12. 2.4 GHz ISM Band Direct Sequence Spread Spectrum Physical Layer Specification

12.1. 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 1 Mb/s and/or a 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 112-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.

12.1.1. 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.

12.1.2. 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 98.
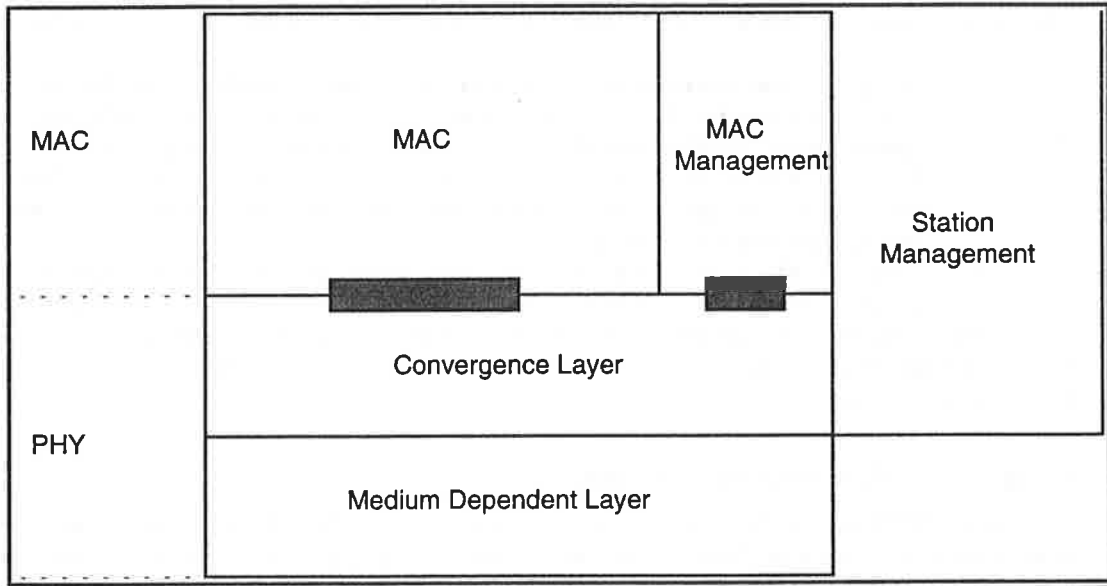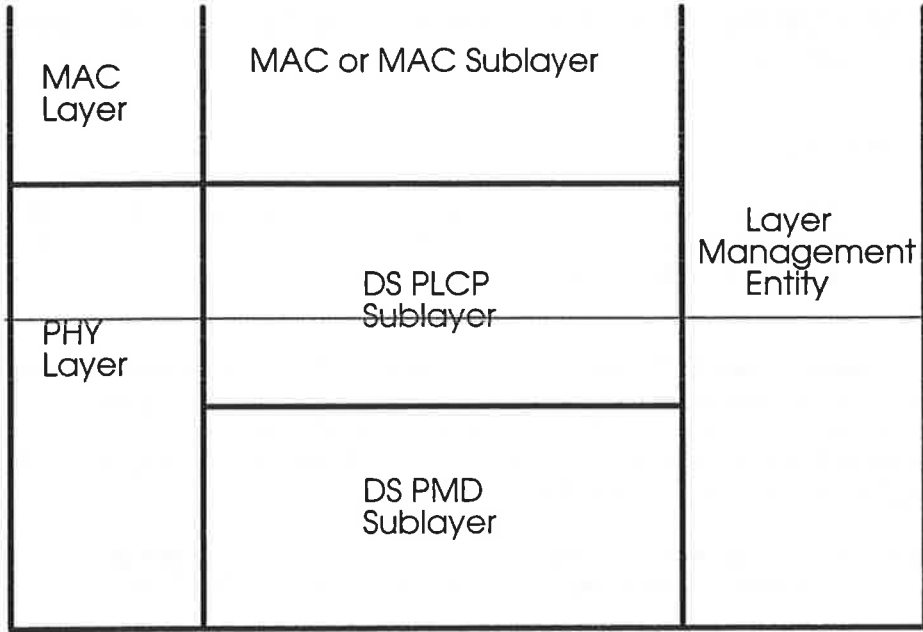
MAC Layer	MAC or MAC Sublayer		
PHY Layer	DS PLCP Sublayer	Layer Management Entity
	DS PMD Sublayer	

MAC	MAC	MAC Management	Station Management
	Convergence Layer		
PHY	Medium Dependent Layer		

Figure 12-1: Protocol Reference Model

12.1.2.1.   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.

12.1.2.2.   Physical Medium Dependent Sublayer

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

12.1.2.3.   Physical Layer Management Entity (LME)

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

12.1.3. 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
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
~~PPDU~~	~~PHY Protocol Data Unit~~
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)
~~SAP~~	~~Service Access Point~~
TXE	Transmit Enable

12.1.4. 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 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.

12.2. DSSS Physical Layer Convergence Procedure Sublayer

12.2.1. Introduction

This section provides a convergence procedure in which MPDUs are converted to and from PPDUs. 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.

12.2.2. 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), CCITT CRC-16. Each of these fields shall be described in detail in section 12.2.3.
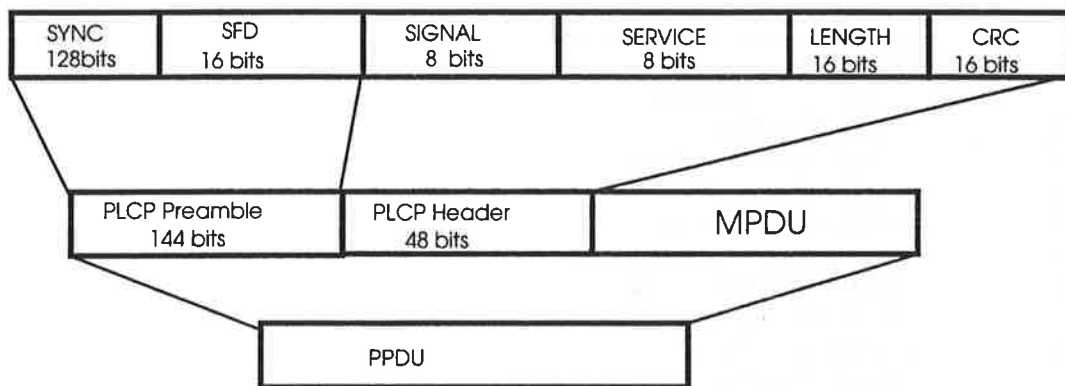

Figure 12-2: PLCP Frame Format

12.2.3. PLCP Field Definitions

The entire PLCP preamble and header shall be transmitted using the 1 Mb/sBPS DBPSK modulation described in section 12.4.7. All transmitted bits shall be scrambled using the feedthrough scrambler described in section 12.4.

12.2.3.1.   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.

12.2.3.2.   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 consist of a 16 bit field, hF3A0 (MSB to LSB). The LSB shall be transmitted first in time.

12.2.3.3.   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/sBPS DBPSK
     b)   h14 (MSB to LSB) for 2 Mb/sBPS DQPSK

The DSSS PHY rate change capability isdescribed in section 12.2.5. This field is protected by the CCITT CRC-16 frame check sequence described in section 12.2.3.6

12.2.3.4.   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 complianceThis field must be set to h00. 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.

12.2.3.5.   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_maximum [per 109.1.4.23]) to be transmitted in the MPDU. The transmitted value is provided by the LENGTH parameter in the PHY_DATA.request primitive described in section 98. 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.

