NINETEENTH ANNUAL

BiTS

Burn-in & Test Strategies Workshop

March 4 - 7, 2018

Hilton Phoenix / Mesa Hotel
Mesa, Arizona

Archive

Application of Uncertainty Quantification in RF Simulations of Test Socket

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Smiths Interconnect

BiTS Workshop
March 4 - 7, 2018

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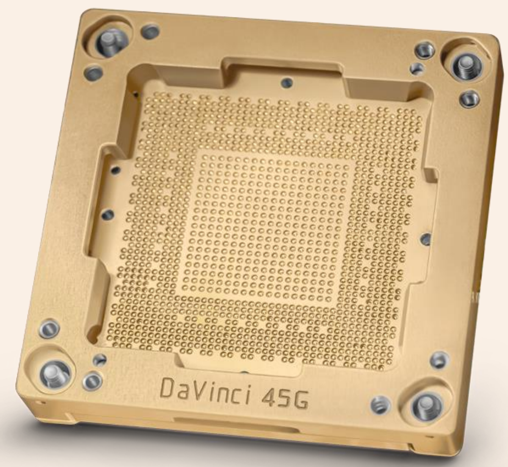
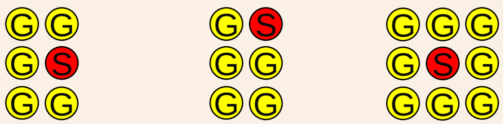
Introduction

- The objective of this work was to develop a more robust simulation tool for designing new high speed interconnects.
- Designs focused on are Smiths Interconnect impedance controlled sockets:
  - DaVinci 35G – capable to 20 Gbps
    - Insertion Loss @ -1 dB > 35 GHz
    - Return Loss @ -10 dB > 35 GHz
  - DaVinci 45G – capable to 26 Gbps
    - Insertion Loss @ -1 dB > 40 GHz
    - Return Loss @ -10 dB > 40 GHz

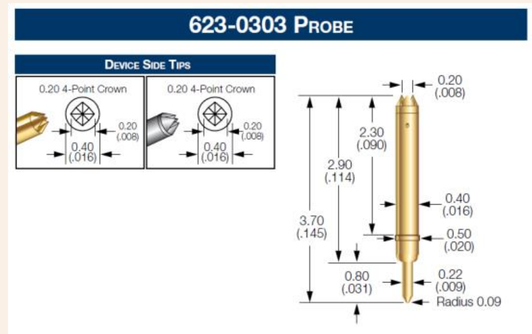


Introduction

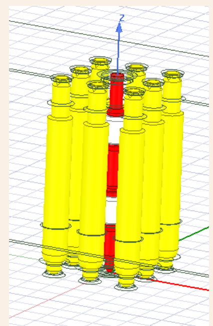
- Benefit of impedance controlled probes for high speed applications:
  - Pitch and location of grounds have greatly reduced impact on impedance.
  - Socket material does not impact impedance due to Smiths Interconnect proprietary material.
- To demonstrate this six 3D EM simulations are presented with the following patterns (3 w/ standard socket and 3 w/ impedance controlled):



