Comments on "TDECQ updates"

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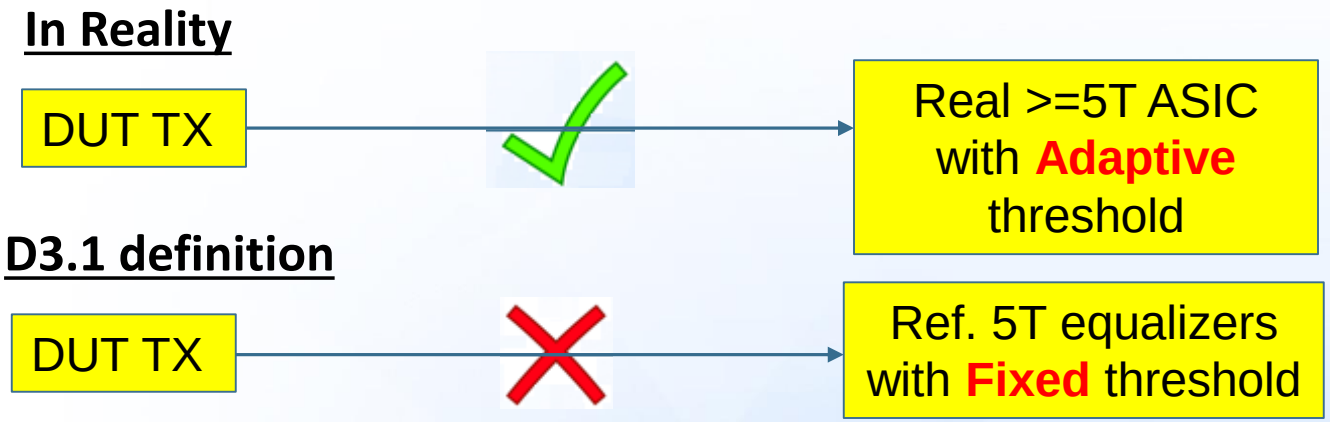
Contents – Notes on “TDECQ updates”

- TDECQ background
  - To put it simple – What we are trying to address?
- Comments on king_3cd_01_0318
  - The data shows adding threshold adjustment to TDECQ reference receiver will improve correlation between TDECQ and RX Sensitivity
- Additional supportive data
  - Adding threshold adjustment improves the correlation between ΔTDECQ and ΔRx Sensitivity.
  - Without threshold adjustment, Rx Sensitivity penalty at 2.4E-4 is overestimated by TDECQ.

TDECQ Background (1)

- Real receiver has threshold adjustments, and current ref. equalizers are defined as fixed threshold.
  - Unfortunately we have to throw away any "**good**" TX that pass real receivers but fail TDECQ using reference 5T equalizers.
  - This impact yield loss, so increase cost.

