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A Proposed Specification for Master Transmit Jitter in 802.3ch

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Transmit Jitter Requirement for Multi-Gbaud BASE-T

- Earlier BASE-T PHYs always ran sub 1GBaud, so Jitter components (RMS, Deterministic, Even-Odd) were either a none issue and/or could easily be met
  - Symbols times were <1ns → Help relax the RMS requirement
  - Transmitter could easily be clocked at baud rate frequency → No Even-Odd & Minimal Deterministic

- 10GBASE-T1 operating PAM4 at 5.6GBaud:
  - Symbols times are <200ps
  - Transmitter cannot easily be clocked at baud rate frequency → Even-Odd & Deterministic Jitter

  → All Jitter components start to be important and need to be specified

Existing 802.3 PAM4 Standard Specifications

- There are already different 802.3 standards that define PHY specification with PAM4 signaling at Multi-Gbaud rates
  - 802.3bj defines specifications for 25Gbps PAM4 signaling at 13.25GBaud
  - 802.3cd defines specifications for 50Gbps PAM4 signaling at 26.5GBaud

- We can adopt the transmit jitter specification of either of the PAM4 Multi-Gbaud standards.
  - Select 802.3bj-KP4:
    - Simpler jitter test setup and closer in baud rates to 10GBASE-T1
    - Can refer to the same standard in future for potentially 25GBASE-T1 as well

Proposed Transmitter Jitter Specifications

- Defining specs for three main Tx jitter parameters:
  - Random RMS (RJ_{RMS}), Deterministic (DJ), Even-Odd Jitter (EOJ)

- Jitter Test pattern: JP03A
  - The JP03A test pattern is generated prior to PAM4 encoding. When the JP03A test pattern is enabled, it replaces the signal from the precoder. The JP03A test pattern is a repeating {0,3} sequence.

- Jitter Test pattern: JP03B
  - The JP03B test pattern is generated prior to PAM4 encoding. When the JP03B test pattern is enabled, it replaces the signal from the precoder. The JP03B test pattern is a repeating sequence of {0,3} repeated 15 times followed by {3,0} repeated 16 times. Total length of the pattern is 62 symbols as follows:

03030303030303030303030303033030303030303030303030303030303030

Proposed RJ_{RMS} & DJ Master Tx Measurement Procedure

- Use the following procedure for RJ_{RMS} & DJ jitter measurement:

1. Transmit JP03A pattern continuously
2. Using a CDR with a corner frequency of ***X*** and a slope of 20dB/decade, capture the zero-crossing times, $T_{ZC}(i)$, of N symbols with N > 10^7 (10G: ***X*** =1MHz, 5G: ***X*** =0.5MHz, 2.5G: ***X*** =0.25MHz)
3. Determine the average pulse width T_{Avg}: $$T_{Avg} = \frac{T_{ZC}(N) - T_{ZC}(1)}{N-1}$$
4. Determine the jitter series, $\tau(j)$, j=2 to N: $$\tau(j) = T_{ZC}(j) - (j-1)\cdot\Delta T_{Avg} - T_{ZC}(1)$$
5. Create a Cumulative Density Function (CDF) of $\tau(j)$.
6. Calculate J5 as the difference between CDF of $\tau(j)$ at the $(1–0.5\times10^{-5})$ and 0.5×10^{-5}.
7. Calculate J6 as the difference between CDF of $\tau(j)$ at the $(1–0.5\times10^{-6})$ and 0.5×10^{-6}.

➔ RJ_{RMS} = 1.0538×(J6-J5) ➔ DJ = J5 - 9.3098×(J6-J5)

Proposed EOJ Master Tx Measurement Procedure

- Use the following procedure for Even-Odd jitter measurement:
  1. Transmit JP03B pattern continuously
  2. Capture the time for 60 consecutive zero-crossing transitions with averaging to reduce noise/jitter effects
  3. Determine the average zero-crossing times, $T_{ZC}(i)$ with i= 1 to 60, where i=1 designates the transition from 3 to 0 after the consecutive pair of symbols {3,3}.
  4. The set of 40 pulse widths, $\Delta T(j)$, isolated from the double-width pulses are determined by

$$\Delta T(j) = \begin{Bmatrix} T_{ZC}(j+10) - T_{ZC}(j+9) & 1 \le j \le 20 \\ T_{ZC}(j+19) - T_{ZC}(j+18) & 21 \le j \le 40 \end{Bmatrix}$$

➔ Even-Odd Jitter = $$\frac{\left| \sum_{j=1}^{20} \Delta T(2 \cdot j) - \sum_{j=1}^{20} \Delta T(2 \cdot j - 1) \right|}{40}$$

802.3ch Proposed RJ_{RMS}, DJ, EOJ Master Tx Jitter Specifications

- Define jitter values, measured according to the specified procedures, relative to the symbol period so they are independent of baud rate

- Proposed Master Transmit jitter specification targets:
  - RJ_{RMS} = 0.005UI
  - DJ = 0.05UI
  - EOJ = 0.02UI

Thank you.

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