

Title: Alien Crosstalk and Network Performance

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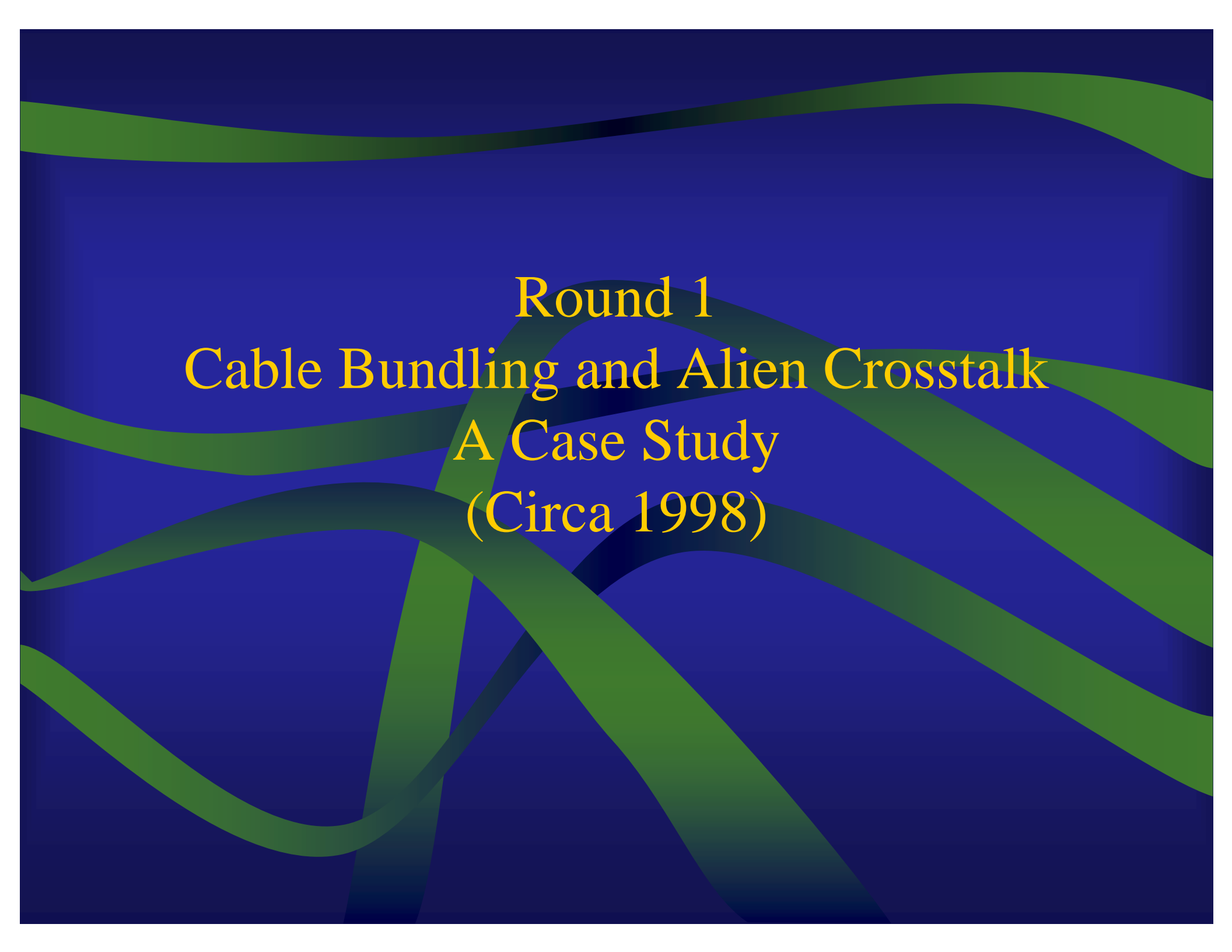
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Location: Dallas, TX

Distribution: IEEE 10GBase-T study group

Abstract: This document examines the alien NEXT performance of various bundled cables and measures the impact upon various networks' performance.

Recommendation: For discussion to help determine alien NEXT characteristics for installed cabling



Round 1
Cable Bundling and Alien Crosstalk
A Case Study
(Circa 1998)

Cable Assemblies Under Test

Binders

Cinched

Conduit

100 Meter Bundled Cable Scenarios

- Six category 5 cables bound by two binders
- Six category 5 cables bound by cinch ties
- Six category 5 cables bound by one inch EMT conduit for a 22% fill factor
- Ten category 5 cables bound by one inch EMT conduit for a 40% fill factor

Bound Cable

- Six category 5 cables bound by two binders
- 100 m sample was laid out and tested on the floor



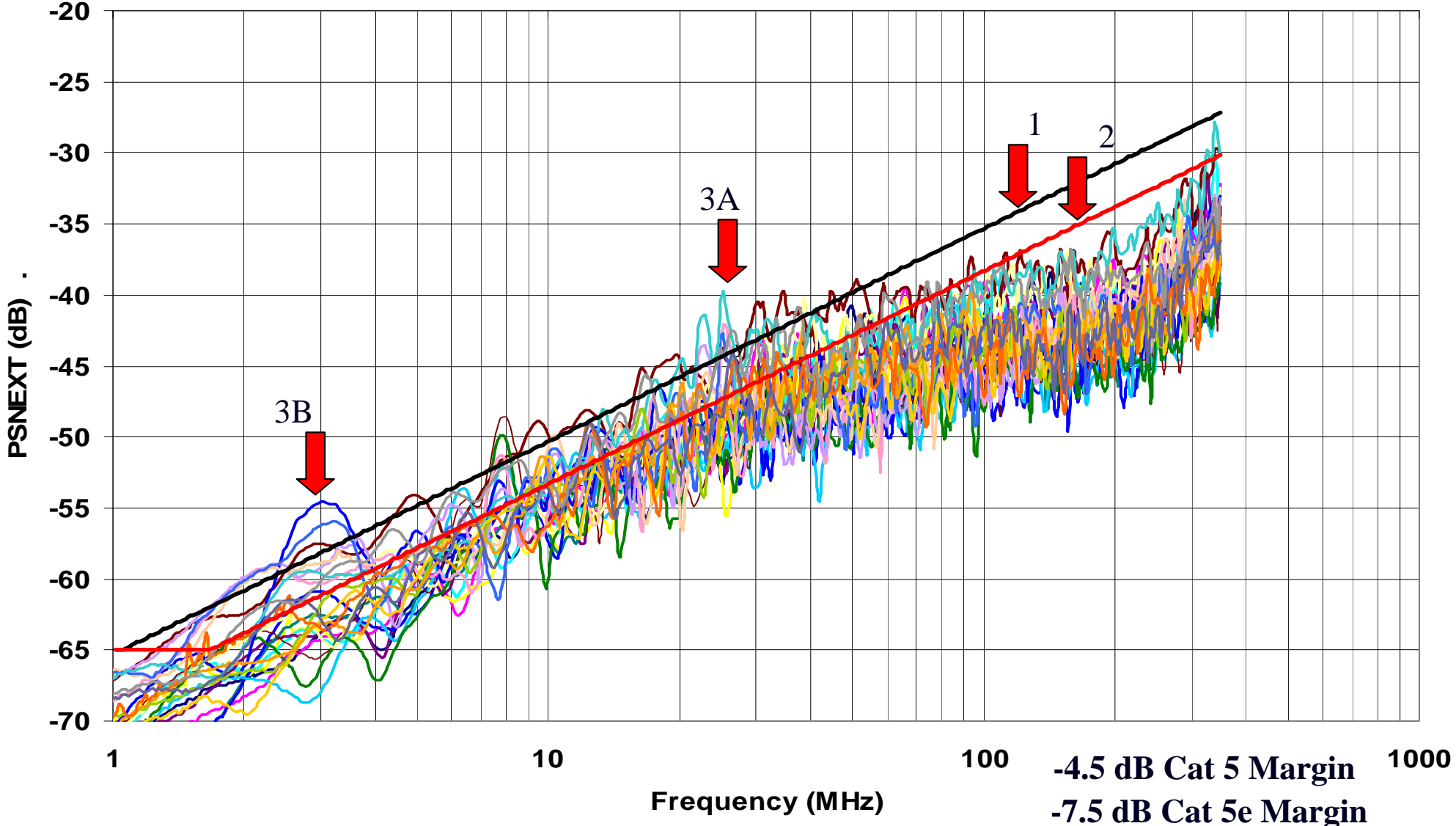
Powersum NEXT Charts

- All six cables displayed
 - 6 cables x 4 pairs/ cable = 24 traces
- Each trace comprises of 20 measurements for that pair
 - Example (Blue 1 to Blu/Org/Grn/Brn X)
 - $2 \leq X \leq 6$



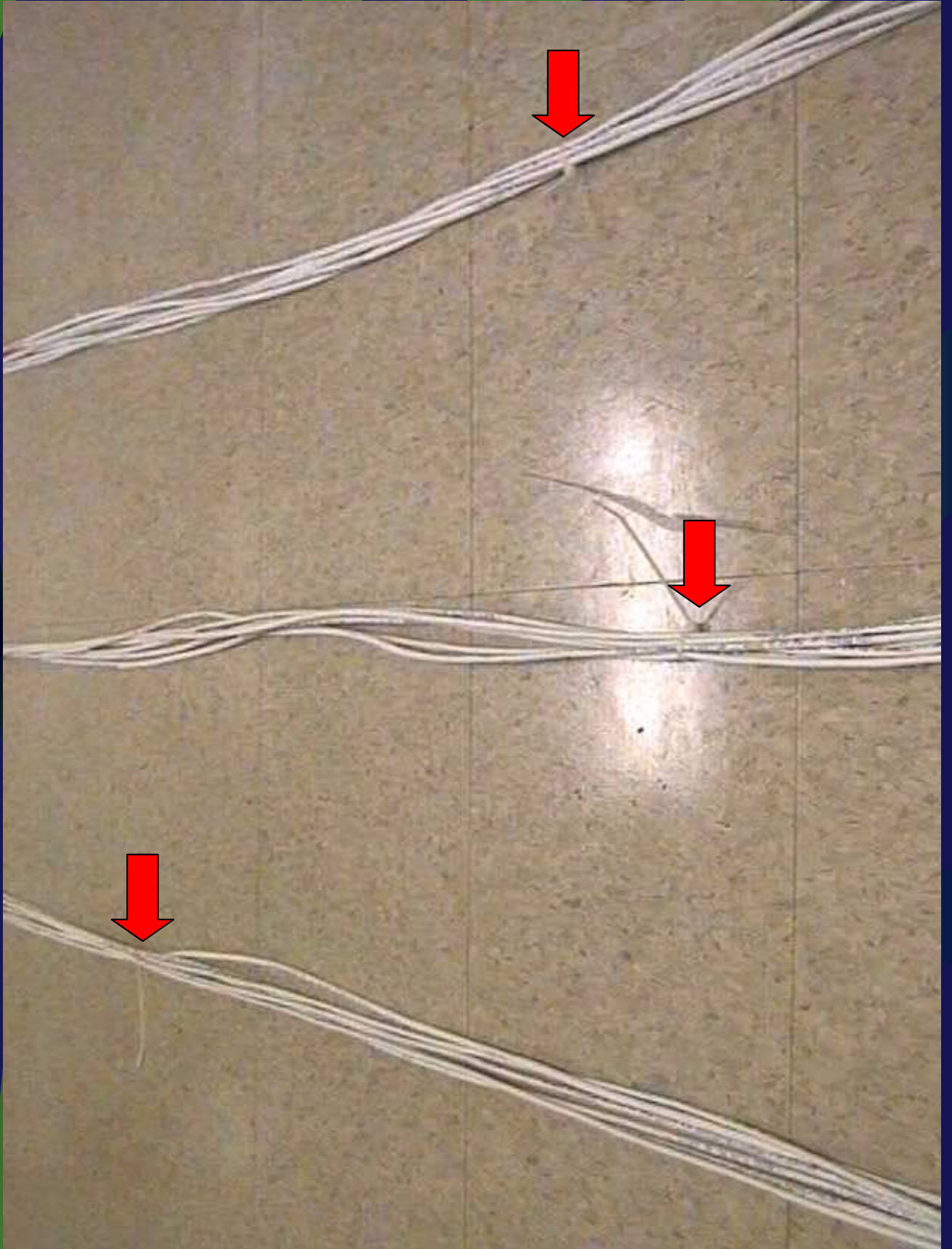
Alien Power Sum NEXT

Six Cat. 5 Cables Double Bound



Cinched Cable Samples

- Cables cinched every 48 inches in accordance with the ANSI/TIA/EIA-569-A guidelines for cable support
- Also gives an approximation of cables supported by hooks or rings
- Cinch ties slightly deformed the cables' jackets
- 100 m sample was laid out on the lab floor



