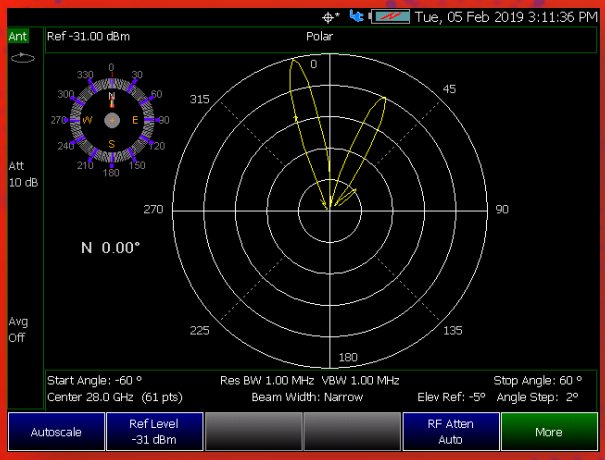


TECHNICAL OVERVIEW

5G mmW Air Interface Characterization with Phased Array Antenna

Keysight Technologies FieldFox microwave analyzer integrated with a phased array antenna

KEYSIGHT TECHNOLOGIES

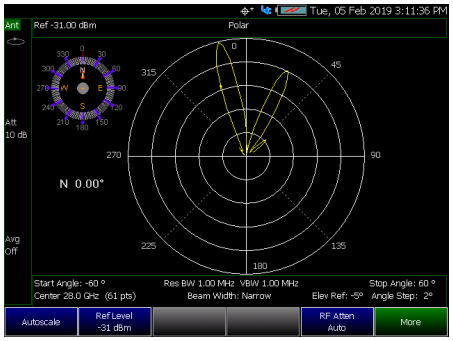
Survey the 5G air interface with an integrated, portable solution

Driving technologies behind 5G networks include wider bandwidths, millimeter wave frequencies, as well as massive MIMO and beamforming control and data channels. MIMO leverages multipath transmission in urban environments and beamforming systems that focus energy transmissions to optimally target specific users. This reduces base station power consumption and enables very high signal-to-noise links necessary to overcome millimeter wave channel losses. These advanced technologies dramatically increase the complexity of the radio access network (RAN).

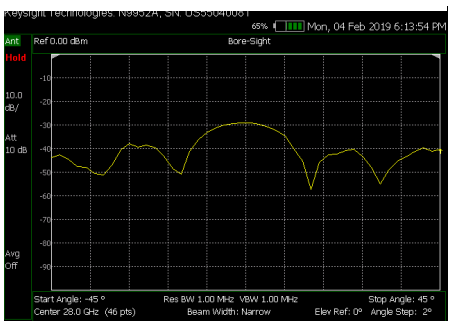
5G operators and network equipment manufacturers will need new over-the-air test tools for network and user equipment (UE) field test, as well as optimization tools to deploy and verify the performance of these networks. Keysight's FieldFox handheld microwave analyzer combined with a phased array antenna provides a unique, portable solution for measuring and analyzing the 5G air interface in the field.

