IEEE 802.11
Wireless Access Methods and Physical Layer Specifications

TITLE: Physical Layer Draft Specification
for
2.4GHz Direct Sequence Spread Spectrum Media

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Introduction

This paper contains the Working Draft Standard for the Direct Sequence Spread Spectrum Physical Layer. In this is included the Direct Sequence Spread Spectrum PMD and PLCP.

IEEE Project 802.11

Wireless Local Area Networks

Proposed Standard:

Physical Layer Specifications
for
2.4 GHz Direct Sequence Spread Spectrum
Wireless LAN

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1. Introduction

1.1 Scope

This document describes the physical layer services provided by the 802.11 wireless LAN MAC for the 2.4 GHz Direct Sequence Spread Spectrum (DS) system. The DS PHY layer consists of two protocol functions as follows:

1. 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 nodes using the associated physical medium dependent system.
2. A Physical Medium Dependent (PMD) system whose function defines the characteristics of, 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.

1.2 DSSS Physical Layer Functions

The 2.4 GHz DS PHY architecture is shown in Figure 1-1. 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 entity at the node through a Service Access Point (SAP) as shown in Figure 1-1 called the PHY_SAP. A set of primitives will also be defined to describe the interface between the physical layer convergence protocol sublayer and the physical medium dependent sublayer called the PMD_SAP.

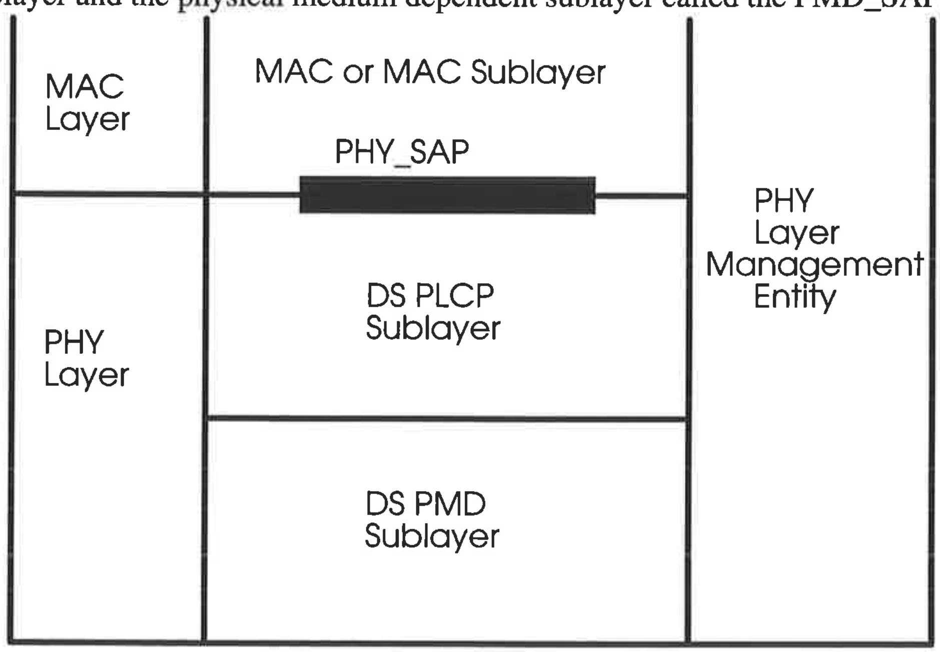

Figure 1-1 Protocol Reference Model

1.2.1 Physical Layer Convergence Procedure Sublayer

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

1.2.2 Physical Medium Dependent Sublayer

The physical medium dependent sublayer provides a transmission to send or receive data between two or more nodes. In this case, the 2.4 GHz ISM bands using Direct Sequence modulation.

1.2.3 Physical Layer Management Entity (LME)

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

1.3 Definitions

This section defines the terms used in this standard. Words in *italics* indicate terms that are defined elsewhere in the lists of definitions

1.4 Acronyms

AMF	Available MAC Frame (transmit)
BPDU	Burst Protocol Data Unit
CRC	Cyclic Reducdancey Check
DBPSK	Differential Binary Shift Key
DQPSK	Differential Quadrature Shift Key
DS	Direct Sequence Spread Spectrum
FCS	Frame Check Sequence
LME	Layer Management Entity
MAC	Media Access Control
MDA	MAC Data Available (receive)
MPDU	MAC Protocol Data Unit
PDU	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)
SAP	Service Access Point
TXE	Transmit Enable

1.5 Service Specification Method and Notation

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

2. DS SS Physical Layer Service Specifications

[Editors note: the language in section 2 is a place holder. This section covers DS PHY template numbers 32, 33, and 34. These items are NOT CLOSED.]

2.1 Scope and Field of Application

This section specifies the services provided by the DS Physical Layer to the 802.11 MAC. These services are described in an abstract way and do not imply any particular implementation or exposed interface.

2.2 Overview of the Service

The DS Physical Layer function is separated into two sublayers: the DS PLCP sublayer and the DS PMD sublayer as shown in Figure 1-1. The function of the PLCP sublayer is to provide a mechanism for transferring MAC Protocol Data Units (MPDUs) between two or more nodes over the DS PMD sublayer. This is accomplished by the PLCP sublayer in the transmit direction by converting MPDUs into Burst Protocol Data Units (BPDUs). The formation of the BPDU is covered in section 3. In the receive direction, the PLCP is responsible for converting BPDUs back into MPDUs. The PLCP is also responsible for generation of the radio preamble at the beginning of the BPDU at the transmitting node. The radio header is used by the receiving node synchronization and BPDU signalling and service information necessary to recover the MPDU.

A number of PLCP services and parameters are passed directly to the PMD. These provide direct control of the PHY by the MAC without any translation at the PMD_SAP.

2.3 Overview of Interactions

The primitives associated with the 802.11 MAC sublayer to the DS PHY layer fall into two basic categories:

1. Service primitives that support MAC peer-to peer interactions (i.e. data transmission and reception)
2. Service primitives that have local significance and support sublayer-to-sublayer interactions

2.4 Basic Service and Options

All the service primitives described in this section are considered mandatory unless otherwise specified. In some cases, the provisions formultiple choices for a given parameter are provided for future expansion where only a single default choice will be required.

2.4.1 PHY_SAP Peer-to-Peer Service Primitives

Primitive	Request	Indicate	Confirm	Response
PHY_DATA	X	X		

Table 1 PHY_SAP Sublayer-to-Sublayer Service Primitives

2.4.2 PHY_SAP Sublayer-to-Sublayer Service Primitives

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

Primitive	Request	Indicate	Confirm	Response
PHY_INFO	X			
PHY_RXSETUP	X			

PHY_CS		X		
PHY_ED		X		
PHY_SETFREQ	X			
PHY_RXBUSY		X		
PHY_TXBUSY		X		

Table 2. PHY_SAP Sublayer-to-Sublayer Service Primitives

2.4.3 PHY_SAP Service Primitive Parameters.

The following table show the parameters used by one or more of the PMD_SAP Service Primitives.

Parameter	Associate Primitive	Value
LENGTH	PHY_DATA.indicate PHY_DATA.response	16 bit unsigned integer 0 - TBD MAX octets
TXDATA	PHY_DATA.request	0 - TBD data octets
RXDATA	PHY_DATA.indicate	0 - TBD data octets
TXPOWER	PHY_DATA.request	see section 4.5.5
ANTSEL	PHY_DATA.indicate PHY_DATA.request	see section 4.5.6
RATE	PHY_DATA.indicate PHY_DATA.request	16 bit unsigned integer see section 3
RSSI	PHY_DATA.indicate	TBD
SQ	PHY_DATA.indicate	TBD
ED_THRESHOLD	PHY_RXSETUP.request	TBD
SQ_THRESHOLD	PHY_RXSETUP.request	TBD
NOISE_LEVEL	PHY_DATA.indicate	TBD
ERROR	PHY_DATA.indicate	3 RX errors: NO_RATEMATCH PREAMCRC_FAIL LENGTH_FAIL
TYPE	PHY_INFO.request	Radio type: DS, IR, FH
NO_CHANNELS	PHY_INFO.request	see section 4.5.6
NO_TXPWRLVS	PHY_INFO.request	see section 4.5.5
NO_SQLVS	PHY_INFO.request	TBD
NO_RSSILVS	PHY_INFO.request	TBD
NO_TXANT	PHY_INFO.request	TBD (1 or 2)
NO_RXANT	PHY_INFO.request	TBD (1 or 2)
CHNL_ID	PHY_SETFREQ.indicate	TBD

Table 3. PHY_SAP Service Primitive Parameters

2.5 PHY_SAP Detailed Service Specification

The following sections describe the services provided by the peer-to-peer and sublayer-to-sublayer primitives listed in section 2.4.

