SWTEST

PROBE TODAY, FOR TOMORROW

RF Probe Simulations And Associated Physical Geometries For Interface Design

RIKA DENSHI

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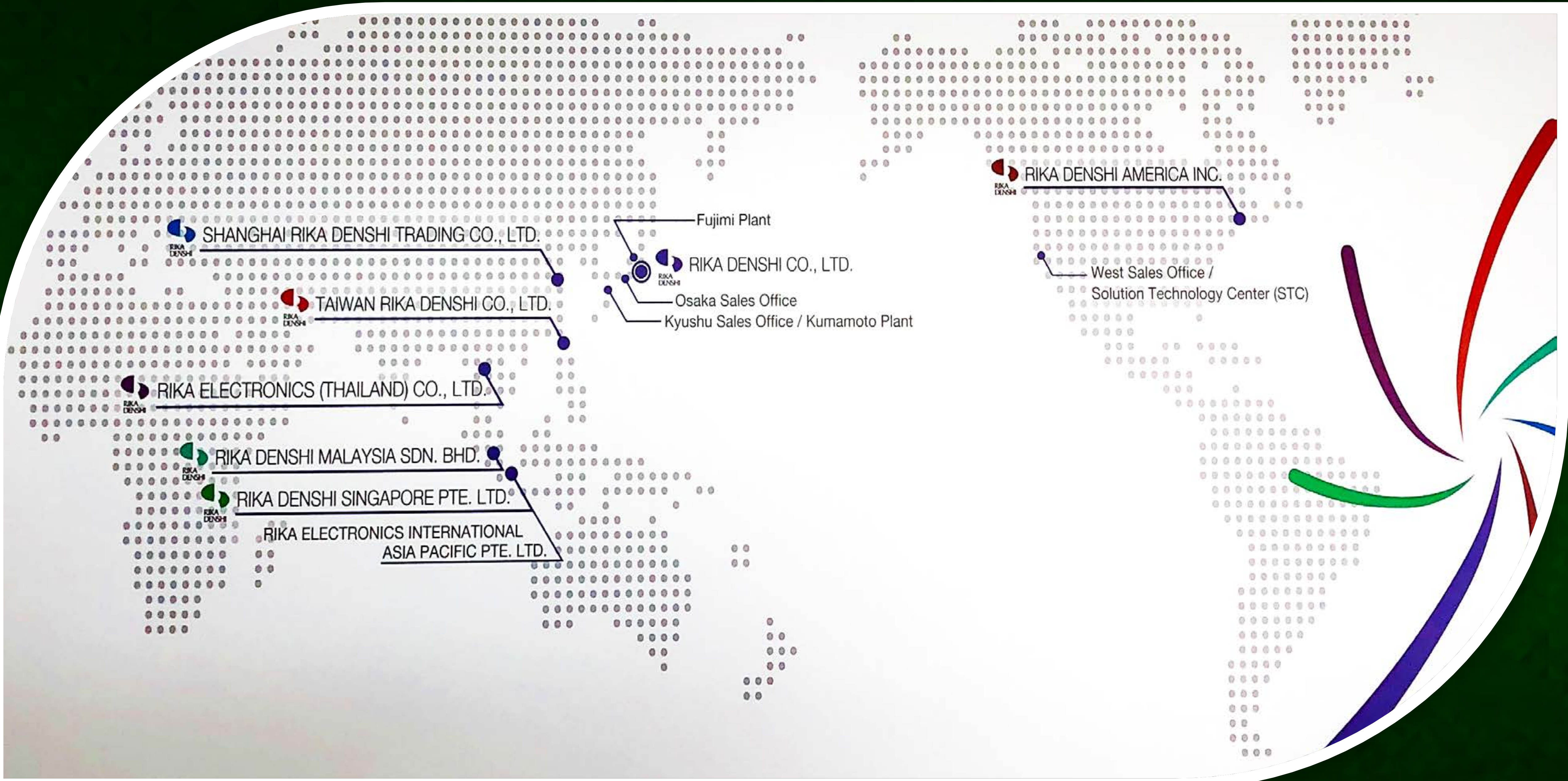
Principal Engineer

June 2-5,2019

Rika Denshi Group, LTD

- 57 years in business as a spring probe manufacturer
- HQ in Tokyo with factories in USA, Thailand and Japan
- Third generation family ownership
- Over 6000 Sq Ft of clean room
- RF lab, experience engineering staff
- Focused on RF/mmWave, High Temperature, Tight Pitch and Non-magnetic spring probes, test sockets and probe heads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Introduction

- **We will share examples of how HFSS simulations are be used to optimize spring probe design and test array patterns for RF applications.**

- **HFSS by ANSYS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards.**

- **Both Magnitude and Phase can be simulated resulting in generation of S11 or Return Loss and S21 or Insertion loss parameters.**

- **Insertion loss = loss of signal power resulting from the insertion of a device (modeled structure or node) in a transmission line or optical fiber and is expressed in decibels (dB).**

- **Return loss = loss of power in the signal returned/reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the signal line. Return loss is usually expressed as a ratio in decibels (dB).**

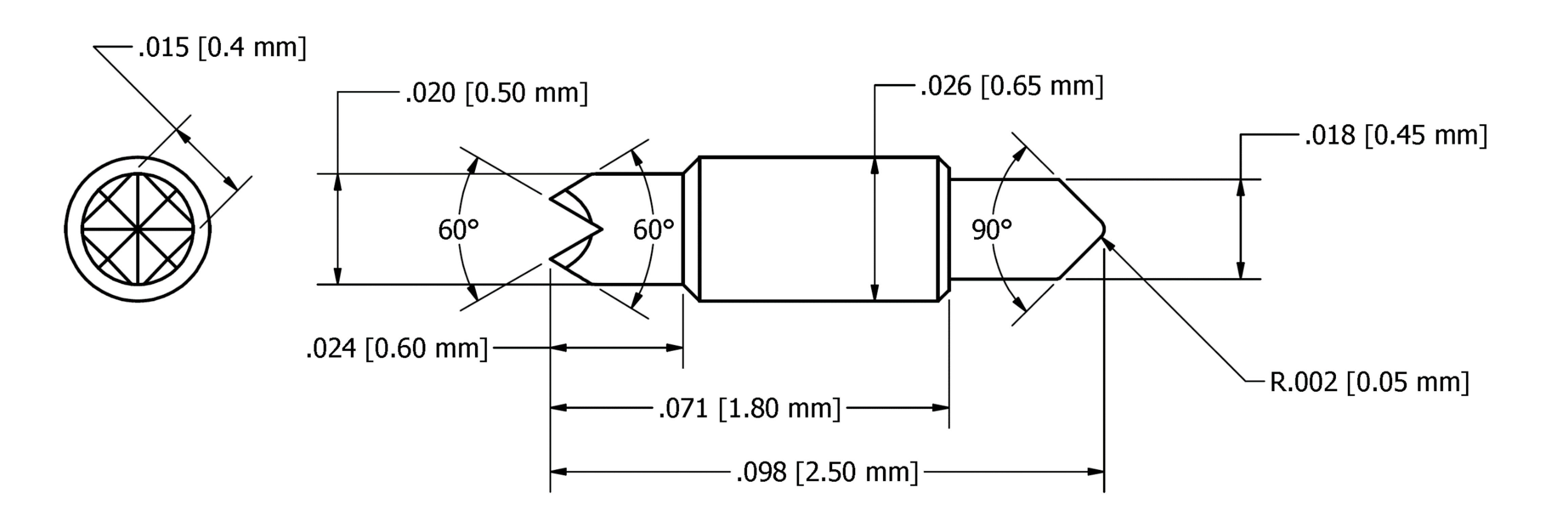
Application – 40 GHz Interface

- An example for Ka band (26GHz-40GHz) transceiver backplane interposer is shared.
- Both a 40 pin and 80 pin interposer were required to maintain a robust RF interface between Ka-band transceiver modules and COMM-SAT chassis backplane.
- Electrical requirements = > 40 GHz bandwidth with as close to 50 Ohm characteristic impedance as possible…while adhering to the mechanical design constraints.
- Mechanical requirements = must survive rocket launch (~20 Gs) and maintain RF performance during satellite lifecycle (5-8) years in temporary earth orbit.
- Operational temperature range -24C to 125C
- Insertion cycles = 1

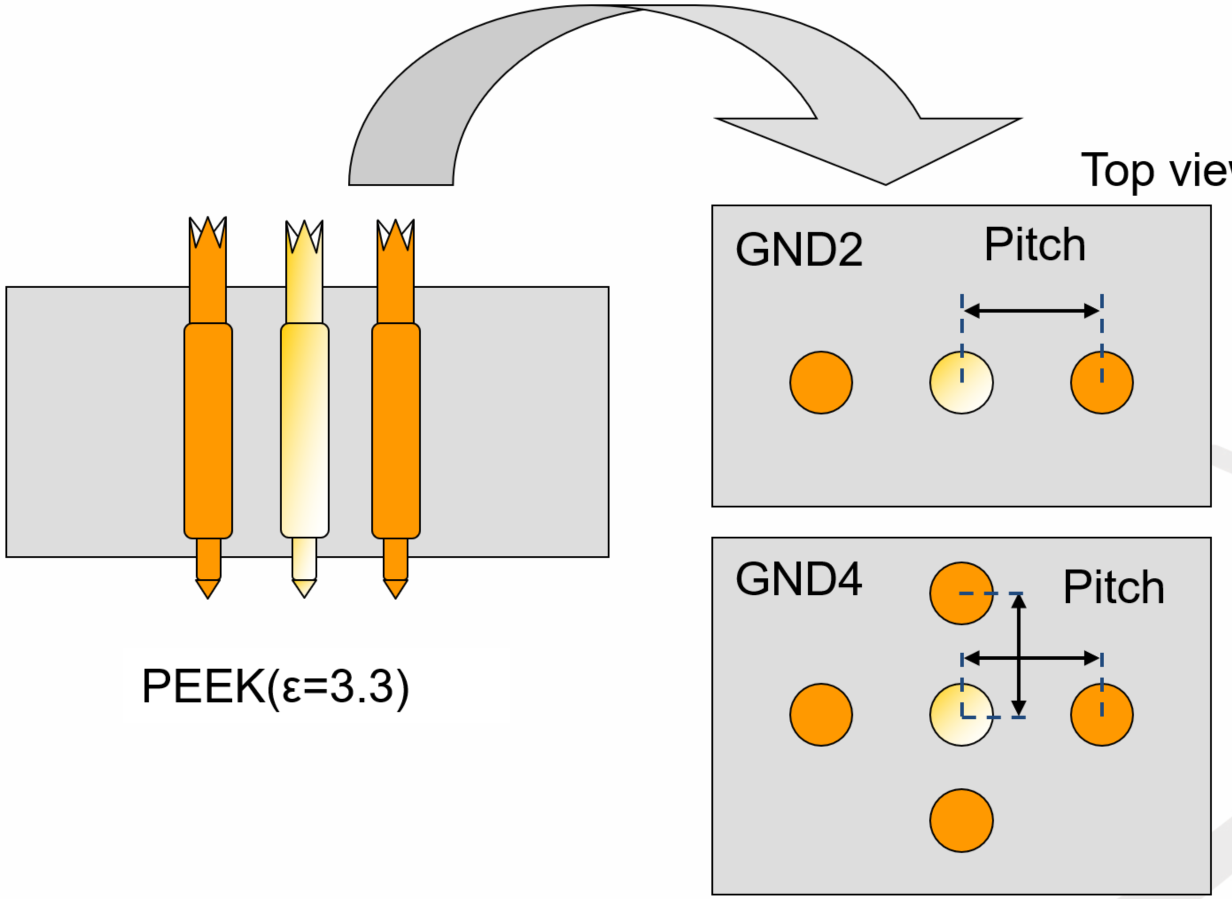
Goals For SI Simulation

- Discover the optimum probe design; mechanical features, shape, location
- Discover the optimum working compression distance
- Discover the optimum SIG to GND probe pitch
- Discover the optimum plunger geometries

Simulating Pitch - Spring Probe - B1859-A1



Socket



Pitch
- 0.80mm
- 0.90mm
- 1.15mm

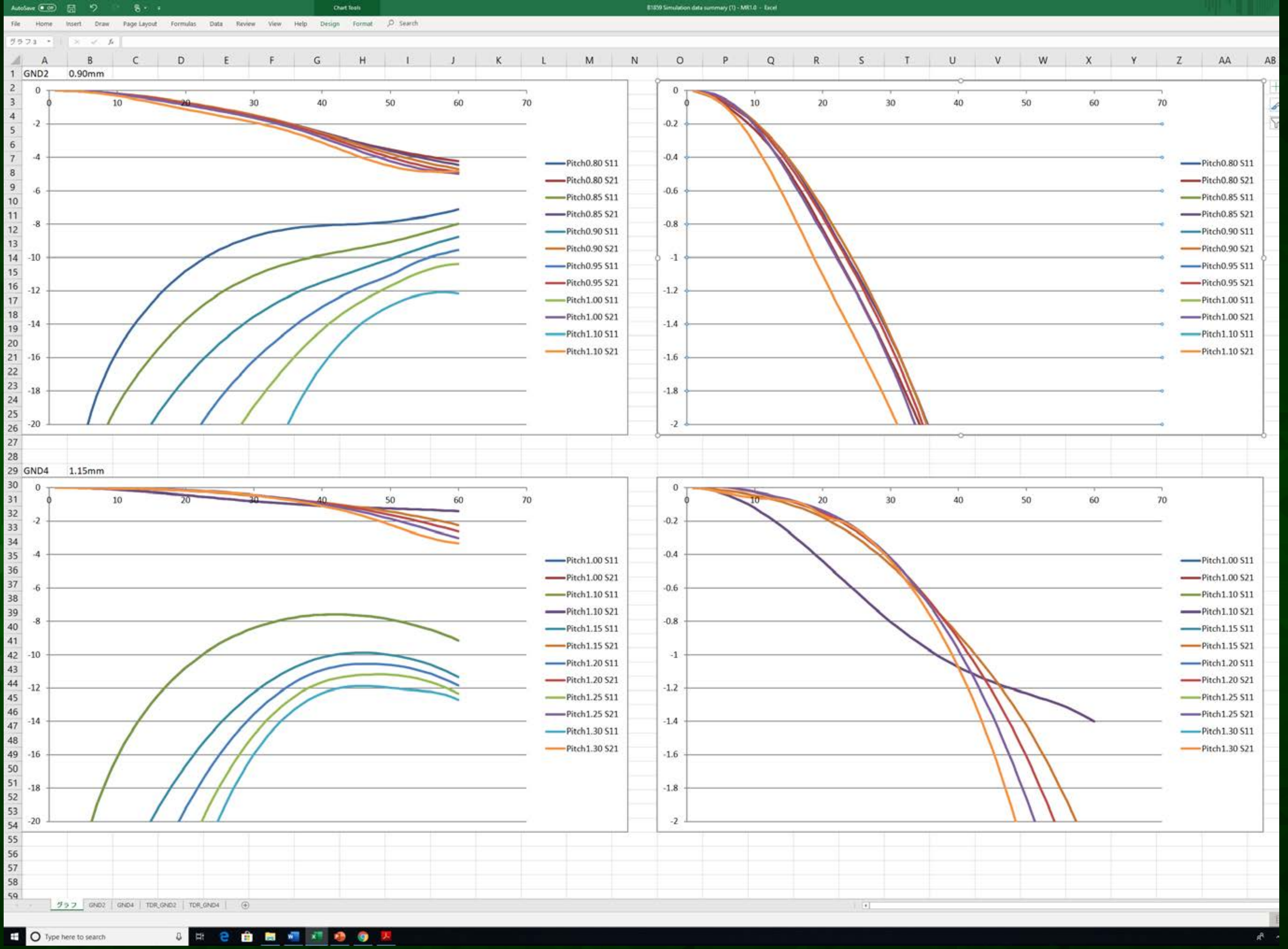
Signal-PROBE
GND-PROBE

Place 1 signal pin surrounded by 2 or 4 ground pins for measurement.
Plastic housing was made in PEEK material for each size of probe.

