Connectors, Vias and Stubs
(some semi-random observations)

- After material loss effects, connector design and especially via transition design has the largest effect upon end-to-end system performance.
  - Via transitions can contain significant stubs which can effect signal quality and bandwidth.
    - These stub form ¼ wave resonant structures that have a severe impact on bandwidth within the region of resonance.

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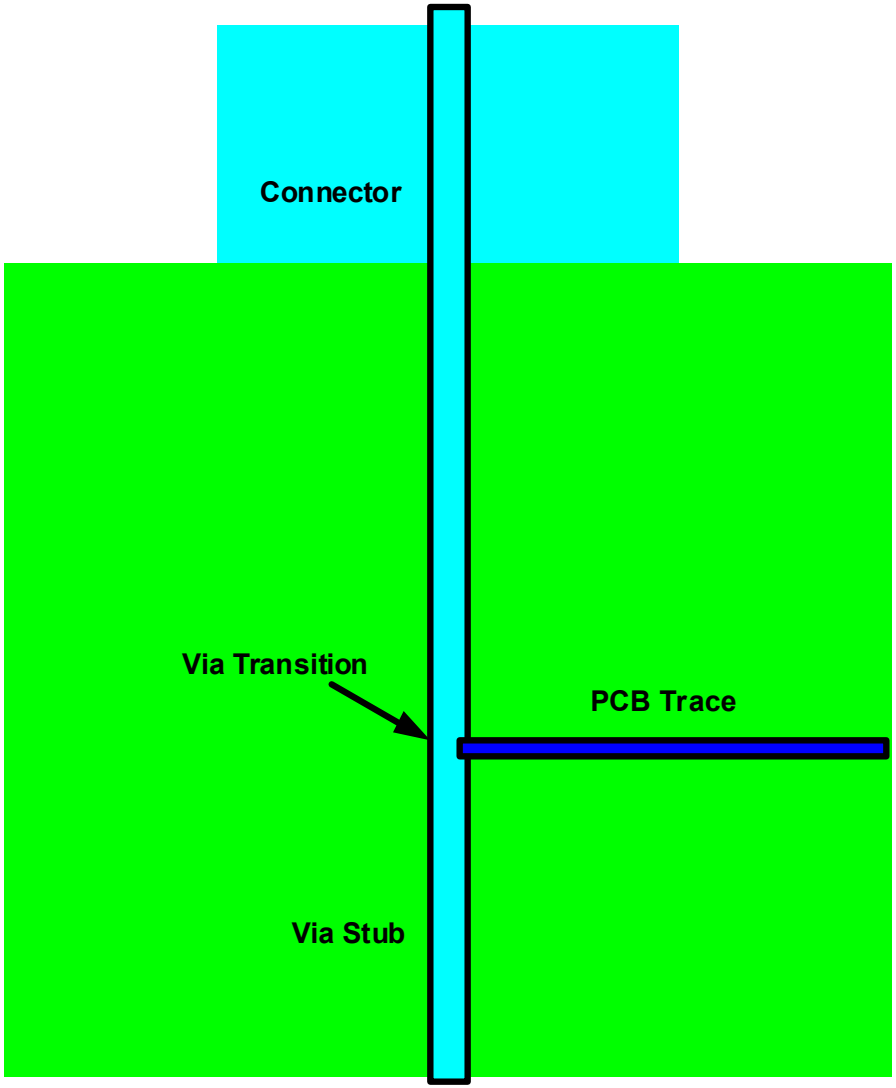
Via Stubs



Connection from the connector PTH to the backplane trace is made at the via transition.

Most transition types leave an open via stub.

This stub forms a high quality quarter wave resonator whose resonant frequency is a function of its length and material properties.

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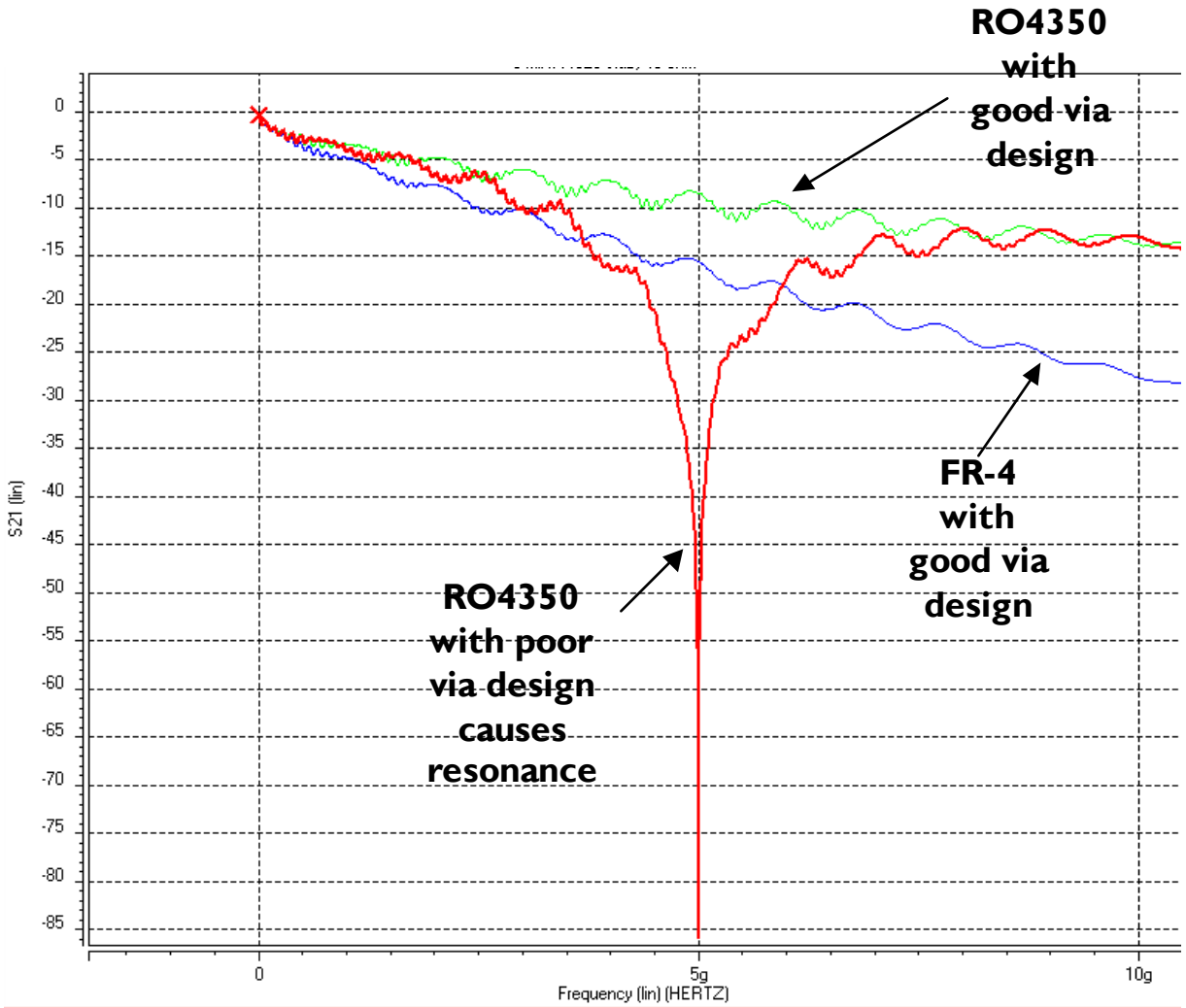
Via Stub Simulations
FR-4 vs. RO4350 for 30-inch System



