

Full-Wave Analysis and Characterization of Via Grounding Techniques Used to Decrease Electromagnetic Coupling Between Striplines

Paula Lucchini, Nathan Roberts, Marcos Vargas
Dr. Mikaya Lumori
University of San Diego

Jerry Aguirre, PH.D., Kyocera America, Inc.
Tim Mobley, DuPont
Jim Krasovic, Ansoft Corp.

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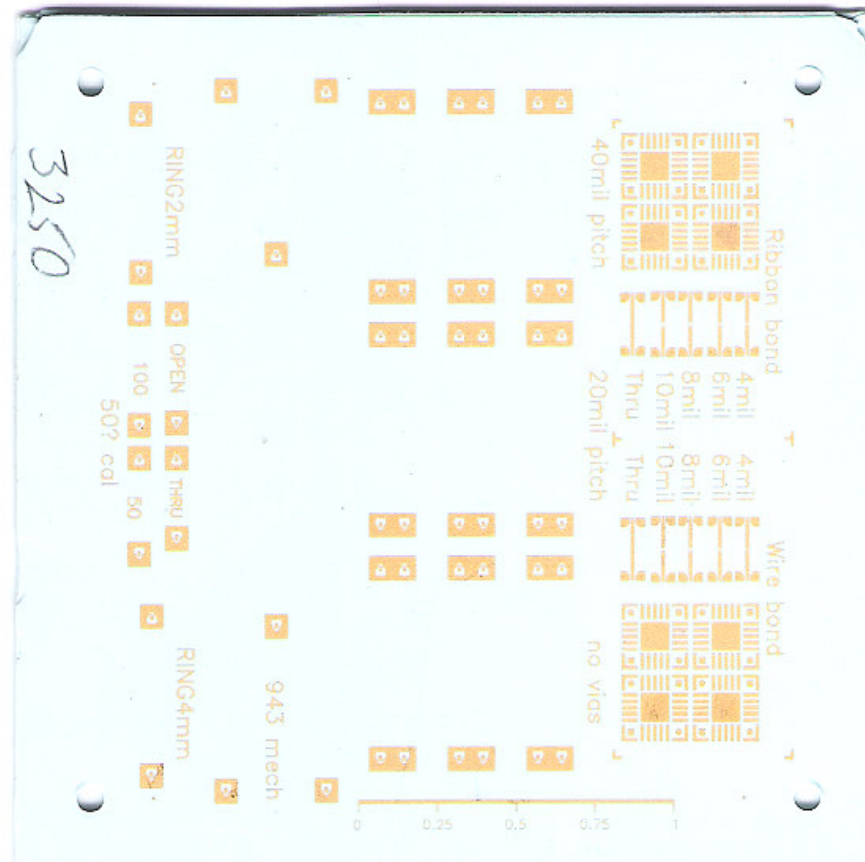
Presentation Outline

- Project Introduction
- LTCC (Low Temperature Co-fired Ceramic)
- Via Isolation Analysis
- Results
- Conclusions



LTCC

(Low Temperature Co-fire Ceramics)



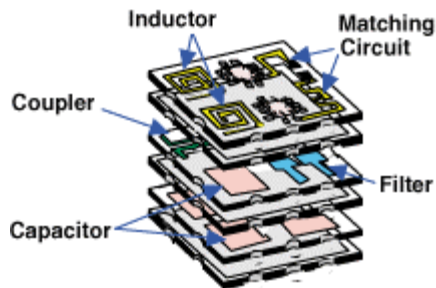
Thanks to Kyocera America and Dupont for the information and images found in the LTCC slides



LTCC Outline

- Introduction
- Green Tape
- LTCC Process
- Advantages/Disadvantages
- Reasons for Use

Introduction



- ‘Dupont Green Tape LTCC provides an option for designers that bridges the gap and combines the benefits of High Temperature Co-fired Ceramics (HTCC) and Thick Film technologies to provide a package that has high density, reliability, performance, and low cost interconnects’

Green Tape

- Low-cost packaging solution made by Dupont
- Dupont 951:
 - Used in Ceramic printing wiring boards, single chip packages, multi-chip modules, RF modules
- Dupont 943:
 - Used in automotive, military, RF/microwave IC packaging, opto-electronics, wireless/satellite communications

