Host channel model and parameters

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Introduction

- We have three host loss designations for CR ports (clause 179) with adopted loss budgets
- The host channel loss for C2M (Annex 176E) is still in debate
- We **do not have** reference host channel models for any of these
  - As a result, COM for cable assemblies is not defined
  - Reference receiver parameters are moving targets
- Many of the PMD/AUI specifications depend on the reference host channels
  - As a result, we have many TBDs
- A host model is a key ingredient

Goals

- Suggest host channel model parameters (sets).
  - Enable running COM for CR channels.
  - Enable moving forward with host output parameters.
- Have the discussion start with some initial values.
  - *“All models are wrong, but some are useful”* (George Box)
  - TBDs do not constitute a very useful model.

What do we have

Device Package + Host PCB	Host-Low 6.5 dB	Host-Nominal 11.5 dB	Host-High 16.5 dB
Host -Low 6.5 dB	CA-A,B,C,D	CA-A,B,C	CA-A,B
Host-Nominal 11.5 dB	CA-A,B,C	CA-A,B	CA-A
Host-High 16.5 dB	CA-A,B	CA-A	not supported

From tracy_3dj_01a_2311, slide 12

"Move to adopt the host and cable assembly insertion loss budgets proposed in the magenta box "proposed baseline content" in tracy_3dj_01a_2311, slide 12"

Table 179A–1—Recommended differential insertion loss limits at 53.125 GHz

Host designation	Host channel		TP0d to TP2 or TP3 to TP5
	Max (dB)	Min (dB)	Max (dB)
Host-Low	6.5	TBD	TBD
Host-Nominal	11.5	TBD	TBD
Host-High	16.5	TBD	TBD

The recommended minimum and maximum differential insertion loss for the host channel, consisting of controlled impedance PCB, device package, and host connector footprints, are determined using Equation (179A–1) and Equation (179A–2), respectively, and illustrated in Figure 179A–1. The recommended host channel differential insertion loss limits at 53.125 GHz are given in Table 179A–1.

What do we have

Table 179–15—Device, package, and PCB model parameters

Parameter	Symbol	Value	Units
Device model			
Single-ended device capacitance for stage 1	$C_d^{(1)}$	40×10^{-6}	nF
Single-ended device capacitance for stage 2	$C_d^{(2)}$	90×10^{-6}	nF
Single-ended device capacitance for stage 3	$C_d^{(3)}$	110×10^{-6}	nF
Single-ended device series inductance for stage 1	$L_s^{(1)}$	0.13	nH
Single-ended device series inductance for stage 2	$L_s^{(2)}$	0.15	nH
Single-ended device series inductance for stage 3	$L_s^{(3)}$	0.14	nH
Single-ended bump capacitance	C_b	30×10^{-6}	nF
Class A package model			
Transmission line parameter γ_0	γ_0	5×10^{-4}	1/mm
Transmission line parameter a_1	a_1	8.9×10^{-4}	$ns^{1/2}$/mm
Transmission line parameter a_2	a_2	2×10^{-4}	ns/mm
Transmission line parameter τ	τ	6.141×10^{-4}	ns/mm
Transmission line 1 length, Test 1	$z_p^{(1)}$	33	mm
Transmission line 1 length, Test 2	$z_p^{(1)}$	12	mm
Transmission line 1 characteristic impedance	$Z_c^{(1)}$	87.5	Ω
Transmission line 2 length	$z_p^{(2)}$	1.8	mm
Transmission line 2 characteristic impedance	$Z_c^{(2)}$	92.5	Ω
Single-ended package capacitance at package-to-board interface	C_p	40×10^{-6}	nF
Class B package model			
Transmission line parameter γ_0	γ_0	5×10^{-4}	1/mm
Transmission line parameter a_1	a_1	6.5×10^{-4}	$ns^{1/2}$/mm
Transmission line parameter a_2	a_2	2.93×10^{-4}	ns/mm
Transmission line parameter τ	τ	6.141×10^{-4}	ns/mm
Transmission line 1 length, Test 1, Tx / Rx	$z_p^{(1)}$	45 / 44	mm
Transmission line 1 length, Test 2, Tx / Rx	$z_p^{(1)}$	30 / 29	mm
Transmission line 1 characteristic impedance	$Z_c^{(1)}$	87.5	Ω
Transmission line 2 length	$z_p^{(2)}$	2	mm
Transmission line 2 characteristic impedance	$Z_c^{(2)}$	95	Ω
Transmission line 3 length	$z_p^{(3)}$	1.3	mm
Transmission line 3 characteristic impedance	$Z_c^{(3)}$	100	Ω
Transmission line 4 length	$z_p^{(4)}$	1.5	mm
Transmission line 4 characteristic impedance	$Z_c^{(4)}$	78	Ω
Single-ended package capacitance at package-to-board interface	C_p	40×10^{-6}	nF
Host PCB model, Host designation Host-Low	TBD		
Host PCB model, Host designation Host-Nominal	TBD		
Host PCB model, Host designation Host-High	TBD		
Single-ended reference resistance	R_0	TBD	Ω
Single-ended transmitter termination resistance	$R_d^{(t)}$	TBD	Ω
Single-ended receiver termination resistance	$R_d^{(r)}$	TBD	Ω

