Cabling Ad Hoc Cat 5e Measurements

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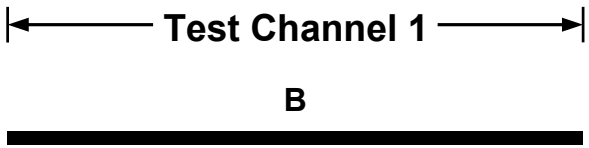
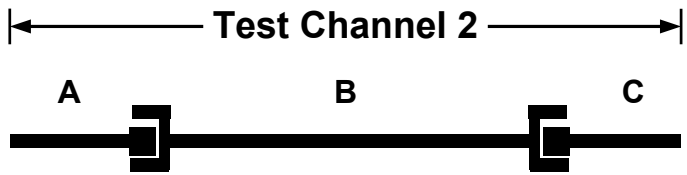
Overview

- Cabling Ad Hoc Test Plan Measurement
  - One Cat 5e horizontal cable sample, four test channel configurations characterized to 500 MHz
  - Insertion loss
  - NEXT: pair-to-pair and power sum
  - ELFEXT: pair-to-pair and power sum
  - Return loss
  - Propagation delay
  - Delay skew
  - Data from both sides of channel
- Measurement of multiple cable samples – insertion loss test
- Conclusion

Test Channel Configurations

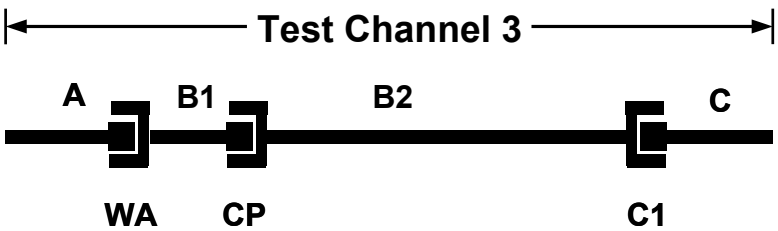


B = 90 meters horizontal cable



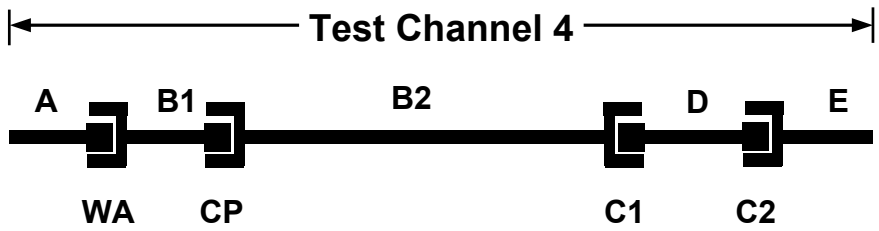
A= 5 meters, B= 90 meters, C=5 meters

A and C = work area and equipment cord: B= 90 meters horizontal cable



A= 5 meters, B1= 5 meters of CP Cable cut from B, B2=85 meters of horizontal cable cut from B, C= 5 meters

B1= CP cable, B2 =horizontal cable ,A and C = work area and equipment cord:



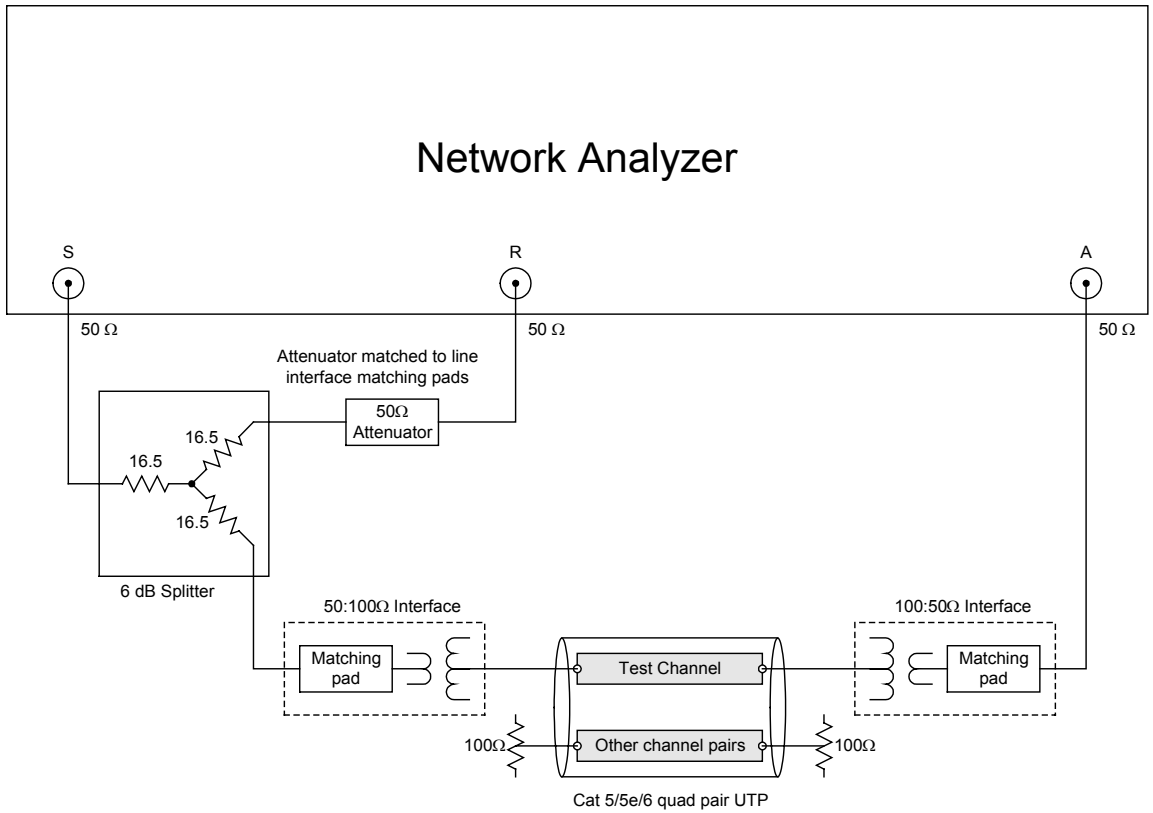
A= 5 meters, B1= 5 meters of CP Cable cut from B, B2=85 meters of horizontal cable cut from B, D= 3 meters, E= 2 meters

B1= CP cable, B2= horizontal cable: A,D and E= work area, patch cord, and equipment cord

