FIFTEENTH ANNUAL BiTS 2014
Burn-in & Test Strategies Workshop

# Session 5

## Tuesday 3/11/14 1:30pm

## SOCKETS WITH INTEGRITY

High frequency signal and power integrity with sockets are essential to successful package testing. The opening presenter shares first-hand experience pairing the design of a high-speed load board with sockets of the desired bandwidth to avoid significantly reduced system performance. The second paper assesses power and ground performance through an examination of signal and power routings and the corresponding ground return paths for a PCB/socket combination. The next presenter looks at how ever shrinking devices with more functionality and higher density I/Os bring sensitive signal lines closer together, contributing to signal integrity issues. The paper closing this session discusses the impact on test hardware with the high-speed digital device world's leap to 28 Gbps Serdes. The presenter will describe what worked at 10 Gbps, what still works for 28 Gbps, and what might be changed and/or optimized to reach test speeds of 28 Gbps.

### High Bandwidth Sockets For SERDES Applications On ATE Load Boards
Don Thompson—R&D Altanova

### Signal and Power Integrity Impact of Ground Slugs in Sockets
Gert Hohenwarter—GateWave Northern, Inc.

This Paper

### Building Blocks and Predictors for Good Contactor Signal Integrity
Jeff Sherry—Johnstech International

# Building Blocks and Predictors for Good Contactor Signal Integrity

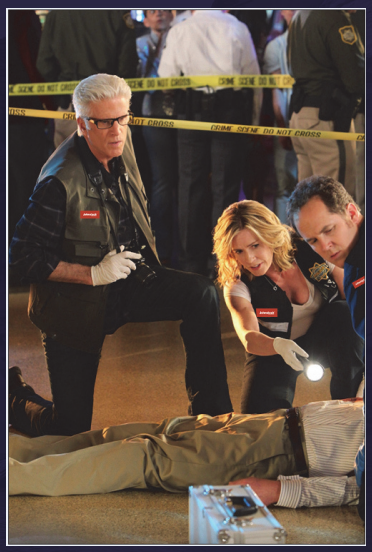
Jeff Sherry
Johnstech International

2014 BiTS Workshop
March 9 - 12, 2014

Johnstech®

## Consult. Analyze. Identify. Solve.

*Getting to the Heart of the Matter with a CSI Approach*



## Agenda

- BGA structure / HFSS model
- Via structure for internal I/O
- RF performance of Edge vs. Field connections
- Ground effects relative to RF location
- Importance of system approach
- Summary



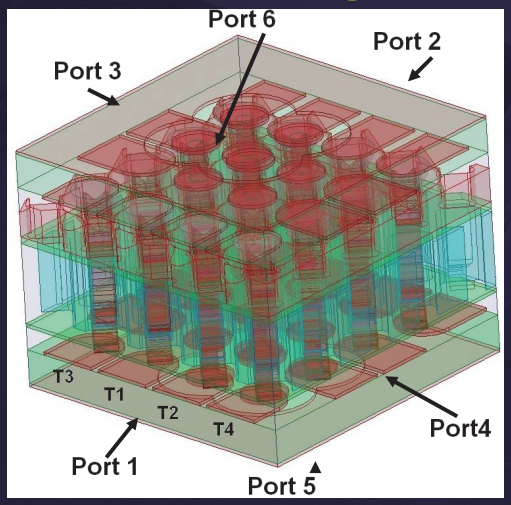
## The Crime Scene

- Engineer has performance problem with internal RF signals
- Device different configuration than test data of contactor
- Device has limited I/O availability

# Consult

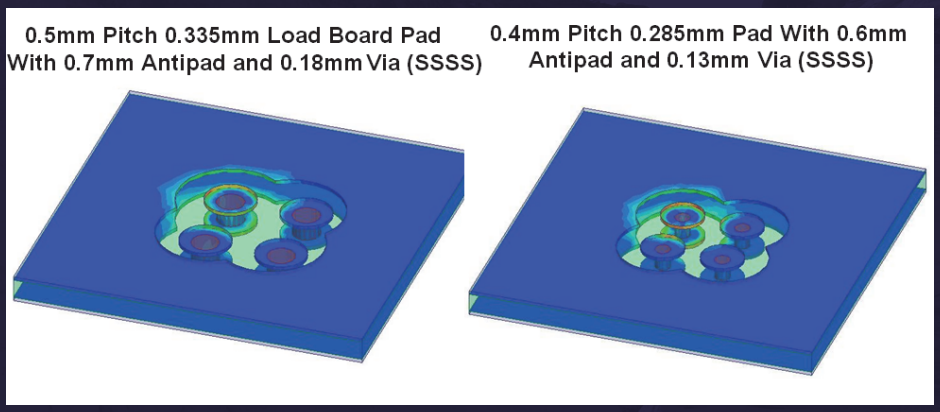


## 0.5mm Pitch Contactor for 4x4 Array - BGA Packaged Device




Layout of device has big impact of contactor performance.

