AUI C2M Channel Loss – The Pieces

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Background

- The AUI-C2M loss budget (ILdd at 53.125 GHz) has been a topic of debate since the beginning of P802.3dj.
- This is a complicated topic…
  - Can be discussed with different bookend points e.g. TP0, TP0d, TP1a, TP1d, host channel, module channel
  - Not all owned by the same supplier
  - Influenced by how systems are expected to be built
  - Influenced by SerDes capabilities
- A lot of COM analysis has been done
  - Consensus has not been achieved (36? 33? 28?)
- We should think about what's needed for moving forward

C2M insertion loss budget depicted in D1.1

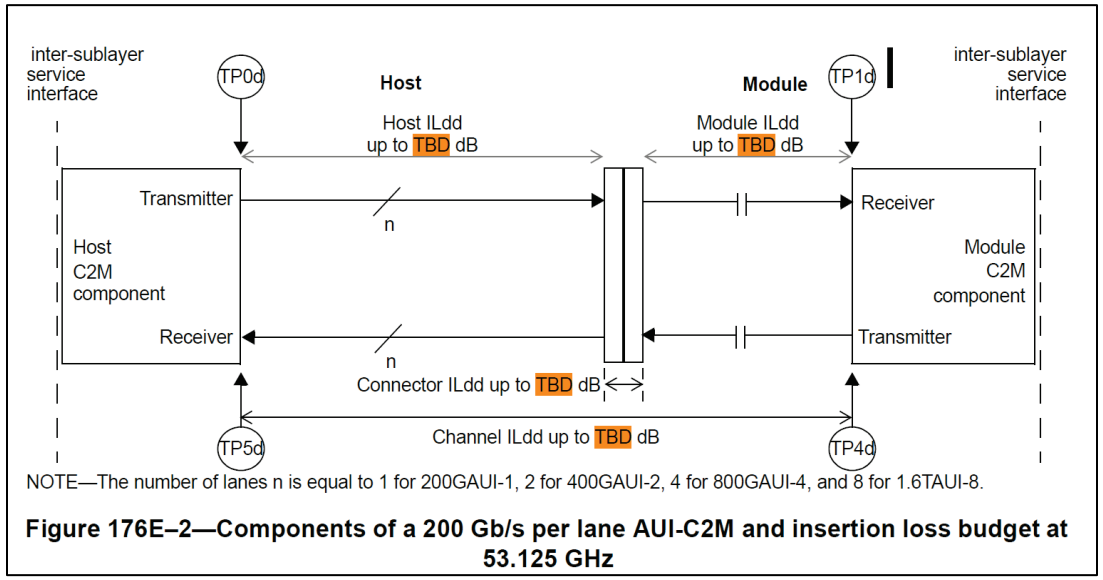


Figure 176E–2—Components of a 200 Gb/s per lane AUI-C2M and insertion loss budget at 53.125 GHz

- This diagram appears in 176E.3 (Functional specification)
- It is informative in nature
  - No point in this diagram is accessible for ILdd measurement
- Previous C2M annexes had similar diagrams with ILdd allocations
- CR/KR/C2C functional specifications have similar diagram but without ILdd

Why ILdd budget is needed

- We do not specify how hosts and modules are built internally
  - We specify how they look externally
  - **Output (“transmitter”) specifications** – measurable signal parameters
  - **Input (“receiver”) specifications** – error performance in specified test conditions
  - And other electrical parameters such as ERL
- In past projects, specifications were defined based on models that we adopted or examples that were provided
  - Host model components: package, PCB trace, vias
  - Mated test fixture – reference S-parameters
  - We had no detailed model for Modules
- Based on the models, we specified how real entities should behave
  - Parameters based on simulations
  - Mathematical calculations for calibrating test conditions

What we currently have (for host)

