Using MWS for High Bandwidth Connector Launch Optimizations

Scott McMorrow
Director of Engineering
Teraspeed Consulting Group LLC

TERASPEED CONSULTING GROUP

Why MWS for Launch Optimizations

- High computational range for aspect ratio can accommodate a wide range of geometries
  - Contact Fingers
  - Coax
  - Edge Card
  - Traces and planes
- Intuitive Parameterization and Optimization
  - Key to versatility.
- Speed
  - Network processing allows for fast simulation of multiple design trials.
- Ease of results interpretation
  - TDR, S-parameters and field visualizations allow the designer multiple windows into the causes of poor performance.
    - Impedance discontinuity
    - Resonance
    - Poor return path control
    - Crosstalk

TERASPEED CONSULTING GROUP

Potential Optimization Techniques

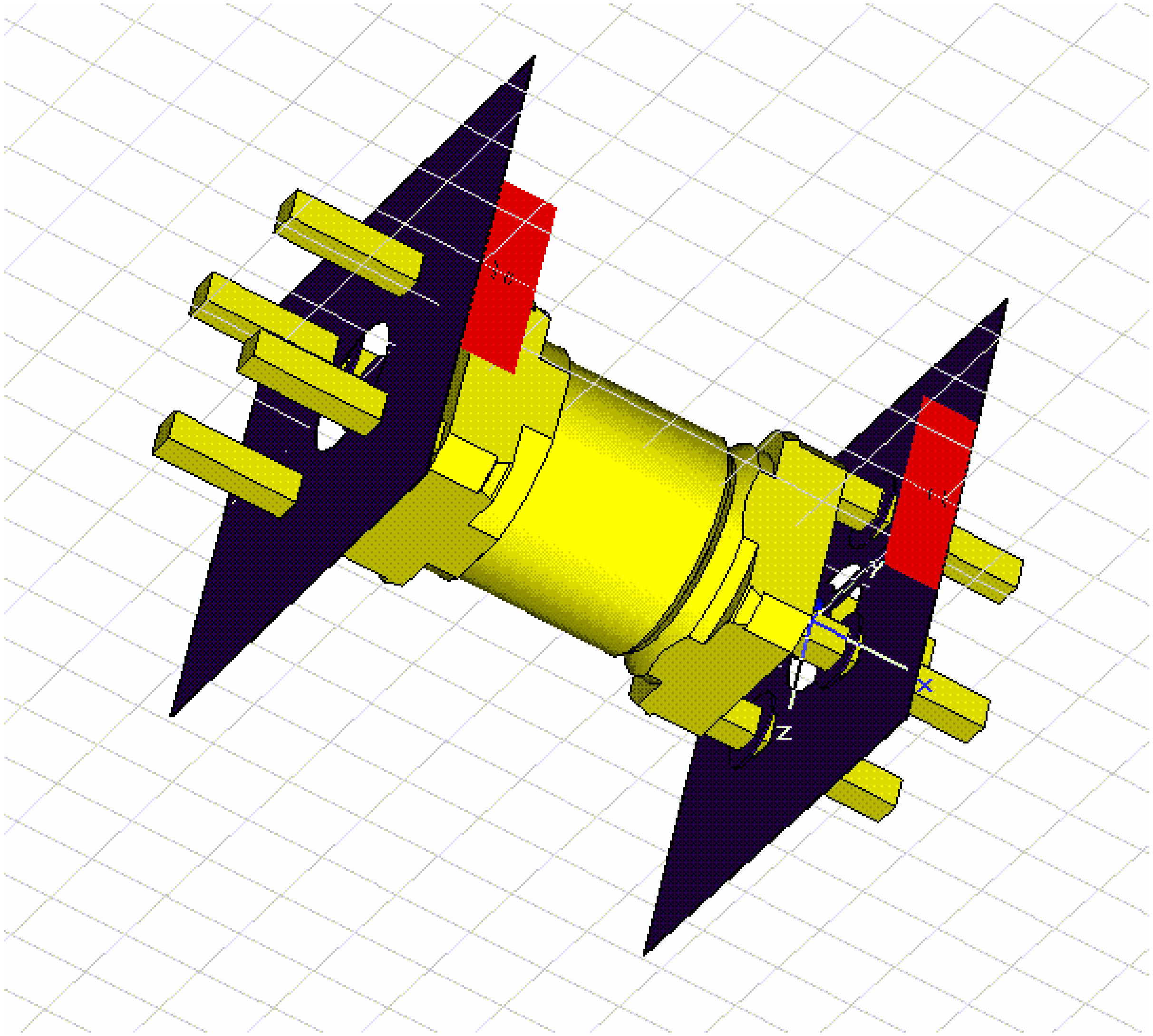
- Via
  - Position
  - Number
  - Drill Size
  - Use to control return path, crosstalk and impedance.
- Pads and Traces
  - Vary pad and trace width for impedance compensation
- Antipad
  - Opening dimensions
  - Position
  - Use to compensate for low impedance regions

TERASPEED CONSULTING GROUP

Optimization Examples

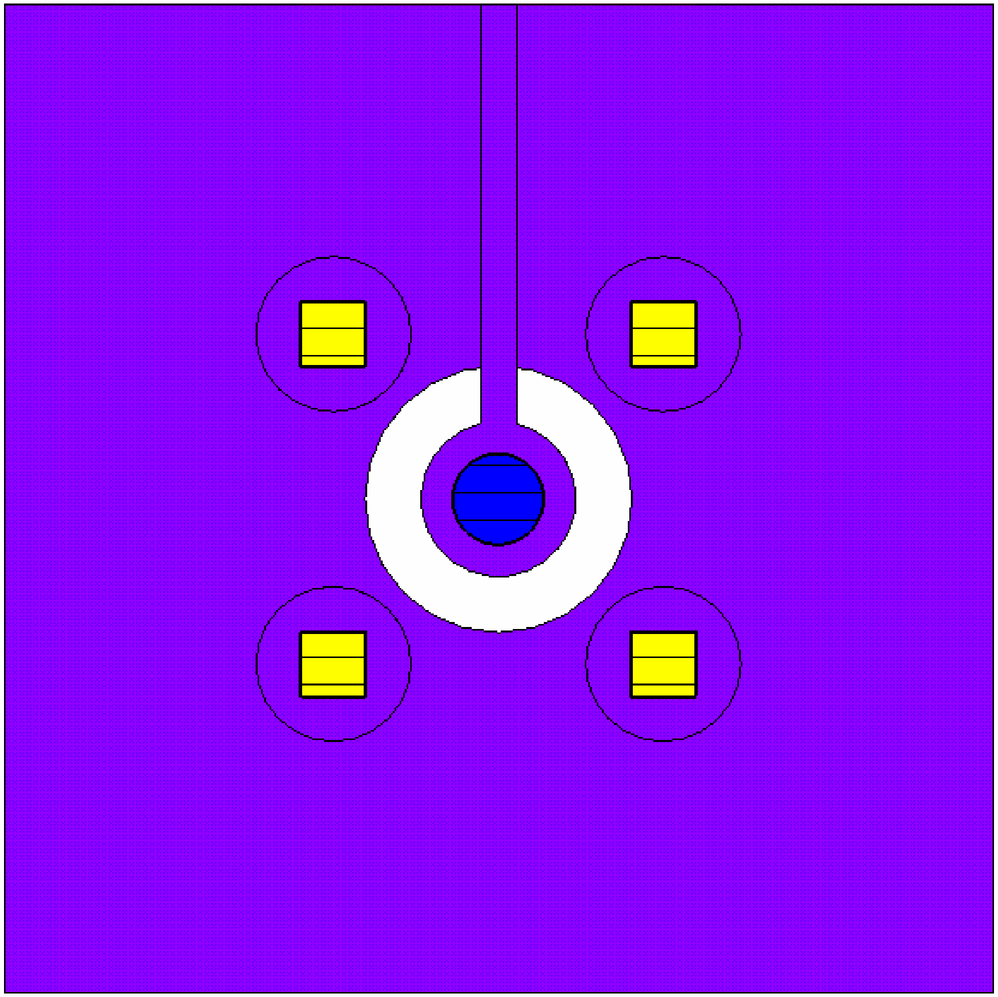
- MMCX connector to PCB transition
- Samtec HSEC8 connector edge card optimization
- Corning Gilbert GPPO RF connector to PCB microstrip optimization.
- Paricon Pariposer elastomeric PCB/Flex interposer optimization.

