AUI-C2M host and module output specifications

(comments #186, #187, #203 against D1.0)

Adee Ran, Cisco

Motivation

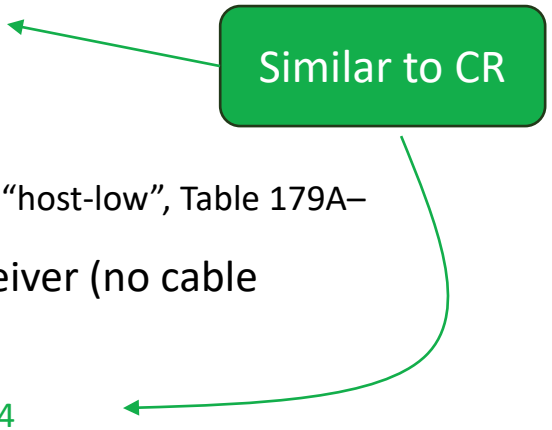
- The host and module output for 200 Gb/s per lane AUI-C2M in Annex 176E should be specified with consideration of the variable output settings that can result from training.
- The methodology used in CR PHYs is suitable for this purpose.
- Differences between CR and AUI-C2M (host and module) should be identified. Some parameter values need to be different.
- This contribution proposes new content for 176E.3.3, 176E.3.4, and 176E.5.

Summary of “Transmitter characteristics” for CR hosts (clause 179)

- Table 179–7 contains the following spec parameters measured at TP2 (host output):
  - Signaling rate range
  - Output voltage limits – differential (enabled/disabled), DC CM, AC CM
  - Impedance related – ERL, RLcc, RLdc
  - Swing and bandwidth related (with equalization off) – v_f, R_{peak}, SNR_{ISI}
  - Linearity and noise related – R_{LM}, SNDR
  - Equalization related – step sizes, coefficient limits
  - Jitter
- These specifications are based on those of clause 162 and previous CR PHYs
- Properties of these specifications:
  - Defined without a complicated reference receiver (only CRU and measurement bandwidth)
    - An exception is SNR_{ISI}, which uses a reference CTLE, but it is not very sensitive to CTLE parameters
  - Less sensitive to test fixture variations, compared to eye diagram
  - Can be measured at different Tx equalization states – not assuming which one the actual Rx chooses
    - Reduces assumptions about Rx design
  - There is good evidence of correlation between meeting/violating these specs and good/bad CR performance (effect on receiver SNR/BER, cable reach, etc.)

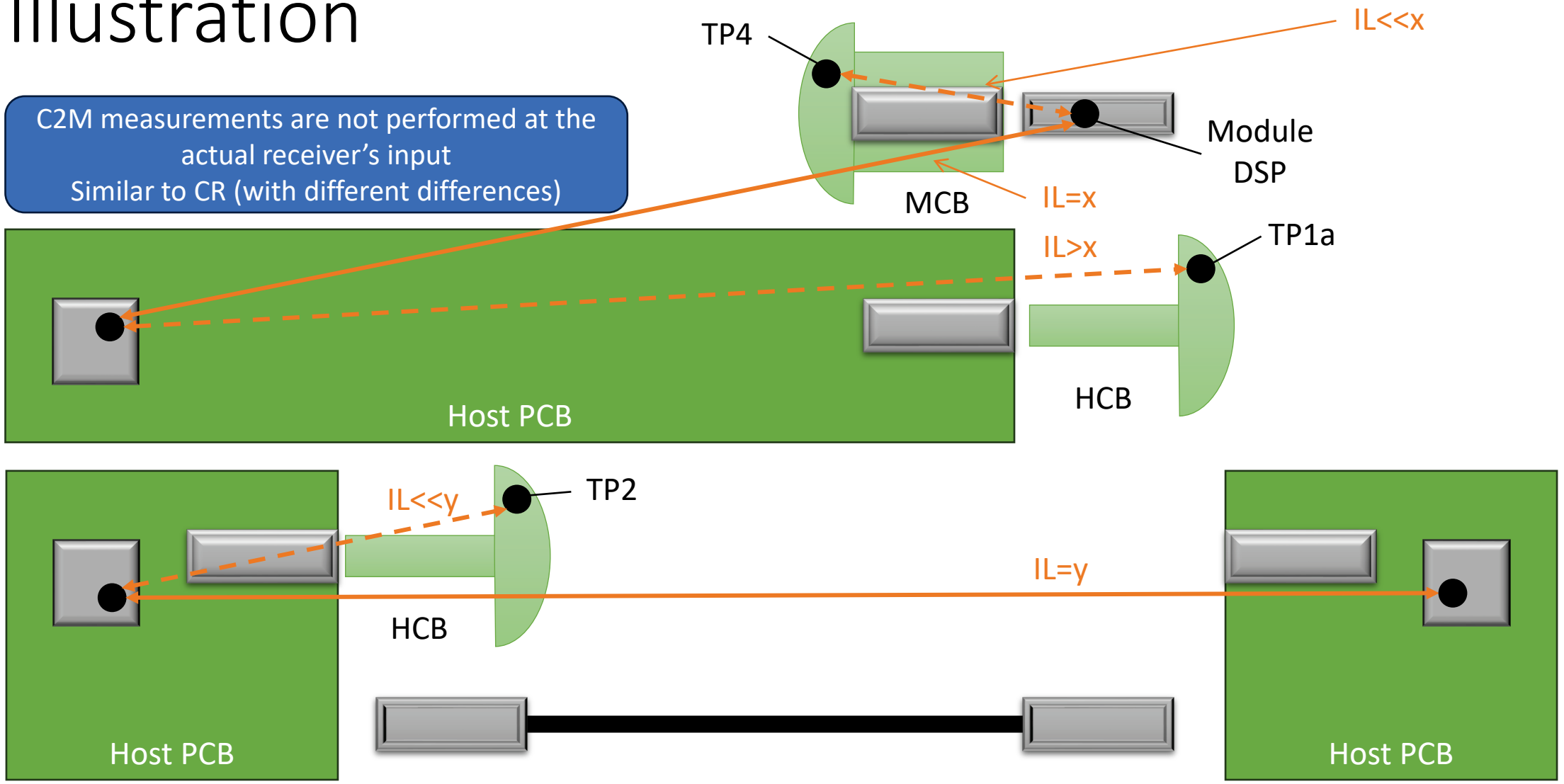
AUI-C2M is different from CR host specs (… but similar)

