
EIGHTEENTH ANNUAL
BiTS
Burn-in & Test Strategies Workshop
March 5 - 8, 2017
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive – Session 8
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Session 8

Hongjun Yao

*Session Chair*

**BiTS Workshop 2017 Schedule**

# Solutions Day

Wednesday March 8 - 10:30 am

## Contact Frequency

**" Small Form Factor Cantilever Concepts for High Performance Analog / RF Applications"**

Gerhard Gschwendtberger – Cohu

**"MRC (MEMS Rubber Contact) Socket Bump Particle Structure & Performance Analysis"**

BoHyun Kim, Dave Oh, Justin Yun - TSE Co., Ltd

**"Flat Probe Technology For High Frequency Test"**

Jason Mroczkowski, Nadia Steckler - Xcerra

BiTS 2017 Burn-in & Test Strategies Workshop

# Flat Probe Technology for RF Test

**Jason Mroczkowski**
**Nadia Steckler**
**Xcerra Corporation**


**BiTS Workshop**
**March 5 - 8, 2017**


# 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

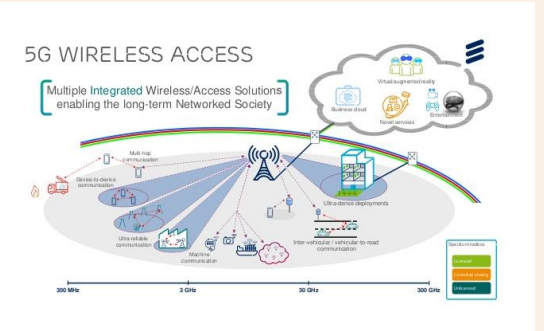
## Applications

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

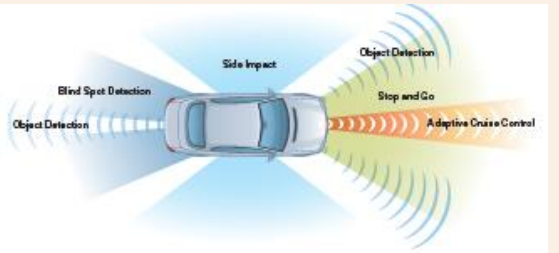
## Devices

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

5G Backhaul




Auto Radar



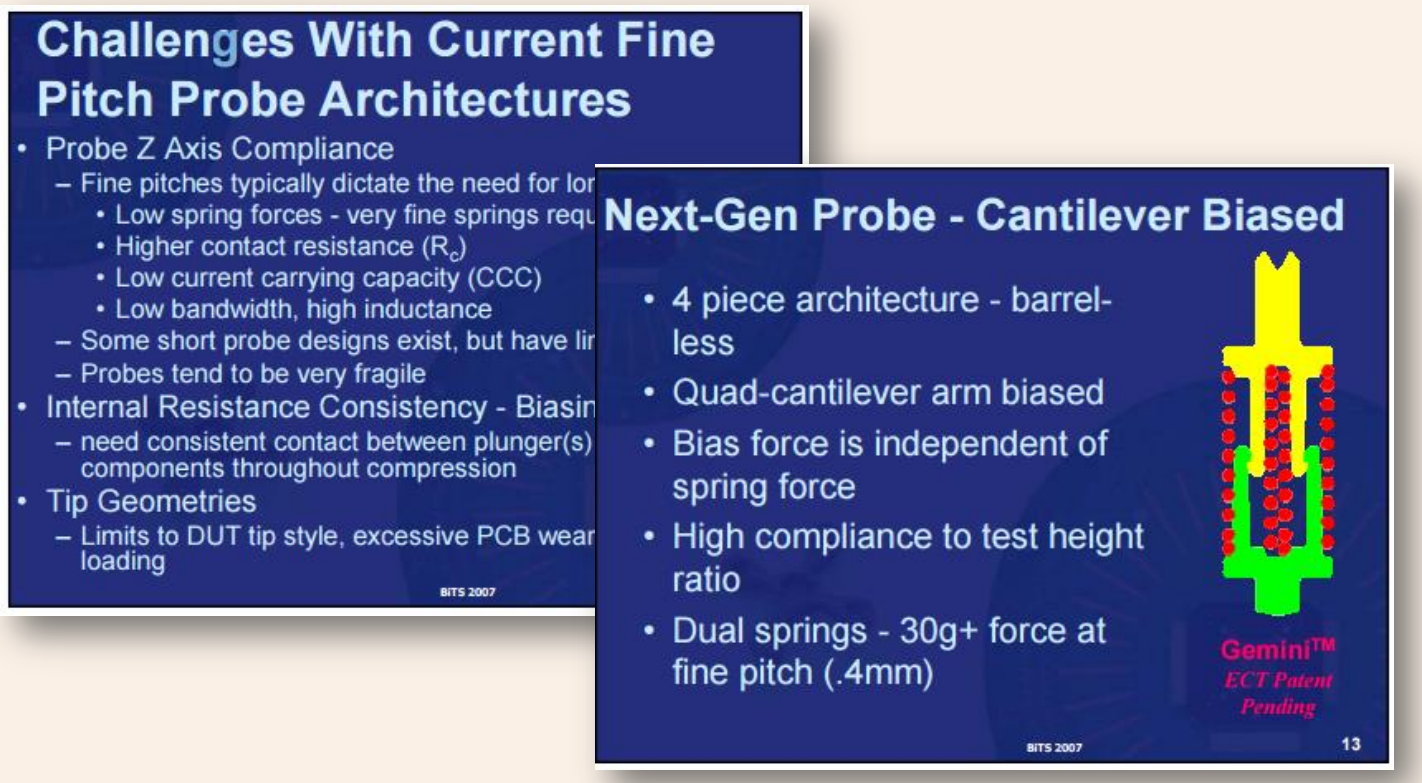

802.11AD (WiGig)

