Insert Clause 168 to Clause 169 in numeric order (see later in this amendment for addition of corresponding annexes):

Editor's Note (to be removed prior to Working Group ballot):

Clause 168 is imported from Clause 147 and modified to remove the point-to-point PHYs, along with opening up the mixing segment and MDI portions. This is detailed in https://www.ieee802.org/3/da/public/111820/zimmerman_3da_01a_111820.pdf as well as the minutes of the November 18, 2020 meeting.

If the task force chooses not to make a new phy type this clause may be deleted.

Commenters are encouraged to review this text considering the following items (in addition to editor's notes sprinkled throughout):
1. If you envision an 802.3da PHY as a minor modification of the clause 147 10BASE-T1S PHY, what aspects of the clause 147 specification need to be modified. Please propose specific text.
2. If you envision significant modifications, please consider which sections to remove and replace, or whether it is better to write a completely new clause - knowing this early will help. For example, inclusion of FEC might be removal and replacement of substantial portions of 168.3, but not 168.4 or 168.5.
3. If you envision the 802.3da PHY to be identical in specification to clause 147 10BASE-T1S, with the only changes being the mixing segment and perhaps MDI loading, please consider how to modify clause 147 from IEEE Std 802.3cg-2019.

There are a few major items needing work in this clause at a minimum:
1. Definition of the Mixing Segment (168.7)
2. Definition of the MDI (168.8)
3. Any PHY specification enhancements necessary to achieve the objectives (right now it is identical to clause 147 specs from a performance standpoint)

168. Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 10BASE-T1M

Editor's Note (to be removed prior to Working Group ballot):

The use of the acronym PHY is aligned with the expected resolution of comments in the IEEE Std 802.3 revision; Alignment should be checked prior to 802.3da entering WG ballot.

This clause defines the type 10BASE-T1M Physical Coding Sublayer (PCS) and type 10BASE-T1M Physical Medium Attachment (PMA) sublayer. Together, the PCS and PMA sublayers comprise a 10BASE-T1M Physical Layer device (PHY). Functional and electrical specifications for the type 10BASE-T1M PCS, PMA, and ~~MDI~~ the interface to the medium, referred to as the Trunk Connection Interface, or TCI (see 168.8) are provided in this clause.

The 10BASE-T1M PHY is specified to be capable of operating at 10 Mb/s using a single balanced pair of conductors as a shared medium. The 10BASE-T1M PHY operates in a half-duplex shared-medium mode capable of operating with multiple stations connected to a mixing segment, defined in 168.7. The medium supporting the operation of the 10BASE-T1M PHY is defined in terms of performance requirements between the attachment points (~~Medium Dependent Interface (MDI)~~TCI), allowing implementers to specify their own media to operate the 10BASE-T1M PHY as long as the normative requirements included in this clause are met.

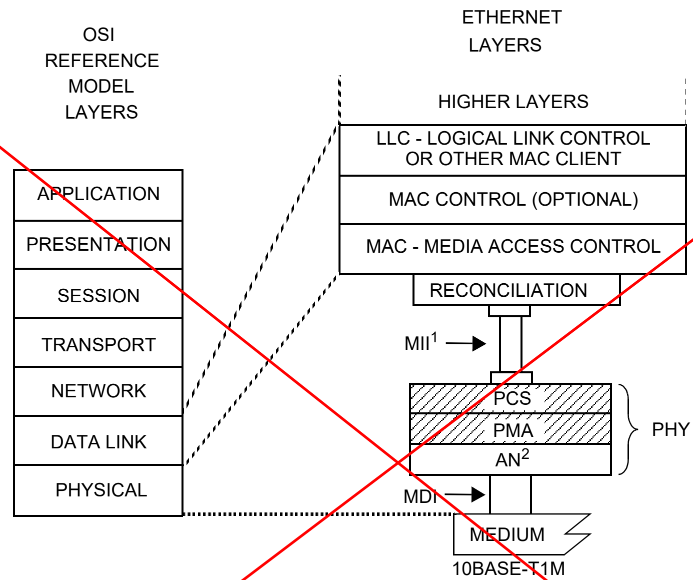
The 10BASE-T1M PHY is interoperable with the Clause 147 10BASE-T1S PHY when the 10BASE-T1S PHY is in multidrop mode and the mixing segment is compliant with 147.8.

10BASE-T1M PHYs optionally support PHY Level Collision Avoidance (PLCA), described in ~~Clause 148~~Clause 148.

10BASE-T1M follows an integrated PCS and PMA architecture and therefore does not support an AUI (see Figure 1–1).

168.1 Relationship of 10BASE-T1M to other standards

The relationship between the 10BASE-T1M PHY, the ISO Open Systems Interconnection (OSI) Reference Model, and the IEEE 802.3 Ethernet model are shown in Figure 168–2. The PHY sublayers (shown shaded) in Figure 168–2 connect one Clause 4 Media Access Control (MAC) layer to the medium. Auto-Negotiation, as defined in Clause 98, is not available for the 10BASE-T1M PHY. A Management Entity is required using MDIO or equivalent functionality. Optional MDIO is defined in ~~Clause 45~~Clause 45.



MDI = MEDIUM DEPENDENT INTERFACE
MII = MEDIA INDEPENDENT INTERFACE

NOTE 1—MII is optional
NOTE 2—Auto-Negotiation is optional

PCS = PHYSICAL CODING SUBLAYER
PMA = PHYSICAL MEDIUM ATTACHMENT
PHY = PHYSICAL LAYER DEVICE
AN = AUTO-NEGOTIATION

Figure 168–1—Relationship of 10BASE-T1M PHY to the ISO/IEC OSI reference model and the IEEE 802.3 Ethernet model

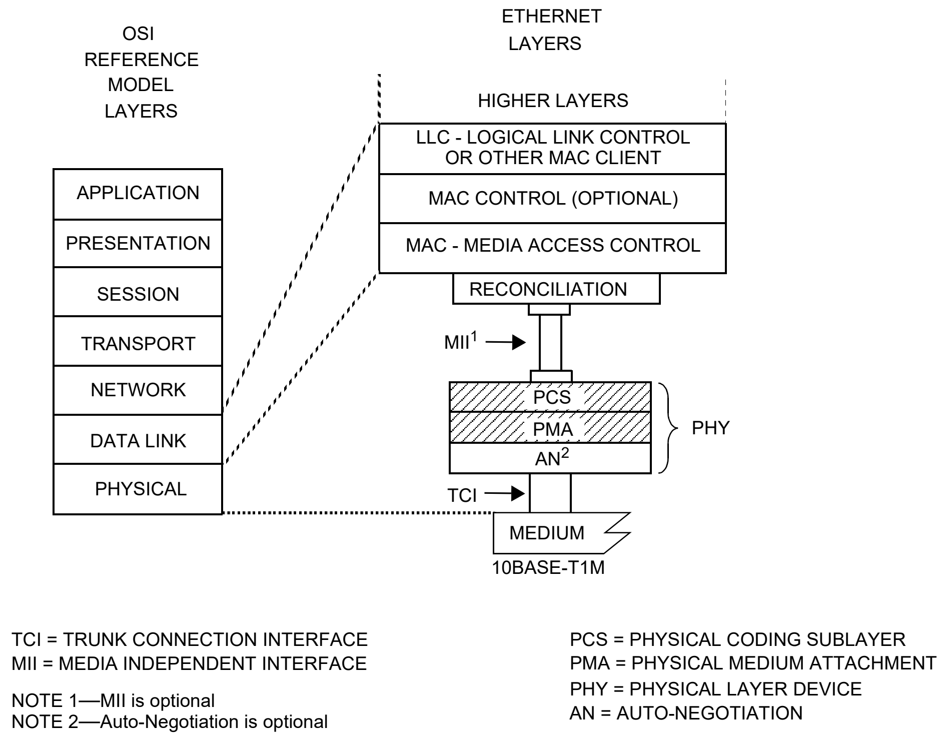


Figure 168–2—Relationship of 10BASE-T1M PHY to the ISO/IEC OSI reference model and the IEEE 802.3 Ethernet model

168.1.1 Conventions in this clause

The body of this clause contains state diagrams including definitions of variables, constants, and functions. Should there be a discrepancy between a state diagram and descriptive text, the state diagram prevails.

