Examining the Impact of Power Structures on EM Model Accuracy

8-TA3

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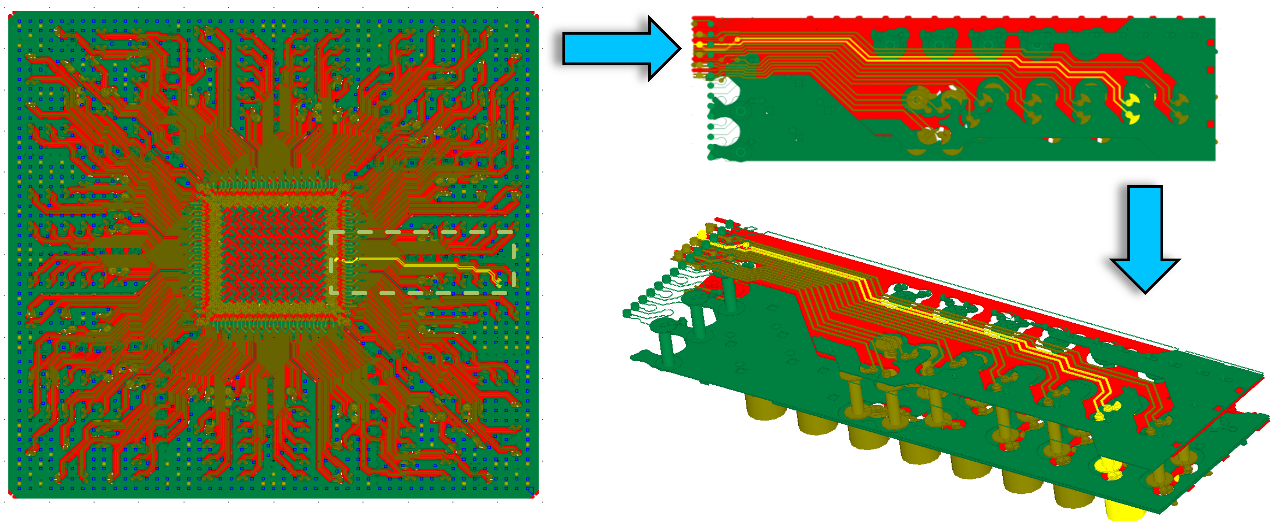
Introduction

- 3D FWS are considered to be some of the most accurate field solvers
- With typical compute resources, it isn't practical to analyze whole packages
- Consequently, 3D EM models are often developed with certain assumptions to reduce solve time



Introduction

- Implicit or explicit assumptions can impact model accuracy
- For example, high-frequency return current resides underneath or in vicinity of trace. But what happens at via transitions?
- Investigate the accuracy and limitations of these assumptions

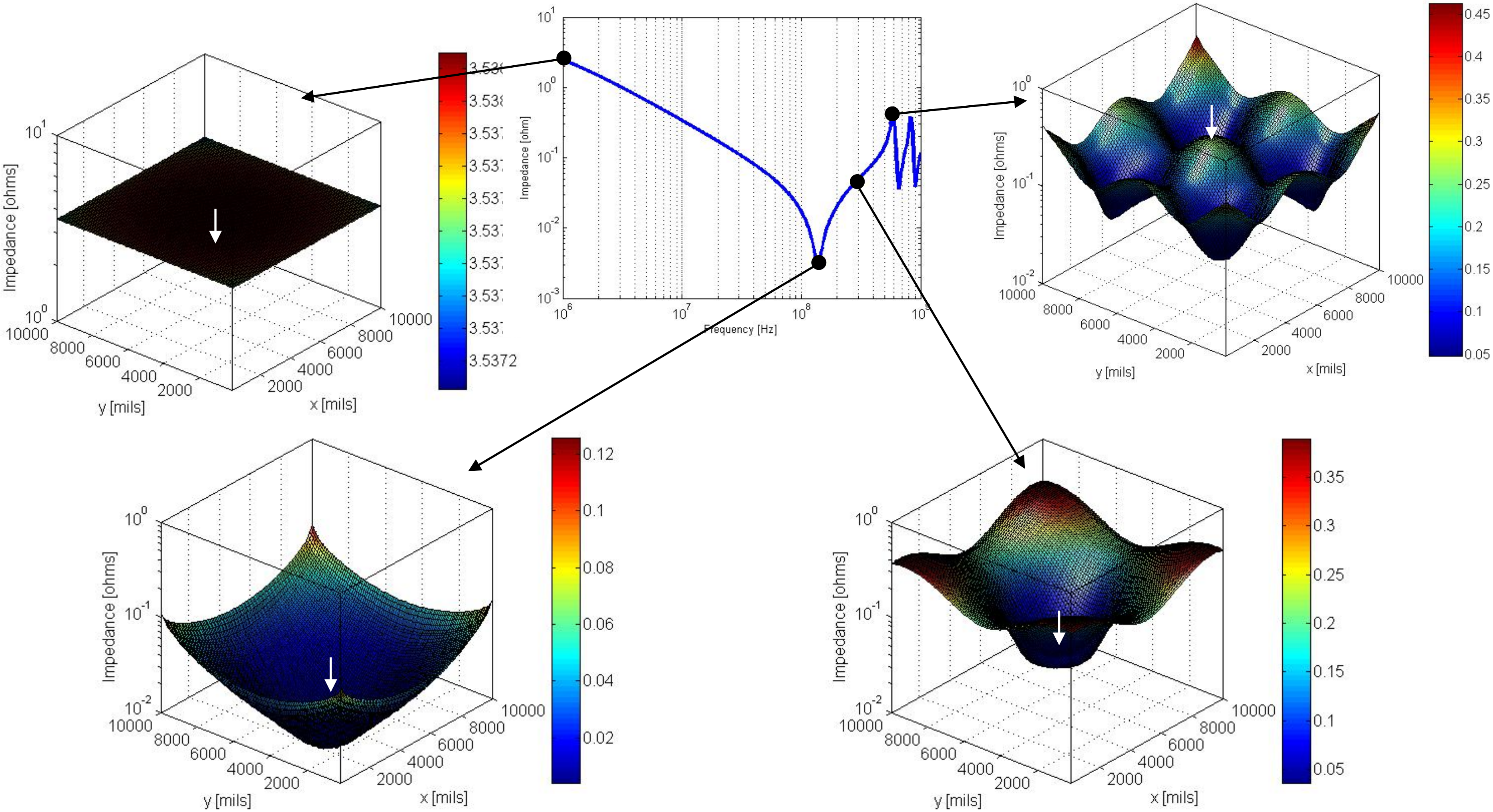
Questions:

- What is missed by sectioning or truncating the package?
- What interaction happens on the scale of typical packages?
- What field solvers can we use to simulate whole packages?
- Ultimately, how can we develop more accurate models?

Agenda

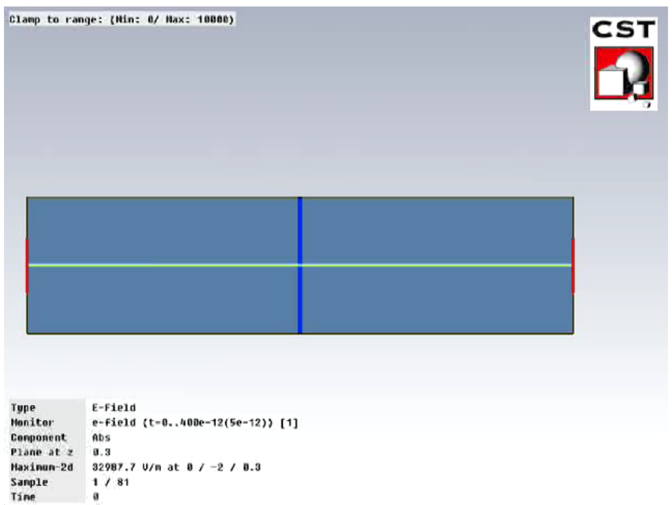
- Brief theory of cavity resonances
- Signal and cavity interactions
  - Excitation of cavities
  - Modifying cavity resonances
  - Containment vias
- Boundary conditions
- Another Take on Via Impedance & Field non-locality
- Simulating signal-plane cavity interactions
  - Two package examples
  - Buildup vias versus core vias
- Correlation to measurements
- Summary

