Further thoughts on TECQ/TDECQ for 200G/L optical PMDs --Relating Comment # 315

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Introduction

- The previous contribution showed changes to Data link reliability has significant impact to optical methodology.
- One key question is how to maintain the correlation between Tx and Rx spec, and the independency of Tx spec.
- This requires revisit of the TECQ/TDECQ measurement.
- This contribution provides some idea for this TF's consideration.

Recap-How we get to TDECQ/TECQ

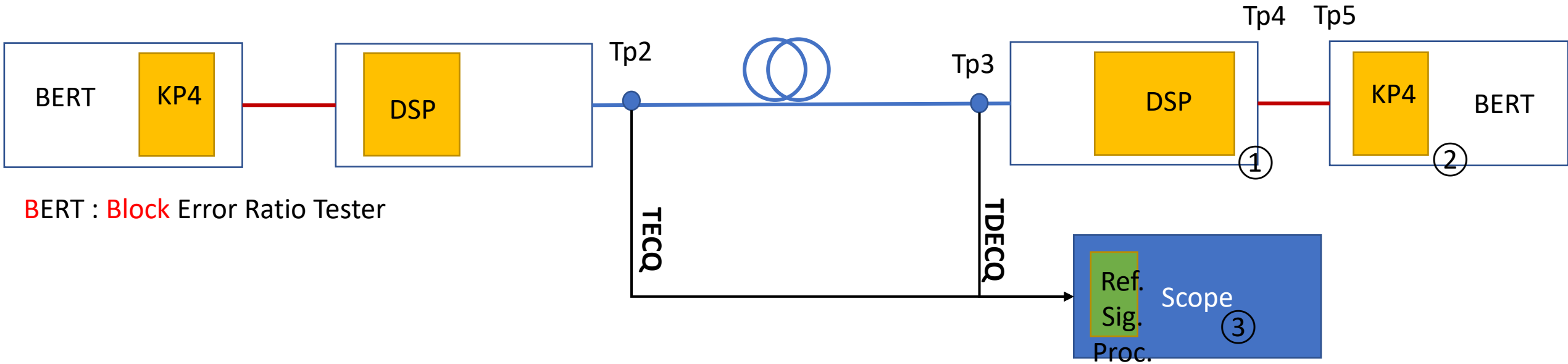
We are defining a set of requirements for optical transmitters so that:

- A Tx meeting the requirements will work satisfactorily in the field
- A Tx failing the requirements will not work in the field
- Minimize the number of Tx, which meet the requirements and not work in the field (unhappy customers)
- Minimize the number of Tx, which fail the requirements but otherwise would have worked satisfactorily in the field (reduced yield by throwing away good devices).

Evolution of Tx Metric

- For 25 Gb/s NRZ systems we used a combination of TDP, transmitter and dispersion penalty, and eye mask.
- For 50 Gb/s PAM4 systems, TDP and eye mask requirements could no longer be used, due to PAM4 signaling and introductions of equalizers. TDECQ was introduced, including the definition of a reference receiver, which defined the minimum capability of the system receiver.
- **For 100 Gb/s PAM4 systems** a single TDECQ specification was not regarded sufficient and additional limits for TECQ (zero dispersion) anod |TDECQ – TECQ| were added including additional parameters such as over/under-shoot and transmitter transition time.
- Now in P802.3dj for 200 Gb/s PAM4 signaling we are finding out that the parameters previously used, such as TDECQ, may need to be modified/refined, due to additional effects such as sensitivity to negative dispersion (not being an issue for lower rates), inner FEC, AUI becomes negligible, etc.

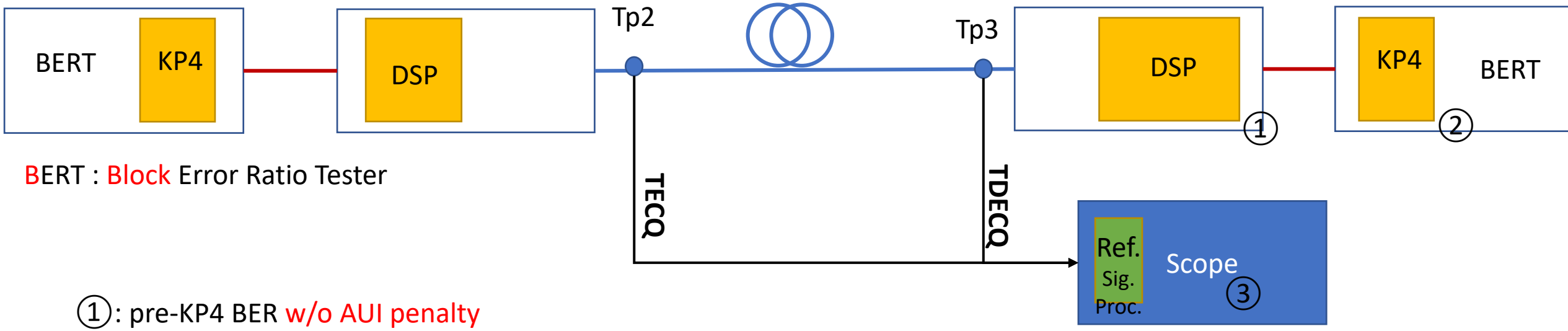
Error Ratio labels used in this contribution and their Relation to TPs in IEEE802.3



