C2M TP1a/TP4 Methodology

Junqing (Phil) Sun, Yasuo Hidaka
Credo Semiconductor

Introduction

- C2M module/host inputs have been qualified at TP1a/TP4 with a reference receiver and test fixtures. With data rate increased to 100Gbps per lane, C2M channels are more challenging and reference receivers are more complicated [sun_3ck_01_0519]. This contribution is to discuss challenges to define reference receivers, reference channels, and test fixtures.

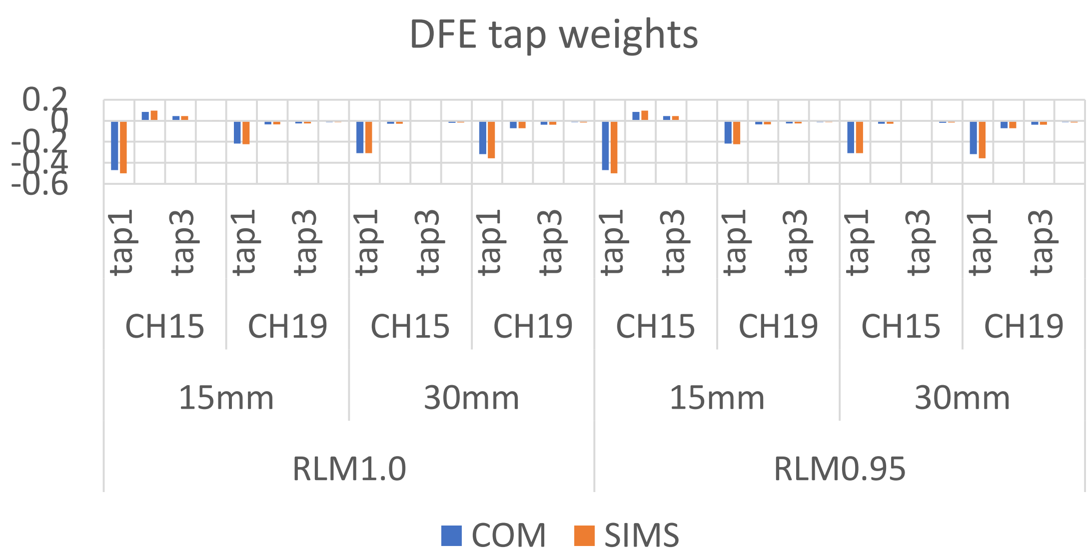
  1. 100G C2M reference receiver is likely to have adaptive filters. Tuning methodology needs to be defined. There are two approaches that may be reused in existing IEEE 802.3 standard - Annex 93A for COM and TDECQ approach.

  2. Module output is qualified at TP4 near- and far-end. Module TX FIR is set with a TP4 far-end reference channel. 100G C2M channel insertion loss is 16dB, and reflection has big impact on performance. How to define far-end reference channels for module TX FIR adjustment and module output signal qualification?

Reference Receiver Tuning Methodology

Ref RX Methodology I – Leverage Annex 93A and 120E

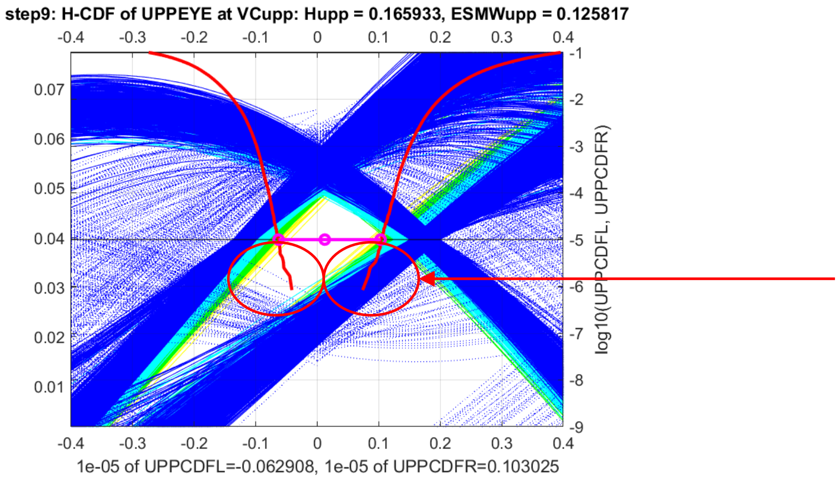
- Pulse fitting to extract pulse response.
- Leverage Annex 93A for optimal phase and DFE tap weight.
- Apply phase and DFE weight on measured waveforms. Noise and distortion are all kept. Reuse Annex 120E for test point measurement.
- Pros: simple algorithm. Reliable and fast. Similarity with COM tool.
- Existing Annex 93A is well documented for receivers that have only DFE taps.