168.1.1.1 State diagram notation

The conventions of 21.5 are adopted with the extension that some states in the state diagrams use an IF-THEN-ELSE-END construct to condition which actions are taken within the state. If the logical expression associated with the IF evaluates TRUE, then all the actions listed between THEN and ELSE will be executed. In the case where ELSE is omitted, the actions listed between THEN and END will be executed. If the logical expression associated with the IF evaluates FALSE, then the actions listed between ELSE and END will be executed. After executing the actions listed between THEN and ELSE, between THEN and END or between ELSE and END, the actions following the END, if any, will be executed.

168.1.1.2 State diagram timer specifications

All timers operate in the manner described in 40.4.5.2.

168.1.1.3 Service specifications

The method and notation used in the service specification follows the conventions of 1.2.2.

primitives and interfaces used by the 10BASE-T1M PHY.

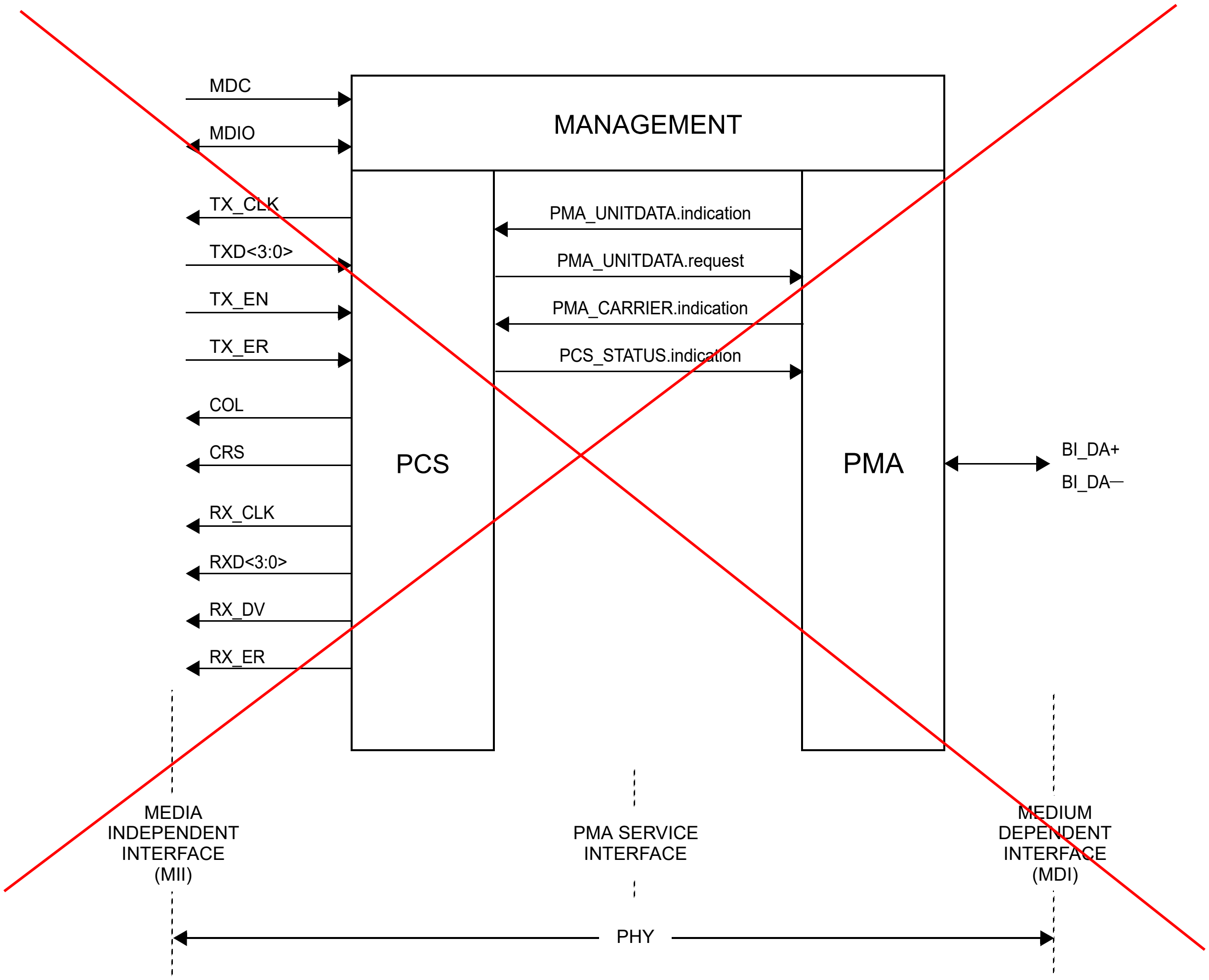


Figure 168–3—10BASE-T1M PHY interfaces

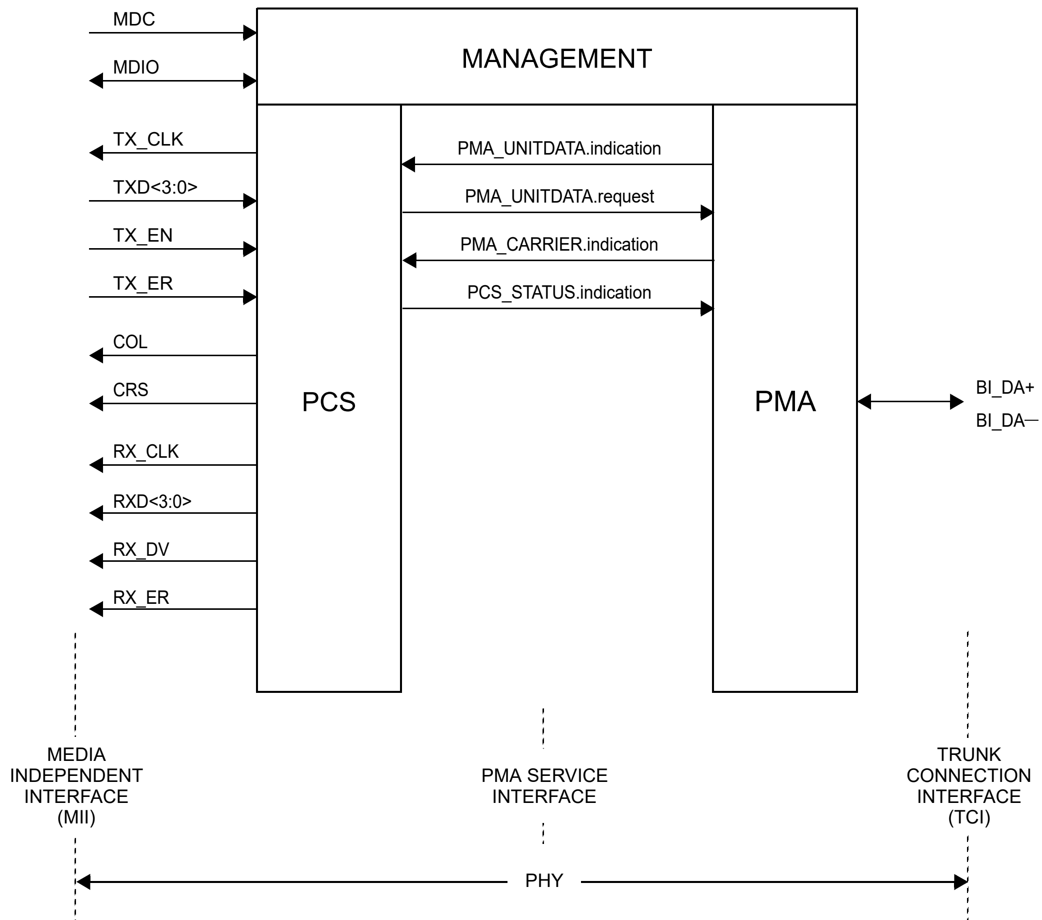


Figure 168–4—10BASE-T1M PHY interfaces

The 10BASE-T1M PHY uses the Media Independent Interface (MII) as specified in ~~Clause 22~~Clause 22.

As shown in Figure 168–4, 10BASE-T1M uses the following service primitives to exchange symbol vectors, status indications, and control signals across the PMA service interface:

PMA_UNITDATA.indication (rx_sym)
PMA_UNITDATA.request (tx_sym)
PMA_CARRIER.indication (pma_crs)
PMA_LINK.indication (link_status)
PMA_LINK.request (link_control)
PCS_STATUS.indication (pcs_status)

168.2.1 PMA_UNITDATA.indication

This primitive defines the transfer of one 5B symbol in the form of the rx_sym parameter from the PMA to the PCS.