# RF Contact Requirements

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

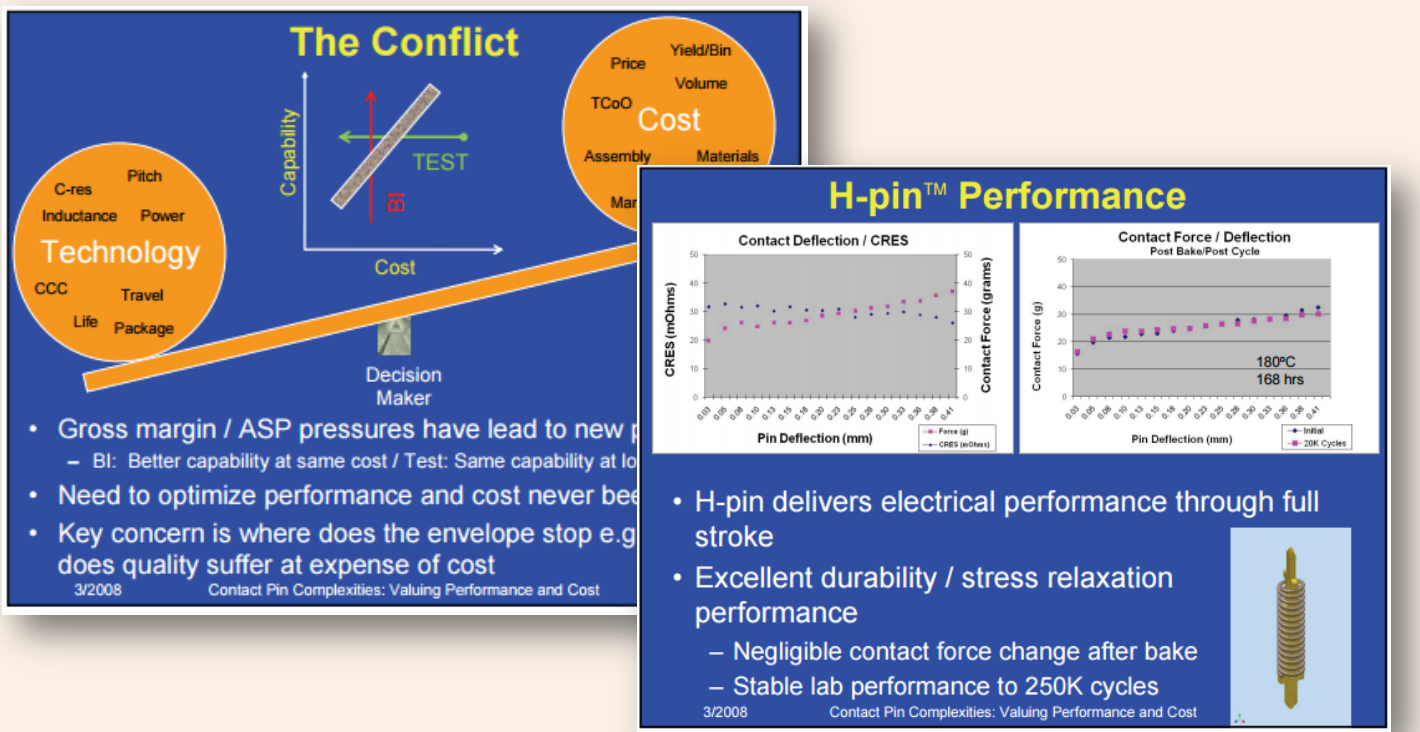
# BiTS Workshop 2007

- Gemini
- Performance



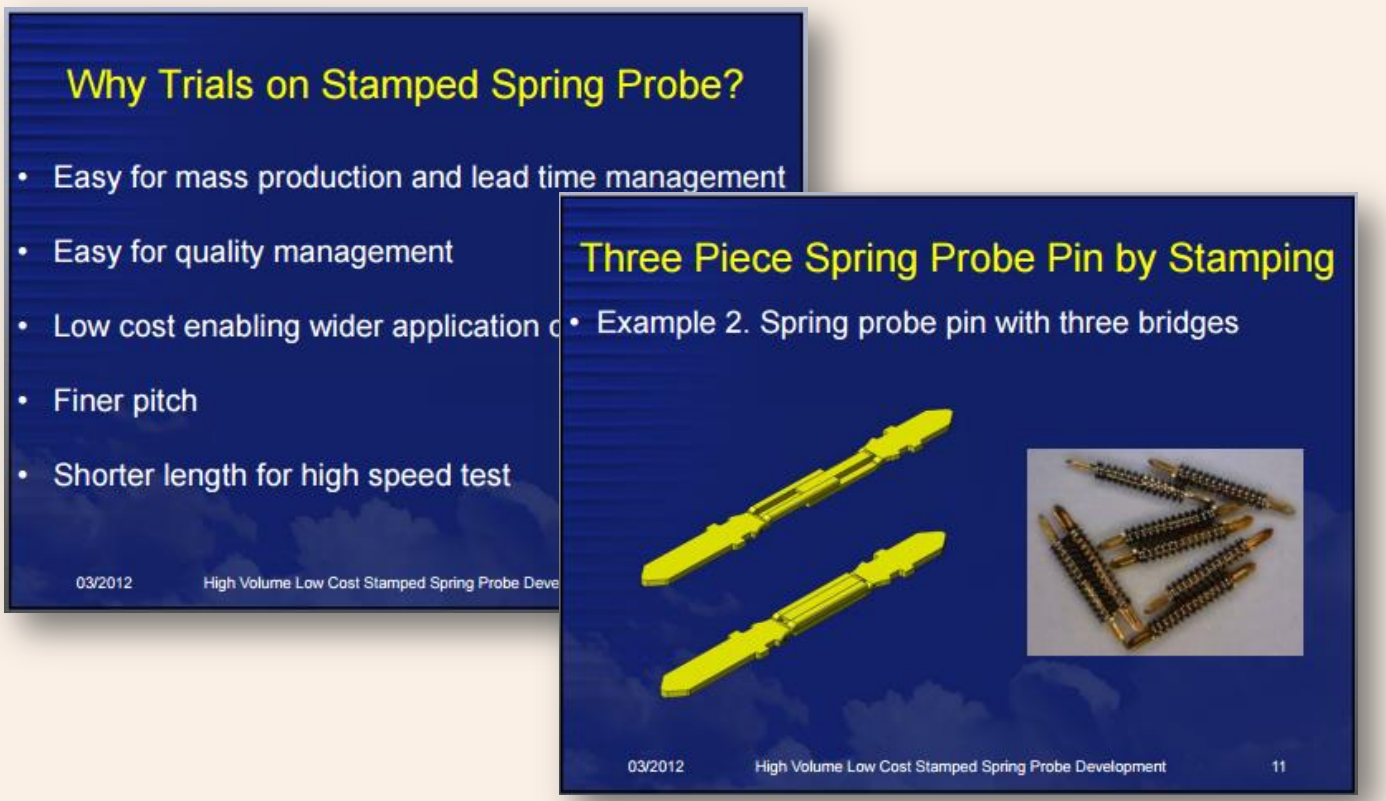
# BiTS Workshop 2008

- H-Pin
- Performance and Cost



# BiTS Workshop 2012

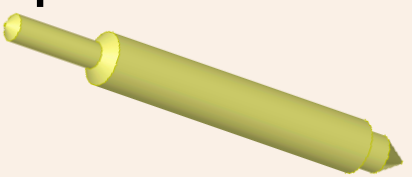
- Stamped Probe
- High Volume



# 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



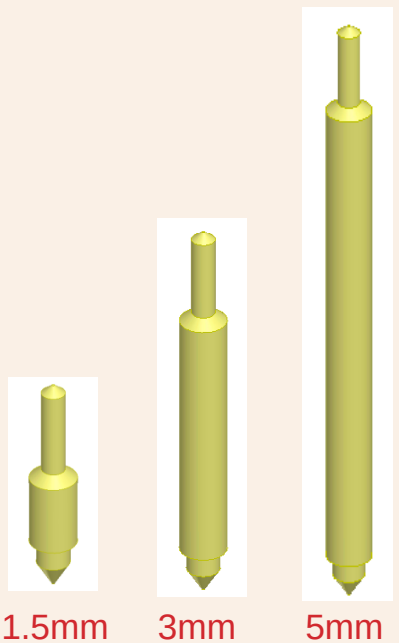
VS.

