Tx Function to Rx Function AdHoc Channel RL Considerations

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Purpose

- TX-RX RL Channel considerations

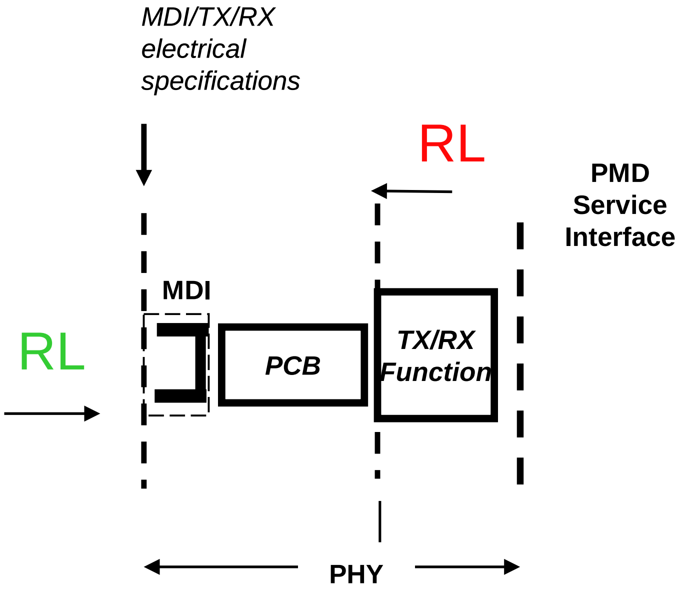
Link Segment (2.5/5/10 Gb/s) – 2.5/5/10GBASE-T1

- Link transmission parameters (up to at least 15 m)
  - Frequency range specified
    - Characteristic impedance
    - Insertion loss - 1 MHz ≤ f ≤ S*fmax MHz
    - Return loss
      - 2.5GBASE-T1 - 1 MHz ≤ f ≤ 1000 MHz
      - 5GBASE-T1 - 1 MHz ≤ f ≤ 2000 MHz – RL mag limit is specified in relationship to IL@1.5 GHz
      - 10GBASE-T1 - 1 MHz ≤ f ≤ 4000 MHz – RL mag limit is specified in relationship to IL@3 GHz
    - Coupling Attenuation - 1 MHz ≤ f ≤ 5500 MHz
    - Shielding Effectiveness - 30 MHz ≤ f ≤ S*fmax MHz
    - Maximum Link Delay - 2 MHz ≤ f ≤ S*fmax MHz

- For 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1, the maximum applicable frequency for the Link Segments specifications is 4000 MHz × S. For 2.5GBASE-T1, S = 0.25; for 5GBASE-T1, S = 0.5; and for 10GBASE-T1, S = 1.

MDI – Medium Dependent Interface- RL

- **802.3ch 2.5/5/10GBASE-T1 - MDI connector**
  - **The mechanical interface to the shielded balanced cabling is a 2-pin connector with a shield.**
- **802.3ch 2.5/5/10GBASE-T1 - MDI connector**
  - **Return Loss**
  - **MDI coupling attenuation (place holder)**



$$MDI\_Return\_Loss(f) \le \left\{ \begin{array}{ll} 20-20\left(\log_{10}\frac{10}{f}\right) & 1 \le f < 10 \\ 20 & 10 \le f \le 500 \\ 12-10\log_{10}(f/3000) & 500 \le f \le 3000 \\ 12-20\log_{10}(f/3000) & 3000 \le f \le 4000 \end{array} \right\} \quad \text{(dB)}$$

where

f is the frequency in MHz.

