SW Test Workshop
Semiconductor Wafer Test Workshop
June 7 - 10, 2015 | San Diego, California

A Proof of Concept - Challenges of testing high-speed interface on wafer at lower cost

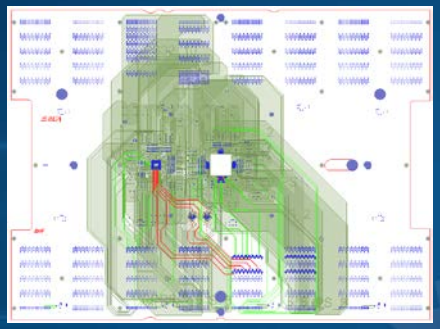
How to expand the bandwidth of the cantilever probe card

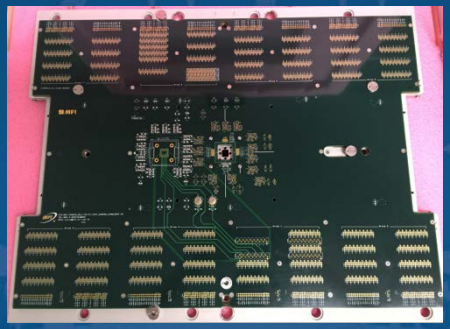
Sony LSI Design Inc.

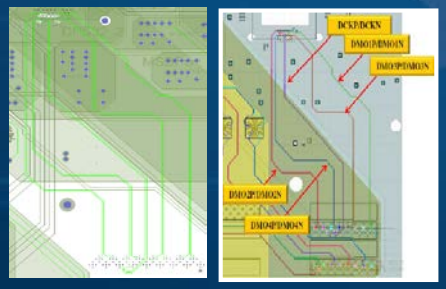
Shohei Nishimura
Shinji Fujita

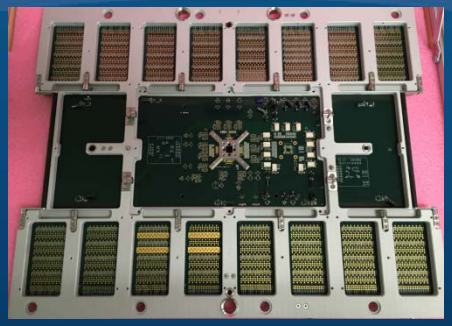
Introduction

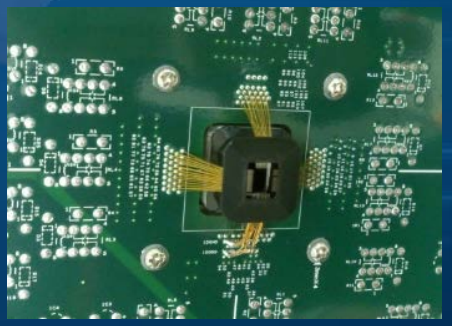
Design & Simulation → PCB Fabrication → Probe Assembly







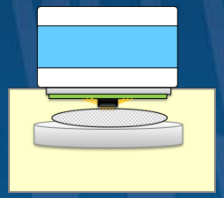


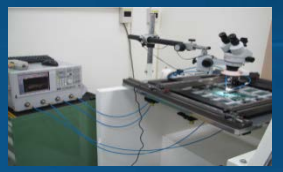


Whole probe card does not always have expected bandwidth !!

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

This presentation is based on User's point of view





Software

Hardware

Measurement

Expand Bandwidth at "*low-cost*"

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

Outline

- Background
- Overview
- Use case study
- Discussion of Results
- Conclusion

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- Use case study
- Discussion of Results
- Conclusion

Background

- **wearable/mobile market with higher CAGR conducts has**
  - Higher data rate, Lower power, Smaller die size
  - Lower cost
- **Under the cost pressure**
  - deliver innovative devices with leading-edge features
  - deliver into the market keeping a timely manner
- **Need taking a balance of quality and cost**
  - test strategy with saving NRE cost
  - judge at early phase with either "design assurance" or "testing assurance"

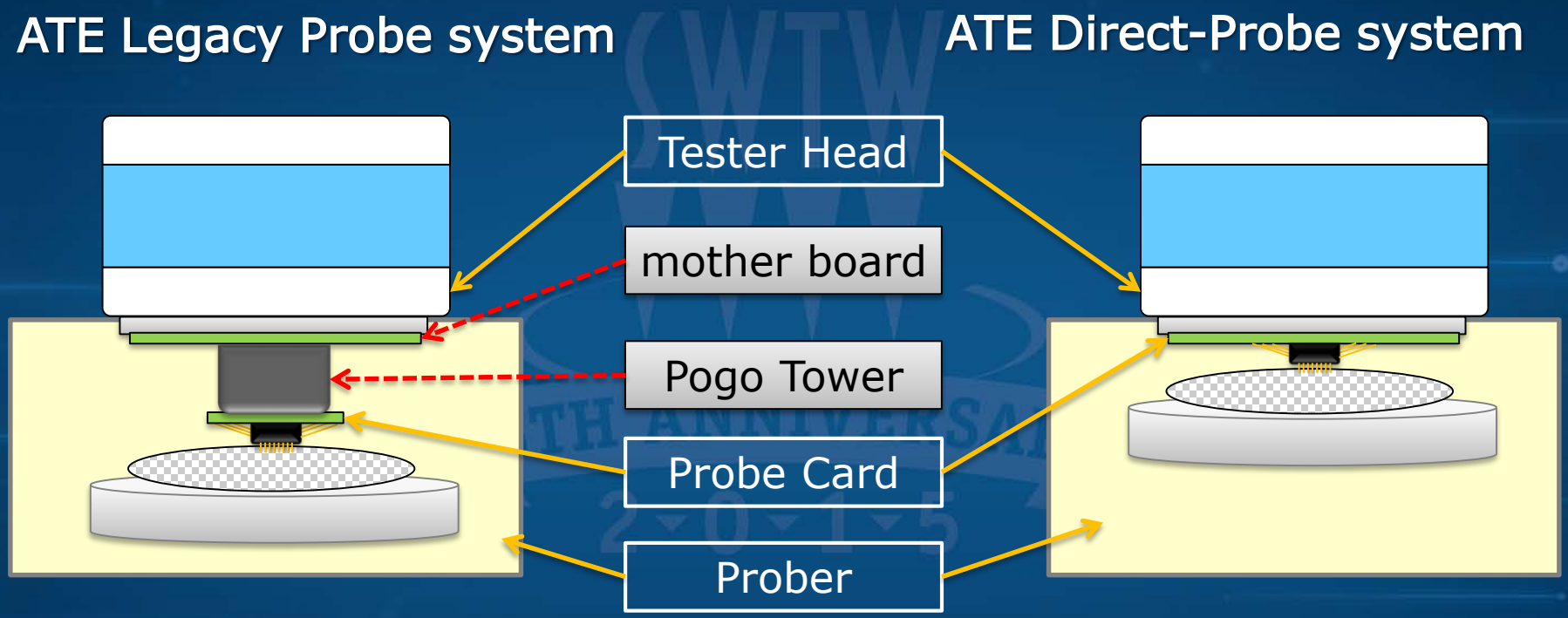
Outline

- Background
- Overview
- Use case study
- Discussion of Results
- Conclusion

Overview

- **What have we developed ?**
  - Cantilever-type Probe card for *Direct-Probe*
  - Methodology of expanding the bandwidth
- **What is the point ?**
  - Adapt both “high speed” and “low cost”
  - “Measurement” and “Mathematics”

What is Direct-Probe ?