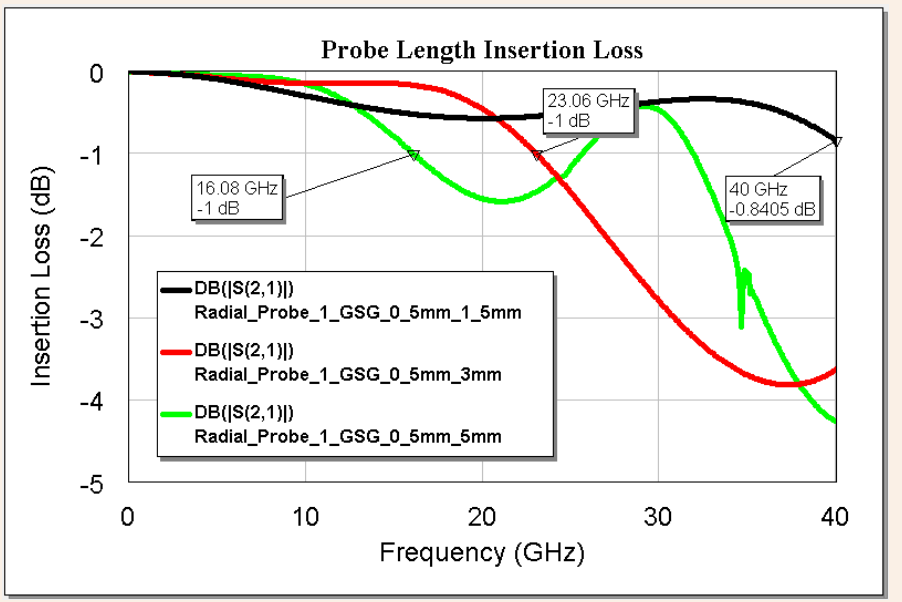
# Factors effecting Spring Probe RF Performance

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

# Factors Effecting Probe RF Performance

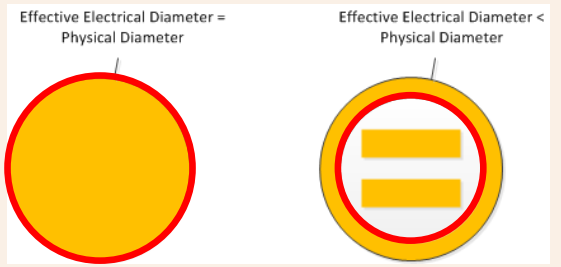
- Length of probe
  - Inverse relationship to bandwidth

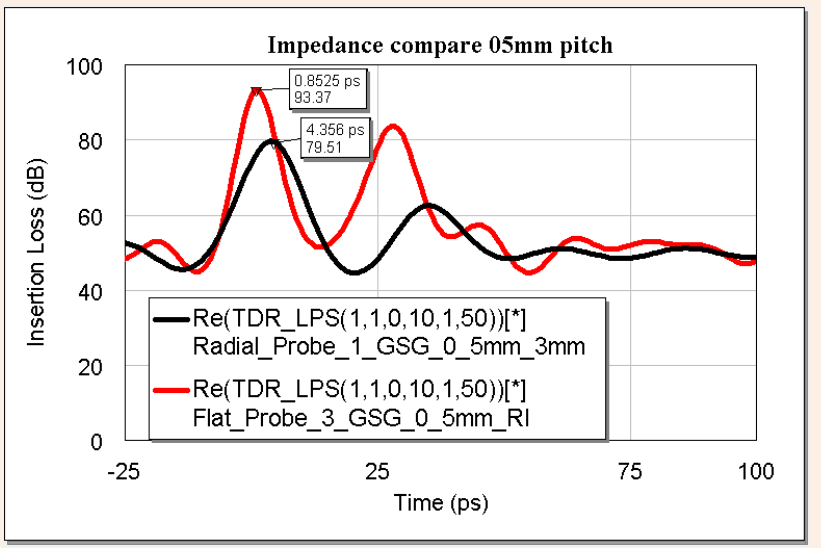


# Factors Effecting Probe Performance

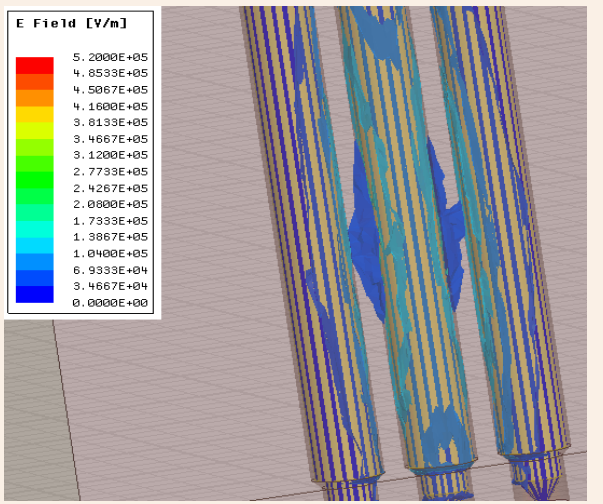
- Diameter of probe
  - At native pitches GSG of Radial probes is near 50 Ohms
  - Flat probes have smaller effective diameter than radial probes
  - Flat probes have higher impedance than Radial Probes of the same diameter