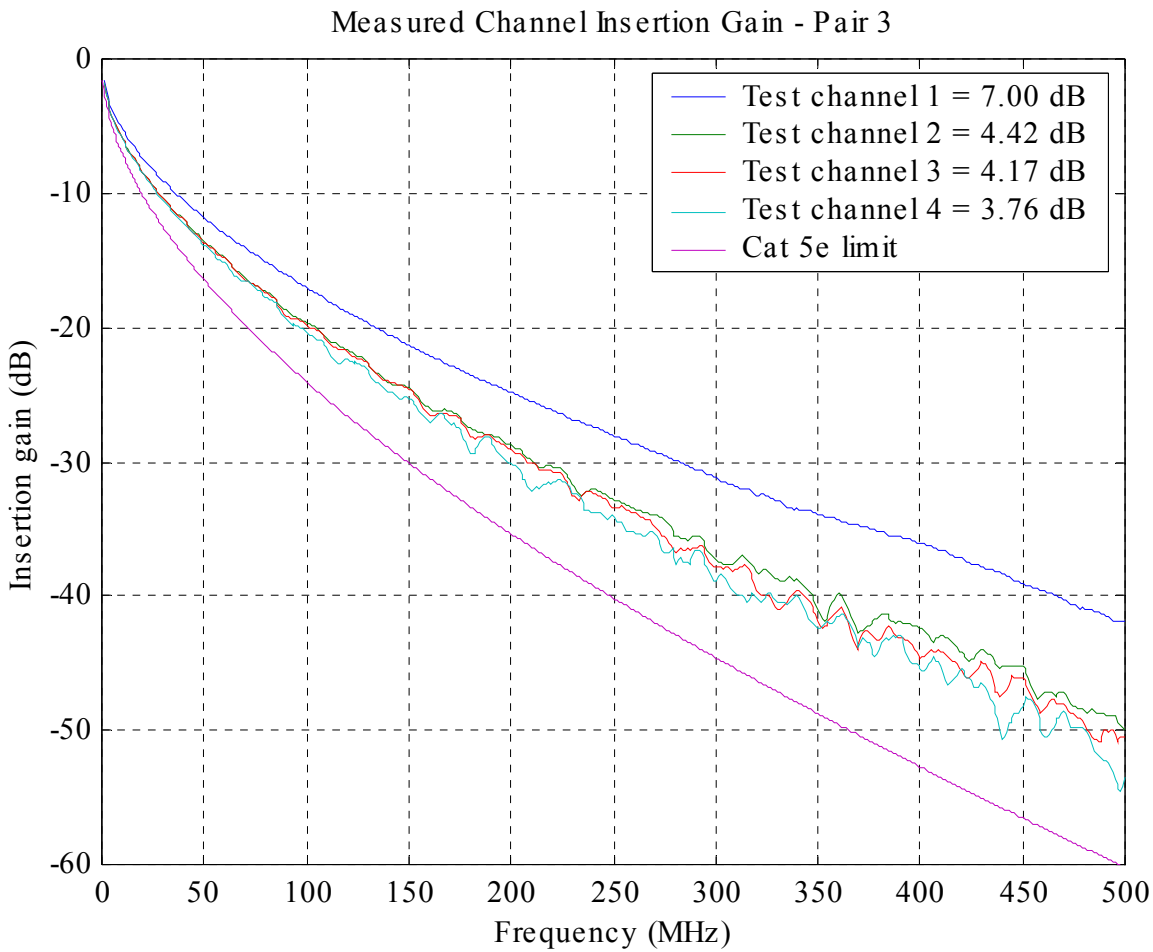
Measurement Environment

- Measurements made at room temperature
- All patch cords and connectors are Cat 5e
- Test cable sample laid out in simple large loop, no stretching or excessive mechanical stress applied
- Channel pairs defined by T568B RJ45 jack pin/pair assignment
- Measurement performed by HP8753C Network Analyzer
- Measurements normalized for test fixture insertion loss
- All test channel interface points are Cat 5e Keystone jack to RJ45 plug (except channel 4 interface between A and B1 is inline Cat 5e coupler)
- No RJ54 interface on test fixture – direct soldered connection

