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# Background Information for Comment #59

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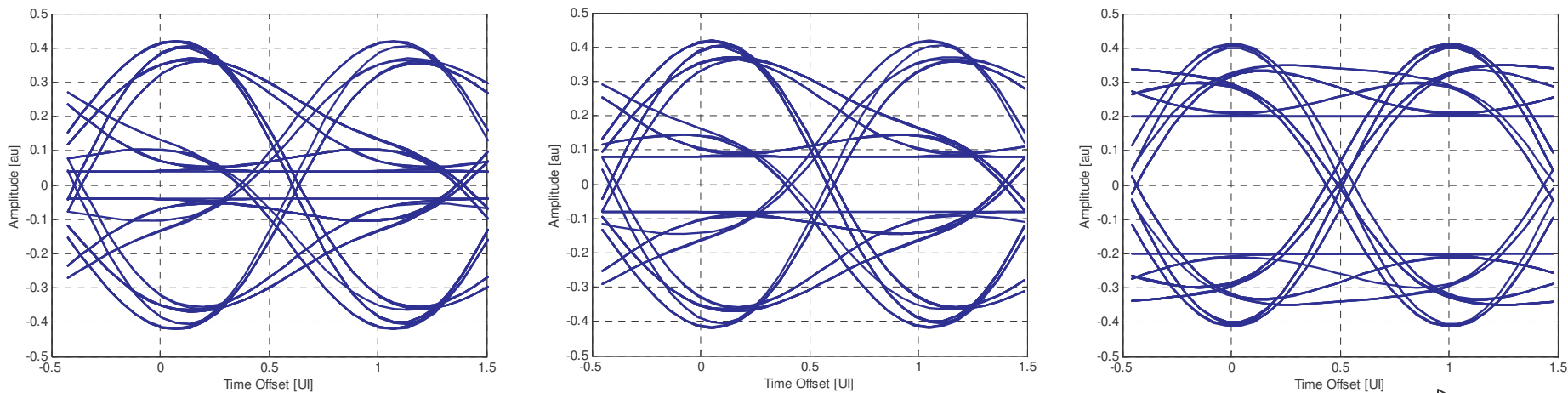
February 2, 2006

## Issues to be discussed

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- Minimum peak-peak differential output amplitude is not clearly defined
- Implied minimum of  $800 \text{ mV}_{\text{pk-pk}}$  may not be sufficient to support highest loss channels with crosstalk and noise
- Back-of-the-envelope analysis based on calculations of crosstalk noise for various PHY types and scenarios
  - Crosstalk calculations well documented

