Radio Test Report

Application for Grant of Equipment Authorization

FCC Part 27 Subpart C & L
IC RSS-139 Issue 3 & RSS-170 Issue 3
2110MHz – 2200MHz

FCC ID:	**VBNFRIJ-01**
IC:	**661W-FRIJ**
Model:	**FRIJ**
Product Name:	**Airscale Base Station RRH**
APPLICANT:	**Nokia Solutions and Networks** **6000 Connection Dr** **Irving, TX. 75039**
TEST SITE(S):	**National Technical Systems - Plano** **1701 E Plano Pkwy #150** **Plano, TX 75074**
REPORT DATE:	**May 10th 2016**
FINAL TEST DATES:	**April 25th – May 19th 2016**
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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	May 10th 2016	(DRAFT) 1st release	Armando Del Angel
1	May 19th 2006	Added AWS-4 Band Radiated emissions testing and addressed customer comments.	Armando Del Angel
2	May 23rd 2016	Changes made 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 FRIJ, 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 and industry Canada.

- Code of Federal Regulations (CFR) Title 47 Part 2
- CFR Title 47 Part 27 Subpart C & L
- RSS-Gen Issue 4 November 13 2014
- 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 C63.4-2009
ANSI TIA-603-C
FCC KDB 971168 D01 v02r02

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant FCC 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 FRIJ and therefore apply only to the tested sample. The sample was selected and prepared by Hobert Smith 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 FRIJ. No additional models were described or supplied for testing.

STATEMENT OF COMPLIANCE

The tested sample of Nokia Solutions and Networks product Airscale Base Station Remote Radio Head (RRH) Model FRIJ 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

FCC Part 27 Subpart C & L and RSS-139 & RSS-170 Issues 3 (Base Stations Operating in 2110MHz-2200MHz band) -Without External Notch Filter

FCC	IC	Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§27.5(h)&(j)	RSS-139 Section 6.1 & RSS-170 Section 5.1	Frequency range(s)	2112.5MHz - 2197.5MHz (5M LTE) 2115.0MHz – 2195.0MHz (10M LTE) 2117.5MHz – 2192.5MHz (15MHz LTE) 2120.0MHz – 2190.0MHz (20MHz LTE) 2110.0MHz-2170.0MHz (WCDMA)	2110.0MHz – 2200.0MHz	Pass
§2.1033(c)(4)	RSS-139 Section 6.2	Modulation Type	QPSK, 16QAM, 64QAM, (5M, 10M, 15M, and 20M for each) WCDMA	Digital	Pass
§27.50(d)(2)	RSS-139 Section 6.5 & RSS-170 Section 5.3.1	Output Power	Conducted Output Power (Highest on Port 4) RMS: 46.03Bm EIRP will depend on antenna gain (unknown)	1640W EIRP	Pass
§27.50(d)(5)	RSS-139 Section 6.5 & RSS-170 Section 5.3.1	Peak to Average Ratio	8.24dB highest	13dB	Pass
§2.1049	RSS-GEN Section 6.6	Emission Bandwidth (99%)	4.5015MHz (5M LTE) 9.0029MHz (10M LTE) 13.4979MHz (15M LTE) 18.006MHz (20MHz LTE) 4.1032MHz (WCDMA)	Remain in Block	Pass
27.53(h)(3)	N/A Informational	Emission Bandwidth (26dB)	4.89MHz (5M LTE) 9.77MHz (10M LTE) 14.627MHz (15M LTE) 19.462MHz (20M LTE) 4.599MHz (WCDMA)	Remain in Block	Pass
Transmitter spurious emissions[1]					
§27.53(h)	RSS-139 Section 6.6 & RSS-170 Section 5.4	At the antenna terminals	< -19.02dBm	-19.03 dBm (per TX chain)	Pass
		Field strength	51.38dBuV/m at 3m Eq. to -43.88dBm EIRP	-13 dBm EIRP	Pass
Other details					
§27.54	RSS-139 Section 6.4 & RSS-170 Section 5.2	Frequency stability	Low = -21.44dBm High = -21.149dBm	Remain in Block (-19.02dBm)	Pass
§1.1310	RSS-102 Issue 5	RF Exposure	N/A		Pass[2]

Notes

Note 1 – Based on 1MHz RBW. In 1MHz bands immediately outside and adjacent to the frequency block an RBW of at least 1% of the emission bandwidth has been used.
Note 2 – Applicant's declaration on a separate exhibit based on hypothetical antenna gains.

	Emission Designators					
	QPSK		16QAM		64QAM	
	FCC	IC	FCC	IC	FCC	IC
5M LTE	4M89F9W	4M50F9W	4M87F9W	4M49F9W	4M87F9W	4M51F9W
10M LTE	9M74F9W	8M99F9W	9M71F9W	9M01F9W	9M77F9W	9M00F9W
15M LTE	14M57F9W	13M49F9W	14M55F9W	13M50F9W	14M63F9W	13M48F9W
20M LTE	19M60F9W	17M96F9W	19M39F9W	18M01F9W	19M47F9W	17M95F9W
WCDMA	4M60F9W	4M11F9W	4M59F9W	4M11F9W	4M60F9W	4M11F9W

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

FCC Part 27 Subpart C & L and RSS-139 & RSS-170 Issues 3 (Base Stations Operating in 2110MHz-2200MHz band)
-With External Notch Filter

FCC	IC	Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§27.5(h)&(j)	RSS-139 Section 6.1 & RSS-170 Section 5.1	Frequency range(s)	2112.5MHz - 2192.5MHz (5M LTE) 2115.0MHz – 2190.0MHz (10M LTE) 2117.5MHz – 2187.5MHz (15MHz LTE) 2120.0MHz – 2185.0MHz (20MHz LTE)	2110.0MHz – 2200.0MHz 2195MHz-2200MHz (Guardband)	Pass
§2.1033(c)(4)	RSS-139 Section 6.2	Modulation Type	QPSK, 16QAM, 64QAM, (5M, 10M, 15M, and 20M for each)	Digital	Pass
§27.50(d)(2)	RSS-139 Section 6.5 & RSS-170 Section 5.3.1	Output Power	Conducted Output Power (Highest on Port 4) RMS: 45.78Bm EIRP will depend on antenna gain (unknown)	1640W EIRP	Pass
§27.50(d)(5)	RSS-139 Section 6.5 & RSS-170 Section 5.3.1	Peak to Average Ratio	8.21dB highest	13dB	Pass
§2.1049	RSS-GEN Section 6.6	Emission Bandwidth (99%)	4.5007MHz (5M LTE) 9.0006MHz (10M LTE) 13.499MHz (15M LTE) 17.9975MHz (20MHz LTE)	Remain in Block	Pass
27.53(h)(3)	N/A Informational	Emission Bandwidth (26dB)	4.889MHz (5M LTE) 9.765MHz (10M LTE) 14.624MHz (15M LTE) 19.469MHz (20M LTE)	Remain in Block	Pass
Transmitter spurious emissions[1]					
§27.53(h)	RSS-139 Section 6.6 & RSS-170 Section 5.4	At the antenna terminals	< -19.02dBm	-19.03 dBm (per TX chain)	Pass
		Field strength	See Results on Table above	-13 dBm EIRP	Pass
§27.1134(e)(i) AWS-4 Band Out of Band Testing	RSS-170 Section 5.4 & 5.4.1.2	At the antenna terminals	-77.18dBm	-69.6dBm (per TX Chain) See note 3	Pass
		Field strength	26.57dBuV/m at 3m Eq to -68.7 dBm EIRP	-46.6dBm EIRP (See note 4)	
Other details					
§27.54	RSS-139 Section 6.4 & RSS-170 Section 5.2	Frequency stability	See Results on Table above	Remain in Block (-19.02dBm)	Pass
§1.1310	RSS-102 Issue 5	RF Exposure	N/A		Pass[2]
Notes					

Note 1 – Based on 1MHz RBW. In 1MHz bands immediately outside and adjacent to the frequency block an RBW of at least 1% of the emission bandwidth has been used.
Note 2 – Applicant's declaration on a separate exhibit based on hypothetical antenna gains.
Note 3 - Limit is equivalent to -69.6 dBm/MHz assuming four port MIMO operation and a 17 dBi antenna gain (i.e.: -100.6 dBW/4kHz (EIRP Limit) + 30dB (dBW to dBm convertion) +24 dB (BW conversion 10 Log [1MHz/4kHz]) - 6 dB (4 port MIMO) -17 dBi (BTS Antenna Gain) = -69.6 dBm/MHz
Note 4 - Limit is -46.6dBm with BTS operating as four port MIMO and 0dBi antenna gain since RRH ports terminated into loads for radiated emissions: -100.6dBW/4kHz (EIRP Limit) + 30dB (dBW to dBm) + 24dB (BW conversion 10 log[1M/4k]) - 0dBi (Antenna Gain) = -46.6dBm/MHz.

	Emission Designators With External Notch Filter					
	LTE-QPSK		**LTE-16QAM**		**LTE-64QAM**	
	FCC	**IC**	**FCC**	**IC**	**FCC**	**IC**
5M	4M89F9W	4M50F9W	4M87F9W	4M49F9W	4M89F9W	4M51F9W
10M	9M74F9W	8M99F9W	9M72F9W	9M01F9W	9M77F9W	9M00F9W
15M	14M58F9W	13M49F9W	14M52F9W	13M50F9W	14M63F9W	13M49F9W
20M	19M43F9W	17M95F9W	19M36F9W	18M00F9W	19M47F9W	17M96F9W

Note: FCC based on 26dB emission bandwidth, IC based on 99% emissions 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 FRIJ. The FRIJ has four co-located transmitters with each transmit port supporting 40 watts maximum rated RF output power. The FRIJ may be operated as MIMO or as non-MIMO. Multi-carrier operation is supported. The FRIJ is multi-standard capable (GSM/EDGE/WCDMA/LTE), but for this effort only the LTE and WCDMA modes are tested.

The FRIJ operates over 3GPP frequency band 66 (BTS Rx: 1710 to 1780 MHz/BTS Tx: 2110 to 2200 MHz) and supports three downlink modulation types (QPSK, 16QAM and 64QAM) for LTE. The FRIJ software supports four LTE channel bandwidths (5 MHz, 10 MHz, 15 MHz and 20 MHz).

The FRIJ operates over 3GPP frequency band X (BTS Rx: 1710 to 1770 MHz/BTS Tx: 2110 to 2170 MHz) and supports three downlink modulation types (QPSK, 16QAM and 64QAM) for WCDMA.

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

A passive RF notch filter is being developed for this effort by a third party. The passive external notch filter is used (to attenuate emissions above FRIJ 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 FRIJ 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 FRIJ is operating in LTE mode.

The FRIJ LTE channel numbers and frequencies are as follows:

Downlink EARFCN E-UTRA Band 66	Downlink Frequency (MHz)	Channel Bandwidth			
		5 MHz	10 MHz	15 MHz	20 MHz
66436	2110.0	Band edge	Band edge	Band edge	Band edge
……					
66461	2112.5	Bottom Channel			
66462	2112.6	BC +1			
……					
66486	2115.0		Bottom Channel		
66487	2115.1		BC + 1		
……					
66511	2117.5			Bottom Channel	
66512	2117.6			BC +1	
……					
66536	2120.0				Bottom Channel
66537	2120.1				BC + 1
……					
66886	2155.0	Middle Channel	Middle Channel	Middle Channel	Middle Channel
……					
67235	2189.9				TC - 1
67236	2190.0				Top Channel
……					
67260	2192.4			TC - 1	
67261	2192.5			Top Channel	
……					
67285	2194.9		TC - 1		
67286	2195.0		Top Channel		
……					
67310	2197.4	TC - 1			
67311	2197.5	Top Channel			
……					
67336	2200.0	Band edge	Band edge	Band edge	Band edge

FRIJ Without the external Notch Filter Downlink LTE Frequency Channels

	Downlink UARFCN UTRA Band X	**Downlink Frequency (MHz)**	**WCDMA Channel**
	3100	2110.0	Band Edge
	……		
	3112	2112.4	Bottom Channel
	3113	2112.6	Bottom Channel + 1
	……		
	3325	2155.0	Middle Channel
	……		
	3387	2167.4	Top Channel - 1
	3388	2167.6	Top Channel
	……		
	3400	2170.0	Band Edge

FRIJ Without the external Notch Filter Downlink WCDMA Frequency Channels

Downlink EARFCN E-UTRA Band 66	Downlink Frequency (MHz)	Channel Bandwidth			
		5 MHz	10 MHz	15 MHz	20 MHz
66436	2110.0	Band edge	Band edge	Band edge	Band edge
……					
66461	2112.5	Bottom Channel			
66462	2112.6	BC +1			
……					
66486	2115.0		Bottom Channel		
66487	2115.1		BC + 1		
……					
66511	2117.5			Bottom Channel	
66512	2117.6			BC +1	
……					
66536	2120.0				Bottom Channel
66537	2120.1				BC + 1
……					
66886	2155.0	Middle Channel	Middle Channel	Middle Channel	Middle Channel
……					
67185	2184.9				TC - 1
67186	2185.0				Top Channel
……					
67210	2187.4			TC - 1	
67211	2187.5			Top Channel	
……					
67235	2189.9		TC - 1		
67236	2190.0		Top Channel		
……					
67260	2192.4	TC - 1			
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

FRIJ With the external Notch Filter Downlink LTE Frequency Channels

The sample was received on April 22, 2016 and tested on April 25 – May 19th, 2016. The EUT consisted of the following component(s):

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	FRIJ	AirScale BTS RRH	Part#: 473368A.x21 Serial#: YK160800020	FCC ID: VBNFRIJ-01 IC ID: 661W-FRIJ

ENCLOSURE

The EUT enclosure is made of heavy duty aluminum and measures approximately 320(W) x 123(D) x 587.2(H) millimeters.

AUXILLARY EQUIPMENT

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	FOSH	6GHz SFP Module (Plugs into FRIJ Opt Ports)	Part#: 472579A.101 Serial#: FR151400271	N/A
Filtronics		AWS 4 External Notch Filter	Part#: US-PSD015-F1V1 Serial#: FI1160500010	N/A
Kathrein		1920-1980/2110-2170 MHz Masthead Amplifier (Note 1)	Part#: 78210613 A00 Serial#: HJF4213898	N/A
Creowave Filters		2110 to 2196 MHz Carrier Reject/Blocking Filter (Note 2)	Part#: CW-DPF-2110-2196-E1-M2 Serial#: 1222001	N/A

Notes:
(1) Only used in radiated emission testing to provide load for FRIJ antenna ports 1 and 3.
(2) Only used in RF conducted emission testing of out-of-band emissions in the 2200 to 2290 MHz range to allow measurement equipment noise floor to be below required measurement levels.

SUPPORT EQUIPMENT

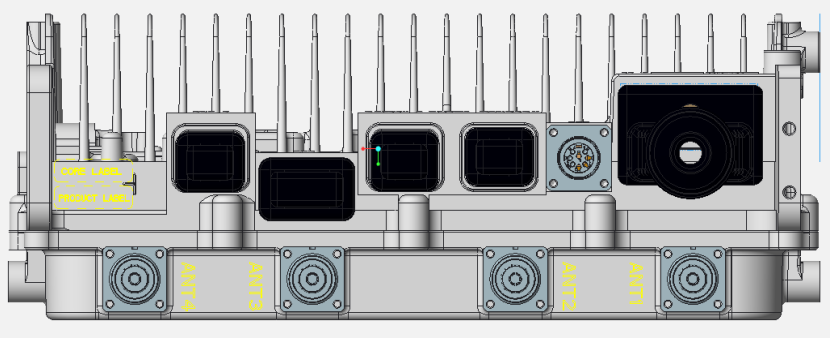
Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	FSMF	Flexi System Module	Part#: 472181A.103	N/A
Nokia Solutions and Networks	FBBC	Baseband Extension Module	Part#: 472797A.101 (2 units per FSMF)	N/A
HP	Elite Book 6930p	Laptop PC	N/A	N/A

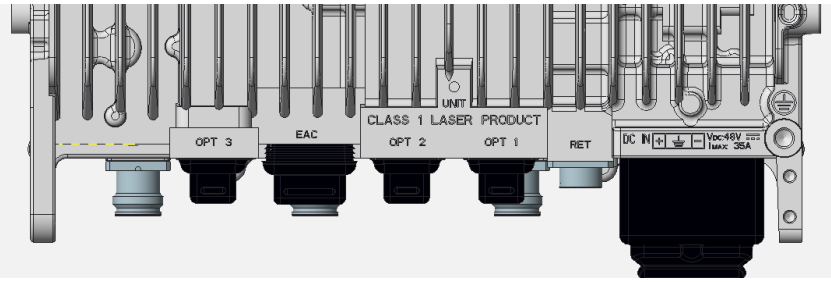
EUT INTERFACE PORTS

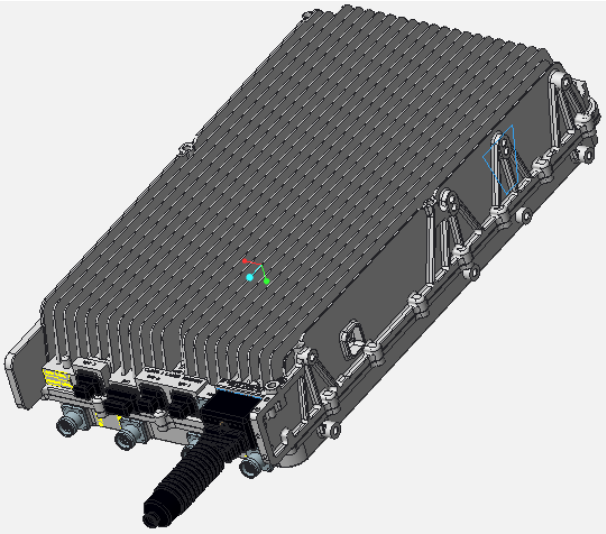
The I/O cabling configuration during testing was as follows:

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, MHA and 50Ω Loads
External Alarm	Signal	Yes	~ 2 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

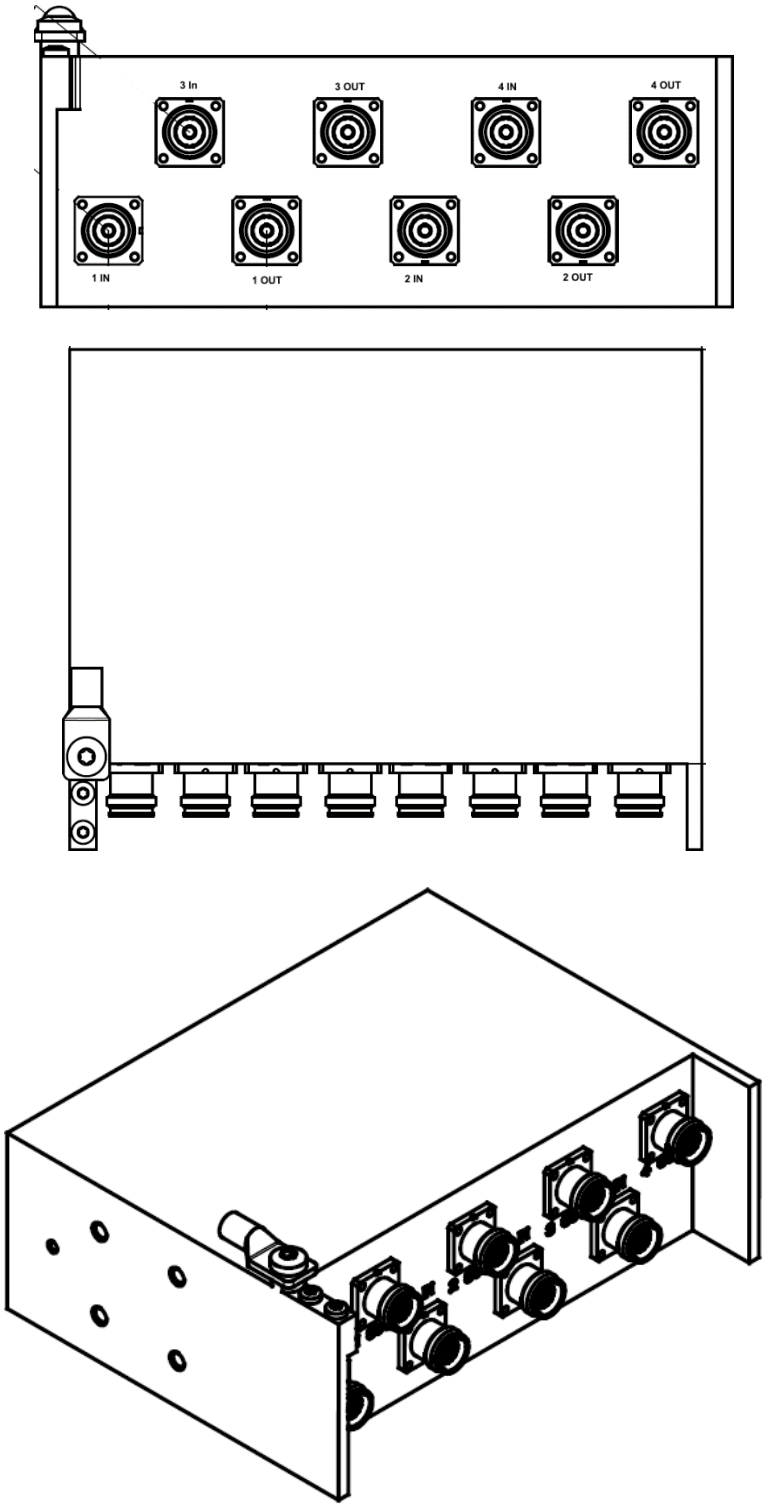
The connector layout for FRIJ is provided below:







Notch Filter Connector Layout and Isometric View:



FRIJ External Interfaces:

Name	Qty	Connector Type	Purpose (and Description)
DC In	1	Screw Terminal	3-port Power Input -48 VDC, up to AWG 4 cable
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	USB	External Alarm Interface (4 alarms)
OPT	3	SFP+ cage	Optical OBSAI Interface up to 6 Gps.
RET	1	8-pin circular connector conforming to IEC 60130-9 – Ed.3.0	AISG 2.0 to external devices
Fan	1	2 port Molex Microfit	Power for RRH Fan. Located on the side of FRIJ.