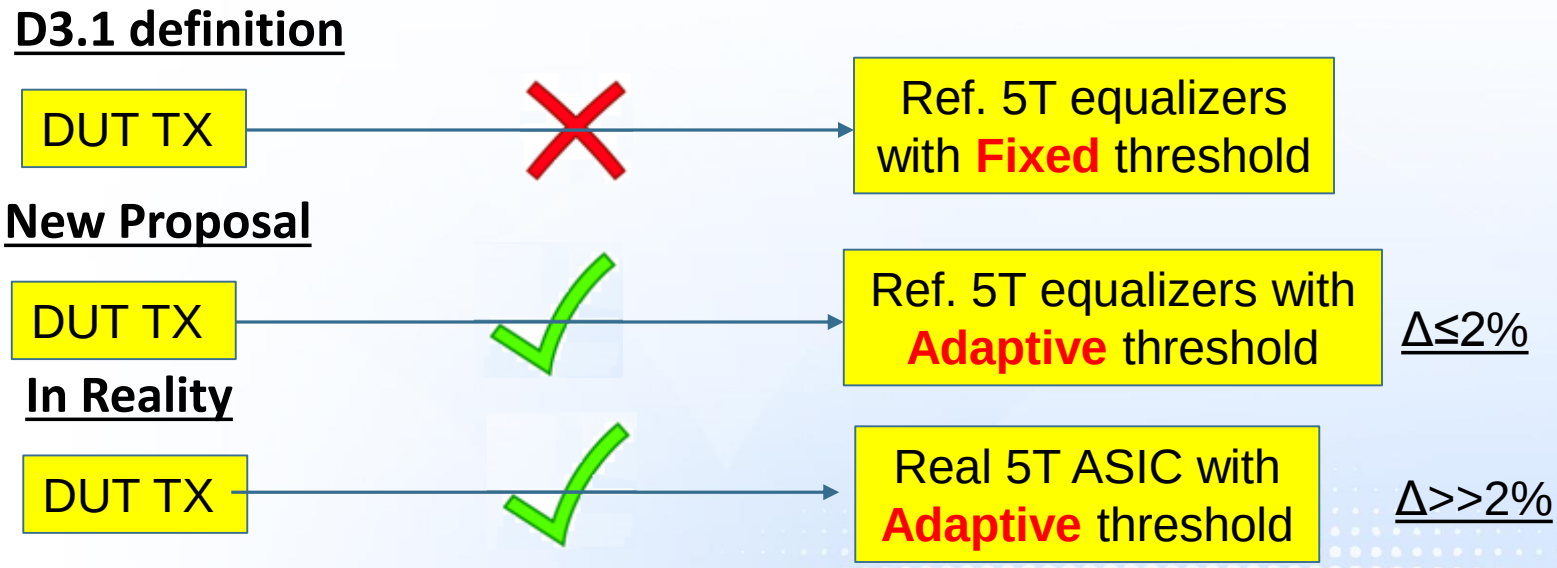


  - "*I don't know of any kind of "real" receiver that won't have some form of ability adjust eye thresholds separately*"

Note: all the test data so far are based on real silicon or production modules, so any implementation penalty is already taken into account.

TDECQ Background (2)

- New proposal requests to change current ref. equalizers by adding threshold adjustment of up to a small amount (≤2%).
  - If reference equalizer add threshold adjustment just like real receiver, then link budget can be kept intact.
  - No interoperability risk fundamentally.



Note: The proposed change does not violate the bottom line that TDECQ should be no better than the worst case real receivers

TDECQ Background (3)

Two important items for any changes to TDECQ (Slides#4):

- Show threshold adjustment doesn't result in the SRS test source having too high a stress for the receiver, test with a fully stressed receiver (ie including baseline wander and sinusoidal jitter) so that the tracking/optimization algorithms are exercised;

- Team response: The FULL stress RX tests (SRS) by chang_3cd_01_0318 show the impact falls well within 0.1-0.2dB. And the real receiver used for the test mimic the worst-case reference 5T equalizers by adding threshold adjustment.

- Show threshold adjustment significantly improves correlation between TDECQ and measured receiver sensitivity.
  - For example, a 'significant improvement' would be reducing RMS error to below 0.1 dB across a range of transmitters and receivers.

- Team response: The conclusion by king_3cd_01_0318 is incorrect when no 1:1 linear fit was actually done. With correction by adding 1:1 linear fit, the data clearly indicate 1:1 linear fit is a better approximation (<0.1) with threshold adjustment than the fixed threshold case.

Comments on king_3cd_01_0318: Guard band

Slide #5

- Real receiver doesn't base threshold on OMA and allows for some non-linearity.
- With threshold adjustment, TDECQ become consistent across temperature and aging, so no guard band required in manufacturing (less test time, higher yield, lower cost).
- If we leave each manufacturer to guard band the optics, there may exist large risk to guarantee interoperability from multiple vendors.
  - Adding threshold adjustment helps manufacturer build interoperable transmitters.

