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BiTS

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Archive

RF Characterization of Contactors for New High Frequency Markets

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BiTS Workshop
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Agenda

- New markets
- Applications Package style
  - 5G automotive radar Wireless LAN
  - BGA, WLCSP,QFN
- Critical paramenters
  - _ Insertion loss, Return loss, Impedance, Crosstalk
- Contactors technologies
  - ACE, Link,mmWave for examples
- Simulation / Measurements
- Challenges and solutions
  - Pitch, Ground signal configuration loss, Impedance control, Port count and Multi-site
- Conclusion

RF Market Drivers

Demand for wireless communication and instantaneous data transfer are driving high bandwidth integrated RF devices applications

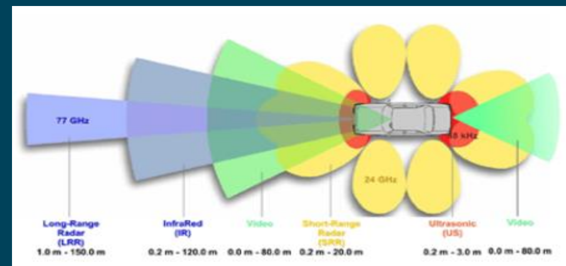
- New wireless applications are leaping from 2.4 GHz to 80+ GHz
- WiGig / 5G / Auto Radar: RF Transceivers, High Gain Amplifiers, LNA's, Filters, Switches, DACs / ADCs

Device Requirements

- Low noise, high gain, advanced power delivery, high frequency

Contactor Requirements

- Low loss (1dB >40GHz)
- High isolation (>60dB)
- Low inductance (<0.1nH)
- Matched impedance (50Ω+/- 5%)

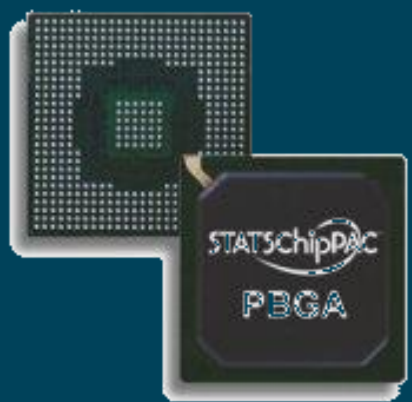


Auto Radar

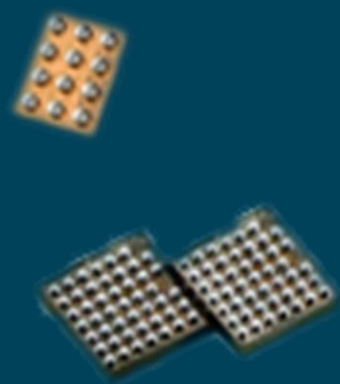
5G Backhaul

802.11AD (WiGig)

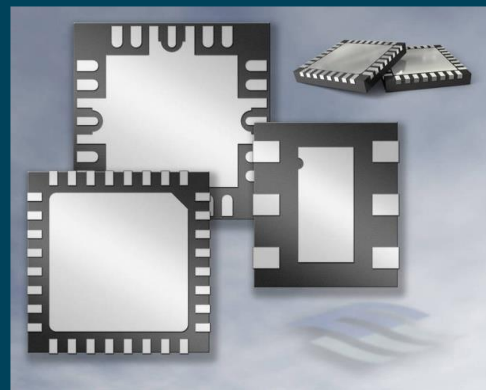
Packages style



Ball-Grid Array Package (BGA)



Wafer level Chip Scale Package (WLCSP)

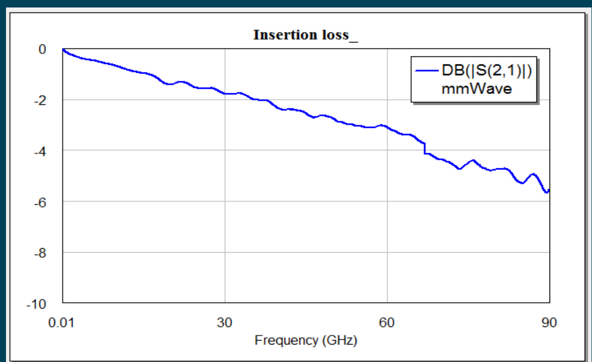


Quad Flat No-lead (QFN)

