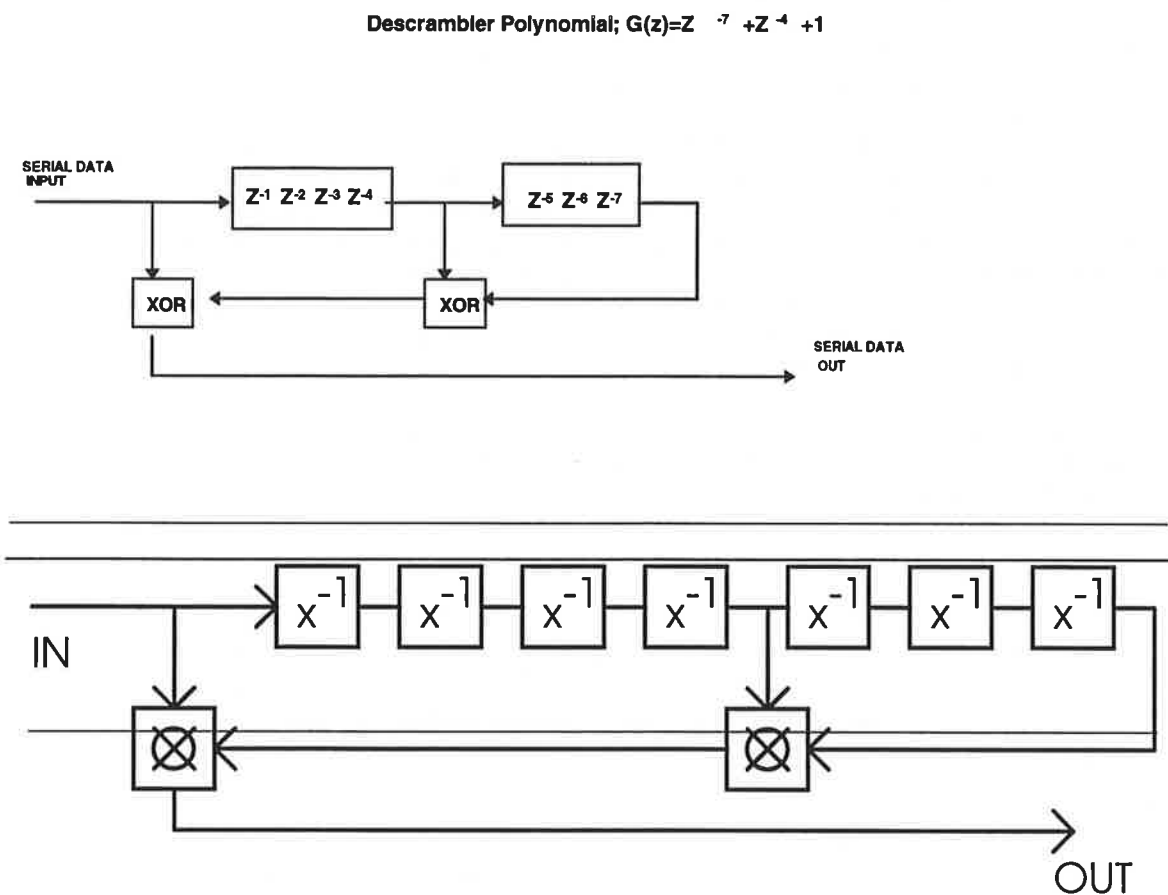


Figure 11-3: Data Scrambler



**Figure 11-4: Data Descrambler**

**11.2.5 PLCP Data Modulation and Modulation Rate Change**

The PLCP preamble shall be transmitted using the 1 Mbps 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 (1bit for DBPSK 2 bits for DQPSK) of the MPDU. The MPDU transmission rate is set by the RATE parameter in PHY\_DATA.request primitive.

**11.2.6 PLCP Transmit Procedure**

The PLCP transmit procedure is shown in Figure 11-5. All commands issued by the MAC require PHY-DATA.confirm primitives to be issued by the PHY. The PHY-DATA.confirm primitives provide flow control between the MAC and the PHY. The PHY-DATA.confirm primitives are not shown in Figure 11-5.

Based on the status of CCA indicated by PHY\_DATA.indicate the MAC will assess that the channel is clear. A clear channel is indicated by PHY\_DATA.indicate(END-OF-ACTIVITY). If the channel is clear, transmission of the MPDU is initiated by issuing the PHY\_DATA.request (START-OF-ACTIVITY) primitive. The TXVECTOR elements for the PHY\_DATA.request(START\_OF\_ACTIVITY) are the PMD Parameters LENGTH, ANTSEL, RATE (SIGNALING), SERVICE, CHNL\_ID, and TXPWR\_LEVEL.

The PLCP will issue PMD\_ANTSEL, PMD\_RATE, PMD\_SERVICE, PMD\_FREQCHNL\_ID, and PMD\_TXPWRLVL primitives to configure the PHY. The PLCP will then issue a PMD\_TXE enable and the PHY entity will immediately initiate data scrambling and transmission of the PLCP preamble based on the parameters passed in the PHY\_DATA.request primitive. The time required for TX power on ramp described in section 11.4.7 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) issued by the MAC and PHY\_DATA.confirm primitives. The modulation rate change, if any, is initiated with the first data symbol of the octet of the MPDU as described in section 11.2.5. 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 each octet is divided into symbols (1 or 2 bits) and presented to the PHY layer through PMD\_DATA.request primitives. The data octets are transmitted in LSB to MSB order with the LSB being transmitted first in time. Transmission is terminated by the MAC through the primitive PHY\_DATA.request(END-OF-DATA) followed by PHY\_DATA.request(END\_OF\_ACTIVITY). PMD\_TXE is disabled with the end of activity. The termination occurs after the transmission of the final bit of the last MPDU octet. The number of octets transmitted must equal the number supplied in the DS PHY preamble LENGTH. The packet transmission is completed and the PHY entity enters the default receive state (i.e. PMD\_TXE is disabled). It is recommended that chipping continues during power down.

