CERTIFICATE #: 0214.19

Radio Test Report

Application for a Class II Permissive Change Equipment Authorization

FCC Part 27 Subpart C
617MHz – 652MHz

FCC ID: VBNFHOA-01

Product Name: Fleximultiradio/Airscale Base Transceiver Station Remote Radio Head
Model: FHOA

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

NTS Plano FCC Laboratory Designation No.: US1077
NTS Plano ISED Laboratory Assigned Code: 4319A

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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	02/22/2019	Initial Draft	BreAnna Cheatham

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SCOPE

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

- Code of Federal Regulations (CFR) Title 47 Part 2
- CFR Title 47 Part 27 Subpart C

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

ANSI C63.26-2015
ANSI C63.4-2014
ANSI TIA-603-E
FCC KDB 971168 D01 v03r01
FCC KDB 971168 D03 v01
FCC KDB 662911D01 v02r01
TIA-102.CAAA-D

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 Fleximultiradio/Airscale Base Station Remote Radio Head (RRH) Model FHOA 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, 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 FHOA. No additional models were described or supplied for testing.

STATEMENT OF COMPLIANCE

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

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

DEVIATIONS FROM THE STANDARDS

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

TEST RESULTS SUMMARY

The following tables provide a summary of the test results:

FCC Part 27 Subpart C (Base Stations Operating in the 617 to 652MHz Band)

FHOA operating in 617MHz to 652MHz Frequency Band- LTE plus single Narrow Band IoT Guard Band carrier				
FCC	Description	Measured	Limit	Results
Transmitter Modulation, output power and other characteristics				
§27.5	Frequency Ranges	LTE10: 622.0 – 647.0MHz LTE15: 624.5 – 644.5MHz LTE20: 627.0 – 642.0MHz	617.0MHz to 652.0MHz	Pass
§2.1033(c)(4)	Modulation Type	NB IoT Guard band (QPSK) with LTE10, LTE15 & LTE20	Digital	Pass
§27.50	Output Power	Highest Conducted Power Output RMS: 46.15dBm ERP depends on antenna gain which is unknown	1000W ERP	Pass
Informational	Peak to Average Power Ratio	Highest Measured PAPR: 7.53dB	13dB	Pass
§2.1049	99% Emission Bandwidth	LTE10: 9.2392MHz LTE15: 13.8233MHz LTE20: 18.3050MHz	Remain in Block	Pass
	26dB down Emission Bandwidth	LTE10: 9.825MHz Emission Designator: 9M83F9W LTE15: 14.742MHz Emission Designator: 14M7F9W LTE20: 19.668MHz Emission Designator: 19M7F9W	Remain in Block	Pass
Transmitter Spurious Emissions[1]				
§27.53(g)	At the antenna terminals	< -19dBm	-19dBm per Transmit Chain	Pass
	Field Strength	48.137dBuV/m at 3m Eq. to -47.063dBm EIRP	-13dBm EIRP	Pass[2]
Other Details				
§27.54	Frequency Stability	Stays within authorized frequency block	Stays within block	Pass[2]
§1.1310	RF Exposure	N/A		Pass[3]

Note 1: Based on 100kHz RBW. In the 100kHz immediately outside and adjacent to the frequency block, a RBW of 30kHz was used. The measurement bandwidth is 100kHz for measurements more than 100kHz from the band edge. See Section 27.53(g) for details.
Note 2: See the original FCC radio certification report for details (NTS Test Report Number PR065304 Revision 1 dated August 2, 2017).
Note 3: Applicant's declaration on a separate exhibit based on hypothetical antenna gains.

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

A class II permissive change on the original filing is being pursued to add single Narrow Band IoT Guard Band (NB IoT GB here after) LTE carrier to the Fleximultiradio/Airscale BTS RRH model FHOA Federal Communication Commission certifications. The original FCC radio certification submittal was NTS Test Report Number PR065304 Revision 1 dated August 2, 2017. The original test effort includes testing for LTE technologies. Please refer to the test report on the original certification for details on all required testing.

All conducted RF testing performed for the original certification testing has been repeated using NB IoT GB for this class II permissive change per correspondence/guidance from Nemko TCB. The same test methodology used in the original certification testing was used in this class II permissive change test effort. NB IoT guard band offsets from LTE carrier center frequencies are as follows - LTE10: ± 4597.5 kHz, LTE 15: ± 6892.5kHz, and LTE20: ± 9097.5kHz. Tests performed under the class II change effort include RF power, peak to average power ratio, emission bandwidth (99% and 26 dB down), band edge spurious emissions, and conducted spurious emissions. The LTE modulation type for this testing was setup according to 3GPP TS 36.141 E-UTRA Test Models and is "E-TM 1.1 (QPSK modulation type) with N-TM (narrow band IoT)".

The testing was performed on the same hardware (FHOA) as the original certification test. The same FHOA RF port (Ant 2) determined in the original certification testing to be the highest power port was used for all testing in this effort. The base station and remote radio head software for this testing is an updated release that includes Narrow Band IoT Guard Band support.

The radiated emissions and frequency stability measurements performed in the original certification was not repeated under this effort per TCB guidance. The radiated emission and frequency stability/accuracy results from the original certification had enough margin to preclude requiring additional testing. The same frequency stability/accuracy radio design is the same for all radio technologies/modulation types.

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

The FHOA RRH has four transmit/four receive antenna ports (4TX/4RX for Band 71). Each antenna port supports 3GPP frequency band 71 (BTS Rx: 663 to 698 MHz/BTS TX: 617 to 652 MHz). The maximum RF output power of the RRH is 160 Watts (40 watts per antenna port and 40 watts per carrier). 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 bandwidth. The RRH supports LTE bandwidths of 5, 10, 15 and 20MHz for 3GPP frequency band 71 operations. 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 OBSAI (OPT) and remote electrical tilt (RET). The RRH with applicable installation kit may be pole or wall mounted.

The FHOA LTE channel numbers and frequencies are as follows:

	Downlink EARFCN	Downlink Frequency (MHz)	LTE Channel Bandwidth			
			5 MHz	10 MHz	15 MHz	20 MHz
Band 71 (Ant 1, 2, 3, 4)	68586	617.0	Band Edge	Band Edge	Band Edge	Band Edge
	……					
	68611	619.5	Bottom Ch			
	……					
	68636	622.0		Bottom Ch		
	……					
	68661	624.5			Bottom Ch	
	……					
	68686	627.0				Bottom Ch
	……					
	68761	634.5	Middle Ch	Middle Ch	Middle Ch	Middle Ch
	……					
	68836	642.0				Top Channel
	……					
	68861	644.5			Top Channel	
	……					
	68886	647.0		Top Channel		
	……					
	68911	649.5	Top Channel			
	……					
	68936	652.0	Band Edge	Band Edge	Band Edge	Band Edge

FHOA Downlink Band Edge LTE Band 71 Frequency Channels

Notes:

(1) Single Narrow Band IoT Guard Band operations are supported on the LTE10, LTE15 and LTE20 channel bandwidths only.

(2) A multicarrier test case with three LTE10 carriers (based upon KDB 971168 D03v01) using two carriers (with minimum spacing between carrier frequencies) at the lower band edge (EARFCN 68636: 622.0 & EARFCN 68736: 632.0MHz) and a third carrier with maximum spacing between the other two carrier frequencies (EARFCN 68886: 647.0MHz) at the upper band edge was verified.

EUT Hardware

The EUT hardware used in testing on February 13, 2019.

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	FHOA	Fleximultiradio/Airscale BTS RRH	Part#: 474088A.Y01 Serial#: K9171629068	FCC ID: VBNFHOA-01

Enclosure

The EUT enclosure is made of heavy-duty aluminum.

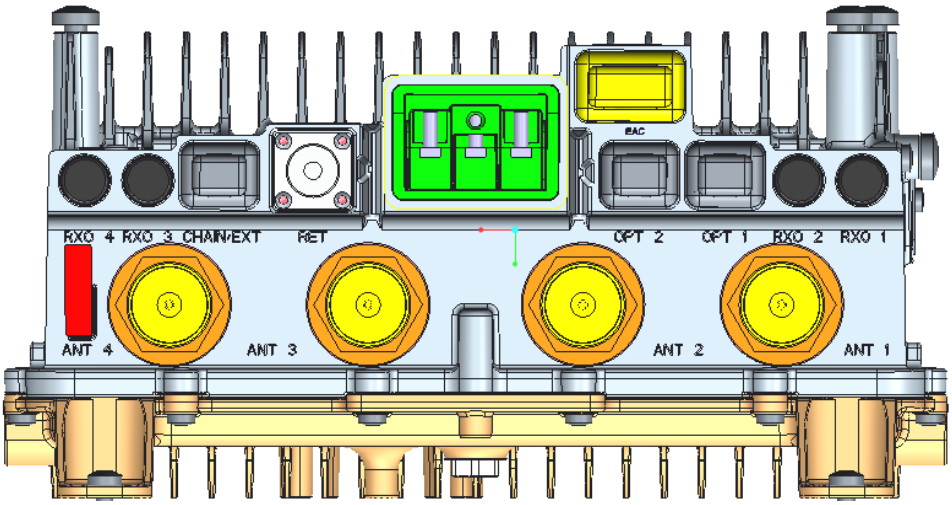
Support Equipment

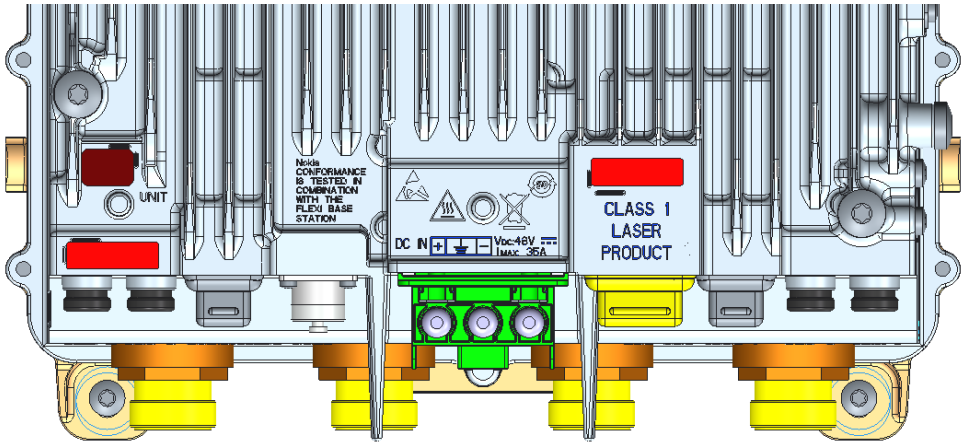
Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	AMIA	Fleximultiradio/Airscale System Module	Part#: 473098A.101 Serial#: RK164201509	N/A
Dell	Studio XPS	Instrumentation PC	N/A	N/A

Auxillary Equipment

Company	Description	Part Number	Serial Number
Nokia	OBSAI SFP Module -FOSH (Plugs into RRH Opt Ports)	472579A.101	CF32LCDSS
RLC Electronics	1.1GHz High Pass Filter-2 Watt[1]	F-14699	0050
Weinschel	Attenuator 20dB-150 Watt[1]	66-20-33	BZ2075
Weinschel	Attenuator 10dB-100 Watt[1]	48-10-34-LIM	BJ1771
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.			

FHOA Connector Layout:





EUT External Interfaces

Name	Qty	Connector Type	Purpose (and Description)
DC In	1	Screw Terminal	3-pole Power Input Terminal, up to AWG 4 cable
GND	1	Screw lug (2xM5/1xM8)	Ground
ANT	4	4.3-10	RF signal for Transmitter/Receiver (50 Ohm)
EAC	1	MDR14	External Alarm Interface (4 alarms)
OPT	3	SFP+ cage	Optical, OBSAI RP3-01 (6.144/3.072 Gbps)
RET	1	8-pin circular connector conforming to IEC 60130-9 – Ed.3.0	AISG 2.0 to external devices

EUT Interface Ports

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

Cable	Type	Shield	Length	Used in Test	Quantity	Termination
Power Input	Power	No	~ 3 m	Yes	1	Power Supply
Earth	Earth	No	~ 1 m	Yes	1	Lab earth ground
Antenna	RF	Yes	~ 3 m	Yes	4	50Ω Loads
External Alarm	Signal	Yes	~ 3 m	Yes	1	Un-terminated
Remote Electrical Tilt	Signal	Yes	~ 3 m	Yes	1	Un-terminated
Multimode Optical	Optical	No	>6 m	Yes	1	System Module

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 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: FRM38.11.R07A
(2) System Module Software: FL18A_ENB_0000_000802_000000
(3) BTS Site Manager: BTSSiteEM-FL18A_0000_000590_000000

Modifications

No modifications were made to the EUT during testing.

TESTING

General Information

Antenna port measurements were taken with NTS personnel (Alex Mathews) 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 during the original certification effort (NTS Test Report Number PR065304 Revision 1 dated August 2, 2017 for details).

Measurement Procedures

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

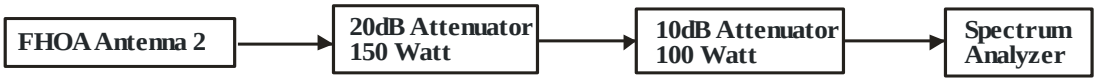
The 26dB emission bandwidth was measured in accordance with Section 4.1 of FCC KDB 971168 D01v03r01 and ANSI C63.26 section 5.4. The 99% occupied bandwidth was measured in accordance with Section 6.7 of RSS-Gen Issue 5. For both measurements, an occupied bandwidth built-in function in the spectrum analyzer was used and Keysight Benchvue Software was used to capture the spectrum analyzer screenshots. Spectrum analyzer settings are shown on their corresponding plots in test results section.

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

Average output power measurements were performed in accordance with sections 5.4 of FCC KDB 971168 D01v03r01 and ANSI C63.26. Measurements were performed with the built-in power meter function found in the spectrum analyzer and the screenshots were captured using Keysight Benchvue Software. Peak to average power ratio (PAPR) was measured in accordance with Section 5.7.2 of FCC KDB 971168 D01v03r01 and ANSI C63.26 section 5.2.3.4. Signal Analyzer CCDF screenshots were captured using Keysight Benchvue Software. Analyzer settings are shown on their corresponding plots in test results section.
Conducted spurious emissions were captured with Keysight Benchvue Software across the 9kHz-7GHz frequency span. A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 1.1GHz. The total measurement RF path loss of the test setup (attenuators, 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.

