SCSI Cable Characterization Methodology and Systems from GigaTest Labs

134 S. Wolfe Rd

Sunnyvale, CA 94086

408-524-2700

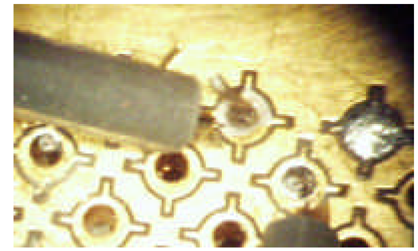
www.GigaTest.com

Overview

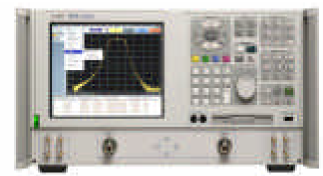
- Methodology summary
- Fixturing
- Instrumentation
- First order performance characterization
- Model extraction

Methodology

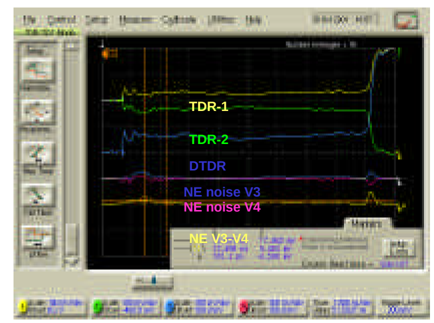
- Minimize probing/fixturing parasitics
  - ✓ Low parasitic fixture board
  - ✓ Precision microprobes



- Read 1st 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

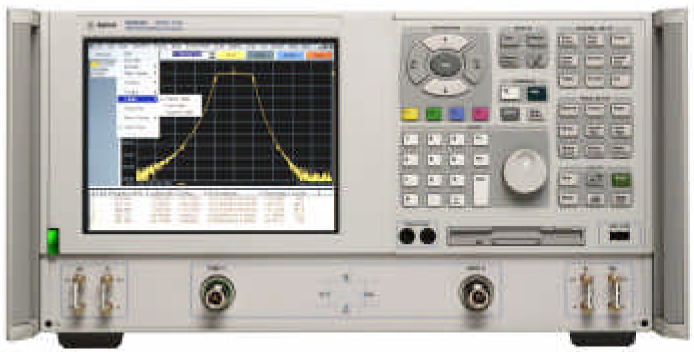


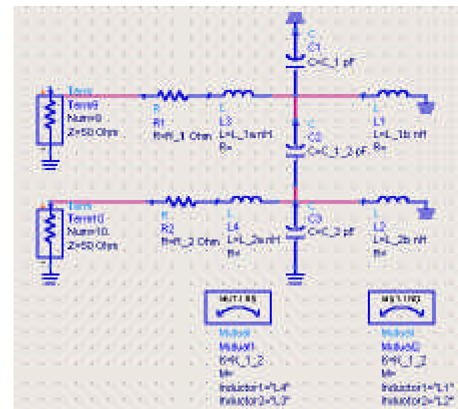
- De-embed cable from fixturing with inverse scattering
  - ✓ More accurate performance evaluation
  - ✓ ADS based multilayer interconnect model (MIM)
  - ✓ Routinely converted into W element for HSPICE

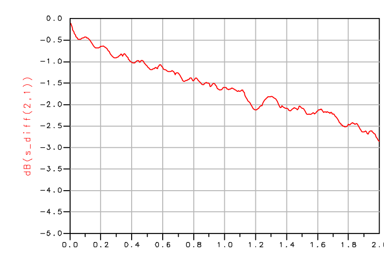
GigaTest Labs

A Precision Instrument is Not Enough!

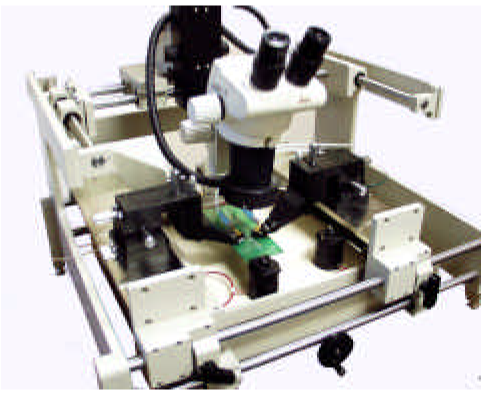
Component to characterize –?→ **Instrument** –?→ **Valuable information**

