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
  - Update from presentation to Arch. Ad hoc

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 = -77.91 for 2.5G, -80.65 for 5G, and -80.89 for 10G

1000BASE-T

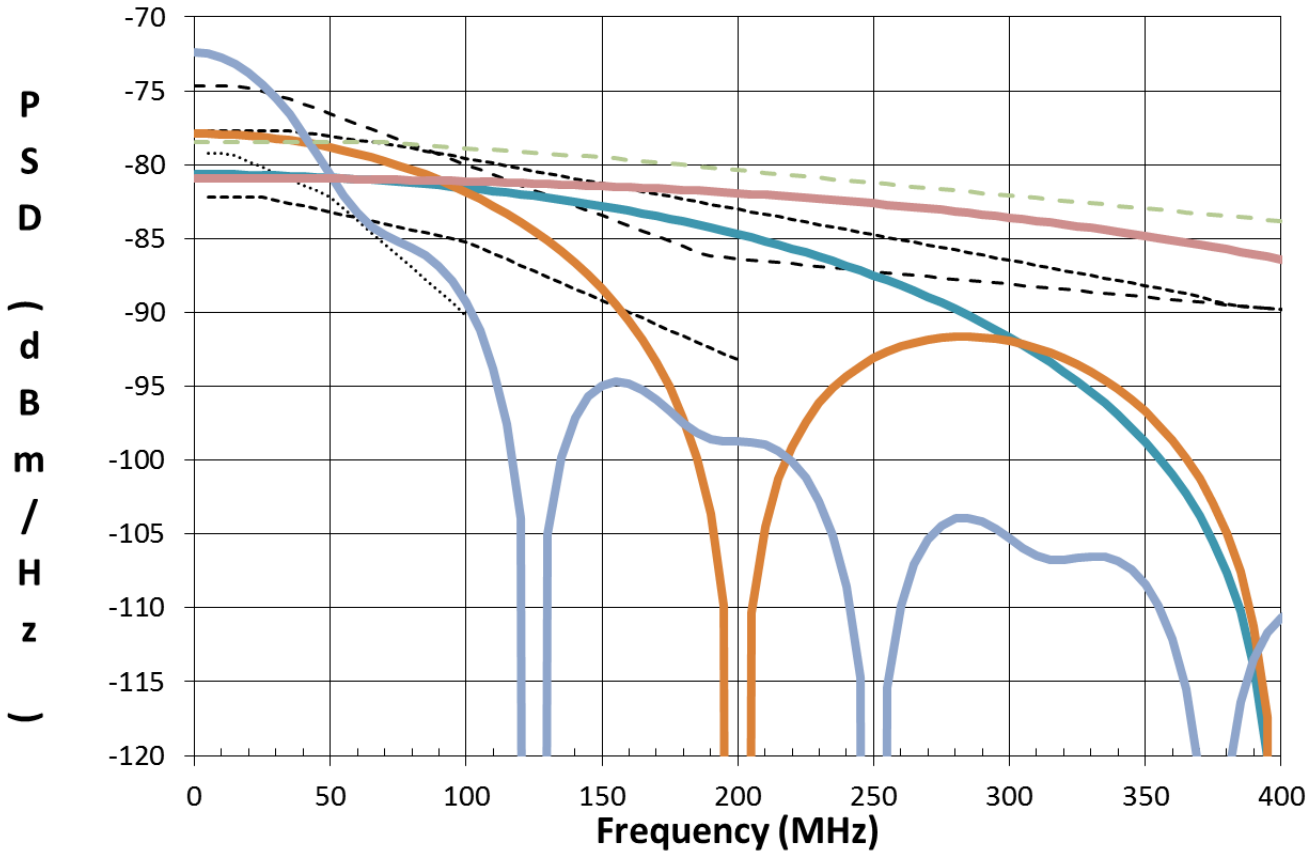
- A bit more difficult, specified as voltage mask w/rise and fall, not as a PSD, and uses pulse shaping filter: $0.75 + 0.25z^{-1}$
- Approximation: (request for comment/revision)
  - 125 MSPS zero-order hold, specified pulse shaping filter, 1st order LPF at 100 MHz, 3.2dBm TX power