Comments on king_3cd_01_0318: Rx penalty prediction (1)

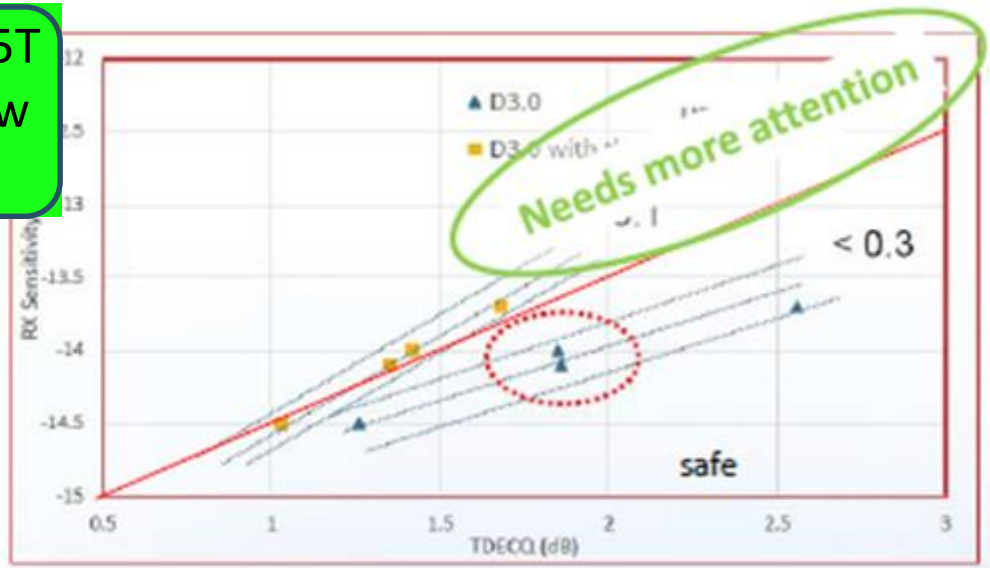
Recap from Slide #6-7

Comments on chang_021418_3cd_adhoc-v2.pdf : 'Rx penalty prediction'

Slide 13 data

- When threshol… slope of Rx sen…
  - This really would be a hole in the spec
- i.e. TDECQ with threshold adjustment underestimates receiver penalty, even though the receiver used has a much longer EQ (10 tap FFE) than the reference EQ
- In contrast, a reference EQ which is representative of the worst case receiver should tend to over-estimate sensitivity penalty (slope of receiver sensitivity vs TDECQ should be ≤1)

