IEEE 802.11
Wireless Access Methods and Physical Layer Specifications

TITLE: Physical Layer Draft Specification for Baseband Infrared Media

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Introduction:

This paper contains the Working Draft Standard for the Baseband Infrared Physical Layer. In this is included the Baseband Infrared PMD and PLCP

1. Introduction

1.1 Scope

This document describes the physical layer services provided by the 802.11 wireless LAN MAC for the Baseband Infrared (IR) system. The Baseband IR 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 Baseband IR 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 Baseband IR Physical Layer Functions

The Baseband IR PHY architecture is shown in Figure 1-1. The Baseband IR 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 Baseband IR 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.

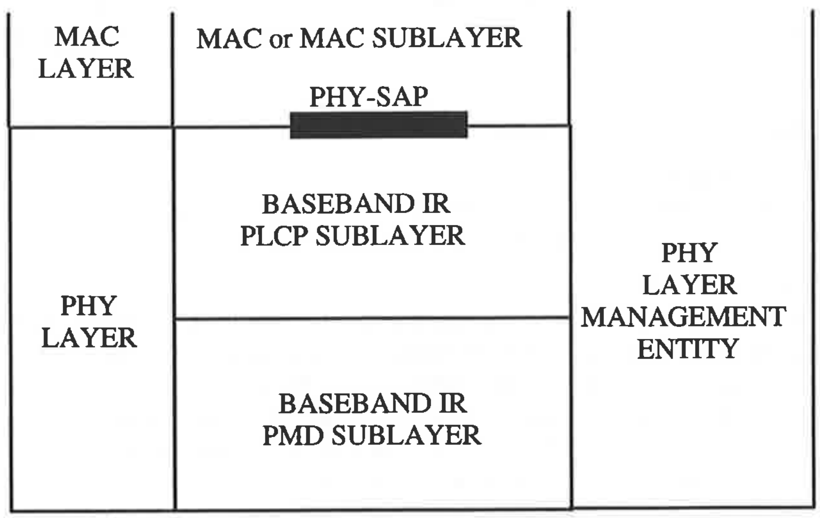

Figure 1-1 Protocol Reference Model

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.

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)
CRC	Cyclic Redundancy Check
FCS	Frame Check Sequence
IR	Infrared
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
PPM	Pulse Position Modulation
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 Baseband IR 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. Baseband IR Physical Layer Service Specifications

2.1 Scope and Field of Application

This section specifies the services provided by the Baseband IR 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 Baseband IR Physical Layer function is separated into two sublayers: the Baseband IR PLCP sublayer and the Baseband IR 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 Baseband IR PMD sublayer. This is accomplished by the PLCP sublayer in the transmit direction by converting MPDUs into Protocol Data Units (PDUs). The formation of the PDU is covered in section 3. In the receive direction, the PLCP is responsible for converting PDUs back into MPDUs. The PLCP is also responsible for adding a Preamble and a Postamble to the PDU at the transmitting node which is used by the receiving nodes for recovering the PDU.

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 Baseband IR 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 for multiple 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_CS		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 shows 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
RATE	PHY_DATA.indicate PHY_DATA.request	16 bit unsigned integer see section 3
TYPE	PHY_INFO.request	Radio type: Baseband IR, IR, FH

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(TXDATA, RATE)

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

RATE. The RATE parameter specifies the data rate (modulation) which will be used to transmit the MPDU portion of the PDU on a per packet basis. The Baseband IR PHY rate change feature is described in section 3.4. The RATE is indicated at the PMD with the PMD_RATE primitive described in section 4.5.5.

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 PDU. The PLCP state machine will generate and transmit the Baseband IR PHY Preamble, as described in section 3, transmit the MPDU defined by TXDATA and generate and transmit the Baseband IR PHY Postamble, as described in section 3.

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(RXDATA, RATE)

RXDATA. The RXDATA parameter is the list of 0 to LENGTH octets which comprises the MPDU the MAC is receiving from the PHY.

