Annex 69A Interference tolerance testing

69A.1 Introduction

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

a) Crosstalk from other data channels running the same kind of signals as the channel of interest. This type of interference is usually subdivided into:
   1. Far-end crosstalk (FEXT), coming from data traveling in the same general direction as the channel of interest.
   2. Near-end crosstalk (NEXT), originating from a channel with a transmitter near the receiver of the channel of interest.

b) Self interference (SI), caused by reflection, due to impedance discontinuities, stubs, etc. This is really just a form of inter-symbol interference (ISI) beyond the time range a reasonable equalizer can handle

c) Foreign interference (FI), crosstalk from unrelated sources such as clocks, other kinds of data, power supply noise etc. If the channel of interest is a very high speed channel, any foreign interference is likely to be at lower frequencies than the FEXT or NEXT would be, and since crosstalk tends to increase with frequency, FI is likely to be of secondary importance.

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.

Interference tolerance test is performed with the setup shown in Figure 69A—1.

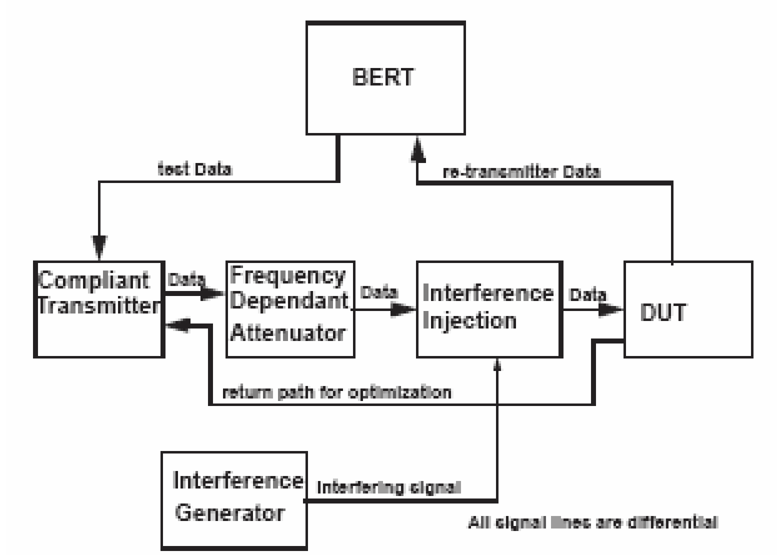

Figure 69A—1—Interference tolerance test setup

The BERT shown in Figure 69A—1 is optional. If the DUT and the compliant transmitter have suitable built in self test (BIST) capability the transmitter can transmit the test pattern and the DUT report Bit Error Ratio (BER).

The compliant transmitter can be any transmitter which is fully compliant to the specifications for the respective port type.

The compliance channel consists of a frequency-dependent attenuator and an interference injection block.

69A.2 Compliance channel

The compliance channel is a 100 Ohm differential system specified with respect to transmission magnitude response and inter-symbol interference (ISI) loss. The limits have been chosen to allow a realistic approximation of the loss and ISI which a normal data link will experience but careful design of the path will make it substantially free of self-interference.

The compliance channel is defined by the attenuation limit described in equation 69A-1 and the value minISIloss. The frequency range of applicability and the value of minISIloss is a function of the port type under test.

The attenuation A(f) is defined to be the least mean squared fit to the insertion loss of the compliance channel over the frequency range f1 to f2, the attenuation shall be greater than the worst case attenuation limit described by the inequality:

$$A(f) > Amin(f) = 20*\log10(e)*(b1*\mathrm{sqrt}(f)+b2*f+b3*f^2+b4*f^3),\ f1<f<f2 \qquad (69A-1)$$

where:

f is the frequency in Hz
b1 is 2.25E-05
b2 is 1.20E-10
b3 is 3.50E-20
b4 is -1.25E-30

f1, f2 and minISIloss are specified independently for each port type.

This limit applies from f1 to f2 The insertion loss of the compliance channel above f2 should be greater than Amin(f2).