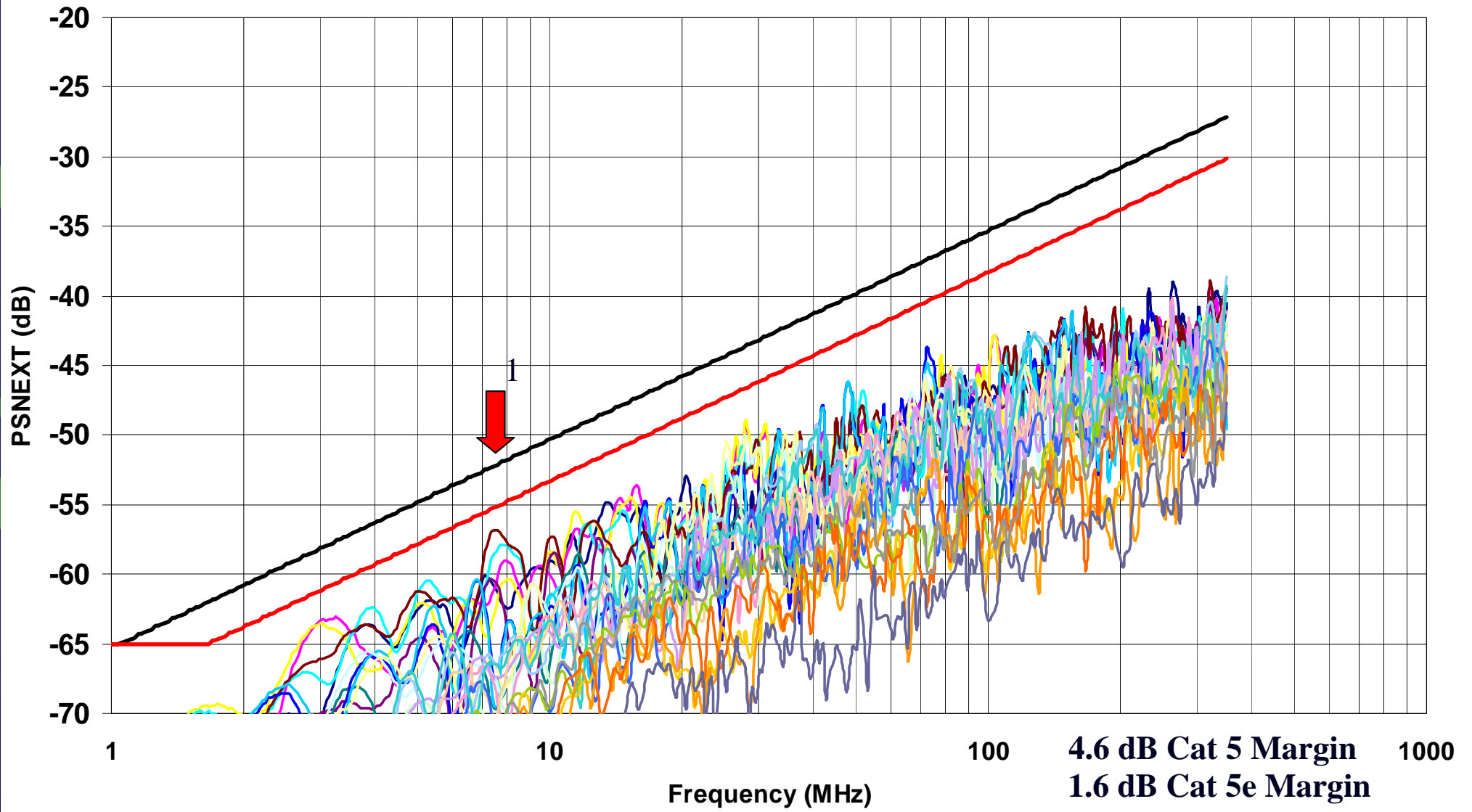


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Alien Power Sum NEXT

Six Cat. 5 Cables Cinched Every 48 Inches



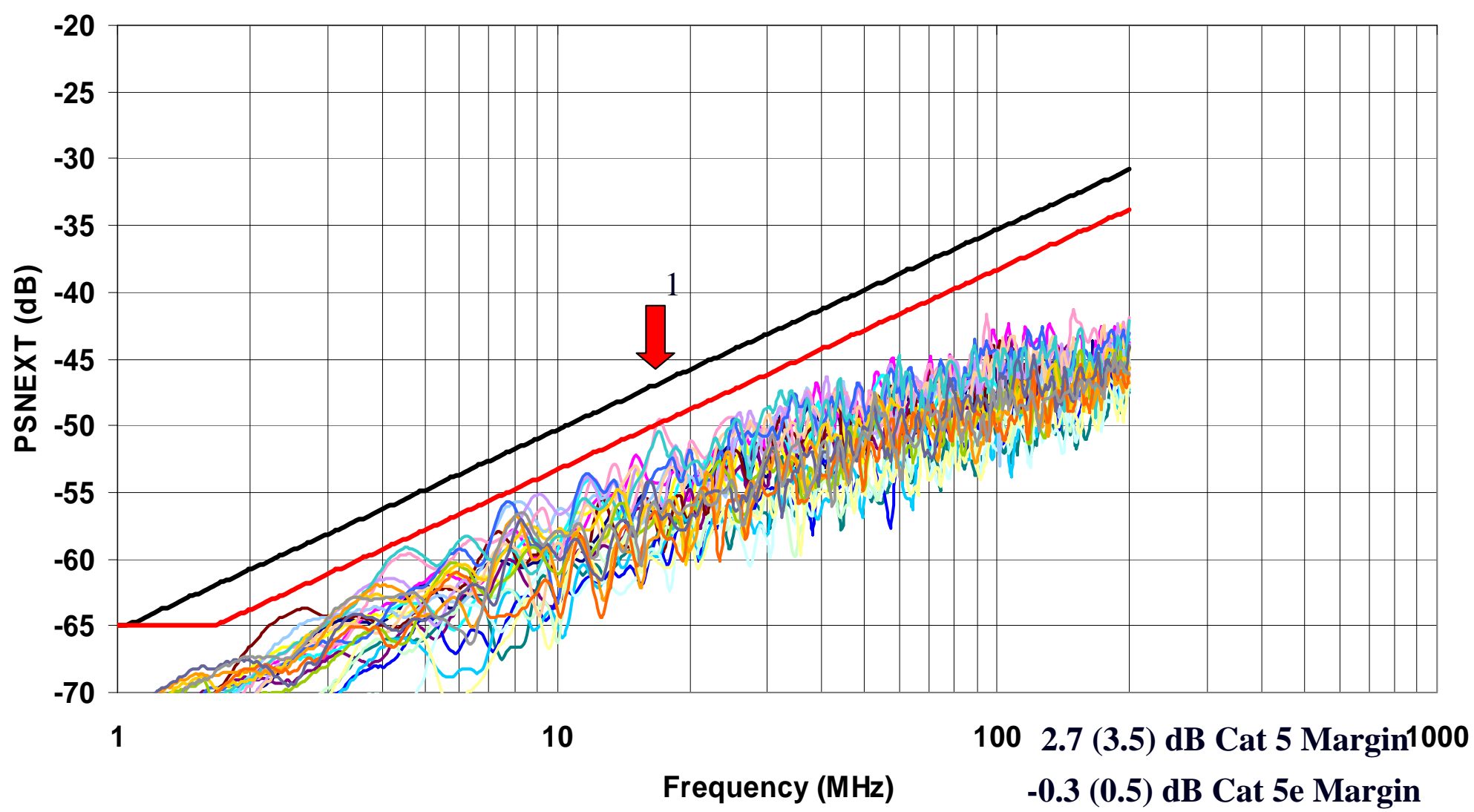
Conduit Sample

- Six 100m cables pulled into 280 ft of 1 inch EMT conduit (24 ft of exposed cable on each end)
- The conduit consisted of two 140 ft straight runs connected at the far end by two 90 degree bends



Alien Power Sum NEXT

Six Cat. 5 Cables - 22% Conduit Fill



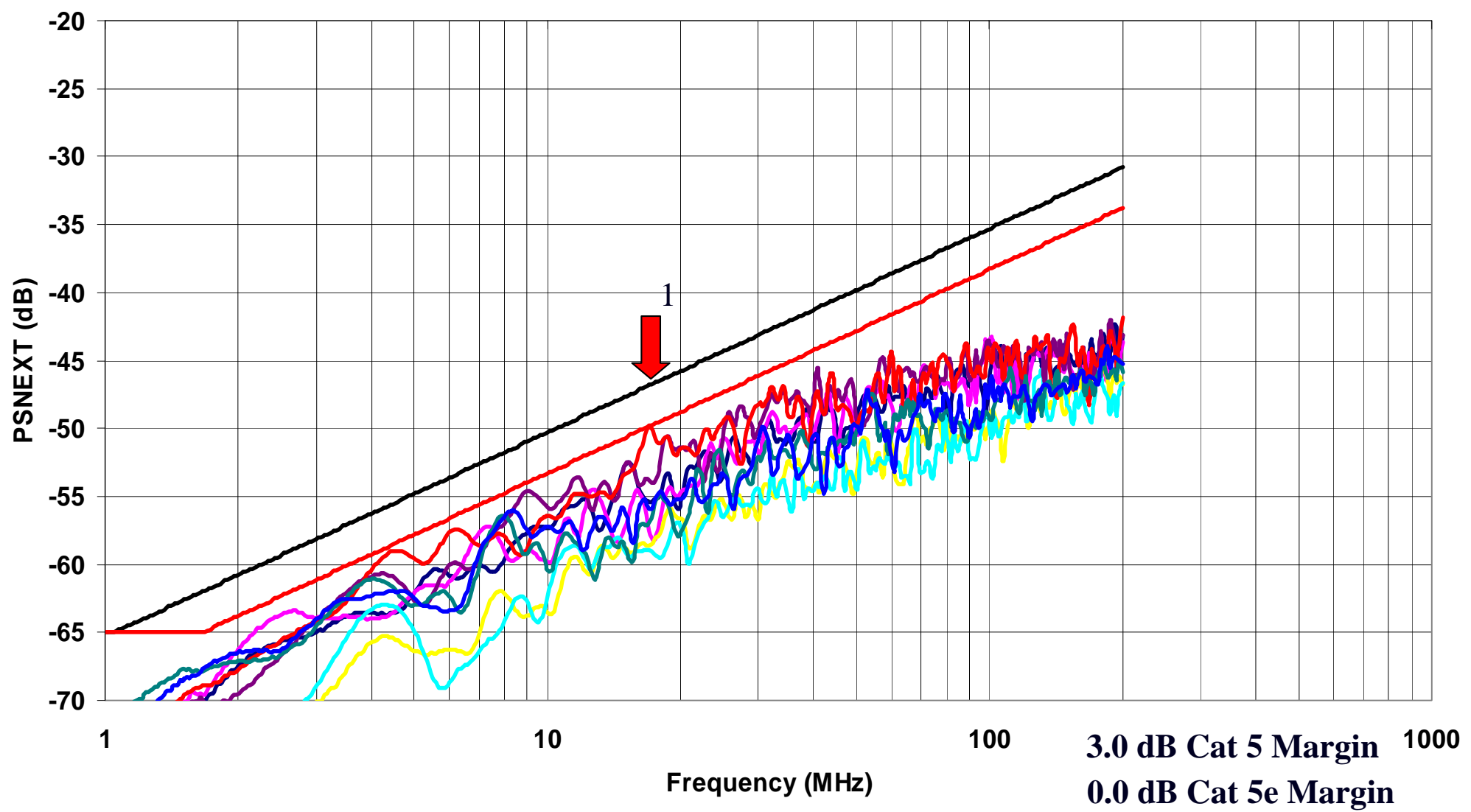
Alien Power Sum NEXT- 40% Fill

- Pulled 4 more cables into conduit
- Two worst case cables from the 6 cable bundle
 - 2 cables x 4 pairs/ cable = 8 traces
- Each trace comprises of 36 measurements for that pair
 - Example (Blue 1 to Blu/Org/Grn/Brn X)
 - $2 \leq X \leq 10$



