CERTIFICATE #: 0214.19

Radio Test Report

Application for Grant of Equipment Authorization

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

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

FCC ID: VBNAHFIB-01
IC ID: 661W-AHFIB

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

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

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

Test Dates: March 16, 2018
Total Number of Pages: 162

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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	3/17/2018	Initial Draft	Armando Del Angel
1	3/18/2018	Revision 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 AHFIB, pursuant to the relevant requirements of the following standard(s) in order 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
- 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 C63.4-2014
ANSI TIA-603-D
TIA-102.CAAA-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 AHFIB 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 AHFIB. 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 AHFIB 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)

AHFIB 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: 45.99dBm 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: 8.09dB	13dB	Pass
	RSS-133 Section 2.3	99% Emission Bandwidth	LTE5: 4.4924MHz LTE10: 8.9816MHz LTE15: 13.4812MHz LTE20: 17.9644MHz	Remain in Block	Pass
24.238		26dB down Emission Bandwidth	LTE5: 4.839MHz LTE10: 9.648MHz LTE15: 14.477MHz LTE20: 19.320MHz	Remain in Block	Pass
Transmitter Spurious Emissions[1]					
24.238	RSS-133 Section 6.5.1	At the antenna terminals	< -19dBm	-19dBm per Transmit Chain	Pass
24.238	RSS-133 Section 6.5.1	Field Strength	57.364dBuV/m at 3m Eq. to -37.836dBm 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.					

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	4M83F9W	4M49F9W
10M	9M64F9W	8M97F9W	9M63F9W	8M98F9W	9M65F9W	8M97F9W	9M64F9W	8M97F9W
15M	14M43F9W	13M46F9W	14M45F9W	13M48F9W	14M47F9W	13M45F9W	14M48F9W	13M47F9W
20M	19M22F9W	17M93F9W	19M21F9W	17M96F9W	19M29F9W	17M94F9W	19M32F9W	17M93F9W
Note: FCC based on 26dB emission bandwidth; IC based on 99% emission bandwidth.								

FCC Part 27 Subpart C&L/IC RSS-139 & RSS-170 (Base Stations Operating in the 2110 - 2200MHz Band)
Without External Notch Filter

AHFIB without External Notch Filter 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 - 2170.0MHz	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: 45.91dBm EIRP depends on antenna gain which is unknown	1640W EIRP	Pass
27.50(d)(5)	RSS-139 Sec 6.5 RSS-170 Sec 5.3.1	Peak to Average Power Ratio	Highest Measured PAPR: 8.13dB	13dB	Pass
	RSS-Gen Sec 6.6	99% Emission Bandwidth	LTE5: 4.4916MHz LTE10: 8.9897MHz LTE15: 13.4732MHz LTE20: 17.9630MHz	Remain in Block	Pass
27.53(h)(3)		26dB down Emission Bandwidth	LTE5: 4.836MHz LTE10: 9.651MHz LTE15: 14.491MHz LTE20: 19.343MHz	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	< -19dBm	-19dBm per Transmit Chain	Pass
		Field strength	57.364dBuV/m at 3m Eq. to -37.836dBm 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	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 without External Notch Filter								
Channel Bandwidth	LTE-QPSK		LTE-16QAM		LTE-64QAM		LTE-256QAM	
	FCC	IC	FCC	IC	FCC	IC	FCC	IC
5M	4M83F9W	4M49F9W	4M81F9W	4M47F9W	4M84F9W	4M49F9W	4M84F9W	4M49F9W
10M	9M64F9W	8M97F9W	9M61F9W	8M99F9W	9M65F9W	8M97F9W	9M65F9W	8M97F9W
15M	14M45F9W	13M46F9W	14M41F9W	13M47F9W	14M49F9W	13M46F9W	14M46F9W	13M46F9W
20M	19M25F9W	17M93F9W	19M23F9W	17M96F9W	19M28F9W	17M94F9W	19M34F9W	17M94F9W

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

FCC Part 27 Subpart C&L/IC RSS-139 & RSS-170 (Base Stations Operating in the 2110 - 2200MHz Band)

With External Notch Filter

AHFIB with External Notch Filter 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 - 2170.0MHz	2110 - 2200MHz 2195 - 2200MHz (Guardband)	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: 45.24dBm EIRP depends on antenna gain which is unknown	1640W EIRP	Pass
27.50(d)(5)	RSS-139 Sec 6.5 RSS-170 Sec 5.3.1	Peak to Average Power Ratio	Highest Measured PAPR: 7.80dB	13dB	Pass
	RSS-Gen Sec 6.6	99% Emission Bandwidth	LTE5: 4.4929MHz LTE10: 8.9874MHz LTE15: 13.4874MHz LTE20: 17.9551MHz	Remain in Block	Pass
27.53(h)(3)		26dB down Emission Bandwidth	LTE5: 4.839MHz LTE10: 9.658MHz LTE15: 14.487MHz LTE20: 19.308MHz	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	< -19dBm	-19dBm per Transmit Chain	Pass
		Field strength	57.364dBuV/m at 3m Eq. to -37.836dBm EIRP	-13dBm EIRP	Pass
27.1134(e)(i) AWS-4 Band Out of Band Testing	RSS-170 Sec 5.4 and Sec 5.4.1.2	At the antenna terminals	-79.48dBm	-69.6dBm per Transmit Chain[3]	Pass
		Field strength	29.97dBuV/m at 3m Eq. to -67.4dBm EIRP	-46.6dBm EIRP[4]	Pass
Other Details					
27.54	RSS-139 Sec 6.4 RSS-170 Sec 5.2	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.

