SCSI Cable Characterization
Methodology and Systems from
GigaTest Labs

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Overview

- Methodology summary
- Fixturing
- Instrumentation
- First order performance characterization
- Model extraction
Methodology

- Minimize probing/fixturing parasitics
  - Low parasitic fixture board
  - Precision microprobes

- Read 1\textsuperscript{st} order performance information directly from the instrument
  - TDR
  - VNA

- First order performance evaluation:
  - Differential impedance (return loss)
  - Differential attenuation (insertion loss)
  - Differential 3dB BW
  - Differential NEXT

- De-embed cable from fixturing with inverse scattering
  - More accurate performance evaluation
  - ADS based multilayer interconnect model (MIM)
  - Routinely converted into W element for HSPICE
A Precision Instrument is Not Enough!

Component to characterize ➔ Instrument ➔ Valuable information
GigaTest System Solutions
Dramatically Increase Productivity

Probes
Probe station

GigaTest Labs
Probe stations

**Instruments**
- Infiniium DCA with TDR
- Vector Network Analyzer

**Controlling software**
- TDA Systems software
- Agilent Advanced Design System (ADS)
GigaTest Signal Integrity
Engineering Turn Key System

Complete set of cables, connectors, probes, fixtures, etc.
GTL Probe Station and Precision Fixture Boards
Why Measure This Way?

• Probing Improves both VNA and TDR measurements.

• Reference plane set AT the probe tips, close to I/Os

• Minimal parasitics
  - No SMA launches, transmission lines, SCSI connectors to de-embed
  - Microprobe/ via input has extremely low parasitics

• Direct, measurement on Bulk Cable
  - Eliminates Connector to Cable discontinuity
Instrument set up for Differential Pair Measurements

- Adjacent wires left unterminated
- Port 1 wire connects to port 3, port 2 wire connects to port 4
- Ports are excited one at a time, then differential response is constructed from mathematical superposition
- Measurements with both TDR and VNA
- Measure single ended parameters
- Convert to balanced parameters using:
  - ADS
  - Agilent Multiport software
  - Built in function of DCA
Differential Impedance Measurement with TDR

1. At the near end, measure the odd mode $Z_0$ of each line in the pair, when both driven differentially

2. $Z_{\text{diff}} = Z_{\text{odd-1}} + Z_{\text{odd-2}}$

3. Display $Z_{\text{diff}}$ directly on the screen

\[ \sim 50 \, \Omega \]
Converting Single Ended to Balanced S Parameters

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<thead>
<tr>
<th>Single Ended</th>
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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3 (and their return paths!)</td>
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<td>4</td>
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<table>
<thead>
<tr>
<th>Response</th>
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<tbody>
<tr>
<td>S_{11}</td>
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<tr>
<td>S_{12}</td>
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<tr>
<td>S_{13}</td>
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<tr>
<td>S_{14}</td>
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<td>S_{21}</td>
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<td>S_{22}</td>
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<td>S_{23}</td>
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<td>S_{42}</td>
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<td>S_{43}</td>
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<td>S_{44}</td>
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<table>
<thead>
<tr>
<th>Stimulus</th>
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<tbody>
<tr>
<td>Differential Signal</td>
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<tr>
<td>Common Signal</td>
</tr>
<tr>
<td>Port 1</td>
</tr>
<tr>
<td>S_{DD11}</td>
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<tr>
<td>S_{DD21}</td>
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<tr>
<td>S_{CD11}</td>
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<tr>
<td>S_{CD21}</td>
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SDD11 and SDD21

Return Loss and Insertion Loss

SDD11: return loss

SDD21: insertion loss

Note: this is based on a 100 Ω matched impedance system

Hitachi 28 AWG twisted pair cable

36 inches long

3 dB BW ~ 1.3 GHz for this sample
SDD21: Differential Insertion Loss and 3 dB BW

Temp-Flex cable 3 ft long

3 dB BW ~ 2 GHz for this sample, 3 ft long
SDD11: Differential NEXT

- Adjacent wires left unterminated
- Far end left open
- Port 1 is positive aggressor, port 2 is negative aggressor, port 3 is positive victim & port 4 is negative victim
- Ports are excited differentially, TDT transmission info is used to compute crosstalk ($V_{\text{victim}}/V_{\text{aggressor}}$)

* Agilent 8753ES with N4414A 4-port test set
* Agilent Infiniium DCA 86100A oscilloscope w/ 54754A differential TDR plug-ins
* GTL-1300-MK-001 fixture
* 36-inch cable
* Coaxial cables (shields not shown)
* All probe GNDs connected to fixture ground plane
NEXT in Time Domain

 Twist-flat ribbon cable
 45 inch pitch
 3 feet long

NEXT ~ 18 mV out of 400 mV = ~4.5%
A Trick to Use Agilent ADS for Modeling a SCSI Cable

**Situation Analysis:**
- ADS does not have a parameterized round cable, mixed dielectric model element that can be used to synthesize a model from the actual geometry
- ADS does have a parameterized, coupled stripline model

**Goal:**
- find the optimum parameters of a stripline that has same performance of SCSI cable: All S parameters
- Use MIL model to predict performance
- Translate MIL model into W element
Optimizing Circuit Parameters to Match Simulated and Measured Performance

As frequency is swept, minimize:
\[ \sum \text{error}^2 \]
Comparing Final Model and Measurement Results

1. Good agreement between modeled and measured S parameters gives confidence that model can predict performance.

2. Extract just the MIL model from the fixture.

3. Can use the MIL model for ADS performance simulations.

4. Can translate the ADS MIL model into an HSPICE W element model.
GTL SCSI Characterization System

- GigaTest 4060 probe station w/ 4 positioners
  - GGB 40A-GS-450-DP and 40A-SG-450-DP probes (two each)
  - GGB CS-11 calibration substrate w/ CK11450 calibration kit
  - 40 GHz coaxial cables (2.92mm connectors)
- GTL Test Fixture (GTL###)
- Agilent 8753ES w/ N4414A 4-port test set (6 GHz BW is fine)
- Agilent Infiniium DCA 86100A oscilloscope w/ 54754A differential TDR plug-ins
- Agilent ADS software (Advanced Design System version 2001)
The GigaTest Solution:
> 100 person years of expertise

• **A Complete Characterization System**
  - Probes
  - Probe station
  - Agilent TDR or VNA instrument
  - Analysis software
  - Up to speed quickly
  - Guaranteed measurement success

• **The Methodology**
  - Calibration and standards
  - Fixture design and de-embedding
  - Measurement techniques
  - Model topology selection
  - Parameter optimization
  - A proven, industry standard methodology

• **Training**
  - Class room style and personalized, hands on
  - Signal integrity fundamentals
  - S parameters and TDR measurement fundamentals
  - Advanced measurement based model extraction
  - All personnel trained
  - A support team
  - Continual updates
GigaTest Labs Courses in Signal Integrity Engineering

GTL122  a SI 101: Fundamental principles of Signal Integrity  
b SI 101: Fundamental principles of Transmission lines

GTL250  a High speed board design: signals  
b High speed board design: switching noise, ground bounce and EMI

GTL260  a Creating high bandwidth models from measurement: 1st order models  
b Creating high bandwidth models from measurement: high bandwidth

GTL262  a Creating high bandwidth models from calculations: 1st order models  
b Creating high bandwidth models from calculations: numerical simulation