BiTS

Burn-in & Test Socket Workshop

March 3-6 , 2002
Hilton Phoenix East/Mesa Hotel
Mesa, Arizona

IEEE

IEEE COMPUTER SOCIETY

Sponsored By The IEEE Computer Society Test Technology Technical Council

BiTS Burn-in & Test Socket Workshop

Technical Program

Session 5
Tuesday 3/05/02 1:00PM

Modeling, Analysis and Characterization

"Electrical Modeling And Contactor Performance In A RF System"

Jim Adley - Johnstech International Corporation
Eric Leung - Johnstech International Corporation
Jeff Sherry - Johnstech International Corporation

"Leaded 2mm Contactors: Measuring And Modeling To 10 GHz"

Tom Strouth - GigaTest Labs
Orlando Bell - GigaTest Labs
Gary Otonari - GigaTest Labs
Eric Bogatin - GigaTest Labs
Jeff Sherry - Johnstech International Corporation

"Force Measurement On Sockets And Contactors"

Richard Block - Advanced Micro Devices
Rafiq Hussain - Advanced Micro Devices

Electrical Modeling and Contactor Performance in a RF Test System

0.5 mm Pitch BGA

Jim Adley, R&D Manager
Eric Leung, R&D Engineer
Jeff Sherry, R&D Engineer
Johnstech International

Johnstech™

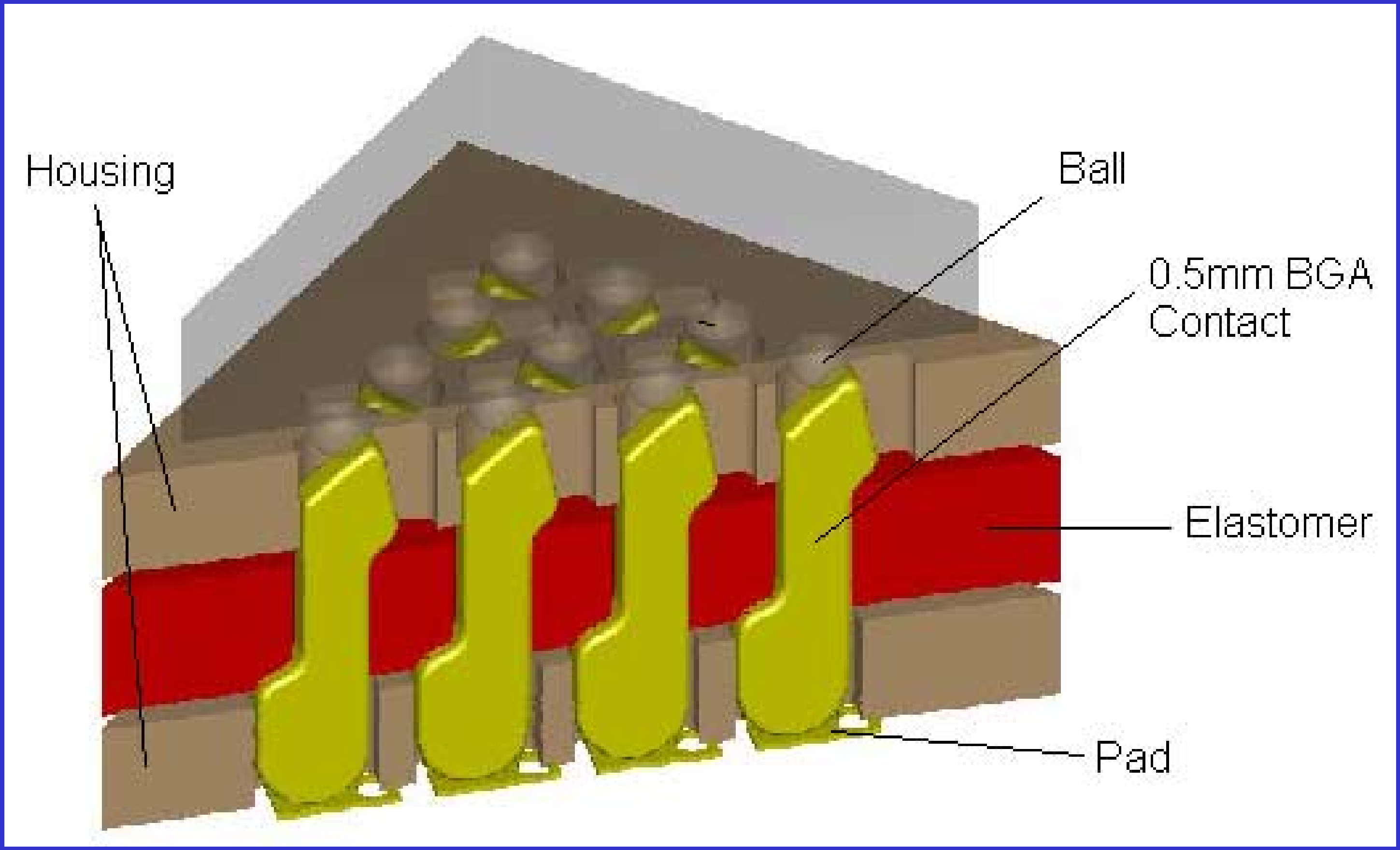
Discussion Topics

- Modeled Data
- Measured Data
- Comparative Data
- Equivalent Circuit Model
- Conclusion

Johnstech

Introduction: 0.5 mm Pitch BGA Contactor

- Cross sectional view of a contactor



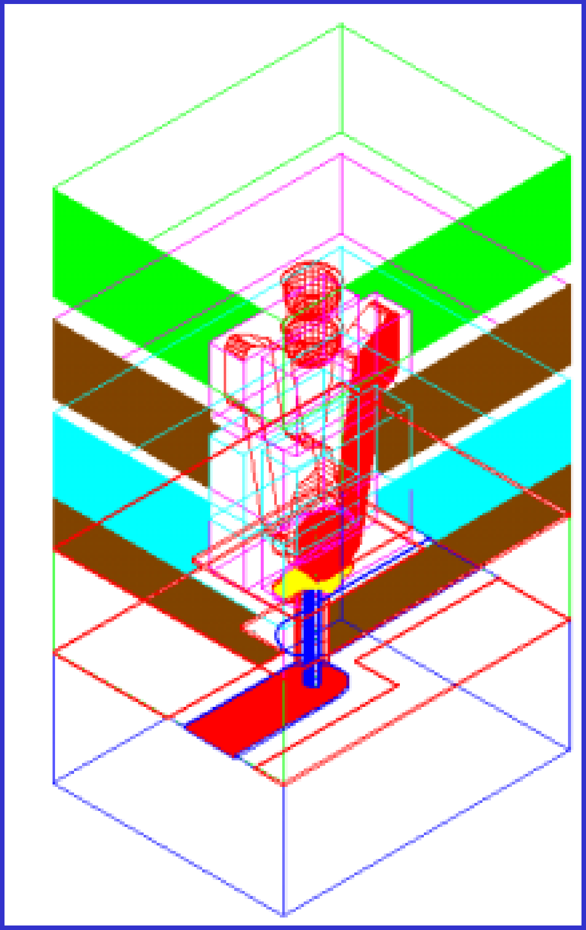
Modeled Data

- Modeling was done using Agilent HFSS software
- An AutoCAD drawing, including the actual structure built by GigaTest Labs, was imported into HFSS
- Data obtained from simulation includes:
  - Return Loss S_{11}
  - Insertion Loss S_{21}

Johnstech

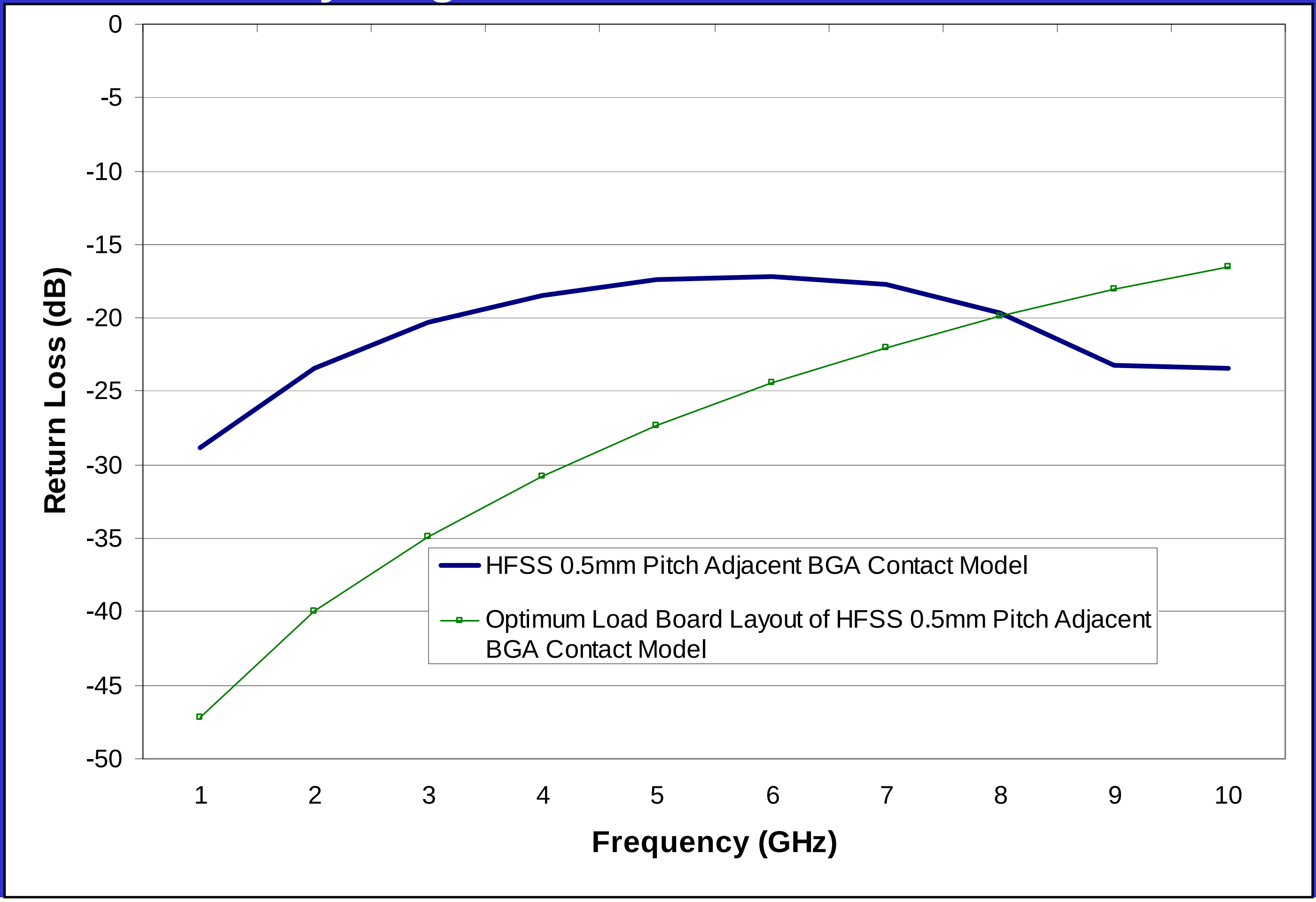
Modeled Data

▼ 0.5 mm pitch BGA model from an AutoCAD file



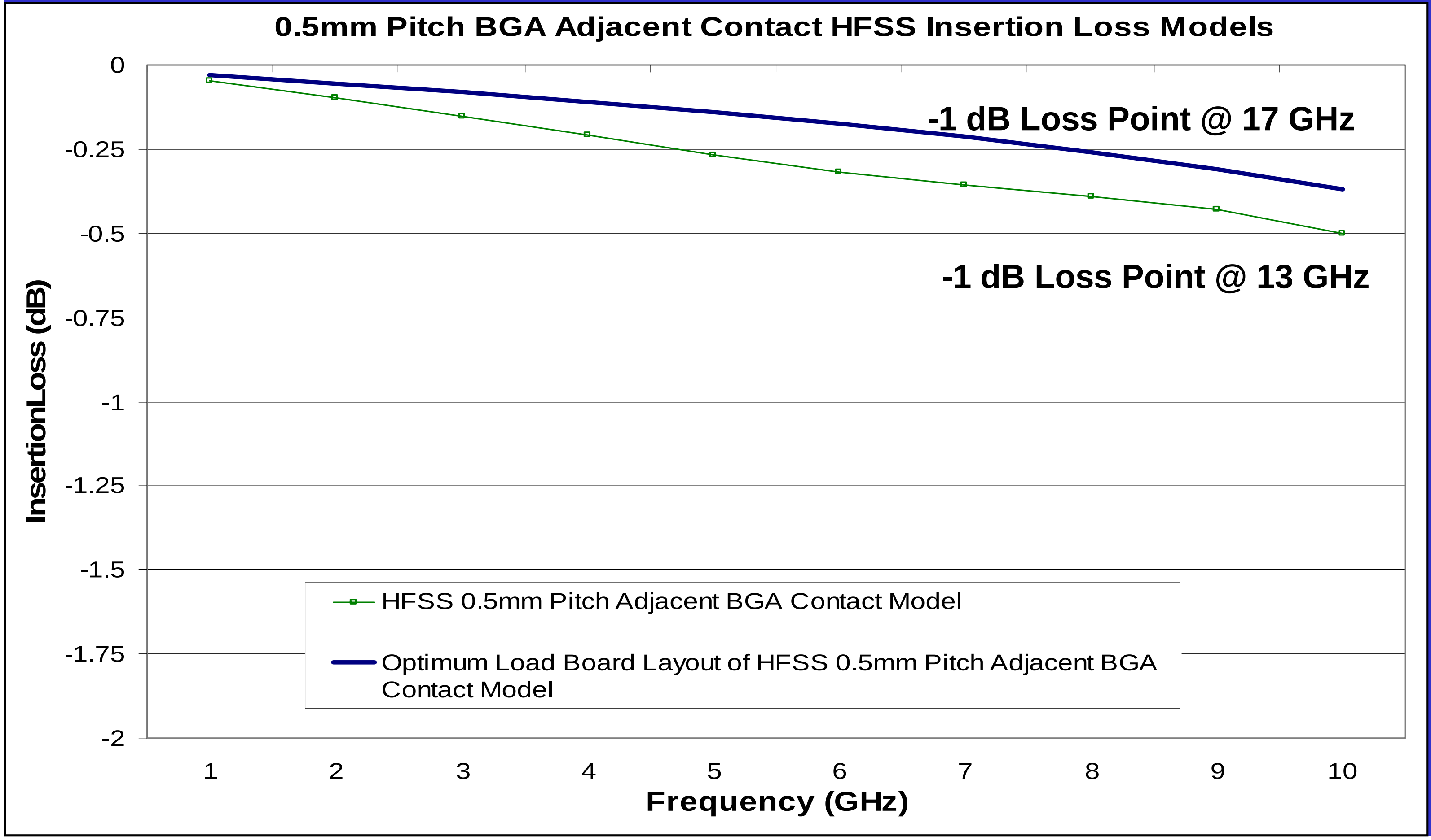
Modeled Data - S_{11}

- This is data from the HFSS model of return loss by the actual 0.5 mm BGA structure tested by GigaTest Labs



Modeled Data - S_{21} & S_{11}

- This is data from the HFSS model of return loss by the actual .5 mm BGA structure tested by GigaTest Labs



Modeled Data

- HFSS Capabilities
  - Contact design parameters
  - Load board design effects
  - Device pad interactions
  - Expected performance
  - Effects of tolerances
  - Interaction between components in system (device, contactor, handler, etc.)
  - Trends

