



CERTIFICATE #: 0214.19

Radio Test Report

Application for Grant of Equipment Authorization

FCC Part 24 and IC RSS-133
[1930MHz – 1995MHz]

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

FCC ID: VBNAHFIA-01
IC ID: 661W-AHFIA

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

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

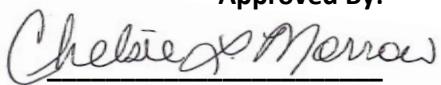
Test Sites: Nokia Solutions and Networks
6000 Connection Drive
Irving, TX 75039
and
National Technical Systems – Plano
1701 E Plano Pkwy #150
Plano, TX 75074

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Prepared By:


Armando Del Angel
EMI Supervisor

Approved By:


Chelsie Morrow
Quality Assurance Manager

Reviewed By:


Jeffrey Viel
General Manager

REVISION HISTORY

| Rev# | Date | Comments | Modified By |
|------|-----------|--------------------------------------|-------------------|
| 0 | 3/17/2018 | Initial Draft | Armando Del Angel |
| 1 | 3/18/2018 | Corrections per Customer comments | Armando Del Angel |
| | | | |

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SCOPE

Tests have been performed on Nokia Solutions and Networks product Airscale Base Station Remote Radio Head (RRH) Model AHFIA, 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 2013 (2GHz Personal Communications Services)
- CFR Title 47 Part 27 Subpart C & L
- RSS-139 Issue 3- July 16, 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 C63.4-2014
ANSI TIA-603-D
FCC KDB 971168 D01 v02r02

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 AHFIA 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 AHFIA. 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 AHFIA 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 1995MHz Band)

| AHFIA 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 | LTE5: 1932.5 – 1992.5MHz LTE10: 1935.0 – 1990.0MHz LTE15: 1937.5 – 1987.5MHz LTE20: 1940.0 – 1985.0MHz | 1930.0 – 1995.0MHz | Pass |
| 2.1047 | RSS-133 Section 6.2 | Modulation Type | QPSK, 16QAM, 64QAM and 256QAM for LTE5, LTE10, LTE15 & LTE20 | Digital | Pass |
| 24.232 | RSS-133 Section 6.4 | Output Power | Highest Conducted Power Output RMS: 46.32dBm EIRP depends on antenna gain which is unknown | FCC: 1640W EIRP IC: 100 Watts Conducted | Pass |
| 24.232 | RSS-133 Section 6.4 | Peak to Average Power Ratio | Highest Measured PAPR: 8.08dB | 13dB | Pass |
| | RSS-133 Section 2.3 | 99% Emission Bandwidth | LTE5: 4.4958MHz LTE10: 8.9942MHz LTE15: 13.4897MHz LTE20: 17.9849MHz | Remain in Block | Pass |
| 24.238 | | 26dB down Emission Bandwidth | LTE5: 4.843MHz LTE10: 9.677MHz LTE15: 14.500MHz LTE20: 19.339MHz | Remain in Block | Pass |
| Transmitter Spurious Emissions¹ | | | | | |
| 24.238 | RSS-133 Section 6.5.1 | At the antenna terminals | < -19dBm | -19dBm per Transmit Chain | Pass |
| | | Field Strength | 47.182dBuV/m at 3m Eq. to -48.018dBm EIRP | -13dBm EIRP | Pass |
| Other Details | | | | | |
| 24.235 | RSS-133 | Frequency Stability | Stays within authorized frequency block | 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. | | | | | |

| PCS Band Emission Designators | | | | | | | | |
|-------------------------------|----------|----------|-----------|----------|-----------|----------|------------|----------|
| Channel Bandwidth | LTE-QPSK | | LTE-16QAM | | LTE-64QAM | | LTE-256QAM | |
| | FCC | IC | FCC | IC | FCC | IC | FCC | IC |
| 5M | 4M84F9W | 4M49F9W | 4M83F9W | 4M48F9W | 4M83F9W | 4M49F9W | 4M84F9W | 4M50F9W |
| 10M | 9M65F9W | 8M97F9W | 9M64F9W | 8M99F9W | 9M68F9W | 8M98F9W | 9M64F9W | 8M97F9W |
| 15M | 14M45F9W | 13M47F9W | 14M43F9W | 13M49F9W | 14M50F9W | 13M46F9W | 14M48F9W | 13M47F9W |
| 20M | 19M29F9W | 17M94F9W | 19M24F9W | 17M99F9W | 19M29F9W | 17M94F9W | 19M34F9W | 17M95F9W |

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)

| AHFIA 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: 46.41dBm 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: 8.08dB | 13dB | Pass |
| | RSS-Gen Sec 6.6 | 99% Emission Bandwidth | LTE5: 4.4966MHz LTE10: 8.9922MHz LTE15: 13.4883MHz LTE20: 17.9740MHz | Remain in Block | Pass |
| 27.53(h)(3) | | 26dB down Emission Bandwidth | LTE5: 4.850MHz LTE10: 9.659MHz LTE15: 14.497MHz LTE20: 19.385MHz | Remain in Block | Pass |
| Transmitter Spurious Emissions¹ | | | | | |
| 27.53(h) | RSS-139 Sec 6.6 | At the antenna terminals | < -19dBm | -19dBm per Transmit Chain | Pass |
| | | Field strength | 56.282dBuV/m at 1m Eq. to -48.418dBm EIRP | -13 dBm EIRP | Pass |
| Other Details | | | | | |
| 27.54 | RSS-139 Sec 6.4 | Frequency Stability | Stays within authorized frequency block | 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. | | | | | |

| AWS Band 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 | 4M84F9W | 4M49F9W | 4M84F9W | 4M50F9W |
| 10M | 9M64F9W | 8M98F9W | 9M66F9W | 8M99F9W | 9M66F9W | 8M98F9W | 9M65F9W | 8M97F9W |
| 15M | 14M44F9W | 13M47F9W | 14M42F9W | 13M49F9W | 14M50F9W | 13M46F9W | 14M46F9W | 13M46F9W |
| 20M | 19M31F9W | 17M93F9W | 19M24F9W | 17M97F9W | 19M29F9W | 17M94F9W | 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) Remote Radio Head (RRH) module, model AHFIA. The AHFIA remote radio head is a multistandard multicarrier radio module designed to support GSM/EDGE, WCDMA, 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 AHFIA RRH has four transmit/four receive antenna ports (4TX/4RX for Band 25 and 4TX/4RX for Band 66a). Each antenna port supports 3GPP frequency band 25 (BTS Rx: 1850 to 1915 MHz/BTS TX: 1930 to 1995 MHz) and 3GPP frequency band 66a (BTS Rx: 1710 to 1780 MHz/BTS TX: 2110 to 2180 MHz). The maximum RF output power of the RRH is 160 Watts (40 watts per carrier, 40 watts per antenna port). 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 5, 10, 15, and 20MHz LTE bandwidths. 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 AHFIA LTE channel numbers and frequencies are as follows:

| | Downlink EARFCN | Downlink Frequency (MHz) | LTE Channel Bandwidth | | | |
|--------------------------------|--------------------|--------------------------------|-----------------------|-------------|-------------|-------------|
| | | | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| AHFIA Band 25 (Ant 1, 2, 3, 4) | 8040 | 1930.0 | Band Edge | Band Edge | Band Edge | Band Edge |
| | | | | | | |
| | 8065 | 1932.5 | Bottom Ch | | | |
| | | | | | | |
| | 8090 | 1935.0 | | Bottom Ch | | |
| | | | | | | |
| | 8115 | 1937.5 | | | Bottom Ch | |
| | | | | | | |
| | 8140 | 1940.0 | | | | Bottom Ch |
| | | | | | | |
| | 8365 | 1962.5 | Middle Ch | Middle Ch | Middle Ch | Middle Ch |
| | | | | | | |
| | 8590 | 1985.0 | | | | Top Channel |
| | | | | | | |
| | 8615 | 1987.5 | | | Top Channel | |
| | | | | | | |
| | 8640 | 1990.0 | | Top Channel | | |
| | | | | | | |
| | 8665 | 1992.5 | Top Channel | | | |
| | | | | | | |
| | 8690 | 1995.0 | Band Edge | Band Edge | Band Edge | Band Edge |

