Proposed changes to 93A.1.2.3, 93A.4, and 92.10.7.1.1:

93A.1.2.3 Two-port network for the package transmission line

The scattering parameters for ~~a 1 mm section of~~ the package transmission line model are a function of the complex propagation coefficient defined by Equation (93A–9), Equation (93A–10), and Equation (93A–11) and the reflection coefficient defined by Equation (93A–12). The values of the parameters ~~values~~ that appear in these equations are defined in Table 93A–3. The units of *f* are GHz.

$$\cancel{s_{11} = s_{22} = \rho_0 + \rho_1(1 - \exp(-j2\pi f\tau))} \qquad (93A–9)$$

$$\cancel{s_{12} = s_{21} = \exp(\gamma_0 + \gamma_1\sqrt{f} + \gamma_2 f + \gamma_4 f^2)} \qquad (93A–10)$$

Table 93A–3—Transmission line model parameters

Parameter	Real	Imaginary	Units
ρ_0	0.001	0	—
ρ_1	0.100	0	—
τ	1.22×10^{-2}	0	1/GHz
γ_0	-1.067×10^{-3}	0	—
γ_1	-3.551×10^{-4}	-3.357×10^{-3}	$1/\text{GHz}^{1/2}$
γ_2	-1.027×10^{-3}	-3.818×10^{-2}	1/GHz
γ_4	-1.179×10^{-5}	3.36×10^{-5}	$1/\text{GHz}^2$

$$\gamma(f) = \begin{cases} \gamma_0 & f = 0 \\ \gamma_0 + \gamma_1\sqrt{f} + \gamma_2(f)f & f > 0 \end{cases} \qquad (93A–9)$$

$$\gamma_1 = a_1(1 + j) \qquad (93A–10)$$

$$\gamma_2(f) = a_2(1 - j(2/\pi)\log_e(f/1\ \text{GHz})) + j2\pi\tau \qquad (93A–11)$$

$$\rho = \frac{Z_c - 2R_0}{Z_c + 2R_0} \qquad (93A–12)$$

The scattering parameters for a package transmission line ~~whose~~ of length z_p ~~is an integer multiple of 1 mm~~ are ~~derived from the scattering parameters of the 1 mm section using Equation (93A–11)~~ defined by Equation (93A–13) and ~~Equation (93A–12)~~ Equation (93A–14).

$$\cancel{s_{11}^{(l)} = s_{22}^{(l)} = s_{11}\sum_{i=1}^{z_p} s_{21}^{2i-2}} \qquad (93A–11)$$

Table 93A–3—Transmission line model parameters and values

Parameter	Value	Units
γ_0	0	1/mm
a_1	1.734×10^{-3}	$ns^{1/2}/mm$
a_2	1.455×10^{-4}	ns/mm
τ	6.141×10^{-3}	ns/mm
Z_c	78.2	Ω

$$s_{12}^{(l)} = s_{21}^{(l)} = s_{21}^{z_p} \quad (93A\text{–}12)$$

$$s_{11}^{(l)}(f) = s_{22}^{(l)}(f) = \frac{\rho(1-\exp(-\gamma(f)2z_p))}{1-\rho^2\exp(-\gamma(f)2z_p)} \quad (93A\text{–}13)$$

$$s_{21}^{(l)}(f) = s_{12}^{(l)}(f) = \frac{(1-\rho^2)\exp(-\gamma(f)z_p)}{1-\rho^2\exp(-\gamma(f)2z_p)} \quad (93A\text{–}14)$$

The transmission line scattering parameter matrix is then denoted as $S^{(l)}$.

NOTE—Equation (93A–9) and Equation (93A–10) are based on a fit to a detailed model of a transmission line with a characteristic impedance of approximately 81 Ω and represents an extent of expected manufacturing variation. The fit is valid over the frequency range 0 to 40 GHz.

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–53).

$$ILD(f) = IL(f) - IL_{fitted}(f) \quad (93A\text{–}53)$$

The RMS insertion loss deviation ILD_{RMS} is aA figure of merit for a channel that is calculated using based on $ILD(f)$ is given by Equation (93A–54). In Equation (93A–54), 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–55).

$$ILD_{RMS} = \left[\sum_n W(f_n)10^{ILD(f_n)/10}\right]^{1/2} \quad FOM_{ILD} = \left[\frac{1}{N}\sum_n W(f_n)ILD^2(f_n)\right]^{1/2} \quad (93A\text{–}54)$$

$$W(f_n) = \text{sinc}^2(f_n/f_b)\left[\frac{1}{1+(f_n/f_t)^4}\right]\left[\frac{1}{1+(f_n/f_r)^8}\right] \quad (93A\text{–}55)$$

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 ~~times~~ 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.

92.10.7.1.1 TP0 to TP1 and TP4 to TP5 signal paths

The additional transmitter and receiver PCB signal paths are calculated using the method defined in 93A.1.2.3. ~~A 1 mm section~~ The scattering parameters for a PCB of ~~the PCB is~~ length z_p are defined by ~~Equation (93A–10)~~Equation (93A–13), ~~Equation (93A–11)~~Equation (93A–14), and the parameter~~s~~ values given in Table 92–12.

For the channel signal path defined in 92.10.7.1 and calculated using Equation (92–33), the transmitter and receiver PCB model are each ~~consist of 141 sections~~ z_p = 151 mm in length representing an insertion loss of 6.26 dB at 12.89 GHz and ~~is~~ are each denoted as $S^{(HOSP)}$.

