CERTIFICATE #: 0214.19

Radio Test Report

Application for Grant of Equipment Authorization

FCC Part 24 and IC RSS-133
[1930MHz – 1990MHz]

FCC Part 27 and IC RSS-139
[2110MHz – 2180MHz]

FCC ID: VBNAHFIC-01
IC ID: 661W-AHFIC

Product Name: Airscale Base Transceiver Station Remote Radio Head
Model: AHFIC

Applicant: Nokia Solutions and Networks
6000 Connection Drive
Irving, TX 75039

Test Sites: Nokia Solutions and Networks
6000 Connection Drive
Irving, TX 75039
and
National Technical Systems – Plano
1701 E Plano Pkwy #150
Plano, TX 75074

Test Dates: March 16, 2018
Total Number of Pages: 155

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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	3/28/18	Initial Draft	Armando Del Angel
1	3/30/18	Correction by customer	

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SCOPE

Tests have been performed on Nokia Solutions and Networks product Airscale Base Station Remote Radio Head (RRH) Model AHFIC, pursuant to the relevant requirements of the following standard(s) to obtain device certification against the regulatory requirements of the Federal Communications Commission (FCC) and Innovation, Science and Economic Development Canada (ISED).

- Code of Federal Regulations (CFR) Title 47 Part 2
- (Radio Standards Specification) RSS-Gen Issue 4, November 2014
- CFR 47 Part 24 Subpart E – Broadband PCS
- RSS-133 Issue 6, January 2018 Amendment (2GHz Personal Communications Services)
- CFR Title 47 Part 27 Subpart C & L
- RSS-139 Issue 3- July 16, 2015 – Advanced Wireless Services (AWS)

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards:

ANSI C63.4-2014
ANSI TIA-603-D
FCC KDB 971168 D01 v02r02
TIA-102.CAAA-D

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant FCC and ISED requirements.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The test results recorded herein are based on a single type test of Nokia Solutions and Networks product Airscale Base Station Remote Radio Head (RRH) Model AHFIC and therefore apply only to the tested sample. The sample was selected and prepared by Hobert Smith and John Rattanavong of Nokia Solutions and Networks.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA and Canada, the device requires certification.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

Testing was performed only on Model AHFIC. No additional models were described or supplied for testing.

STATEMENT OF COMPLIANCE

The tested sample of Nokia Solutions and Networks product Airscale Base Transceiver Station Remote Radio Head (RRH) Model AHFIC complied with the requirements of the standards and frequency bands declared in the scope of this test report.

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS SUMMARY

The following tables provide a summary of the test results:

FCC Part 24 and IC RSS-133 (Base Stations Operating in the 1930MHz to 1990MHz Band)

AHFIC (Antenna Ports 5 – 8) operating in the PCS Band					
FCC	IC	Description	Measured	Limit	Results
Transmitter Modulation, output power and other characteristics					
24.229	RSS-133 Section 6.1	Frequency Ranges	LTE1.4: 1930.7 – 1989.3MHz LTE5: 1931.5 – 1988.5MHz LTE5: 1932.5 – 1987.5MHz LTE10: 1935.0 – 1985.0MHz LTE15: 1937.5 – 1982.5MHz LTE20: 1940.0 – 1980.0MHz	1930.0 – 1990.0MHz	Pass
2.1047	RSS-133 Section 6.2	Modulation Type	QPSK, 16QAM, 64QAM and 256QAM for LTE1.4, LTE3, LTE5, LTE10, LTE15 & LTE20	Digital	Pass
24.232	RSS-133 Section 6.4	Output Power	Highest Conducted Power Output RMS: 46.24dBm EIRP depends on antenna gain which is unknown	1640W EIRP	Pass
24.232	RSS-133 Section 6.4	Peak to Average Power Ratio	Highest Measured PAPR: 8.10dB	13dB	Pass
	RSS-133 Section 2.3	99% Emission Bandwidth	LTE1.4: 1.1155MHz LTE3: 2.7112MHz LTE5: 4.4943MHz LTE10: 8.9828MHz LTE15: 13.4792MHz LTE20: 17.9875MHz	Remain in Block	Pass
24.238		26dB down Emission Bandwidth	LTE1.4: 1.256MHz LTE3: 2.925MHz LTE5: 4.843MHz LTE10: 9.670MHz LTE15: 14.511MHz LTE20: 19.336MHz	Remain in Block	Pass
Transmitter Spurious Emissions[1]					
24.238	RSS-133 Section 6.5.1	At the antenna terminals	< -19dBm	-19dBm per Transmit Chain	Pass
		Field Strength	53.69dBuV/m at 3m Eq. to -41.506dBm EIRP	-13dBm EIRP	Pass
Other Details					
24.235	RSS-133	Frequency Stability	Stays within authorized frequency block (0.001ppm)	Stays within block +/- 1ppm	Pass
1.1310	RSS102	RF Exposure	N/A		Pass[2]

Note 1: Based on 1MHz RBW. In the 1MHz immediately outside and adjacent to the frequency block a RBW of at least 1% of the emission bandwidth was used. The measurement bandwidth is 1MHz for measurements more than 1MHz from the band edge.
Note 2: Applicant's declaration on a separate exh bit based on hypothetical antenna gains.

PCS Band Emission Designators								
Channel Bandwidth	LTE-QPSK		LTE-16QAM		LTE-64QAM		LTE-256QAM	
	FCC	IC	FCC	IC	FCC	IC	FCC	IC
1.4M	1M26F9W	1M12F9W	1M24F9W	1M11F9W	1M24F9W	1M11F9W	1M24F9W	1M11F9W
3M	2M92F9W	2M71F9W	2M93F9W	2M71F9W	2M92F9W	2M71F9W	2M92F9W	2M70F9W
5M	4M84F9W	4M49F9W	4M82F9W	4M48F9W	4M84F9W	4M49F9W	4M84F9W	4M49F9W
10M	9M66F9W	8M98F9W	9M64F9W	8M98F9W	9M67F9W	8M98F9W	9M64F9W	8M97F9W
15M	14M46F9W	13M47F9W	14M42F9W	13M48F9W	14M51F9W	13M47F9W	14M47F9W	13M46F9W
20M	19M29F9W	17M93F9W	19M24F9W	17M99F9W	19M32F9W	17M94F9W	19M34F9W	17M96F9W

Note: FCC based on 26dB emission bandwidth; IC based on 99% emission bandwidth.

FCC Part 27 Subpart C&L/IC RSS-139 (Base Stations Operating in the 2110 - 2180MHz Band)

AHFIC (Antenna Ports 1 – 4) operating in the AWS Band					
FCC	IC	Description	Measured	Limit	Results
Transmitter Modulation, output power and other characteristics					
27.5(h)&(j)	RSS-139 Sec 6.1	Frequency Ranges	LTE5: 2112.5 - 2177.5MHz LTE10: 2115.0 - 2175.0MHz LTE15: 2117.5 - 2172.5MHz LTE20: 2120.0 - 2170.0MHz	2110.0 – 2180.0MHz	Pass
2.1033(c)(4)	RSS-139 Sec 6.2	Modulation Type	QPSK, 16QAM, 64QAM and 256QAM for LTE5, LTE10, LTE15 & LTE20	Digital	Pass
27.50(d)(2)	RSS-139 Sec 6.5	Output Power	Highest Conducted Power Output RMS: 47.75dBm EIRP depends on antenna gain which is unknown	1640W EIRP	Pass
27.50(d)(5)	RSS-139 Sec 6.5	Peak to Average Power Ratio	Highest Measured PAPR: 8.06dB	13dB	Pass
	RSS-Gen Sec 6.6	99% Emission Bandwidth	LTE5: 4.4957MHz LTE10: 8.9979MHz LTE15: 13.4871MHz LTE20: 17.9888MHz	Remain in Block	Pass
27.53(h)(3)		26dB down Emission Bandwidth	LTE5: 4.848MHz LTE10: 9.676MHz LTE15: 14.481MHz LTE20: 19.350MHz	Remain in Block	Pass
Transmitter Spurious Emissions[1]					
27.53(h)	RSS-139 Sec 6.6	At the antenna terminals	< -19dBm	-19dBm per Transmit Chain	Pass
		Field strength	53.69dBuV/m at 3m Eq. to -41.506dBm EIRP	-13 dBm EIRP	Pass
Other Details					
27.54	RSS-139 Sec 6.4	Frequency Stability	Stays within authorized frequency block (0.001ppm)	Stays within block	Pass
1.1310	RSS102	RF Exposure	N/A		Pass[2]

Note 1: Based on 1MHz RBW. In the 1MHz immediately outside and adjacent to the frequency block a RBW of at least 1% of the emission bandwidth was used. The measurement bandwidth is 1MHz for measurements more than 1MHz from the band edge.
Note 2: Applicant's declaration on a separate exh bit based on hypothetical antenna gains.

AWS Band Emission Designators								
Channel Bandwidth	LTE-QPSK		LTE-16QAM		LTE-64QAM		LTE-256QAM	
	FCC	IC	FCC	IC	FCC	IC	FCC	IC
5M	4M84F9W	4M48F9W	4M82F9W	4M47F9W	4M85F9W	4M50F9W	4M84F9W	4M50F9W
10M	9M66F9W	8M98F9W	9M66F9W	9M00F9W	9M68F9W	8M99F9W	9M64F9W	8M98F9W
15M	14M47F9W	13M47F9W	14M44F9W	13M49F9W	14M48F9W	13M47F9W	14M48F9W	13M47F9W
20M	19M32F9W	17M93F9W	19M25F9W	17M99F9W	19M31F9W	17M94F9W	19M35F9W	17M95F9W

Note: FCC based on 26dB emission bandwidth; IC based on 99% emission bandwidth.

Extreme Conditions

Frequency stability is determined over extremes of temperature and voltage.

The extremes of voltage were 85 to 115 percent of the nominal value.

The extremes of temperature were -30°C to +50°C as specified in FCC §2.1055(a)(1).

Measurement Uncertainties

Measurement uncertainties of the test facility based on a 95% confidence level are as follows:

Test	**Uncertainty**
Radio frequency	± 0.2ppm
RF power conducted	±1.2 dB
RF power radiated	±3.3 dB
RF power density conducted	±1.2 dB
Spurious emissions conducted	±1.2 dB
Adjacent channel power	±0.4 dB
Spurious emissions radiated	±4 dB
Temperature	±1°C
Humidity	±1.6 %
Voltage (DC)	±0.2 %
Voltage (AC)	±0.3 %

EQUIPMENT UNDER TEST (EUT) DETAILS

General

The equipment under test (EUT) is a Nokia Solutions and Networks AirScale Base Transceiver Station (BTS) Remote Radio Head (RRH) module, model AHFIC. The AHFIC remote radio head is a multistandard multicarrier radio module designed to support LTE and narrow band IoT (internet of things) operations (in-band, guard band, standalone). The scope of testing in this effort is for LTE-FDD operations.

The AHFIC RRH has eight transmit/eight receive antenna ports (4TX/4RX for Band 2 and 4TX/4RX for Band 66a). Antenna ports 1-4 supports 3GPP frequency band 66a (BTS Rx: 1710 to 1780 MHz/BTS TX: 2110 to 2180 MHz). Antenna ports 5-8 supports 3GPP frequency band 2 (BTS Rx: 1850 to 1910 MHz/BTS TX: 1930 to 1990 MHz). The maximum RF output power of the RRH is 320 Watts (40 watts per carrier for Band 2, 60 watts per carrier for Band 66a). The maximum power output per antenna pair (1&5, 2&6, 3&7, 4&8) is 80 watts. The RRH can be operated as a 4x4 MIMO, 2x2 MIMO or as non-MIMO. The TX and RX instantaneous bandwidth cover the full operational RRH bandwidth. The RRH supports 1.4, 3, 5, 10, 15, and 20MHz LTE bandwidths for Band 2. The RRH supports 5, 10, 15, and 20MHz LTE bandwidths for Band 66a. The RRH supports four LTE downlink modulation types (QPSK, 16QAM, 64QAM and 256QAM). Multi-carrier operation is supported.

The RRH has external interfaces including DC power (DC In), ground, transmit/receive (ANT), external alarm (EAC), optical CPRI (OPT) and remote electrical tilt (RET). The RRH with applicable installation kit may be pole or wall mounted. The RRH may be configured with optional cooling fan.

The AHFIC LTE channel numbers and frequencies are as follows:

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth					
			1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
AHFIC PCS Band (Ant 5, 6, 7, 8)	600	1930.0	Band Edge	Band Edge	Band Edge	Band Edge	Band Edge	Band Edge
	.....							
	607	1930.7	Bottom Ch					
	.....							
	615	1931.5		Bottom Ch				
	.....							
	625	1932.5			Bottom Ch			
	.....							
	650	1935.0				Bottom Ch		
	.....							
	675	1937.5					Bottom Ch	
	.....							
	700	1940.0						Bottom Ch
	.....							
	900	1960.0	Middle Ch	Middle Ch	Middle Ch	Middle Ch	Middle Ch	Middle Ch
	.....							
	1100	1980.0						Top Channel
	.....							
	1125	1982.5					Top Channel	
	.....							
	1150	1985.0				Top Channel		
	.....							
	1175	1987.5			Top Channel			
	.....							
	1185	1988.5		Top Channel				
	.....							
	1193	1989.3	Top Channel					
	.....							
	1200	1990.0	Band Edge	Band Edge	Band Edge	Band Edge	Band Edge	Band Edge

AHFIC Downlink Band Edge LTE Band 2 Frequency Channels

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth			
			5 MHz	10 MHz	15 MHz	20 MHz
AHFIC AWS Band on Ant 1, 2, 3 and 4	66436	2110.0	Band Edge	Band Edge	Band Edge	Band Edge
	.....					
	66461	2112.5	Bottom Ch			
	.....					
	66486	2115.0		Bottom Ch		
	.....					
	66511	2117.5			Bottom Ch	
	.....					
	66536	2120.0				Bottom Ch
	.....					
	66786	2145.0	Middle Ch	Middle Ch	Middle Ch	Middle Ch
	.....					
	67036	2170.0				Top Channel
	.....					
	67061	2172.5			Top Channel	
	.....					
	67086	2175.0		Top Channel		
	.....					
	67111	2177.5	Top Channel			
	.....					
	67136	2180.0	Band Edge	Band Edge	Band Edge	Band Edge

AHFIC Downlink Band Edge LTE Band 66a Frequency Channels

EUT Hardware

The EUT hardware used in testing on March 16, 2018.

