Annex 128 B
(Normative)

Yellow highlighted text indicates refinement is needed

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The section pulled from Annex 69A

Interference tolerance testing

128B.1 Introduction

A major problem in communicating across crowded backplanes is interference. The interfering signal can come from a variety of sources including the following:

Crosstalk from other data channels running the same kind of signals as the channel of interest. This type of interference is usually subdivided into

- Far-end crosstalk (FEXT) coming from data traveling in the same general direction as the
- Channel of interest.
- Near-end crosstalk (NEXT) originating from a channel with a transmitter near the receiver of the channel of interest.
- Self-interference caused by reflections due to impedance discontinuities, stubs, etc. This is a form of intersymbol interference (ISI) that is beyond what a reasonable equalizer can compensate.
- Alien crosstalk, which is defined to be interference from unrelated sources such as clocks, other kinds of data, power supply noise, etc.

For the channel to work, the receiver must be able to extract correct data from the lossy channel in the presences of interference. The ability of the receiver to extract data in the presence of interference is an important characteristic of the receiver and needs to be measured. This ability is called interference tolerance.

128B.2 Test Set Up

The interference tolerance test is performed with the setup shown in Figure 128B–1.

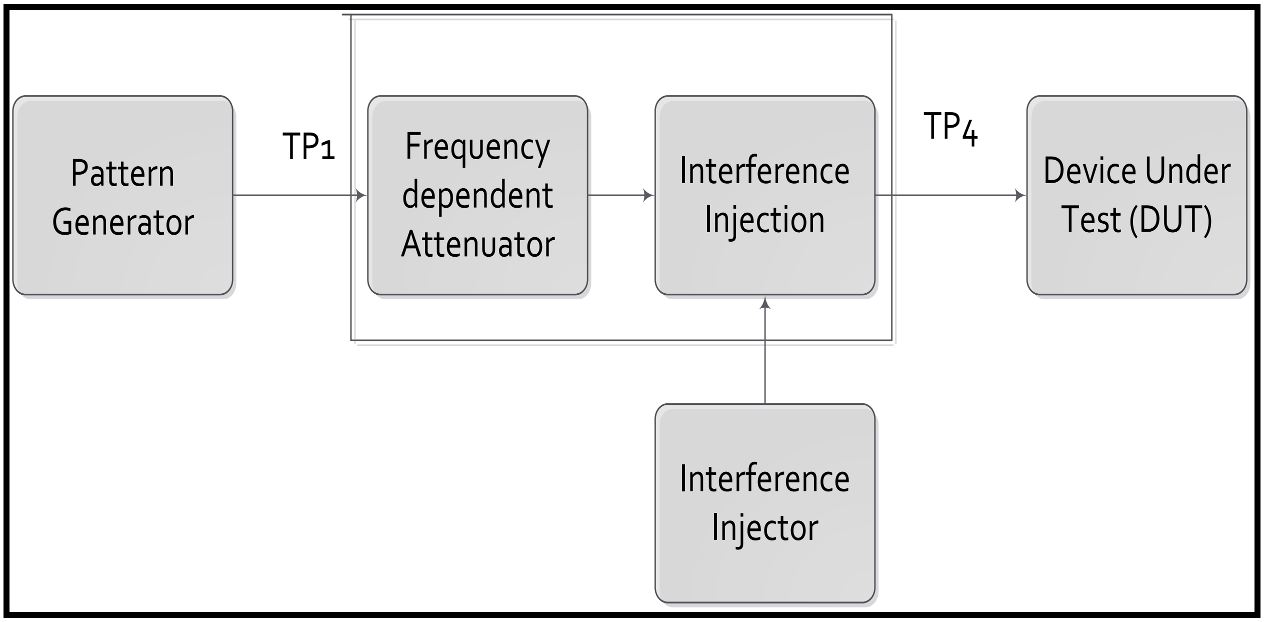

Figure 128B-1

128B.2.1 Pattern generator

For 2.5GBASE-KX, the peak-to-peak amplitude delivered by the pattern generator, as measured on a sequence of alternating ones and zeros, shall be no more than 800 mV, adjusted by a gain bTC as defined in 128B.2.2, regardless of equalization setting.

