Effects of Temperature and Relative Humidity in Transmission Systems Using Differential Signaling
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Presentation Outline

• Introduction
• Previous Research
• Experimental Set Up and Procedure
• Experimental Results Analysis
• Summary
• Acknowledgements
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Introduction

• In this paper, we explore the effects of humidity and temperature on PCB boards with differential signaling.

• Of particular interest is S-parameters mode conversion due to the asymmetry induced by the moisture absorption in the differential lines.

• Note that asymmetry can also convert some of the differential signals into common signals. This asymmetry can also lead to signal skew that affects bandwidth, degrades rise time as well as increases electro-magnetic interference.
• $S_{21}$ measurements, microstrip using FR4 without solder mask

• $S_{21}$ measurements, microstrip using Rogers 4350

Previous Research

- $S_{21}$ magnitude measurements and curve fitting line.
  - $S_{21}$ magnitude vs. time as 1GHz
  - $S_{21}$ magnitude vs. time as 20GHz

DesignCon 2010
Soaked samples were exposed to 1 week of 30 °C and 60 % RH, $S_{21}$ of GMS

Figure 27 Eye diagrams for 5.0 Gb/s transmitter with a 2-inch FR-4 channel (LEFT) and a 20-inch FR-4 channel (RIGHT). The 50-mm transmitter and receiver package model are at 20 °C (BLUE) and 100 °C (RED).

Experimental Set Up and Procedures

- Test devices:
  - Samtec golden standard
  - Milled
  - XAUI
Experimental Set Up

• Temperature & humidity chamber
  – (-34)°C to 190°C
  – 10% to 98% RH

• Performance Network Analyzer
  – Agilent E8364B (0 to 50 GHz)
  – SOLT calibration
  – Physical Layer Test System
Experimental Set Up

- Temperature chamber for baking the DUTs
- Mettler AE 100 lab scale
  - 100g capacity;
  - 0.0001g readability
Experimental Procedure

Bake all DUTs at 80 °C for 4 days

SOLT calibration
S-parameter measurements of DUTs (dry state)

Place DUTs in the environmental chamber kept at 55 °C and 95% RH

S-parameters measurements of DUTs

Every 12 hours for 7 days complete?

Yes

Results analysis and S-parameter simulation

No

SOLT
Freq start: 50 MHz
Freq end: 26 GHz
IF bandwidth: 100 Hz
801 points

Microstrip line test board
Freq start: 50 MHz
Freq end: 26 GHz
IF bandwidth: 100 Hz
801 points
1 measurement each time

12
Experimental Results Analysis

Golden Standard S21 differential to common mode conversion

Golden Standard phase S21 diff. to common mode

Frequency GHz

Phase of S_{dc21}
Experimental Results Analysis

Golden std S21-parameters differential parameters

Golden std phase of S21-parameters diff. parameters
Experimental Results Analysis

Comparisons Golden std S21-parameters differential parameters at 0 Hrs and 7 days

Frequency GHz

dB
Experimental Results Analysis

![Graphs showing experimental results analysis for S31 and S41 parameters for near and far end cross talk.](Image)
Experimental Results Analysis

- **gldstd S11-parameters single ended**
  - Frequency GHz
  - $S_{11}$
  - 0 Hrs
  - 118 Hrs
  - 7 days

- **gldstd S12-parameters single ended**
  - Frequency GHz
  - $S_{12}$
  - 0 Hrs
  - 118 Hrs
  - 7 days
Experimental Results Analysis

XAUI S21-parameters, differential to common mode conversion

XAUI S21-differential parameters

Frequency GHz
Experimental Results Analysis

![Graph showing XAUI S21-parameters, differential to common mode conversion over frequency from 0 to 6 GHz for 0 Hrs and 7 days.](image)
Experimental Results Analysis

XAUI near end crosstalk at 0 Hrs and 7 days

Frequency GHz

0 1 2 3 4 5 6

dB

-90 -80 -70 -60 -50 -40 -30 -20 -10 0

XAUI far end crosstalk at 0 Hrs and 7 days

Frequency GHz

0 1 2 3 4 5 6

dB

-90 -80 -70 -60 -50 -40 -30 -20 -10 0

NEXT 0 Hrs

NEXT 7 days

FEXT 0 Hrs

FEXT 7 days
Conclusions and Future Work

- Differential parameters, for all board analyzed, show consistent degradation in performance while mode conversion shows upswing in some regions of the boards’ range of operation.
- NEXT and FEXT are also affected in some regions of operation but the change seem to be less than mode conversion and in differential S-parameters.
- More research in how moisture absorption and temperature change the balance lines (for example layer placement).
- Influence of the board weave.


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Thank you for your attention

I welcome your questions.

QUESTIONS?