SPE Multidrop Enhancements
Mixing Segment
Baseline Proposals

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IEEE P802.3da Objectives

1. Define performance characteristics of a mixing segment for 10Mb/s multidrop single balanced pair networks supporting up to at least 16 nodes, for up to at least 50m reach
2. Maintain a bit error ratio (BER) at the MAC/PLS service interface of less than or equal to 10^{-10} on the new mixing segment
3. Specify an optional PLCA node ID allocation method
4. Support interoperability with Clause 147 multidrop
5. Support optional Time Synchronization Service Interface (TSSI)
6. Select a single MDI connector
7. Specify improvements for Energy Efficient Ethernet compared to current 10Mb/s multidrop single balanced pair networks
8. Support operation in the noise environments for building, industrial, and transportation applications
9. Specify optional plug-and-play power distribution over the mixing segment
10. PSE shall only energize the mixing segment when at least one PD is connected
11. Support addition and removal of a node or set of nodes to a continuously operating powered mixing segment

IEEE P802.3da Baseline

- Support interoperability with Clause 147 multidrop
  - Support 802.3cg mixing segment
    - 802.3da MDIs – meet 147.9.2
    - Adopt: Table 147–4—MDI impedance limit parameters (TBD)

- Normative: Mixing segment configurations 16 nodes, 50 m trunk cable reach and drop cables.
  - Max 10 cm drop length/Min 20 cm drop separation (TBD)
  - Max 20 cm drop length/Min 40 cm drop separation (TBD)
  - Max 30 cm drop length/Min 60 cm drop separation (TBD)

- Normative Annex: engineered mixing segment configuration >16 nodes (TBD), >50 m trunk cable (TBD) reach and drop cables (TBD).

- Adopt 147.8 Mixing segment characteristics with TBDs as revised;
  - 147.8.1 Insertion loss*1.1 (10% increase)
  - 147.8.2 Return loss (TBD)
  - 147.8.3 Mode conversion loss (TBD)

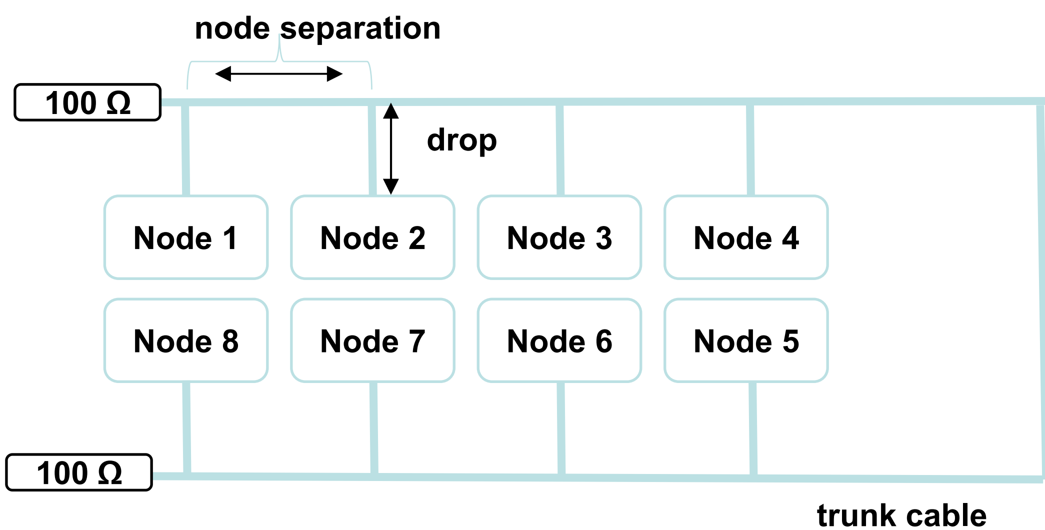
- Adopt FOM_{ILD} method – 93A.3, 93A.4 - FOM_{ILD} (TBD)

- NOTE: Collison detection not addressed but needs be considered to close.

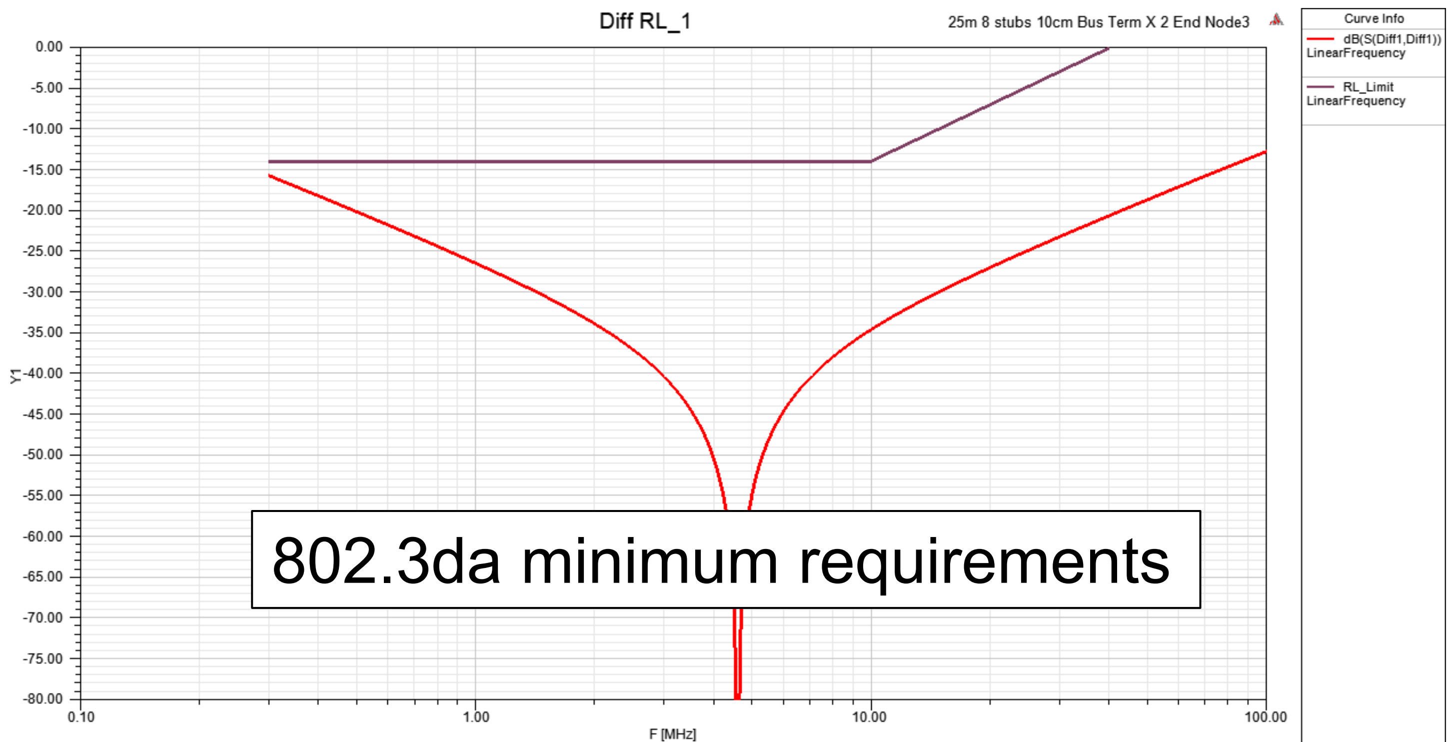
IEEE P802.3da – MDI electricals

- Support interoperability with Clause 147 multidrop
  - <u>Support 802.3cg mixing segment</u>

