SWTW23-43

SWTEST
PROBE TODAY, FOR TOMORROW
2023 CONFERENCE

Optimizing Probe Head Design Using a J-Tuned™ Process on Spring Probe Technology

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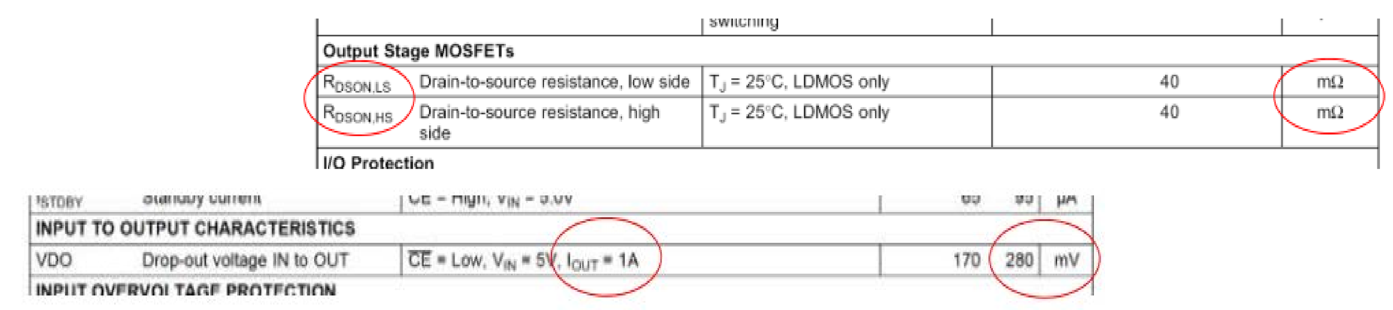
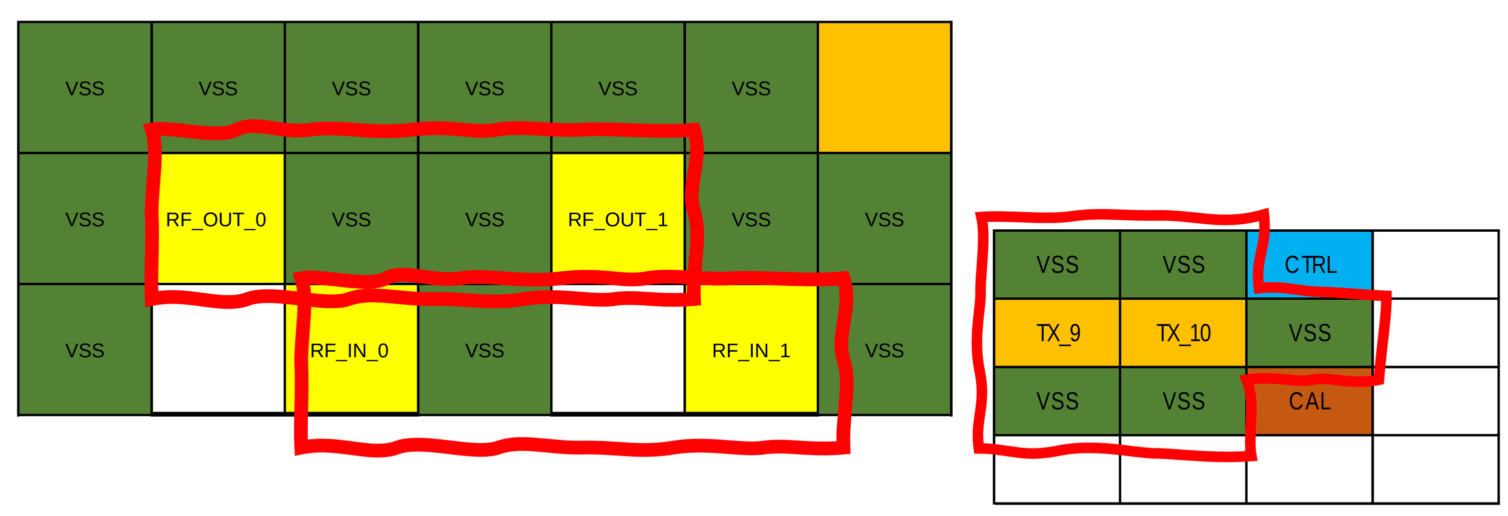
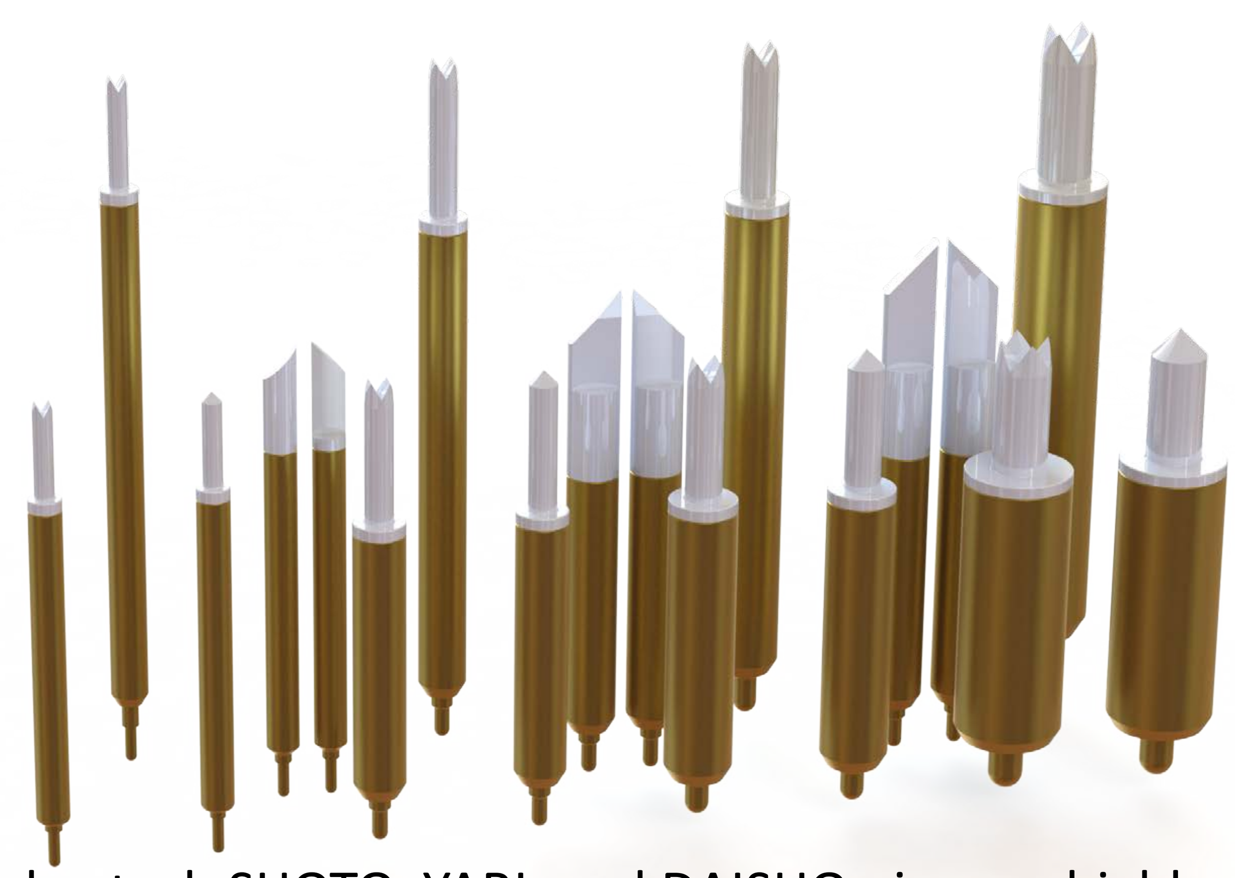
What is the J-Tuning process?