Johnstech™

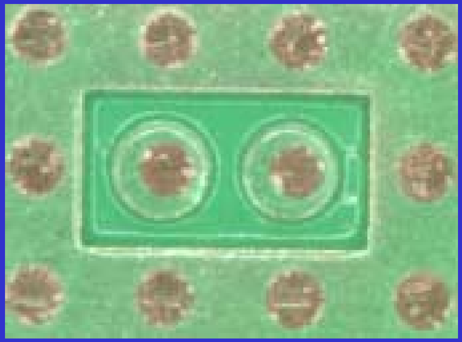
Measured Data

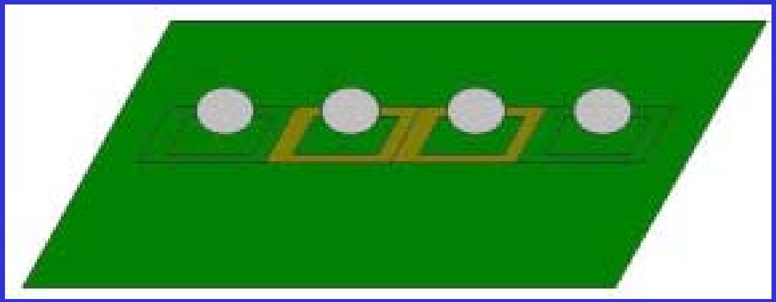
- GigaTest Labs tested a 0.5 mm pitch Ball Series contactor
- GigaTest Labs used a surrogate device - Short, Open, Load, Thru (*SOLT*) to conduct testing
- Data was measured by GigaTest Labs through probing from the back side of a non-optimized load board

Johnstech™

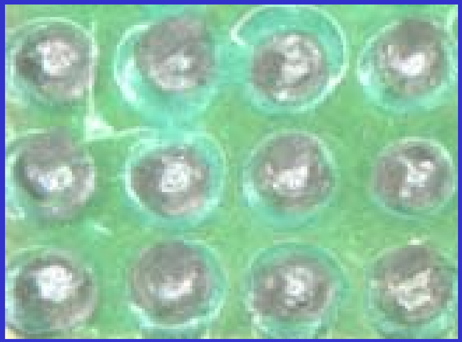
Measured Data

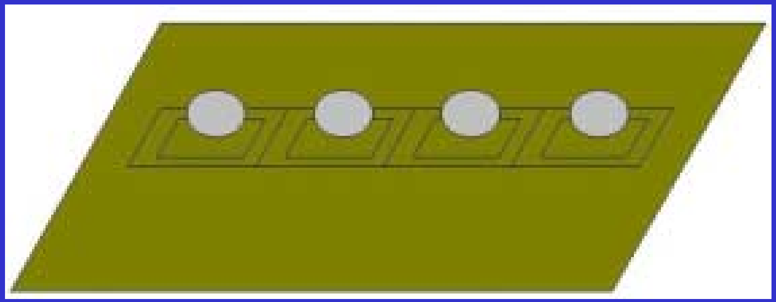
Open



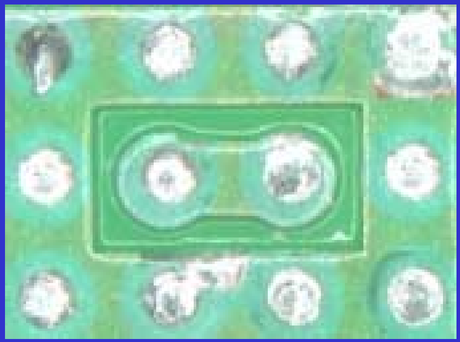


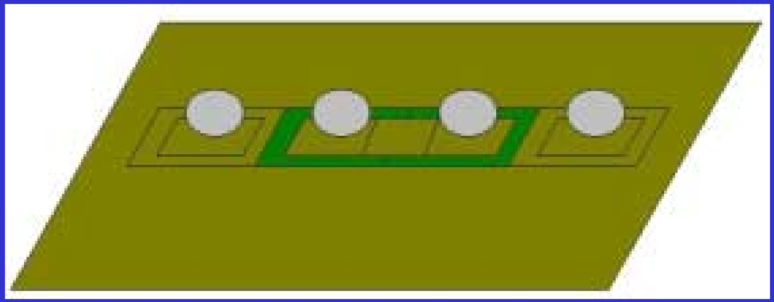
Short





Thru





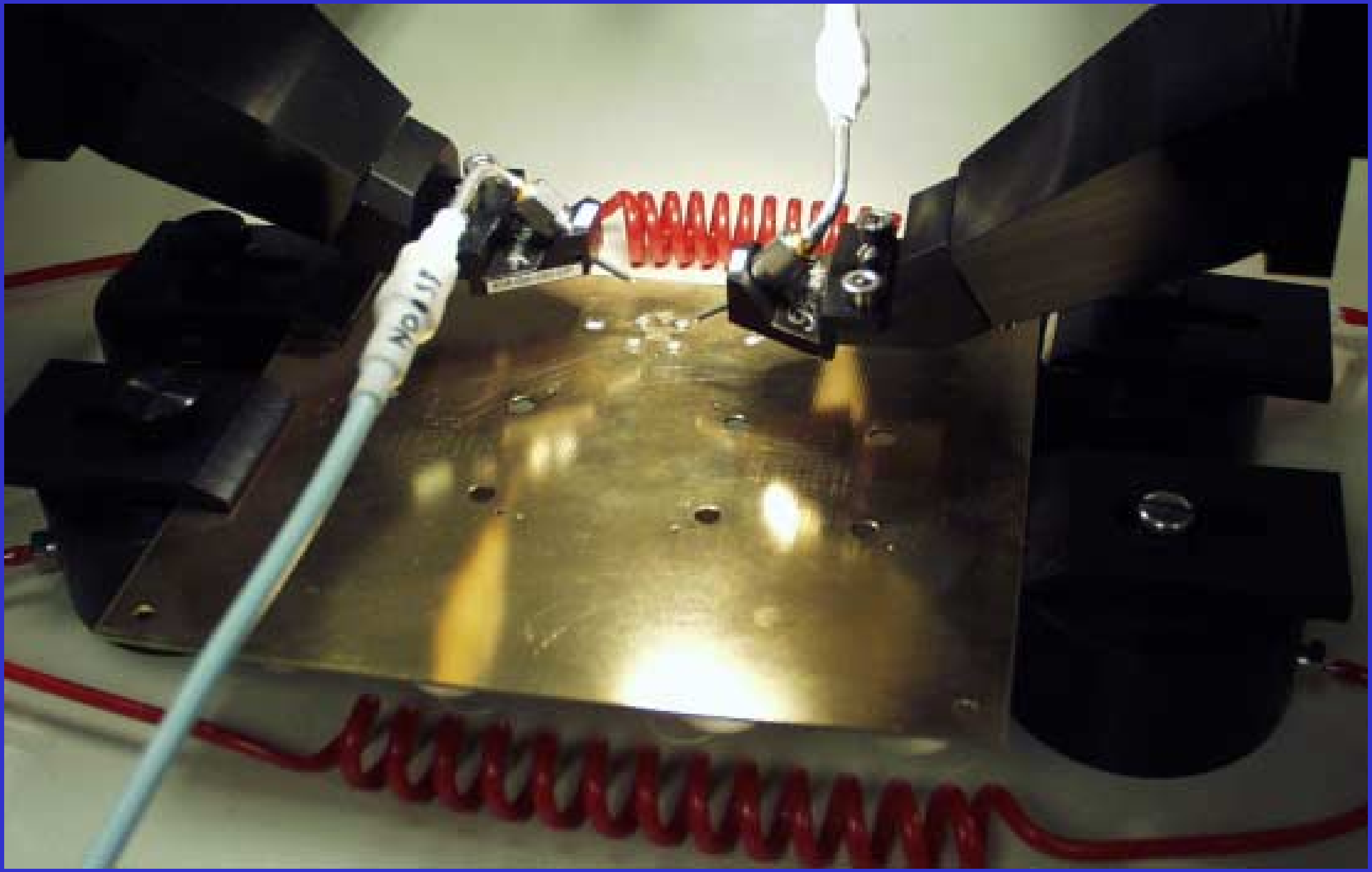
Surrogate

Circuit

Johnstech

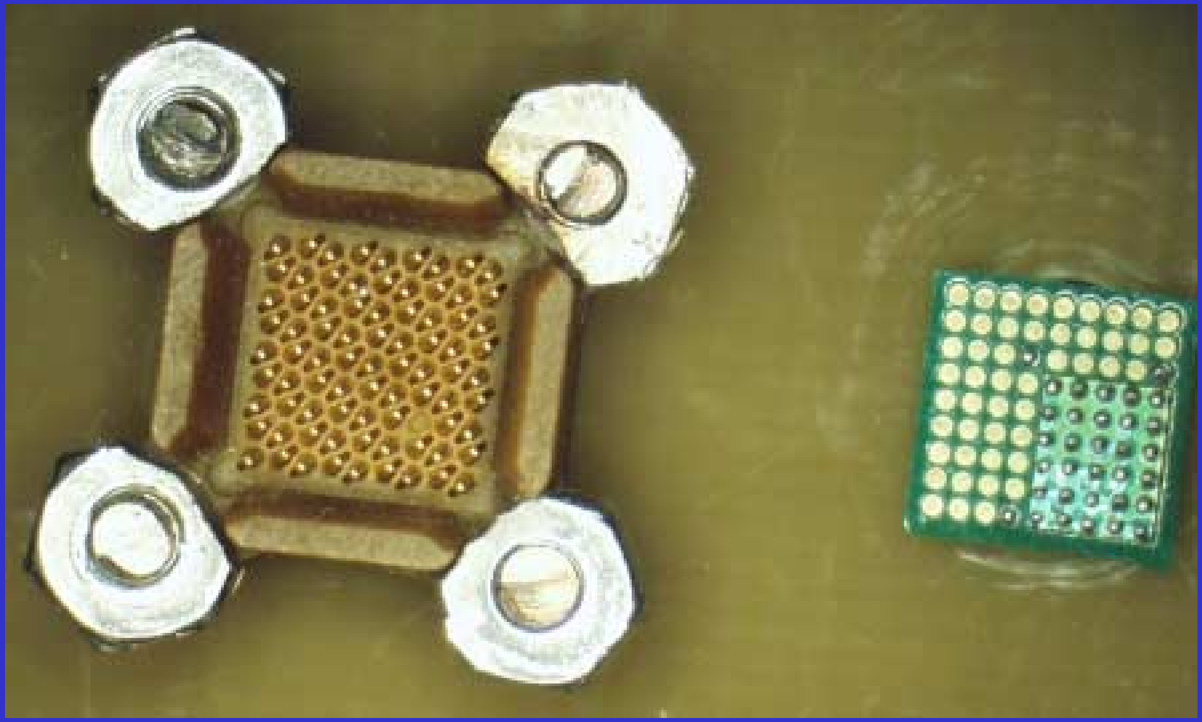
Measured Data

- GigaTest Labs used a micro probe station for measuring two adjacent contacts S-parameters



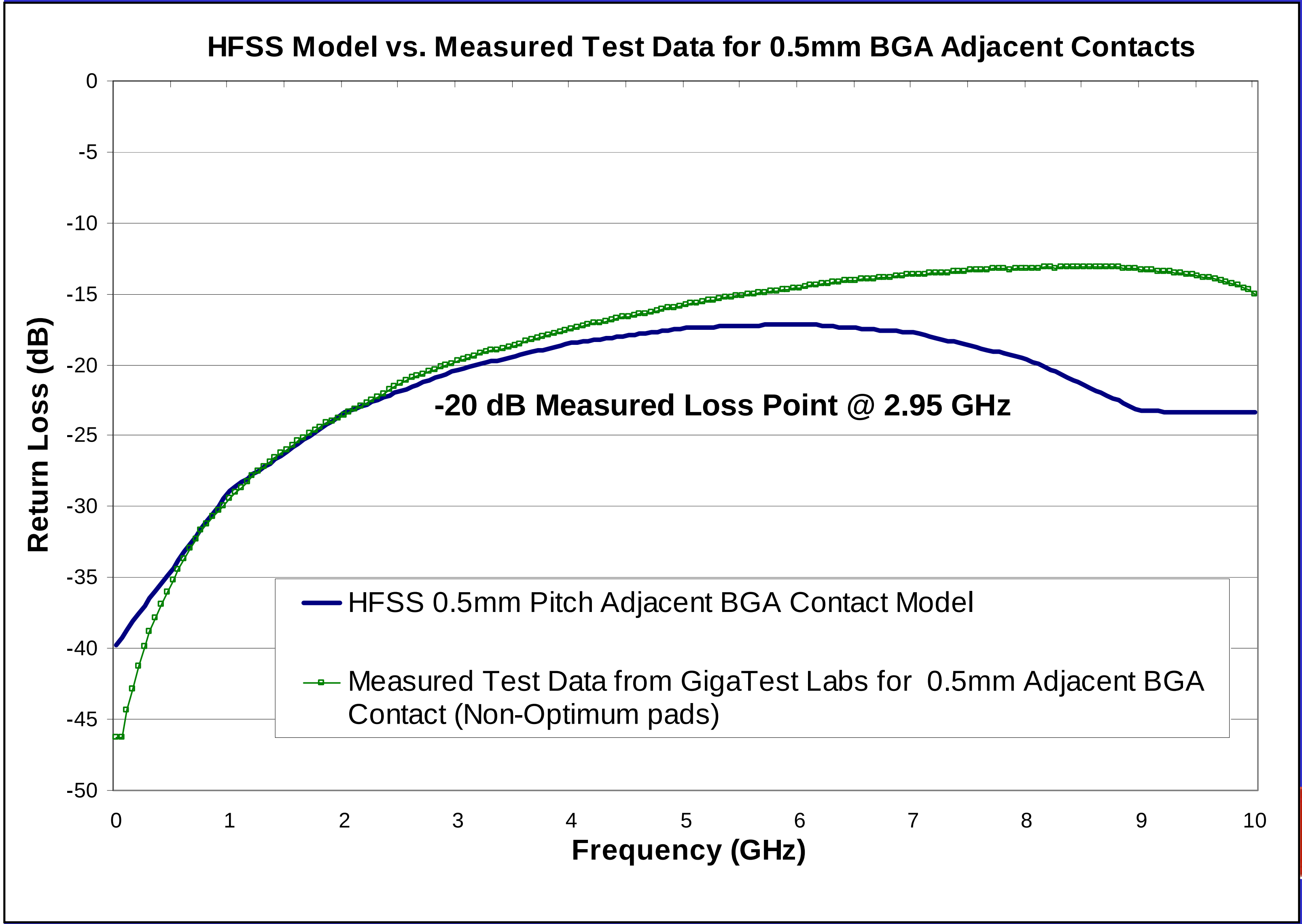
Measured Data

- The 0.5 mm pitch BGA housing and BGA surrogate package

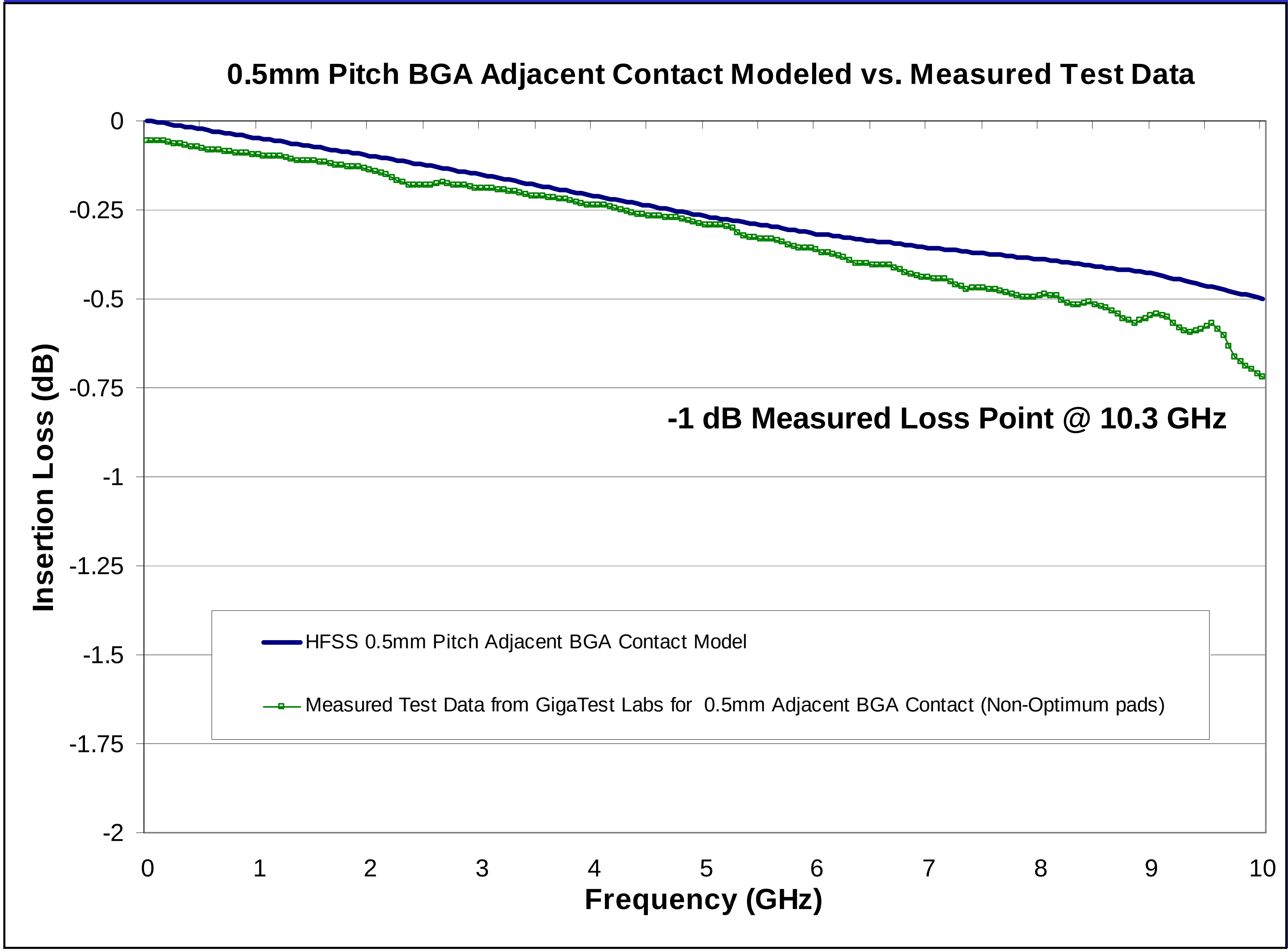


Johnstech

Comparative Data



Comparative Data



Johnstech

Equivalent Circuit Model

- Characterize the parasitic effects
- Simulate the contact with an equivalent circuit for time domain response
- Integrate the contactor into a system level simulation to:
  - Reduce test cost and time
  - Optimize system performance