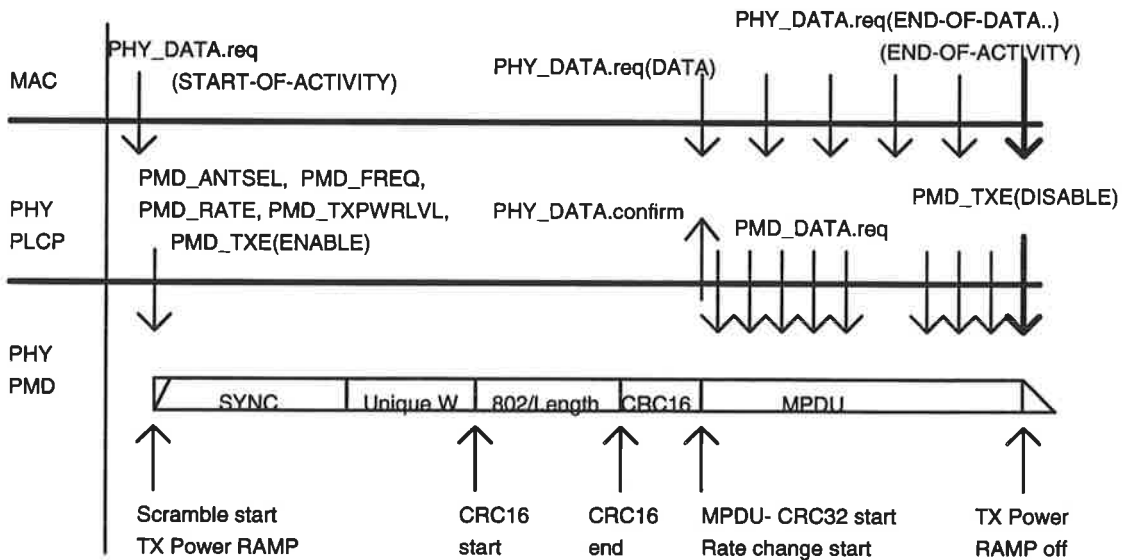


Figure 11-5: PLCP Transmit Procedure

11.2.6.1 Transmit State Machine

A typical state machine implementation of the PLCP transmit procedure is provided in Figure 11-6.

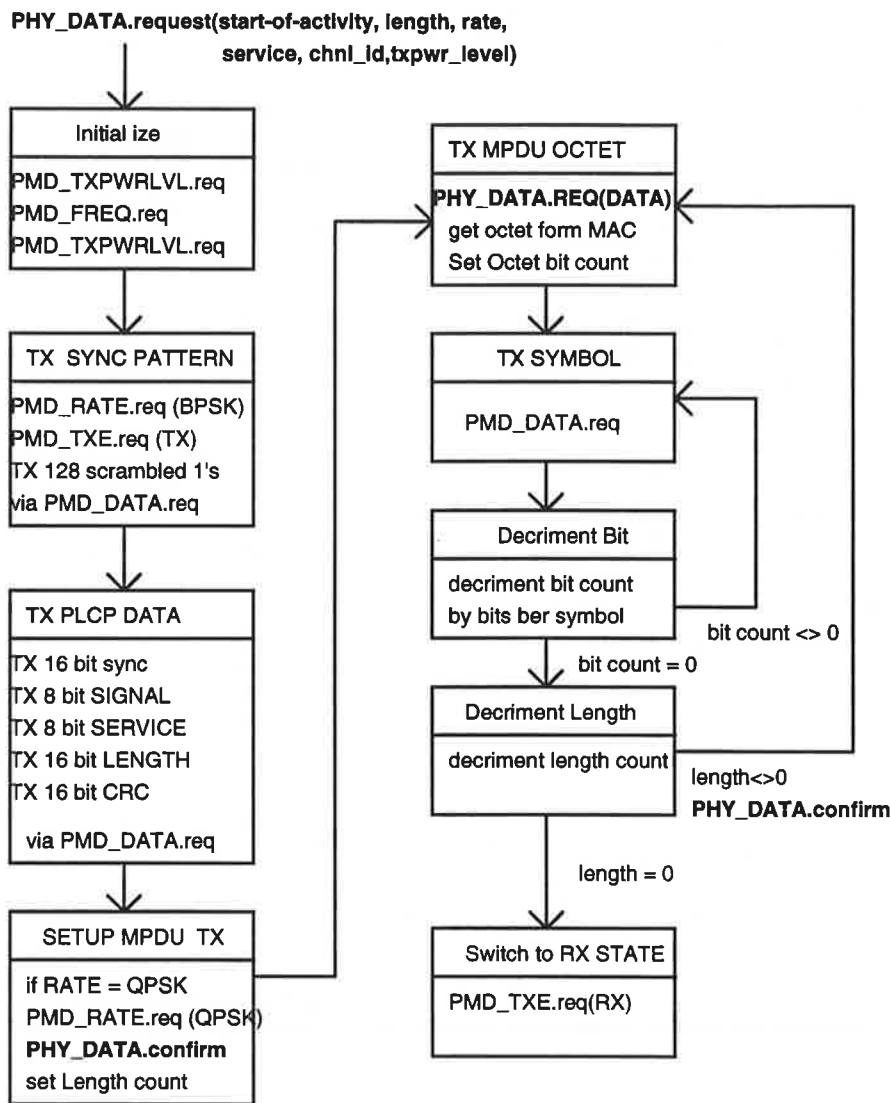


Figure 11-6: PLCP Transmit State Machine

11.2.7 PLCP Receive Procedure

The PLCP receive procedure is shown in Figure 11-7. All commands issued by MAC require PHY-DATA.confirm primitives to be issued by the PHY. The PHY-DATA.confirm primitives provide flow control between the MAC and the PHY. The PHY-DATA.confirm primitives are not shown in Figure 11-7.

In order to receive data, PMD\_TXE must be disabled so that the PHY entity is in the default receive state. Further, the PHY must be set to operate at the appropriate CHNL\_ID through Station Management via the Layer Management Service Access Point (LMSAP). Other receive parameters such as RSSI, SQ (signal quality), and indicated RATE may also be accessed via the LMSAP.

Upon receiving the transmitted energy, the PMD\_ED will be enabled (according to section 11.4.8.4) as the RSSI strength reaches the ED\_THRESHOLD. If the transmitted energy is associated with a DS PHY PLCP preamble synchronization, then and if the PHY entity acquires PN code lock based on the SQ\_THRESHOLD, and then PMD\_CS will be enabled. Based on the CCA (see section 11.4.8.4) these conditions can be used to indicate activity to the MAC. PHY-DATA.indicate(START-OF-ACTIVITY) is issued for energy detection 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.

The PHY entity begins searching for the Unique Word field. Once the Unique word field is detected, CRC16 processing is initiated and the PLCP 802.11 signal, 802.11 service, and Length fields are received. The CRC16 FCS will be processed. If the CRC16 FCS check fails, a PHY-DATA.indicate(END-OF-DATA) primitive will be issued and PHY receiver will be reset. Should code lock be lost during reception prior to completion of either the PLCP header or the full MPDU as indicated by the length field, the PLCP will issue a PHY-DATA.indicate(END-OF-DATA, carrier\_lost).

If the PLCP preamble reception is successful a PHY\_DATA.indicate(START\_OF\_DATA) will be issued. The RXVECTOR associated with this primitive includes the signaling field, the service field, the length field, PMD\_RSSI, and PMD\_SQ.

The received MPDU bits are assembled into octets and presented to the MAC using a series of PHY-DATA.indicate(DATA, octet) and PHY\_DATA.confirm 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 11.2.5. The PHY proceeds with MPDU reception. Reception is terminated after the reception of the final bit of the last MPDU octet indicated by the PLCP preamble LENGTH field. Depending on the state of energy detection and code lock, either a PHY-DATA.indicate(END-OF-DATA, no\_error) or a PHY-DATA.indicate(END-OF-ACTIVITY) primitive is issued to the MAC. Should code lock / synchronization be lost prior to the end of the MPDU as indicated in the PLCP LENGTH field, the error condition PHY-DATA.indicate(END-OF-DATA, carrier\_lost) will be reported to the MAC.