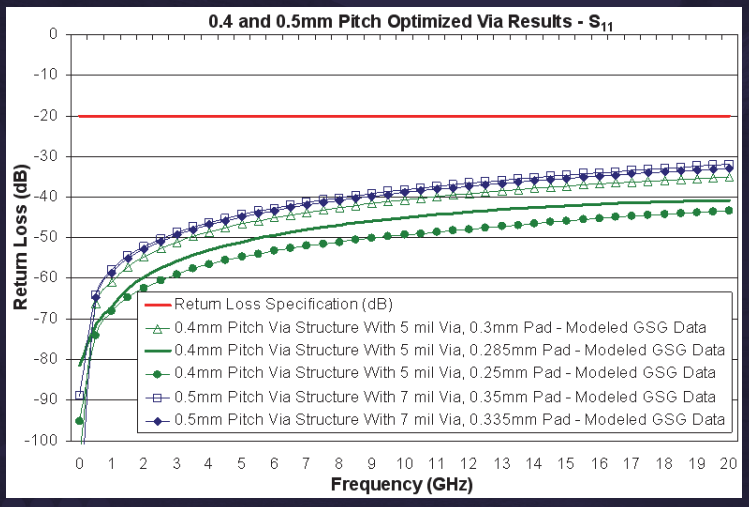
# 0.4 and 0.5mm Pitch Optimized Via E-Field Response




Smaller the pitch the more coupled load board pads become.

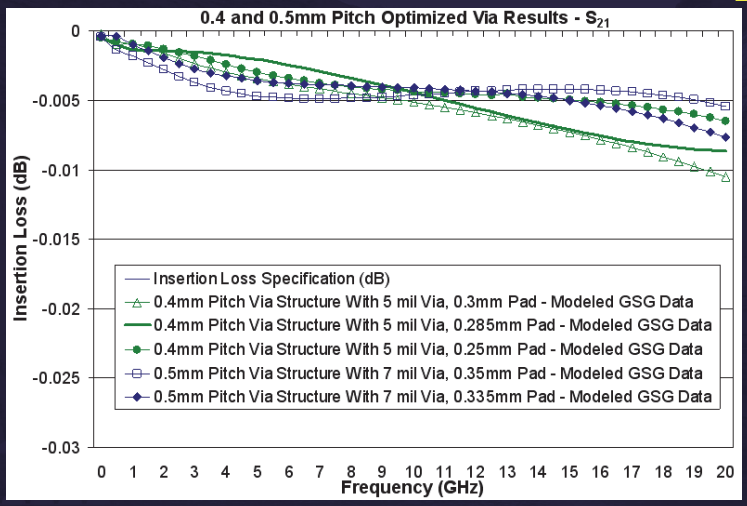


# 0.4 and 0.5mm Pitch Optimized Board Ground Via Return Loss – $S_{11}$




Closer via pad gets to via size the better the match.

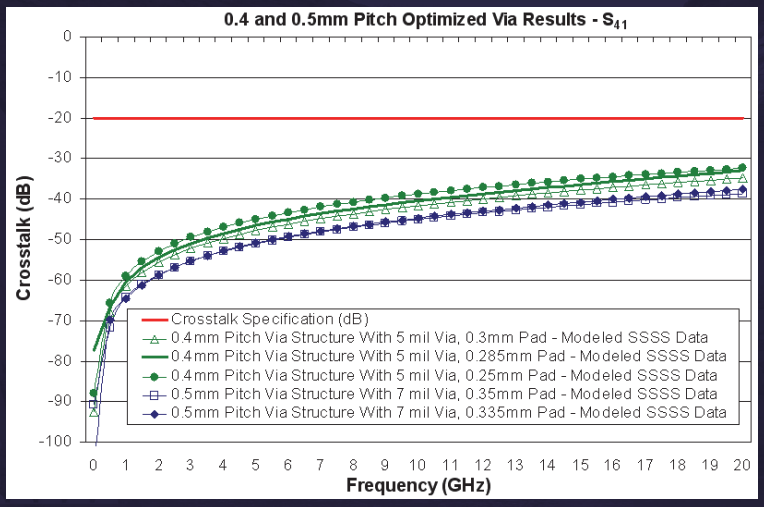
# 0.4 and 0.5mm Pitch Optimized Board Ground Via Insertion Loss – $S_{21}$




Good via match results in very little signal loss.



# 0.4 and 0.5mm Pitch Optimized Board Ground Via Insertion Loss – $S_{41}$




Better the match the better the Crosstalk.

## Array 50 Ohm Via Interface for Different Pitch BGA Devices

- 0.5mm Pitch BGA Device
  - Pad = 0.335mm, Antipad = 0.70mm, 7 mil via
- 0.4mm Pitch BGA Device
  - Pad = 0.285mm, Antipad = 0.60mm, 5 mil via
- 0.3mm Pitch BGA Device
  - Pad = 0.217mm, Antipad = 0.46mm, 3 mil via
- 0.2mm Pitch BGA Device
  - Pad = 0.1575mm, Antipad = 0.35mm, 2 mil via

