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Improving SNDR to allow TP1a HH channels passing conditions

Abstract: SNDR in P802.3dj has undergone minor revisions to Psignal in an effort to make it more resilient in high loss channel conditions commonly found at TP1a (HH) loss conditions. While improving SNDR to make it truly "loss independent" is beyond the scope of this contribution, some steps to improve SNDR margin for TP1a are badly needed. This contribution will review some efforts made regarding this goal.

Comments: I-275, I-181

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SNDR

- As was outlined in: DECEMBER 2025 224G PLUGFEST REPORT : Pg 22 indicates TP4 SNDR results are failing SNDR at high rates.
- Testing with large switch configurations suggest table 179-9 (SNDR limits) are very challenging to achieve particularly at Preset-1.
- This presentation will make a couple observations and recommend a D3.0 spec modification.

SNDR is defined by Equation (179–8).

$$SNDR = 10\log_{10}\left(\frac{P_{Signal}}{\sigma_e^2 + \sigma_n^2}\right) \quad (179–8)$$

When *SNDR* is measured at any of the initial condition settings defined in Table 179–8, its value shall be equal to or larger than the minimum value specified in Table 179–9 for that setting.

Table 179–9—SNDR limits

ic_req	*SNDR* (min)	Units
preset 1	33.5	dB
preset 2	27.5	dB
preset 3	30.7	dB
preset 4	30.2	dB
preset 5	28.7	dB
preset 6 / initialize[a]	31	dB

SNDR

Np = 400UI	
Sigma-n	1.86 mV
Sigma-e	1.9102 mV
Psignal	119.98 mV
SNDR	33.05 dB

Np = 500UI	
Sigma-n	1.86 mV
Sigma-e	1.79378 mV
Psignal	119.837 mV
SNDR	33.317 dB

Np = 600UI	
Sigma-n	1.86 mV
Sigma-e	1.79035 mV
Psignal	119.837 mV
SNDR	33.325 dB

Np = 700UI	
Sigma-n	1.86 mV
Sigma-e	1.69885 mV
Psignal	119.839 mV
SNDR	33.54 dB

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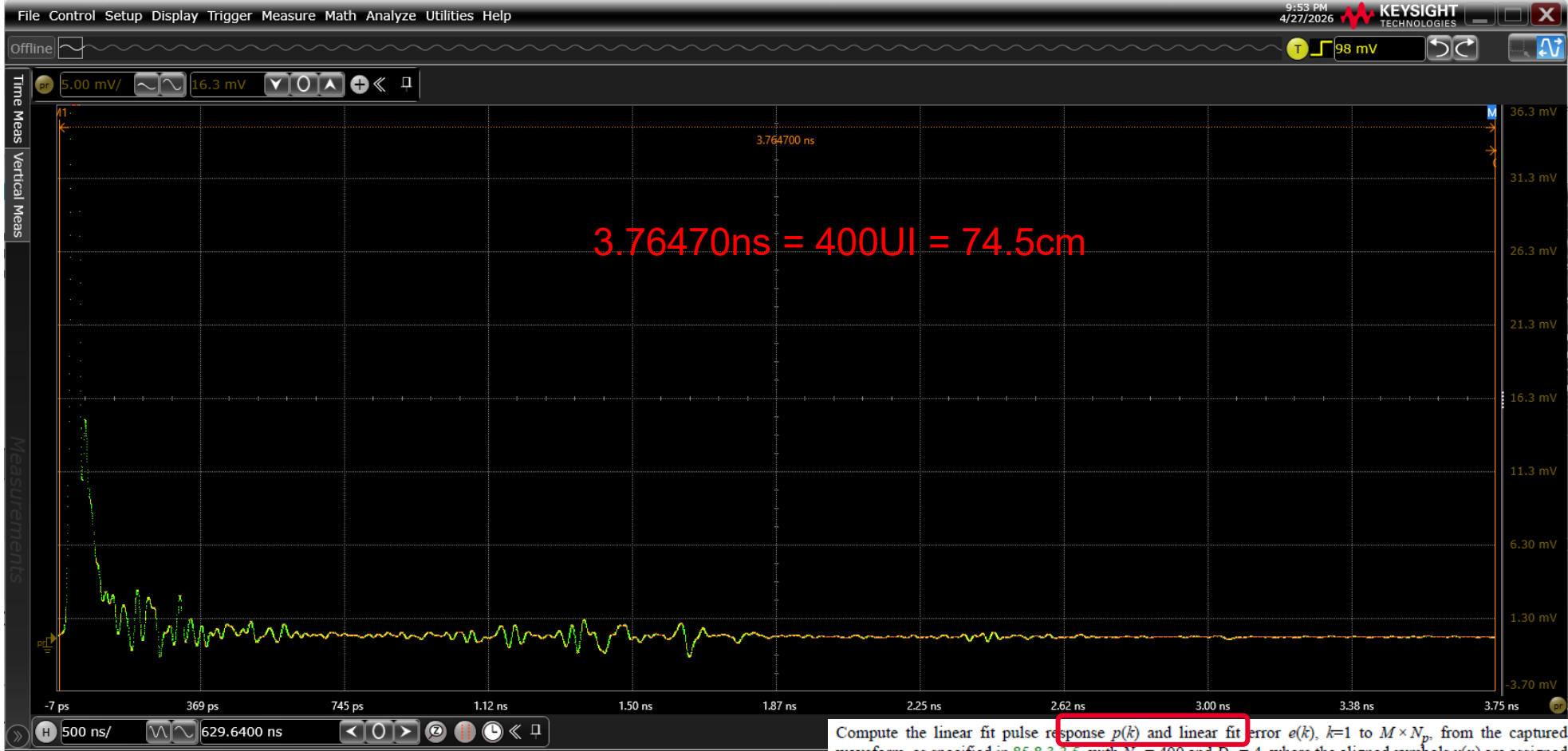
SNDR