MMCX Optimization



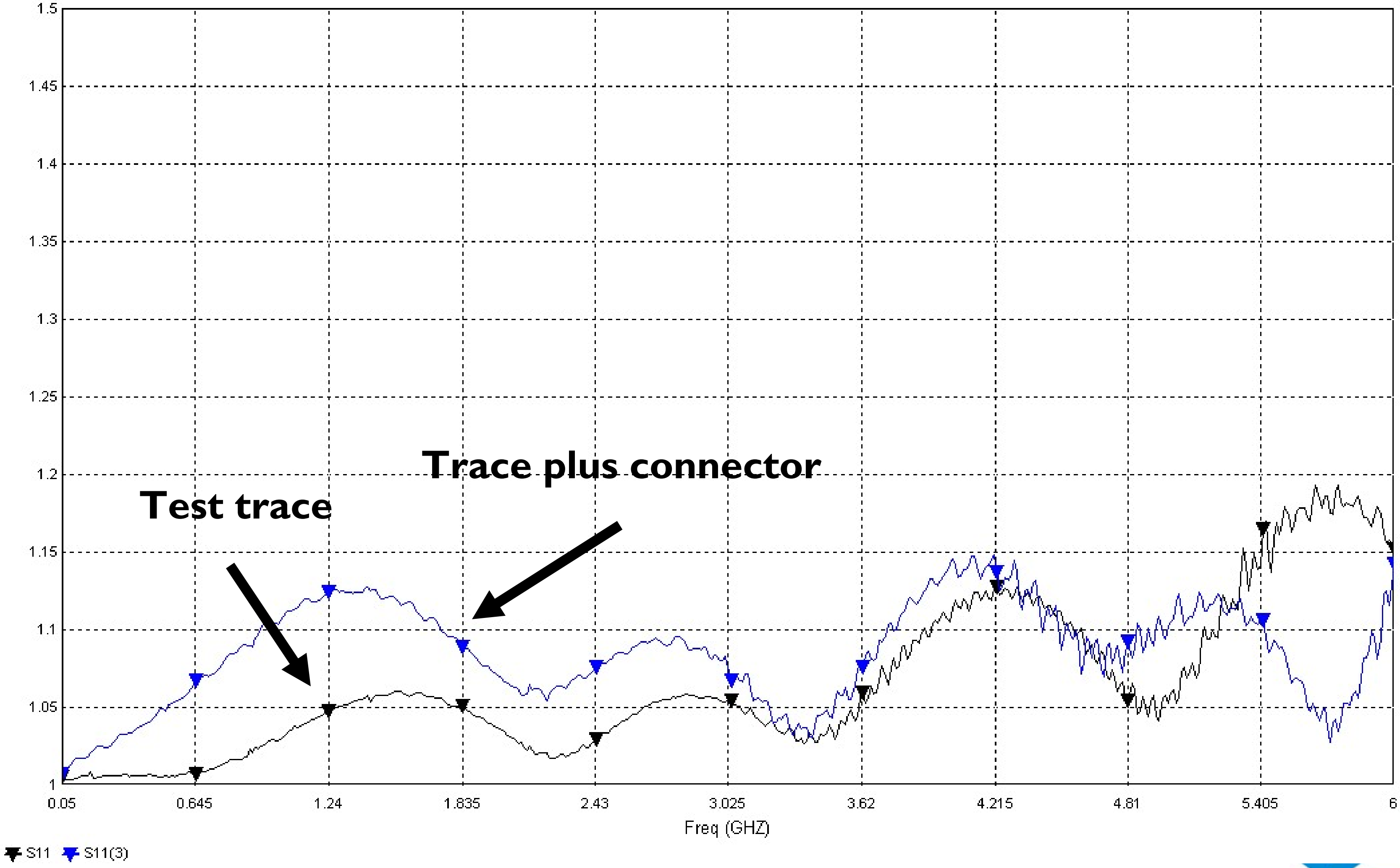
TERASPEED CONSULTING GROUP

MMCX Microstrip Launch Optimization



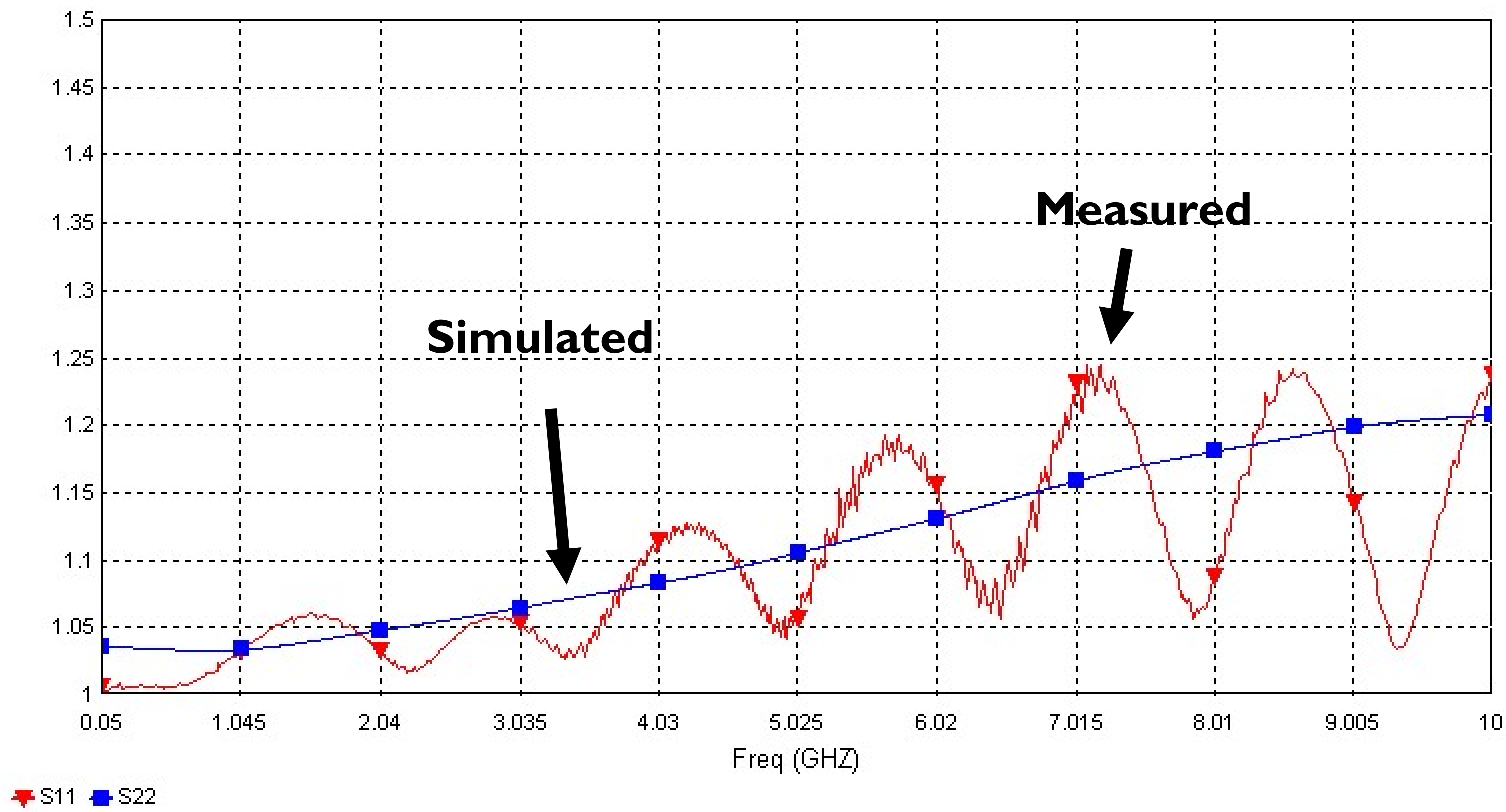
TERASPEED CONSULTING GROUP

VSWR Results Test Trace vs. Trace Plus Connector



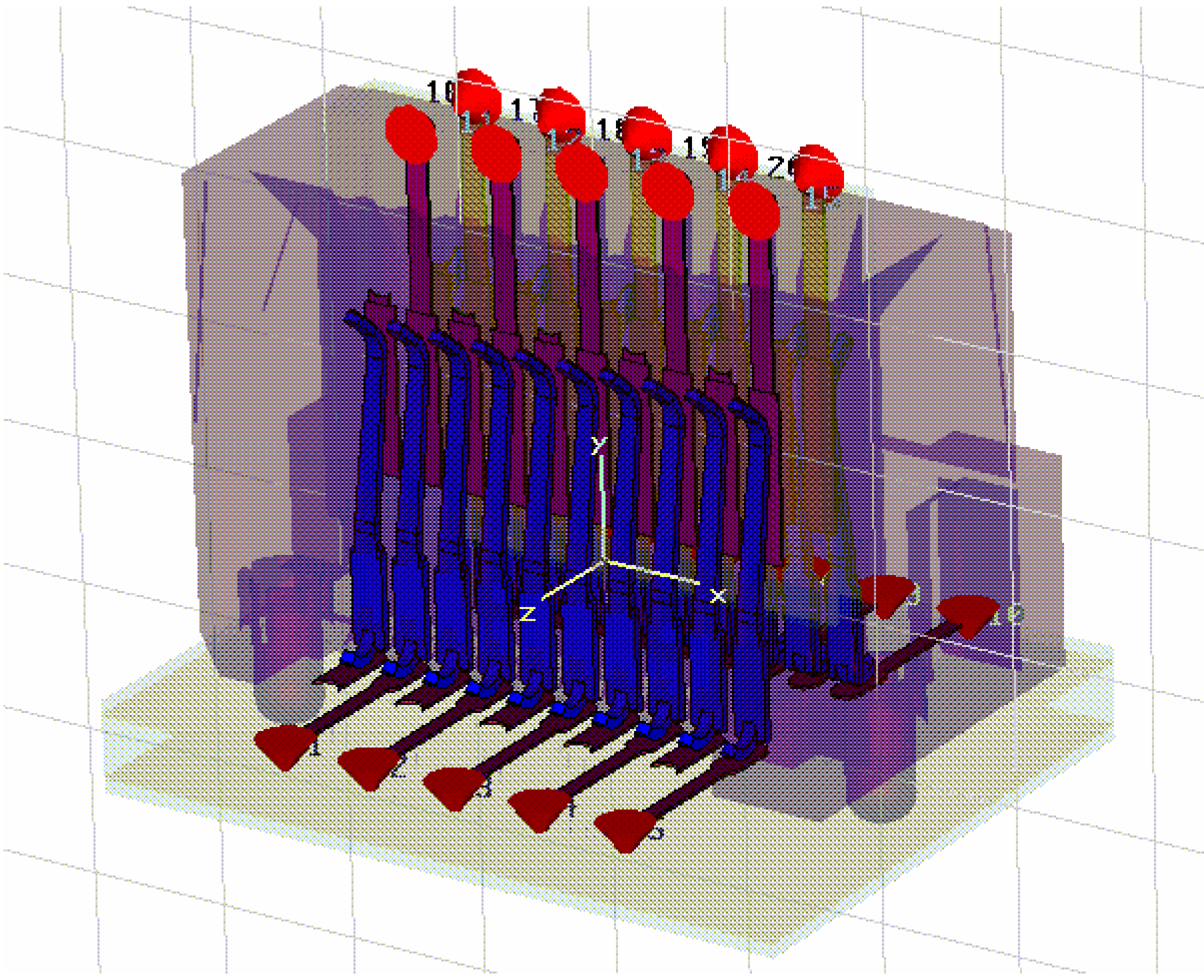
TERASPEED CONSULTING GROUP

VSWR Result Simulation vs. Measurement



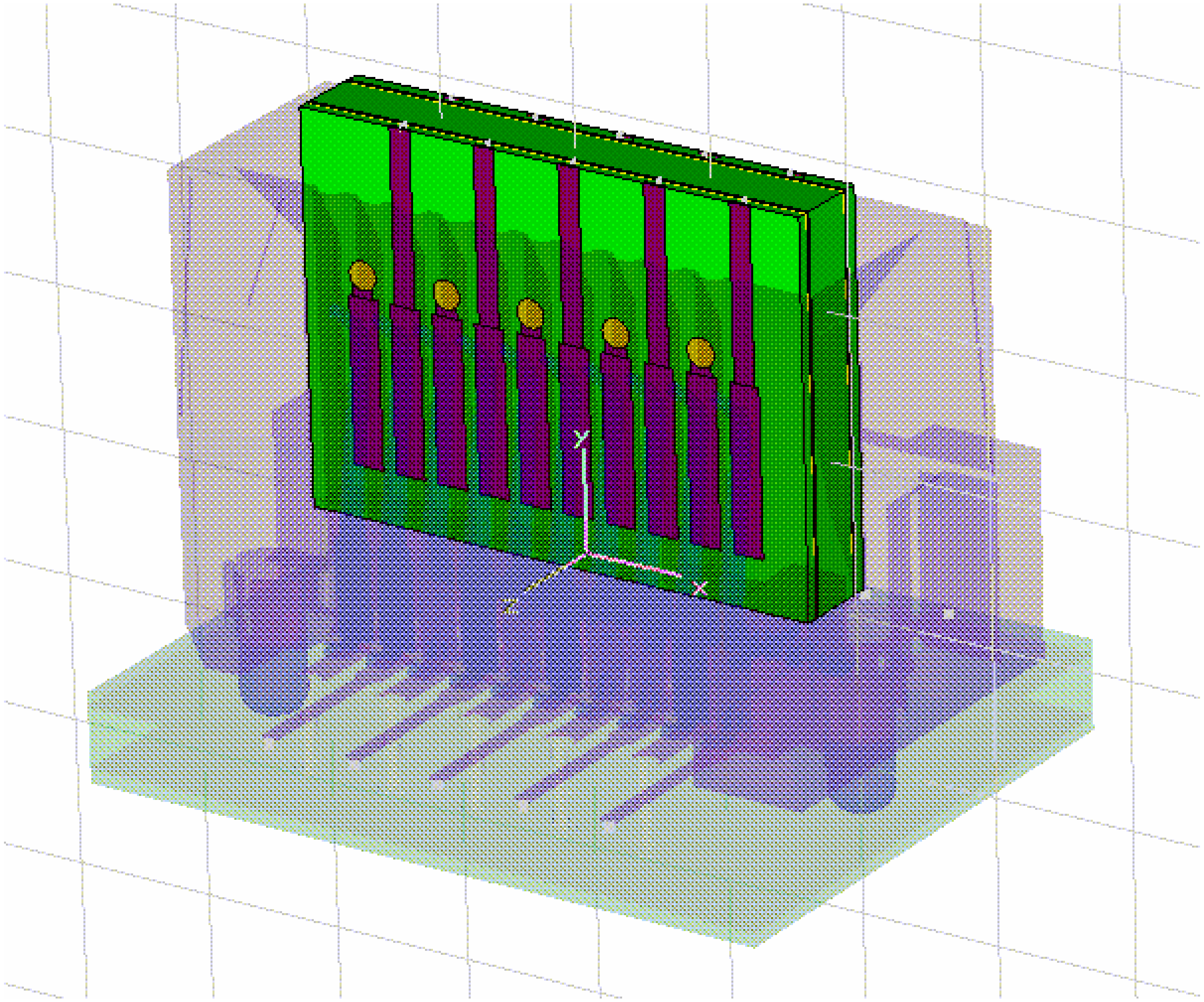
TERASPEED CONSULTING GROUP

RU8 Edge Card Microstrip Launch Transition



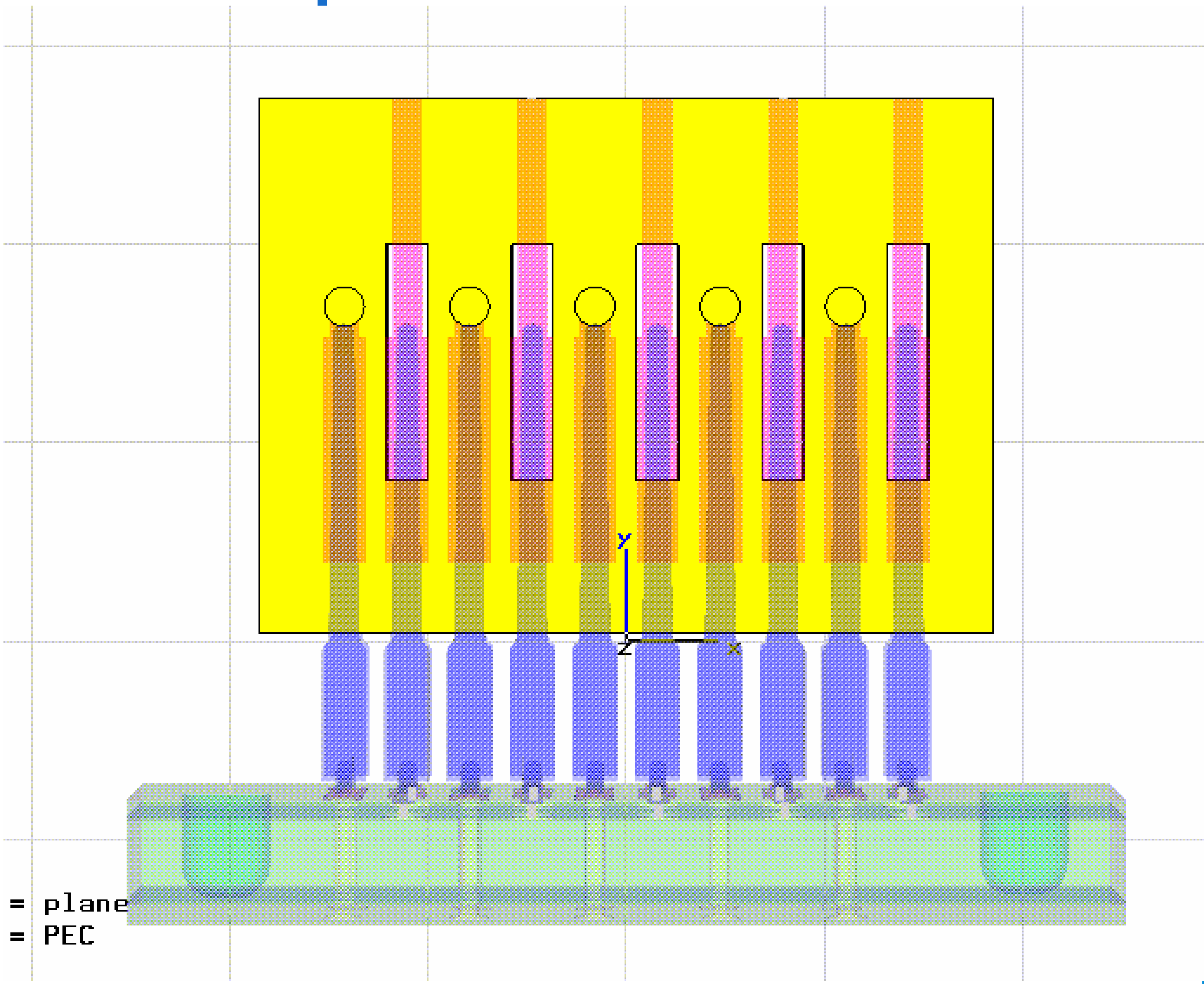
TERASPEED CONSULTING GROUP

Card View



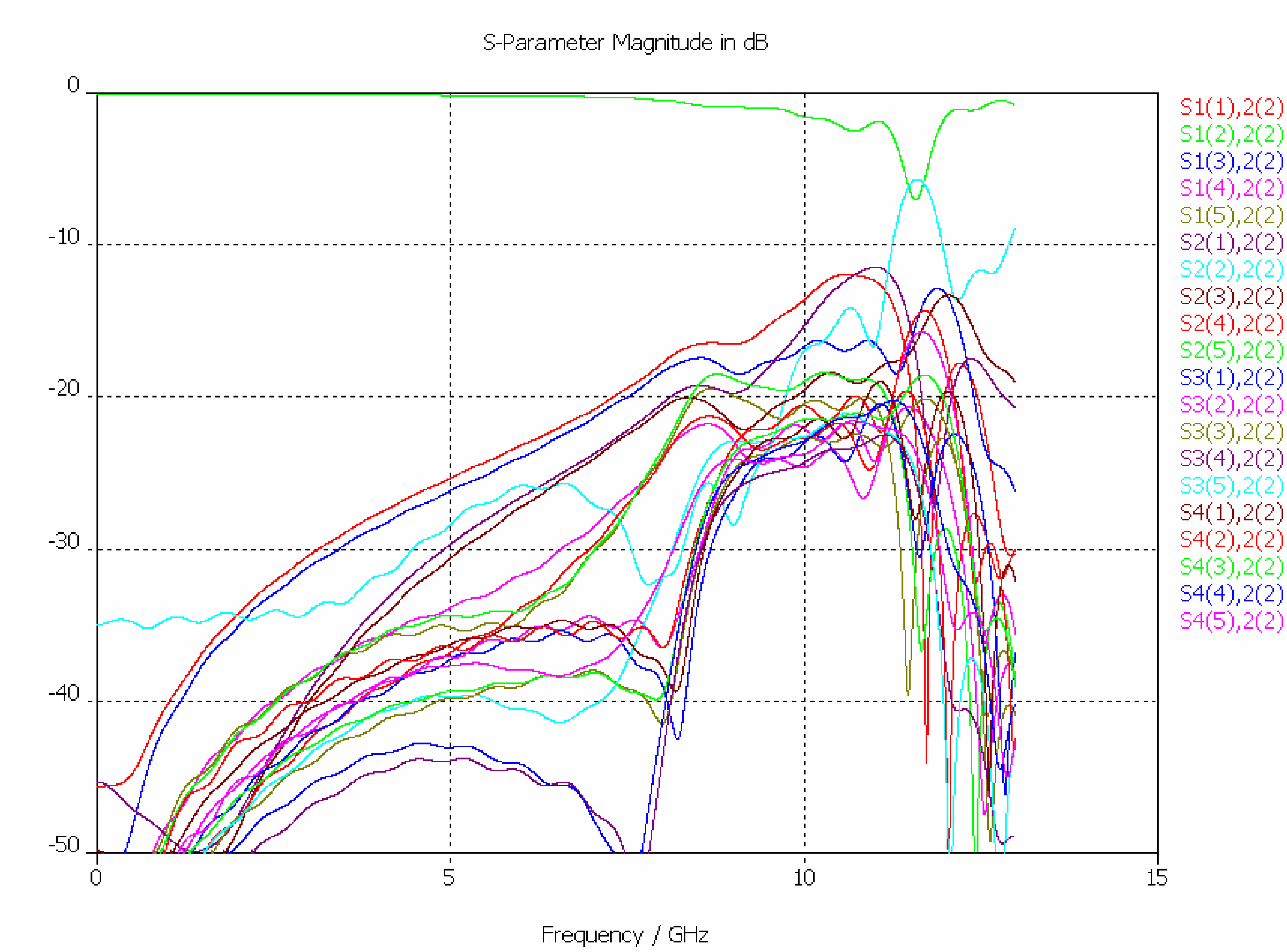
TERASPEED
CONSULTING
GROUP

Optimization Method



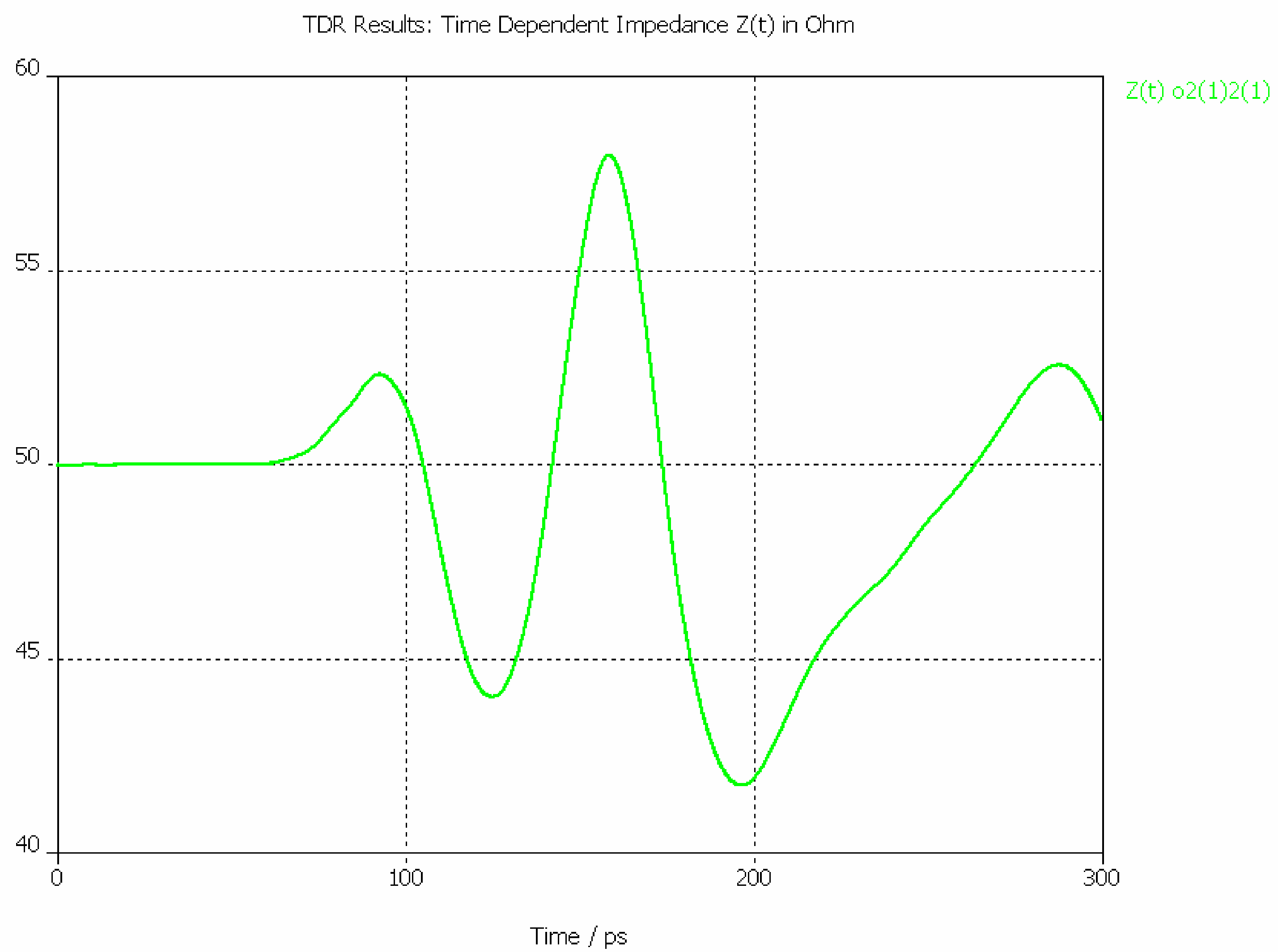
TERASPEED CONSULTING GROUP

S-Parameters



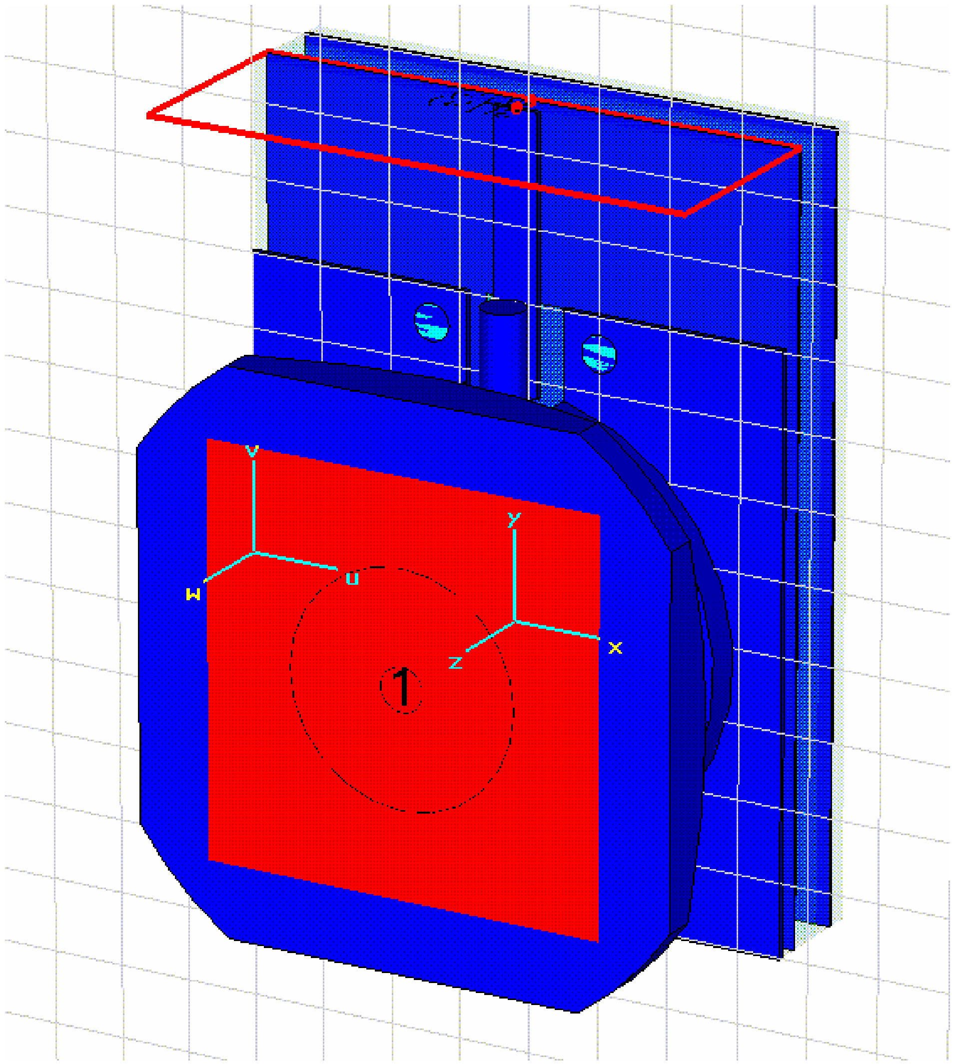
