190.5 PMA electrical specifications

This subclause defines the electrical characteristics of the PMA for a 100BASE-T1L Ethernet PHY.

190.5.1 EMC tests

Operational requirements of the transceiver during the test are determined by the manufacturer.

Applications for the specified device commonly have additional requirements that limit its conducted radio frequency emission and its susceptibility to electromagnetic interference. Such requirements are beyond the scope of this standard.

190.5.2 Test modes

The test modes described in this subclause are provided to allow testing of the transmitter. The test modes can be enabled by setting bits 1.2302.15:12 (100BASE-T1L test mode control register) of the PHY Management register set as described in 45.2.1.236c. If MDIO is not implemented, a similar functionality shall be provided by equivalent means. These test modes shall not alter the electrical and jitter characteristics of the transmitter and receiver from those that can appear in normal (i.e., non-test mode) operation.

a) Test mode 1—Timing jitter test mode at 1.0 Vpp transmit level
b) Test mode 2—Timing jitter test mode at 2.0 Vpp transmit level
c) Test mode 3—Droop test mode at 1.0 Vpp transmit level
d) Test mode 4—Droop test mode at 2.0 Vpp transmit level
e) Test mode 5—Formatted training sequence at 1.0 Vpp transmit level
f) Test mode 6—Formatted training sequence at 2.0 Vpp transmit level
g) Test mode 7—Normal Idle with RS-FEC disabled at 1.0 Vpp transmit level
h) Test mode 8—Normal Idle with RS-FEC disabled at 2.0 Vpp transmit level
i) Test mode 9—Normal Idle with RS-FEC enabled at 1.0 Vpp transmit level
j) Test mode 10—Normal Idle with RS-FEC enabled at 2.0 Vpp transmit level
k) Test mode 11—External PHY loopback with RS-FEC disabled at 1.0 Vpp transmit level
l) Test mode 12—External PHY loopback with RS-FEC disabled at 2.0 Vpp transmit level
m) Test mode 13—External PHY loopback with RS-FEC enabled at 1.0 Vpp transmit level
n) Test mode 14—External PHY loopback with RS-FEC enabled at 2.0 Vpp transmit level

If increased transmit level (2.0 Vpp mode) is supported, the PHY shall transmit at 2.0 Vpp transmit level in even-numbered test modes. If increased transmit level is not supported, even numbered test modes are undefined.

When test mode 1 or test mode 2 is enabled, the PHY shall repeatedly transmit the data symbol sequence (+1, –1). See 190.5.4.5 for transmit clock requirements.

When test mode 3 or test mode 4 is enabled, the PHY shall transmit ten “+1” symbols followed by ten “–1” symbols. This sequence is repeated continually.

When test mode 5 or 6 is enabled, the 100BASE-T1L PHY shall transmit the formatted training sequence described in 190.3.4.2 and in the LEADER data mode.

When test mode 7 or 8 is enabled, the 100BASE-T1L PHY shall transmit without RS-FEC encoding as in non-test operation and in the LEADER data mode with data set to normal Inter-Frame idle signals.

When test mode 9 or 10 is enabled and RS-FEC encoding is supported, the 100BASE-T1L PHY shall transmit with RS-FEC encoding as in non-test operation and in the LEADER data mode with data set to normal Inter-Frame idle signals. If RS-FEC encoding is not supported, test modes 9 and 10 are undefined.

190.5.2.1 PHY external loopback

In test modes 11 and 12 the PHY shall be placed in an external (local) loopback mode with RS-FEC encoding disabled. If RS-FEC encoding is supported, in test modes 13 and 14 the PHY shall be placed in an external (local) loopback mode with RS-FEC encoding enabled. If RS-FEC encoding is not supported, test modes 13 and 14 are undefined.