RATE. The RATE parameter specifies the data rate (modulation) which was used to transmit the MDPU portion of the PDU. The Baseband IR PHY rate change feature is described in section 3.4.

[Editors note: we may want to define an ERROR parameter similar to the DS and FH PHYs.]

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 PDU.

2.5.3 PHY_INFO.indicate

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)

TYPE. The TYPE parameter indicates the PHY type: DS, FHSS, Baseband IR, Carrier IR, or high speed FHSS.

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_CS.indicate

2.5.4.1 Function

This primitive generated by the PHY entity directly informs the MAC entity that a Baseband IR Preamble was detected (carrier sense) and that data reception is in progress.

2.5.4.2 Semantic of the Service Primitive

This primitive indicates a binary PHY entity status of ENABLED or DISABLED. The ENABLED condition indicates that a Preamble was detected and the PHY entity has a data reception in progress. The DISABLED condition indicates that the PHY entity does not currently have valid data reception in progress.

2.5.4.3 When Generated

This primitive is generated by the PHY sublayer whenever the PHY Baseband IR Preamble is detected.

2.5.4.4 Effect of Receipt

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

2.5.5 PHY_RXBUSY.indicate

2.5.5.1 Function

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

2.5.5.2 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 PHY entity.

2.5.5.3 When Generated

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

2.5.5.4 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.

2.5.6 PHY_TXBUSY.indicate

2.5.6.1 Function

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

2.5.6.2 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 PLCP Preamble transmission is complete and transmission of the MPDU is underway. PHY_TXBUSY is DISABLED when the PLCP Postamble has been transmitted by the PHY entity.

2.5.6.3 When Generated

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

2.5.6.4 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.

2.6 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 successfully 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 successfully completed reset of the transmit state machine.

2.7.4.4 Effect of Receipt

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

3. Baseband IR Physical Layer Convergence Procedure Sublayer

3.1 Introduction

This section provides a convergence procedure in which MPDUs are converted to and from PDUs. During transmission, the MPDU is appended with a PLCP Preamble and with a PLCP Postamble to create the PDU. 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 PDU including the PLCP Preamble, the MPDU and the PLCP Postamble. The PLCP Preamble contains the following fields: Synchronization (Sync), Start Frame Delimiter (SFD), Data Rate (DR) and DC Level Adjustment (DC LA). Each of these fields will be described in detail in section 3.3. The PLCP postamble is the End Frame Delimiter (EFD).

PLCP Preamble				MPDU	PLCP Postamble
Sync	SFD	DR	DC LA		EFD
57-73 slots	4 slots	3 slots	32 slots	variable number of octets	16 slots

Figure 3.1. PLCP Frame Format

3.3 PLCP Field Definitions

The entire PLCP Preamble and Postamble shall be transmitted using the basic pulse defined in section 4.8.2. In all fields the right most bit is transmitted first.

3.3.1 PLCP Synchronization (Sync)

The Sync field consists of a sequence of alternated presence and absence of a pulse in consecutive slots. The Sync field has a minimum length of 57 slots and a maximum length of 73 slots and shall terminate with an empty slot. This field is provided so that the receiver can perform clock recovery, automatic gain control (optional), signal-to-noise ratio estimation (optional) and diversity selection (optional).

3.3.2 PLCP Start Frame Delimiter (SFD)

The SFD field length is 4 slots and consists of the binary sequence `1001`. The SFD field is provided to indicate the start of the MPDU and to perform bit and symbol synchronization.

3.3.3 PLCP Data Rate (DR)

The DR field indicates to the PHY the data rate which will be used for the transmission or reception of the MPDU. The DR field has a length of 3 slots. The Baseband IR PHY currently supports two data rates defined by the following binary words:

- 1 Mbps: `000`
- 2 Mbps: `001`

This field allows for the future introduction of a maximum of 8 different data rates.

