

Cat 6 Alien Crosstalk and Related System Margins

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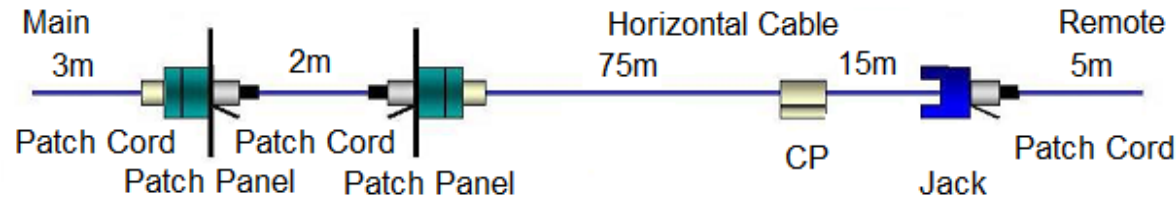
Berk-Tek LLC

IEEE P802.3bz 2.5/5GBASE-T Task Force

May 20, 2015

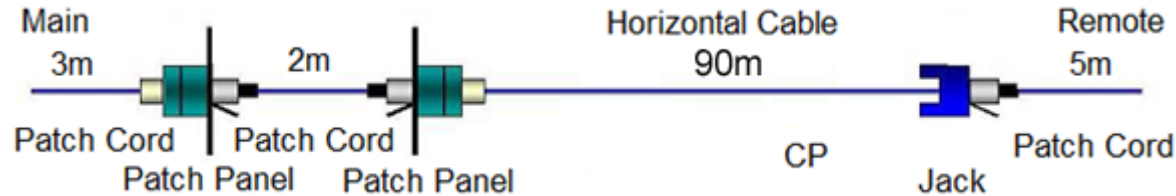
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- Investigate system impact of different generations of UTP cabling
 - ◆ Connector performance varies across 12 year development cycle
 - ◆ Evaluate grades of Category 6 cabling
 - Model system margins using 10GBT system parameters
 - Assess suitability of various cat 6 channels for 5GBASE-T

- 4 Connector Channel (Enterprise/Wireless Configuration)



- 100m - Seven cables bundled, cords included
 - ◆ Assumed conservative worst case
- Measured to 500 MHz, 2048 data points (Linear)
- Internal performance complies with cat 6
- Channels measured from patch panel end as multiple connections in close proximity yield worst case measurements

- 3 Connector Channel (Enterprise/Wireless Configuration)



- Pre-existing samples dictated configuration
- 100m - Seven cables bundled
- Bundling length incrementally reduced to 20m on 100m sample
 - ◆ Replicates branching from trunk line
 - ◆ 20m bundle began at second patch panel, cords not bundled tightly
- Measured to 500 MHz, 2048 data points (Linear)
- Internal performance complies with cat 6
- Channels measured from patch panel end as multiple connections in close proximity yield worst case measurements

Cable Type	Notes
Minimum Cat 6	Available since 2002 - 0 dB NEXT Margin Guarantee
Cat 6+ Construction A	Available since 2000 - 8 dB NEXT Margin Guarantee*
Cat 6+ Construction B	Available since 1996 - 3 dB NEXT Margin Guarantee*

***Precedes TIA category 6 publication**

Cat 6 Connector	Mfg Date
Connector C	2014
Connector D	2008
Connector E	2000-2002*

***Precedes TIA category 6 publication**

- **Step 1: Salz SNR**

$$SNR_{MMSE,DFE} = e^{\frac{1}{W} \left(\int_0^W \log \left(1 + \frac{\varepsilon(f) |H(f)|^2}{N(f)} \right) df \right)}$$

- ◆ Where $H(f)$ is the measured frequency response
- ◆ $\varepsilon(f)$ is the signal power
- ◆ $N(f)$ is the noise power. Includes NEXT, FEXT, Alien
- ◆ W is the bandwidth
 - 2.5Gbps → 100 MHz
 - 5Gbps → 200 MHz

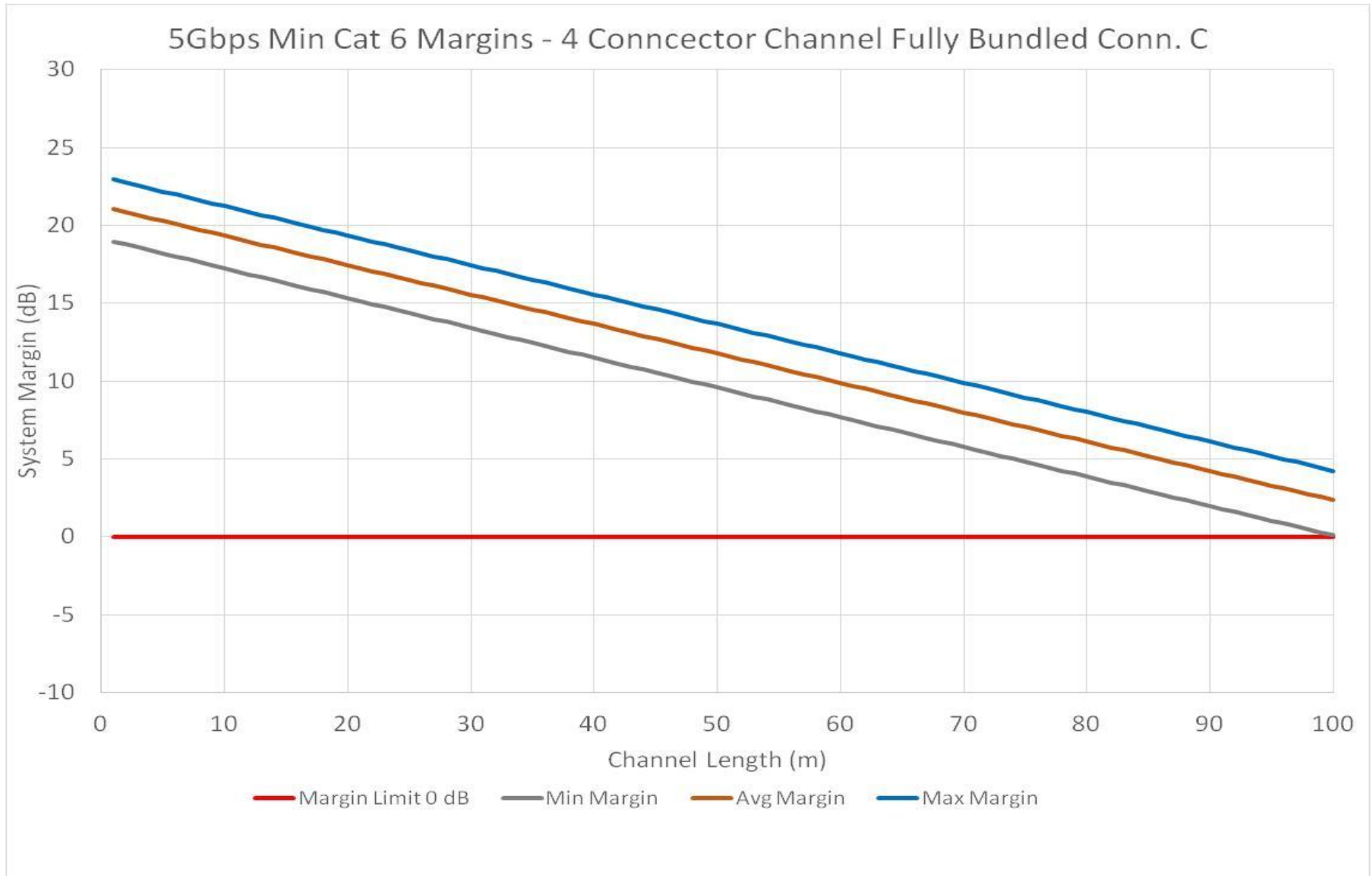
● Step 2: Margin Calculations and Conditions