From lim_3dj_01_2401, slide 8

From lim_3dj_01a_2311

"Move to adopt the proposed Class A and Class B package parameters in lim_3dj_01a_2311 slides 8-9 for 200G/lane backplane and copper cable PHYs as a baseline proposal"

From benartsi_3dj_01_2401

"adopt the updated parameter values for Class B packages per benartsi_3dj_01_2401 slide 7"

No model adopted for C2M host
(But we should assume similar device and package models)

Proposed MCB transmission line and MTF loss

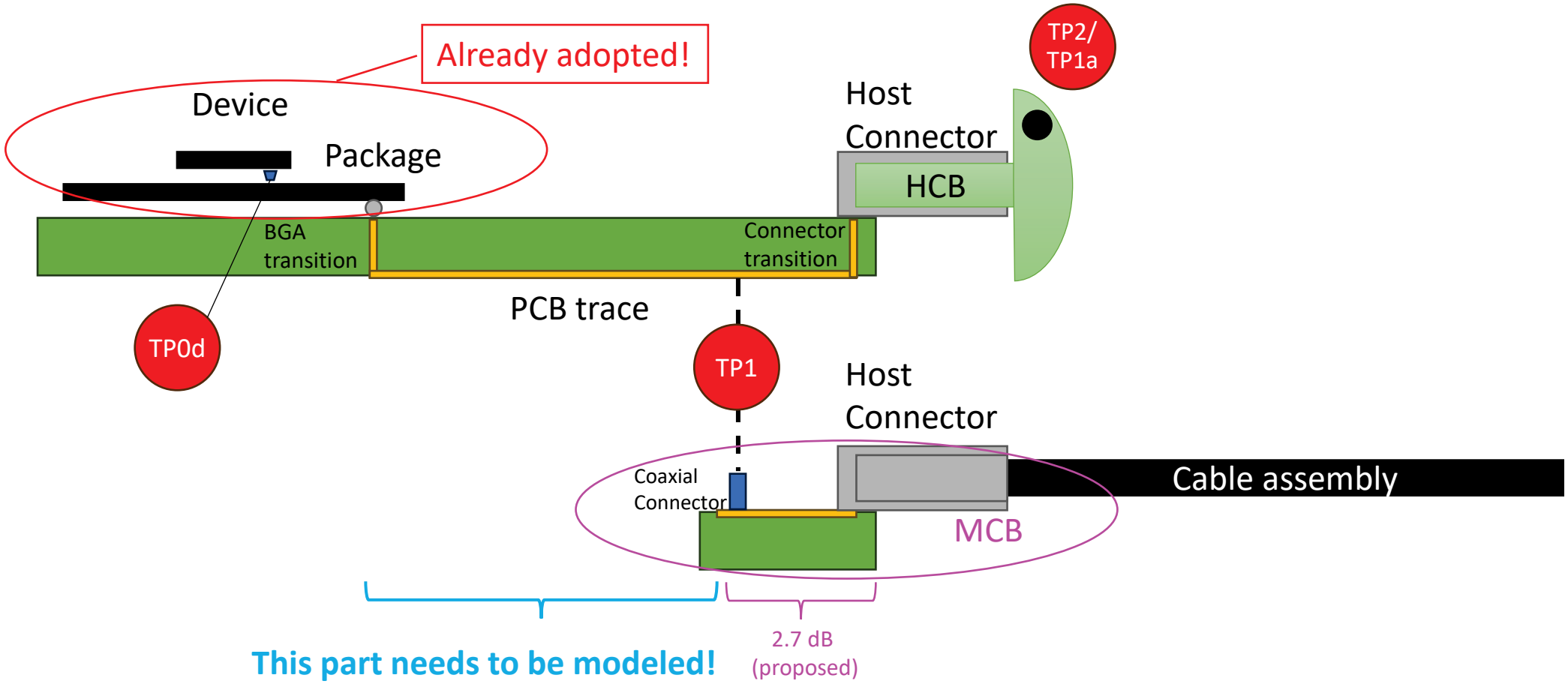
From sekel_3dj_elec_01a_240620 slide 4
(not adopted yet)

Proposed HCB, MCB and MTF IL @ 53.125 GHZ

Component	Insertion Loss (dB)
Module Compliance Board transmission line	2.7
Host Compliance Board transmission line	3.8 (proposed specification)
Mated Test Fixture	9.4 (proposed specification)
MTF connector + associated via's	2.9