2.5.1 PHY_DATA.request

2.5.1.1 Function

This primitive defines the transfer of data from the MAC sublayer to the local PHY entity

2.5.1.2 Semantic of the Service Primitive

This primitive shall provide the following parameters:

PHY_DATA.request(LENGTH, TXDATA, ANTSEL, RATE, TXPOWER)

LENGTH. The LENGTH paramater is an integer value of 1 - TBD. This parameter represents the number of octets in the MPDU being passed from the MAC sublayer to the local PHY entity. The MPDU has a minimum size of 1 octet

TXDATA. The TXDATA parameter is the list of 0 to LENGTH octetes which comprise the MPDU the MAC is requesting to transmit.

ANTSEL *(optional)*. The ANTSEL parameter is passed directly to PMD and is defined by the PMD_ANTSEL primitive in section 4.5.4. The number of avaliable antennas is given by the NO_TXANT parameter of PHY_INFO.request described in section 2.5.3. This parameter allows the MAC entity to specify the antenna used by the PLCP to transmit on a per MPDU basis.

RATE. The RATE parameter specifies the data rate (modulation) which will be used to transmit the MPDU portion of the BPDU on a per packet basis. The DS PHY rate change feature is described in section 3. The RATE is indicated at the PMD with teh PMD_RATE primitive described in section 4.5.7.

TXPOWER *(optional)*. The TXPOWER parameter is pased directly to the PMD and is defined by the PMD_TXPWRLVL primitive in section 4.5.5. The number of avaliable transmit power levels is given by the NO_TXPWRLVS parameter of PHY_INFO.request described in section 2.5.3. This parameter allows the MAC entity to specify the transmit power on a per packet basis.

2.5.1.3 When Generated

This primitive is generated by the MAC sublayer to request the transmission of an MPDU.

2.5.1.4 Effect of Receipt

The receipt of this primitive initiates the transmission of a BPDU. The PLCP state machine will generation and transmit the DS PHY radio preamble as described in section 3 and complete the transmission of the MPDU defined by TXDATA.

2.5.2 PHY_DATA.indicate

2.5.2.1 Function

This primitive indicates to the local MAC entity that the PHY sublayer has completed receiving the MPDU. This primitive defines the transfer of data from the PHY sublayer to the local MAC entity. In addition, this primitive provides the MAC entity a method of updating receive specific parameters to the PHY entity to be applied to subsequent receive operations.

2.5.2.2 Semantic of the Service Primitive

This primitive shall provide the following parameters:

PHY_DATA.indicate(LENGTH, RXDATA, ANTSEL, RATE, RSSI, SQ,
NOISE_LEVEL,ERROR)

LENGTH. The LENGTH parameter is an integer value of 1 - TBD. This parameter represents the number of octets in the MPDU being passed from the PHY sublayer to the local MAC entity. The MPDU has a minimum size of 1 octet
RXDATA. The RXDATA parameter is the list of 0 to LENGTH octets which comprise the MPDU the MAC is receiving from the PHY.
ANTSEL *(optional).* The ANTSEL identifies the antenna which the local PHY entity selected to receive the BPDU. The parameter is passed directly from the PMD and is defined by the PMD_ANTSEL primitive in section 4.5.4. The number of available antennas is given by the NO_TXANT parameter of PHY_INFO.request described in section 2.5.3.
RATE. The RATE parameter specifies the data rate (modulation) which was used to transmit the MDPU portion of the BPDU. The DS PHY rate change feature is described in section 3.
RSSI. The RSSI parameter is passed directly from the PMD and is defined by the PMD_RSSI primitive in section 4.5.9. The number of available RSSI levels is given by the NO_RSSILVS parameter of PHY_INFO.request described in section 2.5.3. This parameter indicates the RSSI level of the receive antenna when carrier sense (CS) is enabled.
SQ. The SQ (signal quality) parameter is passed directly from the PMD and is defined by the PMD_SQ primitive in section 4.5.10. The number of available SQ levels is given by the NO_SQLVS parameter of PHY_INFO.request described in section 2.5.3. This parameter indicates the DS PHY PN code correlation level when carrier sence (CS) is enabled
NOISE_LEVEL. The NOISE_LEVEL parameter is pased directly from the PMD and is defined by the PMD_NOISE_LEVEL primitive in section 4.5.15. The number of avaliable levels is given by the NO_RSSILVS parameter of PHY_INFO.request described in section 2.5.3. This parameter informs the MAC of the average RSSI level at the receive antenna when CS is disabled (no DS PHY signal is present). NOISE_LEVEL is used in the calculation of ED_THRESHOLD which, combined with CS, form the DS PHY clear channel assessment (CCA) capability.
ERROR. The ERROR parameter indicates to the MAC that one of three PLCP errors occured in receipt of the BPDU: NO_RATEMATCH, PREAMCRC_FAIL, and LENGTH_FAIL. NO_MATCH indicates that a failure to identify the MPDU data rate as described in section 3. PREAMCRC_FAIL indicated that the CCITT CRC16 checksum failed for the protected octets in the DS PHY preamble as described in section 3. LENGTH_FAIL indicates that CS was disabled prior to reaching the octet count specified in the DS PHY preamble as described in section 3.

2.5.2.3 When Generated

This primitive is generated by the PHY sublayer to inform the MAC that the reception of an MPDU is complete.

2.5.2.4 Effect of Receipt

The receipt of this primitive indicates the termination of reception of a BPDU. The PLCP state machine will indicate any errors in the reception of the DS PHY radio preamble or in the MPDU length to the MAC. The MAC sublayer can then process or discard the MPDU based on the indicated errors. In addition, the MAC can update the DS PHY receive parameters in preperation for the next receive operation.

2.5.3 PHY_INFO.indicate

[Editors note: we might want to consider creating a new 2.x section as a Management Information Block, MIB, and placing PHY_INFO in it]

2.5.3.1 Function

This primitive allows the local MAC entity to query and receive a list of capabilities from the PHY sublayer.

2.5.3.2 Semantic of the Service Primitive

This primitive shall provide the following parameters:

PHY_INFO.request(TYPE, NO_CHANNELS, NO_TXPWRLVS, NO_SQLVS, NO_RSSILVS, NO_TXANT,N_ORXANT)

TYPE. The TYPE parameter indicates the PHY type: DS, FHSS, IR, or high speed FHSS.
NO_CHANNELS. The NO_CHANNELS parameters indicates the avaliable PHY channels. See section 4.7.2 for further details.
NO_TXPWRLVS. The NO_TXPWRLVS parameter indicates the number of transmit power levels supported by the PHY. See section 4.5.5. for further details
NO_SQLVS. The NO_SQLVS indicates the number of levels available to measure the quality of the correlation of the DS pseudo noise sequence.
NO_RSSILVS. The NO_RSSILVS parameter indicates number of levels which are available to measure the RSSI for background noise measurements and ED_THRESHOLD.
NO_TXANT. This parameter indicates the number of antennas which PHY has avliable for the MAC entity to use for MPDU transmission. The MAC entity uses this parameter to interperate an utilize the ANTSEL parameter in the PHY _DATA command.
NO_RXANT. This parameter indicates the number of antennas which PHY can use for MPDU reception. The MAC entity uses this parameter to interperate an utilize the ANTSEL parameter in the PHY _DATA command.

