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TDECQ Versus High SER Limits

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Background details

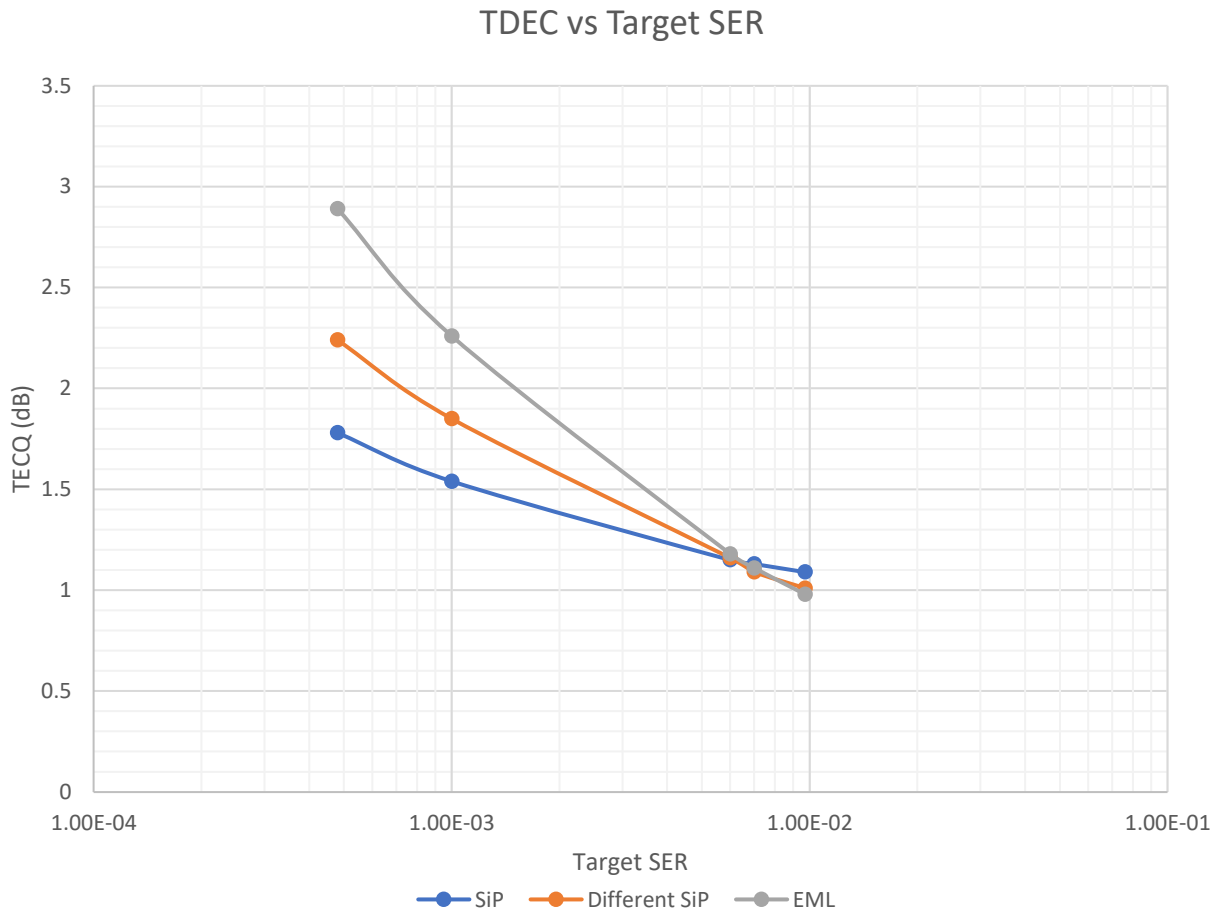
- TDECQ is a key metric used to assess the waveform quality of a PAM4 transmitter
- TDECQ should predict the receiver sensitivity power penalty due to eye closure and dispersion relative to an ideal transmitter
- TDECQ is measured at the pre-FEC SER limit
- Basic measurement process: Determine how much noise can be added to the transmitter and reference transmitter to reach the target SER, compare noise levels to determine power penalty

What do we expect for TDECQ as we increase the target SER?

