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Flat Probe Technology for RF Test

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BiTS China Workshop
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Agenda

- RF Appliction Requirements
- History of Flat probe tech
- Factors that impact Probe RF performance
- RF Design of Flat probe tech
- Radial vs Flat Probe Measurements
- Application Results using Flat Probes
- Future Direction of Flat Probe technology

RF Market Drivers

Demand for instantaneous data transfer is driving high frequency, high bandwidth RF devices

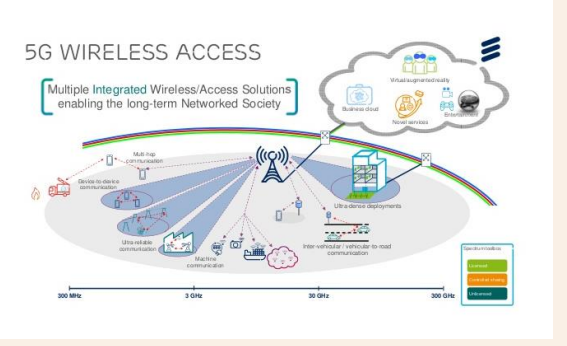
Applications

- WiGig, 5G, Auto Radar, High-Speed Networking

Devices

- RF Transceivers, Power Amplifiers, Low Noise Amplifiers, RF Switches, SERDES, etc.

5G Backhaul



Auto Radar

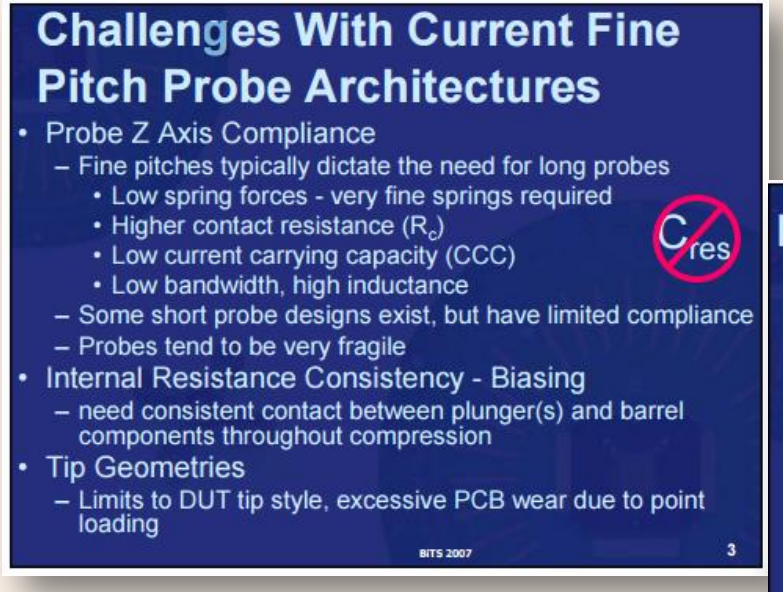
802.11AD (WiGig)

