

EMI, Channel Characteristics, and Alien Crosstalk Results

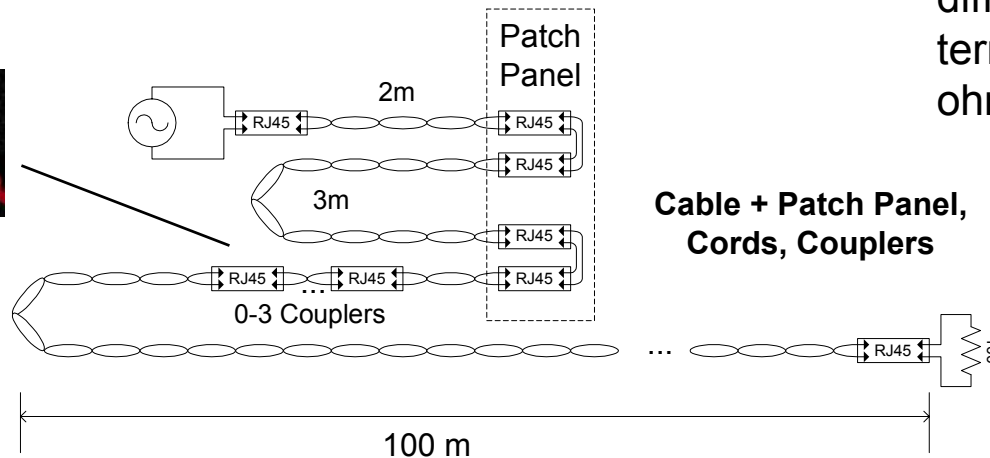
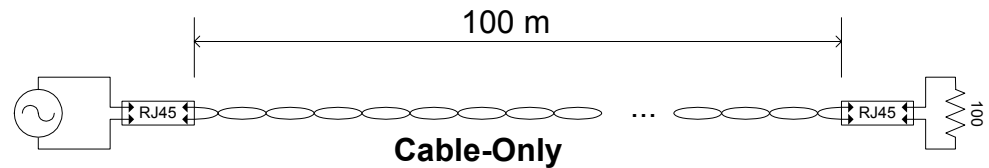
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EMI

EMI Characterization

- Characterize various cable configurations

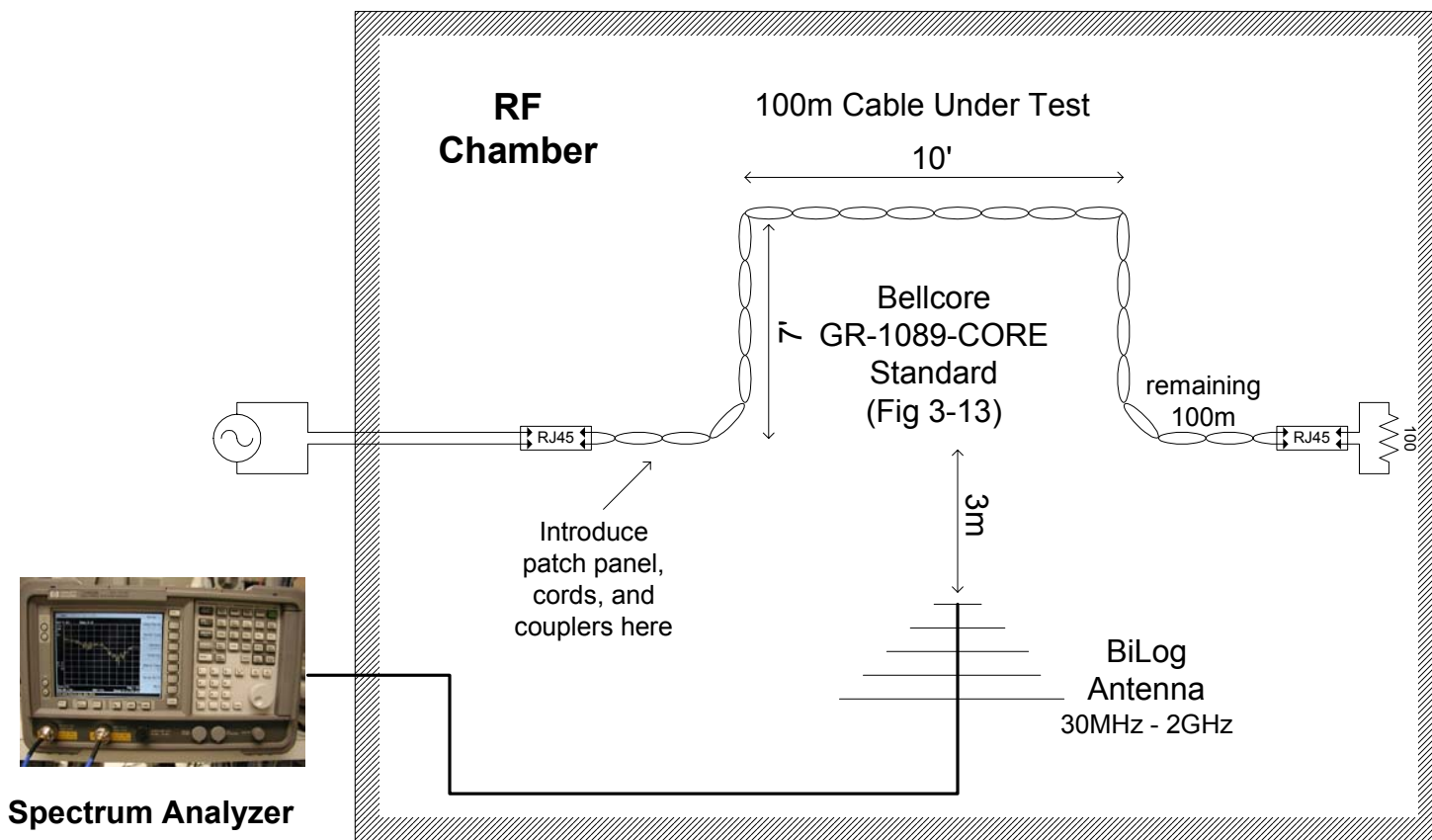
- Unshielded Cat5E to start
- Cable-only
- Cable + patch panel & cords
- Cable + patch panel, cords, and in-line coupler(s)
- EMI from 4 pairs is $\leq 4 \times$ EMI from 1 pair (6dB higher, worst case)



