$$RL(f) \geq RL_{min}(f) = 15 \quad \text{(69B–12)}$$

for 50 MHz ≤ f < 275 MHz and

$$RL(f) \geq RL_{min}(f) = 15 - 9.64\log_{10}\left(\frac{f}{275\ \text{MHz}}\right) \quad \text{(69B–13)}$$

for 275 MHz ≤ f < 3000 MHz and

$$RL(f) \geq RL_{min}(f) = 5 \quad \text{(69B–14)}$$

for 3000 MHz ≤ f ≤ 10321.5 MHz.

The recommendation applies from 50 MHz to the signaling speed of the PHY type of interest. The return loss limit is illustrated in Figure 69B–6..

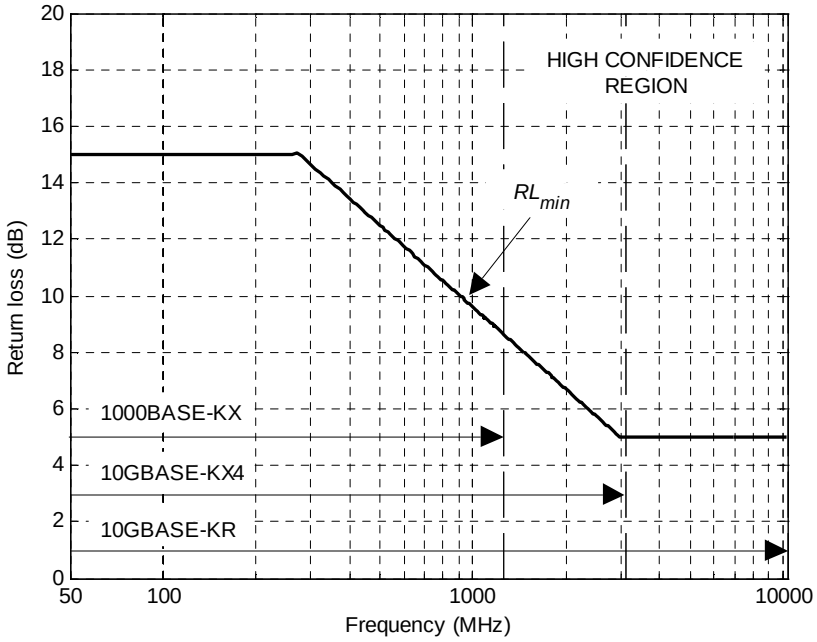

Figure 69B–10—Return loss limits

69B.4.6 Crosstalk

In order to limit the crosstalk at TP4, the differential crosstalk due to near-end and far-end aggressors is specified to meet the BER objective defined in 69.1.2. The following equations and informative model assume that aggressors and victim are driven by PHYs of the same ~~type~~type and transmit characteristics.

69B.4.6.1 Power sum differential near-end crosstalk (PSNEXT)

The differential near-end crosstalk at TP4 is calculated as the power sum of the individual NEXT aggressors (*PSNEXT*). *PSNEXT* is computed as shown in Equation (69B–15), where $NEXT_n$ is the crosstalk loss, in dB, of aggressor *n*. Note that for the case of a single aggressor, *PSNEXT* will be the crosstalk loss for that single aggressor.

$$PSNEXT(f) = -10\log\left(\sum_n 10^{-NEXT_n(f)/10}\right) \quad (69B–15)$$

69B.4.6.2 Power sum differential far-end crosstalk (PSFEXT)

The differential far-end crosstalk at TP4 is calculated as the power sum of the individual FEXT aggressors (*PSFEXT*). *PSFEXT* is computed as shown in Equation (69B–16), where $FEXT_n$ is the crosstalk loss, in dB, of aggressor *n*. Note that for the case of a single aggressor, *PSFEXT* will be the crosstalk loss for that single aggressor.

$$PSFEXT(f) = -10\log\left(\sum_n 10^{-FEXT_n(f)/10}\right) \quad (69B–16)$$

69B.4.6.3 Power sum differential crosstalk

The differential crosstalk at TP4 is calculated as the power sum of the individual NEXT and FEXT aggressors (*PSXT*). *PSXT* may be computed as shown in Equation (69B–17).

$$PSXT(f) = -10\log(10^{-PSNEXT(f)/10} + 10^{-PSFEXT(f)/10}) \quad (69B–17)$$

69B.4.6.4 Insertion loss to crosstalk ratio (ICR)

Insertion loss to crosstalk ratio (*ICR*) is the ratio of the insertion loss, measured from TP1 to TP4, to the total crosstalk measured at TP4. *ICR* may be computed from *IL* and *PSXT* as shown in Equation (69B–18).

