Radio Test Report

Application for Grant of Equipment Authorization

FCC Part 24
[1930MHz – 1995MHz]

FCC ID: VBNAHFB-01

ACCREDITED
CERTIFICATE #: 0214.19

Product Name: Airscale Base Transceiver Station Micro Remote Radio Head
Model: AHFB

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

Test Dates: April 16, 2019
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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	04/22/2019	Initial Draft	BreAnna Cheatham

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SCOPE

Tests have been performed on Nokia Solutions and Networks product Airscale Base Station Micro Remote Radio Head (RRH) Model AHFB, 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 24 Subpart E – Broadband PCS

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 Airscale Base Station Micro Remote Radio Head (RRH) Model AHFB 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 AHFB. No additional models were described or supplied for testing.

STATEMENT OF COMPLIANCE

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

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

DEVIATIONS FROM THE STANDARDS

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

TEST RESULTS SUMMARY

The following tables provide a summary of the test results:

FCC Part 24 (Base Stations Operating in the 1930MHz to 1995MHz Band)

AHFB operating in the PCS Band				
FCC	Description	Measured	Limit	Results
Transmitter Modulation, output power and other characteristics				
24.229	Frequency Ranges	LTE10: 1935.0 – 1990.0MHz LTE15: 1937.5 – 1987.5MHz LTE20: 1940.0 – 1985.0MHz	1930.0 – 1995.0MHz	Pass
2.1047	Modulation Type	NB IoT Guard band (QPSK) with LTE10, LTE15 & LTE20	Digital	Pass
24.232	Output Power	Highest Conducted Power Output RMS: 36.93dBm EIRP depends on antenna gain which is unknown	1640W EIRP	Pass
24.232	Peak to Average Power Ratio	Highest Measured PAPR: 7.37dB	13dB	Pass
	99% Emission Bandwidth	LTE10: 9.2436MHz LTE15: 13.8376MHz LTE20: 18.3368MHz	Remain in Block	Pass
24.238	26dB down Emission Bandwidth	LTE10: 9.825MHz Emission Designator: 9M83F9W LTE15: 14.791MHz Emission Designator: 14M8F9W LTE20: 19.754MHz Emission Designator: 19M8F9W	Remain in Block	Pass
Transmitter Spurious Emissions[1]				
24.238	At the antenna terminals	< -19dBm	-19dBm per Transmit Chain	Pass
	Field Strength	61.6dBuV/m at 3m Eq. to -35.8dBm EIRP	-13dBm EIRP	Pass[2]
Other Details				
24.235	Frequency Stability	Stays within authorized frequency block	Stays within block	Pass[2]
1.1310	RF Exposure	N/A		Pass[3]

Note 1: Based on 1MHz RBW. In the 1MHz immediately outside and adjacent to the frequency block a RBW of at least 1% of the emission bandwidth was used. The measurement bandwidth is 1MHz for measurements more than 1MHz from the band edge.
Note 2: See the original FCC radio certification report for details (TUV Document 75938943 Report 01 Issue 1 dated 10 May 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 Airscale BTS Micro RRH model AHFB Federal Communication Commission certifications. The original FCC radio certification submittal is TUV Report Document Number 75938943 Report 1 Issue 1 dated May 10, 2017. The original test effort includes testing for LTE technologies. Please refer to the test report on the original certification for details.

Conducted RF tests performed under this 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 NB-IoT guard band 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)". NB IoT guard band offsets from LTE carrier center frequencies are as follows - LTE10: $\pm$ 4597.5 kHz, LTE 15: $\pm$ 6892.5kHz, and LTE20: $\pm$ 9097.5kHz. The RRH NB-IoT GB operations are supported with LTE bandwidths of 10, 15 and 20MHz.

The radiated emissions and frequency stability measurements performed in the original certification were 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 Airscale Base Transceiver Station (BTS) Micro Remote Radio Head (RRH) module, model AHFB. The AHFB remote radio head is a 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 AHFB RRH has four Band 25 transmit/four receive antenna ports (4TX/4RX). Each antenna port supports 3GPP frequency band 25 operations (BTS Rx: 1850 to 1915 MHz/BTS TX: 1930 to 1995 MHz). The maximum RF output power of the RRH is 20 Watts (5 watts per carrier, 5 watts per antenna port). The RRH can be operated as a 4x4 MIMO or 2x2 MIMO. The TX and RX instantaneous bandwidth cover the full operational RRH bandwidth. The RRH supports 5, 10, 15, and 20MHz LTE bandwidths. The RRH supports four LTE downlink modulation types (QPSK, 16QAM, 64QAM and 256QAM). Multi-carrier operation (up to four carriers) is supported.

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

The AHFB LTE channel numbers and frequencies are as follows:

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

AHFB Downlink Band Edge LTE Band 25 Frequency Channels

Note:

(1) Narrow Band IoT Guard Band operations are not supported for LTE5 channel bandwidth.
(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 8090: 1935.0 & EARFCN 8190: 1945.0MHz) and a third carrier with maximum spacing between the other two carrier frequencies (EARFCN 8640: 1990.0MHz) at the upper band edge was verified.

EUT Hardware

The EUT hardware used in testing on April 16, 2019.

Company	Model	Description	Part/Serial Number	FCC ID Number
Nokia Solutions and Networks	AHFB	AirScale BTS RRH	Part#: 474036A.101 Serial#: EA171610414	FCC ID: VBNAHFB-01

Enclosure

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

Configuration	Approximate Weight	Approximate Dimensions	Approximate Volume
AHFB	5.5 kg	295x245x55 mm	4 Liters

Support Equipment

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	ASIA	Airscale System Module	Part#: 473095A.101 Serial#: L1164309322	N/A
Dell	Studio XPS	Instrumentation PC	N/A	N/A

Auxillary Equipment

Company	Description	Part Number	Serial Number
Nokia	FOUC 10GHz SFP Module (Plugs into RRH Opt Ports)	473842A.101	KR1618090020071
RLC Electronics	2.4GHz High Pass Filter- 2 Watt	F-100-3000-5-R	0028
Microwave Circuits	1.4GHz Low Pass Filter – 100 Watt	L13502G1	2454-01
Narda	Attenuator 30dB-50 Watt	7768-30	-
Huber & Suhner	RF Cable – 1 meter	Sucoflex 104	551123/4
Huber & Suhner	RF Cable - 1 meter	Sucoflex 106	297370

EUT Operation

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

EUT Software

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

(1) RRH Unit Software: FRM58.11.R32I
(2) System Module Software: FL18A_ENB_0000_020203_000000
(3) BTS Site Manager: BTSSiteEM-FL18A_0000_000604_000000.exe

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 during the original certification effort (See TUV Report Document Number 75938943 Report 1 Issue 1 dated May 10, 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 complementary cumulative distribution function (CCDF) measurements were performed with a 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.

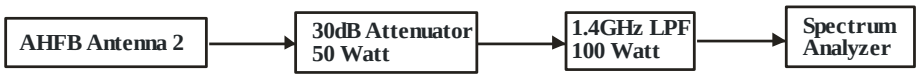
The emissions at the band edges were captured with Keysight Benchvue Software with settings described in the corresponding sections of the FCC and IC regulatory requirements. Spectrum analyzer settings are shown on their corresponding plots in test results section.

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

Conducted spurious emissions were captured with Keysight Benchvue Software across the 9kHz-20GHz frequency span. A low pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges below 20MHz. A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 3GHz. The total measurement RF path loss of the test setup (attenuators, filters 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 are the setups used in the RF conducted emissions testing. Photographs of the test setups are also provided.



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

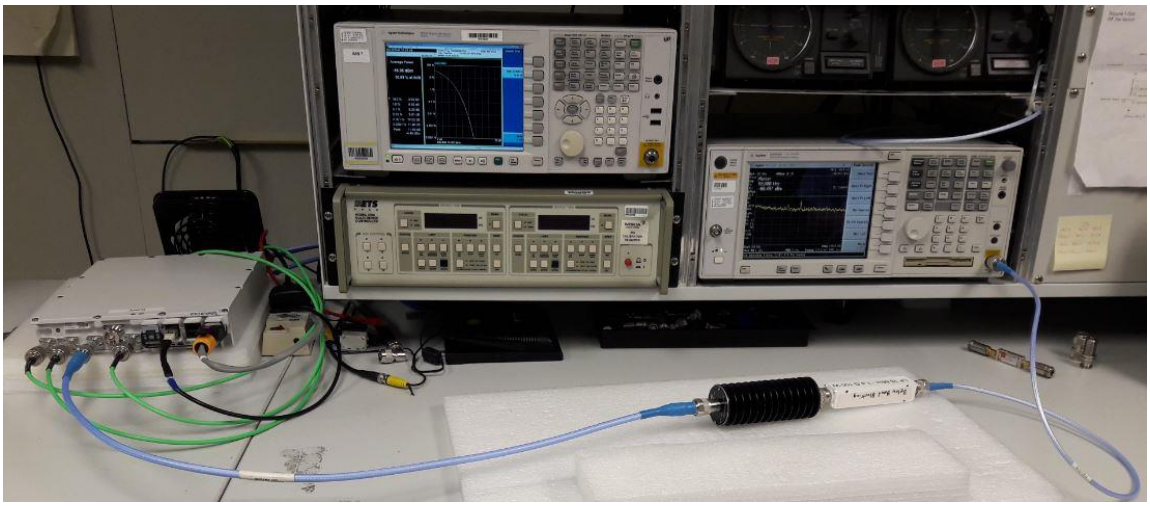


Photo of 9kHz to 150kHz and 150kHz to 20MHz Setup

Setup for 20MHz to 3GHz Measurement

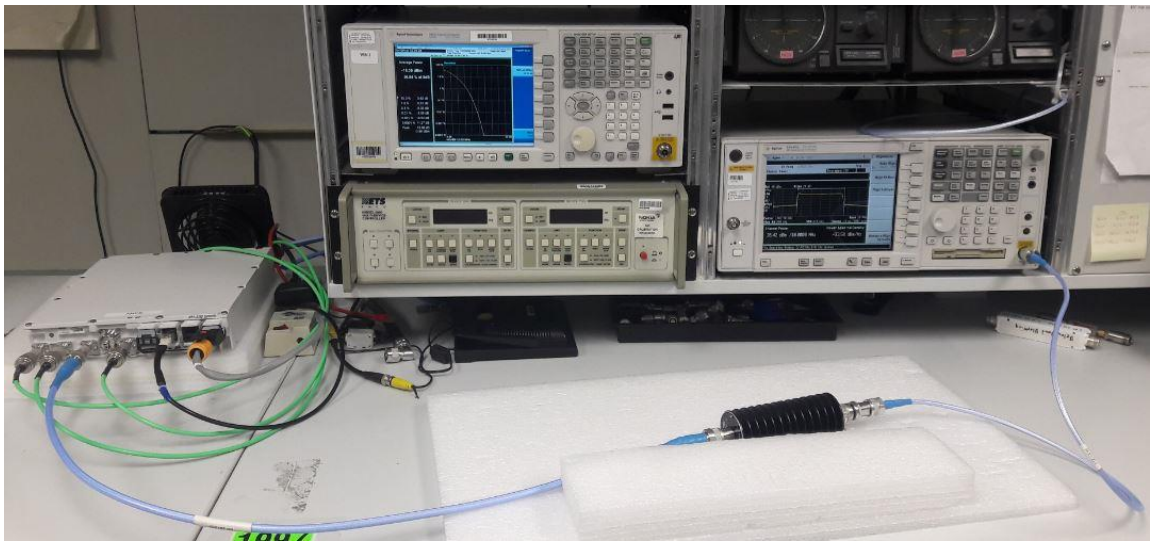
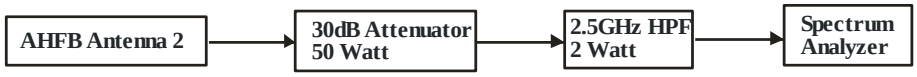


Photo of 20MHz to 3GHz Setup



Setup for 3GHz to 13GHz and 13GHz to 20GHz Measurements

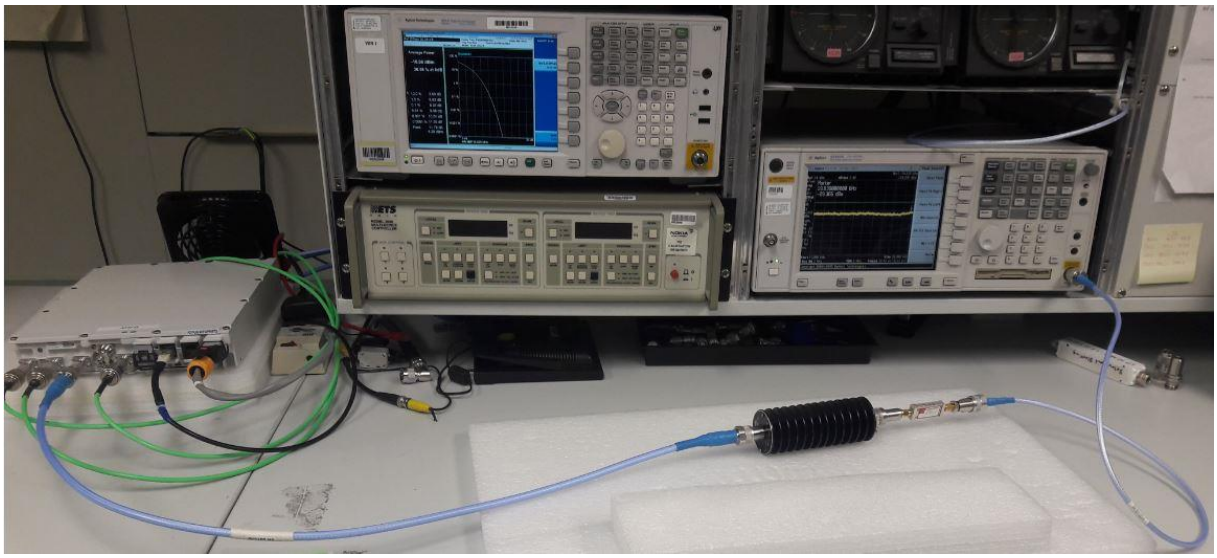


Photo of 3GHz to 13GHz and 13GHz to 20GHz Setup

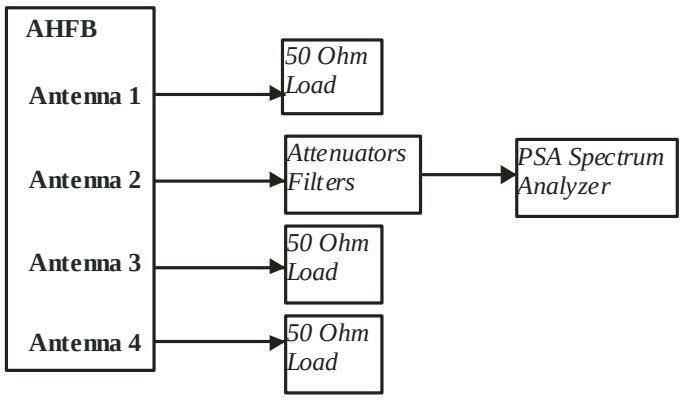
Test Measurement Equipment

Nokia Equipment #	Description	Manufacturer	Model	Calibration Duration	Calibration Due Date
120194	PSA Spectrum Analyzer	Agilent	E4440A	12 Months	10/17/2019
NM04509	Network Analyzer	Rohde & Schwarz	ZVL 3	12 Months	02/12/2020
NM06345	Network Analyzer	Keysight	E5063A	12 Months	12/15/2019
NM06374	MXG Analog Signal Gen	Keysight	N5183B	36 Months	02/04/2021
NM04508	MXA Signal Analyzer	Agilent	N9020A	24 Months	05/02/2019

APPENDIX A: ANTENNA PORT TEST DATA FOR THE PCS BAND

All conducted RF measurements in this section were made at AHFB antenna ports.

All testing in this section was performed with 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 AHFB

RF Output Power

RF output power has been measured in RMS Average terms for each PCS transmit chain at the middle channel (1962.5 MHz) for the Narrow Band IoT Guard Band LTE10 carriers as described in section 5.2 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.4.4. The AHFB 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 the upper narrow band IoT guard band carriers. All results are presented in tabular form below. The highest measured values are highlighted.

Ant Port at LTE Channel	LTE BW with Lower & Upper NB-IoT GB carriers	PAPR (dB)	Average (dBm)
Port 1 at Middle Channel	**10MHz with upper IoT GB carrier**	7.20	36.78
Port 2 at Middle Channel	**10MHz with upper IoT GB carrier**	7.20	**36.93**
Port 3 at Middle Channel	**10MHz with upper IoT GB carrier**	7.18	36.82
Port 4 at Middle Channel	**10MHz with upper IoT GB carrier**	7.20	36.80

The highest power port was selected as the worst case. Based on the results above, Port 2 had the highest RMS average power (represents the worst case) and therefore it was selected for all the remaining antenna port tests.

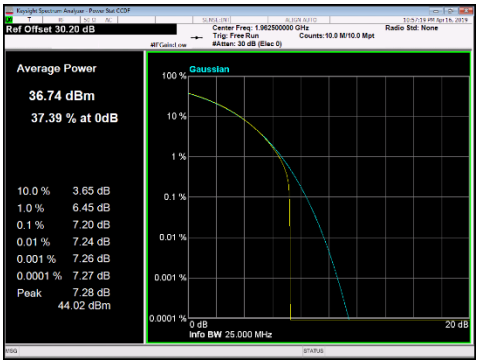
Subsequently output power levels on bottom, middle, and top channels in all 3 LTE channel bandwidths available (10, 15, & 20MHz) for the Narrow Band IoT Guard Band carrier were tested only at Port 2 and the results presented below. Measurements were performed for both the upper and lower narrow band IoT guard band carriers for each LTE channel bandwidth. The highest measured values are highlighted.