For the channel crosstalk paths defined in 92.10.7.2 and calculated using Equation (92–34) and Equation (92–35), the receiver PCB model ~~consists of 141 sections representing an insertion loss of 6.26 dB at 12.89 GHz and~~ is ~~denoted as $S^{(HOSP)}$ and the~~ $S^{(HOSP)}$. The transmitter PCB model ~~consists of 68 sections~~ is z_p = 72 mm in length representing an insertion loss of 3 dB at 12.89 GHz and is denoted as $S^{(HOTxSP)}$. The transmitter PCB insertion loss for the crosstalk channel is less than that for the signal channel to allow for a reasonable worst case crosstalk in the COM calculation.

Table 92–12—Transmission line model parameter values

Parameter	Value	Units
γ_0	0	1/mm
a_1	4.114×10^{-4}	$ns^{1/2}$/mm
a_2	2.547×10^{-4}	ns/mm
τ	6.191×10^{-3}	ns/mm
Z_c	109.8	Ω

~~NOTE—The host transmission line model is based on a fit to a detailed model of a transmission line with a characteristic impedance of approximately 110 Ω and represents an extent of expected manufacturing variation. The fit is valid over the frequency range 0 to 40 GHz.~~

Table 92–12—Transmission line model parameters

Parameter	Real	Imaginary	Units
ρ_0	4×10^{-4}	0	—
ρ_1	4.5×10^{-2}	0	1/GHz
τ	1.21×10^{-2}	0	1/GHz
γ_0	-1.89×10^{-4}	0	—
γ_1	-1.93×10^{-4}	-9.75×10^{-4}	$1/GHz^{1/2}$
γ_2	-2.96×10^{-4}	-3.79×10^{-2}	1/GHz
γ_4	-2.47×10^{-6}	8.89×10^{-6}	$1/GHz^2$

Proposed changes to 93A.1.2.3 and 92.10.7.1.1 with mark-ups removed:

93A.1.2.3 Two-port network for the package transmission line

The scattering parameters for the package transmission line model are a function of the complex propagation coefficient defined by Equation (93A–9), Equation (93A–10), and Equation (93A–11) and the reflection coefficient defined by Equation (93A–12). The values of the parameters that appear in these equations are defined in Table 93A–3. The units of f are GHz.

$$\gamma(f) = \begin{cases} \gamma_0 & f = 0 \\ \gamma_0 + \gamma_1\sqrt{f} + \gamma_2(f)f & f > 0 \end{cases} \quad (93A\text{–}9)$$

$$\gamma_1 = a_1(1 + j) \quad (93A\text{–}10)$$

$$\gamma_2(f) = a_2(1 - j(2/\pi)\log_e(f/1\text{ GHz})) + j2\pi\tau \quad (93A\text{–}11)$$

$$\rho = \frac{Z_c - 2R_0}{Z_c + 2R_0} \quad (93A\text{–}12)$$

Table 93A–3—Transmission line model parameters and values

Parameter	Value	Units
γ_0	0	1/mm
a_1	1.734×10^{-3}	$ns^{1/2}$/mm
a_2	1.455×10^{-4}	ns/mm
τ	6.141×10^{-3}	ns/mm
Z_c	78.2	Ω

The scattering parameters for a package transmission line of length z_p are defined by Equation (93A–13) and Equation (93A–14).

$$s_{11}^{(l)}(f) = s_{22}^{(l)}(f) = \frac{\rho(1 - \exp(-\gamma(f)2z_p))}{1 - \rho^2\exp(-\gamma(f)2z_p)} \quad (93A\text{–}13)$$

$$s_{21}^{(l)}(f) = s_{12}^{(l)}(f) = \frac{(1 - \rho^2)\exp(-\gamma(f)z_p)}{1 - \rho^2\exp(-\gamma(f)2z_p)} \quad (93A\text{–}14)$$

The transmission line scattering parameter matrix is then denoted as $S^{(l)}$.

92.10.7.1.1 TP0 to TP1 and TP4 to TP5 signal paths

The additional transmitter and receiver PCB signal paths are calculated using the method defined in 93A.1.2.3. The scattering parameters for a PCB of length z_p are defined by Equation (93A–13), Equation (93A–14), and the parameter values given in Table 92–12.

For the channel signal path defined in 92.10.7.1 and calculated using Equation (92–33), the transmitter and receiver PCB model are each z_p = 151 mm in length representing an insertion loss of 6.26 dB at 12.89 GHz and are each denoted as $S^{(HOSP)}$.

For the channel crosstalk paths defined in 92.10.7.2 and calculated using Equation (92–34) and Equation (92–35), the receiver PCB model is $S^{(HOSP)}$. The transmitter PCB model is z_p = 72 mm in length representing an insertion loss of 3 dB at 12.89 GHz and is denoted as $S^{(HOTxSP)}$. The transmitter PCB insertion loss for the crosstalk channel is less than that for the signal channel to allow for a reasonable worst case crosstalk in the COM calculation.

Table 92–12—Transmission line model parameter values

Parameter	Value	Units
γ_0	0	1/mm
a_1	4.114×10^{-4}	$ns^{1/2}/mm$
a_2	2.547×10^{-4}	ns/mm
τ	6.191×10^{-3}	ns/mm
Z_c	109.8	Ω