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	AHFIC	AirScale BTS RRH	Part#: 474239A.101 Serial#: K9180317594	FCC ID: VBNAHFIC-01 IC ID: 661W-AHFIC

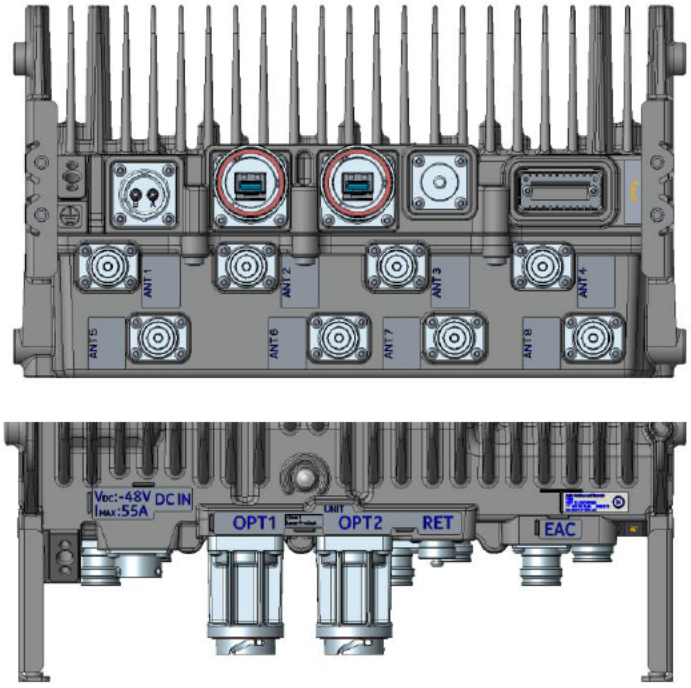
Support Equipment

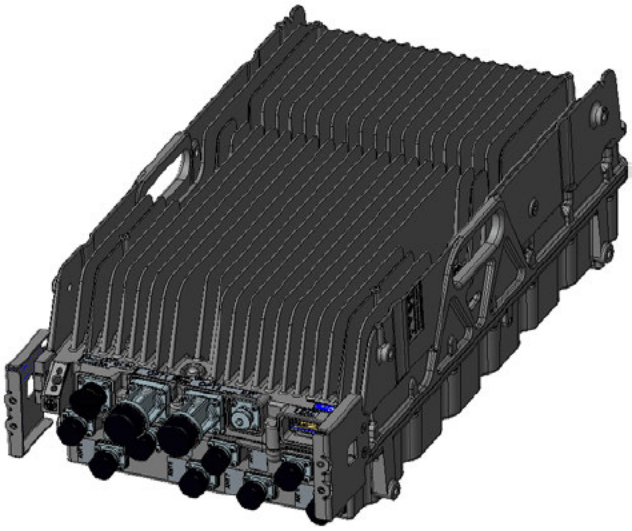
Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	AMIA	Airscale System Module	Part#: 473098A.101 Serial#: RK164201509	N/A
HP	Elite Book 6930p	Laptop PC	N/A	N/A
Dell	Studio XPS	Instrumentation PC	N/A	N/A

Auxillary Equipment

Company	Description	Part Number	Serial Number
Nokia	FOUC 10GHz SFP Module (Plugs into RRH Opt Ports)	473842A.101	KR16180020006
RLC Electronics	2.5GHz High Pass Filter[1]	F-100-3000-5-R	0028
Microwave Circuits	1400MHz Low Pass Filter[1]	L13502G1	2454-01
Weinschel	Attenuator 40dB-250 Watt[1]	58-40-43-LIM	TC909
Weinschel	Attenuator 20dB-150 Watt[1]	66-20-33	BZ2075
Weinschel	Attenuator 10dB-100 Watt[1]	48-10-34-LIM	BJ1771
Weinschel	Attenuator 3dB-100 Watt[1]	47-3-33	CG5493
Narda	Attenuator 30dB-50 Watt[1]	7768-30	-
Huber & Suhner	RF Cable – 0.5 meter[1]	Sucoflex 104	553624/4
Huber & Suhner	RF Cable - 1 meter[1]	Sucoflex 106	297370
Note 1: Used only in antenna port RF conducted emission testing.			

AHFIC Connector Layout:





EUT External Interfaces

Name	Qty	Connector Type	Purpose (and Description)
DC In	1	Quick Disconnect	2-pole Power Circular Connector
GND	1	Screw lug (2xM5/1xM8)	Ground
ANT	8	4.3-10	RF signal for Transmitter/Receiver (50 Ohm)
Unit	1	LED	Unit Status LED
EAC	1	MDR26	External Alarm Interface (4 alarms)
OPT	2	SFP+ cage	Optical CPRI Interface up to 10 Gps.
RET	1	8-pin circular connector conforming to IEC 60130-9 – Ed.3.0	AISG 2.0 to external devices
Fan	1	Molex Microfit	Power for RRH Fan. Located on the side of RRH.

EUT Interface Ports

The I/O cabling configuration during testing was as follows:

Cable	Type	Shield	Length	Used in Test	Quantity	Termination
Power Input	Power	No	~ 3 m	Yes	1	Power Supply
Earth	Earth	No	~ 1 m	Yes	1	Lab earth ground
Antenna	RF	Yes	~ 3 m	Yes	8	50Ω Loads
External Alarm	Signal	Yes	~ 3 m	Yes	1	Un-terminated
Remote Electrical Tilt	Signal	Yes	~ 3 m	Yes	1	Un-terminated
Multimode Optical	Optical	No	>6 m	Yes	1	System Module

EUT Operation

During testing, the EUT was transmitting continuously with 100% duty-cycle at full power on all chains.

EUT Software

The laptop PC connects to the System Module over the LMP (Ethernet) port. The system module controls the RRH via the optical (CPRI) interface. The laptop is used for changing configuration settings, monitoring tests and controlling the BTS. The following software versions are used for the testing:

(1) RRH Unit Software: FRM58.02.R03F
(2) System Module Software: FL18_ENB_0000_000620_000000
(3) BTS Site Manager: BTSSiteEM-FL18-0000_000410_000000

Modifications

No modifications were made to the EUT during testing.

TESTING

General Information

Antenna port measurements were taken with NTS personnel (Jose Mendez) at Nokia premises located at 6000 Connection Drive; Irving, Texas 75309.

Radiated emissions and frequency accuracy/stability measurements were taken at NTS Plano branch, an ISO 17025 accredited laboratory, located at 1701 E Plano Pkwy #150 Plano, TX 75074.

Radiated spurious emissions measurements were taken at the NTS Plano Anechoic Chamber listed below. The sites conform to the requirements of ANSI C63.4-2014: "*American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" and CISPR 16-1-4:2010-04: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus* – Antennas and test sites for radiated disturbance measurements". They are on file with the FCC and Industry Canada.

Site	Registration Numbers		Location
	FCC	Canada	
Chamber 1	A2LA Accredited Designation Number US1077	IC 4319A-2	1701 E Plano Pkwy #150 Plano, TX 75074.

Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements.

Measurement Procedures

The output power, emission bandwidth, conducted spurious and conducted band edge measurements were performed with a spectrum analyzer. The carrier frequency accuracy/stability measurements were performed with a LTE signal analyzer. The EUT was operated at maximum RF output power for all tests. While measuring one transmit chain, the others were terminated with termination blocks. All measurements were corrected for the insertion loss of the RF network (attenuators, filters, and cables) inserted between the RF port of the EUT and the spectrum analyzer. Block diagrams and photographs of the test setups are provided below.

The 26dB emission bandwidth was measured in accordance with Section 4.1 of FCC KDB 971168 D01 v02r02. The 99% occupied bandwidth was measured in accordance with Section 6.6 of RSS-Gen Issue 4. For both measurements, an occupied bandwidth built-in function in the spectrum analyzer was used and Keysight Benchvue Software was used to capture the spectrum analyzer screenshots. Spectrum analyzer settings are shown on their corresponding plots in test results section.

The emissions at the band edges were captured with Keysight Benchvue Software with settings described in the corresponding sections of the FCC and IC regulatory requirements. Spectrum analyzer settings are shown on their corresponding plots in test results section.

Peak and average output power measurements were performed in accordance with FCC KDB 971168 D01 v02r02. Measurements were performed with the built-in power meter function found in the spectrum analyzer and the screenshots were captured using Keysight Benchvue Software.
Peak to average power ratio (PAPR) was calculated in accordance with Section 5.7.2 of FCC KDB 971168 D01 v02r02. Spectrum analyzer settings are shown on their corresponding plots in test results section.

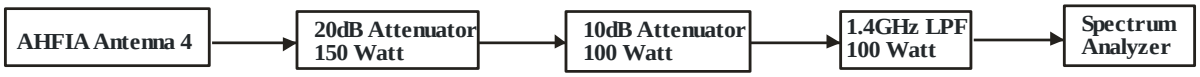
Conducted spurious emissions were captured with Keysight Benchvue Software across the 9kHz-22GHz frequency span. A low pass was used to reduce measurement instrumentation noise floor for the frequency ranges less than 20MHz. A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 6GHz.The total measurement RF path loss of the test setup (attenuators, low pass filter, high pass filter and test cables) were accounted for by the spectrum analyzer reference level offset. Spectrum analyzer settings are described in the corresponding test result section.

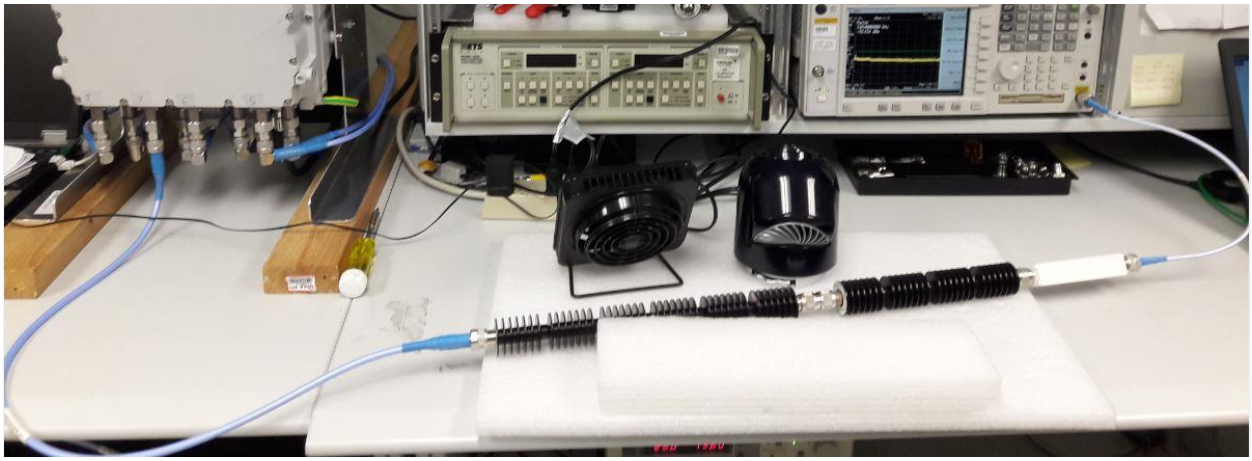
For frequency stability/accuracy measurements, the EUT was placed inside a temperature chamber with all support and test equipment located outside of the chamber. Temperature was varied across the specified range in 10 degree increments and EUT was allowed enough time to stabilize at each temperature step (a minimum of 30 minutes per step). The input voltage was varied as required by FCC/IC regulatory requirements. An LTE signal analyzer as detailed in the test equipment section was used for frequency stability/accuracy measurements.

Transmitter radiated spurious emissions measurements were made in accordance with ANSI C63.4-2014 by measuring the field strength of the emissions from the device at 3m test distance for emissions below 10 GHz and at 1m test distance for emissions above 10 GHz. The eirp limit as specified in the relevant rule part(s) is converted to a field strength at the test distance and the emissions from the EUT are then compared to that limit. Only emissions within 20dB of this limit are subjected to a substitution measurement in accordance with TIA-603. Both preliminary and final measurements were performed at the same FCC listed test chamber. Preliminary scans were performed with TILE6 software. This software corrected the measurements for antenna factors, cable losses and pre-amplifier gains. Both polarizations of the receiving antenna were scanned from 30MHz to 22GHz with a peak detector (RBW=1MHz, VBW=3MHz, with trace max hold over multiple sweeps). Based on the preliminary scan results, frequencies of interest have been maximized via rotating the EUT 360 degrees and varying the height of the test antenna (1m to 4m). Final measurements were also taken with the peak detector as described above. A biconilog antenna was used for 30MHz-1GHz range. A double ridged waveguide horn antenna was used for 1-18GHz range and a smaller horn antenna was used for 18-22GHz range. The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. EUT was placed on a non-conductive RF transparent structure to provide 80cm height from the ground floor. A motorized turntable allowed it to be rotated during testing to determine the angle with the highest level of emissions.

Antenna Port Conducted RF Measurement Test Setup Diagrams

The following setups were used in the RF conducted emissions testing. Photographs of the test setups are also provided.