12.2.3.6.   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, PLCP service, and Length fields for a DBPSK signal with a packet length of 192 would be given by the following:
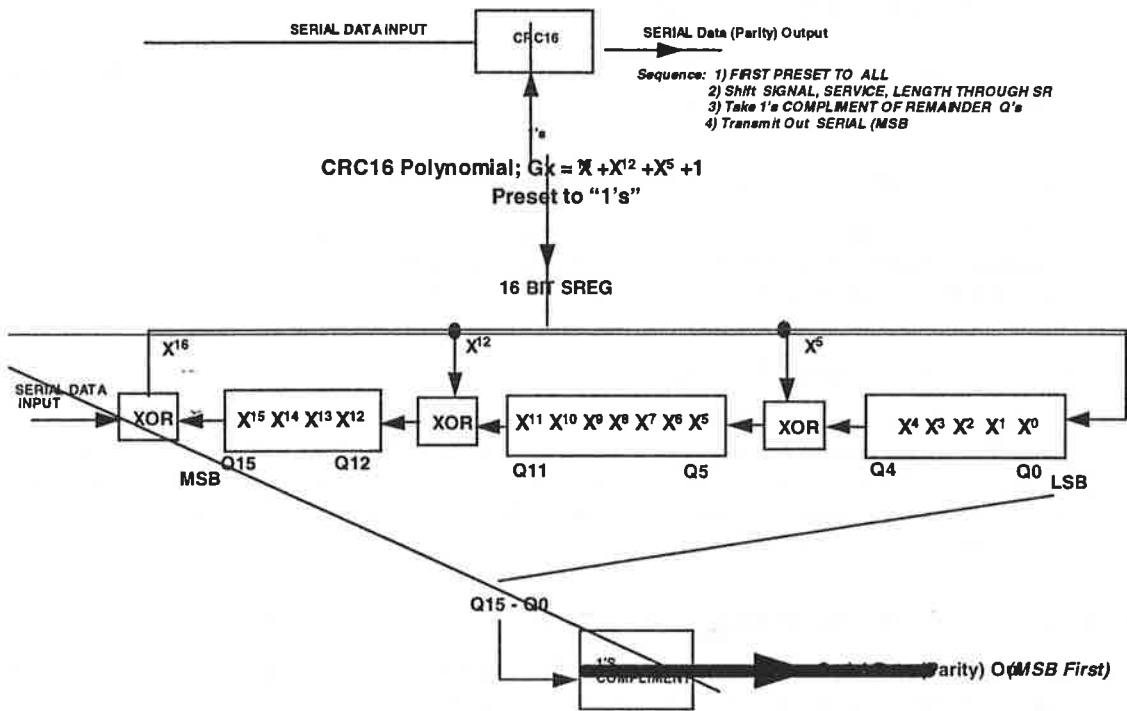
     0101 0000 0000 0000 0000 0011 0000 0000 (left most bit transmitted first in time)

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 12-3 depicts this example.

Transmit and Receive PLCP Header CRC16 Calculator

SERIAL DATA INPUT → CRC16 → SERIAL Data (Parity) Output

Sequence: 1) FIRST PRESET TO ALL
2) Shift SIGNAL, SERVICE, LENGTH THROUGH SR
3) Take 1's COMPLIMENT OF REMAINDER Q's
4) Transmit Out SERIAL (MSB

CRC16 Polynomial; $Gx = X + X^{12} + X^5 + 1$
Preset to "1's"

16 BIT SREG

SERIAL DATA INPUT → X^{16} XOR | X^{15} X^{14} X^{13} X^{12} | X^{12} XOR | X^{11} X^{10} X^9 X^8 X^7 X^6 X^5 | X^5 XOR | X^4 X^3 X^2 X^1 X^0

MSB   Q15   Q12   Q11   Q5   Q4   Q0   LSB

Q15 - Q0

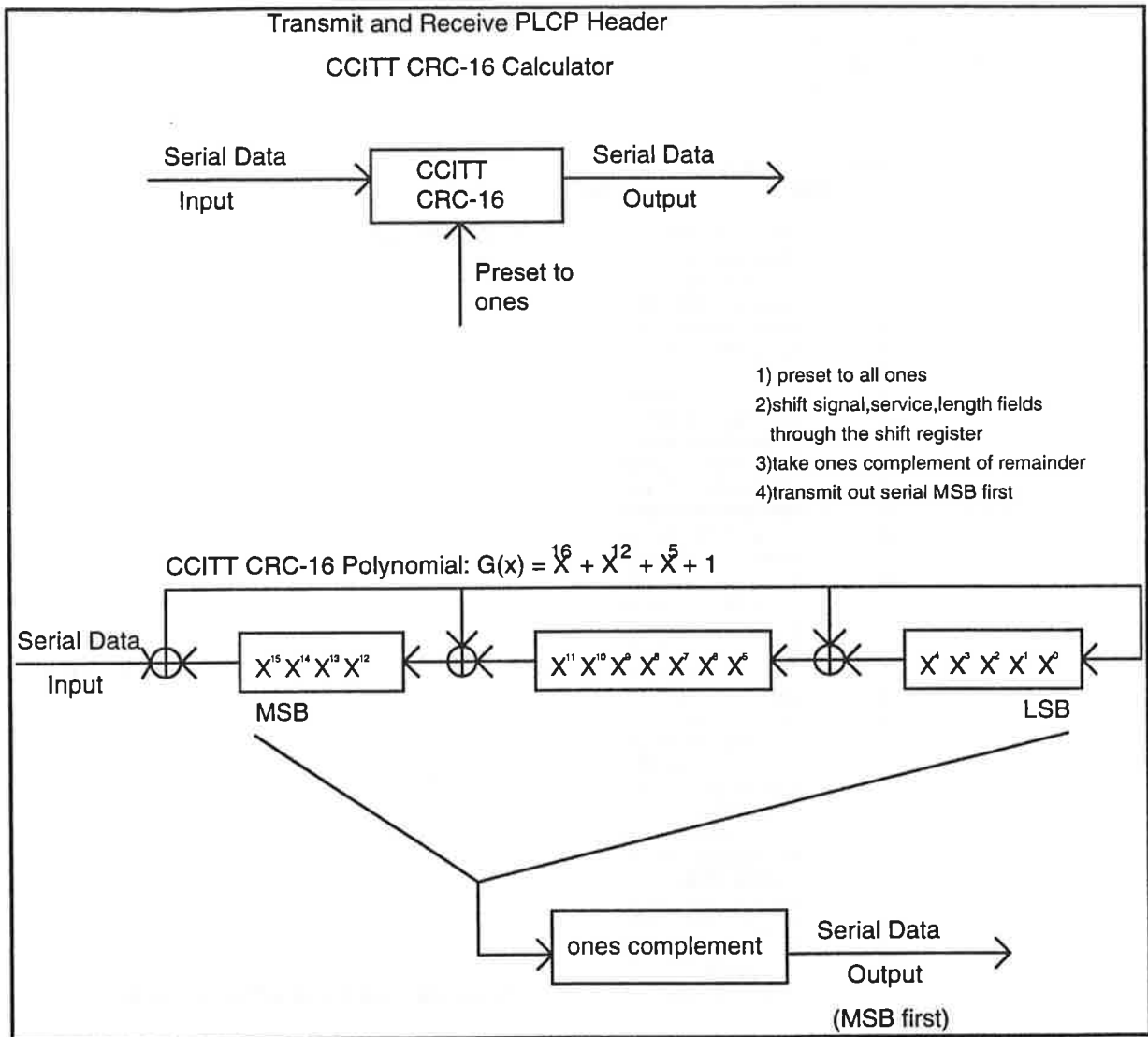1'S COMPLIMENT → (Parity) O(MSB First)

Figure 12-3: CCITT CRC-16 implementation

An illustrative programming example using the above of the CCITT CRC-16 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("      ");
        fprintb(stdout, residue,16);              ;binary print function
        printf("\n");
        for I=0; I<32; I++) {
                fdbd = (residue >> 15) ^ data[i];
                residue = (2 * residue) & 0xFFFF;
                if (fdbk) residue ^=0x1021;
                printf ("%d   ",data[i] );
                fprintb (stdout, residue, 16);
```

