Annex 69B

(informative)

Interconnect characteristics

69B.1 Overview

Backplane Ethernet is primarily intended to operate over differential, controlled impedance traces up to 1 m, including two connectors, on printed circuit boards residing in a backplane environment. The performance of such an interconnect is highly dependent on implementation.

69B.2 Reference model

The backplane interconnect is defined between test points TP1 and TP4 as shown in Figure 69B–1. The transmitter and receiver blocks include all off-chip components associated with the respective block. For example, external AC-coupling capacitors, if required, are to be included in the receiver block.

Informative characteristics and methods of calculation for the insertion loss, crosstalk, and the ratio of insertion loss to crosstalk between TP1 and TP4 are defined in 69B.4.3, 69B.4.5, and 69B.4.5.4 respectively. These characteristics may be applied to a specific implementation of the full path (including transmitter and receiver packaging and supporting components) for a complete assessment of system performance and the interaction of these components.

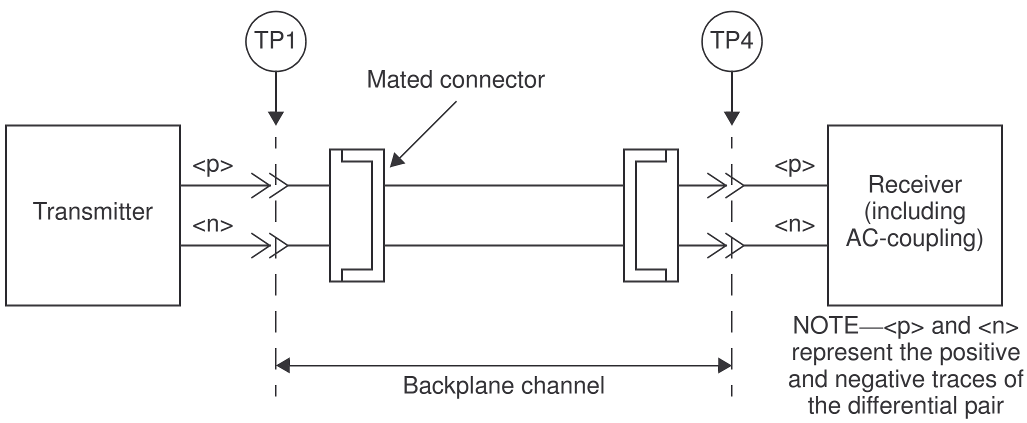

Figure 69B–1— Interconnect reference model

69B.3 Characteristic impedance

The recommended differential characteristic impedance of circuit board trace pairs is 100 Ω ± 10%.

The total differential skew from TP1 to TP4 is recommended to be less than the minimum rise time for port type of interest.

69B.4 Channel parameters

69B.4.1 Overview

A series of informative parameters are defined for use in backplane channel evaluation. These parameters address the channel insertion loss and crosstalk. The informative parameters for channel insertion loss are summarized in Table 69B–2.

The maximum attenuation (A_{max}) due to trace skin effect and dielectric properties is defined in 69B.4.2. The maximum insertion loss (IL_{max}) is defined in 69B.4.3. The maximum deviation of insertion loss from the best-fit attenuation (ILD) is defined in 69B.4.4. The limit on crosstalk in relation to insertion loss (ICR) is defined in 69B.4.5.4.

To enable system trade-offs for the designer a series of confidence curves have been created for the different parameters. All of the different parameters must be considered together in evaluating the overall channel performance..

Table 69B–1—Insertion loss parameters

Parameter	1000BASE-KX	10GBASE-KX4	10GBASE-KR	Units
f_{min}	0.05			GHz
f_{max}	15.00			GHz
b_1	2.25E-5			
b_2	1.20E-10			
b_3	3.50E-20			
b_4	–1.25E-30			
f_1	0.125	0.312	1.000	GHz
f_2	1.250	3.125	6.000	GHz
f_a	0.100	0.100	0.100	GHz
f_b	1.250	3.125	5.15625	GHz
IL_{max1}	Refer to Equation (69B–7) and Equation (69B–8).			dB
IL_{max2}	Refer to Equation (69B–9) and Equation (69B–10)			dB
ILD_{min1}	Refer to Equation (69B–10).			dB
ILD_{min2}	Refer to Equation (69B–11).			dB
ILD_{max1}	Refer to Equation (69B–12).			dB
ILD_{max2}	Refer to Equation (69B–13).			dB