3.3.4 PLCP DC Level Adjustment (DC LA)

The DC LA field is required to allow the receiver to stabilise the DC level after the Sync and SFD fields. The length of the DC LA field is 32 slots and consists of the binary words:

- 1 Mbps: 00000000100000000000000010000000
- 2 Mbps: 00100010001000100010001000100010

3.3.5 PLCP End Frame Delimiter (EFD)

The EFD field is provided to indicate the end of the MPDU. The EFD length is 16 slots and consists of the binary word `0000011011011011`.

3.4 PLCP Data Modulation and Data Rate Change

The PLCP Preamble shall be transmitted using the basic pulse defined in section 4.8.2. The Data Rate field will indicate the data rate which will be used to transmit the MPDU. The 1 Mbps data rate will use 16-PPM and the 2 Mbps data rate will use 4-PPM. The transmitter and receiver will initiate the modulation or demodulation indicated by the DR field starting with the first symbol (4 bits for 16-PPM and 2 bits for 4-PPM) of the MPDU. The MPDU transmission rate is set by the RATE parameter in PHY_DATA.request primitive. Any conformant Baseband IR PHY shall be capable of receiving at 1 Mbps and 2 Mbps. Transmission at 2 Mbps is optional.

3.5 PLCP Transmit Procedure

The PLCP transmit procedure is shown in figure 3.3. Based on the status of PHY_CS 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 immediately initiate transmission of the PLCP Preamble based on the parameters passed in the PHY_DATA.request primitive. 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 3.4. The PHY proceeds with MPDU and PLCP Postamble transmission. Transmission is terminated by disabling the PMD_TXE primitive. The termination occurs after the transmission of the final slot of the PLCP Postamble. Coincident with the termination of PMD_TXE, the PHY_TXBUSY is disabled. The packet transmission is completed and the PHY entity enters the default receive state (PMD_TXE is disabled).

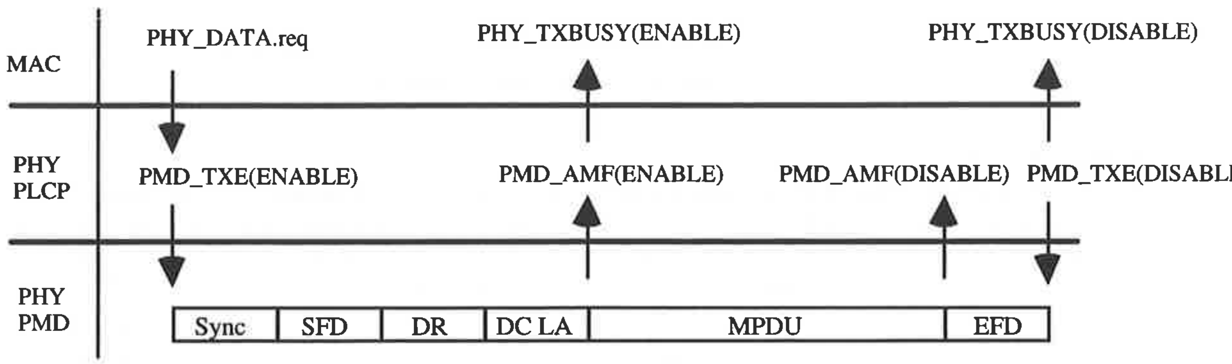

Figure 3.3 PLCP Transmit Procedure

3.6 PLCP Receive Procedure

The PLCP receive procedure is shown in 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 detecting the transmitted Preamble the PMD will enable PMD_CS and the PLCP will enable PHY_CS. The PHY entity begins searching for the SFD field. Once the SFD field is detected the DR and DC LA fields are received. After the last slot of the DC LA field has been received, the PMD_MDA is enabled which in turn enables the PHY_RXBUSY primitive to the MAC. The rate change indicated in the DR field is initiated at this same time as described in section 3.5. The PHY starts immediately searching for the EFD and also proceeds with MPDU reception. Reception is terminated after the reception of the final slot of the EFD. Coincident with the termination PMD_MDA is disabled, PHY_RXBUSY is disabled and a PHY_DATA.indicate primitive is issued. The receiver returns to the default receive state.