What's in the host, what's not

(Example, cartoon, not to scale)



Host channel model used in previous CR clauses

Table 178A–5—Summary of host channel parameters

Parameter	Symbol	Units
Single-ended package capacitance at port 1	C_0	nF
Host transmission line parameter, γ_0	$\gamma_0^{(h)}$	1/mm
Host transmission line parameter, a_1	$a_1^{(h)}$	$ns^{1/2}/mm$
Host transmission line parameter, a_2	$a_2^{(h)}$	ns/mm
Host transmission line parameter, τ	$\tau^{(h)}$	ns/mm
Host transmission line differential characteristic impedance	$Z_c^{(h)}$	Ω
Host transmission line length	$z_p^{(h)}$	mm
Single-ended package capacitance at port 2	C_1	nF

Host channel model parameters in Annex 178A

The parameters in Table 162-21 are the most recently used.
The transmission line parameter values can be re-used in Clause 179 and Annex 176E.

Table 162–21—PCB model parameters and values

Parameter	Value	Units
γ_0	0	1/mm
a_1	3.8206×10^{-4}	$ns^{1/2}/mm$
a_2	9.5909×10^{-5}	ns/mm
τ	5.79×10^{-3}	ns/mm
C_0	2.9×10^{-5}	nF
C_1	1.9×10^{-5}	nF
Z_c	100	Ω
R_0	50	Ω

Host channel model for COM

- COM host channel model should include:
  - Package (class A or B) with specific parameters (currently TBD)
  - BGA ball (modeled as lumped capacitance, 0.04 pF adopted)
  - BGA transition (currently modeled as lumped capacitance C0 - TBD)
  - Trace (currently TBD)
  - No connector via (C1=0)
- Such that:
  - With addition of MCB trace and via loss (assumed 2.7+0.8=3.5 dB)…
  - We get the adopted host budgets from tracy_3dj_01a_2311
- Adding the MTF ILdd (assumed 9.25 dB), we get the TP0d-TP2 ILdd

COM host channel ILdd

Host type	X Max host channel ILdd	Y=X-2.7 dB COM Host model ILdd	Z=Y+9.4 dB TP0d to TP2/TP1a
CR Host-low	6.5	3.8	13.2
CR Host-nominal	11.5	8.8	18.2
CR Host-high	16.5	13.8	23.2
C2M host	27.3	24.6	34

C2M host ILdd has not been adopted; these are placeholder values in preparation for a future proposal.

In C2M this host model is not used for COM, but it is used for the host input test calibration.
It will also be important for deriving Tx specifications.

This is not the die-to-die loss! the full channel depends on module structure and its loss can deviate from this value.

How to achieve the target IL

- The next slides show a few options that achieve the adopted maximum host loss (ILdd, not fitted).
  - None of the options was correlated with any board design.
  - These should be considered as a starting point for calculating COM and for transmitter output specifications.
  - Refinements may be applied using future comments.
  - Whether there should be a via capacitance (C0) in addition to the BGA capacitance – is debatable. Both options are considered.
- We can specify COM calculations with two test cases (as in previous projects)…
  - e.g., one with maximum package loss and one with a lower one
  - Taking this approach will require multiple invocations of COM with different host type on each end!
- Alternatively, only calculate with one host model – to reduce the number of host type combinations.

How to achieve the target IL

- The four options on each slide are combinations of package trace and C0 value.
  - Package trace length cases were adopted for KR/C2C but need not be the same for creating a host channel.
- Option #4 creates the shortest PCB trace. Option #1 creates the longest.
  - #4 is likely the most challenging in terms of discontinuities. It will likely create the lowest COM for a given cable assembly channel.
  - #1 or #2 will likely create the highest COM for a given cable assembly channel.
- Recommending option #2 (max package loss and C0=0), but the other options are ok if there is consensus.

Possible parameters for host-high (X=16.5 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-TP2 IL [dB]
1	30	0	101	0	13.85	16.55	23.25
2	45	0	58.5	0	13.77	16.47	23.17
3	30	29	91.5	0	13.81	16.51	23.21
4	45	29	46.5	0	13.79	16.49	23.19

