3GPP NR Multi-Channel Test Techniques

KEYSIGHT TECHNOLOGIES
The 5G New Radio Vision

**Enhanced Mobile Broadband**
- Gigabytes In a Second
- 3D Video, UHD Screens
- Work and Play in the Cloud
- Augmented Reality
- Industry Automation
- Mission Critical Applications
- Self Driving Cars
- Smart Home Building
- Voice

**Massive Machine Type Communications**

**Ultra-Reliable Low Latency Communications**

**Better Spectral Efficiency**
- Clever modulation & coding schemes

**Use More Spectrum**
- Higher frequencies → Phased Arrays

**3GPP Conformance Tests**
- Tx and Rx tests

Figure 1: Source ITU 5G Recommendations 9/2015
Clever Modulation & Coding Schemes

**SPATIAL MULTIPLEXIN, AKA ‘MIMO’**

Data Splitter

Wireless Channel

Vector Signal Processor

Tx Data $b_3b_2b_1$ → Data Splitter $b_1$ $b_2$ $b_3$ → Wireless Channel → Rx Data

$b_1$ $b_2$ $b_3$ → Wireless Channel → Rx Data

 Tx Tx Tx

 Rx Rx Rx

Tx Data $b_3b_2b_1$ → Data Splitter $b_1$ $b_2$ $b_3$ → Wireless Channel → Rx Data

$b_1$ $b_2$ $b_3$ → Wireless Channel → Rx Data

 Tx Tx Tx

 Rx Rx Rx
Higher Frequencies for Higher Data Rates

Gigabit LTE and beyond: Mobilizing millimeter wave

21.1 GHz of new unlicensed spectrum

Current IMT Bands

24 GHz Licensed
LMDS Licensed
40 GHz Licensed
50 GHz Licensed
60 GHz Licensed
70-80 GHz Licensed

116-123 GHz Unlicensed
174.5-182 GHz Unlicensed
185-190 GHz Unlicensed
244-246 GHz Unlicensed

*Gigabit LTE and beyond: Mobilizing millimeter wave
Phased Array Antennas

OVERCOMING MMW LOSSES

• An array of antenna elements with controlled relative phase & amplitude of each element

• Radiation pattern is the result of summation of output signals from each element

• Enables concentrated energy in desired direction & rapid scanning in wide special area
Phased Arrays

SOME TESTING CAN BE DONE WITH SINGLE CHANNEL

Spectrum Analyzer

Phased Array Antenna

Antenna Pattern
Hybrid beamforming architecture in phased-array antennas
## 3GPP gNB Conformance Tests Overview

**CHAPTER 6, 7, 8 MEASUREMENT DETAIL**

### 3GPP NR gNB Conformance Test Summary (Conducted & Radiated)

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**Summary**
- Requires time aligned digitizers
- Or digitizers with wide BW

**Summary**
- Tests are performed open loop
- Tests require interfering signals
- Performance metric = BLER (calculated by gNB)

**Summary**
- PUSCH tests performed closed loop (implies real-time sig gen)
- Fading of ‘wanted’ & ‘Interfering’ signals & AWGN
- Performance metric = throughput (calculated by gNB)
3GPP gNB Transmitter, Type 1-O & 2-O

BASIC TX TESTS

Any 'suitable' OTA chamber

Test System
Calibrated point

NR BS declared coordinate
reference point & orientation

NR BS

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Test Antenna

Spectrum Analyzer

Tests include: Radiated TX Power, Output Power Dynamics, & TX Signal Quality
3GPP gNB Receiver, Type 1-O & 2-O

ACS, BLOCKING, & NB BLOCKING

Test System
Calibrated point
reference point & orientation

Any ‘suitable’ OTA chamber

Wanted Signal

Signal Generator

Test Antenna polarization can be adjusted

Test Antenna

Signal Generator

CW Interfering Signal

Modulated Interfering Signal

NR BS declared coordinate

NR BS

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Test System
Calibrated point

NR BS declared coordinate
reference point & orientation

∑
3GPP gNB Receiver, Type 1-O

OTA CO-LOCATION BLOCKING

Any ‘suitable’ OTA chamber

NR BS

Test Antenna

Wanted Signal

Co-location Reference Antenna

Signal Generator

Interfering Signal

Signal Generator
• Tests include: one and two port PUSCH, single/multi-user PUCCH, PRACH
• Depending on gNB capability, some tests require: 1x2, 1x4, 1x8, 2x2, 2x4, 2x8
• Feedback may include Timing Adjustment in future 3GPP spec
• Standard indicates feedback can be via RF or digital
Multi-Channel 5G Testbed for NR FR1 and FR2

3GPP CONFORMANCE READY – HIGH PERFORMANCE

Key Features
- 44 GHz Signal Creation / 110 GHz Analysis
- Multi-channel
- High Output Power
- 2 GHz signal Creation BW
- 110 GHz BW Demodulation Analysis
- Swept-tuned measurements to 110 GHz
- Import S-Parameters to de-embed test fixture

Test Signal
2x2 MIMO at 28 GHz

Device Under Test
Cross-polarized 28 GHz phased array

DC Power Analyzer

VXG
44 GHz Dual Ch. Source

UXR
110 GHz Oscilloscope

UXA
110 GHz Signal Analyzer
Multi-Channel 5G Testbed for NR FR1 and FR2
Multi-Channel 5G Testbed for NR FR1 and FR2

ADDITIONAL MEASUREMENTS
Questions?