- Not having “Pogo tower”
- To minimize the number of interconnects

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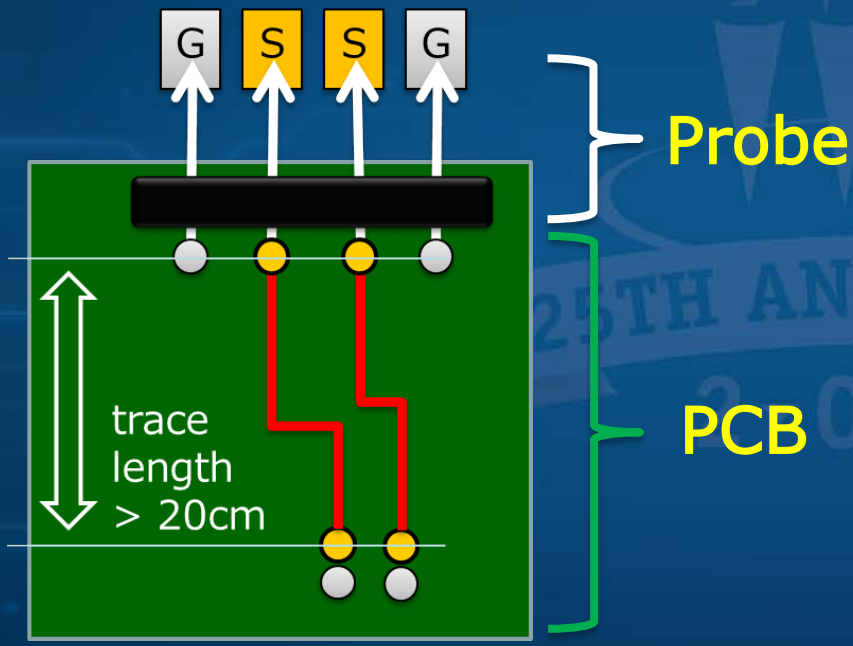
Shinji Fujita
(Sony LSI Design Inc.)

Outline

- Background
- Overview
- **Use case study**
- Discussion of Results
- Conclusion

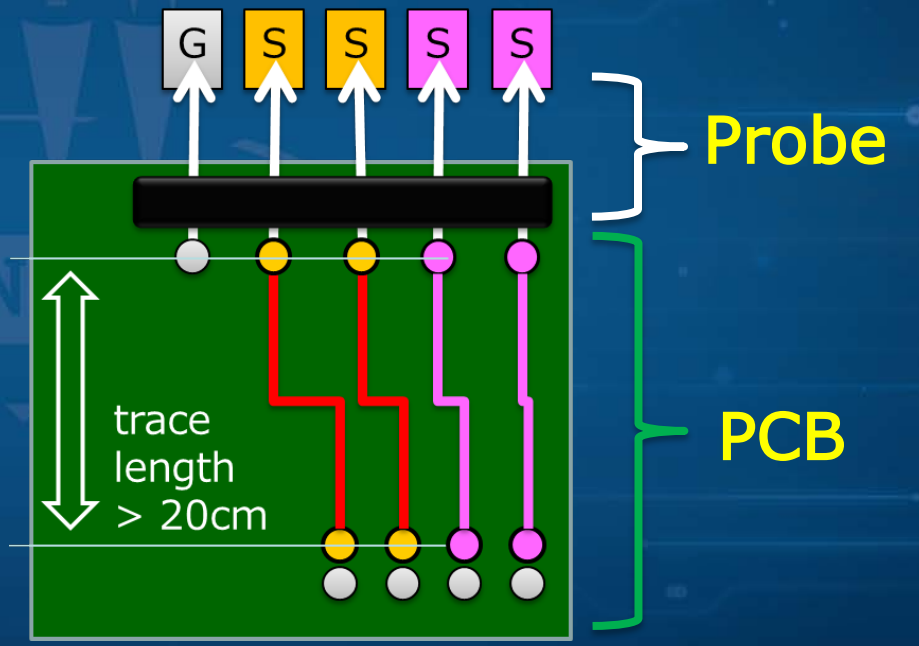
Use case study

- Case1(ideal)



GSSG pad layout

- Case2(un-friendly)



GSSS pad layout

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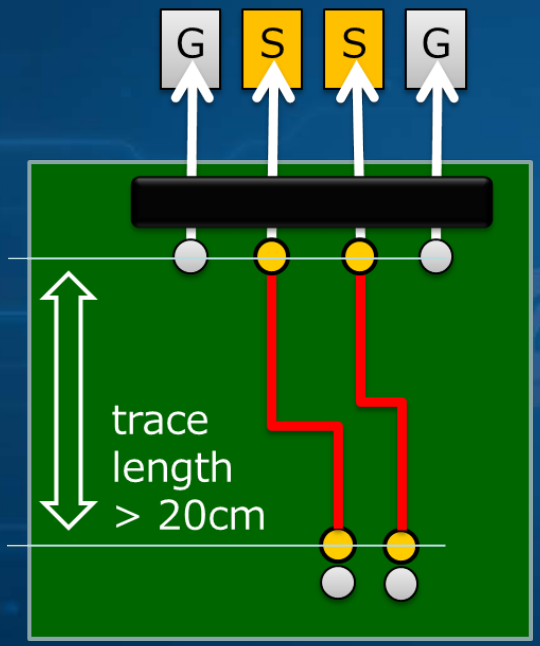
Use case study

Case1(ideal)



GSSG pad layout

- GSSG pad layout
  - Measurement environment
  - Calibration method
  - S-parameter measurement
  - Eye diagram
  - Expand bandwidth

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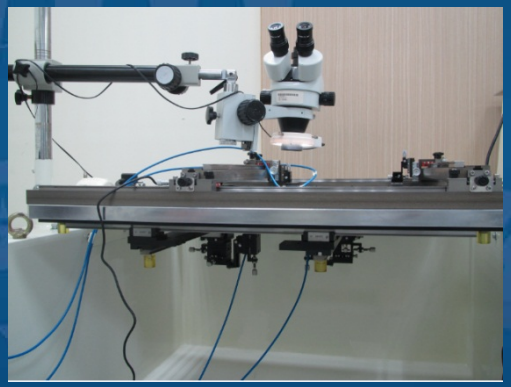
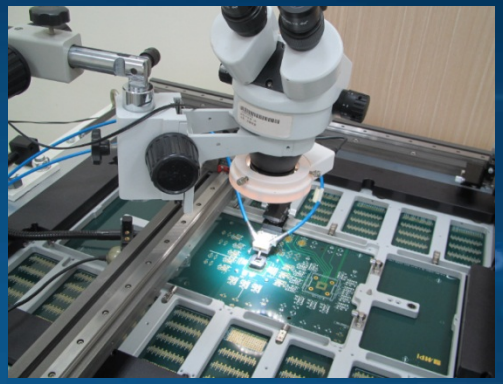
Shinji Fujita
(Sony LSI Design Inc.)