Edge Corner Center

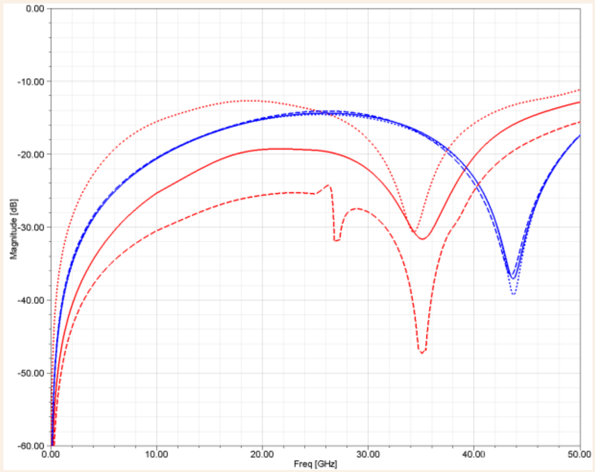


DaVinci 45G - Impedance Controlled

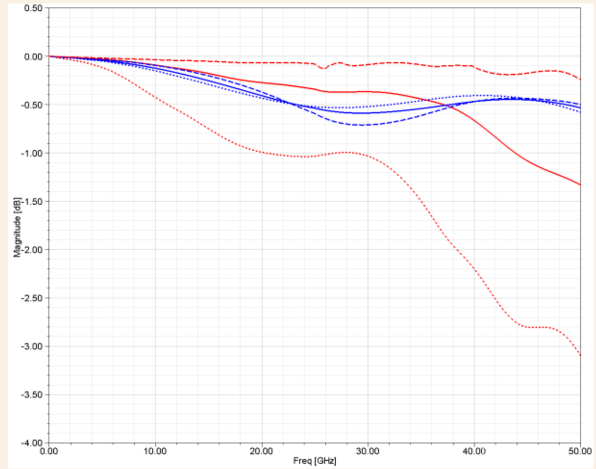


Introduction

Single End Return Loss



Single End Insertion Loss



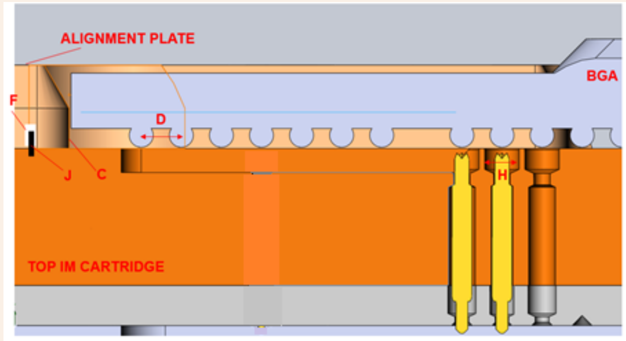
Legend:
- Standard Socket Edge
- Standard Socket Corner
- Standard Socket Center
- DaVinci 45G Socket Edge
- DaVinci 45G Socket Corner
- DaVinci 45G Socket Center

Introduction

- Use of worst case tolerance stack analysis or Monte Carlo simulations are common tools for mechanical designers.
  - Example presented is alignment of BGA DUT in an interconnect pocket with worst case tolerance stack

$$\sigma = \sum |T_i|$$

$$\sigma = D_1 + D_{1,tol} + H_1 + H_{tol} + F_{true\ pos} + \frac{H_{true\ pos}}{2} + (F + F_{tol}) + (J_{tol} - J) + BP_{tol} + C_{tol}$$



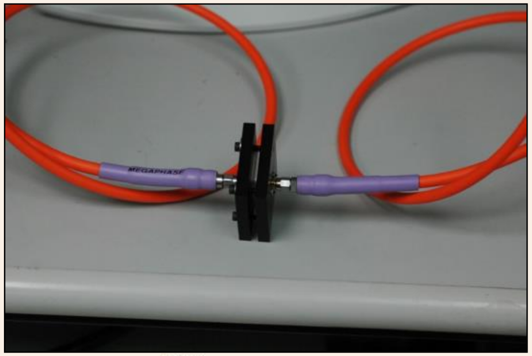
- Application of similar analysis for mechanical properties to RF - Attenuation per length (α) through a uniform transmission line can be estimated with the following first order approximations:

$$\alpha_{dB} = \alpha_{conductor} + \alpha_{dielectric}$$

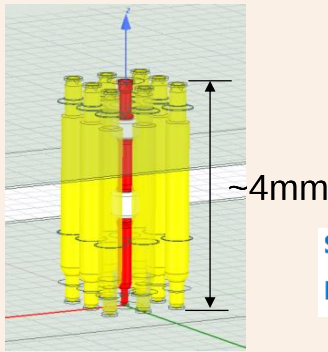
$$\alpha_{conductor} = \frac{36}{wZ_o}\sqrt{f}$$

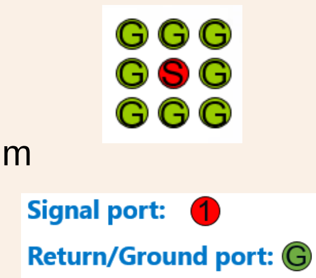
$$\alpha_{dielectric} = 2.3 f tan(\delta)\sqrt{\varepsilon_r}$$