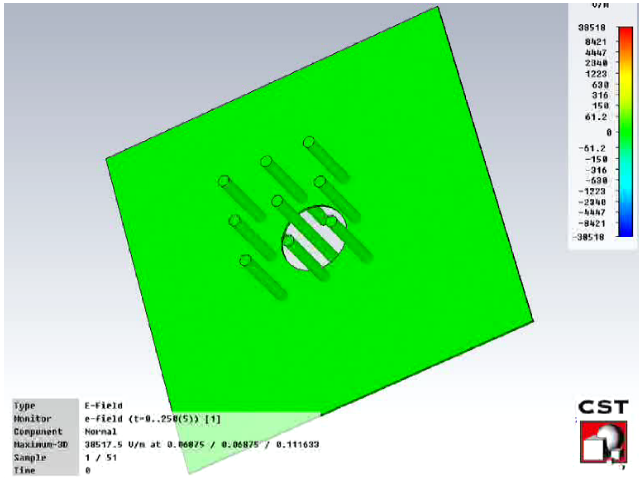
Brief Theory of Cavity Resonances



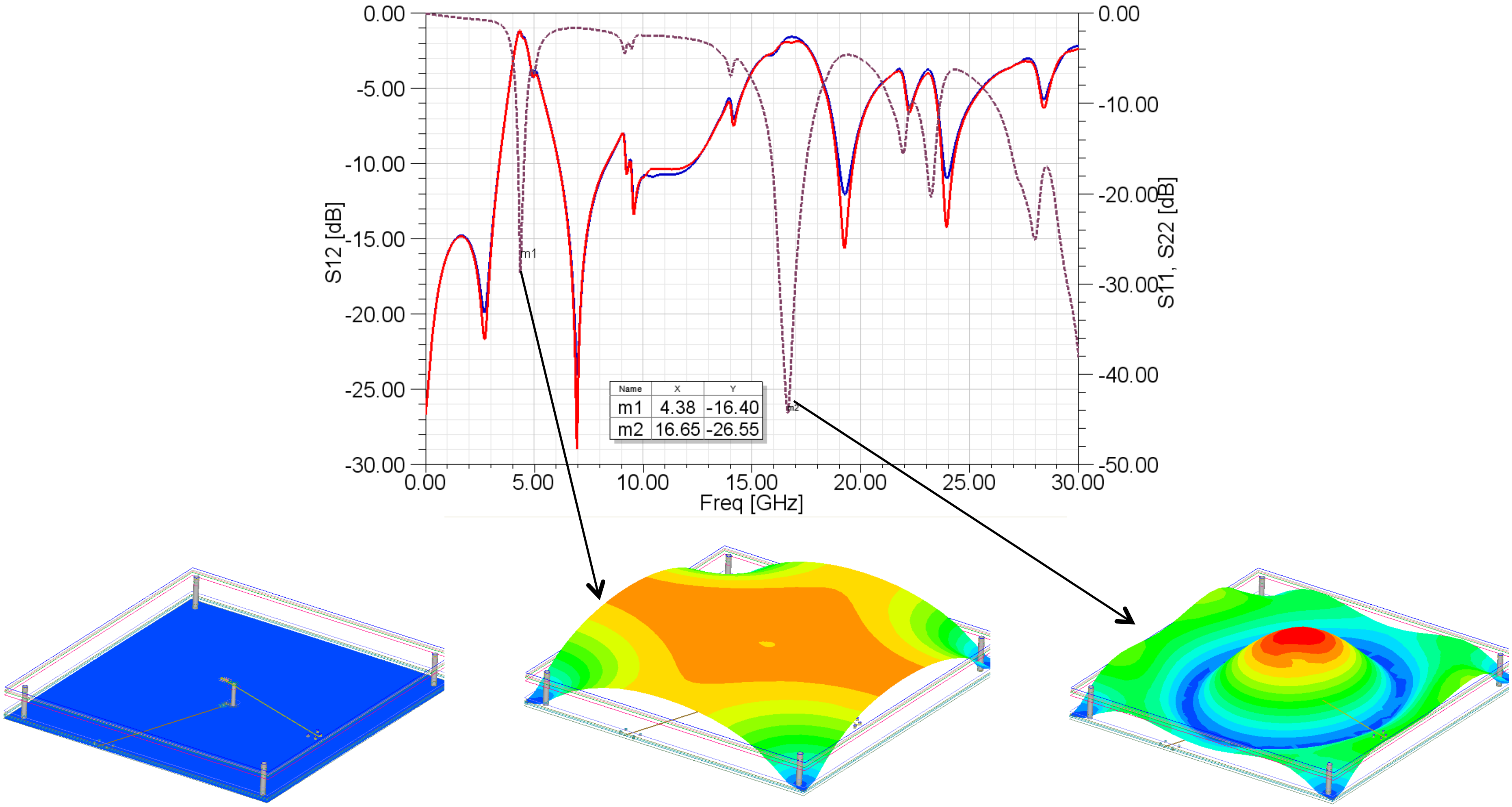
Signal Excitation of Plane Cavities

- Transmission line mode to parallel plane waveguide mode
  - ➢ Signal path discontinuity, e.g. due to a split
  - ➢ Via transitions
- Focus here is on excitation of cavities from signal vias transitioning through cavities.

