TDECQ with DFE tap in Multimode Links

Ramana Murty and Atsushi Otsuka
Broadcom Inc.

IEEE 802.3 200 Gb/s per Wavelength MMF PHYs Study Group
November 11 – 12, 2025
Bangkok, Thailand

Acknowledgments

Thanks to Neal Buren, Keysight Technologies, and Ahmad El-Chayeb, Keysight Technologies, for the TDECQ with DFE analysis support

Tx Tests

P802.3dj is considering several Tx tests for single mode IM/DD links to assess performance and interoperability

▪ TDECQ calculation with 15-tap FFE + 1-tap DFE	P802.3dj D2.2 180.9.6
▪ Tx functional symbol error mask	P802.3dj D2.2 180.9.9
▪ Codeword error ratio (CER) TDECQ	P802.3dj D2.2 180.9.7
▪ Tx output jitter	P802.3dj D2.2 180.9.15

The proposed tests should be evaluated and adapted where necessary for distinctive features of multimode links: limited component bandwidth and nonlinear response of the laser

In multimode 100G per lane links, correlation between TDECQ and Rx sensitivity (OMA@BER 2.4E-4) is not 1:1

G. Le Cheminant and D. Leyba, lecheminant_3dj_01b_2309

Ramana Murty *et al.*, T11-2024-00357-v002

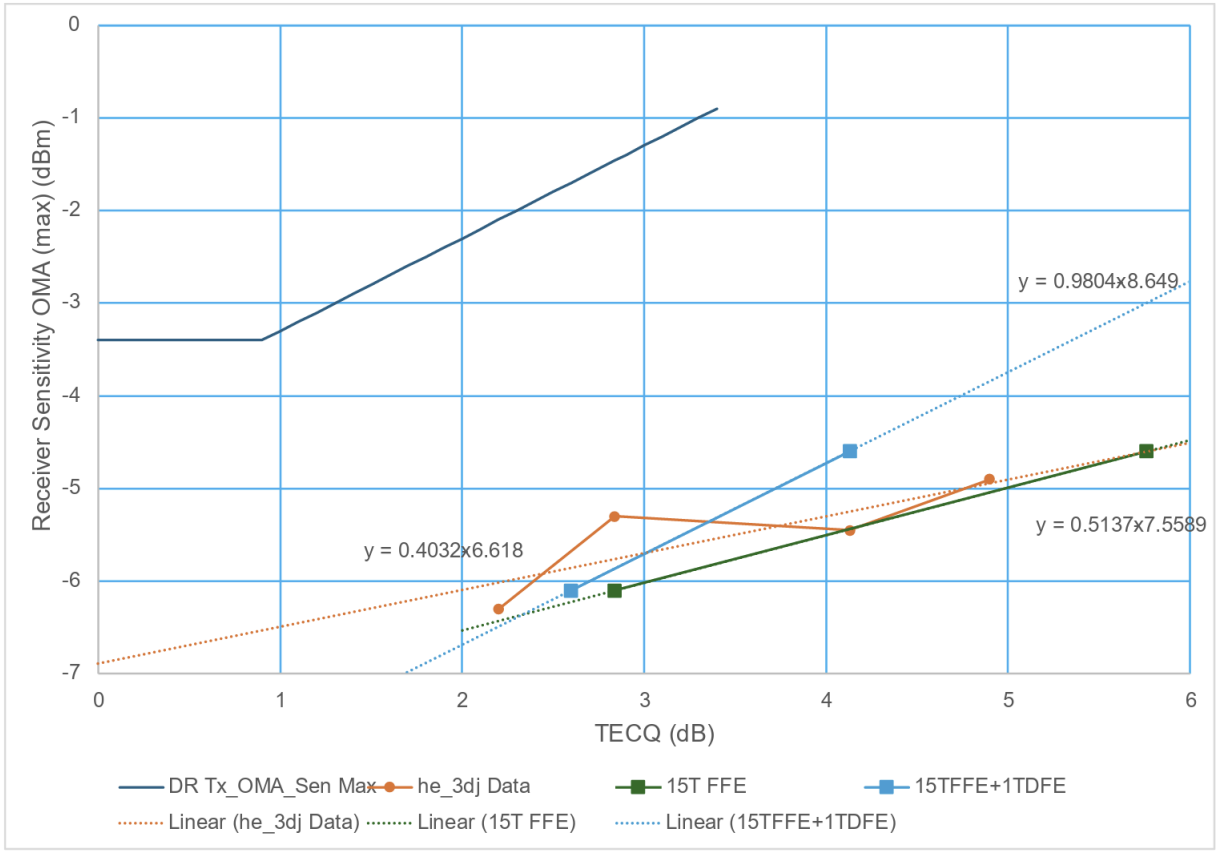
This presentation: Impact of adding 1-tap DFE to TDECQ calculation in multimode 100G per lane links

