Salz SNR Text and Procedure

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Outline

- Where we are
- Holes to be filled
- PSD templates
- Corrections and Simplifications
- Procedure clarifications
- Things to do/division of labor

Where we are

- Task Force accepted use of Salz SNR as the basis of link segment requirements for alien crosstalk (vs. insertion loss)
- Draft 1.0 text has straw man unapproved text loosely based on Clause 55.7 alien crosstalk margin computation steps
- Review and filling out of the specification needs to occur

Holes to be filled

- The current text leaves several items TBD
  - Power Spectral Density functions to use for evaluating interference
  - Precision of modeling
  - Target SNR criterion
  - How to determine the PBO for disturbers
  - How to select ‘disturbing’ link segments

PSD templates

- Base 2.5/5/10G PSD templates on a zero-order hold with a 490 MHz 2nd order LPF
- Normalize 2.5/5G power to 2.0 dBm, 10G to 4.2 dBm

PSD(f) =

$$X1 + 20\log_{10}\left[\frac{|\sin(\pi f/(400\times S))|}{\pi f/(400\times S)}\right] - 10\log_{10}\left[1+\left(\frac{f}{490}\right)^4\right] \text{ dBm/Hz}$$

- Where:
  - *f* is the frequency in MHz,
  - *S* = 0.5 for 2.5GBASE-T, 1.0 for 5GBASE-T (see 126.1.1), and 2.0 for 10G, and
  - *X*1 = -80.65 for 2.5G, -77.91 for 5G, and -80.89 for 10G

Corrected 8/24 for filter 10log10, and power numbers

1000BASE-T

- A bit more difficult, specified as voltage mask w/rise and fall, not as a PSD, and uses pulse shaping filter: $0.75 + 0.25z^{-1}$
- Approximation: (request for comment/revision)
  - 125 MSPS zero-order hold, specified pulse shaping filter, 1st order LPF at 100 MHz, 3.2dBm TX power

