Proposed Receiver Interference Tolerance Specification

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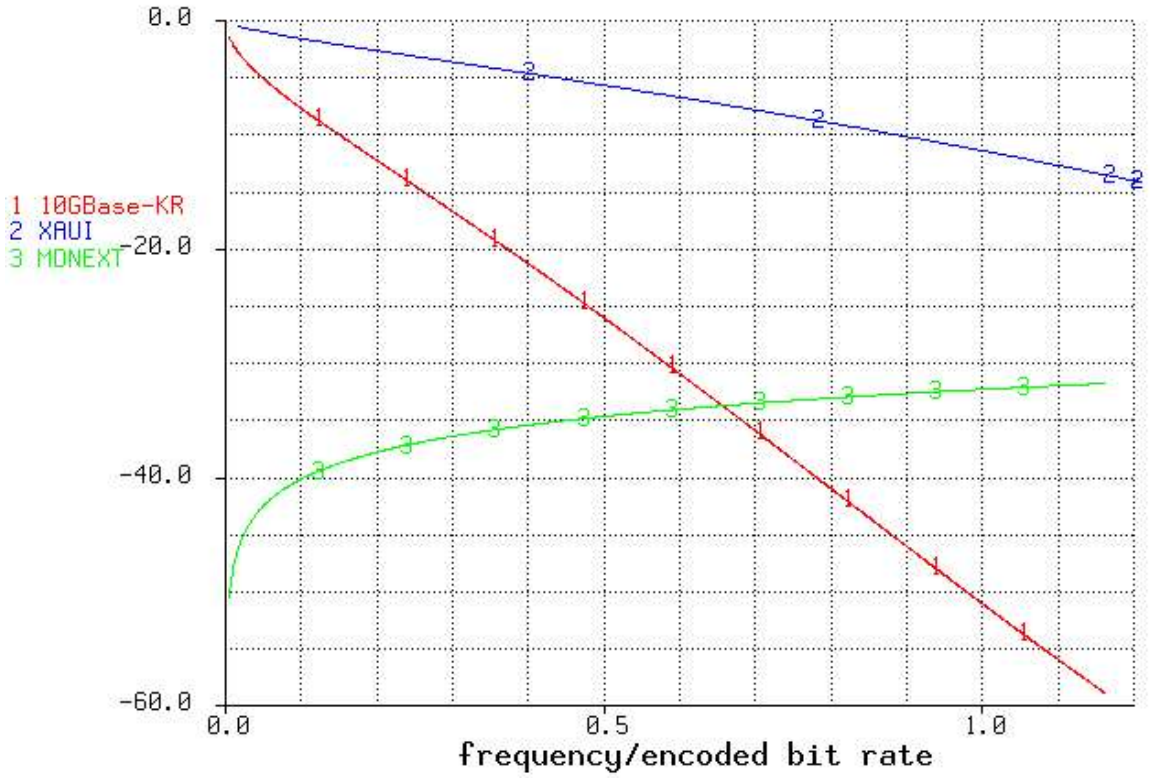
Overview

1. Motivation
2. Outline of test
3. Proposed Spec
4. Comments

Motivation



Channel gains (SDD21)

Motivation

Clearly:

1. **Equalization, which was semi-optional is now a critical issue**

2. **Cross talk, which was a minor nuisance, will be an all-consuming issue**

3. **We need Specs on cross talk, including:**
    1. **Tx specs limiting amplitude range**
    2. **Channel cross talk**
    3. **Rx cross talk sensitivity**

Outline of Test

(This is just a receiver test)

1. **Set up a realistic path without cross talk**
2. **Add calibrated amounts of cross talk like signal**
3. **Measure failure point of Receiver**
4. **Extrapolate to very low BER say $1X10^{-17}$**

Proposed Spec:

Interference tolerance testing.

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

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

1.1 Far End Cross Talk (FEXT), coming from data traveling in the same general direction as the channel of interest.

1.2 Near End Cross Talk (NEXT), originating from a channel with a transmitter near the receiver of the channel of interest.

2. 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.

