146.1.2.1 Physical Coding Sublayer (PCS)

The 10BASE-T1L PCS transmits/receives signals to/from a Media Independent Interface (MII) as described in Clause 22, to/from signals on a 10BASE-T1L PMA, which supports a single balanced twisted-pair medium.

146.1.2.2 Physical Medium Attachment (PMA) Sublayer

The 10BASE-T1L PMA transmits/receives signals to/from the PCS onto the single balanced twisted-pair cable medium and supports the link management and the 10BASE-T1L PHY Control function. The PMA provides full duplex communications at 7.5 MBd over a single balanced twisted-pair cable up to 1000 m in length.

146.1.2.3 Signaling

10BASE-T1L signaling is performed by the PCS generating continuous code-group sequences that the PMA transmits over the single balanced twisted-pair. The signaling scheme achieves a number of objectives including the following:

a) Algorithm mapping and inverse mapping from nibble data to ternary symbols and back.
b) Uncorrelated symbols in the transmitted symbol stream.
c) No correlation between symbol streams traveling both directions.
d) Ability to rapidly or immediately determine if a symbol stream represents data or idle.
e) Robust delimiters for Start-of-Stream delimiter (SSD), End-of-Stream delimiter (ESD), and other control signals.
f) Ability to signal the status of the local receiver to the remote PHY to indicate that the local receiver is not operating reliably and requires retraining.

146.1.3 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 a descriptive text, the state diagram prevails.

146.1.3.1 State Diagram Notation

The notation used in the state diagrams follows the conventions of 21.5.

146.1.3.2 State Diagram Timer specifications

All timers operate in the manner described in 40.4.5.2.

146.1.3.3 Service specifications

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

146.2 Service primitives and interfaces

The 10BASE-T1L PHY shall use the service primitives and interfaces in 40.2, with exception of the following clarifications and differences noted in this section, in support of 10 Mb/s operations over a single balanced twisted-pair channel. Figure 146-xx shows the relationship of the service primitives and interfaces used by the 10BASE-T1L PHY.

