SAS-2 Interconnect Signal-to-Noise Ratio Study (07-484r1)

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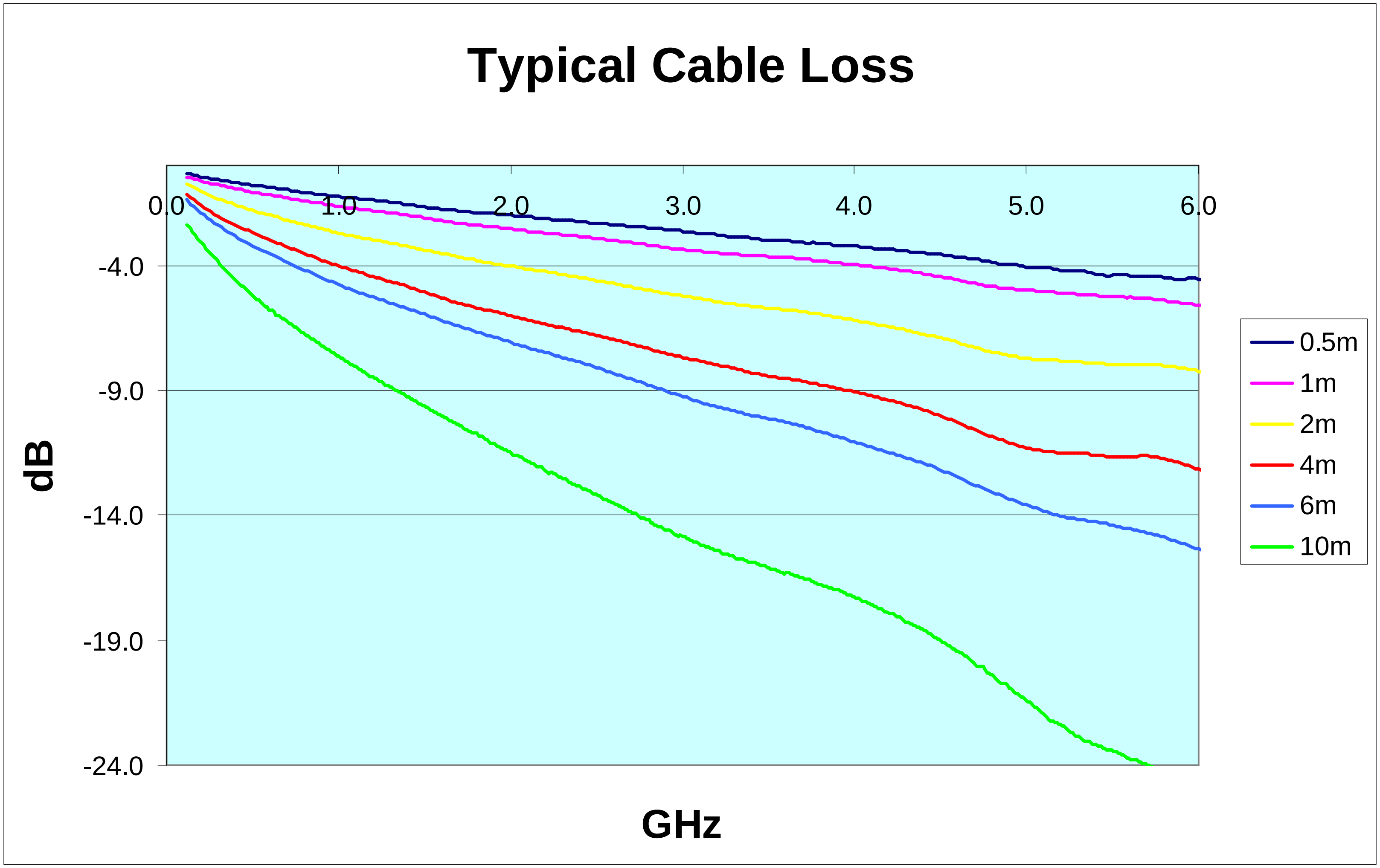
Issue

- While SAS-I and SAS-II specify crosstalk limits on some connector interfaces no guidance is provided for other components or to those involved in system integration
- Crosstalk limit lines are also problematic. Short cables tend to have higher levels of crosstalk but can deliver most of the signal to the load. Long cables deliver only a small portion of the signal to the load but may have low crosstalk levels.
- Is an “insertion loss to crosstalk ratio” specification a more appropriate way to control crosstalk?