Antenna Port Conducted RF Measurement Test Setup Diagrams

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



Setup for 9kHz to 150kHz, 150kHz to 20MHz, 20MHz to 600MHz, 600 to 700MHz and 700MHz to 1.1GHz Measurements

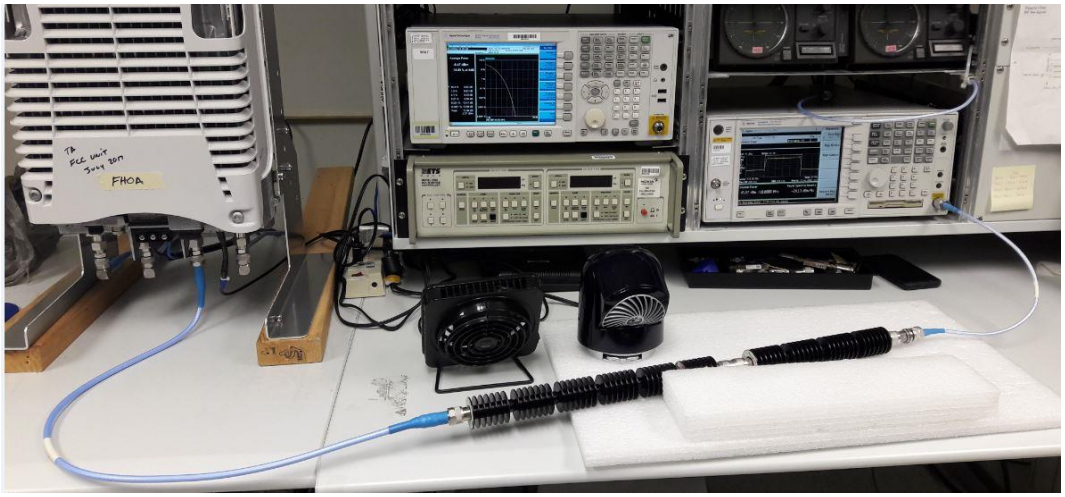
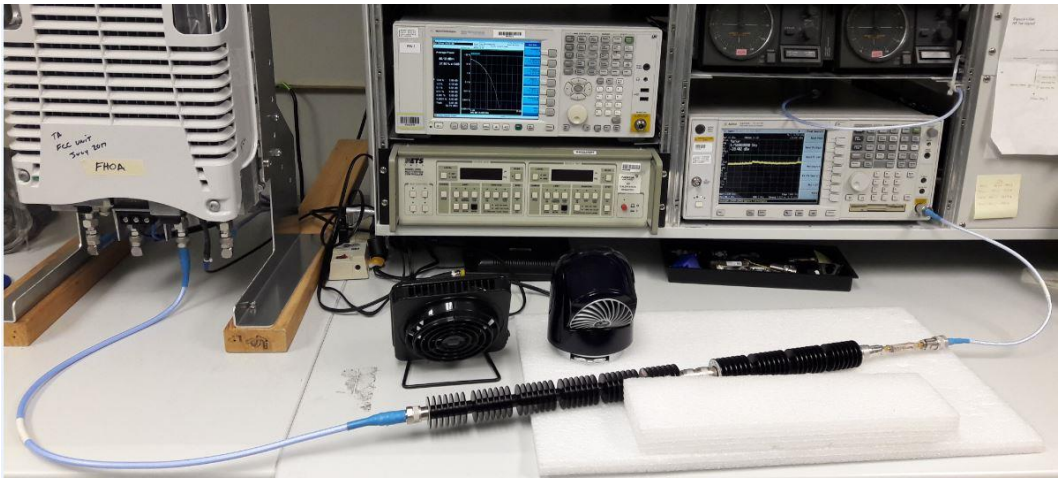


Photo of 9kHz to 150kHz, 150kHz to 20MHz, 20MHz to 600MHz, 600 to 700MHz and 700MHz to 1.1GHz Setup

Setup for 1.1GHz to 7GHz Measurements



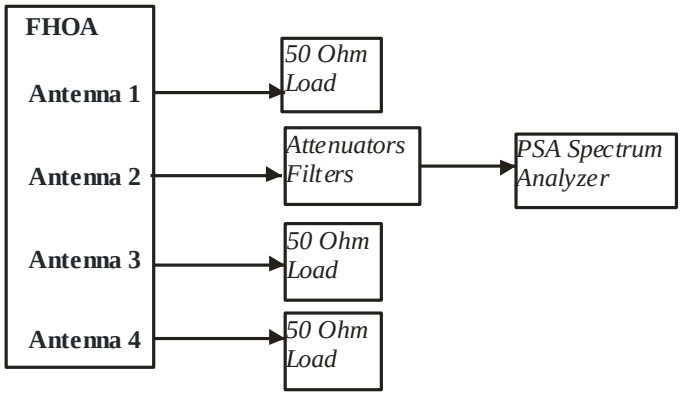
Photograph of 1.1GHz to 7GHz Test Setup

Test Measurement Equipment

Nokia Equipment #	Description	Manufacturer	Model	Calibration Duration	Calibration Due Date
120194	PSA Spectrum Analyzer	Agilent	E4440A	12 Months	10/17/2019
NM05151	Network Analyzer	Rohde & Schwarz	ZVL	12 Months	2/11/20
NM04508	MXA Signal Analyzer	Agilent	N9020A	24 Months	5/2/2019

APPENDIX A: ANTENNA PORT TEST DATA FOR BAND 71 (617-652MHz)

All conducted RF measurements in this section were made at FHOA antenna port 2. The testing was performed on the same hardware (EUT) as the original certification test. The same EUT RF port (Ant 2) determined in the original certification testing to be the highest power port was used for all testing in this effort. All testing in this section was performed with the single Narrow Band IoT Guard Band carriers at LTE10, LTE15 and LTE20 bandwidths. NB IoT guard band offsets from LTE carrier center frequencies were LTE10: ± 4597.5 kHz, LTE 15: ± 6892.5kHz, and LTE20: ± 9097.5kHz. The LTE modulation type for this testing was setup according to 3GPP TS 36.141 E-UTRA Test Models and is "E-TM 1.1 (QPSK modulation type) with N-TM (narrow band IoT)". The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on FHOA

RF Output Power

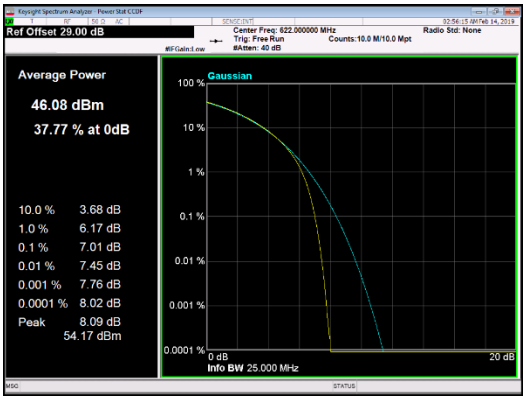
RF output power has been measured in RMS Average terms at the FHOA Antenna Port 2 transmit chain (617 to 652 MHz) at the bottom, middle and top channels for single Narrow Band IoT Guard Band LTE10, LTE15 and LTE20 carriers as described in section 5.2 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.4.4. The FHOA was operated at maximum RF output power. The peak to average power ratio (PAPR) has been measured using the signal analyzer complementary cumulative distribution function (CCDF) for a probability of 0.1% as described in section 5.7.2 of KDB971168 D01v03r01 and ANSI C63.26-2015 section 5.2.3.4. Measurements were performed for both the upper and lower narrow band IoT guard band carriers. All results are presented in tabular form below. The largest measured values are highlighted.

Ant Port 2 LTE Channel	LTE BW with IoT GB carrier	PAPR (dB)	Average (dBm)
Bottom Channel	10MHz with lower IoT GB carrier	7.01	46.01
Bottom Channel	10MHz with upper IoT GB carrier	6.90	46.07
Bottom Channel	15MHz with lower IoT GB carrier	7.39	45.61
Bottom Channel	15MHz with upper IoT GB carrier	7.31	45.61
Bottom Channel	20MHz with lower IoT GB carrier	7.19	46.05
Bottom Channel	20MHz with upper IoT GB carrier	7.07	46.09
Middle Channel	10MHz with lower IoT GB carrier	6.51	46.15
Middle Channel	10MHz with upper IoT GB carrier	6.51	46.09
Middle Channel	15MHz with lower IoT GB carrier	6.95	45.69
Middle Channel	15MHz with upper IoT GB carrier	6.96	45.70
Middle Channel	20MHz with lower IoT GB carrier	6.60	46.04
Middle Channel	20MHz with upper IoT GB carrier	6.62	46.02
Top Channel	10MHz with lower IoT GB carrier	7.09	46.05
Top Channel	10MHz with upper IoT GB carrier	7.23	45.94
Top Channel	15MHz with lower IoT GB carrier	7.45	45.72
Top Channel	15MHz with upper IoT GB carrier	7.53	45.60
Top Channel	20MHz with lower IoT GB carrier	7.30	46.05
Top Channel	20MHz with upper IoT GB carrier	7.43	46.07

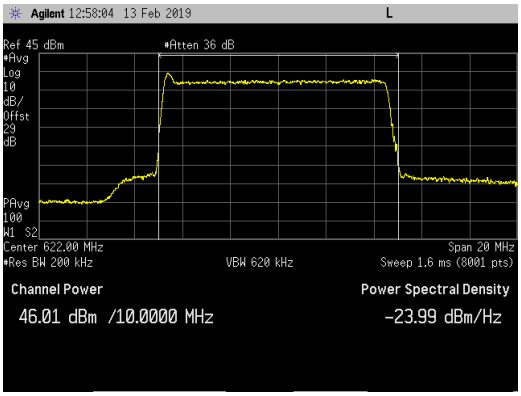
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 29.0 dB and is accounted for by the spectrum analyzer reference level offset.

LTE10 Channel Power Plots for a Single Narrow Band IoT Lower Guard Band Carrier:

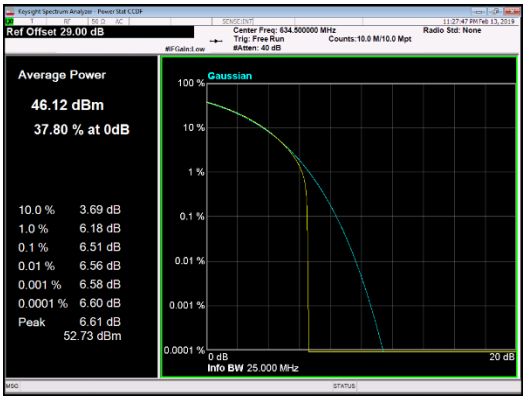
Port 2 – Bottom Channel_ CCDF



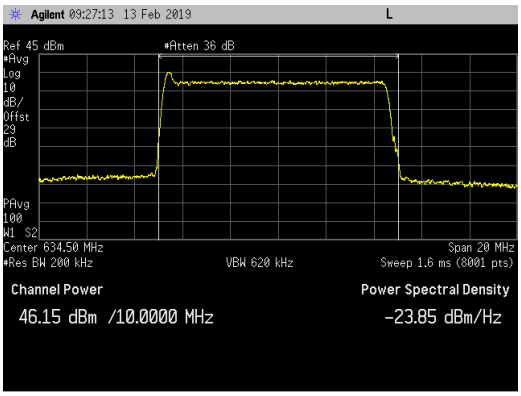
Port 2 – Bottom Channel_ Average



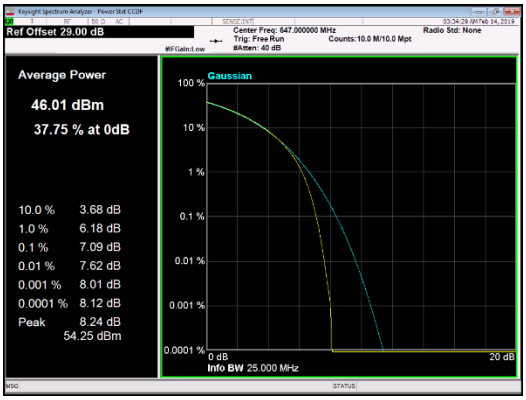
Port 2 – Middle Channel_ CCDF



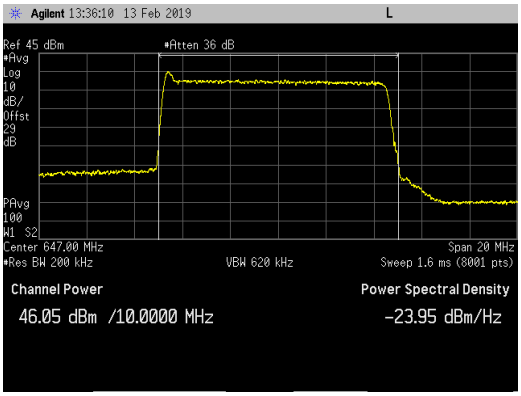
Port 2 – Middle Channel_ Average



Port 2 – Top Channel_ CCDF

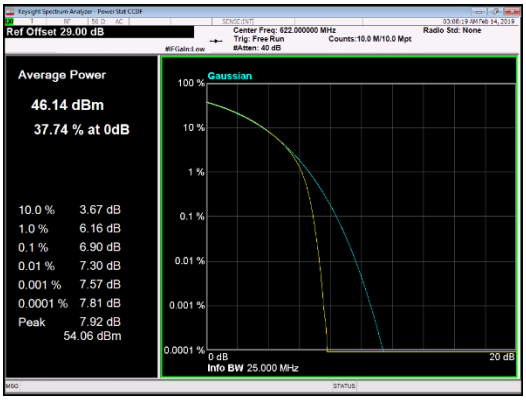


Port 2 – Top Channel_ Average

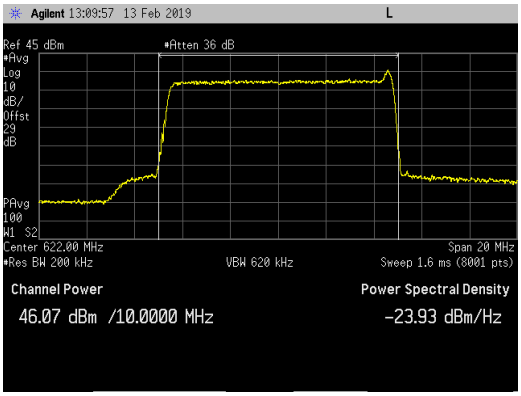


LTE10 Channel Power Plots for a Single Narrow Band IoT Upper Guard Band Carrier:

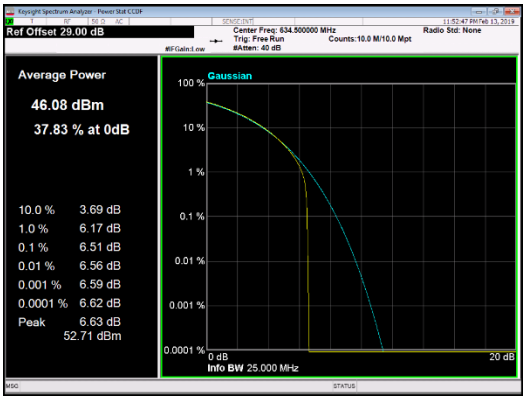
Port 2 – Bottom Channel_ CCDF



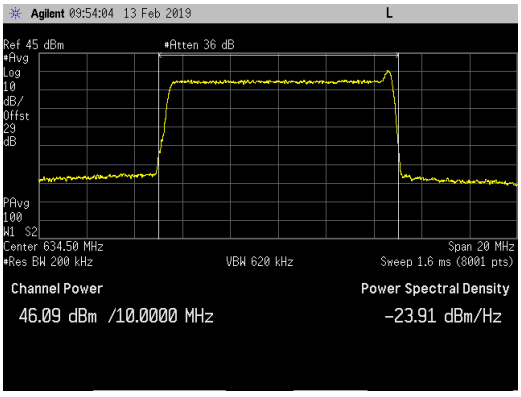
Port 2 – Bottom Channel_ Average



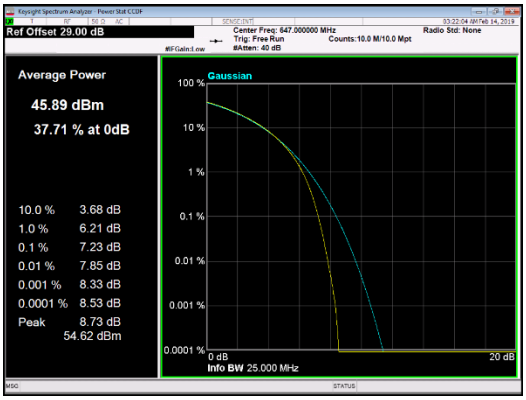
Port 2 – Middle Channel_ CCDF



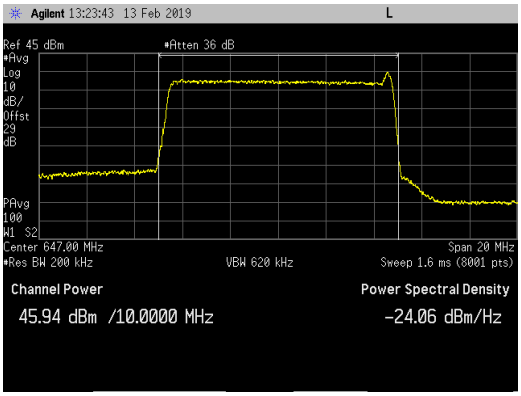
Port 2 – Middle Channel_ Average



Port 2 – Top Channel_ CCDF

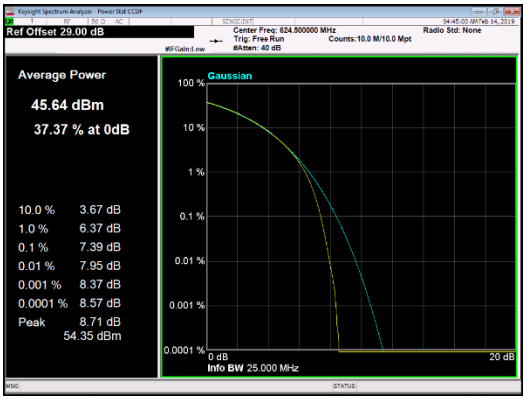


Port 2 – Top Channel_ Average

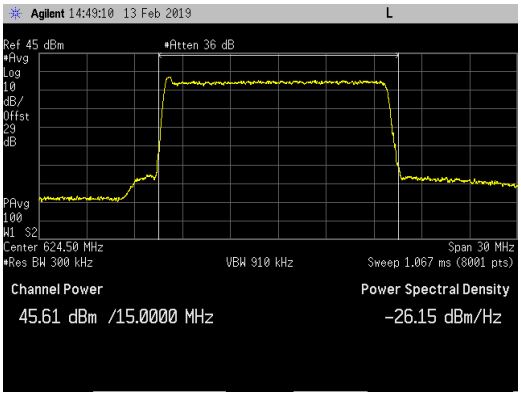


LTE15 Channel Power Plots for a Single Narrow Band IoT Lower Guard Band Carrier:

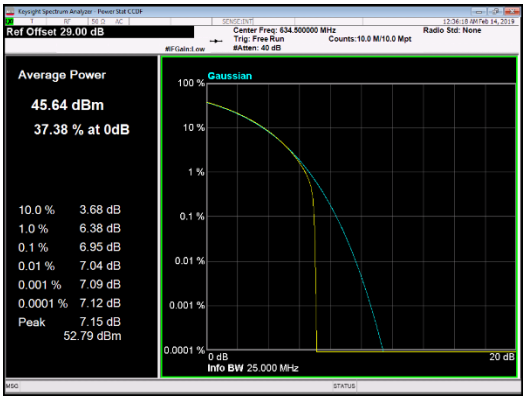
Port 2 – Bottom Channel_ CCDF



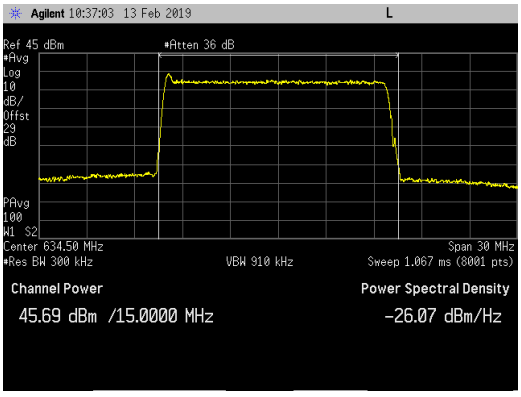
Port 2 – Bottom Channel_ Average



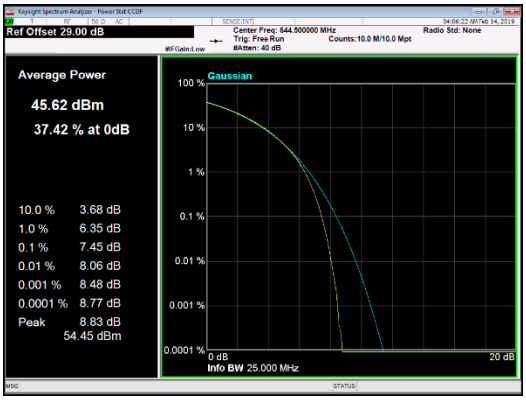
Port 2 – Middle Channel_ CCDF



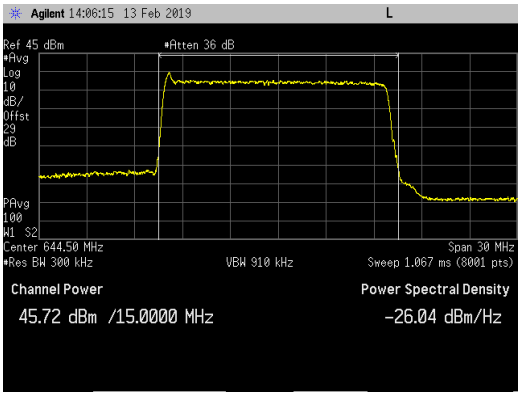
Port 2 – Middle Channel_ Average



Port 2 – Top Channel_ CCDF

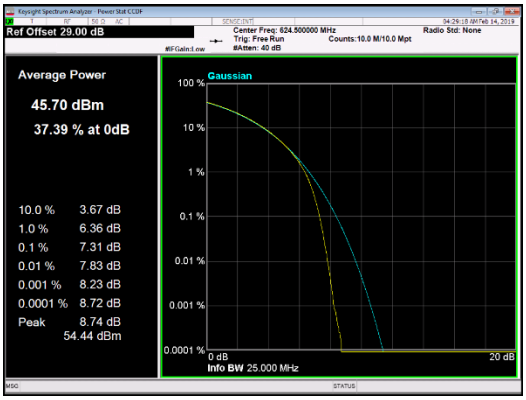


Port 2 – Top Channel_ Average

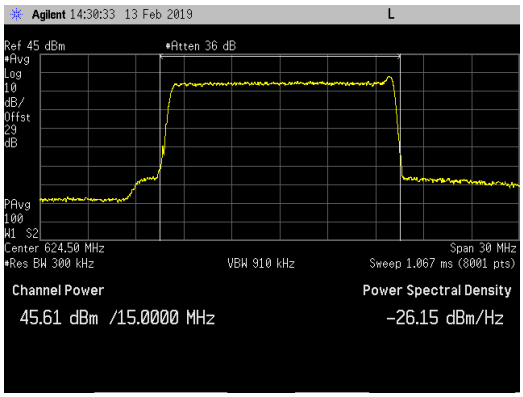


LTE15 Channel Power Plots for a Single Narrow Band IoT Upper Guard Band Carrier:

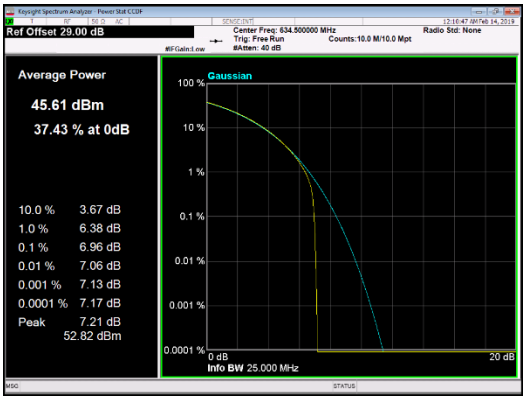
Port 2 – Bottom Channel_ CCDF



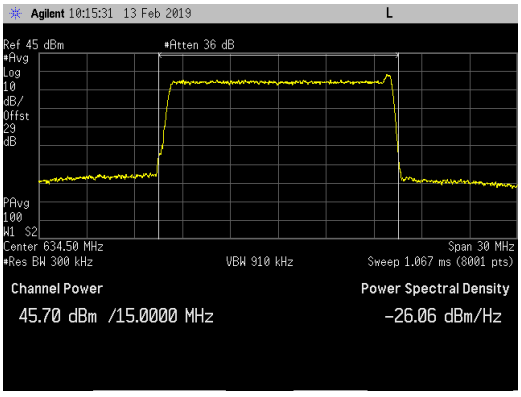
Port 2 – Bottom Channel_ Average



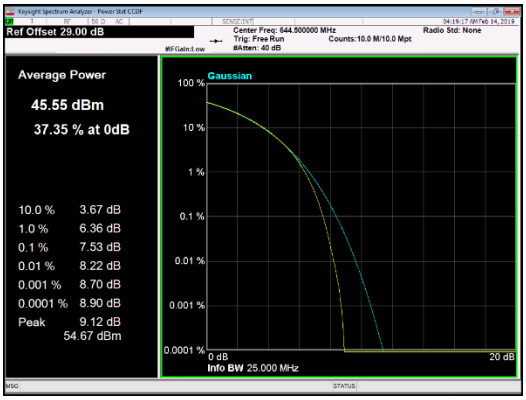
Port 2 – Middle Channel_ CCDF



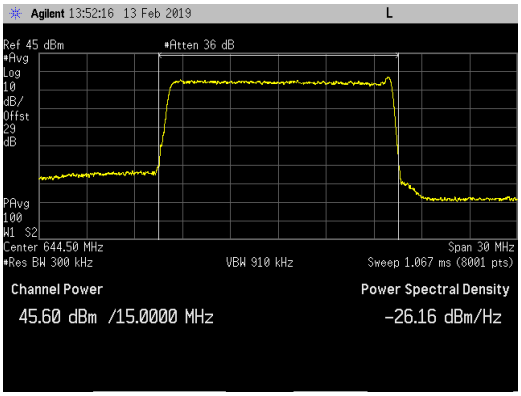
Port 2 – Middle Channel_ Average



Port 2 – Top Channel_ CCDF

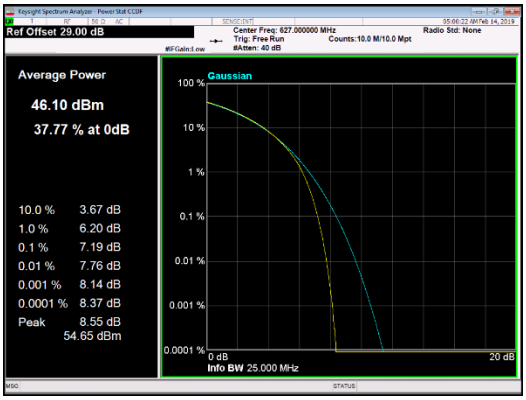


Port 2 – Top Channel_ Average

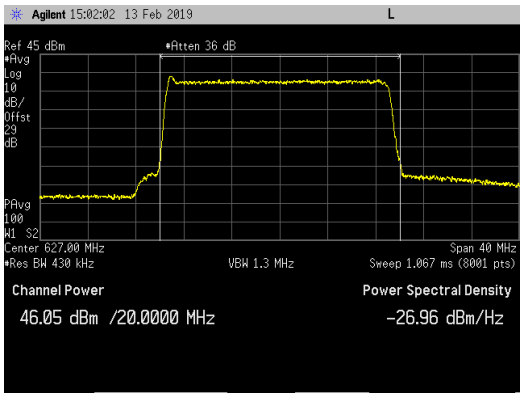


LTE20 Channel Power Plots for a Single Narrow Band IoT Lower Guard Band Carrier:

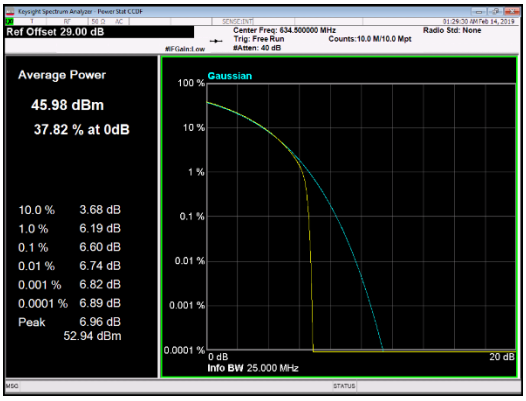
Port 2 – Bottom Channel_ CCDF



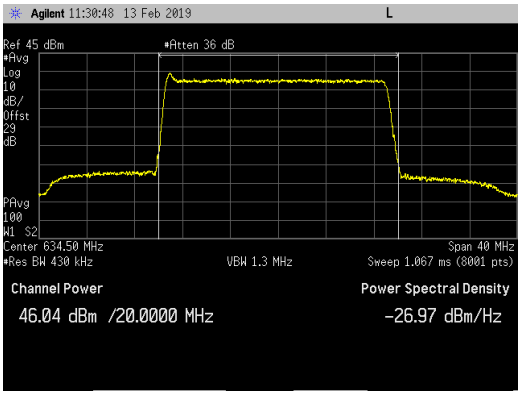
Port 2 – Bottom Channel_ Average



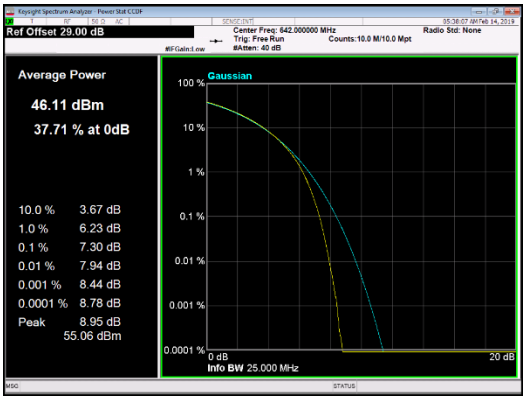
Port 2 – Middle Channel_ CCDF



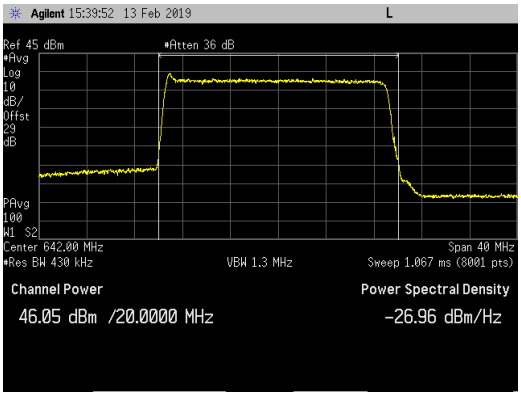
Port 2 – Middle Channel_ Average



Port 2 – Top Channel_ CCDF

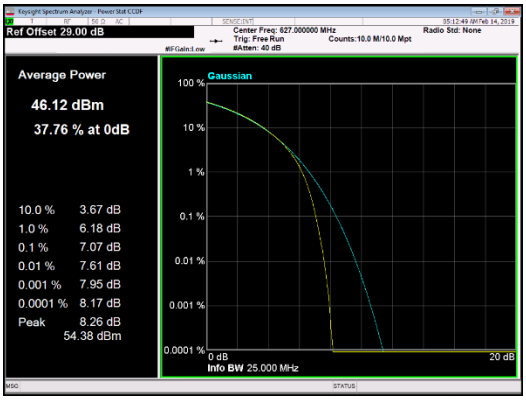


Port 2 – Top Channel_ Average

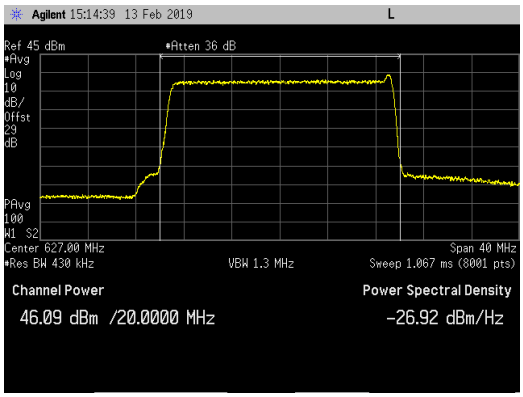


LTE20 Channel Power Plots for a Single Narrow Band IoT Upper Guard Band Carrier:

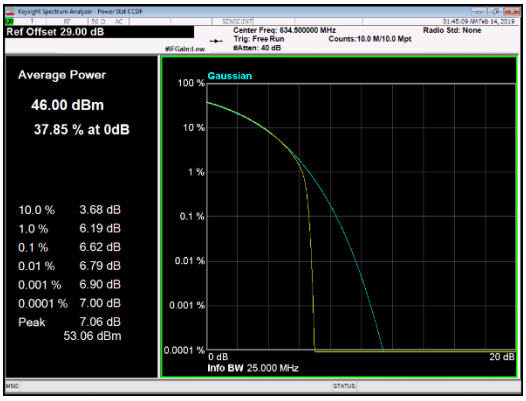
Port 2 – Bottom Channel_ CCDF



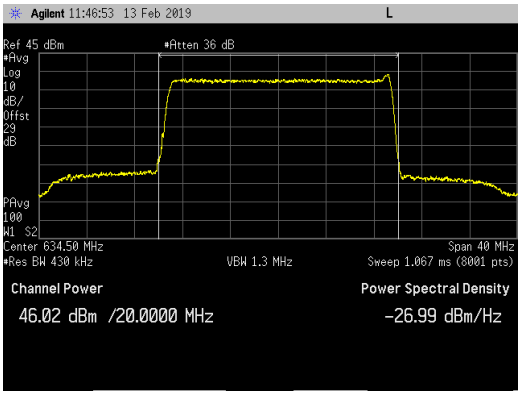
Port 2 – Bottom Channel_ Average



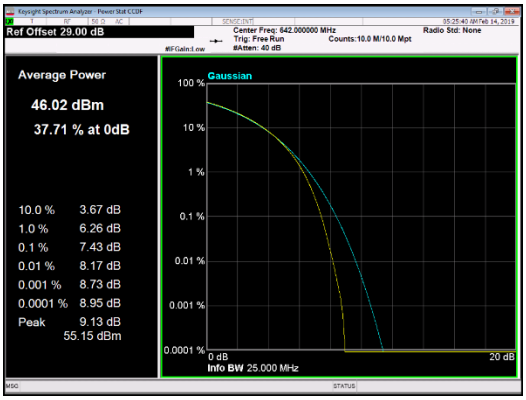
Port 2 – Middle Channel_ CCDF



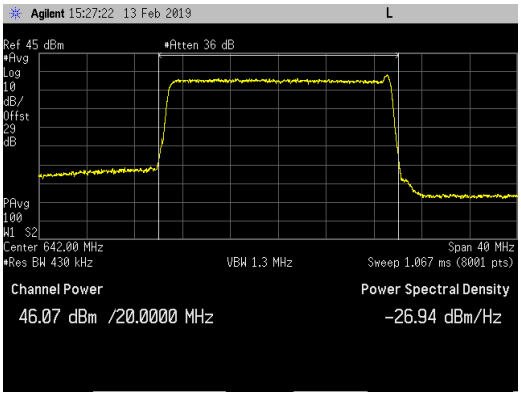
Port 2 – Middle Channel_ Average



Port 2 – Top Channel_ CCDF



Port 2 – Top Channel_ Average



Emission Bandwidth (26 dB down and 99%)

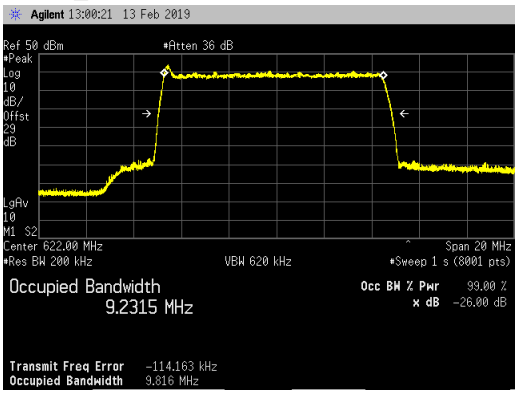
Emission bandwidth measurements were made at FHOA antenna port 2 on the bottom, middle and top channels for single Narrow Band IoT Guard Band LTE10, LTE15 and LTE20 carriers with maximum RF output power. Measurements were performed for both the upper and lower narrow band IoT guard band carriers. The 26dB emission bandwidth was measured in accordance with section 4 of FCC KDB 971168 D01v03r01 and ANSI C63.26 section 5.4. The 99% occupied bandwidth was measured in accordance with section 6.7 of RSS-Gen Issue 5. For both measurements, an occupied bandwidth built-in function in the spectrum analyzer was used. The results are provided in the following tables. The largest emission bandwidths are highlighted.

