Reference Package Model and Parameters Towards COM Baseline

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Background and Objectives

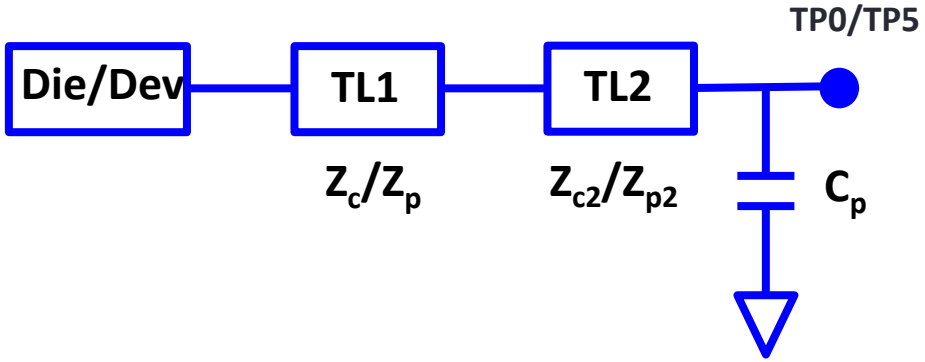
- Presentations for 200G-PAM4 reference package model and parameters extracted from the latest test/design packages for high radix switches and ASICs, as well as roadmap at 2024+, had been presented in 802.3df/dj, and other related forums (e.g., OIF/CEI, Designcon)[1], [2], [3],[4], [5], [6],[7] (“Type A” PKG)
- Other presentations for high radix switches had been presented in 802.3df/dj [8],[9],[10] (“Type B” PKG)
- There are differences in material, design, and performance between “Type A” and “Type B” PKGs, and this presentation intents to highlight those differences, and discuss paths to reach consensus and move forward.

Comparison of Key Design/Material Characteristics of “Type A” vs “Type B” PKGs

Package	“Type A”	“Type B”
ABF (Ajinomoto build-up film) material	GL107 Like	NA
Cross-section	8-2-8, or 10-2-10	6-2-6, to 9-2-9
Core thickness	~1000 µm	800-1200 µm
Trace routing lengths	33 mm max	30-40 mm max
Surface treatment	CZ8401 Like	NA
BGA ball pitch	0.8 mm	> 1.0 mm
Skip Layer	Yes (x%)	No
Trace line / space	~30 / 60 / 30 µm	27-45-27 µm
Trace line / space (Skip Layer)	~80 / 80 / 80 µm	NA
Impedance	~87.5 ohms	90-92 ohms
ABF height	35 µm	40 µm

Comparison Proposed Reference PKG Models for “Type A” vs “Type B”

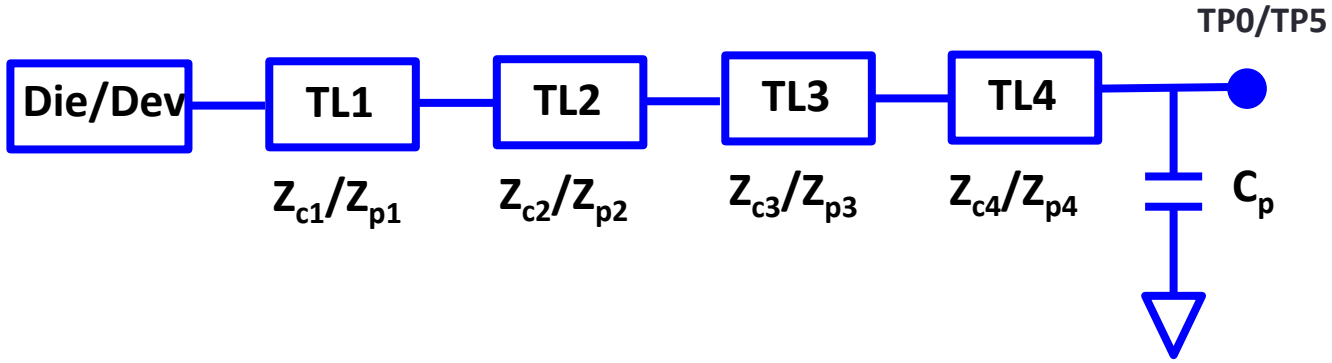
“Type A”



Characteristics

- Same as 802.ck
- TL1 (i.e., horizontal trace) and TL2 (vertical PTH) physical structure correspondences had been well understood/correlated

