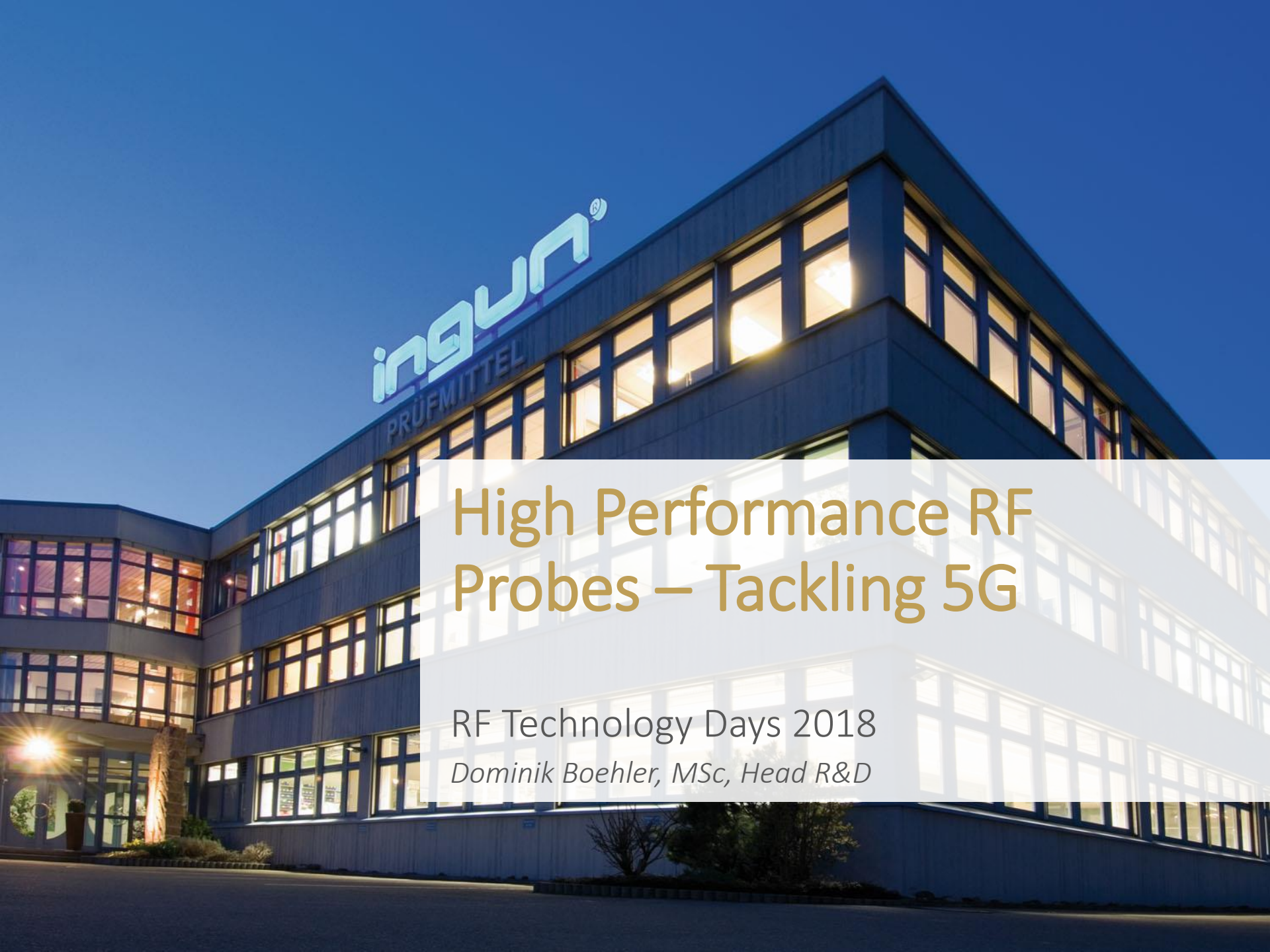
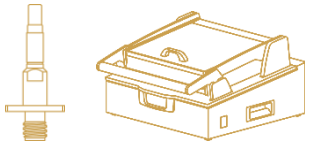