Antenna Port 2 LTE Channel	LTE BW with IoT GB carrier	26dB Emission Bandwidth (MHz)	99% Emission Bandwidth (MHz)
Bottom Channel	10MHz with lower IoT GB carrier	9.816	9.2315
Bottom Channel	10MHz with upper IoT GB carrier	9.783	9.2265
Bottom Channel	15MHz with lower IoT GB carrier	14.742	13.8010
Bottom Channel	15MHz with upper IoT GB carrier	14.701	13.8067
Bottom Channel	20MHz with lower IoT GB carrier	19.668	18.2955
Bottom Channel	20MHz with upper IoT GB carrier	19.566	18.2953
Middle Channel	10MHz with lower IoT GB carrier	9.802	9.2294
Middle Channel	10MHz with upper IoT GB carrier	9.813	9.2392
Middle Channel	15MHz with lower IoT GB carrier	14.700	13.7995
Middle Channel	15MHz with upper IoT GB carrier	14.715	13.8233
Middle Channel	20MHz with lower IoT GB carrier	19.639	18.3000
Middle Channel	20MHz with upper IoT GB carrier	19.610	18.3013
Top Channel	10MHz with lower IoT GB carrier	9.767	9.2114
Top Channel	10MHz with upper IoT GB carrier	9.825	9.2315
Top Channel	15MHz with lower IoT GB carrier	14.689	13.7758
Top Channel	15MHz with upper IoT GB carrier	14.718	13.8081
Top Channel	20MHz with lower IoT GB carrier	19.597	18.2795
Top Channel	20MHz with upper IoT GB carrier	19.659	18.3050

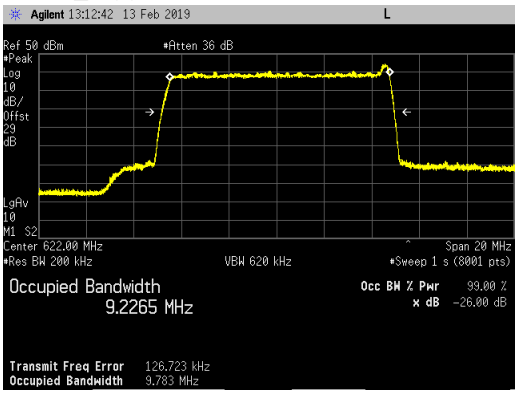
Emission bandwidth measurement data are provided in the following pages.

Emission Bandwidth Plots on the Bottom Channel for Antenna Port 2:

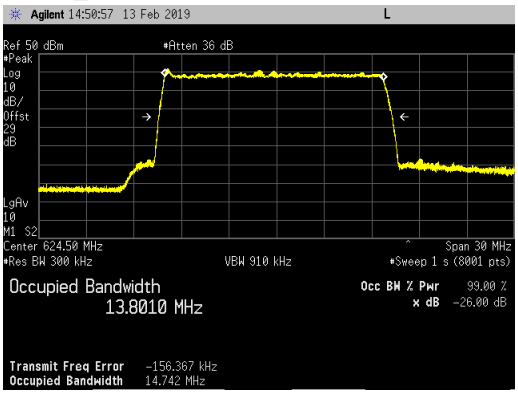
LTE10_ Lower Guard Band



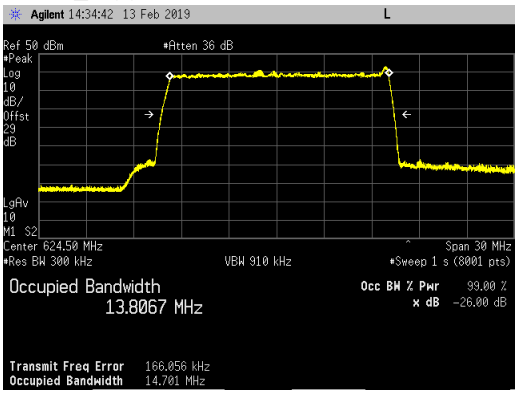
LTE10_ Upper Guard Band



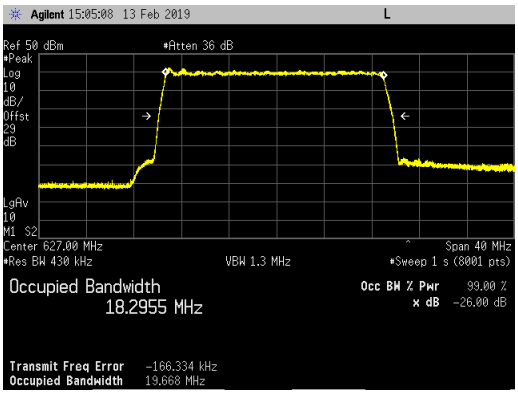
LTE15_ Lower Guard Band



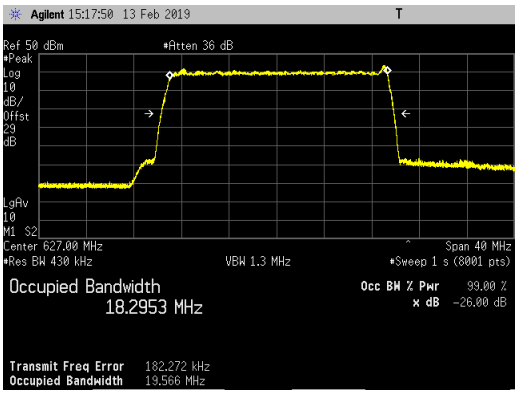
LTE15_ Upper Guard Band



LTE20_ Lower Guard Band

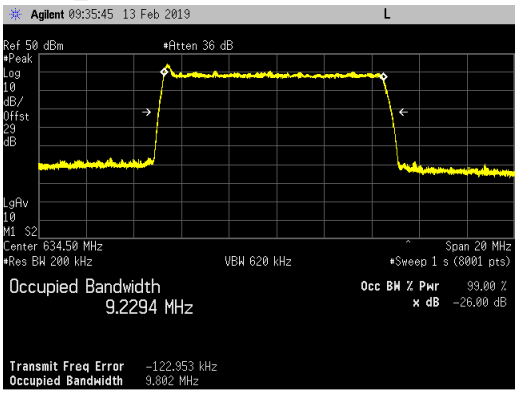


LTE20_ Upper Guard Band

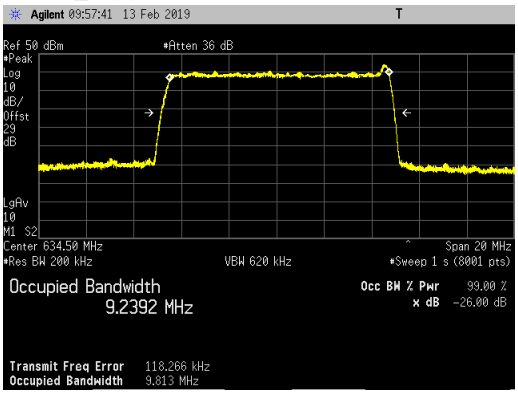


Emission Bandwidth Plots on the Middle Channel for Antenna Port 2:

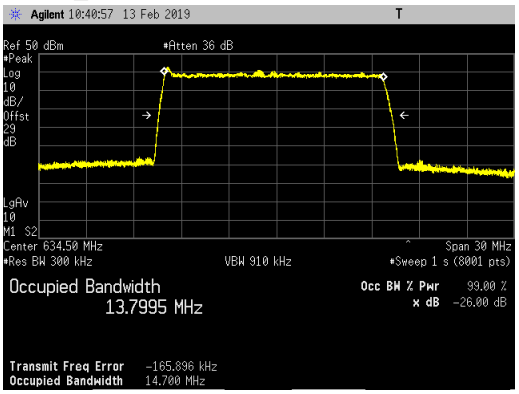
LTE10_ Lower Guard Band



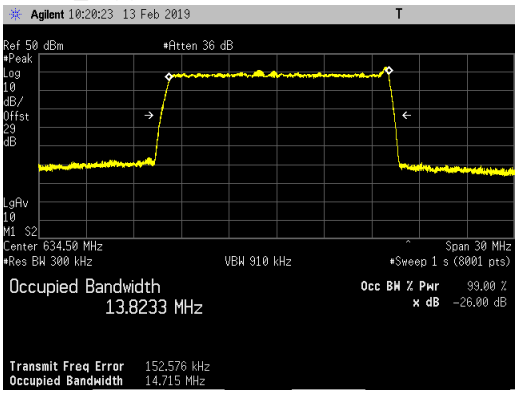
LTE10_ Upper Guard Band



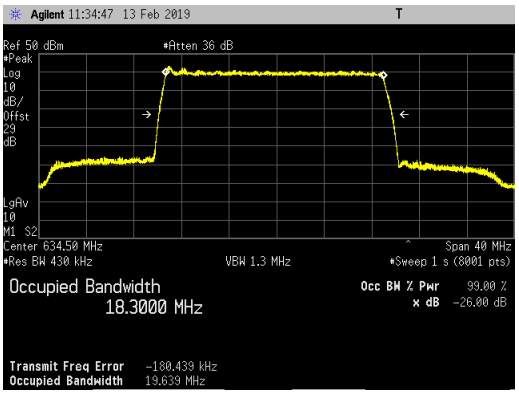
LTE15_ Lower Guard Band



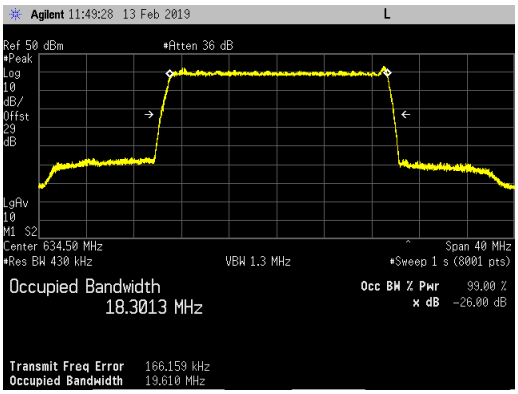
LTE15_ Upper Guard Band



LTE20_ Lower Guard Band

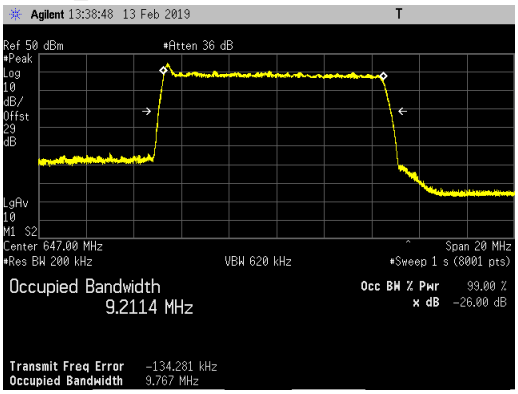


LTE20_ Upper Guard Band

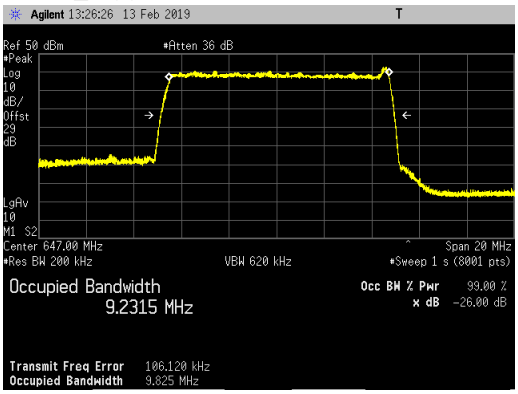


Emission Bandwidth Plots on the Top Channel for Antenna Port 2:

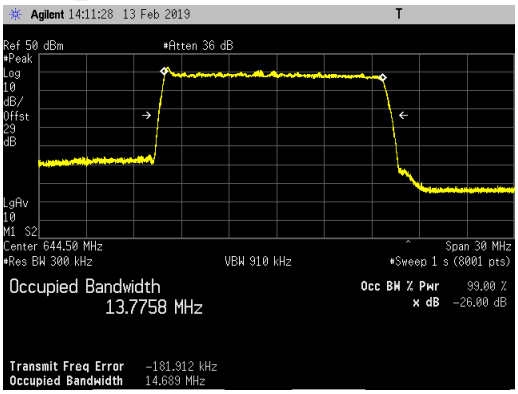
LTE10_ Lower Guard Band



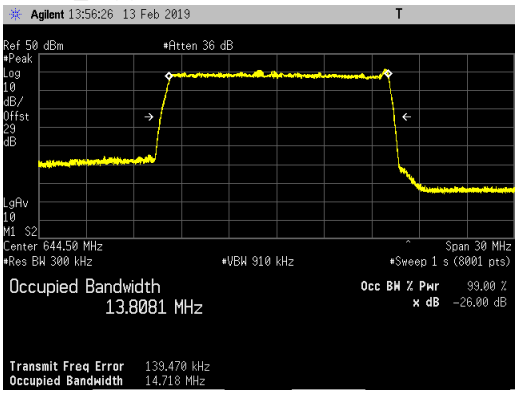
LTE10_ Upper Guard Band



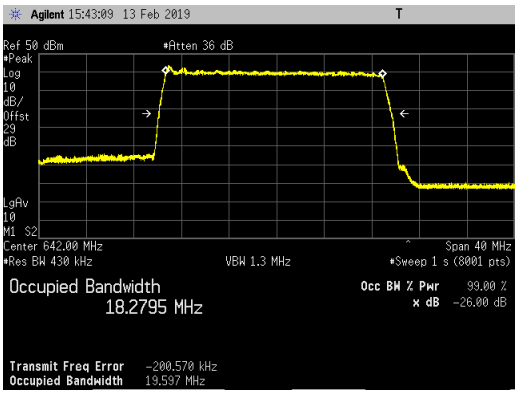
LTE15_ Lower Guard Band



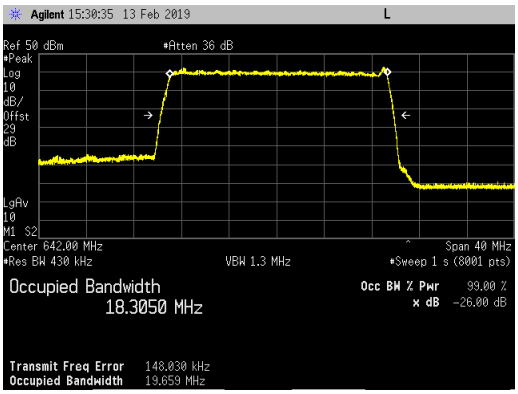
LTE15_ Upper Guard Band



LTE20_ Lower Guard Band



LTE20_ Upper Guard Band



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at RRH antenna port 2. The RRH was operated at the band edge frequencies with a single upper and lower NB IoT GB carrier for 10MHz, 15MHz and 20MHz LTE bandwidths at maximum power.

Single carrier test cases for all LTE bandwidths (LTE10, LTE15, and LTE20) were performed with the carrier operating at the at the lower and upper band edge frequencies at maximum power (40 watts per carrier and 40 watts per port). A multicarrier test case (LTE10 – smallest available bandwidth) based upon KDB 971168 D03v01 using three carriers (at maximum power – ~13 watts per carrier and 40 watts per port) per antenna port was also performed. The multicarrier test case is with two carriers (with minimum spacing between carrier frequencies) at the lower band edge (i.e.: 622 & 632MHz) and a third carrier with maximum spacing between the other two carrier frequencies (647MHz).

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

Measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces. In the 100kHz bands outside and adjacent to the frequency block, a resolution bandwidth of 30kHz as allowed by FCC 27.53(g) was used. Outside the 100kHz band edge noted above, a 100kHz RBW and 300kHz VBW was used. Measurements were performed in the frequency range from the band edge to 20 MHz outside the band edge (i.e.: 597 to 617MHz and 652 to 672MHz bands).