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

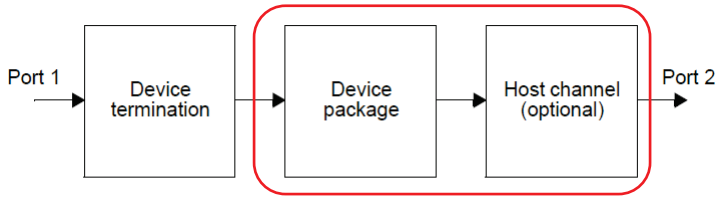
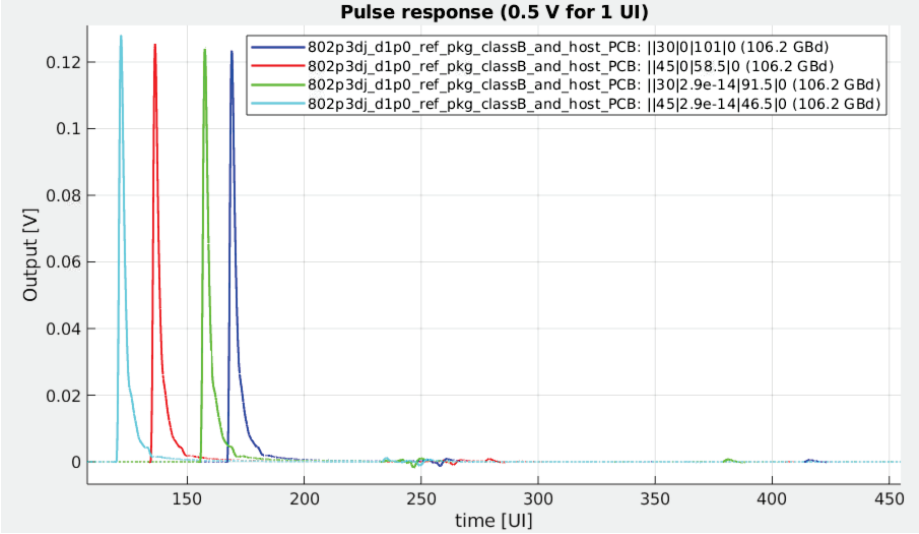


Figure 178A–2—Transmitter S-parameter model

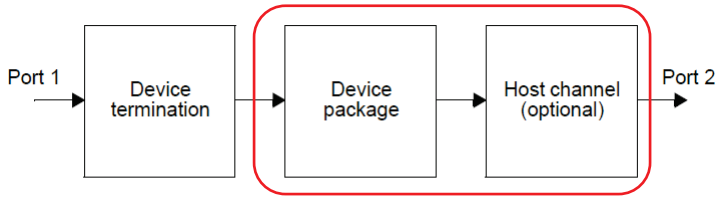


Possible parameters for host-nominal (X=11.5 dB)

Using class B package with zp of either 12 or 20 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-TP2 IL [dB]
1	12	0	73	0	8.83	11.53	18.23
2	20	0	50	0	8.84	11.54	18.24
3	12	29	58.5	0	8.79	11.49	18.19
4	20	29	38	0	8.77	11.47	18.17

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



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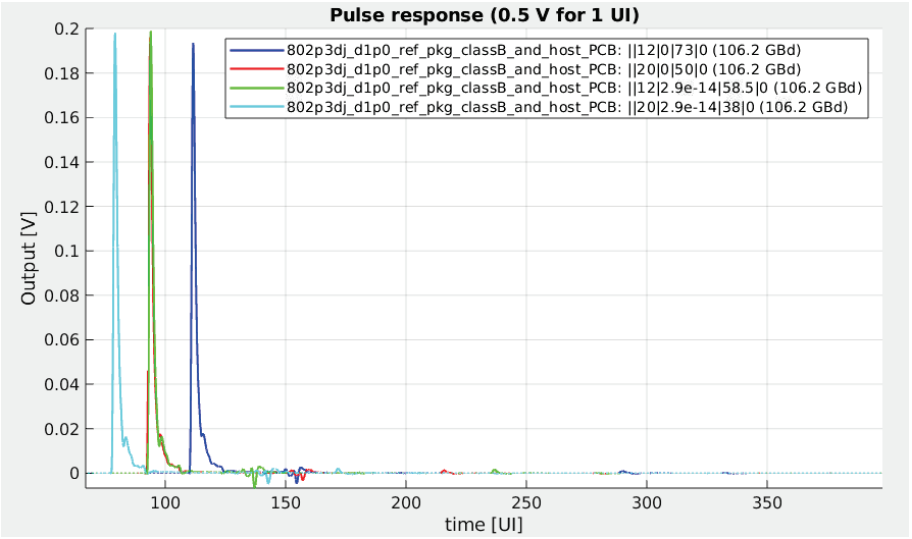


Possible parameters for host-low (X=6.5 dB)

Using class A package with zp of either 0 or 8 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-TP2 IL [dB]
1	0	0	38	0	3.84	6.54	13.24
2	8	0	26.5	0	3.76	6.46	13.16
3	0	29	29.5	0	3.84	6.54	13.24
4	8	29	21.5	0	3.78	6.48	13.18