168.2.1.1 Semantics of the primitive

PMA_UNITDATA.indication (rx_sym)

During reception, the PMA_UNITDATA.indication conveys to the PCS, via the parameter rx_sym, the value of the 5B symbol detected on the ~~MDI~~ TCI during each cycle of the recovered clock.

168.2.1.2 When generated

The PMA generates PMA_UNITDATA.indication (rx_sym) messages synchronously for every 5B symbol received at the ~~MDI~~TCI. The nominal rate of the PMA_UNITDATA.indication primitive is 2.5 MHz, as governed by the recovered clock.

168.2.1.3 Effect of receipt

The effect of receipt of this primitive is unspecified.

168.2.2 PMA_UNITDATA.request

This primitive defines the transfer of one symbol in the form of the tx_sym parameter from the PCS to the PMA.

The symbol is obtained in the PCS Transmit function using the encoding rules defined in 168.3.2 to represent 4B/5B encoded MII data or special out of band signaling.

168.2.2.1 Semantics of the primitive

PMA_UNITDATA.request (tx_sym)

During transmission, the PMA_UNITDATA.request conveys the value of the symbol to be sent over the ~~MDI~~TCI, via the parameter tx_sym.

The tx_sym parameter is one of the allowed 5B codes specified in Table 168–1.

168.2.2.2 When generated

The PCS generates PMA_UNITDATA.request (tx_sym) synchronously with every symb_timer expiration. The symb_timer is defined in 168.3.2.6.

168.2.2.3 Effect of receipt

Upon receipt of this primitive the PMA transmits on the ~~MDI~~ TCI the signals corresponding to the indicated 5B symbol after processing it with DME following the rules in 168.4.

168.2.3 Mapping of PMA_CARRIER.indication

Reports whether a signal compatible with DME encoding rules specified in 168.4.2 is detected on the medium.

168.2.3.1 Function

Maps the primitive PMA_CARRIER.indication to the MII CRS signal.

168.3.3.8 Self-synchronizing descrambler

The PCS Receive function descrambles the 5B/4B decoded data stream and returns the value of RXD<3:0> to the MII. The descrambler shall employ the polynomial $g(x)$ defined in 168.3.2.8. The implementation of the self-synchronizing descrambler by linear-feedback shift register is shown in Figure 168–11. The bits stored in the shift register delay line at time n are denoted by Dcr_n<16:0>. The '+' symbol denotes the exclusive-OR logical operation.

When Dr_n<3:0> is presented at the input of the descrambler, Dc_n<3:0> is produced by shifting in each bit of Dr_n<3:0> as Dr_n<i>, with i ranging from 0 to 3 (i.e., LSB first). The descrambler is reset upon execution of the PCS Reset function. If PCS Reset is executed, all the bits of the 17-bit vector representing the self-synchronizing descrambler state are arbitrarily set. The initialization of the descrambler state is left to the implementer. At every RSCD, if no data is presented at the descrambler input via Dr_n<3:0>, the descrambler may be fed with arbitrary inputs.

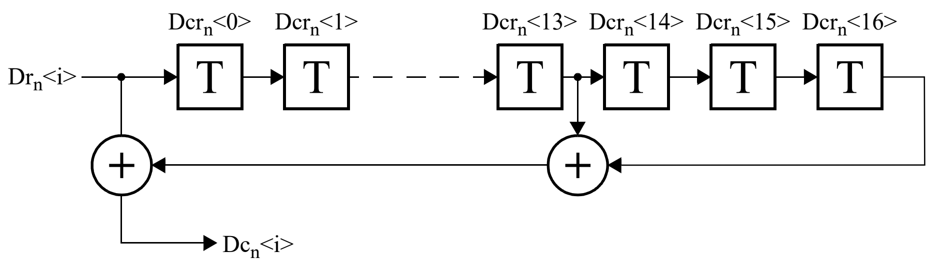


Figure 168–11—Self-synchronizing descrambler

168.3.3.9 Jabber diagnostics

The ESDJAB symbol informs the PCS Receiver that a frame was terminated by the jabber function. The number of received ESDJAB events can be reported to the management entity be the means of MDIO register 3.2293 or similar functionality if MDIO is not implemented.

168.3.4 PCS loopback

The PCS shall be placed in loopback mode when the loopback bit in MDIO register 3.0.14, defined in 45.2.3.1.2, is set to one (or PCS loopback mode is enabled by a similar functionality if MDIO is not implemented). In this mode, the PCS shall accept data on the transmit path from the MII and return it on the receive path to the MII. Additionally, the PHY receive circuitry shall be isolated from the network medium, and the assertion of TX_EN at the MII shall not result in the transmission of data on the network medium.

168.3.5 Collision detection

The 10BASE-T1M PHY shall detect when a transmission initiated locally results in a corrupted signal at the ~~MDI~~ TCI as a collision. When collisions are detected, the PHY shall assert the signal COL on the MII for the duration of the collision or until TX_EN signal is FALSE.

The method for detecting a collision is implementation dependent but the following requirements have to be fulfilled:

a) The PHY shall assert COL when it is transmitting and one or more other stations are also transmitting at the same time.
b) The PHY shall assert CRS in the presence of a signal resulting from a collision between two or more other stations.

PMA functions are illustrated in Figure 168–13.

