ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

MDI Mode Conversion Loss and MDI Fault Tolerance

Philip Curran
Michal Brychta

MDI Mode Conversion Loss

- MDI mode conversion loss is a measure of the impedance-to-ground difference between the two MDI contacts used by a duplex link channel.
  - Longitudinal conversion loss (LCL) is measured by the S parameter Sdc11 and corresponds to common-mode to differential-mode return loss
  - Transverse conversion loss (LCL) is measured by the S parameter Scd11 and corresponds to differential-mode to common-mode return loss
  - Only LCL or TCL needs to be measured as they are reciprocal
- MDI mode conversion loss must be limited to avoid performance impairment
  - Insufficient LCL will cause a large common mode interferer (due to EFT, for example) to reflect back from the MDI as a differential signal on the line
  - Our proposal is to follow clause 55 (10GBASE-T) which operates on shorter cables but with a higher order constellation (PAM16 versus PAM3)

Proposed MDI Mode Conversion Loss Requirements

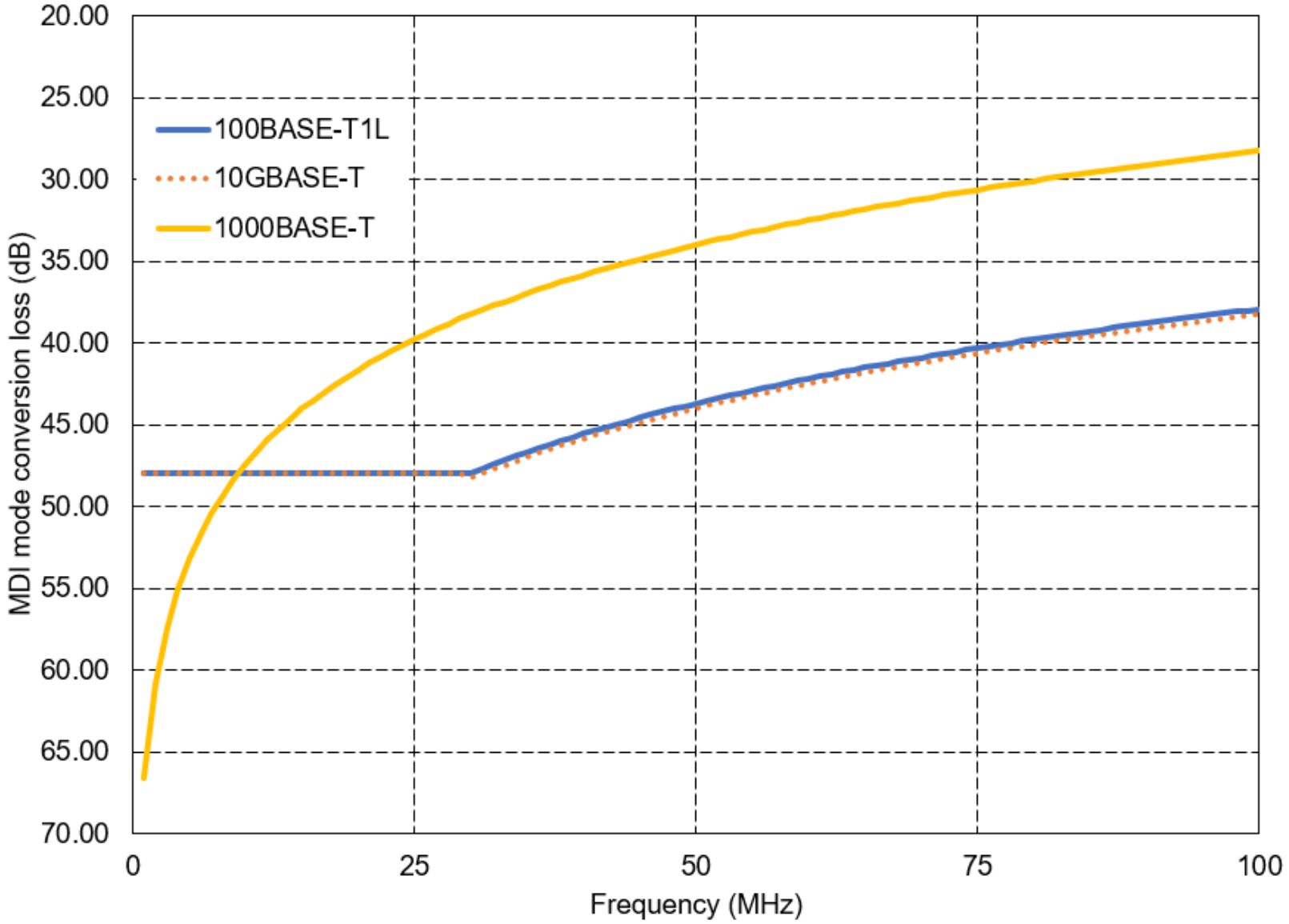
- Mode conversion loss LCL (Sdc11) or TCL (Scd11) of the PHY measured at the MDI shall meet the values determined using Equation (199–XX) at all frequencies from 1 MHz to 100 MHz.