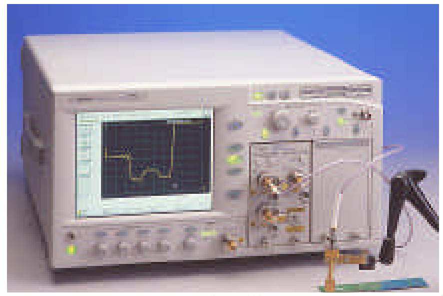


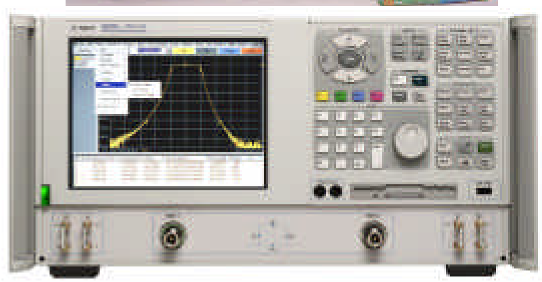


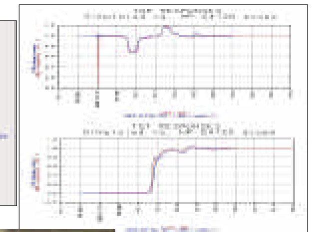


GigaTest System Solutions Dramatically Increase Productivity









Probes
Probe station

GigaTest Labs
Probe stations

Instruments

Infiniium DCA with TDR

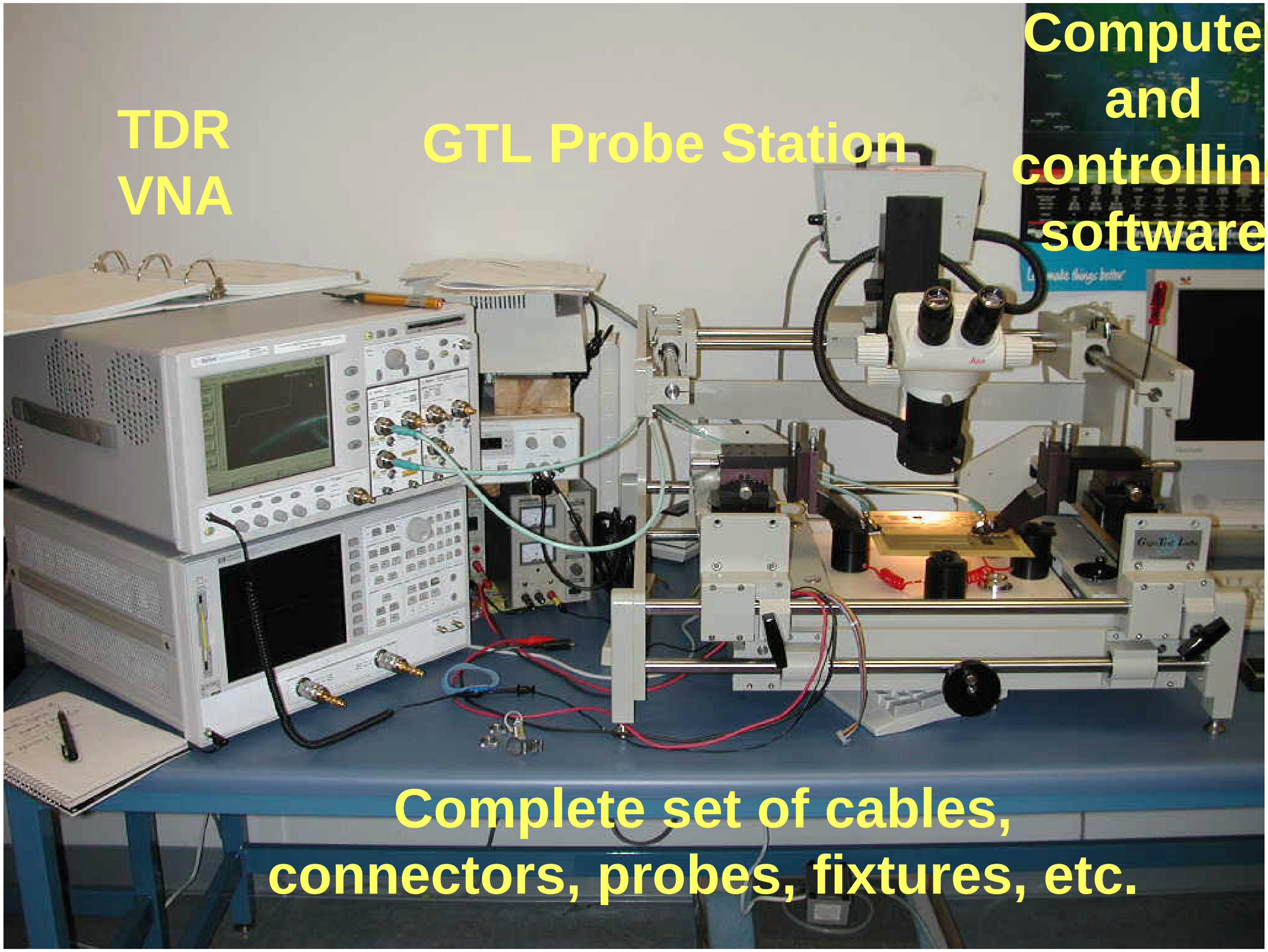
Vector Network Analyzer

Controlling software

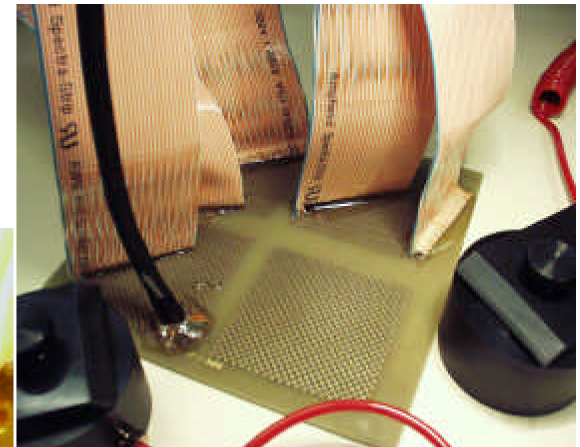
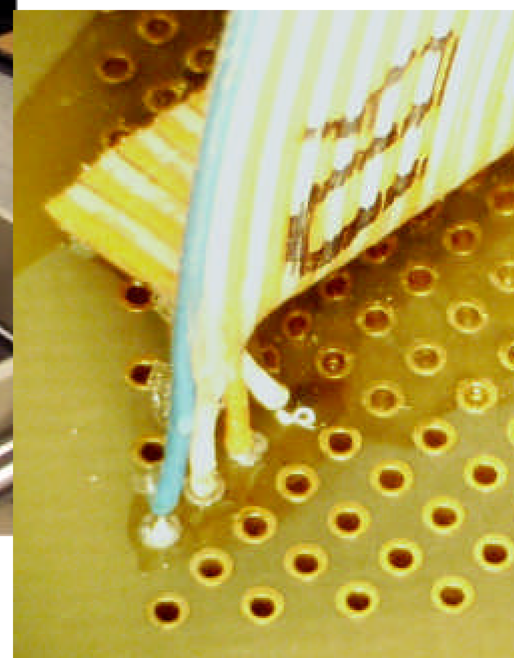
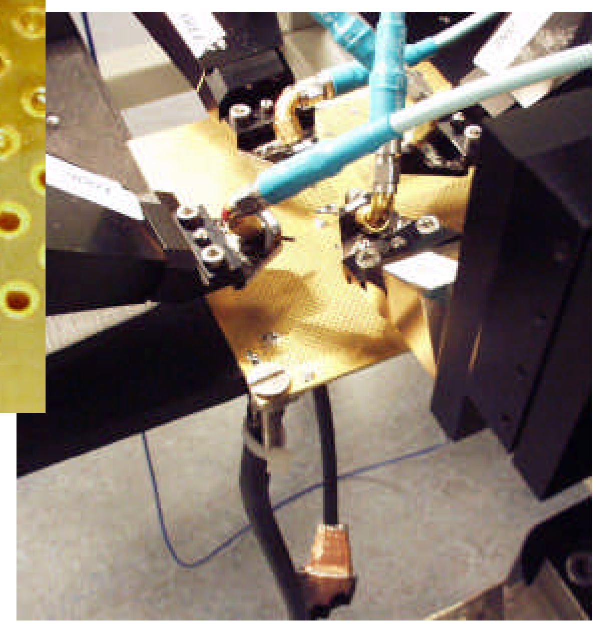
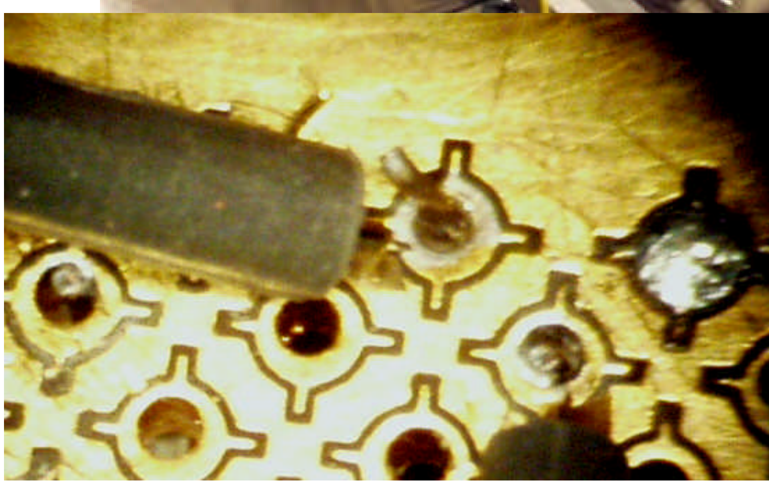
TDA Systems software

