Crosstalk specification from Interference Tolerance

comment #105

By

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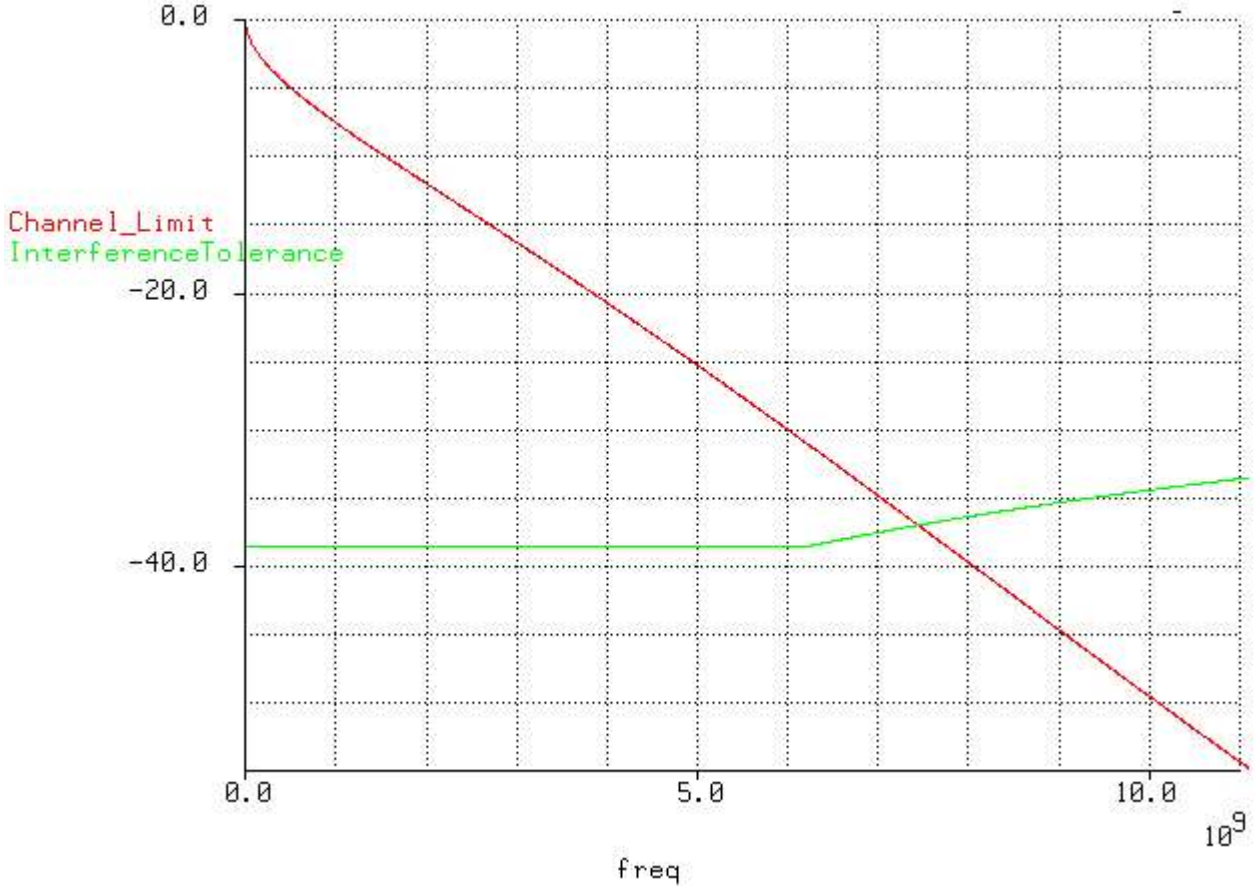
Motivation

How is our Crosstalk spec set? I do not really know.

Let's base the Informative crosstalk spec on the normative Interference tolerance spec, that way channels which meet informative spec really should work. This presentation establishes a direct, mathematical relationship between the Interference Tolerance Test and the Crosstalk Specification.

Let's start by assuming that the data in interfering channels can be, and from time to time, will be (near) square waves at most any frequency up to baud rate/2.