Measurement environment

Overview



Top side



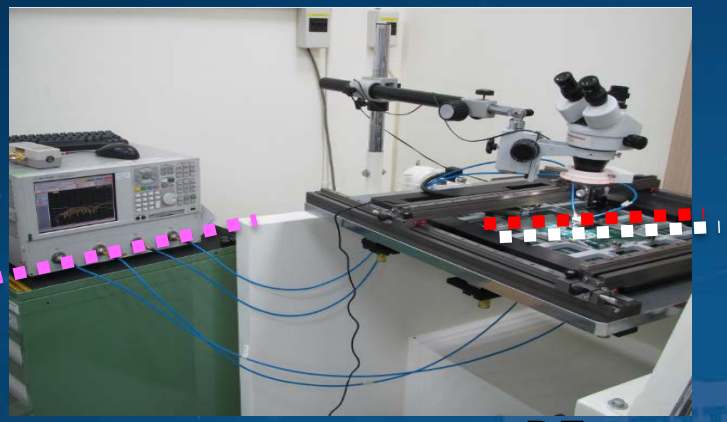
Bottom side

Measurement setup

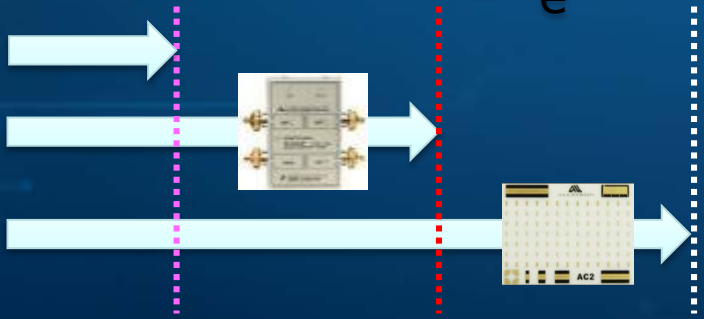
- Stiffener fixture
- Microscope
- Manipulator
- Micro positioner
- Network Analyzer

Calibration method

Typical case

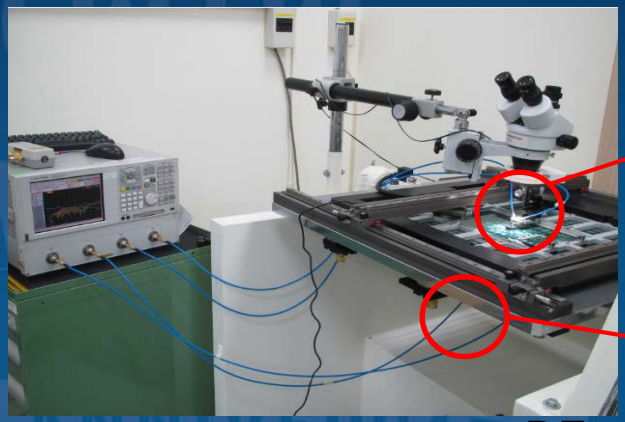


VNA → Cable → RF probe

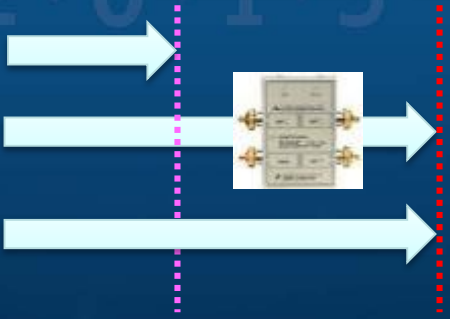


Reference plane

Actual Case



VNA → Cable → RF probe



Reference plane

DUT side

Tester side

Due to different pitches,
We cannot use calibration board !!

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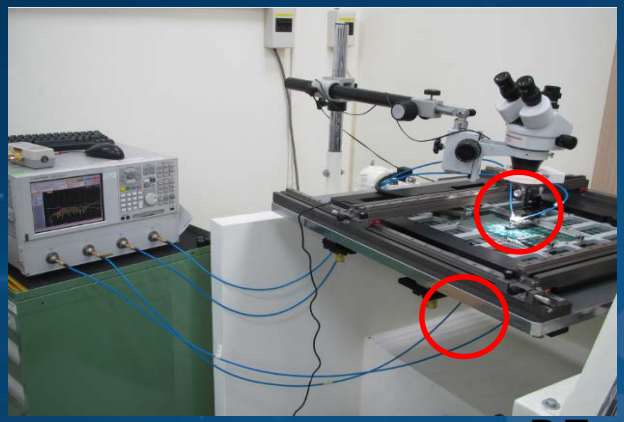
Shinji Fujita
(Sony LSI Design Inc.)

Calibration method

Actual Case

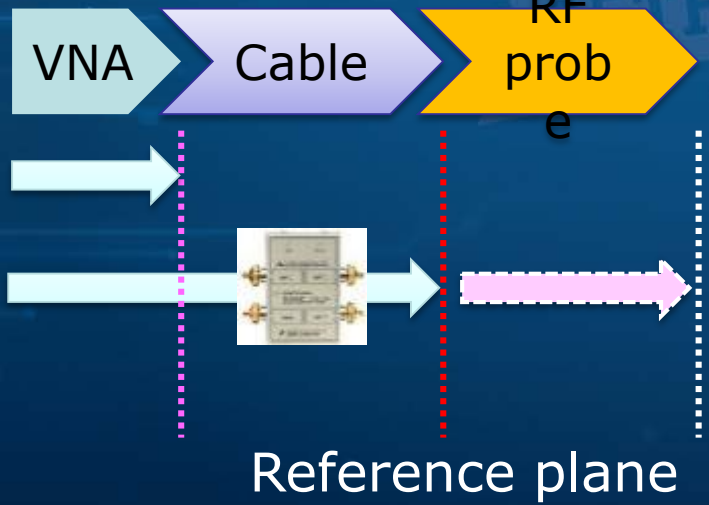


DUT side

different pitches

Tester side

1xx um ≠ 1250 um



- De-embedding using RF-probe's S-parameter

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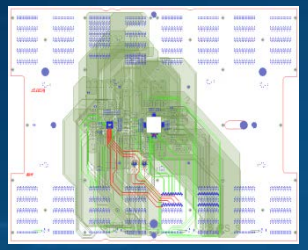
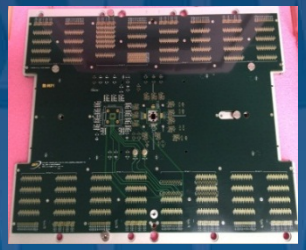
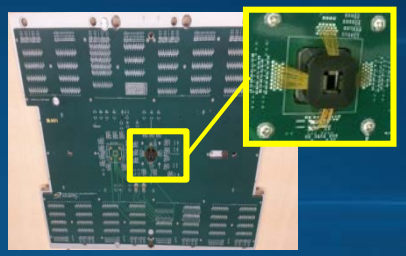
Shinji Fujita
(Sony LSI Design Inc.)

