802.3ck Chip-to-Module TP1a/TP4 Compliance Test Measurement Methodology

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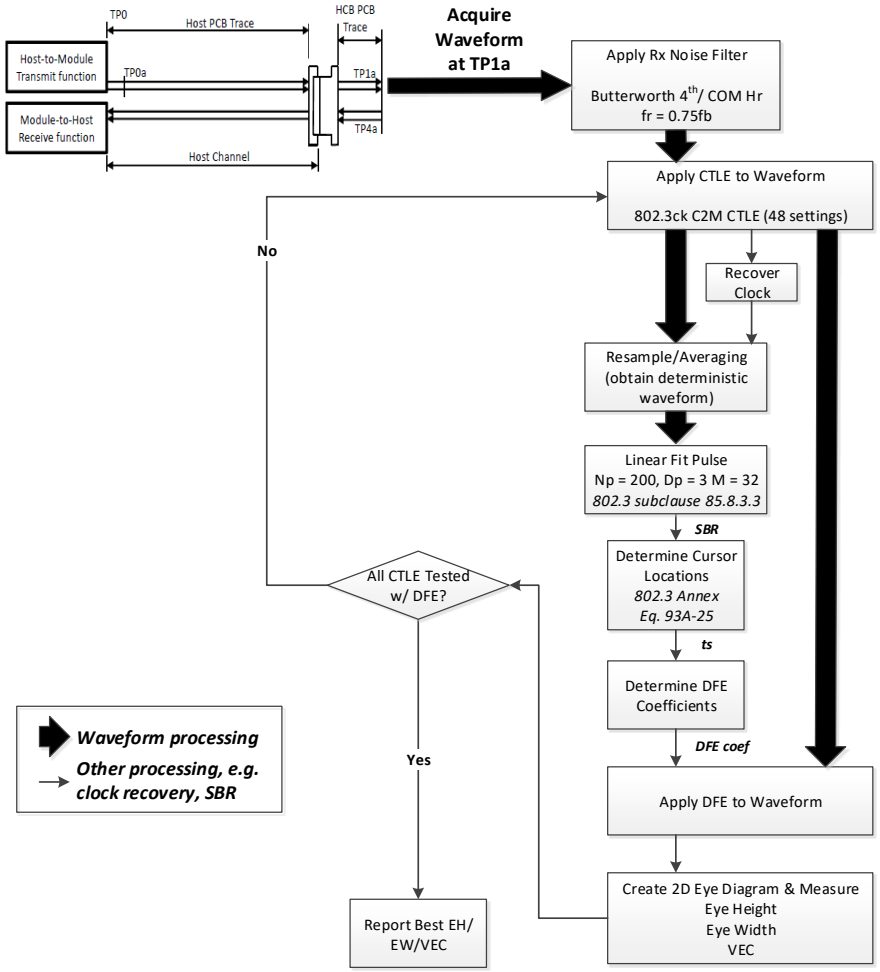
Contents

802.3ck C2M TP1a Compliance Test Measurement Flow

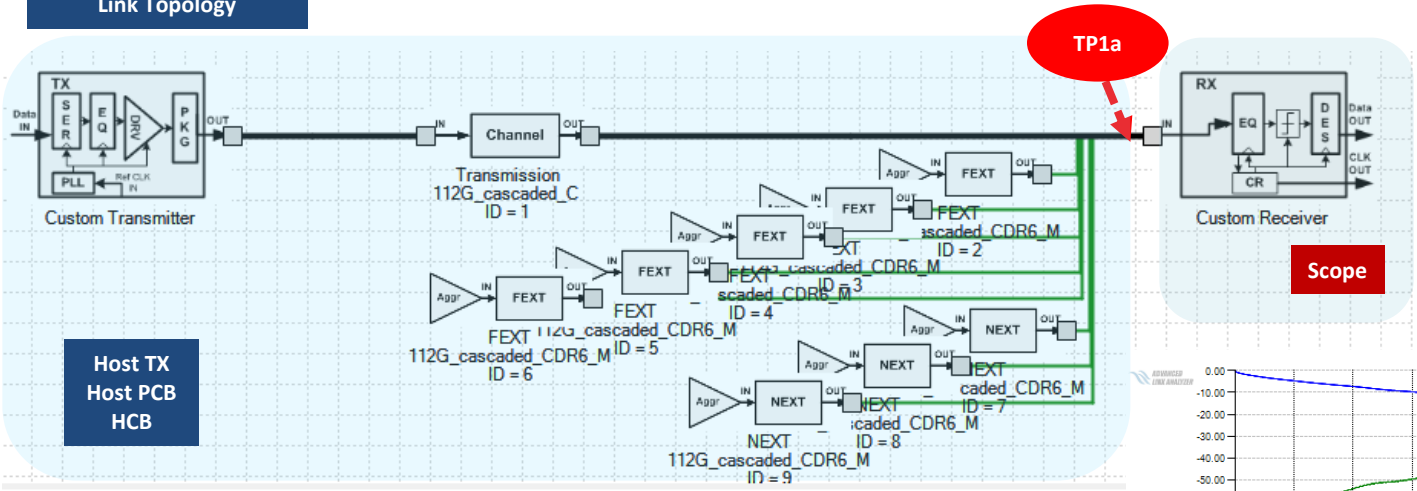
- Waveform is captured at TP1a by a
  - real-time scope