Packaged Devices

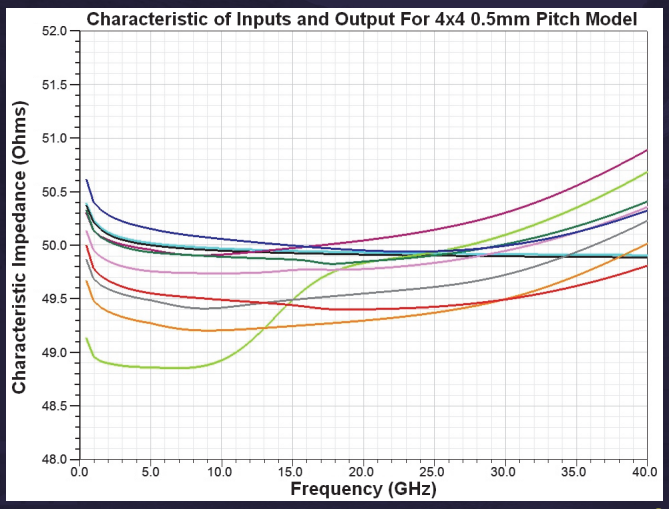
WLCSP

Smaller the Pitch -> Processes/testing needs to change



## Analyze

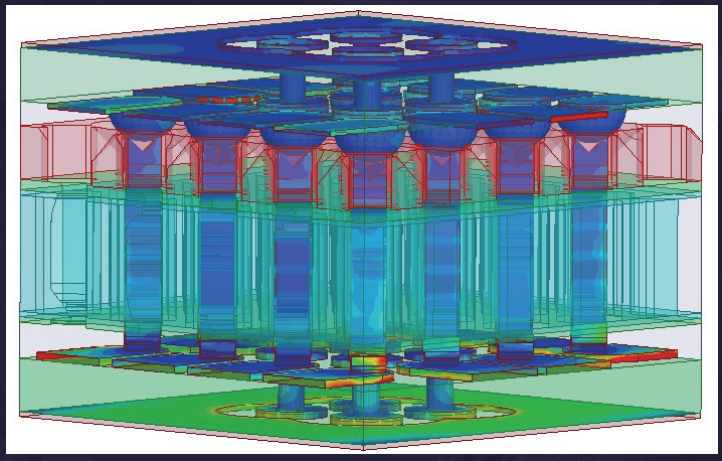
## Characteristic Impedance of 4x4 BGA Array (Inputs and Outputs)




Well matched input and output yields actual response of Contactor.

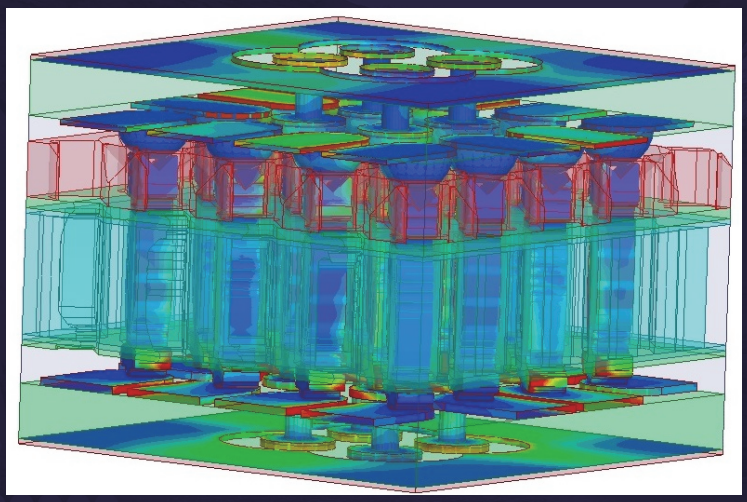


## E-Field Plot of 4x4 BGA Array – SSSS Configuration



One signal on at a time results in lack of E-Fields.

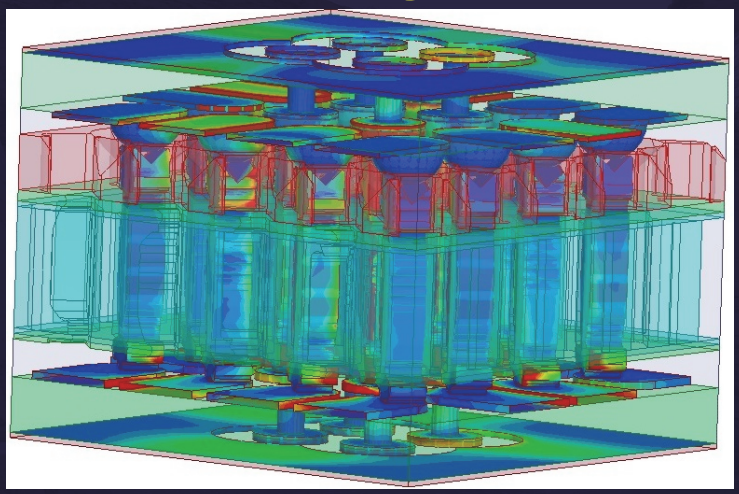
## E-Field Plot of 4x4 BGA Array – GSSG Configuration



More signals on, results in more crosstalk.



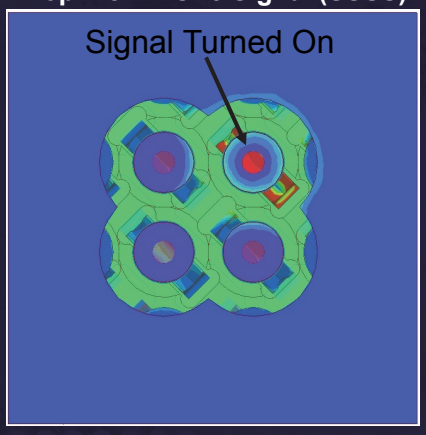
## E-Field Plot of 4x4 BGA Array – GSG Configuration



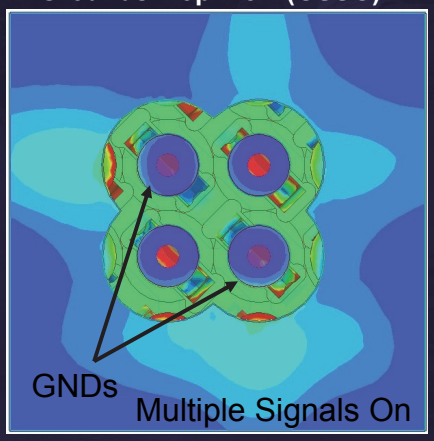
More grounds results in lower crosstalk between signal pins.