Ant Port 2 LTE Channel	LTE BW with Lower & Upper NB-IoT GB carriers	PAPR (dB)	Average (dBm)
Bottom Channel	**10MHz with lower IoT GB carrier**	7.25	36.57
Bottom Channel	**10MHz with upper IoT GB carrier**	7.23	36.63
Bottom Channel	**15MHz with lower IoT GB carrier**	7.31	36.66
Bottom Channel	**15MHz with upper IoT GB carrier**	7.30	36.73
Bottom Channel	**20MHz with lower IoT GB carrier**	**7.37**	36.73
Bottom Channel	**20MHz with upper IoT GB carrier**	7.34	36.80
Middle Channel	**10MHz with lower IoT GB carrier**	7.19	36.92
Middle Channel	**10MHz with upper IoT GB carrier**	7.20	**36.93**
Middle Channel	**15MHz with lower IoT GB carrier**	7.20	36.91
Middle Channel	**15MHz with upper IoT GB carrier**	7.20	**36.93**
Middle Channel	**20MHz with lower IoT GB carrier**	7.19	36.89
Middle Channel	**20MHz with upper IoT GB carrier**	7.19	36.87
Top Channel	**10MHz with lower IoT GB carrier**	7.25	36.59
Top Channel	**10MHz with upper IoT GB carrier**	7.27	36.49
Top Channel	**15MHz with lower IoT GB carrier**	7.29	36.69
Top Channel	**15MHz with upper IoT GB carrier**	7.31	36.64
Top Channel	**20MHz with lower IoT GB carrier**	7.30	36.75
Top Channel	**20MHz with upper IoT GB carrier**	7.32	36.71

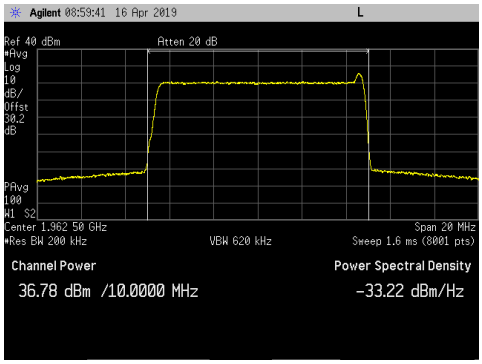
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 30.2 dB and is accounted for by the spectrum analyzer reference level offset.

LTE10 Channel Power Plots at Middle Channel (1962.5MHz) for Single NB-IoT Upper Guard Carriers:

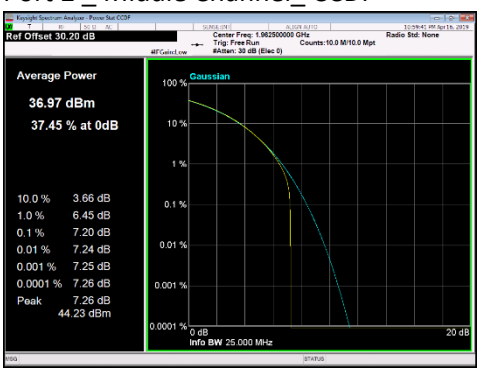
Port 1 _ Middle Channel_ CCDF



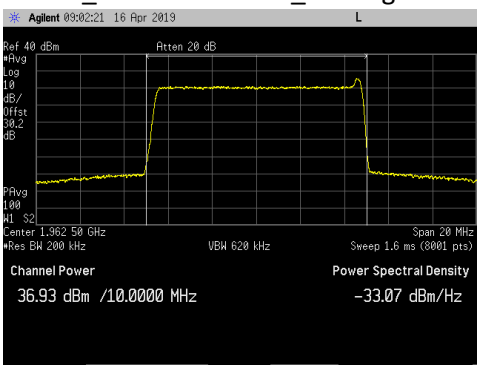
Port 1 _ Middle Channel_ Average



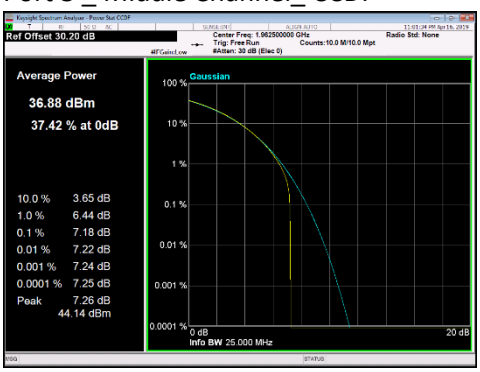
Port 2 _ Middle Channel_ CCDF



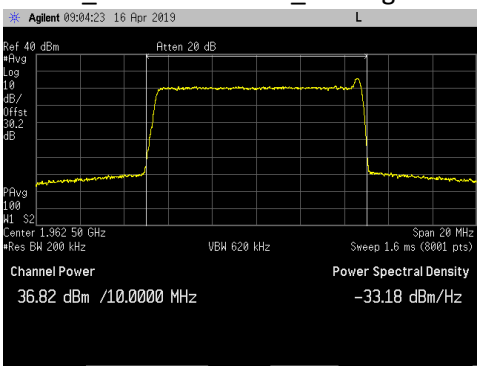
Port 2 _ Middle Channel_ Average



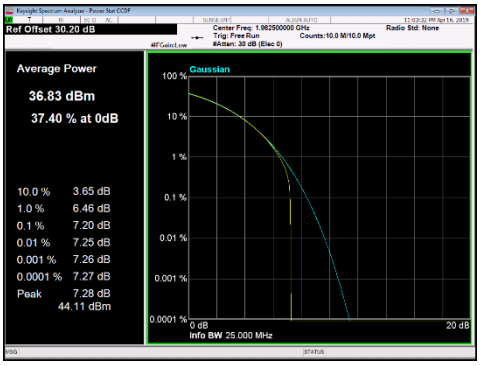
Port 3 _ Middle Channel_ CCDF



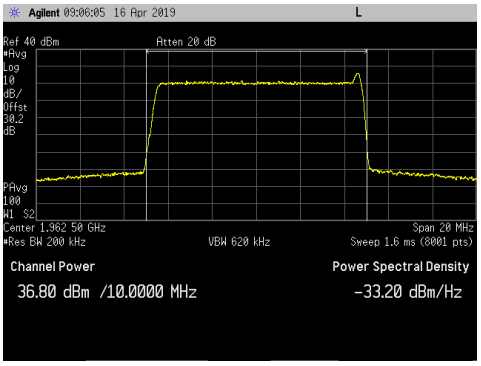
Port 3 _ Middle Channel_ Average



Port 4 _ Middle Channel_ CCDF

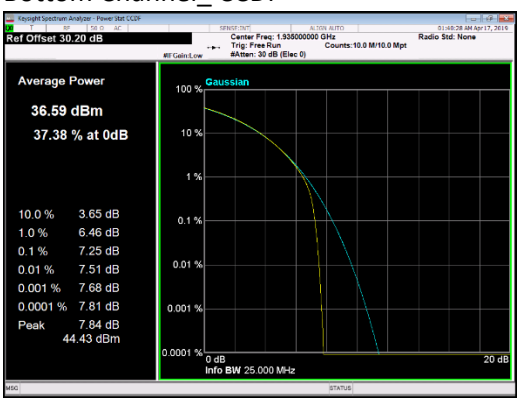


Port 4 _ Middle Channel_ Average

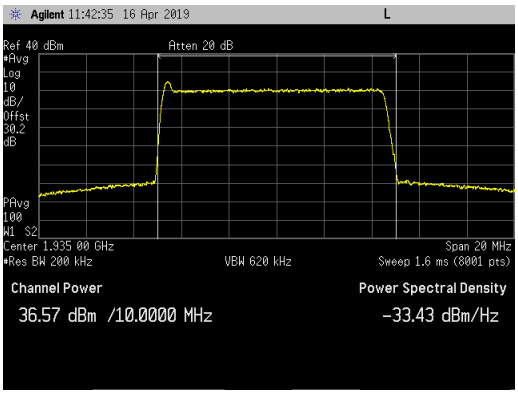


LTE10 Channel Power Plots for Single NB-IoT Lower Guard Band Carriers at Antenna Port 2:

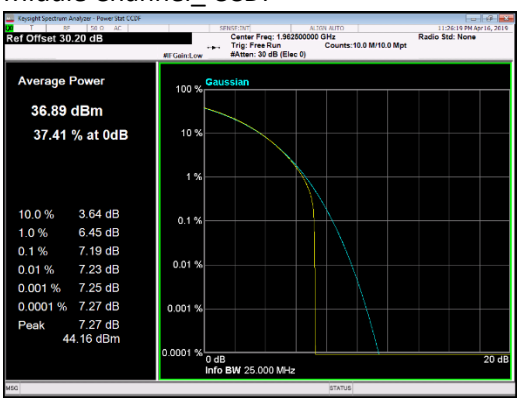
Bottom Channel_ CCDF



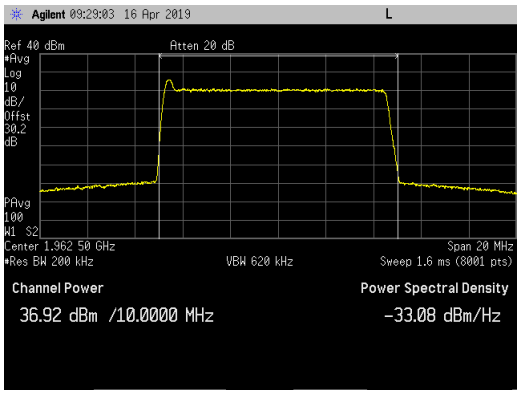
Bottom Channel_ Average



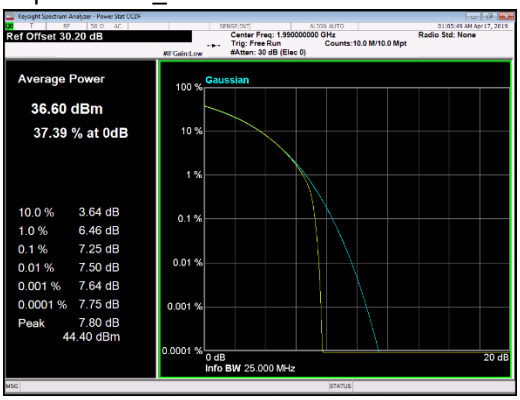
Middle Channel_ CCDF



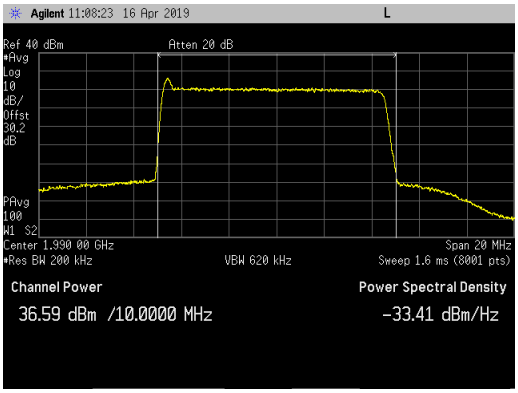
Middle Channel_ Average



Top Channel_ CCDF

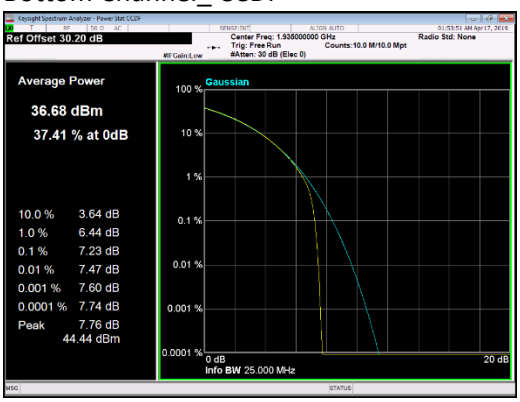


Top Channel_ Average

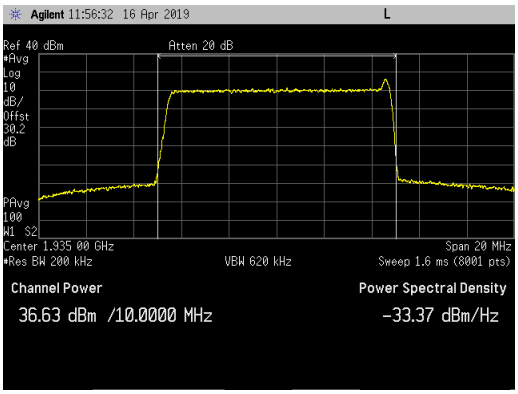


LTE10 Channel Power Plots for Single NB-IoT Upper Guard Band Carriers at Antenna Port 2:

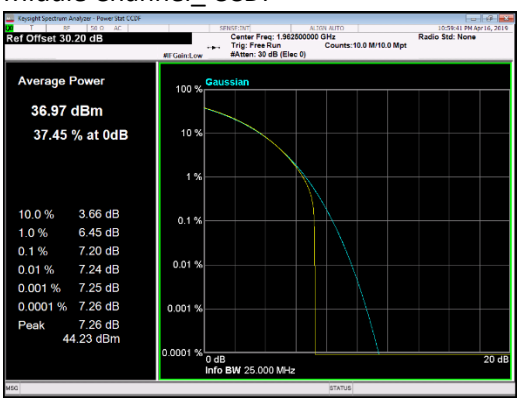
Bottom Channel_ CCDF



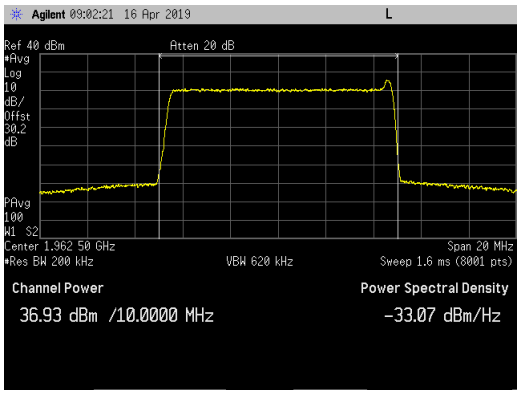
Bottom Channel_ Average



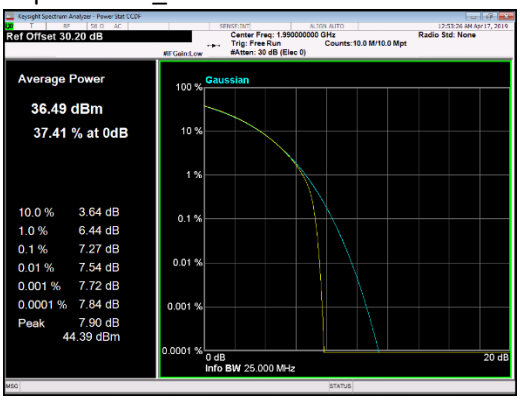
Middle Channel_ CCDF



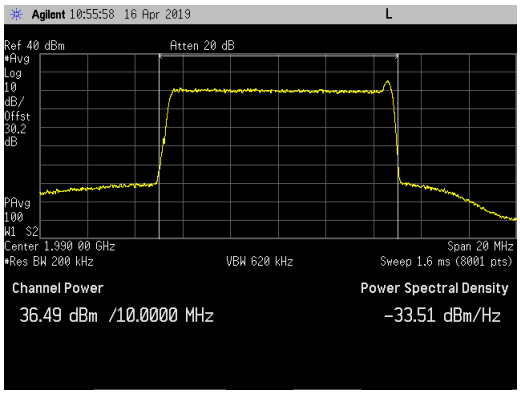
Middle Channel_ Average



Top Channel_ CCDF

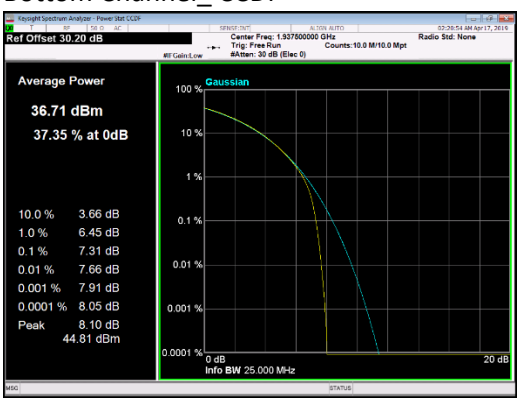


Top Channel_ Average

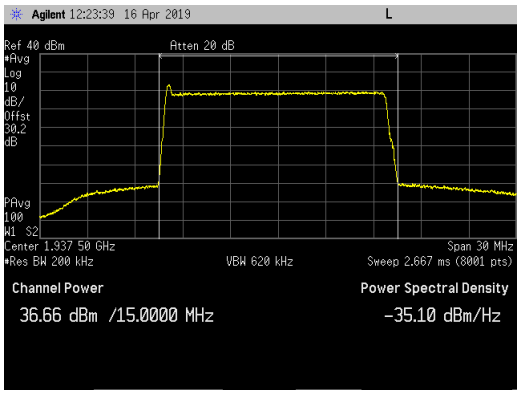


LTE15 Channel Power Plots for Single NB-IoT Lower Guard Band Carriers at Antenna Port 2:

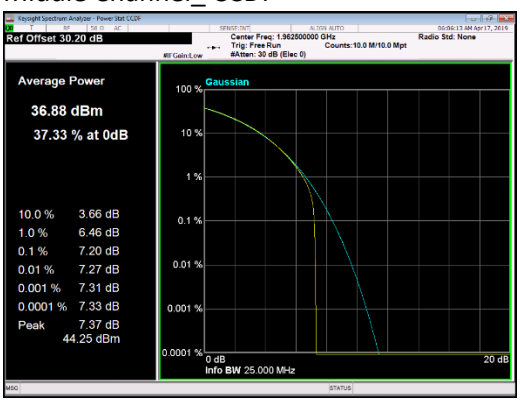
Bottom Channel_ CCDF



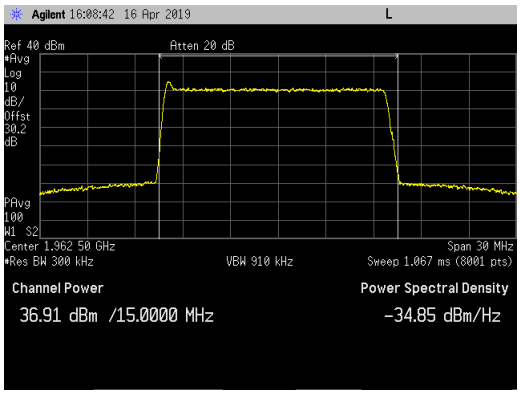
Bottom Channel_ Average



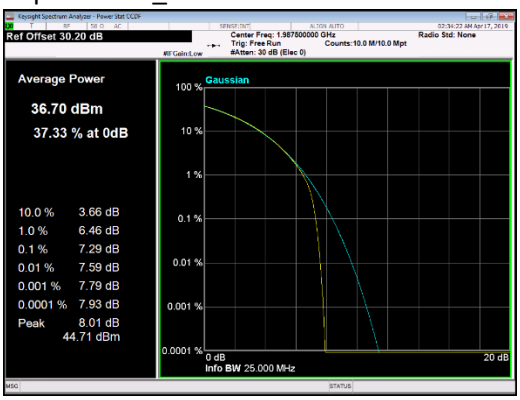
Middle Channel_ CCDF



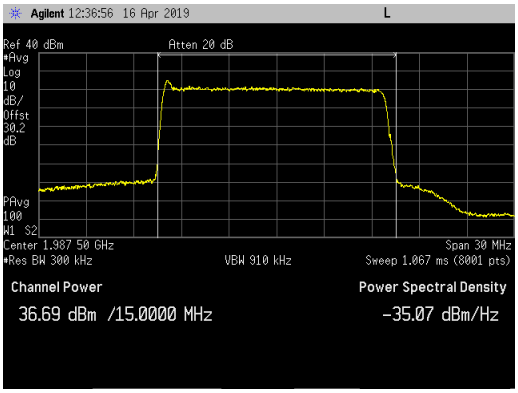
Middle Channel_ Average



Top Channel_ CCDF

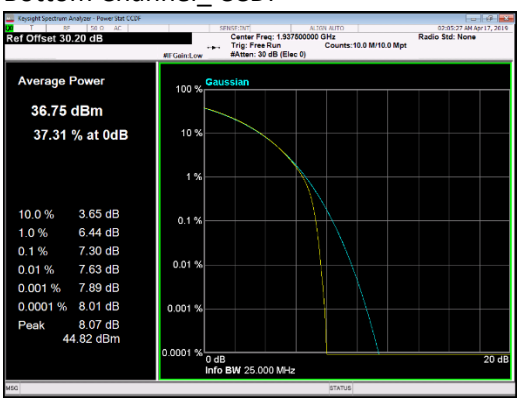


Top Channel_ Average

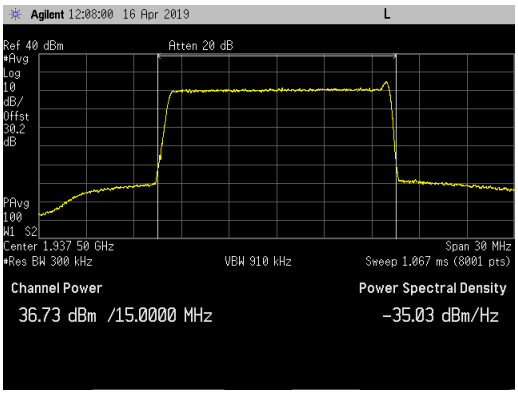


LTE15 Channel Power Plots for Single NB-IoT Upper Guard Band Carriers at Antenna Port 2:

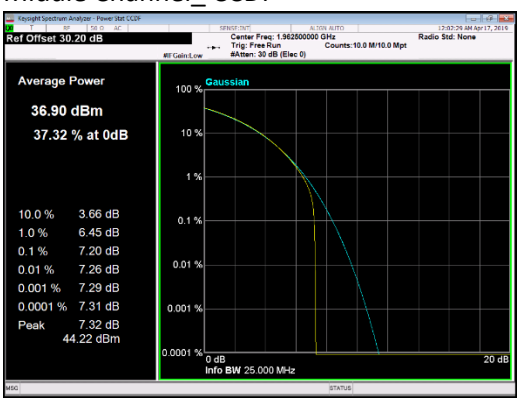
Bottom Channel_ CCDF



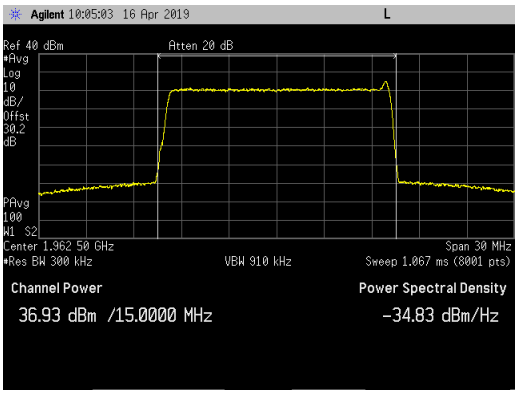
Bottom Channel_ Average



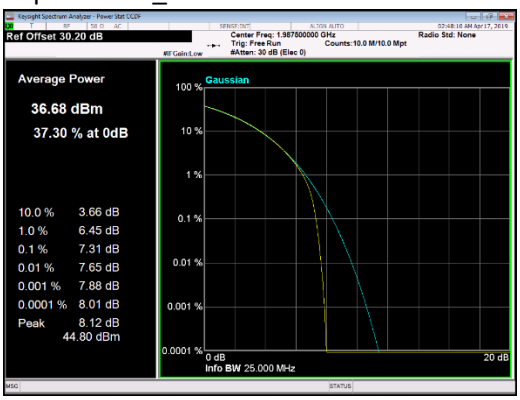
Middle Channel_ CCDF



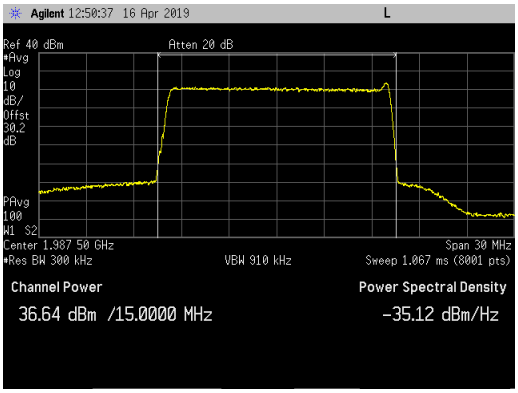
Middle Channel_ Average



Top Channel_ CCDF

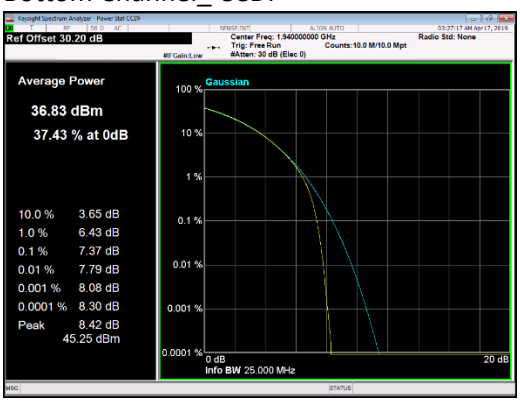


Top Channel_ Average

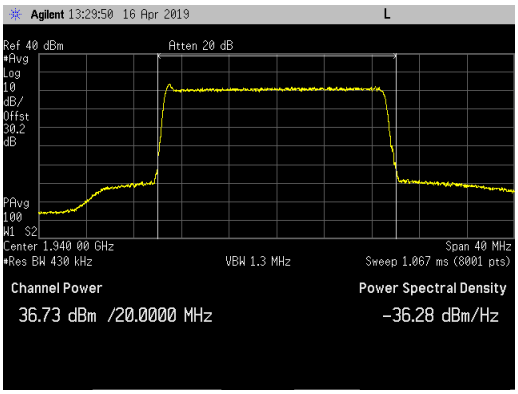


LTE20 Channel Power Plots for Single NB-IoT Lower Guard Band Carriers at Antenna Port 2:

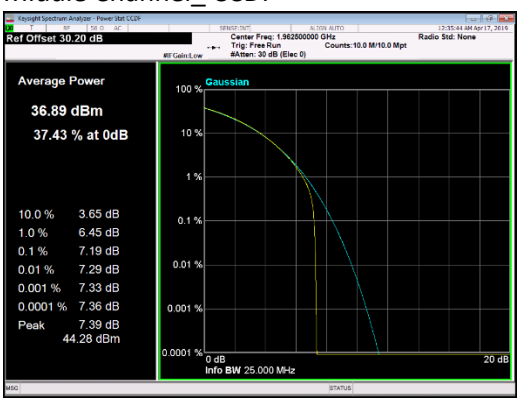
Bottom Channel_ CCDF



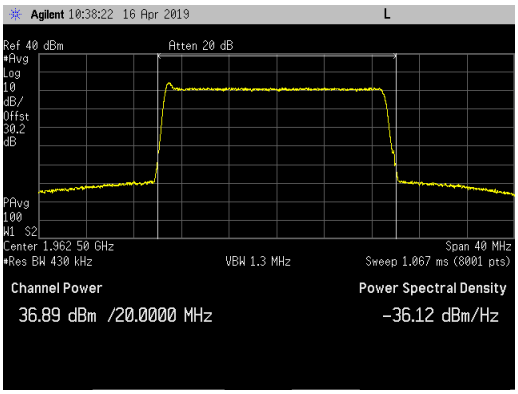
Bottom Channel_ Average



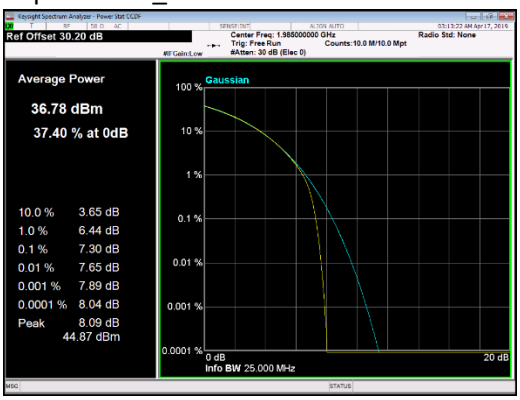
Middle Channel_ CCDF



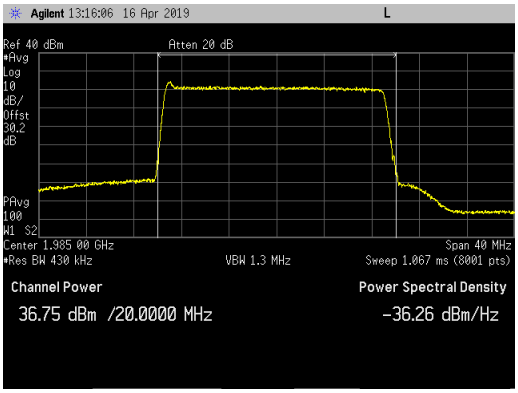
Middle Channel_ Average



Top Channel_ CCDF

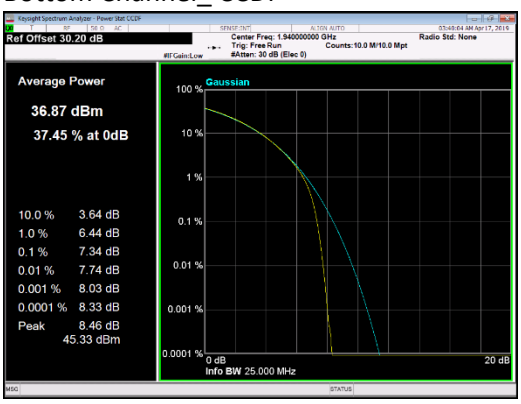


Top Channel_ Average

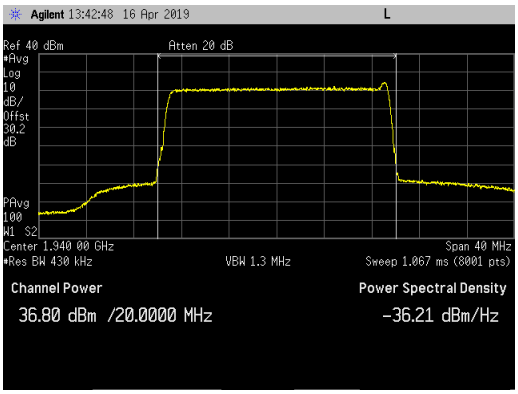


LTE20 Channel Power Plots for Single NB-IoT Upper Guard Band Carriers at Antenna Port 2:

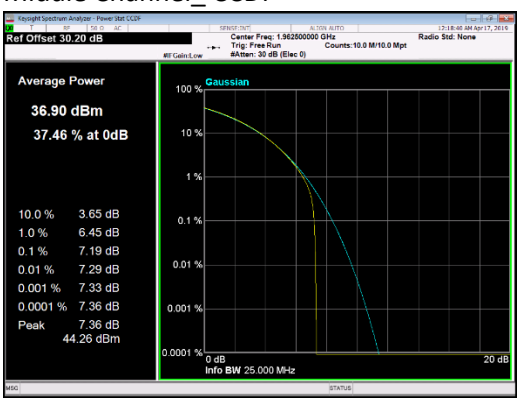
Bottom Channel_ CCDF



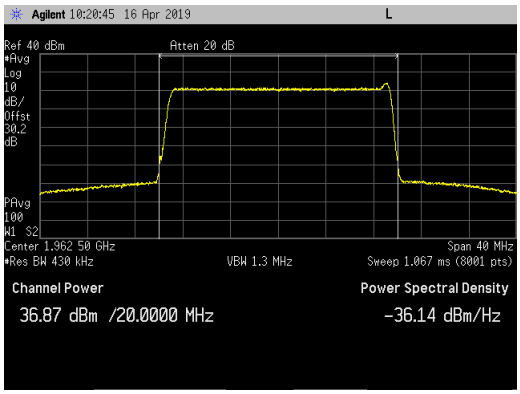
Bottom Channel_ Average



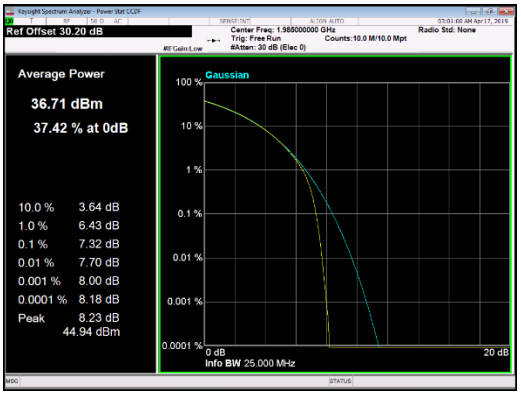
Middle Channel_ CCDF



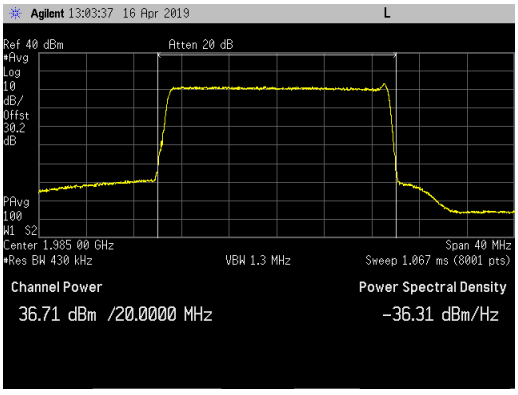
Middle Channel_ Average



Top Channel_ CCDF



Top Channel_ Average



Emission Bandwidth (26 dB down and 99%)

Emission bandwidth measurements were made at AHFB antenna port 2 on the bottom, middle and top channels for a single NB-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.

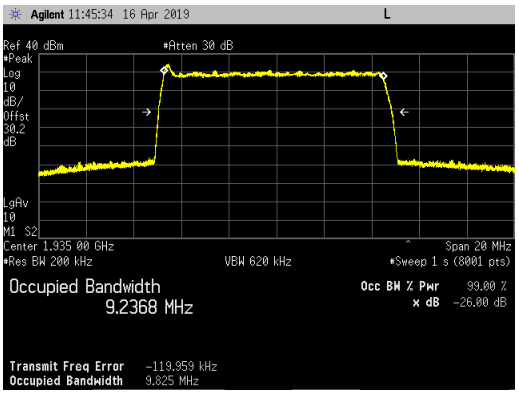
The 26dB emission bandwidth was measured in accordance with section 4 of FCC KDB 971168 D01v03r01 and ANSI C63.26 section 5.4. The 99% occupied bandwidth was measured in accordance with section 6.7 of RSS-Gen Issue 5. For both measurements, an occupied bandwidth built-in function in the spectrum analyzer was used. The results are provided in the following table. The largest emission bandwidths in each channel type are highlighted.

Ant Port 2 LTE Channel	LTE BW with Lower or Upper NB-IoT GB carriers	26dB Down Emission Bandwidth (MHz)	99% Emission Bandwidth (MHz)
Bottom Channel	**10MHz with lower IoT GB carrier**	**9.825**	9.2368
Bottom Channel	**10MHz with upper IoT GB carrier**	9.779	9.2344
Bottom Channel	**15MHz with lower IoT GB carrier**	14.789	13.8194
Bottom Channel	**15MHz with upper IoT GB carrier**	14.718	13.8230
Bottom Channel	**20MHz with lower IoT GB carrier**	**19.754**	18.3095
Bottom Channel	**20MHz with upper IoT GB carrier**	19.684	18.3139
Middle Channel	**10MHz with lower IoT GB carrier**	9.802	9.2370
Middle Channel	**10MHz with upper IoT GB carrier**	9.806	**9.2436**
Middle Channel	**15MHz with lower IoT GB carrier**	14.783	13.8219
Middle Channel	**15MHz with upper IoT GB carrier**	14.759	**13.8376**
Middle Channel	**20MHz with lower IoT GB carrier**	19.736	18.3314
Middle Channel	**20MHz with upper IoT GB carrier**	19.719	**18.3368**
Top Channel	**10MHz with lower IoT GB carrier**	9.785	9.2220
Top Channel	**10MHz with upper IoT GB carrier**	9.819	**9.2436**
Top Channel	**15MHz with lower IoT GB carrier**	14.741	13.7980
Top Channel	**15MHz with upper IoT GB carrier**	**14.791**	13.8293
Top Channel	**20MHz with lower IoT GB carrier**	19.674	18.3004
Top Channel	**20MHz with upper IoT GB carrier**	19.747	18.3229

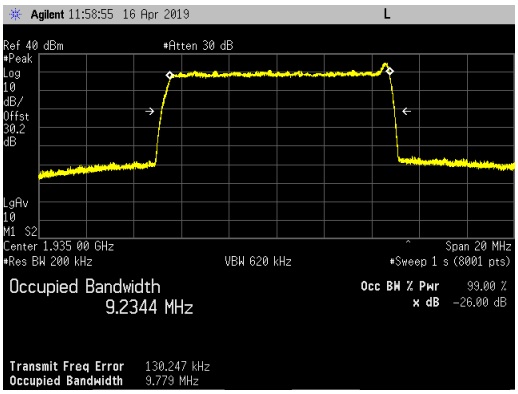
Emission bandwidth measurement data are provided in the following pages.

