

Transmitter Overshoot Penalty

Ali Ghiasi - Ghiasi Quantum/Marvell

**IEEE 802.3dj Plenary Meeting
Vancouver**

March 9, 2025

Background

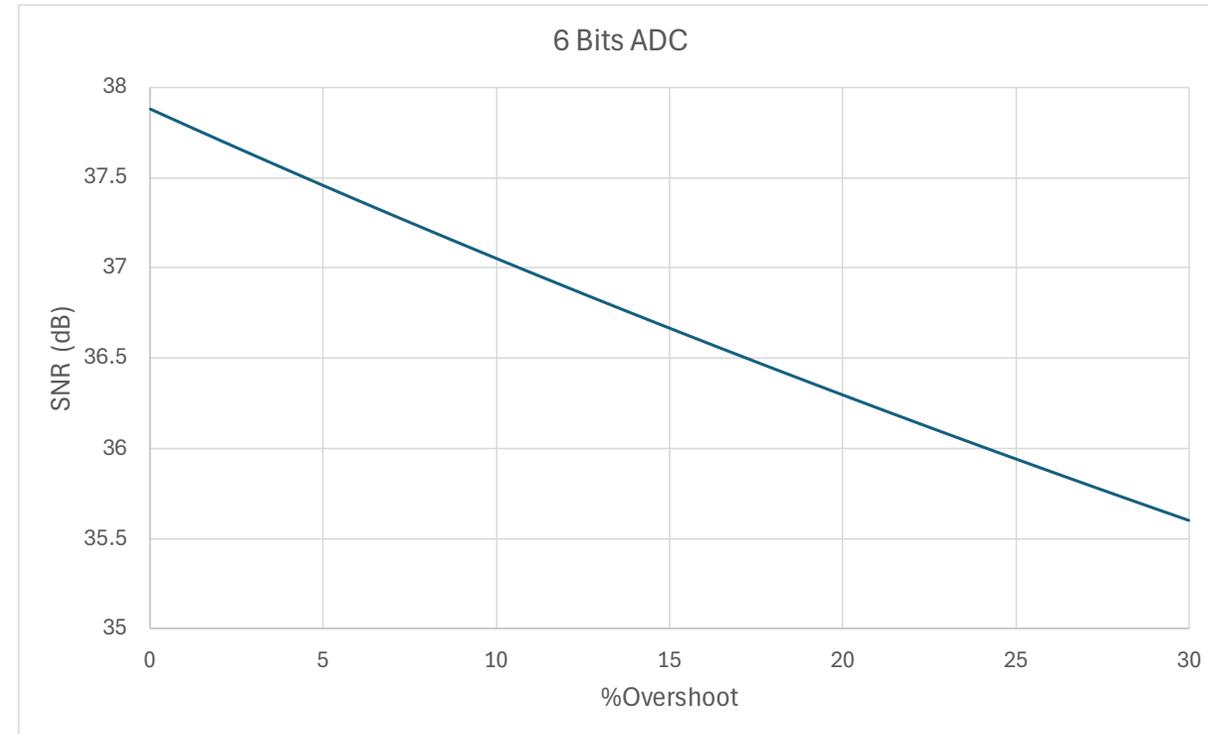
- The 802.3dj TF has been investigating how to improve optical transmitter test coverage, see [ghiasi_3dj_03c_2507](#)
 - Task force since then has supplemented TDECQ test with following enhancements
 - Added tap limit to mitigate reported block errors issue
 - Added DFE to reduce reliance on overshoot where transmitter with less overshoot and higher TDECQ may have better BER
 - With addition of DFE to TDECQ a typical 4.7 dB FFE TDECQ transmitter has ~3.4 dB TDECQ with DFE enabled, see [ghiasi_3dj_01a_2509](#)
 - TDECQ having DFE there is less of a need using overshoot to reduce TDECQ
 - However, underlying problem still exist if one uses the allowed max overshoot of 22% and may result in PAR (Peak to Average Ratio) and ADC clipping without TDECQ accounting for this penalty
 - Functional Receiver FRx may not identify PAR related in few seconds test and there is dependability on the FRx DSP
 - Issues with excessive overshoot were studied by [rodes_3cu_adhoc_030520_v2](#) and [ghiasi_802.3db_01_092321](#).