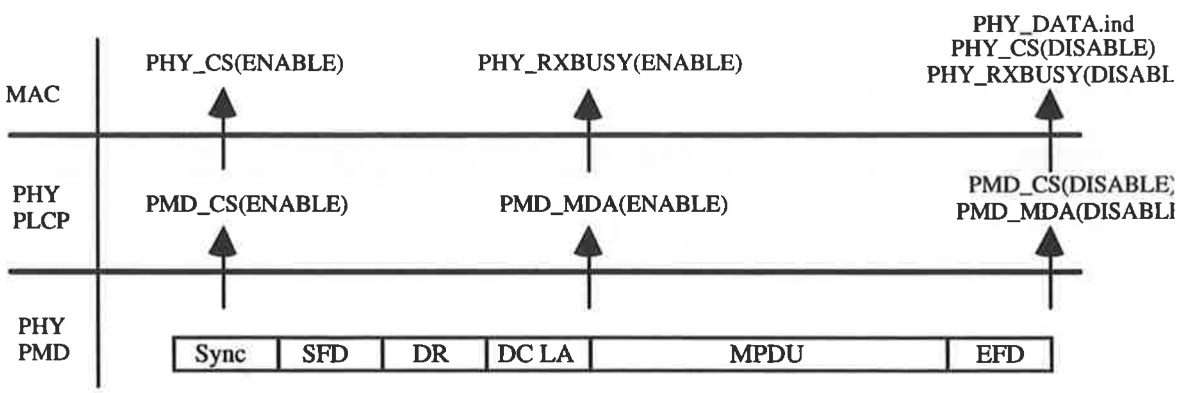

Figure 3.4 PLCP Receive Procedure

4. Baseband IR Physical Medium Dependent

4.1 Scope and Field of Application

This section describes the PMD services provided to the PLCP for the Baseband IR Physical Layer. Also defined in the section are the functional, electrical, and optical characteristics required for interoperability of implementations conforming to this specification. The relationship of this specification to the entire Baseband IR PHY Layer is shown in figure 4.1

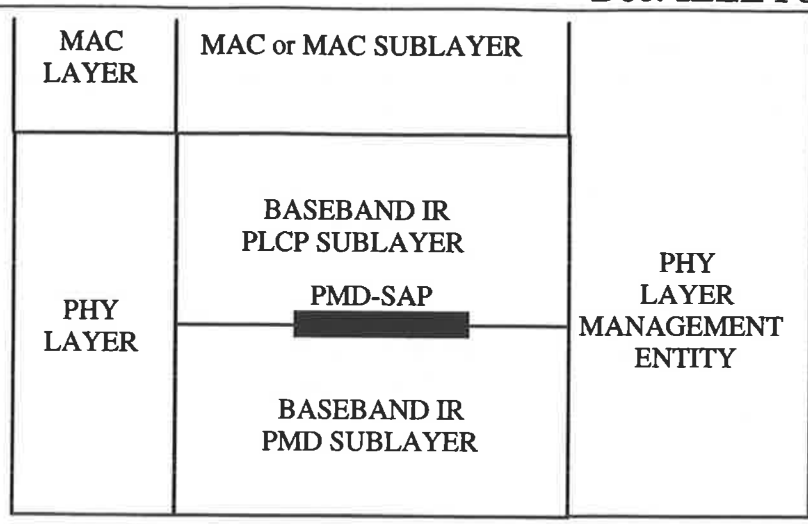

Figure 4.1 PMD Layer Reference Model

4.2 Overview of Service

The Baseband IR 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 Baseband IR PMD sublayer primitives and parameters for the receive function results in a data stream, timing information, and associated received signal parameters being delivered to the PLCP sublayer. A like functionality is provided for data transmission.