# High Performance RF Probes – Tackling 5G

RF Technology Days 2018

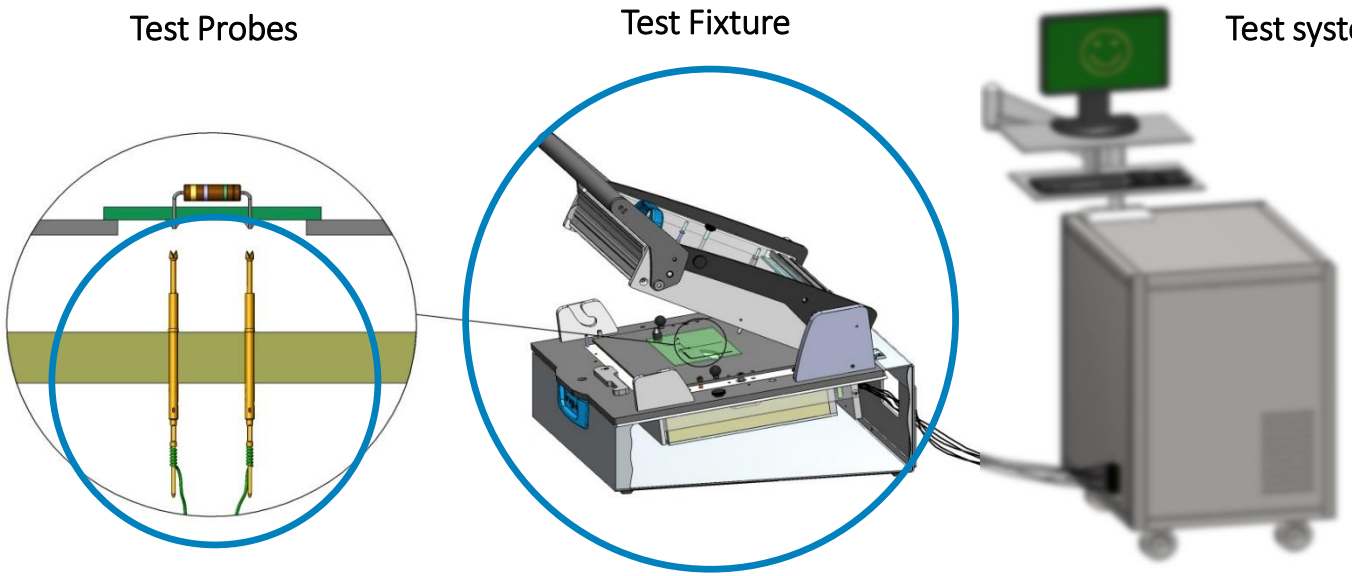
*Dominik Boehler, MSc, Head R&D*

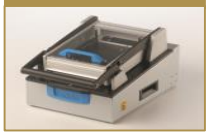
# Content



# Welcome to INGUN

## The Manufacturer of Testing Equipment



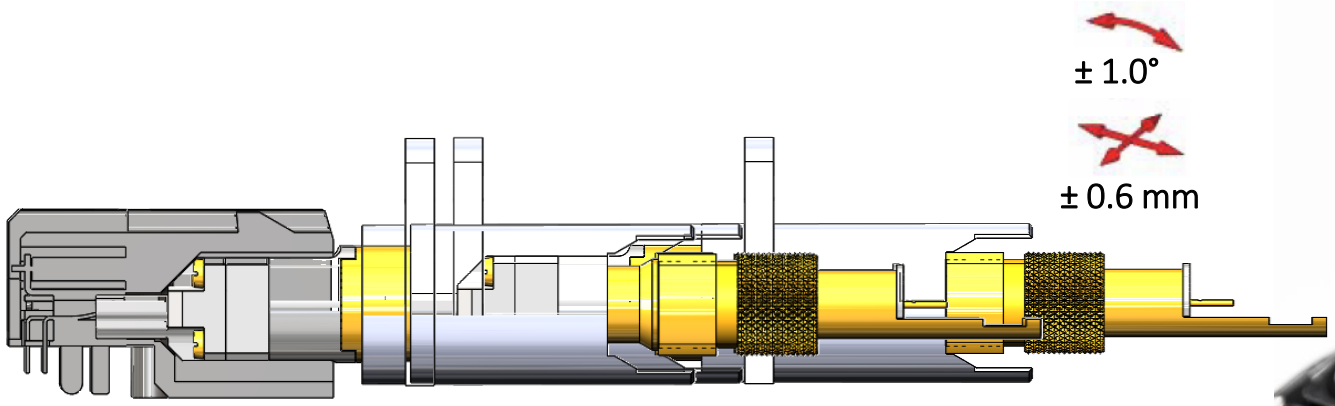

| In-Circuit / Functional | Radio-frequency / Coax | Cable / Connector contacting | High current | Battery / Transfer contacts | Test fixtures WITHOUT customising | Accessories | Test fixtures WITH customising |
|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |

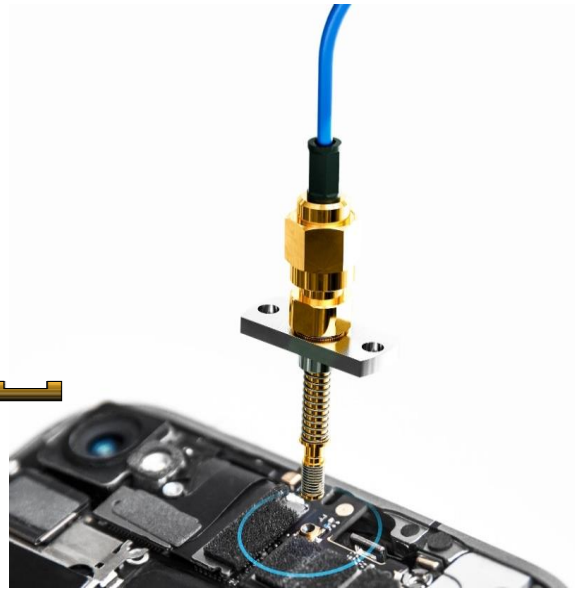
# State of the art

# What can be tested?

Large assortment of RF probes up to 20 GHz - unrivaled range

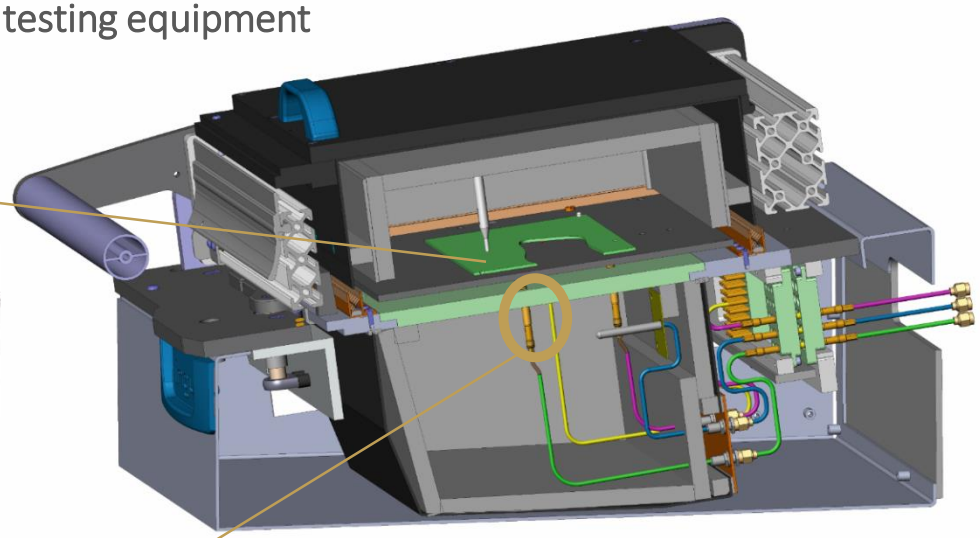
- PCB contacting in grids up to 0.5 mm (= 20 Mil)
- RF probes for all standard connectors from “A” like AMC to “X” like X.FL
- Automotive connectors, such as FAKRA, HSD, etc.
- Integrated technologies, such as filters and attenuators
- High speed testing, e.g., USB 3.1 C, HDMI 2.0



# What can be tested, and how?

Complete set-up of RF testing equipment

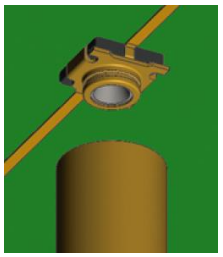


**RF test fixture** for device-under-test (DUT)

**Test system**
(consisting e.g. network analyzer)

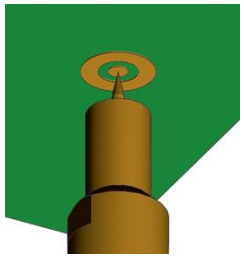
**Available RF test probes for any PCB test points, such as:**