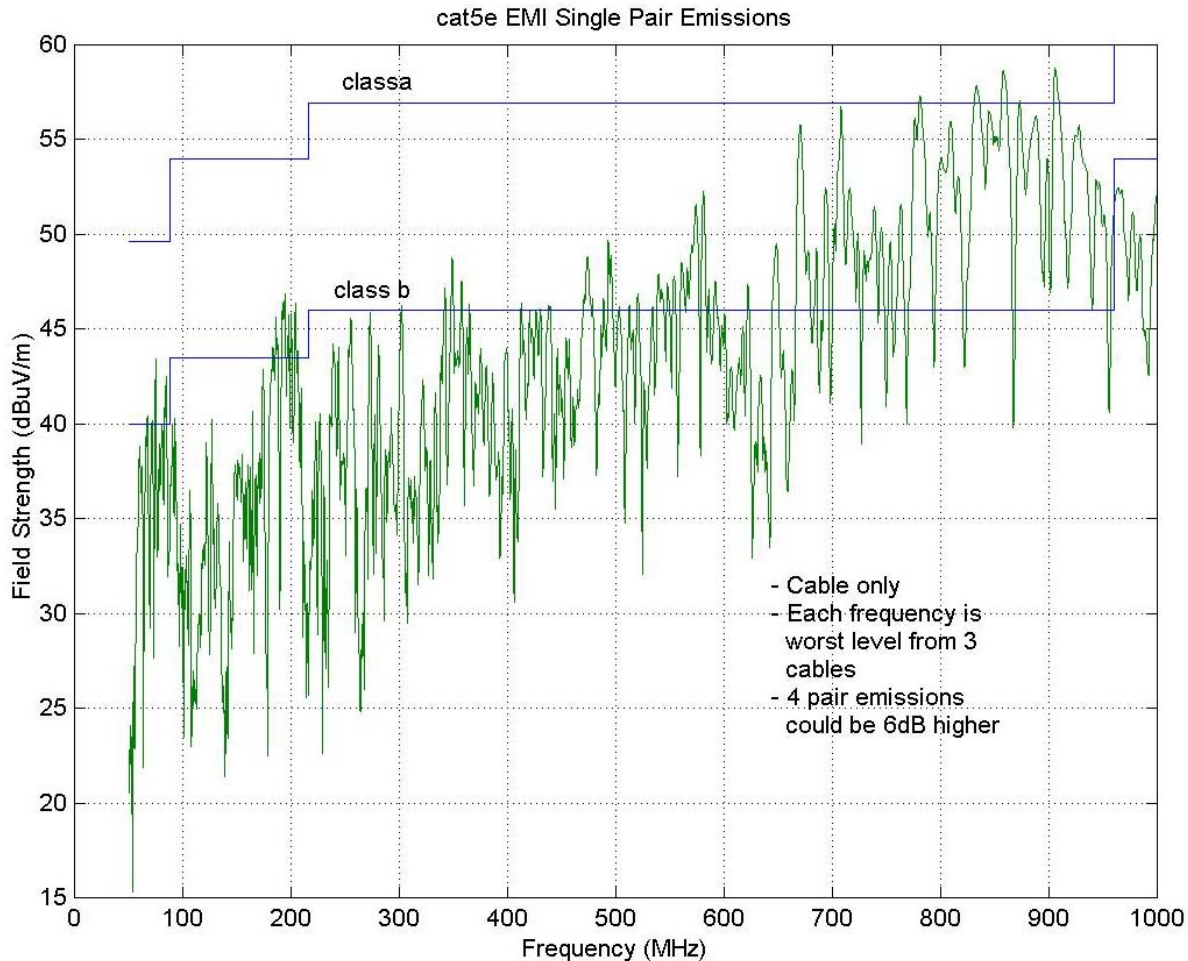
Unused pairs
differentially
terminated in 100
ohms

EMI Test Set-up

- Adjust antenna height and polarity for maximum emissions
- Calibrate cable, fixtures, antenna and background

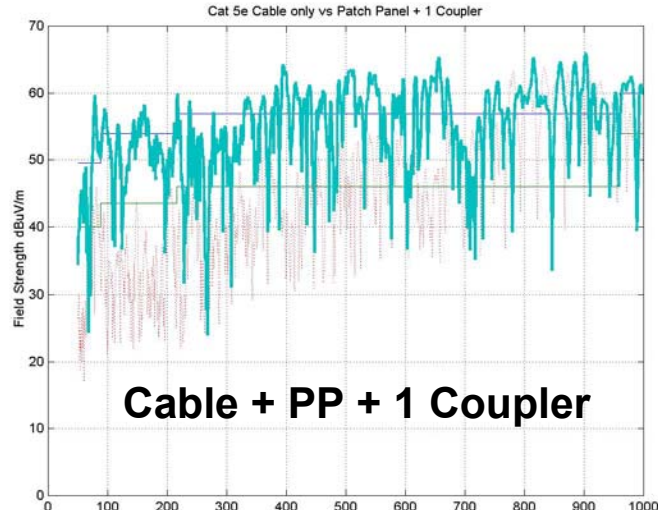
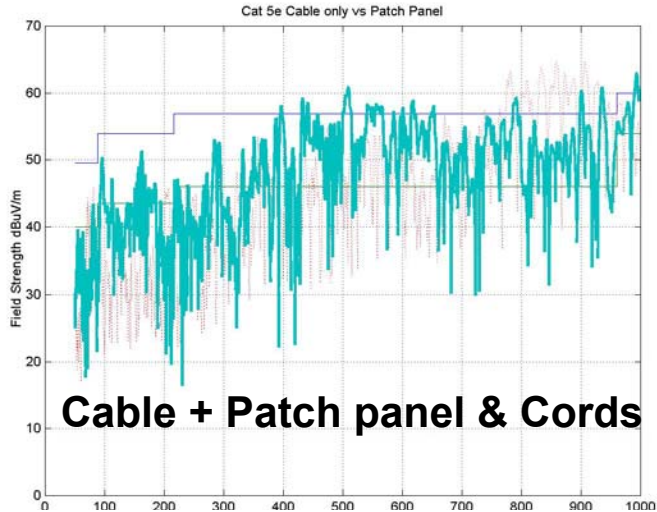