2.5.3.3 When Generated

This primitive is generated by the MAC sublayer during system initialization to query the PHY entity's capabilities and set MAC parameters to make use of these capabilities.

2.5.3.4 Effect of Receipt

The PHY responds to the MAC entities query with the information parameters list.

2.5.4 PHY_RXSETUP.request

[Editors note: we may want to place this primitive in a MIB (see PHY_INFO note)]

2.5.4.1 Function

This primitive allows the local MAC entity to modify energy detection and received DS correlation thresholds at the PHY entity.

2.5.4.2 Semantic of the Service Primitive

This primitive shall provide the following parameters:

PHY_RXSETUP.request(ED_THRESHOLD, SQ_THRESHOLD)

ED_THRESHOLD. The ED_THRESHOLD parameter is passed directly to the PMD and is defined by the PMD_ED_THRESHOLD primitive in section 4.5.14. The number of available ED_THRESHOLD levels is given by the NO_RSSILVS parameter of PHY_INFO.request described in section 2.5.3. This parameter updates the RSSI level of the receive antenna above which the the energy detect (ED) is enabled.

SQ_THRESHOLD. The SQ_THRESHOLD parameter is passed directly to the PMD and is defined by the PMD_SQ_THRESHOLD primitive in section 4.5.13. The number of available SQ_THRESHOLD levels is given by the NO_SQLVS parameter of PHY_INFO.request described in section 2.5.3. This parameter updates the SQ level of the receive antenna above which the carrier sense (SQ) is enabled.

2.5.4.3 When Generated

This primitive is generated by the MAC sublayer during initialization or when reported NOISE_LEVEL or RSSI from PHY_DATA.indicate requires change of the ED_ THRESHOLD and/or the SQ_THRESHOLD.

2.5.4.4 Effect of Receipt

The PHY immediately updates the PMD_ED_THRESHOLD and PMD_SQ_THRESHOLD used determine PHY receive status.

2.5.5 PHY_CS.indicate

2.5.5.1 Function

This primitive generated by the PHY entity directly informs the MAC entity that DS correlation signal quality has exceeded the SQ_THRESHOLD (carrier sense) and that data reception is in progress.

2.5.5.2 Semantic of the Service Primitive

This primitive indicates a binary PHY entity status of ENABLED or DISABLED. The ENABLED condition indicates that the SQ_THRESHOLD has been exceeded and the PHY entity has a data reception in progress. The DISABLED condition indicates that the PHY entity is not currenly have valid data reception in progress.

2.5.5.3 When Generated

This primitive is generated by the PHY sublayer whenever the PHY DS correlation is greater than SQ_THRESHOLD.

2.5.5.4 Effect of Receipt

The recept of this indicator by the MAC entity indicates that the media is busy, and that any pending MPDU transmission should be deferred.

2.5.6 PHY_ED.indicate

2.5.6.1 Function

This primitive, generated by the PHY entity, directly informs the MAC entity that the current PHY RSSI level has exceeded the ED_THRESHOLD (energy detect).

2.5.6.2 Semantic of the Service Primitive

This primitive indicates a binary PHY entity status of ENABLED or DISABLED. The ENABLED condition indicates that the ED_THRESHOLD has been exceeded and a potential interference is present. The ENABLED state may also indicate that a BPDU transmission is in progress but the PHY has not achieved DS pseudo noise code acquistion and lock. The DISABLED condition indicates that the channel is clear and inconjuction with PHY_CS being DISABLED informs the MAC that any pending MPDU transmissions may proceede.

2.5.6.3 When Generated

This primitive is generated by the PHY sublayer whenever the PHY RSSI level is greater than ED_THRESHOLD.

2.5.6.4 Effect of Receipt

The receipt of this indicator by the MAC entity indicates that the media is occupied but not necessarily busy. The PHY_ED is intended to be used in an enhanced CCA capability which may be incorporated into the MAC to shorten the traditional carrier sense latency and to detetct the presence of non-DS PHYs or other radio frequency interference sources.

2.5.7 PHY_SETFREQ.indicate

2.5.7.1 Function

This primitive, generated by the MAC entity, directly informs the PHY entity which of the availabe channels indicated by PHY_INFO.request parameter NO_CHANNELS (section 2.5.3) will be used for transmission and reception.

2.5.7.2 Semantic of the Service Primitive

This primitive shall provide the following parameters:

PHY_SETCHAN.request(CHNL_ID)

CHNL_ID. The CHNL_ID parameter sets the DS PHY channel described in section 4.7.2.

2.5.7.3 When Generated

This primitive is generated by the MAC sublayer whenever a change in the PHY sublayer frequency is required.

2.5.7.4 Effect of Receipt

Upon receipt of this primitive. The PHY sublayer initiates a complete change in channel frequency.

2.5.8 PHY_RXBUSY.indicate

2.5.8.1 Function

This primitive, generated by the PHY entity, directly informs the MAC entity that MPDU data is available.

2.5.8.2 Semantic of the Service Primitive

The PHY_RXBUSY is associated with the PMD_MDA (Mac Data Avaliable) primitive. PHY_RXBUSY indicates a binary PHY entity status of ENABLED or DISABLED. PHY_RXBUSY is ENABLED when the first data bit of the MPDU is available from the PHY entity for use by the MAC entity. MDA is DISABLED when the last data bit has been processed by the PHYentity.

2.5.8.3 When Generated

This primitive is generated by the PHY sublayer when the PHY is receiving the MPDU portion of the BPDU.

2.5.8.4 Effect of Receipt

This indicator is provided to the MAC for information purposes. No specific action is required by the MAC entity upon receipt of this indicator.

2.5.9 PHY_TXBUSY.indicate

2.5.9.1 Function

This primitive, generated by the PHY entity, directly informs the MAC entity the that transmission of the MPDU is underway.

2.5.9.2 Semantic of the Service Primitive

The PHY_TXBUSY is associated with the PMD_AMF (Avaliable MAC Frame) primitive. PHY_TXBUSY indicates a binary PHY entity status of ENABLED or DISABLED. PHY_TXBUSY is ENABLED when the radio header transmission is complete and transmission of the MPDU is underway. PHY_TXBUSY is DISABLED when the last MPDU data bit has been transmitted by the PHY entity.

2.5.9.3 When Generated

This primitive is generated by the PHY sublayer when the PHY is transmitting the MPDU portion of the BPDU.

2.5.9.4 Effect of Receipt

This indicator is provided to the MAC for information purposes. No specific action is required by the MAC entity upon receit of this indicator.

2.6 MPHY_SAP Sublayer Management Primitives

The following messages may be sent between the PHY sublayer entities and the interlayer or higher Layer Management Entities (LME).

Primitive	Request	Indicate	Confirm	Response
MPHY_RXRESET	X		X	
MPHY_TXRESET	X		X	

Table 4. MPHY_SAP Sublayer Management Parameters

2.6.1 MPHY_SAP Management Service Primitive Parameters

The following table shows the parameters used by one or more of the MPHY_SAP Sublayer Management Primitives

Parameter	Associate Primitive	Value
none at this time		

Table 5. PHY_SAP Service Primitive Parameters

2.7 MPHY_SAP Detailed Service Specifications

The following section describes the services provided by each MPHY_SAP Service Primitive.

2.7.1 MPHY_RXRESET.request

2.7.1.1 Function

This primitive is a request by the LME to reset the PHY sublayer receive state machine.

2.7.1.2 Semantic of the Service Primitive

The primitive shall provide the following parameter:

MPHY_RXRESET.request

.There are no parameters associated with this primitive.

2.7.1.3 When Generated

This primitive is generated at any time to reset the receive state machine in the PHY sublayer.

2.7.1.4 Effect of Receipt

Receipt of this primitive by the PHY sublayer will cause the PHY entity to reset the receive state machine to its idle state.

2.7.2 MPHY-RSRESET.confirm

2.7.2.1 Function

This primitive is a confirmation by the PHY layer to the local LME that the PLCP receive state machine was successfully reset.