Johnstech™

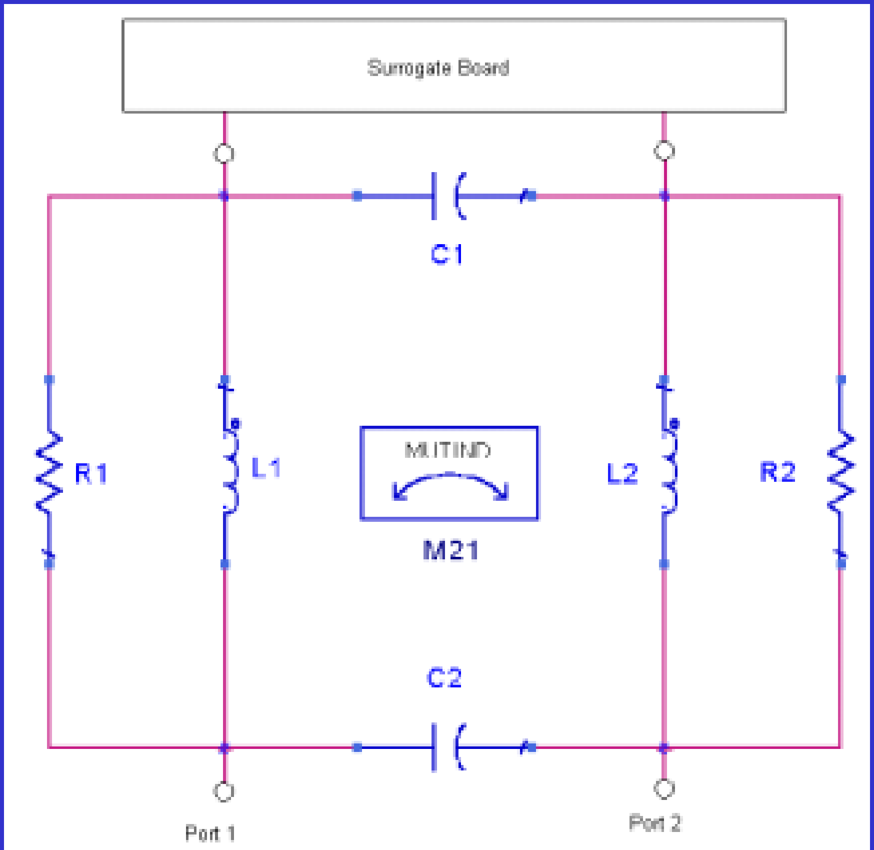
Equivalent Circuit Model

- Measure the S-parameters for short-, open- and thru- fixtures from two adjacent contacts
- Use measured data and Agilent Advanced Design System (ADS) for model extraction and verification
- Compare measured and ADS simulated insertion and return loss

Johnstech

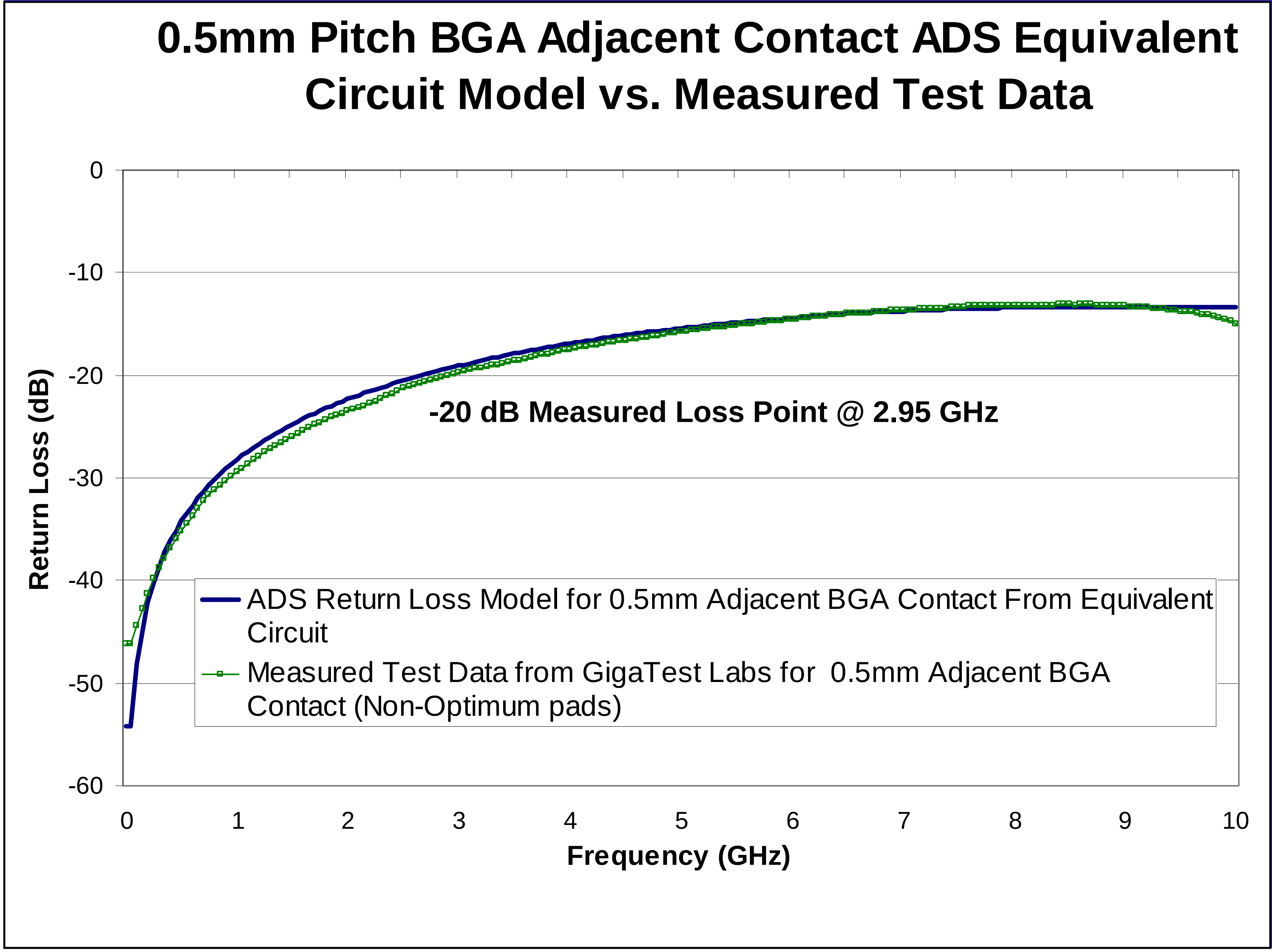
Equivalent Circuit Model

- This figure shows the Equivalent Circuit Model for two adjacent 0.5 mm BGA contacts