Switch connector

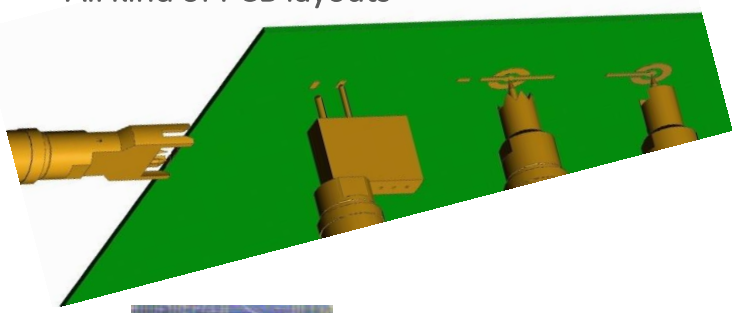


Plug connector

PCB coax closed



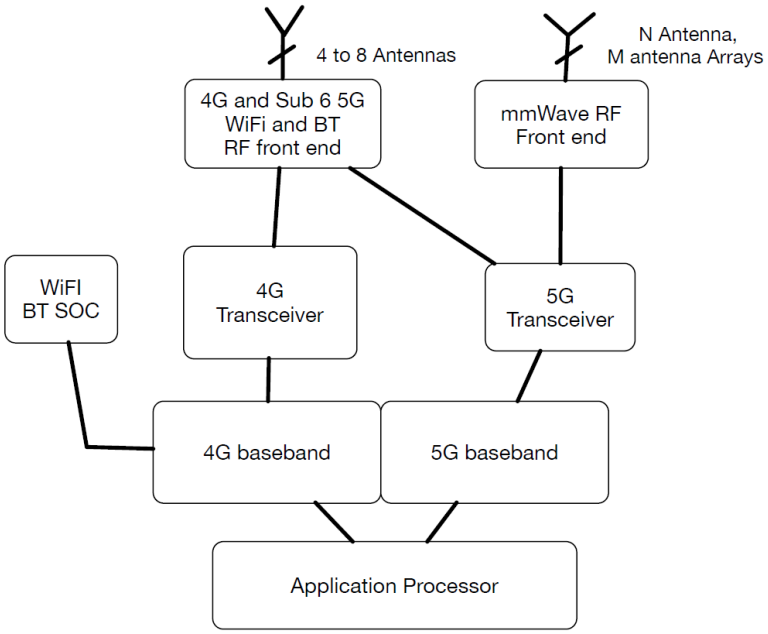
**All kind of PCB layouts**



# Physical Layer Testing Challenges Posed by 5G

# What are the major challenges?

- Usage of new sub-6 GHz bands
- Emergence of mmwave
- Emergence of MIMO
- Low latency
- High density packaging
- Uncertainties about 5G itself
  - Which mmwave band will be used?
  - Which RF architecture will be used?

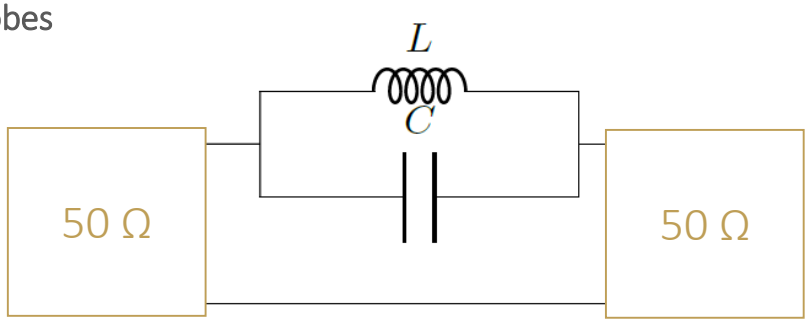



Source: Presented in IMS-2017, 5G summit by Qualcomm

# Resonances in coaxial RF probes

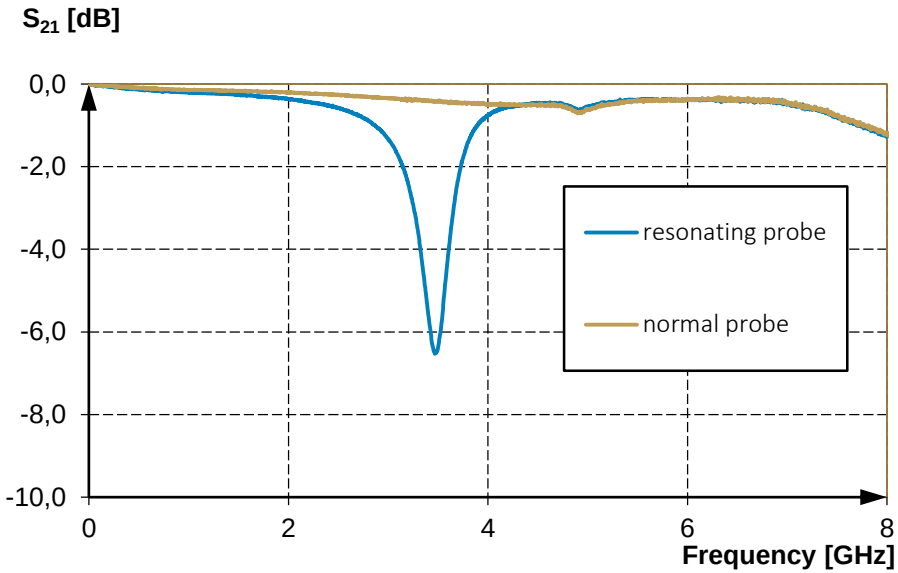
Emergence of new sub 6 GHz bands in 5G calls for broadband probes

- Resonances in coaxial RF probes are unwanted
  - ⇒ **sporadic** phenomena
  - ⇒ unreliable testing
- Resonance frequencies mostly above 3 GHz
- Localization by TDR (Time Domain Reflectometry)