Note 3: The limit is equivalent to -69.6dBm/MHz assuming four port MIMO operation and a 17dBi antenna gain (i.e.: -100.6dBW/4kHz (EIRP Limit) + 30dB (dBW to dBm conversion) + 24dB (BW conversion:10log[1MHz/4kHz]) – 6dB (4 port MIMO) - 17dBi (BTS Antenna Gain) = -69.6 dBm/MHz

Note 4: The limit is equivalent to -46.6dBm/MHz assuming four port MIMO operation and a 0dBi antenna gain (i.e.: -100.6dBW/4kHz (EIRP Limit) + 30dB (dBW to dBm conversion) + 24dB (BW conversion:10log[1MHz/4kHz]) – 0dBi (BTS Antenna Gain) = -46.6 dBm/MHz

Emission Designators with External Notch Filter								
Channel Bandwidth	LTE-QPSK		LTE-16QAM		LTE-64QAM		LTE-256QAM	
	FCC	IC	FCC	IC	FCC	IC	FCC	IC
5M	4M84F9W	4M49F9W	4M82F9W	4M48F9W	4M83F9W	4M49F9W	4M83F9W	4M49F9W
10M	9M62F9W	8M97F9W	9M66F9W	8M99F9W	9M64F9W	8M97F9W	9M65F9W	8M97F9W
15M	14M44F9W	13M46F9W	14M42F9W	13M49F9W	14M49F9W	13M45F9W	14M45F9W	13M45F9W
20M	19M24F9W	17M92F9W	19M20F9W	17M96F9W	19M30F9W	17M94F9W	19M31F9W	17M94F9W

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 AHFIB. The AHFIB remote radio head is a multistandard multicarrier radio module designed to support GSM/EDGE, WCDMA, LTE, and narrow band IoT (internet of things) operations. The scope of testing in this effort is for LTE-FDD operations.

The AHFIB RRH has four transmit/four receive antenna ports (4TX/4RX for Band 25 and 4TX/4RX for Band 66). Each antenna port supports 3GPP frequency band 25 (BTS Rx: 1850 to 1915 MHz/BTS TX: 1930 to 1995 MHz) and 3GPP frequency band 66 (BTS Rx: 1710 to 1780 MHz/BTS TX: 2110 to 2200 MHz). The maximum RF output power of the RRH is 320 Watts (40 watts per carrier, 80 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.

A passive RF notch filter is used for this effort. The passive external notch filter (provided by a third party) is used (to attenuate emissions above the Band 66 RRH transmit band) to meet more stringent emission requirements for base stations operating near Government Space Operations facilities (see FCC Clause 27.1134 and RSS-170). This filter assembly has four RF paths (one for each RRH Tx/Rx port). The RF notch filter is used when the RRH operates in the AWS 4 band (2180 to 2200 MHz). The use of the RF notch filter is only applicable when the AHFIB is operating in LTE mode.

The AHFIB LTE channel numbers and frequencies are as follows:

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth			
			5 MHz	10 MHz	15 MHz	20 MHz
AHFIB 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

AHFIB Downlink Band Edge LTE Band 25 Frequency Channels

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth			
			5 MHz	10 MHz	15 MHz	20 MHz
AHFIB Band 66 (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
	......					
	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

AHFIB without Notch Filter Downlink Band Edge LTE Band 66 Frequency Channels

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth			
			5 MHz	10 MHz	15 MHz	20 MHz
AHFIB Band 66 (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
	......					
	66886	2155.0	Middle Ch	Middle Ch	Middle Ch	Middle Ch
	......					
	67186	2185.0				Top Channel
	......					
	67211	2187.5			Top Channel	
	......					
	67236	2190.0		Top Channel		
	......					
	67261	2192.5	Top Channel			
	......					
	......	2195 to 2200	Guard Band	Guard Band	Guard Band	Guard Band
	67336	2200.0	Band Edge	Band Edge	Band Edge	Band Edge

AHFIB with Notch Filter Downlink Band Edge LTE Band 66 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	AHFIB	AirScale BTS RRH	Part#: 474216A.101 Serial#: K9174553644	FCC ID: VBNAHFIB-01 IC ID: 661W-AHFIB

Enclosure

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

Configuration	Approximate Weight	Approximate Dimensions	Approximate Volume
AHFIB	30 kg	308x560x150 mm	26 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

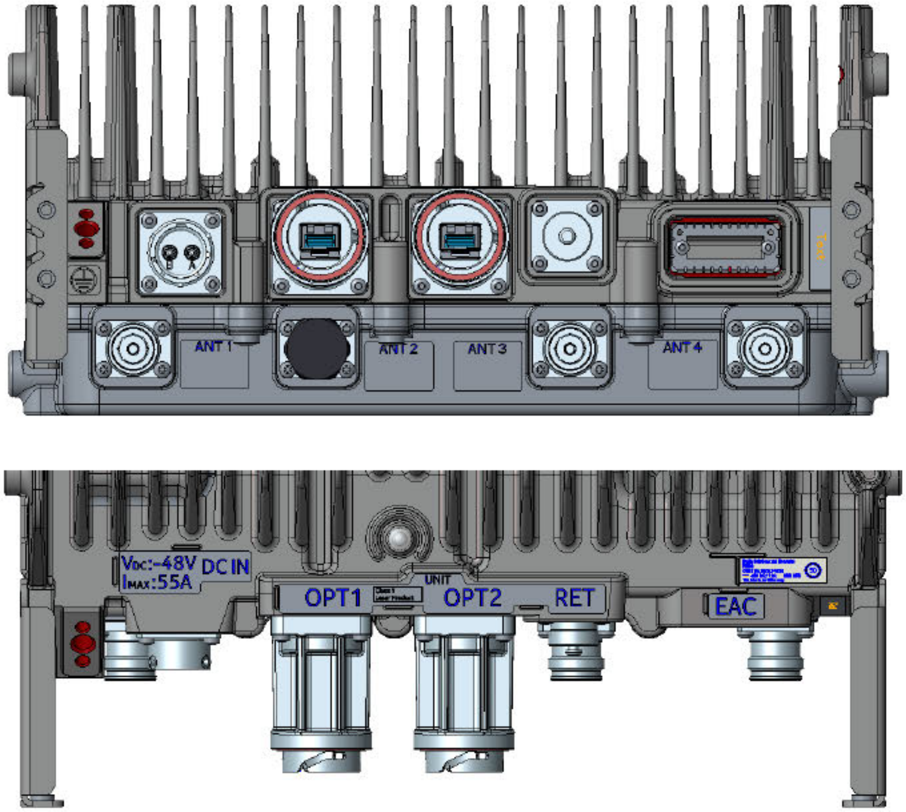
Company	Description	Part Number	Serial Number
Nokia	FOUC 10GHz SFP Module (Plugs into RRH Opt Ports)	473842A.101	KR16090020071
Filtronics	AWS 4 External Notch Filter	US-PSD015-F1V1	FI1160500010
Creowave Filters Oy	Diplexer/Band Stop Filter[1]	CW-DPF-2110-2196-E1-M2	1222001
RLC Electronics	2.5GHz High 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
Weinschel	Termination[1]	1424-4	12123
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	Notch Filter and 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