- With higher levels of FEC, we expect higher pre-FEC SER limits
  - To be determined, but approximately 10X higher than the SER limits used in earlier standards requiring TDECQ
- Should TDECQ change as SER is increased?
  - As SER is increased, more noise can be added to the signal before the target SER is observed
  - More noise can also be added to the reference transmitter. Key question: Does the ratio of the two added noises change as SER is increased?
  - For TDECQ to change the ratio of added noises must change

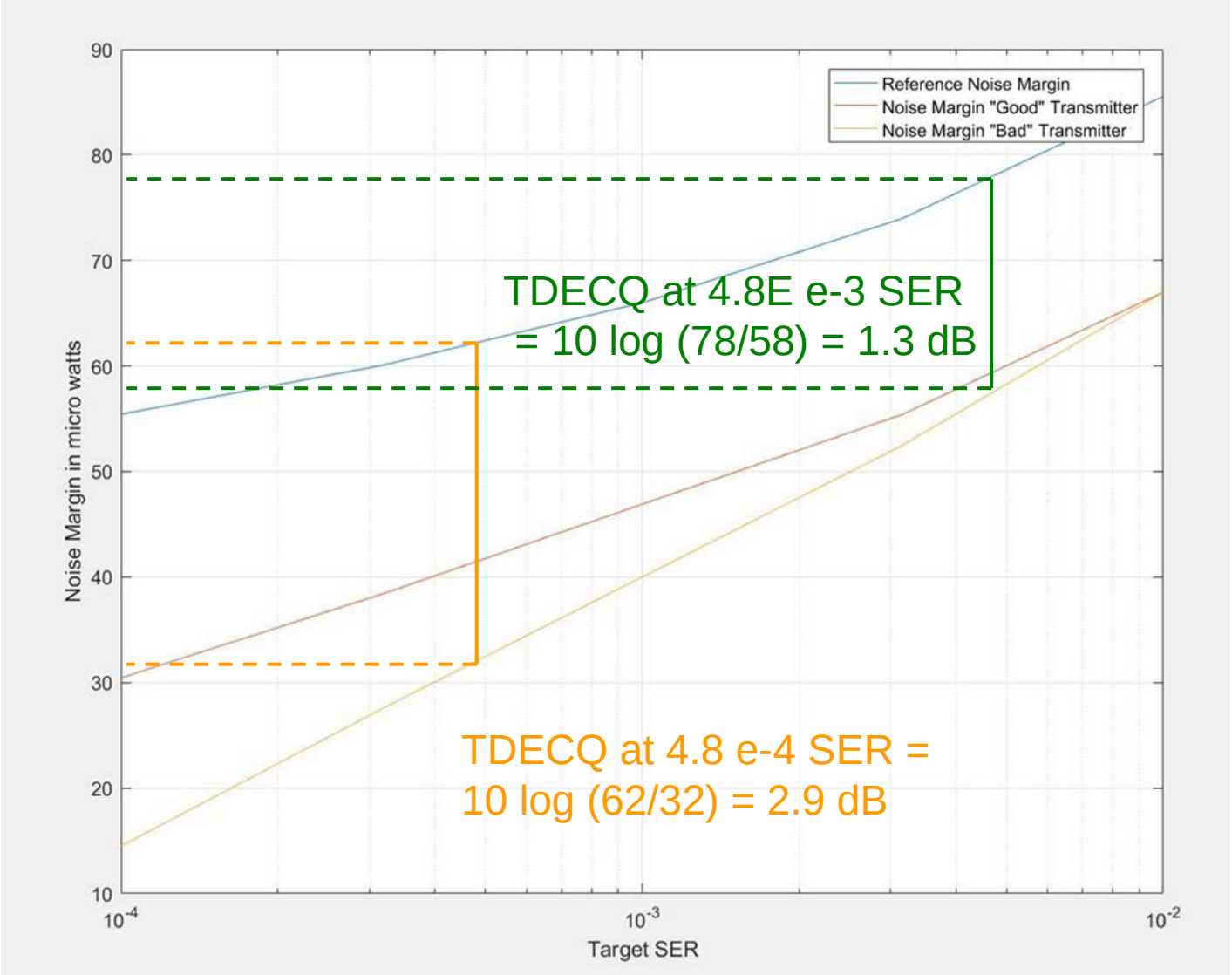
Some observations of measured TDECQ versus SER for real transmitters

- 100G transmitters
- Two SiP and one EML
- One waveform acquired for each transmitter
- 5 tap FFE in TDECQ virtual reference receiver
- SER limit varied from 4.8 e-4 to 9.7e-3
- For the three transmitters a 1.1 dB separation in TDECQ penalty values is observed at common 4.8e-4 SER, but TDECQ converges to very similar values at high SER