Johnstech

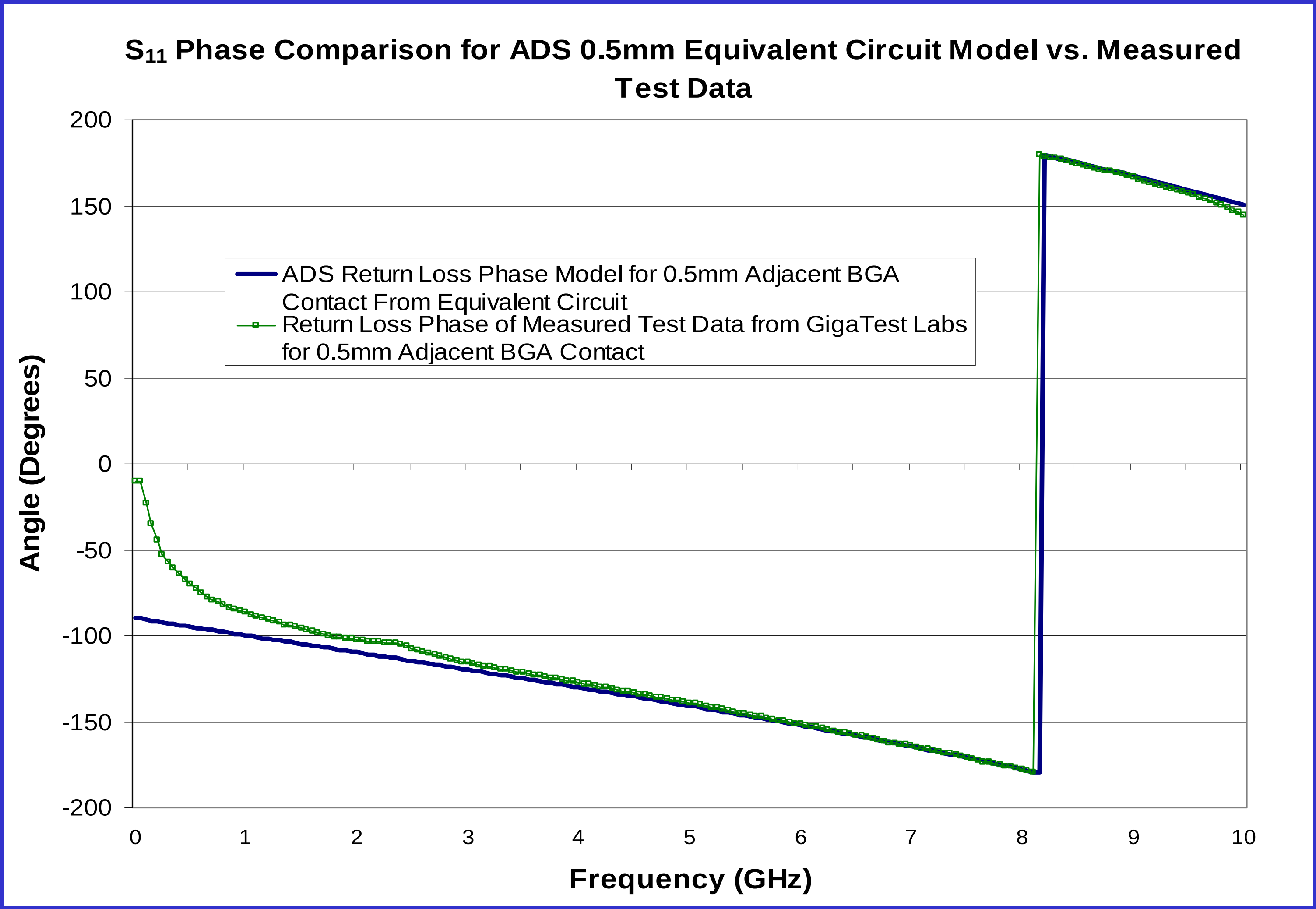
Equivalent Circuit Model



Johnstech

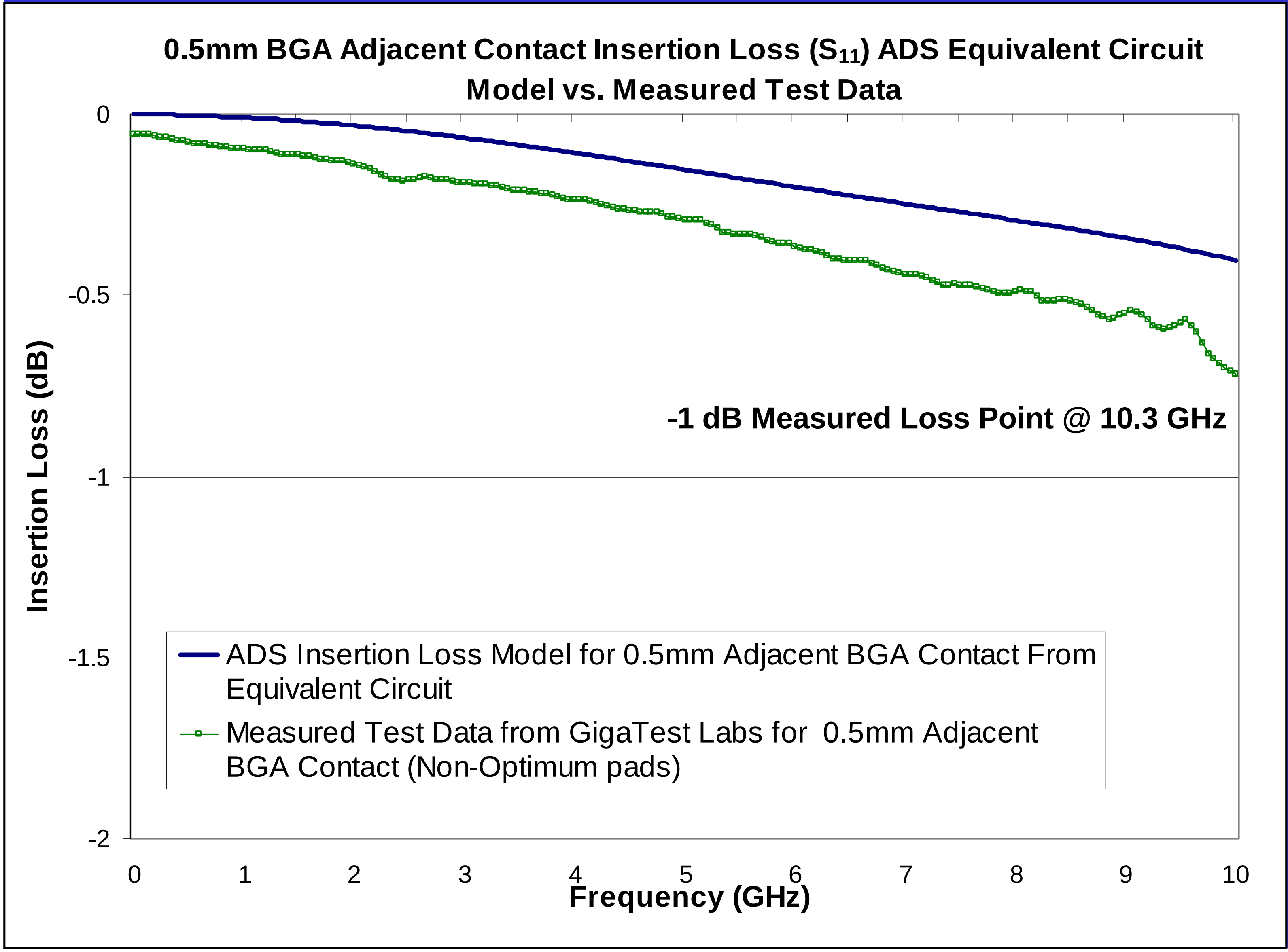
Equivalent Circuit Model

- Phase comparison shows that the contact is linear over the frequency model

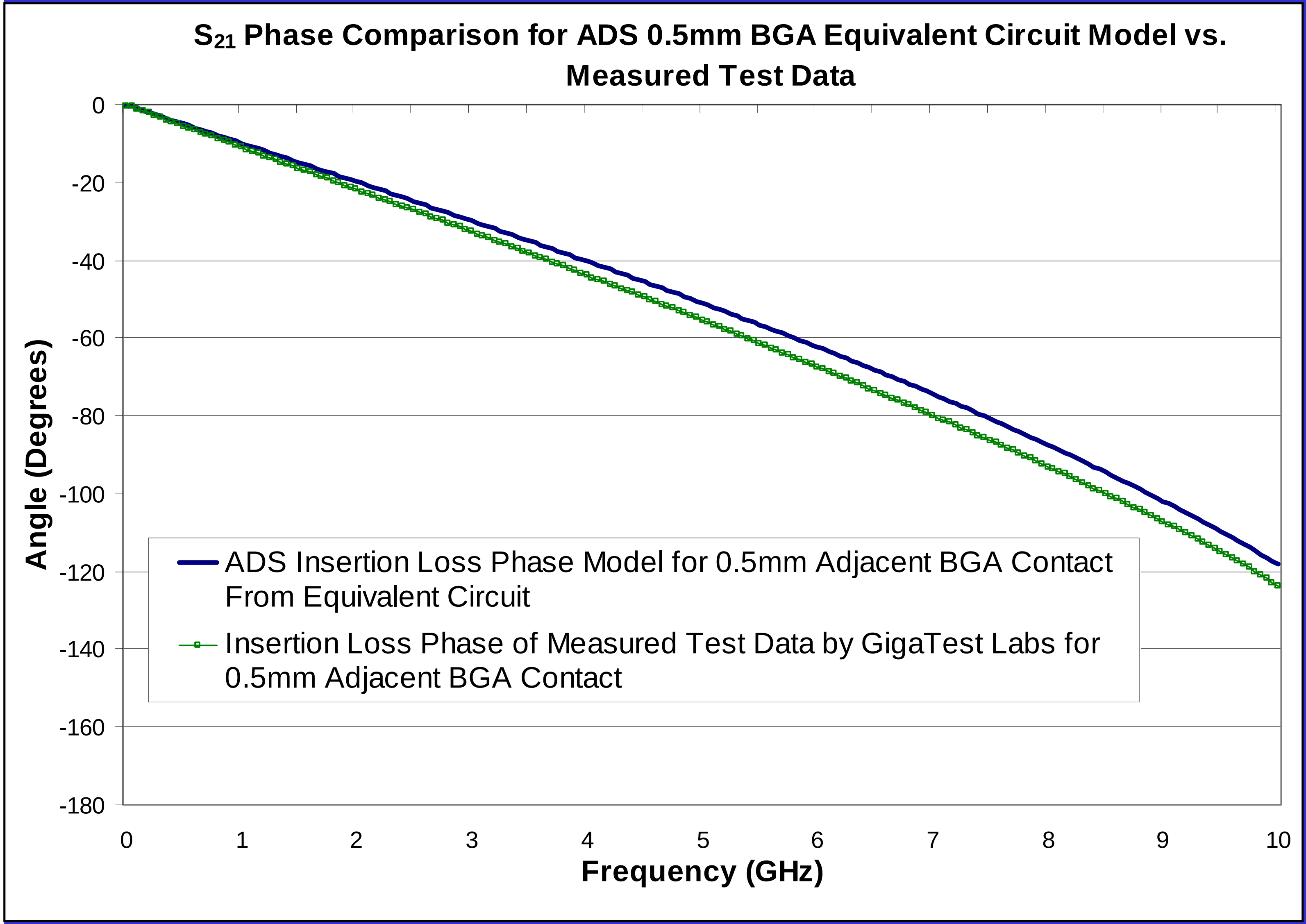


Johnstech

Equivalent Circuit Model Development



Equivalent Circuit Model Development



Johnstech

Conclusion

- For leading edge RF applications such as 0.5 mm pitch, modeling is helpful to achieve optimal system performance
- Accurate equivalent circuit models can represent contact behavior and help in determining complete system response
- Modeling can help RF engineers save time and money in development by correctly predicting system results and eliminating or reducing hardware builds and test iterations

Johnstech

Leaded 2 mm Contactors: Measuring and Modeling to 10 GHz

Tom Strouth, Orlando Bell, Gary Otonari, Eric Bogatin

GigaTest Labs, www.GigaTest.com

and

Jeff Sherry

Johnstech, www.Johnstech.com

Johnstech™

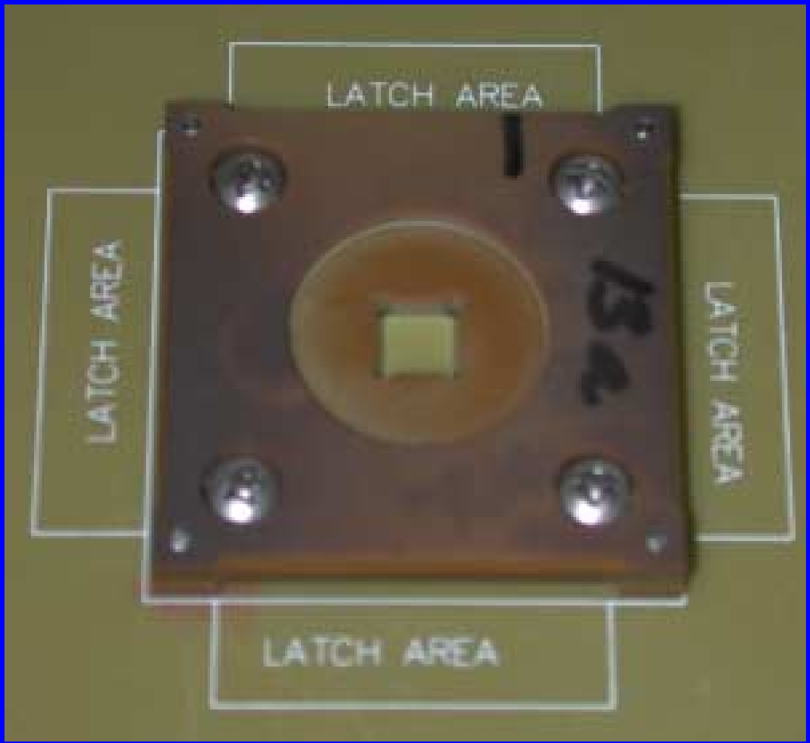
BiTS
BURN-IN & TEST
SOCKET WORKSHOP

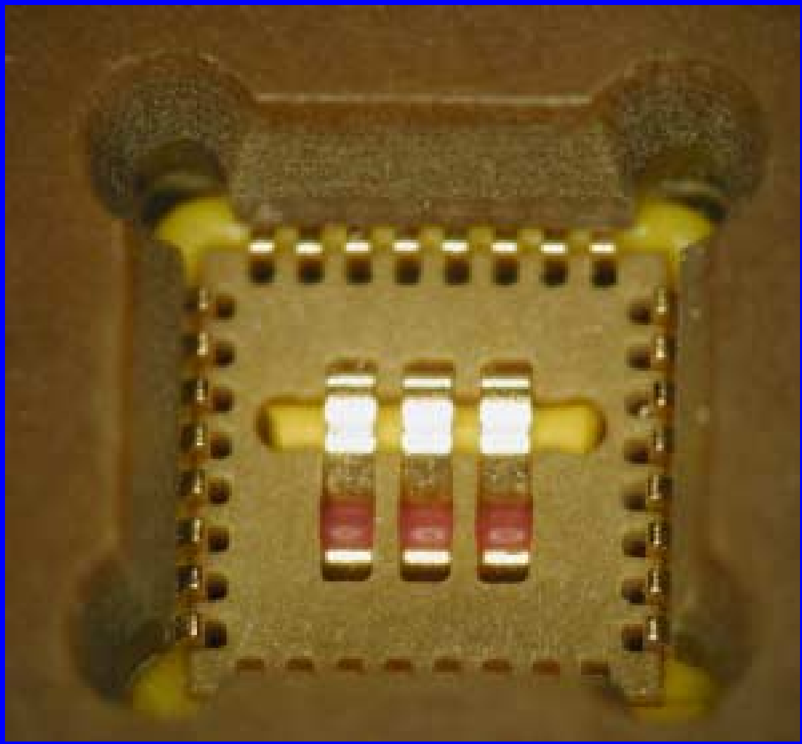
GigaTest Labs

Outline

- Contactors
- Fixturing
- Measurement set up
- Modeling process
- Results
- Using the model for simulation

32 lead MLP2 Contactor

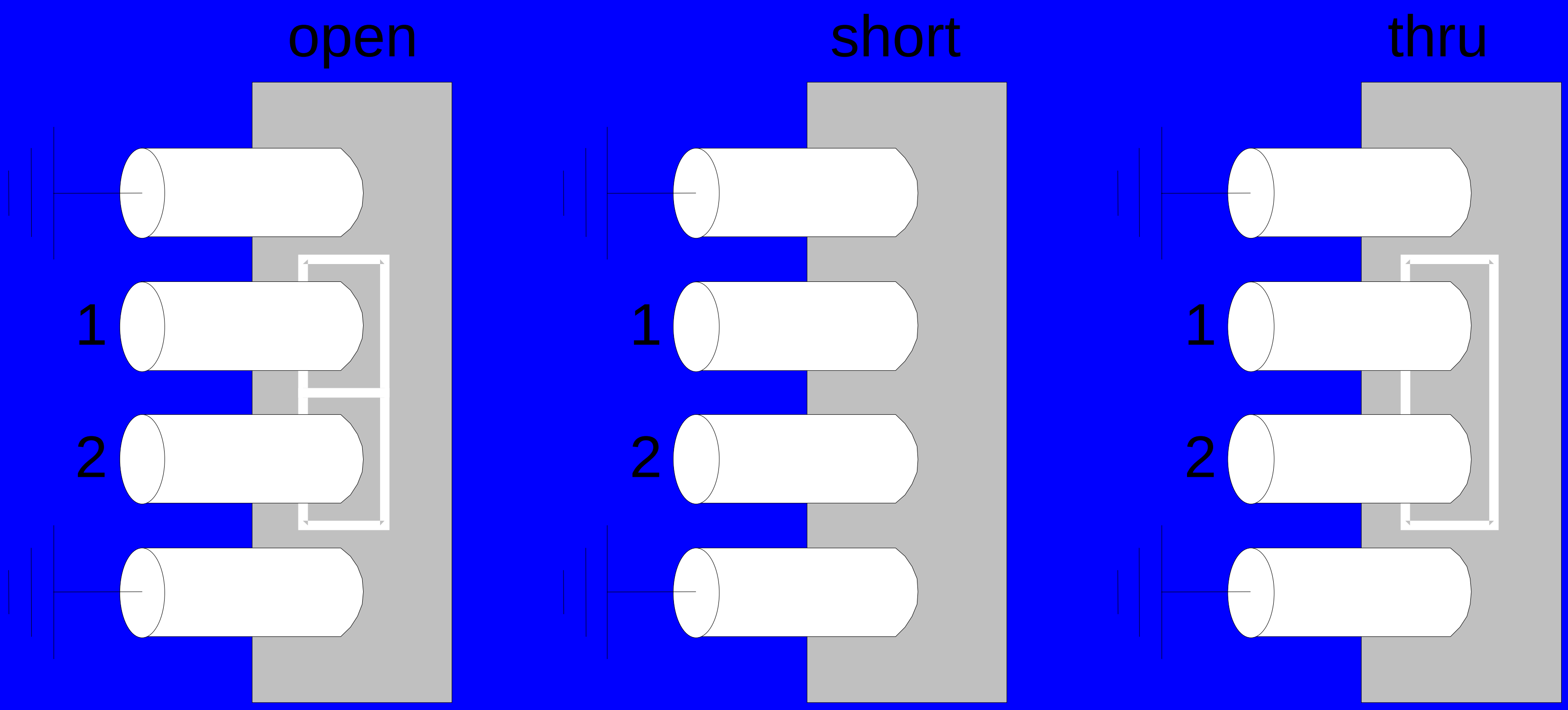




Analysis

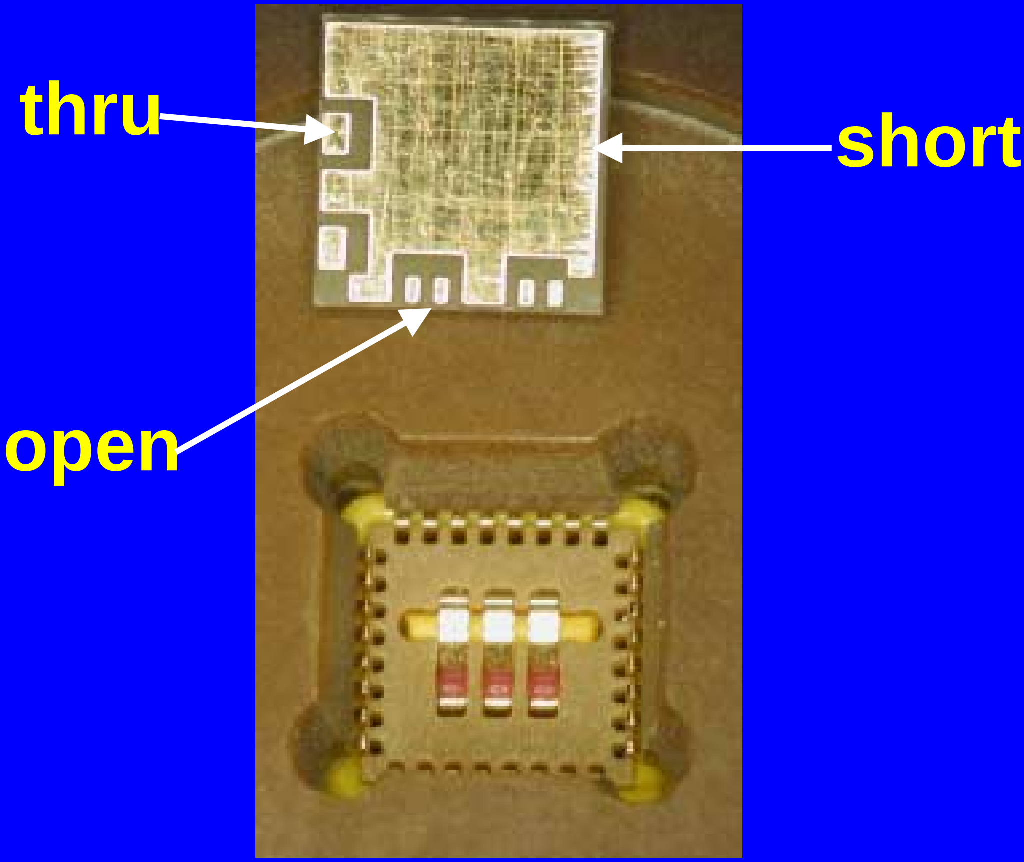
- Goal
  - ✓ Create an equivalent circuit model for two adjacent leads that predicts the measured S parameters
  - ✓ Use this verified, high bandwidth model for performance evaluation
- Strategy
  - ✓ Use measurements of open, short, thru topologies
  - ✓ De-embed the fixturing
  - ✓ Use simplest model for accurate, 10 GHz bandwidth
  - ✓ Use SPICE model of de-embedded contactor for performance simulation

