Characterization of a Printed Circuit Board Via

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Thesis Defense

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Objective

- To Develop an Equivalent Circuit Model for a Printed Circuit Board Via

Purpose

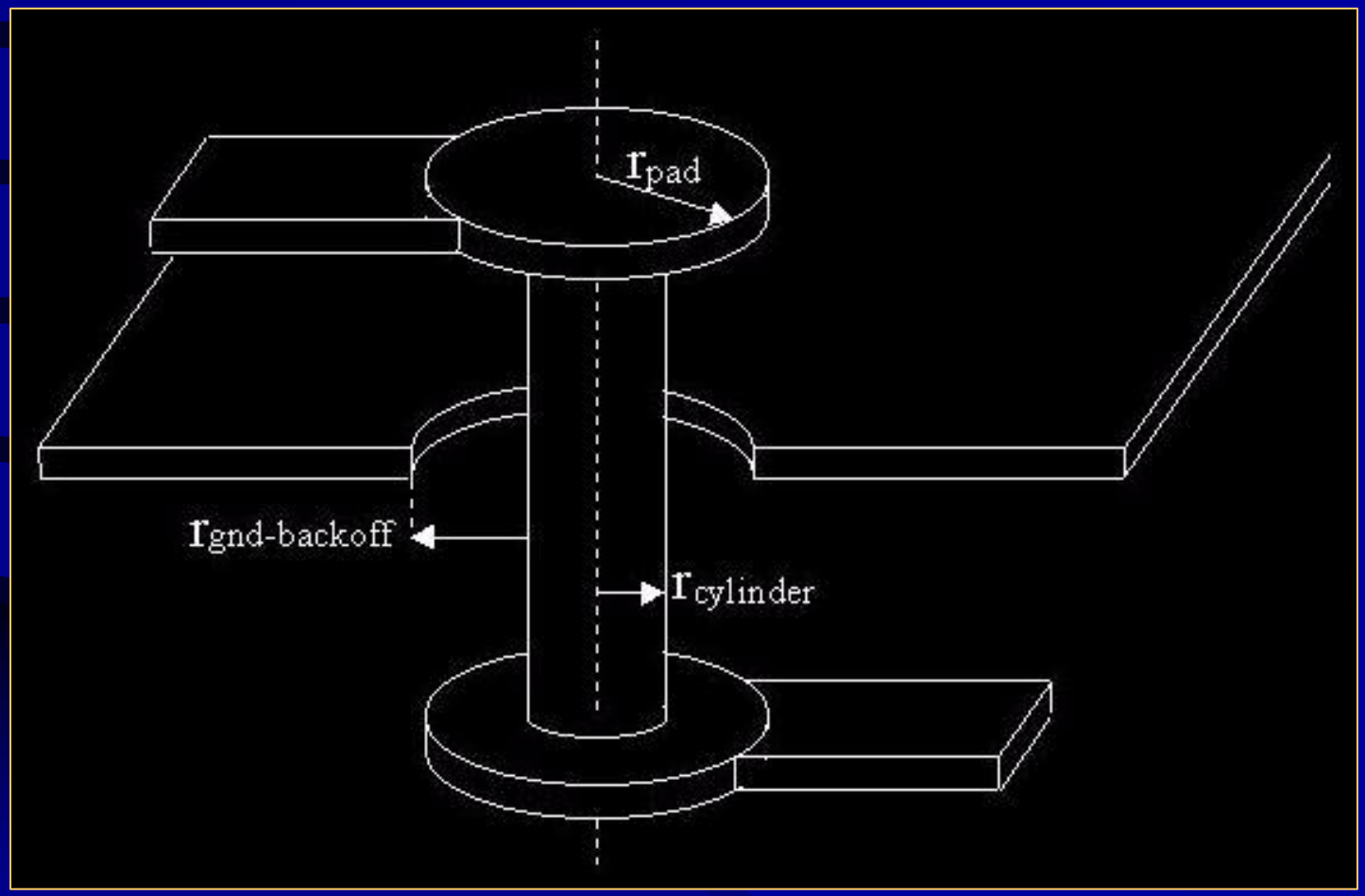
- To Characterize the Discontinuity Caused by a Via
- To Understand How the Physical Dimensions of a Via Contribute to its Electrical Response

Characterization Approach

- Develop an Equivalent Circuit
- 3D Electromagnetic Field Simulations
- SPICE Simulations
- Time Domain Reflectometry
- Network Analysis

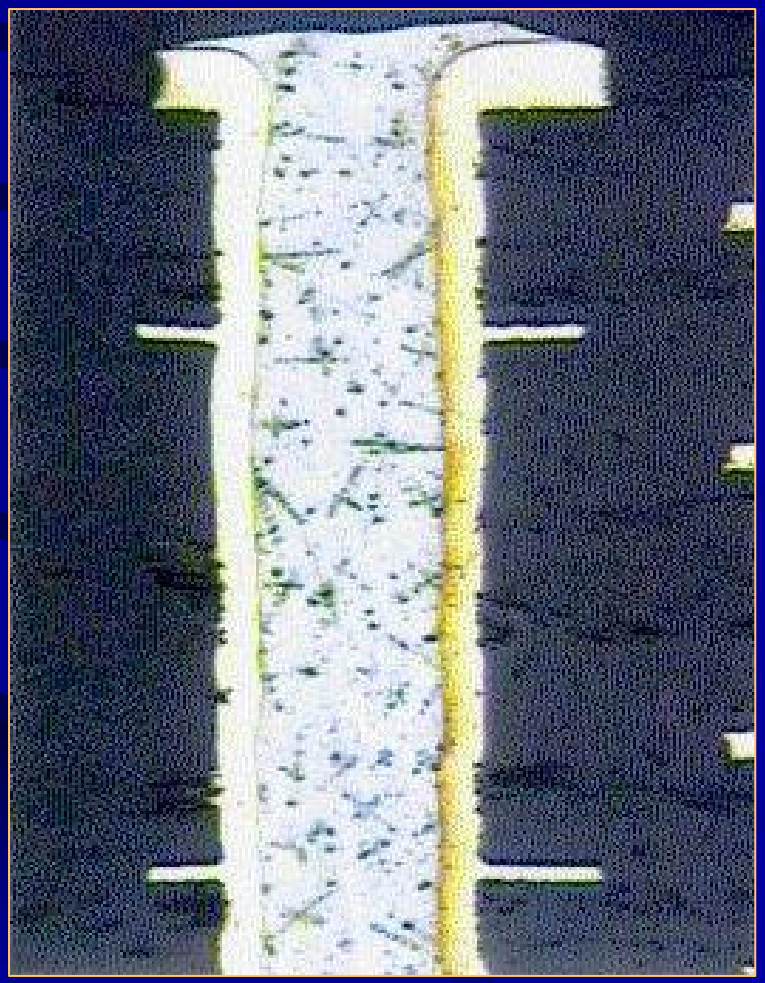
Printed Circuit Board Via

(Cross Section)