Mixing Segment =25 m = trunk cable + drops
Drops=10cm



802.3da MDI electrical specification – TX - PoDL

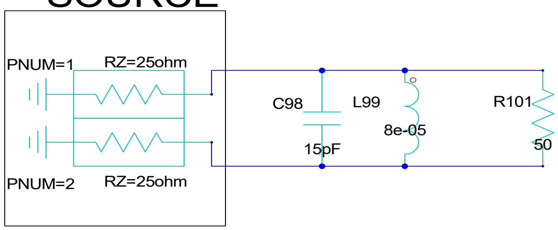


MDI impedance limit parameters

Parameter name	Unit of measure	Minimum value	Maximum value
R	kΩ	10	—
L	µH	80	—
C_{tot}	pF	—	180
C_{node}	pF	—	15

Source: IEEE Std 802.3cg™-2019

SOURCE

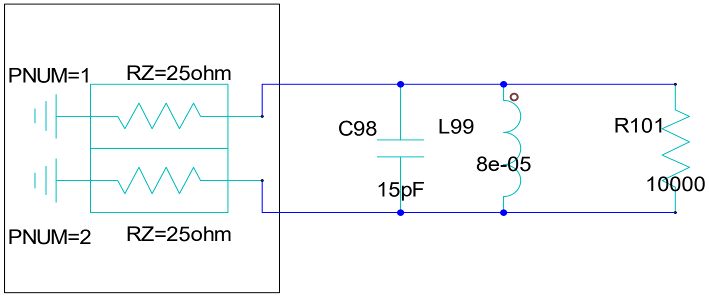


802.3da MDI electrical specification – RX - PoDL

MDI impedance limit parameters

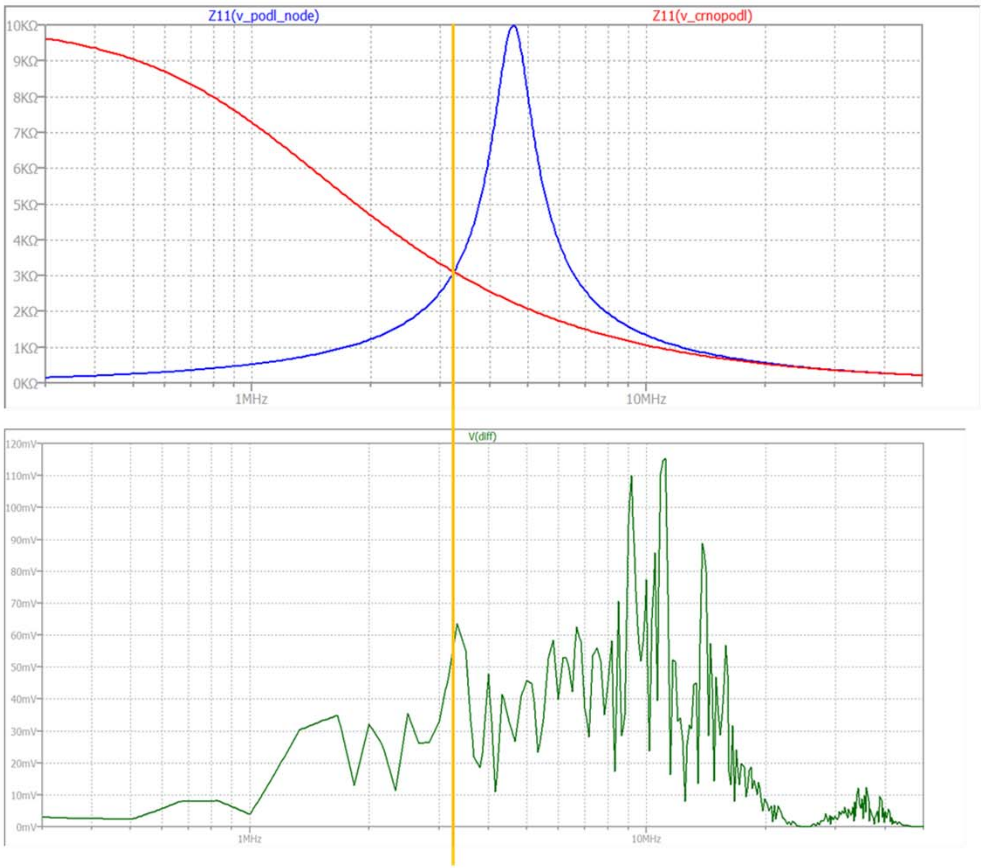
Parameter name	Unit of measure	Minimum value	Maximum value
R	kΩ	10	—
L	µH	80	—
C_{tot}	pF	—	180
C_{node}	pF	—	15

Source: IEEE Std 802.3cg™-2019



802.3da MDI electrical specification – RX - PoDL

WHY 80uH PODL DOES NOT DEGRADE THAT MUCH (LC resonance)



Impedance of a single node:

[10k || 15pF] non-PoDL node

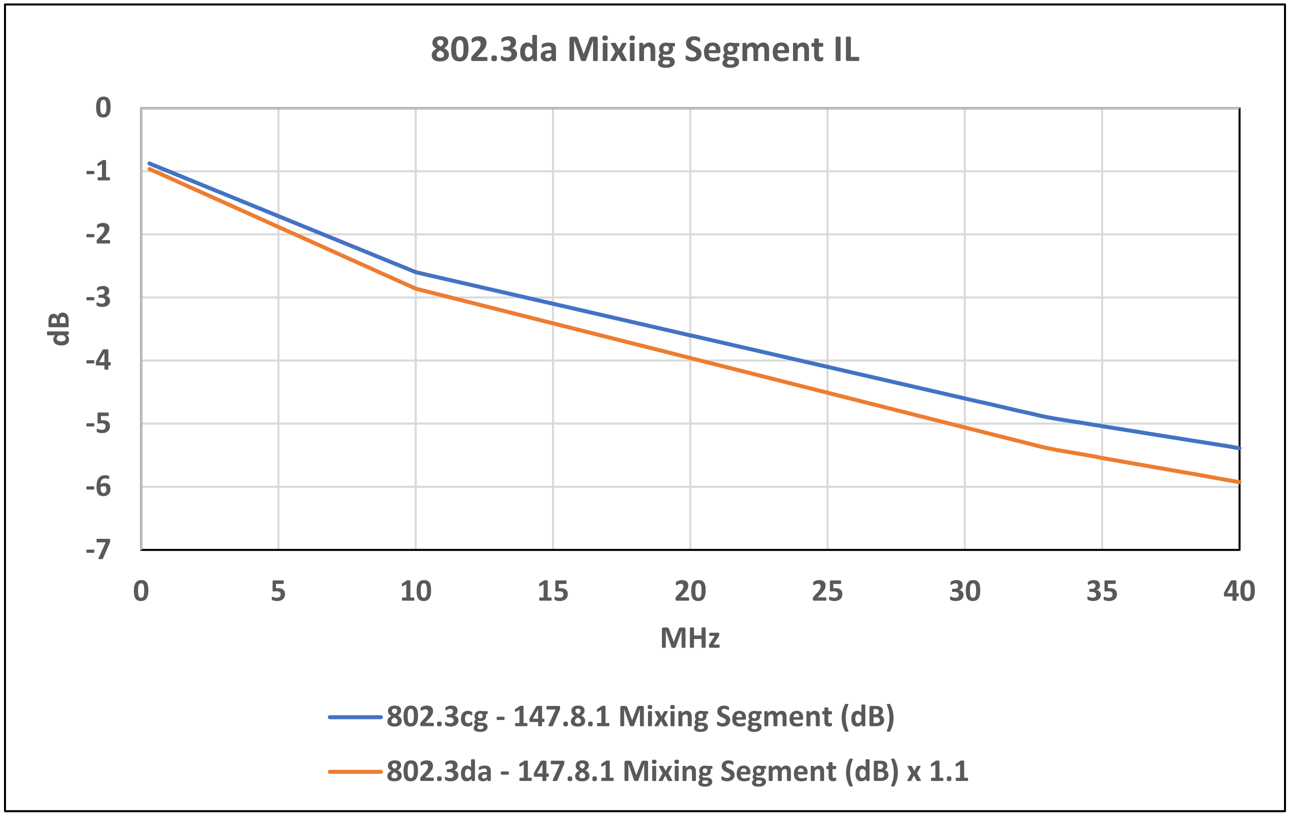
[10k || 15pF || 80uH] PoDL node

FFT of DME signal (10ns rise time)

