100. Physical Medium Attachment (PMA) Sublayer, Physical Medium Dependent (PMD) Sublayer, and Medium for Coaxial Distribution Networks, Type <EPoC_PMD_NAME>

100.1 Overview

This clause describes the Physical Medium Attachment (PMA), the Physical Medium Dependent (PMD) sublayer, and Medium Dependent Interface (MDI) used with {EPoC_PMD_NAME} point-to-multipoint (P2MP) networks. These are passive or active multipoint coaxial distribution networks (CDN) that connect multiple DTEs using a single shared coaxial link. The architecture is asymmetric, based on a tree and branch topology utilizing passive or active coaxial splitters. This type of network requires that the Multipoint MAC Control sublayer exists above MAC instances, as described in {Clause 102}.

100.1.1 Terminology and Conventions

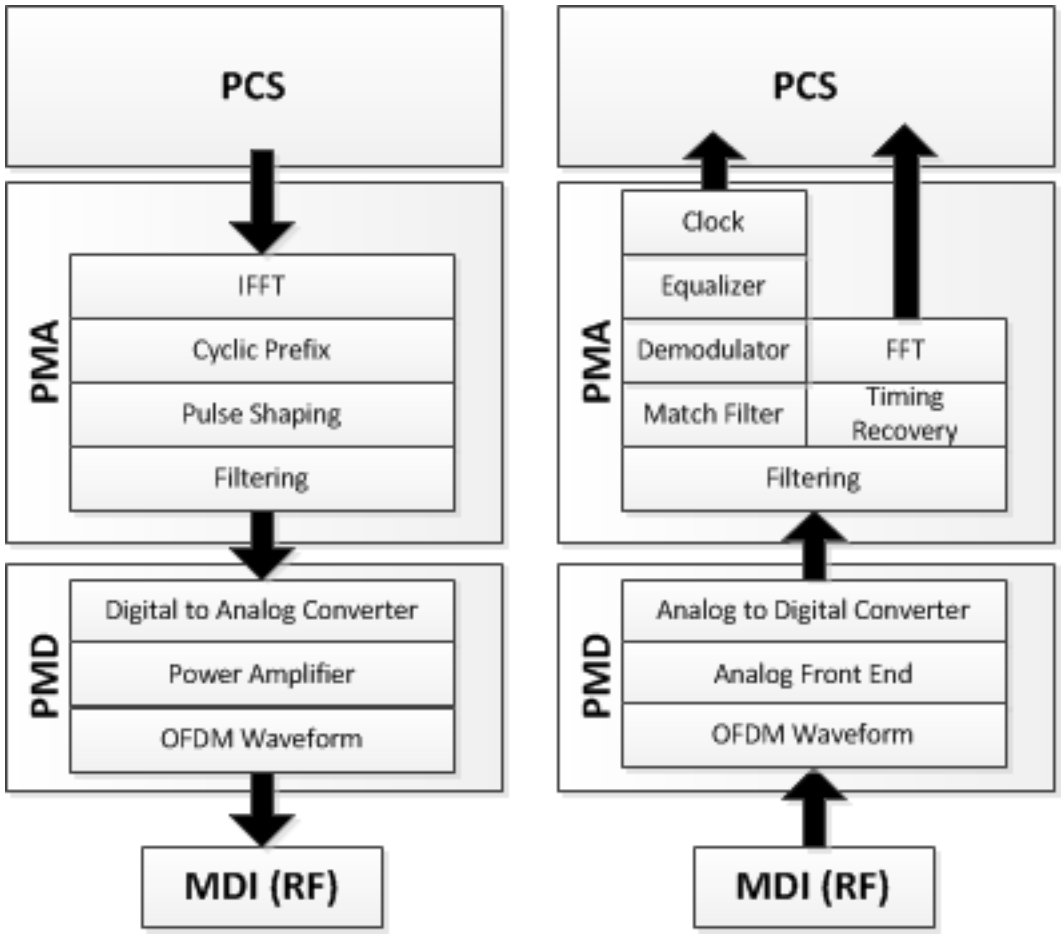
The notation used in the state diagrams in this clause follows the conventions in {21.5}. Should there be a discrepancy between a state diagram and descriptive text, the state diagram prevails. The notation ++ after a counter indicates it is to be incremented by 1. The notation — after a counter indicates it is to be decremented by 1. The notation –= after a counter indicates that the counter value is to be decremented by the following value. The notation += after a counter indicates that the counter value is to be incremented by the following value. Code examples given in this clause adhere to the style of the “C” programming language.