Insertion Loss and Return Loss

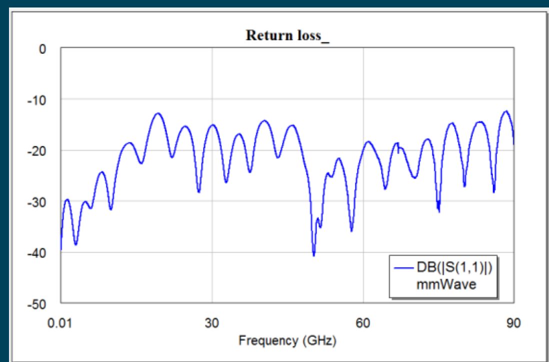
Insertion Loss

- Measures Signal Transmission
- Ratio: Transmitted/Input
- S-Parameters: S_{12}, S_{21}
- Be linear in frequency range of interest



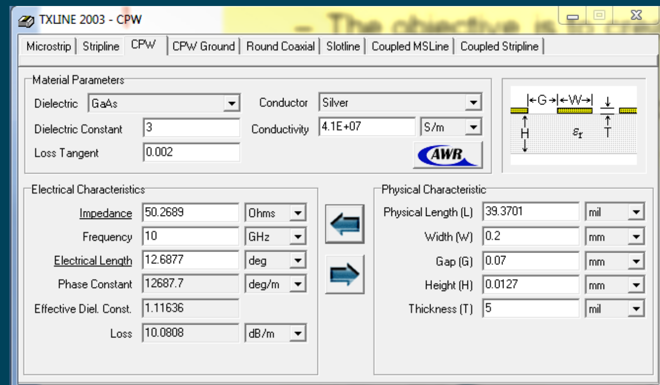
Return Loss

- Measures Signal Reflection
- Ratio: Reflected/Input
- S-Parameters: S_{11}, S_{22}
- Below -10dB in the frequency range of interest



Impedance

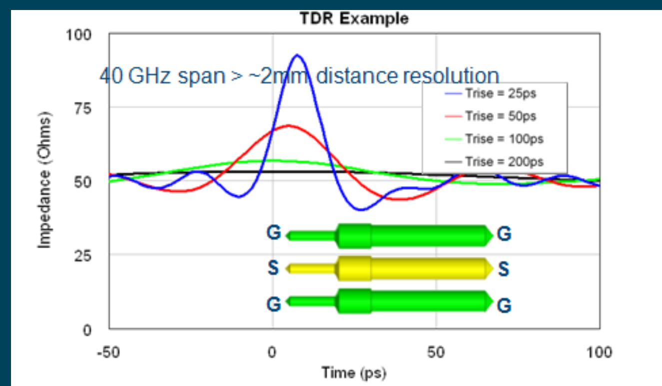
- Impedance is the key electrical property with which signals interact
- Inductance-Capacitance relationship determines the impedance of the signal path
- Describes the amount of reflections seen throughout an interface



Impedance control

- 50 Ohms ideal for single ended
- 100 Ohms ideal differential ended
- Highest bandwith possible
- Minimizing loss and reflection
- +/- 5 to10% Ohms

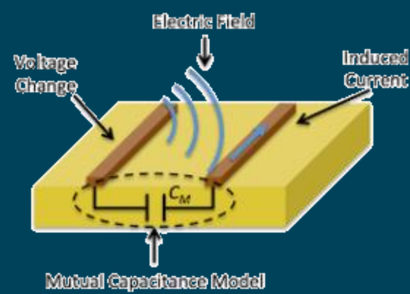
$$Z = \sqrt{\frac{L}{C}}$$

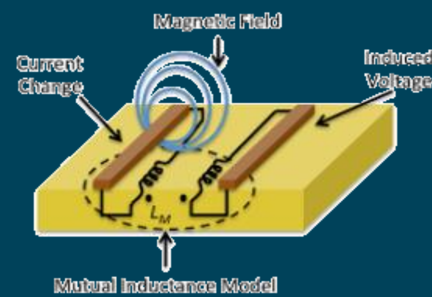


Crosstalk

- Crosstalk (or X-talk) is when the switching on one signal causes noise on an adjacent line
- Crosstalk is measured by applying a source to the “radiator” conductor, and measuring the power amplitude on the adjacent, or “target” conductor
- The Crosstalk can be due to Electric or Magnetic Field lines interacting with a neighboring line.
- Cross talk is due to the capacitance and inductance between conductors, which we call:

Coupling Capacitance (C_m)
Mutual Inductance (L_M)





Coverage for cmWave and mmWave frequencies

ACE Spring probe

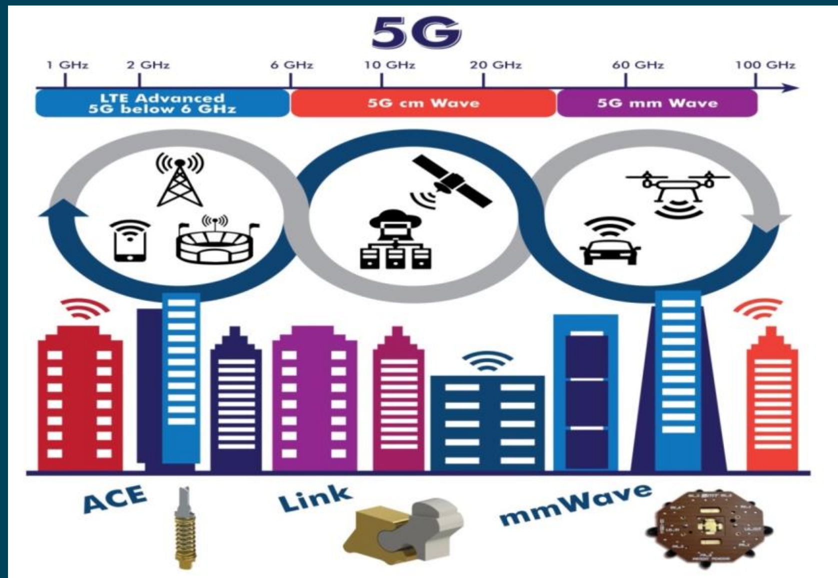
- **Lowest CoT to 40GHz**
- **Short MEMS flat probes**
- **Homogeneous sharp tips**

LINK

- **Optimal power and thermal to 60GHz**
- **No board wear**
- **Controlled scrub**

mmWave

- **Broadband 100GHz made simple**
- **100% test coverage**
- **Short time to production**



ACE Spring probe

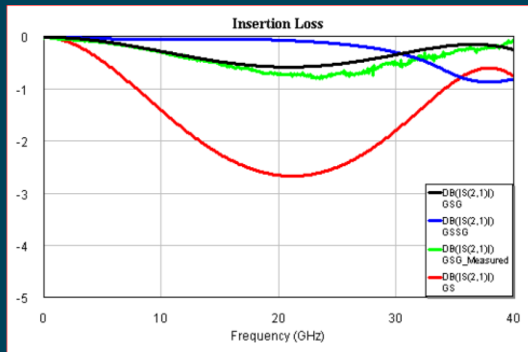
Short signal path
- Excellent RF performance
- High power
- Low inductance

Extremely sharp tips
- Reduce contact force
- Reduce preload

Homogeneous material
- Low, consistent contact resistance
- Long life

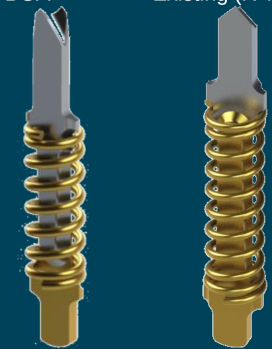
Innovative Architecture
- Large contact area between plungers

Low cost of ownership
- Low initial price
- Low replacement probe price

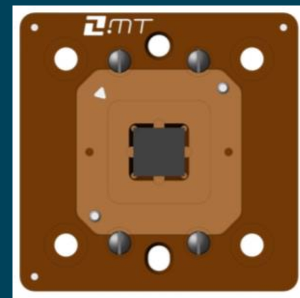


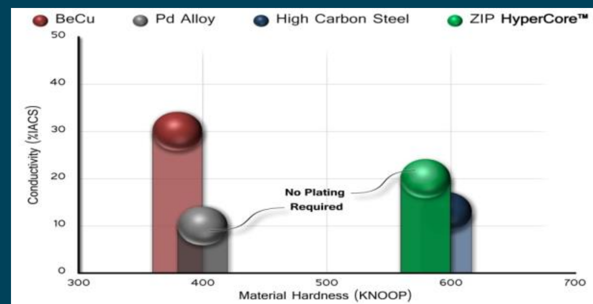
INSERTION LOSS (dB)	SINGLE-ENDED G-S	**SINGLE-ENDED G-S-G**	DIFFERENTIAL G-S-S-G
-1	8.1 GHz	**>40 GHz**	>40 GHz
-3	>40 GHz	**>40 GHz**	>40 GHz