AHFIA Downlink Band Edge LTE Band 25 Frequency Channels

| | Downlink EARFCN | Downlink Frequency (MHz) | LTE Channel Bandwidth | | | |
|---------------------------------|--------------------|--------------------------------|-----------------------|-------------|-------------|-------------|
| | | | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| AHFIA Band 66a (Ant 1, 2, 3, 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 |

AHFIA 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 | AHFIA | AirScale BTS RRH | Part#: 473967A.101 Serial#: K9174623559 | FCC ID: VBNAHFIA-01 IC ID: 661W-AHFIA |

Enclosure

The EUT enclosure is made of heavy duty aluminum and has the following physical characteristics:

| Configuration | Approximate Weight | Approximate Dimensions | Approximate Volume |
|---------------|--------------------|------------------------|--------------------|
| AHFIA | 24 kg | 308x560x125 mm | 24 Liters |

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 | KR16180010053 |
| 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 |

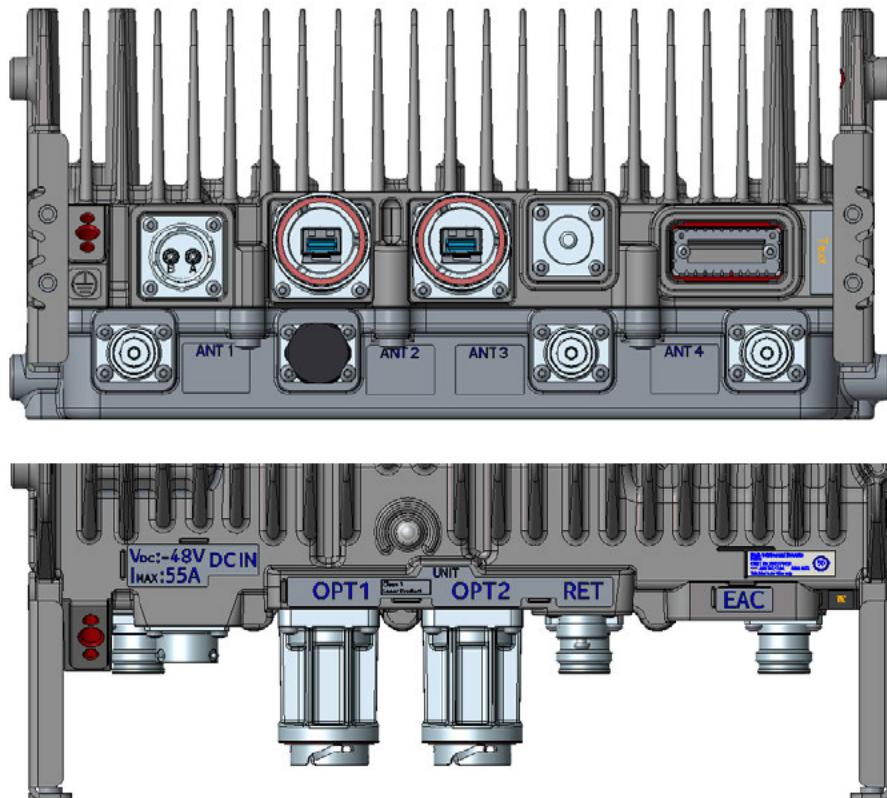
Note 1: Used only in antenna port RF conducted emission testing.

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 | 4 | 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 |

AHFIA 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 | 4 | 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 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: FRM58.01.R05
- (2) System Module Software: FL18SP_FSM4_9999_180117_003281
- (3) BTS Site Manager: BTSSite-EM_FL00_0000_000401_000000

Modifications

No modifications were made to the EUT during testing.

TESTING

General Information

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

Radiated emissions and frequency accuracy/stability measurements were taken 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 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-4 | 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.

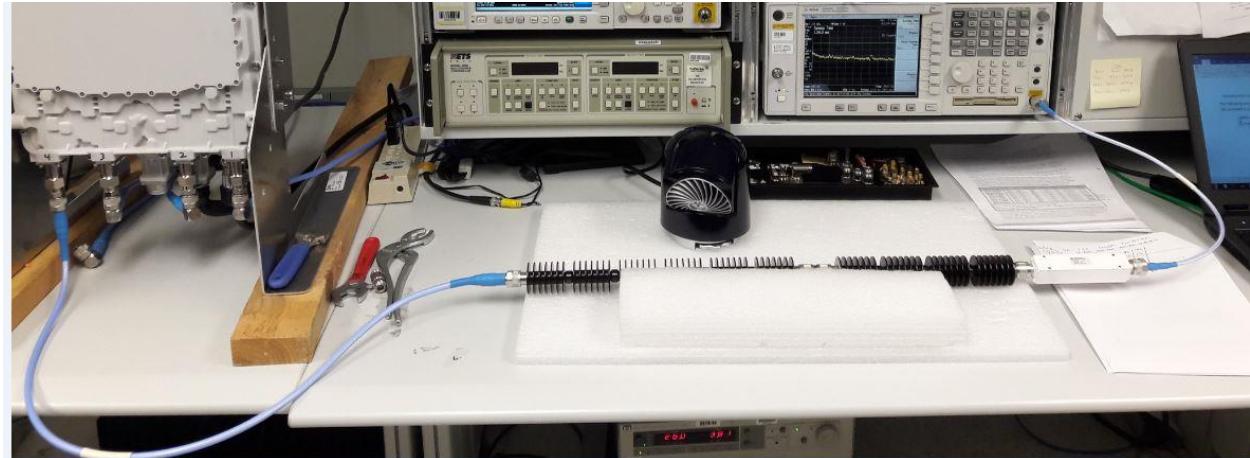
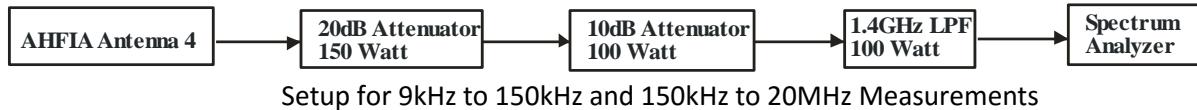
Conducted spurious emissions were captured with Keysight BenchVue Software across the 9kHz-22GHz frequency span. A low pass was used to reduce measurement instrumentation noise floor for the frequency ranges less than 20MHz. A high pass filter was used to reduce measurement instrumentation noise floor 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-C-2004. 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 biconic log 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

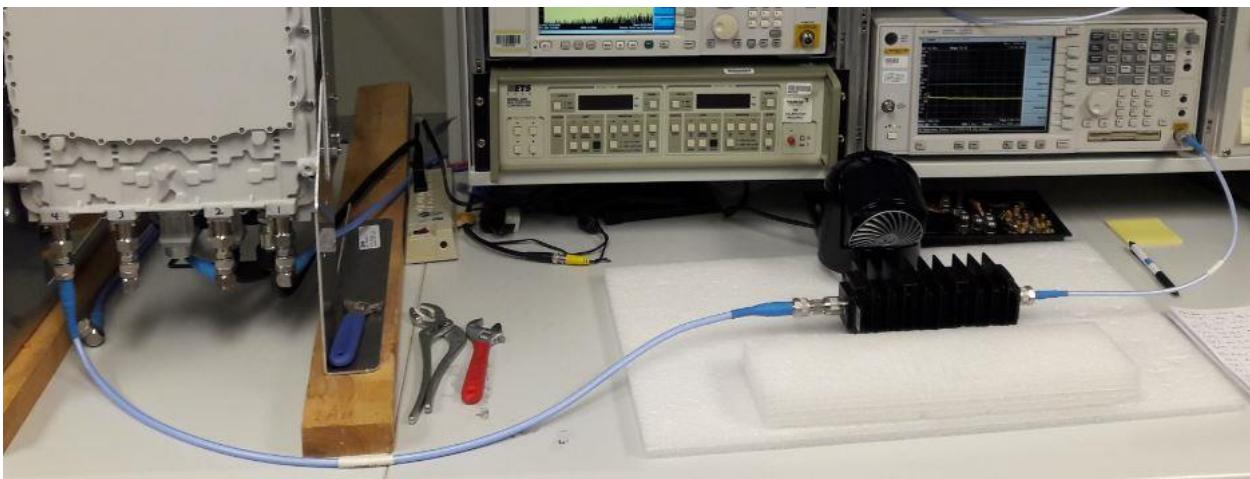
The following setups were used in the RF conducted emissions testing. Photographs of the test setups are also provided.