- Current Np limits the pulse response to 400UI per clause 179.9.4.2.1 Linear fit to the measured waveform



Compute the linear fit pulse response $p(k)$ and linear fit error $e(k)$, k=1 to $M \times N_p$, from the captured waveform, as specified in 85.8.3.3.5, with $N_p = 400$ and $D_p = 4$, where the aligned symbols $x(n)$ are assigned normalized amplitudes −1, $-ES$, ES, and 1 to represent the PAM4 symbol values 0, 1, 2, and 3 respectively. ES is defined as $(|ES1| + |ES2|)/2$ where $ES1$ and $ES2$ are calculated according to 120D.3.1.2.

Define $r(k)$ to be the linear fit pulse response $p(k)$ when the transmit equalizer coefficients have been set to the "preset 1" values.

NOTE—$r(k)$ is required for calculation of the normalized transmit equalizer coefficients from a measurement. The same $r(k)$ is used in this calculation for any configuration of the transmit equalizer, but it needs to be calculated from a separate measurement.

For each value of m in the range $-M/2$ to $M/2 - 1$ when M is even and $-(M-1)/2$ to $(M-1)/2$ when M is odd:

a) Define an $M \times N_p$-by-5 matrix R_m. The elements of R_m are assigned values per Equation (179–1) where $i = -3$ to 1 and $j = 1$ to $M \times N_p$.

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- Extending Np limits to 700UI (PCIe uses 600UI for this reason) improves the Sigma-e result by ~.5dB by picking up deep field pulse aberrations caused by reflections.

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SNDR – Relax limits (Particularly at TP1a)

Supporting proposed adjustments to SNDR outlined in "TX SNDR and Rpeak limits for CR and C2M: Alexander Rysin and Piers Dawe, NVIDIA"

SNDR has not achieved true channel loss resilience. The Psignal method improves matters, but it is still impacted by high loss (HH) profiles and particularly reflections.

- Adjust the SNDR limits based on the lab data:

Preset	Current limit [dB]	Proposed limit [dB]
1	33.5	32
2	27.5	28
3	30.7	29.5
4	30.2	27
5	28.7	25.7
6 (initialize)	31	30

- Alternatively, define SNDR limits per host class, with values derived from lab data and reflecting measured dependence on loss and signal swing.

SNDR Conclusion

- SNDR for TP1a high loss channel switch configurations (HH) has little to no margin in most cases and are under margin in many high loss situations.
- The simplest fix is to modify Np allowance (pg 425) to 700UI's (up from 400) to permit better tracking of round trip reflections off of the MTF assemblies keeping Sigma-e as clean as possible.

Np = 700

Compute the linear fit pulse response $p(k)$ and linear fit error $e(k)$, k=1 to $M \times N_p$, from the captured waveform, as specified in 85.8.3.3.5, with N_p ~~= 400~~ and $D_p = 4$, where the aligned symbols $x(n)$ are assigned normalized amplitudes −1, $-ES$, ES, and 1 to represent the PAM4 symbol values 0, 1, 2, and 3 respectively. ES is defined as $(|ES1| + |ES2|)/2$ where $ES1$ and $ES2$ are calculated according to 120D.3.1.2.