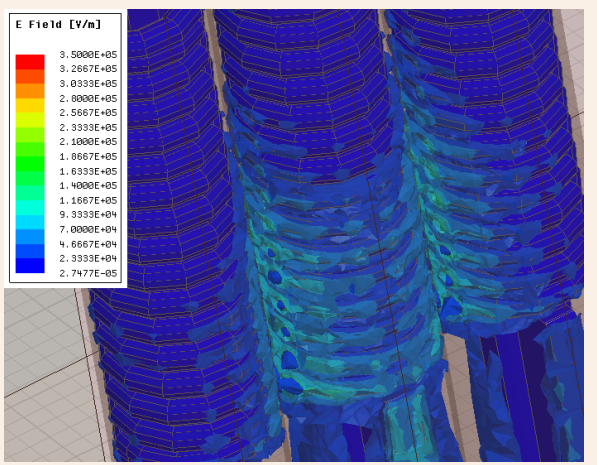


# RF Factors - Skin Effect

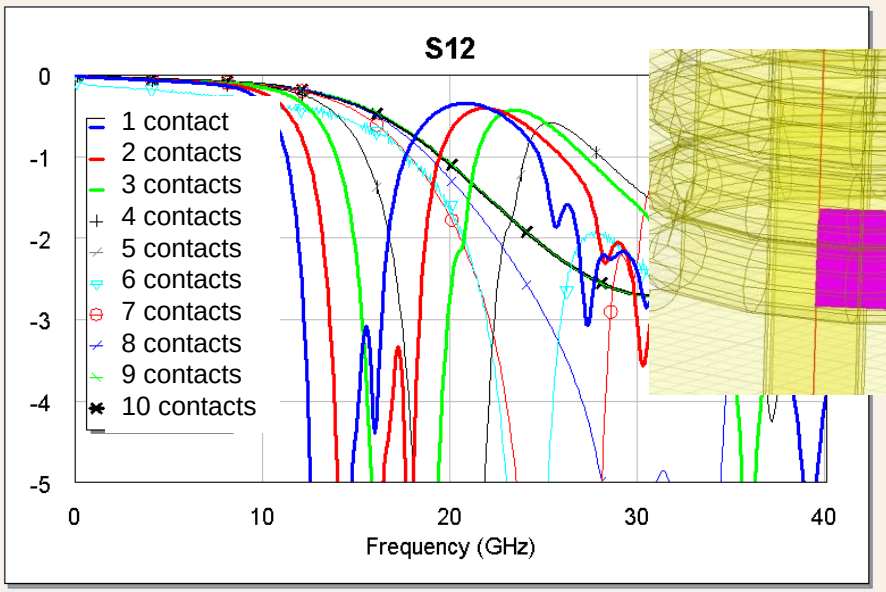
- Skin effect concentrates current on surface nearest return path
  - Radial
    - Round
    - Solid Surface
    - Simple electrical model
  - Flat
    - External Spring
    - Complex electrical model
    - Smaller effective diameter