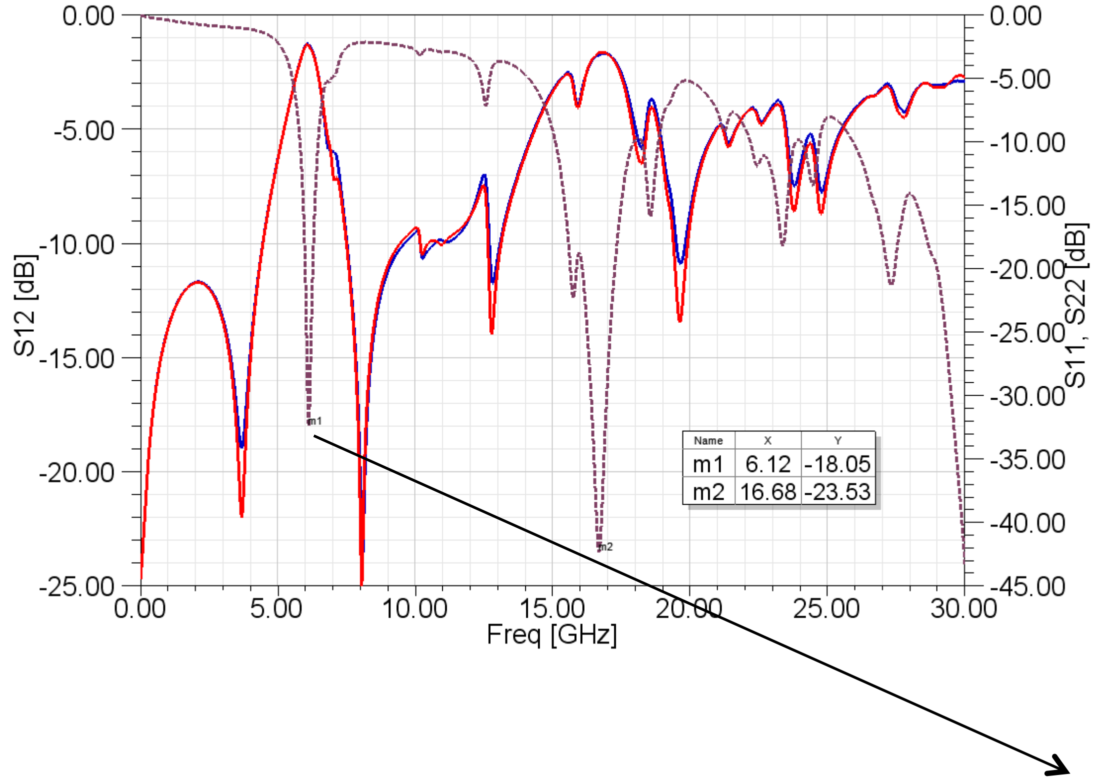


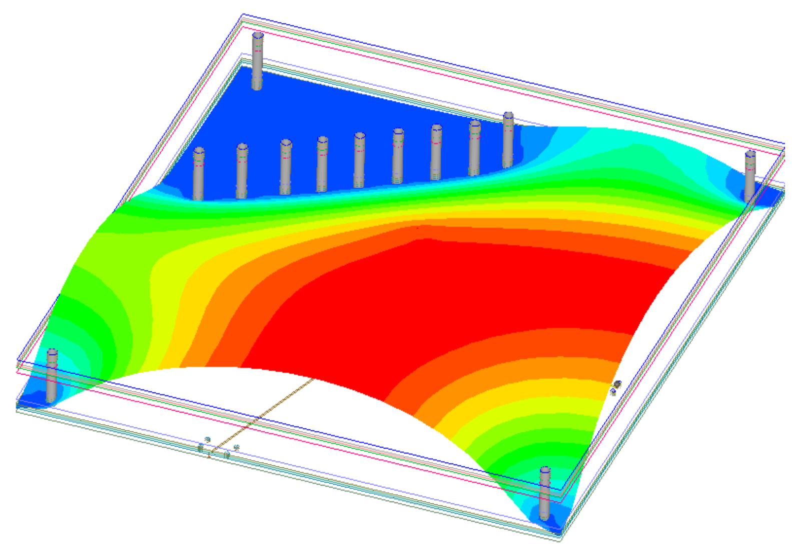


Signal and Cavity Interactions

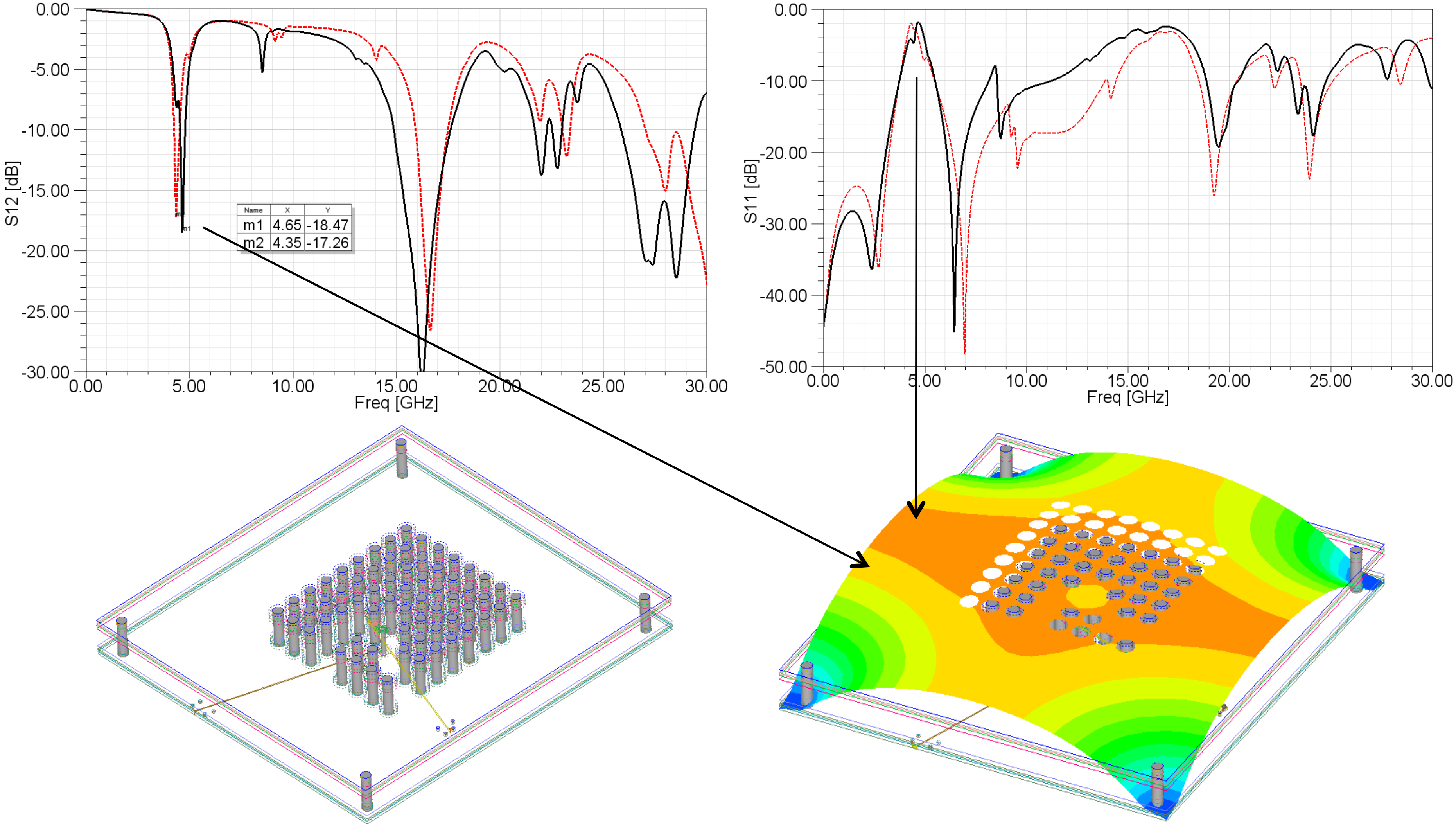


Modifying Cavity Resonances

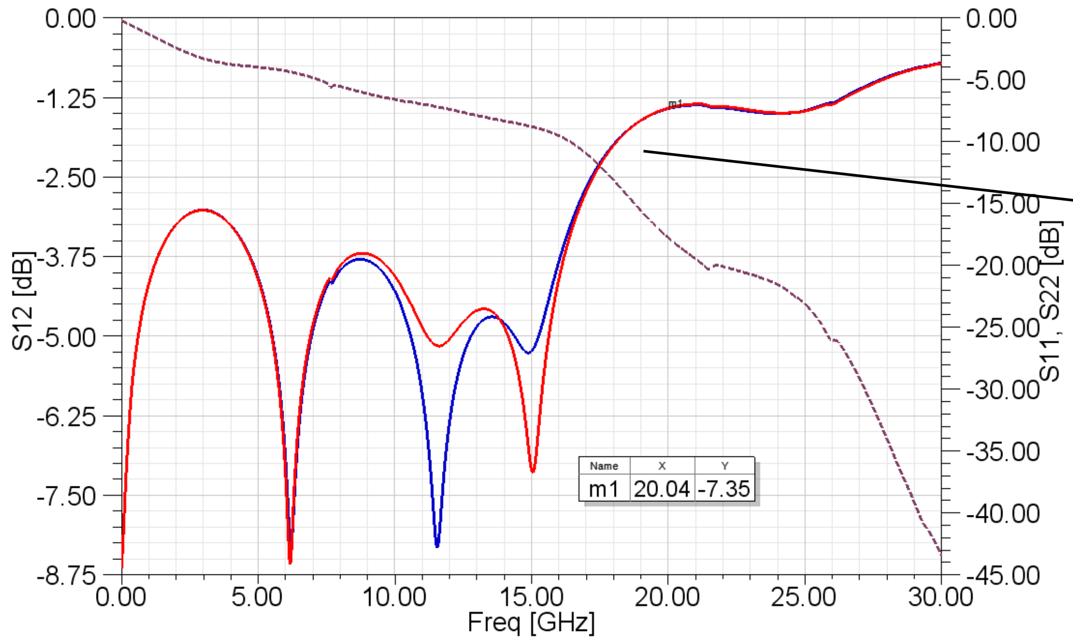


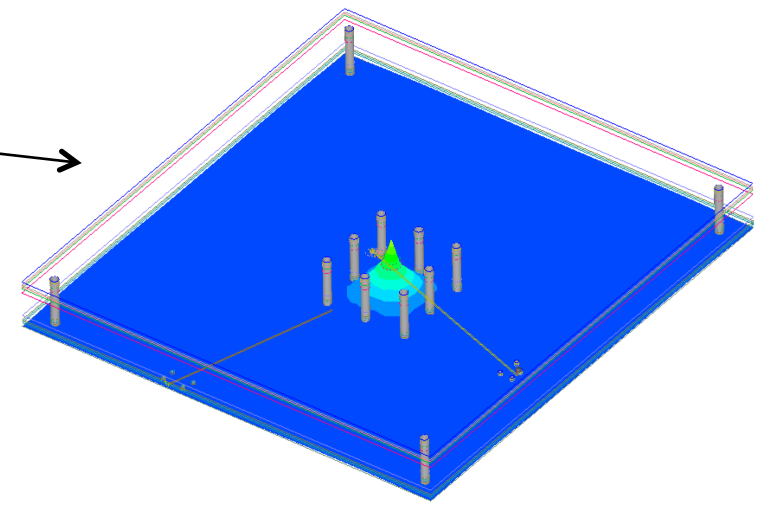


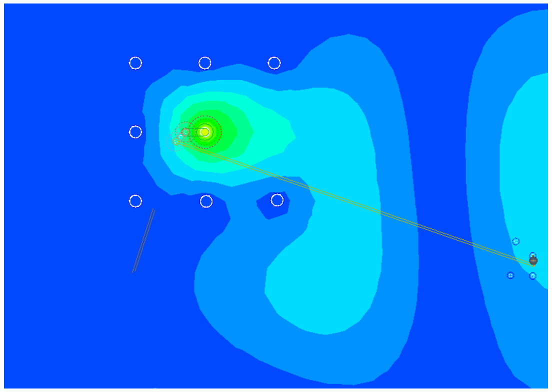
Modifying Cavity Resonances

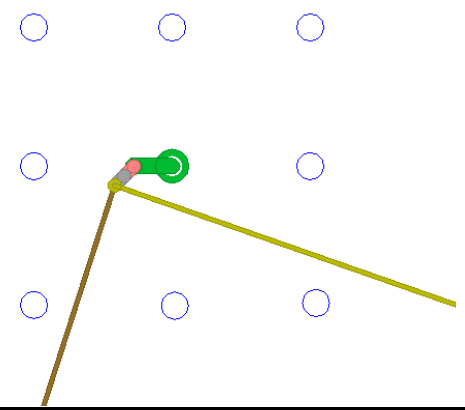


Containment Vias

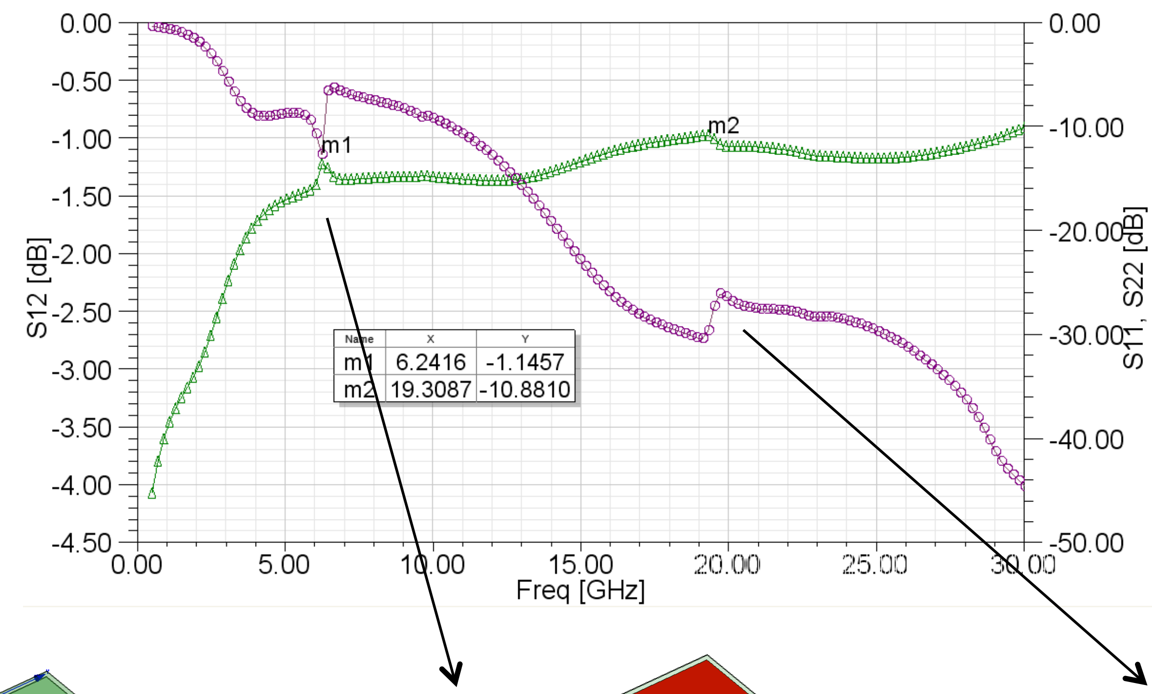


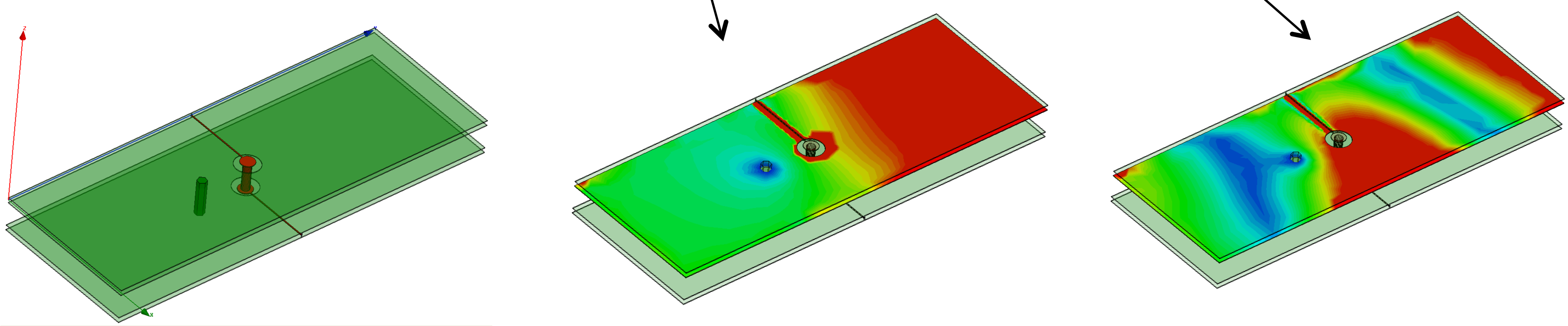






Solver Boundary Conditions





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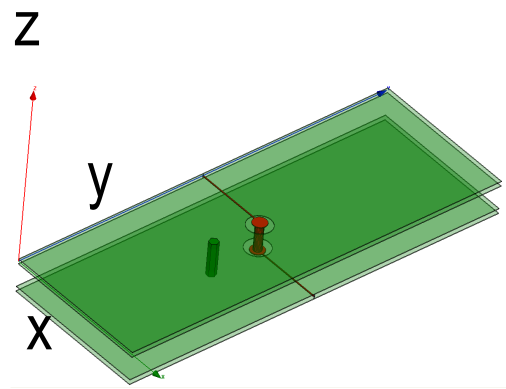
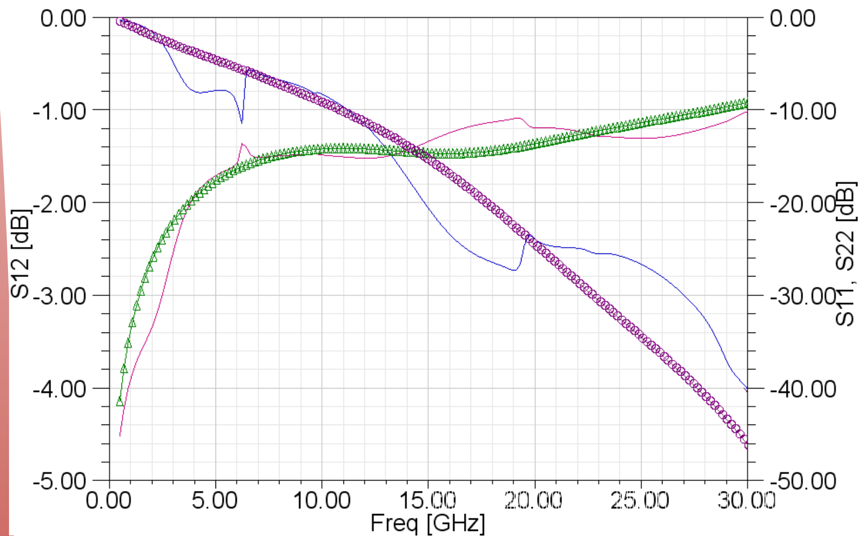
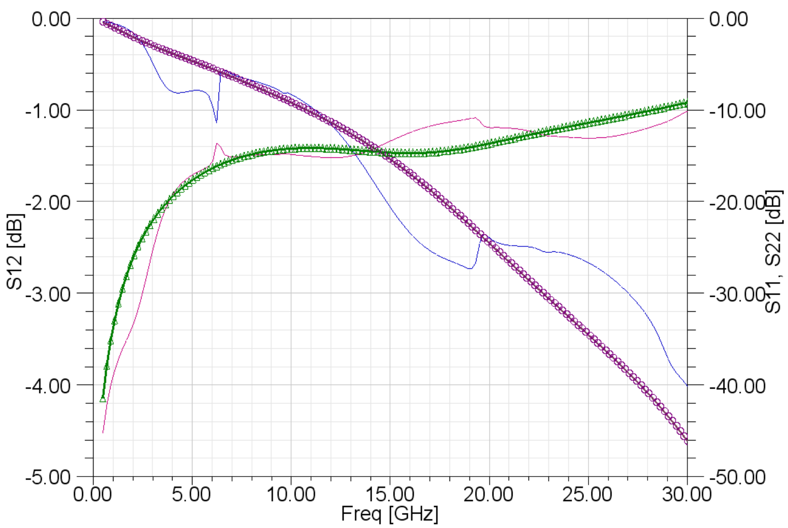