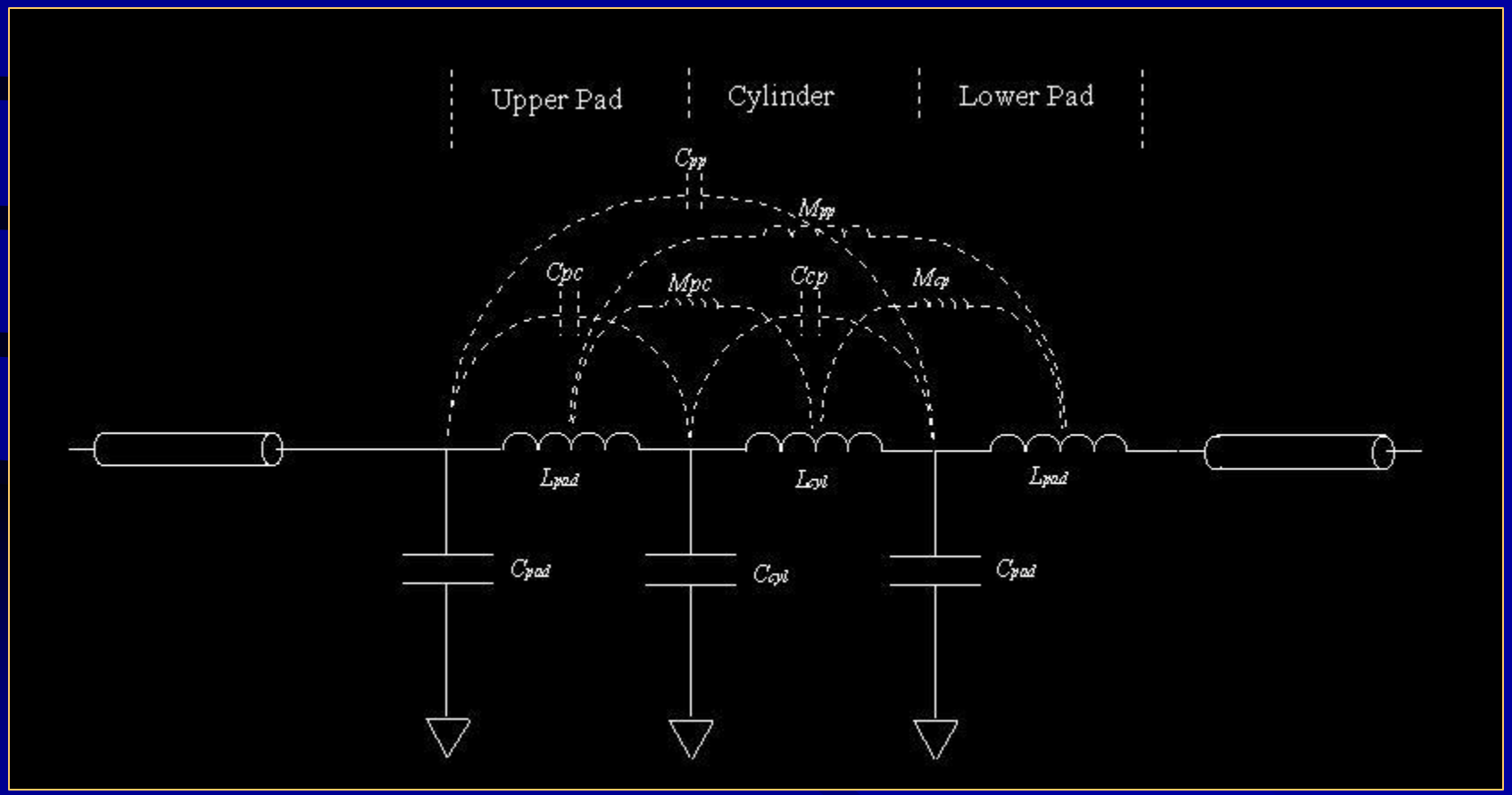
Printed Circuit Board Via

(Actual Via)



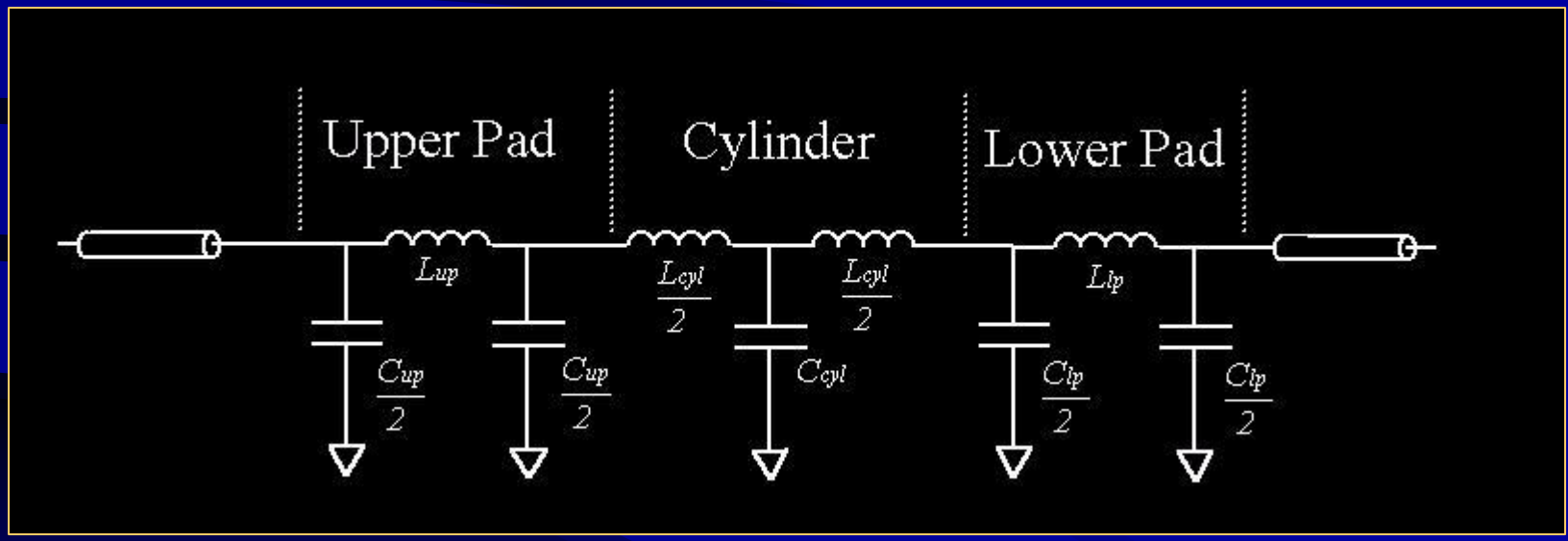
Equivalent Circuit

(Coupled Model)