When the PHY is in the external loopback mode, the PMA Receive function utilizes the echo signals from the open MDI and decodes these signals to pass the data back to the MII Receive interface. The data flow of the external loopback is shown in Figure 190–20. When PHY external loopback is enabled, the PCS transmit scrambler polynomial and the receiver descrambler polynomial should be matched, e.g., the LEADER scrambler polynomial and the FOLLOWER descrambler polynomial, in order for looped data to be properly descrambled at the MII.

A MAC client can compare the packets sent through the MII Transmit function to the packets received from the MII

Receive function to validate the 100BASE-T1L PCS and PMA functions.

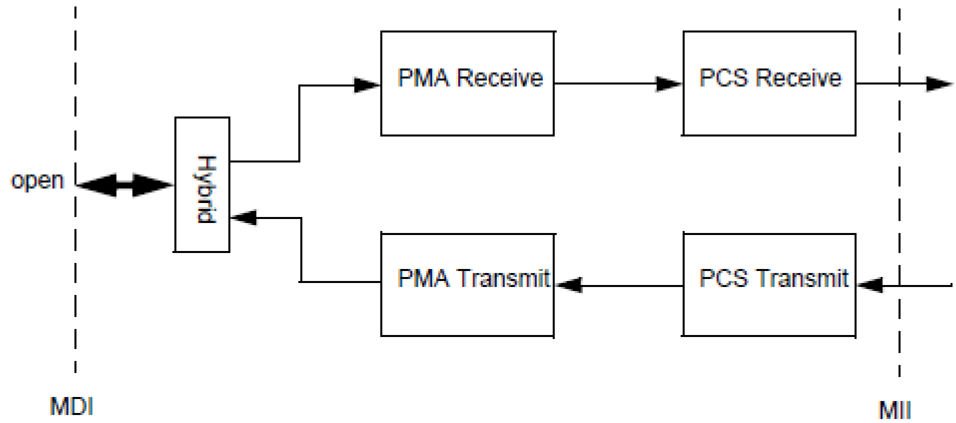

Figure 190-20 PMA Loopback data flow

190.5.3 Test fixture

The following fixtures (illustrated by Figure 190–21, Figure 190–22, and Figure 190-23), or their functional equivalents, can be used for measuring the transmitter specifications described in 190.5.4. All the transmitter tests are defined at the MDI.

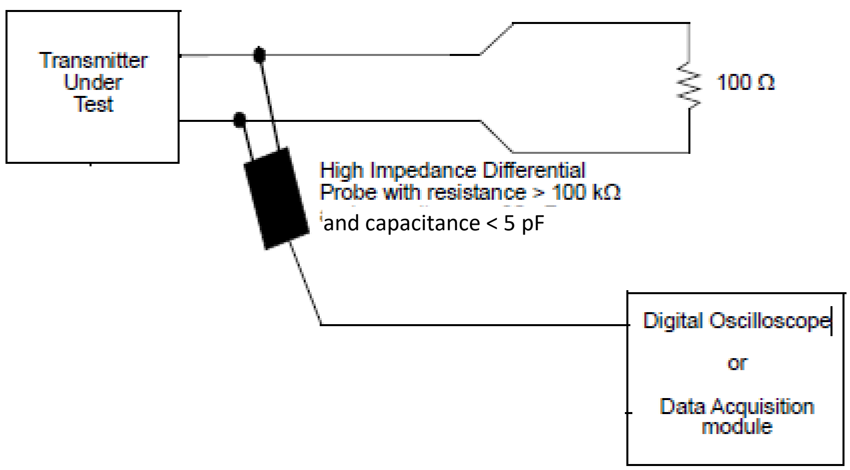

Figure 190–21—Transmitter test fixture 1 for transmitter voltage, transmitter droop, and transmitter timing jitter