$$PSD(f) =$$

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

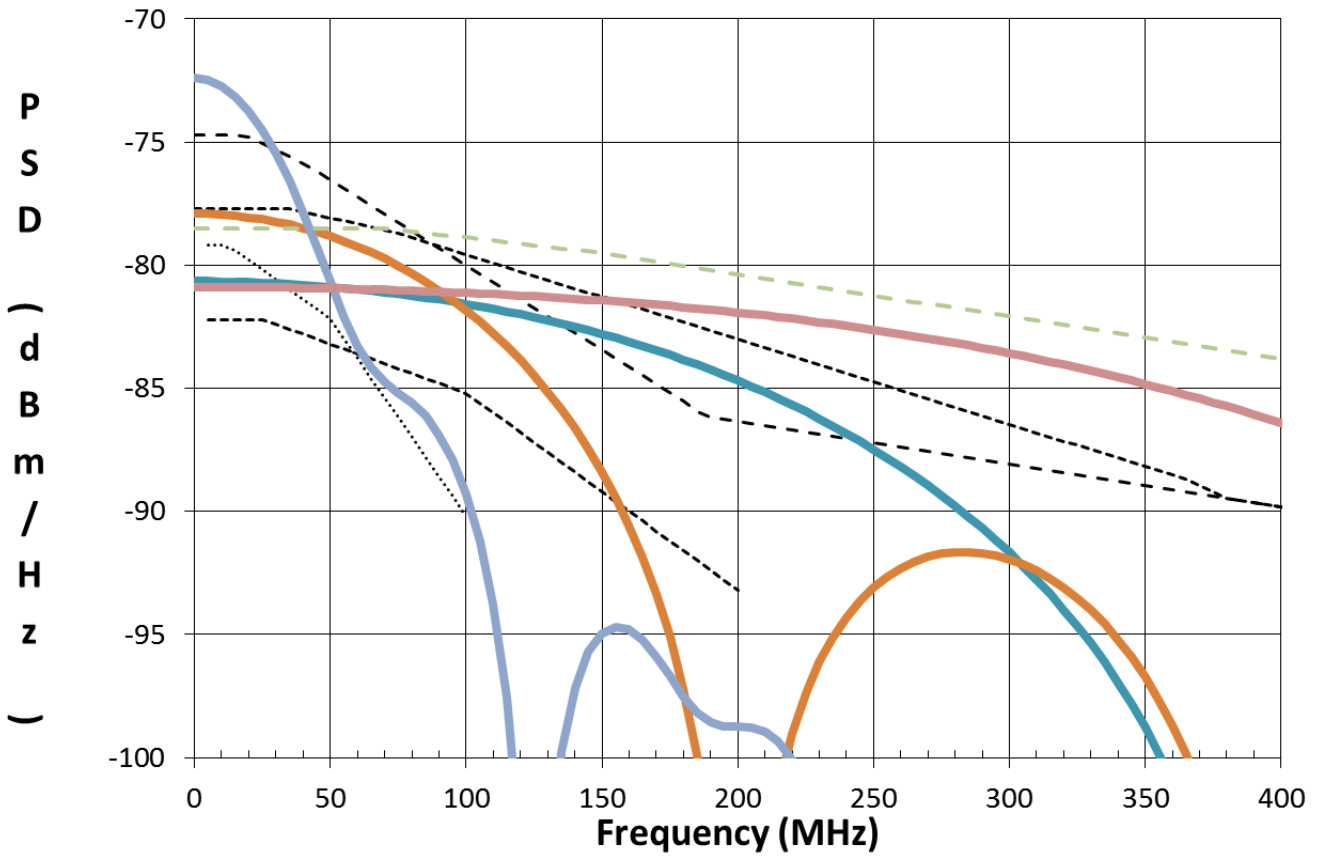
$$+ 10\log_{10}\left[0.625 + 0.375\cos\frac{2\pi f}{125}\right] \text{ dBm/Hz}$$

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?
  - Proposal: Alien-limited SNR > 31 dB

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
    - BUT, minimal impact to final result
    - Recommend 1 MHz for consistency with cabling specs
- PBO determinations
  - PBO must be determined on a per-cable (4 pairs, same PBO) basis
  - Determine PBO based on 4 pair average, single, fixed pair, or worst (least IL) pair?
    - Recommend referencing the specifying PHY clause to determine PBO

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 – introduces optimism which may miss interfering links that matter
- Recommend reference either an annex or cabling specifications, leave informative note that simplifications may be used

Things to do, Division of Labor

- Details of repeatable calculations, e.g., how to do the integration (Number of points, frequency resolution)
- These are appropriate for TIA TR42.7 test specs, and may benefit from alignment with existing TIA tester specifications
  - Recommend IEEE provide framework, TIA and ISO may provide next-level tester detail, including simplifications

THANK YOU!