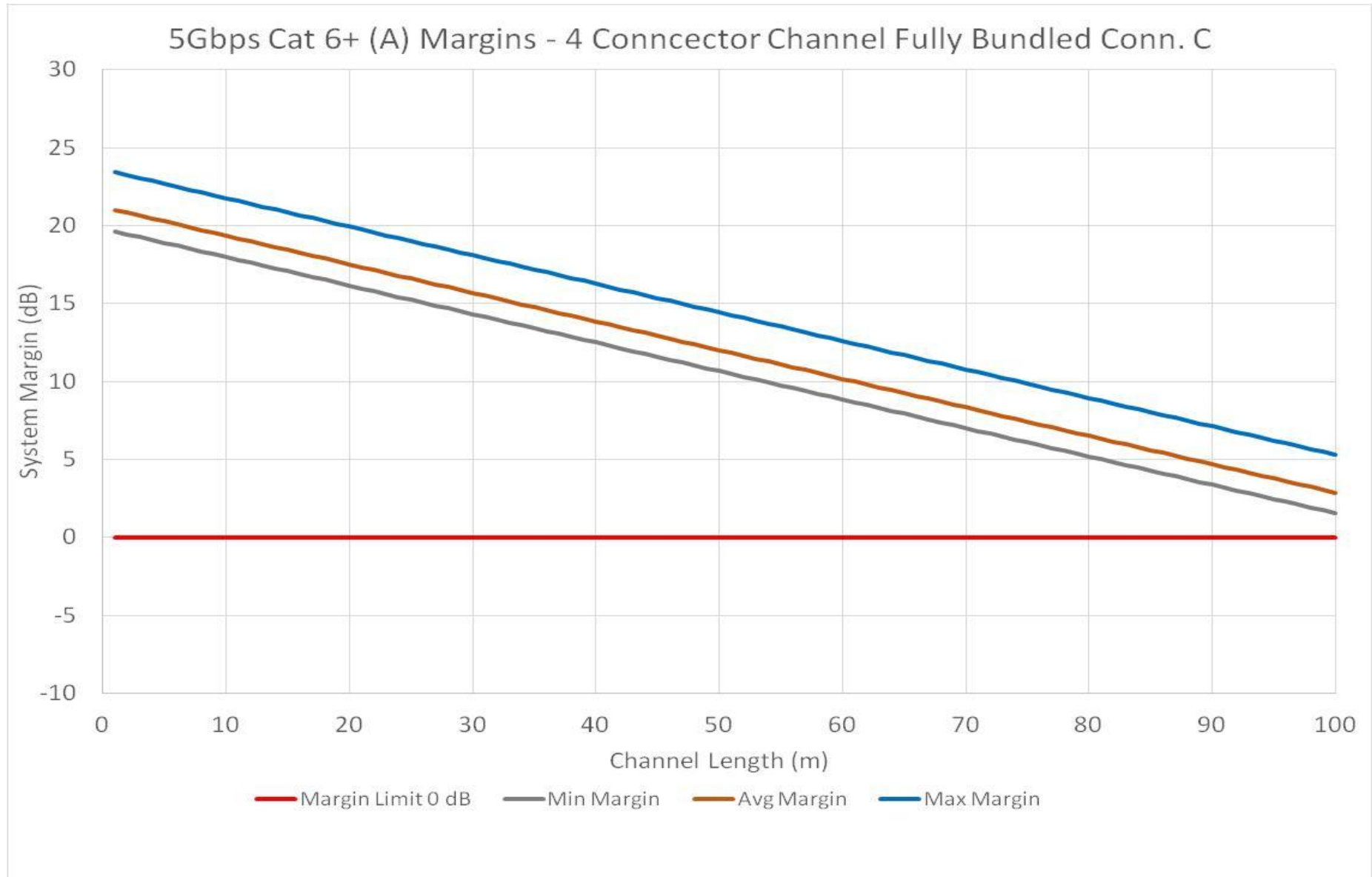
- ◆ Margin = SalzSNR – SNR Threshold
- ◆ SNR Threshold = 23.8 dB*
 - (For 128-DSQ and LDPC codes)
- ◆ TX Power = 4 dBm
- ◆ Echo, NEXT and FEXT Cancellation = 60dB
 - Assuming non-contributing and incorporated into the system noise floor
- ◆ N_0 (dBm/Hz) = -140dBm/Hz
- ◆ Zero ANEXT and AFEXT cancellation