Source: Wojciech Koczwara, Scott Griffiths, David Brandt, Sebastian Konewko - Rockwell

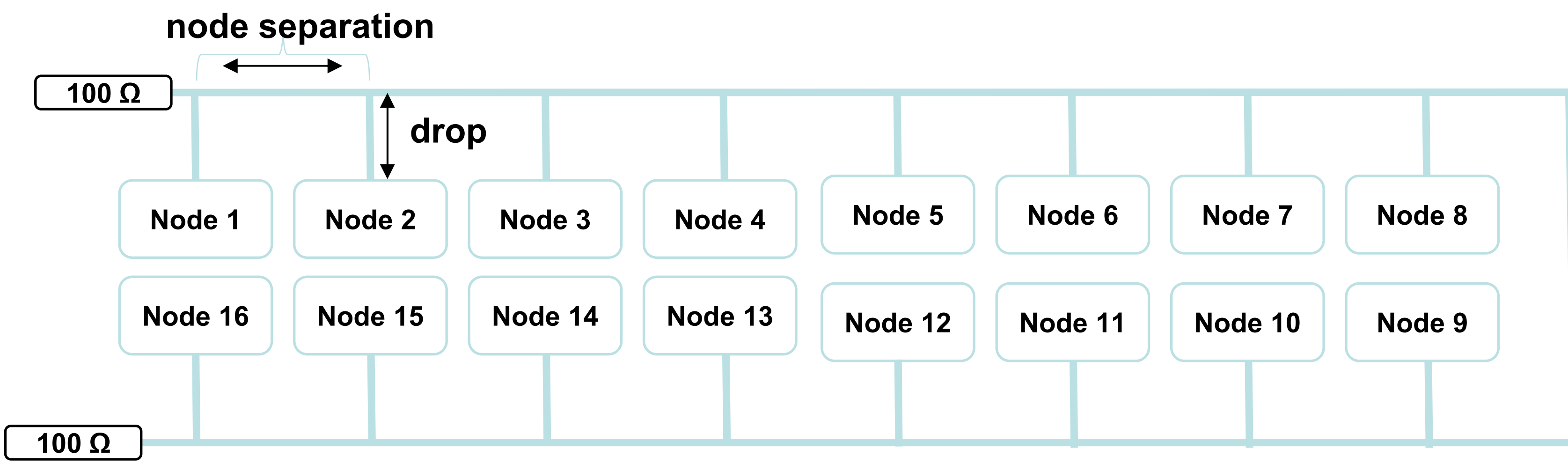
802.3da – Mixing Segment IL

- **147.8.1 Mixing Segment Insertion loss*1.1 (10% increase)**



IEEE P802.3da Mixing Segment

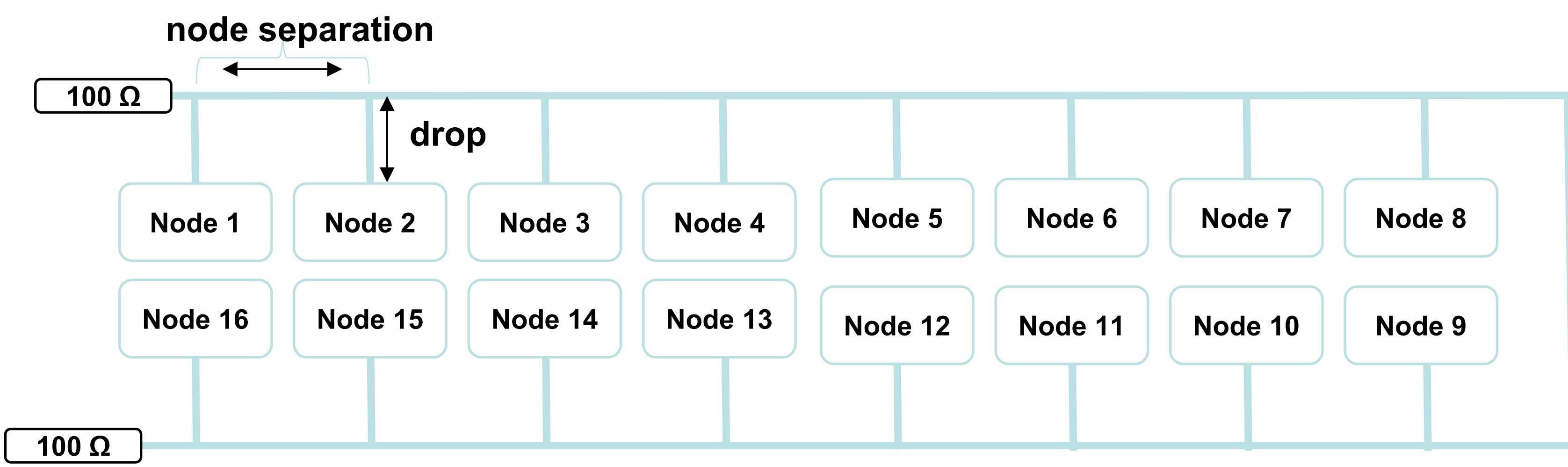
- Normative: mixing segment configuration requirements
- 16 nodes, 50 m trunk cable reach, drop cable (TBD)
    - Mixing Segment = 50 m trunk cable + drops
        - Max 10 cm drop length/Min 20 cm drop separation (TBD)
        - Max 20 cm drop length/Min 40 cm drop separation (TBD)
        - Max 30 cm drop length/Min 60 cm drop separation (TBD)