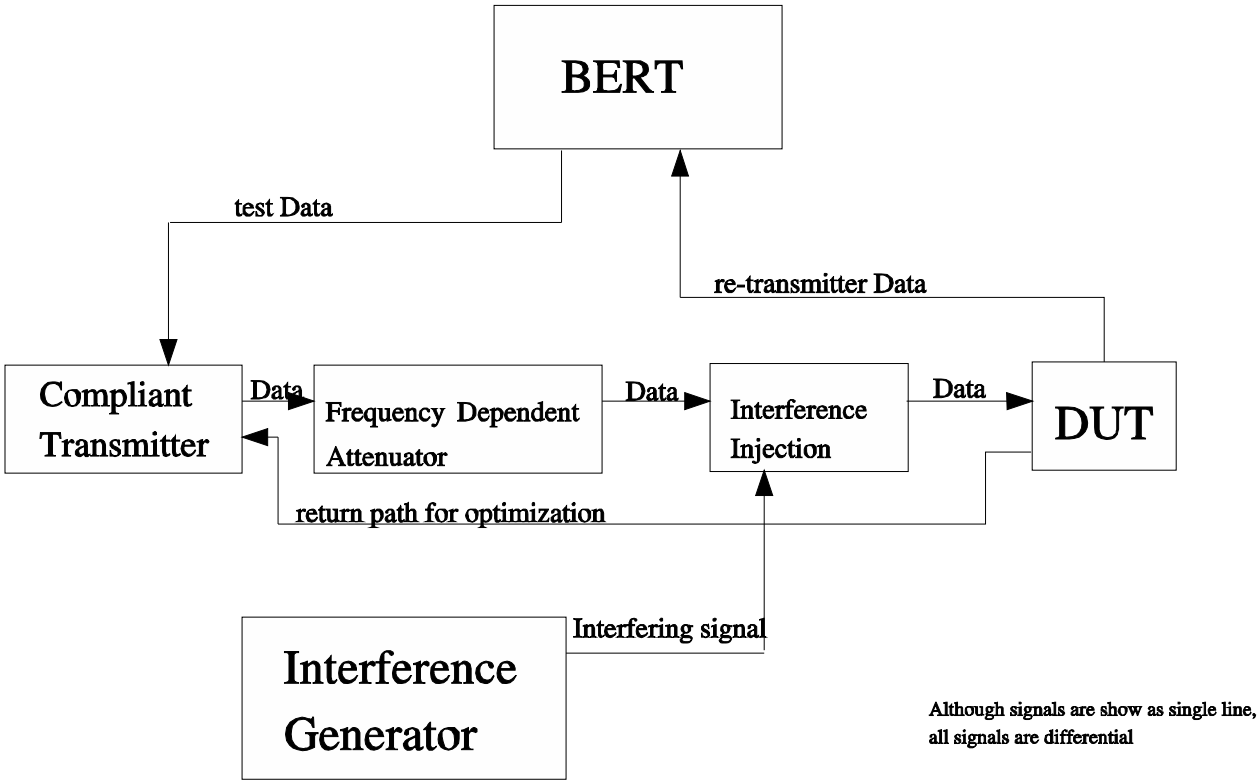
3. Foreign Interference (FI), cross talk from unrelated sources such as clocks, other kinds of data, power supply noise etc. If the channel of interest is a very high performance channel, any foreign interference is likely to be at lower frequencies than the FEXT or NEXT would be, and since cross talk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

Proposed Spec:

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 X.1.

Proposed Spec:



Test setup for Interference Tolerance test

- **Figure X.1**

Proposed Spec:

The BERT shown in Figure X.1 is optional, if the DUT and the Compliant Transmitter have suitable Built In Self Test (BIST) capability the transmitter can transmit a PRBS pattern and the DUT report Bit Error Rate (BER).

Proposed Spec:

The Compliant Transmitter can be any transmitter which is fully compliant with 10GBaseKR specifications, except that it shall have no more than 3 equalization taps or the equivalent.

Proposed Spec:

The Frequency dependent attenuator combined with the interference injection block should be a Compliance interconnect for the data sent through.