100.1.2 Goals and Objectives

100.1.3 Positioning of the PMA and PMD Sublayers within the IEEE 802.3 Architecture

100.1.4 PMA/PMD Block Diagram

Figure 1—PMA/PMD Block Diagram



This section might need to be expanded into much more detail than what was shown in 10G-EPON. What we need to show is interaction between PMD and PMA similar to Figure 95-3, but we can also show more details on internal PMD structure, relative to functional blocks etc.

100.2 PMA Functional Specification

100.2.1 PMA Service Interface

100.2.1.1 Delay Constraints

A critical subclause which provides delay constraints for PMD we specify for EPoC. Usually, we provide delay and variability (jitter) in here, expressed in units of TQ.

100.2.1.1.1 Relative Processing Delays

Requirements for messaging processing delay through the PMD

100.2.1.2 PMA_UNITDATA.request

Describes how the data is transferred from PMA (digital interface) into analog front-end

100.2.1.3 PMA_UNITDATA.indication

Describes how the data is transferred to PMA (digital interface) from analog front-end

100.2.1.4 PMA_SIGNAL.request

Describes how the PMA controls the transmitter state (on / off). It will be needed for burst mode transmission. We could also control the status of the auto-negotiation process, data rate control etc. To be discussed in more detail later.

100.2.1.5 PMA_SIGNAL.indication

Describes how the PMA learns about the incoming signal (presence of data). It will be needed for burst mode transmission and continuous mode transmission alike. Here, we will be also able to indicate whether the link is operating, in hunting mode, stable, etc.

100.2.2 CLT Transmit OFDM Numerology

100.2.2.1 Number of Channels, Channel size and Sampling Frequency

The EPoC PHY shall use two OFDM channels for data in the downstream direction. An OFDM downstream channel shall have a bandwidth of 192 MHz with an OFDM sampling frequency of integer multiples of 10.24 MHz.
Decision 7: Downstream OFDM sampling frequency - Motion 12, September 2012

The EPoC PHY shall support combining multiple 192 MHz OFDM channels for the purpose of increasing capacity.
Decision 8: Support for higher capacity - Motion 14, September 2012

The EPoC system shall provide a granularity of 1 MHz for setting the center frequency of an OFDM channel.
Decision 30: Center Frequency Granularity - Motion 16, March 2013

100.2.2.1.1 PLC Channel Size

The downstream PLC shall be 400KHz wide.
Decision 39: PLC Subcarriers - Motion 26, March 2013

100.2.2.2 FFT size(s)

100.2.2.3 Available Subcarriers

An OFDM channel shall be composed of ***x*** sub-carriers.

Sub-carriers within an OFDM channel shall have a spacing of either 25MHz or 50 MHz. The sub-carrier spacing shall be consistent within an OFDM channel (within a system? Can you have one channel with 50 MHz spacing and another channel with 25 MHz spacing?)

The EPoC PHY shall support the exclusion of one or more sub-carriers.Excluded sub-carriers may be present in any portion of the OFDM channel. An OFDM channel shall have at least 24 MHz of contiguous spectrum between excluded sub-carriers.Contiguous sub-carriers may have contain nulled sub-carriers that do not carry data; these nulled sub-carriers do not make the block of sub-carriers non-contiguous.

Excluded sub-carriers in the downstream shall be communicated to the CNU from the CLT via the PHY link channel.

The PLC shall be composed of either eight sub-carriers with a spacing of 50 MHz or 16 sub-carriers with a spacing of 25 MHz.