EUT OPERATION

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

EUT FIRMWARE/SOFTWARE

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

(1) RRH Unit Software: FRM36.04.R07
(2) System Module Software for LTE Testing: FL16A_FSM3_9999_160411_029420
(3) System Module Software for WCDMA Testing: WN0000_0000_1231_00

MODIFICATIONS

No modifications were made to the EUT during testing.

TESTING

GENERAL INFORMATION

Antenna port measurements were taken at NTS Plano branch located at 1701 E Plano Pkwy #150 Plano, TX 75074.

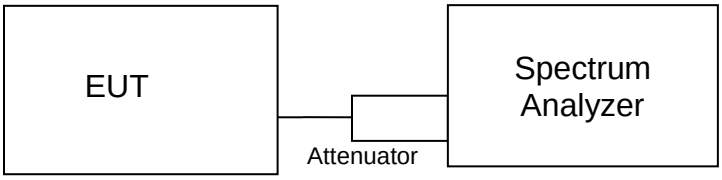
Radiated spurious emissions measurements were taken at the NTS Plano Anechoic Chamber listed below. The sites conform to the requirements of ANSI C63.4-2009 *American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz* and CISPR 16-1-4:2007 - *Specification for radio disturbance and immunity measuring apparatus and methods Part 1-4: Radio disturbance and immunity measuring apparatus Ancillary equipment Radiated disturbances*. 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	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

Output power, emission bandwidth, conducted spurious, conducted bandedge and carrier frequency stability measurements were all performed via a spectrum analyzer connected to the individual RF chains via a 40dB attenuator and an RF cable. The EUT was operating in 4x4 MIMO configuration at full 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 attenuator and cable inserted between the RF port of the EUT and the spectrum analyzer. Simple test diagram is shown below.



Test Configuration for Antenna Port Measurements

26dB emission bandwidth was measured in accordance with Section 4.1 of FCC KDB 971168 D01 v02r02. 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.

Emissions at the band-edges were also captured with Keysight Benchvue Software with settings described in the corresponding sections of the FCC and IC rules. 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 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.

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 was calculated in accordance with Section 5.7.2 of FCC KDB 971168 D01 v02r02.

Conducted spurious emissions were captured with TILE6 software which corrected the readings for cable loss and attenuator loss across the 9kHz-22GHz frequency span. A MicroTronics notch filter was used in addition to a 40 dB attenuator to measure emissions in the 9kHz -22GHz range to reduce measurement instrumentation noise

floor.Settings of the spectrum analyzer are described in the corresponding test result section.

For frequency stability, 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 spectrum analyzer as detailed in the test equipment section has been used to measure the Low and High channels, making sure they remain inside the allocated frequency band.

Transmitter radiated spurious emissions measurements were made in accordance with ANSI C63.4-2009 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.

Test Equipment

NTS Equipment #	Description	Manufacturer	Model	Calibration Duration	Calibration Due Date
E1345P	PSA	Agilent	E4440A	12 Months	12/30/2016
E1554P	PreAmp (1GHz-40GHz)	MITEQ	JS32-00104000-62-5P	12 Months	1/27/2017
E1148P	PreAmp (30MHz-1GHz)	MITEQ	AM-1431-N-1179WP	12 Months	9/29/2016
E1524P	Biconilog Antenna (30MHz-1GHz)	ETS Lindgren	3142D	12 Months	10/28/2016
E1149P	Horn Antenna (1GHz-18GHz)	EMCO	3115	12 Months	12/16/2016
E1068P	Horn Antenna (18GHz-40GHz)	EMCO	3116	12 Months	9/15/2016
E1447P	RMS Multimeter	Fluke	87V	12 Months	5/27/2016

Appendix A Test Data Without Notch Filter

(All conducted RF measurements were made at the FRIJ antenna ports)

RF Output Power

RF output power has been measured in both Peak and RMS Average terms for each transmit chain at the center channel for all modulations and bandwidth modes. Peak to average ratio (PAR) has been calculated as described in Section 5.7.2 of KDB971168 D01 v02r02 and all results are presented in tabular form below.

		LTE - QPSK			LTE - 16QAM			LTE - 64QAM		
		Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)
Port 1 Center Channel	5M	53.63	45.61	8.02	53.55	45.78	7.77	53.64	45.68	7.96
	10M	53.8	45.74	8.06	53.83	45.75	8.08	53.76	45.78	7.98
	15M	53.75	45.59	8.16	53.85	45.61	8.24	53.79	45.69	8.1
	20M	53.8	45.65	8.15	53.79	45.65	8.14	53.83	45.69	8.14
Port 2 Center Channel	5M	53.44	45.56	7.88	53.36	45.71	7.65	53.42	45.5	7.92
	10M	53.6	45.56	8.04	53.62	45.58	8.04	53.56	45.53	8.03
	15M	53.66	45.56	8.1	53.69	45.56	8.13	53.65	45.55	8.1
	20M	53.66	45.43	8.23	53.7	45.46	8.24	53.64	45.47	8.17
Port 3 Center Channel	5M	53.5	45.61	7.89	53.47	45.61	7.86	53.54	45.6	7.94
	10M	53.77	45.54	8.23	53.64	45.68	7.96	53.57	45.52	8.05
	15M	53.69	45.54	8.15	53.76	45.6	8.16	53.65	45.55	8.1
	20M	53.66	45.5	8.16	53.66	45.54	8.12	53.69	45.59	8.1
Port 4 Center Channel	5M	53.66	45.77	7.89	53.67	45.87	7.8	53.73	45.85	7.88
	10M	53.85	45.72	8.13	53.89	45.8	8.09	53.77	45.81	7.96
	15M	53.86	45.73	8.13	53.9	45.81	8.09	53.84	45.77	8.07
	20M	53.91	45.69	8.22	53.93	45.89	8.04	53.87	45.69	8.18
Combined Center Channel	5M	59.58	51.66	7.92	59.53	51.76	7.77	59.6	51.68	7.92
	10M	59.78	51.66	8.12	59.77	51.72	8.05	59.69	51.68	8.01
	15M	59.76	51.63	8.13	59.82	51.67	8.15	59.75	51.66	8.09
	20M	59.78	51.59	8.19	59.79	51.66	8.13	59.78	51.63	8.15

Center Channel		QPSK			16QAM			64QAM		
		Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)
Port 1	WCDMA	53.73	45.59	8.14	53.49	45.51	7.98	53.46	45.74	7.72
Port 2	WCDMA	53.51	45.51	8	53.22	45.48	7.74	53.39	45.34	8.05
Port 3	WCDMA	53.65	45.52	8.13	53.27	45.43	7.84	53.39	45.69	7.7
Port 4	WCDMA	53.81	45.59	8.22	53.54	45.89	7.65	53.75	45.68	8.07
Combined	WCDMA	59.7	51.57	8.13	59.4	51.6	7.8	59.52	51.64	7.88

Based on the results above, Port 4 had the highest RMS average power and therefore it was selected for all the remaining antenna port tests on the product.

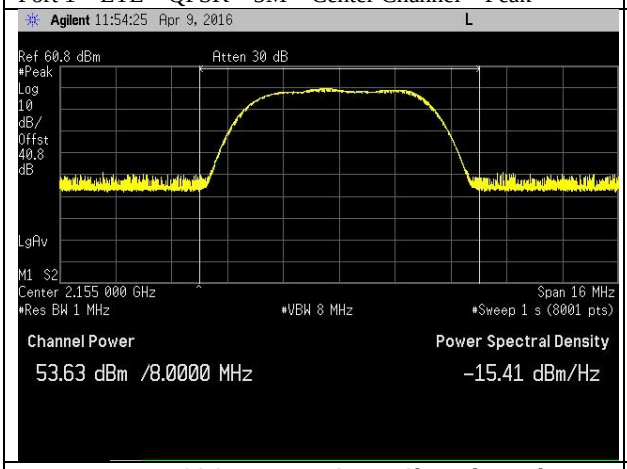
Subsequently output power levels on lowest and highest channels in all 4 channel bandwidths were tested only at Port 4 and results presented below.

		LTE - QPSK			LTE - 16QAM			LTE - 64QAM		
		Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)
Port 4 Bottom Channel	5M	53.83	45.92	7.91	53.7	45.93	7.77	53.79	45.87	7.92
	10M	54.02	45.95	8.07	54.07	45.98	8.09	53.94	45.92	8.02
	15M	54.06	45.93	8.13	54.13	45.94	8.19	54	45.86	8.14
	20M	54.07	45.97	8.1	54.12	46.03	8.09	54.02	45.9	8.12
Port 4 Top Channel	5M	53.65	45.94	7.71	53.67	45.81	7.86	53.65	45.82	7.83
	10M	53.86	45.8	8.06	53.88	45.89	7.99	53.79	45.84	7.95
	15M	53.94	45.82	8.12	54	45.86	8.14	53.88	45.8	8.08
	20M	53.99	45.89	8.1	53.95	45.9	8.05	53.96	45.82	8.14

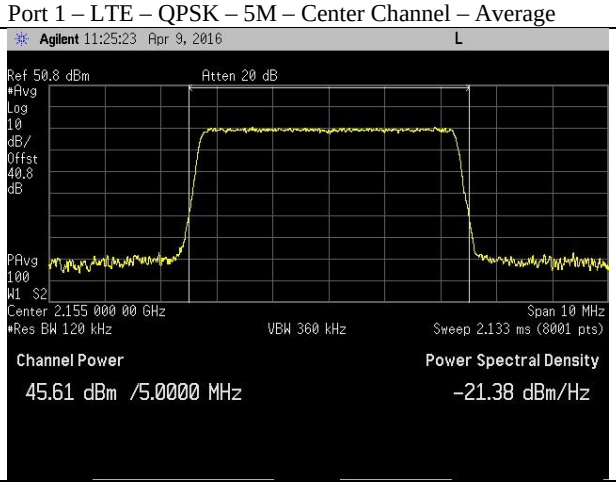
Port 4		QPSK			16QAM			64QAM		
		Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)	Peak (dBm)	Average (dBm)	PAR (dB)
Bottom CH	WCDMA	53.94	45.96	7.98	54.05	45.8	8.25	53.71	45.85	7.86
Top CH	WCDMA	53.99	45.88	8.11	54.14	45.84	8.3	53.76	46.15	7.61

All corresponding plots included on the following pages. Total path loss of 40.8dB (Attenuator Loss: 40dB, RF cable loss: 0.8dB) accounted in via reference level offset to the spectrum analyzer.

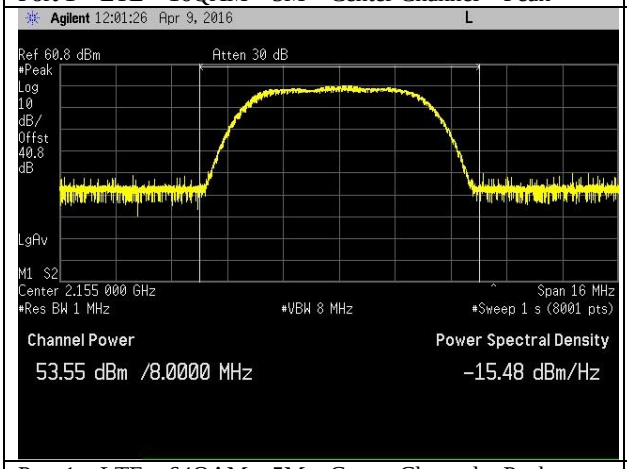
Port 1 – LTE – QPSK – 5M – Center Channel – Peak



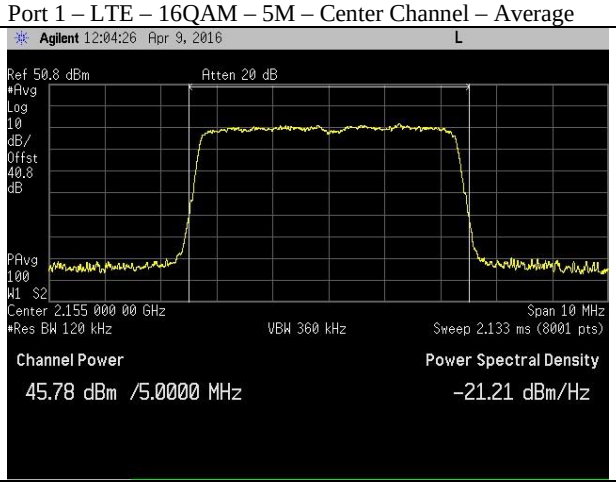
Port 1 – LTE – QPSK – 5M – Center Channel – Average



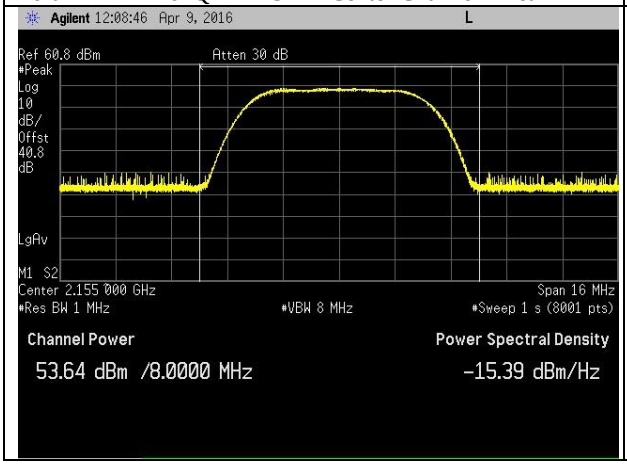
Port 1 – LTE – 16QAM – 5M – Center Channel – Peak



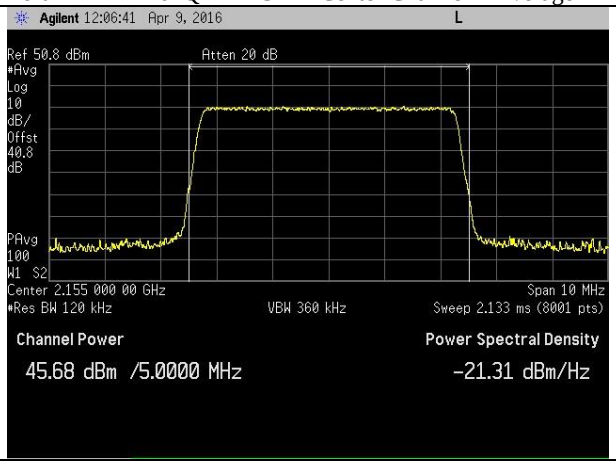
Port 1 – LTE – 16QAM – 5M – Center Channel – Average



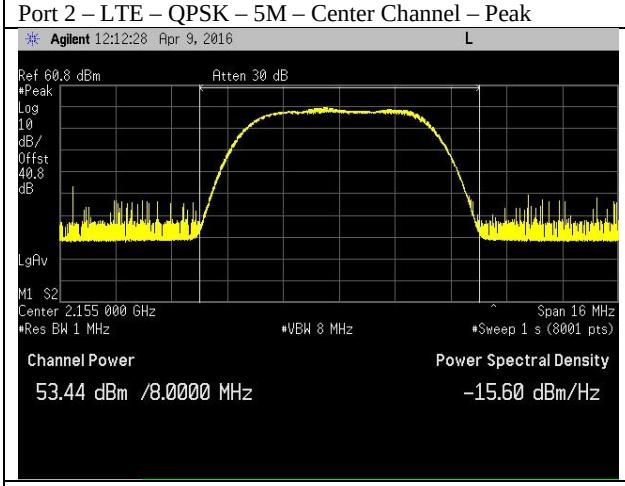
Port 1 – LTE – 64QAM – 5M – Center Channel – Peak



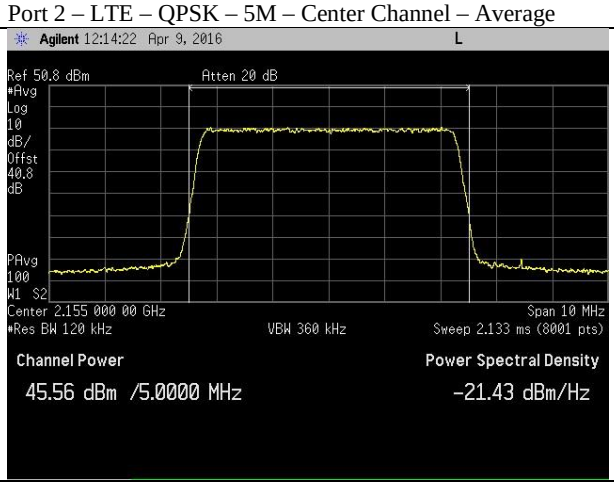
Port 1 – LTE – 64QAM – 5M – Center Channel – Average



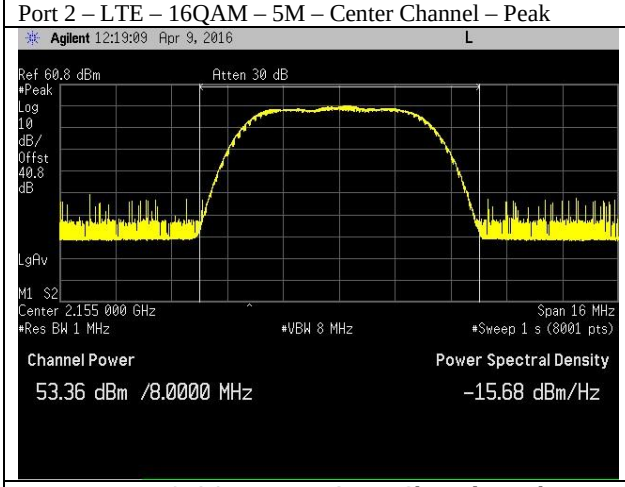
Port 2 – LTE – QPSK – 5M – Center Channel – Peak



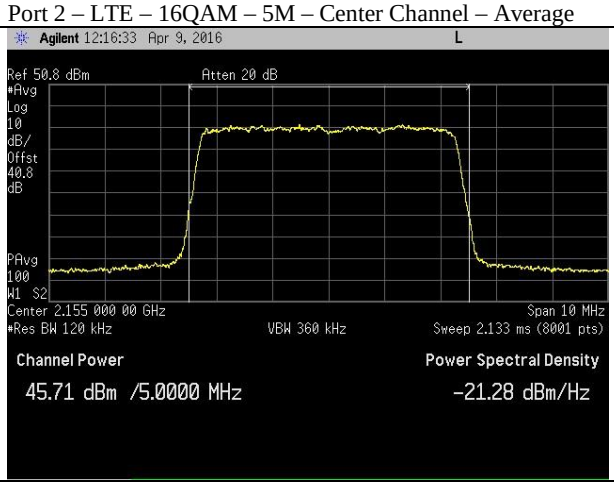
Port 2 – LTE – QPSK – 5M – Center Channel – Average



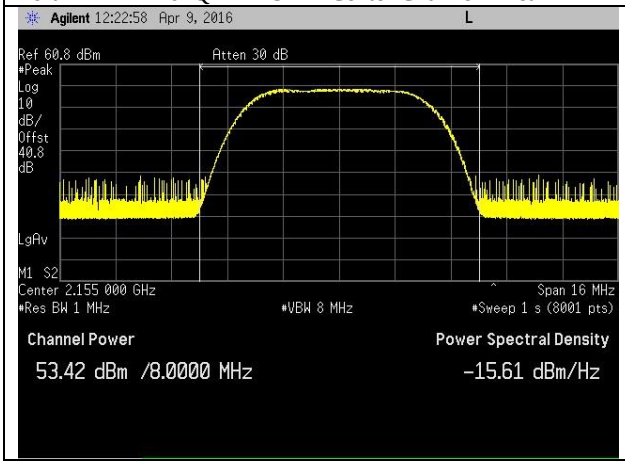
Port 2 – LTE – 16QAM – 5M – Center Channel – Peak



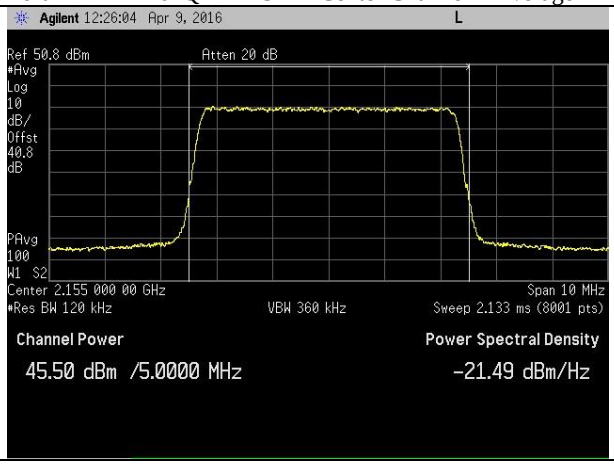
Port 2 – LTE – 16QAM – 5M – Center Channel – Average



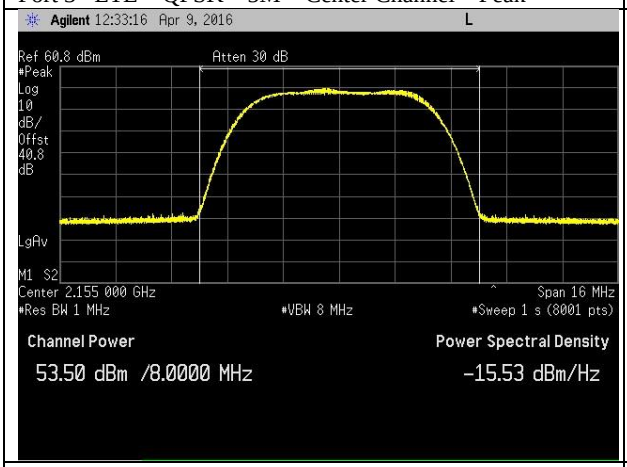
Port 2 – LTE – 64QAM – 5M – Center Channel – Peak



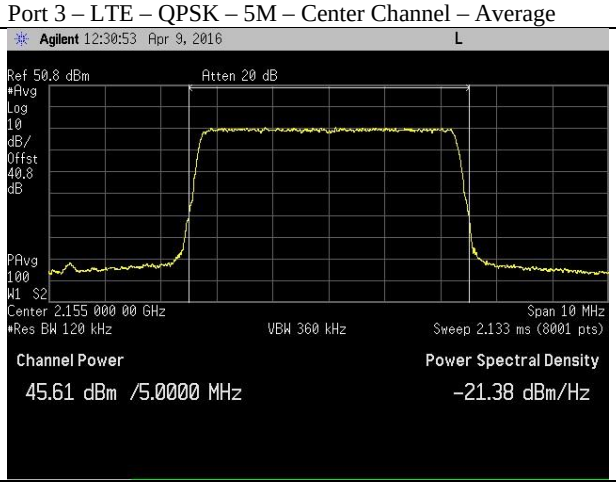
Port 2 – LTE – 64QAM – 5M – Center Channel – Average