TERASPEED CONSULTING GROUP

TDR @ 35 ps Trise



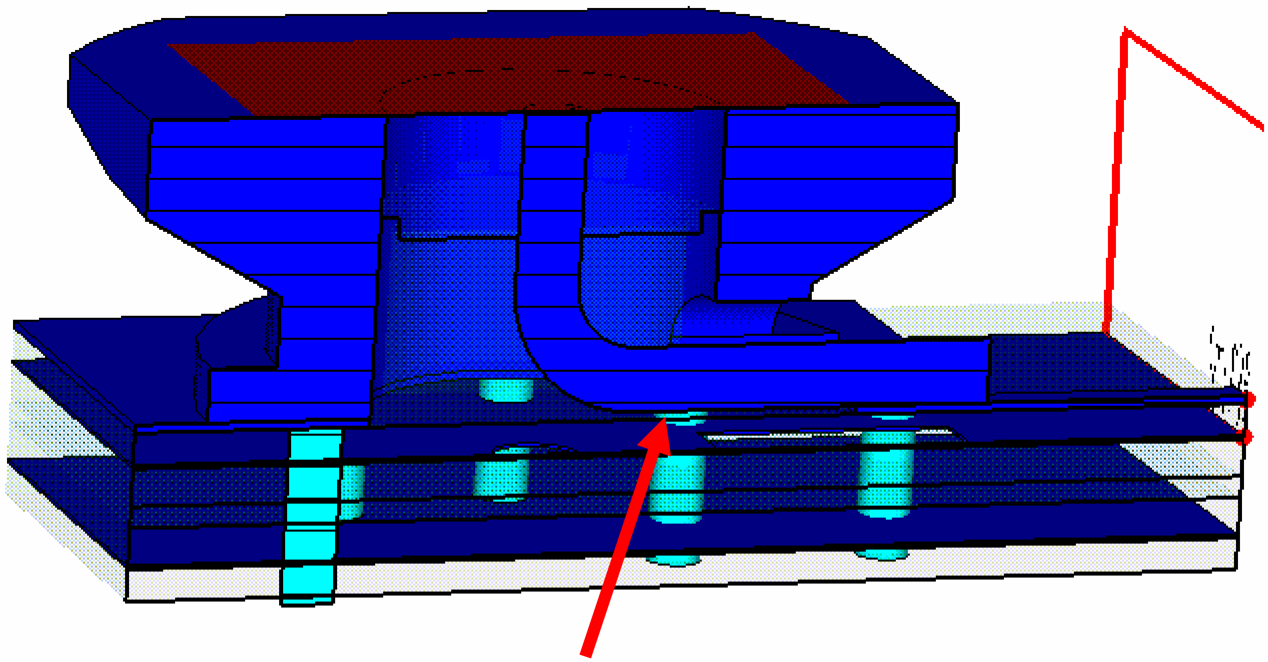
TERASPEED CONSULTING GROUP

GPPO Surface Mount Microstrip Launch



TERASPEED CONSULTING GROUP

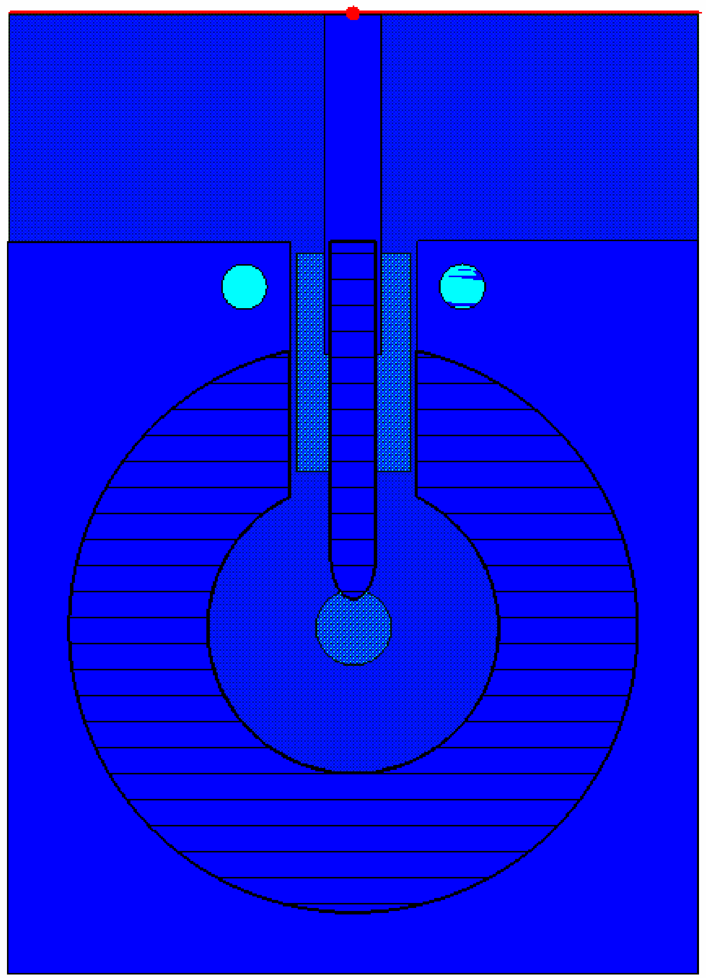
GPPO Side Section



Low Impedance Area

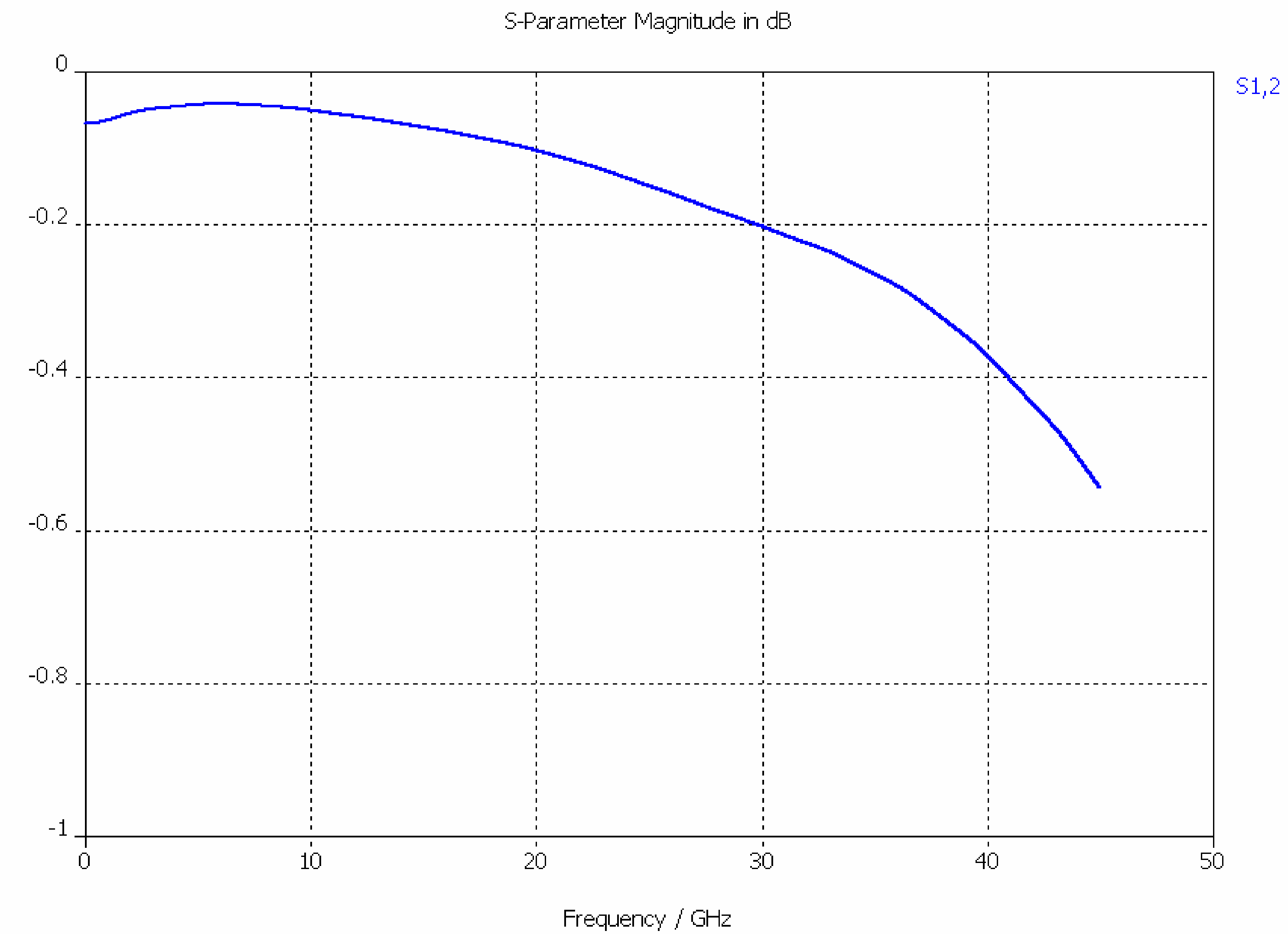
TERASPEED CONSULTING GROUP

GPPO Board View



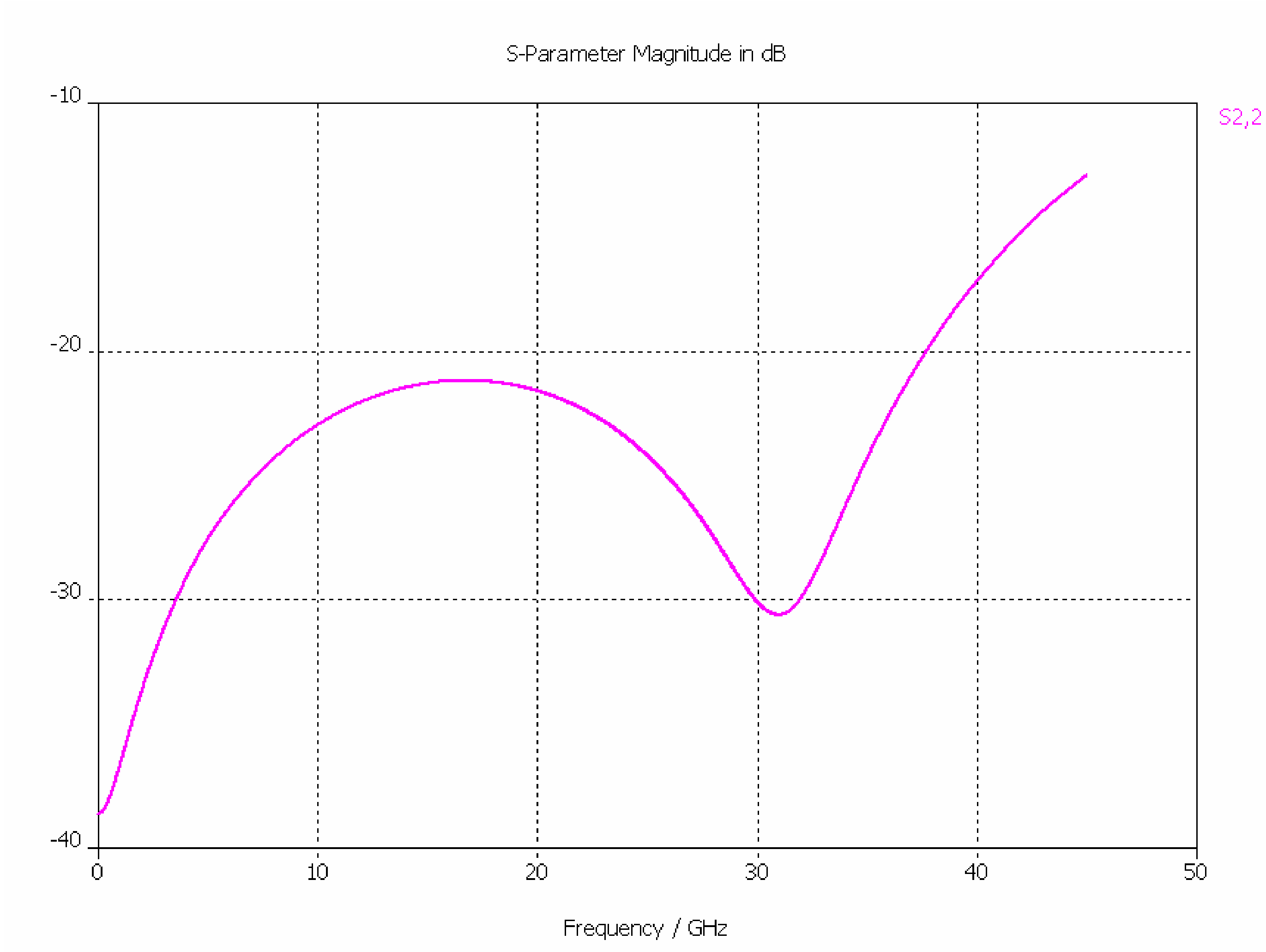
TERASPEED
CONSULTING
GROUP

GPPO S21



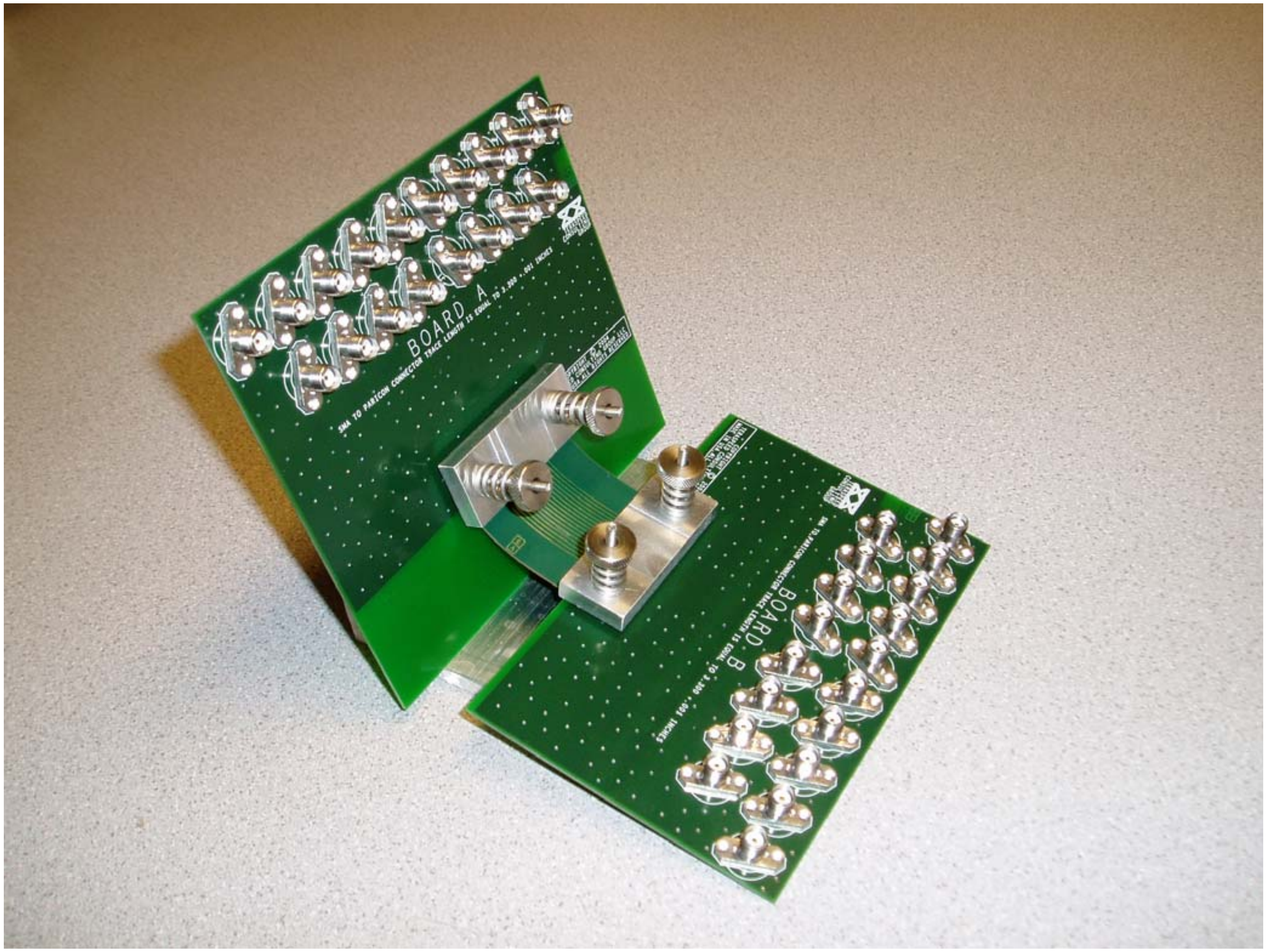
TERASPEED CONSULTING GROUP

GPPO S11



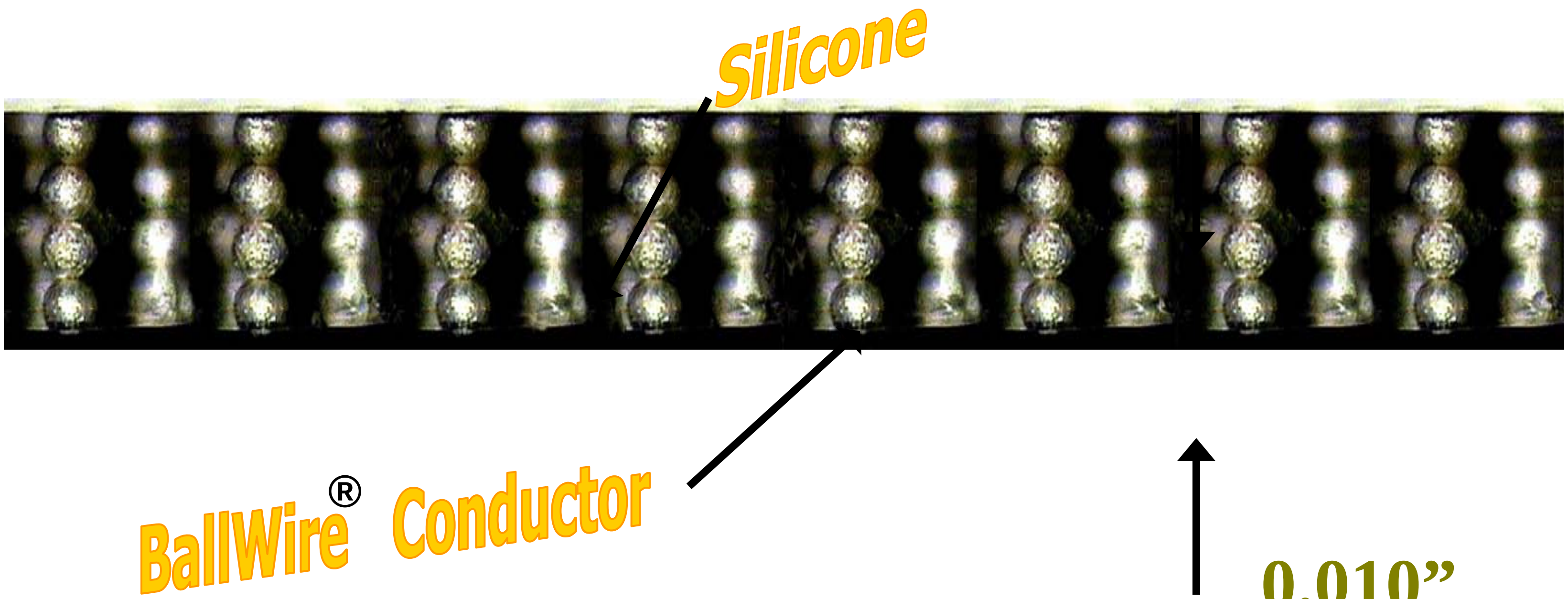
TERASPEED CONSULTING GROUP

Paricon GigaConn™ Connector Evaluation Platform



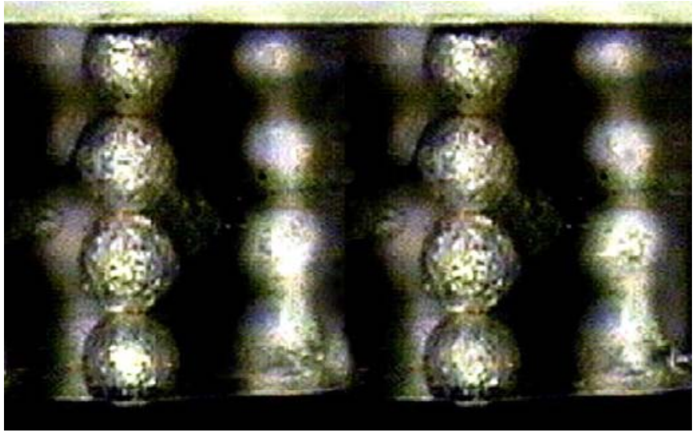
TERASPEED CONSULTING GROUP

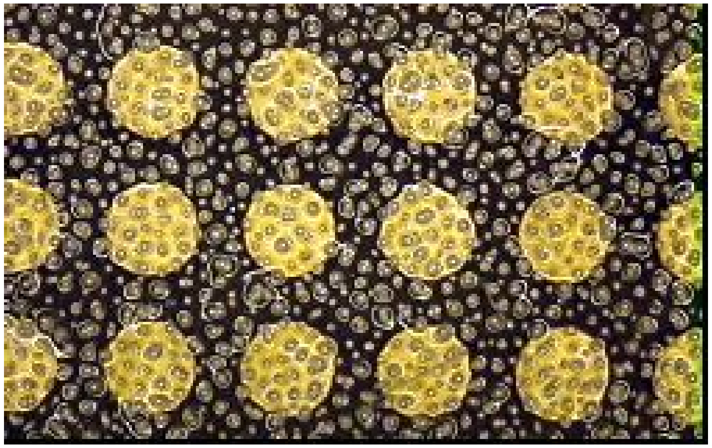