Poor via transition design can cause unwanted stubs.

These stubs for ¼ wave resonators, which reduce and limit system bandwidth.

Even though Rogers 4350 material has superior loss properties over FR-4, poor via transition design can negate this performance advantage.

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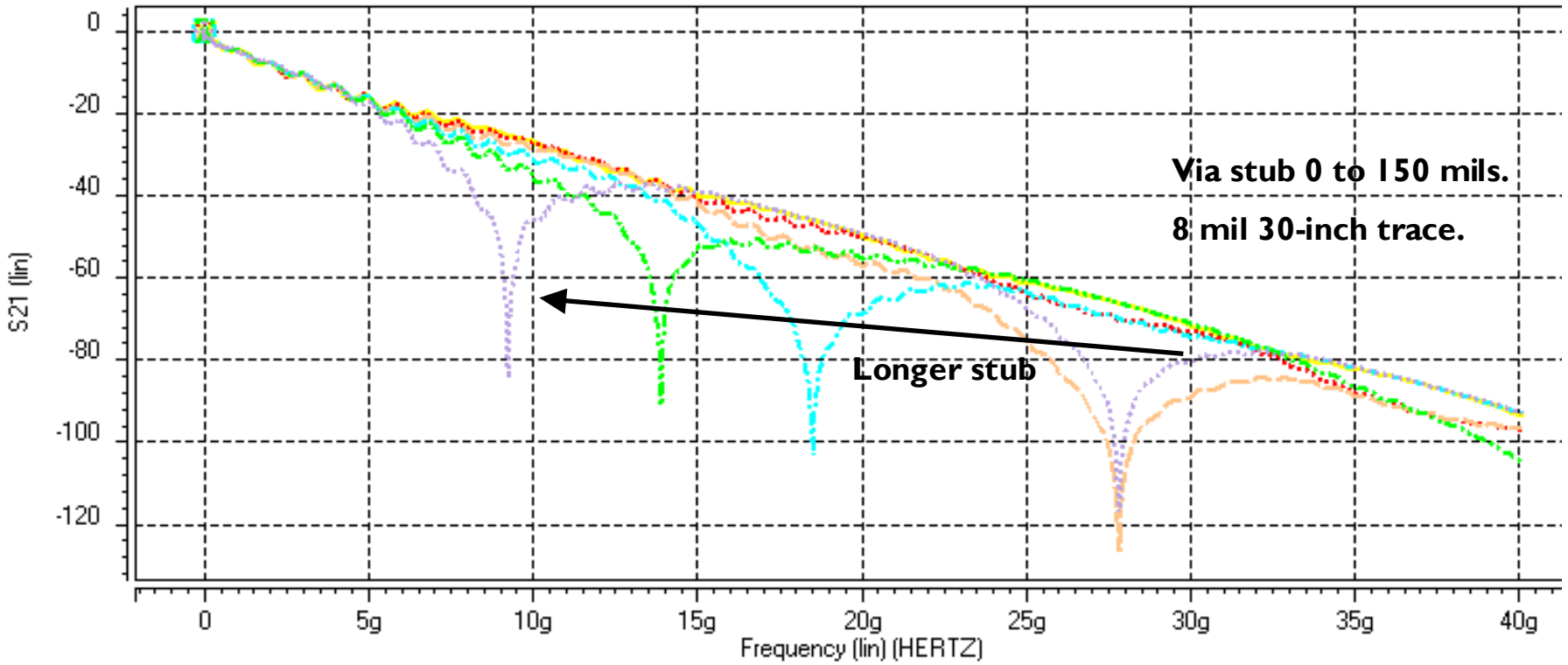
Via Stub Reduction

- Methods for reduction of via stub resonators:
  - Preferential routing to reduce stub length.
    - Uses lowest routing layers. (Lowest cost with performance relative to stub length.)
  - Counter-boring.
    - Removes unwanted stubs by controlled depth drilling as a final manufacturing step. (Additional cost and manufacturing loss with similar performance to buried vias. Difficult to test!)
  - Buried Via Technology
    - Additive laminate and laser drilling. (Highest cost with highest potential performance.)
  - Reduction of Parasitic Capacitance
    - Pad removal
    - Anti-pad enlargement

Insertion Loss vs. Via Stub Length
FR-4



Note: Internal stubs within connectors will also limit performance in this way.