Experimental Measurement Setup



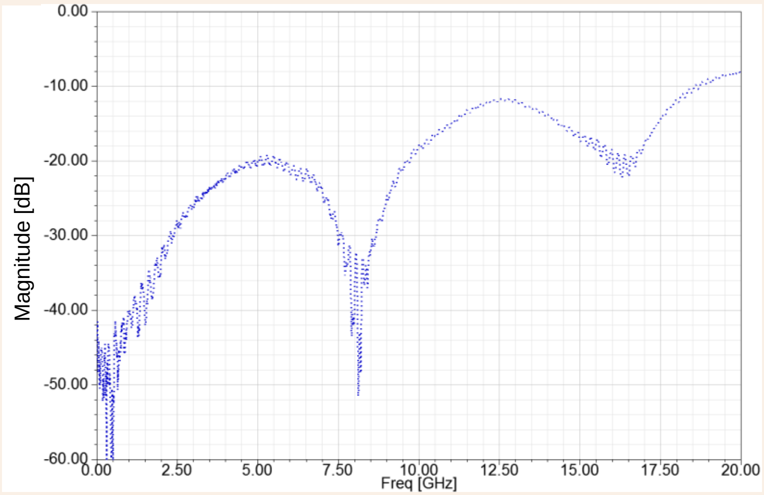
- Each signal/return configuration is measured on an Agilent VNA utilizing Smiths Interconnect designed fixtures to characterize the S-parameters through 67 GHz.
- The fixture influence is de-embedded from the S-parameter result to determine the S-parameters for the socket only.
- Have conducted measurement-to-measurement verification with measurements from an outside lab using the same socket
- Data presented here for DaVinci 35G but limited to 20 GHz due to proprietary nature, validated performance to 37 GHz by outside lab