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

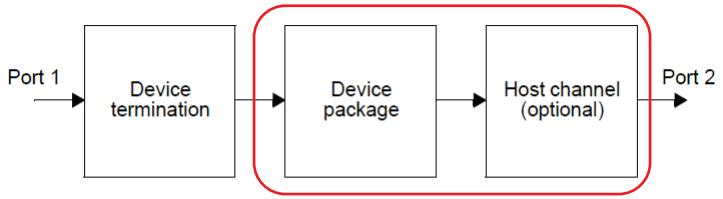
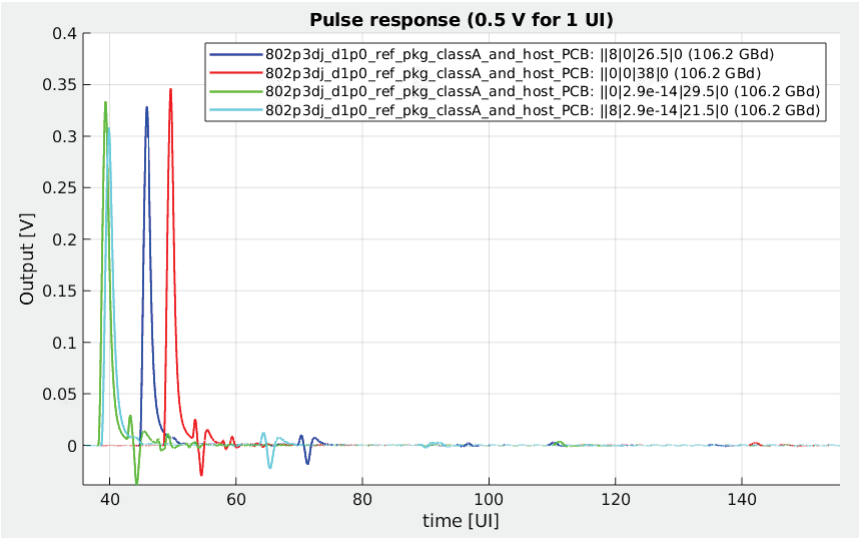


Figure 178A–2—Transmitter S-parameter model



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

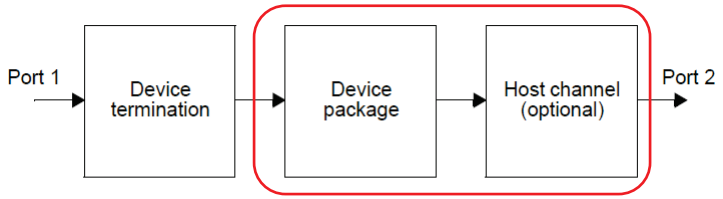
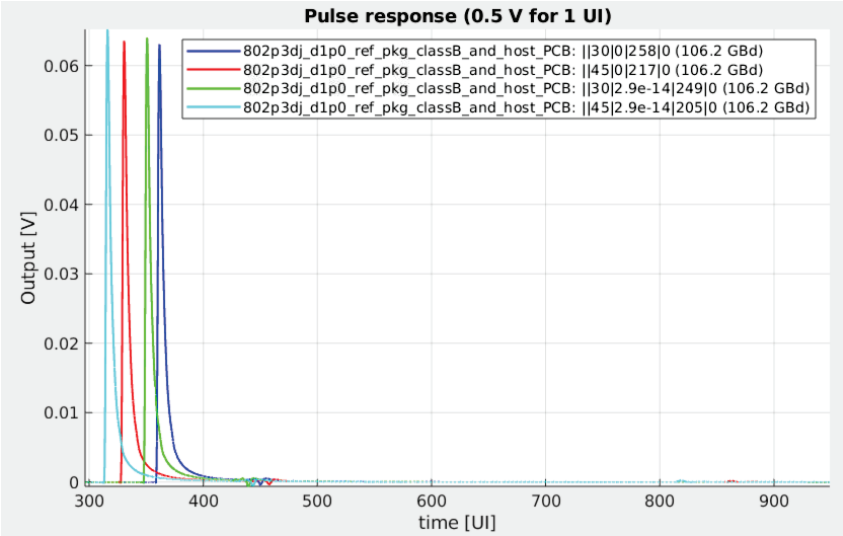


Figure 178A–2—Transmitter S-parameter model



Summary

- Host channel model is key for creating CR and C2C host specifications.
  - In addition to its obvious necessity for evaluating cable assemblies with COM.
- Several options presented for parameters of the host channel models (package+PCB) that achieve adopted CR host loss values.
  - Based on recommended limits in D1.0 (tracy_3dj_01a_2311) and MCB loss of 2.7 dB.
  - The models use the PCB transmission line parameter values in Table 162-21.
  - Model option 2 (long package trace, C0=C1=0) is recommended.
- Target host channel loss for C2M presented as 27.3 dB, creating 34 dB TP0d-TP1a.
  - These are placeholder values in preparation for a future proposal.
- Adopting host channel models will enable progress in closing other TBDs.