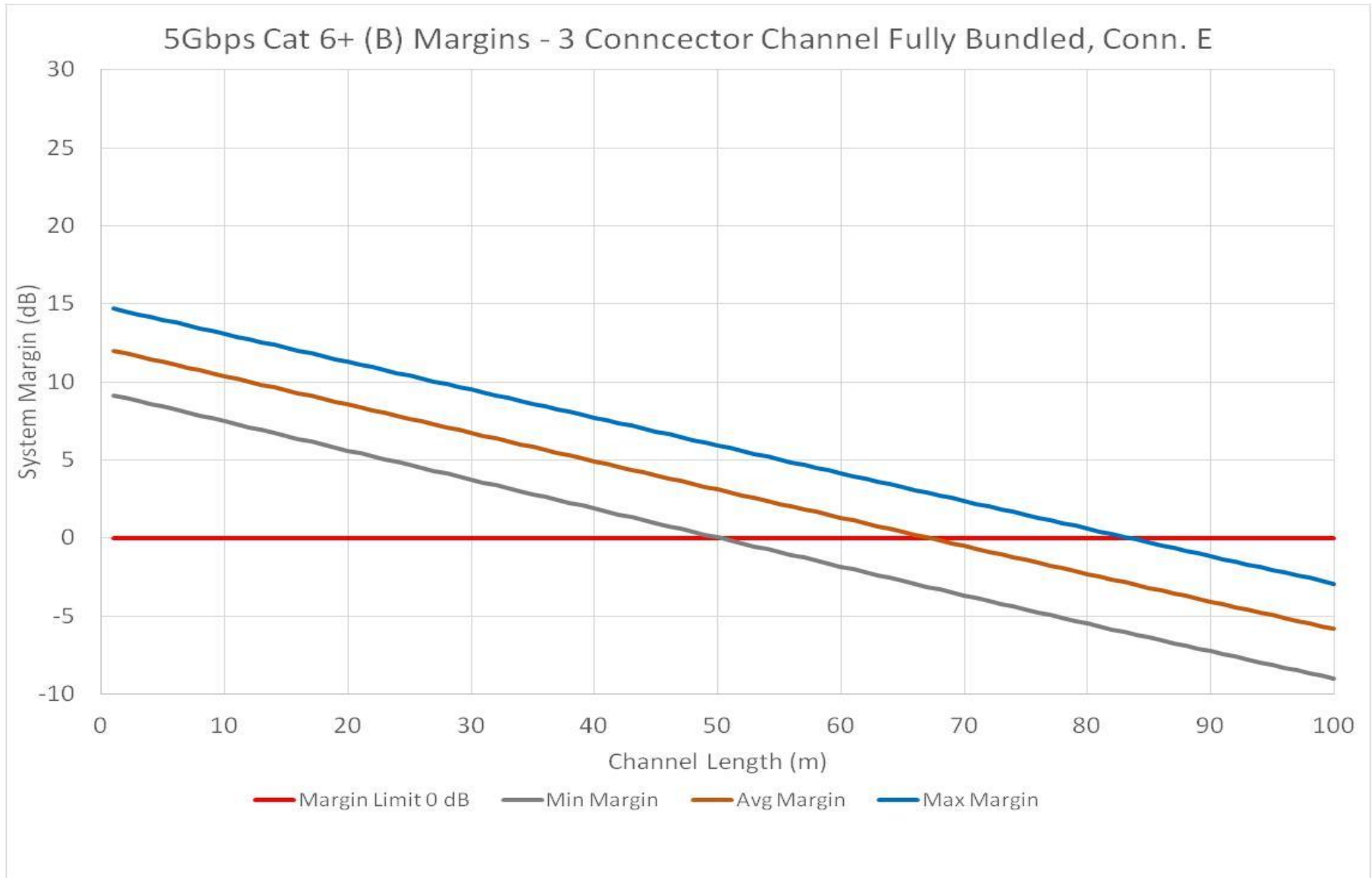
* <http://users.ecs.soton.ac.uk/sqc/EL336/10GBASE-T.pdf>

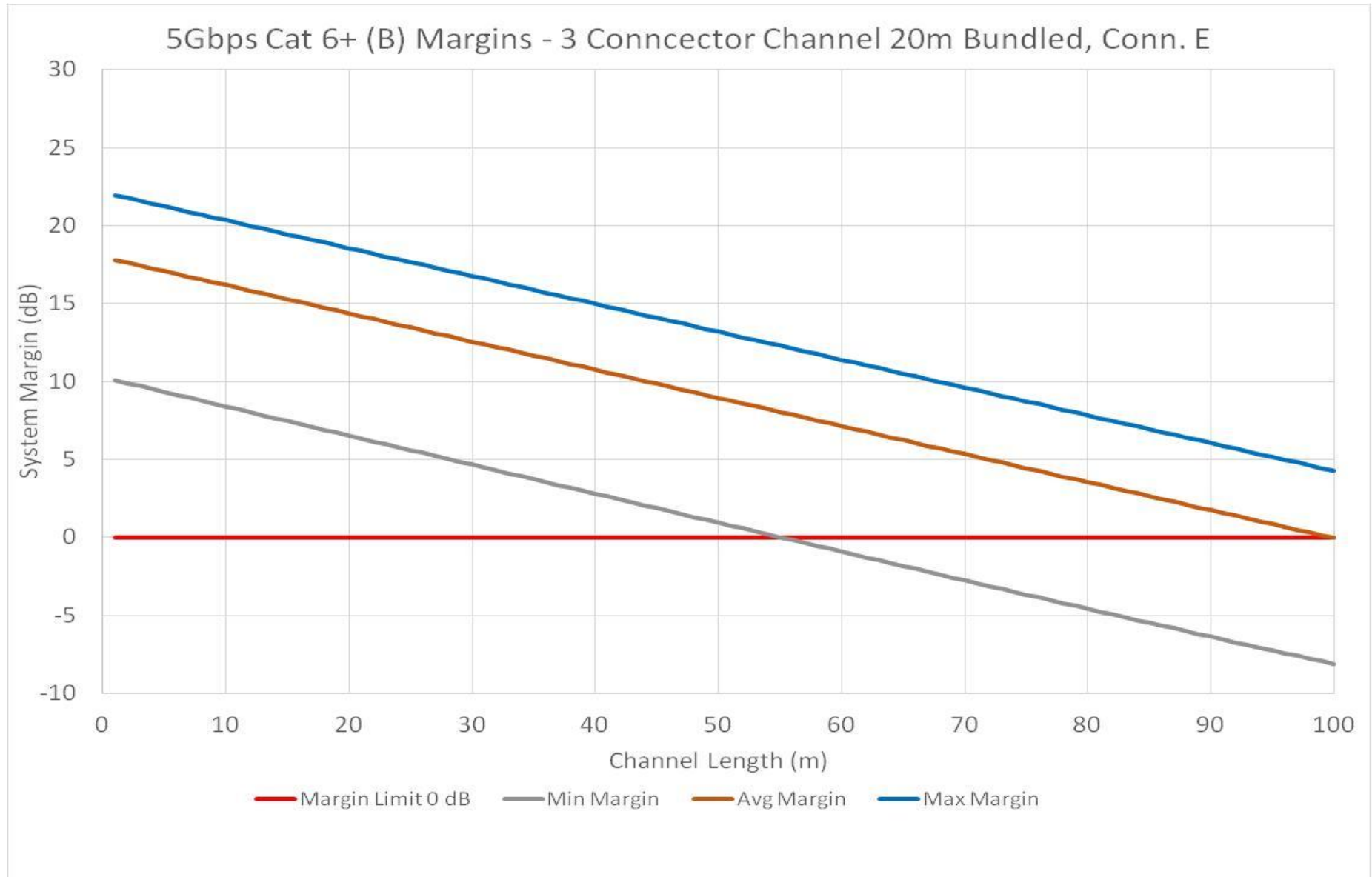
- Minimum margin - derived from cable worst pair
- Average margin - reflects average of all 4 pairs' margins
- Maximum Margin – reflects best pair margin