IEEE P802.3da Mixing Segment

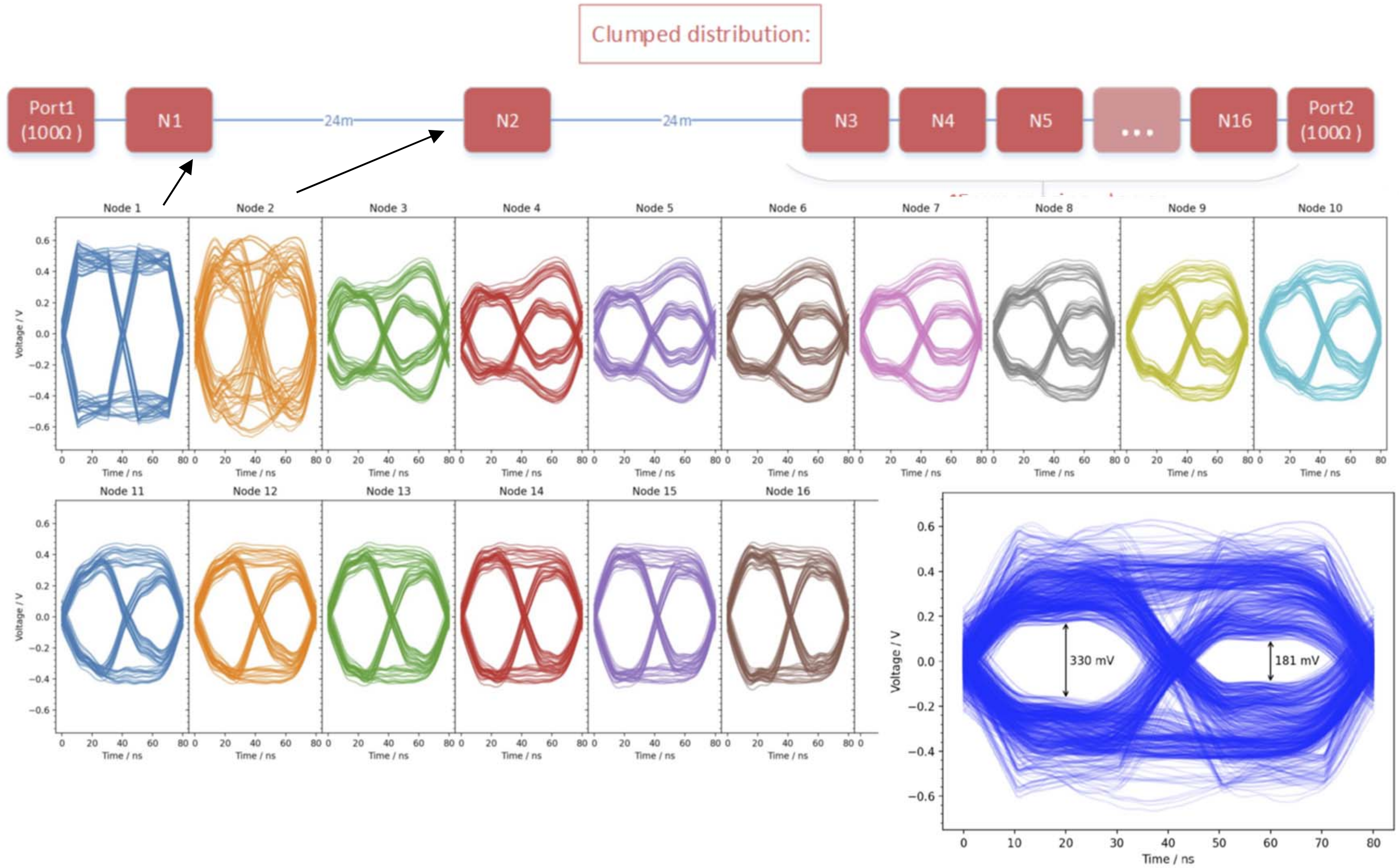
- Normative Annex: mixing segment engineered
- > 50 m (TBD) reach, >16 nodes (TBD)

Mixing Segment >50 m (TBD) trunk cable + drops (TBD)



IEEE P802.3da Mixing Segment Distribution

- 10 cm drop/20 cm separation – 80 uH, 160 uH PoDL
- 20 cm drop/40 cm separation – 80 uH PoDL
- 30 cm drop/60 cm separation – 80 uH PoDL, 160 uH PoDL

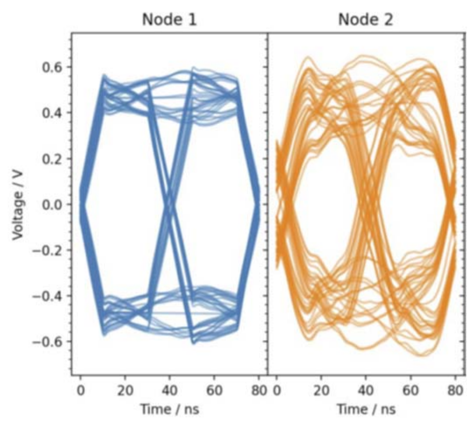


Source: Wojciech Koczwara, Scott Griffiths, David Brandt, Sebastian Konewko - Rockwell

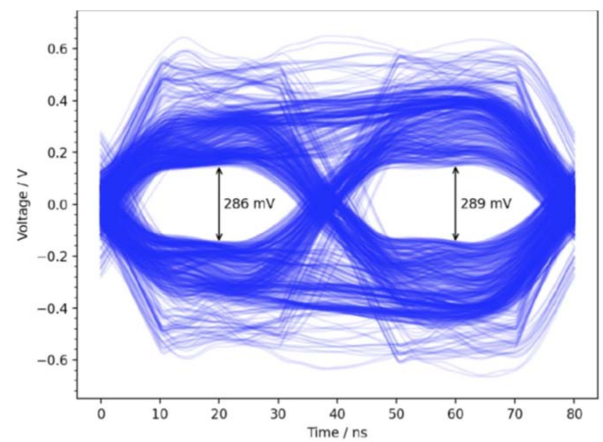
IEEE P802.3da Mixing Segment Distribution

Clumped, no PoDL, Tx1 node 10 cm stub, 20 cm separation

worse case

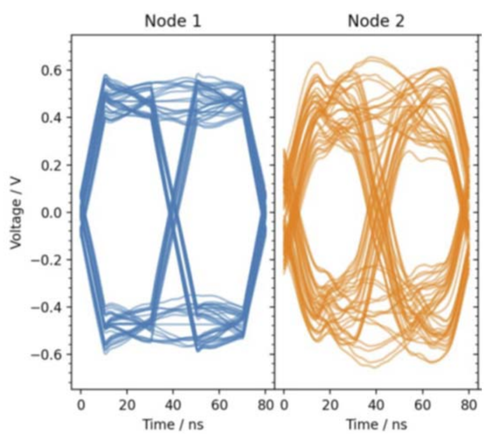


16 nodes

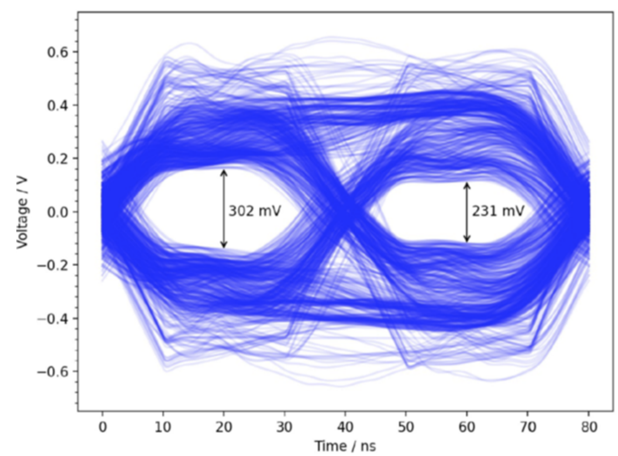


Clumped, with 160 uH PoDL, Tx1 node 10 cm stub, 20 cm separation

worse case



16 nodes

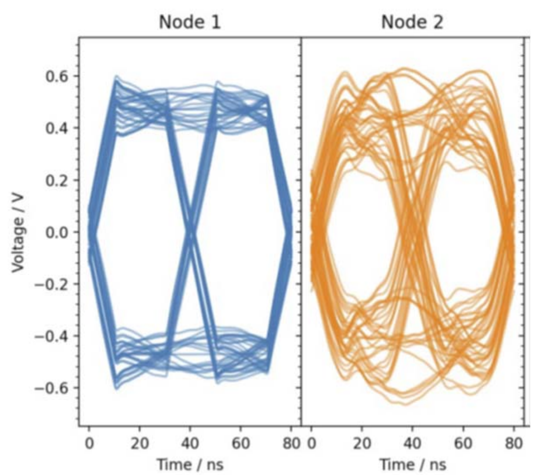


Source: Wojciech Koczwara, Scott Griffiths, David Brandt, Sebastian Konewko - Rockwell