$$ICR(f) = -IL(f) + PSXT(f) \quad (69B–18)$$

Assuming ICR is computed at *N* uniformly-spaced frequencies f_n spanning the frequency range f_a to f_b, ICR_{fit} may be computed using Equations (69B–19) through (69B–23). The values of f_a and f_b are dependent on port type and are provided in Table 69B–1.

$$x_{avg} = \frac{1}{N}\sum_n \log(f_n) \quad (69B–19)$$

$$ICR_{avg} = \frac{1}{N}\sum_n ICR(f_n) \quad (69B–20)$$

$$m_{ICR} = \frac{\sum_n (\log(f_n) - x_{avg})(ICR(f_n) - ICR_{avg})}{\sum_n (\log(f_n) - x_{avg})^2} \quad (69B–21)$$

$$b_{ICR} = ICR_{avg} - m_{ICR}x_{avg} \quad (69B–22)$$

$$ICR_{fit}(f) = m_{ICR}\log(f) + b_{ICR} \quad (69B–23)$$

The ICR_{fit} computed in Equation (69B–23) does not consider channel self-interference and system configuration extremes. Two ICR penalties are introduced to account for these conditions: an ILD penalty, P_{ILD}, and a system configuration penalty, P_{SYS}.

Given that the insertion loss deviation, *ILD*, is computed an *n* evenly-spaced frequencies, f_n, spanning f_a to f_b. P_{ILD} is defined in Equation (69B–24).

$$P_{ILD} = 5.0\left(\frac{1}{N}\sum_{n} ILD^2(f_n)\right) - 0.1(A_{max}(f_b) - A(f_b)) - 0.8 \quad (69B–24)$$

The system configuration penalty is defined in Equation (69B–25) and Table 69B–2. This penalty accounts for the potential differences in characteristcs (e.g. amplitude, rise and fall times), between the victim and aggressor transmitters. The penalties listed in Table 69B–2 are maximum values based on the worst-case mismatch between the victim and aggressor transmitters. The penalty values may be refined based on knowledge of the specific system implemenation.

$$P_{SYS} = P_A + P_{RE} \quad (69B–25)$$

Table 69B–2—System configuration penalty

Penalty	Description	Value	Units
P_A	Difference in amplitude between victim and aggressor transmitters	3.5	dB
P_{RE}	Difference in rise and fall times and equalization setting between victim and aggressor transmitters	2.0	dB
P_{SYS}	Total system configuration penalty	5.5	dB

It is recommended that ~~ICR_{fit}~~ ICR_{fit}, offset by P_{ILD} and P_{SYS}, be greater than than or equal to ICR_{min} as defined in Equation (69B–26).

~~$ICR_{fit}(f) \geq ICR_{min}(f) = 14.8 - 18.7\log\left(\frac{f}{5\ \text{GHz}}\right)$~~

$$ICR_{fit} - P_{ILD} - P_{SYS} \geq ICR_{min}(f) = 14.8 - 18.7\log\left(\frac{f}{5\ \text{GHz}}\right) \quad (69B–26)$$

for $f_a \leq f \leq f_b$.

The insertion loss to crosstalk ratio limit for each port type is illustrated in Figure 69B–11.

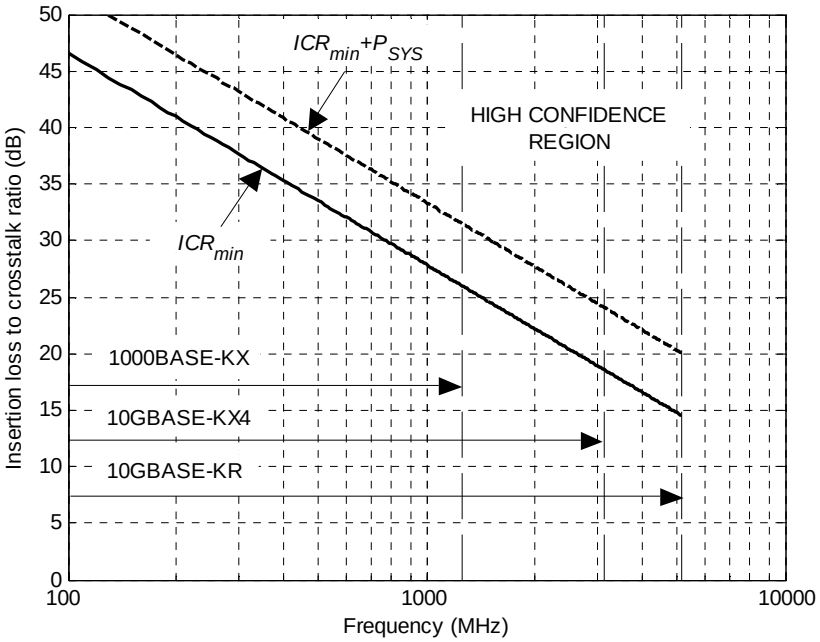

Figure 69B–11—Insertion loss to crosstalk ratio limit