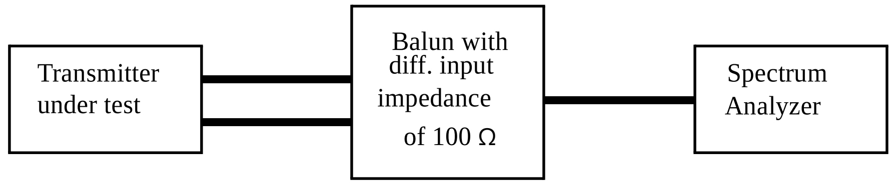

Figure 190–22—Transmitter test fixture 2 for power spectral density measurement and transmit power level measurement

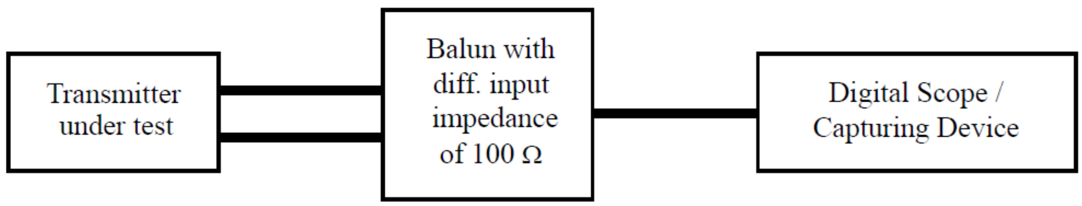

Figure 190-23—Transmitter test fixture 3 alternative for MDI jitter measurement

190.5.4 Transmitter electrical specifications

The PMA shall operate with ac coupling to the MDI. Where a load is not specified, the transmitter shall meet the requirements of 190.5.4 with a 100 Ω ± 0.1% resistive differential load connected to the transmitter output.

190.5.4.1 Transmitter output voltage

When tested with the test fixture shown in Figure 190–21 with the transmitter in test mode 1, the transmitter output voltage shall be 1 V ± 5% peak-to-peak (for the 1.0 Vpp operating mode).
If 2.0Vpp mode is supported, when tested with the test fixture shown in Figure 190–21 with the transmitter in test mode 2, the transmitter output voltage shall be 2 V ± 5% peak-to-peak (for the 2.0 Vpp operating mode).
.

NOTE—The above specification is applicable to test modes 1 and 2, which have minimal impact from droop. In other transmit modes, the peak-to-peak amplitude can be greater due to additional signal droop.

190.5.4.2 Transmitter output droop

With the transmitter in test mode 3 and, if 2.0 Vpp mode is supported, in test mode 4, and using the transmitter test fixture shown in Figure 190–21:

When a Clause 104 Type G PSE or PD PI is not encompassed within the MDI, the magnitude of both the positive and negative droop shall be less than 10% measured with respect to an initial value at 37.5 ns after the zero crossing and a final value at 100 ns after the zero crossing.

When a Clause 104 Type G PSE or PD PI is encompassed within the MDI, the magnitude of both the positive and negative droop shall be less than 25% measured with respect to an initial value at 37.5 ns after the zero crossing and a final value at 100 ns after the zero crossing.

Implementers should consider transmitter amplitude limitations when appropriate to the application such as those applications addressed in Annex 146A. This specification is at the MDI with the MDI loaded as specified in 190.5.4. Addition of power coupling networks and measurement noise can increase the apparent droop. For example, a power coupling network might add 3% and noise might further increase droop by 2%, adding up to 5%. Limiting additional apparent droop due to test setup is strongly encouraged and should be corrected for according to the measurement configuration being used.

190.5.4.3 Transmitter timing jitter

When tested using the test fixture shown in Figure 190–21 or Figure 190-23 with the transmitter in test mode 1 for 1.0Vpp mode, and test mode 2 for 2.0Vpp mode if supported, the RMS value of the MDI output jitter relative to an unjittered reference shall be less than 50 ps. Jitter shall be measured over an interval of 1 ms ± 10%. The bandwidth of the measurement device shall be larger than 200 MHz, and preferably at least 1 GHz.

Unjittered reference is a constant clock frequency extracted from each record of captured differential output on MDI. The unjittered reference is based on linear regression of frequency and phase that produces minimum Time Interval Error.

