# TDECQ Updates with Threshold Adjustment (1): VCSEL Results*

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* With data to support comment resolution for adding Adaptive Threshold Adj in computing TDECQ (float slicing).

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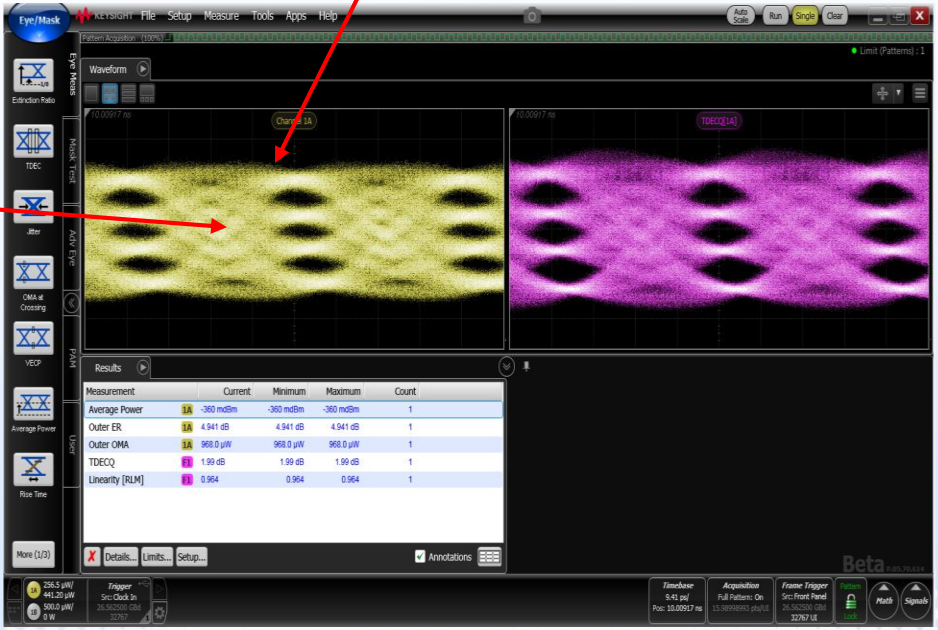
# Problem Statements

- Adaptive slicing seems promising to resolve TDECQ specs dilemma
  - Consider Precise threshold is optimized to further minimize TDECQ (Cisco) (mazzini_120617_3cd_adhoc-v2)
  - TDECQ improvements have shown using DML (AOI).
- There exists 2 major concerns associated with TDECQ (SECQ)
  - Is TDECQ methodology robust from different testers?
  - How adaptive slicing (vertical threshold adj) work on non-DML transmitters: VCSEL, EML, and MZM (e.g. for SRS)?
- This will facilitate the PAM4 module compliance/manufacturability without throwing away any known good TXs (improve yield).
- This report:
  - Focus on looking into VCSEL TX, in some way similar to DFB for direct modulated type of lasers.
  - Test results for EML and MZM will follow up next.

# TDECQ Test Configurations

- Firstly test against 2 different testers under GOLDEN VCSEL TX
  - Evaluation board mounted commercial PAM4 ASIC with direct drive test board mounted 50Gb/s VCSELs (Similar to chang_3cd_01a_0917)
    - Driverless
  - TDECQ SR tests (no test fiber needed)
    - PRBS $2^{15}$-1
- Secondly apply threshold Adj.
- Reasonably open eyes with timing window to start with.
- 3 scenarios with Golden VCSELs
  - Varying filter BWs
  - Varying the number of taps
  - Test deviations of multiple tests

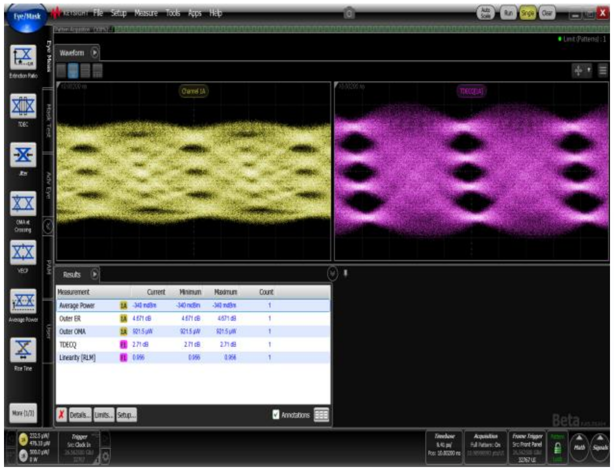
Raw eye with 19.3GHz RX filter BW



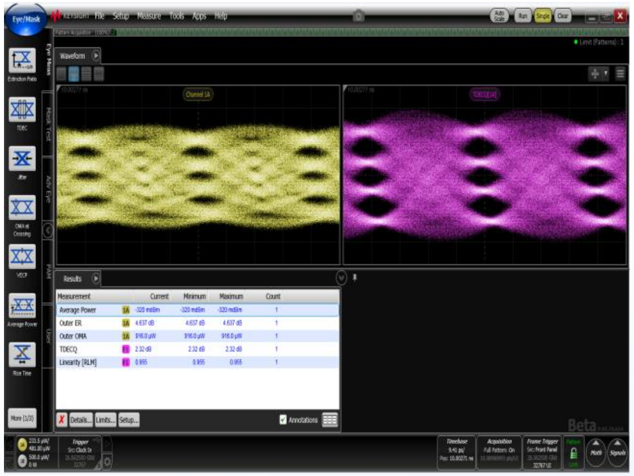
# Under different filter BWs for 2 testers - 1