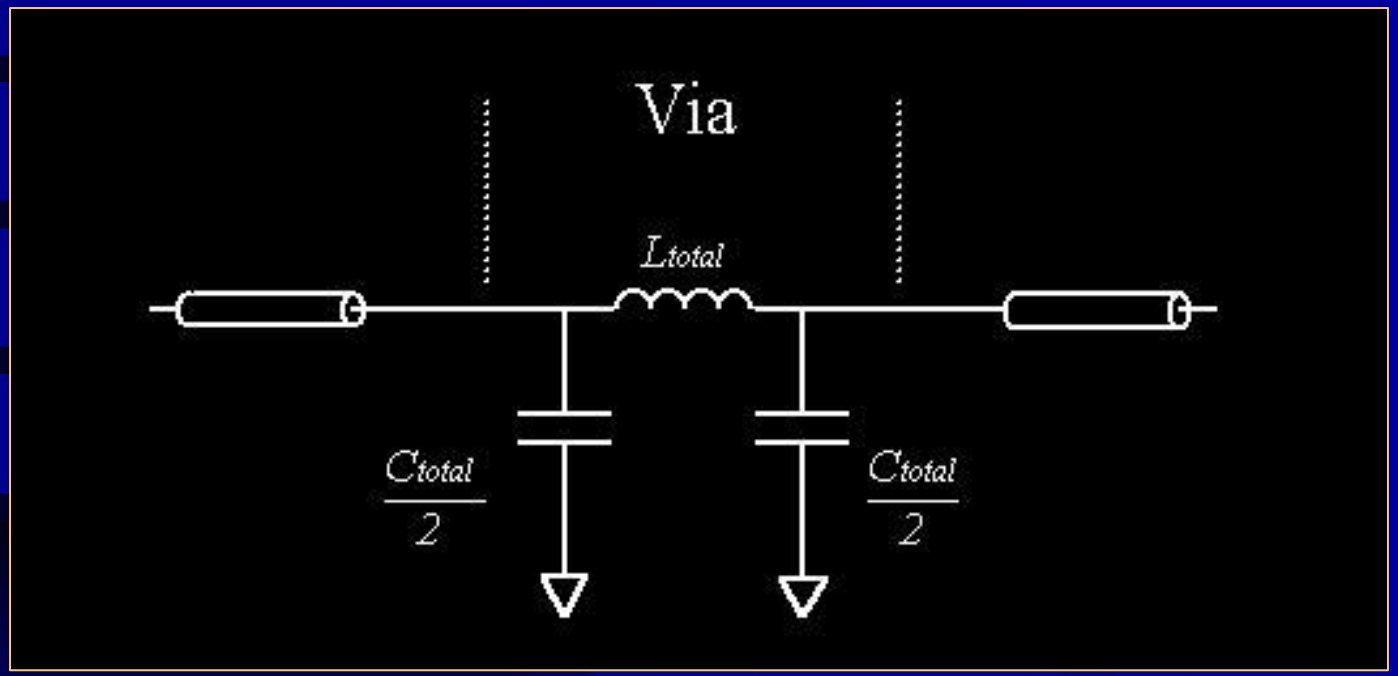
Equivalent Circuit

(Distributed Model)



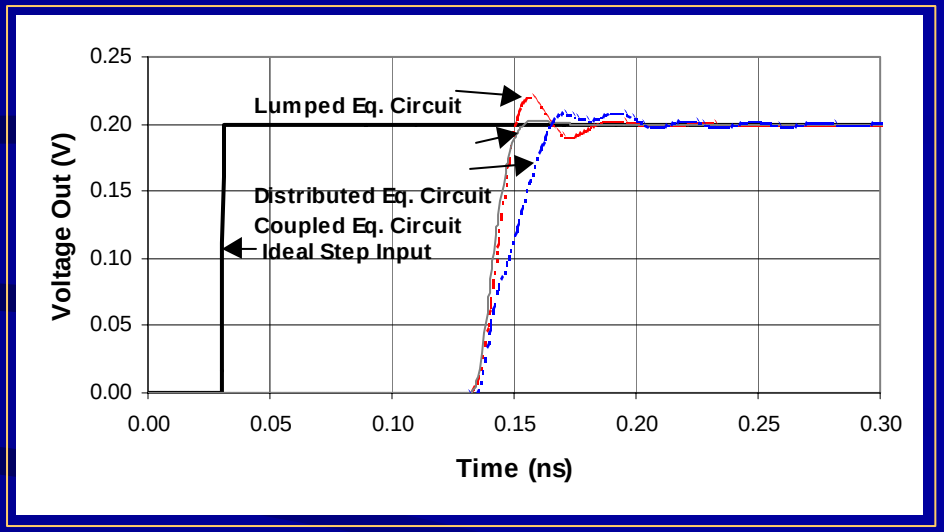
Equivalent Circuit

(Lumped Model)