PariPoser® Interconnection Fabric

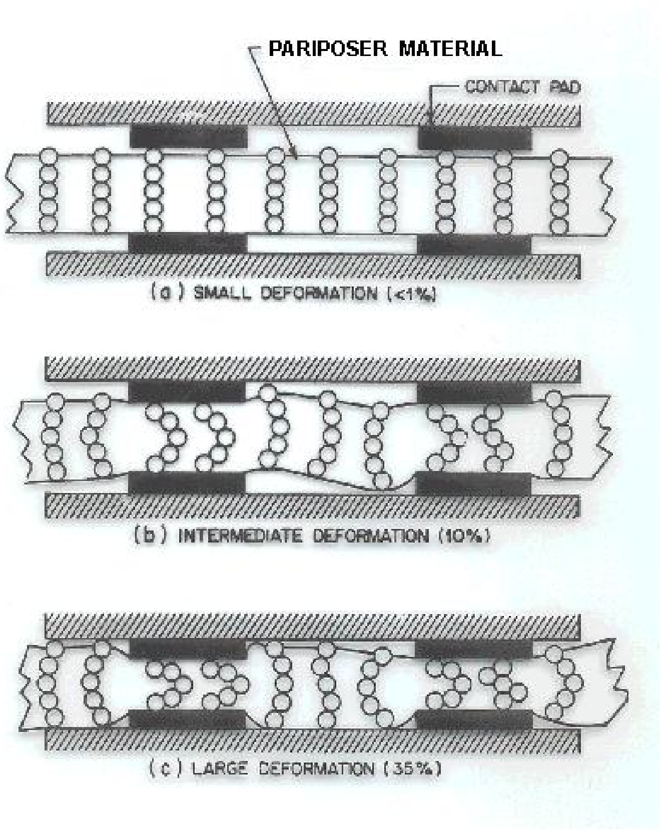


TERASPEED
CONSULTING
GROUP

Visco-Elastic Conductive Fabric







TERASPEED CONSULTING GROUP

Paricon Pariposer

- Pariposer material has the following advantages in any interposer application.
  - A thin high-performance interposing fabric with bandwidth greater than 50 GHz.
    - Material is electrically near-transparent.
  - A contact region that conforms to the geometry of the application.
    - Material reconfigures for each application.
  - A contact region that matches the performance capability of the underlying design.
    - Advanced contact and transition designs can take advantage of the extraordinary performance of the material.

GigaCon™ Test Vehicle