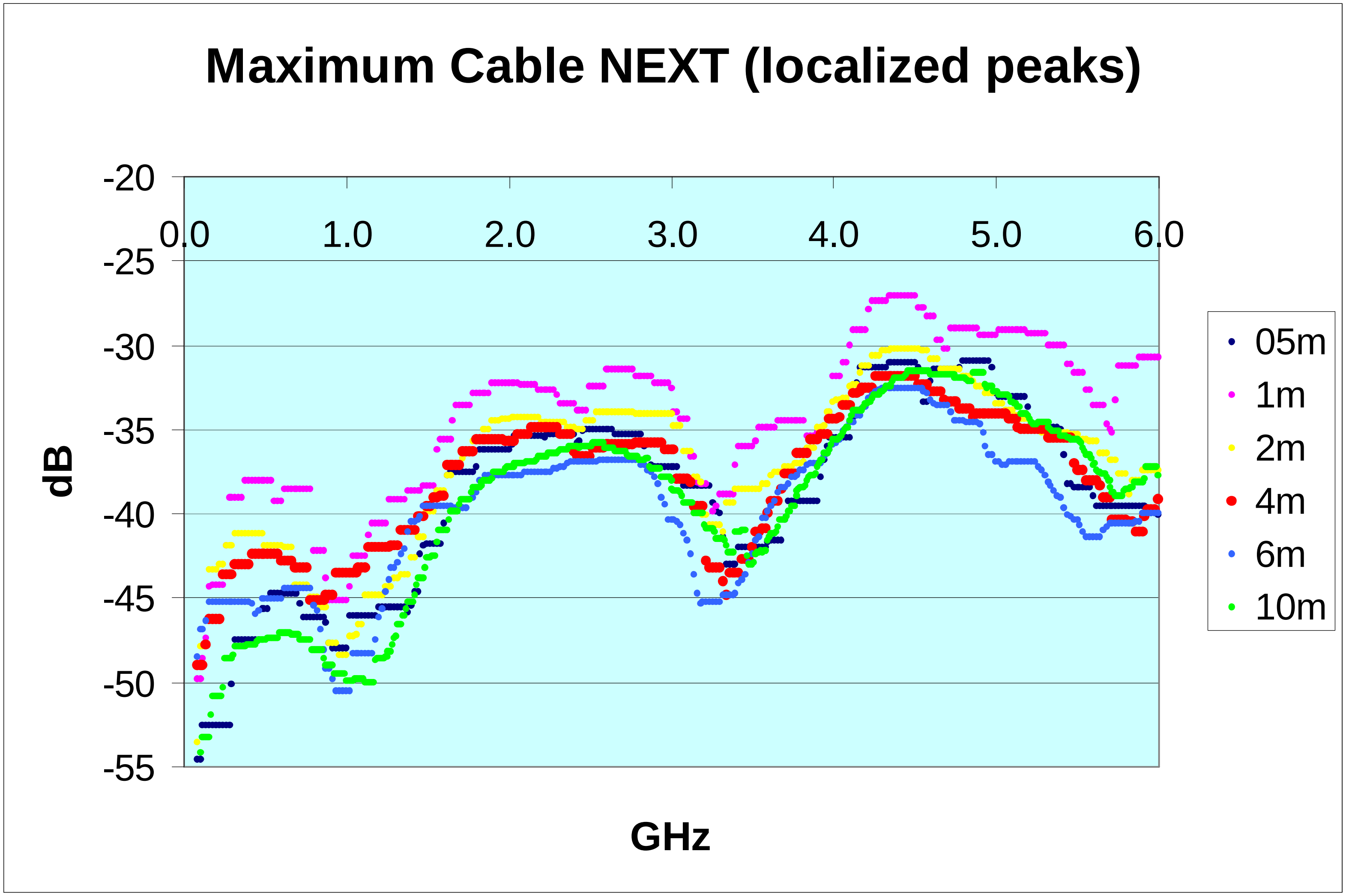
Measurements

- A sampling of cables lengths from 0.5 to 10 meters is first characterized for crosstalk and insertion loss.
- The data is then processed to estimate the insertion loss to crosstalk ratio from 100MHz to 6GHz