$$\text{Mode conversion loss}\,(f) \geq \begin{cases} 48 & \text{dB for 1 MHz} \leq f < 30\ \text{MHz} \\ 43.7 - 19.2log_{10}\left(\frac{f}{50}\right) & \text{dB for 30 MHz} \leq f \leq 100\ \text{MHz} \end{cases}$$

where f is the frequency in MHz.

- Propose a slight adjustment to avoid the small discontinuity at 30 MHz
- Propose to specify only up to 100 MHz

Comparison of Proposed Limit Curve



MDI Fault Tolerance

- Several other standards specify a requirement to withstand the application of DC power to the MDI pins
  - Clause 96 (100BASE-T1) has the following requirements:

Table 96–6—Connection fault

BI_DA+	BI_DA-
No fault	No fault
BI_DA–	BI_DA+
Ground	No fault
No fault	Ground
+50 V dc	No fault
No fault	+50 V dc
Ground	+50 V dc
+50 V dc	Ground

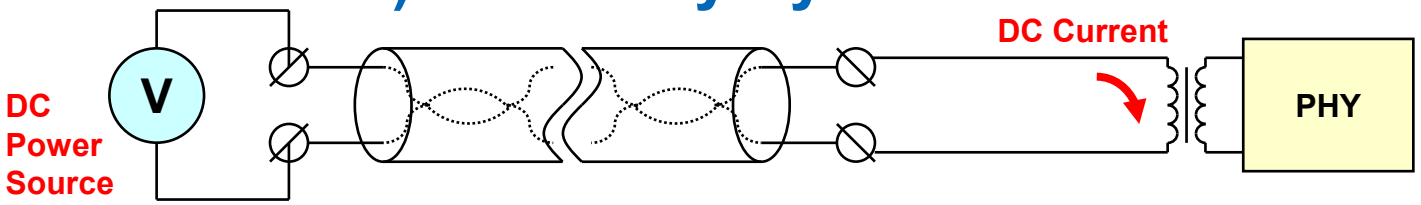
  - Other clauses (97, 149 and 165, for example) refer to the requirements in clause 96
  - Some other clauses (146 and 147, for example) specify a higher power supply voltage of 60 V DC.

MDI Fault Tolerance

- The requirement to withstand the application of DC power has significant cost implications and may not be applicable in all applications
- Propose to remove the requirement to withstand the application of DC power to the MDI
  - This requirement can be introduced by applications that need it