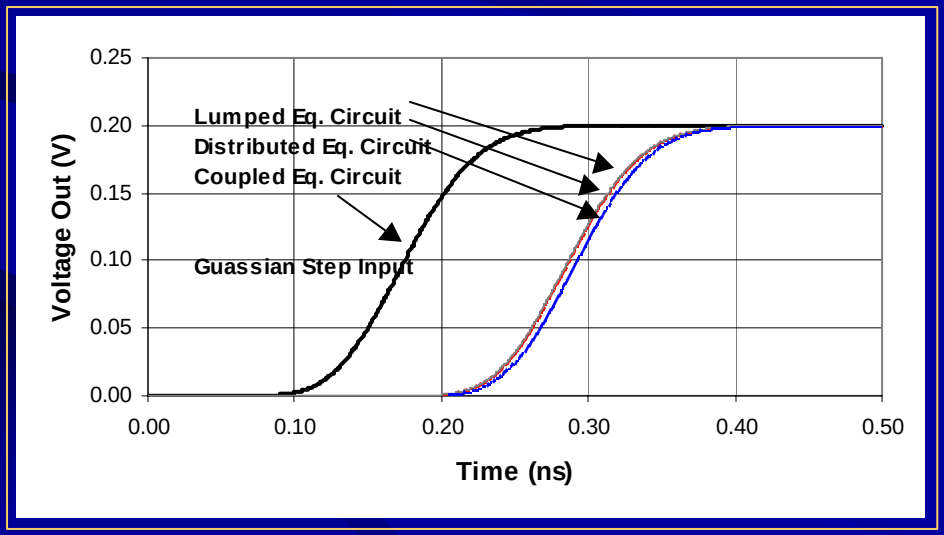


Equivalent Circuit Response

- Perfect Step



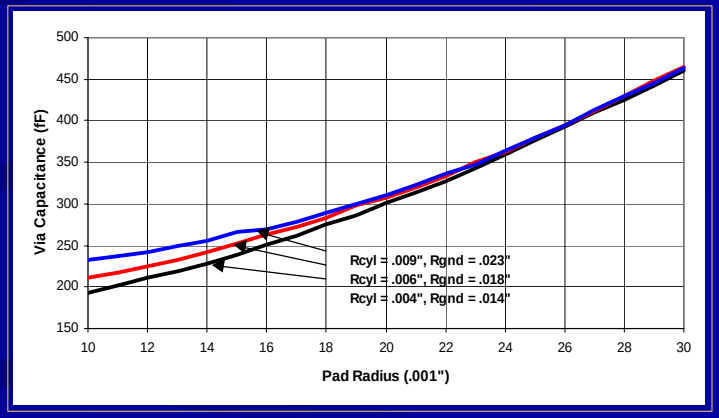
- **100ps Guassian Step**

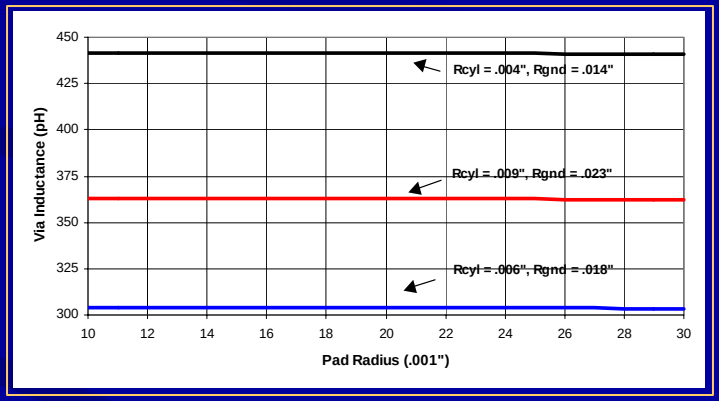


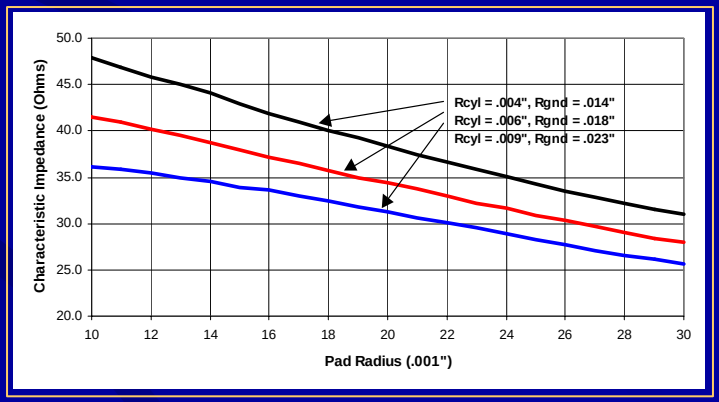
3D EM Field Simulations

(Varying Pad Radius)

- Capacitance vs. Pad Radius
- Inductance vs. Pad Radius
- Zo vs. Pad Radius

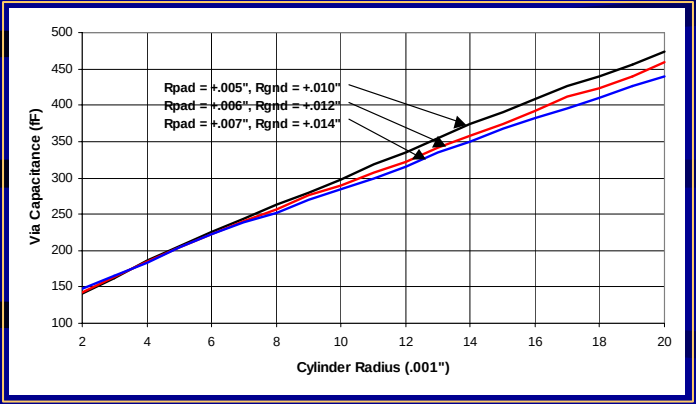




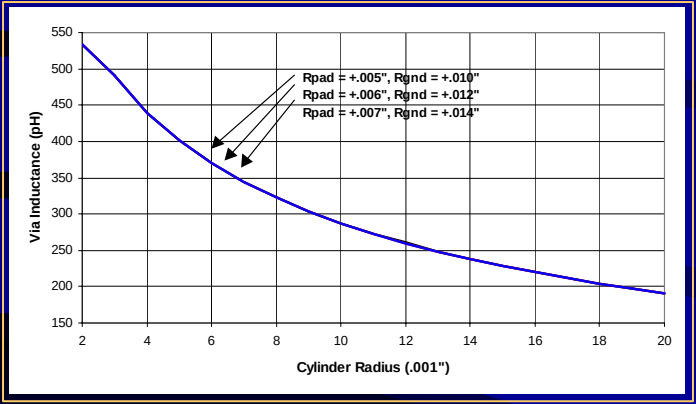


3D EM Field Simulations

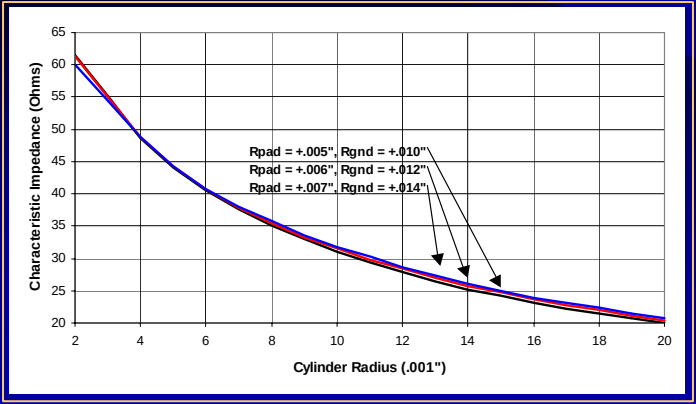
(Varying Cylinder Radius)