5G Phased Array Field Test Solution Benefits

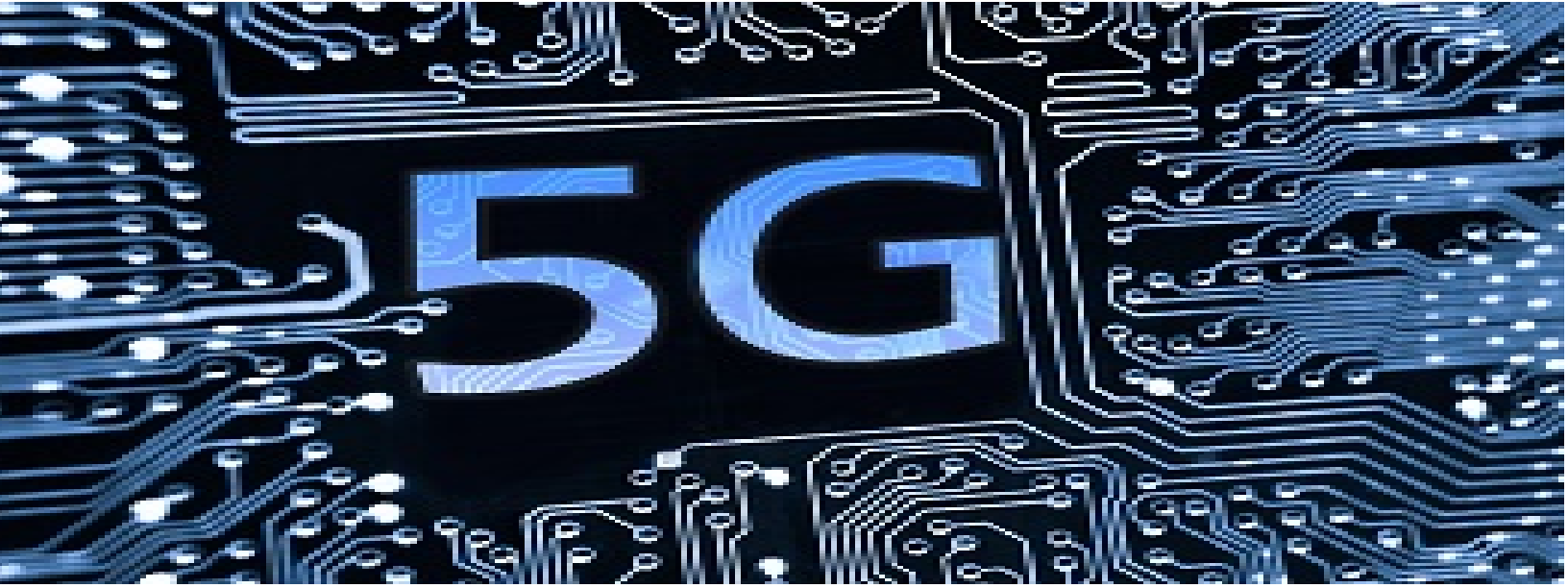
- Understand gNB beam characteristics by measuring signal power level across azimuth and elevation from base stations
- Reduce measurement complexity with integrated RF probe and phased array solution to capture energy radiated from gNB
- Calibrated millimeter wave phased array antenna simulates 5G UE antenna performance
- Phased array performance verification showing boresight, polar antenna pattern with compass, and heat map (azimuth vs. elevation)
- Battery powered, no internal fan or vents, and IP53 rated design to test 5G gNB under any condition
- Phased array antenna operating frequency is 28 GHz



Polar antenna pattern with compass



Boresight scan



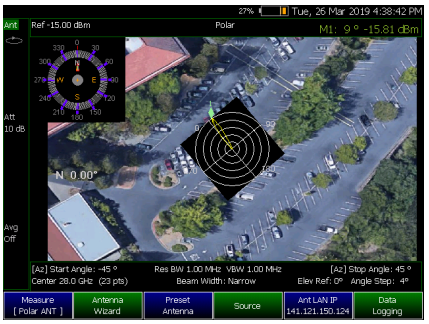
FieldFox Microwave Analyzer Supports for

- both FR1 and FR2 5G bands, up to 54 GHz
- gNB RF parametric test over-the-air in the field
- millimeter-wave beam sweep survey
- spectrum analysis, real-time spectrum analysis, transmitter power, adjacent channel power ratio and channel scanner
- LTE FDD/TDD and 5G over-the-air (OTA) measurements

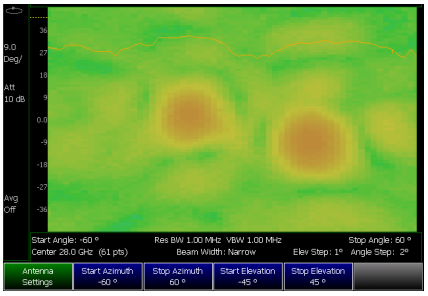
Over-the-Air Measurements for 5G

The key challenges for 5G network deployment are characterizing millimeter wave pathloss and coverage. 5G network technology uses beamforming and massive MIMO to achieve high data rates and the control channels are not always on. To measure the effective coverage, FieldFox 5G NR OTA can measure and display control channel power, physical cell identifier, SSB index and channel signal qualities to gain insight into network utilization and capacity.