Updated slides

Proposed MCB transmission line and MTF loss

From sekel_3dj_elec_01a_240620 slide 4
(not adopted yet)

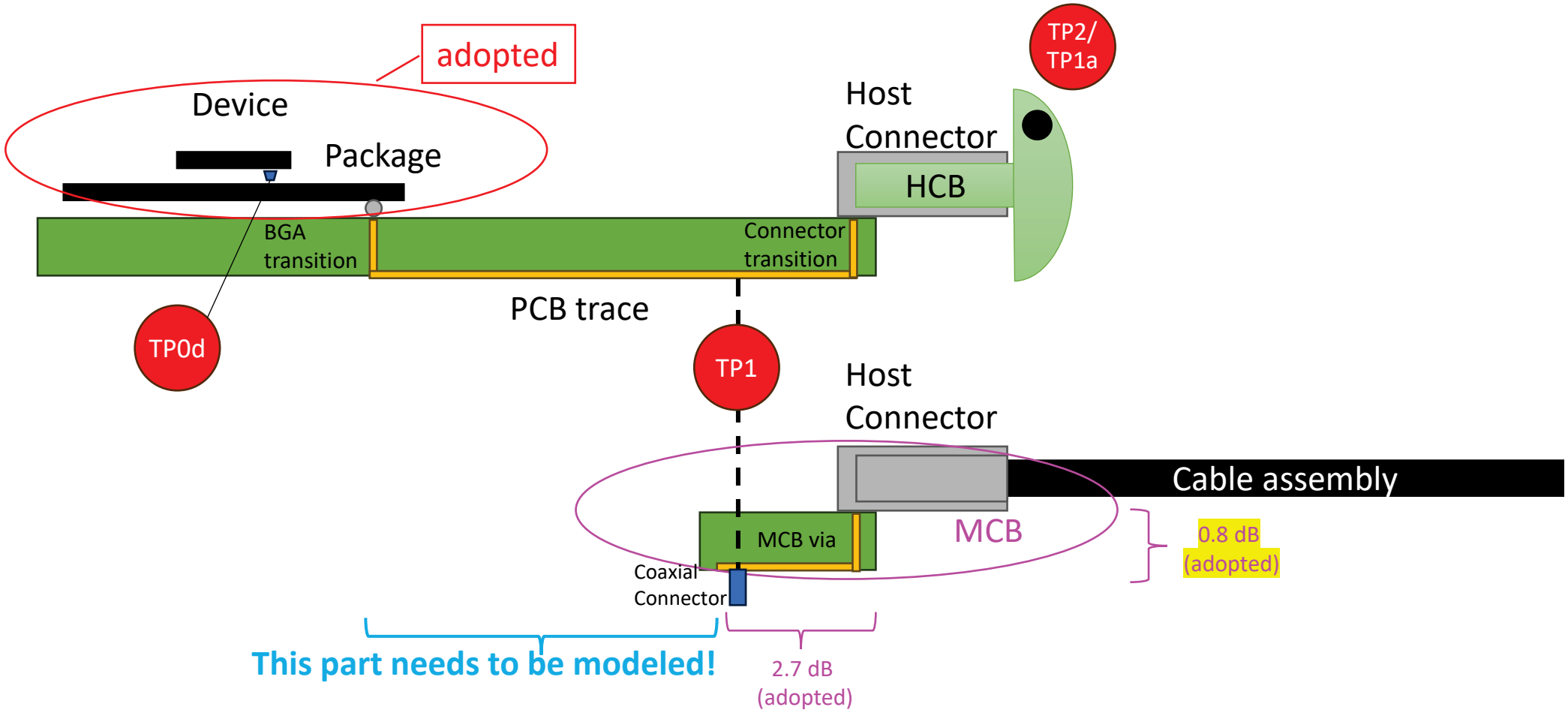
Proposed HCB, MCB and MTF IL @ 53.125 GHZ

Component	Insertion Loss (dB)
Module Compliance Board transmission line	2.7
Host Compliance Board transmission line	3.8 (proposed specification)
Mated Test Fixture	9.4 (proposed specification)
MTF connector + associated via's	2.9

Updated proposal: 9.25

What's in the host, what's not

(Example, cartoon, not to scale)



Host channel model used in previous CR clauses

Table 178A–5—Summary of host channel parameters

Parameter	Symbol	Units
Single-ended package capacitance at port 1	C_0	nF
Host transmission line parameter, γ_0	$\gamma_0^{(h)}$	1/mm
Host transmission line parameter, a_1	$a_1^{(h)}$	$ns^{1/2}/mm$
Host transmission line parameter, a_2	$a_2^{(h)}$	ns/mm
Host transmission line parameter, τ	$\tau^{(h)}$	ns/mm
Host transmission line differential characteristic impedance	$Z_c^{(h)}$	Ω
Host transmission line length	$z_p^{(h)}$	mm
Single-ended package capacitance at port 2	C_1	nF

Host channel model parameters in Annex 178A

The parameters in Table 162-21 are the most recently used.
The transmission line parameter values can be re-used in Clause 179 and Annex 176E.