- W.r.t 5T Equalizers, PRBS $2^{15}$-1 for one tester

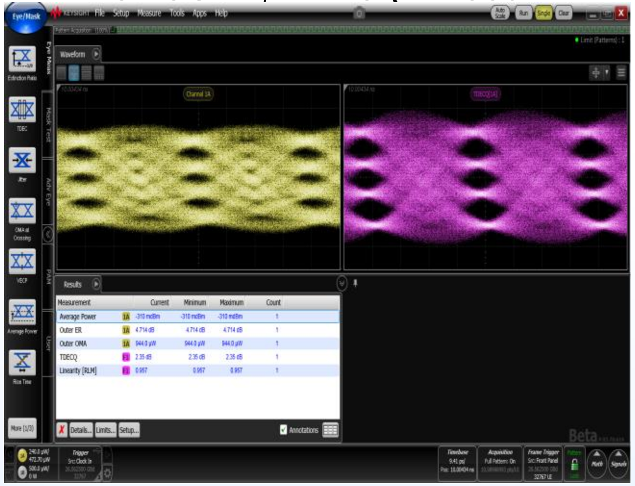
11.2GHz, TDECQ=2.71dB



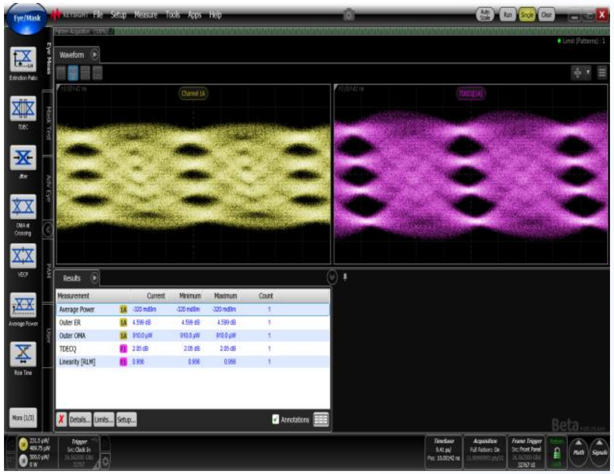
12.6GHz, TDECQ=2.32dB



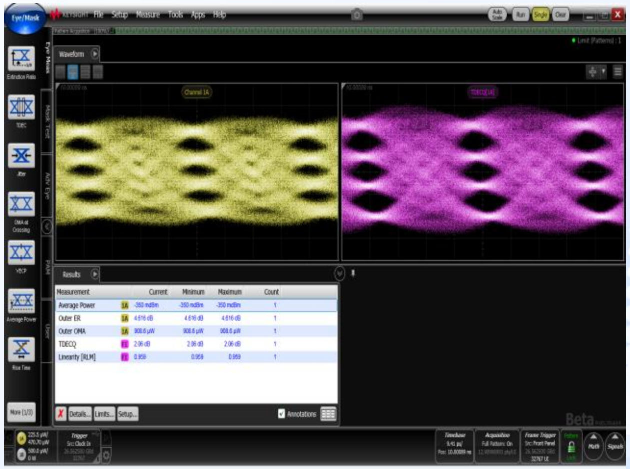
13.28GHz, TDECQ=2.35dB



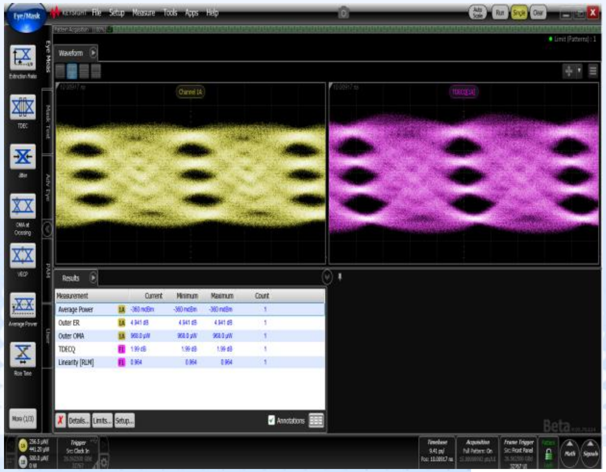
14.5GHz, TDECQ=2.09dB



15.9GHz, TDECQ=2.06dB



19.3GHz, TDECQ=2.02dB



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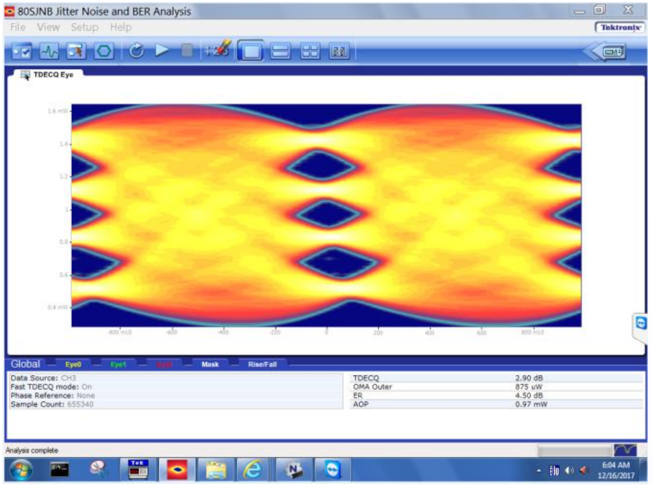
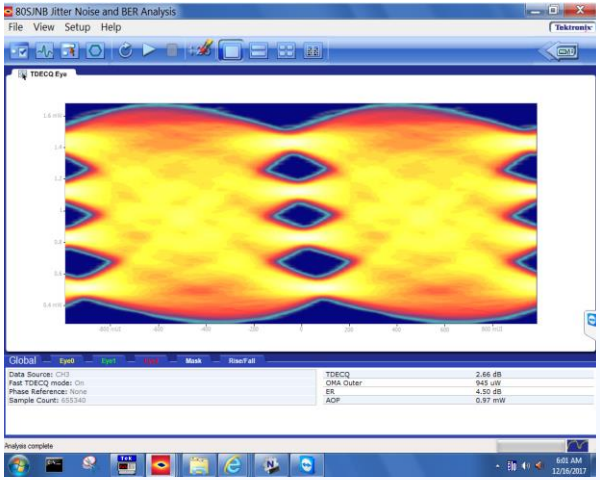
# Under different filter BWs for 2 testers - 2