Compliance interconnect definition:

The compliance interconnect is a 100 Ohm differential system specified with respect to transmission magnitude response and inter symbol interference (ISI) loss. The compliance interconnect 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 SI. The transmission magnitude response, |s21|, of the compliance interconnect in dB satisfies Equation (X-1).

$$|S21| <= |S21|limit = -20*log10(e)*(bh*sqrt(f)+b1*f+b2*f^{2}+b3*f^{3}) \quad (X\text{-}1)$$

Proposed Spec:

where:

f is frequency in Hz

bh is 6.5E-06

b1 is 3.3E-10

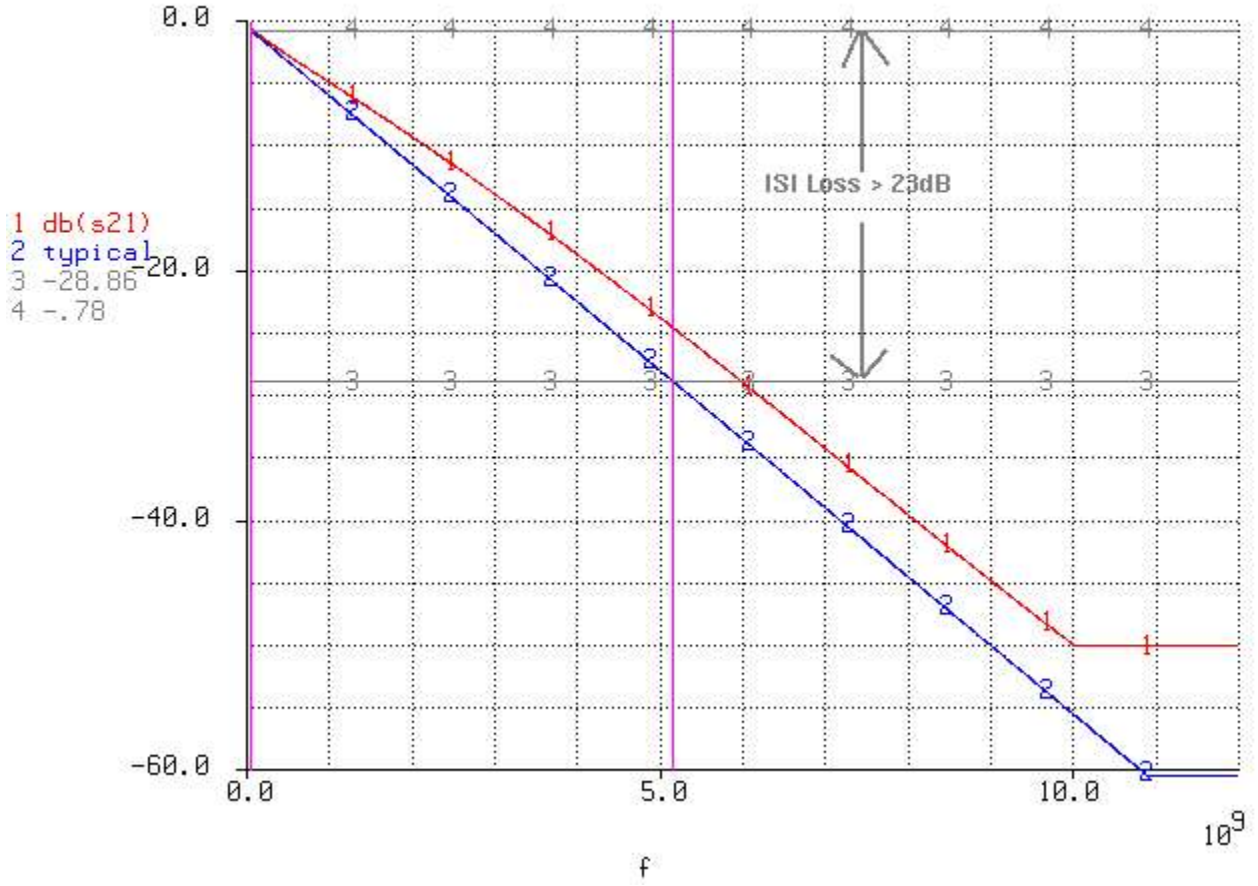
b2 is 3.2E-20

b3 is -1.4E-30

This limit applies from 50MHz to 10GHz.The magnitude response above 10.3125GHz does not exceed -50 dB.