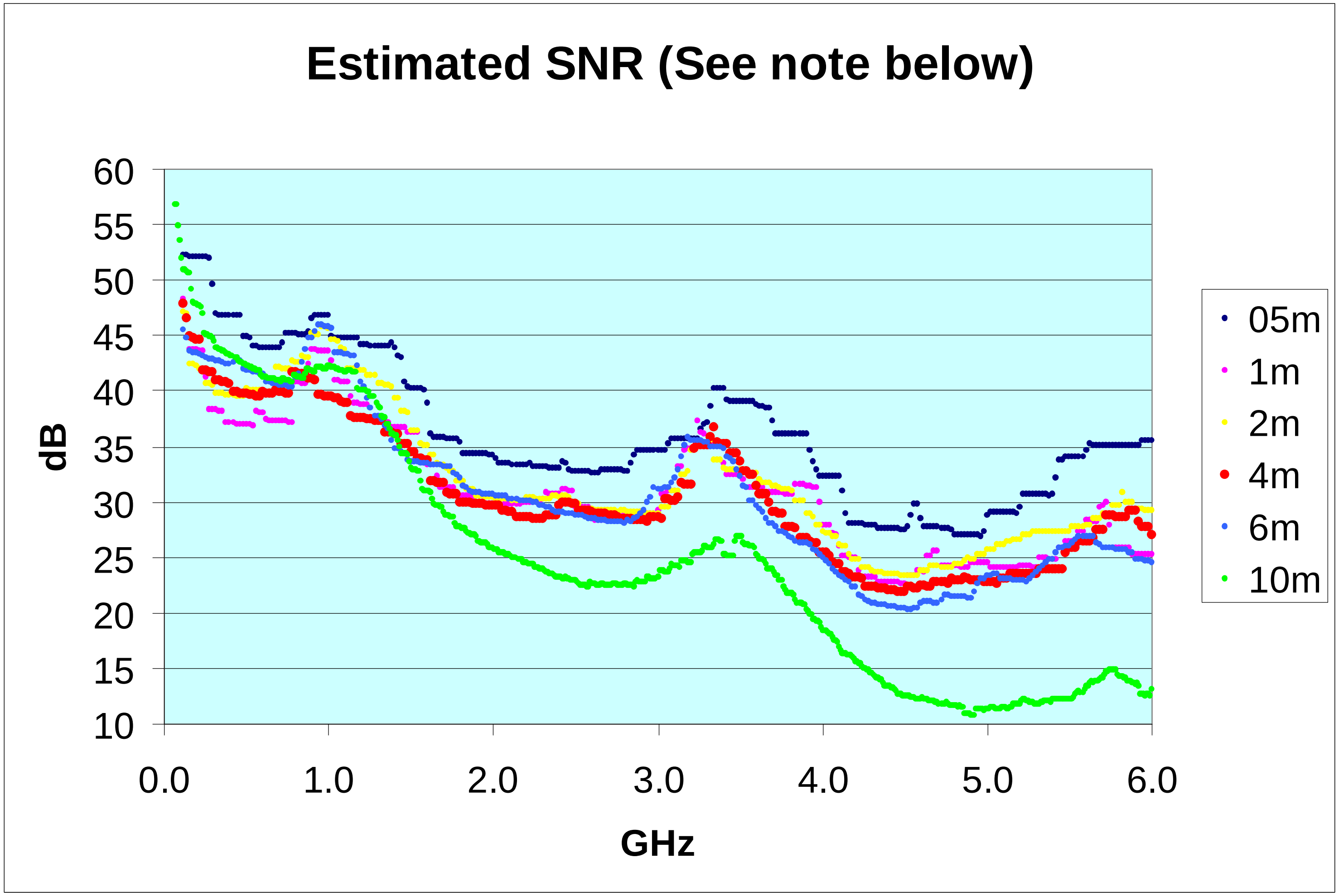
Typical Insertion Loss



Cable NEXT (Smoothed by using peak value in sliding window)



Estimated Insertion Loss to NEXT ratio



The crosstalk curves used to derive this estimate may include a resonance response. Frequencies where the resonances cancel out will still be problematic for digital signaling

Conclusions

- Using this type of approach for noise will not penalize short interconnect.
- Also, an SNR type of specification will encourage those developing lossy interconnects (10m cable or more) to focus on minimizing crosstalk.

Further Investigation