  or
  - sampling scope with clock recovery module (CRU)
- Performs post processing to determine compliance FOM (EH/EW/VEC)
  - Key post-processing components
    - Noise filter
    - CTLE
    - Clock Recovery/Resampling/Averaging
    - SBR fitting
    - DFE coefficients from SBR
    - Apply DFE to CTEL output waveform
    - Eye diagram construction
- TP4 measurement method will be similar to that for TP1a

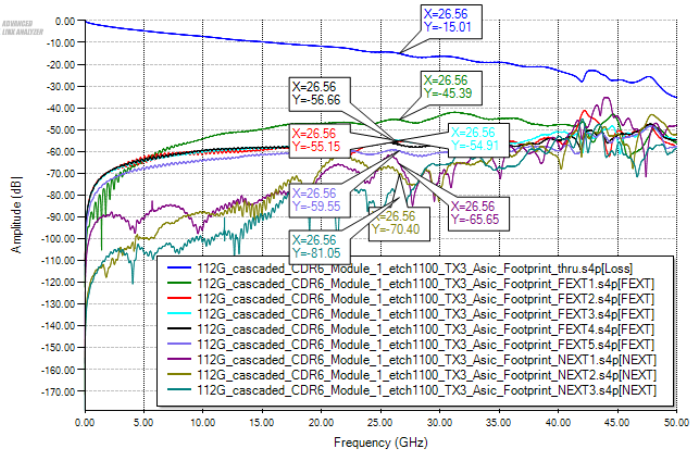


802.3ck C2M TP1a Compliance Test Measurement Example

Link Topology



Channel Characteristics

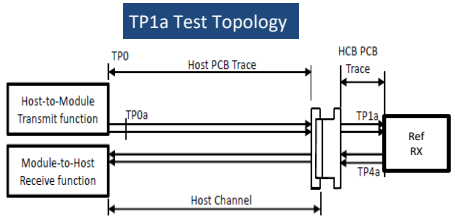


Channel	Description	Insertion Loss (dB) @ 26.56 GHz	ICN (mV-rms)*
6	112G_16dB_(QSFPDD+module card)_TX3_Asic	15.01 + TX Pkg	1.29

802.3ck C2M TP1a Simulations: Link & Device Configurations

- Data Rate: 106.25 Gbps, PAM-4
- Test Pattern: PRBS13Q, 1M Symbols (for waveform simulations)
- Target BER: 10^{-5}
- TX Die
  - VOD: 830 mV-pp (TP0a amplitude)
  - 20%-80% Rise/Fall Time: 6.16 ps
  - TX FIR:
    - Configuration:
      - 4 or 5 taps: 2 or 3 pre-taps and 1 post-tap
      - Pre-tap 1: [-0.3:0.02:0]
      - Pre-tap 2: [0:0.02:0.1]
      - Pre-tap 3: [0]
      - Post-tap1: [-0.1:0.05:0]
  - RLM (level mismatch): 0.95
  - TX termination: 50 Ω
  - TX Capacitance
    - Cp=120 fF, Ls=120nF, Cb=30fF
    - Jitter/Noise
      - DJ: 0.04 UI-pp (dual-Dirac)
      - RJ: 0.01 UI-rms
      - Noise: ~9.92mV-rms (SNR_{TX}=33dB)

- TX/Host Package
  - Package model
    - Length: 30mm T-line + 1.8mm PTH
    - T-line/PTH parameters: a1=0.0009909, a2= 0.0002772, tau=6.14e-3 ns/mm, $Zc_{T\text{-}line}$=87.5Ω, Zc_{PTH}=92.5Ω
    - Cp = 87fF
  - Package crosstalk is < -60 dB (by design)



802.3ck C2M TP1a Simulations: Link & Device Configuration (cont.)