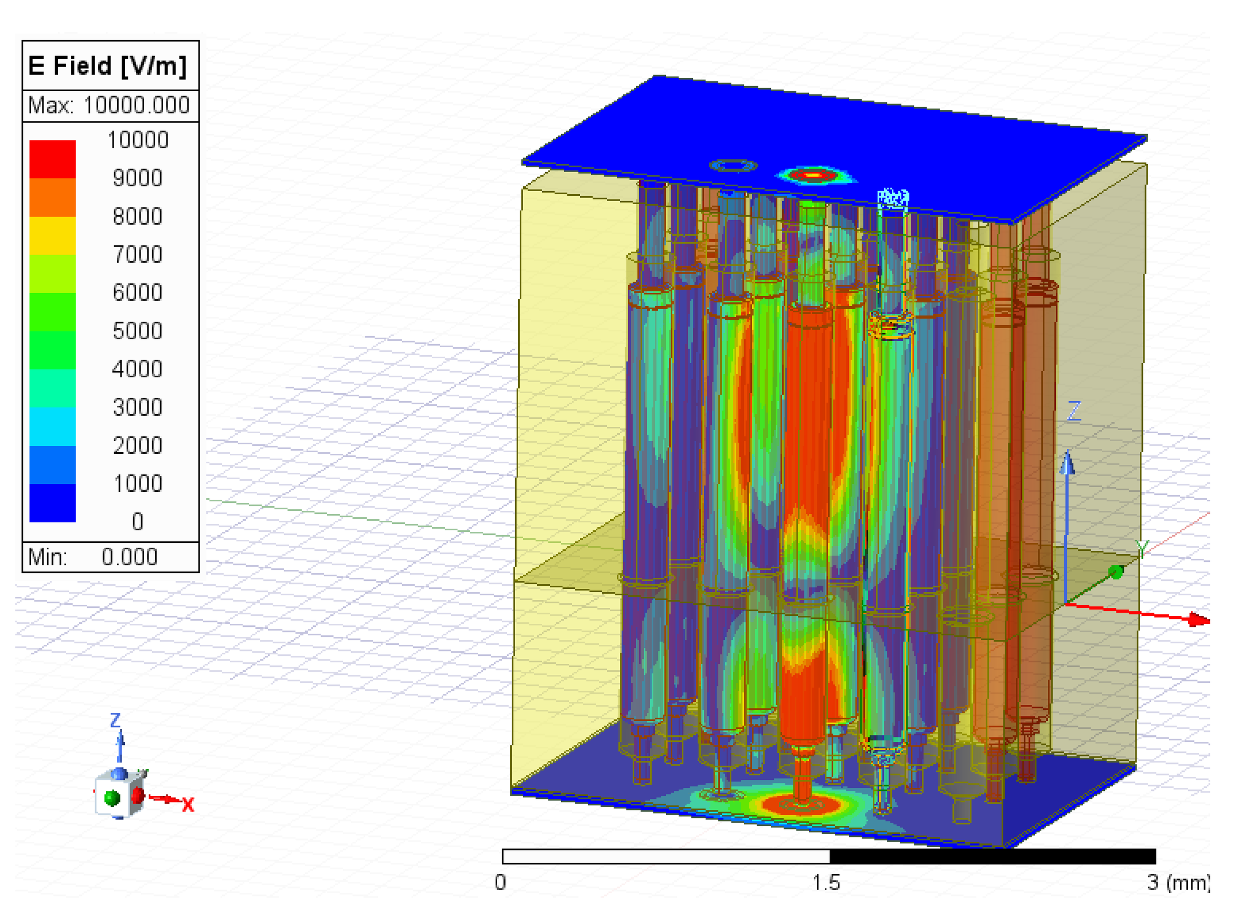
- Analyzing and understanding all the critical DUT signal pin configurations – stripping them down to basic structures:
  - Analog signals and their Insertion Loss and Return Loss requirements at given frequencies
  - Digital signals – differential pairs at given impedances: 50Ω, 100Ω, other
  - Mechanical POD/Wafer-map for physical location of signal pins, ground pins, and other pins, within DUT array
  - PCB, encrypted DUT S-Parameter models and other inputs can be included
- Review DUT data sheet parameters that are most critical:
  - Required digital data rates and modulation – NRZ, PAM-4, etc.
  - Analog losses – Insertion and Return vs. frequency (wide and narrow-band)
  - Crosstalk limits between signals
  - Kelvin requirements: R_{DSON}, critical VDO,…
  - Power requirements
- Modeling critical configurations in HFSS and other simulation tools – worst case or unique signal conditions
  - Building valid and quality S-parameter models using frequency-dependent dielectric properties
- Tuning the design models to achieve best desired performance using the available design 'knobs':
  - Choosing the best SHOTO or YARI spring pin for the configuration
  - Configuring the housing for optimal impedance matching to the DUT signal environment
  - Additional ANSYS mechanical and/or thermal modeling may be needed to optimize for planarity and thermal requirements







Johnstech SHOTO, YARI, and DAISHO pins are highly standardized to give maximum flexibility for J-Tuning probe head performance

