400GPL Package Model

Thoughts and Preliminary Model

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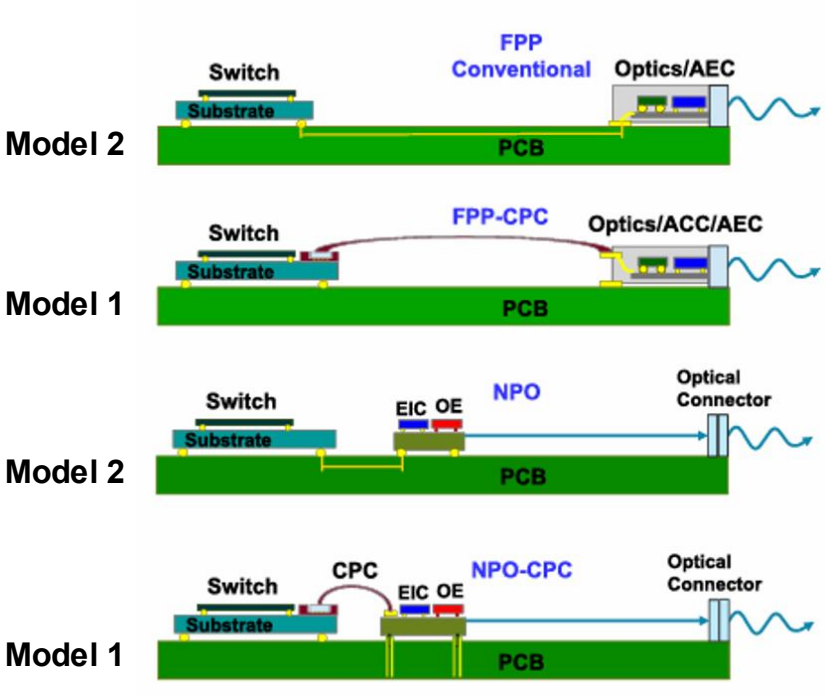
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Agenda

- Background - Package model types
- Top of package connection launch model
- Bump to BGA model
- Observations
- Further work

Package models

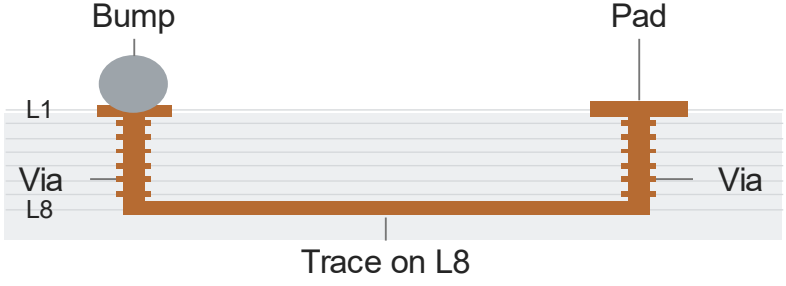
- Package models architectures that were suggested and presented by Ali Ghiasi et al. in the 400GPL study group meeting in Lisbon.
- Two package architectures are considered by the suggested models, to accommodate a “high radix optimized” solution
  - Model 1 – Top of package connection
  - Model 2 – Bump to BGA ball connection



Source: ghiasi_400GPL_01a_2609, slide #7

Package model 1 (top of package)

- Stack-up
  - 9-layer Buildup
  - 45 µm GL107-Like, copper 18 µm
- Trace characteristics:
  - Total length 31 mm
    - may be altered according to (Radix optimized) package architecture definition, once connection target length is agreed
  - Route: bump ➔ via stack L1 to L8 ➔ ~85 Ω strip-line ➔ via stack L8 to L1
- Extracted at 90 ºC