Emission Bandwidth Plots on the Bottom Channel for NB-IoT Guard Band Carriers on Antenna Port 2:

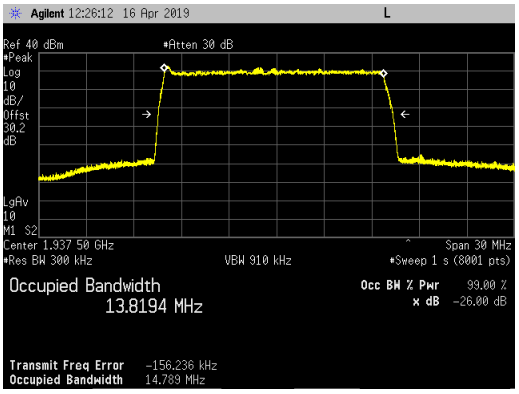
LTE10_ Lower Guard Band



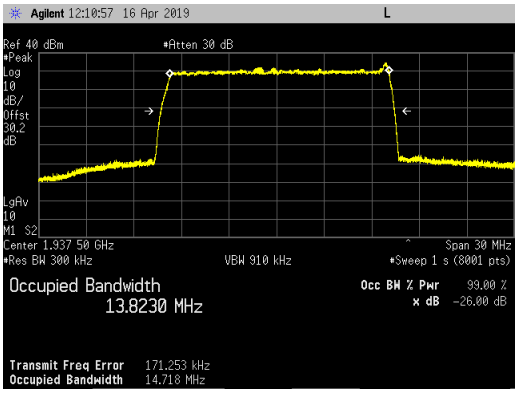
LTE10_ Upper Guard Band



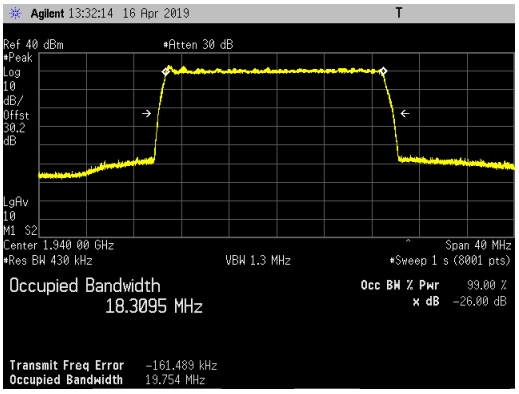
LTE15_ Lower Guard Band



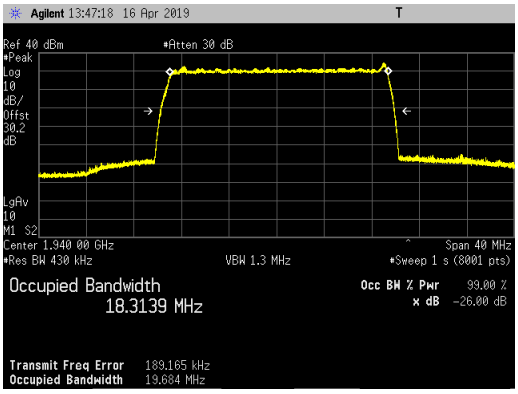
LTE15_ Upper Guard Band



LTE20_ Lower Guard Band

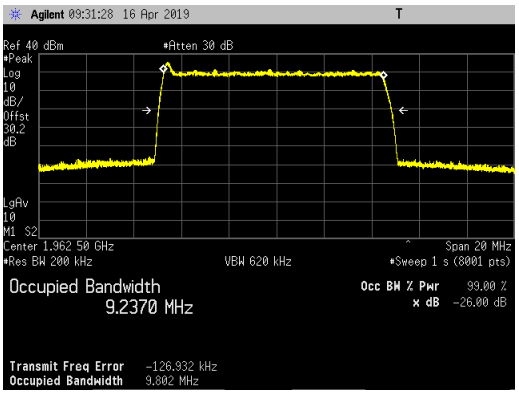


LTE20_ Upper Guard Band

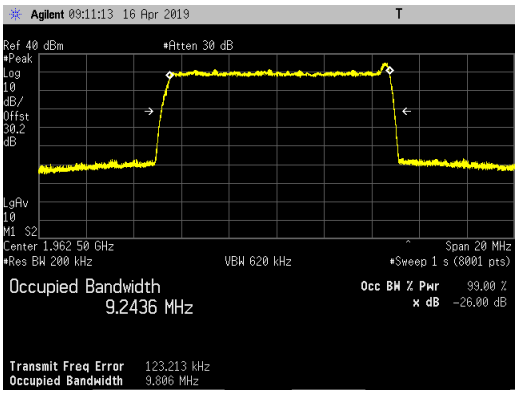


Emission Bandwidth Plots on the Middle Channel for NB-IoT Guard Band Carriers on Antenna Port 2:

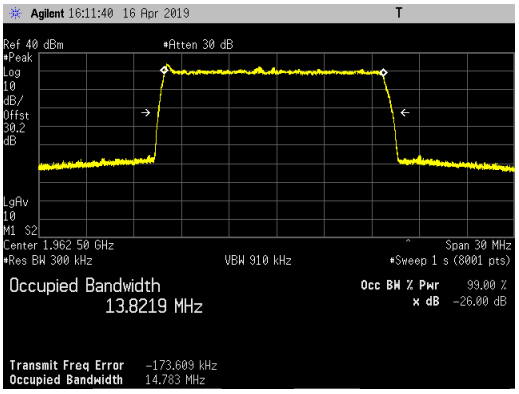
LTE10_ Lower Guard Band



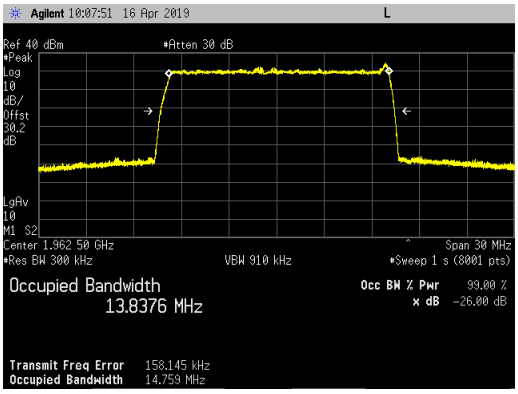
LTE10_ Upper Guard Band



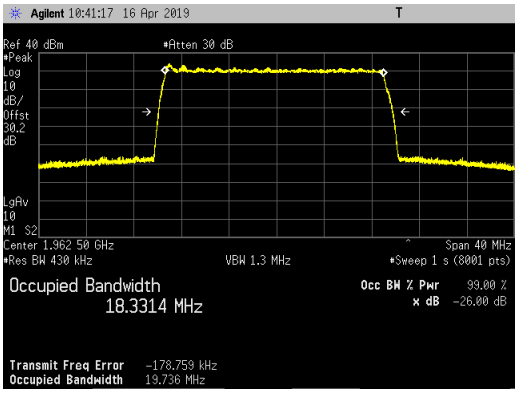
LTE15_ Lower Guard Band



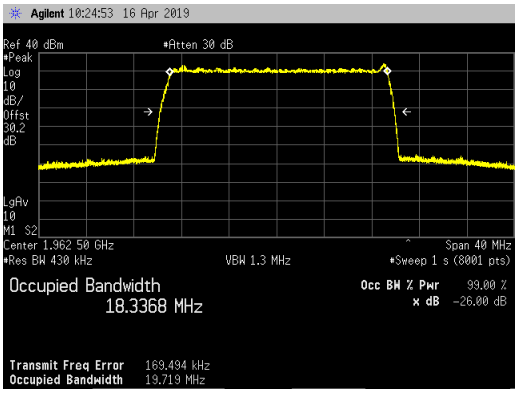
LTE15_ Upper Guard Band



LTE20_ Lower Guard Band

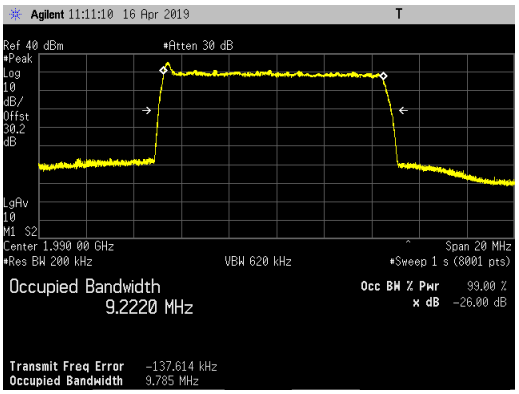


LTE20_ Upper Guard Band

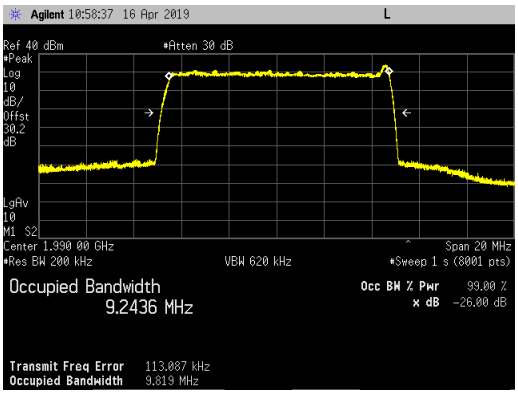


Emission Bandwidth Plots on the Top Channel for NB-IoT Guard Band Carriers on Antenna Port 2:

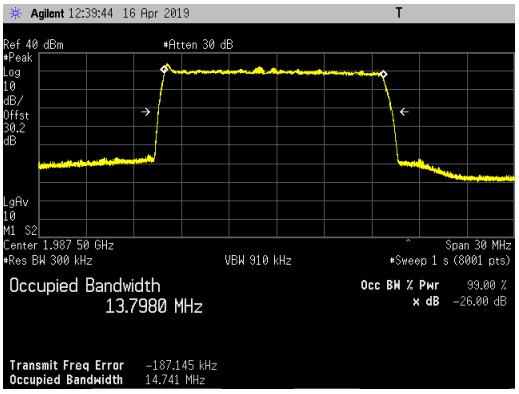
LTE10_ Lower Guard Band



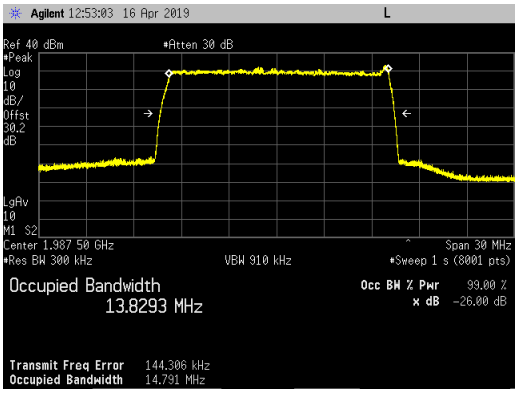
LTE10_ Upper Guard Band



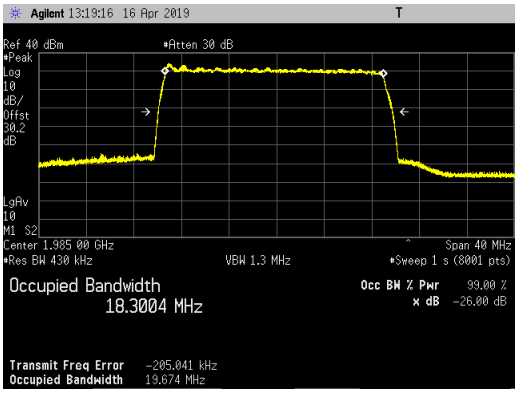
LTE15_ Lower Guard Band



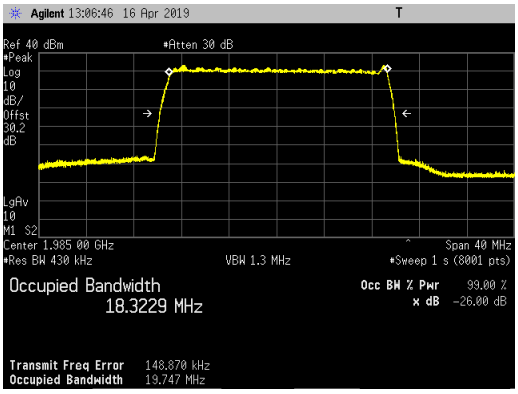
LTE15_ Upper Guard Band



LTE20_ Lower Guard Band



LTE20_ Upper Guard Band



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at RRH antenna port 2. For the single carrier test cases, 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 channel bandwidth at maximum power (5 watts/port and 5 watts/carrier).

A multicarrier test case based upon KDB 971168 D03v01 using three carriers (with smallest available carrier bandwidth – 10MHz) per antenna port was performed at maximum power (5 watts/port and 1.6 watts/carrier). The multicarrier test case is with two carriers (with minimum spacing between carrier frequencies) at the lower band edge (EARFCN 8090: 1935.0 & EARFCN 8190: 1945.0MHz) and a third carrier with maximum spacing between the other two carrier frequencies (EARFCN 8640: 1990.0MHz) at the upper band edge.

The limit of -19dBm was used in the certification testing. The limit is adjusted to -19dBm [-13dBm -10 log (4)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 4 port MIMO transmitter. Measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces. In the 1MHz bands outside and adjacent to the frequency block, a resolution bandwidth of 1% of the emission bandwidth was used. In the 1 to 2MHz frequency range outside the band edge (i.e.: 1928 to 1929MHz and 1996 to 1997MHz bands) the RBW was again reduced to 1% of the emission bandwidth and the power integrated over 1MHz. In the 2 to 22MHz frequency range outside the band edge (i.e.: 1908 to 1928MHz and 1997 to 2017MHz bands) a 1MHz RBW and 3MHz VBW was used.

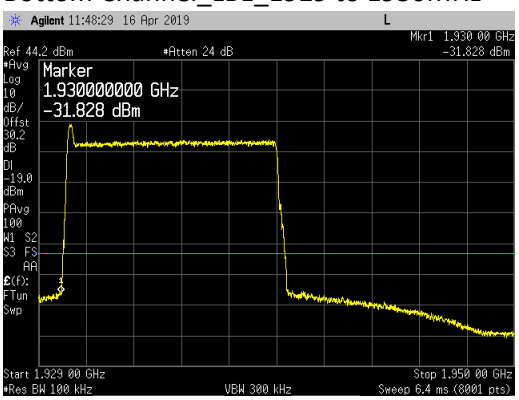
The results are summarized in the following table. The highest (worst case) emissions from the measurement data are provided.

Channel BW, Carrier Frequency, Carrier Power	NB IoT Guard Band Placement	Lower Band Edge (dBm)	Upper Band Edge (dBm)
Single 10MHz Carrier, 1935.0MHz (BC), 5W	**Lower**	**-23.210**	N/A
Single 10MHz Carrier, 1935.0MHz (BC), 5W	**Upper**	-24.078	N/A
Single 15MHz Carrier, 1937.5MHz (BC), 5W	**Lower**	-25.084	N/A
Single 15MHz Carrier, 1937.5MHz (BC), 5W	**Upper**	-25.717	N/A
Single 20MHz Carrier, 1940.0MHz (BC), 5W	**Lower**	-26.256	N/A
Single 20MHz Carrier, 1940.0MHz (BC), 5W	**Upper**	-26.609	N/A
Single 10MHz Carrier, 1990.0MHz (TC), 5W	**Lower**	N/A	-26.82
Single 10MHz Carrier, 1990.0MHz (TC), 5W	**Upper**	N/A	-25.85
Single 15MHz Carrier, 1987.5MHz (TC), 5W	**Lower**	N/A	-28.18
Single 15MHz Carrier, 1987.5MHz (TC), 5W	**Upper**	N/A	-27.13
Single 20MHz Carrier, 1985.0MHz (TC), 5W	**Lower**	N/A	-28.79
Single 20MHz Carrier, 1985.0MHz (TC), 5W	**Upper**	N/A	-28.496
Multi 10MHz Carriers, 1935, 1945 & 1990MHz at 1.6W/Carrier & 5W/port	**Lower**	-27.267	-29.29
Multi 10MHz Carriers, 1935, 1945 & 1990MHz at 1.6W/Carrier & 5W/port	**Upper**	-27.883	-28.65

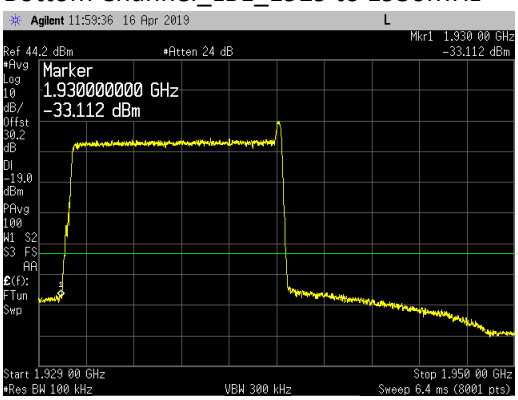
The total measurement RF path loss of the test setup (attenuator and test cables) was 30.2 dB and is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit. Conducted band edge measurements are provided in the following pages.