- W.r.t 5T Equalizers, PRBS $2^{15}$-1 for another tester

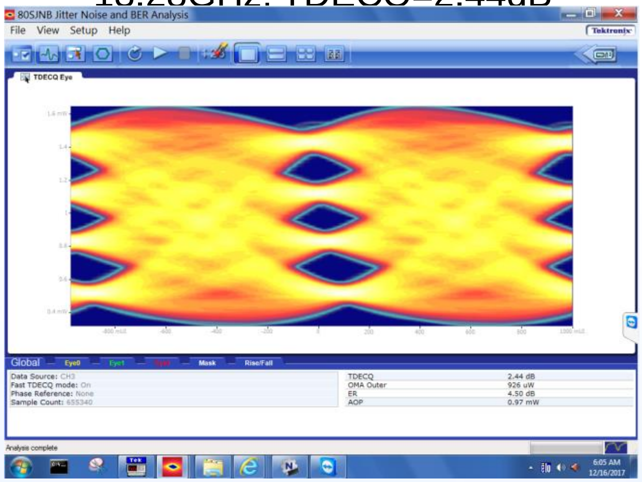
11.2GHz, TDECQ=2.9dB



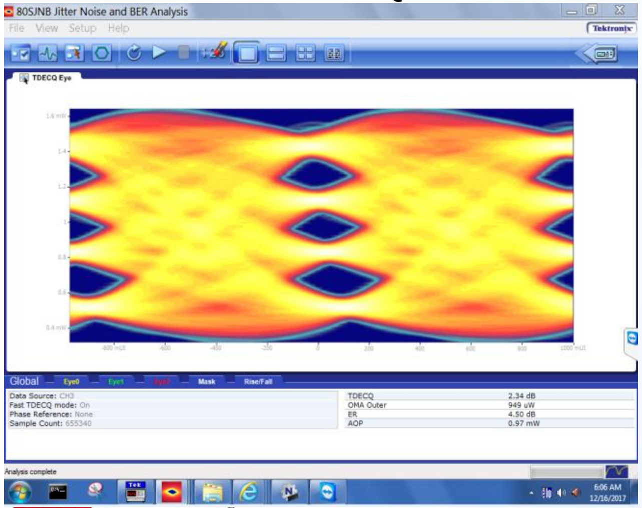

12.6GHz, TDECQ=2.66dB



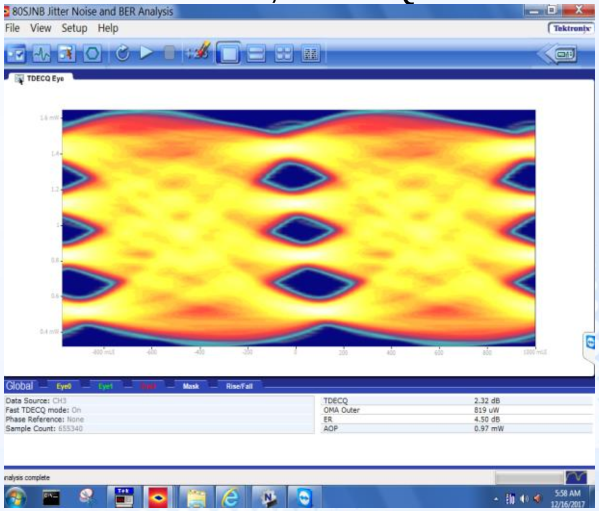

13.28GHz, TDECQ=2.44dB



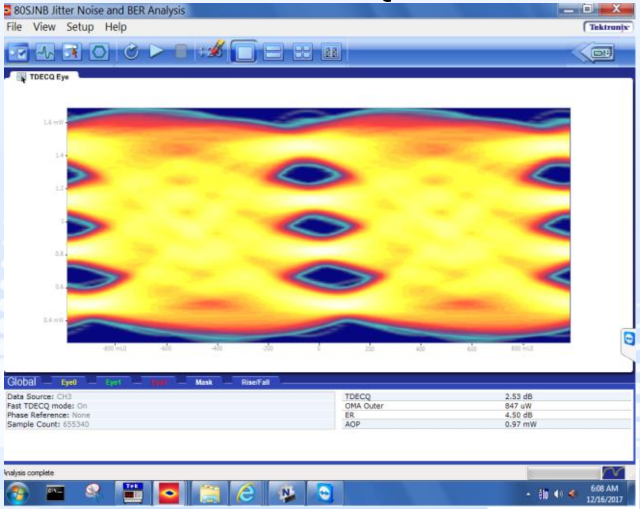

14.5GHz, TDECQ=2.34dB




15.9GHz, TDECQ=2.32dB




19.3GHz, TDECQ=2.53dB

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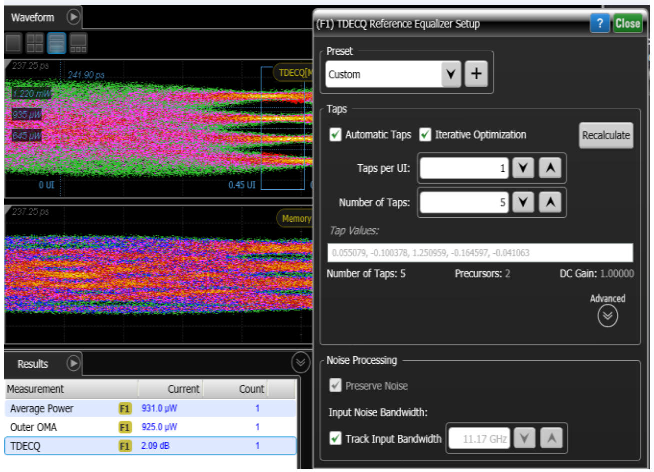
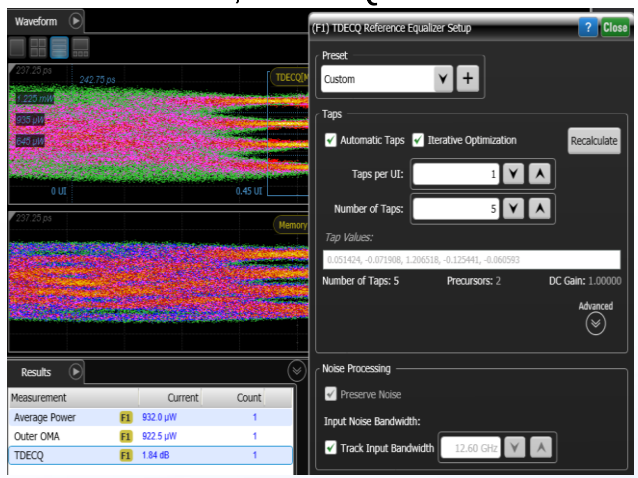
# Under different filter BWs for 2 testers - 3

- W.r.t 5T Equalizers with Threshold Adj (post-processed)