## Where do they come from?

- Deviation from pure coaxial lines because of structures integrated in them
  - ⇒ reliable contact to DUT possible
  - ⇒ movability of the probe
- These structures sometimes have inductive and capacitive nature
  - ⇒ resonances



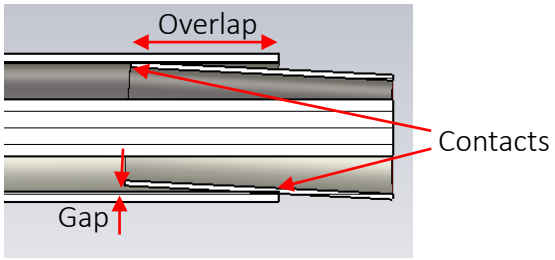

## Remedies

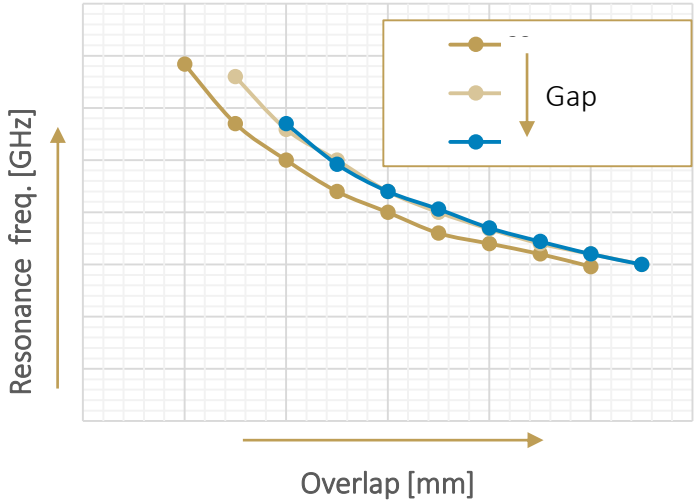
- Avoiding parasitics
- Modifying parasitics
  - ⇒ resonance frequency out of operating range
- High mechanical and RF repeatability

# Resonances in coaxial probes

Example 1: Probes consisting of two moving cylinders

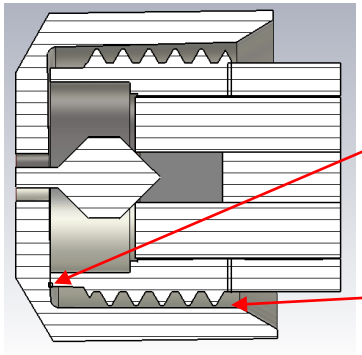
- Coaxial probes consisting of two moving cylinders are vulnerable to resonance
  - contact is produced with the tilting of the inner cylinder
  - The resonance frequency is a function of the gap and overlap between the two cylinders amongst other factors



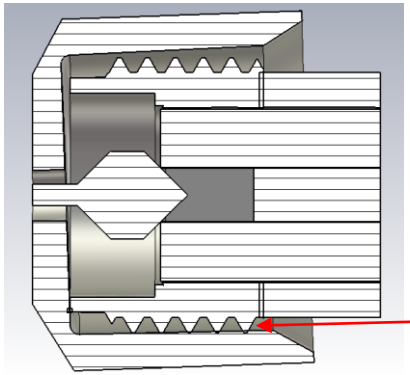



# Resonances in coaxial probes

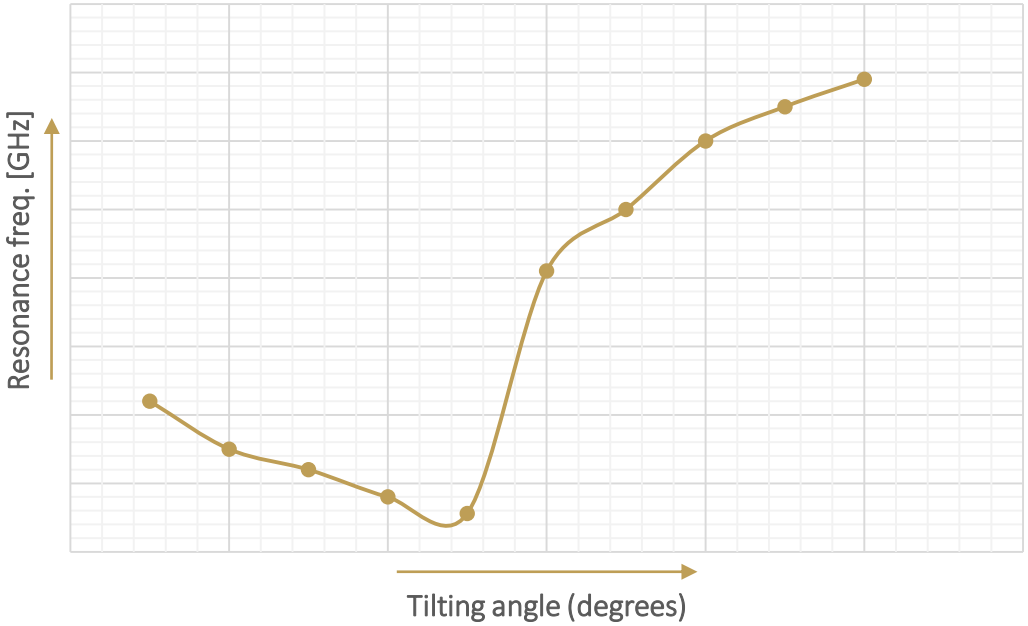
Example 2: Frontal contact, rotation angle dependence. The frontal contact point is also the center of rotation.




