Crosstalk Summation on 10G Channels

Brian Von Herzen, Ph.D.

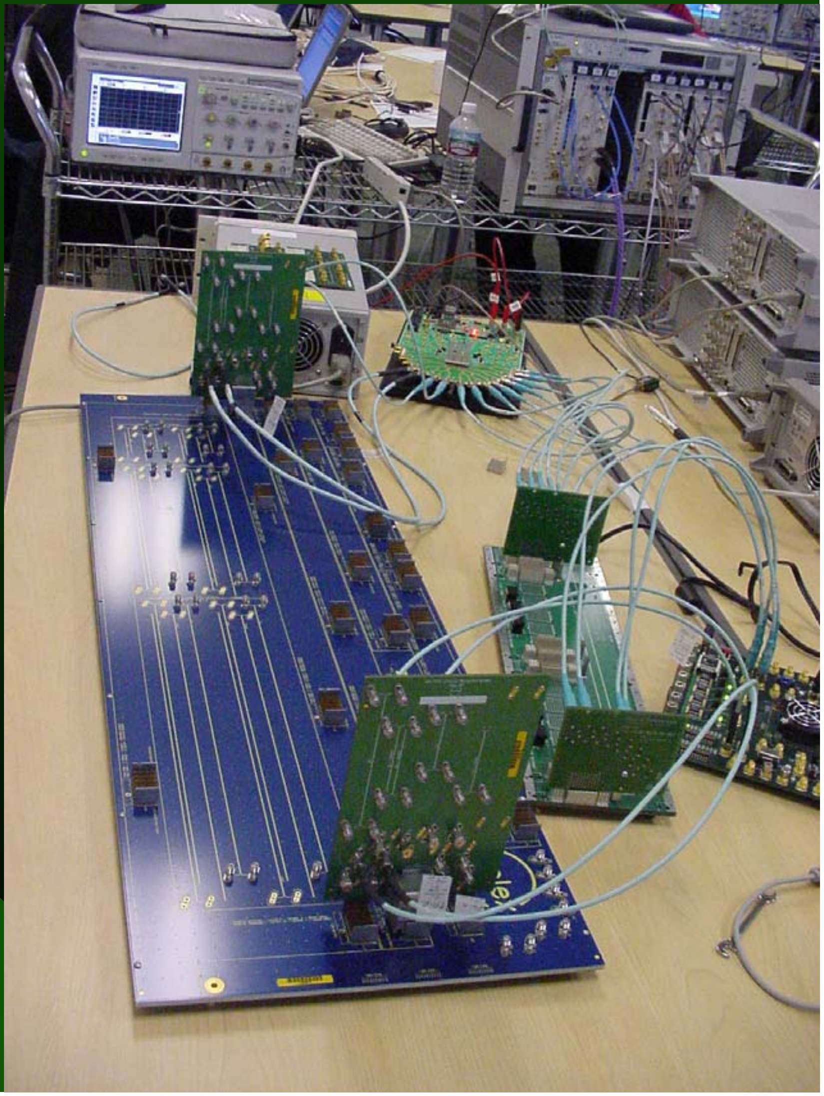
www.FPGA.com

+1 775-790-5000

Brian@FPGA.com

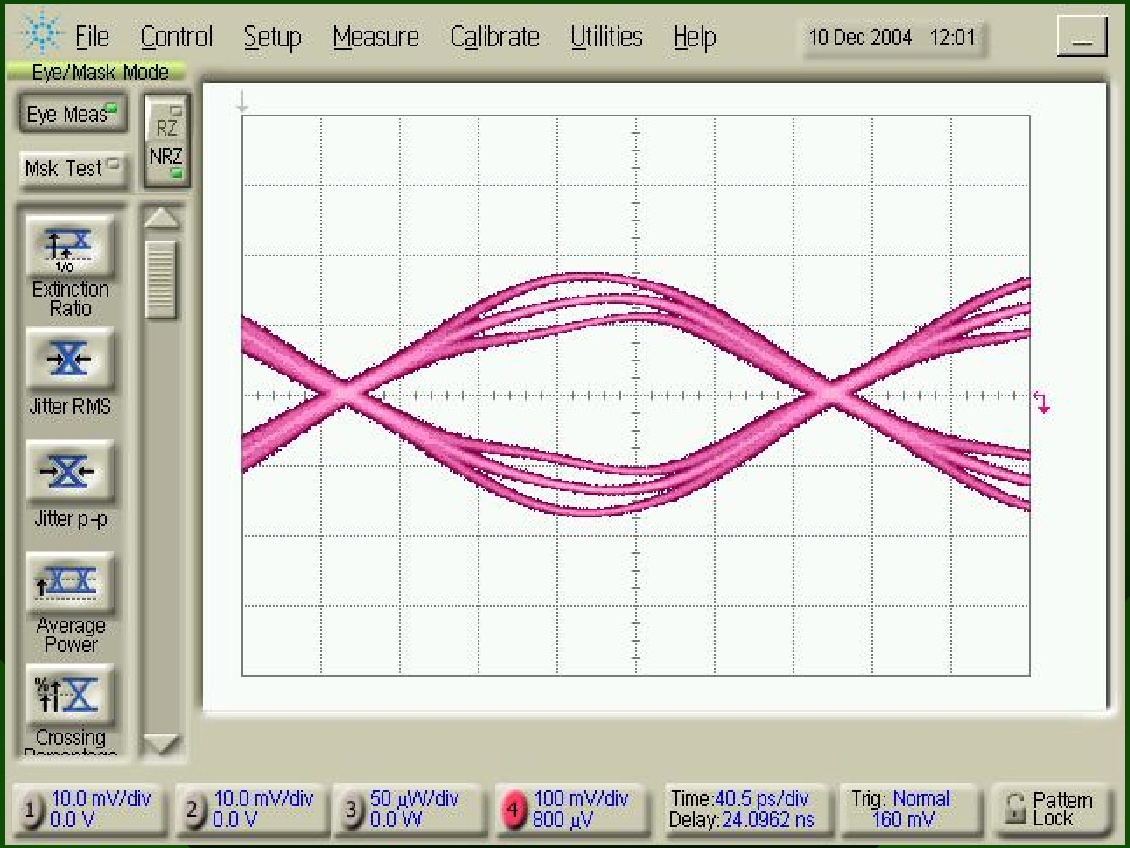
How should we sum crosstalk for our 10G channels?

- Three cases to consider
- 1. Frequency locked
- 2. Plesiochronous frequency locked (
  - 100 ppm)
- 3. Random frequency.
