X. Electrical specifications

This Clause defines the electrical specifications for the PSE and PD. The specifications shall apply at the cabling side of the mated connection where power is supplied or received and when specified the requirements shall apply only to the transmit and receive pairs. When specified as an operating condition the requirements shall apply while transmitting data and when power is applied to a load.

X.1 Isolation

The PSE or PD shall provide electrical isolation between the port device circuits, including frame ground (if any) and all MDI leads. This electrical separation shall withstand at least one of the following electrical strength tests:

a. 1500 V rms at 50-60 Hz for 60 s, applied as specified in Section 5.3.2 of IEC 60950: 1991.
b. 2250 Vdc for 60 s, applied as specified in Section 5.3.2 of IEC 60950: 1991.
c. A sequence of ten 2400 V impulses of alternating polarity, applied at intervals of not less than 1s. The shape of the impulses shall be 1.2/50 micro second (1.2 micro second virtual front time, 50 micro second virtual time or half value), as defined in IEC 60060.

There shall be no insulation breakdown, as defined in Section 5.3.2 of IEC 60950: 1991, during the test. The resistance after the test shall be at least 2 mega-ohms, measured at 500 Vdc.

X.2 Fault tolerance

Each wire pair of the PSE or PD shall, under all operating conditions, withstand without damage the application of short circuits of any wire to any other wire within the 4-pair cable for an indefinite period of time and shall resume normal operation after the short circuit(s) are removed. The magnitude of the current through such a short circuit shall not exceed 500 ma.

Each wire pair shall withstand without damage a 1000V common-mode impulse applied at Ecm of either polarity (as indicated in Figure X-1). The shape of the impulse shall be 0.3/50 µs (300 ns virtual front time, 50 µs virtual time of half value), as defined in IEC 60060.

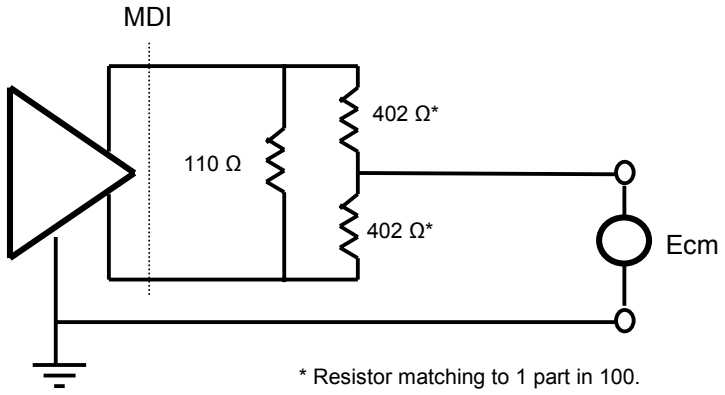

Figure X-1 MDI fault tolerance test circuit

X.3 Impedance balance

Impedance balance is a measurement of the common-mode-to-differential-mode impedance balance of the MDI port. The common-mode-to-differential-mode impedance balance for the transmit and receive pairs shall not exceed,

$29 - 17\log_{10}(f/10)$ dB from 2.0-20 MHz for a 10 Mbit/s PHY, (1)

$34 - 19.2\log_{10}(f/50)$ dB from 1.0-100 MHz for a 100 Mbit/s or greater PHY, (2)

where f is the frequency in MHz.

The impedance balance is defined as

$20\log_{10}(Ecm/Edif)$ (3)

where Ecm is an externally applied sine wave voltage as shown in Figure X-2 and Edif is the resulting waveform due only to the applied sine wave.