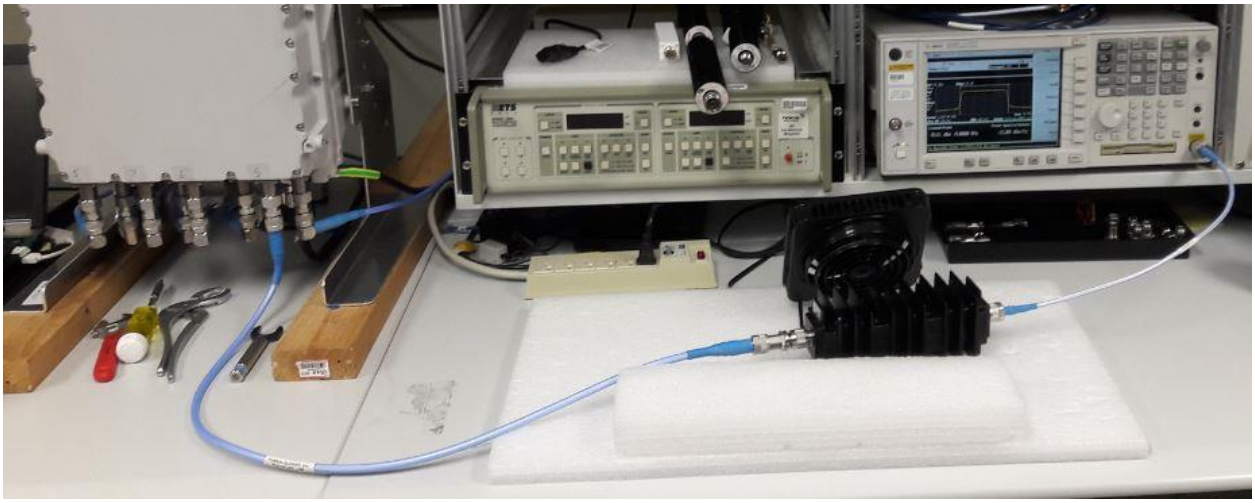




Setup for 9kHz to 150kHz and 150kHz to 20MHz Measurements

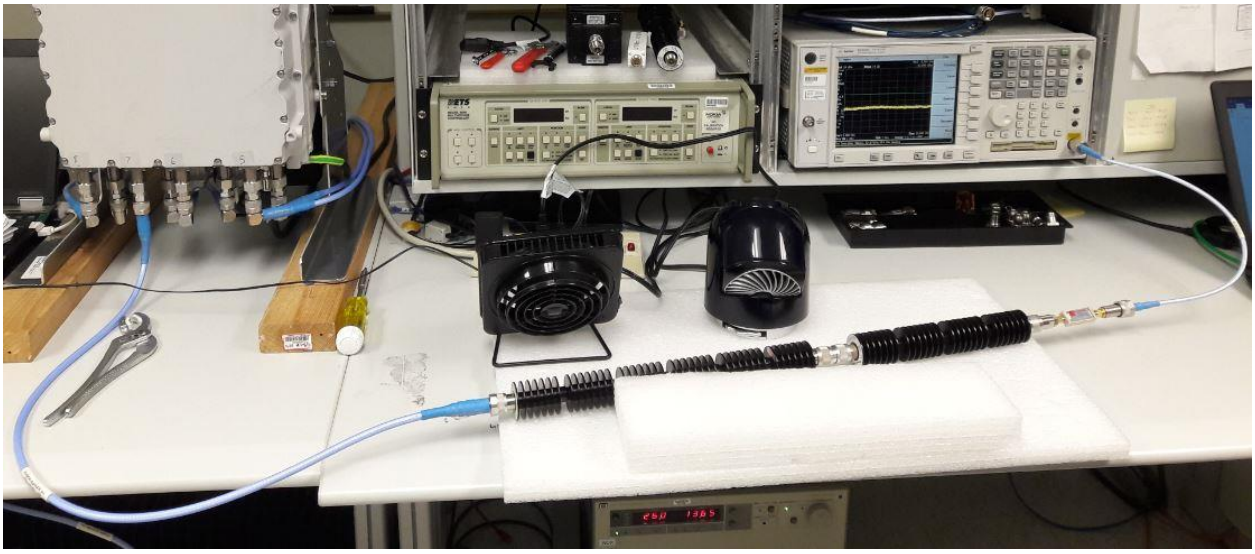
Photograph of 9kHz to 150kHz and 150kHz to 20MHz Test Setup

Setup for 20MHz to 3GHz and 3GHz to 6GHz Measurements

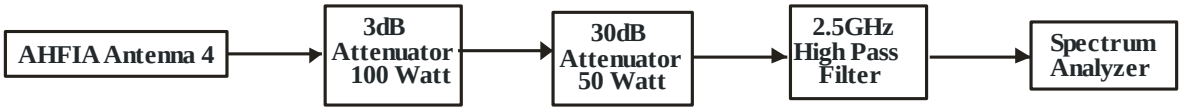


Photograph of 20MHz to 3GHz and 3GHz to 6GHz Test Setup

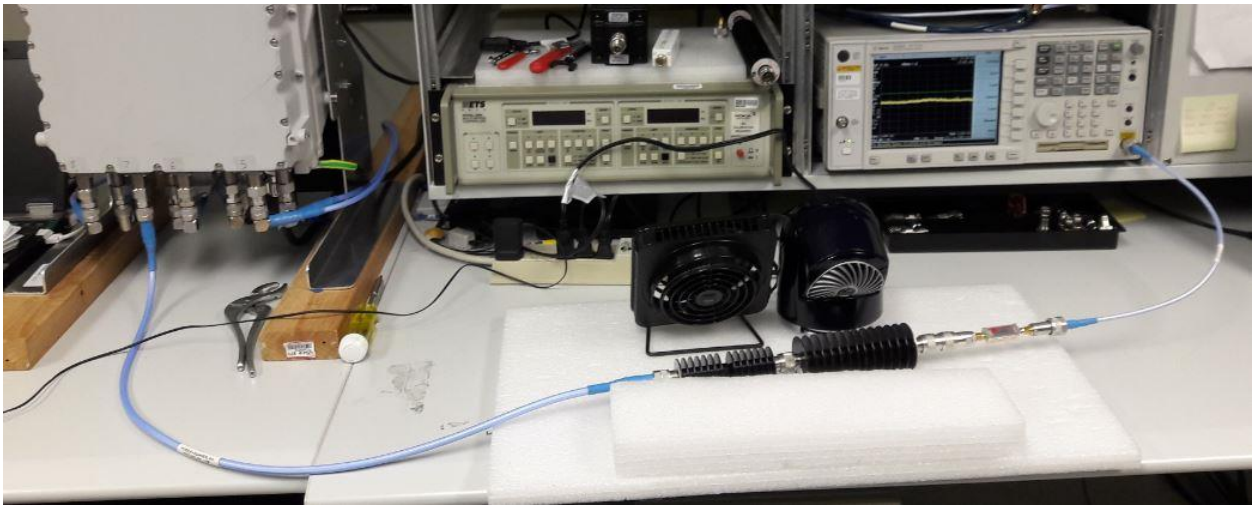
Setup for 6GHz to 10GHz, 10GHz to 14GHz and 14GHz to 18GHz Measurements



Photograph of 6GHz to 10GHz, 10GHz to 14GHz and 14GHz to 18GHz Test Setup



Setup for 18GHz to 22GHz Measurements



Photograph of 18GHz to 22GHz Test Setup

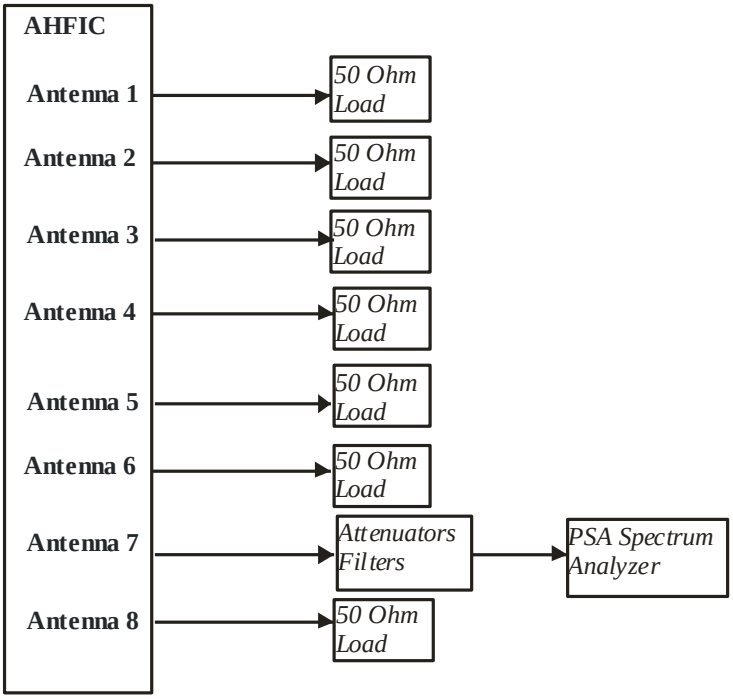
Test Measurement Equipment

NTS Equipment #	Description	Manufacturer	Model	Calibration Duration	Calibration Due Date
ENV1195P	Climatic Chamber	Thermotron	SE-300-2-2	N/A	NCR
E1529P	PSA	Agilent	E4446A	12 Months	4/16/2018
E1260P	PreAmp (1GHz-18GHz)	MITEQ	AFS44-01001800-45-10P-44	12 Months	5/1/2018
E1365P	PreAmp (30MHz-1GHz)	MITEQ	AM-1431-N-1197SC	12 Months	5/14/2018
E1289P	Biconilog Antenna (30MHz-1GHz)	ETS Lindgren	3142C	12 Months	4/21/2018
E1149P	Horn Antenna (1GHz-18GHz)	EMCO	3115	12 Months	3/24/2018
E1068P	Horn Antenna (18GHz-40GHz)	EMCO	3116	12 Months	11/15/2018
E1447P	RMS Multimeter	Fluke	87V	12 Months	7/5/2018
ENV1035P	Thermometer	Fluke	52 II	12 Months	4/13/2018
120194[1]	PSA Spectrum Analyzer	Agilent	E4440A	12 Months	10/25/2018
NM06345[1]	ENA Network Analyzer	Keysight	E5063A	12 Months	11/20/2018
NM04509[1]	Network Analyzer	Rohde & Schwarz	ZVL 3	12 Months	02/03/2019
NM06374[1]	MXG Analog Signal Gen	Keysight	N5183B	36 Months	02/04/2021
NM04508[2]	MXA Signal Analyzer	Agilent	N9020A	24 Months	5/2/2019

Note 1: Customer equipment used in antenna port RF conducted emission testing.
Note 2: Customer equipment used in LTE frequency accuracy/stability measurements.

APPENDIX A: ANTENNA PORT TEST DATA FOR THE PCS BAND

All conducted RF measurements in this section were made at AHFIC antenna ports 5 through 8. The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on AHFIC

RF Output Power

RF output power has been measured in both Peak and RMS Average terms for each PCS transmit chain at the middle channel for 256QAM modulation and LTE5 bandwidth. Peak to average power ratio (PAPR) has been calculated as described in Section 5.7.2 of KDB971168 D01 v02r02 and all results are presented in tabular form below.

Antenna	LTE Bandwidth	LTE - 256QAM		
		Peak (dBm)	Average (dBm)	PAPR (dB)
Port 5 Middle Channel	5M	53.69	45.92	7.77
Port 6 Middle Channel	5M	53.67	45.92	7.75
Port 7 Middle Channel	5M	53.75	46.02	7.73
Port 8 Middle Channel	5M	53.69	45.97	7.72

The variation in RMS output power levels between the antenna ports is 0.10 dB per data sample provided above. Pre-compliance testing (and testing of similar EUTs) shows that the output power variation between antenna ports is small (the output ports are essentially electrically identical). The highest power port was selected as the worst case.

Pre-compliance testing has shown that the output power variation between modulation types is small. Antenna port 7 power output measurements for the LTE5 bandwidth for all modulation types on the middle (center) channel are provided below.

	Modulation Type							
	QPSK		16QAM		64QAM		256QAM	
	Peak (dBm)	Ave (dBm)	Peak (dBm)	Ave (dBm)	Peak (dBm)	Ave (dBm)	Peak (dBm)	Ave (dBm)
Antenna Port 7 Middle Channel LTE5	53.73	46.03	53.67	46.05	53.75	46.05	53.75	46.02

The output power variation between modulation types is small in this measurement snapshot (and from past efforts on similar hardware as well). The variation of average power output versus modulation type is 0.03dB for the data snapshot provided. The variation of peak power output versus modulation type is 0.08dB for the data snapshot provided. All power measurements in this report (except the sample test noted above) were performed with the EUT operating with 256QAM modulation.

Based on the results above, Port 7 had the highest RMS average power for the PCS band (represents the worst case) and therefore it was selected for all the remaining antenna port tests.
Subsequently output power levels on bottom, middle, and top channels in all 6 LTE channel bandwidths using 256QAM modulation type were tested only at Port 7 and the results presented below. The highest measured values are highlighted.

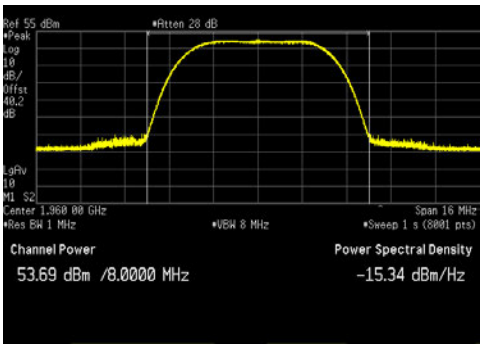
Antenna LTE Channel	LTE Bandwidth	LTE - 256QAM		
		Peak (dBm)	Ave (dBm)	PAPR (dB)
Port 7 Bottom Channel	1.4M	52.47	45.54	6.93
	3M	52.84	45.76	7.08
	5M	53.14	45.75	7.39
	10M	54.03	46.10	7.93
	15M	53.53	45.91	7.62
	20M	53.77	45.97	7.80
Port 7 Middle Channel	1.4M	53.10	46.02	7.08
	3M	53.42	45.90	7.52
	5M	53.75	46.02	7.73
	10M	53.89	46.03	7.86
	15M	53.95	46.04	7.91
	20M	53.87	45.98	7.89
Port 7 Top Channel	1.4M	53.24	46.07	7.17
	3M	53.62	46.00	7.62
	5M	54.00	46.16	7.84
	10M	**54.28**	**46.24**	8.04
	15M	54.10	46.07	8.03
	20M	54.14	46.04	**8.10**

The data provided in the table shows (and testing of similar EUTs) that the output RMS power variation between channel bandwidths at the center frequency channel is small (0.14dB).