```
                    printf ("\n"); }
          residue ^= 0xFFFF;
          printf ("CRC parity        ");
          fprintb (stdout, residue,16);
          printf ("\n"); }
```

Data	Register		
	MSB		LSB
	1111111111111111		; Initialize Preset to 1's
0	1110111111011111		
1	1101111110111110		
0	1010111101011101		
1	0101111010111010		
0	1011110101110100		
0	0110101011001001		
0	1101010110010010		
0	1011101100000101		
0	0110011000101011		
0	1100110001010110		
0	1000100010001101		
0	0000000100111011		
0	0000001001110110		
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		
	0101101101010111		; 1's Complement, Result = CRC FCS Parity

12.2.4. PLCP / DS PHY Data Scrambler and Descrambler

The polynomial $1 + z^{-4} + z^{-7} + z^{-4} + 1$ 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 either transmit or receive processing. Figures 12-3 and 12-4 show typical implementations of the data scrambler and descrambler. Other implementations are possible.

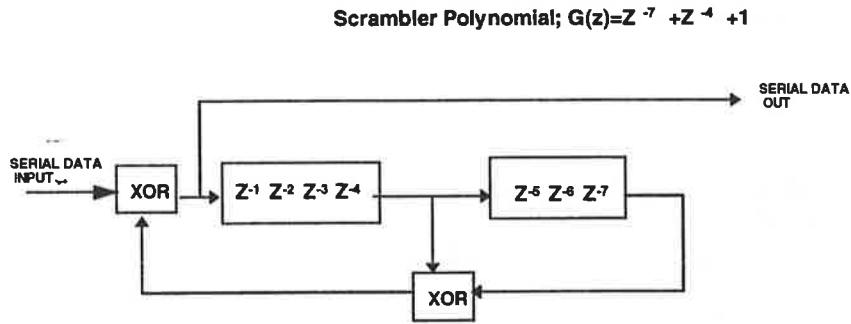The scrambler should be initialized to any state except all ones when transmitting.

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

Figure 12-3: Data Scrambler

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

SERIAL DATA INPUT

Z-1 Z-2 Z-3 Z-4   Z-5 Z-6 Z-7

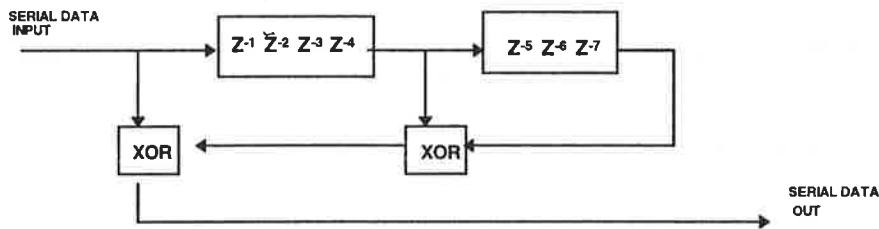XOR   XOR

SERIAL DATA OUT

Figure 12-4: Data Descrambler

12.2.5. PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mb/ps 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.

12.2.6. PLCP Transmit Procedure

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

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 PLCP header parameters SIGNAL, SERVICE and LENGTH and the PMD pParameters of ANT_STATE, CHNL_ID, and TXPWR_LEVEL. ~~LENGTH, ANTSEL, RATE (SIGNALING), SERVICE, CHNL_ID, and TXPWR_LEVEL.~~

The PLCP will issue PMD_ANTSEL, PMD_RATE, PMD_SERVICE, PMD_CHANNELCHNL_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 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) issued by the MAC and PHY_DATA.confirm primitives. 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 PMD_DATA.request primitives. 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 DSSS 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.
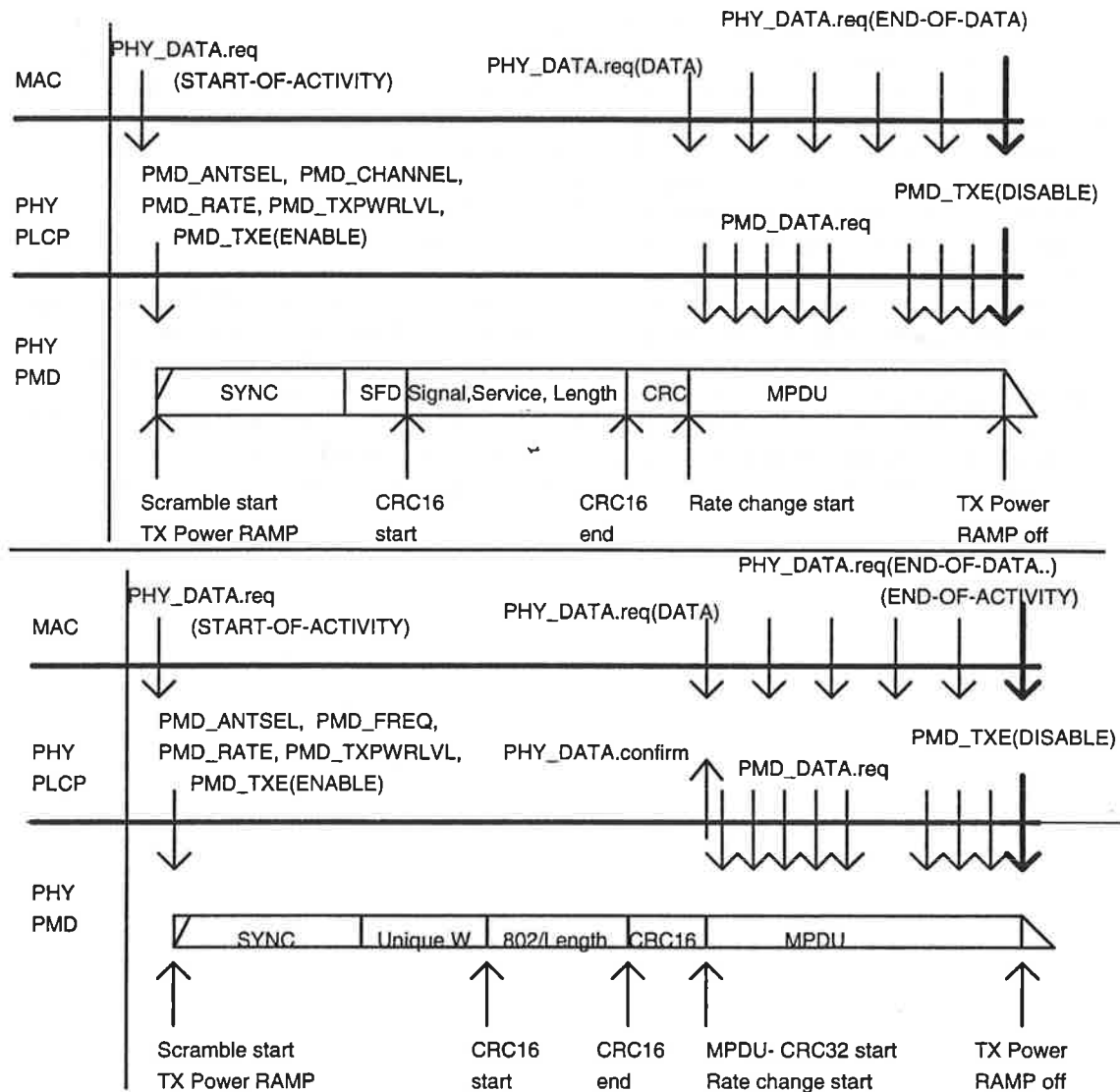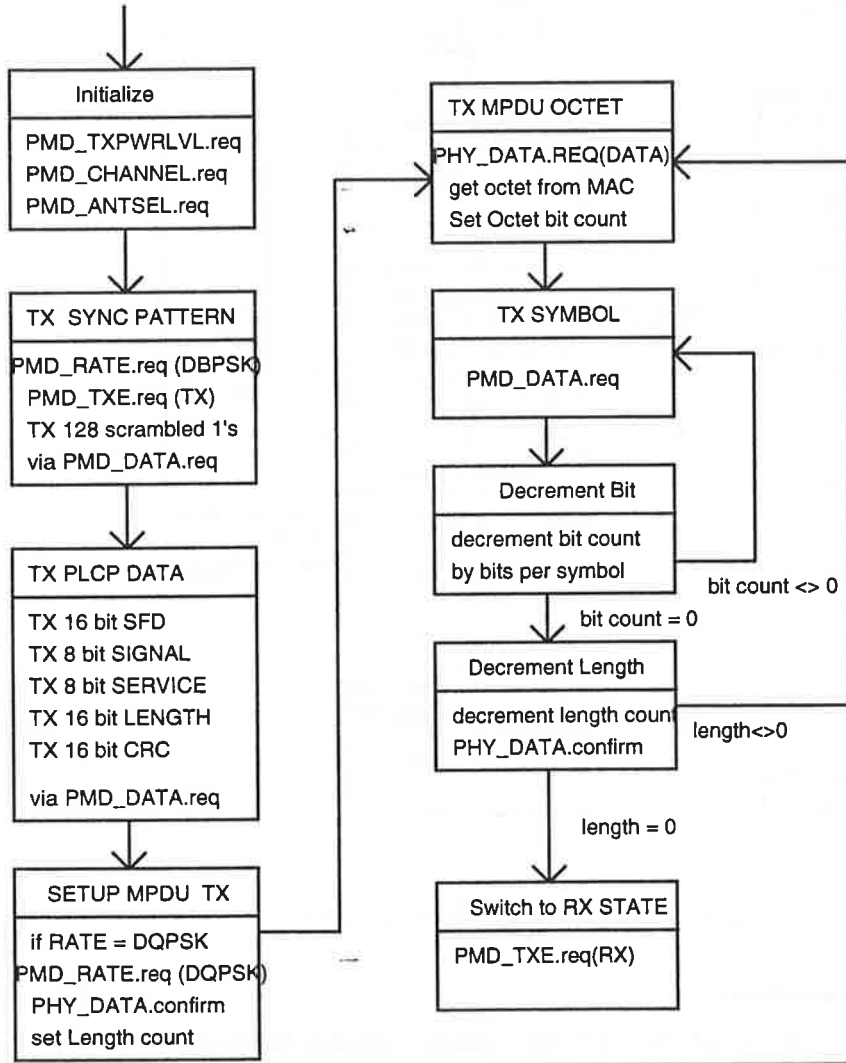
Figure 12-5: PLCP Transmit Procedure

12.2.6.1.   Transmit State Machine

A typical state machine implementation of the PLCP transmit procedure is provided in Figure 12-6.
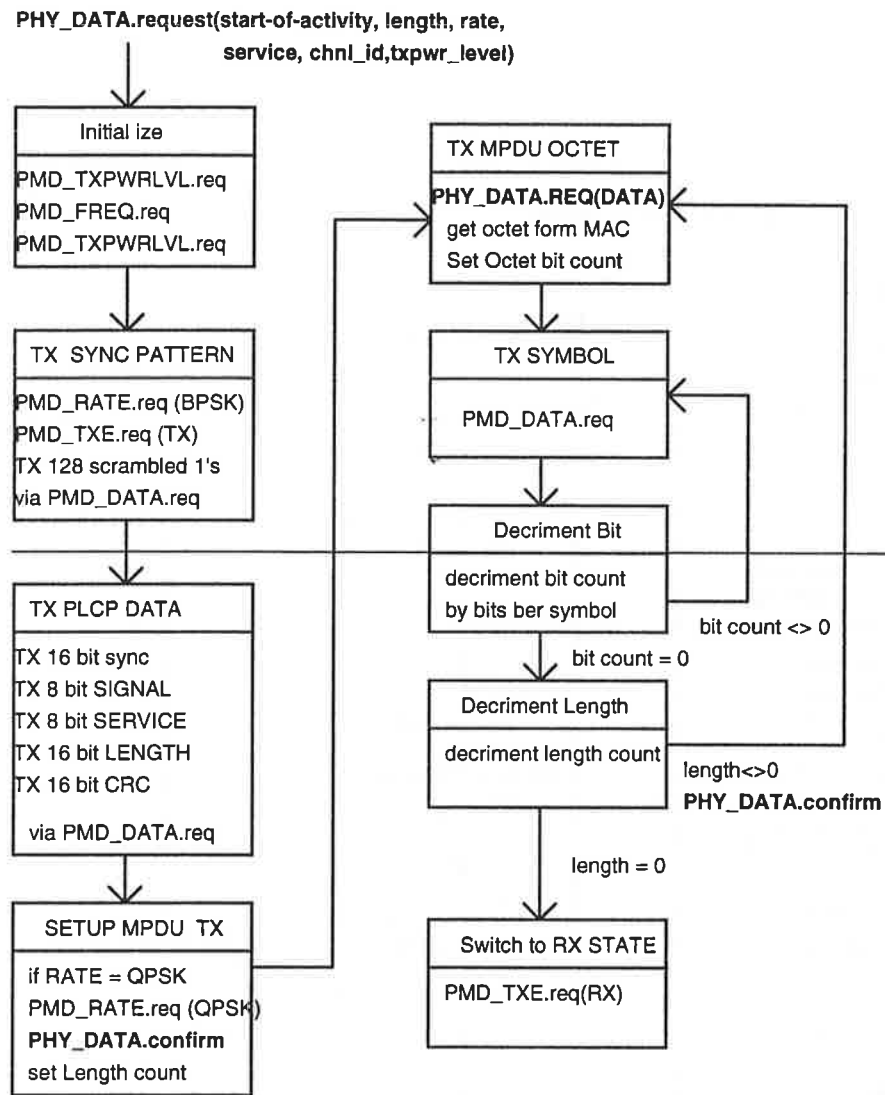
PHY_DATA.request(start-of-activity, Txvector)

