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3D Package Model for Electromagnetic Field Solver used in More High-Speed Channel Simulation

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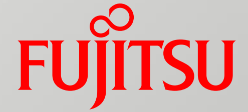
Agenda



- Background
- Verification of 3D Package model superiority
- Challenges for 3D Package model
- Summary

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Background

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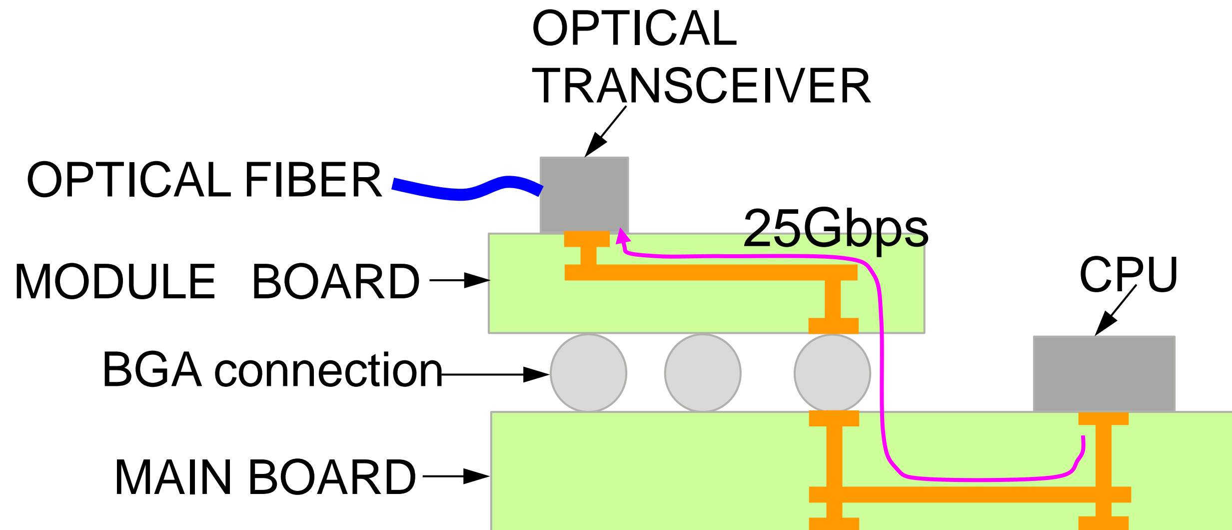
In Optical Transmission System Board Development

Board configuration



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Background

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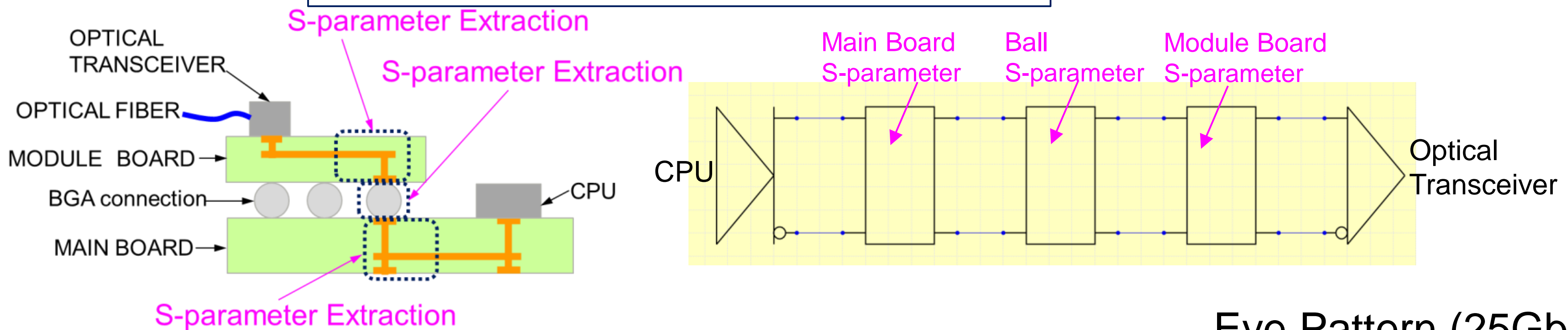
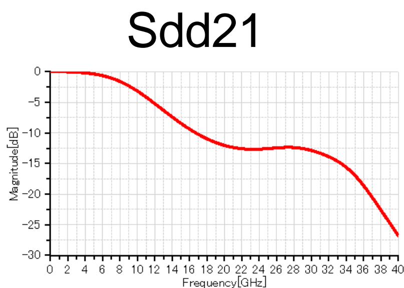
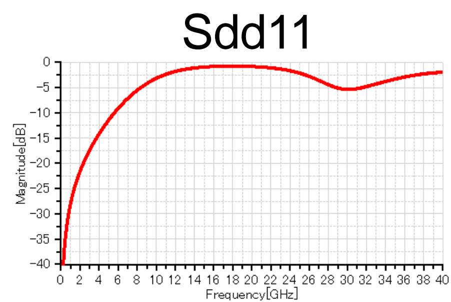
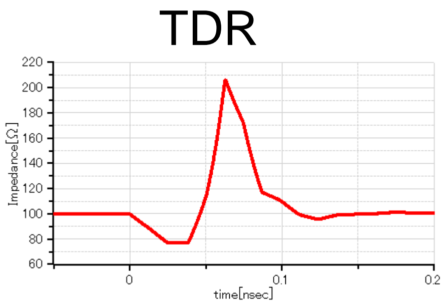
In Optical Transmission System Board Development