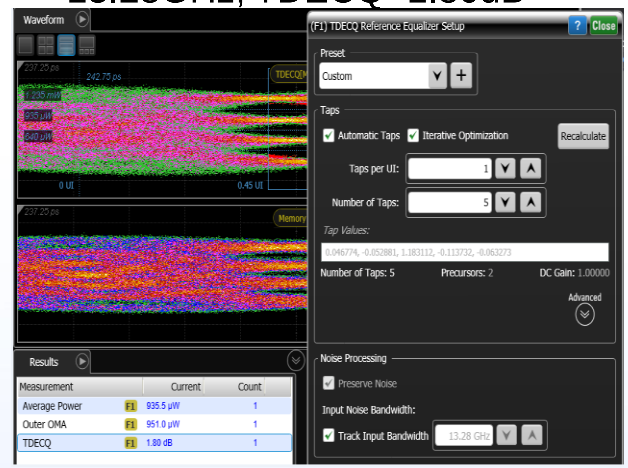
11.2GHz, TDECQ=2.09dB



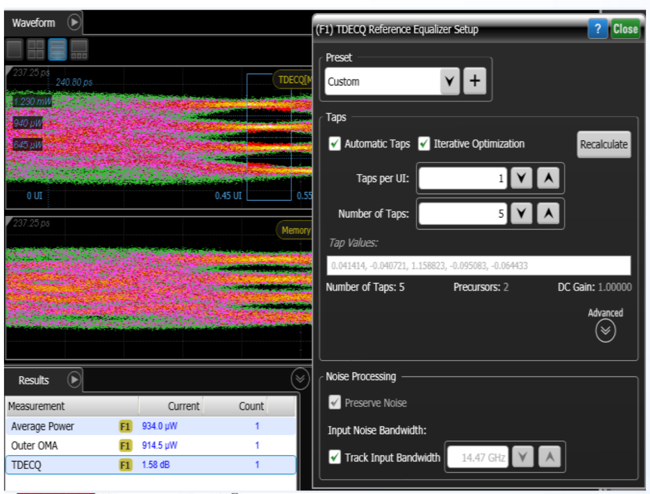

12.6GHz, TDECQ=1.84dB



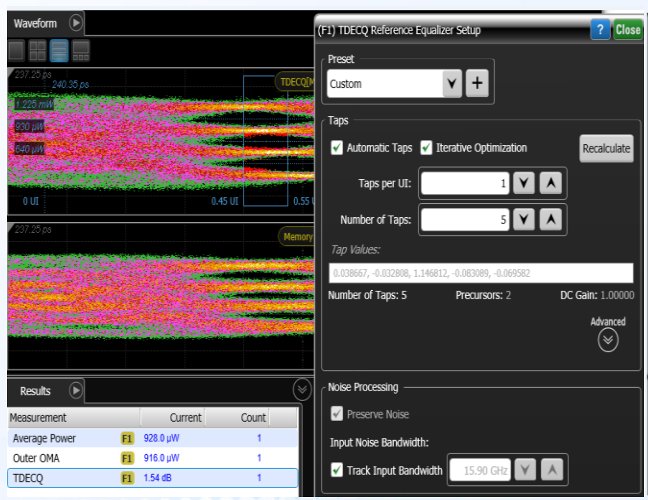

13.28GHz, TDECQ=1.80dB



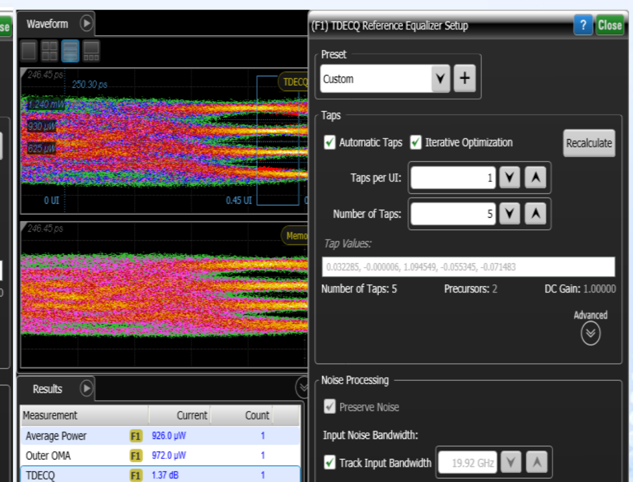

14.5GHz, TDECQ=1.58dB




15.9GHz, TDECQ=1.54dB

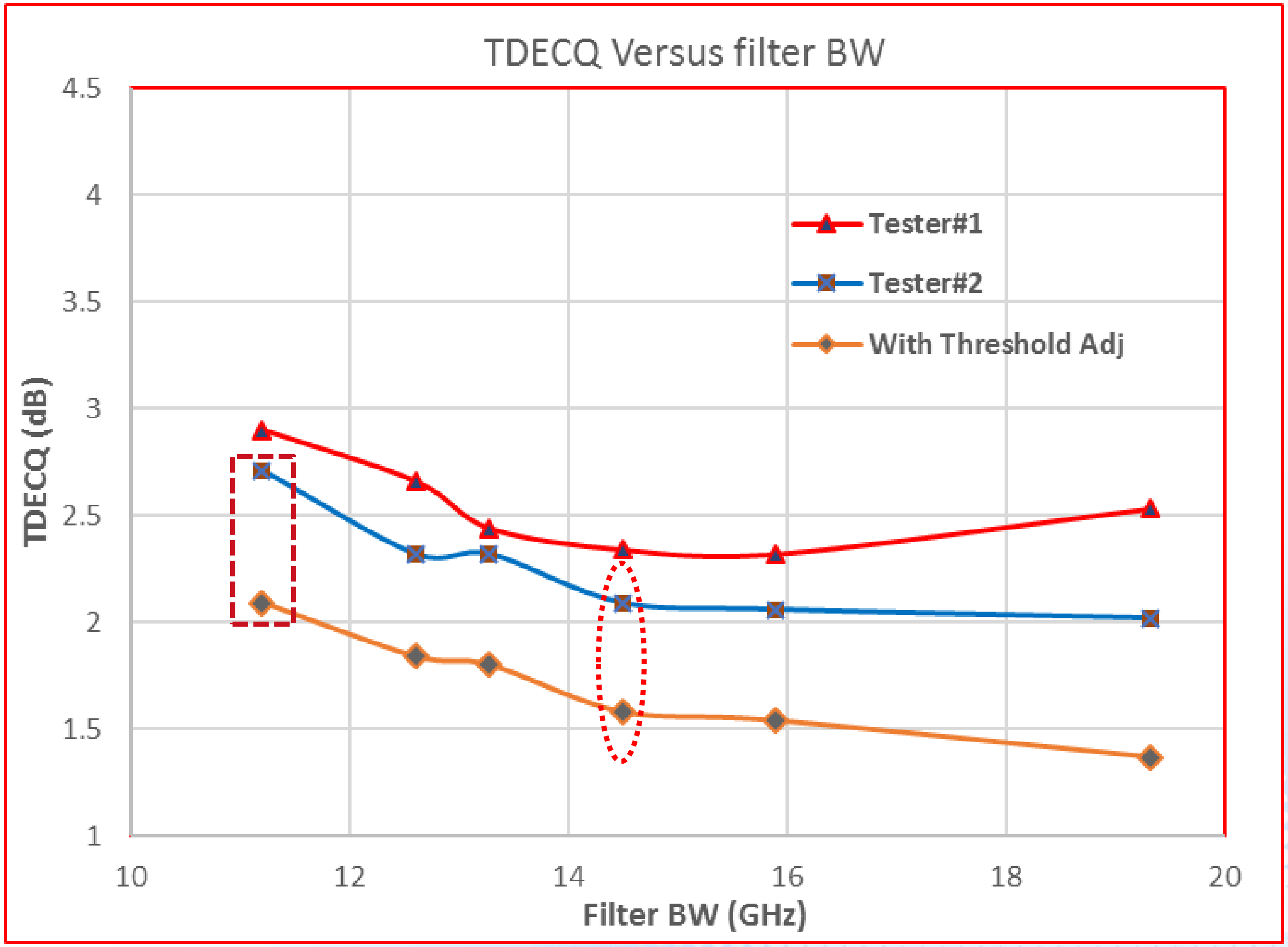



19.3GHz, TDECQ=1.37dB



# Under different filter BWs for 2 testers - 4

- W.r.t 5T Equalizers with Threshold Adj (post-processed)