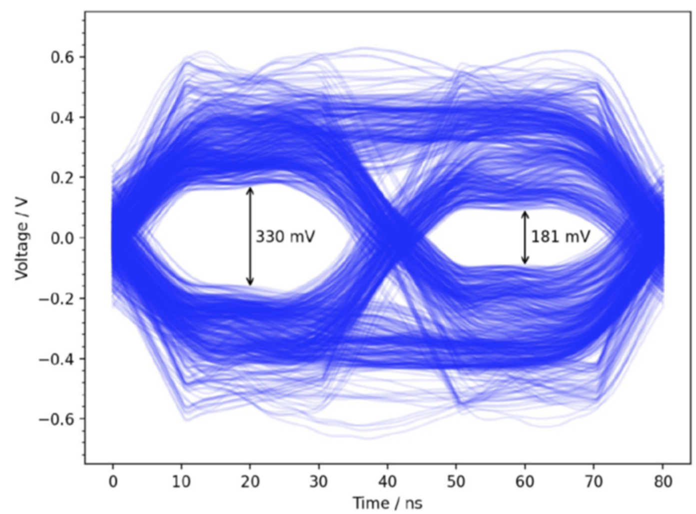
IEEE P802.3da Mixing Segment Distribution

Clumped, with 80 uH PoDL, Tx1 node 10 cm stub, 20 cm separation

worse case

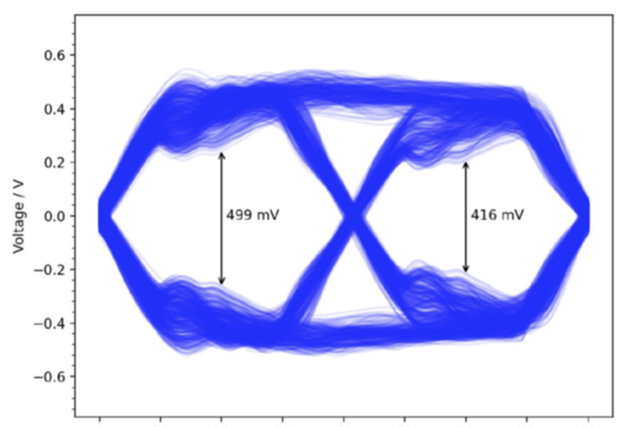


16 nodes



Clumped, with 80 uH PoDL, Tx10 node 10 cm stub, 20 cm separation

16 nodes

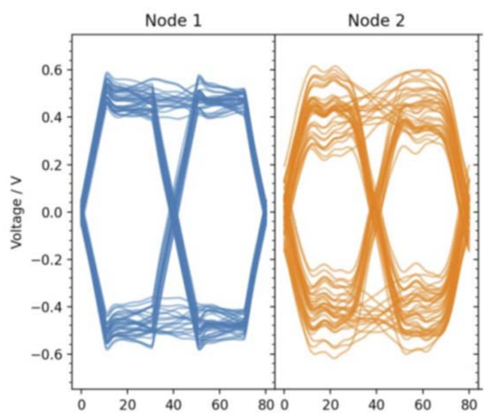


Source: Wojciech Koczwara, Scott Griffiths, David Brandt, Sebastian Konewko - Rockwell

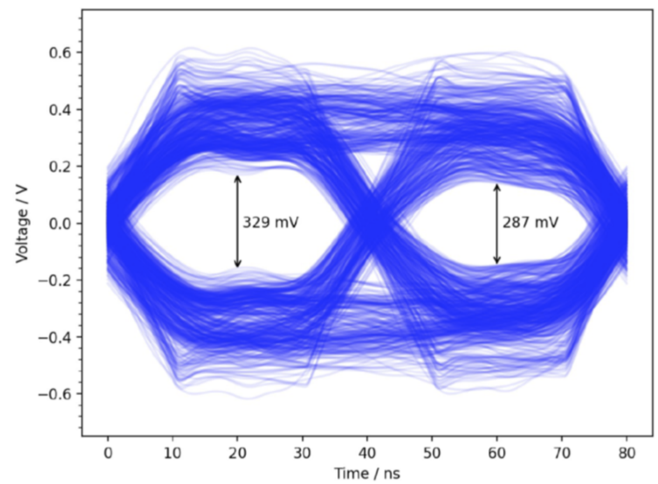
IEEE P802.3da Mixing Segment Distribution

Clumped, with 80 uH PoDL, Tx1 node 20 cm stub, 40 cm separation

worse case

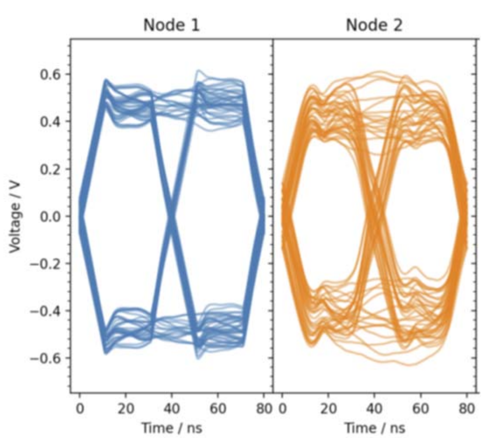


16 nodes

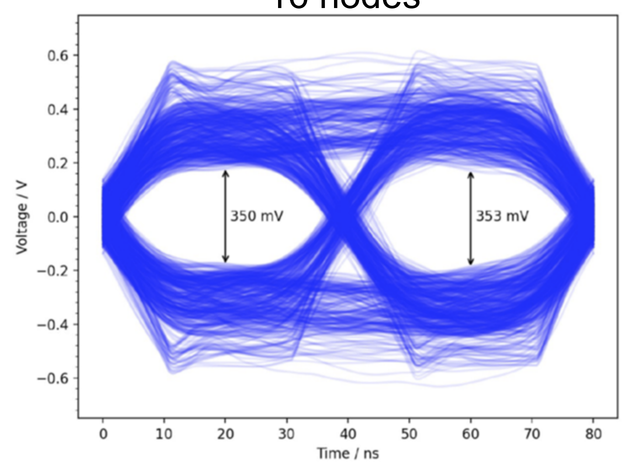


Clumped, no PoDL, Tx1 node 30 cm stub, 60 cm separation

worse case



16 nodes

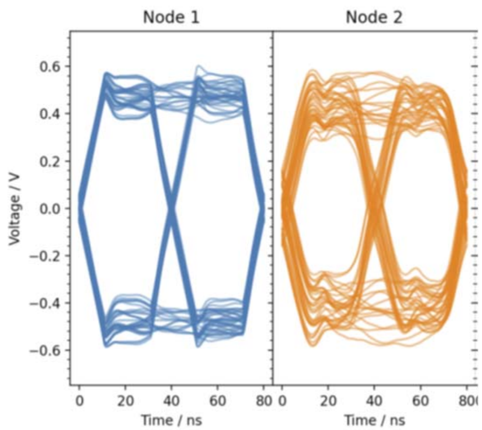


Source: Wojciech Koczwara, Scott Griffiths, David Brandt, Sebastian Konewko - Rockwell

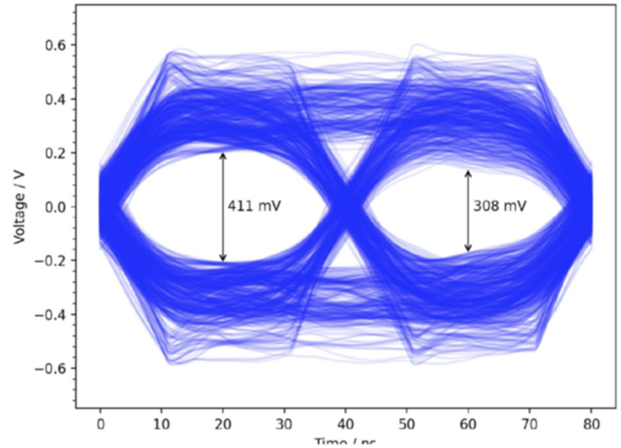
IEEE P802.3da Mixing Segment Distribution

