Radio Test Report

Application for Grant of Equipment Authorization

CERTIFICATE #: 0214.19

FCC Part 27, IC RSS-139, and RSS-170
[2110MHz – 2200MHz]

FCC ID: VBNAAIC-01
IC ID: 661W-AAIC

Product Name: Airscale Base Transceiver Station Radio Module
Model: AAIC

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: December 17-18, 2018 and January 2-4, 2019
Total Number of Pages: 90

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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	01/09/2018	Initial Draft	Christian Booker
1	01/11/2019	Updated Per Customer Redlines	BreAnna Cheatham

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SCOPE

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

- Code of Federal Regulations (CFR) Title 47 Part 2
- (Radio Standards Specification) RSS-Gen Issue 5 – April 2018
- CFR Title 47 Part 27 Subpart C & L
- RSS-139 Issue 3- July 16, 2015
- RSS-170 Issue 3- July 9, 2015

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 C63.26-2015
ANSI C63.4-2014
ANSI TIA-603-E
FCC KDB 971168 D01 v03r01
FCC KDB 971168 D03 v01
FCC KDB 662911D01 v02r01
FCC KDB 662911D02 v01
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 Radio Module Model AAIC 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 AAIC. 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 Radio Module Model AAIC 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 27 Subpart C&L/IC RSS-139 & RSS-170 (Base Stations Operating in 2110 - 2200MHz Band)

AAIC 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 RSS-170 Sec 5.1	Frequency Ranges	LTE5: 2112.5 - 2197.5MHz LTE10: 2115.0 - 2195.0MHz LTE15: 2117.5 - 2192.5MHz LTE20: 2120.0 - 2190.0MHz	2110.0 – 2200.0MHz	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 RSS-170 Sec 5.3.1	Output Power	Highest Conducted Power Output RMS: 40.0 dBm EIRP/MHz depends on antenna gain and bandwidth (See EIRP Calculations Section)	1640W/MHz EIRP/MHz	Pass
27.50(d)(5)	RSS-139 Sec 6.5 RSS-170 Sec 5.3.1	Peak to Average Power Ratio	Highest Measured PAPR: 7.29dB	13dB	Pass
	RSS-Gen Sec 6.6	99% Emission Bandwidth	LTE5: 4.4968MHz LTE10: 8.9908MHz LTE15: 13.4888MHz LTE20: 17.9905MHz	Remain in Block	Pass
27.53(h)(3)		26dB down Emission Bandwidth	LTE5: 4.850MHz LTE10: 9.677MHz LTE15: 14.503MHz LTE20: 19.387MHz	Remain in Block	Pass
Transmitter Spurious Emissions[1]					
27.53(h)	RSS-139 Sec 6.6 RSS-170 Sec 5.4	At the antenna terminals	< -25dBm	-25dBm per Transmit Chain	Pass
		Field strength	53.775dBuV/m at 1m Eq. to -51.025dBm EIRP	-13 dBm EIRP	Pass
Other Details					
27.54	RSS-139 Sec 6.4 RSS-170 Sec 5.2	Frequency Stability	Stays within authorized frequency block 0.002ppm	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 exhibit based on hypothetical antenna gains.

Emission Designators								
Channel Bandwidth	**LTE-QPSK**		**LTE-16QAM**		**LTE-64QAM**		**LTE-256QAM**	
	FCC	**IC**	**FCC**	**IC**	**FCC**	**IC**	**FCC**	**IC**
5M	4M85F9W	4M49F9W	4M82F9W	4M48F9W	4M85F9W	4M50F9W	4M84F9W	4M50F9W
10M	9M65F9W	8M98F9W	9M66F9W	8M99F9W	9M68F9W	8M99F9W	9M65F9W	8M98F9W
15M	14M47F9W	13M47F9W	14M45F9W	13M49F9W	14M50F9W	13M47F9W	14M47F9W	13M47F9W
20M	19M27F9W	17M95F9W	19M25F9W	17M99F9W	19M27F9W	17M95F9W	19M39F9W	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) radio module, model AAIC. The AAIC radio module is a subassembly of the massive MIMO adaptive antenna (MMAA) assembly. The MMAA integrates the radio module variants with various antenna variants into one assembly. The MMAA assembly/antenna variants are not directly used/part of this radio approval test effort (i.e.: The radio module is tested under this effort. The antenna assembly is not part of the test under this effort). The MMAA assembly version AAFIB contains the AAIC and AAFB radio modules with 4-column antennas. The AAFB radio module certification/testing is documented elsewhere.

The AAIC has 16 transmit/receive antenna ports that supports 3GPP frequency band 66 operations (BTS RX: 1710 to 1780 MHz/BTS TX: 2110 to 2200 MHz). The maximum RF output power of the radio module antenna port is 9.375 watts. The total RF output power for the AAIC radio module is 150 watts (16 x 9.375 watts). The radio module supports LTE-FDD, and narrow band IoT (internet of things) operations (in-band, guard band, standalone). The TX and RX instantaneous bandwidth cover the full operational (Band 66) bandwidth. The radio module supports 5, 10, 15, and 20MHz LTE bandwidths. The radio module supports four LTE downlink modulation types (QPSK, 16QAM, 64QAM and 256QAM) and NB-IoT. Multi-carrier operation is supported with the maximum bandwidth for all carriers of 40MHz. The scope of testing in this effort is for LTE-FDD single carrier operations.

The radio module has external interfaces including DC power (DC In), ground, transmit/receive (ANT), and optical (OPT). The massive MIMO adaptive antenna assembly (configured with AAIC and AAFB radios) may be pole or wall mounted. The radio module may be configured with an optional cooling fan.

The AAIC LTE channel numbers and frequencies are as follows:

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth			
			5 MHz	10 MHz	15 MHz	20 MHz
AAIC Band 66 (Antennas 1 through 16)	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
	……					
	66886	2155.0	Middle Ch	Middle Ch	Middle Ch	Middle Ch
	……					
	67236	2190.0				Top Channel
	……					
	67261	2192.5			Top Channel	
	……					
	67286	2195.0		Top Channel		
	……					
	67311	2197.5	Top Channel			
	……					
	67336	2200.0	Band Edge	Band Edge	Band Edge	Band Edge

AAIC Downlink Band Edge LTE Band 66 Frequency Channels

EUT Hardware

The EUT hardware used in testing for December 17-18, 2018 and January 2-4, 2019.

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	AAIC	AirScale BTS Band 66 Radio Module	Part#: 090709A.101 Serial#: YK184300486	FCC ID: VBNAAIC-01 IC ID: 661W-AAIC

Enclosure

The EUT enclosure is made of heavy duty aluminum.

Support Equipment

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	ASIA	Airscale System Module	Part#: 473095A.101 Serial#: L1163817366	N/A
HP	Pro Book 6740b	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 Optical Ports)	473842A.101	KR16090020071
Nokia	Cover Plate Test Fixture (Simulates mechanical interface to MMAA and provides RF interface to radio module antenna ports.)	None	None
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 10dB-100 Watt[1]	48-10-34-LIM	BJ1771
Narda	10dB Coaxial Directional Coupler[1]	3042B-10	42180
Huber & Suhner	RF Cable – 0.5 meter[1]	Sucoflex 104	553624/4
Huber & Suhner	RF Cable - 1 meter[1]	Sucoflex 106	297370
Narda	Attenuator 30dB-50 Watt[1]	7768-30	-
Note 1: Used only in antenna port RF conducted emission testing.			

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	~ 2 m	Yes	16	50Ω Loads
Optical	Optical	No	>6 m	Yes	1	System Module

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	16	4.3-10 Blind Mate/Quick Disconnect	RF signal for Transmitter/Receiver (50 Ohm)
Unit	1	LED	Unit Status LED
OPT	2	SFP+ cage	Optical Interface
Fan	1	Microfit	Power for fan on the side of radio module.

EUT Operation

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

EUT Software

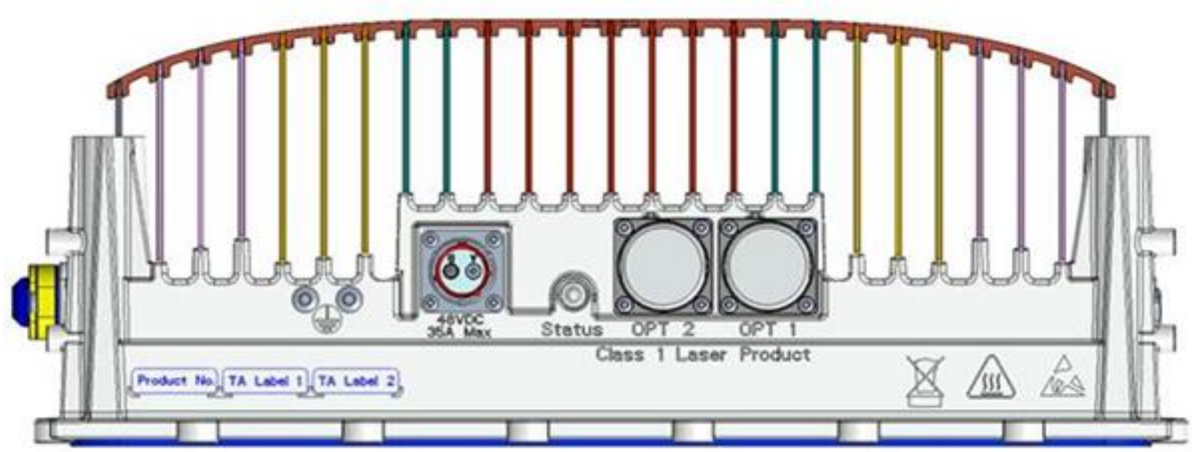
The laptop PC connects to the System Module over the LMP (Ethernet) port. The system module controls the radio module via the optical interface. The laptop is used for changing configuration settings, monitoring tests and controlling the BTS. The following software versions are used for the testing:

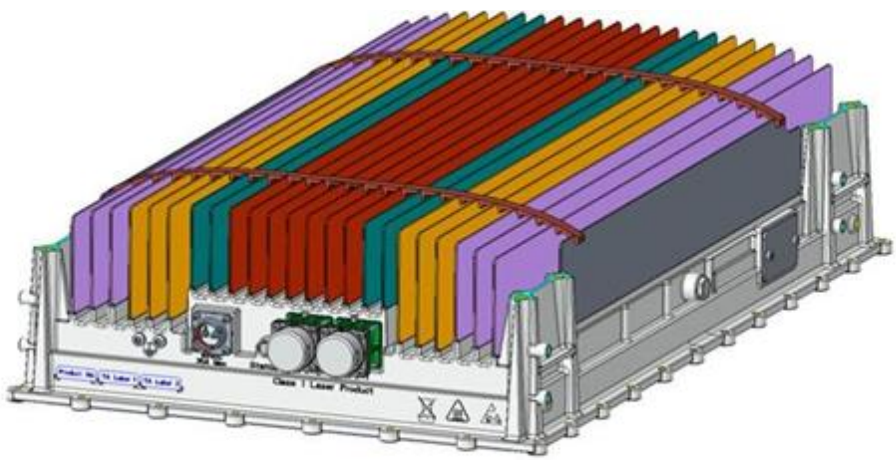
(1) Radio Module Software: SRM58.09.R14x
(2) System Module Software: FB_PS_REL_2018_02_014

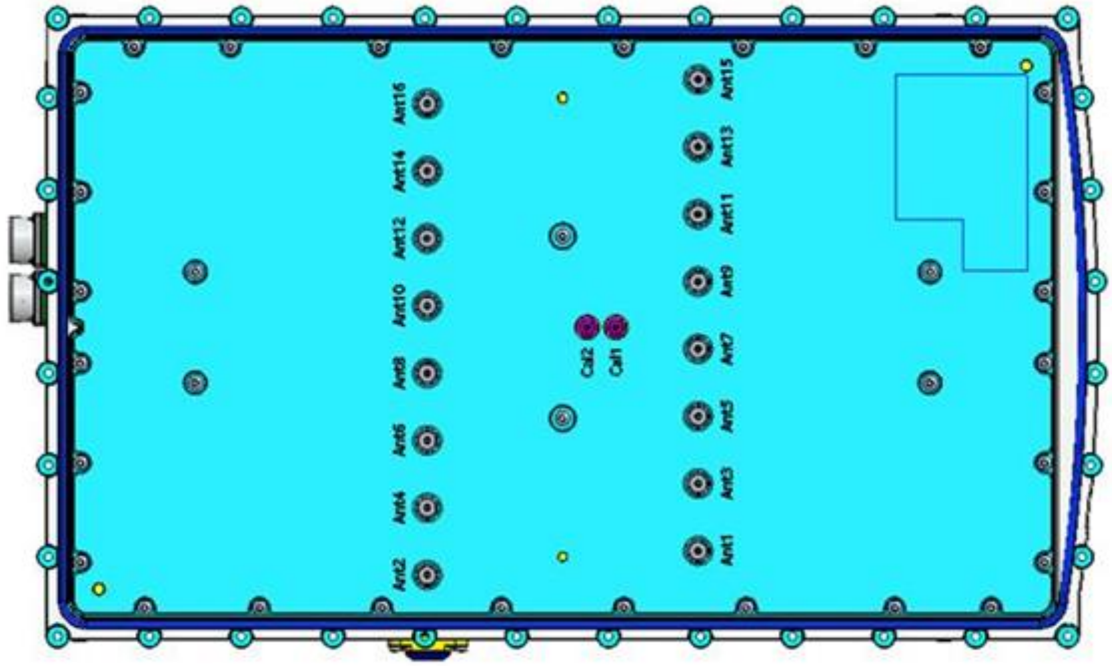
Modifications

No modifications were made to the EUT during testing.

AAIC Connector Layout:






Ant16
Ant14
Ant12
Ant10
Ant8
Ant6
Ant4
Ant2
Ant15
Ant13
Ant11
Ant9
Ant7
Ant5
Ant3
Ant1
Cal2
Cal1

TESTING

GENERAL INFORMATION

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

Radiated emissions and frequency accuracy/stability measurements were taken by Christian Booker at NTS Plano branch 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 site conforms 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". The site is 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 RMS average output power, emission bandwidth, conducted spurious and conducted band edge measurements were performed with a spectrum analyzer. The carrier frequency accuracy/stability and complementary cumulative distribution function (CCDF) 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 other one was terminated with termination blocks. All measurements were corrected for the insertion loss of the RF network (attenuators, couplers, 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 of FCC KDB 971168 D01v03r01 and ANSI C63.26 section 5.4. The 99% occupied bandwidth was measured in accordance with section 6.7 of RSS-Gen Issue 5. 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.

Average output power measurements were performed in accordance with sections 5.4 of FCC KDB 971168 D01v03r01 and ANSI C63.26. Measurements were performed with the built-in channel power function found in the spectrum analyzer and the screenshots were captured using Keysight Benchvue Software. Peak to average power ratio (PAPR) was measured in accordance with Section 5.7.2 of FCC KDB 971168 D01v03r01 and ANSI C63.26 section 5.2.3.4. Signal Analyzer CCDF screenshots were captured using Keysight Benchvue Software. Analyzer settings are shown on their corresponding plots in test results section.

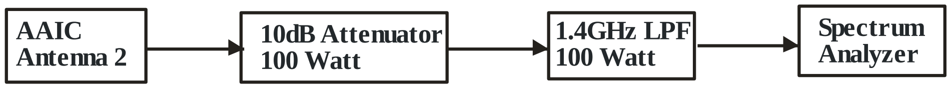
Conducted spurious emissions were captured with Keysight Benchvue Software across the 9kHz-22GHz frequency span. A low pass was used to reduce measurement instrumentation noise floor for the frequency ranges less than 20MHz. A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 3GHz.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.

