

AWGN Noise models for PHY Evaluation

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2/7/2024 AD HOC

Agreed Baseline ANEXT/AFEXT

https://www.ieee802.org/3/dg/link_segment_090723.pdf

PSANEXT & PSAACR-F (July 2023)

PSANEXT:	$50 + 5 \times N$	$0.1 \leq f < 10$ MHz
	$50 + 5 \times N - 15 \times \log_{10}(f/10)$	$10 \leq f \leq 60$ MHz

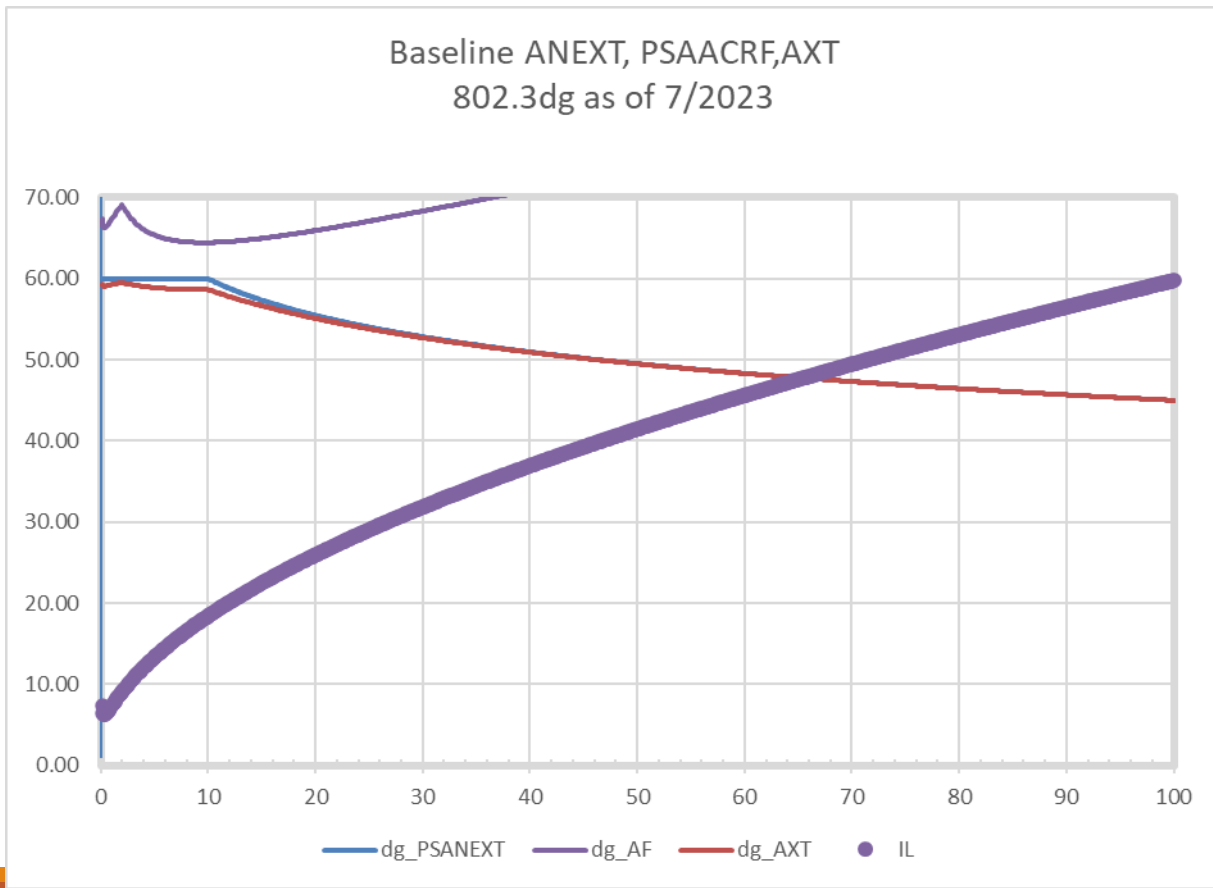
PSAACRF:	$50 + 5 \times N$	$0.1 \leq f < 2$ MHz
	$36 + 5 \times N - 20 \times \log_{10}(f/10)$	$2 \leq f \leq 60$ MHz