- Feedback from the rev 0 presentation indicated that further investigation into system noise levels would yield valuable information

Noise Sources

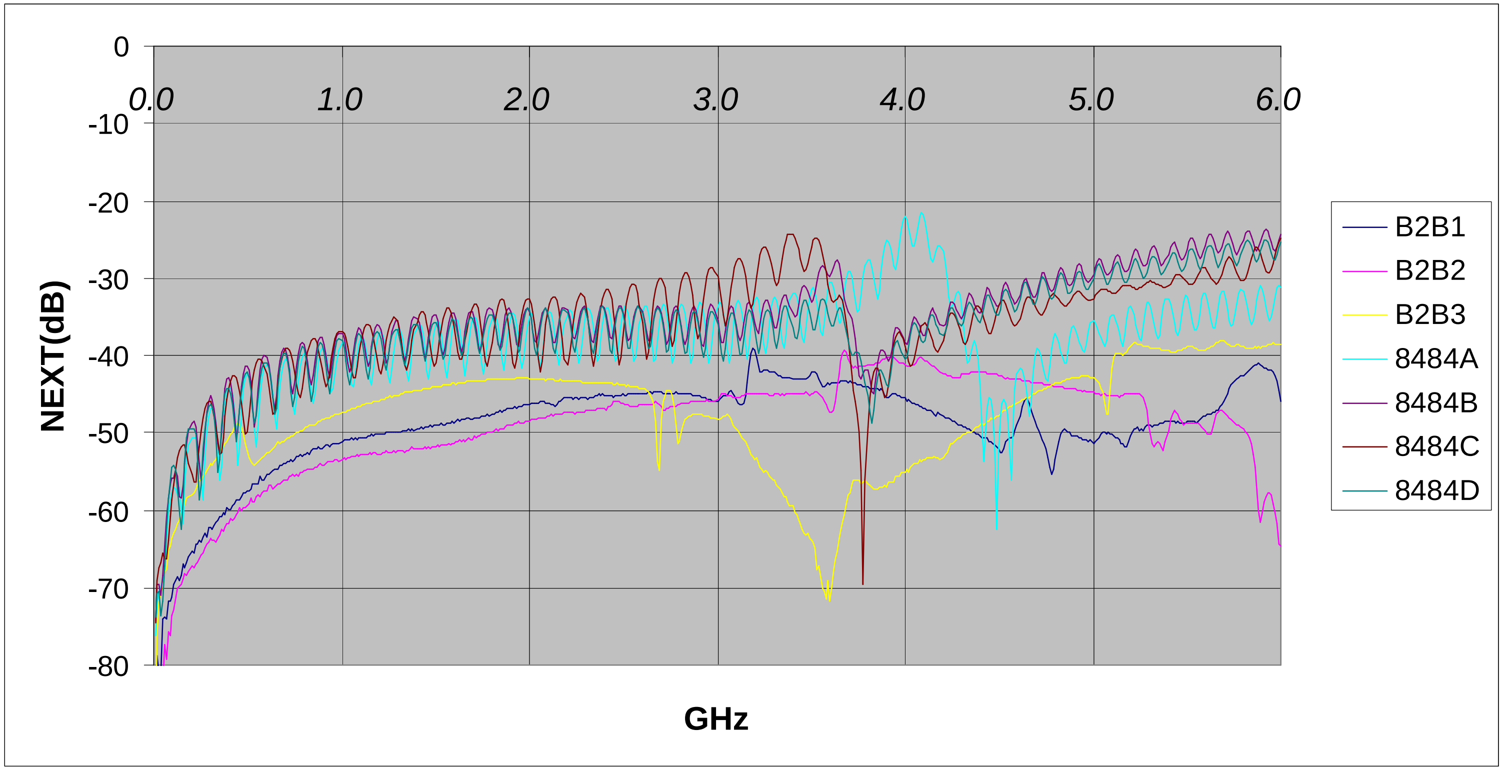
- Additional product surveys indicate that the dominant noise sources continue to be crosstalk in the connector interfaces, component footprints and in some cases integrated circuit layout
- Poor printed circuit board layout in other regions can also induce crosstalk but layout modifications can eliminate the problem. This problem is frequently observed as a common mode signal present on the differential signaling.