## 0.5mm Pitch E-Fields for 4x4 Array – All Signals vs. Differential

**0.5mm Pitch 4x4 Array With Signals Top View – One Signal (SSSS)**




**0.5mm Pitch 4x4 Array With Grounds Top View (GSSG)**

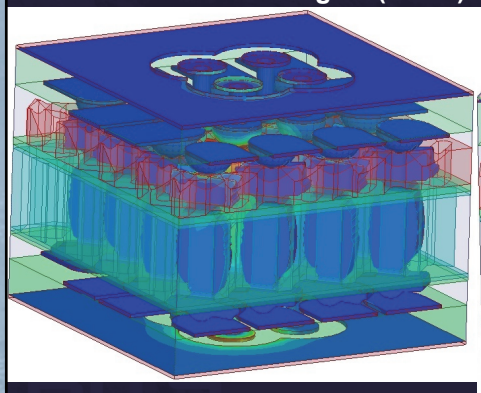



Different configurations result in different fields and crosstalk.

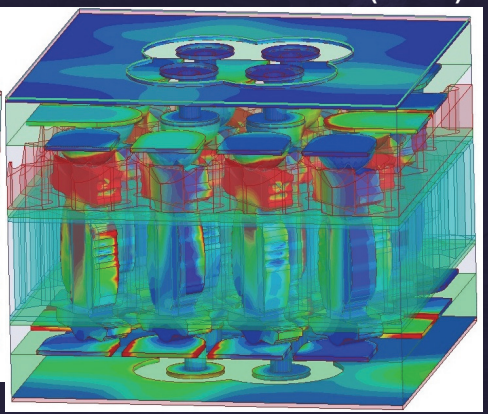


## 0.5mm Pitch E-Fields for 4x4 Array – All Signals vs. Differential

**0.5mm Pitch 4x4 Array With Signals Isometric View – One Signal (SSSS)**

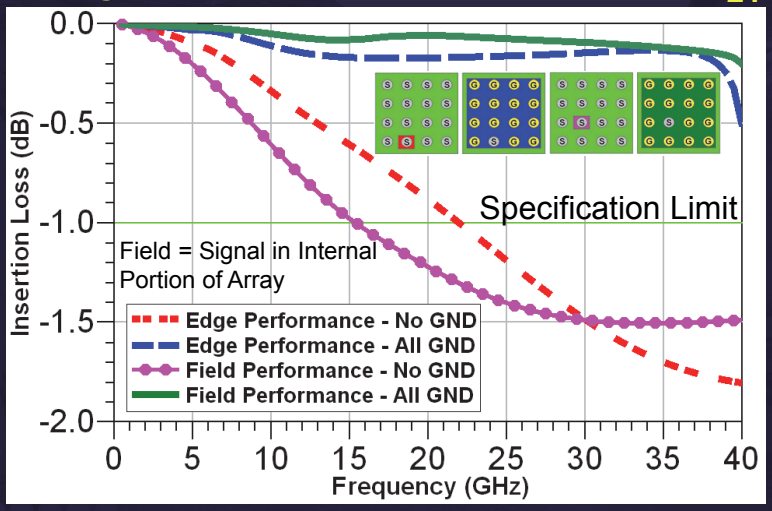


**0.5mm Pitch 4x4 Array With Grounds Isometric View (GSSG)**



More signals on at same time results in more crosstalk

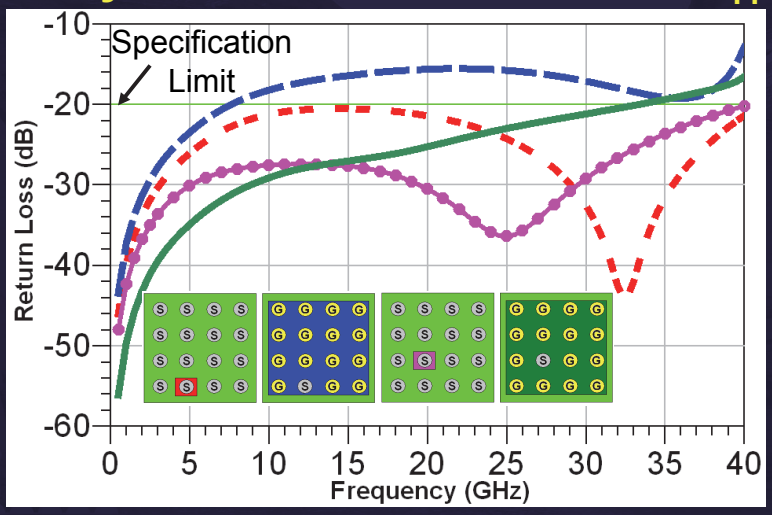
## 0.5mm Pitch Array Performance for 4x4 Array – Best vs. Worst Case – $S_{21}$




Higher the test frequency the more important grounds are!



## 0.5mm Pitch Array Performance for 4x4 Array – Best vs. Worst Case – $S_{11}$




Return Loss in general degrades the higher the frequency.