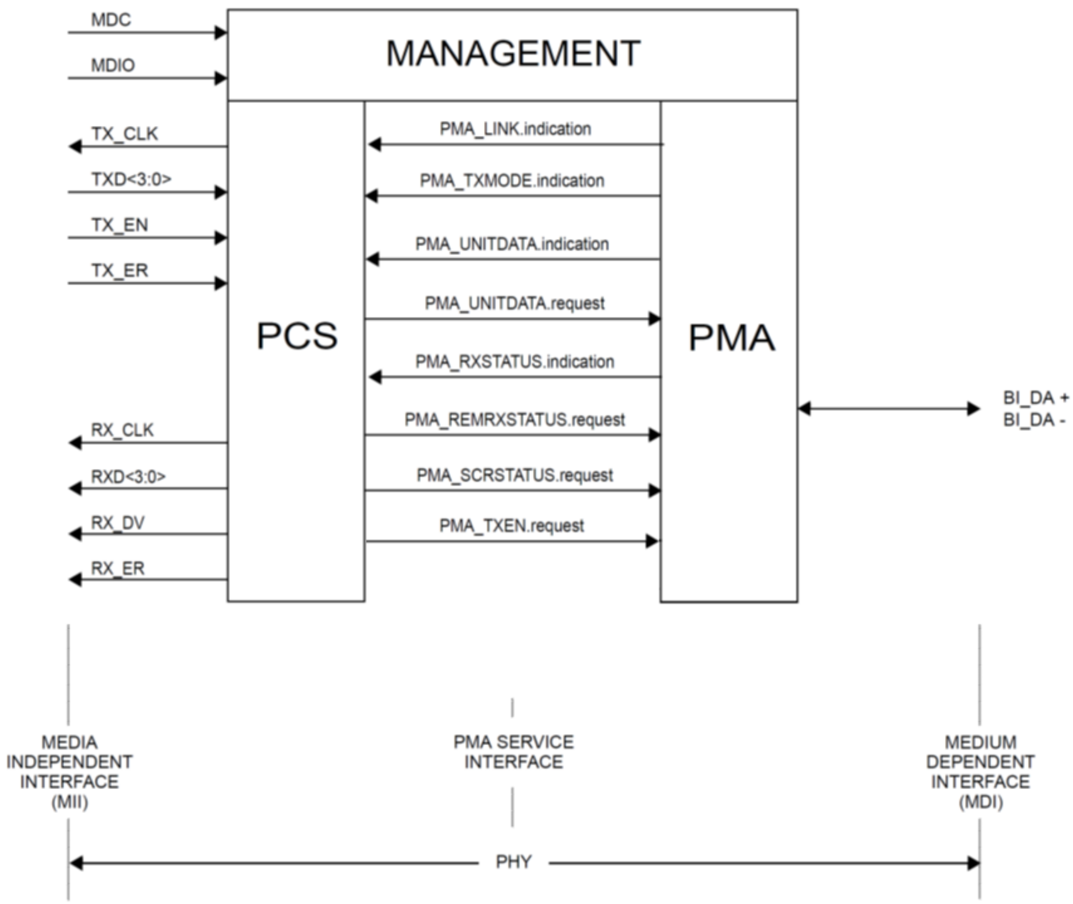

Figure 146-xx 10BASE-T1L PHY interfaces

The 10BASE-T1L PHY uses the Media Independent Interface (MII) as specified in Clause 22 instead of a Gigabit Media Independent Interface (GMII).

As shown in Figure 146-xx, 10BASE-T1L uses the following service primitives to exchange symbol vectors, status indications, and control signals across the PMA service interface:

PMA_LINK.indication (link_status)
PMA_TXMODE.indication (tx_mode)
PMA_UNITDATA.indication (rx_symb_vector)
PMA_UNITDATA.request (tx_symb_vector)
PMA_RXSTATUS.indication (loc_rcvr_status)
PMA_REMRXSTATUS.request (rem_rcvr_status)
PMA_SCRSTATUS.request (scr_status)
PMA_TXEN.request (TX_EN)

146.8 MDI Specification

This section defines the MDI for 10BASE-T1L.

146.8.1 MDI Connectors

The mechanical interface to the balanced cabling is a 3-pin connector (BI_DA+, BI_DA-, and SHIELD) or alternatively a 2-pin connector with an additional mechanical shield connection which conforms to the link segment specification defined in 146.7.

For industrial applications also a four pin M8/M12 or a four pin 7/8" connector may be used as long as it conforms to the requirements of the link segment defined in 146.7.

Alternatively for applications with lower environmental requirements a standard RJ45 connector may be used. In this case pin 3 (BI_DA+) and pin 6 (BI_DA-) of the RJ45 connector shall be used.

> ***Editor's Note (to be removed prior to Draft 2.0):***
>
> Do we need additional protection, when using pins 3 and 6 when connected to standard Ethernet ports (with or without PoE)?

146.8.2 MDI electrical specification

The MDI connector mated with a specified single balanced twisted-pair cable connector shall meet the electrical requirements specified in 146.7.

146.8.3 MDI return loss

The MDI return loss (RL) shall meet or exceed Equation 146-xx for all frequencies from 100 kHz to 20 MHz (with 100 Ω ± 0.1 % reference impedance) at all times when the PHY is transmitting data or idle symbols.

$$MDI\ Return\ Loss(f) \geq \begin{cases} 20\ dB & for\ 0.1\ MHz \leq f \leq 1\ MHz \\ 20\ dB - 16\ dB \cdot log_{10}\left(\frac{f_{MHz}}{1\ MHz}\right) & for\ 1\ MHz < f \leq 20\ MHz \end{cases} \quad (146\text{-}xx)$$

> ***Editor's Note (to be removed prior to Draft 2.0):***
>
> The provided values for the MDI return loss are preliminary values only and are subject to change.

146.8.4 MDI fault tolerance

For industrial applications the wire pair of the MDI shall, under all operating conditions, withstand without damage the application of short circuits of any wire to the other wire of the same pair or ground potential or positive voltages of up to 60 V dc with the source current limited to 1200 mA, as per Table 146-xx, for an indefinite period of time. Normal operation shall resume after the short circuit(s) is/are removed.