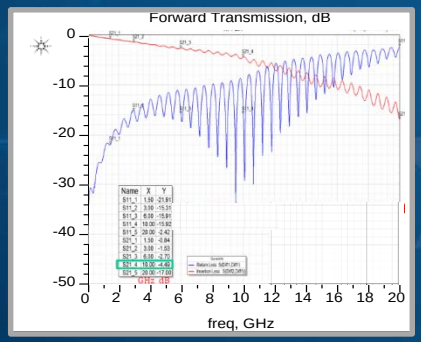
Measurement result

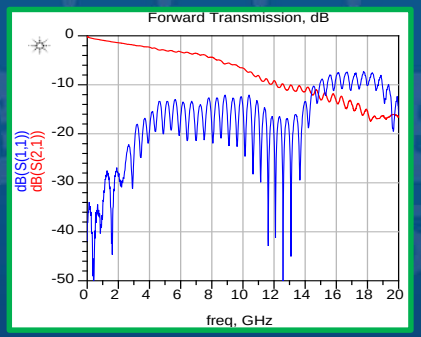
Simulation result	PCB measurement	Probe card measurement

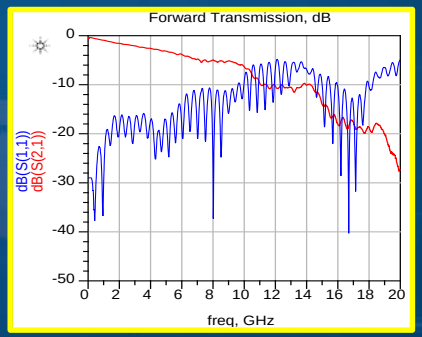












S21=6.81GHz@-3dB S11=8.10GHz@-10dB	S21= 5.35GHz@-3dB S11=15.19GHz@-10dB	S21=4.84GHz@-3dB S11=9.61GHz@-10dB

Enough bandwidth as targeted

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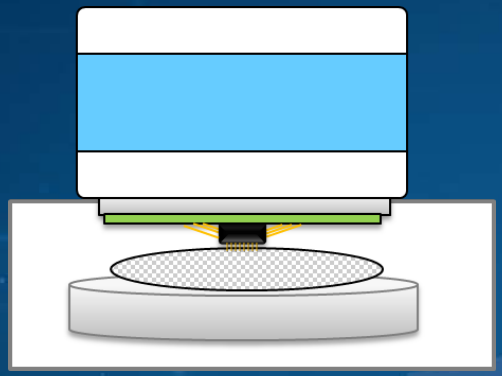
(Sony LSI Design Inc.)

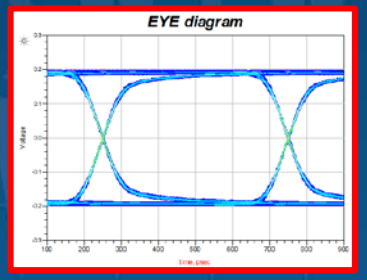
Eye-diagram result

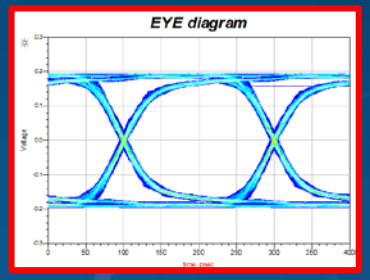
Ideal case (GSSG)

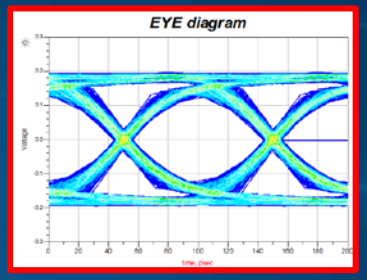


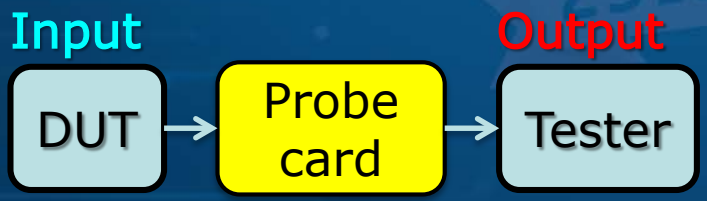
2Gbps,PRBS 5Gbps,PRBS 10Gbps,PRBS

measured









We see Eye-opening at 10Gbps, but it might cause a low-yield in case of production.

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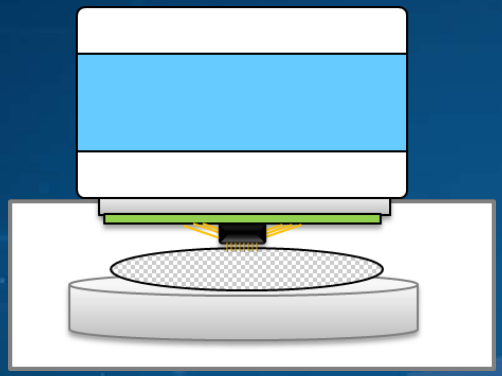
Expand bandwidth

Ideal case (GSSG)

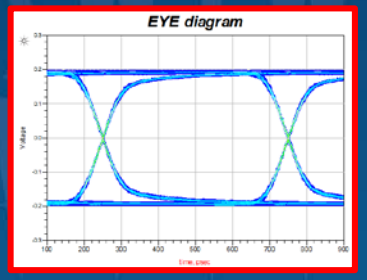


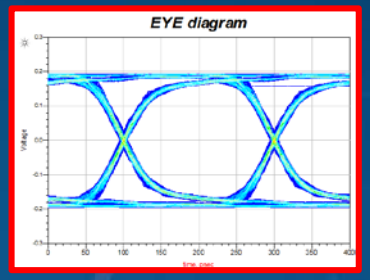
Input → DUT → Probe card → Output → Tester

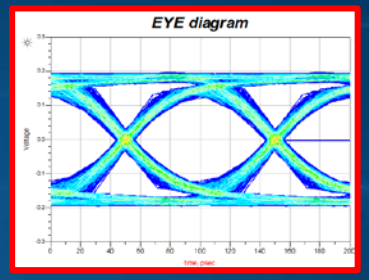
Cancel out
Using measured S-para
(mathematics)

2Gbps,PRBS　5Gbps,PRBS　10Gbps,PRBS

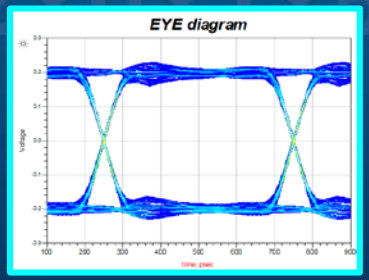
Before

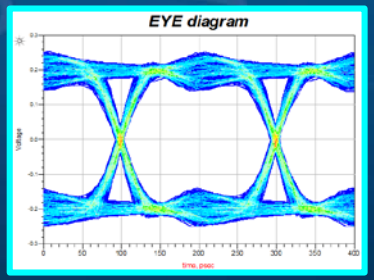


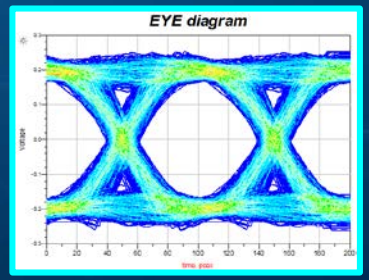




After　Applying "cancel out"