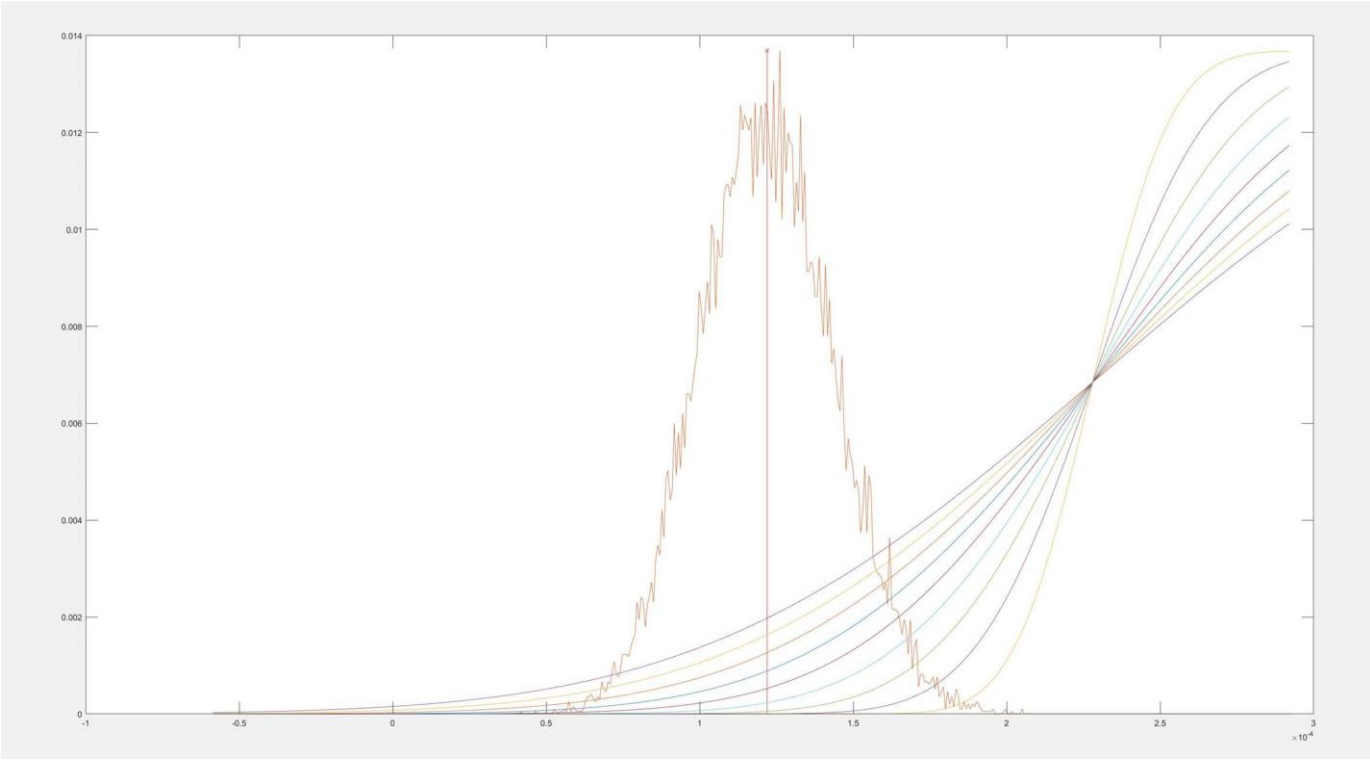
Is convergence expected? (Updated slide)

- Plot noise margin in microwatts versus SER for:
  - Ideal reference signal with no impairment
  - Measured signal: Best TX and worst TX
- TDECQ is the ratio of the noise margins at a given SER
- As SER is increased, TDECQ decreases and eventually converges for the two measured transmitters



Behavior of TDECQ for large SER

- Graphically show relationship of added noise for a variety of sigma and an ideal (shown as an impulse) and real signal (with magnitude histogram)
  - Magnitudes of these three have been modified so they can be seen together.
- Contribution to SER is the area under the product of the data histogram (or ideal signal impulse) and the added noise CDF
- As SER is increased, noise sigma increases. Increased sigma results in SER contribution converging for ideal and real signals



Implications on specifying and testing transmitters

- Analysis performed on 100G lanes. Assume that it scales and represents what will occur for 200G lanes
  - Can be easily verified with 200G lanes by acquiring a waveform and adjusting the SER target in the TDECQ reference receiver
- Key question: Does this convergence represent behavior in real systems?
  - Does the TDECQ penalty represent the receiver sensitivity penalty observed at a high SER?
  - Would two transmitters that have different TDECQ at low SER, but similar TDECQ at high SER yield similar receiver sensitivities observed at the high SER?
- This is early work and requires further analysis and physical verification

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Thank you