AWGN Noise models for PHY Evaluation

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Agreed Baseline ANEXT/AFEXT

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

PSANEXT & PSAACR-F (July 2023)

PSANEXT:	50 + 5 x N	0.1 ≤ f < 10 MHz
	50 + 5 x N - 15 x log10 (f/10)	10 ≤ f ≤ 60 MHz
PSAACRF:	50 + 5 x N	0.1 ≤ f < 2 MHz
	36 + 5 x N - 20 x log10 (f/10)	2 ≤ f ≤ 60 MHz

With N =	0	for IL_20 < 16 dB
	0.5 x (IL_20 – 16)	for 16 ≤ IL_20 < 18 dB
	1	for 18 ≤ IL_20 < 21 dB
	1 + 0.5 x (IL_20 – 21)	for 21 ≤ IL_20 < 23 dB
	2	for 23 ≤ IL_20 (dB)

(f is in MHz)

AFEXT dominates when disturber line is short

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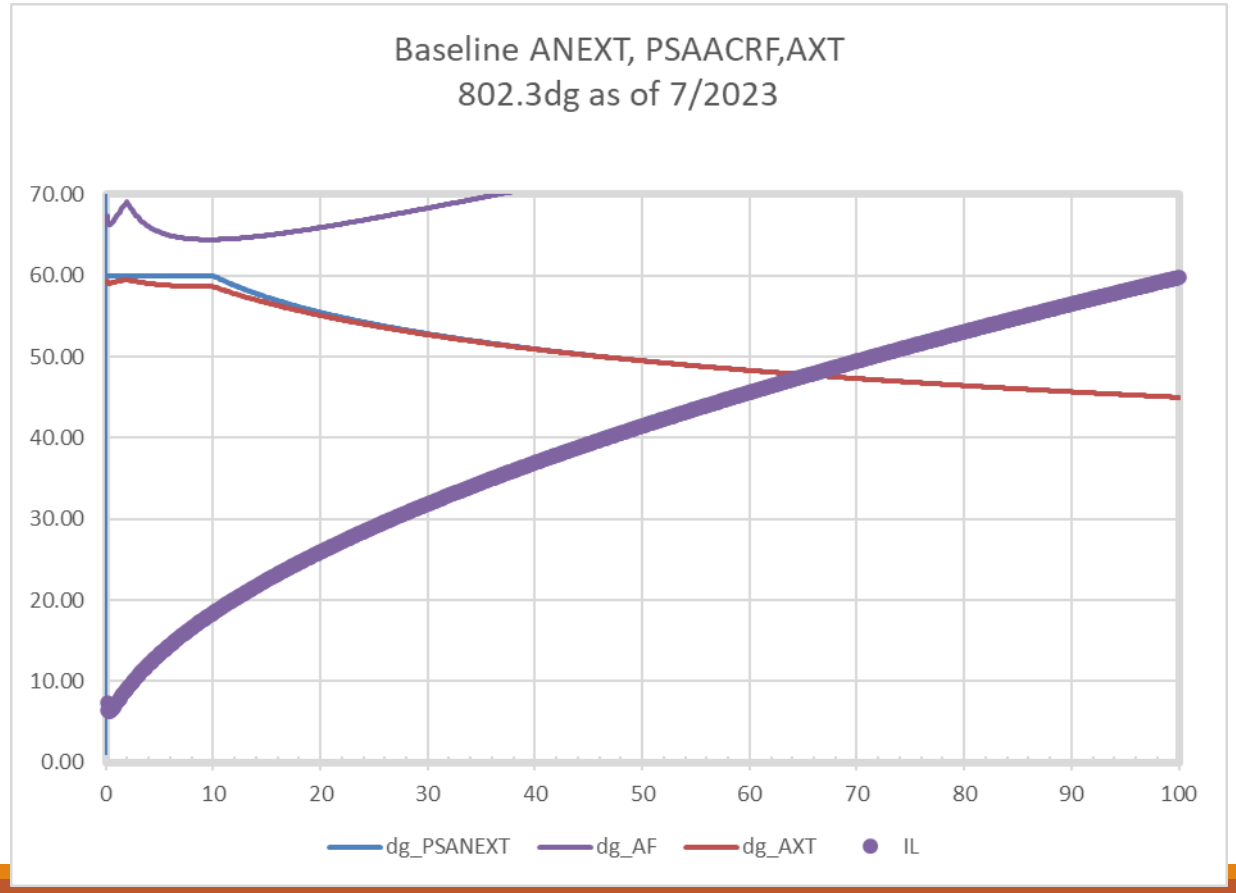
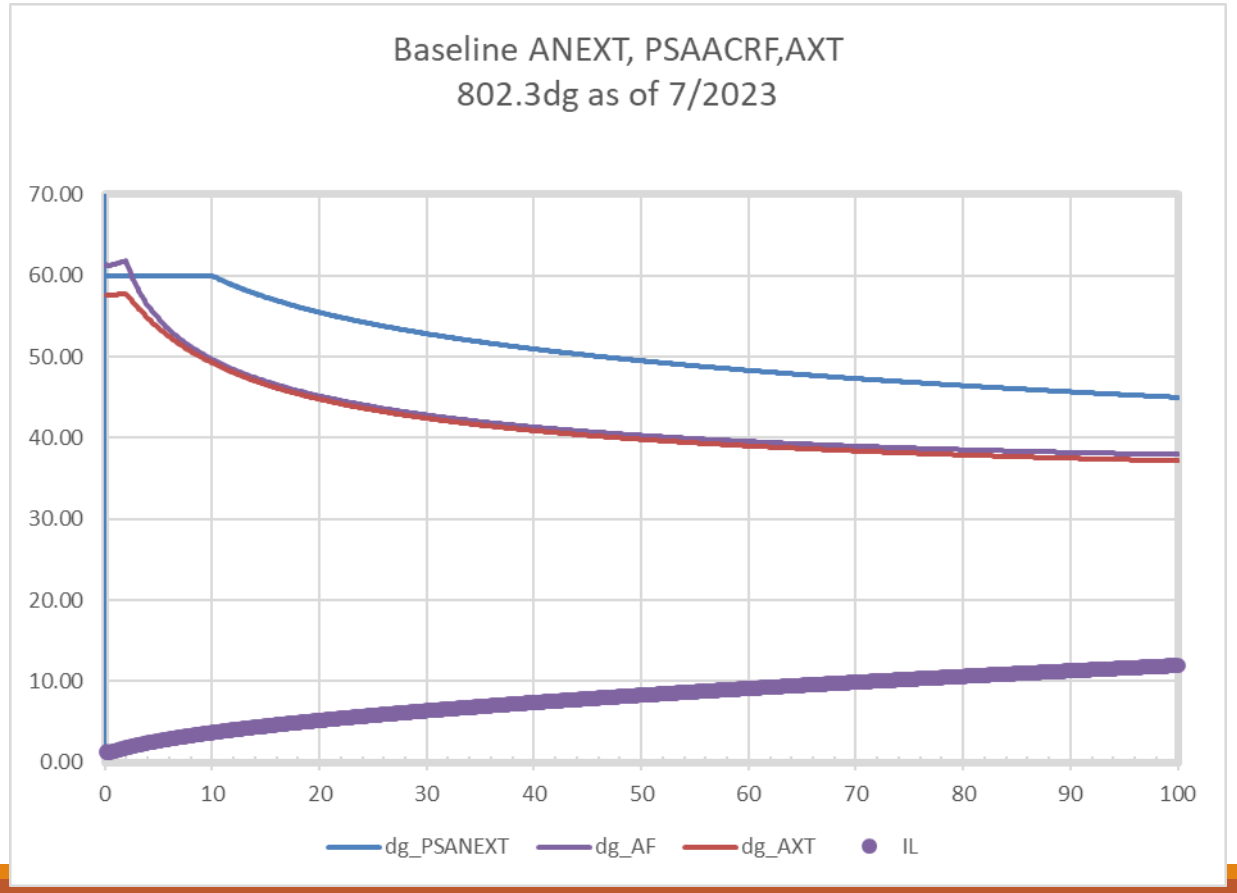
500m disturber



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



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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*log10(fbaud/7.5MHz) dB
- E.g., 75 Mbaud means -57 dBm/Hz -> -67 dBm/Hz
- Call the flat PSD level (-57 – 10log10(fbaud/7.5 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: TXpsd(0) = -57-10log10(fbaud/7.5 MHz) dBm/Hz
- TXpsd(f) = TXpsd(0) dBm/Hz for 0< f <25 MHz
- TXpsd(f) = TXpsd(0) – 0.16*(f – 25 MHz) dBm/Hz for 25≤ f < 125 MHz