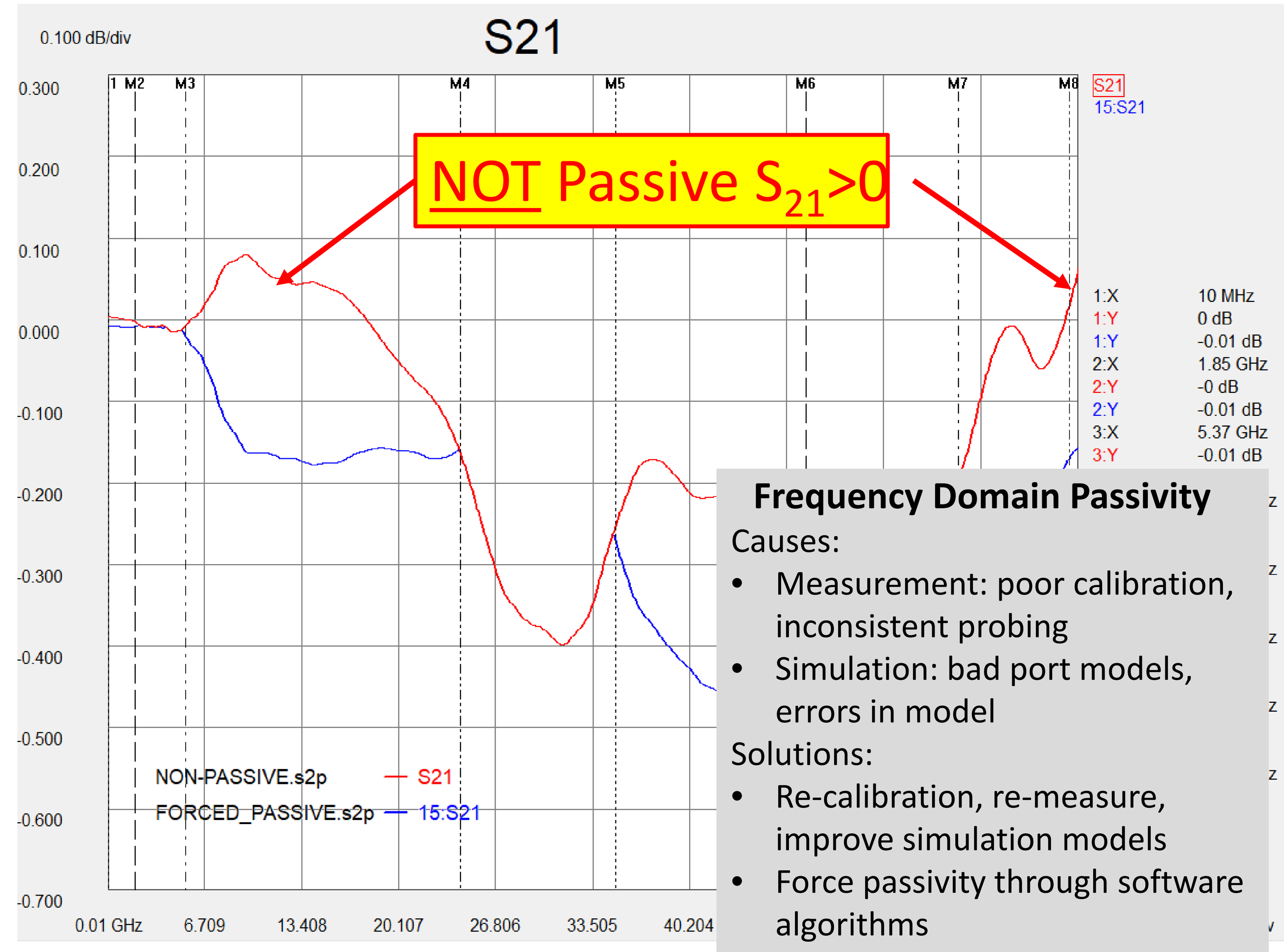


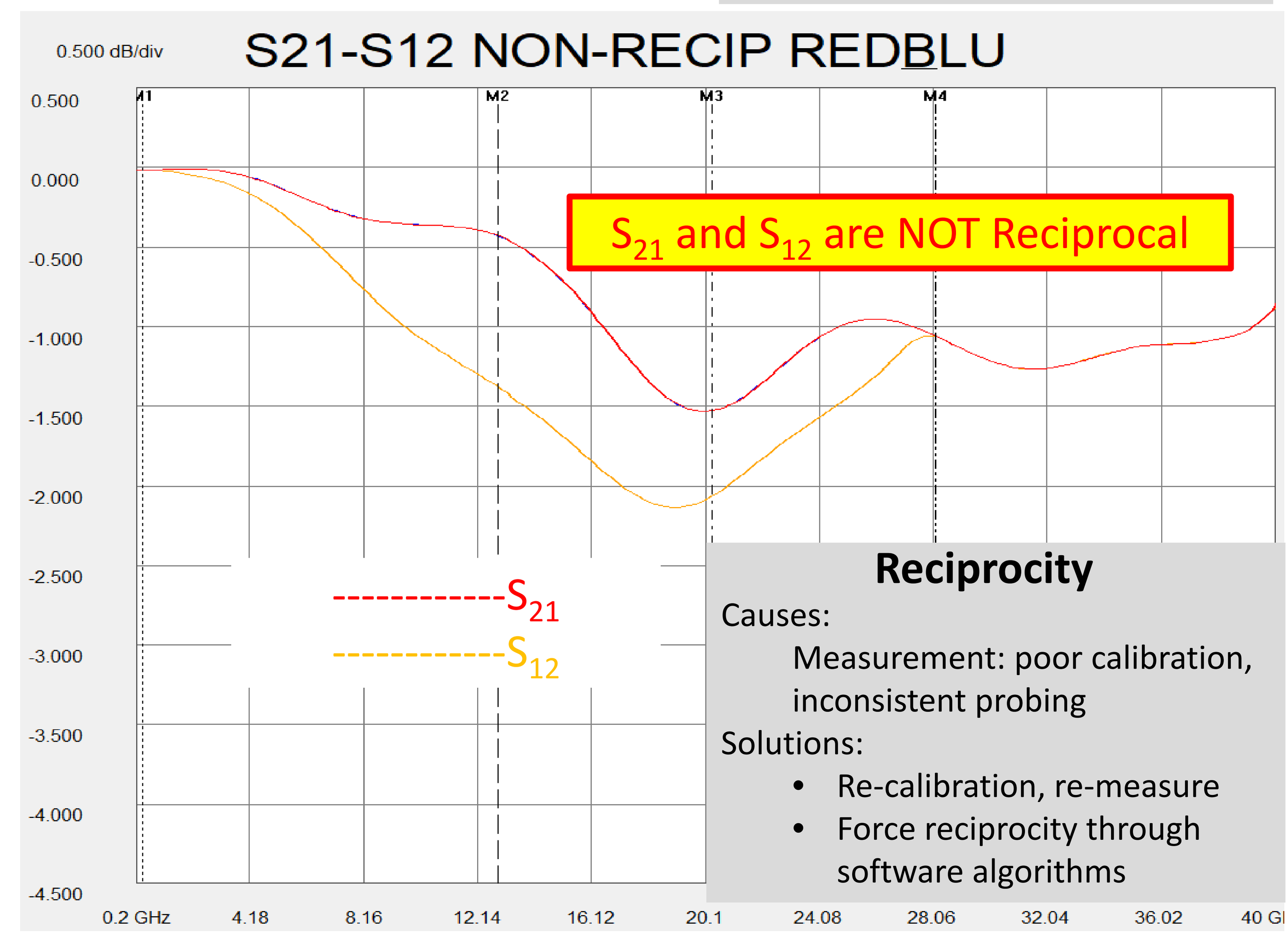
Validating Models and Measurements

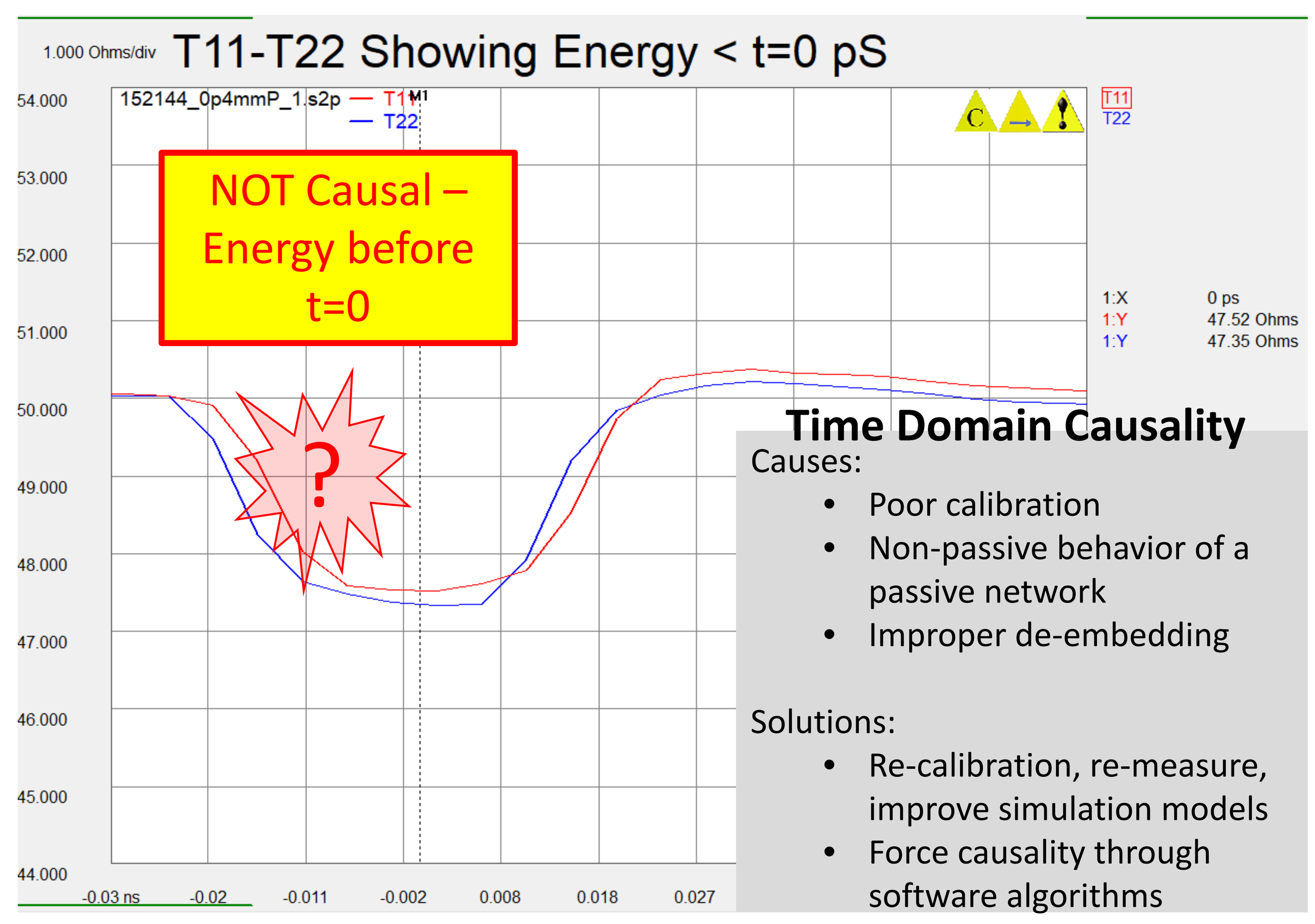
Probe heads are considered as a passive bi-directional transmission lines. The S-parameter representations must then always demonstrate Passivity, Reciprocity, and Causality:

- Passivity:
  - The component is passive if it consumes energy, but does not produce energy
  - Is incapable of power gain
  - $S_{21} < 0$
  - $-1 < S_{11}$ or $S_{22} < +1$
  - There must be no energy of the propagating EM wave before t=0 in the TDR (Time Domain) plot
- Reciprocity:
  - A reciprocal network always has a symmetric S-parameter matrix. The transmission of a signal between any two ports should not depend on the direction of propagation
  - For a passive system, $S_{12} = S_{21}$
- Causality:
  - Extrapolates to > sweep range. Not a real physical model. Used mainly for transient simulations, so optional
  - 2 ways of determining / forcing causality:
    1. DFT (Discrete Fourier Transform) (Keysight)
    2. Causality estimation (Anritsu) using Smith Chart techniques of phase rotation

  There is discussion over which method is better and for which type of application
- Testing and Correcting For Passivity, Reciprocity
  - Post-processing software offered on the market can test for these 3 validity tests on a S-parameter files and force the S parameter matrices to be valid

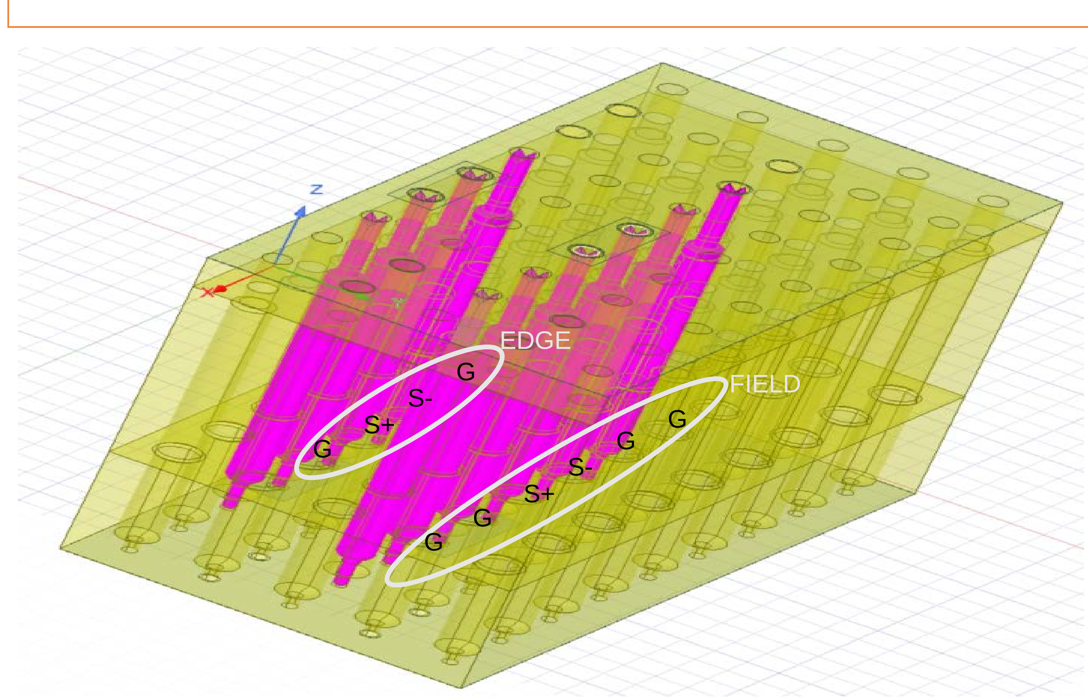


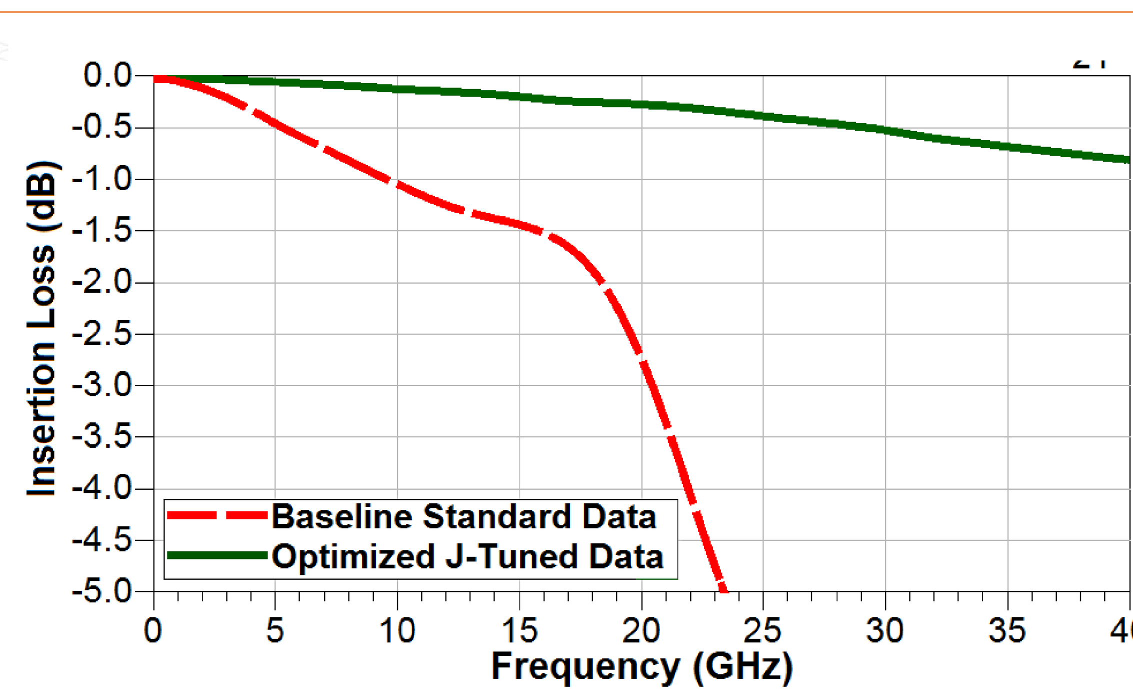


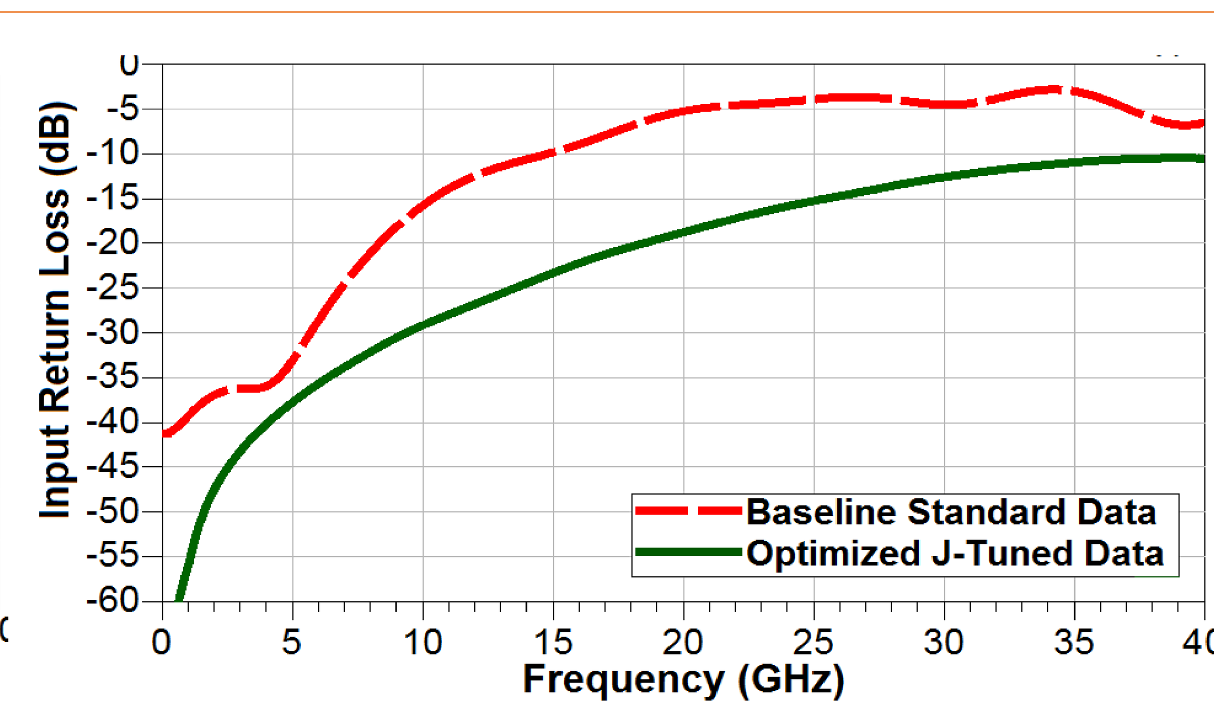


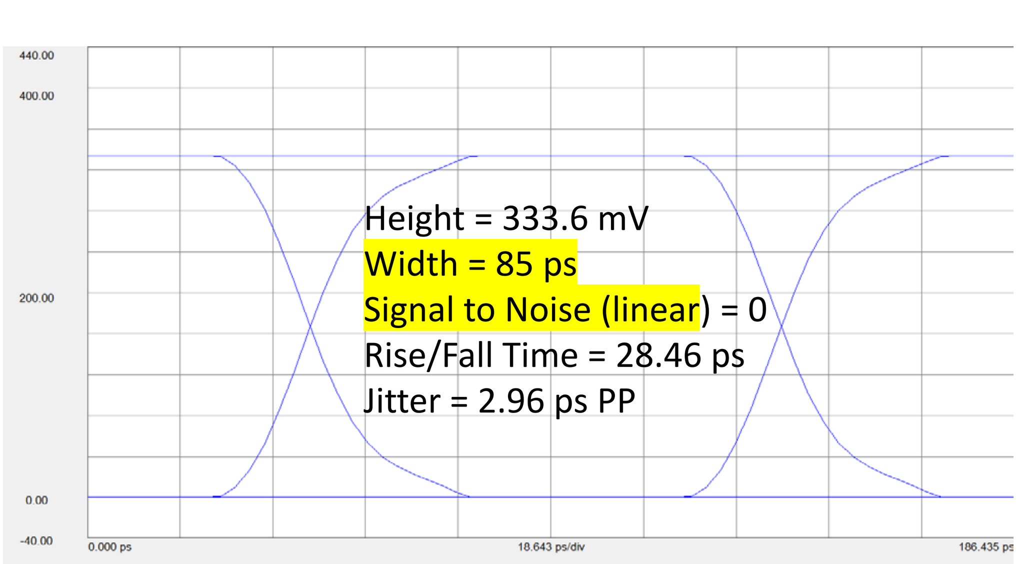
J-Tuning Optimization Case Study 1

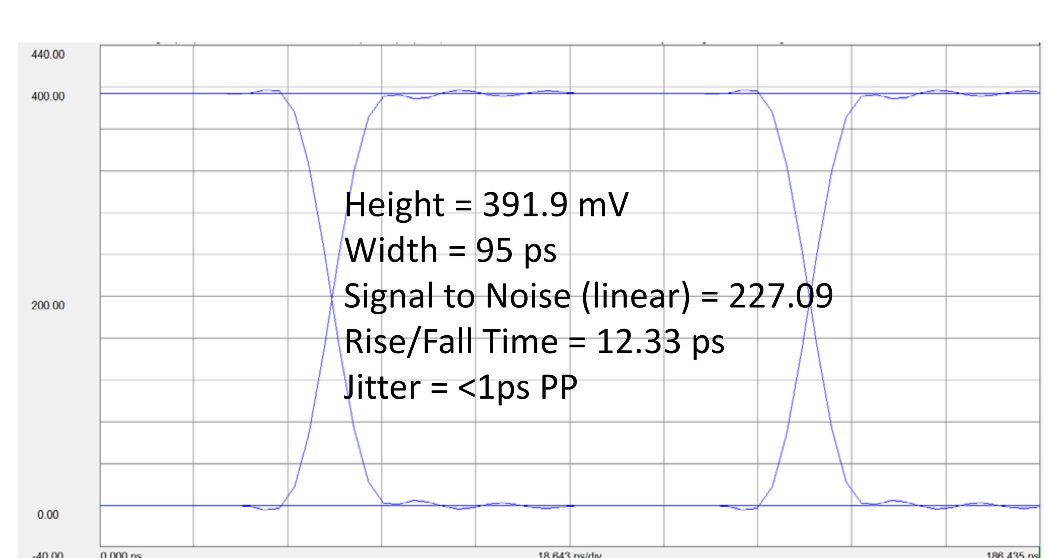
- **DOE of 6 simulation models applied to customer data sheet specifications:**
  - Data rate: 10.56 Gbps serial NRZ – BW 5.28 GHz
  - 3rd, 5th, 7th harmonic GSSG bandwidth: 15.8, 26.4, 37 GHZ
  - Match 100Ω differential and 25Ω common mode impedance