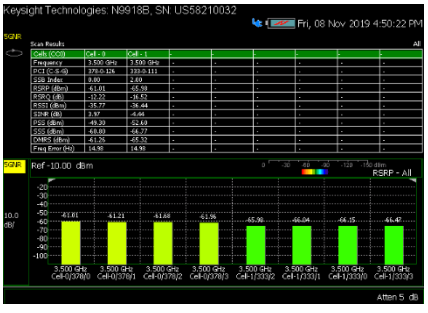
Since 5G control channels are based on beamforming technology, and are not always on, this can make it challenging to determine the location of the 5G signal. Switching into RTSA mode on FieldFox can quickly and reliably detect 5G signals, detect control channels and provide insights to beamforming performance.



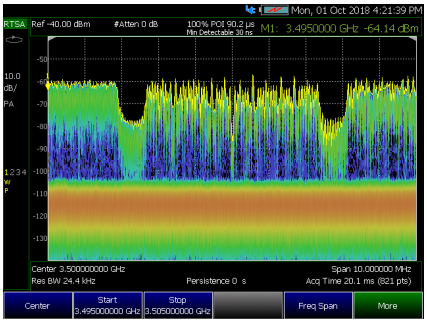
Polar antenna pattern to image map



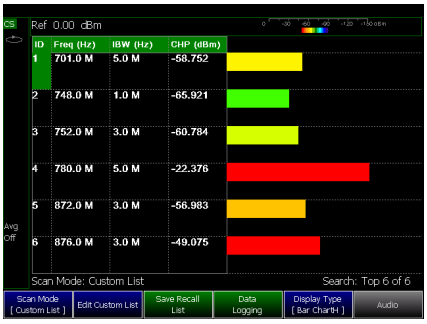
2D scan heat map (azimuth vs. elevation)



5G NR OTA measures control channels, SSB index and cell ID



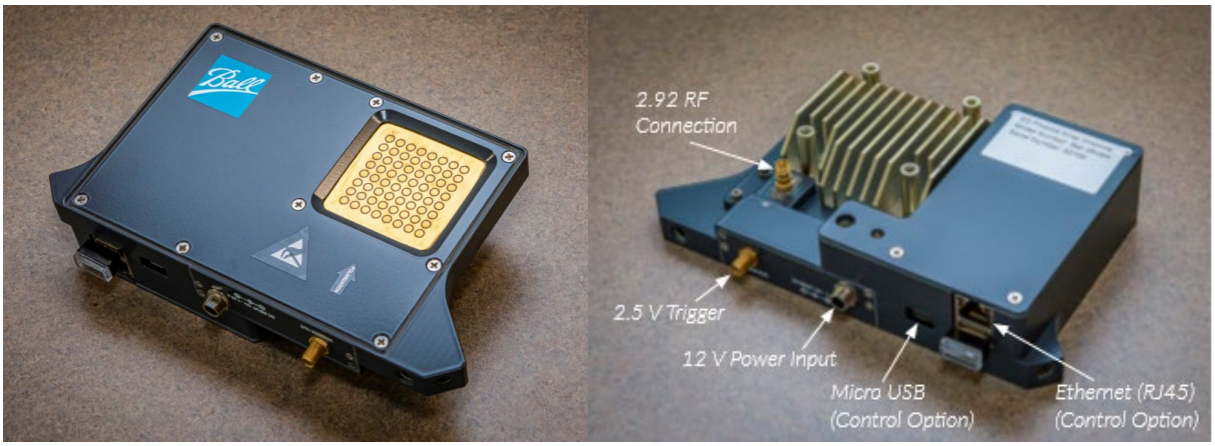
Switching into RTSA mode detects various 5G control channels



Add channel scanner capability for coverage test optimization

Phased Array Antenna

The phased array antenna used in the system is a planar phased array, supporting multiple beam widths, that can be used for channel acquisition, RF probing and signal-to-noise ratio enhancement.