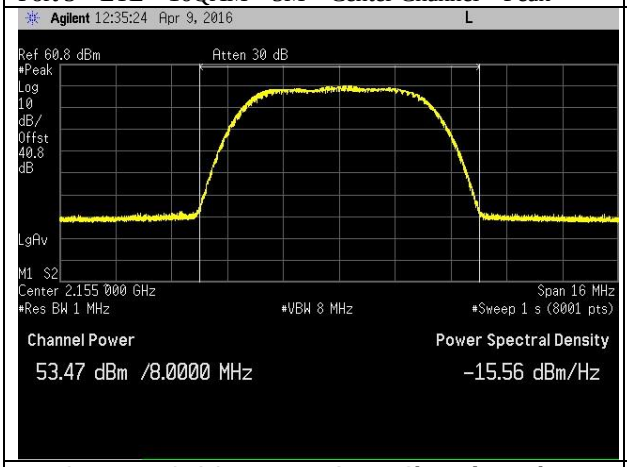
Port 3– LTE – QPSK – 5M – Center Channel – Peak



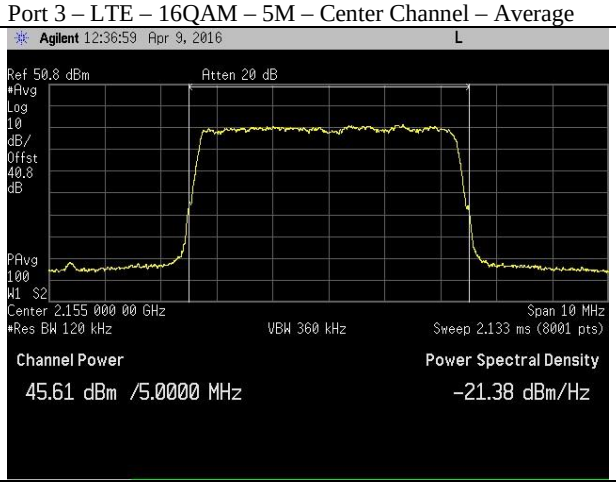
Port 3 – LTE – QPSK – 5M – Center Channel – Average



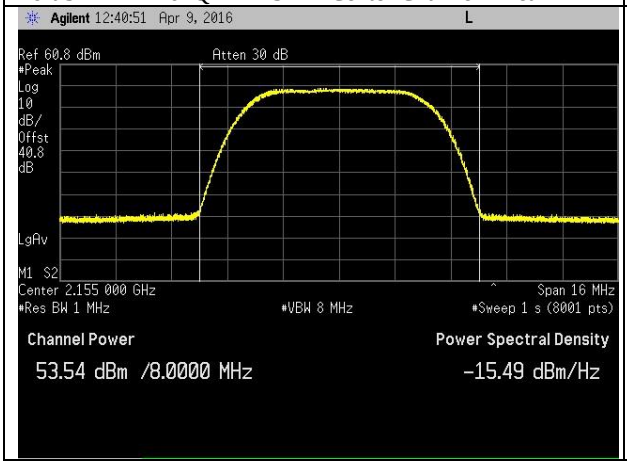
Port 3 – LTE – 16QAM – 5M – Center Channel – Peak



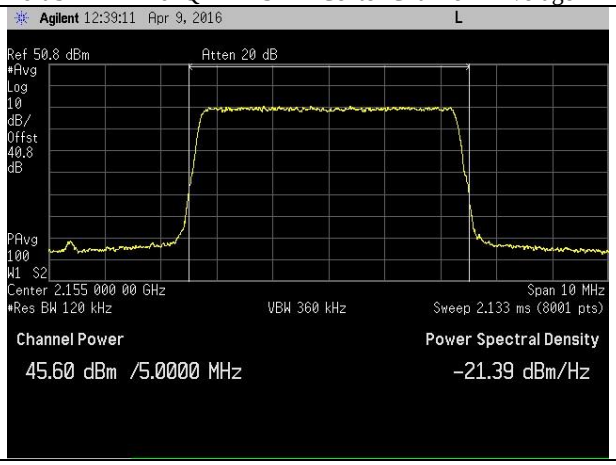
Port 3 – LTE – 16QAM – 5M – Center Channel – Average



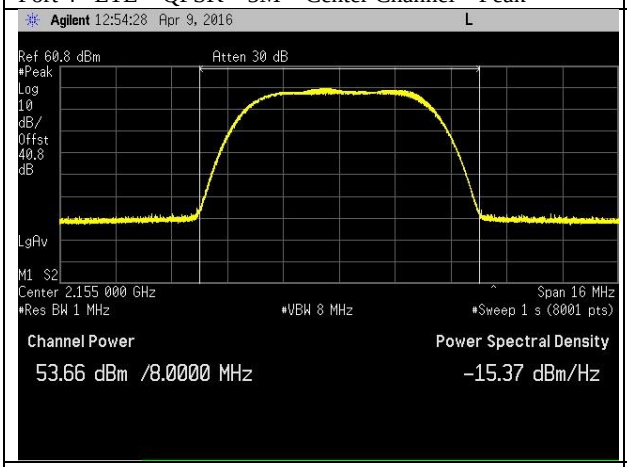
Port 3 – LTE – 64QAM – 5M – Center Channel – Peak



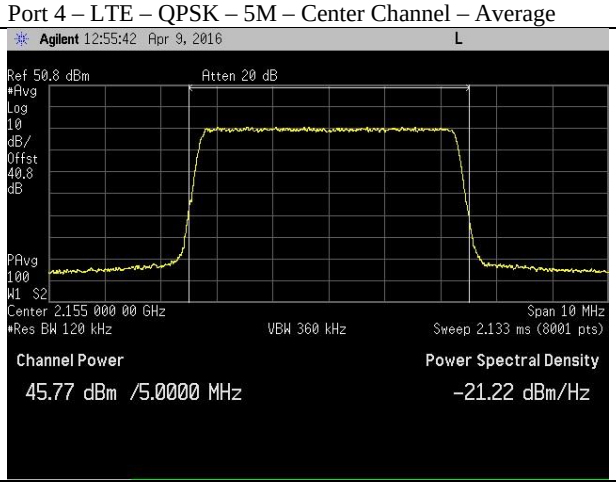
Port 3 – LTE – 64QAM – 5M – Center Channel – Average



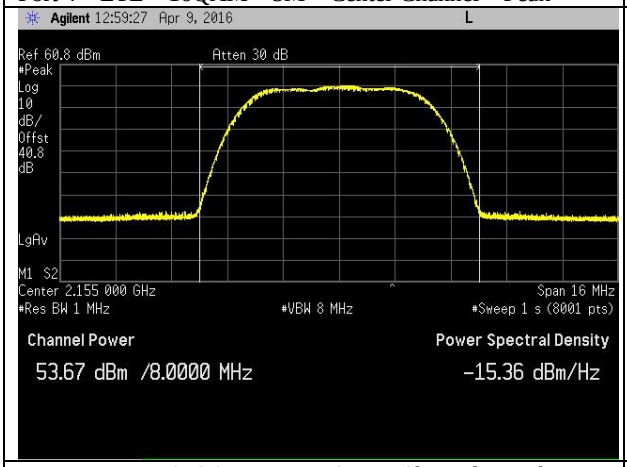
Port 4– LTE – QPSK – 5M – Center Channel – Peak



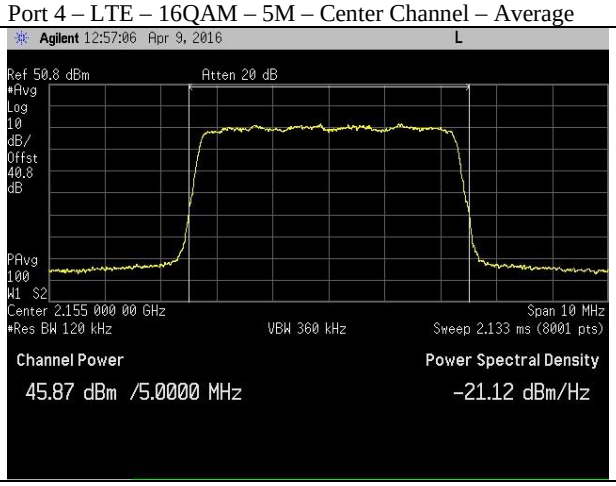
Port 4 – LTE – QPSK – 5M – Center Channel – Average



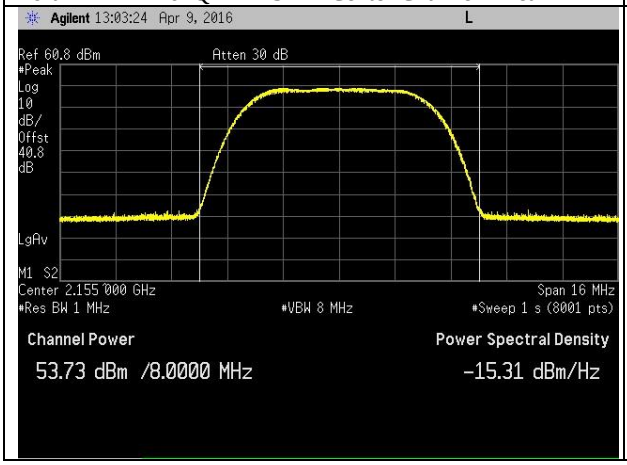
Port 4 – LTE – 16QAM – 5M – Center Channel – Peak



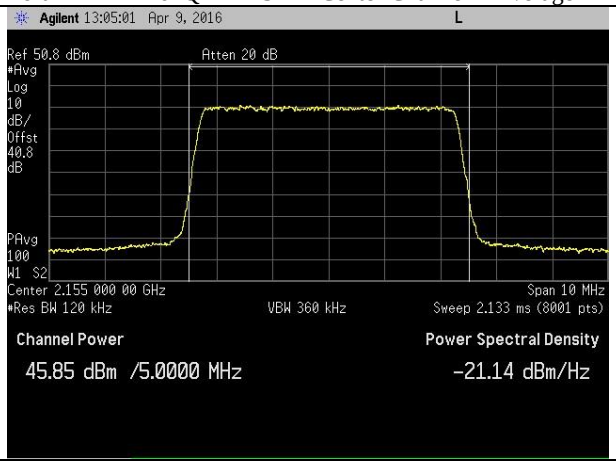
Port 4 – LTE – 16QAM – 5M – Center Channel – Average



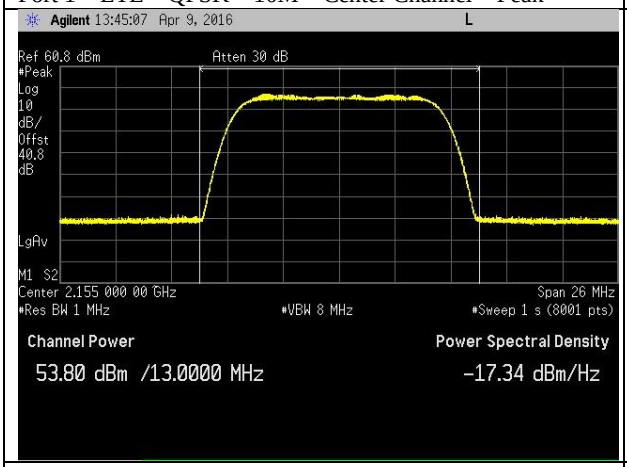
Port 4 – LTE – 64QAM – 5M – Center Channel – Peak



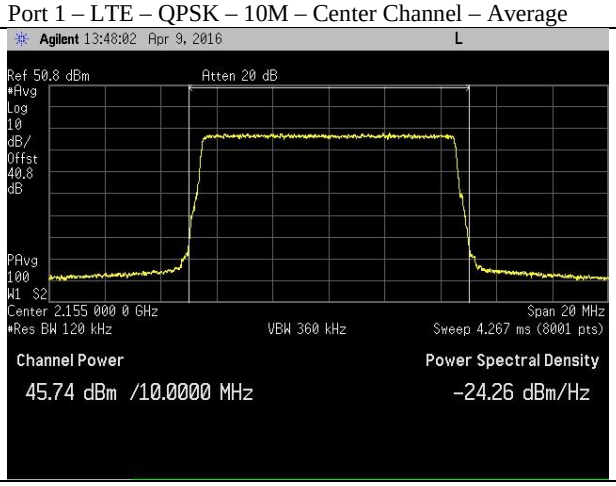
Port 4 – LTE – 64QAM – 5M – Center Channel – Average



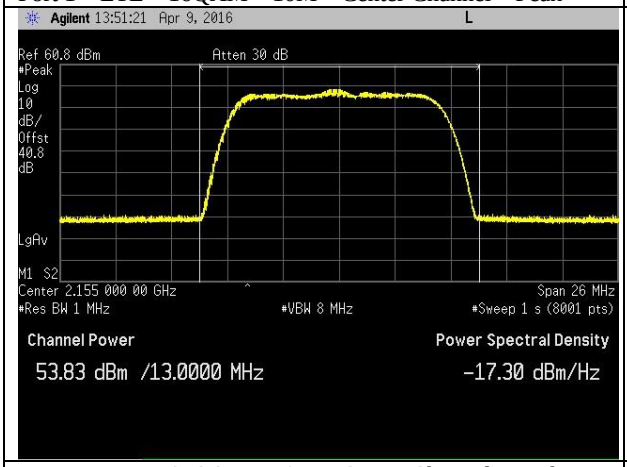
Port 1 – LTE – QPSK – 10M – Center Channel – Peak



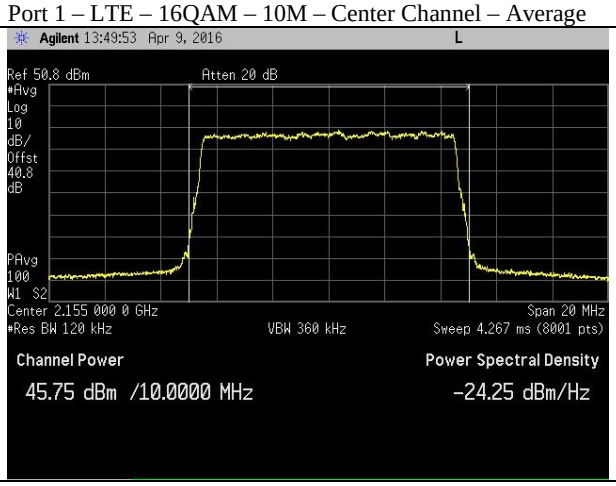
Port 1 – LTE – QPSK – 10M – Center Channel – Average



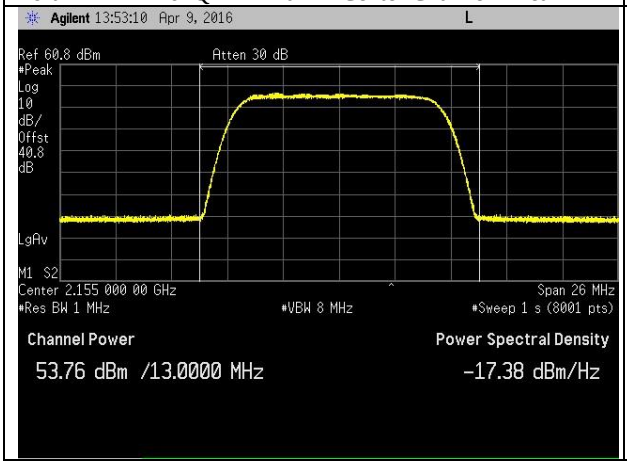
Port 1 – LTE – 16QAM – 10M – Center Channel – Peak



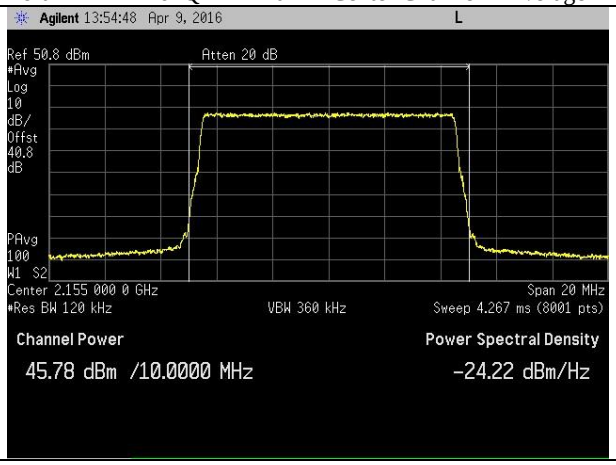
Port 1 – LTE – 16QAM – 10M – Center Channel – Average



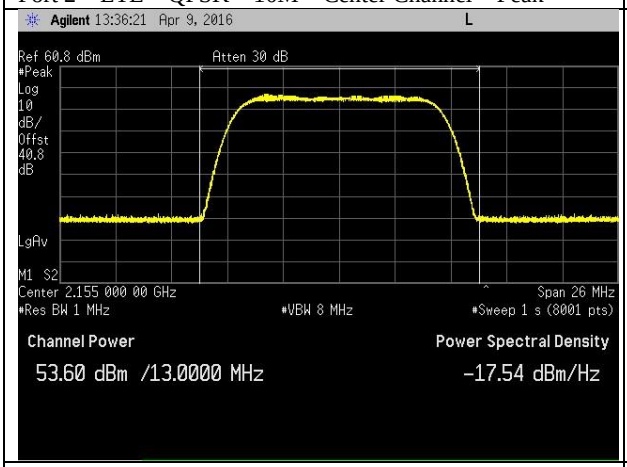
Port 1 – LTE – 64QAM – 10M – Center Channel – Peak



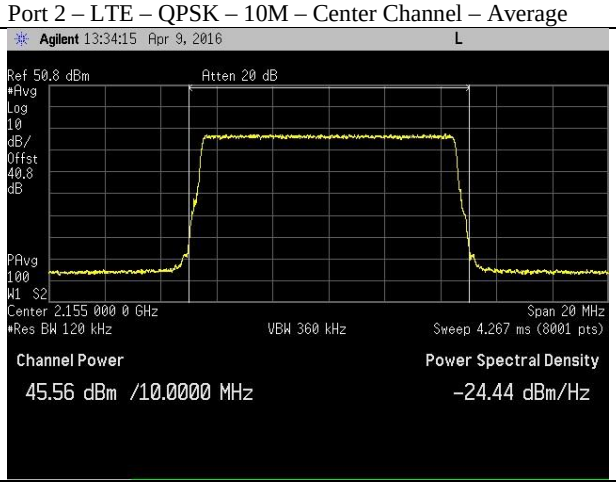
Port 1 – LTE – 64QAM – 10M – Center Channel – Average



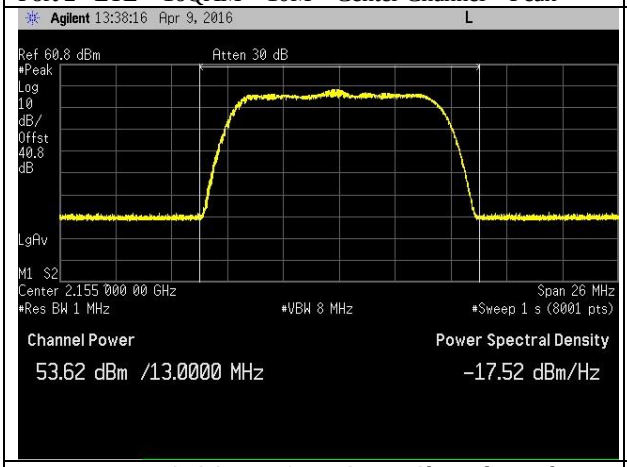
Port 2 – LTE – QPSK – 10M – Center Channel – Peak



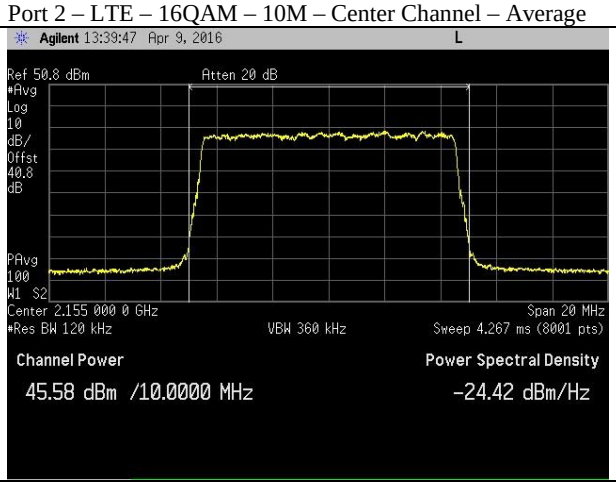
Port 2 – LTE – QPSK – 10M – Center Channel – Average



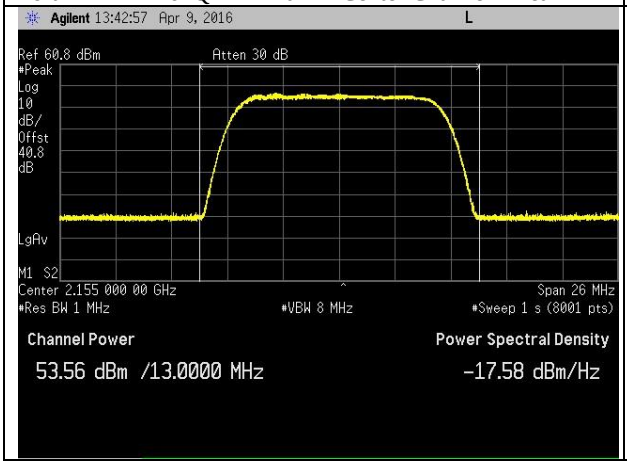
Port 2– LTE – 16QAM – 10M – Center Channel – Peak