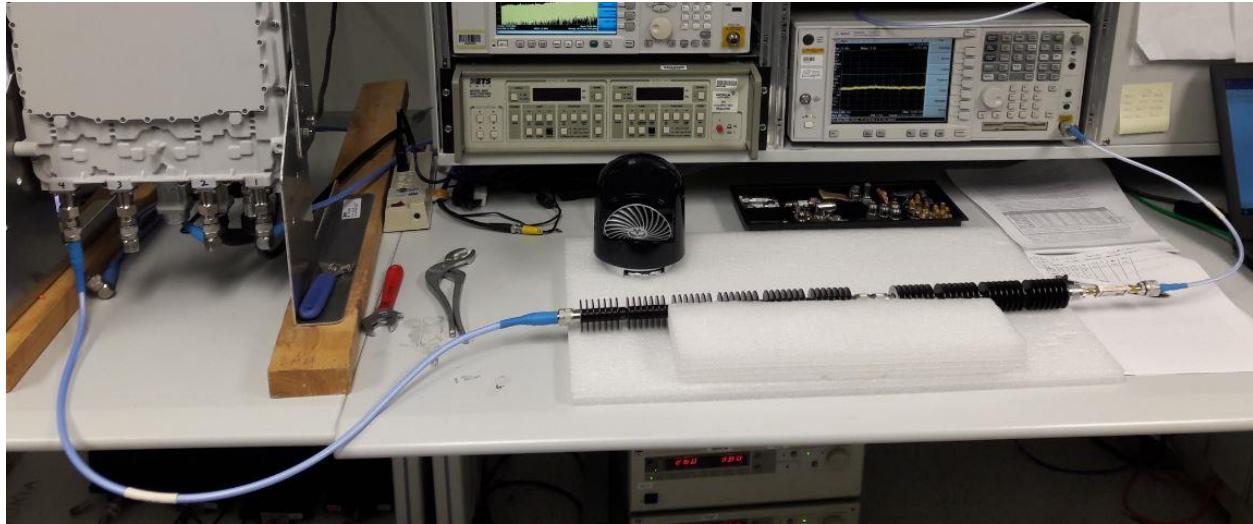
Photograph of 9kHz to 150kHz and 150kHz to 20MHz Test Setup



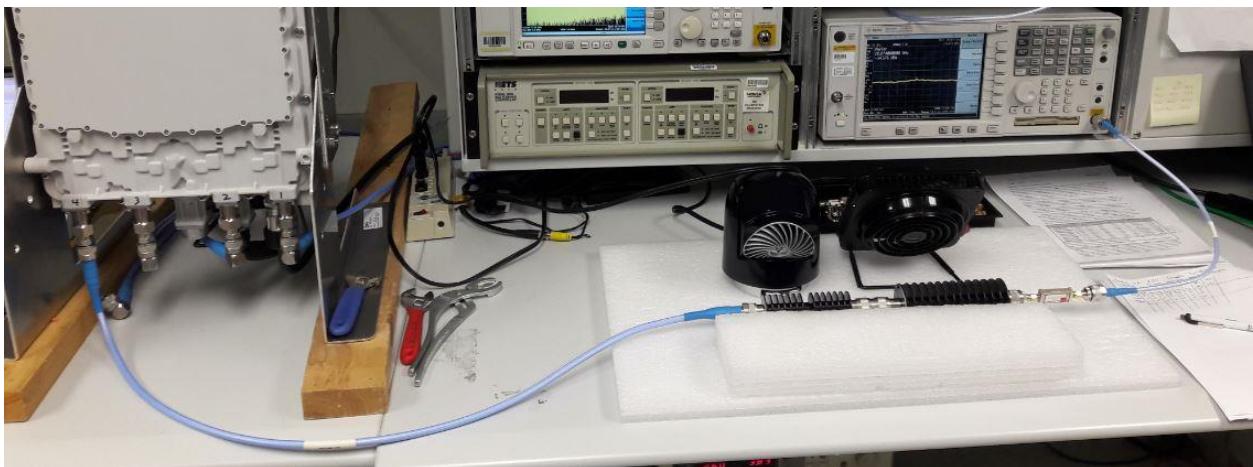
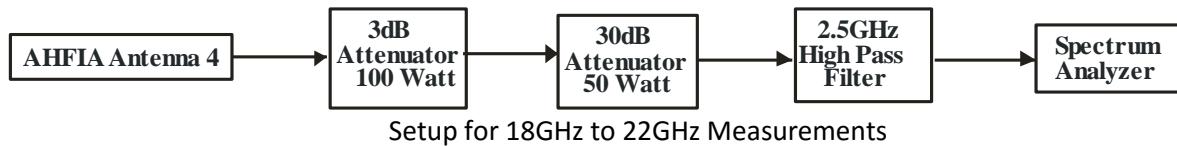
Setup for 20MHz to 3GHz and 3GHz to 6GHz Measurements



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



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



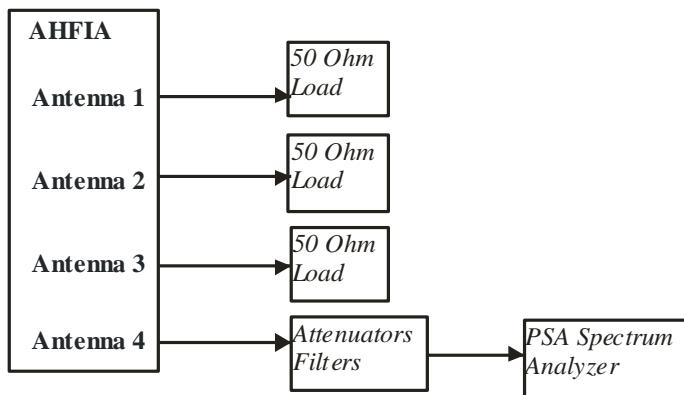
Photograph of 18GHz to 22GHz Test Setup

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 |
| E1366P | PreAmp (30MHz-1GHz) | MITEQ | AM-1431-N-1197SC | 12 Months | 2/15/2019 |
| E1009P | PreAmp (18-27GHz) | HP | 8449B | 12 Months | 2/14/2019 |
| 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 |
| NM06112 ¹ | PNA Network Analyzer | Keysight | N5224A | 12 Months | 9/5/2018 |
| NM04509 ¹ | Network Analyzer | Rohde & Schwarz | ZVL 3 | 12 Months | 2/25/2019 |
| 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 AHFIA antenna ports. The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on AHFIA

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 1 Middle Channel | 5M | 53.94 | 46.0 | 7.94 |
| Port 2 Middle Channel | 5M | 53.97 | 46.0 | 7.97 |
| Port 3 Middle Channel | 5M | 54.07 | 46.08 | 7.99 |
| Port 4 Middle Channel | 5M | 54.15 | 46.25 | 7.90 |

The variation in RMS output power levels between the antenna ports is 0.25 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 4 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 4 Middle Channel LTE5 | 54.17 | 46.25 | 54.09 | 46.26 | 54.15 | 46.24 | 54.15 | 46.25 |

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 0.02dB 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 4 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. Port 4 has the highest combined RMS average power for the AWS + PCS bands.

Subsequently output power levels on bottom, middle, and top channels in all 4 LTE channel bandwidths using 256QAM modulation type were tested only at Port 4 and the results presented below. The highest measured values are highlighted.