B1859-A1

Measurement Report

- Pitch 0.80mm
- Pitch 0.90mm
- Pitch 1.15mm



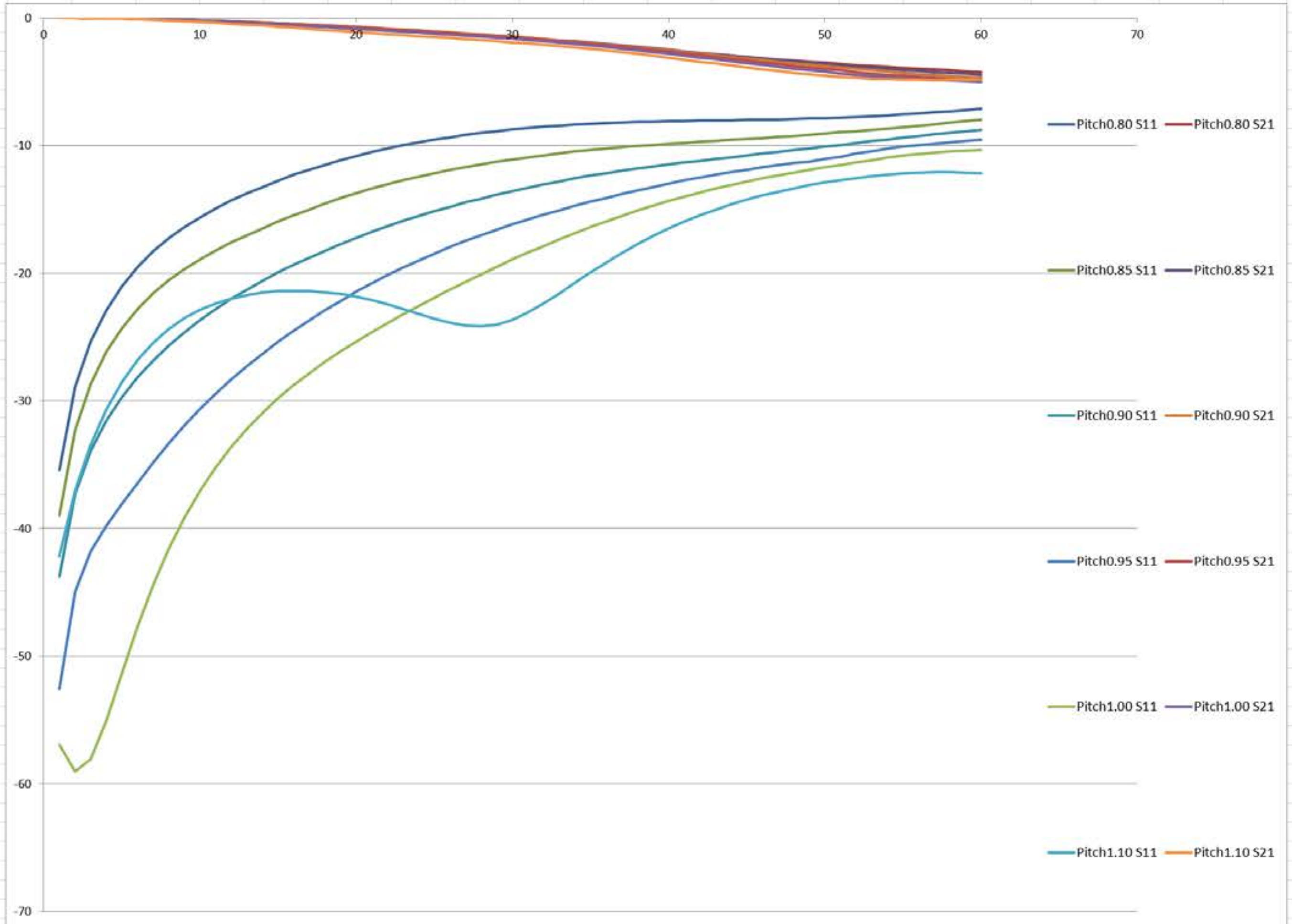
B1859-A1

Measurement Report

2 GND

- Pitch 0.80mm
- Pitch 0.90mm
- Pitch 1.15mm

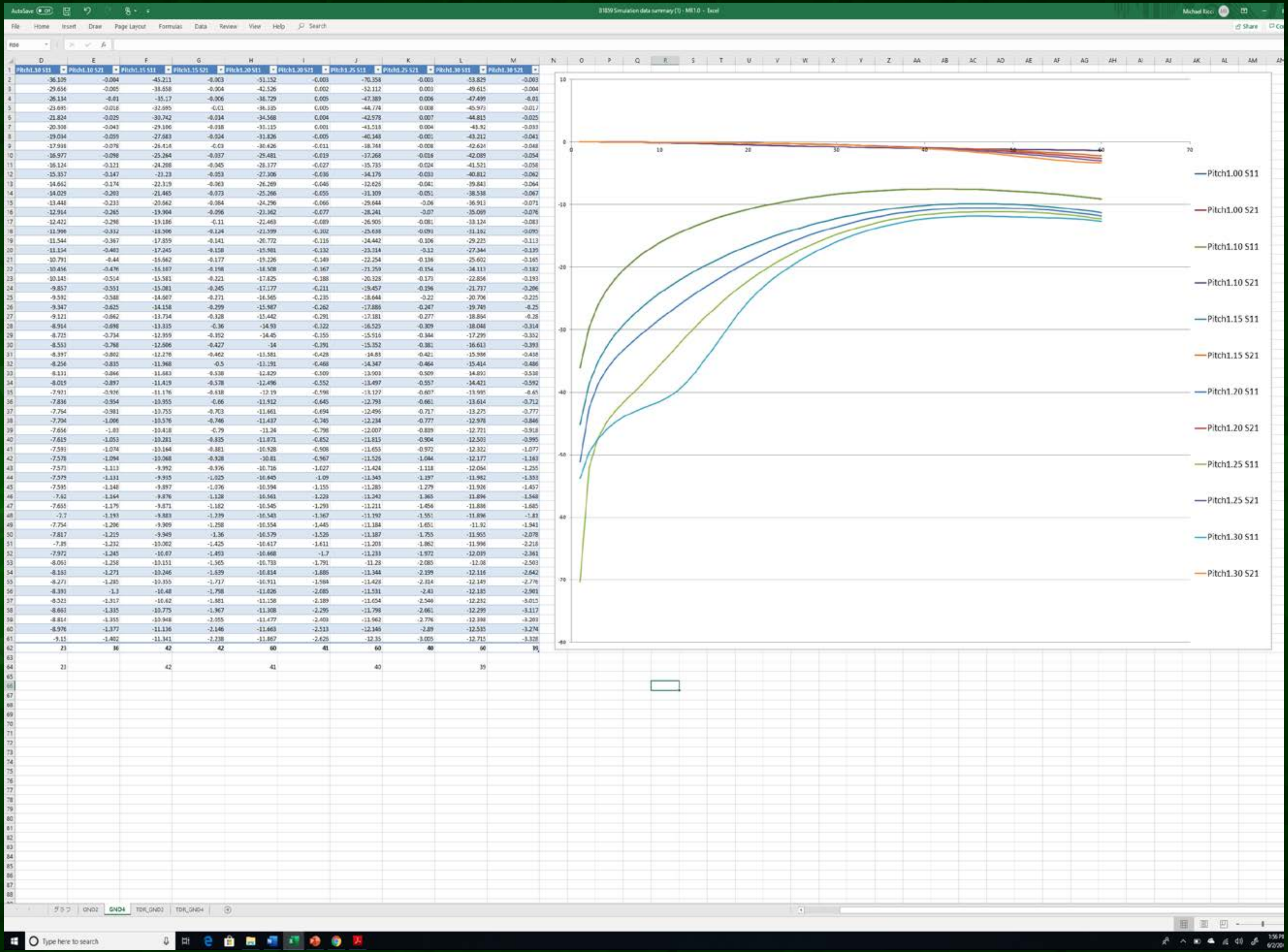
Pitch1.00 S11	Pitch1.00 S21	Pitch1.10 S11	Pitch1.10 S21
-56.944	-0.004	-42.141	-0.005
-59.041	-0.006	-37.047	-0.012
-58.084	-0.012	-33.445	-0.025
-55.06	-0.022	-30.694	-0.045
-51.308	-0.037	-28.527	-0.072
-47.661	-0.059	-26.804	-0.108
-44.405	-0.087	-25.436	-0.151
-41.578	-0.121	-24.355	-0.201
-39.14	-0.161	-23.509	-0.258
-37.033	-0.208	-22.854	-0.321
-35.202	-0.259	-22.355	-0.388
-33.602	-0.315	-21.982	-0.46
-32.19	-0.376	-21.713	-0.535
-30.935	-0.439	-21.53	-0.613
-29.808	-0.505	-21.422	-0.693
-28.785	-0.572	-21.381	-0.775
-27.846	-0.641	-21.404	-0.858
-26.976	-0.711	-21.489	-0.941
-26.16	-0.782	-21.635	-1.024
-25.387	-0.852	-21.843	-1.106
-24.648	-0.924	-22.11	-1.187
-23.937	-0.996	-22.431	-1.267
-23.249	-1.069	-22.794	-1.346
-22.581	-1.143	-23.181	-1.425
-21.931	-1.218	-23.56	-1.503
-21.298	-1.296	-23.89	-1.582
-20.682	-1.376	-24.113	-1.662
-20.084	-1.459	-24.172	-1.743
-19.504	-1.546	-24.022	-1.826
-18.942	-1.636	-23.653	-1.912
-18.397	-1.73	-23.091	-2.002
-17.871	-1.829	-22.387	-2.098
-17.363	-1.933	-21.599	-2.2
-16.873	-2.041	-20.778	-2.309
-16.401	-2.155	-19.961	-2.425
-15.948	-2.274	-19.172	-2.549
-15.514	-2.399	-18.425	-2.681
-15.1	-2.529	-17.729	-2.819
-14.708	-2.665	-17.085	-2.963
-14.338	-2.804	-16.494	-3.112
-13.99	-2.948	-15.954	-3.264
-13.666	-3.094	-15.461	-3.418
-13.365	-3.242	-15.012	-3.572
-13.084	-3.39	-14.606	-3.727
-12.824	-3.536	-14.239	-3.878
-12.58	-3.681	-13.908	-4.026
-12.351	-3.823	-13.611	-4.167
-12.134	-3.96	-13.345	-4.299
-11.924	-4.092	-13.108	-4.42
-11.72	-4.218	-12.897	-4.528
-11.519	-4.337	-12.71	-4.623
-11.322	-4.448	-12.548	-4.702
-11.132	-4.551	-12.408	-4.766
-10.954	-4.645	-12.292	-4.815
-10.794	-4.728	-12.2	-4.849
-10.658	-4.8	-12.134	-4.869
-10.549	-4.862	-12.095	-4.876
-10.467	-4.912	-12.086	-4.872
-10.409	-4.954	-12.106	-4.859
-10.371	-4.986	-12.158	-4.839
60	22	60	18



B1859-A1

Measurement Report

4 GND
Standard Pitch 0.80mm
Various Pitches
0.90mm,1.15mm…1.3mm



Measuring Instruments

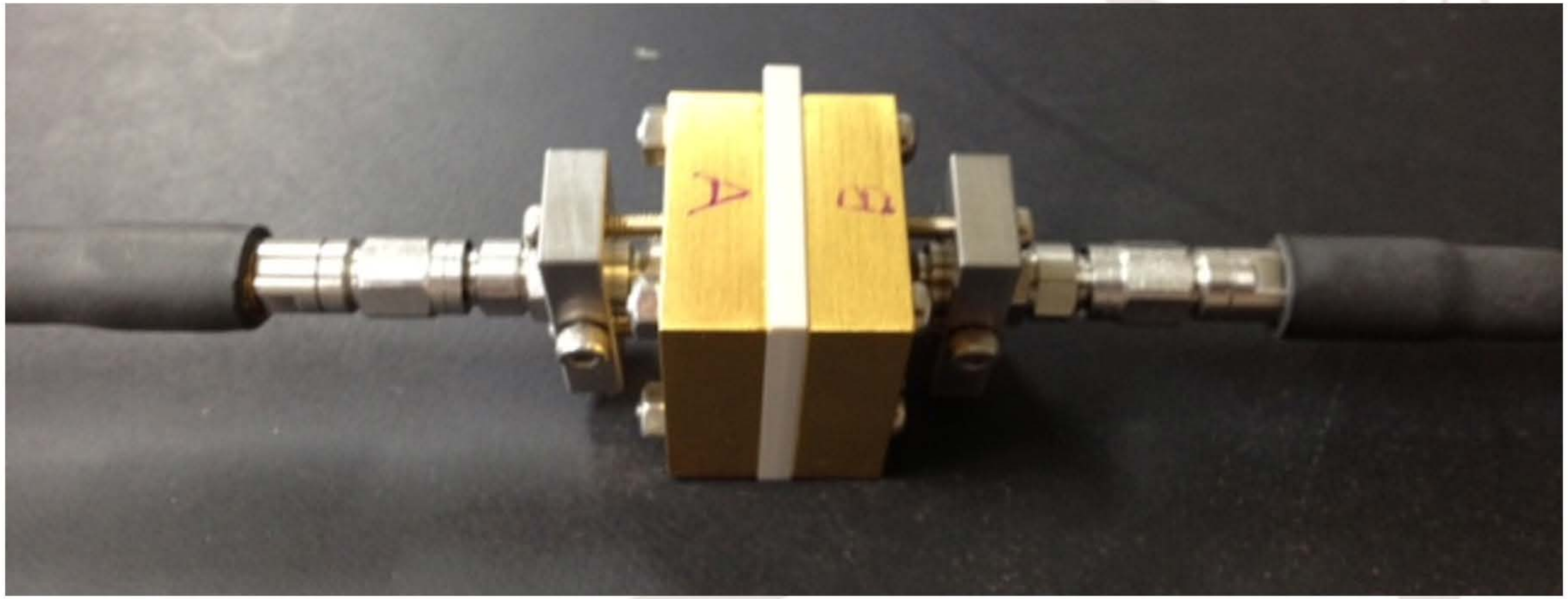
- Agilent E8364C VNA
  Frequency 10M - 50GHz