4.3 Overview of Interactions

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

1. Service primitives that support PLCP peer-to-peer 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 mandatory 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_RATE	X	X		
PMD_AMF		X		
PMD_MDA		X		
PMD_CS		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
IR_STATE	PMD_TXE.request	Receive, Transmit
RATE	PMD_RATE.indicate PMD_RATE.request	0 for 1 MBPS 16-PPM 1 for 2 MBPS 4-PPM

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

4.5.1.1 Function

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

4.5.1.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_DATA.request(TXD_UNIT)

The TXD_UNIT parameter takes on the value of ONE or ZERO. This parameter represents a single data bit.

4.5.1.3 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.

4.5.1.4 Effect of Receipt

The PMD performs 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 received signal 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 recovered clock.

4.5.2.4 Effect of Receipt

The PLCP sublayer either interpretates 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 PDU transmission by the PMD layer.

4.5.3.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_TXE.request(IR_STATE)

IR_STATE. The IR_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.

4.5.3.3 When Generated

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

4.5.3.4 Effect of Receipt

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

4.5.4 PMD_RATE.request

4.5.4.1 Function

This primitive, generated by the PHY PLCP sublayer, selects the data RATE which will be used by the Baseband IR PHY for transmission.

4.5.4.2 Semantic of the Service Primitive

The primitive shall provide the following parameters:

PMD_RATE.request(RATE)

RATE. RATE selects which of the Baseband IR PHY data rates will be used for MPDU transmission. Section 4.7.1 provides further information on the Baseband IR PHY data rates. The Baseband IR PHY rate change capability is fully described in section 3.4.

4.5.4.3 When Generated

This primitive is generated by the PLCP sublayer to change or set the current Baseband IR PHY data rate.

4.5.4.4 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 Baseband IR PHY will still be capable of receiving at all the required Baseband IR PHY data rates.

4.5.5 PMD_RATE.indicate

4.5.5.1 Function

This primitive, generated by the PMD sublayer, indicates which data rate was used to receive the MPDU part of the PDU. The data rate is indicated in the PLCP Preamble 802.11 DATA RATE field.

4.5.5.2 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 Baseband IR PHY data rates was used to process the MPDU part of the PDU. Section 4.7.1 provides further information on the Baseband IR PHY modulation rates. The Baseband IR PHY rate change capability is fully described in section 3.4.

4.5.5.3 When Generated

This primitive is generated by the PMD sublayer when the PLCP Preamble 802.11 DATA RATE field has been properly detected.

4.5.5.4 Effect of Receipt

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

4.5.6 PMD_AMF.indicate

4.5.6.1 Function

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

4.5.6.2 Semantic of the Service Primitive

The PMD_AMF (Avaliable MAC Frame) primitive is associated 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 PHY entity.

4.5.6.3 When Generated

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

4.5.6.4 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.

4.5.7 PMD_MDA.indicate

4.5.7.1 Function

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

4.5.7.2 Semantic of the Service Primitive

The PMD_MDA (Mac Data Avaliable) primitive is associated 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 PHY entity.

4.5.7.3 When Generated

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

4.5.7.4 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.

4.5.8 PMD_CS.indicate

4.5.8.1 Function

This primitive, generated by the PMD, indicates to the PLCP layer that the receiver has detected a valid Preamble.

4.5.8.2 Semantic of the Service Primitive

The PMD_CS (Carrier Sense) primitive is associated with the PLCP layer PHY_CS primitive. PMD_CS indicates a binary PHY entity status of ENABLED or DISABLED. PHY_CS is ENABLED when a valid Preamble has been detected and data is being received.

4.5.8.3 When Generated

This primitive is generated by the PMD sublayer when the PHY is receiving PDU and a valid Preamble has been detected.

4.5.8.4 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 IR media is busy and occupied by an IR PHY signal. The Baseband IR PHY should not be placed into the transmit state when PMD_CS is ENABLED.