“Type B”



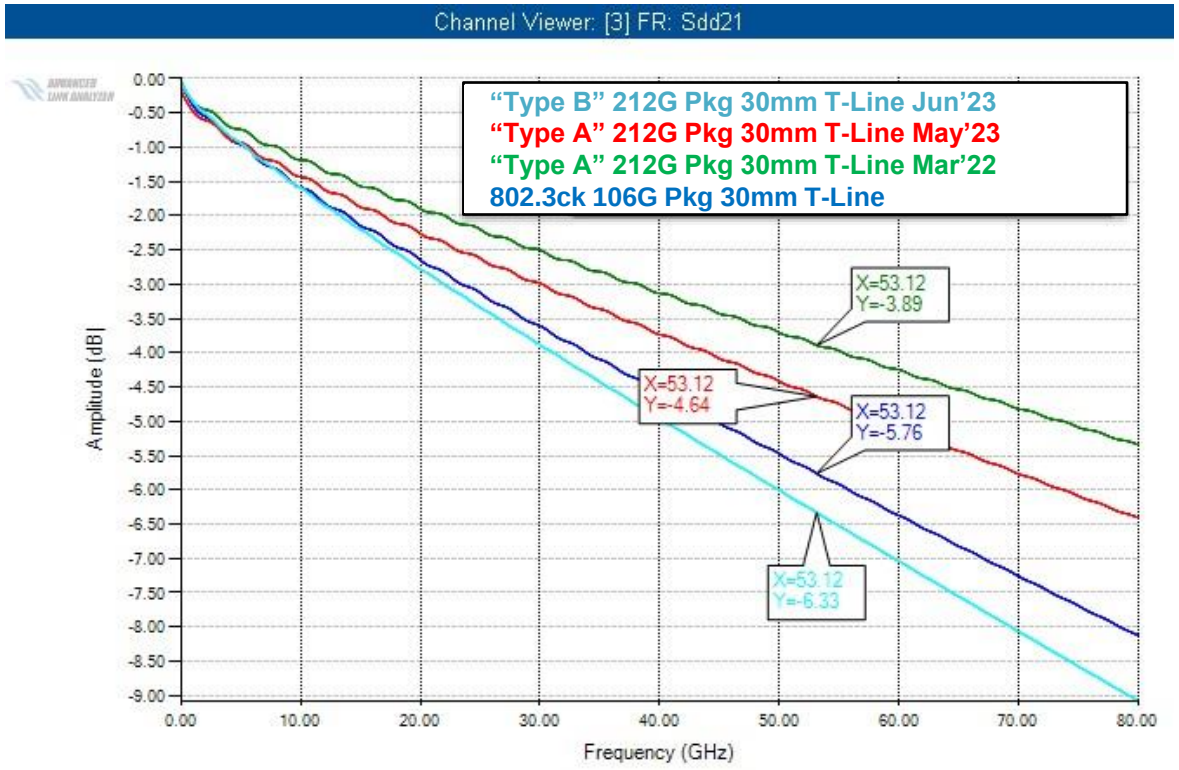
Characteristics

- New
- TL3 and TL4 physical structure correspondences need to be explained, justified, and correlated

Comparison of The Proposed Reference PKG Performance for "Type A" vs "Type B" (1/3)

Param	802/3ck PKG T-Line Model Param	Prop 212G "Type A" PKG T-Line Model Param (Mar'22 [5])	Prop 212G "Type A" PKG T-Line Model Param (May'23 [7])	Prop 212G "Type B" PKG T-Line Model Param ([8],[9],[10])
Z_p	30 mm	30 mm	30 mm	30 mm
γ_0	0 /mm	0 /mm	**5e-4 /mm**	**0 /mm**
τ	6.141e-3 ns/mm	6.141e-3 ns/mm	6.141e-3 ns/mm	**6.44805e-3 ns/mm**
a_1	9.909e-4 $ns^{1/2}$/mm	8.9e-4 $ns^{1/2}$/mm	8.9e-4 $ns^{1/2}$/mm	**8.455e-4 $ns^{1/2}$/mm**
a_2	2.772e-4 ns/mm	1.55e-4 ns/mm	**2.0e-4 ns/mm**	**3.40225e-4 ns/mm**
Z_c	87.5 Ω	87.5 Ω	87.5 Ω	**92 Ω**
R_o	50 Ω	50 Ω	50 Ω	50 Ω