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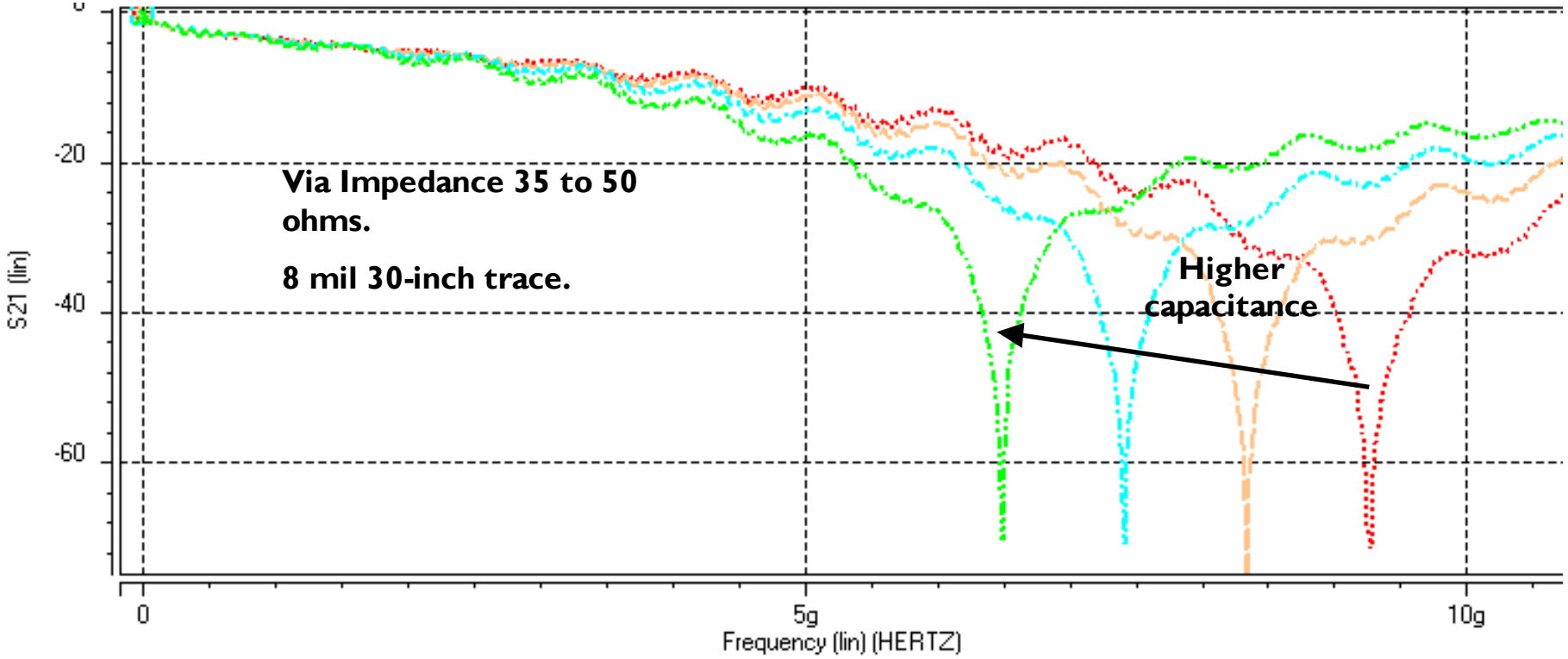
Insertion Loss vs Via Impedance
Rogers 4350



Increased via capacitance leads to increased impedance. These effectively load the via stub structure and decrease the resonant frequency. The reduction in resonant frequency is seen in a loss in system bandwidth.