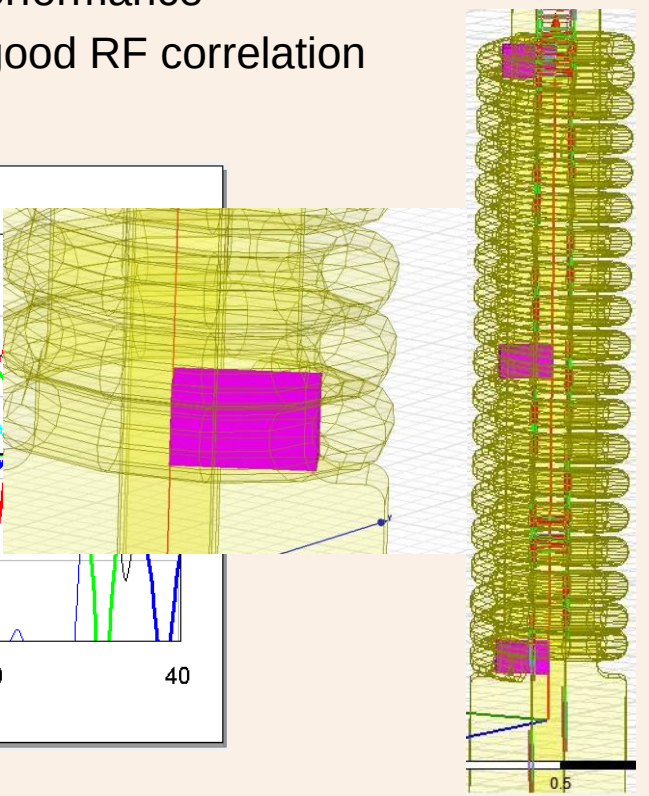


# Factors Effecting Flat Probe RF Performance

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

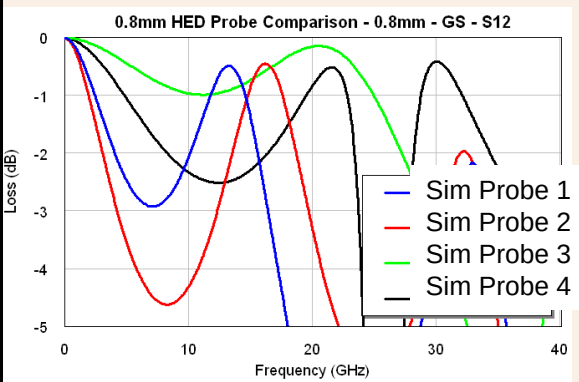


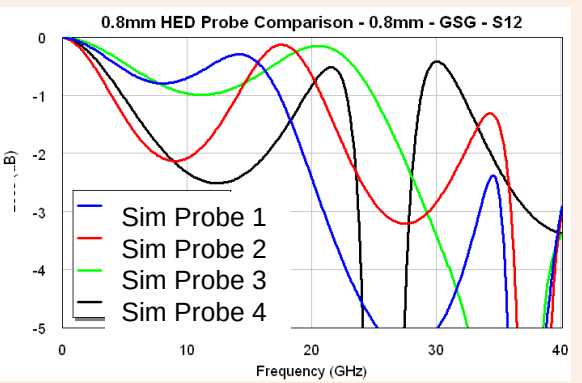



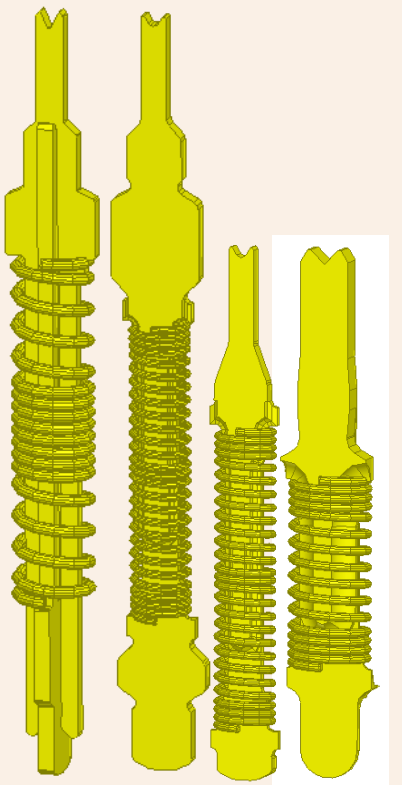
# Various Flat Probe Simulation Results

- 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 |



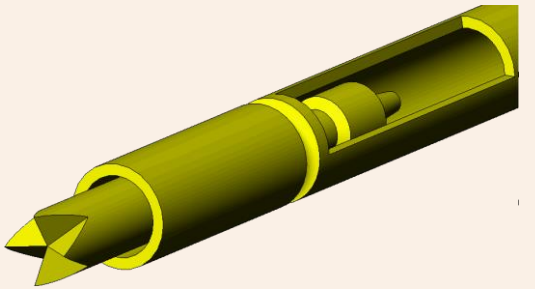

- Flat probe RF performance is impacted by multiple design variables

# Factors effecting Contact Resistance Stability

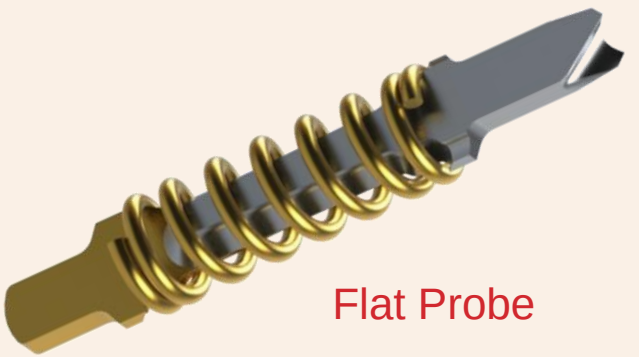
- Length (Minor)
- Cross section (Major)
- Material (Minor)
- Tip design (Major)
- Force (Major)