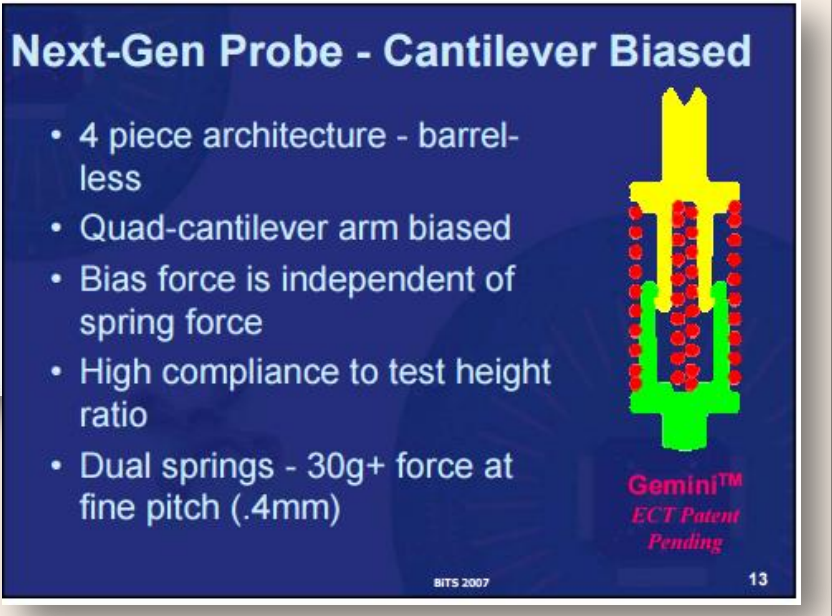
RF Contact Requirements

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

BiTS Workshop 2007

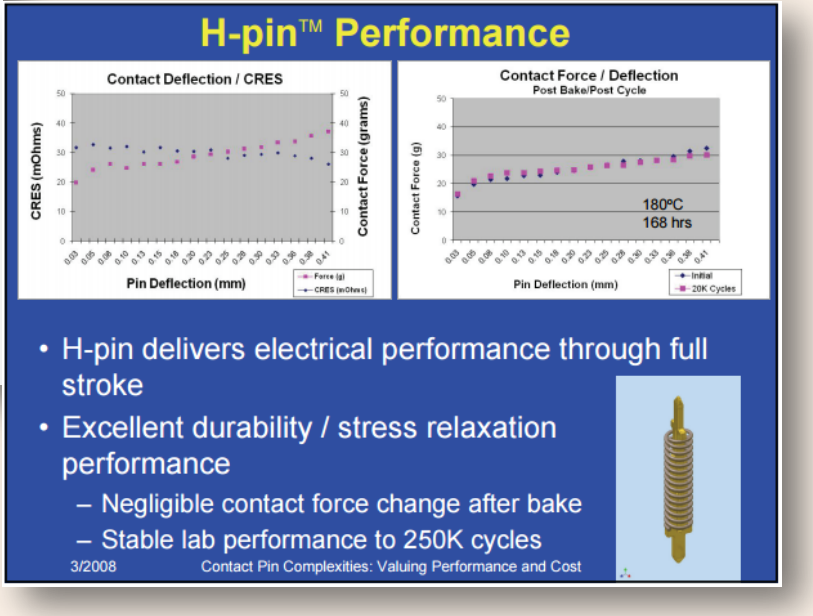
- Gemini
- Performance





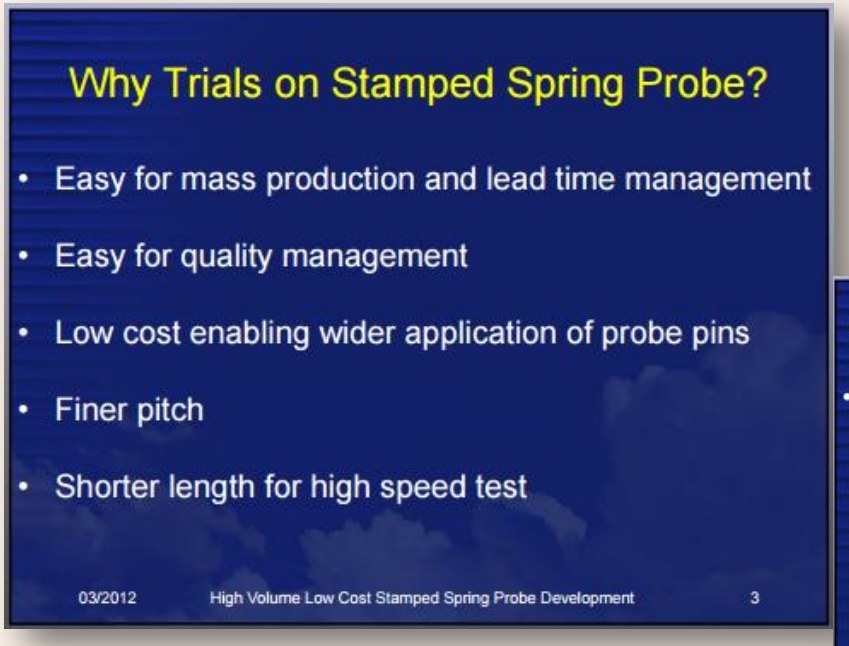
BiTS Workshop 2008

- H-Pin
- Performance and Cost



BiTS Workshop 2012

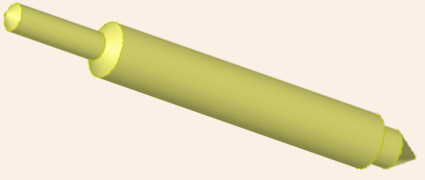
- Stamped Probe
- High Volume



Flat Probes

- Many Flat probe options available today
- Are they a fad or do they truly add value?

- First lets look at what impacts probe performance
- Then we'll look at specific radial and flat probe characteristics



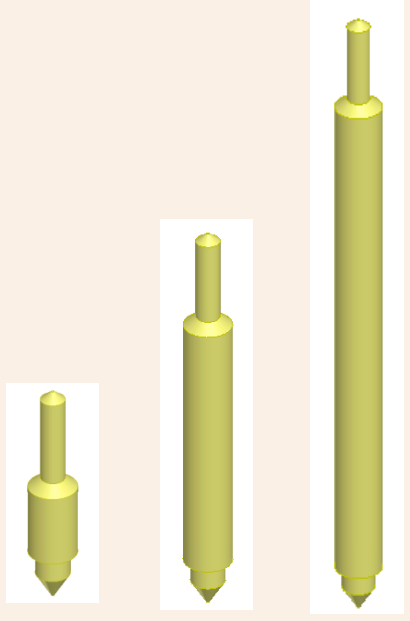
VS.

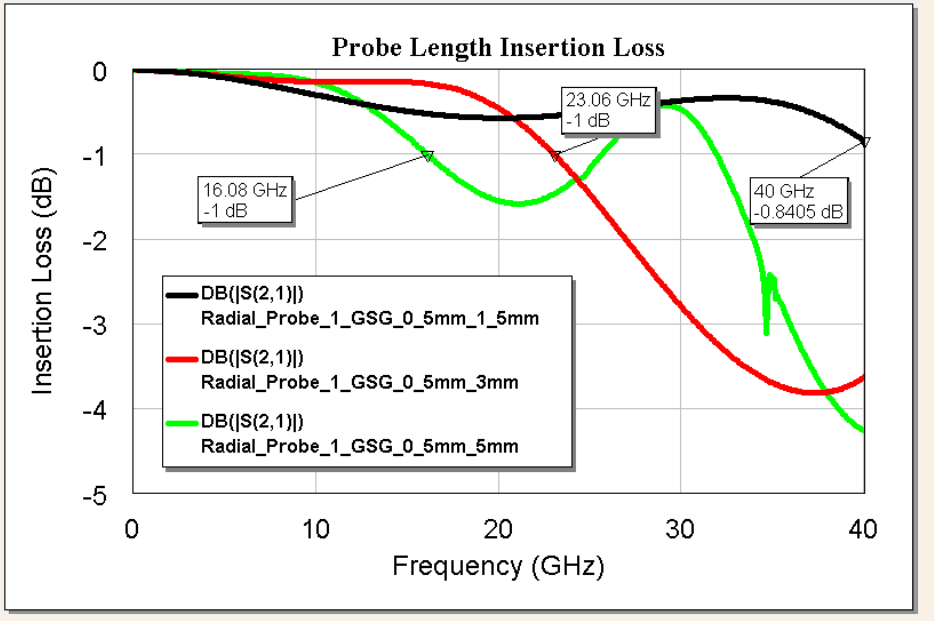
Factors Affecting Spring Probe RF Performance

- Length (Major)
- Cross section (Major)
- Material (Minor)
- Tip design (Minor)
- Force (Minor)

Factors Affecting Probe RF Performance

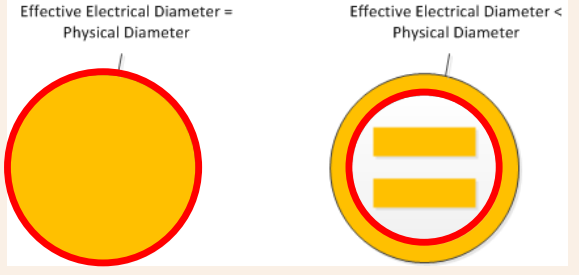
- Length of probe
  - Inverse relationship to bandwidth

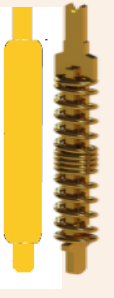


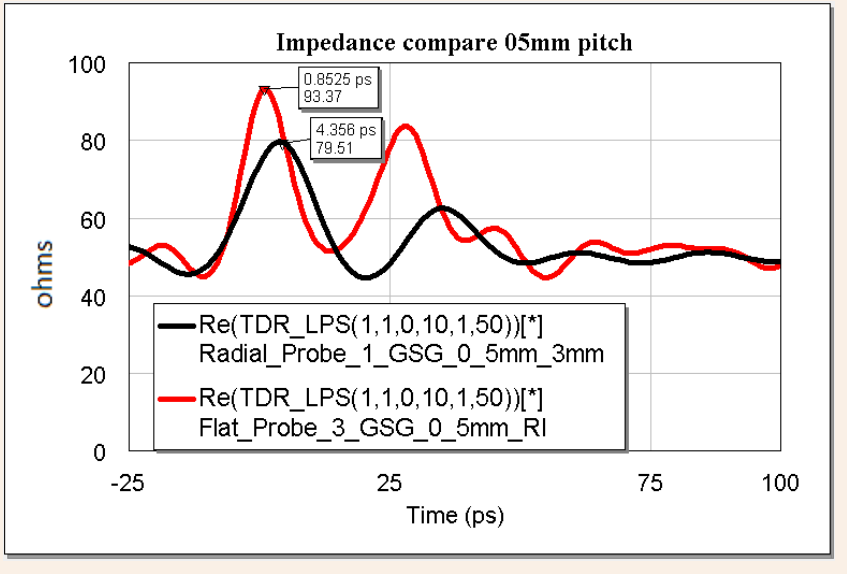


Factors Affecting Probe Performance

- Diameter of probe
  - At native pitches GSG of Radial probes is near 50 Ohms
  - Flat probes have smaller effective diameter than radial probes
  - Flat probes have higher impedance than Radial Probes of the same diameter

