Specifying Crosstalk

Charles Moore
2005 March 8

Agilent Technologies

Outline:

1. Goals
2. Method
3. Results
4. Disclaimer
5. Analysis
6. Conclusions

Goal:

I want to specify Crosstalk from crosstalk channel S-parameter magnitudes only. This allows:

1. Crosstalk determination without conversion from frequency to time domain
2. Separation between channel specification and Receiver and Transmitter return loss by:

   •Specifying limits on magnitude of Rx, Tx return Loss.

   •Treating channel reflections as “Re-reflection interference.” see moore_01_1104

More on Goal

I want to separate the Rx, Tx return loss from the channel return loss since they are provided by different vendors. This separation will work best when using signal-budget system specification.

Method

1. Examine integrals of the product of the crosstalk SDD21 times the spectral density of the expected aggressor signal.
2. Compare these measures with results of PDF convolution at BER=10^{-12} as described in moore_c1_0305.pdf, which I treat as a standard.
3. Also look at simplified time domain measures.

Method

- The spectral density of the expected aggressor signal I used in the integrals is the product of two terms, a sinc function, to represent the pulse excitation of the channel and a transformed peaking function, which corrects for expected peaking (Tx de-emphasis) in the aggressor . If:

$$\tau = 1/10.3125\,\mathrm{GHz}$$

$$a = \text{Tx de-emphasis (I assume -10dB)}$$

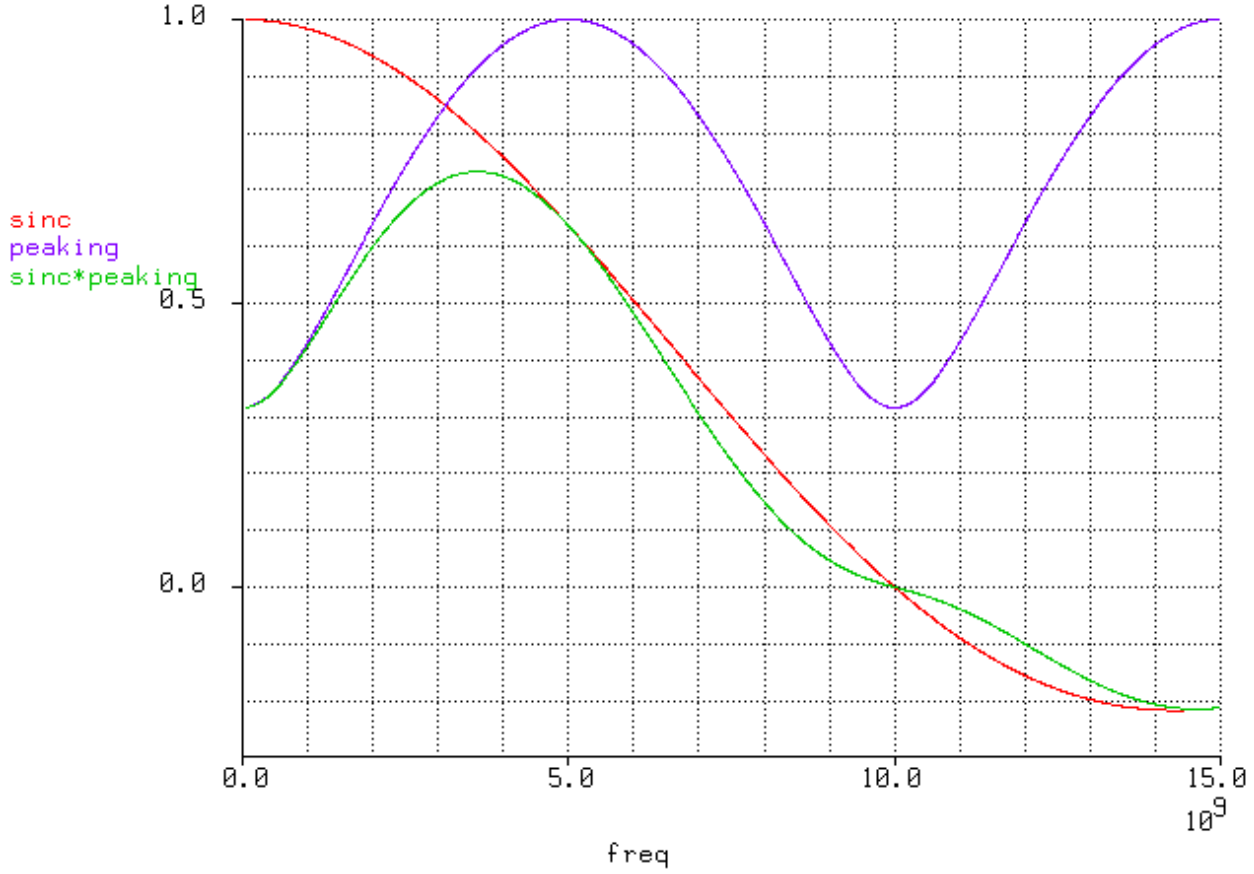
Method: weights

Then

$$\mathrm{sinc} = \sin(\pi \cdot f \cdot \tau)/(\pi \cdot f \cdot \tau)$$

$$\mathrm{Peaking} = \sqrt{(1 + a^2 + (1 - a^2) * \cos(2 \cdot \pi \cdot f \cdot \tau))/2}$$

Method: Signal Power functions



Method

$$S_W = SDD21_{crosstalk} \cdot sinc \cdot peaking$$

$$Int1 = \int_0^{15GHz} S_W \cdot \tau \cdot df$$

$$Int2 = \int_0^{15GHz} S_{W^2} \cdot \tau \cdot df$$

$$FpeakSum = \sum_{aggressors} Int1$$

$$rootPowerSum = \sqrt{\sum_{aggressors} Int2}$$

Method:

Proposed metrics are:

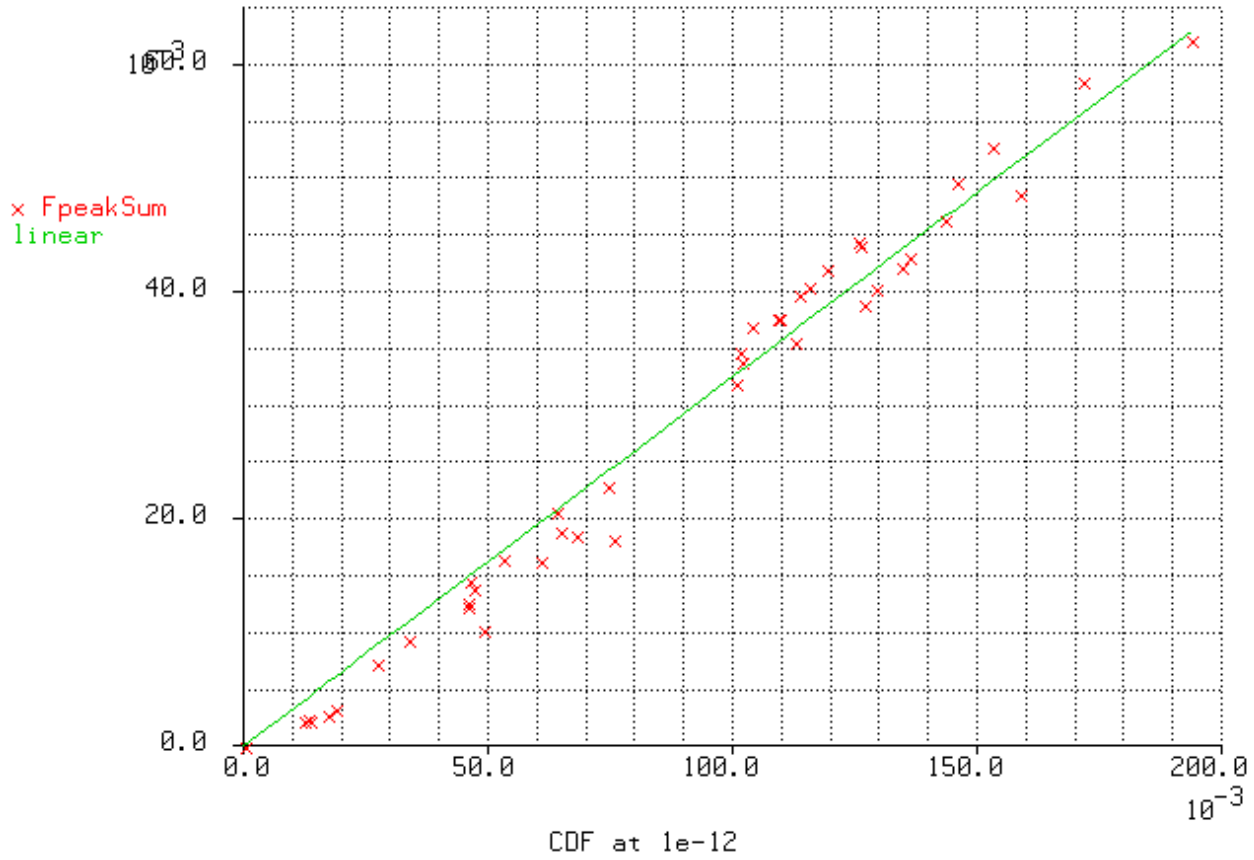
1. FpeakSum
2. rootPowerSum
3. rssPeak per popescu_1_02-5
4. Peak Interference per moore_1_0704