The applied transition time at the pattern generator output shall be no less than the minimum value specified for the port type being tested. If the transition time of the pattern generator is less than the minimum specified applied transition time, an equivalent stress may be introduced in the test channel.

The test channel, defined in 128B.2.2, is chosen so that the insertion loss of the test channel has a specific relationship to the maximum fitted attenuation, Amax, defined in 128B.4.2.

The signaling speed of the pattern generator shall be offset ±100 ppm relative to the nominal signaling speed of the port type being tested. The pattern generator shall have jitter on its output.

This jitter shall consist of sinusoidal jitter at a frequency no less than 1/250 of signaling speed, duty cycle distortion, and random jitter. The random jitter shall be measured at the output of a single pole high-pass filter with cut-off frequency at 1/250 of the signaling speed. The sinusoidal jitter, duty cycle distortion, and random jitter shall each be no less than the amount specified for the port type being tested.

128B.2.2 TEST Channel

The test channel is a 100 Ω differential system consisting of a frequency-dependent attenuator and an interference injection block. The interference injection block may be a pair of directional couplers, a pair of pick-off tees, or any other component, as long as the combination of the interference injection block and the frequency-dependent attenuator satisfies the requirements of the test channel.

The frequency dependent attenuator is recommended to be constructed in such a way that it accurately represents the insertion loss and group delay characteristics of differential traces on an FR-4 printed circuit board. The test channel is specified with respect to transmission magnitude response, ILTC, and return loss.

Assuming the transmission magnitude response is measured at N uniformly-spaced frequencies fn spanning the frequency range f1 to f2, the transmission magnitude is described by two parameters, mTC and bTC, as defined in Equation (128B–2) through Equation (128B–7).

$$m_X = \frac{1}{N}\sum_n A_{max}(f_n) \quad (128B–2)$$

$$m_Y = \frac{1}{N}\sum_n IL_{TC}(f_n) \quad (128B–3)$$

$$m_{XY} = \frac{1}{N}\sum_n A_{max}(f_n) IL_{TC}(f_n) \quad (128B–4)$$

$$m_{XX} = \frac{1}{N}\sum_n A_{max}(f_n) A_{max}(f_n) \quad (128B–5)$$

$$m_{TC} = \frac{m_{XY} - m_X m_Y}{m_{XX} - m_X m_X} \quad (128B–6)$$

$$b_{TC} = m_Y - m_{TC} m_X \quad (128B–7)$$

The values f1 and f2 are a function of the port type under test (see Table 128B–1) and Amax is defined in 128B.4.2.

The test channel shall have mTC greater than the minimum value specified for the port type under test and the test being performed. The test channel return loss, as measured at TP1 and TP4, shall be greater than or equal to 11 dB from fmin to f2

128B.2.3 Interference generator

The interference generator is a broadband noise generator capable of producing white Gaussian noise with adjustable amplitude. The power spectral density shall be flat to ±3 dB from f1 to 0.5 times the signaling speed for the port type under test with a crest factor of no less than 5. The noise shall be measured at the output of a filter connected to TP4. The filter for this measurement shall have no more than a 40 dB/decade roll-off and a 3 dB cut-off frequency at least 0.5 times the signaling speed.

128B.2.4 Transmitter control

For 2.5GBASE-KX testing, the pattern generator is controlled by transmitter control. Transmitter control is used to adjust the pattern generator.

128B.3 Test methodology

For 2.5GBASE-KX testing, the pattern generator shall first be configured to transmit the test pattern defined in 128.6.10.2.

The broadband noise source shall then be set to the amplitude specified for the port type being tested, as measured at TP4. The measured BER shall be less than the target BER specified for the port type under test. The interference tolerance test parameters are specified in Table 128–10 for 2.5GBASE-KX.

Annex 128C

(Informative)

Interconnect characteristics

128C.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.

128C.2 Reference model

The backplane interconnect is defined between test points TP1 and TP4 as shown in Figure 128C–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, insertion loss deviation, return loss, crosstalk, and the ratio of insertion loss to crosstalk between TP1 and TP4 are defined in 128C.4.3, 128C.4.4, 128C.4.5, 128C.4.6, and 128C.4.6.4 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.

