Concerns with Installed Cabling for 10GBASE-T

Scott Powell, Broadcom

IEEE P802.3an 10GBASE-T

Interim Meeting February 23-24 2005, Santa Clara

Agenda

- Alien Far-end Crosstalk (AFEXT) measurements on Cat 6 cabling
  - Installed base concerns
- Expected performance with un-equal SNR per wire pair
  - With currently envisioned system

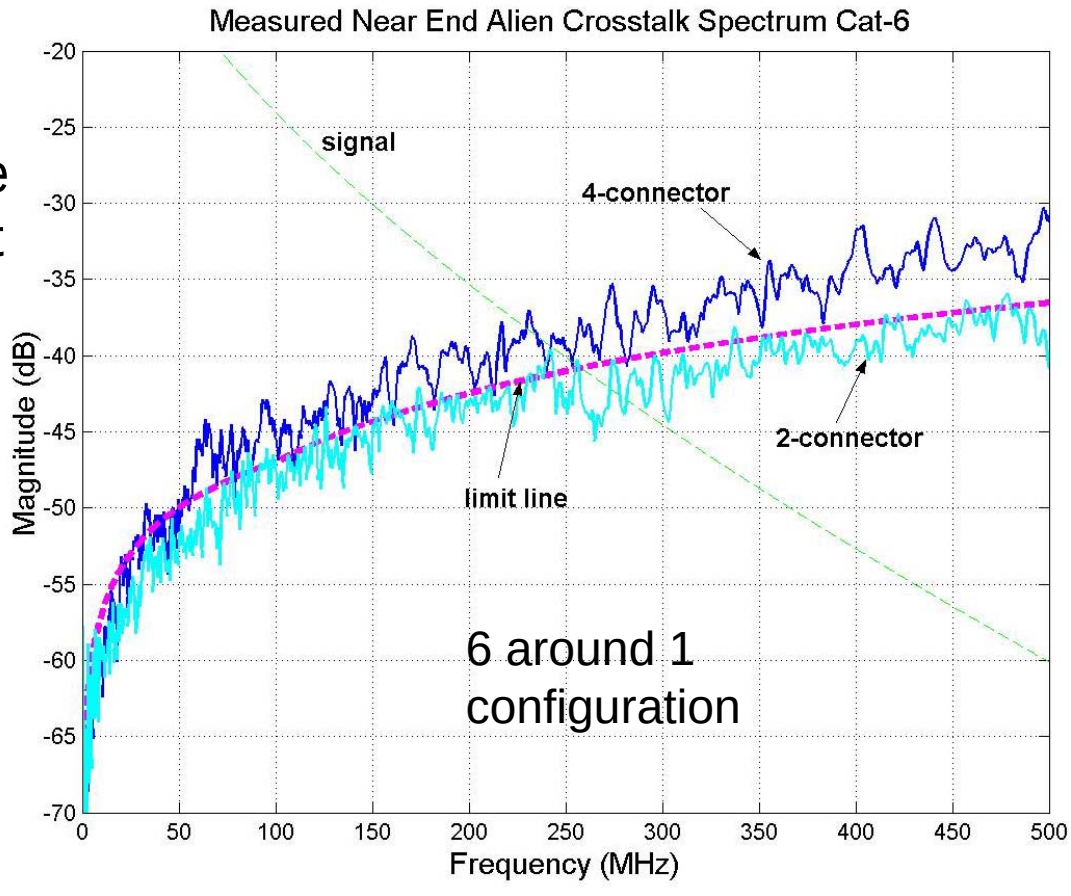
Support for Installed Base

- Main limitation to 10GBASE-T performance is noise introduced by alien crosstalk
  - Cable-to-cable crosstalk
  - Cancellation not possible without knowledge of source
- Alien crosstalk of an installed cable plant is difficult to characterize
  - Depends on traffic in adjacent cables ⇒ time varying
  - Depends on cable installation practices (bundling)
  - Accurate assessment requires access to both ends of every cable within a bundle

Robust operation over a given length of installed cabling can only be reasonably guaranteed if 10GBASE-T transceivers are designed to operate with the worst case alien crosstalk

Alien Near-End Crosstalk over Today's Cat 6 UTP Cabling

- Maximum permissible ANEXT was computed, agreed upon in March 2004 (kasturia_1_0304.pdf), and adopted into D1.0 (55.7.3.4.1)
  - Measurements confirm that maximum permissible ANEXT is "close" to worst case ANEXT in the installed base
  - Very little operating margin, however