NOTE – LEADER/FOLLOWER jitter when the link is operational is covered by the receiver performance tests in the presence of noise.

190.5.4.4 Transmitter Power Spectral Density (PSD) and power level

Editor's note (not for draft) – transmit power levels and PSD levels are derived from 10BASE-T1L, scaled by for 80 Mbaud vs. 7.5 Mbaud, and 2Vpp vs 2.4Vpp as required. Possibly other adjustments are required. Proposals requested.

Tests for transmit power and PSD may be performed while transmitting as LEADER. For the 1.0Vpp operating mode, in test mode 7, and, if RS-FEC encoding is supported, in test mode 9, the transmit power shall be 1.0 ± 1.2 dBm. If 2.0Vpp mode is supported, with the transmitter in test mode 8 and, if RS-FEC encoding is supported, in test mode 10, the transmit power shall be 7.0 ± 1.2 dBm. The power spectral density of the transmitter, measured into a 100 Ω load using the test fixture shown in Figure 190–21, shall be between the upper and lower masks specified in Equation (190–6) and Equation (190–7) for the 2.0 Vpp transmit amplitude and by Equation (190–8) and Equation (190–9) for the 1.0 Vpp transmit amplitude. The masks are shown in Figure 190–22 and Figure 190–23. Transmit power spectral density is measured with test modes 7 through 10, as appropriate to the transmit amplitude and RS-FEC modes supported.

For the 1 Vpp transmit signal amplitude:

$$\text{Upper PSD}(f) = \begin{cases} -69.3 - 1.5 \times \dfrac{f-1}{19} & \text{dBm/Hz for 1 MHz } \le f < 20\text{ MHz} \\ -70.8 - 3.7 \times \dfrac{f-20}{20} & \text{dBm/Hz for 20 MHz } \le f < 40\text{ MHz} \\ -74.5 - 19 \times \dfrac{f-40}{40} & \text{dBm/Hz for 40 MHz } \le f < 80\text{ MHz} \\ -93.5 & \text{dBm/Hz for 80 MHz } \le f \le 250\text{ MHz} \end{cases} \qquad (190\text{–}6)$$

$$\text{Lower PSD}(f) = \begin{cases} -77.9 - 3.9 \times \dfrac{f-5}{15} & \text{dBm/Hz for 5 MHz } \le f < 20\text{ MHz} \\ -81.8 - 13.4 \times \dfrac{f-20}{20} & \text{dBm/Hz for 20 MHz } \le f \le 40\text{ MHz} \end{cases} \qquad (190\text{–}7)$$

where f is the frequency in MHz.

For the 2 Vpp transmit signal amplitude:

$$\text{Upper PSD}(f) = \begin{cases} -63.3 - 1.5 \times \dfrac{f-1}{19} & \text{dBm/Hz for 1 MHz } \le f < 20\text{ MHz} \\ -64.8 - 3.7 \times \dfrac{f-20}{20} & \text{dBm/Hz for 20 MHz } \le f < 40\text{ MHz} \\ -68.5 - 19 \times \dfrac{f-40}{40} & \text{dBm/Hz for 40 MHz } \le f < 80\text{ MHz} \\ -87.5 & \text{dBm/Hz for 80 MHz } \le f \le 250\text{ MHz} \end{cases} \qquad (190\text{–}8)$$

$$\text{Lower PSD}(f) = \begin{cases} -71.9 - 3.9 \times \dfrac{f-5}{15} & \text{dBm/Hz for 5 MHz } \le f < 20\text{ MHz} \\ -75.8 - 13.4 \times \dfrac{f-20}{20} & \text{dBm/Hz for 20 MHz } \le f \le 40\text{ MHz} \end{cases} \qquad (190\text{–}9)$$

where f is the frequency in MHz.

Editor's note (to be removed prior to initial SA ballot): Figures to be redrawn as postscript.