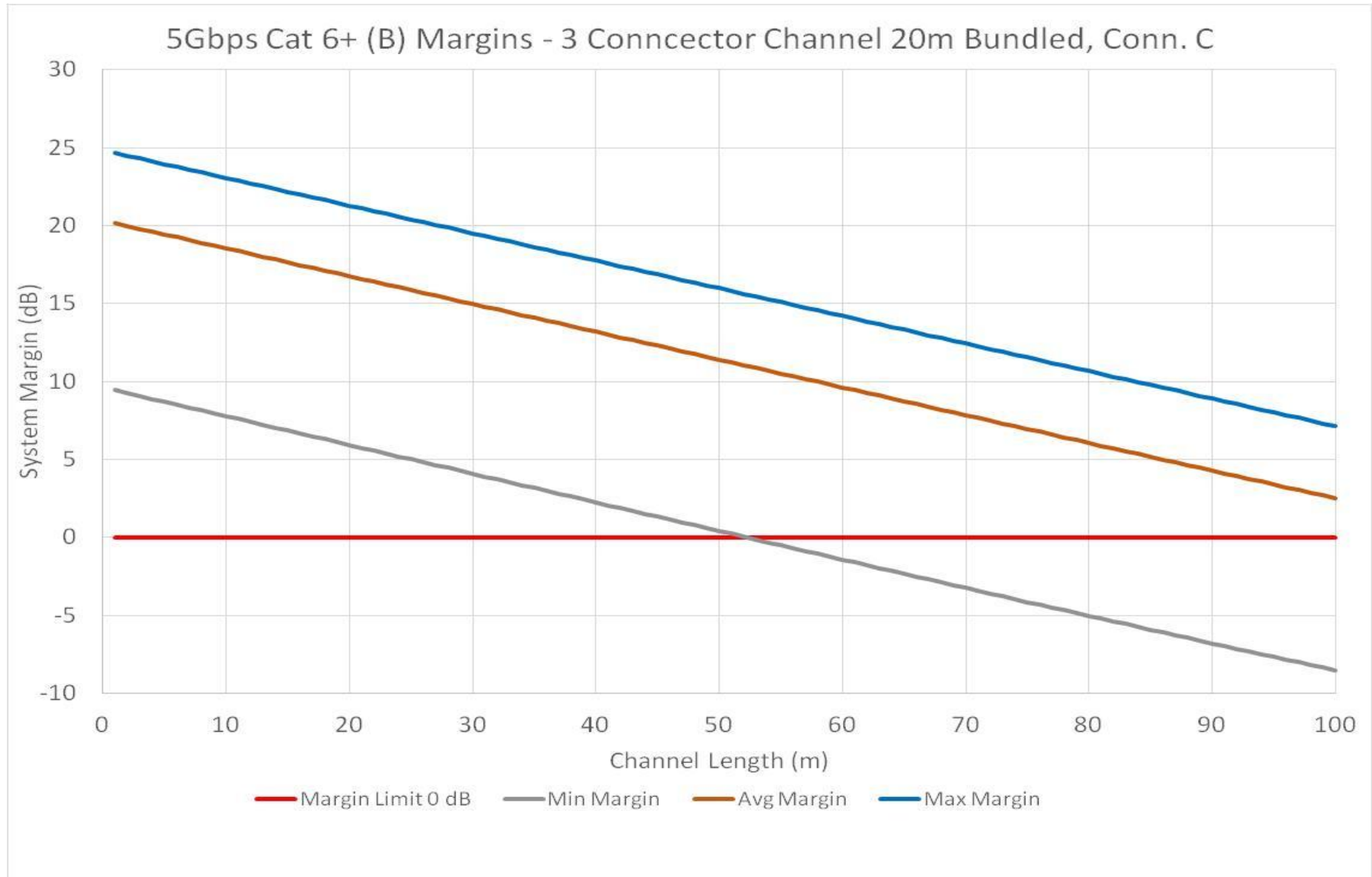
Raw channel and margin data available upon request