4.6 MPMD_SAP Sublayer Management Primitives

No sublayer management primitives are defined for the Baseband IR PHY PMD

4.7 PMD Operating Specifications General

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

4.7.1 Modulation and Channel Data Rates

Two modulation formats and data rates are specified for the Baseband IR PHY: a Basic Access Rate and an Enhanced Access Rate. The Basic Access Rate is based on 1 MBPS 16-PPM modulation. The 16-PPM encoding is specified in Table 4.6. Each group of 4 data bits is mapped in one of 16 PPM symbols. The Enhanced Access Rate is based on 2 MBPS 4-PPM. The 4-PPM encoding is specified in Table 4.7. Each group of 2 data bits is mapped into one of 4 PPM symbols.

16-PPM	PPM Symbol
0000	1 - 0000000000000001
0001	2 - 0000000000000010
0010	3 - 0000000000000100
0011	4 - 0000000000001000
0100	5 - 0000000000010000
0101	6 - 0000000000100000
0110	7 - 0000000001000000
0111	8 - 0000000010000000
1000	9 - 0000000100000000
1001	10 - 0000001000000000
1010	11 - 0000010000000000
1011	12 - 0000100000000000
1100	13 - 0001000000000000
1101	14 - 0010000000000000
1110	15 - 0100000000000000
1111	16 - 1000000000000000

Table 4.6 1 MBPS 16-PPM Basic Rate Mapping Table

4-PPM	PPM Symbol
00	1 - 0001
01	2 - 0010
10	3 - 0100
11	4 - 1000

Table 4.7 2 MBPS 4-PPM Enhanced Rate Mapping Table

4.7.2 Transmit to Receive Turnaround Time

The time from transition of the PMD_TXE control from the TX state to the RX state until the transceiver is in receive mode shall be less than or equal to TBD usec.

4.7.3 Receive to Transmit Turnaround Time

The time from transition of the PMD_TXE control from the RX state to the TX state until the transceiver is in transmit mode shall be less than or equal to TBD usec.

4.8 PMD Transmit Specifications

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

4.8.1 Transmitted Peak Optical Power

The peak optical power shall be 2 W ± 20%.

4.8.2 Basic Pulse Shape and Parameters

The transmitted optical format of the basic pulse is shown in figure 4.1. The basic pulse width measured between the 50% amplitude points, shall be 250 ns ± 10 ns. The pulse rise time, measured between the 10% and 90% amplitude points, shall be lower than or equal to 40 ns. The pulse fall time, measured between the 10% and 90% amplitude points, shall be lower than or equal to 40 ns. The pulse jitter, defined as the absolute deviation in time of the a pulse from its correct position, shall be lower than or equal to 10 ns.

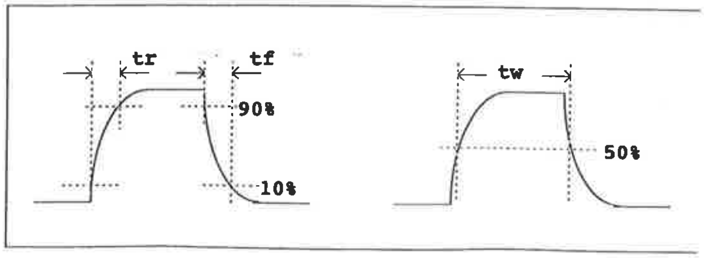

Figure 4.1 Basic Pulse Shape

4.8.3 Optical Radiation Pattern Mask

The optical radiation pattern mask is TBD.

4.8.4 Transmit Spectrum Mask

The Transmit Spectrum Mask is TBD.

Figure 4.2 Transmit Spectrum Mask

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 Sensitivity

The Receiver Sensitivity defined as the minimum irradiance (in dBm/cm^2) at the photodetector plane required for a FER of $4x10^{-5}$ with an MPDU of 512 octets and with an ambient light level of - 10 dBm/cm^2, shall be:

- 1 MBPS: - 47 dBm/cm^2
- 2 MBPS: - 41 dBm/cm^2

[Editors note: for conformance testing we need to specify a noise source (a tungsten lamp seems a good candidate) and a calibrated receiver].