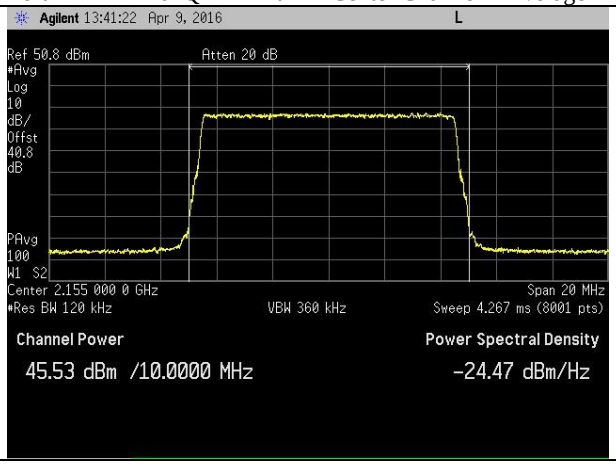
Port 2 – LTE – 16QAM – 10M – Center Channel – Average



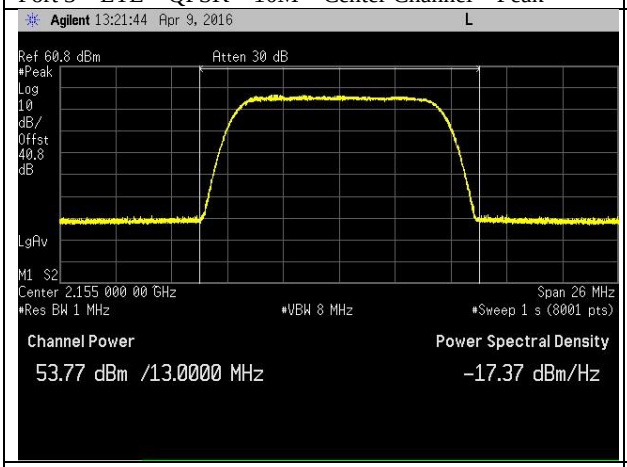
Port 2 – LTE – 64QAM – 10M – Center Channel – Peak



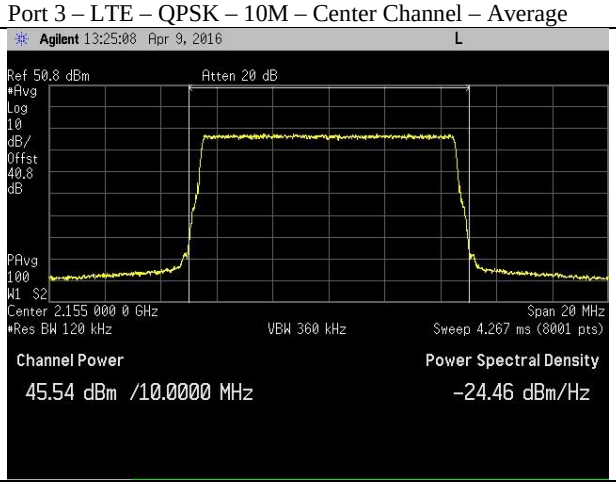
Port 2 – LTE – 64QAM – 10M – Center Channel – Average



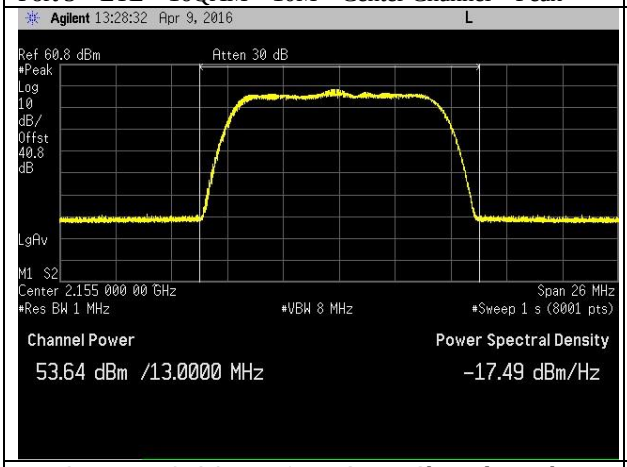
Port 3 – LTE – QPSK – 10M – Center Channel – Peak



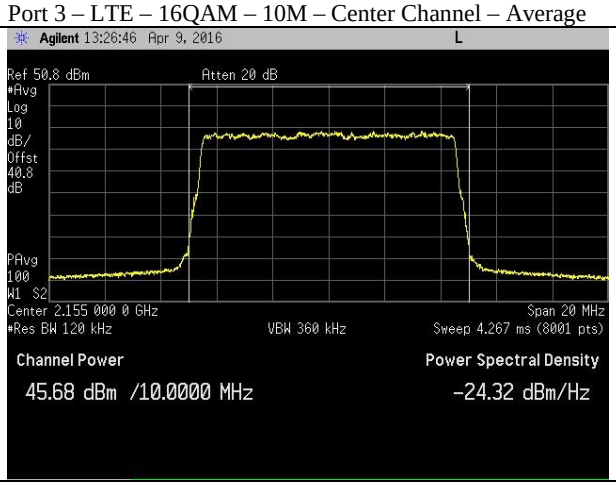
Port 3 – LTE – QPSK – 10M – Center Channel – Average



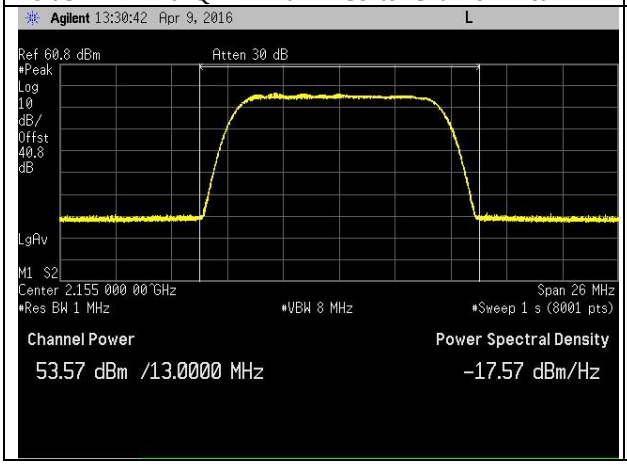
Port 3 – LTE – 16QAM – 10M – Center Channel – Peak



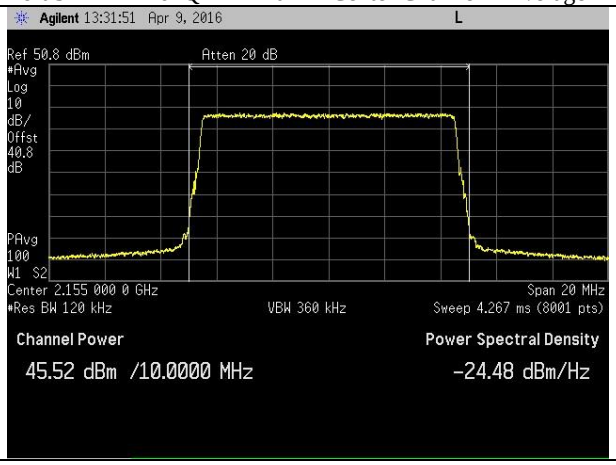
Port 3 – LTE – 16QAM – 10M – Center Channel – Average



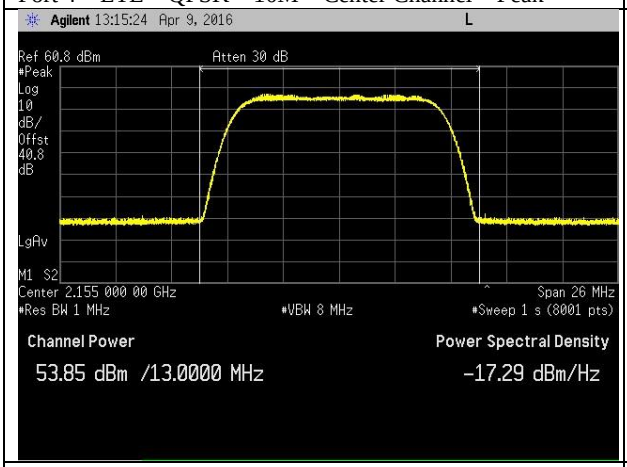
Port 3 – LTE – 64QAM – 10M – Center Channel – Peak



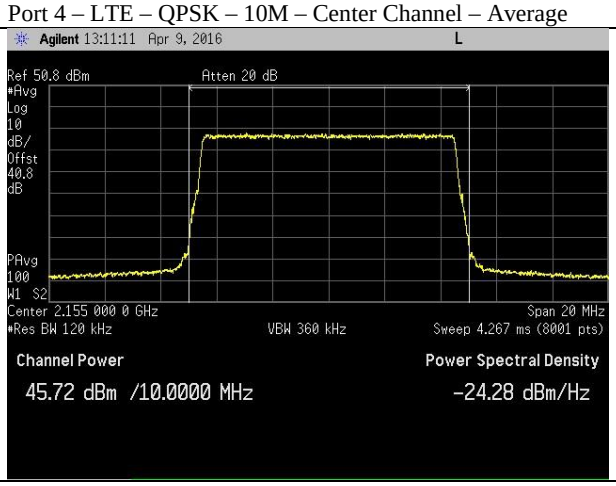
Port 3 – LTE – 64QAM – 10M – Center Channel – Average



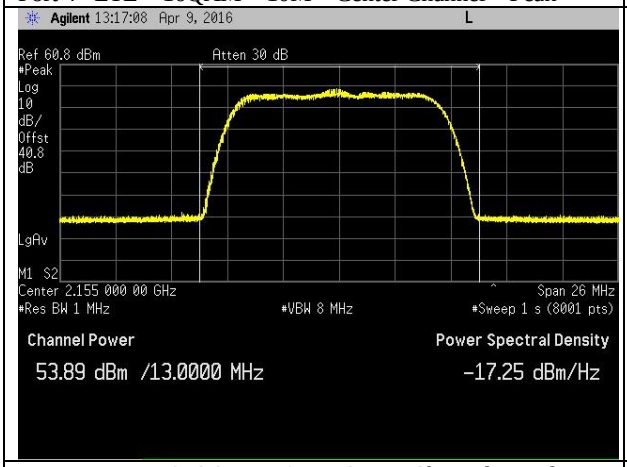
Port 4 – LTE – QPSK – 10M – Center Channel – Peak



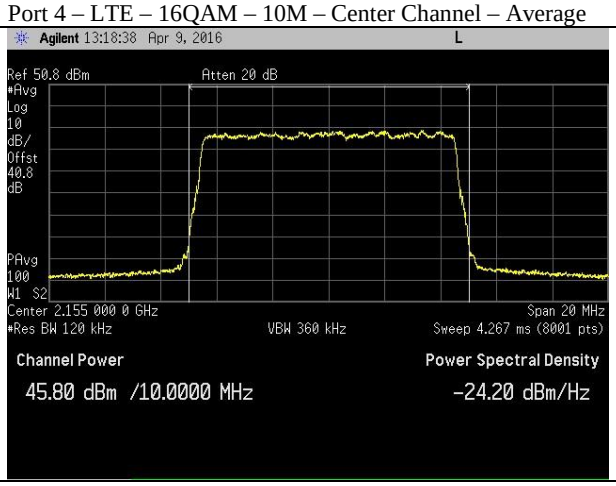
Port 4 – LTE – QPSK – 10M – Center Channel – Average



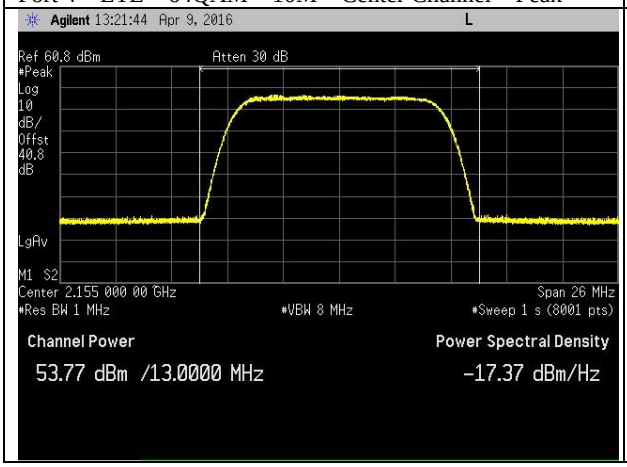
Port 4– LTE – 16QAM – 10M – Center Channel – Peak



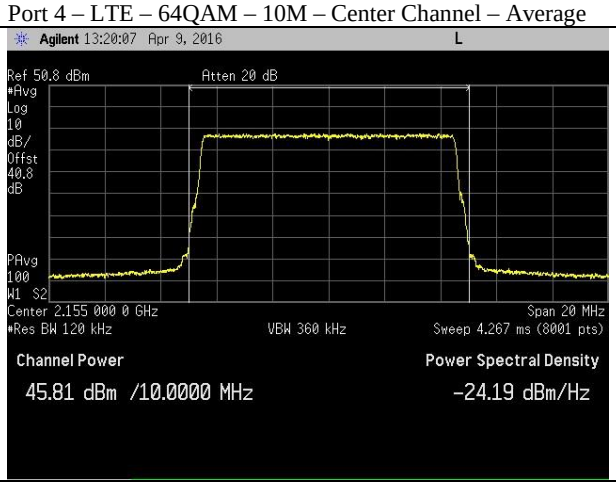
Port 4 – LTE – 16QAM – 10M – Center Channel – Average



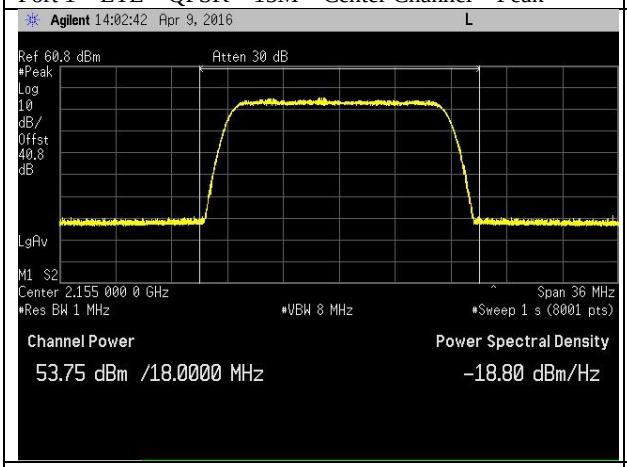
Port 4 – LTE – 64QAM – 10M – Center Channel – Peak



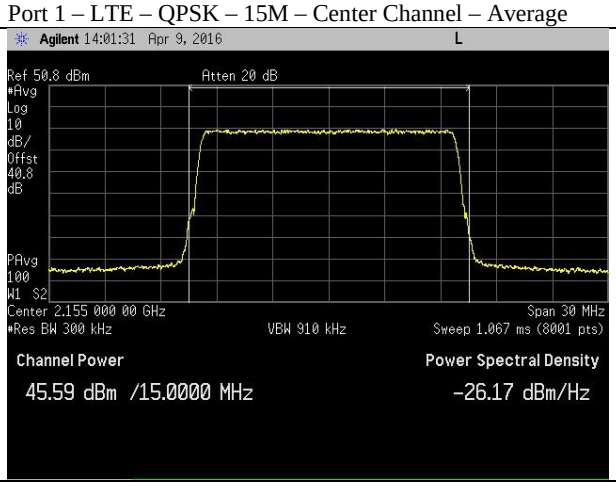
Port 4 – LTE – 64QAM – 10M – Center Channel – Average



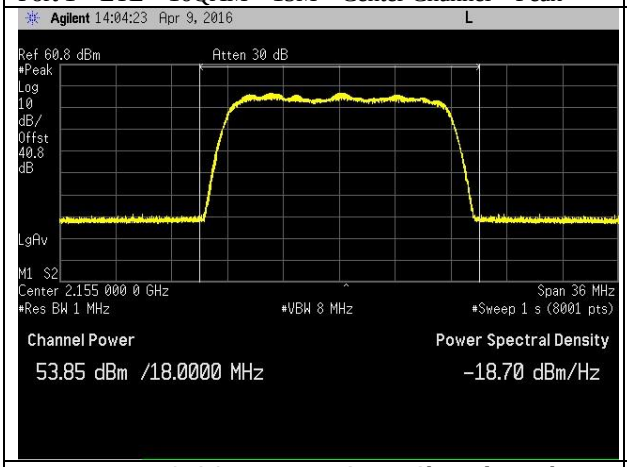
Port 1 – LTE – QPSK – 15M – Center Channel – Peak



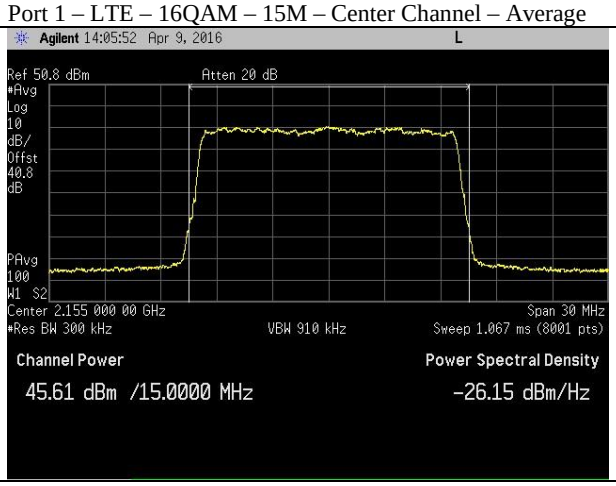
Port 1 – LTE – QPSK – 15M – Center Channel – Average



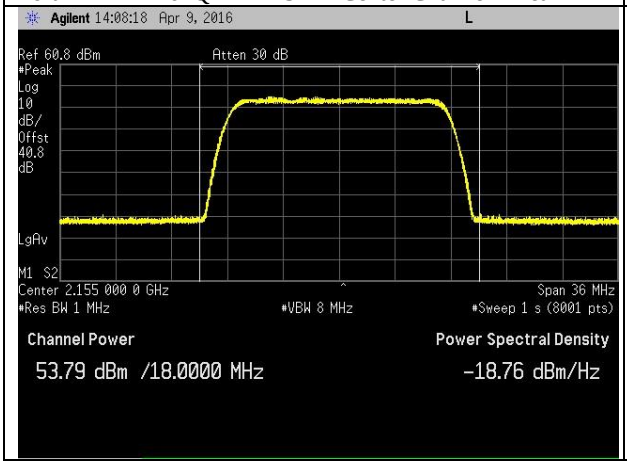
Port 1 – LTE – 16QAM – 15M – Center Channel – Peak



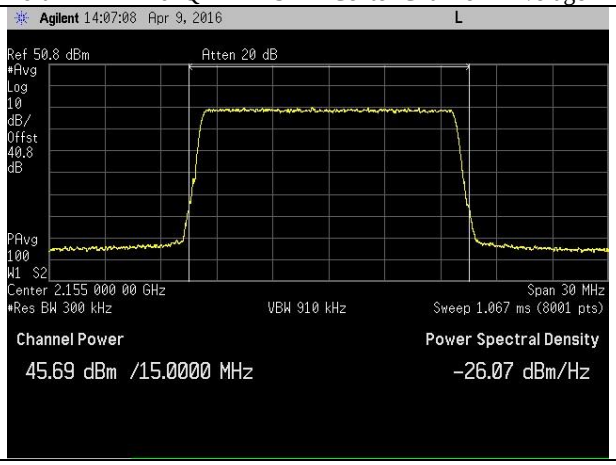
Port 1 – LTE – 16QAM – 15M – Center Channel – Average



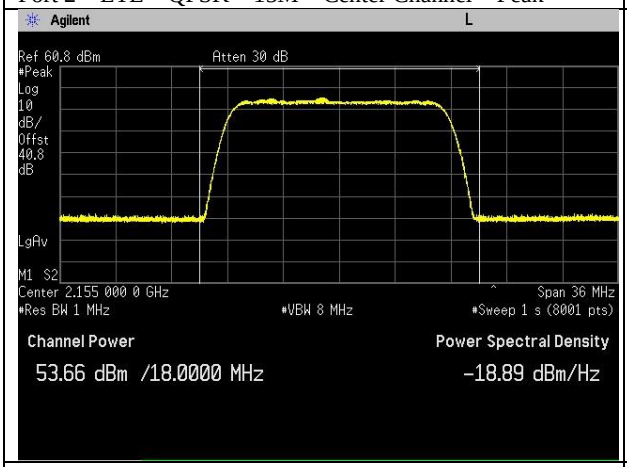
Port 1 – LTE – 64QAM – 15M – Center Channel – Peak



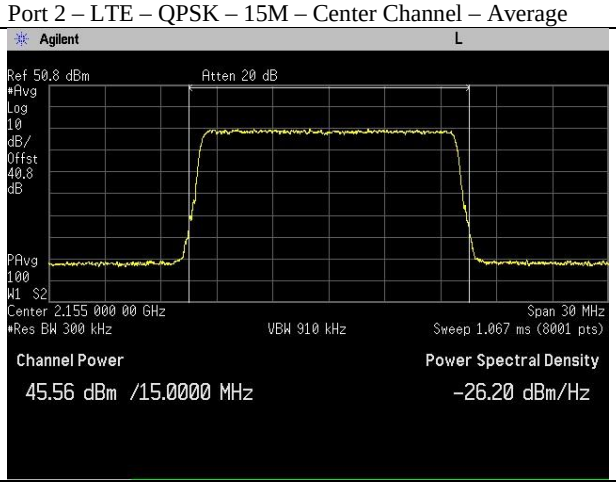
Port 1 – LTE – 64QAM – 15M – Center Channel – Average



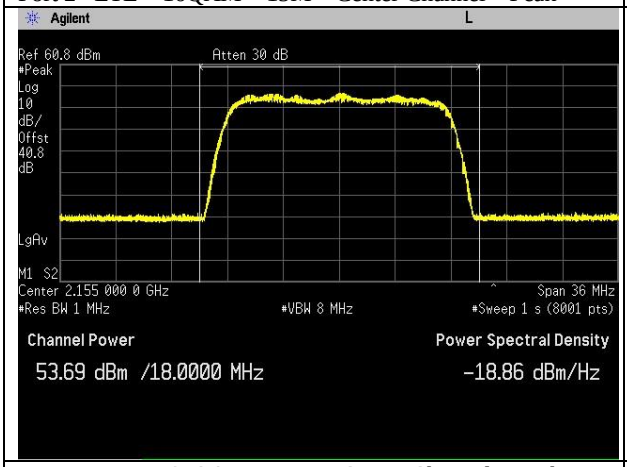
Port 2 – LTE – QPSK – 15M – Center Channel – Peak