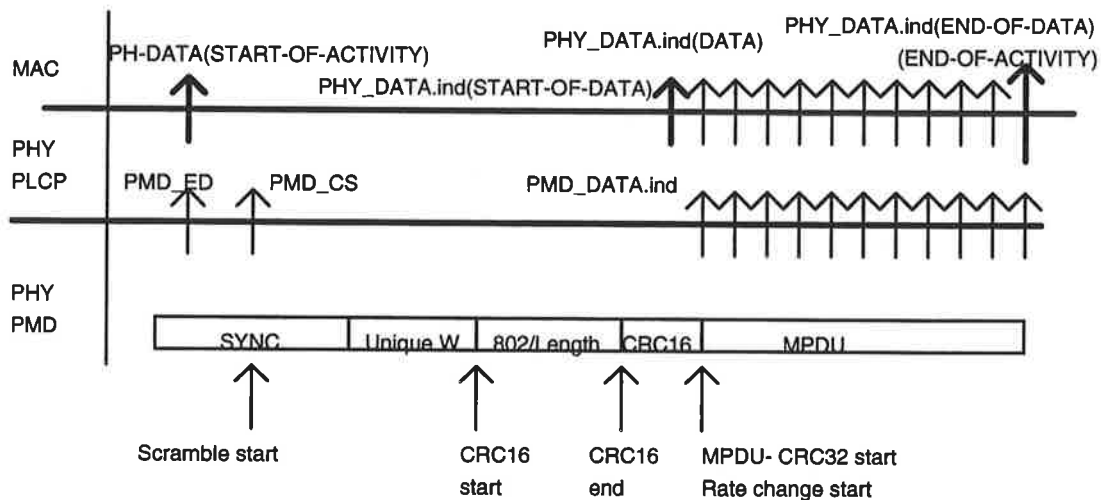


Figure 11-7: PLCP Receive Procedure

11.2.7.1 Receive State Machine

A typical state machine implementation of the PLCP transmit procedure is provided in figure 11-8.

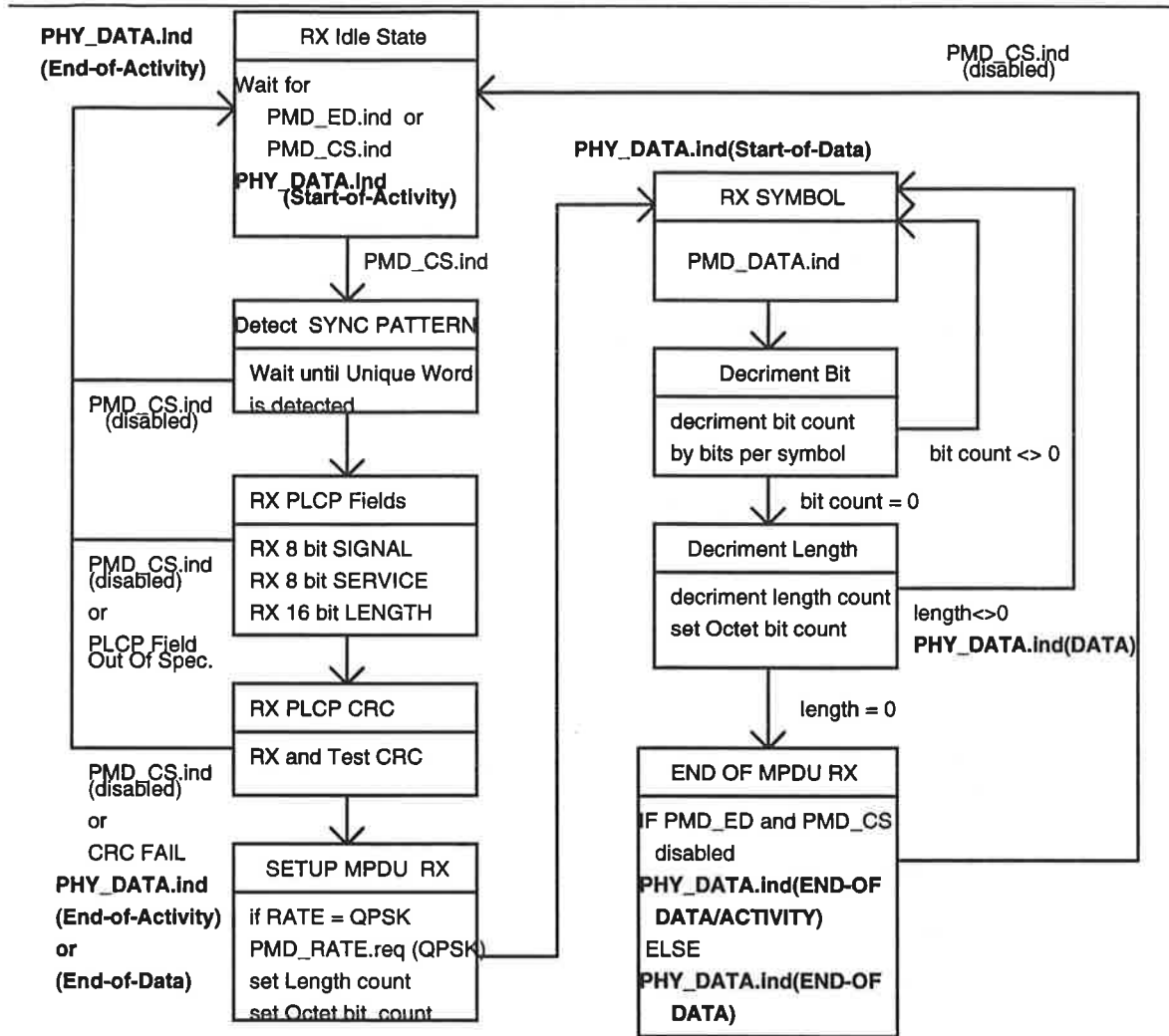


Figure 11-8: PLCP Receive State Machine

### 11.3 DSSS Physical Layer Management Entity

#### 11.3.1 MPHY\_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
MPHY_RESET	X		X	

Table 11-1: MPHY\_SAP Sublayer Management Primitives

#### 11.3.2 MPHY\_SAP Management Service Primitive Parameters

There are currently no parameters associated with the MPHY\_SAP service primitives.

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### 11.3.3 MPHY\_SAP Detailed Service Specification

#### 11.3.3.1 MPHY\_RESET.request

##### 11.3.3.1.1 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.

##### 11.3.3.1.2 Semantics of the Service Primitive

The primitive shall provide the following parameters:

MPHY\_RESET.request

There are no parameters associated with this primitive.

##### 11.3.3.1.3 When Generated

This primitive is generated at any time to reset the PHY.