For automotive applications the wire pair of the MDI shall, under all operating conditions, withstand without damage the application of short circuits of any wire to the other wire of the same pair or ground potential or positive voltages of up to 50 V dc with the source current limited to 150 mA, as per Table 146-xx, for an indefinite period of time. Normal operation shall resume after the short circuit(s) is/are removed.

The wire pair of the MDI shall also withstand without damage high-voltage transient noises and ESD per application requirements. The following table gives an overview about possible connection faults for the wire pair (BI_DA+ and BI_DA-):

BI_DA+	**BI_DA-**
BI_DA-	BI_DA+
Ground	---
---	Ground
Ground	Ground
+50/60 V dc	---
---	+50/60 V dc
+50/60 V dc	+50/60 V dc
Ground	+50/60 V dc
+50/60 V dc	Ground

Table 164-xx Fault conditions

Note: Typically industrial control circuits are SELV/PELV limited to a maximum voltage of 60 V. The maximum current is limited by the 50 ohm termination resistors in each signal line. Depending on the internal structure of the PHY IC additional external clamping diodes could be necessary. Due to the AC signal coupling the maximum current is only applied while charging the signal coupling capacitors.

146.9.2 Network safety

All cabling and equipment subject to this clause is expected to be mechanically and electrically secure in a professional manner. In industrial applications, all 10BASE-T1L cabling shall be routed according to any applicable local, state or national standards considering all relevant safety requirements. In automotive applications, all 10BASE-T1L cabling shall be routed in way to provide maximum protection by the motor vehicle sheet metal and structural components, following SAE J1292, ISO 14229, and ISO 15764.

146.9.2.1 Environmental safety

In industrial applications, all equipment subject to this clause shall conform to the potential environmental stresses with respect to their mounting location, as defined in the following specifications, where applicable:

a) Environmental loads: IEC 60529 and ISO 4892
b) Mechanical loads: IEC 60068-2-6/31
c) Climatic loads: IEC 60068-2-1/2/14/27/30/38/52/78

In automotive applications, all equipment subject to this clause shall conform to the potential environmental stresses with respect to their mounting location, as defined in the following specifications:

a) General loads: ISO 16750-1
b) Electrical loads: ISO 16750-2, ISO 7637-2:2008, and ISO 8820-1
c) Mechanical loads: ISO 16750-3, ASTM D4728, and ISO 12103-1
d) Climatic loads: ISO 16750-4 and IEC 60068-2-1/27/30/38/52/64/78
e) Chemical loads: ISO 167540-5 and ISO 20653

Industrial and automotive environmental conditions are generally more severe than those found in many commercial environments. The targeted application environment(s) require careful analysis prior to implementation.

146.9.2.2 Electromagnetic compatibility

A system integrating the 10BASE-T1L PHY shall comply with all applicable local and national codes. In addition, the system may need to comply with more stringent requirements as agreed upon between customer and supplier, for the limitation of electromagnetic interference.

In industrial applications a 10BASE-T1L PHY shall be tested according to the MICE classification depending on the intended electromagnetic classification (MICE E_1 to MICE E_3). Where applicable, also testing according to IEC 61326 and NE21 test methods, which are similar or even more severe than a MICE E_3 environment shall be done and the following industrial EMC requirements shall be met:

a) Radiated/Conducted Emissions: IEC 61000-6-4
b) Radiated/Conducted Immunity: IEC 61000-4-3 and IEC 61000-4-6
c) Electrical Fast Transients: IEC 61000-4-4
d) Electrostatic Discharge: IEC 61000-4-2
e) Surge: IEC 61000-4-5

In automotive applications, a 10BASE-T1L PHY shall be tested according to CISPR 25 test methods, and shall meet the following motor vehicle EMC requirements:

a) Radiated/Conducted Emissions: IEC CISPR 25, IEC 61967-1/4, and IEC 61000-4-21
b) Radiated/Conducted Immunity: ISO 11452, IEC 62132-1/4, and IEC 61000-4-21
c) Electrostatic Discharge: ISO 10605 and IEC 61000-4-2/3
d) Electrical Disturbances: IEC 62215-3 and ISO 7637-2/3

Exact test setup and test limit values may be adapted to each specific application, subject to agreement between the customer and the supplier.