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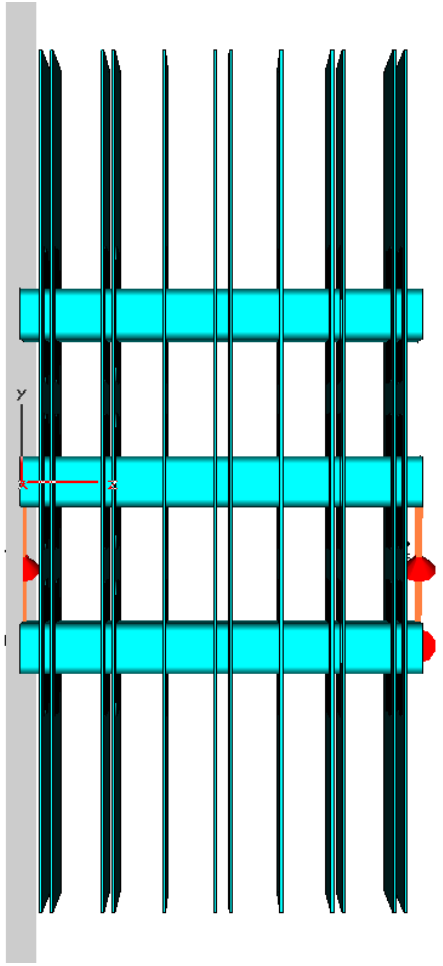
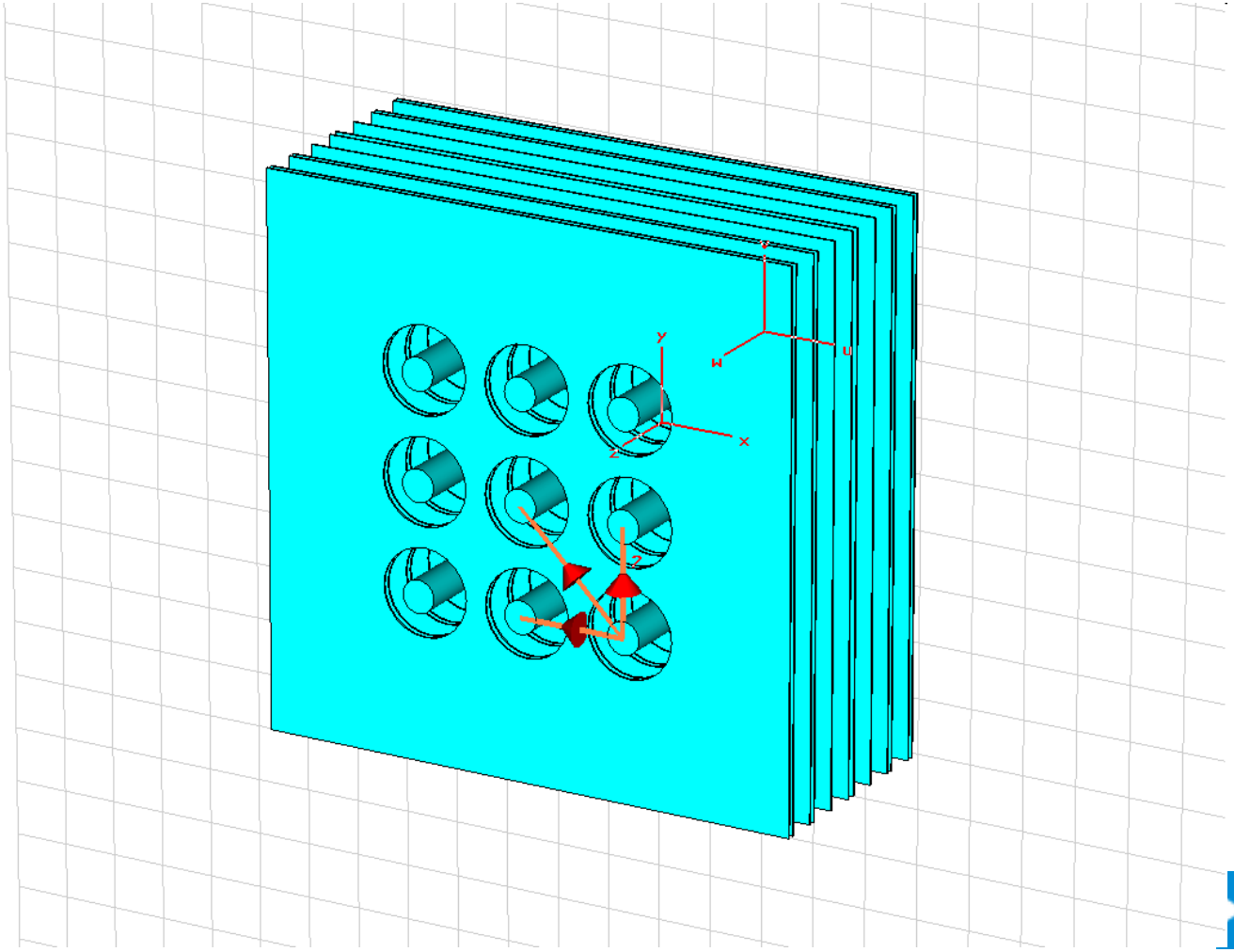
BGA Breakout Via Coupling Simulations

- CST Microwave was used to perform detailed modeling and simulation of via breakout region under BGA devices.
  - 3D Finite Integration Technique time-domain field solver and simulator with bandwidth well beyond 50 GHz.
- Field solver transforms time domain simulations into frequency domain using Discrete Fourier Transform of system stimulated with a Gaussian pulse.

Via Geometry
Side View



Via Geometry
Perspective View



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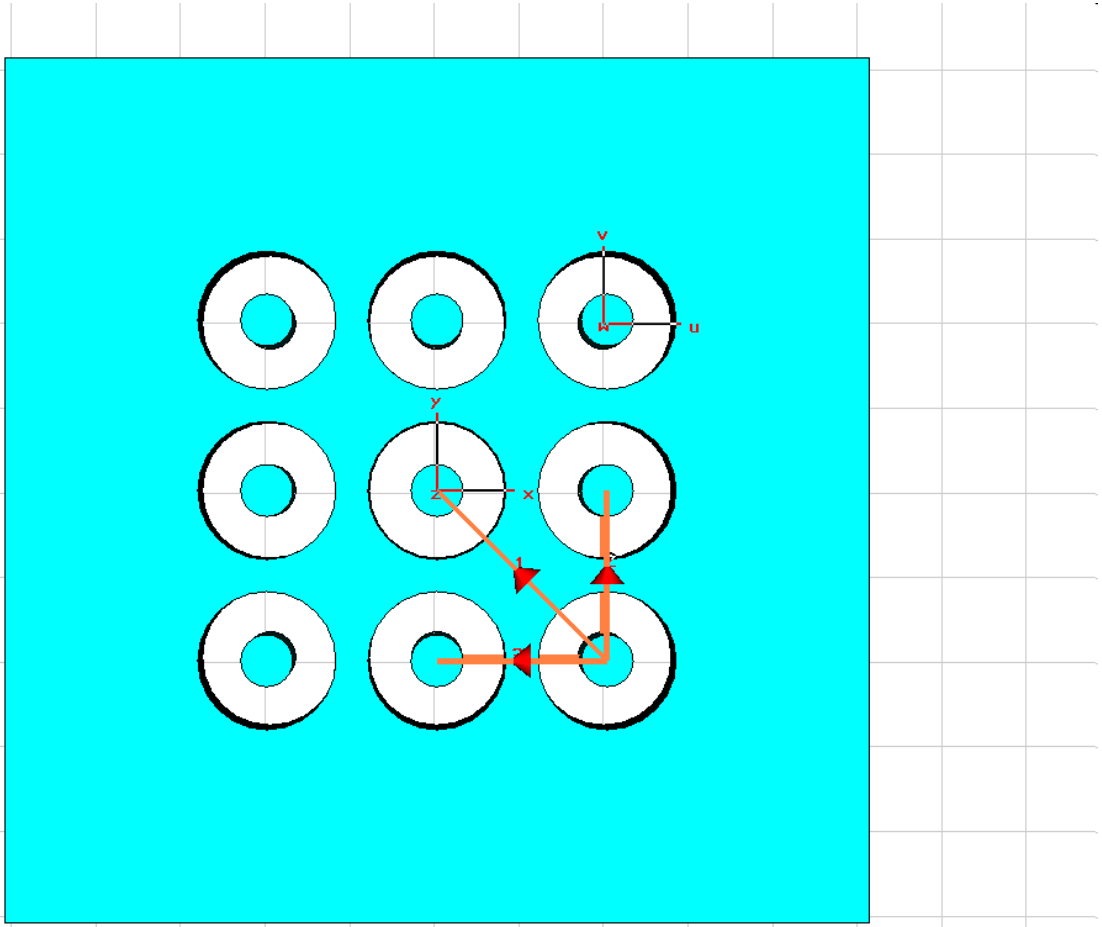
Via Geometry
Top View