- Agilent 86100C DSO
  Frequency DC - 18GHz

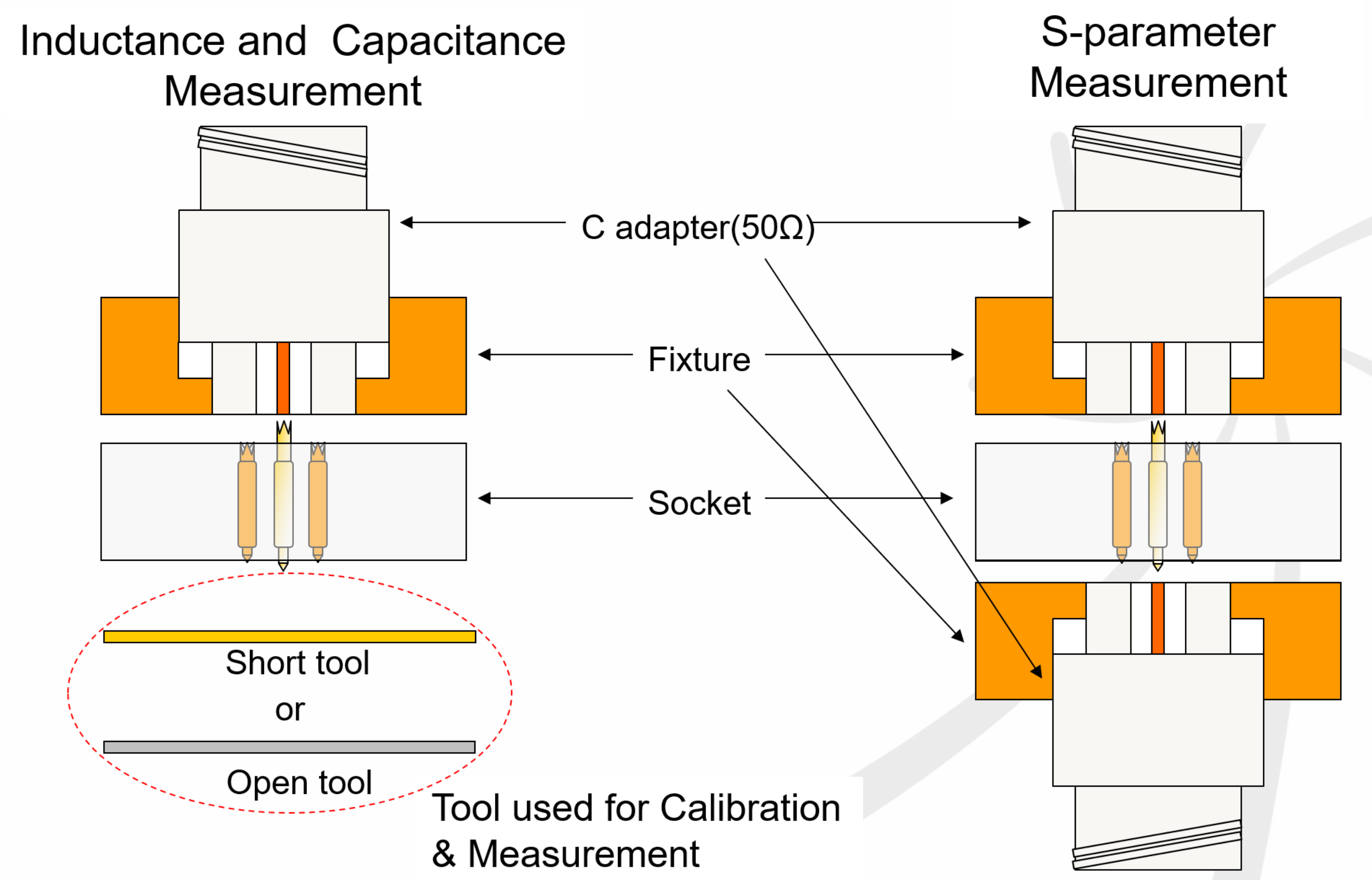
Measurement Fixtures

RF Coupler ~ 50GHz

RF Measurement Fixture

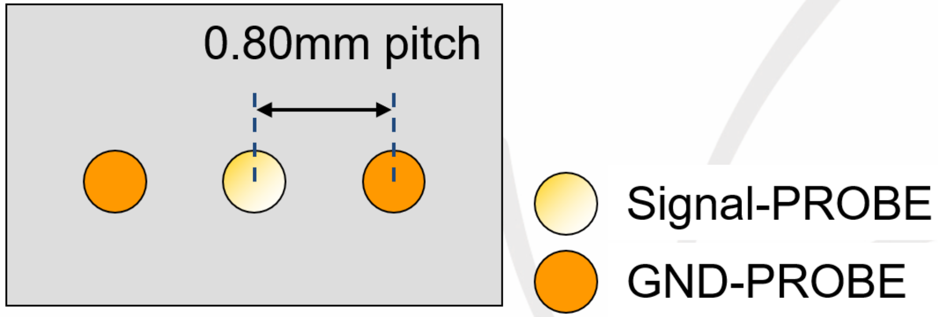


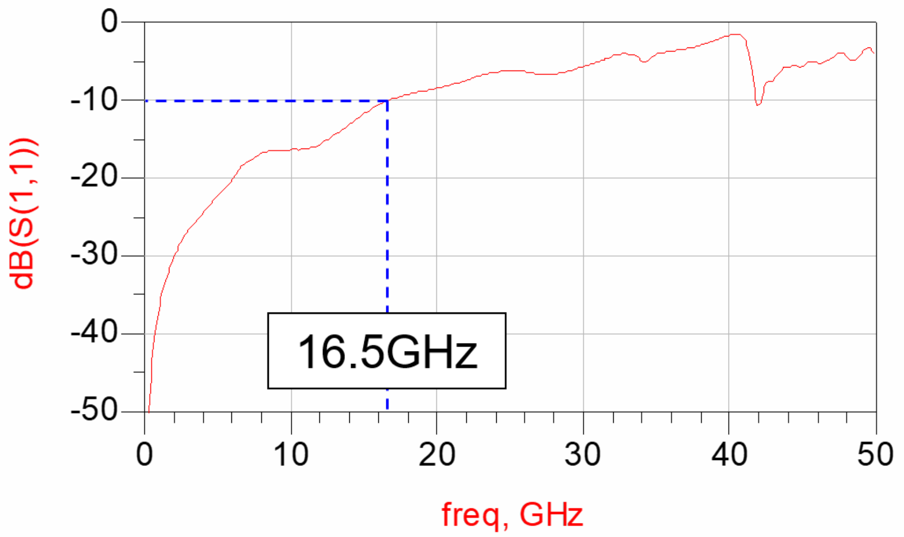
Measuring Method



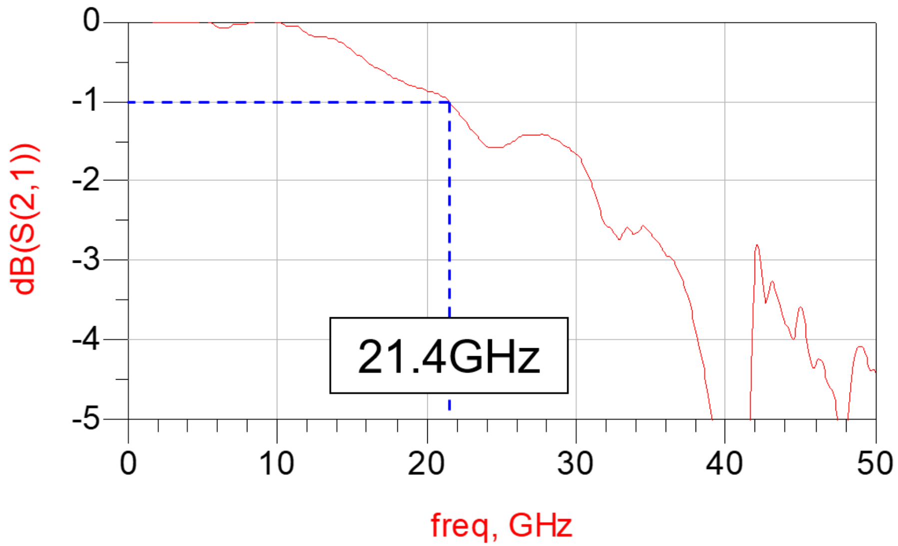
S-parameter for B1859-A1

Pitch 0.80mm, GND2





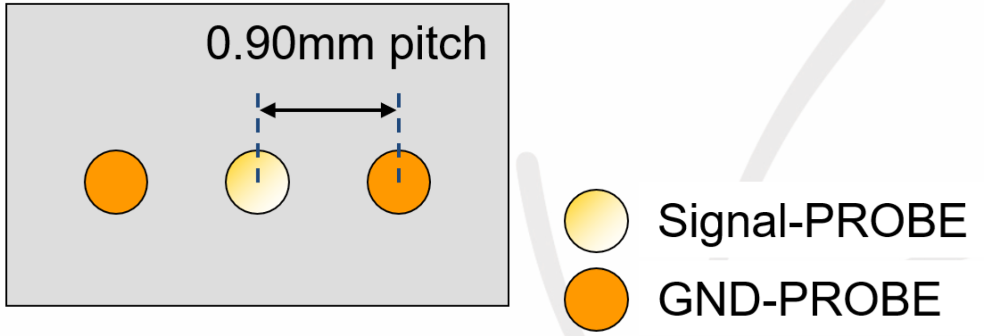
S11 Return Loss

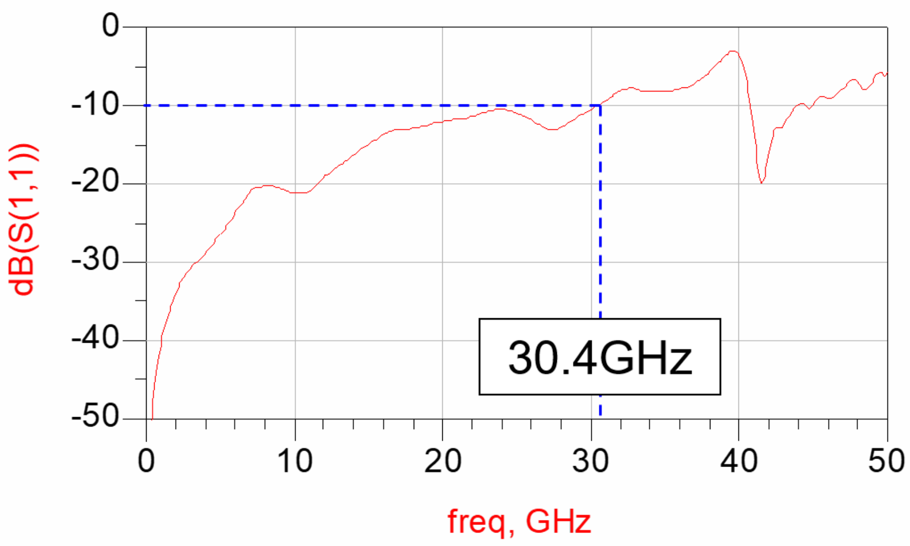


S21 Insertion Loss

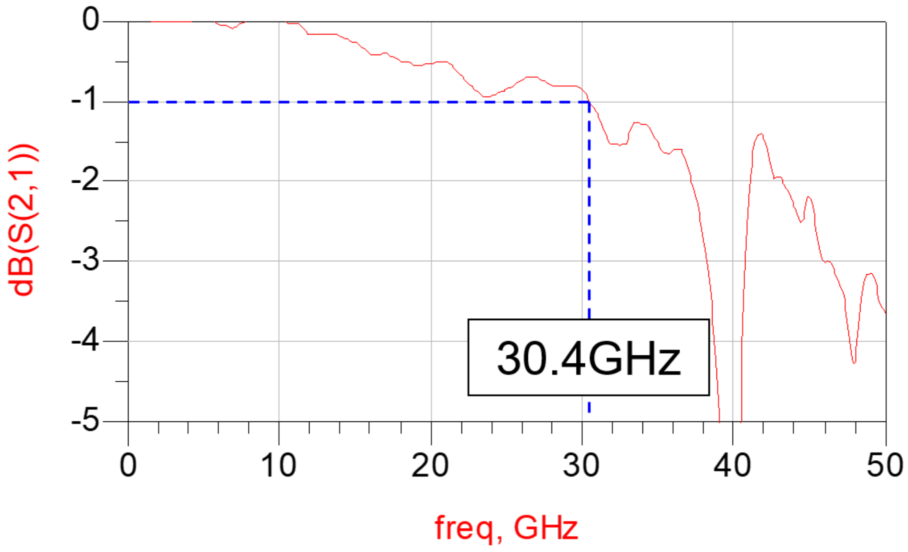
S-parameter for B1859-A1

Pitch 0.90mm, GND2





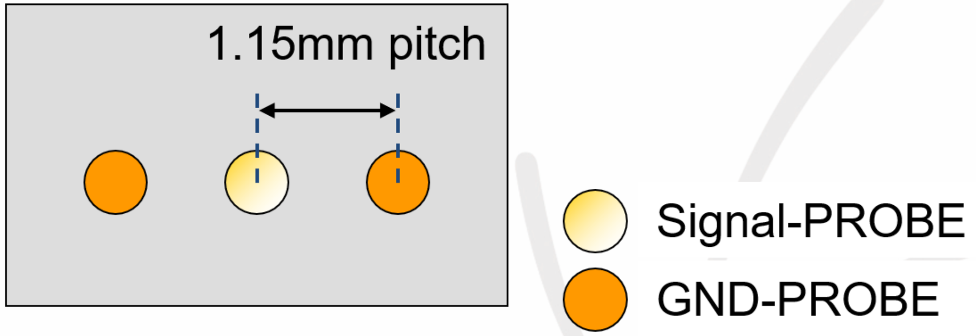
S11 Return Loss

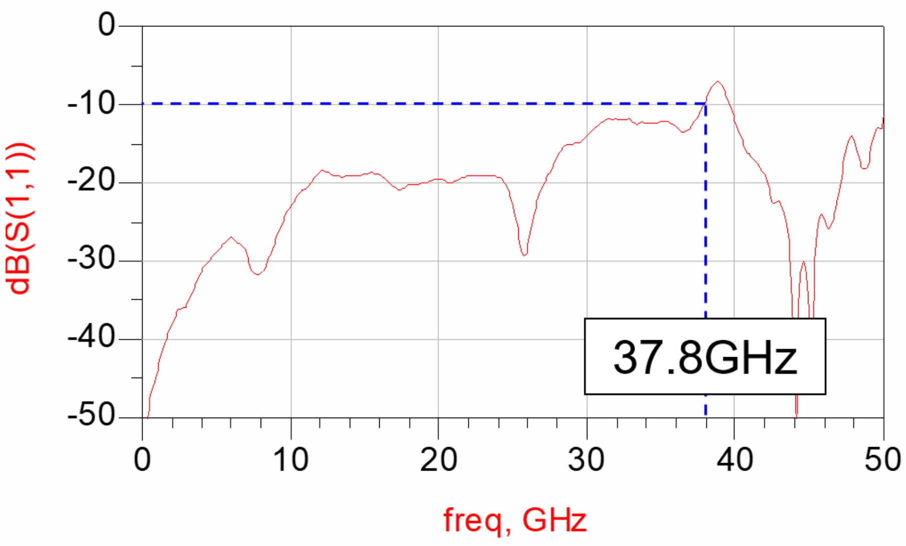


S21 Insertion Loss

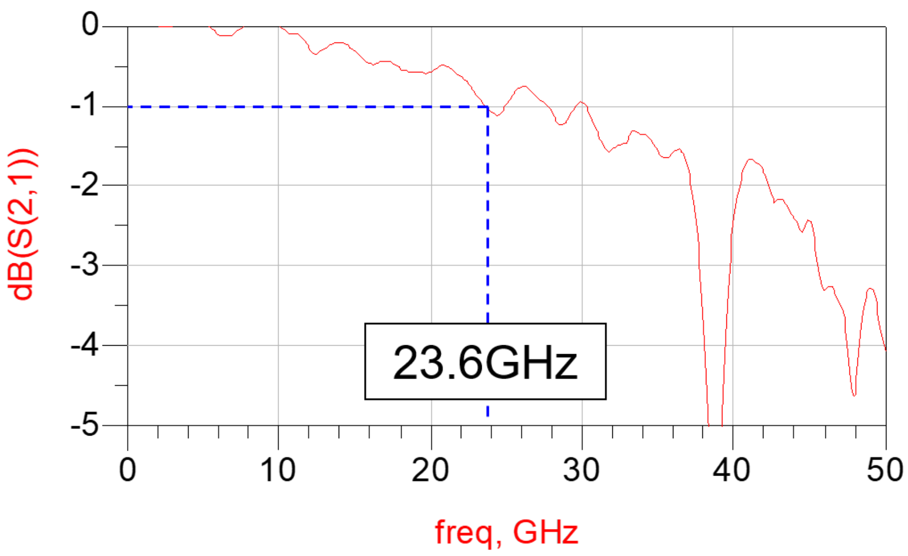
S-parameter for B1859-A1

Pitch 1.15mm, GND2



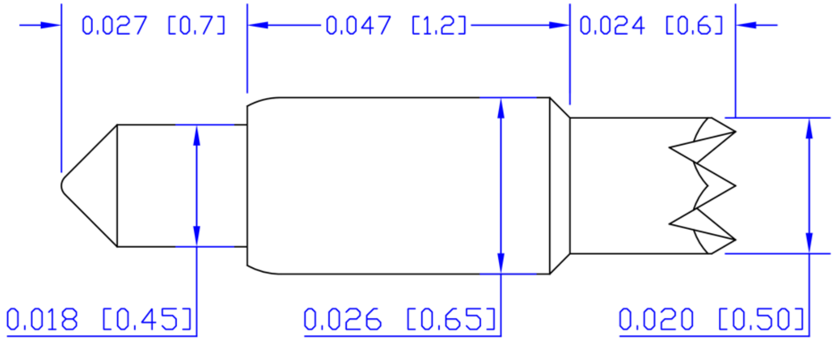


S11 Return Loss



S21 Insertion Loss

(B1859-A1·GND2)



