CERTIFICATE #: 0214.19

Radio Test Report

Application for Grant of Equipment Authorization

FCC Part 27 Subpart C
[722MHz – 728MHz]

FCC Part 27 Subpart C
[1995MHz – 2020MHz]

FCC ID: VBNAHLJA-01

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

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

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

Test Dates: September 25 – October 8, 2018
Total Number of Pages: 66

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REVISION HISTORY

Rev#	Date	Comments	Modified By
0	10/12/2018	Initial Draft	BreAnna Cheatham
1	10/16/2018	Updated Per Customer Request	BreAnna Cheatham

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SCOPE

Tests have been performed on Nokia Solutions and Networks product Airscale Base Station Remote Radio Head (RRH) Model AHLJA, 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
- FCC DA 13-2409 Items 25 and 47 dated December 20, 2013

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 Remote Radio Head (RRH) Model AHLJA and therefore apply only to the tested sample. The sample was selected and prepared by Hobert Smith and John Rattanavong of Nokia Solutions and Networks.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA and Canada, the device requires certification.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

Testing was performed only on Model AHLJA. No additional models were described or supplied for testing.

STATEMENT OF COMPLIANCE

The tested sample of Nokia Solutions and Networks product Airscale Base Transceiver Station Remote Radio Head (RRH) Model AHLJA 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 722 to 728MHz Band)

AHLJA operating in 722MHz to 728MHz Frequency Band				
FCC	Description	Measured	Limit	Results
Transmitter Modulation, output power and other characteristics				
§27.5	Frequency Ranges	IoT Stand-Alone: 722.2 – 727.8MHz	722.0MHz to 728.0MHz	Pass
§2.1033(c)(4)	Modulation Type	QPSK for IoT Stand-Alone	Digital	Pass
§27.50	Output Power	Highest Conducted Port Power Output RMS: 45.7dBm Highest Conducted Carrier Power Output RMS: 43.2dBm ERP depends on antenna gain which is unknown	1000W ERP	Pass
Informational	Peak to Average Power Ratio	Highest Measured PAPR: 8.7dB	13dB	Pass
§2.1049	99% Emission Bandwidth	IoT Stand-Alone: 198.1817kHz	Remain in Block	Pass
	26dB down Emission Bandwidth	IoT Stand-Alone: 287KG7D	Remain in Block	Pass
Transmitter Spurious Emissions[1]				
§27.53(g)	At the antenna terminals	< -13dBm	-13dBm per Transmit Chain	Pass[1]
	Field Strength	58.712dBuV/m at 1m Eq. to -46.08dBm EIRP	-13dBm EIRP	Pass
Other Details				
§27.54	Frequency Stability	Stays within authorized frequency block	Stays within block	Pass
§1.1310	RF Exposure	N/A		Pass[2]

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: Applicant's declaration on a separate exhibit based on hypothetical antenna gains.

FCC Part 27 Subpart C (Base Stations Operating in the 1995 to 2020MHz Band)

AHLJA operating in the 1995 to 2020MHz Frequency Band				
FCC	Description	Measured	Limit	Results
Transmitter Modulation, output power and other characteristics				
§27.5(h)&(j)	Frequency Ranges	IoT Stand-Alone: 1995.2 – 2019.8MHz	2110.0 to 2190.0MHz	Pass
§2.1033(c)(4)	Modulation Type	QPSK for IoT Stand-Alone	Digital	Pass
§27.50(d)(2i)	Output Power	Highest Conducted Port Power Output RMS: 47.3dBm Highest Conducted Carrier Power Output RMS: 42.9dBm EIRP depends on antenna gain which is unknown	EIRP $\leq$ 1640W	Pass
§27.50(d)(5)	Peak to Average Power Ratio	Highest Measured PAPR: 9.1dB	13dB	Pass
§2.1049	99% Emission Bandwidth	IoT Stand-Alone: 201.9194kHz	Remain in Block	Pass
§27.53(h)(3)	26dB down Emission Bandwidth	IoT Stand-Alone: 293KG7D	Remain in Block	Pass
Transmitter Spurious Emissions[1]				
§27.53(h) and DA13-2409 Items 25 & 47	At the antenna terminals	< -13dBm	-13dBm per Transmit Chain	Pass
	Field strength	58.712dBuV/m at 1m Eq. to -46.08dBm EIRP	-13 dBm EIRP	Pass
Other Details				
§27.54	Frequency Stability	Stays within authorized frequency block	Stays within block	Pass
§1.1310	RF Exposure	N/A		Pass[2]

Note 1: Based on 1MHz RBW. In the 1MHz immediately outside and adjacent to the frequency block a RBW of at least 1% of the emission bandwidth was used. The measurement bandwidth is 1MHz for measurements more than 1MHz from the band edge.
Note 2: Applicant's declaration on a separate exhibit based on hypothetical antenna gains.

Extreme Conditions

Frequency stability is determined over extremes of temperature and voltage.

The extremes of voltage were 85 to 115 percent of the nominal value.

The extremes of temperature were -30°C to +50°C as specified in FCC §2.1055(a)(1).

Measurement Uncertainties

Measurement uncertainties of the test facility based on a 95% confidence level are as follows:

Test	**Uncertainty**
Radio frequency	± 0.2ppm
RF power conducted	±1.2 dB
RF power radiated	±3.3 dB
RF power density conducted	±1.2 dB
Spurious emissions conducted	±1.2 dB
Adjacent channel power	±0.4 dB
Spurious emissions radiated	±4 dB
Temperature	±1°C
Humidity	±1.6 %
Voltage (DC)	±0.2 %
Voltage (AC)	±0.3 %

EQUIPMENT UNDER TEST (EUT) DETAILS

General

The equipment under test (EUT) is a Nokia Solutions and Networks Airscale Base Transceiver Station (BTS) Remote Radio Head (RRH) module, model AHLJA. The AHLJA remote radio head is a multi-standard multi-carrier radio module designed to support narrow band IoT (internet of things) stand-alone operations. The scope of testing in this effort is for stand-alone IoT operations.

The AHLJA RRH has four transmit/two receive antenna ports (2TX for Band 29 and 2TX/2RX for Band 70). Antenna ports 1&2 supports 3GPP frequency band 70 (BTS Rx: 1915 to 1920 MHz/BTS TX: 1995 to 2020 MHz). Antenna port 3&4 supports 3GPP frequency band 29 (BTS TX: 722 to 728 MHz). The maximum RF output power of the RRH is 200 Watts (20 watts per carrier, 60 watts per antenna port for Band 70 and 20 watts per carrier, 40 watts per antenna port for Band 29). The TX and RX instantaneous bandwidth cover the full operational bandwidth. The RRH supports a 200kHz bandwidth for NB-IoT stand-alone carrier (QPSK). Multi-carrier operation is supported.

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

The AHLJA channel numbers and frequencies are as follows:

The narrow band IoT channel bandwidth is 200kHz. The minimum spacing between adjacent IoT carriers is 300kHz. The spacing is 100 kHz between channel numbers.

	Downlink EARFCN	Downlink Frequency (MHz)	Narrow Band IoT Channels
Band 29_AHLJA Antennas 3 and 4	……	722.0	Band Edge
	11132	722.1	
	11133	722.2	Bottom Channel
	11134	722.3	Bottom Channel + 1
	……		
	11161	725.0	Middle Channel
	……		
	11188	722.7	Top Channel - 1
	11189	727.8	Top Channel
	11190	727.9	
	……	728.0	Band Edge

AHLJA Downlink Band Edge Band 29 Narrow Band IoT Stand-Alone Frequency Channels

Multicarrier Test Cases:

(1) Two carriers with minimum spacing between carriers at the lower band edge are 11133 EARFCN: 722.2MHz and 11136 EARFCN: 722.5MHz.
(2) Two carriers with minimum spacing between carriers at the center frequency are 11161 EARFCN: 725.0MHz and 11164 EARFCN: 725.3MHz.
(3) Two carriers with minimum spacing between carriers at the upper band edge are 11186 EARFCN: 727.5MHz and 11189 EARFCN: 727.8MHz.
(4) Three carriers based upon KDB 971168 D03v01 using two carriers at the lower band edge with minimum spacing between carriers and one carrier at the upper band edge with maximum spacing between the other two carriers are 11133 EARFCN: 722.2MHz, 11136 EARFCN: 722.5MHz and 11189 EARFCN: 727.8MHz.

The narrow band IoT channel bandwidth is 200kHz. The minimum spacing between adjacent IoT carriers is 300kHz. The spacing is 100 kHz between channel numbers.

	Downlink EARFCN	Downlink Frequency (MHz)	Narrow Band IoT Channels
Band 70_AHLJA Antennas 1 and 2	……	1995.0	Band Edge
	13112	1995.1	
	13113	1995.2	Bottom Channel
	13114	1995.3	Bottom Channel + 1
	……		
	13236	2007.5	Middle Channel
	……		
	13358	2019.7	Top Channel - 1
	13359	2019.8	Top Channel
	13360	2019.9	
	……	2020.0	Band Edge

AHLJA Downlink Band Edge Band 70 Narrow Band IoT Stand-Alone Frequency Channels

Multicarrier Test Cases:

(1) Three carriers with minimum spacing between carriers at the lower band edge are 13113 EARFCN: 1995.2MHz, 13116 EARFCN: 1995.5MHz and 13119 EARFCN: 1995.8MHz.
(2) Three carriers with minimum spacing between carriers at the center frequency are 13233 EARFCN: 2007.2MHz, 13236 EARFCN: 2007.5MHz and 13239 EARFCN: 2007.8MHz.
(3) Three carriers with minimum spacing between carriers at the upper band edge are 13353 EARFCN: 2019.2MHz, 13356 EARFCN: 2019.5MHz and 13359 EARFCN: 2019.8MHz.
(4) Three carriers based upon KDB 971168 D03v01 using two carriers at the lower band edge with minimum spacing between carriers and one carrier at the upper band edge with maximum spacing between the other two carriers are 13113 EARFCN: 1995.2MHz, 13116 EARFCN: 1995.5MHz and 13359 EARFCN: 2019.8MHz.

EUT Hardware

The EUT hardware used in testing on September 25 – October 8, 2018.

Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	AHLJA	AirScale BTS RRH	Part#: 474663A.101 Serial#: K9183303578	FCC ID: VBNAHLJA-01

Enclosure

The EUT enclosure is made of heavy duty aluminum.

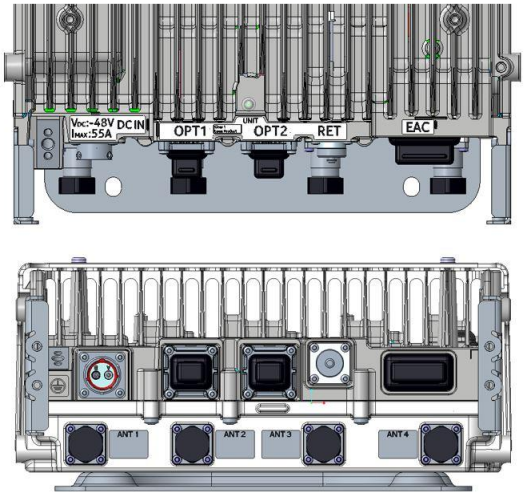
Support Equipment

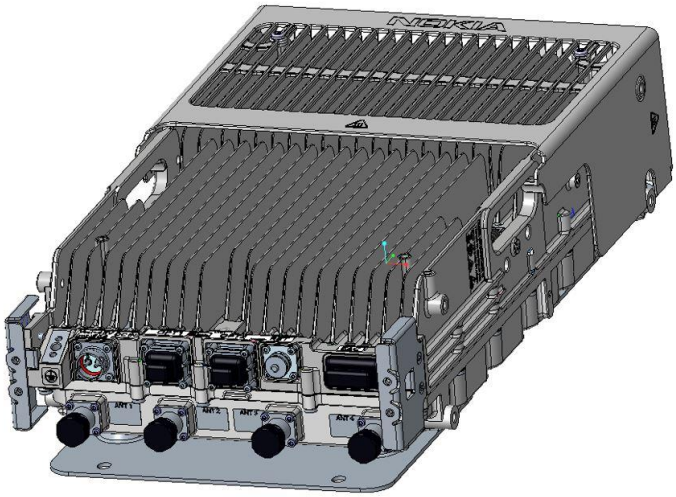
Company	Model	Description	Part/Serial Number	FCC ID/IC Number
Nokia Solutions and Networks	AMIA	Airscale System Module	Part#: 473098A.101 Serial#: RK164201509	N/A
HP	Elite Book 6930p	Laptop PC	N/A	N/A
Dell	Studio XPS	Instrumentation PC	N/A	N/A

Auxillary Equipment

Company	Description	Part Number	Serial Number
Nokia	FOUC 10GHz SFP Module (Plugs into RRH Opt Ports)	473842A.101	KR16180010011
Nokia	APAF AC Power Supply Mounts on RRH and provides DC power to RRH via 1 Meter cable	474676A.x21	A9183050057
RLC Electronics	2.4GHz High Pass Filter -2 Watt[1]	F-100-3000-5-R	0028
RLC Electronics	1.1GHz High Pass Filter -2 Watt[1]	F-14699	0050
Microwave Circuits	1.4GHz Low Pass Filter -100 Watt[1]	L13502G1	2454-01
Weinschel	Attenuator 20dB -150 Watt[1]	66-20-33-LIM	BZ2075
Weinschel	Attenuator 40dB -250 Watt[1]	58-40-43-LIM	TC909
Weinschel	Attenuator 10dB -250 Watt[1]	58-10-43-LIM	TD446
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.			

AHLJA Connector Layout:





EUT External Interfaces

Name	Qty	Connector Type	Purpose (and Description)
DC In	1	Quick Disconnect	2-pole Power Circular Connector
GND	1	Screw lug (2xM5/1xM8)	Ground
ANT	4	4.3-10	RF signal for Transmitter/Receiver (50 Ohm)
Unit	1	LED	Unit Status LED
EAC	1	MDR26	External Alarm Interface (4 alarms)
OPT	2	SFP+ cage	Optical Interface
RET	1	8-pin circular connector conforming to IEC 60130-9 – Ed.3.0	AISG 2.0 to external devices
Fan	1	Molex Microfit	Power for RRH Fan. Located on the side of RRH.

EUT Interface Ports

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

Cable	Type	Shield	Length	Used in Test	Quantity	Termination
RRH Power Input	Power	No	~ 2 m	Yes	1	APAF or DC Power Supply
Earth	Earth	No	~ 1.5 m	Yes	1	Lab earth ground
Antenna	RF	Yes	~ 2 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: FRM58.08.R09

(2) System Module Software: FL00_FSM4_9999_180828_021891
(3) BTS Site Manager: BTSSiteEM-FL00-0000_000533_000000

Modifications

No modifications were made to the EUT during testing.

TESTING

General Information

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

Radiated emissions and frequency accuracy/stability measurements were taken at NTS Plano branch located at 1701 E Plano Pkwy #150 Plano, TX 75074.

Radiated spurious emissions measurements were taken at the NTS Plano Anechoic Chamber listed below. The sites conform to the requirements of ANSI C63.4-2014: "*American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" and CISPR 16-1-4:2010-04: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus* – Antennas and test sites for radiated disturbance measurements". They are on file with the FCC and Industry Canada.

Site	Registration Numbers		Location
	FCC	Canada	
Chamber 1	A2LA Accredited Designation Number US1077	IC 4319A-2	1701 E Plano Pkwy #150 Plano, TX 75074.