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

Test Case - LTE BW Carrier Frequency	NB IoT Guard Band Placement	Lower Band Edge (dBm)	Upper Band Edge (dBm)
Single Carrier – LTE10 622.0MHz - Bot Ch	Lower	-21.134	Not Applicable
Single Carrier – LTE10 622.0MHz - Bot Ch	Upper	-23.044	Not Applicable
Single Carrier – LTE10 647.0MHz - Top Ch	Lower	Not Applicable	-25.736
Single Carrier – LTE10 647.0MHz - Top Ch	Upper	Not Applicable	-25.176
Single Carrier – LTE15 624.5MHz - Bot Ch	Lower	-24.804	Not Applicable
Single Carrier – LTE15 624.5MHz - Bot Ch	Upper	-25.269	Not Applicable
Single Carrier – LTE15 644.5MHz - Top Ch	Lower	Not Applicable	-29.954
Single Carrier – LTE15 644.5MHz - Top Ch	Upper	Not Applicable	-29.860
Single Carrier – LTE20 627.0MHz - Bot Ch	Lower	-25.175	Not Applicable
Single Carrier – LTE20 627.0MHz - Bot Ch	Upper	-25.024	Not Applicable
Single Carrier – LTE20 642.0MHz - Top Ch	Lower	Not Applicable	-29.617
Single Carrier – LTE20 642.0MHz - Top Ch	Upper	Not Applicable	-29.576
Multi Carrier – LTE10 622, 632 & 647MHz	Lower	-25.407	-22.327
Multi Carrier – LTE10 622, 632 & 647MHz	Upper	-21.817	-26.305

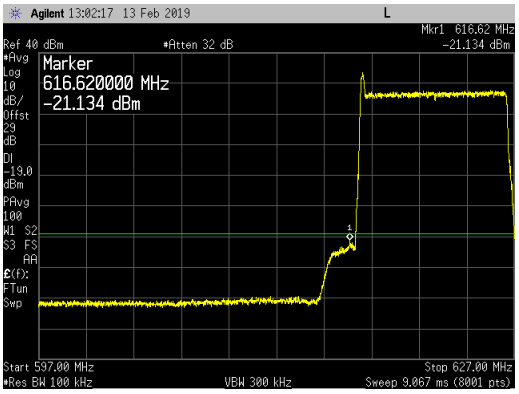
The total measurement RF path loss of the test setup (attenuator and test cables) was 29.0 dB and is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.

Conducted band edge measurements are provided in the following pages.

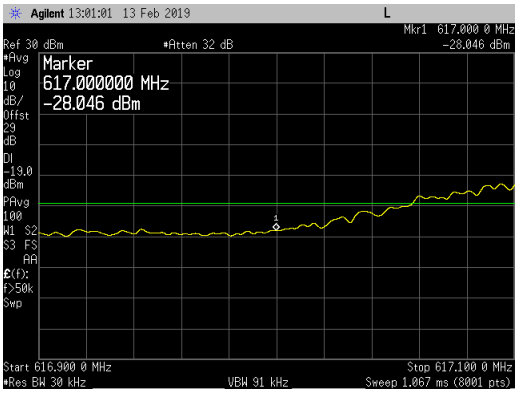
Single LTE10 40W Carrier at 622.0MHz_ Lower Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Bot Ch_LBE_597 to 627MHz

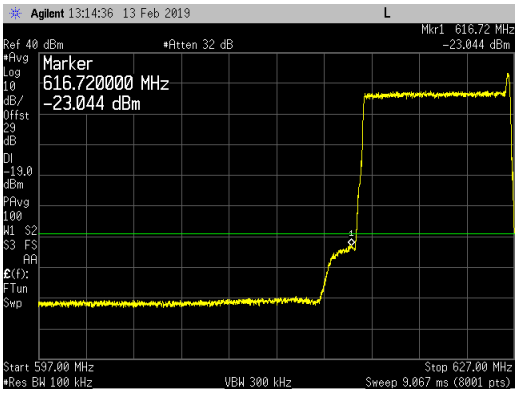


Bot Ch_LBE_616.9 to 617.1MHz

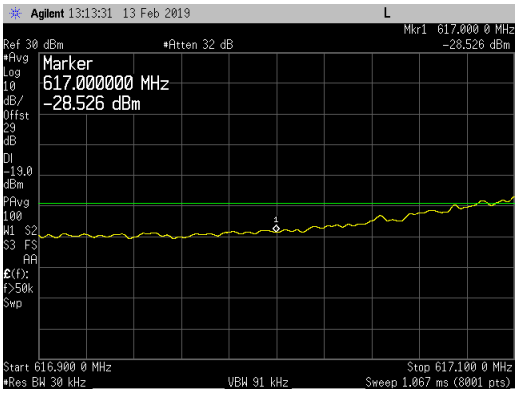


IoT Guard Band Carrier at Upper Placement

Bot Ch_LBE_597 to 627MHz



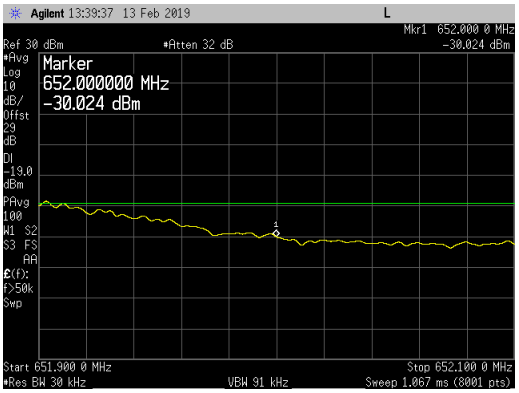
Bot Ch_LBE_616.9 to 617.1MHz



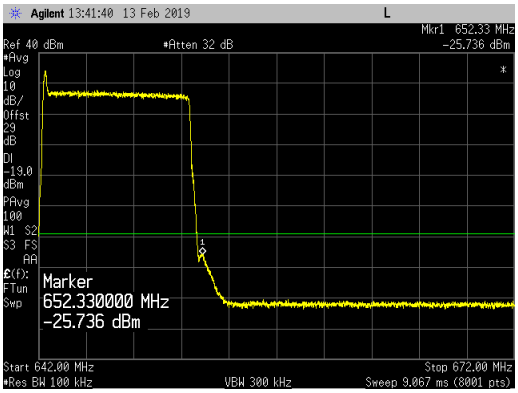
Single LTE10 40W Carrier at 647.0MHz_ Upper Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Top Ch_UBE_651.9 to 652.1MHz

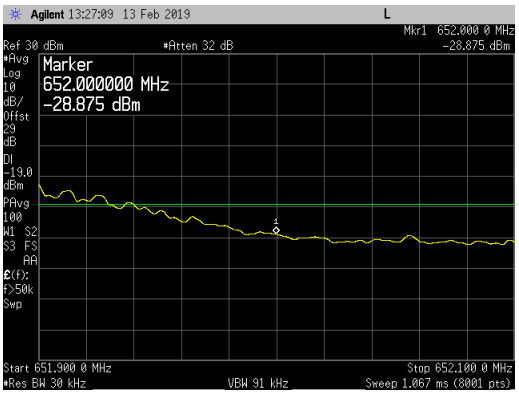


Top Ch_UBE_642.0 to 672.0MHz

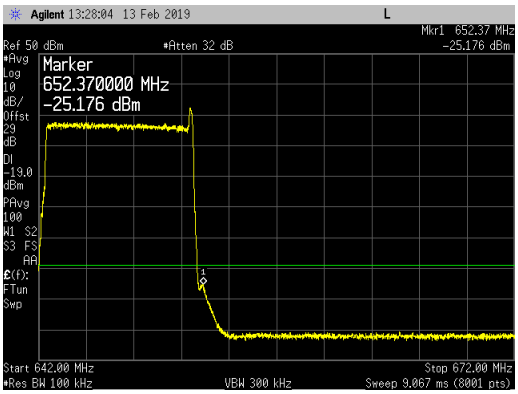


IoT Guard Band Carrier at Upper Placement

Top Ch_UBE_651.9 to 652.1MHz



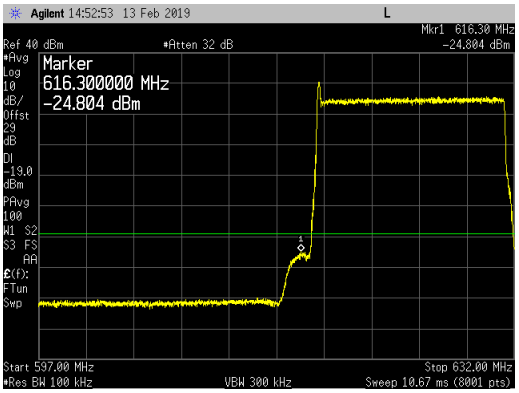
Top Ch_UBE_642.0 to 672.0MHz



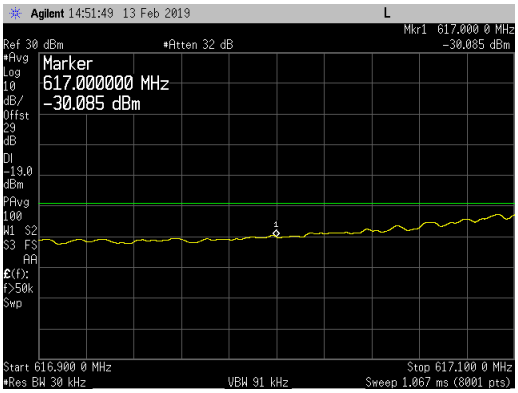
Single LTE15 40W Carrier at 624.5MHz_ Lower Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Bot Ch_LBE_597 to 632MHz

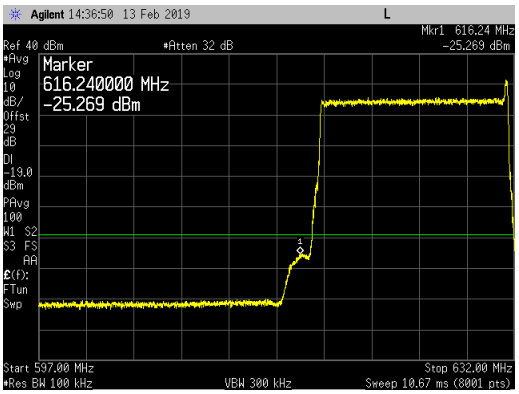


Bot Ch_LBE_616.9 to 617.1MHz

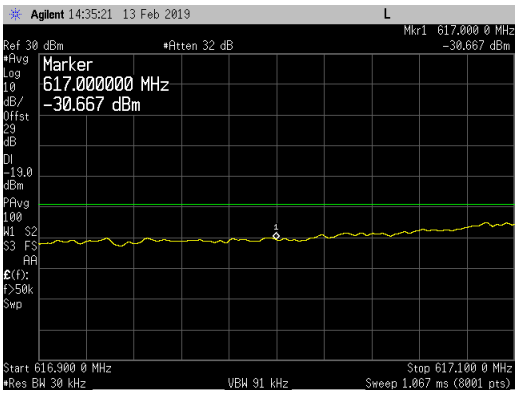


IoT Guard Band Carrier at Upper Placement

Bot Ch_LBE_597 to 632MHz



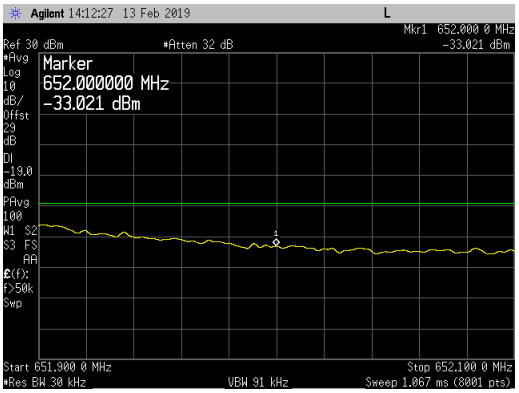
Bot Ch_LBE_616.9 to 617.1MHz



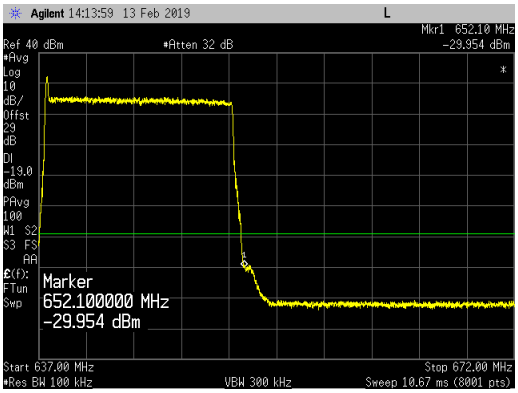
Single LTE15 40W Carrier at 644.5MHz_ Upper Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Top Ch_UBE_651.9 to 652.1MHz

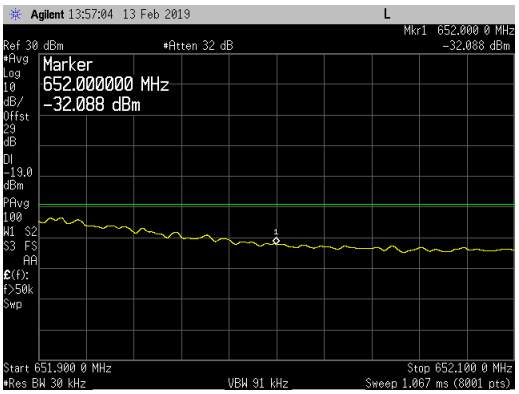


Top Ch_UBE_637.0 to 672.0MHz

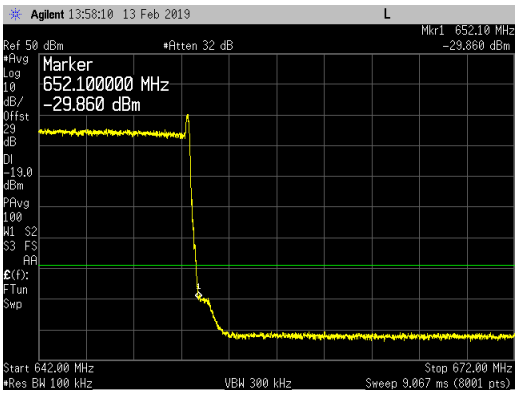


IoT Guard Band Carrier at Upper Placement

Top Ch_UBE_651.9 to 652.1MHz



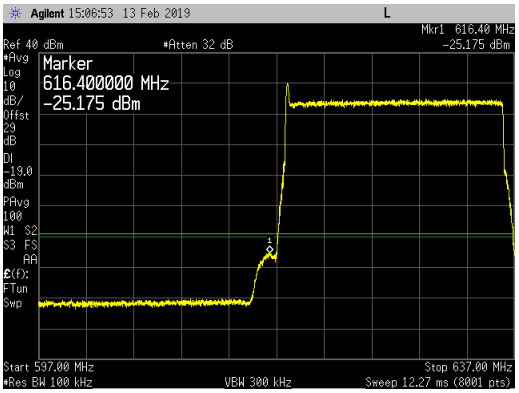
Top Ch_UBE_637.0 to 672.0MHz



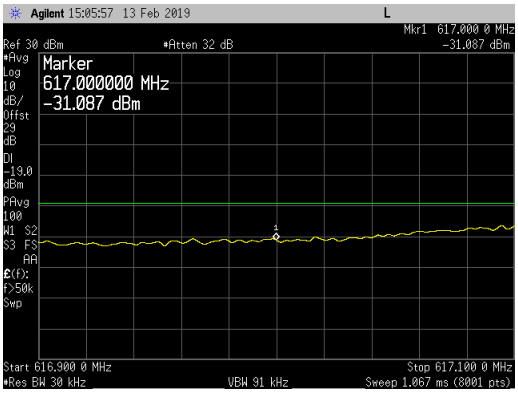
Single LTE20 40W Carrier at 627.0MHz_ Lower Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Bot Ch_LBE_597 to 637MHz