- Let's consider each of these 3 cases separately.



Case #1: Frequency Locked Crosstalk

- Frequency locked crosstalk subtracts directly from the voltage margin of an eye



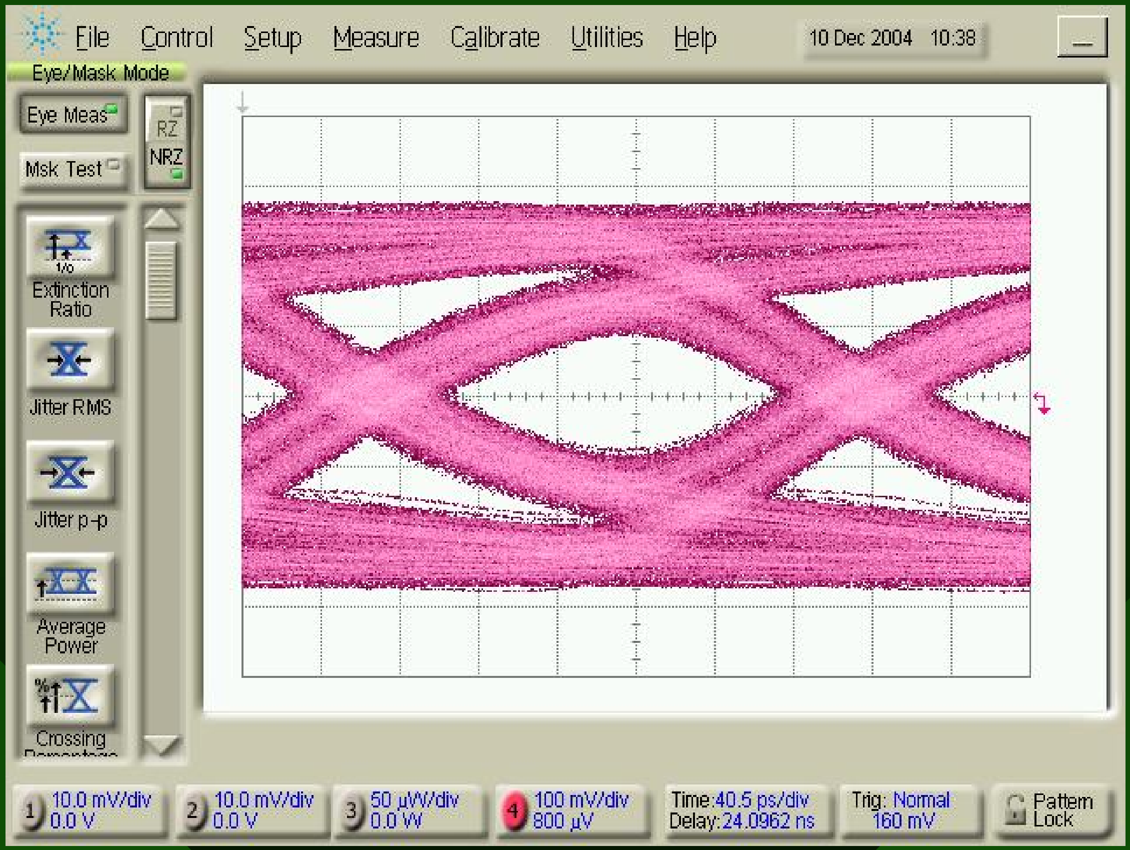
- Courtesy Tim Tan, Ransom Stephens, Agilent
- This example shows a clock signal with an aggressor data signal that is pi/2 out of phase with the clock signal.