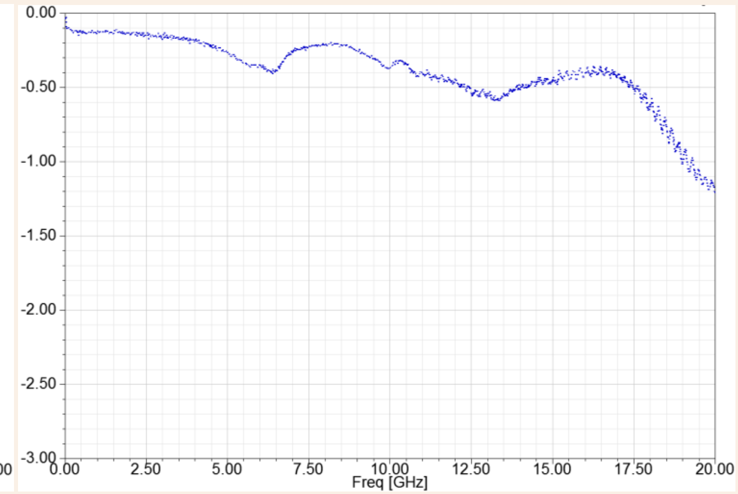


DaVinci 35G Measurement Verification Data Set

Single End Return Loss



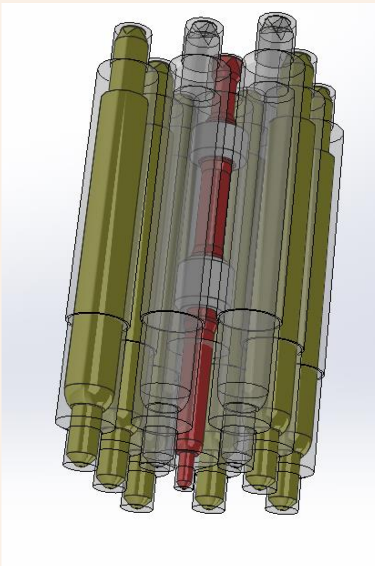
Single End Insertion Loss



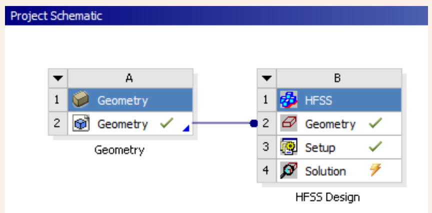
Legend:
.... Measured Data

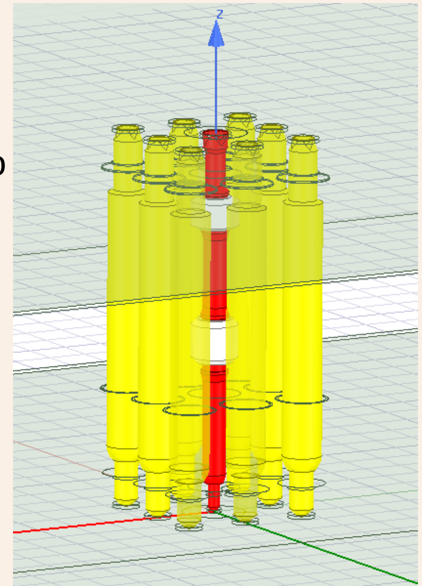
3D EM Simulation Setup

- 3D geometry setup in test condition in Solidworks™ and imported directly to ANSYS HFSS™.
- Geometry is parameterized in Solidworks™ to allow for sensitivity study of manufacturing tolerances impact on RF performance.
- Material properties and boundary conditions assigned and frequency sweep analyzed for setup.
- For parameterization chose to assess worst case tolerance stack up instead of statistical analysis with Monte Carlo Simulation



Solidworks setup

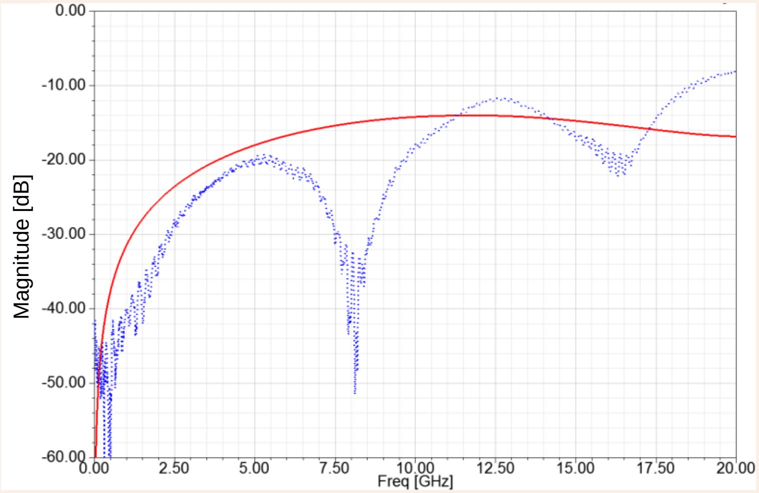




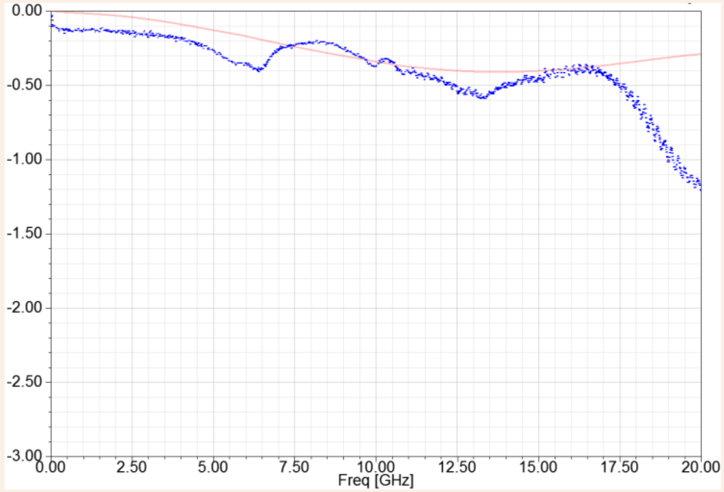
HFSS setup

Comparison of Measured Data w/ Simulation with Nominal Dimensions for Probe and Cavity