Table 176E–1—Summary of host output specifications at TP1a

Parameter	Reference	Value	Units
Signaling rate, each lane (range)		106.25 ± 50 ppm[a]	GBd
Differential peak-to-peak voltage (max)[b] Output enabled Output disabled	176E.6.1	 1200 30	 mV mV
DC common-mode voltage (max)[b]	176E.6.1	1.9	V
AC common-mode peak-to-peak voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}	176E.6.1	 30 85	 mV mV
Effective return loss, ERL (min)	176E.6.2	TBD	dB
Common-mode to common-mode return loss, *RLcc* (min)	176E.6.3	Equation (179–9)	dB
Common-mode to differential-mode return loss, *RLdc* (min)	176E.6.3	Equation (179–10)	dB
Transmitter steady-state voltage, v_f (min)	176E.6.4	0.387	V
Transmitter steady-state voltage, v_f (max)	176E.6.4	0.6	V
Linear fit pulse peak ratio, R_{peak} (min)	176E.6.4	TBD	—
Level separation mismatch ratio, R_{LM} (min)	176E.6.5	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)	 176E.6.6 176E.6.6 176E.6.6 176E.6.6 176E.6.6 176E.6.6 176E.6.6	 0.005 0.025 −0.06 0.12 −0.34 0.5 −0.2	 — — — — — — —
Signal-to-noise-and-distortion ratio, SNDR (min)	176E.6.7	33.5	dB
Signal-to-residual-intersymbol-interference ratio, SNR_{ISI} (min)	176E.6.8	26	dB
Output jitter (max) J_{RMS03} EOJ_{03} $J4u_{03}$	176E.6.9	 0.023 0.025 0.135	 UI UI UI

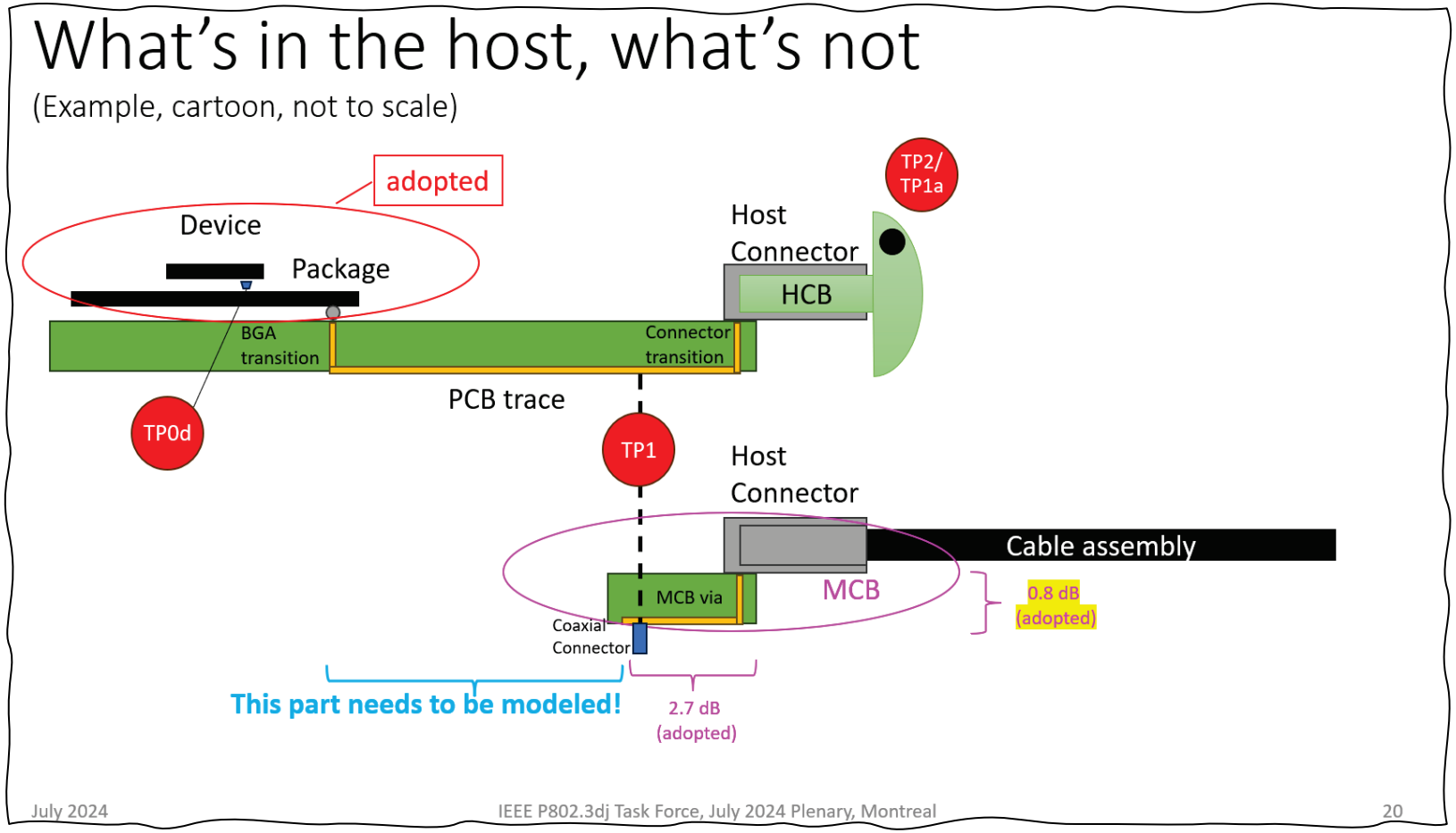
Table 176E–3—Summary of host input specifications at TP4a