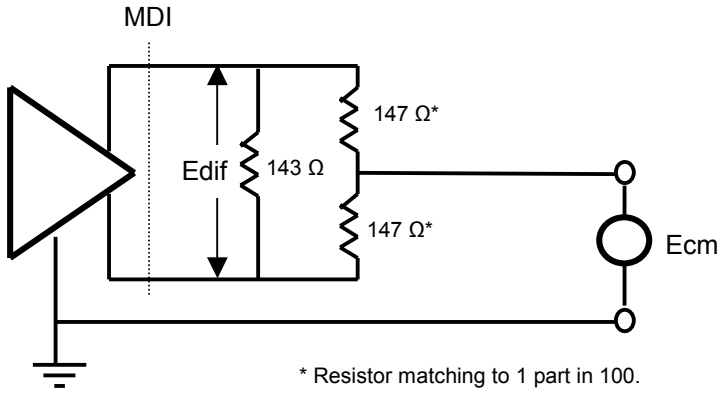

Figure X-2 MDI impedance balance test circuit

NOTE – The balance of the test equipment (such as the matching of the test resistors) must be insignificant relative to the balance requirements.

X.4 Common-mode output voltage

The magnitude of the total common-mode output voltage measured according to Figure X-3 at the transmit port while transmitting data and with power applied, Ecm_out, shall not exceed 50 mV peak when operating at 10Mbit/s and 50 mV peak-to-peak when operating at 100Mbit/s or greater. The magnitude of the common-mode AC voltage shall not exceed 50 mV peak-to-peak measured at all other ports. The frequency of the measurement shall be from 0.15 MHz to 100 MHz.

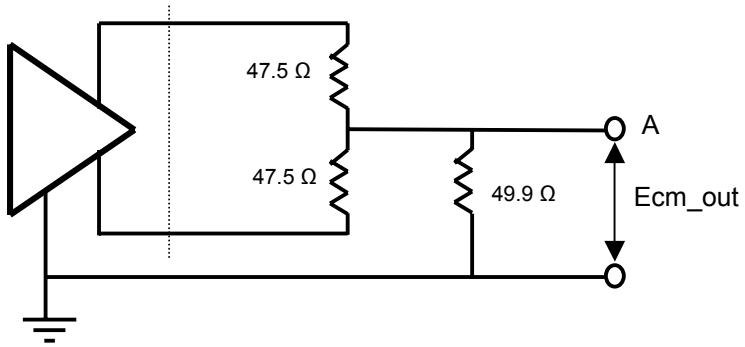

Figure X-3 Common-mode output voltage test

NOTE - The implementer should consider any applicable local, national, or international regulations that may require more stringent specifications. One such specification can be found in the European Standard EN 55022:1998.

X.5 Common to Common output voltage (TBD)

With power applied the common (A in Figure X-3) to common differential AC voltage between the two PSE pairs that supply power shall not exceed 50 mV peak-to-peak. The frequency of the measurement shall be from 0.15 MHz to 100 MHz.

X.6 Differential noise voltage

The noise coupled from a operating PSE to the differential transmit and receive pairs shall not exceed 20 mV peak-to-peak measured from 0.15 MHz to 100 MHz.

X.7 Return loss

The differential impedance at the transmit and receive pairs shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having an impedance of 100 ohms is at least 15 dB below the incident signal, over the frequency range of 5 MHz to 10 MHz, for a 10 Mbit/s PHY; and shall be at least 16 dB from 1.0 MHz to 40 MHz and at least $10 - 20\log_{10}(f/80)$ dB from 40 MHz to 100MHz, for a 100Mbit/s or greater PHY.

X.8 Connector

The transmit and receive pairs when mated with a specified balanced cabling connection shall meet or exceed the electrical requirements for the defined category of connection as specified in ANSI/TIA/EIA-568-B.2.

X.9 Cable plant

The cable plant specification for 4-pair unshielded twisted-pair (UTP) cabling systems is described in ANSI/TIA/EIA-568-B and ISO/IEC 11801-2000. The primary application for spare pair power is expected to be in the telecommunications room. The maximum configuration for the telecommunication room consists of a full cross-connect consisting of two connectors, illustrated in Figure X-4.