Agilent Advanced Design System (ADS)

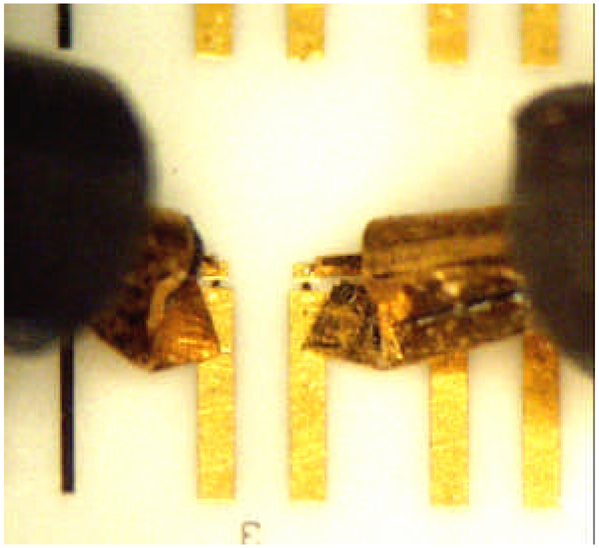
GigaTest Signal Integrity Engineering Turn Key System



GTL Probe Station and Precision Fixture Boards

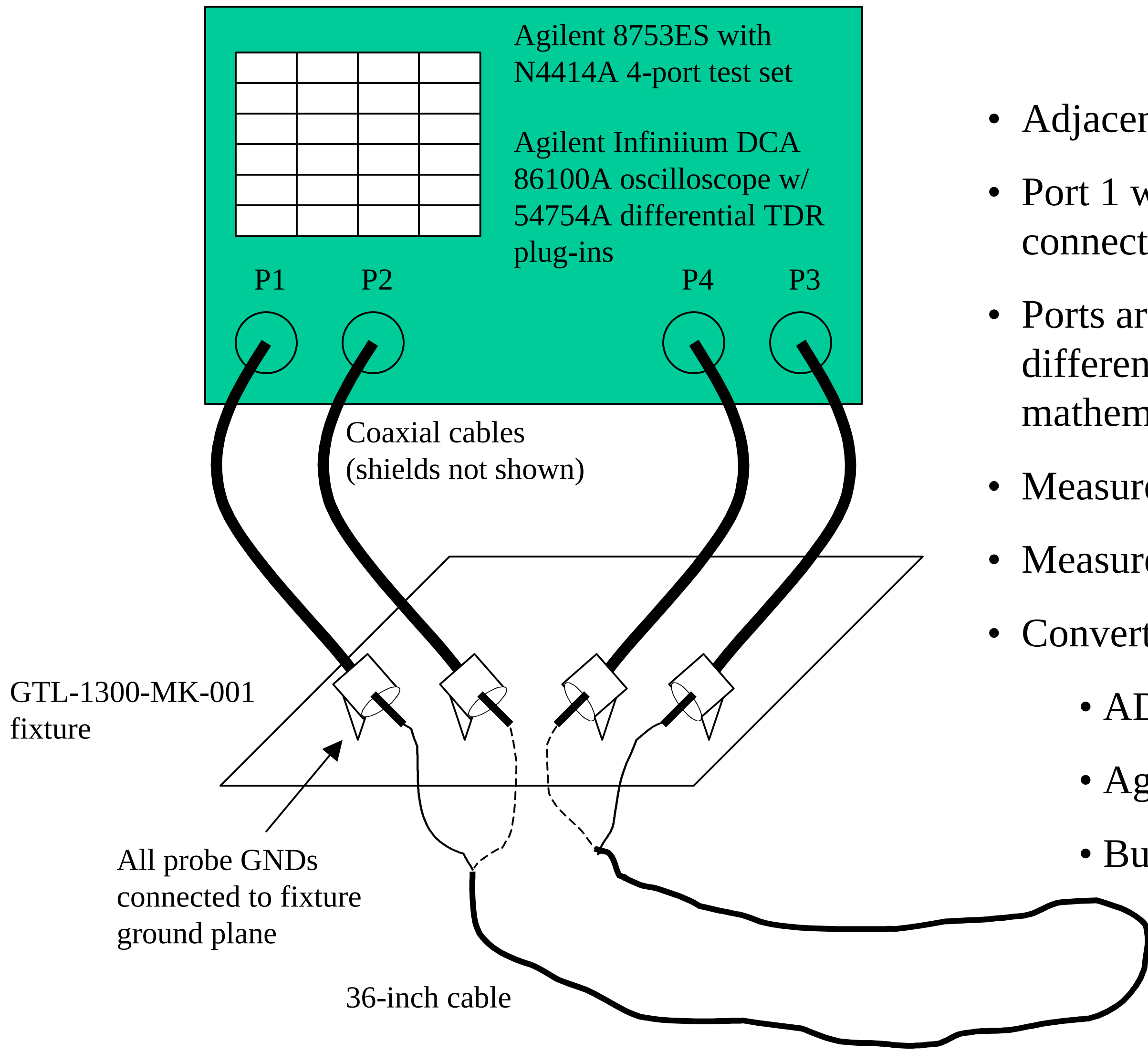






Why Measure This Way?



- **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**

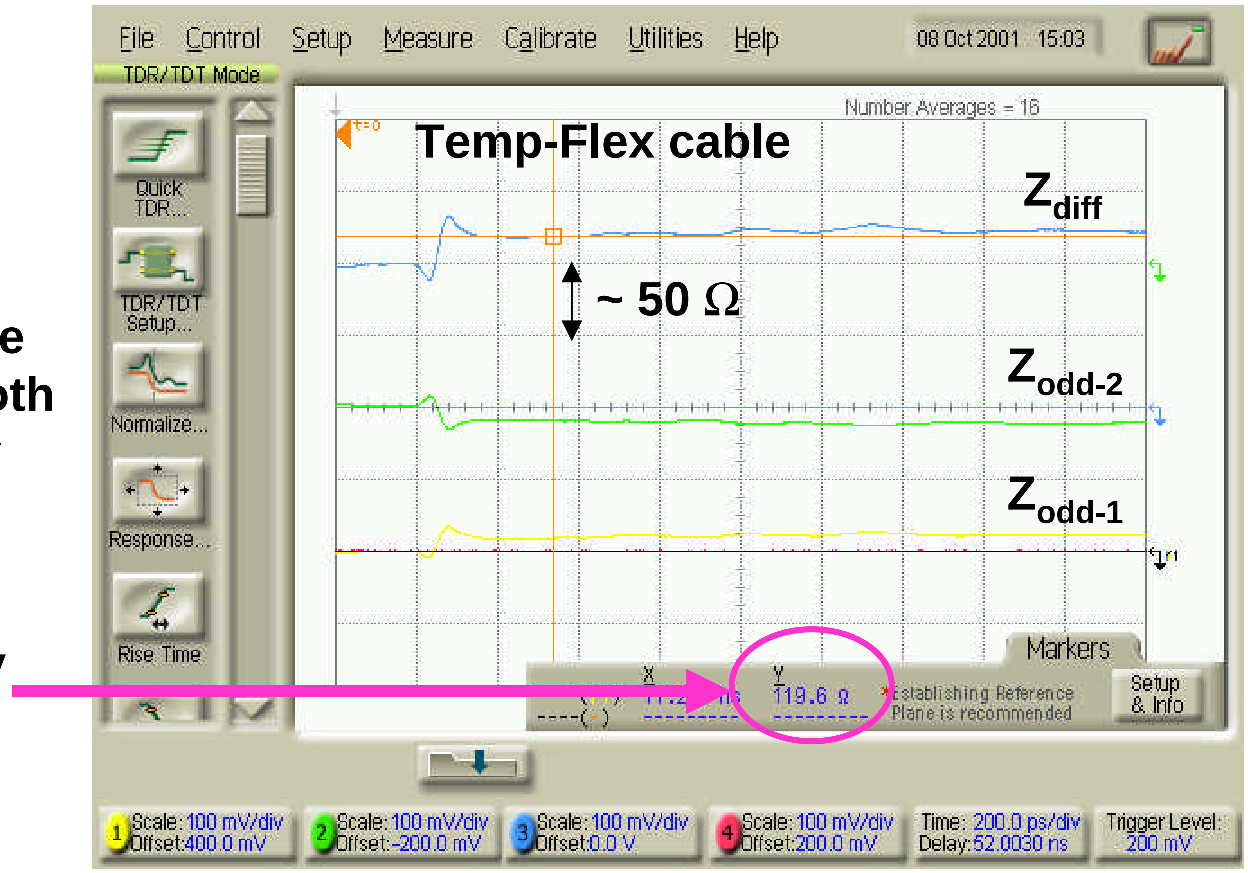
Instrument set up for Differential Pair Measurements



- 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. **$Z_{diff} = Z_{odd\text{-}1} + Z_{odd\text{-}2}$**
3. **Display Z_{diff} directly on the screen**



Converting Single Ended to Balanced S Parameters

Single Ended

Response (columns) / **Stimulus** (rows)