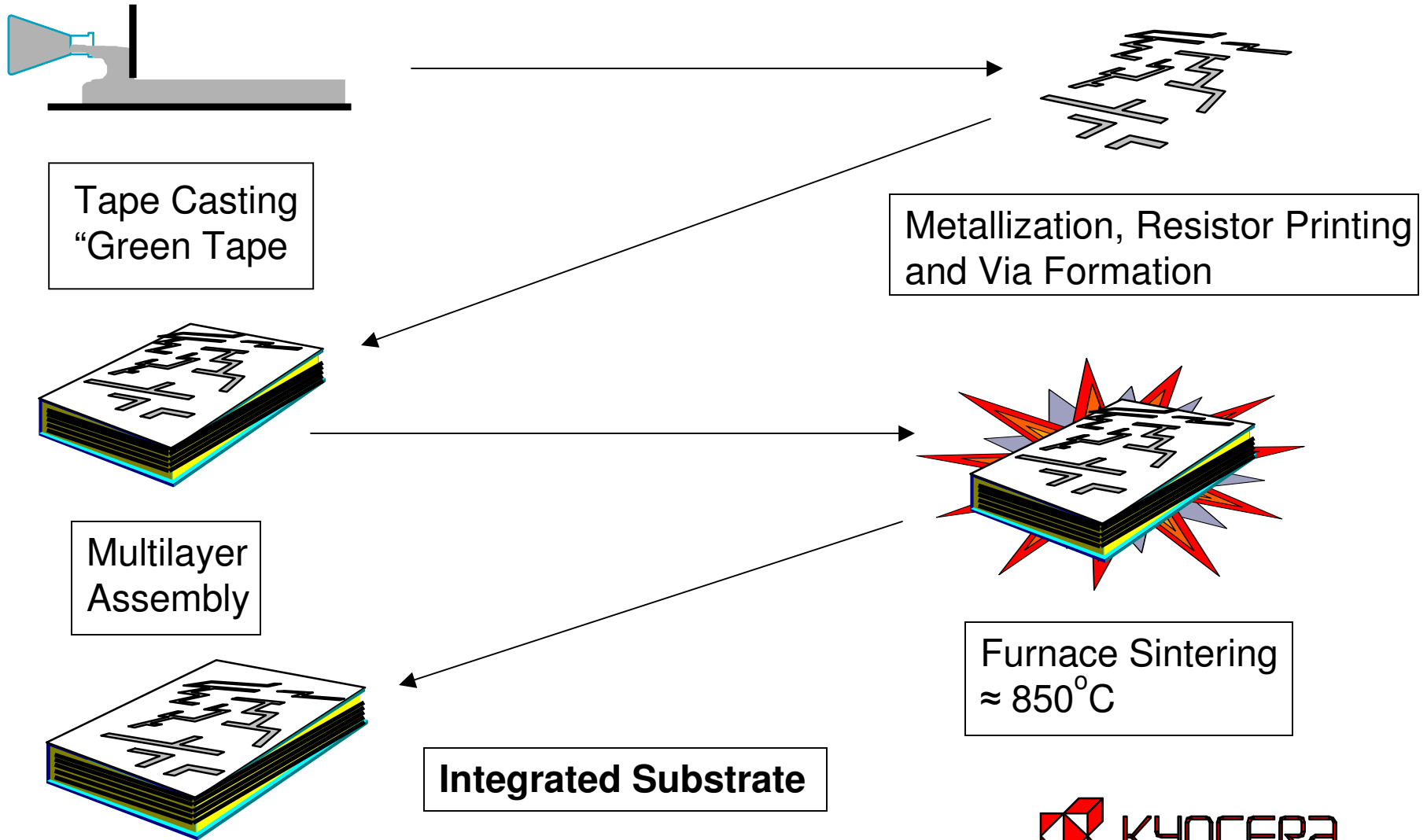


Two General Categories of Co-firing

- HTCC (High Temperature Co-fired Ceramic)
 - Alumina
 - Process Temperature (1600° – 1800° C)
 - Refractory Metals (W, Mo, MoMn)
- LTCC (Low Temperature Co-fired Ceramic)
 - Ferro, Dupont
 - Process Temperature (850° C)
 - Precious Metals (Au, Ag, Cu)



LTCC Process



LTCC Drawbacks Compared to HTCC

LOWER SUBSTRATE STRENGTH

- MECHANICAL ISSUES IN HANDLING PACKAGES
- LOWER PIN-PULL VALUES

LOWER STRENGTH OF BRAZES

- INNOVATIONS TO IMPROVE STRENGTH WHERE POSSIBLE

PRECIOUS METAL BRAZE MATERIALS (Au/Sn, Au/Ge)

- INTERMETALLICS READILY FORMED
- BRAZE-COMPONENT INTERACTION DIFFERENT THAN HTCC

REACTIVITY OF SUBSTRATE MATERIALS

- BORO SILICATES TEND TO BE QUITE REACTIVE
- ONLY COMPATIBLE MATERIALS (PASTES) MUST BE USED
- CLOSE RELATIONSHIP WITH SUPPLIER IS PARAMOUNT



HTCC vs. LTCC

HTCC	LTCC
Mechanically robust	Low-resistance conductors
High thermal conductivity (20~200 W/mK)	Low insertion loss
Embedded inductors, capacitors, couplers, filters, couplers, baluns	Embedded inductors, capacitors, resistors , filters, couplers, baluns
High dielectric strength	Mixed dielectric constant systems
Well-established and reliable braze and post-braze technology	Multiple conductor (Ag, Au) and dielectric (k) tape combinations for optimal design and performance

Reasons to Use LTCC in High Frequency Applications

- High conductivity metals – low loss
- 3-D structures – small size/footprint
- Low dielectric constant – high signal speed
- Embedded passive components – smaller size, increased functionality
- High reliability solutions
- Brazed pins, seal rings, connectors and heat sinks – increased functionality and reliability
- Low density – lighter weight solutions



Via Isolation



General Notion: The more vias the better...

True or False?

Initial results in Ansoft Designer showed the No Via model with better isolation than the Via models.

Is this real?



Model

Using Ansoft HFSS:

Via Fence in between two perfect electrical conductors.

Trace spacing (G), Via pitch (P), and Substrate height (H) are varied.

Substrate is Dupont 943

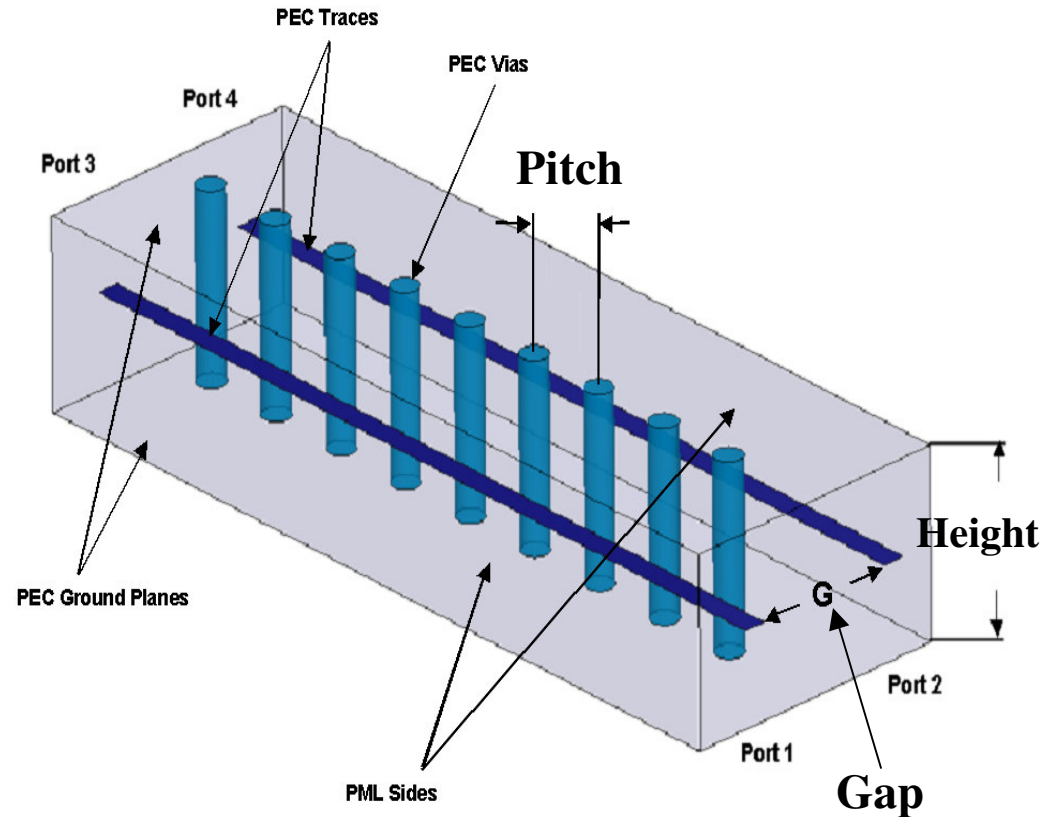
- Dielectric constant = 7.4
- Loss tangent = 0.002