Clumped, 160 uH PoDL, Tx1 node 30 cm stub, 60 cm separation

worse case

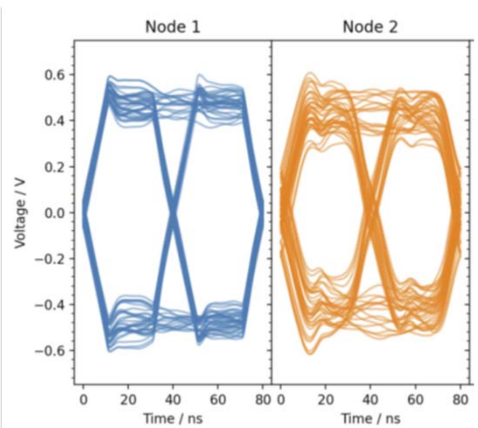


16 nodes

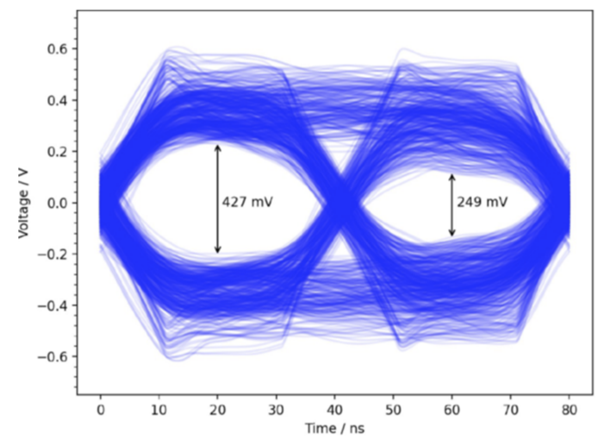


Clumped, 80 uH PoDL, Tx1 node 30 cm stub, 60 cm separation

worse case



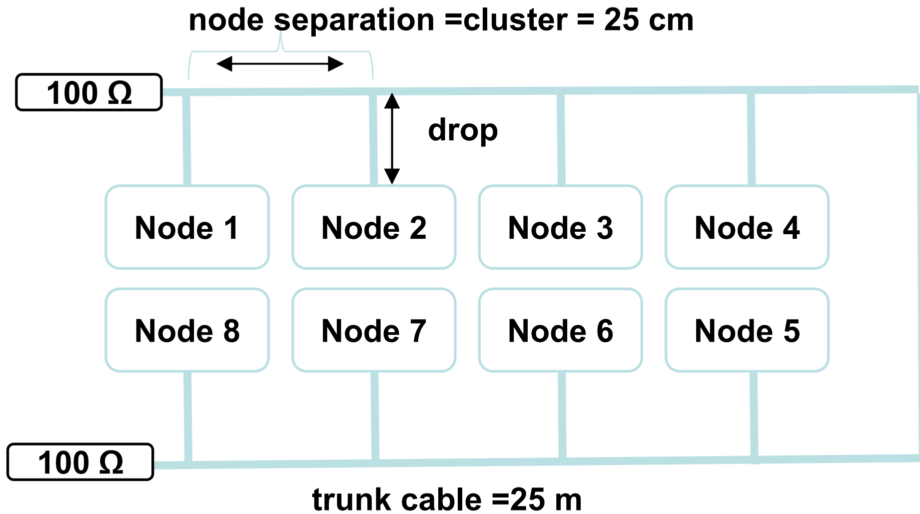
16 nodes

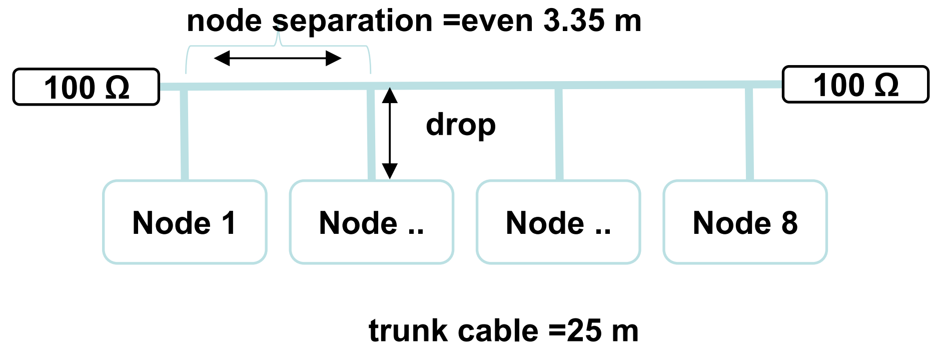


Source: Wojciech Koczwara, Scott Griffiths, David Brandt, Sebastian Konewko - Rockwell

