Resolution of the ongoing discussion on use of MMSE tap-weight optimization for TDECQ

Relative to Comments I-28 (Ghiasi), I-37 (Le Cheminant) against draft 3.0 802.3db

IEEE P802.3db 100 Gb/s, 200 Gb/s, and 400 Gb/s Short Reach Fiber Task Force

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TDECQ uses a multi-tap FFE with tap weights adjusted to minimize reported penalty

- TDECQ works well, does what it was intended to do
  - Quantify relative power penalty due to TX impairments and dispersion
- Measurement is somewhat complex but uncontroversial
- Optimization of TDECQ reference receiver EQ is defined simply: Find whatever tap values provide the lowest TDECQ penalty (Clause 121).
  - Any search method that does not consider every possible tap weight combination yields a solution that is a subset of the clause 121 'full search' solution set.
  - Full search definition: Every possible allowed tap weight combination is verified

TDECQ reference receiver

- Real receivers typically optimize tap weights through some form of eye quality optimization and not a full search of all possible tap weights
- No physical receiver has infinite resolution in setting tap weights
- The clause 121 optimization method is a useful measurement concept
  - It is very simple to define
  - It generates the best TDECQ penalty possible
  - It provides a simple way to easily validate any alternative optimization methods (assuming the TDECQ measurement method is constant)
    - How close was the alternative reported TDECQ value to the value obtained with the clause 121 'full search'

How is TDECQ performed today?

- T&M vendors I am familiar with provide a 'full search' to optimize EQ tap weights yielding the lowest observed TDECQ penalty. However, 'full search' is a secondary method (they default to faster optimization methods)
  - T&M 1: "Iterative Optimization" must be enabled to perform Clause 121 full search
  - T&M 2: "Extended search" must be enabled to perform Clause 121 full search

- Our opinion: Majority, perhaps 90% of TDECQ measurements made today are performed using something other than the full search allowed/defined by clause 121 to optimize EQ tap weights

Tap weight optimization tradeoffs

o Earlier discussions on this topic showed that an MMSE-based TDECQ tap weight optimization is performed in less than 1 second with a TDECQ result within 0.1-0.2 dB of a full search result

o By definition the full search should yield a TDECQ result that is less than or equal to any other optimization method applied to the same waveform. (Measurement uncertainty/repeatability can occasionally result in other optimizations yielding slightly lower values)