##### 11.3.3.1.4 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 default receive state.

#### 11.3.3.2 MPHY\_RESET.confirm

##### 11.3.3.2.1 Function

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

##### 11.3.3.2.2 Semantics of the Service Primitive

The primitive shall provide the following parameters:

MPHY\_RESET.confirm

There are no parameters associated with this primitive.

##### 11.3.3.2.3 When Generated

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

##### 11.3.3.2.4 Effect of Receipt

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

### 11.3.4 DSSS Physical Layer Management Information Base

The following parameters will be included in the DS PHY MIB. All fields are 8 bits in length and represent either integers from 0 to 255 or as the exact field definition in the PLCP or PMD sections of this documents.



Static PHY capabilities reported to the MAC:

Parameter	Definition
NO_ANT	Number of Antennas
NO_TXPWRLVLS	Number of transmit power levels
NO_CHANNELS	Number of channels
NO_RATES	Number of Rates
RATE(0) - RATE(255)	RATE list of PLCP signal fields which indicate the rates supported

Operational Parameters set by the MAC:

Parameter	Definition
CHNL_ID	The current DS-PHY channel which may be set by either Layer management or by a PHY_DATA.request primitive issued by the MAC
SQ_THRESHOLD	Signal Quality / Correlation Threshold for the PMD_CS function
RSSI_THRESHOLD	RSSI threshold for the PMD_ED

Operational PHY Status:

Parameter	Definition
RSSI	RSSI level measured at the point of PMD_CS enable (code lock)
SQ	Signal Quality / Correlation level at the point of PMD_CS enable (code lock)
ANT_STATE	Current Antenna Position

Managed Object	Default Value / Range	Operational Semantics	Operational Behaviour / Notes
PHY Type	DSSS-2.4 (02)	Static	Identical for all DSSS PHYs operating in 2.4 GHz.
Num Supported Regulatory Domains	implementation dependent	Static	Reports the number of approvals received
FCC	10 / (10-1F)	Static	as appropriate
DOC	20 / (20-2F)	Static	as appropriate
ETSI	30 / (30-3F)	Static	as appropriate
MKK	40 / (40-4F)	Static	as appropriate
Slot Time	20 usec	Static	
CCA Assessment Time	15 usec	Static	Energy detect time
RxTx Turnaround	5 usec	Static	
TxRx Turnaround	10 usec	Static	
SIFS Time	10 usec	Static	
Num RX Antenna	implementation dependent	Static	reports number of physical antenna connectors and/or
Num TX Antenna	implementation dependent	Static	fixed integrated RX and TX antennae
Antenna Diversity Control	0x00 = on, 0xYY = dedicated antenna #YY	Dynamic	Diversity on will use all antennae, Diversity is off otherwise and will only use the selected antenna YY
Num TX PowerLevels	implementation dependent	Static	reports number of supported power levels.
PowerLevel 1	value in dBm (0-30)	Static	MAC must determine the
PowerLevel 2	...	Static	allowed levels for a particular geographic area
...	...	Static	
PowerLevel xXx	value in dBm (0-30)	Static	
Max TXPower Level	value in dBm (0-30)	Dynamic	
Sleep TurnOn Time	value in usec - implementation dependent	Static	Cold-Start power on time
Doze TurnOn Time	value in usec - implementation dependent	Static	Warm-Start power on time

11.4 DSSS Physical Medium Dependent Sublayer

11.4.1 Scope and Field of Application

This section describes the PMD services provided to the PLCP for the DS 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 DS PHY Layer is shown in Figure 11-9.

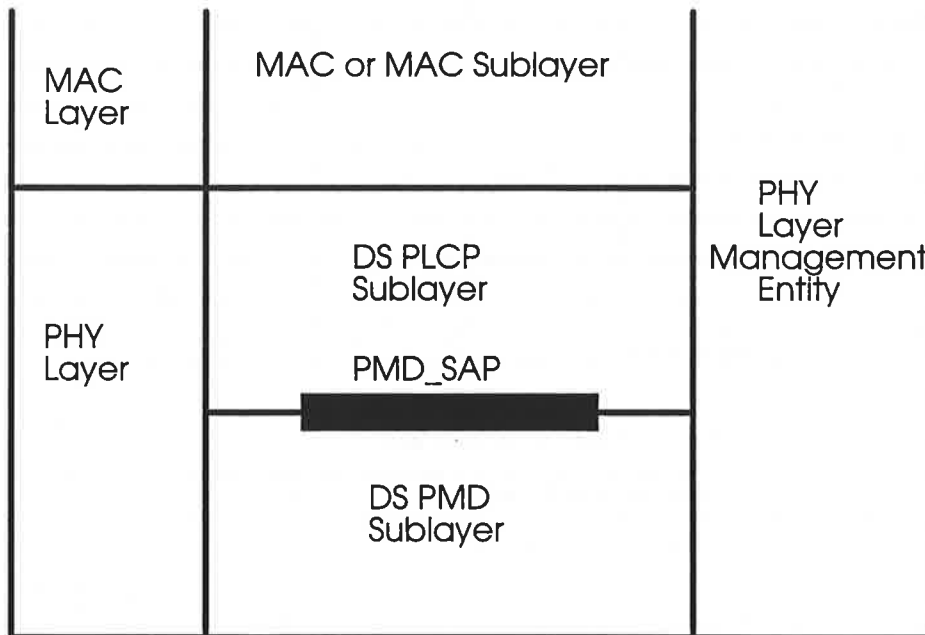


Figure 11-9 PMD Layer Reference Model

11.4.2 Overview of Service

The DS 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 DS 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 like functionality is provided for data transmission.

11.4.3 Overview of Interactions

The primitives associated with the 802.11 PLCP sublayer to the DS 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.

11.4.4 Basic Service and Options

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

11.4.4.1 PMD\_SAP Peer-to-Peer Service Primitives

The following table indicates the primitives for peer-to-peer interactions.

Primitive	Request	Indicate	Confirm	Response
PMD_DATA	X	X		

Table 11-2: PMD\_SAP Peer-to-Peer Service Primitives

## 11.4.4.2 PMD\_SAP Sublayer-to-Sublayer Service Primitives

Primitive	Request	Indicate	Confirm	Response
PMD_TXE	X			
PMD_ANTSEL	X			
PMD_TXPWRLVL	X			
PMD_FREQ	X			
PMD_RATE	X	X		
PMD_RSSI		X		
PMD_SQ		X		
PMD_CS		X		
PMD_ED		X		

Table 11-3: PMD\_SAP Sublayer-to-Sublayer Service Primitives

## 11.4.4.3 PMD\_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
TXD_UNIT	PMD_DATA.request	One(1), Zero(0): BPSK di bit combinations 00,01,11,10: QPSK
RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): BPSK di bit combinations 00,01,11,10: QPSK
RF_STATE	PMD_TXE.request	Receive, Transmit
ANT_STATE	PMD_ANTSEL.request	1 to 256
TXPWR_LEVEL	PMD_TXPWRLVL	0,1,2,3 (max of 4 levels)
CHNL_ID	PMD_FREQ.request	1 to 110-6 for channel set
RATE	PMD_RATE.indicate PMD_RATE.request	h0A for 1 MBPS DBPSK h14 for 2 MBPS DQPSK
RSSI	PMD_RSSI.indicate	0-7 bits of RSSI
SQ	PMD_SQ.indicate	0-7 bits of Signal Quality

Table 11-4: List of Parameters for the PMD Primitives

## 11.4.5 PMD\_SAP Detailed Service Specification

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

## 11.4.5.1 PMD\_DATA request

## 11.4.5.1.1 Function

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

#### 11.4.5.1.2 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 symbol of data-bit which in turn is used by the PHY to be differential encoded into a DBPSK or DQPSK transmitted symbol. The symbol itself is spread by the PN code prior to transmission.

