2. FMD Innovation Days
Microwave and Terahertz
Frankfurt (Oder)

ROHDE & SCHWARZ
Make ideas real
5G GENERAL REQUIREMENTS

► Enhanced Mobile Broadband requires higher frequency bands
► Sub 6GHz for ‘basics’: Mobility, coverage, connectivity
► Difference in downlink data rates between LTE and 5G for <6GHz not so big

► Big increase in data rates due to increase in bandwidth
► Millimeter wave (28GHz, 39GHz) for high data traffic / hotspots

► Backhaul: Millimeter Wave / E-band or fiber links

► Beamforming and Massive MIMO – Antenna arrays
5G COMPONENTS AND HOW TO TEST THEM

► Integration of transceiver frontend and antenna array
► Over-the-air (OTA) testing for modules
► Far field conditions at short distances
► Shielded Chambers

R&S®PWC200 plane wave converter

Typical architecture of a massive MIMO active antenna system
Signal Generator / Spectrum Analyzer

- More complex modulation (16/64/256 QAM)
  - EVM measurements are important
  - Constellation Diagrams
- Broadband for signal generation and spectrum analysis
  - 2GHz internal bandwidth (R&S)
  - 5GHz in combination with oscilloscope (R&S)
5G COMPONENTS AND HOW TO TEST THEM

Vector Network Analyzer:
► On-Wafer characterization of components in millimeter wave range
► Amplifiers, Mixers, Antennas,…
► S-Parameters
► IMD, Harmonics
► Compression
► Noise Figure
► Load Pull
► ….
COHERENT SOURCES FOR BEAMFORMING

Four coherent sources with definable amplitude and phase differences
ACTIVE AND PASSIVE ANTENNA RETURN LOSS MEASUREMENT

Antenna Array Return Loss Measurements

Active Return Loss Simultaneous Measurements

Passive Return Loss Single Element

Passive Return Loss

Active Return Loss distorted by the mutual coupling

Source: Signal Processing Magazine, IEEE, Jan 2013
ACTIVE AND PASSIVE ANTENNA RETURN LOSS MEASUREMENT

Coupling effects between antenna elements, active and passive measurement
ON-WAFER MEASUREMENTS WITH PROBE STATION

Millimeter Wave Systems for E- and W-band

Component characterization in E- and W-Band requires

- High output power of converter for active device characterization
- Power sweep and compression point capability
What are the trends?

- 76GHz to 81GHz instead of / in addition to 24GHz band
- Higher frequency bands in future
- Higher resolution (4cm vs 75cm) and accuracy compared to 24GHz due to higher bandwidth
- Smaller in size
Material characterization of mobile phones and shielding materials for automotive radar gets more important

► Basic measurement of Epsilon and Tan Delta versus frequency with VNA
► More antennas in handsets
► Millimeter Wave Frequencies
TECHNOLOGIES IN 5G

There will be a mix of different technologies in 5G

► CMOS (e.g. Tablets)
► SiGe (e.g. Small Cells)
► GaAs (e.g. Mobile Phones)
► GaN (e.g. T/R module of BTS)

► Combination of different technologies for different devices
► Combination of different technologies in one device
► Evolving while 5G is progressing
TECHNOLOGIES IN 5G

GaN Power Amplifier for 5G BTS

- Mainly used in Aerospace & Defense Applications so far
- High efficiency (e.g. Doherty PA) leads to less antenna elements and smaller antenna arrays
- High Output Power
- Higher voltage in smaller space
- Low power consumption
- Capable of millimeter wave frequencies

Drawbacks:
- Thermal challenge due to higher power density
- Expensive compared to Si
  - Cost reduction by higher integration or lower cost substrates (e.g. Si) necessary
THANK YOU FOR YOUR ATTENTION

1950: World’s first Vector Network Analyzer
- made by R&S

Direct display of S-Parameters in a complex plane

> 65 years of experience in network analysis

Rohde & Schwarz  09/12/2019  5G component tests