Decision 5: OFDM Subcarrier Exclusion - Motion 10, September 2012
Decision 14: Exclusion subbands placement - Motion 6, January 2013
Decision 17: Downstream subcarrier spacings - Motion 11, January 2013
Decision 33: Exclusion bands configured by PLC - Motion 19, March 2013
Decision 35: Minimum contiguous spectrum - Motion 21, March 2013
Decision 39: PLC Subcarriers - Motion 26, March 2013

100.2.2.4 Cyclic prefix

An OFDM channel shall use a cyclic prefix size of ***x***.

The PLC shall use the same cyclic prefix used by downstream OFDM channels.

The CNU shall automatically detect the CP size used by the PLC.

Decision 12: PHY Link downstream cyclic prefix auto-detect - Motion 4, January 2013
Decision 13: PHY Link downstream cyclic prefix and symbol duration - Motion 5, January 2013

100.2.2.5 Pulse Window Shaping (alpha and filter type)

Decision 23: Windowing - Motion 9, March 2013

100.2.2.6 Guard Size

100.2.2.7 Cyclic Prefix Prepend

Describes the size and structure of the cyclic prefix

100.2.3 CNU Transmit OFDMA Numerology

100.2.3.1 Number of Channels, Channel Size, and Sampling Frequency

The EPoC PHY shall use a single OFDMA channel for data in the upstream direction.An OFDMA channel shall have a bandwidth of 192 MHz.

Decision 24: Upstream RF bandwidth - Motion 10, March 2013

100.2.3.2 Sub-Band width(s)

100.2.3.3 FFT size(s)

100.2.3.4 Subcarrier width

100.2.3.5 Number of Subcarriers

100.2.3.6 Subcarrier Group Size

100.2.3.7 Subcarrier Per Transmitter

100.2.3.8 Available Subcarriers

Total subcarriers available for payload after all of the overhead is accounted for.

100.2.3.9 Cyclic prefix/Guard Size

100.2.3.10 Pulse Window Shaping (alpha and filter type)

100.3 PMD Functional Specification

100.3.1 PMD Service Interface

100.3.1.1 Delay Constraints

A critical subclause which provides delay constraints for PMD we specify for EPoC. Usually, we provide delay and variability (jitter) in here, expressed in units of TQ.

100.3.1.1.1 Relative Processing Delays

Requirements for messaging processing delay through the PMD

100.3.1.2 PMD_UNITDATA.request

Describes how the data is transferred from PMD (digital interface) into analog front-end

100.3.1.3 PMD_UNITDATA.indication

Describes how the data is transferred to PMD (digital interface) from analog front-end

100.3.1.4 PMD_SIGNAL.request

Describes how the PMD controls the transmitter state (on / off). It will be needed for burst mode transmission. We could also control the status of the auto-negotiation process, data rate control etc. To be discussed in more detail later.

100.3.1.5 PMD_SIGNAL.indication

Describes how the PMD learns about the incoming signal (presence of data). It will be needed for burst mode transmission and continuous mode transmission alike. Here, we will be also able to indicate whether the link is operating, in hunting mode, stable, etc.

100.3.2 PMD Transmit Function

100.3.2.1 Modulation Formats

The EPoC PHY shall support the following downstream modulation order for data channels:

- 16QAM
- 256QAM
- 512QAM
- 1024QAM
- 2048QAM
- 4096QAM

The EPoC PHY shall support the following upstream modulation orders for data channels:

- 16QAM
- 256QAM
- 512QAM
- 1024QAM

The PLC shall use a fixed 16QAM modulation order.

Details the modulation formats that must be supported for each channel - PLC, Data, and pilots for DS and US (e.g.256QAM, 512QAM, 1024QAM etc.)

Where do we talk about MMP?

Decision 6: Multiple Modulation Orders - Motion 11, September 2012
Decision 11: Downstream PHY link modulation order - Motion 3, January 2013
Decision 19: Multiple Modulation Profiles - Motion 4, March 2013

100.3.2.1.1 Total Information Data Rate for OFDM Channels

In baseline channel conditions, as defined in Annex ***x***, a192 MHz OFDM channel shall target a 1.6 Gbps data rate at MAC/PLS. The MAC/PLS date rate shall scale linearly with the number of OFDM channels, in the same baseline channel conditions in each channel.