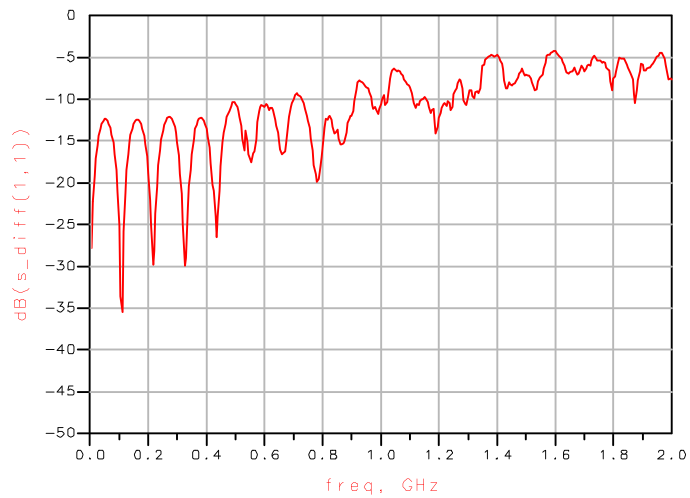
S_{11}	S_{12}	S_{13}	S_{14}
S_{21}	S_{22}	S_{23}	S_{24}
S_{31}	S_{32}	S_{33}	S_{34}
S_{41}	S_{42}	S_{43}	S_{44}

Stimulus

Response		Differential Signal		Common Signal	
		Port 1	Port 2	Port 1	Port 2
Differential Signal	Port 1	S_{DD11}	S_{DD12}	S_{DC11}	S_{DC12}
	Port 2	S_{DD21}	S_{DD22}	S_{DC21}	S_{DC22}
Common Signal	Port 1	S_{CD11}	S_{CD12}	S_{CC11}	S_{CC12}
	Port 2	S_{CD21}	S_{CD22}	S_{CC21}	S_{CC22}

