

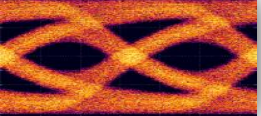
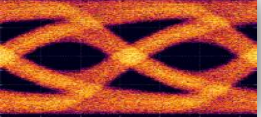
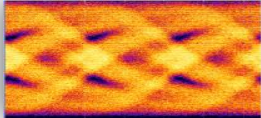
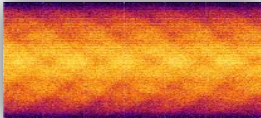
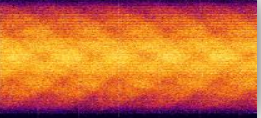
PCIe Signal Integrity Challenges and Remedies

TI Precision Labs – PCIe

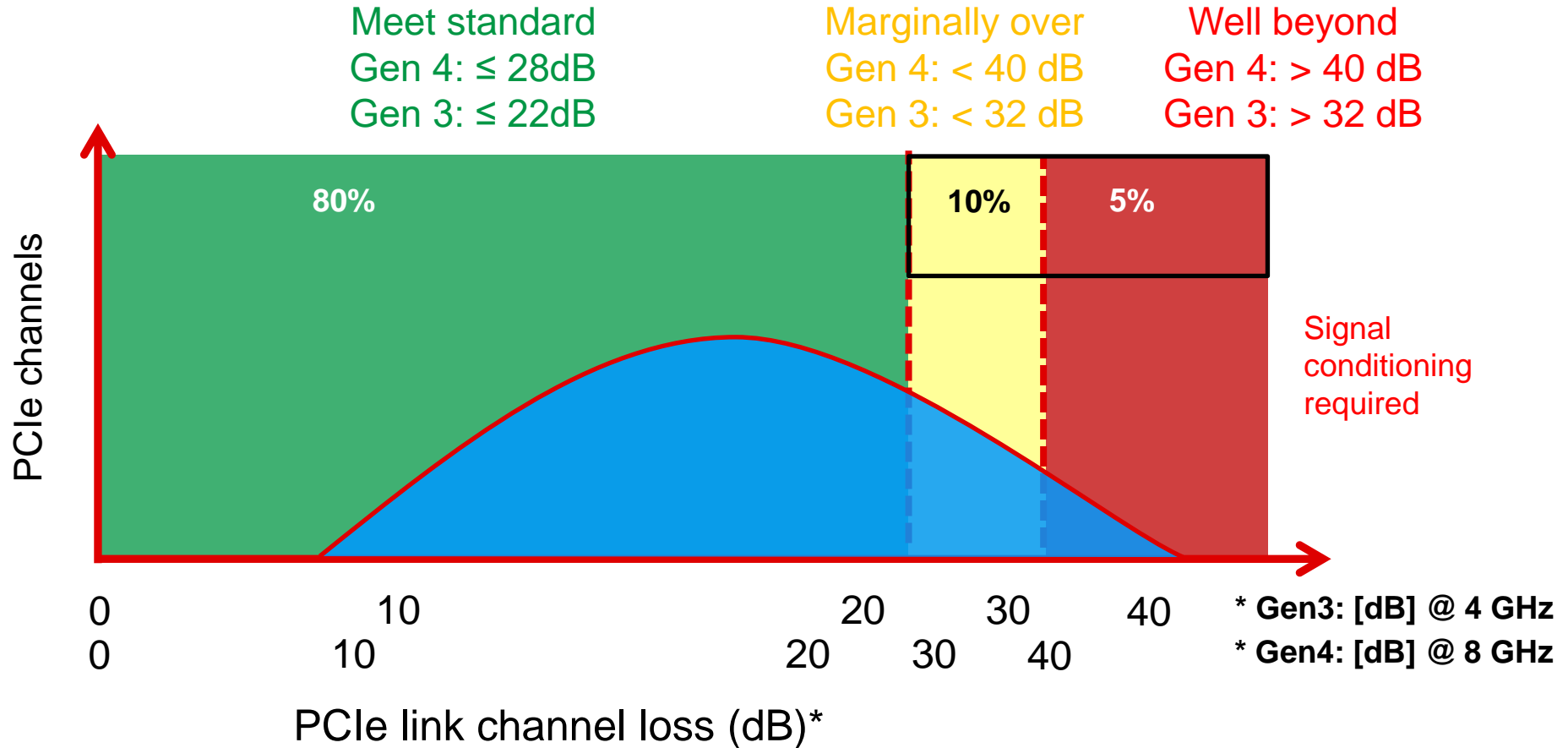
Prepared by Lee Sledjeski

Presented by Nicholas Malone

Five generations of PCI Express

PCIe	Bandwidth	Line rate	Coding	UI	Media	Stressed eye	Eye pattern