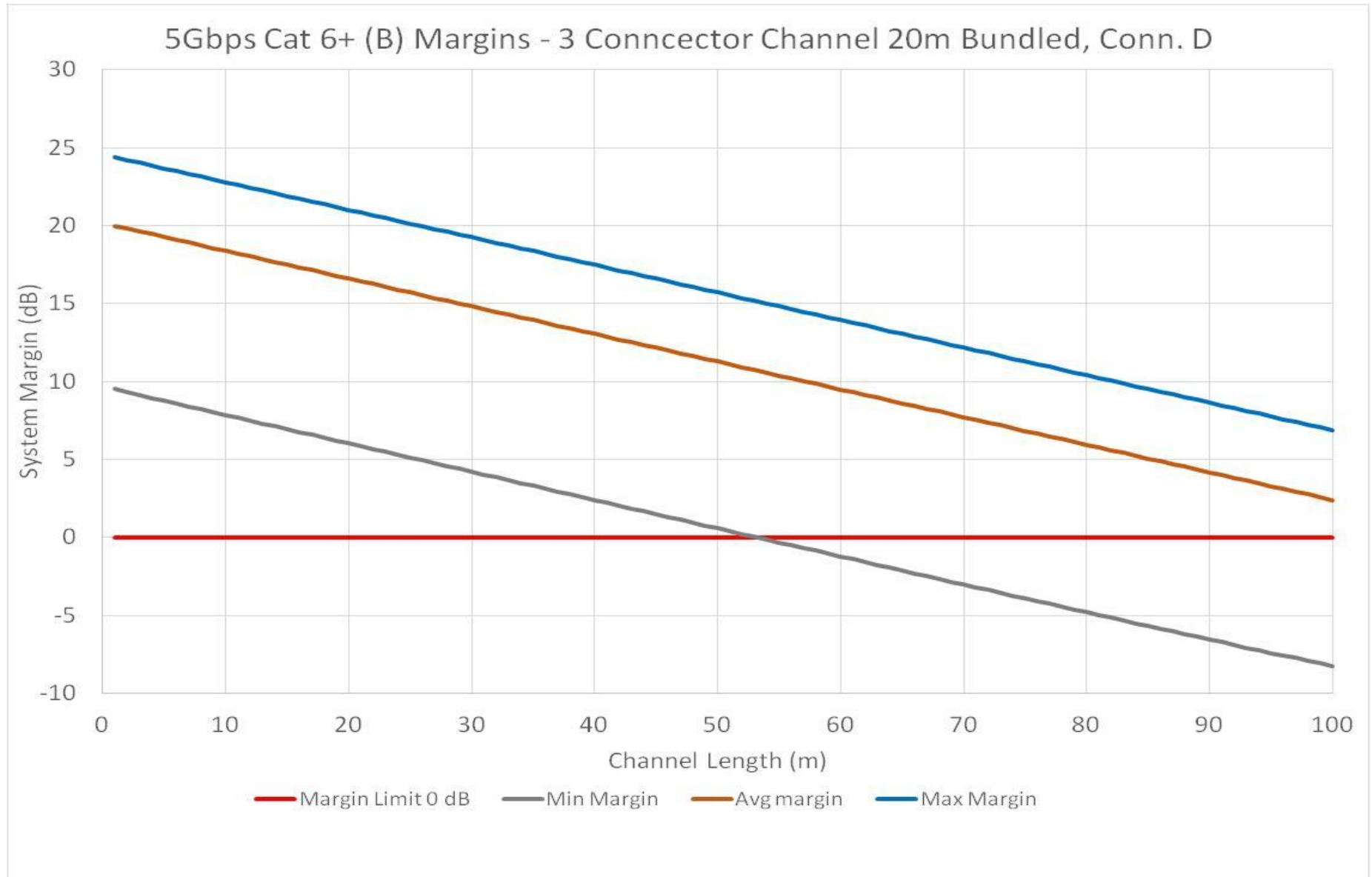


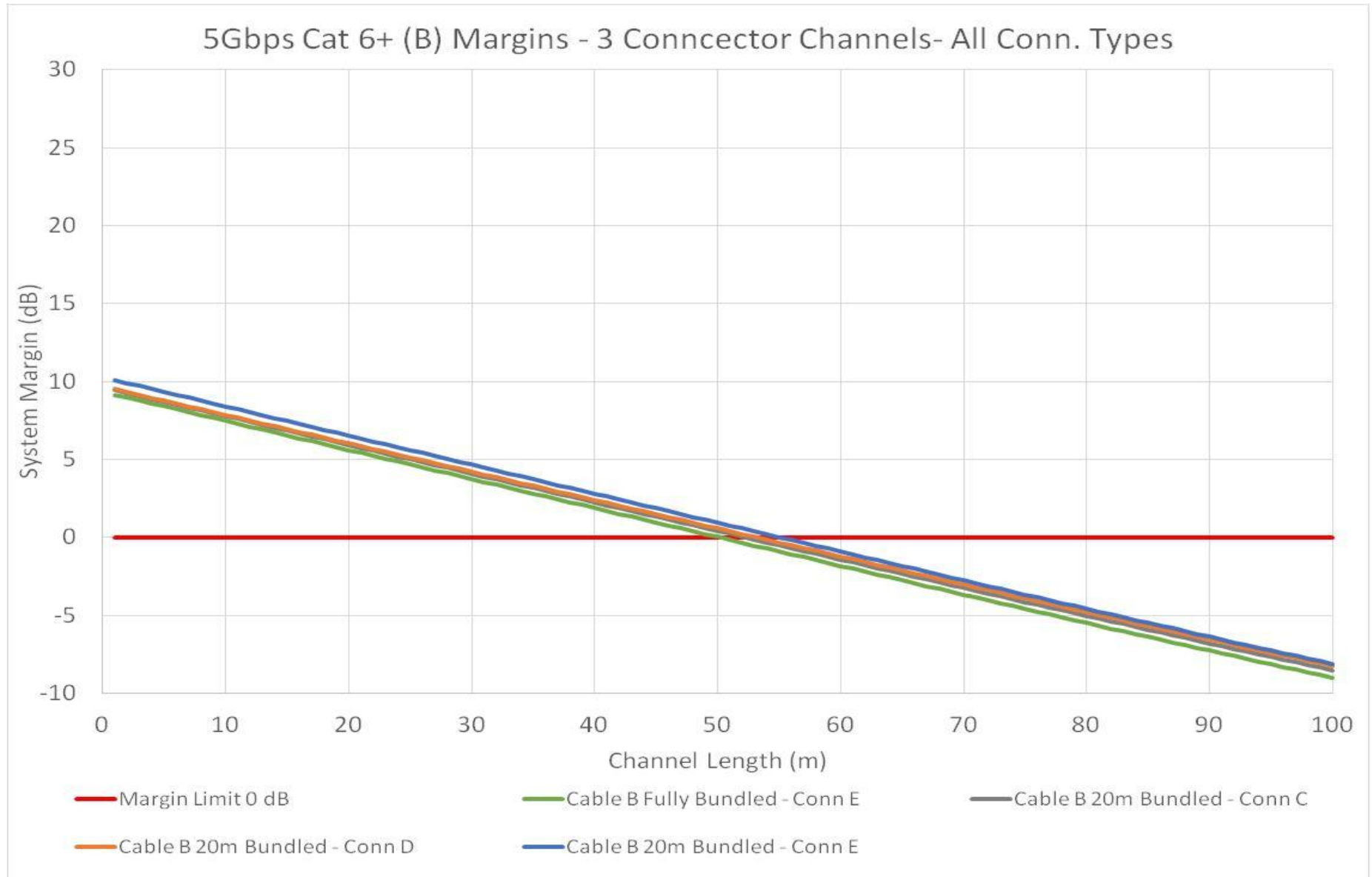


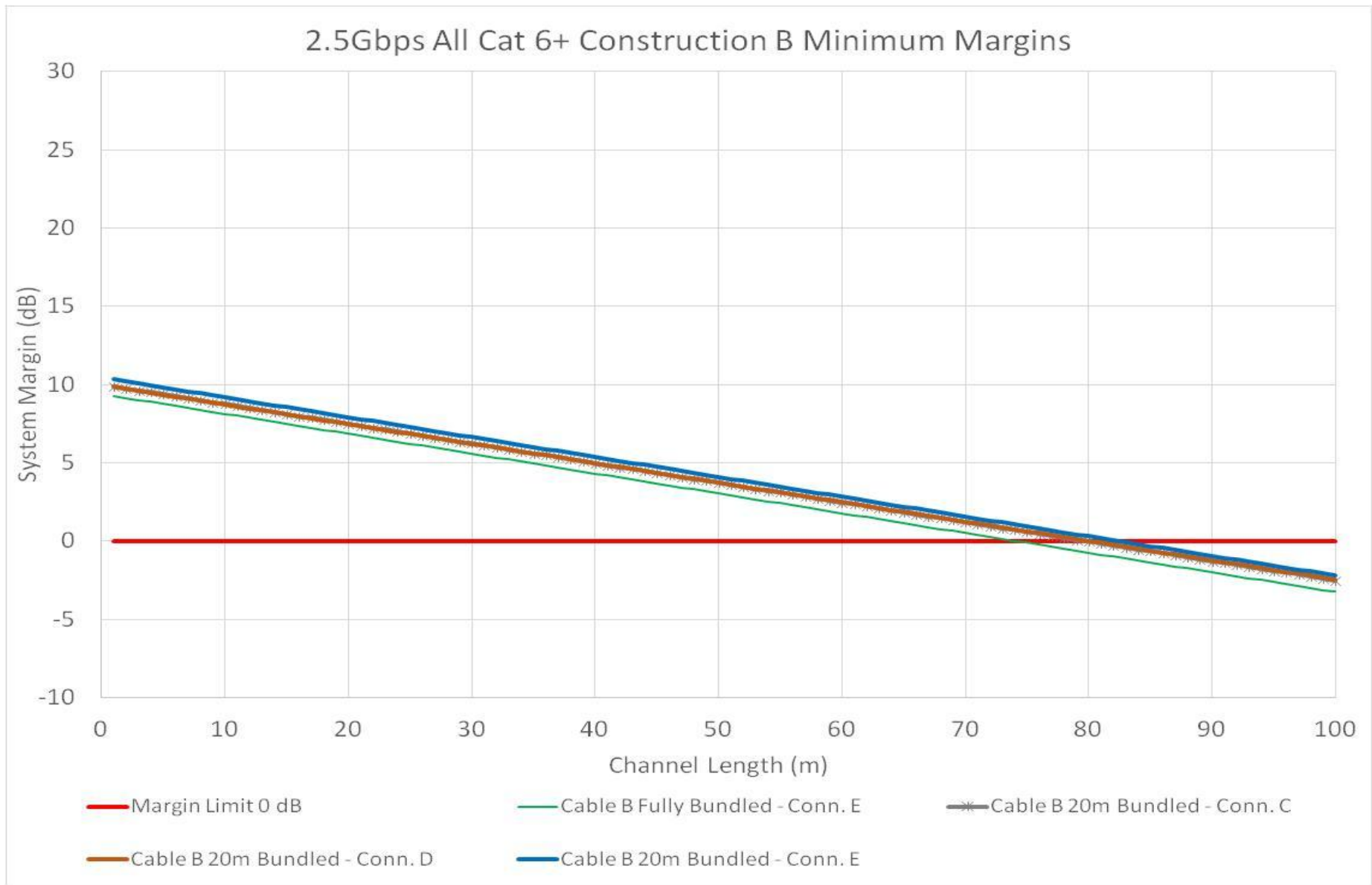


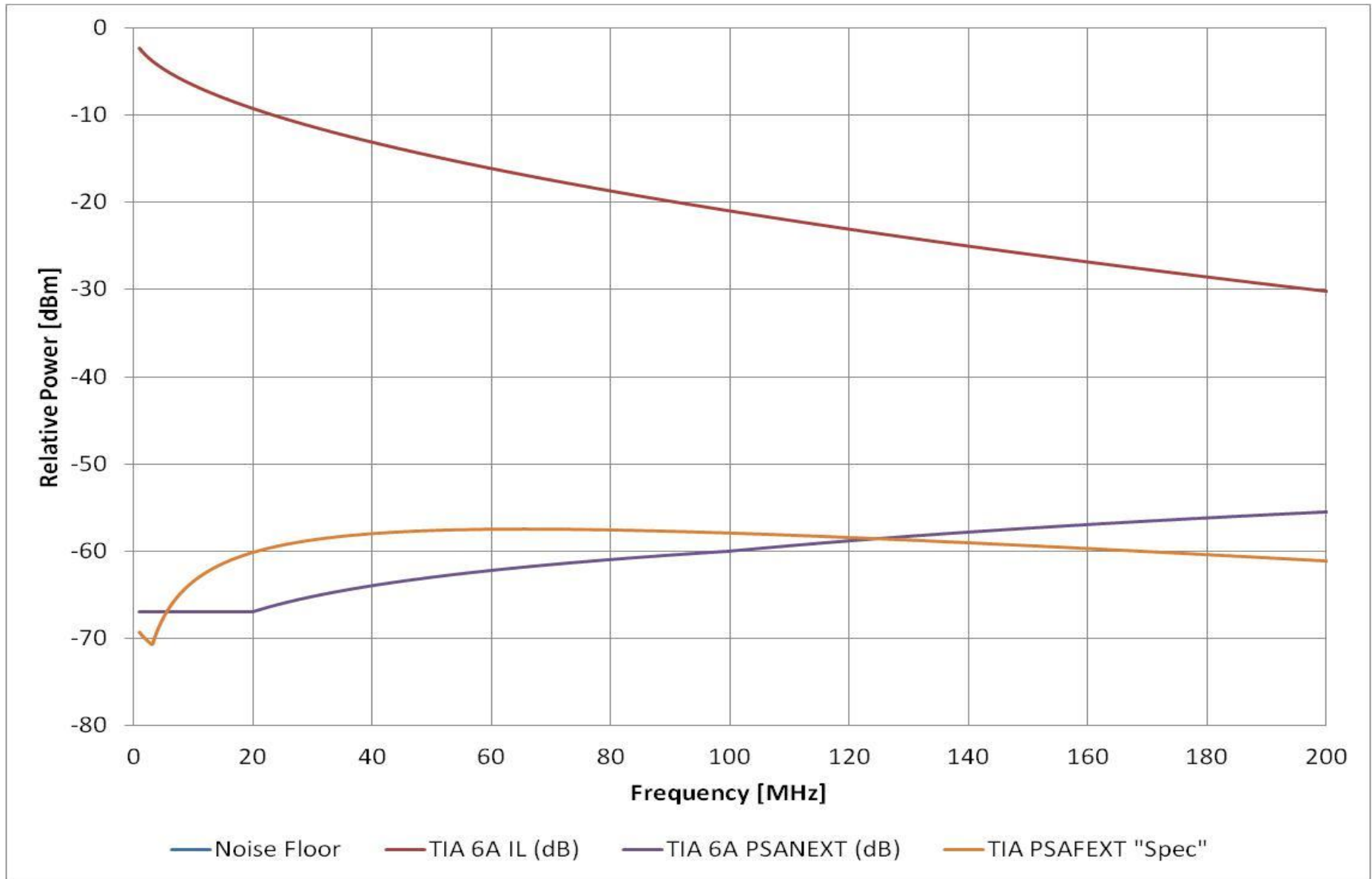




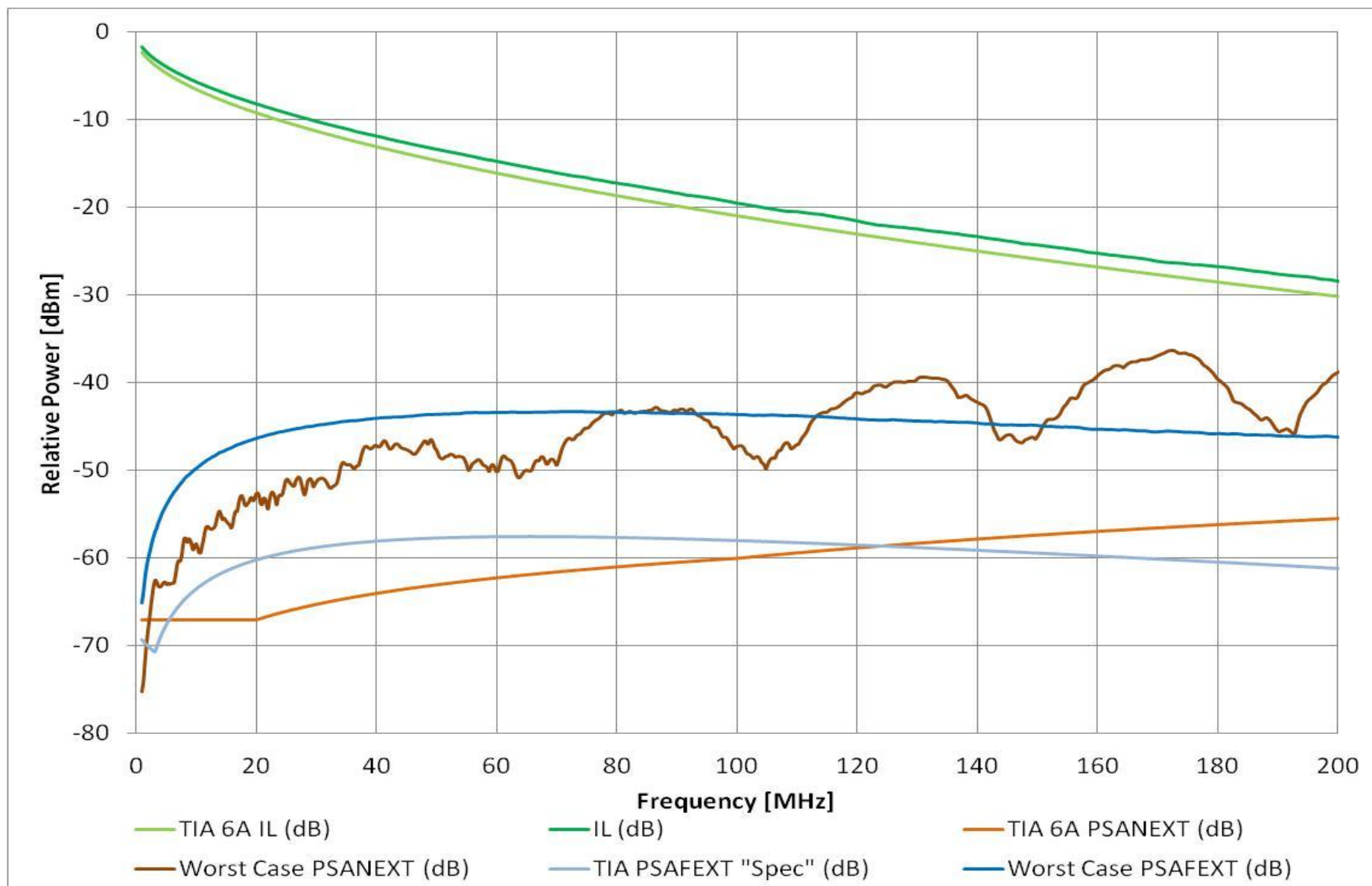




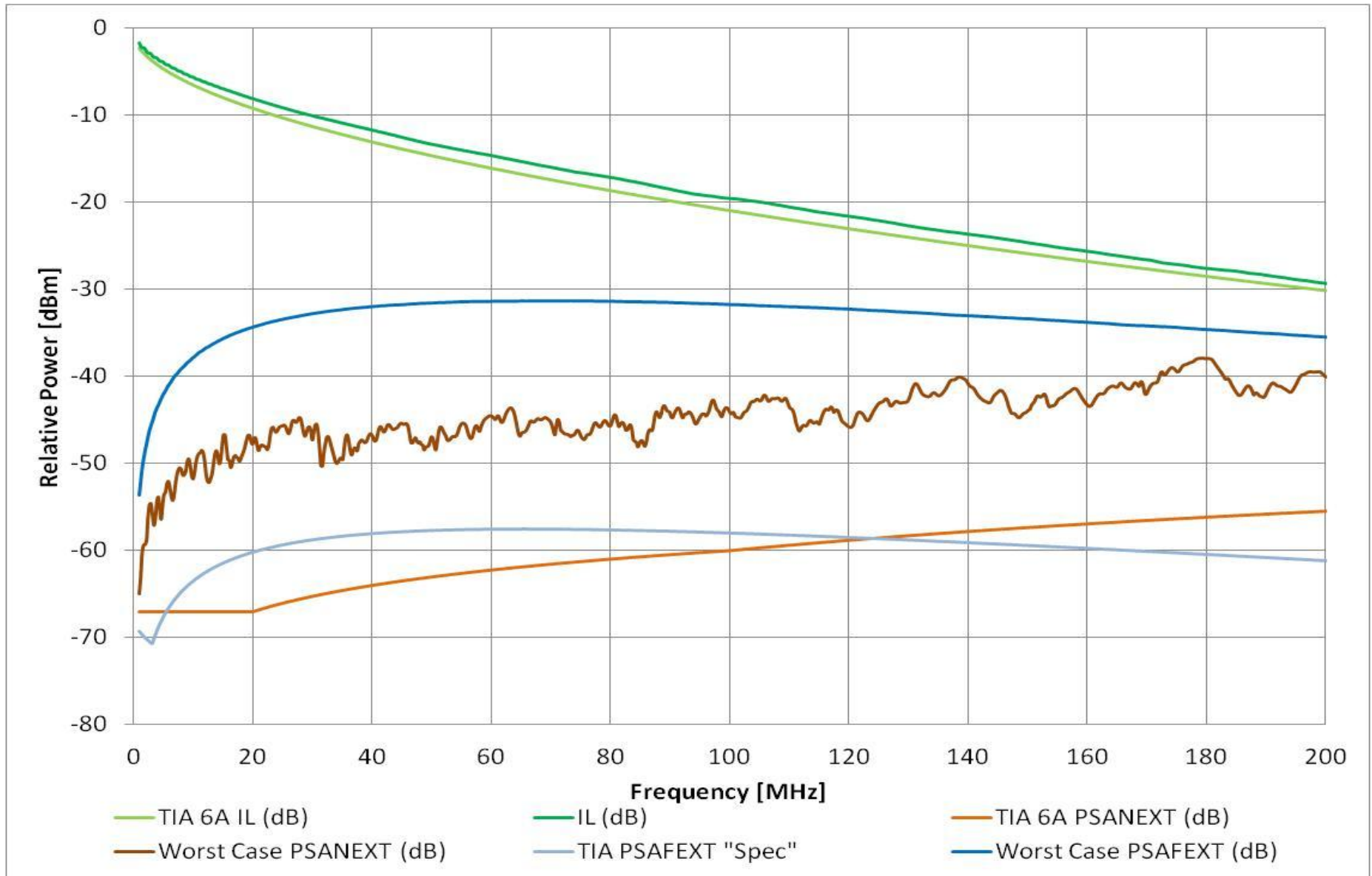




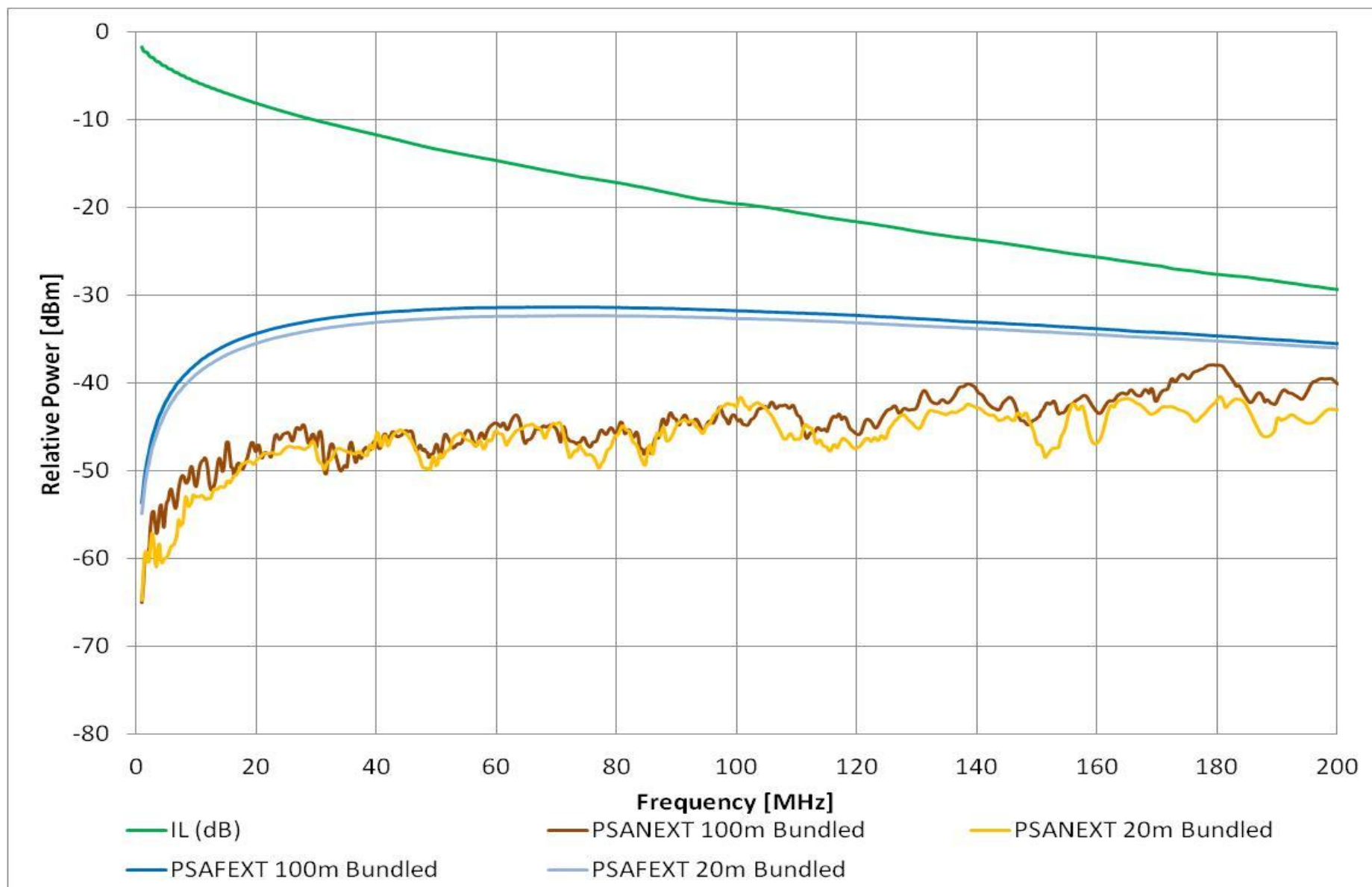
Noise Floor = -115.3 dBm



Cat 6+ Construction B Fully Bundled Min Margins Alien Crosstalk Related Impairments



Cat 6+ Construction B Fully Bundled vs. 20m Min Margin Alien Crosstalk Related Impairments



- Min Cat 6 and Cat 6+ Construction A
 - ◆ Min Cat 6 system margins ~0
 - No margin for elevated environmental temperatures – further investigation needed
 - Reducing bundled segment lengths should slightly improve margins - further investigation needed
 - ◆ Cat 6+ Construction A system margin ~ 1.6 dB
 - ◆ Approximately 1-2 dB margin to be gained through cord unbundling or connector improvements

- Cat 6+ Construction B limited by Alien FEXT
 - ◆ 5Gbps reach ~52m
 - ◆ 2.5Gbps reach ~ 78m
 - ◆ Bundle segment length has minimal impact on PSAFEXT
 - ◆ Reducing bundle lengths substantially improved average and maximum system margins
 - ◆ Different connectors designs had limited impact on min system margin – cable limited
 - ◆ Traditional mitigation techniques ineffective