The ISI loss, defined as the difference in magnitude response between two frequencies, is greater than 23.0 dB between 50 MHz and 5.156 GHz. The magnitude response and ISI loss limits are illustrated in Figure X.2

Proposed Spec:



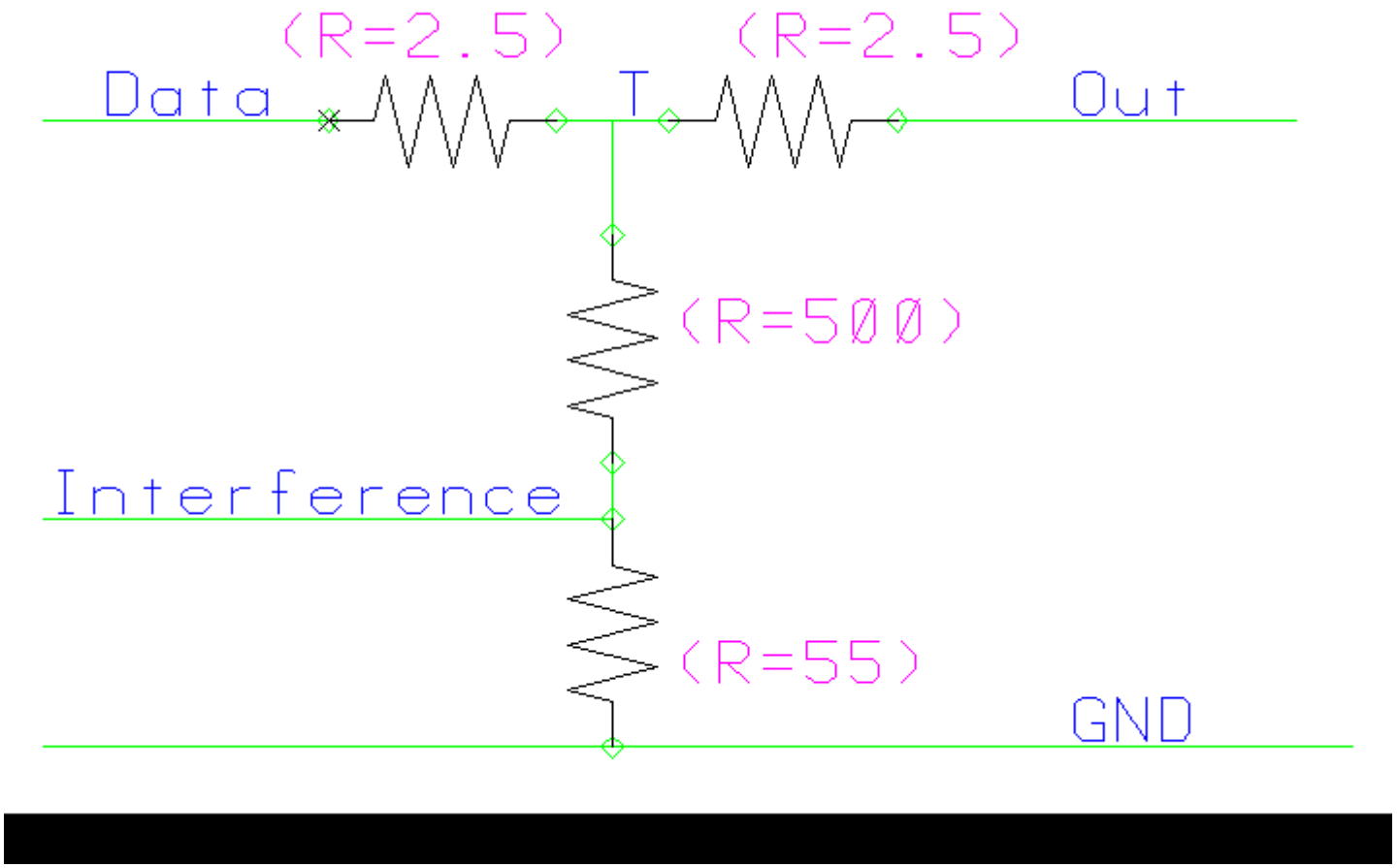
- **Figure X.2**

Proposed Spec:

Interference injection block:

The design of the interference injection block is shown in figure X.3. It allows a differential interference to be summed into the data path with a gain of -27.0dB, while the data suffers only 1dB of loss.