#### 11.4.5.1.3 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.

#### 11.4.5.1.4 Effect of Receipt

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

#### 11.4.5.2 PMD\_DATA.indicate

##### 11.4.5.2.1 Function

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

##### 11.4.5.2.2 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.

##### 11.4.5.2.3 When Generated

This primitive is 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.

##### 11.4.5.2.4 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.

#### 11.4.5.3 PHY\_TXE.indicate

##### 11.4.5.3.1 Function

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

---

#### 11.4.5.3.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD\_TXE.request(RF\_STATE)

~~RF\_STATE~~—The RF\_STATE parameter indicates one of two possible PHY operating conditions: Receive or Transmit. This primitive is a Transmit Enable. The default PHY state is receive.

#### 11.4.5.3.3 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 setting RF\_STATE = transmit within the PMD\_TXE command.

#### 11.4.5.3.4 Effect of Receipt

PMD\_TXE initiates or terminates transmission of a PPDU by the PMD sublayer.

#### 11.4.5.4 PMD\_ANTSEL.request

##### 11.4.5.4.1 Function

This primitive, generated by the PHY PLCP sublayer, selects the antenna used by the PHY for transmission or reception.

##### 11.4.5.4.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD\_ANTSEL.request(ANT\_STATE)

~~ANT\_STATE~~—ANT\_STATE selects which of the available antennas should be used for transmit. The number of available antenna is determined by the PHY\_INFO parameters NO\_ANT. ( Note: receive antenna selection, if any, is a function of the vendor implemented PHY.)

##### 11.4.5.4.3 When Generated

This primitive is generated by the PLCP sublayer to select a specific antenna for transmission. While not required, multiple antennas can be used to implement a receive antenna diversity scheme. The PMD parameters RSSI and SQ are provided for the optional antenna diversity implementation.

##### 11.4.5.4.4 Effect of Receipt

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

#### 11.4.5.5 PMD\_TXPWRLVL.request

##### 11.4.5.5.1 Function

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

#### 11.4.5.5.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD\_TXPWRLVL.request(TXPWR\_LEVEL)

~~TXPWR\_LEVEL~~-TXPWR\_LEVEL selects which of the optional transmit power levels ~~provide antennas~~ should be used for the current packet transmission. The number of available power levels is determined by the MIB parameter NO\_TXPWRLVLS. Section 11.4.7.3 provides further information on the optional DS PHY power level control capabilities.

#### 11.4.5.5.3 When Generated

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

#### 11.4.5.5.4 Effect of Receipt

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

#### 11.4.5.6 PMD\_FREQ.request

##### 11.4.5.6.1 Function

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

##### 11.4.5.6.2 Semantics of the Service Primitive

The primitive shall provide the following parameters:

PMD\_FREQ.request(CHNL\_ID)

~~CHNL\_ID~~-CHNL\_ID selects which of the DS PHY channels frequencies will be used for transmission or reception. Section 11.4.6.2 provides further information on the DS PHY channel plan.

##### 11.4.5.6.3 When Generated

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

##### 11.4.5.6.4 Effect of Receipt

The receipt of PMD\_FREQ immediately changes the frequency channel as set by the CHNL\_ID parameter.

#### 11.4.5.7 PMD\_RATE.request

##### 11.4.5.7.1 Function

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

##### 11.4.5.7.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

---

PMD\_RATE.request(RATE)

~~RATE.~~ RATE selects which of the DS PHY data rates will be used for MPDU transmission. Section 11.4.6.4 provides further information on the DS PHY modulation rates. The DS PHY rate change capability is fully described in section 11.2.

#### 11.4.5.7.3 When Generated

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

#### 11.4.5.7.4 Effect of Receipt

The receipt of PMD\_RATE selects the rate which will be used for all MPDU transmissions. This rate will be used for transmission only. The DS PHY will still be capable of receiving all the required DS PHY modulation rates.

#### 11.4.5.8 PMD\_RATE.indicate

##### 11.4.5.8.1 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.

##### 11.4.5.8.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD\_RATE.indicate(RATE)

~~RATE.~~ In receive mode, the RATE parameter informs the PLCP layer which of the DS PHY data rates was used to process the MPDU portion of the PPDU. Section 11.4.6.4 provides further information on the DS PHY modulation rates. The DS PHY rate change capability is fully described in section 11.2.

##### 11.4.5.8.3 When Generated

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

##### 11.4.5.8.4 Effect of Receipt

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

#### 11.4.5.9 PMD\_RSSI.indicate

##### 11.4.5.9.1 Function

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

##### 11.4.5.9.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:



---

PMD\_RSSI.indicate(RSSI)

~~RSSI~~-The RSSI is a measure of the RF energy received by the DS PHY. RSSI indications of up to 8 bits (256 levels) are supported.

#### 11.4.5.9.3 When Generated

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

#### 11.4.5.9.4 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.

#### 11.4.5.10 PMD\_SQ.indicate

##### 11.4.5.10.1 Function

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

##### 11.4.5.10.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD\_SQ.indicate(SQ)

~~SQ~~-The SQ is a measure of the PN code correlation quality ~~received~~ by the DS PHY. SQ indications of up to 8 bits (256 levels) are supported.

##### 11.4.5.10.3 When Generated

This primitive is generated by the PMD when the DS 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.

##### 11.4.5.10.4 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 ~~the section 11.4.5.11, PMD\_CS.in~~

#### 11.4.5.11 PMD\_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.

##### 11.4.5.11.1 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.

#### 11.4.5.11.2 Semantic of the Service Primitive

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

#### 11.4.5.11.3 When Generated

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

#### 11.4.5.11.4 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 DS PHY signal. The DS PHY should not be placed into the transmit state when PMD\_CS is ENABLED.

#### 11.4.5.12 PMD\_ED.indicate

##### 11.4.5.12.1 ~~10.0.0.0.1.~~ Function

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

##### 11.4.5.12.1 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\_DATA primitive. PMD\_ED indicates a binary status of ENABLED or DISABLED. PHY\_ED is ENABLED when the RSSI indicated in PMD\_RSSI is greater than the ED\_THRESHOLD parameter. PMD\_ED is DISABLED when the PMD\_RSSI falls below the energy detect threshold.