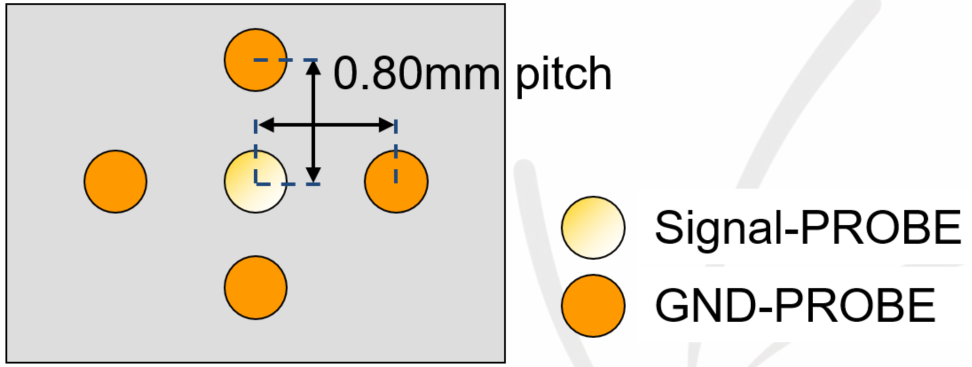
DIMENSIONS ARE INCHES [MM REF]

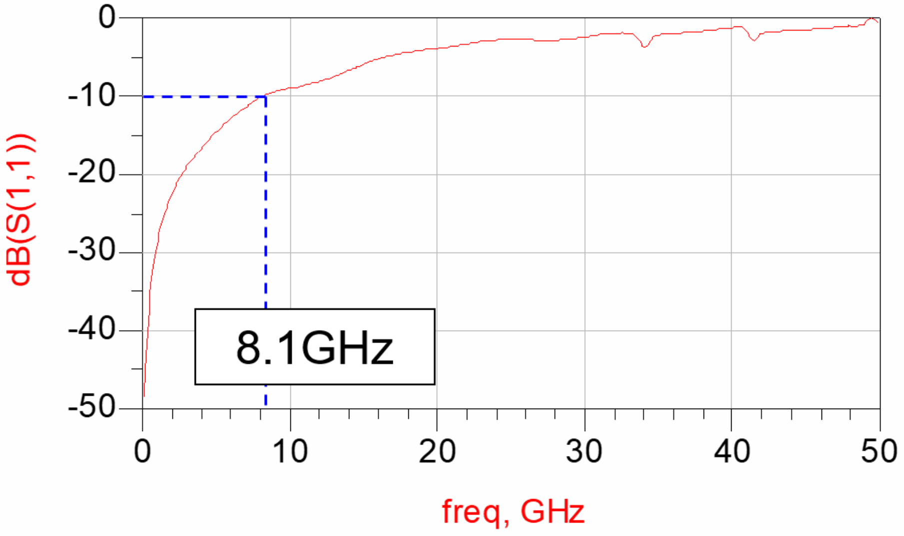
SPRING FORCE (g)	20
OPERATING POSITION (mm)	2.0
GND PROBE (pcs)	2

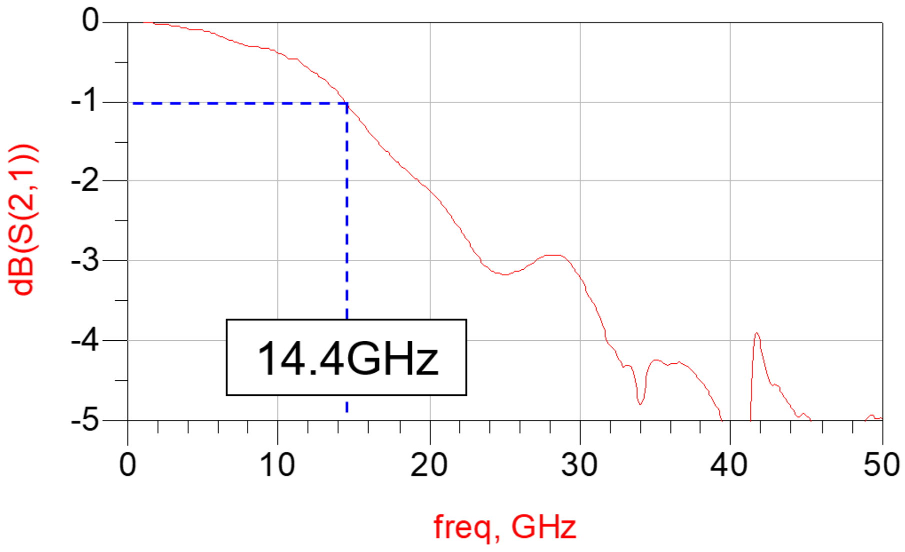
Pitch (mm)	0.80	0.90	1.15
Return Loss (dB)	-10dB@16.5GHz	-10dB@30.4GHz	-10dB@37.8GHz
Insertion Loss (dB)	-1dB@21.4GHz	-1dB@30.4GHz	-1dB@23.6GHz
Inductance (nH)	0.60	0.70	0.82
Capacitance (pF)	0.28	0.26	0.23
Characteristic Impedance (Ω)	46.0	52.0	59.8

S-parameter for B1859-A1

Pitch 0.80mm, GND4





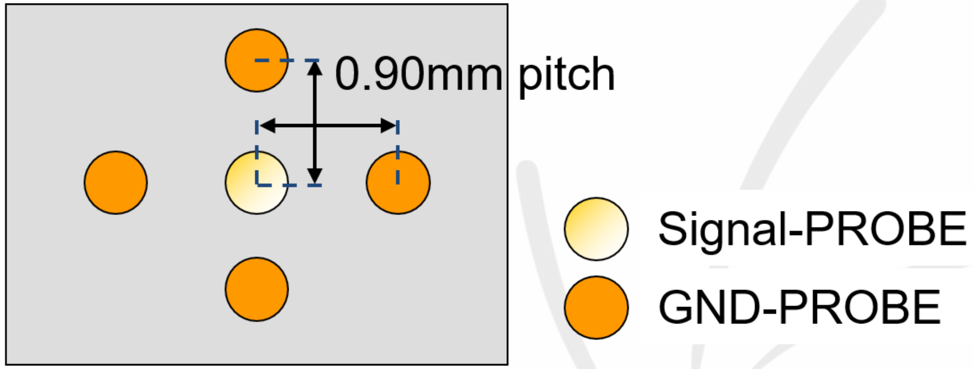


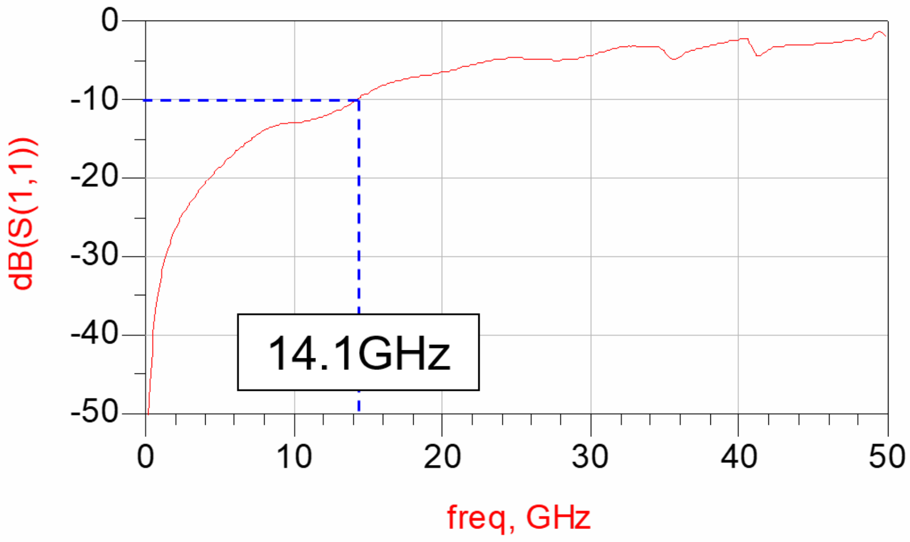
S11 Return Loss

S21 Insertion Loss

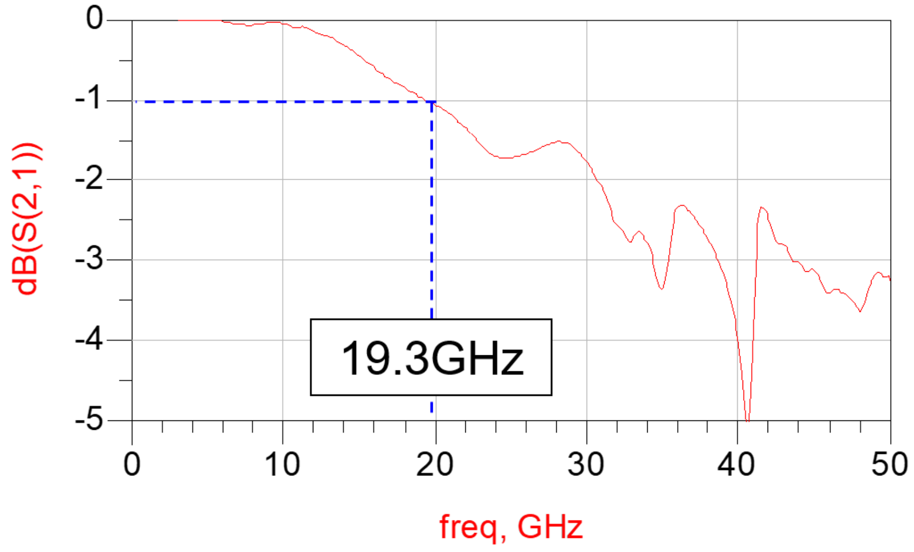
S-parameter for B1859-A1

Pitch 0.90mm, GND4





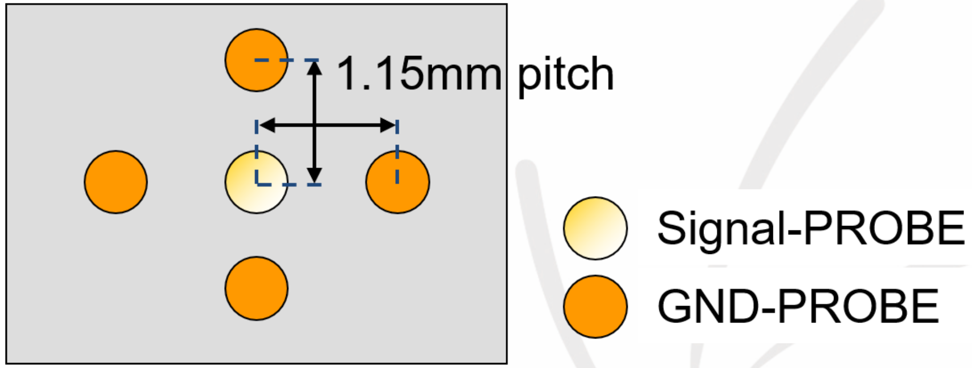
S11 Return Loss

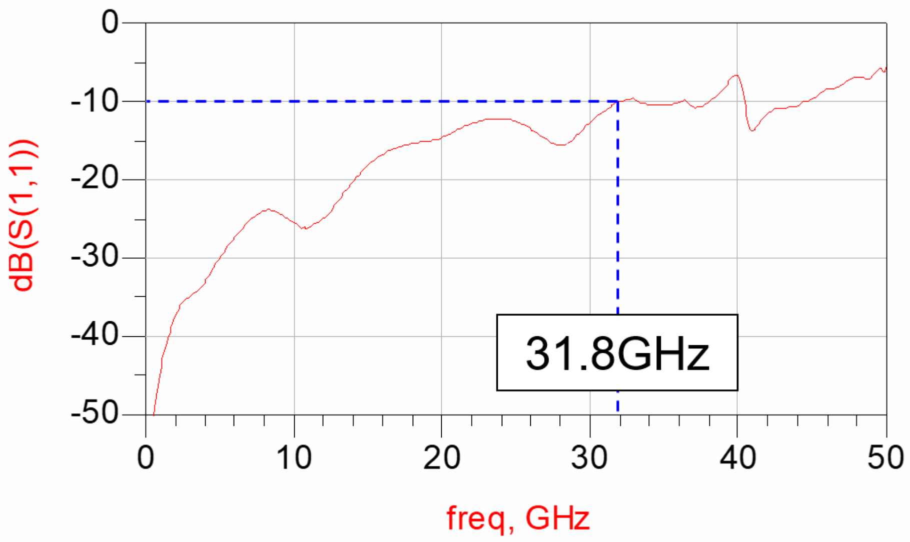


S21 Insertion Loss

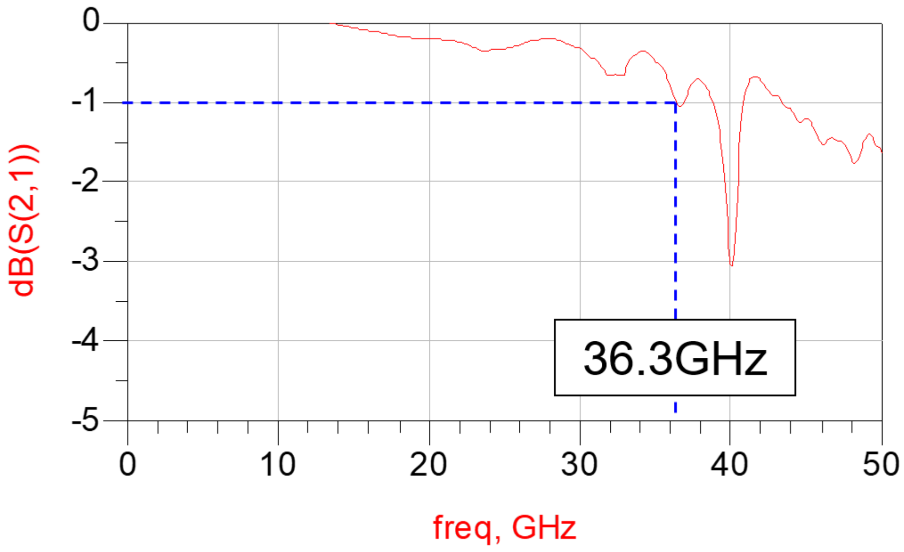
S-parameter for B1859-A1

Pitch 1.15mm, GND4



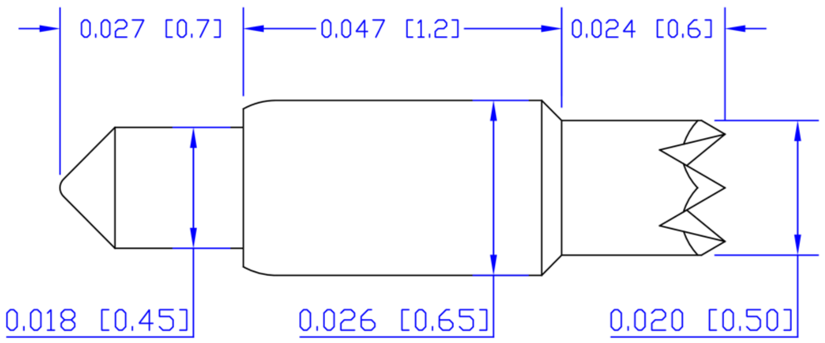


S11 Return Loss



S21 Insertion Loss

(B1859-A1·GND4)