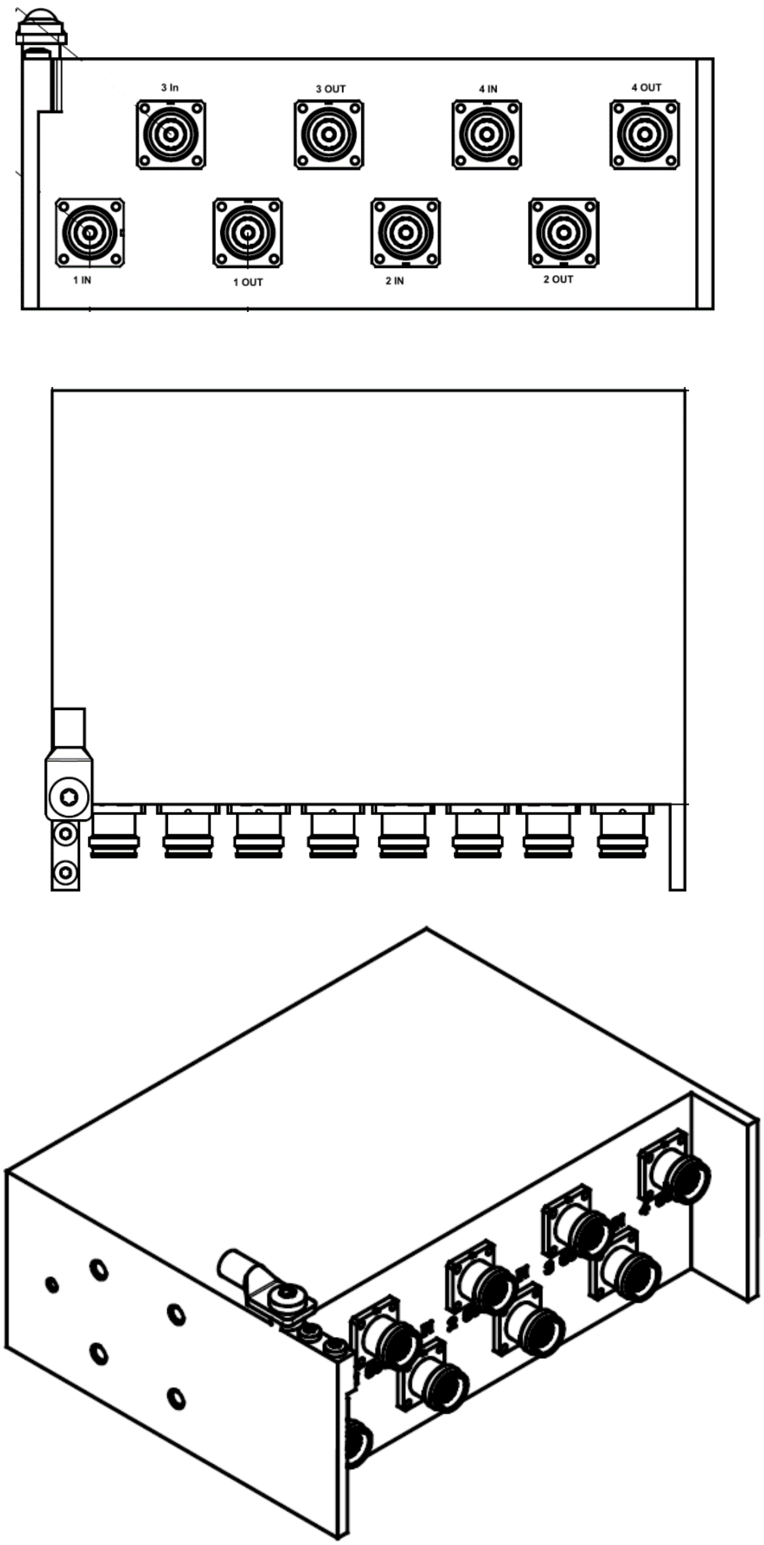
AHFIB Connector Layout:



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.

Notch Filter Connector Layout and Isometric View



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: FRM57.11.R06
(2) System Module Software: FL17A_ENB_1000_000622_000000
(3) BTS Site Manager: EM-FL17A-1708_000363_000000

Modifications

No modifications were made to the EUT during testing.

TESTING

GENERAL INFORMATION

Antenna port measurements were taken with NTS personnel 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-2	1701 E Plano Pkwy #150 Plano, TX 75074.

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

MEASUREMENT PROCEDURES

The output power, emission bandwidth, conducted spurious and conducted band edge measurements were performed with a spectrum analyzer. The carrier frequency accuracy/stability measurements were performed with a LTE signal analyzer. The EUT was operated at maximum RF output power for all tests. While measuring one transmit chain, the other one was 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.

A customer provided filter (Creowave Filter p/n: CW-DPF-2110-2196-E1-M2) was used to make measurements defined by FCC 27.1134 and RSS-170 in the 2200 to 2290MHz frequency range. This filter blocks RRH AWS carrier power and allows the measurement instrumentation noise floor to be reduced to needed levels. The filters insertion loss was characterized in the measurement band and was factored in via reference level offset of the spectrum analyzer. Keysight Benchvue Software was used to capture the spectrum analyzer screenshots. 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.

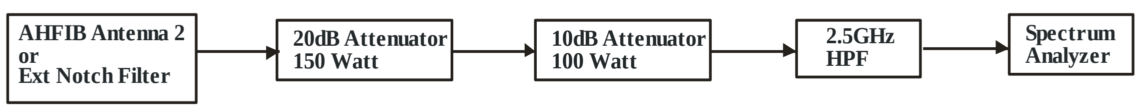
Transmitter radiated spurious emissions measurements were made in accordance with ANSI C63.4-2014 by measuring the field strength of the emissions from the device at 3m test distance for emissions below 10 GHz and at 1m test distance for emissions above 10 GHz. The eirp limit as specified in the relevant 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 biconilog antenna was used for 30MHz-1GHz range. A double ridged waveguide horn antenna was used for 1-18GHz range and a smaller horn antenna was used for 18-22GHz range. The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. EUT was placed on a non-conductive RF transparent structure to provide 80cm height from the ground floor. A motorized turntable allowed it to be rotated during testing to determine the angle with the highest level of emissions.