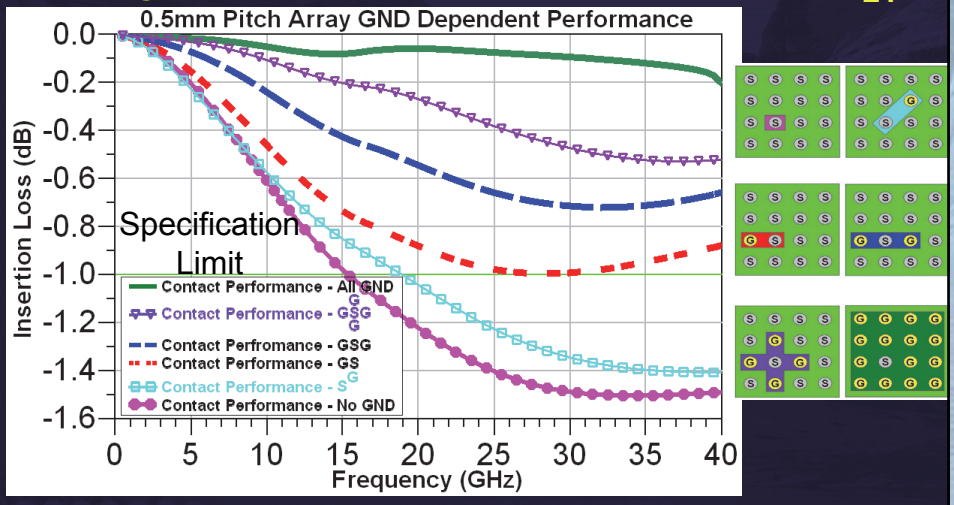
# Identify

## The Suspects:

- Load Board
- Contactor
- Device/Chip

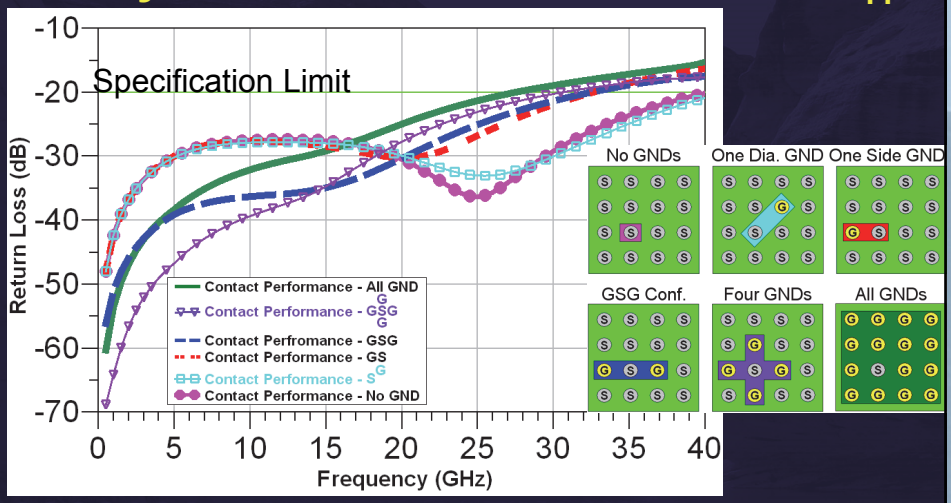


## 0.5mm Pitch Array Performance for 4x4 Array – Different GND Locations – $S_{21}$




More grounds close to RF signal the better the Insertion Loss.

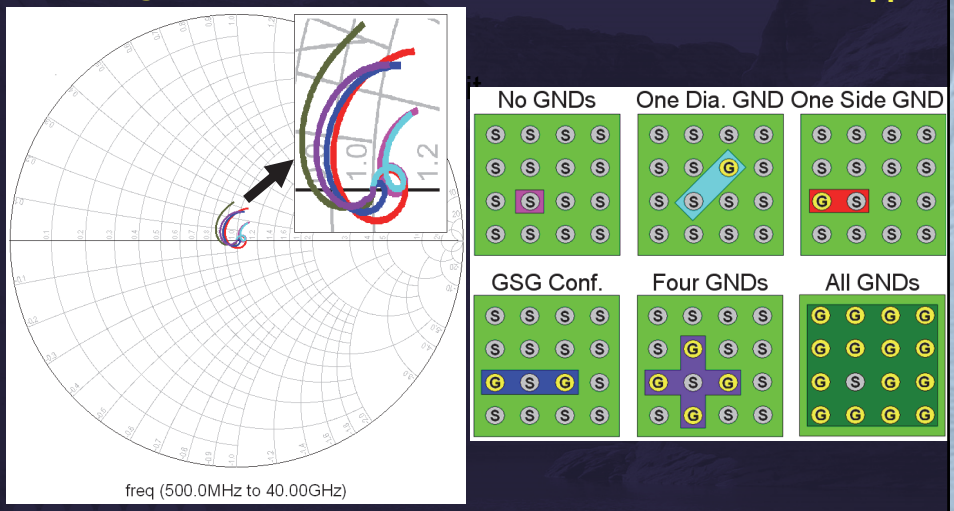
## 0.5mm Pitch Array Performance for 4x4 Array – Different GND Locations – $S_{11}$




Fewer grounds results in a reactive part and a dip in Return Loss.

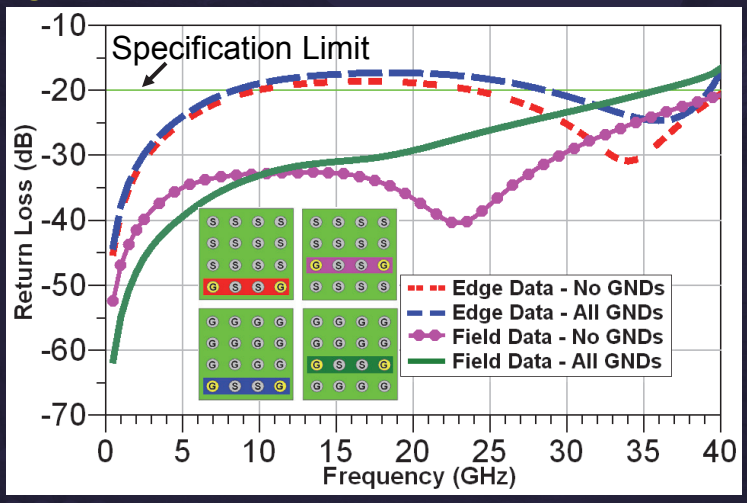


## 0.5mm Pitch Array Performance for 4x4 Array – Different GND Locations – $S_{11}$




Fewer grounds results in a reactive part and a dip in Return Loss.