- Board-to-board or Board-to-flex-to-board.
  - Common Low-cost materials
    - FR-4 (4-layer, 0.062" thick, Er = 4.2, TanDelta = 0.025)
    - Polyimide Flex (2-layer, Er = 3.1, TanDelta = 0.014)
    - SMA instrumentation connectors (> 30 GHz bandwidth)
  - Each PCB contains:
    - SMA
    - 3.3" FR-4 trace
    - GigaCon™ optimized contact area.
  - Mating flex contains:
    - Via in pad optimized contact area.
  - Pariposer material used as the contact interposer.

TERASPEED CONSULTING GROUP

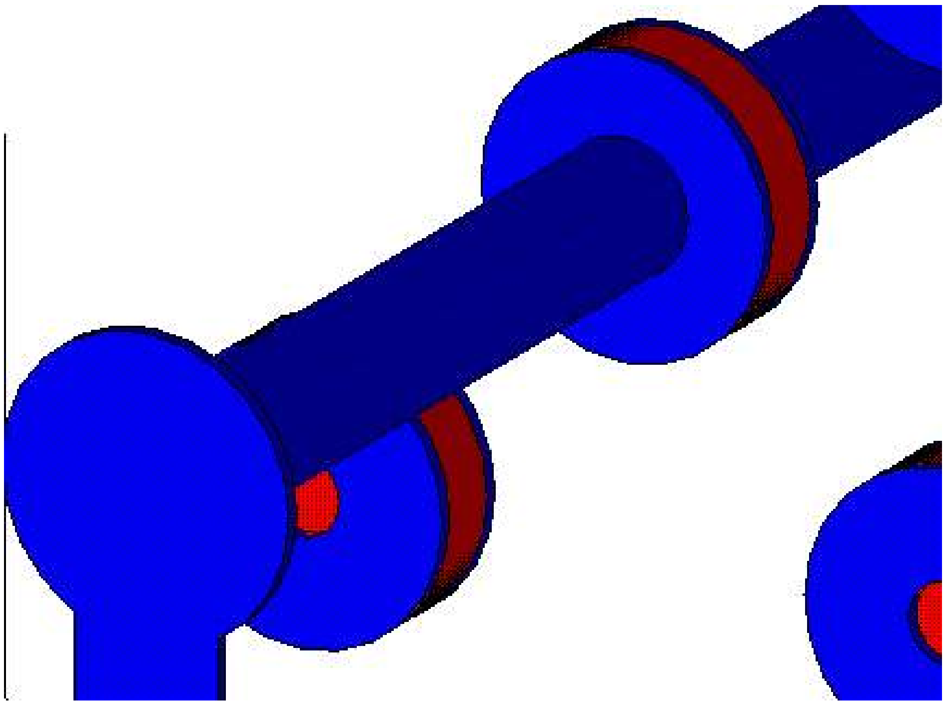
GigaCon™ Transition Structure

- Potential GigaCon contact transition structures were modeled with CST Microwave Studio, Finite Integration Technique full wave time domain field solver.
  - Two approaches taken:
    - Ideal contacts.