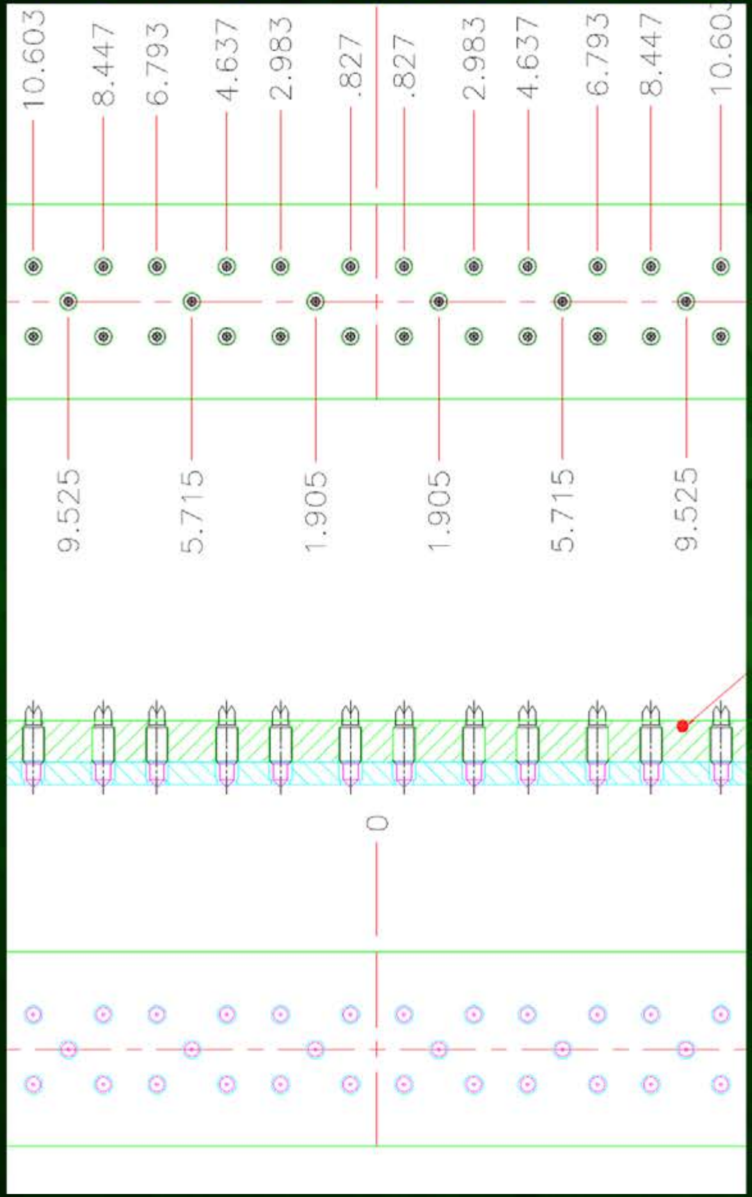


DIMENSIONS ARE INCHES [MM REF]

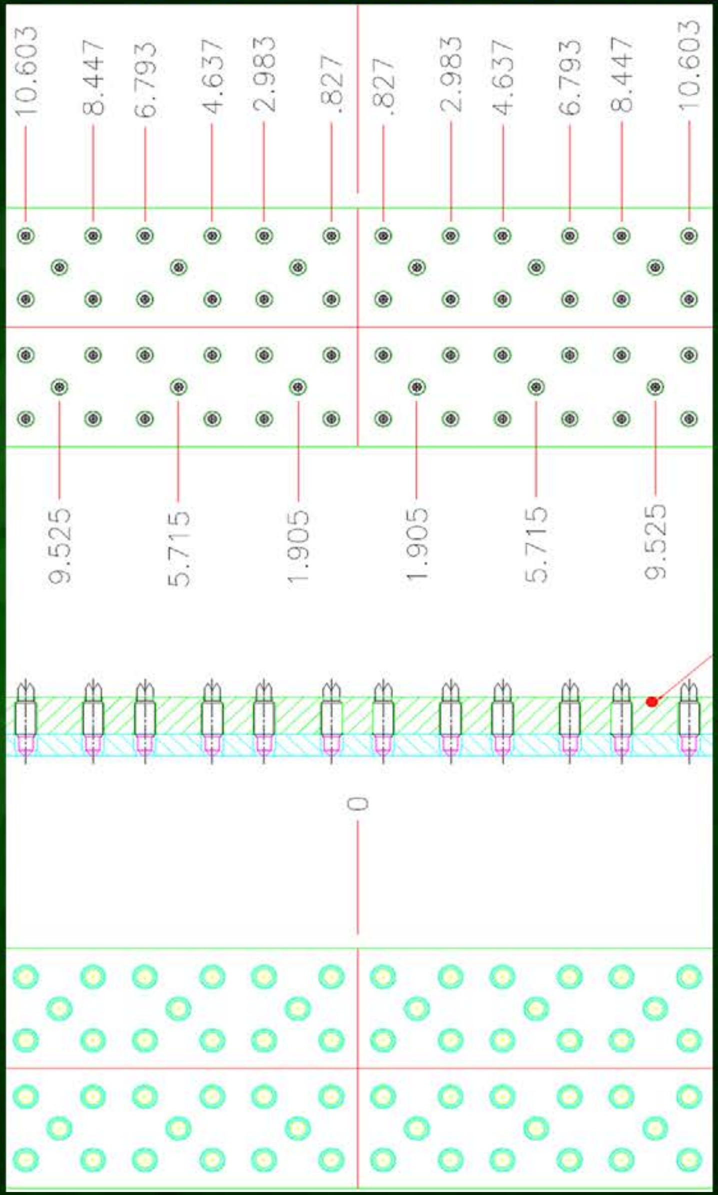
SPRING FORCE (g)	20
OPERATING POSITION (mm)	2.0
GND PROBES (pcs)	4

Pitch (mm)	0.80	0.90	1.15
Return Loss (dB)	-10dB@8.1GHz	-10dB@14.1GHz	-10dB@31.8GHz
Insertion Loss (dB)	-1dB@14.4GHz	-1dB@19.3GHz	-1dB@36.3GHz
Inductance (nH)	0.48	0.56	0.70
Capacitance (pF)	0.40	0.32	0.26
Characteristic Impedance (Ω)	34.8	41.7	52.4