Alien Power Sum NEXT

Ten Cat. 5 Cables - 40% Conduit Fill





Alien Power Sum NEXT Margins to Category 5

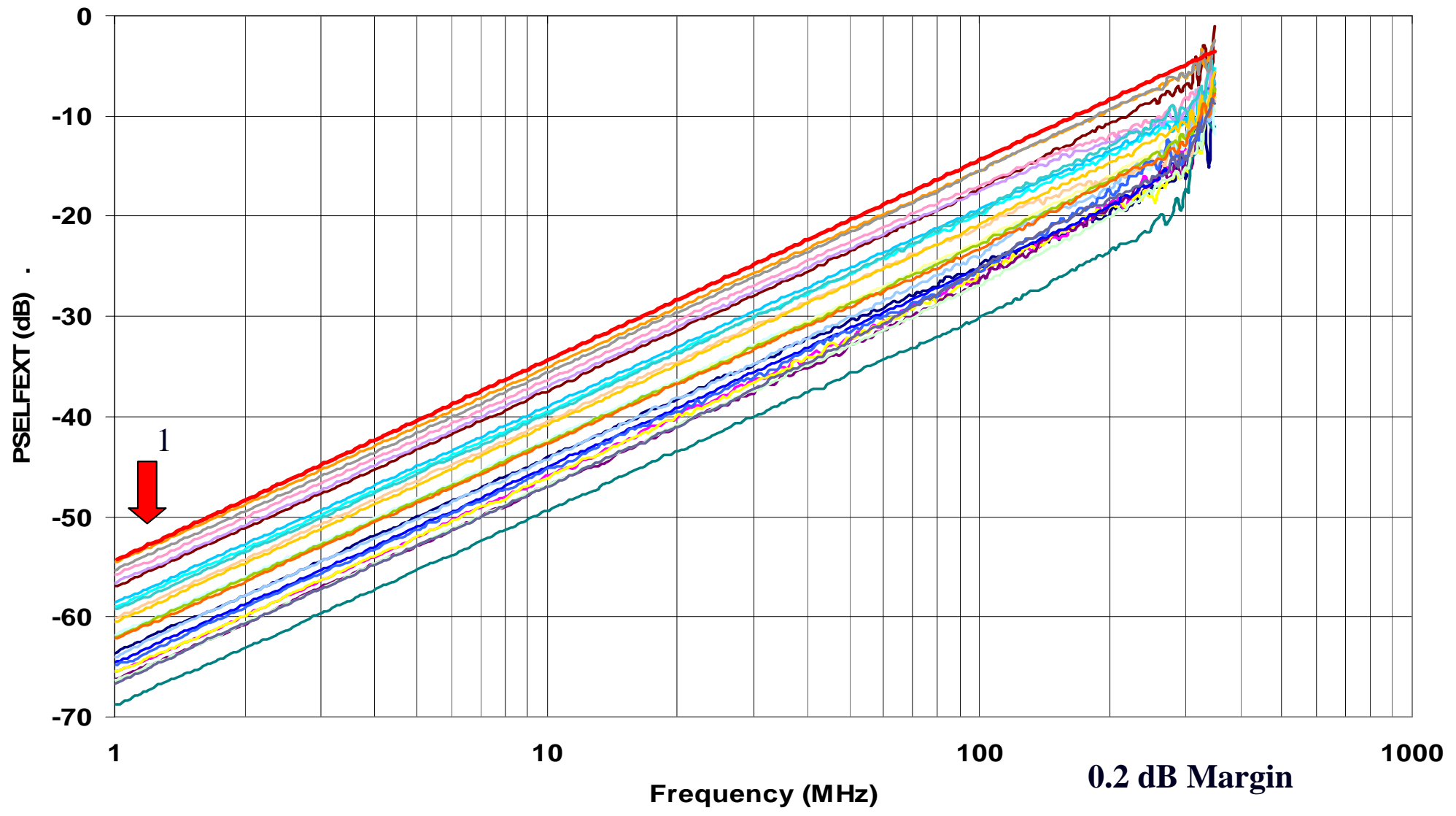
Assembly Type	Original Margin	Corrected Margin
Double bound	-4.5	No Change
Cinched	4.6	No Change
22% Fill Conduit	3.5	2.7
40% Fill Conduit	3.0	Not Available

Alien Power Sum ELFEXT

- No current specification covering Alien PS-ELFEXT
- Wanted to take a preliminary look at how these assemblies performed
- All comparisons were made to the Cat 5e channel PS-ELFEXT requirements



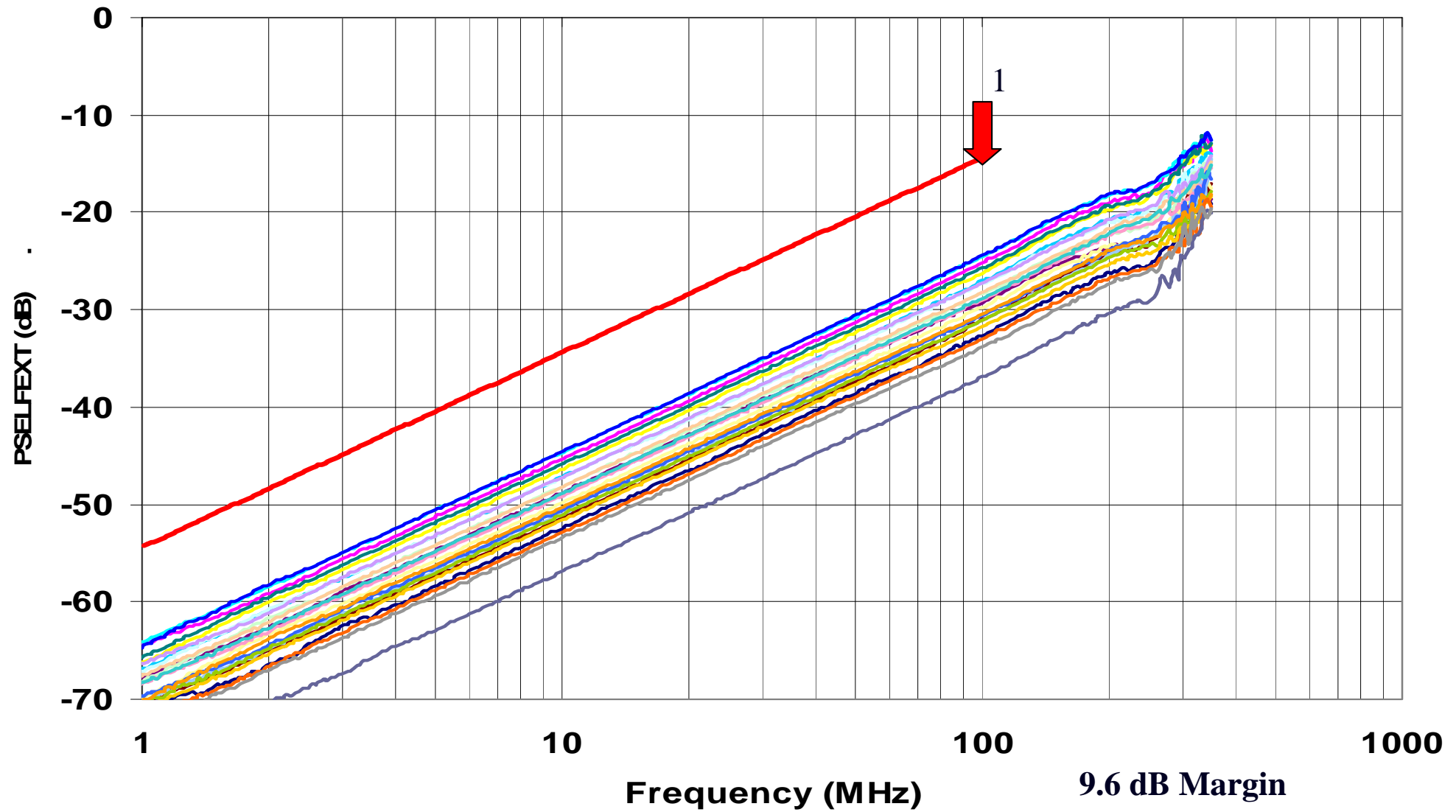
Alien Power Sum ELFEXT Six Cables Double Bound