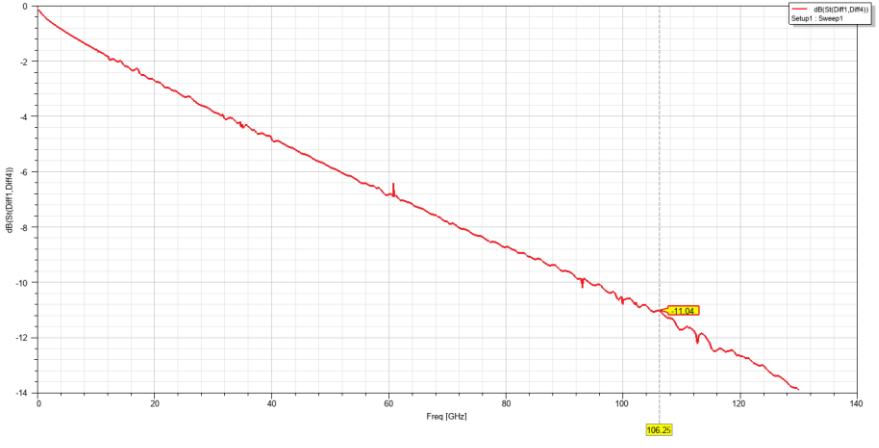


Package design specifics	"Class B" package characteristics
Buildup	GL107 like
Cross section	9-2-9
Core thickness	N/A
Trace routing length	31 mm
Surface treatment	CZ8401 like
BGA ball pitch	N/A
Skip layer	no
Trace line/space	~34/45/34
Impedance	~85 Ω
ABF height	45 µm

Package model 1 (cont.)

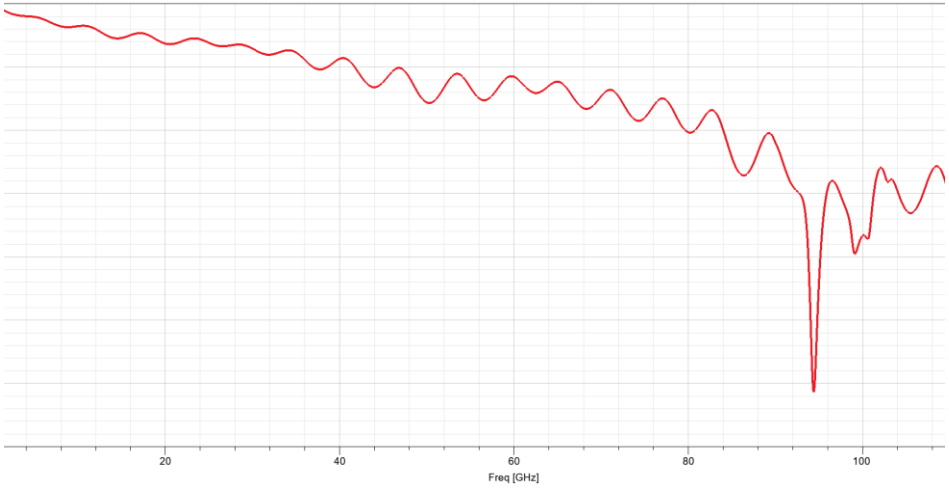
- Observations
  - Differential IL @106.25 GHz ≈11dB ➔ ~0.35 dB/mm
  - Bandwidth seems to be sufficient for PAM4
  - Model launch includes pad only
    - Need to consider the correct methodology for attaching a connector/Interconnect model

Bump to pad



Package model 2 (BGA)

- Observations
  - Bandwidth seems capped at 80-90 GHz range (current optimization)
  - Trace differential IL @85 GHz is ~0.285 dB/mm
  - Trace length TBD, may need to be longer than “top of package launch” due to coarser ball pitch
- **Work in progress**



Main Observations

- Bandwidth
  - Top of package connection meets BW≥110 GHz
  - “BGA like” is capped at the 80-90 GHz range

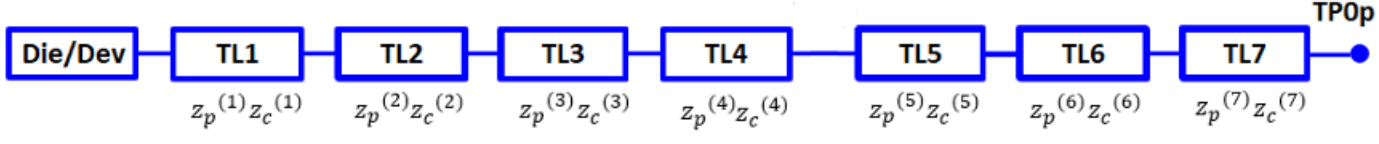
- Loss/mm
  - ≈ 0.35 dB for “PAM4” 106.25 GHz
  - ≈ 0.285 dB for “PAM6” 85 GHz