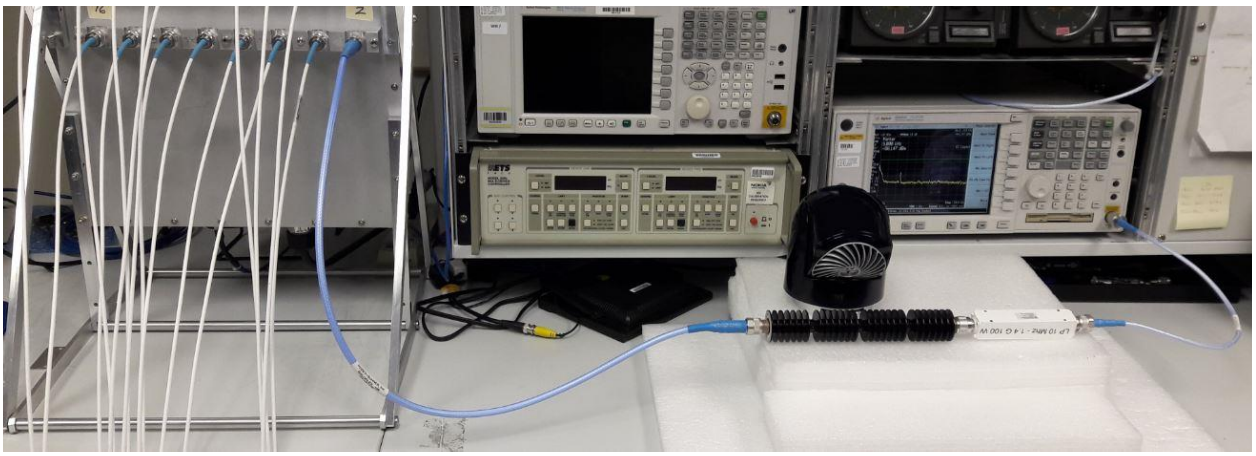
Transmitter radiated spurious emissions measurements were made in accordance with ANSI C63.4-2014 by measuring the field strength of the emissions from the device at 3m test distance for emissions below 10 GHz and at 1m test distance for emissions above 10 GHz. The eirp limit as specified in the relevant 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. The EUT was placed on a non-conductive RF transparent structure to provide 80cm height from the ground floor for frequencies < 1GHz and 150cm height from the ground floor for frequencies > 1GHz in accordance with ANSI C63.26-2015. 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.

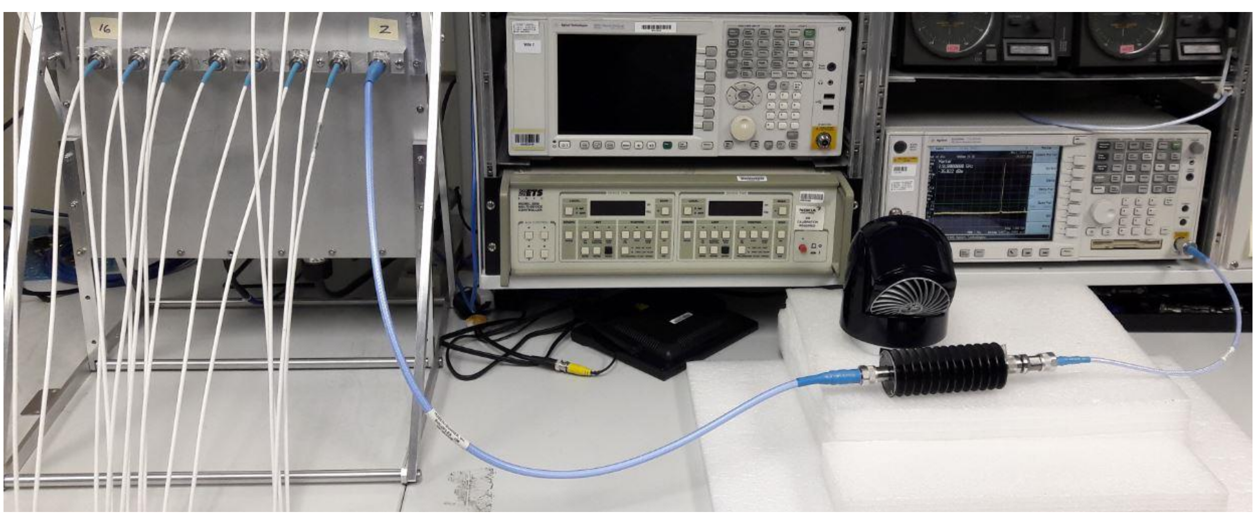


Setup for 9kHz to 150kHz and 150kHz to 20MHz Measurements

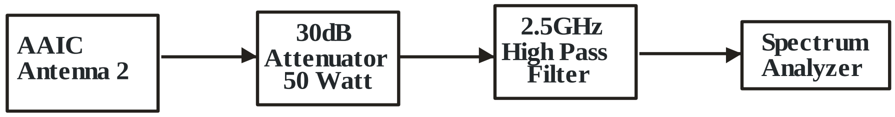


Photograph of 9kHz to 150kHz and 150kHz to 20MHz Test Setup

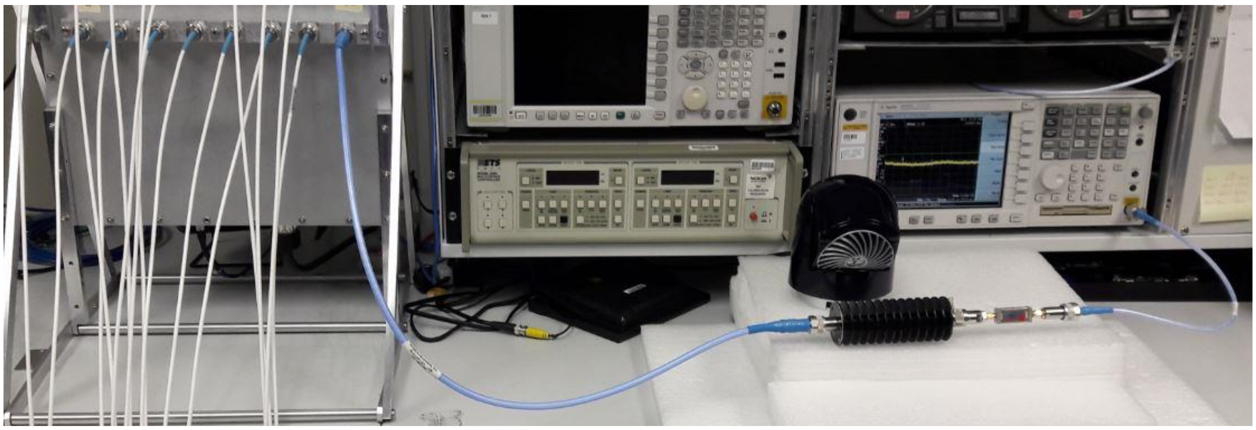
Setup for 20MHz to 3GHz Measurements



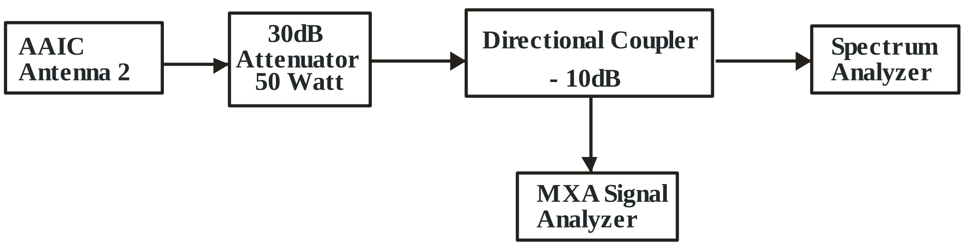
Photograph of 20MHz to 3GHz Test Setup



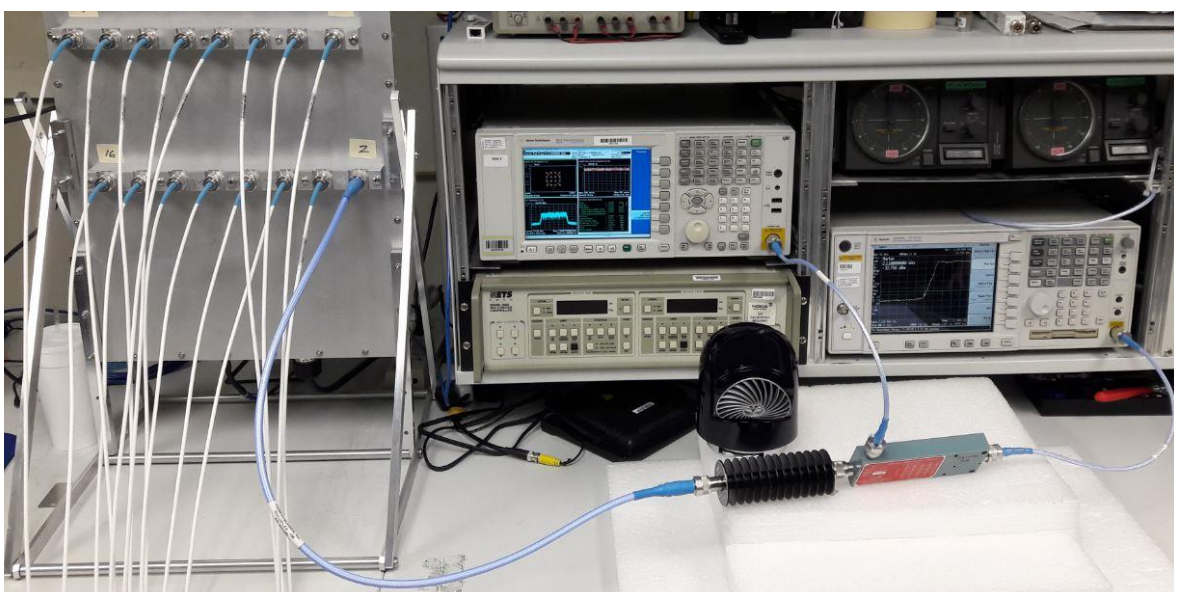
Setup for 3GHz to 10GHz, 10GHz to 18GHz and 18GHz to 22GHz Measurements



Photograph of 3GHz to 10GHz, 10GHz to 18GHz and 18GHz to 22GHz Test Setup



Setup for AWS Band Measurements



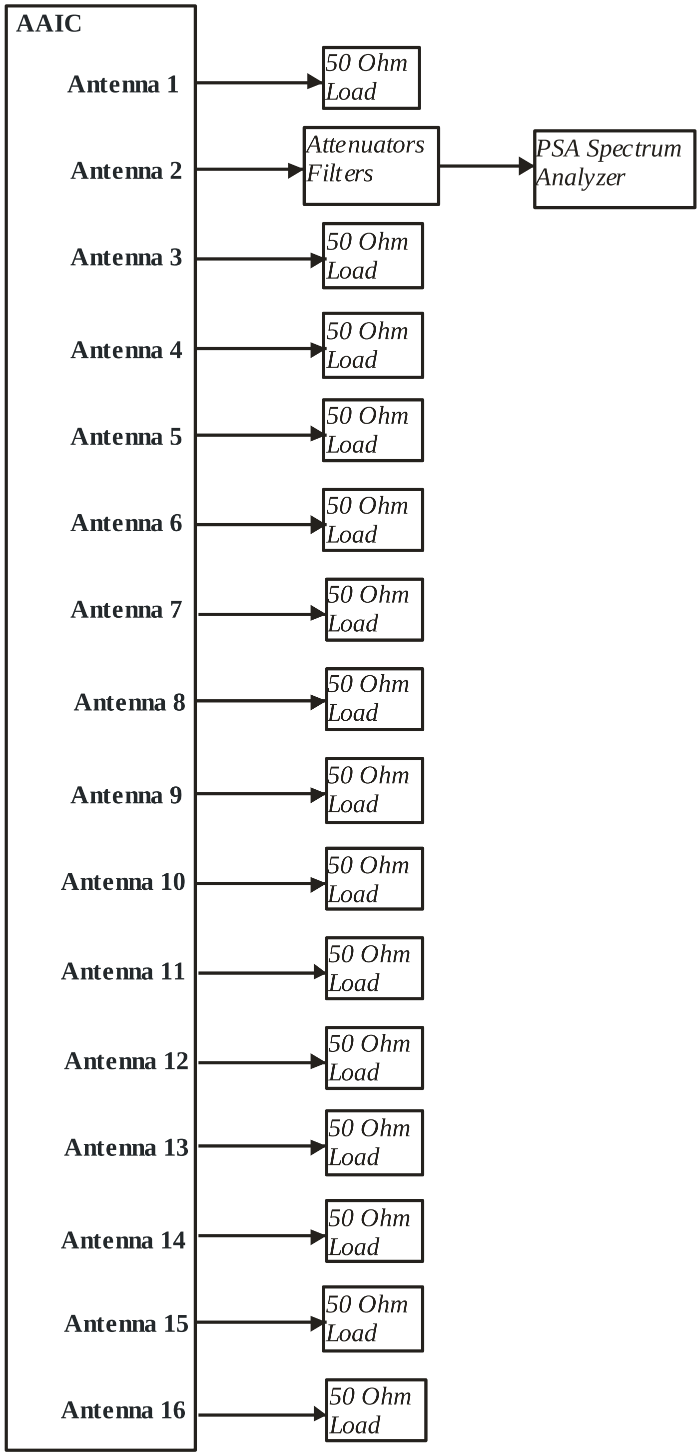
Photograph of AWS Band Test Setup

Test Measurement Equipment

NTS Equipment #	Description	Manufacturer	Model	Calibration Duration	Calibration Due Date
WC020917	Antenna	ETS	3142D	24 Months	1/15/2019
WC025240	Spectrum Analyzer	Agilent	E4446A	12 Months	3/3/2019
WC021468	30MHz-1GHz Preamp	MiTeq	AM-1431-N1197SC	12 Months	8/10/2019
WC021478	1-26.5GHz Preamp	HP	8449B	12 Months	3/19/2019
WC0201206	Antenna	ETS	3115	12 Months	1/12/2019
WC021208	Antenna	EMCO	3116	12 Months	12/4/2019
WC021684	Climate Chamber	Russells Technical Products	RD-45-5-5	NCR	NCR
WC027005	Multimeter	Fluke	87V	12 Months	7/17/2019
120194[1]	PSA Spectrum Analyzer	Agilent	E4440A	12 Months	10/17/2019
NM05979[1]	Network Analyzer	Rohde & Schwarz	ZVA 24	12 Months	2/11/2019
NM04509[1]	Network Analyzer	Rohde & Schwarz	ZVL 3	12 Months	2/03/2019
NM04508[1]	MXA Signal Analyzer	Agilent	N9020A	24 Months	5/2/2019
Note 1: Customer equipment					

APPENDIX A: ANTENNA PORT TEST DATA FOR THE AWS BAND

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



Test Setup Used for Conducted RF Measurements on AAIC

RF Output Power

RF output power has been measured in RMS Average terms for each AWS transmit chain at the middle channel for 256QAM modulation and LTE5 bandwidth as described in section 5.2 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.4.4. The peak to average power ratio (PAPR) has been measured using the signal analyzer complementary cumulative distribution function (CCDF) for a probability of 0.1% as described in section 5.7.2 of KDB971168 D01v03r01 and ANSI C63.26-2015 section 5.2.3.4. All results are presented in tabular form below. The highest measured values are highlighted. Measurements were rounded off to three digits.

Antenna (LTE Channel)	LTE BW	LTE - 256QAM		
		PAPR (dB)	Average Power	
			dBm	Watts
Port 1 (Mid Ch)	**5M**	7.25	39.6	9.12
Port 2 (Mid Ch)	**5M**	7.23	**39.8**	9.55
Port 3 (Mid Ch)	**5M**	7.27	39.7	9.33
Port 4 (Mid Ch)	**5M**	7.25	39.6	9.12
Port 5 (Mid Ch)	**5M**	7.24	39.6	9.12
Port 6 (Mid Ch)	**5M**	**7.29**	39.7	9.33
Port 7 (Mid Ch)	**5M**	7.23	39.7	9.33
Port 8 (Mid Ch)	**5M**	7.26	39.6	9.12
Port 9 (Mid Ch)	**5M**	7.26	39.5	8.91
Port 10 (Mid Ch)	**5M**	7.24	**39.8**	9.55
Port 11 (Mid Ch)	**5M**	7.28	39.1	8.13
Port 12 (Mid Ch)	**5M**	7.25	39.6	9.12
Port 13 (Mid Ch)	**5M**	7.25	39.4	8.71
Port 14 (Mid Ch)	**5M**	7.27	39.6	9.12
Port 15 (Mid Ch)	**5M**	7.24	39.2	8.32
Port 16 (Mid Ch)	**5M**	7.24	39.7	9.33
Total Power Middle Channel	**5M**	-	51.6	145.2

The variation in RMS output power levels between the antenna ports is 0.7 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). One of the highest power ports (Port 2) was selected as the worst case.

Pre-compliance testing has shown that the output power variation between modulation types is small. Antenna port 2 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**	
	PAPR (dB)	**Ave (dBm)**	**PAPR (dB)**	**Ave (dBm)**	**PAPR (dB)**	**Ave (dBm)**	**PAPR (dB)**	**Ave (dBm)**
Antenna Port 2 Middle Channel LTE5	7.20	39.81	7.22	39.84	7.18	39.82	7.23	39.75

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 0.09dB for the data snapshot provided. The variation of PAPR versus modulation type is 0.05dB 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 2 had the highest RMS average power (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 4 LTE channel bandwidths and 256QAM modulation type were tested only at Port 2. The results are presented below. The highest measured values are highlighted. Measurements were rounded off to three digits.