Alien Far-End Crosstalk over Today's Cat 6 UTP Cabling

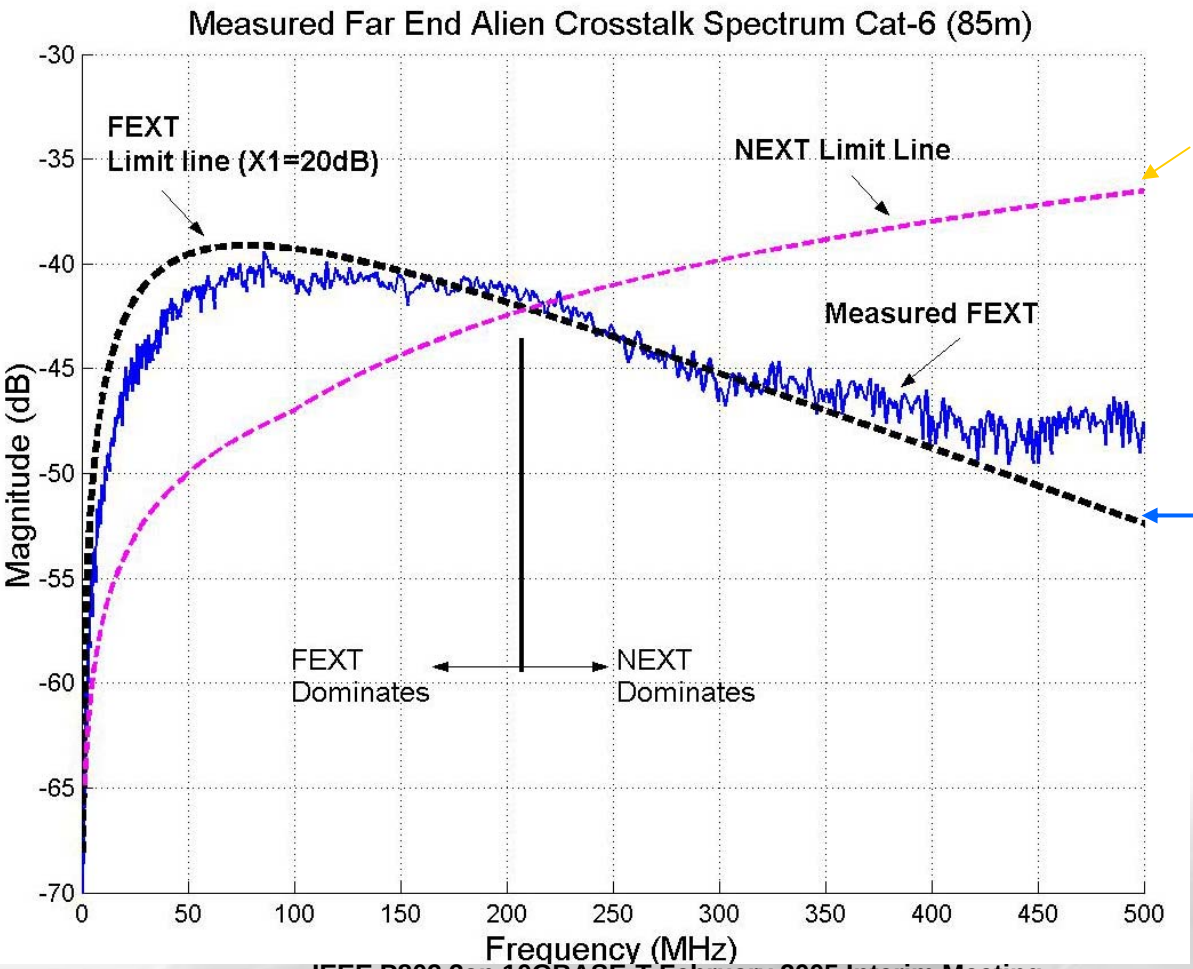
- AFEXT previously thought to be negligible
  - Not considered when agreement on 55m cable length objective was formed for Cat 6 (Sept 2003 Interim)
  - Not considered when maximum ANEXT agreement was reached
- Maximum permissible AFEXT was computed, agreed upon in January 2005 (zimmerman_2_0105.pdf), and adopted into D1.3 (55.7.3.2.2)
  - Measurements indicate maximum permissible AFEXT is much less than the actual AFEXT in the installed base