    - Approximate multiple cylindrical contacts.
  - Modeled section included:
    - Two 0.062" thickness FR-4 printed circuit boards.
    - Contact Pads and 0.062" thru vias.
    - Entry and exit microstrip traces.
    - Pariposer modeling.
  - Transitions were simulated and their structures optimized for minimum return loss.

TERASPEED
CONSULTING
GROUP

Ideal Modeling

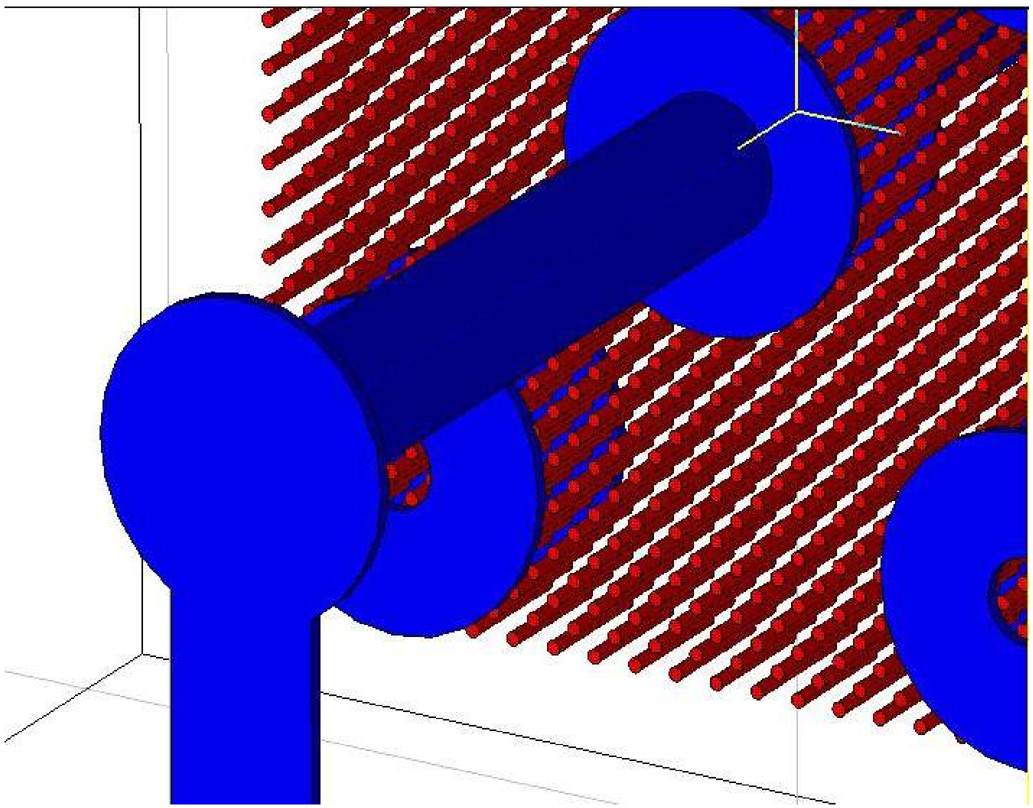
- Contact surface was modeled as a complete cylindrical metal surface with no additional interstitial conductive material.



TERASPEED CONSULTING GROUP

Approximate Modeling

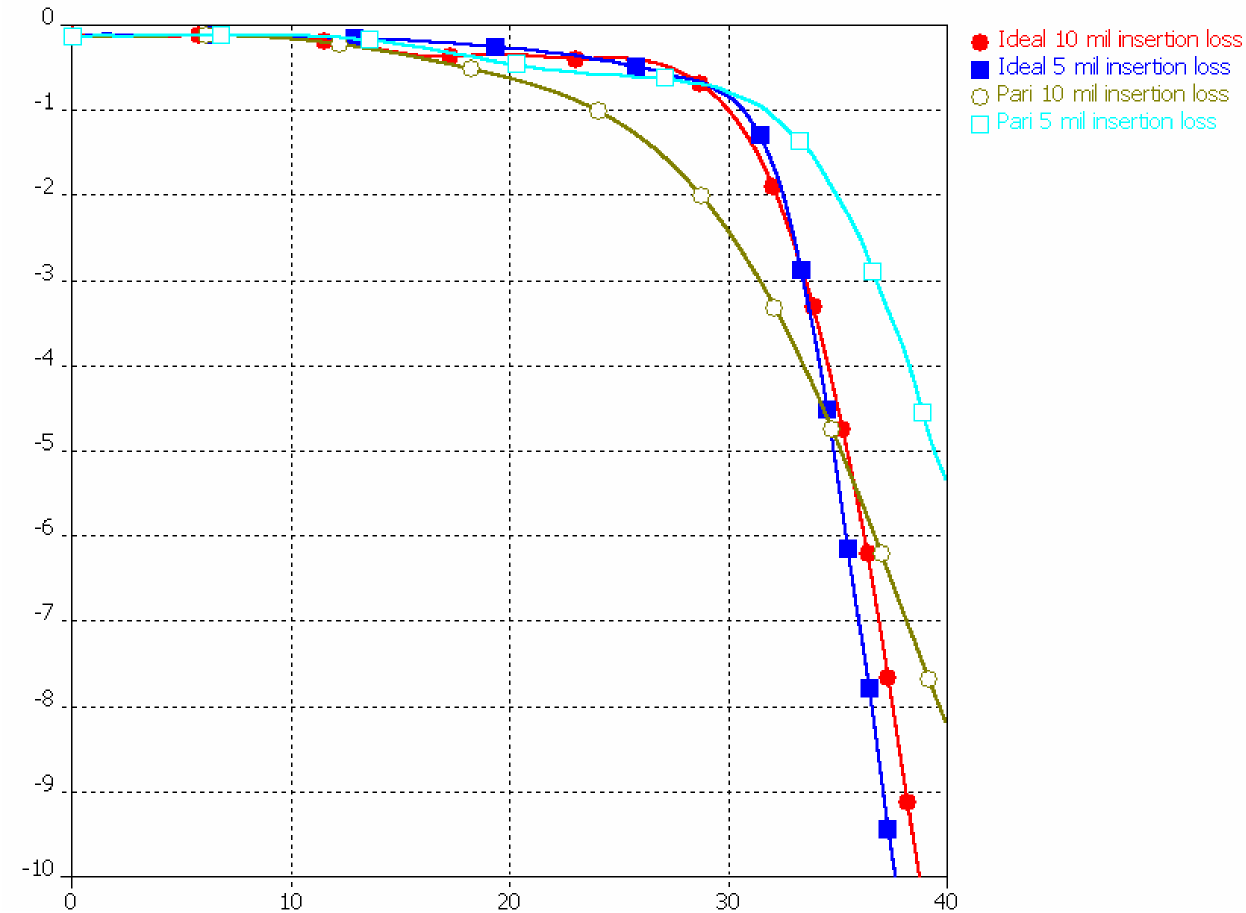
- Contact surface was modeled with multiple cylindrical contacts approximating general Ballwire size and spacing.