Good correlation is observed for DFE coefficients by waveform simulation and COM tool. This helps to use COM tool for system study.

Ref RX Methodology II – TDECQ Approach + Annex 120E

- TDECQ approach. Reuse Annex 120E for test point measurements.
- The standard does not specify how to optimize FFE. VEC/VEO/EW is calculated for each step/combination of FFE coefficients. Best setting is picked based on eye statistics.
- Pros: it has been implemented for TDECQ in existing scopes.
- Cons: optimized based on eye statistics. Reliability and tuning speed may be a challenge.
- Theoretically this approach can be applied on both FFE- and DFE-based receivers. But involving DFE taps will require additional phase optimization. Existing TDECQ method is for a receiver with only FFE taps.



- Sufficient samples are needed to construct reliable VEC/EH/EW etc.
- As it is statistics based, multiple settings may result in similar measured results.

TP4 Reference Channel Model and MCB

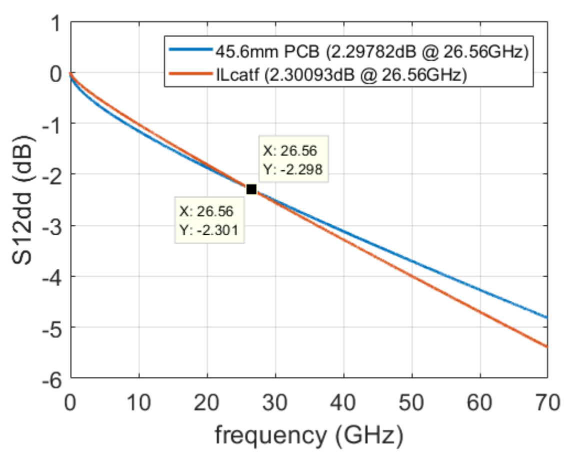
- A first cut to try ideal reference channel and test fixture models with focus on module TX FIR setting.

TP4 - MCB model

- Same Insertion Loss as $IL_{CATF}(f)$ in diminico_3ck_01_0519.pdf slide 4
  - $IL_{CATF}(f) = 1.073 \times \left(-0.00125 + 0.12\sqrt{f} + 0.0575f\right)$
    - 2.30 dB at 26.56GHz

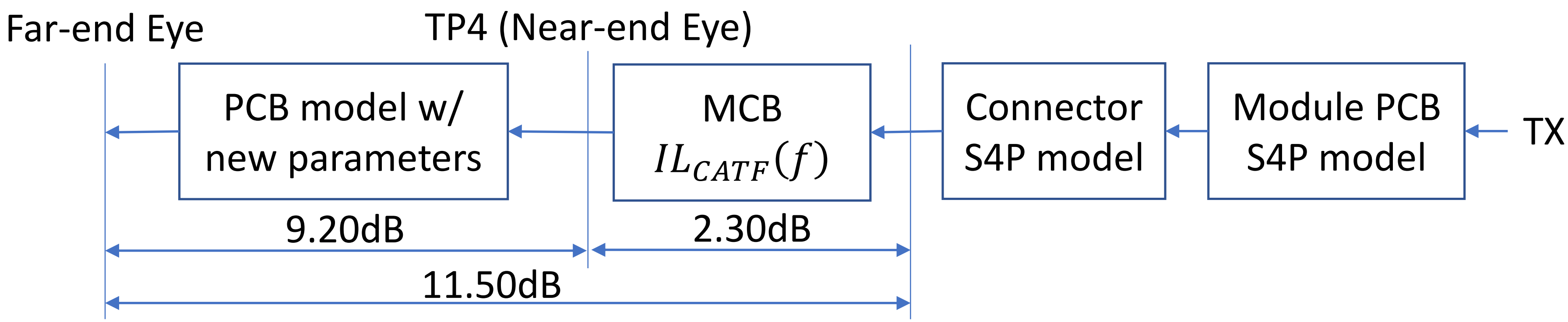
- S-parameter:
  - Phase is to match 2.30dB PCB model
  - 45.6mm PCB model has 2.30dB at 26.56GHz using Table 92-12 parameters shown in config_example_ieee8023_93a=3ck_KR_mellitz_06_12_2019
    - $\gamma_0 = 0,\ a_1 = 5.990 \times 10^{-4},\ a_2 = 1.022 \times 10^{-4},\ \tau = 6.200 \times 10^{-3}$