Case #1: Frequency Locked Crosstalk

- If the crosstalk sources are frequency locked, their fields superimpose linearly and they subtract linearly from the output margin.

Case #1: Frequency Locked Crosstalk

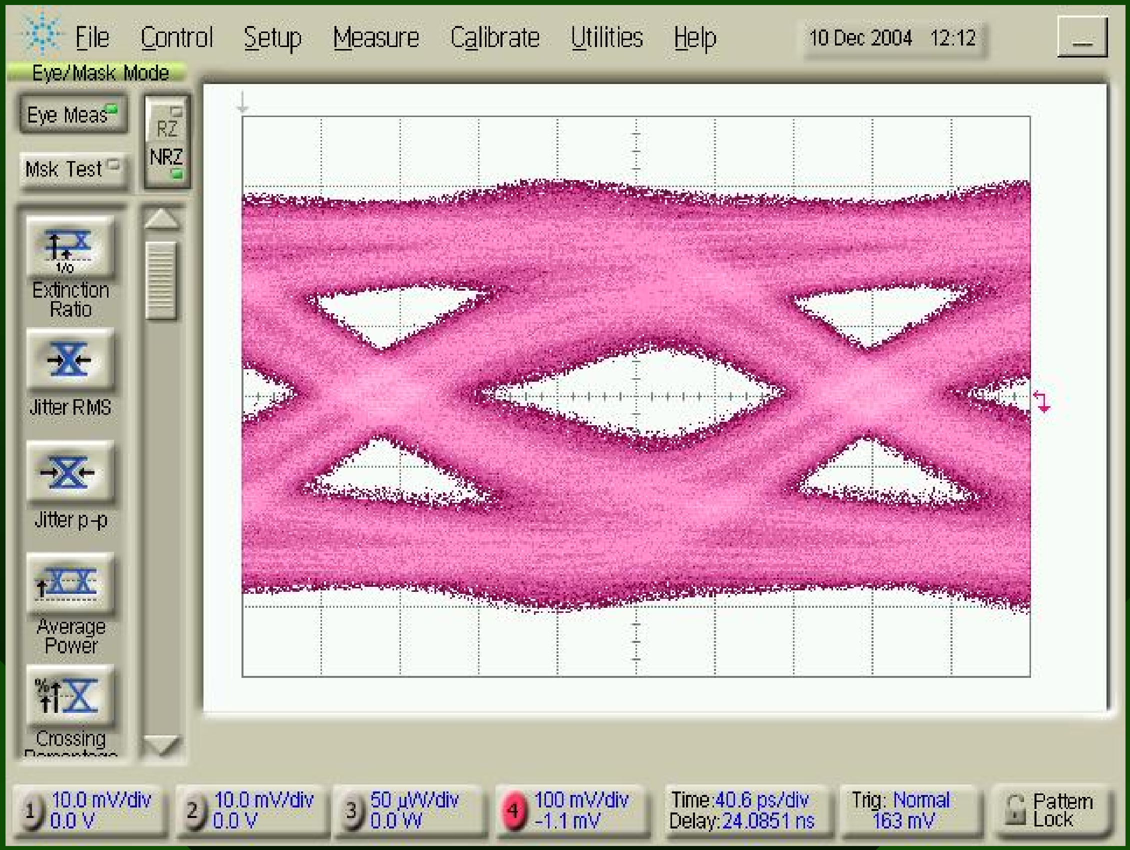
- Data gets affected in a way similar to the clock example:
- Courtesy Tim Tan, Ransom Stephens, Agilent



- This example shows a data signal with no crosstalk.