Alien Power Sum ELFEXT

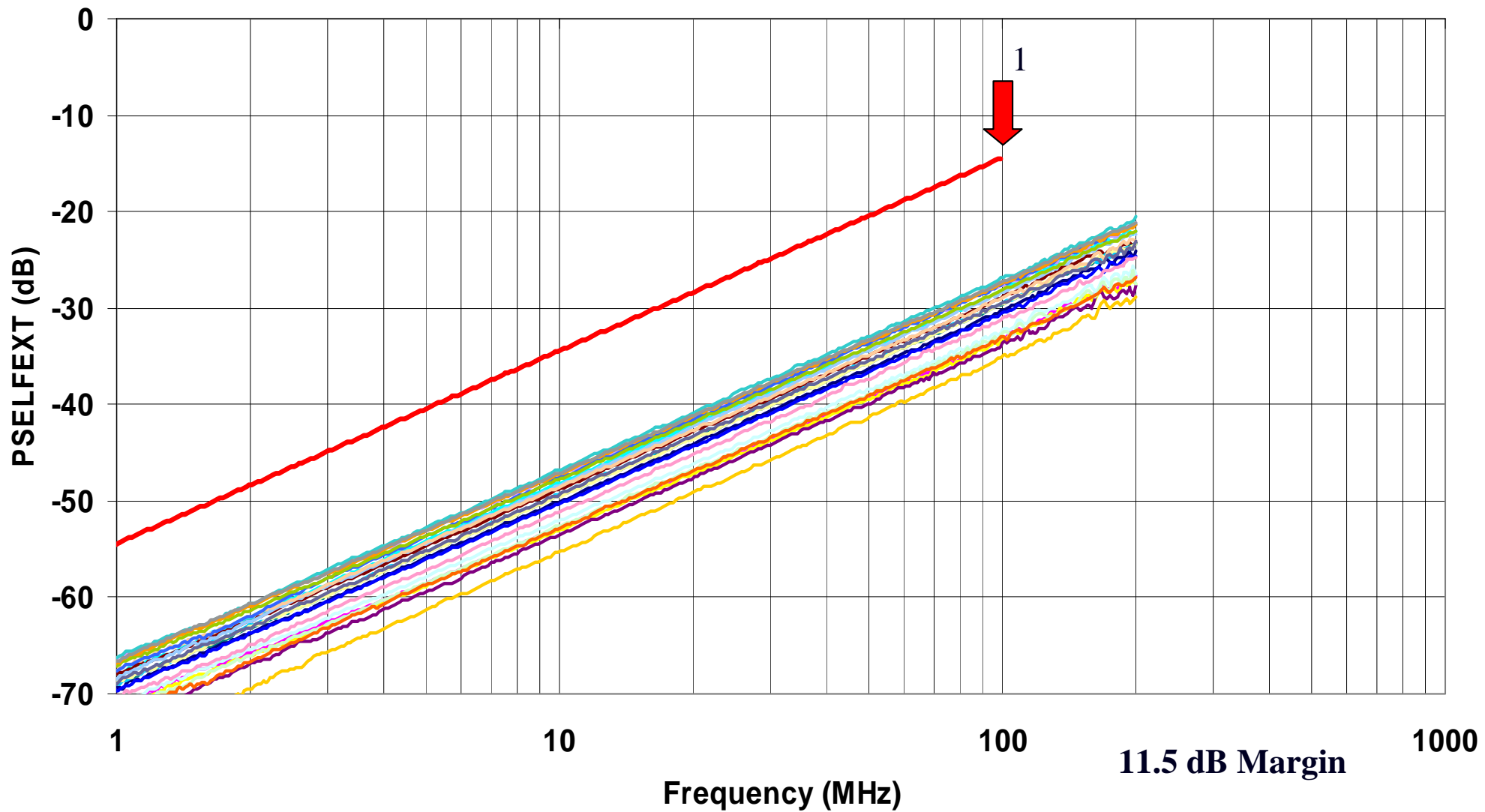
Six Cables Cinched Every 48 Inches





Alien Power Sum ELFEXT

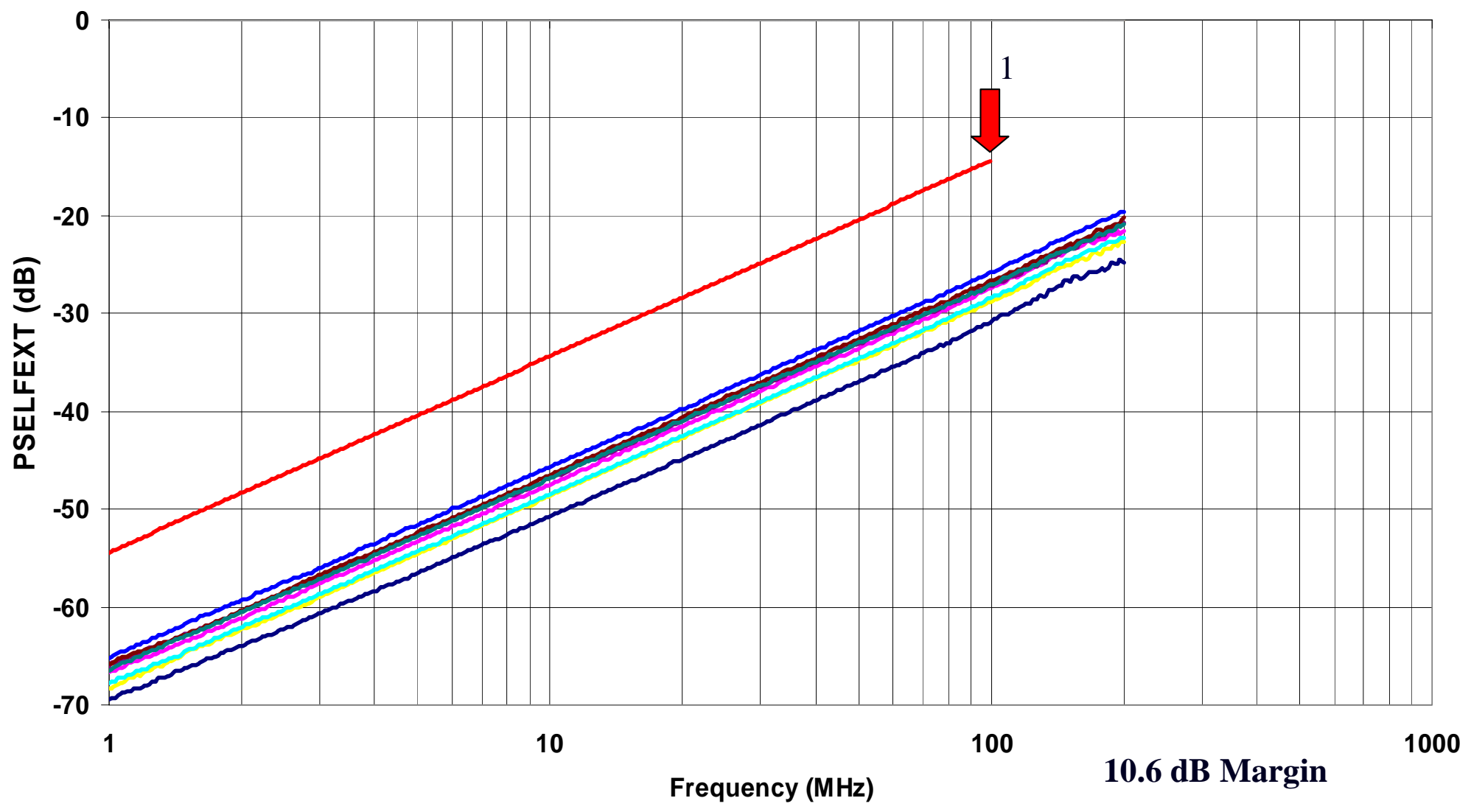
Six Cables - 22% Conduit Fill





Alien Power Sum ELFEXT

Ten Cables - 40% Conduit Fill





Alien ELFEXT Margins to the Cat 5e Channel PS-ELFEXT Specification

ASSEMBLY TYPE	MARGIN
Double Bound	0.2 dB
Cinched	9.6 dB
22% Fill Conduit	11.5 dB
40% Fill Conduit	10.6 dB

First Round Conclusions

- Continuously tightly bound assemblies exhibited the worst alien next
- The most common method of bundling appear to improve alien next readings by approximately 9dB
- Alien PSELFEXT was below the channel requirements in all configurations



Round 2
Various Cable Assemblies Under Test
Circa 2001
Category 5e
Category 6
Improved Category 6

Initial Cable Performance

- Six cables cabled and bound with a binder
- 100 m samples were laid out and tested in a ladder type tray
- The cables were assembled with minimal impact to the initial performance to try to isolate the effects of alien crosstalk upon the network
- Tested with and Agilent® 8753ES Network Analyzer



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Initial Cable Performance



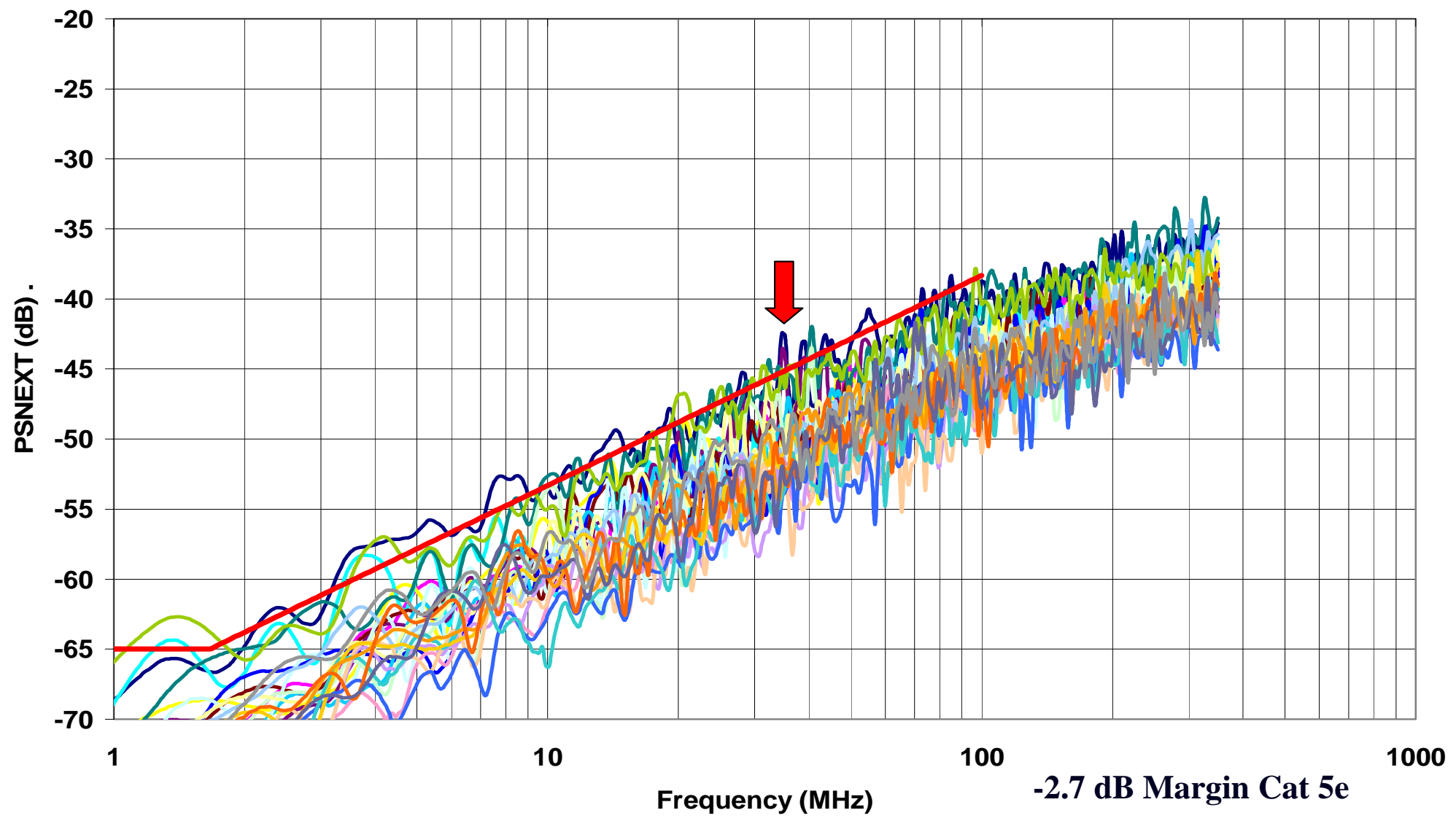
Initial Internal Cable Performance

CHANNEL TYPE	MARGIN CAT 5E	MARGIN CAT 6
Category 5e	9.4 dB	--
Category 6	--	5.5 dB
Improved Cat 6	--	12.6 dB