Single End Return Loss



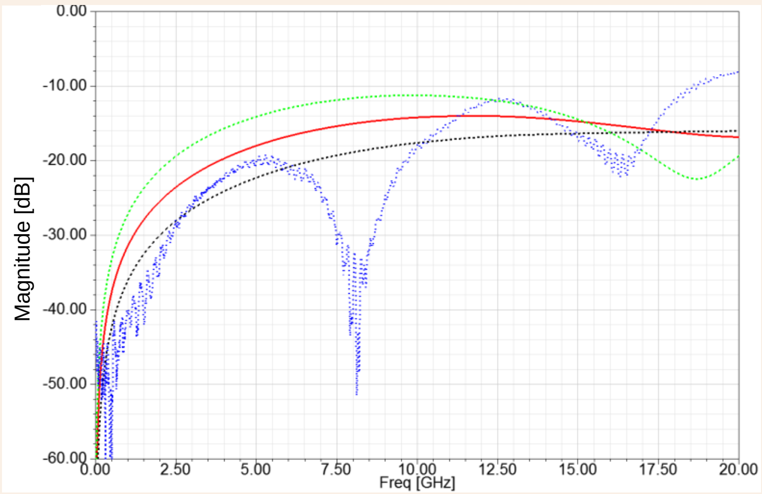
Single End Insertion Loss



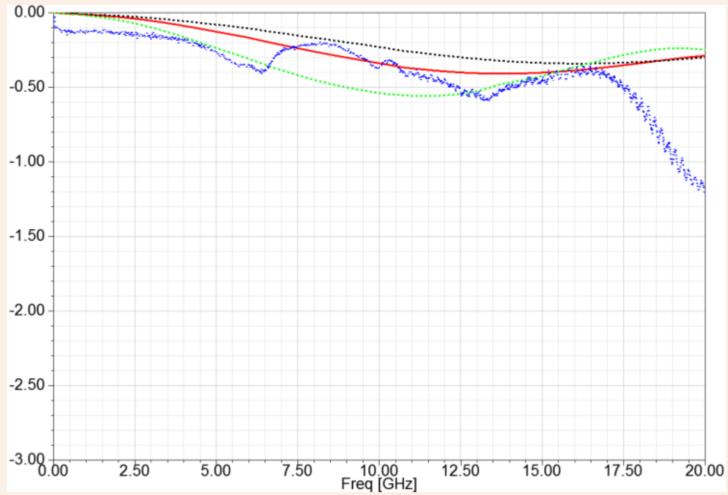
Legend:
Measured Data
Baseline Simulation

Simulation Results for Best and Worst Case Based on Parameterization of Probe and Cavity Tolerances

Single End Return Loss

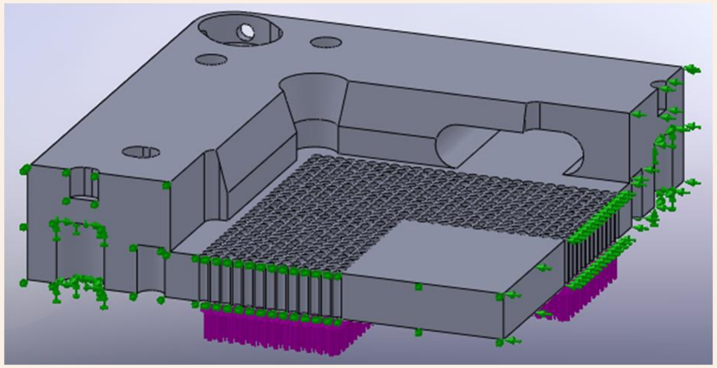


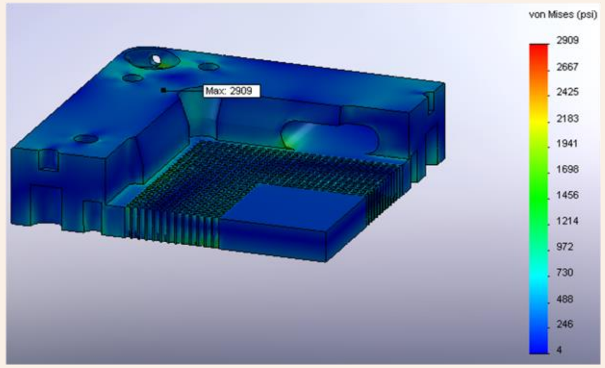
Single End Insertion Loss



Legend:
- Measured Data
- Baseline Simulation
- Simulation with optimum performance
- Simulation with worst case performance