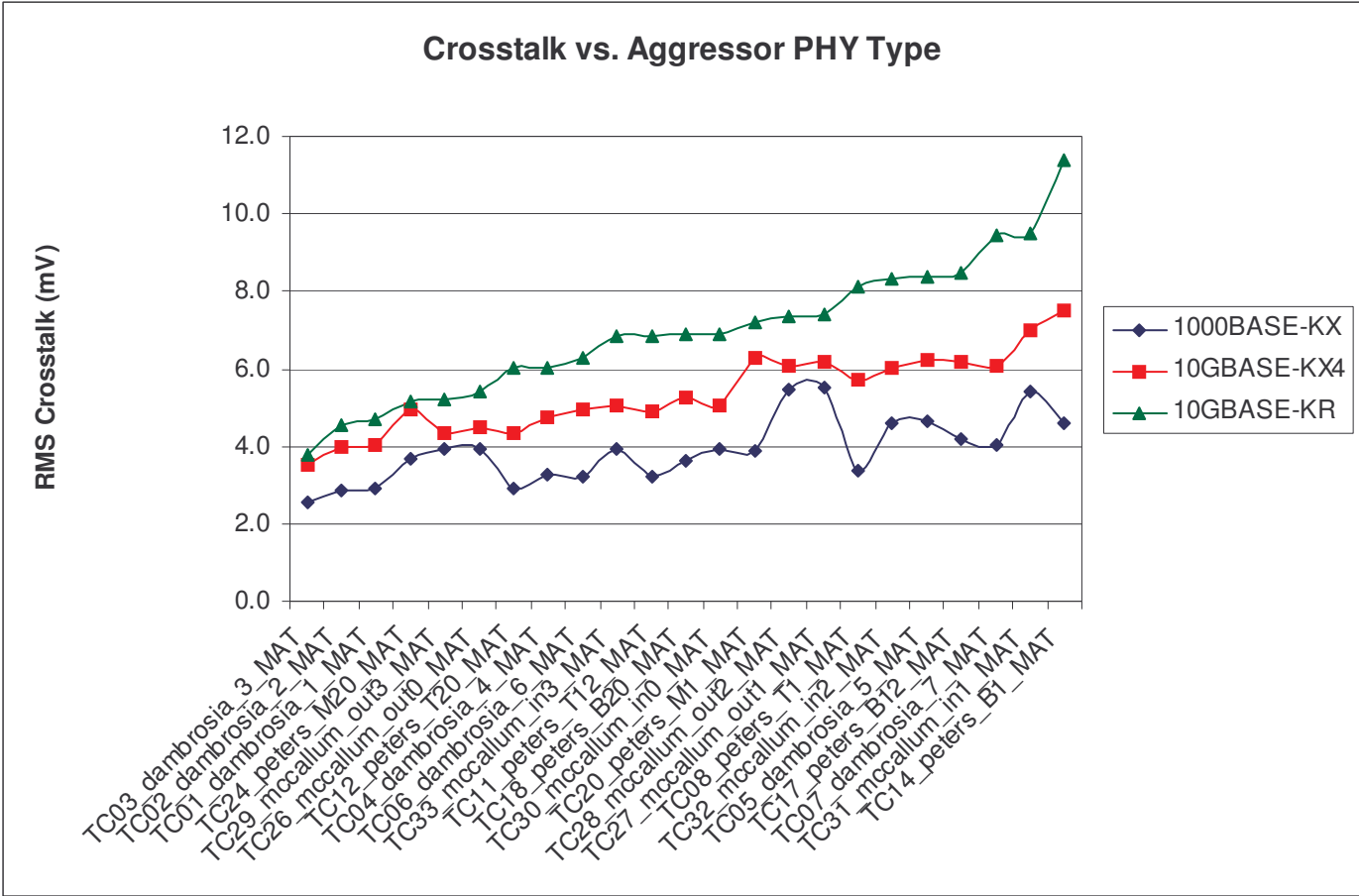
# Summary of the issue



*Increasing receiver input noise*

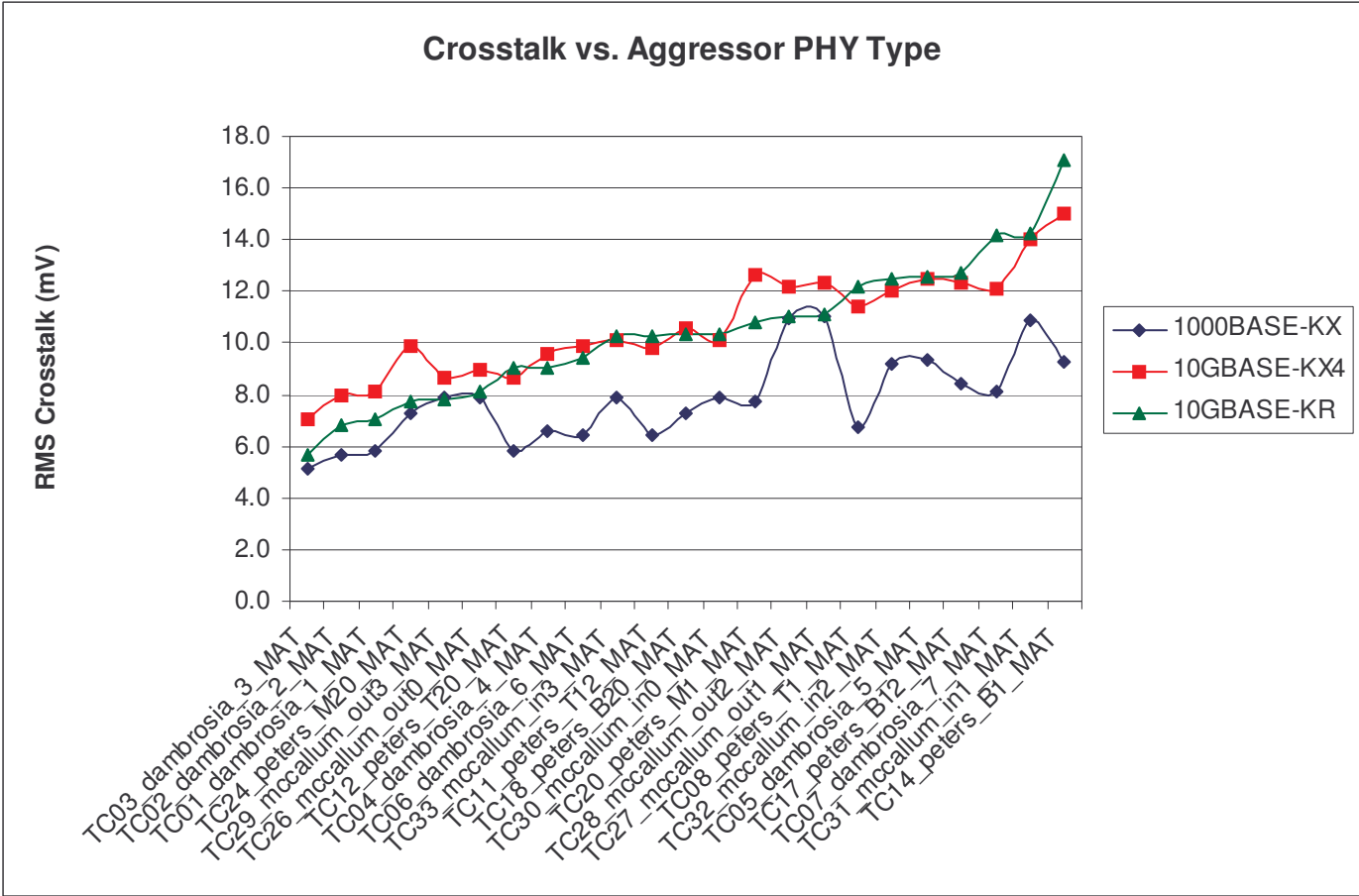
- As receiver input noise increases, minimum steady state voltage must also increase to accommodate it
- If the maximum output voltage is limited, the maximum equalization available from the transmitter will be limited
- The burden is shifted to the receiver, which may not be able to bear it
- Simple solution is the increase the maximum transmitter output voltage to enable higher equalization gain