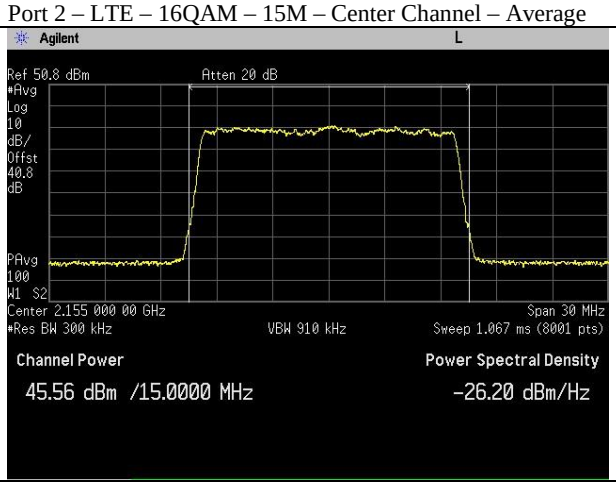
Port 2 – LTE – QPSK – 15M – Center Channel – Average



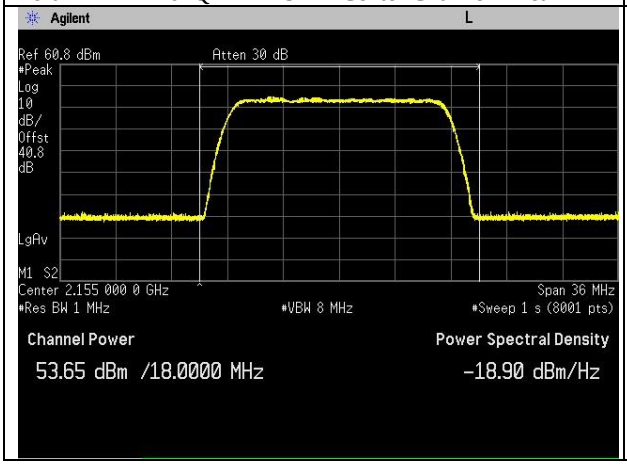
Port 2– LTE – 16QAM – 15M – Center Channel – Peak



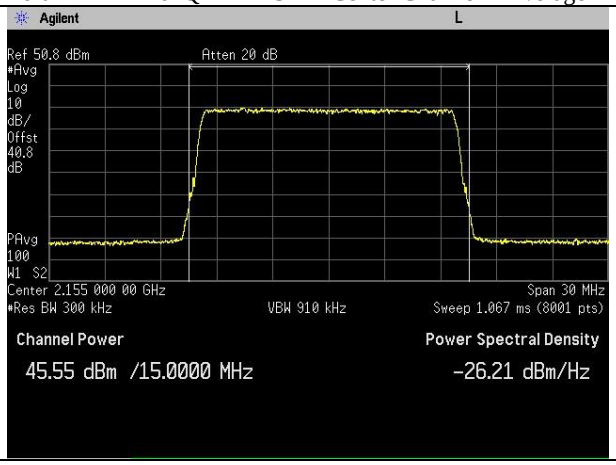
Port 2 – LTE – 16QAM – 15M – Center Channel – Average



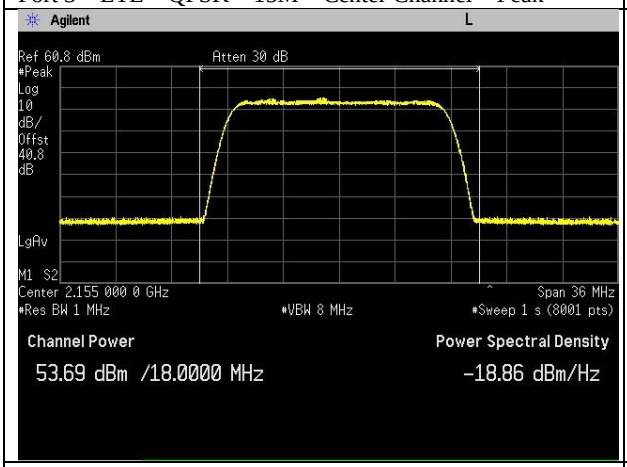
Port 2 – LTE – 64QAM – 15M – Center Channel – Peak



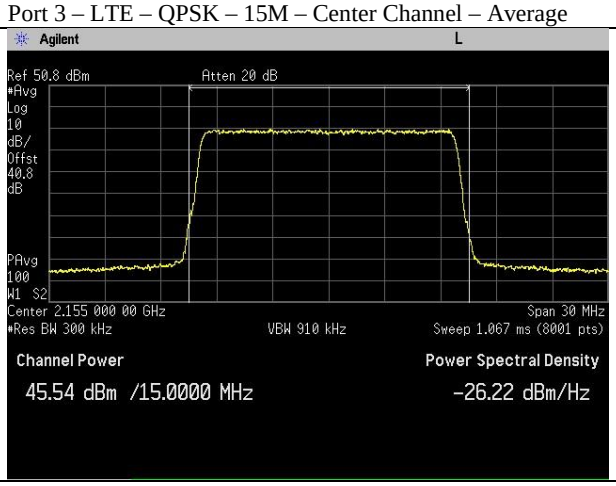
Port 2 – LTE – 64QAM – 15M – Center Channel – Average



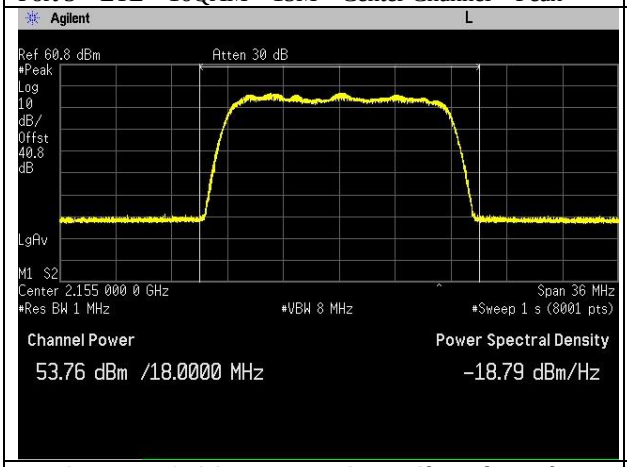
Port 3 – LTE – QPSK – 15M – Center Channel – Peak



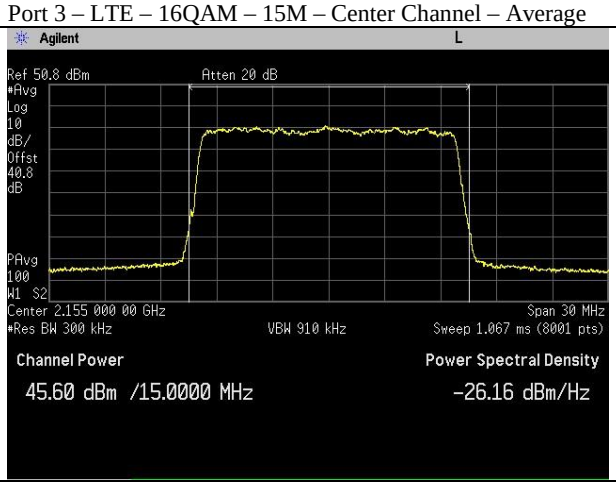
Port 3 – LTE – QPSK – 15M – Center Channel – Average



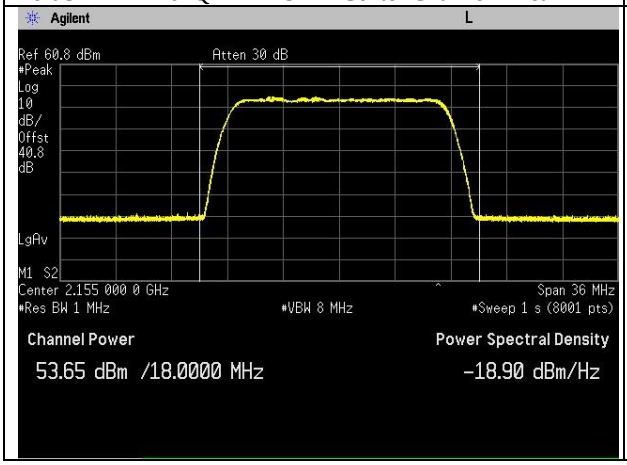
Port 3 – LTE – 16QAM – 15M – Center Channel – Peak



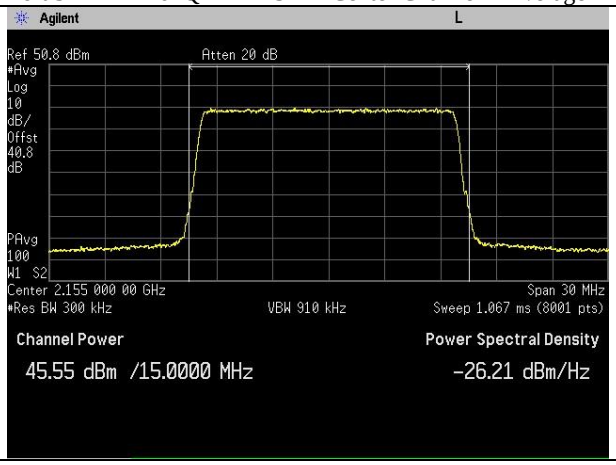
Port 3 – LTE – 16QAM – 15M – Center Channel – Average



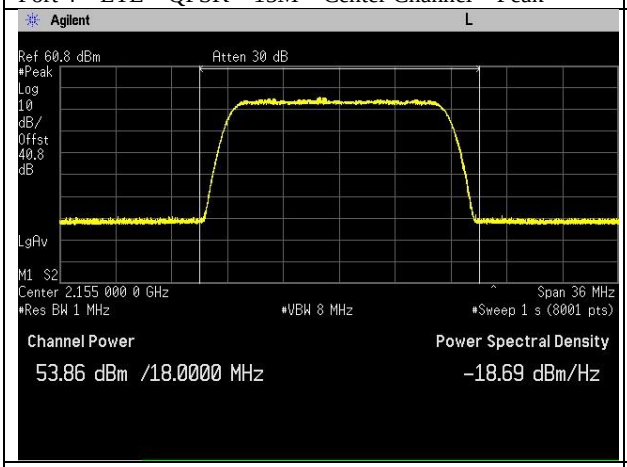
Port 3 – LTE – 64QAM – 15M – Center Channel – Peak



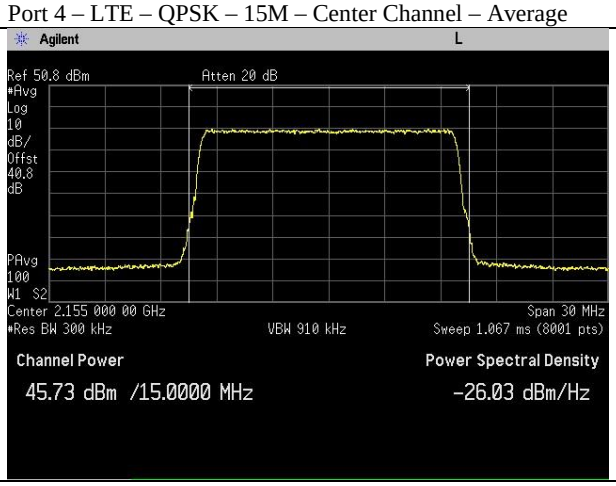
Port 3 – LTE – 64QAM – 15M – Center Channel – Average



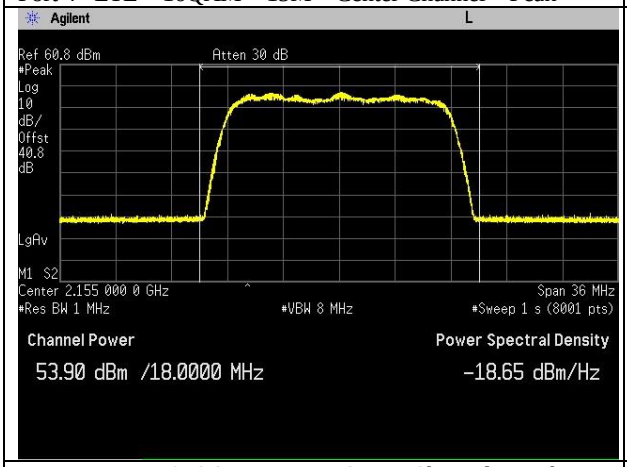
Port 4 – LTE – QPSK – 15M – Center Channel – Peak



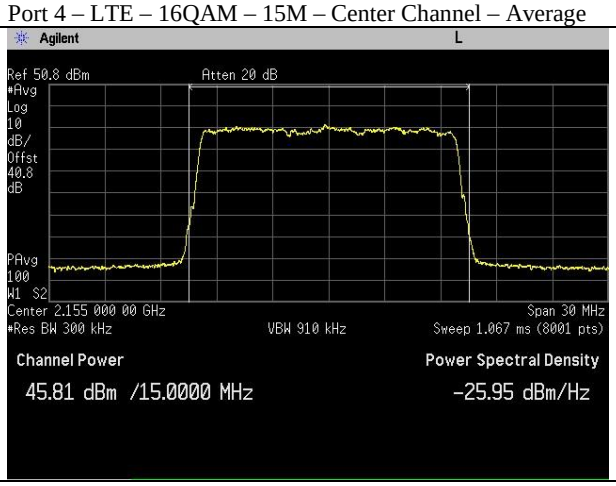
Port 4 – LTE – QPSK – 15M – Center Channel – Average



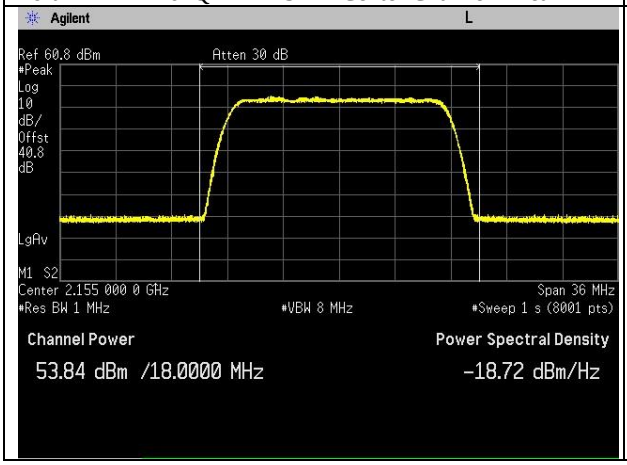
Port 4– LTE – 16QAM – 15M – Center Channel – Peak



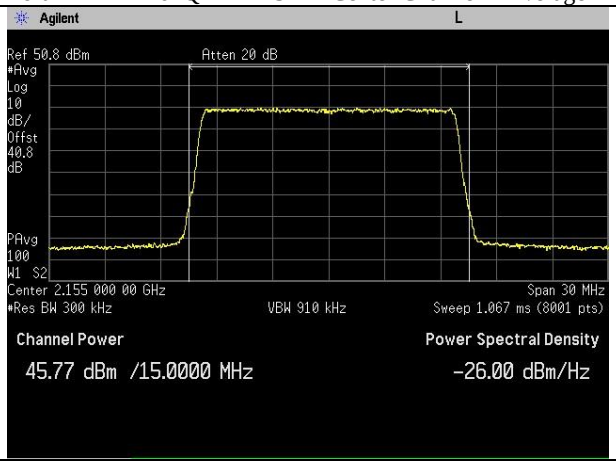
Port 4 – LTE – 16QAM – 15M – Center Channel – Average



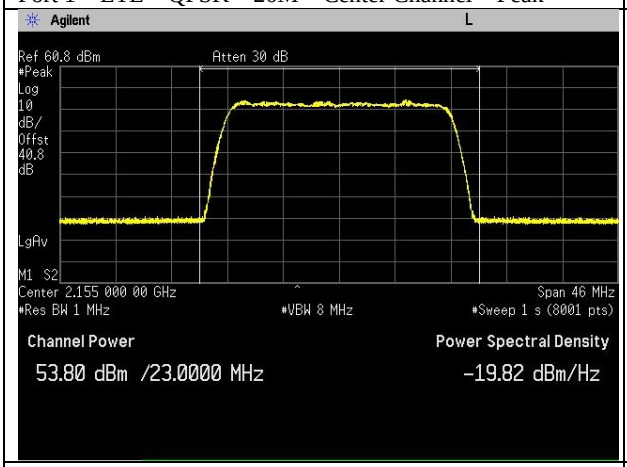
Port 4 – LTE – 64QAM – 15M – Center Channel – Peak



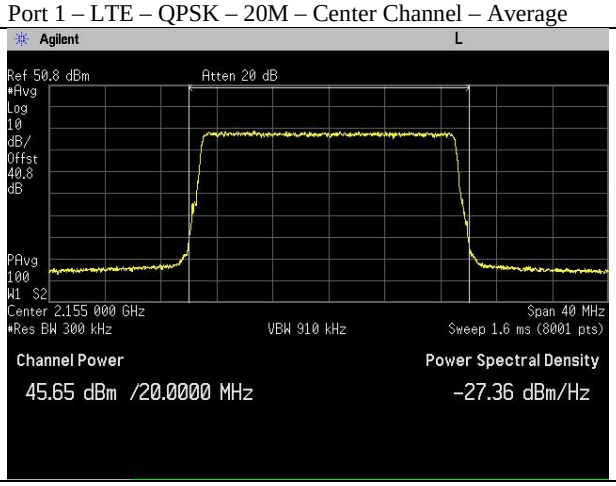
Port 4 – LTE – 64QAM – 15M – Center Channel – Average



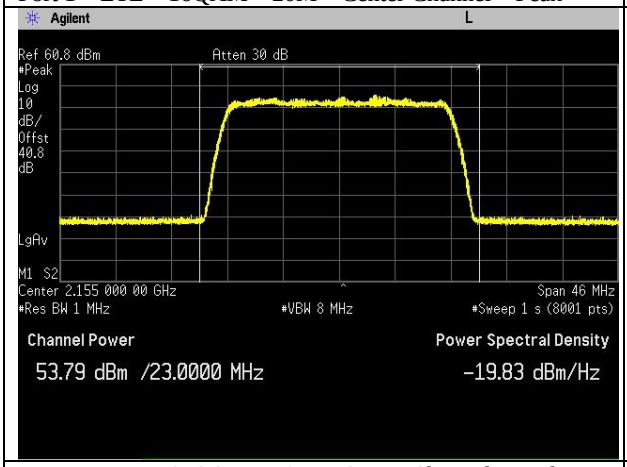
Port 1 – LTE – QPSK – 20M – Center Channel – Peak



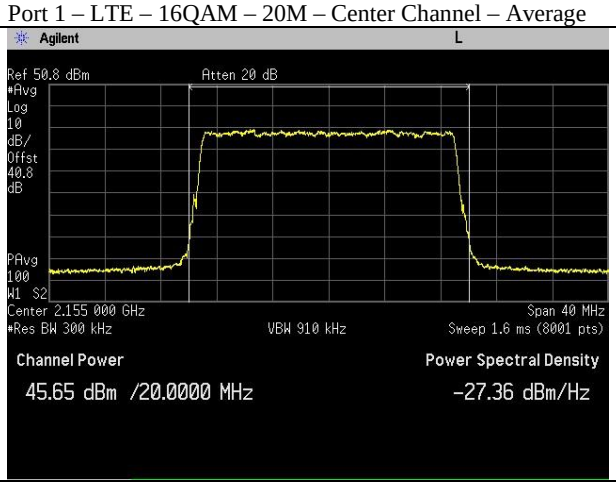
Port 1 – LTE – QPSK – 20M – Center Channel – Average



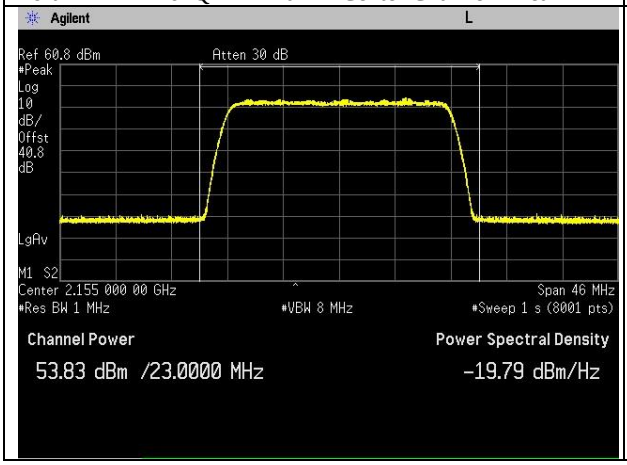
Port 1 – LTE – 16QAM – 20M – Center Channel – Peak



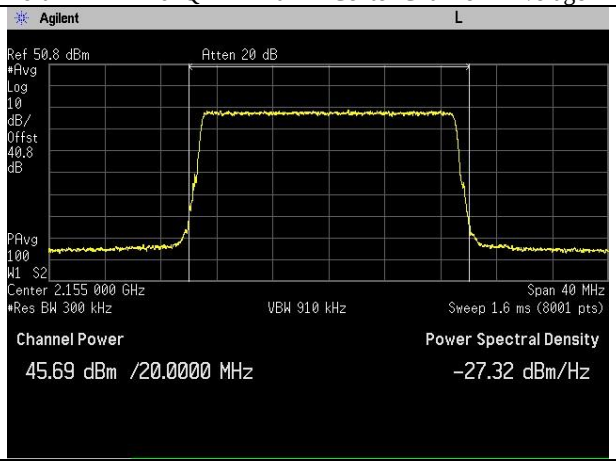
Port 1 – LTE – 16QAM – 20M – Center Channel – Average