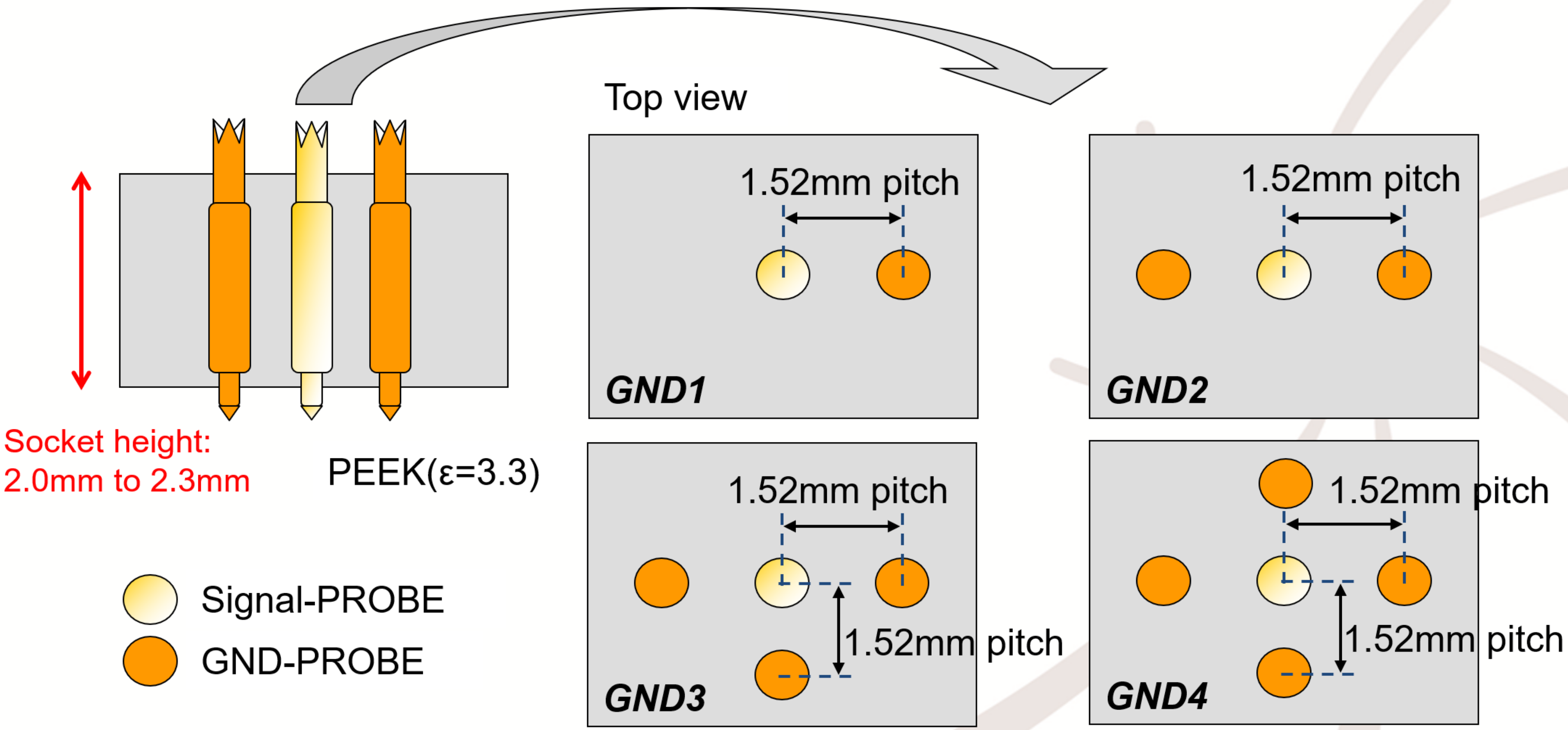
40 Pin Interface



80 Pin Interface

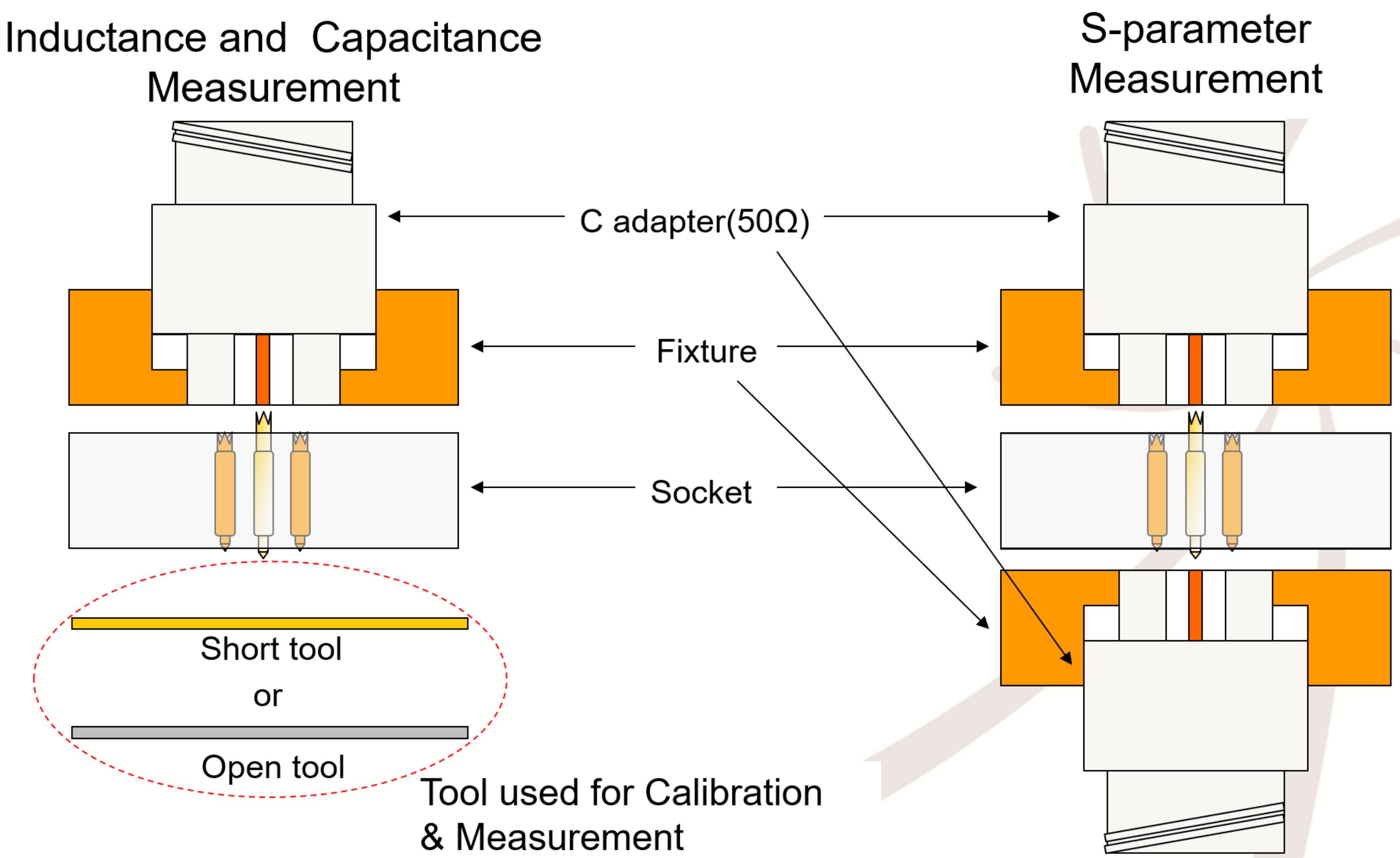


Signal to GND Probe in Socket

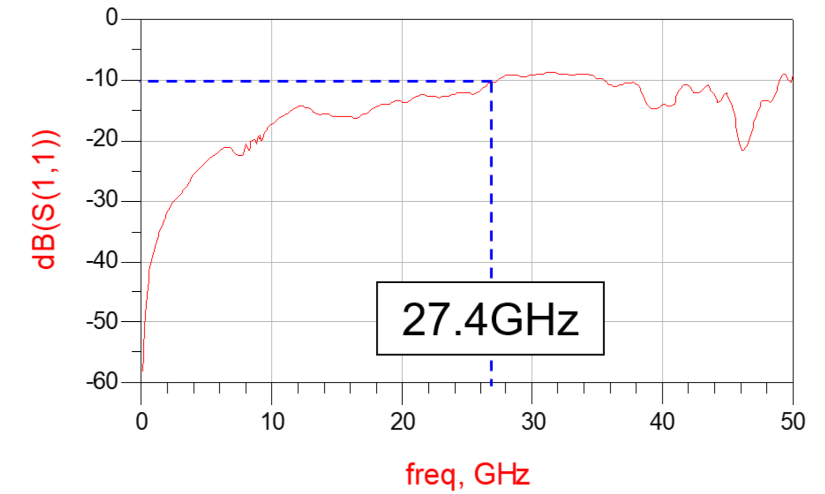
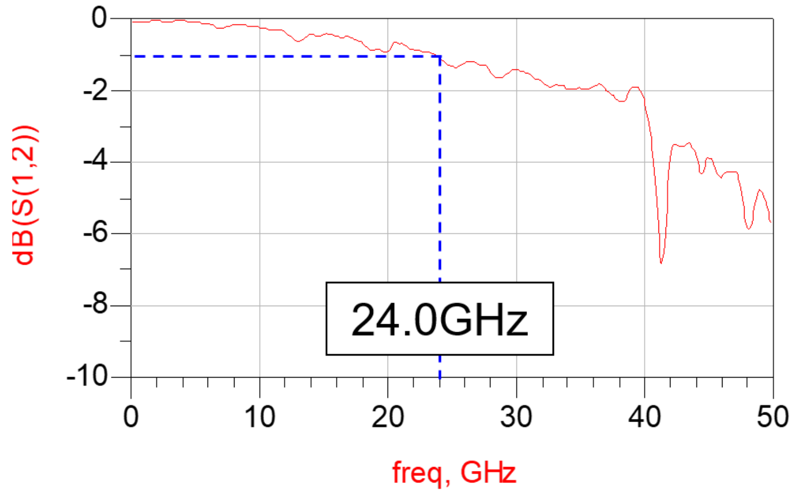
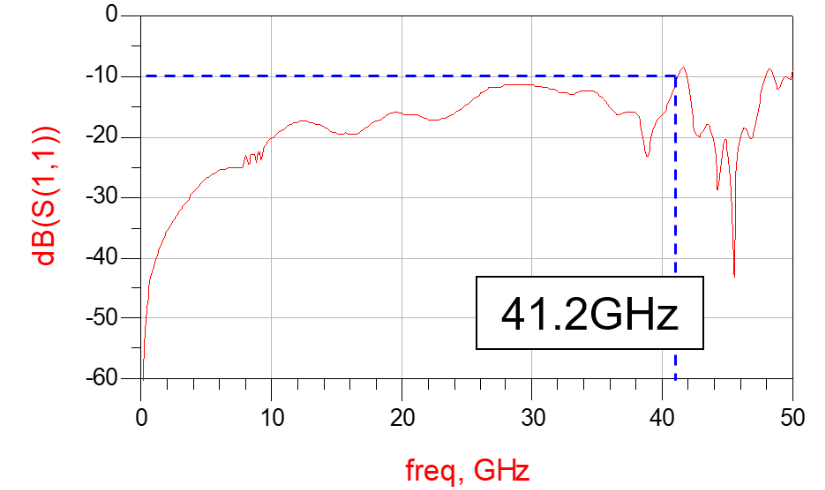
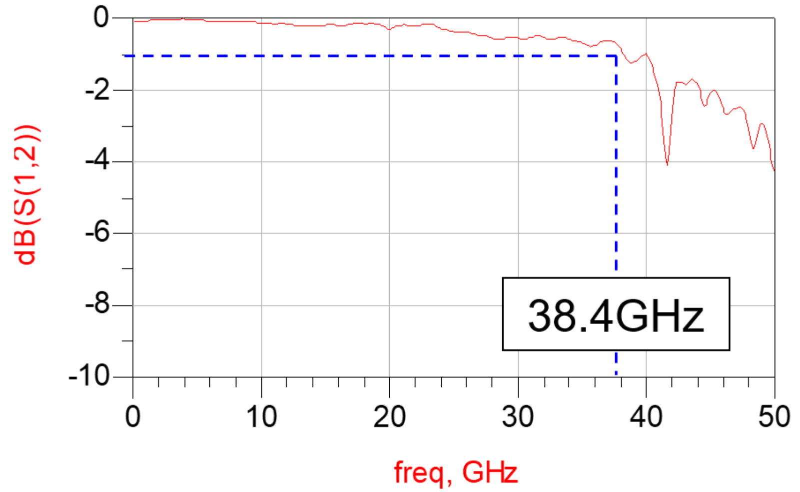


Place 1 signal pin surrounded by 1 ~ 4 ground pins for measurement.
Plastic housing was made in PEEK material for each size of probes.
Using different height sockets for each operating lengths of probes.

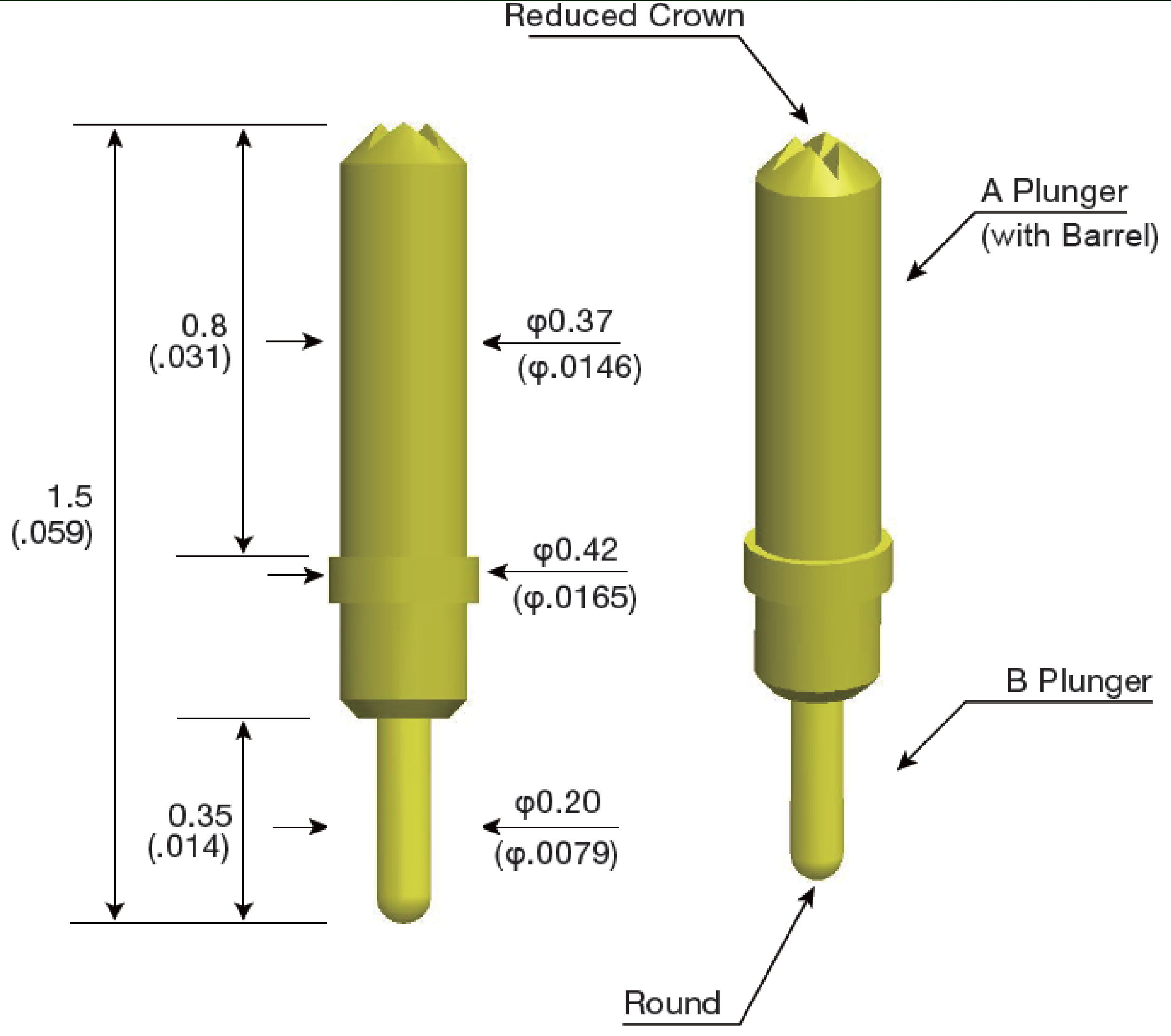
Measuring Method



S-parameter for B1859-A1 (Operating position 2.0mm)

	Return Loss (S11)	Insertion Loss (S21)
GND3		
GND4		

- **RI-037LA-02-A2 Spring Probe**
- **Barrel Length Comparison**
- **RF Simulations – HFSS**



Overview

- HFSS simulation of probes with different length of barrel
- Area of optimization is RED dimension bellow

Length of Barrel	Operating length	Difference
0.165	0.75	-0.50
0.415	1.00	-0.25
0.665	**1.25**	**0 (Original)**
0.915	1.50	+0.25
1.165	1.75	+0.50
1.415	2.00	+0.75

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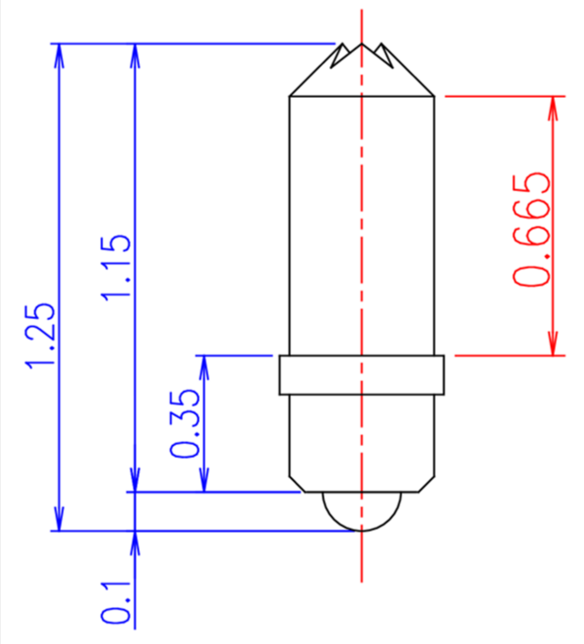
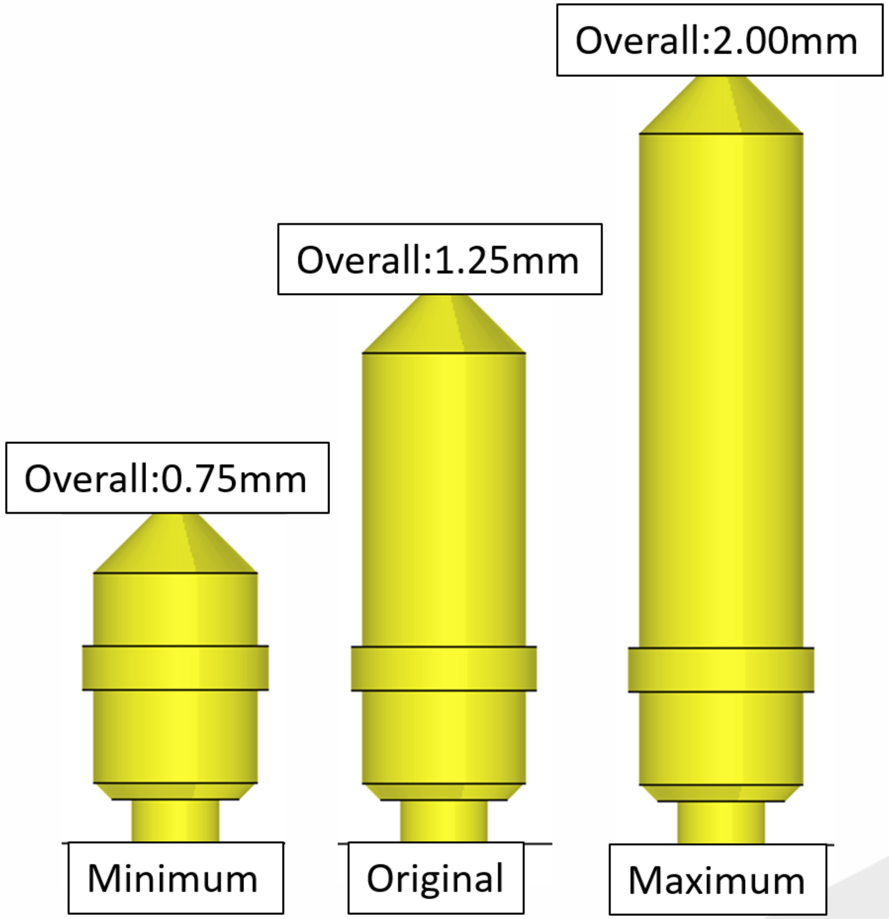
RI-037LA-02-A2
Operating length 1.25mm
(Stroke:0.25mm)