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Separated, equal-length 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:

- Flat PSD Level : TXpsd(0) = -127 – 10log10(fbaud/75 MHz)

TXpsd dBm/Hz	for 0 < f < 10 MHz
TXpsd – 15log10(f/10) dBm/Hz	for 10 ≤ f < 25 MHz
TXpsd – 15log10(f/10) – 0.16(f-25MHz) dBm/Hz	for f ≥ 25 MHz

Separated Equal Length Long Line

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

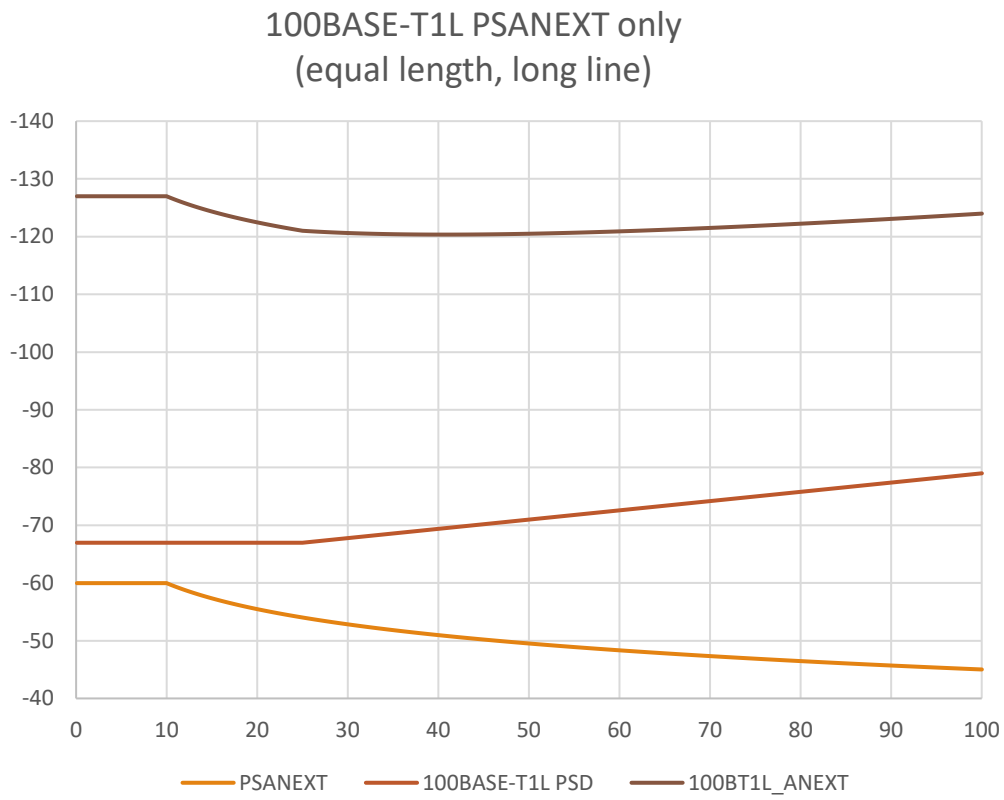
(average over 60 MHz is 1.1 dB lower)

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

Recommend for this case, AWGN:

-122.7 dBm/Hz – 10log10(fbaud/75) dBm/Hz

0 to 60 MHz



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Dealing with near-far AXT

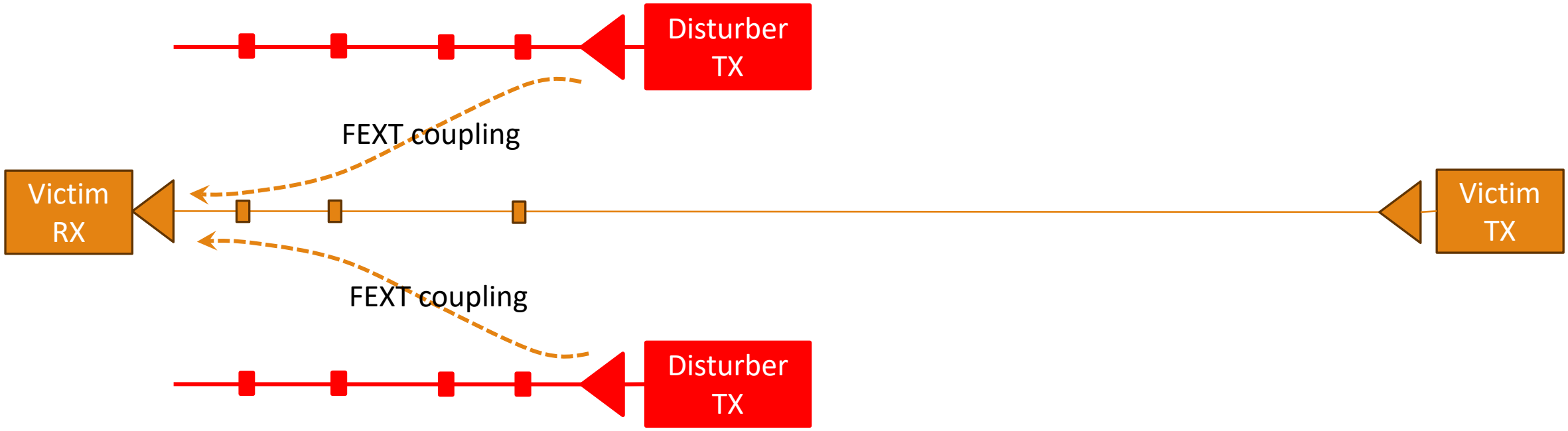
Far-end crosstalk from shorter disturbers coupled in near to a receiver can dominate noise

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<8.5MHz)

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

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

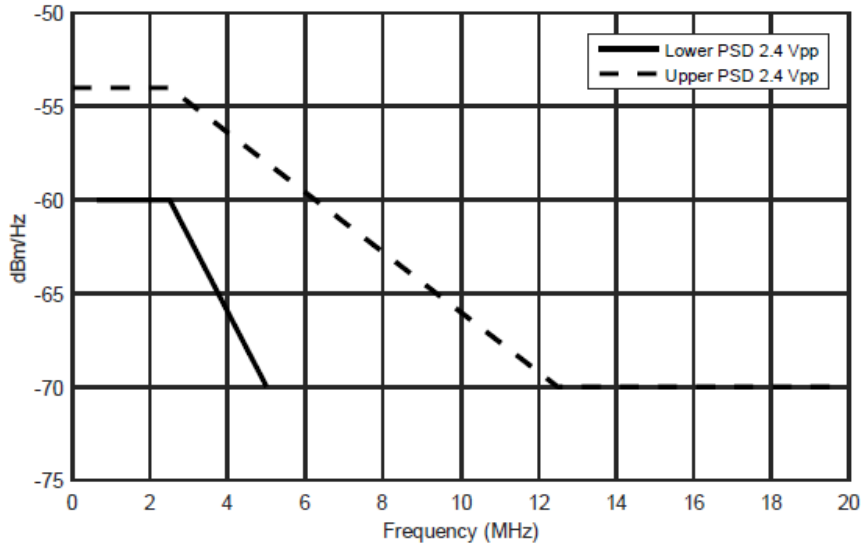


Figure 146–22—Transmitter Power Spectral Density, 2.4 Vpp Transmit Amplitude, Upper and Lower Masks

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

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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, ANEXT coupling model for 100BASE-T1L

IF near-far problem is NOT addressed

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Separated Equal Length Long Line