Average worst case - six cables

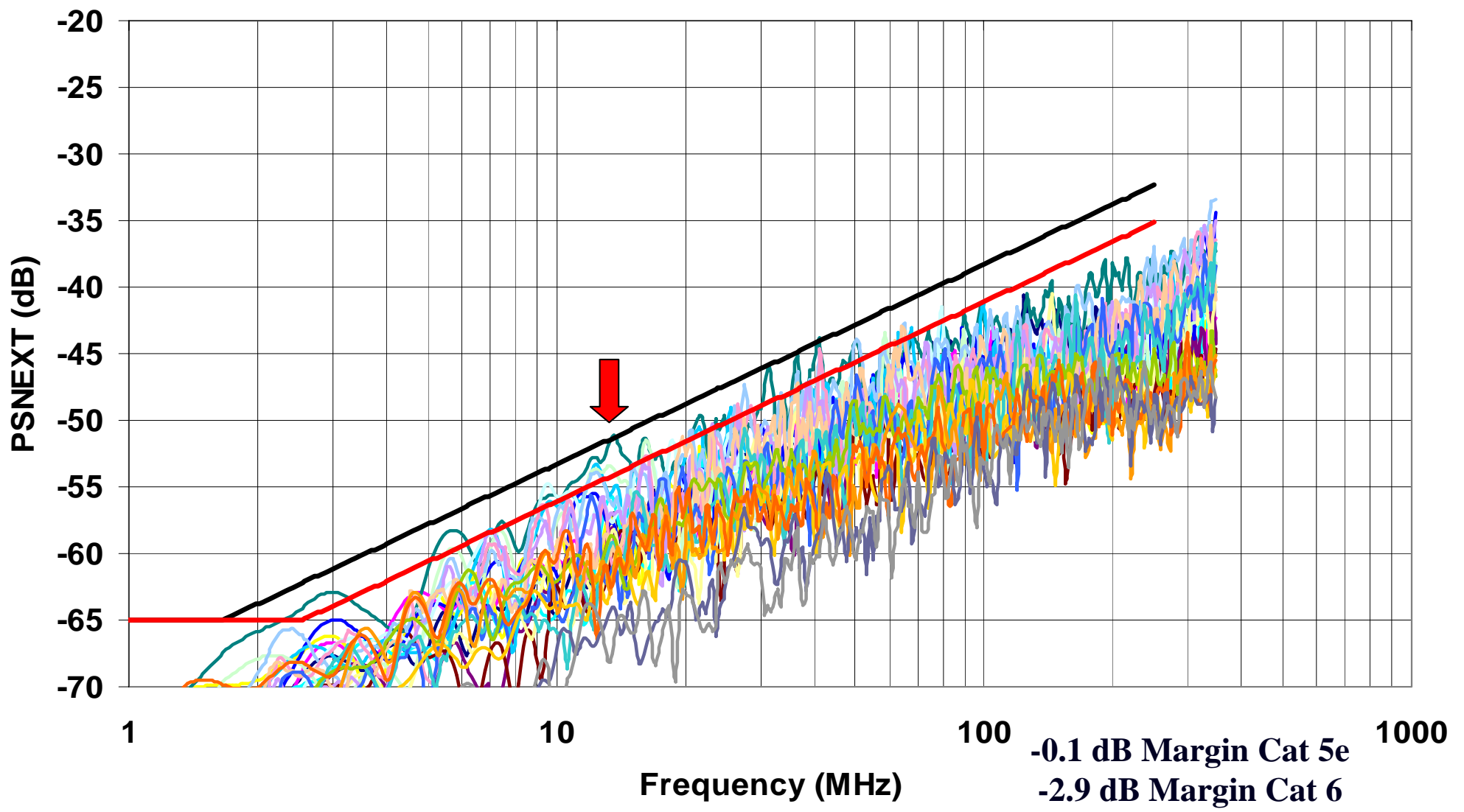


Alien PSNEXT Category 5e



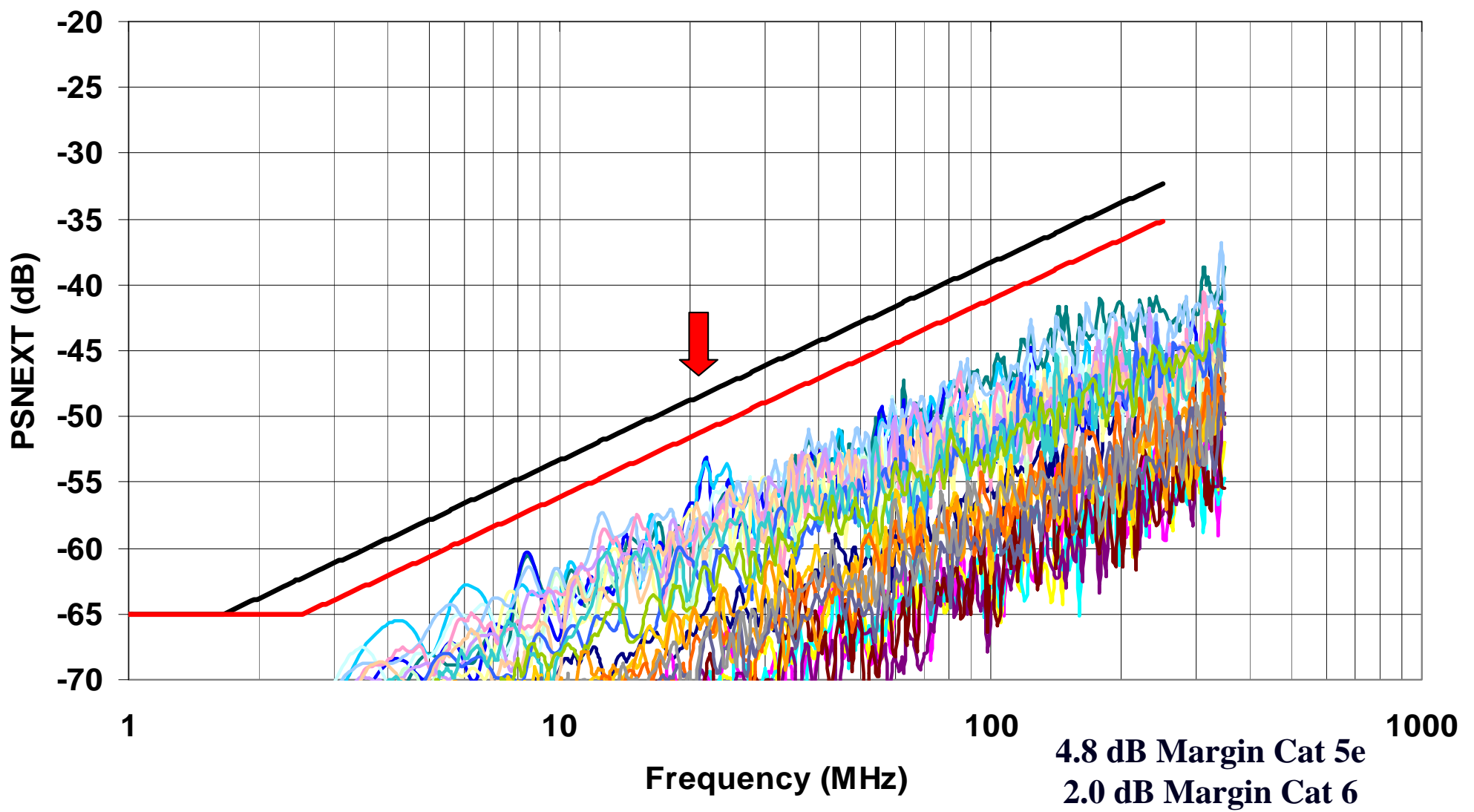


Alien PSNEXT Category 6





Alien PSNEXT Improved Category 6



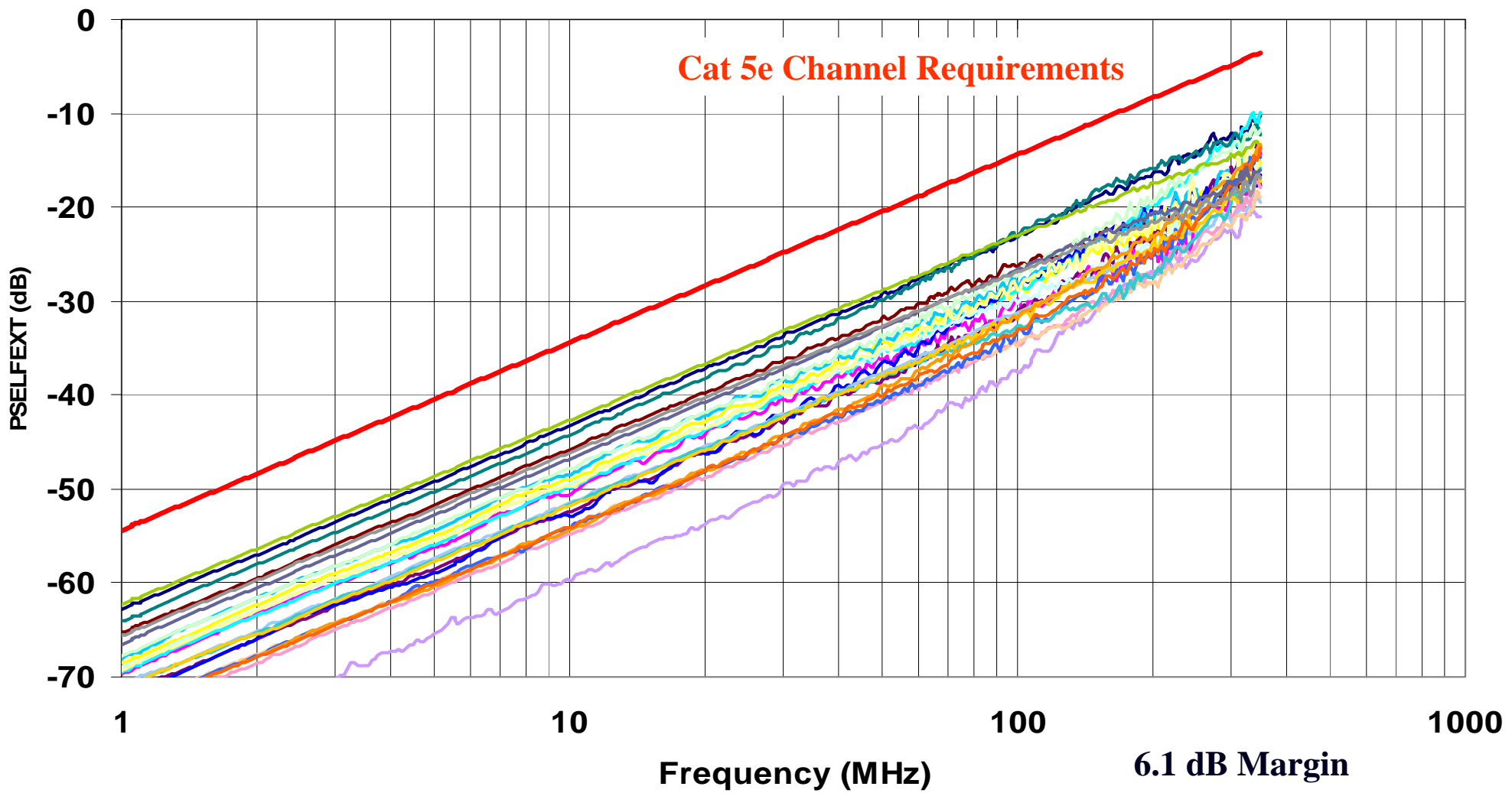


Alien PSNEXT Margins to TIA/EIA 568B.2

Assembly Type	Margin Cat 5e	Margin Cat 6
Category 5e	-2.7 dB	N/A
Category 6	-0.1 dB	-2.9 dB
Improved Category 6	4.8 dB	2.0 dB