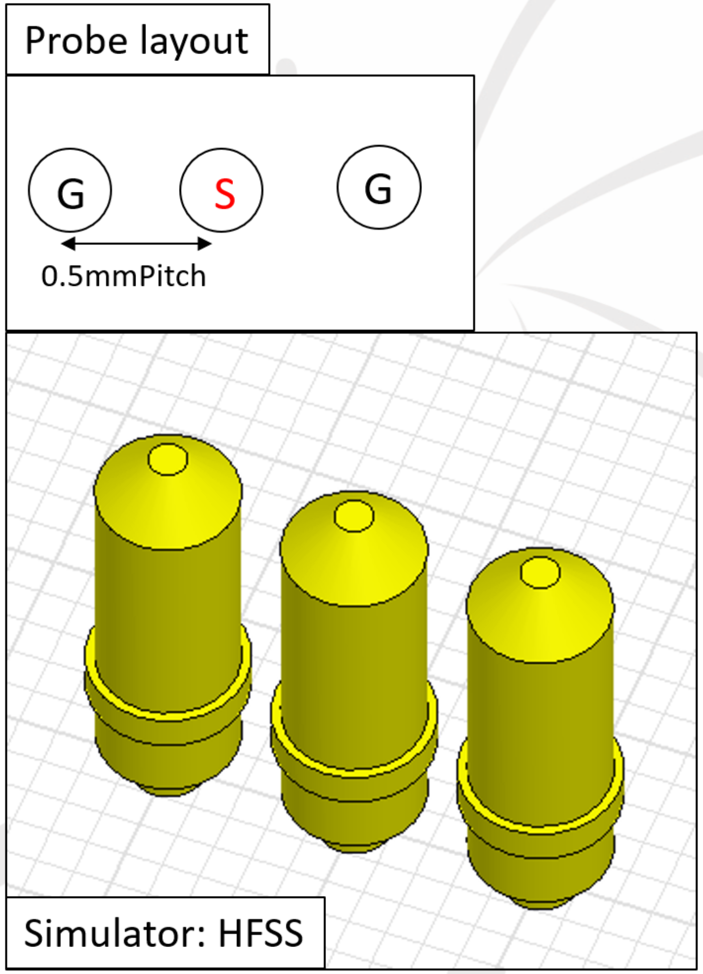


3

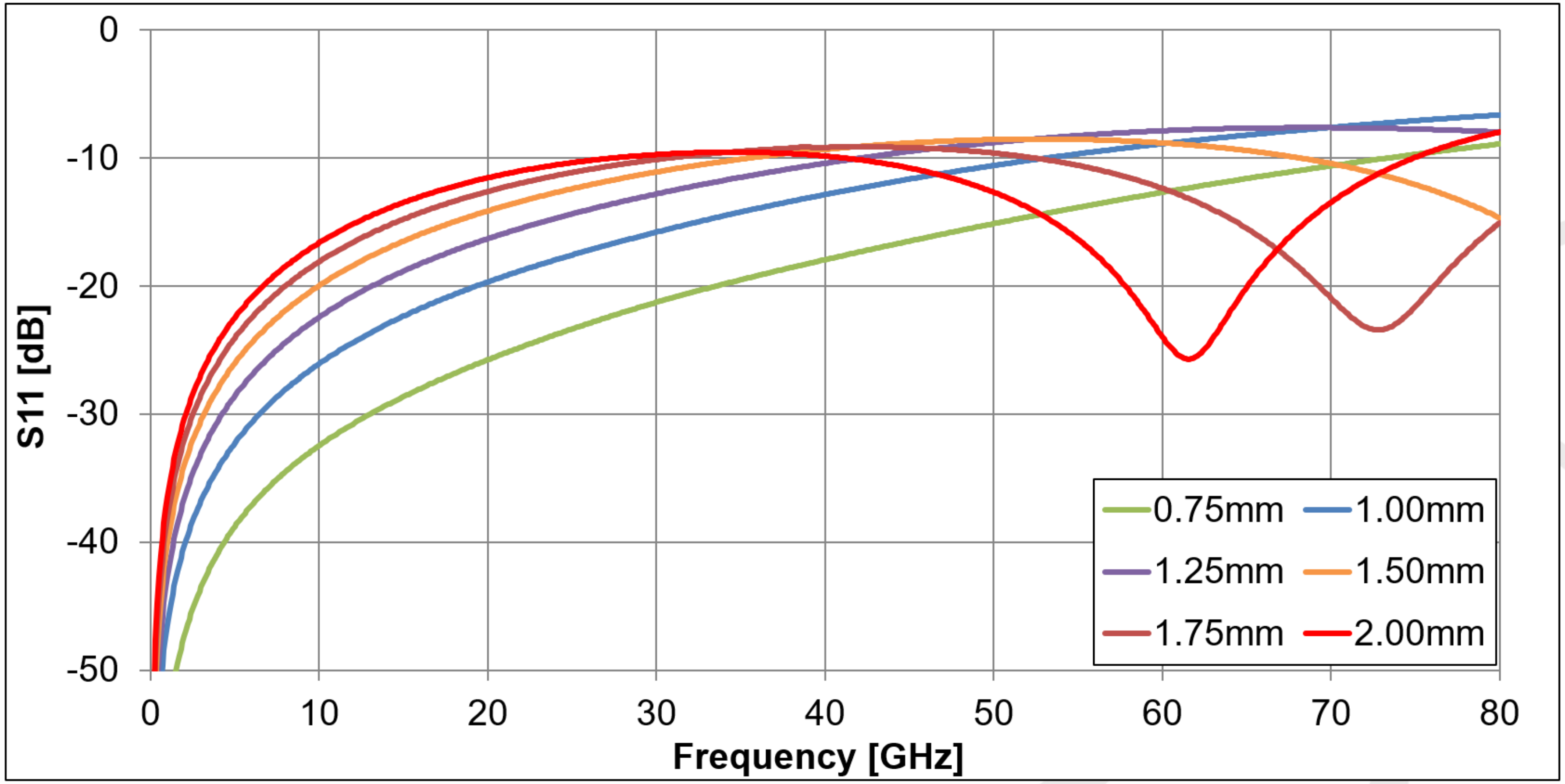
Simulation Models

- These are models for the RF simulation





Simulation Results(Return Loss)



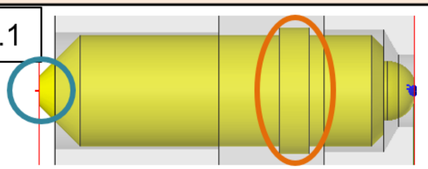
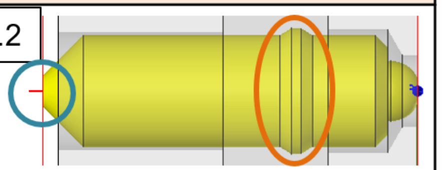
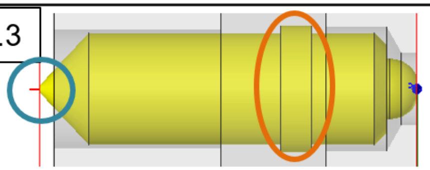
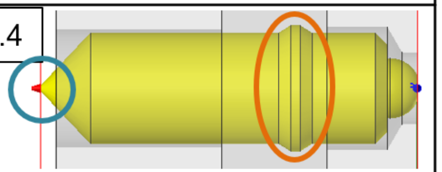
- Shorter probes have better Return loss

RI-037LA-02-A2 Falcon RF Spring Probe Design Simulations

- **Simulation for retaining feature shape and location**

Simulation Of Falcon Probe Features

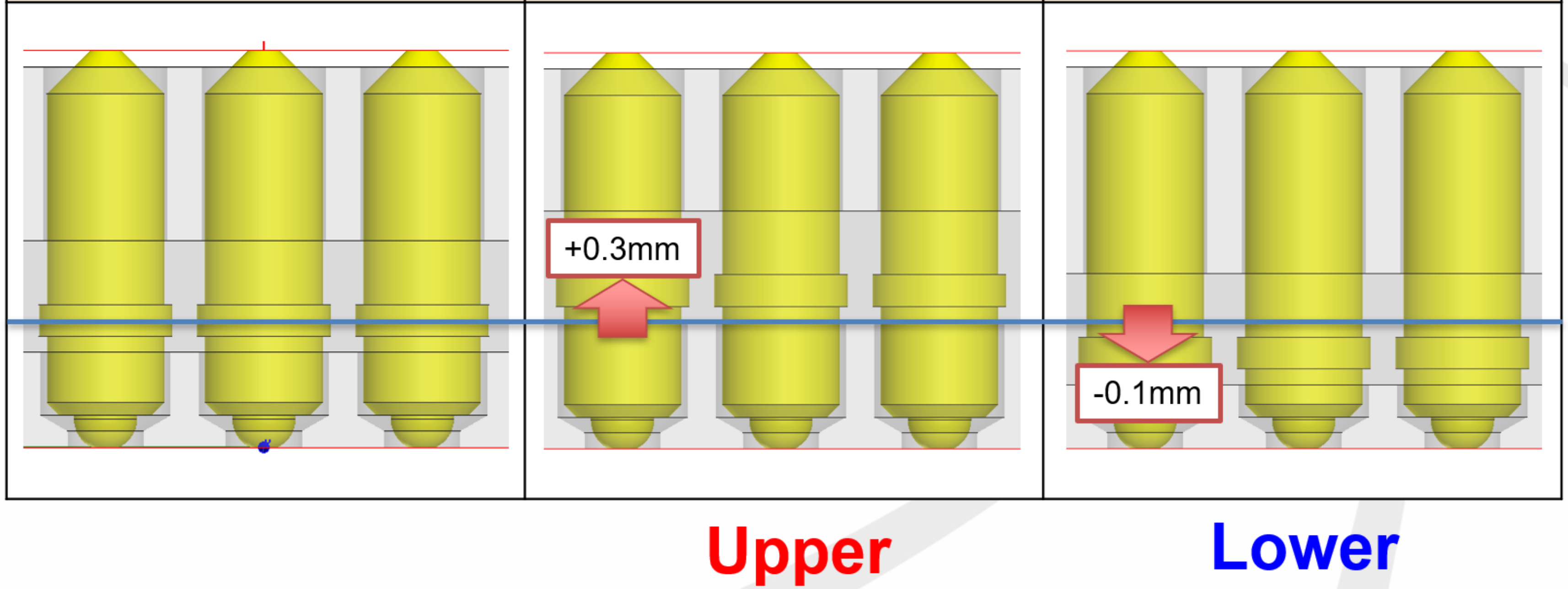
- Probe model includes a retention feature (collar) with right angles.
- Simulation results analyzed to understand if tapered collar would improve RF performance.
- Simulation results analyzed to understand if collar location on barrel would improve RF performance

GND probe : 2pcs		Flange	
		Normal	Taper
Plunger A	Crown	No.1 	No.2 
	Conical	No.3 	No.4 

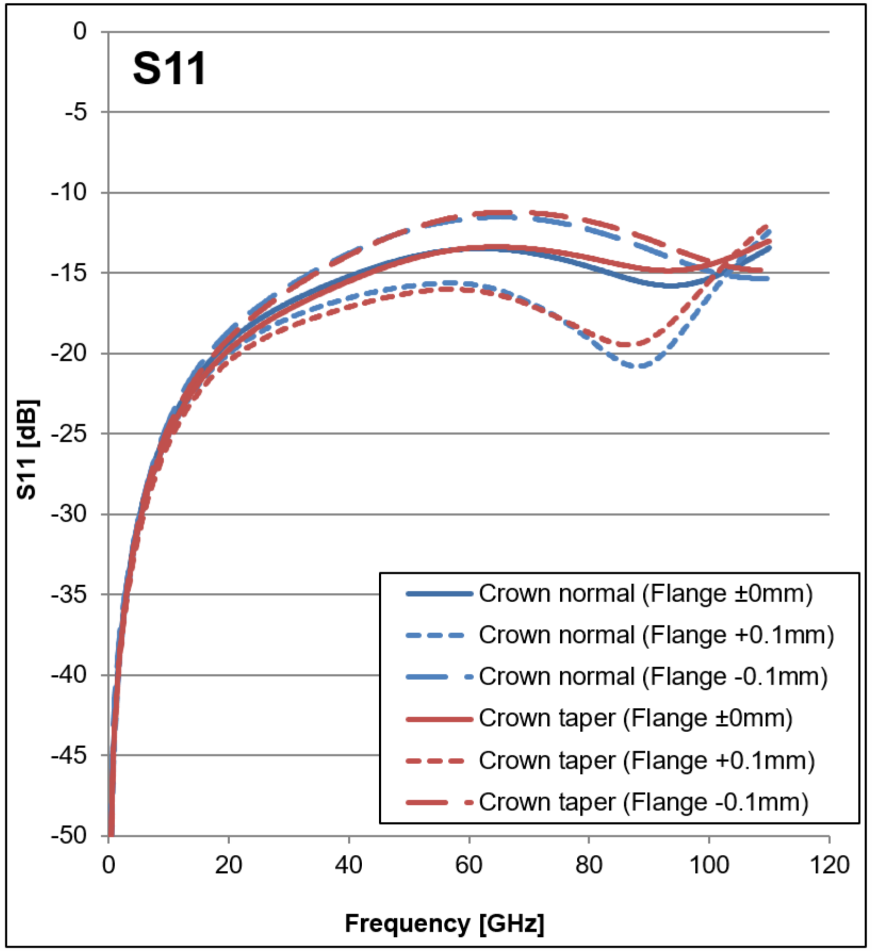
About simulation

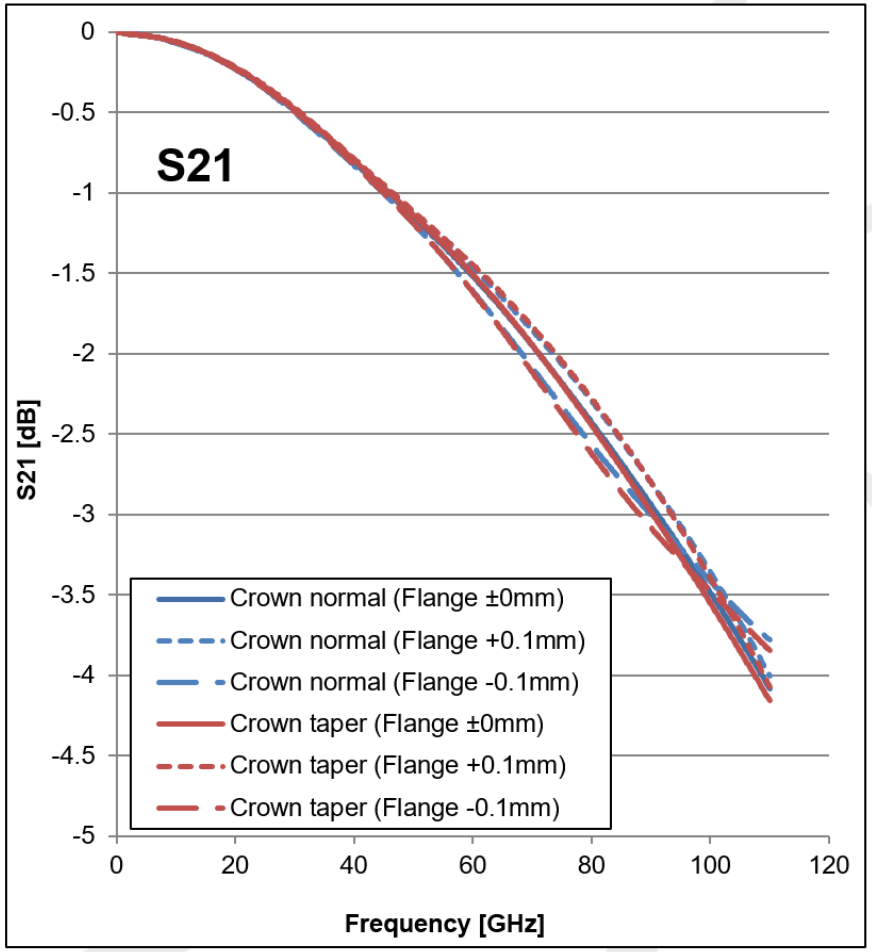
- RF simulation for optimum collar location moved up and down. (Upper: up to 0.3mm, Lower: down to 0.1mm)