- 8 x 8 phased array antenna
- Individually calibrated elements, magnitude and phase
- Covers beam sweep -60 to +60 azimuth, 90° elevation with 1° per step

Antenna Specifications

Parameter	Description
Frequency	27.5 to 30.0 GHz (operating frequency of 28 GHz when connected to FieldFox)
Rx antenna gain	42 dB
G/T	> -6 dB/K (measured at boresight)
Polarization	Linear (vertical or horizontal)
Beam steering	Electronic, analog beam forming
Electronic beam scan	+/- 60° 2D
Number beams	Single radiation beam (can be broadened)
3 dB beam widths	Multiple beam widths, wide to narrow (15 degree)
Beam steer update rate	15.9 microsec
RF interface	2.92 mm female
Average power	18 W DC
Size	11 x 15 x 4 cm / 4.25 x 6.0 x 1.55 inches
Weight	0.5 kg / 1.1 lb.
Supply voltage	6 to 20 VDC
Peak power	14 W receive mode
Control interfaces	Ethernet
Trigger port	2.5 V

Solution Configuration

FieldFox analyzer models

Step 1: Select one of the supported FieldFox models below:

Model	Description	VNA frequency	SA frequency	Test port connectors
N9953B	54 GHz FieldFox microwave analyzer	300 kHz to 54GHz	9 kHz to 54 GHz	1.8 mm (m)
N9963B	54 GHz FieldFox microwave signal analyzer	—	9 kHz to 54 GHz	1.8 mm (m)
N9952B	50 GHz FieldFox microwave analyzer	300 kHz to 50 GHz	9 kHz to 50 GHz	2.4 mm (m)
N9962B	50 GHz FieldFox microwave signal analyzer	—	9 kHz to 50 GHz	2.4 mm (m)
N9951B	44 GHz FieldFox microwave analyzer	300 kHz to 44 GHz	9 kHz to 44 GHz	2.4 mm (m)
N9961B	44 GHz FieldFox microwave signal analyzer	—	9 kHz to 44 GHz	2.4 mm (m)
N9950B	32 GHz FieldFox microwave analyzer	300 kHz to 32 GHz	9 kHz to 32 GHz	2.4 mm (m)
N9960B	32 GHz FieldFox microwave signal analyzer	—	9 kHz to 32 GHz	2.4 mm (m)
N9952A	50 GHz FieldFox microwave analyzer	300 kHz to 50 GHz	9 kHz to 50 GHz	2.4 mm (m)
N9962A	50 GHz FieldFox microwave spectrum analyzer	—	9 kHz to 50 GHz	2.4 mm (m)
N9951A	44 GHz FieldFox microwave analyzer	300 kHz to 44 GHz	9 kHz to 44 GHz	2.4 mm (m)
N9961A	44 GHz FieldFox microwave spectrum analyzer	—	9 kHz to 44 GHz	2.4 mm (m)
N9950A	32 GHz FieldFox microwave analyzer	300 kHz to 32 GHz	9 kHz to 32 GHz	2.4 mm (m)
N9960A	32 GHz FieldFox microwave spectrum analyzer	—	9 kHz to 32 GHz	2.4 mm (m)
N9918B[1]	26.5 GHz FieldFox microwave analyzer	30 kHz to 26.5 GHz	9 kHz to 26.5 GHz	3.5 mm (m)
N9938B[1]	26.5 GHz FieldFox microwave signal analyzer	—	9 kHz to 26.5 GHz	Type-N (f) or 3.5 mm (m)[2]
N9917B[1]	18 GHz FieldFox microwave analyzer	30 kHz to 18 GHz	9 kHz to 18 GHz	Type-N (f)
N9937B[1]	18 GHz FieldFox microwave signal analyzer	—	9 kHz to 18 GHz	Type-N (f)
N9916B[1]	14 GHz FieldFox microwave analyzer	30 kHz to 14 GHz	9 kHz to 14 GHz	Type-N (f)
N9936B[1]	14 GHz FieldFox microwave signal analyzer	—	9 kHz to 14 GHz	Type-N (f)