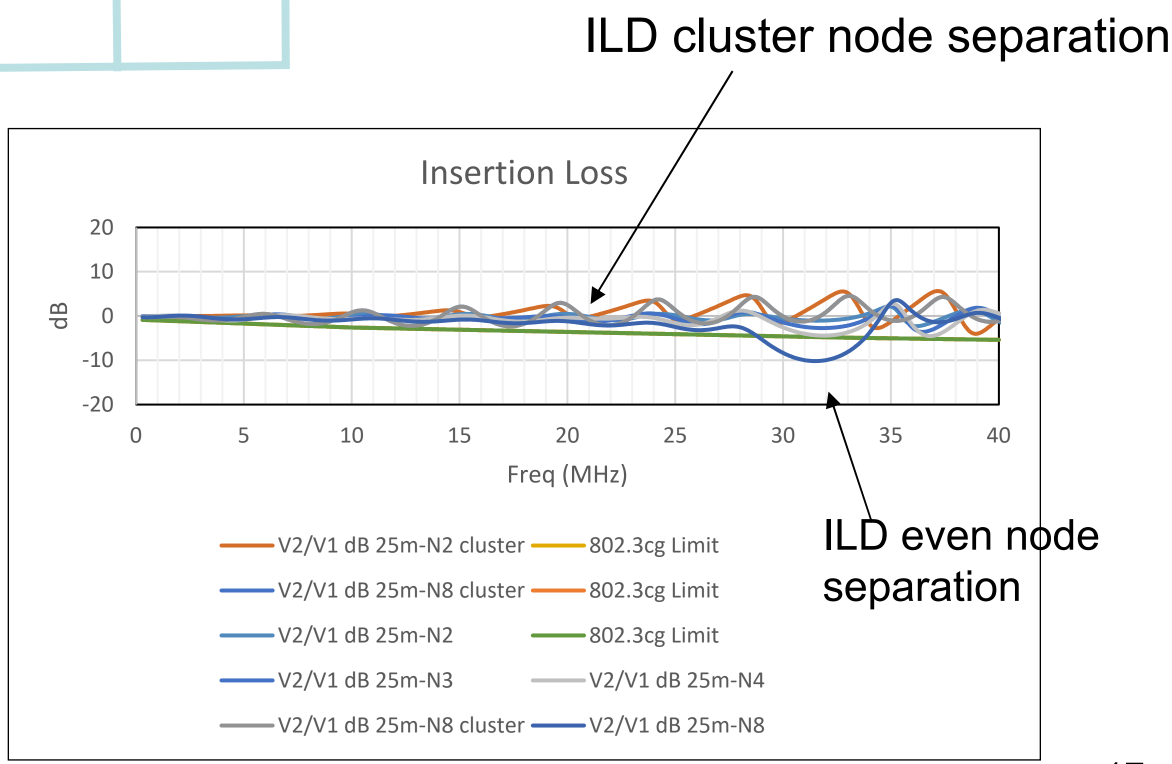
16

25 m 18 AWG 8 node – Configurations

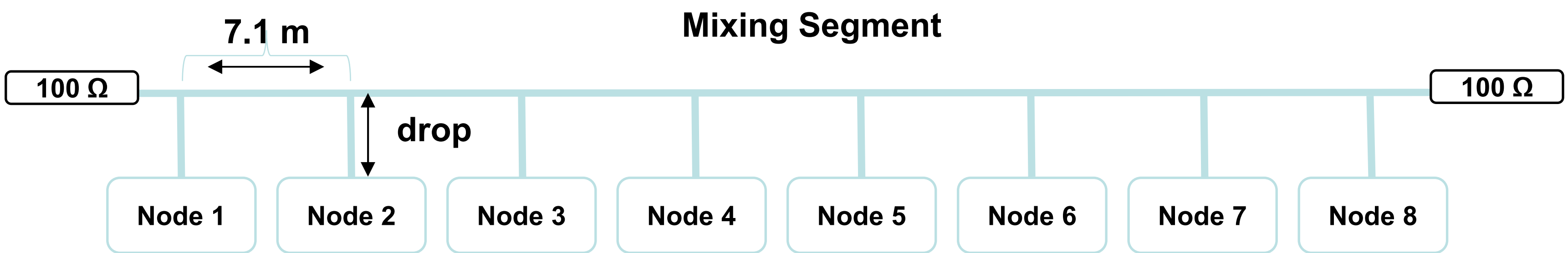




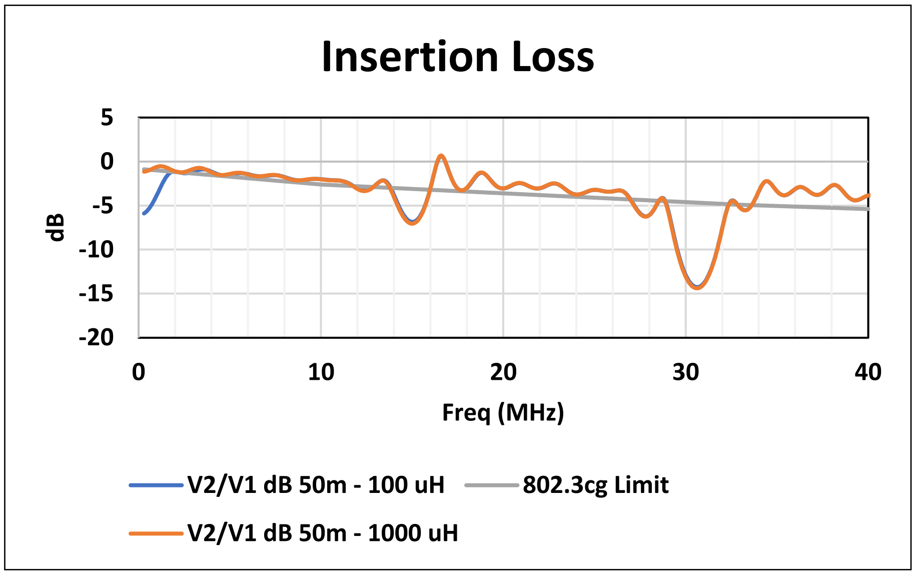
Even distributions can yield deeper IL suck outs but less in band ILD as observed in impacting eye

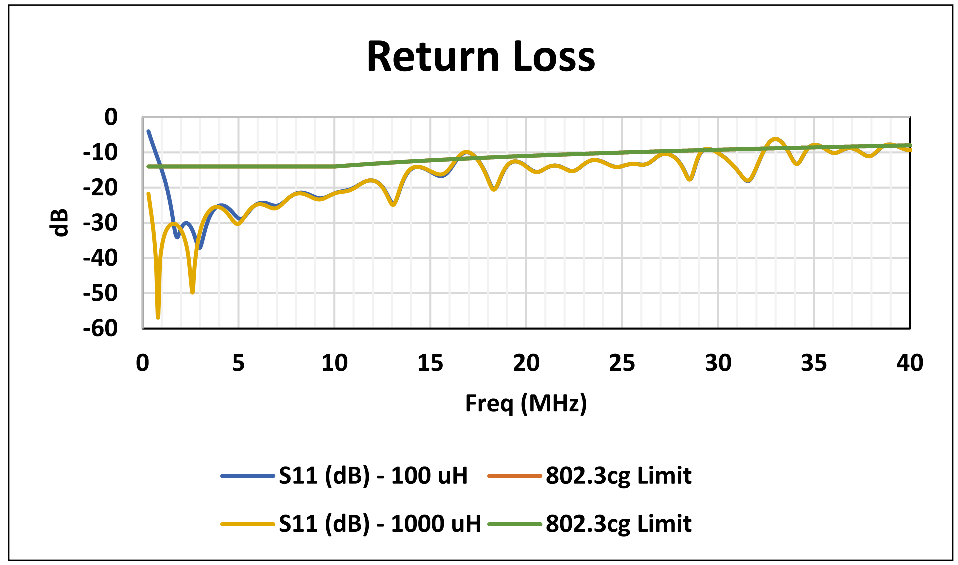


50m 18 AWG 8 node – 7.1 m separation - PoDL



Drop = 500 mm





Insertion Loss Deviation

IEEE Std 802.3bj-2014 - FOM_{ILD}

93A.3 Fitted insertion loss

The fitted insertion loss as a function of frequency is given by Equation (93A–51).

$$IL_{fitted}(f) = a_0 + a_1\sqrt{f} + a_2 f + a_4 f^2 \quad (93A\text{–}51)$$

Denote the insertion loss, in dB, measured at frequency f_n as $IL(f_n)$. Given the insertion loss measured at N uniformly-spaced frequencies from start frequency f_{min} to stop frequency f_{max} with step no larger than Δf, the coefficients for the fitted insertion loss shall be calculated as follows.

Define the weighted frequency matrix F using Equation (93A–52).

$$F = \begin{bmatrix} 10^{-IL(f_1)/20} & \sqrt{f_1}10^{-IL(f_1)/20} & f_1 10^{-IL(f_1)/20} & f_1^2 10^{-IL(f_1)/20} \\ 10^{-IL(f_2)/20} & \sqrt{f_2}10^{-IL(f_2)/20} & f_2 10^{-IL(f_2)/20} & f_2^2 10^{-IL(f_2)/20} \\ \cdots & \cdots & \cdots & \cdots \\ 10^{-IL(f_N)/20} & \sqrt{f_N}10^{-IL(f_N)/20} & f_N 10^{-IL(f_N)/20} & f_N^2 10^{-IL(f_N)/20} \end{bmatrix} \quad (93A\text{–}52)$$

Define the weighted insertion loss vector L using Equation (93A–53).

$$L = \begin{bmatrix} IL(f_1)10^{-IL(f_1)/20} \\ IL(f_2)10^{-IL(f_2)/20} \\ \cdots \\ IL(f_N)10^{-IL(f_N)/20} \end{bmatrix} \quad (93A\text{–}53)$$

The fitted insertion loss coefficients are then given by Equation (93A–54).

$$\begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_4 \end{bmatrix} = (F^T F)^{-1} F^T L \quad (93A\text{–}54)$$

The values assigned to f_{min}, f_{max}, and Δf are defined by the Physical Layer specification that invokes this method.