Gen 1.0 (2003)	250 MB/s	2.5 Gbps	8b/10b	400 ps	FR-4	Open – N/A	
Gen 2.0 (2005)	500 MB/s	5 Gbps	8b/10b	200 ps	FR-4	Open – N/A	
Gen 3.0 (2010)	1 GB/s	8 Gbps	128b/130b	125 ps	FR-4	HEO: ≤ 0.30 UI VEO: ≤ 25 mV	
Gen 4.0 (2017)	2 GB/s	16 Gbps	128b/130b	62.5 ps	Low-loss PCB	HEO: ≤ 0.30 UI VEO: ≤ 15 mV	
Gen 5.0 (2019)	4 GB/s	32 Gbps	128b/130b	31.25 ps	Ultra-low-loss PCB	HEO: ≤ 0.30 UI VEO: ≤ 15 mV	

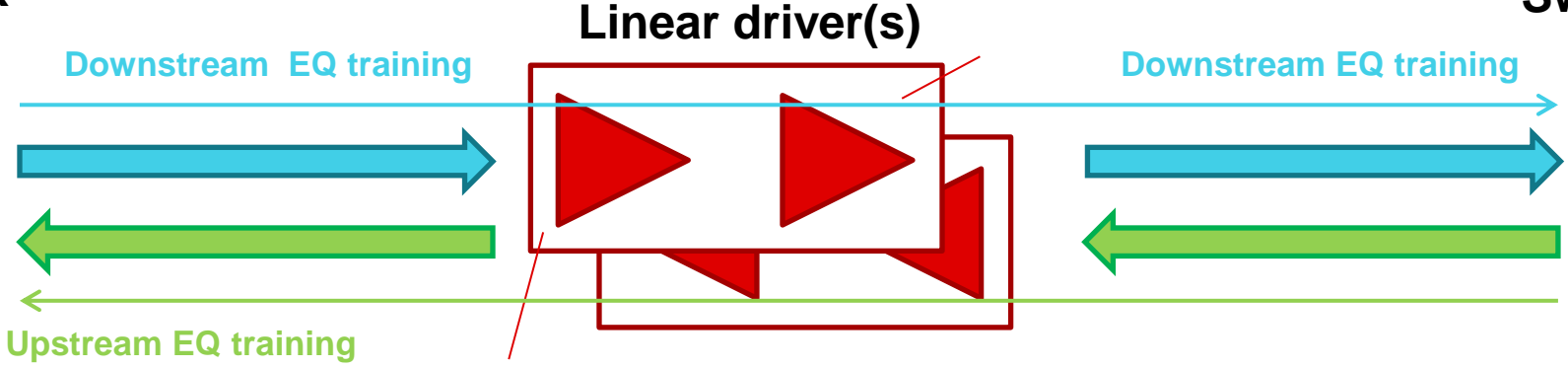
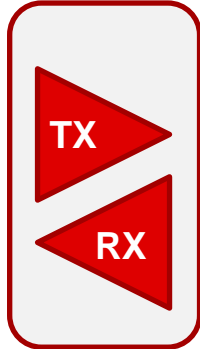
PCIe Gen3/4 insertion loss landscape model