TERASPEED CONSULTING GROUP

GigaCon Insertion Loss

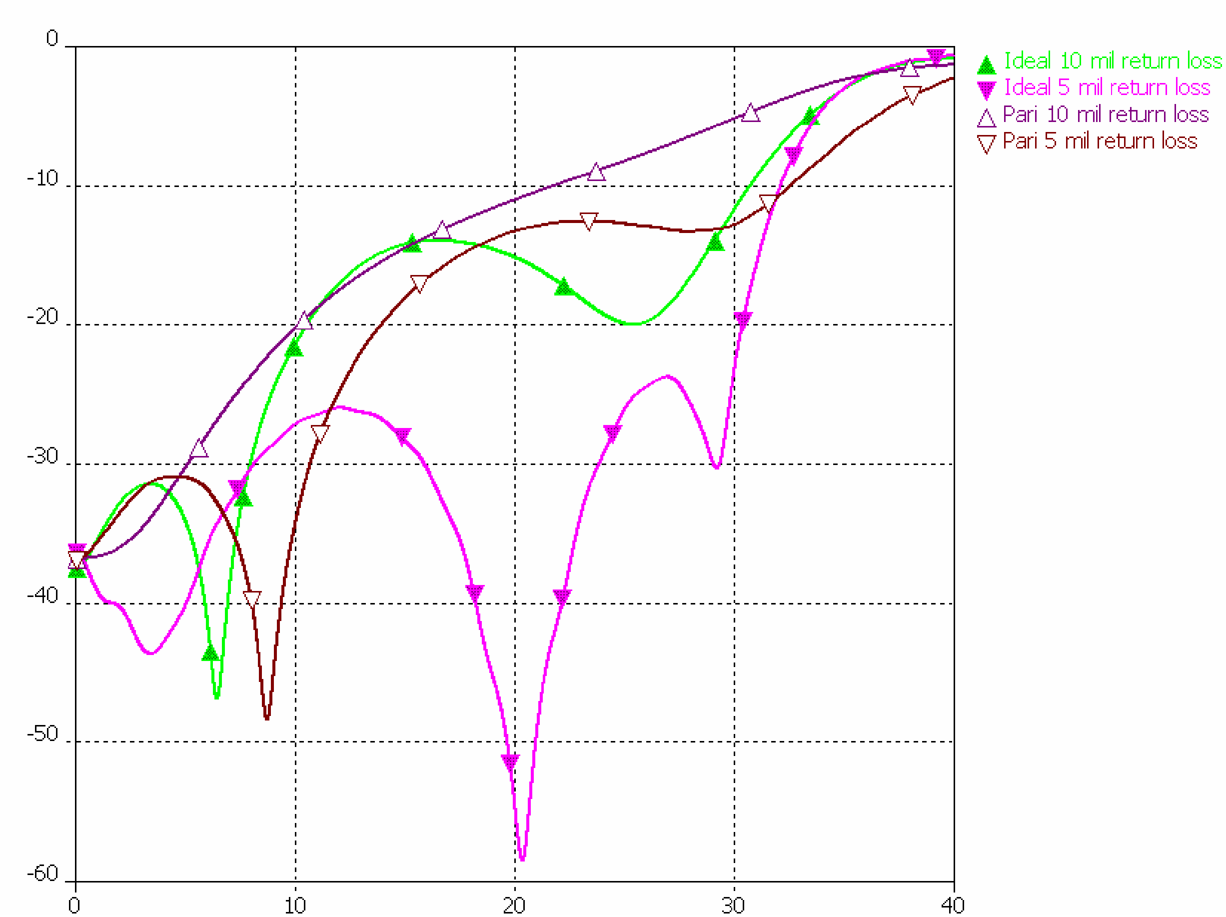
- Insertion loss is dependent upon Pariposer thickness and modeling method.
- In all cases, sufficient bandwidth exists out beyond 20 GHz for 10 mil thickness, sufficient for 40 Gbps NRZ data transmission, and beyond 30 GHz for 5 mil thick material.



TERASPEED CONSULTING GROUP

GigaCon Return Loss

- Return loss in all cases is below –10 dB out to 20 GHz.
- Return loss for 5 mil thick material is below –12 dB out to 30 GHz
- Additional interstitial metal causes a shift in return loss peaking, indicative of a decrease in effective Er, due to reduction of dielectric volume.

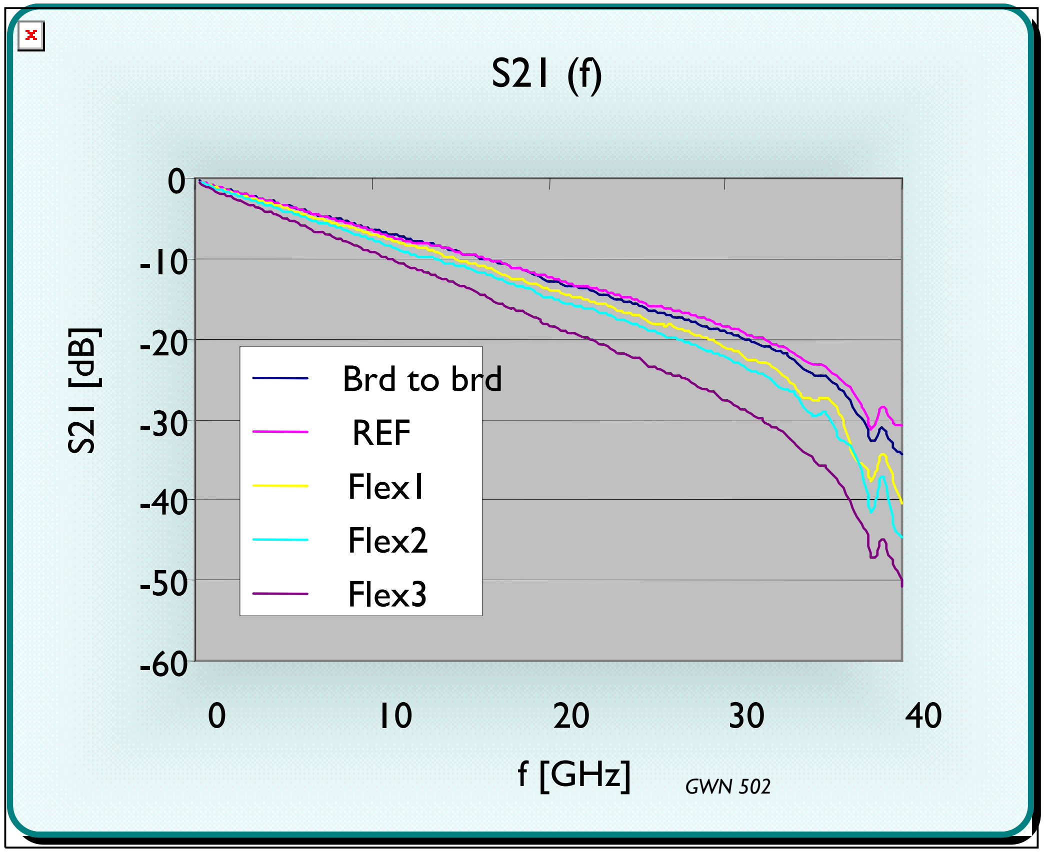


TERASPEED CONSULTING GROUP

Measured Insertion Loss (SMAs, GigaCon Connector and PCB)

- PCB = 6.6" FR-4
- Flex 1 = 1" length
- Flex 2 = 2" length
- Flex 3 = 5" length

- Board to board interface without flex shows nearly identical performance to Reference test trace.
- Clearly insertion loss is well-behaved out beyond 30 GHz.



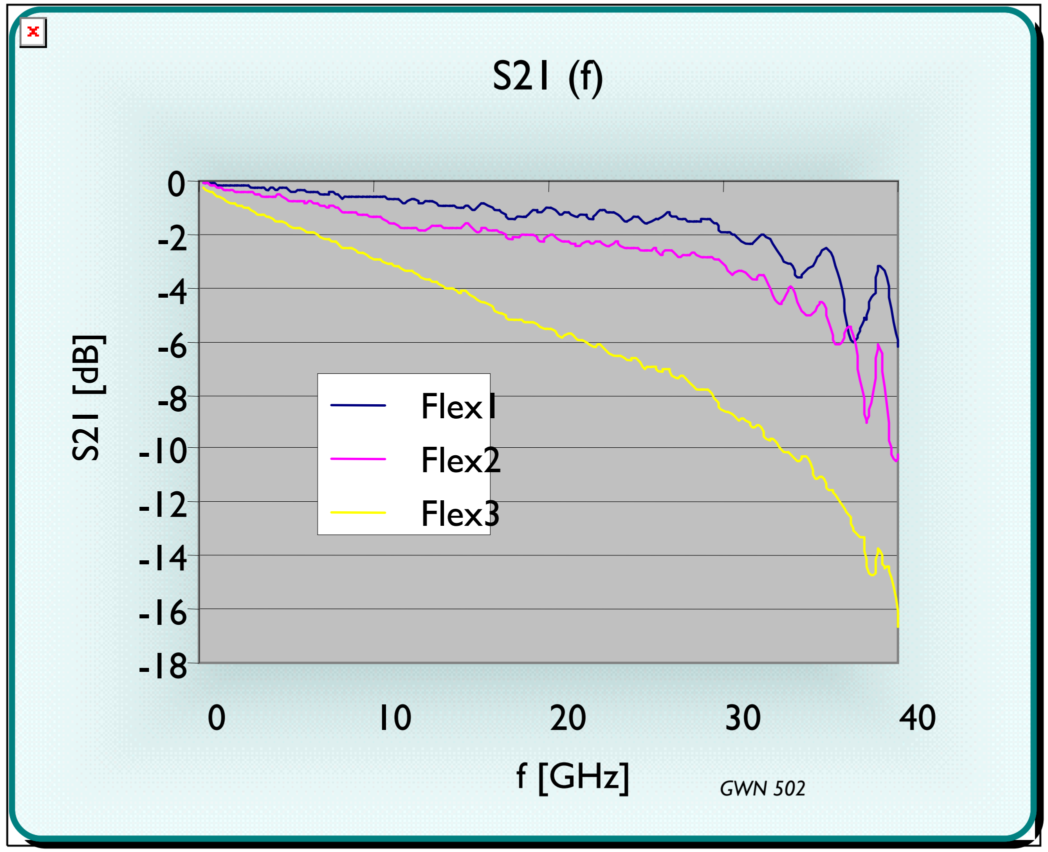
TERASPEED CONSULTING GROUP

De-embedded Insertion Loss (GigaCon Connector)

- Flex 1 = 1" length
- Flex 2 = 2" length
- Flex 3 = 5" length

- Insertion loss of flex material dominates performance out to 30 GHz.

- Clearly insertion loss is well-behaved out beyond 30 GHz.