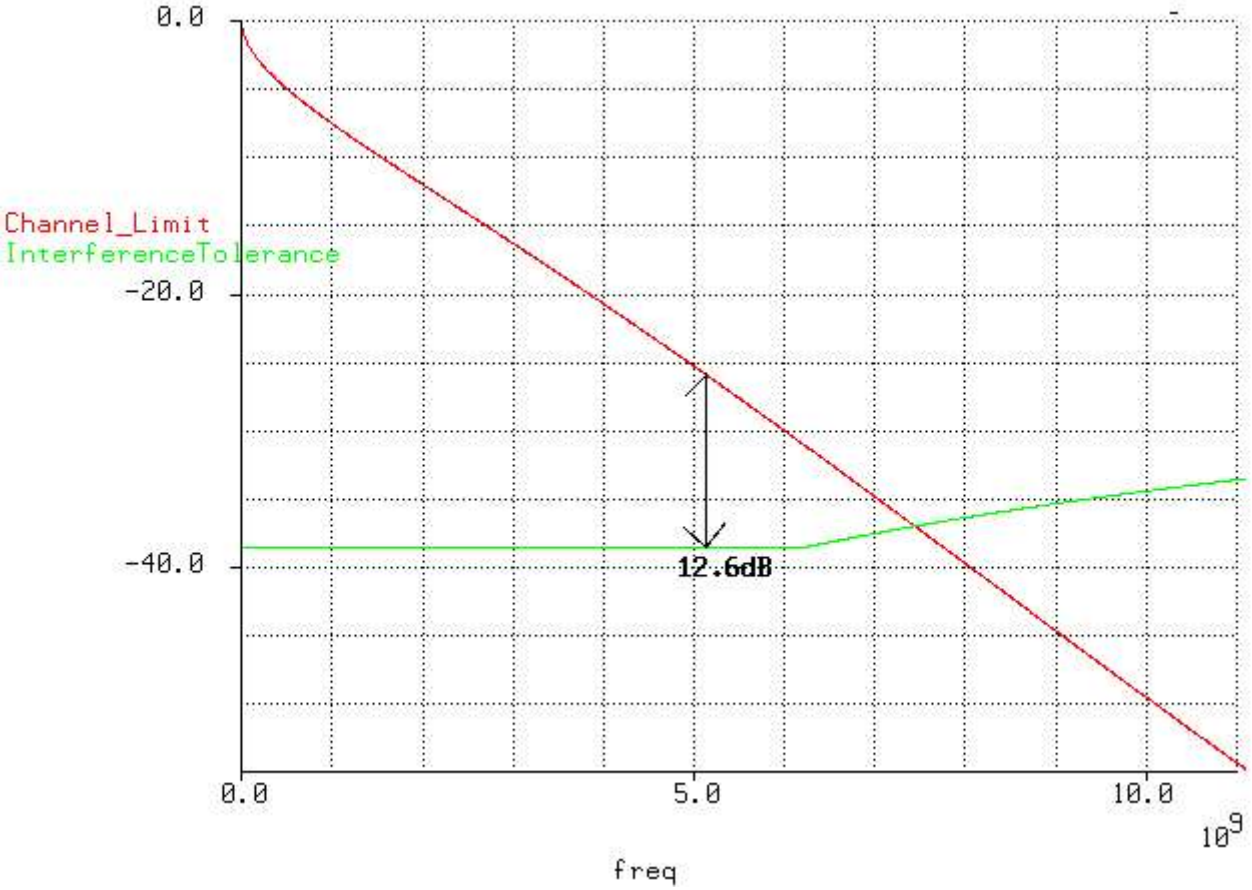
Channel gain limit and Interference Tolerance limit for 10G BASE KR



Interference Tolerance is shown relative to the sinusoidal component of a 1V p-p square wave.

The Interference tolerance spec is flat over most of the frequency range. Measured interference tolerance tends to be flat as well. This indicates that Rx's are disrupted similarly by noise of the same energy level of different spectral types. For example, it seems reasonable to expect that broadband and sinusoidal noise of the same energy would disrupt the Rx the same.

Therefore I think that the total crosstalk spec should be flat. This ensures that the informative crosstalk spec allows