Many channels can be serviced by a simple linear equalizer

Signal conditioners to remedy impairments

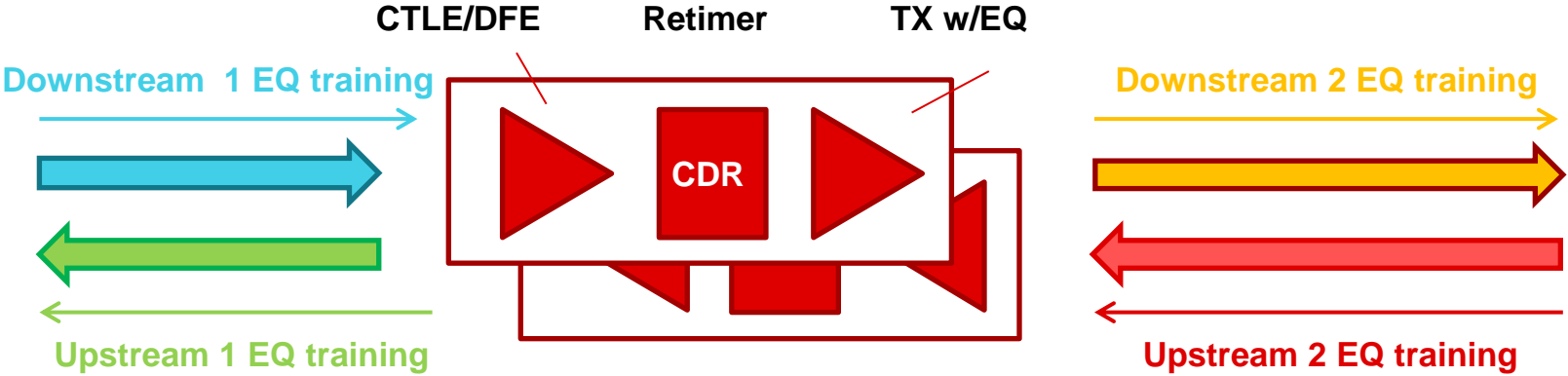
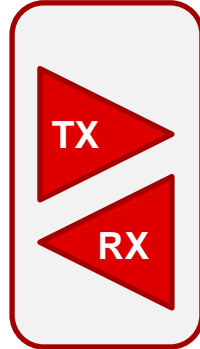
Root complex