Cable-only EMI – single wire pair

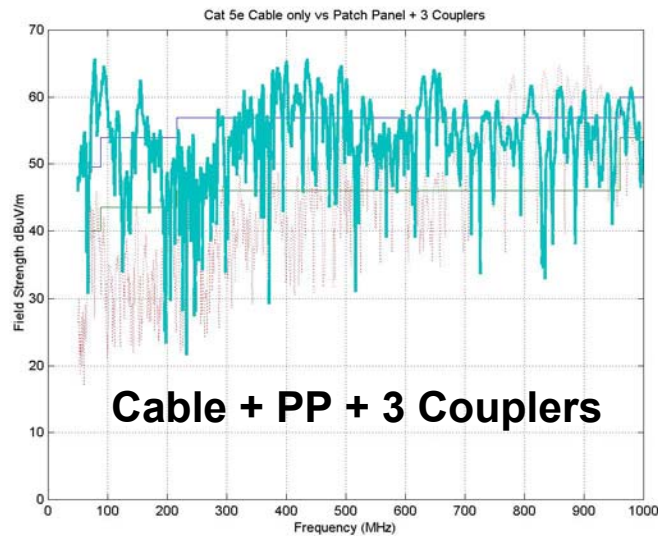
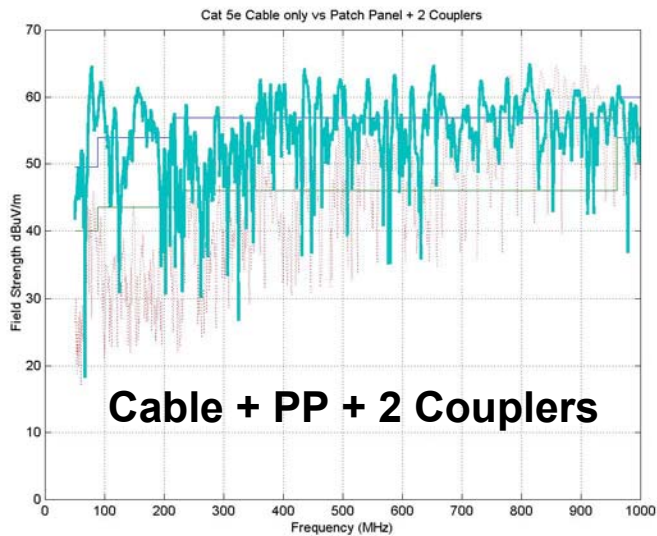


- Purely differential – bounds “best” EMI performance possible
- Single wire pair
 - 4 pairs \approx 6dB higher

Impact of Connectors



(red is cable-only measurement)



Maximum Launch Power for Class A EMI Limit

- Launch power appears to be significantly constrained with the inclusion of connectors
 - Highly dependent on configuration or cable/connectors
 - Spectral shaping may help
 - Limited data – independent verification needed