the maximal possible crosstalk that the Rx can handle. In keeping with ACR approach, I suggest that the crosstalk spec be referred to the thur channel gain, specifically $A(F_{Nyquist})$**, the best linear fit to the channel gain, evaluated at half the data rate.**


0.0
Channel_Limit
InterferenceTolerance
-20.0
-40.0
12.6dB
0.0
5.0
10.0
10^9
freq

In specifying crosstalk I want some margin to allow for thru channel reflection which will look somewhat like crosstalk and produce more stress than the presumably clean compliance channel used in interference tolerance testing. Therefore specify:

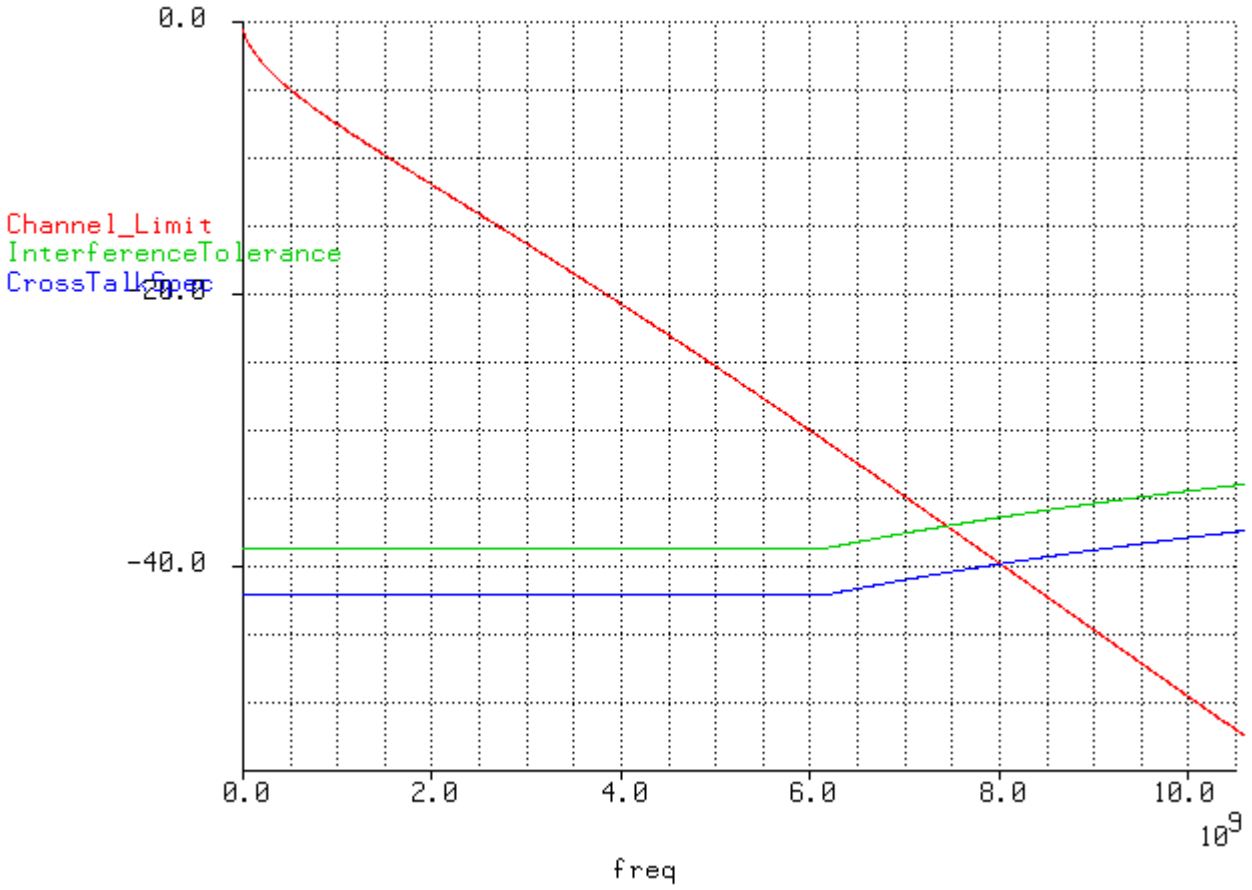
$$PSXT < -(A(SignalSpeed/2)+16) \qquad f < 0.6 * SignalSpeed$$