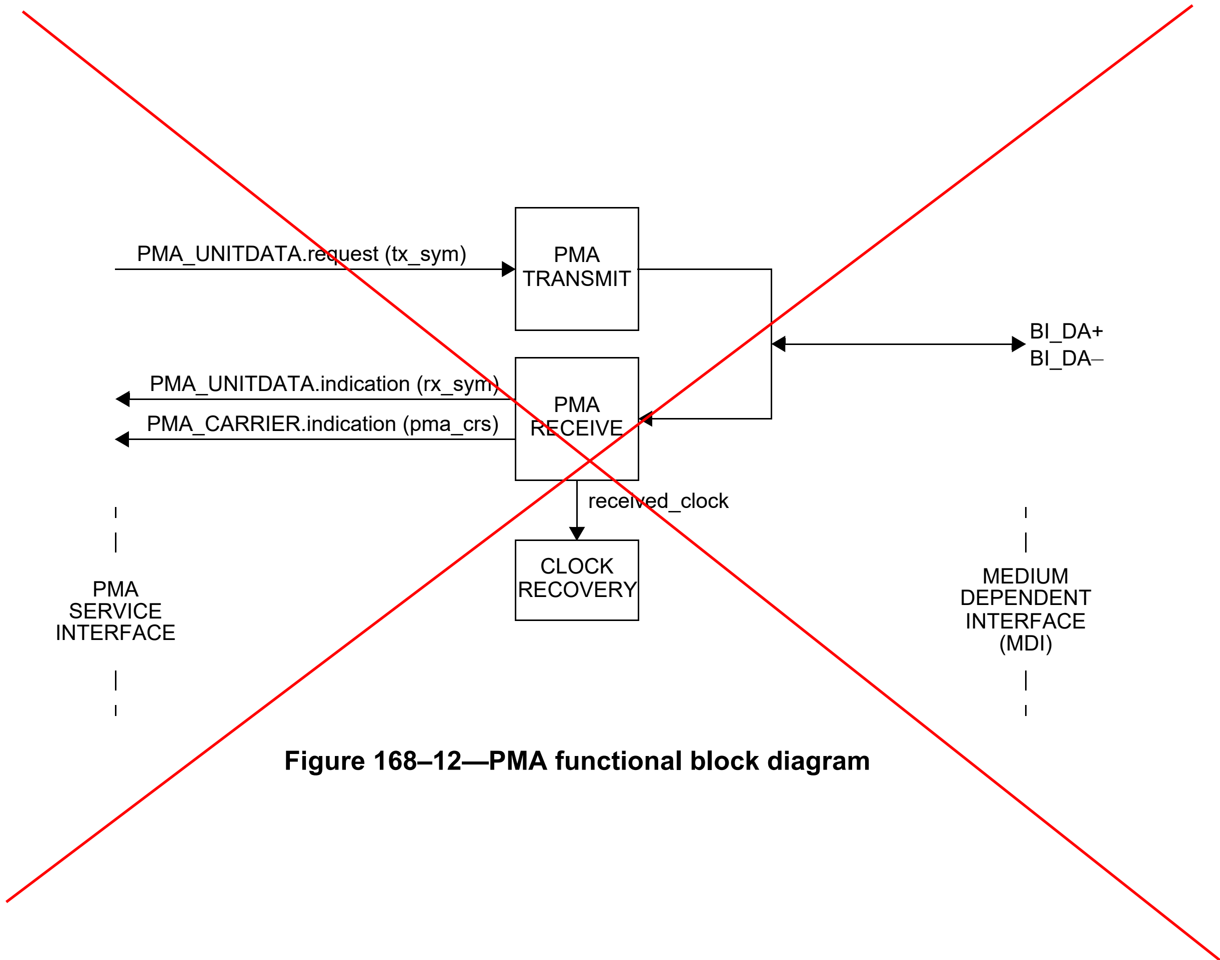


Figure 168–12—PMA functional block diagram

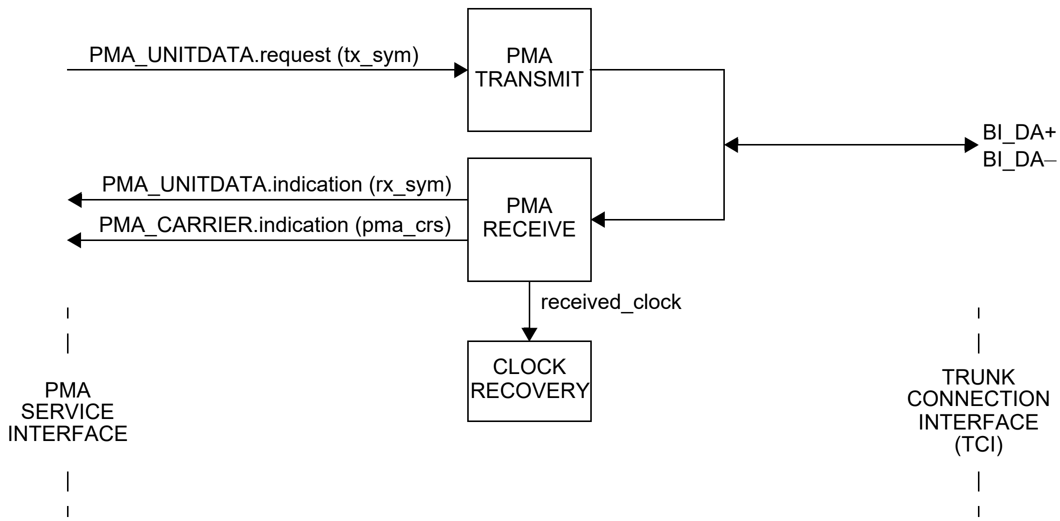


Figure 168–13—PMA functional block diagram

> ***Editor's Note (to be removed prior to Working Group Ballot):***
>
> Technology Dependent Interface was removed since the PMA_LINK primitives were deleted; LINK MONITOR was removed since PCS_STATUS.indication was removed by comment 36 on D0.51

The reference diagrams do not explicitly show the PMA Reset function.

The PMA couples messages from the PMA service interface specified in 168.3.1 onto the 10BASE-T1M physical medium. The PMA provides half duplex communications to and from the medium. The interface between PMA and the baseband medium is the ~~Medium Dependent~~ Trunk Connection Interface (~~MDI~~TCI), which is specified in 168.8.

168.4.1 PMA Reset function

The PMA Reset function shall be executed whenever one of the two following conditions occur:

— Power on (see 36.2.5.1.3).
— The receipt of a request for reset from the management entity.

The PMA Reset function carries out the following tasks:

— PMA Transmit output is set to high-impedance state.
— PMA_UNITDATA.indication is cleared.

168.4.2 PMA Transmit function

During transmission, PMA_UNITDATA.request conveys the tx_sym variable to the PMA. The value of the tx_sym variable is sent over the single balanced pair of conductors, BI_DA.

The tx_sym variable is a 5B symbol, to be encoded LSB first, using DME rules defined below:

If the tx_sym parameter value is the special 5B symbol 'I', the PMA shall, in the following order:

a) Transmit an additional DME encoded 0 if the previous value of the tx_sym parameter was anything but the 5B symbol 'I'.
b) Present the minimum impedance described in 168.8.2 at the ~~MDI~~TCI. This shall happen within 40 ns after the additional DME encoded 0 has been transmitted..

> ***Editor's Note (to be removed before Working Group Ballot):***
>
> This specification either needs to be changed to reflect maintaining the TCI RL specification approach, or a minimum impedance at the TC3 interface needs to be added to 168.8.

If tx_sym value is anything other than 'I', the following rules apply:

— A "clock transition" shall always be generated at the start of each bit.
— A "data transition" in the middle of a nominal bit period shall be generated if the bit to be transmitted is a logical '1'. Otherwise, no transition shall be generated until the next bit.

See Figure 168–14 and Table 168–2.

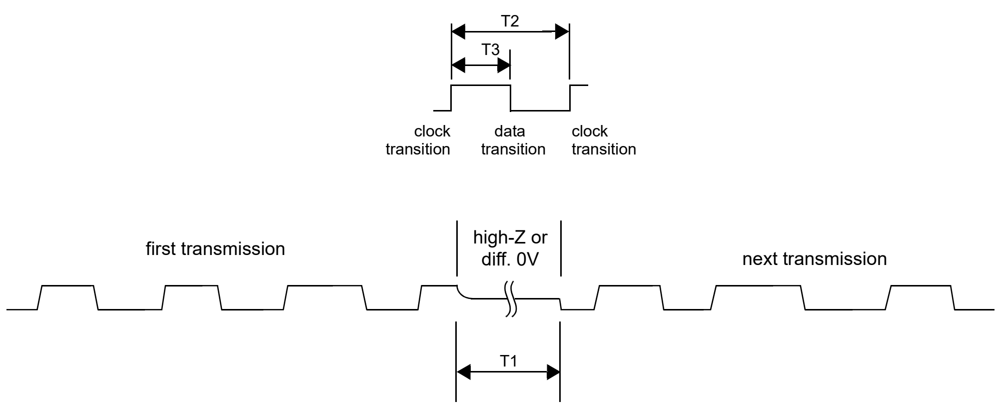


Figure 168–14—DME encoding scheme

Table 168–2—DME timings

Parameter name	Description	Minimum value	Nominal value	Maximum value	Unit of measure
T1	Delay between transmissions	480	—	—	ns
T2	Clock transition to clock transition	–100 ppm	80	+100 ppm	ns
T3	Clock transition to data transition (data = 1)	38	40	42	ns

168.4.3 PMA Receive function

The 10BASE-T1M PMA Receive function comprises a single receiver (PMA Receive) for DME modulated signals on a single balanced pair of conductors, BI_DA. PMA Receive has the ability to translate the received signals on the single balanced pair of conductors into the PMA_UNITDATA.indication parameter rx_sym. It detects 5B symbols from the signals received at the ~~MDI~~ TCI and presents these sequences to the PCS Receive function.

The PMA Receive function recovers encoded clock and data information from the DME encoded stream received at the ~~MDI~~TCI. The clock recovery provides a synchronous clock for sampling the signal on the pair. While it may not drive the MII directly, the clock recovery function is the underlying source of RX_CLK. In order to meet the specifications of 168.5.5.1, the PMA Receive function must achieve proper synchronization on both the DME stream and the 5B boundary within 800 ns.

The PMA Receive function interprets the signals at the ~~MDI~~ TCI using the inverse mapping described in 168.4.2 for the PMA Transmit function and transfers the 5B code groups by the means of the PMA_UNITDATA.indication. When the PMA Receive function does not detect activity on the line, it shall convey the symbol 'I' (meaning SILENCE.)

168.5 PMA electrical specifications

This subclause defines the electrical characteristics of the PMA for a 10BASE-T1M PHY.

168.5.1 EMC tests

Direct Power Injection (DPI) and 150 Ω emission tests for noise immunity and emission as per 168.5.1.1 and 168.5.1.2 may be used to establish a baseline for PHY EMC performance. These tests provide a high degree of repeatability and a good correlation to immunity and emission measurements. 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.