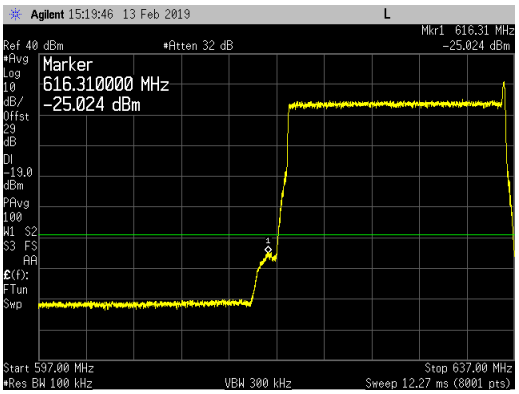


Bot Ch_LBE_616.9 to 617.1MHz

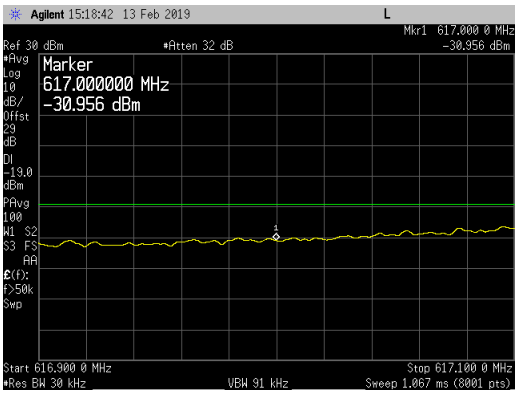


IoT Guard Band Carrier at Upper Placement

Bot Ch_LBE_597 to 637MHz



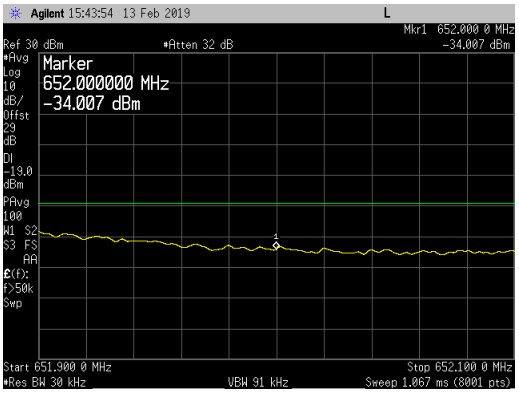
Bot Ch_LBE_616.9 to 617.1MHz



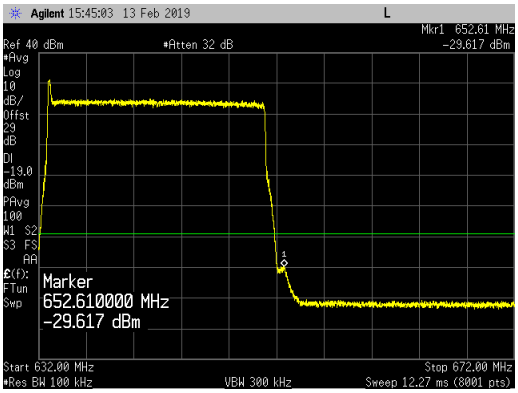
Single LTE20 40W Carrier at 642.0MHz_ Upper Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Top Ch_UBE_651.9 to 652.1MHz

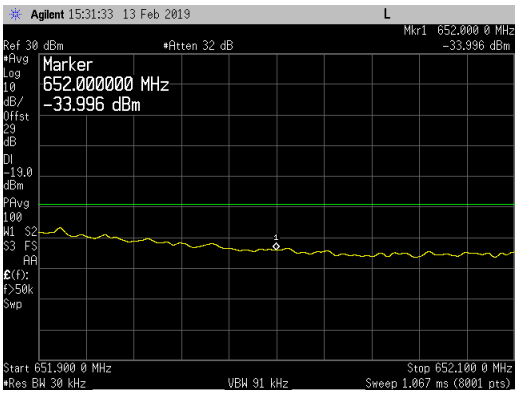


Top Ch_UBE_632.0 to 672.0MHz

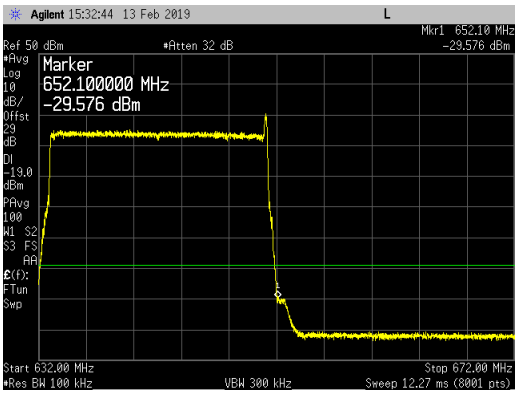


IoT Guard Band Carrier at Upper Placement

Top Ch_UBE_651.9 to 652.1MHz



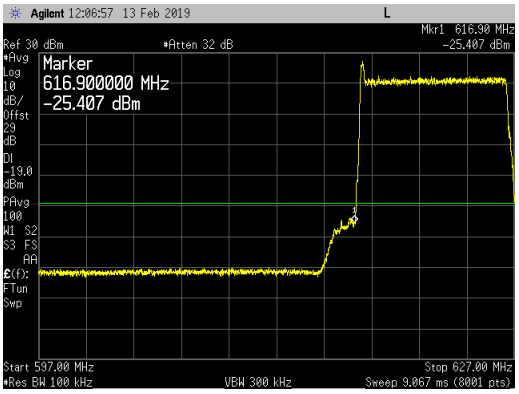
Top Ch_UBE_632.0 to 672.0MHz



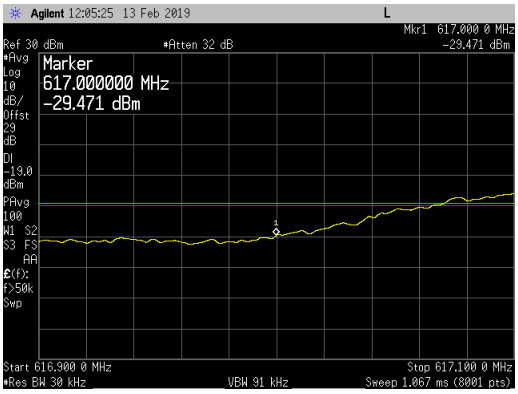
Multi Carrier LTE10 Carriers at 622, 632 & 647MHz at 40W/Port_ Lower Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Bot Ch_LBE_597 to 627MHz

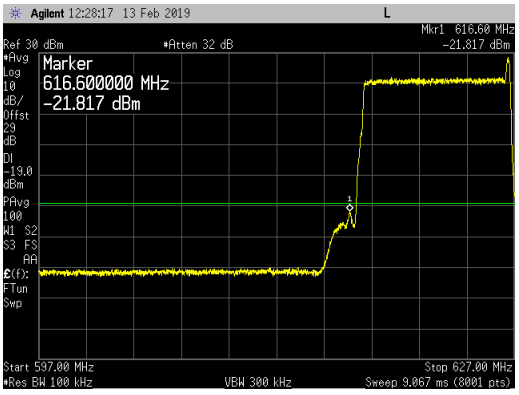


Bot Ch_LBE_616.9 to 617.1MHz

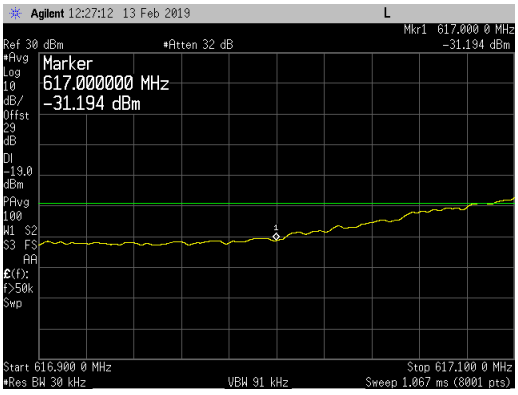


IoT Guard Band Carrier at Upper Placement

Bot Ch_LBE_597 to 627MHz



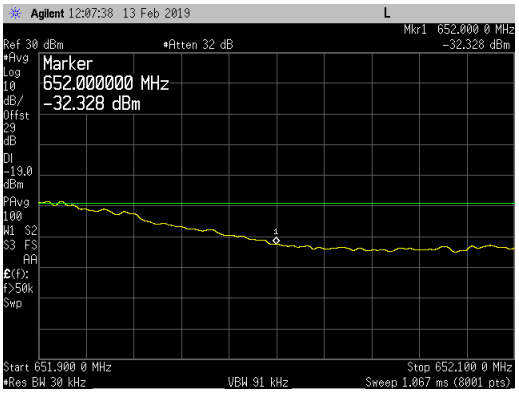
Bot Ch_LBE_616.9 to 617.1MHz



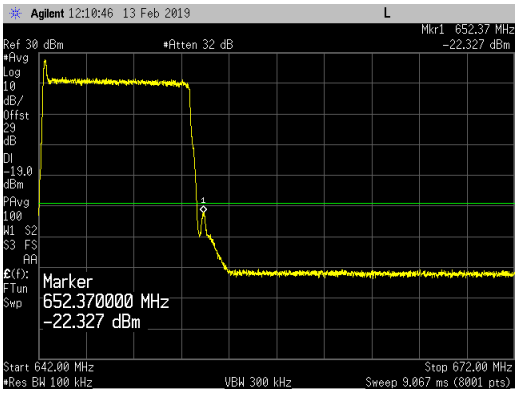
Multi Carrier LTE10 Carriers at 622, 632 & 647MHz at 40W/Port _ Upper Band Edge Plots for Antenna Port 2:

IoT Guard Band Carrier at Lower Placement

Top Ch_UBE_651.9 to 652.1MHz

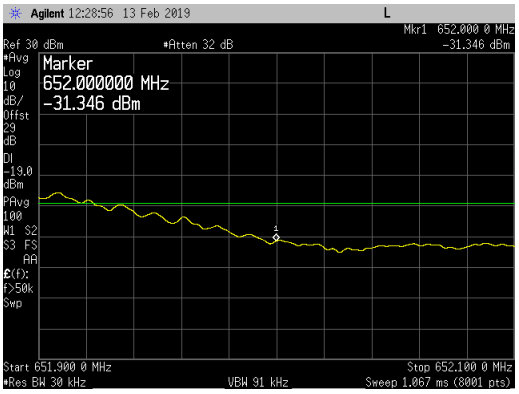


Top Ch_UBE_642.0 to 672.0MHz

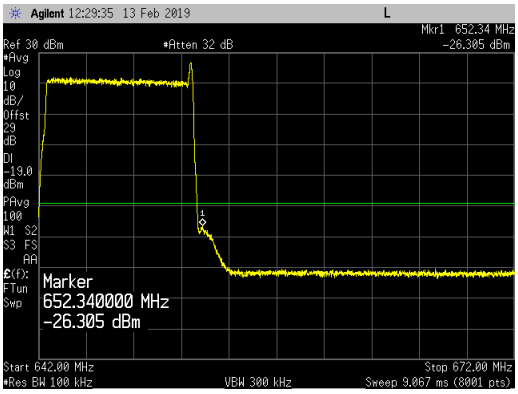


IoT Guard Band Carrier at Upper Placement

Top Ch_UBE_651.9 to 652.1MHz



Top Ch_UBE_642.0 to 672.0MHz



Transmitter Antenna Port Conducted Emissions

Transmitter conducted emission measurements were made at RRH antenna port 2. Measurements were performed over the 9kHz to 7GHz frequency range. The FHOA was operated with a single upper and lower NB IoT GB carrier for all test cases.

Single carrier test cases for all LTE bandwidths (LTE10, LTE15, and LTE20) were performed with the carrier operating at the at the middle channel (634.5MHz) at maximum power (40 watts per carrier and 40 watts per port).

A multicarrier test case (LTE10 – smallest available bandwidth) based upon KDB 971168 D03v01 using three carriers (at maximum power – 40 watts per port) per antenna port was also performed. The multicarrier test case is with two carriers (with minimum spacing between carrier frequencies) at the lower band edge (i.e.: 622 & 632MHz) and a third carrier with maximum spacing between the other two carrier frequencies (647MHz).

The same limit of -19dBm used in the original certification testing is used for this testing. The limit is adjusted to -19dBm [-13dBm -10 log (4)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 4 port MIMO transmitter. The required measurement parameters include a 100kHz bandwidth with power measured in average value (since transmitter power was measured in average value).

Measurements were performed with a spectrum analyzer using a peak detector with max hold over 50 sweeps (except for the 600MHz to 700MHz frequency range). Measurements for the 600MHz to 700MHz frequency range was performed with the spectrum analyzer in the RMS average mode over 100 traces.

The limit for the 9kHz to 150kHz frequency range was adjusted to –39dBm to correct for a spectrum analyzer RBW of 1kHz versus required RBW of 100kHz [i.e.: -39dBm = -19dBm -10log(100kHz/1kHz)]. The limit for the 150kHz to 20MHz frequency range was adjusted to –29dBm to correct for a spectrum analyzer RBW of 10kHz versus required RBW of 100kHz [i.e.: -29dBm = -19dBm -10log(100kHz/10kHz)]. The required limit of -19dBm with a RBW of $\geq$100kHz was used for all other frequency ranges. The spectrum analyzer settings that were used for this test are summarized in the following table.

Frequency Range	RBW	VBW	Number of Data Points	Detector	Sweep Time	Max Hold over	Offset Note 1
9kHz to 150kHz	1kHz	3kHz	8001	Peak	Auto	50 Sweeps	28.0dB
150kHz to 20MHz	10kHz	30kHz	8001	Peak	Auto	50 Sweeps	28.0dB
20MHz to 600MHz	300kHz	910kHz	8001	Peak	Auto	50 Sweeps	28.8dB
600MHz to 700MHz	100kHz	300kHz	8001	Average	Auto	Note 2	29.0dB
700MHz to 1.1GHz	100kHz	300kHz	8192	Peak	Auto	50 Sweeps	29.3dB
1.1GHz to 7GHz	2MHz	6MHz	8192	Peak	Auto	50 Sweeps	32.7dB

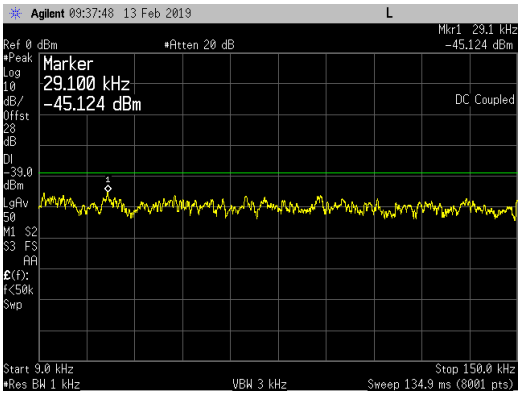
Note 1: The total measurement RF path loss of the test setup (attenuators, filters and test cables) is accounted for by the spectrum analyzer reference level offset.
Note 2: Max Hold not used and instead measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces.

A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 1100MHz. The total measurement RF path loss of the test setup (attenuators, high pass filter and test cables) as shown in the table is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.

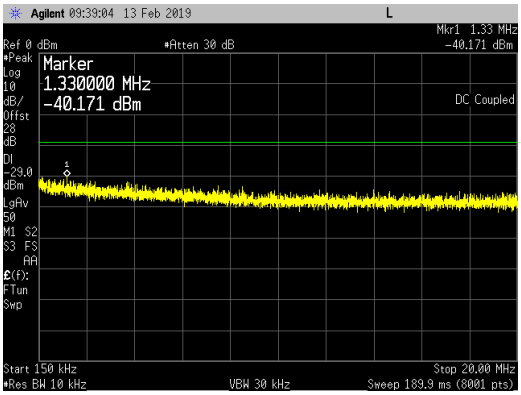
Conducted spurious emission plots/measurements are provided in the following pages.