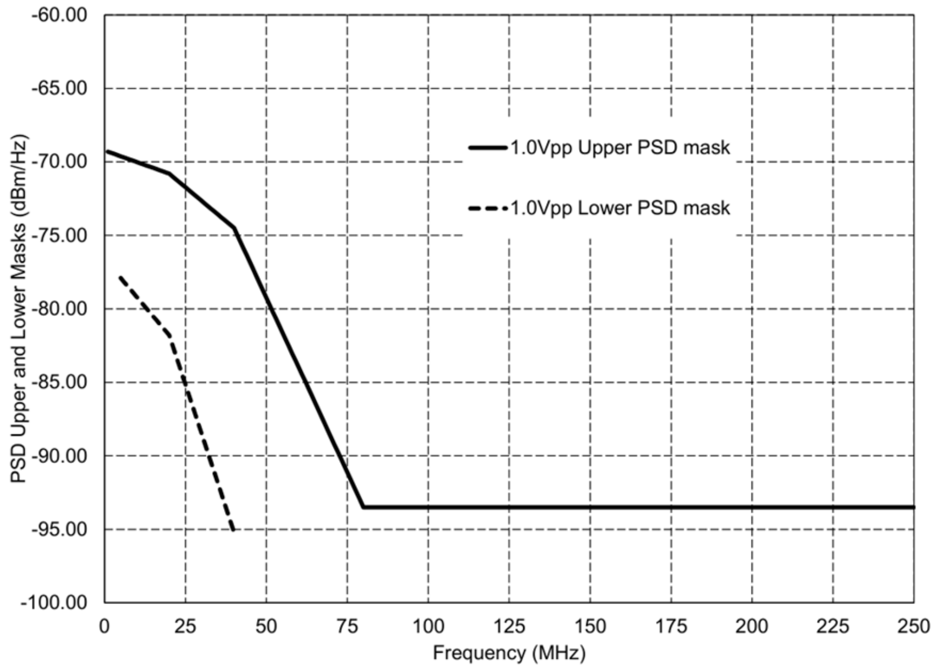

Figure 190–22—Transmitter Power Spectral Density, 2.0 Vpp Transmit Amplitude, Upper and Lower Masks

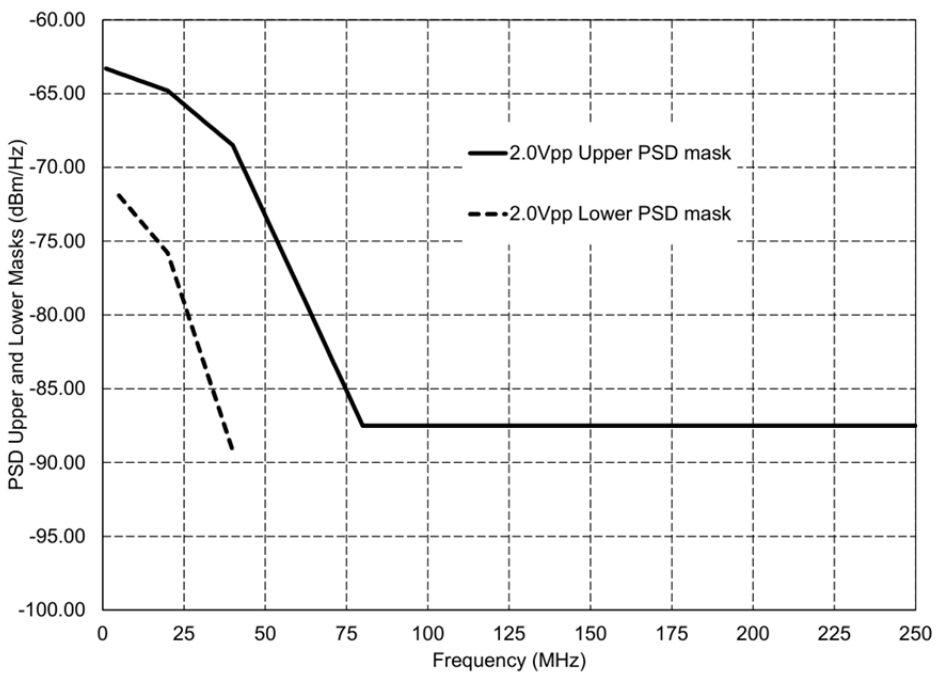

Figure 190–23—Transmitter Power Spectral Density, 1 Vpp Transmit Amplitude, Upper and Lower Masks