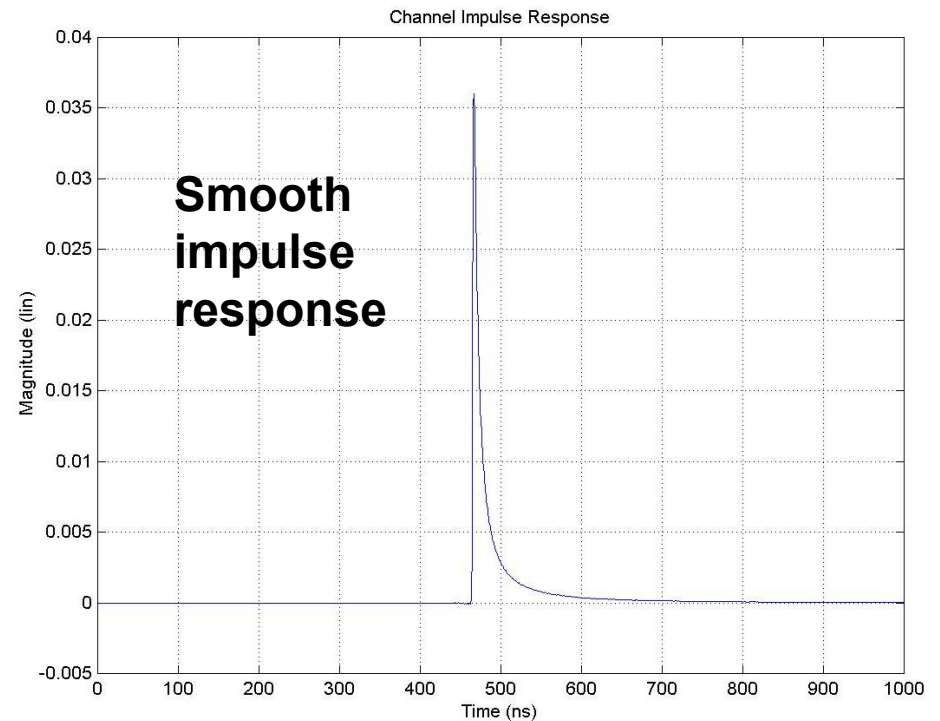
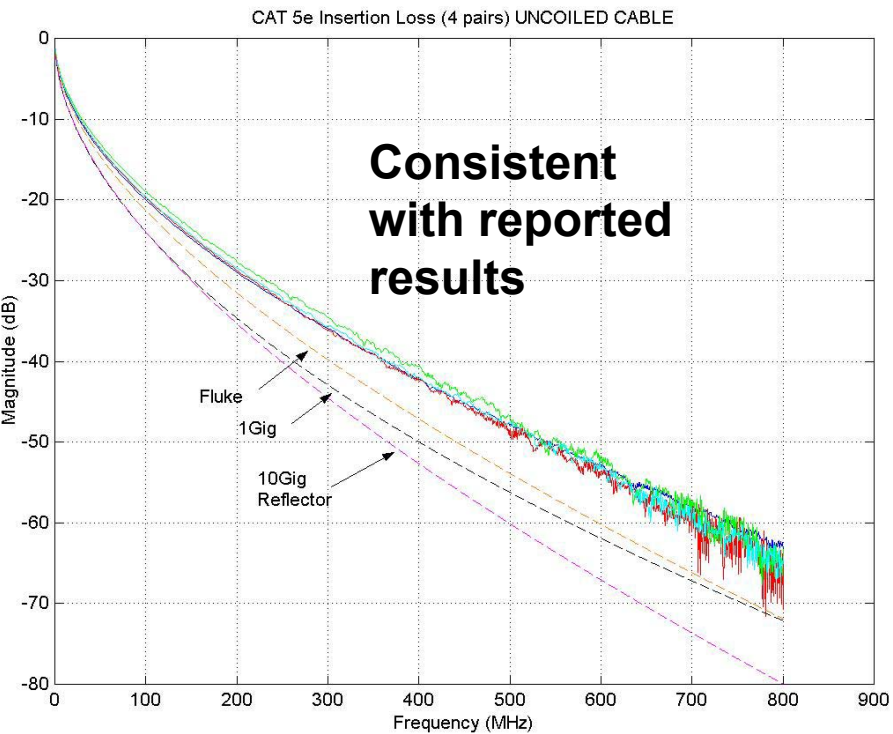
Launch Power Degradation

<u>Approach</u>	<u>BW</u>	<u>Cable-Only</u>	<u>Cable + PP</u>	<u>Cable + PP+1cplr</u>	<u>Cable + PP+2cplr</u>
PAM10	833	X dBm	X-2.5 dBm	X-14.2 dBm	X-19.3 dBm
Filtered PAM10	416	X dBm	X-1.1 dBm	X-14.2 dBm	X-19.2 dBm
Spectrally Shaped	416	X+3.9 dBm	X+1.7 dBm	X-7 dBm	X-7.6 dBm

Channel Characterization

Insertion Loss – uncoiled cable

- Measured with 4-port Network Analyzer

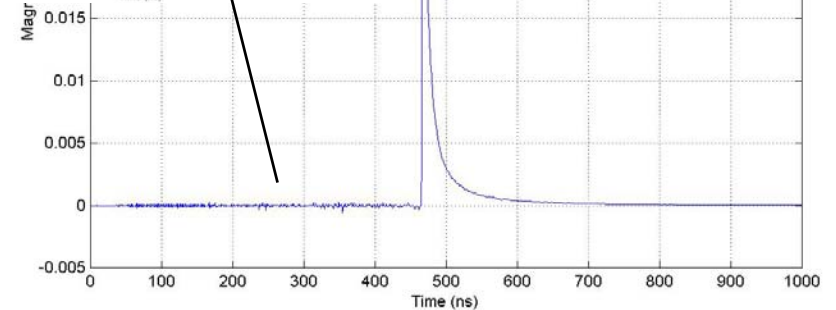
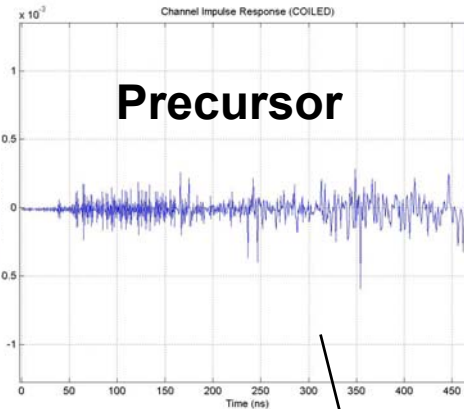
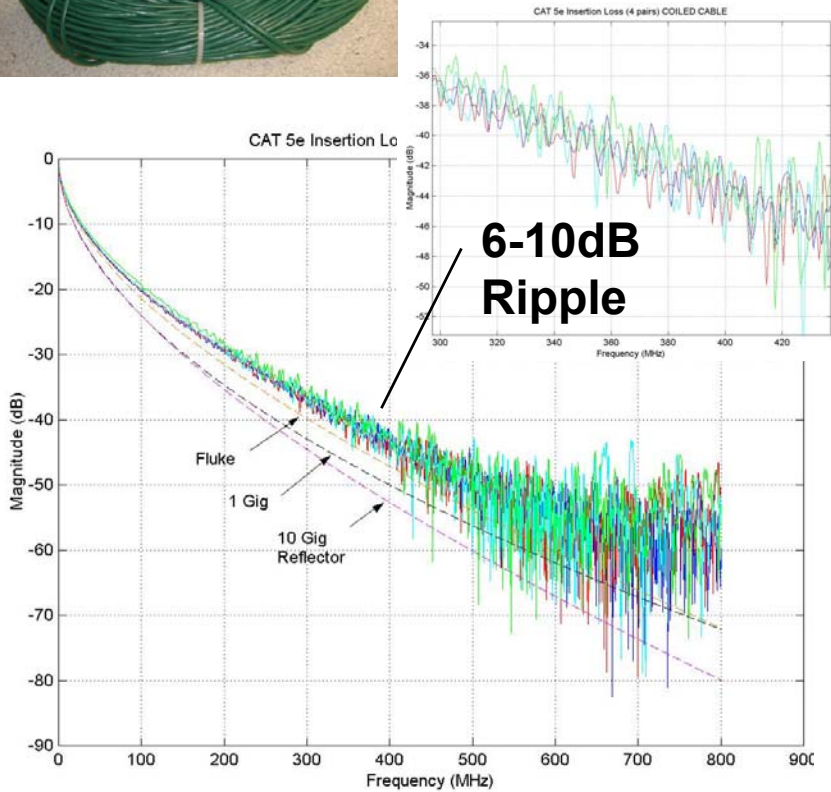