Signal to Noise Ratio

- After further analysis it is apparent that an SNR based specification is inadvisable at this time for the following reasons
  1) Such an approach would greatly complicate receiver margin testing. It is likely that tolerable SNR varies with receiver signal strength.
  2) Quantitative data to support such a proposal does not exist.
- Future consideration should not be ruled out given the motivation to solve the above to problems exists.

Form of Specification

- Limit line specifications appear to be a reasonable approximation for multi-aggressor crosstalk. The exception is at low frequencies (below ~500MHz).



Crosstalk Level

- Data supports a -26dB (5% through 3GHz) total crosstalk estimate.

Crosstalk Level

- Value to be used in stressed eye testing needs to be carefully selected. Calibration of crosstalk test setup needs to replicate real levels. Selection of RMS limit must consider broadband crosstalk specification.

Crosstalk Level

- Assuming a flat crosstalk transfer profile of -26dB what is the RMS signal level of a PRBS7 at the victim?
- A simulation with edge rates (20/80) ranging from slow (0.4UI) to fast (0.2UI) yields a range of 26.5mV to 28.4mV

Recommendations

- Recommend using existing -26dB NEXT value for the crosstalk budget. Additional margin may be desirable.
- Add line item in “Table 56 – General electrical characteristics” and add note “c” as shown on the following slide.

Recommended Changes

Table 56 — General electrical characteristics

Characteristic	Units	1,5 Gbps (i.e., G1)	3 Gbps (i.e., G2)	6 Gbps (i.e., G3)
Physical link rate (nominal)	MBps	150	300	600
Bit rate (nominal)	Mbaud	1 500	3 000	6 000
Unit interval (UI)(nominal)	ps	666,667	333,333	166,667
Differential TxRx connection impedance (nominal)	ohm	100		
Maximum A.C. coupling capacitor [a]	nF	12		
Maximum noise during OOB idle time [b]	mV(P-P)	120		
Maximum near end crosstalk power sum at Rx end of any TxRx connection [c]	**dB**	**-26**		

a. The coupling capacitor value for A.C. coupled transmit and receive pairs. A.C. coupling requirements for transmitter devices are described in 5.3.6.1. A.C. coupling requirements for receiver devices are described in 5.3.7.1. The ESR at 3 GHz should be less than one ohm.

b. With a measurement bandwidth of 1,5 times the highest supported baud rate (e.g., 9,0 GHz for 6 Gbps), no signal level during the idle time shall exceed the specified maximum differential amplitude.

c. This is a system level requirement that can not be guaranteed by individual components.