New BGA Existing (R TIP)



1.7mm 1.5mm





LINK

Scrubs through surface oxides
Increases Yields

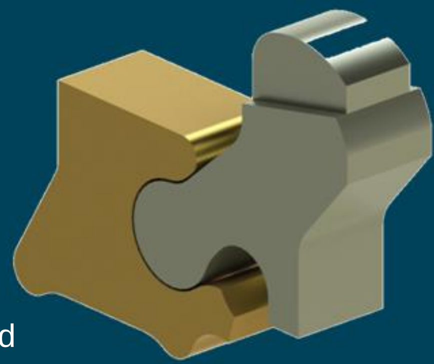
Short signal path
Excellent RF performance
High power
Low inductance

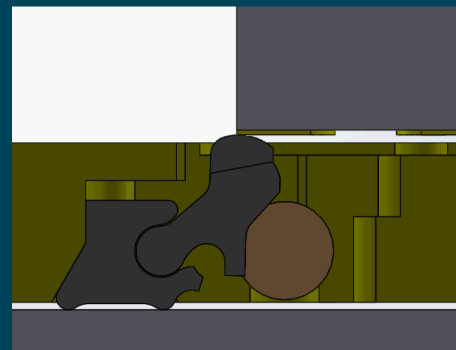
Contact motion decoupled from the load board
No board wear

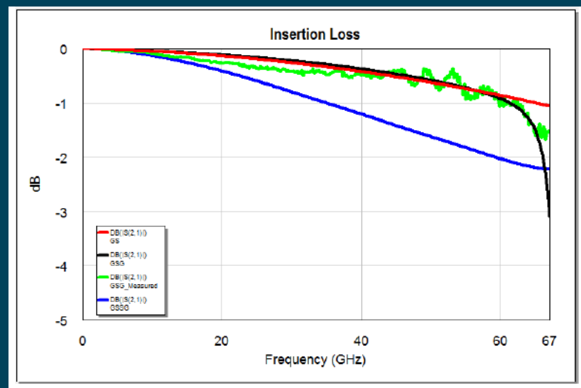
Self-cleaning contact tip
Reduces maintenance

Single elastomer
Easy field maintenance

Homogeneous material
Low, consistent contact resistance
Long life







mmWave Contactor

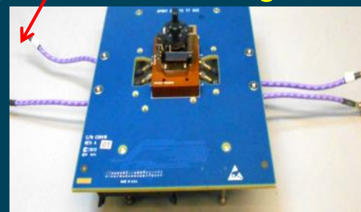
Best Signal Integrity

- New paradigm eliminates board and Pogo pins from RF path
- Shortest possible, coplanar waveguide
- Compatible with single-ended and differential signals
- Minimum number of transitions

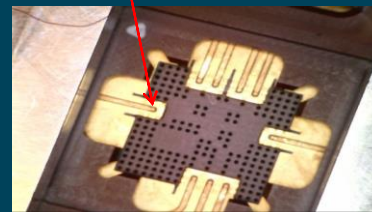
Highly Integrated Solution

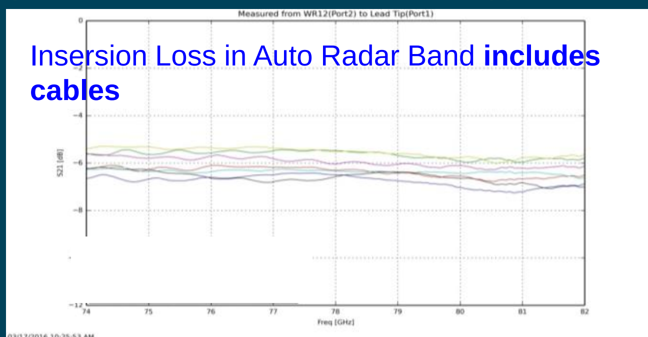
- Contactor includes entire path from tester to DUT
- Only power and control signals use board and Pogo pins
- Tri Temp Capable (-55 to 155°C) for automotive applications

