TX LINEARITY MEASUREMENT PROPOSAL

(IN SUPPORT OF COMMENT #118)

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OVERVIEW

- **Overview of CDAUI-8 c2c TX linearity Specifications in Draft 1.1**
- **Proposal to change usage of R_{LM} & SNDR**
- **Proposal to change method to measure PAM4 TX levels**

CDAUI-8 C2C CURRENT METHOD

- **Inherited from Clause 94 (100GBase-KP4) and referenced by TX SNDR & R_{LM}**
  - **94.3.12.5.1 Transmitter linearity**
    - Measure TX Linearity Test Pattern to obtain V_A, V_B, V_C, V_D
    - Calculate **ES_1 & ES_2** (to allow for asymmetric inner PAM4 data levels) and R_{LM}

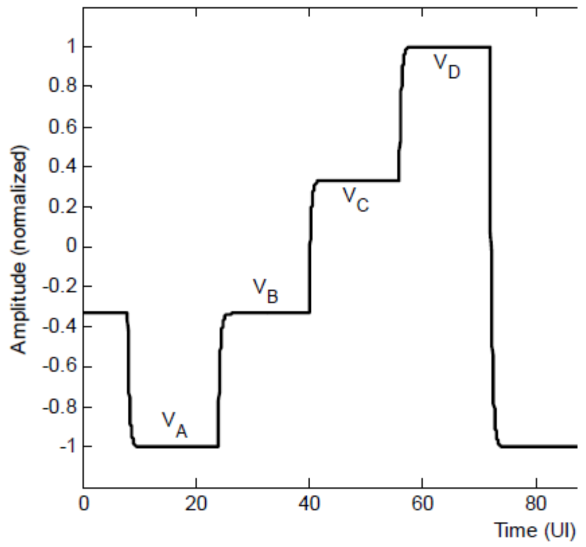
$$S_{min} = \frac{\min(V_D - V_C, V_C - V_B, V_B - V_A)}{2}$$

$$V_{avg} = \frac{V_A + V_B + V_C + V_D}{4}$$

$$ES_1 = \frac{V_B - V_{avg}}{V_A - V_{avg}}$$

$$ES_2 = \frac{V_C - V_{avg}}{V_D - V_{avg}}$$

$$R_{LM} = \frac{6 \cdot S_{min}}{V_D - V_A}$$



  - **94.3.12.5.2 Linear fit to the measured waveform**
    - Measure PRBS13Q
    - Calculate **SNDR, p(k)** using an assumption that data levels are (-1,**-ES_1,ES_2**,1)

CURRENT DEFINITION

- **R_{LM} constraint on the TX should provide reasonable implementation margin for TX while limiting impact on the RX complexity and link budget**

- **Current R_{LM} specification is based on the minimum eye opening between the 4 PAM levels**

- **PAM4 levels are [-1,-ES1,+ES2,+1] with ES1=ES2=1/3 in the normal case**
  - Current R_{LM} spec allows these TX cases with no downside or penalties

% error on ES1 & ES2	Notes
-5%, -5%	Symmetric case with 5% smaller middle eye
+10%,+10%	Symmetric case with 5% smaller outer eyes (compressed outer levels)
-20%,+10%	Asymmetric case with 10% larger lower eye and 5% smaller upper eye
+10%,-20%	Asymmetric case with 5% smaller lower eye and 10% larger upper eye

  - For a 1Vpp example, the asymmetric cases have voltage levels of [-500, -133,+183,+500] mV
  - The difference between the +1/3 and -1/3 levels is 50mV

MOTIVATION TO CHANGE RLM & SNDR DEFINITION

- **Transmitters designed for electrical links have good vertical symmetry (ES1 ~= ES2)**
  - CAUI4, 100G-CR4 & 100G-KR4 constrain vertical asymmetry by SNDR. We can do the same here.
- **Current spec allows large deviations from ideal levels (up to 20% in asymmetric case)**
  - COM models the reduction in ideal eye opening implied by R_{LM}, but assumes perfect ISI cancellation by DFE
  - It is not practical for a DFE to achieve this when TX levels are distorted
  - Margin impact is proportional to the max. error on ES1 and ES2 and DFE tap weights
  - Need to constrain the maximum error on ES1 and ES2 to avoid the worst case effect
  - Assume that 5% errors in ES1 and ES2 can be absorbed by RX implementation budgets
- **R_{LM} spec allows larger deviation (+10%) on the positive side of ES1 and ES2**
  - In addition to DFE's imperfect ISI cancellation, this case is further aggravated by RX circuit compression
  - Even with perfect linearity in the RX, PAM4 outer eyes are already more distorted.
- **With the proposed best fit method to estimate ES1 & ES2 accurately, there is less concern about measurement errors**

PROPOSAL FOR RLM & SNDR

- **Estimate ES1 & ES2 using best fit method**
- **R_{LM} defined to capture maximum deviation from ideal**
  - R_{LM} = Min(3*ES1, 3*ES2, 2-3*ES1, 2-3*ES2) with limit of 0.95
  - This will allow ES1 and ES2 to assume values of +/- 5% around ideal value of 1/3
- **Define ES = (ES1 + ES2)/2**
- **Change SNDR to use the source TX levels as [-1, -ES,+ES,+1]**
- **+/-5 % error in TX levels should be absorbed by RX implementation, but recommend 3dB COM margin**
- **Advantages**
  - No impact to common TX cases with symmetric levels within +/-5% of ideal
  - SNDR now captures symmetry errors
    - Low levels of vertical asymmetry do not affect SNDR measurably
      - ES1,ES2 = (+2%,-2%) results in < 0.1dB SNDR penalty