```
┌─────────────────────┐
│     Initialize      │
├─────────────────────┤
│ PMD_TXPWRLVL.req    │
│ PMD_CHANNEL.req     │
│ PMD_ANTSEL.req      │
└─────────────────────┘

┌─────────────────────┐
│  TX  SYNC PATTERN   │
├─────────────────────┤
│ PMD_RATE.req (DBPSK)│
│ PMD_TXE.req (TX)    │
│ TX 128 scrambled 1's│
│ via PMD_DATA.req    │
└─────────────────────┘

┌─────────────────────┐
│    TX PLCP DATA     │
├─────────────────────┤
│ TX 16 bit SFD       │
│ TX 8 bit SIGNAL     │
│ TX 8 bit SERVICE    │
│ TX 16 bit LENGTH    │
│ TX 16 bit CRC       │
│                     │
│ via PMD_DATA.req    │
└─────────────────────┘

┌─────────────────────┐
│   SETUP MPDU  TX    │
├─────────────────────┤
│ if RATE = DQPSK     │
│ PMD_RATE.req (DQPSK)│
│ PHY_DATA.confirm    │
│ set Length count    │
└─────────────────────┘
```

```
┌─────────────────────┐
│   TX MPDU OCTET     │
├─────────────────────┤
│ PHY_DATA.REQ(DATA)  │
│ get octet from MAC  │
│ Set Octet bit count │
└─────────────────────┘

┌─────────────────────┐
│     TX SYMBOL       │
├─────────────────────┤
│  PMD_DATA.req       │
└─────────────────────┘

┌─────────────────────┐
│   Decrement Bit     │
├─────────────────────┤
│ decrement bit count │
│ by bits per symbol  │
└─────────────────────┘
              bit count <> 0
     bit count = 0

┌─────────────────────┐
│  Decrement Length   │
├─────────────────────┤
│ decrement length coun│
│ PHY_DATA.confirm    │    length<>0
└─────────────────────┘