Insertion Loss – Coiled Cable



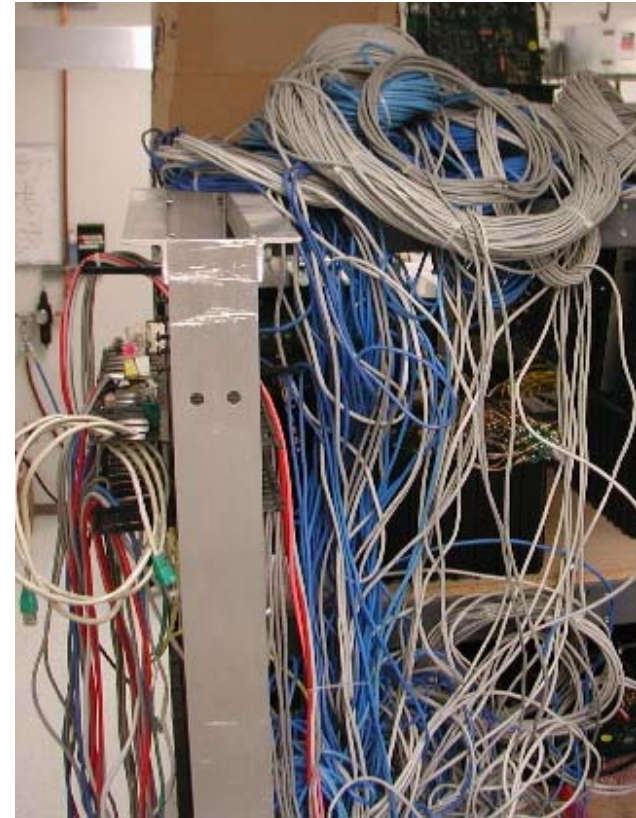
Approx 18"
diameter

- Self-coupling causes long non-causal precursor



Coiled vs Uncoiled

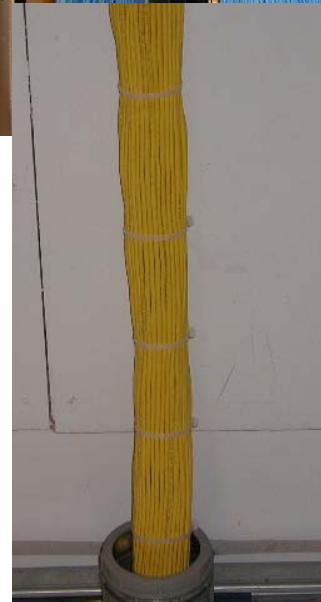
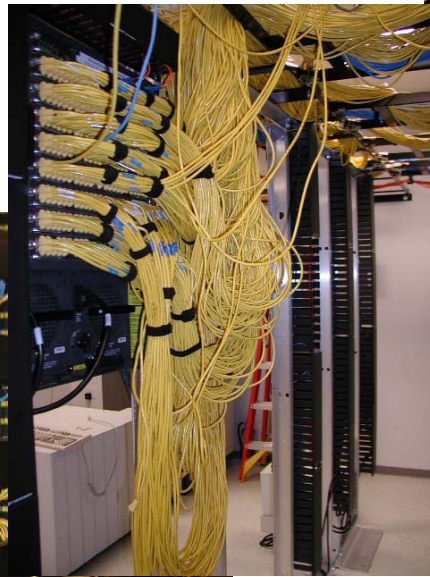
- **Pre-cursor power is about 33dB below signal power**
 - Eats into already slim noise budget
 - May be able to live with this but it's something to be aware of for a worst case channel
- **Long forward equalizers required to remove precursor**