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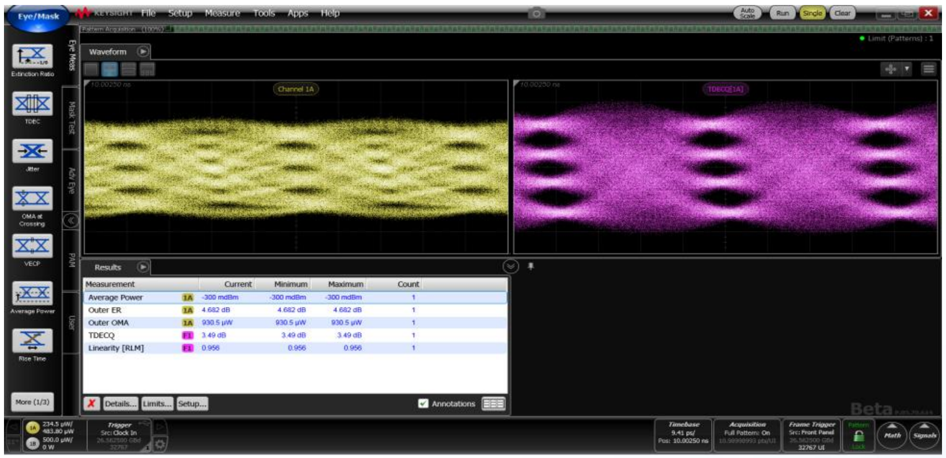
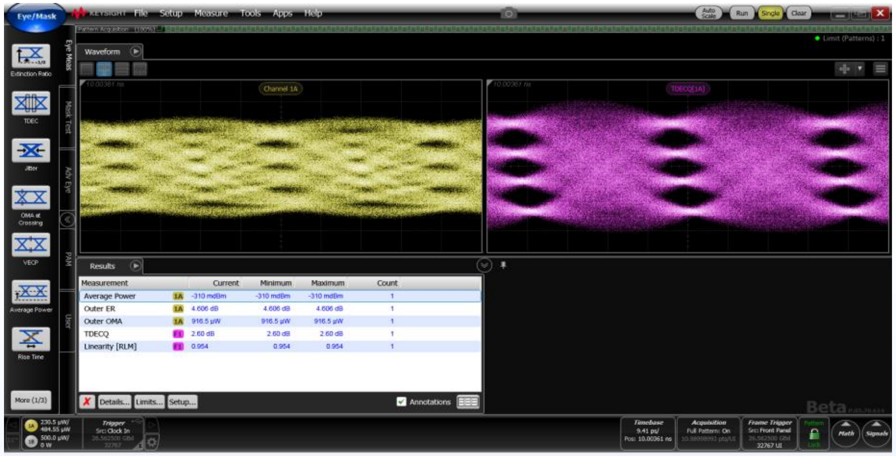
# Under different # of Taps for 2 testers - 1