		Actual	
	Max Permissible	Worst Case	Nominal
-X2 in eqn (55-28) Draft D1.3	-31 dB	-20 dB	-25 dB

Actual AFEXT in installed base is 6~11dB worse than required specification for 10GBASE-T

Worst Case Alien Crosstalk Over Today's Cat 6 UTP Cabling

- 85m Cat 6 cable, 2 connector channel, 6 around 1 configuration



Only noise source previously considered

Violates D1.3 specification by 11dB

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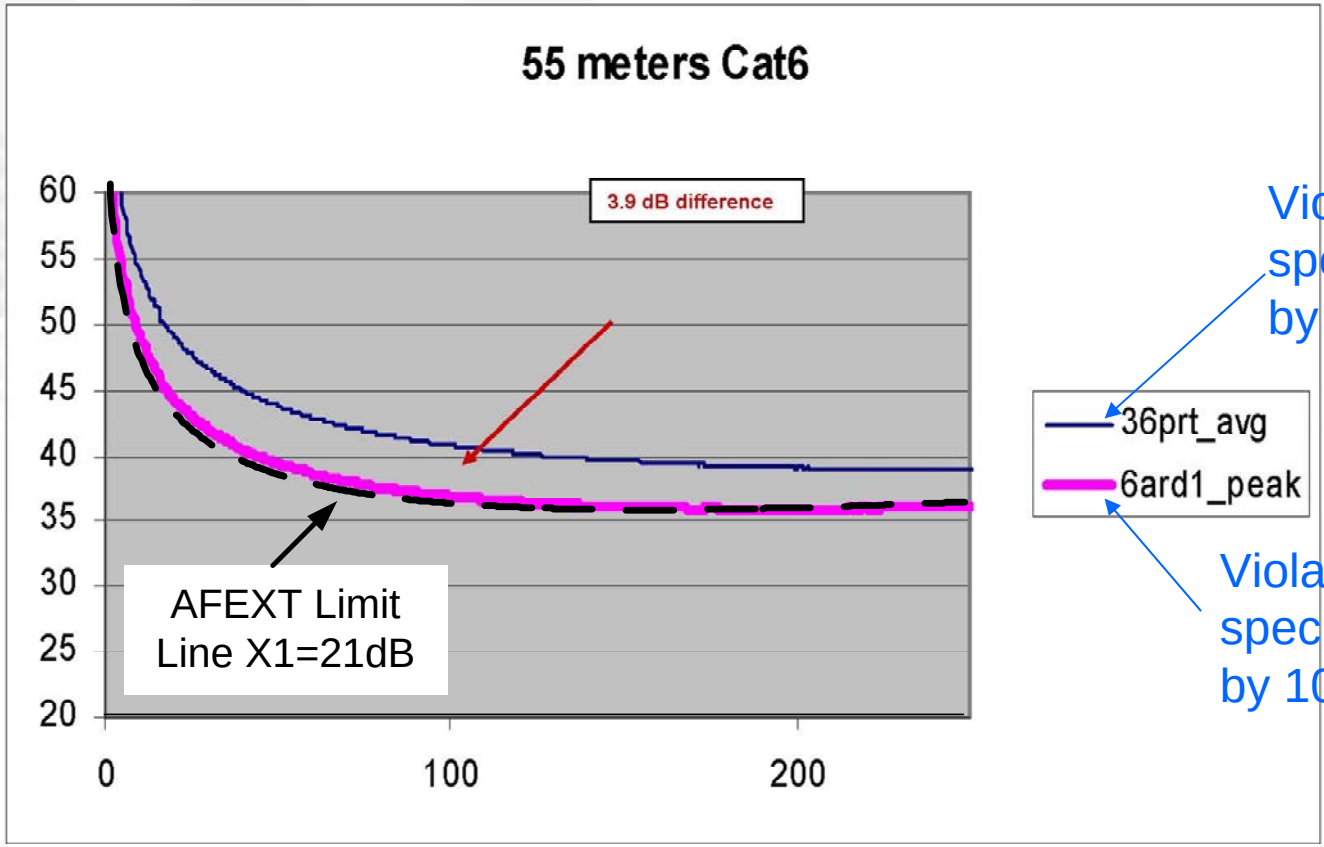
Other Measurements