LTE10 Single 5W Carrier Lower Band Edge Plots for Antenna Port 2:

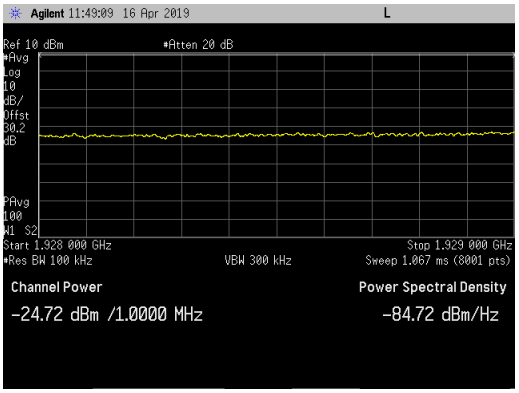
IoT Guard Band Carrier at Lower Placement
Bottom Channel_LBE_1929 to 1950MHz



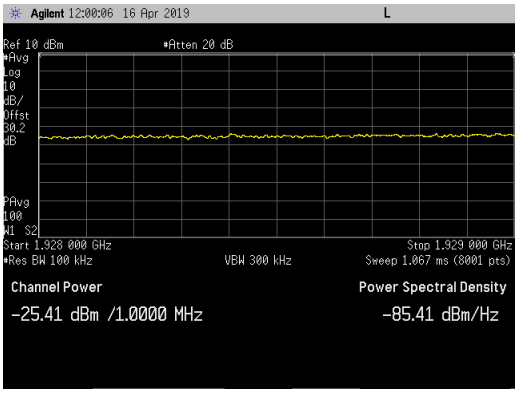
IoT Guard Band Carrier at Upper Placement
Bottom Channel_LBE_1929 to 1950MHz



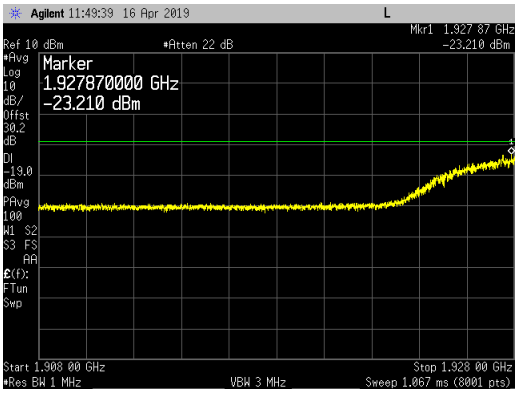
Bottom Channel_LBE_1928 to 1929MHz



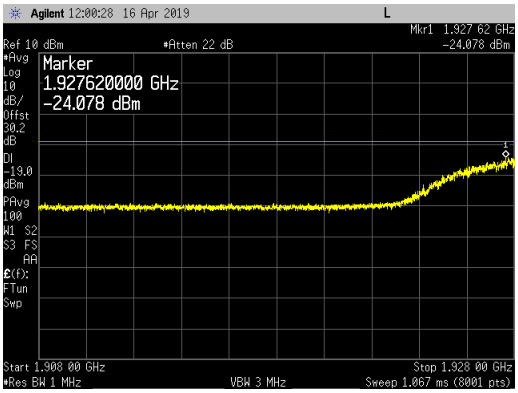
Bottom Channel_LBE_1928 to 1929MHz



Bottom Channel_LBE_1908 to 1928MHz

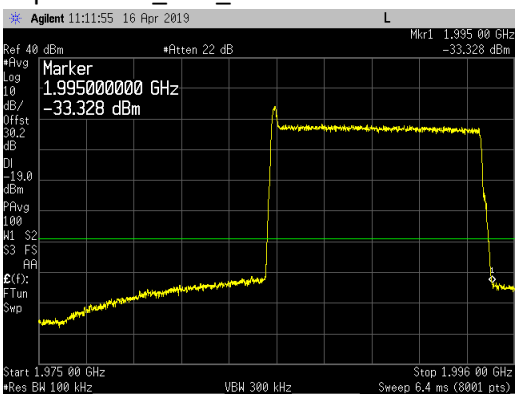


Bottom Channel_LBE_1908 to 1928MHz

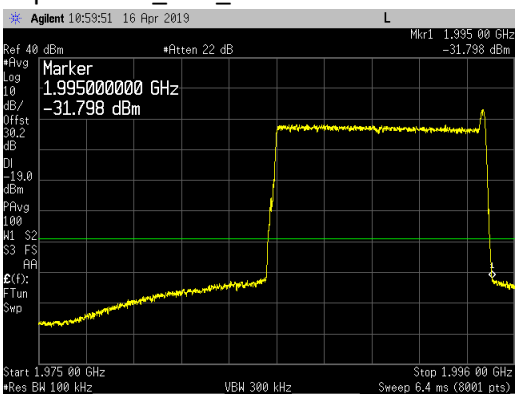


LTE10 Single 5W Carrier Upper Band Edge Plots for Antenna Port 2:

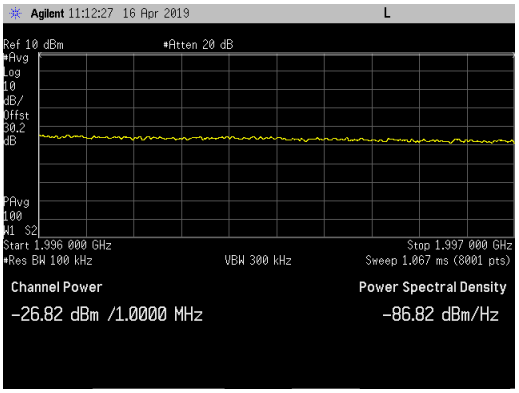
IoT Guard Band Carrier at Lower Placement
Top Channel_UBE_1975 to 1996MHz



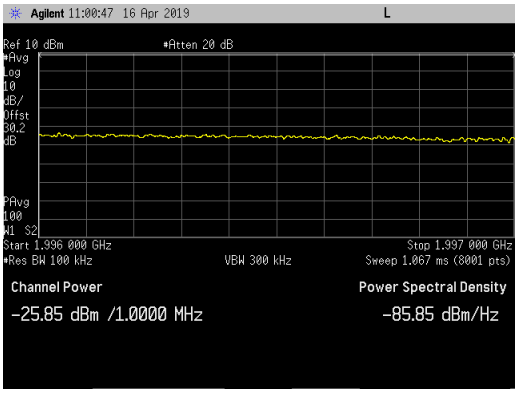
IoT Guard Band Carrier at Upper Placement
Top Channel_UBE_1975 to 1996MHz



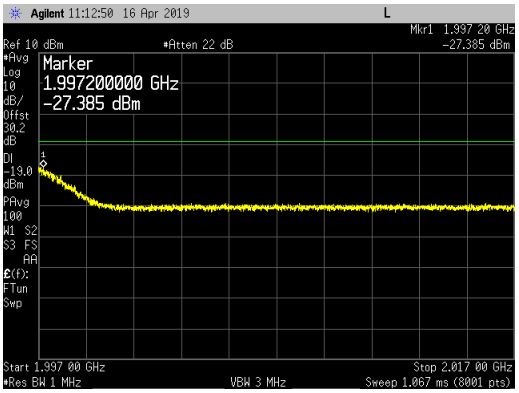
Top Channel_UBE_1996 to 1997MHz



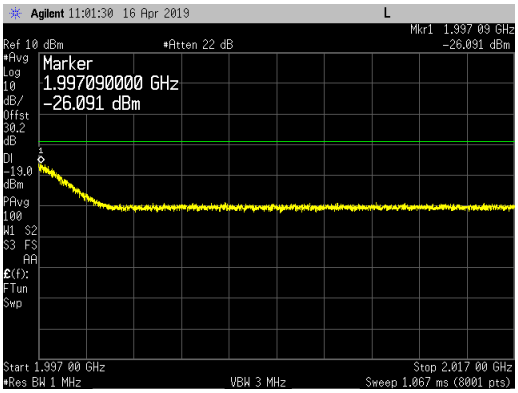
Top Channel_UBE_1996 to 1997MHz



Top Channel_UBE_1997 to 2017MHz

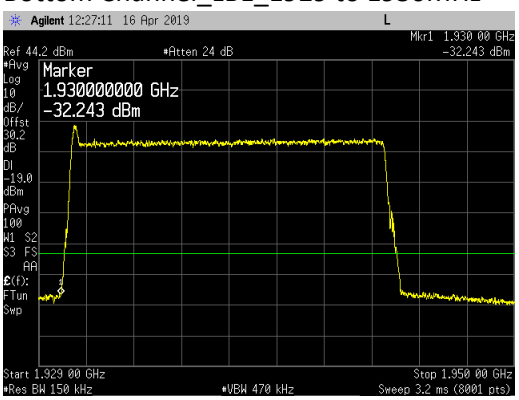


Top Channel_UBE_1997 to 2017MHz

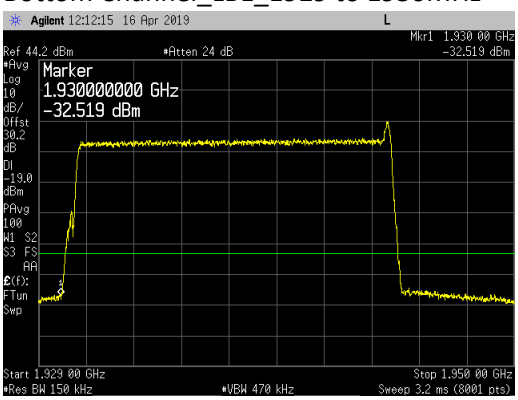


LTE15 Single 5W Carrier Lower Band Edge Plots for Antenna Port 2:

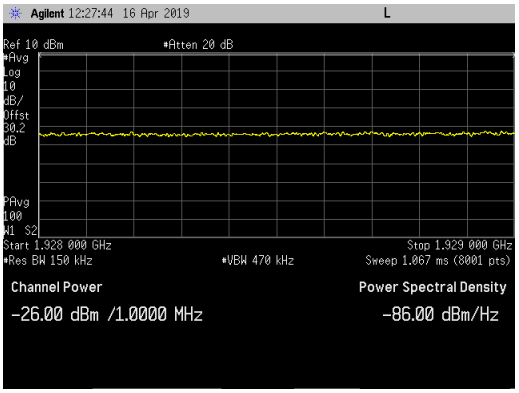
IoT Guard Band Carrier at Lower Placement
Bottom Channel_LBE_1929 to 1950MHz



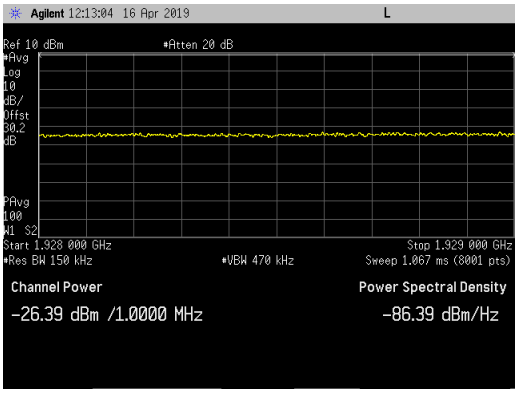
IoT Guard Band Carrier at Upper Placement
Bottom Channel_LBE_1929 to 1950MHz



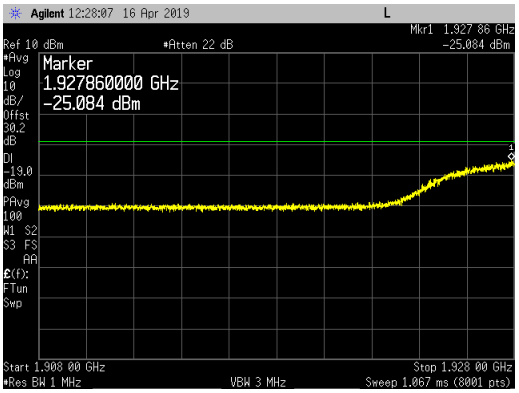
Bottom Channel_LBE_1928 to 1929MHz



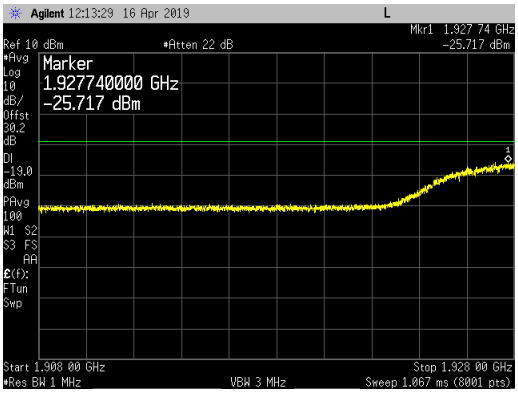
Bottom Channel_LBE_1928 to 1929MHz



Bottom Channel_LBE_1908 to 1928MHz

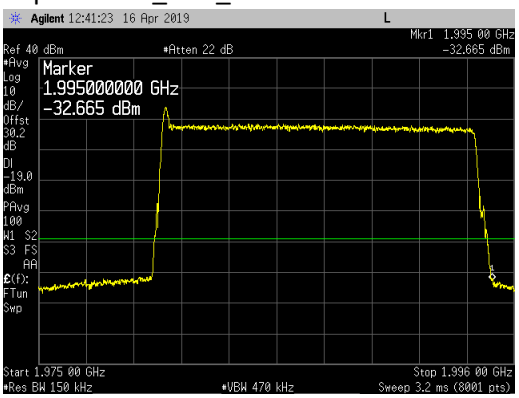


Bottom Channel_LBE_1908 to 1928MHz

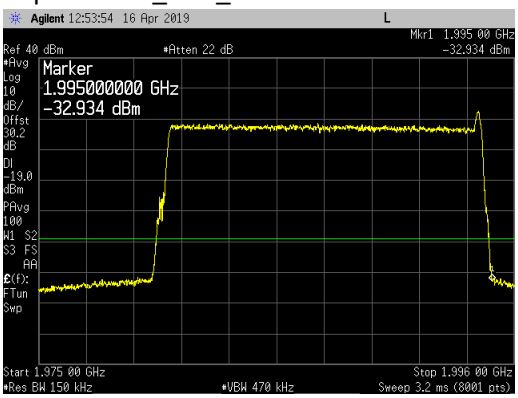


LTE15 Single 5W Carrier Upper Band Edge Plots for Antenna Port 2:

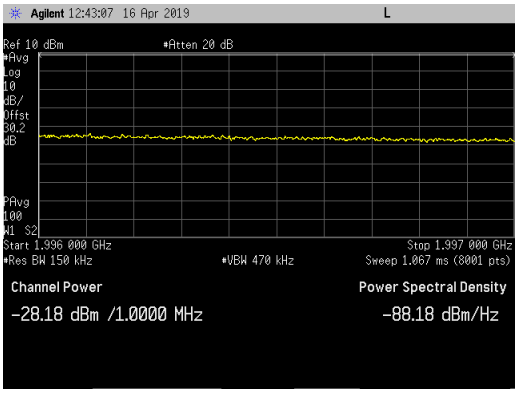
IoT Guard Band Carrier at Lower Placement
Top Channel_UBE_1975 to 1996MHz



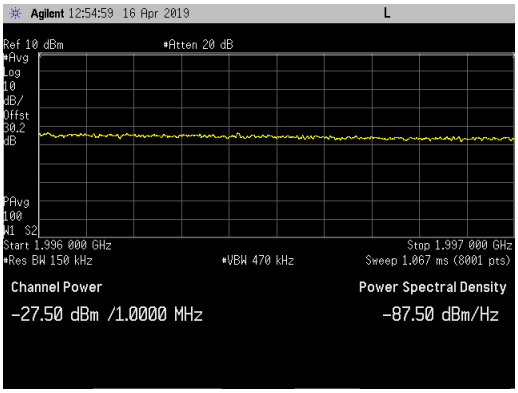
IoT Guard Band Carrier at Upper Placement
Top Channel_UBE_1975 to 1996MHz



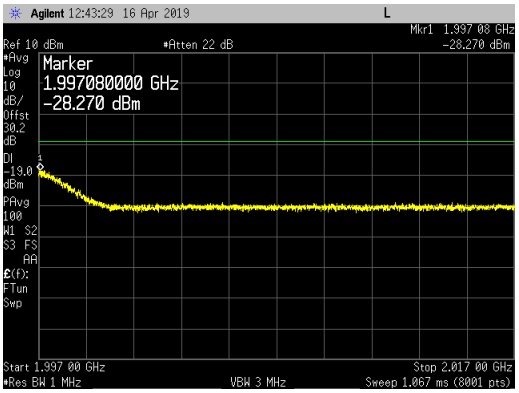
Top Channel_UBE_1996 to 1997MHz



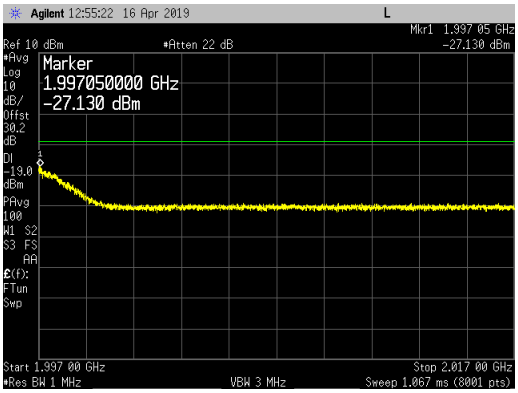
Top Channel_UBE_1996 to 1997MHz



Top Channel_UBE_1997 to 2017MHz

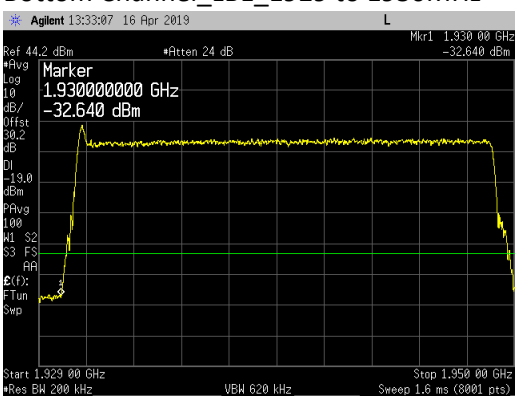


Top Channel_UBE_1997 to 2017MHz

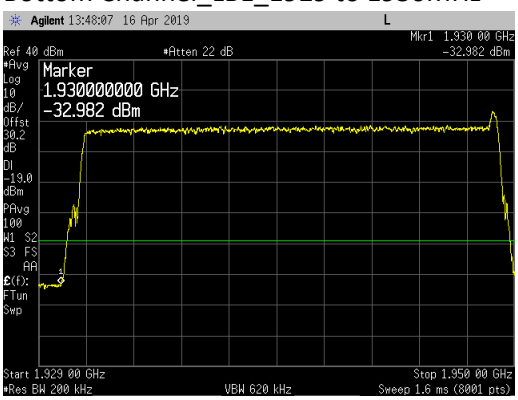


LTE20 Single 5W Carrier Lower Band Edge Plots for Antenna Port 2:

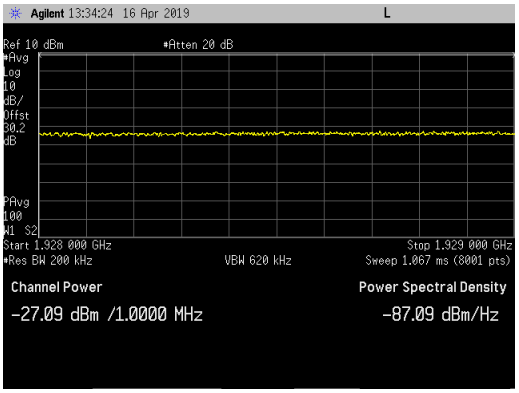
IoT Guard Band Carrier at Lower Placement
Bottom Channel_LBE_1929 to 1950MHz



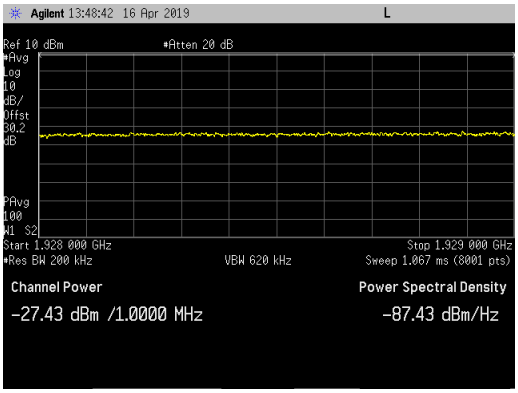
IoT Guard Band Carrier at Upper Placement
Bottom Channel_LBE_1929 to 1950MHz