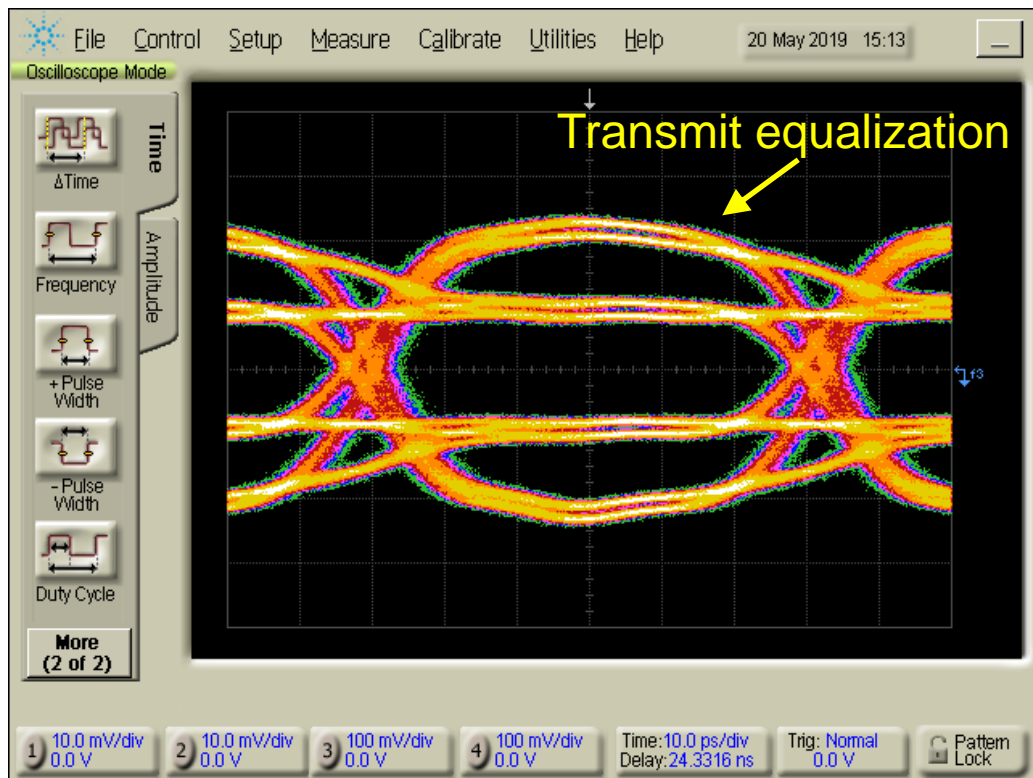
Switch /endpoint



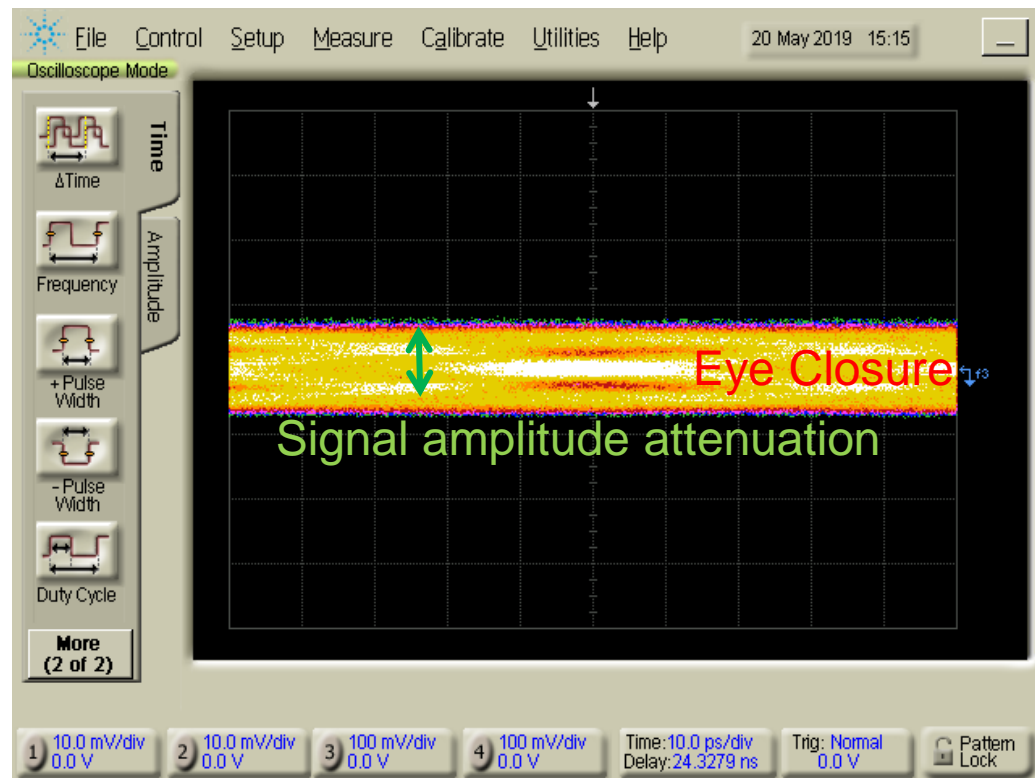
CTLE (Continuous time linear equalization)