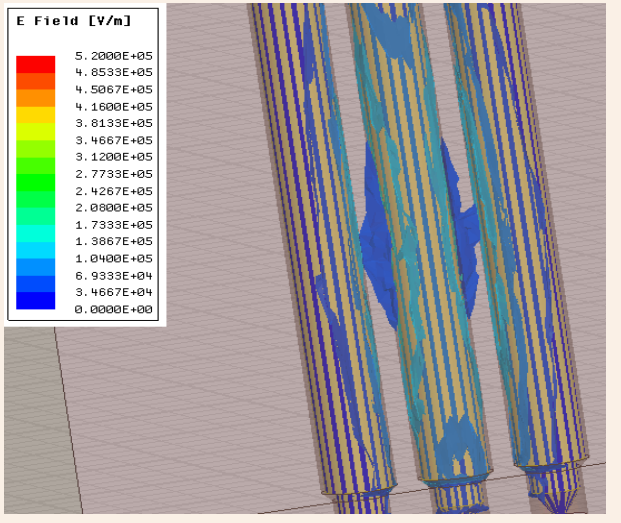


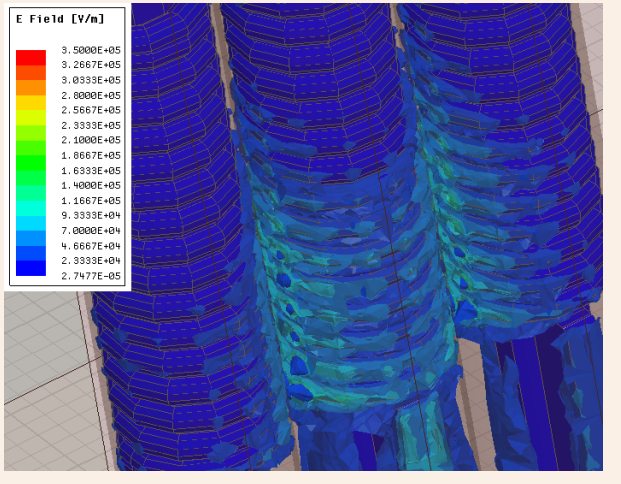




RF Factors - Skin Effect

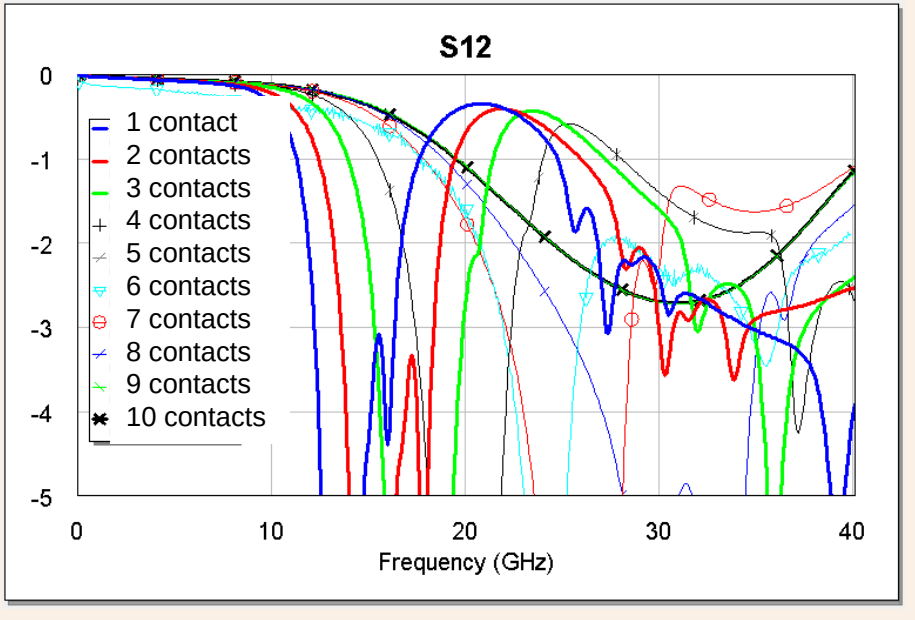
- Skin effect concentrates current on surface nearest return path
  - Radial
    - Round
    - Solid Surface
    - Simple electrical model
  - Flat
    - External Spring
    - Complex electrical model
    - Smaller effective diameter

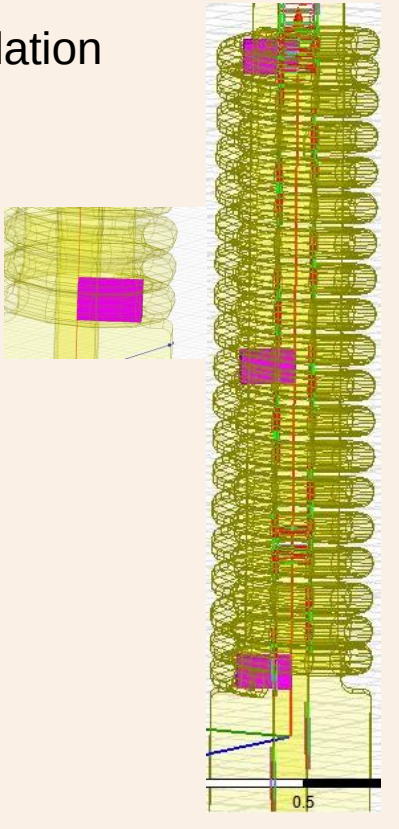




Factors Affecting Flat Probe RF Performance

- **Must short the spring** to ensure consistent RF performance
- More windings shorted = better performance
- Minimum 3 contacts required for good RF correlation

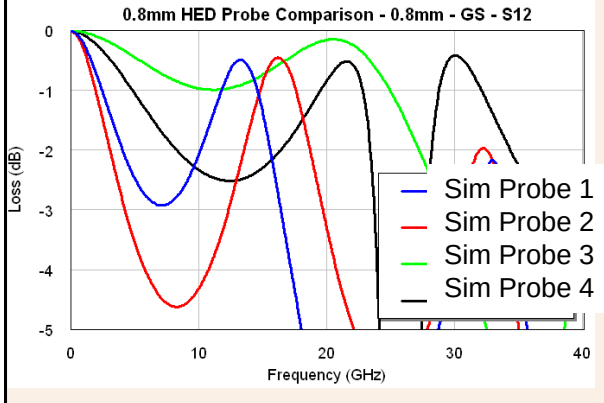


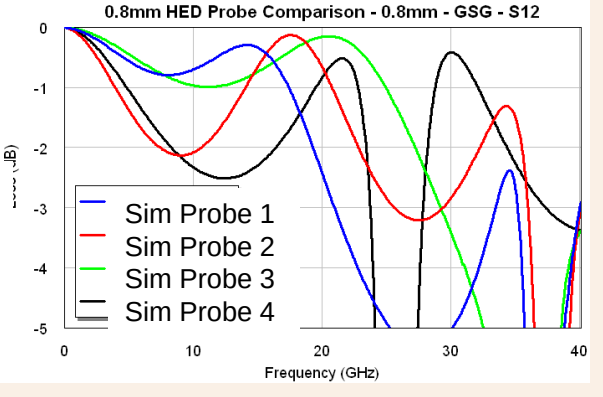


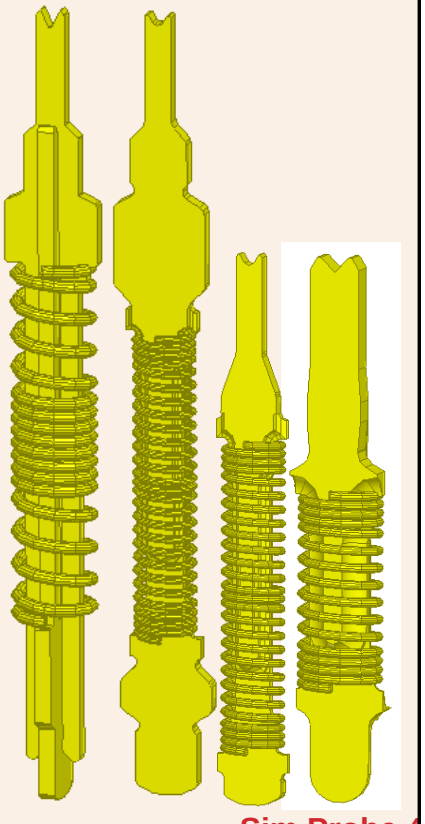
Various Flat Probe Simulation Results

- Results show very different performance depending on cross section and length

	Sim Probe 1	Sim Probe 2	Sim Probe 3	Sim Probe 4
S12 GS (-1dB)	2.4 GHz	2.0 GHz	>40 GHz	2.4 GHz
S12 GSG (-1dB)	17.4 GHz	4.2 GHz	25.0 GHz	4.9 GHz