BERT : Block Error Ratio Tester

TP2 and TP3 : not measuring error ratio, a PAM4 target SER ③ is used in the calculation of TECQ/TDECQ
TP4 : Bit Error Ratio ① can be measured at the output of an optical module with MCB and/or BERT
New : Post-KP4 Error Ratio ②

The x Error Ratio metrics



BERT : Block Error Ratio Tester

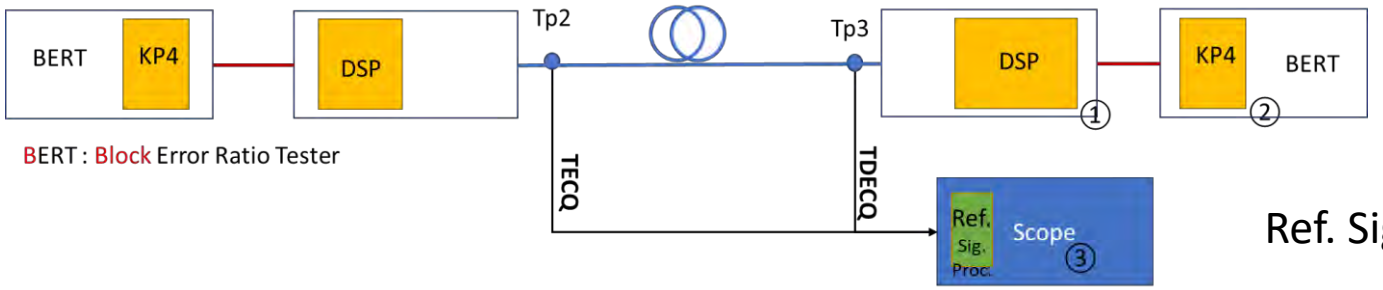
①: pre-KP4 BER w/o AUI penalty

②: post-KP4 BlockER w/ BER_{added} allocation for AUI penalty

③ : equivalent to what is achievable @ ①, but with a Ref. Rx

- Defined as target PAM4 SER, = 2x pre-KP4 BER
- Allow independently qualify Tx
- A mutually agreed baseline as a Ref. Signal Processing., representing the bare minimum of Rx capability (some concerns have been raised regarding the strength of the Ref Rx. Up for discussion another day.)

Possible approach 1 of TDECQ, indirect of BlockER



Ref. Sig. Processing only includes 15-tap FFE

Build relation : 2x raw BER @ TP3/2 => 2x BER ① = 2x *f*(Block Error Ratio②)

FECo

- Agree on target PAM4 SER *b*, that allows good distinction of Tx performance
- Use *b* for all FECo PMDs, i.e., DRx, FR4-500
- *b* has been 4.8e-4, there has been concerns on the number, whether it needs some tightening

FECi

- Agree on target PAM4 SER *a*, that encapsulates the distinct capabilities of different implementation of Inner FEC
- Use *a* for all FECi PMDs, i.e., DRx-2, FR4, LR4
- In the comment a = 9.6e-3, which the author has no strong feeling towards. Could use a as place holder during discussion.

Analysis needed regarding the choice of *a* and *b*

Possible approach 2 to adapt to the new metric

If a calculation relation can be established for
Pre-BER = *f*(Block Error Ratio)

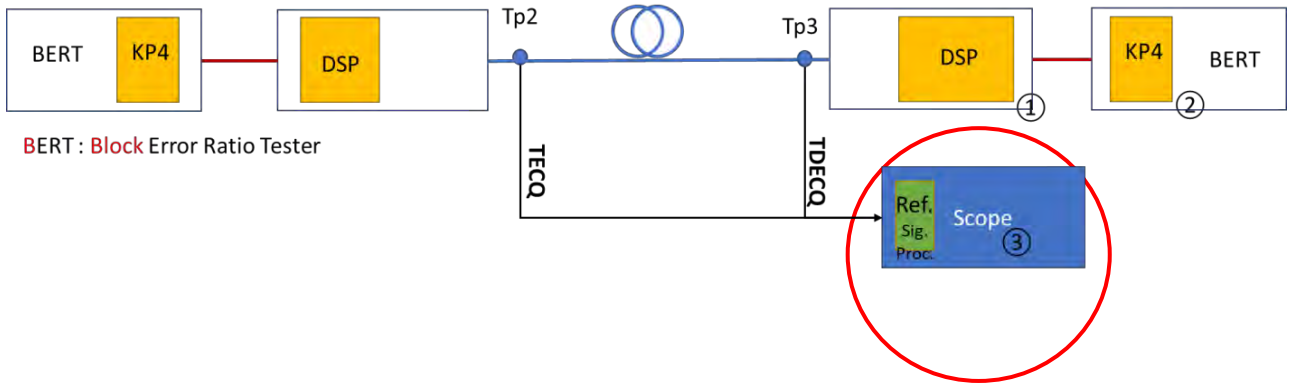
Then we may find consensus on a new Target PAM4 SER