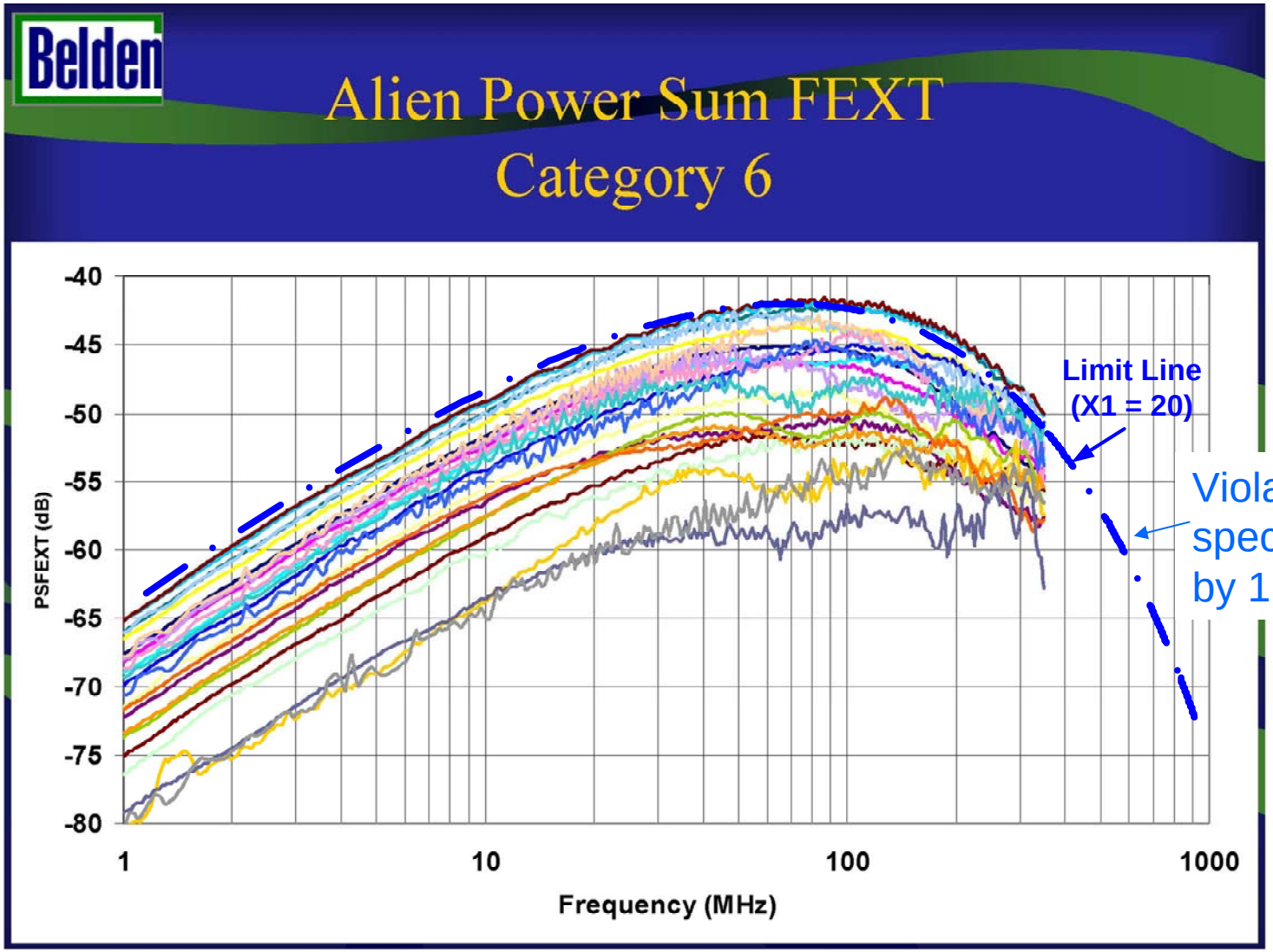
(zimmerman_1_0105.pdf)

Comparing PSFEXT 36 port average to the 6 around 1 peak



Other Measurements

(vanderlaan_1_0303.pdf)