2.7.2.2 Semantic of the Service Primitive

The primitive shall provide the following parameter:

MPHY_RXRESET.confirm

There are no parameters associated with this primitive.

2.7.2.3 When Generated

This primitive is generated as a response to the MPHY_RXRESET.request primitive once the PLCP has sucessfully completed reset of the receive state machine.

2.7.2.4 Effect of Receipt

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

2.7.3 MPHY_TXRESET.request

2.7.3.1 Function

This primitive is a request by the LME to reset the PHY sublayer transmit state machine.

2.7.3.2 Semantic of the Service Primitive

The primitive shall provide the following parameter:

MPHY_TXRESET.request

There are no parameters associated with this primitive.

2.7.3.3 When Generated

This primitive is generated at any time to reset the transmit state machine in the PHY sublayer.

2.7.3.4 Effect of Receipt

Receipt of this primitive by the PHY sublayer will cause the PHY entity to reset the transmit state machine to its idle state.

2.7.4 MPHY_TXRESET.confirm

2.7.4.1 Function

This primitive is a confirmation by the PHY layer to the local LME that the PLCP transmit state machine was successfully reset.

2.7.4.2 Semantic of the Service Primitive

The primitive shall provide the following parameter:

MPHY_TXRESET.confirm

There are no parameters associated with this primitive.

2.7.4.3 When Generated

This primitive is generated as a response to the MPHY_TXRESET.request primitive once the PLCP has sucessfully completed reset of the transmit state machine.

2.7.2.4 Effect of Receipt

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

3. DSSS Physical Layer Convergence Procedure Sublayer

[Editors note: DS PHY Temeplet items 3 and 18 are covered in this section]

3.1 Introduction

This section provides a convergence procedure in which MPDUs are converted to and from BPDUs. During transmission, the MPDU is appended with a PLCP preamble (radio header) to create the BPDU. At the receiver, the PLCP preamble is processed and the internal data fields are processed to aid in demodulation and delivery of the MPDU.

3.2 Physical Layer Convergence Procedure Frame Format

Figure 3.1 shows the format for the BPDU including the PLCP preamble and the MPDU. The PLCP preamble contains the following fields: synchronization, unique word, 802.11 signaling, 802.11 service, length, CRC16. Each of these fields will be described in detail in section 3.3.

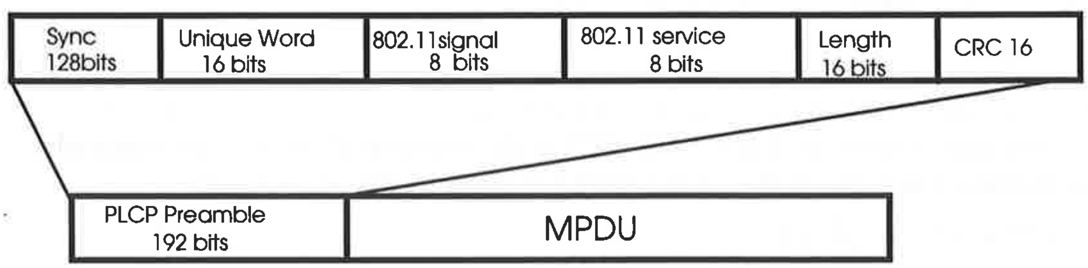

Figure 3.1. PLCP Frame Format

3.3 PLCP Field Definitions

The entire PLCP preamble shall be transmitted using the 1 MBPS DBPSK Basic Rate modulation described in section 4.x. All the transmitted data bits shall be scrambled using the feedthrough scrambler described in section 3.4.

3.3.1 PLCP Synchronization (Sync)

The synchromization field consits of 128 bits of scrambled 1 bits. This field is provided so that the receive can perform diversity antenna selection, PN code acquisition, and carrier lock.

3.3.2 PLCP Unique Word Field

The Unique Word (or start frame delimiter) is porovided to indicate the start of PHY dependent perameters within PLCP preamble. The Unique Word constist of 16 bit word h05CF. In binary, the Unique Word is: 0000010111001111. The left most bit shall be transmitted first in time.

3.3.3 PLCP 802.11 Signal Field

The 8 bit 802.11 signal field indicates to the PHY the modulation which will be used for tranmission or reception of the MPDU. The DS PHY currently support two manditory modulation services given by the following 8 bit words:

1. hC0 / binary 11000000 for 1 MBPS DBPSK Basic Rate Service
2. h30 / binary 00110000 for 2 MBPS DQPSK Enhanced Rate Service

The DS PHY rate change capability will be described in section 3.5. The left most 802.11 signal field bit shall be transmitted first in time. This field is protected by the CRC16 frame check sequnce described in section 3.3.6

3.3.4 PLCP 802.11 Service Field

The 8 bit 802.11 service field is reserved for future use. This field must be set to h00 / binary 00000000. The left most 802.11 service field bit shall be transmitted first in time. This field is protected by the CRC16 frame check sequnce described in section 3.3.6

3.3.5 PLCP Length Field

The PLCP length field is an unsigned 16 bit integer which inicates the number of octets (1 to TBD) to be transmitted in the MPDU. The transmitted value is provided by the LENGH parameter in the PHY_DATA.request primitive described in section 2.5.1. The LSB (least significant bit) shall 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 CRC16 frame check sequnce described in section 3.3.6

3.3.6 PLCP CRC16 Field

The 802.11 signal, 802.11 service, and length field shall be protected with a CCITT CRC16 FCS (frame check sequence). The CRC16 FCS is the ones compliment 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 a typical implementation at the transmitter, the initial contents of the register of the device computing the division is preset to all 1's and is then modified by the division by the generator polynomial (as described above) of the PLCP data fields. The ones complement of the resulting remainder is transmitted as the 16 bit FCS.

As a typical implementation at the receiver, the initial contents of the register of th edevice computing the remainderis preset to all 1's. The final remainder, after multiplication by x^{16} and then modulo 2 division by the generator polynomial (above) of the serial incomming protected bits (after randomizer has been removed) will be 0001 1101 0000 1111 (x^{15} to x^0) in the absense of of transmission errors.

As an example, the PLCP signal, PLCP service, and Length fields for a DQPSK signal witha packet length of 3 would be given by the following:

0011 0000 0000 0000 1100 0000 0000 0000 (left most bit transmitted first in time)

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

0100 0001 1000 0010 (left most bit transmitted first in time)

3.4 PLCP / DS PHY Data Scrambler

The polynomial $1 + x^{-4} + x^{-7}$ shall be used to scramble ALL data transmitted by the DS PHY. The feedthrough configuration of the scrambler requires is self initializing. No aprior initialization of the scrambler is required for either transmit or receive processing. Figure 3.2 shows a typical transmit implemenation of the data scrambler. Other implementations are possible.

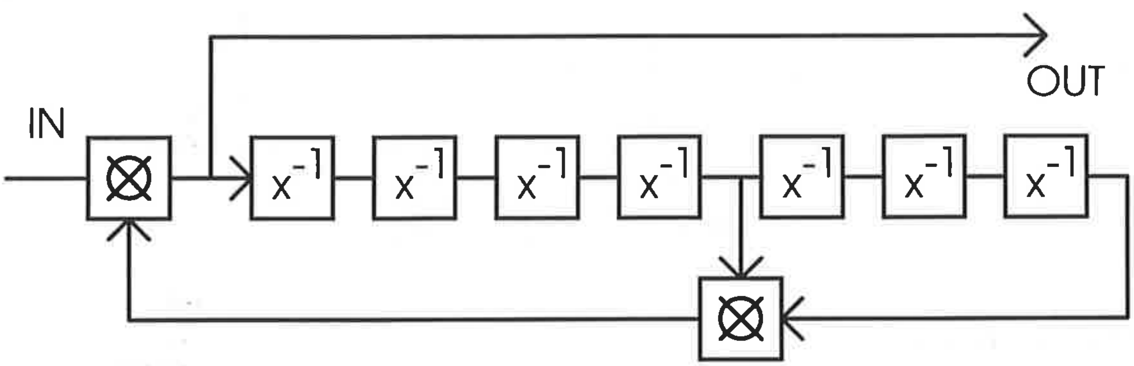

Figure 3.2 Data Scrambler

3.5 PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mbps DBPSK Basic Rate 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.