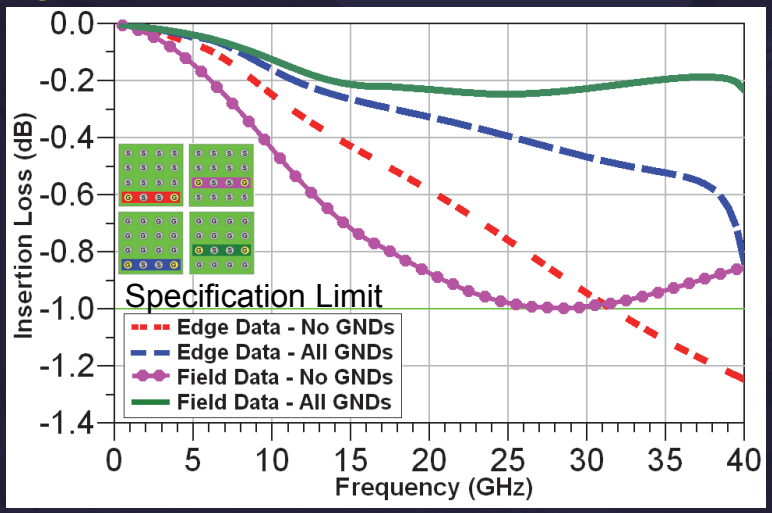
## 0.5mm Pitch Array Performance for 4x4 Array – Different GSSG Locations – $S_{11}$




Location of signals have effect on RF performance.

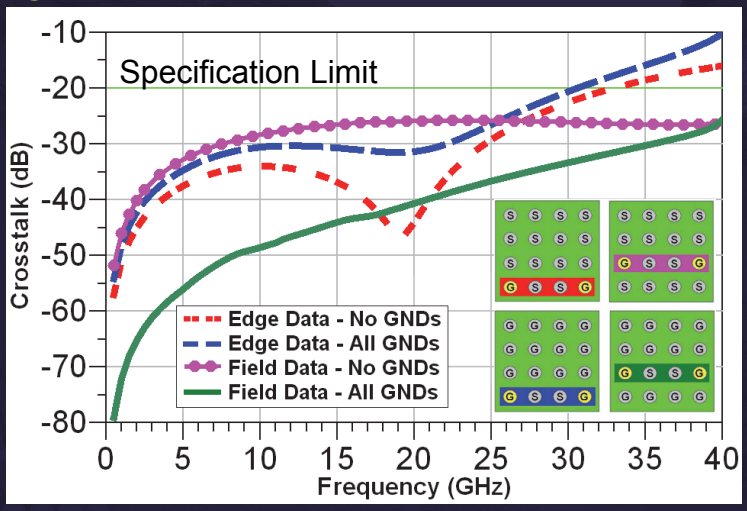


## 0.5mm Pitch Array Performance for 4x4 Array – Different GSSG Locations – $S_{21}$




More grounds surrounding signals improves Insertion loss.

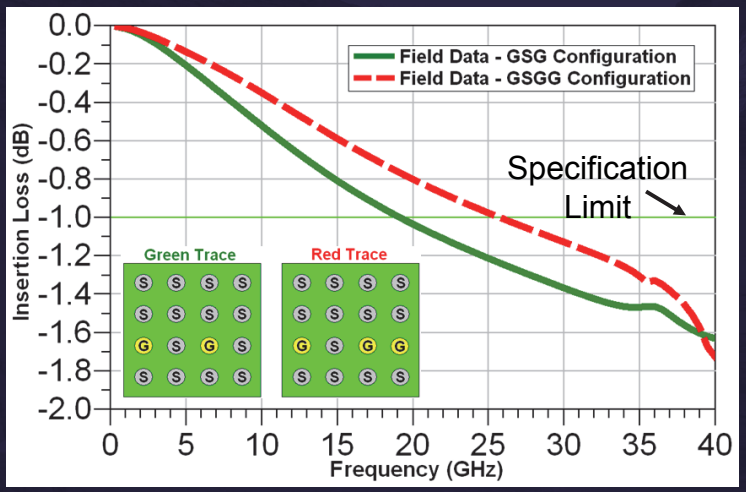
## 0.5mm Pitch Array Performance for 4x4 Array – Different GSSG Locations – $S_{41}$