FieldFox required options (combination analyzer models)

Step 2: Select the required options below for N9953/52/51/50B, N9952/51/50A or N9918/17/16B models:

Option	Description	Prerequisite options / notes
Spectrum analysis		
233	Spectrum analyzer	—
N995xA-360 or N995xAU-360	Phased array antenna control	233
N991xB-360 or N991xBU-360	Phased array antenna control	233, requires external mixer (see footnote 1 below)
N995xB-360 or N995xBU-360	Phase array antenna control	233

[1] Requires external mixer to down convert millimeter wave frequency to intermediate frequency (IF). Recommend OML Inc. WR-28 26.5 to 40 GHz harmonic mixer, orderable as Keysight model N9910XM28 option H2A or option H2N (Options H2A and H2N have different connectors to the FieldFox test ports. Refer to FieldFox configuration guide, 5992-3701EN, for details), or direct from OML model M28H2ADC-K. OML harmonic mixer M28H2ADC-K requires LO input frequency between 12 to 20 GHz with FieldFox providing the LO, and therefore, is not supported on FieldFox B models N9913/14/15B and N9933/34/35B.
[2] Order Option 100 for 3.5 mm (m) test port connectors.

FieldFox required options (signal/spectrum analyzer models)

Step 2: Select the required options below for N9963/62/61/60B, N9962/61/60A or N9938/37/36B models:

Option	Description	Prerequisite options / notes
Spectrum analysis		
—	Spectrum analyzer	Base (standard option)
N996xA-360 or N996xAU-360	Phased array antenna control	—
N993xB-360 or N993xBU-360	Phased array antenna control	Requires external mixer (see footnote 1 below)[1]
N996xB-360 or N996xBU-360	Phased array antenna control	

[1] Requires external mixer to down convert millimeter wave frequency to intermediate frequency (IF). Recommend OML Inc. WR-28 26.5 to 40 GHz harmonic mixer, orderable as Keysight model N9910XM28 option H2A or option H2N (Options H2A and H2N have different connectors to the FieldFox test ports. Refer to FieldFox configuration guide, 5992-3701EN, for details), or direct from OML model M28H2ADC-K. OML harmonic mixer M28H2ADC-K requires LO input frequency between 12 to 20 GHz with FieldFox providing the LO, and therefore, is not supported on FieldFox B models N9913/14/15B and N9933/34/35B.

FieldFox recommended options (combination analyzer models)

Step 3: Select from the recommended options below for N9953/52/51/50B, or N9952/51/50A, or N9918/17/16B models:

Option	Description	Prerequisite options / notes
Spectrum analysis		
235	Pre-amplifier	Requires 233
236	Interference analyzer and spectrogram	Requires 233
312	Channel scanner	Requires 233
350	Real-time spectrum analyzer (RTSA)	Requires 233, recommend 235.
352	Indoor and outdoor mapping	Requires 233, 307, and at least one of 312, 360, 370, 377 or 378.
370	Over-the-air (OTA) LTE FDD	Requires 233, 307, recommend 235.
377	Over-the-air (OTA) 5GTF	Requires 233, 307, recommend 235. Supported on N995xB/N995xA and N9916/17/18B models. FR2 frequencies above 26.5 GHz require external mixer on N9916/17/18B models.
378	Over-the-air (OTA) 5G NR	Supported on N991xB/N995xB models only. Requires 233, B10, 307. Recommend 235. FR2 frequencies above 26.5 GHz require external mixer on N9916/17/18B models.
System features		
307	GNSS / GPS receiver	Need to order GPS antenna, N9910X-825.
309	DC bias variable-voltage source	—