Table 69B–2—Insertion loss parameters

Parameter	1000BASE-KX	10GBASE-KX4	10GBASE-KR	Units
f_{min}	0.05			GHz
f_{max}	15.00			GHz
b_1	2.25E-5			
b_2	1.20E-10			
b_3	3.50E-20			
b_4	–1.25E-30			
f_1	0.125	0.312	1.000	GHz
f_2	1.250	3.125	6.000	GHz
f_a	0.100	0.100	0.100	GHz
f_b	1.250	3.125	5.15625	GHz
IL_{max}	Refer to Equation (69B–9) and Equation (69B–10)			dB
ILD_{min}	Refer to Equation (69B–12).			dB
ILD_{max}	Refer to Equation (69B–13).			dB

69B.4.2Fitted attenuation

The fitted attenuation, A, is defined to be the least mean squares line fit to the insertion loss computed over the frequency range f_1 to f_2. Assuming the transmission magnitude response is measured at N uniformly-spaced frequencies f_n spanning the frequency range f_1 to f_2, the least mean squares line fit procedure is defined by Equations (69B–1) through (69B–5).

$$f_{avg} = \frac{1}{N}\sum_n f_n \tag{69B–1}$$

$$IL_{avg} = \frac{1}{N}\sum_n IL(f_n) \tag{69B–2}$$

$$m_A = \frac{\sum_n (f_n - f_{avg})(IL(f_n) - IL_{avg})}{\sum_n (f_n - f_{avg})^2} \tag{69B–3}$$

$$b_A = IL_{avg} - m_A f_{avg} \tag{69B–4}$$

$$A(f) = m_A f + b_A \tag{69B–5}$$

It is recommended that the fitted attenuation of the channel be less than or equal to A_{max} as defined in Equation (69B–6), where f is expressed in Hz and the coefficients b_1 through b_4 are given in Table 69B–2.

$$A(f) \le A_{max}(f) = 20\log(e) \times (b_1\sqrt{f} + b_2 f + b_3 f^2 + b_4 f^3) \tag{69B–6}$$

In addition, it is recommended that the insertion loss also satisfy the insertion loss limit defined in 69B.4.3, the insertion loss deviation limit defined in 69B.4.4, and the insertion loss to crosstalk ratio limit defined in 69B.4.5.4. The fitted attenuation limit for each port type is illustrated in Figures 69B–2, 69B–3 and 69B–4.

69B.4.3 Insertion loss

Insertion loss is defined as the magnitude, expresssed in decibels, of the differential response measured from TP1 to TP4. It is recommended that the insertion loss magnitude, *IL*, be ~~less than or equal to~~ within the ~~limit~~ high confidence region defined by Equation (69B–7) and Equation (69B–8).

~~$IL(f) \le IL_{max1}(f) = A_{max}(f) + 1.1 + 9.0\times10^{-10}f$~~ (69B–7)

~~for $f_{min} \le f \le f_2$~~

~~$IL(f) \le IL_{max1}(f) = A_{max}(f) + 1.1 + 9.0\times10^{-10}f_2 + 2\times10^{-8}(f - f_2)$~~ (69B–8)

~~for $f_2 < f \le f_{max}$~~

~~The values of f_{min}, f_2, and f_{max} are given in Table 69B–2 and A_{max} is given in Equation (69B–6).~~

~~A high confidence acceptance region for *IL* is constrained by Equation (69B–9) and Equation (69B–10).~~

~~$IL(f) \le IL_{max2}(f) = A(f) + 0.8 + 2.0\times10^{-10}f$~~ $IL(f) \le IL_{max}(f) = A(f) + 0.8 + 2.0\times10^{-10}f$ (69B–9)

for $f_{min} \le f \le f_2$

~~$IL(f) \le IL_{max2}(f) = A(f) + 0.8 + 2.0\times10^{-10}f_2 + 1\times10^{-8}(f - f_2)$~~

$IL(f) \le IL_{max}(f) = A(f) + 0.8 + 2.0\times10^{-10}f_2 + 1\times10^{-8}(f - f_2)$ (69B–10)

for $f_2 < f \le f_{max}$

The values of ~~f_1~~ f_{min}, f_2, and ~~f_2~~ f_{max} are ~~dependent on port type~~ given in Table 69B–2 and ~~are~~ A_{max} is given in ~~Table 69B–2~~ Equation (69B–6).