Channel Insertion Loss Measurement Setup

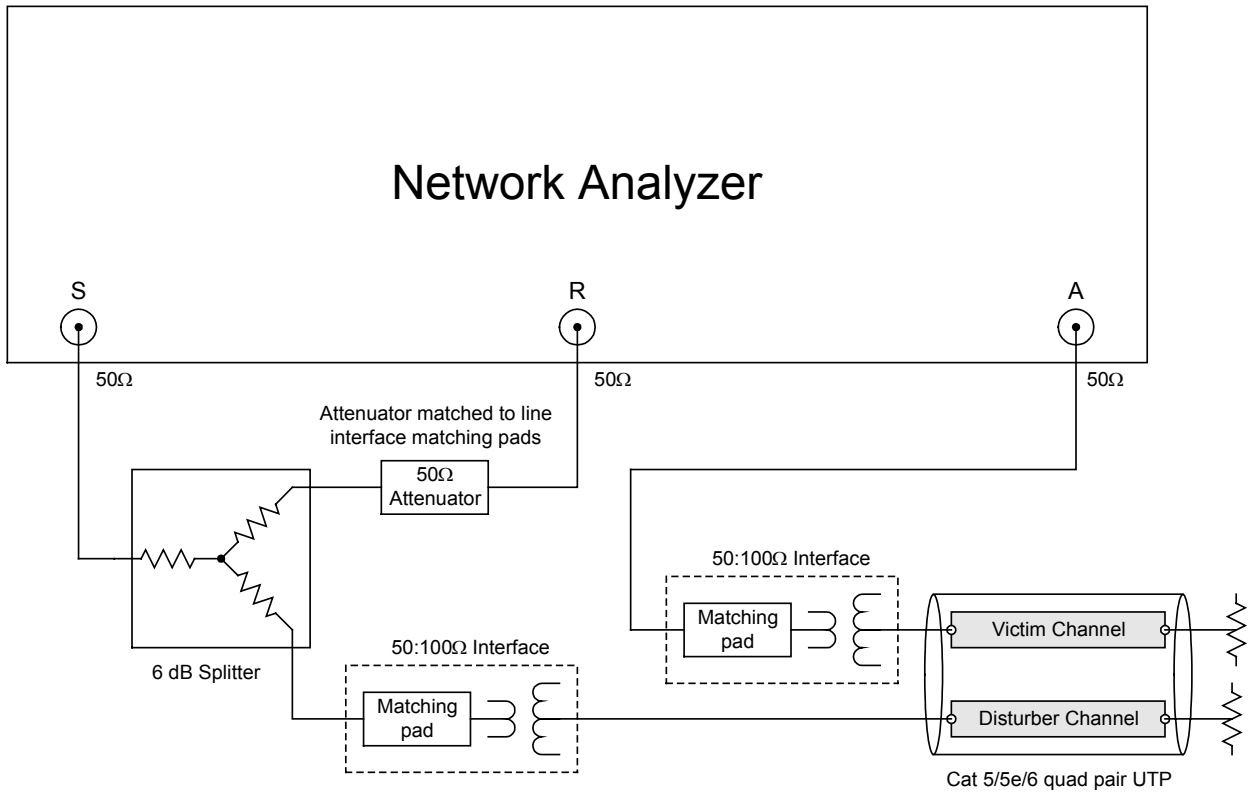


Insertion Loss Measurement

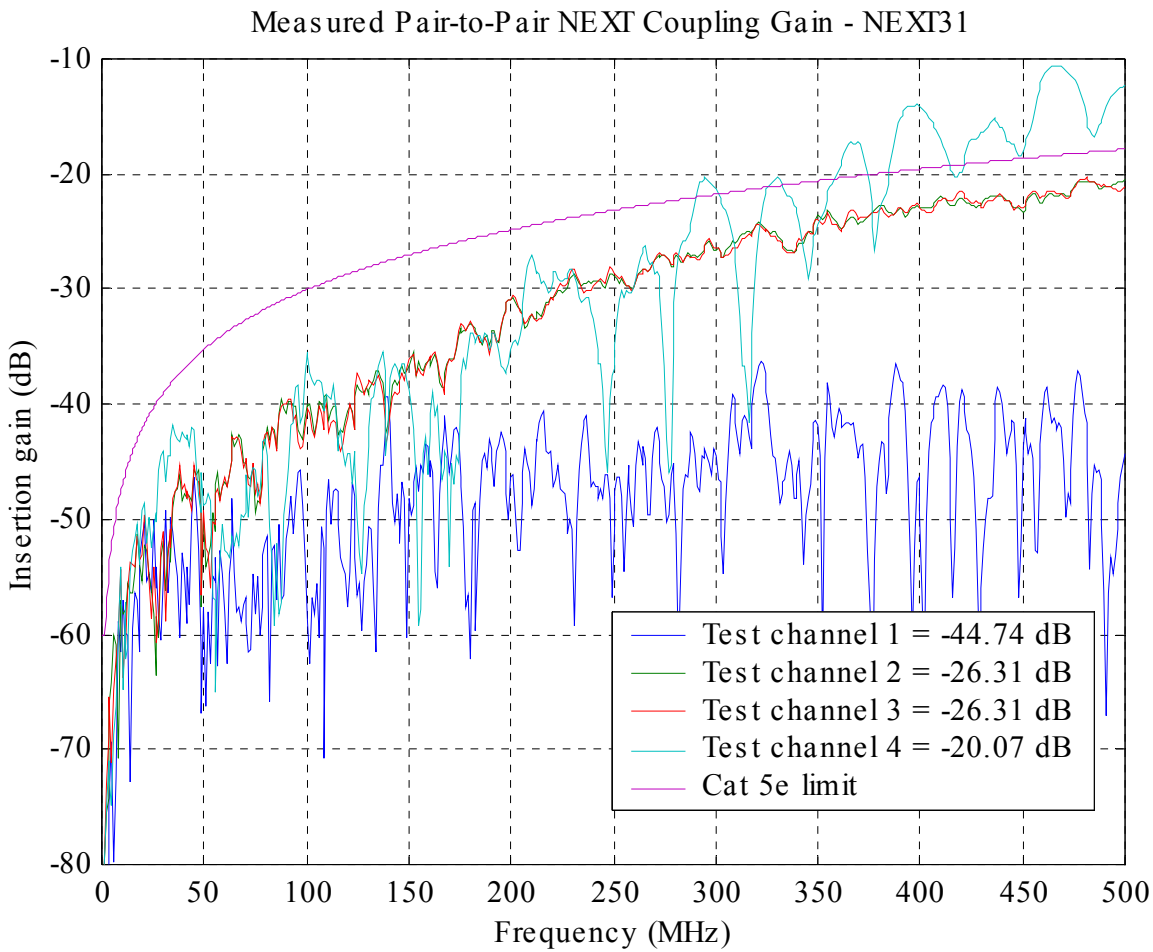


- Figure of merit is margin above Cat 5e channel limit at 100 MHz
- Connectors increase loss slightly and cause insertion loss deviation (ILD)
- Cat 5e margin (extrapolated limit) increases with frequency