Antenna Port Conducted RF Measurement Test Setup Diagrams

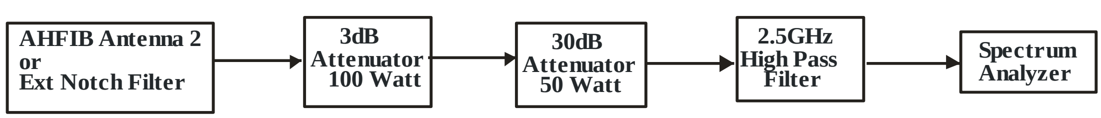
The following are the setups used in the RF conducted emissions testing. Photographs of the test setups are provided in a separate document/exhibit.

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

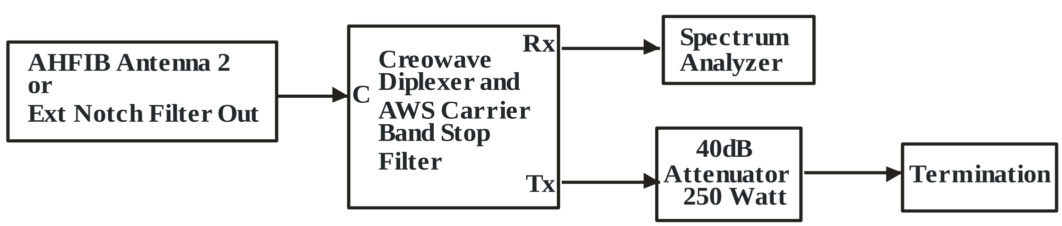
Setup for 20MHz to 3GHz and 3GHz to 6GHz Measurements



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



Setup for 18GHz to 22GHz Measurements



Setup for AWS-4 OOB Measurements

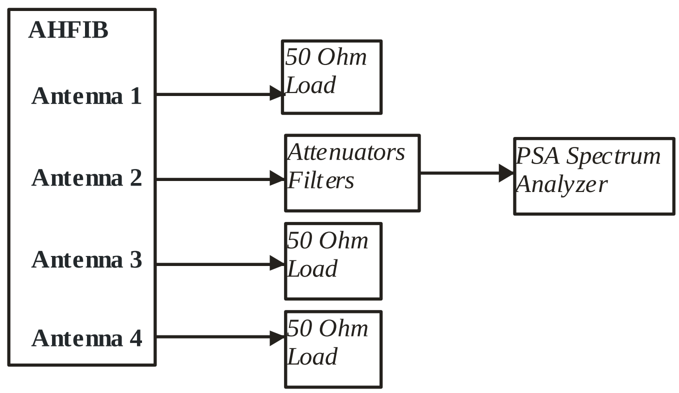
Test Measurement Equipment

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 AHFIB antenna ports. Antenna port RF conducted measurements in this section were made without the external notch filter. The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on AHFIB without External Notch Filter

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**	53.68	45.79	7.89
Port 2 Middle Channel	**5M**	53.73	45.79	7.94
Port 3 Middle Channel	**5M**	53.64	45.69	7.95
Port 4 Middle Channel	**5M**	53.55	45.58	7.97

The variation in RMS output power levels between the antenna ports is 0.21 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 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	
	Peak (dBm)	Ave (dBm)	Peak (dBm)	Ave (dBm)	Peak (dBm)	Ave (dBm)	Peak (dBm)	Ave (dBm)
Antenna Port 2 Middle Channel LTE5	53.71	45.78	53.66	45.77	53.68	45.75	53.67	45.77

The output power variation between modulation types is small in this measurement snapshot (and from past efforts on similar hardware as well). The variation of average power output versus modulation type is 0.03dB for the data snapshot provided. The variation of peak power output versus modulation type is 0.05dB 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 for the PCS band (represents the worst case) and therefore it was selected for all the remaining antenna port tests. Port 2 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 and 256QAM modulation type were tested only at Port 2 and the results presented below. The highest measured values are highlighted.

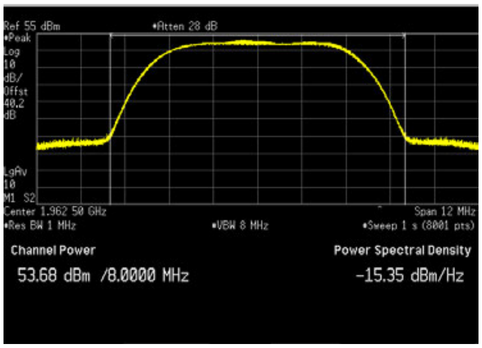
Antenna LTE Channel	LTE Bandwidth	LTE - 256QAM		
		Peak (dBm)	Average (dBm)	PAPR (dB)
Port 2 Bottom Channel	5M	53.70	45.81	7.89
	10M	53.99	45.90	**8.09**
	15M	**54.02**	**45.99**	8.03
	20M	53.95	**45.99**	7.96
Port 2 Middle Channel	5M	53.73	45.79	7.94
	10M	53.85	45.84	8.01
	15M	53.82	45.80	8.02
	20M	53.89	45.83	8.06
Port 2 Top Channel	5M	53.63	45.73	7.90
	10M	53.83	45.81	8.02
	15M	53.85	45.82	8.03
	20M	53.91	45.84	8.07

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 (0.05dB).

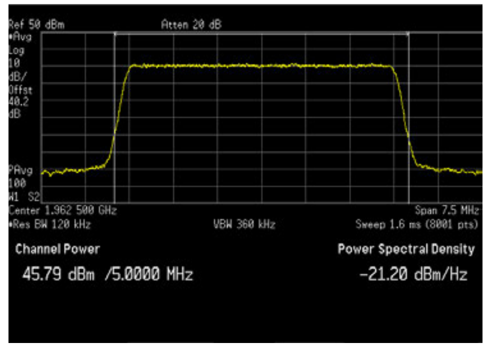
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