4.9.2 Receiver Dynamic Range

The receiver dynamic range, defined as the ratio between the maximum and minimum irradiance at the photodetector plane that assure a FER lower than or equal to $4x10^{-5}$ with an MPDU of 512 octets and with an ambient light level of - 10 dBm/cm^2, shall be greater or equal to 30 dB.

4.9.3 Receiver Field-of-View (FOV)

The receiver FOV defined as twice the angle from the normal of the detector surface to the direction at which no more optical power impinges on the detector shall be greater than or equal to 150°.

[Editors note: we may want to redefine this specification to make it more clear how conformance testing could be done]

4.9.4 Receiver Interference Level Tolerance

The receiver interference level tolerance from other non-baseband IR PHYs is TBD.

4.9.5 Receiver Carrier Detection Response Time

The maximum response time from the first transition of the PLCP Sync signal to PMD_CS ENABLE shall be less than or equal to 12 usec.

Appendix A Approved Baseband IR PHY Template

General Specifications

Parameter	Value	Comments
Spectrum Occupancy	DC to 5 MHz	Baseband
Data Rate	1 and 2 Mbps	
Wavelength	850 - 950 nm	
Modulation Method	PPM	16-PPM for 1 Mbps 4-PPM for 2 Mbps
Number of Channels	1	
Propagation Mode	Diffuse	Non aimed transceivers

Transmitter Specifications

Parameter	Value	Comments
Output Peak Power	2.0 W ± 20%	@900 nm
Pulse Format		See fig. 3 doc:94/96
• tw (pulse width)	250 ns ± 10 ns	1 and 2 Mbps
• tr (rise time)	40 ns (max)	10 to 90%
• tf (fall time)	40 ns (max)	10 to 90%
• tj (jitter)	10 ns (max)	absolute deviation
Emitter Radiation Pattern	TBD	

Receiver Specifications

Parameter	Value	Comments
Sensitivity (BER=10^{-9}) (max)	-47 dBm/cm^2 (1 Mbps) -41 dBm/cm^2 (2 Mbps)	-10 dBm/cm^2 ambient light
Minimum Dynamic Range	30 dB	On the irradiance at the receiver detector
Minimum Field of View	150°	At the physical limit
Frame Error Rate (FER)	± 4 X 10^{-5}	MAC frame = 512 octets
Carrier Sense out to MAC	± 12 μs	After the preamble start
TX-RX turnaround time	TBD	
RX-TX turnaround time	TBD	
IR silence to Carrier Sense deassert	16 μs	In case of EFD failure

Frame Specifications I

Parameter	Value	Comments
Preamble	57 - 73 time slots	See "Frame specs. II"
Start of Frame Delimiter	4 time slots	See "Frame specs. II"
Data Rate Field	3 time slots	See "Frame specs. II"
DC Level Adjustment	32 time slots	See "Frame specs. II"
MAC Frame	TBD	Integer number of octets
End of Frame Delimiter	16 time slots	See "Frame specs. II"

Frame Specifications II

Parameter	Format	Comments
Preamble Format	010101...0101010	1 and 2 Mbps
SFD Format	1001	1 and 2 Mbps
DC Level Adjustment	2 X symbol '8':	1 Mbps / 16-PPM
Field Format	8 X symbol '2':	2 Mbps / 4-PPM
Data Rate Field Format	000	1 Mbps
	001	2 Mbps
	other formats:	TBD
EFD Format	0000011011011011	1 and 2 Mbps

PPM Mapping Table

4-PPM	16-PPM	PPM Symbol
00	0000	1 - 0000000000000001
01	0001	2 - 0000000000000010
10	0010	3 - 0000000000000100
11	0011	4 - 0000000000001000
	0100	5 - 0000000000010000
	0101	6 - 0000000000100000
	0110	7 - 0000000001000000
	0111	8 - 0000000010000000
	1000	9 - 0000000100000000
	1001	10 - 0000001000000000
	1010	11 - 0000010000000000
	1011	12 - 0000100000000000
	1100	13 - 0001000000000000
	1101	14 - 0010000000000000
	1110	15 - 0100000000000000
	1111	16 - 1000000000000000