NEXT Measurement Setup

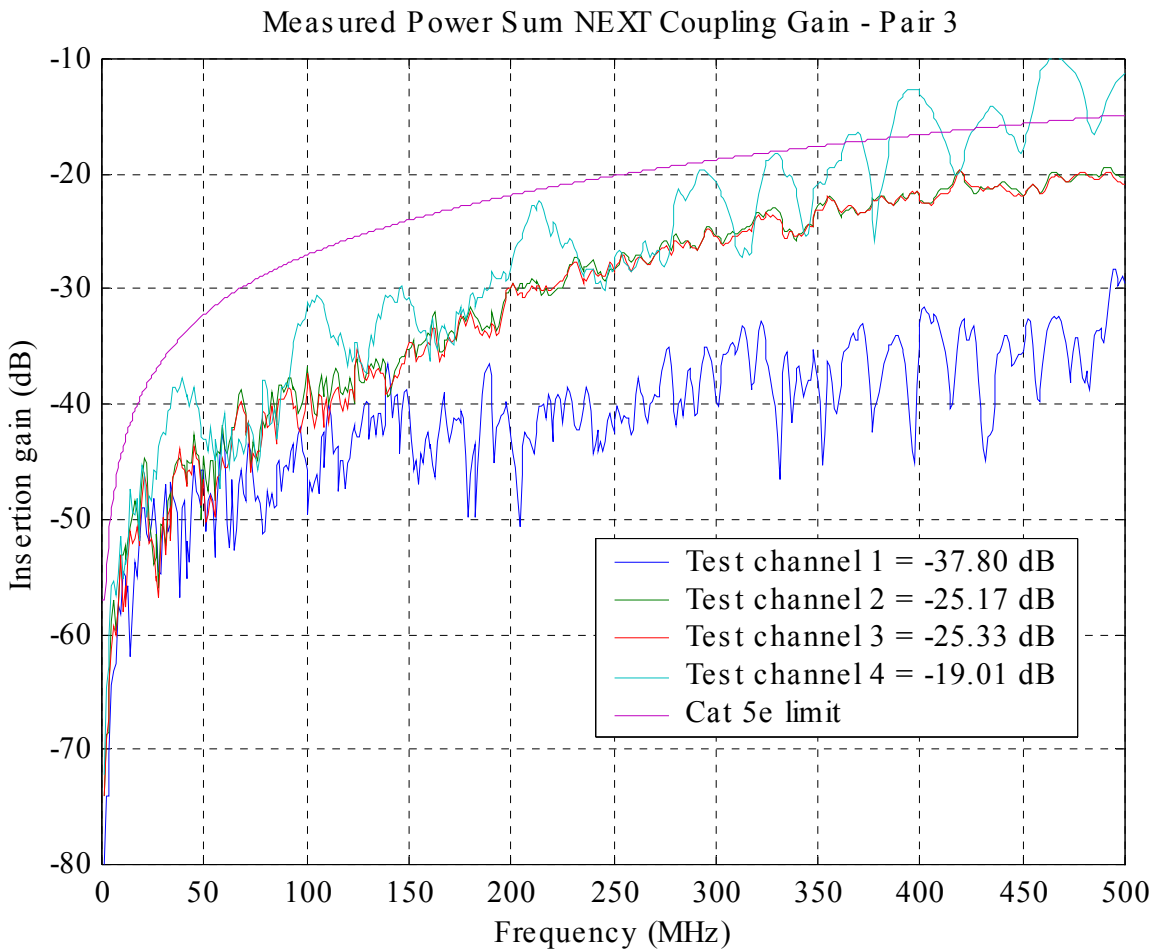


Pair-to-Pair NEXT Measurement – Interior Pairs



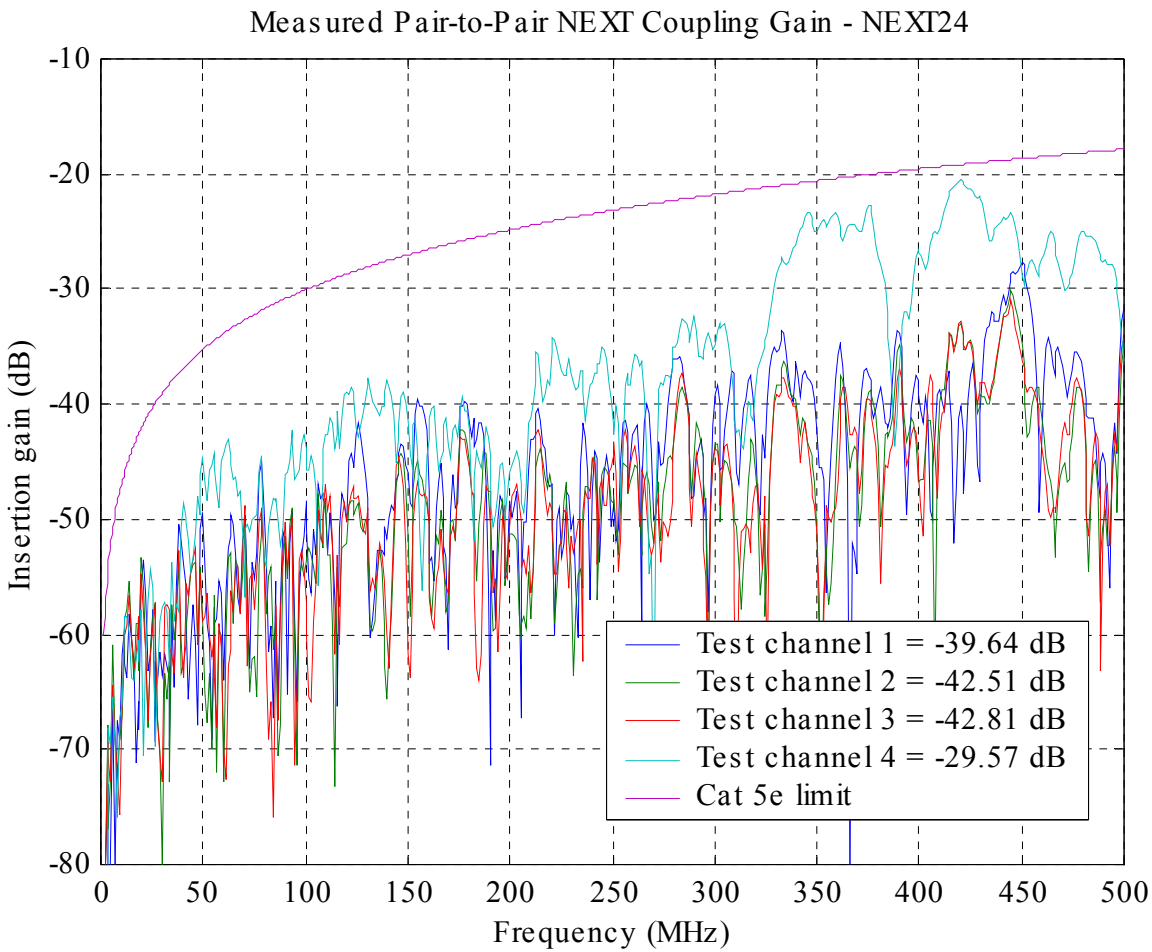
- NEXT at equipment room termination
- Figure of merit is integrated (average) power coupling loss to 500 MHz
- Adding connectors significantly increases interior pair NEXT coupling
- Connectors are dominant NEXT source

Power Sum NEXT Measurement – Interior Pairs



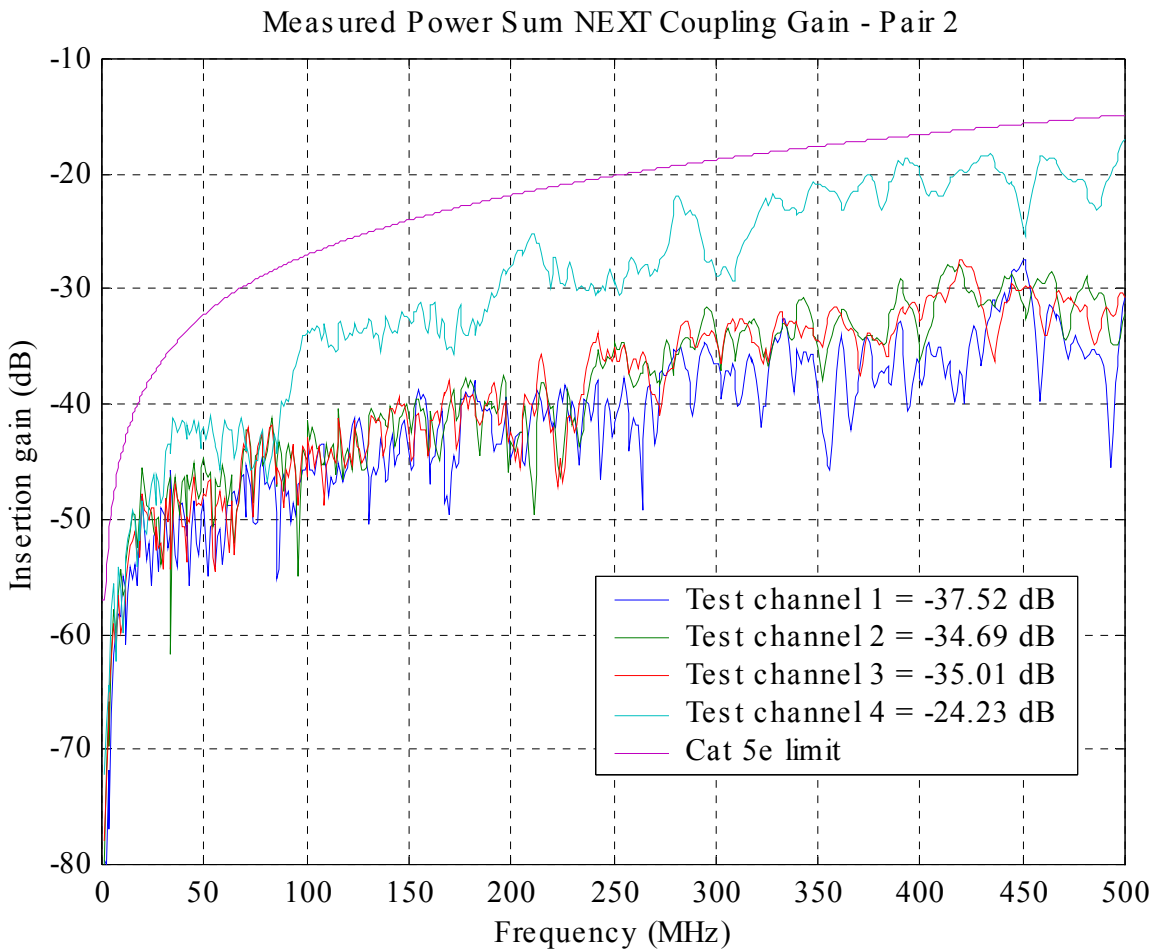
- Connector-dominated NEXT has different slope characteristic than cable-dominated NEXT
- Connector NEXT shows smooth curve or large periodic fluctuations – cable NEXT is "noisy"