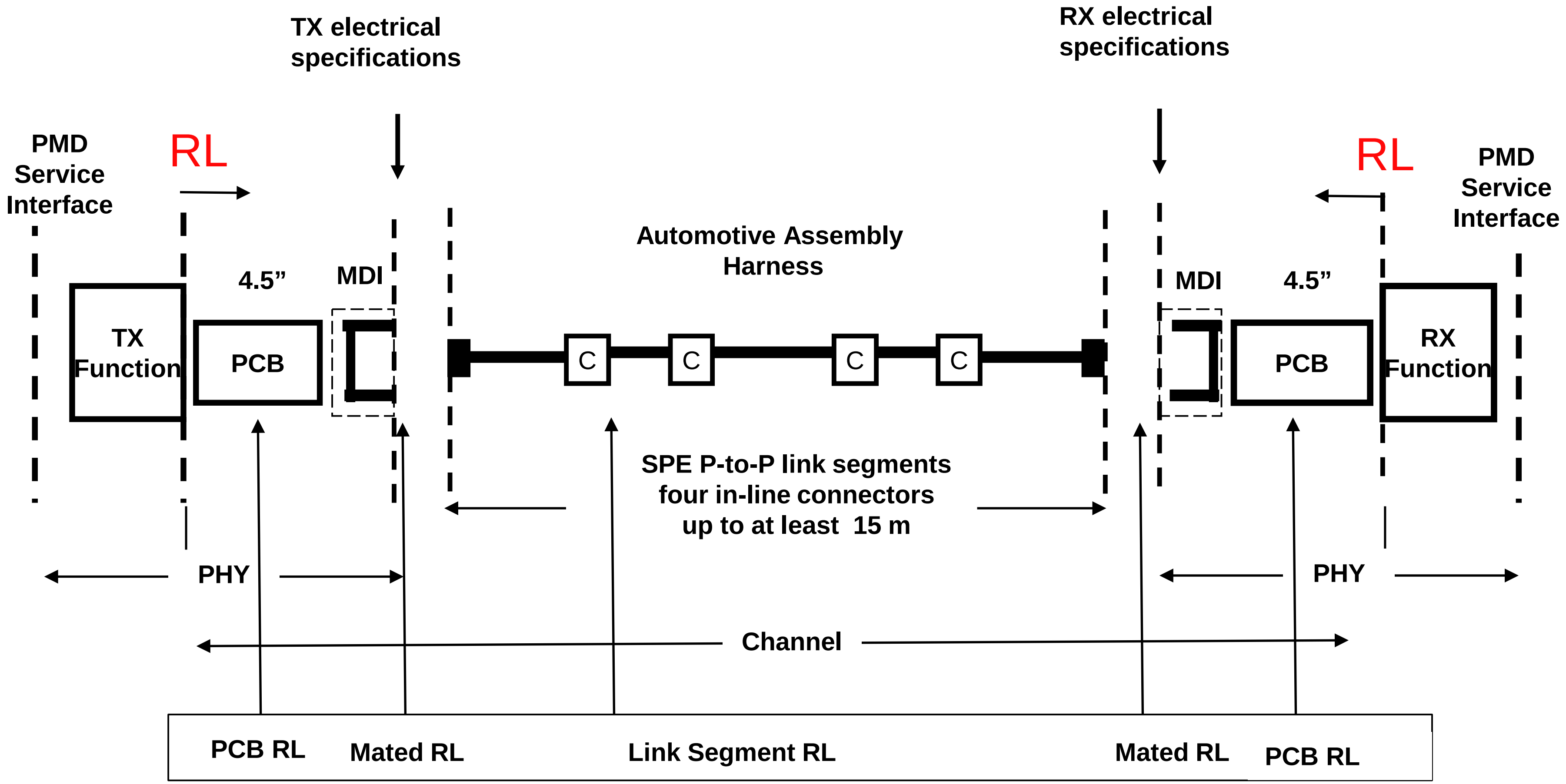
For 2.5GBASE-T1, 5GBASE-T1, and 10GBASE-T1, the maximum applicable frequency for the MDI return loss is 4000 × *S* MHz. See Table 149–1 for definition of *S*.