- **TP1a Reference RX**
  - Die Termination: 50 ohms
  - No package and die capacitance
  - AFE Filter and CTLE

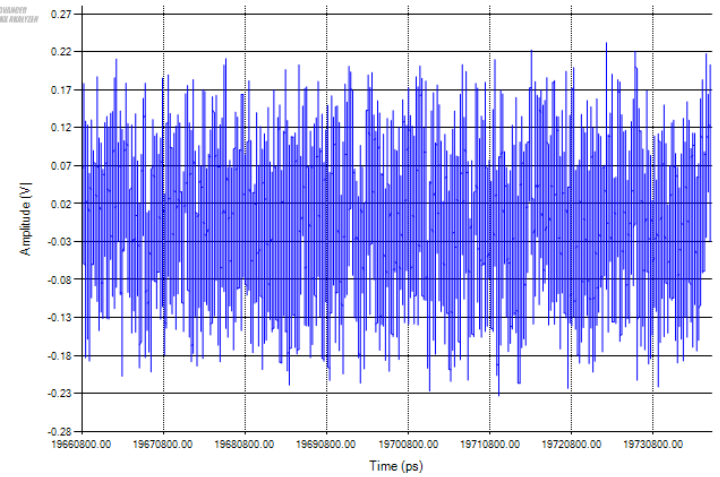
$$H_r(f) = \frac{1}{1 - 3.414214 \cdot \left(\frac{f}{f_r}\right)^2 + \left(\frac{f}{f_r}\right)^4 + j \cdot 2.613126 \cdot \left(\frac{f}{f_r} - \left(\frac{f}{f_r}\right)^3\right)}$$

$$H_{CTF}(f) = G \cdot \frac{\left(10^{\frac{g_{dc2}}{20}} + j\frac{f}{f_{z2}}\right)}{\left(1 + j\frac{f}{f_{zp}}\right)} \cdot \frac{\left(10^{\frac{g_{dc}}{20}} + j\frac{f}{f_{z1}}\right)}{\left(1 + j\frac{f}{f_{p1}}\right)\left(1 + j\frac{f}{f_{p2}}\right)}$$

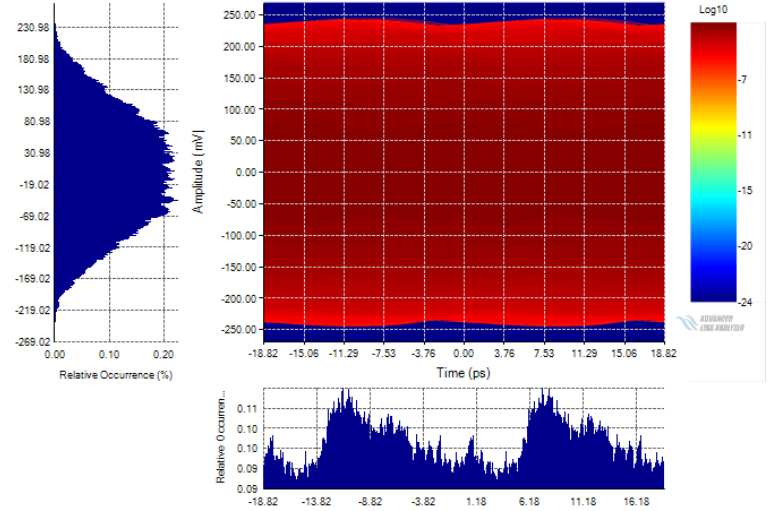
    - Baud: 53.125 Gbd
    - CTLE
      - » fp1 / fp2 / fz1 / fz2 / fzp = 20 / 28 / 12.58 / 1.328 GHz
    - g_{DC}: *-3 to -14dB*
    - g_{DC2}: *0 to -3dB*
    - G: 1.0 (constant)
  - DFE:
    - 4 taps
      - First tap: +/-0.5, others: +/-0.2
  - Jitter/Noise:
    - Input noise: 8.2e-9 V^2/GHz