3.6 PLCP Transmit Procedure

The PLCP transmit procedure is shown if figure 3.3. Based on the status of PHY_CS and PHY_ED the MAC will assess that the channel is clear and initiate the PHY_DATA.request primitive. The PLCP will enable the PMD_TXE (TX mode) and the PHY entity will immediatly initiale 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 4 is included in the PLCP synchronization field. Once the PLCP preamble transmission is completed, PMD_AMF is enabled which in turn enables the PHY_TXBUSY primitive to the MAC. The rate change, if any, is initiated at this same time as described in section 3.5. The PHY procedes with MPDU transmission. Transmission is terminated by disabling the PMD_TXE primitive. The termination occurs after the transmission of the final bit of the last MPDU octet indidicated by the LENGTH parameter in PHY_DATA.request. Coincident with the termination of PMD_TXE, the PHY_TXBUSY is disabled. The packet transmisson is completed and the PHY entity enters the default receive state (PMD_TXE is disabled).

[Editors note: are the octets being transmitted little endian (LSB to MSB) or big endian (MSB to LSB)? This is very important for interoperablility!!!!]

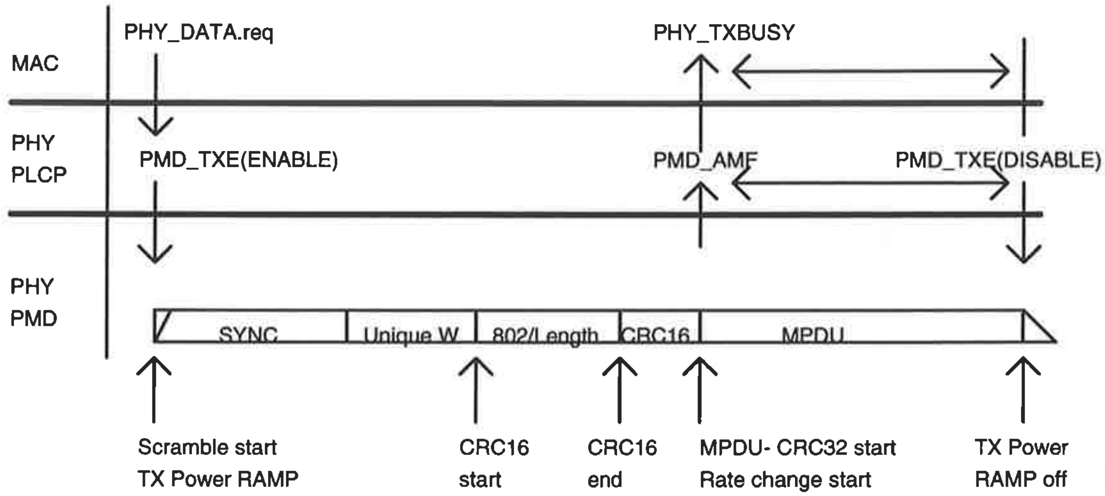

Figure 3.3 PLCP Transmit Procedure

3.7 PLCP ReceiveProcedure

The PLCP receive procedure is shown if figure 3.4. In order to receive data, PMD_TXE must be disabled so that the PHY entity is in the default receive state. Upon receiving the transmitted PLCP preamble synchronization field, The PMD_ED will be enabled as the RSSI strength reaches the ED_THRESHOLD. The PLCP will, like wise, enable PHY_ED to indicate this status to the MAC entity. When the PHY entity aquires PN code lock based on the SQ_THRESHOLD, PMD_CS will be enabled and the PLCP will enable. PHY_CS. The PHY entity begins searching for the Unique Word field. Once the Unique word field is detetced, CRC16 processing is initiated and the PLCP 802.11 signal, 802.11 service, and Length fields are received. The CRC16 FSC will be processed. If the CRC16 FCS check fails or no match is found for the 802.11 signal or service fields, a PHY_RXERROR.indicate primitive will be issued and PHY receiver will be reset. If the PLCP preamble reception is sucessful, PMD_MDA is enabled which in turn enables the PHY_RXBUSY primitive to the MAC. The rate change indicated in the 802.11 signal field is initiated at this same time as described in section 3.5. The PHY procedes with MPDU reception. Reception is terminated after the reception of the final bit of the last MPDU octet indidicated by the PLCP preamble LENGTH field. Coincident with the termination, a PMD_MDA is disabled, PHY_RXBUSY is disabled and a PHY_DATA.indicate primitive is issued. The receiver retures to the default receive state. Should PMD_CS be disabled during the PLCP preamble processing or prior to the complete MPDU length being processed, a PHY_RXERROR indicator will be issued.

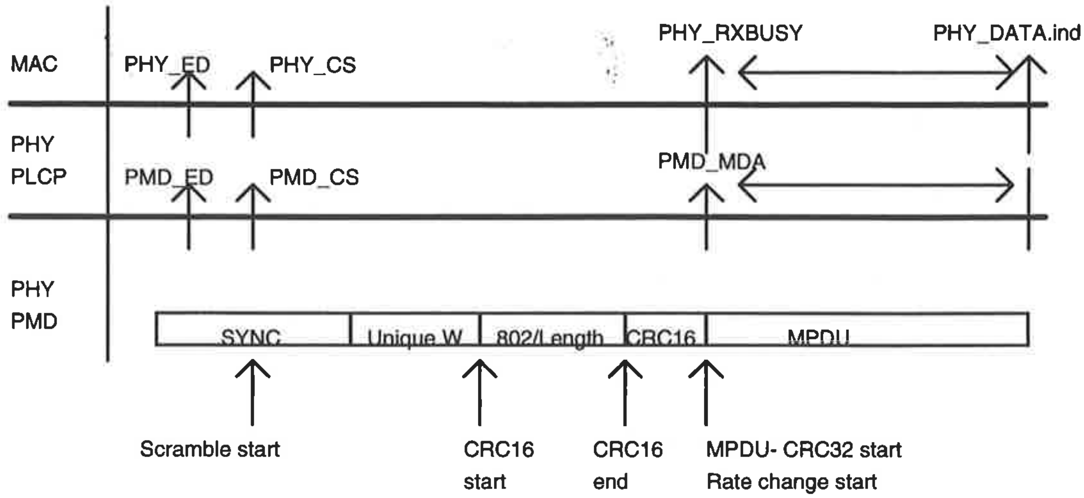

Figure 3.4 PLCP Receive Procedure

4. DSSS Physical Medium Dependent

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 the section are the functional, electrical, and RF characteristics required for interoperablity of implementations conforming to this specification. The relationship of this specification to the entire DS OHY Layer is shown in figure 4.1

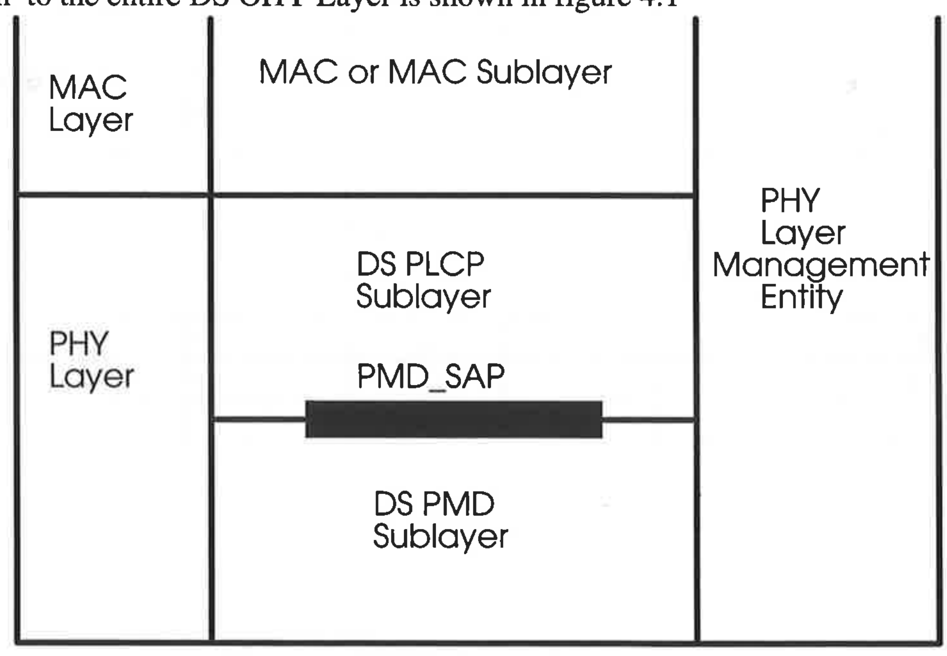

Figure 4.1 PMD Layer Reference Model

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, timming information, and associated received signal parameters being delivered to the PLCP sublayer. A like functionality is provided for data transmission.