LTE10 Single Narrow Band IoT Lower Guard Band Carrier
-Single Carrier at Middle Channel (634.5MHz) at 40 watts/carrier and 40 watts/port:

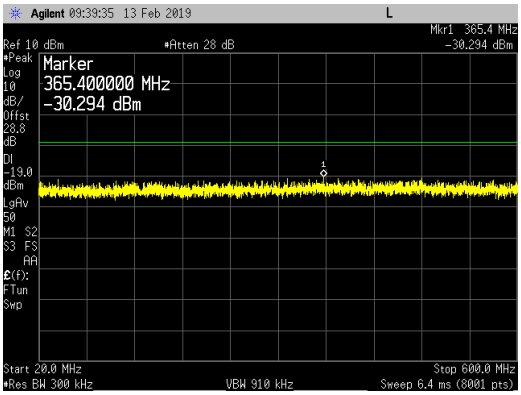
9kHz to 150kHz



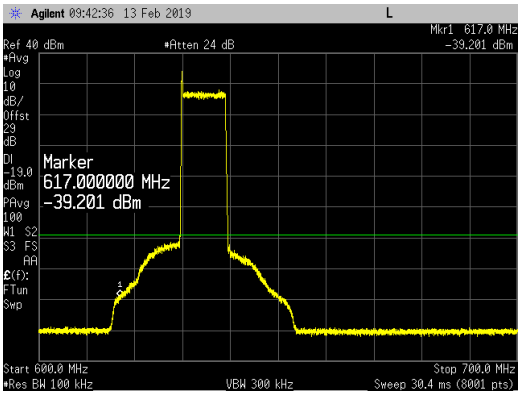
150kHz to 20MHz



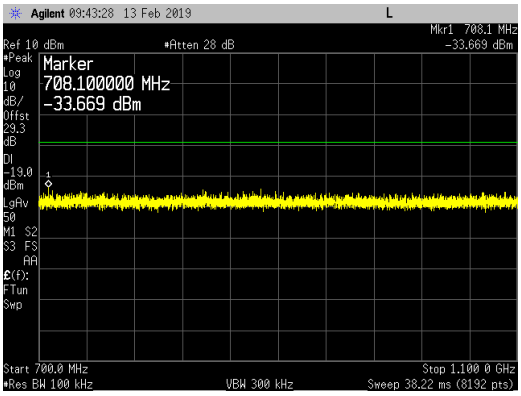
20MHz to 600MHz



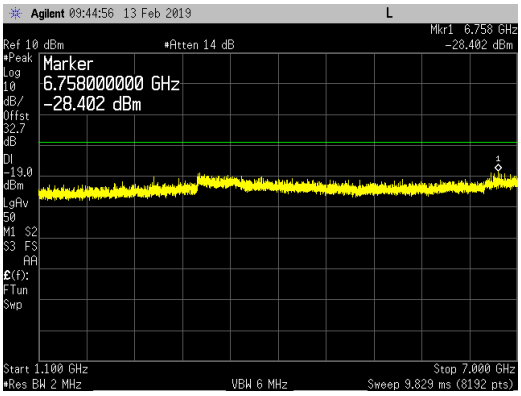
600MHz to 700MHz



700MHz to 1.1GHz

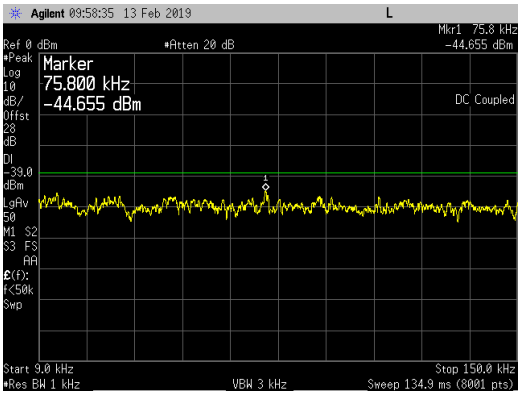


1.1GHz to 7GHz

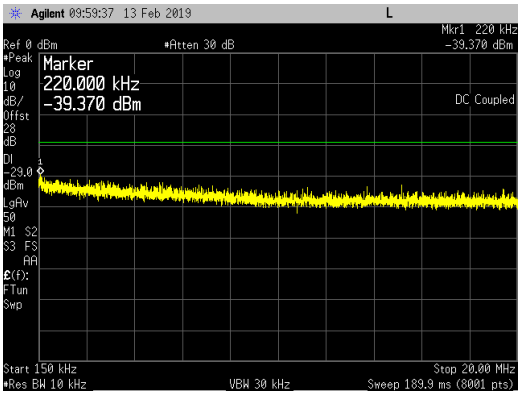


LTE10 Single Narrow Band IoT Upper Guard Band Carrier
-Single Carrier at Middle Channel (634.5MHz) at 40 watts/carrier and 40 watts/port:

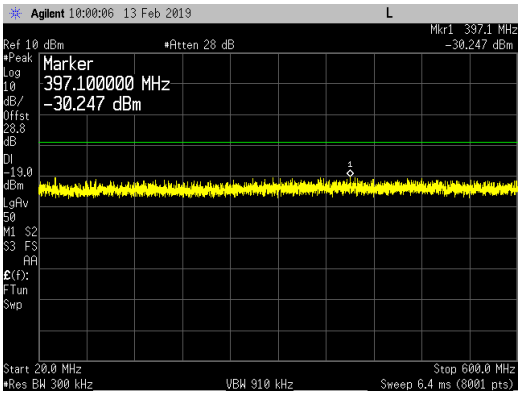
9kHz to 150kHz



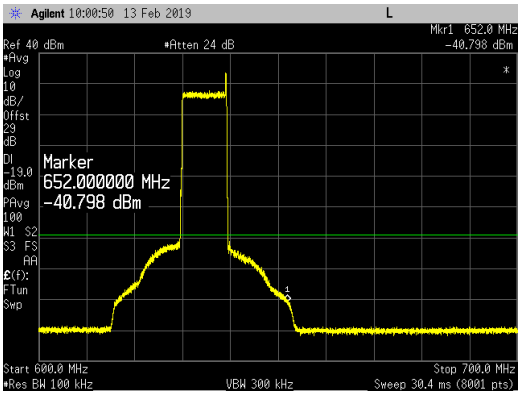
150kHz to 20MHz



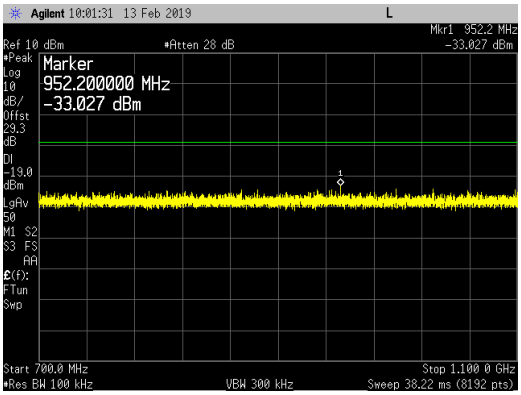
20MHz to 600MHz



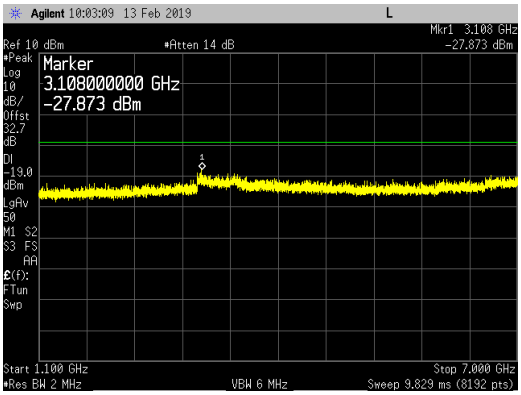
600MHz to 700MHz



700MHz to 1.1GHz

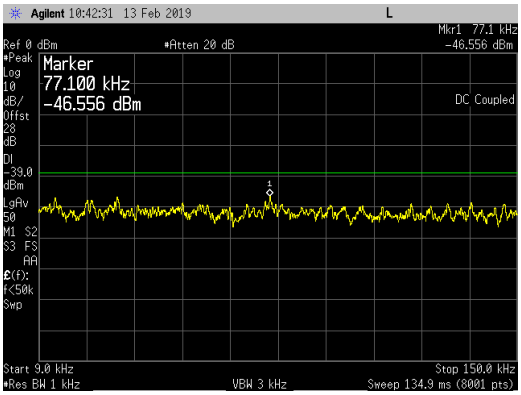


1.1GHz to 7GHz

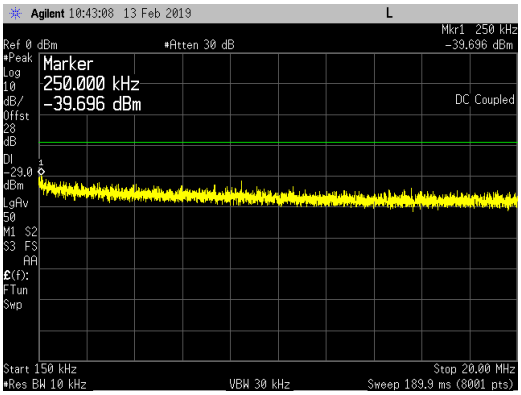


LTE15 Single Narrow Band IoT Lower Guard Band Carrier
-Single Carrier at Middle Channel (634.5MHz) at 40 watts/carrier and 40 watts/port:

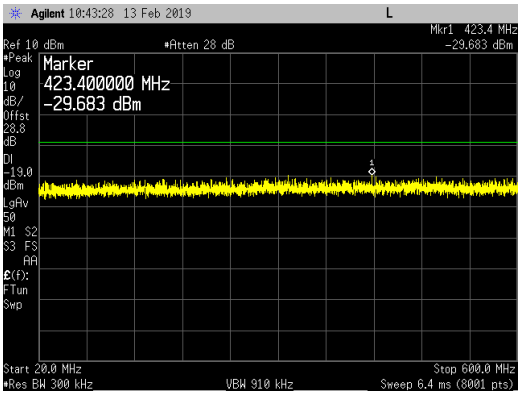
9kHz to 150kHz



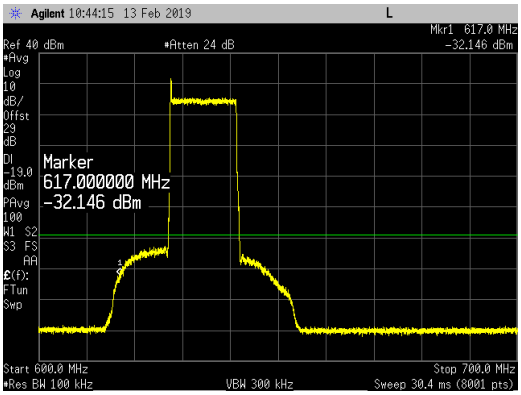
150kHz to 20MHz



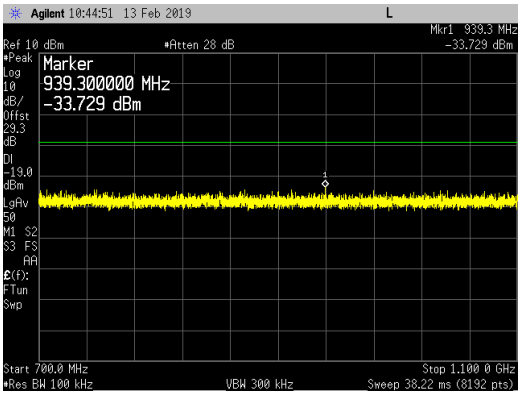
20MHz to 600MHz



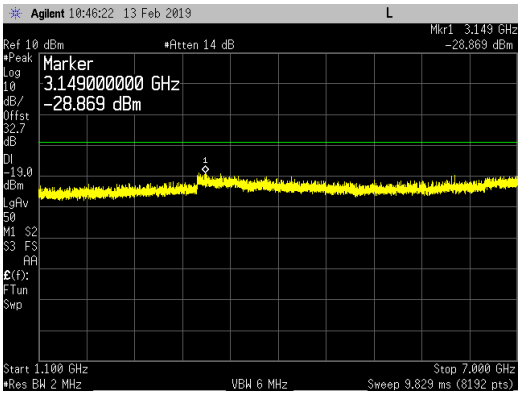
600MHz to 700MHz



700MHz to 1.1GHz

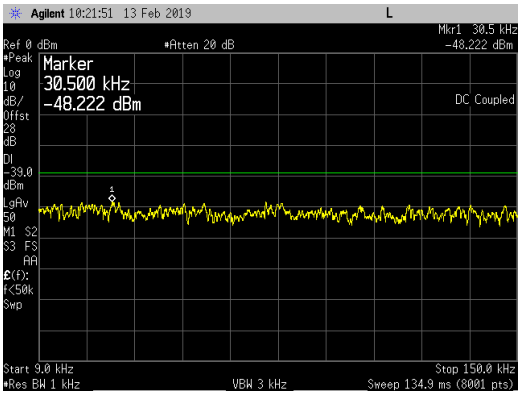


1.1GHz to 7GHz

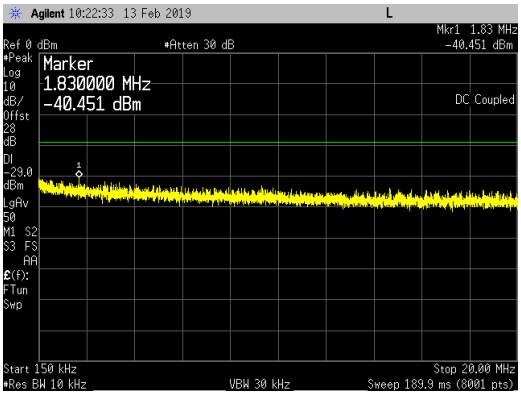


LTE15 Single Narrow Band IoT Upper Guard Band Carrier
-Single Carrier at Middle Channel (634.5MHz) at 40 watts/carrier and 40 watts/port:

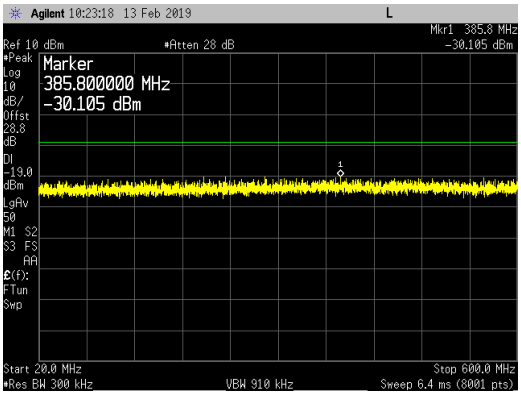
9kHz to 150kHz



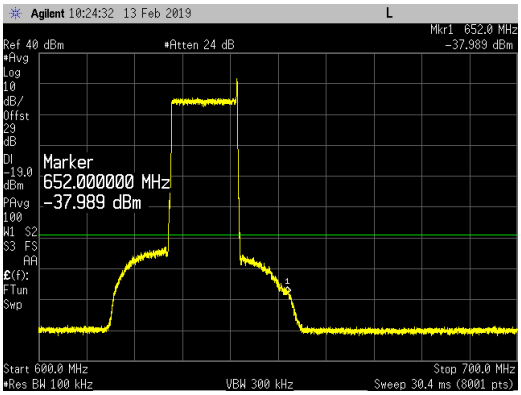
150kHz to 20MHz



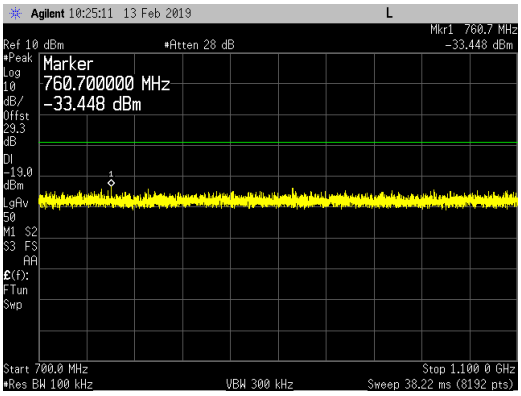
20MHz to 600MHz



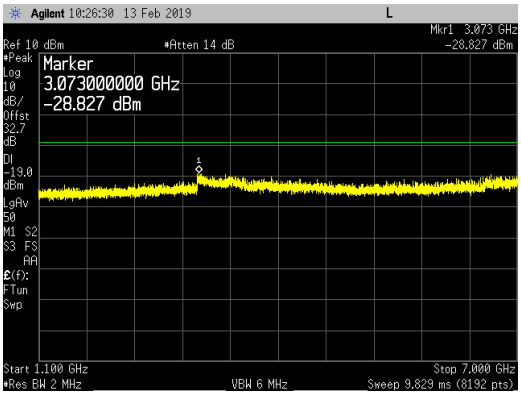
600MHz to 700MHz



700MHz to 1.1GHz

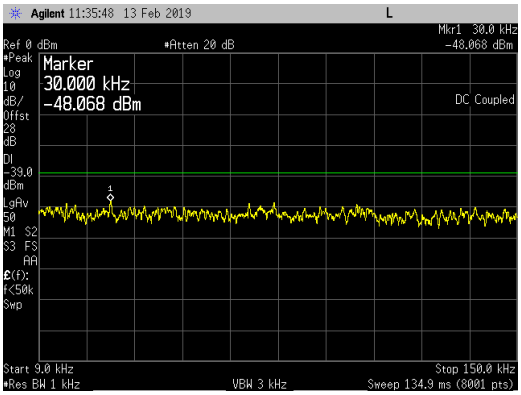


1.1GHz to 7GHz

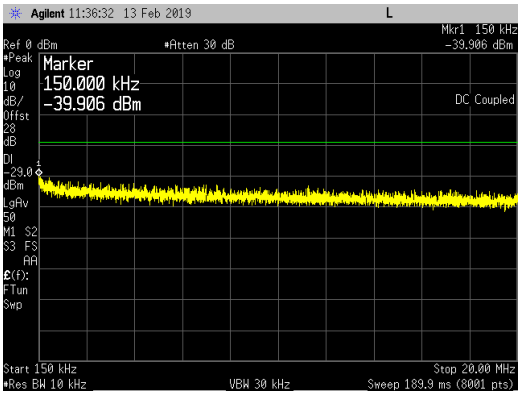


LTE20 Single Narrow Band IoT Lower Guard Band Carrier
-Single Carrier at Middle Channel (634.5MHz) at 40 watts/carrier and 40 watts/port:

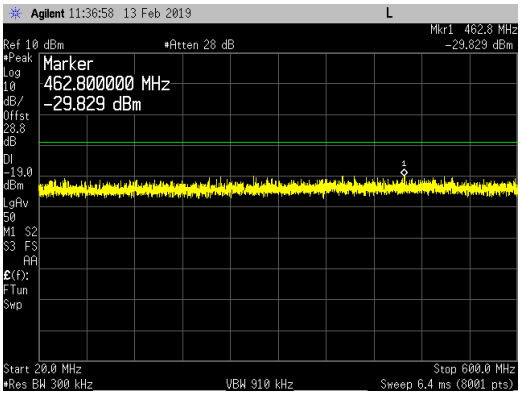
9kHz to 150kHz



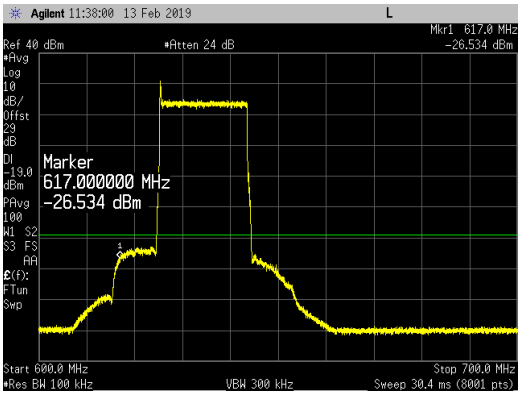
150kHz to 20MHz



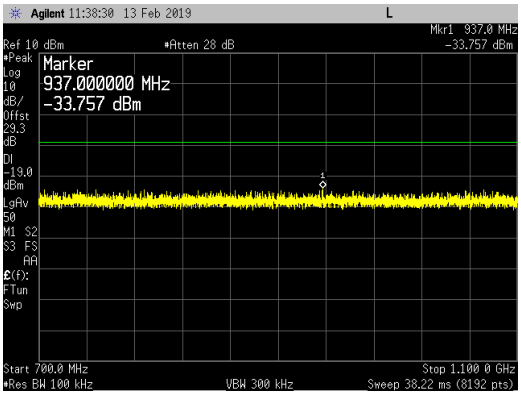
20MHz to 600MHz



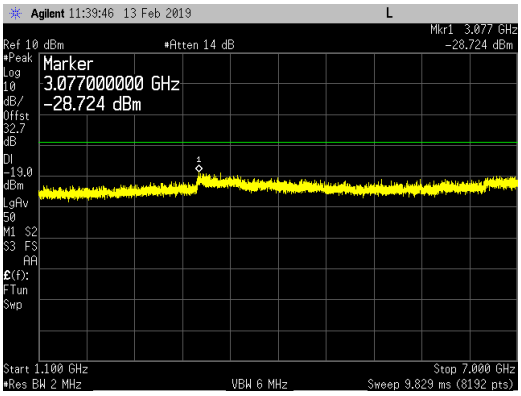
600MHz to 700MHz



700MHz to 1.1GHz

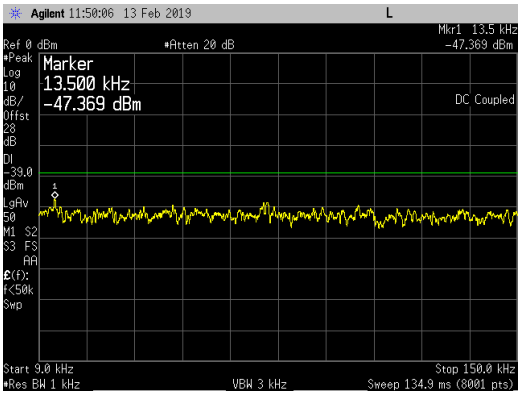


1.1GHz to 7GHz

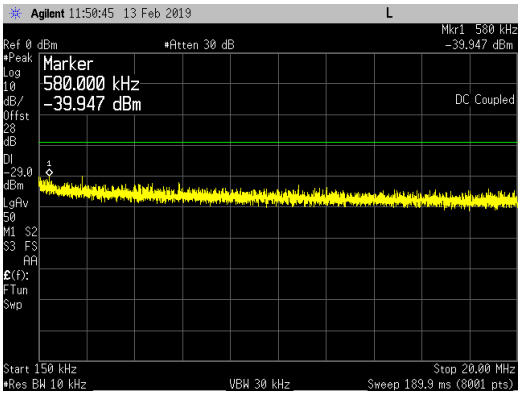


LTE20 Single Narrow Band IoT Upper Guard Band Carrier
-Single Carrier at Middle Channel (634.5MHz) at 40 watts/carrier and 40 watts/port:

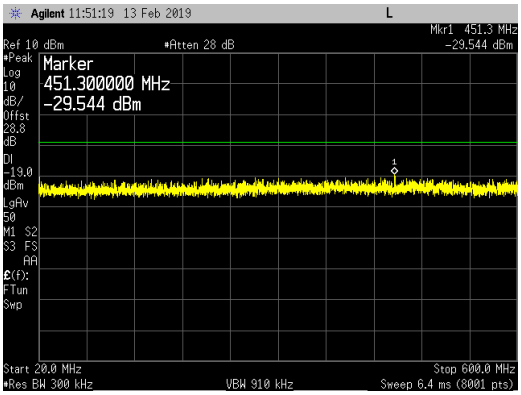
9kHz to 150kHz



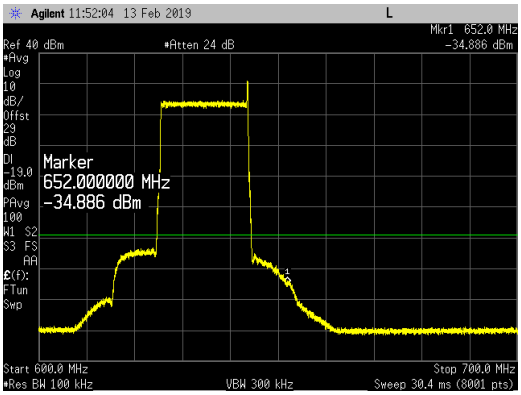
150kHz to 20MHz



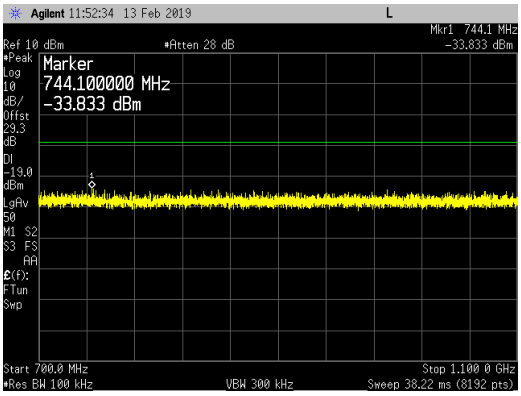
20MHz to 600MHz



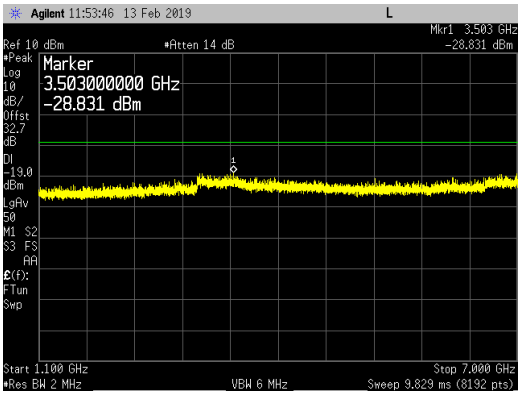
600MHz to 700MHz



700MHz to 1.1GHz

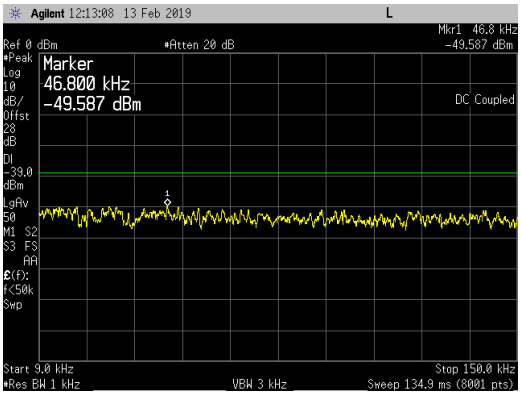


1.1GHz to 7GHz

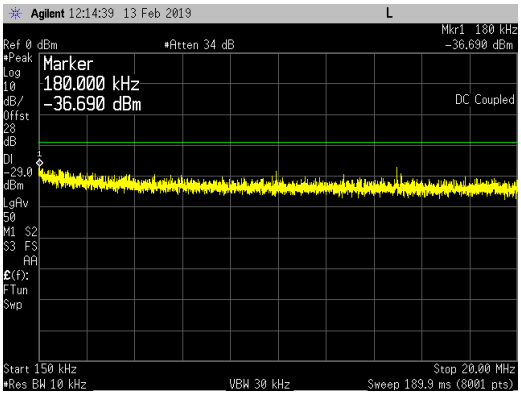


Single Narrow Band IoT Lower Guard Band Carrier
- Multi Carrier_LTE10 Carriers at 622, 632 & 647MHz at 40W/Port:

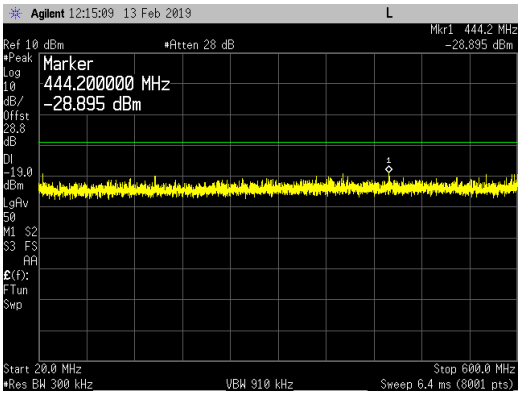
9kHz to 150kHz



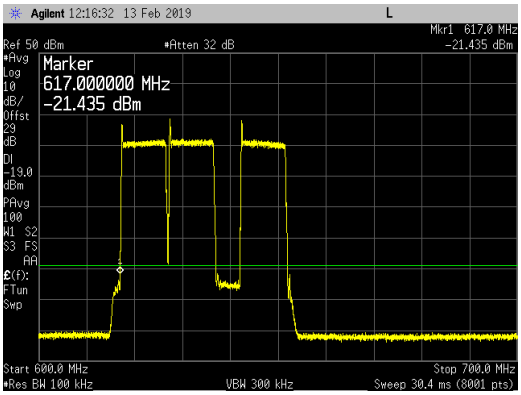
150kHz to 20MHz



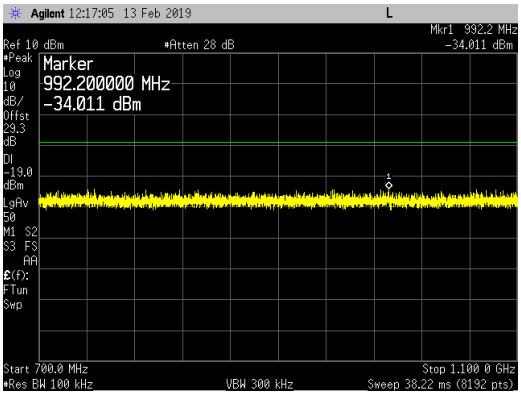
20MHz to 600MHz



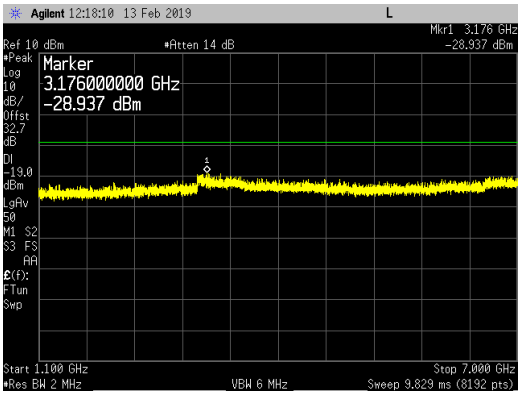
600MHz to 700MHz



700MHz to 1.1GHz

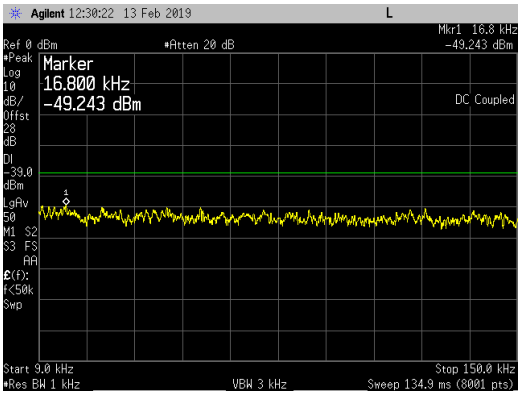


1.1GHz to 7GHz

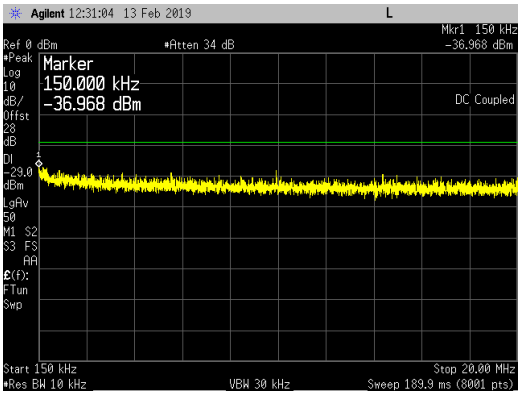


Single Narrow Band IoT Upper Guard Band Carrier
- Multi Carrier_LTE10 Carriers at 622, 632 & 647MHz at 40W/Port:

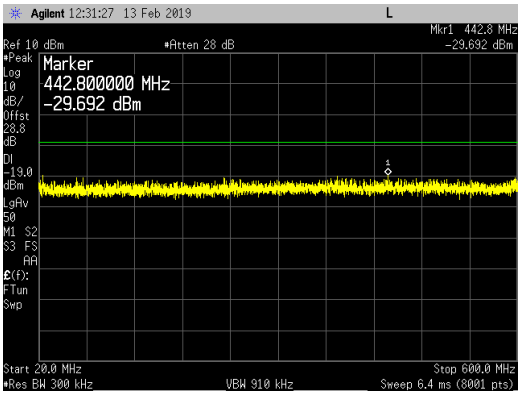
9kHz to 150kHz



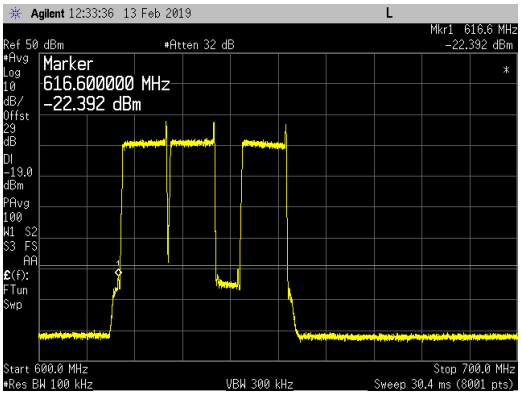
150kHz to 20MHz



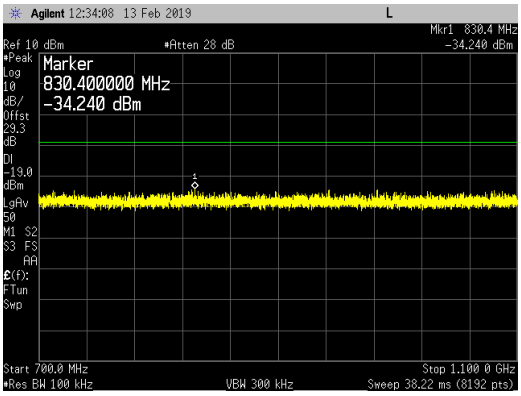
20MHz to 600MHz



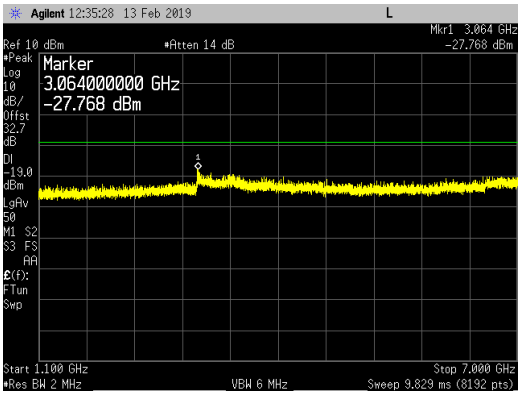
600MHz to 700MHz



700MHz to 1.1GHz



1.1GHz to 7GHz



Transmitter Radiated Spurious Emissions

Radiated spurious emission plots/measurement results are in the original FCC and IC radio certification submittal (NTS Test Report Number PR065304 Revision 1 dated August 2, 2017).

Frequency Stability/Accuracy

Frequency Stability/Accuracy measurement results are in the original FCC and IC radio certification submittal (NTS Test Report Number PR065304 Revision 1 dated August 2, 2017).

End of Report