Dimensions:

- Length = 480 mil
- Width = 300 mil
 - *Width increased by the amount of increase in trace spacing
- Via Diameter = 10 mil

Design Guidelines:

- Via Center to Part Edge*
 - Preferred: 3 x Via Diameter
- Via Pitch
 - Preferred: 3 x Via Diameter
 - Minimum: 2 x Via Diameter (no less than 14 mil)



Trends

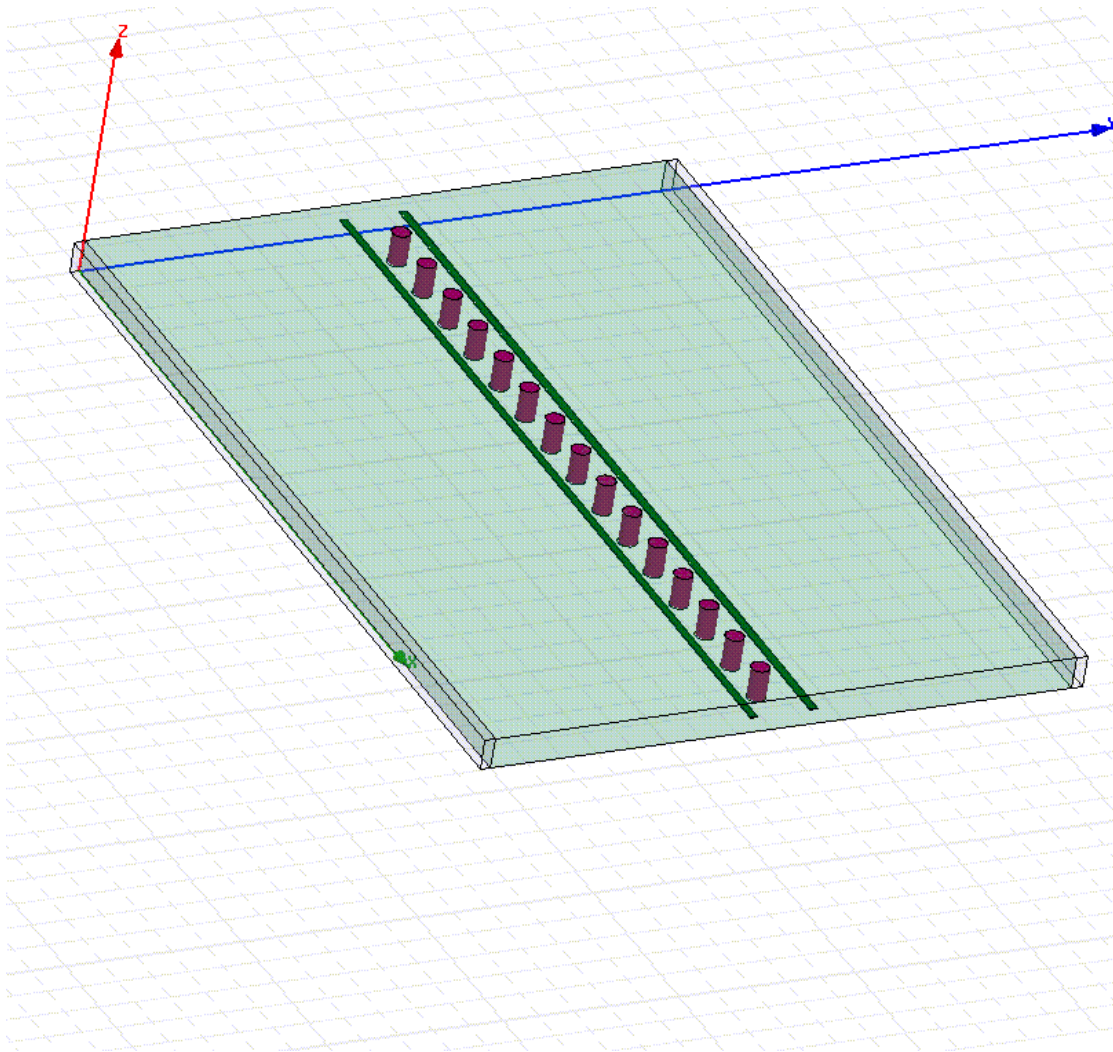
Near and Far End Coupling

- Coupling increases as substrate height increases (independent of frequency)
- Coupling decreases with increasing trace gap.
- Coupling increases with increasing frequency

Effect of Vias

- Improve Near End Isolation
- Degrade Far End Isolation

Varying Substrate Height



Dimensions:

Substrate Length = 480mil

Substrate Width = 300mil

*widens w/ increasing trace gap

Trace Thickness = 0.35mil

Substrate Height (H) Varied:

18mil to 26mil in 4mil steps

Trace Width Varied w/ Substrate Hgt:

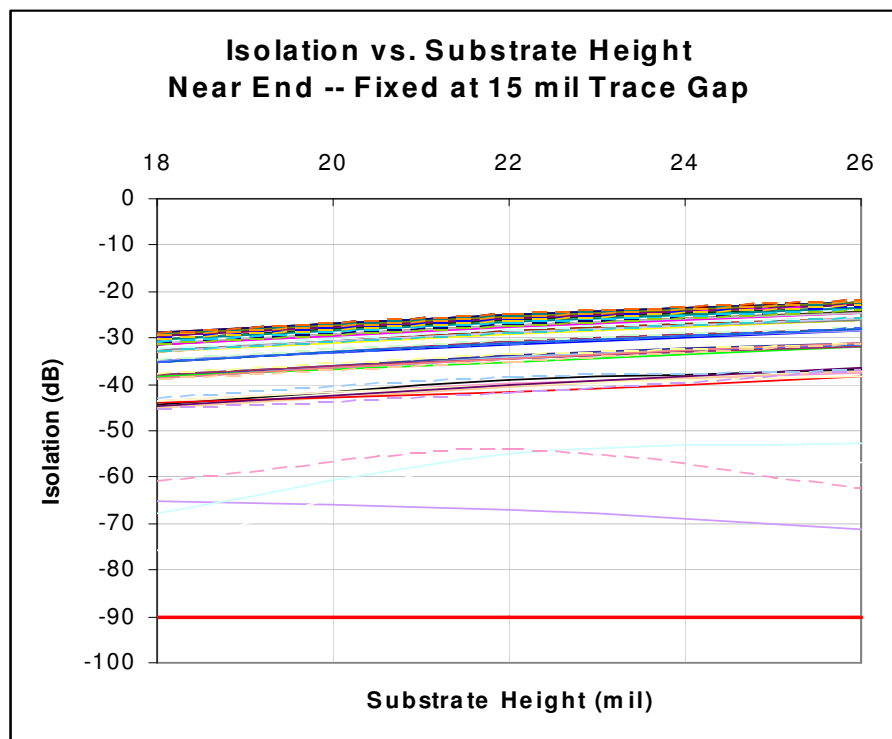
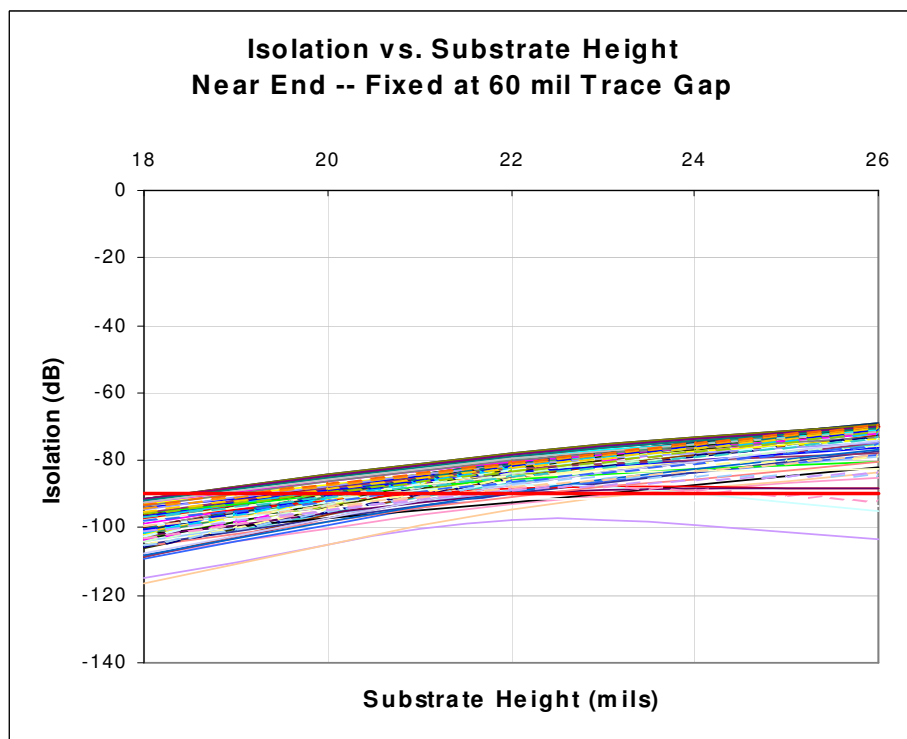
4mil to 6mil in 1mil steps