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

Measurement Procedures

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

The 26dB emission bandwidth was measured in accordance with section 4 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 5.2 of FCC KDB 971168 D01v03r01 and ANSI C63.26 and the screenshots were captured using Keysight Benchvue Software. Peak power measurements were performed as described in section 5.1 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.3.3 and the screenshots were captured using Keysight Benchvue Software. The peak to average power ratio (PAPR) has been calculated as described in section 5.7 of KDB971168 D01v03r01 and ANSI C63.26-2015 section 5.2.6. Analyzer settings are shown on their corresponding plots in test results section.

Conducted spurious emissions on AHLJA Antenna Ports 1&2 were captured with Keysight Benchvue Software across the 9kHz-21GHz 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 6GHz. 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. Conducted spurious emissions on AHLJA Antenna Ports 3&4 were captured with Keysight Benchvue Software across the 9kHz-8GHz 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.

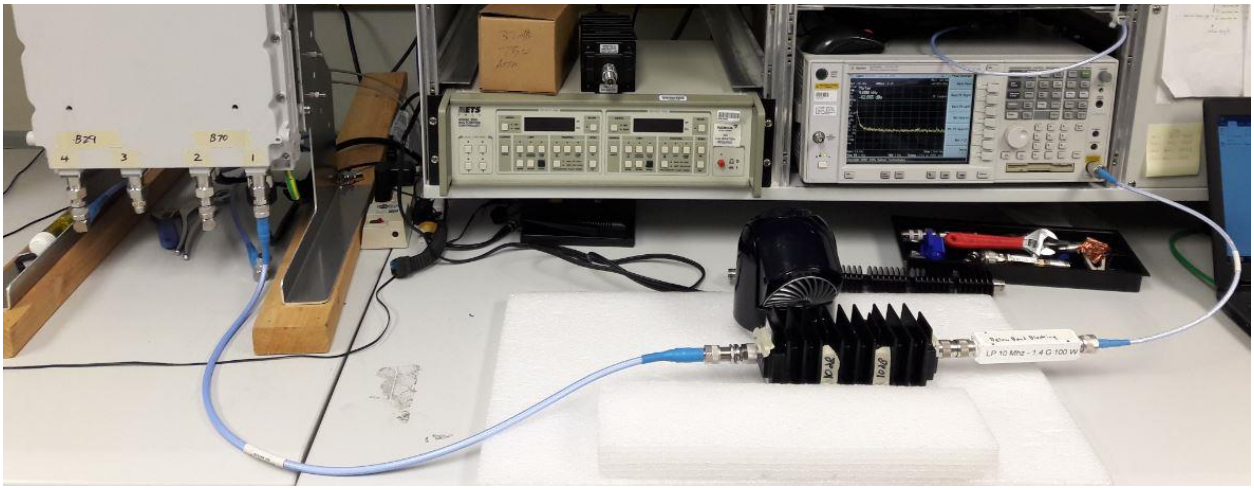
For frequency stability/accuracy measurements, the EUT was placed inside a temperature chamber with all support and test equipment located outside of the chamber. Temperature was varied across the specified range in 10-degree increments and EUT was allowed enough time to stabilize at each temperature step (a minimum of 30 minutes per step). The input voltage was varied as required by FCC/IC regulatory requirements.

Transmitter radiated spurious emissions measurements were made in accordance with ANSI C63.4-2014 by measuring the field strength of the emissions from the device at 3m test distance for emissions below 10 GHz and at 1m test distance for emissions above 10 GHz. The eirp limit as specified in the relevant rule part(s) is converted to a field strength at the test distance and the emissions from the EUT are then compared to that limit. Only emissions within 20dB of this limit are subjected to a substitution measurement in accordance with TIA-603. Both preliminary and final measurements were performed at the same FCC listed test chamber. Preliminary scans were performed with TILE6 software. This software corrected the measurements for antenna factors, cable losses and pre-amplifier gains. Both polarizations of the receiving antenna were scanned from 30MHz to 21GHz with a peak detector (RBW=1MHz, VBW=3MHz, with trace max hold over multiple sweeps). Based on the preliminary scan results, frequencies of interest have been maximized via rotating the EUT 360 degrees and varying the height of the test antenna (1m to 4m). Final measurements were also taken with the peak detector as described above. A biconilog antenna was used for 30MHz-1GHz range. A double ridged waveguide horn antenna was used for 1-18GHz range and a smaller horn antenna was used for 18-21GHz range. The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. EUT was placed on a non-conductive RF transparent structure to provide 80cm height from the ground floor for frequencies $\leq$ 1GHz and 150cm height from the ground floor for frequencies > 1GHz in accordance with ANSI C63.26-2015. A motorized turntable allowed it to be rotated during testing to determine the angle with the highest level of emissions.

Antenna Port Conducted RF Measurement Test Setup Diagrams

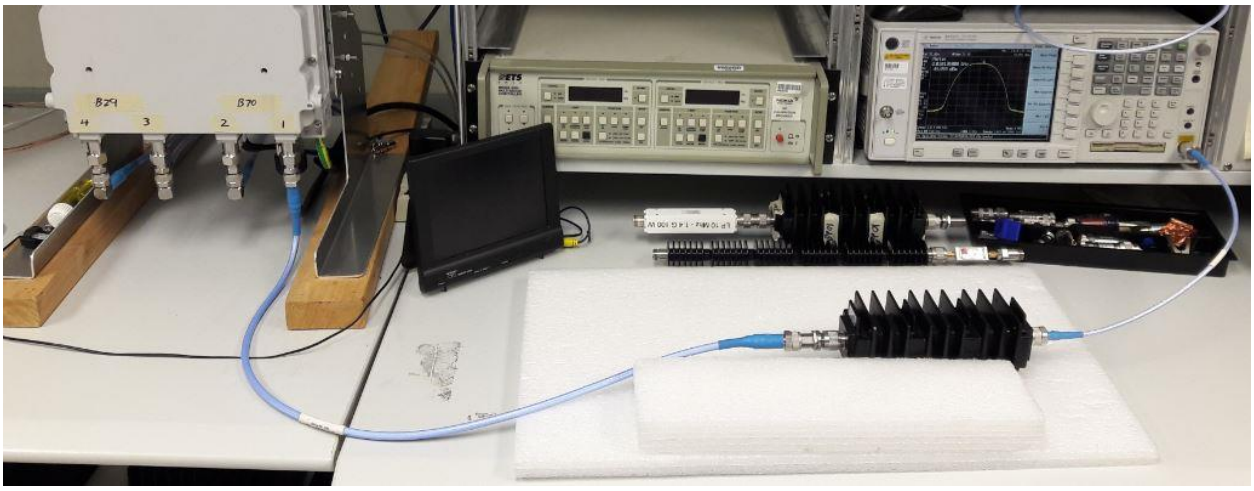
The following setups were used in the RF conducted emissions testing for AHLJA Antenna Ports 1 and 2. The photographs of the test setups are also provided.

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

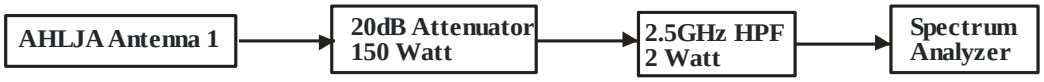


Photograph of 9kHz to 150kHz and 150kHz to 20MHz Test Setup

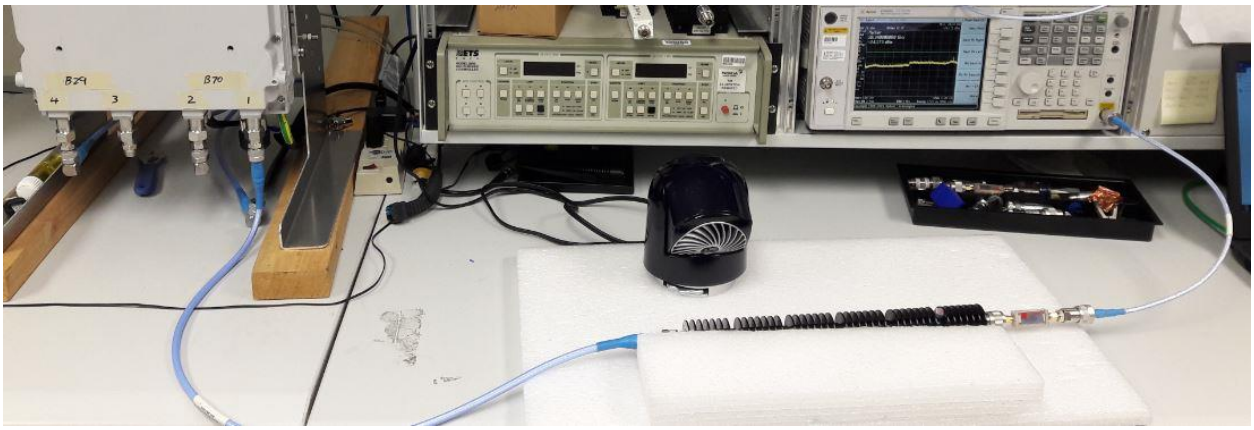
Setup for 20MHz to 3GHz and 3GHz to 6GHz Measurements



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



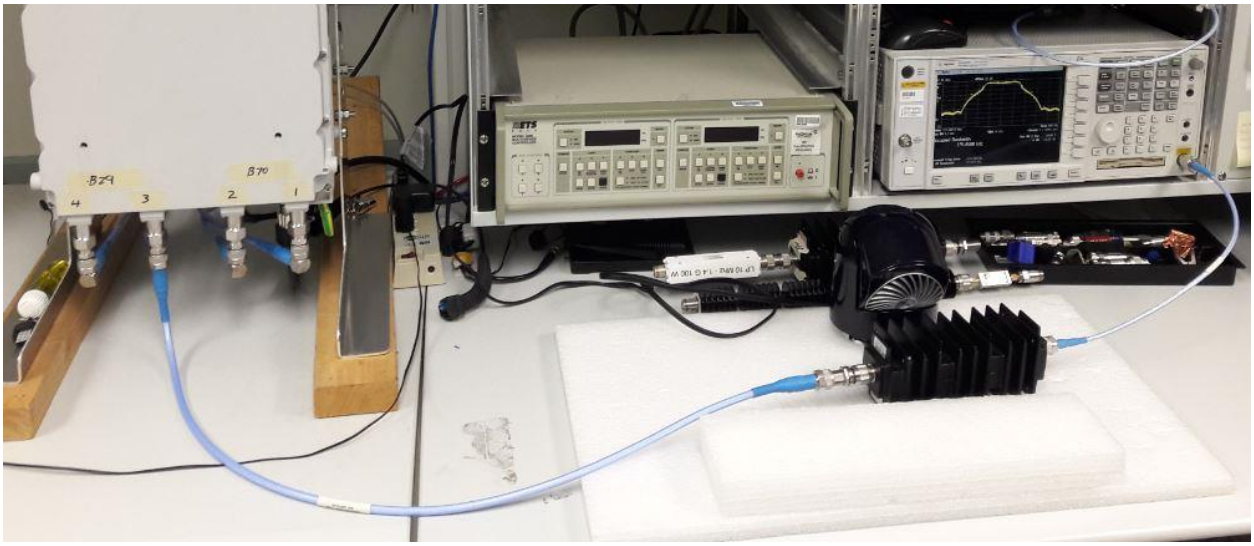
Setup for 6GHz to 21GHz Measurements



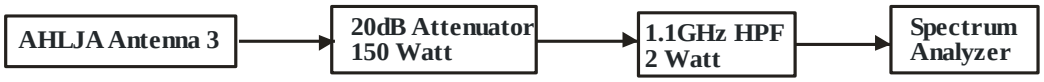
Photograph of for 6GHz to 21GHz Test Setup

The following setups were used in the RF conducted emissions testing for AHLJA Antenna Ports 3 and 4. The photographs of the test setups are also provided.

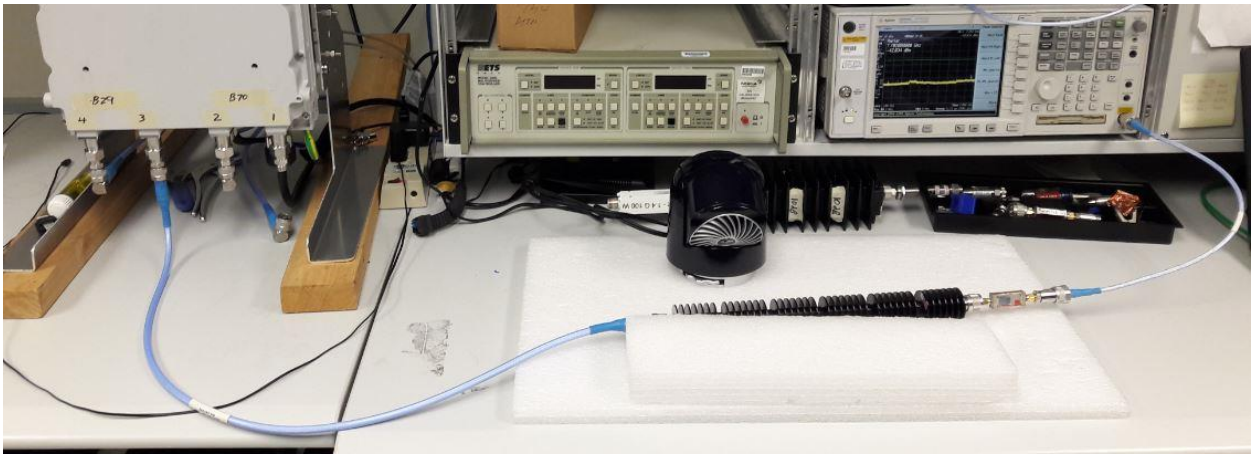
Setup for 9kHz to 150kHz, 150kHz to 20MHz and 20MHz to 1100MHz Measurements



Photograph of 9kHz to 150kHz, 150kHz to 20MHz and 20MHz to 1100MHz Test Setup



Setup for 1.1GHz to 8GHz Measurements



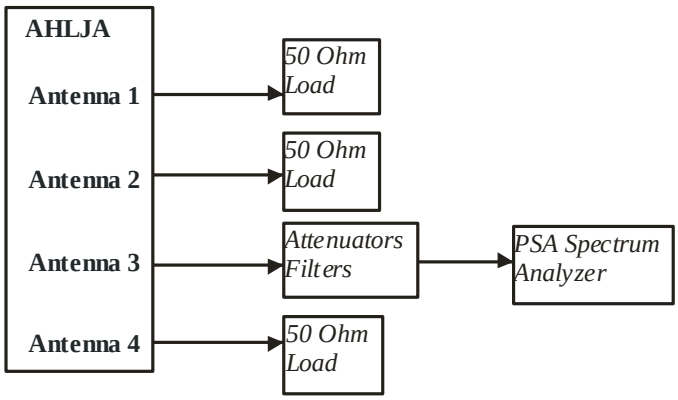
Photograph of 1.1GHz to 8GHz Test Setup

Test Measurement Equipment

NTS Equipment #	Description	Manufacturer	Model	Calibration Duration	Calibration Due Date
WC020917	Bilog Antenna	ETS-Lindgren	3142D	24 Months	11/15/2019
WC025240	Spectrum Analyzer	Agilent	E4446A	12 Months	3/3/2019
WC021471	Preamp	MITEQ	AM-1431-N11975C	12 Months	2/6/2019
WC021478	Preamp	HP	8449B	12 Months	3/19/2019
WC021206	Horn Antenna	ETS-Lindgren	3115	12 Months	1/12/2019
WC021208	Small Horn Antenna	EMCO	3116	12 Months	11/15/2018
WC038434	Preamp	MITEQ	JS32-00104000-62-5P	12 Months	10/13/2018
WC021859	Spectrum Analyzer	Agilent	E4440A	12 Months	9/6/2019
WC027005	True RMS Multimeter	Fluke	87V	12 Months	7/17/2019
WC021659	Chamber (Temperature/Humidity)	Thermotron	S-16-Mini-Max	No Calibration Required	No Calibration Required
WC038555	Controller (Temperature)	Watlow	F4	12 Months	8/22/2019
120194[1]	PSA Spectrum Analyzer	Agilent	E4440A	12 Months	10/25/2018
NM06345[1]	ENA Network Analyzer	Keysight	E5063A	12 Months	11/20/2018
NM04509[1]	Network Analyzer	Rohde & Schwarz	ZVL 3	12 Months	2/03/2019
NM06374[1]	MXG Analog Signal Gen	Keysight	N5183B	36 Months	02/04/2021
Note 1: Customer equipment					

APPENDIX A: ANTENNA PORT TEST DATA FOR BAND 29 (722-728MHZ)

All conducted RF measurements in this section were made at AHLJA antenna ports 3 and 4 for the Band 29 measurements. The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on AHLJA

RF Output Power

RF output power has been measured in both Peak and RMS Average terms for each Band 29 (722 to 728MHz) transmit chain (AHLJA Antenna Ports 3&4) at the bottom, middle and top frequency channels for a NB-IoT stand-alone single carrier (QPSK). RMS Average power was measured as described in section 5.2 of KDB 971168 D01v03r01 and ANSI C63.26-2015 sections 5.2.4.3 & 5.2.4.4. Peak power was measured as described in section 5.1 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.3.3. The peak to average power ratio (PAPR) has been calculated as described in section 5.7 of KDB971168 D01v03r01 and ANSI C63.26-2015 section 5.2.6.