Pair-to-Pair NEXT Measurement – Exterior Pairs



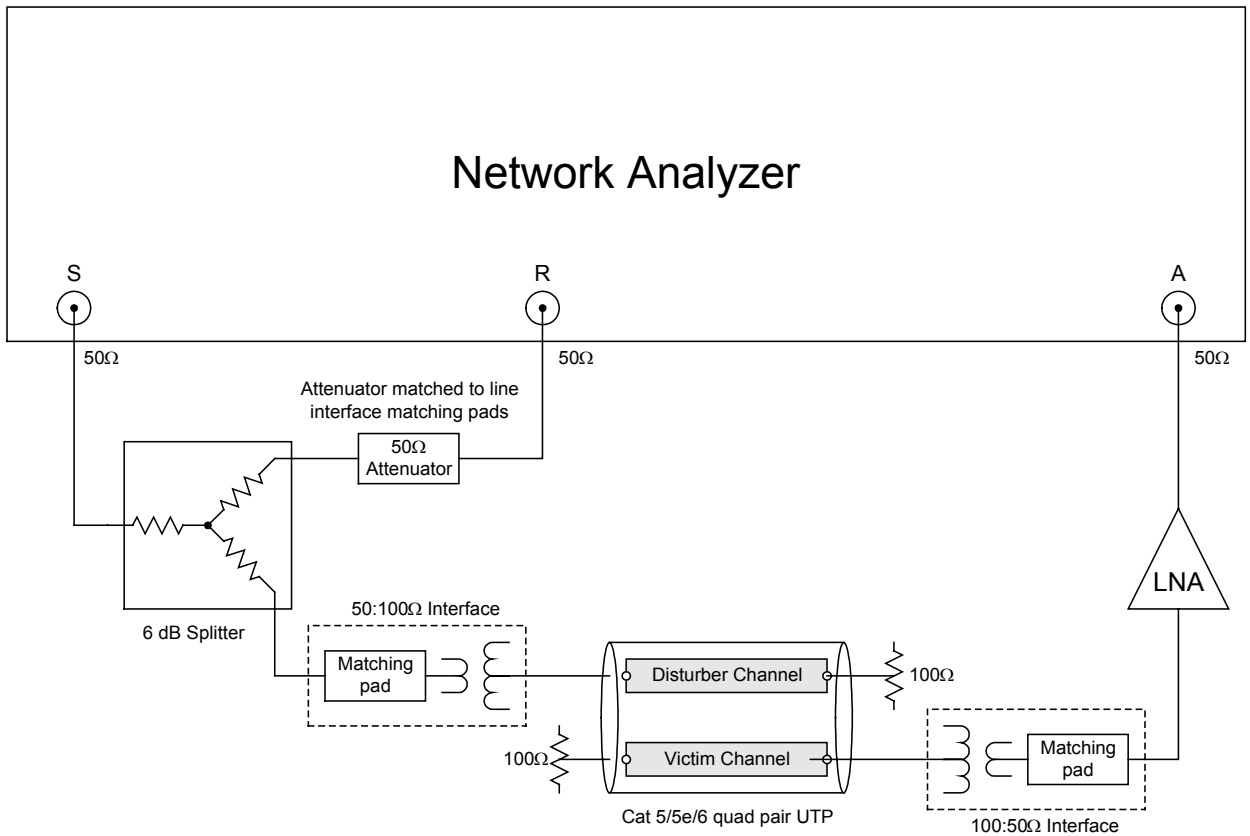
- Connectors have less effect on exterior pair NEXT coupling – physical separation
- Added connector in test channel 4 is an inline coupler – worse than ordinary connector.