# Comparison of Different Aggressor Types



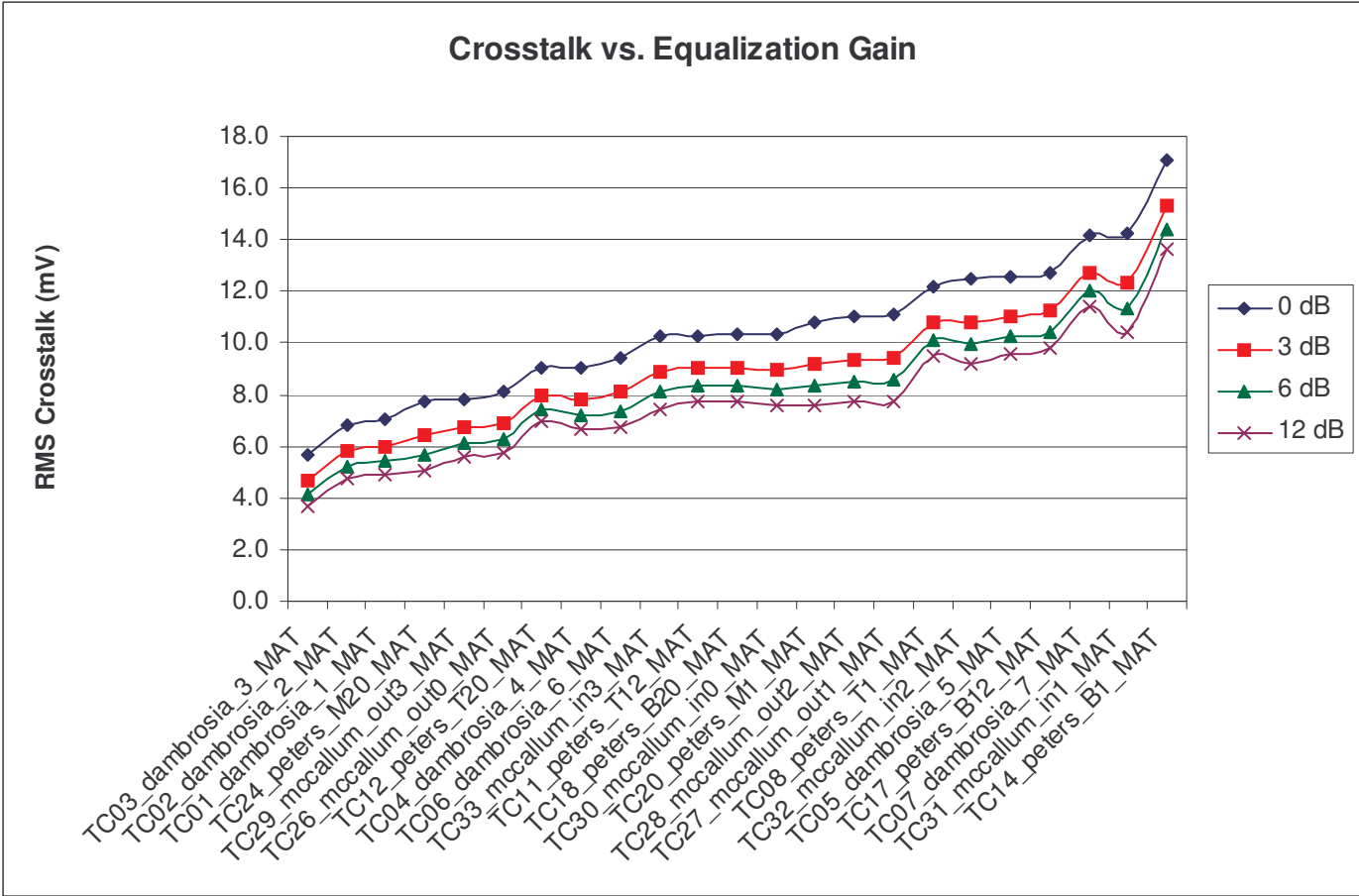
Differential output voltage is 800 mV<sub>pk-pk</sub>. Source rise time (20 to 80%) is 60 ps for -KX and -KX4, and 24 ps for -KR. Receive filter is a 4th order Bessel-Thomson with 3 dB frequency at 3/4 of the 10GBASE-KR signaling speed. Equalization gain of 2 dB assumed for -KX4.