The RMS Average power output on Antenna Ports 3&4 (3GPP frequency band 29) was also measured using two carriers per antenna port on the bottom, middle and top channels (with minimum spacing between carrier frequencies). Based upon these multi-carrier power measurements the antenna port with the highest RMS Average power output for 3GPP frequency band 29 is to be used for the remaining radio compliance conducted measurements. The port power measurements are required to be performed with multiple carriers to produce maximum power output on the port. The maximum single carrier power output is 20 watts while the maximum port power output is 40 watts for ports 3&4. All results are presented in tabular form below. The highest measured values for carrier peak power, carrier average power and port average power are highlighted. Measurements were rounded off to the nearest tenth.

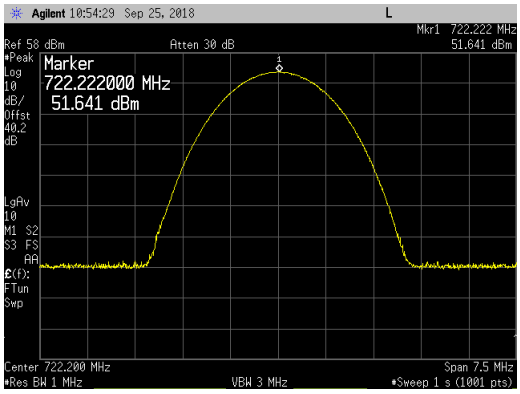
Antenna Port RF Channel	Carrier Frequencies	Measurement	Peak (dBm)	Average (dBm)	PAPR (dB)
Port 3 Bottom Channel	**722.2 MHz**	**Carrier Power**	51.6	**43.2**	8.4
	722.2 and 722.5 MHz	**Port Power**	N/A	45.5	N/A
Port 3 Middle Channel	**725.0 MHz**	**Carrier Power**	51.6	42.9	**8.7**
	725.0 and 725.3 MHz	**Port Power**	N/A	45.6	N/A
Port 3 Top Channel	**727.8 MHz**	**Carrier Power**	51.4	43.0	8.4
	727.5 and 727.8 MHz	**Port Power**	N/A	45.5	N/A
Port 4 Bottom Channel	**722.2 MHz**	**Carrier Power**	**51.7**	**43.2**	8.5
	722.2 and 722.5 MHz	**Port Power**	N/A	**45.7**	N/A
Port 4 Middle Channel	**725.0 MHz**	**Carrier Power**	51.6	**43.2**	8.4
	725.0 and 725.3 MHz	**Port Power**	N/A	45.5	N/A
Port 4 Top Channel	**727.8 MHz**	**Carrier Power**	51.1	42.8	8.3
	727.5 and 727.8 MHz	**Port Power**	N/A	45.1	N/A

Port 3 has the highest middle channel RMS average port power and was selected for all the remaining antenna port conducted emission tests.

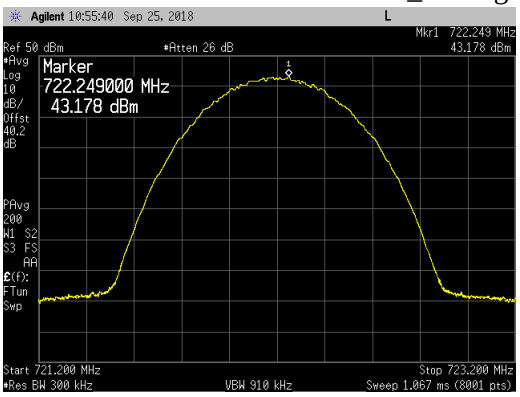
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

Power Plots at Antenna Ports 3 and 4 for the Bottom Channel (Single and Multicarrier):

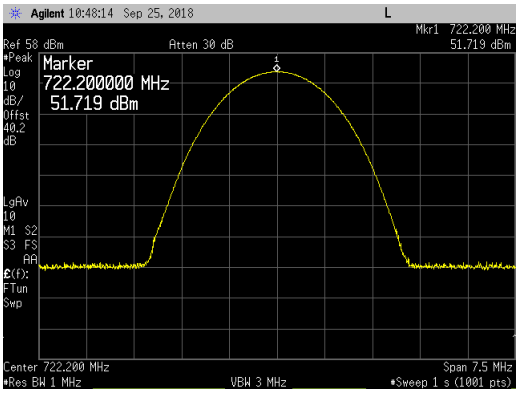
Carrier Power -Port 3 - 722.2MHz_Peak



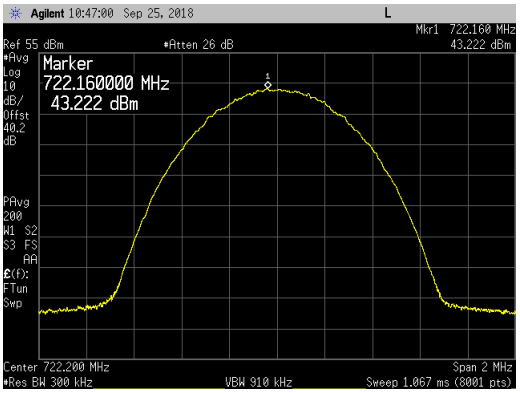
Carrier Power -Port 3 - 722.2MHz_Average



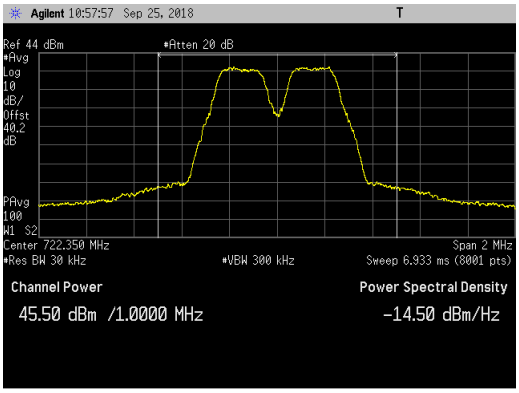
Carrier Power -Port 4 – 722.2MHz_Peak



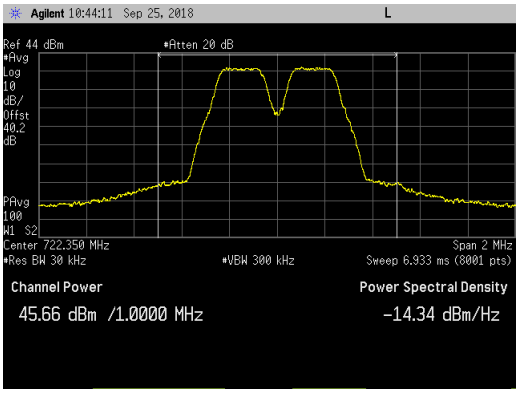
Carrier Power -Port 4 – 722.2MHz_Average



Port Pwr -Port 3 – 722.2&722.5MHz_Average

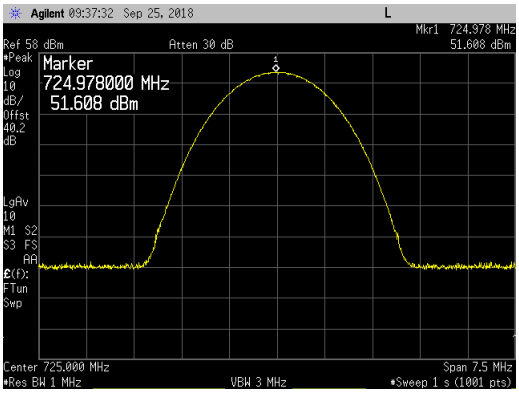


Port Pwr -Port 4 – 722.2&722.5MHz_Average

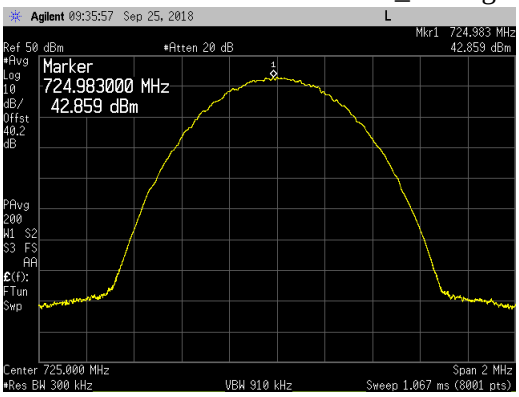


Power Plots at Antenna Ports 3 and 4 for the Middle Channel (Single and Multicarrier):

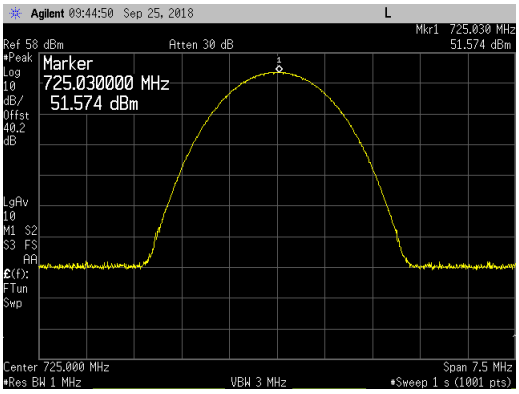
Carrier Power Port 3 – 725.0MHz_Peak



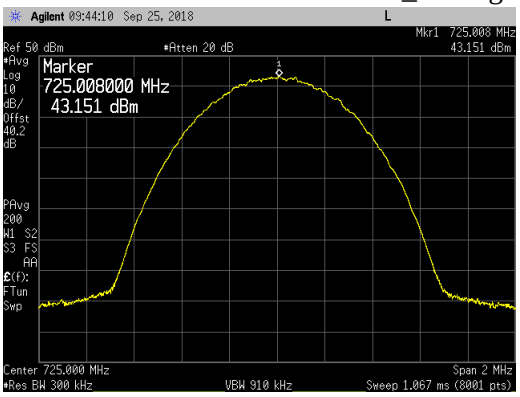
Carrier Power Port 3 – 725.0MHz_Average



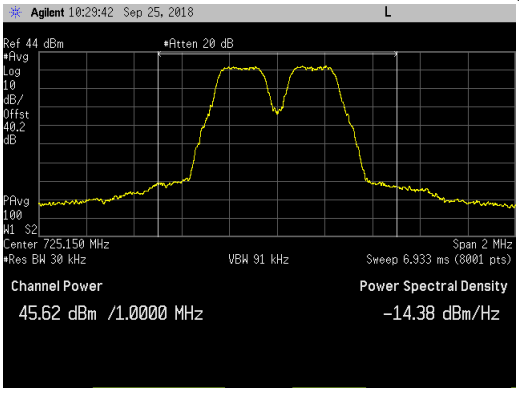
Carrier Power Port 4 – 725.0MHz_Peak



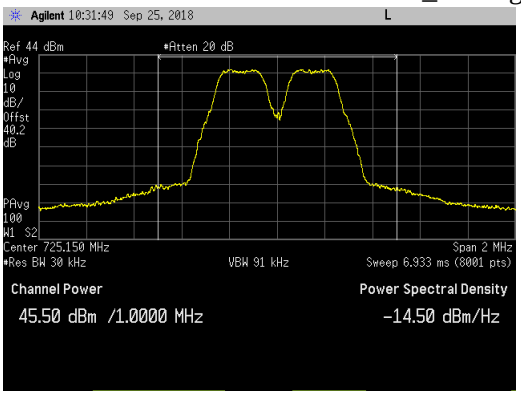
Carrier Power Port 4 – 725.0MHz_Average



Port Pwr Port 3 – 725.0&725.3MHz_Average

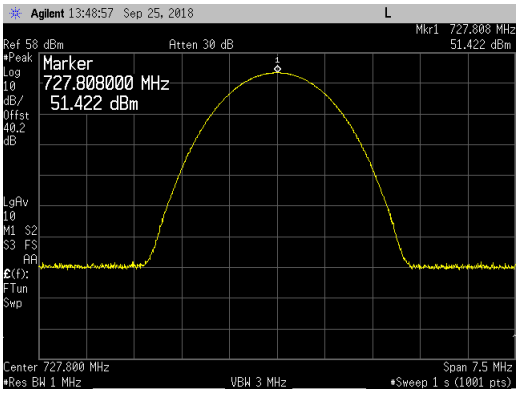


Port Pwr Port 4 – 725.0&725.3MHz_Average

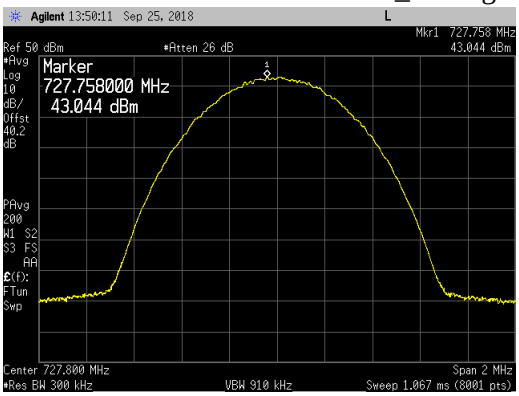


Power Plots at Antenna Ports 3 and 4 for the Top Channel (Single and Multicarrier):