0.75°




2°



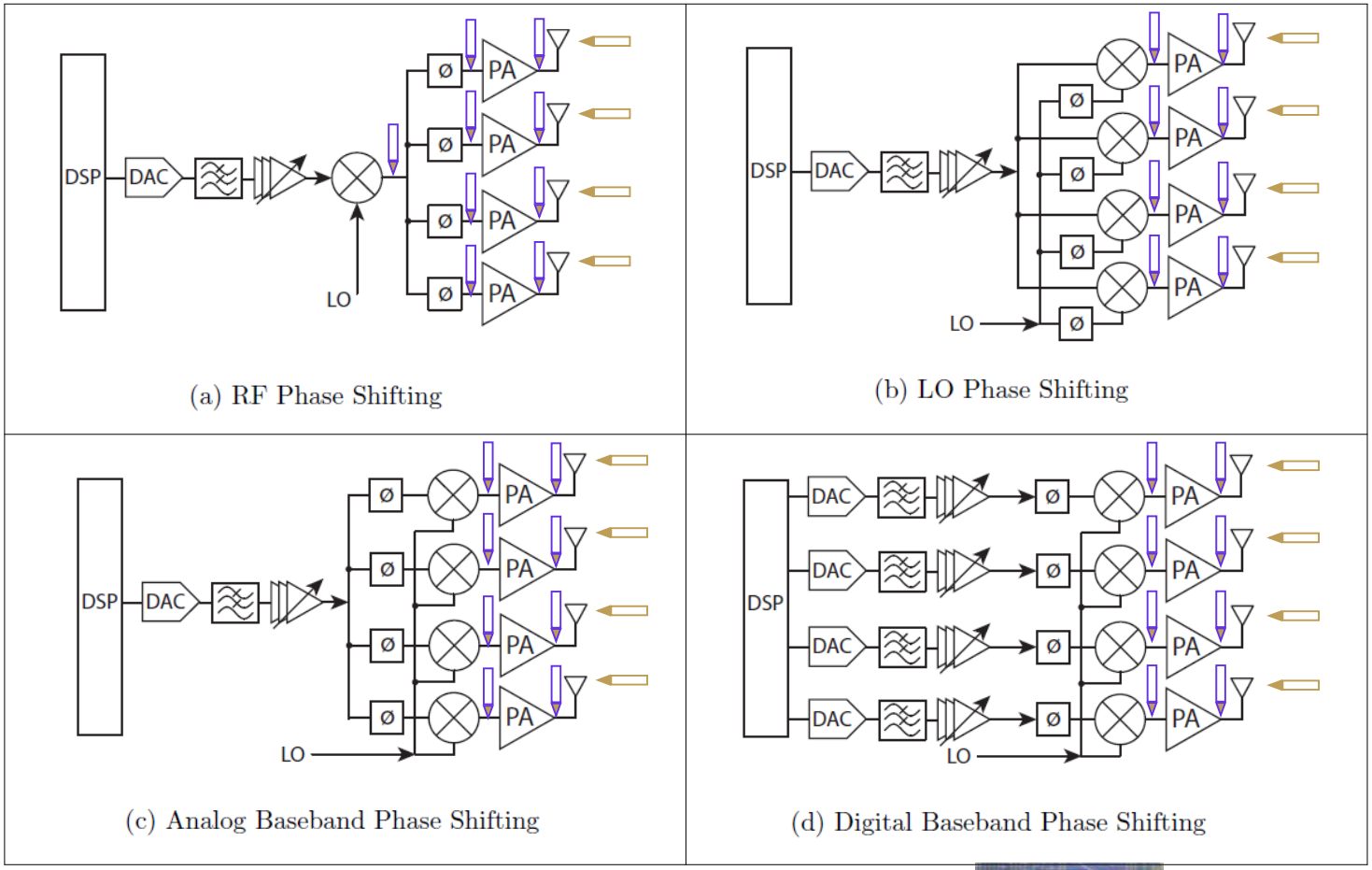

As soon as side contact is takes place, the resonance frequency almost doubles.