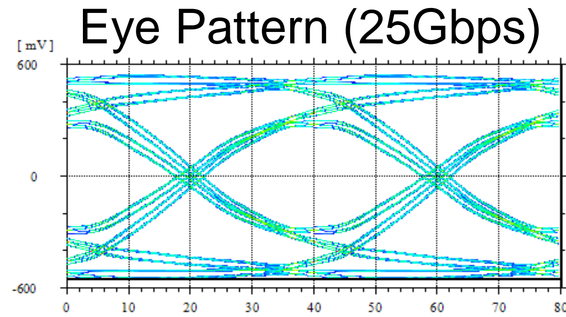
25Gbps Line Channel Simulation











- Against expectation, Simulation results were bad.
- Review the Analog Channel Model.

  Changed S-parameter extraction method.

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Background

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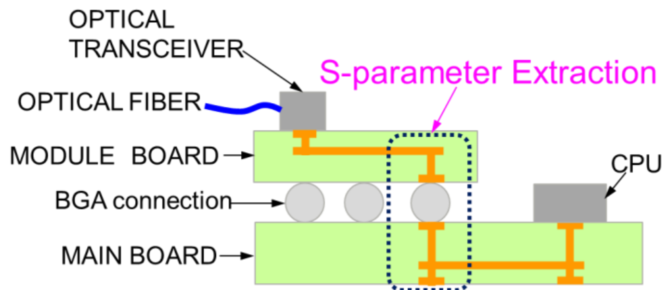
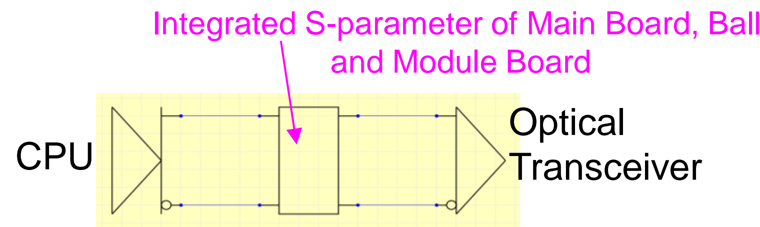
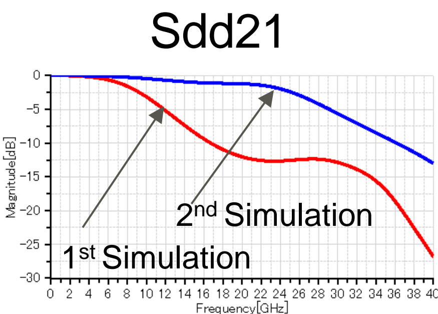
In Optical Transmission System Board Development