In addition, it is recommended that the insertion loss also satisfy the fitted attenuation limit defined in 69B.4.2, the insertion loss deviation limit defined in 69B.4.4, and the insertion loss to crosstalk ratio limit defined in 69B.4.5.4. The insertion loss limit is illustrated in Figures 69B–2, 69B–3 and 69B–4.

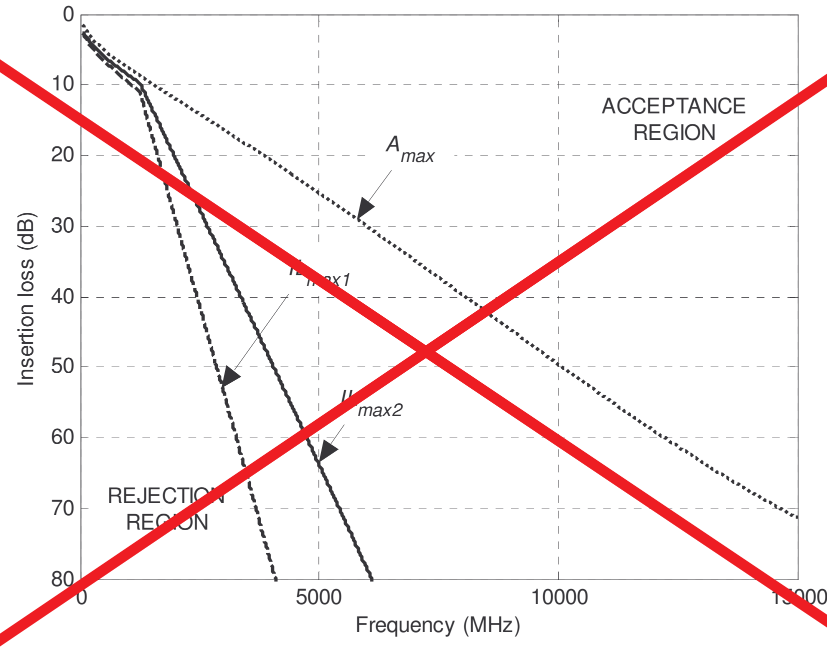