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

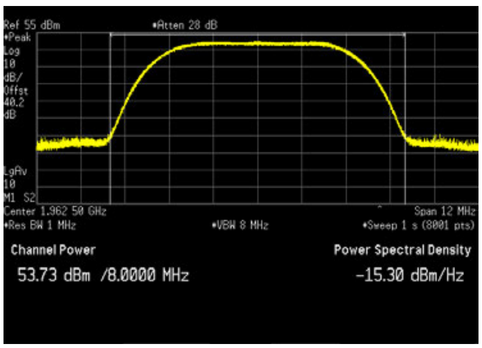
Port 1 - LTE5_ Middle Channel_Peak



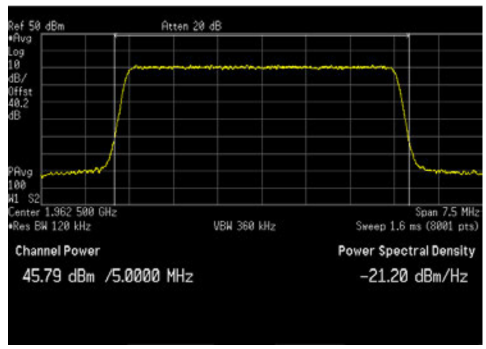
Port 1 - LTE5_ Middle Channel_Average



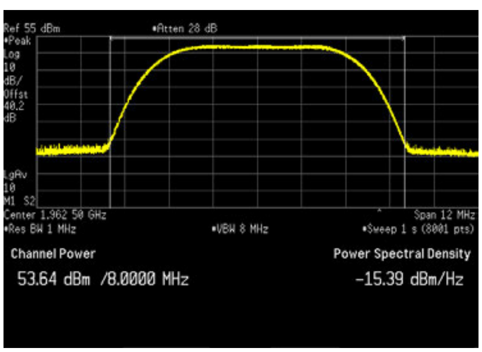
Port 2 - LTE5_Middle Channel_Peak



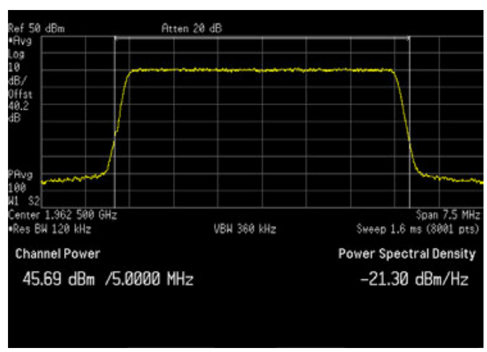
Port 2 - LTE5_Middle Channel_Average



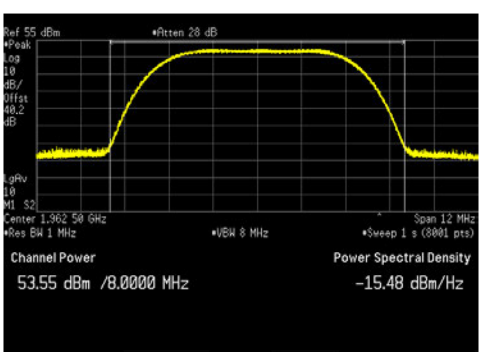
Port 3 - LTE5_ Middle Channel_Peak



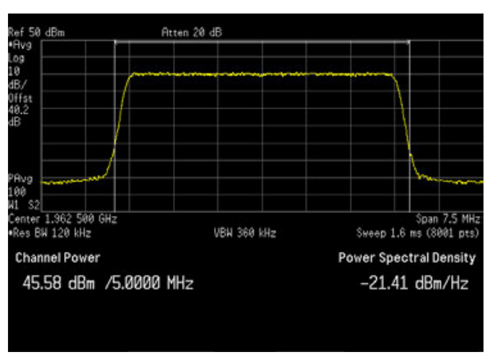
Port 3 - LTE5_ Middle Channel_Average



Port 4 - LTE5_ Middle Channel_Peak

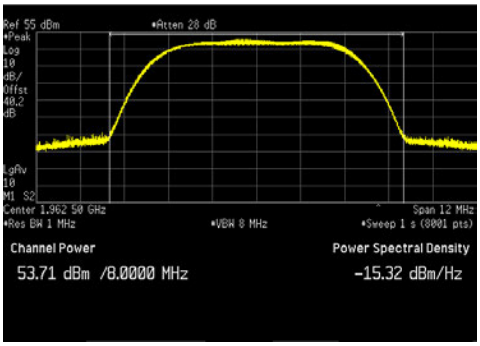


Port 4 - LTE5_ Middle Channel_Average

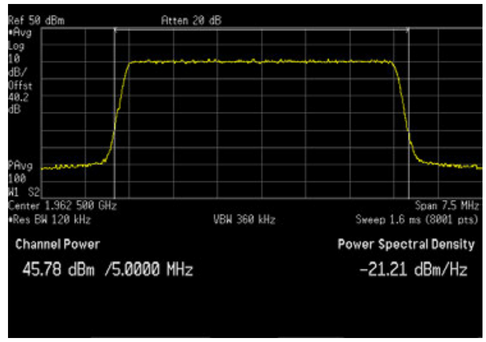


LTE5 Channel Power Plots for Antenna Port 2 at Middle Channel and all Modulation Types:

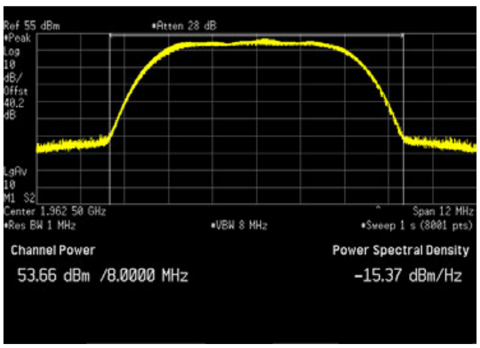
LTE5_ Middle Channel_QPSK_Peak



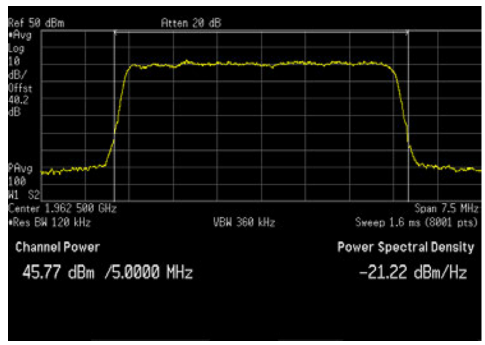
Port 1 - LTE5_ Middle Channel_QPSK_Average