- For "Type B" PKG, only highlighted in "light-blue" parameters are in its latest proposal[10]
- "Type B" horizontal loss is worse than 802.3ck by 0.57 dB at Nyquist, with Zp=30 mm, γ_0 = 0 /mm, and R_0 = 50 Ω



"Type B" 212G Pkg 30mm T-Line Jun'23

"Type A" 212G Pkg 30mm T-Line May'23

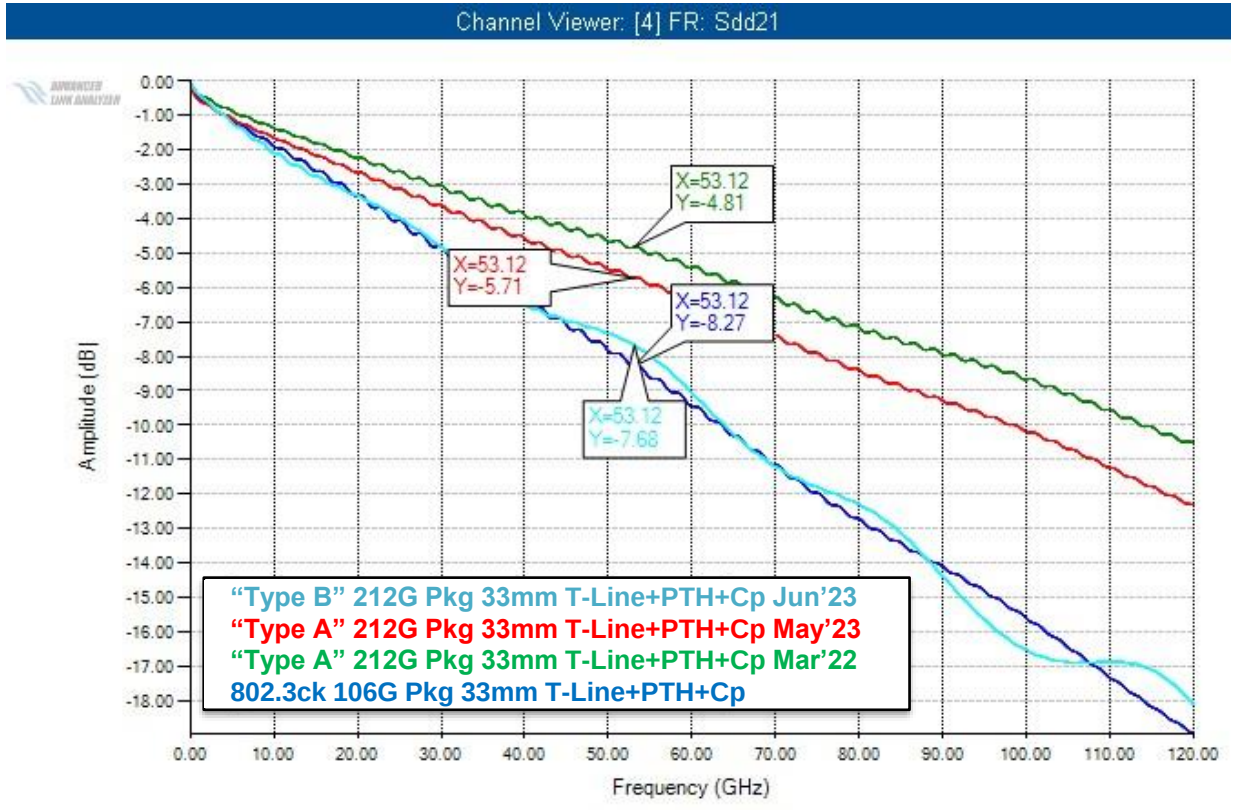
"Type A" 212G Pkg 30mm T-Line Mar'22

802.3ck 106G Pkg 30mm T-Line

- **"Type A" temp at 90C**
- **"Type B" temp not available from [8],[9],[10]**

Comparison of The Proposed Reference PKG Performance for "Type A" vs "Type B" (2/3)