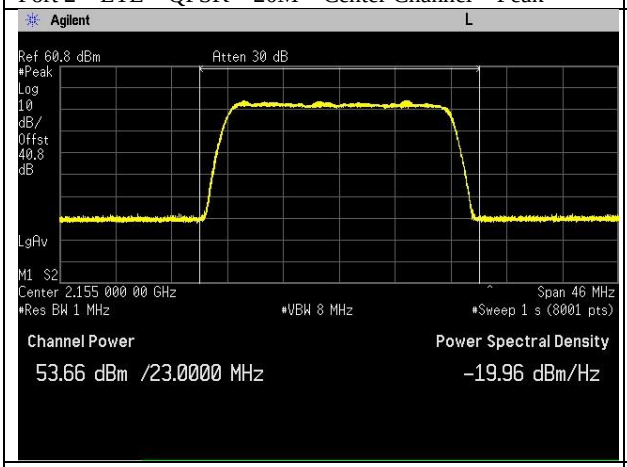
Port 1 – LTE – 64QAM – 20M – Center Channel – Peak



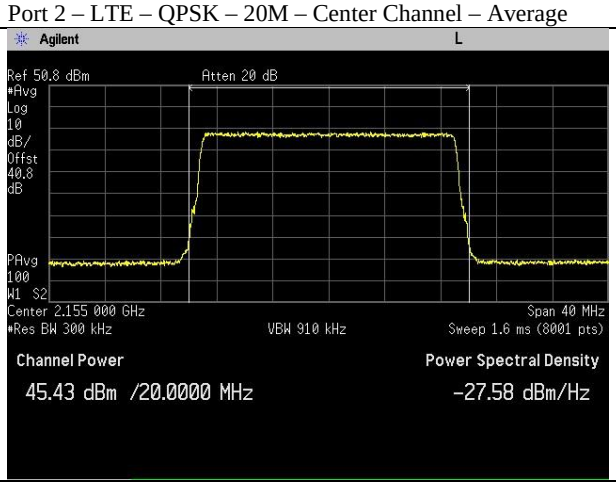
Port 1 – LTE – 64QAM – 20M – Center Channel – Average



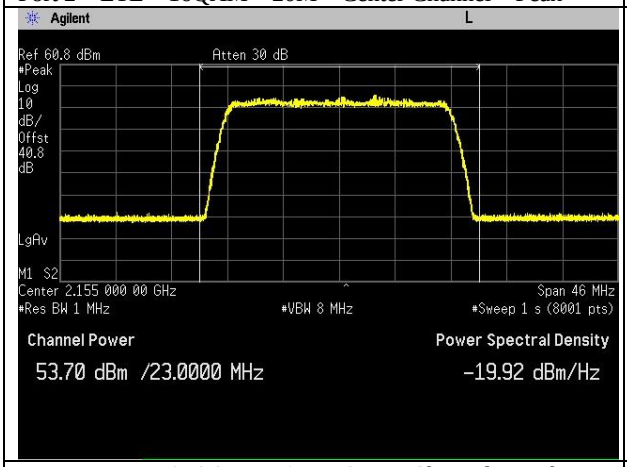
Port 2 – LTE – QPSK – 20M – Center Channel – Peak



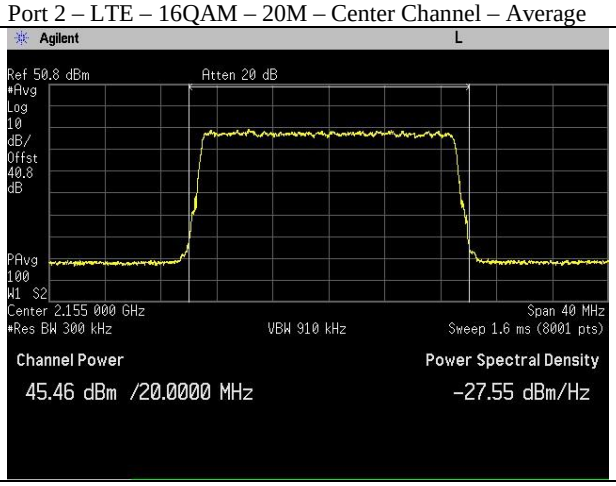
Port 2 – LTE – QPSK – 20M – Center Channel – Average



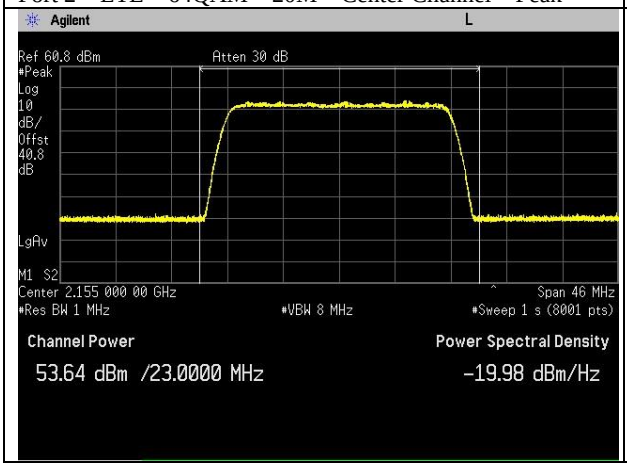
Port 2 – LTE – 16QAM – 20M – Center Channel – Peak



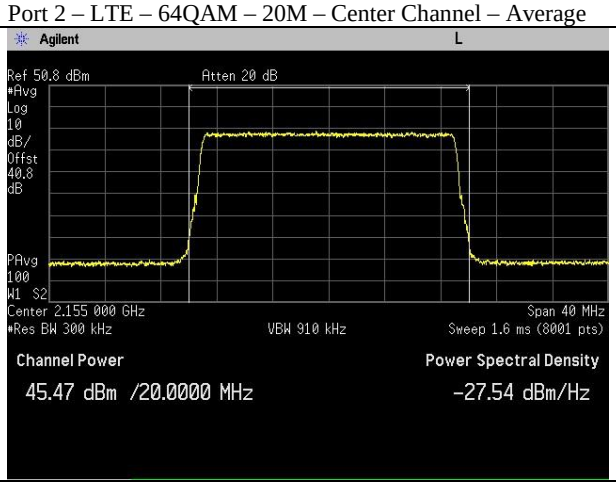
Port 2 – LTE – 16QAM – 20M – Center Channel – Average



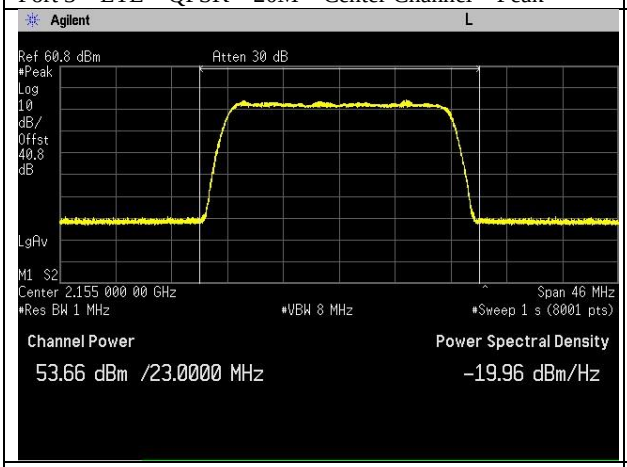
Port 2 – LTE – 64QAM – 20M – Center Channel – Peak



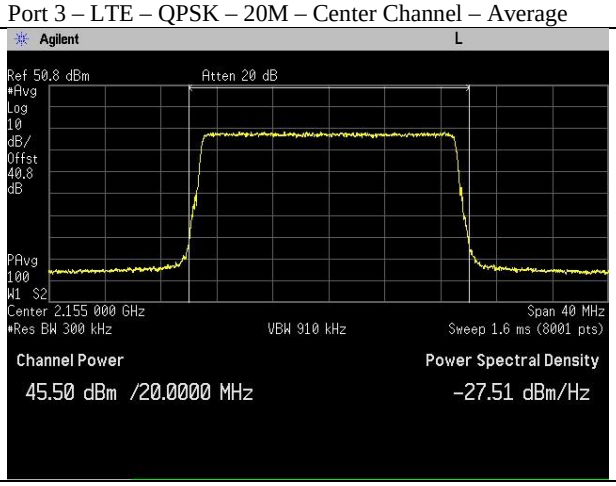
Port 2 – LTE – 64QAM – 20M – Center Channel – Average



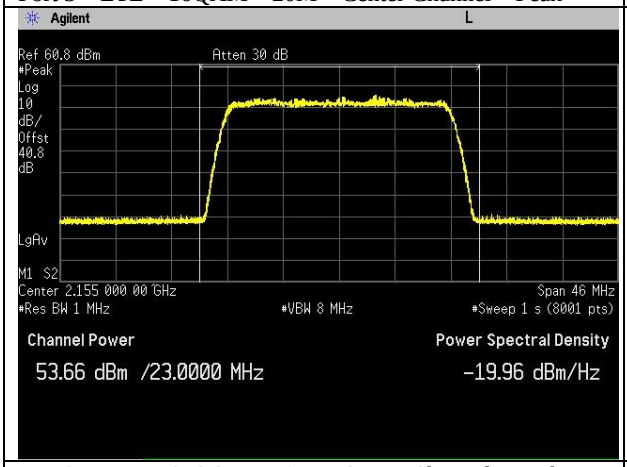
Port 3 – LTE – QPSK – 20M – Center Channel – Peak



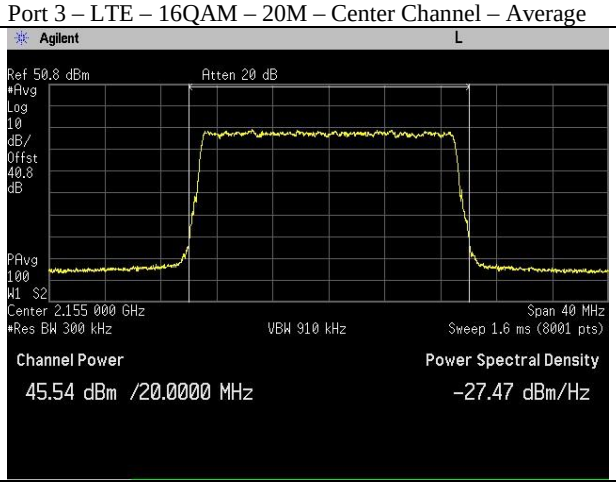
Port 3 – LTE – QPSK – 20M – Center Channel – Average



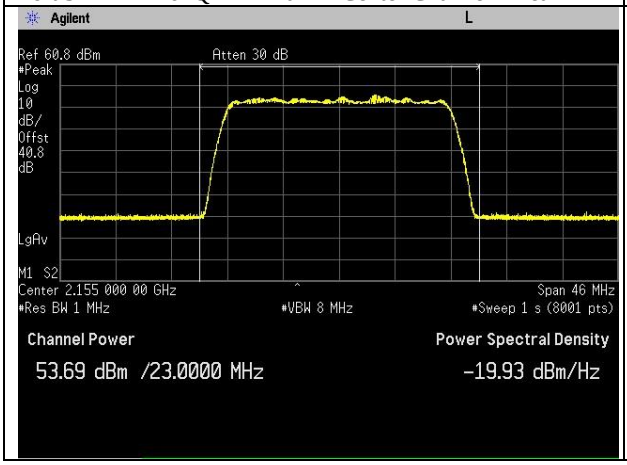
Port 3 – LTE – 16QAM – 20M – Center Channel – Peak



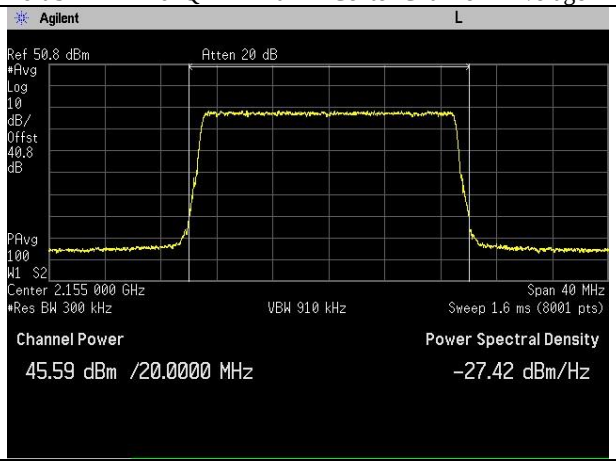
Port 3 – LTE – 16QAM – 20M – Center Channel – Average



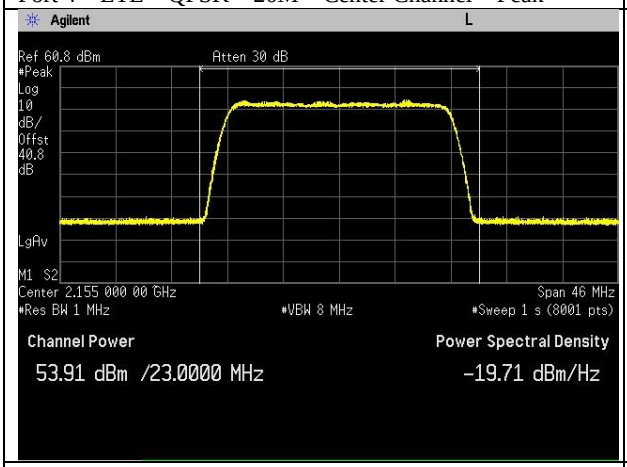
Port 3 – LTE – 64QAM – 20M – Center Channel – Peak



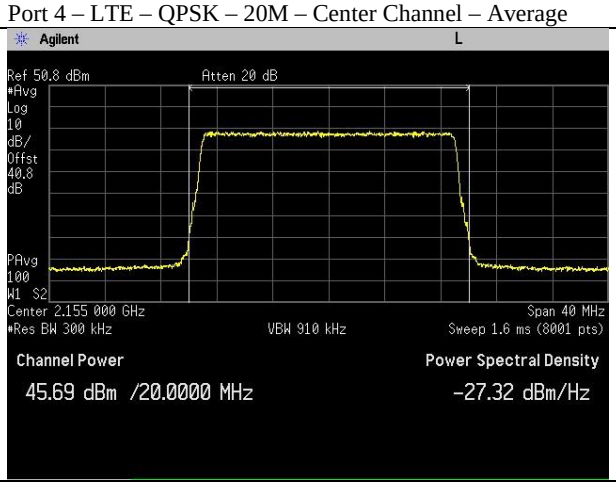
Port 3 – LTE – 64QAM – 20M – Center Channel – Average



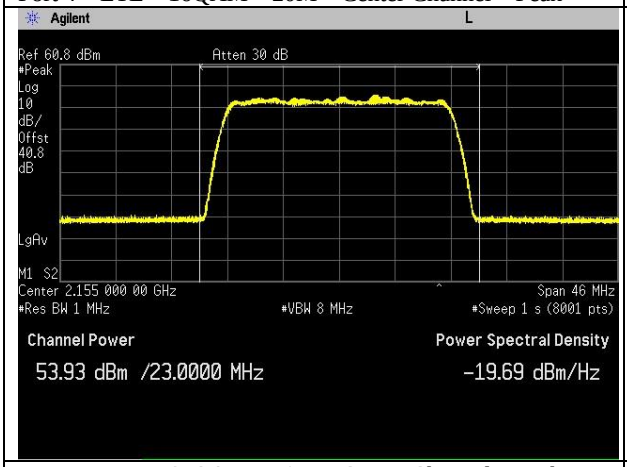
Port 4 – LTE – QPSK – 20M – Center Channel – Peak



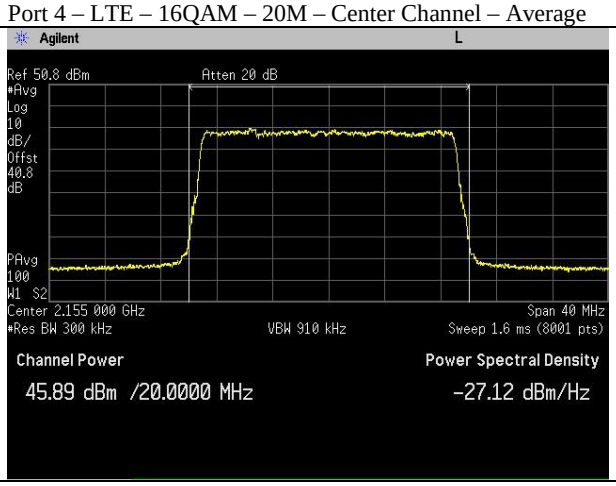
Port 4 – LTE – QPSK – 20M – Center Channel – Average



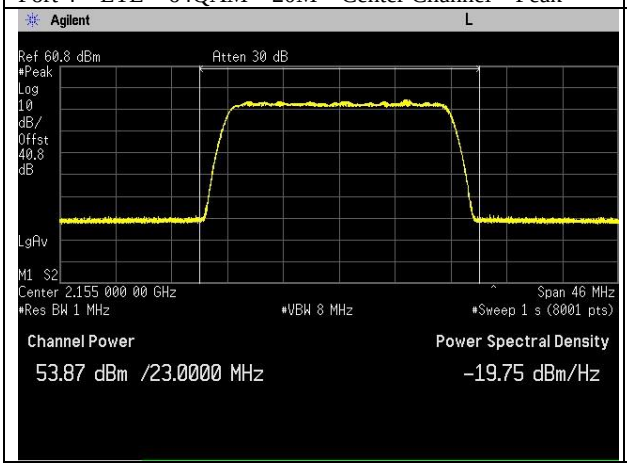
Port 4 – LTE – 16QAM – 20M – Center Channel – Peak



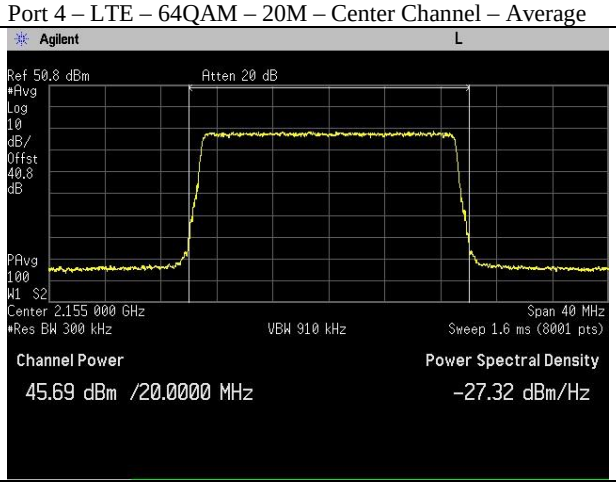
Port 4 – LTE – 16QAM – 20M – Center Channel – Average



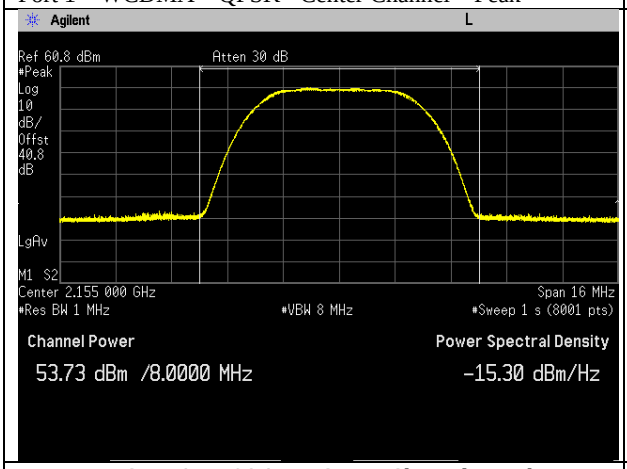
Port 4 – LTE – 64QAM – 20M – Center Channel – Peak



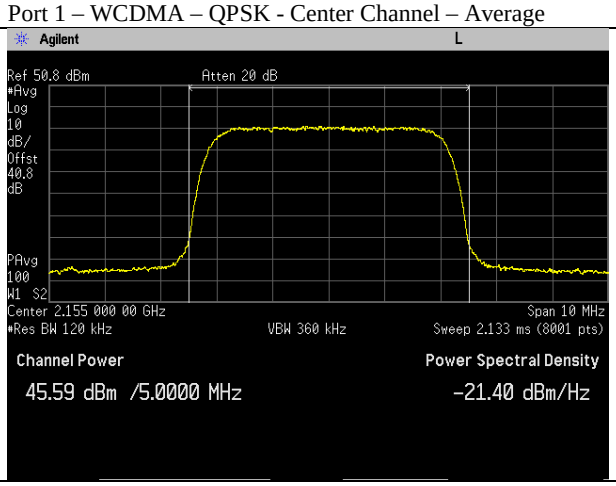
Port 4 – LTE – 64QAM – 20M – Center Channel – Average



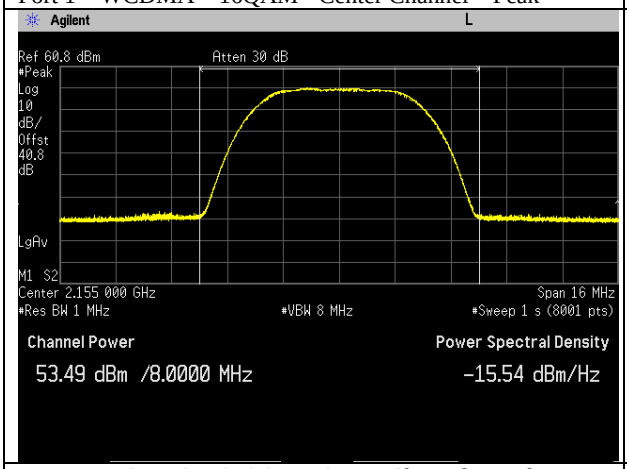
Port 1 – WCDMA – QPSK - Center Channel – Peak



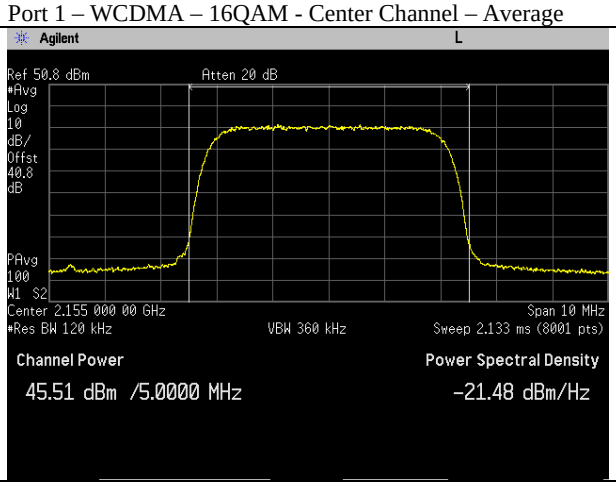
Port 1 – WCDMA – QPSK - Center Channel – Average