With N =	0	for $IL_{20} < 16$ dB
	$0.5 \times (IL_{20} - 16)$	for $16 \leq IL_{20} < 18$ dB
	1	for $18 \leq IL_{20} < 21$ dB
	$1 + 0.5 \times (IL_{20} - 21)$	for $21 \leq IL_{20} < 23$ dB
	2	for $23 \leq IL_{20}$ (dB)

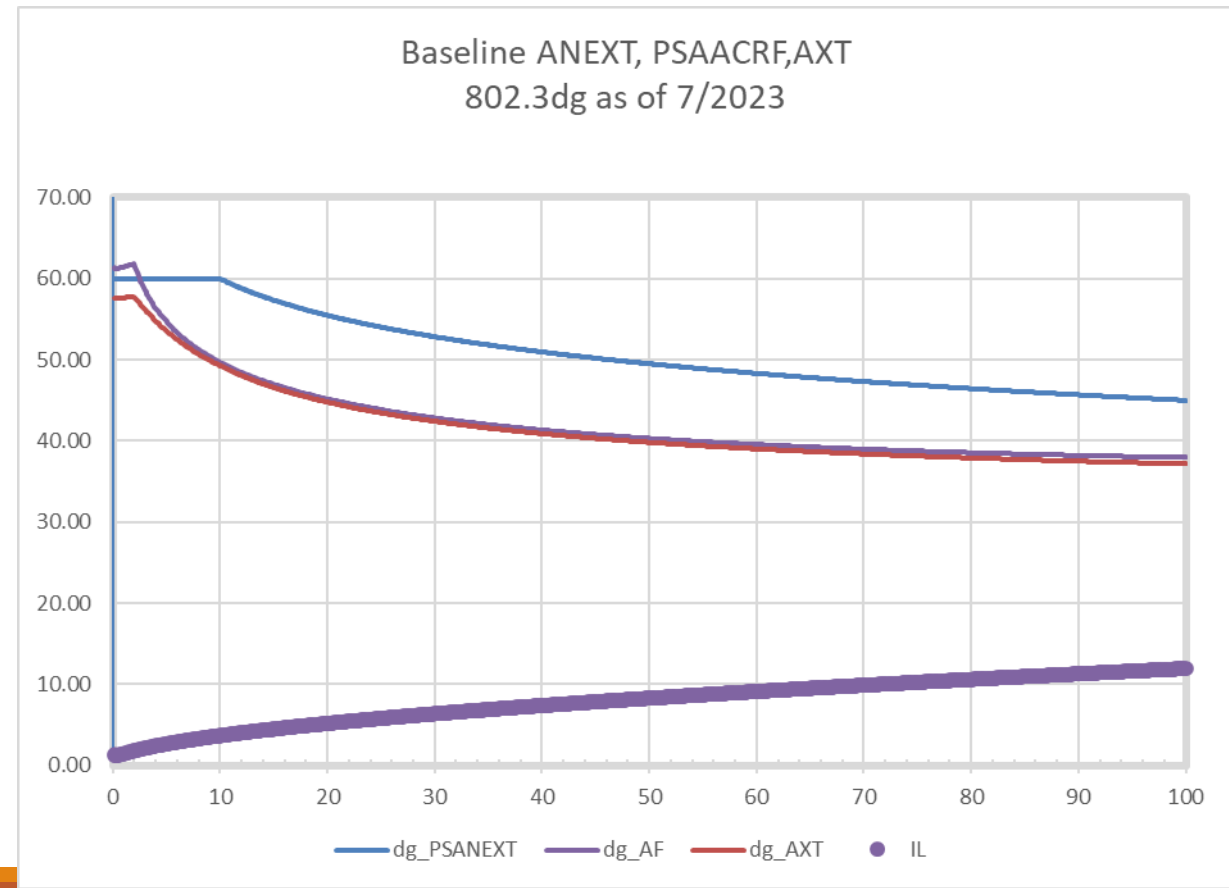
(f is in MHz)

AFEXT dominates when disturber line is short (coupling loss functions-not noise level)

500m disturber



100m disturber (500m victim ANEXT/AACRF limits)



Model Source for 100BASE-T1L

Start with 10BASE-T1L PSD mask

- Lower 3 dB (halfway between 2 masks) (-54 -> -57dBm/Hz)
- Assume 10x baud for shape of PSD, adjust level to compensate for actual baud