38
39
40
41
42

- High Sigma-e is correlated to high EOJ. The PCIe SNDRTX method does a good job of mitigating this sensitivity on an even test pattern, and has not been determined useful (yet) on a PRBS13Q pattern. <updated: No observable effect on an odd length pattern>
- No effort is taken to improving Sigma-n as this is considered to be at the limit of present measurement technology, and will improve soon with higher ENOB instrumentation.
- Reconciling relaxed SNDR values –vs- COM could be justified in that COM does not see the same reflections that physical test systems are observing, and these impacts on Sigma-e

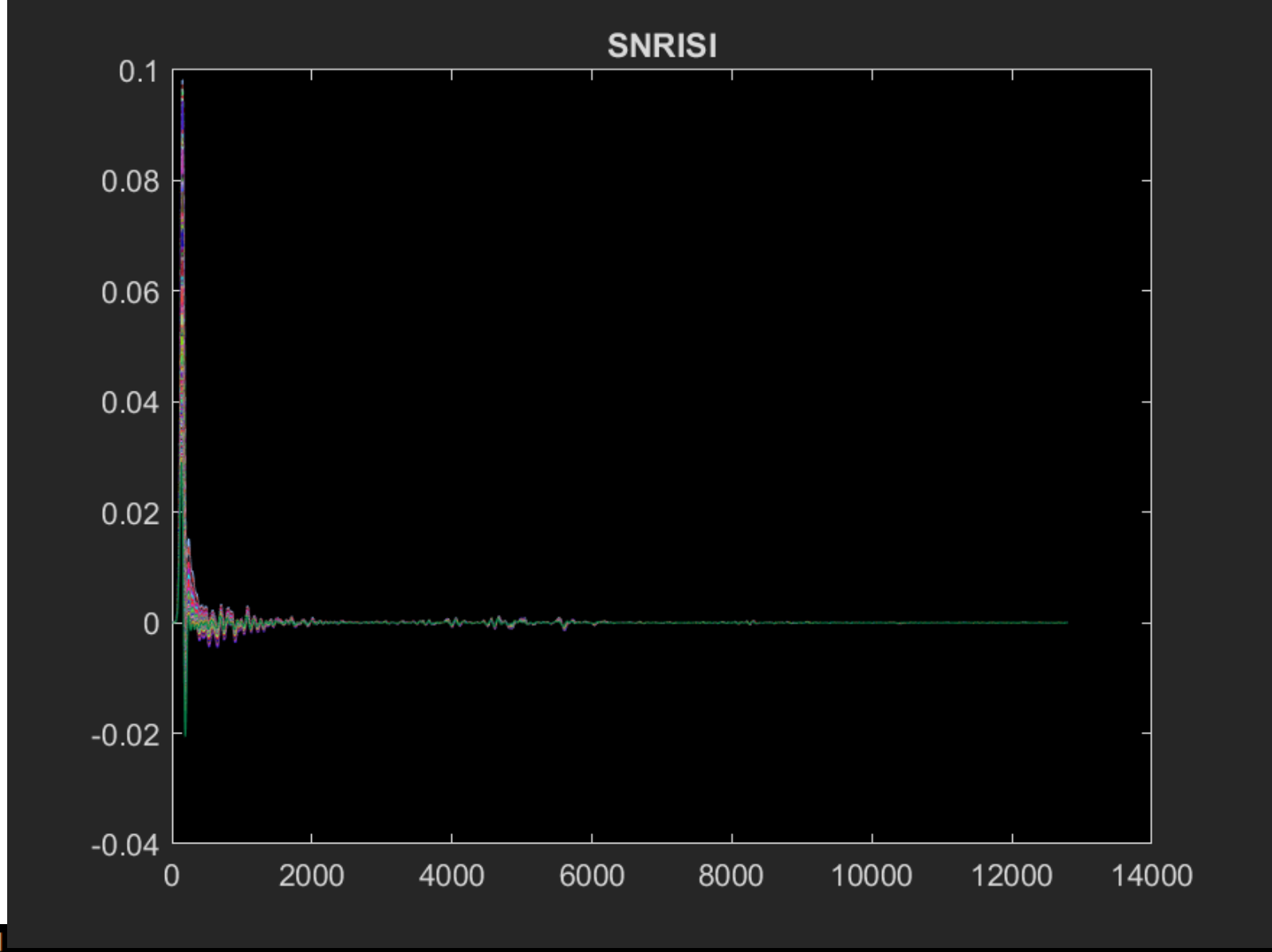
SNDR: Remedial Steps

1. Permit wider Np (400) windowing to 700UI's to accommodate MTF and Transmission path reflections. (note this offered ~.5dB of improvement)
2. Relax the limits on table 179-9 (SNDR limits) to offer high loss channel configurations some room to pass the 33.5dB spec. (reduce limit to 32dB, and correspondingly lower the other preset limits as well)

Backup

SNRISI

- Regardless of the outcome of SNDR, this channel still comes up short on the SNRISI evaluation with a 23.56dB result. TP1a requires no less than 26dB of SNRISI and it should be noted this operations leverages Np as well. Increasing Np (if we continue to share Np between SNDR and SNRISI) will make SNRISI worse.



Signal-to-Residual-Intersymbol-Interference Ratio, SNRISI

Test Summary: FAIL Test Description: Measures the SNRISI

Pass Limits: >= 26.00 dB | Signal-to-Residual-Intersymbol-Interference Ratio, SNRISI - IEEE802.3dj TP1a | 23.56 dB