Table 149–1—Scaling parameter

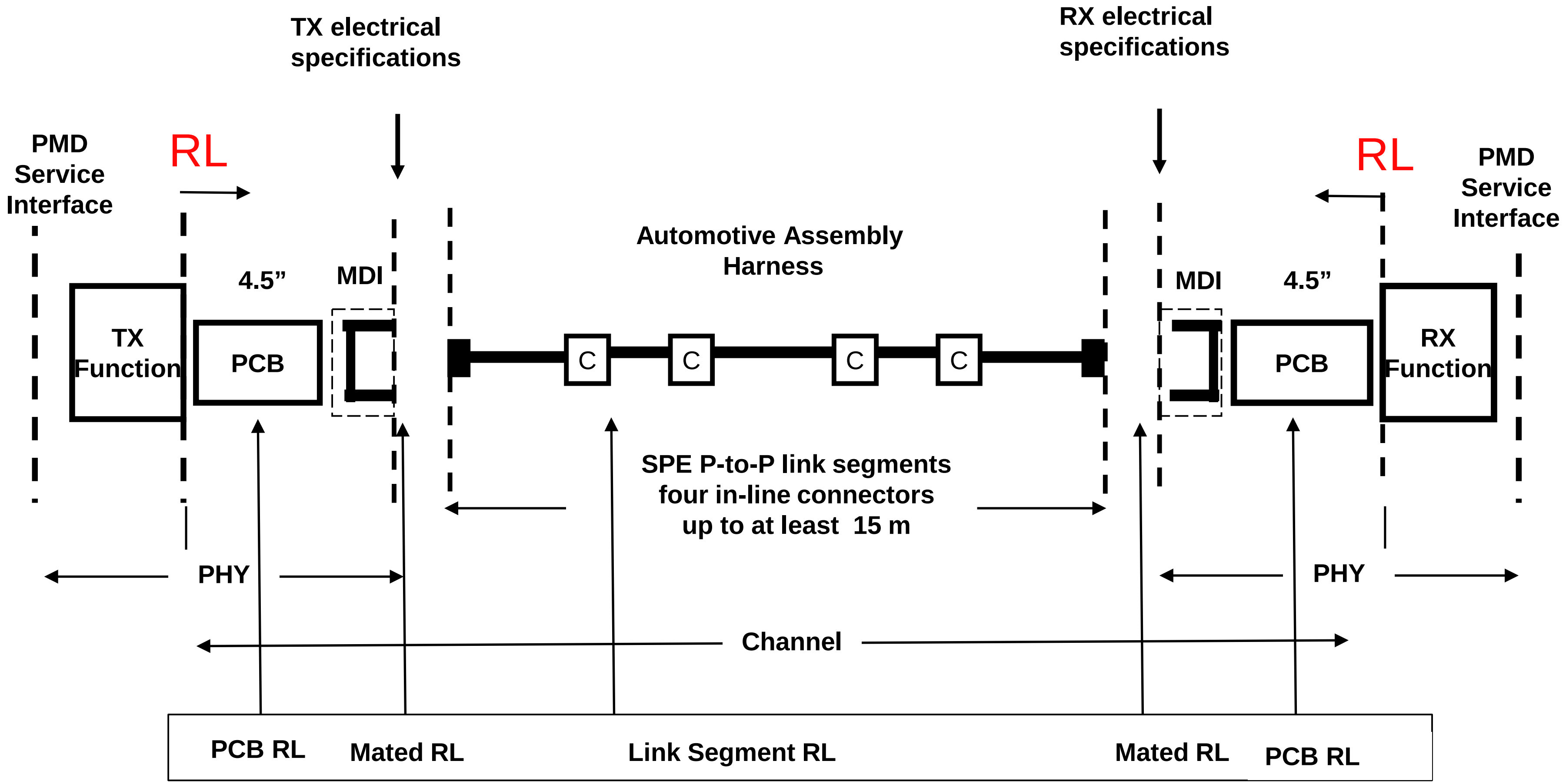
PHY type	S
10GBASE-T1	1
5GBASE-T1	0.5
2.5GBASE-T1	0.25

MDI = *PHY is coupled to the cabling at the MDI.*
= *MDI requirements: mechanical (to ensure complete compatibility) and electrical.*