Measurement Configurations



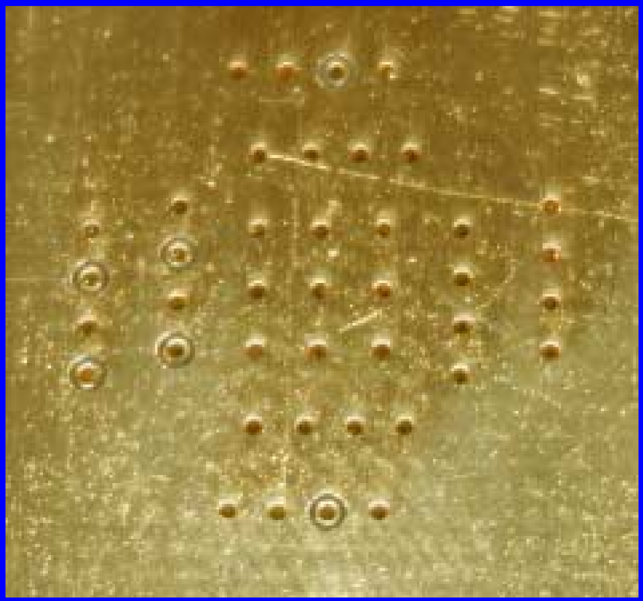
Surrogate Package:

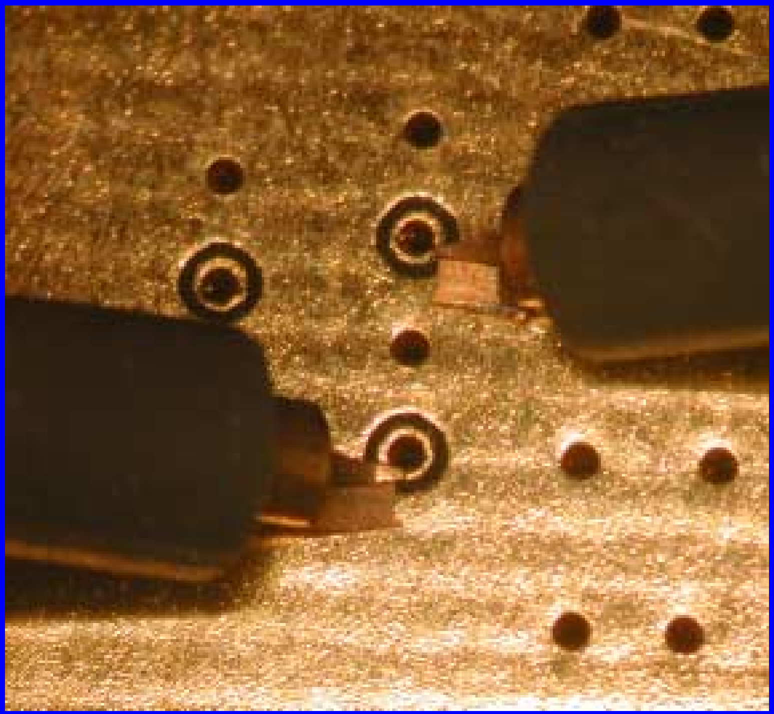
Enables configuring open, short, thru connections for edge and corner leads



Instrument Set Up

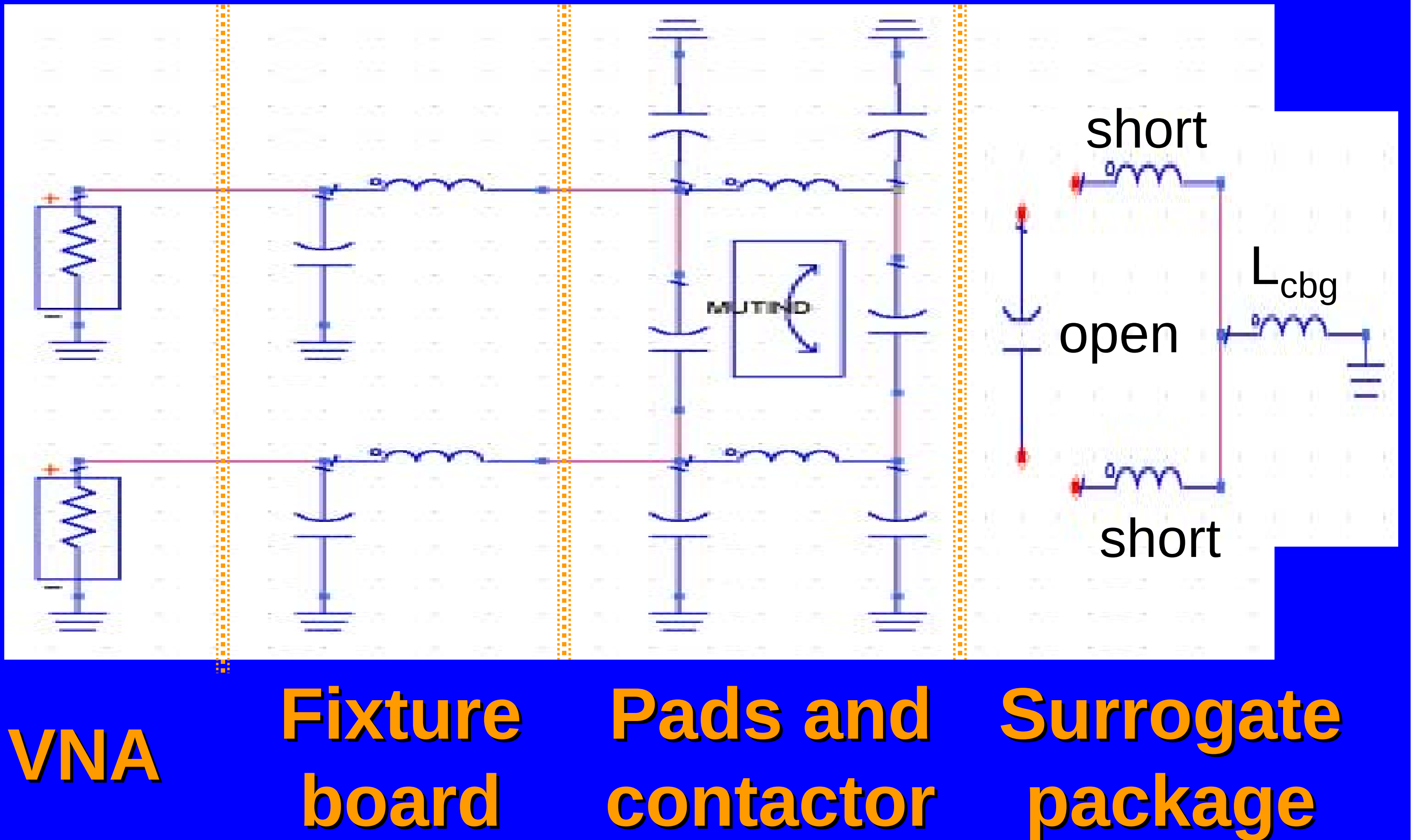
Probing From the Back Side





Probing using microprobes and a GigaTest Probe Station

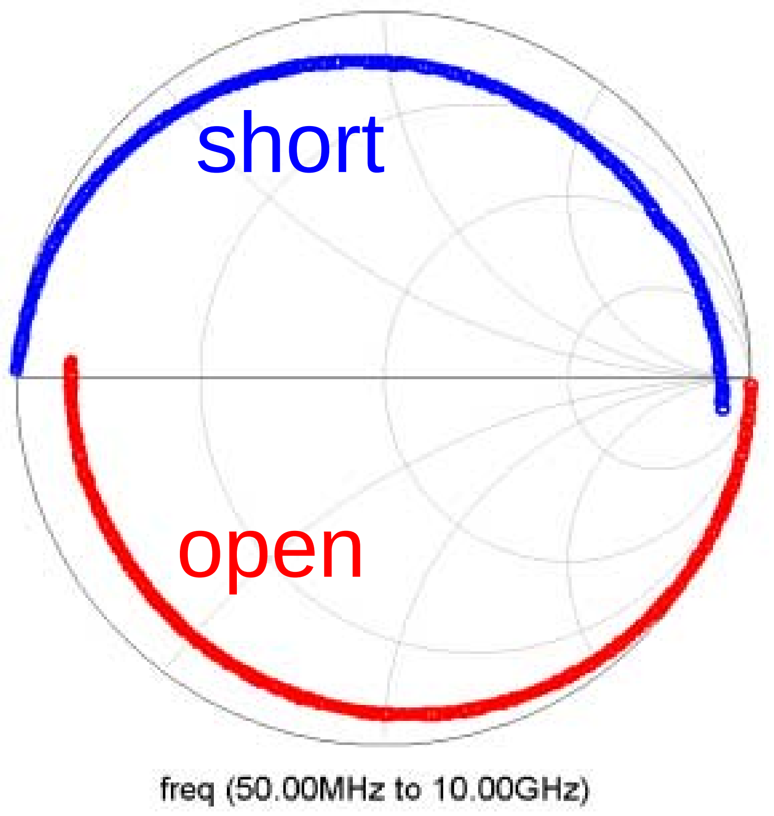
Modeling the System with Agilent ADS



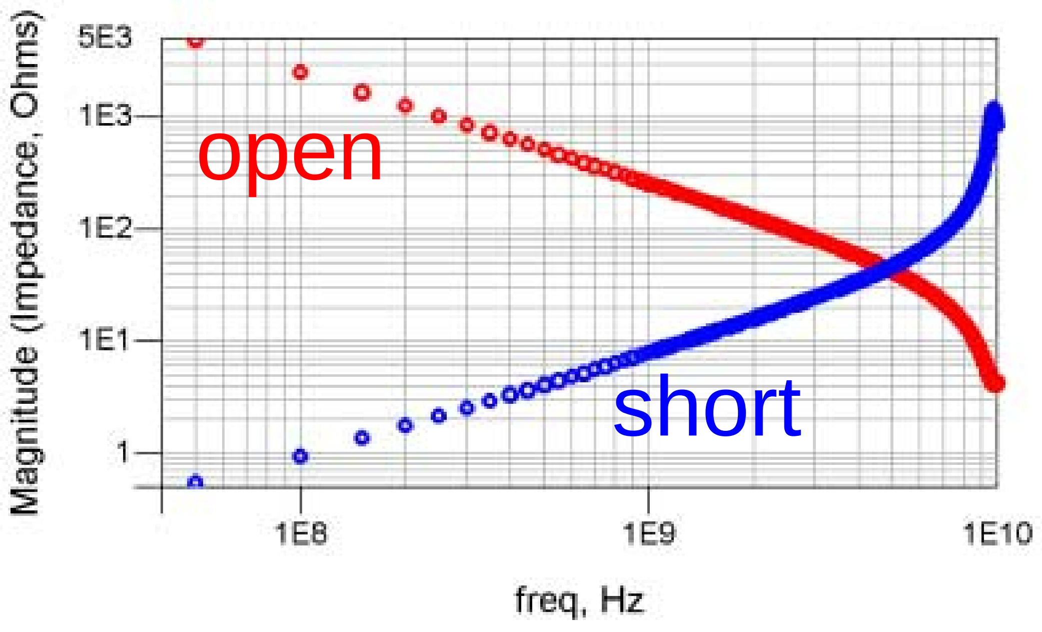
Methodology

- Measure S parameters of calibration vias in bare fixture board
- Extract model for just the fixture
- Select two adjacent corner leads (longest leads)
- Measure open, short, thru for the pair of leads
- Extract model of contactor pins and surrogate package
- Use de-embedded contactor circuit model to simulate performance