# Adjust for Max. Differential Output Voltage



Differential output voltage is 1600 mV<sub>pk-pk</sub> for -KX and -KX4 and 1200 mV<sub>pk-pk</sub> for -KR. Source rise time (20 to 80%) is 60 ps for -KX and -KX4, and 24 ps for -KR. Receive filter is a 4th order Bessel-Thomson with 3 dB frequency at 3/4 of the 10GBASE-KR signaling speed.

# Vary the Transmit Equalizer Gain



Differential output voltage is 1200 mV<sub>pk-pk</sub>. Source rise time (20 to 80%) is 24 ps. Receive filter is a 4th order Bessel-Thomson with 3 dB frequency at 3/4 of the 10GBASE-KR signaling speed.

# Observations

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- Assuming equivalent output amplitude, 10GBASE-KR aggressors yield the maximum crosstalk noise
- For a given peak output amplitude, increasing equalizer gain decreases crosstalk
- For near-end aggressors, it is reasonable to assume that the output amplitudes will be comparable, because the transmitter and aggressors are likely in the same device
- It is not necessarily the case that the aggressor transmit equalization settings will be identical to the transmitter

# Back of the Envelope Calculations

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- Consider Tyco Test Case #1
  - 7 mV RMS crosstalk based on 1200 mV<sub>pk-pk</sub> aggressors (no equalization)
  - $V_{ss}$  must be at least 50 mV ( $7.03 \times 7$  mV) for operation at 1E-12
  - To allow 20 dB equalization gain,  $V_{pk}$  must be no less than 500 mV ( $10 \times 50$  mV)
- If the aggressors are reduced to 800 mV<sub>pk-pk</sub>, then  $V_{pk} = 10 V_{ss} = 330$  mV
- These simple calculations do not consider residual ISI due to incomplete equalization, intrinsic noise in the receiver, or ambient noise



## Options to Consider...

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- Complete definition of minimum peak-peak differential output amplitude test conditions and limits
- Consider increasing the limit above  $800 \text{ mV}_{\text{pk-pk}}$  for high-loss channels
- Consider better control of the noise environment
- Do all of the above...
  - Set maximum noise level for high-loss channels via ICR
  - Test the receiver at that level via the sinusoidal interference in the interference tolerance test
  - Set minimum peak-peak differential output amplitude based on these limits