$$PSXT < -(A(SignalSpeed/2)+16)+20*\log\left(\frac{f}{(0.6*SignalSpeed)}\right) \qquad SignalSpeed > f > 0.6*SignalSpeed$$

This Should replace 69.3.3.5.4 and may go into 69.3.3.5.3

Note: as defined, PSXT is negative while A(f) is positive.

Channel limit
Interference tolerance
and Crosstalk spec



Some Q&A

Some Q & A

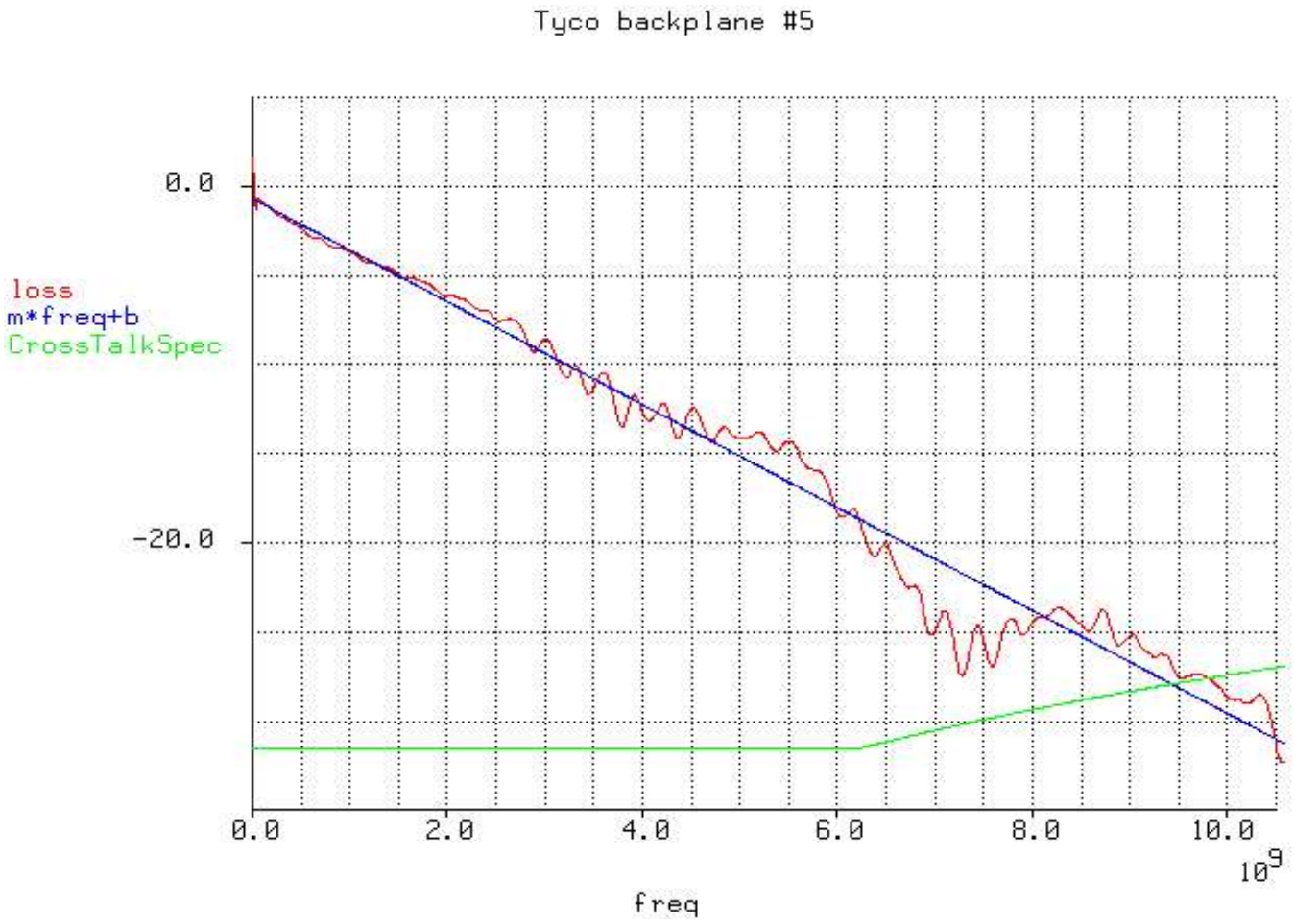
Q. Isn't 3.4dB excessive margin?