# Mmwave Probing

- $\uparrow freq \Rightarrow \downarrow \lambda$
- As $\lambda$ gets smaller, even small transmission line irregularities will be magnified resulting in losses due to reflection.
- Coaxial probes generally have a low pass curve

# Phase shifting architectures & potential test points

Potential phase shifting architectures and mmWave test points of 5G handset




Contact based (cabled)

OTA

Architectures from a UC Berkley PhD thesis, presented in IMS-2017 5G summit by Qualcomm; test points added by INGUN

# RF Testing Topologies

# Testing with probe in series with the DUT

RF Probes in series

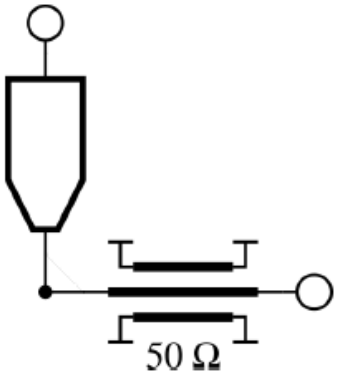
- Probing before the components (e.g. antenna) are populated
- Probe impedance should match DUT line impedance ⇒ mostly 50 Ω

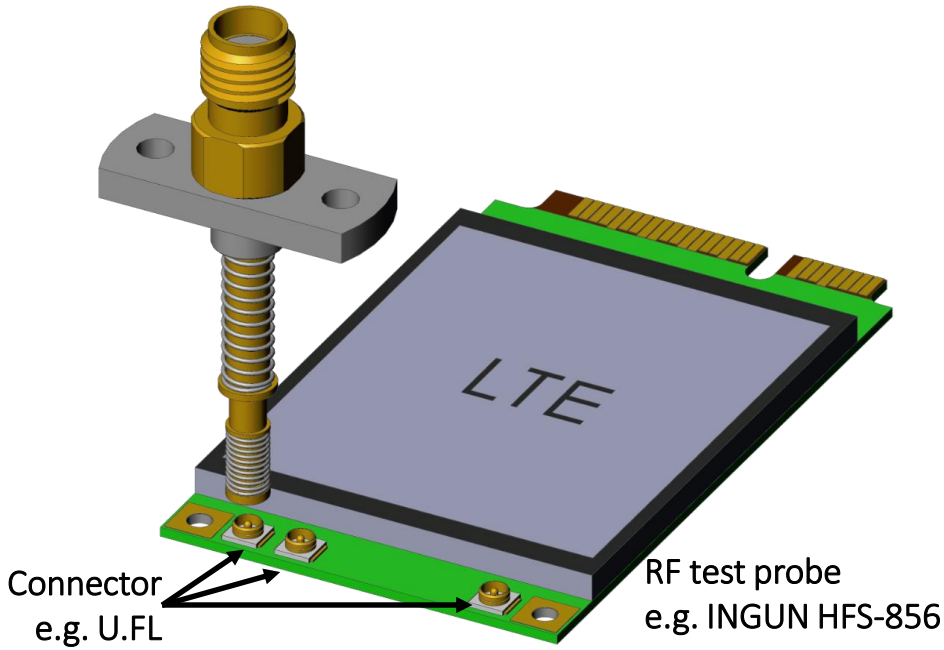
## Advantages

- Non intrusive
- Low reflection measurement possible

## Disadvantages

- Change of characteristics after populating



# Testing with probe in parallel with the DUT

RF Probes in parallel

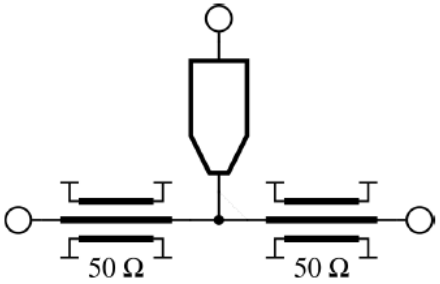
- Probing is possible after the components are populated
- Probe impedance should be chosen not to intrude in the measurement
  - Two different variants possible

## Advantages

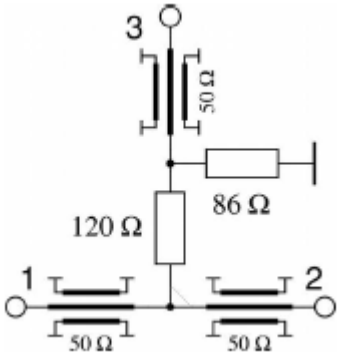
- Easier for a populated PCB

## Disadvantages

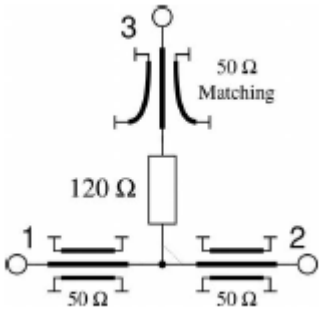
- A lossless reciprocal 3-port circuit cannot be simultaneously matched
- More intrusive than series