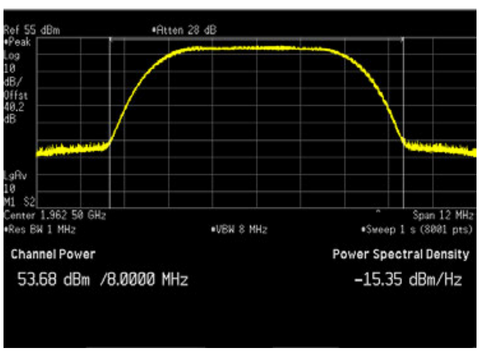
LTE5_Middle Channel_16QAM_Peak



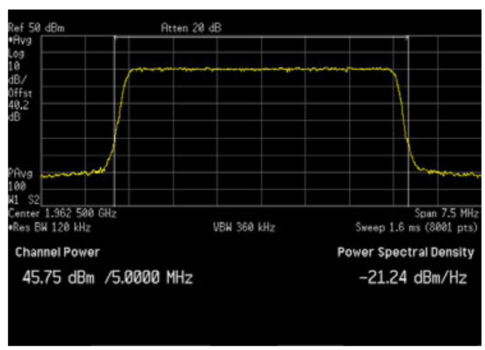
LTE5_Middle Channel_16QAM_Average



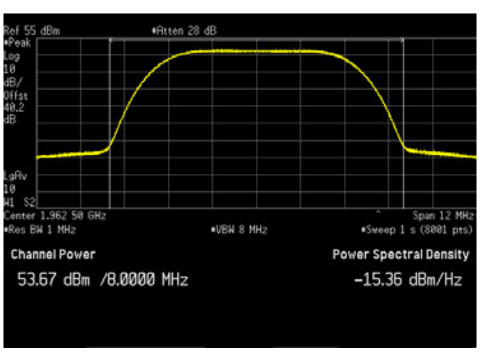
LTE5_ Middle Channel_64QAM_Peak



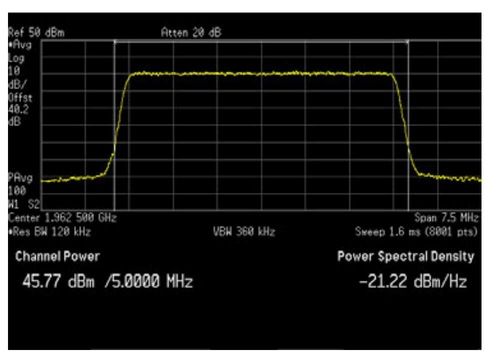
LTE5_ Middle Channel_64QAM_Average



LTE5_ Middle Channel_256QAM_Peak

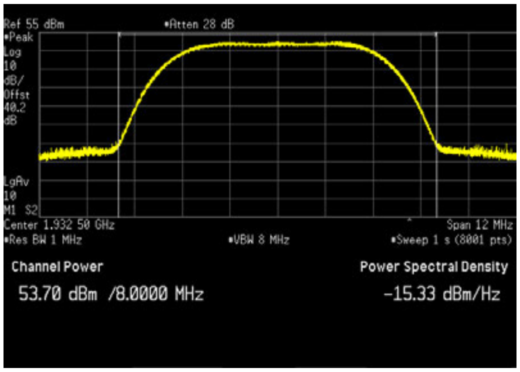


LTE5_ Middle Channel_256QAM_Average

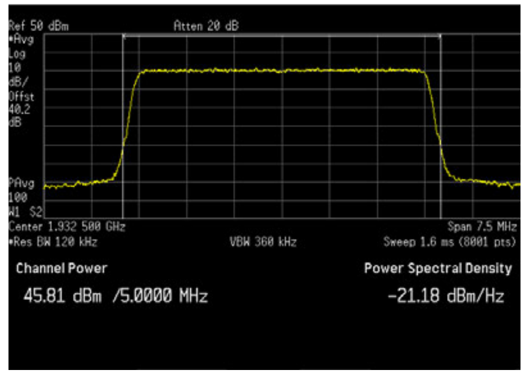


LTE5 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

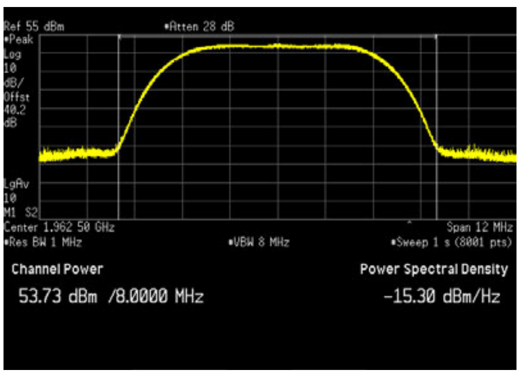
LTE5_Bottom Channel_Peak



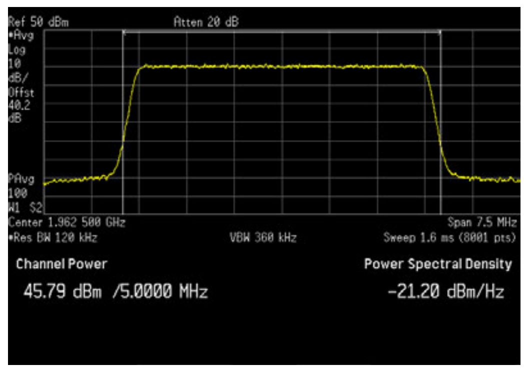
LTE5_Bottom Channel_Average



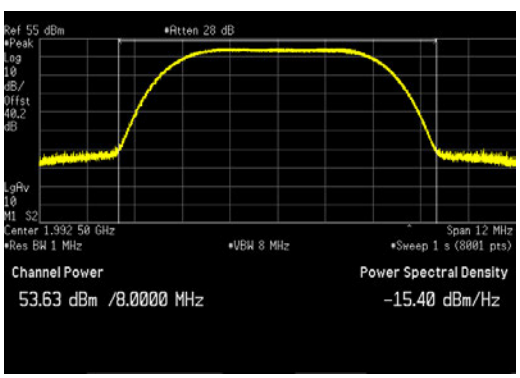
LTE5_Middle Channel_Peak



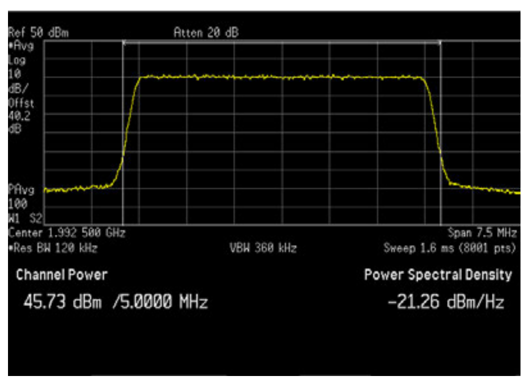