93A.4 Insertion loss deviation

The insertion loss deviation $ILD(f)$ is the difference between the measured insertion loss $IL(f)$ and the fitted insertion loss $IL_{fitted}(f)$ (see 93A.3) as shown in Equation (93A–55).

$$ILD(f) = IL(f) - IL_{fitted}(f) \quad (93A\text{–}55)$$

A figure of merit for a channel that is based on $ILD(f)$ is given by Equation (93A–56). In Equation (93A–56), f_n are the frequencies considered in the computation of the fitted insertion loss and $W(f_n)$ is the weight at each frequency as defined by Equation (93A–57).

$$FOM_{ILD} = \left[\frac{1}{N}\sum_n W(f_n) ILD^2(f_n)\right]^{1/2} \quad (93A\text{–}56)$$

$$W(f_n) = \text{sinc}^2(f_n/f_b)\left[\frac{1}{1+(f_n/f_t)^4}\right]\left[\frac{1}{1+(f_n/f_r)^8}\right] \quad (93A\text{–}57)$$

The variable f_b is the signaling rate. The 3 dB transmit filter bandwidth f_t is inversely proportional to the 20% to 80% rise and fall time T_t. The constant of proportionality is 0.2365 (e.g., $T_t f_t$ = 0.2365; with f_t in Hertz and T_t in seconds). The variable f_r is the 3 dB reference receiver bandwidth.

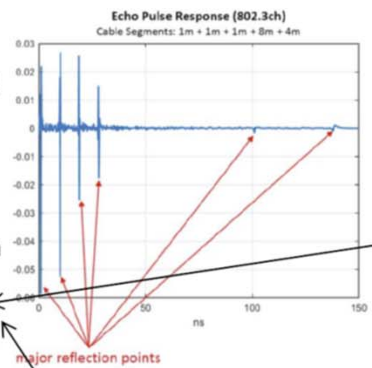
The values assigned to f_b, T_t, and f_r are defined by the Physical Layer specification that invokes this method.

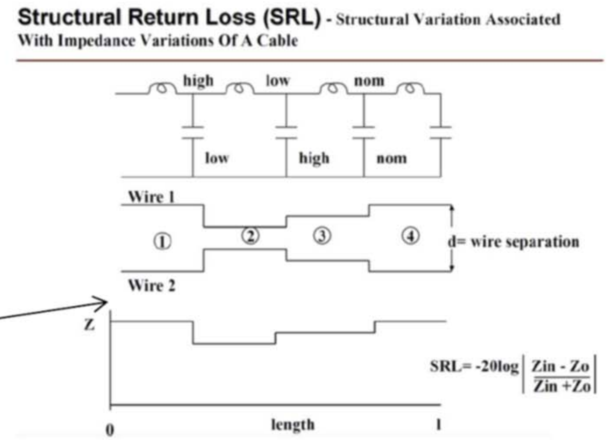
Insertion Loss Deviation

Insertion Loss Deviation

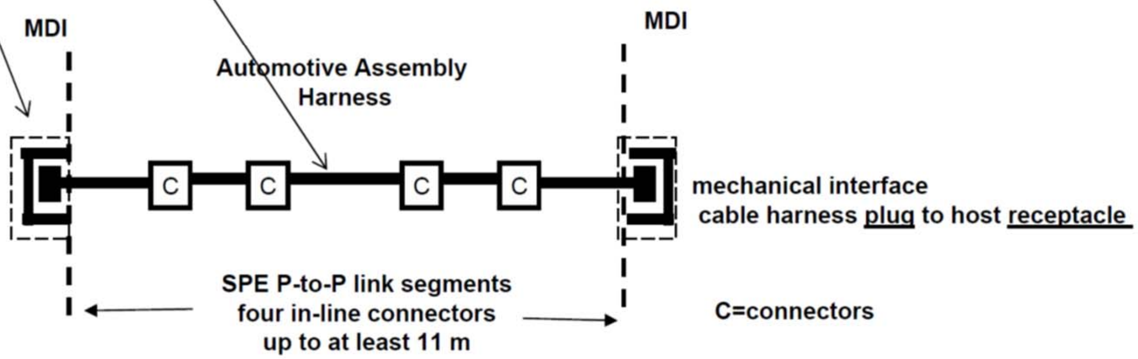
Echo Response in Time

- The echo pulse response consists of major reflections from a maximum of 6 discontinuities in the link segment
  - 2 MDI interfaces
  - No more than 4 connectors
- There are micro reflections, in between discontinuities and spread throughout the cable, due to cable inhomogeneity (nonuniform characteristic impedance)



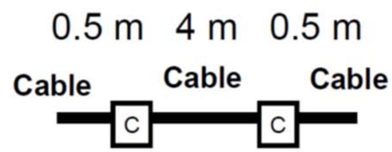


https://grouper.ieee.org/groups/802/3/cy/public/adhoc/sedarat_3cy_01_0920.pdf

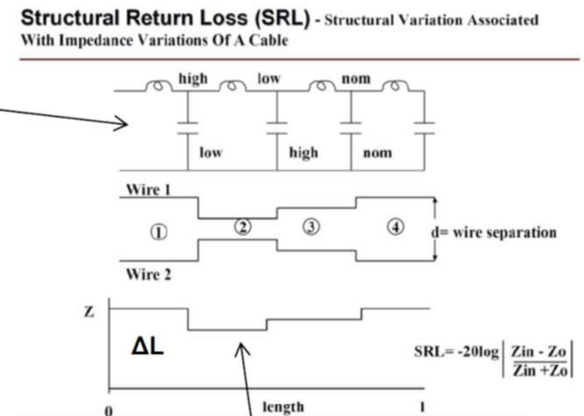


Insertion Loss Deviation

Insertion Loss Deviation



C=connectors 30 dB @ 100MHz



Return loss is computed by multiplication of transmission matrices for each component (cable and connectors) in the link segment. Each component is modeled by its transmission matrix. Cable structure is added as pseudorandom impedance to asymptotic cable impedance.

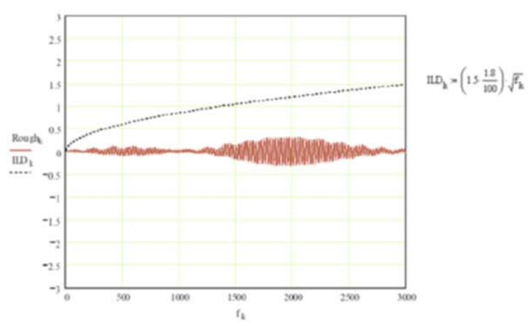
$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \prod_k [T_k] \qquad Z_{in} = \frac{A + \frac{B}{100}}{C + \frac{D}{100}} \qquad RL = -20\log\left(\frac{Z_{in} - 100}{Z_{in} + 100}\right)$$

Cable Insertion Loss Specification Scaled to Length of Channel

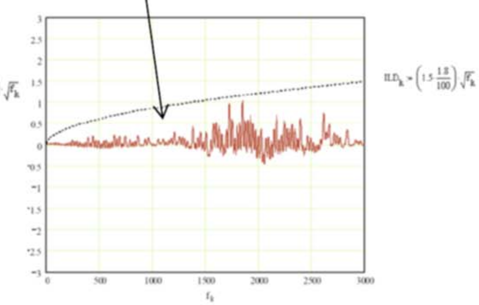
$$Atten_k := \frac{Att_k \cdot x_9}{100}$$

Insertion Loss Deviation Channel IL - Cable IL spec

$$Rough_k := 1 \cdot (IL_k - Atten_k)$$



cable without structure



cable with structure added pseudo-random Z ΔL