Correlation of Full Grid Search and MMSE-based tap weight optimization

- Result from ghiasi_802.3db_01_092321
  - For 2% threshold that was adopted the MMSE vs full grid search has an R^2=0.9989!
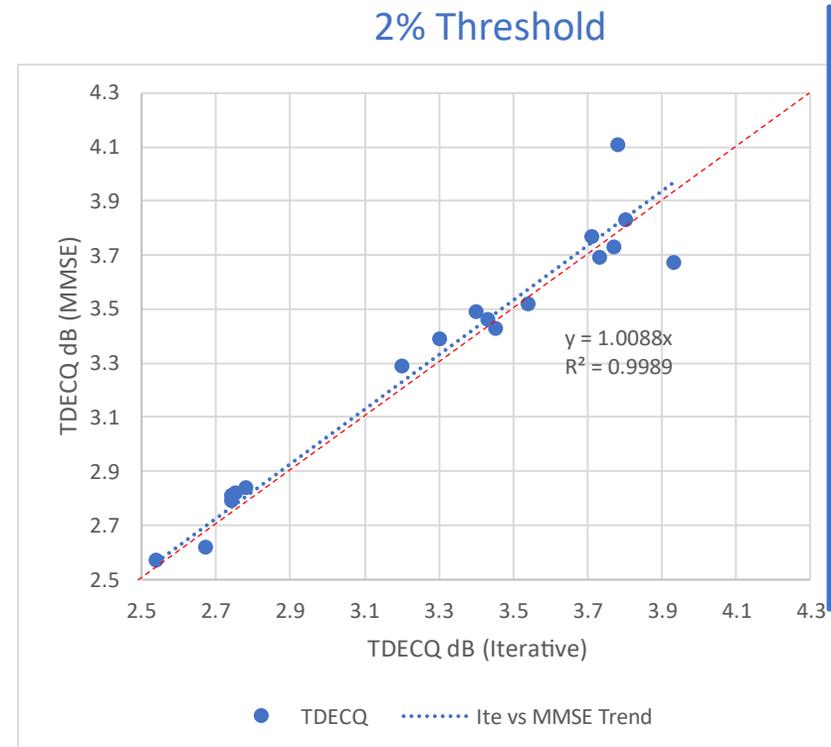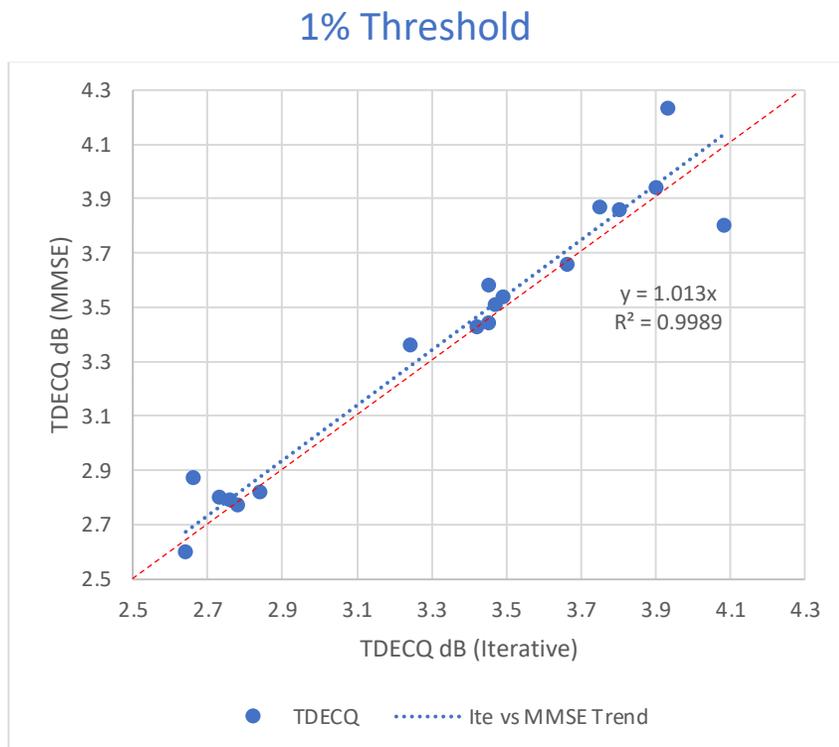
Note fitted trendline (blue) slightly above ideal 1:1 (red).

MMSE values should be greater than or equal to Full Search values for the same waveform. (Measurement uncertainty/repeatability can result in MMSE reporting slightly lower values)

Possible improvement for 802.3db

- As we move from the 5 tap EQ used in previous 802.3 standards using TDECQ, to a 9 tap EQ in 802.3db, a full search will require much longer optimization times
- Can we be informative about methods to reduce test times without changing the TDECQ optimization method as it is currently defined in clause 121?

Proposed remedy

- Clause 121 is unchanged
- In clause 167.8.6 where TDECQ is described/referenced, there is an exception list documenting the key differences in the 802.3db method from clause 121.8.5 including the fiber emulation and wider decision threshold limits.
- Modify the text of clause 167 by adding another item to the exception list, currently found on draft 3.0 page 57 line 40:

- *The lowest possible TDECQ value is achieved with the equalizer optimization method described in clause 121.8.5. Test times can be significantly reduced using optimization methods such as minimum mean squared error (MMSE) to determine equalizer tap weights. The tradeoff of reduced test time and a possibly higher reported TDECQ penalty for the same waveform should be considered. There is no change in specification limits when using alternate optimization methods.*

Note that this text is modified from what was originally submitted through comment #37

Impact of this change

- Clause 121 'full search' EQ tap optimization remains unchanged
- With this modification, an implementer of the 802.3db standard, with its longer reference receiver equalizer, is informed that the TDECQ measurement can be performed in a more time efficient manner and will be aware of the tradeoff of a possible higher reported value

- Since the optimization of tap weights is potentially modified, and not the measurement itself, there is no interoperability risk from false positives.