Case #1: Frequency Locked Crosstalk

- Data gets affected in a way similar to the clock example:
- Courtesy Tim Tan, Ransom Stephens, Agilent



- This example shows a data signal with an aggressor data signal that is pi/2 out of phase from the victim data signal.

Case #1: Frequency Locked Crosstalk

- Frequency locked crosstalk subtracts directly from the voltage margin of an eye
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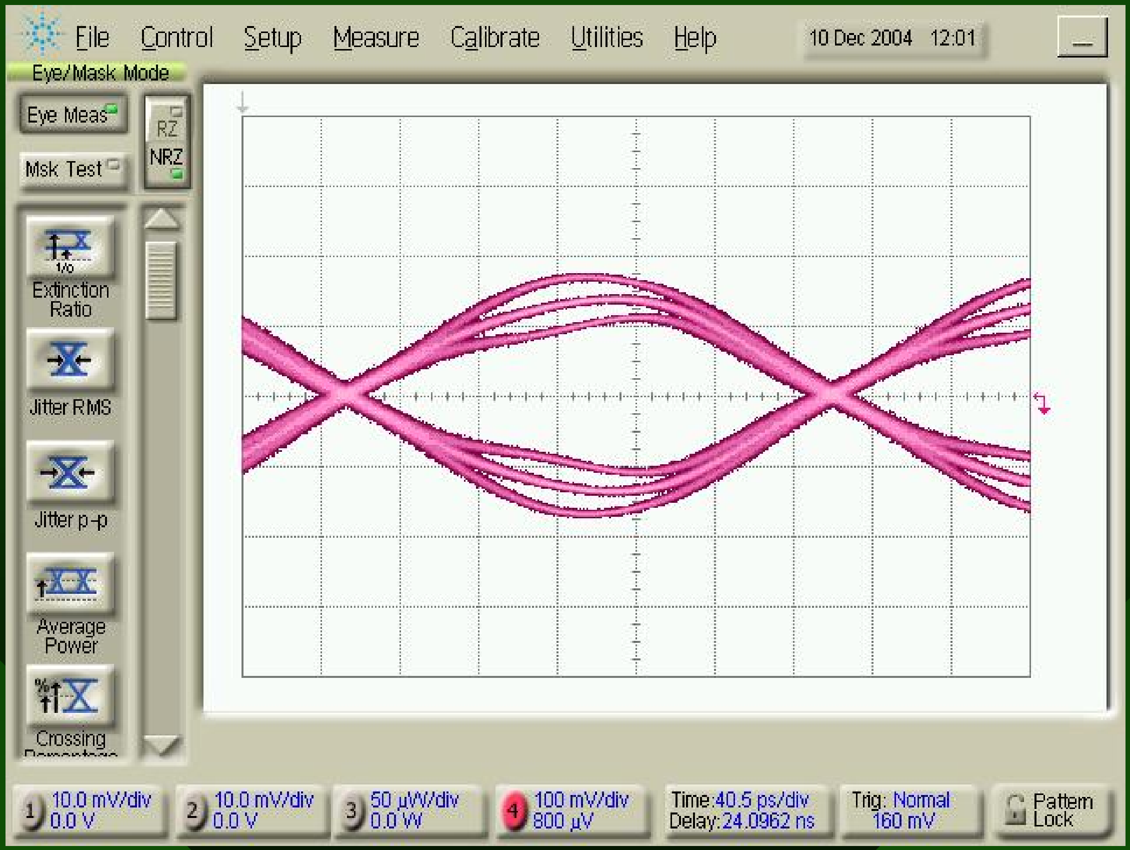
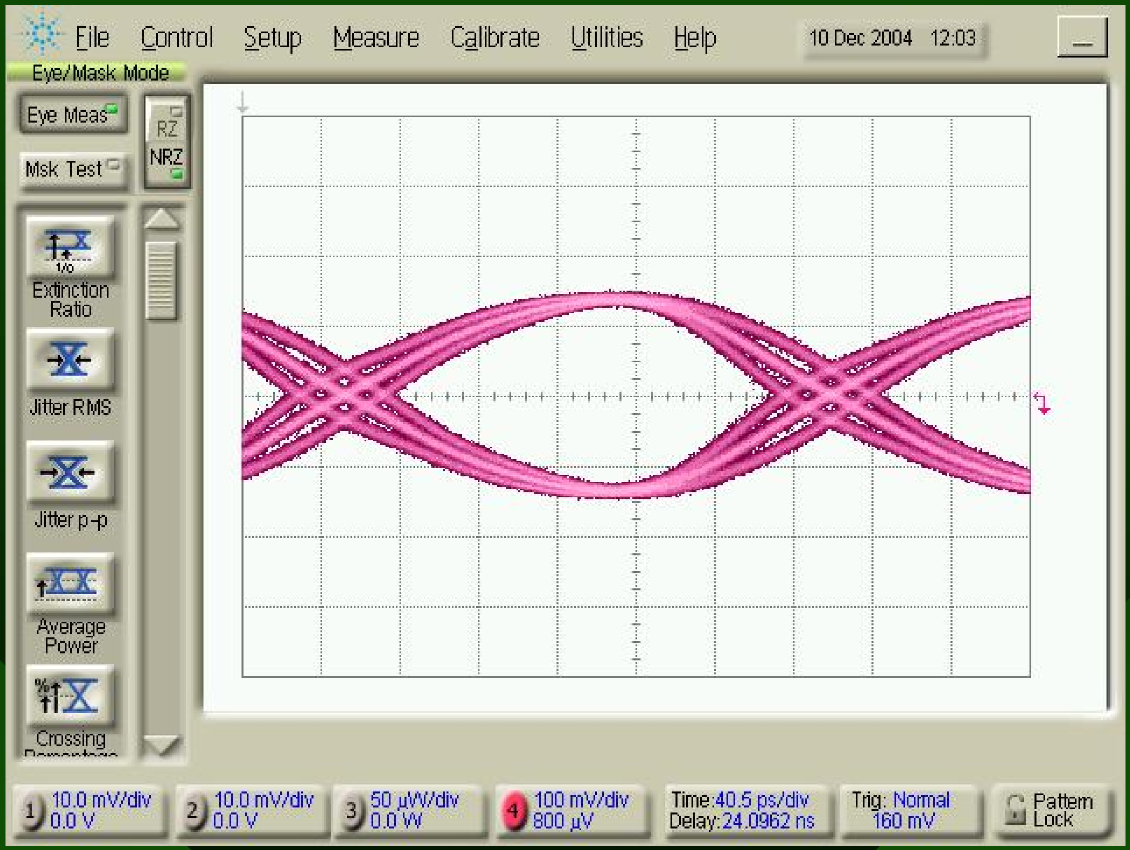