The ISI loss of the compliance interconnect, defined as the difference in insertion loss between f1and f2, should be greater than minISIloss. The magnitude response and ISI loss limits for 10GBASE-KR are illustrated in Figure 69A—2

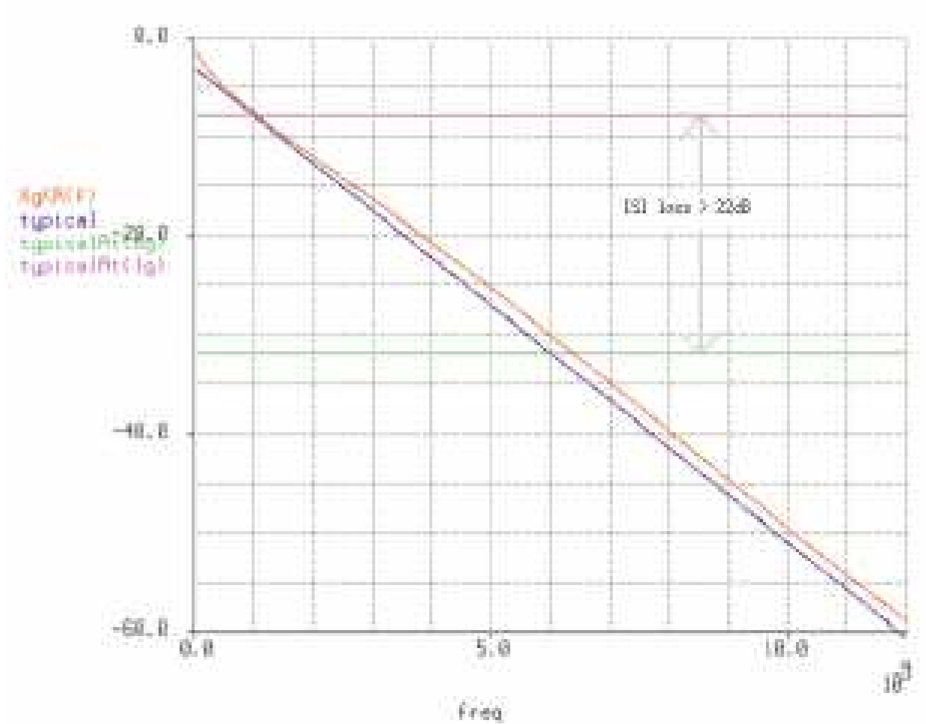

Figure 69A—2—Magnitude response and ISI loss limits

69A.3 Interference injection block

This block may be a pair directional couplers, a pair of pick-off tees, or any other component, as long as it passes data with sufficiently small loss so that the combination of the interference injection block and the frequency-dependent attenuator satisfies the requirements of the compliance channel. It should also be capable of injecting differential interference large enough to cause a BER of at least 10^{-4}.

69A.4 Interference Generator

The interference generator is a signal generator capable of producing sine waves from f1 to fbaud with adjustable amplitude. The path of the interfering signal to the DUT should be calibrated so the amplitude of interference will be known accurately.

69A.5 Test Methodology

Interference tolerance is measured at a standard BER and then extrapolated to a BER of 10^{-12}. The standard BER should be as low as practical to allow accurate extrapolation. It is recommended that the error rates be lower than 1 per second (BER $\leq 10^{-9}$ for 1000BASE-KX, BER $\leq 3.2 \times 10^{-10}$ for 10GBASE-KX4, or BER $\leq 10^{-10}$ for 10GBASE-KR).

To measure interference, first turn the output amplitude of the interference generator to zero or a very low value. With the interference low, allow the compliant transmitter and the DUT to complete auto-negotiation (if enabled) and, for 10GBASE-KR, training (if enabled).

Once the DUT has arrived at a state where it is able to receive data, the compliant transmitter will transmit either

a) So the compliant transmitter accepts data from the BERT and re-transmits it to the DUT, and the DUT re-transmits its input from the compliant transmitter to the BERT. The BERT transmits a pattern prescribed for the port type being tested and measures the BER to this pattern at its input.

b) So the Compliant Transmitter transmits a BIST generated pattern prescribed for the port type being tested and the BIST function of the DUT measures BER to this pattern at its input.

With the interference generator amplitude still zero or very low, establish that the BER measured by either the BERT or the DUT BIST (mBER) is very low. This can be established by observing that there are no errors in several seconds.

Set the frequency of the signal generator to f1 and output of the interference generator to a non-zero amplitude which does not produce an mBER > standard BER. The exact level will not affect the result of the test but if the level is near the amplitude which does generate mBER > standard BER, the test will take less time.

Iteratively increment the amplitude of the interference generator, measure mBER, and record the interference amplitude p-p differential at the DUT and mBER. The increments should be such that the interference amplitude p-p differential at the DUT increases by 1mV for each increment. Enough time should be allowed in the mBER measurement so the standard BER could be detected with 50% probability, generally at least 1 second. Continue the iterations until mBER is at least 1000 times the standard BER.