##### 11.4.5.12.2 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.

##### 11.4.5.12.3 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 DS PHY compliant. If a DS PHY source is being received, the PMD\_CS function will be enabled shortly after the PMD\_ED function is enabled.

#### 11.4.6 PMD Operating Specifications General

The following sections provide general specifications for the DS Physical Medium Dependent sublayer. These specifications apply to both -the receive and the transmit functions and general operation of a DS PHY.

11.4.6.1 **Operating Frequency Range**

The DS 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.

Additional frequency bands will follow as they are made available.

11.4.6.2 **Number of Operating Channels**

For the 2.4 to 2.4835 GHz frequency band, 11 channels are shall be specified. The channel center frequencies and CHNL\_ID numbers shall be as shown in Table 11.5 for FCC (North America), and ETSI (Europe), and For Japan, operation is specified as 2.471 to 2.497 GHz. CHNL\_ID 12 is specified for operation in Japan.

	Group			
1	1a	2412 kHz	N/A	N/A
2	1b	2442 KHz	2442 KHz	N/A
3	2a	2422 KHz	2422 KHz	N/A
4	2b	2452 KHz	2452 KHz	N/A
5	3a	2432 KHz	2432 KHz	N/A
6	3b	2462 KHz	2462 KHz	N/A
7	4	N/A	N/A	2484 KHz

**Table 11-5: DS PHY Frequency Channel Plan**

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	241284 MHz

**Table 11-5: DS PHY Frequency Channel Plan**

In a multiple cell network topology, adjacent cells using different channels can operate simultaneously without interference if the distance between the center frequencies is at least 30 MHz. ~~In a similar fashion, group 2 and 3 channels can operate simultaneously with other group 2 and 3 channels. Group 1, 2, and 3 channels may be used simultaneously in a cellular frequency plan where the interference effects have been factored into the cell plan. The Group 4 eChannel 12 is designated specifically for operation in Japan.~~

**11.4.6.3 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 as the start of a transmitted symbol. The symbol duration is exactly 11 chips long.

**11.4.6.4 Modulation and Channel Data Rates**

Two modulation formats and data rates are specified for the DS PHY: a Basic Access Rate and an Enhanced Access Rate. The Basic Access Rate is based on 1 MBPS DBPSK modulation. The DBPSK encoder is specified in Table 11-6. The Enhanced Access Rate is based on 2 MBPS DQPSK. The DQPSK encoder is specified in Table 11-7.

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

**Table 11-6: 1 MBPS 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 11-7: 2 MBPS DQPSK Encoding Table**

**11.4.6.5 Transmit and Receive In Band and Out of Band Spurious Emissions**

- The DS 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.

**11.4.6.6 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 11.4.7.7.

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. 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 11.4.8.4). A receiver input signal 3dB above the ED threshold described in section 11.4.8.4 shall be present at the receiver.

**11.4.6.7 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 11.4.8.6.

**11.4.6.8 Slottime**

The slot time for the DS PHY is the sum of the RX to TX turnaround time (5 usec) and the energy detect time (15 usec specified in section 11.4.8.4) The propagation delay, which is in the order of 1 usec, is regarded to be included in the energy detect time.

**11.4.6.9 Transmit and Receive Antenna Port Impedance**

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

**11.4.6.10 Transmit and Receive Operating Temperature Range**

Two temperature ranges for full operation compliance to the DS 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.

**11.4.7 PMD Transmit Specifications**

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

**11.4.7.1 Transmit Power Levels**

The maximum Equivalent Isotropically Radiated Power (EIRP) as measured in accordance with practices specified by the regulatory bodies is shown in Table 11.4.7. In the USA, the radiated emissions should also conform with the ANSI uncontrolled radiation emission standards (ANSI document C95.1 published in 1991).

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

**Table 11-8: Transmit Power Levels**

**11.4.7.2 Minimum Transmitted Power Level**

The minimum transmitted power shall be no less than 1 mW.

**11.4.7.3 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.

**11.4.7.4 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 11-10. The measurements shall be made using 100 KHz resolution bandwidth.

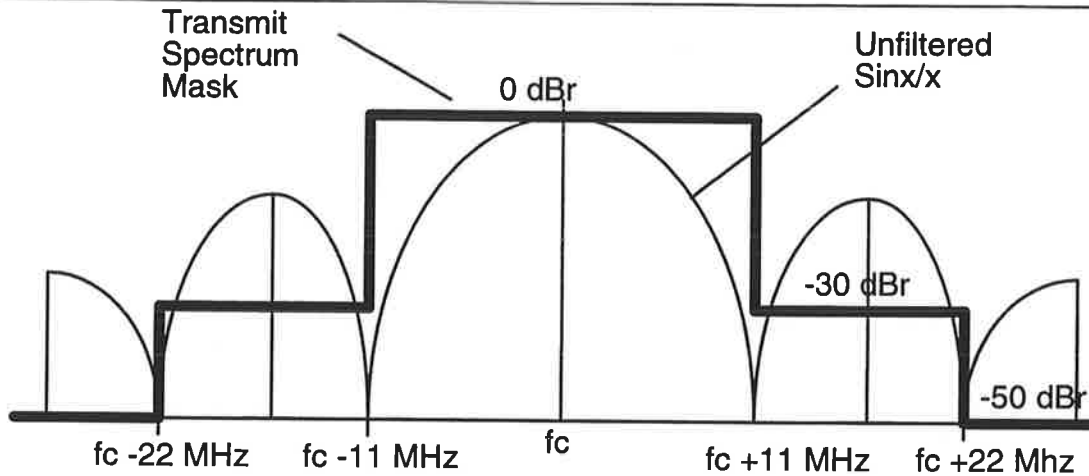


Figure 11-10: Transmit Spectrum Mask

**11.4.7.5 Transmit Center Frequency Tolerance**

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

**11.4.7.6 Chip Clock Frequency Tolerance**

The PN code chip clock frequency tolerance shall be better than +/- 25ppm maximum.