LTE5_Middle Channel_Average



LTE5_Top Channel_Peak

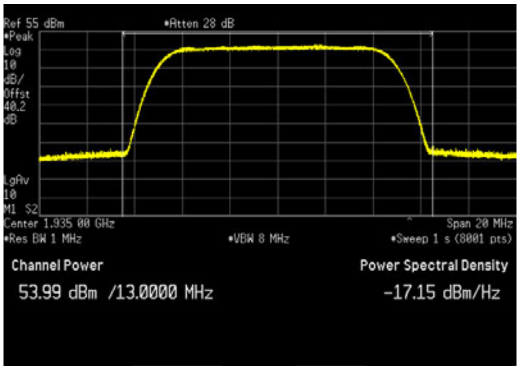


LTE5_Top Channel_Average

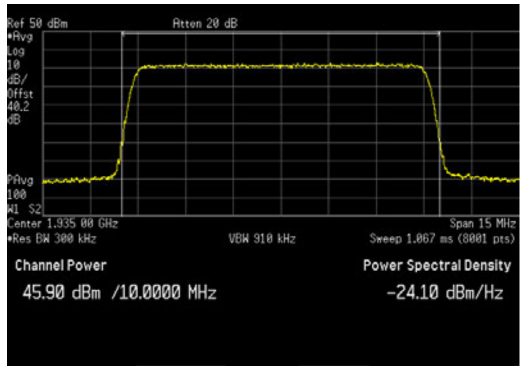


LTE10 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

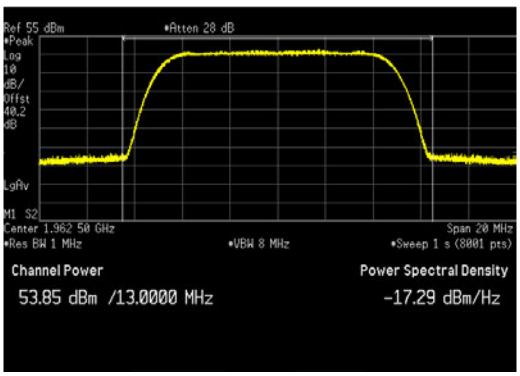
LTE10_Bottom Channel_Peak



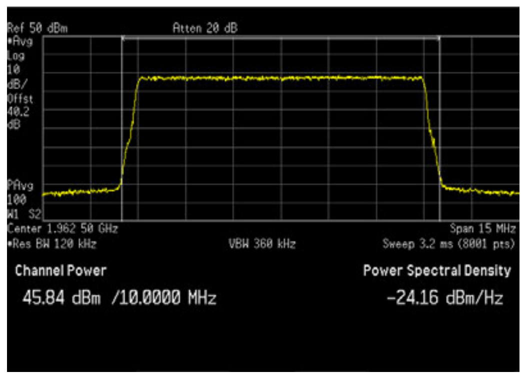
LTE10_Bottom Channel_Average



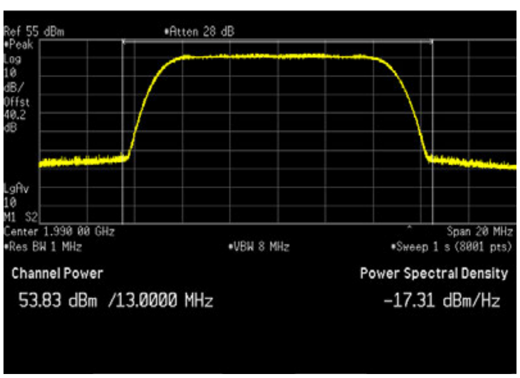
LTE10_Middle Channel_Peak



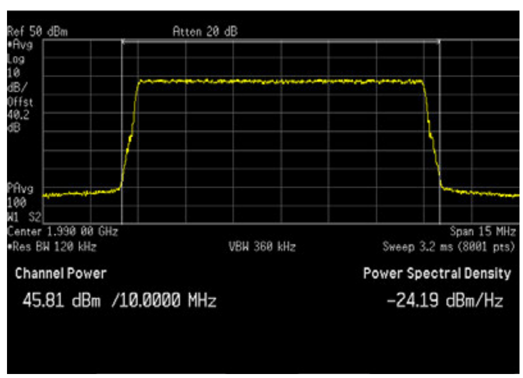
LTE10_Middle Channel_Average



LTE10_Top Channel_Peak

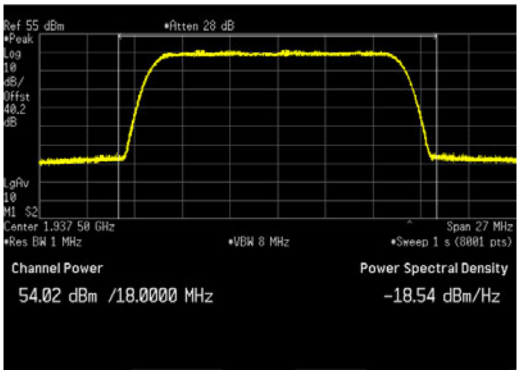


LTE10_Top Channel_Average

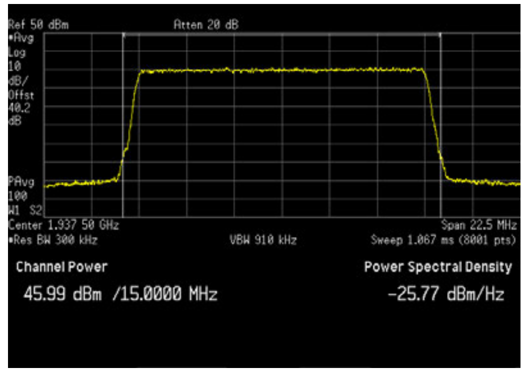


LTE15 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

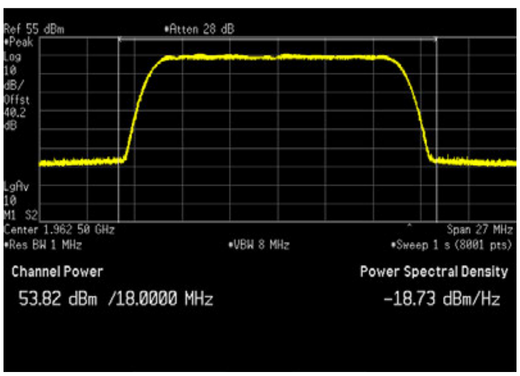