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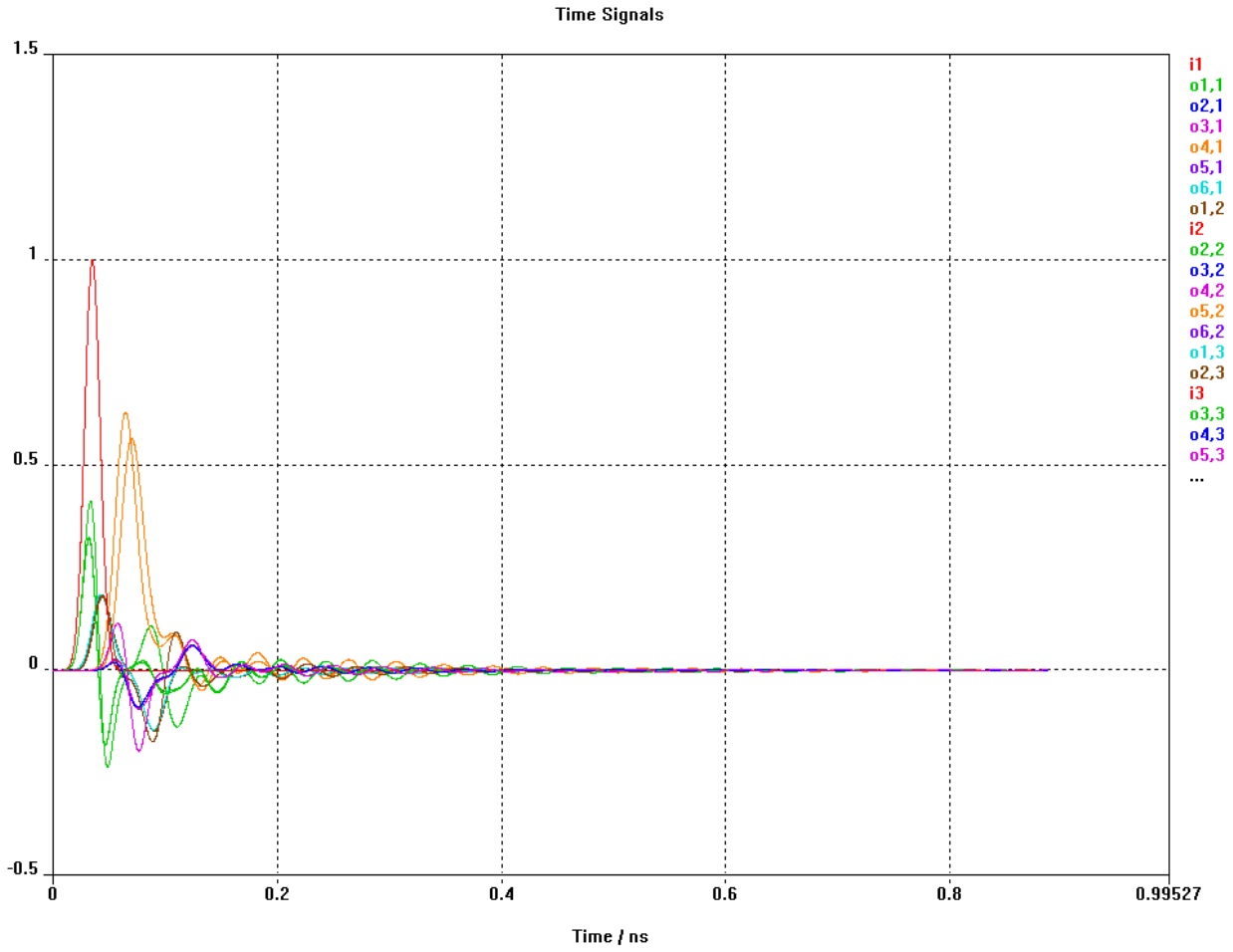
Time Domain Gaussian Pulse Simulation