Alien Crosstalk

A Typical Network Closet

- Alien crosstalk ... big-time
 - Tightly bundled cables common

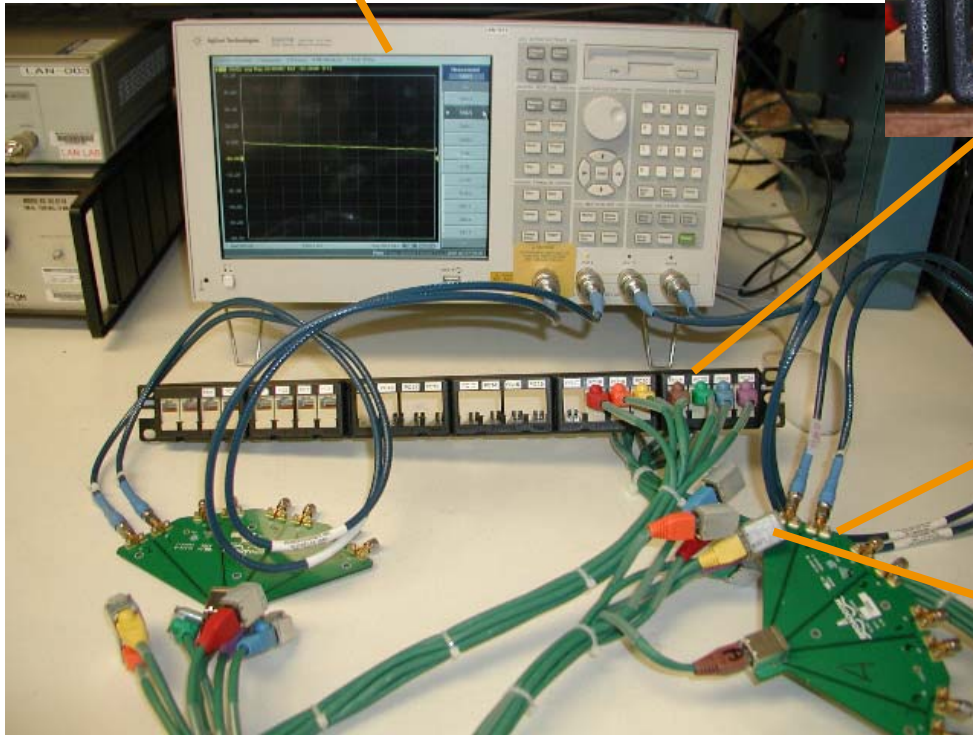


Test Fixtures/Equipment

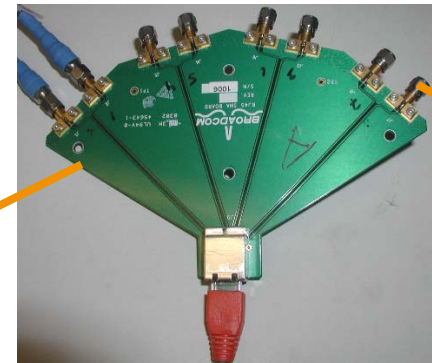
Optional Patch Panel



4-Port Network Analyzer



RJ45 to SMA



SMA 50Ω term.

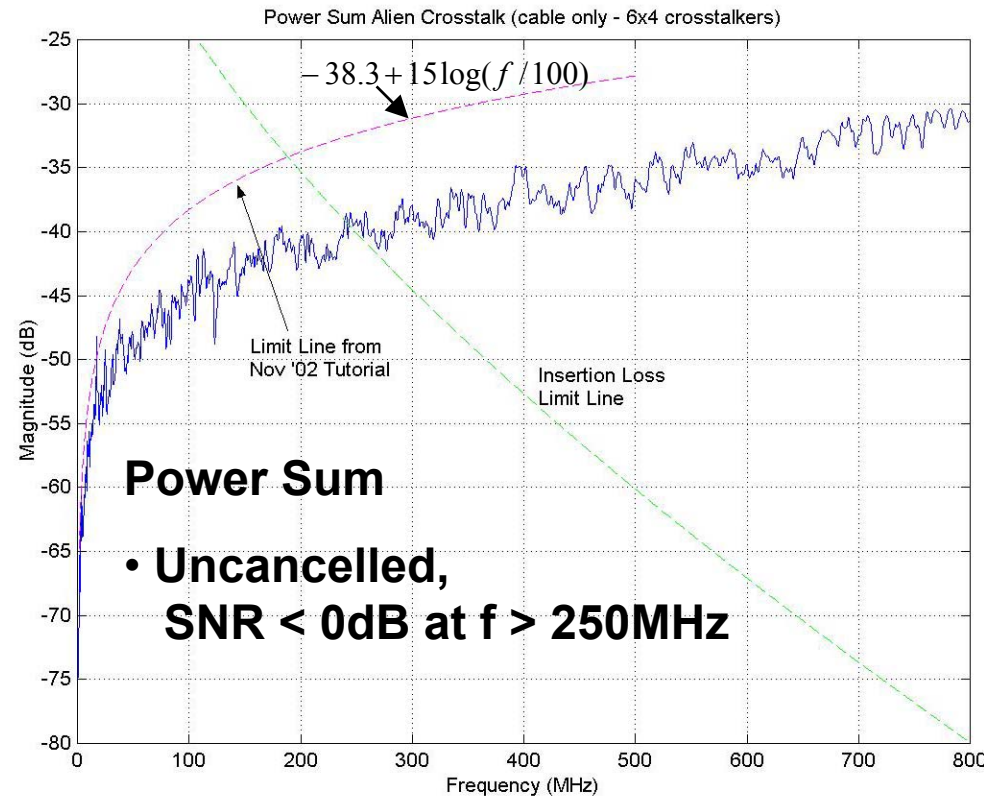
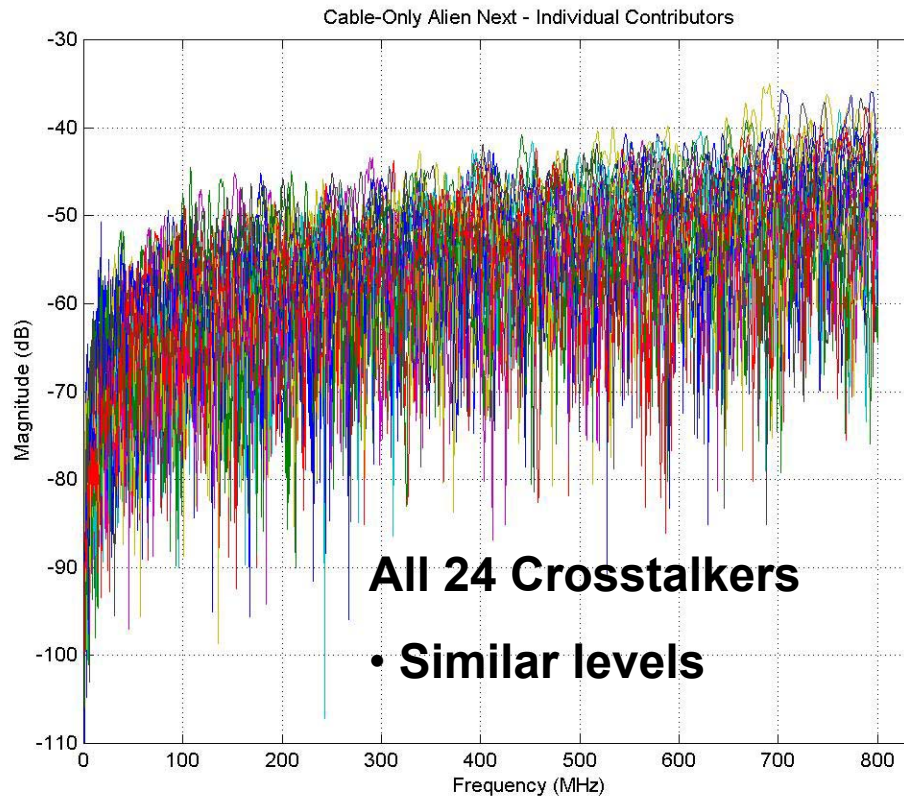
4x100Ω RJ45 terminations