Package Model Parameters

- Initial “top of package connection” model parameters to be used in COM

Same as 802.3dj Class B

Parameter	Symbol	Value	Unit
Transmission line parameter γ_0	γ_0	5.000E-04	1/mm
Transmission line parameter a_1	a_1	6.500E-04	ns^1/2/mm
Transmission line parameter a_2	a_2	2.930E-04	ns/mm
Transmission line parameter τ	τ	6.141E-03	ns/mm
Transmission line 1 length	Z_{P1}	0.63	mm
Transmission line 1 characteristic impedance	Z_{c1}	72	Ω
Transmission line 2 length	Z_{P3}	1.0	mm
Transmission line 2 characteristic impedance	Z_{c2}	85	Ω
Transmission line 3 length	Z_{P3}	2.5	mm
Transmission line 3 characteristic impedance	Z_{c3}	89	Ω
Transmission line 4 length	Z_{P4}	28	mm
Transmission line 4 characteristic impedance	Z_{c4}	87	Ω
Transmission line 5 length	Z_{P5}	0.5	mm
Transmission line 5 characteristic impedance	Z_{c5}	81	Ω
Transmission line 6 length	Z_{P6}	0.4	mm
Transmission line 6 characteristic impedance	Z_{c6}	92	Ω
Transmission line 7 length	Z_{P7}	0.3	mm
Transmission line 7 characteristic impedance	Z_{c7}	80.6	Ω



Summary

Current results

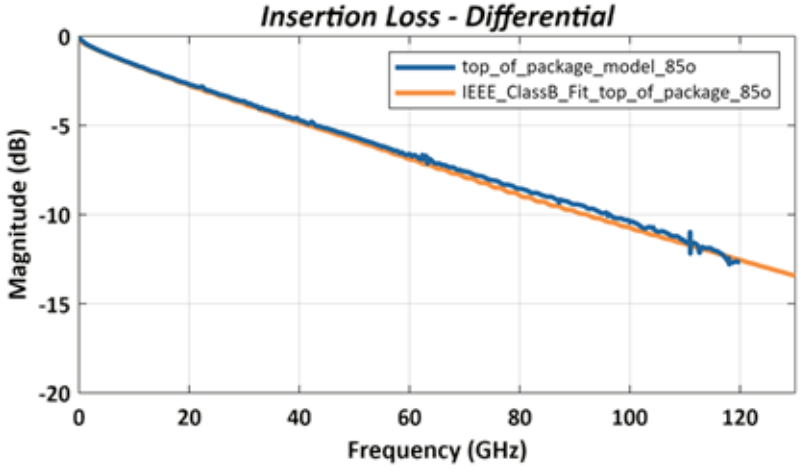
- An initial bump to top of package model was presented, fitted and model parameters supplied – BW seems sufficient for PAM4 modulation.
- Bump to BGA model is WIP – BW may be at the 80-90 GHz range.
  - Model parameters to be provided in a future contribution.