SDD11 and SDD21 Return Loss and Insertion Loss

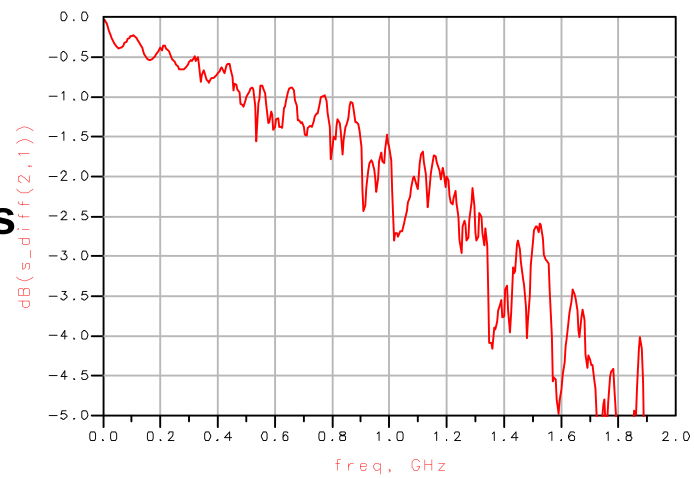
SDD11: return loss



Hitachi 28 AWG twisted pair cable

36 inches long

SDD21: insertion loss

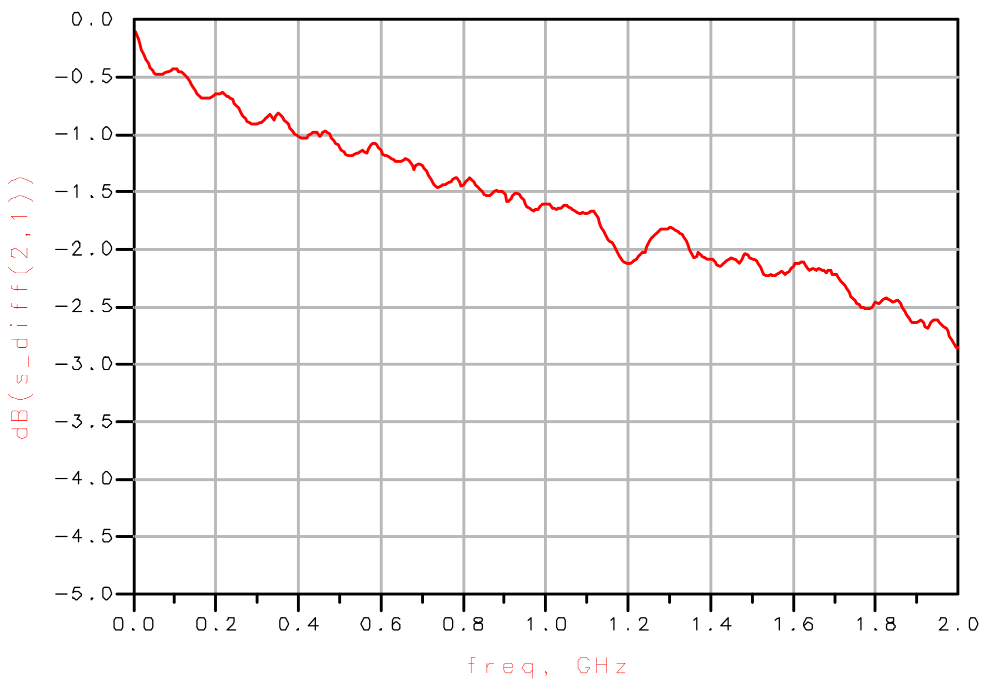


Note: this is based on a 100 Ω matched impedance system