Parameter	Reference	Value	Units
Signaling rate, each lane (range) 200GAUI-1 and 400GAUI-2 800GAUI-4 and 1.6TAUI-8		 106.25 ± 100 ppm 106.25 ± 50 ppm	 GBd GBd
Peak-to-peak AC common-mode voltage tolerance (min) Low-frequency, VCM_{LF} Full-band, VCM_{FB}	176E.6.10	 32 80	 mV mV
Effective return loss, ERL (min)	176E.6.2	TBD	dB
Differential-mode to common-mode return loss, *RLcd* (min)	176E.6.3	Equation (176E–2)	dB
Amplitude tolerance	176E.6.11	1200	mV
Interference tolerance	176E.6.12	Test calibration	
Jitter tolerance	176E.6.13	TBD	
Common-mode voltage[a] Min Max	176E.6.1	 –0.3 2.8	 V V

[a] Generated by host, referred to host ground.

All highlighted parameters need to be updated (explicitly or implicitly TBD)
Modules have similar TBDs

Host channel discussion has already started



Source: ran_3dj_01b_2407, slide 20

Possible model for C2M host (not adopted yet)

Possible parameters for C2M (X=27.3 dB)

Using class B package with zp of either 30 or 45 mm, with/without C0

Option	pkg zp [mm]	C0 [fF]	PCB zp [mm]	C1 [fF]	COM channel IL [dB]	Total host channel IL [dB]	Tp0d-TP1a IL [dB]
1	30	0	258	0	24.58	27.28	33.98
2	45	0	217	0	24.62	27.32	34.02
3	30	29	249	0	24.62	27.32	34.02
4	45	29	205	0	24.61	27.31	34.01

IL and pulse responses are for the "total host channel" and include the path from C_b to C_1

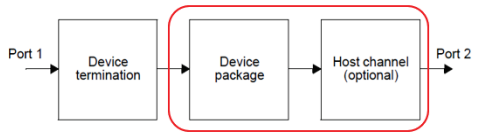
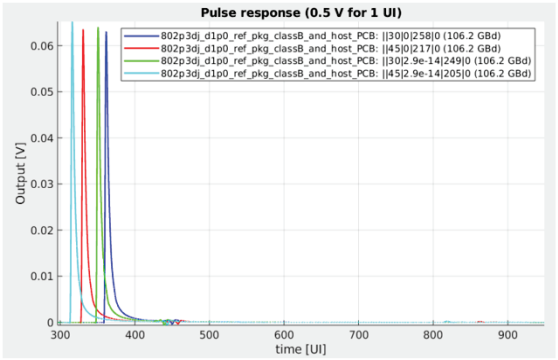