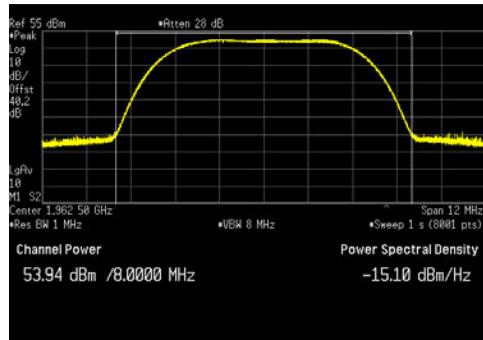
| Antenna LTE Channel | LTE Bandwidth | LTE - 256QAM | | |
|-----------------------------|---------------|---------------|--------------|--------------|
| | | Peak (dBm) | Ave (dBm) | PAPR (dB) |
| Port 4 Bottom Channel | 5M | 54.01 | 46.11 | 7.90 |
| | 10M | 54.27 | 46.23 | 8.04 |
| | 15M | 54.26 | 46.26 | 8.00 |
| | 20M | 54.31 | 46.28 | 8.03 |
| Port 4 Middle Channel | 5M | 54.17 | 46.25 | 7.92 |
| | 10M | 54.37 | 46.29 | 8.08 |
| | 15M | 54.18 | 46.19 | 7.99 |
| | 20M | 54.30 | 46.22 | 8.08 |
| Port 4 Top Channel | 5M | 54.08 | 46.22 | 7.86 |
| | 10M | 54.21 | 46.25 | 7.96 |
| | 15M | 54.34 | 46.32 | 8.02 |
| | 20M | 54.37 | 46.29 | 8.08 |

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 (0.10dB).

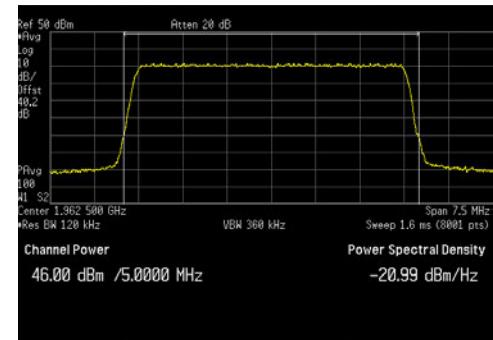
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

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

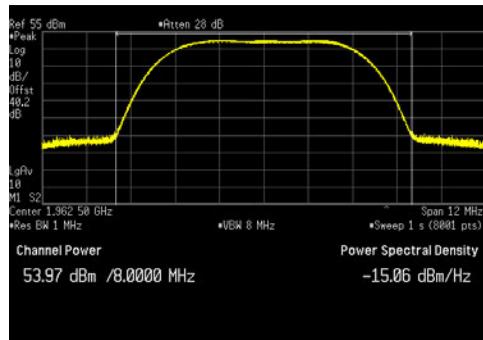
Port 1 - LTE5_Middle Channel_Peak



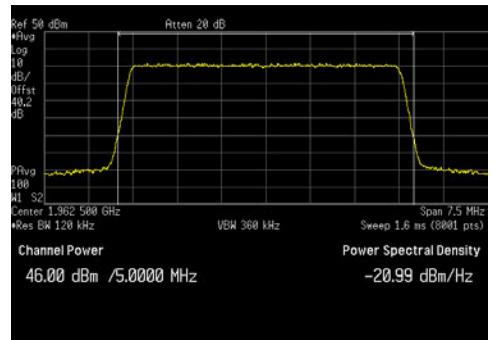
Port 1 - LTE5_Middle Channel_Average



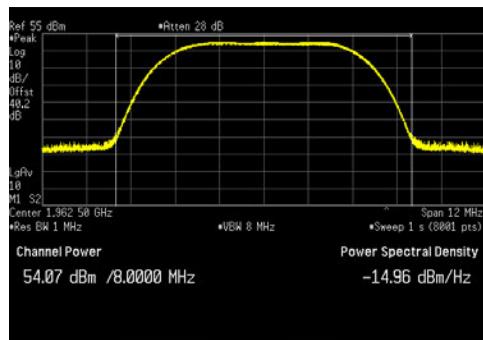
Port 2 - LTE5_Middle Channel_Peak



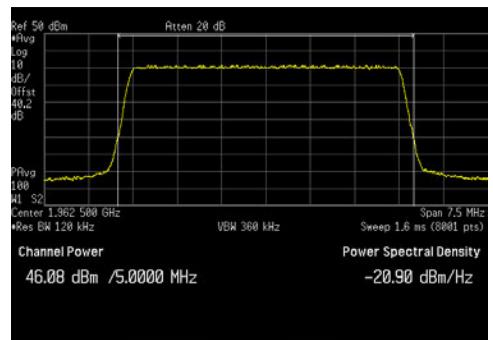
Port 2 - LTE5_Middle Channel_Average



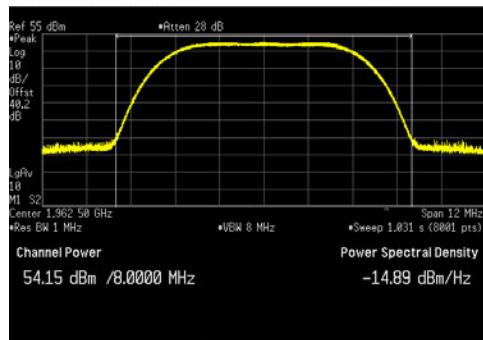
Port 3 - LTE5_Middle Channel_Peak



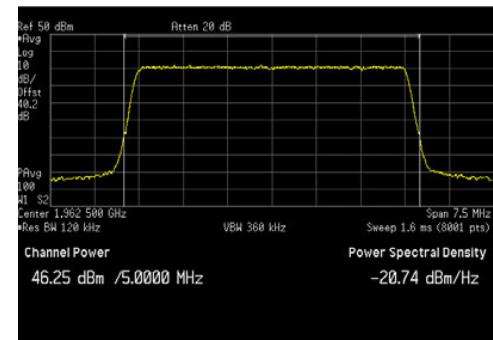
Port 3 - LTE5_Middle Channel_Average



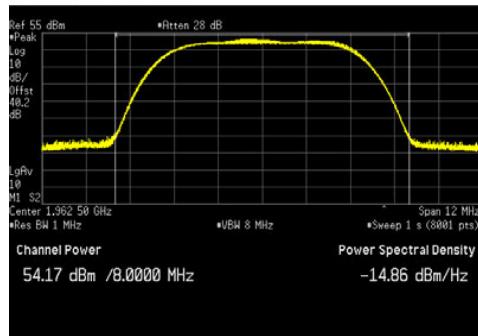
Port 4 - LTE5_Middle Channel_Peak



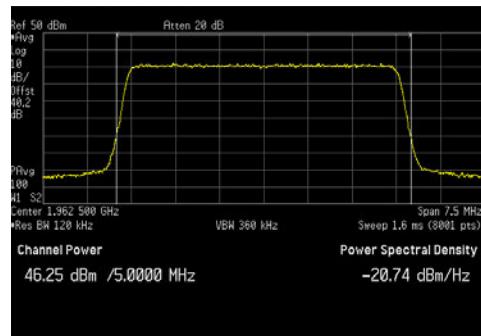
Port 4 - LTE5_Middle Channel_Average



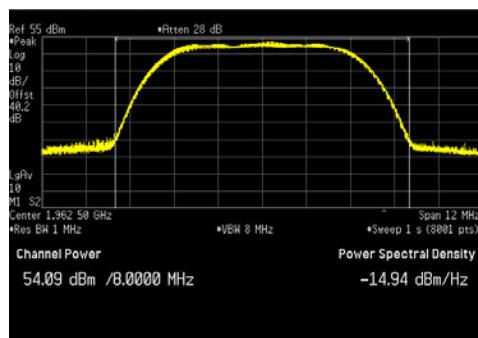
LTE5 Channel Power Plots for Antenna Port 4 at Middle Channel and all Modulation Types:
LTE5_Middle Channel_QPSK_Peak