802.3ck C2M TP1a Measurement Data

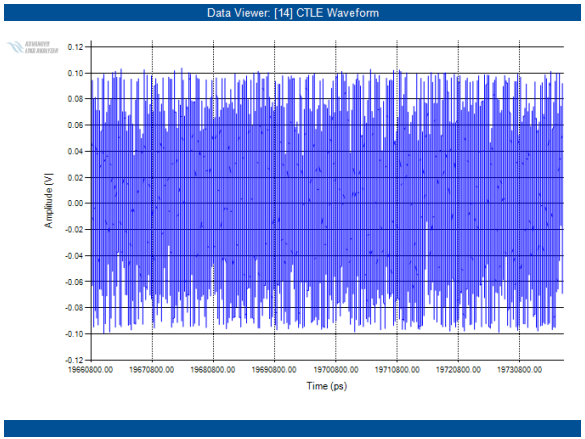
Data Viewer: [9] CH Waveform

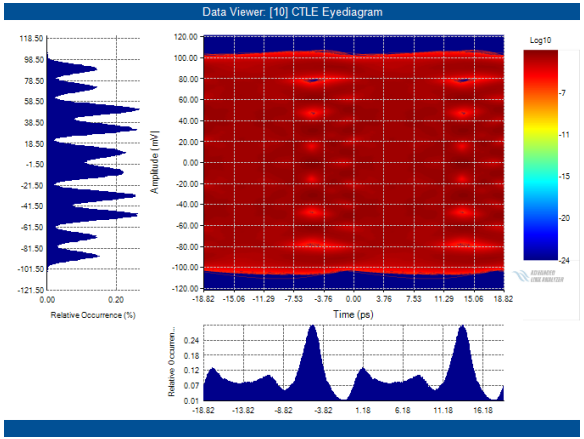


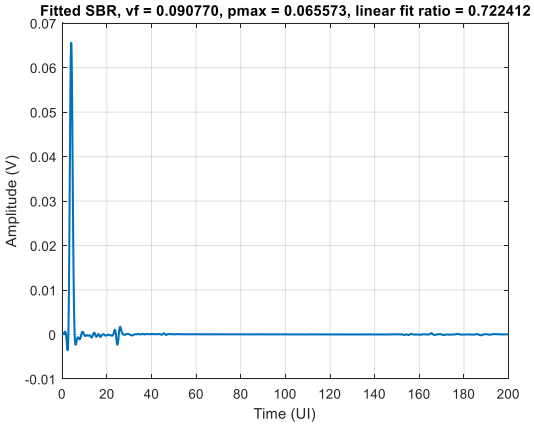
Data Viewer: [5] CH Eyediagram



Post-Processing: Rx Noise Filter, CTLE and SBR Fit

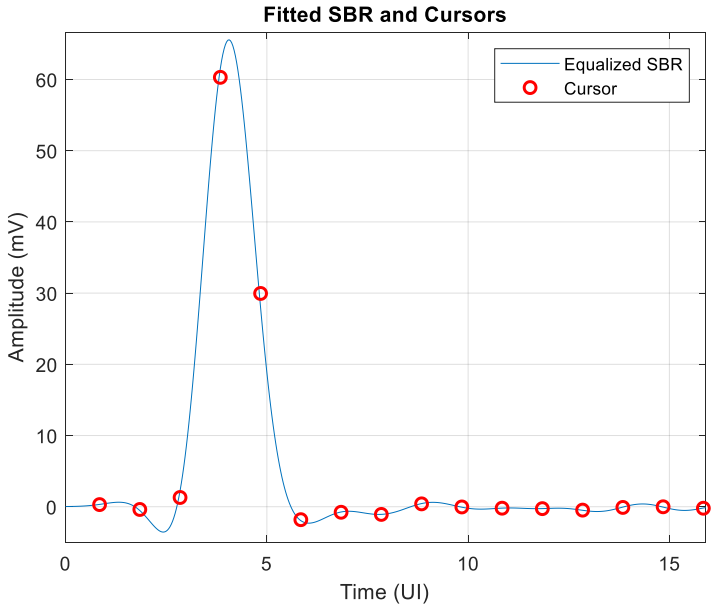






- Rx Noise Filter
  - fr=0.75*fb
- CTLE
  - G_DC = -7dB, g_DC_HP = -3dB
- Linear Fit Pulse Configuration
  - Np = 200, Dp = 3, M = 32
  - per 802.3 subclause 85.8.3.3