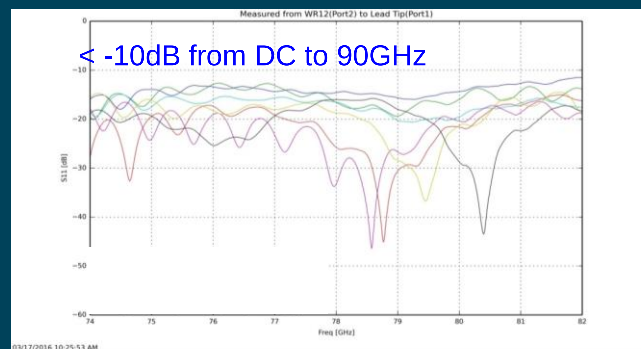
WR12 Waveguide



DUT Interface



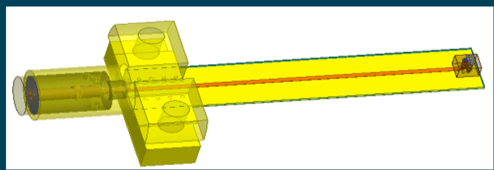




Simulation

3) Full 3D Electromagnetic Simulation
- Required for complex structures such as contactors
- Most resource intensive, but also most accurate

Why Simulation?



➢Trial & Error can work, but usually not the most accurate
➢Simulation Provides the opportunity to offset the contactor prior to design
➢Accurate models help accelerate your design cycle.

HFSS: High Frequency structure simulator

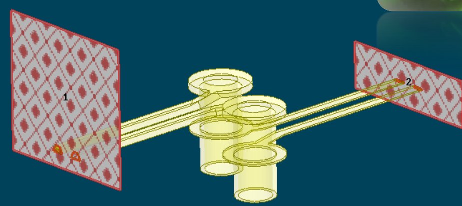
❑ Procedure to simulate
- Draw or modify objects
- Assign material Property
- Port Excitations
- Define Boundary Conditions
- Solve
- Display Results
- Extract S2p files

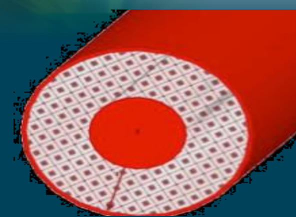
Simulation Setup

HFSS

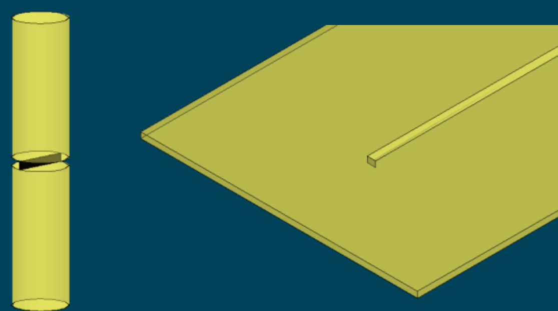
Port Excitations Very important !

1) Wave port
- 2D FEM solver calculates requested number of modes
- Solves for impedances and propagation constants
- Supports multiple modes and de-embedding





2) Lumped port
- User-assigned constant impedance
- Uniform electric field on surface
- Single TEM mode with no de-embedding
- Can be internal to model

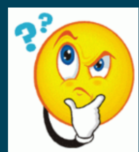


VNA Characterization

– Vector Network Analyzer

- Measures S parameters: Insertion Loss, Return Loss, Crosstalk
- Swept across frequency
- 4 ports required for differential measurements
- Time Domain option for impedance analysis, eye diagrams

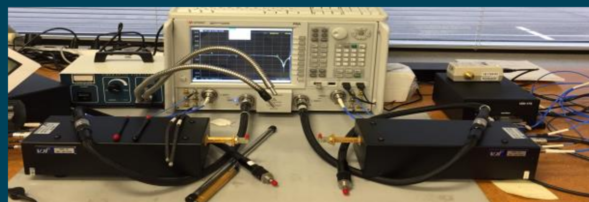
Why VNA Mesurement?