Figure 178A–2—Transmitter S-parameter model



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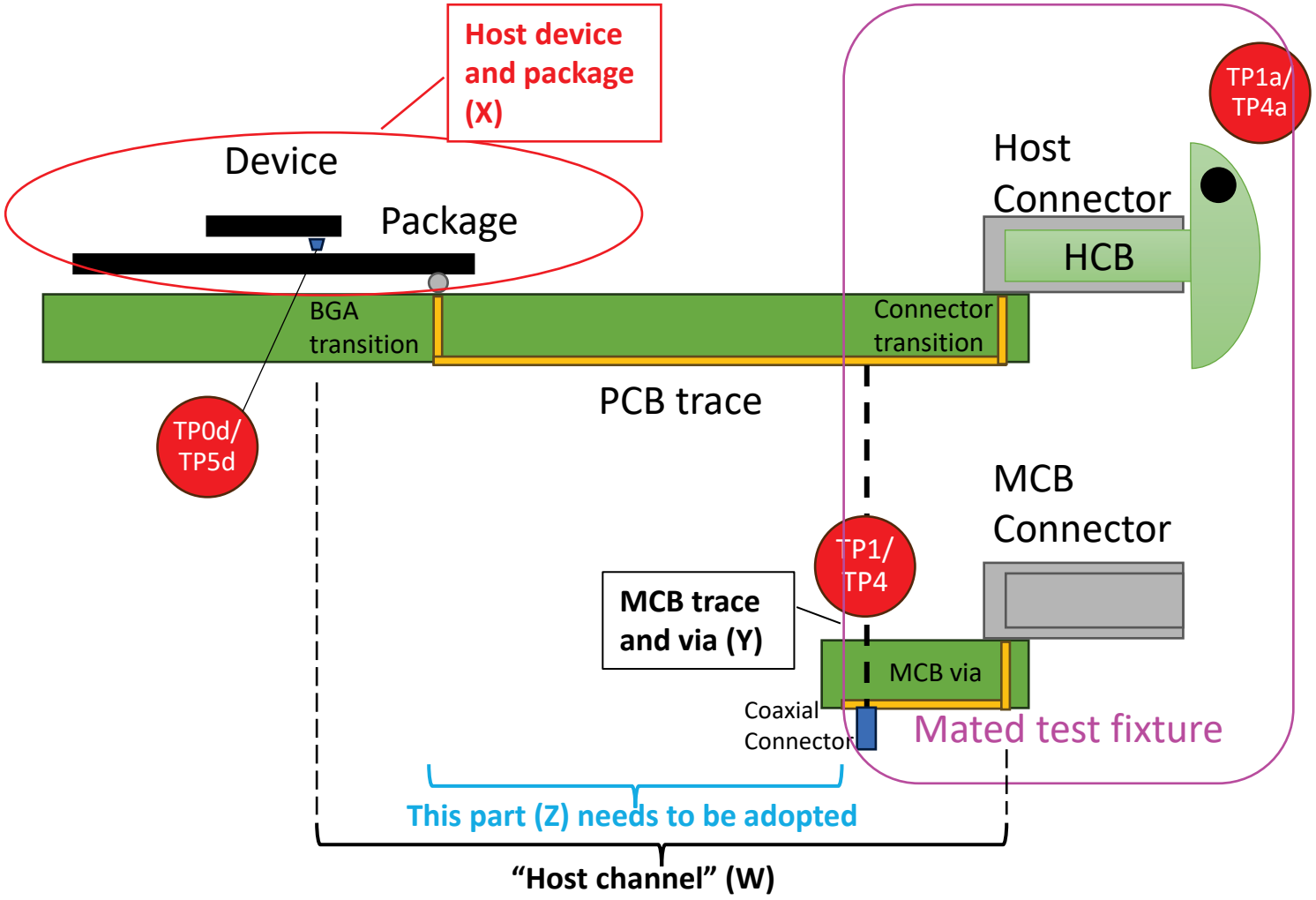
Creating C2M Host specifications



- Using a model as shown on the left we can:
  - Calculate the host+HCB (TP0d-TP1a and TP4a-TP5d) channels
  - Simulate the expected channel-dependent output parameters (current TBDs)
  - Use COM to calibrate receiver test conditions
- Thus, this model is required for creation of normative specifications
- The ILdd of the actual die-to-die channel (as it appears in Figure 176E–2) is not required
  - We only need the indicated portion of the PCB trace (Z) and the device/package model (X)