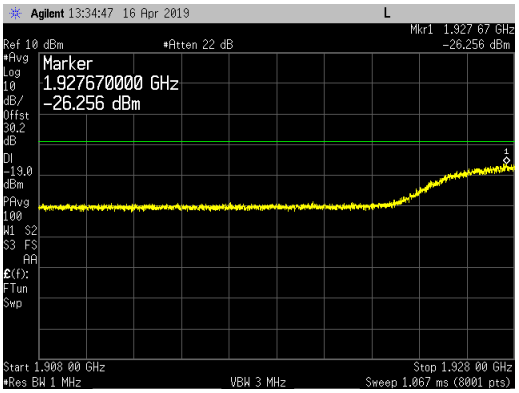
Bottom Channel_LBE_1928 to 1929MHz



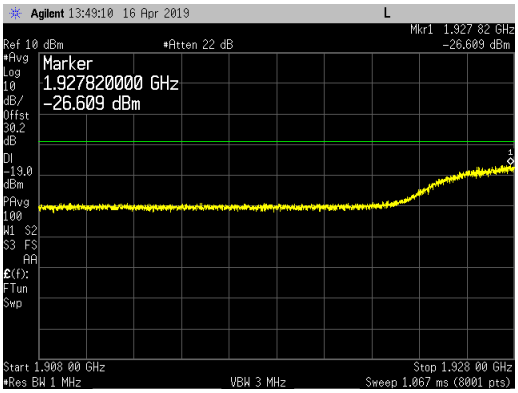
Bottom Channel_LBE_1928 to 1929MHz



Bottom Channel_LBE_1908 to 1928MHz

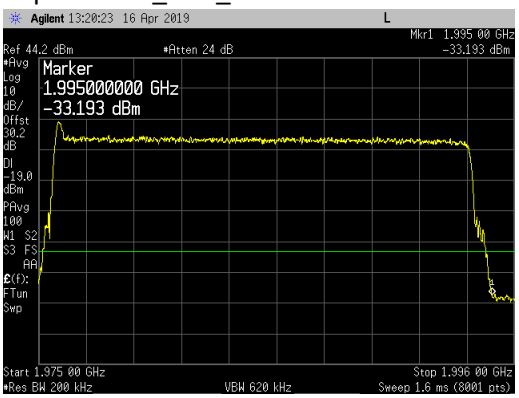


Bottom Channel_LBE_1908 to 1928MHz

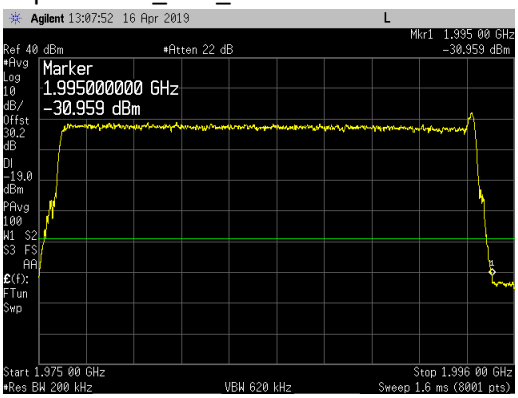


LTE20 Single 5W Carrier Upper Band Edge Plots for Antenna Port 2:

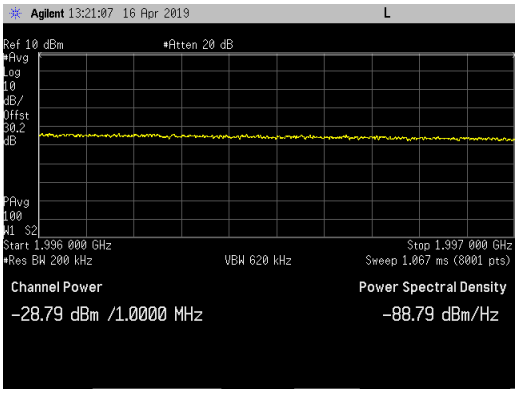
IoT Guard Band Carrier at Lower Placement
Top Channel_UBE_1975 to 1996MHz



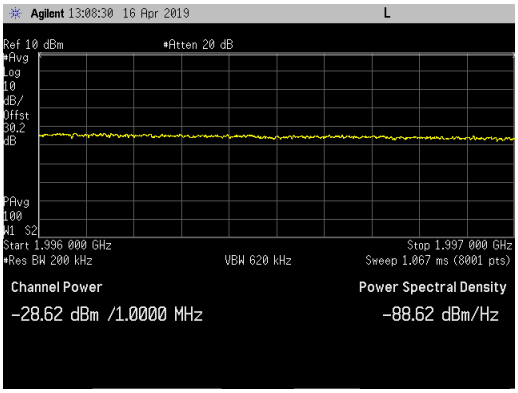
IoT Guard Band Carrier at Upper Placement
Top Channel_UBE_1975 to 1996MHz



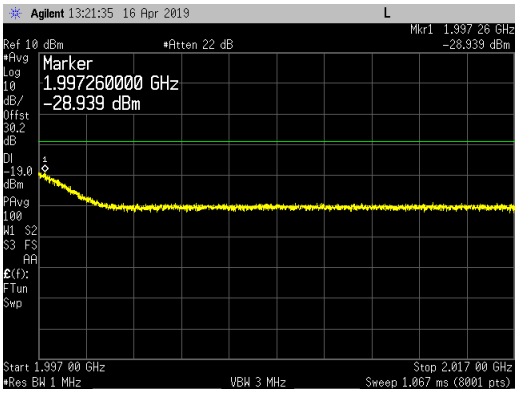
Top Channel_UBE_1996 to 1997MHz



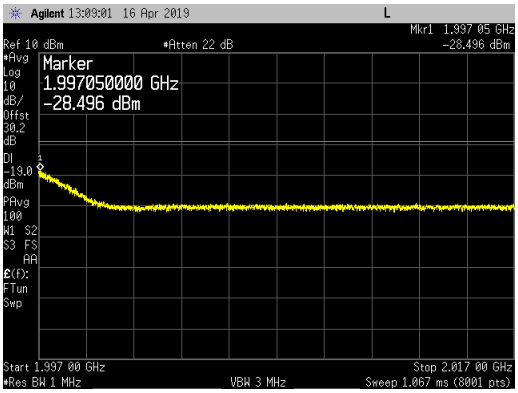
Top Channel_UBE_1996 to 1997MHz



Top Channel_UBE_1997 to 2017MHz

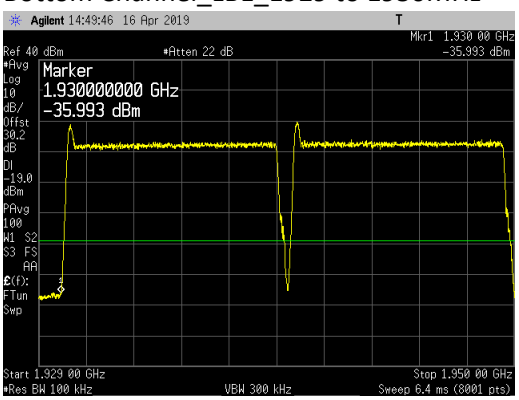


Top Channel_UBE_1997 to 2017MHz

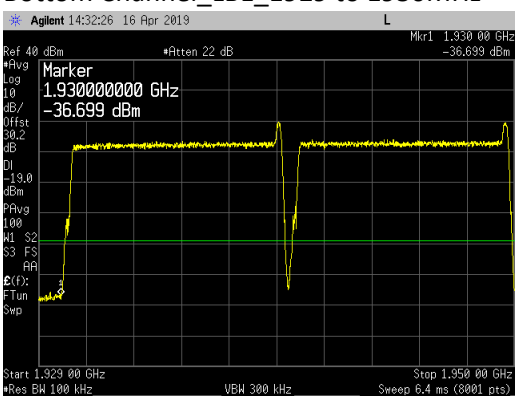


Multi LTE10 Carriers at 1935, 1945 & 1990MHz at 5W/Port_ Lower Band Edge Plots for Antenna Port 2:

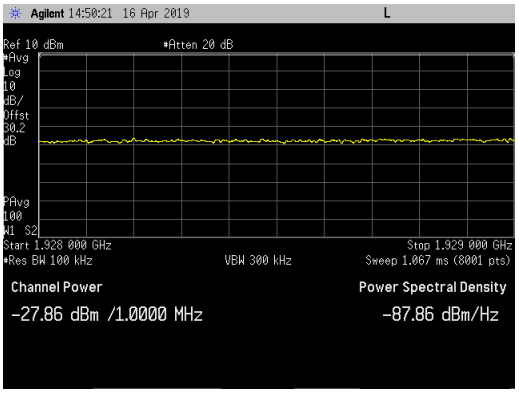
IoT Guard Band Carrier at Lower Placement
Bottom Channel_LBE_1929 to 1950MHz



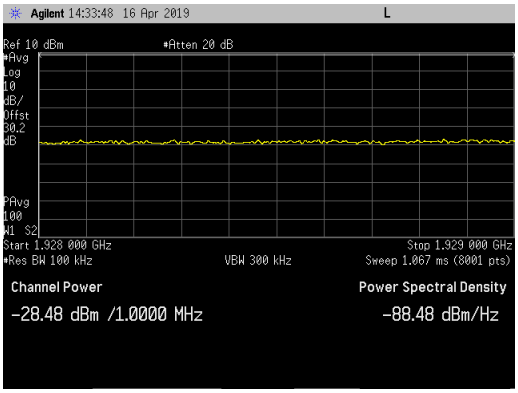
IoT Guard Band Carrier at Upper Placement
Bottom Channel_LBE_1929 to 1950MHz



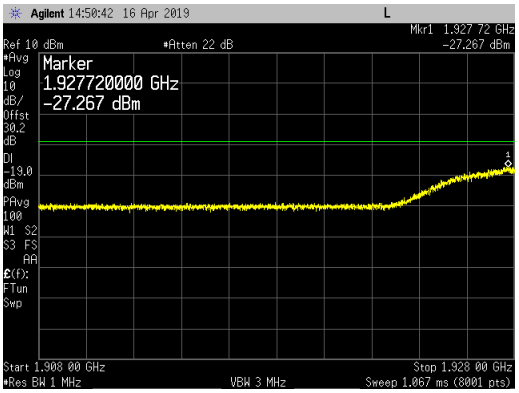
Bottom Channel_LBE_1928 to 1929MHz



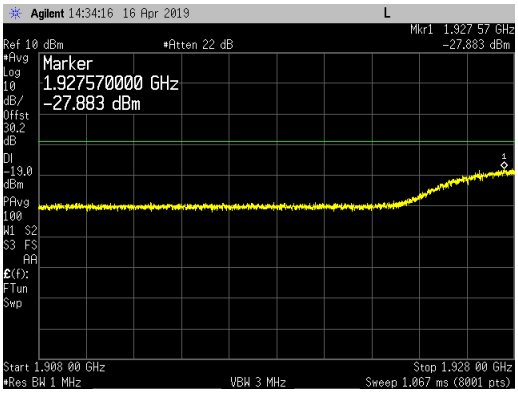
Bottom Channel_LBE_1928 to 1929MHz



Bottom Channel_LBE_1908 to 1928MHz

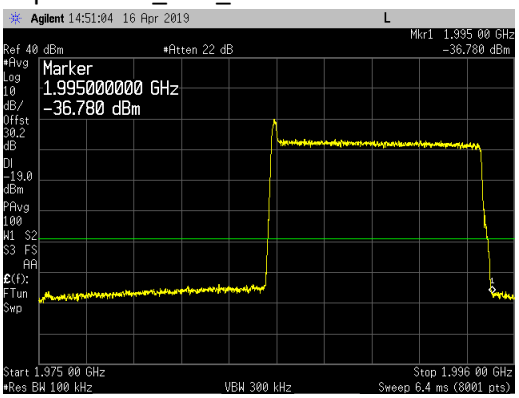


Bottom Channel_LBE_1908 to 1928MHz

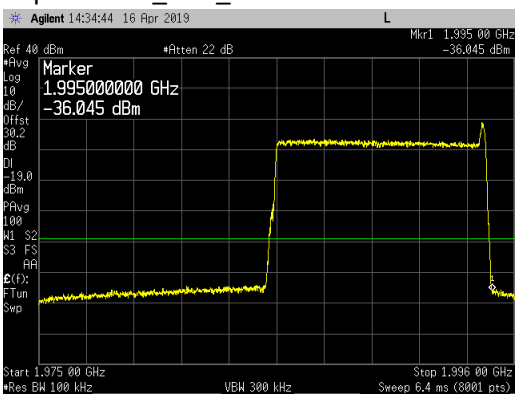


Multi LTE10 Carriers at 1935, 1945 & 1990MHz at 5W/Port_ Upper Band Edge Plots for Antenna Port 2:

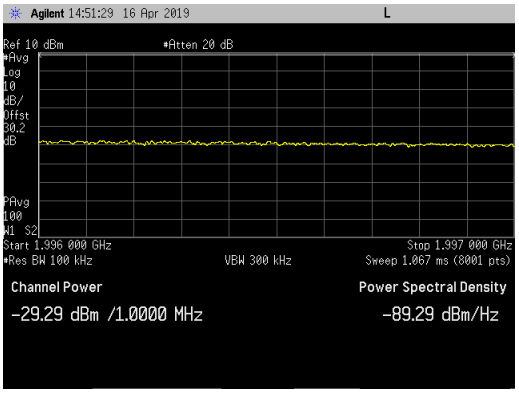
IoT Guard Band Carrier at Lower Placement
Top Channel_UBE_1975 to 1996MHz



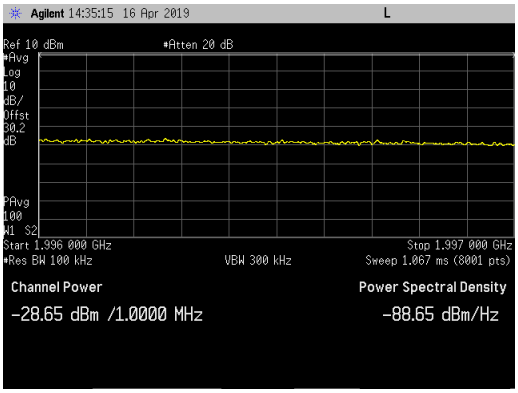
IoT Guard Band Carrier at Upper Placement
Top Channel_UBE_1975 to 1996MHz



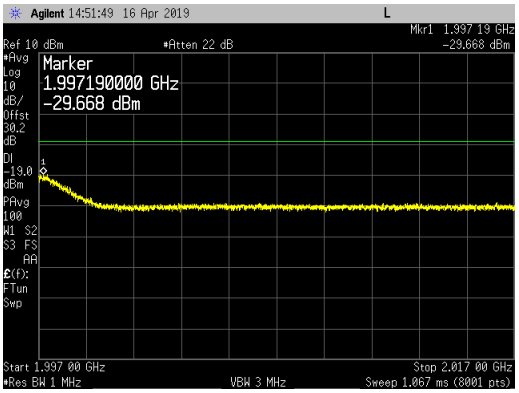
Top Channel_UBE_1996 to 1997MHz



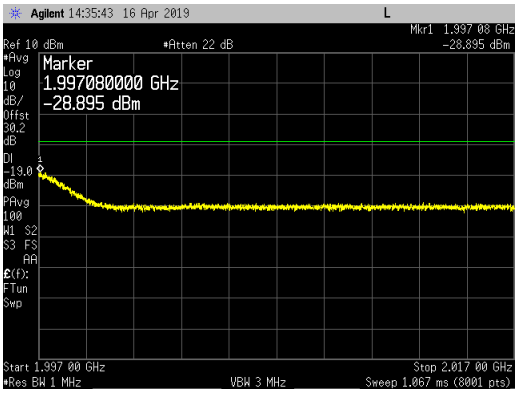
Top Channel_UBE_1996 to 1997MHz



Top Channel_UBE_1997 to 2017MHz



Top Channel_UBE_1997 to 2017MHz



Transmitter Antenna Port Conducted Emissions

Transmitter conducted emission measurements were made at RRH antenna port 2. Measurements were performed over the 9kHz to 20GHz frequency range. The AHFB was operated with a single upper and lower NB IoT GB carrier for all test cases.

The RRH was operated using NB-IoT GB carriers for 10MHz, 15MHz and 20MHz LTE channel bandwidth at maximum power (5 watts/port and 5 watts/carrier) on the PCS middle channel (1962.5MHz) for the single carrier test cases.

A multicarrier test case based upon KDB 971168 D03v01 using three carriers (with smallest available carrier bandwidth – 10MHz) per antenna port was performed at maximum power (5 watts/port and 1.6 watts/carrier). The multicarrier test case is with two carriers (with minimum spacing between carrier frequencies) at the lower band edge (EARFCN 8090: 1935.0 & EARFCN 8190: 1945.0MHz) and a third carrier with maximum spacing between the other two carrier frequencies (EARFCN 8640: 1990.0MHz) at the upper band edge.

The limit of -19dBm was used in the certification testing. The limit is adjusted to -19dBm [-13dBm -10 log (4)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 4 port MIMO transmitter. The required measurement parameters include a 1MHz 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 1925 to 2000MHz frequency range). Measurements for the 1925 to 2000MHz frequency range were 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 –49dBm to correct for a spectrum analyzer RBW of 1kHz versus required RBW of 1MHz [i.e.: -49dBm = -19dBm -10log(1MHz/1kHz)]. The limit for the 150kHz to 20MHz frequency range was adjusted to –39dBm to correct for a spectrum analyzer RBW of 10kHz versus required RBW of 1MHz [i.e.: -39dBm = -19dBm -10log(1MHz/10kHz)]. The required limit of -19dBm with a RBW of $\geq$1MHz 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	29.4dB
150kHz to 20MHz	10kHz	30kHz	8001	Peak	Auto	50 Sweeps	29.4dB
20MHz to 3GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	30.4dB
3GHz to 13GHz	2MHz	6MHz	8192	Peak	Auto	50 Sweeps	32.0dB
13GHz to 20GHz	2MHz	6MHz	8192	Peak	Auto	50 Sweeps	37.3dB
1925 to 2000MHz	1MHz	3MHz	8001	Average	Auto	Note (2)	30.2dB

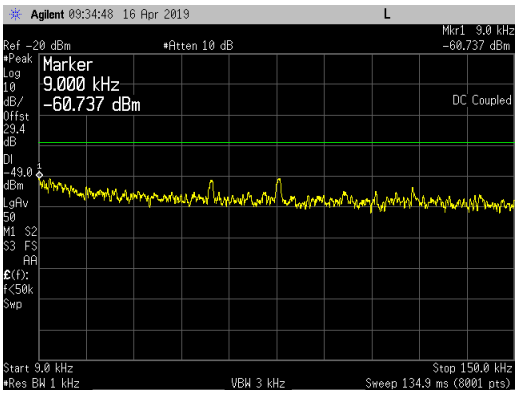
Note 1: The total measurement RF path loss of the test setup (attenuators, test cables and filters) is accounted for by the spectrum analyzer reference level offset.
Note 2: Max Hold not used and instead measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces.