3 dB BW ~ 1.3 GHz for this sample

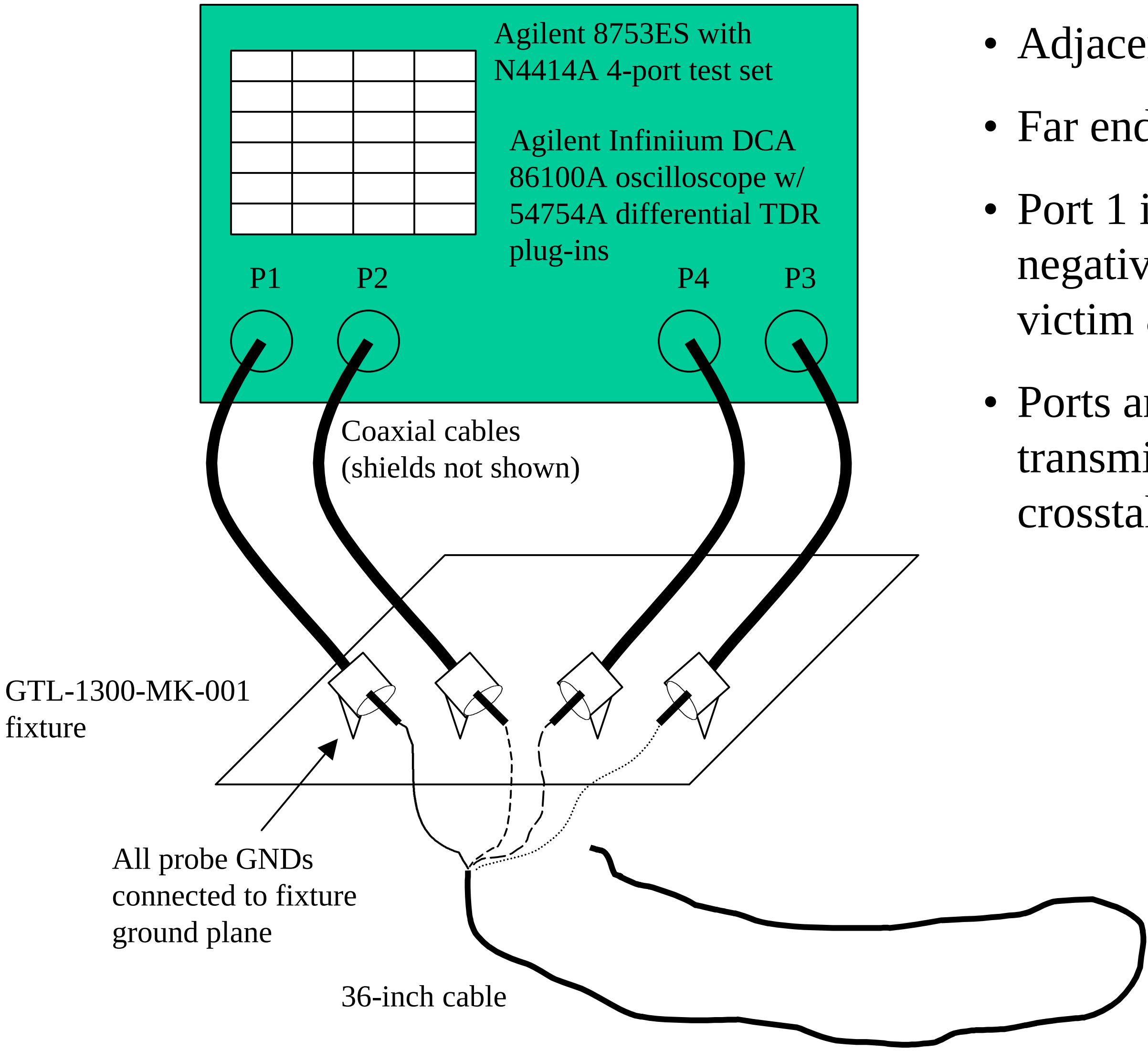
SDD21:Differential Insertion Loss and 3 dB BW

Temp-Flex cable 3 ft long



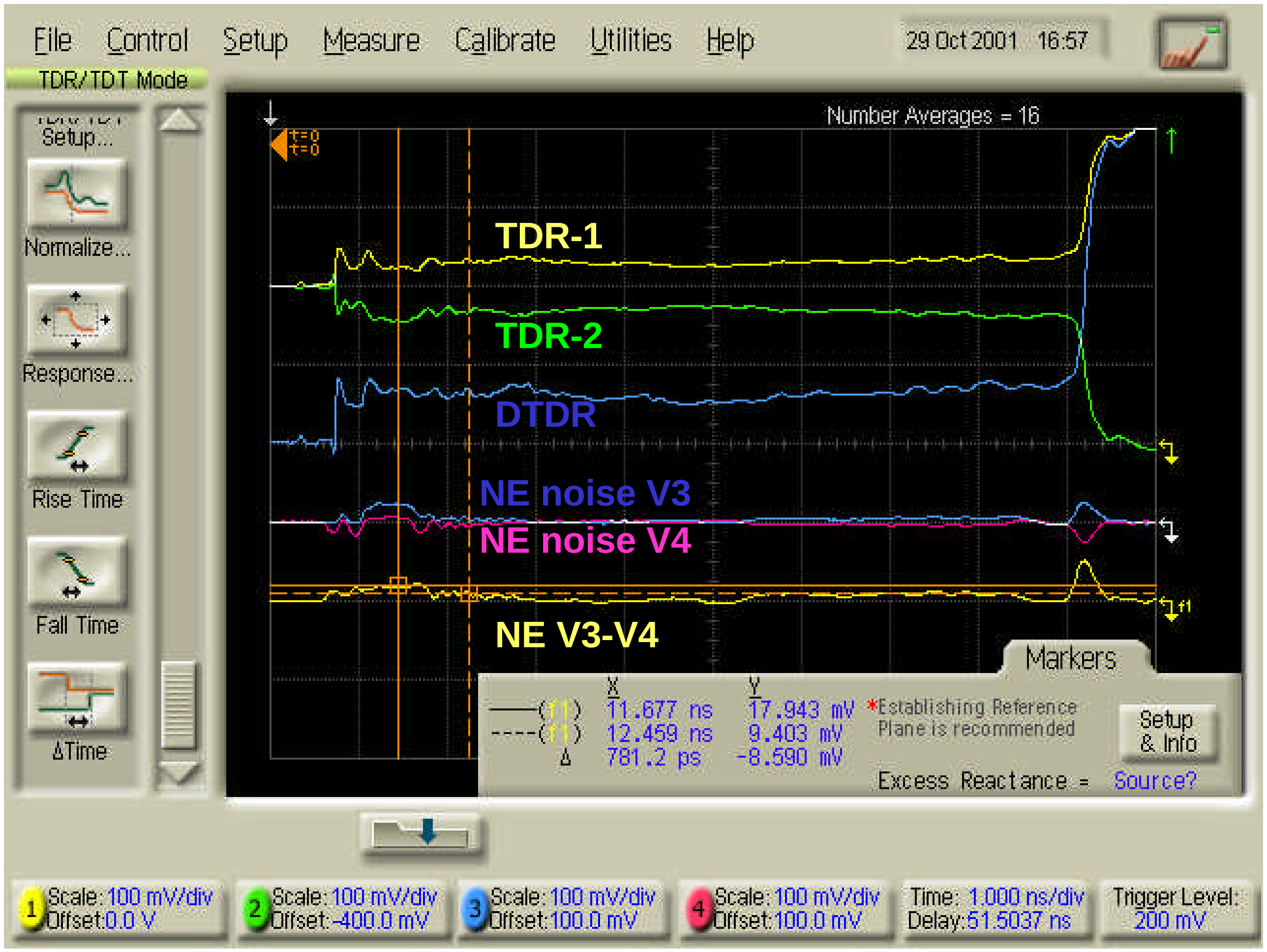
3 dB BW ~ 2 GHz for this sample, 3 ft long