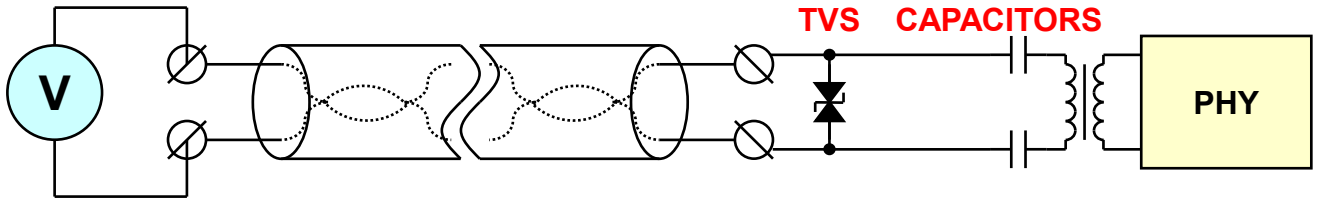
MDI Fault Tolerance

A) Data Only System



Transformer withstands only limited current

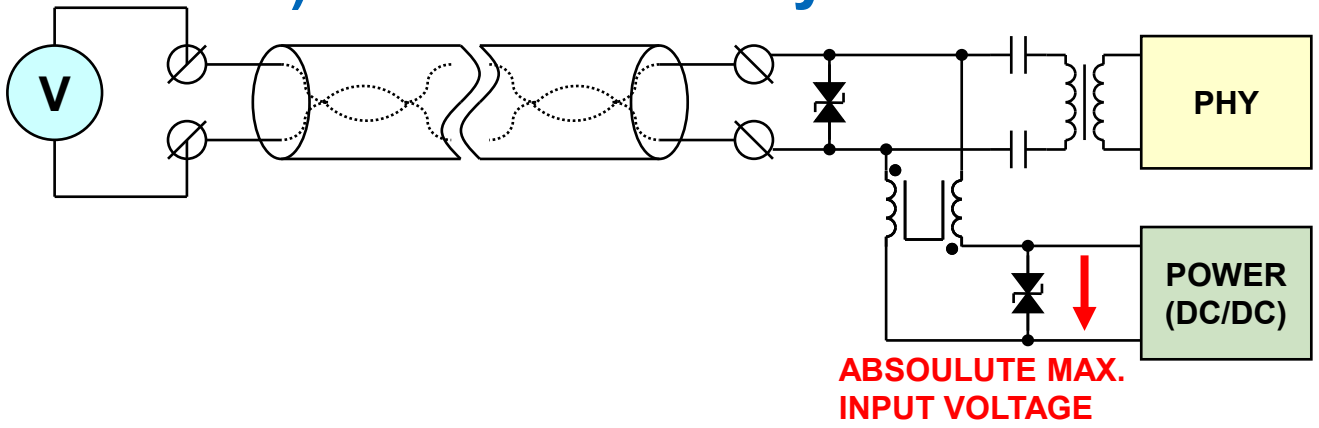
B) Data Only DC Tolerant System



TVS
clamping voltage higher than stand-off voltage

Capacitors
higher voltage rating
-> increasing size & cost

C) Data + Power System



Silicon components
higher voltage rating
-> increasing cost

Proposed MDI Fault Tolerance Requirements

- The wire pair of the MDI shall withstand without damage the application of short circuits of any wire to the other wire of the pair or ground potential, as per Table 190–XX, under all operating conditions, for an indefinite period of time. Normal operation shall resume after the short circuit(s) is/are removed.

BI_DA+	BI_DA-
BI_DA-	BI_DA+
Ground	No fault
No fault	Ground
Ground	Ground

- Applications requiring tolerance to the application of DC powering voltages to the wires of the MDI may require special consideration beyond the scope of this standard.

Proposed Text for the Draft

Proposed Text for the Draft – MDI Mode Conversion

- Text for section 190.8.2.2 MDI mode conversion loss
  - Insert following new section

IEEE P802.3dg™/D1.2, 7th July 2025

190.8.2.2 MDI mode conversion loss

New Text

Mode conversion loss LCL (Sdc11) or TCL (Scd11) of the PHY measured at the MDI shall meet the values determined using Equation (199–11) at all frequencies from 1 MHz to 100 MHz.

$$\text{Mode conversion loss}\,(f) \geq \begin{cases} 48 & \text{dB for 1 MHz} \leq f < 30 \text{ MHz} \\ 43.7 - 19.2\log_{10}\left(\frac{f}{50}\right) & \text{dB for 30 MHz} \leq f \leq 100 \text{ MHz} \end{cases} \quad (199\text{–}11)$$

where f is the frequency in MHz.

Proposed Text for the Draft – MDI Fault Tolerance

- Text for section 190.8.3 MDI fault tolerance
  - Insert following new section

IEEE P802.3dg™/D1.2, 7th July 2025

190.8.3 MDI fault tolerance

New Text

The wire pair of the MDI shall withstand without damage the application of short circuits of any wire to the other wire of the pair or ground potential, as per Table 190–14, under all operating conditions, for an indefinite period of time. Normal operation shall resume after the short circuit(s) is/are removed.

Table 190–14—MDI fault conditions

BI_DA+	BI_DA-
BI_DA-	BI_DA+
Ground	No fault
No fault	Ground
Ground	Ground

Applications requiring tolerance to the application of DC powering voltages to the wires of the MDI may require special consideration beyond the scope of this standard.