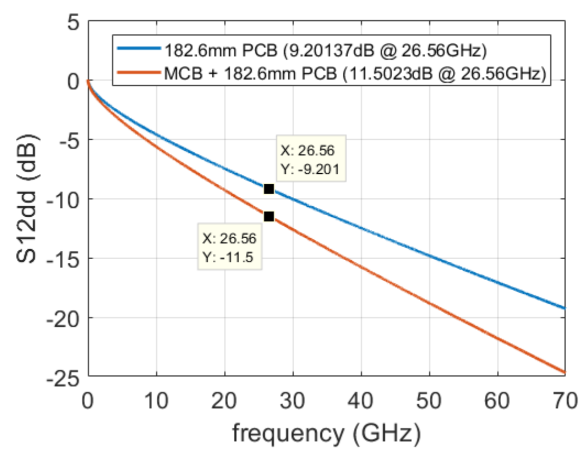
- Use the exact $IL_{CATF}(f)$ equation with same delay as PCB model



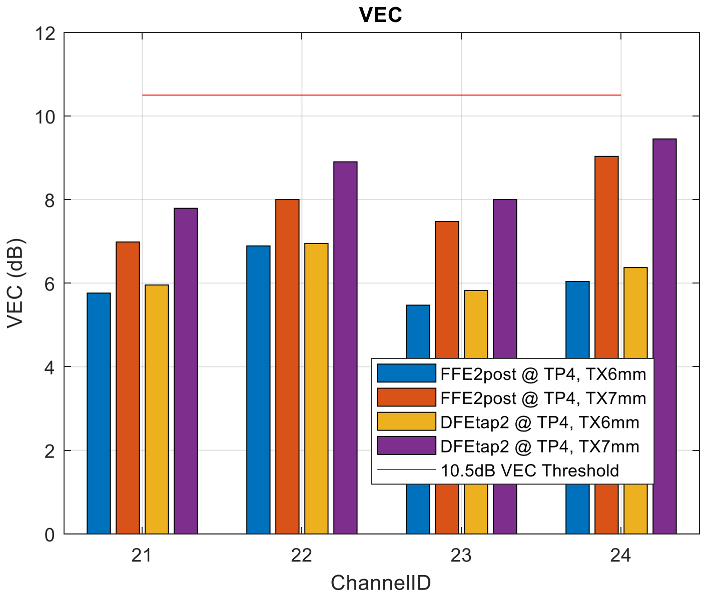
Module Output Far-End Reference Channel model

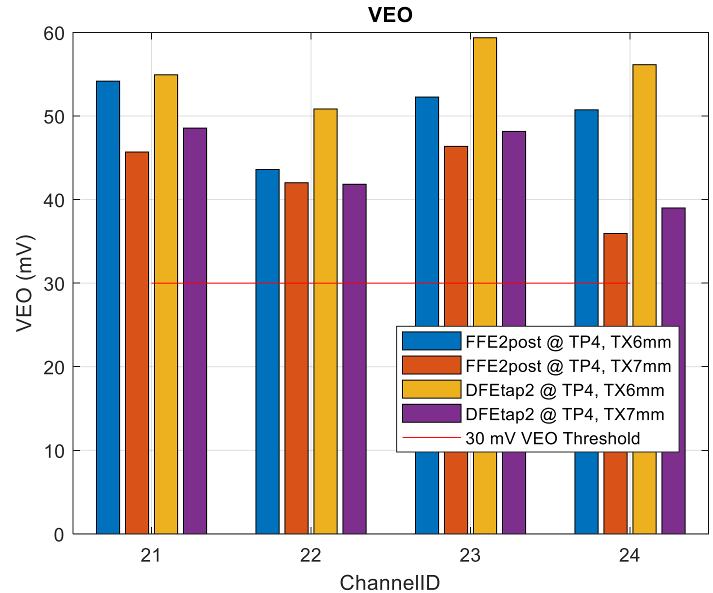
- Host IL (11.5dB) – MCB IL (2.3dB) = PCB model IL budget (9.2dB)
  - 182.6mm PCB model has 9.20dB at 26.56GHz using Table 92-12 parameters shown in config_example_ieee8023_93a=3ck_KR_mellitz_06_12_2019
    - $\gamma_0 = 0,\ a_1 = 5.990 \times 10^{-4},\ a_2 = 1.022 \times 10^{-4},\ \tau = 6.200 \times 10^{-3}$