Locations of grounds lead to large differences in Return Loss

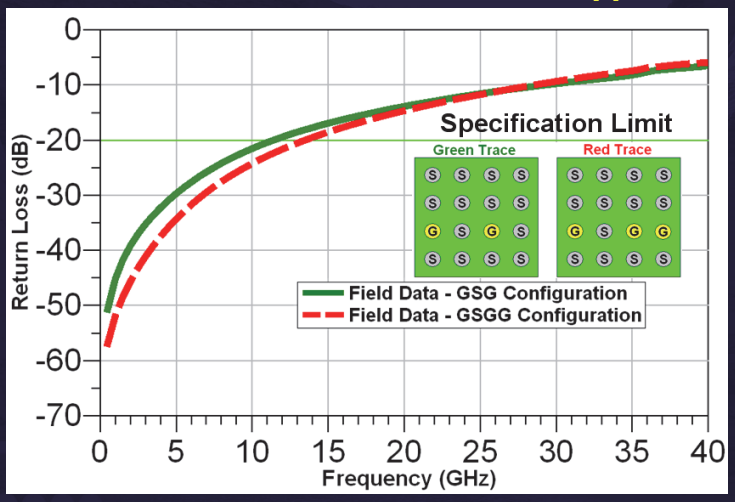


## Array Performance for 4x4 Array – GSG vs. GSGG – $S_{21}$




Closest ground has most impact to RF signal Insertion Loss

## Array Performance for 4x4 Array – GSG vs. GSGG – $S_{11}$

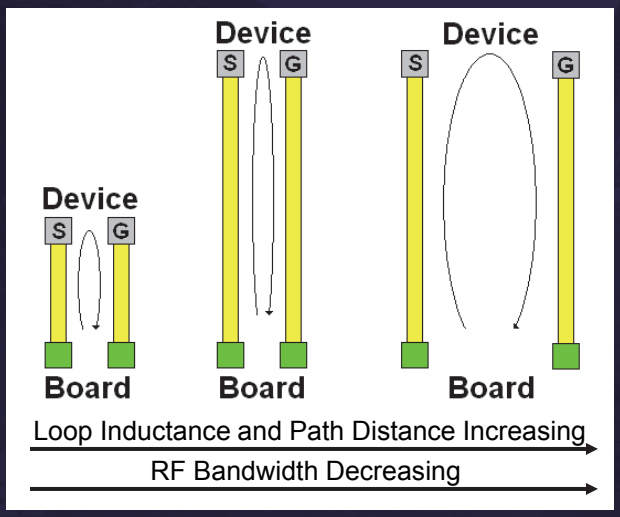



Farther away ground is to RF signal the less impact it has on data.



# Solve

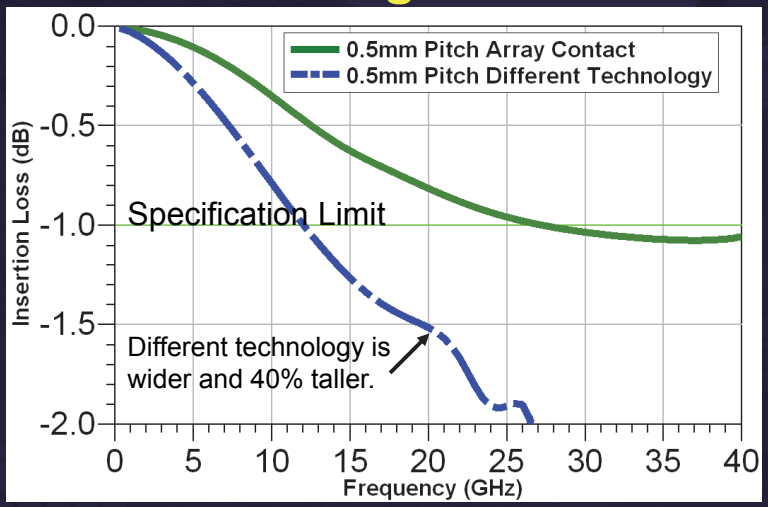
## Contact Length and Pitch vs. Bandwidth




Not all test solutions or conditions are the same!

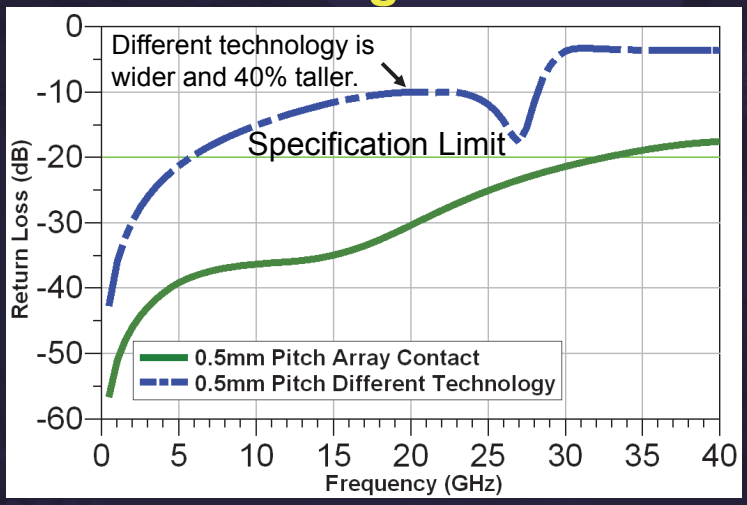


## Comparison of Same Configurations With Different Height Contacts – $S_{21}$




Longer contacts result in degraded performance!

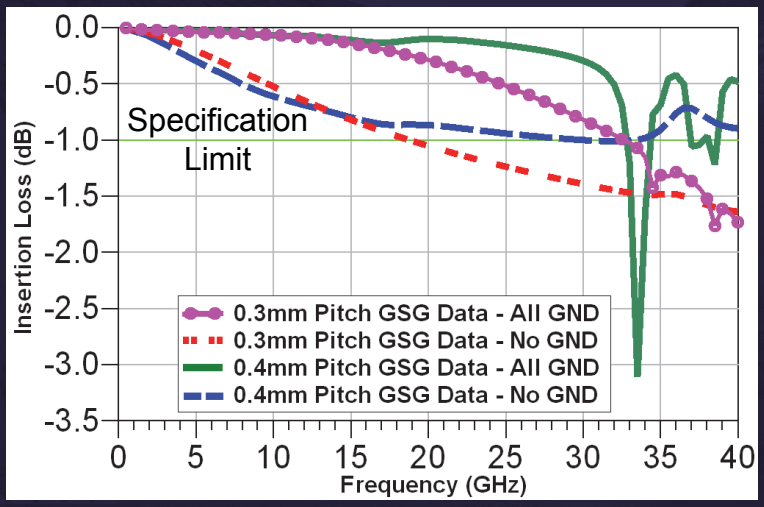
## Comparison of Same Configurations With Different Height Contacts – $S_{11}$




Longer contacts result in degraded performance!