LTE15_Bottom Channel_Peak



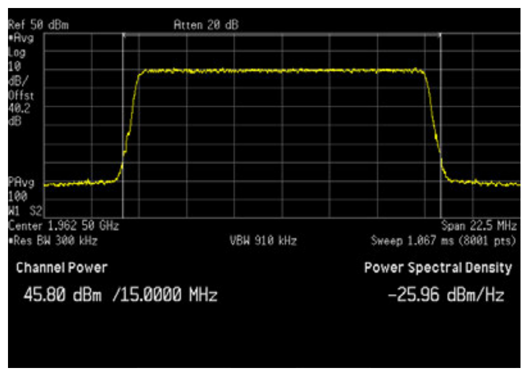
LTE15_Bottom Channel_Average



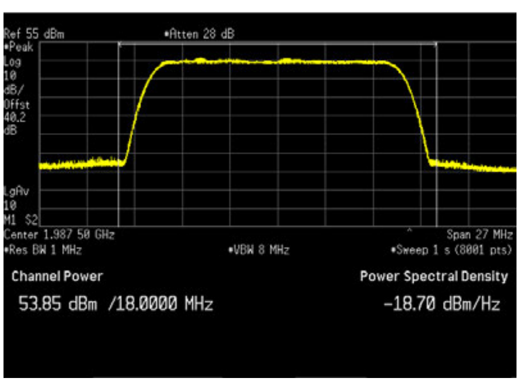
LTE15_Middle Channel_Peak



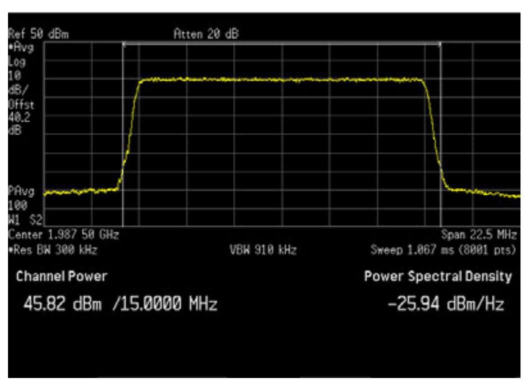
LTE15_Middle Channel_Average



LTE15_Top Channel_Peak

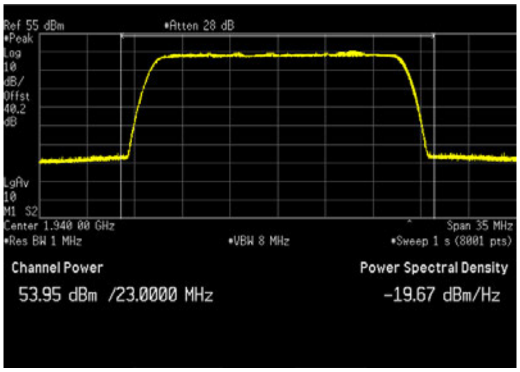


LTE15_Top Channel_Average

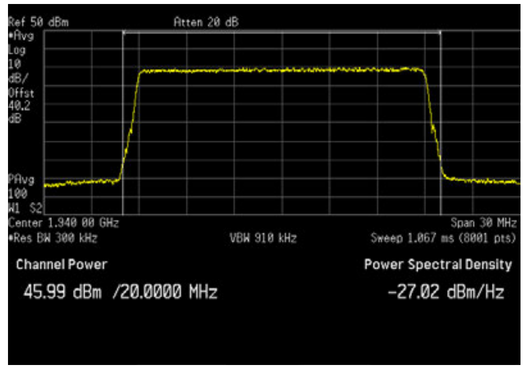


LTE20 Channel Power Plots for Antenna Port 2 and 256QAM Modulation:

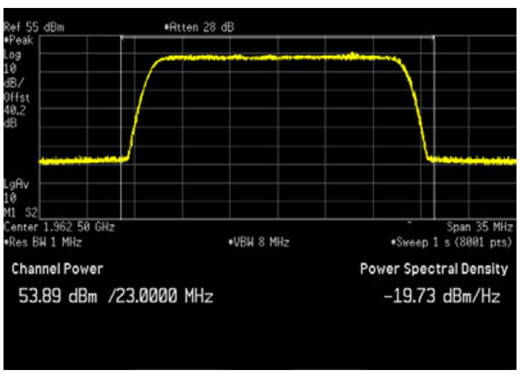
LTE20_Bottom Channel_Peak



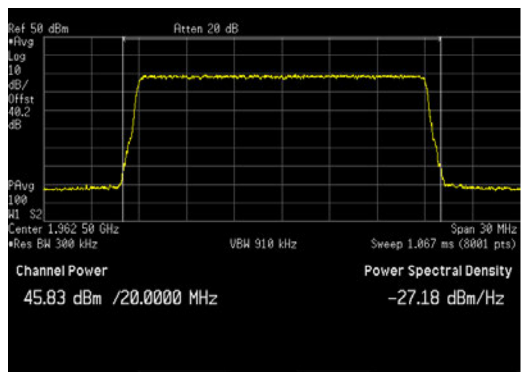
LTE20_Bottom Channel_Average



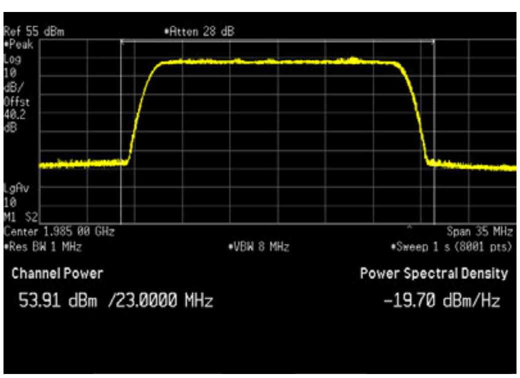
LTE20_Middle Channel_Peak



LTE20_Middle Channel_Average



LTE20_Top Channel_Peak



LTE20_Top Channel_Average