All Other Dimensions Fixed

Frequency Swept from 1 to 20 GHz



Isolation Increases w/ Decreasing Substrate Height



- Approx. 3.4 dB/mil gain in isolation as substrate height is decreased

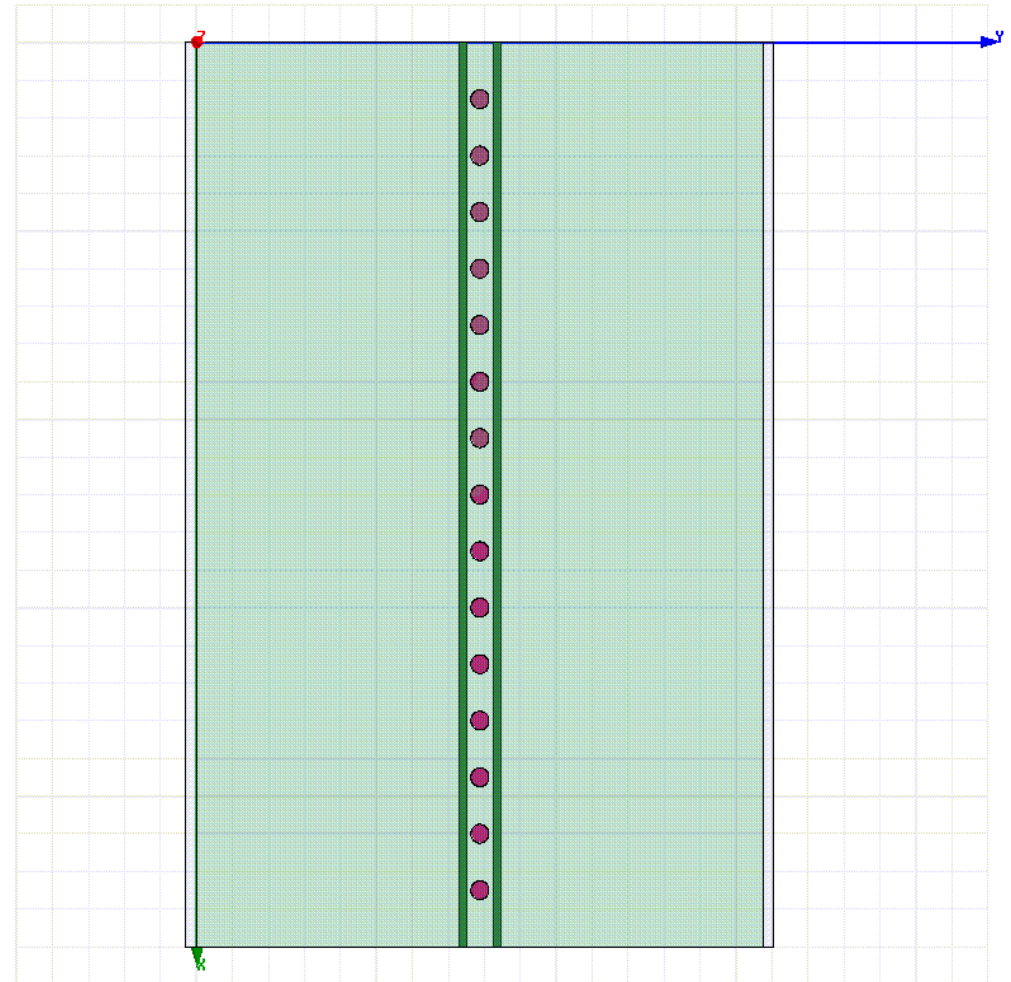
Substrate Height is increased from 18mil to 26mil and Frequency is swept from 1 to 20 GHz w/ 250 MHz step



Via vs. No Via

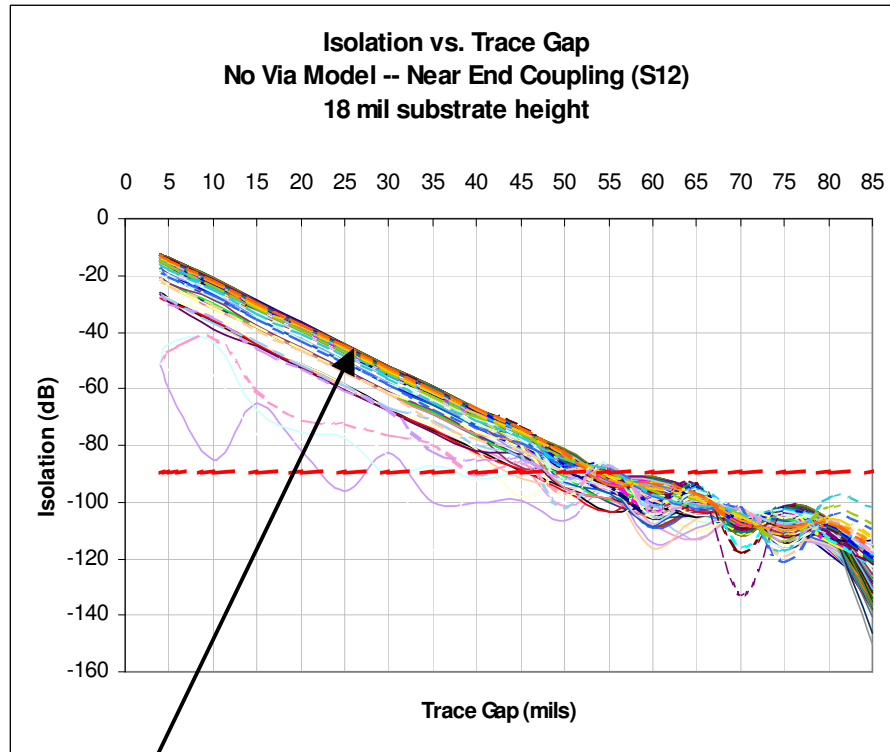
Dimensions:

- Substrate and traces are the same as the previous models
- Trace Spacing (**G**) varied
 - No Via case from 4mil to 85mil
 - Via case from 15mil to 85mil
- Via Diameter = 10 mil
- Via Pitch (**P**) varied from 12mil to 30mil
- Via Center to Part Edge = 30mil
- Substrate Height (**H**) varied from 18mil to 26mil at 4mil step.
- Trace Width varied from 4mil to 6mil at 1mil step to maintain $Z_o = 50 \Omega$.
- Analysis done using driven terminal solutions in HFSS