- Host output:
  - Significantly higher host loss (to TP1a)
    - For C2M the maximum is likely >30 dB (specific value not adopted yet), while CR “host-high” has 16.5 dB (Table 179A–1)
  - Module receiver is close to the measurement point (TP1a) while CR Link partner receiver is separated by cable assembly and host channel
  - But
    - Different modules can prefer different Tx equalization/swing, so there is no single “optimized eye” at TP1a
    - TP1a is not identical to the module receiver’s input (see illustration on next slide)
- Module output:
  - Significantly lower loss to TP4 compared to host (even CR)
    - MCB loss is not adopted yet but likely < 4 dB, while the minimum CR class has an allocation of 6.5 dB (“host-low”, Table 179A–1) without the HCB.
  - Host receiver is closer to the measurement point (TP4) compared to the Link partner receiver (no cable assembly in the middle)
  - But
    - Different hosts can prefer different Tx equalization / swing, so there is no single “optimized eye” at TP4
    - TP4 is very different from the host receiver’s input (see illustration on next slide)



Illustration

C2M measurements are not performed at the actual receiver's input
Similar to CR (with different differences)



Proposed host output summary table

Parameter	Subclause reference	Value	Units
Signaling rate, each lane (range)		106.25 ± 50 ppm	GBd
Differential pk-pk voltage with Tx disabled (max)[b]		30	mV
DC common-mode voltage (max)[b]		1.9	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}		 30 85	 mV mV
Differential pk-pk voltage, v_{di} (max)[b]		1200	mV
Effective return loss, ERL (min)		TBD	dB
Common-mode to common-mode return loss, RLcc (min)		See Equation (179–6)	dB
Common-mode to differential-mode return loss, RLdc (min)		See Equation (179–7)	dB

Yellow highlighted – same as in Table 179-7
~~Deleted~~ – not to be copied from Table 179-7
Blue highlighted – proposed, different from table 179-7

Parameter	Subclause reference	Value	Units
Transmitter steady-state voltage, v_f (min) ~~Host designation Host-Low~~ ~~Host designation Host-Nominal~~ ~~Host designation Host-High~~		0.387 ~~TBD~~ ~~TBD~~ ~~TBD~~	 V V V
Transmitter steady-state voltage, v_f (max)		0.6	V
Linear fit pulse peak ratio, R_{peak} (min) ~~Host designation Host-Low~~ ~~Host designation Host-Nominal~~ ~~Host designation Host-High~~		 TBD TBD TBD	 — — —
Level separation mismatch ratio R_{LM} (min)		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)		 0.005 0.025 –0.06 0.12 –0.34 0.5 –0.2	 — — — — — — —
Signal-to-noise-and-distortion ratio, SNDR (min)		30 dB	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)		26 dB	dB
Output jitter (max) J_{RMS} J3u J6u EOJ, pk-pk		 0.026 0.122 0.159 0.027	 UI UI UI