Plot sqrt(log(mBER)) vs. amplitude at the DUT, to get a plot similar to Figure 69A—6. The data should approximate a straight line at low BER but flattens out and deviates more and more at higher BER. The linear part of the data should be extrapolated to BER = 10^{-12} as shown in Figure 69A—6. The difference between the amplitude causing a mBER = standard BER and the extrapolated value at eBER=10^{-12} is the extrapolation offset (EO).

The frequency of the interference generator is then stepped from f1 to fbaud. At each frequency the amplitude is adjusted to give mBER = standard BER. At each frequency extrapolated interference tolerance (EIT) is computed by subtracting EO from the amplitude which give mBER = standard BER. At each frequency the frequency and EIT is recorded.

The EIT values are compared to a frequency dependent EIT baseline, defined as:

EIT baseline = EITbase for f < 0.6*fbaud
= EITbase * (f/0.6*fbaud) for f > 0.6*fbaud

The value of EITbase is a function of the port type being tested.

The difference between the EIT baseline and EIT for lowest EIT relative to the EIT baseline is the baseline relative EIT (BREIT). BREIT is reported as the result for the interference tolerance test.

A comparison between EIT and EIT baseline is illustrated in Figure 69A—7

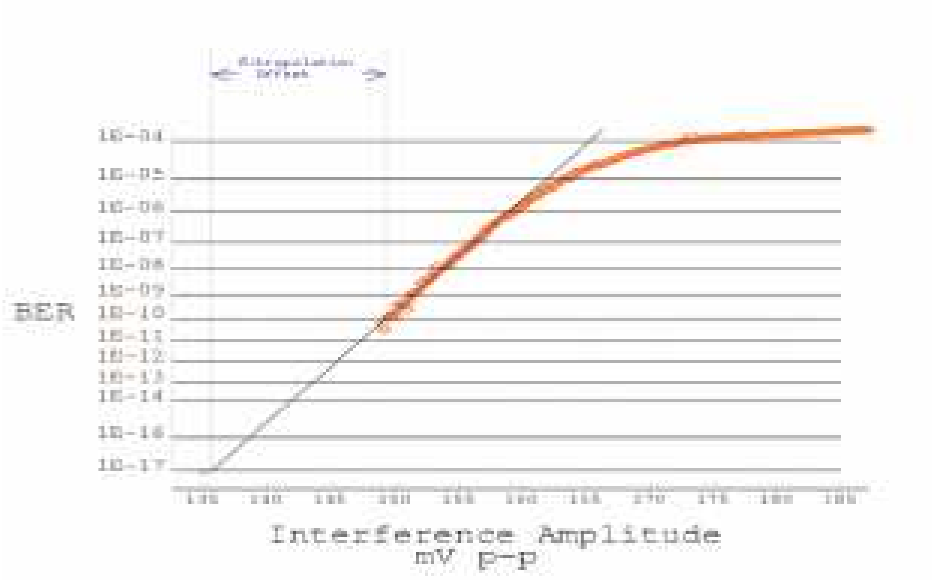

Figure 69A—6—Extrapolation offset

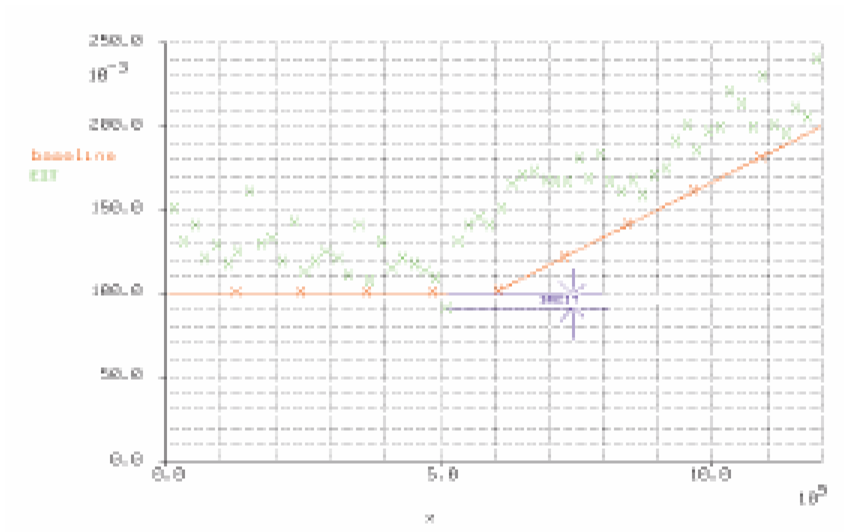

Figure 69A—7—Extrapolated Interference Tolerance (EIT)