Scale level with baud being evaluated: $-10 \cdot \log_{10}(f_{\text{baud}}/7.5\text{MHz})$ dB

- E.g., 75 Mbaud means -57 dBm/Hz -> -67 dBm/Hz
- Call the flat PSD level ($-57 - 10\log_{10}(f_{\text{baud}}/7.5\text{ MHz})$), TXpsd

Frequency-scale corner & rolloff:

- Extend corner frequency: (2.5 MHz -> 25 MHz)
- Scale rolloff by 10x as well: (-1.6 dB/MHz becomes -0.16 dB/MHz)

Result: $\text{TXpsd}(0) = -57 - 10\log_{10}(f_{\text{baud}}/7.5\text{ MHz})$ dBm/Hz

- $\text{TXpsd}(f) = \text{TXpsd}(0)$ dBm/Hz for $0 < f < 25\text{ MHz}$
- $\text{TXpsd}(f) = \text{TXpsd}(0) - 0.16 \cdot (f - 25\text{ MHz})$ dBm/Hz for $25 \leq f < 125\text{ MHz}$

Separated, equal-length (long) Link model

If no 10BASE-T1L connectors are adjacent to 100BASE-T1L we can use just the PSANEXT coupling model on long links, as this will dominate.

Normalize to 75 Mbaud (10x) 10BASE-T1L TXpsd, *60 dB loss at low freq.*

- Flat *Noise* PSD Level : $NSpsd(0) = -127 - 10\log_{10}(f_{baud}/75 \text{ MHz})$

$NSpsd$ for $0 < f < 10 \text{ MHz}$

$NSpsd + 15\log_{10}(f/10) \text{ dBm/Hz}$ for $10 \leq f < 25 \text{ MHz}$

$NSpsd + 15\log_{10}(f/10) - 0.16(f-25\text{MHz}) \text{ dBm/Hz}$ for $f \geq 25 \text{ MHz}$

Correction, nomenclature (doesn't change result): TXpsd is $-67 - 10\log_{10}(f_{baud}/75)$,
but noise psd starts at -127 dBm/Hz from 0 to 10 MHz
Correct typo on sign in $15\log_{10}(f/10)$ term... (was correct in spreadsheet calculations)

Separated Equal Length Long Line

(linear) Average over Nyquist band for 75 Mbaud signal is -122.7 dBm/Hz

(average over 60 MHz is 1.1 dB higher recommend inband levels are more appropriate for evaluation)

Peak to peak ripple is 7 dB, with lower noise for $f < 10$ MHz.

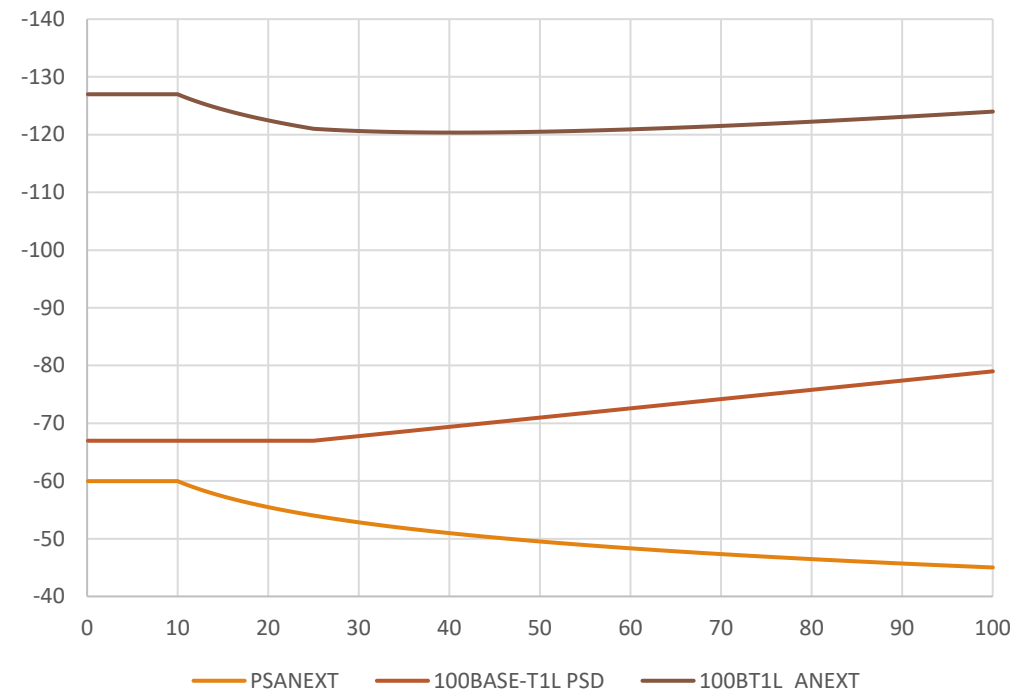
Recommend for this case, AWGN:

$-122.7 \text{ dBm/Hz} - 10\log_{10}(f_{\text{baud}}/75) \text{ dBm/Hz}$

0 to 60 MHz

Error – 60 MHz wideband average is higher, not lower,
Clarified – linear average, not geometric (db)

100BASE-T1L PSANEXT only
(equal length, long line)



Dealing with near-far AXT

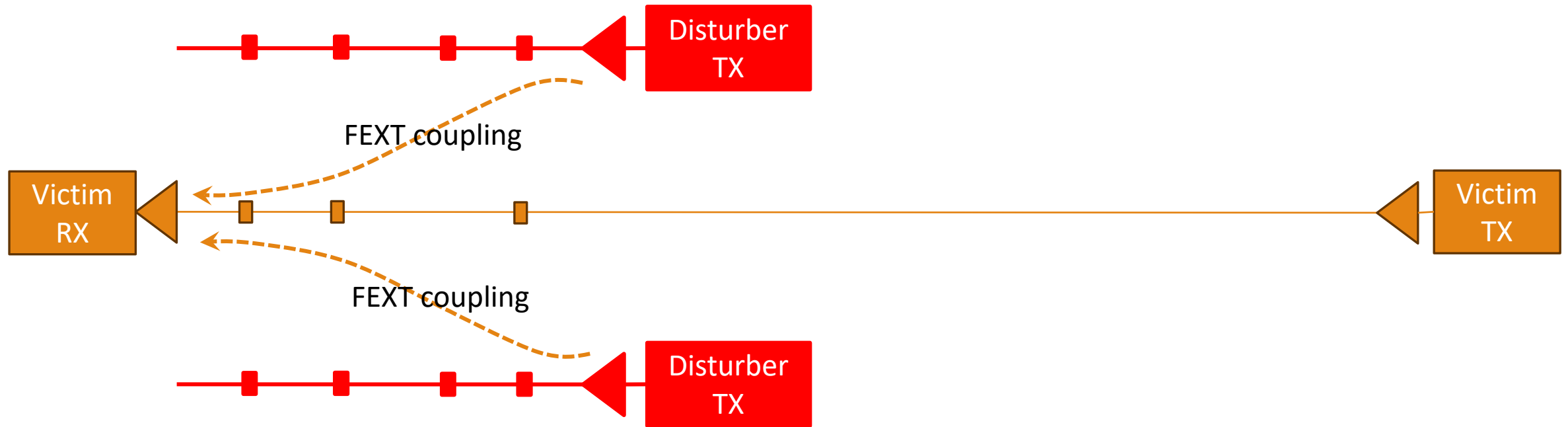
Far-end crosstalk from shorter disturbers coupled in near to a receiver can dominate noise

If this is expected, recommend we implement a power back off strategy

BUT – we need to be careful with this because it will make shorter links more vulnerable with impulse noise.

100BASE-T1L might use power back off to avoid this and keep ANEXT dominant for 100BASE-T1L disturbers...