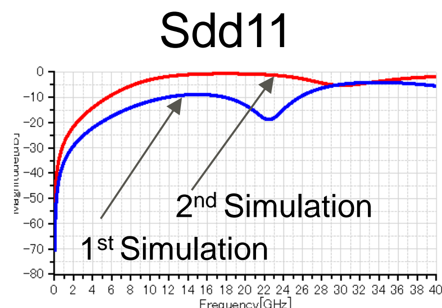
25Gbps Line Channel Simulation

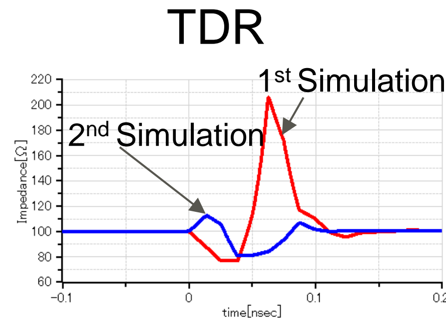
2nd Simulation Analog Channel Model

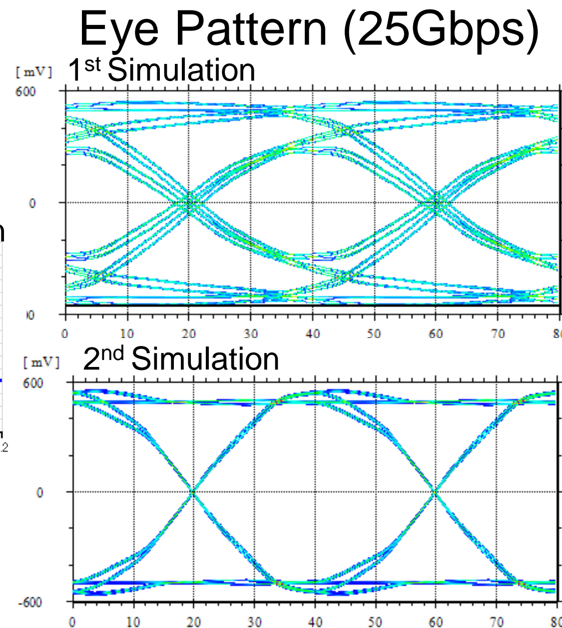












- By reviewing the S-parameter extraction method, good simulation results were obtained as expected.

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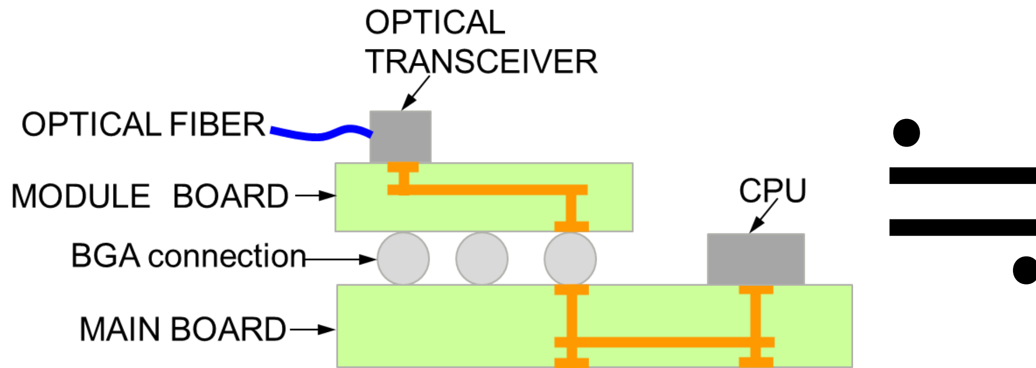
Optical Transmission System Board Configuration



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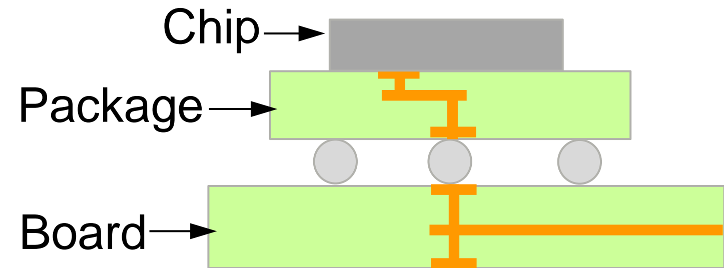
Chip-Package-Board Configuration



- The interconnect structure of the Optical Transmission System Board is like that of Chip, Package, and Board.
- So, it seems that more accurate simulation results can be obtained by extracting the S-parameter with the Package integrated with the Board.
- At that time, the Package requires a model for 3D ELECTROMAGNETIC FIELD SIMULATOR.
- Therefore, we verified **the superiority of using a 3D Model for Package** by simulating with a **simple 3D Model** of Package and Board.
- Also, we examined **the issues of 3D Models**.