Modified PCB model parameter values creating 1.1 dB/inch

Parameter	Value	Units
γ_0	0	1/mm
a_1	~~3.8206×10^{-4}~~ 2.61e-4	$ns^{1/2}/mm$
a_2	~~9.5909×10^{-5}~~ 5.75e-5	ns/mm
τ	5.79×10^{-3}	ns/mm
C_0	2.9×10^{-5}	nF
C_1	1.9×10^{-5}	nF
Z_c	100	Ω
R_0	50	Ω

COM host channel ILdd

Numbers modified due to via and MTF changes

Host type	X Max host channel ILdd	Y=X-3.5 dB COM Host model Ildd	Z=Y+9.25 dB TP0d to TP2/TP1a
CR Host-low	6.5	3	12.75
CR Host-nominal	11.5	8	17.75
CR Host-high	16.5	13	22.75
C2M host	27.25	24.75	34

C2M host ILdd has not been adopted; these are placeholder values in preparation for a future proposal.

In C2M this host model is not used for COM, but it is used for the host input test calibration.
It will also be important for deriving Tx specifications.

This is not the die-to-die loss! the full channel depends on module structure and its loss can deviate from this value.

Possible parameters for host-high (X=16.5 dB)

Numbers modified due to via and MTF changes and modified PCB model

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 Goal=16.5 [dB]	Tp0d-TP2 IL [dB]
1	30	0	142	0	13.01	16.51	22.76
2	45	0	77	0	13.03	16.53	22.78
3	30	29	127	0	13.04	16.54	22.79
4	45	29	55	0	13.04	16.54	22.79

IL and pulse responses are for the “total host channel” and include the path from C_b to C_1. “Device termination” effect other than adding a delay is insignificant.

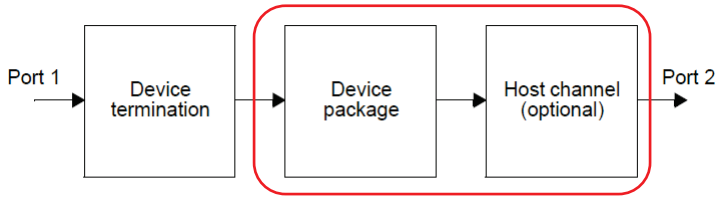
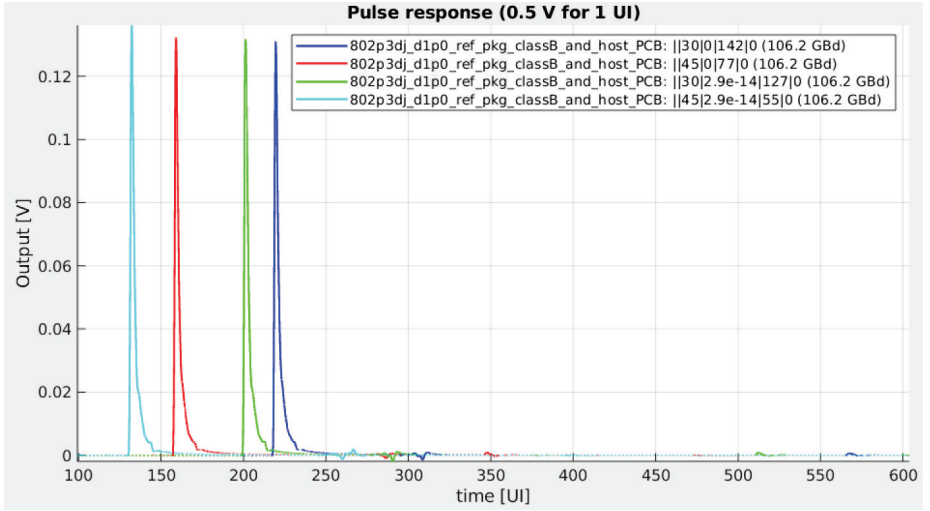


Figure 178A–2—Transmitter S-parameter model



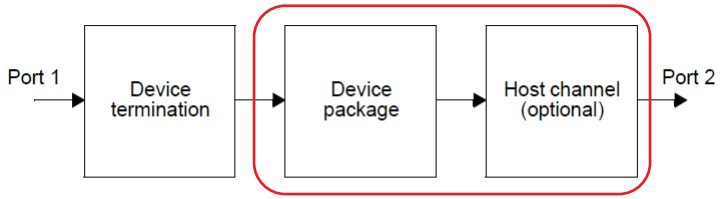
Possible parameters for host-nominal (X=11.5 dB)

Numbers modified due to via and MTF changes and modified PCB model

Using class B package with zp of either 12 or 20 mm, with/without C0

Option	pkg zp [mm]	C0 [fF]	PCB zp [mm]	C1 [fF]	COM channel IL [dB]	Total host channel IL Goal=11.5 [dB]	Tp0d-TP2 IL [dB]
1	12	0	73	0	7.96	11.46	17.71
2	20	0	60	0	8.00	11.50	17.75
3	12	29	77	0	7.95	11.45	17.70
4	20	29	39	0	7.93	11.43	17.68

IL and pulse responses are for the “total host channel” and include the path from C_b to C_1. “Device termination” effect other than adding a delay is insignificant.