Implementation of Mechanical FEA Simulations in 3D EM Simulation



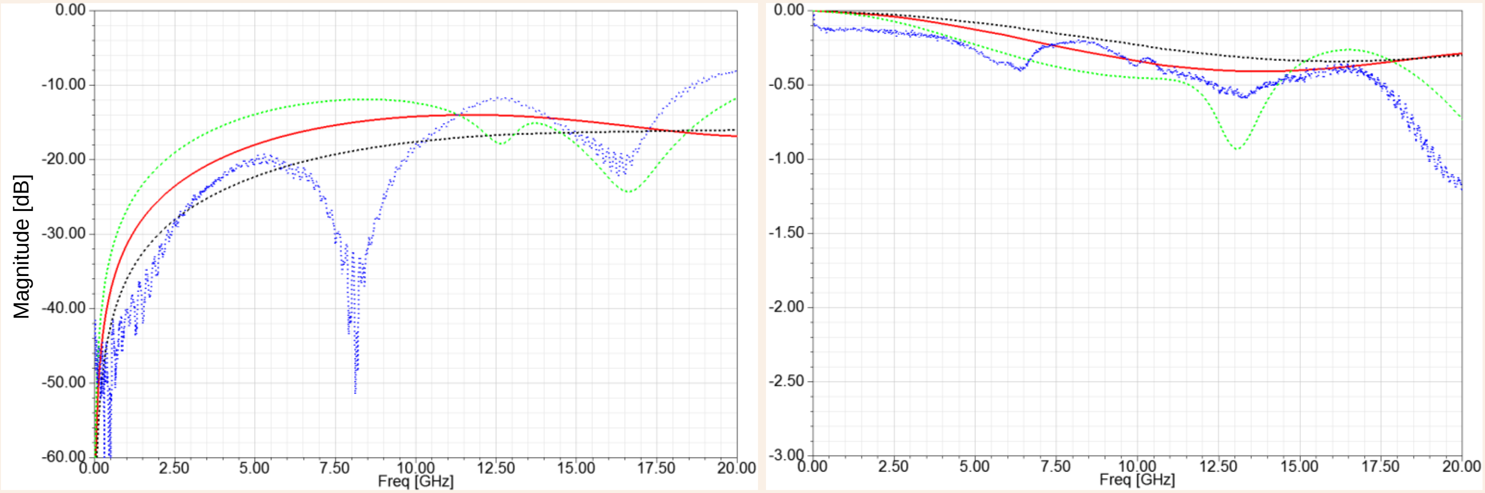


- Mechanical FEA simulations conducted in Solidworks CosmosWorks.
- Utilized to determine maximum stress and deflection within the socket during the worst case scenario which will be when the socket is in the pre-load condition.
- Deflection of socket then implemented in 3D EM simulation.

Simulation Results with Implementation of Mechanical FEA Results

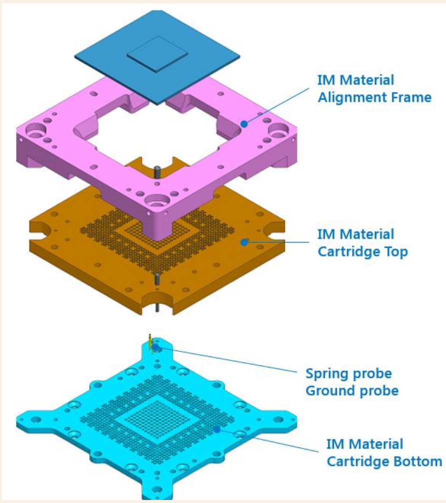
Single End Return Loss

Single End Insertion Loss



Legend:
- Measured Data
- Baseline Simulation
- Simulation with optimum performance
- Simulation with worst case and FEA deflection