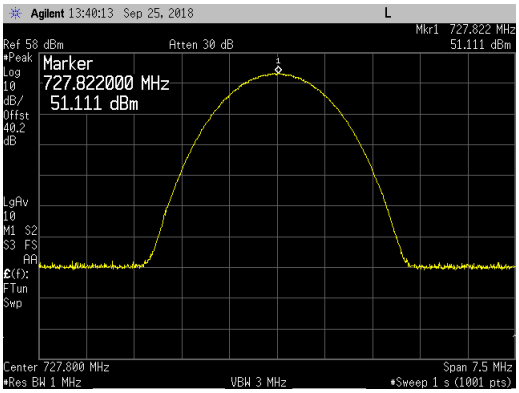
Carrier Power Port 3 – 727.8MHz_Peak



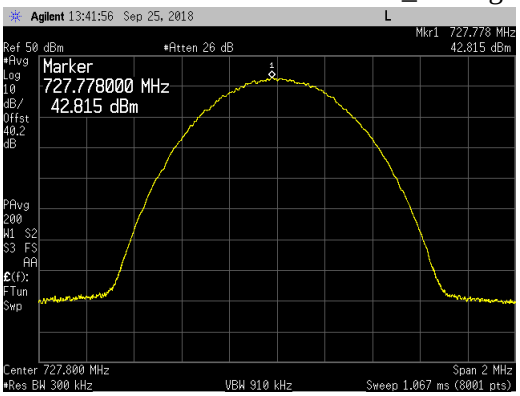
Carrier Power Port 3 – 727.8MHz_Average



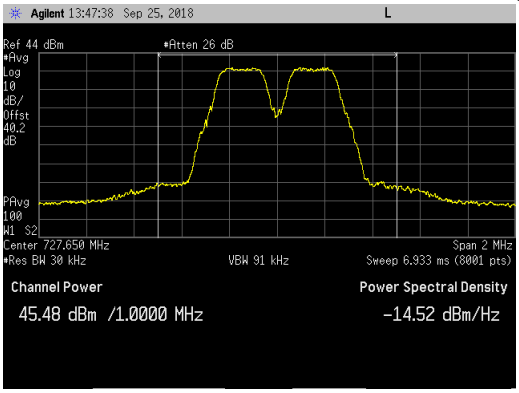
Carrier Power Port 4 – 727.8MHz_Peak



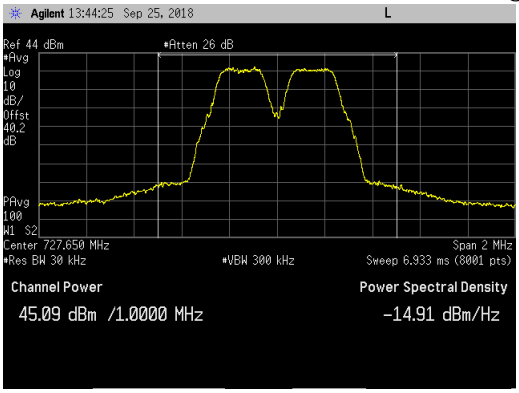
Carrier Power Port 4 – 727.8MHz_Average



Port Pwr Port 3 – 727.5&727.8MHz_Average



Port Pwr Port 4 – 727.5&727.8MHz_Average



Emission Bandwidth (26 dB down and 99%)

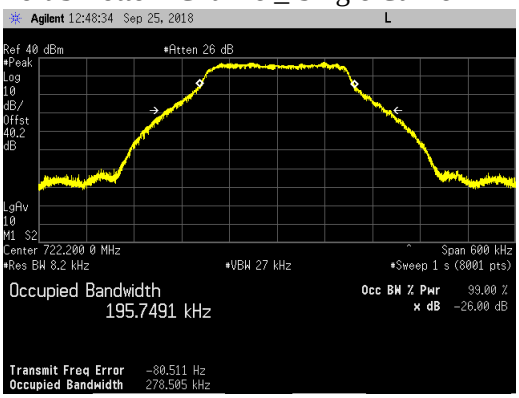
Emission bandwidth measurements were made at antenna ports 3&4 on the bottom, middle and top channels. The AHLJA was operated at maximum RF output power for NB-IoT stand-alone single carrier (QPSK). The results are provided in the following table. The largest emission bandwidth is highlighted.

Antenna Port	RF Channel	Emission Bandwidth (kHz)	
		26dB	99%
Port 3	Bottom Channel	278.505	195.7491
	Middle Channel	279.685	195.8172
	Top Channel	278.805	198.1306
Port 4	Bottom Channel	278.041	**198.1817**
	Middle Channel	278.805	197.9537
	Top Channel	**286.583**	198.0871

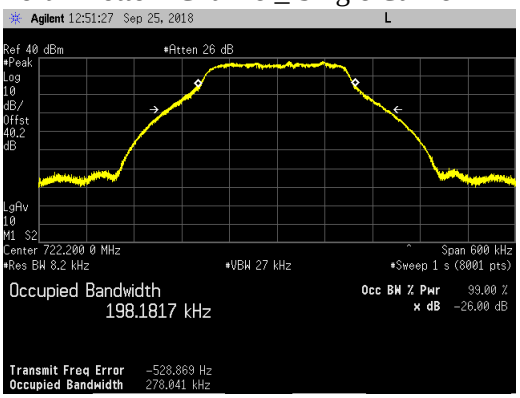
Emission bandwidth measurement data are provided in the following pages.

Emission Bandwidth Plots at Antenna Ports 3 and 4 for the Bottom, Middle and Top Frequency Channels:

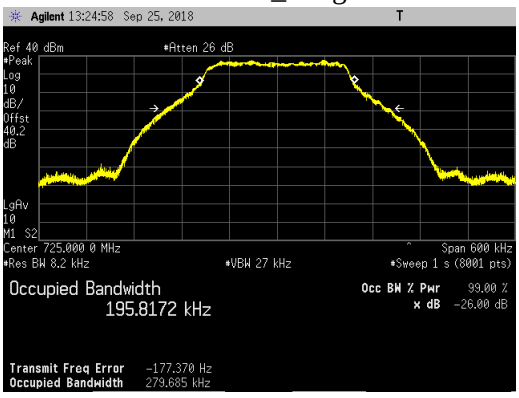
Port 3 Bottom Channel_ Single Carrier



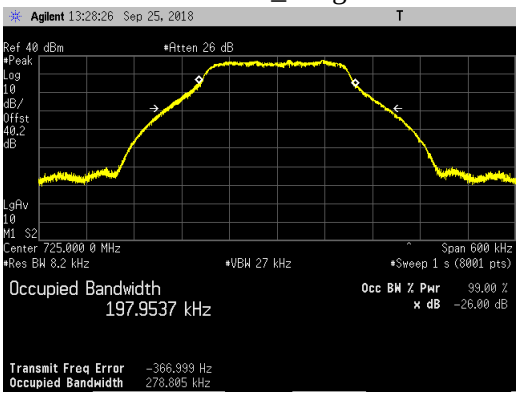
Port 4 Bottom Channel_ Single Carrier



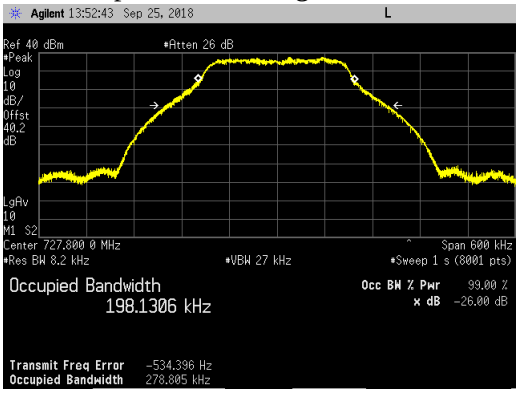
Port 3 Middle Channel_ Single Carrier



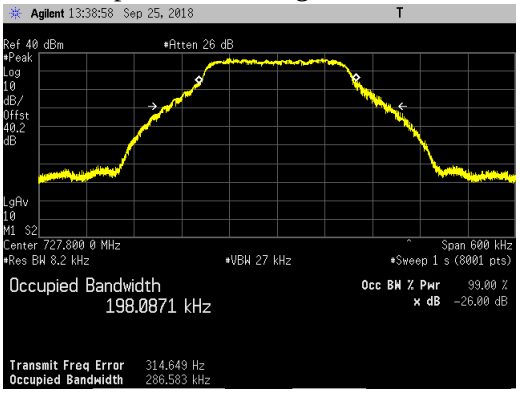
Port 4 Middle Channel_ Single Carrier



Port 3 Top Channel_ Single Carrier



Port 4 Top Channel_ Single Carrier



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at RRH antenna port 3. The RRH was operated at maximum power with a single carrier at the band edge frequencies. Measurements were also performed with two carriers (with minimum spacing between carrier frequencies) per antenna port on the bottom and top channels. Two carriers are required to produce maximum port power output. The maximum single carrier power output is 20 watts while the maximum port power output is 40 watts for ports 3&4.

Another multicarrier test case based upon KDB 971168 D03v01 using three carriers per antenna port was performed with two carriers (with minimum spacing between carrier frequencies) at the lower band edge and a third carrier (with maximum spacing between the other two carrier frequencies) at the upper band edge.

The power of any emission outside of the authorized operating frequency range cannot exceed -13 dBm as specified in FCC 27.53(g).

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. In the 100 to 200kHz frequency range outside the band edge (i.e.: 721.8 to 721.9MHz and 728.1 to 728.2MHz bands) the RBW was set to 30kHz and the power integrated over 100kHz. In the 200kHz to 22.2MHz frequency range outside the band edge (i.e.: 701.8 to 721.8MHz and 728.2 to 748.2MHz bands) a 100kHz RBW and 300kHz VBW was used.

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

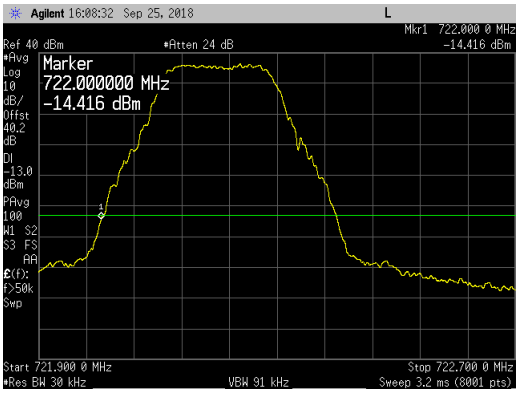
Band 29 Carrier Frequency Carrier Power and Port Power	**Port 3 (dBm)**	
	Lower	**Upper**
Single Carrier at Bottom Channel (722.2MHz)/Top Channel (727.8MHz) 20W per Carrier and 20W per Port	-14.416	-14.704
Two Carriers at Bot Chs (722.2 & 722.5MHz)/Top Chs (727.5 & 727.8MHz) 20W per Carrier and 40W per Port	-14.925	-14.617
Three Carriers at Bot Chs (722.2 & 722.5MHz) and at Top Ch (727.8MHz) 13W per Carrier and 40W per Port	-16.158	-16.041

The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.

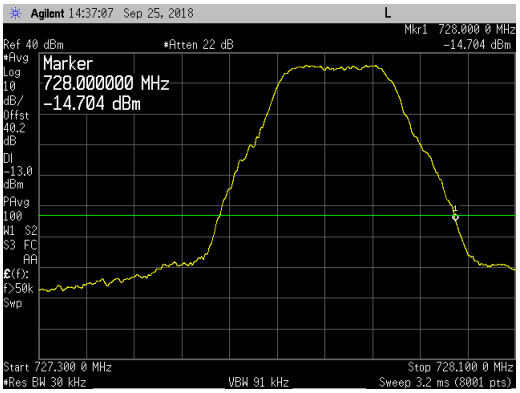
Conducted band edge measurements are provided in the following pages.

Band 29 Single Carrier at 20W/Carrier and 20W/Port -Lower and Upper Band Edge Plots:

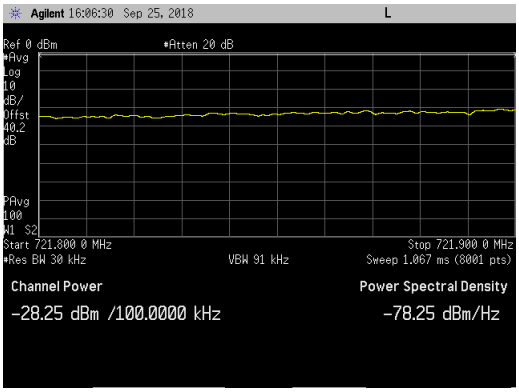
Carrier at Bottom Channel (722.2MHz)
Port 3_LBE_721.9 to 722.7MHz



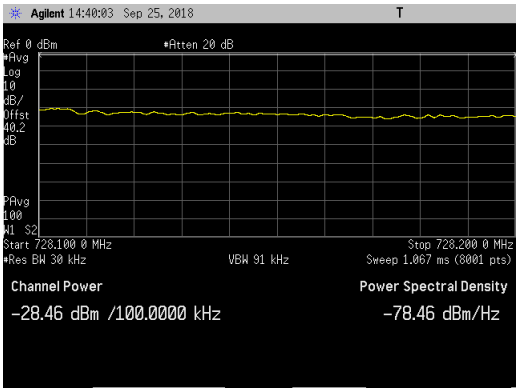
Carrier at Top Channel (727.8MHz)
Port 3_UBE_727.3 to 728.1MHz



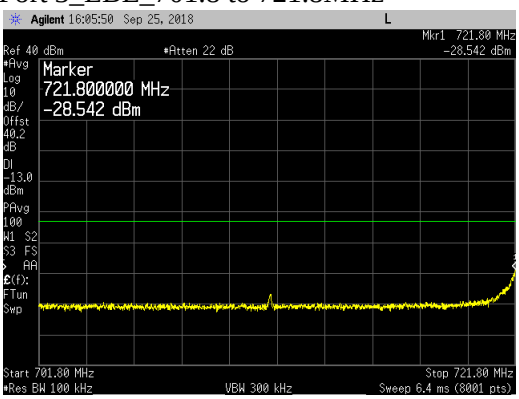
Port 3_LBE_721.8 to 721.9MHz



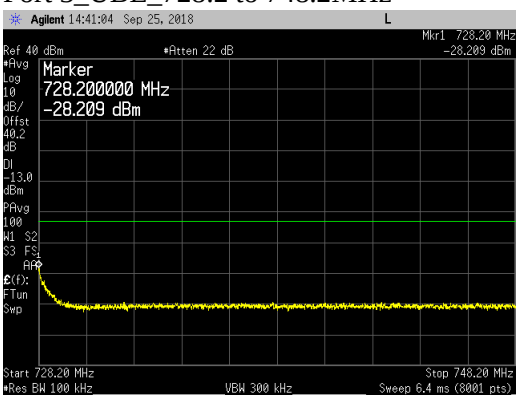
Port 3_UBE_728.1 to 728.2MHz



Port 3_LBE_701.8 to 721.8MHz

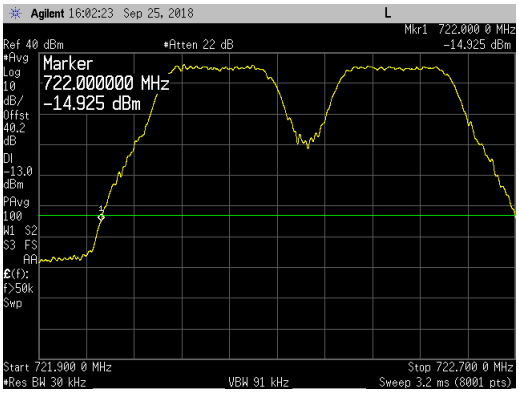


Port 3_UBE_728.2 to 748.2MHz

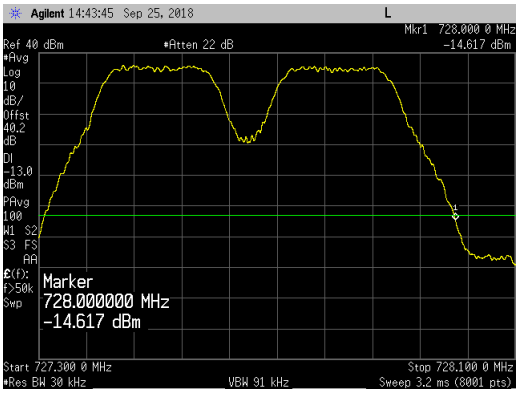


Band 29 Two Carriers at 20W/Carrier and 40W/Port -Lower and Upper Band Edge Plots:

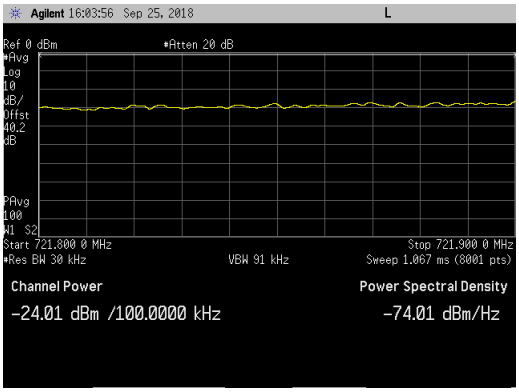
Carriers at BCs (722.2 & 722.5MHz)
Port 3_LBE_721.9 to 722.7MHz



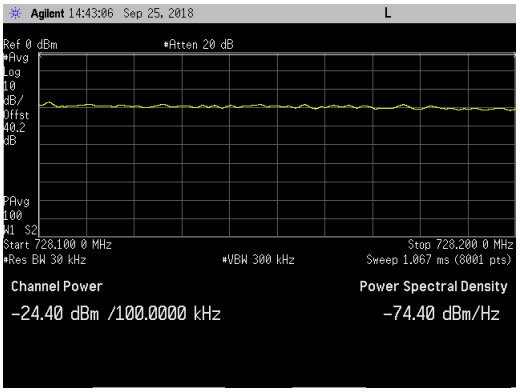
Carrier at TCs (727.5 & 727.8MHz)
Port 3_UBE_727.3 to 728.1MHz



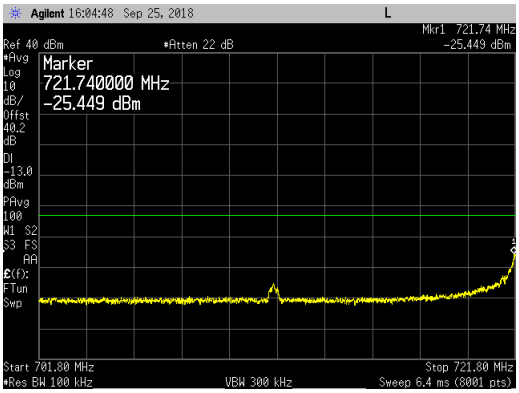
Port 3_LBE_721.8 to 721.9MHz



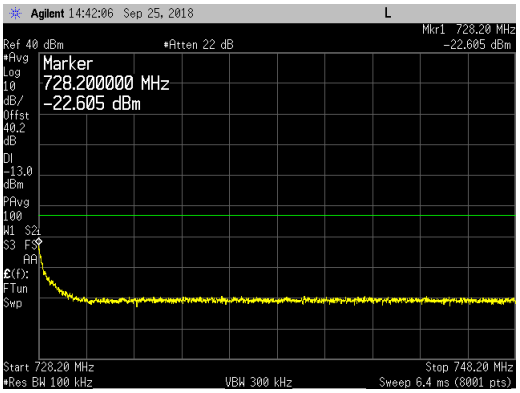
Port 3_UBE_728.1 to 728.2MHz



Port 3_LBE_701.8 to 721.8MHz

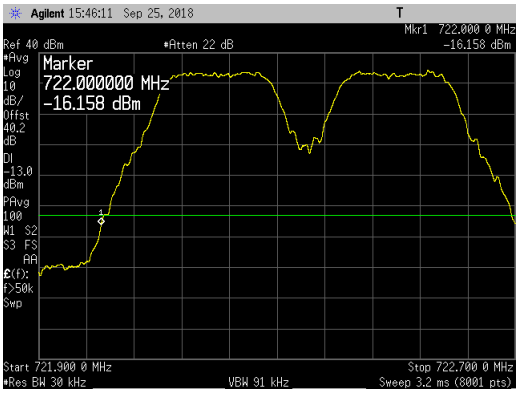


Port 3_UBE_728.2 to 748.2MHz

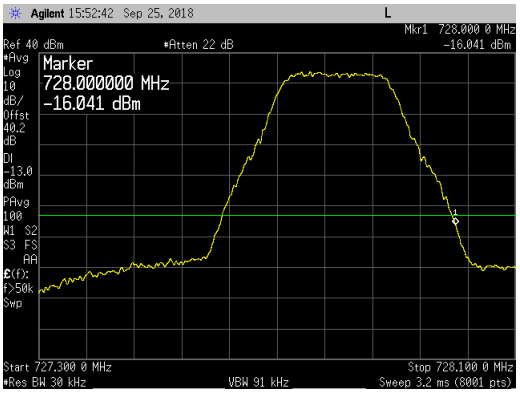


Band 29 Three Carriers at 13W/Carrier and 40W/Port -Lower and Upper Band Edge Plots:

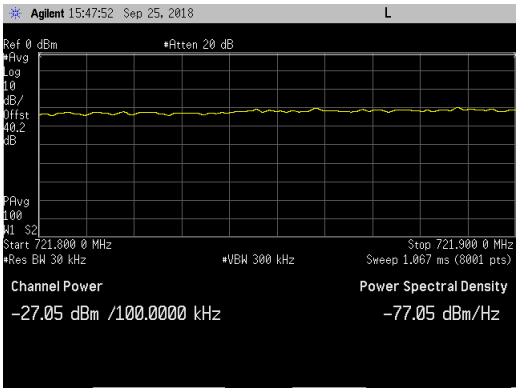
Carriers at 722.2, 722.5 & 727.8MHz
Port 3_LBE_721.9 to 728.0MHz



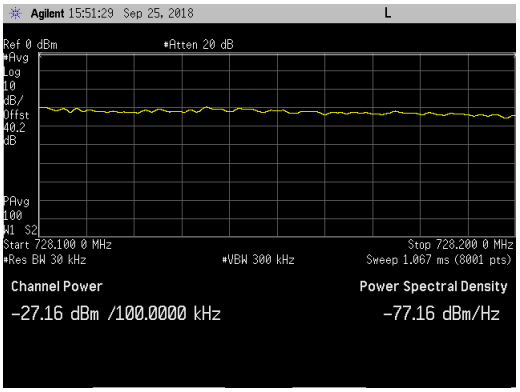
Carriers at 722.2, 722.5 & 727.8MHz
Port 3_UBE_722.0 to 728.1MHz



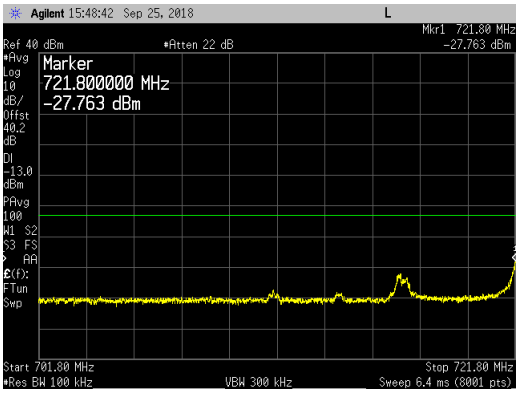
Port 3_LBE_721.8 to 721.9MHz



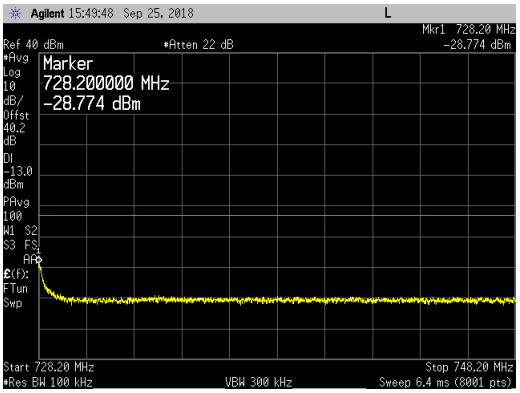
Port 3_UBE_728.1 to 728.2MHz



Port 3_LBE_701.8 to 721.8MHz



Port 3_UBE_728.2 to 748.2MHz



Transmitter Antenna Port Conducted Emissions

Transmitter conducted emission measurements were made at RRH antenna port 3. Measurements were performed over the 9kHz to 8GHz frequency range. The RRH was operated at maximum power with a single carrier on the Band 29 middle channel (725.0MHz). Measurements were also performed with two carriers (with minimum spacing between carrier frequencies) per antenna port on the middle channels (725.0 & 725.3MHz). Two carriers are required to produce maximum port power output. The maximum single carrier power output is 20 watts while the maximum port power output is 40 watts for ports 3&4.

Another multicarrier test case based upon KDB 971168 D03v01 using three carriers per antenna port was performed with two carriers (with minimum spacing between carrier frequencies) at the lower band edge (722.2 & 722.5MHz) and a third carrier (with maximum spacing between the other two carrier frequencies) at the upper band edge (727.8MHz).

The power of any emission outside of the authorized operating frequency range cannot exceed -13 dBm as specified in FCC 27.53(g). 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 or with the spectrum analyzer using average detector in RMS average mode over 100 traces.

The limit for the 9kHz to 150kHz frequency range was adjusted to –33dBm to correct for a spectrum analyzer RBW of 1kHz versus required RBW of 100kHz [i.e.: -33dBm = -13dBm -10log(100kHz/1kHz)]. The limit for the 150kHz to 20MHz frequency range was adjusted to –23dBm to correct for a spectrum analyzer RBW of 10kHz versus required RBW of 100kHz [i.e.: -23dBm = -13dBm -10log(100kHz/10kHz)]. The required limit of -13dBm with a RBW of ≥100kHz was used for all other frequency ranges. The spectrum analyzer settings that were used for this test are summarized in the following table.

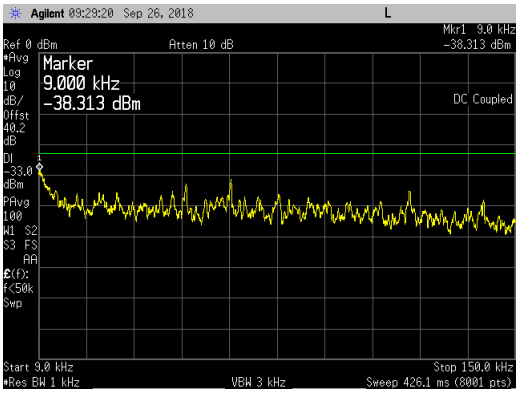
Frequency Range	RBW	VBW	Number of Data Points	Detector	Sweep Time	Max Hold over	Offset Note 1
9kHz to 150kHz	1kHz	3kHz	8001	Average	Auto	Note 2	40.2dB
150kHz to 20MHz	10kHz	30kHz	8001	Average	Auto	Note 2	40.1dB
20MHz to 1100MHz	1MHz	3MHz	8001	Average	Auto	Note 2	40.2dB
1.1GHz to 8GHz	2MHz	6MHz	8001	Peak	Auto	50 Sweeps	22.5dB

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.

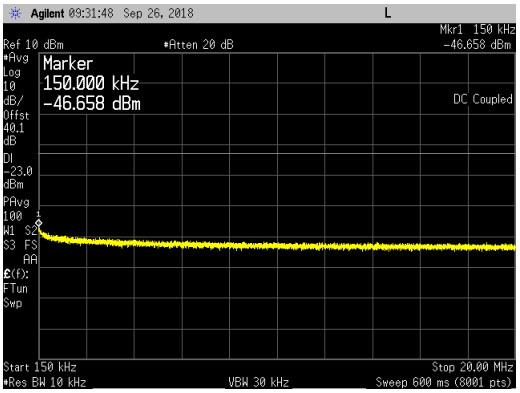
A high pass filter was used to reduce measurement instrumentation noise floor for the frequency range above 1100MHz. The total measurement RF path loss of the test setup (attenuators, high pass filter and test cables) as shown in the table is accounted for by the spectrum analyzer reference level offset.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

Band 29 Single Carrier at Middle Channel (725.0MHz) with 20W/Carrier and 20W/Port:

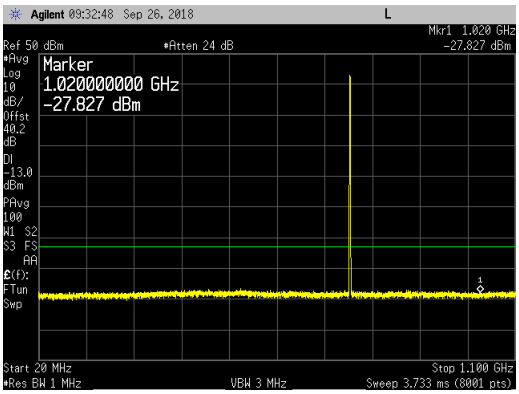
9kHz to 150kHz



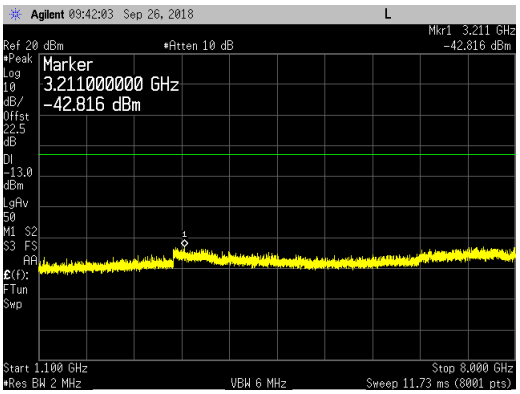
150kHz to 20MHz



20MHz to 1100MHz

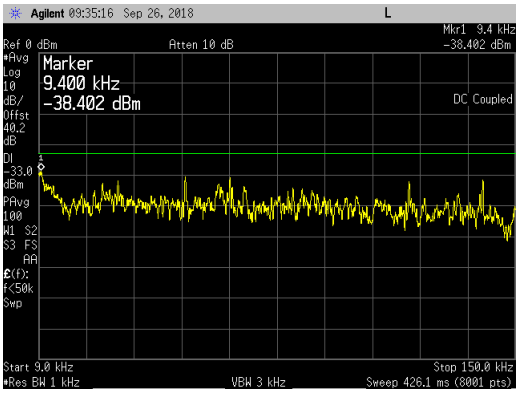


1.1GHz to 8GHz

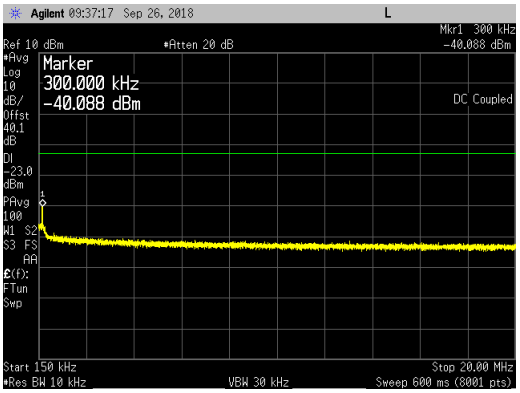


Band 29 Two Carriers at Middle Channels (725.0 & 725.3MHz) with 20W/Carrier and 40W/Port:

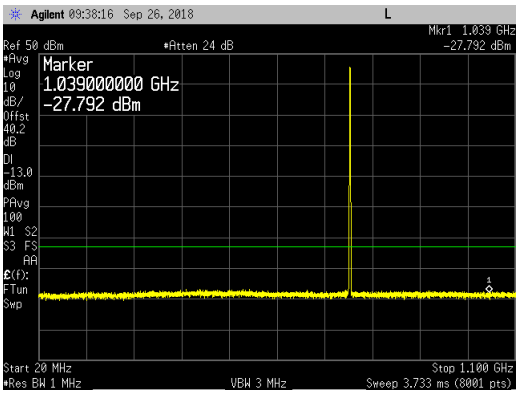
9kHz to 150kHz



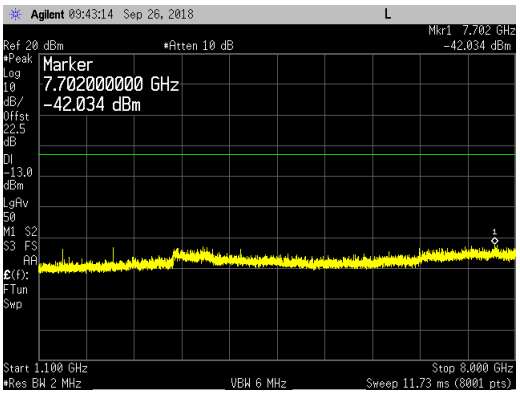
150kHz to 20MHz



20MHz to 1100MHz

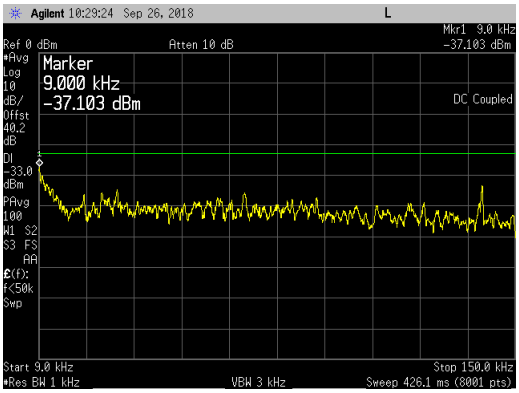


1.1GHz to 8GHz

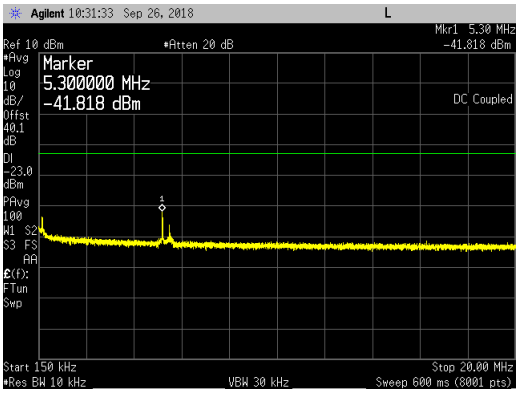


Band 29 Three Carriers at BCs (722.2 & 722.5MHz) & TC (727.8MHz) with 13W/Carrier and 40W/Port:

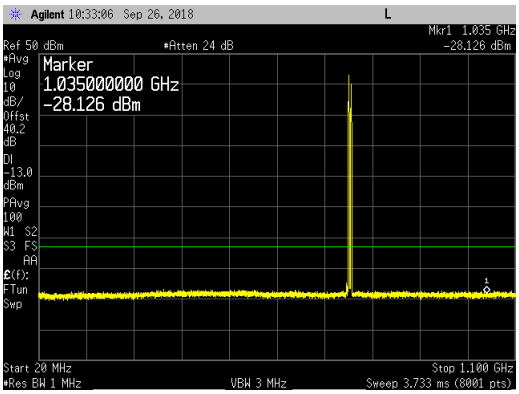
9kHz to 150kHz



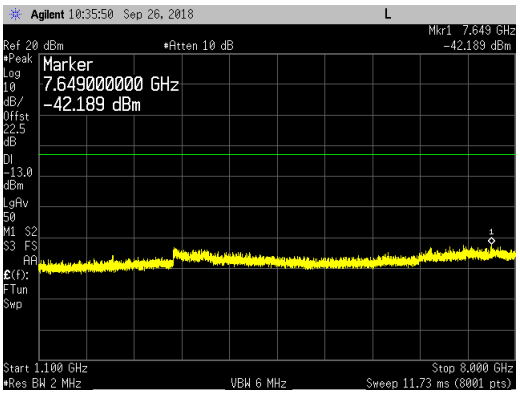
150kHz to 20MHz



20MHz to 1100MHz

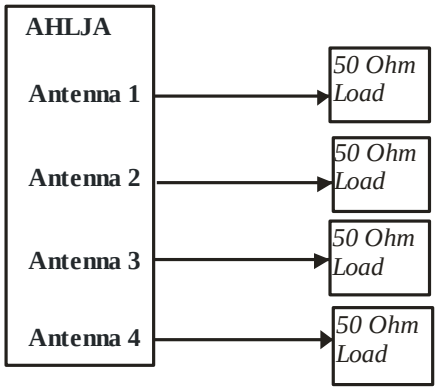


1.1GHz to 8GHz



Transmitter Radiated Spurious Emissions

During radiated emission testing all antenna ports of the base station were terminated with 50ohm termination blocks as shown in the diagram below.



See ANSI C63.26-2015 paragraph 5.1 for details of test setup requirements. Based on antenna port conducted spurious emissions tests results, preliminary scans for radiated spurious emissions were performed in 30MHz – 21GHz frequency range.

One radiated emission test configuration (with the RRH fan assembly and RRH AC Power Supply options) were used to prove compliance for both 3GPP Band 29 and the 3GPP Band 70 frequency bands. The Band 29 IoT carriers were enabled on the bottom and top frequency channels at maximum power (20 watts per carrier and 40 watts per antenna port) on Antenna ports 3 & 4. The Band 70 IoT carriers were enabled on the bottom, middle and top frequency channels at maximum power (20 watts per carrier and 60 watts per antenna port) on Antenna ports 1 & 2. The RRH antenna ports are to be terminated using RF cables/loads. Final maximized radiated emissions are measured in these modes. The carrier configuration for the radiated emission testing is provided below.

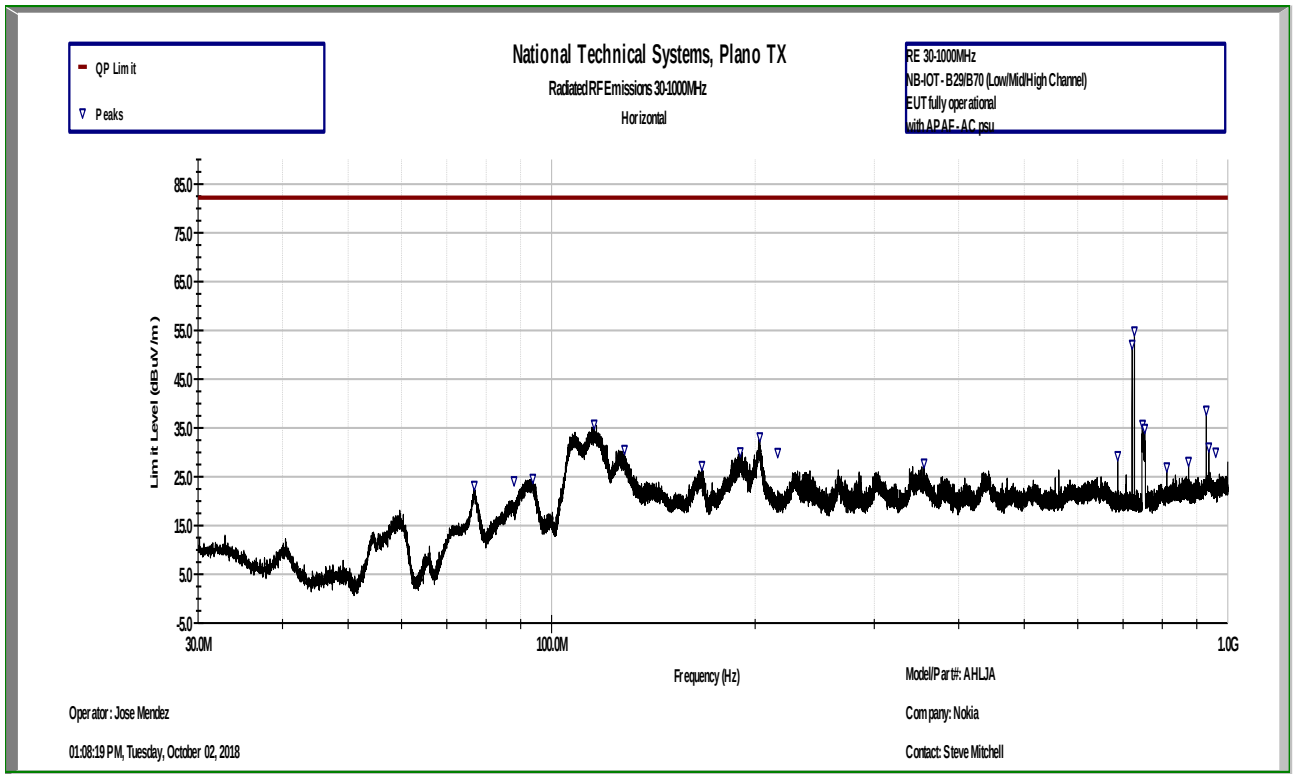
Frequency Band	Antenna Port	EARFCN	Transmit Frequency	Carrier Power
Band 70	1	13113 (Bottom Channel)	1995.2 MHz	20 Watts
Band 70	1	13116 (Bottom Channel +3)	1995.5 MHz	20 Watts
Band 70	1	13359 (Top Channel)	2019.8 MHz	20 Watts
Band 70	2	13233 (Middle Channel -3)	2007.2 MHz	20 Watts
Band 70	2	13236 (Middle Channel)	2007.5 MHz	20 Watts
Band 70	2	13239 (Middle Channel +3)	2007.8 MHz	20 Watts
Band 29	3	11133 (Bottom Channel)	722.2 MHz	20 Watts
Band 29	3	11189 (Top Channel)	727.8 MHz	20 Watts
Band 29	4	11133 (Bottom Channel)	722.2 MHz	20 Watts
Band 29	4	11189 (Top Channel)	727.8 MHz	20 Watts

Antenna Ports and Band 29/70 Carriers at Maximum Power (20W/carrier)

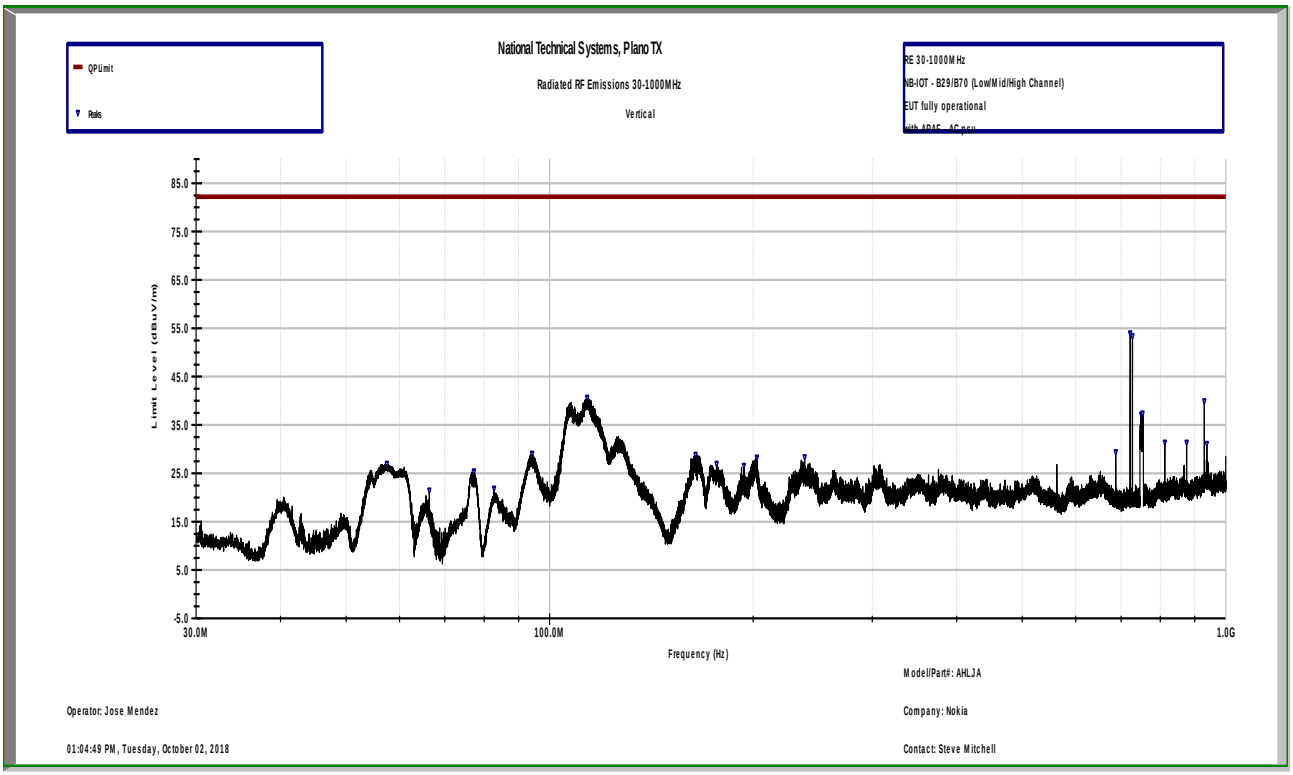
RE Data for NB-IOT - B29/B70 (Low/Mid/High Channel):

Frequency	Peaks Raw	Antenna	Pre Amp	Cable Loss	Peaks	Limit	Margin	Tower	Turntable	Polarity
MHz	dBuV/m	dB	dB	dB	dBuV/m	dBuV/m	dB	cm	Degrees	H/V
19247.1	36.267	45.012	-27.467	4.9	58.712	91.7	-32.988	300	359	V
17772.9	29.942	47.442	-28.718	8.095	56.761	91.7	-34.939	100	1	V
18298.8	34.608	44.87	-27.728	4.9	56.65	91.7	-35.05	300	359	V
17963.4	28.152	48.544	-28.891	8.952	56.603	91.7	-35.097	100	1	H
13339.6	34.538	41.058	-28.346	9.231	56.481	91.7	-35.219	100	1	H
13298	34.027	40.817	-28.315	9.16	56.02	91.7	-35.68	100	1	V
17989.4	25.059	48.723	-28.914	9.07	53.721	91.7	-37.979	100	1	V
18816.8	30.985	44.768	-27.925	4.9	52.728	91.7	-38.972	242	1	H
19614.7	30.411	44.911	-28.288	4.9	51.935	91.7	-39.765	300	1	H
20015.2	30.801	44.656	-28.524	4.913	51.845	91.7	-39.855	300	1	H
18297.5	29.607	44.872	-27.728	4.9	51.65	91.7	-40.05	300	359	V
19498.2	29.568	45.027	-27.958	4.9	51.536	91.7	-40.164	300	130	V
20415.9	28.383	44.684	-28.361	4.946	49.654	91.7	-42.046	300	1	H
20771.3	27.157	44.986	-27.765	4.975	49.353	91.7	-42.347	300	1	H
18568.1	27.152	44.82	-27.781	4.9	49.091	91.7	-42.609	300	1	H
20805	26.88	45.012	-27.85	4.978	49.021	91.7	-42.679	300	1	V
11713	34.296	39.491	-28.843	3.646	48.595	91.7	-43.105	100	1	V
11785.7	34.085	39.539	-28.873	3.682	48.434	91.7	-43.266	100	1	H
18324.3	24.78	44.844	-27.724	4.9	46.799	91.7	-44.901	300	359	V
17847.5	17.955	47.913	-28.786	8.427	45.451	91.7	-46.249	100	1	H
14156.9	26.697	42.054	-29.512	3.003	42.241	91.7	-49.459	100	1	H
12650.3	21.662	39.382	-30.109	7.314	38.445	91.7	-53.255	100	1	H
10109.9	27.342	38.544	-31.23	3.126	37.756	91.7	-53.944	100	1	V
14959.2	21.079	39.384	-29.232	3.396	34.627	91.7	-57.073	100	1	V
9359.51	3.22E+01	37.706	-38.8	3.4	34.466	82.2	-47.734	100	359	H
7860.78	2.95E+01	36.509	-38.102	6.1	33.967	82.2	-48.233	100	359	H
3229.70	3.40E+01	30.897	-37.116	4.657	32.454	82.2	-49.746	100	359	H
107.79	60.166	9.021	-37.74	0.942	32.388	82.2	-49.812	100	132	V
8542.33	2.71E+01	37.354	-38.237	4.861	31.096	82.2	-51.104	100	359	H
4015.06	3.04E+01	32.542	-36.881	4.988	31.029	82.2	-51.171	100	359	H
7194.63	24.121	35.766	-37.387	6.579	29.077	82.2	-53.123	100	359	V
4010.18	27.112	32.56	-36.887	4.982	27.766	82.2	-54.434	100	359	V
8537.71	23.121	37.347	-38.222	4.878	27.125	82.2	-55.075	100	359	V
1889.08	26.656	27.474	-38.043	9.125	25.212	82.2	-56.988	100	226	V
875.01	34.343	24.199	-36.781	2.98	24.742	82.2	-57.458	231	257	V
113.33	51.572	8.767	-37.742	0.966	23.563	82.2	-58.637	100	1	V
9439.61	20.934	37.742	-38.8	3.376	23.252	82.2	-58.948	100	359	V
1889.79	2.37E+01	27.473	-38.042	9.099	22.217	82.2	-59.983	100	359	H
1859.45	24.21	27.272	-38.055	8.486	21.912	82.2	-60.288	100	1	V
108.13	47.83	9	-37.74	0.944	20.033	82.2	-62.167	325	359	H
748.27	30.922	23.2	-36.663	2.457	19.917	82.2	-62.283	142	1	H
875.01	25.791	24.2	-36.781	2.98	16.191	82.2	-66.009	100	85	H
750.33	21.993	23.3	-36.67	2.466	11.09	82.2	-71.11	100	1	V
929.62	19.188	25.7	-36.955	2.968	10.904	82.2	-71.296	121	1	H
203.39	35.382	11.3	-37.514	1.226	10.393	82.2	-71.807	325	157	H
753.48	18.442	23.4	-36.68	2.48	7.642	82.2	-74.558	249	1	V
115.69	34.649	8.631	-37.741	0.963	6.502	82.2	-75.698	213	359	H
929.61	14.528	25.7	-36.955	2.968	6.244	82.2	-75.956	283	359	V

