Improvements to consider for jitter measurements

Comments #211, #212, #213, #64

Adee Ran, Cisco

The current state (as of draft 1.2)

- Following comments #204 and #236 against D1.0, the jitter measurements are made only on the “large transitions” (hence 03 suffix) and the limits of J3u03/J4u03 are different for different loss cases.
  - See ran_3dj_03a_2405 and slide 35 of ran_3dj_01f_2406
- It is recognized that the results of jitter measurements, especially J3u/J4u are affected by the insertion loss before the measurement point.
  - Editor’s notes state that “*These values were adopted based on the assumption that the measured jitter is affected by the loss to the measurement point. Further work related to this assumption is encouraged.*”

C2M host output specifications, Table 176D-1

Output jitter (max)	176D.7.9		
J_{RMS03}		0.023	UI
EOJ_{03}		0.025	UI
$J4u_{03}$		0.135	UI

C2M module output specifications, Table 176D-2

Output jitter (max)	176D.7.9		
J_{RMS03}		0.023	UI
EOJ_{03}		0.025	UI
$J4u_{03}$		0.118	UI

C2C transmitter specifications, Table 176C-1

Output jitter (max)	176C.4.3.6		
J_{RMS03}		0.023	UI
EOJ_{03}		0.025	UI
$J4u_{03}$			
Tx package Class A		0.118	UI
Tx package Class B		0.12	UI

CR transmitter (host output) specifications, Table 179-7

Output jitter (max)	179.9.4.7		
J_{RMS03}		0.023	UI
EOJ_{03}		0.025	UI
$J3u_{03}$			
Host class HL		0.115	UI
Host class HN		0.122	UI
Host class HH		0.128	UI

Comments addressed

Cl 176D SC 176D.5.3 P700 L50 # 211

Rysin, Alexander NVIDIA

Comment Type TR *Comment Status* D *Jitter*

J3u and JRMS measurements at TP1a are highly affected by the effects of slew rate and noise and do not reflect actual uncorrelated jitter. These effects are exacerbated by the characteristics of practical channels between TP0d and TP1a - loss and reflections, and are highly dependent on the transmitted signal amplitude. Accounting only for the faster edges does not work for practical channels at 106.25 Gbd rate and the currently proposed numbers cannot be met (and sometimes cannot be measured) even with commercial test equipment PPG. The issue was demonstrated in rysin_3dj_01a_2407.

SuggestedRemedy

Other method of uncorrelated jitter measurement should be considered.

- #211 addresses Host output jitter parameters, where the loss from the transmitter (TP0d) to the measurement point (TP1a) is up to 32 dB.
- #212 is similar for module output (where the loss is much lower).
- #213 is similar for CR host channels (where the loss is somewhere in between).

Comments addressed (cont.)

Cl **178** *SC* **178.9.2** *P* **322** *L* **46** # 64

Ran, Adee — Cisco Systems, Inc.

Comment Type **T** *Comment Status* **X**

In previous projects there were two different specifications, J3u_03 for PMDs and for J4u_03 for AUIs. This was based on the different BER allocations which translated to average FEC symbol error ratios. The limit values were based on the same dual-Dirac model, and the different maximum values are a constant source of confusion.

We now know that jitter creates correlated errors. Therefore, peak-to-peak jitter should be specified at probabilities lower than the expected average symbol error ratio. The probability allowed for jitter peaks should not be higher for PMDs.

With that in mind, having two specifications, J3u and J4u, is not justified anymore. J3u is faster to measure, but if J4u is measurable for an AUI it is also measurable for a PMD.

J4u should be used for PMD specs too. The maximum specs should be changed accordingly, including accounting for measurement degradation due to package or host channel loss.

SuggestedRemedy

For KR (Table 178–6), change J3u_03 to J4u_03 with the same maximum values as in C2C (Table 176C–1): 0.118 for class A and 0.12 for class B.

For CR (Table 179-7), change J3u_03 to J4u_03 with maximum values:
0.128, 0.126, and 0.143 for HL, HN, and HH, respectively.

Change the definitions accordingly, and in other places as necessary with editorial license.

- Even if rationale of the comment is agreeable, the proposed response has inconsistent values…
  - Limit for HN should be higher than for HL.
  - Limit for HH should be lower than for C2M host output (0.135 UI).

Additional data

calvin_3dj_01b_2407 reports measurement of j3u after a 33 dB IL (more than the 32 dB assumed for C2M host) with 120/109 mUI on the two large transitions.

This is J3u, not J4u, but these two results are well below the 128 mUI currently specified for CR host class HH (which is assumed to have IL only up to 22.75 dB).

The “composite result” mentioned needs to be addressed.