Proposed Spec:



- **Figure X.3**

Proposed Spec:

The test:

There are 2 tests, one with data like interference and one with swept frequency sinusoid interference.

Proposed Spec:

Data like interference test.

For the data like interference test the interference generator is a data generator producing a PRBS pattern at the data rate. The PRBS pattern should be a minimum of 7 bits (repeating no more often than every 2^7-1 bits) but cannot be the same pattern as the data PRBS. The interference generator must have adjustable amplitude. The path of the interfering signal to the DUT should be calibrated so the amplitude of interference will be known accurately.

Proposed Spec:

To measure interference tolerance, 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 perform normal Auto Negotiation and optimize equalization.

Proposed Spec:

When optimization is complete, switch the mode of operation, either

1. 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. BERT to transmit a PRBS pattern of at least 23bits (repeating no more often that every 2^{23}-1 bits) and to measure BER to this pattern in its input.

Or

2. So the Compliant Transmitter transmits a BIST generated PRBS pattern of at least 23bits (repeating no more often that every 2^{23}-1 bits) and the BIST function of the DUT measures BER to this pattern at its input.

Proposed Spec:

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 significantly less than 10^{-10}. This can be established by observing that there are no errors in several seconds time.

Set the output of the interference generator to a non zero amplitude which does not produce an mBER > 10^{-10}. The exact level will not effect the result of the test but if the level is near the amplitude which does generate mBER > 10^{-10}, the test will take less time.

Proposed Spec:

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 about 1mV for each increment. Enough time should be allowed in the mBER measurement to allow a BER of 10^{-10} to be detected with 50% probability, generally at least 1 second. Continue the iterations until mBER is at least 10^{-4}.

Proposed Spec:

If one plots sqrt(log(mBER)) vs interference amplitude at the DUT, one get a plot similar to Figure X.4. This shows data which fairly well follows a straight line at low BER but flattens out and deviates more and more at higher BER. The linear part of the curve should be extrapolated to BER=10^{-17} as shown in Figure X.4. The interference amplitude at BER=10^{-17} is the Extrapolated Interference Tolerance (EIT).

Proposed Spec:

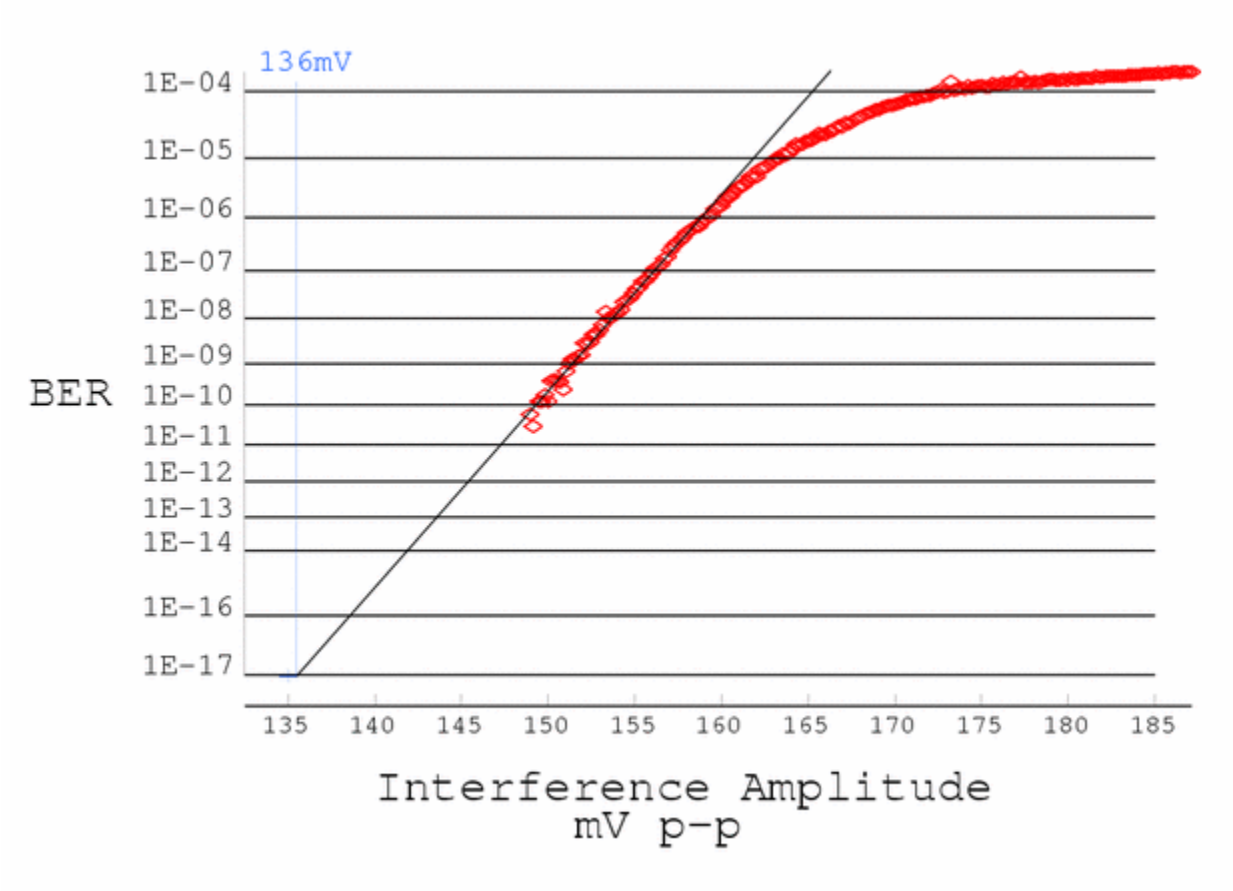


Figure X.4

Proposed Spec:

Sinusoidal interference

For Sinusoidal interference test the interference generator is a single frequency signal generator capable of producing sine waves from 100MHz to 10GHz. The interference generator must have adjustable amplitude. The path of the interfering signal to the DUT should be calibrated so the amplitude of interference will be known accurately.

Proposed Spec:

To measure interference tolerance, 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 perform normal Auto Negotiation and optimize equalization.

Proposed Spec:

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 significantly less than 10^{-10}. This can be established by observing that there are no errors in several seconds time.

Set the frequency of the signal generator to 5GHz and output of the interference generator to a non zero amplitude which does not produce an mBER > 10^{-10}. The exact level will not effect the result of the test but if the level is near the interference amplitude which does generate mBER > 10^{-10}, the test will take less time.

Proposed Spec:

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 about 1mV for each increment. Enough time should be allowed in the mBER measurement to allow a BER of 10^{-10} to be detected with 50% probability, generally at least 1 second. Continue the iterations until mBER is at least 10^{-4}.

Proposed Spec:

If one plots sqrt(log(mBER)) vs interference amplitude at the DUT, one get a plot similar to Figure X.5, which in turn will be fundamentally similar to Figure X.4. This shows data which fairly well follows 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^{-17} as shown in Figure X.5. The difference between the amplitude causing a mBER=10^{-10} and the extrapolated value at eBER=10^{-17} is the Extrapolation Offset (EO).

