Test & Simulation Results in Support of SAS-2

Kevin Witt, M. Bari, B. Holway
Test Results in Support of SAS-2

Test Channels Investigated
- Infiniband Cable links 1, 3, 5, 6, 7, & 9 meters with corresponding AWG of 26, 26, 28, 24, 24 & 24.
- FR4 Micro strip Traces 5, 10, 20 & 25".

Frequency of Operation
- 3 and 6 Gbps

Observations and Analysis
- De-Emphasis Output Driver Test
  - 0.13 um CMOS
- Receiver Equalization Simulations (with optimal LMS coefficient)
  - Based on 10 Gbps design in 0.13 um CMOS
Test Configuration w/ InfiniBand Cable

- Test Chip Driver w/ De-Emphasis
- Gore Adapter Board
- Gore Adapter Board
- Digital Scope
- Infiniband Cable 1,3,4,6,7,9 meters
3G Test Results

Test Results w/ InfiniBand Cable De-Emphasis Disabled (3Gbps)

Signal integrity issues at 3G require some equalization
3G Test Results

Test Results w/ InfiniBand Cable De-Emphasis Enabled (3Gbps)

Tx De-Emphasis works well at 3Gbps
Signal integrity issues at 6G are more interesting
Test Results w/ InfiniBand Cable De-Emphasis (1:0.5) Enabled (6Gbps)

Tx De-Emphasis only is not enough!
Equalizer Simulation Methodology

- Collect the pulse response and PRBS response for back to back and through channel under test
- Estimate the channel model based on the pulse response of channel
- Compute the LMS equalizer Coefficients
- Estimate the Equalizer output
Equalizer Simulation Results w/ InfiniBand Cable De-Emphasis Disabled
6G Simulation Results

Equalizer Simulation Results w/ InfiniBand Cable De-Emphasis Enabled

- 1m
- 3m
- 4m
- 6m
- 7m
- 9m
Simulation Results w/ InfiniBand Cable Summary

- Semi-analytic BER Estimation
- 1, 3, 4, 6, 7 & 9 meter Cables

De-Emphasis Disabled

De-Emphasis Enabled

Theoretical Bound
Equalized
Power Penalty ~4.2dB @ 1e-15
Except 9m Cable

Un-Equalized

Theoretical Bound
Equalized
Power Penalty ~4dB @ 1e-15

Un-Equalized
FR4 Data Collection Setup

Test Configuration w/ FR4 Test Board

- Test Chip Driver w/ De-Emphasis
- FR4 Test Board
- Digital Scope

FR Test Board
- Micro Strip
- ½ Oz Cu
- 100ohm Diff
- 12mil traces
- 40mil spacing
- 8mil above Gnd Plane
3G Test Results

Test Results w/ FR4 (3Gbps)

16” De-Emphasis Disabled

26”

31” De-Emphasis Enabled

Signal integrity issues at 3G require some equalization, De-Emphasis works
6G Test Results

Test Results w/ FR4 (6Gbps)

De-Emphasis Disabled

5”  10”  20”  25”

De-Emphasis Enabled

5”  10”  20”  25”

Signal integrity issues at 6G can be solved with De-Emphasis alone
Simulation Results FR4 De-Emphasis Disabled

- Receiver Equalization also works instead of De-Emphasis
6G Simulation Results

Simulation Results w/ FR4 Summary

- Semi-analytic BER Estimation
- 5, 10, 20 & 25 inches FR4

De-Emphasis Disabled

De-Emphasis Enabled

Un-Equalized

Equalized

Power Penalty ~1dB @ 1e-15

Power Penalty ~2 dB @ 1e-15
Limitations of Analysis

- Links do not have near or far end crosstalk
- Optimal LMS Coefficients used in Equalizer
- Effects of Jitter neglected
- Implementation penalty due to Non-Idealities neglected

Summary

- The FR4 channels investigated can be equalized with De-emphasis alone
- Equalization will be required for robust 6 Gbps Operation on longer Infiniband Cable
- A combination of De-Emphasis and Receive Equalization looks promising for all channel considered.
- The required Receiver Equalization and De-Emphasis Driver have been implemented in 0.13 um CMOS with power consumption comparable to the 3G Phy.