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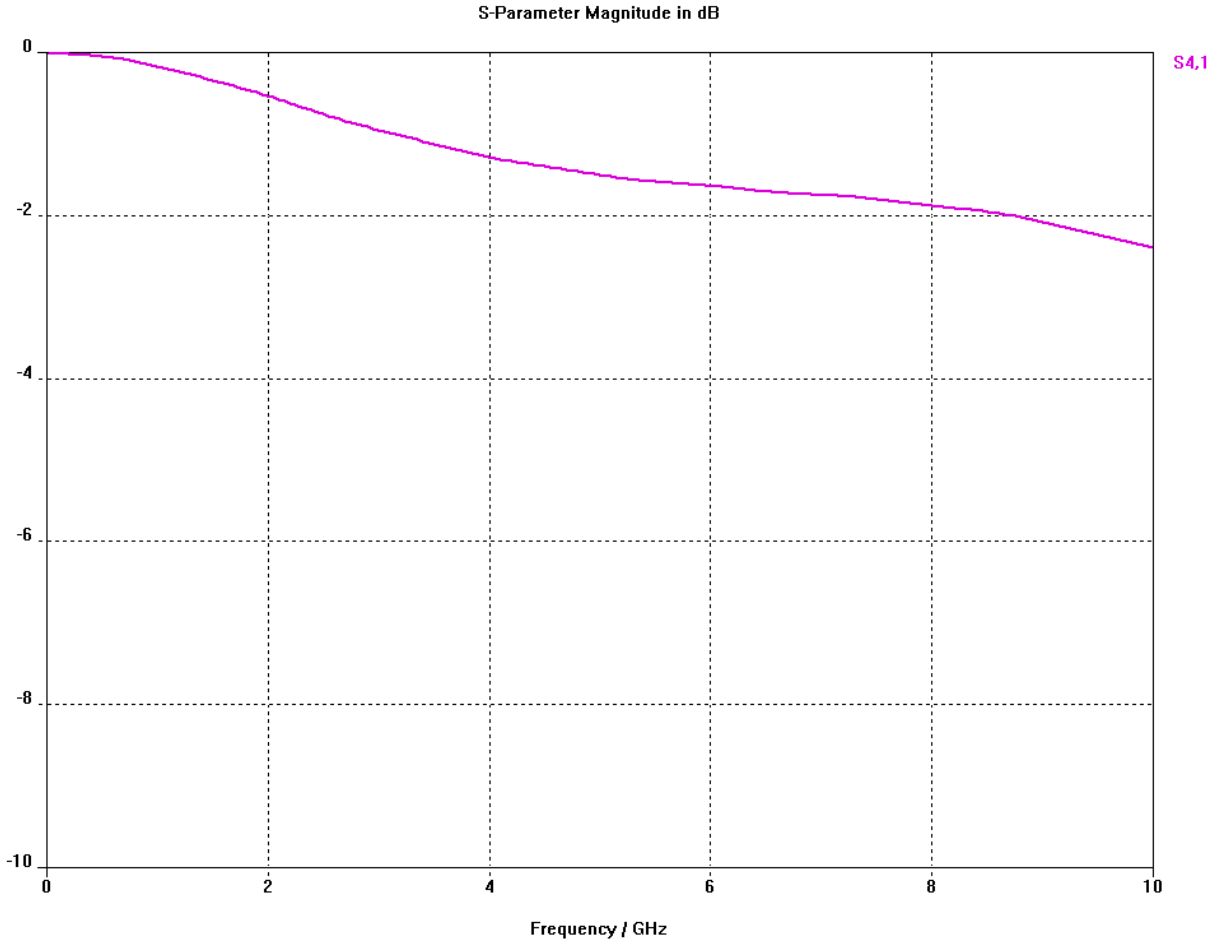
S41 (Insertion Loss)



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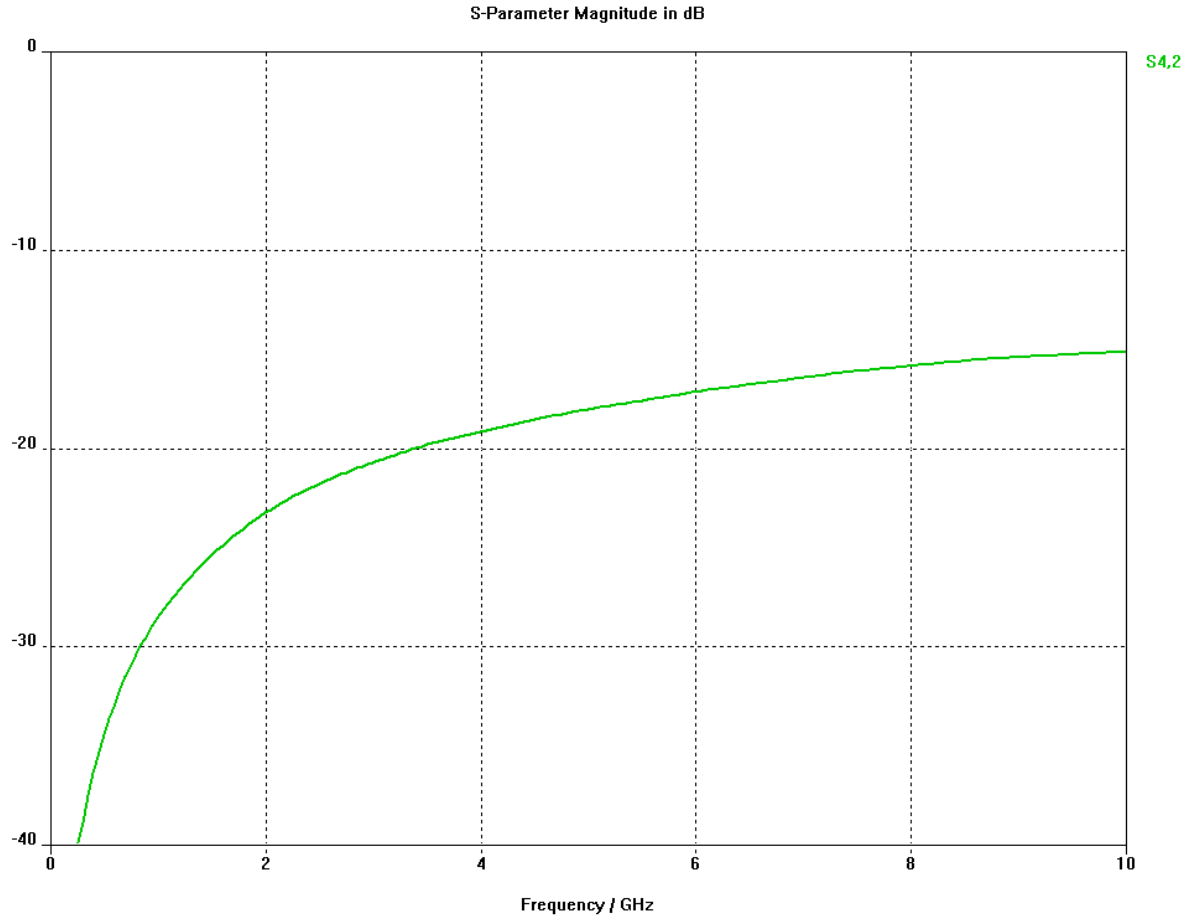
S42 (Crosstalk)