Channel Return Loss



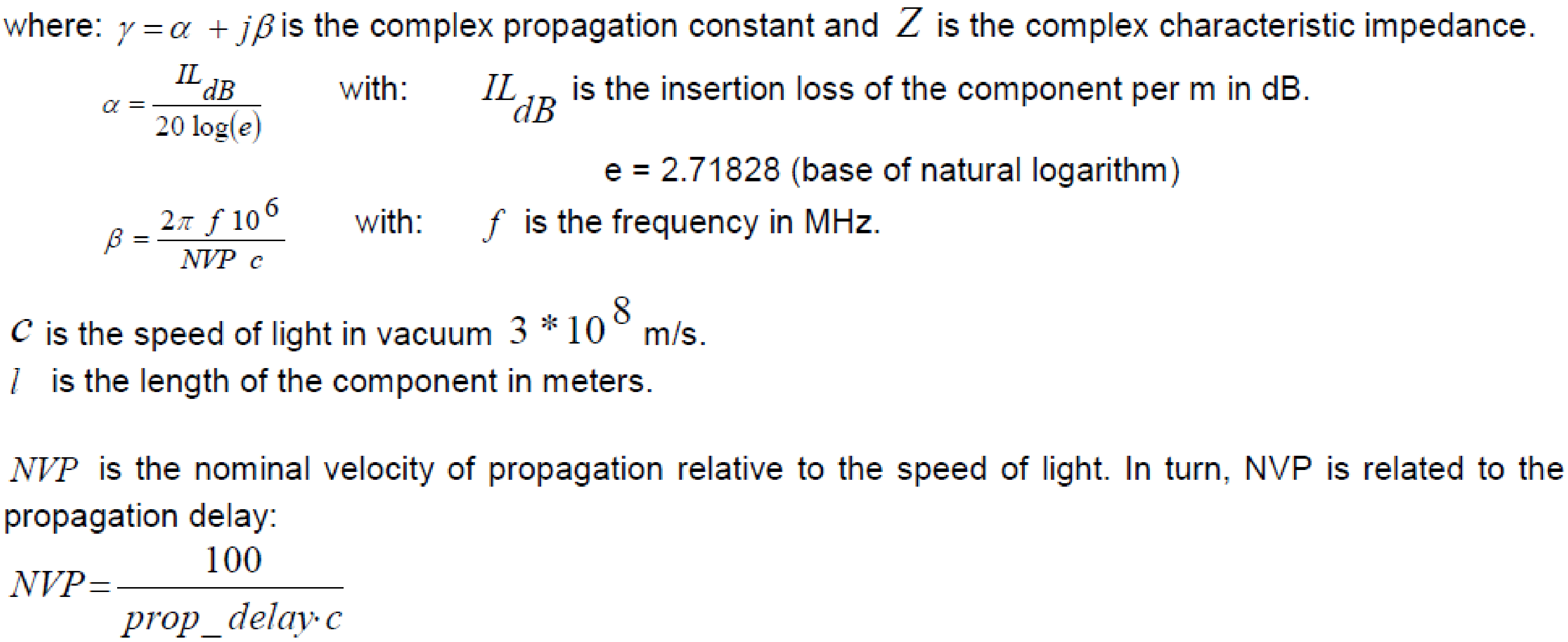
Channel Return Loss



Return loss – Link Segment

Return loss is computed by multiplication of transmission matrices for each component in the link segment. Each component is modeled by its transmission matrix as shown in equation (1).

$$\begin{bmatrix} \cosh(\gamma\, l) & Z \sinh(\gamma\, l) \\ \dfrac{\sinh(\gamma\, l)}{Z} & \cosh(\gamma\, l) \end{bmatrix} \qquad (1)$$



where: $\gamma = \alpha + j\beta$ is the complex propagation constant and Z is the complex characteristic impedance.

$\alpha = \dfrac{IL_{dB}}{20\log(e)}$ with: IL_{dB} is the insertion loss of the component per m in dB.

e = 2.71828 (base of natural logarithm)

$\beta = \dfrac{2\pi\ f\ 10^{6}}{NVP\ c}$ with: f is the frequency in MHz.

c is the speed of light in vacuum $3 * 10^{8}$ m/s.