Method

Peak interference at BER=10^{-12} and the 4 candidate metrics were evaluated for:

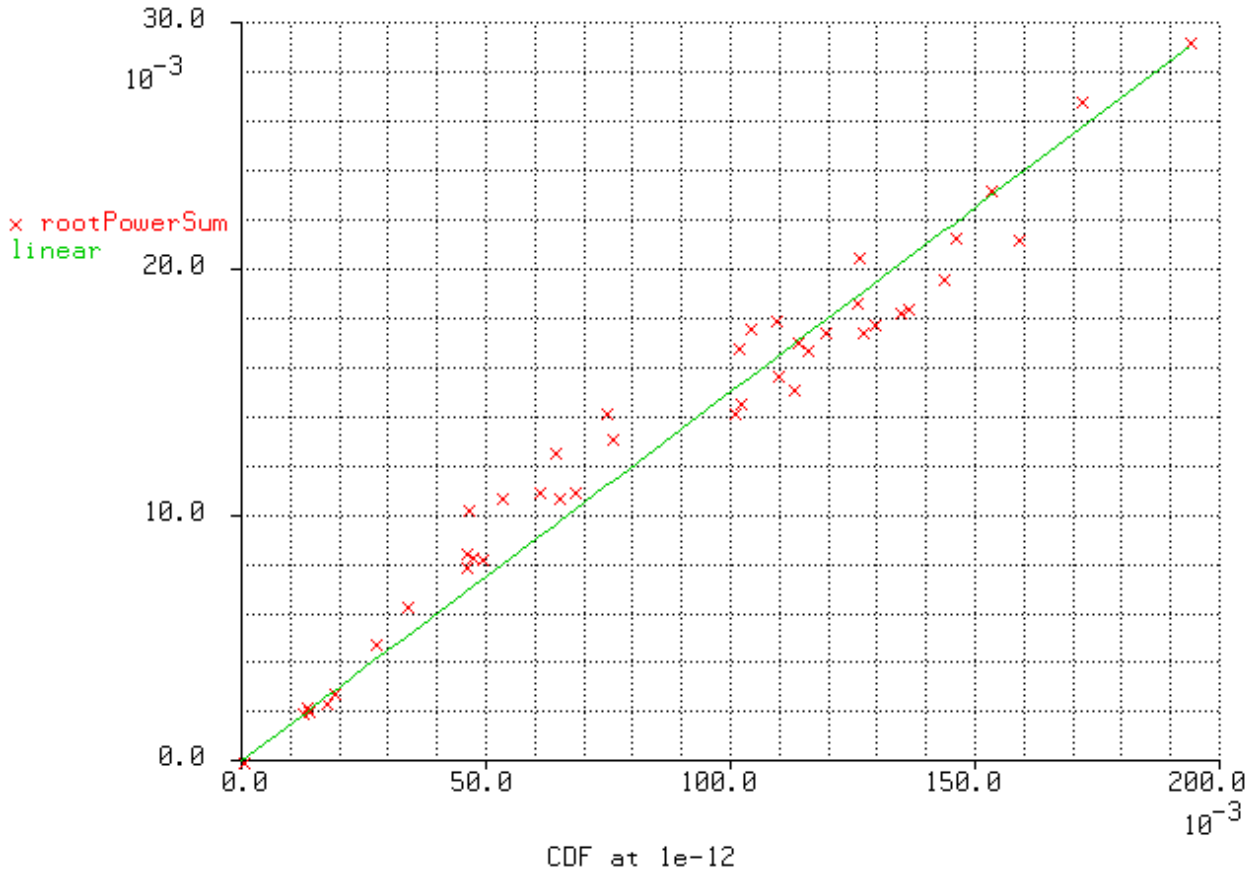
1. 6 d'Ambrosia channels with 2-3 aggressors each
2. 9 McCallum channels with 7 aggressors each
3. 18 Peters channels with 8 aggressors each
4. 9 Goergen channels with 2 or 8 aggressors each