- W.r.t 11.2GHz filter BW for one tester

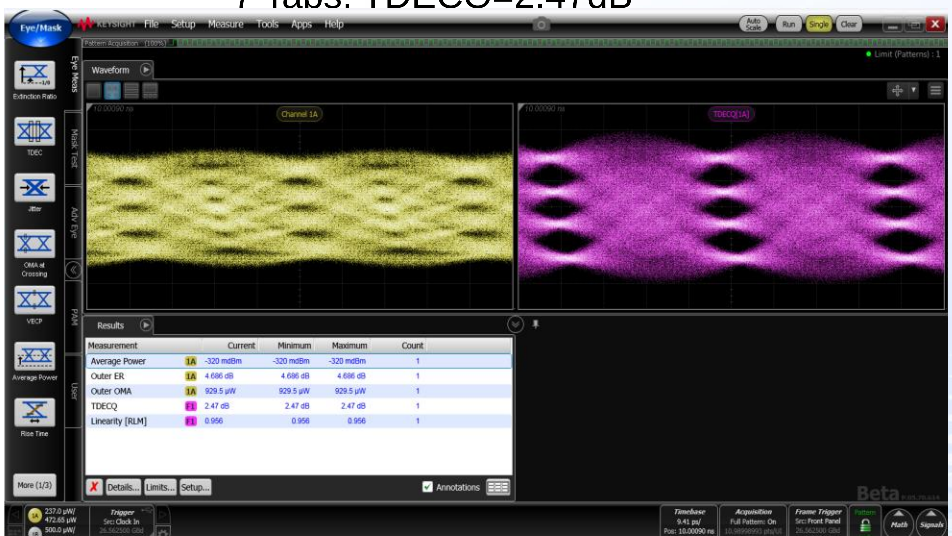
3 Taps, TDECQ=3.49dB



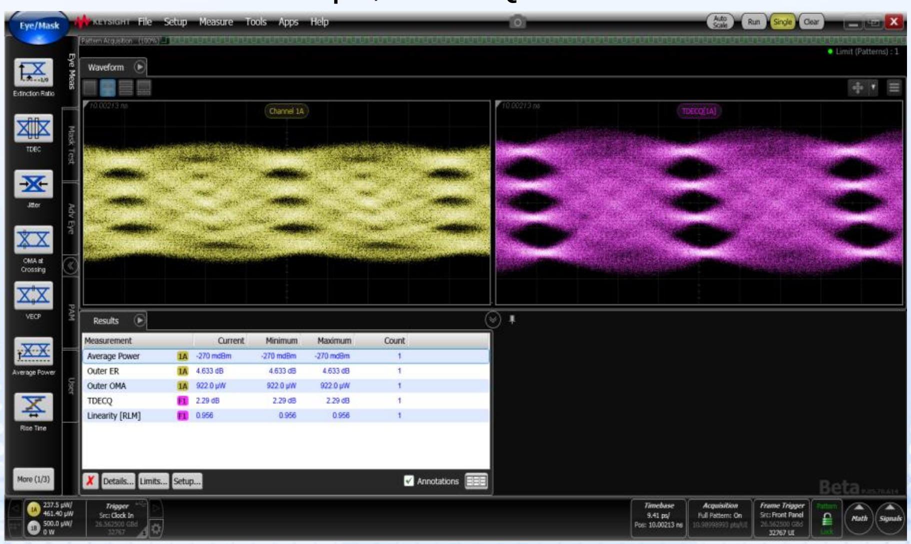
5 Taps, TDECQ=2.6dB



7 Taps, TDECQ=2.47dB



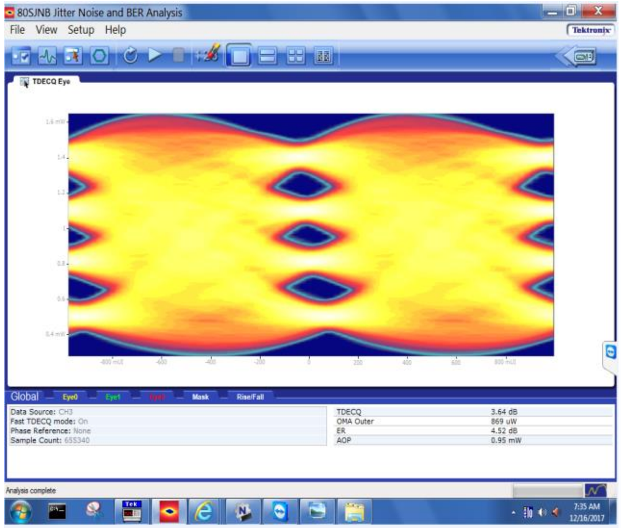
9 Taps, TDECQ=2.29dB



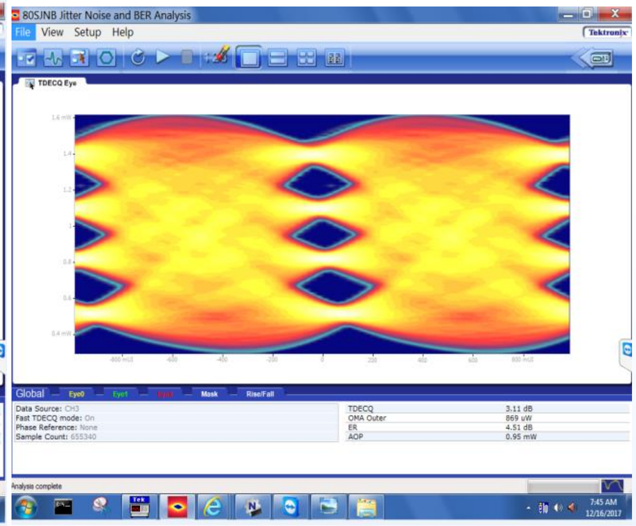
# Under different # of Taps for 2 testers - 2