Near-far problem diagram



PSAACR-F specification stays constant, but attenuation (IL) seen by the noise (disturber) path is substantially less than that seen by the desired (victim) signal
This can happen at marshalling connections where signals fan-out to facility traveling different lengths

Crosstalk from 10BASE-T1L

Likely 10 dB higher peak PSD (same launch voltage, less bandwidth) (higher for $f < 8.5$ MHz)

Also, 10BASE-T1L does NOT have power backoff so we will have to consider short-line AFEXT

Adds 10dB to coupling starting at ~ 8.5 MHz

Assume rolloff continues beyond floor at 12 MHz

Short-line PSAFEXT from 10BASE-T1L will dominate at frequencies to ~ 17 MHz based on mask & coupling

$$\text{Upper PSD Limit } (f) \geq \begin{cases} -54 \text{ dBm/Hz} & 0 \leq f \leq 2.5 \\ -54 - 1.6 \times (f - 2.5) \text{ dBm/Hz} & 2.5 < f < 12.5 \\ -70 \text{ dBm/Hz} & 12.5 \leq f \leq 20 \end{cases}$$

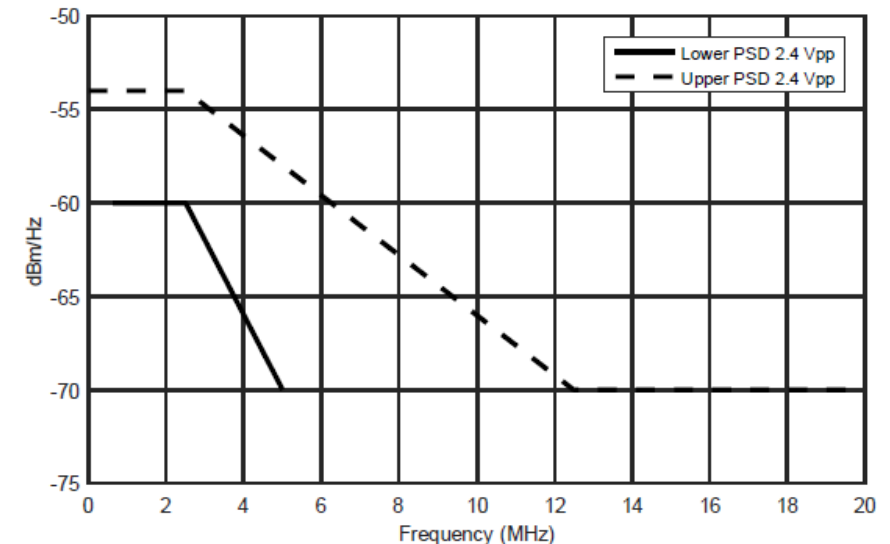


Figure 146-22—Transmitter Power Spectral Density, 2.4 Vpp Transmit Amplitude, Upper and Lower Masks

Source: IEEE Std 802.3-2022 Eqn 146-6 and Fig 146-22

Mixed Crosstalk Disturbing source

Equal parts 10BASE-T1L & 100BASE-T1L

- Reduce each disturbing PSD by 3dB to account for fewer disturbers

IF near-far problem is addressed for 100BASE-T1L then we can use 100m AFEXT coupling model for 10BASE-T1L, *and* ANEXT coupling model for 100BASE-T1L

IF near-far problem is NOT addressed *we would need to include a 100m AFEXT coupling model as well for 100BASE-T1L.*

Clarified – sentence completed in last paragraph

Mixed Crosstalk / Near-far “fixed” for 100BASE-T1L (100BASE-TL ANEXT dominates)

Average over Nyquist band for 75 Mbaud signal is -120.3 dBm/Hz

(average over 60 MHz is 0.9 dB lower)

Peak to peak ripple is ~10 dB, with higher noise for $f < 20$ MHz.