Decision 40: Downstream MAC/PLS data rate target - Motion 27, March 2013
Decision 9: Data scaling with OFDM channels - Motion 6, November 2012

100.3.2.1.2 Total Information Data Rate for OFDMA Channels

100.3.2.2 Frequency Plan

Range of transmitter frequencies

100.3.2.2.1 FDD/TDD Downstream Frequency Plan

The EPoC PHY shall support an upper band edge of at least 5 GHz.
Decision 31: RF Spectrum Upper Bound - Motion 17, March 2013

100.3.2.2.2 FDD Upstream Frequency Plan

100.3.2.3 Carrier Muting

100.3.3 CLT Transmitter Requirements

100.3.3.1 CLT Transmit Power Requirements

Transmit power requirements for the CLT, including range of reported transmit power per channel, step size of power commands, step size accuracy, and absolute accuracy of CLT.

100.3.3.1.1 OFDM Transmit Power Calculations

100.3.3.1.2 Transmit Power Step Size

100.3.3.1.3 PAPR

100.3.3.2 CLT Transmit Fidelity Requirements

100.3.3.2.1 Spectral Nulling

100.3.3.2.2 Adjacent Channel Spurious Emissions

100.3.3.2.3 Spurious Emissions in the Frequency Range

100.3.3.2.4 Spurious Emissions During Burst On/Off Transients

100.3.3.2.5 Modulation Error Ratio

Includes definitions and requirements

100.3.3.2.6 Filter Distortion

100.3.3.2.7 Carrier Phase Noise

100.3.3.2.8 Channel Frequency Accuracy

100.3.3.2.9 Modulation Rate Accuracy

100.3.3.2.10 Modulation Timing Jitter

100.3.4 CNU Transmitter Requirements

100.3.4.1 CNU Transmitter Pre-Equalizer

100.3.4.2 CNU Transmit Power Requirements

Transmit power requirements the CNU, including range of reported transmit power per channel, step size of power commands, step size accuracy, and absolute accuracy of CNU.

100.3.4.2.1 OFDMA Transmit Power Calculations

100.3.4.2.2 Transmit Power Step Size

100.3.4.2.3 Transmit Power Requirements with Multiple Transmitters

100.3.4.2.4 PAPR

100.3.4.3 CNU Transmitter Burst Timing Ramp Up/Down

100.3.4.4 CNU Transmitter Frequency Agility and Range

100.3.4.5 CNU Transmitter Capabilities

Describes what CNU capabilities the CNU must report to the FCU and OLT - TDD capable, for example

100.3.4.6 CNU Transmitter Fidelity Requirements

100.3.4.6.1 Adjacent Channel Spurious Emissions

100.3.4.6.2 Spurious Emissions in the Upstream Frequency Range

100.3.4.6.3 Spurious Emissions During Burst On/Off Transients

100.3.4.6.4 Modulation Error Ratio

100.3.4.6.5 Carrier Phase Noise

100.3.4.6.6 Channel Frequency Accuracy

100.3.4.6.7 Modulation Rate Accuracy

100.3.4.6.8 Modulation Timing Jitter

100.3.4.6.9 Clock Recovery

100.3.5 PMD Receive Function

100.3.5.1 PMD Auto-Negotiation Function

This subclause will be brand new and will describe the process of auto-negotiating data rate across EPoC link

100.3.6 CNU Receive Requirements

100.3.6.1 Input Signal Characteristics at CNU Receiver

Describes the characteristics of the input signal at the receiver(e.g, signal level, power spectral density (PSD) etc.),.

100.3.6.2 CNU Tuner Frequency Range

100.3.6.3 Frame Error Rate

Specifies the downstream frame error ratio. From objectives: better than 10^-6 at the MAC/PLS service interface. Complete details required (channel conditions, frame sizes, etc.).

100.3.6.4 Input Return Loss

100.3.6.5 Input Impedance

100.3.6.6 Image Rejection Performance

For example: Performance MUST be met with an analog or a digital signal at +10 dBc in any portion of the RF band. For adjacent and nonadjacent channels.