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Verification of 3D Package model superiority

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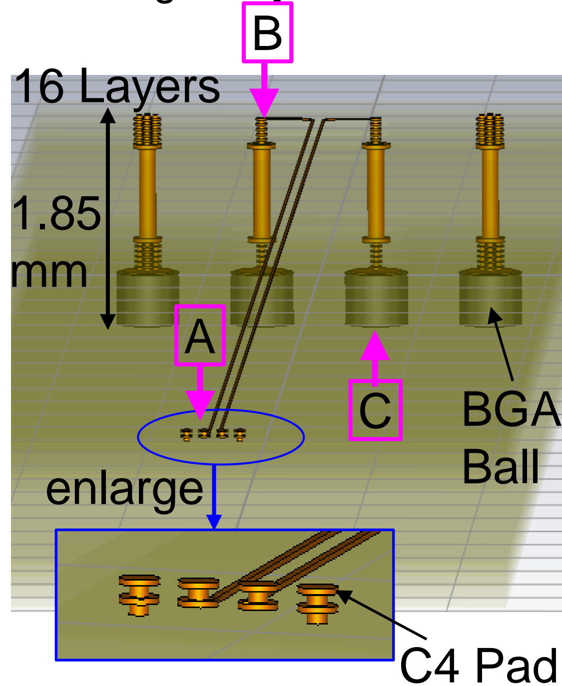
Simple 3D Model for Verification

