

# Transmitter Overshoot Penalty (comments I-248, I-249, I-250, I-251)

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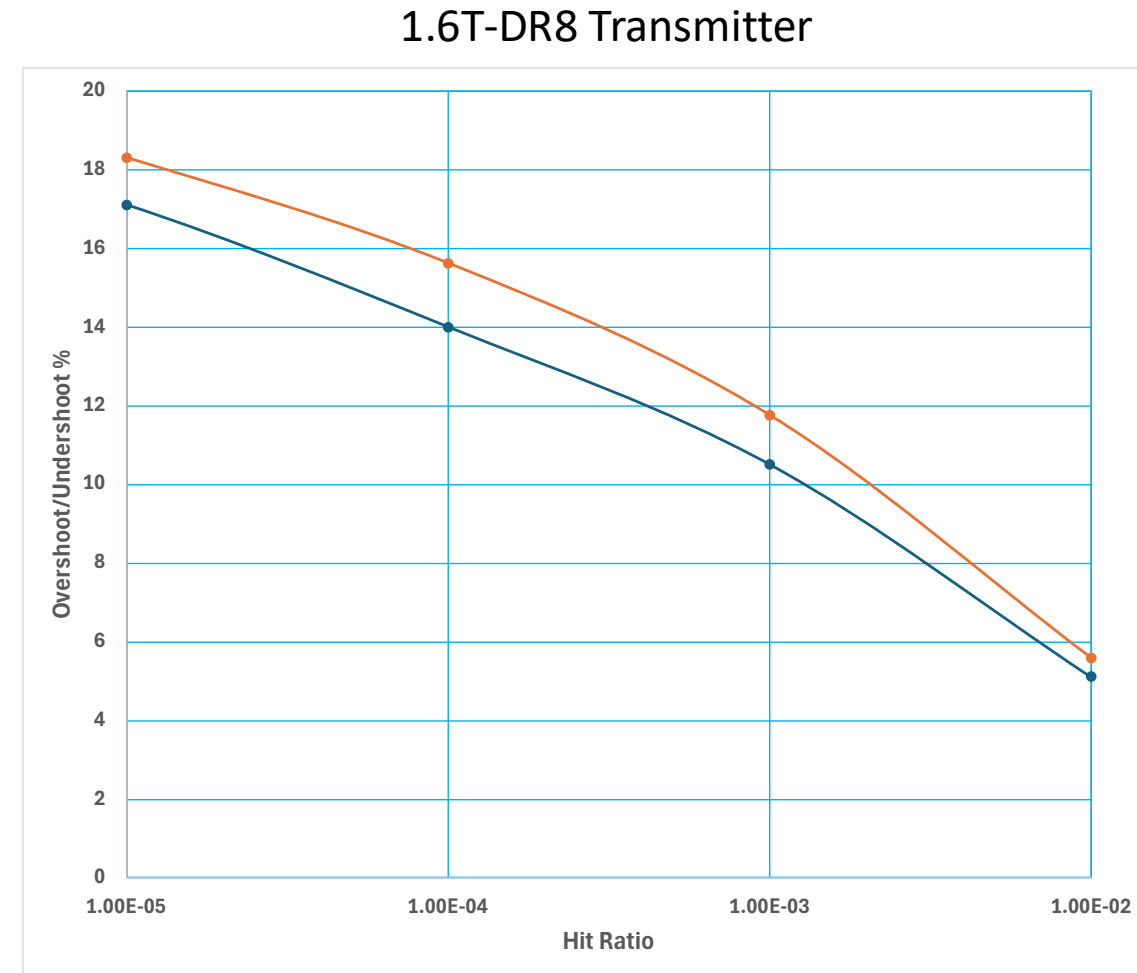
# Background

- 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 but higher TDECQ often had 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 receiver incorporating DFE doesn't need to rely on excessive overshoot which often degrades the BER
    - However, underlying problem is that TDECQ ignores PAR (Peak to Average Ratio), see the back up slide
    - Max overshoot of 22% at hit ratio of  $1 \times 10^{-2}$  has no technical justification given the rich scrambled Ethernet data – 802.3dj electrical signals are evaluated at a hit ratio of  $1 \times 10^{-7}$
  - Issues with excessive overshoot were studied by [rodes\\_3cu\\_adhoc\\_030520\\_v2](#) and [ghiasi\\_802.3db\\_01\\_092321](#).