Sim Probe 2 Sim Probe 4
Sim Probe 1 Sim Probe 3

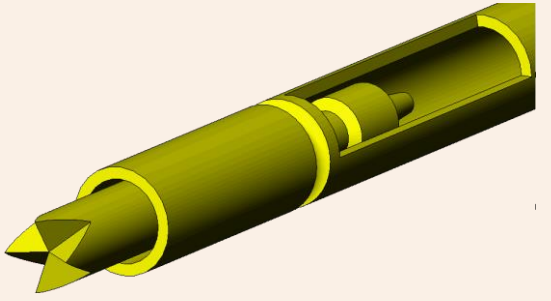
- Flat probe RF performance is impacted by multiple design variables

Factors Affecting Contact Resistance Stability

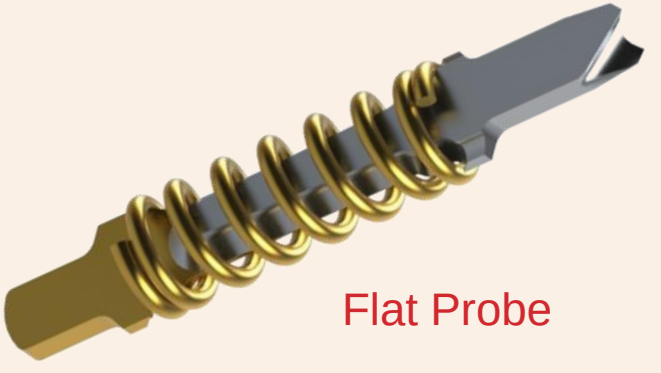
- Length (Minor)
- Cross section (Major)
- Material (Minor)
- Tip design (Major)
- Force (Major)

Factors impacting Contact Resistance

- Radial
  - Internal surfaces require plating specification
  - Make/Break Barrel plating process causes layering
  - Barrel plunger contact 1 or 2 points
- Flat
  - Flat external plating surfaces
  - Large contact surface between top and bottom plungers
  - Improved biasing