Corner Leads (worse case): Open/short Measurements

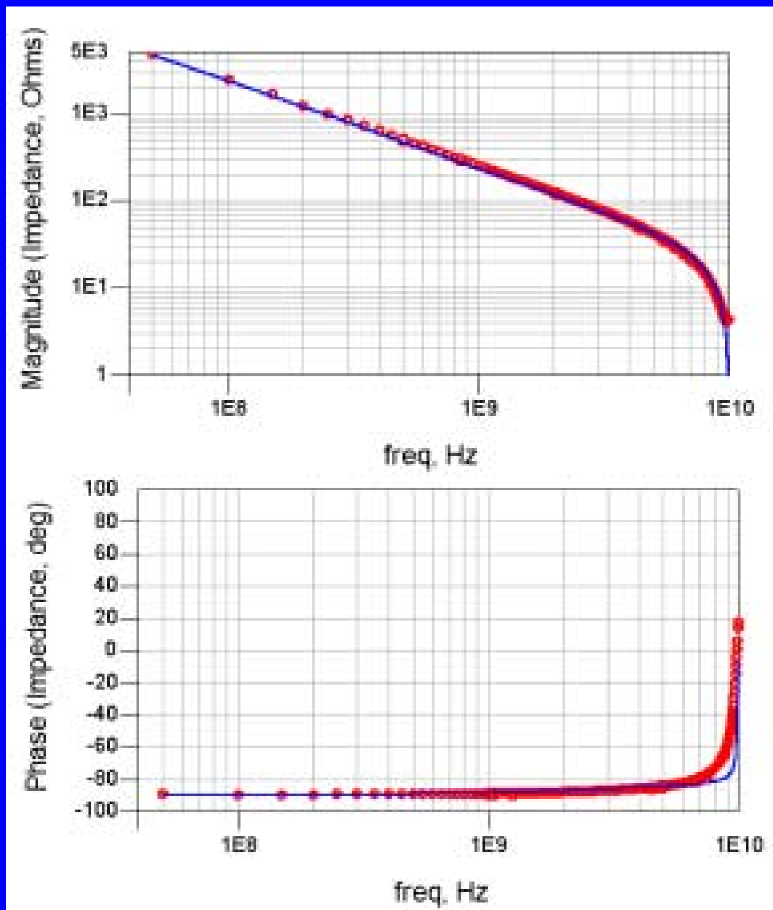


$$Z = 50\frac{1+S}{1-S}$$

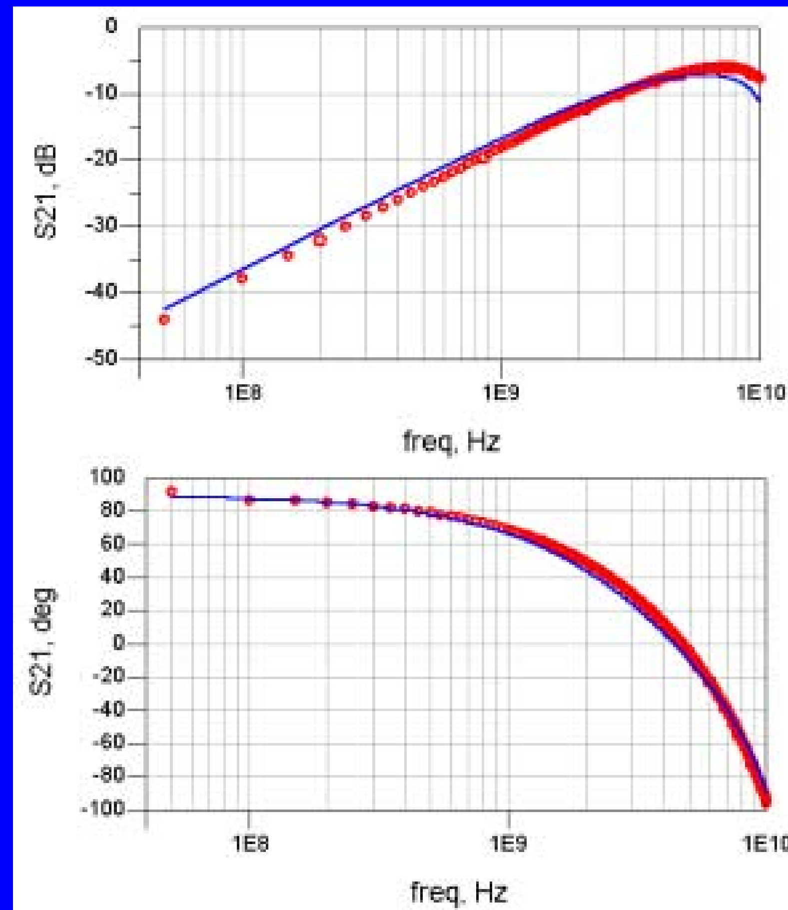


Optimized Model: Open

Impedance of one trace



Coupling between traces



Solid Line is Simulated

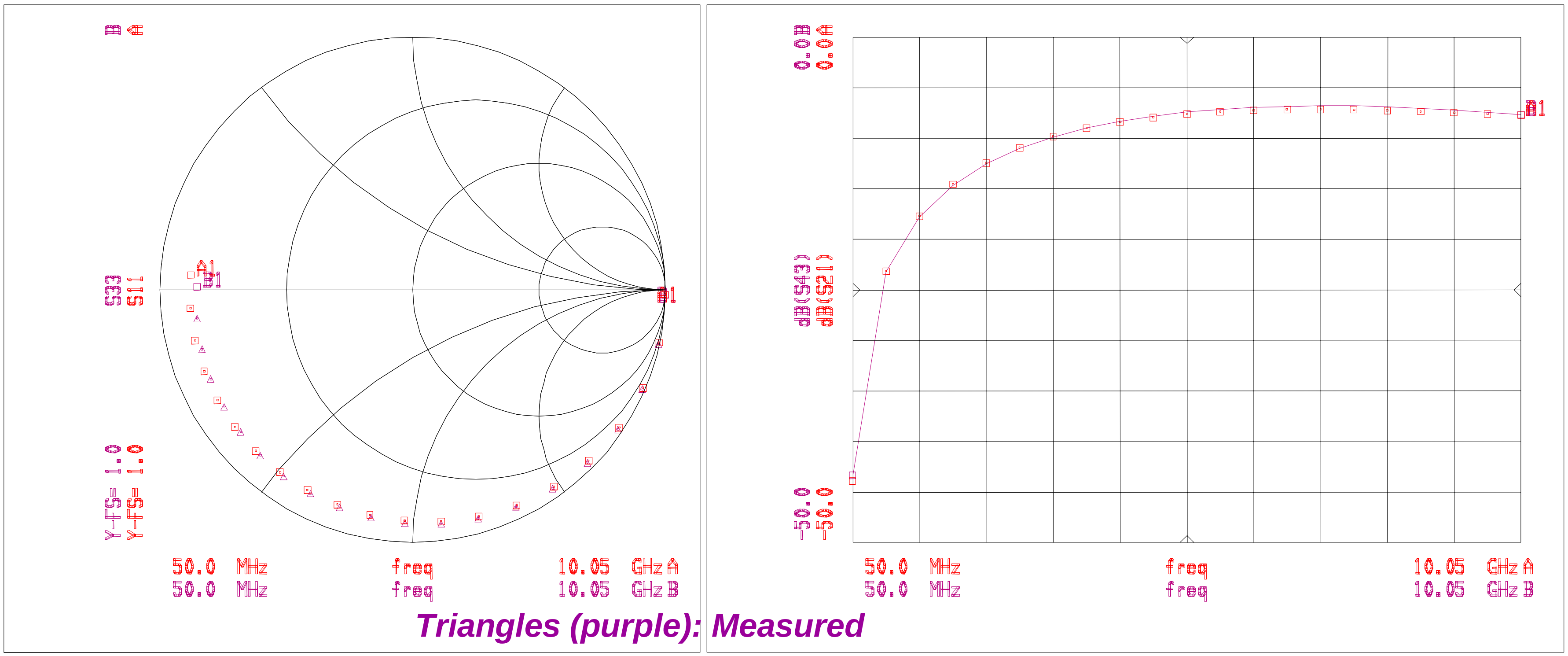
Johnstech™

GigaTest Labs

Optimized Model: Open

Reflection

Transmission

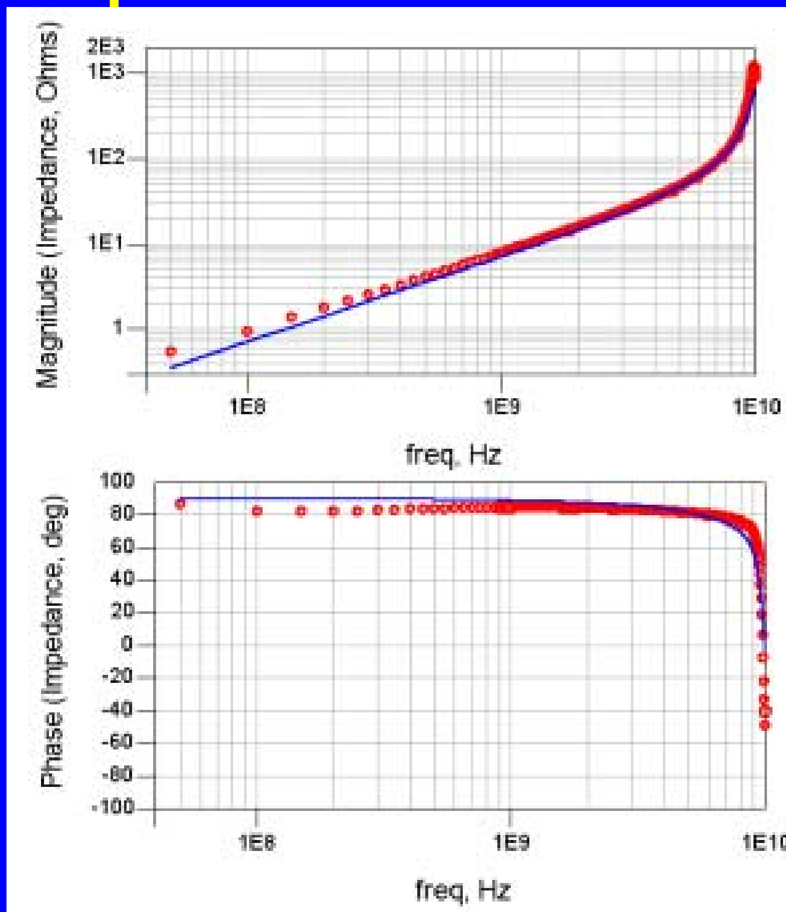


Triangles (purple): Measured

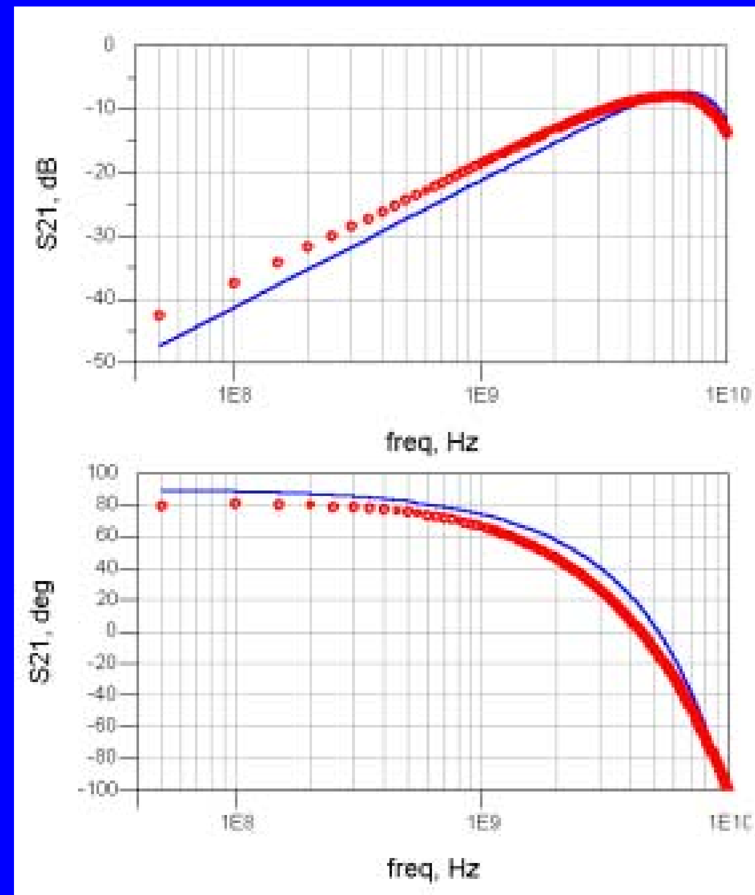
Open provides mutual capacitance info

Optimized Model: Short

Impedance of one trace



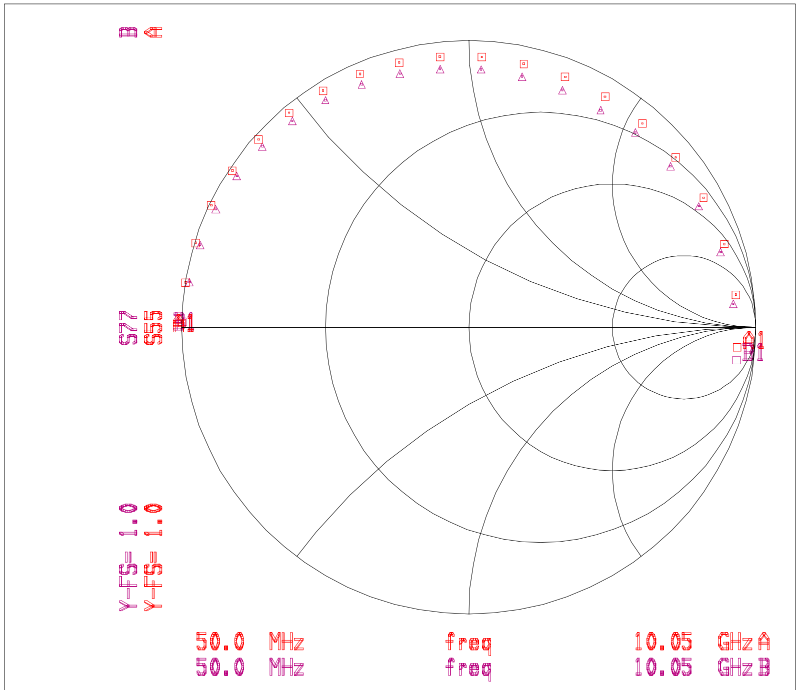
Coupling between traces



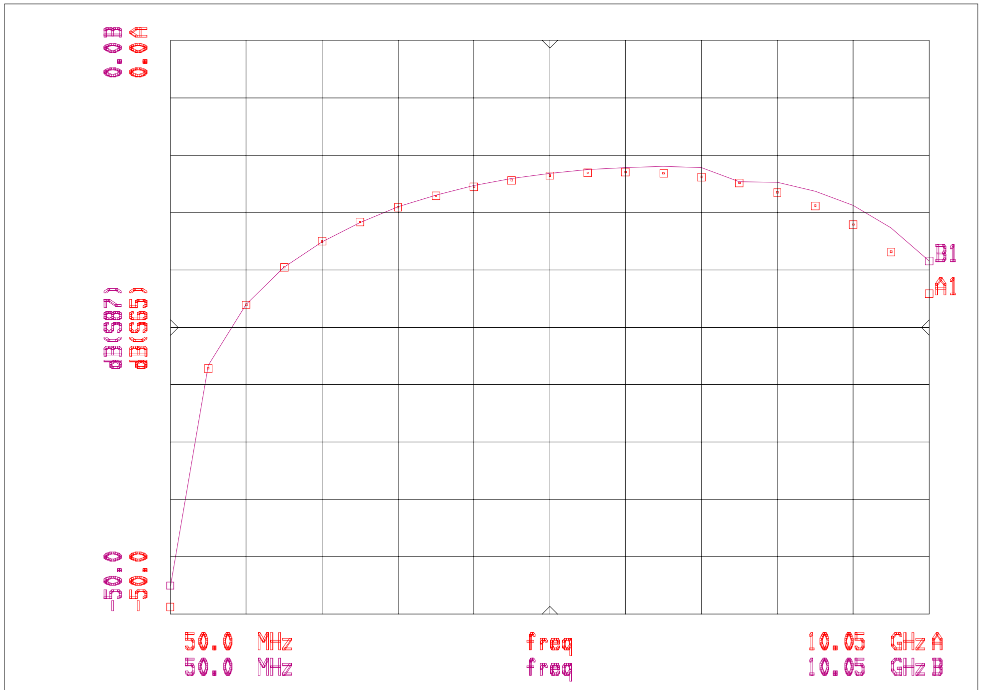
Solid Line is Simulated

Optimized Model: Short

Reflection



Transmission (coupling)