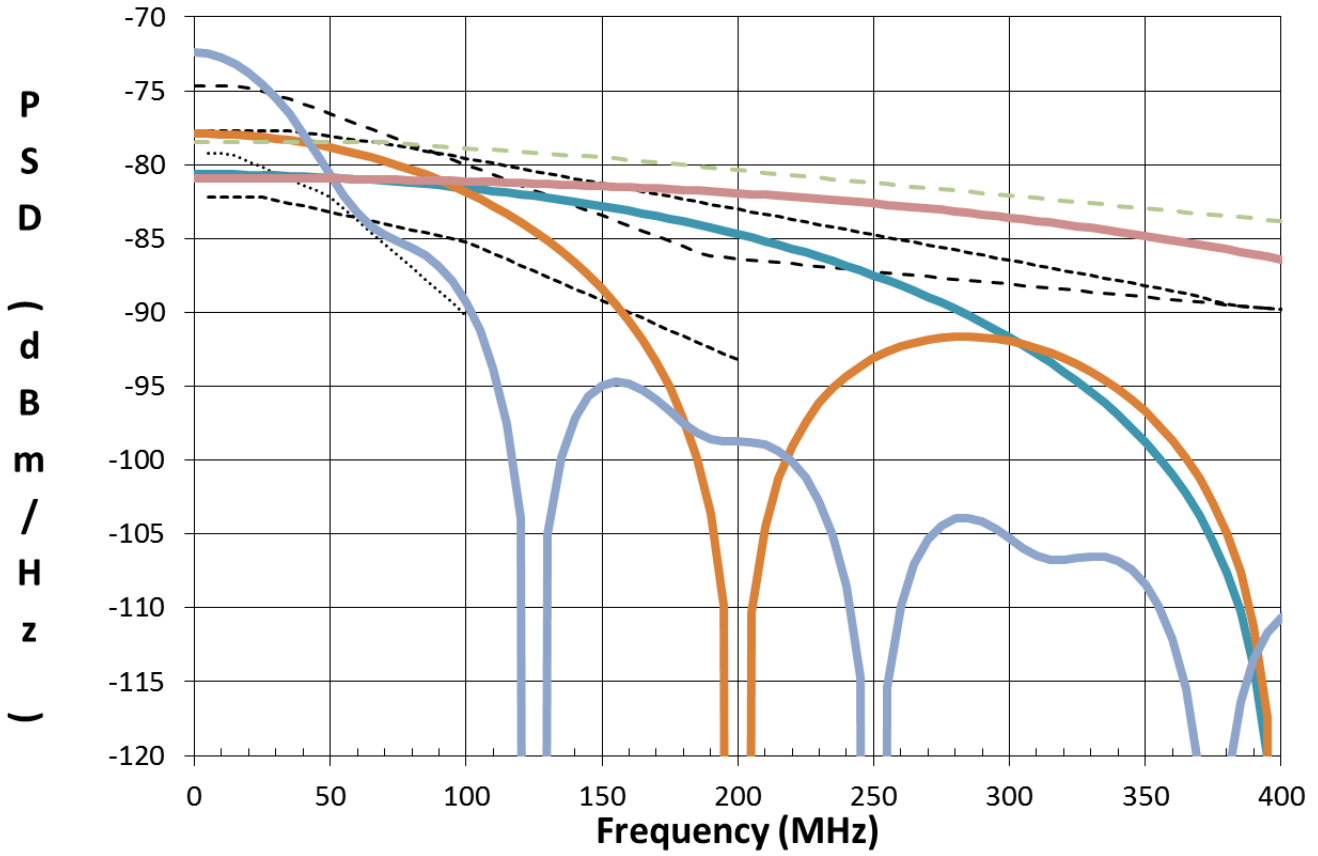
$$PSD(f) =$$

$$-72.38 + 20\log_{10}\left[\frac{|\sin(\pi f/125)|}{\pi f/125}\right] - 10\log_{10}\left[1+\left(\frac{f}{100}\right)^2\right]$$

$$-10\log_{10}\left[0.625 + 0.375\cos\frac{2\pi f}{125}\right] \text{ dBm/Hz}$$

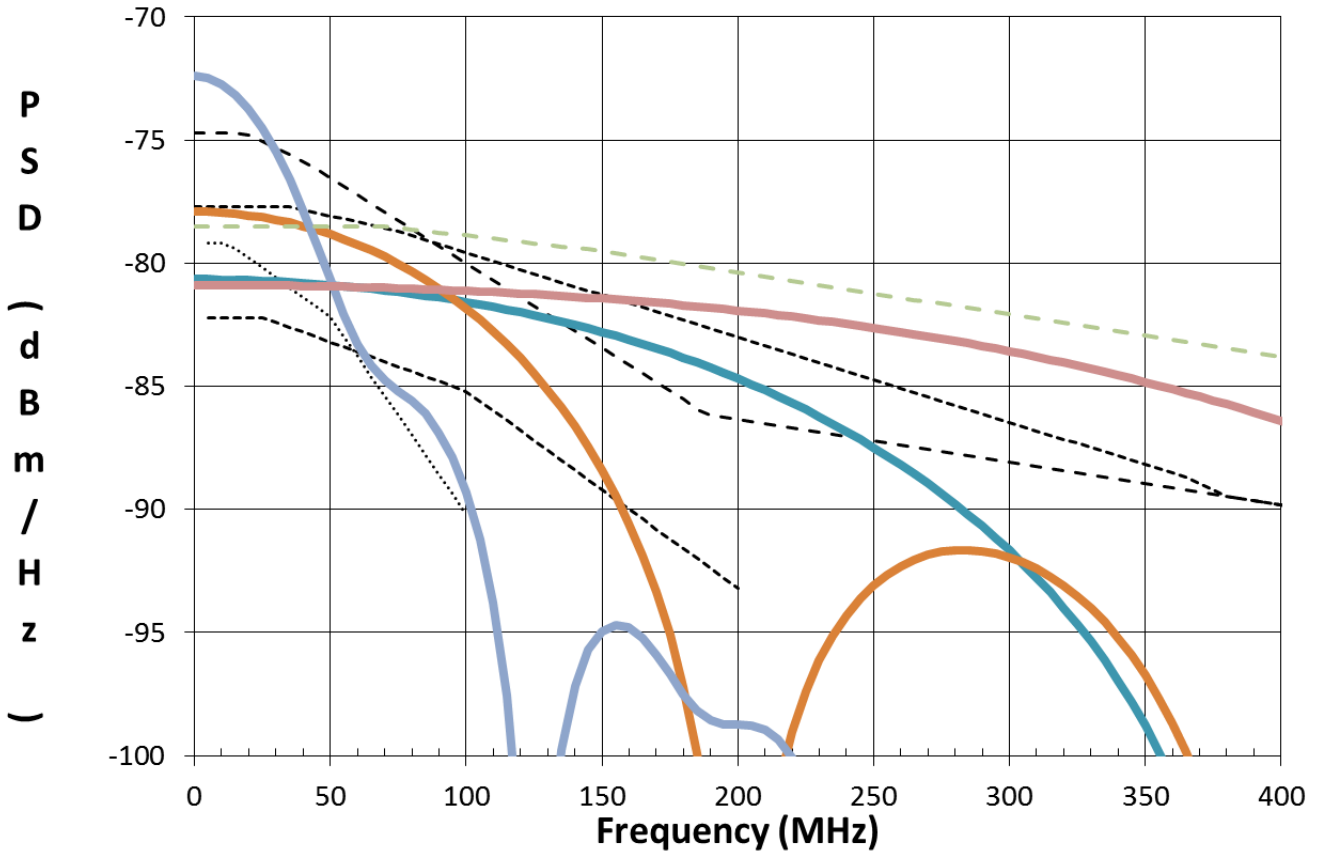
Corrected 8/24 for filter 10log10, and power numbers