- VNAs are exceptionally accurate and repeatable instruments when you implement proper measurement techniques and user calibration
- Accurate measuret helps you correlate to the simulation
- ments provide the confidence to make performance/cost decisions
- Test vehicles can be created quickly and easily by confirming model accuracy

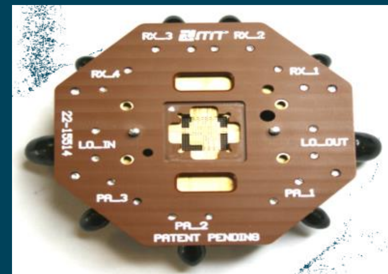
VNA Measurement Procedures

- **Prepare**
  - Place VNA in a stable environment and warm up VNA for proper amount of time at least 30mns
  - Use high-quality adaptors, cables, and torque wrenches
  - Check that all connections are clean and undamaged, use connectors lint-free swab to moisten with isopropyl alcohol
- **Check**
  - Set the VNA frequencies, IF bandwidth, power, and other parameters
  - Ensure that the calibration standards and device under test connect properly to the VNA
  - Plan for any special accommodations such as non-insertable devices and the loading of calibration kit definitions
- **Calibrate**
  - Remove the device under test and calibrate the VNA by stepping through the calibration procedure
  - Verify that the calibration is good and store the instrument state and calibration
- **Perform**
  - Connect the DUT (device under test)
  - Make the measurements
  - Extract the S-parameters



Measured Performance - RF to 110GHz

- 2 RF Labs in USA
  - Keysight 70GHz PNA-X with WR10 Waveguides (70-110GHz) and PLTS, 50GHz PNA-X with WR12 Waveguides (60-90GHz), PLTS
  - S-parameters, Eye Diagrams, Impedance Plots, Crosstalk, 4 port capability for differential measurement
  - ESD Controlled (Floors, Chairs, Benches, Equipment, Personnel)



VNA Measurement Recommendations

- ❑ Stability of the system and good planarity setup to ensure repeatibility of measurement

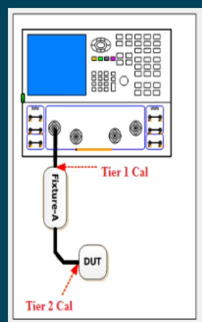
- ❑ Good calibration and verification
  - Electronic Calibration (ECAL)
  - SOLT Short Open Load Thru
  - SOLR Short Open Load Reciprocal
  - LRM Line Reflect Match
  - LRRM Line Reflect Reflect Match
  - TRL Thru Reflect Line

Ecal

Calibration Substrate

Calibration Kit

- ❑ Correction methods
  - CPM (Cal Plane Manager)
  - WinCal correction method
  - AFR (Automatic Fixture Removal)



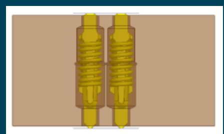
- ❑ Verification methods
  - By measuring other devices

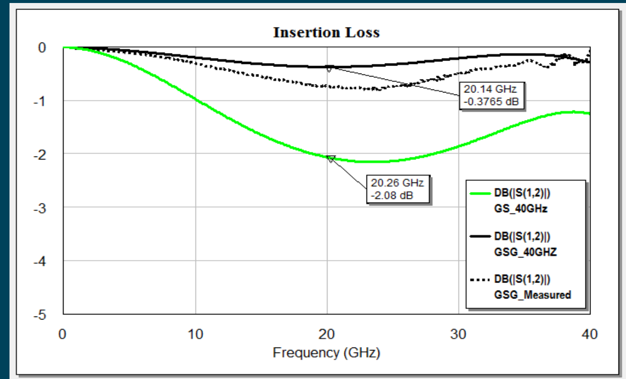
- ❑ Maintain integrity of device under test

Challenges and Solutions

– Pitch and Configuration: Ex: ACE040

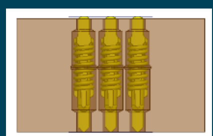
GS Configuration

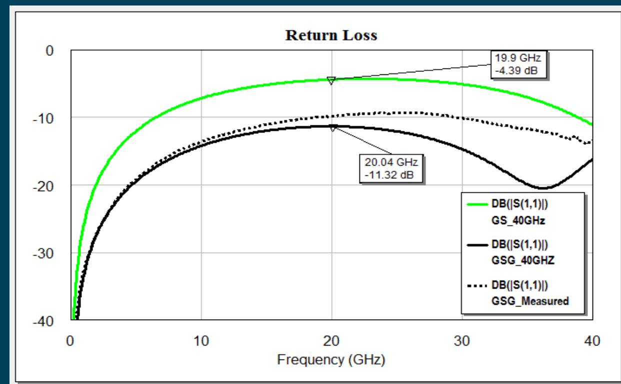




- Insertion loss is -2dB at 20Ghz
- Need at least -10dB return loss at 20Ghz for application in GS Configuration