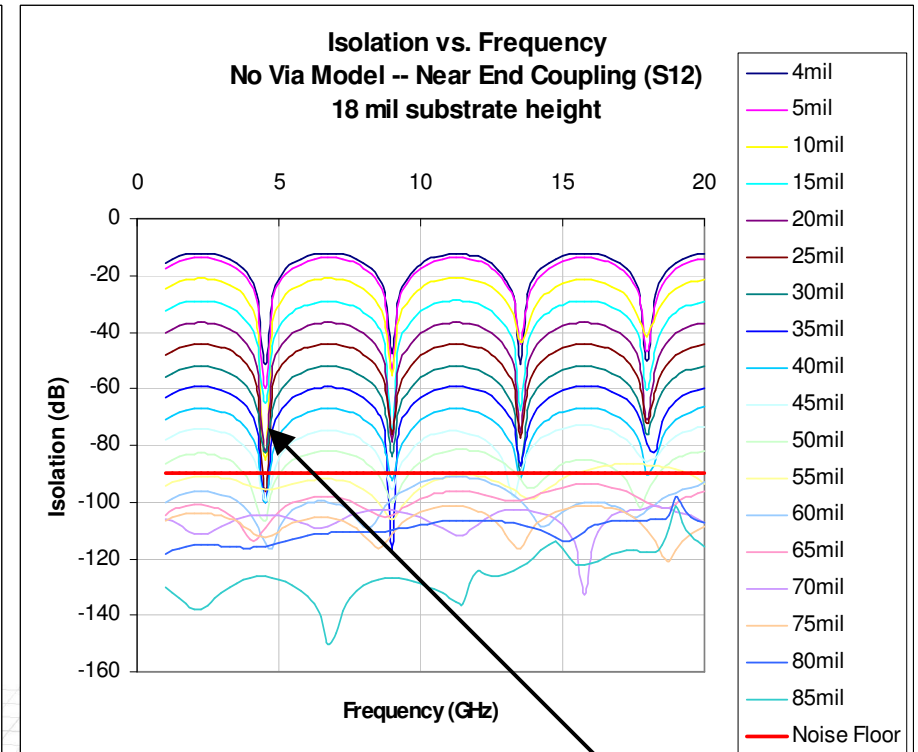


No Vias: Near End Coupling

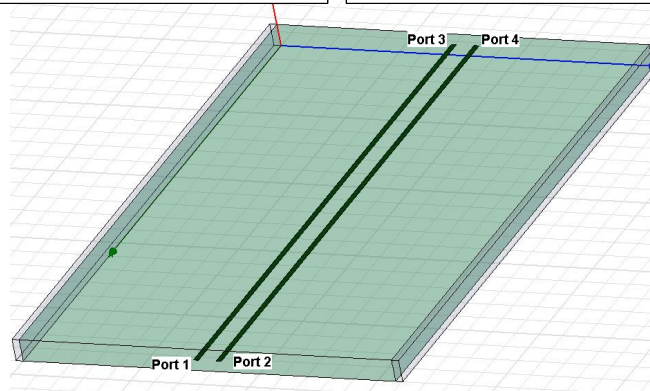
Plots Provide Useful Guides in Design.



1.5 dB/mil Isolation Gain



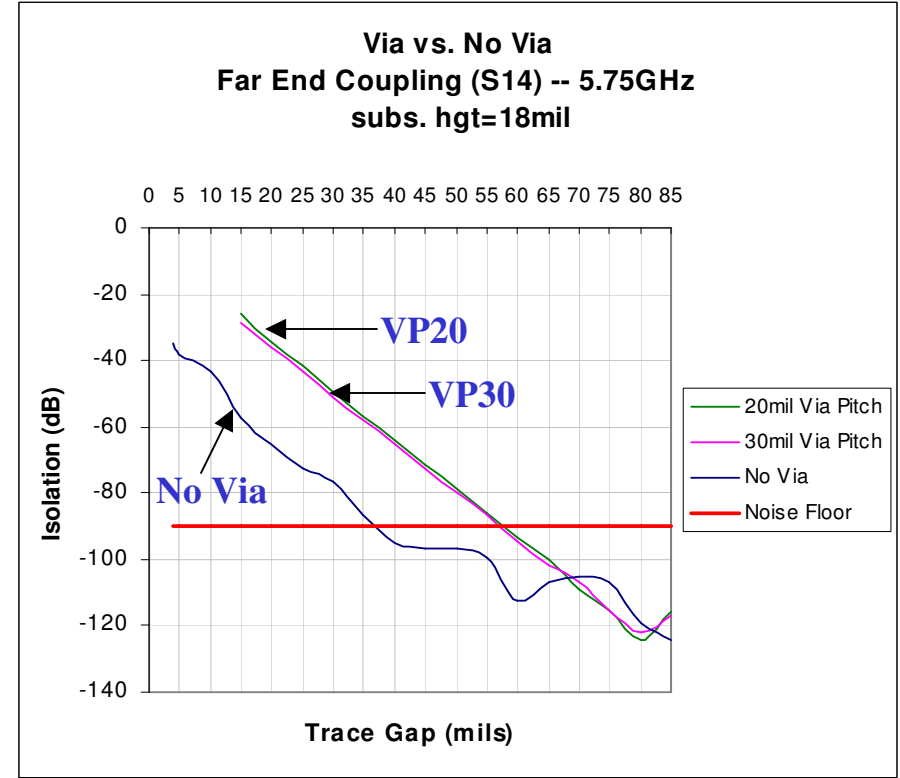
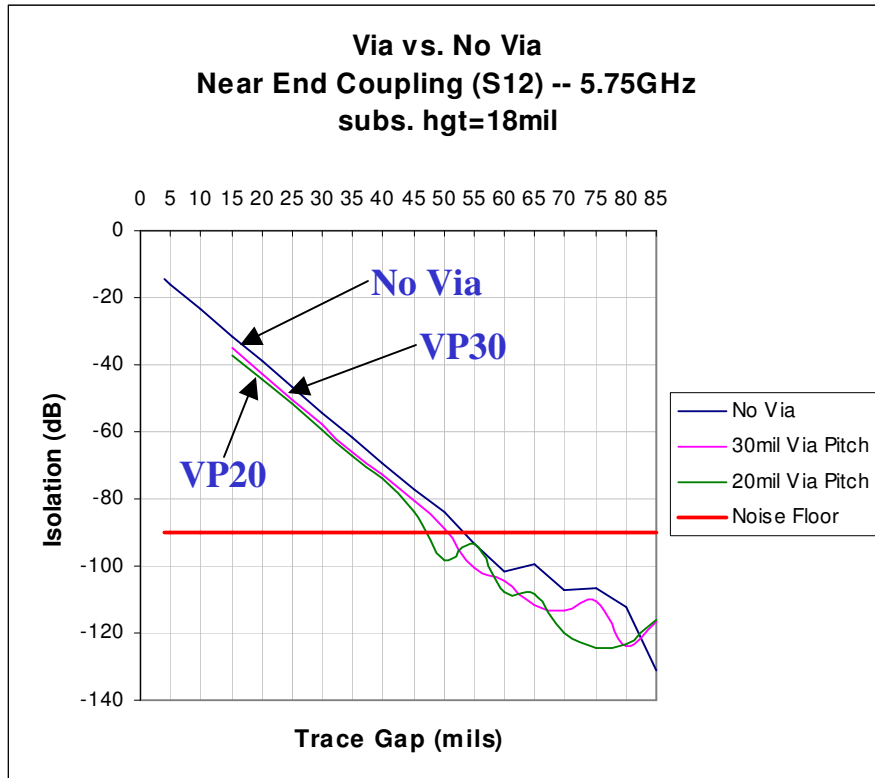
Nulls Correspond to Problem Space. Frequency Corresponds to Length of Substrate (480mil)



For Two Adjacent Striplines Between Package Components...