Power Sum NEXT Measurement – Exterior Pairs

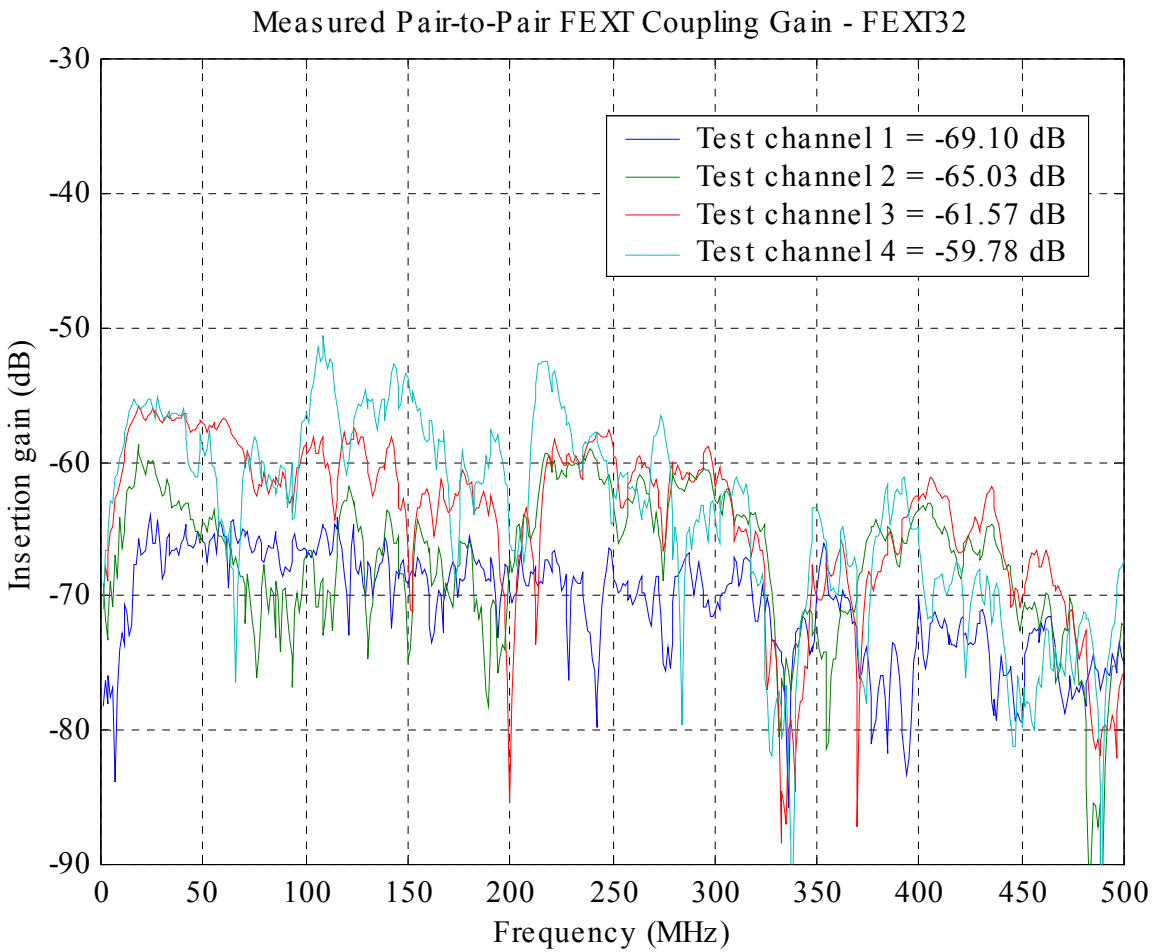


•One bad connector can significantly increase NEXT coupling (added inline coupler for channel 4)

FEXT/ELFEXT Measurement Setup

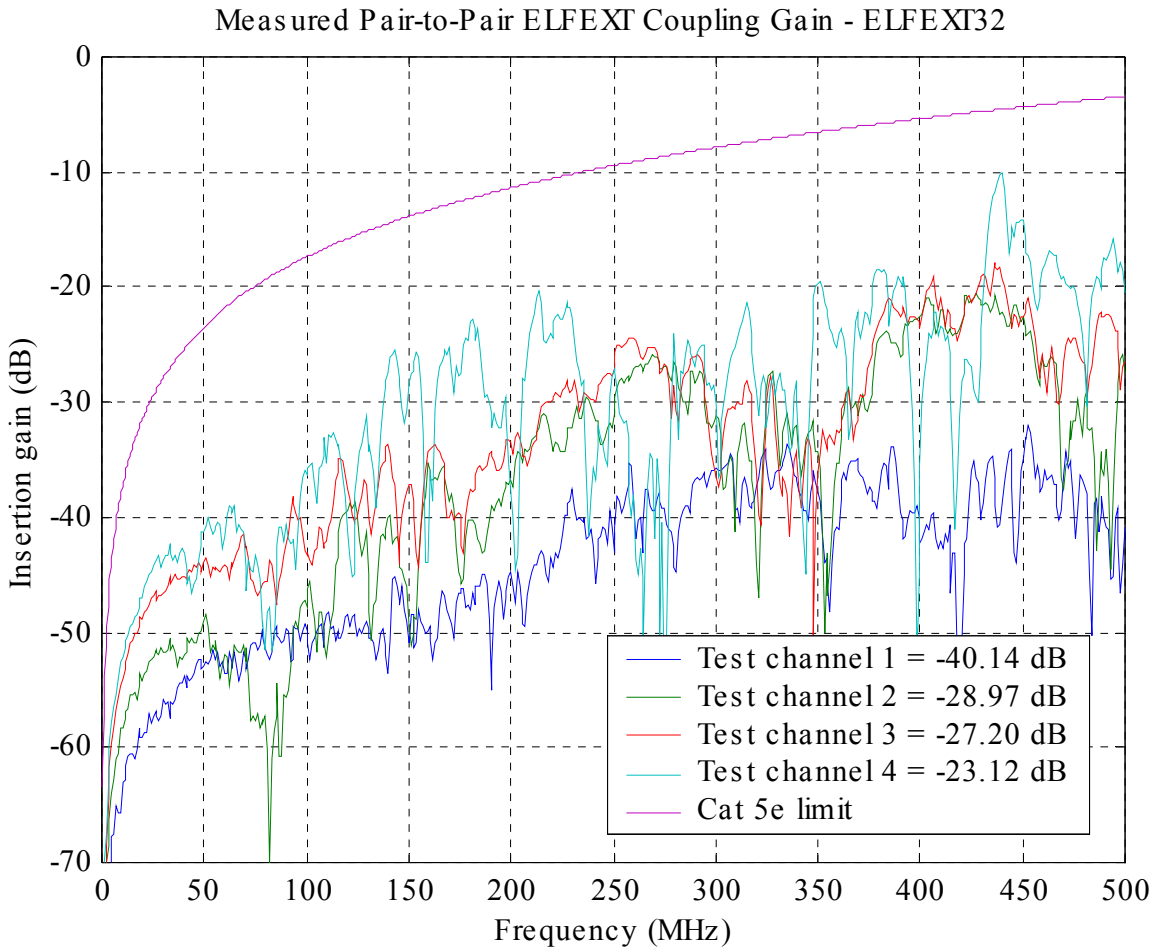


Pair-to-Pair FEXT Measurement



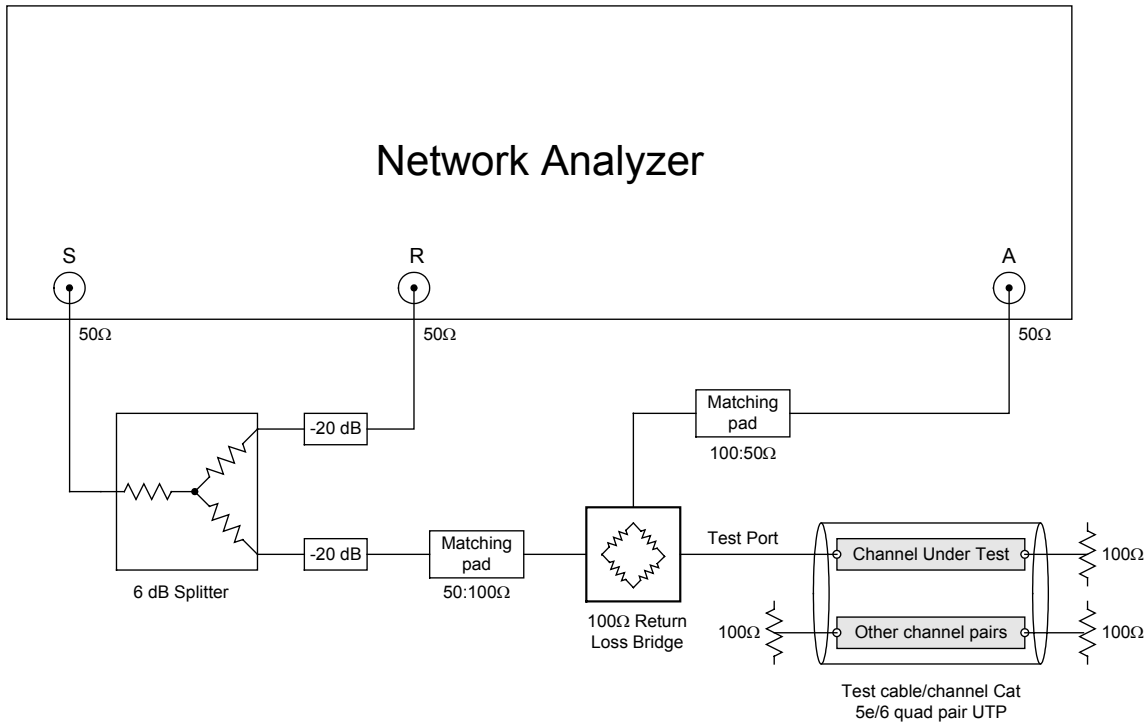
- FEXT is much less than NEXT on long lengths
- Measured FEXT becomes stronger on short lengths
- FEXT increased by connectors