Violates D1.3 specification by 11dB

Conclusions

- Current system defined in 10GBASE-T standard will not broadly achieve 55m objective over the installed base of Cat 6 cabling
  - At least three contributions to the task force have demonstrated AFEXT in the installed base could be much greater than the levels agreed necessary to support 10Gbps traffic
- The channel requirements specified in 10GBASE-T D1.3 standard are inconsistent with the Cat 6 objective
  - Alien FEXT is main issue
- Some installations will not be worst case and should support 10Gbps operation
  - Data has not been shown to estimate percentage of currently installed cabling systems which have sufficiently low alien FEXT to support 10Gbps

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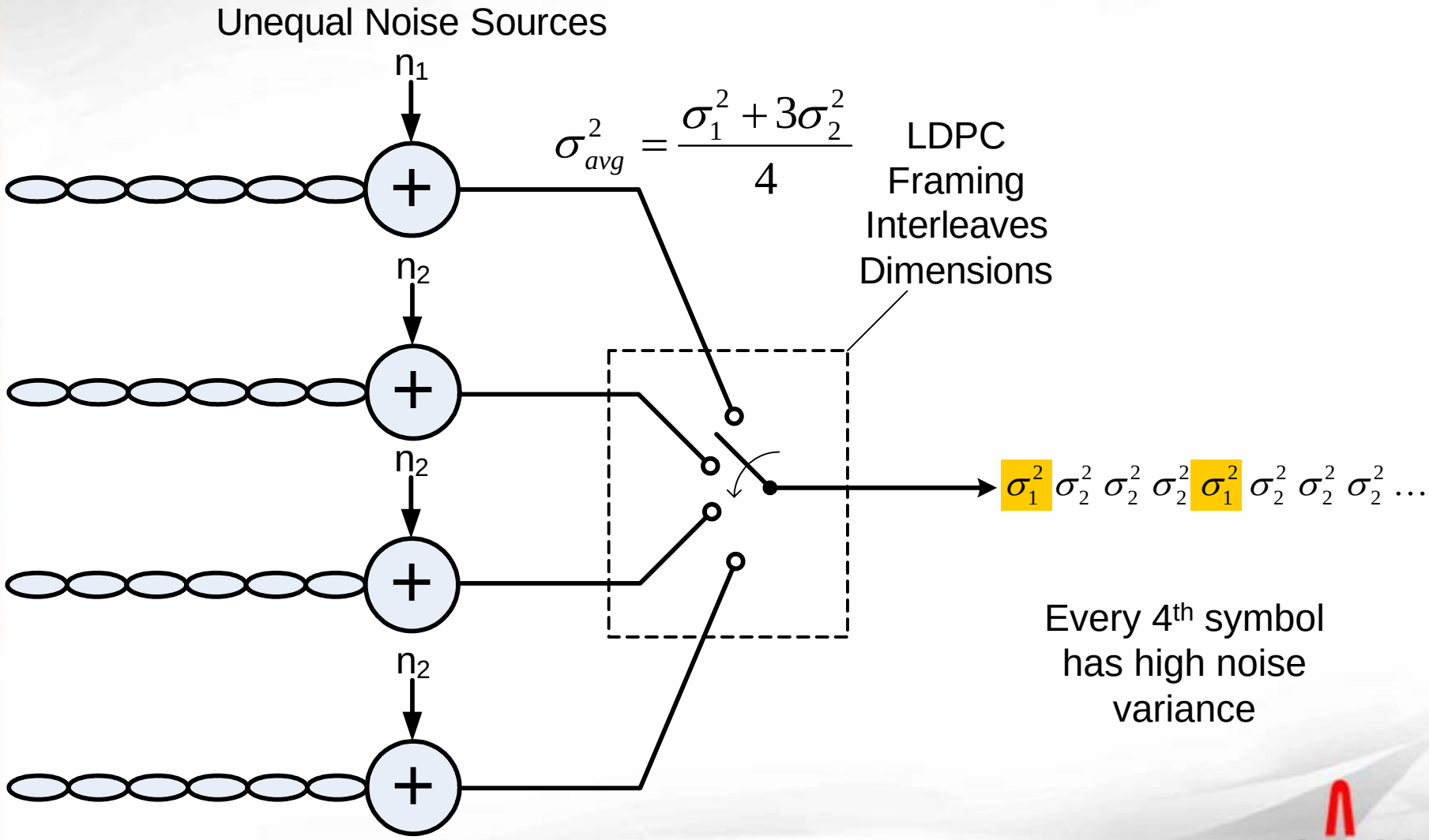
The "Dominant" AFEXT Pair