- Given a particular frequency, how much isolation is expected?
- Given a particular trace gap, how much isolation is expected?

Vias Improve Isolation at the Near End but Degrade Isolation at the Far End



Via Fences Help Isolation at the Near End

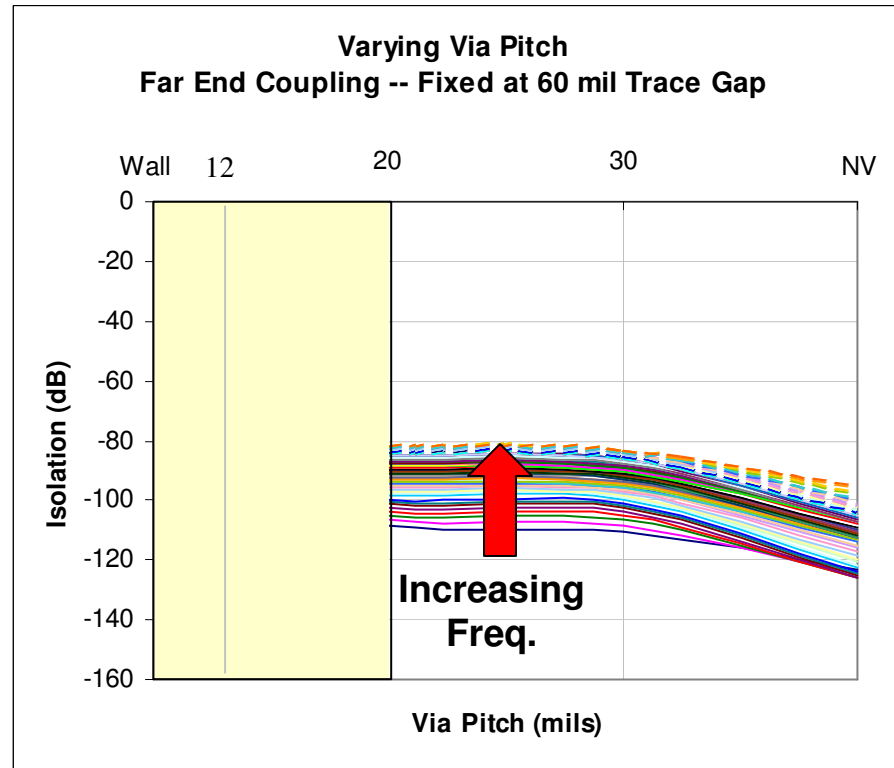
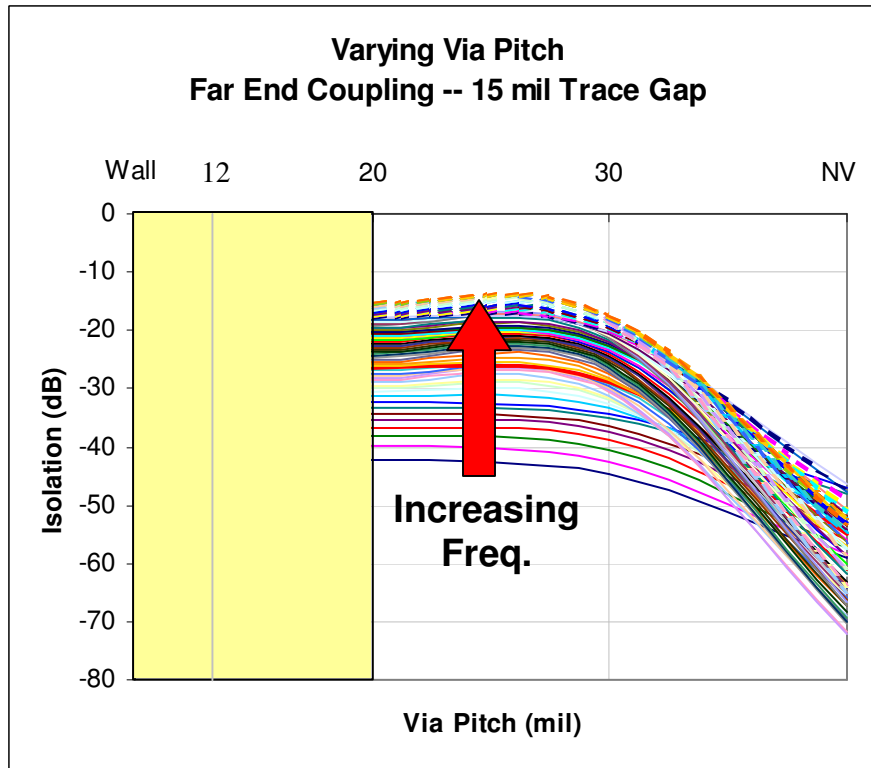
- 2 dB gain in isolation by tightening the via pitch by 10 mil
- 5.5 dB difference between via (30mil pitch) and no via model
- 7.5 dB difference between via (20mil pitch) and no via model

Far End Isolation is Degraded with Via Fences

- 2 dB difference between via models
- Average of 30 dB difference between no via and via models