168.5.1.1 Immunity—DPI test

In a real application, radio frequency (RF) common mode (CM) noise at the PHY is the result of electromagnetic interference coupling to the cabling system. Additional differential mode (DM) noise at the PHY is generated from the CM noise by mode conversion of all parts of the cabling system and the ~~MDI~~TCI. The sensitivity of the PMA's receiver to RF CM noise may be tested according to the DPI method of IEC 62132-4.

168.5.1.2 Emission—Conducted emission test

The emission of the PMA transmitter to its electrical environment may be tested according to the 150 Ω direct coupling method of IEC 61967-4, and may need to comply with more stringent requirements.

168.5.2 Test modes

The test modes described in this subclause shall be provided to allow testing of the transmitter. The test modes can be enabled by setting bits 1.2299.15:13 **(TBD)** (10BASE-T1M test mode control register) of the PHY Management register set as described in 45.2.1.186f.1**(TBD)**. If MDIO is not implemented a similar functionality shall be provided by equivalent means. These test modes shall change only the data symbols

To allow an easy synchronization of the measurement equipment, the PHY shall provide access to TX_CLK.

168.5.4 Transmitter electrical specification

The PMA shall operate with AC coupling to the ~~MDI~~TCI.

Where a load is not specified, the transmitter shall meet the requirements of this subclause with a 50 Ω resistive differential load connected to the transmitter output. Transmitter electrical tests are specified with a load tolerance of ± 0.1%.

168.5.4.1 Transmitter output voltage

When tested using the test fixture shown in Figure 168–15 with the transmitter in test mode 1, the transmitter output voltage shall be 1 V ± 20% peak-to-peak differential.

168.5.4.2 Transmitter output droop

Editor's Note (to be removed prior to Working Group Ballot):

Commenters are encouraged to consider the appropriateness of an 800ns time constant droop test for a DME transmitter which must transition every 80ns. Alternatives include a traditional pulse template, a tighter PSD mask, or a different time constant. Impact of not having the test on collisions may also be considered (as well as whether the test fixture needs modification for that).

When tested using the text fixture shown in Figure 168–15 with the transmitter in test mode 2, the magnitude of both the positive and negative droop measured with respect to the initial peak value after the zero crossing and the value 800 ns after the initial peak, depicted by Figure 168–17, shall be less than 30%.

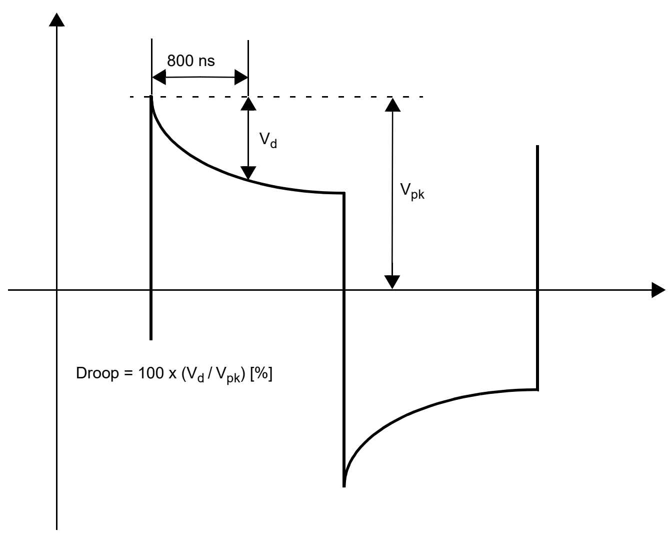


Figure 168–17—Transmitter output droop

168.5.4.3 Transmitter timing jitter

When measured using the test fixture shown in Figure 168–15 with the transmitter in test mode 1, the maximum jitter at the transmitter side shall be less than 5 ns symbol-to-symbol.

168.5.4.5 Transmitter high impedance mode

> ***Editor's Note (to be removed at draft 0.6):***
>
> This was changed from 'shall present the minimum' in clause 147 to "shall present at least the minimum" for clarity. No change in requirement was meant.

In test mode 4, a transmitter shall present at least the minimum parallel impedance across the ~~MDI attachment points~~ TC3 interface of the TCI to enable meeting the electrical specifications for the TCI with a DTE in place as specified in 168.8.2.

168.5.5 Receiver electrical specifications

168.5.5.1 Receiver differential input signals

Differential signals received at the ~~MDI~~ TCI that were transmitted from a remote transmitter within the specifications of 168.5.4 and have passed through a mixing segment specified in 168.7 shall be received with a Bit Error Ratio (BER) of less than 10^{-10} and sent to the MII during normal data transmission. This specification can be verified by a frame error ratio less than 10^{-7} for 125 octet frames.

168.5.5.2 Alien crosstalk noise rejection

> ***Editor's Note (to be removed prior to Working Group Ballot):***
>
> Consider more precise definition of the noise source, and whether the level is compatible with the 802.3da objectives, including link segment length and noise environment.

The test is performed with a noise source such that noise with a Gaussian distribution bandwidth of 40 MHz, and magnitude of –101 dBm/Hz is present at the ~~MDI~~TCI.

The receive DUT is connected to these noise sources through a resistive network as shown in Figure 168–19 with mixing segment as defined in 168.7. 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 frames measured at MAC/PLS service interface.

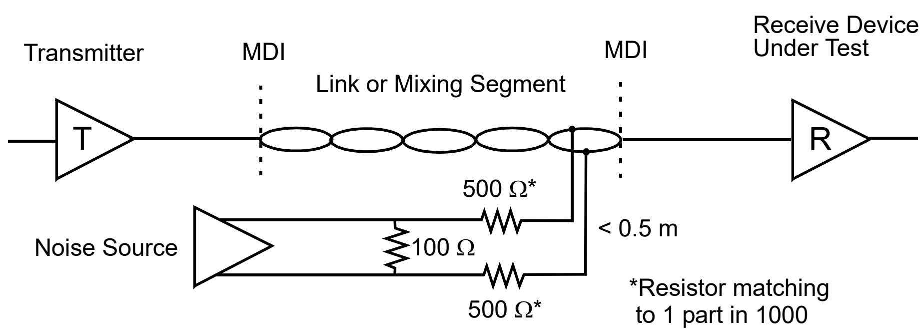


Figure 168–19—Alien crosstalk noise rejection test set-up

168.5.6 PMA local loopback

The PMA local loopback function is optional. If supported, the PMA shall be placed in local loopback mode when the PMA local loopback bit in MDIO register 1.0.0, defined in 45.2.1.1, or the PMA loopback bit in MDIO register 1.2297.13**(TBD)**, defined in 45.2.1.186d.5 **(TBD)**, is set to one (or PMA loopback mode is enabled by a similar functionality if MDIO is not implemented).

The PMA and PCS Receive functions shall pass to the MII RX the data decoded from the signal which is normally received during a transmission for the purpose of detecting collisions.

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 10BASE-T1M PCS and PMA functions.

168.6 Management interface

10BASE-T1M uses the management interface as specified in ~~Clause 45~~Clause 45. The ~~Clause 45~~Clause 45 MDIO electrical interface is optional. Where no physical embodiment of the MDIO exists, provision of an equivalent mechanism to access the registers is recommended.

168.7 Mixing segment characteristics

10BASE-T1M PHYs are designed to operate over media that meet the requirements specified in this subclause. The 10BASE-T1M mixing segment (1.4.331) is a single balanced pair of conductors that may have more than two ~~MDIs~~ DTEs attached. The TCI is an MDI for the shared transmission medium (single balanced pair of conductors). The cable media is referred to as "trunk" cable.

The mixing segment shall be a linear topology, with DTE attached at a TCI, where each TCI has two interfaces on the mixing segment, one interface facing in the direction of left edge termination of the mixing segment (TC1), and one facing in the direction of the right edge termination of the mixing segment (TC2), and a four-wire interface facing the PMA (and any associated stub or service loop) (TC3) (see Figure 168–22). The TCI is part of the mixing segment, and the requirements of 168.7 are met with TCIs in place with or without attached DTEs as specified for the particular specification. Like the MDI, the specification of the TCI is not a device, but rather a (set of) interface planes.