We used emulated 5T equalizers under low power mode

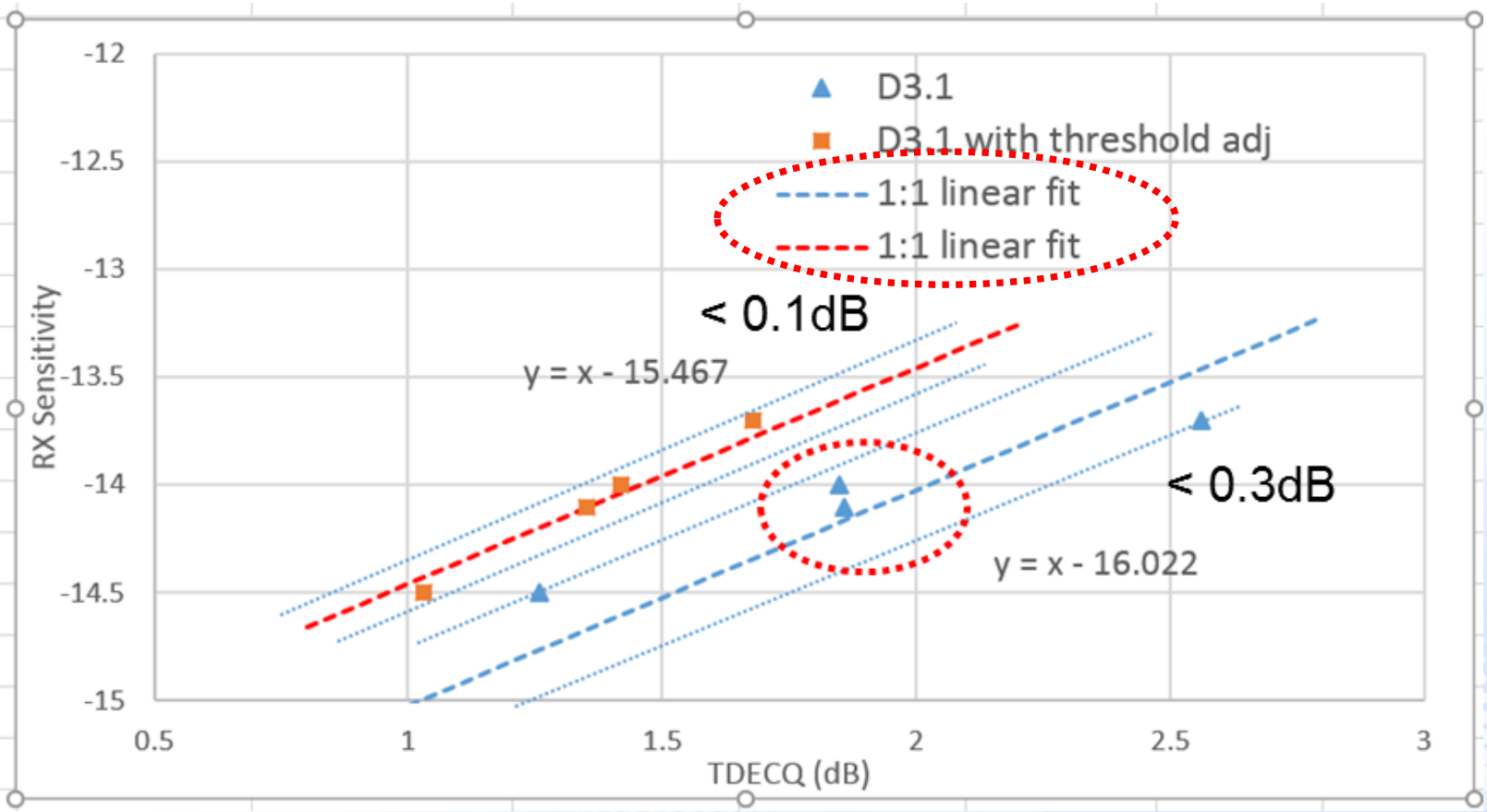


king_3cd_01_0318 make big deal on this plot, but NO actually 1:1 linear fit was done, so the conclusion could be misleading.

Comments on king_3cd_01_0318: Rx penalty prediction (2)

Slide #6-7

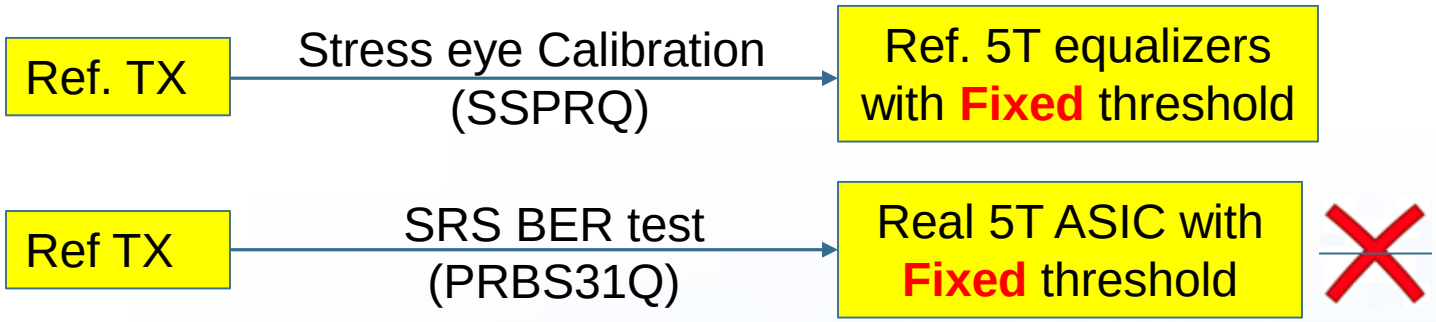
- Threshold adjustment obviously gives a better 1:1 linear fit than fixed thresholds.