Tightening Via Pitch Increases Coupling



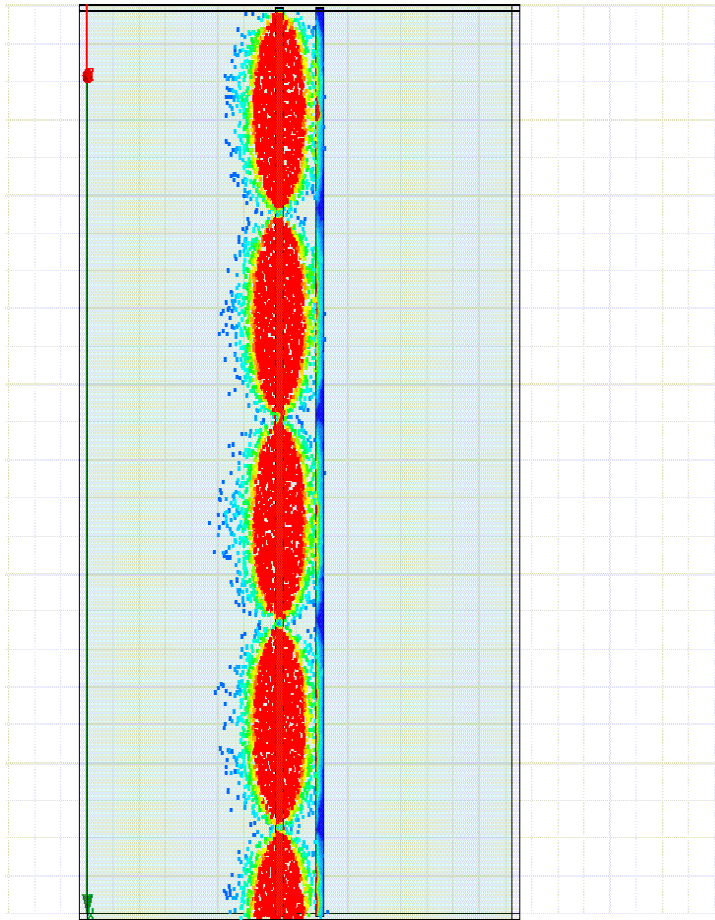
- Shaded area signifies pitch values that violate design guidelines with a 10 mil via diameter
- Each curve is a frequency from 1 to 20 GHz in 250MHz steps. The lowest curve corresponds to the lowest frequency with each curve representing a higher frequency.

*Substrate thickness = 18 mil

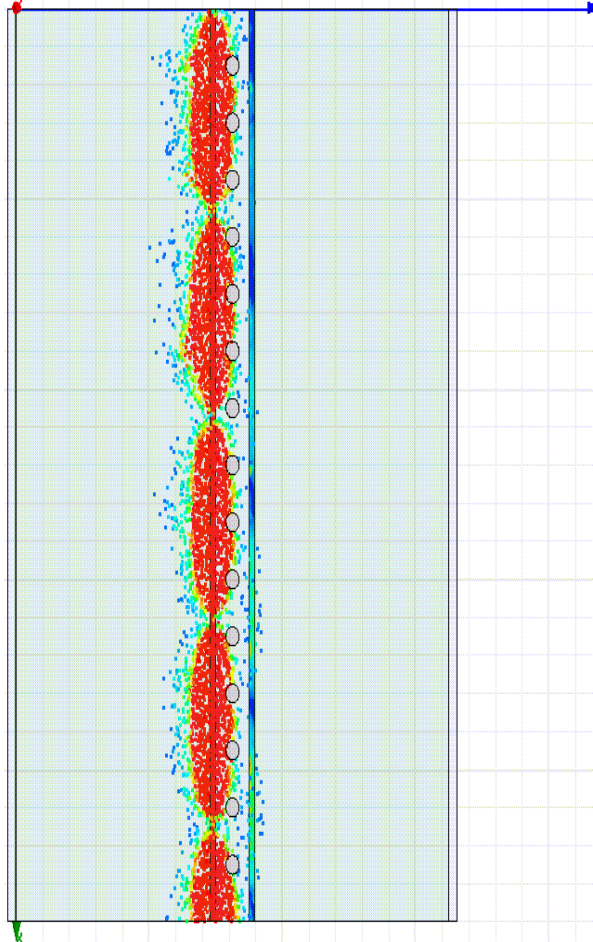


What is Happening?

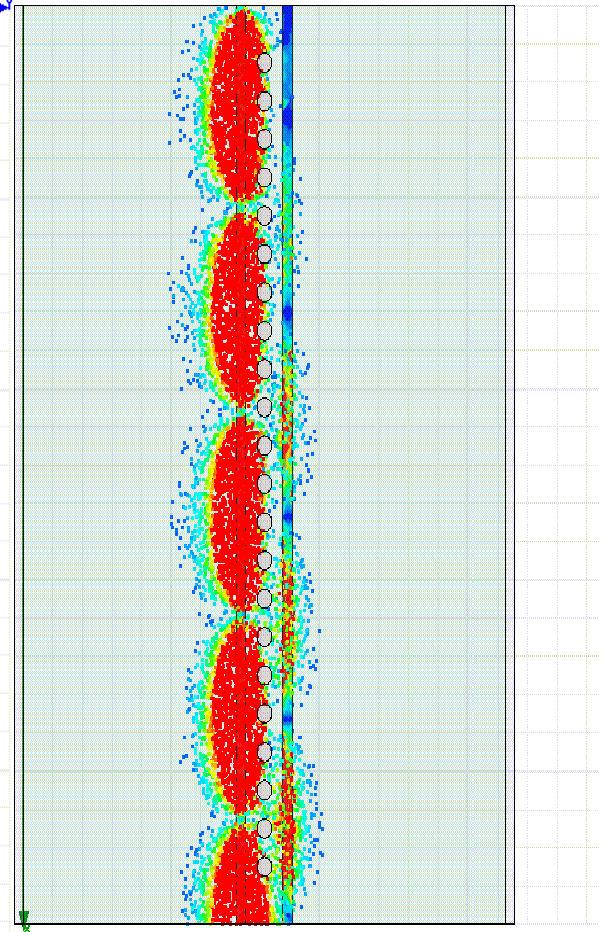
No Vias



30mil Via Pitch



20mil Via Pitch



In Summary

Near and Far End Coupling

- Coupling increased as substrate height increased
- Coupling decreased with increasing trace gap.
- Coupling increased with increasing frequency at the Far End. Stayed relatively the same at the Near End.

Effect of Vias

- Improved Near End Isolation (Tighter the via pitch, the better the isolation)
- Degraded Far End Isolation (Tighter the via pitch, the greater the coupling)

Thank You

Acknowledgements:

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