4.3 Overview of Interactions

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

1. Service primitives that support PLCP per-to-per interactions
2. Service primitives that have local significance and support sublayer-to-sublayer interactions.

4.4 Basic Service and Options

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

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 4.1 PMD_SAP Peer-to-Peer Service Primitives

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_AMF		X		
PMD_MDA		X		
PMD_CS		X		
PMD_ED		X		
PMD_NOISE_LEVEL		X		

Table 4.2 PMD_SAP Sublayer-to-Sublayer Service Primitives

4.4.3 PMD_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
TXD_UNIT	PMD_DATA.request	One, Zero
RXD_UNIT	PMD_DATA.indicate	One, Zero
RF_STATE	PMD_TXE.request	Receive, Transmit

ANT_STATE	PMD_ANTSEL.request	1,2 (assumes 2 antennas)
TXPWR_LEVEL	PMD_TXPWRLVL	0,1,2,3 (max of 4 levels)
CHNL_ID	PMD_FREQ.request	0-4 for channel set
RATE	PMD_RATE.indicate PMD_RATE.request	0 for 1 MBPS DBPSK 1 for 2 MBPS DQPSK
RSSI	PMD_RSSI.indicate	0-x bits of RSSI x is set by "INFO" value
SQ	PMD_SQ.indicate	0-x Signal Quality bits x is set by "INFO" value
NOISE_LEVEL	PMD_NOISE_LEVEL.indicat e	0-x bits of RSSI x is set by RSSI

Table 4.3 List of Parameters for the PMD Primitives

4.5 PMD_SAP Detailed Service Specification

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

4.5.1 PMD_DATA.request

4.5.4.1 Function

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

4.5.4.2 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 ONE or ZERO. This parameter represents a single 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 tranmission.

4.5.4.3 When Generated

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

4.5.3.4 Effect of Receipt

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

4.5.2 PMD_DATA.indicate

4.5.2.1 Function

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

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 or ZERO. This parameter represents a single data bit which has been recovered from the demodulated by the PMD entity.

4.5.2.3 When Generated

This primitive is generated by the PMD entity forward received data to the PCLP sublayer. The data clock for this primitive is supplied by PMD layer based on the PN code repetition.

4.5.2.4 Effect of Receipt

The PLCP sublayer either interperates the data bit as part of the PLCP convergence procedure or pass the data to the MAC layer as part of the MPDU.

4.5.3 PHY_TXE.indicate

4.5.3.1 Function

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

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. Thedefault PHY sate is receive.

4.5.3.3 When Generated

This primitive is generated by the PLCP sublayer to initiate the PMD layer transmission of the BPDU. The PHY_DATA.request primitive must be provided to the PLCP sublayer prior to setting RF_STATE = transmit within the PMD_TXE command.

4.5.3.4 Effect of Receipt

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

4.5.4 PMD_ANTSEL.request

4.5.4.1 Function

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

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 avaliable antennas should be used for receive or transmit. The number of avaliable antenna is determined by the PHY_INFO parameters NO_TXANT and NO_RXANT.

4.5.4.3 When Generated

This primitive is generated by the PLCP sublayer to select a specific antenna for tranmission or reception. While not required, multiple antennas are used to implement a receive antennà diversity scheme. The PMD paramaters RSSI, SQ, and NOISE_LEVEL are provided for diversity implementation.

4.5.4.4 Effect of Receipt

PMD_ANTSEL immediatly selects the antenna specified by ANT_STATE

4.5.5 PMD_TXPWRLVL.request

4.5.5.1 Function

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

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 paclet transmission. The number of avaliable power levels is determined by the PHY_INFO parameters NO_TXPWRLVLS. Section 4.8.3 provides further information on the optional DS PHY power level control capabilities.

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.

4.5.5.4 Effect of Receipt

PMD_TXPWRLVL immediatly sets the transmit power level given by TXPWR_LEVEL.

4.5.6 PMD_FREQ.request

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.

4.5.6.2 Semantic 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. The number of avaliable channel is determined by the PHY_INFO parameters NO_CHANNELS. Section 4.7.3 provides further information on the DS PHY channel plan.

4.5.6.3 When Generated

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

4.5.6.4 Effect of Receipt

The receipt of PMD_FREQ immediatly changes the frequency channel as set by the CHNL_ID parameter.

4.5.7 PMD_RATE.request

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.

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 4.7.4 provides further information on the DS PHY modulation rates. The DS PHY ratechange capability is fully described in section 3.

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 MPDU portion of a BPDU.

4.5.7.4 Effect of Receipt

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

4.5.8 PMD_RATE.indicate

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 BPDU. The modulation is indicated in the PLCP preamble 802.11 SIGNALLING field.

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 BPDU. Section 4.7.4 provides further information on the DS PHY modulation rates. The DS PHY ratechange capability is fully described in section 3.

4.5.8.3 When Generated

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

4.5.8.4 Effect of Receipt

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

4.5.9 PMD_RSSI.indicate

4.5.9.1 Function

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

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. The number of RSSI levels supportted by the DS PHY is given by the NO_RSSILVS parameter in the PHY_INFO primitive.

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 avaliable to the PLCP which inturn provides the parameter to the MAC entity.

4.5.9.4 Effect of Receipt

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

4.5.10 PMD_SQ.indicate

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 quallity is sampled when the DS PHY achieves code lock and held until the next code lock acquisition.

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. The number of SQ levels supportted by the DS PHY is given by the NO_SQLVS parameter in the PHY_INFO primitive.

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 avaliable to the PLCP which inturn provides the parameter to the MAC entity.

4.5.10.4 Effect of Receipt

This parameter is provided to the PLCP layer for information only. The SQ may be used in conjuction with RSSI and NOISE_LEVEL as part of a Clear Channel Assessment scheme.SQ may also be used a a code lock indication based on the SQ_THRESHOLD parameter of the primitive PHY_RXSETUP.

4.5.11 PMD_AMF.indicate

4.5.11.1 Function

This primitive, generated by the PMD, indicates to the PLCP layer that transmission of the MPDU portion of the BPDU is underway.

4.5.11.2 Semantic of the Service Primitive

.The PMD_AMF (Avaliable MAC Freme) primitive is assocoated with the PLCP layer PHY_TXBUSY primitive. PMD_AMF indicates a binary PHY entity status of ENABLED or DISABLED. PHY_AMF is ENABLED when the first data bit of the MPDU is required for transmission. PHY_AMF is DISABLED when the last MPDU data bit has been transmitted by the PHYentity.

4.5.11.3 When Generated

This primitive is generated by the PHY sublayer when the PHY is transmitting the MPDU portion of the BPDU.

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_TXBUSY indicator. No specific action is required by the MAC entity upon receipt of this indicator.

4.5.12 PMD_MDA.indicate

4.5.12.1 Function

This primitive, generated by the PMD, indicates to the PLCP layer that MPDU data is bing processed and that data is available.