x-y-z absorbing boundary



x-z open boundary



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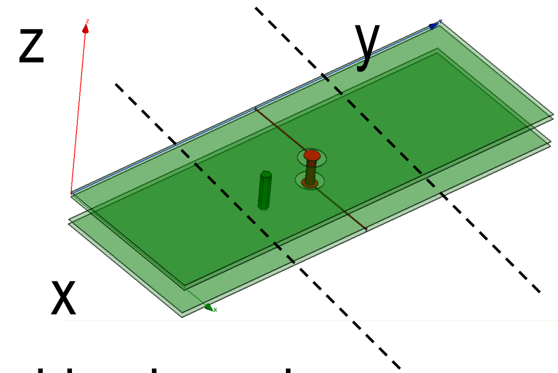
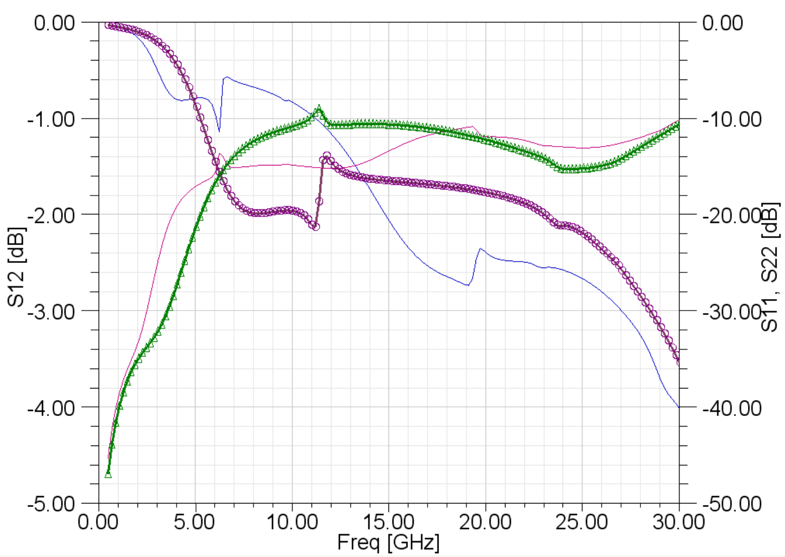
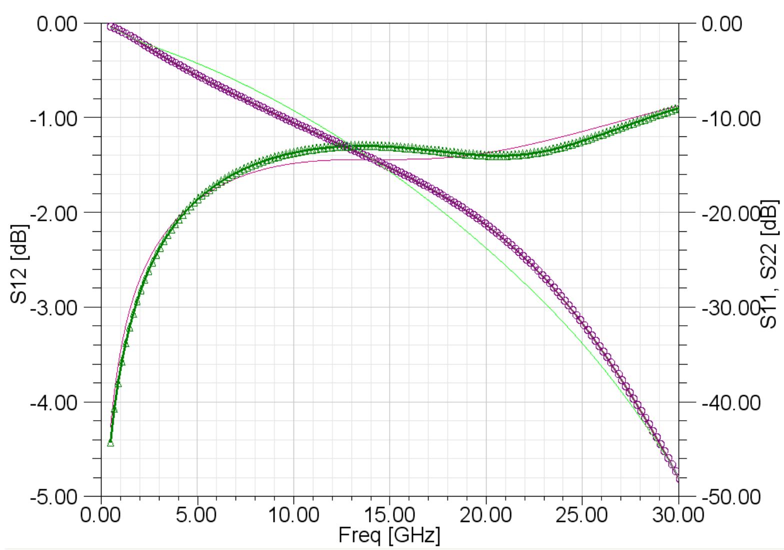