# 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



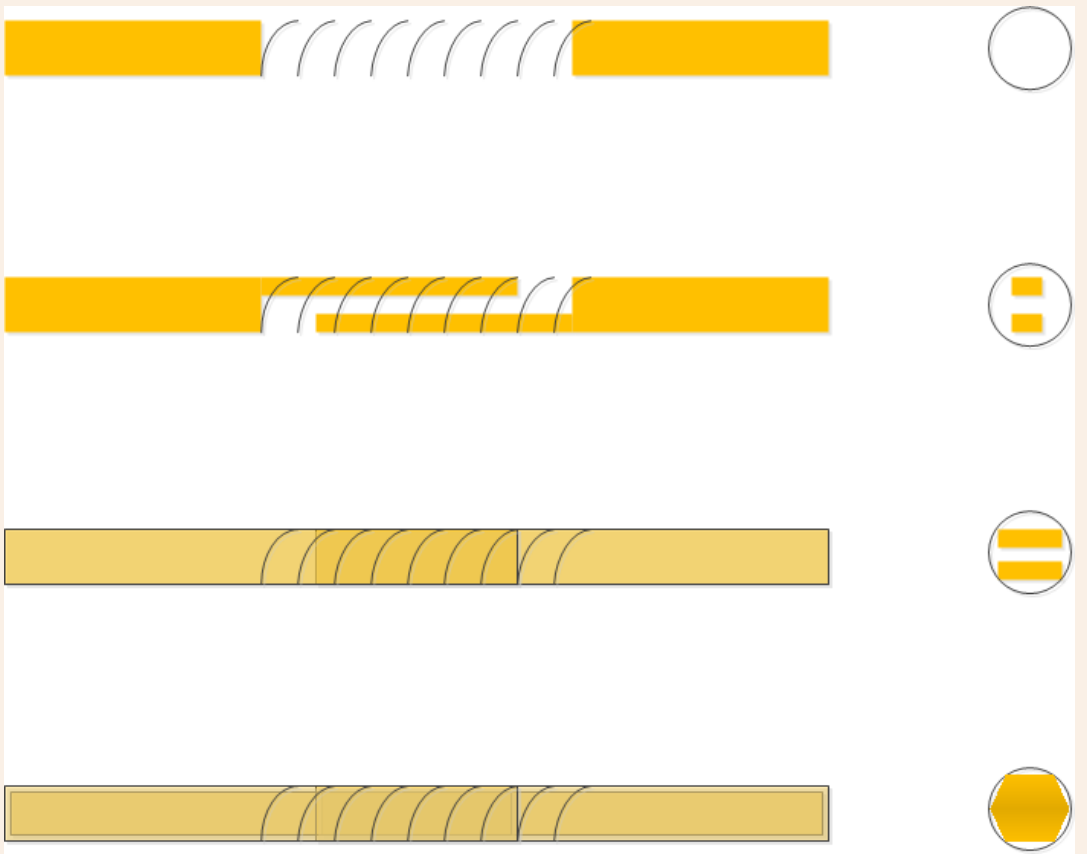
Radial Probe



Flat Probe

# Flat Probe Cross-Section Design

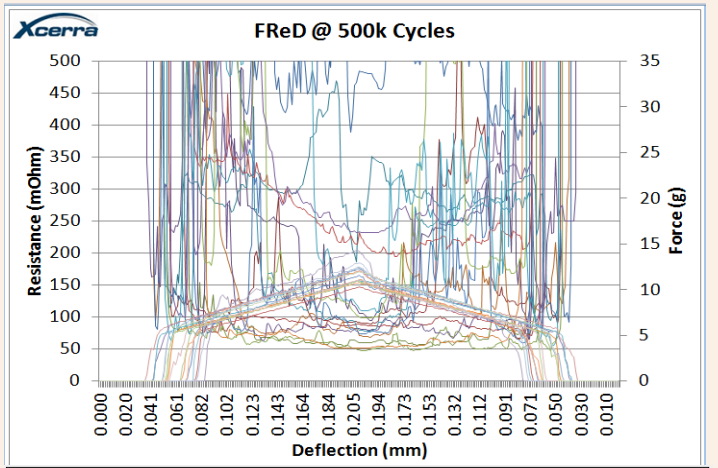
- Worst
- Bad
- Good
- Best

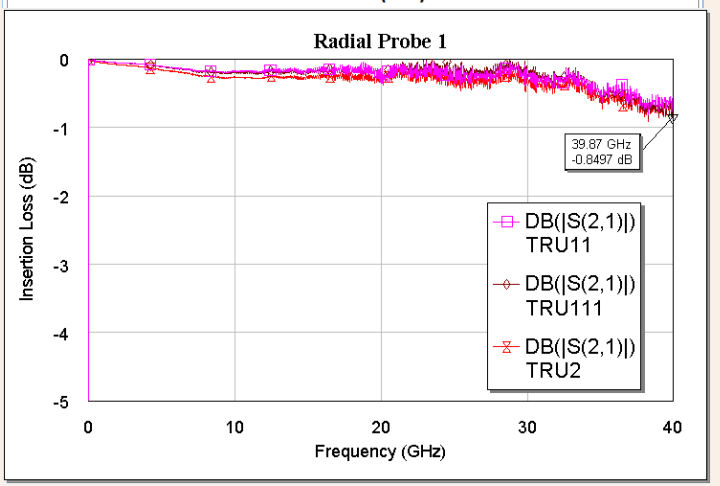


# Radial Probe 1

- 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 |

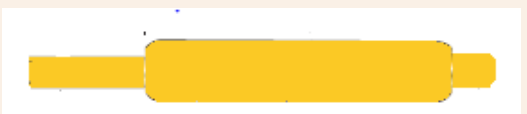


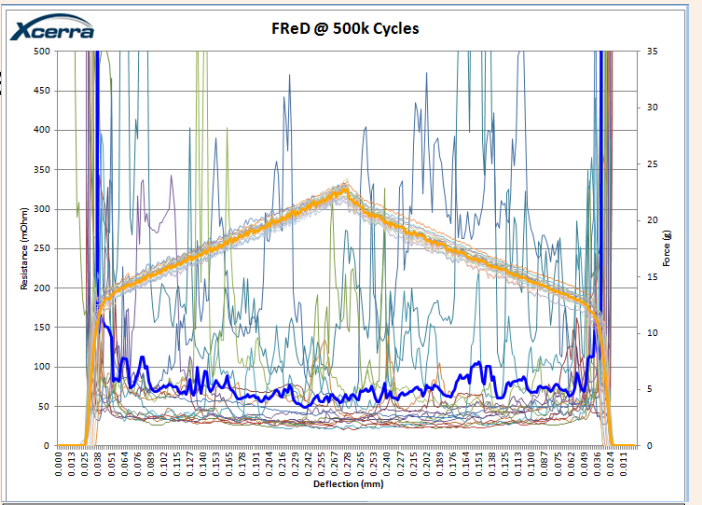



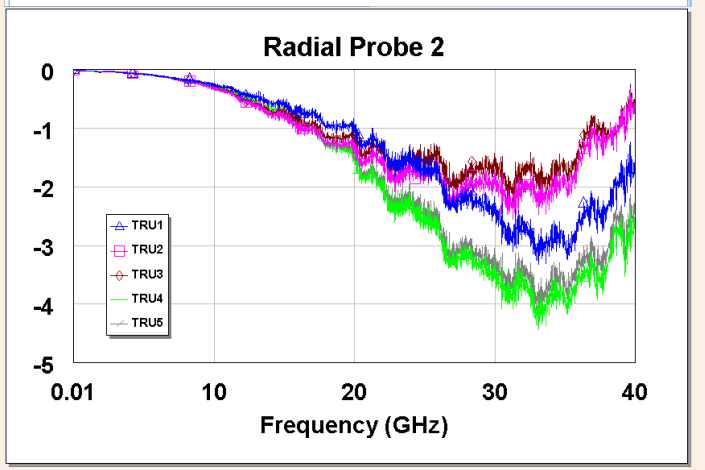
# Radial Probe 2

- 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 |



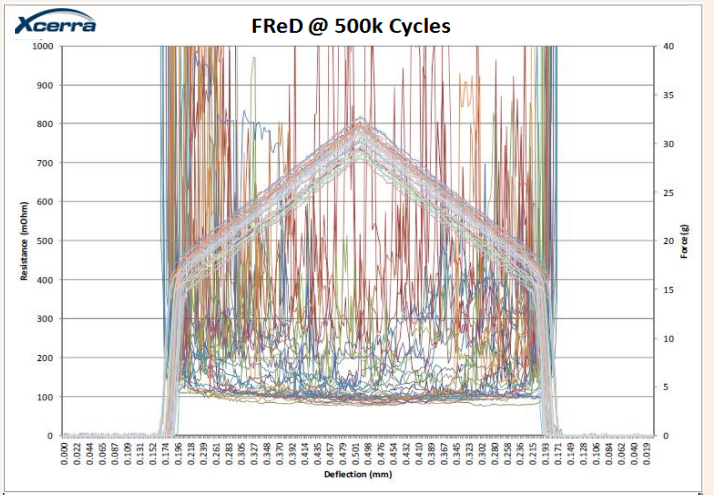


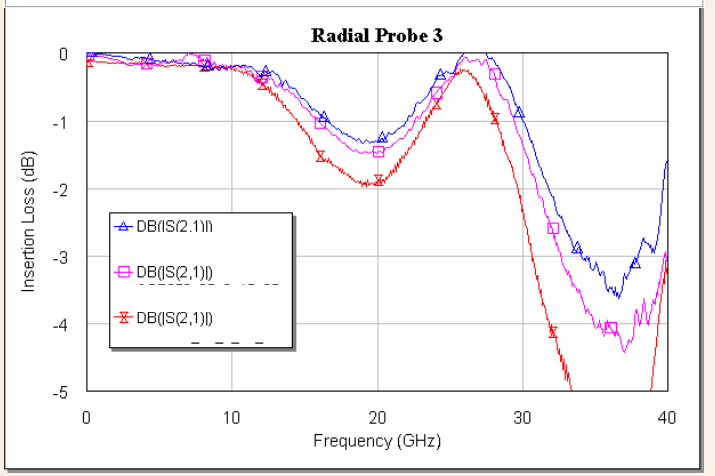



# Radial Probe 3

- 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 |

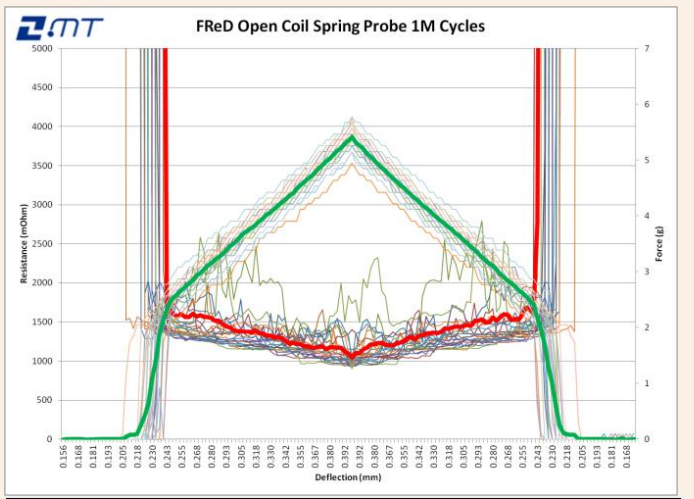