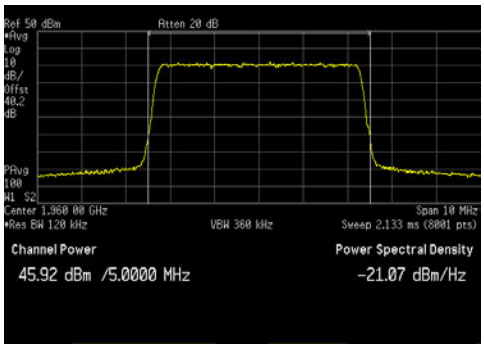
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

LTE5 Channel Power Plots at Middle Channel and 256QAM Modulation:

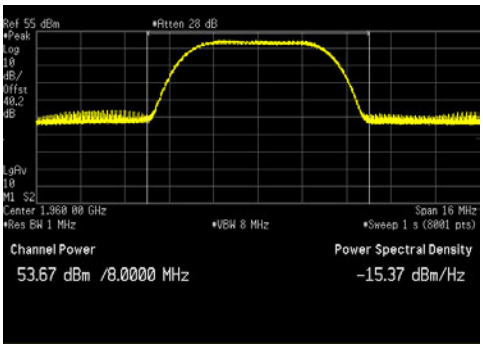
Port 5 - LTE5_ Middle Channel_Peak



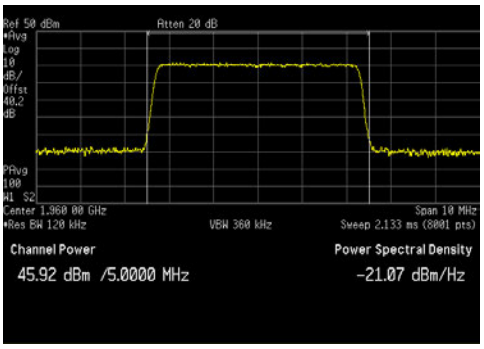
Port 5 - LTE5_ Middle Channel_Average



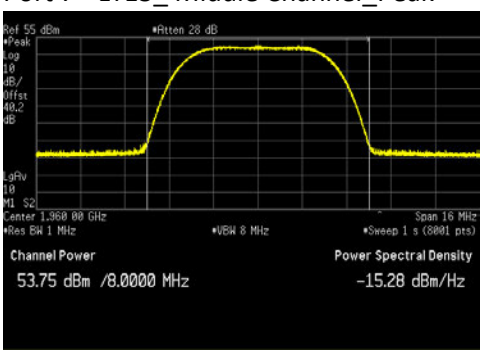
Port 6 - LTE5_Middle Channel_Peak



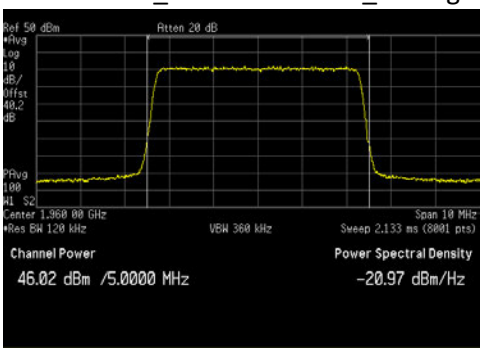
Port 6 - LTE5_Middle Channel_Average



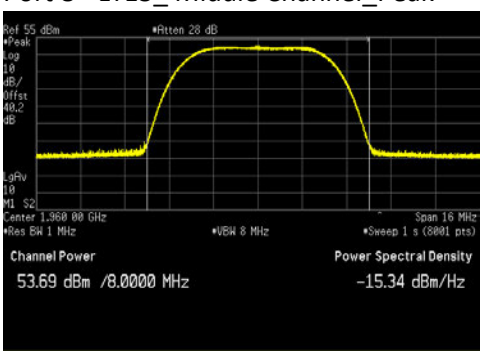
Port 7 - LTE5_ Middle Channel_Peak



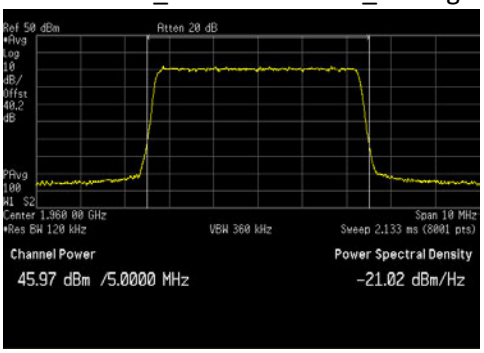
Port 7 - LTE5_ Middle Channel_Average



Port 8 - LTE5_ Middle Channel_Peak

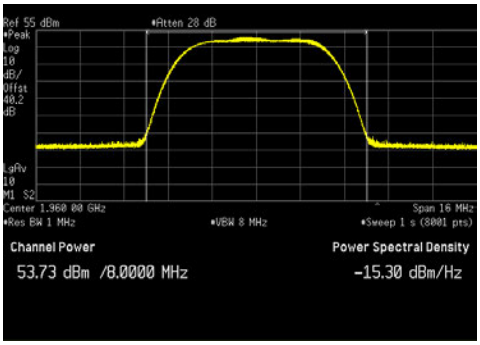


Port 8 - LTE5_ Middle Channel_Average

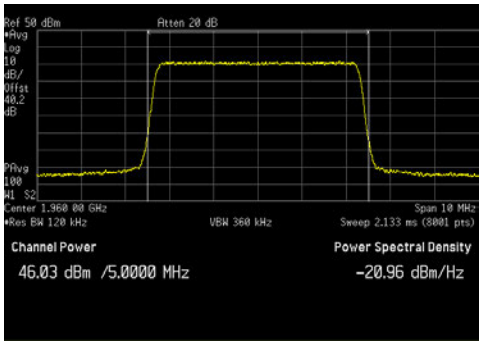


LTE5 Channel Power Plots for Antenna Port 7 at Middle Channel and all Modulation Types:

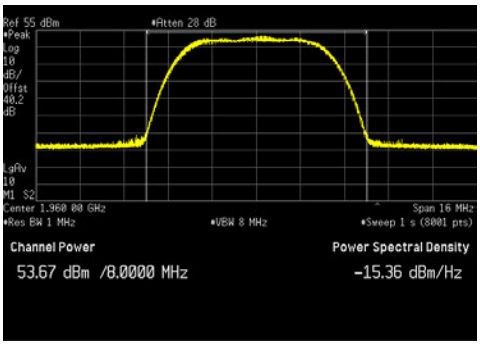
LTE5_ Middle Channel_QPSK_Peak



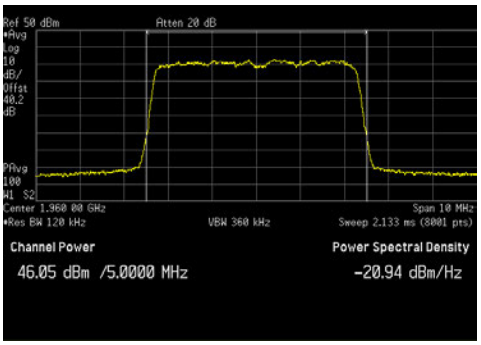
LTE5_ Middle Channel_QPSK_Average



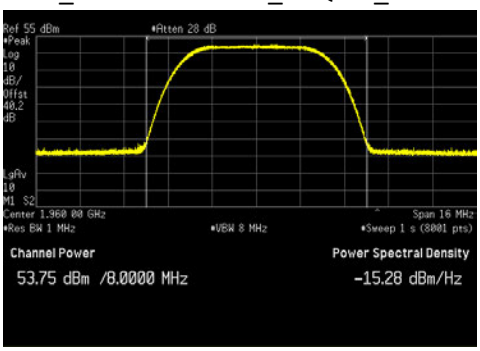
LTE5_Middle Channel_16QAM_Peak



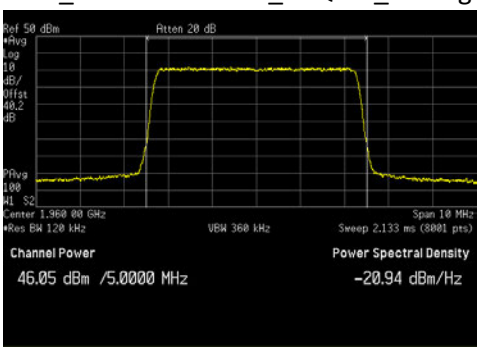
LTE5_Middle Channel_16QAM_Average



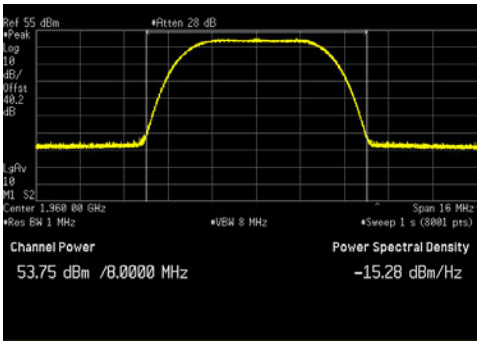
LTE5_ Middle Channel_64QAM_Peak



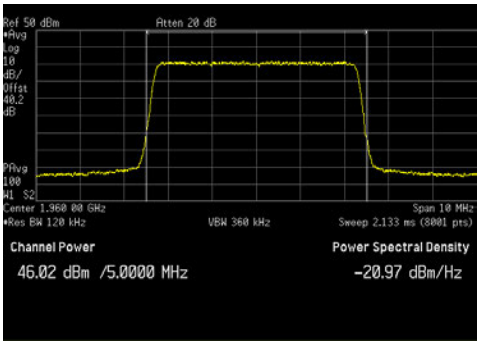
LTE5_ Middle Channel_64QAM_Average



LTE5_ Middle Channel_256QAM_Peak

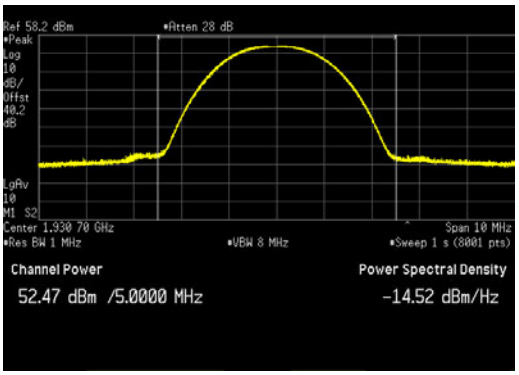


LTE5_ Middle Channel_256QAM_Average

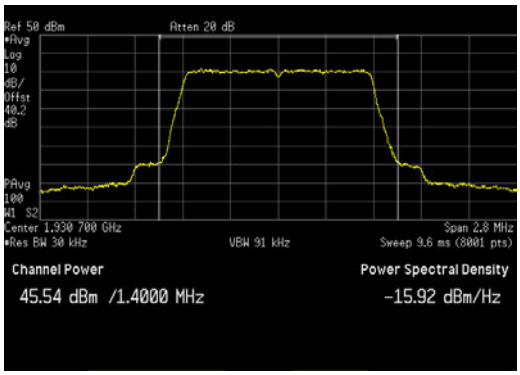


LTE1.4 Channel Power Plots for Antenna Port 7 and 256QAM Modulation:

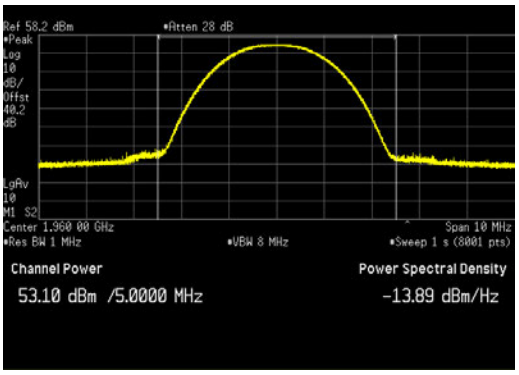
LTE1.4_Bottom Channel_Peak



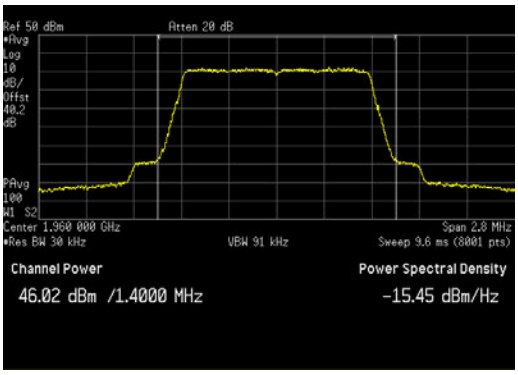
LTE1.4_Bottom Channel_Average



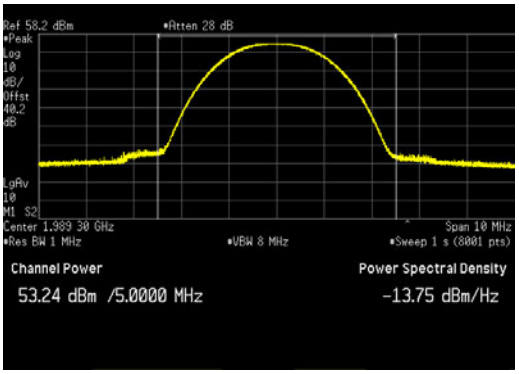
LTE1.4_Middle Channel_Peak



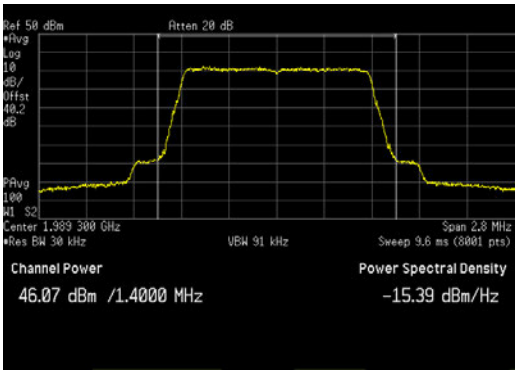
LTE1.4_Middle Channel_Average



LTE1.4_Top Channel_Peak

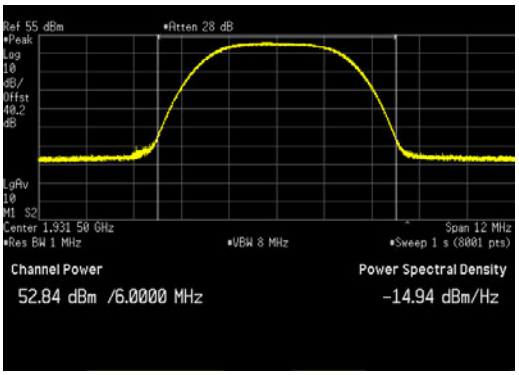


LTE1.4_Top Channel_Average

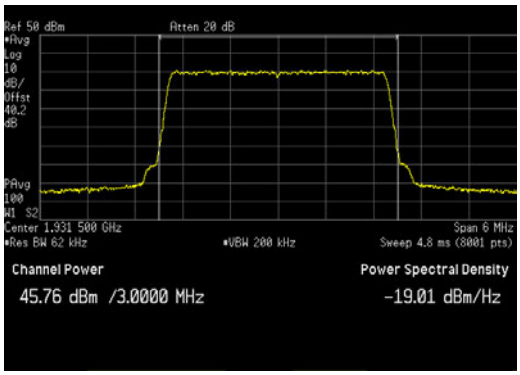


LTE3 Channel Power Plots for Antenna Port 7 and 256QAM Modulation:

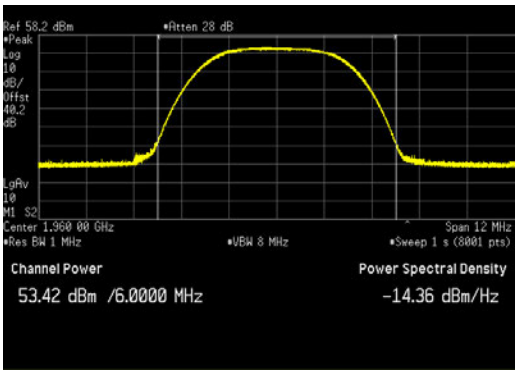
LTE3_Bottom Channel_Peak



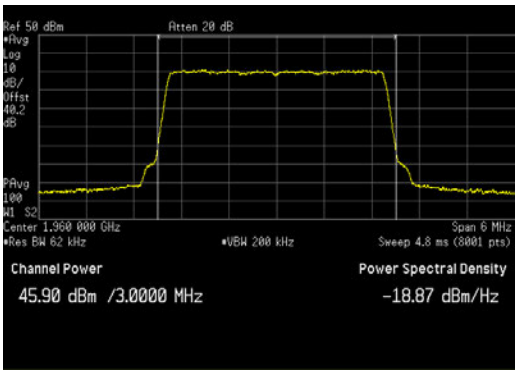
LTE3_Bottom Channel_Average



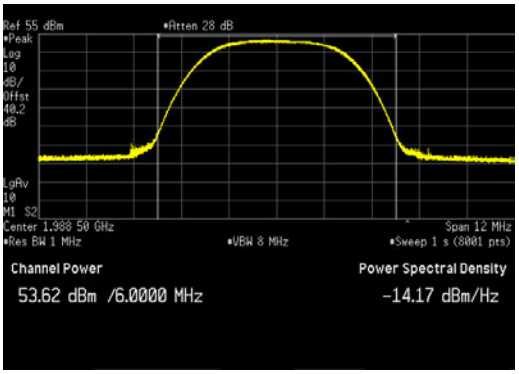
LTE3_Middle Channel_Peak



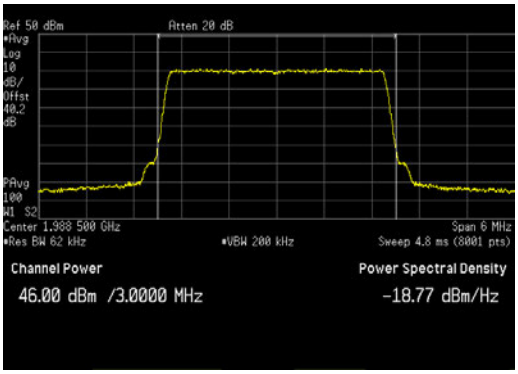
LTE3_Middle Channel_Average



LTE3_Top Channel_Peak

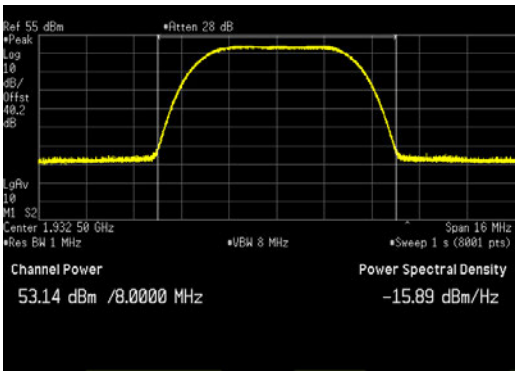


LTE3_Top Channel_Average

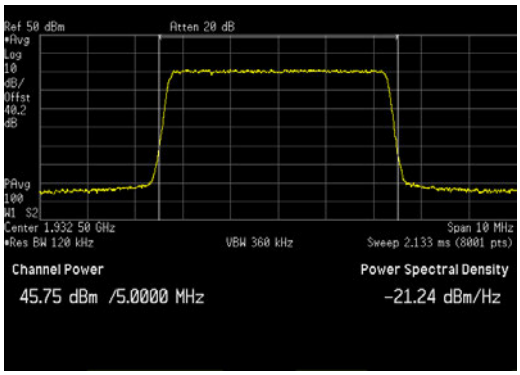


LTE5 Channel Power Plots for Antenna Port 7 and 256QAM Modulation:

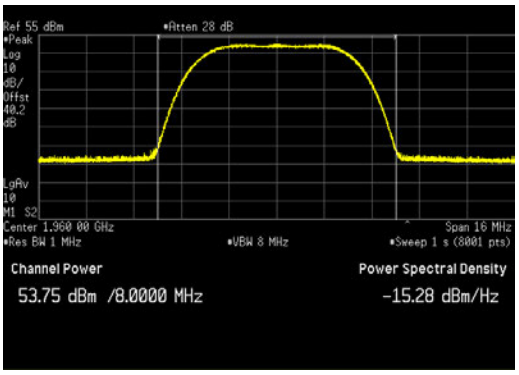
LTE5_Bottom Channel_Peak



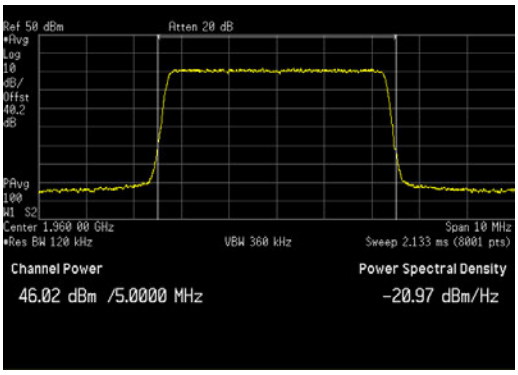
LTE5_Bottom Channel_Average



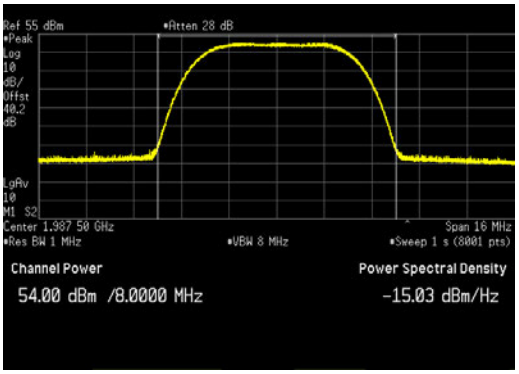
LTE5_Middle Channel_Peak



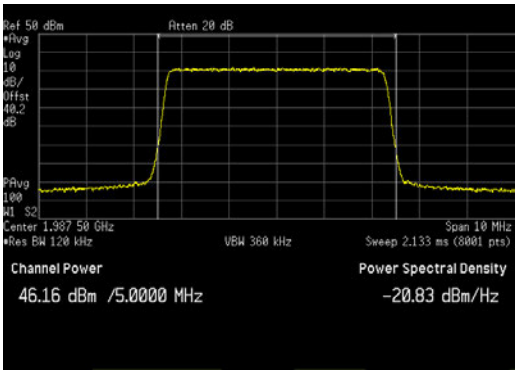
LTE5_Middle Channel_Average



LTE5_Top Channel_Peak

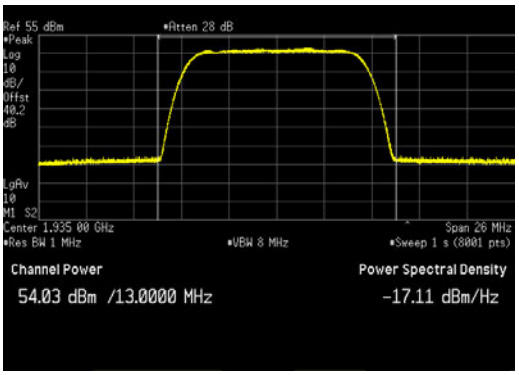


LTE5_Top Channel_Average

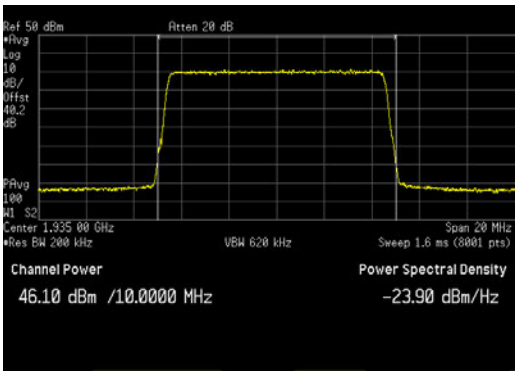


LTE10 Channel Power Plots for Antenna Port 7 and 256QAM Modulation:

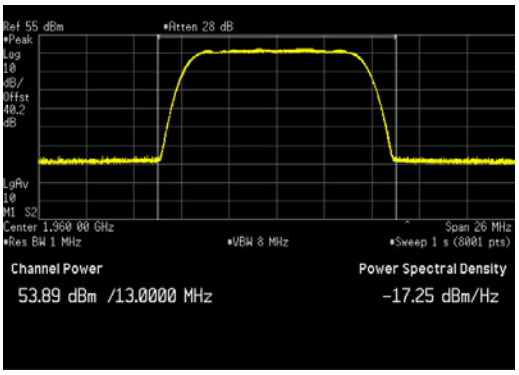
LTE10_Bottom Channel_Peak



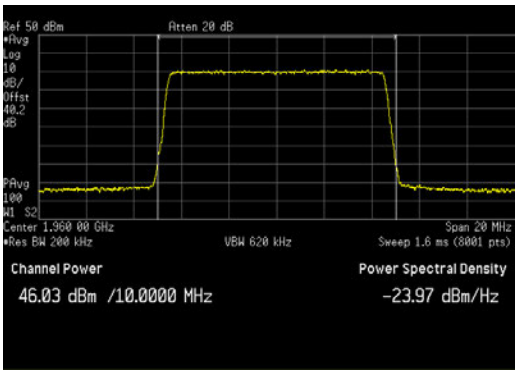
LTE10_Bottom Channel_Average



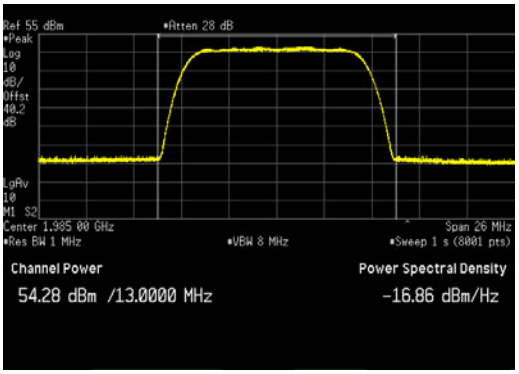
LTE10_Middle Channel_Peak



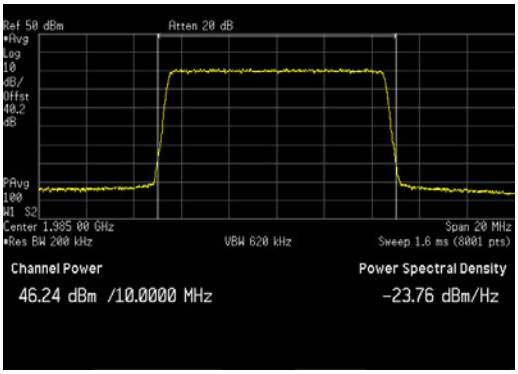
LTE10_Middle Channel_Average



LTE10_Top Channel_Peak

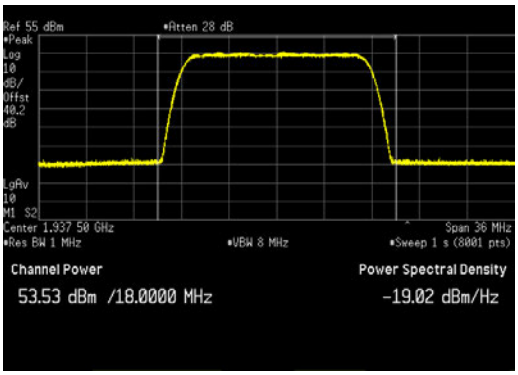


LTE10_Top Channel_Average

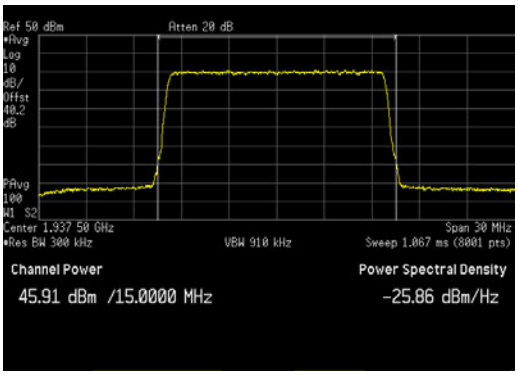


LTE15 Channel Power Plots for Antenna Port 7 and 256QAM Modulation:

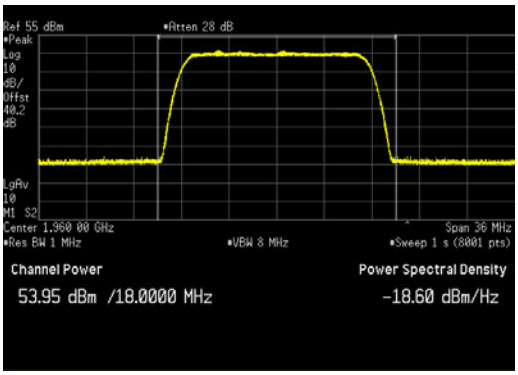
LTE15_Bottom Channel_Peak



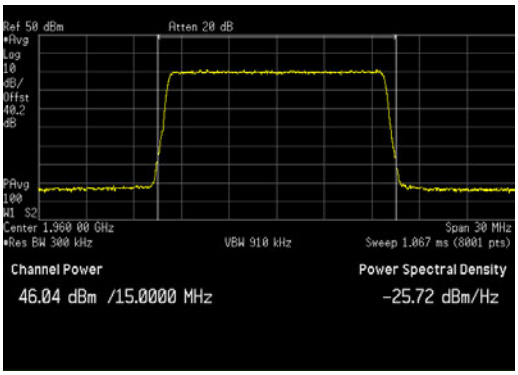
LTE15_Bottom Channel_Average



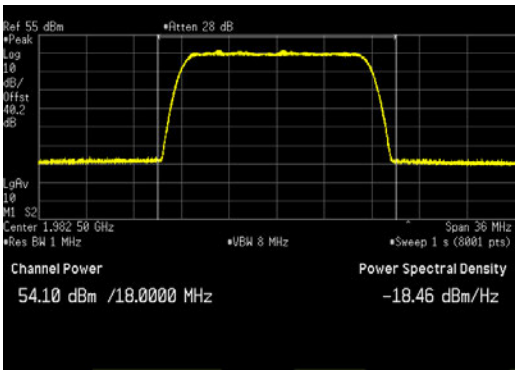
LTE15_Middle Channel_Peak



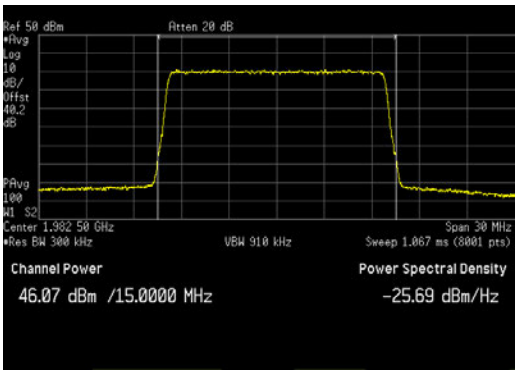
LTE15_Middle Channel_Average



LTE15_Top Channel_Peak

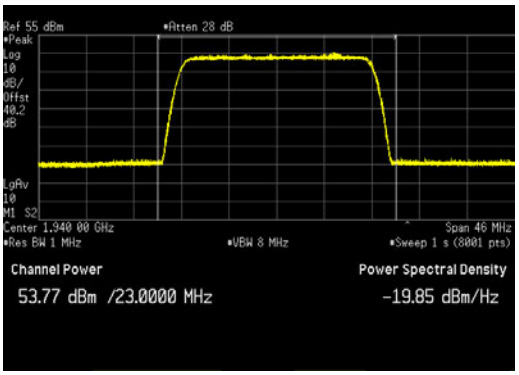


LTE15_Top Channel_Average

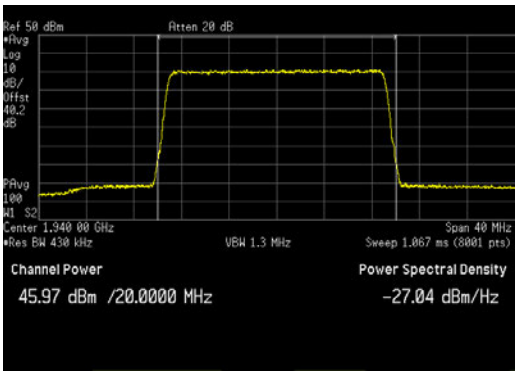


LTE20 Channel Power Plots for Antenna Port 7 and 256QAM Modulation:

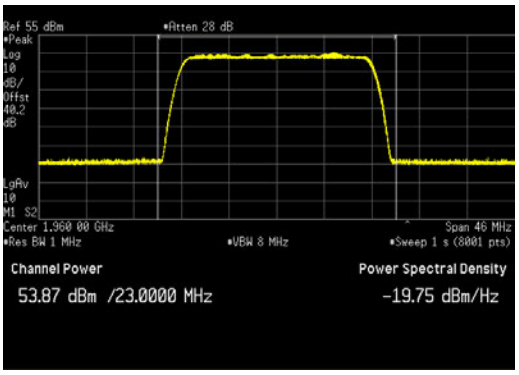
LTE20_Bottom Channel_Peak



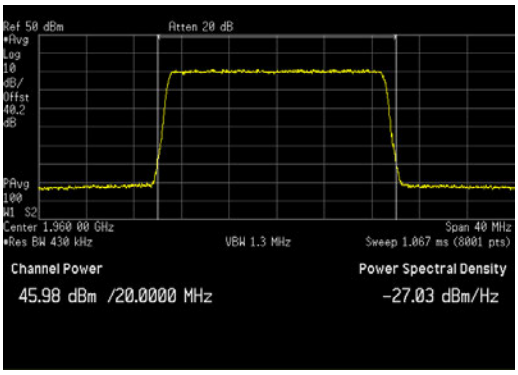
LTE20_Bottom Channel_Average



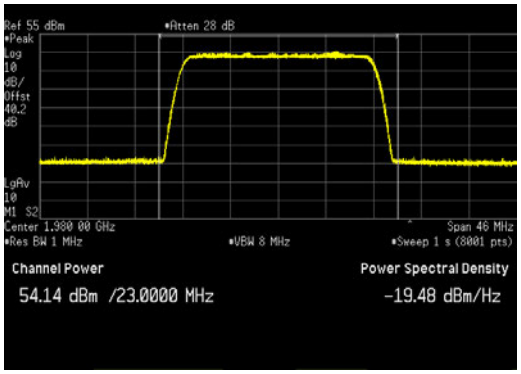
LTE20_Middle Channel_Peak



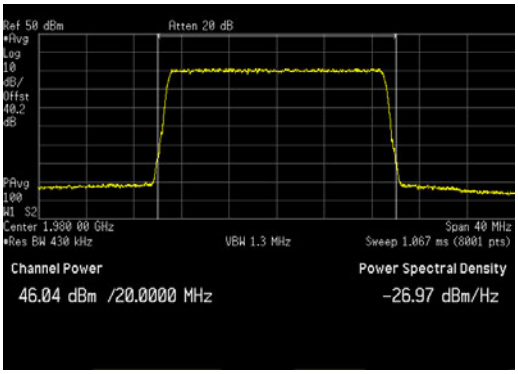
LTE20_Middle Channel_Average



LTE20_Top Channel_Peak



LTE20_Top Channel_Average



Emission Bandwidth (26 dB down and 99%)

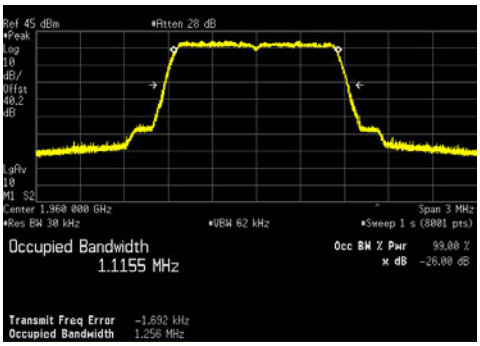
Emission bandwidth measurements were made at antenna port 7 on the middle channel with maximum RF output power. All available LTE modulations (QPSK, 16QAM, 64QAM, 256QAM) were used. All available LTE channel bandwidths (1.4MHz, 3MHz, 5MHz, 10MHz, 15MHz, and 20MHz) were used. The results are provided in the following table. The largest emission bandwidths in each channel type are highlighted.

LTE Ch BW	Modulation Type							
	QPSK		16QAM		64QAM		256QAM	
	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)
1.4M	**1.256**	**1.1155**	1.237	1.1056	1.239	1.1069	1.243	1.1061
3M	2.920	2.7082	**2.925**	2.7068	2.921	**2.7112**	2.924	2.7040
5M	4.838	4.4862	4.819	4.4794	4.842	**4.4943**	**4.843**	**4.4943**
10M	9.655	8.9766	9.643	8.9822	**9.670**	**8.9828**	9.637	8.9737
15M	14.457	13.4672	14.424	**13.4792**	**14.511**	13.4690	14.468	13.4598
20M	19.289	17.9328	19.236	**17.9875**	19.316	17.9417	**19.336**	17.9610

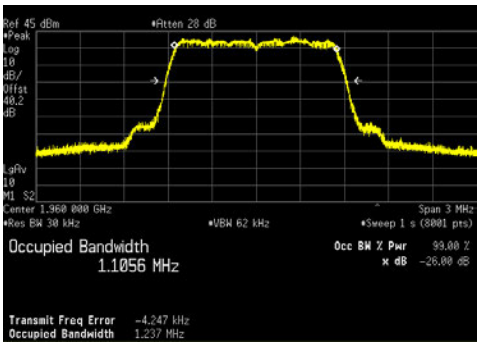
Emission bandwidth measurement data are provided in the following pages.

LTE1.4 and LTE3 Emission Bandwidth Plots on the Middle Channel for Antenna Port 7:

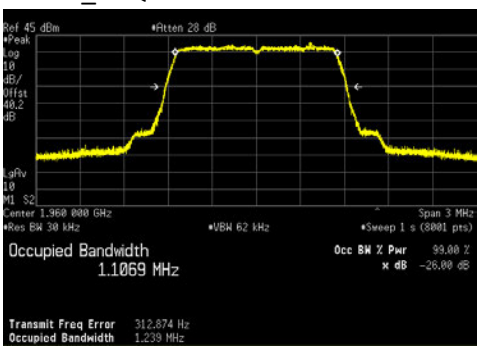
LTE1.4_QPSK



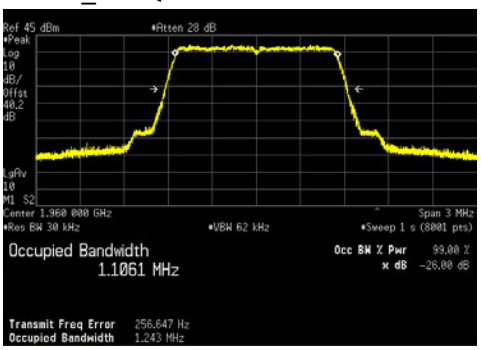
LTE1.4_16QAM



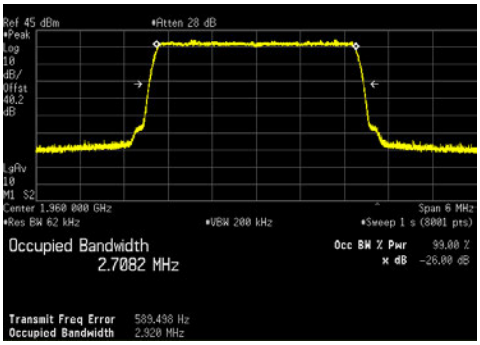
LTE1.4_64QAM



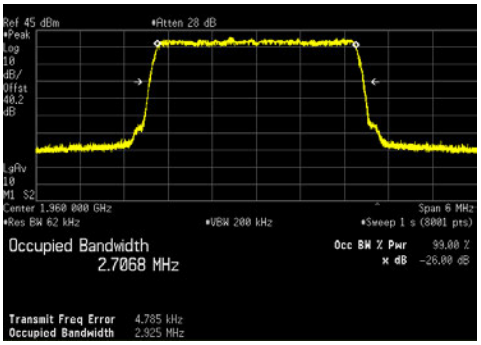
LTE1.4_256QAM



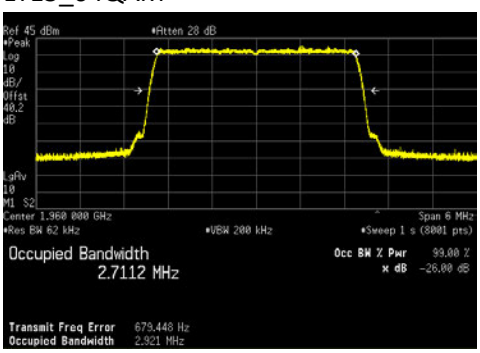
LTE3_QPSK



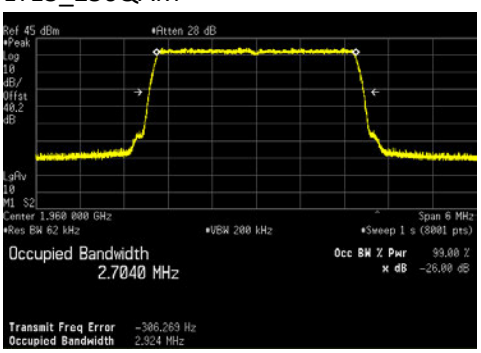
LTE3_16QAM



LTE3_64QAM

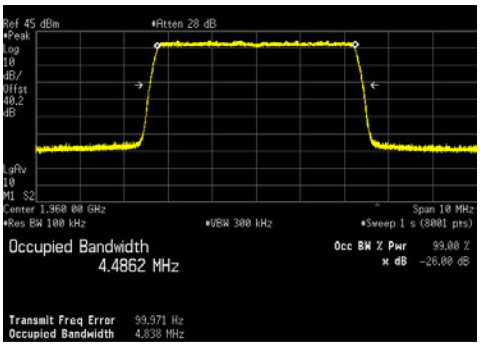


LTE3_256QAM

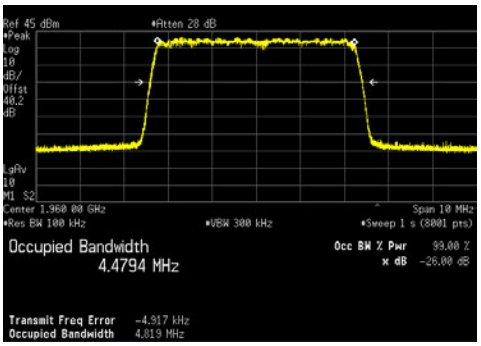


LTE5 and LTE10 Emission Bandwidth Plots on the Middle Channel for Antenna Port 7:

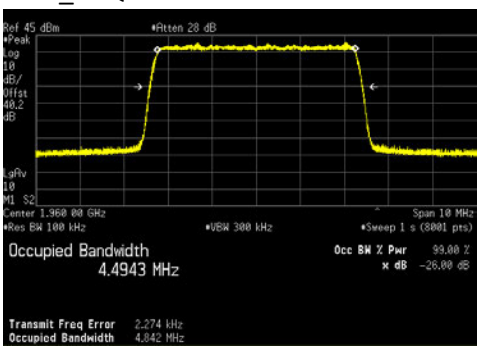
LTE5_QPSK



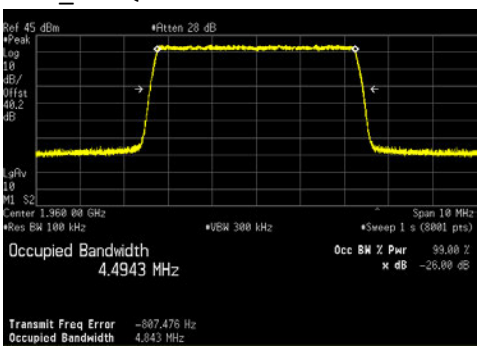
LTE5_16QAM



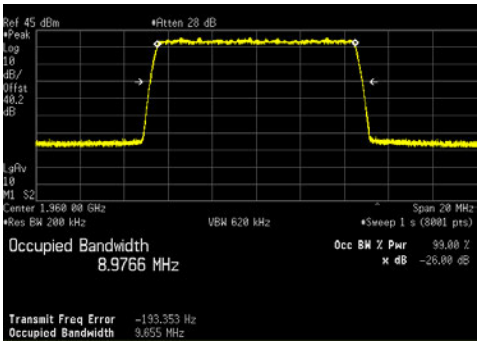
LTE5_64QAM



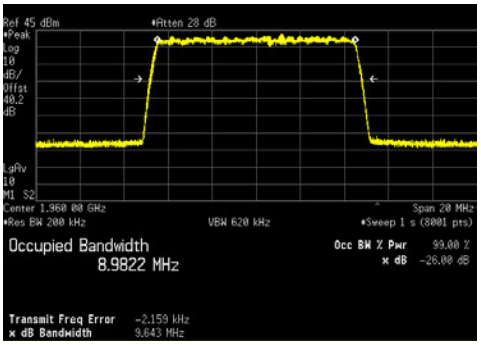
LTE5_256QAM



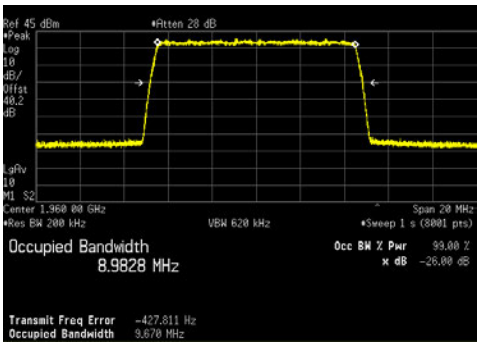
LTE10_QPSK



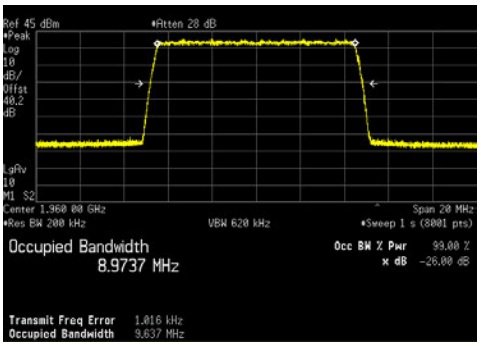
LTE10_16QAM



LTE10_64QAM

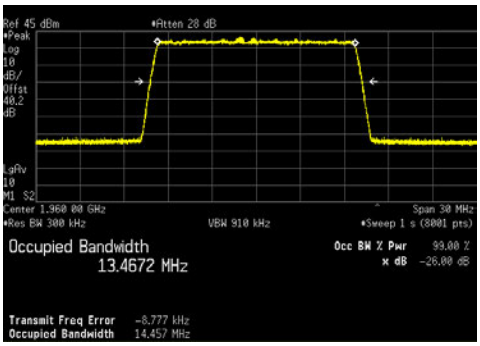


LTE10_256QAM

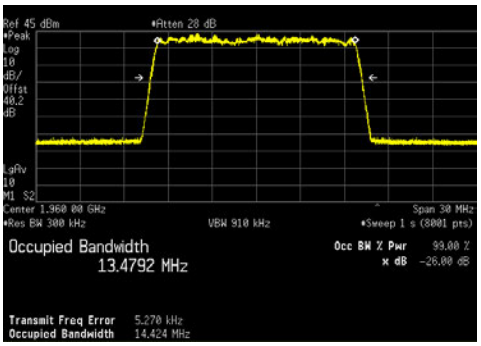


LTE15 and LTE20 Emission Bandwidth Plots on the Middle Channel for Antenna Port 7:

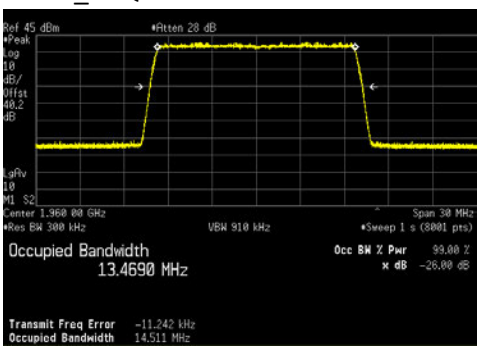
LTE15_QPSK



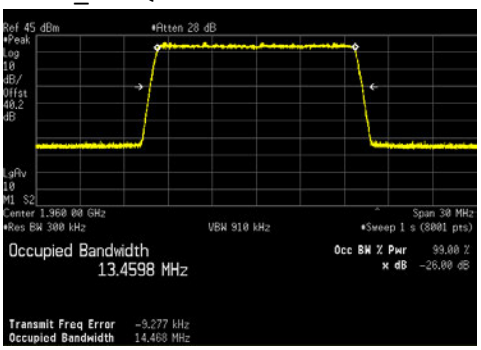
LTE15_16QAM



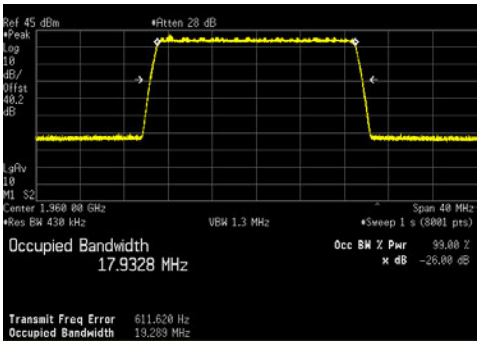
LTE15_64QAM



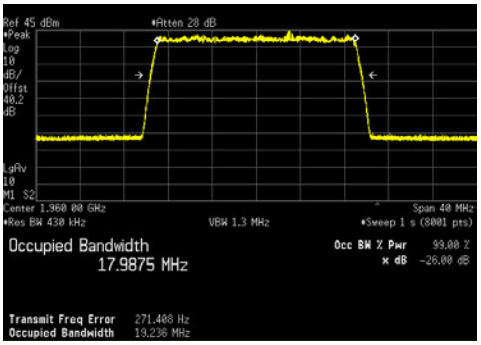
LTE15_256QAM



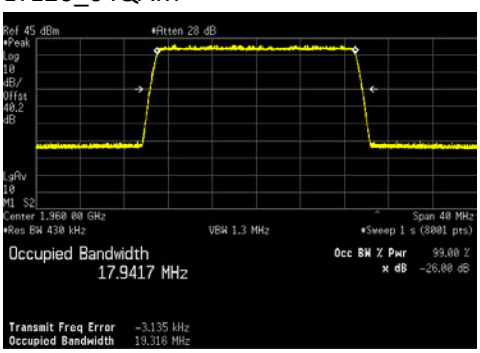
LTE20_QPSK



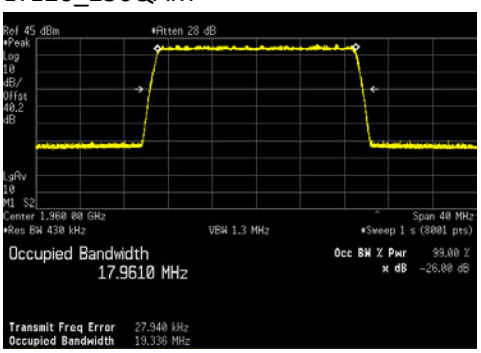
LTE20_16QAM



LTE20_64QAM



LTE20_256QAM



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at RRH antenna port 7. The RRH was operated at the band edge frequencies with all modulation types (QPSK, 16QAM, 64QAM, 256QAM) for 1.4MHz, 3MHz, 5MHz, 10MHz, 15MHz and 20MHz LTE bandwidths.

The limit of -19dBm was used in the certification testing. The limit is adjusted to -19dBm [-13dBm -10 log (4)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 4 port MIMO transmitter.

Measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces. In the 1MHz bands outside and adjacent to the frequency block, a resolution bandwidth of 1% of the emission bandwidth was used. In the 1 to 2MHz frequency range outside the band edge (i.e.: 1928 to 1929MHz and 1991 to 1992MHz bands) the RBW was again reduced to 1% of the emission bandwidth and the power integrated over 1MHz. In the 2 to 5MHz frequency range outside the band edge (i.e.: 1925 to 1928MHz and 1992 to 1995MHz bands) a 1MHz RBW and 3MHz VBW was used.

The results are summarized in the following table. The highest (worst case) emissions from the measurement data are provided.

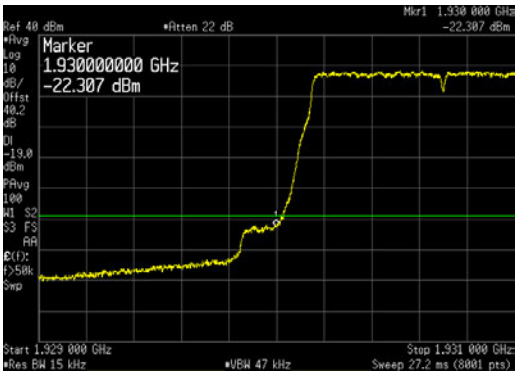
LTE BW	QPSK (dBm)		16QAM (dBm)		64QAM (dBm)		256QAM (dBm)	
	Bottom Channel	Top Channel	Bottom Channel	Top Channel	Bottom Channel	Top Channel	Bottom Channel	Top Channel
1.4M	-20.241	-20.286	-20.285	-20.715	-20.144	-20.633	-19.908	-20.630
3M	-21.320	-20.337	-21.137	-20.498	-20.384	-20.031	-21.209	-20.235
5M	-22.182	-22.155	-22.304	-22.251	-22.719	-21.558	-22.587	-21.691
10M	-24.724	-25.491	-24.676	-24.500	24.899	-25.199	-24.950	-25.090
15M	-25.688	-24.387	-24.308	-24.343	-25.587	-23.388	-24.519	-24.219
20M	-26.251	-26.018	-25.958	-26.174	-26.343	-26.431	-25.119	-26.300
Dual 5M	-20.390	-20.297	-21.111	-20.964	-21.072	-19.905	-20.852	-20.397

The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.

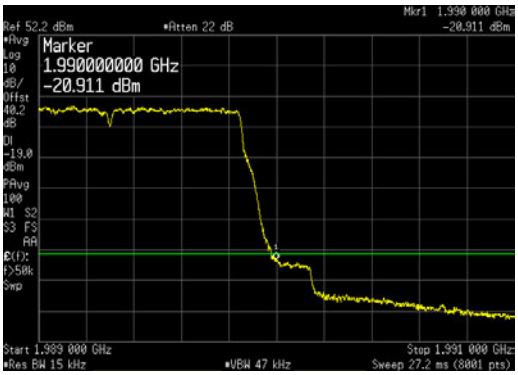
Conducted band edge measurements are provided in the following pages.