A TCI may be physically implemented as a "T" type connection to provide a means of connecting the segments of balanced conductors and attaching the PMA of a DTE to the trunk.The TCI is specified in 168.8 to enable the mixing segment specifications in 168.7 to be met. TCIs with compensation are expected to be matched to a particular DTE/PMA implementation, including any associated stub or service loop.

Figure 168–21 shows an example mixing segment with reference points. The mixing segment ~~specificationsin~~ specifications in 168.7 are referenced to these designated points and are to be met without the ~~MDI~~ DTE or other loads attached. The mixing segment specifications ~~are based on~~ provide for a trunk-stub configuration~~. Other configurations may be possible~~, ~~provided they meet~~ extended from the TCI. The electrical parameters in ~~this~~ 168.7 include any trunk connection interface (TCI) connecting the left and right sides of the mixing segment, but do not include any external connection such as a stub or service loop from the TCI to the DTE hardware. The example ~~configuration assumes that the~~ trunk comprises TBD m of 1.02 mm (18 AWG) 100 Ω ~~cabling and the stubs are 100 Ω balanced pairs of conductors up to 30 cm long~~cabling, with a TCI at each location that a DTE may attach. The trunk is terminated at each end into ~~100~~

~~Ù~~100 Ω, at ~~a~~ the point designated the ‘edge termination’~~. One end of the stub is designated the trunk connection (TC) and the other designated the ‘MDI attachment point’~~.

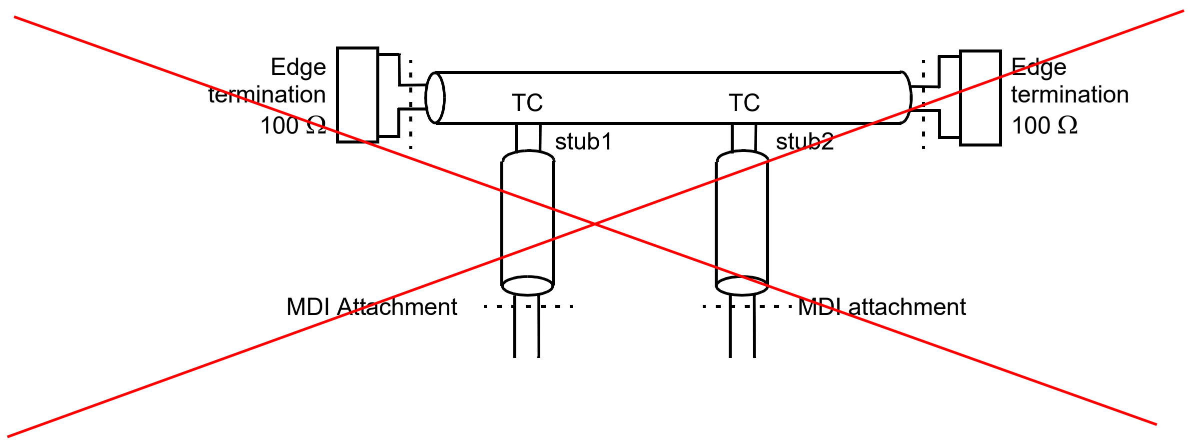


Figure 168–20—Mixing segment and reference points

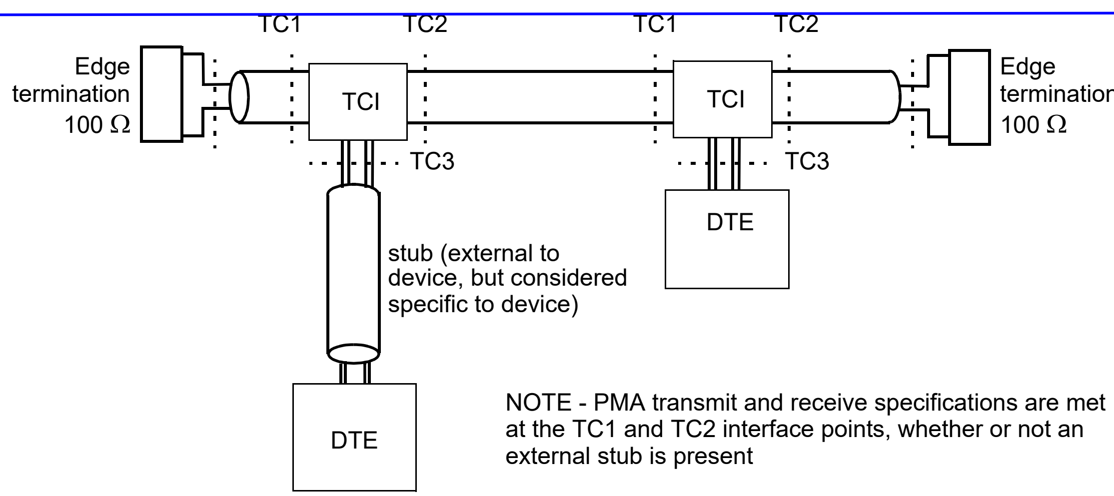


Figure 168–21—Mixing segment and reference points

Editor’s Note (to be removed prior to Working Group ballot):

Contributions to fill in the detailed specifications of the mixing segment are needed, including at least example figures, reference points, and the electrical parameters in the skeleton below.

Editor’s Note (to be removed prior to Working Group ballot):

Contributions to fill in the detailed specifications of the mixing segment are needed, including at least the electrical parameters in the skeleton below.

168.7.1 Insertion ~~loss and delay~~loss

~~The mixing segment insertion loss is specified by independently meeting the requirements specified in this section for trunks and stubs. The stub time delay is specified to limit reflective resonances.~~

The mixing segment insertion loss is specified including any through-path insertion loss for the TCIs. See 168.8.2 for specification of the insertion loss and return loss (reflections) at the TCI interfaces.

The mixing segment insertion loss, without ~~the MDI or other loads~~ any DTEs attached, shall meet the values determined using Equation (168–3) between edge termination attachment points. The reference impedance is 100 Ω. If the mixing segment includes TCI connectors which are specified to use a dummy load, this requirement may be met with the dummy load attached.

$$IL(f) \le TBD \text{ dB},\ 0.3 \text{ MHz} \le f \le 40 \text{ MHz} \tag{168–3}$$

..

> ***Editor's Note (to be removed prior to Working Group ballot):***
>
> Consider insertion loss equation (147-3) as a starting point.

~~The insertion loss of each stub, between MDI attachment point and trunk connection point (TC), shall meet the values determined using Equation (168–4). The reference impedance is 100 Ω.~~

$$\cancel{IL(f) \le 0.15 \text{ dB},\ 0.3 \text{ MHz} \le f \le 40 \text{ MHz}} \tag{168–4}$$

~~The time delay of each stub, between MDI attachment point and trunk connection point (TC), shall meet the values determined using Equation (168–5) at a frequency of 10 MHz. The reference impedance is 100 Ω.~~

$$\cancel{\text{time delay} \le 1.6 \text{ ns}} \tag{168–5}$$

168.7.2 Return loss

The mixing segment at ~~any MDI attachment point~~each point TC3, without ~~the MDI or other loads~~ any DTEs attached, shall meet the return loss values determined using Equation (168–6). The reference impedance is 50 Ω. If the mixing segment includes TCI connectors which are specified to use a dummy load, this requirement may be met with the dummy load attached.

$$RL(f) \ge TBD \text{ dB},\ 0.3 \text{ MHz} \le f \le 40 \text{ MHz} \tag{168–6}$$

The mixing segment edge terminations, without ~~the MDI or other loads~~ any DTEs attached, shall meet the return loss values determined using Equation (168–7). The reference impedance is 100 Ω. If the mixing segment includes TCI connectors which are specified to use a dummy load, this requirement may be met with the dummy load attached.

$$RL(f) \ge TBD \text{ dB},\ 0.3 \text{ MHz} \le f \le 40 \text{ MHz} \tag{168–7}$$

.

> ***Editor's Note (to be removed prior to Working Group ballot):***
>
> Consider 147.7.2 return loss equation(147-4) as starting point.

168.8 ~~MDI~~ TCI specification

Editor's Note (to be removed prior to Working Group ballot):

Contributions and baselines are needed to fill out the MDI connector and the electrical specification in the subclauses here. See 802.3cg clause 147 for example text.

Editor's Note (to be removed prior to Working Group ballot):

Contributions and baselines are needed to fill out the TCI electrical specification in the subclauses here.