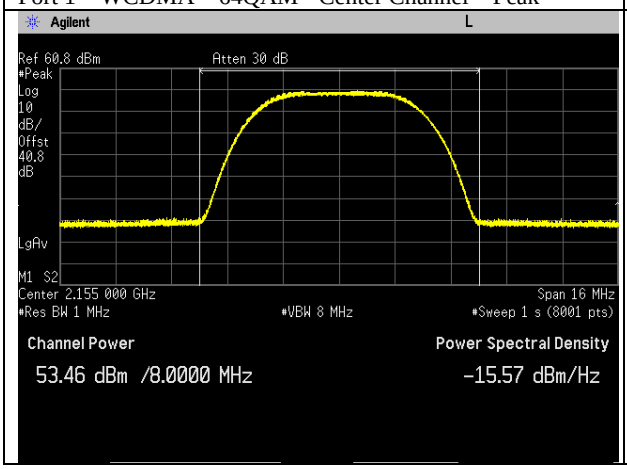
Port 1 – WCDMA – 16QAM - Center Channel – Peak



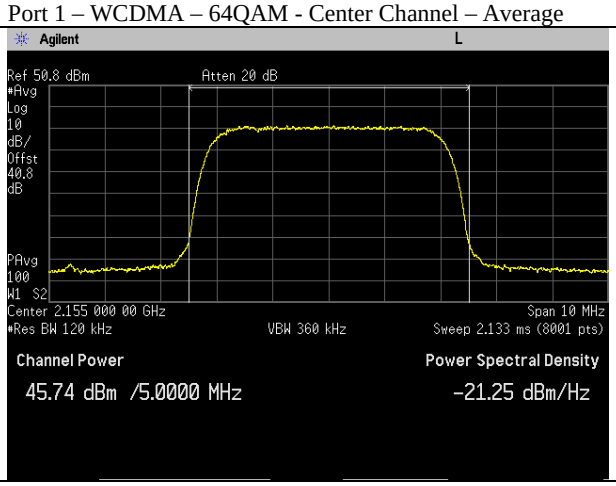
Port 1 – WCDMA – 16QAM - Center Channel – Average



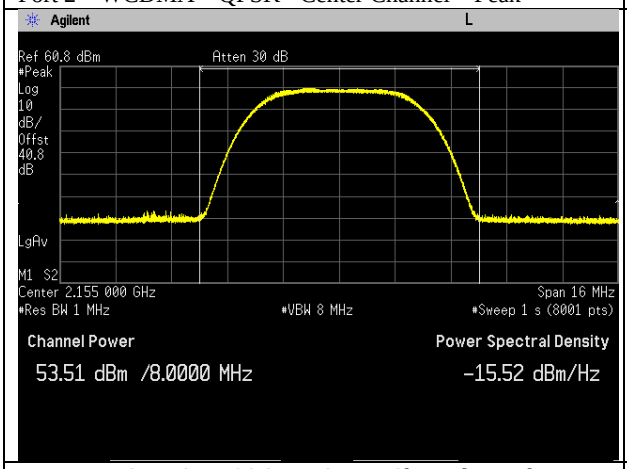
Port 1 – WCDMA – 64QAM - Center Channel – Peak



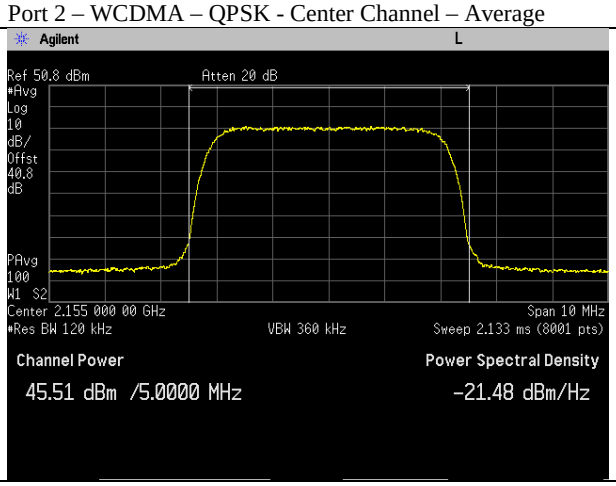
Port 1 – WCDMA – 64QAM - Center Channel – Average



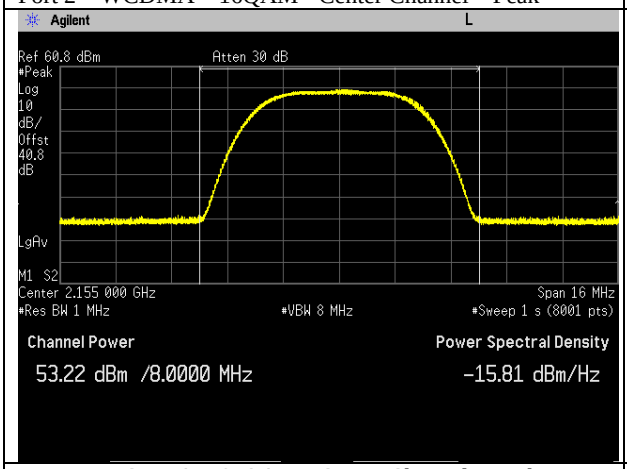
Port 2 – WCDMA – QPSK - Center Channel – Peak



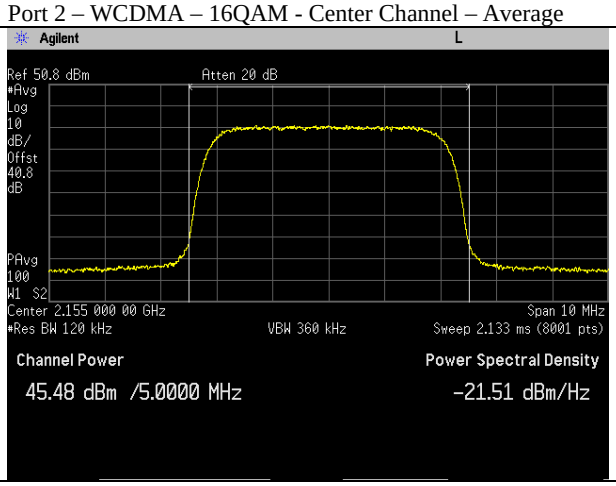
Port 2 – WCDMA – QPSK - Center Channel – Average



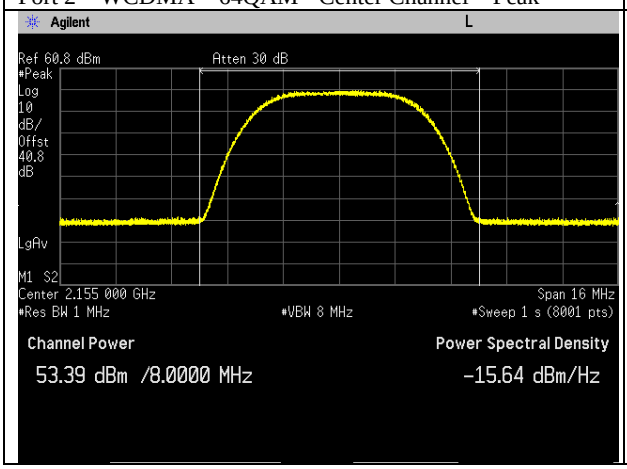
Port 2 – WCDMA – 16QAM - Center Channel – Peak



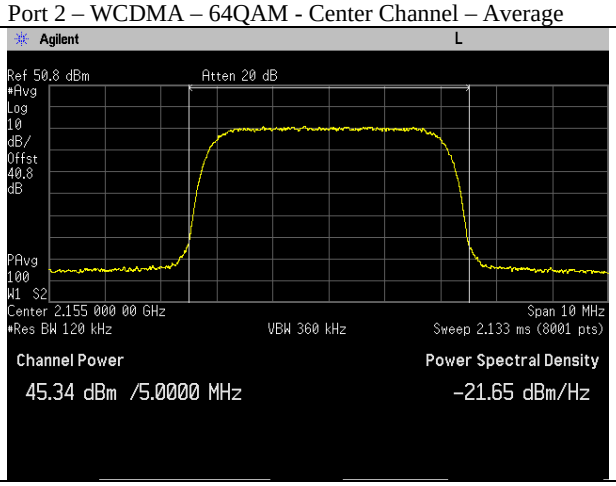
Port 2 – WCDMA – 16QAM - Center Channel – Average



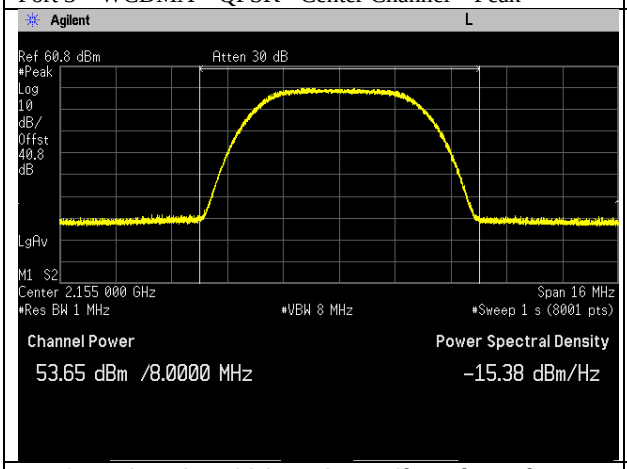
Port 2 – WCDMA – 64QAM - Center Channel – Peak



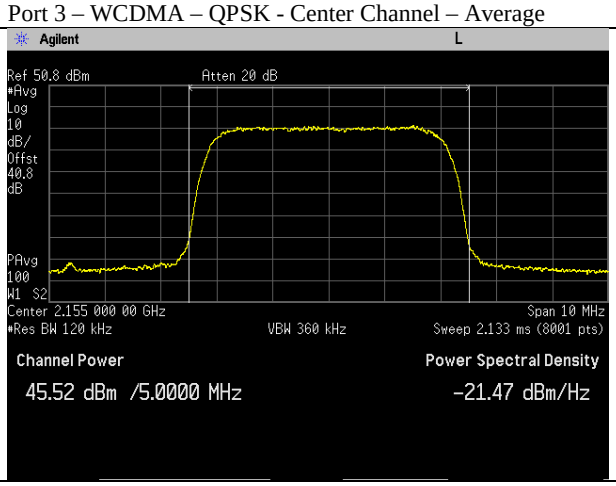
Port 2 – WCDMA – 64QAM - Center Channel – Average



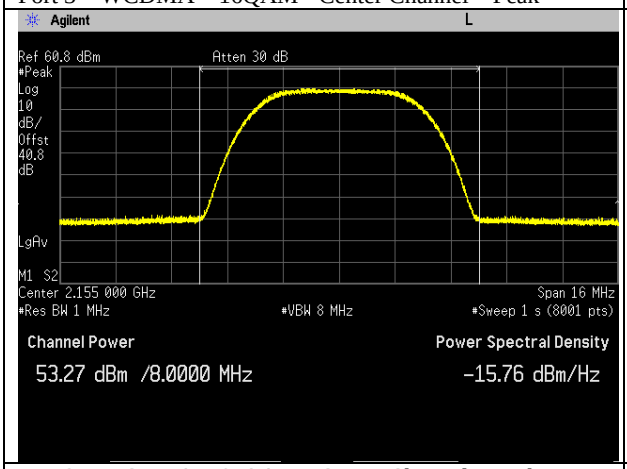
Port 3 – WCDMA – QPSK - Center Channel – Peak



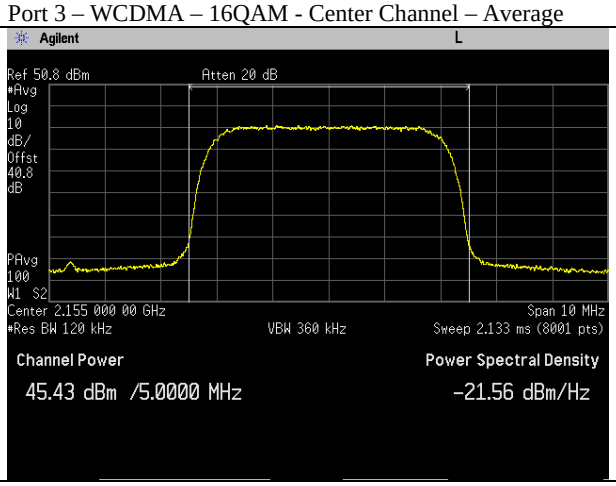
Port 3 – WCDMA – QPSK - Center Channel – Average



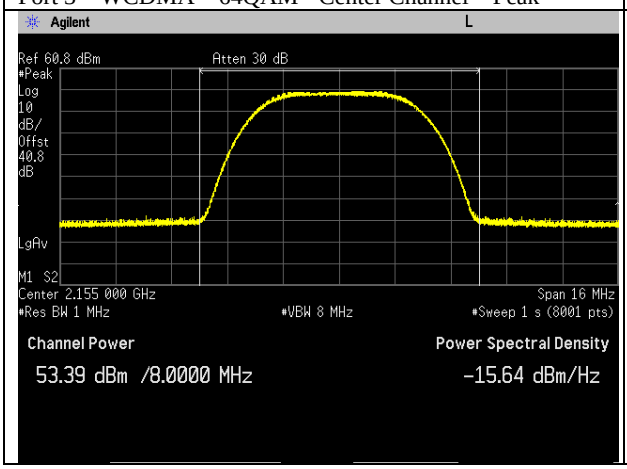
Port 3 – WCDMA – 16QAM - Center Channel – Peak



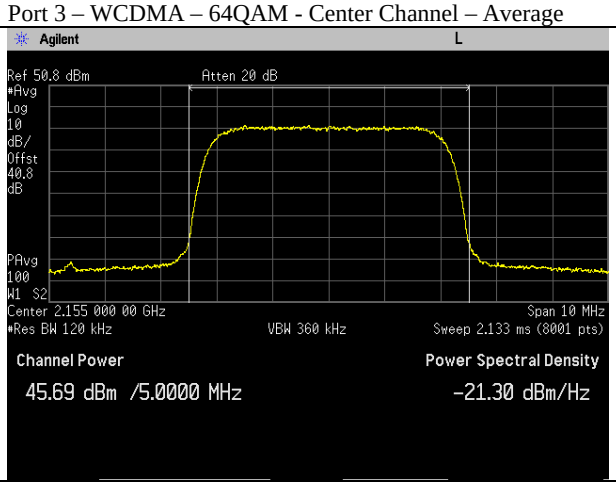
Port 3 – WCDMA – 16QAM - Center Channel – Average



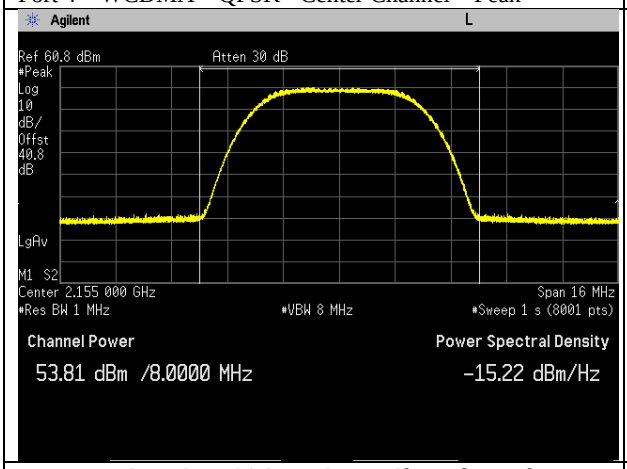
Port 3 – WCDMA – 64QAM - Center Channel – Peak



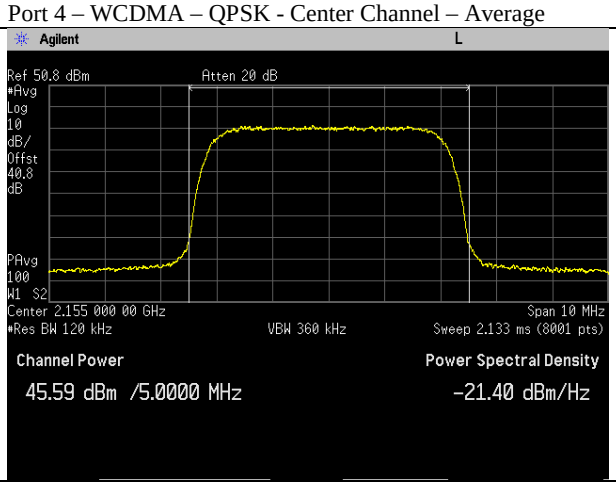
Port 3 – WCDMA – 64QAM - Center Channel – Average



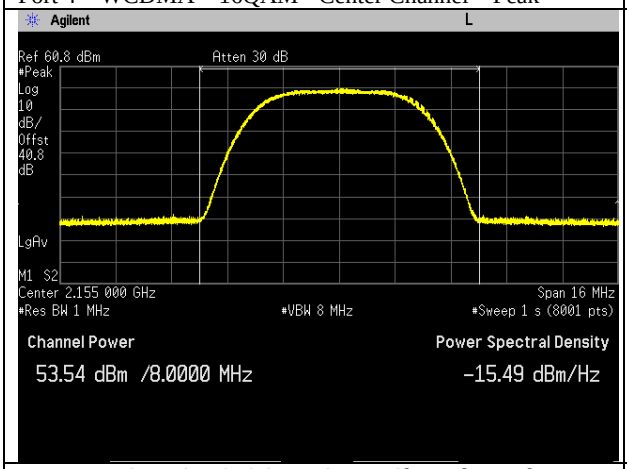
Port 4 – WCDMA – QPSK - Center Channel – Peak



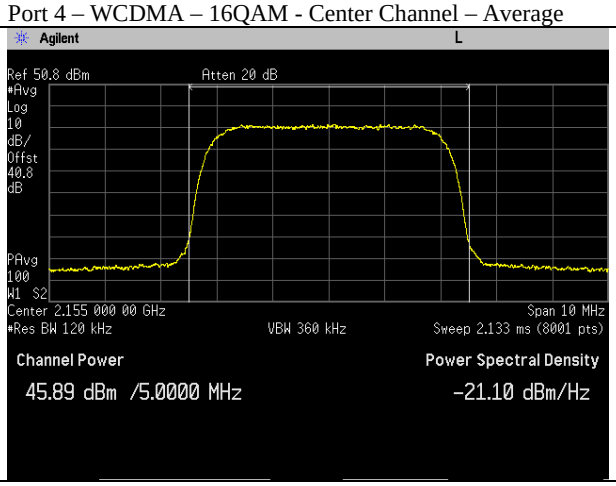
Port 4 – WCDMA – QPSK - Center Channel – Average



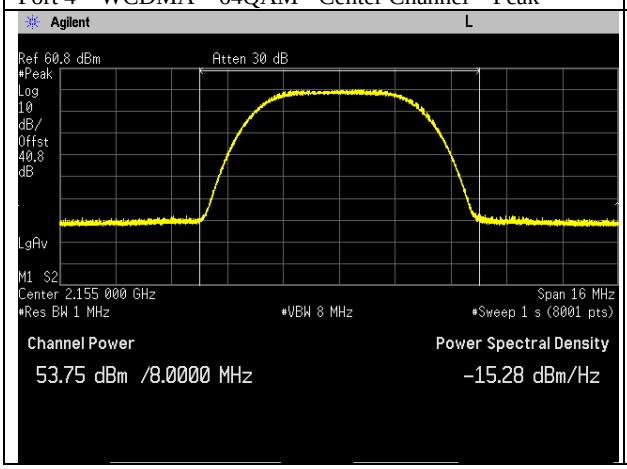
Port 4 – WCDMA – 16QAM - Center Channel – Peak



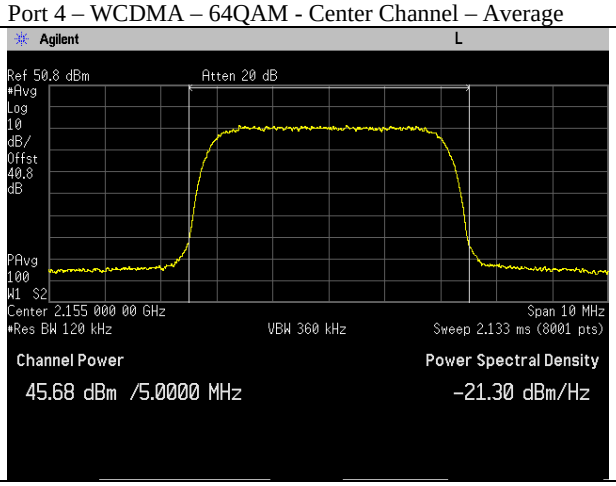
Port 4 – WCDMA – 16QAM - Center Channel – Average



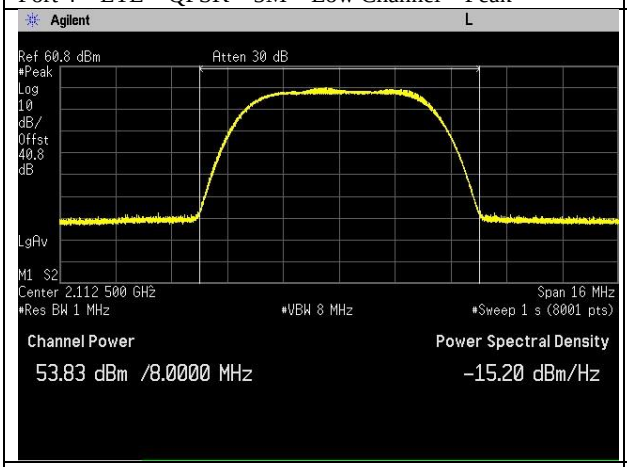
Port 4 – WCDMA – 64QAM - Center Channel – Peak



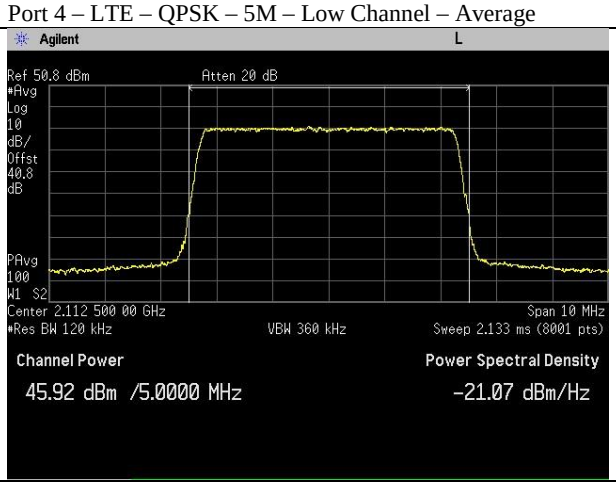
Port 4 – WCDMA – 64QAM - Center Channel – Average