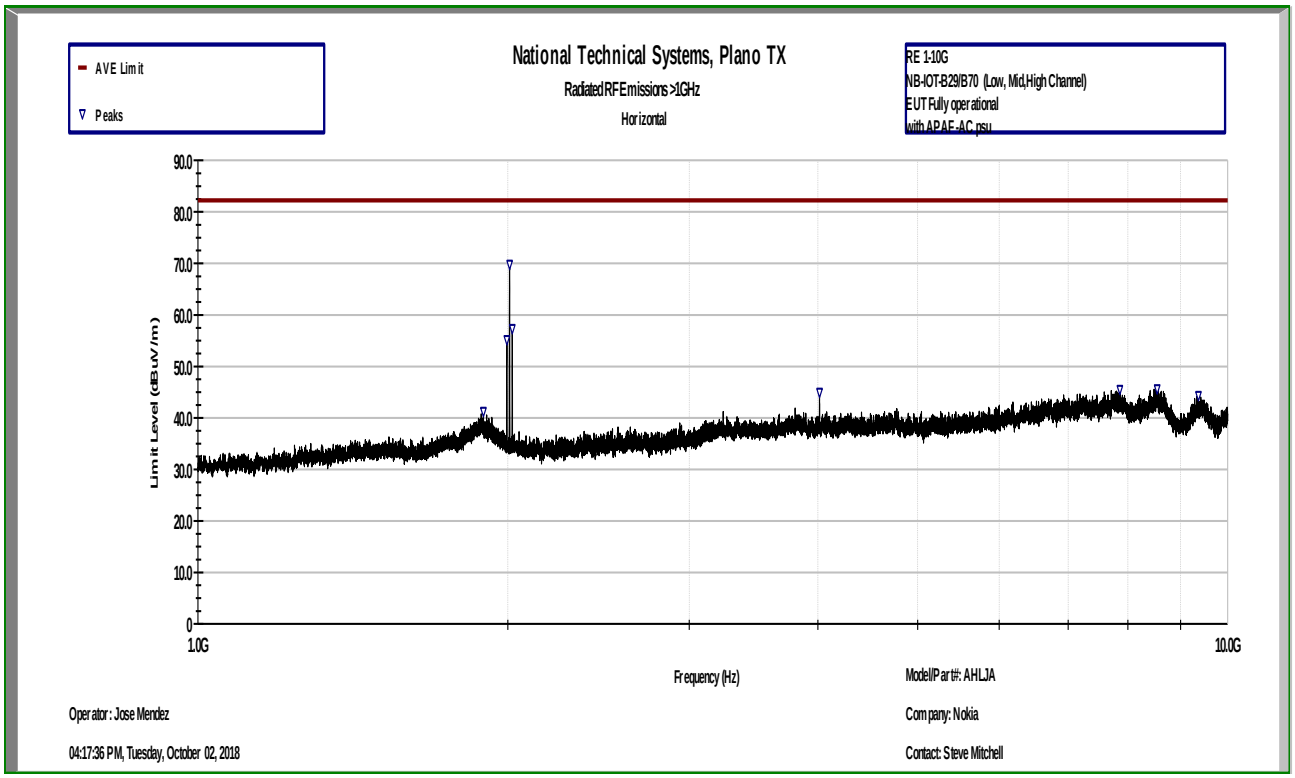
A three-meter measurement distance was used for radiated emission less than 10GHz. A one-meter measurement distance was used for radiated emission greater than 10GHz. The highest radiated emissions detected were more than 20dB below the three-meter limit of 82.2dBuV/m and the one -meter limit of 91.7dBuV/m (equivalent to -13dBm EIRP). Since all maximized measurements were more than 20dB below these levels, substitution measurements were not performed. TILE software was used for all preliminary scans and plots that are included on the following pages.



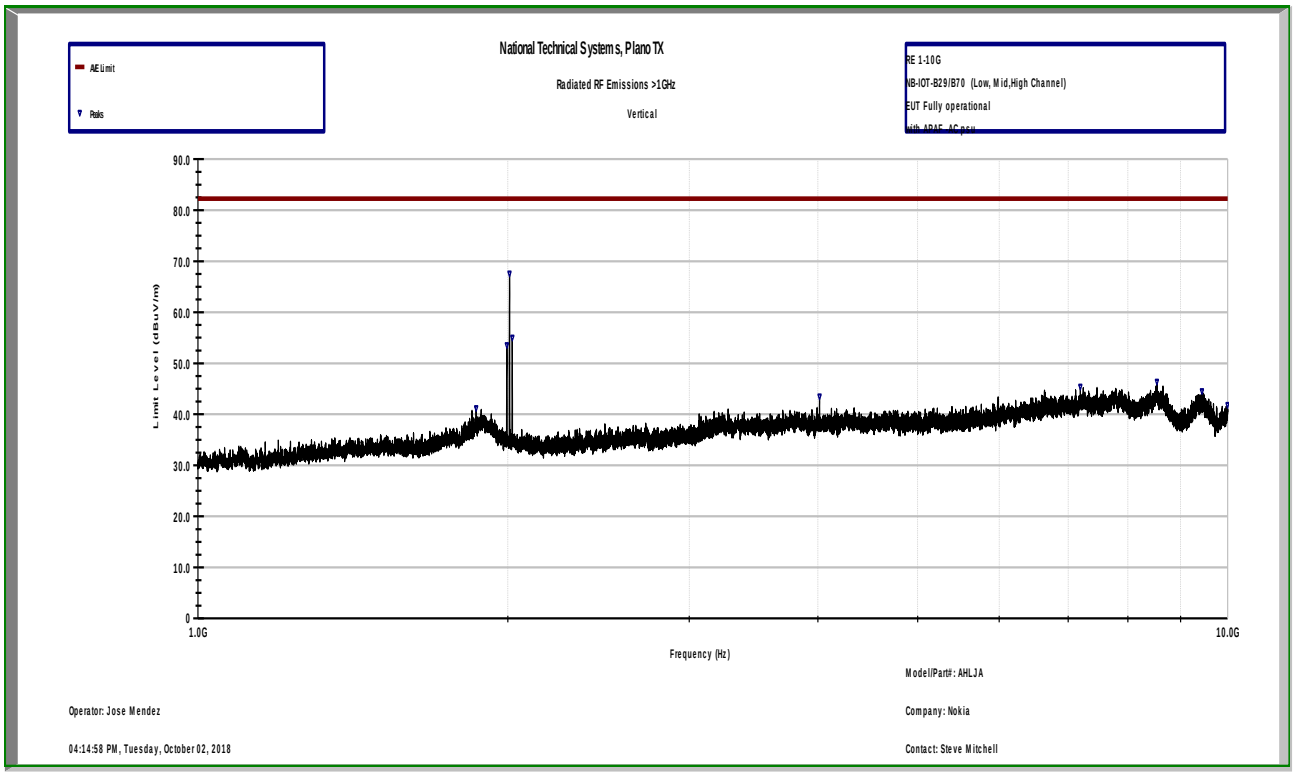
Radiated Spurious Emissions 30MHz-1GHz Horizontal at 3m NB-IOT - B29/B70 (Low/Mid/High Channel)



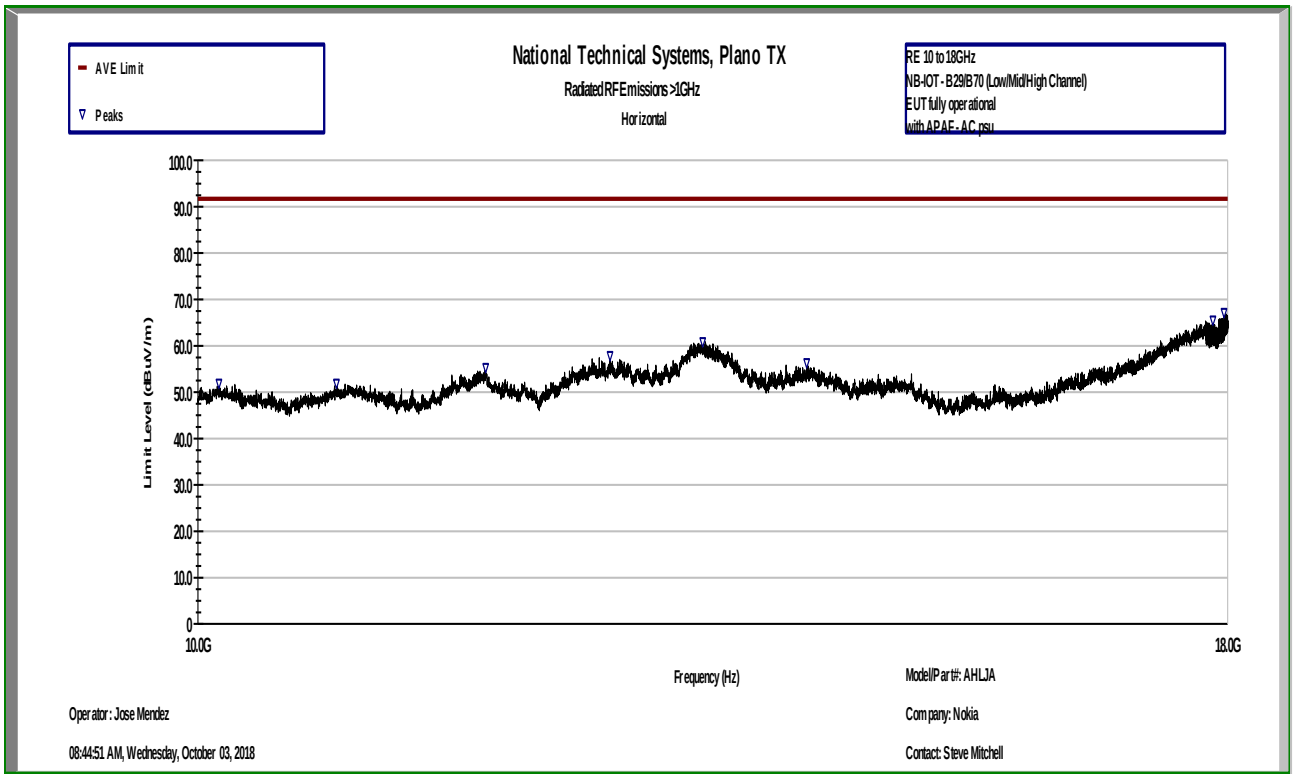
Radiated Spurious Emissions 30MHz-1GHz Vertical at 3m NB-IOT - B29/B70 (Low/Mid/High Channel)



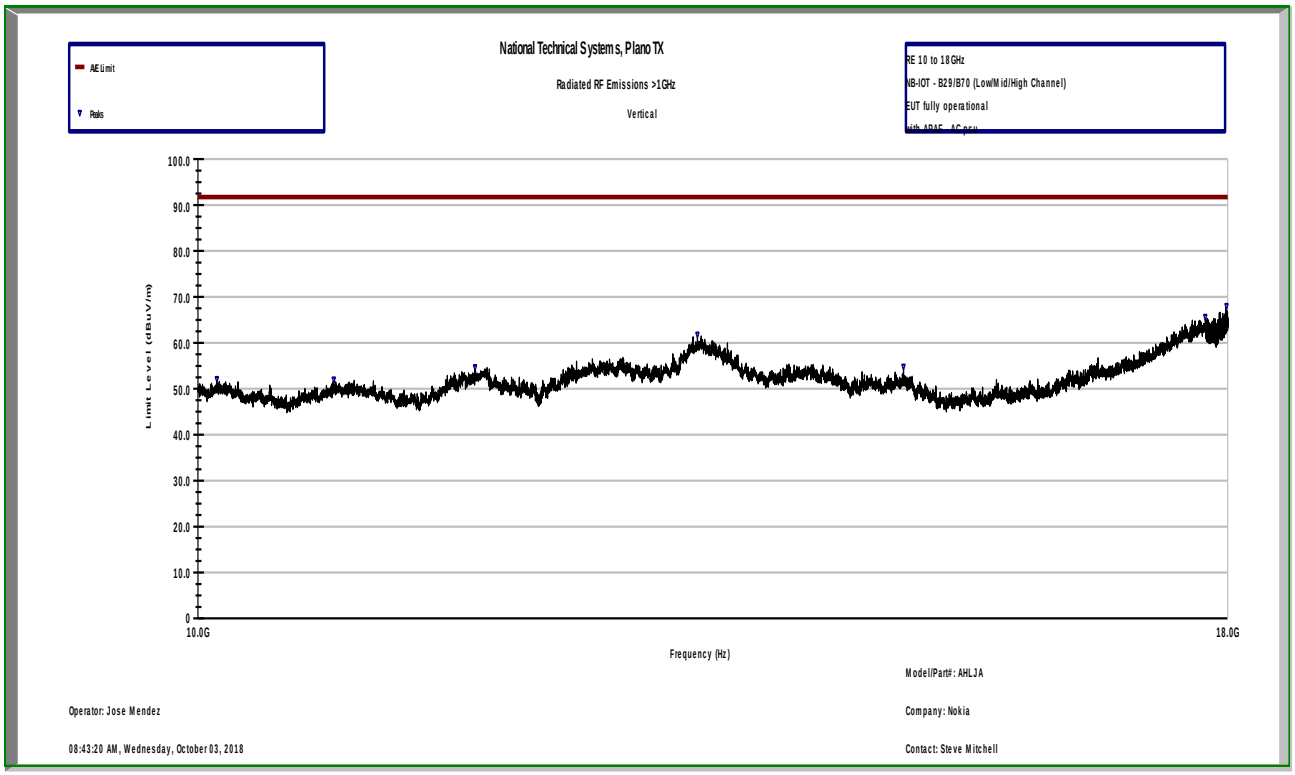
Radiated Spurious Emissions 1-10GHz Horizontal at 3m NB-IOT - B29/B70 (Low/Mid/High Channel)