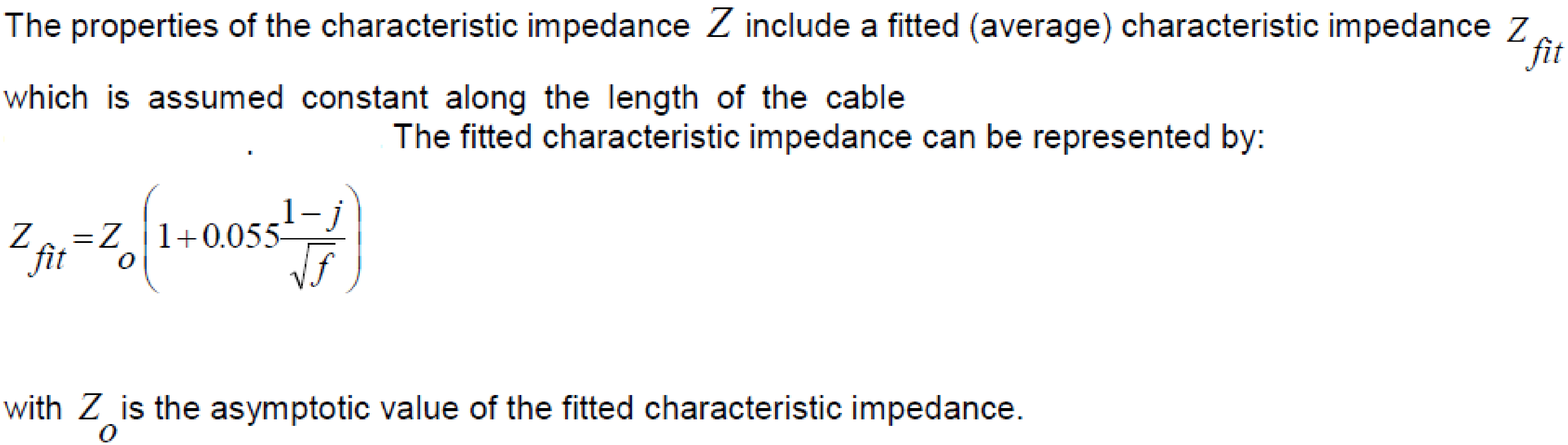
l is the length of the component in meters.

NVP is the nominal velocity of propagation relative to the speed of light. In turn, NVP is related to the propagation delay:

$$NVP = \frac{100}{prop\_delay \cdot c}$$

ANSI/TIA-568.2-D: Annex K (informative) - Development of channel and component return loss limits

Return loss – Cable



The properties of the characteristic impedance Z include a fitted (average) characteristic impedance Z_{fit} which is assumed constant along the length of the cable

The fitted characteristic impedance can be represented by:

$$Z_{fit} = Z_o\left(1 + 0.055\frac{1-j}{\sqrt{f}}\right)$$

with Z_o is the asymptotic value of the fitted characteristic impedance.

Return loss – Connector

For a connector, the product of the propagation delay constant and length is used.

$$\gamma\, l = \alpha\; l + j\beta\, l$$

The electrical length l_{conn} is obtained from: $l_{conn} = NVP\; c\, \dfrac{\phi_x}{360\; f_x}$

where:

ϕ_x is the measured phase angle in degrees between the output and input of the connector at a high frequency f_x (e.g., 50 MHz)

The connector is now modeled as a short transmission line of electrical length l_{conn}. The frequency response exhibits a 20 dB/decade slope within the frequency range of interest. The value of the characteristic impedance Z_{conn} for the connector is adjusted so that the specified return loss at a certain frequency is matched. Practical values of l_{conn} lie between 5 cm and 10 cm.

The attenuation constant $\alpha\; l = k_c \sqrt{f}$

where k_c is the constant in the connector insertion loss equation.

The phase constant $\beta\; l = \dfrac{\pi}{180} \phi_x \dfrac{f}{f_x}$