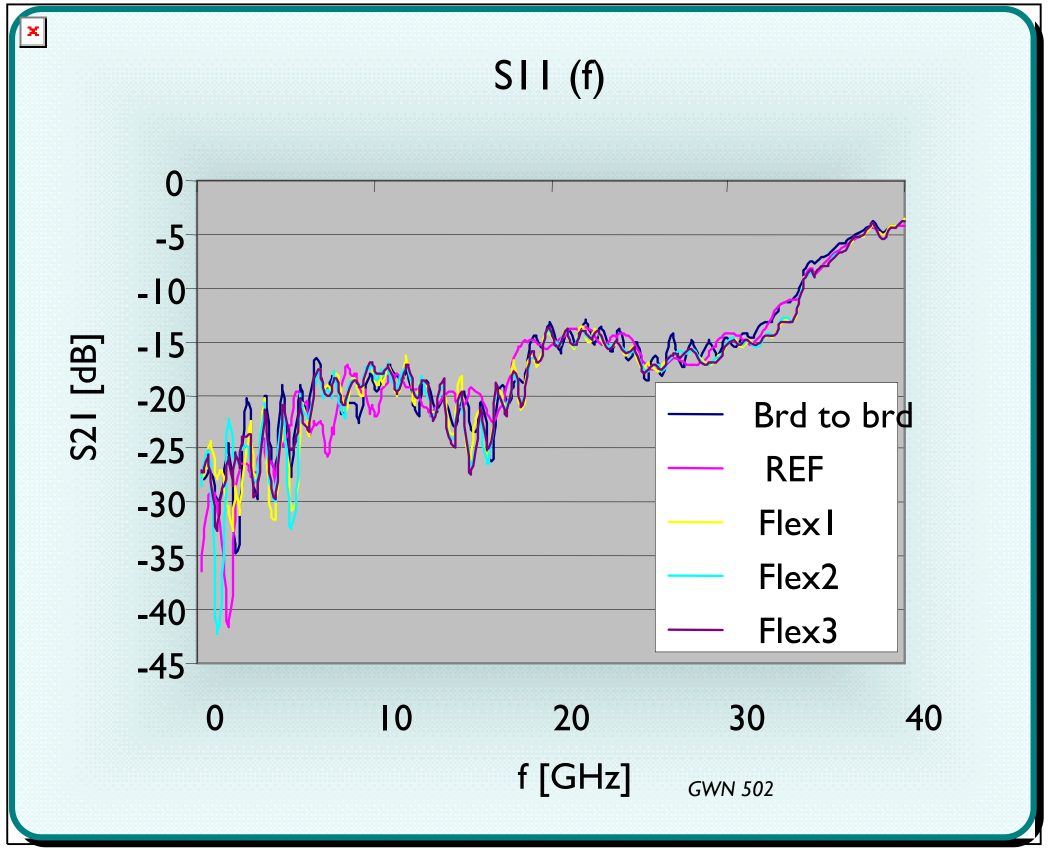


TERASPEED CONSULTING GROUP

Measured Return Loss (SMAs, GigaCon Connector and PCB)

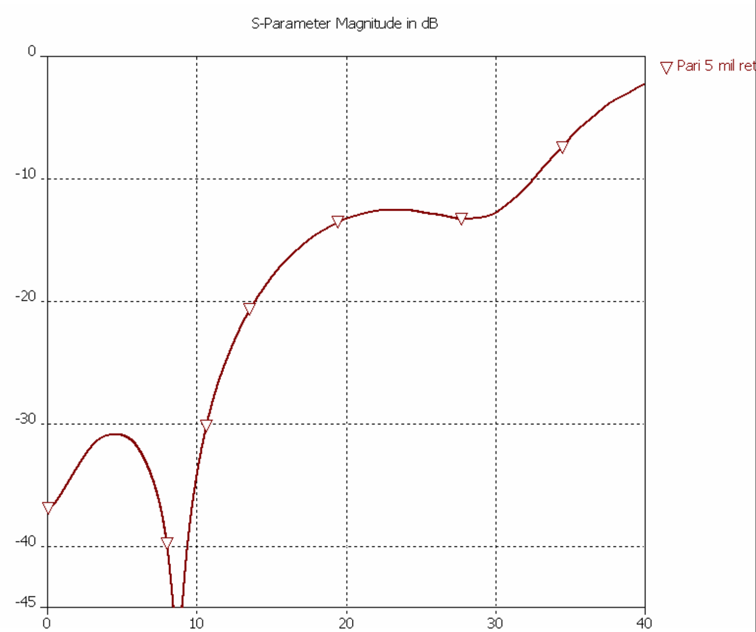
- Flex 1 = 1" length
- Flex 2 = 2" length
- Flex 3 = 5" length

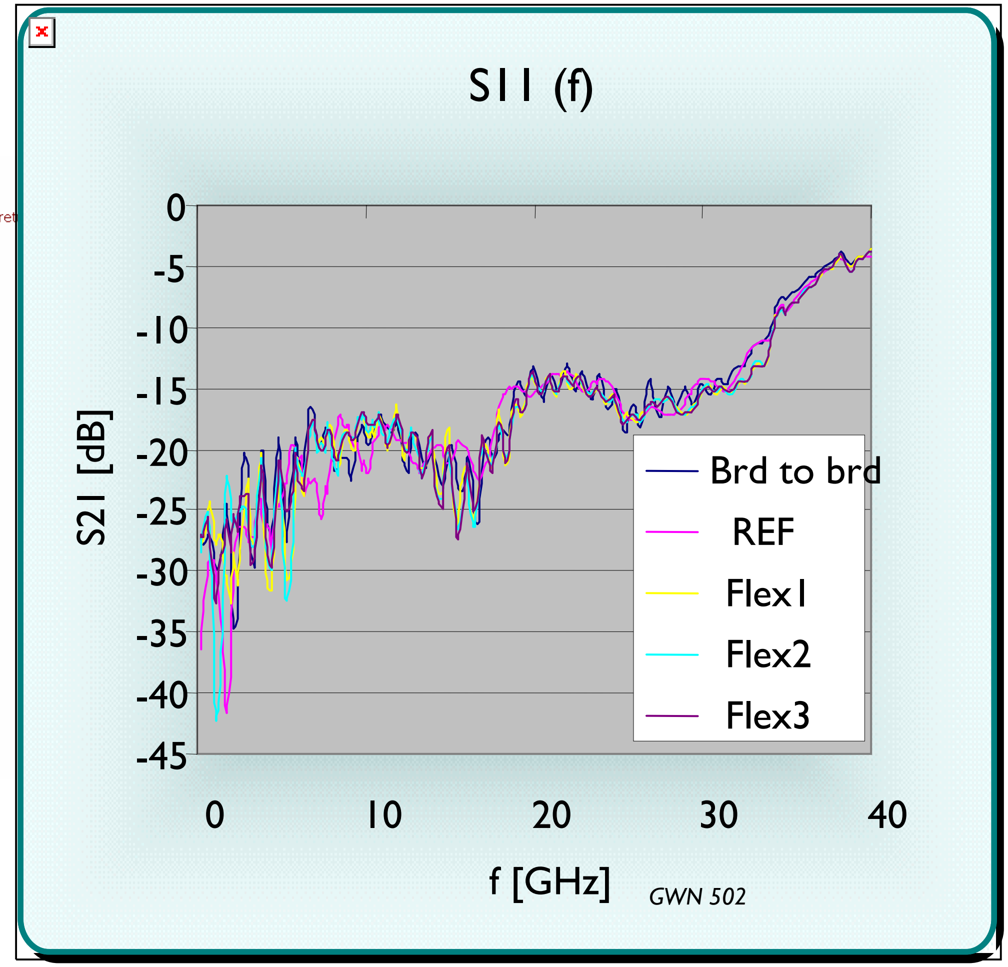
- Return loss in all cases is below –12 dB beyond 30 GHz for all cases.
- Return loss appears to be limited by return loss of trace and SMA instrumentation connectors.



TERASPEED CONSULTING GROUP

Return Loss Comparison to Modeling





Favorable comparison with 5 mil approximate modeling.

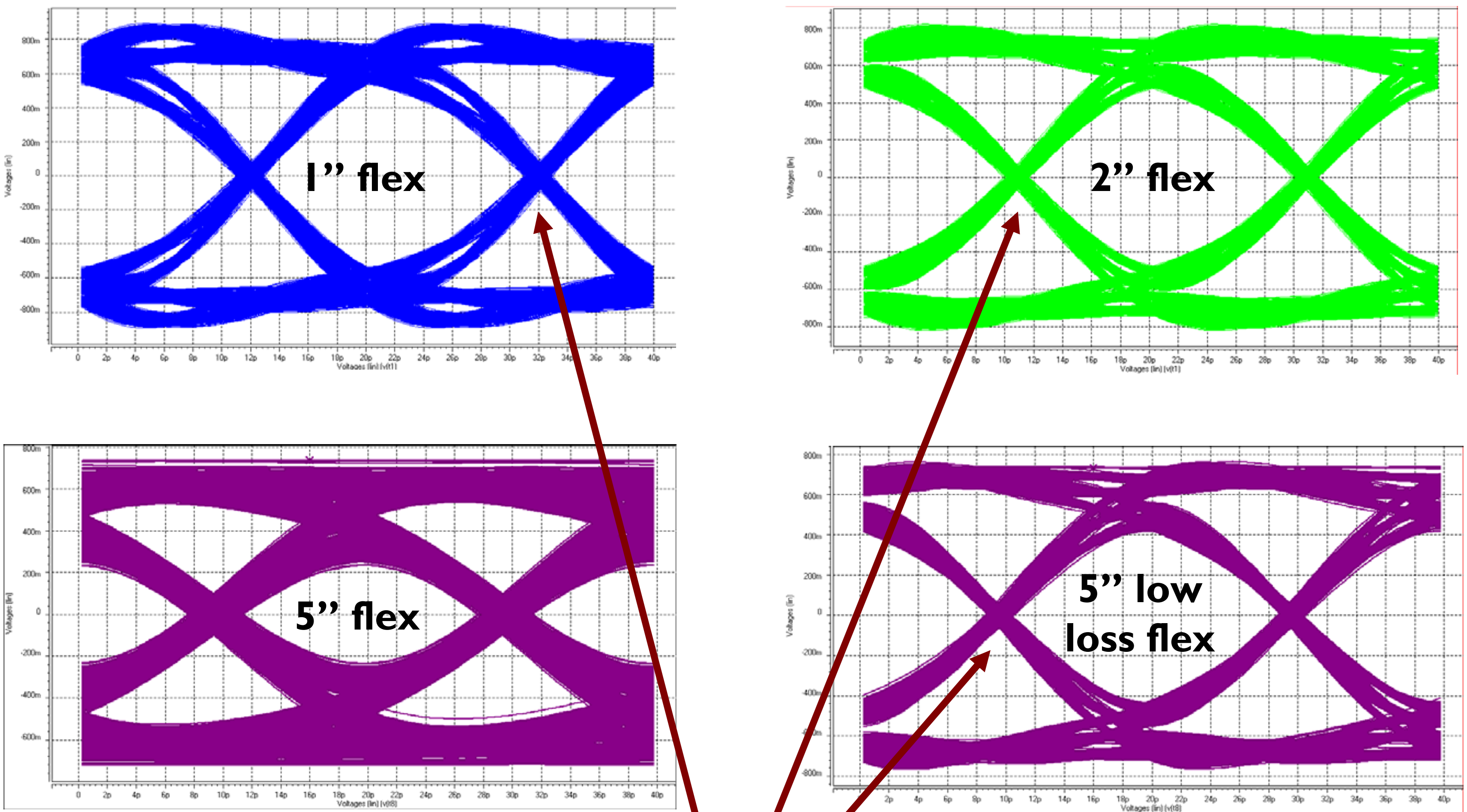
TERASPEED CONSULTING GROUP

Performance Studies

- Simulation models created for performance study with:
  - CST Microwave Studio (connector transitions)
  - Ansoft 2D (trace cross-sections)
  - Sigrity Broadband Spice (Laplace pole/zero modeler)
- Models were converted to S-parameters with 40 GHz bandwidth, correlated to measured VNA data, and converted to HSPICE pole-zero models with Sigrity Broadband Spice.
- Eye pattern predictions were simulated in HSPICE.

TERASPEED CONSULTING GROUP

GigaCon 50 Gbps Eyes



2 ps Deterministic Jitter @ 50 Gbps !

TERASPEED CONSULTING GROUP