- Capacitance vs. Cylinder Radius



- Inductance vs. Cylinder Radius

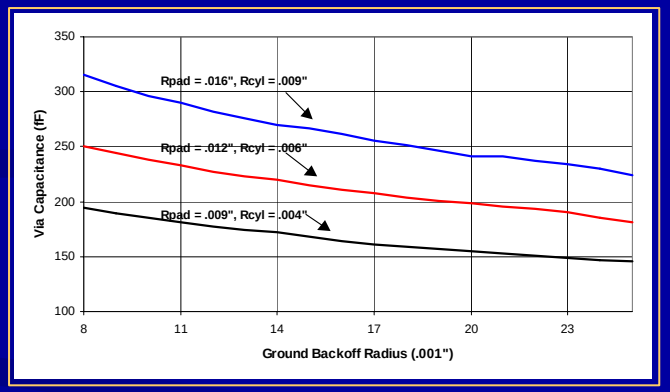


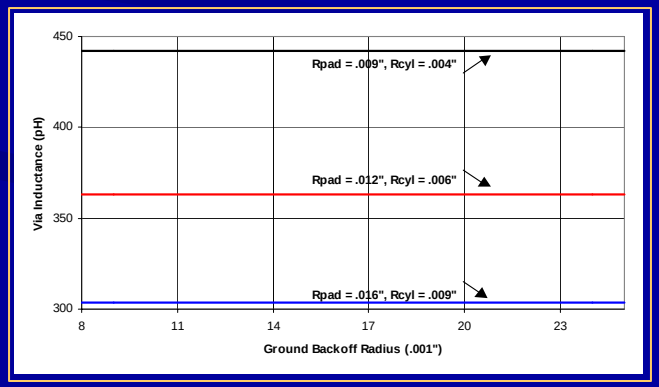
- Zo vs. Cylinder Radius

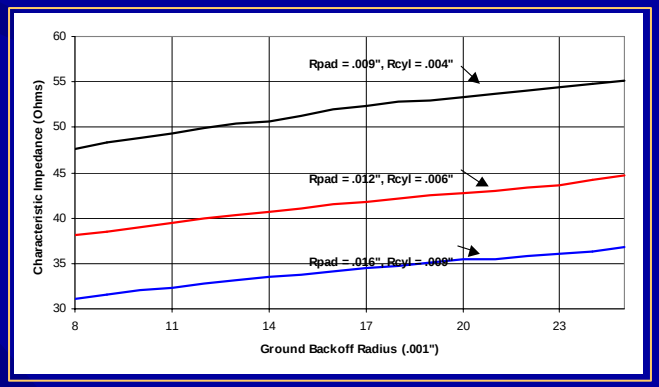
3D EM Field Simulations

(Varying Ground Clearance Radius)

- Capacitance vs.
  Ground Clearance Radius
- Inductance vs.
  Ground Clearance Radius
- Zo vs.
  Ground Clearance Radius

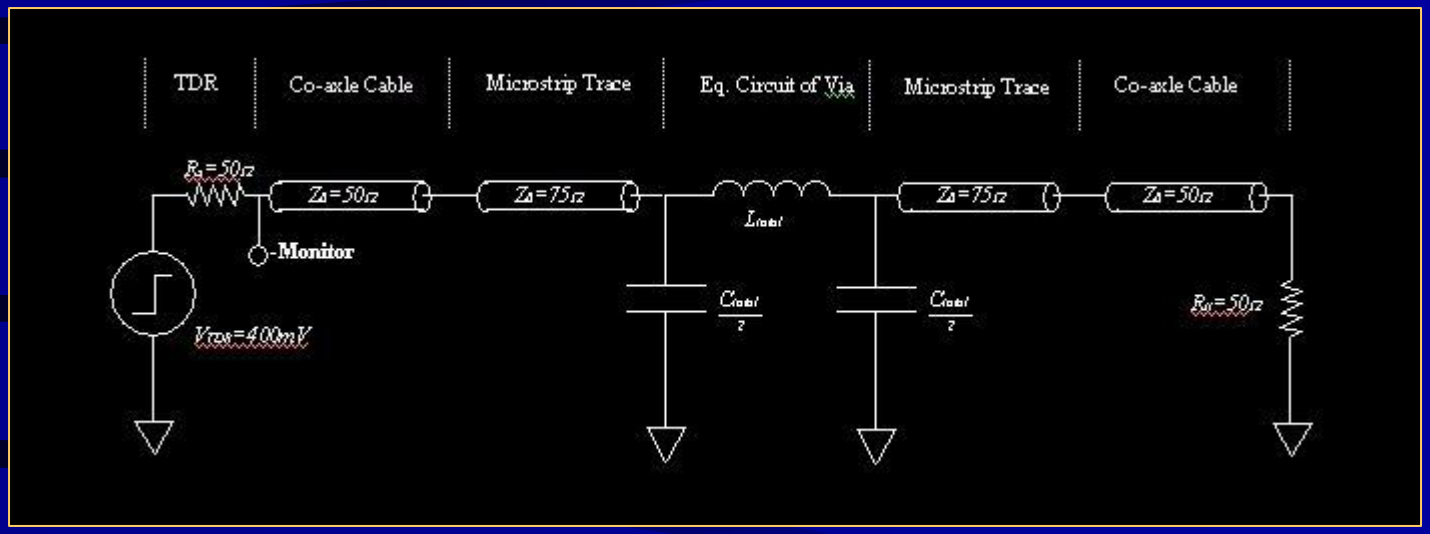




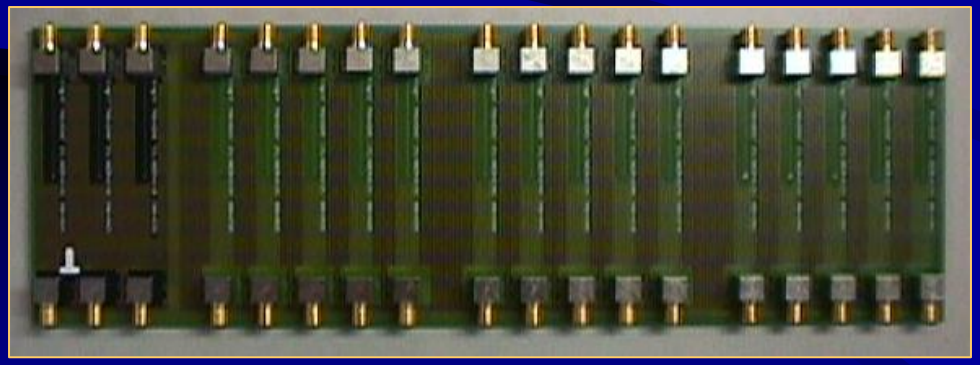


Time Domain Reflectometry

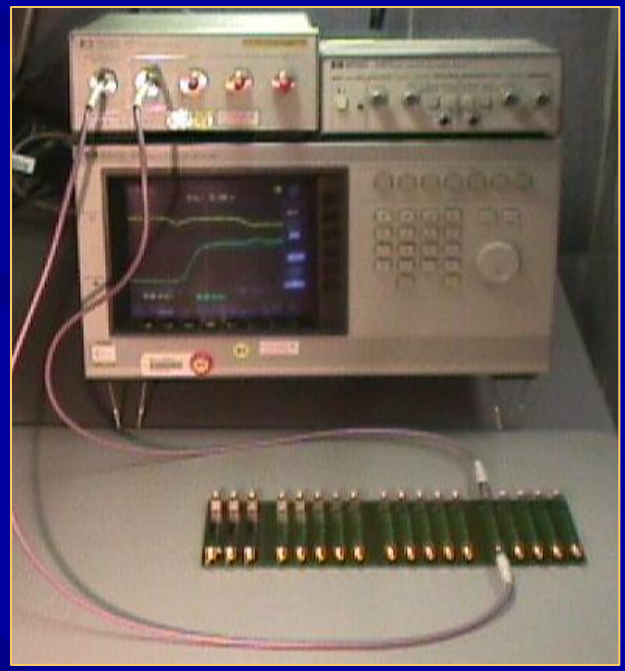
(Experimental Setup)