**11.4.7.7 Transmit Power On Ramp 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 11-11.

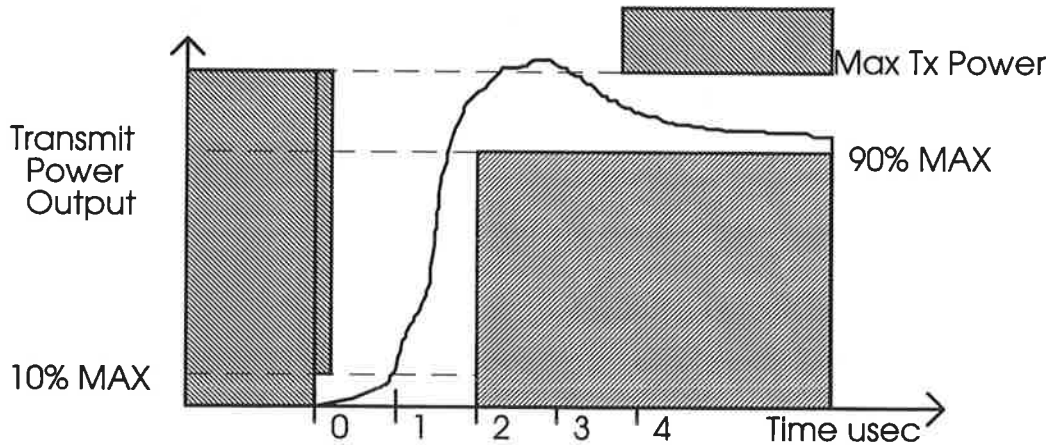
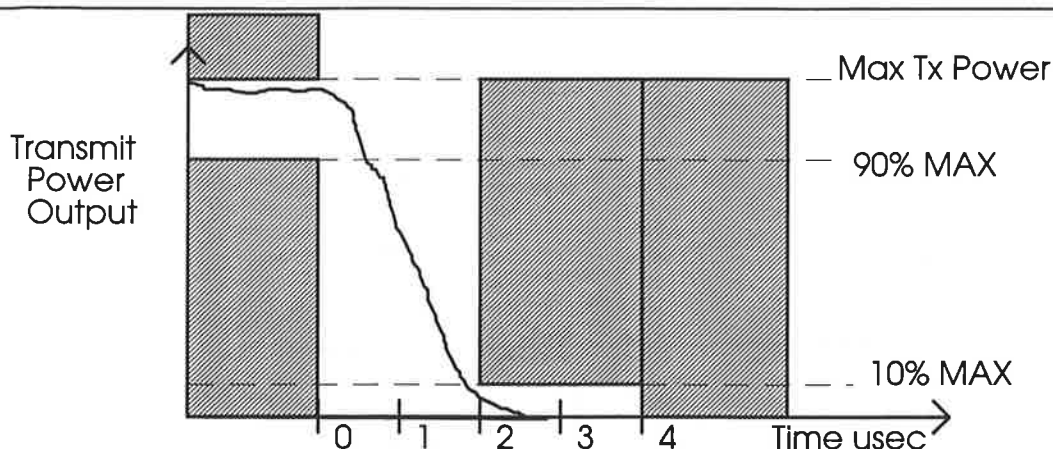


Figure 11-11: Transmit Power On Ramp

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 11-12.



**Figure 11-12: Transmit Power Down Ramp**

The transmit power ramps shall be constructed such that the DS PHY emissions conform with spurious frequency product specification defined in section 11.4.6.5.

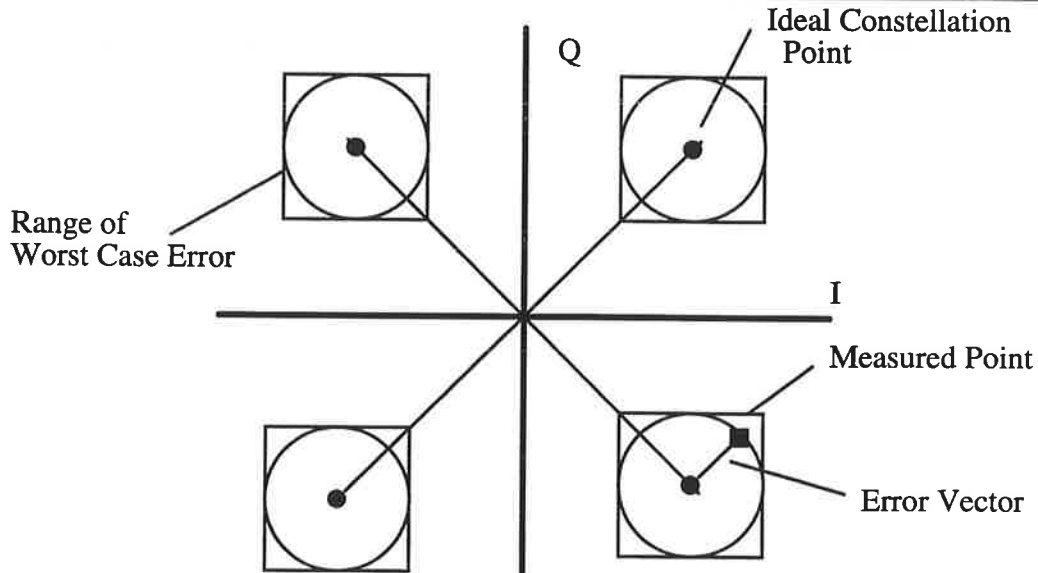
#### 11.4.7.8 RF Carrier Suppression

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.

#### 11.4.7.9 Transmit Modulation Accuracy

The transmit modulation accuracy requirement for the DS 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 QPSK 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 11-13 illustrates the ideal QPSK constellation points and range of worst case error specified for modulation accuracy.



**Figure 11-13: Modulation Accuracy Measurement Example**

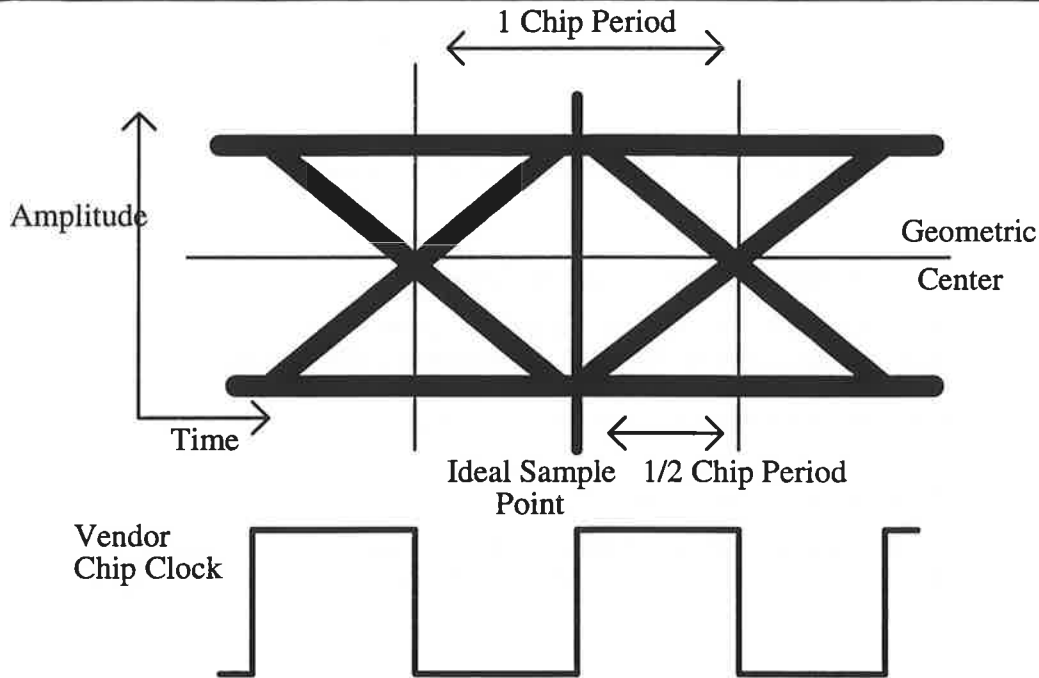
Error vector measurement requires a reference receiver capable of carrier lock. All measurements shall be made under carrier lock conditions. The distortion induced in the constellation by the reference receiver shall be calibrated and measured. The test data error vectors described below will be corrected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

The ~~Vendor~~-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 11-14 below). This is the ideal center of the EYE and may not be the point of maximum EYE OPENING.