x-y-z open boundary
3 mm vs. 8 mm



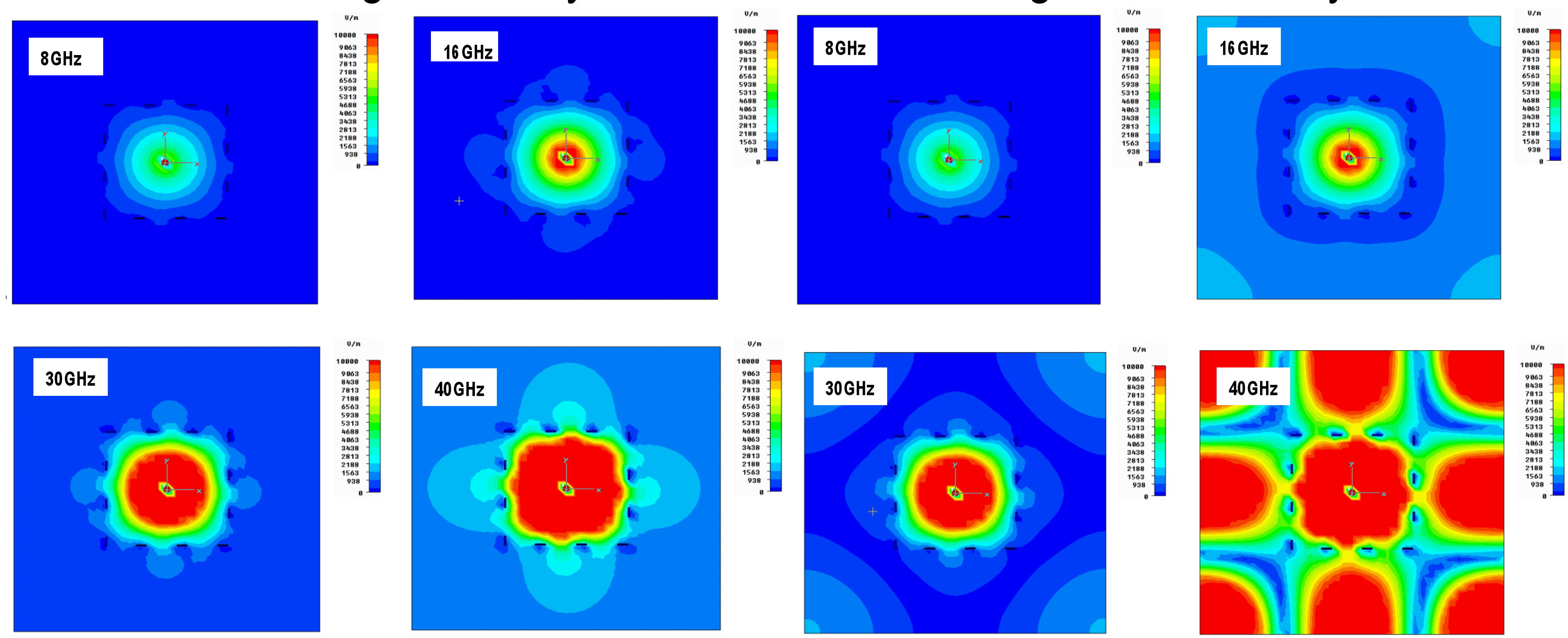
absorbing boundary
3 mm vs. 8 mm



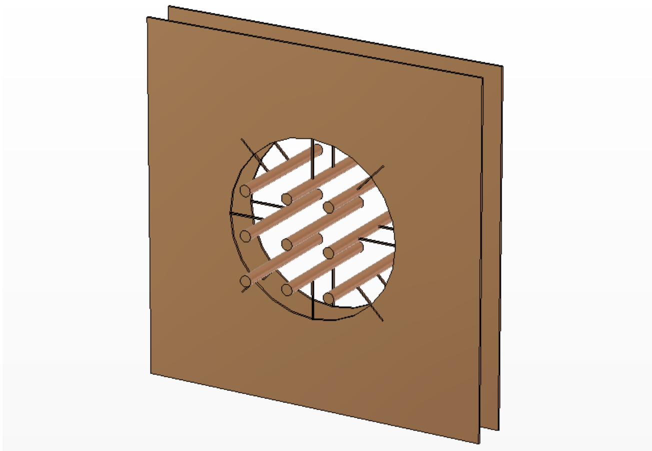
Containment Vias

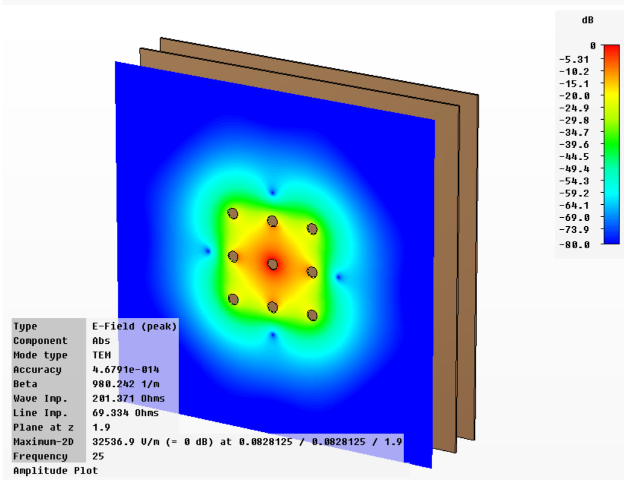
Absorbing Boundary

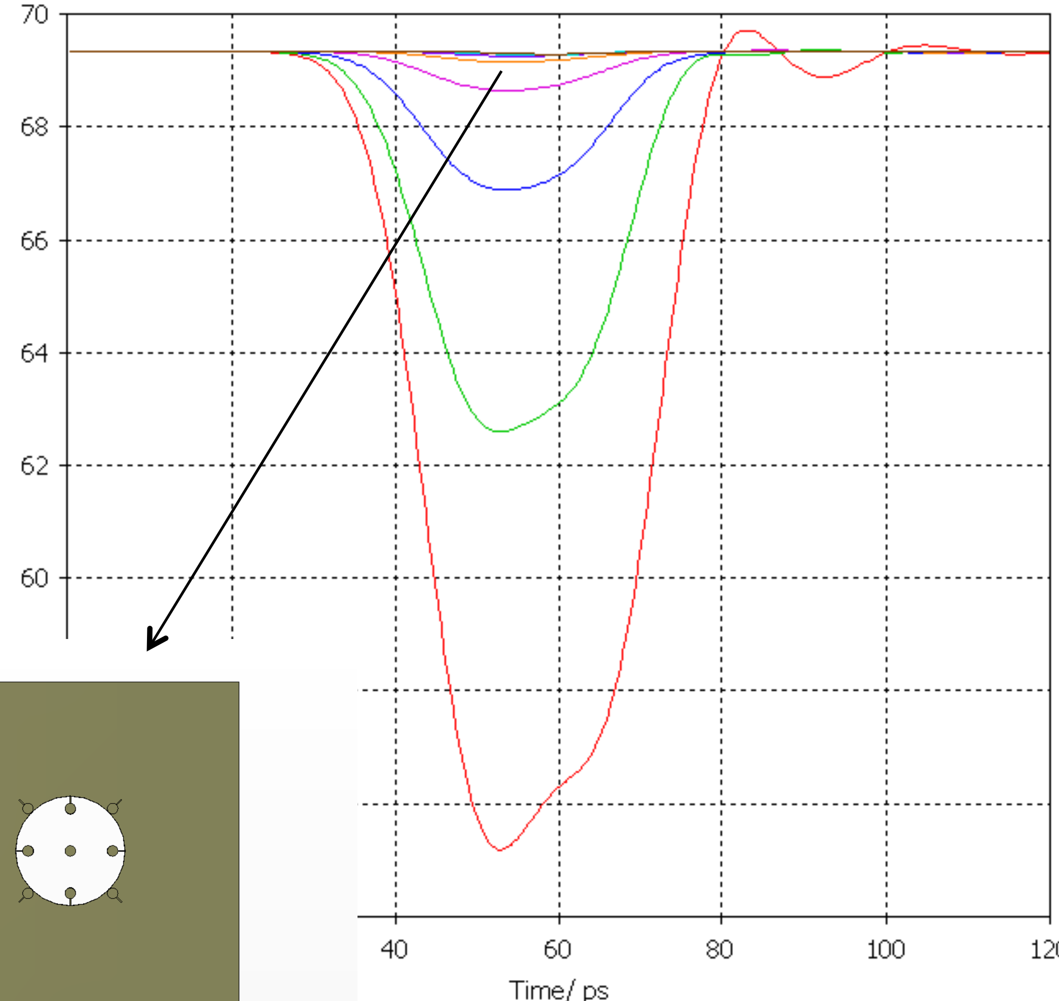
Magnetic Boundary



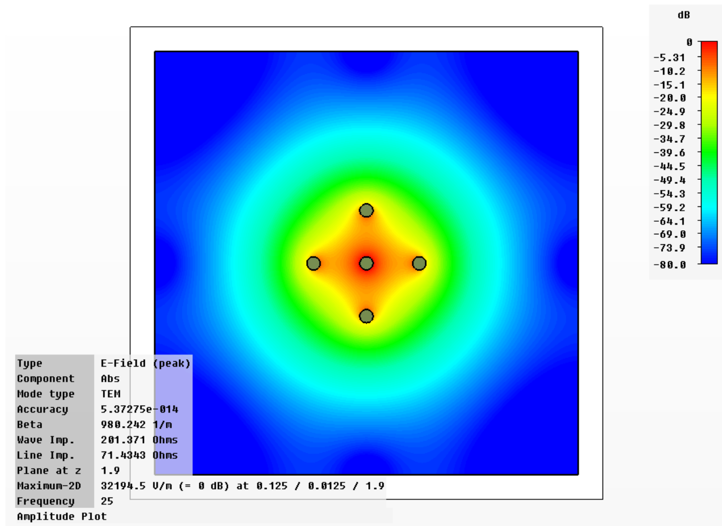
Another Take on Via Impedance

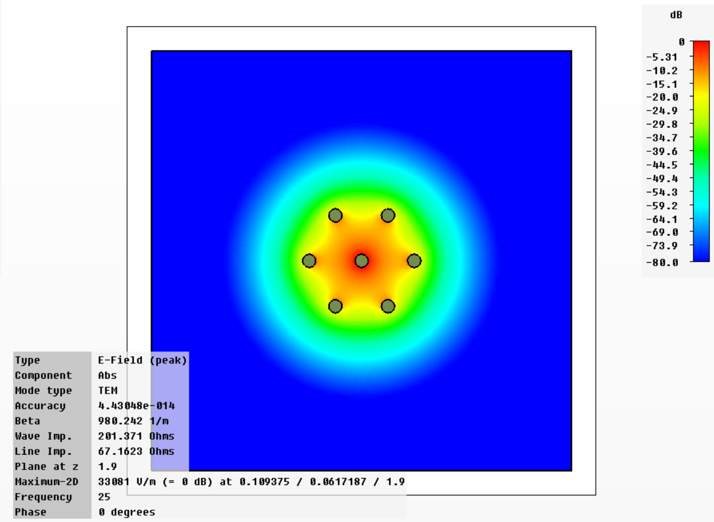