FieldFox recommended options (signal/spectrum analyzer models)

Step 3: Select from the recommended options below for N9963/62/61/60B, or N9962/61/60A, or N9938/37/36B models:

Option	Description	Prerequisite options / notes
Spectrum analysis		
235	Pre-amplifier	—
236	Interference analyzer and spectrogram	—
312	Channel scanner	—
350	Real-time spectrum analyzer (RTSA)	Recommend 235.
352	Indoor and outdoor mapping	Requires 307, and at least one of 312, 360, 370, 377 or 378.
370	Over-the-air (OTA) LTE FDD	Requires 307, recommend 235.
377	Over-the-air (OTA) 5GTF	Requires 307, recommend 235. Supported on N996xB/N996xA and N9936/37/38B models. FR2 frequencies above 26.5 GHz require external mixer on N9936/37/38B models.
378	Over-the-air (OTA) 5G NR	Supported on N993xB/N996xB models only. Requires B10, 307. Recommend 235. FR2 frequencies above 26.5 GHz require external mixer on N9936/37/38B models.
System features		
307	GNSS / GPS receiver	Need to order GPS antenna, N9910X-825.
309	DC bias variable-voltage source	—

5G phased array antenna required options

Step 4: The following phased array antenna is required.

Model	Description	Prerequisites\Notes
85571A-028	5G phased array antenna[1]	All items listed within this section are included with 85571A-028.
	Cable assembly, antenna power	
	AC/DC power adaptor	
	Battery, rechargeable Li-Ion 71 WH	Identical to the battery used in the FieldFox analyzer
	Portable battery holder	
	LAN cable RJ-45 (m) to RJ-45 (m)	
	2.4 mm (f) to 2.92 mm (m) cable 1-meter	
	2.4 mm (m) to K (m) adaptor	Required for FieldFox B model units to connect to OML mixer.
	Soft case, with backpack and shoulder strap	
	Power indicator USB light	

[1] The antenna product is currently not RoHS compliant.

Solution Configuration (continued)

Accessories

Step 5: The following accessories are not required but recommended.

Model	Description	Prerequisites\Notes
N9910X-876	Battery, high capacity rechargeable Li-Ion 71 WH	Identical to the battery used in the FieldFox analyzer
N9910X-872	External battery charger	
N9910X-875	DC car charger and adapter	

FieldFox with Ball Aerospace / Anokiwave Phased Array Antenna Control Diagram

Local point-to-point LAN connection

The minimum firmware version required to support the phased array control mode is A.11.26. The control communication with the antenna is over the LAN interface and static IP configuration is recommended for field use. Consult the N9928-90005 User's Guide if DHCP network connection is required.

Carry Precision with You

Every piece of gear in your field kit had to prove its worth. Measuring up and earning a spot is the driving idea behind Keysight's FieldFox analyzers. They're equipped to handle routine maintenance, in-depth troubleshooting and anything in between. Better yet, FieldFox delivers precise microwave and millimeter-wave measurements- wherever you need to go. Add FieldFox to your kit and carry precision with you.

Related Literature	Number
FieldFox Handheld Analyzers, B-Series Data Sheet	5992-3702EN
FieldFox Handheld Analyzers, B-Series Configuration Guide	5992-3701EN
FieldFox Handheld Analyzers, B-Series Technical Overview	5992-3703EN
FieldFox Handheld Analyzers, A-Series Data Sheet	5990-9783EN
FieldFox Handheld Analyzers, A-Series Configuration Guide	5990-9836EN
FieldFox Handheld Analyzers, A-Series Technical Overview	5992-0772EN
FieldFox and Phased Array Antenna User's Guide	N9928-90005

Download application notes, watch videos, and learn more: www.keysight.com/find/fieldfox

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

KEYSIGHT TECHNOLOGIES