Optional In-Line Coupler



Cat 5e: Cable-Only ANEXT

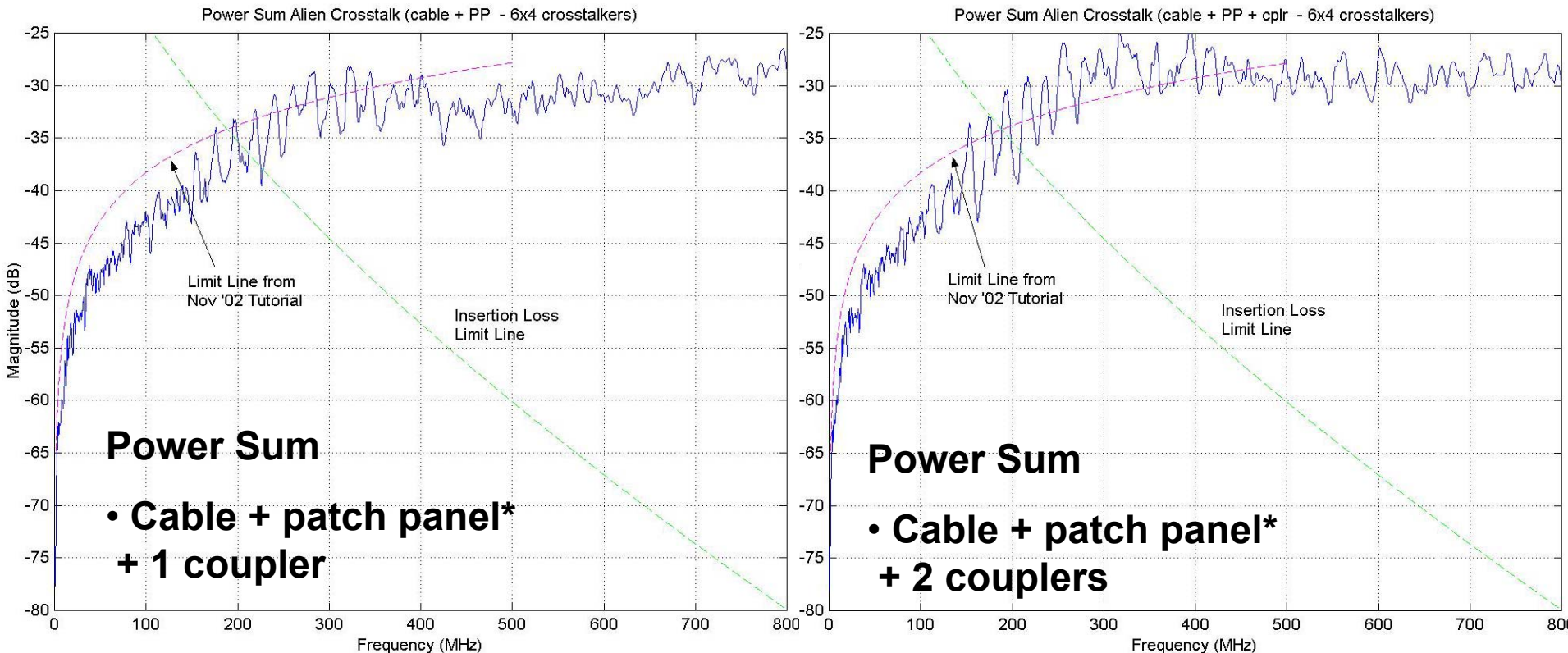
- ANEXT transfer functions: 24 crosstalkers to a single victim pair



- 7.5dB margin to load line (integrated power to 400MHz)

Impact of Patch Panel & Couplers on ANEXT

Same Cat 5e cable bundle & single victim pair as previous slide



- 1dB margin to load line
- 6.5dB worse than cable-only

- Exceeds load line by 2dB
- 9.5 dB worse than cable-only

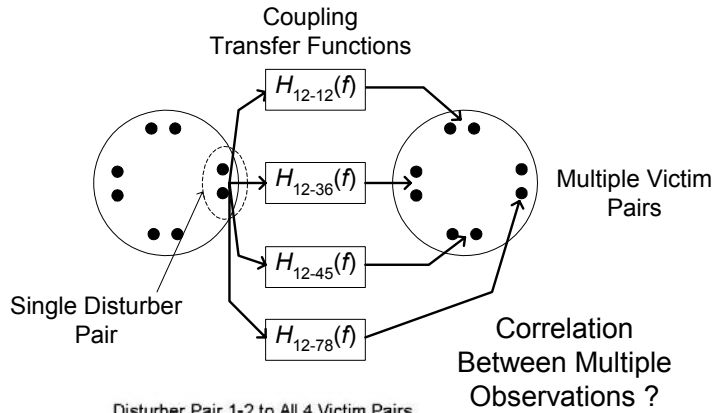
Required Suppression (Cat 5e)

Let: $SNR_{ANEXT} \equiv (\text{Rx Signal Power}) / (\text{ANEXT Power})$ in BW=400MHz