ELFEXT Measurement

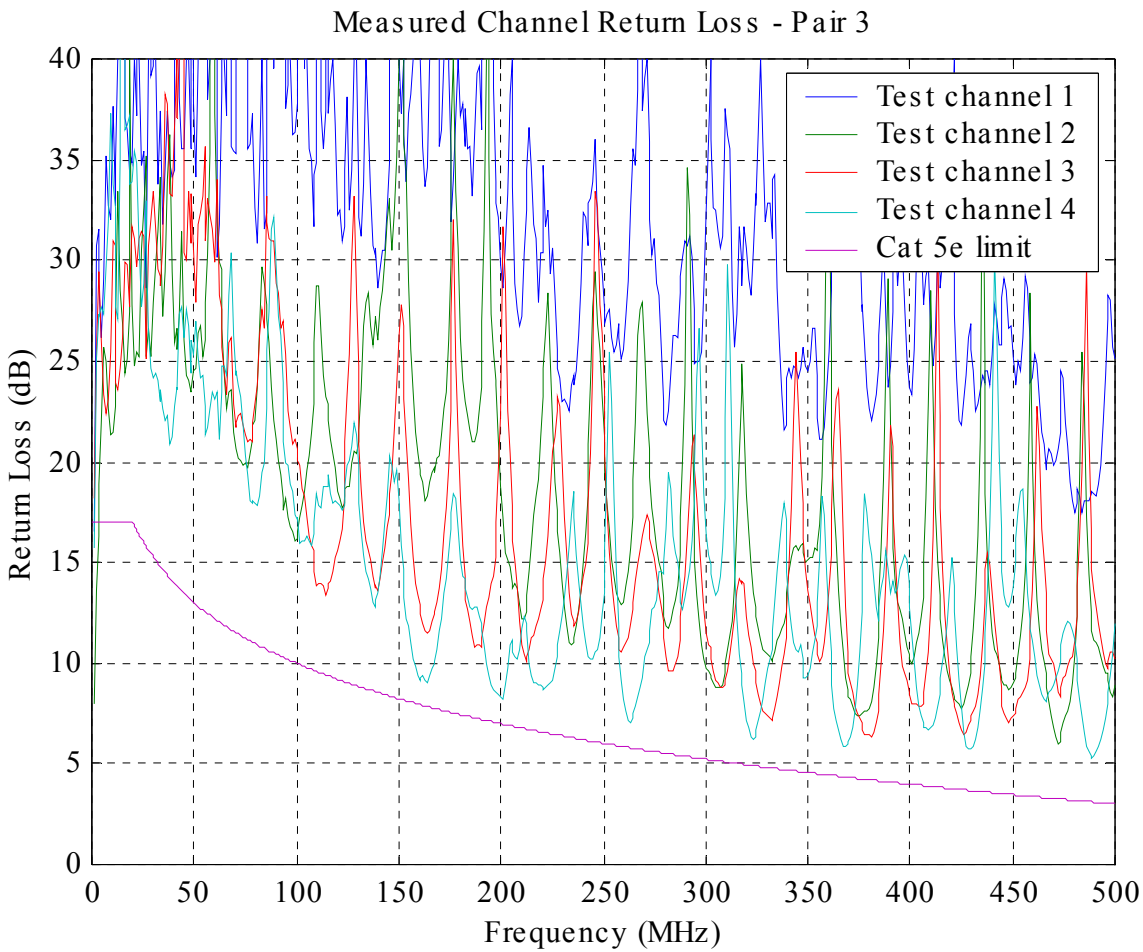


- FEXT is measured directly
- ELFEXT is FEXT normalized by channel loss
- Greater margin to limit than NEXT
- ELFEXT increased by connectors

Return Loss Measurement Setup

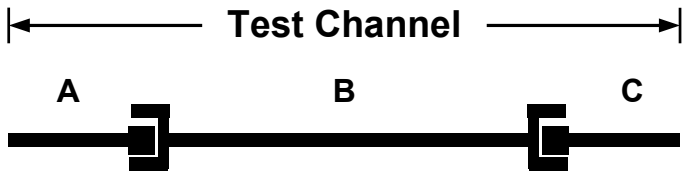


Return Loss Measurement



- Cable return loss is excellent
- Return loss is degraded by adding connectors
- Connector effects reduced by distance