Circuit of Experimental Setup



Test Printed Circuit Board

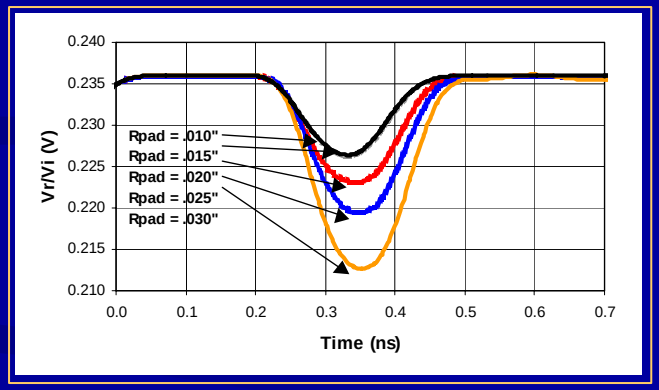


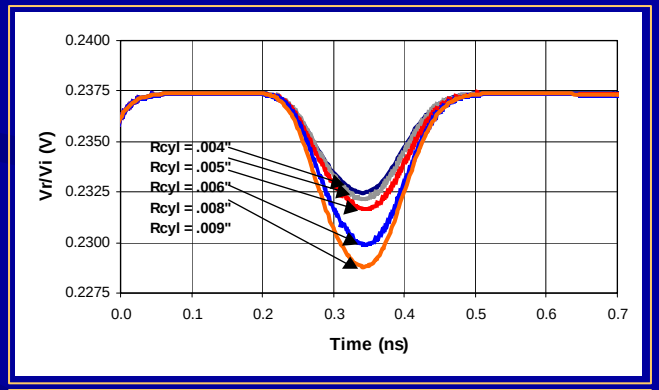
Actual Laboratory Setup

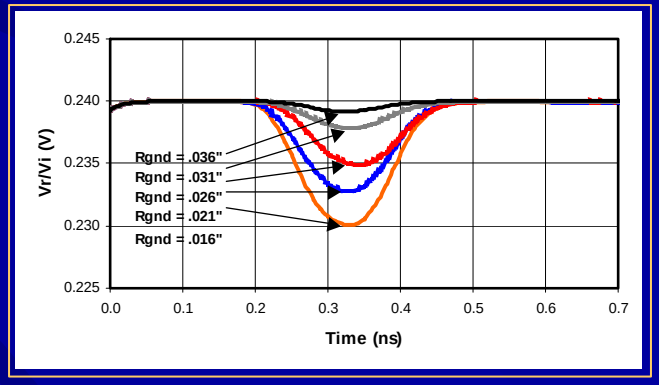
Time Domain Reflectometry

(Empirical Results)

- TDR varying Pad Radius
  (Zo decreases)
- TDR varying Cylinder Radius
  (Zo decreases)
- TDR varying Ground Clearance Radius
  (Zo increases)

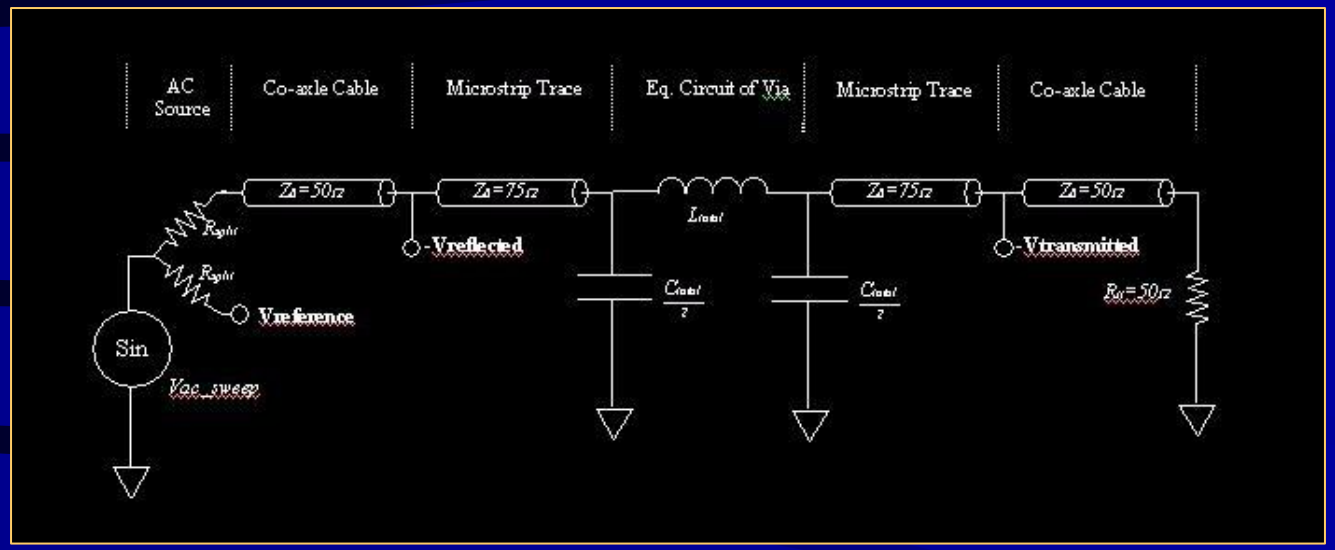






Network Analysis

(Experimental Setup)