Figure 69B–2—Insertion loss and attenuation limits for 1000BASE-KX

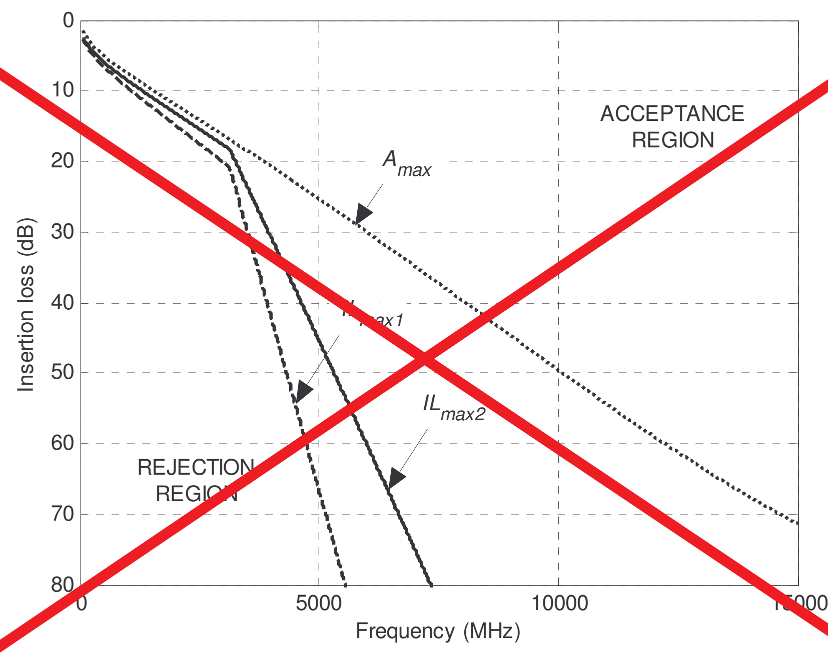

Figure 69B–3—Insertion loss and attenuation limits for 10GBASE-KX4

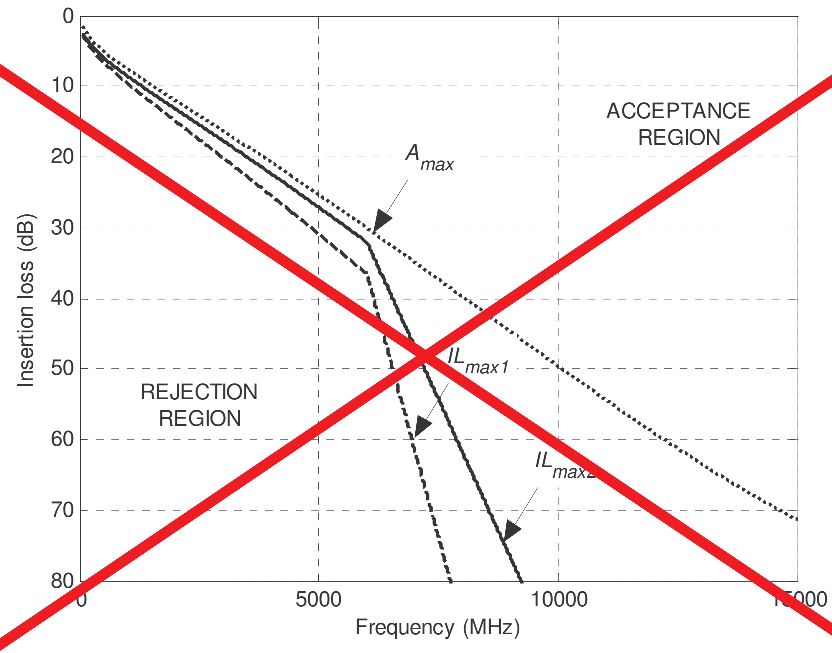

Figure 69B–4— Insertion loss and attenuation limits for 10GBASE-KR

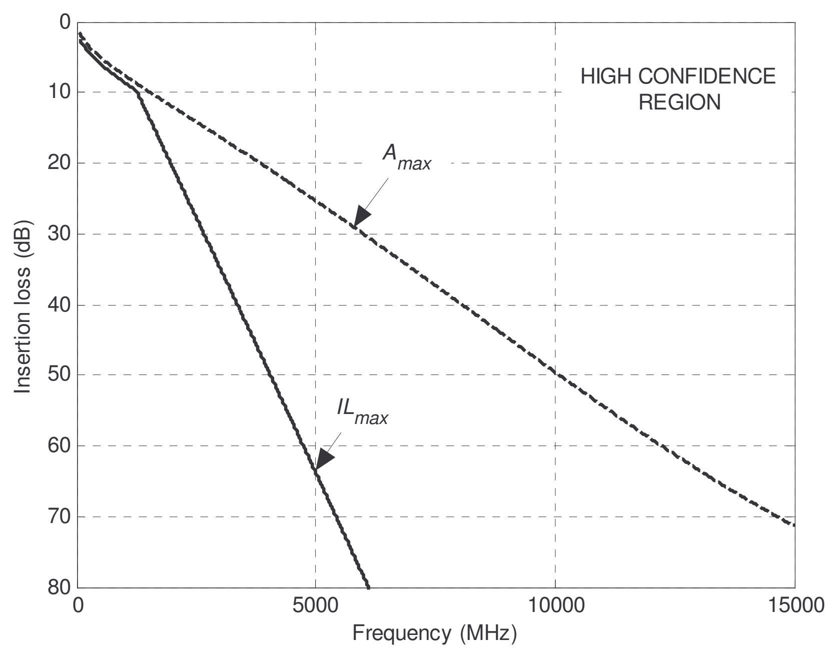

Figure 69B–2—Insertion loss and attenuation limits for 1000BASE-KX

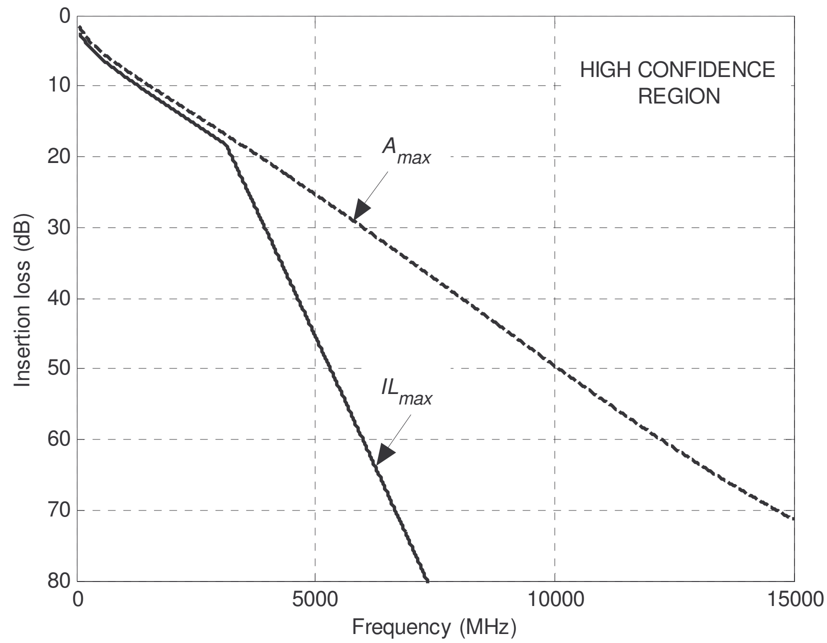