Rationale for host output proposal

- Starting from clause 162 values (which assume Pkg+PCB+HCB loss of ~11+4=15 dB); parameters that are not affected by the different loss are proposed to have the same specifications.
- Impedance related parameters are expected to be insensitive to host channel loss ➔ same as CR
- Higher AC common-mode noise can be allowed, since there is no additional contribution from the cable and remote host
  - However, end-to-end loss is comparable to that of clause 162, so common mode noise should still be well controlled
  - CR allowance at TP2 may need to be tightened
- v_f is measured without equalization, value should be close to half of the min Vdpp. Value taken from clause 162, may need adjustment.
  - With 50% shorter UI, 200 UI may not be enough to show settled voltage – if so, N_v should be increased to 400 UI rather than changing the minimum v_f.
- SNDR and SNR_{ISI}
  - Measured after a longer channel compared to CR, so some degradation is expected. Since measurement is closer to the true receiver, lower values should be tolerable.
  - Based on clause 162 values with relaxation: 31.5➔30, 26.7➔26.
- Jitter
  - calvin_3dj_elec_01a_240104 reported that the jitter methodology used in 802.3ck (specifically J_{3u03}) is still usable after a 30 dB channel.
  - Due to higher loss, AM/PM conversion from xtalk and measurement noise can cause measured jitter to be higher than in clause 162.
  - Proposed J_{3u} and J_{RMS} are calculated from COM values $A_{DD} = 0.02, \sigma_{RJ} = 0.01$ with relaxation of 15% for AM/PM conversion.
  - New parameter J_{6u} and other jitter methodology is addressed by a separate presentation.

Proposed module output summary table

Parameter	Subclause reference	Value	Units
Signaling rate, each lane (range)		106.25 ± 50 ppm[a]	GBd
Differential pk-pk voltage with Tx disabled (max)[b]		30	mV
DC common-mode voltage (max)[b]		1.9	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}		 30 60	 mV mV
Differential pk-pk voltage, v_{di} (max)[b]		1200	mV
Effective return loss, ERL (min)		TBD	dB
Common-mode to common-mode return loss, RLcc (min)		See Equation (179–6)	dB
Common-mode to differential-mode return loss, RLdc (min)		See Equation (179–7)	dB

Yellow highlighted – same as in Table 179-7
~~Deleted~~ – not to be copied from Table 179-7
Blue highlighted – proposed, different from table 179-7

Parameter	Subclause reference	Value	Units
Transmitter steady-state voltage, v_f (min) ~~Host designation Host-Low~~ ~~Host designation Host-Nominal~~ ~~Host designation Host-High~~		0.4 ~~TBD~~ ~~TBD~~ ~~TBD~~	 V V V
Transmitter steady-state voltage, v_f (max)		0.6	V
Linear fit pulse peak ratio, R_{peak} (min) ~~Host designation Host-Low~~ ~~Host designation Host-Nominal~~ ~~Host designation Host-High~~		 TBD TBD TBD	 — — —
Level separation mismatch ratio R_{LM} (min)		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)		 0.005 0.025 –0.06 0.12 –0.34 0.5 –0.2	 — — — — — — —
Signal-to-noise-and-distortion ratio, SNDR (min)		32.5 dB	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)		28 dB	dB
Output jitter (max) J_{RMS} J3u J6u EOJ, pk-pk		 0.022 0.106 0.138 0.024	 UI UI UI