Package-only 3D Model

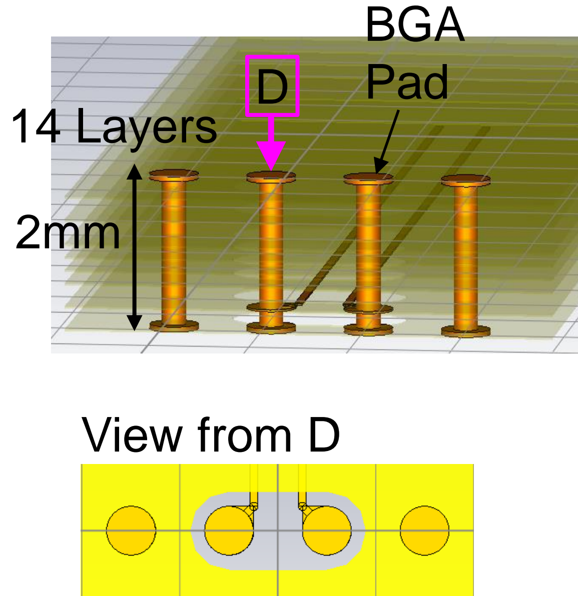


View from A

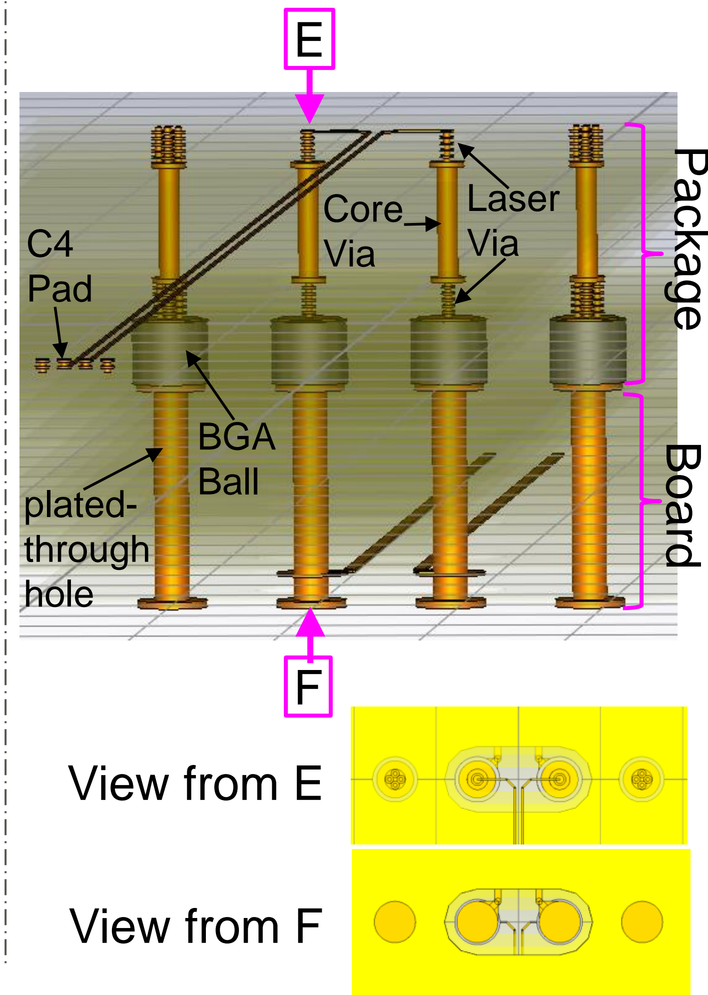
View from B

View from C

Board-only 3D Model



Integrated Package and Board 3D model



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Verification of 3D Package model superiority

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Verification Case

- Case2 (More accurate simulation result) vs. Case1 (Simulation result by conventional topology)
- What is the difference between Case1 and Case2?

Case	Analog Channel Model Configuration	Verification Items		
		Insertion Loss Return Loss	Zdiff	Eye Pattern
1	Package-only 3D Model / Board-only 3D Model Conventional Simulation Topology	SDD21 SDD11	TDR	5Gbps NRZ 10Gbps NRZ 16Gbps NRZ 28Gbps NRZ 56Gbps NRZ 56Gbps PAM4
2	Integrated Package and Board 3D model	SDD21 SDD11	TDR	5Gbps NRZ 10Gbps NRZ 16Gbps NRZ 28Gbps NRZ 56Gbps NRZ 56Gbps PAM4

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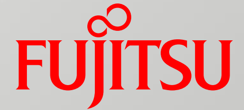
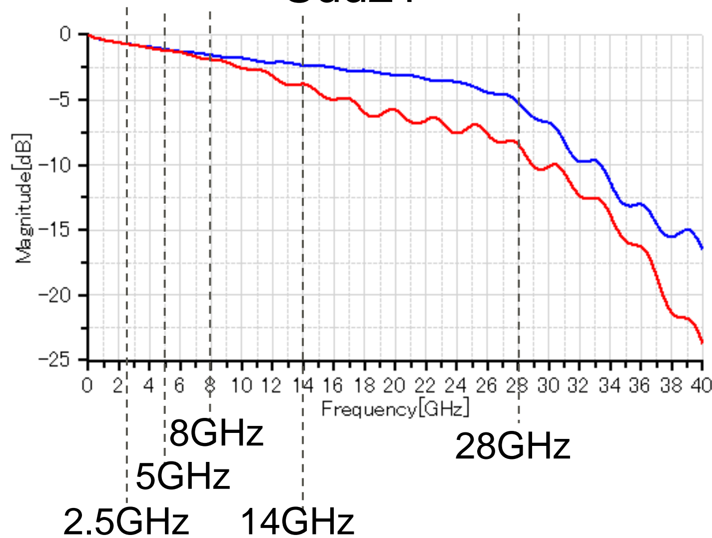
Verification of 3D Package model superiority



Simulation Results

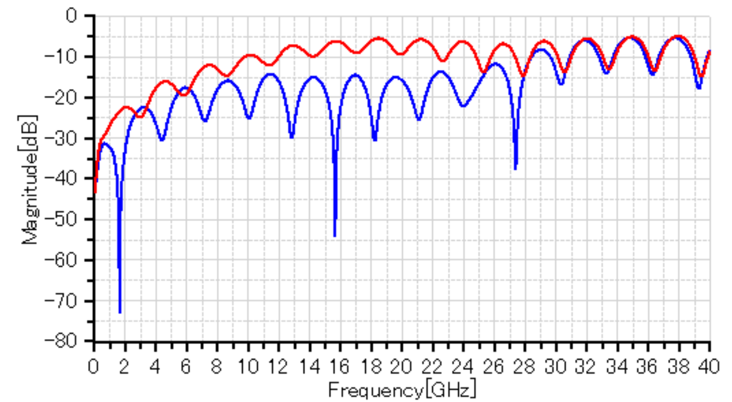
Red: Case1 (Package-only + Board-only) Blue: Case2 (Integrated Package and Board)