Figure 69B–3—Insertion loss and attenuation limits for 10GBASE-KX4

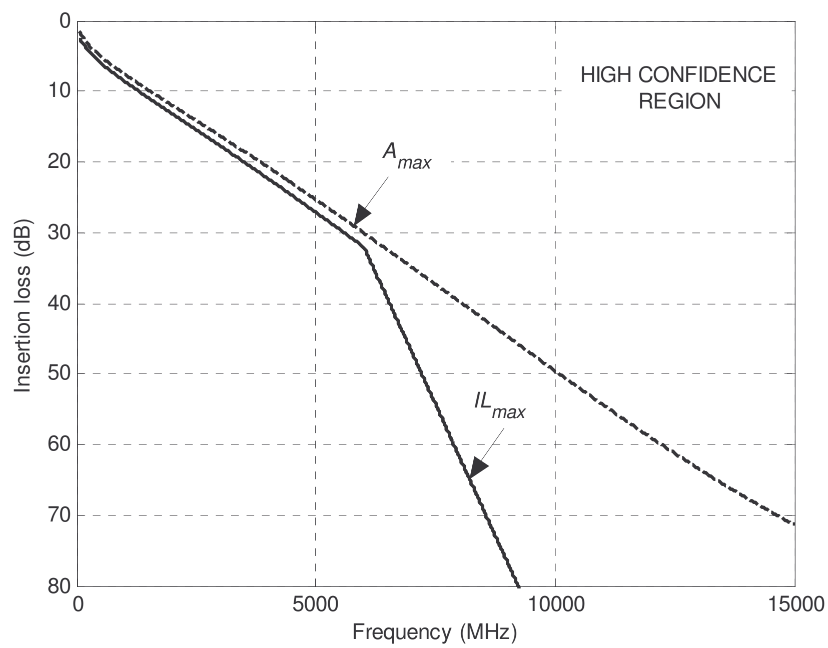

Figure 69B–4— Insertion loss and attenuation limits for 10GBASE-KR

69B.4.4Insertion loss deviation

The insertion loss deviation, as defined by Equation (69B–9), is the difference between the insertion loss and the least mean squares fit defined in 69B.4.2.