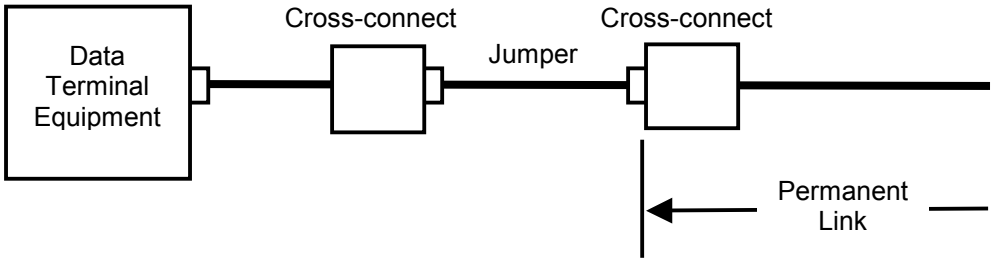

Figure X-4 Telecommunication room

Insertion of spare pair power may replace one of the cross-connects with a PSE or may replace the jumper cord with a cord that would include the PSE. Configurations with only one connection in the cross-connect could add an additional connection with the PSE port.

The insertion of a PSE shall not increase the length of the Telecommunication room cabling plus the equipment cabling at the end of the channel beyond the specified 10 meters as defined in ANSI/TIA/EIA-568-B and ISO/IEC 11801-2000.

Applications that insert spare pair power outside the telecommunication room shall not alter the transmit and receive pair parameters, and shall meet the link requirements for the transmit and receive pairs with power applied as specified in ANSI/TIA/EIA-568-B and ISO/IEC 11801-2000, and this Clause.

X.9.1 Cross-connector PSE

Replacing one of the cross-connectors with a PSE or the addition of a connector when only one cross-connect exists is equivalent to one (1) mated connection. The PSE shall meet the requirements of this sub-clause when tested in accordance with the transmission test methods specified in ANSI/TIA/EIA-568-B and ASTM D4566 for connecting hardware that is used to terminate to 100 Ω balanced twisted-pair cabling.

X.9.1.1 Cross-connect insertion loss

Insertion loss is a measure of the signal loss between the transmitter and receiver, expressed in dB relative to the received signal level. Insertion loss shall be measured for a cross-connect with a PSE device for all transmit and receive pairs from 1 MHz to 100 MHz, and shall meet the values determined using equation (4), but not less than 0.1 dB.

$$Insertion\_loss_{conn} \leq 0.04\sqrt{f}\,dB \qquad (4)$$

X.9.1.2 Cross-connect Near-end crosstalk (NEXT) loss

NEXT loss is a measure of the unwanted signal coupling from a transmitter at the near-end into neighboring pairs measured at the near-end. NEXT loss is expressed in dB relative to the received signal level. NEXT loss shall be measured for a cross-connect with a PSE device for all transmit and receive pair combinations from 1 MHz to 100 MHz and shall meet the values determined by equation (5), but not greater that 65 dB.

$$NEXT_{conn} \geq 40 - 20\log(f/100)dB \quad (5)$$

X.9.1.3 Cross-connect return loss

Return loss is a measure of the reflected energy caused by impedance mismatches in the cabling system and is expressed in dB relative to the reflected signal level. Return loss shall be measured for a cross-connect with a PSE device for all transmit and receive pairs from 1 MHz to 100 Mhz and shall meet or exceed the values specified in table 1.

Table 1 – Cross-connect return loss

Frequency (MHz)	Return Loss (dB)
$1 \leq f \leq 20$	23
$20 < f \leq 100$	14

X.9.2 Jumper cord PSE

Replacing the existing jumper cord between the cross-connect with a cord or cords that include a PSE device should not alter the requirements of a jumper cord. The transmit and receive pairs of a jumper cord with a PSE device shall meet the requirements of this sub-clause when tested according to ANSI/TIA/EIA-568-B.2 and ASTM D4566.

X.9.2.1 Jumper cord insertion loss

The insertion loss of the jumper cord with a PSE device with an equivalent length of *L* meters shall not exceed the value determined using equation (6) measured from 1 MHz to 100 MHz.

$$Insertion\_loss_{cord,L} \leq \left(\frac{Derating_{Atten} * L}{100}\right)\left(1.967\sqrt{f} + 0.023f + \frac{0.050}{\sqrt{f}}\right)dB \quad (6)$$

where $Derating_{Atten} = 1.2$.