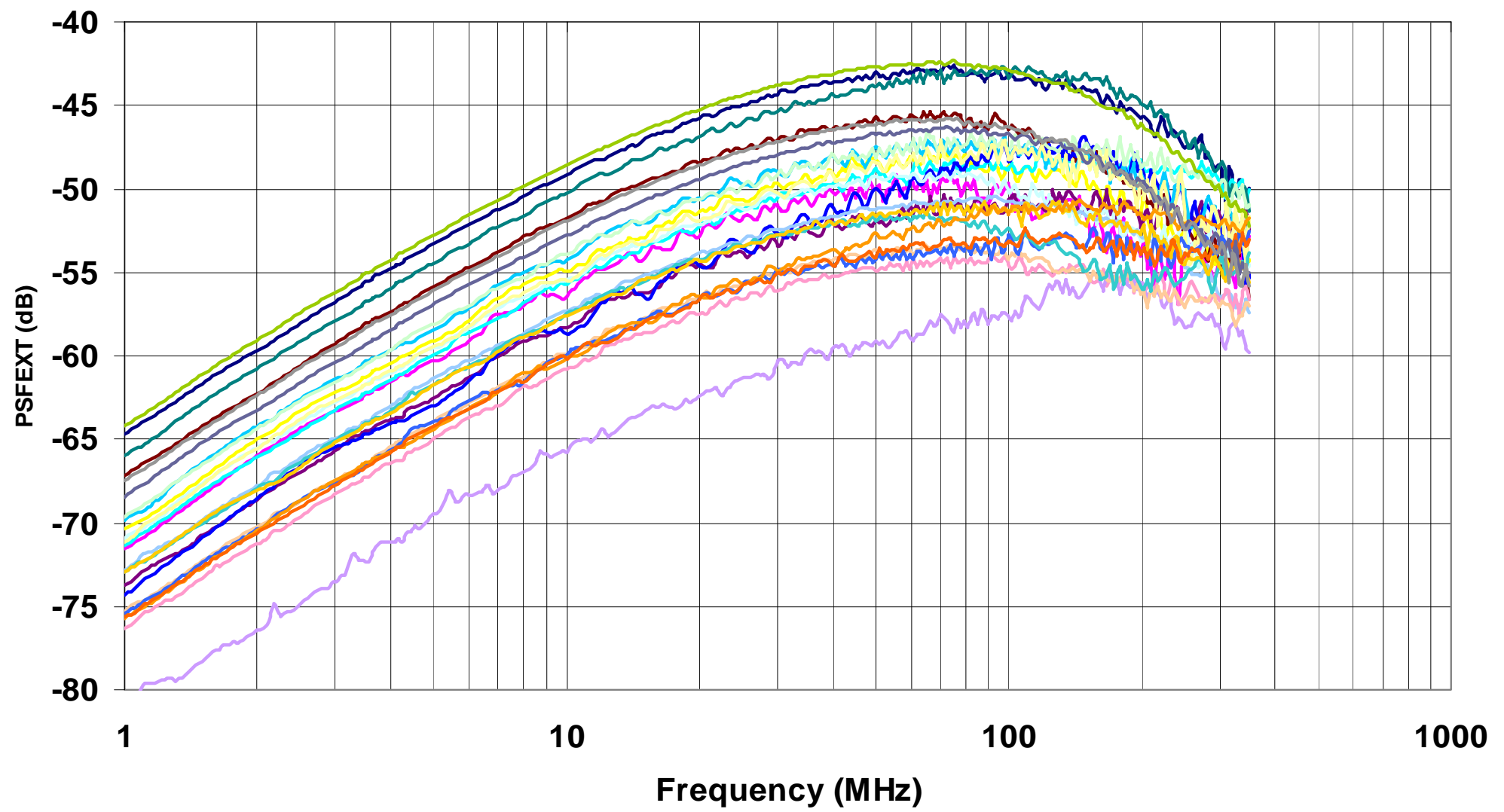


Alien Power Sum ELFEXT Category 5e (PS Channel Spec.)



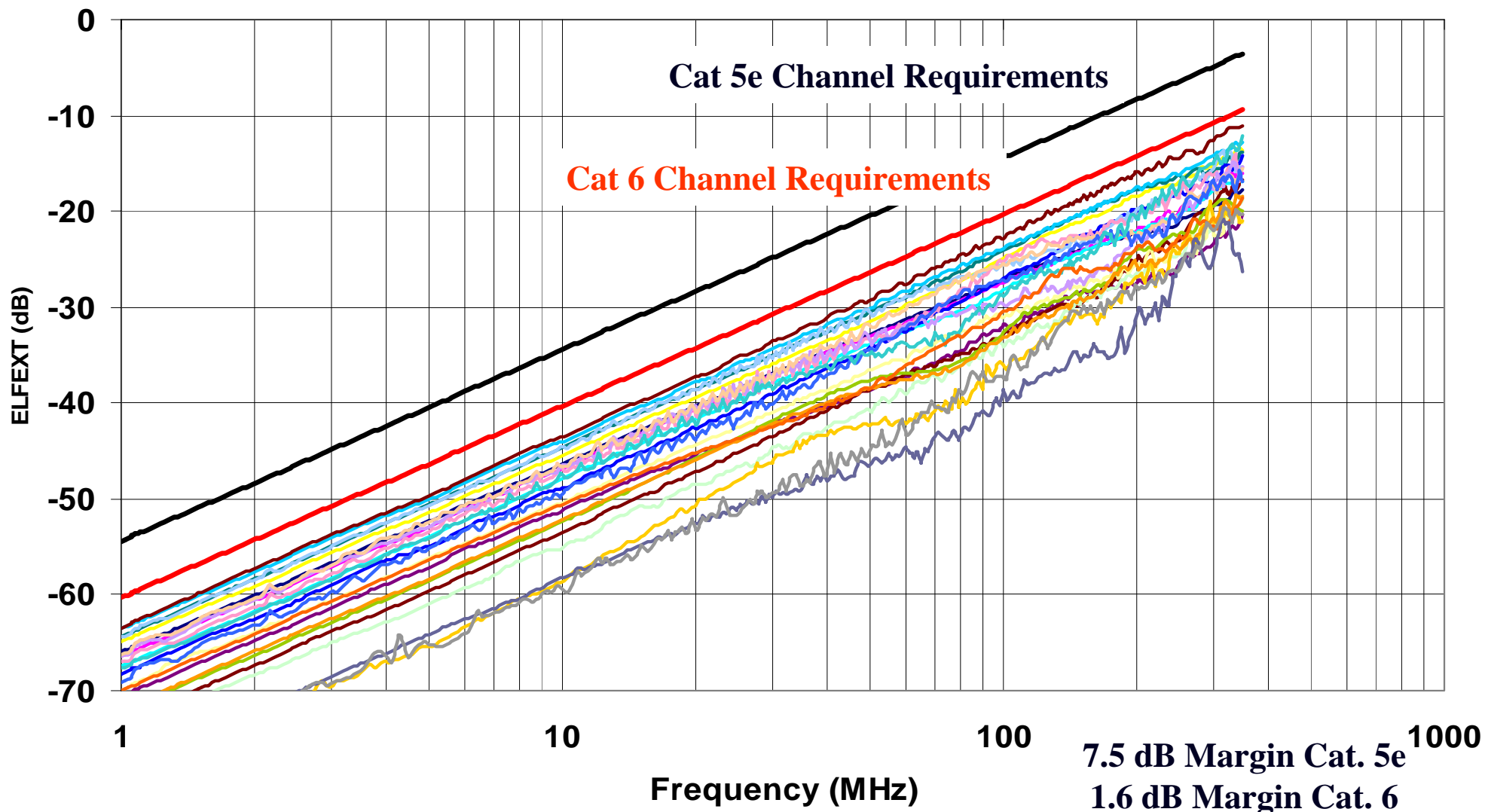


Alien Power Sum FEXT Category 5e





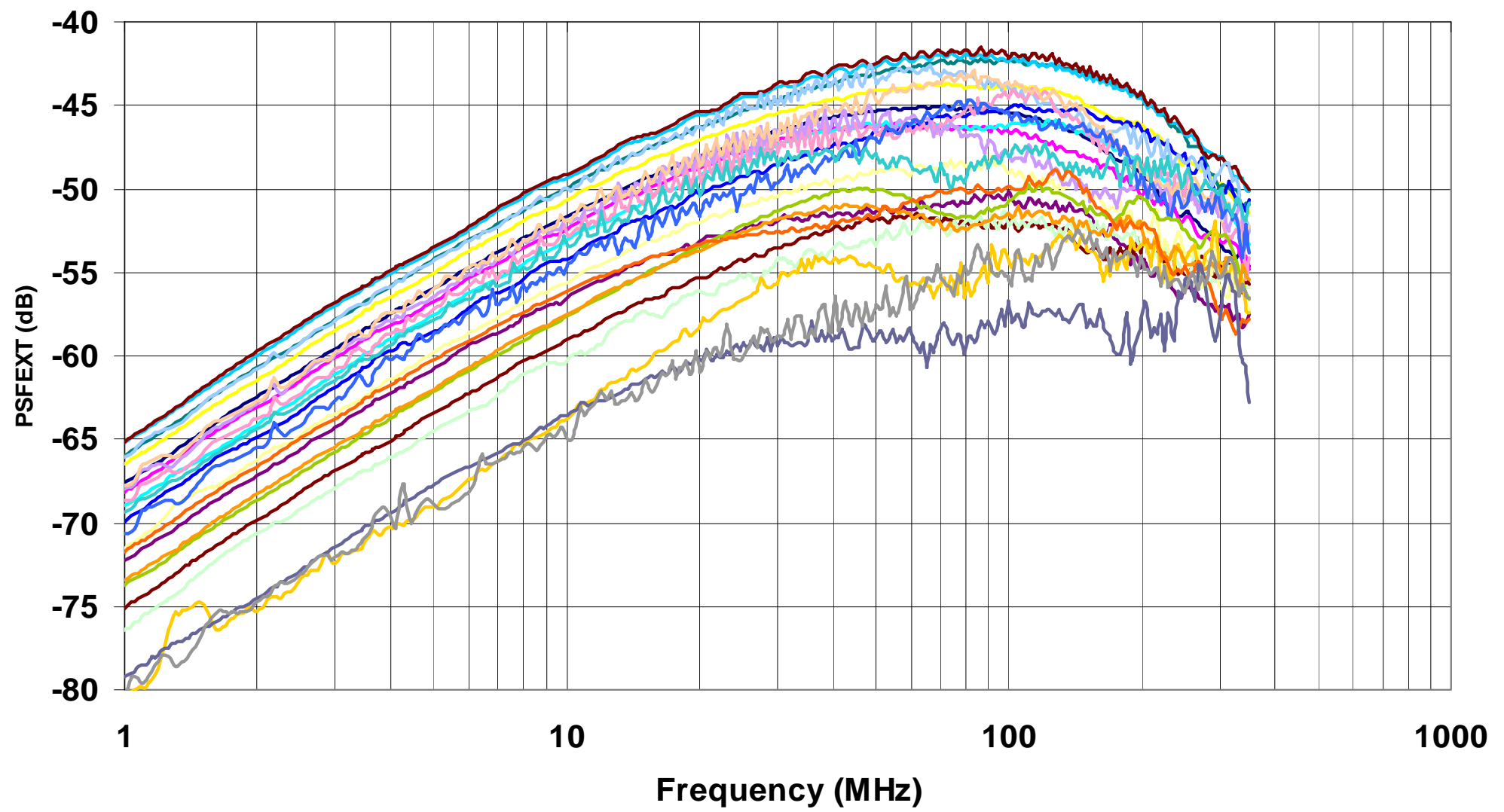
Alien Power Sum ELFEXT Category 6 (PS Channel Spec.)