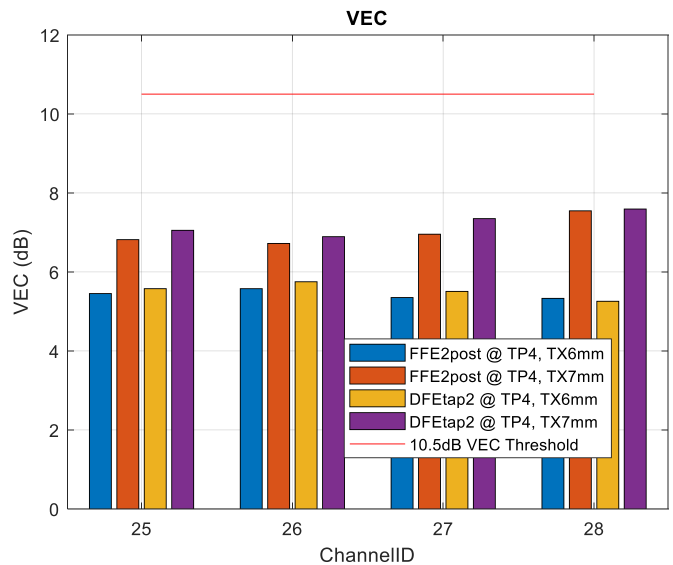
Module Output Near-End

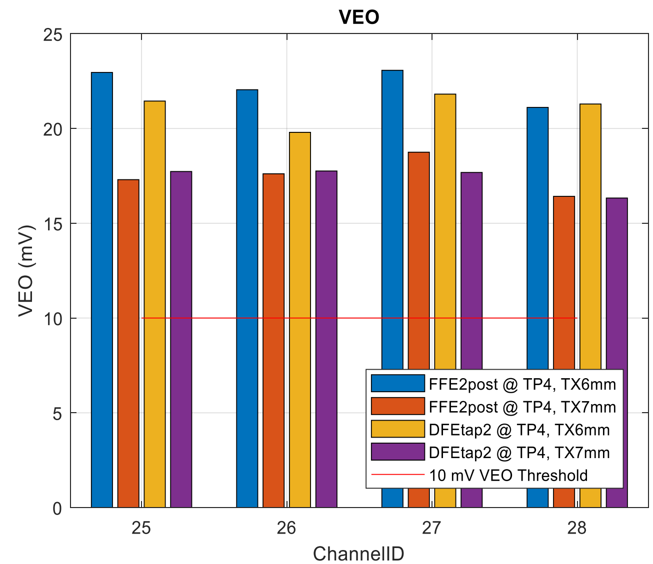




- Ch 21-24 are module trace of channel 17-20 in sun_3ck_01_0519 cascaded with MCB.
- Reference receivers are C2 (3-tap FFE) and D2 (1-tap DFE on post 2).
- Inductor termination model for module.

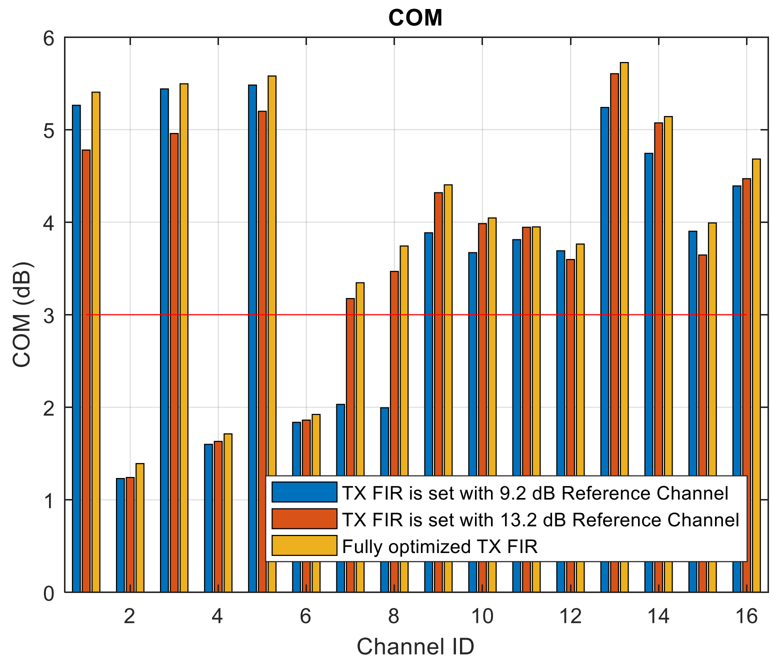
Module Output Far-End with Reference Channel





- Ch 25-28 are module trace of channel 17-20 in sun_3ck_01_0519 cascaded with MCB and 9.2 dB far-end reference channel.
- Far-end signal has lower VEO but better VEC.

Module TX FIR Settings



- TX FIR optimized at TP4 far-end with reference RX C2 are applied to all channels to check TX FIR sensitivity.
  - One case is with TX for channel 25 (with MCB and 9.2 dB reference channel).
  - The other case is with reference channel increased to 13.2 dB to cover host package loss.
- 13.2dB reference channel helps performance of 7 and 8 by more than 1 dB.
- XTK of these C2M channels contributed to ck project is not accurate for module-to-host simulation. It has limited impact to this study.

Conclusion

- Annex 93A or TDECQ methodology may be reused for reference receiver tuning. Existing Annex 93A is well documented for “DFE-only” receivers, while TDECQ methodology is used for a “FFE-only” receiver.

- More than one reference channels may be needed to cover different host traces.