GSG Configuration





- Insertion loss is >20Ghz AT 1dB→ good for application
- Return loss is >20Ghz at 10dB

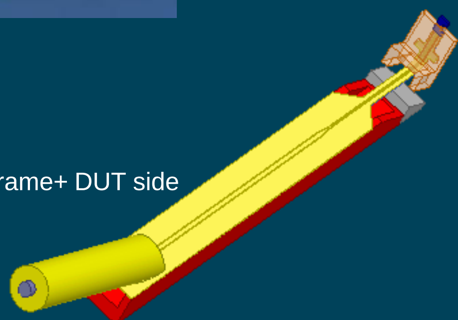
Challenges and Solutions

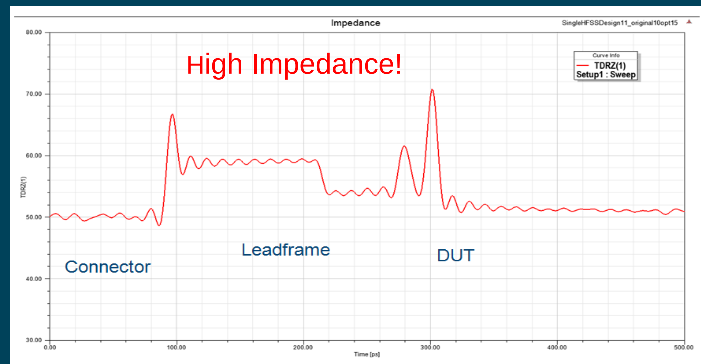
– Impedance Control: Ex: WLCSP mmWave

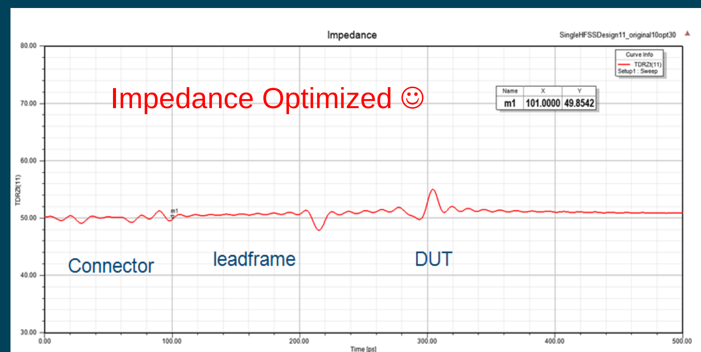
-Gap size optimized in coplanar waveguide
-Launch optimized
-Port selection

-High impedance
-Voids in Substrate
-Discontinuities

1mm Connector + CPW leadframe+ DUT side







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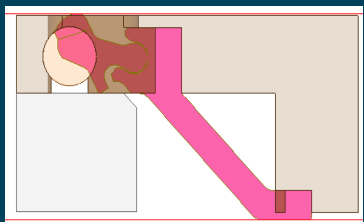
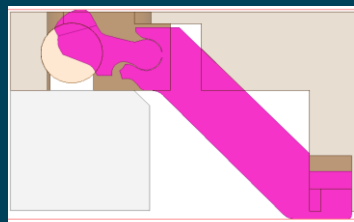
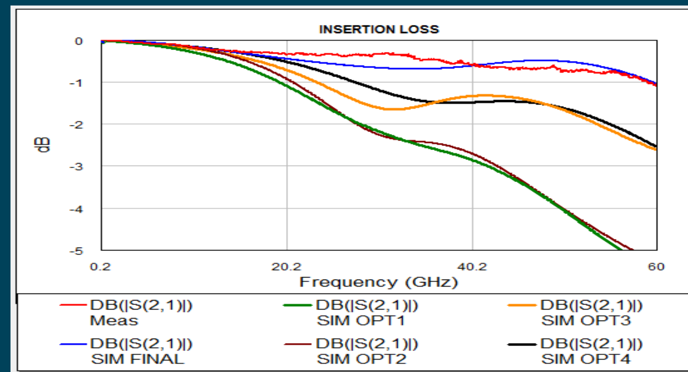
Impedance Control Example