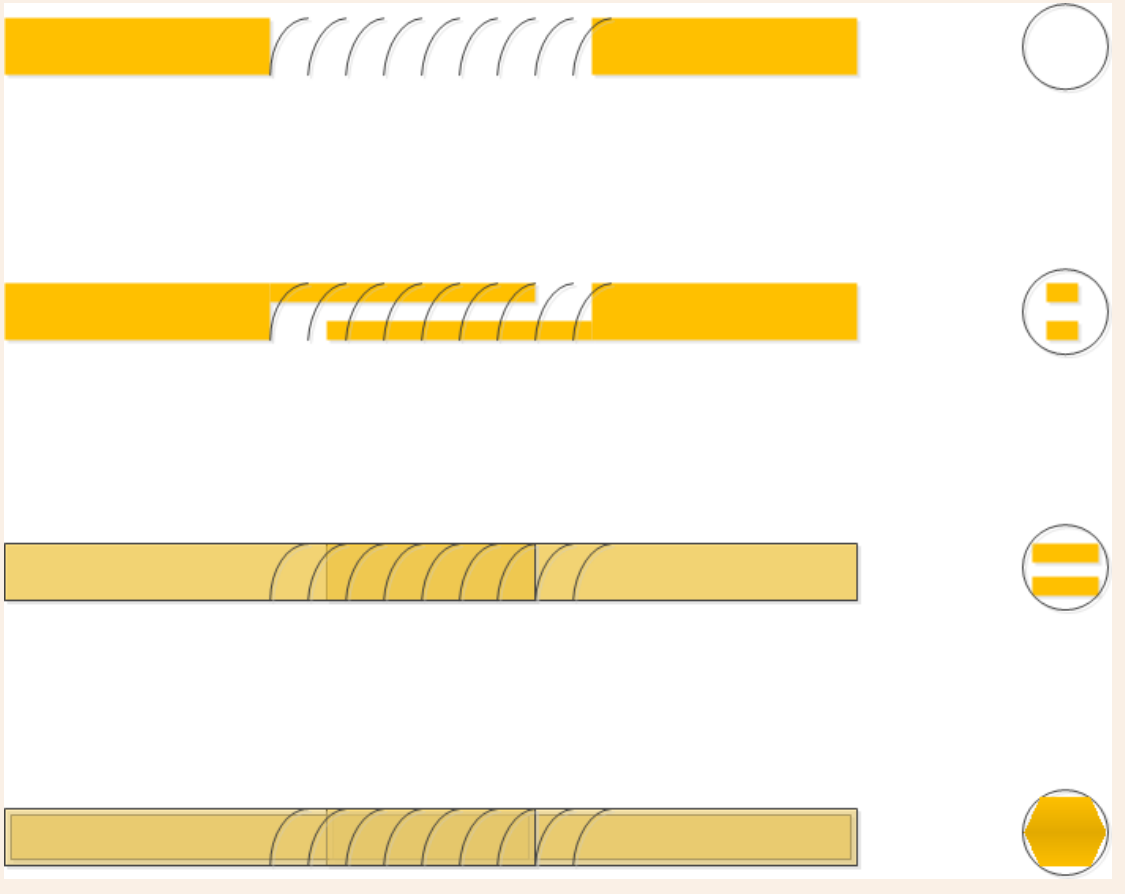
Radial Probe



Flat Probe

Flat Probe Cross-Section Design

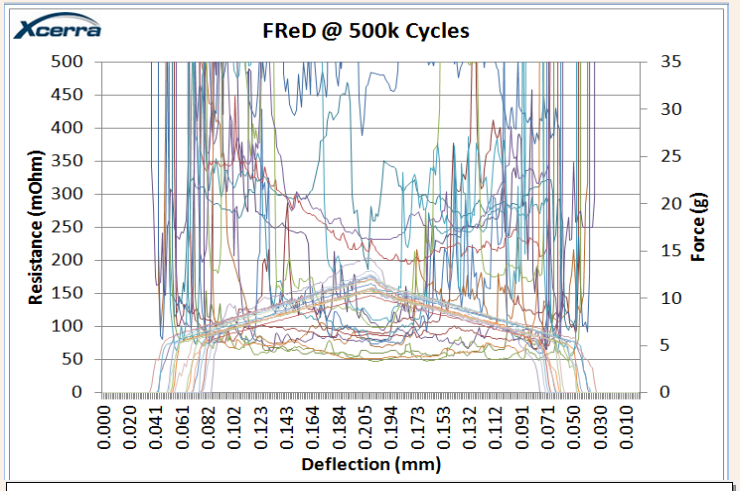
- Worst
- Bad
- Good
- Best

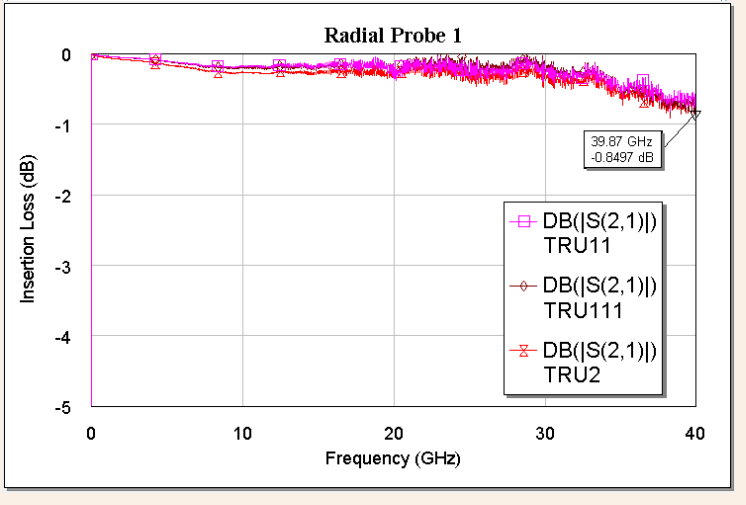


Radial Probe 1

- Short Single ended spring probe
- Consistent high bandwidth
- Low Force
- Contact resistance instability

Probe Characteristics	
Pitch	0.5mm
Diameter	0.38mm
Length	1.7mm
Force	15g

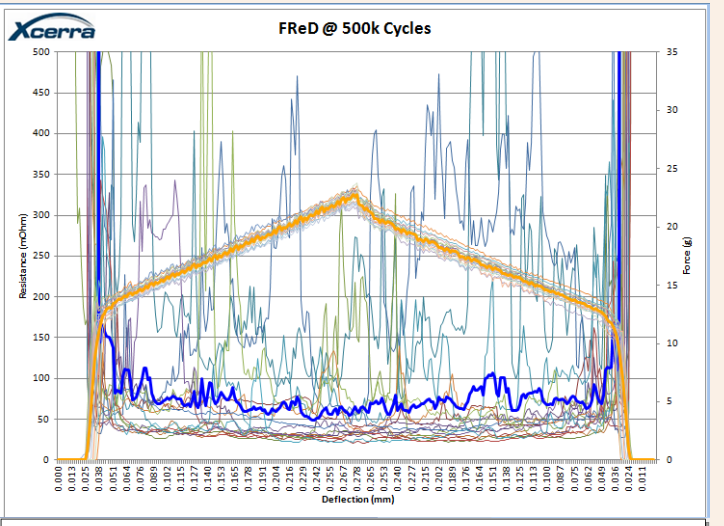


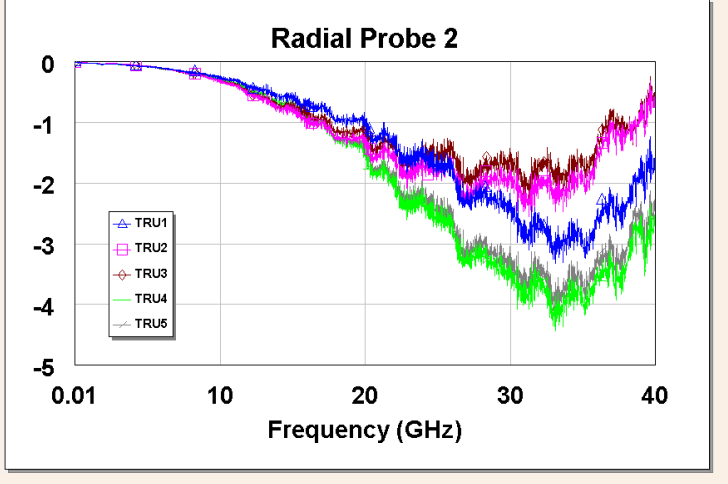


Radial Probe 2

- Standard single ended spring probe
- Average length
- Consistent bandwidth to 20GHz
- Contact resistance instability

Probe Characteristics	
Pitch	0.5mm
Diameter	0.3mm
Length	3mm
Force	30g

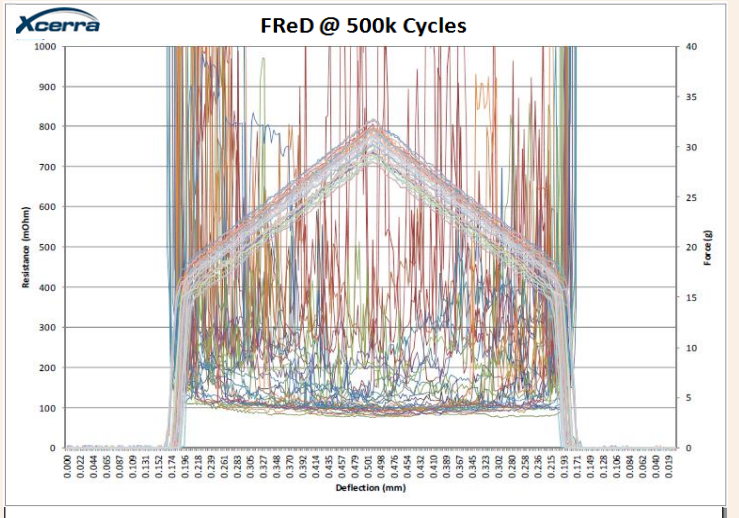


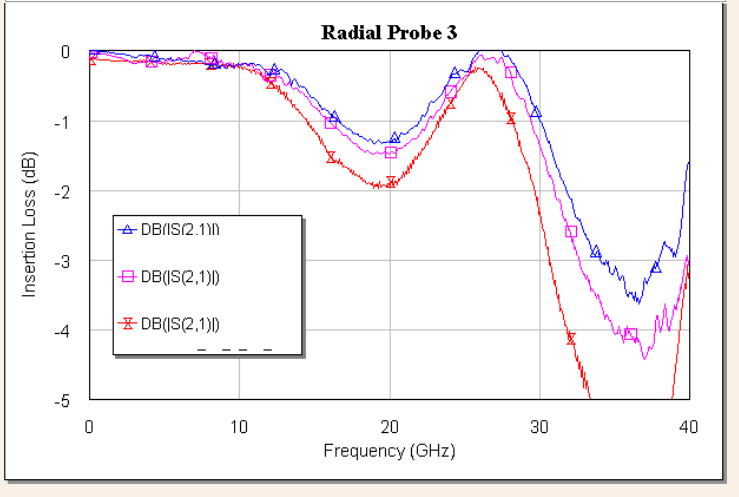


Radial Probe 3

- Long double ended spring probe
- High Impedance mismatch
- 15Ghz Bandwidth
- Contact resistance instability
- No internal bias