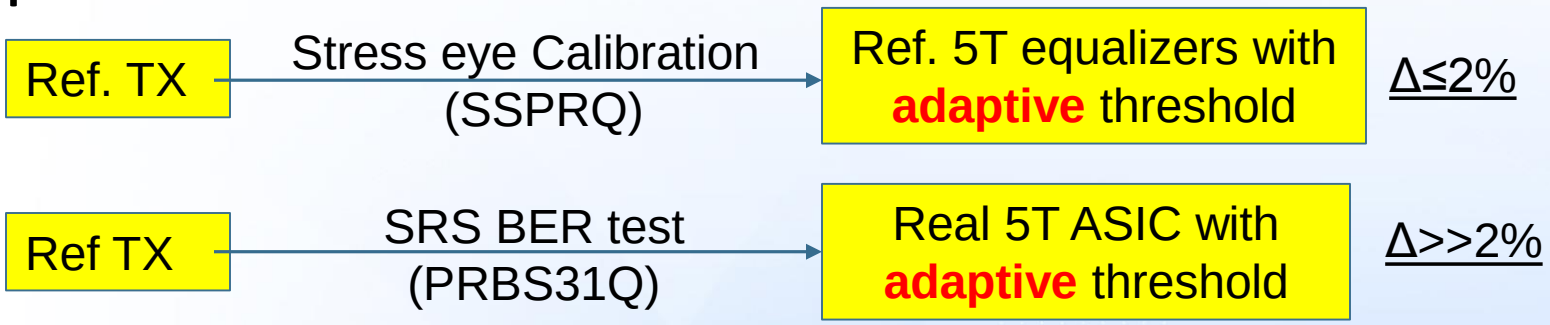
Comments on king_3cd_01_0318: SRS

Slide #9-10

D3.1 definition



New proposal



If the reference receiver has less threshold adjustment range than real receiver, then the receiver performance and yield is not going to be impacted