168.8.1 ~~MDI connectors~~

The interface of the Clause 168 PHY to the mixing segment is called the Trunk Connection Interface (TCI). The TCI is an MDI for the shared transmission medium (single balanced pair of conductors). While technically the TCI aligns with the definition of an MDI in 1.4.395, the fact that the TCI has two interfaces to the medium and plays a role in mixing segment specifications by connecting the left and right sides of the linear mixing segment mandates it has a unique role beyond what is normally considered in an MDI.

Each TCI has one interface facing each direction of the mixing segment (TC1 and TC2), and a four-wire interface facing the PMA (and any associated stub or service loop) (TC3) as shown in Figure 168–22.

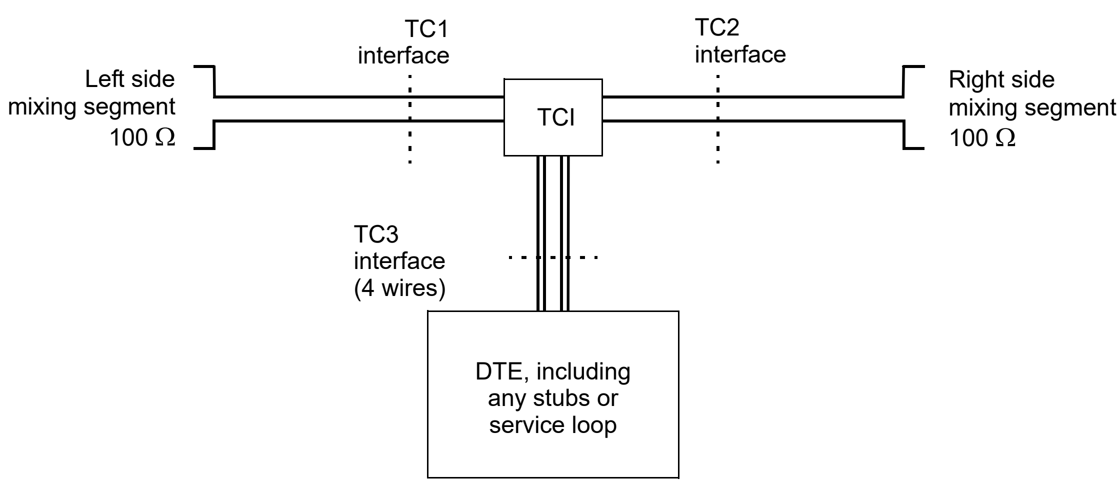


Figure 168–22—TCI ports and connections

A TCI may physically be implemented as a "T" type connection to provide a means of connecting the trunk segments and attaching a PMA to the mixing segment.

The TCI is part of the mixing segment, and the requirements of 168.7 are met with TCIs in place with or without attached DTEs as specified for the particular specification. TCIs with compensation are expected to be matched to a particular PMA.

The TCI may physically be implemented as two two-wire connections to the DTE or as an adapter separate from the DTE's PMA assembly or the TCI and the PMA of the DTE may be located within a single assembly. The latter configuration presents a negligible stub length when the PMA attachment is open circuit. Either configuration may include compensation engaged when a PMA or PMA load is attached. Figure 168–21 shows one example of each configuration.

168.8.2 ~~MDI~~ TCI electrical specification

168.8.2.1 TCI Insertion Loss

Without a PMA or PMA loading present, the differential insertion loss of the TCI between TC1 and TC2 shall be less than TBD dB *(ed note - small number)* from 0.3 to 40 MHz, in each direction, measured into 100 Ω.. This specification does not apply if the DTE cannot be electrically disconnected from the TCI.

With the PMA (or PMA load specified for the TCI) present at TC3, the differential insertion loss of the TCI between TC1 and TC2 shall be less than TBD dB *(ed note - allows for compensation and phy loading –may be an equation)* from 0.3 to 40 MHz, in each direction, measured into 100 Ω.

168.8.2.2 TCI Return Loss

Without a PMA (or PMA load specified for the TCI) present at TC3, the return loss of the TCI at TC1 and TC2 shall be greater than Equation (168–8) with the other trunk interface (i.e., TC2 or TC1, respectively) terminated in 100 Ω. This specification does not apply if the DTE cannot be electrically disconnected from the TCI.

NOTE – this is to allow meeting the unloaded mixing segment RL specification at 168.7.2.

$$RL(f) \geq TBD \text{ dB}, \ 0.3 \text{ MHz} \leq f \leq 40 \text{ MHz} \quad (168\text{–}8)$$

With a PMA or PMA load present at the TCI attachment, the return loss of the TCI at TC1 and TC2 shall be greater than Equation (168–9) with the other trunk interface (i.e., TC2 or TC1, respectively) terminated in 100 Ω.

NOTE – this specification replaces the MDI return loss and is measured at the TCI.

$$RL(f) \geq TBD \text{ dB}, \ 0.3 \text{ MHz} \leq f \leq 40 \text{ MHz} \quad (168\text{–}9)$$

168.8.3 ~~MDI~~ TCI line powering voltage tolerance

The DTE shall withstand without damage the application of any voltages between 0 V dc and 60 V dc with the source current limited to 2000 mA, applied across TC1 or TC2's BI_DA+ and BI_DA– in either polarity, under all operating conditions indefinitely.

168.8.4 ~~MDI~~ TCI fault tolerance

~~The wire~~ Each balanced pair of the ~~MDI~~ TCI shall withstand without damage the application of short circuits of any wire to the other wire of the same pair or ground potential, as per Table 168–4, under all operating conditions indefinitely. Normal operation shall resume after all short circuits have been removed.

Table 168–4—Fault conditions

BI_DA+	BI_DA–
BI_DA–	BI_DA+
Ground	No fault
No fault	Ground
Ground	Ground

— Climatic loads: ISO 16750-4, and IEC 60068-2-1, IEC 60068-2-27, IEC 60068-2-30, IEC 60068-2-38, IEC 60068-2-52, IEC 60068-2-64, and IEC 60068-2-78
— Chemical loads: ISO 16750-5 and ISO 20653

The following specifications define potential environmental stresses in an industrial environment:

— Environmental loads: IEC 60529 and ISO 4892
— Mechanical loads: IEC 60068-2-6 and IEC 60068-2-31
— Climatic loads: IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-30, IEC 60068-2-38, IEC 60068-2-52, and IEC 60068-2-78

Additional environment(s) require careful analysis prior to implementation to determine appropriate environmental safety requirements.

168.9.2.2 Electromagnetic compatibility

A system integrating the 10BASE-T1M PHY is expected to comply with all applicable local and national codes for electromagnetic compatibility. In addition, the system may need to comply with more stringent requirements for the limitation of electromagnetic interference.

168.10 Delay constraints

The PHY shall comply with the timing requirements specified in Table 168–5.

Table 168–5—10BASE-T1M delay constraints

Event	Minimum value	Maximum value	Unit of measure	Input timing reference	Output timing reference
TX_EN/TX_ER sampled to ~~MDI~~ TCI output	120	440	ns	Rising edge of MII TX_CLK	First DME clock transition at the ~~MDI~~TCI
~~MDI~~ TCI input to CRS asserted	400	1040	ns	First DME clock transition at the ~~MDI~~TCI	Rising edge of CRS
~~MDI~~ TCI input to CRS deasserted	640	1120	ns	Last DME encoded zero clock transition at the ~~MDI~~TCI	Falling edge of CRS
~~MDI~~ TCI input to COL asserted	0	5	µs	Start of corrupted transmitted signal at the ~~MDI~~TCI	Rising edge of COL
~~MDI~~ TCI input to COL deasserted	0	3.2	µs	End of transmission at the ~~MDI~~TCI	Falling edge of COL
~~MDI~~ TCI input to RX_DV asserted	2.4	4	µs	First DME clock transition at the ~~MDI~~TCI	Rising edge of RX_DV
~~MDI~~ TCI input to RX_ER asserted	1.6	4	µs	First DME clock transition at the ~~MDI~~TCI	Rising edge of RX_ER