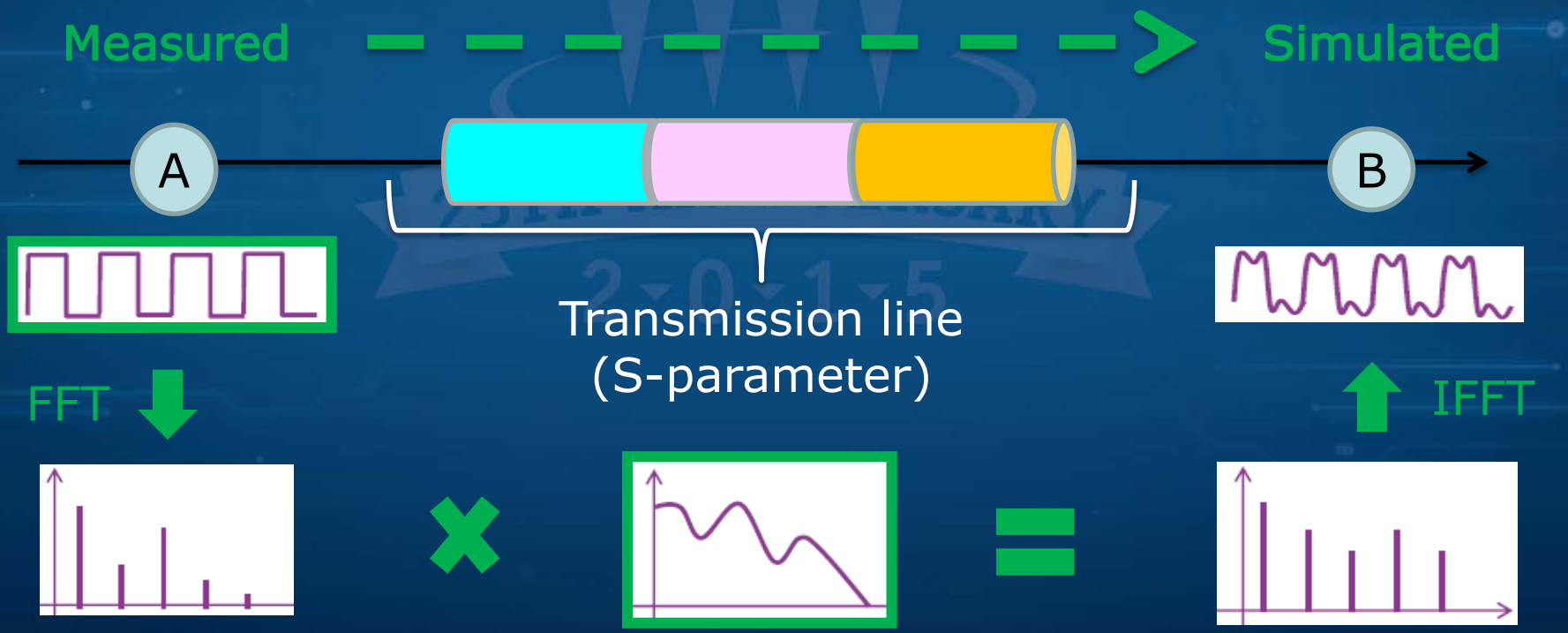


Even at 10Gbps, Functional Test is OK !!

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

How can we cancel out?

- **Same as "SI simulation" methodology**
  - Mathematically "put-in" the transmission line



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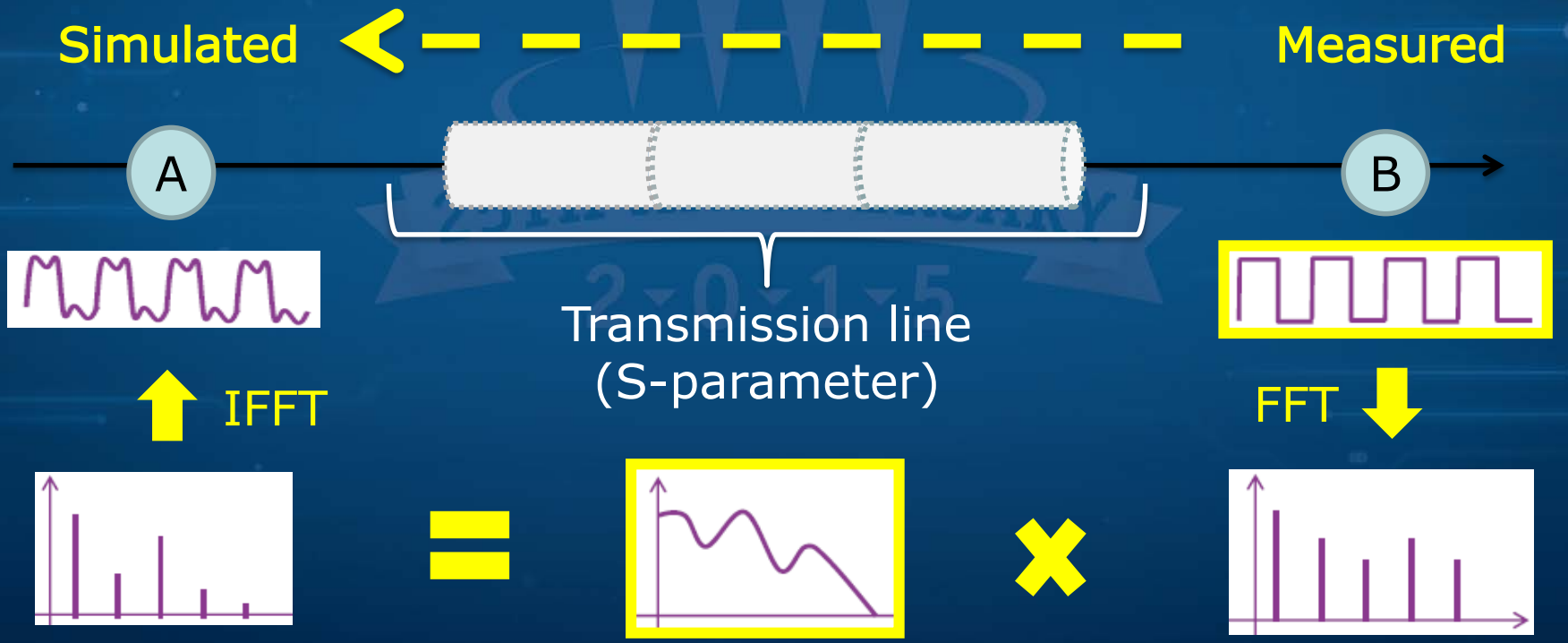
How can we cancel out?