Param	802/3ck PKG T-Line Model Param	Prop 212G "Type A" PKG T-Line Model Param (Mar'22 [5])	Prop 212G "Type A" PKG T-Line Model Param (May'23 [7])	Prop 212G "Type B" PKG T-Line Model Param ([8],[9],[10])
Z_p	33 mm	33 mm	**33 mm**	33mm
γ_0	0 /mm	0 /mm	**5e-4 /mm**	**0 /mm**
τ	6.141e-3 ns/mm	6.141e-3 ns/mm	6.141e-3 ns/mm	**6.44805e-3 ns/mm**
a_1	9.909e-4 $ns^{1/2}$/mm	8.9e-4 $ns^{1/2}$/mm	8.9e-4 $ns^{1/2}$/mm	**8.455e-4 $ns^{1/2}$/mm**
a_2	2.772e-4 ns/mm	1.55e-4 ns/mm	**2.0e-4 ns/mm**	**3.40225e-4 ns/mm**
Z_c	87.5 Ω	87.5 Ω	87.5 Ω	**92 Ω**
Z_{p2}	1.8	1.8	1.8	**2.5 (1+1+0.5)**
Z_{c2}	92.5 Ω	92.5 Ω	92.5 Ω	**70/80/100 Ω**
R_o	50 Ω	50 Ω	50 Ω	50 Ω
Cp	87 fF	40 fF	40 fF	**50 fF**



"Type B" 212G Pkg 33mm T-Line+PTH+Cp Jun'23

"Type A" 212G Pkg 33mm T-Line+PTH+Cp May'23

"Type A" 212G Pkg 33mm T-Line+PTH+Cp Mar'22

802.3ck 106G Pkg 33mm T-Line+PTH+Cp

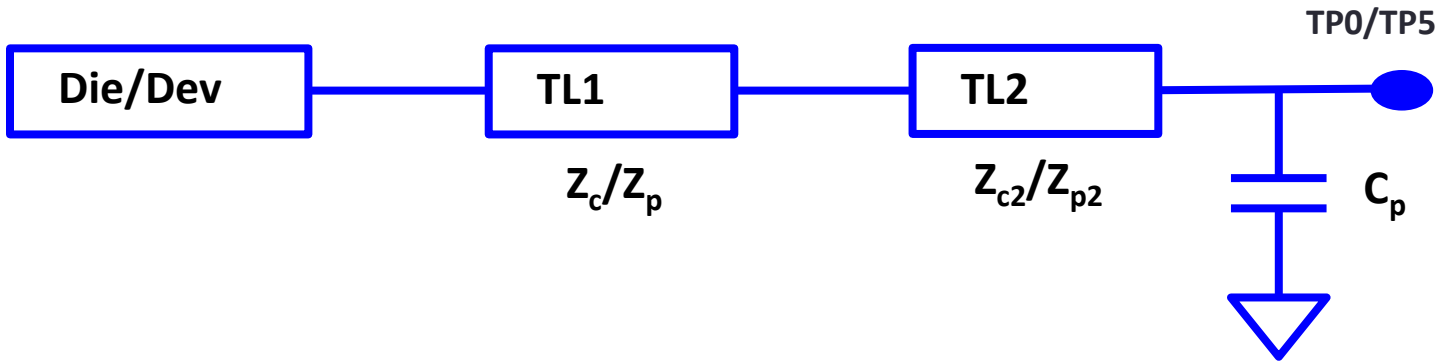
- "Type A" temp at 90C
- "Type B" temp not available from [8],[9],[10]

Comparison of The Proposed Reference PKG Performance for “Type A” vs “Type B” (3/3)

	IL (Horizontal trace, Zp=30mm, dB)	IL (All, Zp=33mm, dB)	Delay τ (ns/mm)	ΔIL (Horizontal trace, Zp=30mm , dB wrt 802.3ck)	ΔIL (All, dB wrt 802.3ck)	ΔDelay τ (ns/mm)
“Type A”	4.64	5.71	6.141e-3	-1.12	-2.56	0
“Type B”	6.33	7.68	6.44805e-3	+0.57	-0.59	+0.30705e-3
802.3ck	5.76	8.27	6.141e-3	_____	_____	_____