Proposed Template PSDs



Corrected 8/24

Proposed Template PSDs (close up)



Corrected 8/24

Precise Modeling not Required

- Experience suggests Salz SNR criterion reflects performance no better than ~2 dB
- Precision in Criterion ~1dB should be sufficient (any finer is false!)
- Pass/Fail threshold should include implementation margin
- Metric may be simplified since precision only matters around ‘pass-fail threshold’

Getting to a Target SNR

- Don’t worry about anything below the decimal point!
- Start at 24 dB (10G rounded off)
- Add 6 dB implementation margin
- Add up to 2 dB for PBO uncertainty

- Result: Target SNR between 30 and 32 dB
  - Reasonable?

Salz SNR calculation

- Equation in D1.0 has issues:
  - Linear SNR form, when what is used is dB's

$$SNR_{Salz}(l) = e^{\frac{\int_0^W log\left(1+\frac{S_l(f)}{N_l(f)}\right)\cdot df}{W}} - 1$$

  - 'Unbiased receiver' SNR, not pure Salz (BSTJ, Oct 1973):

$$\mathrm{MSE} = \sigma_a^2 \exp\left\{-\frac{\mathrm{T}}{2\pi}\int_{-\pi/T}^{\pi/T} \ln[Y(\omega)+1]d\omega\right\}, \qquad (13)$$

  - Complex integration w/additions, exponentiation, all because of small added terms

Corrections & Simplifications

- Rewrite as dB SNR:

$$SNR_{Salz} = 10\log_{10}\left[\exp\left(\frac{1}{W}\int_0^W \log_e\left(1+\frac{S_i(f)}{N_i(f)}\right)df\right)-1\right]$$

- Delete "-1" term to get true Salz optimum:

$$SNR_{Salz} = 10\log_{10}\left[\exp\left(\frac{1}{W}\int_0^W \log_e\left(1+\frac{S_i(f)}{N_i(f)}\right)df\right)\right]$$

- Target SNR >> 1, so ln(1+S/N) ~ ln(S/N)
  - At 15dB S/N, 1% error is introduced (0.15dB)
  - At 30dB target SNR, ~0.01% error (0.004dB)
- Simplifies metric dramatically:

$$SNR_{Salz} \approx \frac{1}{W}\int_0^W 10\log_{10}\frac{S_i(f)}{N_i(f)}df = \text{Avg}_{0<f<W}[SNR_{dB}(f)]$$

Procedure Clarifications

- Frequency ranges for measurements:
  - For PBO – need received power to calculate PBO
    - Current text ambiguously references line length
    - Power may require IL to 400 MHz for 10GBASE-T PBO
  - For Salz Calculation: all Crosstalk functions and IL to (100, 200 MHz) for (2.5G, 5G)BASE-T
  - What frequency to start at? – transformer blocks DC
    - Recommend 3 MHz
- PBO determinations
  - Determine PBO based on 4 pair average, single, fixed pair, or worst (least IL) pair?

Procedure clarification

- “Step 2” determine minimum PBO for each link segment
  - Must be done for each possible disturber signal type with PBO (2.5G, 5G, 10G)
- “Step 5” (Find desired receive signal PSD) out of place
  - Should be done once per desired link segment, outside of ‘for each disturber type’ loop, e.g., the missing step 3.
- ‘Minimize Salz SNR over disturbers’ Loop becomes steps 4, 6, 7 & 8
  - PBO-adjust and power sum ANEXT+AFEXT crosstalk of current combination of disturbers & cables
  - Add background noise
  - Compute Salz, compare to find minimum

Procedure clarifications

- Search across all disturbers

"For all possible combination of disturber rates, find the PSD of the noise at the desired signal receiver over the bandwidth (W) relevant to the rate by the following:"

  - CAN BE PAINFUL
    - 4 disturber types -> $4^{Number\_of\_disturber\_cables}$
    - 6 around 1: 4 disturber types = 4096 possibilities
      - 8 adjacent patch panel ports = 64K
    - These aren't too bad, BUT, 24 cable bundles = 2.8e14
  - LOOK FOR SIMPLIFICATIONS
    - METHODS TO EXCLUDE PORTS

Things to do, Division of Labor

- Details of repeatable calculations:
  - Number of points
  - Frequency resolution
  - Bandwidths
- These are appropriate for TIA TR42.7 test specs, and may benefit from alignment with existing TIA tester specifications
  - Recommend IEEE provide framework, TIA provide next-level computation detail

THANK YOU!