- "Moving observation point" methodology
  - Mathematically "cancel out"
  - Similar to oscilloscope function



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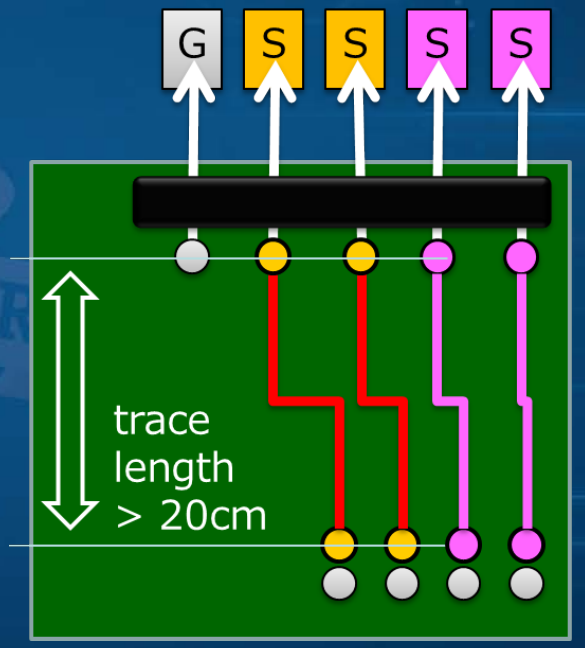
(Sony LSI Design Inc.)

Use case study

☐ Case2(un-friendly)

- GSSS pad layout

  – Measurement environment
  – S-parameter measurement
  – Eye diagram
  – Expand bandwidth

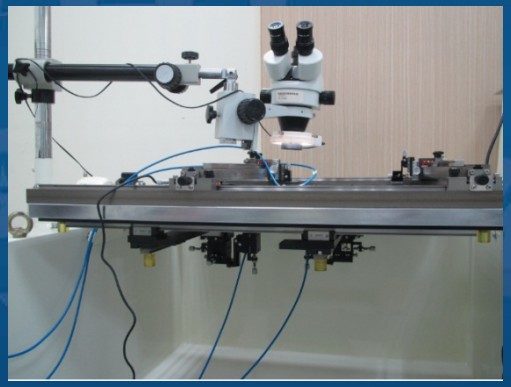


GSSS pad layout

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

GSSS
Measurement environment

Overview



Top side

Bottom side

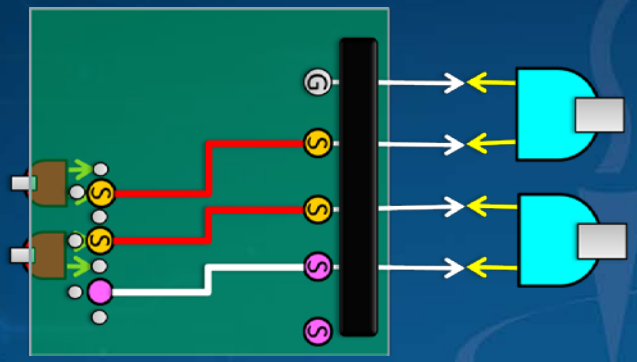
Measurement setup

- Stiffener fixture
- Microscope
- Manipulator
- Micro positioner
- Network Analyzer

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

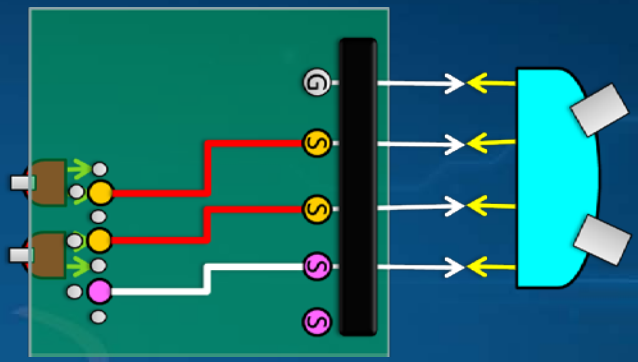
GSSS Measurement setup

- Single x2, Single x2



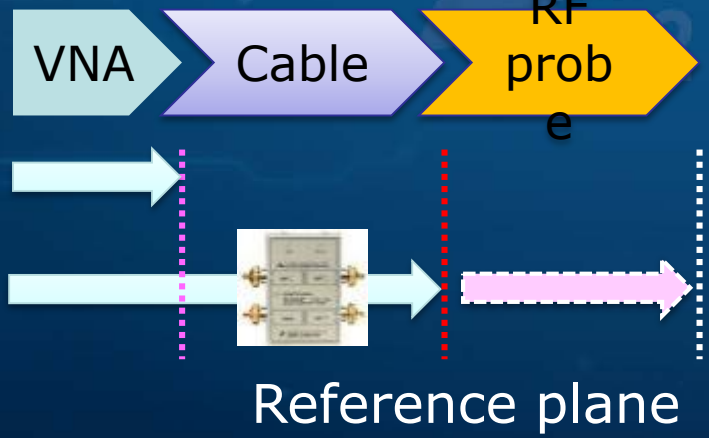
RF-probe to via RF-probe on probe

- Single x2, Dual x1



RF-probe to via RF-probe on probe

- Calibration



- De-embedding using RF-probe's S-parameter

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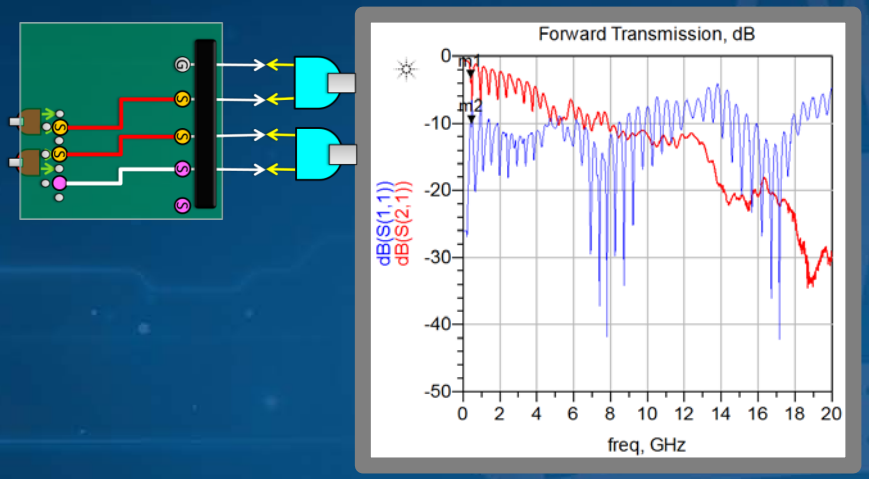
Shinji Fujita
(Sony LSI Design Inc.)