A. I do not think so. Unless we control Rx, Tx, and channel Return Loss, reflections may be a worse problem than crosstalk.

Some Q & A

Q. Are we stuck with 42dB PSXT

A. No this value is for very lossy (long) channels for lower loss channels the allowable PSXT rises. For instance in TYCO channel 5:



Crosstalk spec is now -31.5dB

Some Q & A

Q. Interference tolerance and using it to define crosstalk limit assume sinusoidal interference, but real crosstalk in noise-like, is this OK?

A. Well sort of. We assume that sinusoidal interference, which is always there, is a reasonable analog for a noise-like signal which has larger but rare peaks. This will be a useful approximation assuming

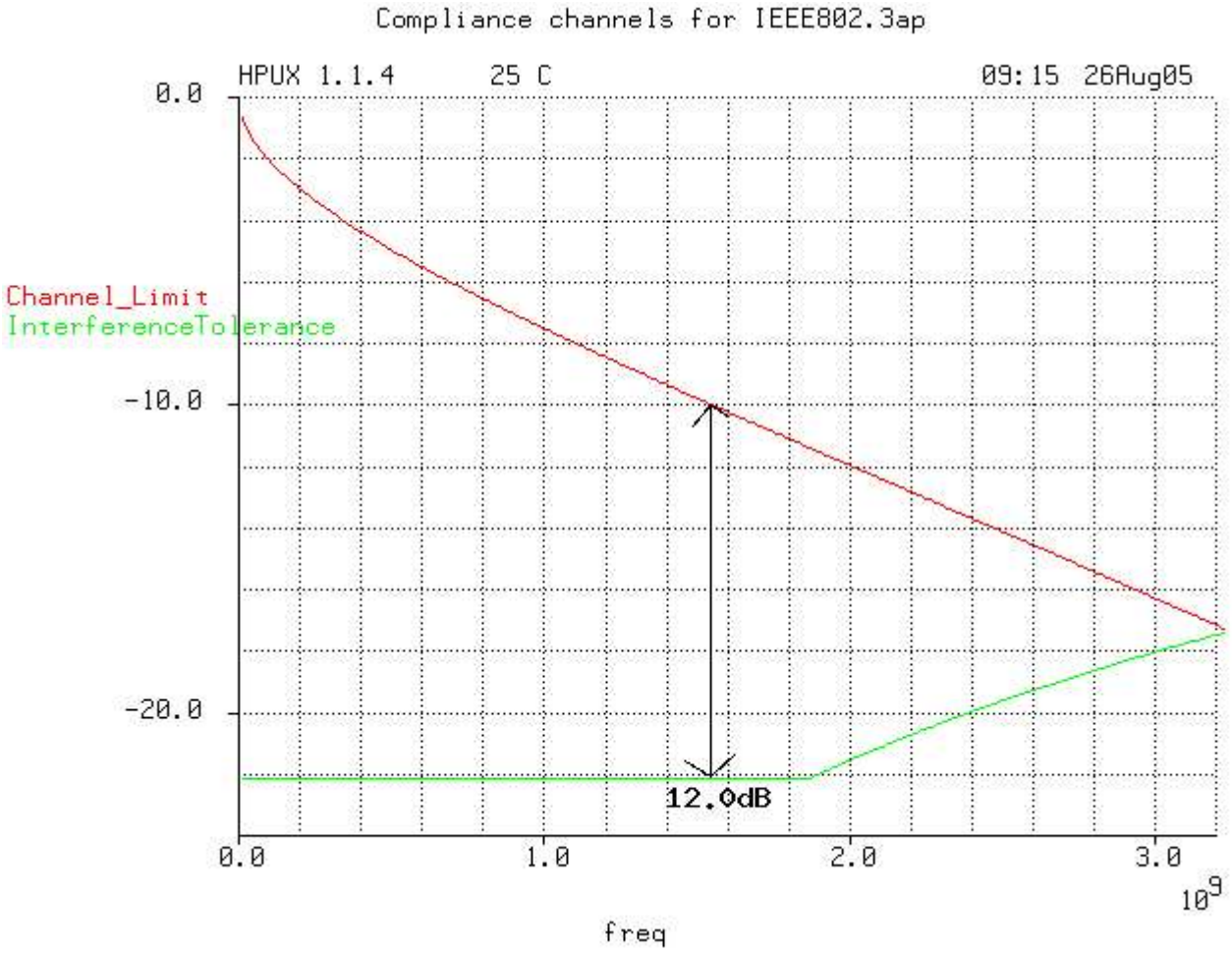
1. We use the correct ratio
2. The upper and lower boundaries of the Rx EYE are thick relative to the opening.

Some Q & A

Q. Should the crosstalk limit scale with thru gain at Nyquist? Shouldn't it scale with some lower frequency which will change less from long to short channels?