Flange ±0mm	Flange +0.1mm	Flange -0.1mm



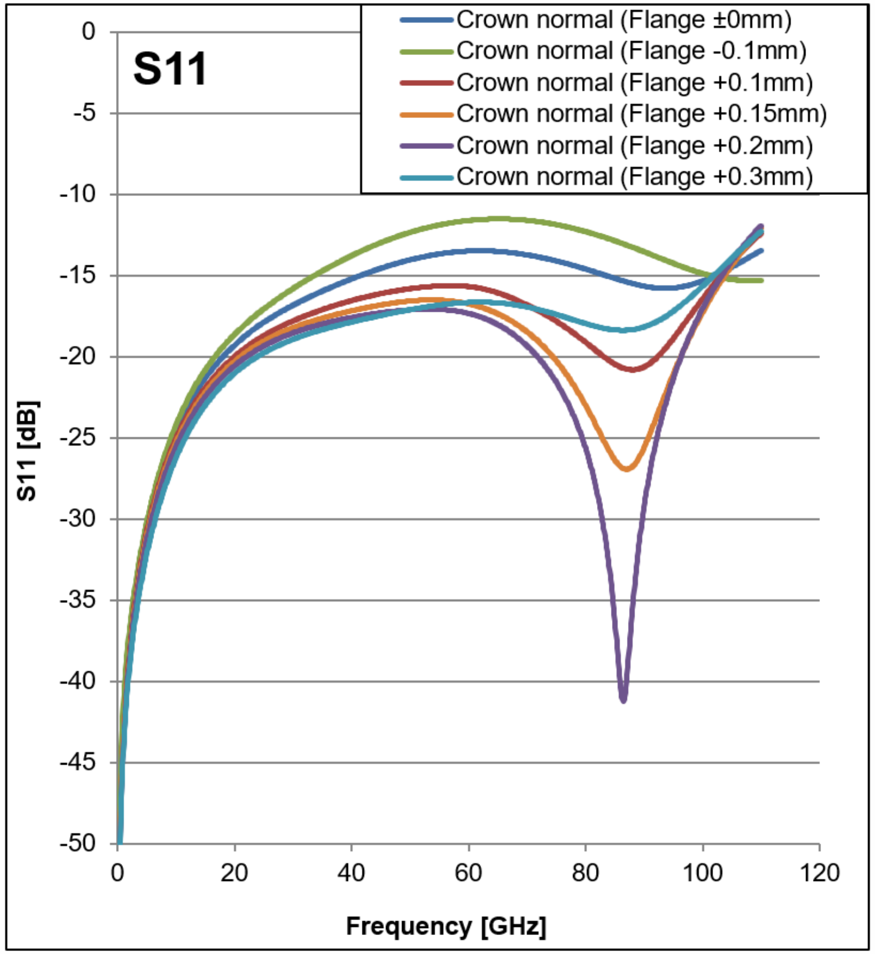
Result (Crown / Normal, Taper)

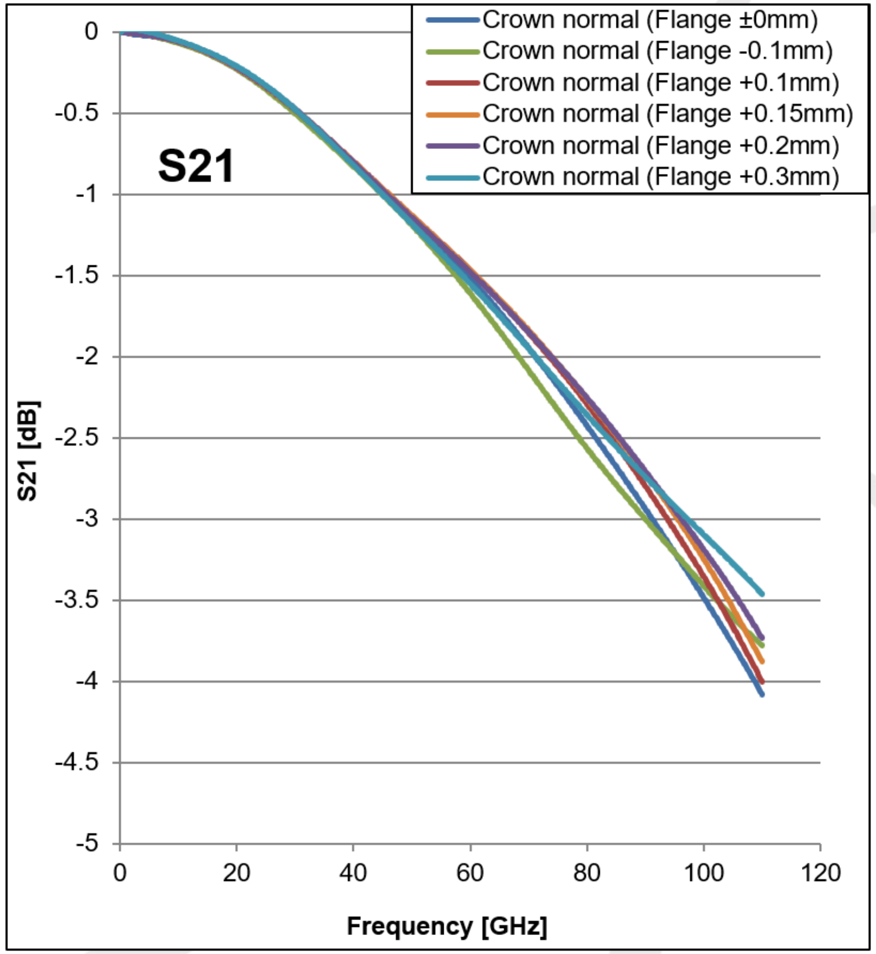




- Simulation results for collar position.

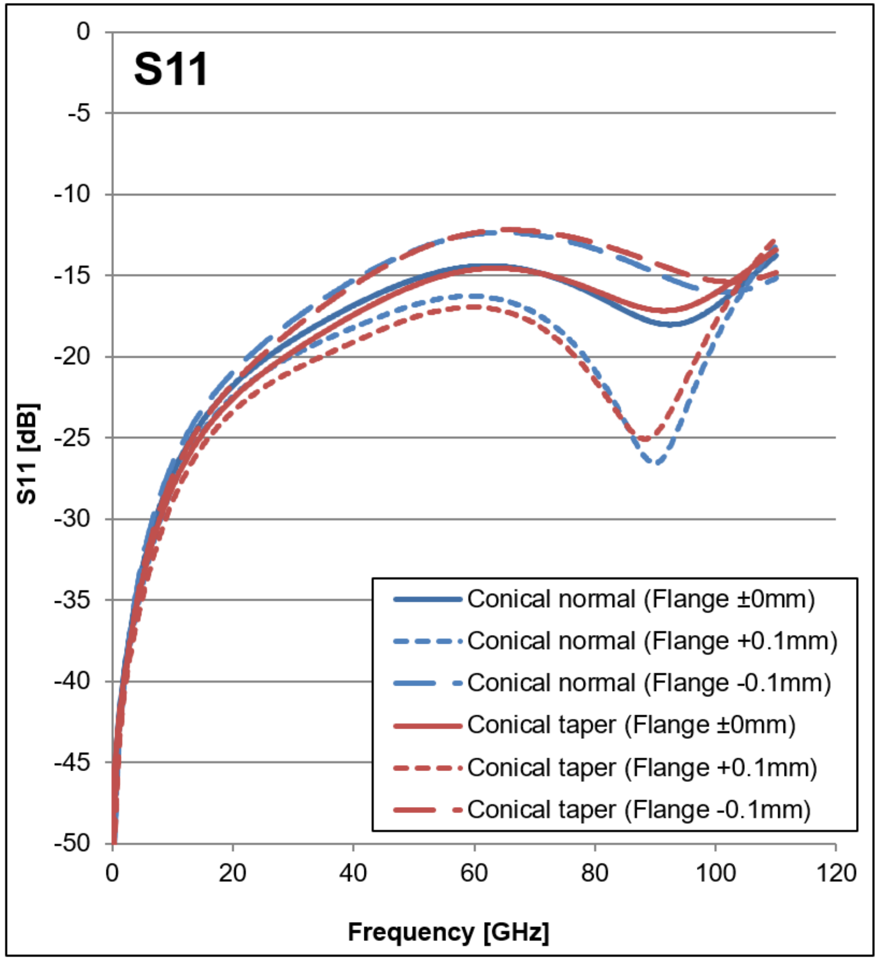
Result (Crown / -0.1mm, +0.3mm)

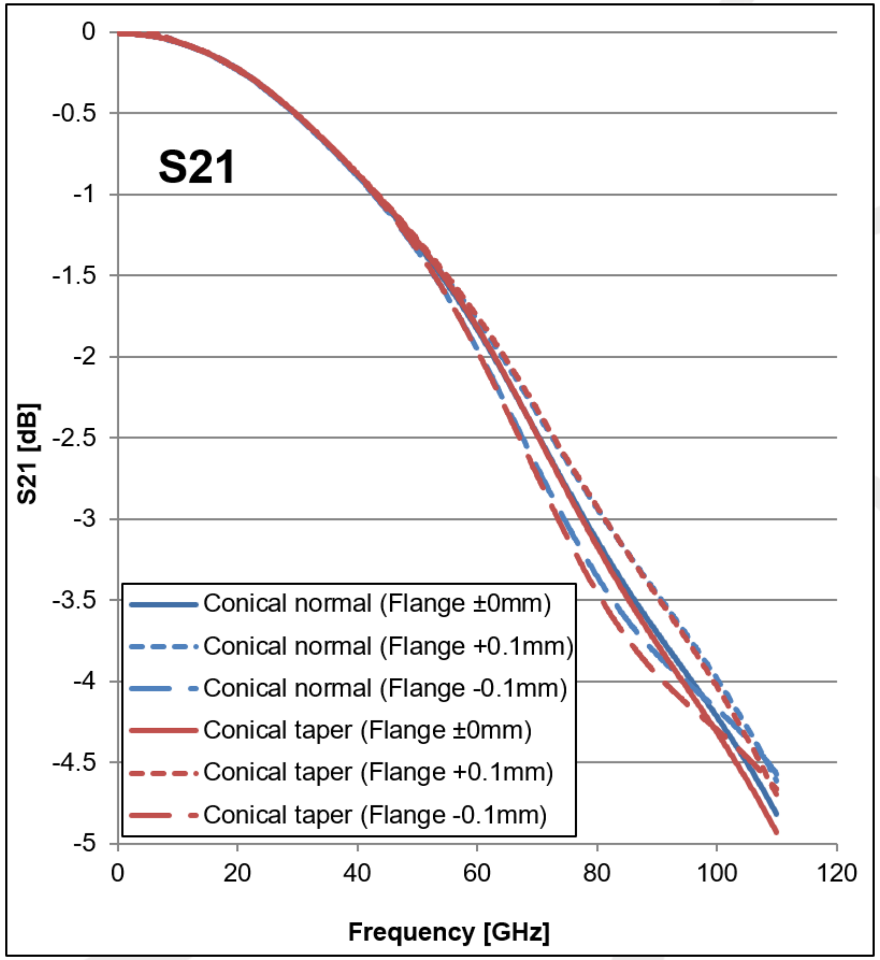




- Simulation result for flange position.

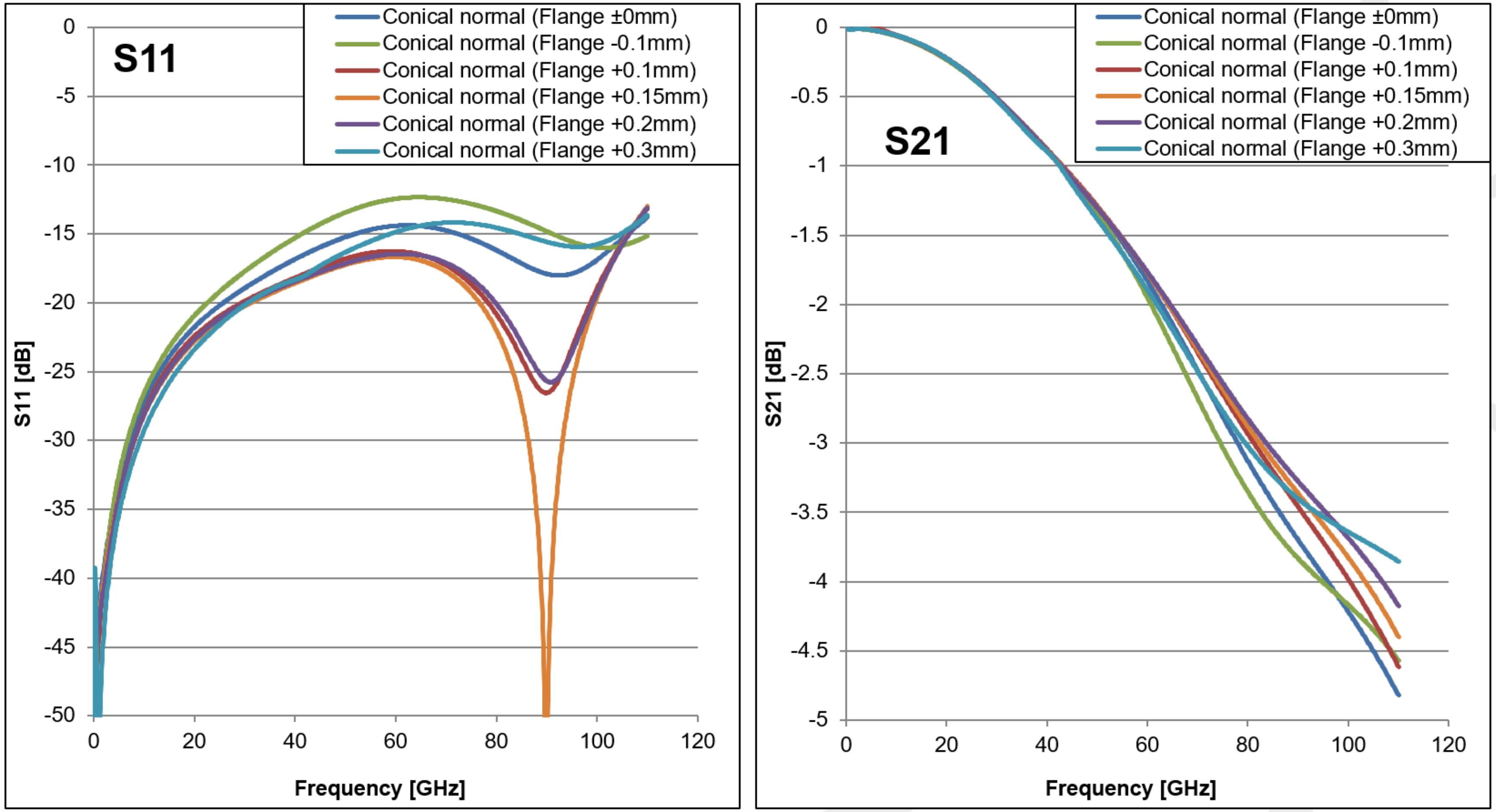
Result (Conical / Normal, Taper)





- Simulation result for flange position.

Result (Conical / -0.1mm, +0.3mm)



- Simulation result for flange position.

Simulation result (S21)

■ Simulation result of S21.

GND probe : 2pcs		Flange Normal					
		-0.1	±0	+0.1	+0.15	+0.2	+0.3
Plunger A	Crown	-1dB@44.9GHz -3dB@89.9GHz	-1dB@45.6GHz -3dB@91.1GHz	-1dB@46GHz -3dB@93.7GHz	-1dB@46GHz -3dB@95.5GHz	-1dB@45.7GHz -3dB@96.1GHz	-1dB@44.9GHz -3dB@97.2GHz
	Conical	-1dB@42.7GHz -3dB@74.5GHz	-1dB@42.9GHz -3dB@77.9GHz	-1dB@43GHz -3dB@81.2GHz	-1dB@42.7GHz -3dB@82.2GHz	-1dB@42.7GHz -3dB@83.6GHz	-1dB@42.5GHz -3dB@79.4GHz

Notes

- RF Simulations are a software prediction that should be validated with physical measurements.
- Do not be surprised if simulation results do not immediately correlate with physical measurements.
- Simulation models can be optimized and simulation parameters can be altered to archive more accurate results by applying the knowledge learned from physical measurement results.
- RF measurements are difficult to repeat; follow RF test lab best practices such as calibrating instruments, taking care of cables, using proper tools, knowing torque specs for each connector type…brass requires less torque than SS connectors, keep everything clean.
- Maintain appropriate lab conditions; temp, humidity, ESD, vibration control.

Thank You? Your questions are welcome…

Michael Ricci
Principal Engineer