Proposed Spec:

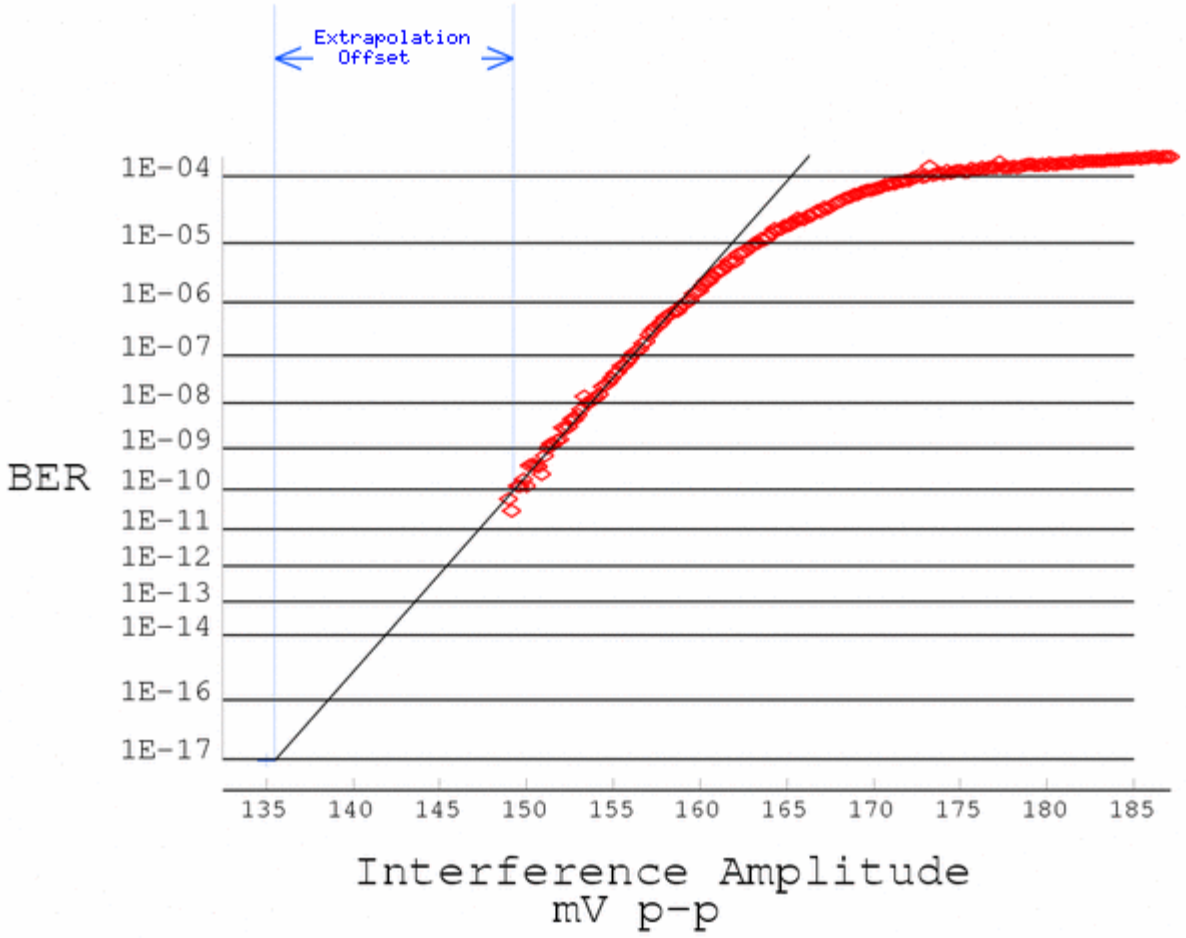


Figure X.5

Proposed Spec:

The frequency of the interference generator is then reduced to 100MHz and the the frequency is stepped from 100MHz to 12GHz At each frequency the interference amplitude is adjusted to give mBER=10^{-10}. At each frequency EIT is computed by subtracting EO from the interference amplitude which give mBER=10^{-10}. At each frequency the frequency and EIT is recorded.

Proposed Spec:

The EIT values are compared to a frequency dependent EIT baseline. The baseline has the value:

$$\text{EIT baseline} = 100\text{mV} \quad \text{for } f < 6\text{GHz}$$

$$= 100\text{mV} * (f/6\text{GHz}) \quad \text{for } f > 6\text{GHz}$$

Such a comparison is shown in Figure X.6.