     length = 0

┌─────────────────────┐
│  Switch to RX STATE │
├─────────────────────┤
│ PMD_TXE.req(RX)     │
└─────────────────────┘
```

PHY_DATA.request(start-of-activity, length, rate,
service, chnl_id,txpwr_level)

Initialize

PMD_TXPWRLVL.req
PMD_FREQ.req
PMD_TXPWRLVL.req

TX SYNC PATTERN

PMD_RATE.req (BPSK)
PMD_TXE.req (TX)
TX 128 scrambled 1's
via PMD_DATA.req

TX PLCP DATA

TX 16 bit sync
TX 8 bit SIGNAL
TX 8 bit SERVICE
TX 16 bit LENGTH
TX 16 bit CRC

via PMD_DATA.req

SETUP MPDU TX

if RATE = QPSK
PMD_RATE.req (QPSK)
PHY_DATA.confirm
set Length count

TX MPDU OCTET

PHY_DATA.REQ(DATA)
get octet form MAC
Set Octet bit count

TX SYMBOL

PMD_DATA.req

Decriment Bit

decriment bit count
by bits ber symbol

bit count <> 0

bit count = 0

Decriment Length

decriment length count

length<>0
PHY_DATA.confirm

length = 0

Switch to RX STATE

PMD_TXE.req(RX)

Figure 12-6: PLCP Transmit State Machine

12.2.7. PLCP Receive Procedure

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

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 12.4.8.4) as the RSSI strength reaches the ED_THRESHOLD. 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 PMD_CS will be enabled. Based on the CCA (see section 12.4.8.4) 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 SFDUnique Word field. Once the SFDUnique word 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, a PHY-DATA.indicate(END-OF-DATA) primitive will be issued and the PHY receiver will-be resetreturn to the Rx Idle state as depicted in Figure 12-8. 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 12.2.5. The PHY proceeds with MPDU reception. Reception is terminated aAfter 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. Depending on the state of energy detection and code lock, either A PHY_-DATA.indicate(END-OF-DATA, no_error) primitive is issued. orA PHY_-DATA.indicate(END-OF-ACTIVITY) primitive is issued following a change in PMD_CS or PMD_ED. 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.
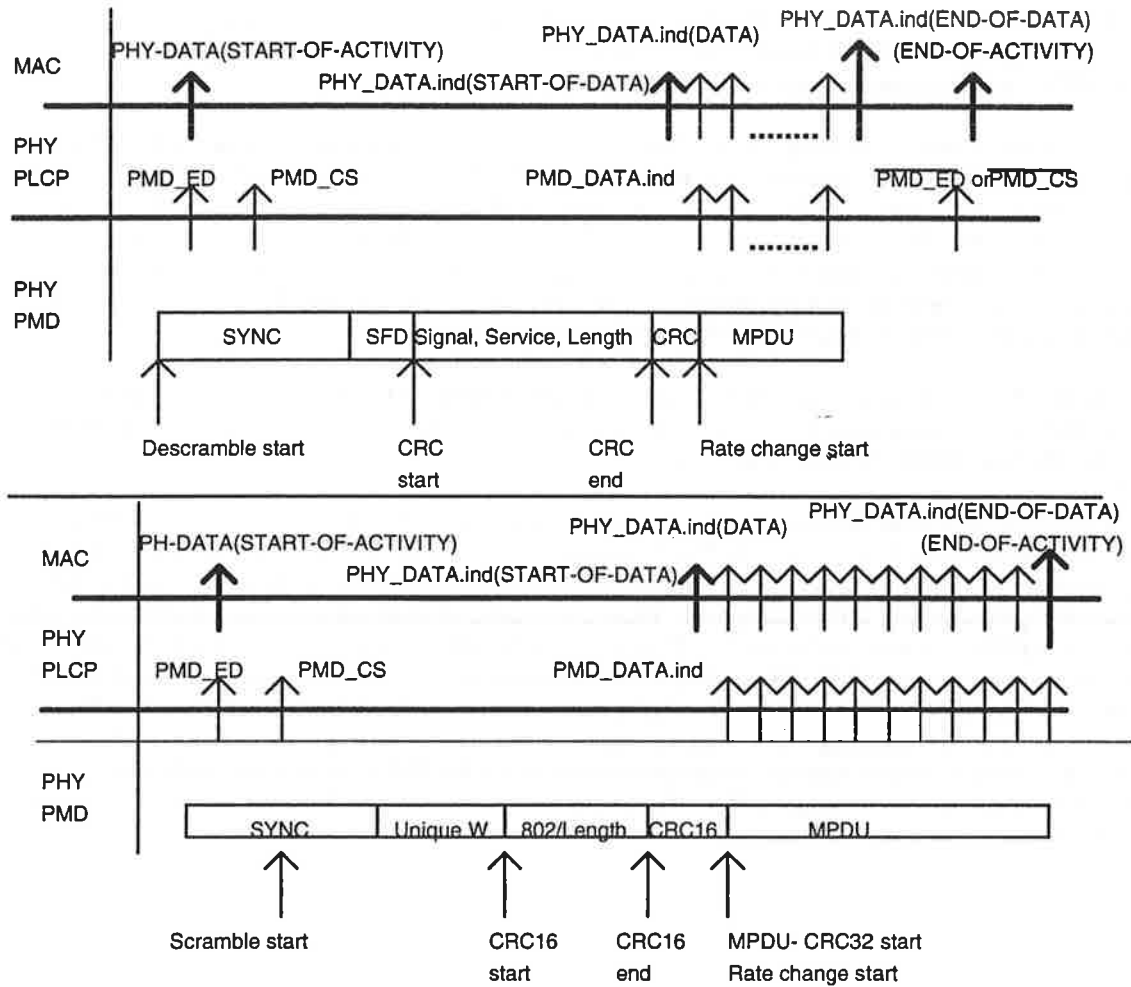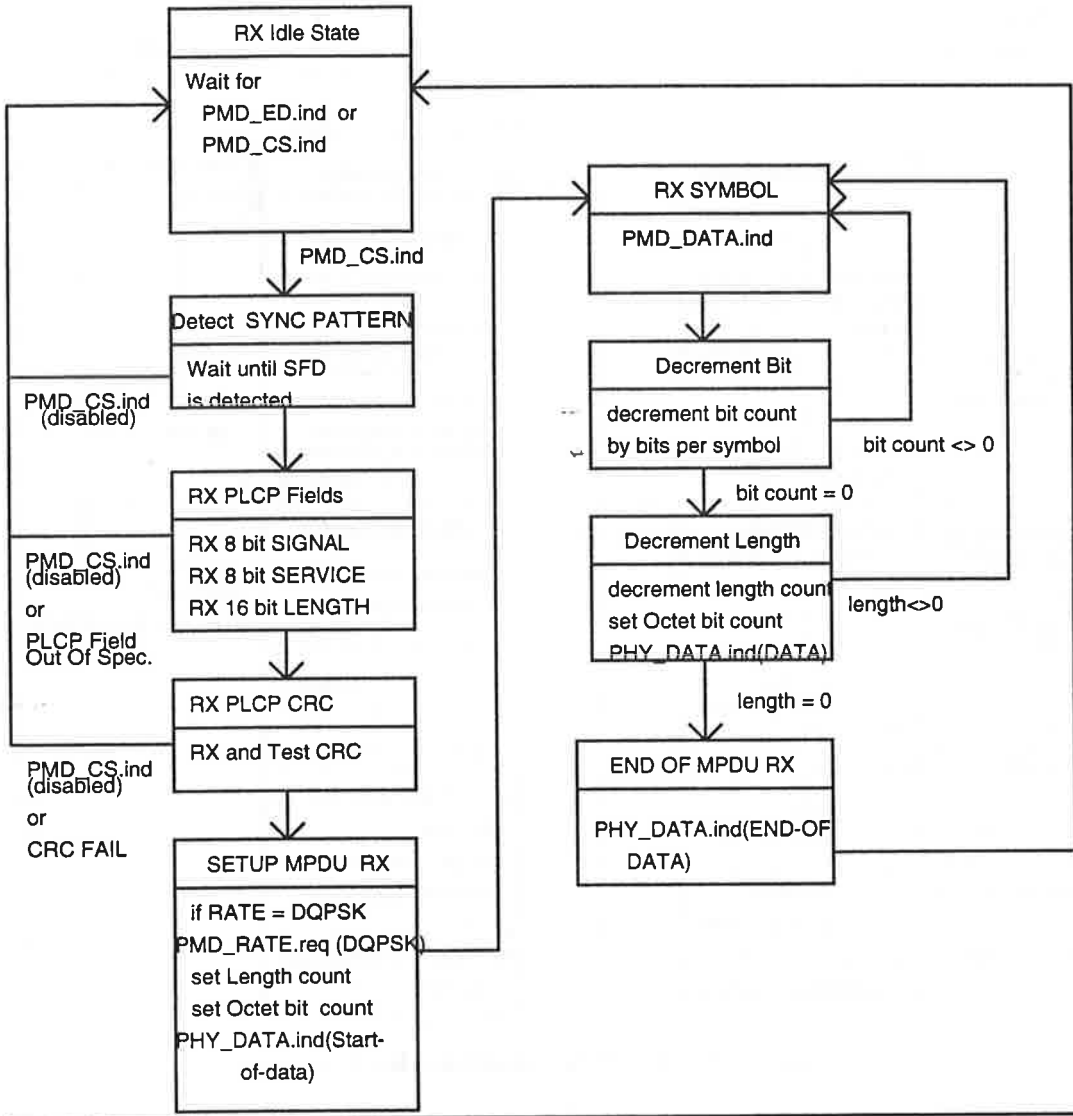
Figure 12-7: PLCP Receive Procedure

12.2.7.1.　　　Receive State Machine

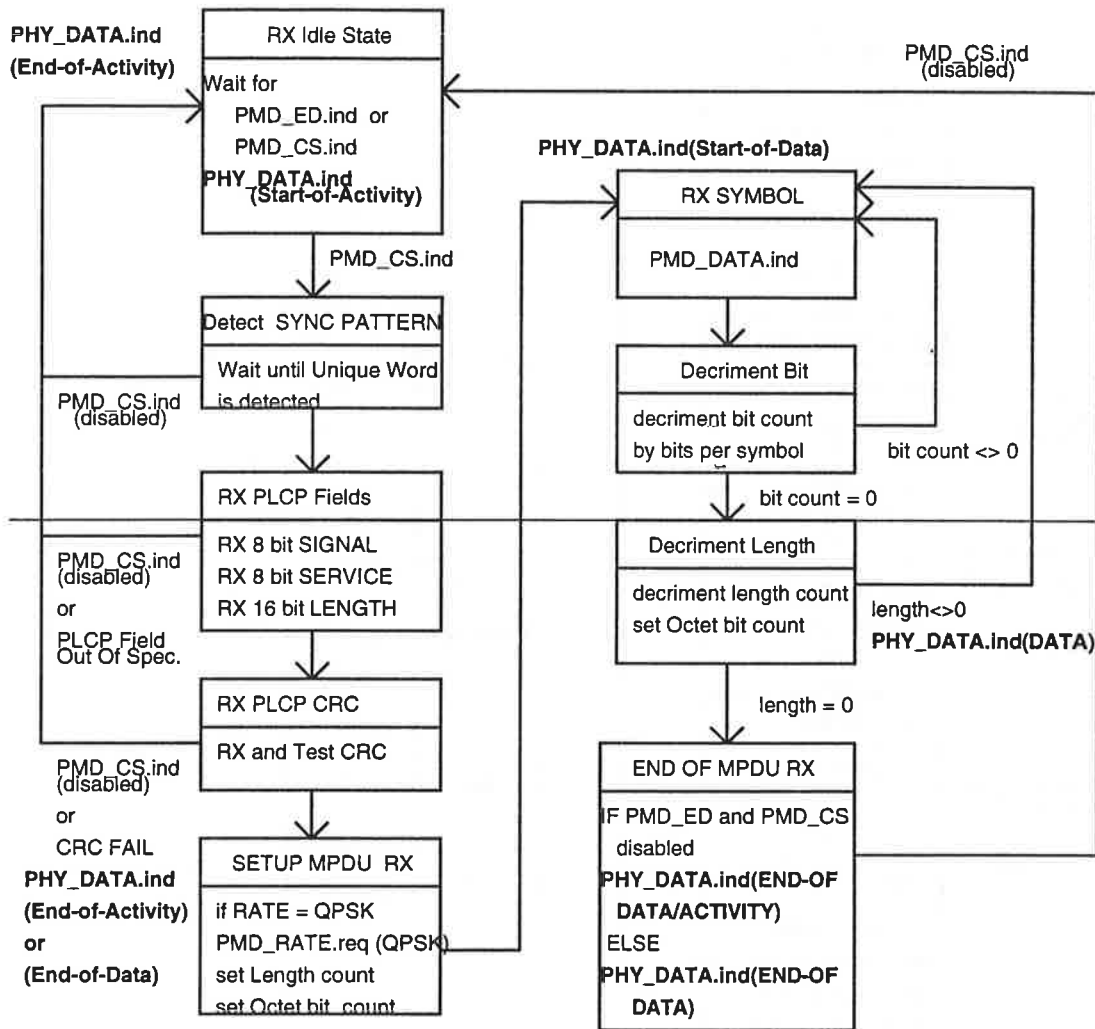A typical state machine implementation of the PLCP transmit procedure is provided in Ffigure 12-8.

RX Idle State

Wait for
PMD_ED.ind or
PMD_CS.ind

PMD_CS.ind

Detect SYNC PATTERN

Wait until SFD
is detected

PMD_CS.ind
(disabled)

RX PLCP Fields

RX 8 bit SIGNAL
RX 8 bit SERVICE
RX 16 bit LENGTH

PMD_CS.ind
(disabled)
or
PLCP Field
Out Of Spec.

RX PLCP CRC

RX and Test CRC

PMD_CS.ind
(disabled)
or
CRC FAIL

SETUP MPDU RX

if RATE = DQPSK
PMD_RATE.req (DQPSK)
set Length count
set Octet bit count
PHY_DATA.ind(Start-
of-data)

RX SYMBOL

PMD_DATA.ind

Decrement Bit

decrement bit count
by bits per symbol