X.9.2.2 Jumper cord Near-end crosstalk (NEXT) loss

The NEXT loss of a jumper cord with a PSE device shall be measured for all transmit and receive pair combinations from 1 MHz to 100 MHz. The NEXT loss shall meet or exceed the values determined using Equation (28) in ANSI/TIA/EIA-568-B clause 6.3.3, where:

$Atten_{cable,100m}$ is the insertion loss determined using equation (6) in X.9.2.1 with *L* = 100,

$Derating_{Atten}$ is equal to 1.2,

$Atten_{conn}$ is the insertion loss determined using equation (4) in X.9.1.1, and

$$NEXT_{cable,100m} \geq 32.3 - 15\log(f/100)dB\,. \quad (7)$$

X.9.2.3 Jumper cord return loss

The return loss of a jumper cord with a PSE device shall be measured for all transmit and receive pairs from 1 MHz to 100 Mhz and shall meet or exceed the values specified in table 2.

Table 2 – Jumper cord return loss

Frequency (MHz)	Return Loss (dB)
$1 \leq f < 20$	23
$20 \leq f \leq 100$	$16 - 10\log(f/100)$ (8)

Y. Environmental

Y.1 General safety

All equipment meeting this standard shall conform to IEC publication 950.

Y.2 Network safety

This clause sets forth a number of recommendations and guidelines related to safety concerns; the list is neither complete nor does it address all possible safety issues. The designer is urged to consult the relevant local, national, and international safety regulations to ensure compliance with the appropriate requirements.

LAN cabling systems described in this clause are subject to at least four direct electrical safety hazards during their installation and use. These hazards are as follows:

a) Direct contact between LAN components and power, lighting, or communications circuits.
b) Static charge buildup on LAN cabling and components.
c) High-energy transients coupled onto the LAN cabling system.
d) Voltage potential differences between safety grounds to which various LAN components are connected.

Such electrical safety hazards must be avoided or appropriately protected against for proper network installation and performance. In addition to provisions for proper handling of these conditions in an operational system, special measures must be taken to ensure that the intended safety features are not negated during installation of a new network or during modification of an existing network.

Y.3 Installation

It is a mandatory functional requirement that sound installation practice, as defined by applicable local codes and regulations, be followed in every instance in which such practice is applicable.

Y.4 Installation and maintenance guidelines

It is a mandatory functional requirement that, during installation of the cabling plant, care be taken to ensure that non-insulated network cabling conductors do not make electrical contact with unintended conductors or ground.

Y.5 Telephony voltages

The use of building wiring brings with it the possibility of wiring errors that may connect telephony voltages to a PSE or PD. Other than voice signals, the primary voltages that may be encountered are the “battery” and ringing voltages. Although there is no universal standard. The following maximums generally apply.

Battery voltage to a telephone line is generally 56 Vdc applied to the line through a balanced 400 Ω source impedance.

Ringing voltage is a composite signal consisting of an AC component and a DC component. The

ac component is up to 175 V peak at 20 Hz to 60Hz with a 100 Ω source resistance. The DC component is 56 Vdc with 100-600 Ω source resistance. Large reactive transients can occur at the start and end of each ring interval.

Application of any of the above voltage shall not result in any safety hazard.

Y.6 Electromagnetic emissions

The PD and PSE powered cabling link shall comply with applicable local and national codes for the limitation of electromagnetic interference.

Y.7 Temperature and humidity

The PD and PSE powered cabling link is expected to operate over a reasonable range of environmental conditions related to temperature, humidity, and physical handling. Specific requirements and values for these parameters are considered to be beyond the scope of this standard.

Y.8 Labeling

It is recommended that the PSE (and supporting documentation) or PD be labeled in a manner visible to the user with at least the following parameters:

a) Power level in terms of maximum current drain.
b) Port type (i.e. 100Base-TX, TIA Category or ISO Class)
c) Any applicable safety warnings