Recommend for this case, Sum of 2 AWGN sources

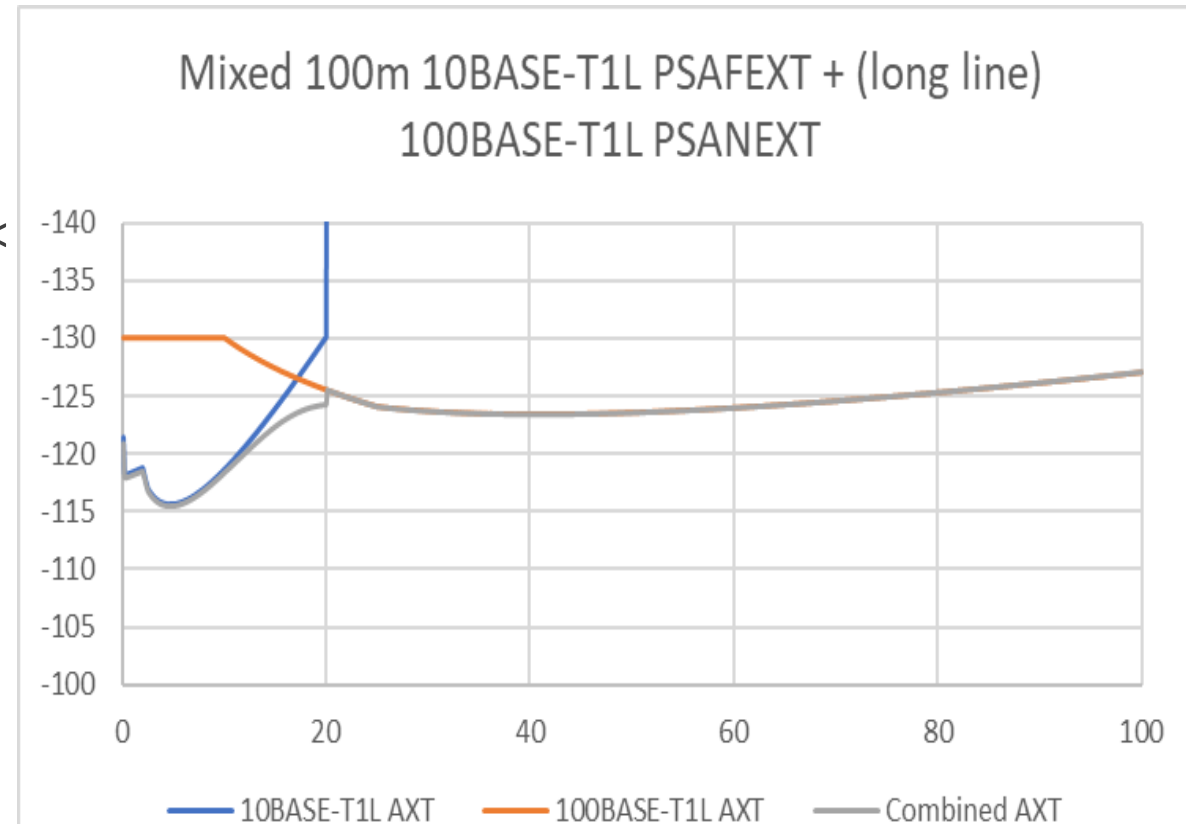
Source 1:

-121.2 dBm/Hz – $10\log_{10}(f_{\text{baud}}/75)$ dBm/Hz

0 to 60 MHz

Source 2:

-116.8 dBm/Hz 0 to 20 Mhz, filtered by 2nd order LPF at 5 MHz

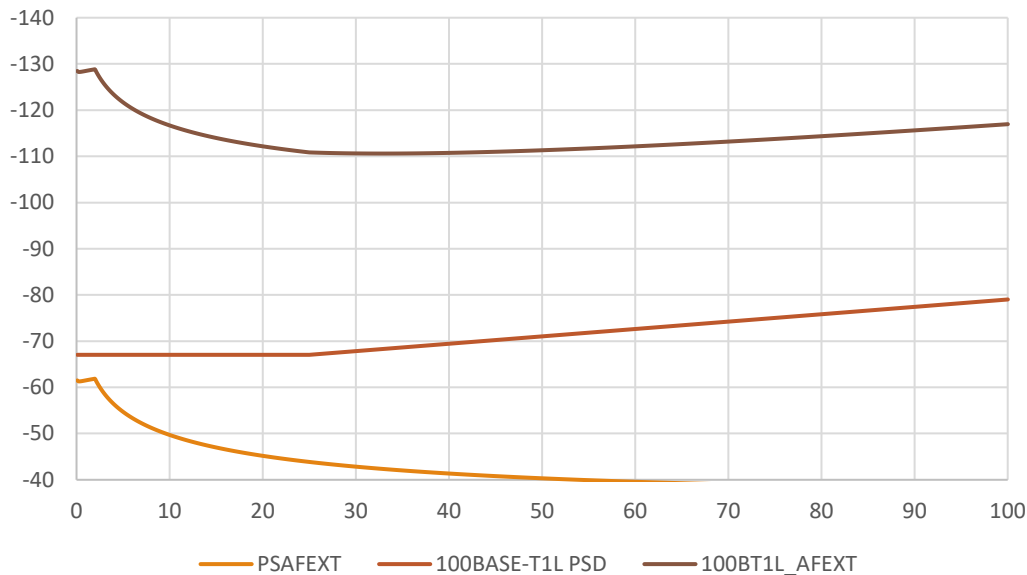


Slide title corrected, levels adjusted based on average measurements for 0-5Mhz, 5Mhz-37.5MHz linear po
for source 1 is -121.2 (1.3 dB higher), source 2 -116.8 (0.2 dB higher)