Probe Characteristics	
Pitch	0.5mm
Diameter	0.3mm
Length	6mm
Force	32g

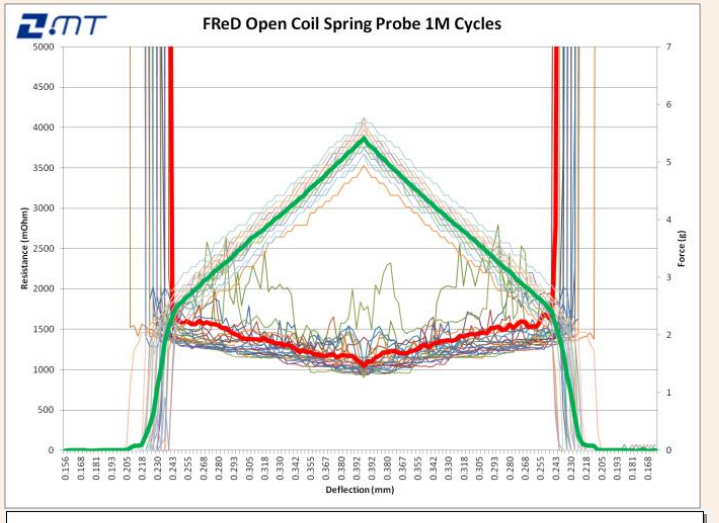


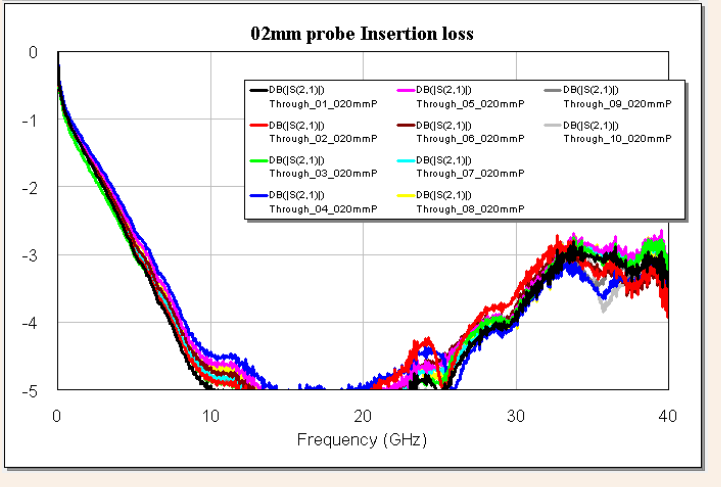


Flat Probe 1

- Long Flat Probe for WLCSP applications
- Spring is DC and RF Path
- Poor RF performance of spring inductor

Probe Characteristics	
Pitch	0.2mm
Diameter	0.1mm
Length	7mm
Force	6g

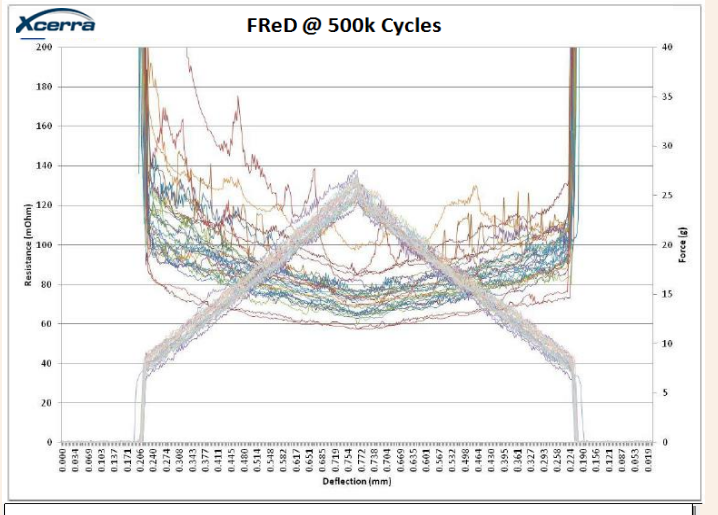


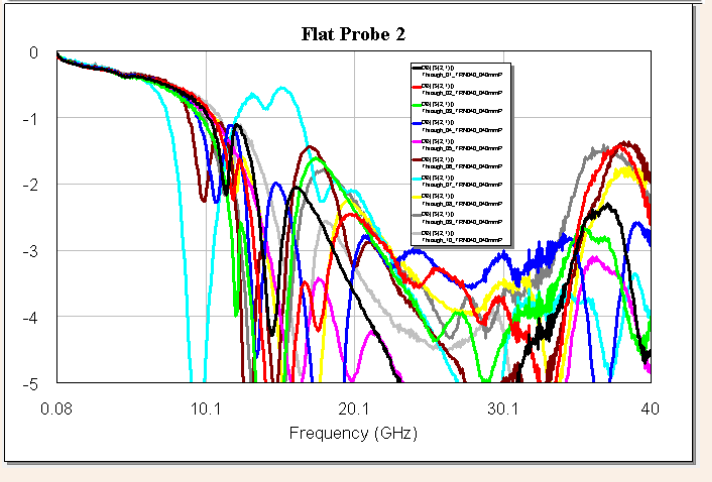


Flat Probe 2

- Standard double ended probe length
- Small Plungers
- Inconsistent spring contact causes resonance above 7GHz

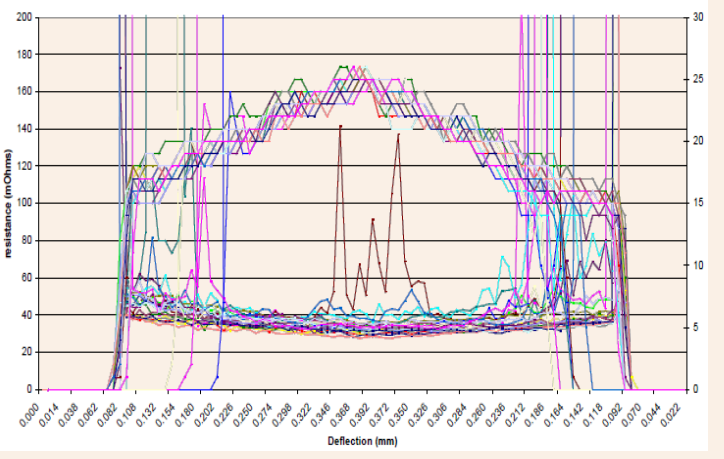
Probe Characteristics	
Pitch	0.4mm
Diameter	0.33mm
Length	5mm
Force	25g



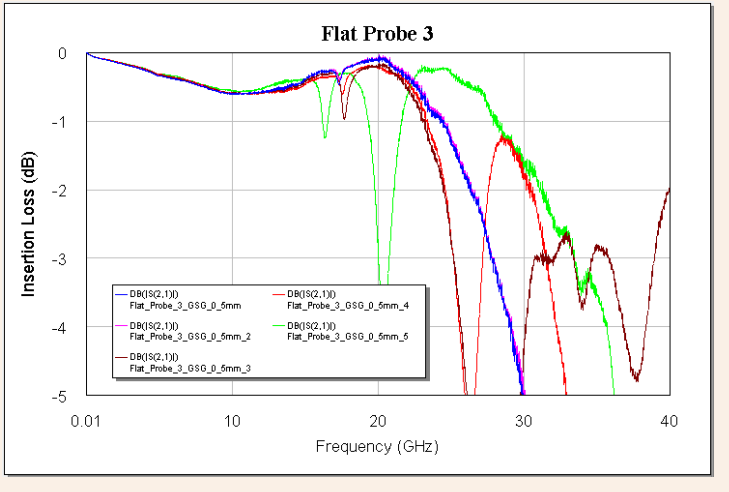


Flat Probe 3

- Standard single ended probe length
- Consistent resistance
- Minor spring resonance @17Ghz