A. I have not done a lot of experiments yet on interference tolerance vs channel loss, but the 10G BASE KX4 spec is just about right where you would expect if interference tolerance scales as I assume:

Channel gain limit and Interference Tolerance limit for 10G BASE KX4



Specifying Channel Attenuation

comment #103

As defined the Compliance channel for Rx Interference tolerance testing may have to have excessive attenuation, significantly worse than worse case informative channel model, to get all ripple components below the spec line.

Solution: specify that a smoothed approximation to the attenuation be below the spec line ($A_{max}(f)$)

I suggest that we approximate the compliance channel by a LMS fit to

$$A(f) = m * A_{min}(f) + b$$

find m and b by:

$$mx = \int_{f1}^{f2} A_{min}(f) * df/(f2 - f1)$$

$$my = \int_{f1}^{f2} IL(f) * df/(f2 - f1)$$

$$mxy = \int_{f1}^{f2} IL(f) * A_{min}(f) * df/(f2 - f1)$$

$$mxx = \int_{f1}^{f2} A_{min}^2(f) df/(f2 - f1)$$

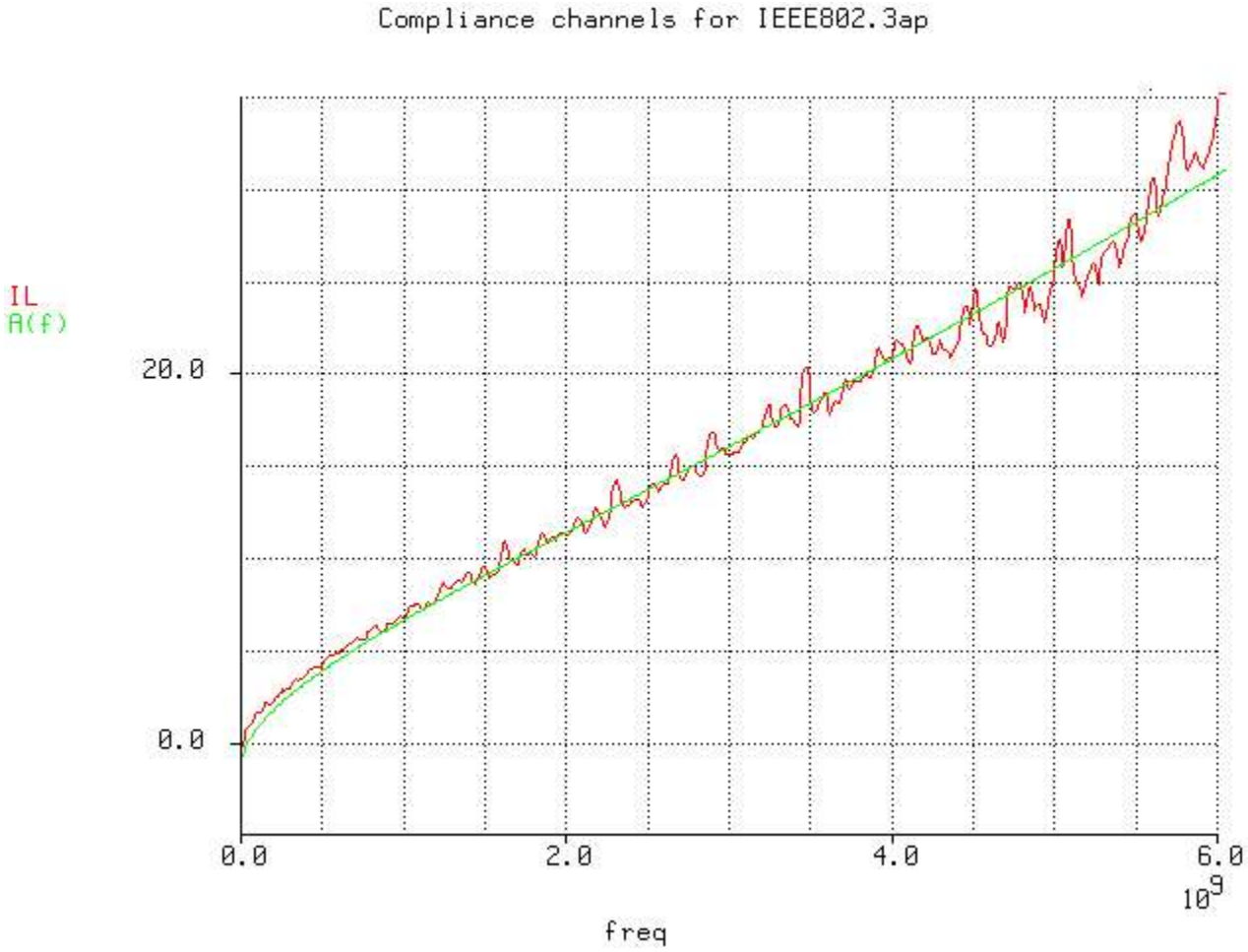
$$m = (mxy - mx * my)/(mxx - mx * mx)$$

$$b = my - m * mx$$

If m >= 1.0 then the attenuation is generally greater than A_{min} and the compliance channel meets spec. If b > 2 and a transmitter, or instrument being used in liu of a transmitter, is capable of it, the transmitter amplitude may be raised (b-2)dB above the maximum level which would otherwise be allowed, to compensate for excess DC loss in the compliance channel

If this specification is accepted, ISI loss becomes unnecessary and all references to it and min ISI loss (in Tables 70-8, 71-8 and 72-10) should be deleted.