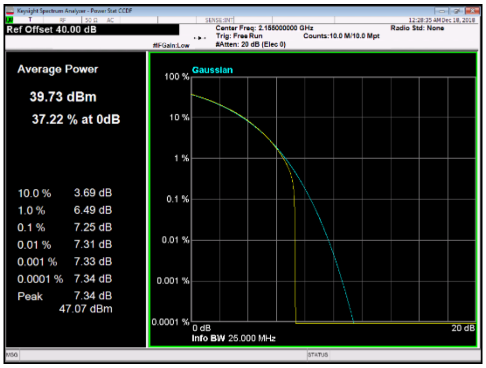
Antenna LTE Channel	LTE Bandwidth	LTE - 256QAM		
		PAPR (dB)	Average	
			dBm	Watts
Port 2 Bottom Channel	5M	7.24	39.7	9.33
	10M	7.23	39.9	9.77
	15M	7.24	39.9	9.77
	20M	7.22	39.9	9.77
Port 2 Middle Channel	5M	7.23	39.8	9.55
	10M	7.20	39.7	9.77
	15M	7.21	39.8	9.55
	20M	7.16	39.8	9.55
Port 2 Top Channel	5M	7.24	39.8	9.55
	10M	7.22	**40.0**	10.0
	15M	**7.26**	39.9	9.77
	20M	7.25	**40.0**	10.0

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 (0.1dB).

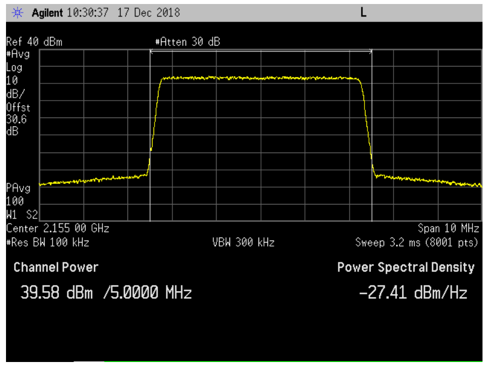
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator, coupler and test cables) was 30.6 dB for the average power path & 40.0 dB for the CCDF path and is accounted for by the spectrum/signal analyzer reference level offset.

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

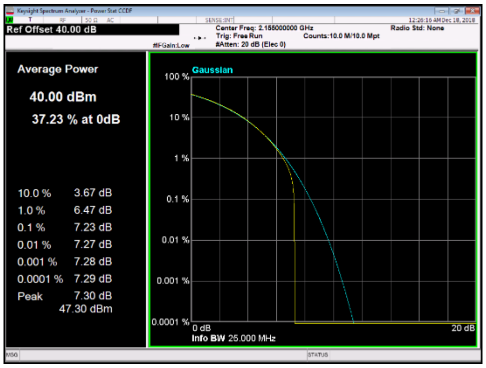
Port 1 - LTE5_ Middle Channel_CCDF



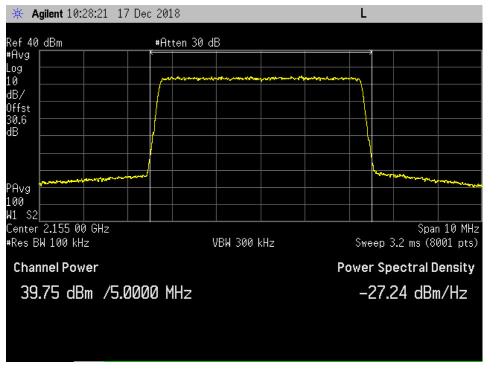
Port 1 - LTE5_ Middle Channel_Average



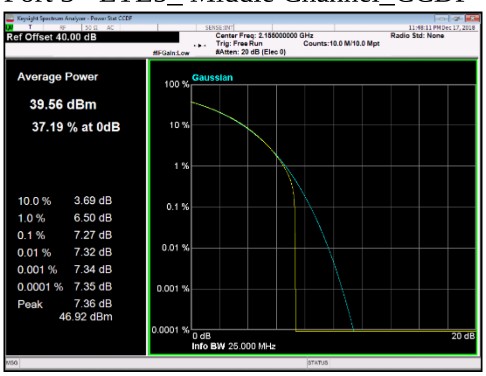
Port 2 - LTE5_Middle Channel_CCDF



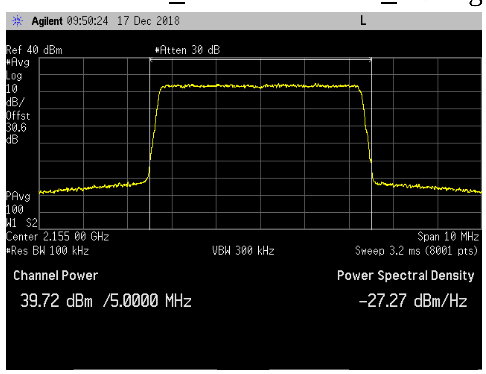
Port 2 - LTE5_Middle Channel_Average



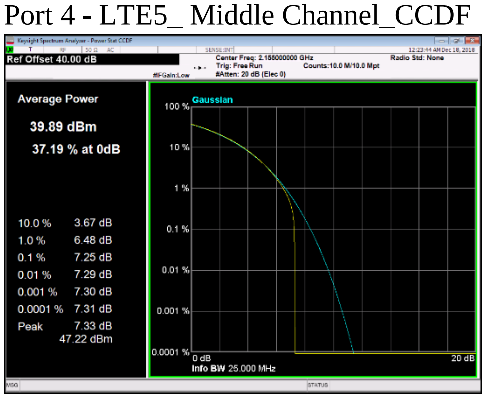
Port 3 - LTE5_ Middle Channel_CCDF



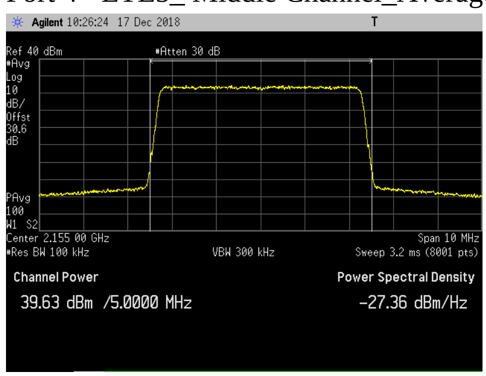
Port 3 - LTE5_ Middle Channel_Average



Port 4 - LTE5_ Middle Channel_CCDF

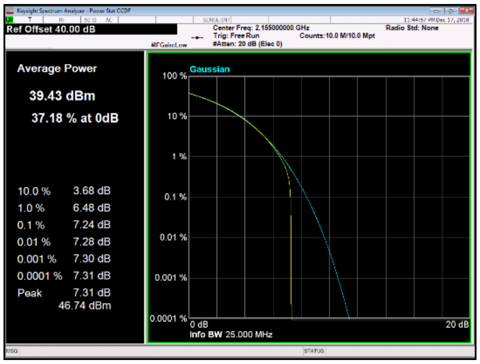


Port 4 - LTE5_ Middle Channel_Average

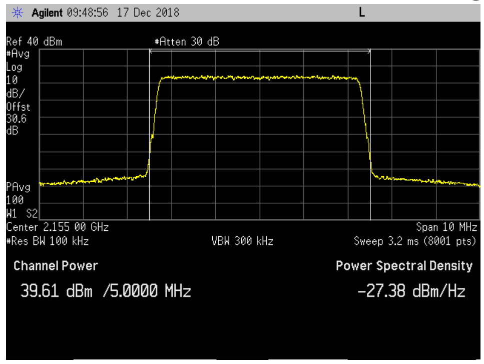


LTE5 Channel Power Plots at Middle Channel and 256QAM Modulation:

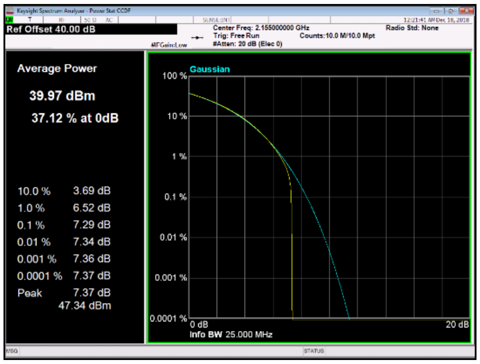
Port 5 - LTE5_ Middle Channel_CCDF



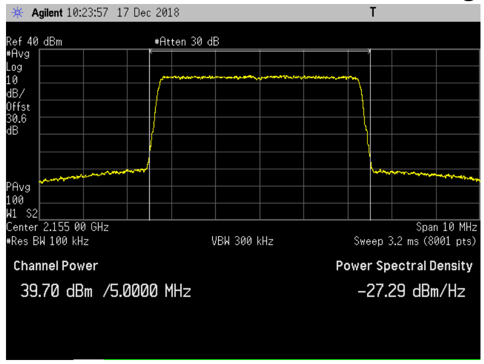
Port 5 - LTE5_ Middle Channel_Average



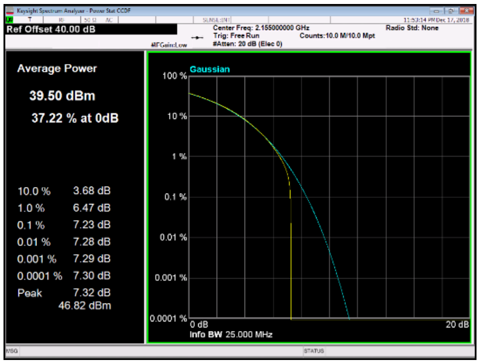
Port 6 - LTE5_Middle Channel_CCDF



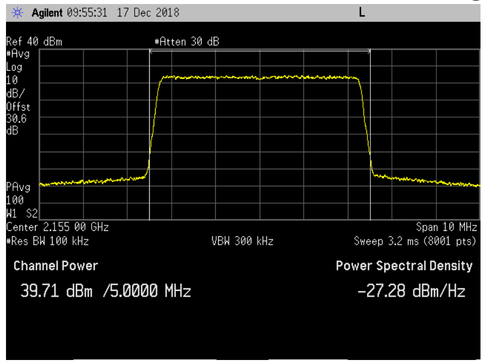
Port 6 - LTE5_Middle Channel_Average



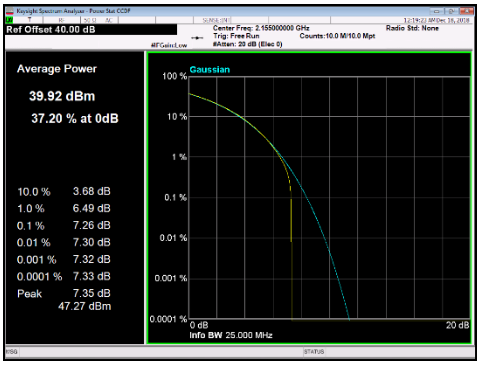
Port 7 - LTE5_ Middle Channel_CCDF



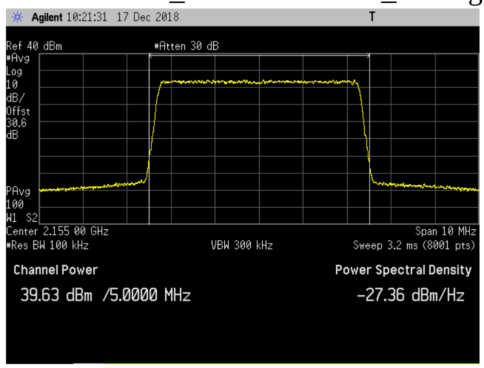
Port 7 - LTE5_ Middle Channel_Average



Port 8 - LTE5_ Middle Channel_CCDF

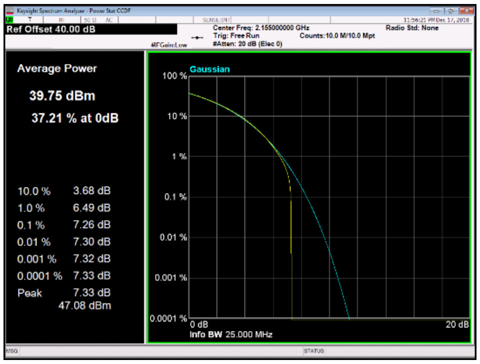


Port 8 - LTE5_ Middle Channel_Average

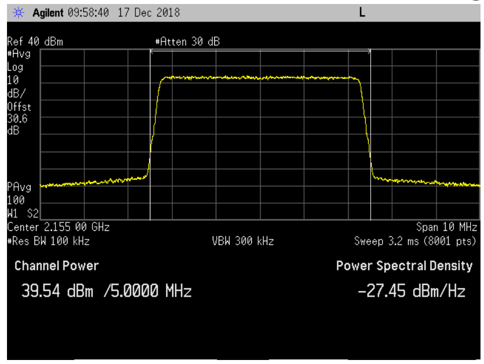


LTE5 Channel Power Plots at Middle Channel and 256QAM Modulation:

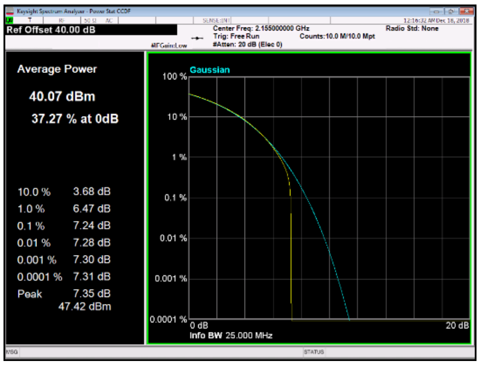
Port 9 - LTE5_ Middle Channel_CCDF



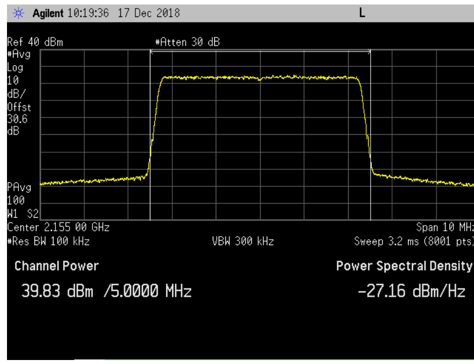
Port 9 - LTE5_ Middle Channel_Average



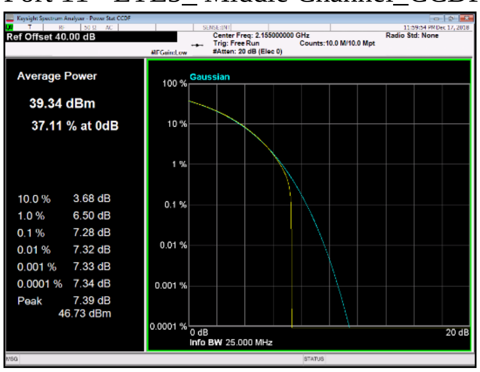
Port 10 - LTE5_Middle Channel_CCDF



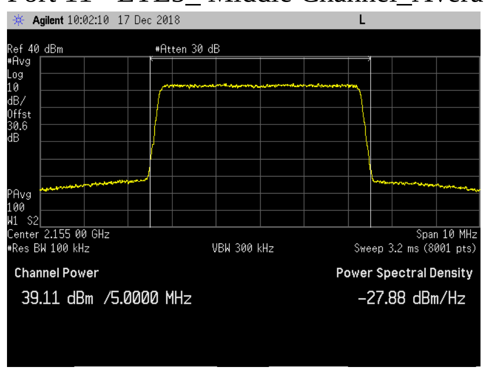
Port 10 - LTE5_Middle Channel_Average



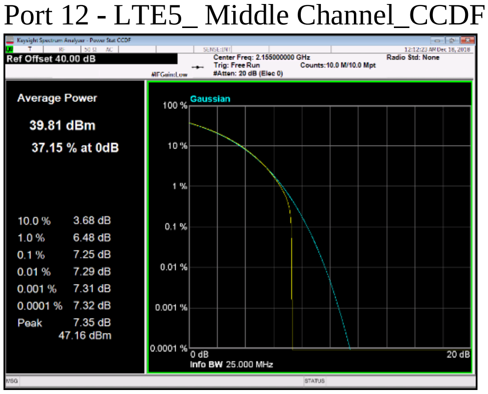
Port 11 - LTE5_ Middle Channel_CCDF



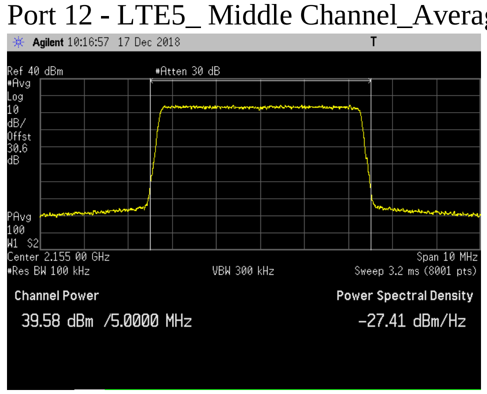
Port 11 - LTE5_ Middle Channel_Average



Port 12 - LTE5_ Middle Channel_CCDF

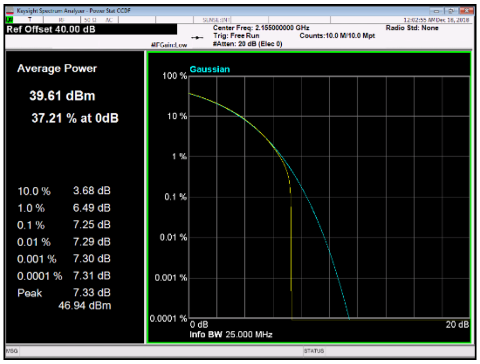


Port 12 - LTE5_ Middle Channel_Average

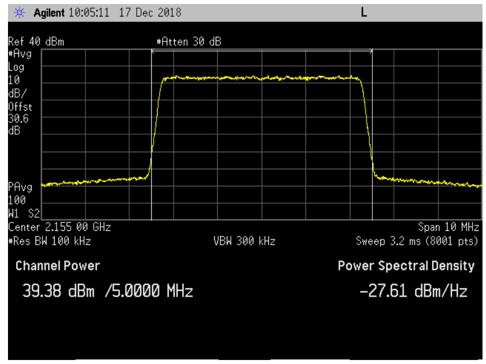


LTE5 Channel Power Plots at Middle Channel and 256QAM Modulation:

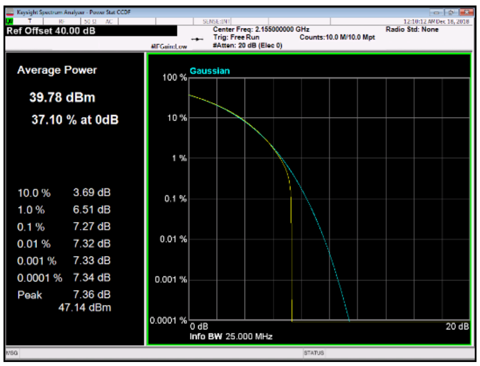
Port 13 - LTE5_ Middle Channel_CCDF



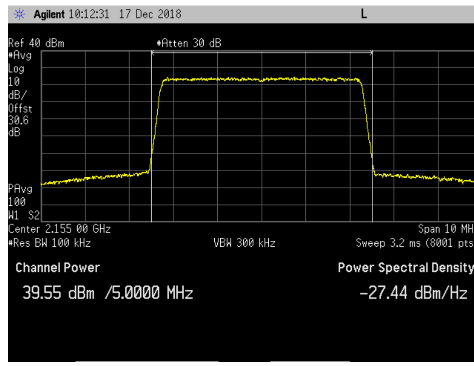
Port 13 - LTE5_ Middle Channel_Average



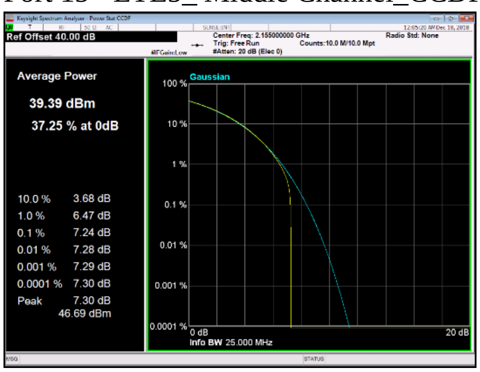
Port 14 - LTE5_Middle Channel_CCDF



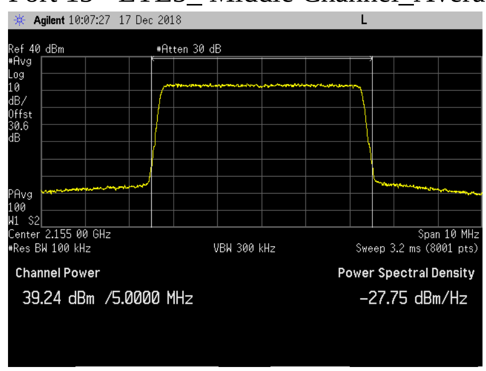
Port 14 - LTE5_Middle Channel_Average



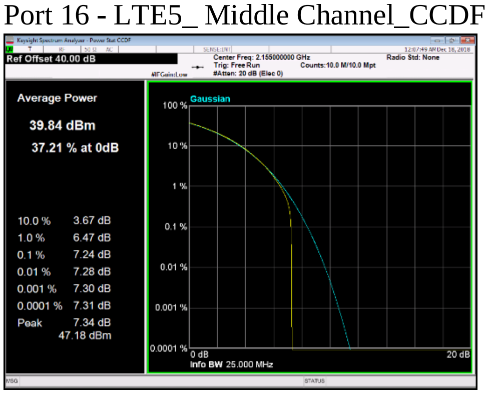
Port 15 - LTE5_ Middle Channel_CCDF



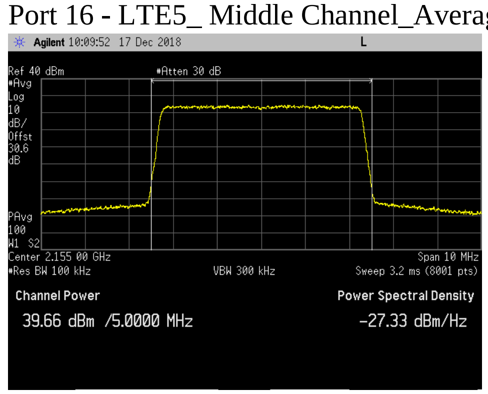
Port 15 - LTE5_ Middle Channel_Average



Port 16 - LTE5_ Middle Channel_CCDF

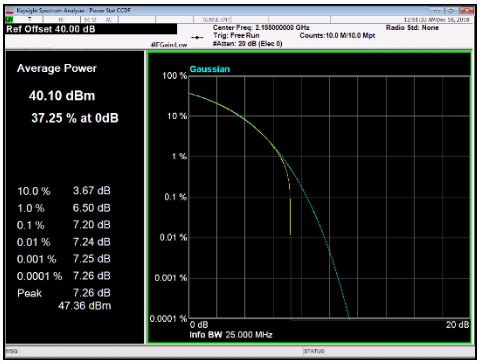


Port 16 - LTE5_ Middle Channel_Average

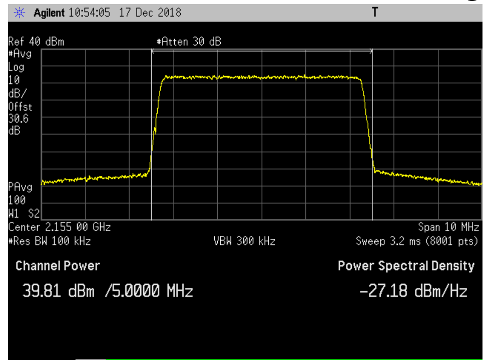


LTE5 Channel Power Plots for Antenna Port 2 at Middle Channel and all Modulation Types:

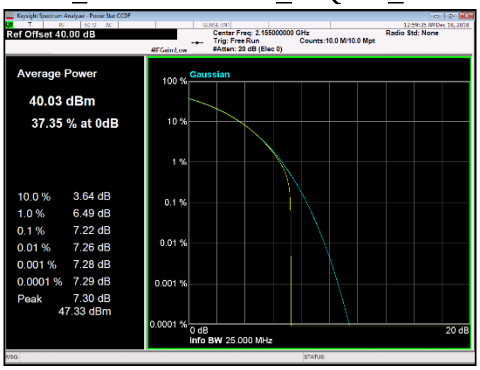
LTE5_ Middle Channel_QPSK_CCDF



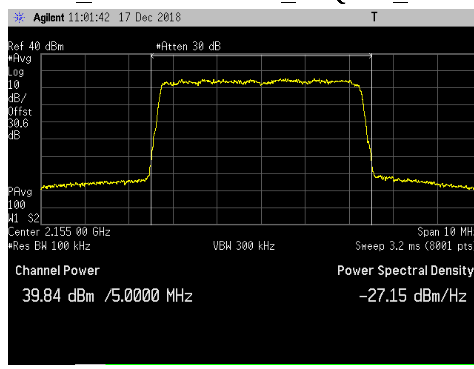
LTE5_ Middle Channel_QPSK_Average



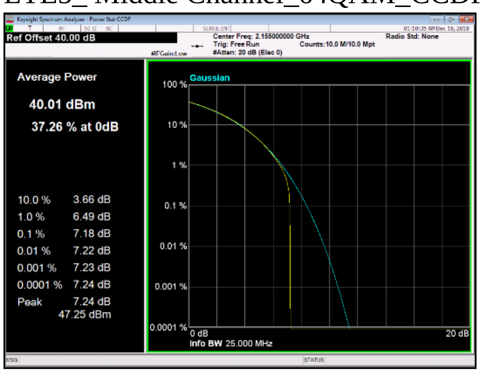
LTE5_Middle Channel_16QAM_CCDF



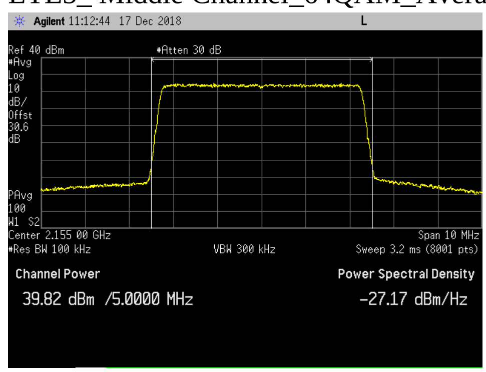
LTE5_Middle Channel_16QAM_Average



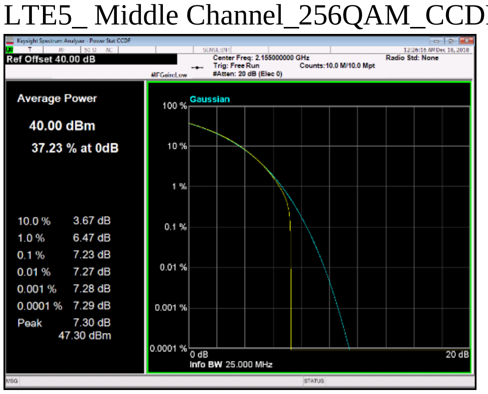
LTE5_ Middle Channel_64QAM_CCDF



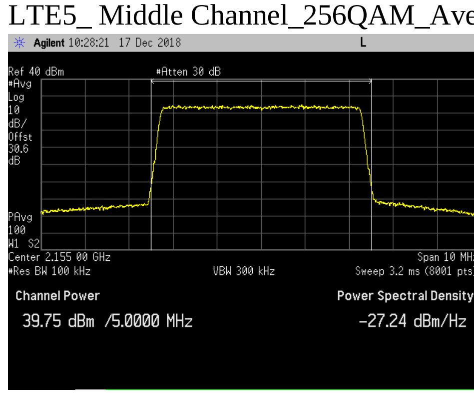
LTE5_ Middle Channel_64QAM_Average



LTE5_ Middle Channel_256QAM_CCDF

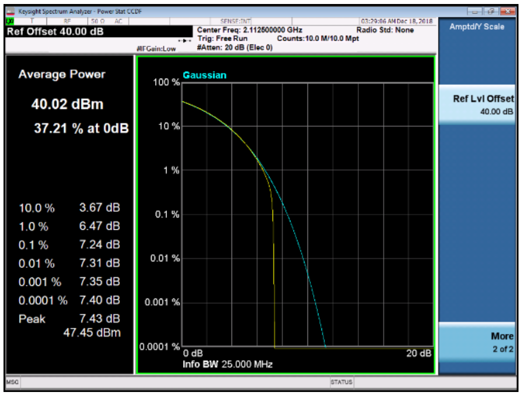


LTE5_ Middle Channel_256QAM_Average

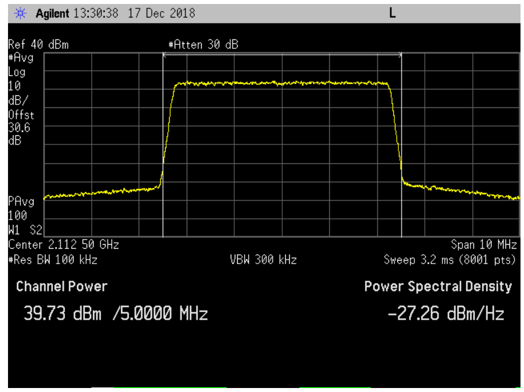


LTE5 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

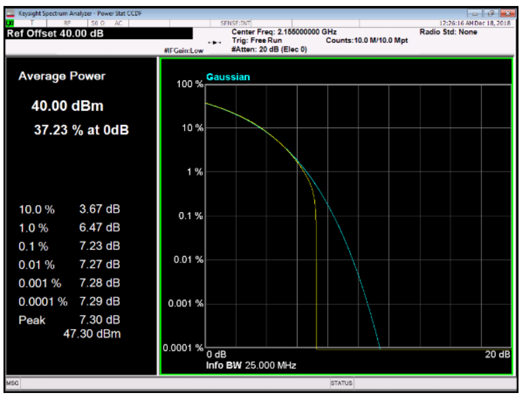
LTE5_Bottom Channel_CCDF



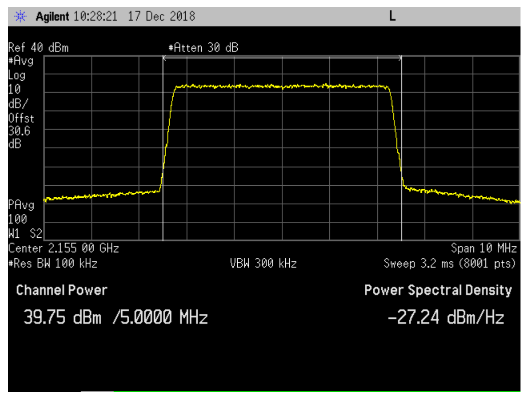
LTE5_Bottom Channel_Average



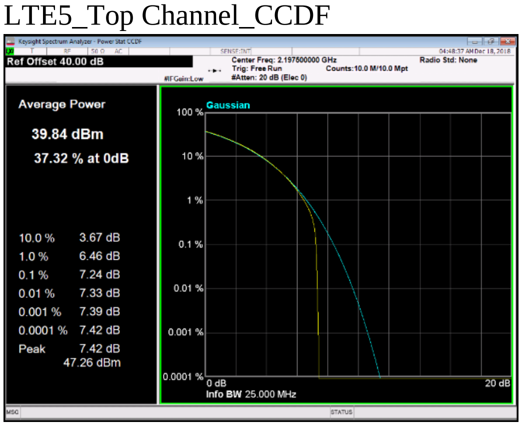
LTE5_Middle Channel_CCDF



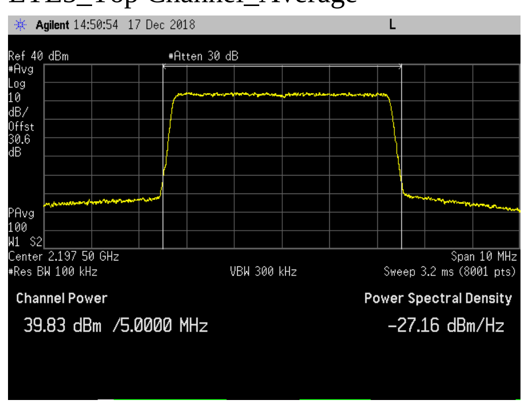
LTE5_Middle Channel_Average



LTE5_Top Channel_CCDF

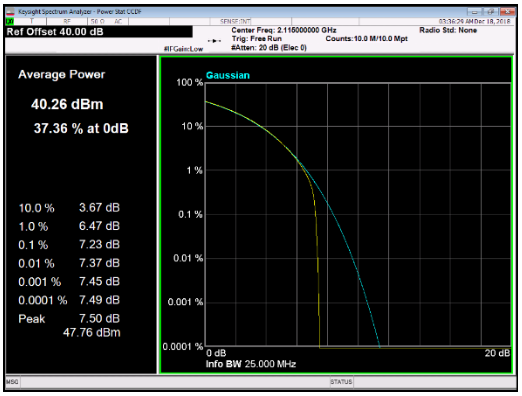


LTE5_Top Channel_Average

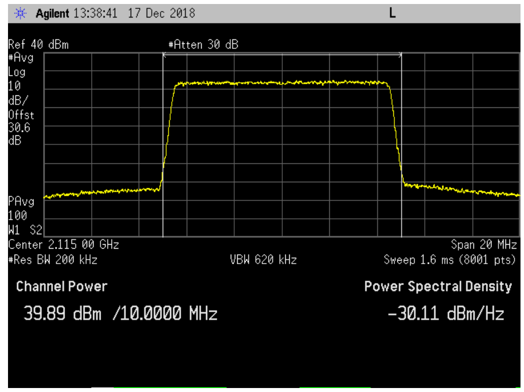


LTE10 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

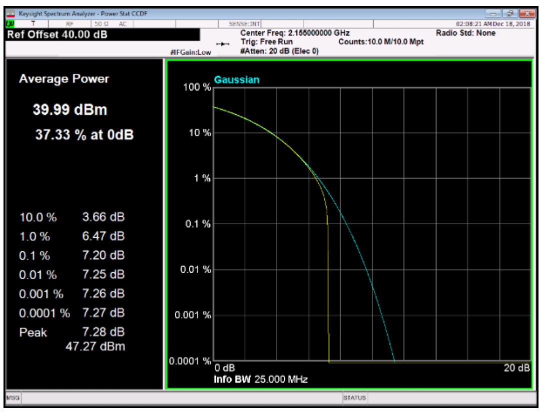
LTE10_Bottom Channel_CCDF



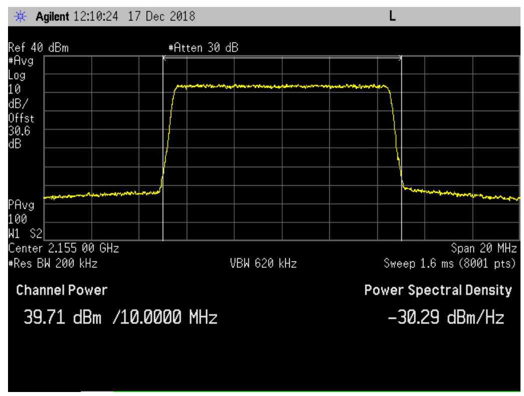
LTE10_Bottom Channel_Average



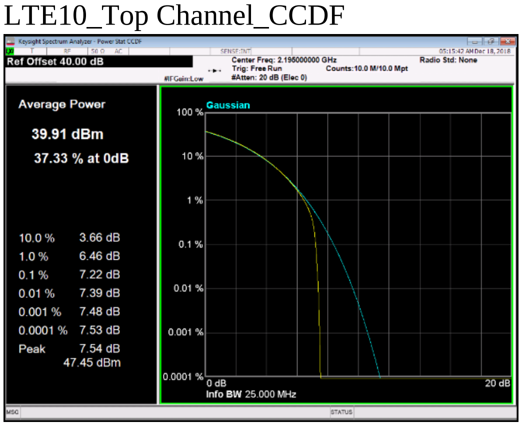
LTE10_Middle Channel_CCDF



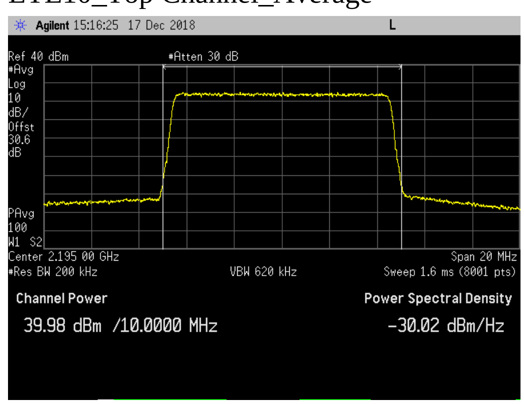
LTE10_Middle Channel_Average



LTE10_Top Channel_CCDF

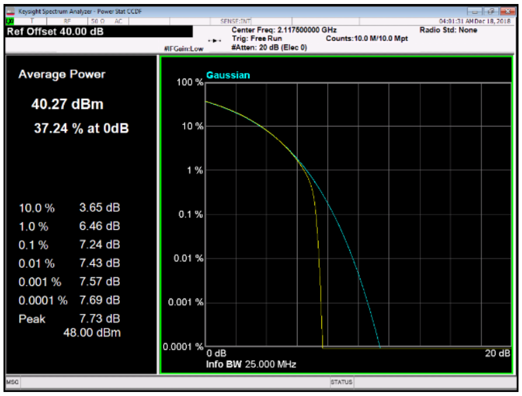


LTE10_Top Channel_Average

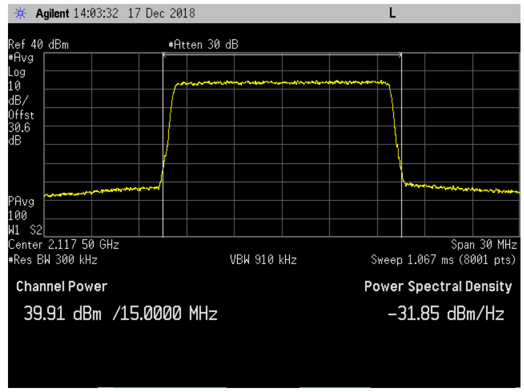


LTE15 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

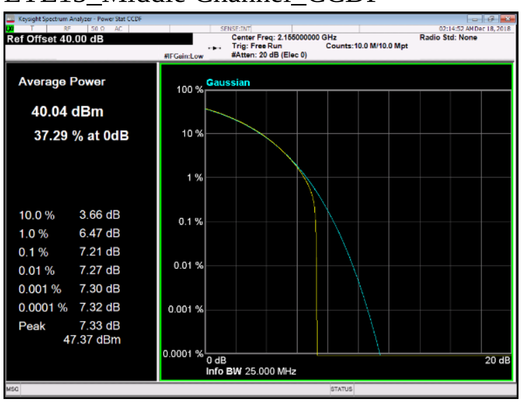
LTE15_Bottom Channel_CCDF



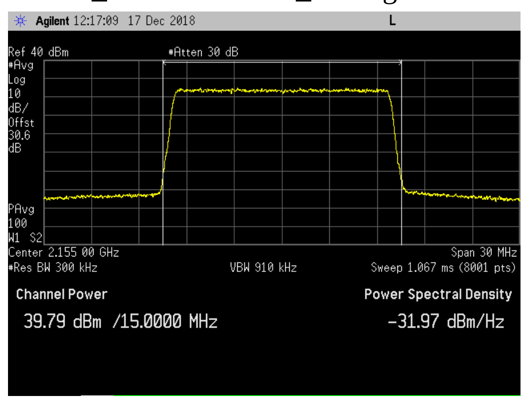
LTE15_Bottom Channel_Average



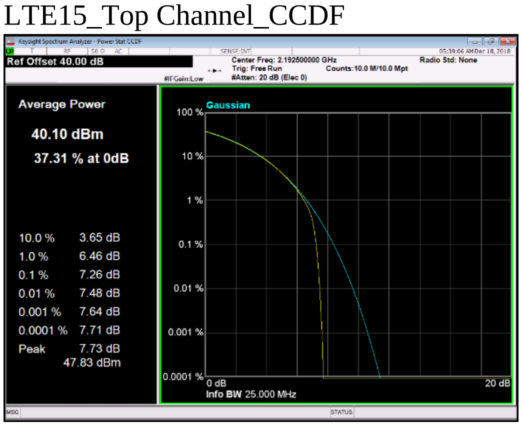
LTE15_Middle Channel_CCDF



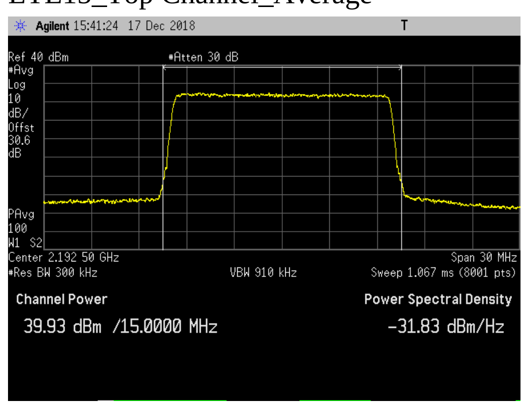
LTE15_Middle Channel_Average



LTE15_Top Channel_CCDF

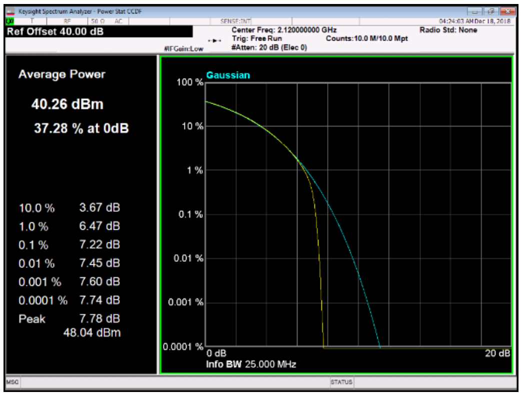


LTE15_Top Channel_Average

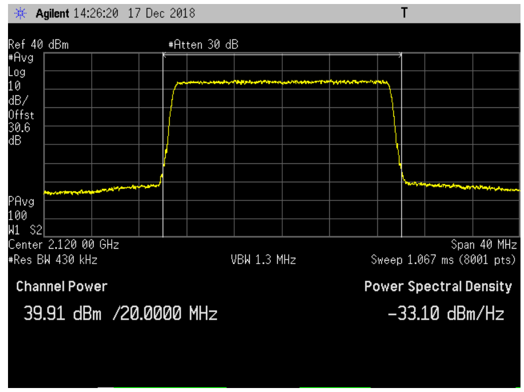


LTE20 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

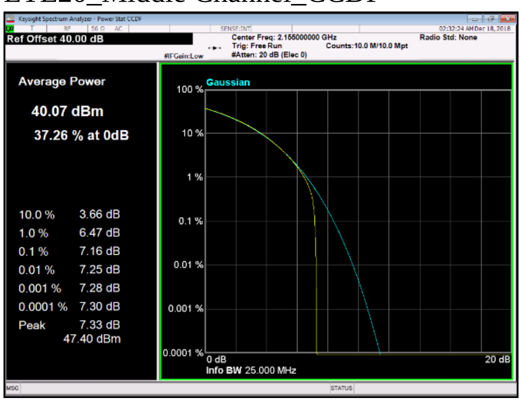
LTE20_Bottom Channel_CCDF



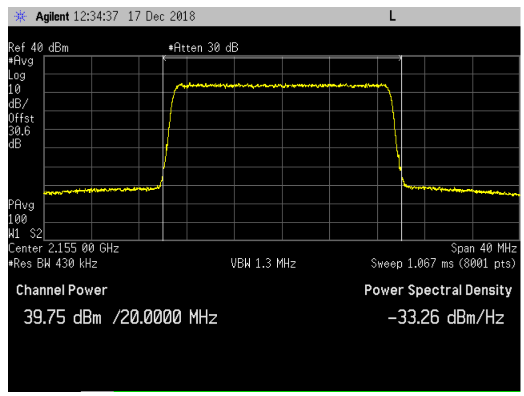
LTE20_Bottom Channel_Average



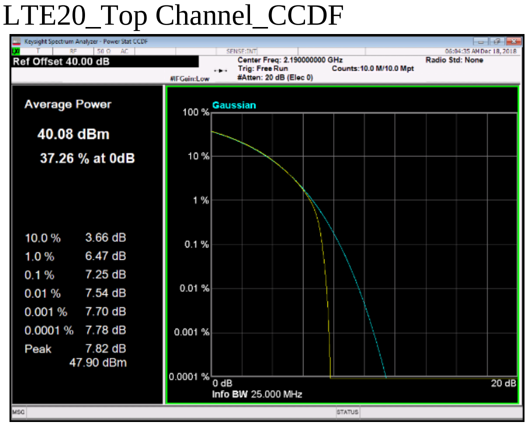
LTE20_Middle Channel_CCDF



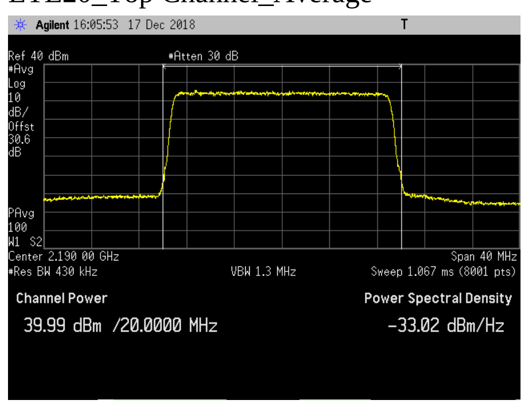
LTE20_Middle Channel_Average



LTE20_Top Channel_CCDF



LTE20_Top Channel_Average



EIRP Calculations

The RF conducted output power has been measured on the radio modules highest output antenna port for all four LTE channel bandwidths (5, 10, 15 & 20MHz) at the bottom, middle and top channel frequencies (See table in previous section for results summary of power measurements). The RF conducted power was measured in RMS Average terms as described in section 5.2 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.4.4. The worst-case/highest power output measurement was 40.0 dBm or 10.0 watts.

The 4-column antenna is used with the AAIC radio module. The 4-column antenna maximum beamforming gain is 21 dBi. The columns within the antenna have ±45° cross-polarized (orthogonal) radiators. The sixteen AAIC transmitter outputs are connected to the columns (eight are connected to +45° radiators/antennas and eight are connected to the -45° radiators/antennas). The AAIC radio module provides transmitter outputs for two 4-column antennas.

Equivalent Isotropically Radiated Power (EIRP) is calculated (as specified in KDB 662911 D02v01 for a system of correlated output signals) from the results of power measurements (highest measured output power). Calculation of worst-case EIRP is as follows:

Parameter	4-Column Antenna
Pout/Tx	40.0 dBm
Pout/Tx	10.0 Watts
Cable Loss	0 dB
Number of TRXs/Polarization	4
Pout/Polarization	40.0 Watts
Pout/Polarization	46.0 dBm
Maximum Antenna Beamforming Gain/Polarization	21 dBi
EIRP/Polarization	67.0 dBm
EIRP/Polarization	5012 Watts
Number of Polarizations	2
EIRP Total (See Note)	5012 Watts
EIRP Total (See Note)	67.0 dBm

Note: The EIRP per antenna polarity is required to be below the regulatory limit as described in KDB 662911 D02v01 page 3 example (2) since the two transmitter outputs to each antenna are 90 degree-phase shifted relative to each other (cross-polarized radiators).

The regulatory requirement for EIRP density (W/MHz) of 1640Watts/MHz or 62.15dBm/MHz is provided in FCC 27.50(d)(2)(ii) and IC RSS-139 section 6.5/RSS-170 section 5.3.1. The EIRP density is dependent on the channel bandwidth and is calculated for each LTE bandwidth as follows.

For the 4-column Antenna:

LTE Ch BW	EIRP Total	EIRP/LTE Ch BW	EIRP/LTE Ch BW	Tx Power Output Reduction needed to meet Regulatory Requirements
20 MHz	5012 W	251 W/MHz	54.0 dBm/MHz	0 dB
15 MHz	5012 W	334 W/MHz	55.2 dBm/MHz	0 dB
10 MHz	5012 W	501 W/MHz	57.0 dBm/MHz	0 dB
5 MHz	5012 W	1002 W/MHz	60.0 dBm/MHz	0 dB

Several variables are used to determine the maximum regulatory EIRP limits (such as antenna height and population density). Refer to FCC 27.50(d), IC SRSP-513 section 5.1.1, and IC SRSP-519 section 5.1 for details of regulatory EIRP limits on base stations. Base station antenna characteristics are a major contributor for EIRP determination as well. Due to these factors, EIRP calculations are needed at each transmitter location to optimize base station operational performance while meeting regulatory requirements.