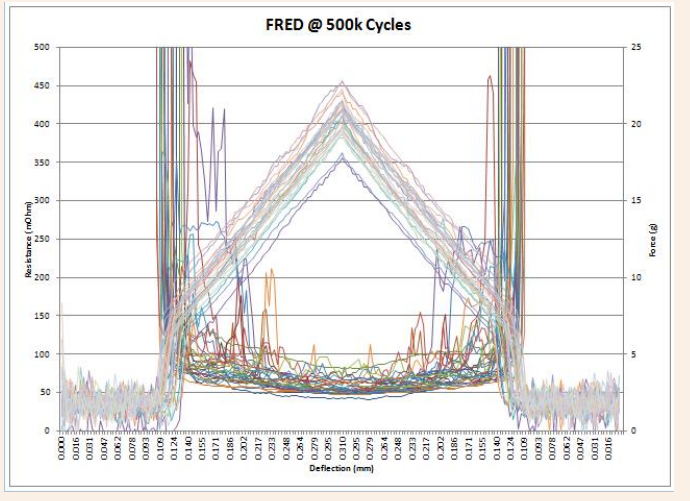
Probe Characteristics	
Pitch	0.5mm
Diameter	0.3mm
Length	3mm
Force	25g

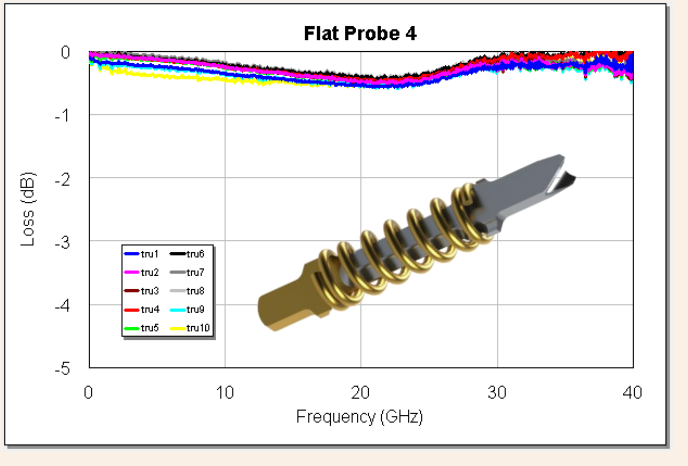


Flat Probe 4 - ACE

- Short Probe
- Large Plungers
- Consistent spring contact – no resonances
- Consistent and low resistance

Probe Characteristics	
Pitch	0.4mm
Diameter	0.29mm
Length	1.5mm
Force	17g

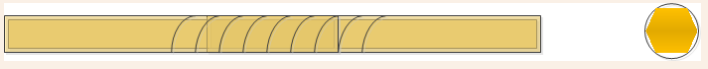


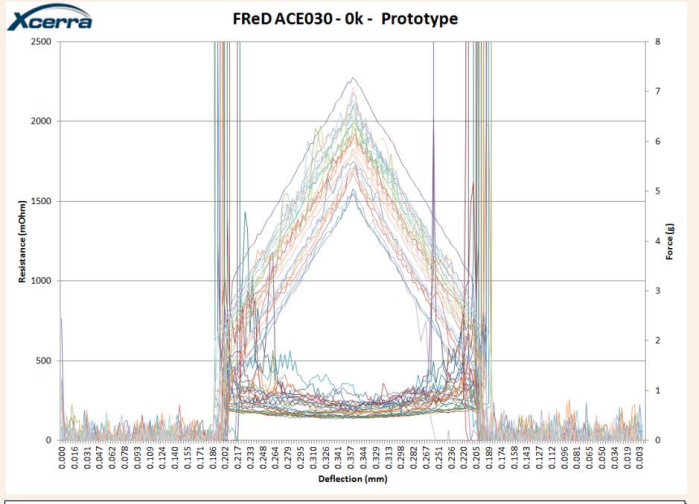


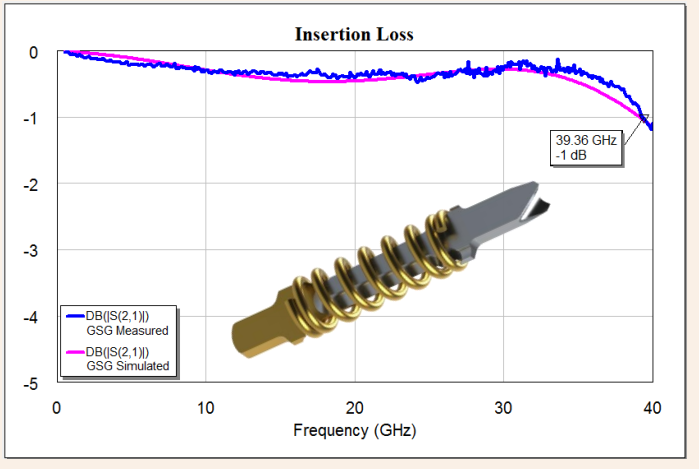
Flat Probe 5 - ACE

- Short Probe
- Large Plungers
- Consistent spring contact – no resonances
- Consistent and low resistance
- Still in development stage, need to improve Mechanical stability