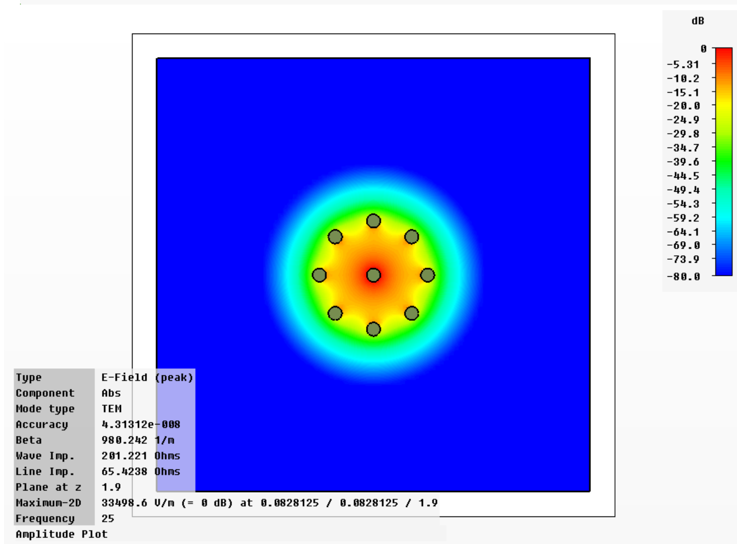


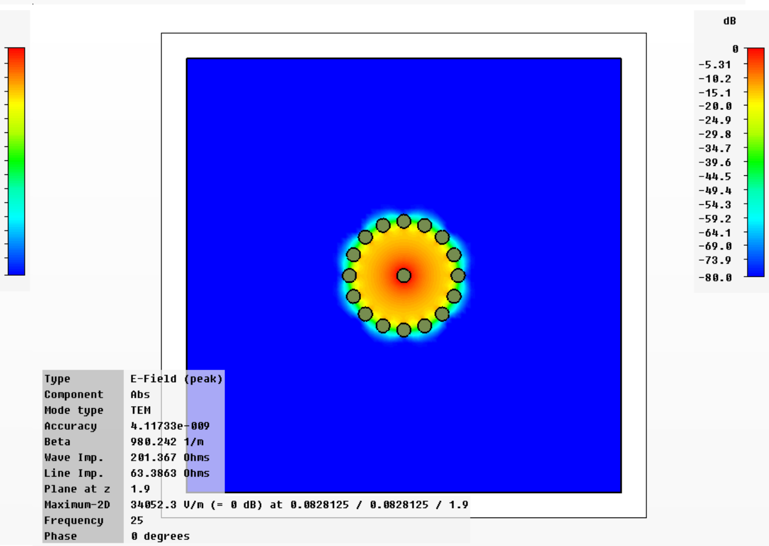


Non-locality of Fields









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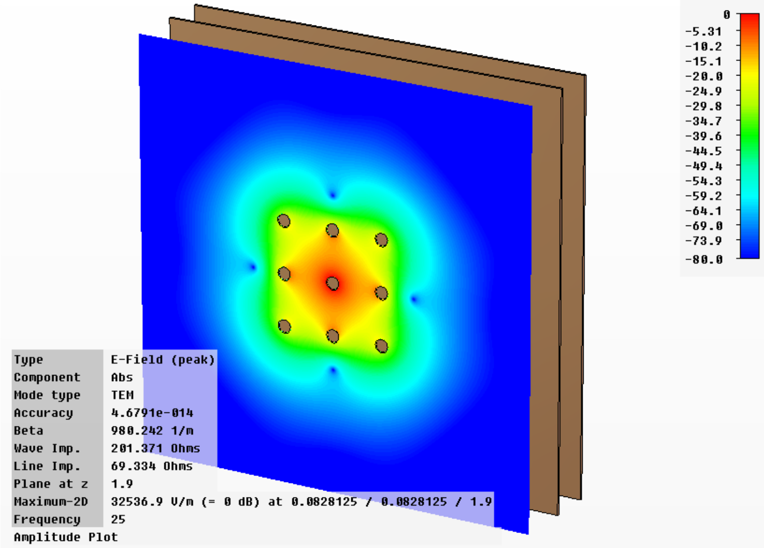
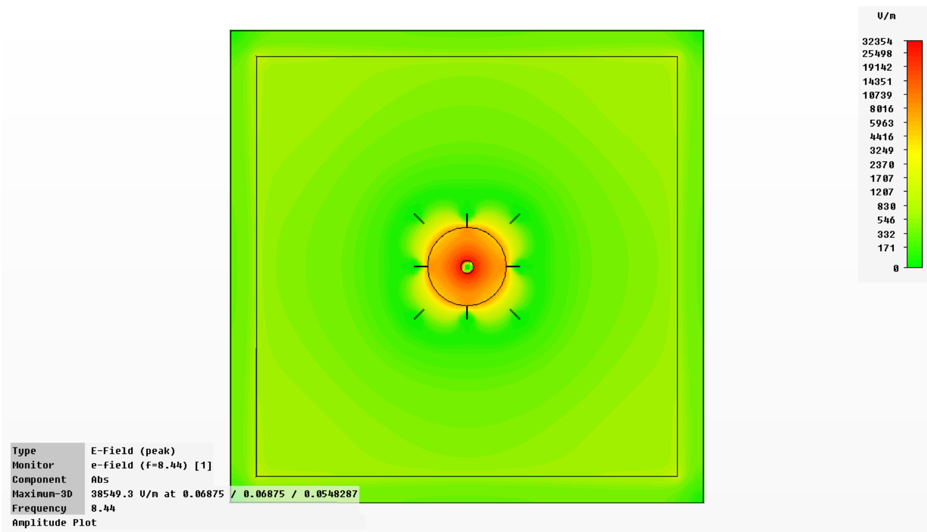
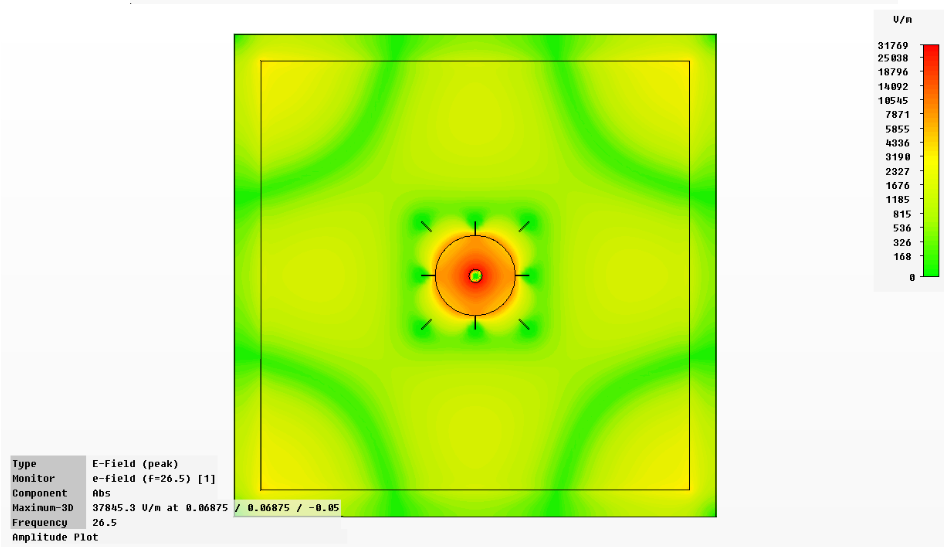
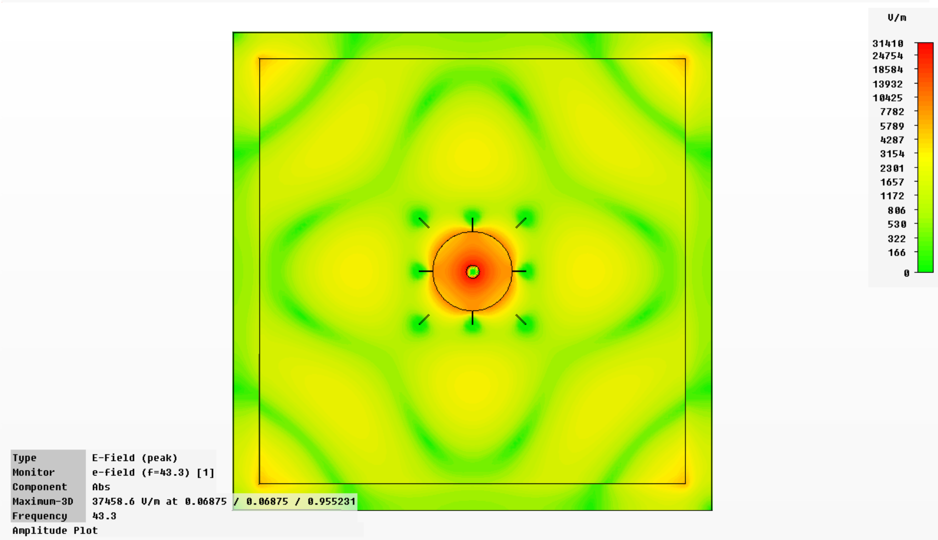
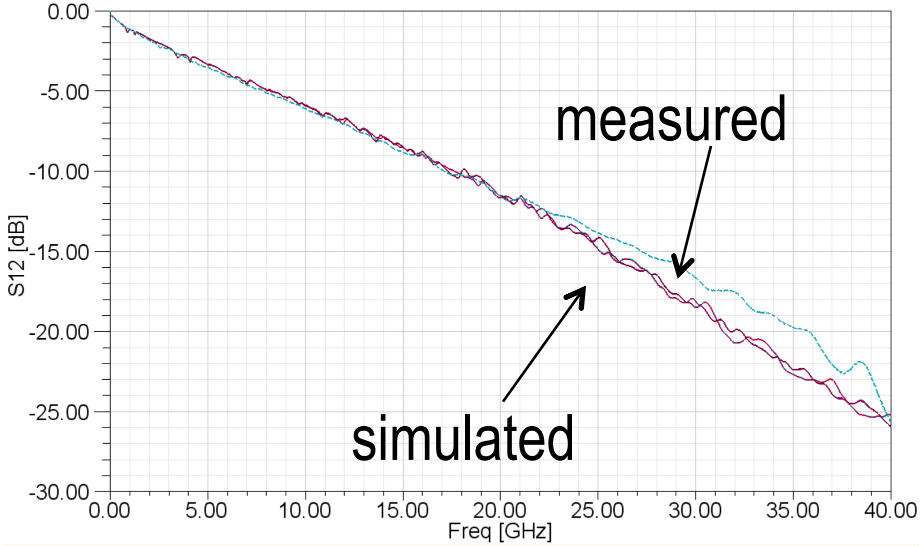