TDECQ calculation for the 200G link

Addition of DFE

Benefit of adding DFE to the TDECQ calculation
ghiasi_3dj_04c_2507

- Reduces TDECQ value, and sensitivity to number of FFE taps
- Improvement in correlation of TDECQ penalty with change in Rx sensitivity from 0.51:1 (15-tap FFE) to 0.98:1 (15-tap FFE + 1-tap DFE)



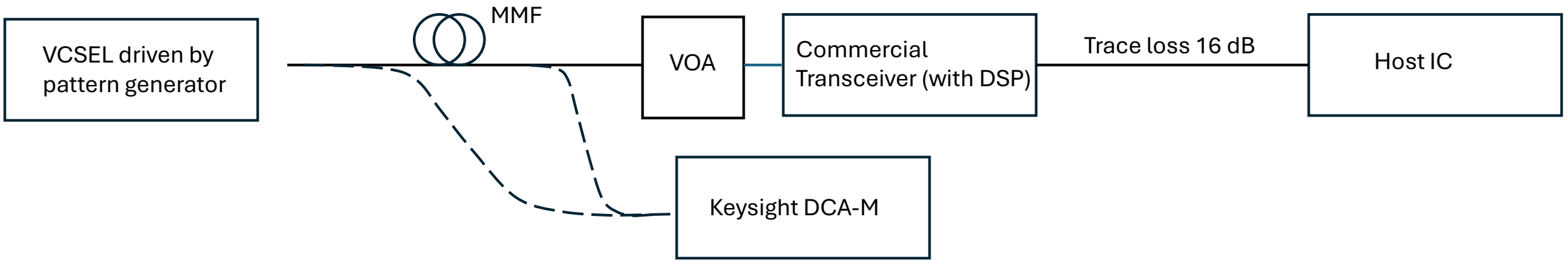
Experimental data from
he_3dj_01_2505
ghiasi_3dj_04c_2507

Test Setup

TDECQ varied by changing Tx FIR, fiber length, and/or temperature
- Eye measurements with Keysight N1092B DCA-M
- BER recorded at the host IC

Measurements with multiple VCSELs (Tx) and a single Rx

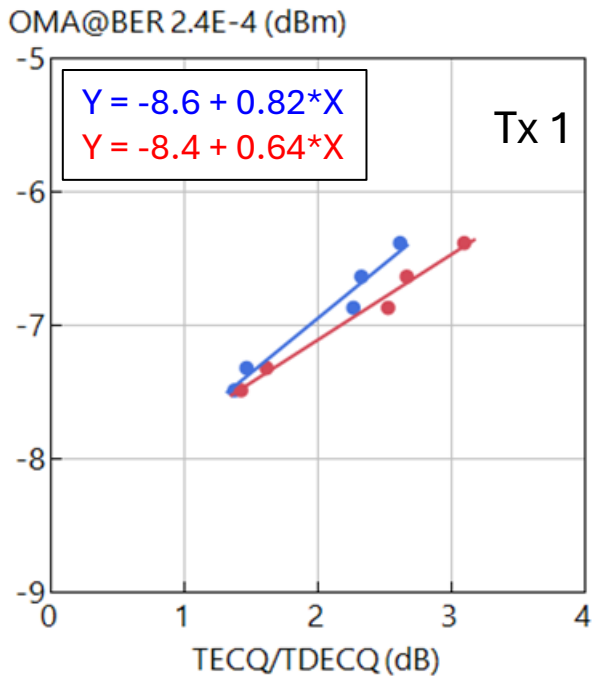
Data rate	106.25 Gb/s
Pattern	PRBS31Q (BER)
	SSPRQ (Eye)
Target SER	4.8E-4