PCIe Gen4 without in-channel linear equalization



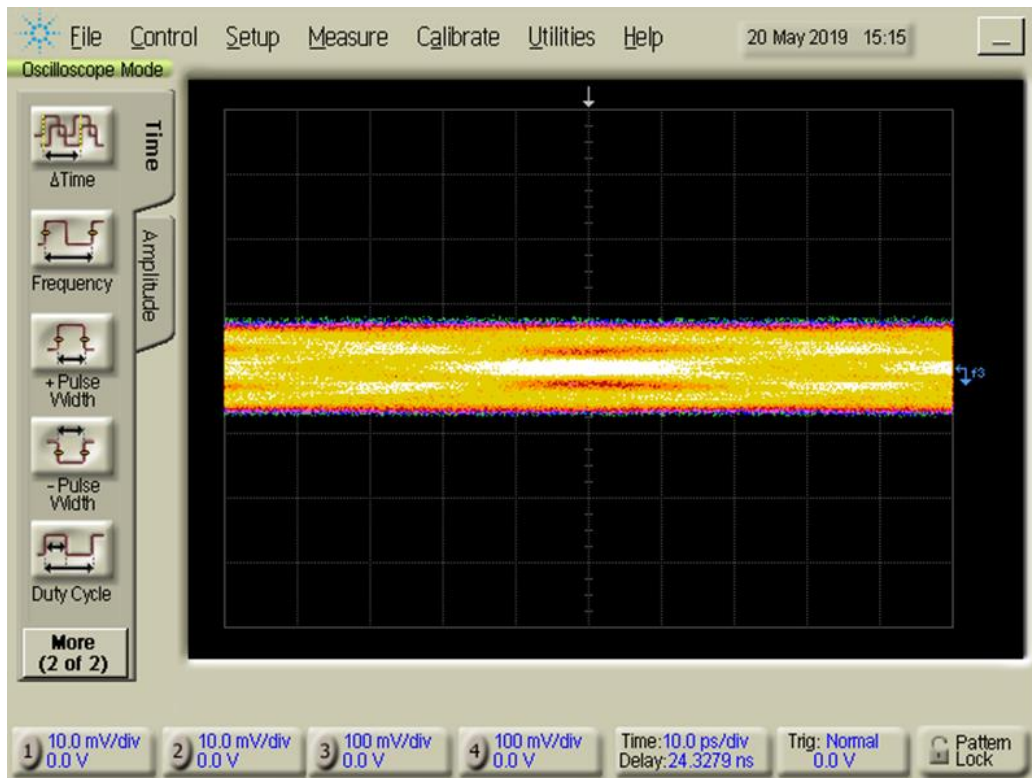
At signal source (< 1-dB loss)