Sdd21

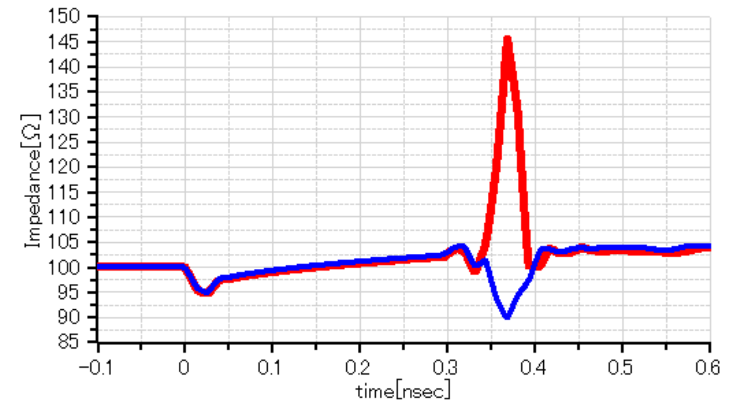


Data Rate	$f_{Nyquist}$
5Gbps NRZ	2.5GHz
10Gbps NRZ	5GHz
16Gbps NRZ	8GHz
28Gbps NRZ	14GHz
56Gbps NRZ	28GHz
56Gbps PAM4	14GHz