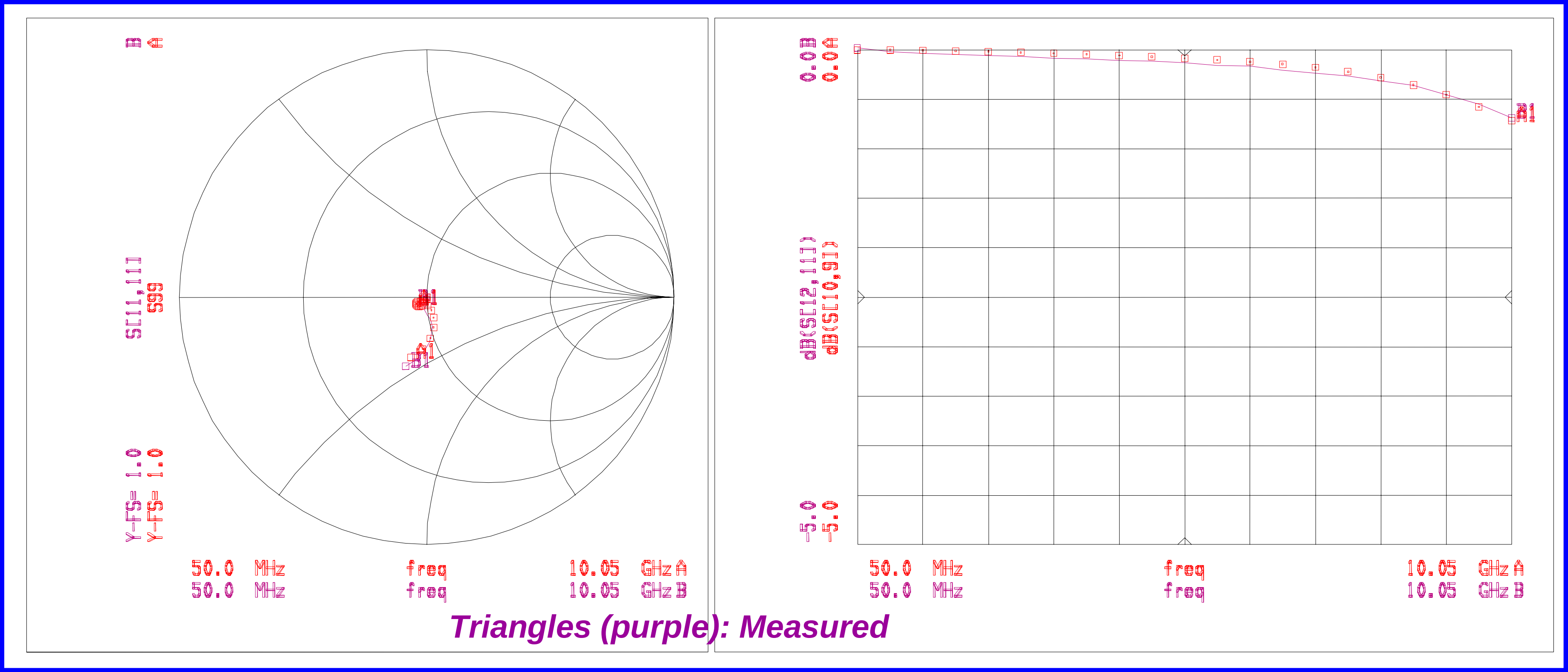


Triangles (purple): Measured

Short provides mutual inductance info

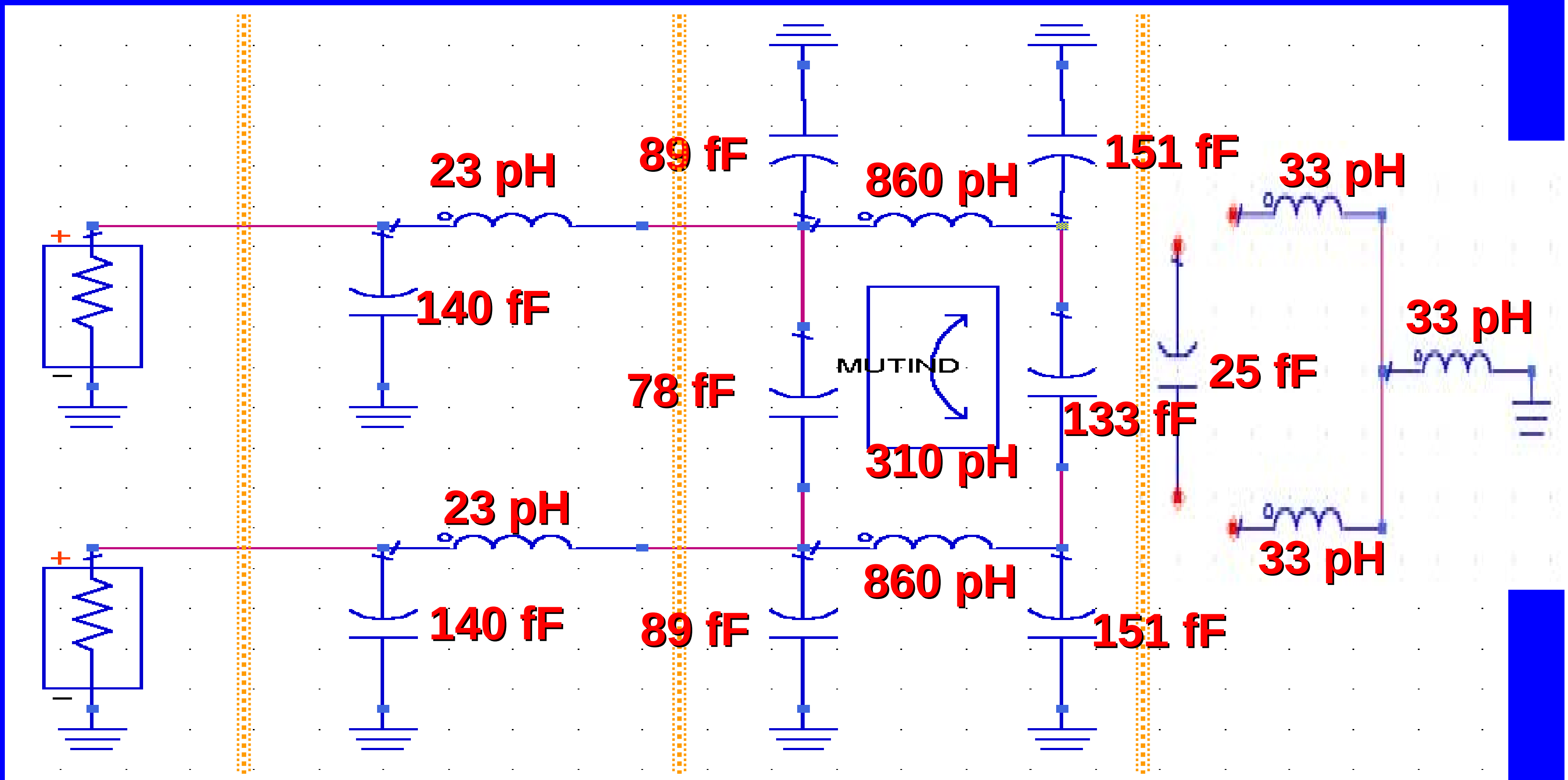
Optimized Model: Loop-Thru

Reflection / Transmission



Bandwidth of the model > 10 GHz

Summary of Extracted Parameters

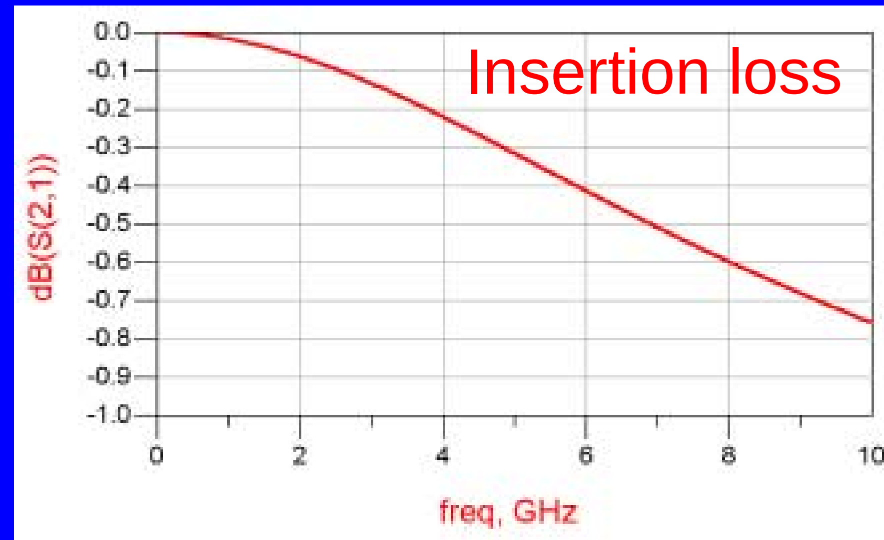


VNA Fixture Contactor Surrogate

Note: load board was not optimized for performance

Slide - 18

De-Embedded Insertion and Return Loss of Contactor

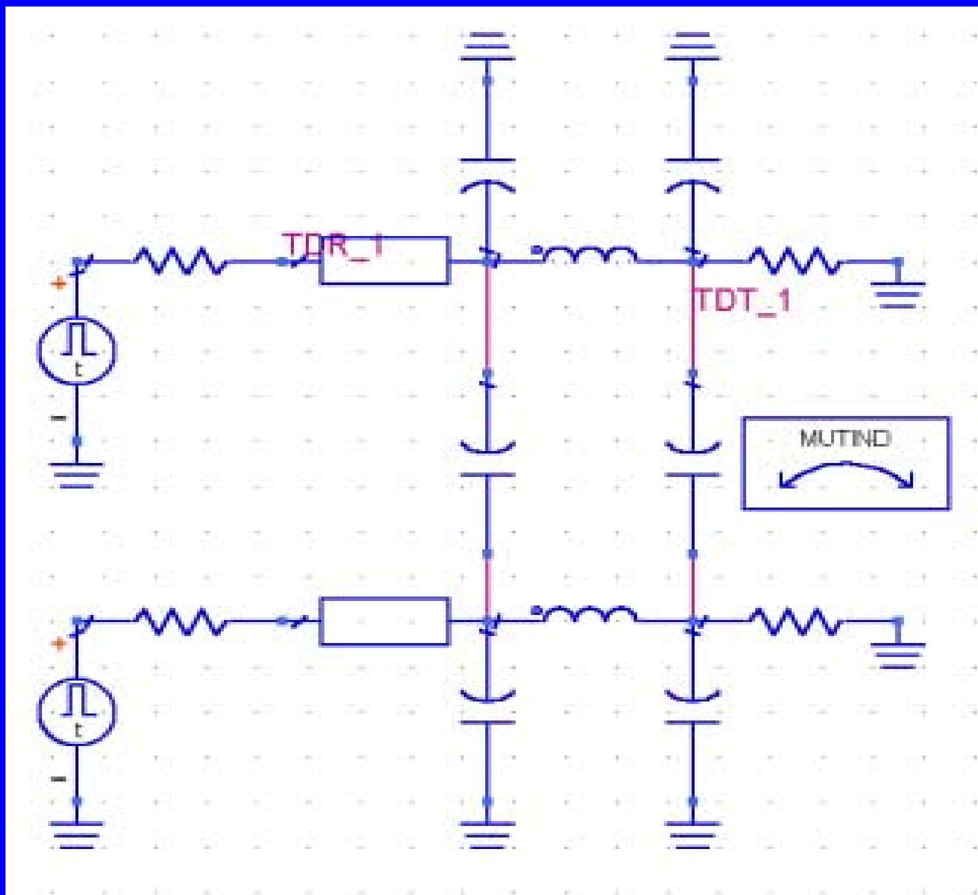


Meets specification:
< -20 dB, below 10 GHz

Meets specification:
> -1 dB, below 10 GHz

Note: load board is not optimized for performance, standard contactor - *not* enhanced contactor

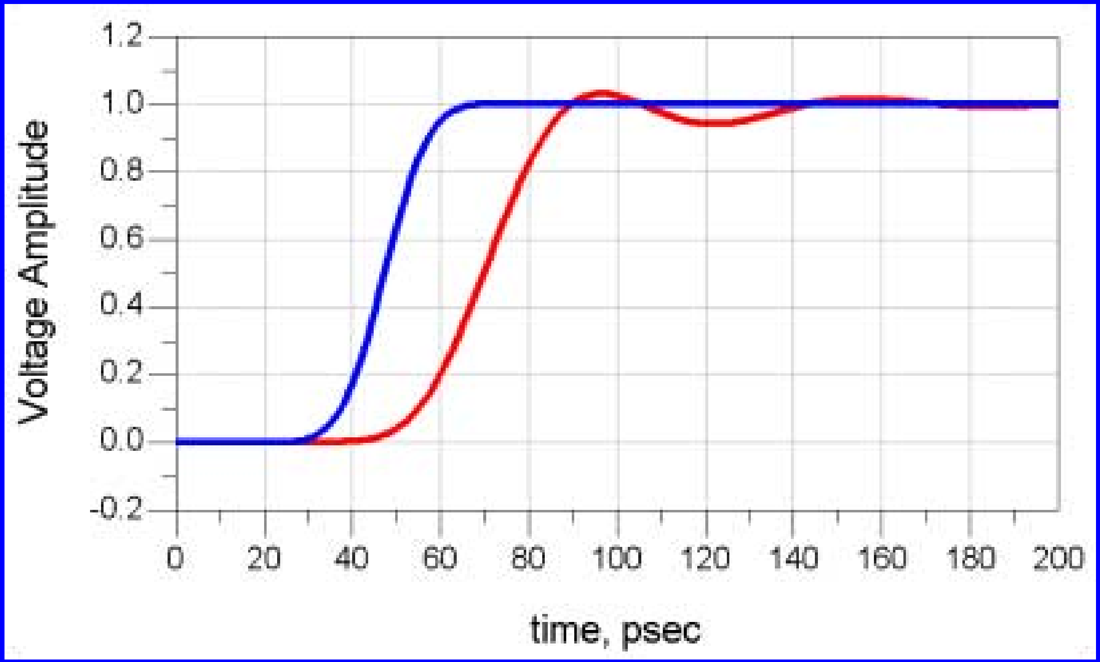
Transient Simulation Using De-embedded Contactor Model



Specs:

- ✓ De-embedded contactor model
- ✓ 20 psec rise time
- ✓ 50 Ω source, termination
- ✓ Differential drive

Transient Simulation with 20 psec Rise Time



- 20 psec input rise time
- 28 psec output rise time
- 20 psec intrinsic interconnect rise time (> 15 GHz bandwidth)
- 21 psec time delay

Note: load board is not optimized for performance, standard contactor - *not* enhanced contactor

Conclusions

- A contactor model can be de-embedded from S-parameter measurements
- A simple model matches measured data up to at least 10 GHz. (model could have more bandwidth)
- A model extracted from frequency domain measurements can be used in a transient simulation.

Force Measurement on Sockets and Contactors

2002 Burn-in and Test Socket Workshop
March 3 - 6, 2002

Presenter: **Richard Block**

Rafiq Hussain

BURN-IN & TEST SOCKET WORKSHOP

Agenda

- Force Issues in Test and Burn-In Env.
- Force Measurement Unit
- Experimentation & Test Data
- Conclusions
- Looking Forward

Force Issues in Test and Burn-In Env.

- Bent Pins / Deformed Balls
- Overdriving of Pogos
- Crack/Chipped Die or Pkg
- Pkg warping
- Force Distribution

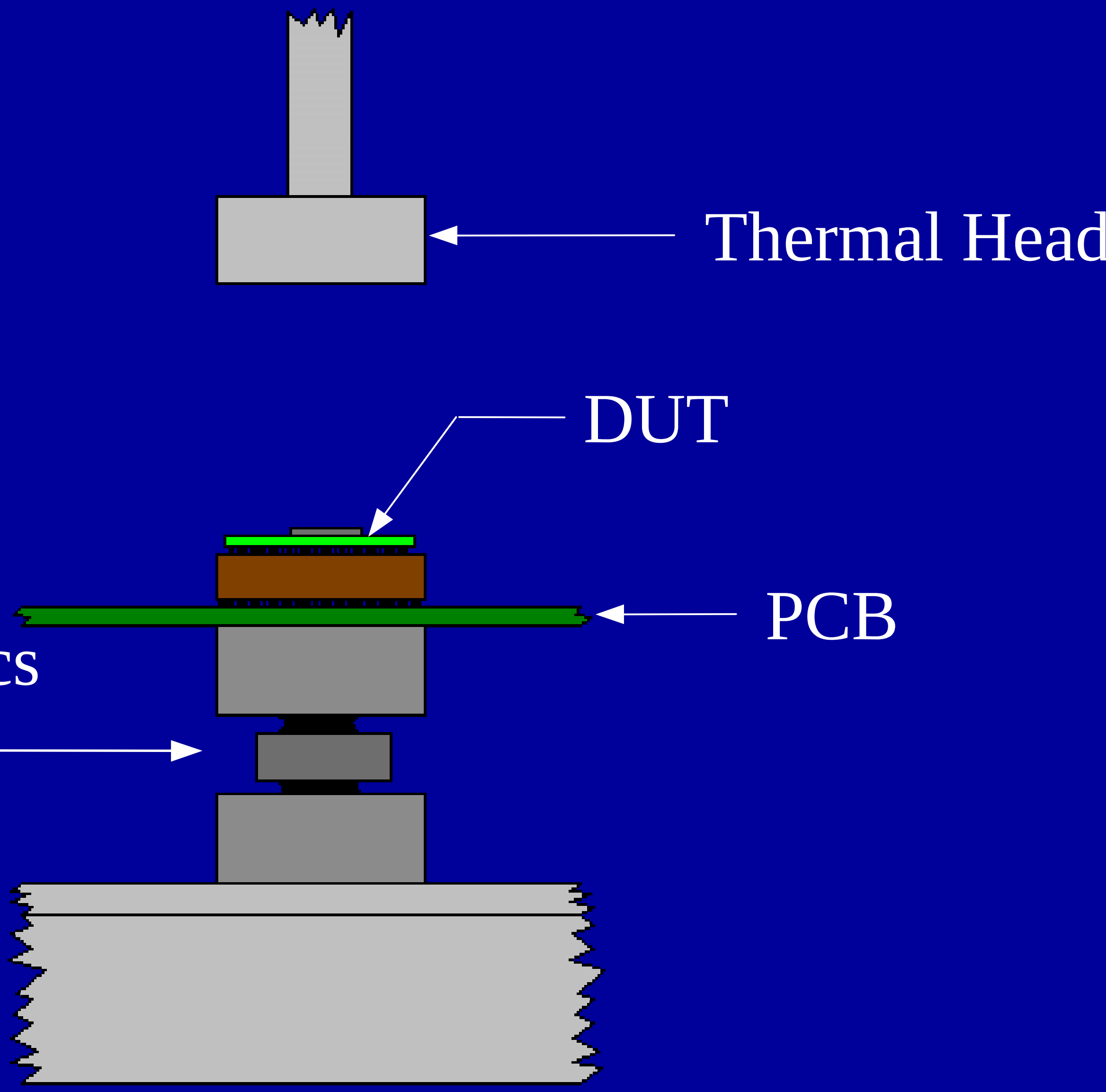
Force Measurement Unit

- Simple Design
  - 1 transducer
  - 2 spacers
  - 1 digital display (giving real-time force readouts to 0.1 lb accuracy)
- Location
  - Replaced support under PCB and Socket