100.3.6.7 Multi-Channel Receiver Operation

Are there any requirements for multi-channel receiver requirements needed?

100.3.6.8 Reconfiguration of CNU Receiver

Specifies requirements for the CNU to dynamically change the receive channel parameters it is currently using. This could be used for modulation profiles, bit loading, etc.

100.3.6.9 PMD Transmit Enable Function

Assuming burst mode transmission is done in upstream only

100.3.6.10 PMD Signal Detect

Table similar to Table 95-4 will need to be specified in here, indicating when and how signal presence is detected and when it is not

100.3.7 CLT Receive Requirements

100.3.7.1 Input Signal Characteristics at CLT Receiver

Describes the characteristics of the input signal at the receiver (e.g, signal level, power spectral density (PSD), .

100.3.7.2 Tuner Frequency Range

100.3.7.3 Frame Error Rate

Specifies the downstream frame error ratio. From objectives: better than 5x10^-5 at the MAC/PLS service interface. Complete details required (channel conditions, frame sizes, etc.).

100.3.7.4 Input Return Loss

100.3.7.5 Input Impedance

100.3.7.6 Image Rejection Performance

Performance MUST be met with an analog or a digital signal at +10 dBc in any portion of the RF band.

Covers adjacent and non-adjacent channels

100.3.7.7 Multi-Channel Receiver Operation

Are there any requirements for multi-channel receiver requirements needed? Not defined yet.

100.3.7.8 PMD Signal Detect

100.4 Definitions of Parameters and Measurement Methods

10G-EPON spec contains several subclauses which are not going to be applicable to coaxial plant. The list below accounts for the subclauses most likely to apply to coaxial section, but also other (new) subclauses are possible, as long as TF agrees to their presence.

100.4.1 Insertion Loss?

Is this channel model defined

100.4.2 Test Patterns

100.4.3 Frequency and Frequency Range Measurement

100.4.4 RF Power Measurements

100.4.5 Transmit Waveform and MER (Constellation diagram)

100.4.6 Transmit Penalty?

100.4.7 Receive Sensitivity

100.4.8 Stressed Receiver Conformance Test

We will need to discuss whether such a test makes sense for RF devices.

100.4.9 Jitter Measurements

100.4.10 Transmitter On/Off Timing Measurements

Might be needed if transmitter is indeed switched on/off between bursts.

100.4.11 Receiver Settling Timing Measurement

Might be needed for CLT Rx, where bursts from individual CNUs are incoming time interleaved.

100.5 Environmental, Safety, and Labeling

10G-EPON spec contains several subclauses which are not going to be applicable to coaxial plant. The list below accounts for the subclauses most likely to apply to coaxial section, but also other (new) subclauses are possible, as long as TF agrees to their presence. The set below is a minimum set which has been used for PMD description in the past. This set is likely to be extended

100.5.1 General Safety

100.5.2 RF Safety

100.5.3 Installation

100.5.4 Environment

100.5.5 PMD Labeling?

100.6 Channel Characteristics

The channel is composed of coax, active components (amps,) and passive components (taps, etc). This should refer to the channel model appendix.

100.6.1 Coaxial Cabling Model

100.6.2 Coaxial Cable

100.6.3 Coaxial Connectors

100.6.4 Medium Dependent Interface (MDI)

100.7 EEE Capability

This subclause might contain summary of the EEE capabilities for this PMD type. Given that it is a new PMD design, the suggestion is to in-build EEE capability from day one, rather than add it in a fashion similar to P802.3az project. This material will all be new in 802.3bn

100.8 TimeSync Capability

This subclause might contain summary of the TimeSync capabilities for this PMD type. Given that it is a new PMD design, we can embed TimeSync capability from day one. This involves primarily guaranteeing repeatable and stable delay as well as support for specific capability registers. See Clause 90 for more details.

100.9 Protocol implementation conformance statement (PICS) proforma for Clause 100, Physical Medium Dependent (PMD) sublayer and medium for coaxial distribution networks, type EPoc_PMD_Name

To be filled in once the main spec is ready (Clause 100 work is largely technically complete)