A low pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges less than 20MHz. A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 3GHz. The total measurement RF path loss of the test setup (attenuators, low pass filter, high pass filter and test cables) 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.

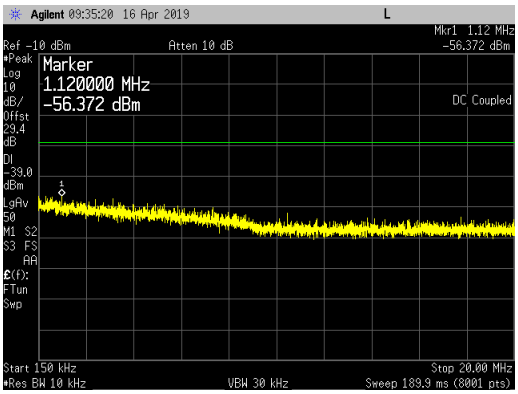
Conducted spurious emission plots/measurements are provided in the following pages.

LTE10 Single 5W Carrier _ Middle Channel (1962.5MHz) for Antenna Port 2_ NB-IoT Lower GB:

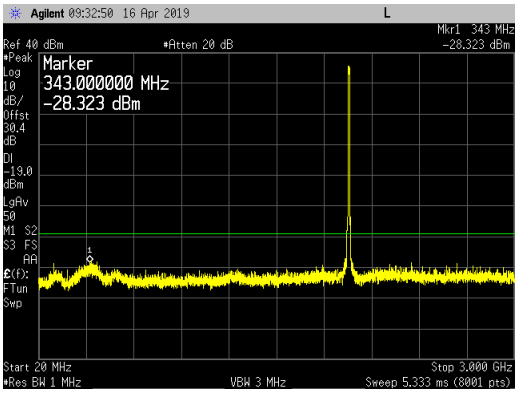
9kHz to 150kHz



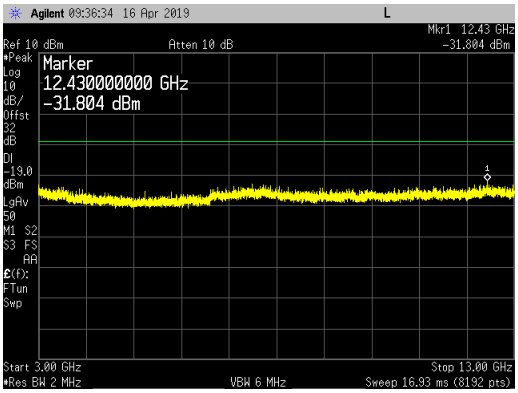
150kHz to 20MHz



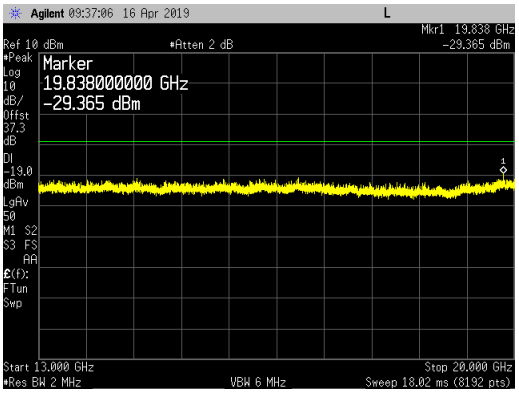
20MHz to 3GHz



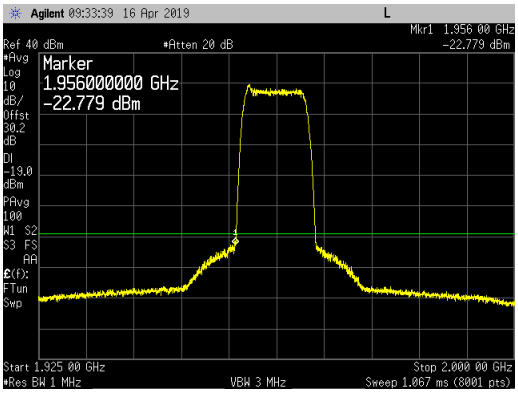
3GHz to 13GHz



13GHz to 20GHz

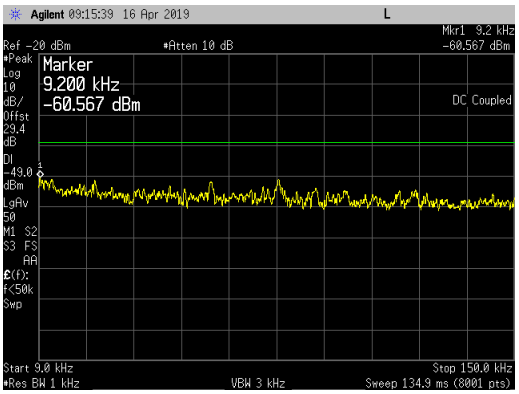


1925MHz to 2000MHz

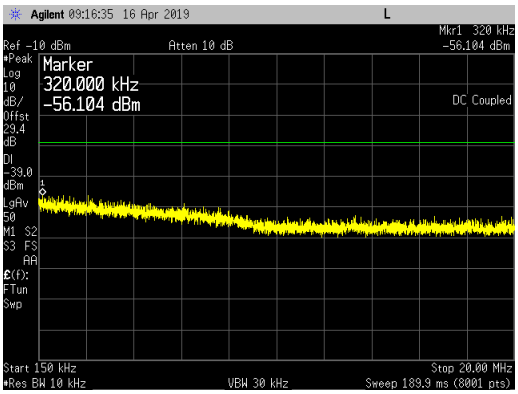


LTE10 Single 5W Carrier _ Middle Channel (1962.5MHz) for Antenna Port 2_ NB-IoT Upper GB:

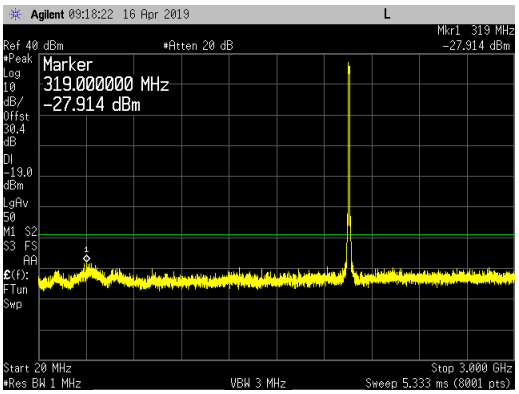
9kHz to 150kHz



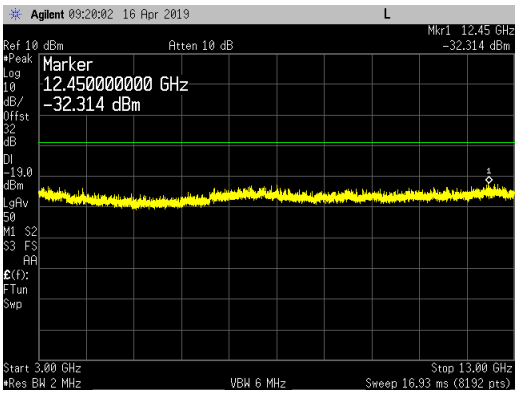
150kHz to 20MHz



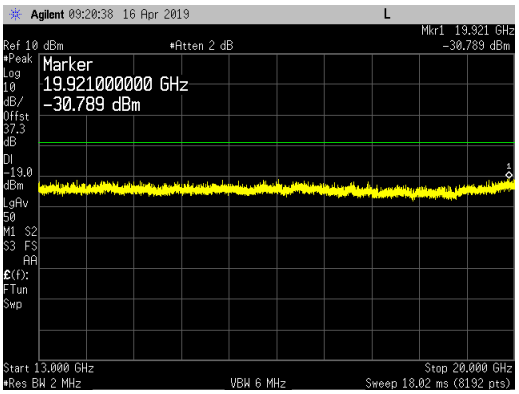
20MHz to 3GHz



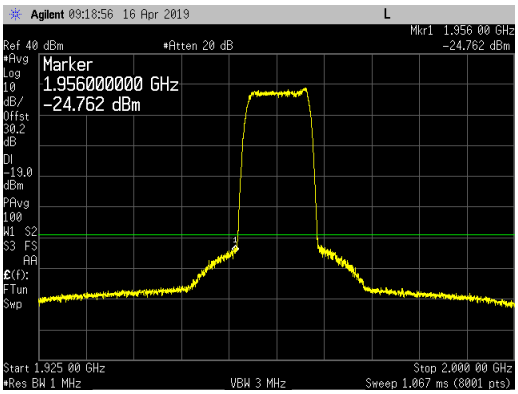
3GHz to 13GHz



13GHz to 20GHz

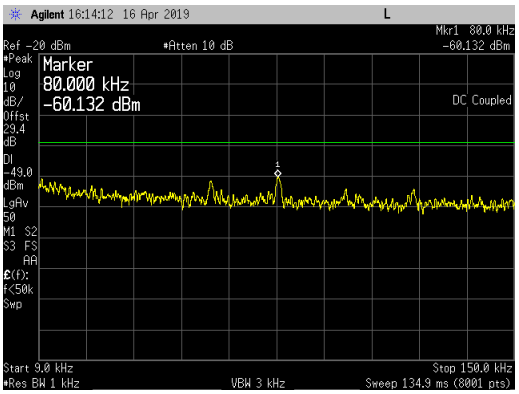


1925MHz to 2000MHz

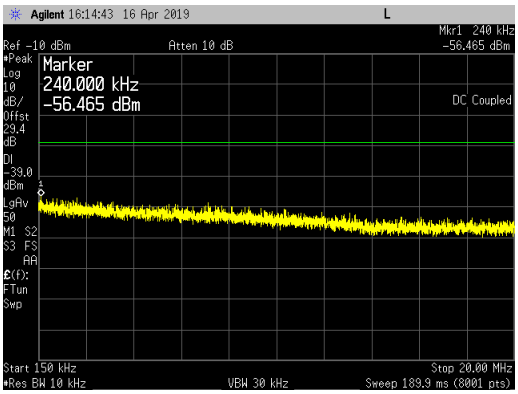


LTE15 Single 5W Carrier _ Middle Channel (1962.5MHz) for Antenna Port 2_ NB-IoT Lower GB:

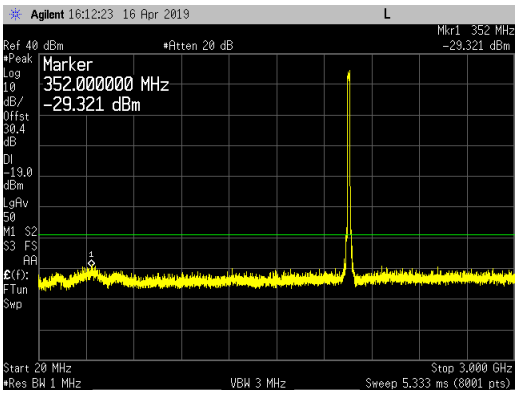
9kHz to 150kHz



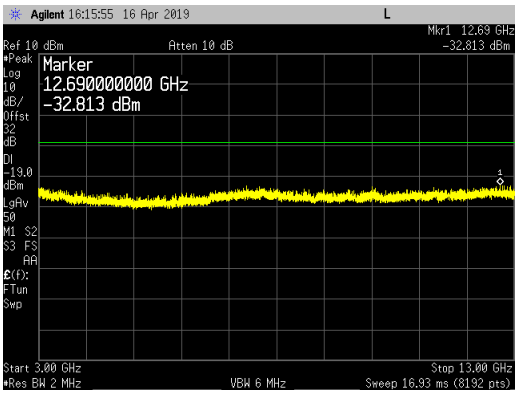
150kHz to 20MHz



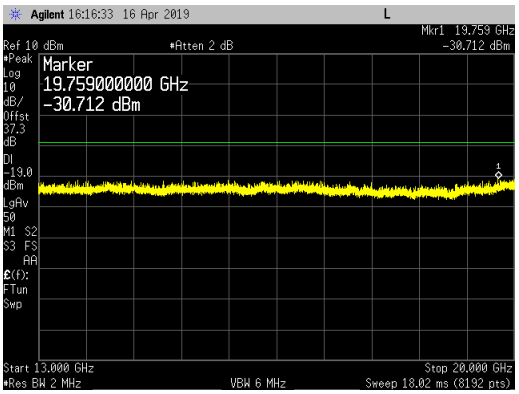
20MHz to 3GHz



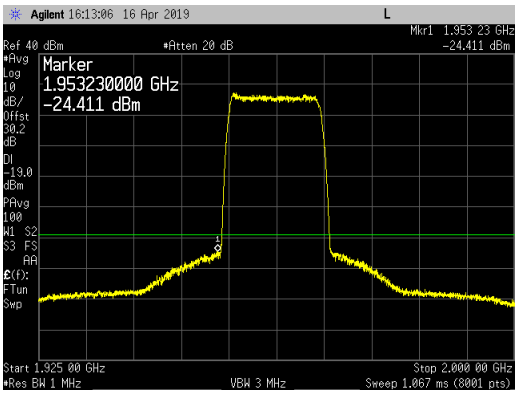
3GHz to 13GHz



13GHz to 20GHz

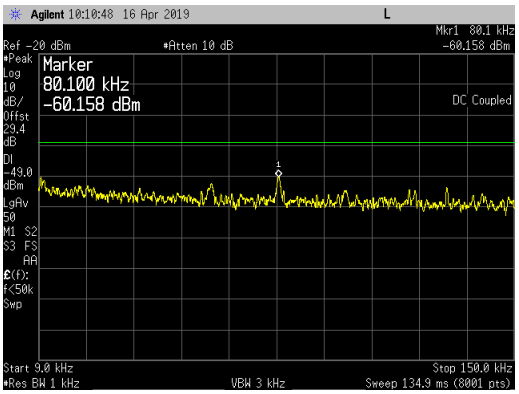


1925MHz to 2000MHz

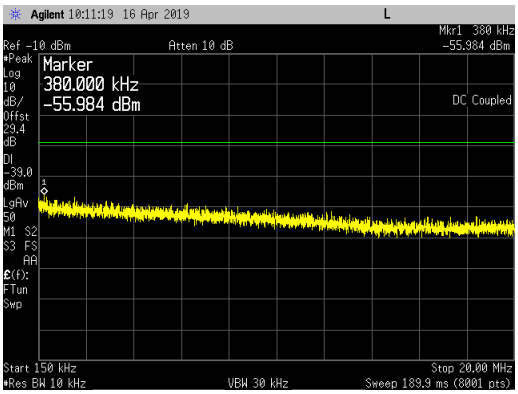


LTE15 Single 5W Carrier _ Middle Channel (1962.5MHz) for Antenna Port 2_ NB-IoT Upper GB:

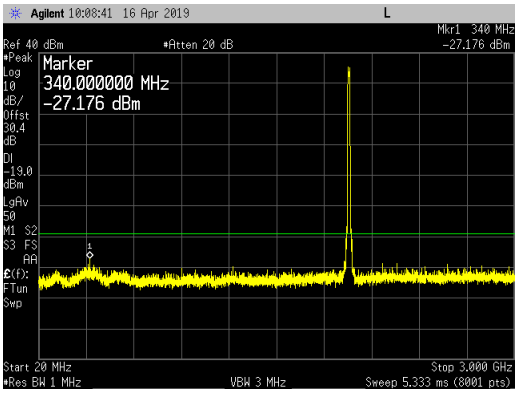
9kHz to 150kHz



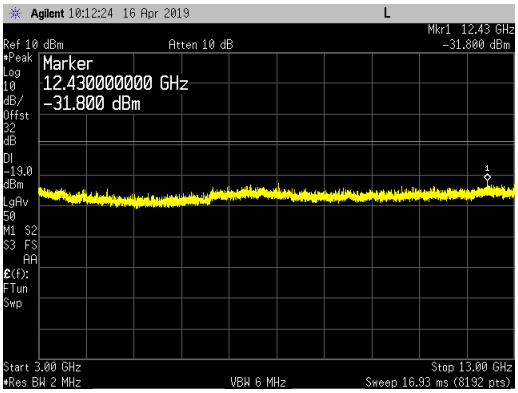
150kHz to 20MHz



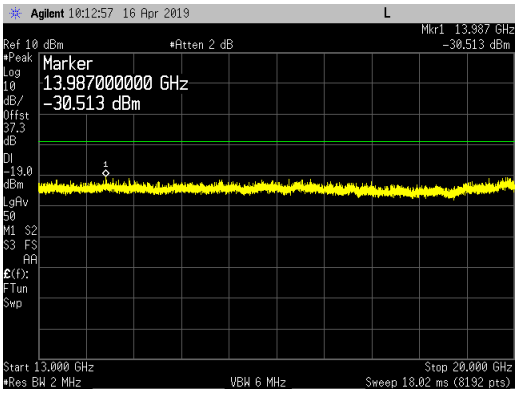
20MHz to 3GHz



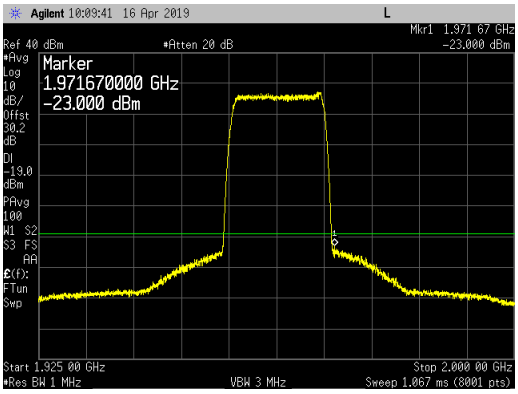
3GHz to 13GHz



13GHz to 20GHz

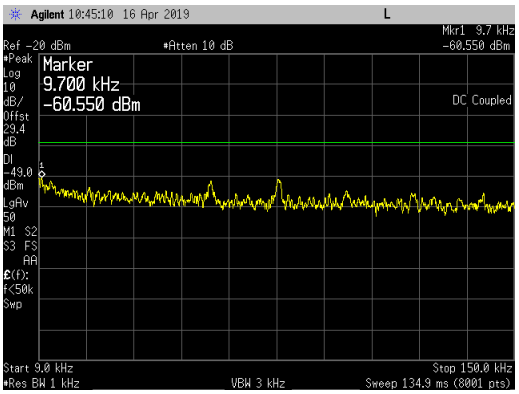


1925MHz to 2000MHz

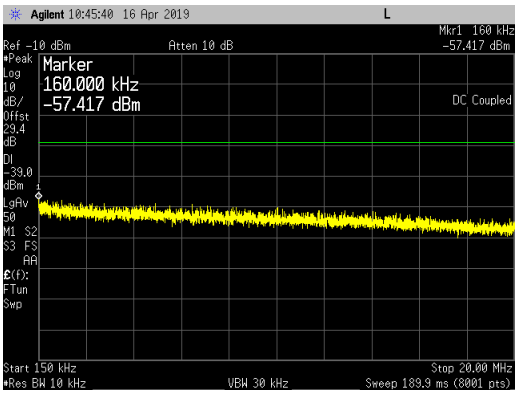


LTE20 Single 5W Carrier _ Middle Channel (1962.5MHz) for Antenna Port 2_ NB-IoT Lower GB:

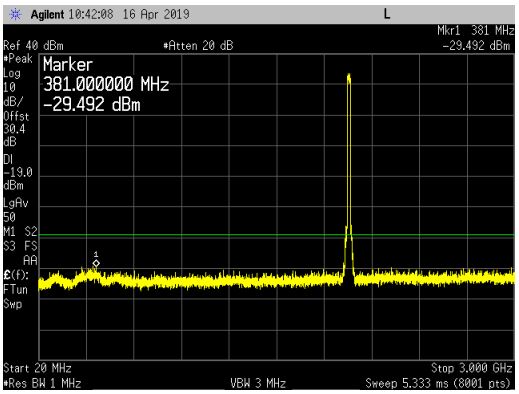
9kHz to 150kHz



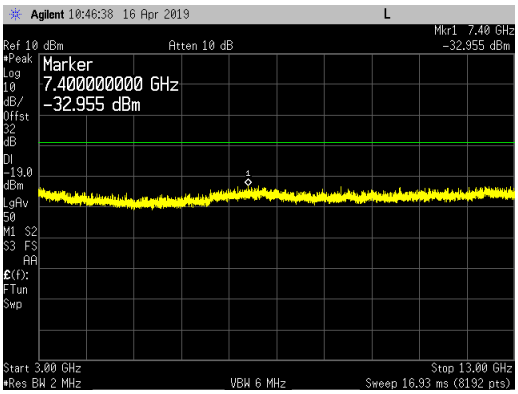
150kHz to 20MHz



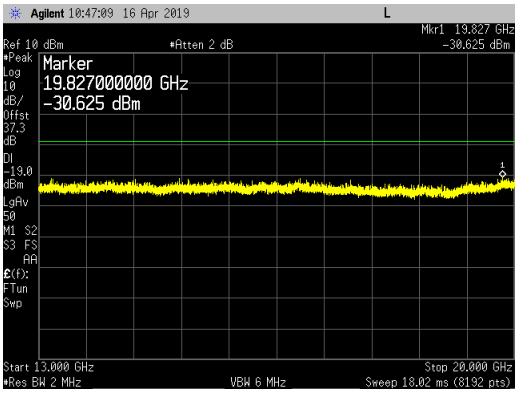
20MHz to 3GHz



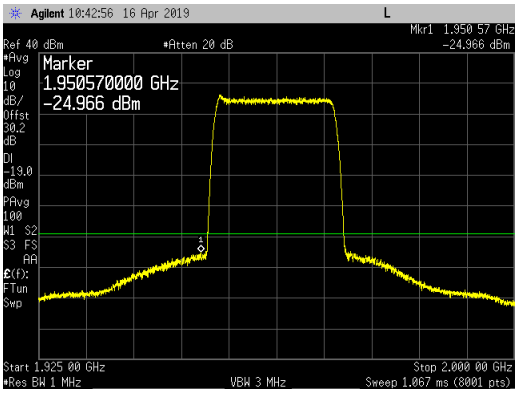
3GHz to 13GHz



13GHz to 20GHz

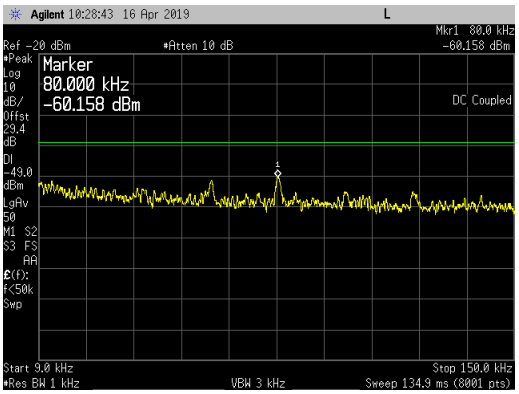


1925MHz to 2000MHz

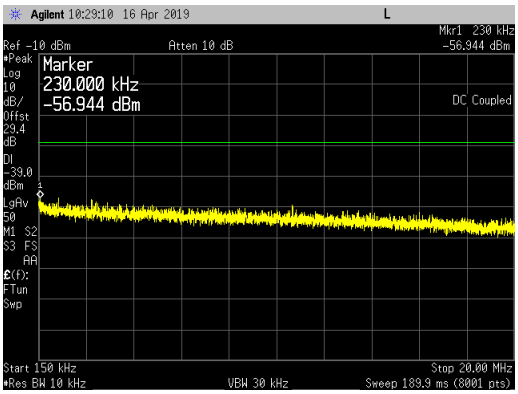


LTE20 Single 5W Carrier _ Middle Channel (1962.5MHz) for Antenna Port 2_ NB-IoT Upper GB:

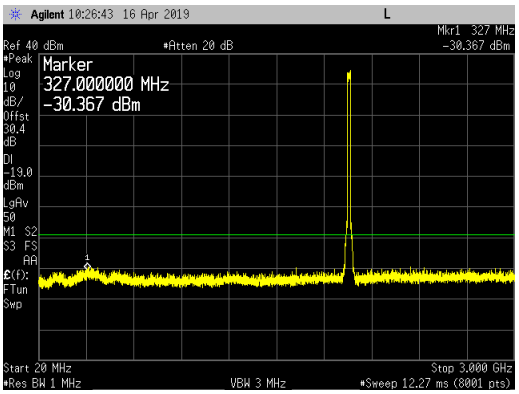
9kHz to 150kHz



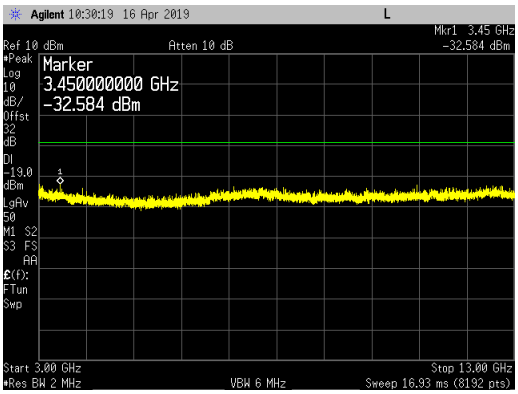
150kHz to 20MHz



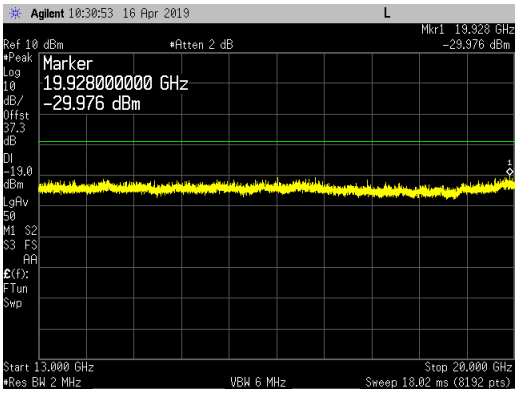
20MHz to 3GHz



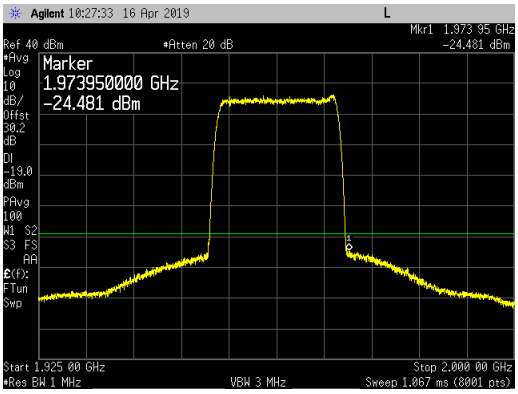
3GHz to 13GHz



13GHz to 20GHz

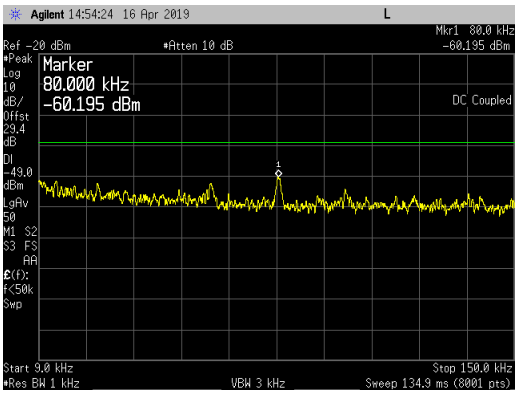


1925MHz to 2000MHz

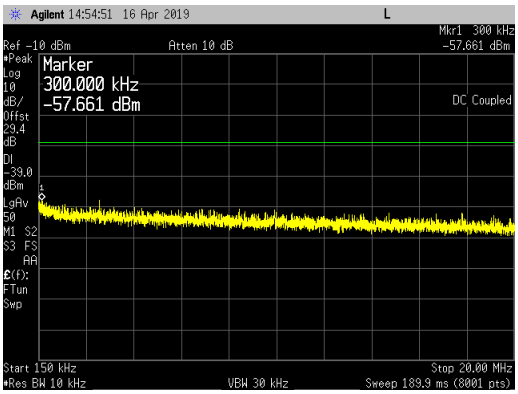


LTE 10 Multicarrier for Antenna Port 2_ NB-IoT Lower GB_ LTE10 Carriers at 1935, 1945 & 1990MHz (1.6W/carrier & 5W/port):

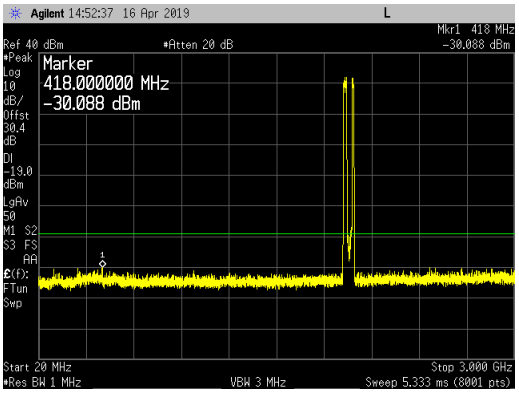
9kHz to 150kHz



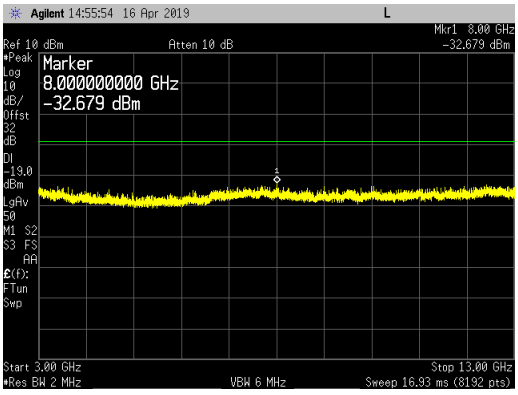
150kHz to 20MHz



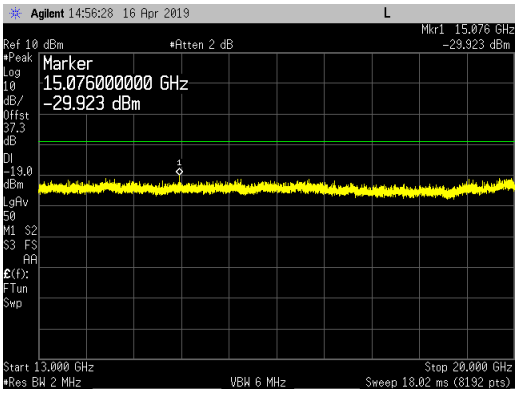
20MHz to 3GHz



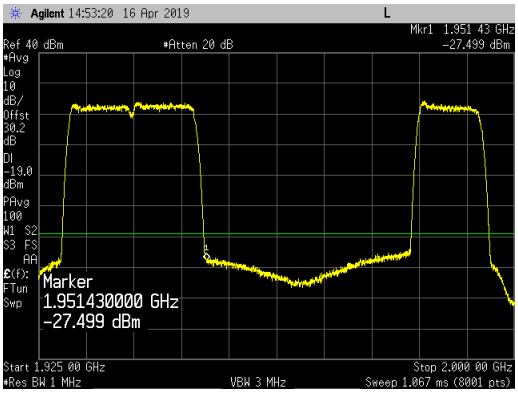
3GHz to 13GHz



13GHz to 20GHz

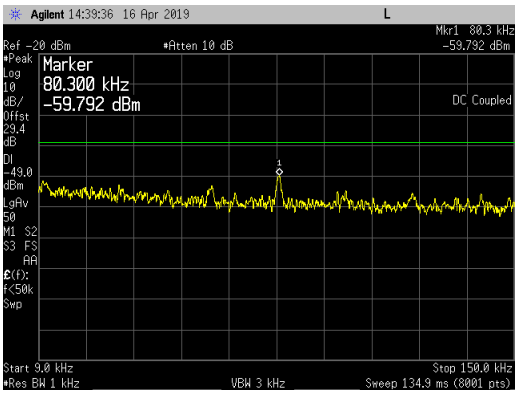


1925MHz to 2000MHz

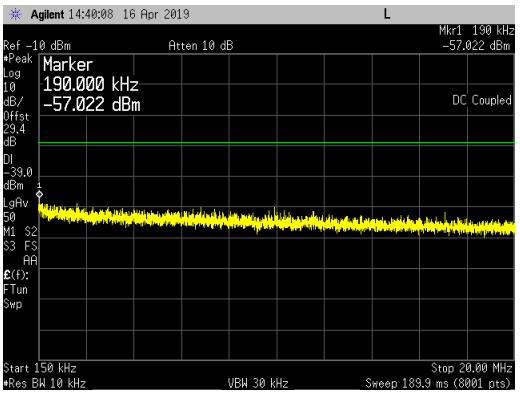


LTE 10 Multicarrier for Antenna Port 2_ NB-IoT Upper GB_LTE10 Carriers at 1935, 1945 & 1990MHz (1.6W/carrier & 5W/port):

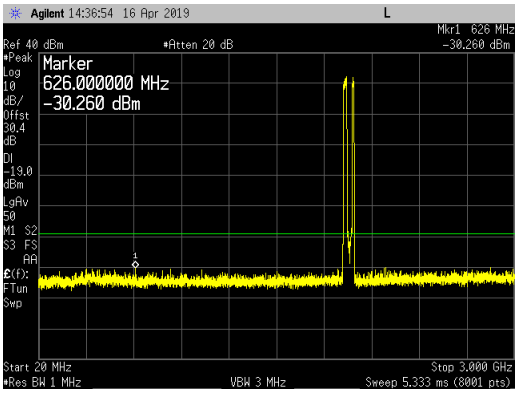
9kHz to 150kHz



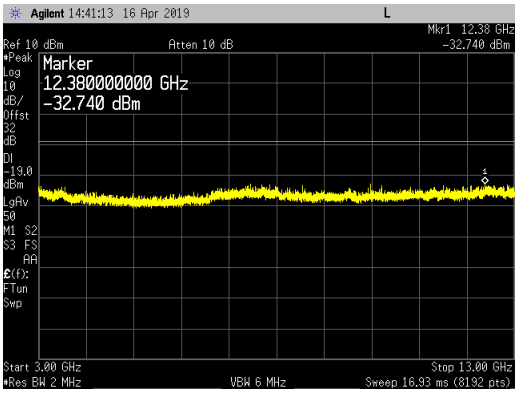
150kHz to 20MHz



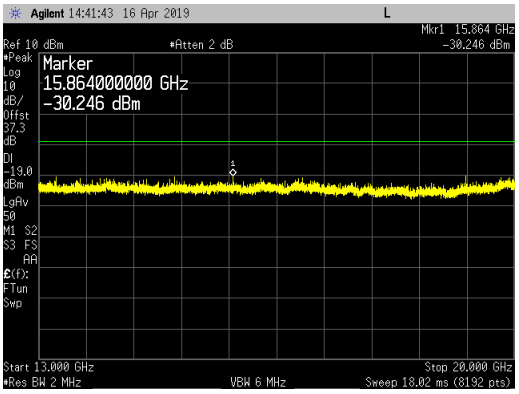
20MHz to 3GHz



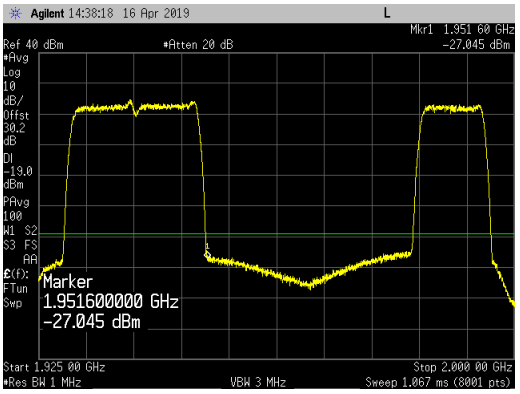
3GHz to 13GHz



13GHz to 20GHz



1925MHz to 2000MHz



Transmitter Radiated Spurious Emissions

Radiated spurious emission plots/measurement results are in the original FCC radio certification submittal (TUV Report Document Number 75938943 Report 1 Issue 1 dated May 10, 2017).

Frequency Stability/Accuracy

Frequency Stability/Accuracy measurement results are in the original FCC radio certification submittal (TUV Report Document Number 75938943 Report 1 Issue 1 dated May 10, 2017).

End of Report