190.5.4.5 Transmit clock frequency

The symbol transmission rate of the LEADER PHY shall be within the range 80 MBd ± 50 ppm. For a LEADER PHY, when the transmitter is in the LPI transmit mode, the transmitter clock short-term rate of frequency variation shall be less than 0.1 ppm/second. The short-term frequency variation limit shall also apply when switching to and from the LPI mode.

190.5.5 Receiver electrical specifications

The PMA shall meet the requirements specified in PMA Receive function and the electrical specifications of this subclause. The link segment used in the test configurations shall be within the limits specified in 190.7

190.5.5.1 Receiver differential input signals

Differential signals received at the MDI, that were transmitted from a remote transmitter within the specifications of 190.5.4, and have passed through a link segment specified in 190.7, shall be received with a bit error ratio less than 10^{-10} after PCS processing and sent to the MII after completion of link training. This specification can be verified by a frame error ratio less than 10^{-7} for 125 octet frames.

190.5.5.2 Receiver frequency tolerance

The receiver shall properly receive incoming data with a symbol rate within the range 80 MBd ± 50 ppm.

190.5.5.3 Alien crosstalk noise rejection

Editor's note (not to be included in draft) – levels from the time domain simulation uses the AWGN Noise models for PHY Evaluation from zimmerman_3dgah_01b_0129202. This approximates to a flat AWGN Noise source at -113 dBm/Hz over 0 to 100 MHz for a 75 MSym/s baud rate which is 7 mV rms.

This specification is provided to verify the receiver's tolerance to alien crosstalk noise. The test is performed with a noise source such that noise with a Gaussian distribution, bandwidth of 100 MHz, and magnitude of –113 dBm/Hz is present at the MDI. The receive DUT is connected to these noise sources through a resistive network, as shown in Figure 190–24, with a link segment as defined in 190.7. The BER shall be less than 10^{-10}. This specification may be considered satisfied when the frame loss ratio is less than 10^{-7} for 125 octet packets measured at MAC/PLS service interface.

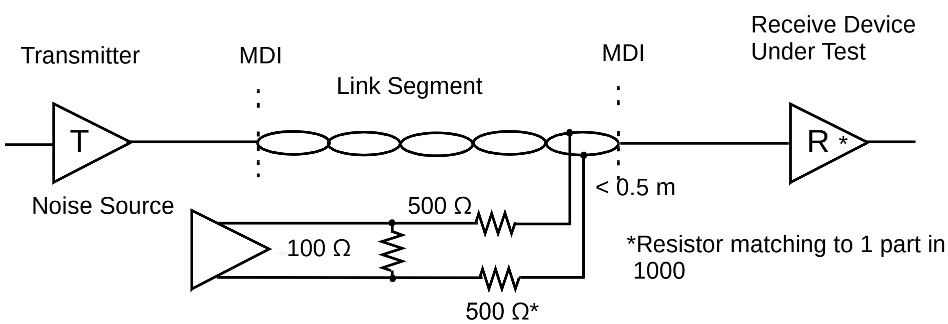

Figure 190–24—Alien crosstalk noise rejection test set-up

NOTE—If the output level is too high for the noise generator, the resistor divider network may be adapted to allow for a lower noise generator output level so that the noise signal fed into the receiver has a magnitude of –113 dBm/Hz with a bandwidth of 100 MHz, taking the 100 Ω termination within the PHY into account.