ADC SNR Definition and PAR Penalty

□ ADC SNR is defined as following in textbooks

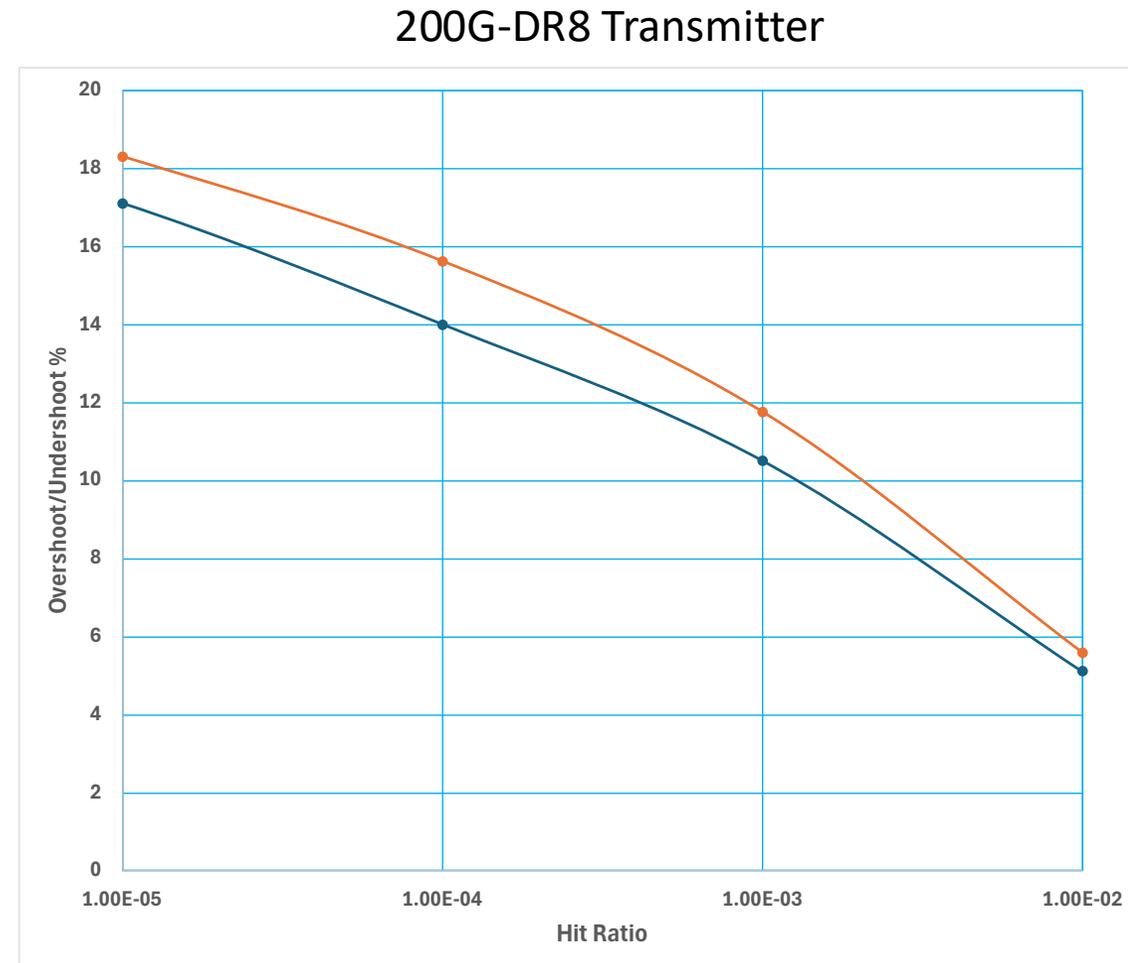
wirelesspi.com

- $SNR = 6.02N + 1.76 - 20\log_{10}\frac{V_{max}}{A}$, where N is number of ADC bits, V_{max} upper range of ADC, and A is the amplitude.
 - A 6 bits ADC with zero overshoot has an SNR of 37.88 dB
 - A 6 bits ADC with 22% overshoot has an SNR of 36.15 dB or 1.7 dB of PAR (Peak to Average Ratio) penalty
- Reducing overshoot to 12% reduces PAR penalty to 1 dB which is a good trade-off for a TDECQ with 1T DFE.



Over/under-shoot Definition

- **Over/under-shoot is defined at 10^{-2} hit ratio and maximum limit of 22%**
 - PAR penalty and ADC clipping may manifest itself at the extreme of scramblers and can be infrequently
 - Even for SSPRQ moderate size pattern (65,535 bits) overshoot triples from ~5% at hit ratio of 10^{-2} to ~15% at hit ratio of 10^{-4}
 - A typical transmitter with 15%, 20%, or 22% overshoot at 10^{-2} hit where the overshoot is >50% at 10^{-4} hit is problematic



TDECQ as Function of Overshoot

□ MZM transmitter TDECQ as function of overshoot/undershoot

- With TDECQ not capturing PAR penalty as illustrated below TDECQ can be reduced to 1.74 dB where the pre-FEC BER is ~2 orders of magnitude worse
 - CER TDECQ seems to somewhat capture overshoot penalty – still under investigation
- Functional Receiver FRx is not sensitive enough with everyone of over/undershoot setting below passing
- Waterfall test can be used to determine best pre/post FEC operating point but is time consuming