Probe Characteristics	
Pitch	0.3mm
Diameter	0.29mm
Length	1.5mm
Force	17g

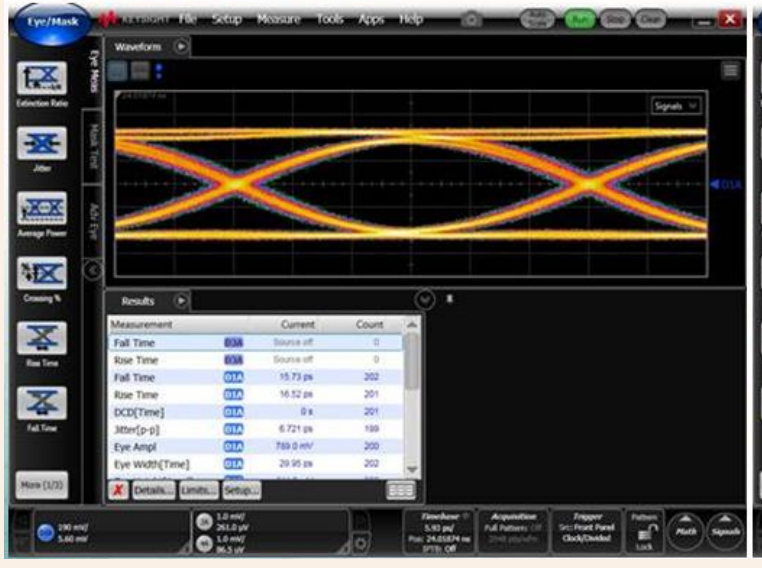




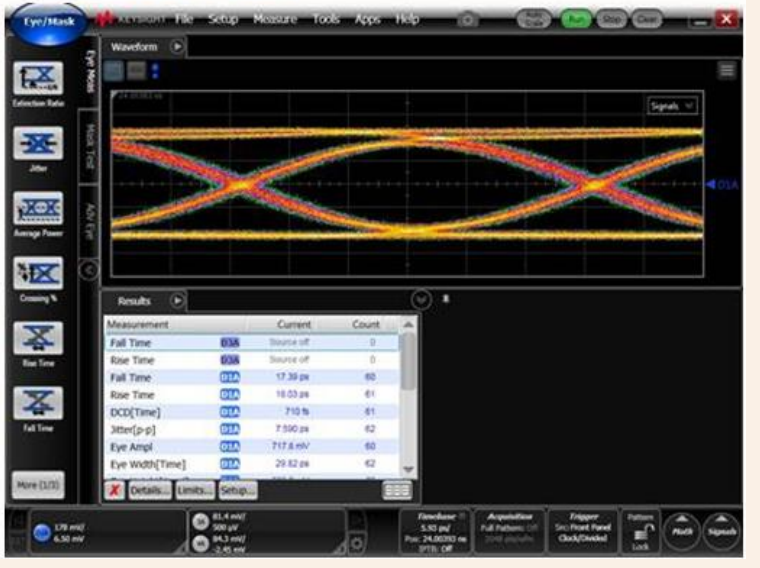


Application Feedback - ACE

Soldered down @ 28G



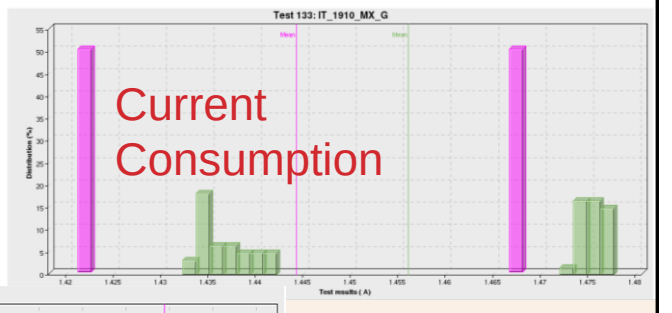
Socketed @ 28G

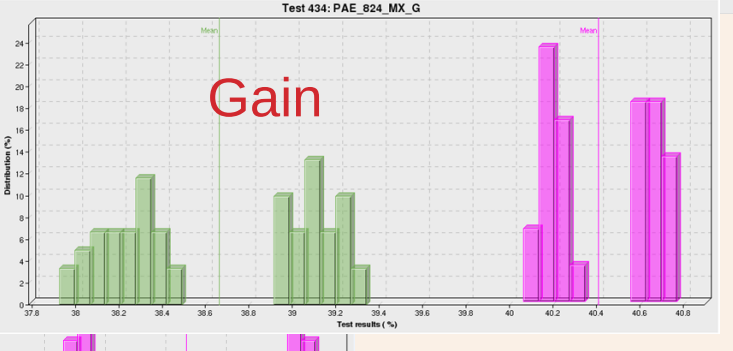


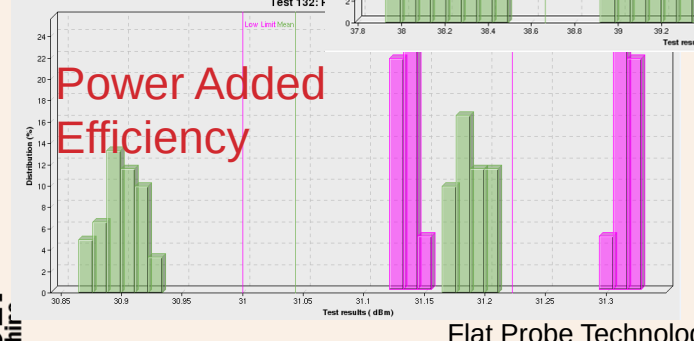
		25.078 Gbps			28.05 Gbps		
Parameters	Units	Solder	Socket	Delta	Solder	Socket	Delta
Tr	pS	15.74	17.54	-1.8	15.73	17.39	-1.7
Tf	pS	16.43	16.05	0.4	16.52	16.05	0.5
Jpp	pS	5.762	7.138	-1.4	6.721	7.59	-0.9
EYE Amp	Vpp	802	734.2	68	789	717.8	71
EYE Width	pS	33.6	33.11	0.5	29.95	29.82	0.1

Customer Feedback - ACE

- Flat has Lower Current Consumption
- Flat Standard Deviation is Less
- Flat results in higher Gain
- Flat adds 2% Power Added Efficiency





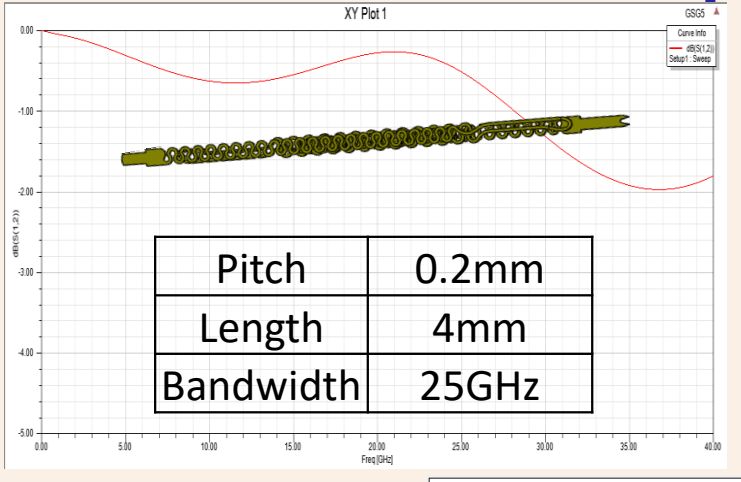


Flat Performance Wins!

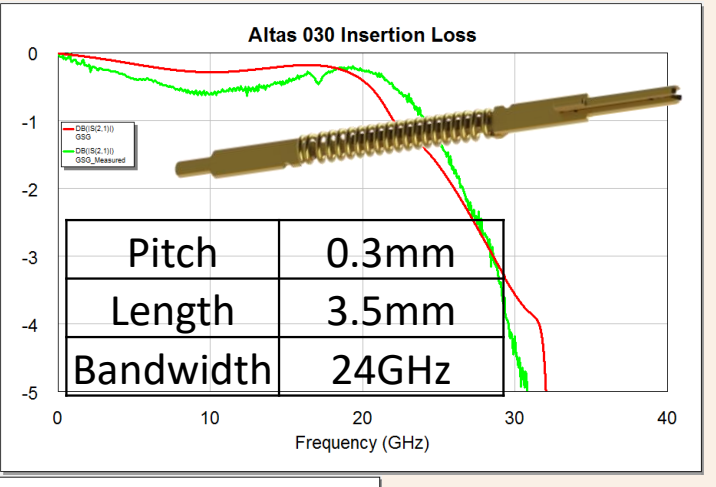
Conclusion

- You can in fact use Flat Probes for RF applications
- Flat Probes offer High Performance and Low Cost of Test
- Flat Probes For RF applications need to be designed and fabricated with care to avoid spring resonances

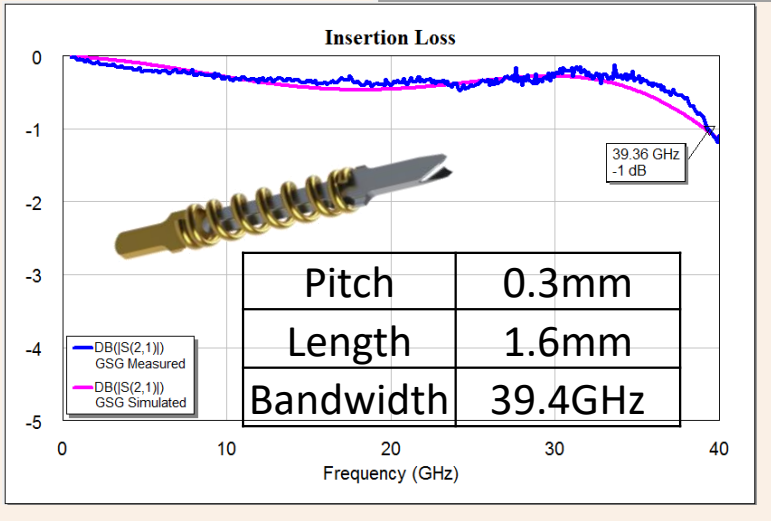
Flat Probe Roadmap: Atlas, ACE, Nexus



Pitch	0.2mm
Length	4mm
Bandwidth	25GHz



Pitch	0.3mm
Length	3.5mm
Bandwidth	24GHz



Pitch	0.3mm
Length	1.6mm
Bandwidth	39.4GHz