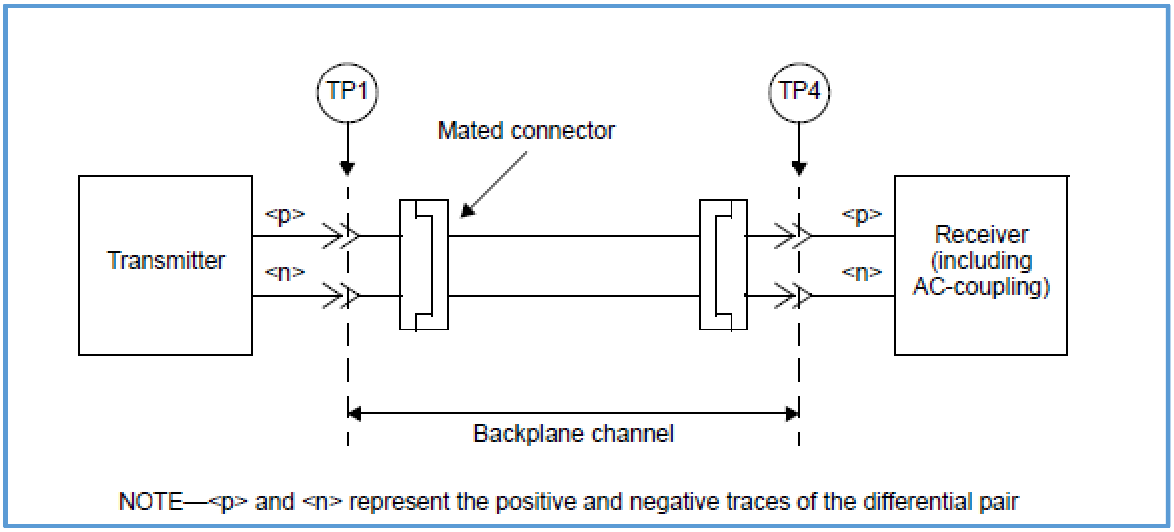

Figure 128C–1: Interconnect Reference Model

128C.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 transition time for port type of interest.

128C.4 Channel parameters

128C.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 based on the amount of loss allowed for a given level of interference as verified by the interference tolerance test procedure defined in Annex 128B.

The informative parameters for channel insertion loss are summarized in Table 128C–1. The maximum fitted attenuation (Amax) due to trace skin effect and dielectric properties is defined in 128C.4.2 The maximum insertion loss (ILmax) is defined in 128C.4.3. The maximum deviation of insertion loss from the best-fit attenuation (ILD) is defined in 128C.4.4. The minimum return loss (RLmin) is defined in 128C.4.5. The limit on crosstalk in relation to insertion loss (ICRmin) is defined in 128C.4.6.4. All of the different parameters must be considered together in evaluating the overall channel performance.

Table 128C–1—Insertion loss parameters

Parameter	2.5GBase-KX	Units
Fmin	0.05	GHz
Fmax	15	GHz
b1	2E-5	
b2	1.1E-10	
b3	4.1E-20	
b4	-1.6 E-30	
f1	0.312	GHz
f2	1.5625	GHz
fa	0.1	GHz
fb	1.5625	GHz

128C.4.2 Fitted attenuation

The fitted attenuation, A, is defined to be the least mean squares line fit to the insertion loss computed over the frequency range f1 to f2. Assuming the transmission magnitude response is measured at N uniformly-spaced frequencies fn spanning the frequency range f1 to f2, the least mean squares line fit procedure is defined by Equation (128C–1) through Equation (128C–5).