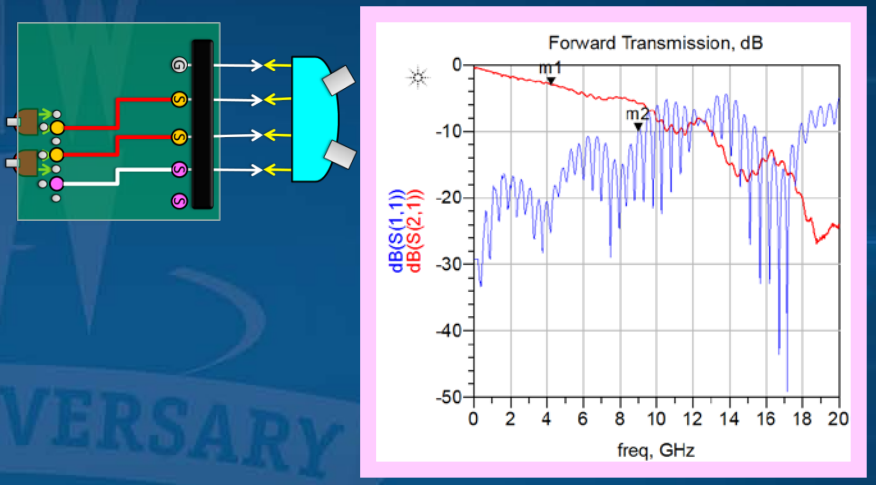
GSSS Measurement result

- Single x2, Single x2



S21= 0.40GHz@-3dB
S11= 0.39GHz@-10dB

- Single x2, **Dual x1**



S21= 4.23GHz@-3dB
S11= 9.00GHz@-10dB

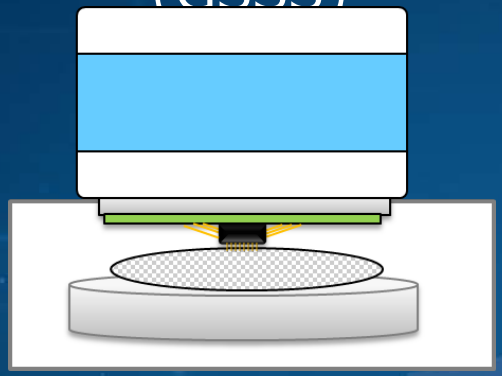
Case1(GSSG) result
S21=4.84GHz
S11=9.61GHz

Dual-type is better

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

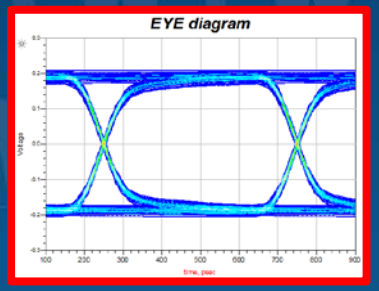
GSSS Eye-diagram result

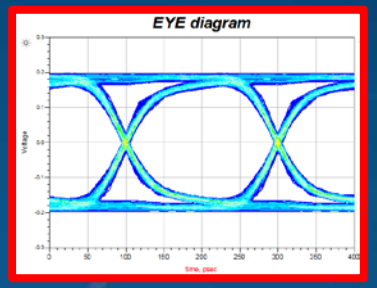
Un-friendly case (GSSS)

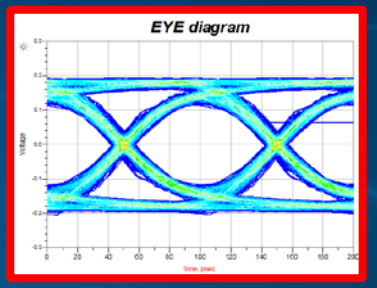


2Gbps,PRBS 5Gbps,PRBS 10Gbps,PRBS

measured







Input Output

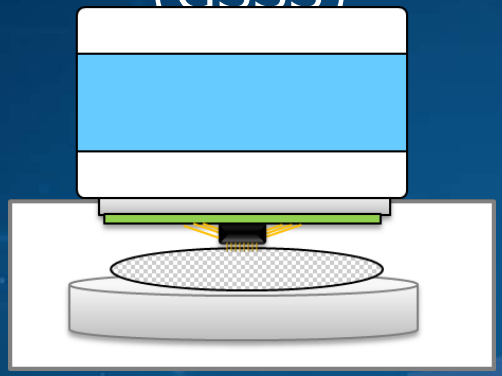
DUT → Probe card → Tester

We see eye-opening at 10Gbps, but it might cause a low-yield in case of production.

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

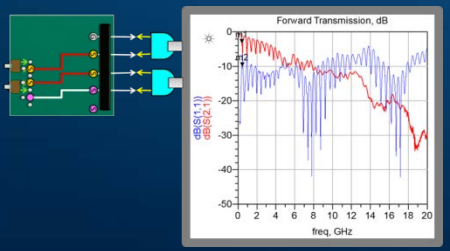
GSSS Expand bandwidth

Un-friendly case (GSSS)



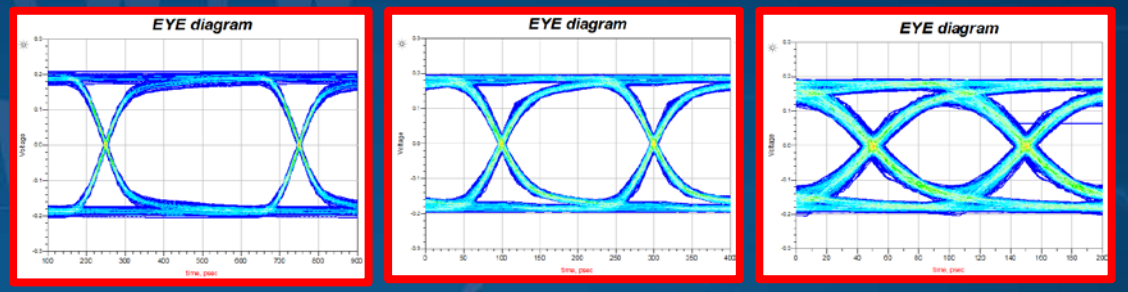
Input → Cancel out → Output

DUT → Probe card → Tester



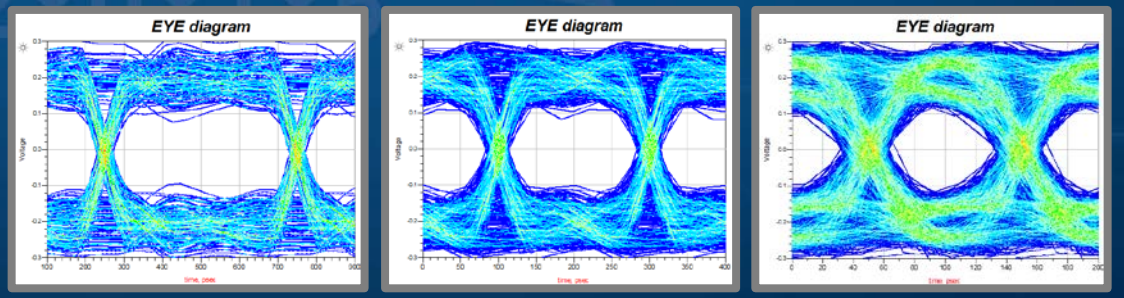
2Gbps,PRBS 5Gbps,PRBS 10Gbps,PRBS

Before



After

Apply worse S-parameter

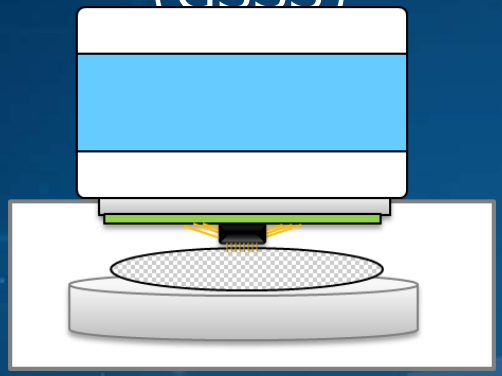


we cannot "cancel out"

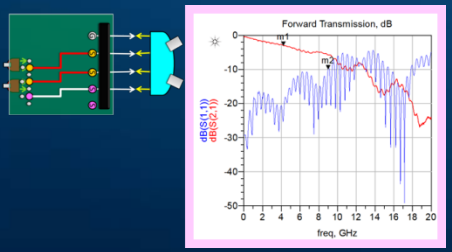
Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