168.11.4.4 Collision detection

Item	Feature	Subclause	Value/Comment	Status	Support
CD1	Detect collisions on the media during data transmission	168.3.5	When a transmission initiated locally results in a corrupted signal at the ~~MDI~~TCI, a collision is detected	M	Yes [ ] N/A[ ]
CD2	When collisions are detected	168.3.5	Assert the signal COL on the MII for the duration of the collision or until TX_EN signal is FALSE	M	Yes [ ] N/A[ ]
CD3	CRS asserted during collision of two or more other stations	168.3.5	See 168.3.5	M	Yes [ ] N/A[ ]
CD4	Sense when the media is busy	168.3.6	Assert the signal CRS on the MII as specified in 22.2.2.11	M	Yes [ ] N/A[ ]

168.11.4.5 Physical Medium Attachment (PMA)

168.11.4.5.1 PMA function

Item	Feature	Subclause	Value/Comment	Status	Support
PMA1	PMA reset function	168.4.1	See 168.4.1	M	Yes [ ]
PMA2	tx_sym parameter value is the special 5B symbol 'I'	168.4.2	See 168.4.2	M	Yes [ ]
PMA3	receive SILENCE	168.4.3	PMA receive conveys symbol ‘I’ when no activity is detected on the line	M	Yes [ ]

168.11.4.5.2 PMA electrical specification

Item	Feature	Subclause	Value/Comment	Status	Support
PMAE1	Test modes	168.5.2	Implemented in PHY to allow testing transmitter electrical requirements	M	Yes [ ]
PMAE2	Enable test modes	168.5.2	Enable by setting bits 1.2299.15:13 **(TBD)** as described in 45.2.1.186f **(TBD)** when MDIO implemented; similar functionality provided otherwise	MDIO:M	Yes [ ] N/A[ ]
PMAE3	These test modes shall change only the data symbols provided to the transmitter circuitry and shall not alter the electrical and jitter characteristics of the transmitter and receiver from those of normal (non-test mode) operation	168.5.2		M	Yes [ ]
PMAE4	Test mode 1	168.5.2	When enabled, PHY repeatedly transmits DME encoded ones	M	Yes [ ]
PMAE5	Test mode 2	168.5.2	When enabled, PHY repeatedly transmits a positive differential voltage for 1.6 µs followed by a negative differential voltage level for 1.6 µs	M	Yes [ ]
PMAE6	Test mode 3	168.5.2	When test mode 3 is enabled, the PHY shall transmit continually a pseudo-random sequence of positive and negative voltage levels, generated by the scrambler defined in 168.3.2.8 and encoded using Differential Manchester Encoding (DME) as in 168.4.2	M	Yes [ ]
PMAE7	Test mode 4	168.5.2	When enabled, PHY transmitter shall present a high impedance termination to the line as specified in 168.4.2	M	Yes [ ] N/A[ ]
PMAE8	TX_CLK	168.5.3	PHY to provide access to TX_CLK	M	Yes [ ]
PMAE9	AC coupling at ~~MDI~~TCI	168.5.4		M	Yes [ ]
PMAE10	The transmitter shall meet the requirements of this subclause with a 50 Ω ± 0.1% resistive differential load connected to the transmitter output	168.5.4		M	Yes [ ] N/A[ ]
PMAE11	Transmitter output voltage	168.5.4.1	1.0 V ± 20% peak-to-peak differential when measured on test mode 1	M	Yes [ ]

Item	Feature	Subclause	Value/Comment	Status	Support
PMAE12	Transmitter output droop	168.5.4.2	Less than 30% when measured on test mode 2	M	Yes [ ]
PMAE13	Transmitter timing jitter	168.5.4.3	Less than 5 ns symbol-to-symbol jitter when measured on test mode 1	M	Yes [ ]
PMAE14	Transmit power spectral density	168.5.4.4	Between the upper and lower masks specified in Equation (168–1) and Equation (168–2) when measured on test mode 3	M	Yes [ ]
PMAE15	A transmitter configured for test mode 4	168.5.4.5	~~Presents the minimum parallel impedance across the MDI attachment points~~ Presents at least the minimum parallel impedance across the PMA port of the TCI to meet the TCI specifications in 168.8.2	M	Yes [ ]
PMAE16	Receiver differential input signals	168.5.5.1	Can be verified with a frame error ratio less than 1×10^{-7} for 125 octet frames	M	Yes [ ]
PMAE17	Alien crosstalk noise rejection	168.5.5.2	BER < 10^{-10} with an alien crosstalk noise of Gaussian distribution of magnitude of –101 dBm/Hz and bandwidth of 40 MHz at the ~~MDI~~TCI	M	Yes [ ]
PMAE18	PMA local loopback	168.5.6	The PMA shall be placed in loopback mode when the PMA local loopback bit in MDIO register 1.0.0, defined in 45.2.1.1, or in MDIO register 1.2297.13 **(TBD)**, defined in 45.2.1.186d.5 **(TBD)** is set to one	MDIO:O	Yes [ ] No [ ] N/A[ ]
PMAE19	PMA local loopback	168.5.6	The PMA and PCS Receive functions pass the data decoded from the signal to the MII RX	MDIO:M	Yes [ ] No [ ] N/A[ ]

168.11.4.6 Mixing segment characteristics

Editor's Note (to be removed prior to Working Group ballot):

Clarification that the insertion loss and mode conversion loss needs to be met between any two MDI attachment points is required. This needs to be met between all combinations. See note at 168.7.1 - when this text is updated, the Value/Comment text at MXS1 and MXS3 may need updating.

Item	Feature	Subclause	Value/Comment	Status	Support
MXS1	Insertion loss	168.7.1	Measured between any pair of MDI attachment points	INS-MIX:M	Yes [ ]
MXS2	Return loss	168.7.2	Measured with a reference impedance of 50 Ω	INS-MIX:M	Yes [ ]
MXS3	Mode conversion loss	168.7.3	Measured between any two MDI attachment points	INS-MIX:M	Yes [ ]

Editor's Note (to be removed prior to Working Group ballot):

Clarified to represent TCI text. Mode conversion specifications still need work, regardless of TCI.

Item	Feature	Subclause	Value/Comment	Status	Support
MXS1	Linear topology	168.7	with edge terminations and TCI's where DTEs are attached	INS-MIX:M	Yes [ ]
MXS2	Insertion loss	168.7.1	Measured between edge termination attachment points	INS-MIX:M	Yes [ ]
MXS3	Return loss at each PMA port of each TCI	168.7.2	Measured with a reference impedance of 50 Ω	INS-MIX:M	Yes [ ]
MXS4	Return loss at edge termination attachments points	168.7.2	Measured with a reference impedance of 100 Ω	INS-MIX:M	Yes [ ]
MXS5	Mode conversion loss	168.7.3	TBD	INS-MIX:M	Yes [ ]

168.11.4.7 ~~MDI~~ TCI specification

Item	Feature	Subclause	Value/Comment	Status	Support
MDI1	MDI Electrical parameter 1 (e.g., minimum electrical impedance)	168.8.2		M	Yes [ ]
MDI2	MDI line powering voltage tolerance	168.8.3	Up to 60 V dc with the source current limited to 2000 mA	M	Yes [ ]
MDI3	MDI fault tolerance	168.8.4	Withstand without damage the application of a short circuit of any wire to the other wire of the same pair or ground potential. Normal operation resumes after all short circuits are removed.	M	Yes [ ]

Item	Feature	Subclause	Value/Comment	Status	Support
TCI1	If the DTE can be disconnected, TCI insertion loss between TC1 and TC2 without PMA loading	168.8.2.1	In each direction, measured with a reference impedance of 100 Ω	M	Yes [ ]
TCI2	TCI insertion loss between TC1 and TC2 with PMA loading	168.8.2.1	In each direction, measured with a reference impedance of 100 Ω	M	Yes [ ]
TCI3	If the DTE can be disconnected, TCI return loss at ports TC1 and TC2 without PMA loading	168.8.2.2	In each direction, measured with a reference impedance of 100 Ω	M	Yes [ ] N/A []
TCI4	TCI insertion loss at ports TC1 and TC2 with PMA loading	168.8.2.2	In each direction, measured with a reference impedance of 100 Ω	M	Yes [ ]
TCI5	MDI line powering voltage tolerance	168.8.3	Up to 60 V dc with the source current limited to 2000 mA	M	Yes [ ]
TCI6	MDI fault tolerance	168.8.4	Withstand without damage the application of a short circuit of any wire to the other wire of the same pair or ground potential. Normal operation resumes after all short circuits are removed.	M	Yes [ ]