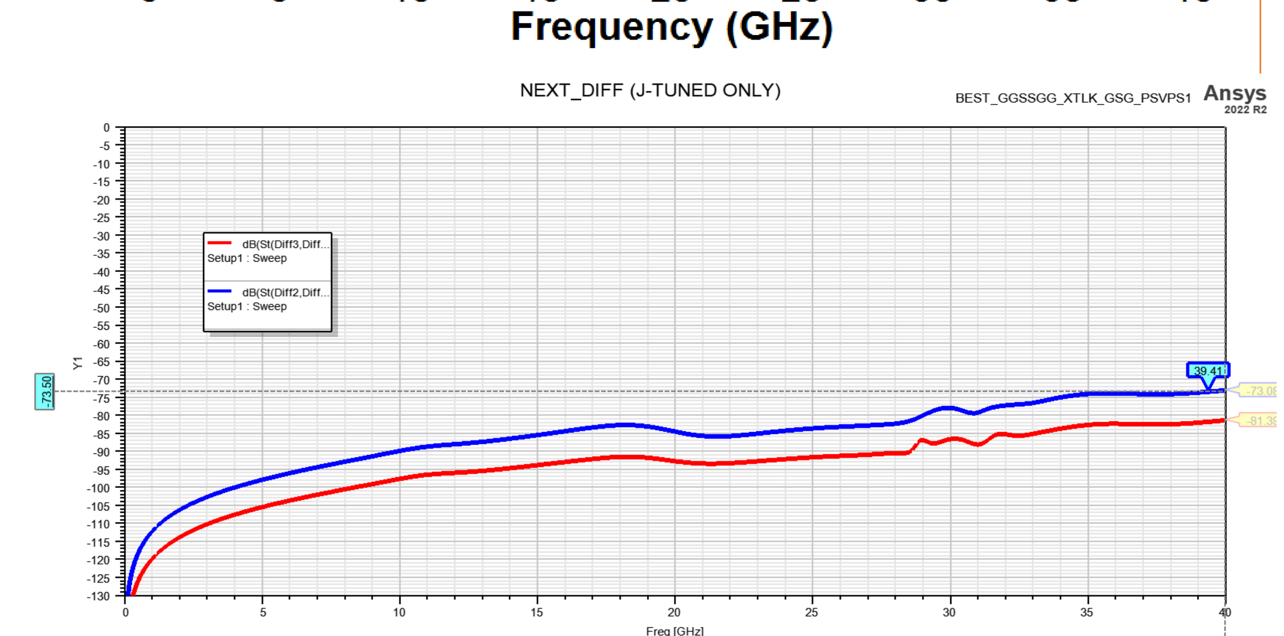






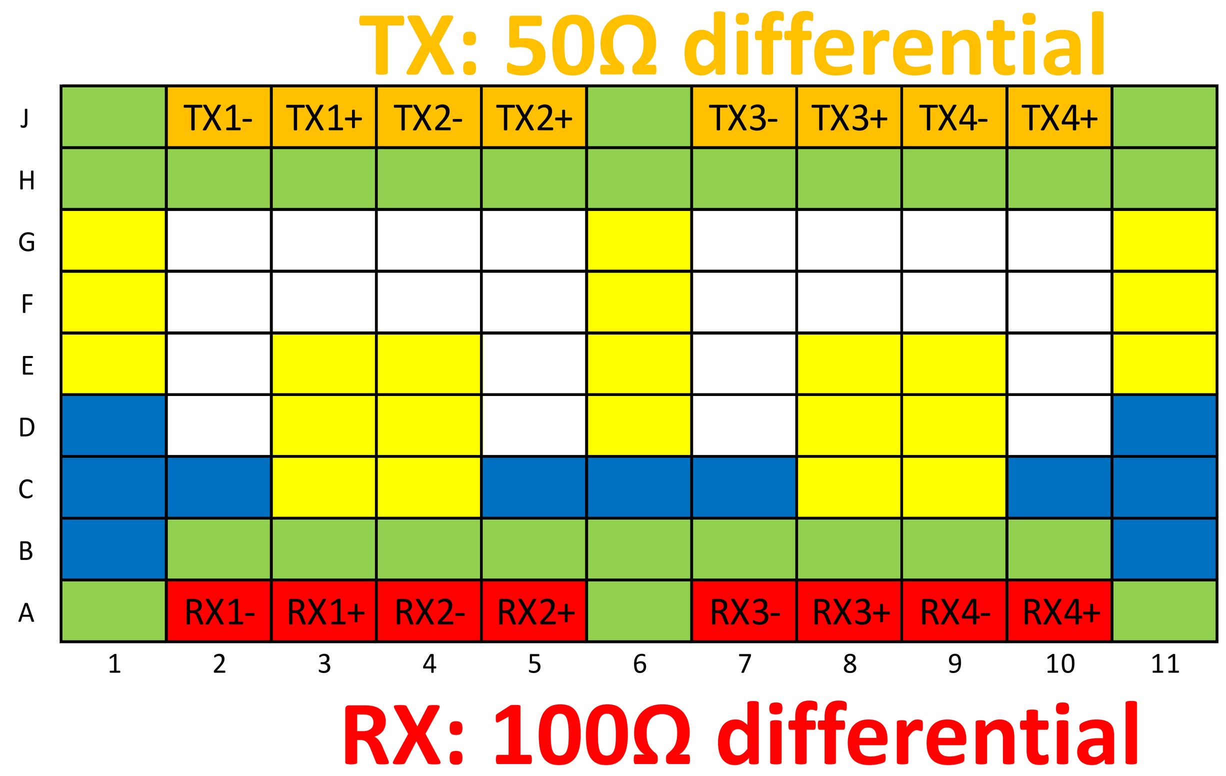


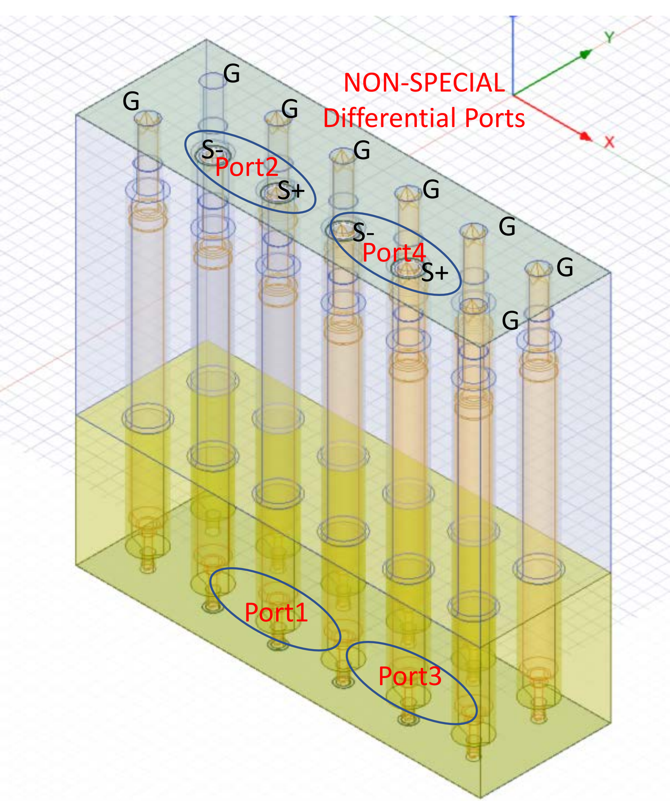


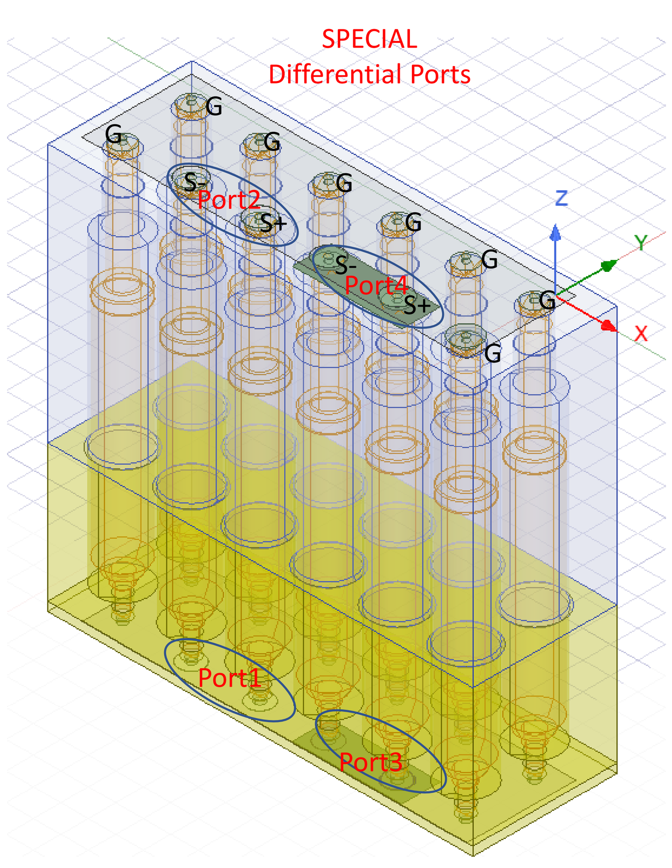


J-Tuning Optimization Case Study 2

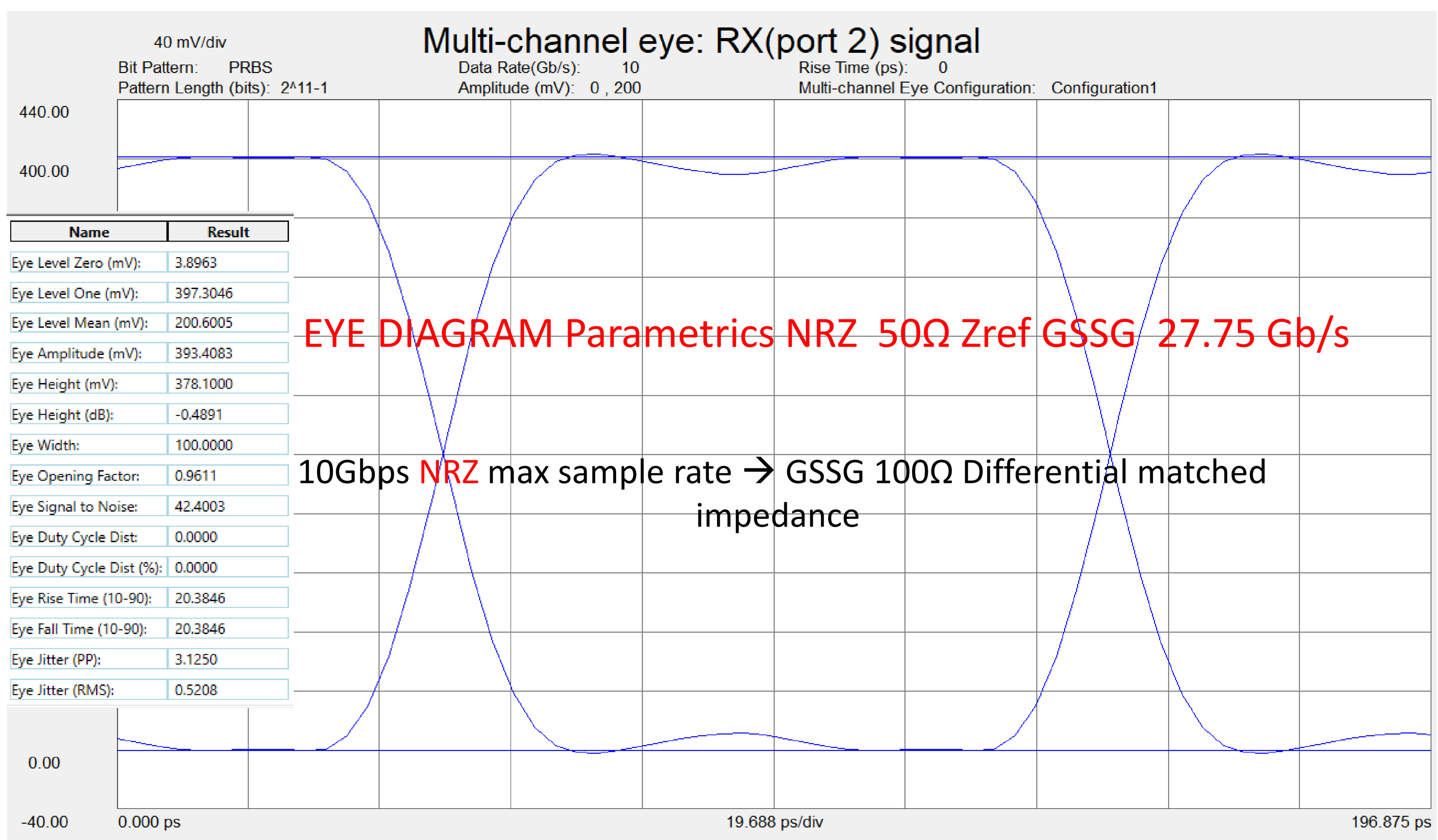
- **Goal: Replace existing multisite probe head with more robust spring probe solution without degradation in RF performance:**
  - Data rate: 10.56 Gbps serial NRZ – BW 5.28 GHz