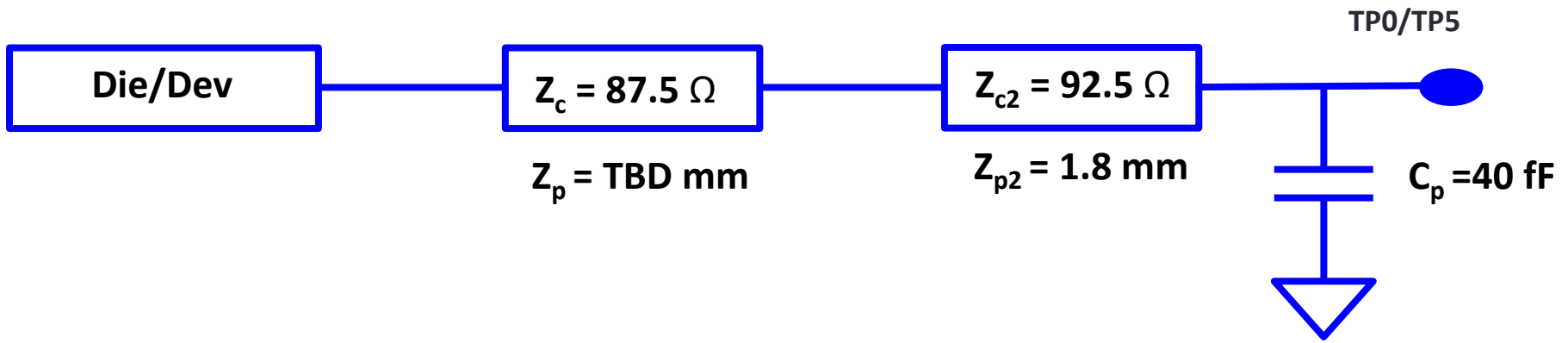
IL is measured at Nyquist

Recap of Proposed “Type A” PKG Model



Recap of Proposed “Type A” PKG Model Parameters for High SERDES Density Devices

Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5; 92.5 92.5]	Ohm



Summary and Discussions

- Two proposed reference PKG model and parameters are reviewed and compared, in design techniques/choices, and associated performances
- “Type A” reference PKG has generational improvements for both horizontal trace loss and overall loss vs 802.3ck, with two TL models same as 802.3ck
- “Type B” reference PKG has negative generational improvements for horizontal trace loss and delay, however a slight overall loss improvement vs 802.3ck, but with four TL models, different from 802.3ck
- All 200G/L link subsystems/components need to provide generational advancements/improvements over previous 100G/L, to meet the required use cases (e.g., up to 40 dB (bump-to-bump) for KR and CR with >= 1m DAC)
    - SERDES had demonstrated 2x in speed, BW, jitter, noise improvements
    - Connectors had demonstrated > 2x BW/IL improvements
    - PKG needs to move in the same direction

References

[1] J. Jiang et al, “Designing 224G PAM4 High Performance FPGA Package and Board with Confidence”, *Designcon*, 2021.

[2] M. Li et al. “224G Package Investigations and COM Reference Model”, OIF (https://www.oiforum.com, oif2021.263.00), Nov, 2021

[3] M. Li et al. “Reference Die and Package Models for CEI-224G-PAM4”, OIF (https://www.oiforum.com, oif2022.065.01), Feb, 2022

[4] M. Li et al. : https://www.ieee802.org/3/df/public/22_03/mli_3df_01a_220316.pdf, Mar, 2022

[5] M. Li et al. : https://www.ieee802.org/3/df/public/22_03/mli_3df_02a_220316.pdf, Mar, 2022

[6] Melitz et al. : https://www.ieee802.org/3/df/public/22_03/mellitz_3df_01b_220316.pdf, Mar, 2022

[7] M. Li et al. : https://www.ieee802.org/3/dj/public/23_05/li_3dj_02_2305.pdf , May, 2023

[8] L. Ben-Artsi, and R. Mellitz: https://www.ieee802.org/3/df/public/22_07/benartsi_3df_01b_2207.pdf, Jul, 2022

[9] R. Mellitz, A. Ran, L. Ben-Artsi: https://www.ieee802.org/3/df/public/22_11/benartsi_3df_01a_2211.pdf , Jul, 2022

[10] A. Ghiasi, A. Ran, R. Mellitz, L. Ben-Artsi: https://www.ieee802.org/3/dj/public/adhoc/electrical/23_0622/benartsi_3dj_elec_01a_230622.pdf , June, 2023

Straw Poll 1

I would support the direction of the 200G/L package model to Annex 93A (COM) on slide 8

a) Yes
b) No
c) NMI
d) Abstain

Straw Poll 2

I would support package model parameters on slide 9 for COM of 200G/Lane KR, CR, AUI chip-to-chip and chip-to-module host/high density SERDES devices

a) Yes
b) No
c) NMI
d) Abstain

Thank You!