Assessment of Probe Tilt from Cartridge Alignment and FEA Analysis

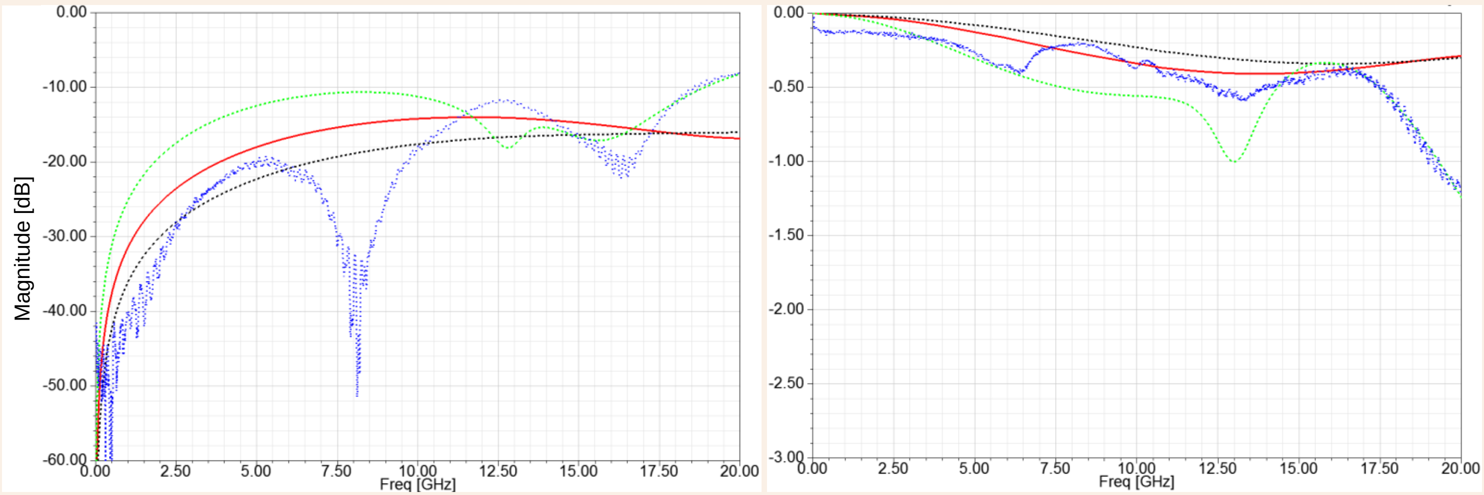


- Utilized information from the FEA analysis coupled with worst case tolerance stack analysis where cavity alignment is taken into consideration.
- Impact of allowable probe tilt from this worst case tolerance analysis presented.

Simulation Results with Implementation of Mechanical FEA Results and Probe Tilt

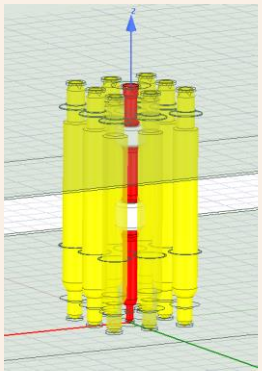
Single End Return Loss

Single End Insertion Loss

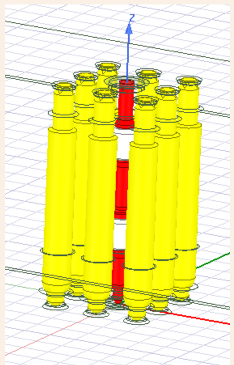


Legend:
Measured Data
Baseline Simulation
Simulation with optimum performance
Sim with worst case, FEA deflect, & Probe Tilt

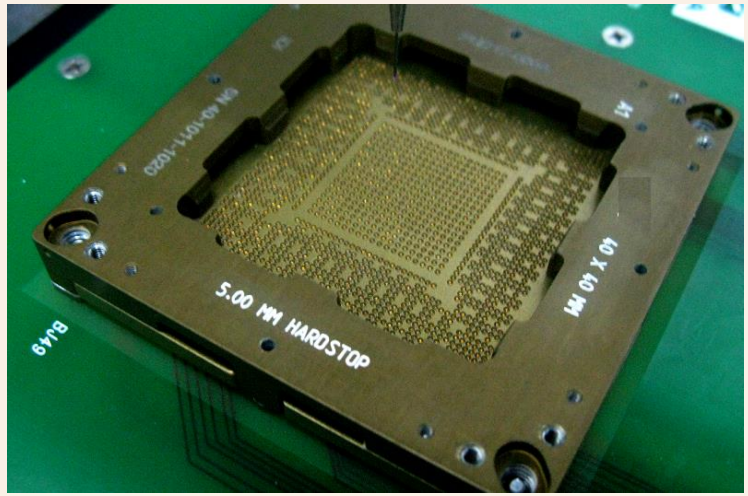
Impact of Frequency Dependent Dielectric Properties on DaVinci 45G