Below is a plot of the attenuation used in the test shown in sawyer_10_0905 and the fitting curve, with m=1.07 and b=1.4


Compliance channels for IEEE802.3ap
IL
A(f)
20.0
0.0
0.0
2.0
4.0
6.0
10^9
freq

Remarks on comment 106

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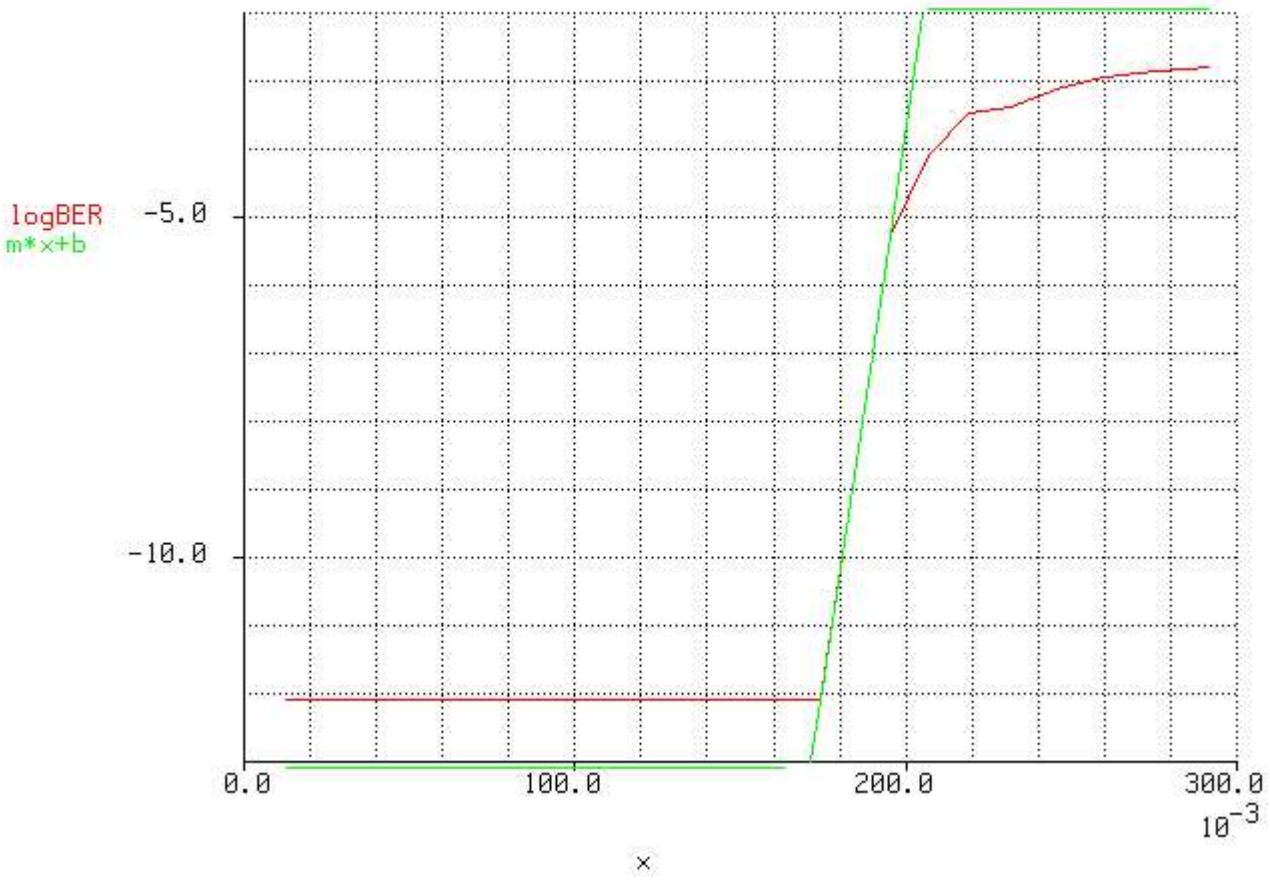
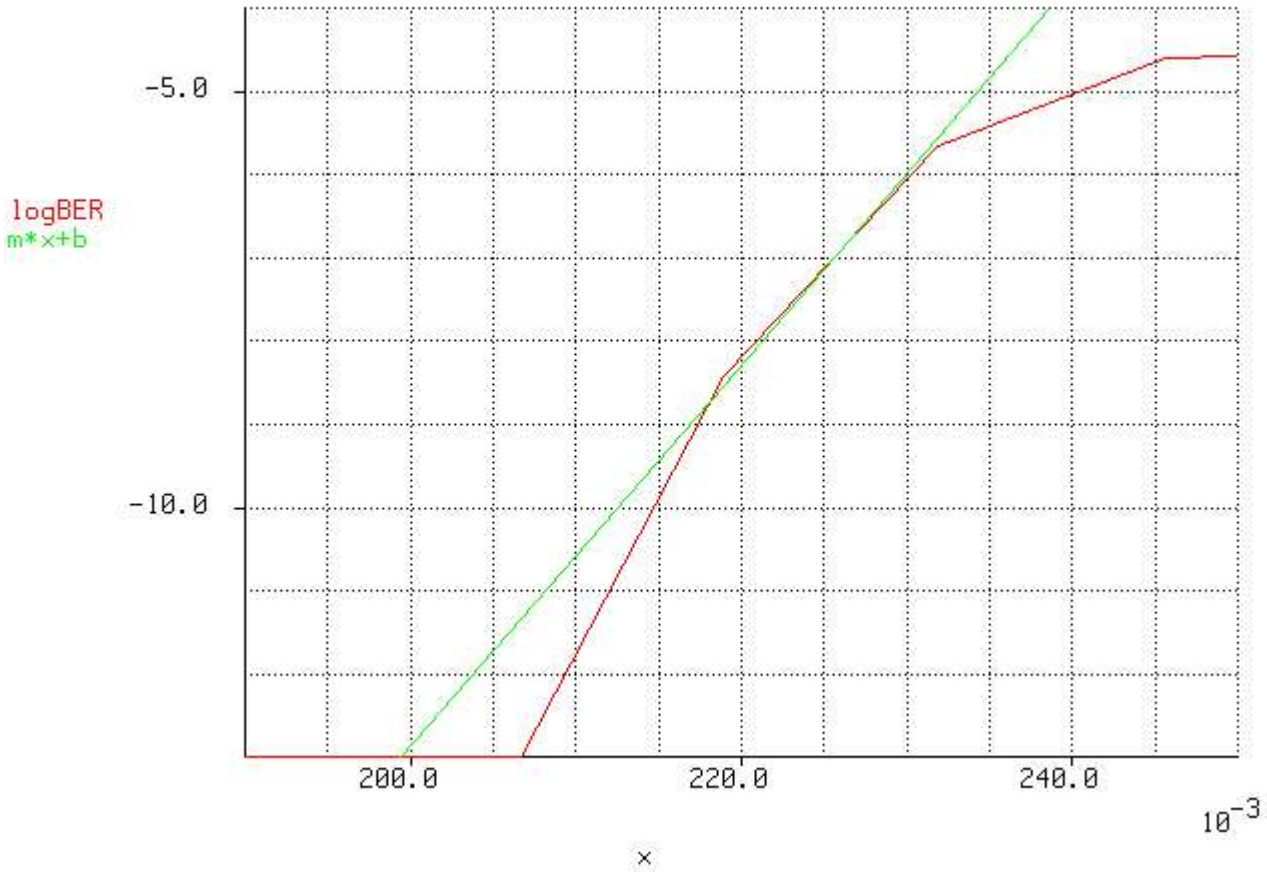
I suggest that extrapolation be required but the exact method not be required. Generally, as the accuracy of the method improves EO gets smaller and the Rx looks better, but by small amounts.