$$ILD(f) = IL(f) - A(f) \quad (69B\text{–}9)$$

~~The insertion loss deviation, *ILD*,~~ It is recommended ~~to~~ that *ILD* be ~~constrained~~ within the ~~limits~~ high confidence region defined by ~~Equation (69B–10)~~Equation (69B–12) and ~~Equation (69B–11)~~Equation (69B–13):

~~$$ILD(f) \geq ILD_{min1}(f) = -2.1 - 0.9\times10^{-9}f \quad (69B\text{–}10)$$~~

~~$$ILD(f) \leq ILD_{max1}(f) = 1.5 + 1.0\times10^{-9}f \quad (69B\text{–}11)$$~~

~~for $f_1 \leq f \leq f_2$.~~

~~A high confidence acceptance region for *ILD* is constrained by Equation (69B–12) and Equation (69B–13):~~

$$~~ILD(f) \geq ILD_{min2}(f) = -1.0 - 0.5\times10^{-9}f~~ \; ILD(f) \geq ILD_{min}(f) = -1.0 - 0.5\times10^{-9}f \quad (69B\text{–}12)$$

$$~~ILD(f) \leq ILD_{max2}(f) = 1.0 + 0.5\times10^{-9}f~~ \; ILD(f) \leq ILD_{max}(f) = 1.0 + 0.5\times10^{-9}f \quad (69B\text{–}13)$$

for $f_1 \leq f \leq f_2$.

The values of f_1 and f_2 are dependent on port type and are given in Table 69B–2.

In addition, it is recommended that the insertion loss also satisfy the attenuation limit defined in 69B.4.2, the insertion loss limit defined in 69B.4.3, and the insertion loss to crosstalk ratio limit defined in 69B.4.5.4. The insertion loss deviation limit for each port type is illustrated in Figure 69B–5.