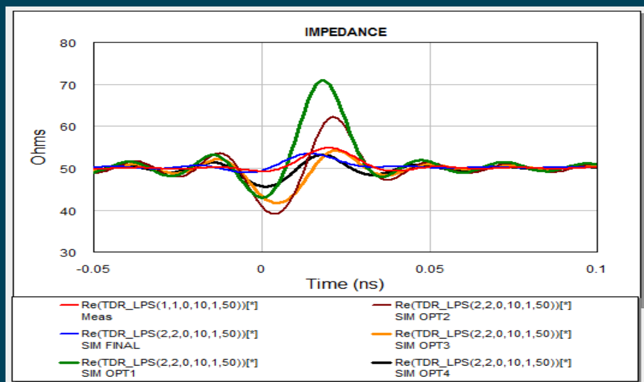


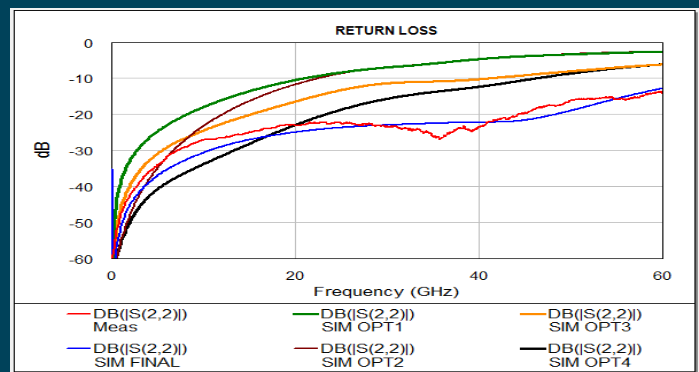
Inintial design



Final design optimized







RF Characterization of Contactors for New High Frequency Markets

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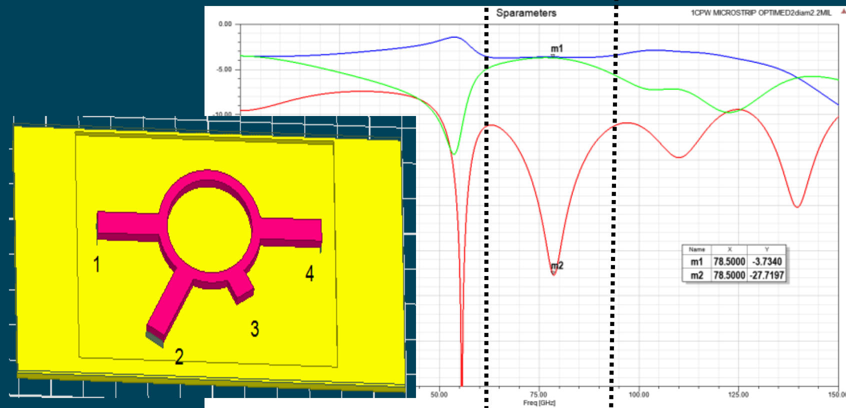
Challenges and Solutions

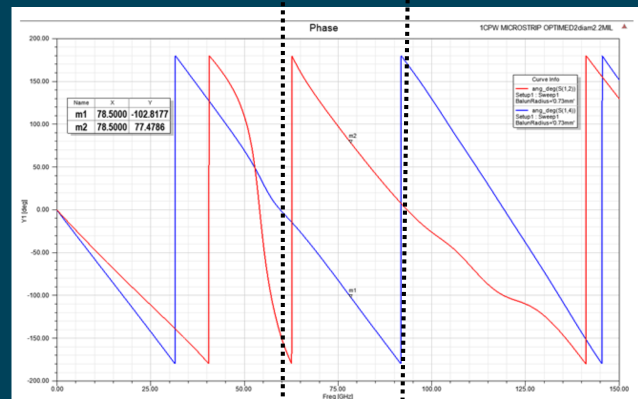
– Port Count and multi Site: Ex: Rat race Coupler

- Reduce Tester Channels
- Center frequency 78.5Ghz bandwith 76 to 81Ghz
- 180 degree out of Phase
- Can be cascaded for more channels
- Can be designed using microstrip or Coplanar Waveguide



❑ Challenges
•Split Signals with High Bandwith
•Increase ports count and enable multi-site without increasing cost
•Operating Temperature

❑ Solutions
•Rat Race in Contactor
•Geometrie and material selection
•Microstrip to CPW



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CONCLUSION

- Much more details to be considered in mmwave design than low frequency RF
- More Challenging with the Wavelength being shorter
- Discontinuities create more impact in high frequency
- With tools available now: VNA and 3D Software we are able to design solutions not previously possible with a “slide rule”