DaVinci 35G: Coaxial Structure

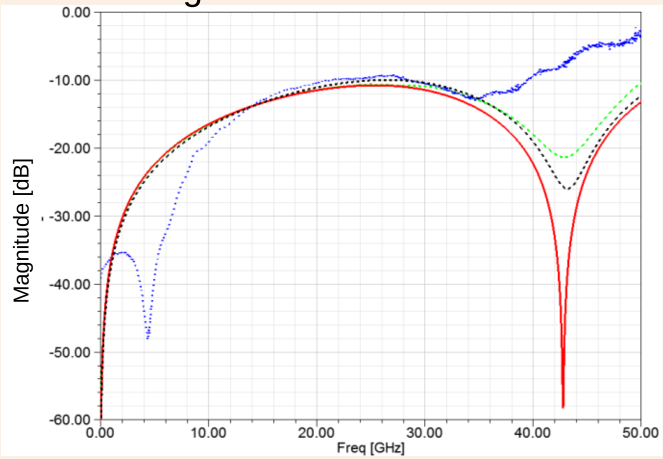


DaVinci 45G: Optimized Coaxial Structure

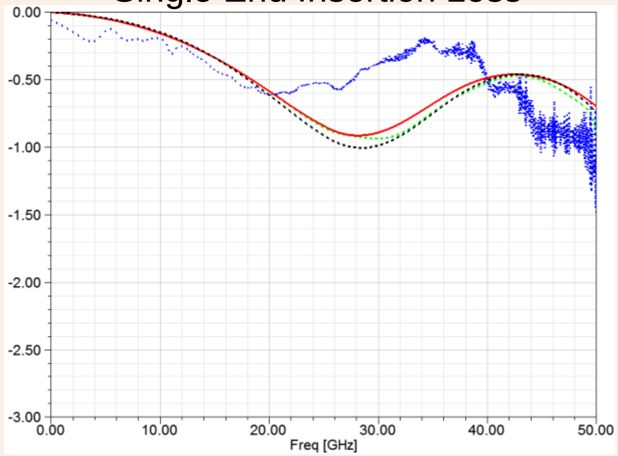


Impact of Frequency Dependent Dielectric Properties on DaVinci 45G

Single End Return Loss



Single End Insertion Loss

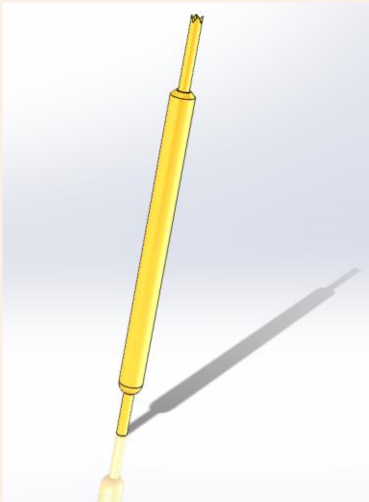


Legend:
- Measured Data
- Baseline Simulation
- Simulation with uncertainty for mechanical performance
- Simulation with uncertainty for mechanical performance and frequency dependent material properties*

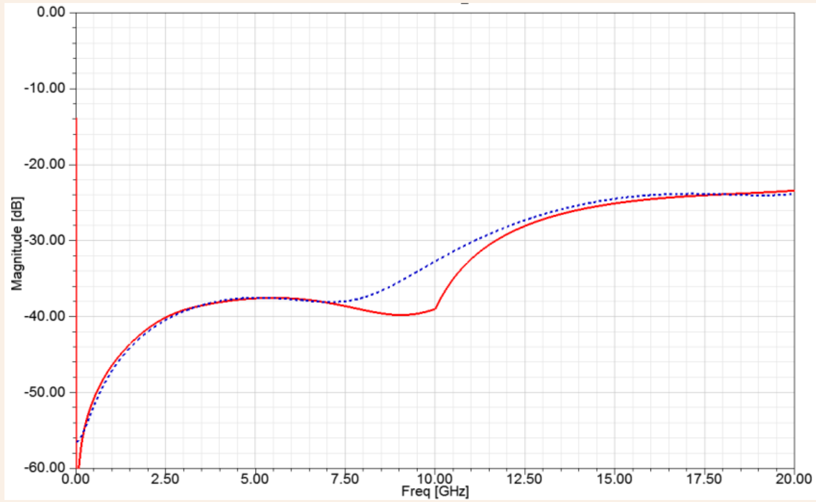
$$\alpha_{dielectric} = 2.3 f \tan(\delta)\sqrt{\varepsilon_r}$$

* Frequency dependent data for materials through 20 GHz from 2003 BiTS presentation by Mroczkowski, J.

Implementation of Uncertainty Analysis for Development of Low Return Loss Single End Probe Design



Single End Return Loss



Legend:
Measured Data
Simulation Data

Summary and Future Work

- Benefits of parameterized studies in HFSS to better understand impact of uncertainty for both mechanical tolerance and material properties.
  - Application of unilateral tolerances typical for mechanical fit to RF performance
- Clear need for frequency dependent measurements of material properties to have successful simulations at higher frequency.
  - Smiths Interconnect test lab in process of developing these capabilities.

$$\alpha_{dielectric} = 2.3 f tan(\delta)\sqrt{\varepsilon_r}$$

- Utilizing these design techniques for development of next generation high frequency test sockets.