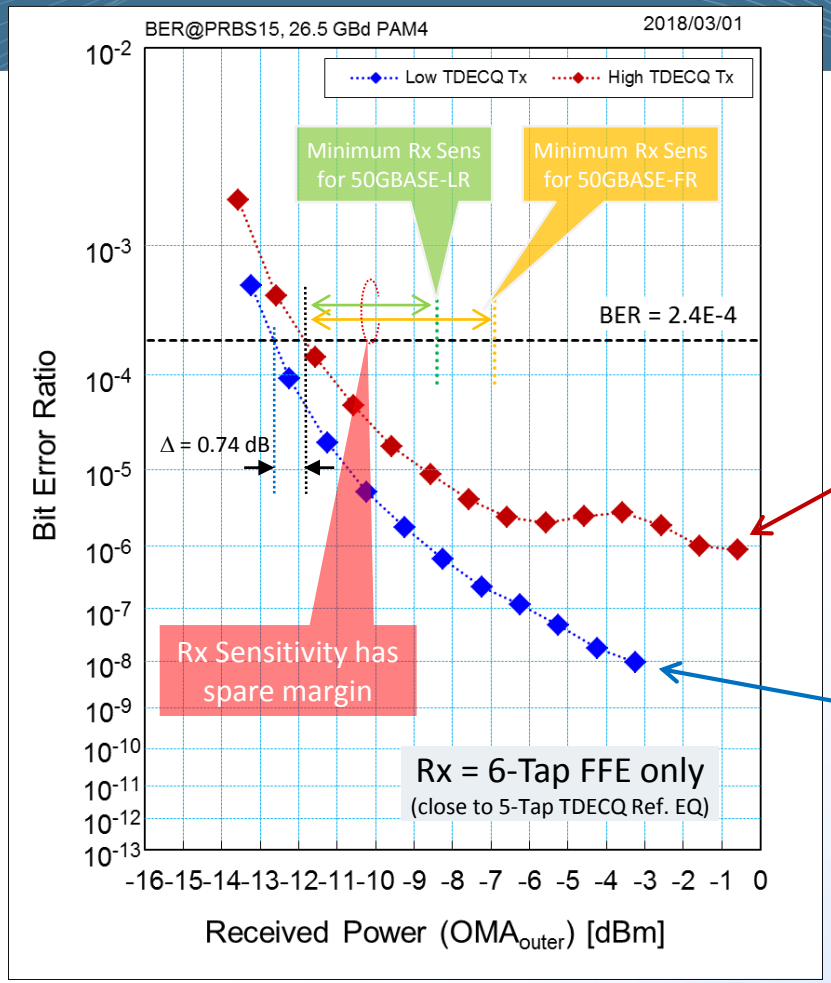
Additional Supporting Data

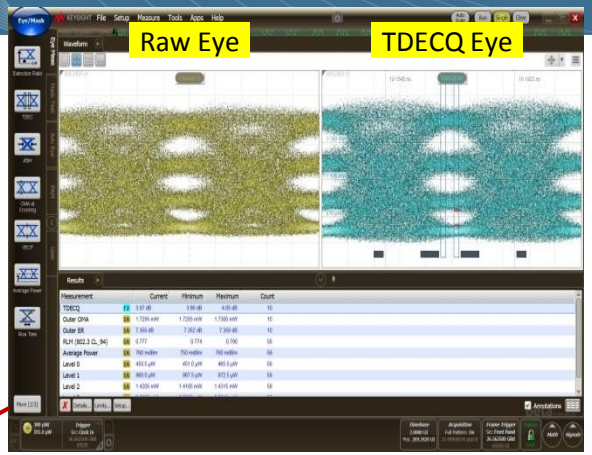
Introduction

- BER measured for low and high TDECQ* Tx using 50G-PAM4 Rx with 6-Tap FFE.
- TDECQ/SECQ (SSPRQ, no reference fiber) measured for low and high TDECQ Tx at different levels of threshold adjustment.
- Observed the following when comparing Rx Sensitivity for low and high TDECQ Tx:
  1. Rx Sensitivity specification has margin.
  2. Without threshold adjustment, TDECQ overestimated Rx penalty at 2.4E-4 BER.
  3. Threshold adjustment of up to 2% of OMA_{outer} showed good correlation to Rx penalty.

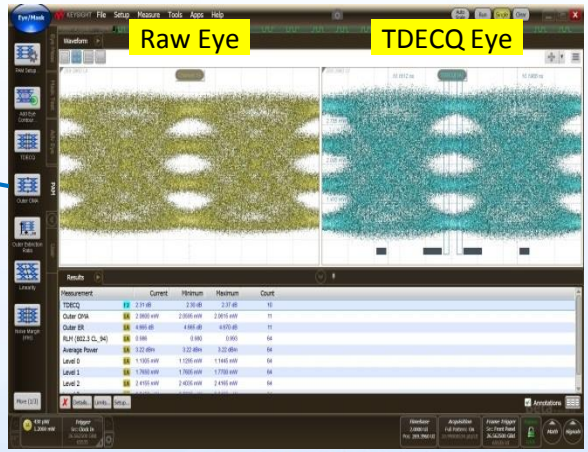
* “Low” and “high” TDECQ refer to values measured per D3.1.