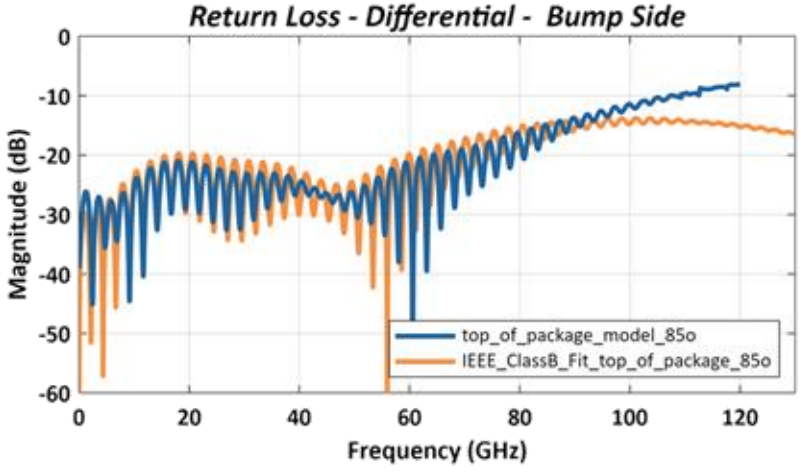
Further exploration

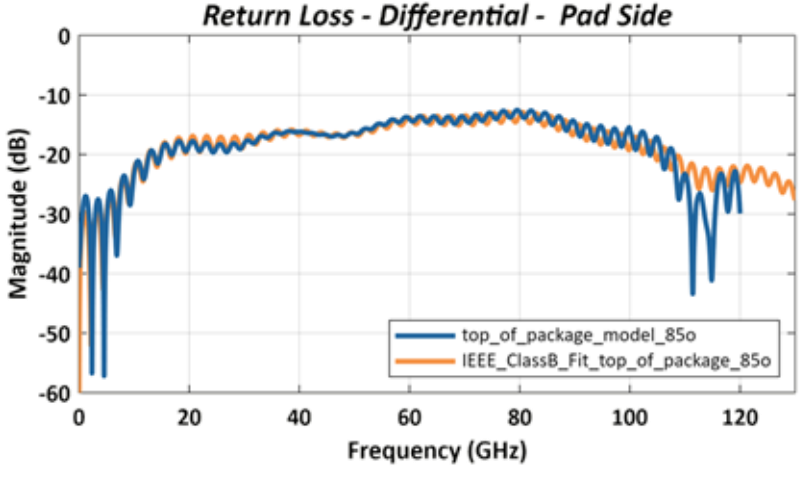
- Crosstalk effect within the package model
- Do we include any representation of common mode/mode conversion
- What is the expected routing length per architecture
- TEM connections
  - Do we take the “pad area” side inward to a more TEM point?
    - Will cable models include package launch?
    - Will any other “top of package” connection include the launch?
  - Provide a model that includes a partial via into the PCB?