Alien Power Sum FEXT

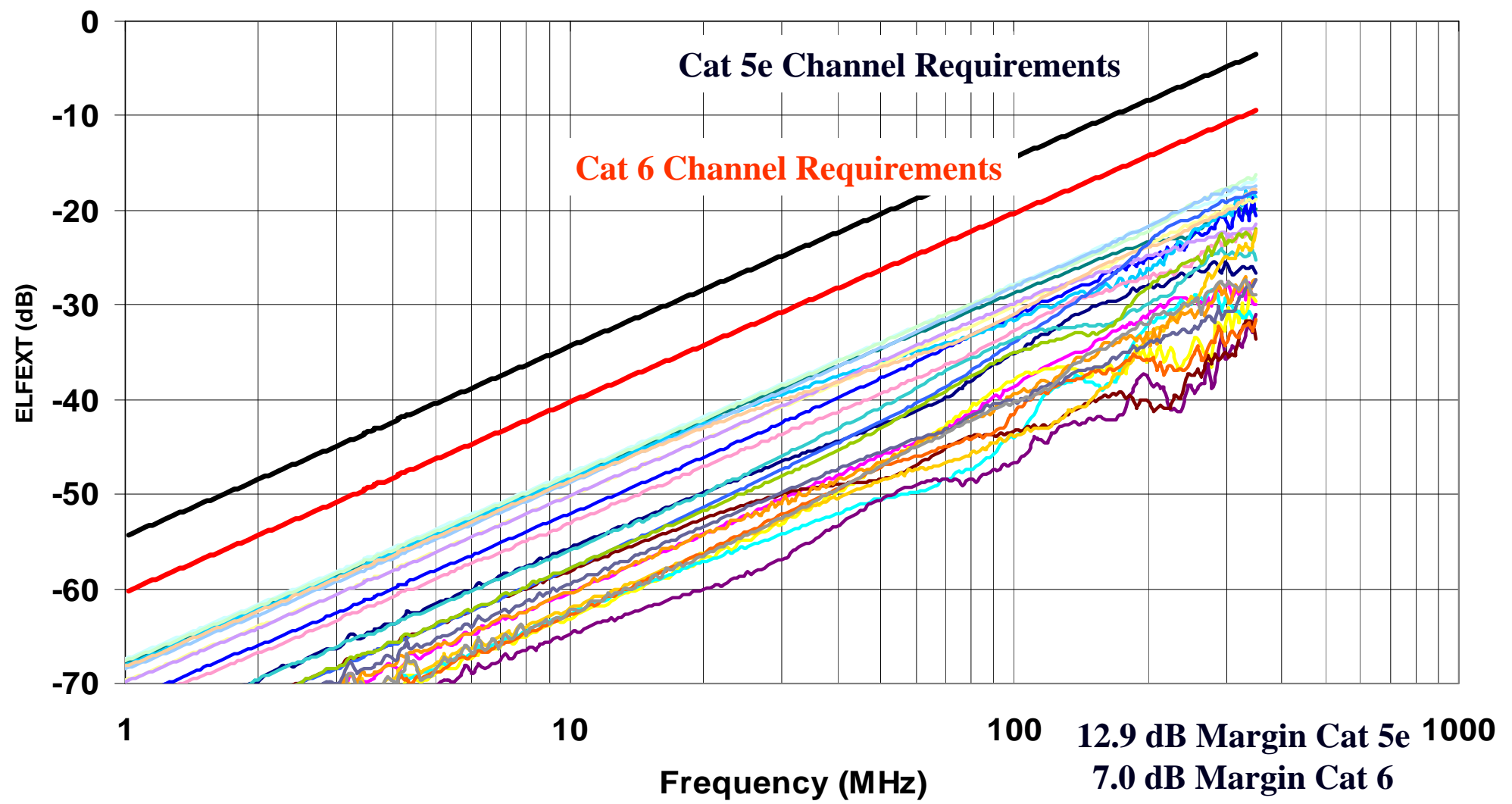
Category 6





Alien Power Sum ELFEXT

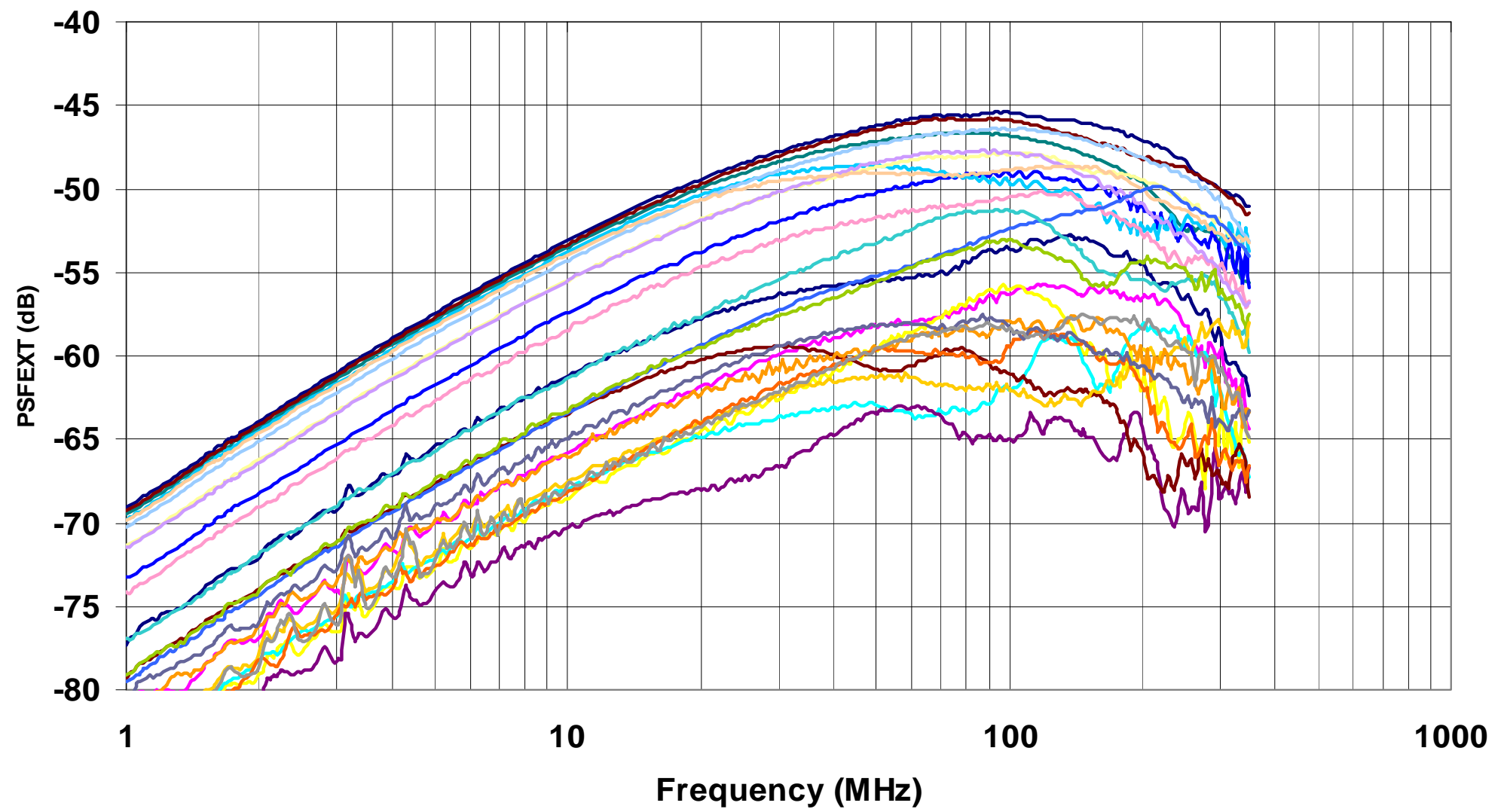
Improved Category 6 (PS Channel Spec.)





Alien Power Sum ELFEXT

Improved Category 6 (PS Channel Spec.)





Alien PSELFEXT Margins to Respective Channel Specifications

Assembly Type	Margin Cat 5e	Margin Cat 6
Category 5e	6.1 dB	N/A
Category 6	7.5 dB	1.6 dB
Improved Category 6	12.9 dB	7.0 dB

Channel Testing

- Connectorized each bundle of cables with the respective category of connecting hardware
 - Category 5e cable – Category 5e hardware
 - Category 6 cable – Category 6 hardware
 - Improved Category 6 cable – Category 6 hardware
- Three connector topology
- Measured the performance of each channel from the wiring closet with FLUKE[®] DSP 4100



Channel Topology

**Fluke
DSP 4100
Remote**



A: 9 ft Patch/equipment Cable
B: 90 Meters of Horizontal Cable

**Fluke
DSP 4100**



Channel PSNEXT Margin TIA/EIA 568B.1 and Cat. 6

CHANNEL TYPE	MARGIN CAT 5E	MARGIN CAT 6
Category 5e	10.7dB	--
Category 6	--	4.6 dB
Improved Cat 6	--	6.1 dB

Average worst case - six cables



Channel PSELFEXT Margin TIA/EIA 568B.1 and Cat. 6

CHANNEL TYPE	MARGIN CAT 5E	MARGIN CAT 6
Category 5e	10.6dB	--
Category 6	--	7.5 dB
Improved Cat 6	--	7.4 dB

Average worst case - six cables



Channel PSACR Margin TIA/EIA 568B.1 and Cat. 6

CHANNEL TYPE	MARGIN CAT 5E	MARGIN CAT 6
Category 5e	13.3 dB	--
Category 6	--	5.5 dB
Improved Cat 6	--	7.2 dB

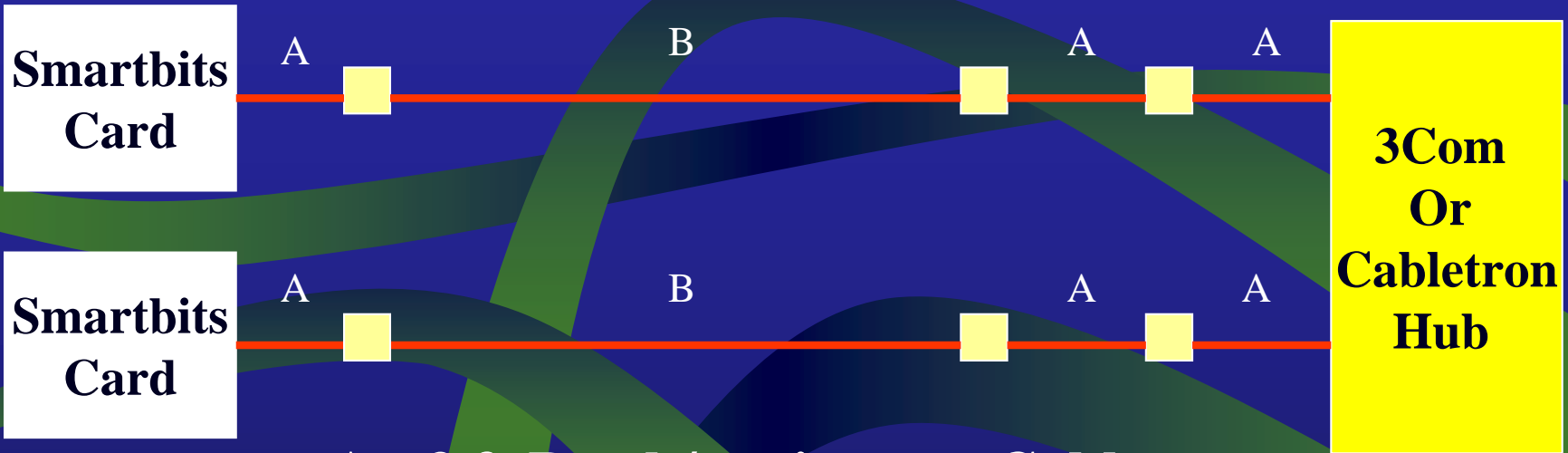
Average worst case - six cables

Live Network Testing

- Equipment
 - Spirent Communications® Smartbits 2000 Chassis
 - Smartbits GX-1420B Gigabit Copper Card
 - Smartbits SX-7410B 100MB Copper Card
 - Smartbits TR-8405 Token Ring Copper Card
 - 3Com Superstack® 3 4900 Switch
 - Cabletron Systems® Micro MMAC-441 Token Ring Hub
 - 150Ω-100Ω Media Converters for the Token Ring hub