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 is negative victim
- Ports are excited differentially, TDT transmission info is used to compute crosstalk ($V_{victim}/V_{aggressor}$)

NEXT in Time Domain

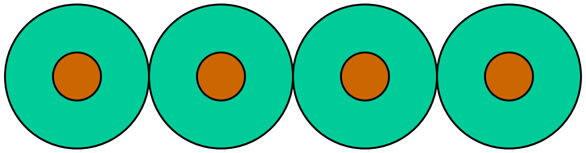


Twist-flat ribbon cable
45 inch pitch
3 feet long

NEXT ~ 18 mV out of 400 mV = ~4.5%

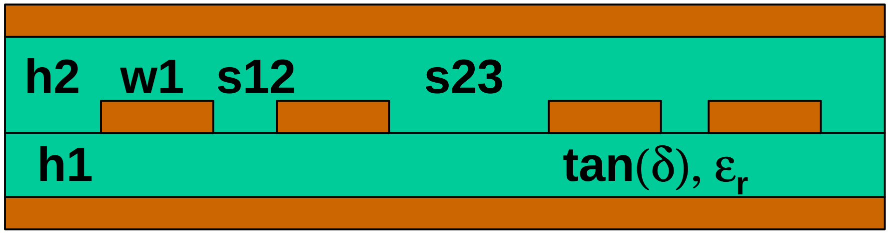
A Trick to Use Agilent ADS for Modeling a SCSI Cable

SCSI cable



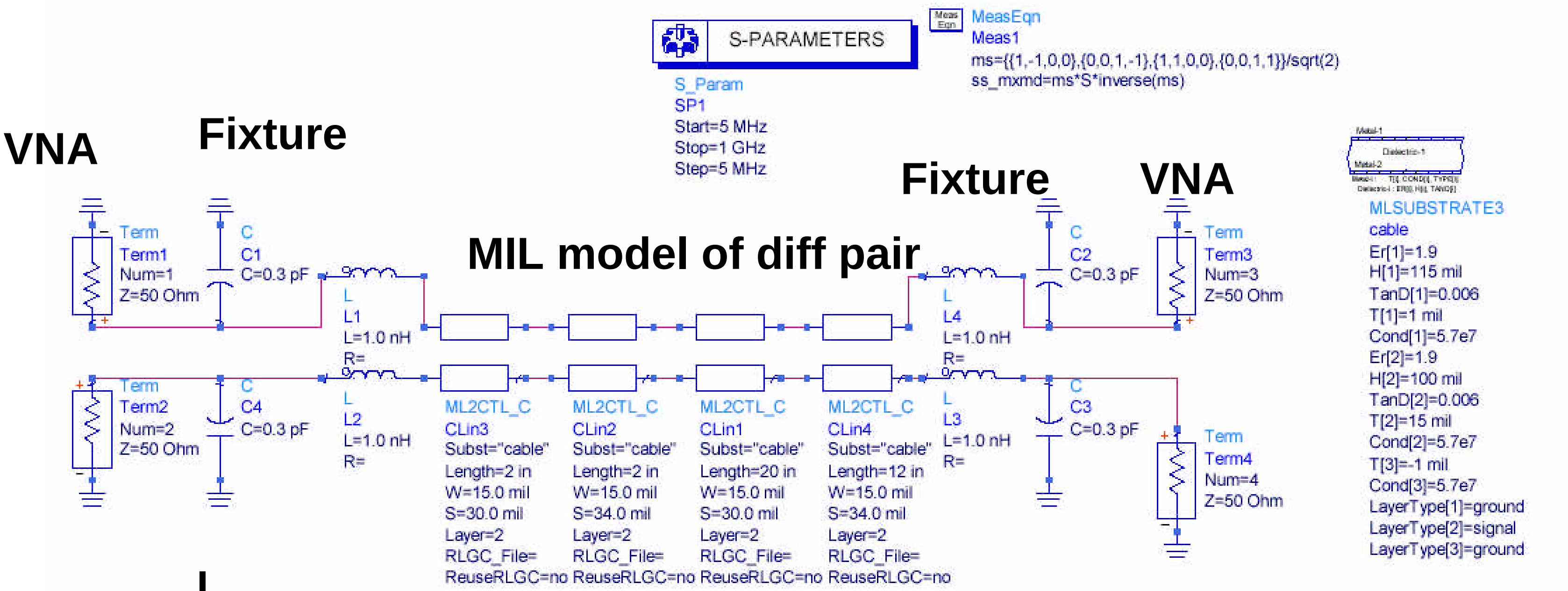
- Situation Analysis:
  - ✓ ADS does not have a parameterized round cable, mixed dielectric model element that can be used to synthesize a model from the actual geometry
  - ✓ ADS does have a parameterized, coupled stripline model