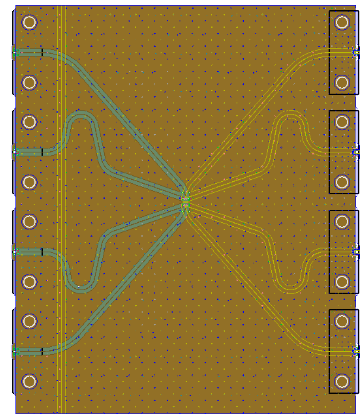


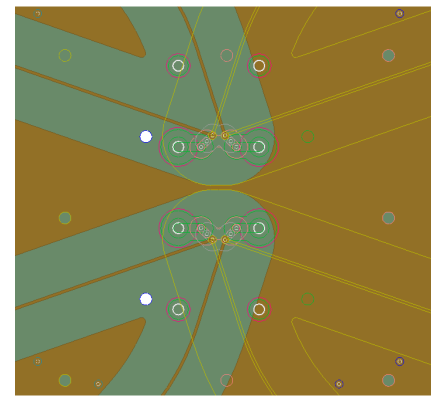


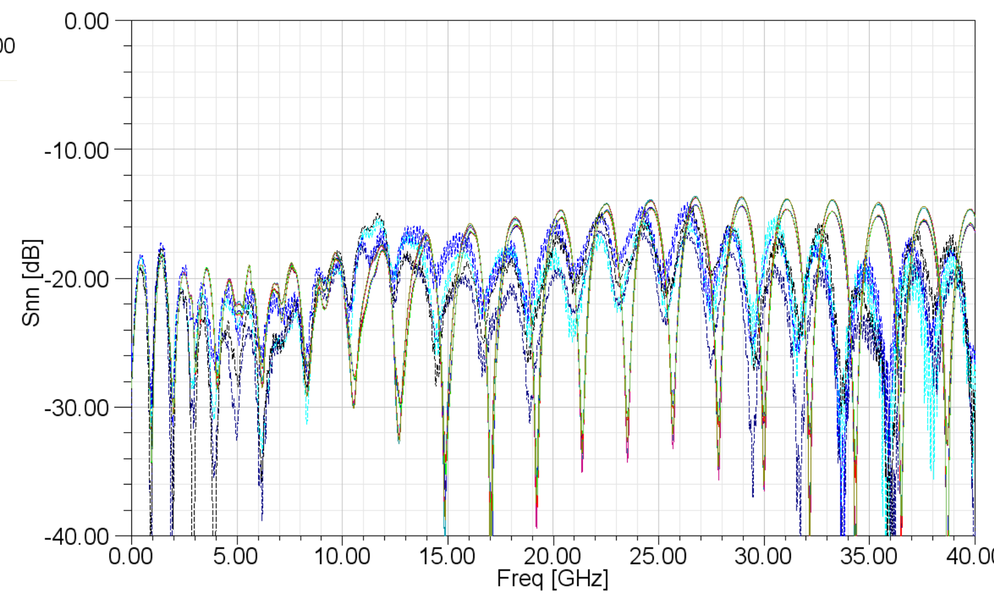


Coupled Differential Via Correlation

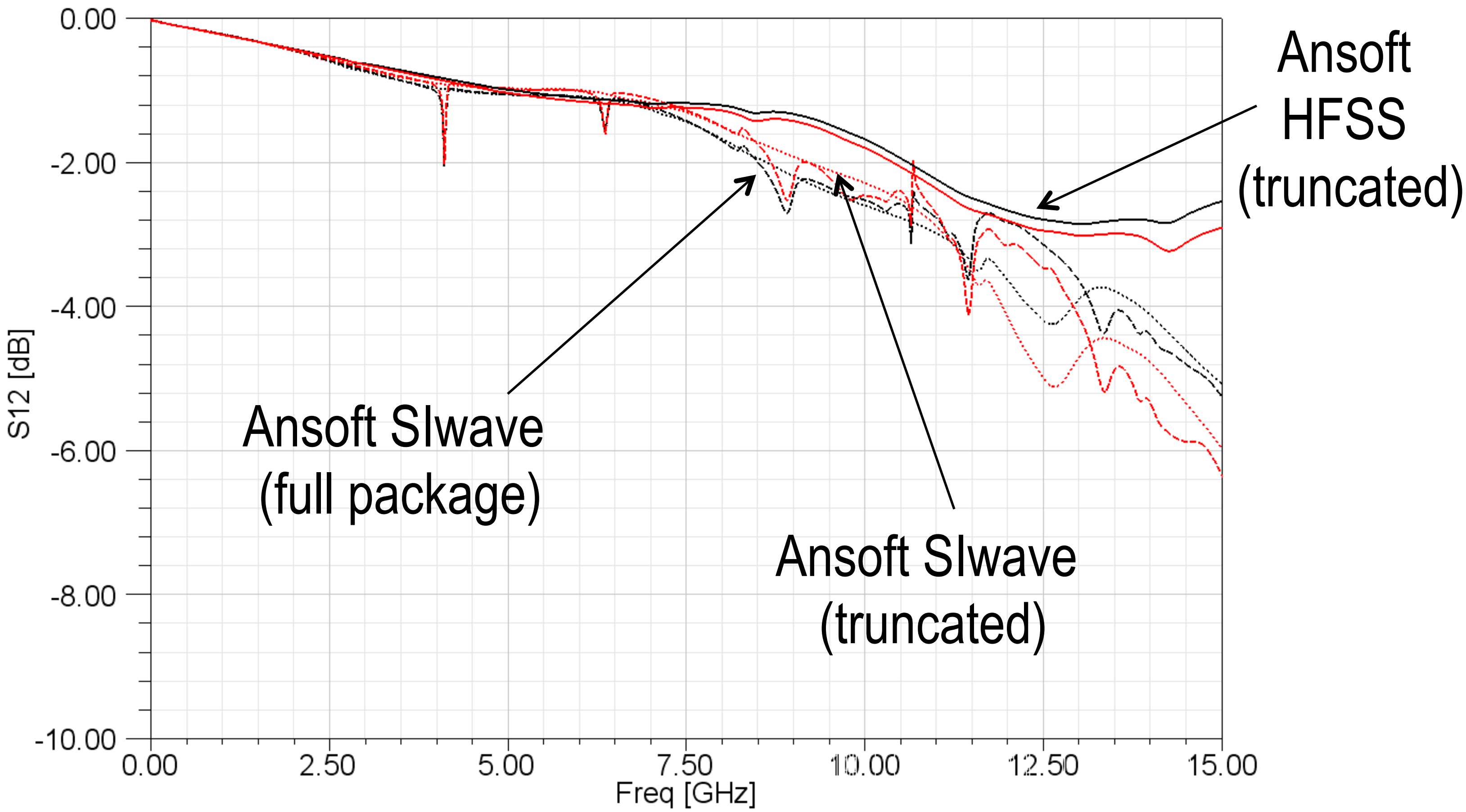








Simulating Signal-Plane Cavity Interactions



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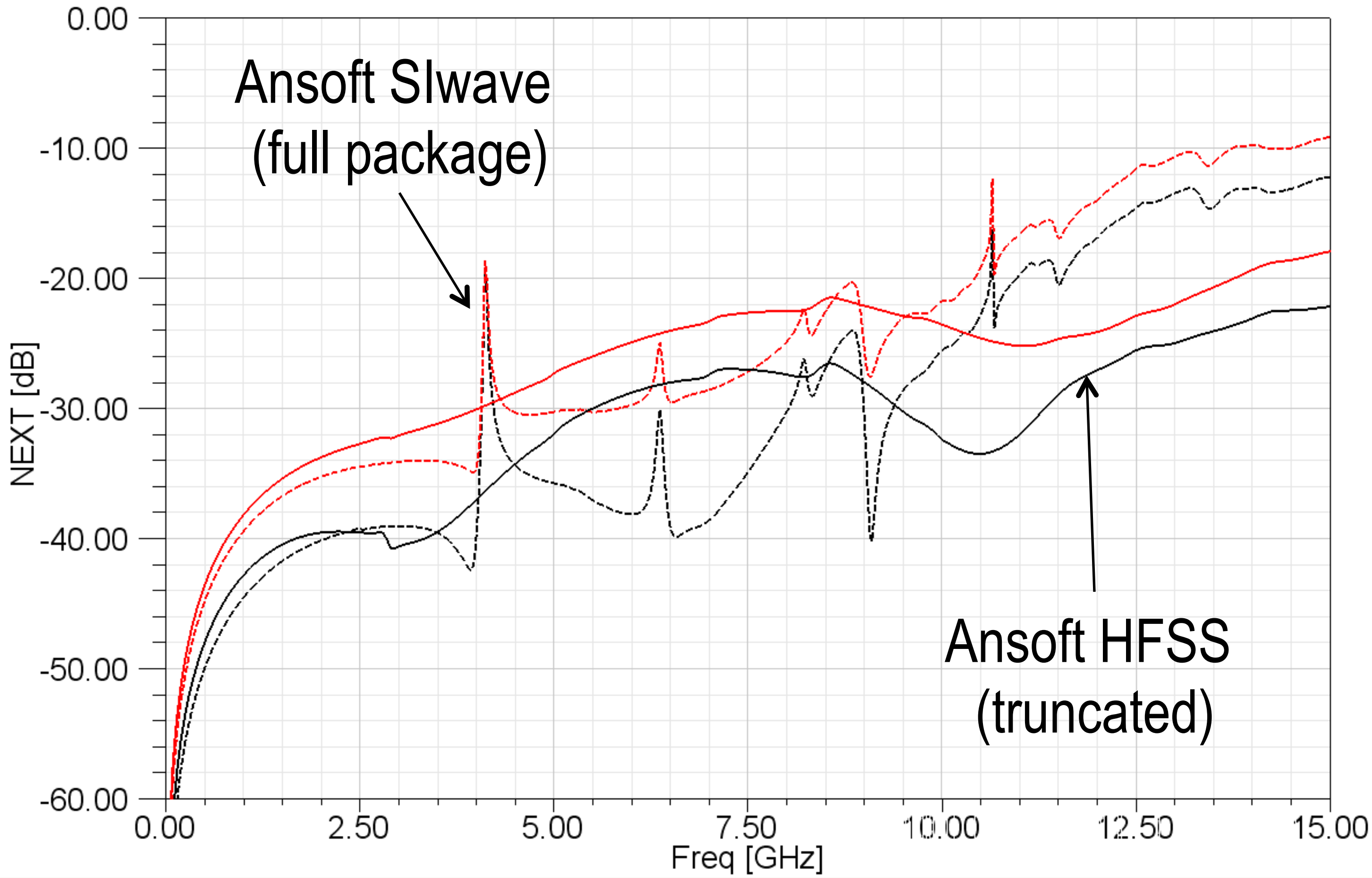
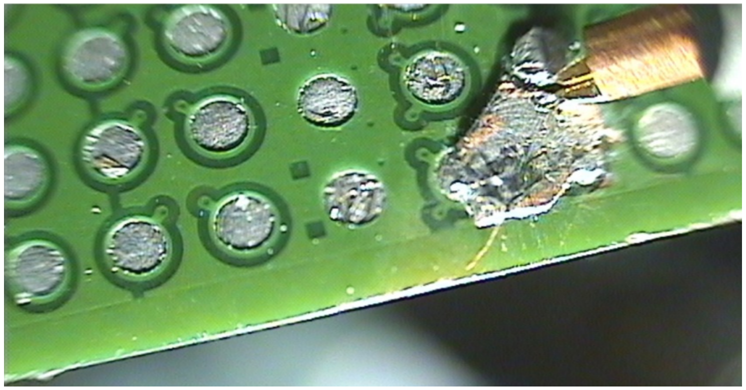
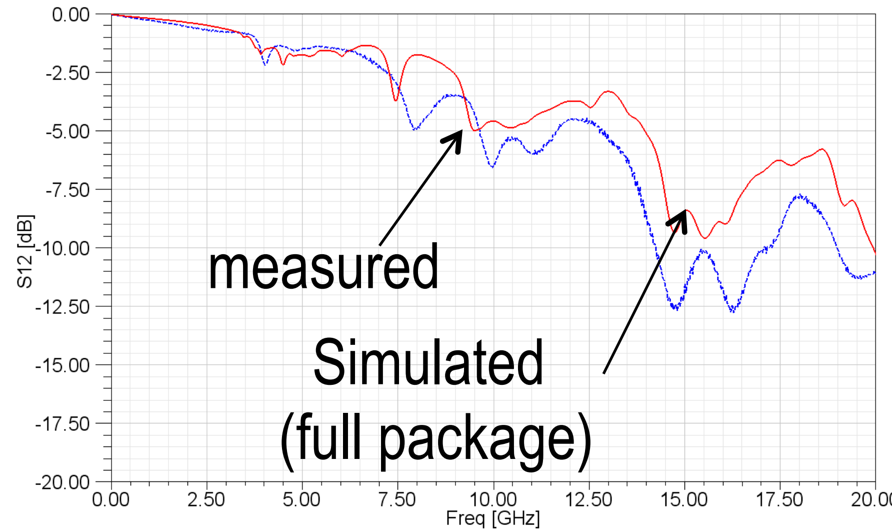


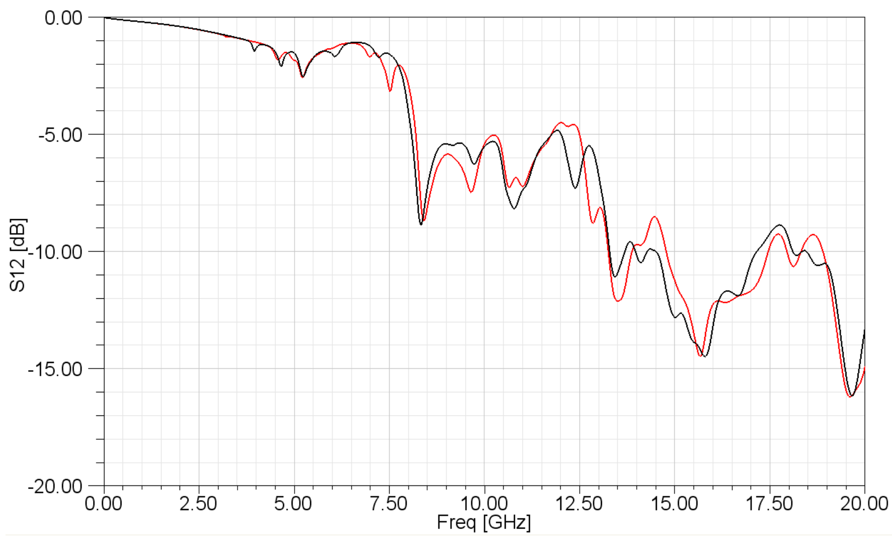
Differential vs. Single Ended Signals

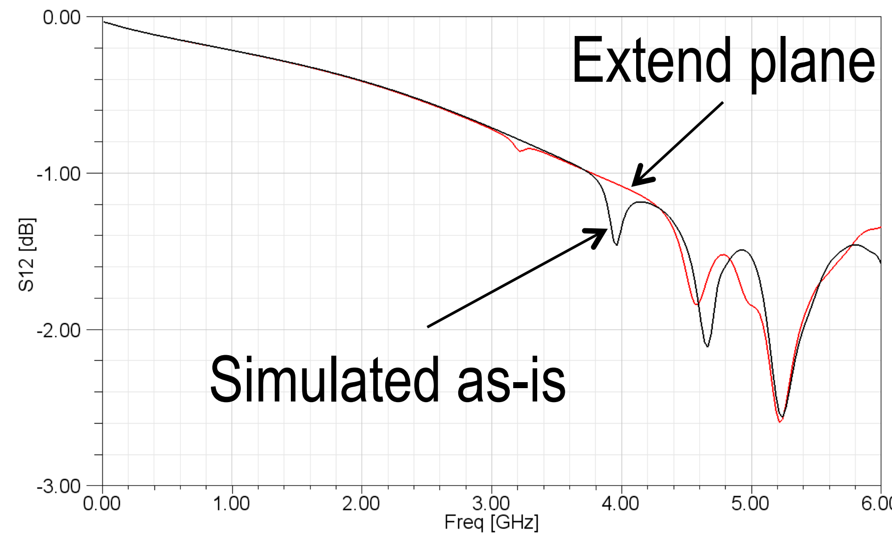
- In general differential signals show less IL and crosstalk peaking due to cavity modal resonances
- BUT mode conversion and NEXT will not make this go away
- NEXT is not subjected to channel losses
    - If Rx is subjected to say 20 dB channel loss than every channel will have 1-10% crosstalk
- Also note that this crosstalk is NOT localized, i.e. simply separating Rx and Tx doesn't necessarily address this