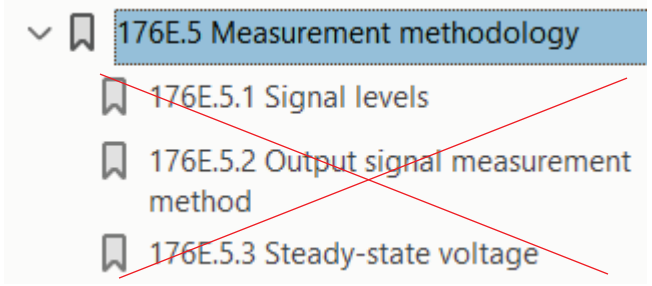
Rationale for module output proposal

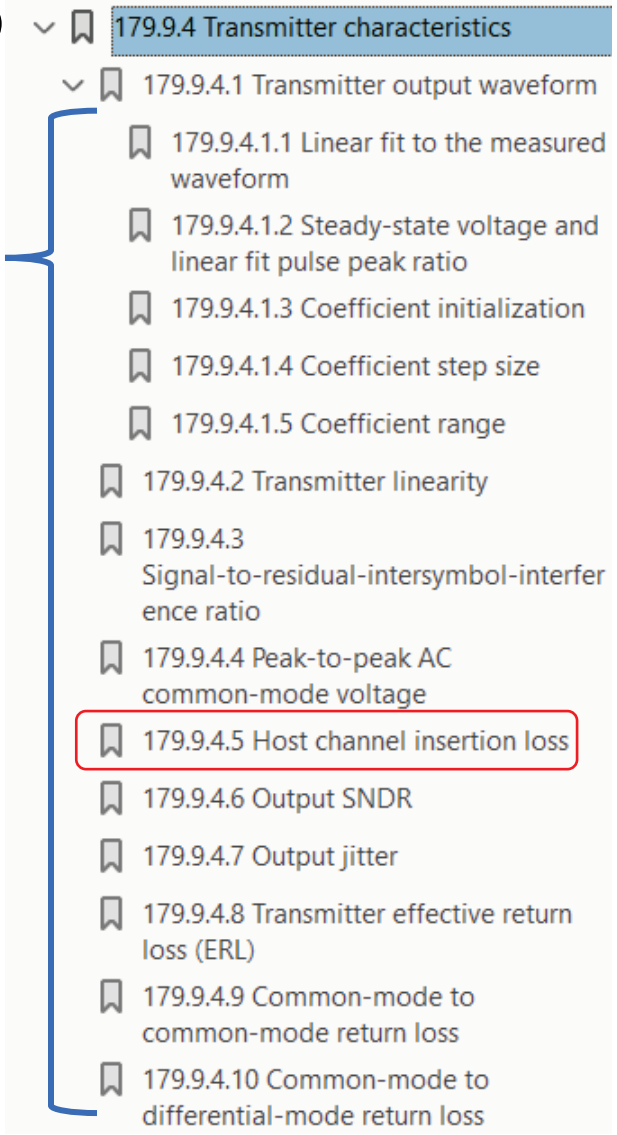
- Starting from clause 162 values (which assume Pkg+PCB+HCB loss of ~11+4=15 dB); parameters that are not affected by the different loss are proposed to have the same specifications.
- ERL for modules can be higher than for hosts, as in 120G. Other Impedance related parameters are expected to be similar to those of hosts and cable assemblies, due to presence of mated test fixtures in all cases.
  - May be changed if there is evidence to the contrary.
- AC common-mode noise is tightened from the value in clause 162 (80 ➔ 60), since it is measured closer to the transmittter, and the host channel can cause large conversion to differential noise
  - Lower mode conversion can be expected, since module and MCB routing is well controlled
- v_f is measured without equalization, and after a very low loss, so its value should be half of the min Vdpp.
  - With 50% shorter UI, 200 UI may not be enough to show settled voltage – if so, N_v should be increased to 400 UI rather than changing the minimum v_f.
- SNDR and SNR_{ISI}
  - Proposed values are same as in clause 163 (measured close to the transmitter).
  - Module and MCB are low loss and well controlled, so there is reason to believe these specs are feasible.
- Jitter
  - Similar to host, but measurement is with a lower loss channel (smaller package in modules).
  - Proposed J_{3u} and J_{RMS} are calculated from COM values $A_{DD} = 0.02, \sigma_{RJ} = 0.01$ with no relaxation
    - Slightly tighter than clause 163 values, due to reduced measurement noise sensitivity.
  - New parameter J_{6u} and other jitter methodology is addressed by a separate presentation.

Methodology subclause

- If the methodology for AUI-C2M host, AUI-C2M module, and CR is the same, it should be defined once.
- Common measurement methods are typically defined in annexes.
- 176E.5 states that it “describes common measurement tools and methodology”…
  - We can have the output measurement methodology defined in 176E.5 and have clause 179 refer to it.
  - Alternatively, 176E.5 can be moved to a separate annex that all interfaces will refer to.

Proposed content/changes in 176E.5





- Remove the current content (hierarchy above)
  - The current 176E.5.2 is the EH/VEC calculation from 120G
  - The current 176E.5.1 and 176E.5.3 point to 179.9.4
- Move the subclauses from 179.9.4 (shown on the right) into subclauses to 176E.5
  - Except 179.9.4.5 (marked) which should stay in 179 (let the editor find the right place to put it)
- Change cross-references in 179 and 178 appropriately

That’s all

Questions?