Multiple Sample Test – 100 meter channel

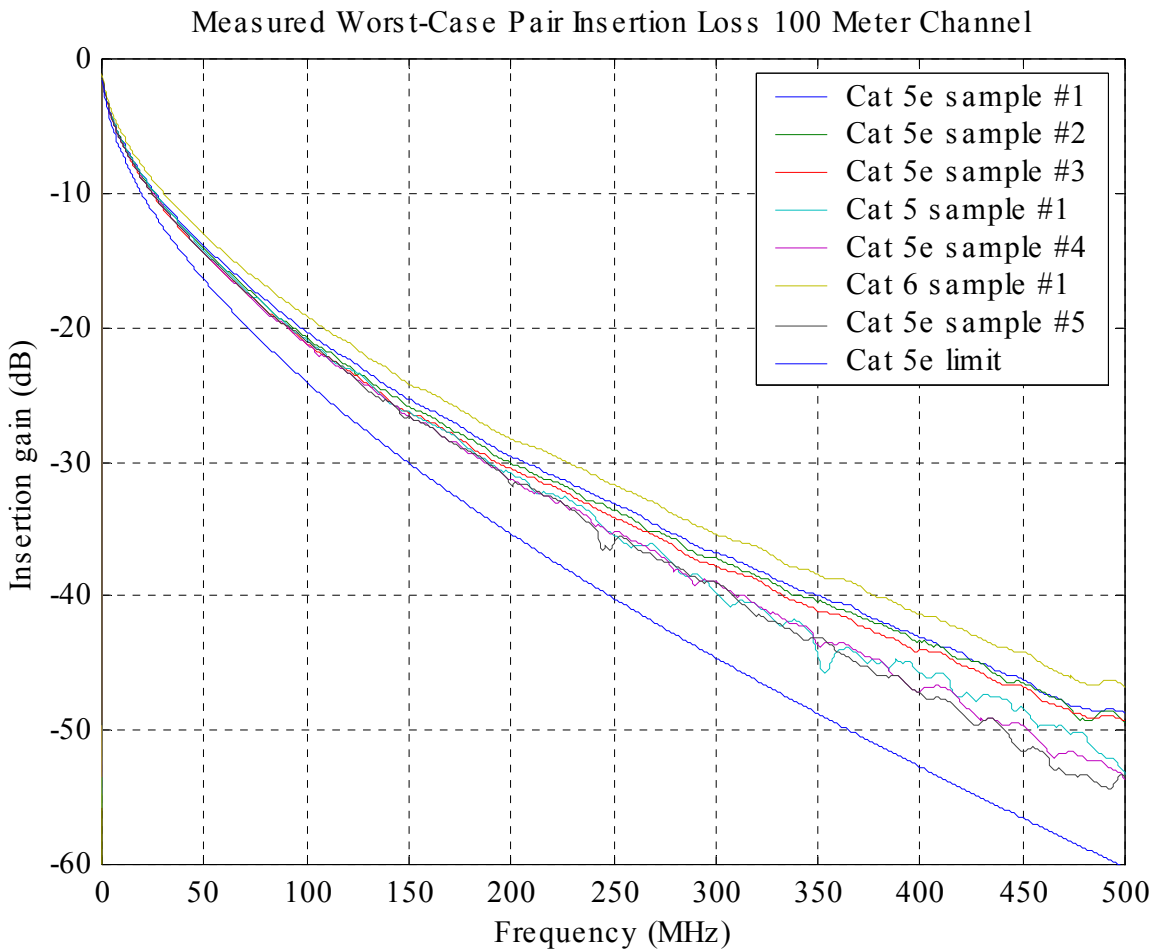


A= 2 meters, B= 93 meters, C=4.5 meters

A and C = Cat 5e work area and equipment cord: B = 93 meters horizontal cable

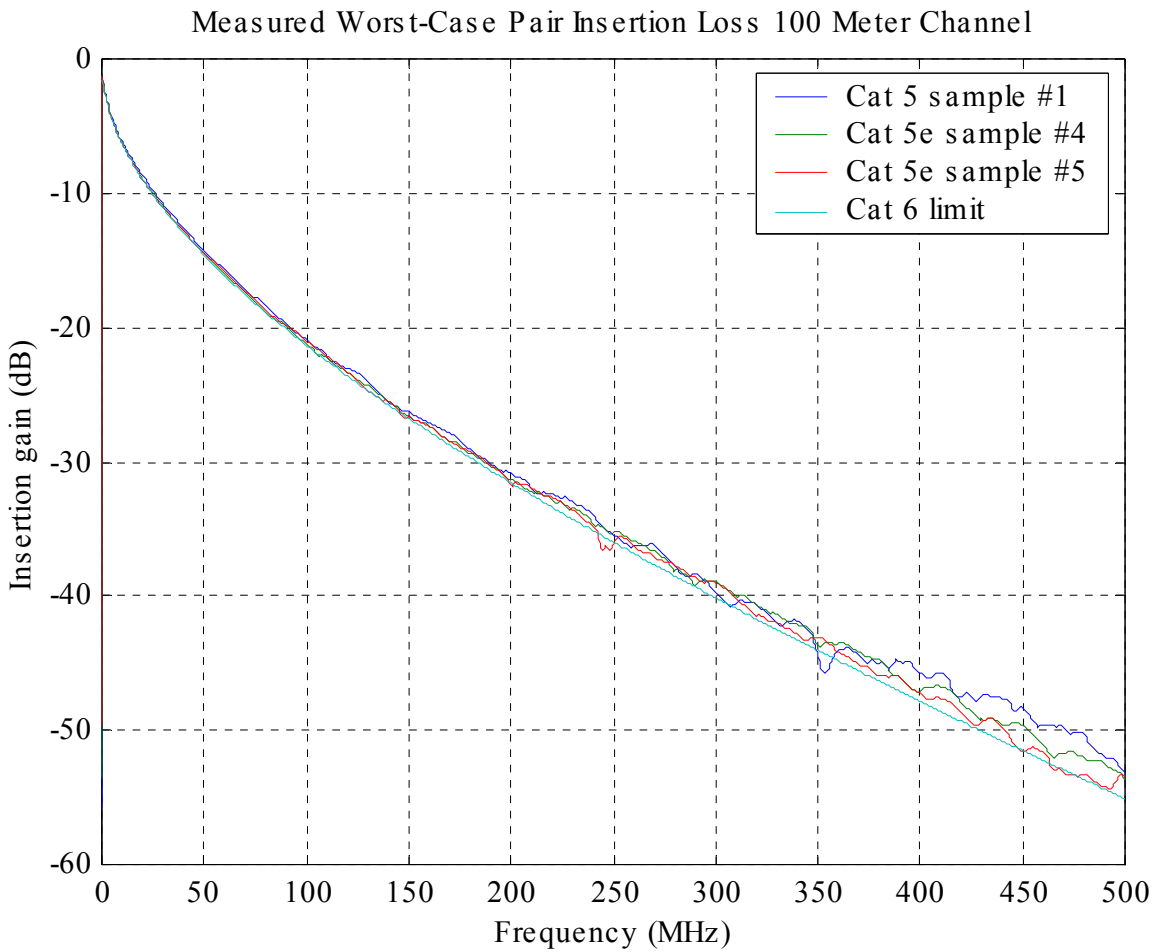
- Compare different cable samples from different manufacturers
- Measurements made at room temperature
- No stretching or excessive mechanical stress applied to test cable
- No RJ54 interface on test fixture – direct soldered connection

Insertion Loss from Cable Samples



- All sample channels are significantly better than the extrapolated Cat 5e/Class D channel limit line
- Cat 6 test channel better than all Cat 5/5e test channels

Worst Measured Cat 5/5e Loss vs. Cat 6 Limit



•Worst Cat5/5e channel approximated by extrapolated Cat 6 channel limit line

Propagation Delay and Delay Skew

- Propagation delay derived from time-domain conversion (IFFT) of measured network analyzer data
- Propagation delay varied from 450 to 500 nsec over different cable samples (be careful using propagation delay to measure length!)
- No correlation between loss and propagation delay across different cables brands
- Delay skew less than 15 nsec over various cable samples

Cat 5e Measurement Summary

- Lots of Cat 5e cable performs much better than specified TIA/ISO limits
- Most significant channel degradations are due to connectors
- Poor connectors can significantly increase internal crosstalk and reduce return loss
- TIA/ISO limits are designed for worst-case pass/fail limit bounds
  - Never intended as a typical channel characterization
  - Provide margin for test equipment imperfections and measurement noise
  - Use of extrapolated TIA/ISO insertion loss limits as a channel model is very pessimistic with respect to a typical Cat 5e channel
- Typical Cat 5e channel insertion loss at room temperature can be approximated by the extrapolated Cat 6 channel limit line
- Significant channel degradations can be mitigated by replacing connectors