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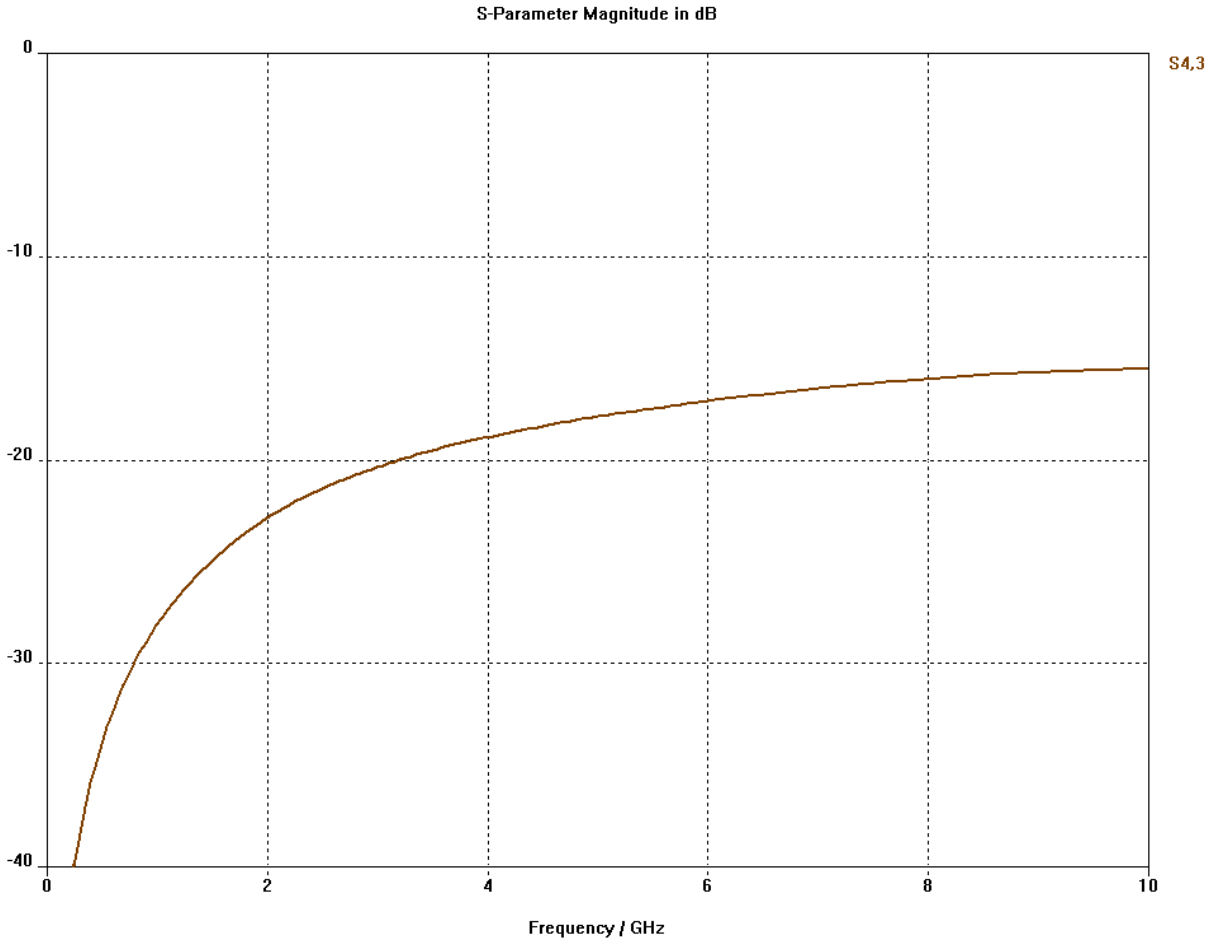
S43 (Crosstalk)