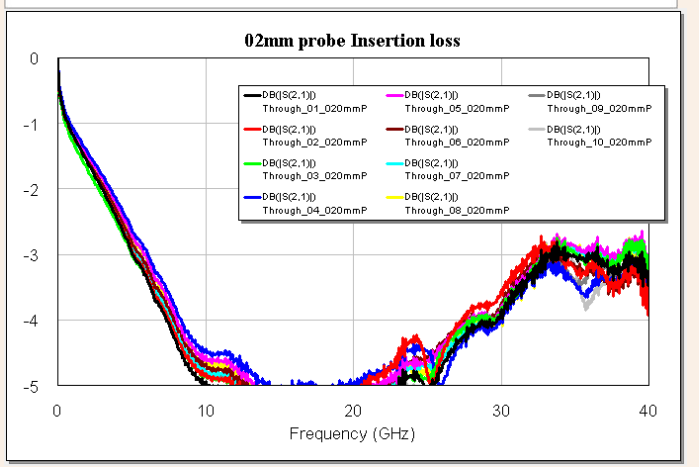



# Flat Probe 1

- 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 |

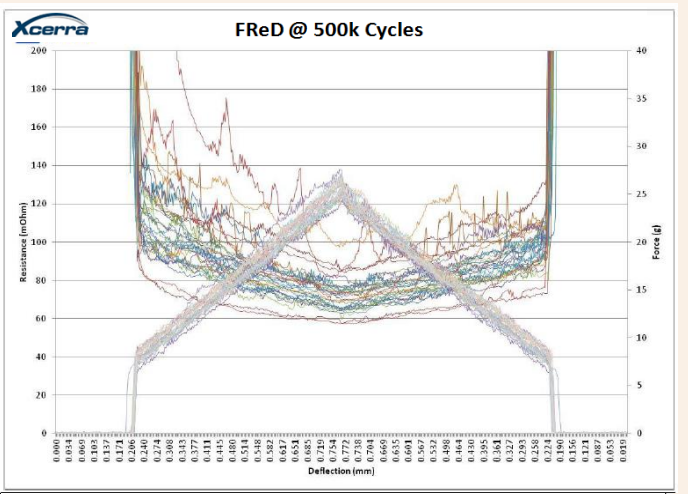


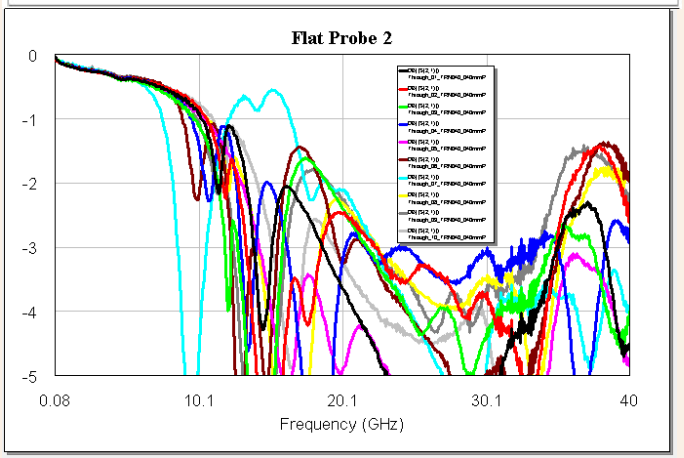



# Flat Probe 2

- 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 |

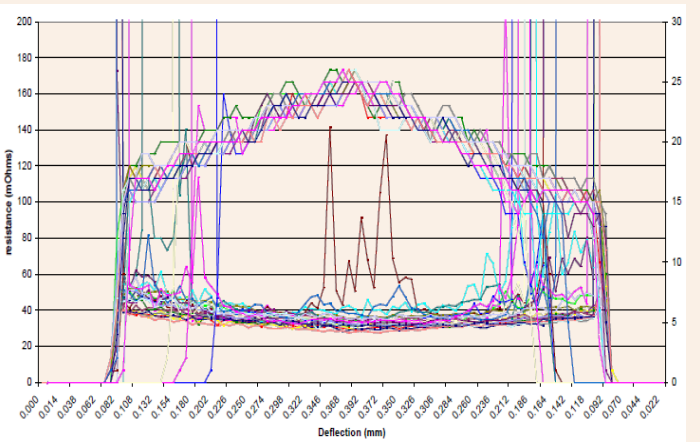


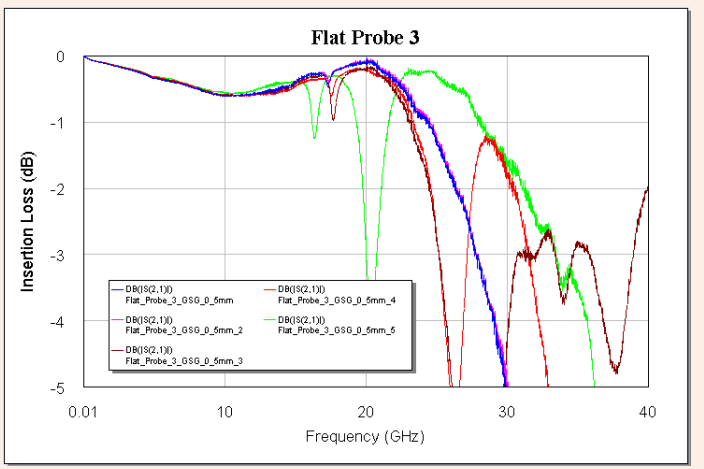



# Flat Probe 3

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

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

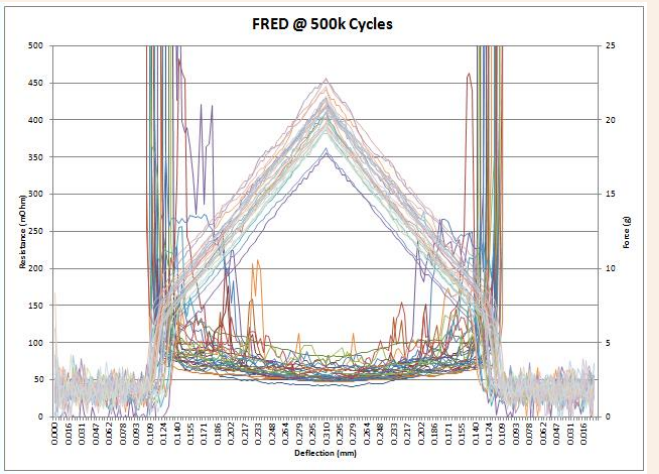


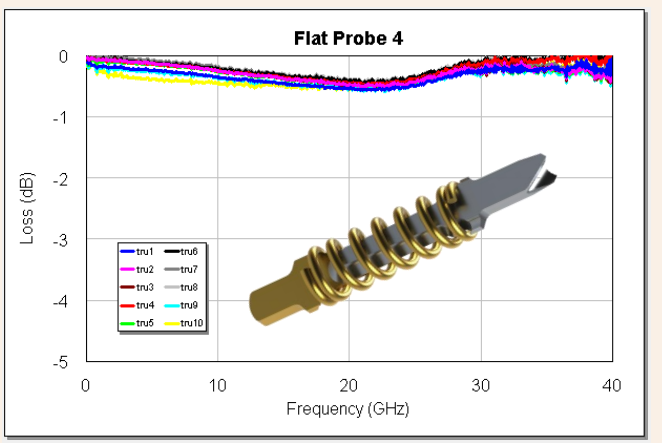



# Flat Probe 4 - ACE

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

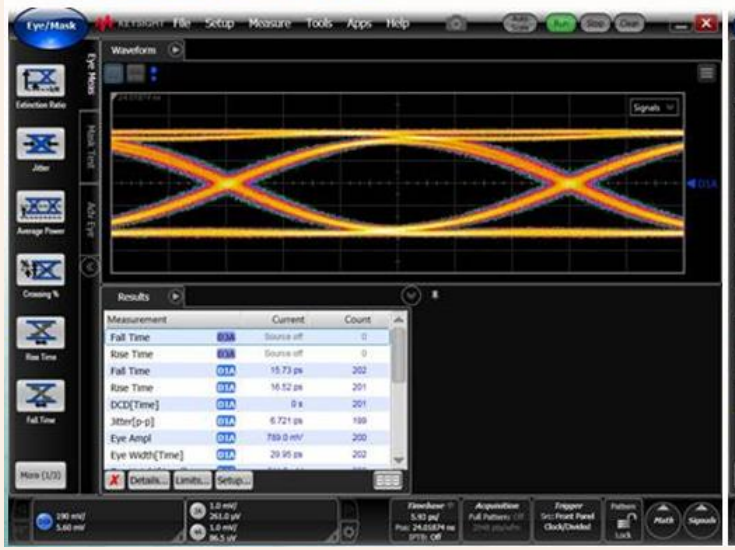
| Probe Characteristics | |
|---|---|
| Pitch | 0.4mm |
| Diameter | 0.29mm |