bit count <> 0

bit count = 0

Decrement Length

decrement length count
set Octet bit count
PHY_DATA.ind(DATA)

length<>0

length = 0

END OF MPDU RX

PHY_DATA.ind(END-OF
DATA)

Figure 12-8: PLCP Receive State Machine

12.3. DSSS Physical Layer Management Entity (PLME)

12.3.1. PLMEPHY_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
PLMEPHY_RESET	X		X	

Table 12-1: PLMEPHY_SAP Sublayer Management Primitives

12.3.2. PLMEPHY_SAP Management Service Primitive Parameters

There are currently no parameters associated with the PLMEPHY_SAP service primitives.

12.3.3. PLMEMPHY_ SAP Detailed Service Specification

12.3.3.1.   PLMEMPHY_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:

PLMEMPHY_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 default-receive state.

12.3.3.2.   PLMEMPHY_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:

PLMEMPHY_RESET.confirm

There are no parameters associated with this primitive.

When Generated

This primitive is generated as a response to the PLMEMPHY_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.

12.3.4. 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.

All DSSS Physical Layer Management Information Base variables are defined in Section 10 with specific values defined in section 12.5.

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 antennaes
Antennna_Diversity_Control	0x00 = on, 0xYY = dedicated antenna #YY	Dynamic	Diversity on will use all antennaes, 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 part-
...	...	Static	icular geographic area
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

12.4. DSSS Physical Medium Dependent Sublayer

12.4.1. 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.
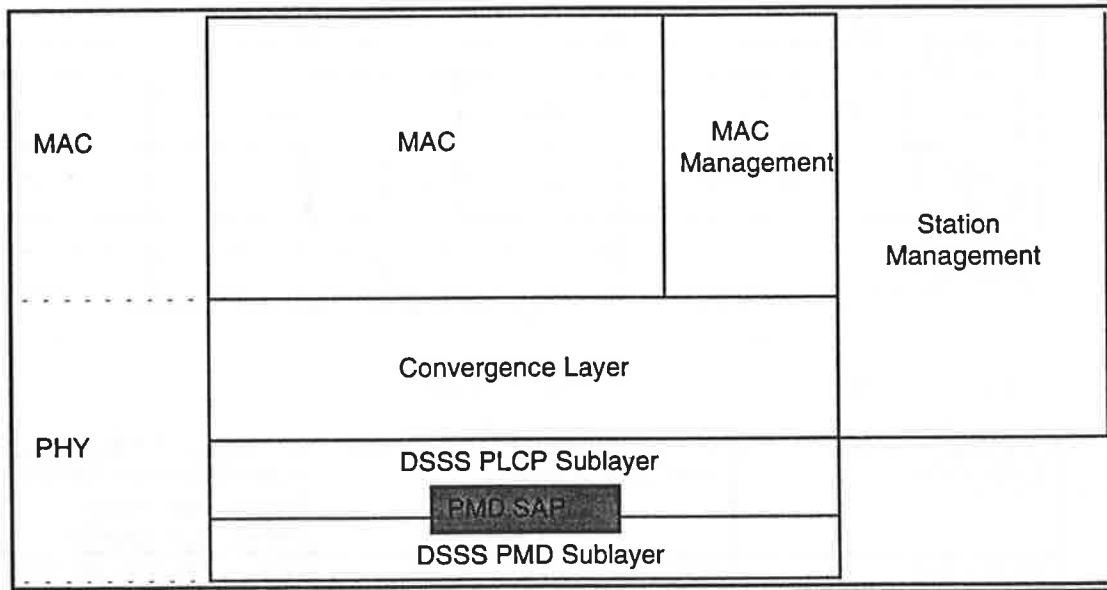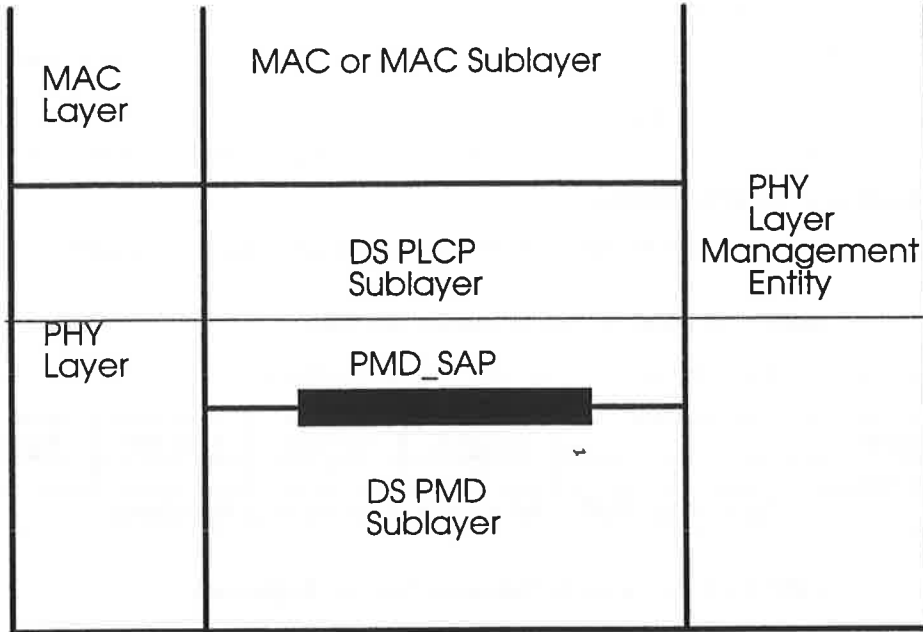
```
┌──────────┬──────────────────────────────────┬──────────────┐
│          │                                  │              │
│ MAC      │   MAC or MAC Sublayer            │              │
│ Layer    │                                  │              │
│          ├──────────────────────────────────┤ PHY          │
│          │                                  │ Layer        │
│          │   DS PLCP                        │ Management   │
│          │   Sublayer                       │ Entity       │
├──────────┼──────────────────────────────────┤              │
│ PHY      │   PMD_SAP                        │              │
│ Layer    │   ████████████████               │              │
│          │                                  │              │
│          │   DS PMD                         │              │
│          │   Sublayer                       │              │
│          │                                  │              │
└──────────┴──────────────────────────────────┴──────────────┘
```