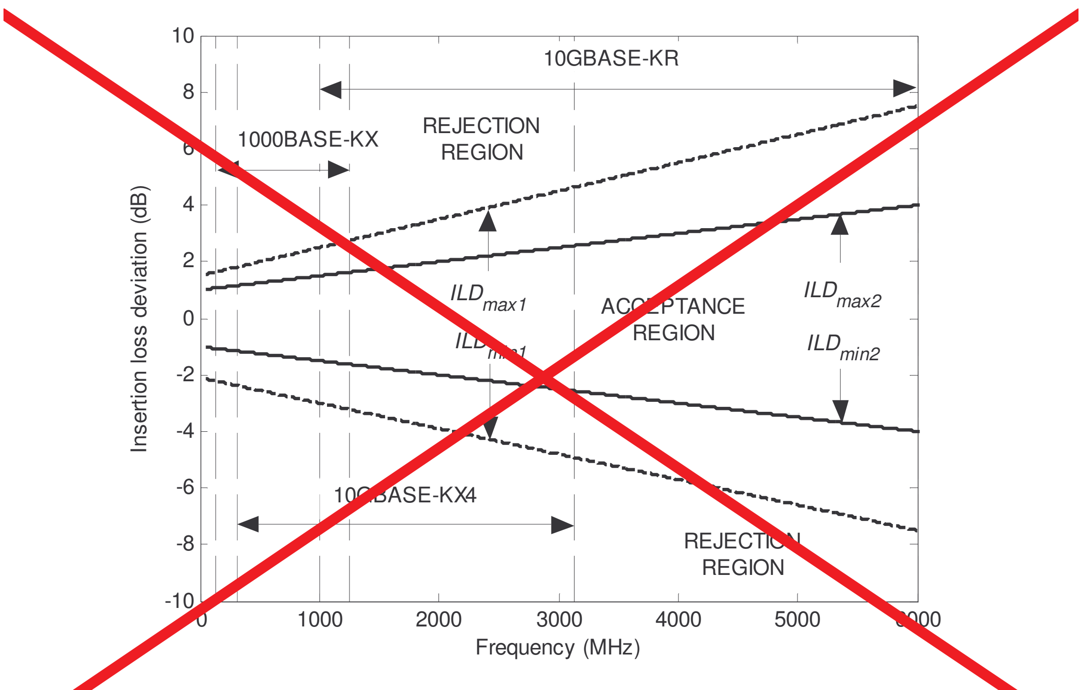

Figure 69B–5—Insertion loss deviation limits

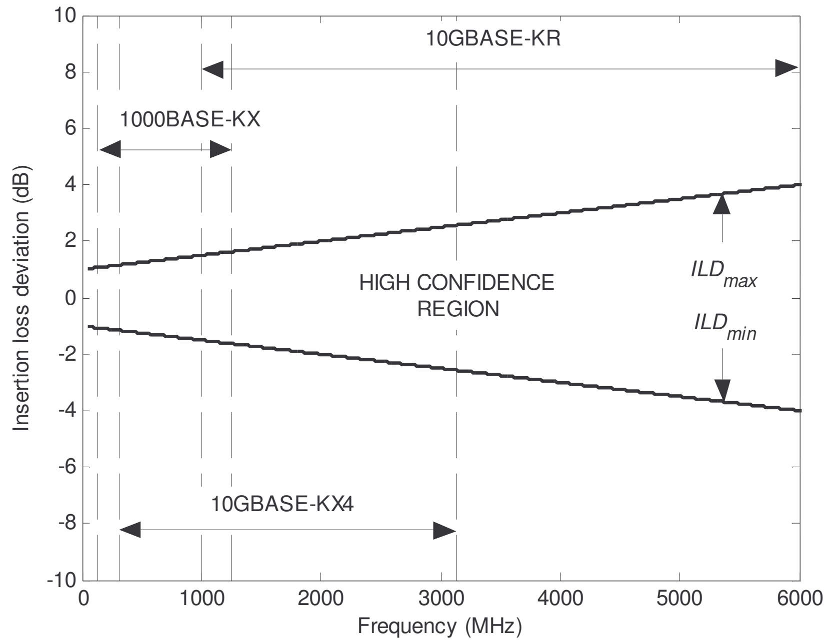

Figure 69B–5—Insertion loss deviation limits

69B.4.5Crosstalk

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.

69B.4.5.1 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–12), 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.

$$PSNEXT(f) = -10\log\left(\sum_n 10^{-NEXT_n(f)/10}\right) \quad (69B–12)$$

69B.4.5.2 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–13), 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.

$$PSFEXT(f) = -10\log\left(\sum_n 10^{-FEXT_n(f)/10}\right) \quad (69B–13)$$

69B.4.5.3 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–14).

$$PSXT(f) = -10\log(10^{-PSNEXT(f)/10} + 10^{-PSFEXT(f)/10}) \quad (69B\text{–}14)$$

69B.4.5.4 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–15).

$$ICR(f) = -IL(f) + PSXT(f) \quad (69B\text{–}15)$$

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–16) through (69B–20). The values of f_a and f_b are dependent on port type and are provided in Table 69B–2.

$$x_{avg} = \frac{1}{N}\sum_n \log(f_n) \quad (69B\text{–}16)$$

$$ICR_{avg} = \frac{1}{N}\sum_n ICR(f_n) \quad (69B\text{–}17)$$

$$m_{ICR} = \frac{\sum_n (\log(f_n) - x_{avg})(ICR(f_n) - ICR_{avg})}{\sum_n (\log(f_n) - x_{avg})^2} \quad (69B\text{–}18)$$

$$b_{ICR} = ICR_{avg} - m_{ICR}x_{avg} \quad (69B\text{–}19)$$

$$ICR_{fit}(f) = m_{ICR}\log(f) + b_{ICR} \quad (69B\text{–}20)$$

It is recommended that ICR_{fit} be greater than than or equal to ICR_{min} as defined in Equation (69B–21).

$$ICR_{fit}(f) \ge ICR_{min}(f) = 12.5 - 20\log\left(\frac{f}{5\ \text{GHz}}\right) \quad (69B\text{–}21)$$

for $f_a \le f \le f_b$.

The insertion loss to crosstalk ratio limit for each port type is illustrated in Figure 69B–6.