4.5.12.2 Semantic of the Service Primitive

The PMD_MDA (Mac Data Avaliable) primitive is assocoated with the PLCP layer PHY_RXBUSY primitive. PMD_MDA indicates a binary PHY entity status of ENABLED or DISABLED. PHY_PMD is ENABLED when the first data bit of the MPDU is available from the PHY entity for use by the MAC entity. PHY_MDA is DISABLED when the last data bit has been processed by the PHYentity.

4.5.12.3 When Generated

This primitive is generated by the PHY sublayer when the PHY is receiving the MPDU portion of the BPDU.

4.5.12.4 Effect of Receipt

This indicator is provided to the PLCP for forwarding to the MAC entity for information purposes through the PHY_RXBUSY indicator. No specific action is required by the MAC entity upon receipt of this indicator.

4.5.13 PMD_CS.indicate

4.5.13.1 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.

4.5.13.2 Semantic of the Service Primitive

The PMD_CS (Carrier Sense) primitive is assocoated with the PLCP layer PHY_CS primitive. PMD_CS indicates a binary PHY entity status of ENABLED or DISABLED. PHY_CS is ENABLED when the correlator signals quality indicated in PMD_SQ is greater than the CS_THRESHOLD parameter of the PHY_RXSETUP primitive. PHY_CS is DISABLED when the PMD_SQ falls below the correlation threshold.

4.5.13.3 When Generated

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

4.5.13.4 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 sould not be placed into the transmit state when PMD_CS is ENABLED.

4.5.14 PMD_ED.indicate

4.5.14.1 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.

4.5.14.2 Semantic of the Service Primitive

The PMD_ED (Energy Detect) primitive is assocoated with the PLCP layer PHY_ED primitive. PMD_ED indicates a binary PHY entity status of ENABLED or DISABLED. PHY_EDis ENABLED when the RSSI indicated in PMD_RSSI is greater than the ED_THRESHOLD parameter of the PHY_RXSETUP primitive. PMD_ED is DISABLED when the PMD_RSSI falls below the energy detect threshold.

4.5.14.3 When Generated

This primitive is generated by the PHY sublayer when the PHY is receiving RF enegy from any source which exceedes the ED_THRESHOLD parameter of the PHY _RXSTEUP primitive.

4.5.14.4 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. This parameter can be used by the MAC entity for enhanced CCA capability which detetcts the presence of RF sources which do not origionate from a DS PHY compliant RF source.

4.5.15 PMD_NOISE_LEVEL.indicate

4.5.15.1 Function

This primitive, generated by the PMD sublayer, provides to the PLCP and MAC entity the with an estimate of the radio frequency background noise level when the PMD_CS.indicate primitive is disabled.

4.5.15.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_NOISE_LEVEL.indicate(NOISE_LEVEL)

NOISE_LEVEL. The NOISE_LEVEL is a measure of the RF energy received by the DS PHY when the PMD_CS is DISABLED. The number of NOISE_LEVEL levels supportted by the DS PHY is given by the NO_RSSILVS parameter in the PHY_INFO primitive.

4.5.15.3 When Generated

This primitive is generated by the PMD when the DS PHY is in the receive state and PHY_CS.indicate is DISABLED.

4.5.15.4 Effect of Receipt

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

4.6 MPMD_SAP Sublayer Management Primitives

No sublayer managment primitives are defined for the DS PHY PMD

4.7 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 transmit functions and general operation of a compliant DS PHY.

4.7.1 Operating Frequency Range *[Templet 1]*

The DS PHY will operate in the frequency range of 2.4 to 2.4835 GHz as allocated by regulatory bodies in the USA and Europe.

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.

4.7.2 Number of Operating Channels *[Templet 2]*

For the 2.4 to 2.4835 GHz frequency band, 5 channels are specified. These channels are divided into two channels groups: group 1 and group 2. The group 1 and group 2 channel center frequencies and CHNL_ID numbers a shown in table 4.5.

CHNL_ID	Group	Frequency GHz
1	1a	2412
2	1b	2442
3	1c	2472
4	2a	2427
5	2b	2457

Table 4.5 DS PHY Frequency Channel Plan

In a multiple cell network topology, adjacent cells using different group 1 channels can operate simultaneously without interference. In a similar fashion, group 2 channels can operate simultaneously with other group 2 channels. Group 1 and group 2 channels may be used simultaneously in a cellular frequency plan where the interference effects have been factored into the cell plan.

4.7.3 Spreading Sequence *[Templet 3]*

The following 11 chip Barker sequence shall be used :

+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.

4.7.4 Modulation and Channel Data Rates *[Templet 14 and 15]*

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 4.6. The Enhanced Access Rate is based on 2 MBPS DQPSK. The DQPSK encoder is specified in Table 4.7.

Bit Input	Phase Change (+jw)
0	0
1	Π

Table 4.6 1 MBPS DBPSK Basic Rate Encoding Table

Dibit pattern (d0,d1) d0 is first in time	Phase Change (+jw)
00	0
01	Π/2
11	Π
10	3Π/2 (-Π/2)

Table 4.7 2 MBPS DQPSK Enhanced Rate Encoding Table

4.7.5 Transmit and Receive In Band and Out of Band Spurious Emissions *[Templet 22]*

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 ETSI res 02-09.

4.7.6 Transmit to Receive Turnaround Time *[Templet 23]*

The time from transition of the PMD_TXE control from the TX state to the RX state until the radio is in receive mode shall be less than or equal to 25 usec. This includes the transmit power down ramp described in section 4.8.6.

4.7.7 Receive to Transmit Turnaround Time *[Templet 22]*

The time from transition of the PMD_TXE control from the RX state to the TX state until the radio is in transmit mode shall be less than or equal to 10 usec. This includes the transmit power up ramp described in section 4.8.6.

4.7.8 Transmit and Receive Antenna Port Impedance *[Templet 30]*

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

4.7.9 Transmit and Receive VSWR *[Templet 31]*

DS PHY devices shall withstand no damage and remain stable over the range 0≤ VSWR≤ ∞.

4.8 PMD Transmit Specifications

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

4.8.1 Transmit Power Levels *[Templet 4 and 6]*

The maximum Equivalent Radiated Power (EIRP) as mesured in accordance with practices specified by the regulatory bodies is shown in Table 4.8. In the USA, the radiated emissions should also conform with the ANSI uncontrolled radiation emission standards (ANSI document C95.1 publised in 1991).

Maximum EIRP [mw]	Geographic Location	Compliance Document
1000	USA	FCC 15.247
100	EUROPE	ETSI res 02-09

Table 4.8. Transmit Power Levels

4.8.2 Minimum Transmitted Power Level *[Templet 4]*

The minimum transmitted power shall be no less than 10 mW.

4.8.3 Transmit Power Level Control *[Templet 5]*

Power control shall be provided for transmitted power greater than 100 mW. A maximum of 4 power levels shall be provided between 100 mW and 1000 mW. At a minimum, a radio capable of transmission greater than 100 mW must be capable of switching power back to 100 mW or less.

4.8.3 Transmit Spectrum Shape *[Templet 12]*

The Transmitted spectral products shall be less than -30 dbc (dB compared with the SINx/x center peak) for -22 MHz < fc < -11 MHz and 11 MHz < fc < 22 MHz and - 50 dBc for fc < -22 MHz and fc > 22 MHz. The Transmit spectral mask is shown in figure 4.1.