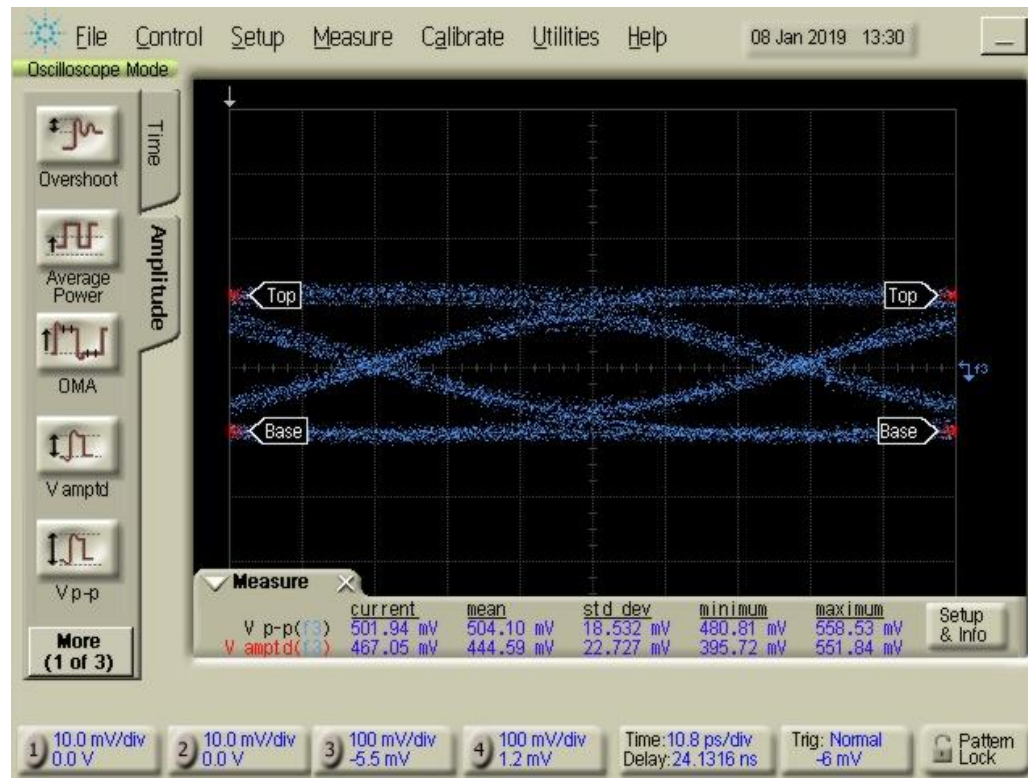
After -24-dB channel

PCIe Gen4 with in-channel linear equalization

The redriver restores horizontal and vertical eye opening



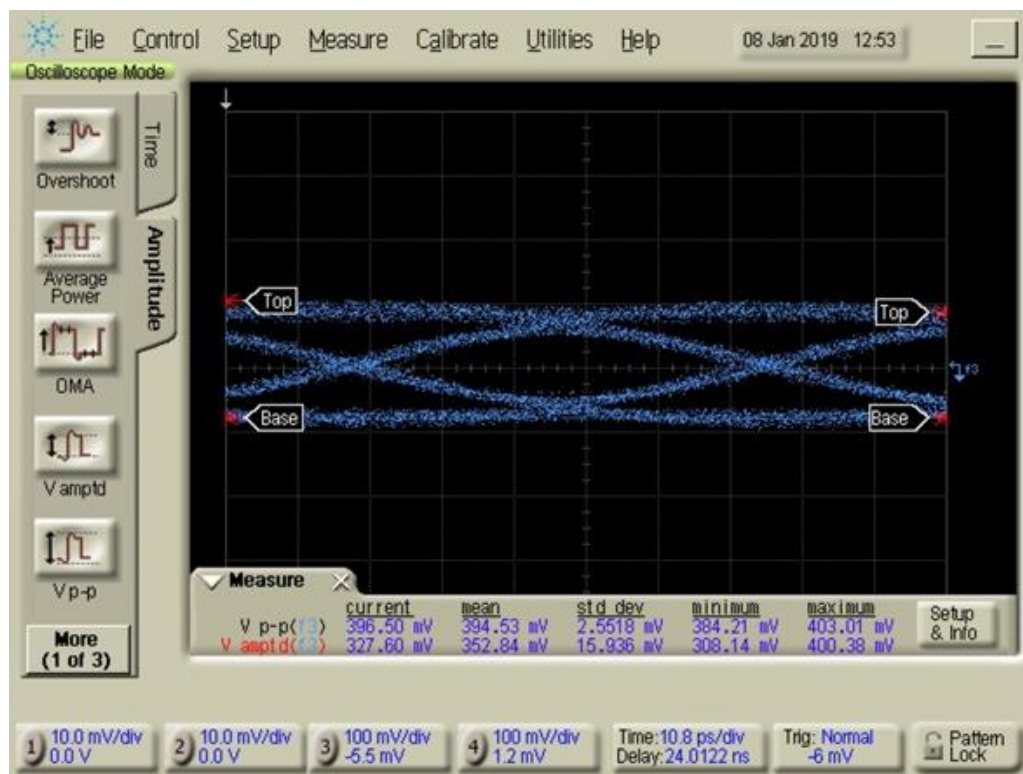
After -240-dB channel with no redriver CTLE