$$f_{\mathrm{avg}} = \frac{1}{N}\sum_{n} f_{\mathrm{n}}$$

$$IL_{\mathrm{avg}} = \frac{1}{N}\sum_{n} IL(f_{\mathrm{n}})$$

$$m_{\mathrm{A}} = \frac{\sum_{n}(f_{\mathrm{n}} - f_{\mathrm{avg}})(IL(f_{\mathrm{n}}) - IL_{\mathrm{avg}})}{\sum_{n}(f_{\mathrm{n}} - f_{\mathrm{avg}})^2}$$

$$b_{\mathrm{A}} = IL_{\mathrm{avg}} - m_{\mathrm{A}} f_{\mathrm{avg}}$$

$$A(f) = m_{\mathrm{A}} f + b_{\mathrm{A}}$$

It is recommended that the fitted attenuation of the channel be less than or equal to Amax as defined by the Equation (128C–6), where f is expressed in Hz and the coefficients b1 through b4 are given in Table 128C–1.

$$A(f) \le A_{max}(f) = 20\log_{10}(e) \times (b_1\sqrt{f} + b_2 f + b_3 f^2 + b_4 f^3) \qquad \text{(128C-6)}$$

for f1 ≤ f ≤ f2. The fitted attenuation limit is illustrated in Figure 128C–2.

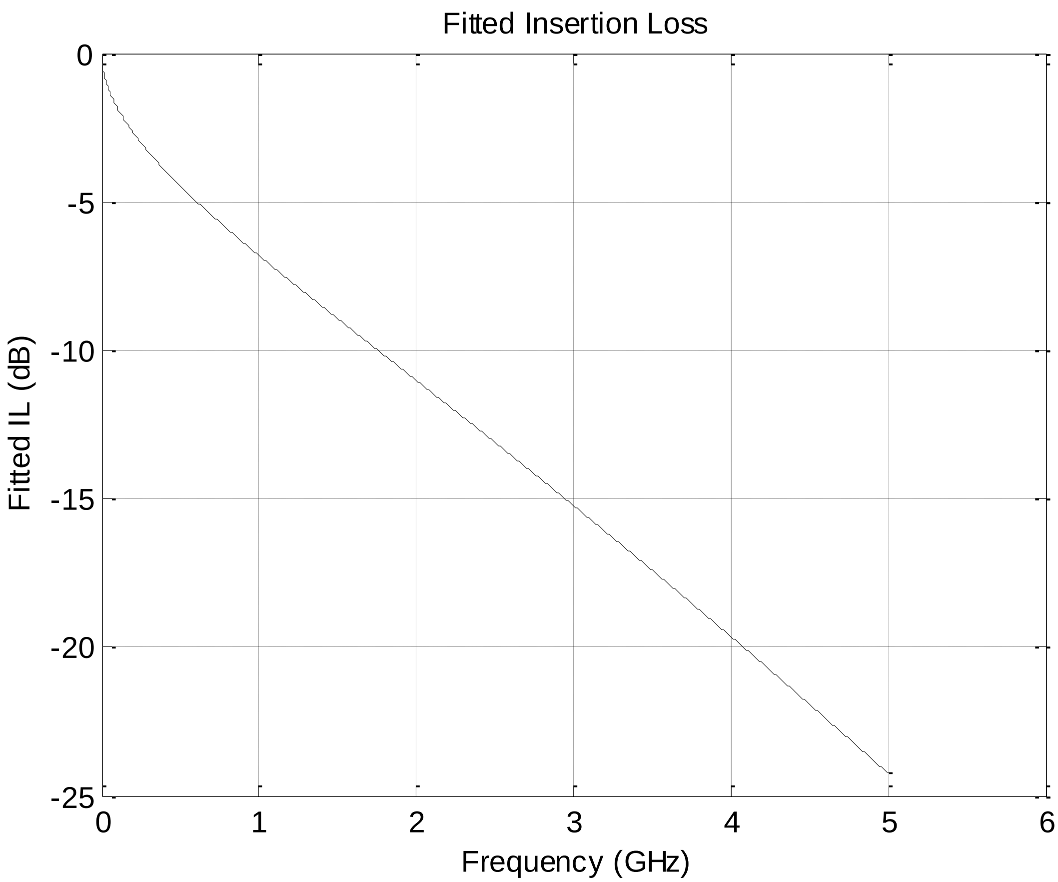

Figure 128C-2

128C.4.3 Insertion loss

Insertion loss is defined as the magnitude, expressed in decibels, of the differential response measured from TP1 to TP4. It is recommended that the insertion loss magnitude, IL, be within the high confidence region defined by Equation (128C–7)

$$\begin{array}{lll} 0.668 + 3.755\sqrt{f} + 3.608f & 0.05 \le f < 1.5625 & \text{GHz} \\ -23.753 + 22.242f & 1.5625 \le f \le 2.34375 & \text{GHz} \end{array} \qquad [128C\text{-}7]$$