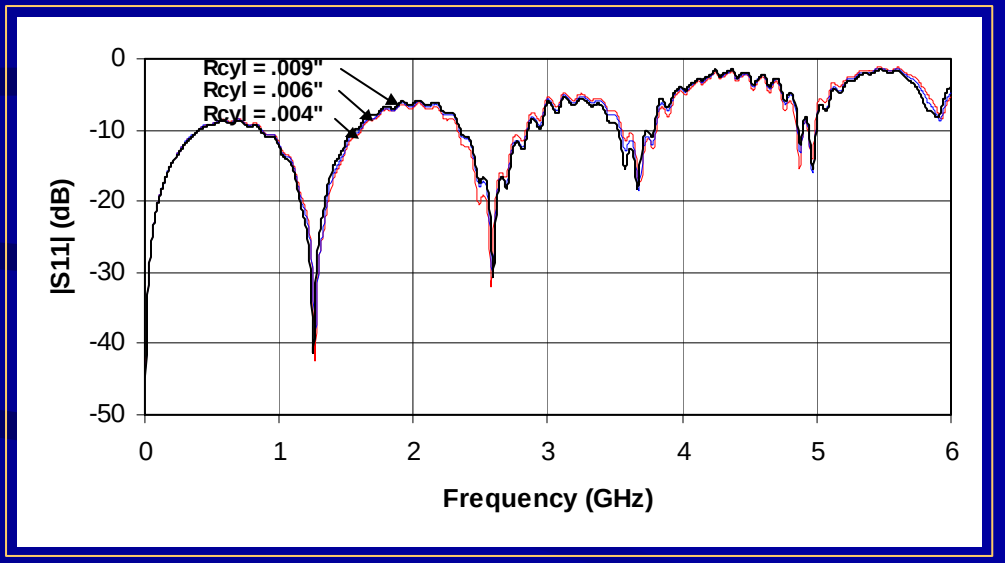
Circuit of Experimental Setup

Actual Laboratory Setup

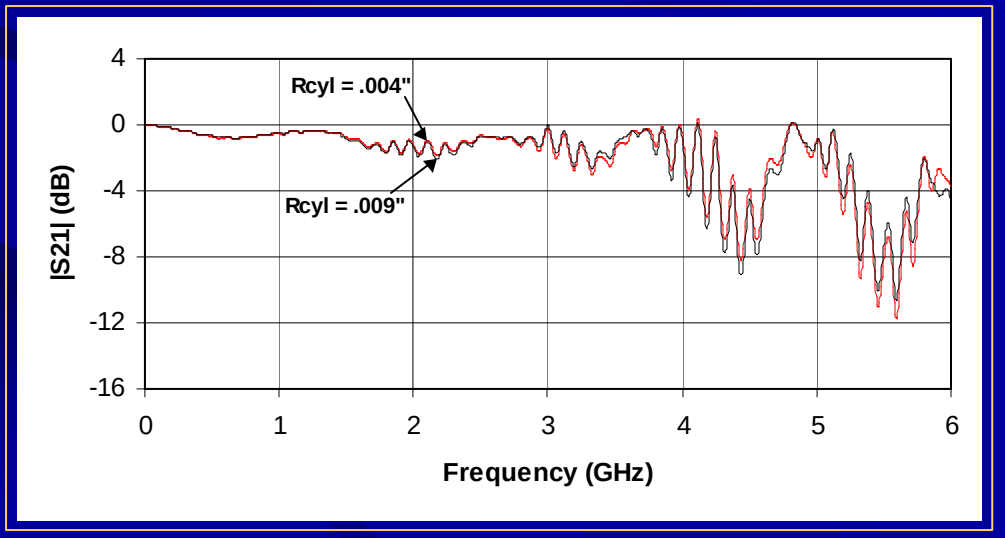
Network Analysis

(Empirical Data)

- $|S_{11}|$ (dB) (reflected) varying cylinder radius



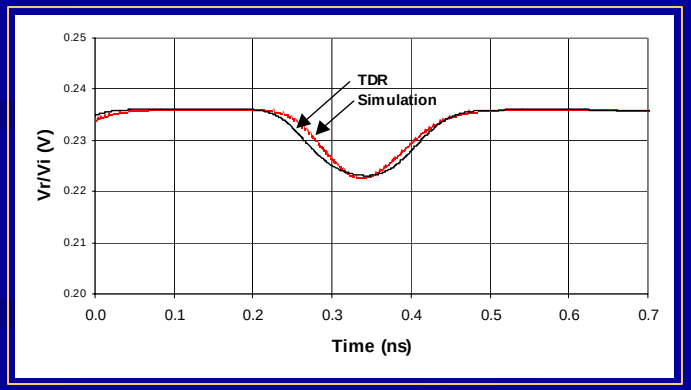
- $|S_{21}|$ (dB) (transmitted) varying cylinder radius



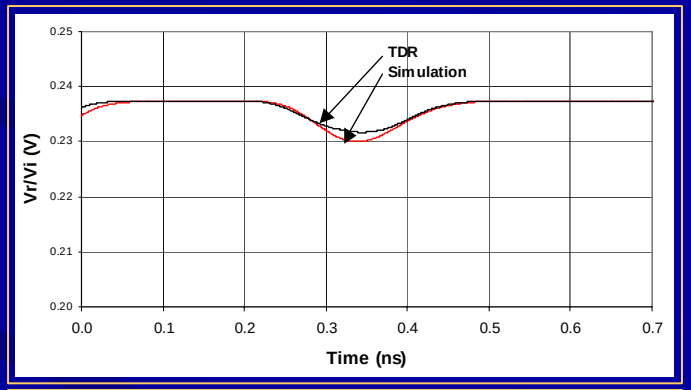
Simulation vs. Empirical Data

(Time Domain Reflectometry)