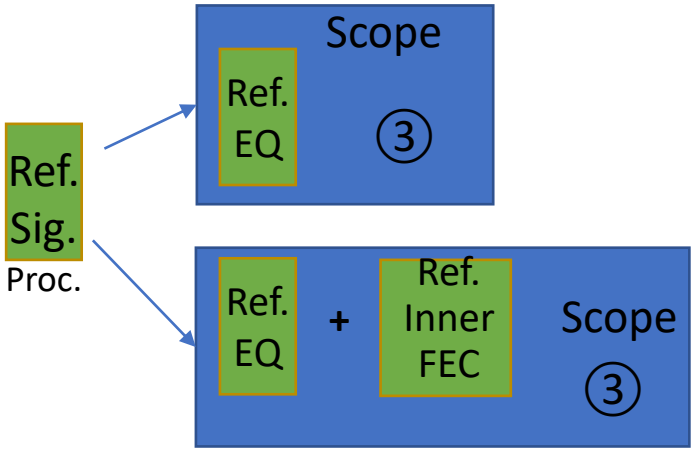
@output of module
i.e. after EQ and inner FEC

2x pre-KP4 BER① = 2x *f*(Block Error Ratio②)

→ PRBS31Q @ FECo
→ PRBS31Q encoded by inner FEC

Issue 1: Need to think about Ref. Rx., for FECo and FECi





Both output an Eye Diagram which can be used for calculation of TDECQ
Creating a universal measure for all 200G/L PMDs, Regardless of FECo/FECi

Possible approach 2 to adapt to the new metric

If a calculation relation can be established for
Pre-BER = *f*(Block Error Ratio)

Then we may find consensus on a new Target PAM4 SER

- = 2x pre-KP4 BER = 2x *f*(Block Error Ratio)

Issue 1: Need to think about Ref. Rx., for FECo and FECi

Ref. EQ + Ref. Inner FEC Scope ③

Chase-II decoder with 42 test patterns (flipping up to 3 bits out of 6 least reliable positions)
Block diagram as shown on page 6, he_3df_01a_220308
→Looking for feedbacks if further details is believed to be needed.

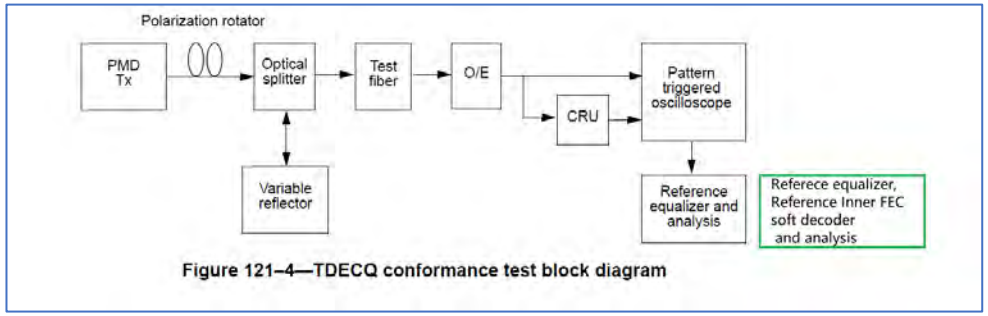


Figure 121–4—TDECQ conformance test block diagram

Creating a universal measure for all 200G/L PMDs, Regardless of FECo/FECi

Possible approach 2 to adapt to the new metric

If a calculation relation can be established for
Pre-BER = *f*(Block Error Ratio)

Then we may find consensus on a new Target PAM4 SER

- = 2x pre-KP4 BER = 2x *f*(Block Error Ratio, BER_{added})

Issue 2： Need to think about what to do with AUI's BER_{added}

? Possible to built in the maths in TECQ/TDECQ algorithms?

- Provide some flexibility in R&D
- Recommended is BERadded = 4e-5 for worst case possible AUI link

Another way of looking at this

For a given Tx(with possible impairments), if we were to quantify its performance using a pre KP4-FEC BER value, We need to first rule out influencing factors from other parts of the link:

- Receiver bandwidth → set by 3dB bandwidth and BT filter response a , as defined 121.8.5.1
- Equalizer strength → set by reference equalizer
- ✓ FEC → KP4 is fixed. Inner FEC needs to be dealt with.
- ✓ AUI → we didn't care too much in 100G/L, but care seems needed in 200G/L

Summary

- This contribution discusses the change to TECQ/TDECQ methodology due to the newly adopted Block Error Ratio.
- A possible approach is provided to adapt to the new situation.
  - A relation can be established between BER and Block error ratio. Updating the target PAM4 SER according to the relation seems reasonable. A complexity comes from the BER_{added}, some further discussion needed.
  - The BER is at the output of an optical module. For FECi optical PMDs, that is post- inner FEC. Adapting reference receiver used for TECQ/TDECQ to include a reference inner FEC helps build a universal measure of 200G/L optical PMDs.