FMU consists of 3 pcs

2 spacers

1 transducer



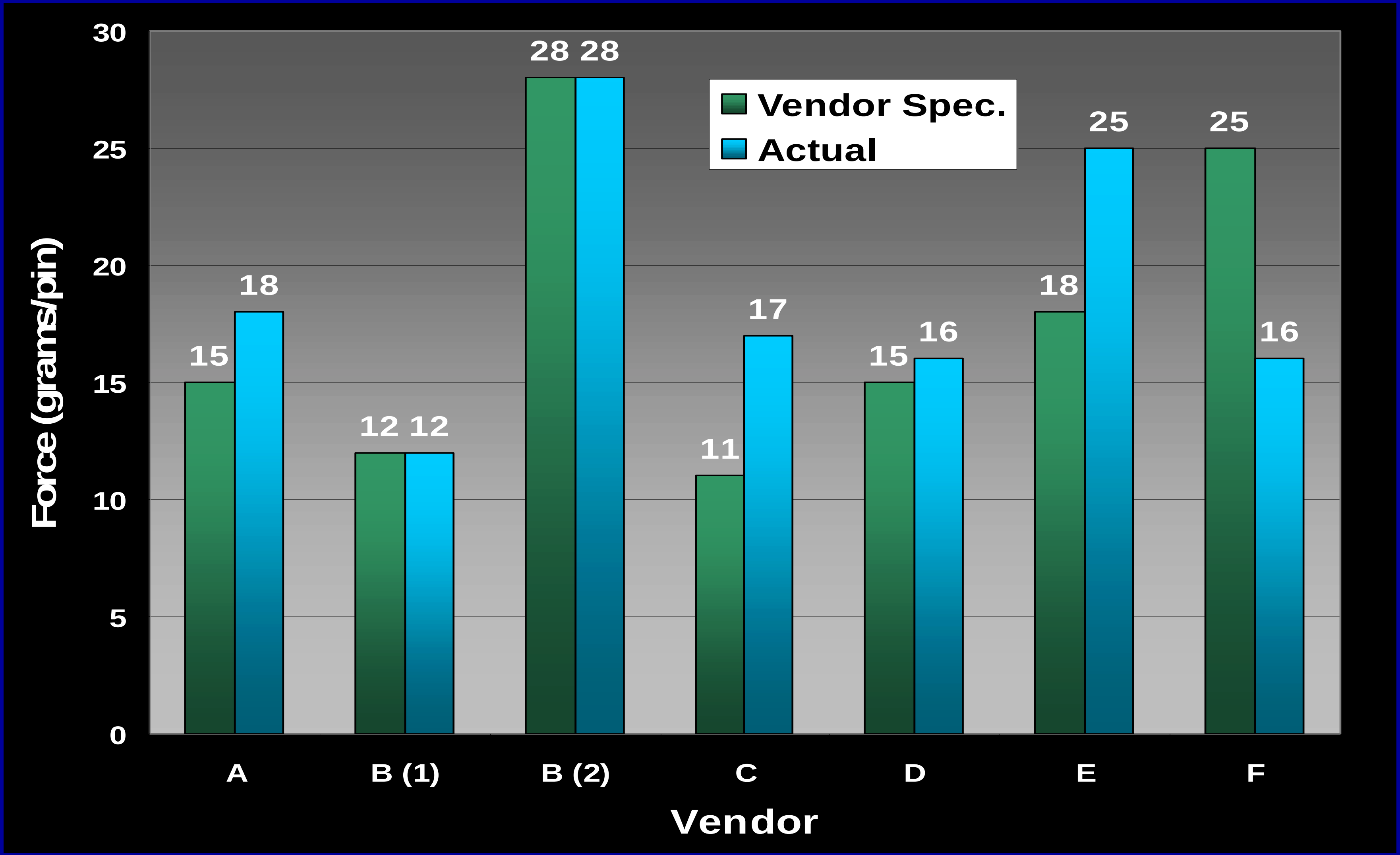
Board Deflection

- Motherboard deflection was necessary for transducer to take measurements
  - Motherboard was 62 mils thick
  - Transducer max deflection was 3 mils for 250lbs
  - Deflection did not create any noticeable error in force readout
    - 2 lb, 5 lb, and 10 lb weights were used for confirmation

Experimentation

- FMU was used for various validations
  - First Experiment
  - Actual force (g/pin) vs. Vendors Spec (g/pin)
    - LLCR measurements were taken at various forces
      - Passing tests consisted of "no opens pins"
    - Both Shorted and Thermal Vehicle pkgs were used

Actual Force vs. Vendor Spec



Experimentation cont.

- FMU was used for various validations
  - Second Experiment
  - Insertion study to find optimal force vs. Pogo life
    - First run:
      - 100,000 insertions were made at ideal force first experiment
      - LLCR measurements were taken periodically to see if resistance values increased
    - Second run:
      - 100,000 insertions at different force
      - LLCR measurements were compared to first run

Insertion Life vs. Force

Vendor	Insertions	ave ohms
A	Low	22.02
18 g/p	25 k	22.04
	50 k	22.10
	75 k	22.09
B (1)	Low	23.11
12 g/p	25 k	23.27
	50 k	22.93
	75 k	22.68
C	Low	22.82
17 g/p	40 k	22.04
	80 k	22.16

Vendor	Insertions	ave ohms
D	Low	23.37
16 g/p	25 k	22.75
	50 k	22.70
	75 k	22.57
E	Low	22.24
25 g/p	25k	22.10
	50k	22.34
	75k	22.30
	96 k	22.14
F	Low	22.25
16 g/p	25 k	22.47
	50 k	22.30
	75 k	22.38

Insertion Life vs. Force cont.

- Insertions were done at a greater force then first series of insertions.
  - ~3 to 4 g/p depending on initial required force
- Vendor D had pin failures at this higher force

Vendor	Insertions	ave ohms
B (1)		
	Low	23.11
15 g/p	30 k	23.41
	50 k	23.21
	70 k	23.21
D		
	Low	22.57
19 g/p	25 k	22.73
	40 k	22.40
E		
	Low	22.24
28 g/p	25k	26.67
	75k	26.35

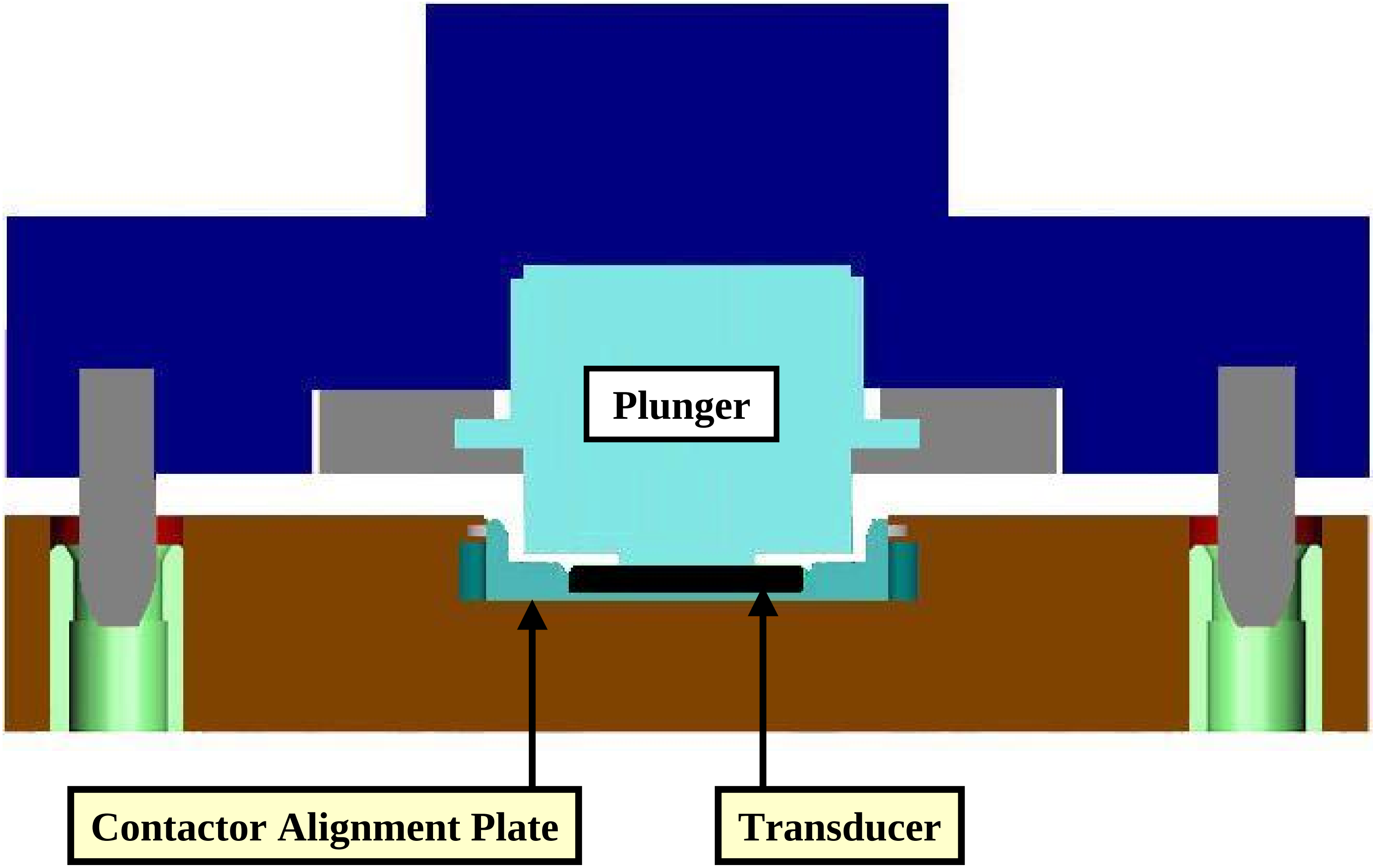
Conclusions

- Insight into vendors tolerance control and machining ability
- Confirmation of test forces on DUT with reaction forces based on complete test setup, not individual pieces tested separately
- More accurate qualification for compression based sockets

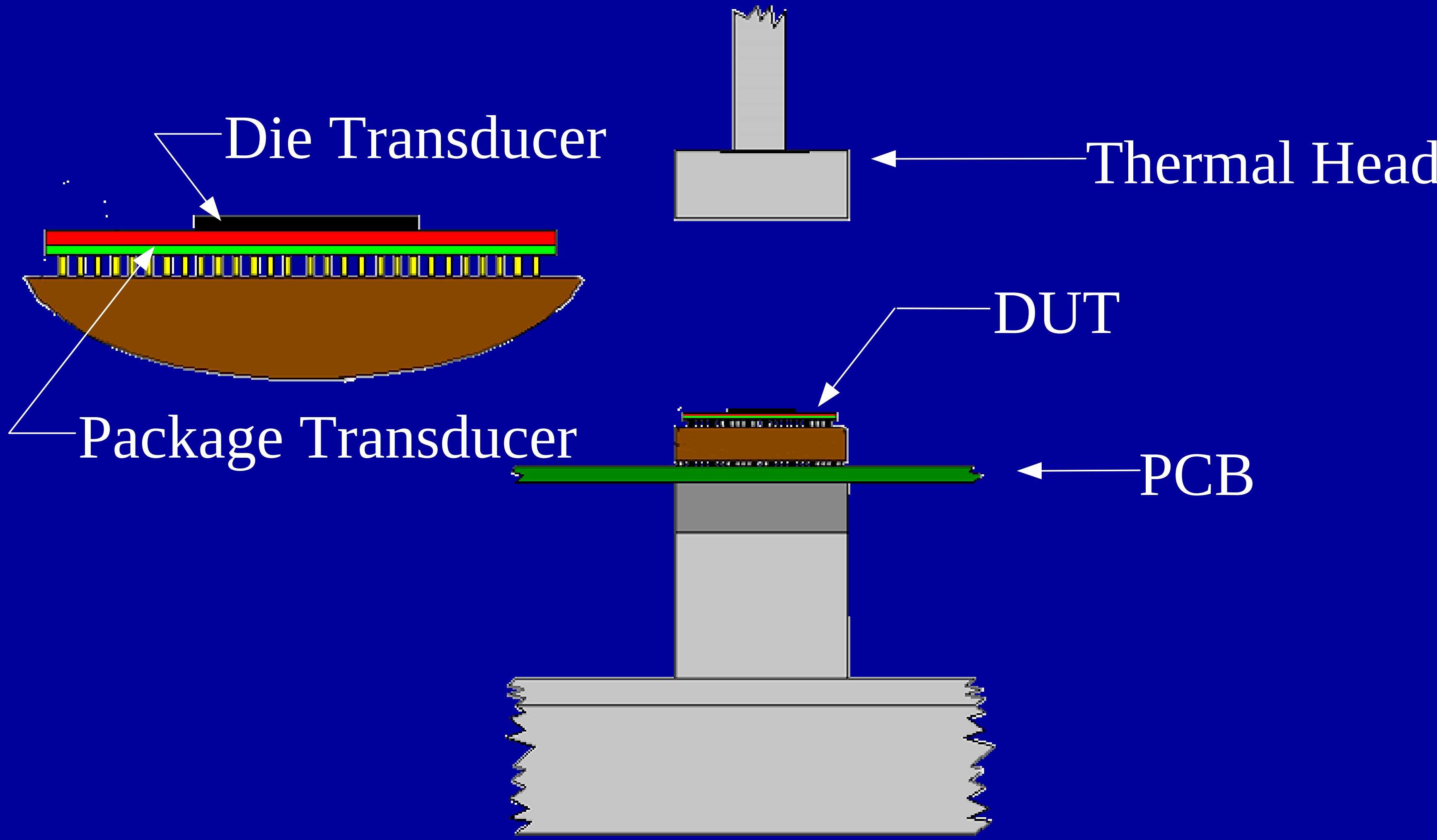
Looking Forward

- Die size Transducers
- Force variation across die/pkg

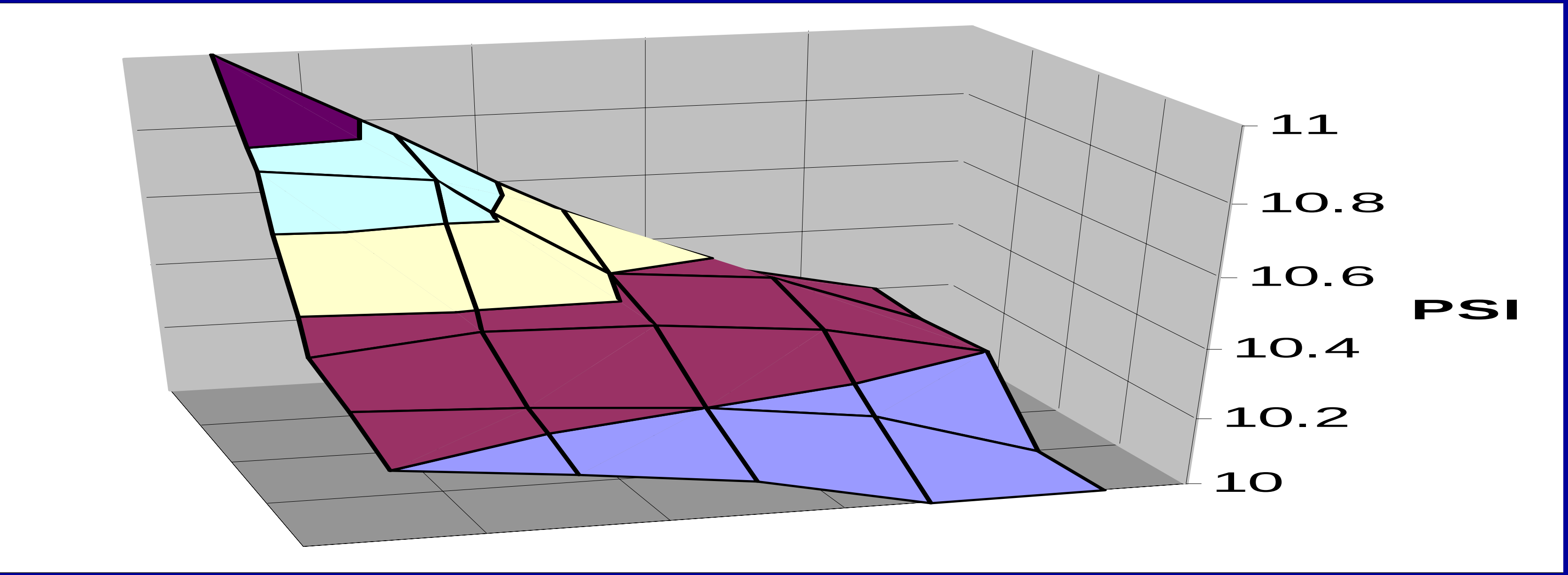
Transducer for Handlers Example



Package/Die Transducer Example



Distribution of Force over Die/Pkg Example



- Check Force across die surface
  - Check flatness of thermal head
  - Check that socket is level