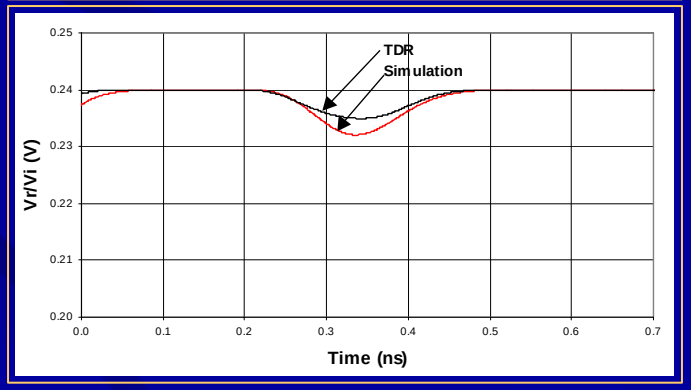
- Pad Radius Example



- Cylinder Radius Example



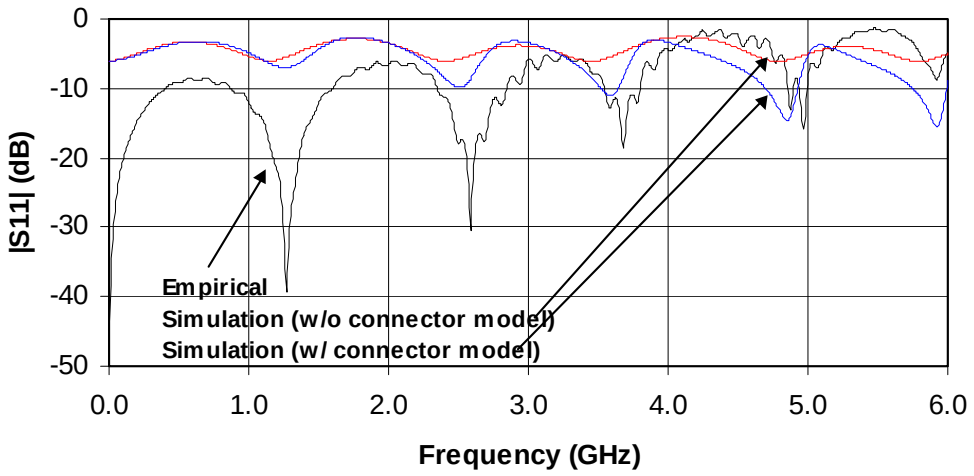
- Ground Clearance Radius Example



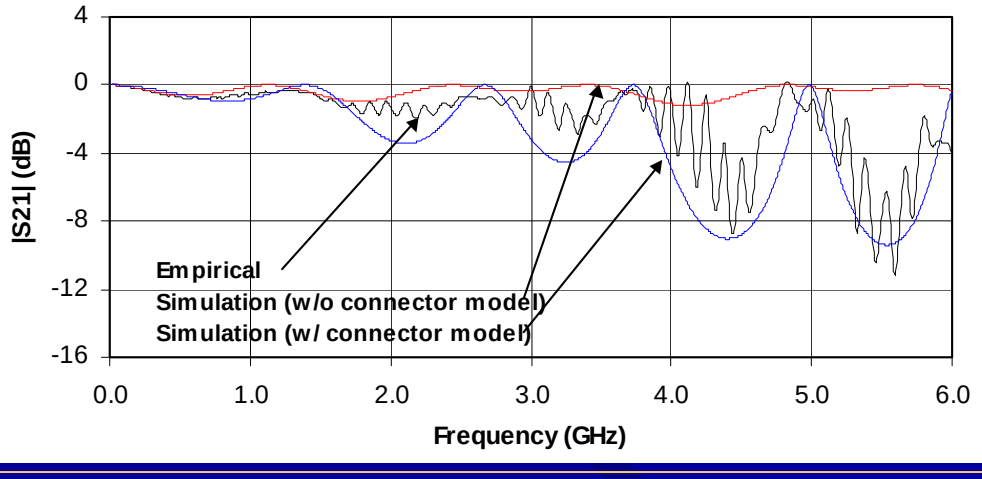
Simulation vs. Empirical Data

(Network Analysis)

- $|S_{11}|$ (dB)

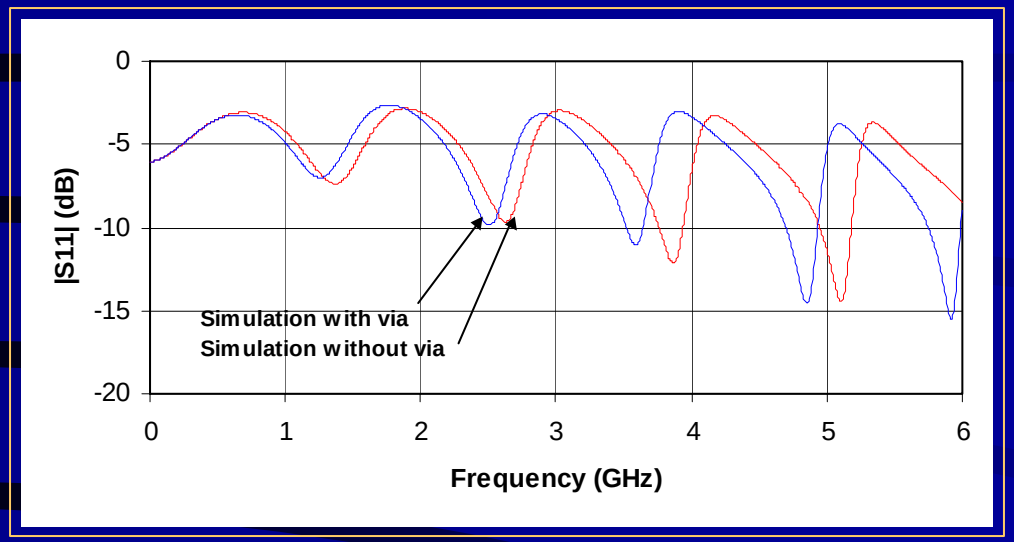


- $|S_{21}|$ (dB)



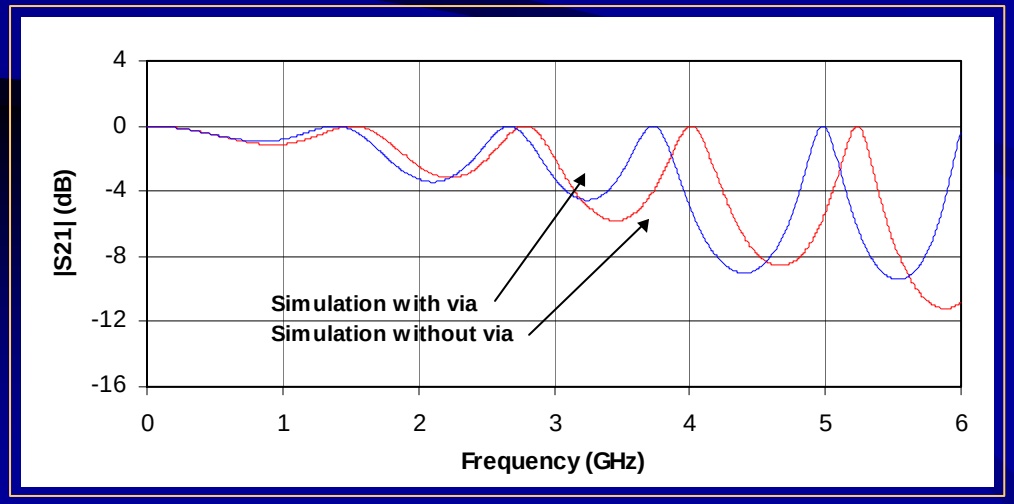
Effect of Via on S-Parameters

(including trace and pcb connectors)



- $|S_{11}|$ (dB)

  (with and without via)



- $|S_{21}|$ (dB)

  (with and without via)

Design Guidelines

(for minimizing the via discontinuity)

[1] Use the minimum size drill bit for creating the via cylinder.

[2] Use the minimum size via pad radius.

[3] Do not use the minimum size ground clearance radius.

[4] Use the thinnest printed circuit board possible.

[5] Place ground vias around the signal via when passing through multiple ground planes.

Conclusion

- An Equivalent Circuit was presented that can accurately characterize a printed circuit board via.
- When used with 3D EM Field Simulation, the actual response of the via can be predicted.

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Questions or Comments?

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