5G - NEW REQUIREMENTS FOR COMPONENT TESTS

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</p>
- ► 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



5G COMPONENTS AND HOW TO TEST THEM

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)

The R&S®FSW-K144 5G New Radio downlink measurement application

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MultiView 📑 Spect	rum × 5	G NR	×				₄ Reference		
Ref Level -17.00 dBm I Att O dB YIG Bypass	Freq 24.65 GHz M Fr	ode ame Count	Downlink, 100 MH 2 of 2(2	z Capture Time 50.)	0 ms BWP/SS All	SGL	∢ Transducer		
1 Capture Buffer	s	1 Clrw 7	Alloc ID vs Symb	OIX Carrier	5 Power Spectr	um •1 Clrw 11[1] -176.20 dBm/Hz	User		
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4 Allocation Summary	Allocation	No of	Rel	Madulation	Power per	▼ TableConfig EVM	∢ Display		
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Frame Results Averaged		Mean	Мах	Min 🔺	Points Measured : 880800		Config		
EVM PDSCH QPSK (%) EVM PDSCH 16QAM (%) EVM PDSCH 64QAM (%)		0.87	0.87	0.87			Service + Support		
EVM All (%)		0.87	0.87	0.87	••••	• • • •			
EVM Phys Channel (%)		0.87	0.87	0.87			■ + ■ + ■		
Frequency Error (Hz) Sampling Error (ppm)		-9.81	-9.58	-10.04					
Power (dBm)		15.45	-15.45	-15.45 -			overnen		
Sync Found Ready									

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

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COHERENT SOURCES FOR BEAMFORMING



Г)efined (Coherenc	e Mode				X			
	Referenc	e Port:	1	Same f	or all Ports!					
	Phys Port#	Gen	Def d Phase Coherence	Ref Port	Relative Amplitude	Relative Phase				
	1			v	0 dB	0°				
	2		N		1 dB	30°				
	3	ব	ব		-1 dB	40°				
	4	N	ব		-2 dB	120°				
Tolerance										
Close										
								\odot		

Four coherent sources with definable amplitude and phase differences



ACTIVE AND PASSIVE ANTENNA RETURN LOSS MEASUREMENT



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



Millimeter Wave Prober system

Component characterization in E- and W-Band requires

- High output power of converter for active device characterization
- Power sweep and compression point capability



AUTOMOTIVE RADAR

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



Figure 3: Relative antenna sizes for 24GHz and 77GHz



MATERIAL MEASUREMENTS

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
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AMPLIFIER CHARACTERIZATION - EXAMPLE



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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

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