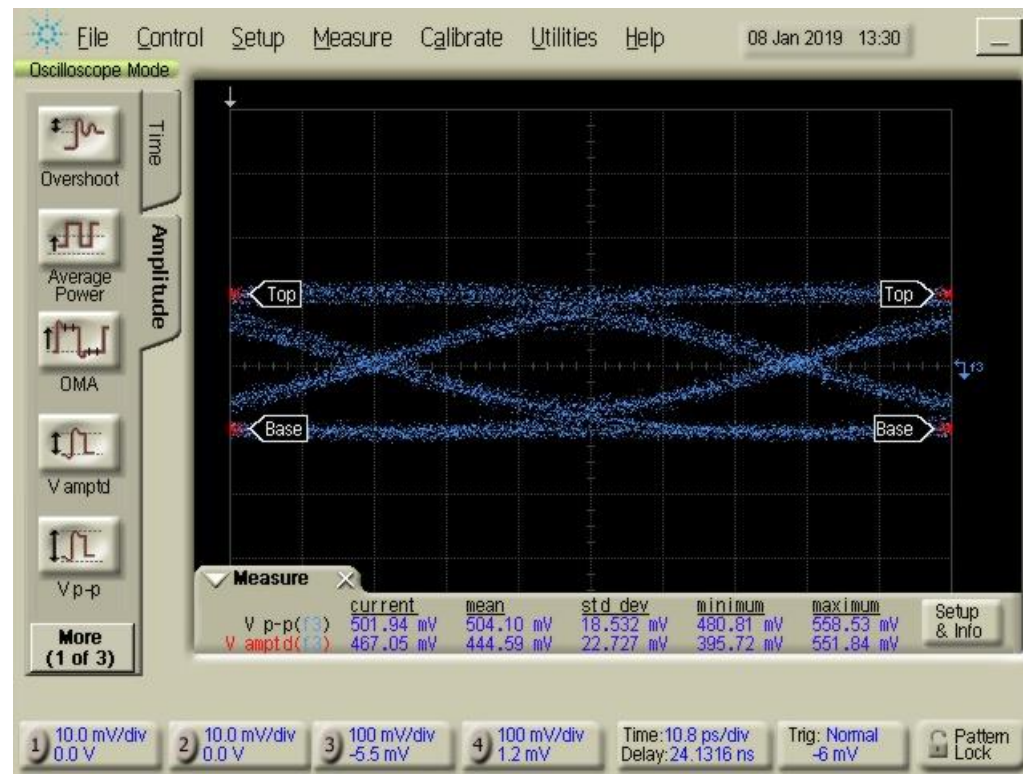
After -24-dB channel + redriver CTLE

PCIe Gen4 with in channel linear equalization

Longer channel with redriver looks exactly like shorter channel without redriver



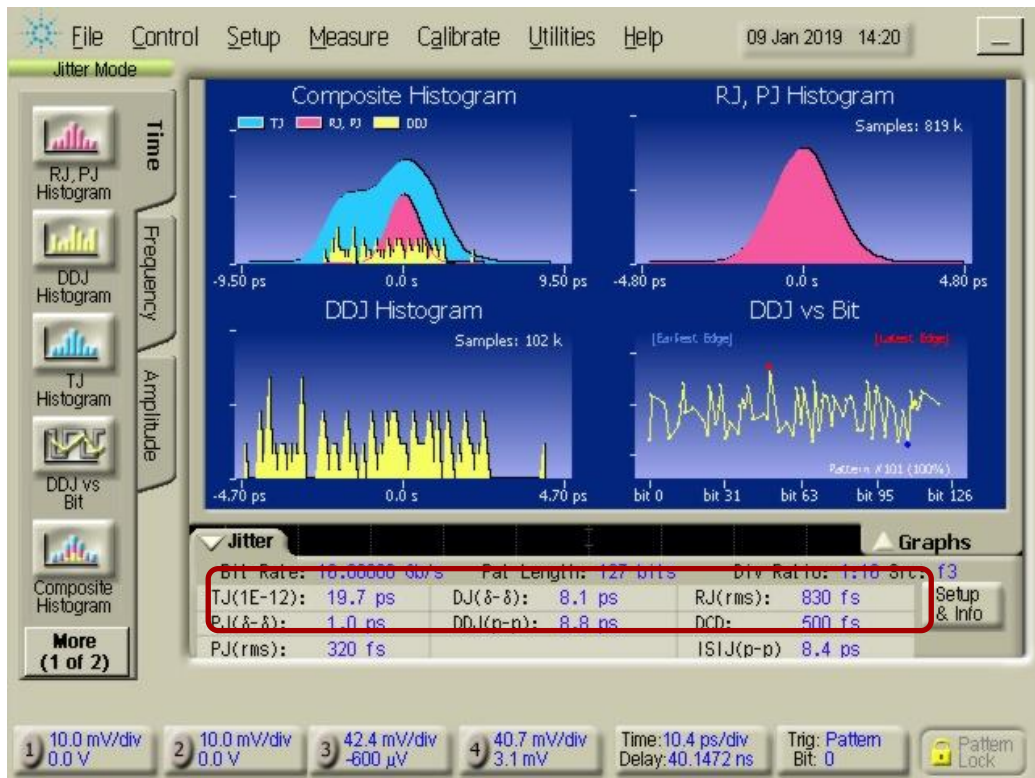
After -10 dB channel with no redriver



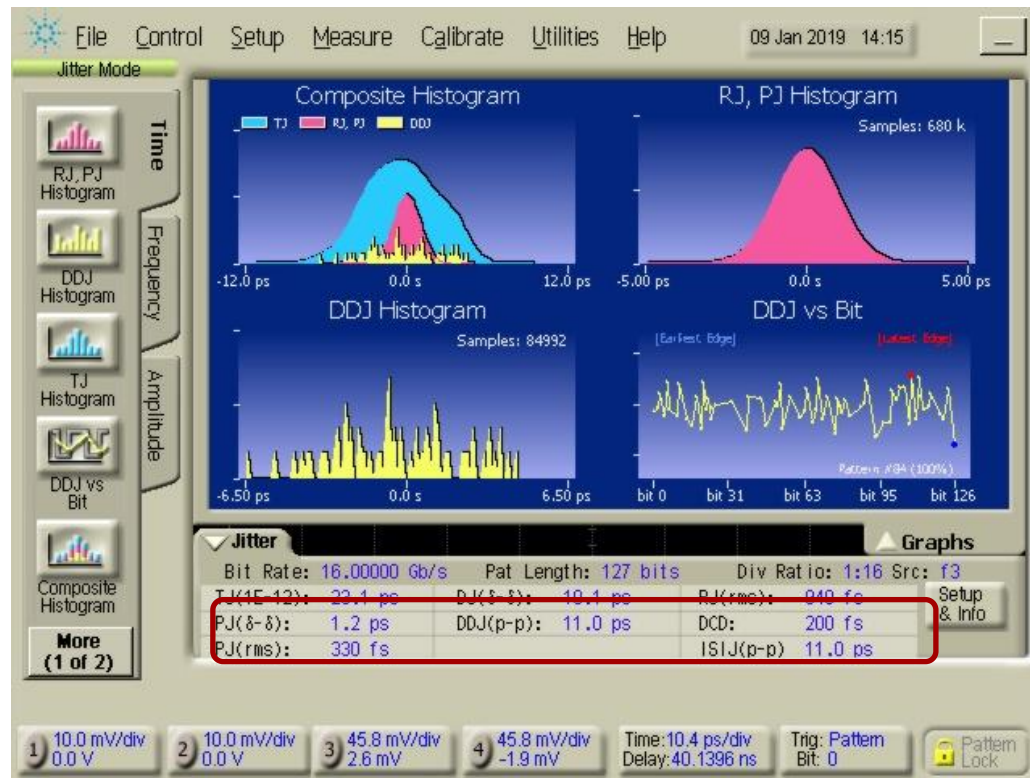
After -24 dB channel + redriver CTLE

PCIe Gen4 linear equalization – jitter comparison

Rj: + 100fs Dj: + 2ps Tj: + 3.4ps



After -10 dB channel with no redriver



After -24 dB channel + redriver CTLE

Short quiz

1. Check all correct statements:
 - A. PCI Express is a serial bus protocol
 - B. PCI Express uses a 100 MHz clock to provide robust setup and hold time on the PCI data
 - C. PCI Express currently operates up to 16 Gbps
 - D. PCI Express never uses any signal conditioning components
2. Check all correct statements:
 - A. PCI Express is a widely used standard in computers
 - B. Not all PCI Express channels will need signal conditioning
 - C. Linear equalization can be very effective extending the reach of a PCIe link
 - D. Protocol Aware Retimer operation is defined by the PCIe 4.0 standard.
3. PCI Express repeaters using Linear equalization have extremely low latency.
 - A. True
 - B. False
 - C. Unknown



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