The values of fmin, f2, and fmax are given in Table 128C–1. The insertion loss limit is illustrated in Figure 128C–3

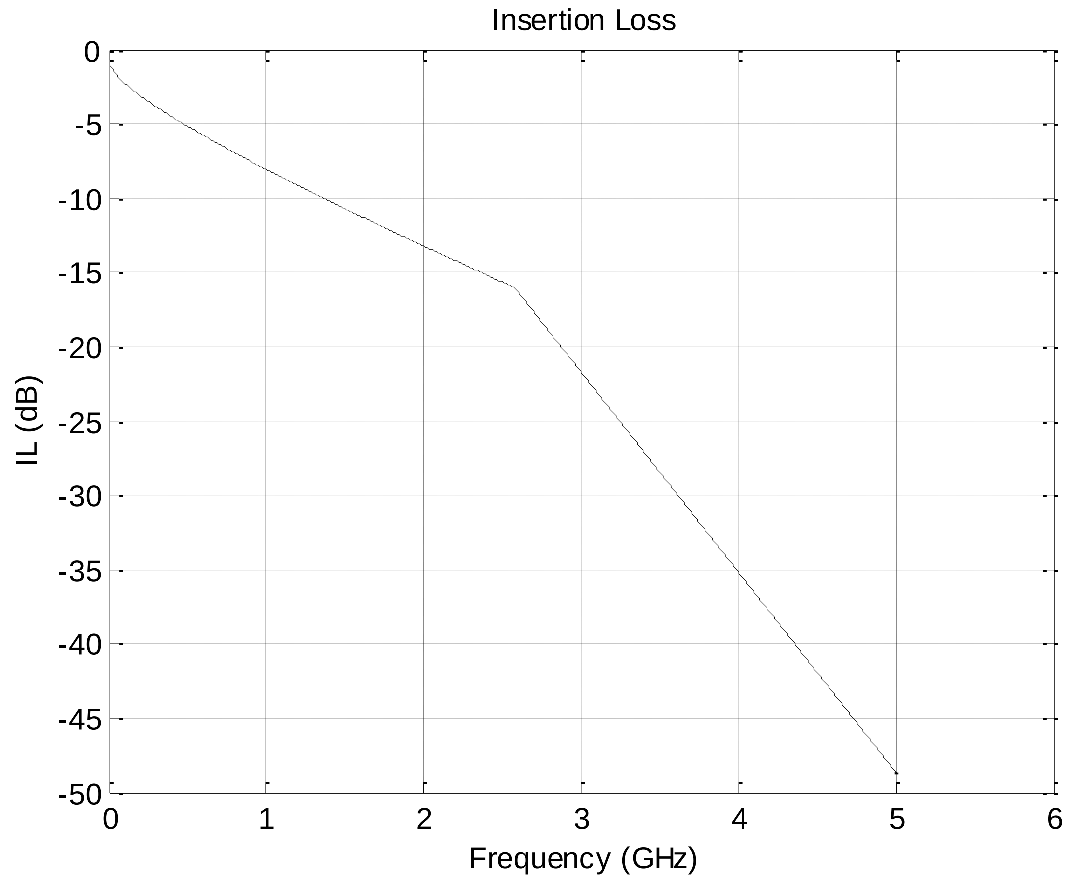

Figure-128C-3

128C.4.4 Insertion loss deviation

The insertion loss deviation, as defined by Equation (128C–8), is the difference between the insertion loss and the fitted attenuation defined in 128C.4.2.

$$ILD(f) = IL(f) - A(f) \quad (128C–8)$$

It is recommended that ILD be within the high-confidence region defined by Equation (128C–9) and Equation (128C–10).