Parallel configuration




T-with attenuator

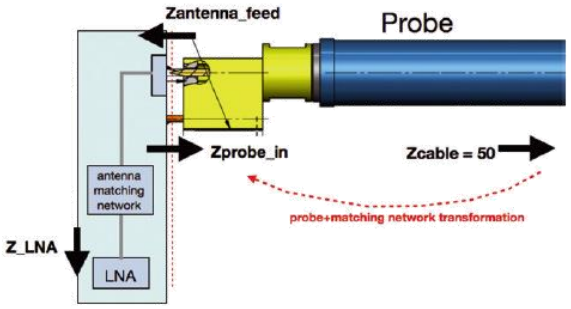



T-with resistor and matching

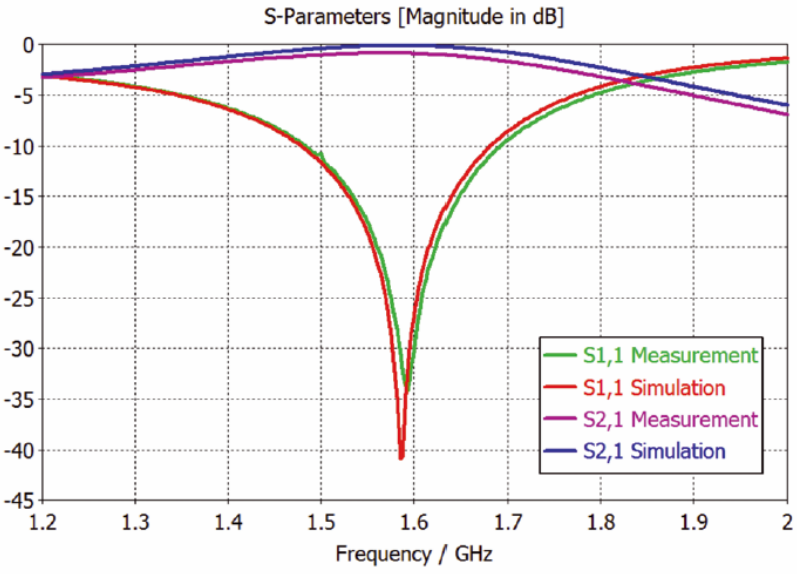
# Testing with probe in parallel

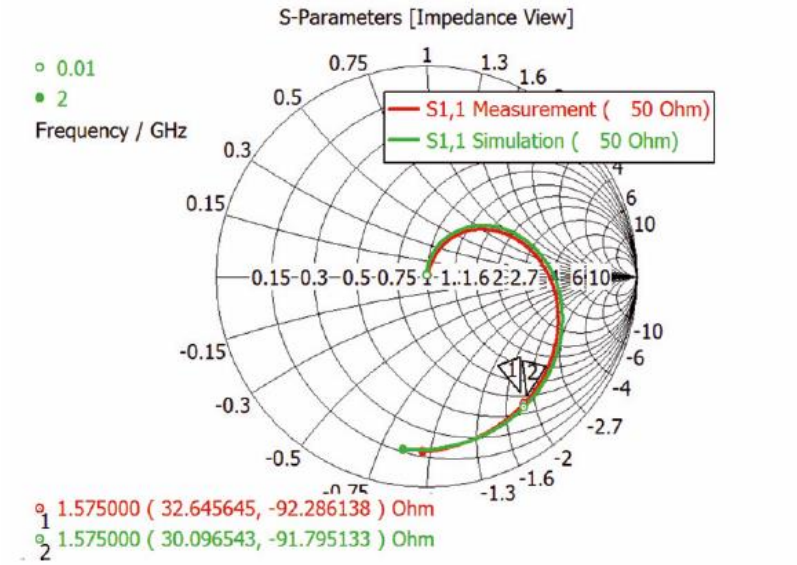
Impedance-matching probe for antenna feed testing


*RF test probe with narrow band matching network*




*Example for the use of a RF test probe with narrow band matching network*




*Comparision of simulation and measurement: The transformation shown in the Smith chart*

# Conclusion


- Usage of new sub-6 GHz bands
  - *Resonance free probes*
- Emergence of mmWave
  - *Mm wave probes*
- Emergence of MIMO
  - *OTA Probes*
- Low latency
  - *Probes with repeatable electrical length*
- High density packaging
  - *Probe miniaturisation*
- Uncertainties about 5G itself
  - *Preparing for different scenarios*

# Thank you for your attention

Need more advice?
Don’t hesitate to contact us.

**INGUN Prüfmittelbau GmbH**
Max-Stromeyer-Straße 162
78467 Konstanz
Germany
info@ingun.com
www.ingun.com