Channel Topology

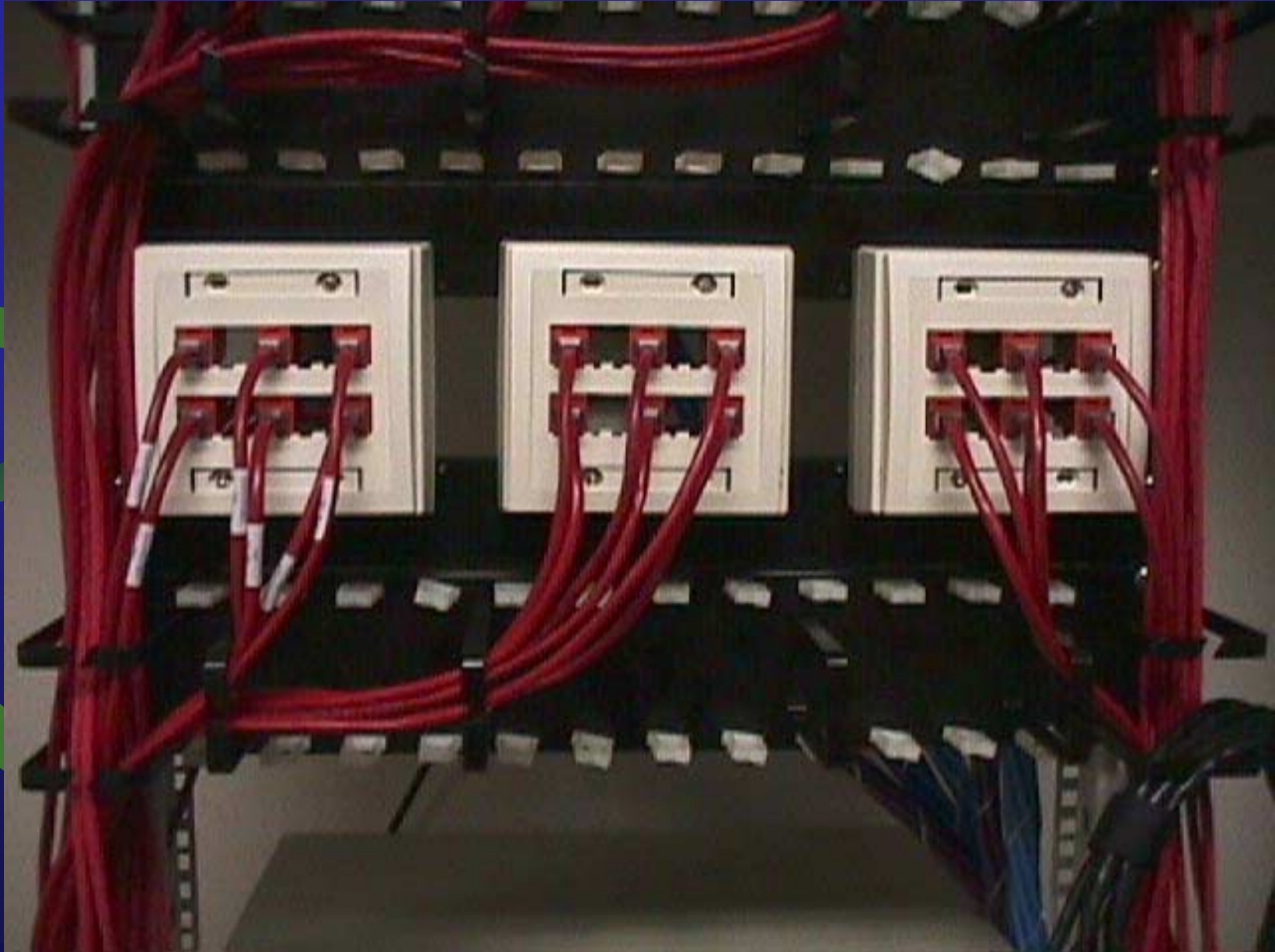


A: 9 ft Patch/equipment Cable
B: 90 Meters of Horizontal Cable

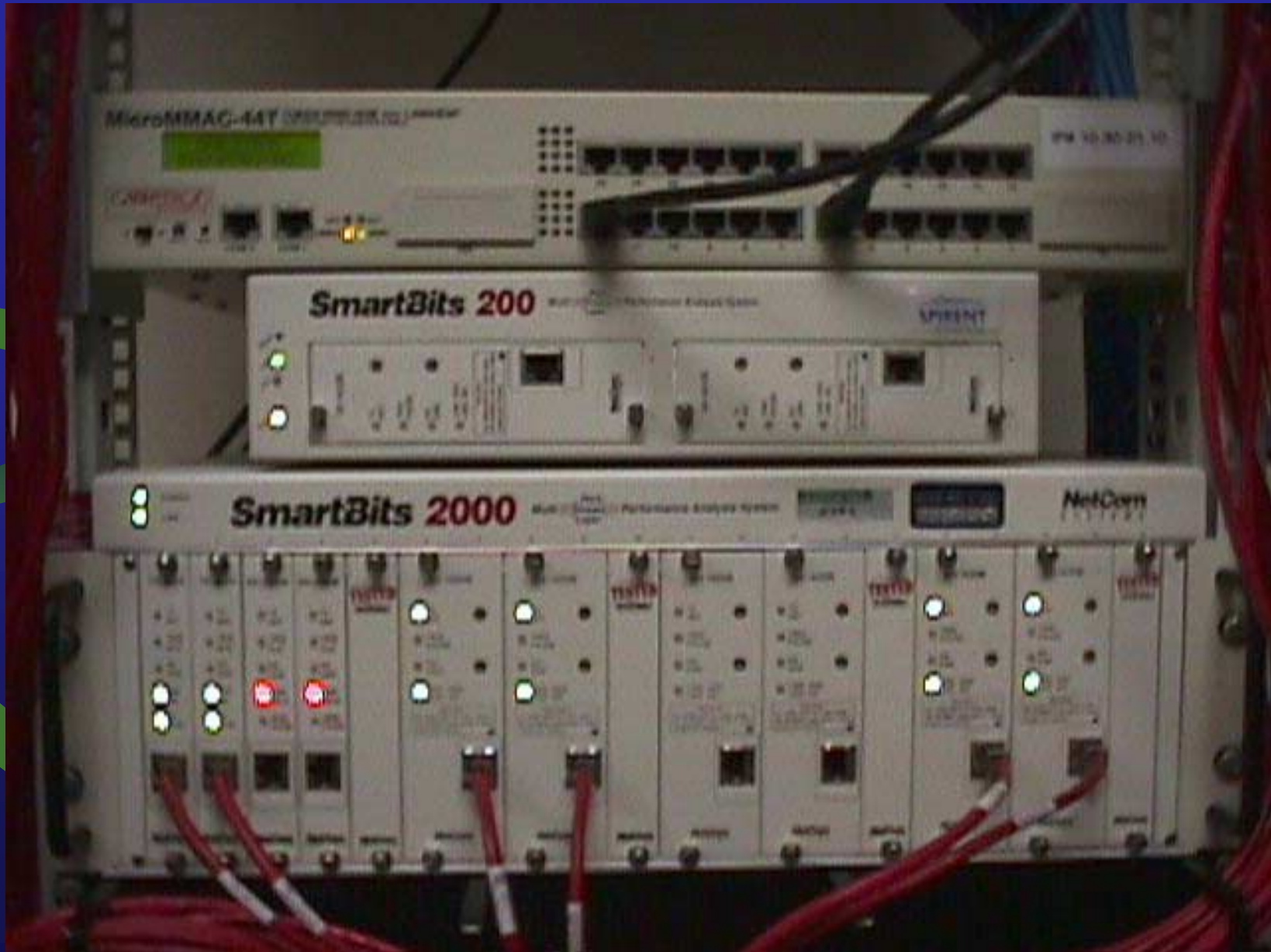
Live Network Testing



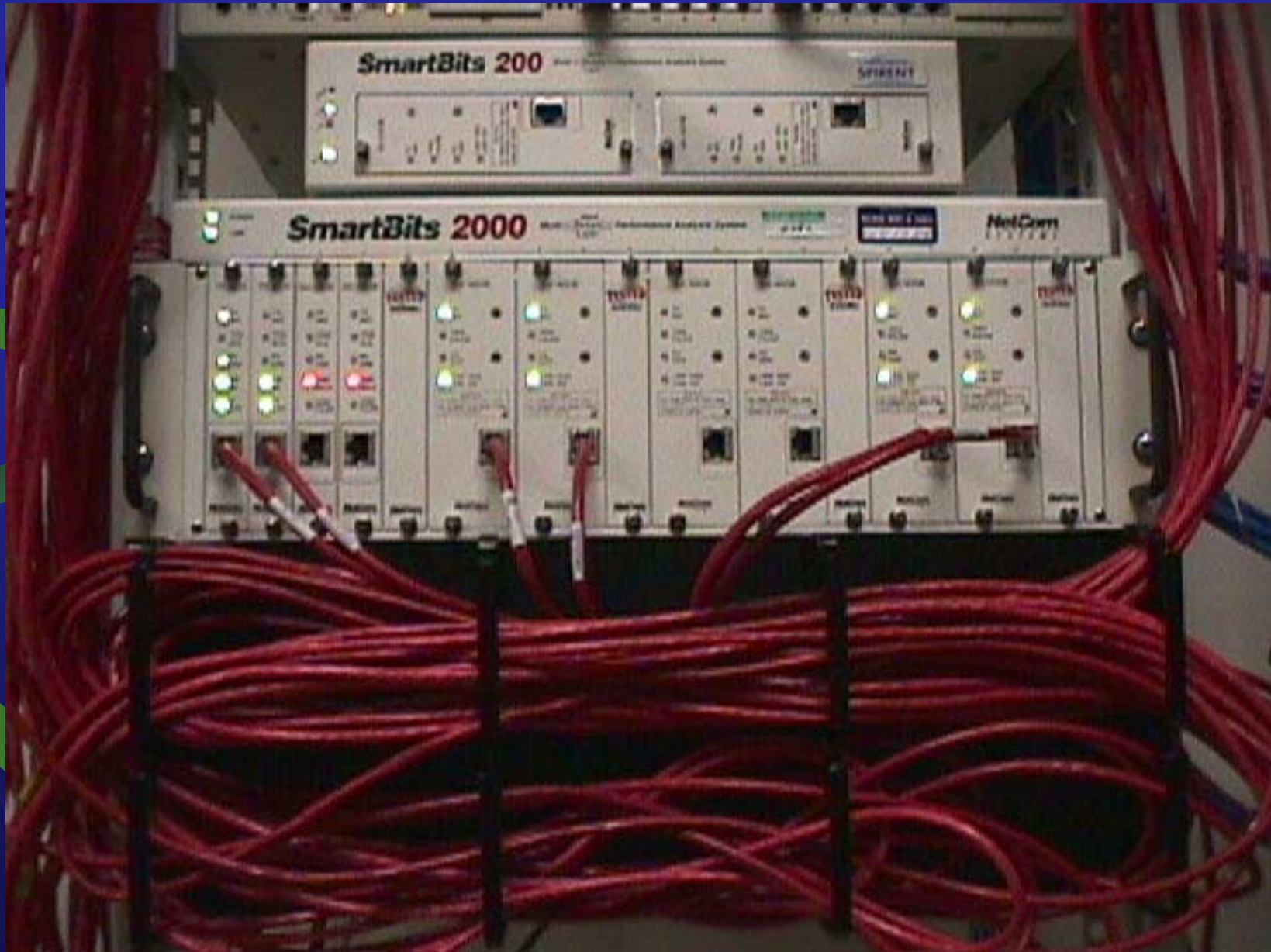
Live Network Testing



Live Network Testing



Live Network Testing





Throughput: All Channels Gigabit

CHANNEL TYPE	PERCENT THROUGHPUT
Category 5e	100%
Category 6	100%
Improved Cat 6	100%



Throughput:

4 Channels Gigabit, 2 Channels 100BaseT

CHANNEL TYPE	PERCENT THROUGHPUT
Category 5e	100%
Category 6	100%
Improved Cat 6	100%



Throughput:

2 Channels Gigabit, 2 Channels 100BaseT,
2 channels Token Ring

CHANNEL TYPE	PERCENT THROUGHPUT
Category 5e	100%
Category 6	100%
Improved Cat 6	100%

Conclusions

- Tightly bound assemblies exhibit a worst case alien crosstalk coupling function
- Normal cable installation improved the cat 5 performance by approximately 9dB
- Anticipate the same improvement with category 6 cable

Conclusions (Continued)

- Higher performing cables can reduce the amount of alien PSNEXT, (7.5 dB in this study)
- Alien PSELFEXT appears harder to improve (reduced by only 3.9 dB)
- However, the levels of alien PSELFEXT were significantly lower than what is required internally for individual category 5e channels
- Alien FEXT performance difference between good cat 5 and nominal cat 6 is minimal.