**Figure 11-14: 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 magnitude 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 samples 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 DS PHY implementation shall be compliant if for all N = 1000 samples the following condition is met:

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

#### 11.4.8 PMD Receiver Specifications

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

##### 11.4.8.1 Receiver Minimum Input Level Sensitivity

The FrameError Rate (FER) shall be less than  $8 \cdot 10^{-3}$  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 MBPS DQPSK modulated with the 11 chip Barker spreading sequence. The test for the minimum input level sensitivity shall be conducted with the energy detection threshold set ~~to~~ less than or equal to -80 dBm.

##### 11.4.8.2 Receiver Maximum Input Level

The receiver shall provide a ~~minimum~~ maximum FER of  $8 \cdot 10^{-3}$  at a maximum input level of -4 dBm measured at the antenna. This FER is specified for 2 MBPS DQPSK modulated with the 11 chip Barker spreading sequence.

##### 11.4.8.3 Receiver Adjacent Channel Rejection

Adjacent channel rejection is defined between the two channels in each channel group defined in section 11.4.6.2.

The adjacent channel rejection shall be equal to or better than 35 dB with a FER of  $8 \cdot 10^{-3}$  ~~BER of  $10^{-5}$~~  using 2 MBPS DQPSK modulated with the 11-chip Barker spreading code.

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

Input a 2 MBPS DQPSK signal spread with the 11 chip Barker spreading code at a level 6 dB greater than specified in section 11.4.8.1. In an adjacent channel (greater than 30 MHz separation as defined by the channel numbering groups), input a signal modulated in a similar fashion which adheres to the transmit mask specified in section 11.4.7.3 to a level 41 dB above the level specified in 11.4.8.1. The adjacent channel signal must be derived from a separate signal source. It can-not be a frequency shifted version of the reference channel. Under these conditions, the ~~BER~~ FER shall be no worse than  ~~$10^{-5}$~~   $8 \cdot 10^{-3}$ .

##### 11.4.8.4 Clear Channel Assessment

The DS PHY shall provide the capability to perform Clear Channel Assessment (CCA).

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 PMD primitive, PMD\_ED. The carrier sense status is 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\_DATA.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 DS PHY CCA state machine is shown in Figure 11-15. CCA operation shall be based on the following parameters: The CCA shall be TRUE if there is no energy detect or carrier sense. If ED is active for a period of 22 msec without carrier sense being active, then CCA will go TRUE until a positive change in energy detect or carrier sense or a transmit to receive condition as described below in (c). 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 <= 50 mW.
- b) The watchdog timer period shall be 11 msec +/- 10%
- c) The watchdog timer count for detection of continuous energy sources will be 2 timer periods. This results in a worst case access period of 22 msec in the presence a continuous interference source.
- db) The worst case latency 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.
- ec) The CCA state machine shall be reset upon transition from the TX state to the RX state.

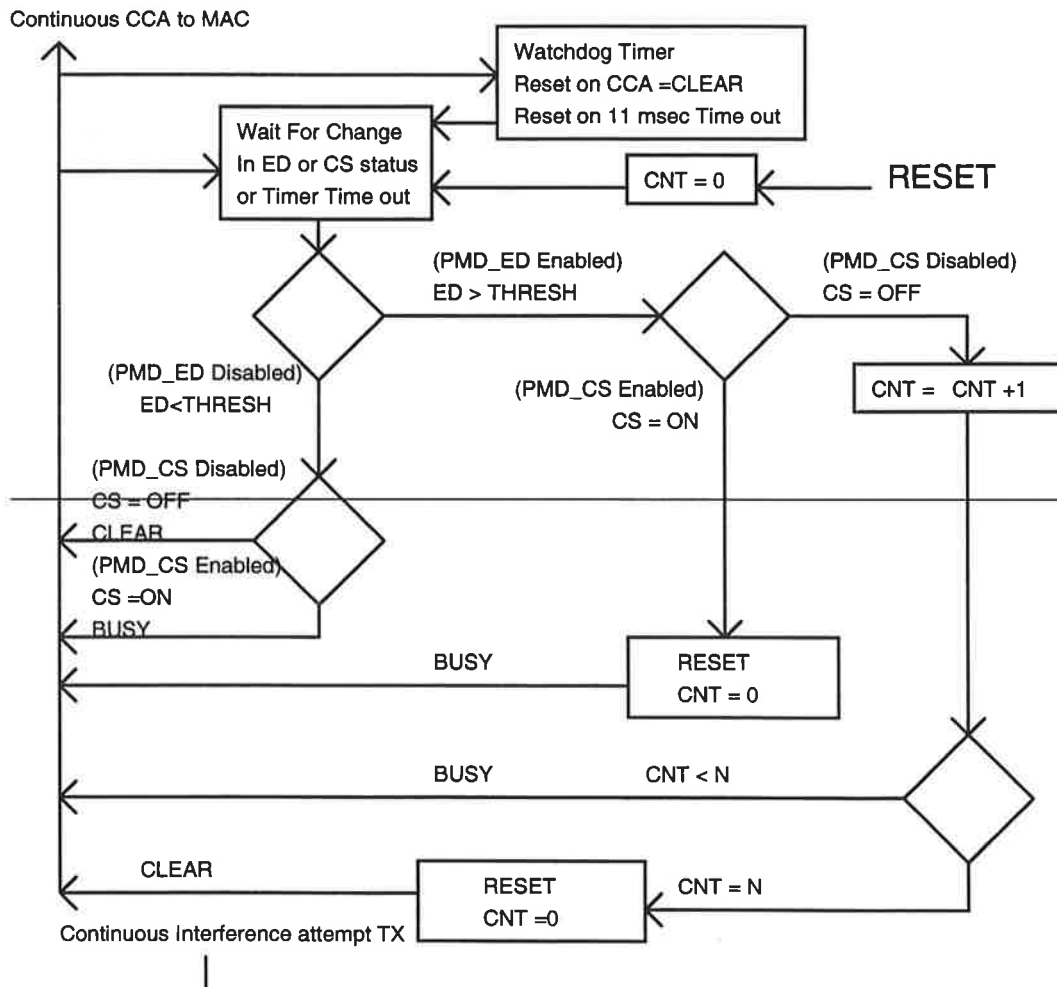


Figure 11-15: DS PHY CCA State Machine

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Conformance to DS PHY CCA shall be demonstrated by applying continuous and pulsed CW (-above and below the appropriate energy detect threshold) and DS PHY compliant signals such that all conditions described above ~~states shown in figure 11-15~~ are demonstrated.