GSSS Expand bandwidth

Un-friendly case (GSSS)

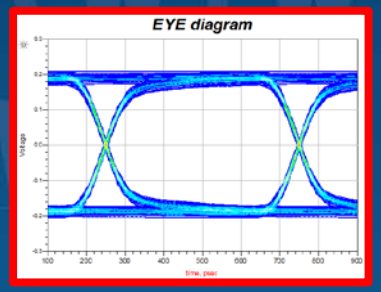


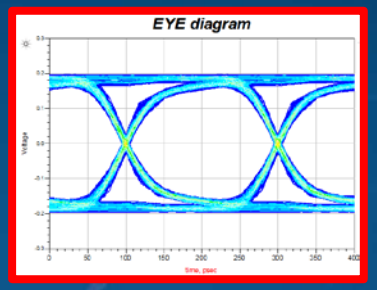
Input → Cancel out → Output

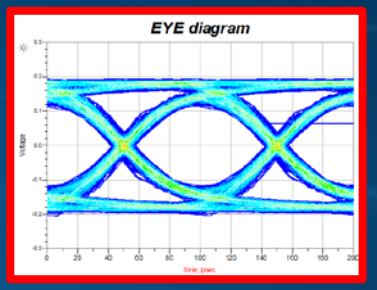


2Gbps,PRBS 5Gbps,PRBS 10Gbps,PRBS

Before

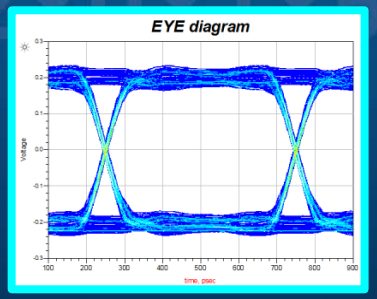


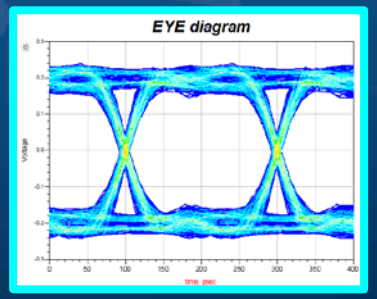


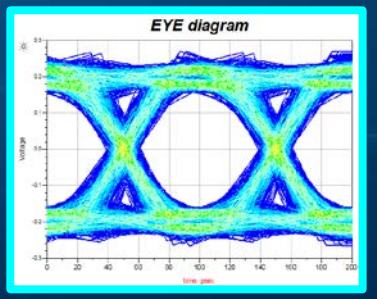


After

Apply better S-parameter







we can “cancel out”

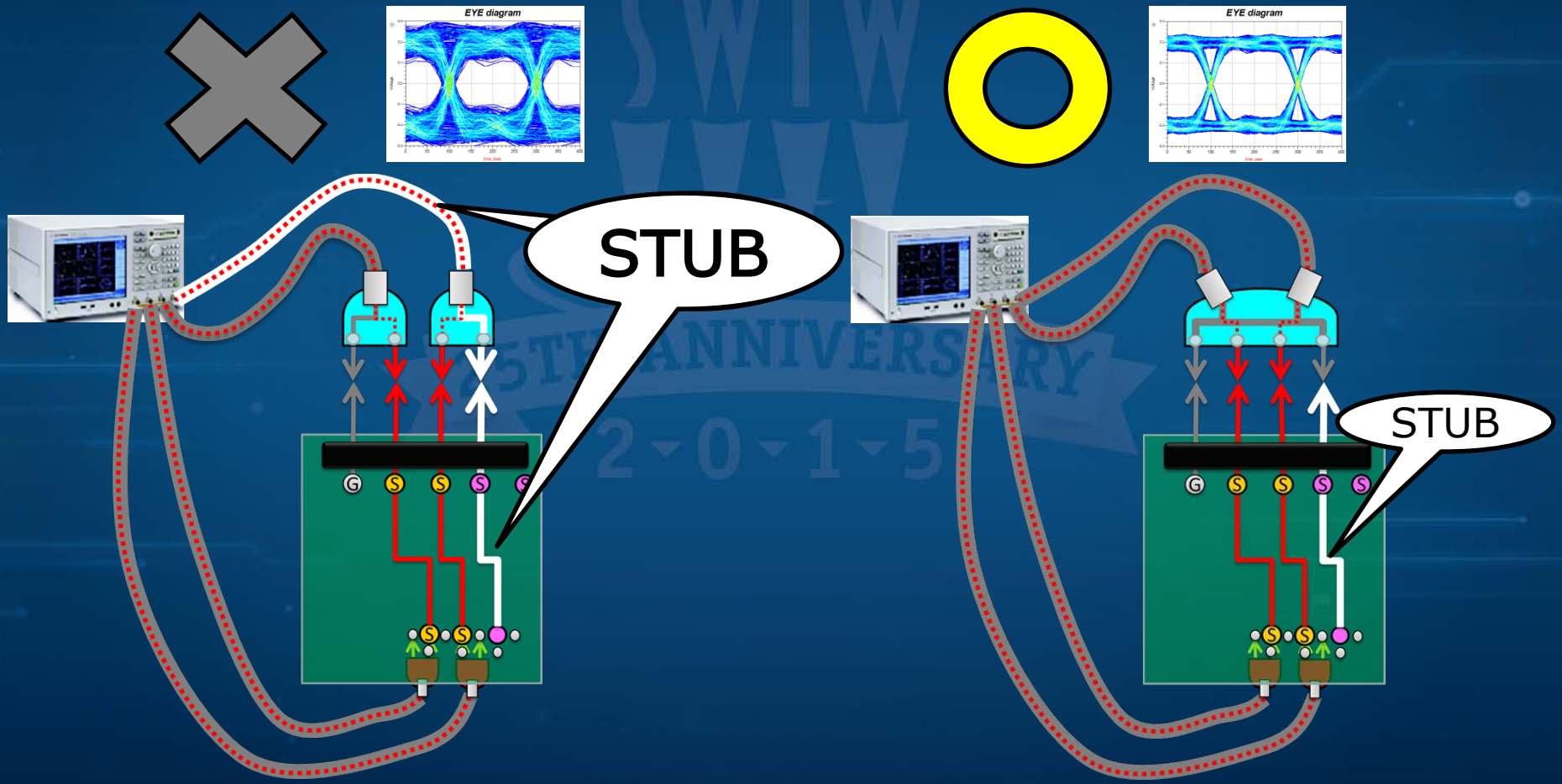
Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

Outline

- Introduction
- Background
- Overview
- Development
- Use case study
- **Discussion of Results**
- Conclusion

Discussion of GSSS-Results

- what makes the results so different?



Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)

Outline

- Introduction
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Conclusion

- We have developed a cantilever-type probe card saving much NRE cost.
- Measuring S-parameters should carefully be done in case of un-friendly pad layout.
- By applying "cancel out" methodology, we can test even at 10Gbps in Production.

Thank you!!

Q&A

Shohei Nishimura
Shinji Fujita
(Sony LSI Design Inc.)