If the near-far problem isn't addressed for 100BASE-T1L (Mixed Crosstalk case)

100BASE-T1L AFEXT dominates

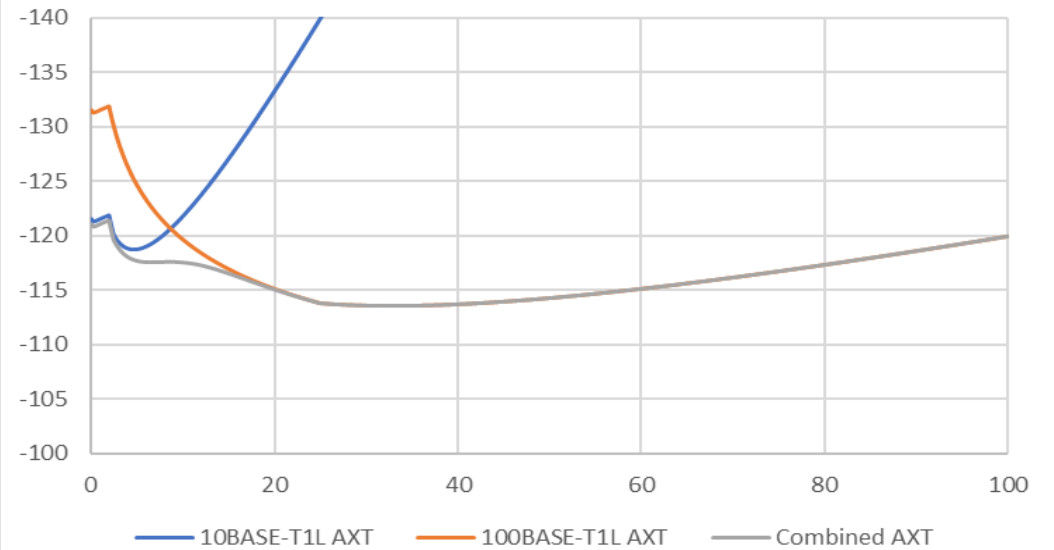
100BASE-T1L PSAFEXT only
(100m AFEXT)



Use $-112.9 - 10\log_{10}(f_{\text{baud}}/75)$ dBm/Hz AWGN source

10/100 Mixed Crosstalk

Mixed 100m 10BASE-T1L PSAFEXT + (100m)
100BASE-T1L PSAFEXT



Use combined -116.7 dBm/Hz 5MHz 2nd order filtered plus -115.0 dBm/Hz- $10\log_{10}(f_{\text{baud}}/75)$ dBm/Hz source
OR use -115.4 dBm/Hz $-10\log_{10}(f_{\text{baud}}/75)$ AWGN source

FIXED TO SHOW CORRECT WORST CASE – 100BASE-T1L FEXT AND LEVELS FIXED
previous slide showed right hand case only

Comments

We need to determine is whether 10BASE-T1L will be collocated with 100BASE-T1L – I believe this is likely - This drives the mixed crosstalk model

Recommend for now - need to coexist with mixtures of 10BASE-T1L

PHY evaluators need to consider the near-far problem

Any power reductions should be taken from impulse immunity, AWGN AFEXT levels need to be shown and evaluated based on scheme used

*If near-far problem isn't fixed use slide 12: $-112.9 - 10 \log_{10}(f_{\text{baud}}/75)$ dBm/Hz
AWGN source 100BASE-T1L AFEXT is worst case, and mixed source.*

If near-far problem is addressed, use mixed source on slide 11.

These models are for PHY evaluation only – we will have to redo them when we write the Alien Crosstalk Rejection test.

Source levels aligned with slides 11 & 12