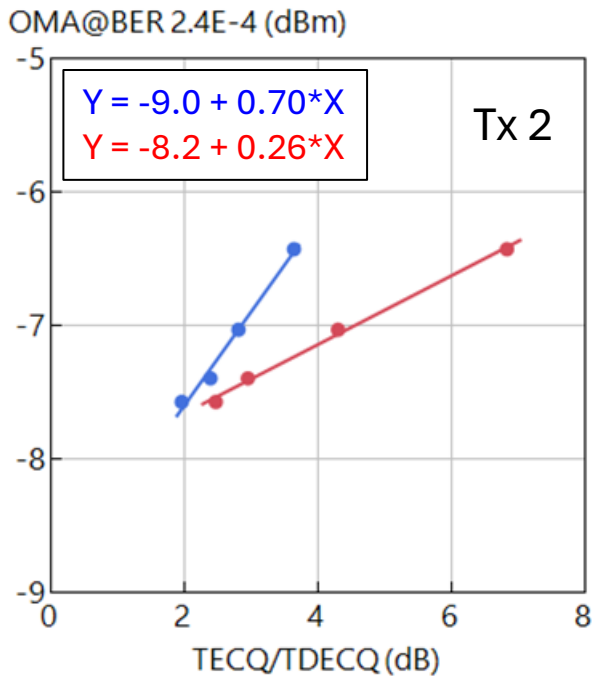


TDECQ

- With just the 9-tap FFE, slope of Rx sensitivity (OMA@BER 2.4E-4) vs. TECQ/TDECQ is well below 1 in the examples below
- Addition of the DFE tap brings the TECQ/TDECQ penalty closer to the change in Rx sensitivity (OMA@BER 2.4E-4). However, slope is still below 1 in the examples below.
- DFE tap values ranged from 0.1 to 0.3

- 9-tap FFE + 1-tap DFE
- 9-tap FFE





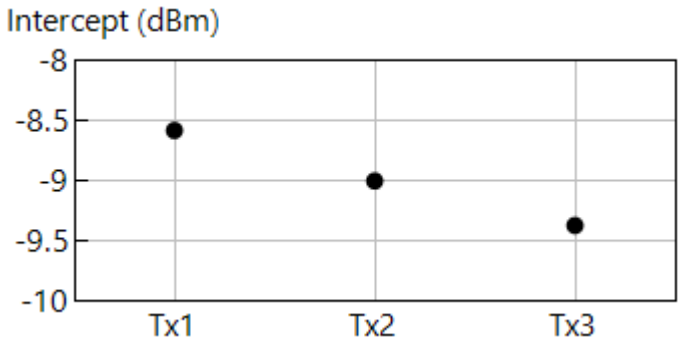
Observations

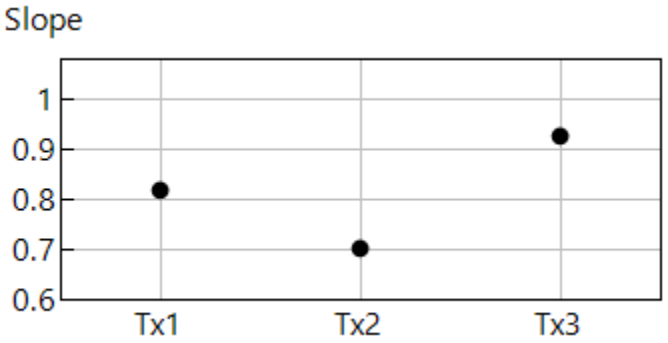
- Addition of the DFE tap
  - decreases noise enhancement (C_{eq}) and value of main tap from the FFE section of the equalizer
  - TECQ/TDECQ is less sensitive to the number of FFE taps

  These were also noted in ghiasi_3dj_04c_2507

- For the given Rx, both the y-axis intercept (OMA@BER 2.4E-4) and slope (OMA@BER 2.4E-4 vs. TECQ/TDECQ) depend on the Tx. Rx sensitivity is not a unique value and has some dependence on the input optical waveform.

- For the Tx symbol error test, this suggests setting the operating OMA using the approach proposed by Marco Mazzini
  (a) identify OMA@BER 2.28E-4, and
  (b) add test margin (1.5 dB) [plus an additional margin based on launch OMA]





200G Links

1. **TDECQ calculation** The slope of Rx sensitivity vs. TECQ/TDECQ can be brought closer to 1 with a histogram spacing less than 0.1 UI for TDECQ calculation. This will benefit 200G multimode links with the smaller lateral eye opening.

2. **DFE tap coefficient** 200G multimode links will see a higher DFE tap coefficient than 100G because of more ISI. The max limit on the DFE tap coefficient (0.3 in P802.3dj D2.2) needs a closer look.

3. **FFE tap coefficients** Limits on the FFE tap coefficients in P802.3dj D2.2 can be adopted for the 30 m OM4 link.