Determine Cursor Locations & DFE Coefficients



- Cursor locations
  - Determine by using 802.3 Annex 93A Eq. 93A-25

$$h^{(0)}(t_s - T_b) = h^{(0)}(t_s + T_b) - h^{(0)}(t_s)b(1)$$

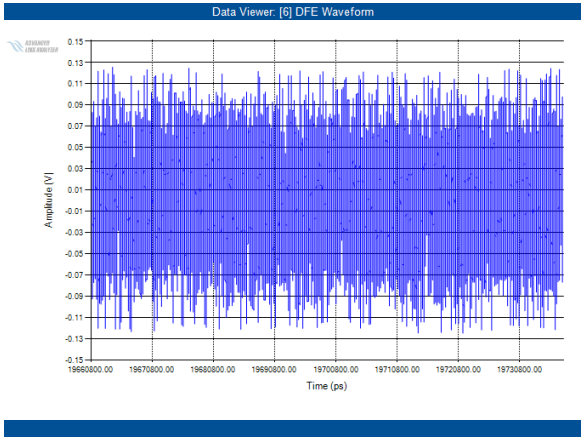
where b(1) = *0.5*

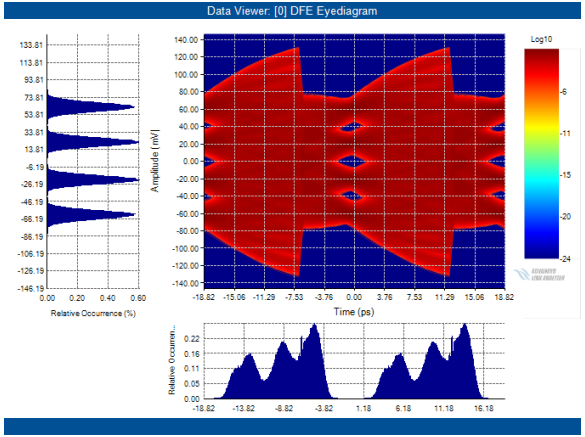
- DFE coefficients
  - Determine by using 802.3 Annex 93A Eq. 93A-26

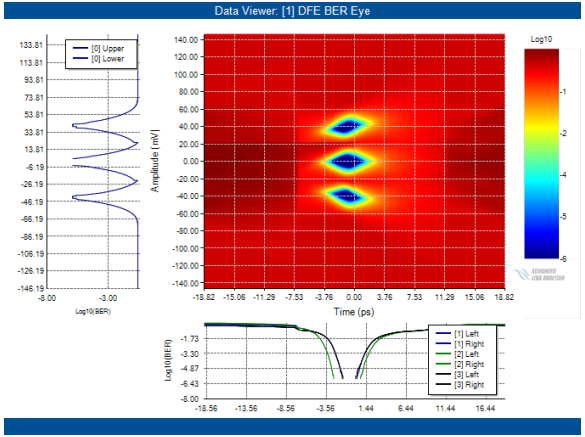
$$b(n) = \begin{Bmatrix} -b_{\max}(n) & h^{(0)}(t_s + nT_b)/h^{(0)}(t_s) < -b_{\max}(n) \\ b_{\max}(n) & h^{(0)}(t_s + nT_b)/h^{(0)}(t_s) > b_{\max}(n) \\ h^{(0)}(t_s + nT_b)/h^{(0)}(t_s) & \text{otherwise} \end{Bmatrix}$$

  - For this example, main cursor is 60.3mV and post cursors are *[29.952 -1.818 -0.775 -1.078] mV or [0.497 -0.030 -0.013 -0.018]* of main cursor amplitude
  - DFE coefficients are *[0.497 -0.030 -0.013 -0.018] according to Eq. 93A-26*

Apply DFE to Waveform and FOM Measurement







- DFE coefficient *[0.497 -0.030 -0.013 -0.018]* is applied to CTLE output waveform
- Eye Height ≈ 11.41mV, Eye Width ≈ 0.13UI, VEC ≈ 9.04dB

Thank You !