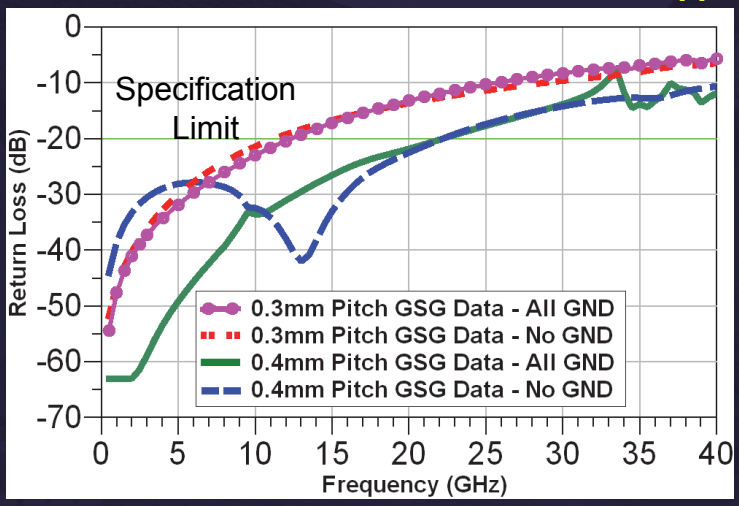


## Comparison of Same Configurations With Different Pitches – $S_{21}$




Placing more grounds around signal improves the Insertion Loss!

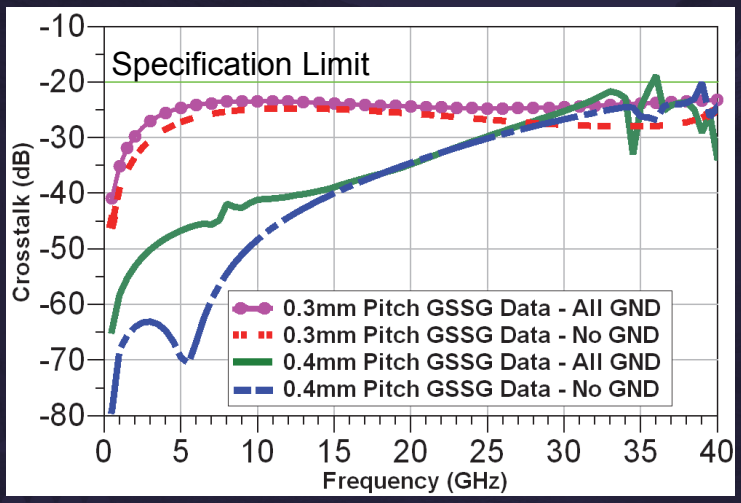
## Comparison of Same Configurations With Different Pitches – $S_{11}$




Change in performance with change in pitch!

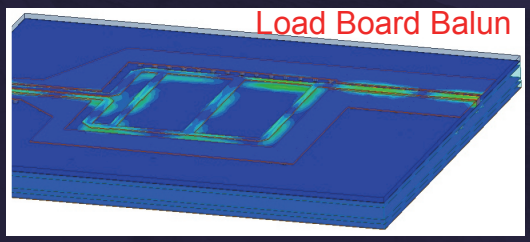


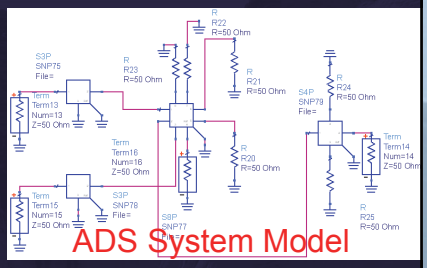
## Comparison of Same Configurations With Different Pitches – $S_{41}$

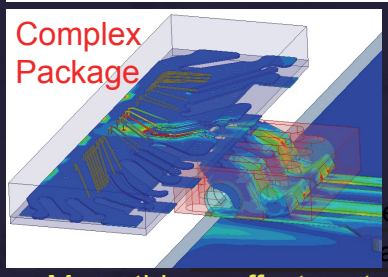


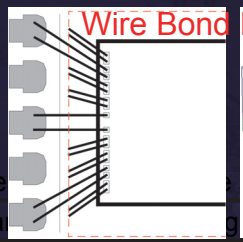

Larger the contact separation the better the Crosstalk!

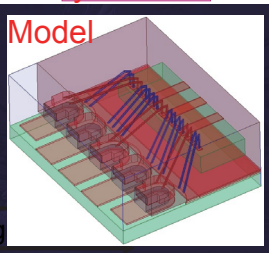
## Testing Needs a System Approach That Starts Early in the Design Phase



Many things effect system performance – need to model all!



## Conclusions

- Location of GNDs affect performance
- Number of GNDs affect performance
- Smaller Inductance –> Higher BW
- GND location and pitch affects Return Loss
- DFT needs to occur early in design phase
- Test suppliers need to have expertise and tools to improve test effectiveness