Proposed Spec:

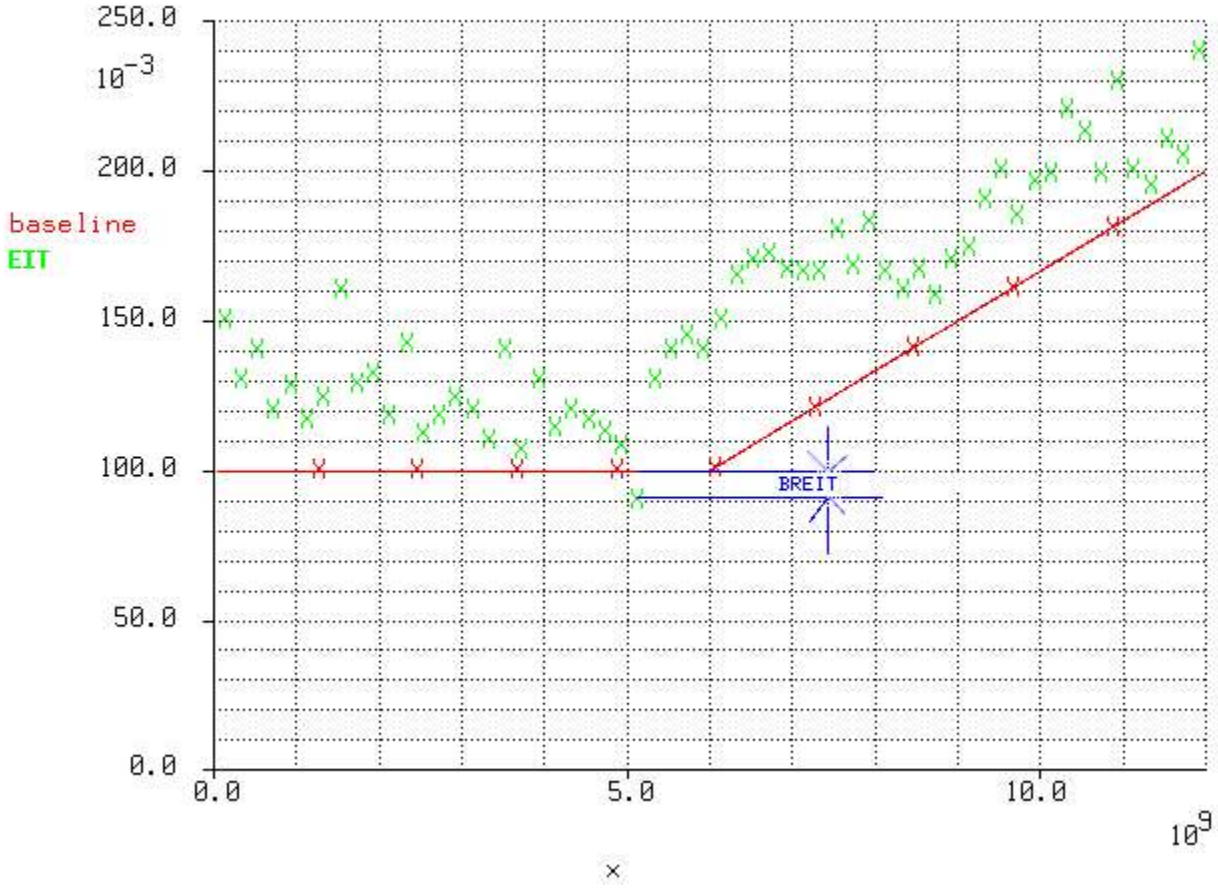


Figure X.6

Proposed Spec:

The lowest EIT relative to the baseline is found and the difference between it and the baseline is the Baseline Relative Extrapolated Interference Tolerance (BREIT). BREIT may be either positive or negative.

Proposed Spec:

1. **The result for the Data like interference is the EIT.**

2. **The result for the sinusoidal interference is the BREIT.**

Comments

This spec is not complete

1. It assumes that the baud rate will be around 10Gb This when a signaling method is selected this may have to change

2. As written it is not a spec on Receivers but on how they are described, there is no EIT limit. We may wish to add a limit, either Normative or Informative, in conjunction with defining the channel, including cross talk limits.

3. It shows two forms of injected interference. We may want to drop one of them.