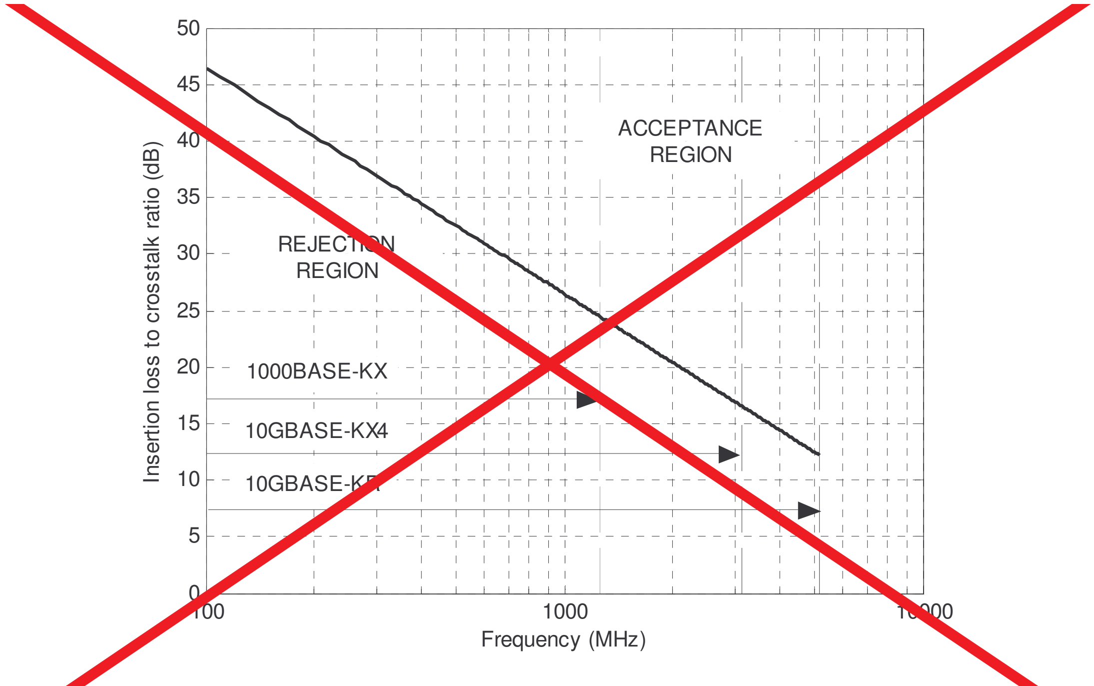

Figure 69B–6—Insertion loss to crosstalk ratio limit

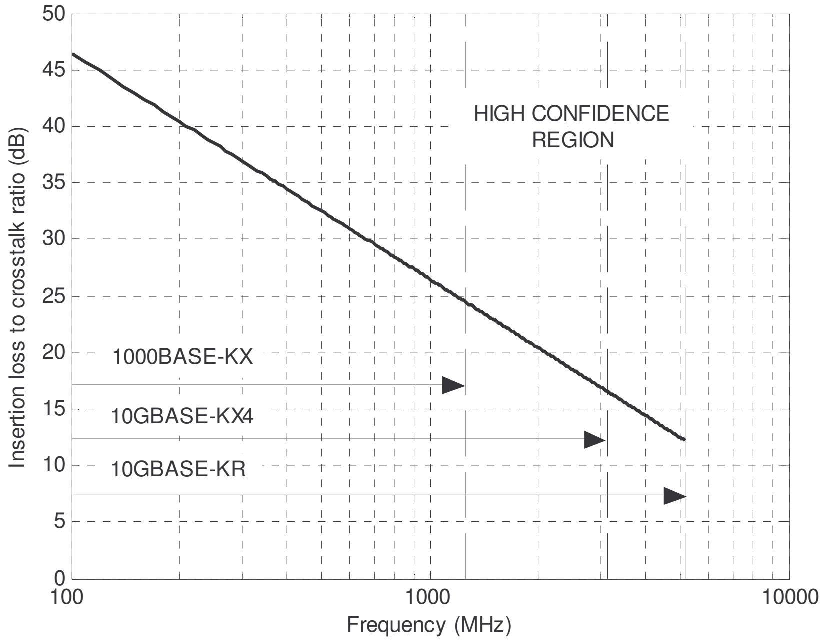

Figure 69B–6—Insertion loss to crosstalk ratio limit