Sdd11



TDR



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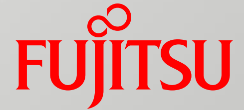
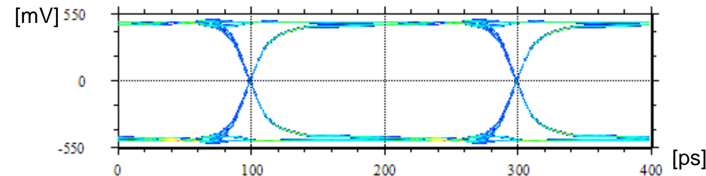
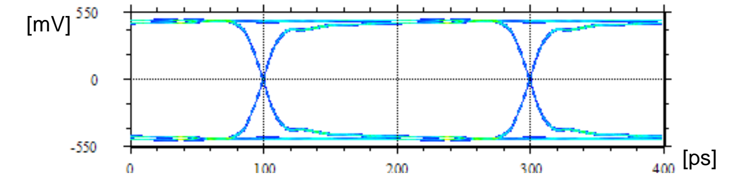
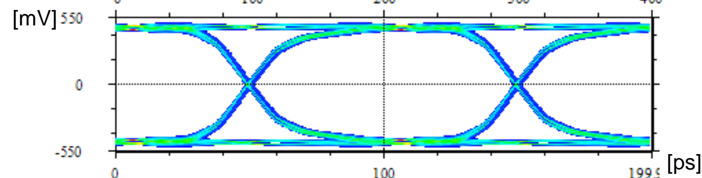
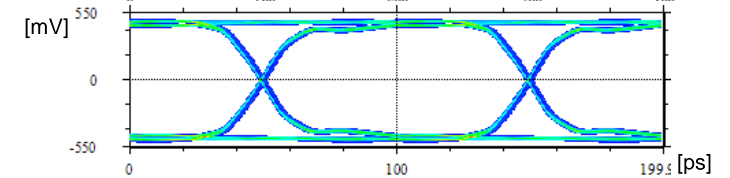
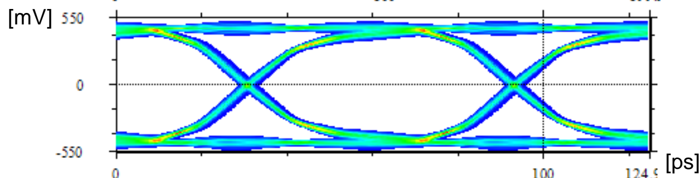
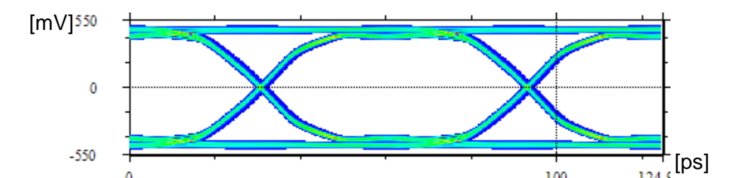
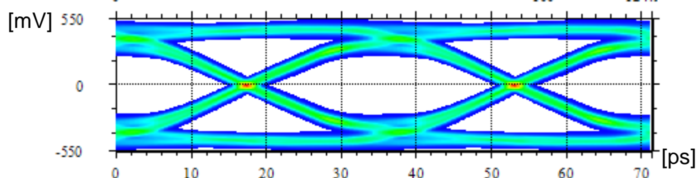
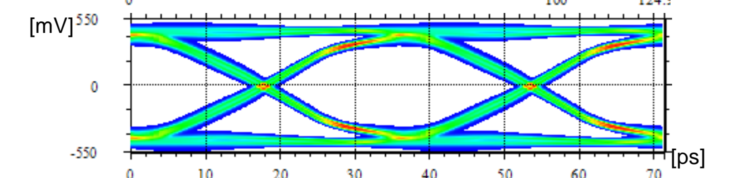
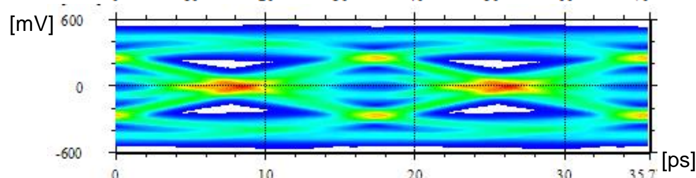
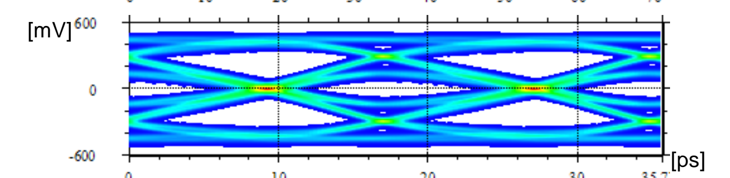
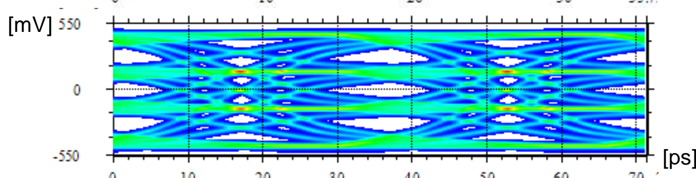
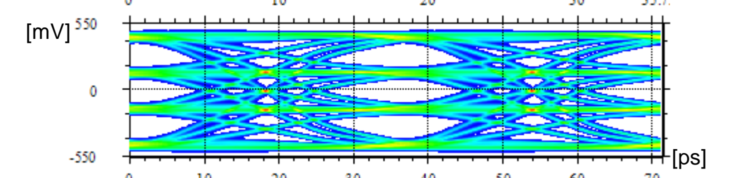
Verification of 3D Package model superiority



Simulation Results

	[Case1] Package-only + Board-only	[Case2] Integrated Package and Board
5Gbps NRZ		
10Gbps NRZ		
16Gbps NRZ		
28Gbps NRZ		
56Gbps NRZ		
56Gbps PAM4		

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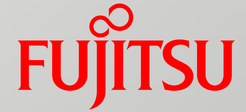
Verification of 3D Package model superiority



- Case1 (Package-only + Board-only) has a larger Impedance mismatch than Case2 (Integrated Package and Board) at the connection between the Package and the Board.

- Therefore, Case1 has worse Insertion Loss and Reflection Loss than Case2.

- Also, the higher the Data Rate, the smaller the Eye opening in Case1 than in Case2.

- In the future, when the Data Rate becomes higher ($\mathbf{f}_{Nyquist} \geq$ 28GHz, for example, 112G, 224G), it may be necessary to simulate with the extracted S-parameter by integrated Package and Board in order to improve the analysis accuracy.