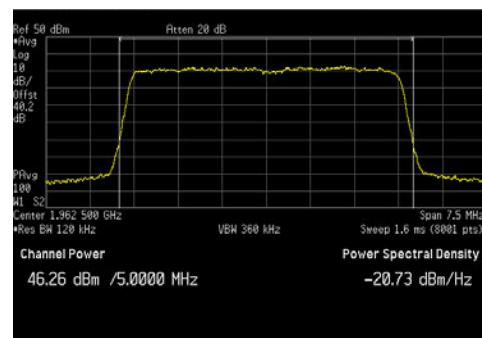
LTE5_Middle Channel_QPSK_Average



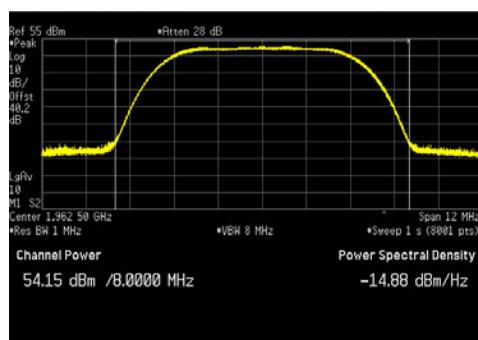
LTE5_Middle Channel_16QAM_Peak



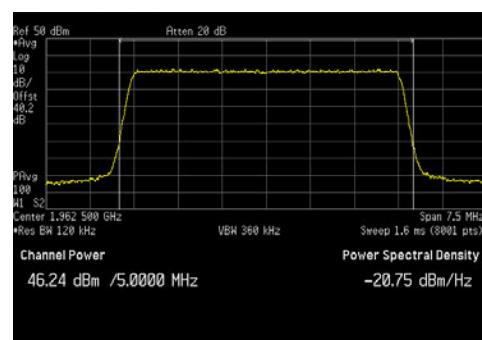
LTE5_Middle Channel_16QAM_Average



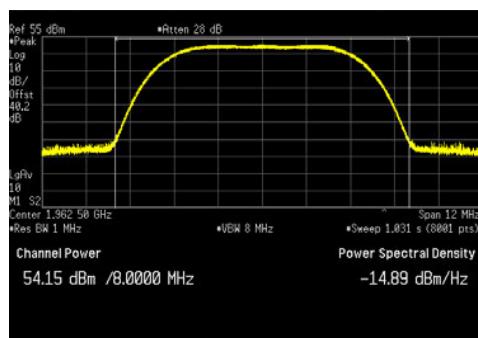
LTE5_Middle Channel_64QAM_Peak



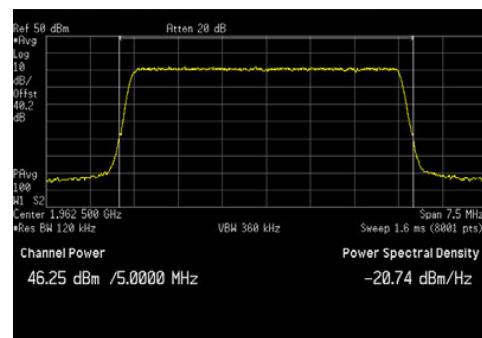
LTE5_Middle Channel_64QAM_Average



LTE5_Middle Channel_256QAM_Peak

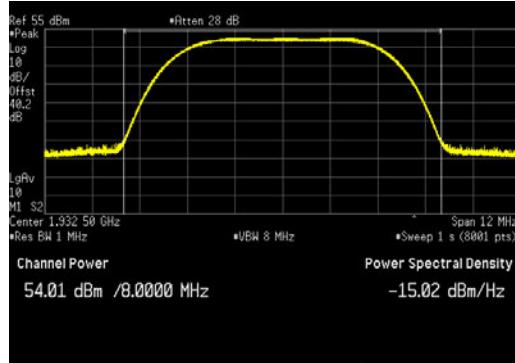


LTE5_Middle Channel_256QAM_Average

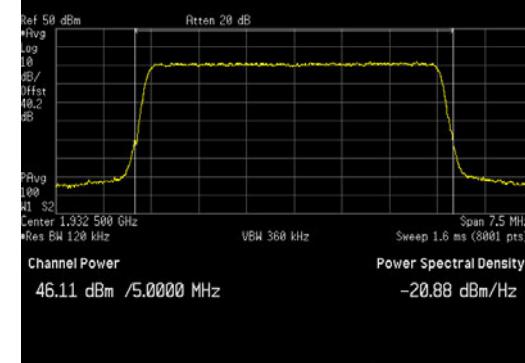


LTE5 Channel Power Plots for Antenna Port 4 and 256QAM Modulation:

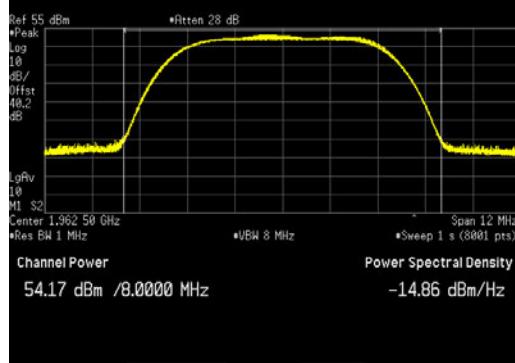
LTE5_Bottom Channel_Peak



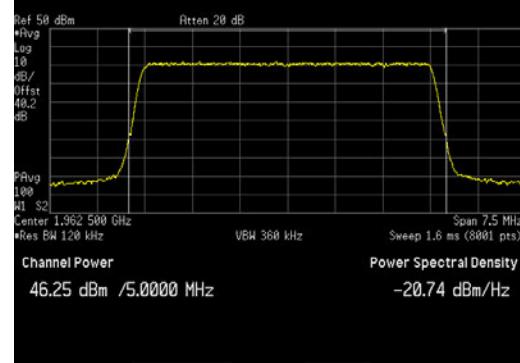
LTE5_Bottom Channel_Average



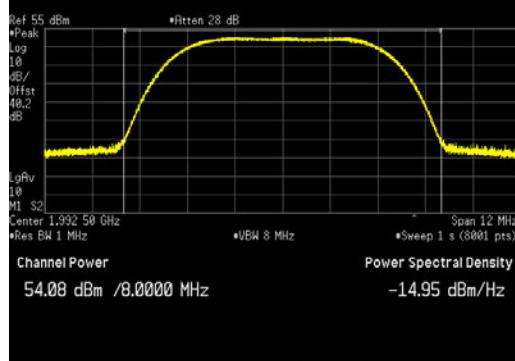
LTE5_Middle Channel_Peak



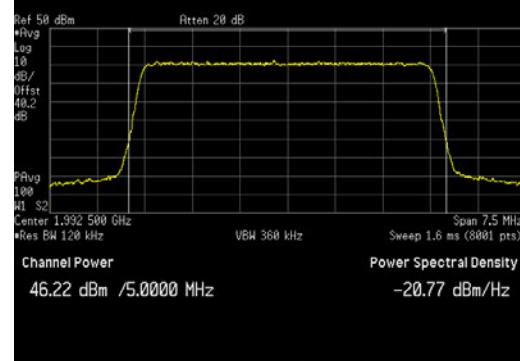
LTE5_Middle Channel_Average



LTE5_Top Channel_Peak

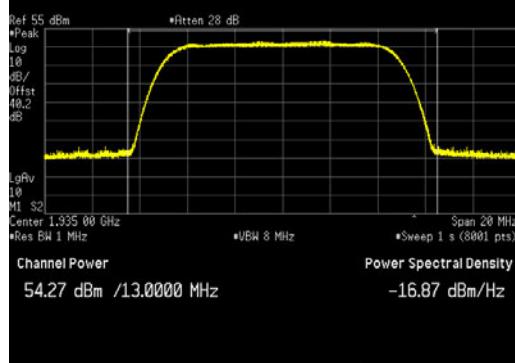


LTE5_Top Channel_Average

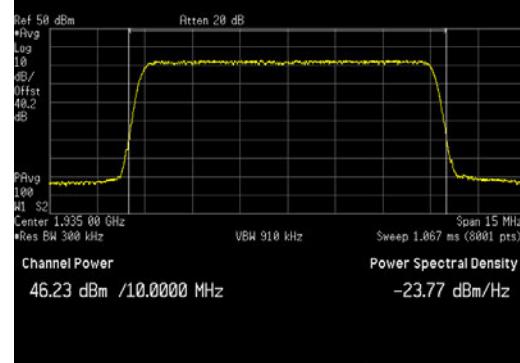


LTE10 Channel Power Plots for Antenna Port 4 and 256QAM Modulation:

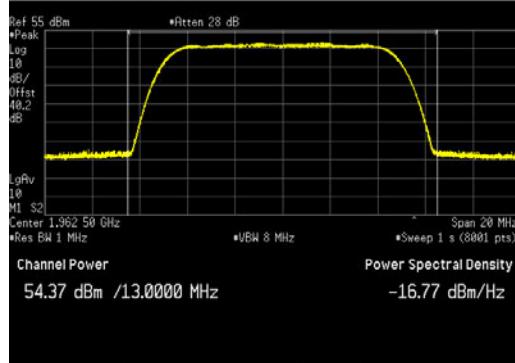
LTE10_Bottom Channel_Peak



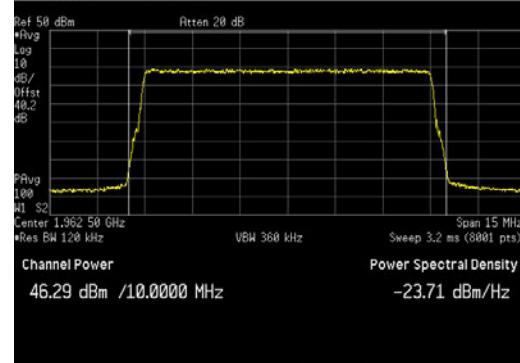
LTE10_Bottom Channel_Average



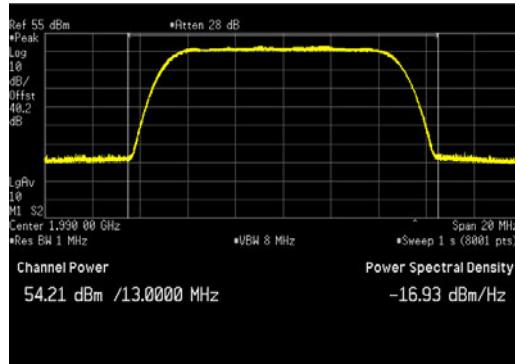
LTE10_Middle Channel_Peak



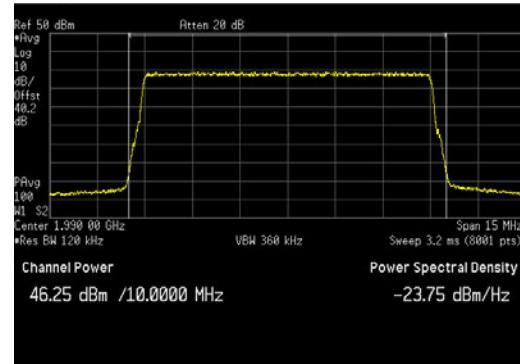
LTE10_Middle Channel_Average



LTE10_Top Channel_Peak

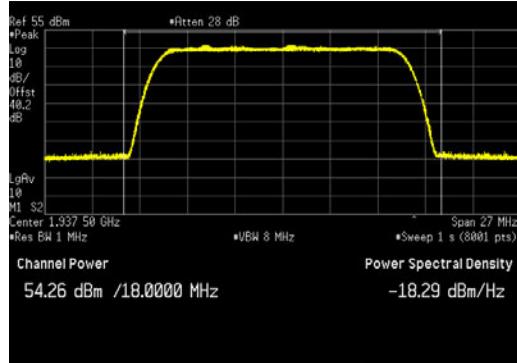


LTE10_Top Channel_Average

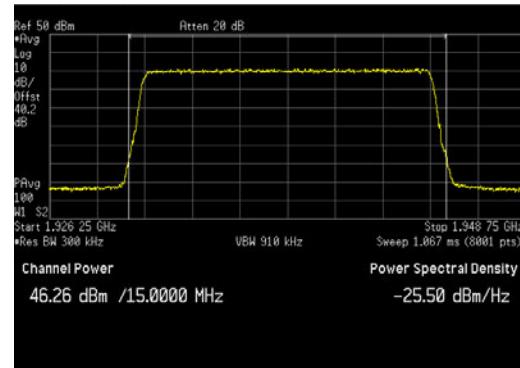


LTE15 Channel Power Plots for Antenna Port 4 and 256QAM Modulation:

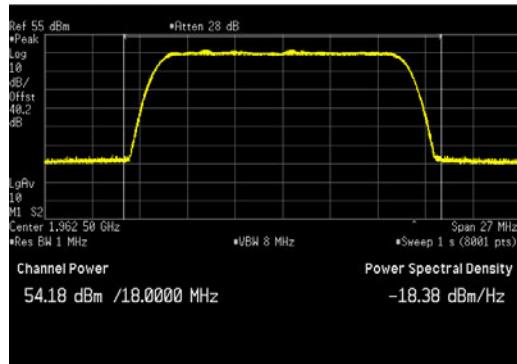
LTE15_Bottom Channel_Peak



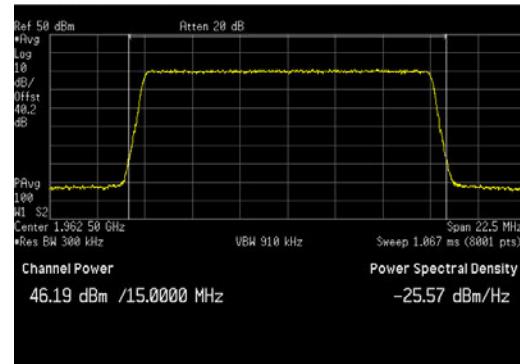
LTE15_Bottom Channel_Average



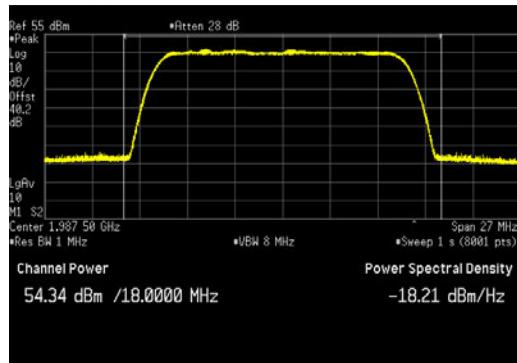
LTE15_Middle Channel_Peak



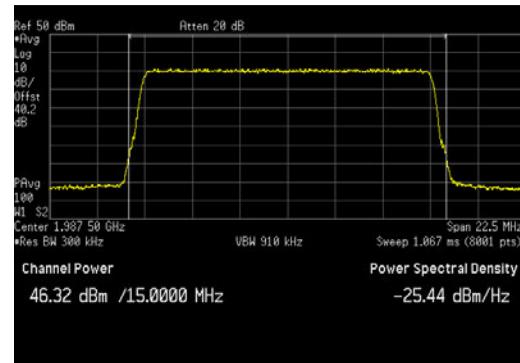
LTE15_Middle Channel_Average



LTE15_Top Channel_Peak

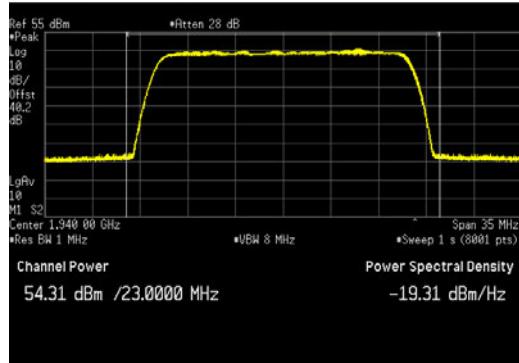


LTE15_Top Channel_Average

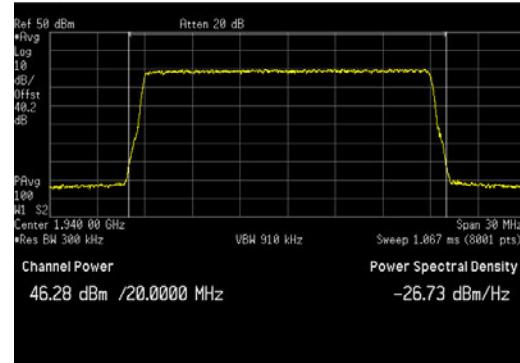


LTE20 Channel Power Plots for Antenna Port 4 and 256QAM Modulation:

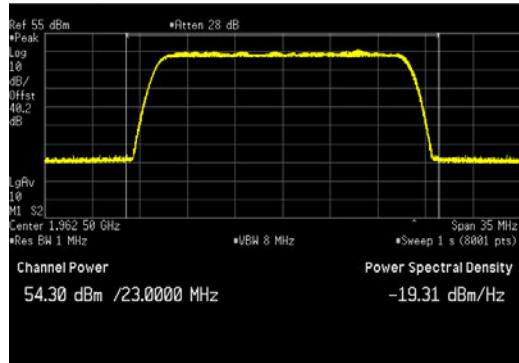
LTE20_Bottom Channel_Peak



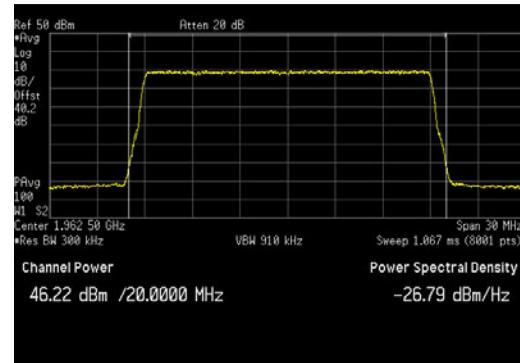
LTE20_Bottom Channel_Average



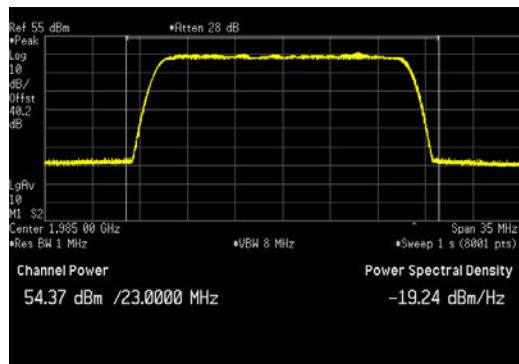
LTE20_Middle Channel_Peak



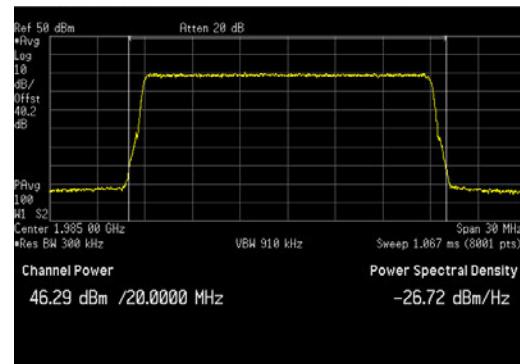
LTE20_Middle Channel_Average



LTE20_Top Channel_Peak



LTE20_Top Channel_Average



Emission Bandwidth (26 dB down and 99%)

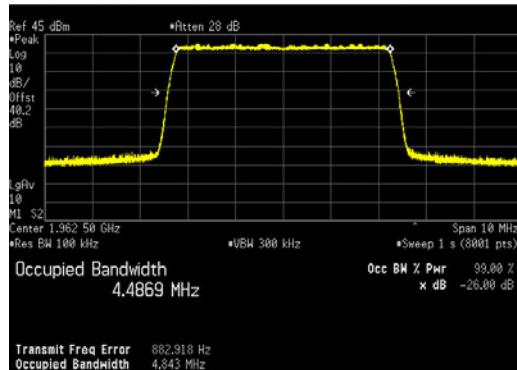
Emission bandwidth measurements were made at antenna port 4 on the middle channel with maximum RF output power. All available LTE modulations (QPSK, 16QAM, 64QAM, 256QAM) were used. All available LTE channel bandwidths (5MHz, 10MHz, 15MHz, and 20MHz) were used. The results are provided in the following table. The largest emission bandwidths in each channel type are highlighted.

| LTE Ch BW | Modulation Type | | | | | | | |
|-----------------|-----------------|--------------|---------------|----------------|---------------|--------------|---------------|---------------|
| | QPSK | | 16QAM | | 64QAM | | 256QAM | |
| | 26dB (MHz) | 99% (MHz) | 26dB (MHz) | 99% (MHz) | 26dB (MHz) | 99% (MHz) | 26dB (MHz) | 99% (MHz) |
| 5M | 4.843 | 4.4869 | 4.826 | 4.4790 | 4.833 | 4.4932 | 4.839 | 4.4958 |
| 10M | 9.652 | 8.9735 | 9.638 | 8.9942 | 9.677 | 8.9784 | 9.642 | 8.9717 |
| 15M | 14.448 | 13.4706 | 14.429 | 13.4897 | 14.500 | 13.4639 | 14.478 | 13.4665 |
| 20M | 19.287 | 17.9418 | 19.237 | 17.9849 | 19.288 | 17.9391 | 19.339 | 17.9529 |

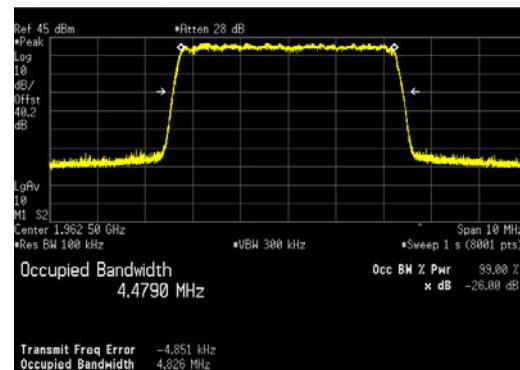
Emission bandwidth measurement data are provided in the following pages.

LTE5 Emission Bandwidth Plots on the Middle Channel for Antenna Port 4:

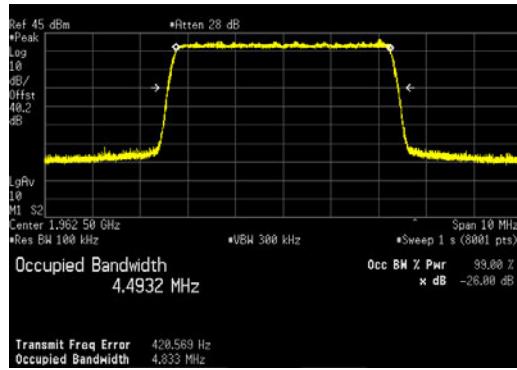
LTE5_QPSK



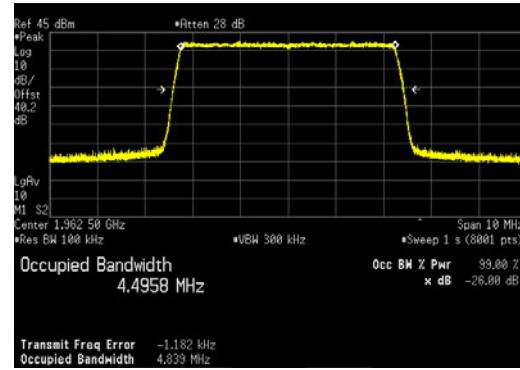
LTE5_16QAM



LTE5_64QAM

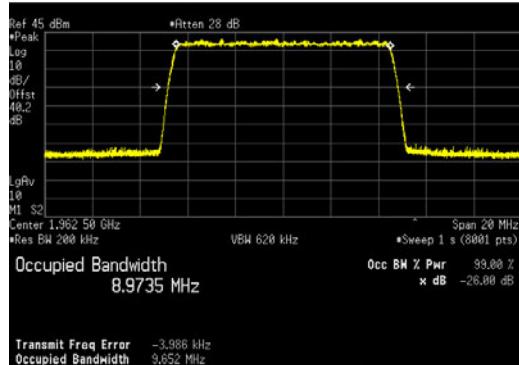


LTE5_256QAM

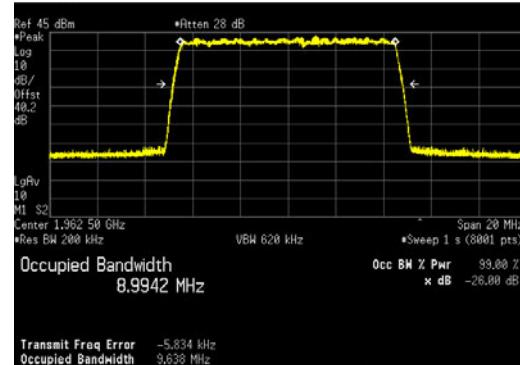


LTE10 Emission Bandwidth Plots on the Middle Channel for Antenna Port 4:

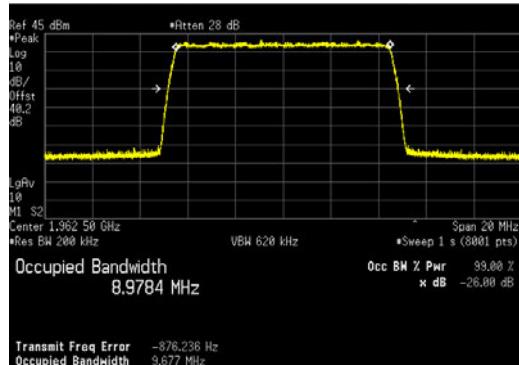
LTE10_QPSK



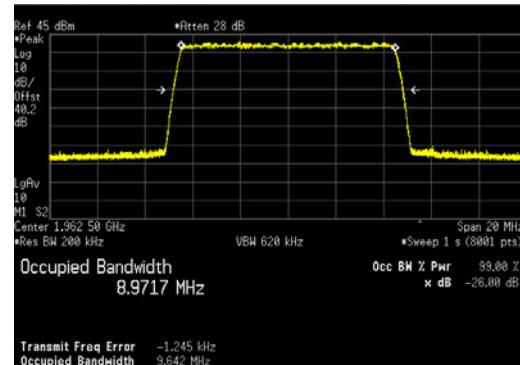
LTE10_16QAM



LTE10_64QAM

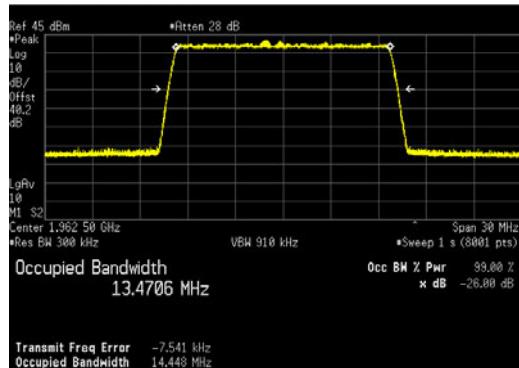


LTE10_256QAM

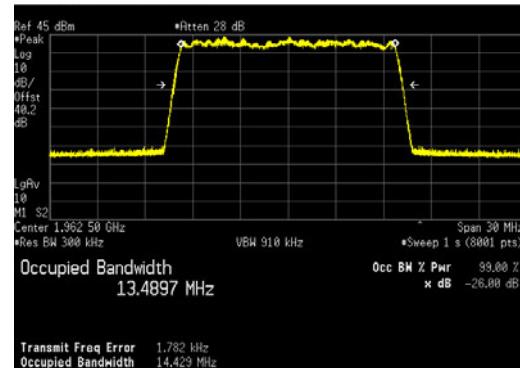


LTE15 Emission Bandwidth Plots on the Middle Channel for Antenna Port 4:

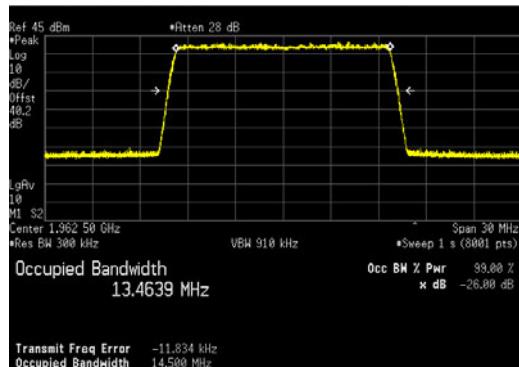
LTE15_QPSK



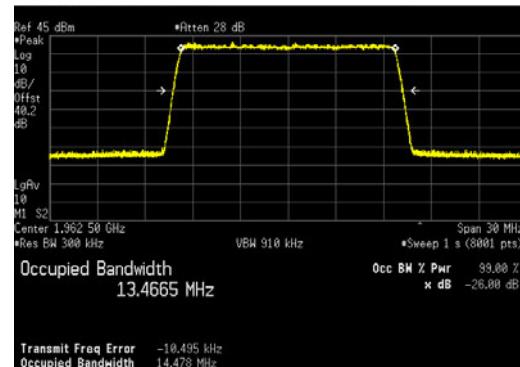
LTE15_16QAM



LTE15_64QAM

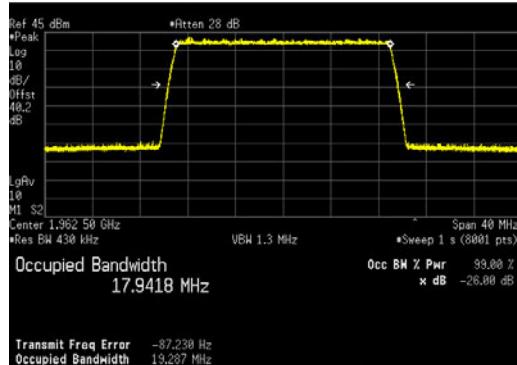


LTE15_256QAM

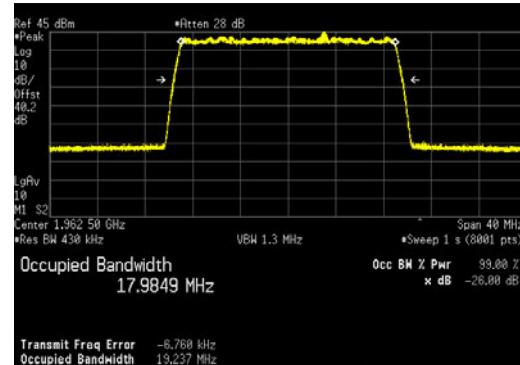


LTE20 Emission Bandwidth Plots on the Middle Channel for Antenna Port 4:

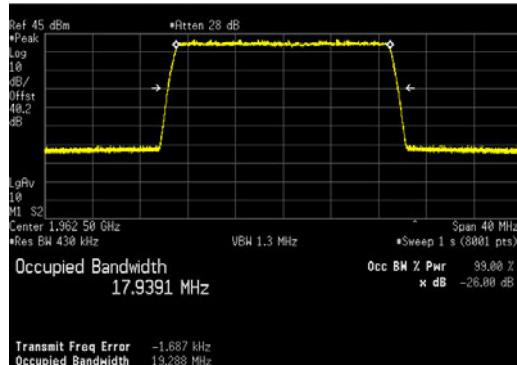
LTE20_QPSK



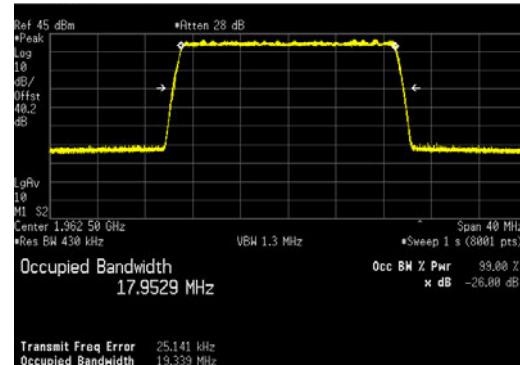
LTE20_16QAM



LTE20_64QAM



LTE20_256QAM



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at RRH antenna port 4. The RRH was operated at the band edge frequencies with all modulation types (QPSK, 16QAM, 64QAM, 256QAM) for 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 1996 to 1997MHz 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 1997 to 2000MHz bands) a 1MHz RBW and 3MHz VBW was used. An additional measurement was performed for the dual LTE5 cases to show compliance at the upper and lower band edges.

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 |
| 5M | -21.381 | -21.458 | -23.033 | -22.284 | -21.675 | -22.008 | -22.283 | -20.359 |
| 10M | -25.274 | -24.379 | -25.110 | -24.461 | -25.556 | -24.524 | -25.699 | -25.969 |
| 15M | -24.358 | -24.505 | -22.939 | -24.559 | -22.739 | -23.166 | -25.268 | -25.546 |
| 20M | -25.285 | -24.966 | -25.535 | -25.579 | -26.013 | -25.438 | -25.665 | -25.657 |
| Dual 5M | -24.72 | -23.051 | -24.987 | -23.269 | -23.557 | -22.759 | -23.471 | -21.707 |

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.