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

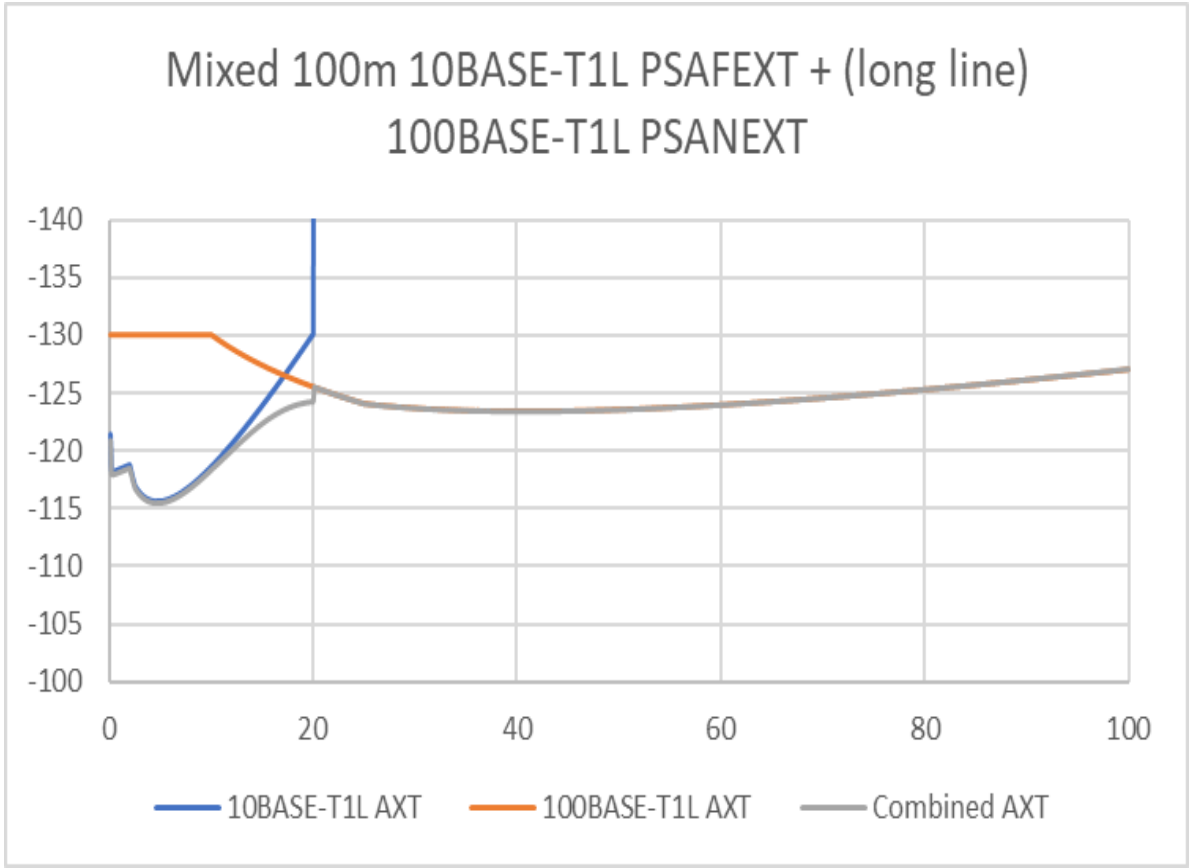
Source 1:

-123.5 dBm/Hz – 10log10(fbaud/75) dBm/Hz

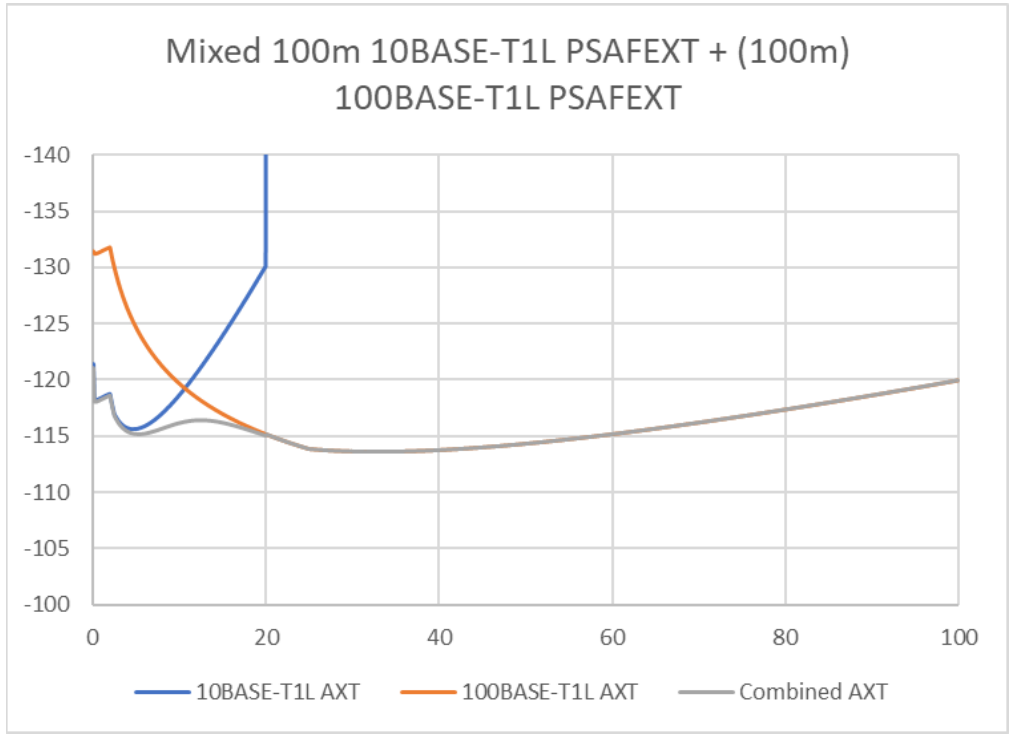
0 to 60 MHz

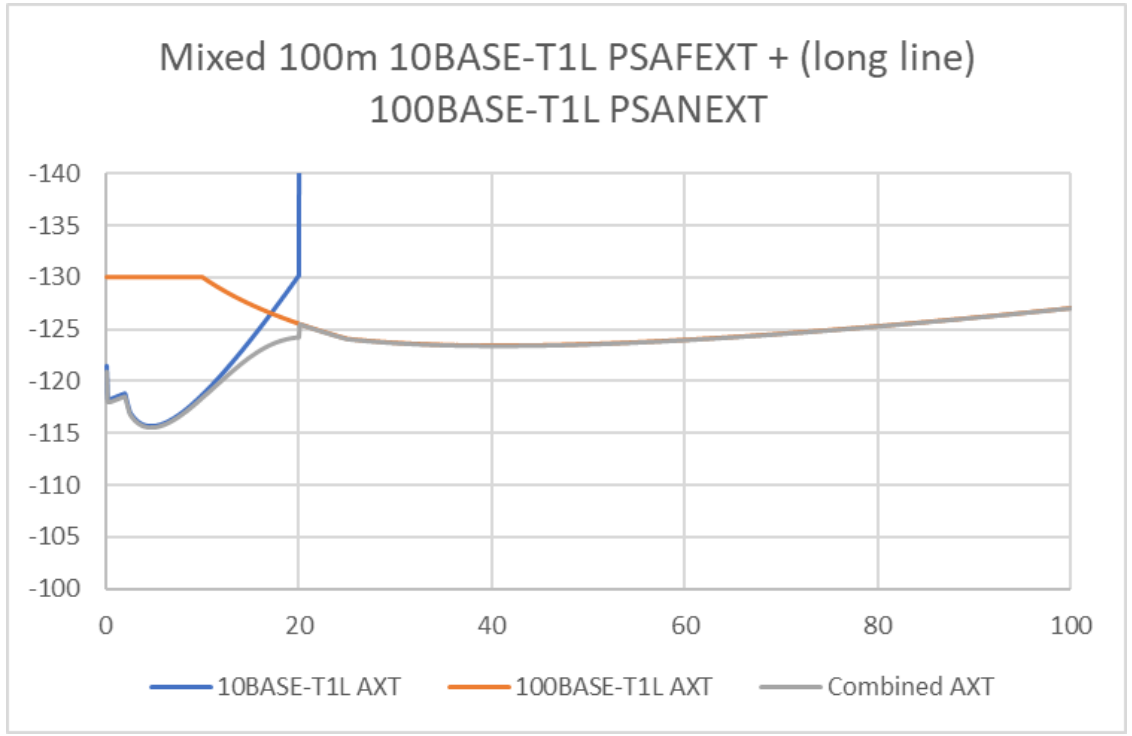
Source 2:

-117 dBm/Hz 0 to 20 Mhz, filtered by 2nd order LPF at 5 MHz



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





Use -113 – 10log10(fbaud/75) dBm/Hz AWGN source

Use combined -117 dBm/Hz 5MHz 2nd order filtered plus -123.5 dBm/Hz-10log10(fbaud/75) dBm/Hz source

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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 used use -113-10log10(fbaud/75) dBm/Hz AWGN source for mixed crosstalk (can use same for 100BASE-T1L only)

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