I have found in the limited number of cases I have looked at that the measured data from the amplitude sweep looks pretty good for extrapolation from about 3*Standard BER to BER=1e-6. The slide below show 3 cases of linear extrapolation in log(BER) using this range and LMS fitting.

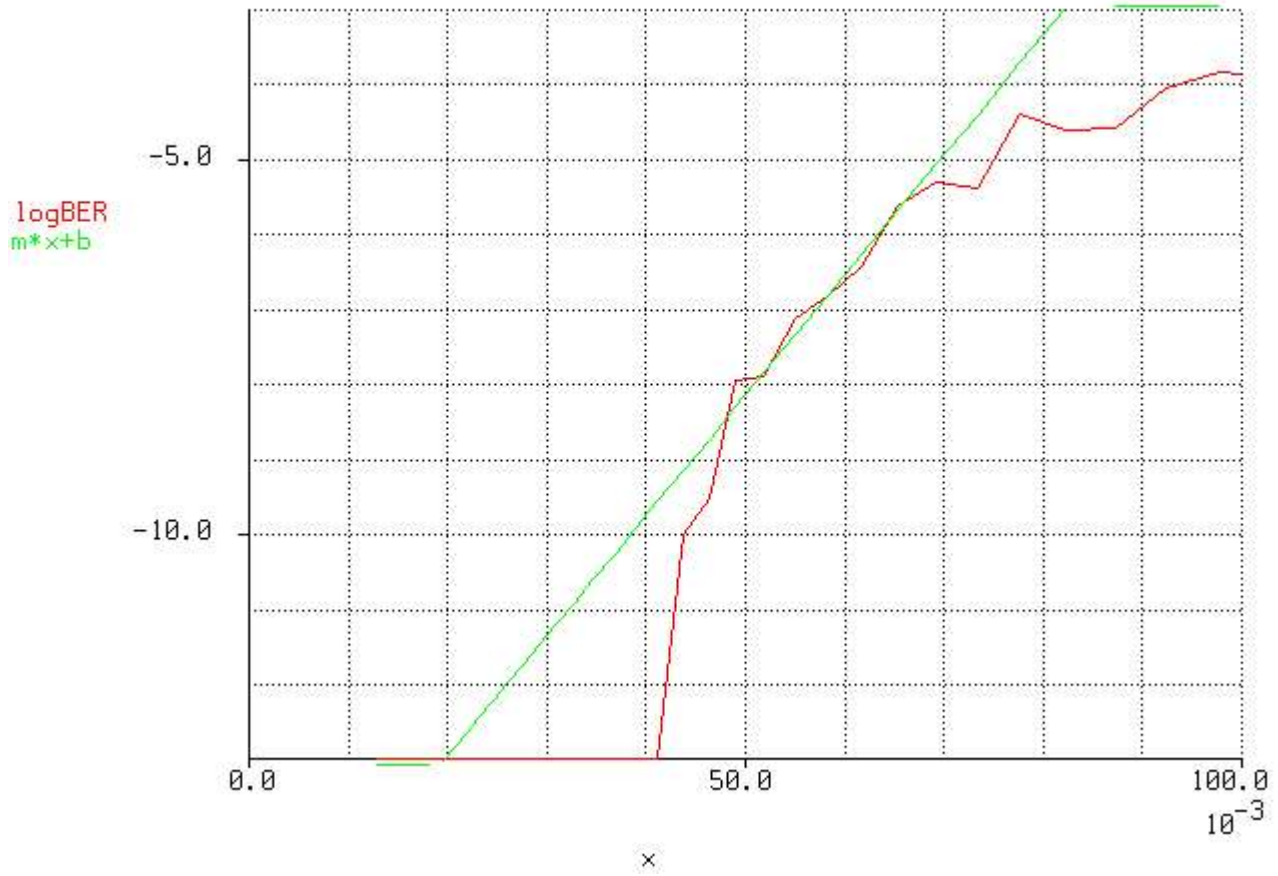
# A 1000BASEKX transceiver
EO = 9.0mV



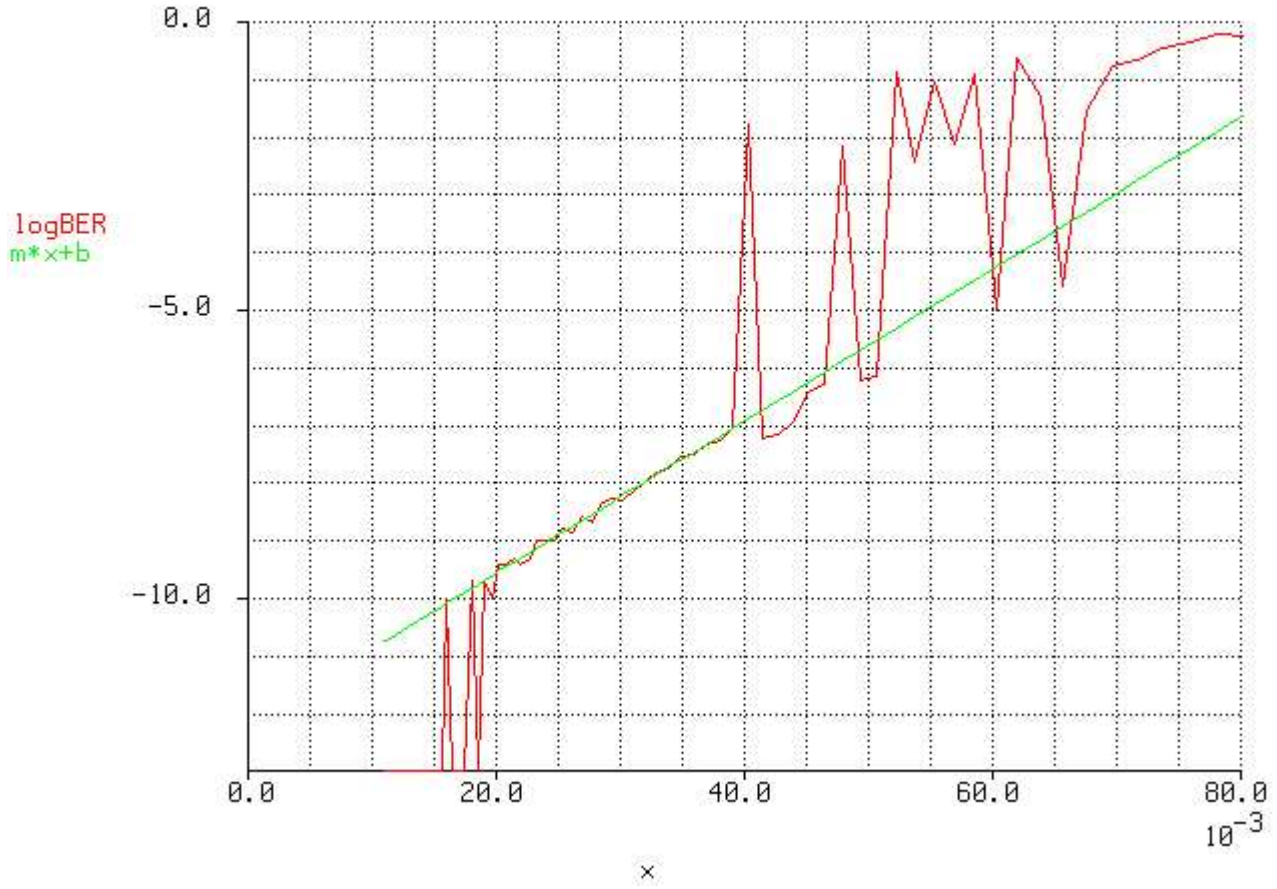
A 10GBASEKX4 transceiver
EO = 12.0mV



A 6.25Gb transceiver simulating 10GBASEKR
EO = 14.0mV



A 10GBASEKR transceiver
EO = 14.0mV



Propose text:

Extrapolate the interference-BER data to a BER of 10^{-12}. The difference between the interference at standard BER and the extrapolated value at 10^{-12} is the extrapolation off-set (EO). The extrapolation can be done several ways. A suggested way is by a linear LMS fit to the data from a BER of 3*standard BER to a BER of 10^{-6}. Another way which is likely to give slightly more accurate and optimistic results is to use a quadratic LMS fit to the data from a BER of 3*standard BER to a BER of 10^{-6}.