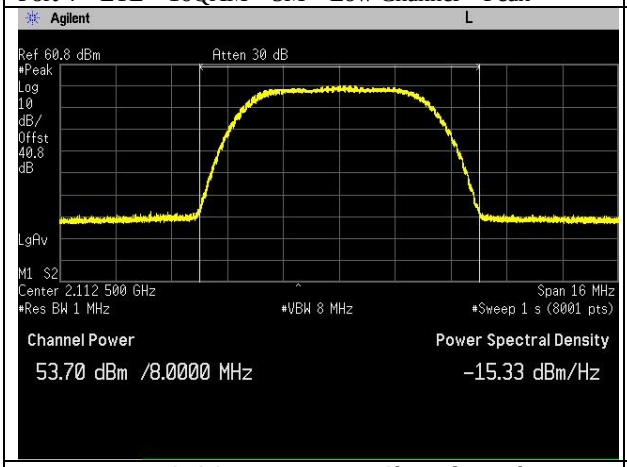
Port 4 – LTE – QPSK – 5M – Low Channel – Peak



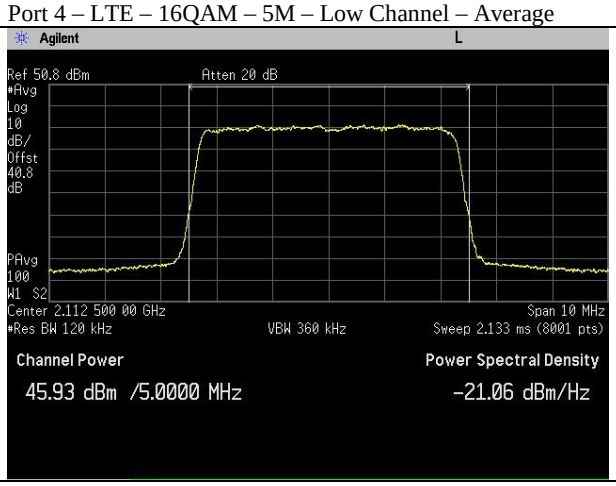
Port 4 – LTE – QPSK – 5M – Low Channel – Average



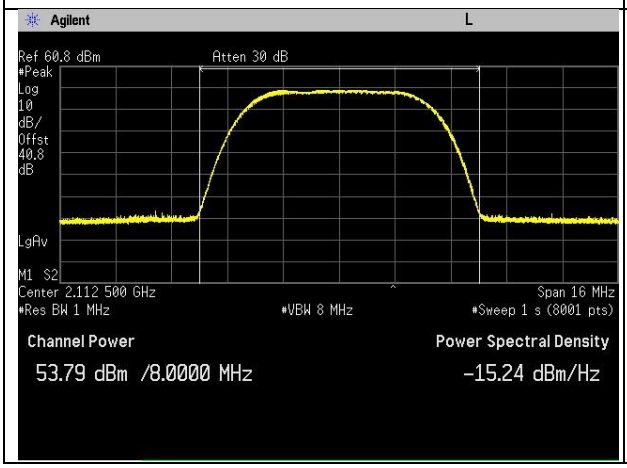
Port 4 – LTE – 16QAM – 5M – Low Channel – Peak



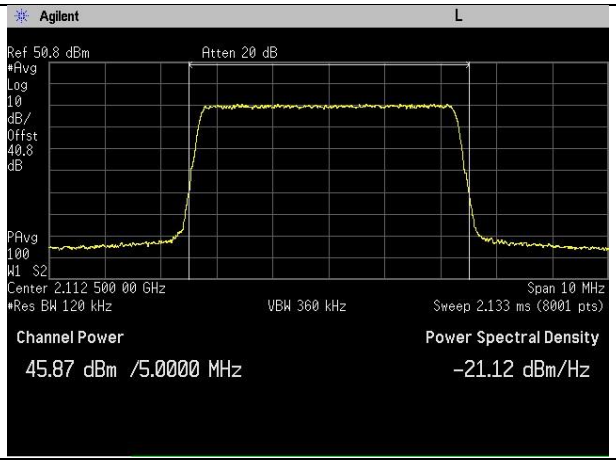
Port 4 – LTE – 16QAM – 5M – Low Channel – Average



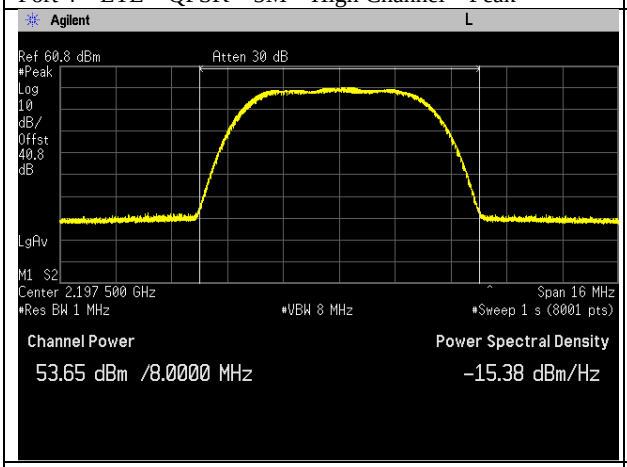
Port 4 – LTE – 64QAM – 5M – Low Channel – Peak



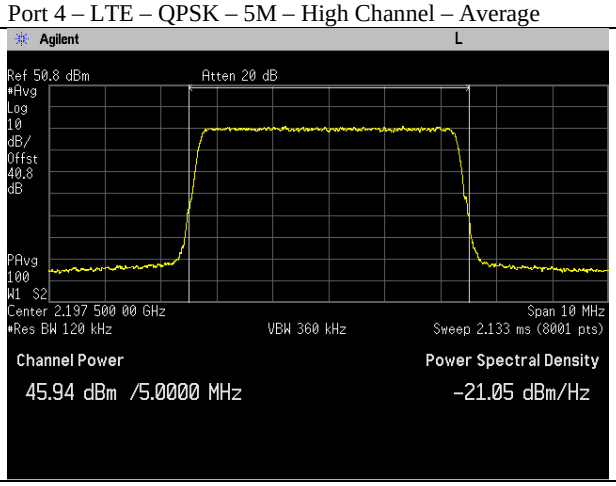
Port 4 – LTE – 64QAM – 5M – Low Channel – Average



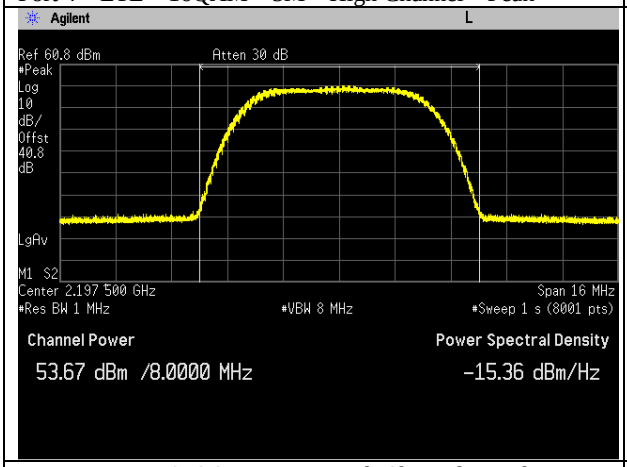
Port 4 – LTE – QPSK – 5M – High Channel – Peak



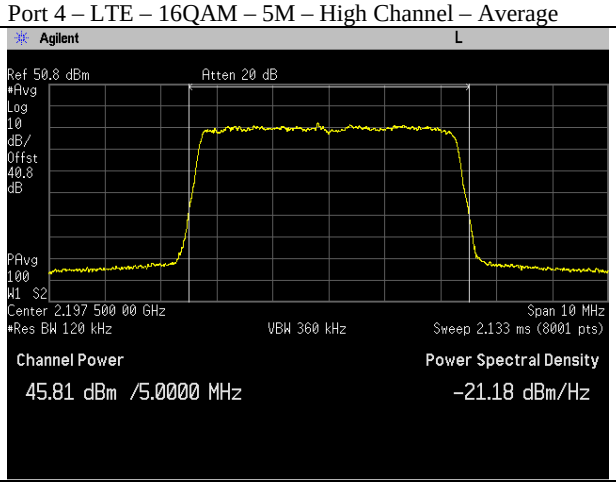
Port 4 – LTE – QPSK – 5M – High Channel – Average



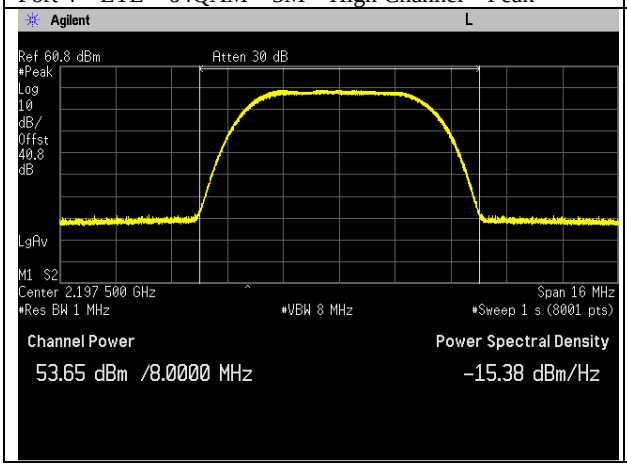
Port 4 – LTE – 16QAM – 5M – High Channel – Peak



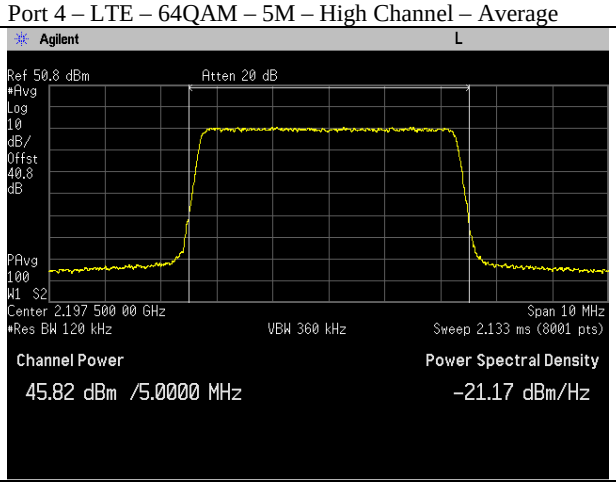
Port 4 – LTE – 16QAM – 5M – High Channel – Average



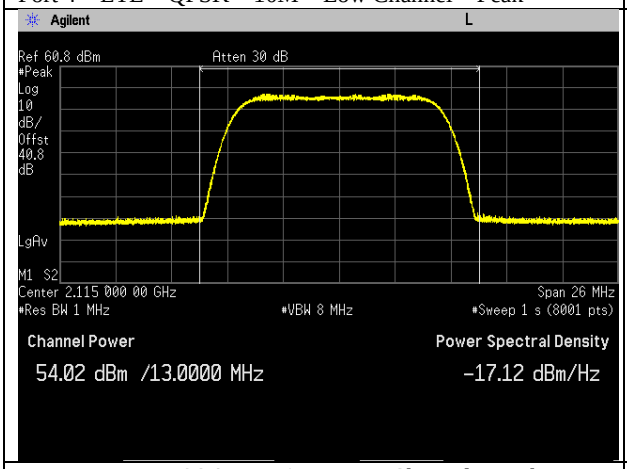
Port 4 – LTE – 64QAM – 5M – High Channel – Peak



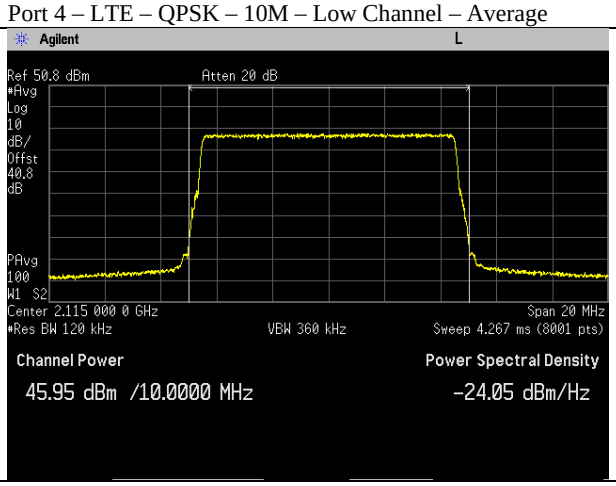
Port 4 – LTE – 64QAM – 5M – High Channel – Average



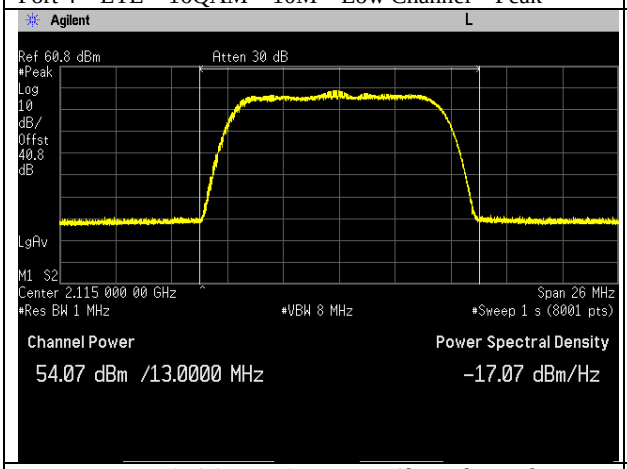
Port 4 – LTE – QPSK – 10M – Low Channel – Peak



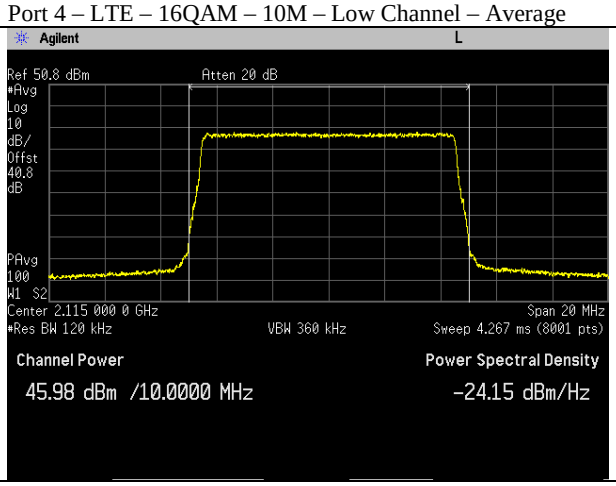
Port 4 – LTE – QPSK – 10M – Low Channel – Average



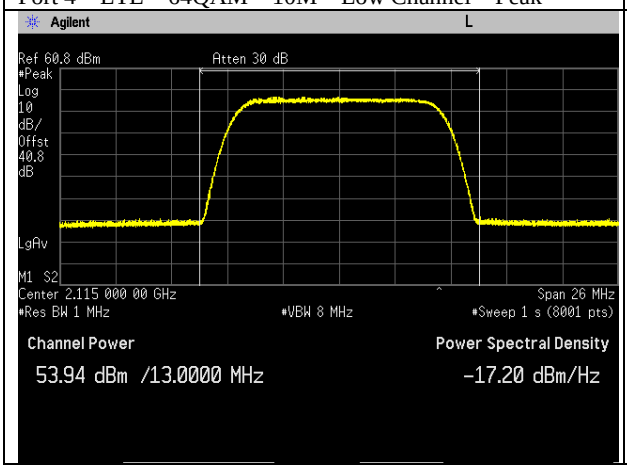
Port 4 – LTE – 16QAM – 10M – Low Channel – Peak



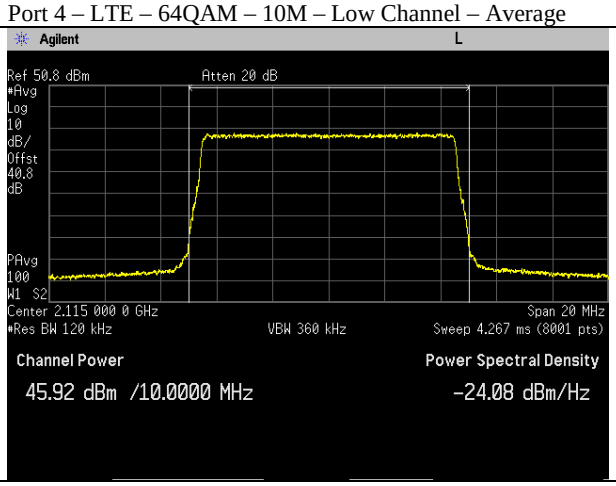
Port 4 – LTE – 16QAM – 10M – Low Channel – Average



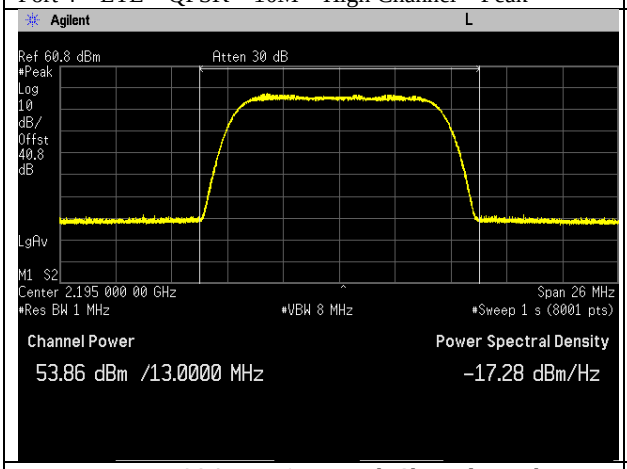
Port 4 – LTE – 64QAM – 10M – Low Channel – Peak



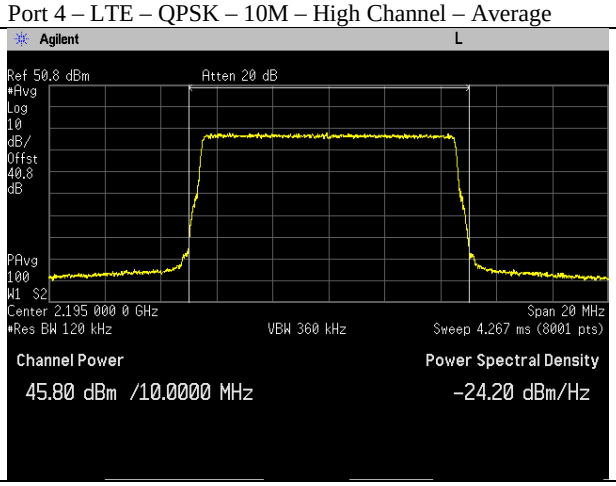
Port 4 – LTE – 64QAM – 10M – Low Channel – Average



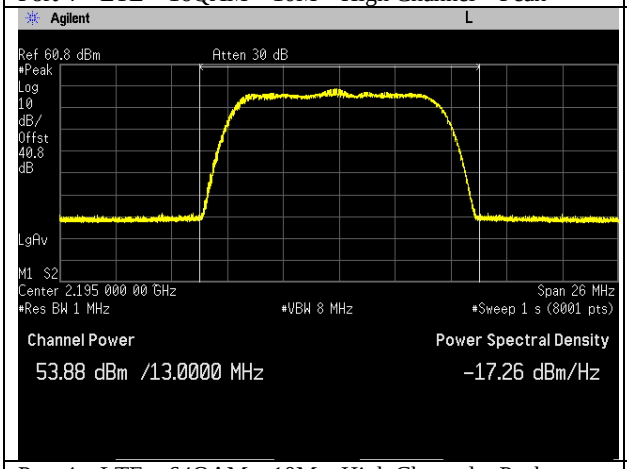
Port 4 – LTE – QPSK – 10M – High Channel – Peak



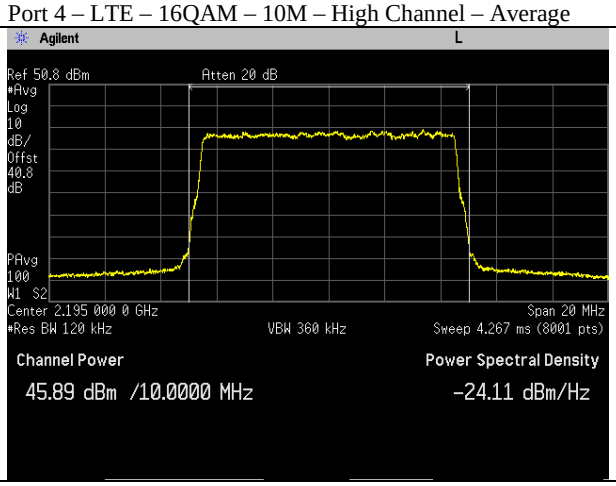
Port 4 – LTE – QPSK – 10M – High Channel – Average



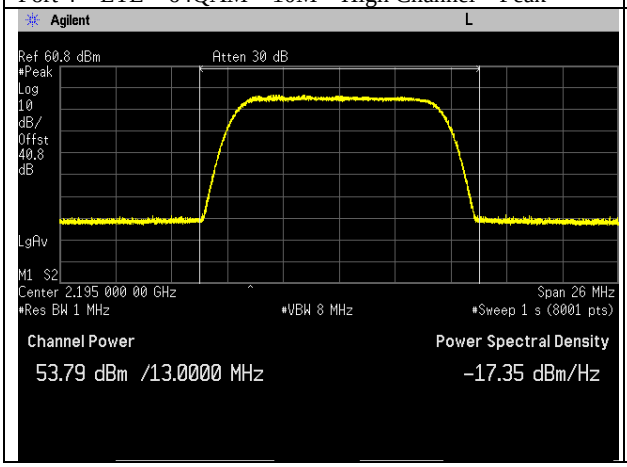
Port 4 – LTE – 16QAM – 10M – High Channel – Peak



Port 4 – LTE – 16QAM – 10M – High Channel – Average



Port 4 – LTE – 64QAM – 10M – High Channel – Peak



Port 4 – LTE – 64QAM – 10M – High Channel – Average