Results:



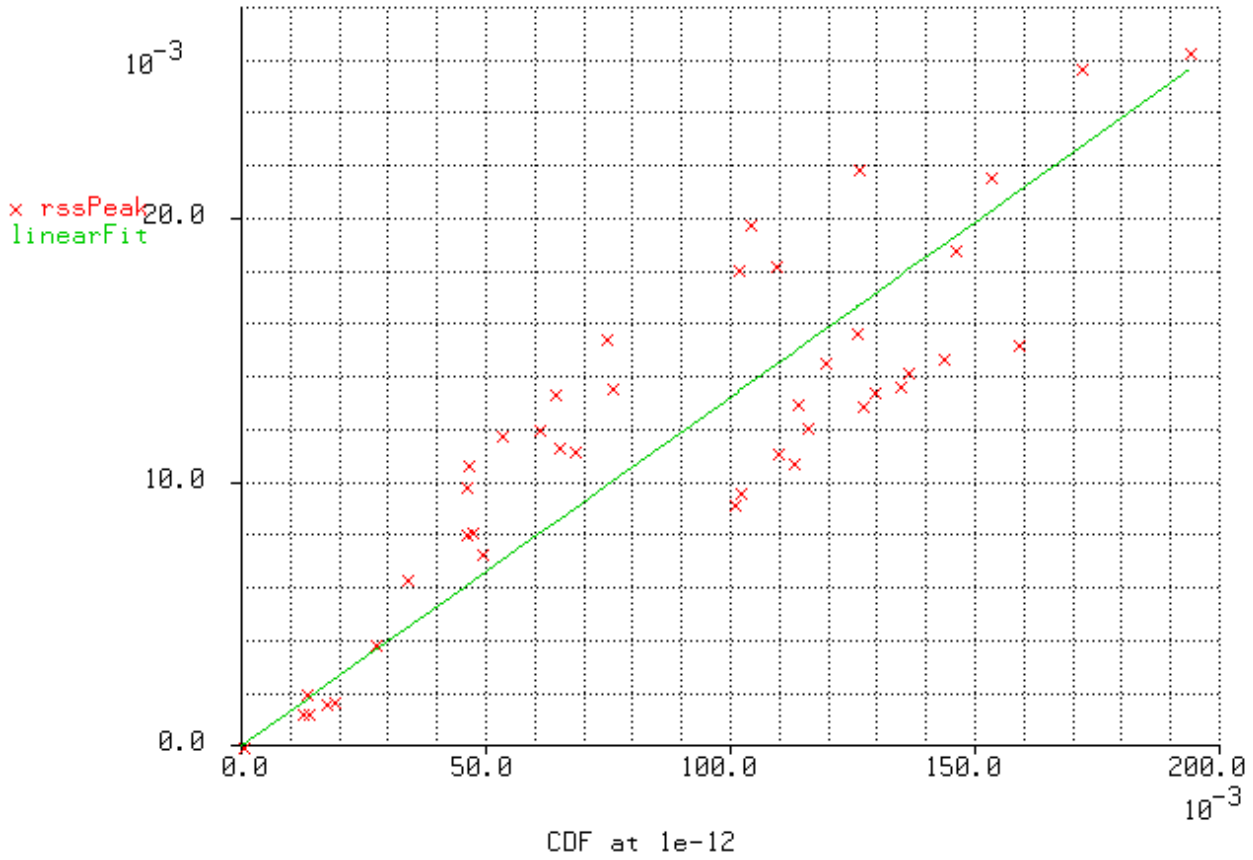
FpeakSum vs CDF at 10^{-12}

Results:



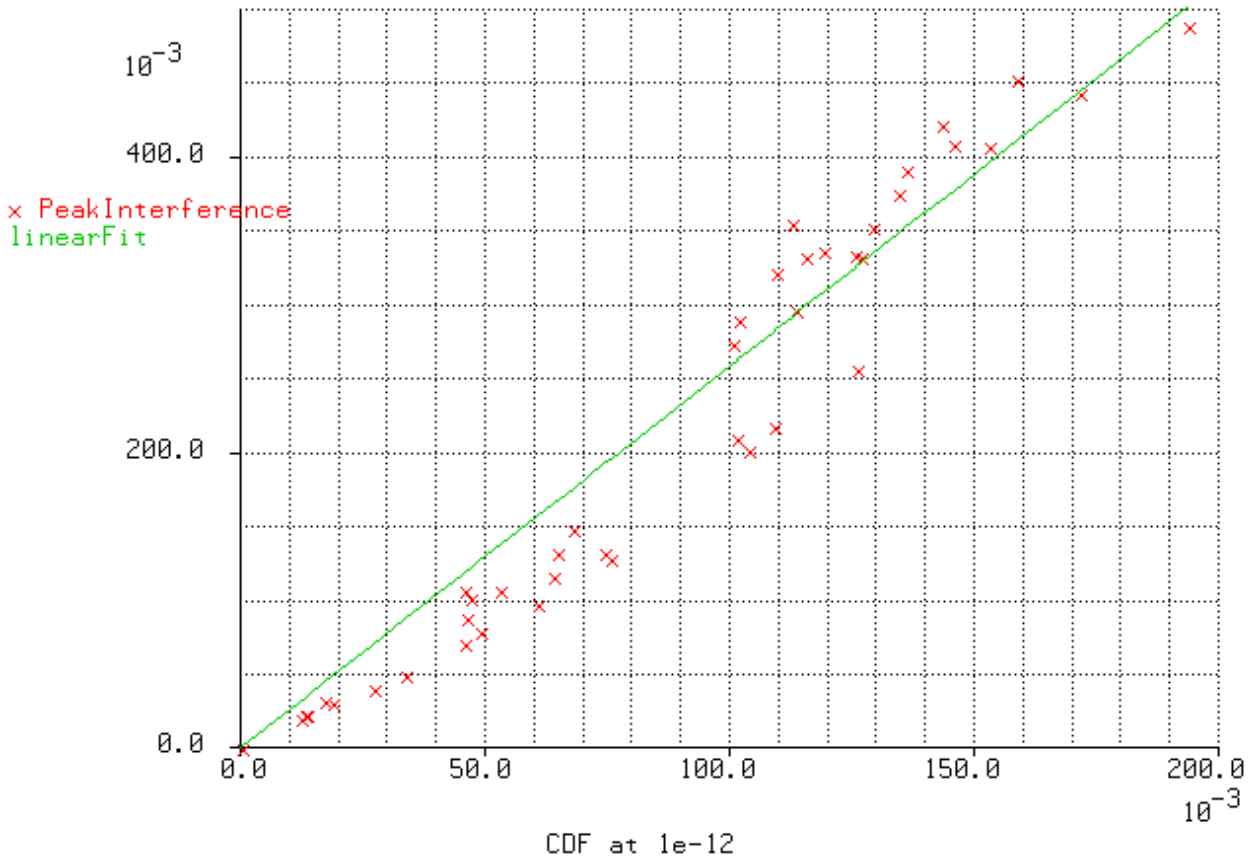
rootPowerSum vs CDF at 10^{-12}

Results:



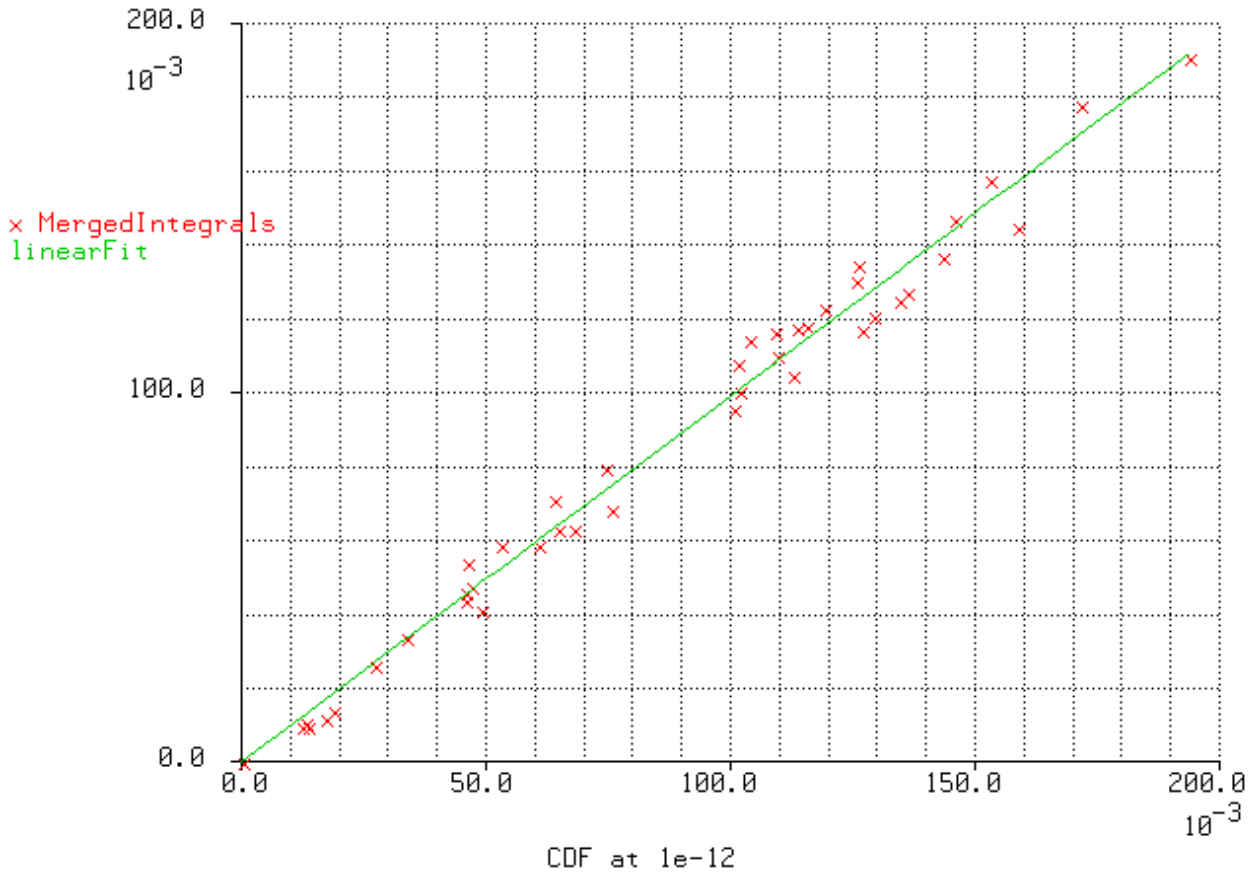
rssPeak vs CDF at 10^{-12}

Results:



PeakInterference vs CDF at 10^{-12}

Results:



summed Frequency domain measurements vs CDF at 10^{-12}

Disclaimer:

1. This presentation “proves” nothing, it just shows that some methods seem to be reasonably accurate over the largest and broadest set of data readily available.
2. The Convolution method I use as a standard is only valid if the aggressor and victim operate with a frequency offset. This will generally not be true and some crosstalk channels show almost a 2:1 variation in crosstalk at the center of the EYE depending on phase between victim and aggressor.

Analysis:

1. Either of the frequency domain methods correlates fairly well with the convolution method.
2. A weighted average of the 2 frequency domain methods correlates a bit better still.
3. The two time domain methods give poorer correlation.

Conclusions

I recommend that

- We use a weighted sum of *FpeakSum* and *rootPowerSum* to specify crosstalk.
- We use the re-reflection method spelled out in moore_01_1104 to define an equivalent crosstalk due to interactions between the return losses of the channel and the Rx and Tx and lump it into the crosstalk spec.