  - 3rd harmonic GSSG bandwidth: 15 GHz -1dB Insertion Loss, 10dB Return Loss
  - Match 50Ω differential and 100Ω differential impedance

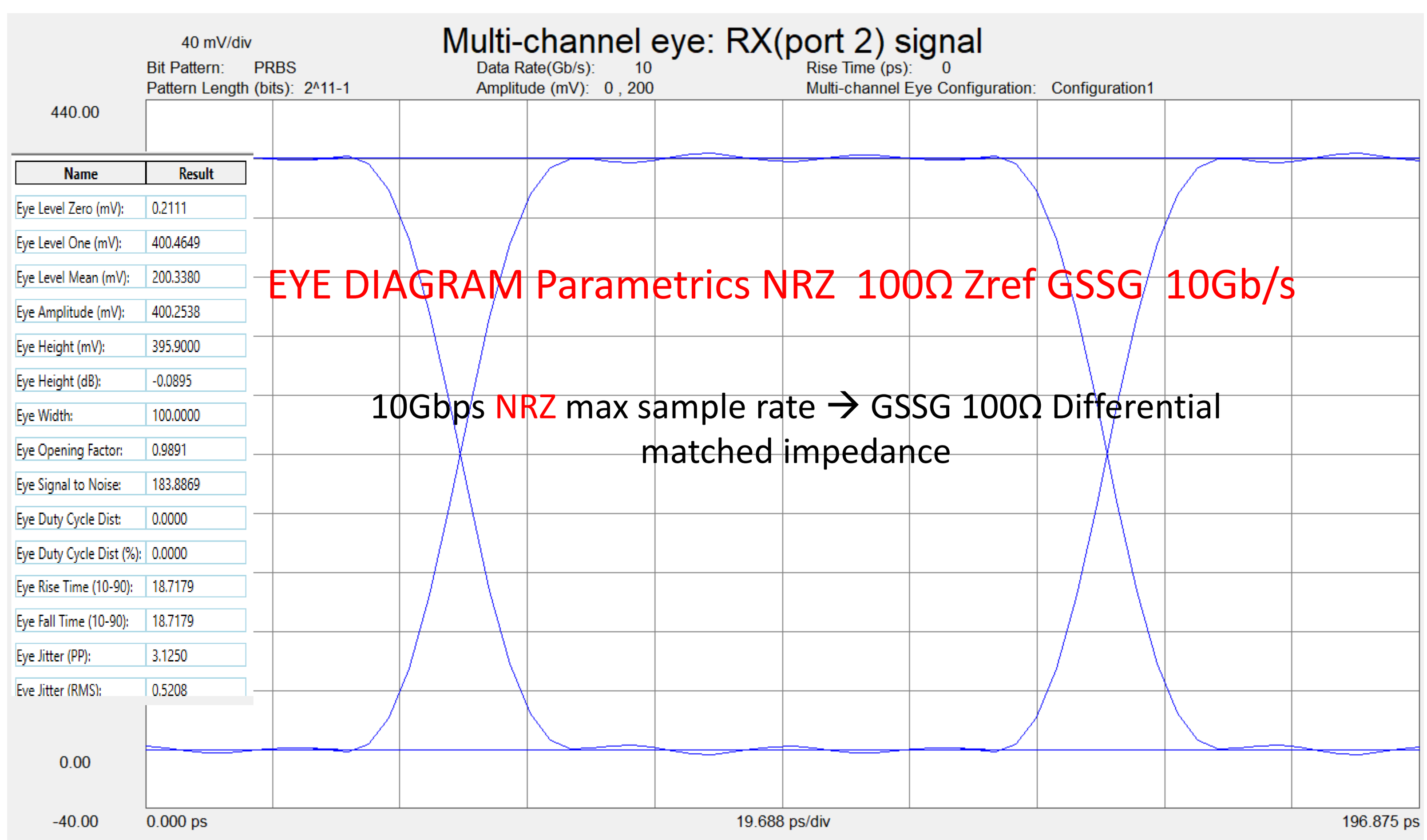






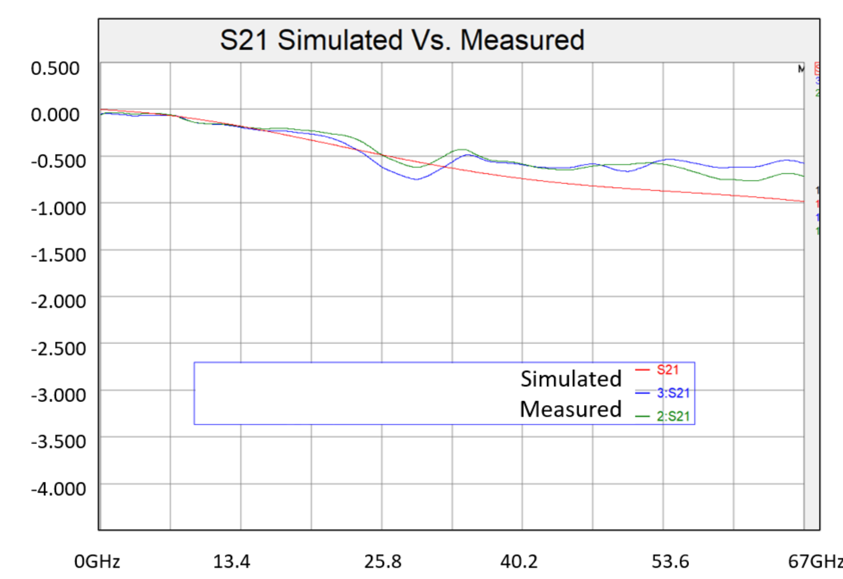
Final J-Tuned Model Type	Differential Impedance	-1 dB Insertion Loss (GHz) / @15 GHz	-10 dB Return Loss (GHz) Sdd22 DUT Side / @15 GHz
PROBE/HSG CONFIG A	100 Ω Diff	>40 GHz -0.25 dB	24.9 GHz/-19.5 dB
PROBE/HSG CONFIG B	50 Ω Diff	20.8GHz / -0.24 dB	19 GHz/-14.9 dB