50G-PAM4 BER For Low And High TDECQ Tx





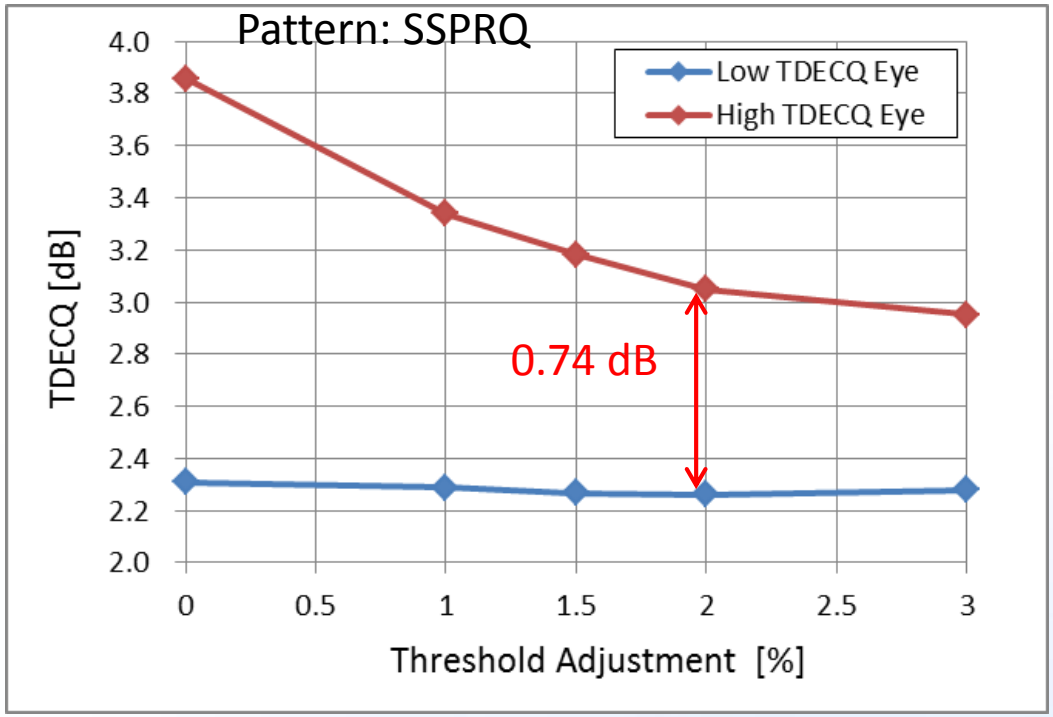
High TDECQ Tx (3.8 dB)



Low TDECQ Tx (2.3 dB)

1. Measurements of 50G-PAM4 BER suggest Rx Sensitivity specifications for 50GBASE-FR and -LR have spare margin.
2. Reasonable to increase margin of Tx TDECQ by allowing small amount of threshold adjustment, which will help Tx yield.

TDECQ Versus Threshold Adjustment For Low And High TDECQ Tx



1. ΔTDECQ without threshold adjustment (i.e. 0%) overestimates ΔRx Sensitivity at 2.4E-4 BER → ΔTDECQ = 1.6 dB corresponded to ΔRx Sensitivity = 0.74 dB (Δ is difference between low and high TDECQ Tx measurements).
2. Threshold adjustment lowers TDECQ of high TDECQ Tx and gives better correlation to Rx penalty.
3. At 2% threshold adjustment, ΔTDECQ ≃ ΔRx Sensitivity.

Conclusions

- Rx Sensitivity has spare margin, so no risk in introducing small increase in margin of Tx TDECQ by allowing small amount of threshold adjustment in reference receiver.
- Threshold adjustment improves correlation between TDECQ and Rx Sensitivity.
- Up to 2% of OMA_{outer} for threshold adjustment range gives good correlation between ΔTDECQ and ΔRx Sensitivity.

Thank You