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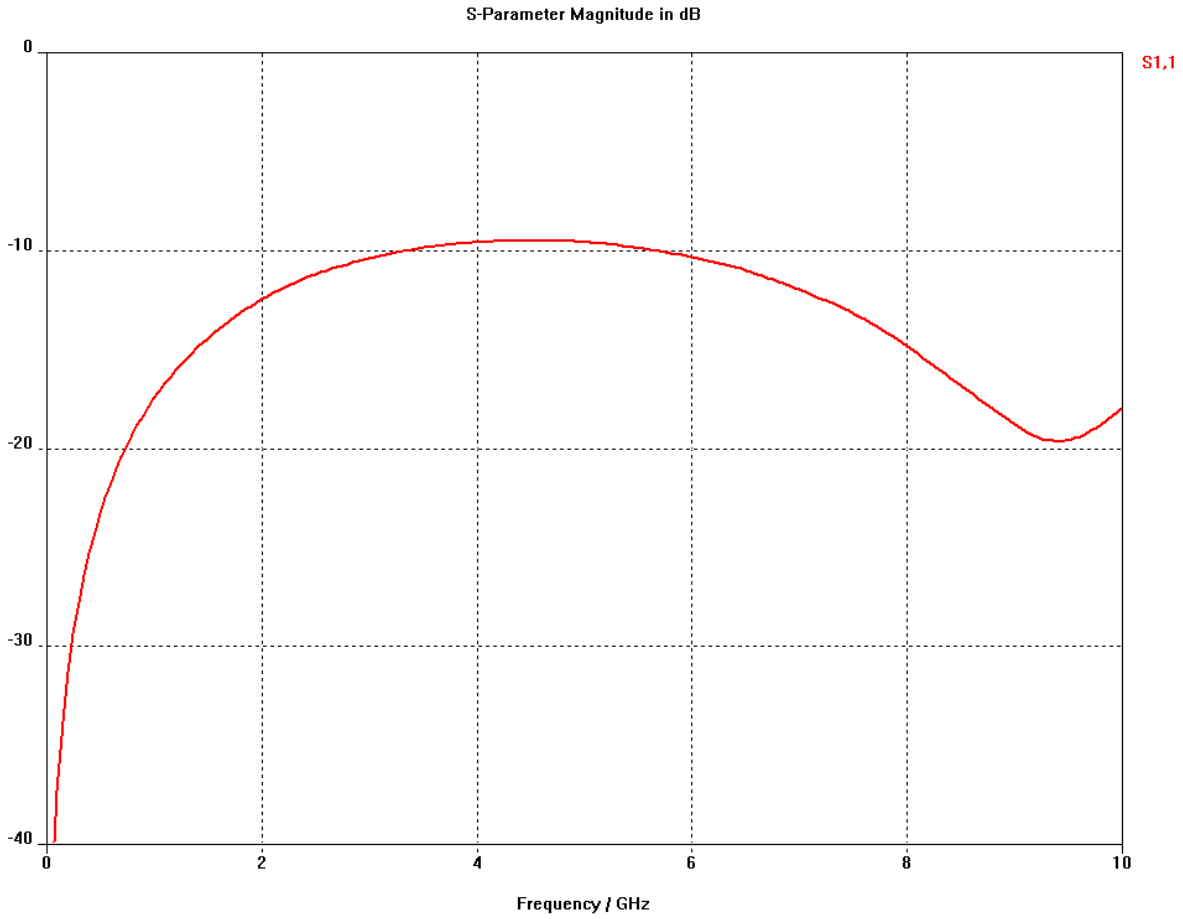
S11 (Return Loss)



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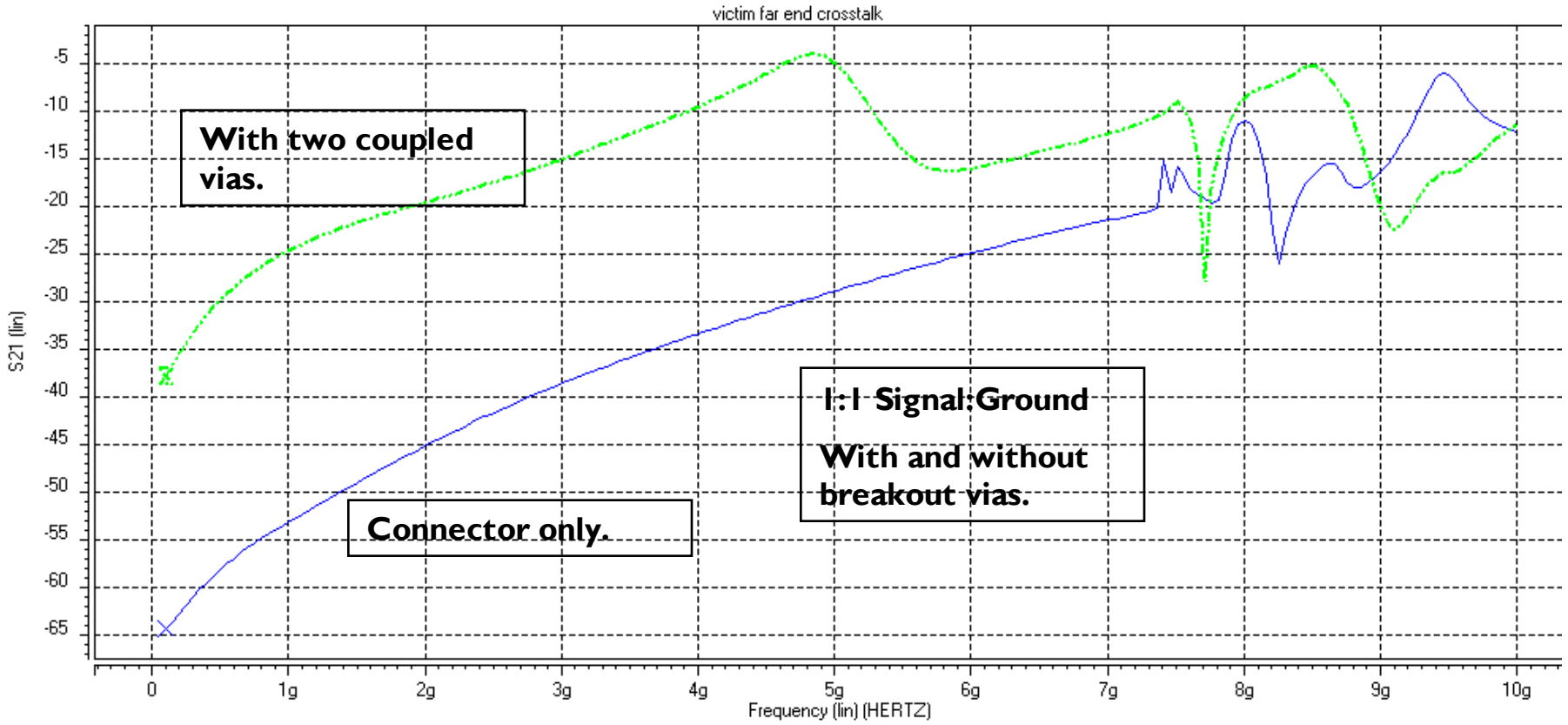
FEXT Connector with Vias



Via-to-via crosstalk can easily exceed connector crosstalk, when signal vias are not well referenced and isolated by ground vias.

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