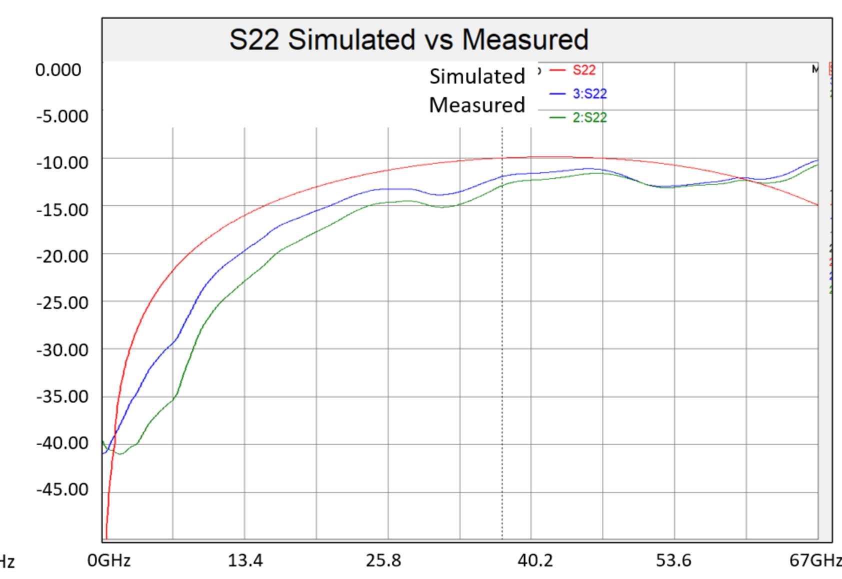


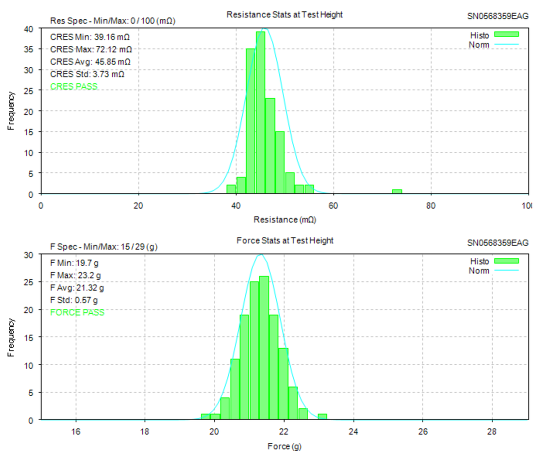


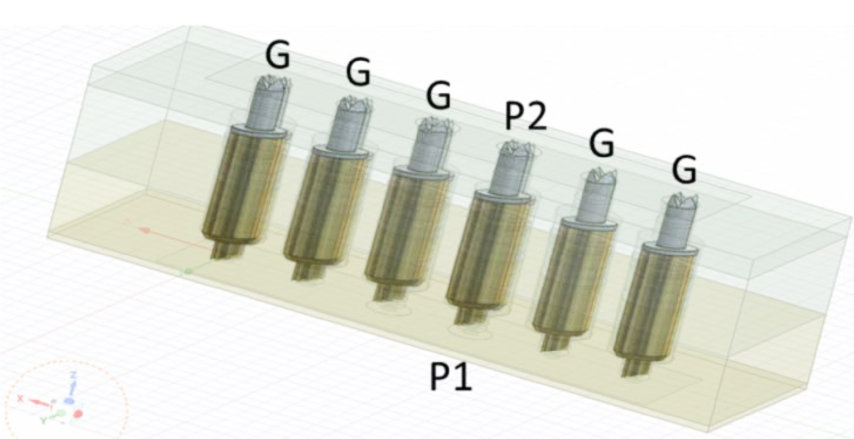
Measurement Validation and Discussion

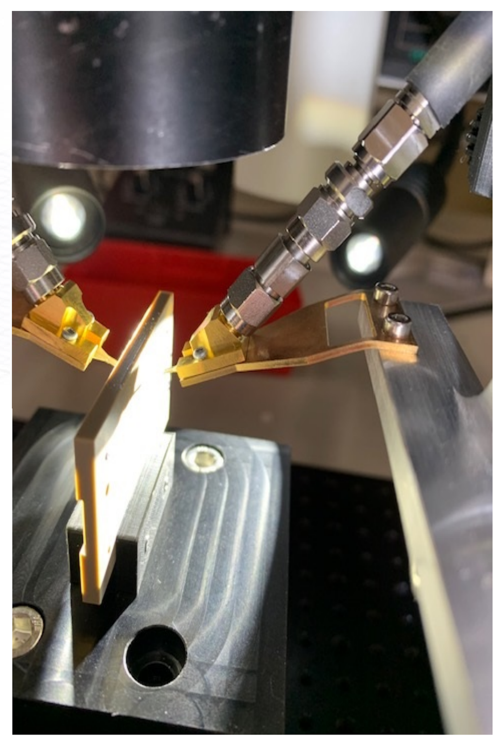
- S-Parameter validity checks:
  - Passivity ☑
  - Reciprocity ☑
  - Causality ☑
- VNA Measurements of identical configurations as simulation
- DC and mechanical checks:
  - Probe card analyzer, FRD: Contact Resistance and Planarity

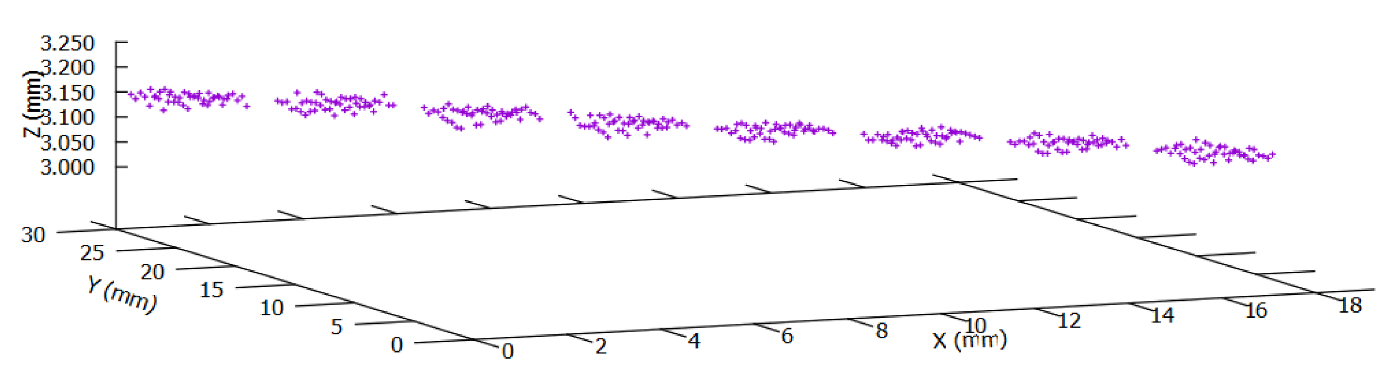












Questions ?

If you have any questions, please contact Valts Treibergs (vtreibergs@johnstech.com) or Jim Hattis (jmhattis@johnstech.com), or to request a J-TUNED® optimized probe head, contact Johnstech Sales at info@johnstech.com

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