Emission Bandwidth (26 dB down and 99%)

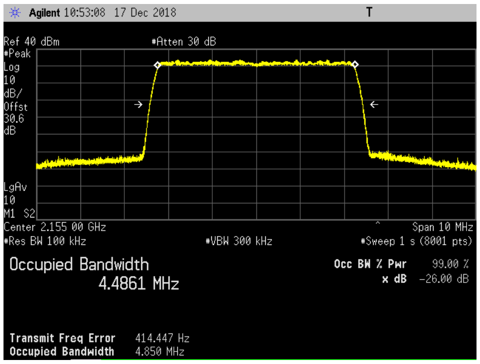
Emission bandwidth measurements were made at antenna port 2 on the middle channel with maximum RF output power. All available LTE modulations (QPSK, 16QAM, 64QAM and 256QAM) were used. All available LTE channel bandwidths (5MHz, 10MHz, 15MHz, and 20MHz) were used. The results are provided in the following table. The largest emission bandwidths in each channel type are highlighted.

LTE Channel Bandwidth	Modulation Type							
	QPSK		16QAM		64QAM		256QAM	
	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)
5M	**4.850**	4.4861	4.827	4.4788	4.845	4.4946	4.843	**4.4968**
10M	9.650	8.9790	9.663	**8.9908**	**9.677**	8.9855	9.646	8.9754
15M	14.469	13.4726	14.446	**13.4888**	**14.503**	13.4704	14.467	13.4715
20M	19.268	17.9523	19.253	**17.9905**	19.273	17.9446	**19.387**	17.9533

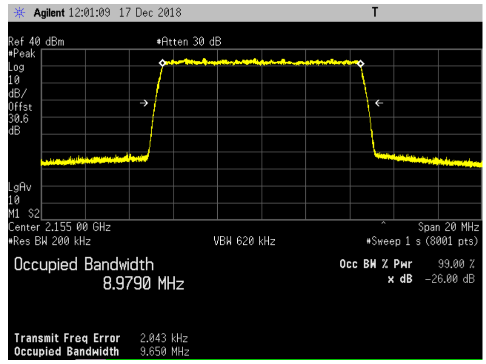
Emission bandwidth measurement data are provided in the following pages.

LTE5 and LTE10 Emission Bandwidth Plots on the Middle Channel for Antenna Port 2:

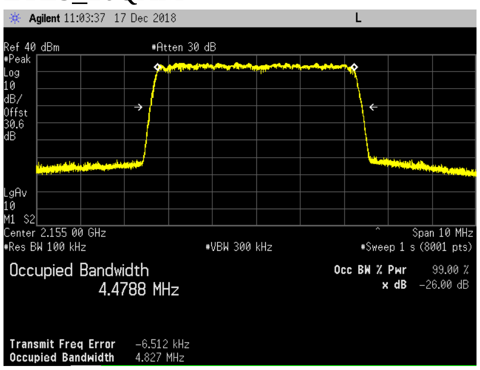
LTE5_QPSK



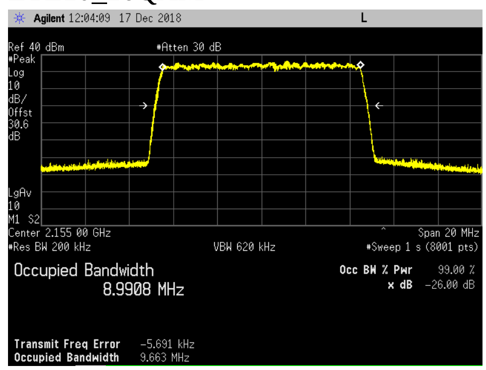
LTE10_ QPSK



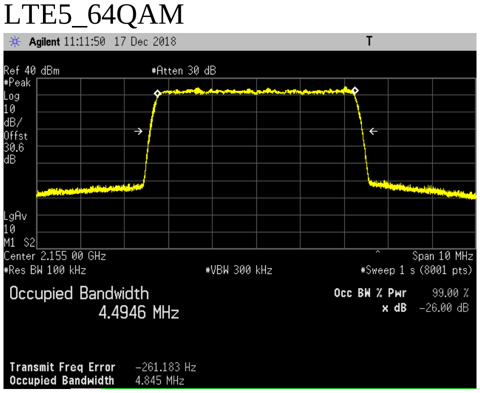
LTE5_16QAM



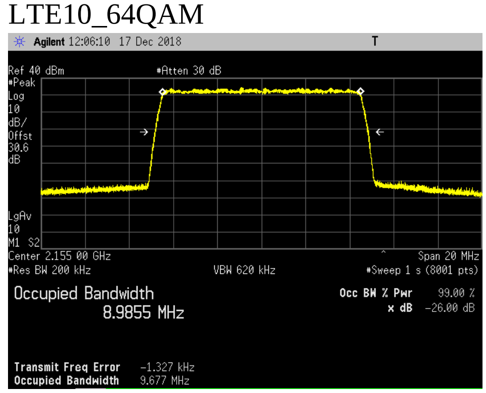
LTE10_16QAM



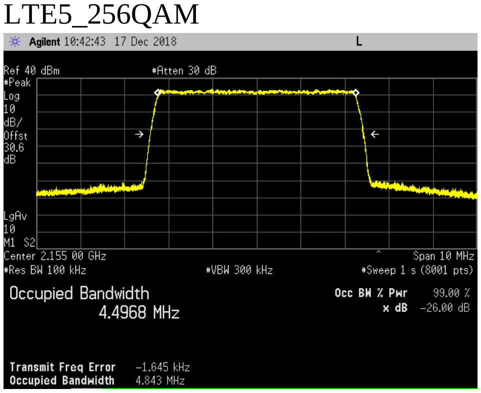
LTE5_64QAM



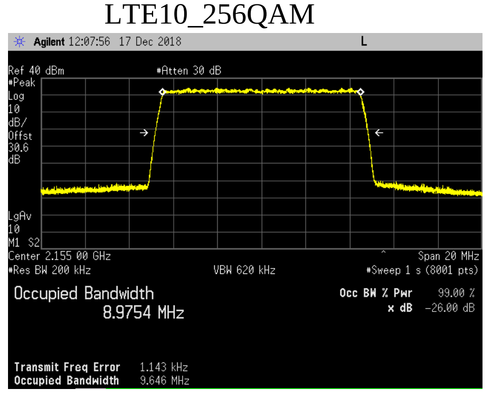
LTE10_64QAM



LTE5_256QAM

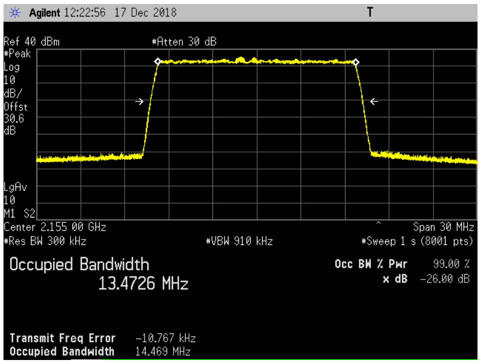


LTE10_256QAM

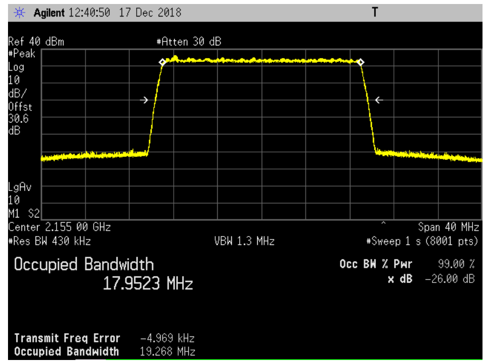


LTE15 and LTE20 Emission Bandwidth Plots on the Middle Channel for Antenna Port 2:

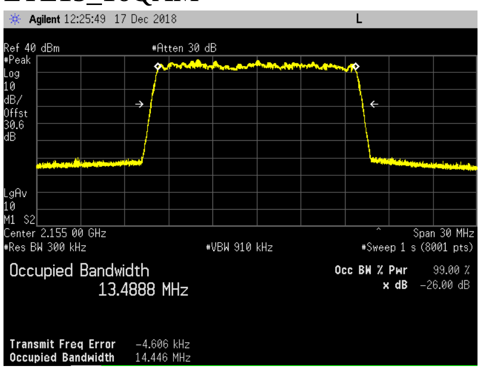
LTE15_QPSK



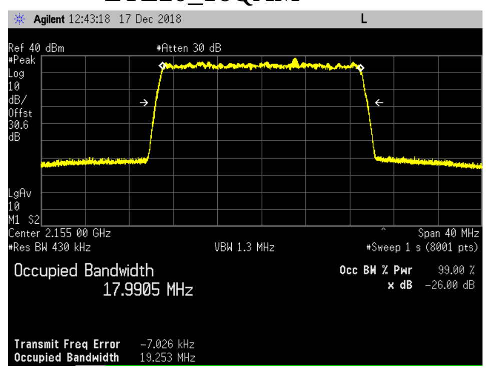
LTE20_ QPSK



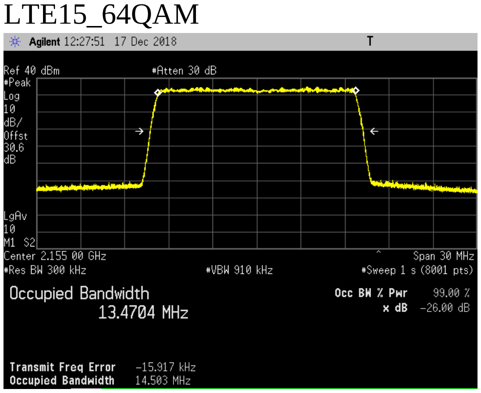
LTE15_16QAM



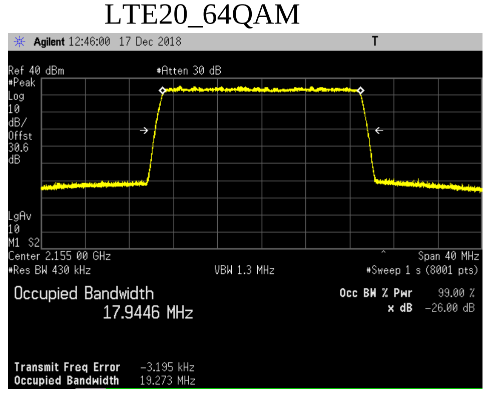
LTE20_16QAM



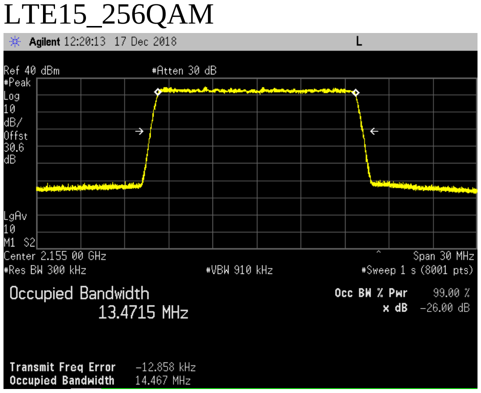
LTE15_64QAM



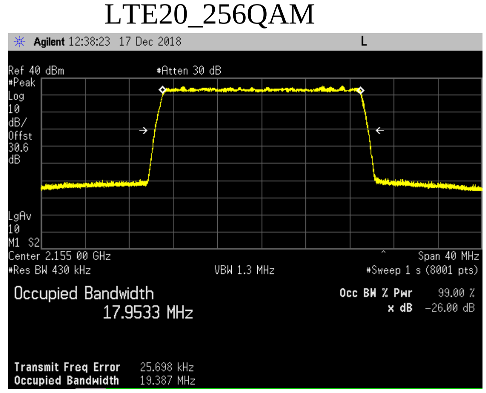
LTE20_64QAM



LTE15_256QAM



LTE20_256QAM



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at radio module antenna port 2. The radio module was operated with a single carrier at the band edge frequencies with all modulation types (QPSK, 16QAM, 64QAM and 256QAM) for 5MHz, 10MHz, 15MHz and 20MHz LTE bandwidths.

The limit of -25dBm was used in the certification testing. The limit is adjusted to -25dBm [-13dBm -10 log (16)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 16 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.: 2108 to 2109MHz and 2201 to 2202MHz bands) the RBW was again reduced to 1% of the emission bandwidth and the power integrated over 1MHz. In the 2 to 22MHz frequency range outside the band edge (i.e.: 2088 to 2108MHz and 2202 to 2222MHz 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.

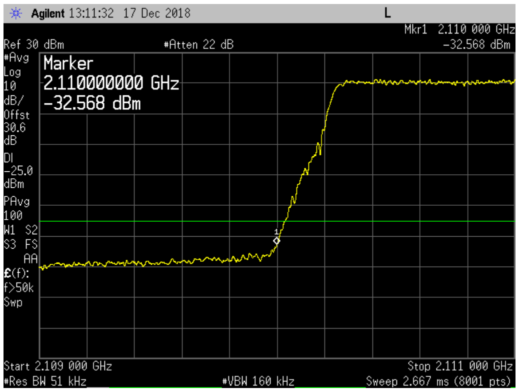
LTE Carrier Bandwidth	LTE - QPSK		LTE - 16QAM		LTE - 64QAM		LTE - 256QAM	
	Bottom (dBm)	Top (dBm)	Bottom (dBm)	Top (dBm)	Bottom (dBm)	Top (dBm)	Bottom (dBm)	Top (dBm)
5M	-27.448	-27.29	-27.469	-27.40	-27.724	-27.06	-27.670	-27.13
10M	-28.773	-27.721	-28.778	-28.42	-28.697	-28.088	-28.987	-28.27
15M	-30.257	-29.151	-30.202	-29.082	-30.243	-29.069	-30.013	-28.916
20M	-30.445	-29.510	-30.270	-29.549	-30.225	-29.515	-30.542	-29.553

The total measurement RF path loss of the test setup (attenuator, coupler and test cables) was 30.6 dB and is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.

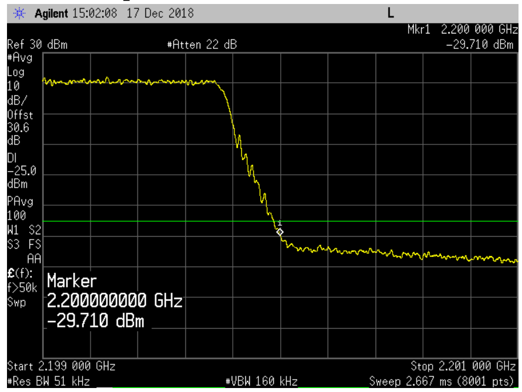
Conducted band edge measurements are provided in the following pages.