- Pair to pair AFEXT noise differences have been observed in measurements
  - 4dB proposed in zimmerman_2_0105.pdf, appears in D1.3 55.7.3.2.2
  - Also observed in our measurements
- Data and/or analysis needed to indicate how broadly this observation applies to installed base
  - Very small sample set presented so far
- If broadly applicable, differences in noise/pair can be exploited for system gain
  - Natural interleaving of LDPC + framing in current system will help
  - Further system improvements possible
    - Current approach designed under assumption of same SNR on each wire pair

Unequal SNR per Wire pair



Every 4th symbol has high noise variance

Analyzing Impact of Unequal SNR/wire-pair on LDPC Decoder

- Expect results to be better than the SNR of the worst pair
  - … but, worse than the SNR of the best pair

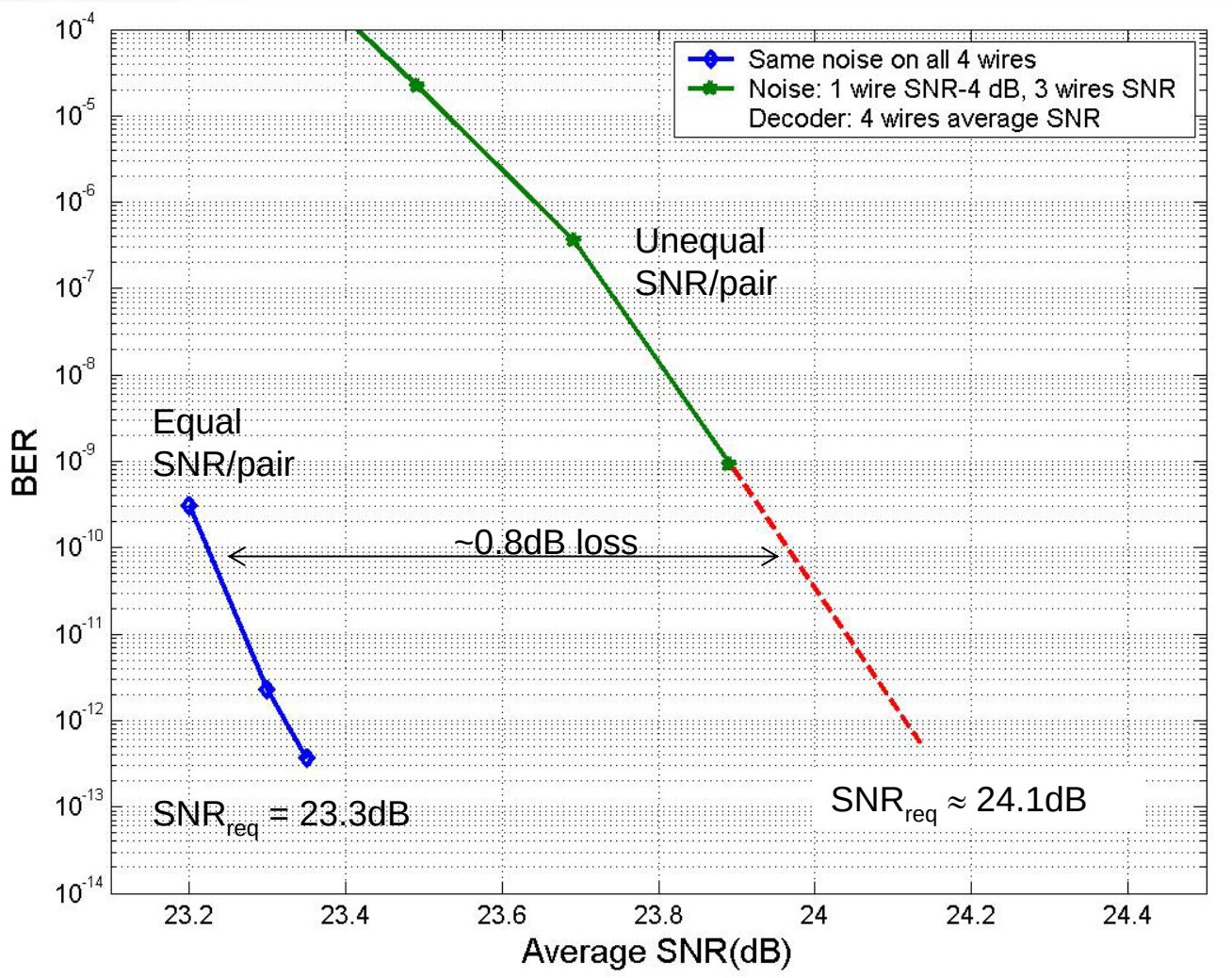
- Construct DSQ symbol stream where every 4th symbol has lower SNR (ie: SNR_1 SNR_2 SNR_2 SNR_2 SNR_1 SNR_2 SNR_2 SNR_2 …)
  - Simulate de-mapping and LDPC decoding
  - Present results as BER vs SNR_{avg}