- A TDECQ metric that is more closely correlatable to BER is the best option given TDECQ is a 1-2 seconds test!

Over/Undershoot	OMA (dBm)	CEQ (dB)	TDECQ_FFE (dB)	TDECQ_DFE (dB)	OMA-TDECQ (dBm)	CER TDECQ_DFE (dB)	Pre-FEC BER
3.87/4.29	1.79	1.51	3.06	2.59	-0.65	3.65	1.95E-12
4.73/5.20	1.48	1.23	2.84	2.44	-0.93	3.8	1.19E-11
5.82/5.86	1.19	1.0	2.66	2.4	-0.99	3.21	1.34E-11
5.59/7.58	1.03	0.88	2.47	2.19	-1.12	2.62	4.74E-11
7.14/8.94	0.6	0.41	2.31	2.16	-1.29	3.08	4.15E-11
10.2/12.2%	0.09	0.19	2.02	1.74	-1.6	3.09	8.78E-10

Summary

- ❑ **As part of effort to improve interoperability and reducing link flaps better management of overshoot/undershoot is needed**
 - Before adoption of 1T DFE (July-2025) higher overshoot may have been necessary to meet TDECQ
 - TDECQ with DFE provides 1.5-2 dB TDECQ reduction for a slow transmitter and keeping the same 22% overshoot only allows sloppy transmitters
 - The worst part is that a 22% overshoot at 10^{-2} hit may actually have >50% overshoot at higher hit ratio
- ❑ **Given TDECQ decreases with increasing overshoot as the BER degrades may result in transmitter optimization where link BER is 2-3 order of magnitude worse and FRx is passing**
 - Excess overshoot may cause ADC clipping even-though such events are infrequent, but when it happens likely will result in link flap
- ❑ **Several option to consider:**
 - A 10^{-2} hit ratio given rich data pattern has no merits and should be changed to 10^{-4} hit ratio
 - Next either reduce 22% overshoot to something like 15-15% or alternatively incorporate PAR penalty into TDECQ assuming ADC ENOB=6 bits (same ENOB is assumed in COM).

Thank You!