ILD(f)>= -1.0-0.7e-9*f (128C-9)

ILD(f)<=1.0+0.7e-9*f (128C-10)

for f1 < f < f2.

The values of f1 and f2 are dependent on port type and are given in Table 128C–1. The insertion loss deviation limits for each port type is illustrated in Figure 128C–4.

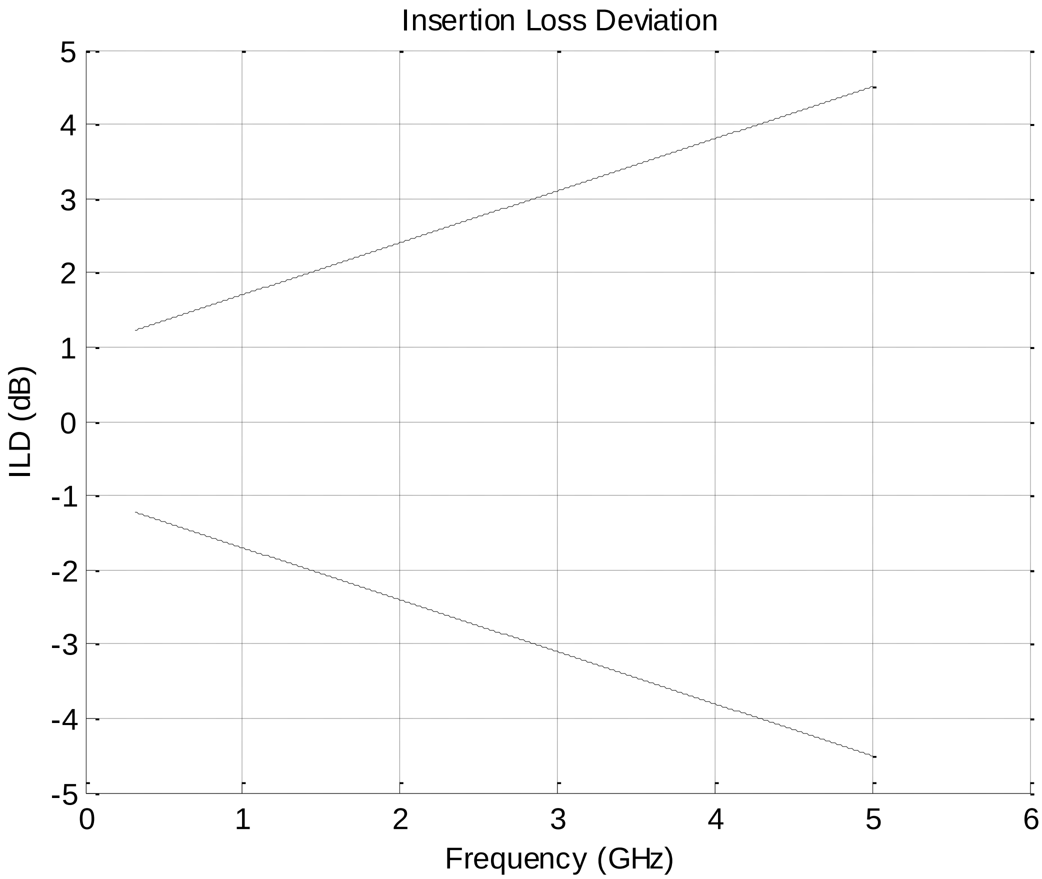

Figure 128C-4

128C.4.5 Return loss

It is recommended that the channel return loss, RL, measured in dB at TP1 and TP4, be greater than or equal to RLmin as defined by Equation (128C–11) through Equation (128C–13).

$RL(f) \geq RLmin(f) = 12$ (128C-11)
for $50\ MHz \leq f < 275\ MHz$

$RL(f) \geq RLmin(f) = 12-6.75*log10(f/275MHz)$ (128C-12)
for $275\ MHz \leq f < 3000\ MHz$
$RL(f) \geq RLmin(f) = 5$ (128C-13)
for $3000\ MHz \leq f < 5.15625\ MHz$

128C.4.6 Crosstalk

The following equations and informative model assume that aggressors and victim are driven by a compliant PHY of any type.

