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

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Introduction

Whole probe card does not always have expected bandwidth!!
This presentation is based on User's point of view

Hardware

Software

Measurement

Expand Bandwidth at "low-cost"
Outline

• Background
• Overview
• Use case study
• Discussion of Results
• Conclusion
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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"
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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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Outline

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Use case study

- Case 1 (ideal)
- Case 2 (un-friendly)

GSSG pad layout

GSSS pad layout
Use case study

Case 1 (ideal)

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

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Measurement environment

Overview

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

Top side

Bottom side
Calibration method

Typical case

Actual Case

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

Actual Case

DUT side

Tester side

different pitches

1xx um ≠ 1250 um

VNA

Cable

RF probe

Reference plane

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

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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
Eye-diagram result

Ideal case (GSSG)

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

Ideal case (GSSG)

Input
DUT
Probe card

Output
DUT
Tester

Cancel out
Using measured S-para
(mathematics)

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

After
Applying “cancel out”

Even at 10Gbps, Functional Test is OK!!
How can we cancel out?

- **Same as “SI simulation” methodology**
  - Mathematically “put-in” the transmission line
How can we cancel out?

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

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Use case study

- GSSS pad layout
- Measurement environment
- S-parameter measurement
- Eye diagram
- Expand bandwidth

Case2 (un-friendly)

GSSS pad layout

trace length > 20cm
GSSS
Measurement environment

Overview

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

Top side

Bottom side
GSSS Measurement setup

- Single x2, Single x2
- Single x2, Dual x1

RF-probe to via
RF-probe on probe
RF-probe to via
RF-probe on probe

Calibration

VNA → Cable → RF-probe → Reference plane

De-embedding using RF-probe’s S-parameter
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
GSSS Eye-diagram result

Un-friendly case (GSSS)

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

Un-friendly case (GSSS)

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

Before

After

Apply worse S-parameter

Input Cancel out Output

DUT Probe card Tester

we cannot “cancel out”

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June 7-10, 2015

25TH ANNIVERSARY
2015

SW Test Workshop
GSSS Expand bandwidth

Un-friendly case (GSSS)

Before

2Gbps, PRBS

5Gbps, PRBS

10Gbps, PRBS

After

Apply better S-parameter

we can “cancel out”

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Discussion of GSSS-Results

- what makes the results so different?
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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