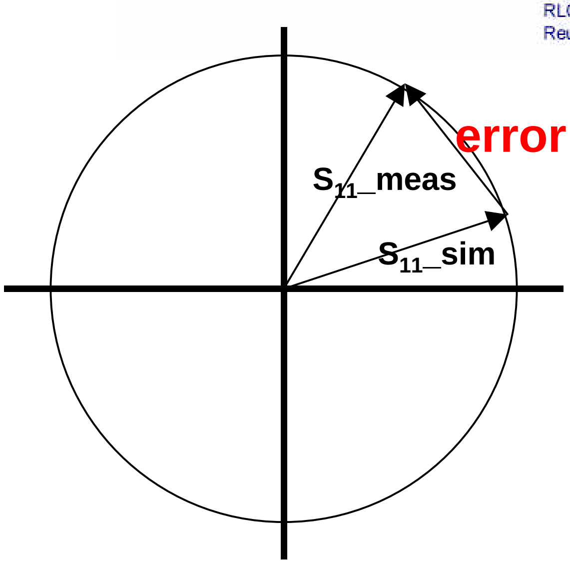
ADS parameterized coupled stripline MIM model:



- 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



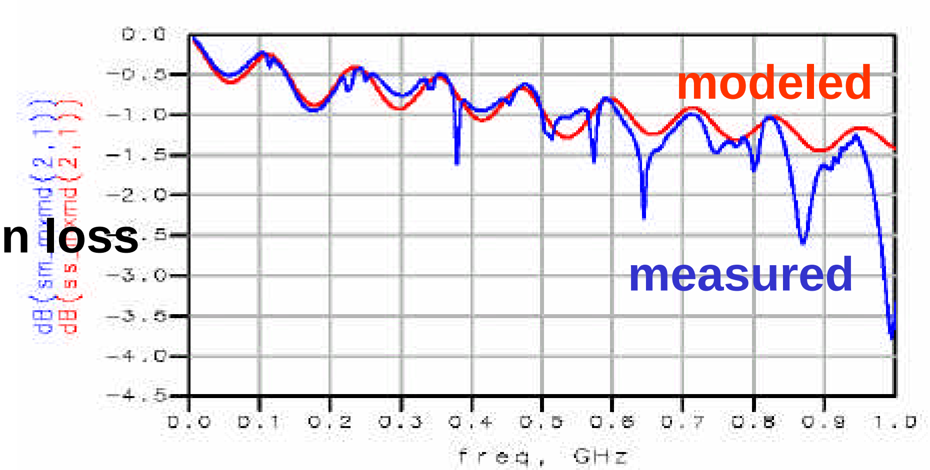


As frequency is swept, minimize:

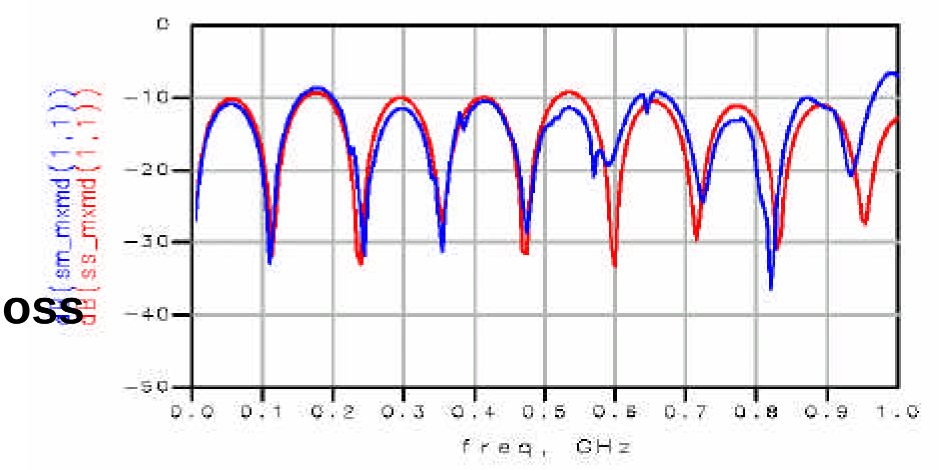
$$\left\{ \sum \text{error}^2 \right\}$$

Comparing Final Model and Measurement Results

SDD21: Insertion loss

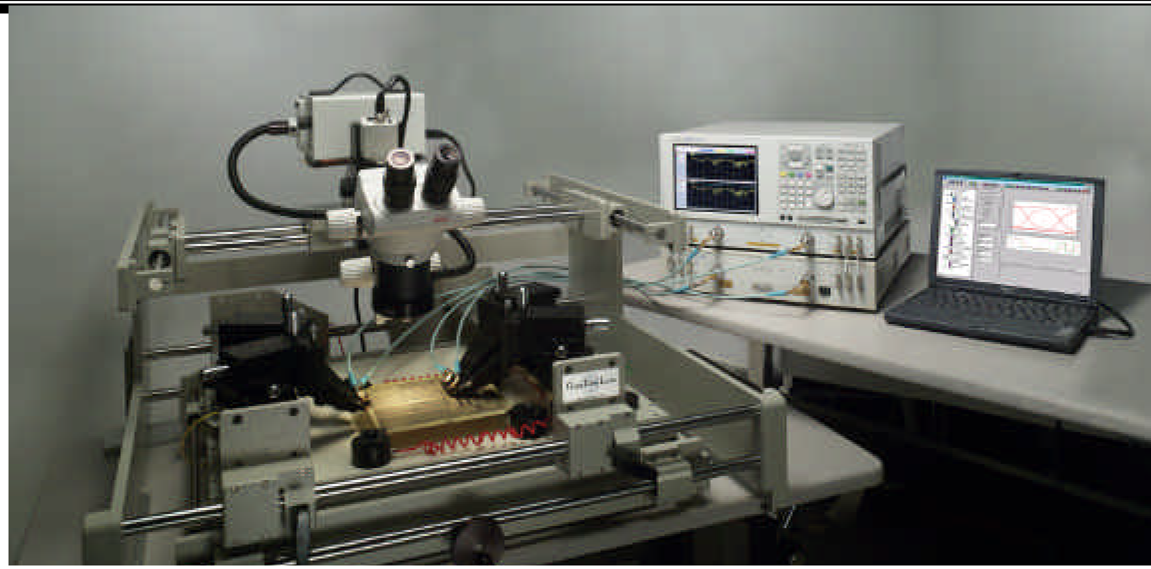


SDD11: Return loss



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