```
┌──────┬────────────────────────┬─────────────┬──────────────┐
│      │                        │             │              │
│ MAC  │      MAC               │ MAC         │              │
│      │                        │ Management  │              │
│      │                        │             │ Station      │
│      ├────────────────────────┴─────────────┤ Management   │
│      │   Convergence Layer                  │              │
│ PHY  ├────────────────────────────────────  │              │
│      │   DSSS PLCP Sublayer                 │              │
│      │   ▓▓▓ PMD SAP ▓▓▓                    │              │
│      │   DSSS PMD Sublayer                  │              │
└──────┴──────────────────────────────────────┴──────────────┘
```

Figure 12-9 PMD Layer Reference Model

12.4.2. 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 similarlike functionality is provided for data transmission.

12.4.3. 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.

12.4.4. Basic Service and Options

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

12.4.4.1.　　　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 12-2: PMD_SAP Peer-to-Peer Service Primitives

12.4.4.2.　　　PMD_SAP Sublayer-to-Sublayer Service Primitives

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

Table 12-3: PMD_SAP Sublayer-to-Sublayer Service Primitives

12.4.4.3.　　　PMD_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
TXD_UNIT	PMD_DATA.request	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK
RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK
RF_STATE	PMD_TXE.request	Receive, Transmit
ANT_STATE	PMD_ANTSEL.indicate PMD_ANTSEL.request	1 to 256
DIV_CONTROL	PMD_DIVERSITY.request	On, Off
TXPWR_LEVEL	PMD_TXPWRLVL	0,1,2,3 (max of 4 levels)
CHNL_ID	PMD_CHANNELFREQ.request	1 to 121
RATE	PMD_RATE.indicate PMD_RATE.request	h0A for 1 Mb/sBPS DBPSK h14 for 2 Mb/sBPS DQPSK
RSSI	PMD_RSSI.indicate	0-7 bits of RSSI

SQ	PMD_SQ.indicate	0-7 bits of Signal Quality

Table 12-4: List of Parameters for the PMD Primitives

12.4.5. PMD_SAP Detailed Service Specification

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

12.4.5.1.   PMD_DATA.-request

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_DATA.request(TXD_UNIT)

The TXD_UNIT parameter takes on the value of either ONE(1) or ZERO(0) for DBPSK modulation or the di-bit combination 00, 01, 11, or 10 for DQPSK modulation. This parameter represents a single block of data which in turn 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.

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 coding, PN code modulation, and transmission of the data.

12.4.5.2.   PMD_DATA.indicate

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_DATA.indicate(RXD_UNIT)

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

When Generated·

This primitive generated by the PMD entity, forwards received data to the PLCP sublayer. The data clock for this primitive 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.

12.4.5.3.   PMDHY_TXE.requestindicate

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_TXE.request(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 after power up or after a reset.

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.

Effect of Receipt

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

12.4.5.4.   PMD_ANTSEL.request

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_ANTSEL.request(ANT_STATE)

ANT_STATE selects which of the available antennas should be used for transmit. The number of available antenna is determined by the PHY_INFO??? parameters NO_ANT. (Note: receive antenna selection, if any, is a function of the vendor implemented PHY.)

When Generated

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

Effect of Receipt

PMD_ANTSEL immediately selects the antenna specified by ANT_STATE.

12.4.5.5.   PMD_ANTSEL.indicate

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_ANTSEL.indicate(ANT_STATE)

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

When Generated

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

Effect of Receipt

PMD_ANTSEL immediately reports the antenna specified by ANT_STATE.

12.4.5.6.   PMD_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:

PMD_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**

PMD_DIVERSITY immediately alters the receive state machine to operate according the DIV_CONTROL.

12.4.5.7.   PMD_TXPWRLVL.request

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_TXPWRLVL.request(TXPWR_LEVEL)

TXPWR_LEVEL selects which of the optional transmit power levels should be used for the current packet transmission. The number of available power levels 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 PMD_TXE into the transmit state.

Effect of Receipt

PMD_TXPWRLVL immediately sets the transmit power level given by TXPWR_LEVEL.

12.4.5.8.   PMD_FREQCHANNEL.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:

PMD_CHANNELFREQ.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, frequency.

Effect of Receipt

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

12.4.5.9.   PMD_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:

PMD_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 PMD_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.

12.4.5.10.   PMD_RATE.indicate

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_RATE.indicate(RATE)

In receive mode, the RATE parameter informs the PLCP layer which of the DSSS PHY data rates was used to process the MPDU portion of the PPDU. 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.

12.4.5.11.   PMD_RSSI.indicate

Function

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

Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_RSSI.indicate(RSSI)

The RSSI 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.

12.4.5.12.   PMD_SQ.indicate

Function

This 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:

PMD_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.

12.4.5.13.   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.

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 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.

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 PMD_CS is ENABLED.

12.4.5.14.   PMD_ED.indicate

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.

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.

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 PMD_CS function will be enabled shortly after the PMD_ED function is enabled.

12.4.6. 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.

12.4.6.1.   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.

~~Additional frequency bands will follow as they are made available.~~

12.4.6.2.   Number of Operating Channels