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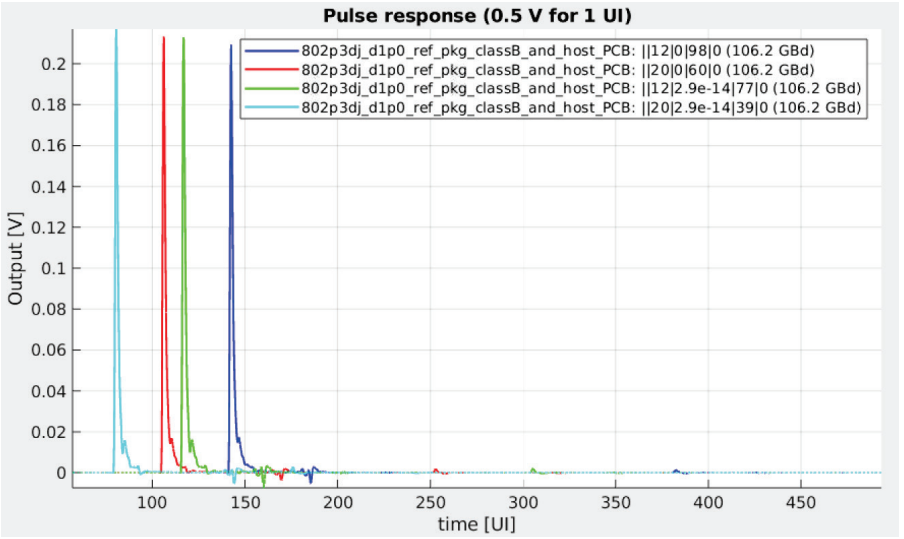


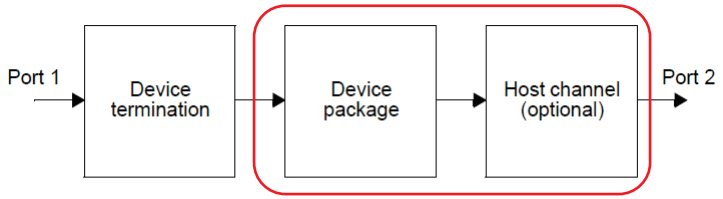
Possible parameters for host-low (X=6.5 dB)

Numbers modified due to via and MTF changes and modified PCB model

Using class A package with zp of either 0 or 8 mm, with/without C0

Option	pkg zp [mm]	C0 [fF]	PCB zp [mm]	C1 [fF]	COM channel IL [dB]	Total host channel IL Goal=6.5 [dB]	Tp0d-TP2 IL [dB]
1	0	0	41	0	2.94	6.44	12.69
2	8	0	26	0	3.05	6.55	12.80
3	0	29	28	0	3.02	6.52	12.77
4	8	29	18	0	3.06	6.56	12.81

IL and pulse responses are for the “total host channel” and include the path from C_b to C_1. “Device termination” effect other than adding a delay is insignificant.



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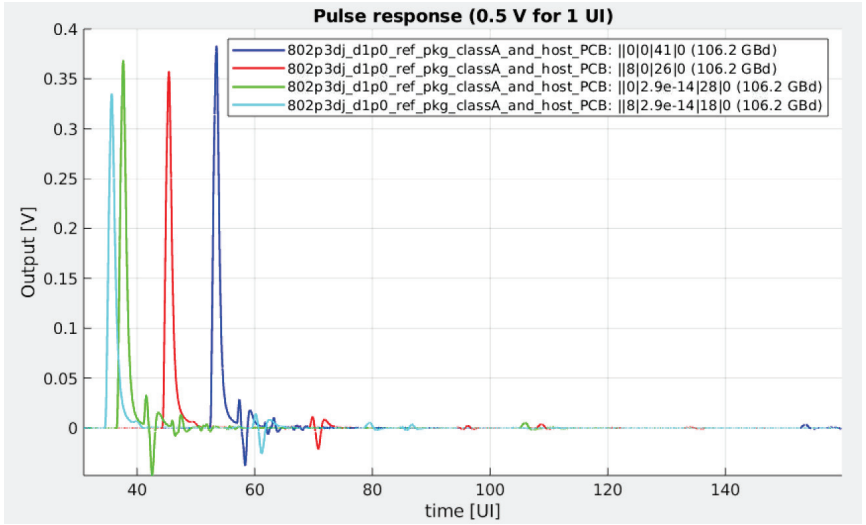

That’s all

Questions?