$$SNR_{avg} = 10\log_{10}\left(\frac{10^{\frac{SNR_1}{10}} + 3\cdot 10^{\frac{SNR_2}{10}}}{4}\right)$$

  - $SNR_1 = SNR_2 - 4$ dB, $SNR_2 = SNR_{avg} + 0.708$dB
  - Compare to BER vs SNR where $SNR_1 = SNR_2$
    - Ie: All pairs with same noise

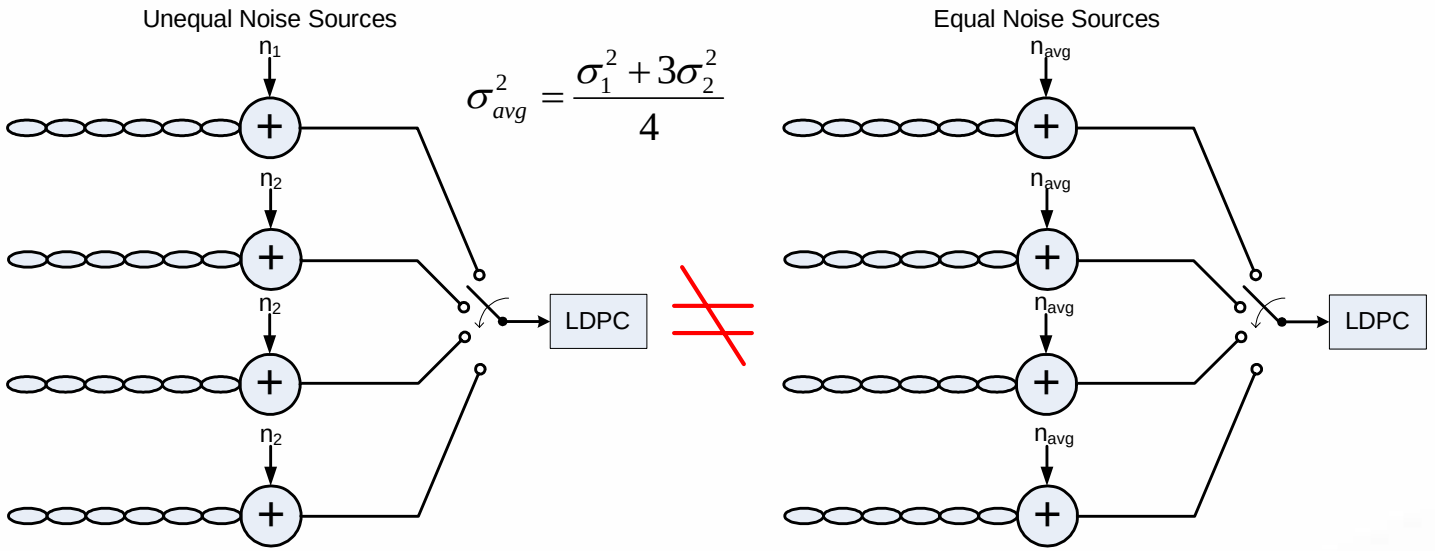
Simulation Results 2/20/05

(Will be updated with latest sim results prior to presentation)



Conclusions

- Performance of current system with un-equal SNR/wire-pair is <u>not</u> equivalent to the performance with equal SNR_{avg}/wire-pair
  - Unequal case is has ~0.8dB loss when $SNR_{worst} = SNR_{best}$-4dB



- System investigation to regain some/all of the loss may be fruitful