For the 2.4 to 2.4835 GHz frequency band, 11channels are specified. The channel center frequencies and CHNL_ID numbers shall be as shown in Table 12.5 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.

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 12-5: DSSS 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. Channel 12 is designated specifically for operation in Japan.

12.4.6.3.   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.

12.4.6.4.   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 BPS DBPSK modulation. The DBPSK encoder is specified in Table 12.6. The Enhanced Access Rate is based on 2 Mb/s BPS DQPSK. The DQPSK encoder is specified in Table 12.7. (In the tables, $+j\omega$ is defined as counterclockwise rotation.)

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

Table 12-6: 1 Mb/s BPS DBPSK   Encoding Table

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

Table 12-7: 2 Mb/s BPS DQPSK   Encoding Table

12.4.6.5.   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.

12.4.6.6.   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. The CCA should occur within 25 usec (10 usec for turnaround time plus 15 usec for energy detect) or by the next slot boundery occuring 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.

12.4.6.7.   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.

12.4.6.8.   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.

12.4.6.9. ──Transmit and Receive Antenna Port Impedance

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

12.4.6.10.──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.

12.4.7.─ PMD Transmit Specifications

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

12.4.7.1.   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 12-8.4.7. 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 12-8: Transmit Power Levels

12.4.7.2.   Minimum Transmitted Power Level

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

12.4.7.3.   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.

12.4.7.4.   Transmit Spectrum Mask

The tTransmitted spectral products shall be less than -30 dBr (dB relative to the SINx/x peak) for f_c -22 MHz < f < f_c -11 MHz and f_c +11 MHz < f < f_c + 22 MHz and - 50 dBr for f < f_c -22 MHz and f > f_c + 22 MHz where f_c is the channel center frequency. The tTransmit spectral mask is shown in figure 12-10. The measurements shall be made using 100 KHz resolution bandwidth.
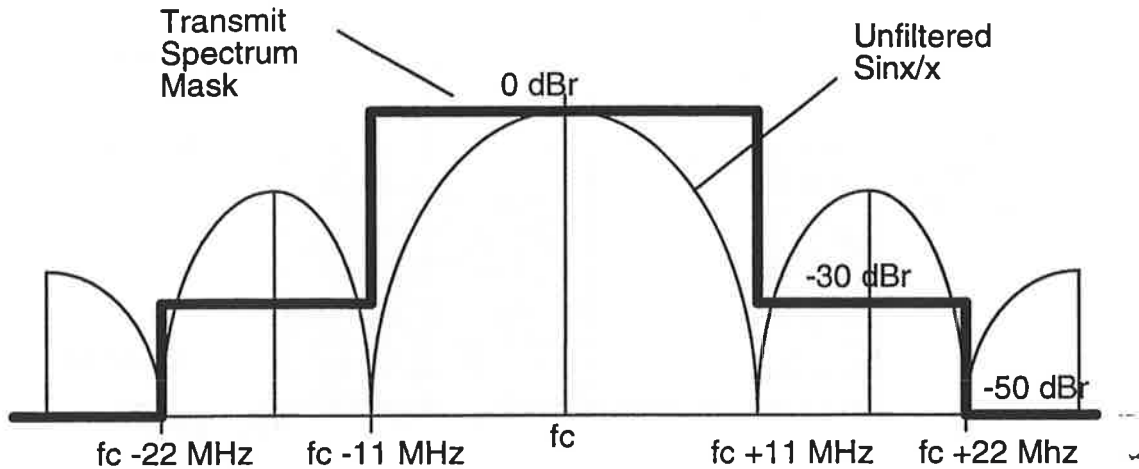
Figure 12-10: Transmit Spectrum Mask

12.4.7.5.   Transmit Center Frequency Tolerance

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

12.4.7.6.   Chip Clock Frequency Tolerance

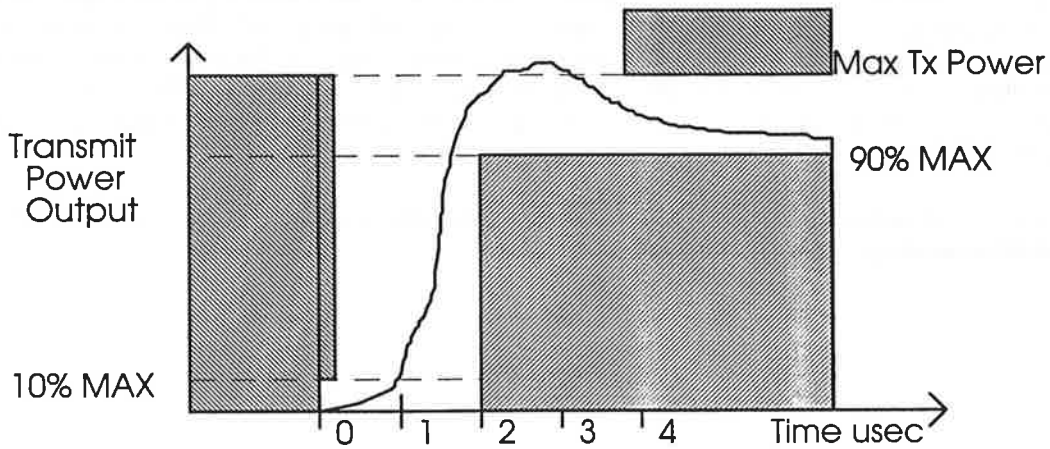The PN code chip clock frequency tolerance shall be better than +/- 25ppm maximum.

12.4.7.7.   Transmit Power On and Power Down Ramp

The tTransmit 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 tTransmit 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.
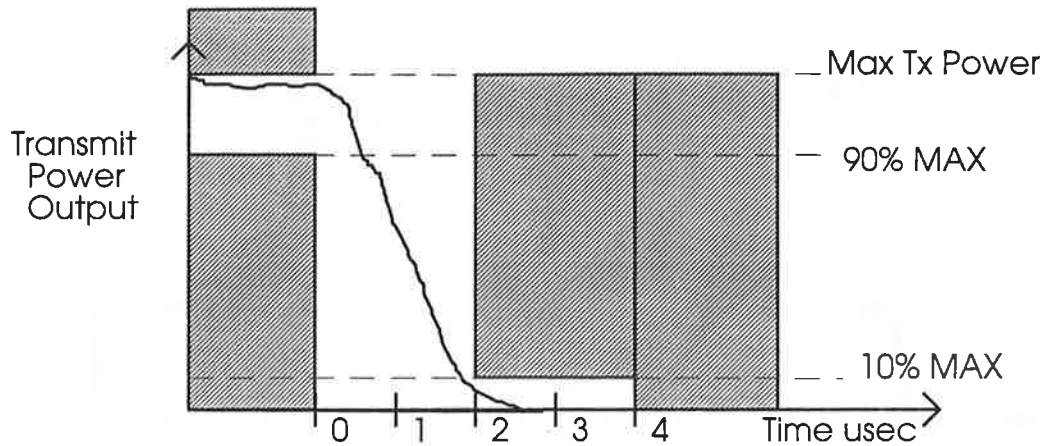
Figure 12-12: Transmit Power Down Ramp

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.

12.4.7.8.   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 cCarrier sSuppression 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.

12.4.7.9.   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.
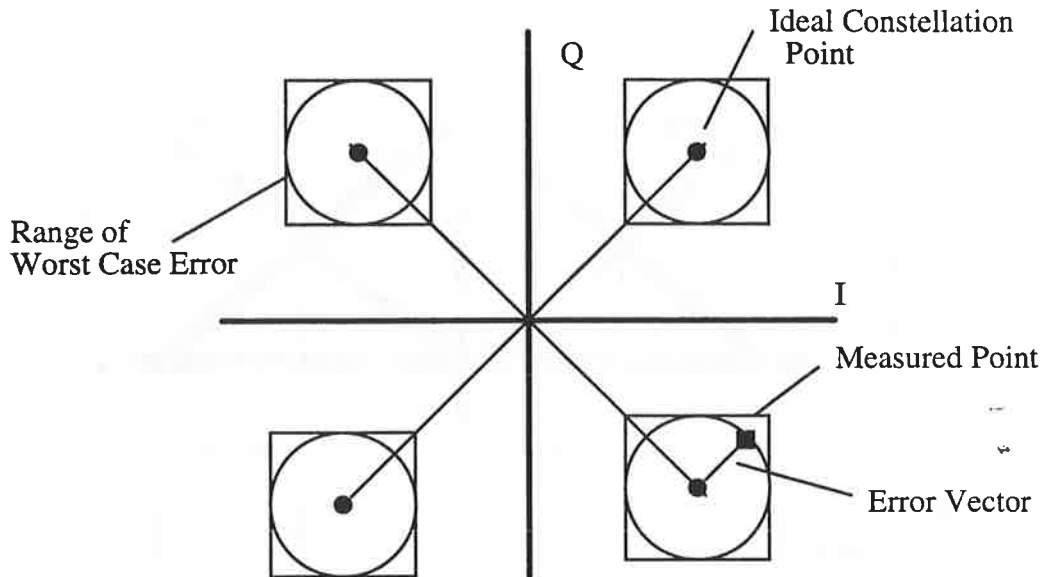
Q

Ideal Constellation
Point

Range of
Worst Case Error

I

Measured Point

Error Vector

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.
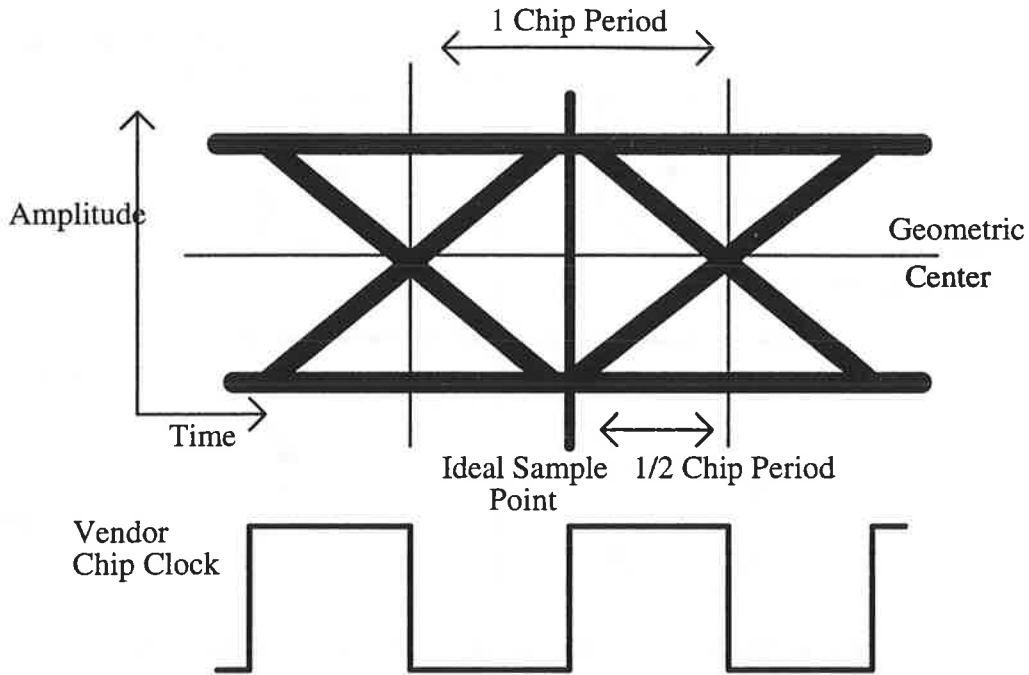
Figure 12-14: Chip Clock Alignment with Baseband Eye pattern

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.

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

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

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

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

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

Calculate the average magnitude of I and Q samples.

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

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

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

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

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

12.4.8. -PMD Receiver Specifications

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

12.4.8.1.   Receiver Minimum Input Level Sensitivity

The FrameError Rate (FER) shall be less than $8*10^{-3}$ 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 Mb/sBPS 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 less than or equal to -80 dBm.

12.4.8.2.   Receiver Maximum Input Level

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

12.4.8.3.   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 $8*10^{-3}$ using 2 Mb/sBPS DQPSK modulated with the 11chip Barker spreading code.

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

Input a 2 Mb/sBPS DQPSK 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 12.4.7.3 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 $8*10^{-3}$.

12.4.8.4.   Clear Channel Assessment

The DSSS 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 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 is allowed to~~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 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 occuring after the 15 usec has elapsed. This implies that the CCA signal is available as an exposed test point.

    c)   The CCA state machine shall be reset upon transition from the TX state to the RX state.

Conformance to DS<u>SS</u> PHY CCA shall be demonstrated by applying <u>a DSSS compliant signal</u>~~continuous and pulsed CW~~ (above and below the appropriate energy detect threshold)~~and DS PHY compliant signals~~ such that all conditions described above are demonstrated.

12.5. MIB Value Table

Managed Object	Default Value / Range	Operational Semantics
agPhyOperation_grp		
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
agPhyRate_grp		
aSuprt_Data_Rates	00,01,02	Static
aMPDU_Maximum_Length	$2^{16} - 1$	Static
agPhyAntenna_grp		
aSuprt_Tx_Antennas	implementation dependent	Static
aCurrent_Tx_Antenna	implementation dependent	Dynamic
aSuprt_Rx_Antennas	implementation dependent	Static
aDiversity_Suprt	implementation dependent	Static
aDiversity_Slct_Rx	implementation dependent	Dynamic
agPhyTxPwr_grp		
aNbr_Suprtd_Pwr_Lvls	implementation dependent	Static
aTx_Pwr_Lvl1	implementation dependent	Static
aTx_Pwr_Lvl2	implementation dependent	Static
aTx_Pwr_Lvl3	implementation dependent	Static
aTx_Pwr_Lvl4	implementation dependent	Static
aTx_Pwr_Lvl5	implementation dependent	Static
aTx_Pwr_Lvl6	implementation dependent	Static
aTx_Pwr_Lvl7	implementation dependent	Static
aTx_Pwr_Lvl8	implementation dependent	Static
aCurrent_Tx_PwrLvl	implementation dependent	dynamic
agPhyStatus_grp		
aSynthesizer_Locked	not applicable	n/a