- This example shows a clock signal with an aggressor data signal that is pi/2 out of phase with the clock signal.

Case #1: Frequency Locked Crosstalk

- In-phase crosstalk affects the jitter margin of the eye more than the voltage margin
- Courtesy Tim Tan, Ransom Stephens, Agilent



- This example shows a clock signal with an aggressor data signal that is in phase with the clock signal.

Case #1: Frequency Locked Crosstalk Analysis

- Aggressor data signals can either be rising, falling, or transitionless
- Aggressor data can be in phase or out of phase.
- Random data has 25% probability of a rising transition
- 10G data has a 25% probability of being in phase with other aggressors assuming >0.25 UI transition time

Case #1: Frequency Locked Crosstalk Analysis

- Assume 4 nearest-neighbor aggressors:
- They have 25% probability of transitioning in the same direction.
- They have 25% probability of being in the same phase
- = (1/4)^4 * (1/4)^4 = (1/2)^16 = 1.5E-5
- Therefore with probability 1.5E-5, there will be 4 aggressors adding linearly to the victim at the same part of the eye. Voltage summation, not RMS.

Case #2: Plesiochronous frequency locked

- Plesiochronous systems are usually specified at +/- 100 PPM between transmitter and receiver
- If one transmitter is at +100 ppm and the other transmitter is at –100 ppm, at 10G a one-UI difference takes ½ microsec. Or 5000 UI
- ¼ UI phase offset takes 1250 UI.

Case #2: Plesiochronous frequency locked

- For physical interactions of less than 1250 UI in duration, plesiochronous systems can be treated as frequency locked for purposes of crosstalk analysis.
- Same conclusion holds: crosstalk adds linearly.
- Probability of a 4-aggressors attack assuming random phase and random data is still 1.5E-5. If this event causes an error then the error rate will also be 1.5E-5.

Case #3: Random Frequency

- In the case of random frequency aggressors far from the victim frequency, the distribution of noise approaches a gaussian profile in the case of dozens of similar-amplitude aggressors.
  - 1e-17 and all equal aggressors-- = 2^56, 56 aggressors needed, if they are all equal
- In this case RMS summation is more appropriate.

Conclusion

- For frequency locked and plesiochronous aggressors, linear voltage summation of crosstalk is required for accurate results even when the aggressors transmit random data patterns.
- For a large number of random-frequency aggressors, RMS summation may be appropriate.
- Future work is needed to include a full impulse response of each aggressor in place of only the1st transition