- W.r.t 11.2GHz filter BW for another tester

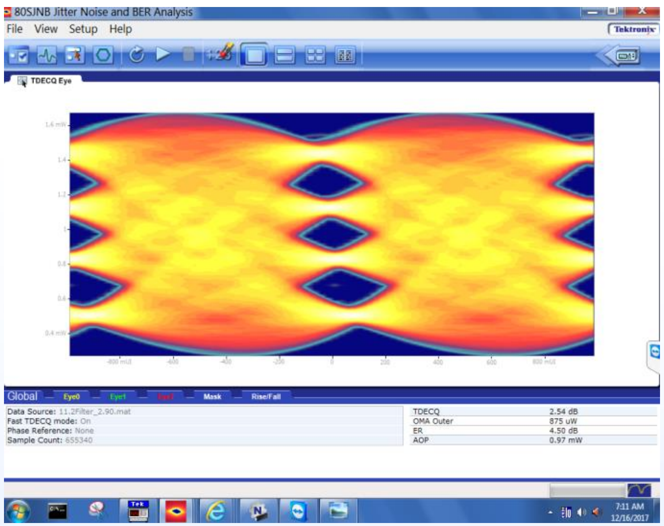
3 Taps, TDECQ=3.63dB



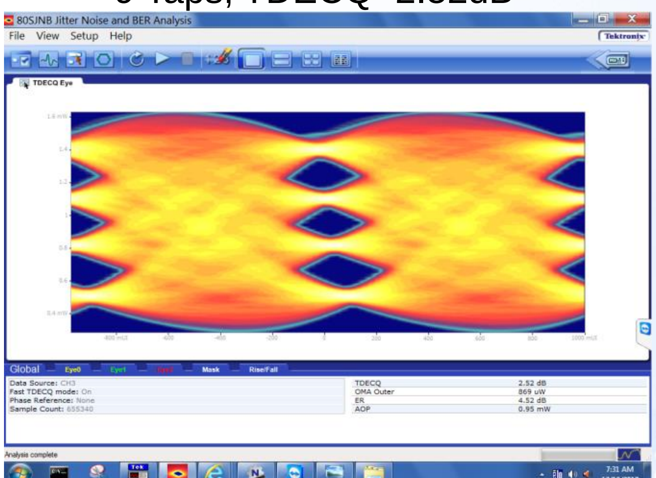

5 Taps, TDECQ=3.11dB



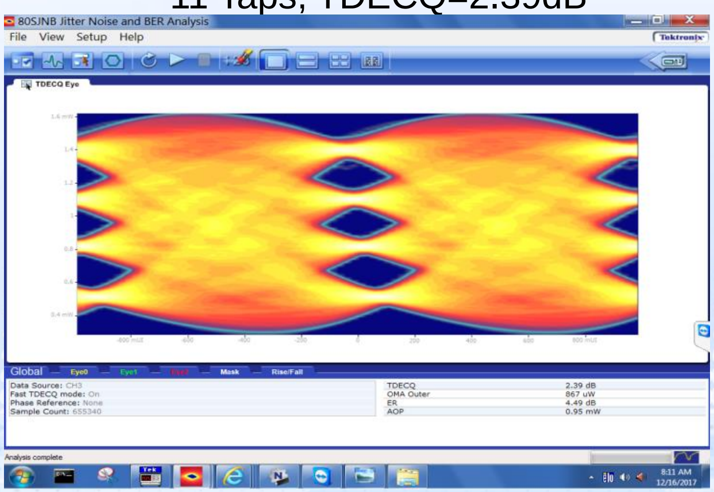

7 Taps, TDECQ=2.54dB




9 Taps, TDECQ=2.52dB



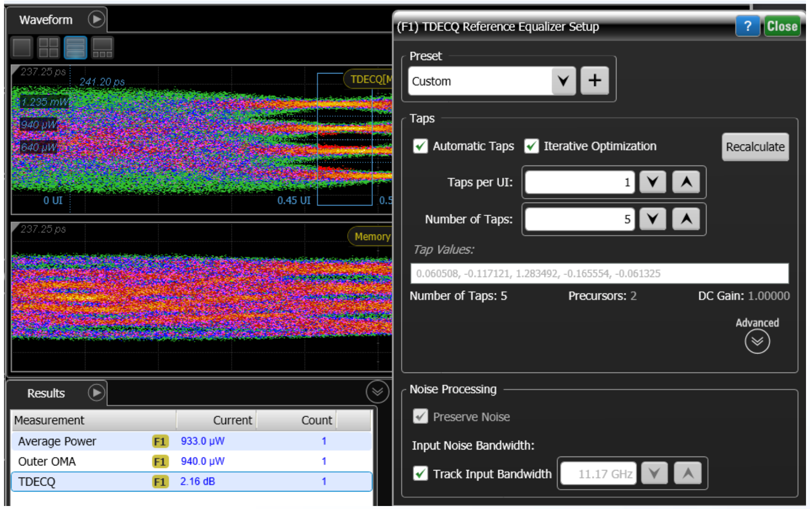

11 Taps, TDECQ=2.39dB



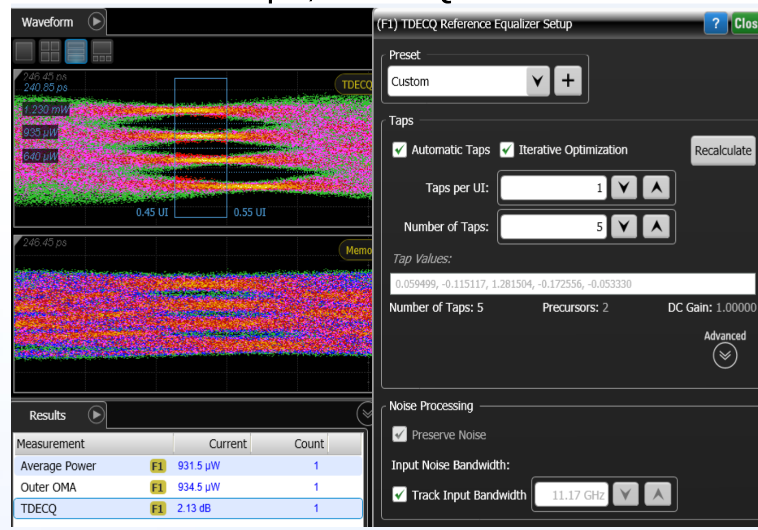
# Under different # of Taps for 2 testers - 3

- W.r.t 11.2GHz filter BW with Threshold Adj (post-processed)

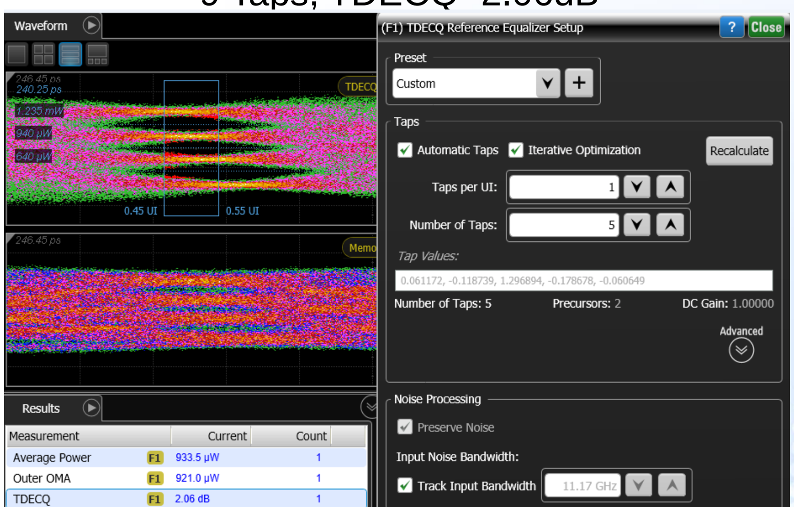
5 Taps, TDECQ=2.16dB




7 Taps, TDECQ=2.13dB




9 Taps, TDECQ=2.06dB




Note: the post-processed data is actually done in 5 taps only using threshold adj. so somewhat pessimistic for larger number of taps. This has no impact to the conclusion we are making.