128C.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 (128C–14), where NEXTn 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.

$$PSNEXT(f) = -10\log\left(\sum_n 10^{-NEXT_n(f)/10}\right) \qquad (128C\text{-}14)$$

128C.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 (128C–15), where FEXTn 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.

$$PSFEXT(f) = -10\log\left(\sum_n 10^{-FEXT_n(f)/10}\right) \qquad (128C\text{-}15)$$

128C.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 (128C–16).

$$PSXT(f) = -10\log\left(10^{-PSNEXT(f)/10} + 10^{-PSFEXT(f)/10}\right) \qquad (128C\text{-}16)$$

128C.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 (128C–17).

ICR(f) = –IL (f) + PSXT(f) (128C-17)

It is recommended that ICRfit be greater than or equal to ICRmin as defined by Equation (128C–28).

$$ICR_{fit}(f) \geq ICR_{min}(f) = 28 - 18\log_{10}\left(\frac{f}{2GHz}\right) \qquad (128C\text{-}18)$$

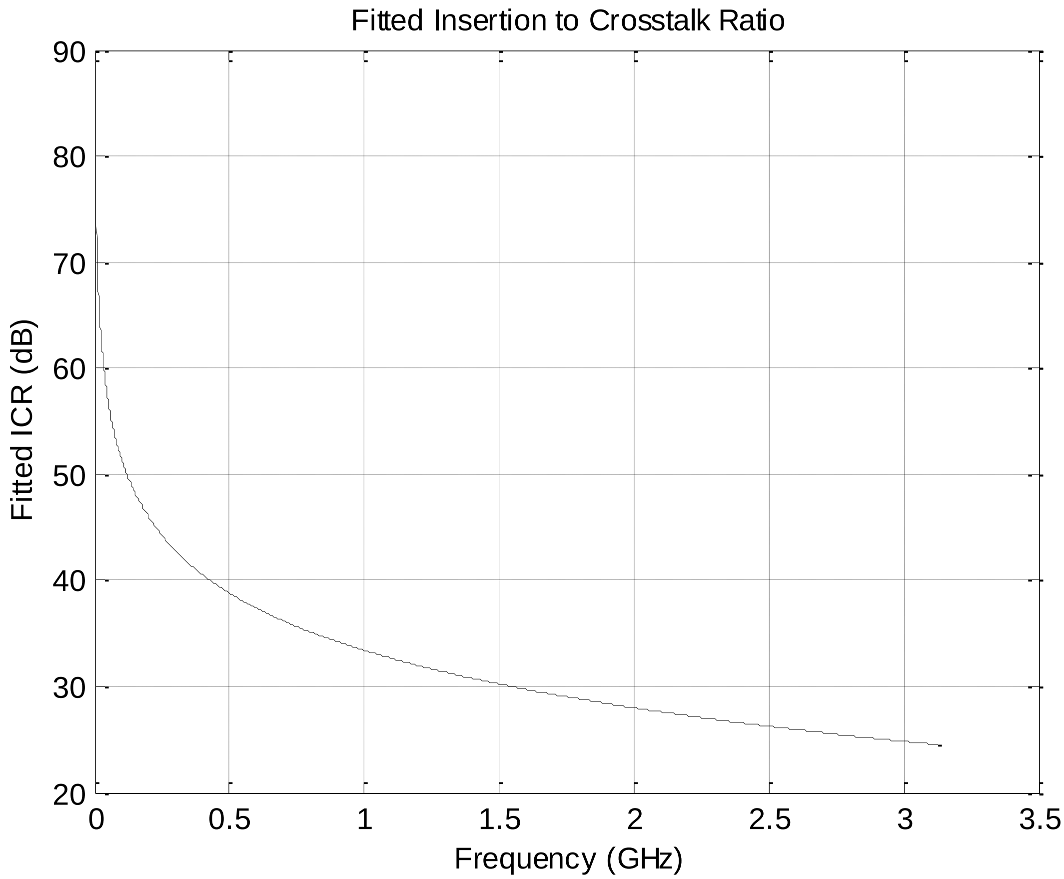

Figure 128C-6