Simulating Signal-Plane Cavity Interactions

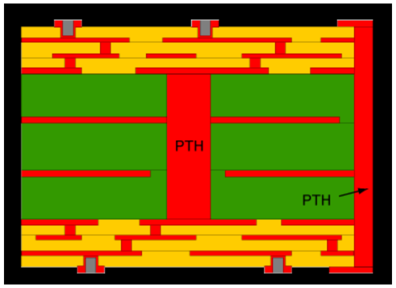


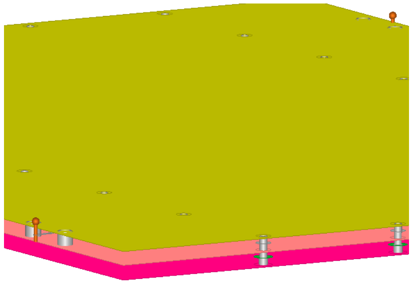


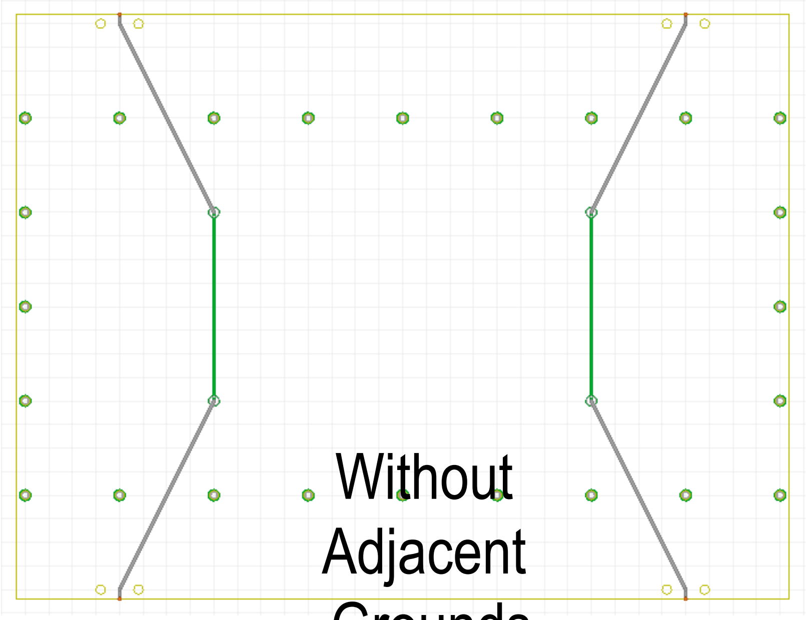


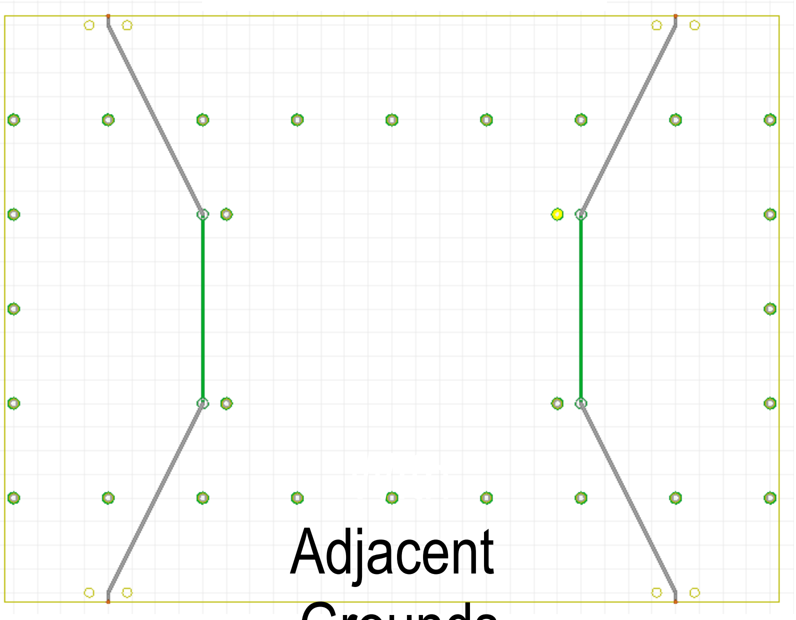


Thin Buildup Layer Test Design
Do those thin layers help?

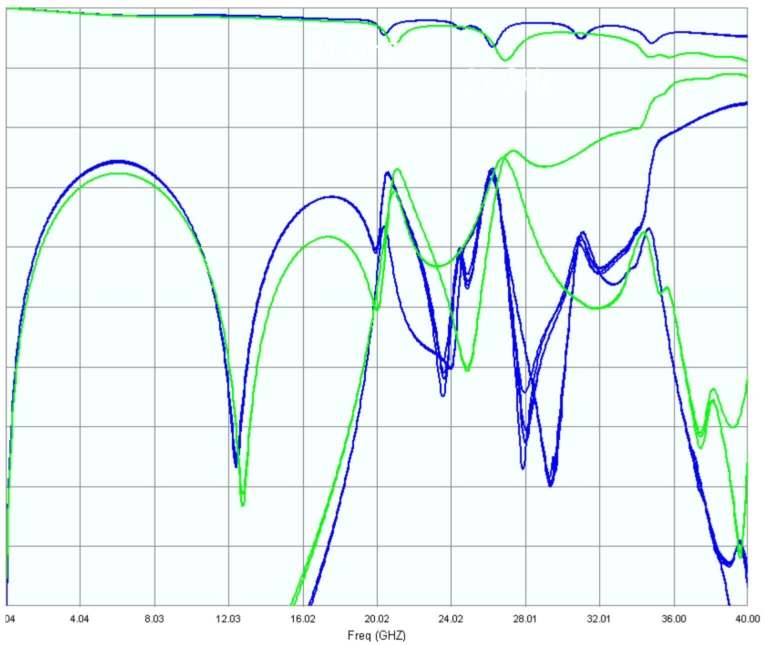




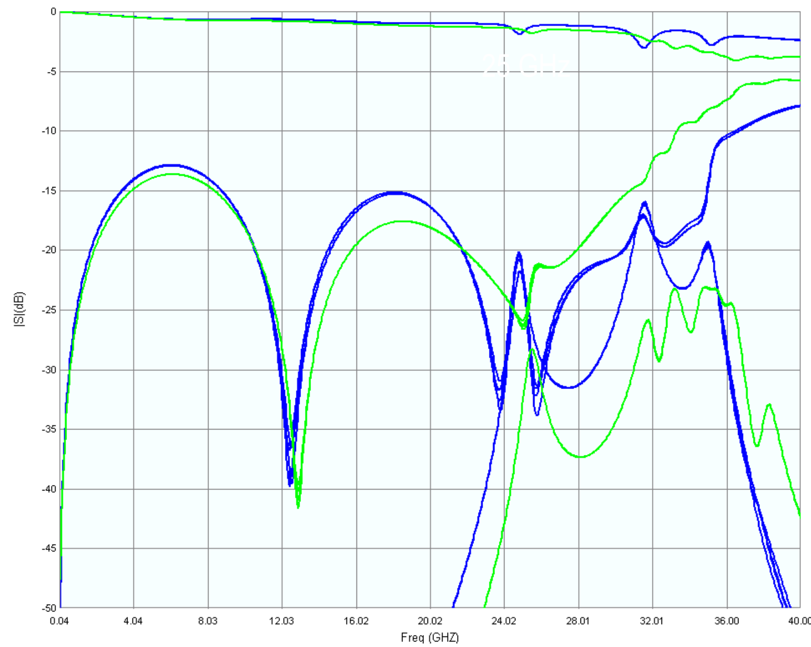




Thin Buildup Layer Via Excitation Simulation Comparison



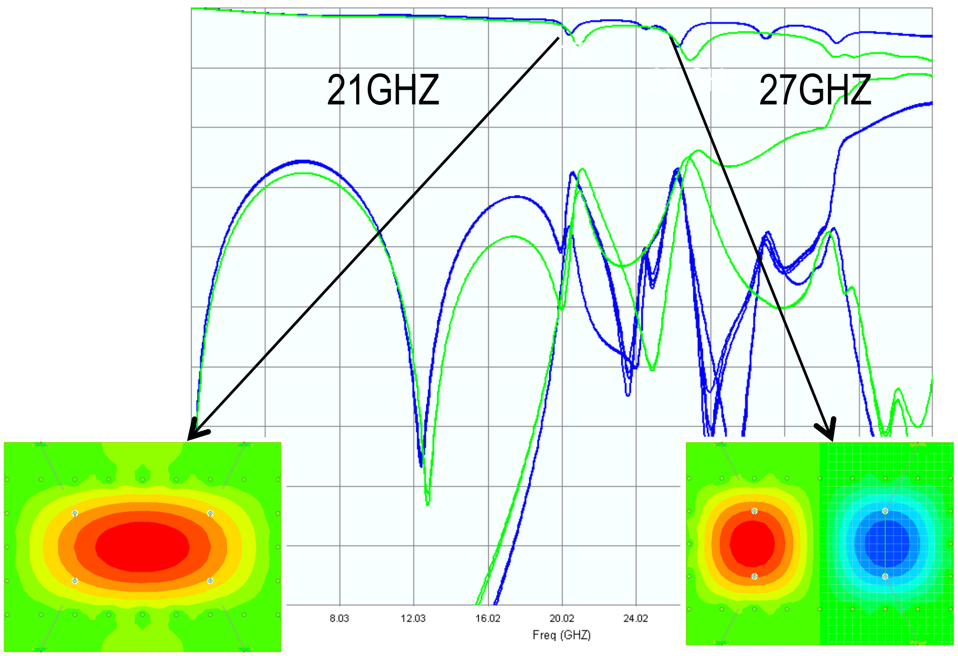
Signal vias only
Closest ground via 1 mm away



Ground vias adjacent to signal vias

Green – SIwave
Blue - HFSS

Thin Buildup Layer Via Excitation Simulation Comparison



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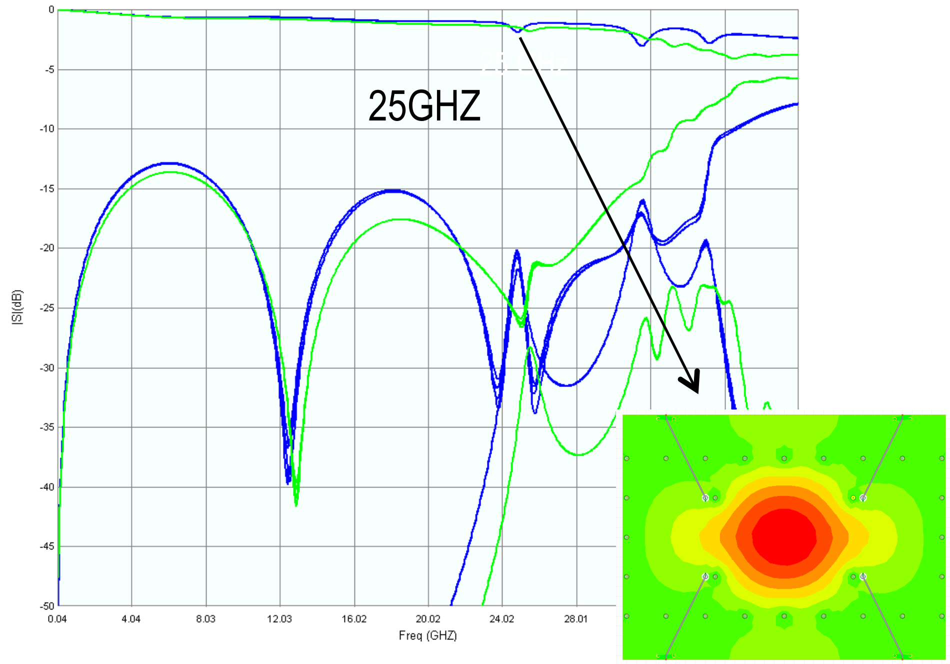

Ground vias adjacent to signal vias

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Conservation of Misery

- Without additional dissipation, ground vias only serve to move resonance problems out of band.
- The higher the frequency, the harder it is to “Whack” the mole.

Summary

- Package model extraction using truncated or segmented models has assumptions and limitations
- Vertical transitions in packages and PCBs can excite cavities
- Cavity resonances can have a significant impact on the signal loss, crosstalk and return loss
- Cavity resonances can generate crosstalk that is highly non-localized (as we saw from the e-fields distribution plots)
- Boundary conditions also determine whether these resonances are captured
- "Containing" the energy in a vertical transition may be an option but may introduce its own resonances and may not be practical

Summary

- Capturing the signal to plane pair cavity coupling can require that electrically large structures are simulated.
- Hybrid solvers are a good choice for analyzing this type of problem if they are characterized against benchmark structures and their limitations understood