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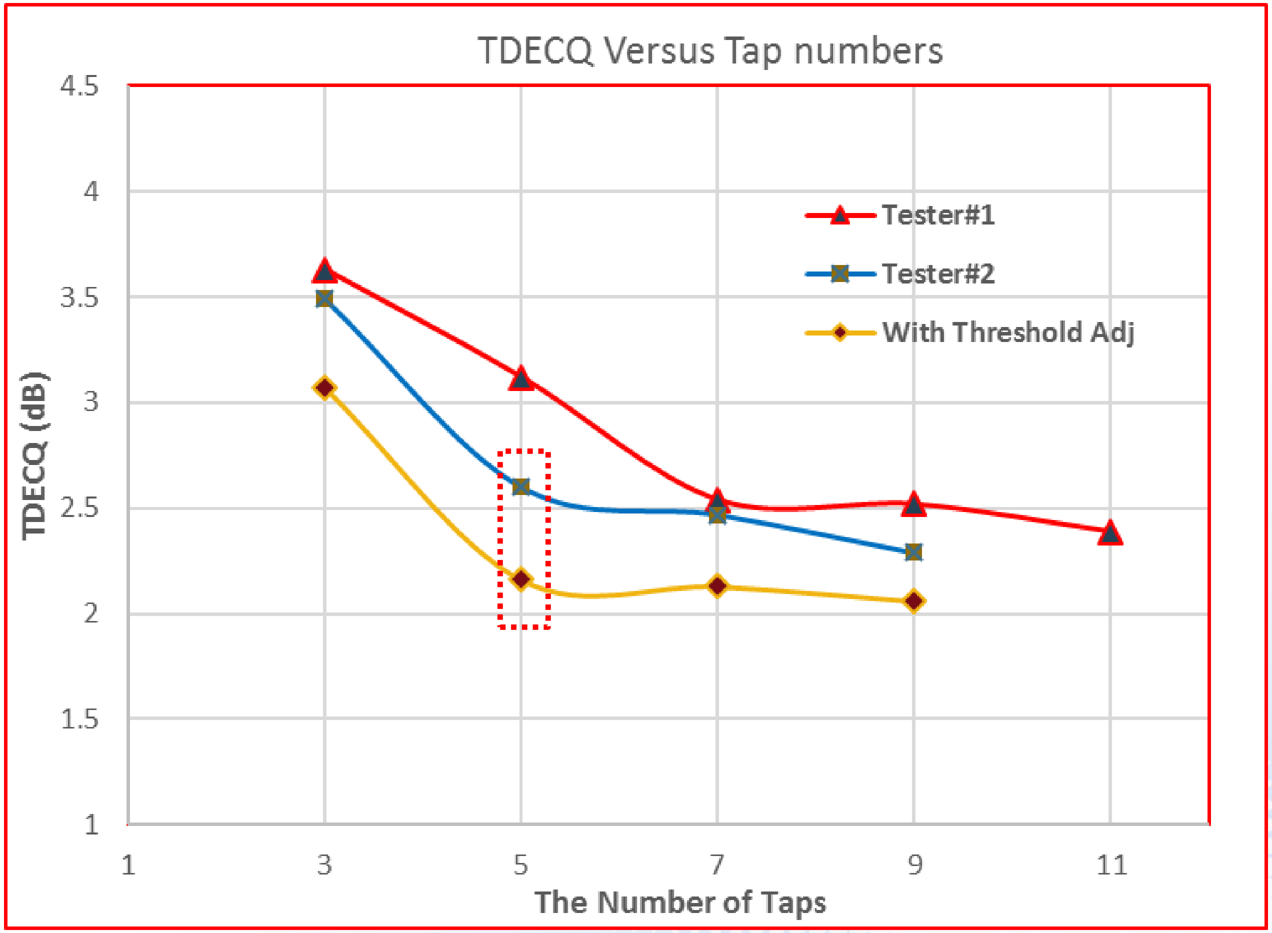
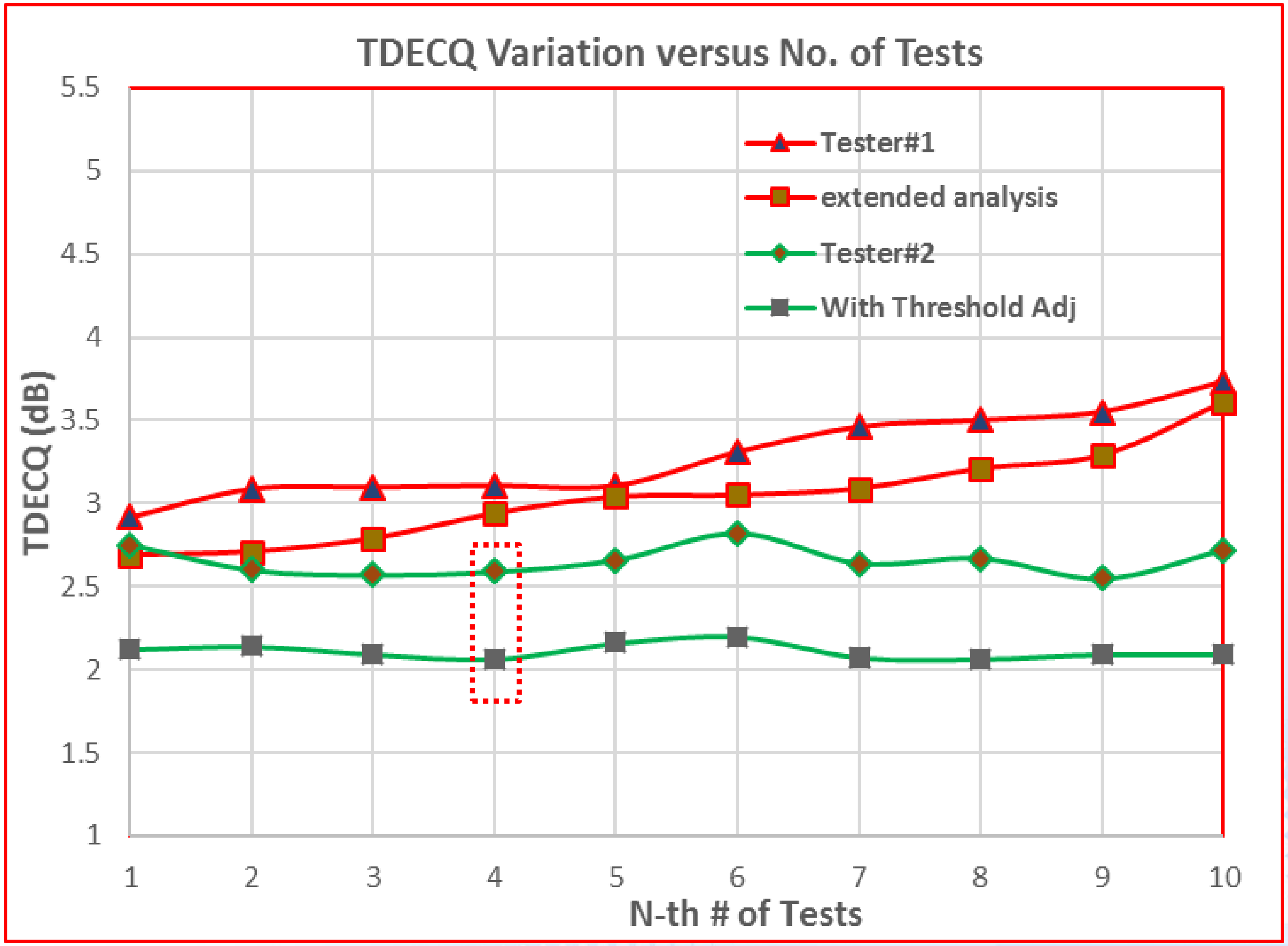
# Under different # of Taps for 2 testers - 4

- W.r.t 5T Equalizers with Threshold Adj (post-processed)



# Test Variations for 2 testers - 1

- W.r.t 11.2GHz, 5T Equalizers with Threshold Adj (post-processed)



# Concluding Remarks

- We compared test results for two testers off-the-shelf. The discrepancy could be as high as 0.5-1dB between different testers w.r.t. VCSEL TX.
  - There may be room to improve repeatability.
- Under golden TX configuration, It's consistently shown improvement by 0.4-0.5dB due to threshold adjustment.
  - The data support to implement threshold adjustment into TDECQ measurements.
- Under well-controlled lab environment, RLM is maintained higher than 0.95 for most cases. A limit should be set for RLM in actual manufacturing environment for TX, RX compliance.
  - RLM ≥ 0.9 seems good strawman proposal to start with.