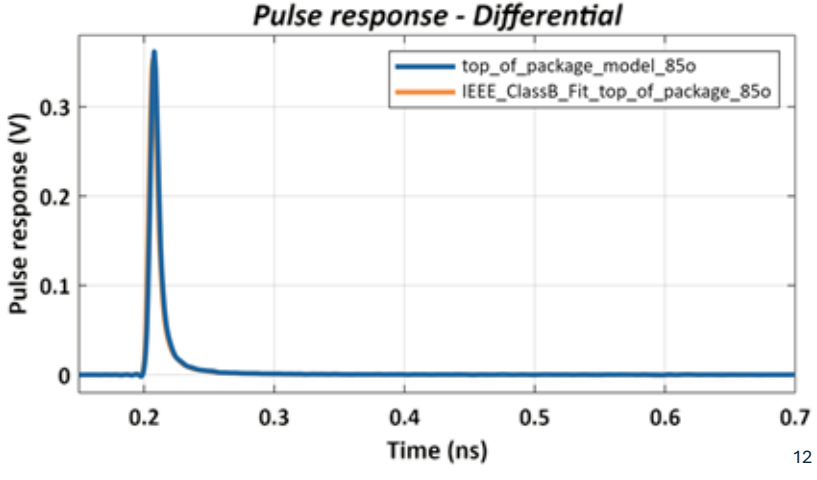
Q/A

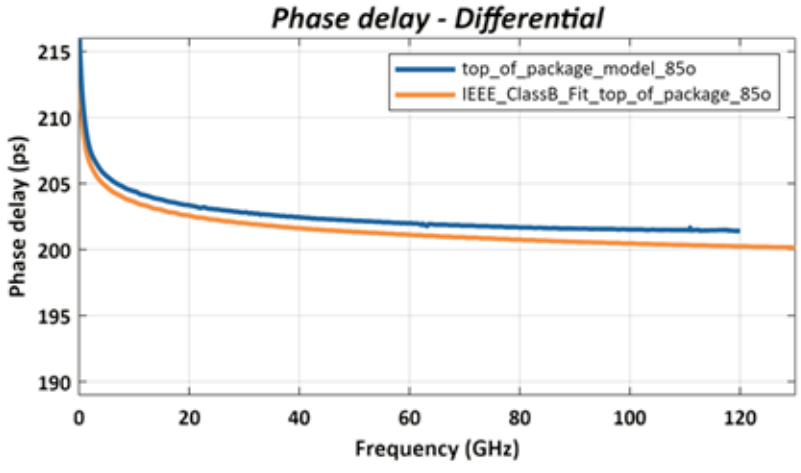
Backup

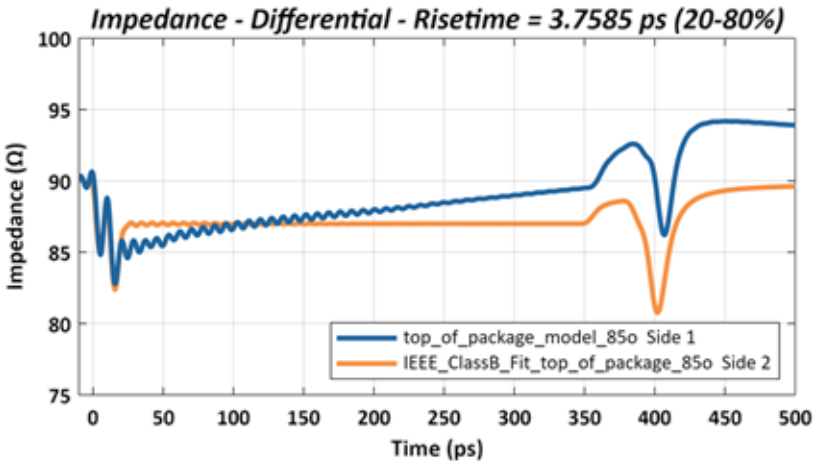

Insertion Loss - Differential
top_of_package_model_85o
IEEE_ClassB_Fit_top_of_package_85o
Magnitude (dB)
Frequency (GHz)
0
-5
-10
-15
-20
0
20
40
60
80
100
120

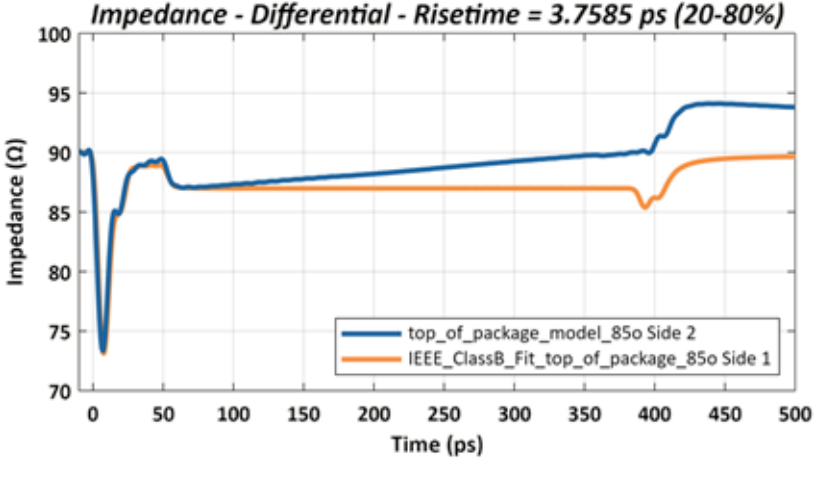

Return Loss - Differential - Bump Side
top_of_package_model_85o
IEEE_ClassB_Fit_top_of_package_85o
Magnitude (dB)
Frequency (GHz)
0
-10
-20
-30
-40
-50
-60
0
20
40
60
80
100
120


Return Loss - Differential - Pad Side
top_of_package_model_85o
IEEE_ClassB_Fit_top_of_package_85o
Magnitude (dB)
Frequency (GHz)
0
-10
-20
-30
-40
-50
-60
0
20
40
60
80
100
120


Pulse response - Differential
top_of_package_model_85o
IEEE_ClassB_Fit_top_of_package_85o
Pulse response (V)
Time (ns)
0.3
0.2
0.1
0
0.2
0.3
0.4
0.5
0.6
0.7


Phase delay - Differential
top_of_package_model_85o
IEEE_ClassB_Fit_top_of_package_85o
Phase delay (ps)
Frequency (GHz)
215
210
205
200
195
190
0
20
40
60
80
100
120


Impedance - Differential - Risetime = 3.7585 ps (20-80%)
top_of_package_model_85o Side 1
IEEE_ClassB_Fit_top_of_package_85o Side 2
Impedance (Ω)
Time (ps)
100
95
90
85
80
75
0
50
100
150
200
250
300
350
400
450
500


Impedance - Differential - Risetime = 3.7585 ps (20-80%)
top_of_package_model_85o Side 2
IEEE_ClassB_Fit_top_of_package_85o Side 1
Impedance (Ω)
Time (ps)
100
95
90
85
80
75
70
0
50
100
150
200
250
300
350
400
450
500