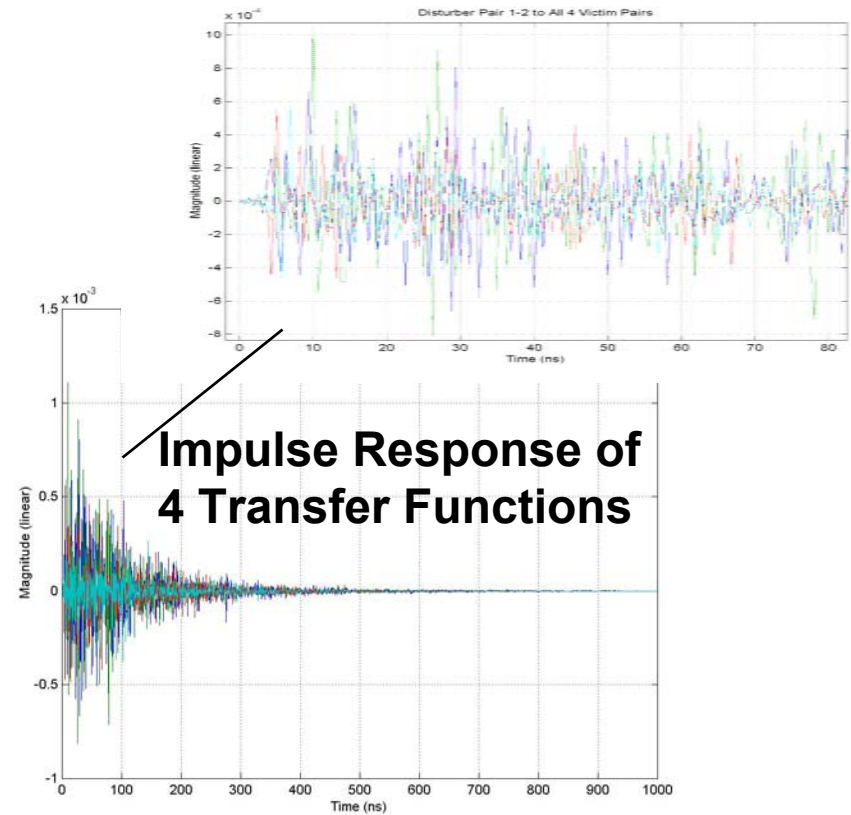
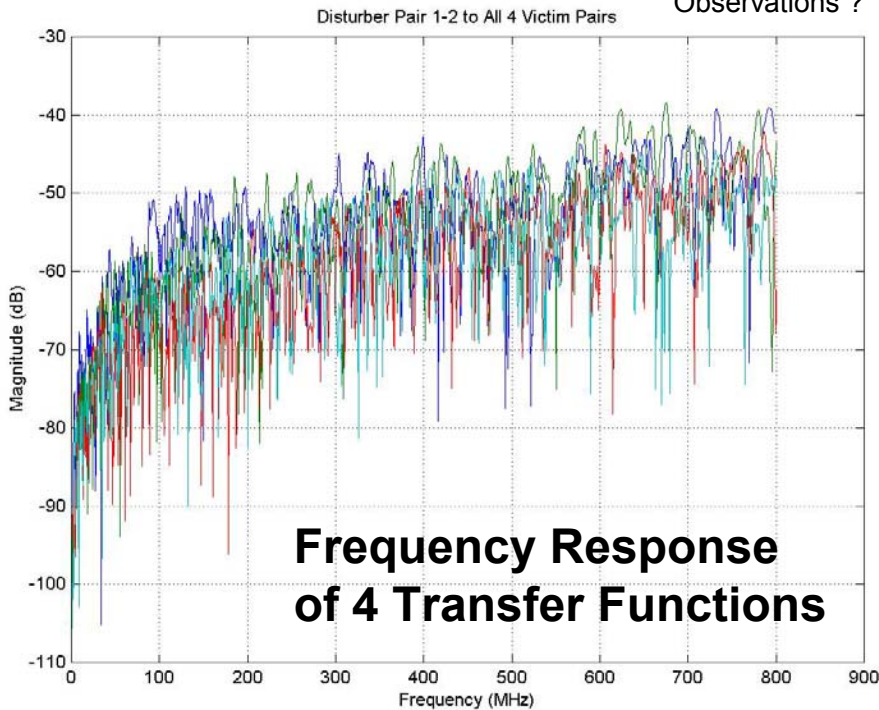
	Single Disturber Cable	6 disturber Cables	6 Cables + Patch Panel	6 + Patch Panel + Coupler
SNR_{ANEXT}	30.6 dB	24.8 dB	18.3 dB	15.3 dB
Suppression for PAM10	2.7 dB	8.5 dB	15.0 dB	18.0 dB

- **Up to 18dB ANEXT suppression required for baseband PAM in worst case**
 - 33.3 dB target permits 6 dominant noise sources to achieve 25.5 dB composite

ANEXT Suppression (Cat 5e)



- Correlation decreases as number of disturbers increase



Summary of Results

- **EMI**

- Connectors/patches can reduce available launch power by as much as 2-20 dB for baseband PAM

- **Insertion Loss**

- High frequency degradation if loops/turns are permitted in cable run
 - Up to 6-10dB ripples in magnitude response within “usable BW”
 - Non-causal precursor in impulse response

- **Alien Crosstalk**

- Connectors/patches can increase crosstalk power by as much as 6-10 dB for baseband PAM

Can a “1G” Approach Solve “10G” Issues ?

- **The environment which led to a baseband PAM approach for 1Gig has changed substantially for 10G**
 - Additional set of non-idealities must be addressed
- **Measurements of fundamental limits raise serious concerns about the viability of extending a “1G-like” baseband PAM approach to 10Gig for 100m UTP**
- **Other approaches may be better suited to address the more difficult concerns for 10Gig**
 - ADC (and sampling) precision/speed
 - EMI compliance
 - Alien crosstalk tolerance
 - Equalization complexity