Creating C2M Host specifications (cont)

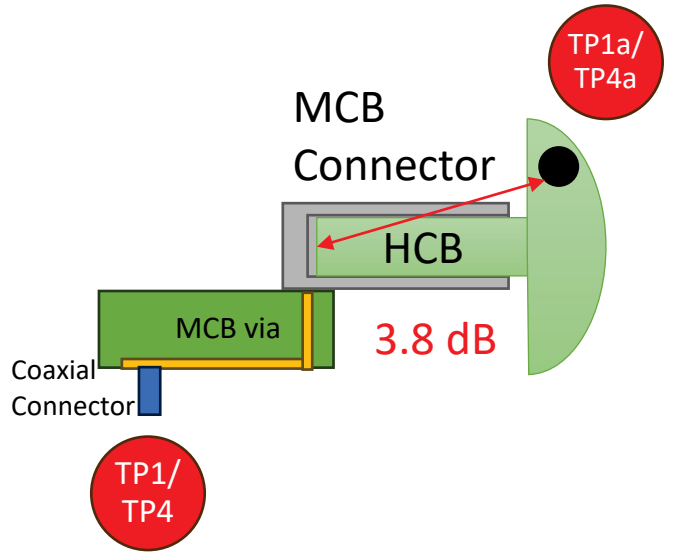
- Host device and package model (X) already adopted in KR/CR; we need to choose specific parameters for C2M
- MCB trace and via ILdd (Y) already adopted (2.7+0.8=3.5 dB)
- If we agree on host channel ILdd allocation (W dB), we can find the PCB trace component (Z) from a PCB trace model:
  - Z = W – X – Y (dB)
  - Derive the length in mm to create that ILdd
  - The full S-parameters of Z, $S^{(Z)}$, can be calculated
- The TP0d-TP1a and TP4a-TP5d channel S-parameters are **cascade($S^{(X)}$, $S^{(Z)}$, $S^{(MTF)}$)**, where $S^{(MTF)}$ are measured S-parameters

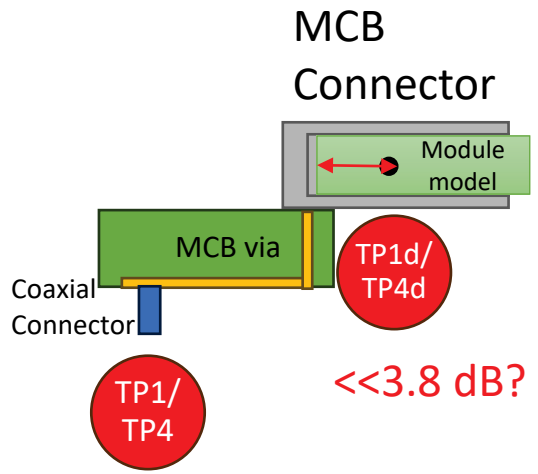
Creating C2M module specifications

- We need to build consensus on what a module looks like
  - Then adopt a model
  - Then specify output parameters and calibrating input test conditions
- It should represent “reasonable worst case”
  - E.g., if we expect some modules will use a package – then include it
- No proposals for a reference modules have been discussed
  - COM simulations were done with different, often undocumented assumptions
  - This is a missing essential ingredient

Creating C2M module specifications (cont)

- Even if we had a reference model for the module… deriving input/output specifications is more complicated than the host case
- We need reference models of the TP1-TP1d and TP4d-TP4 channels
  - These are shorter than TP1-TP1a and TP4a-TP4 in a mated test fixture
  - We can’t start with measured MTF S-parameters and add some mathematical model, as in the host case…
- Contributions in this area are encouraged
  - Mathematical expressions
  - Explicit S-parameters
  - Combinations
  - Other ideas





Summary

- For technical completeness we need to agree on and adopt host and module input/output characteristics
- Host is straightforward
  - We need host channel ILdd allocation to start → **call for action**
  - The rest is simple to calculate, as shown
- Module requires more work
  - We need a reference model for a module, which should then be combined with an MCB to create reference TP1-TP1d and TP4d-TP4 channels → **call for action**
  - Once we have these channels, we can proceed as in the host

That’s all

Discussion / questions