Transmitter Overshoot Penalty

(Comments 108, 109, 110, and 111)

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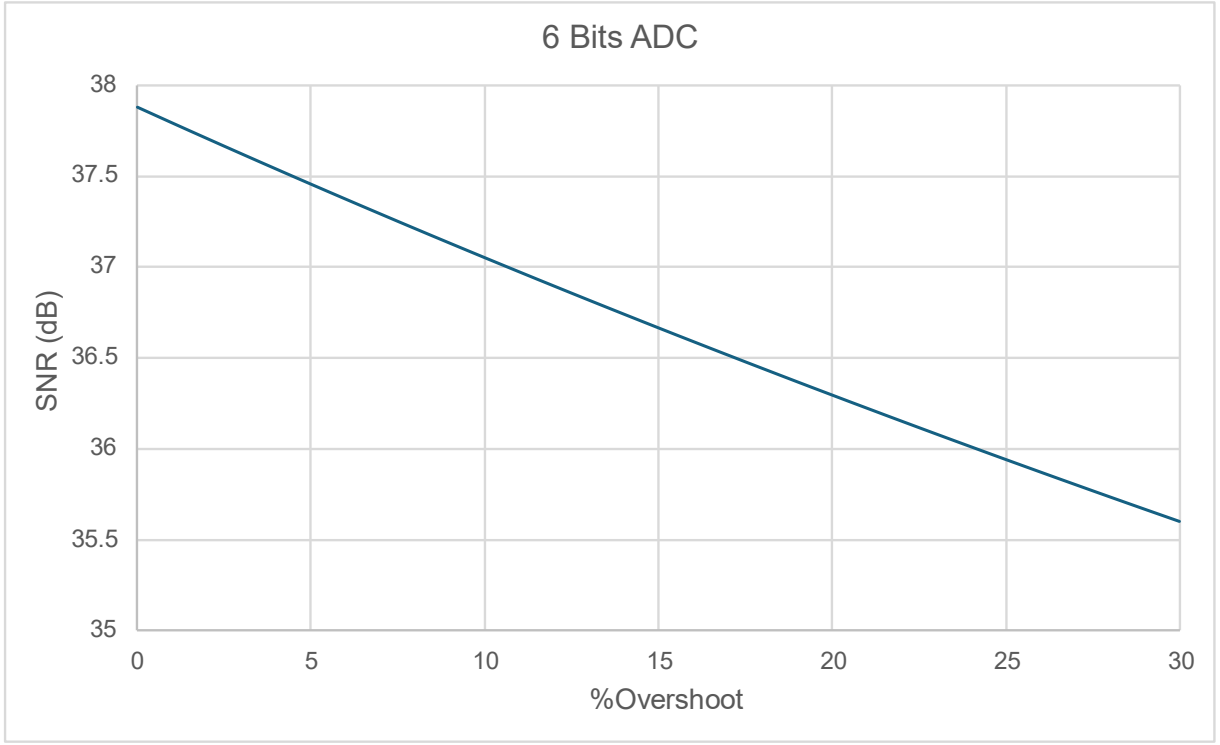
Background

- **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, underlaying 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.

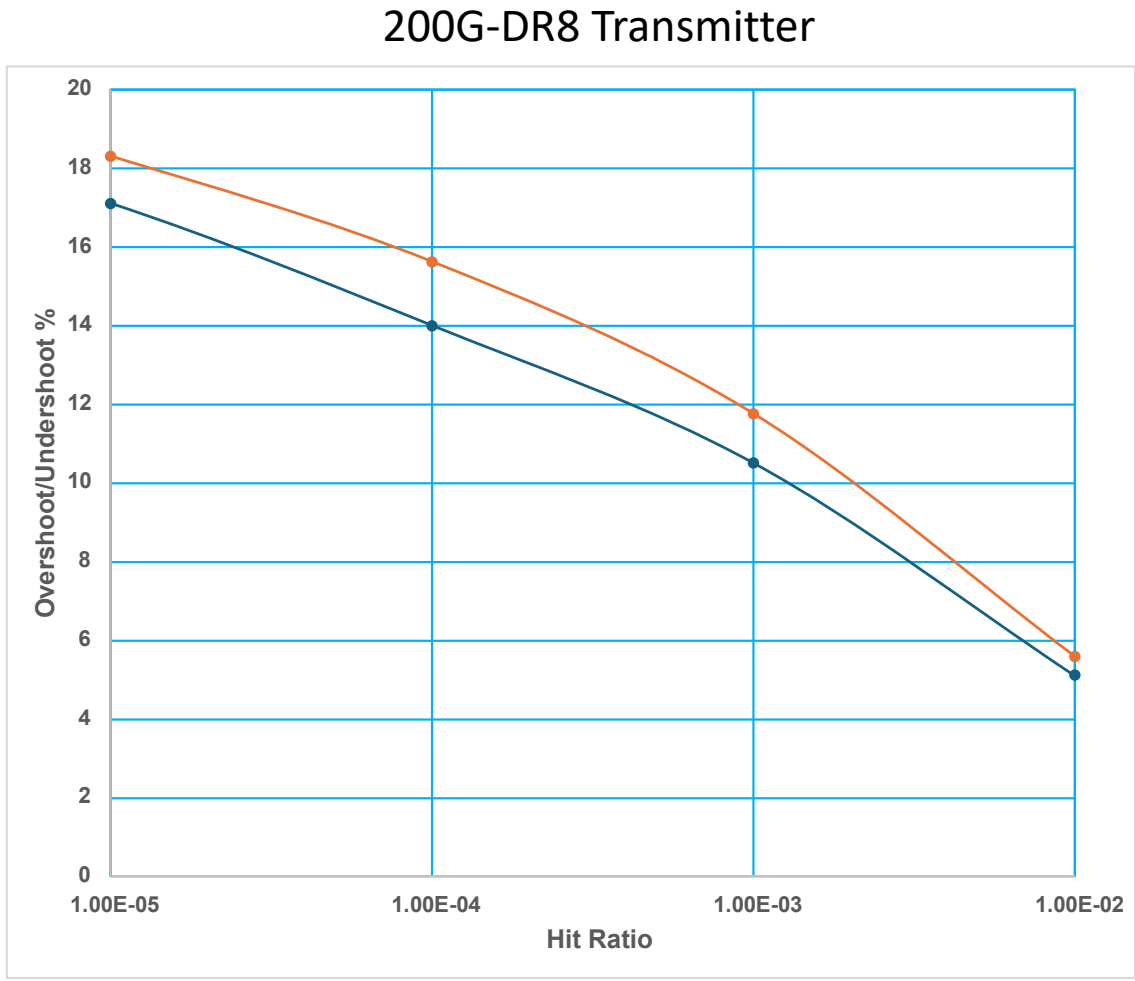
ADC SNR Definition and PAR Penalty

- **ADC SNR is defined as following in textbooks wirelesspi.com**
  - $SNR = 6.02N + 1.76 - 20log_{10}\frac{Vmax}{A}$, where N is number of ADC bits, Vmax 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 ratio can be 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 corelatable 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**
  - Comment 261, 262, 263, and 264 recommends reducing overshoot from 22% to 12%
    - The overall benefit of enabling DFE is much greater than reducing the overshoot from 22% to 12%
    - Generally, 10% overshoot is sufficient for DR/FR optics but one supplier has suggested overshoot of ~16% is for LR4 links based on EMLs
- **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
  - Longer term one option is to incorporate PAR penalty into TDECQ assuming assuming an ADC ENOB of 6 bits.

Thank You!