LTE1.4 Band Edge Plots for Antenna Port 7 and QPSK Modulation:

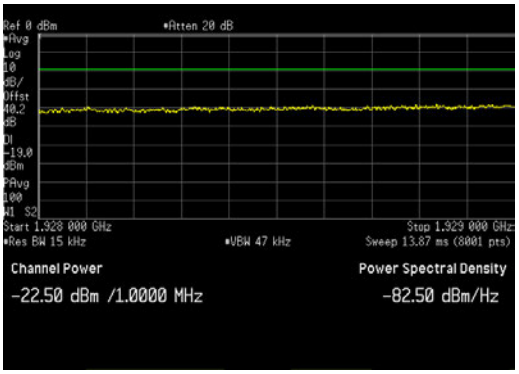
LTE1.4_Bottom Channel_LBE_1929 to 1931MHz



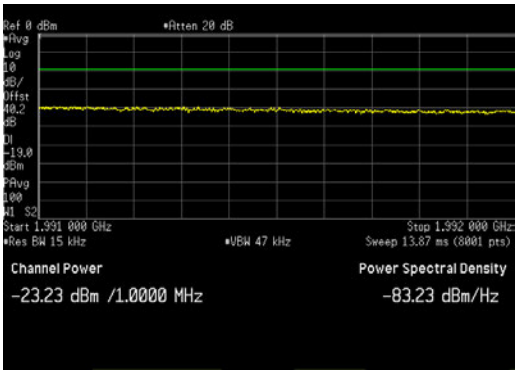
LTE1.4_Top Channel_UBE_1989 to 1991MHz



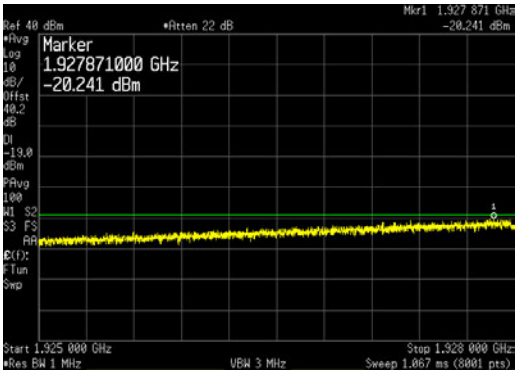
LTE1.4_Bottom Channel_LBE_1928 to 1929MHz



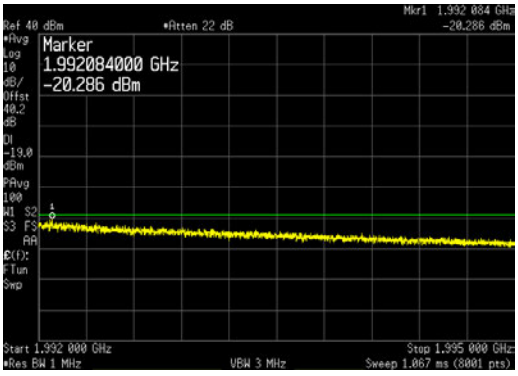
LTE1.4_Top Channel_UBE_1991 to 1992MHz



LTE1.4_Bottom Channel_LBE_1925 to 1928MHz

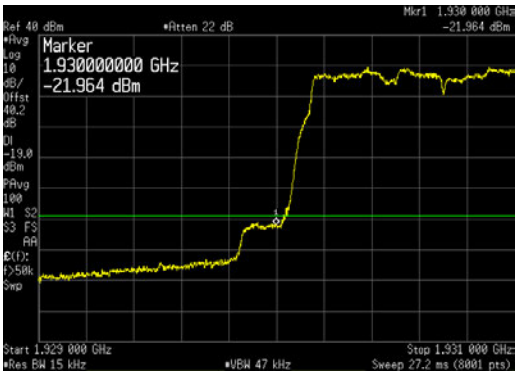


LTE1.4_Top Channel_UBE_1992 to 1995MHz

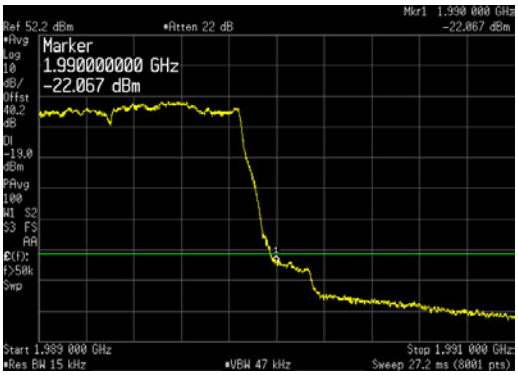


LTE1.4 Band Edge Plots for Antenna Port 7 and 16QAM Modulation:

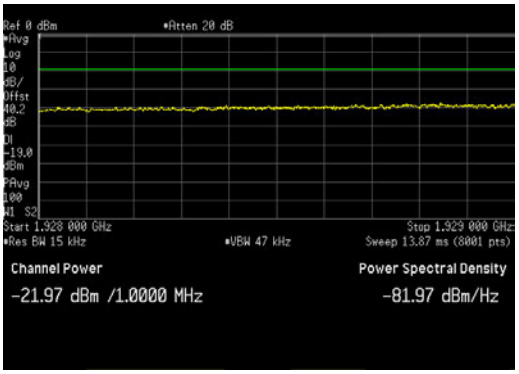
LTE1.4_Bottom Channel_LBE_1929 to 1931MHz



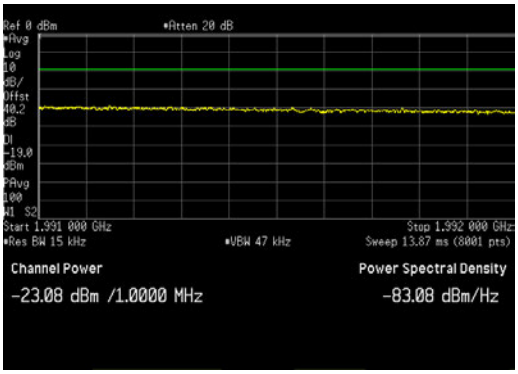
LTE1.4_Top Channel_UBE_1989 to 1991MHz



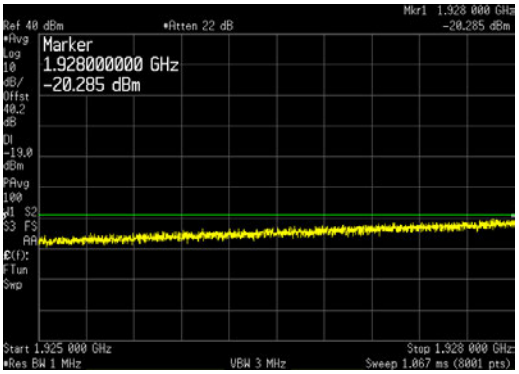
LTE1.4_Bottom Channel_LBE_1928 to 1929MHz



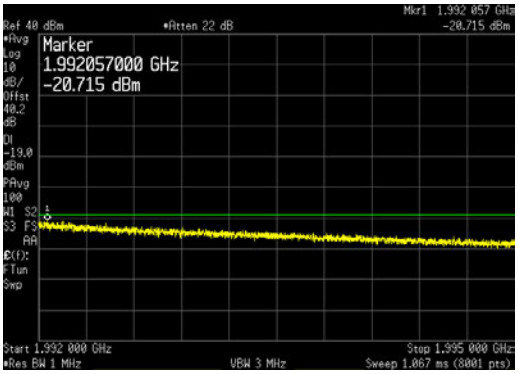
LTE1.4_Top Channel_UBE_1991 to 1992MHz



LTE1.4_Bottom Channel_LBE_1925 to 1928MHz

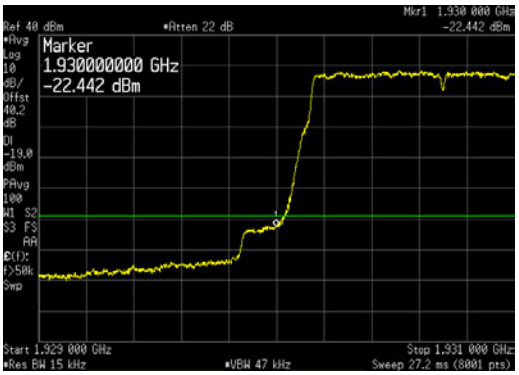


LTE1.4_Top Channel_UBE_1992 to 1995MHz

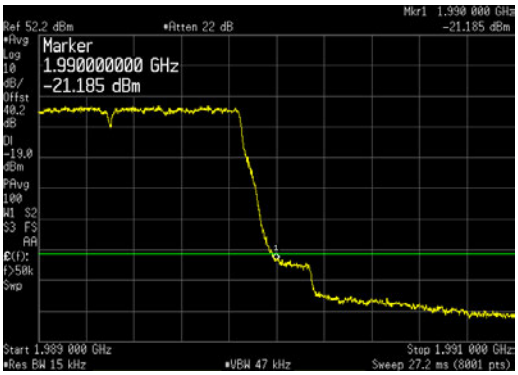


LTE1.4 Band Edge Plots for Antenna Port 7 and 64QAM Modulation:

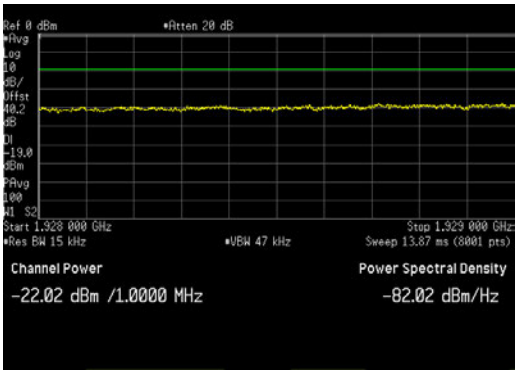
LTE1.4_Bottom Channel_LBE_1929 to 1931MHz



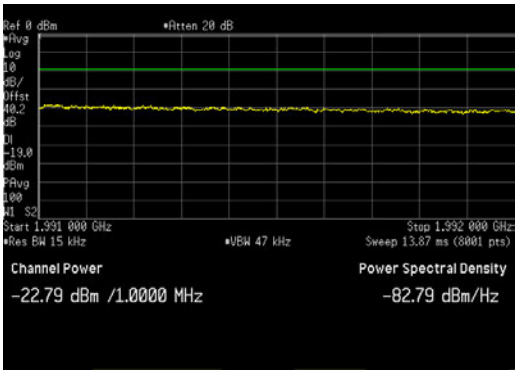
LTE1.4_Top Channel_UBE_1989 to 1991MHz



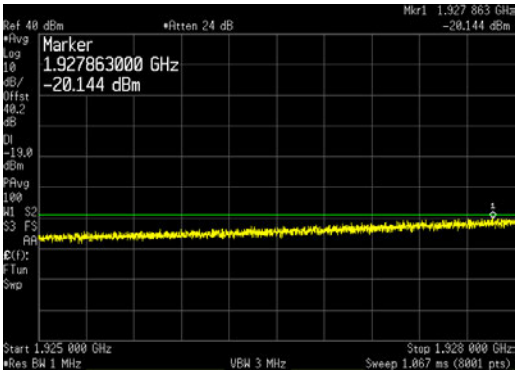
LTE1.4_Bottom Channel_LBE_1928 to 1929MHz



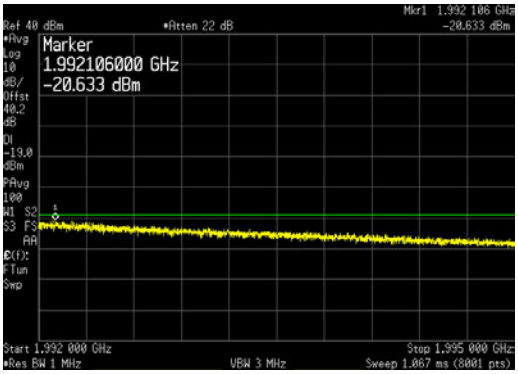
LTE1.4_Top Channel_UBE_1991 to 1992MHz



LTE1.4_Bottom Channel_LBE_1925 to 1928MHz

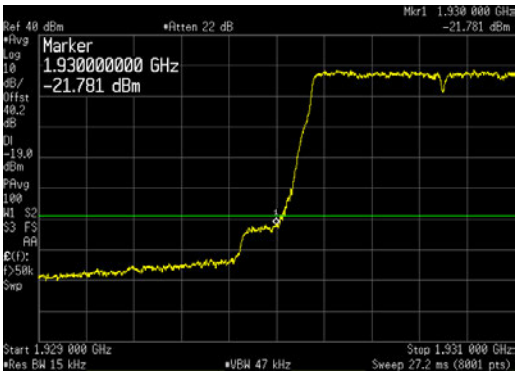


LTE1.4_Top Channel_UBE_1992 to 1995MHz

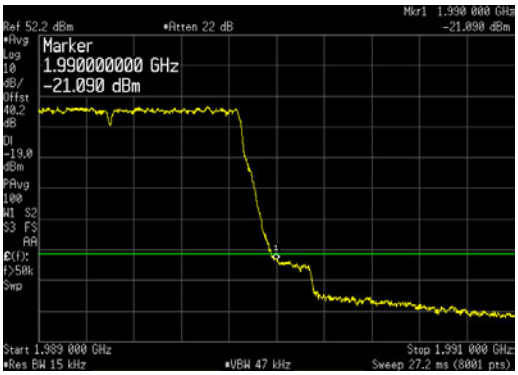


LTE1.4 Band Edge Plots for Antenna Port 7 and 256QAM Modulation:

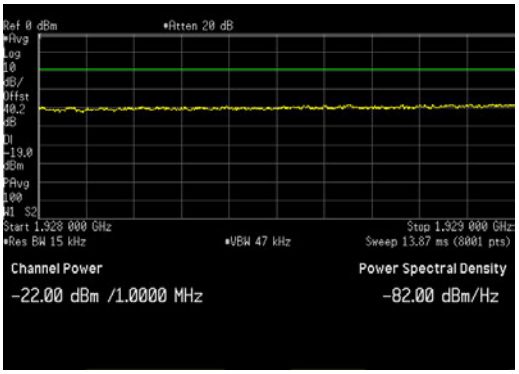
LTE1.4_Bottom Channel_LBE_1929 to 1931MHz



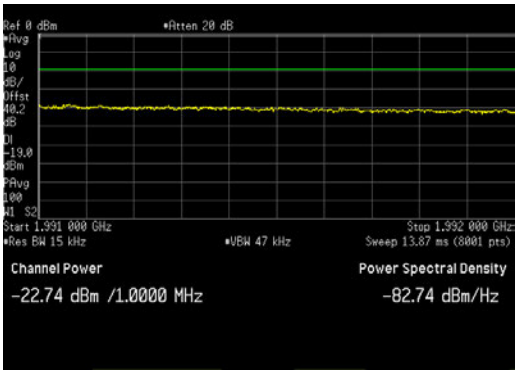
LTE1.4_Top Channel_UBE_1989 to 1991MHz



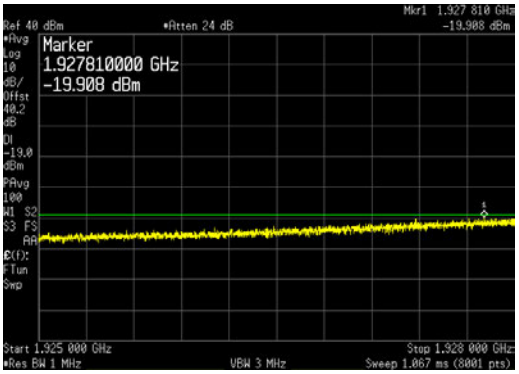
LTE1.4_Bottom Channel_LBE_1928 to 1929MHz



LTE1.4_Top Channel_UBE_1991 to 1992MHz



LTE1.4_Bottom Channel_LBE_1925 to 1928MHz



LTE1.4_Top Channel_UBE_1992 to 1995MHz