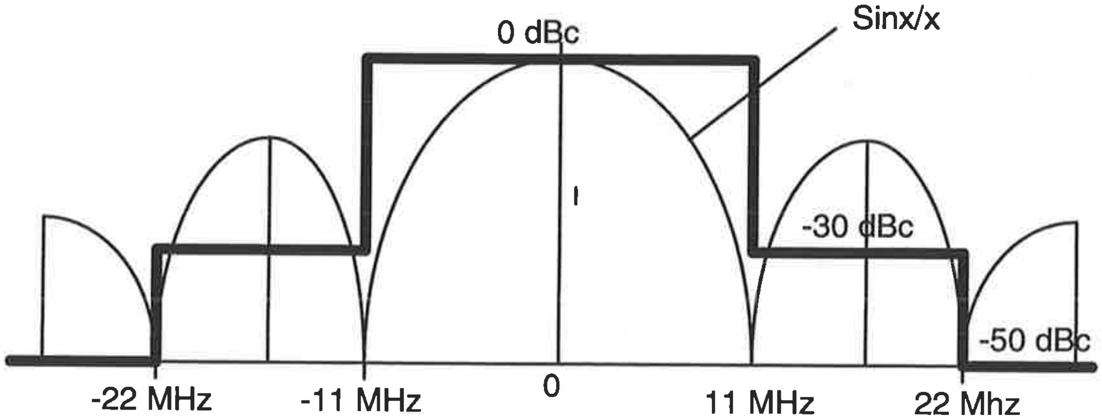

Figure 4.1 Transmit Spectrum Mask

[Editors note: need amplitude and group to the 3dB frequency cutoff]

4.8.4 Transmit Center Frequency Tolerance *[Templet 13]*

The transmitted center frequency tolerance is +/- 25 ppm over the specified temperature. Two temperature ranges are specified. Type 1 is defined as 0^{o} C to 40^{o} C for office environments. Type 2 is defined as -30^{o} C to 70^{o} C.

4.8.5 Chip Clock Accuracy *[Templet 17]*

The PN code chip clock accuracy sall be less than +/- 50ppm across the Type1 or Type 2 temperature ranges specificed in section 4.8.4.

4.8.6 Transmit Power on and Power Down Ramp *[Templet 23 and 24]*

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 4.2.

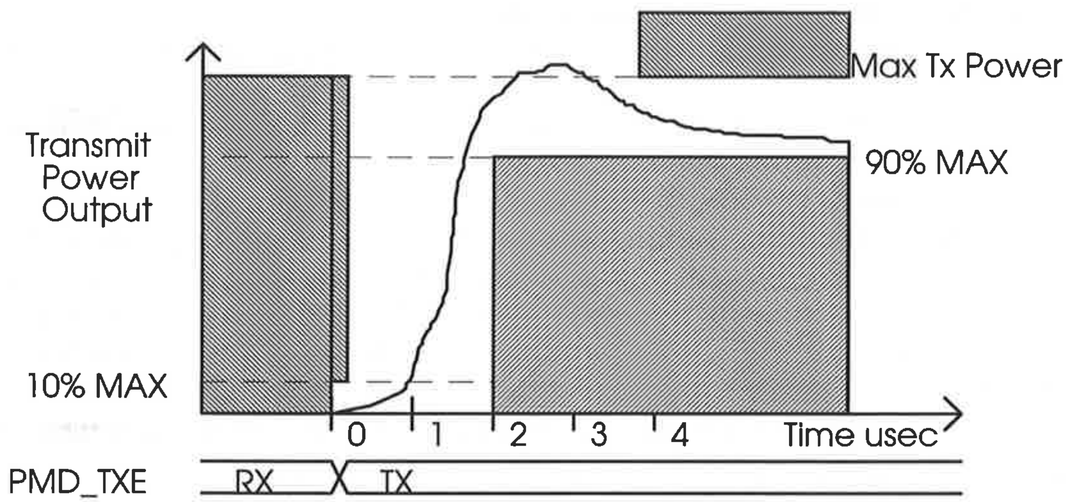

Figure 4.2 Transmit Power On Ramp

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 4.3.

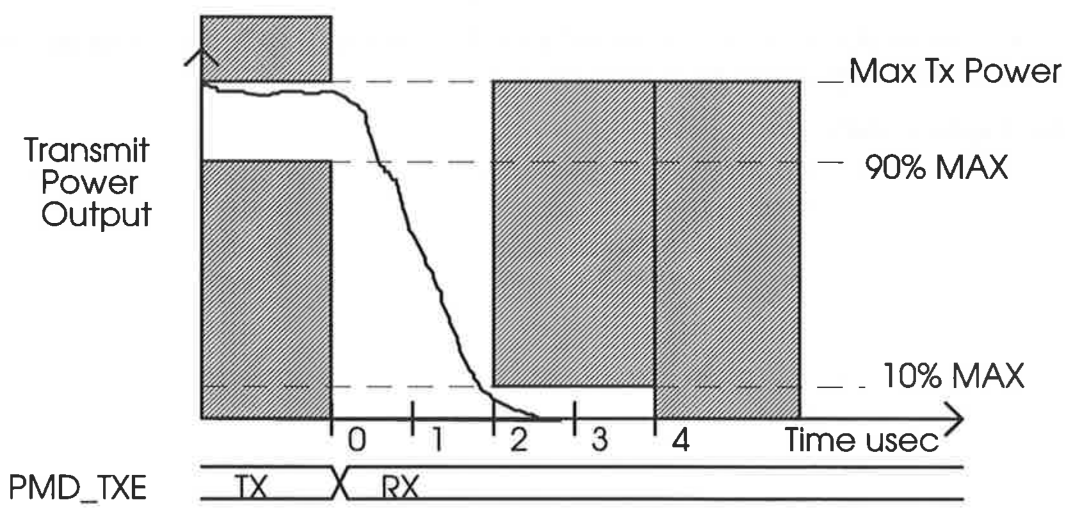

Figure 4.3 Transmit Power Down Ramp

The transmit power ramps are measured from the transition of the PMD_TXE control signal. The transmit power ramps shall be constructed such that the DS PHY emissions conform with spurious frequency product specification defined in section 4.7.5.

4.9 PMD Receiver Specifications

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

4.9.1 Receiver Minimum Input Level Sensitivity *[Templet 4]*

The Bit Error Rate (BER) shall be less than 10^{-5} for an input level of -80 dBm measured at the antenna connector. This BER is specified for 2 MBPS QPSK modulated with the 11 chip Barker spreading sequence.

4.9.2 Receiver Maximum Input Level *[Templet 9]*

The receiver shall tolerate a maximum input level of -4 dBm measured at the antenna.

4.9.3 Receiver Adjacent Channel Rejection *[Templet 10]*

Adjacent channel rejection is defined for the channel groups (group 1 or group 2) defined in section 4.7.2.

The adjacent channel rejection shall be equal to or better than 35 dB with a BER of 10^{-5} using 2 MBPS QPSK with the 11 chip Barker spreading code.

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

Input a 2 MBPS QPSK signal spread with the 11 chip Barker spreading code at a level 6 dB greater than specified in section 4.9.1. In an adjacent channel (as defined by the channel groups), input a signal modulated in a similar fashion which adhears to the transmit mask specified in section 4.8.3 to a level 41 dB above the level specified in 4.9.1. 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 shall be no worse than 10^{-5}.

4.9.4 Receive Energy Detetction Time and Threshold *[Templet 22]*

The maximum response time from energy incident upon the receiver antenna to receiver signal level crossing the Energy Detection Threshold shall be less than or equal to 20 usec.

The Energy Detection Threshold is set by the PMD_ED_TTHRESHOLD.request primitive.

[Editors note: Further details on the ***recomended*** *CCA ED function using long term and short term correlation with an offset will be included here]*

4.9.5 Frame Capture Ratio *[Templet 26]*

The radio shall capture a DS PHY packet signal when the packet signal is greater than or equal to 10 dB for any continuous interferer or other DS PHY source within the channel.

Given a continuous interferer at -50 dbm, an error rate of 10^{-5} shall be maintained from a desired packetized source of -40 dBm. Both signals shall conform to DS PHY modulation.

4.9.6 Receiver Bit Error Rate

The receiver shall provide a BER of 10^{-5} when the Eb/No = 17 dB. The despread PSK Eb/No shall be used for this calculation.

Appendix A Approved DS PHY Sub-issues

The DS PHY specification is a single 802.11 issue consisting of a number of subissues which document individual PHY specification. Document 93/232, The DS PHY Templet, contains a complete and upto date summary of the the DS PHY sub-issues and there status. Templet numbers are indicated in the DS PHY draft standard in *italics.*