# Over/under-shoot Definition

## □ Over/under-shoot is defined at 22% for a hit ratio of $1 \times 10^{-2}$

- For this 1.6T-DR8 transmitter operating with SSPRQ (65,535 bits ) overshoot increased by  $\sim 2.5x$  going from a hit ratio of  $1 \times 10^{-2}$  to  $1 \times 10^{-4}$ 
  - There is no technical merits in the hit ratio of  $1 \times 10^{-2}$  for comparisons 802.3dj electrical clauses use a more robust hit ratio of  $1 \times 10^{-7}$
  - OIF 224G-RTL is using hit ratio of  $1 \times 10^{-4}$



# What is a Reasonable Hit Ratio

- ❑ **In C2M Annex 176D.8.2 peak-to-peak output voltage test method is defined as:**
  - A maximum output voltage is defined as the value  $V_{max}$  such that the probability that  $V_{out} > V_{max}$  is  $P/2$ . A minimum output voltage is defined as the value  $V_{min}$  such that the probability that  $V_{out} < V_{min}$  is  $P/2$ . A peak-to-peak output voltage is defined as  $V_{max} - V_{min}$ .
  - Differential peak-to-peak output voltage is defined with  $P=10^{-7}$  for the differential output signal. For compliance testing, it is sufficient to measure it from a square wave output with a period of at least 128 UI, while lanes not under test transmit PRBS31Q
- ❑ **There is no logical explanation to test optical transmitters overshoot at a hit ratio of  $P=10^{-2}$  given the rich Ethernet data patterns**
  - The optical signal with 22% overshoot at hit ratio  $P=10^{-2}$  gets converted linearly by the TIA to an electrical signal that gets received by the DSP or send to the host DSP in case of RTL or Linear implementations
  - The current hit ratio in Annex 176D is more robust at  $P=10^{-7}$  not to overstress the receive DSP.

# The Penalty of Tolerating Signal with High Overshoot

- ❑ **Excess overshoot is evident in the 224G-RTL R TP4 specification peak to average signal levels as result of excess overshoot from optical transmitters**
  - The same issue also exist in case of retimer module with an internal DSP
  - The peak-peak differential signal are limited to avoid clipping and/or high distortion
  - The low VMA is by-product of excessive overshoot which reduces SNR and channel that can be supported in case of RTL R/Linear applications.

Parameter for 224G-RTL R	Min.	Max.	Unit
Differential output voltage, pk-pk			mV
Short mode	-	500	
Long mode	-	720	
VMA			mV
Short mode	200	-	
Long mode	350	-	

# Summary

- ❑ **For improved interoperability and to minimize link flap better control of overshoot and undershoot is necessary**
  - Unfortunately, even with the latest TDECQ method increasing overshoot typically reduces the TDECQ while degrading the BER, since TDECQ does not incorporate Peak-to-Average Ratio penalties
  - The current TDECQ equalizer with DFE has reduced the need for overshoot
  - TDECQ equalizer with DFE has reduced TDECQ by 1.5–2 dB for slower transmitters so there is less need to use overshoot which can cause more issues
- ❑ **We can all agree that 22% overshoot at a hit ratio of  $1 \times 10^{-2}$  that can result in ~50% overshoot at hit ratio of  $1 \times 10^{-4}$  can be catastrophic – for comparisons DJ electrical clause use a hit ratio of  $1 \times 10^{-7}$** 
  - Recommend TF to define the 22% overshoot/undershoot for optical transmitters based on a hit ratio of of  $1 \times 10^{-4}$ .

# Backup

# TDECQ Doesn't Incorporate PAR Penalty

□ ADC SNR is defined as following in textbooks

[wirelesspi.com](http://wirelesspi.com)

- $SNR = 6.02N + 1.76 - 20\log_{10}\frac{V_{max}}{A}$ , 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 at hit ratio of  $1E^{-2}$  result in over 50% overshoot at hit ratio of  $1E^{-2}$  with ~3.5 dB of SNR penalty not captured currently by TDECQ due to PAR (Peak to Average Ratio) penalty.