- Therefore, it may be necessary to add a standard for 3D Package model to IBIS specification in the future.

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Verification of 3D Package model superiority

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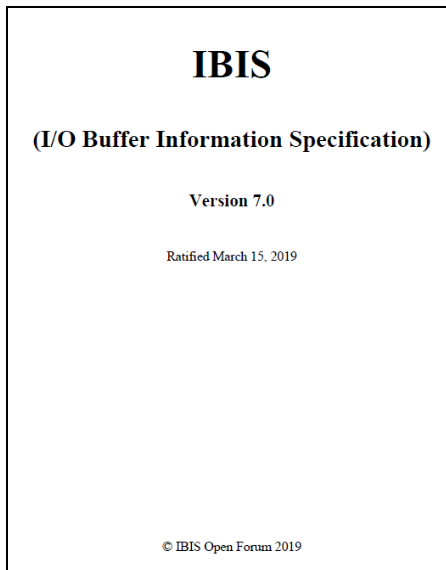
New Subparameter "FILE_3D" may be needed in the future.


IBIS

(I/O Buffer Information Specification)

Version 7.0

Ratified March 15, 2019

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File_3D

Table 46 – Interconnect Modeling Keywords and Subparameters

Keyword or Subparameter	Notes
[Interconnect Model Set]	
[Manufacturer]	(note 1)
[Description]	(note 1)
[Interconnect Model]	(note 2)
Param	
File_TS	(note 3)
File_IBIS-ISS	(note 3)
Unused_port_termination	(note 4)
Number_of_terminals	(note 5)
<terminal line>	(note 6)
[End Interconnect Model]	(note 7)
[End Interconnect Model Set]	(note 8)

296

Existing model format

Notes:

1) [Manufacturer] and [Description] are each optional keywords within any [Interconnect Model Set].
2) At least one [Interconnect Model] is required for each [Interconnect Model Set].
3) One of either the File_TS or File_IBIS-ISS subparameters is required.

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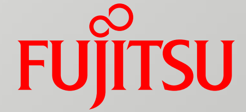
Challenges for 3D Package model



- Package design and material property values are revealed.
- 3D ELECTROMAGNETIC FIELD SIMULATOR is required.
- The analysis result differs depending on the ELECTROMAGNETIC FIELD SIMULATOR settings (Number of meshes, Analysis frequency range, Boundary conditions, Port settings).
- Simulation time is longer than S-parameter.

etc.

There seems to be many challenges for realization.

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Summary

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- We investigated the superiority of the 3D Package model.
- At higher data rates (112G, 224G), the 3D Package model helps improve analysis accuracy.
- On the other hand, the 3D Package model has many challenges (standardization and usage).

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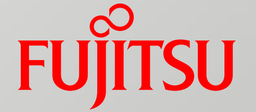
References



- “IBIS (I/O Buffer Information Specification) Version 7.0”,
 IBIS Open Forum 2019
 http://www.ibis.org/ver7.0/

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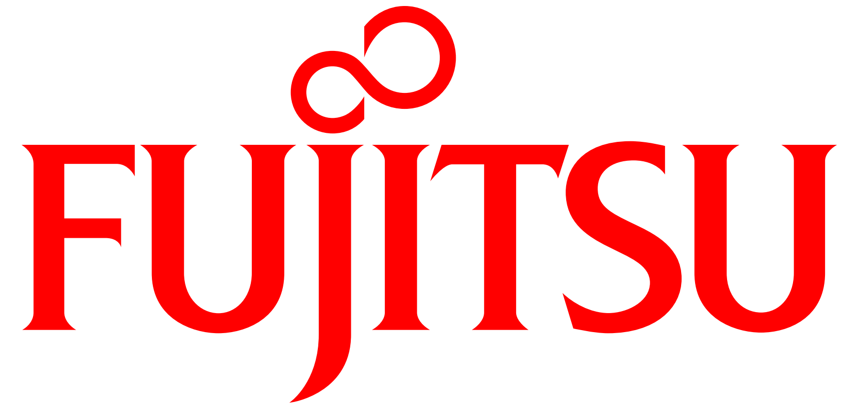

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