LTE5 Band Edge Plots for Antenna Port 2 and QPSK Modulation:

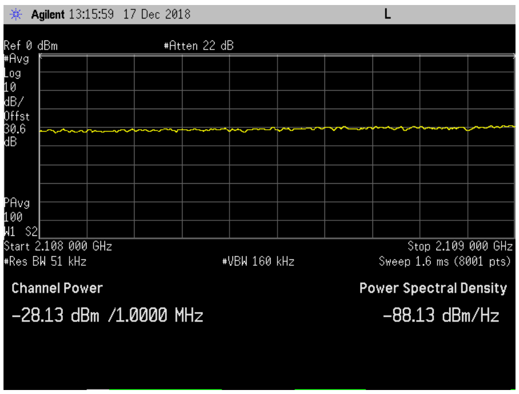
LTE5_Bottom Channel_LBE_2109 to 2111MHz



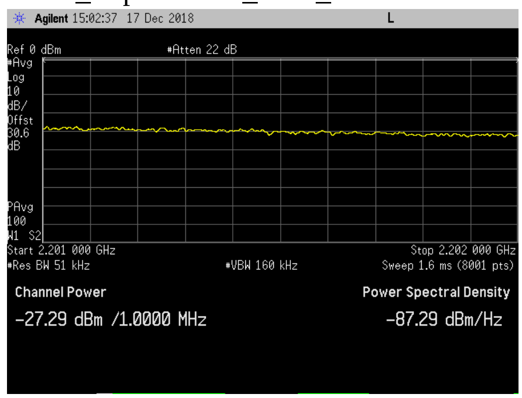
LTE5_Top Channel_UBE_2199 to 2201MHz



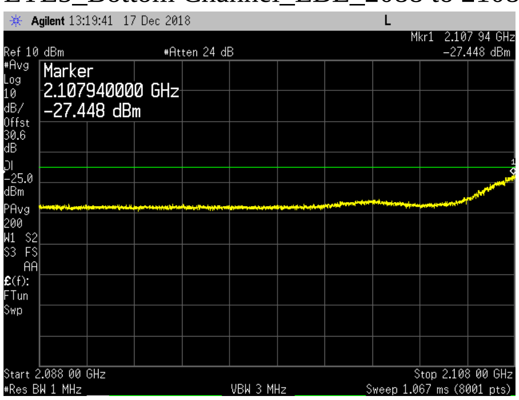
LTE5_Bottom Channel_LBE_2108 to 2109MHz



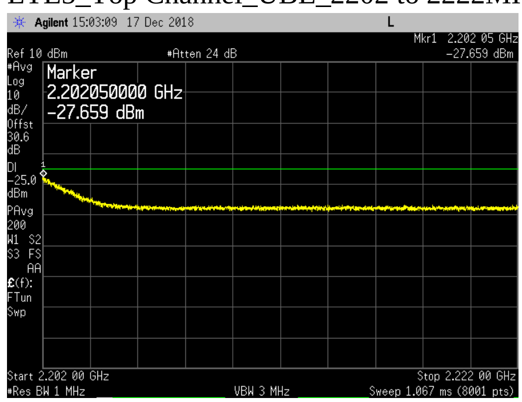
LTE5_Top Channel_UBE_2201 to 2202MHz



LTE5_Bottom Channel_LBE_2088 to 2108MHz

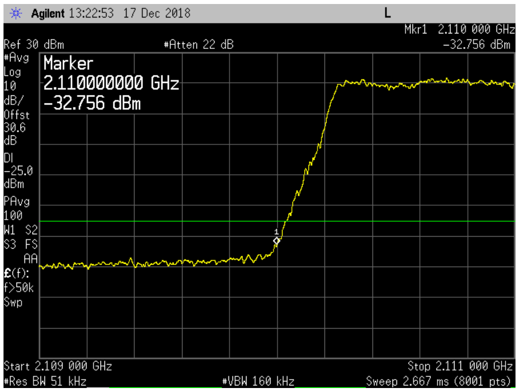


LTE5_Top Channel_UBE_2202 to 2222MHz

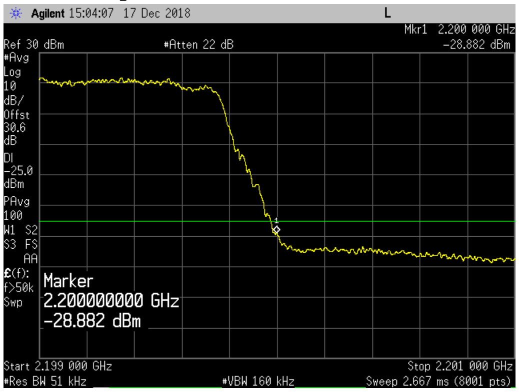


LTE5 Band Edge Plots for Antenna Port 2 and 16QAM Modulation:

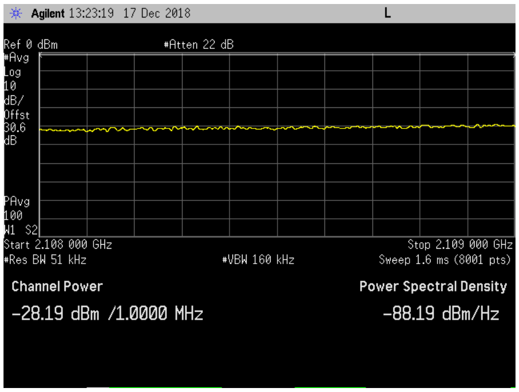
LTE5_Bottom Channel_LBE_2109 to 2111MHz



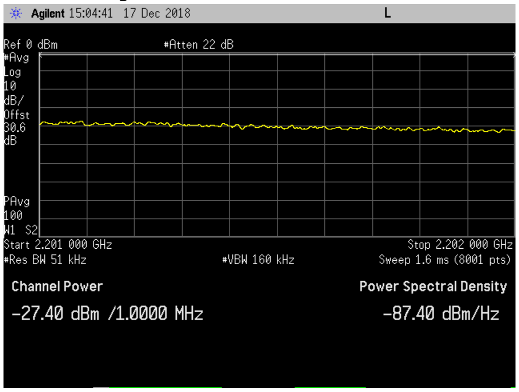
LTE5_Top Channel_UBE_2199 to 2201MHz



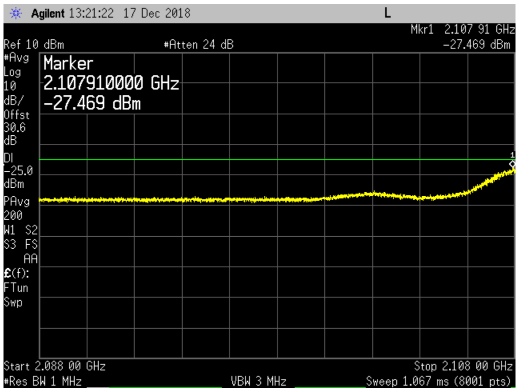
LTE5_Bottom Channel_LBE_2108 to 2109MHz



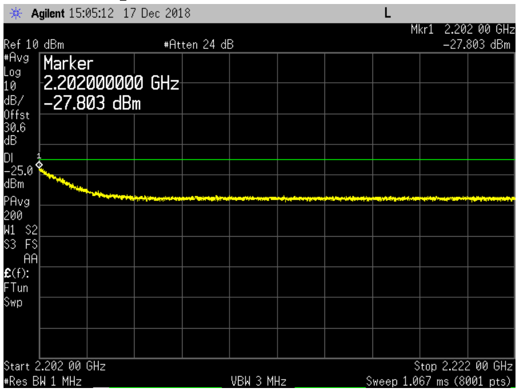
LTE5_Top Channel_UBE_2201 to 2202MHz



LTE5_Bottom Channel_LBE_2088 to 2108MHz

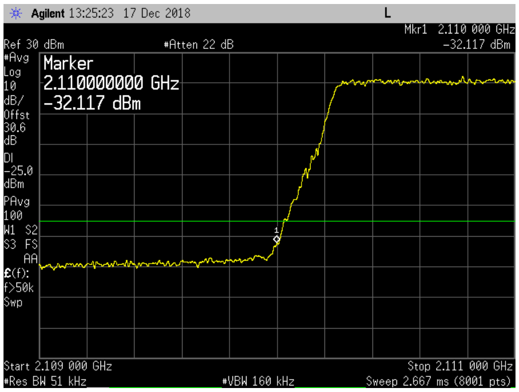


LTE5_Top Channel_UBE_2202 to 2222MHz

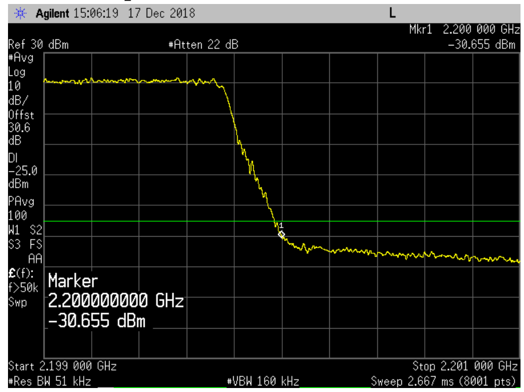


LTE5 Band Edge Plots for Antenna Port 2 and 64QAM Modulation:

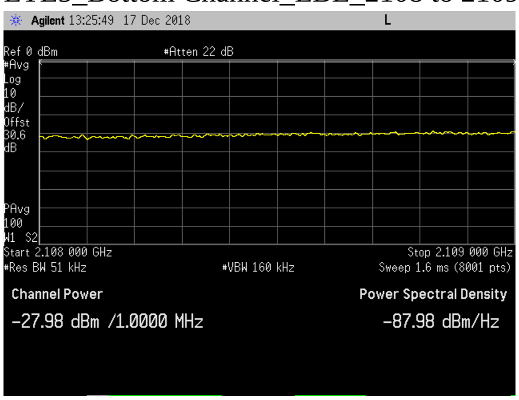
LTE5_Bottom Channel_LBE_2109 to 2111MHz



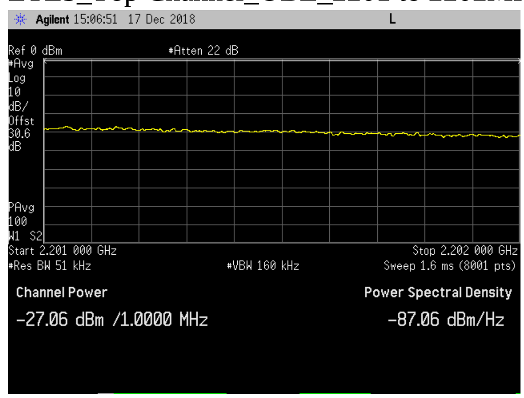
LTE5_Top Channel_UBE_2199 to 2201MHz



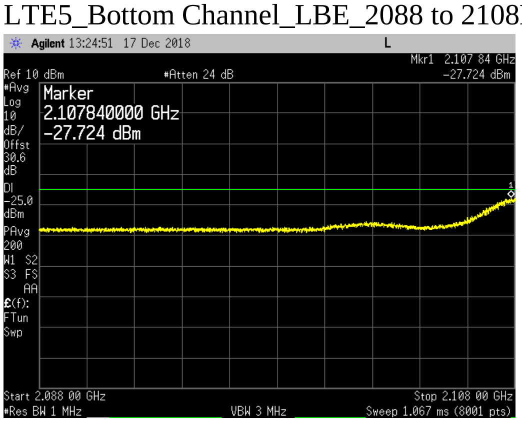
LTE5_Bottom Channel_LBE_2108 to 2109MHz



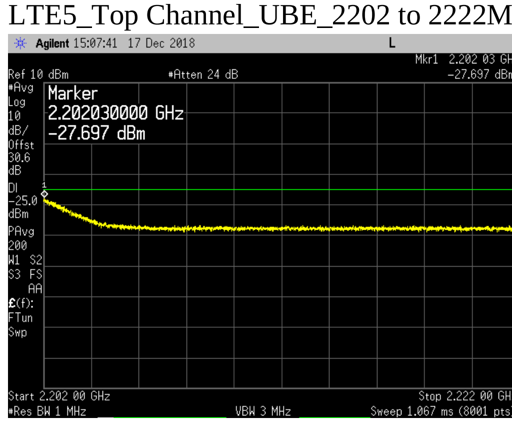
LTE5_Top Channel_UBE_2201 to 2202MHz



LTE5_Bottom Channel_LBE_2088 to 2108MHz

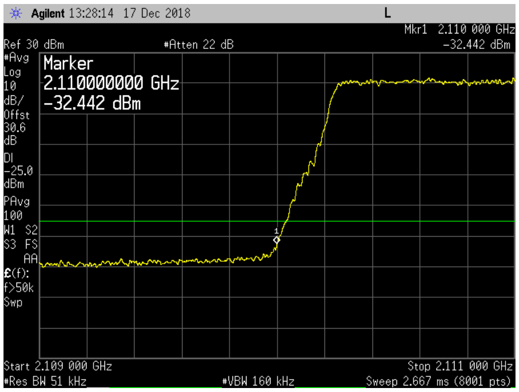


LTE5_Top Channel_UBE_2202 to 2222MHz

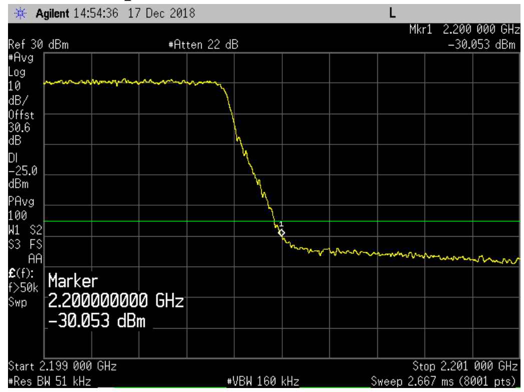


LTE5 Band Edge Plots for Antenna Port 2 and 256QAM Modulation:

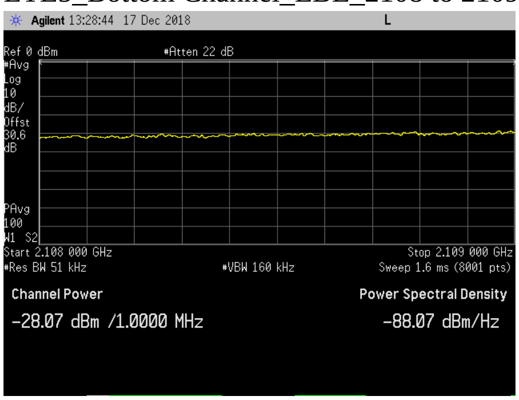
LTE5_Bottom Channel_LBE_2109 to 2111MHz



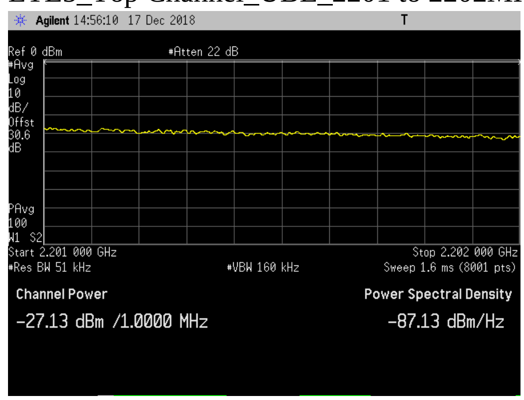
LTE5_Top Channel_UBE_2199 to 2201MHz



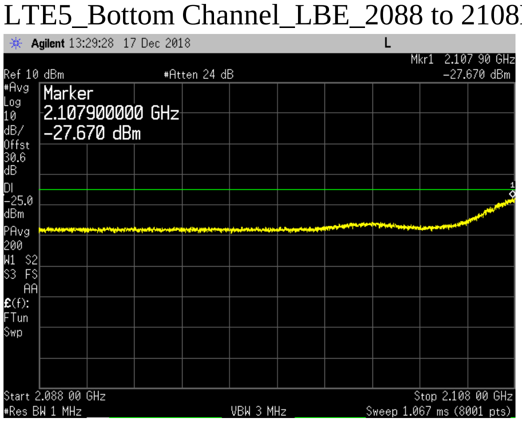
LTE5_Bottom Channel_LBE_2108 to 2109MHz



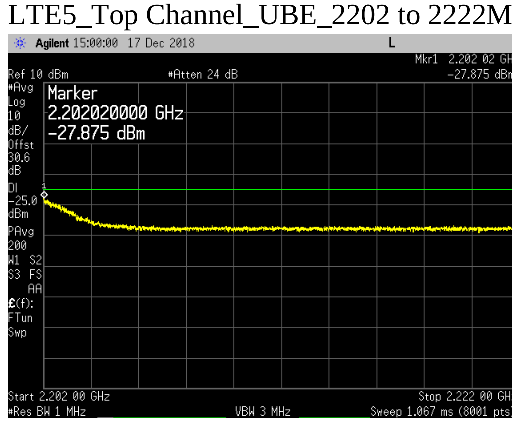
LTE5_Top Channel_UBE_2201 to 2202MHz



LTE5_Bottom Channel_LBE_2088 to 2108MHz

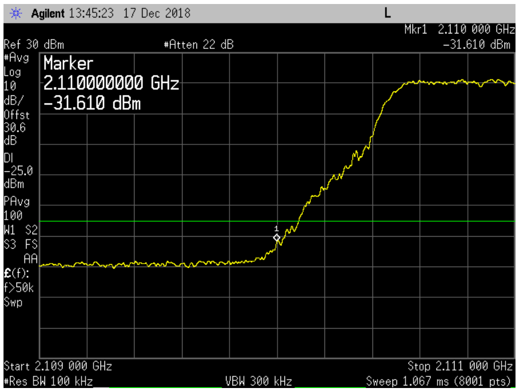


LTE5_Top Channel_UBE_2202 to 2222MHz

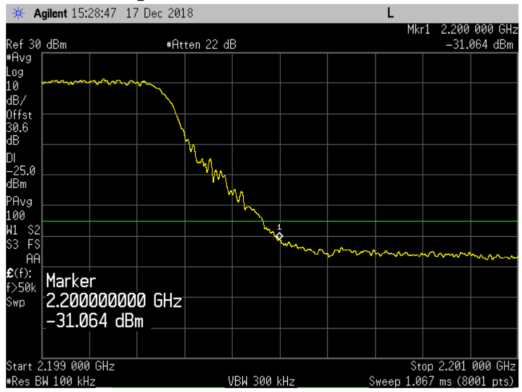


LTE10 Band Edge Plots for Antenna Port 2 and QPSK Modulation:

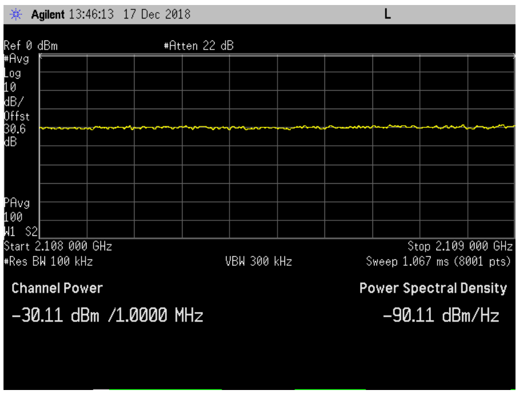
LTE10_Bottom Channel_LBE_2109 to 2111MHz



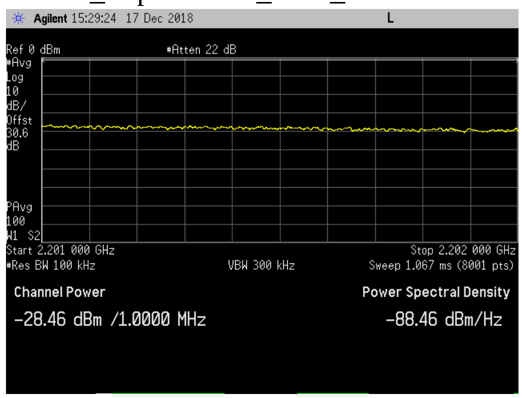
LTE10_Top Channel_UBE_2199 to 2201MHz



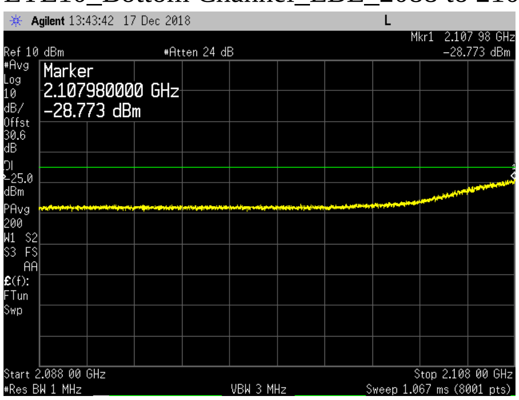
LTE10_Bottom Channel_LBE_2108 to 2109MHz



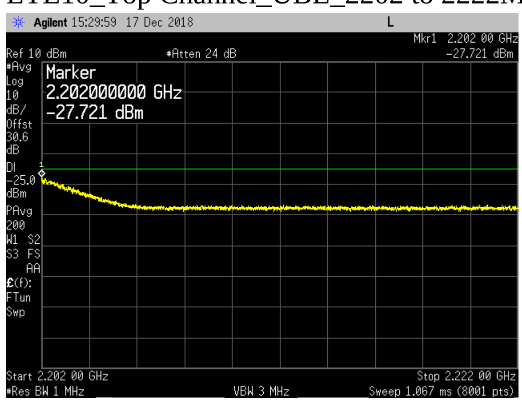
LTE10_Top Channel_UBE_2201 to 2202MHz



LTE10_Bottom Channel_LBE_2088 to 2108MHz

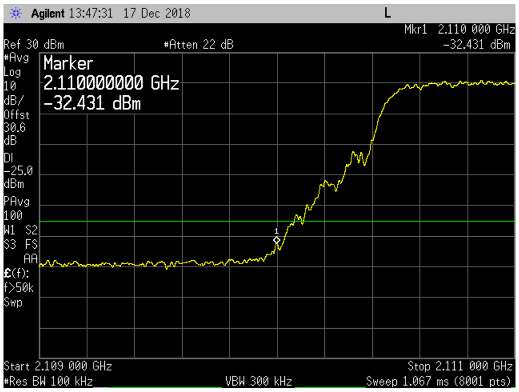


LTE10_Top Channel_UBE_2202 to 2222MHz

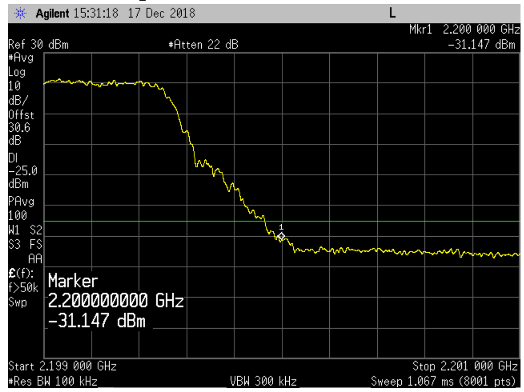


LTE10 Band Edge Plots for Antenna Port 2 and 16QAM Modulation:

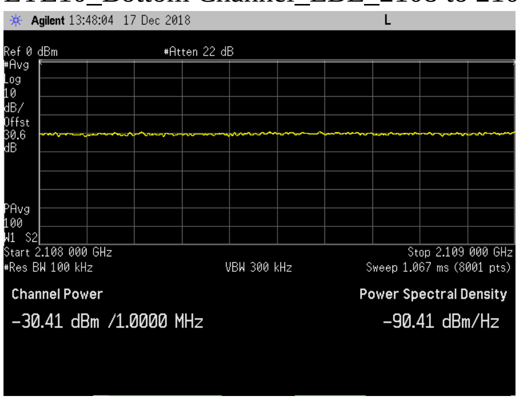
LTE10_Bottom Channel_LBE_2109 to 2111MHz



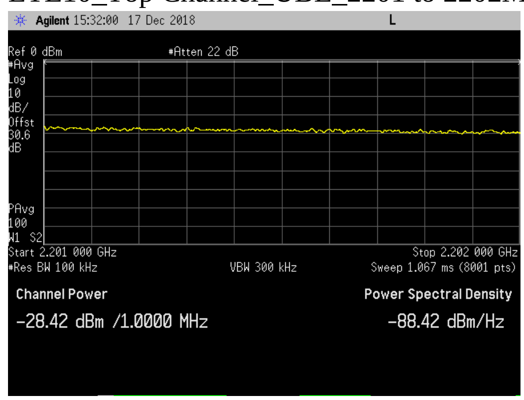
LTE10_Top Channel_UBE_2199 to 2201MHz



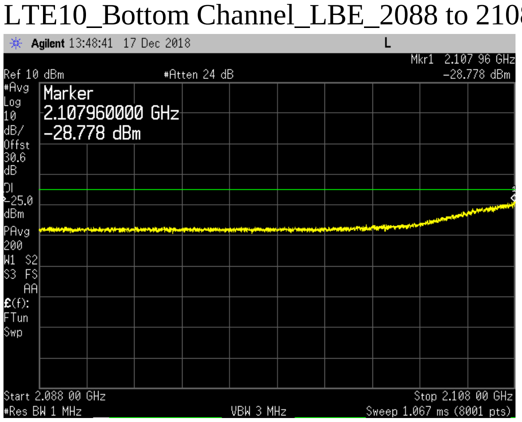
LTE10_Bottom Channel_LBE_2108 to 2109MHz



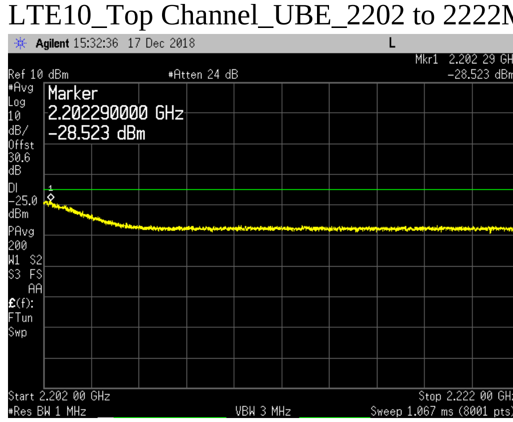
LTE10_Top Channel_UBE_2201 to 2202MHz



LTE10_Bottom Channel_LBE_2088 to 2108MHz

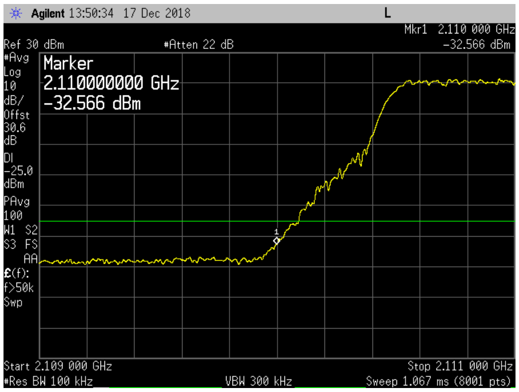


LTE10_Top Channel_UBE_2202 to 2222MHz

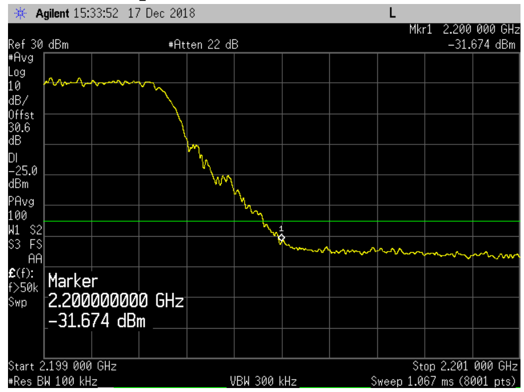


LTE10 Band Edge Plots for Antenna Port 2 and 64QAM Modulation:

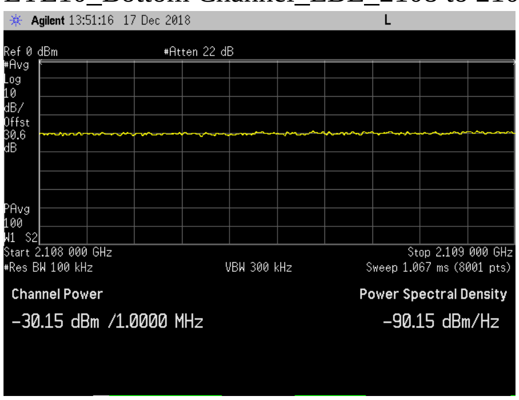
LTE10_Bottom Channel_LBE_2109 to 2111MHz



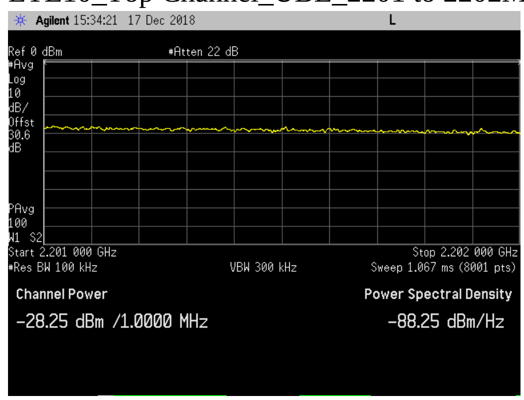
LTE10_Top Channel_UBE_2199 to 2201MHz



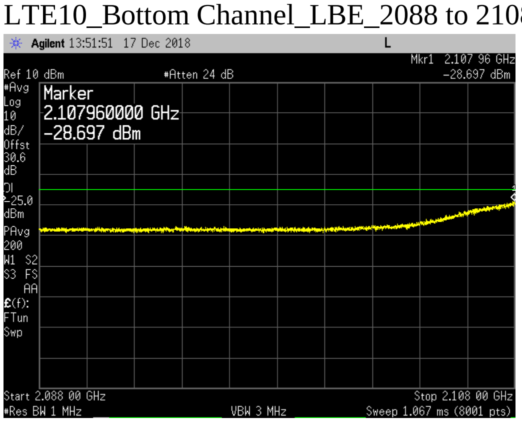
LTE10_Bottom Channel_LBE_2108 to 2109MHz



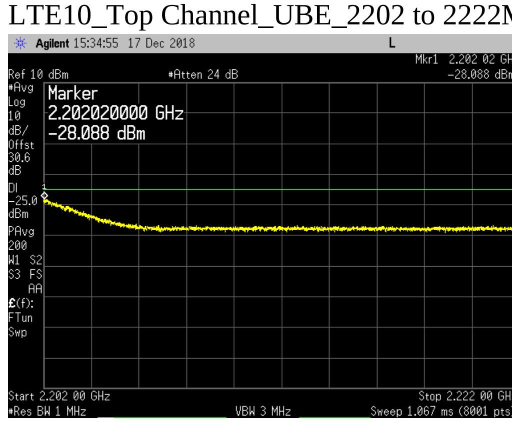
LTE10_Top Channel_UBE_2201 to 2202MHz



LTE10_Bottom Channel_LBE_2088 to 2108MHz

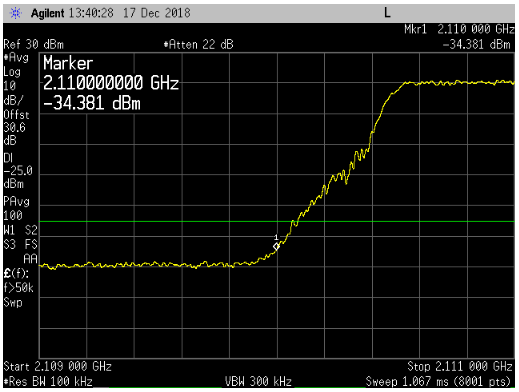


LTE10_Top Channel_UBE_2202 to 2222MHz

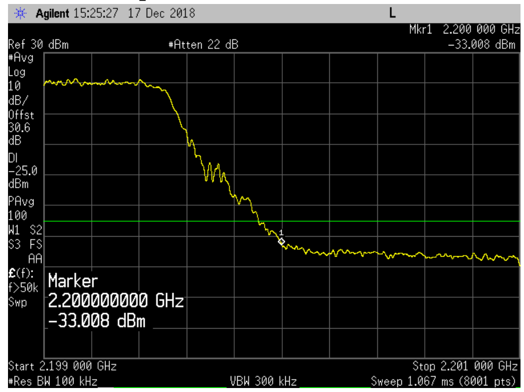


LTE10 Band Edge Plots for Antenna Port 2 and 256QAM Modulation:

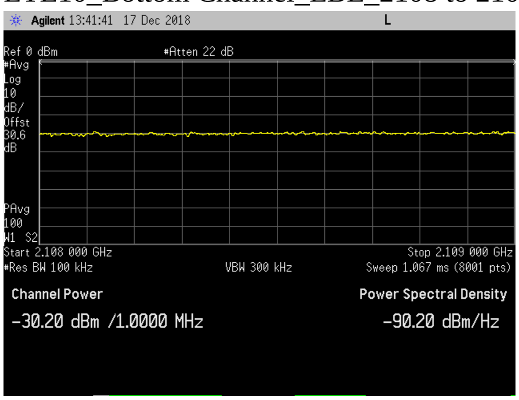
LTE10_Bottom Channel_LBE_2109 to 2111MHz



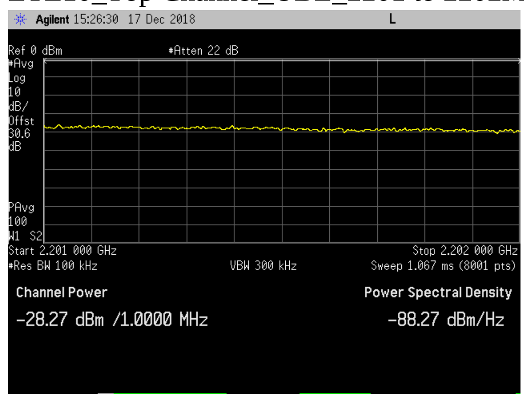
LTE10_Top Channel_UBE_2199 to 2201MHz



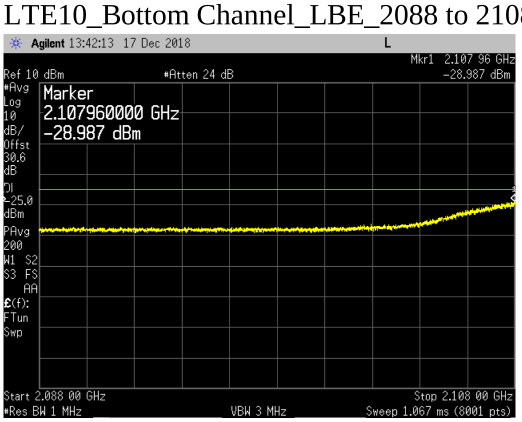
LTE10_Bottom Channel_LBE_2108 to 2109MHz



LTE10_Top Channel_UBE_2201 to 2202MHz



LTE10_Bottom Channel_LBE_2088 to 2108MHz



LTE10_Top Channel_UBE_2202 to 2222MHz