Output jitter (max) analysis

Table 179–7—Summary of transmitter specifications at TP2 *(continued)*

Parameter	Subclause reference	Value	Units
Transmitter steady-state voltage, v_f (min) Host designation Host-Low Host designation Host-Nominal Host designation Host-High	179.9.4.1.2	 TBD TBD TBD	 V V V
Transmitter steady-state voltage, v_f (max)	179.9.4.1.2	0.6	V
Linear fit pulse peak ratio, R_{peak} (min) Host designation Host-Low Host designation Host-Nominal Host designation Host-High	179.9.4.1.2	 TBD TBD TBD	 — — —
Level separation mismatch ratio R_{LM} (min)	179.9.4.2	0.95	—
Transmitter output waveform absolute value of step size for all taps (min) absolute value of step size for all taps (max) value at minimum state for $c(-3)$ (max) value at maximum state for $c(-2)$ (min) value at minimum state for $c(-1)$ (max) value at minimum state for $c(0)$ (max) value at minimum state for $c(1)$ (max)	 179.9.4.1.4 179.9.4.1.4 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5 179.9.4.1.5	 0.005 0.025 −0.06 0.12 −0.34 0.5 −0.2	 — — — — — — —
Signal-to-noise-and-distortion ratio, SNDR (min)	179.9.4.6	31.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	179.9.4.3	26.7	dB
Output jitter (max) TBD	179.9.4.7	 TBD	 UI

Table 176E–1—Summary of host output specifications at TP1a *(continued)*

Output jitter (max) J_{RMS03} EOJ_{03} $J4u_{03}$	176E.6.9	 0.023 0.025 0.135	 UI UI UI

Ch 1 J3u Table (220 Patterns)

From	To L0	To L1	To L2	To L3
All	186.458 mUI			
L3	119.790 mUI	206.195 mUI	301.569 mUI	
L2	208.866 mUI	309.057 mUI		292.380 mUI
L1	296.663 mUI		291.097 mUI	194.962 mUI
L0		293.189 mUI	210.147 mUI	109.196 mUI

$J3U_{03}$ is formed from a composite of targeted L3->0 and L0->3 uncorrelated edge jitter. The composite result has some questions but the the individual values are solid.
Similarly EOJ_{03} is formed from a composite of targeted L3->0 and L0->3 Even/Odd jitter elements. The composite value here is WIP, but the individual L3->0 and L0->3 values are correct.

Ch 1 EOJ Table (220 Patterns)

From	To L0	To L1	To L2	To L3
All	17.0513 mUI			
L3	5.37965 mUI	10.5830 mUI	10.7893 mUI	
L2	3.82602 mUI	3.88568 mUI		10.3853 mUI
L1	5.37965 mUI		610.675 µUI	5.72331 mUI
L0		17.0513 mUI	3.82602 mUI	3.88568 mUI

Concerns

- Current specifications are based on definitions in 120D.3.1.8 which include:
  - A requirement that "Transmitters on lanes not under test transmit PRBS31Q, or a valid 200GBASE-R or 400GBASE-R signal".
    - We know that crosstalk affects the measurement due to "AM/PM conversion". This can only increase the measured jitter, and it is not what we want to measure.
    - Crosstalk is measured as part of SNDR – including it in jitter measurement is "double jeopardy".
  - A requirement to "Combine the sets $S0_i$, i=1 to 12, to create an estimated probability distribution $f_J(t)$."
    - This part of the procedure essentially assumes that jitter distribution should be independent of the transition (and any deviation from this assumption is penalized).
    - In practice, the distributions of rising and falling transitions tend to be mirror-images of each other.
    - When the distributions are asymmetric, this increases the measured jitter results without good justification.
  - Specific transitions and threshold levels to measure on (Table 120D–4)
    - The transitions specified in is likely good but not necessarily the best in all cases – depending on the channel and transmitter equalization, other transitions may turn out to be better.
    - Measuring jitter on a steeper slope is expected to provide a lower result, which is more accurate.

Proposed changes for addressing comments #211, #212, #213

- Make additional exceptions to the procedure in 120D.3.1.8 :
  1. Transmitters on lanes not under test are disabled.
  2. Define the jitter parameters as the maximum of the two measurements on the transitions R03 and F30, instead of being based on “combined” sets of measurements as in 120D.3.1.8.1.
  3. R03 and F30 are transitions from the symbol 0 to the symbol 3 and vice versa. The specific transitions and the threshold levels are chosen from the measured signal to minimize any or all of the jitter parameters. The transitions and thresholds in Table 120D–4 or Table 162–13 are expected to be close to the minimum and can be chosen in many practical cases.
- Implement the above with editorial license.

Updated proposal for comment #64 (CR/KR)

- The KR/CR specs should be aligned with C2C/C2M with accounting for the different losses.
  - Currently C2C and KR are aligned (both based on A_{DD}=0.02 and σ_{RJ}=0.01 at different probabilities, but with no relaxation for insertion loss).
  - CR and C2M do not seem to be aligned; the relaxation for CR (especially HH) seems to be very high and is not justified by the measurement results in calvin_3dj_01b_2407.
- Rationale for calculations:
  - The tightest specification for $J4u_{03}$ (C2M module output) is 0.118 UI. The loosest specification (C2M host output) is 0.135 UI.
  - The corresponding IL in these two cases are 9.75 dB and 32 dB. This suggests the linear equation y=0.11+7.73e-4*x.
  - Interpolate for CR host IL assumptions of 12.75, 17.75, and 22.75 dB.
- The resulting $J4u_{03}$ maximum would be
  - HL: 0.12 UI
  - HN: 0.124 UI
  - HH: 0.128 UI
- $J4u_{03}$ for KR should be the same as for C2C (as in the suggested remedy).

That’s all

Questions?