| Length | 1.5mm |
| Force | 17g |



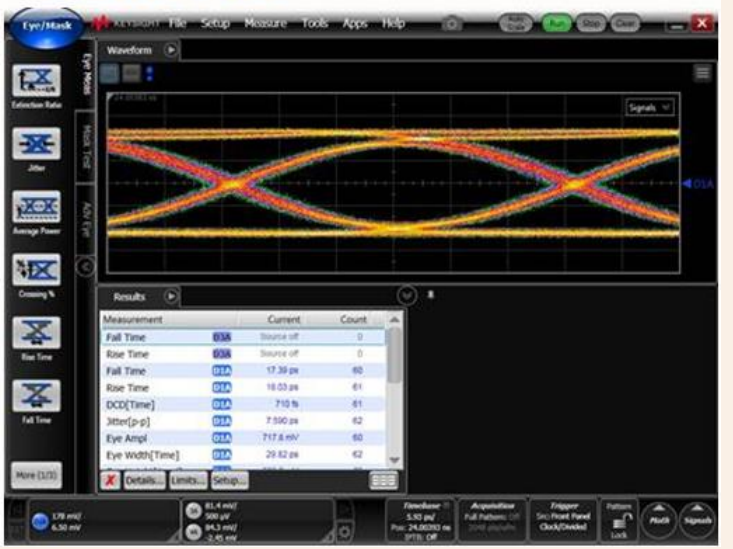



# Application Feedback - ACE

Soldered down @ 28G



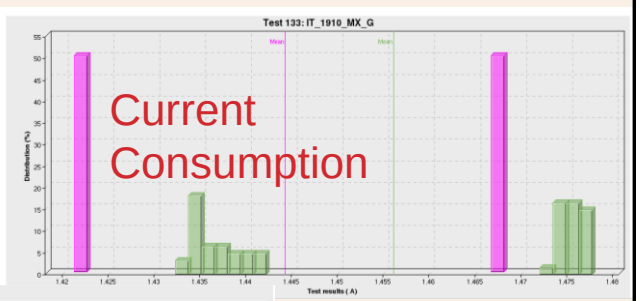
Socketed @ 28G

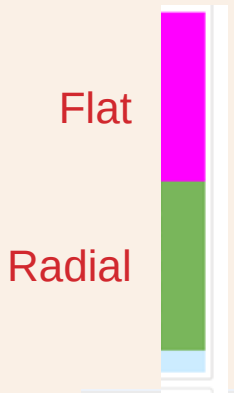


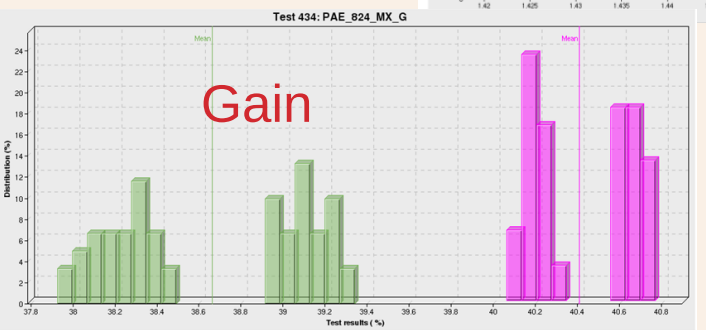
| | | 25.078 Gbps | | | 28.05 Gbps | | |
|---|---|---|---|---|---|---|---|
| **Parameters** | **Units** | **Solder** | **Socket** | **Delta** | **Solder** | **Socket** | **Delta** |
| Tr | pS | 15.74 | 17.54 | -1.8 | 15.73 | 17.39 | -1.7 |
| Tf | pS | 16.43 | 16.05 | 0.4 | 16.52 | 16.05 | 0.5 |
| Jpp | 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 |

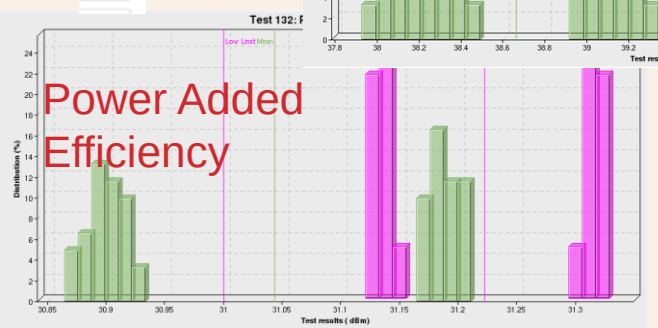
# Customer Feedback - ACE

- 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