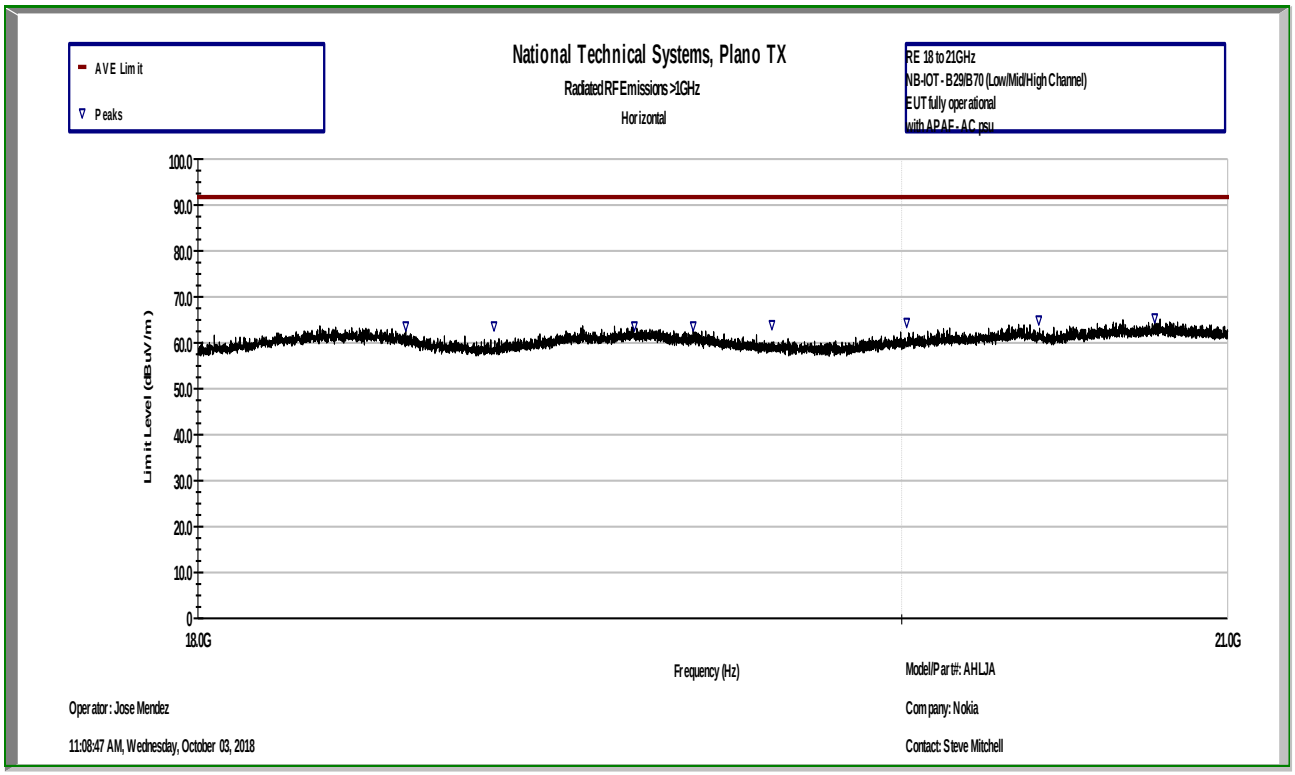
Radiated Spurious Emissions 1-10GHz Vertical at 3m NB-IOT - B29/B70 (Low/Mid/High Channel)



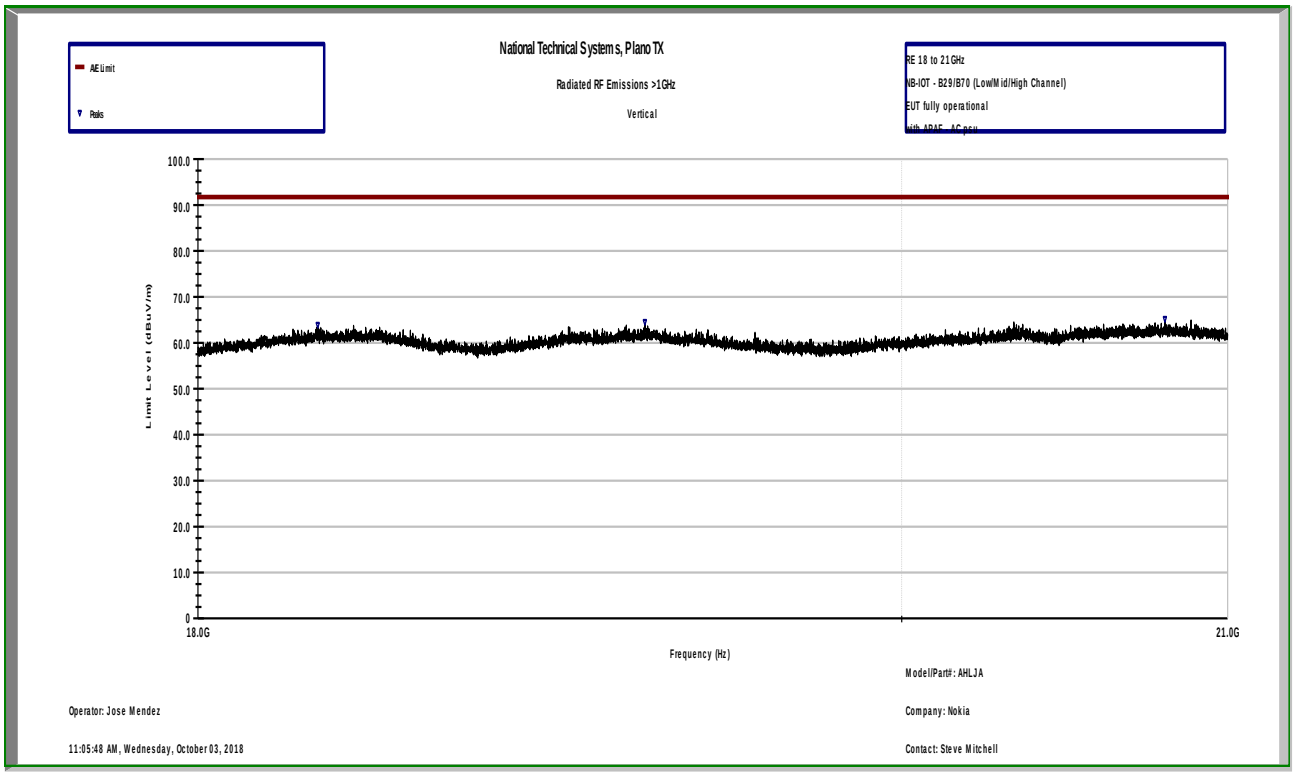
Radiated Spurious Emissions 10-18GHz Horizontal at 1m NB-IOT - B29/B70 (Low/Mid/High Channel)



Radiated Spurious Emissions 10-18GHz Vertical at 1m NB-IOT - B29/B70 (Low/Mid/High Channel)



Radiated Spurious Emissions 18-21GHz Horizontal at 1m NB-IOT - B29/B70 (Low/Mid/High Channel)



Radiated Spurious Emissions 18-21GHz Vertical at 1m NB-IOT - B29/B70 (Low/Mid/High Channel)

Frequency Stability/Accuracy

Measurement methods are detailed in KDB 971168 D01v03r01 section 9 and ANSI C63.26-2015. Section 27.54 defines the frequency deviation limit as follows: “The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation." Carrier frequency stability of the EUT at extreme temperatures and voltages was measured. The frequency stability was measured as follows:

(1) EUT transmitting with NB-IoT stand-alone carriers at the bottom and top frequency channels (722.2 and 727.8MHz) on port 3 at maximum carrier power
(2) The EUT temperature was stabilized at each temperature step (for a minimum of 30 minutes) prior to frequency accuracy/band edge measurements measurement.
(3) RF conducted emissions measurements were performed at the lower and upper band edges to insure regulatory compliance (< -13dBm) – as detailed in the band edge measurement section.

The nominal operating voltage of the product is declared as 48VDC for the DC power configuration. The nominal operating voltage of the product is declared as 120VAC for the AC power configuration. The band edge measurement results are listed below for extreme voltages and temperatures.

Extreme Voltages:

Percentage of Rated Supply	DC Voltage (VDC)	Band Edge Readings (dBm) at 20°C	
		Lower	Upper
85%	40.8	-14.1	-14.3
100%	48.0	-14.4	-14.2
115%	55.2	-14.2	-14.6
Percentage of Rated Supply	**AC Voltage (VAC)**	**Band Edge Readings (dBm) at 20°C**	
		Lower	**Upper**
85%	102.0	**-13.6**	-14.6
100%	120.0	-14.2	-14.9
115%	138.0	-14.3	-14.6

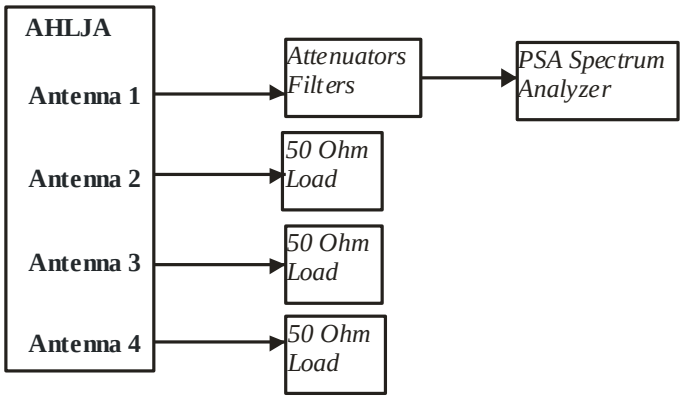
Extreme Temperatures:

Temperature	Band Edge Readings (dBm) at 48VDC		Band Edge Readings (dBm) at 120VAC	
	Lower	Upper	Lower	Upper
-30 °C	-14.9	-15.1	-13.8	-14.8
-20 °C	-14.2	-15.2	-14.1	-14.7
-10 °C	-14.2	-14.0	-13.9	-14.9
0 °C	**-13.9**	-14.2	-15.1	-14.3
10 °C	-14.0	**-13.9**	-14.3	-14.5
20 °C	-14.5	-14.1	-13.8	-13.8
30 °C	-14.2	-14.7	-13.8	-13.7
40 °C	**-13.9**	-14.4	-13.7	-14.4
50 °C	-14.2	-14.7	-14.2	-14.0

Based on the results above, the highest recorded band edge measurement (-13.9dBm for DC power configuration and -13.6dBm for AC power configuration) ensures that the transmitted signal remains in its authorized frequency block at extreme voltages and temperatures. The results above are deemed sufficient to demonstrate the RRH meets regulatory frequency stability requirements.

APPENDIX B: ANTENNA PORT TEST DATA FOR BAND 70 (1995-2020MHZ)

All conducted RF measurements for this test effort in this section were made at AHLJA antenna ports 1 and 2 for the Band 70 measurements. The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on AHLJA

RF Output Power

RF output power has been measured in both Peak and RMS Average terms for each Band 70 (1995 to 2020MHz) transmit chain (AHLJA Antenna Ports 1&2) at the bottom, middle and top frequency channels for NB-IoT stand-alone single carriers (QPSK). RMS Average power was measured as described in section 5.2 of KDB 971168 D01v03r01 and ANSI C63.26-2015 sections 5.2.4.3 & 5.2.4.4. Peak power was measured as described in section 5.1 of KDB 971168 D01v03r01 and ANSI C63.26-2015 section 5.2.3.3. The peak to average power ratio (PAPR) has been calculated as described in section 5.7 of KDB971168 D01v03r01 and ANSI C63.26-2015 section 5.2.6.

The RMS Average power output on Antenna Ports 1&2 (3GPP frequency band 70) was also measured using three carriers per antenna port on the bottom, middle and top channels (with minimum spacing between carrier frequencies). Based upon these multi-carrier power measurements the antenna port with the highest RMS average power output for 3GPP frequency band 70 is to be used for the remaining radio compliance conducted measurements. The port power measurements are required to be performed with multiple carriers to produce maximum power output on the port. The maximum single carrier power output is 20 watts while the maximum port power output is 60 watts for ports 1&2. All results are presented in tabular form below. The highest measured values for carrier peak power, carrier average power and port average power are highlighted. Measurements were rounded off to the nearest tenth.

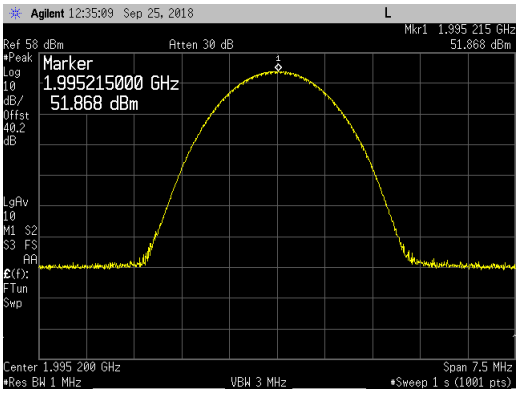
Antenna Port RF Channel	Carrier Frequencies	Measurement	Peak (dBm)	Average (dBm)	PAPR (dB)
Port 1 Bottom Channel	**1995.2 MHz**	**Carrier Power**	**51.9**	42.8	**9.1**
	1995.2, 1995.5 & 1995.8 MHz	**Port Power**	N/A	**47.3**	N/A
Port 1 Middle Channel	**2007.5 MHz**	**Carrier Power**	**51.9**	**42.9**	9.0
	2007.2, 2007.5 & 2007.8 MHz	**Port Power**	N/A	**47.3**	N/A
Port 1 Top Channel	**2019.8 MHz**	**Carrier Power**	50.9	**42.9**	8.0
	2019.2, 2019.5 & 2019.8 MHz	**Port Power**	N/A	47.2	N/A
Port 2 Bottom Channel	**1995.2 MHz**	**Carrier Power**	51.0	42.7	8.3
	1995.2, 1995.5 & 1995.8 MHz	**Port Power**	N/A	47.1	N/A
Port 2 Middle Channel	**2007.5 MHz**	**Carrier Power**	51.8	42.8	9.0
	2007.2, 2007.5 & 2007.8 MHz	**Port Power**	N/A	47.0	N/A
Port 2 Top Channel	**2019.8 MHz**	**Carrier Power**	51.6	42.6	9.0
	2019.2, 2019.5 & 2019.8 MHz	**Port Power**	N/A	47.0	N/A

Port 1 had the highest middle channel RMS average port power and was selected for all the remaining antenna port conducted emission tests.

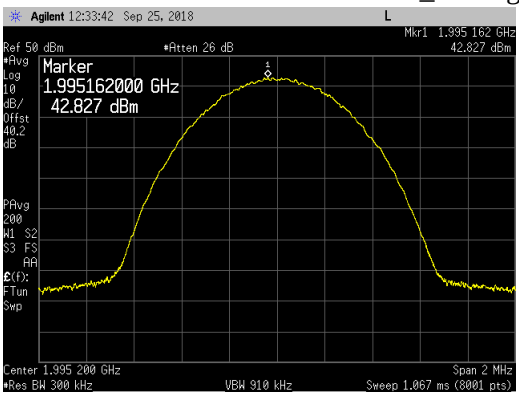
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

Power Plots at Antenna Ports 1 and 2 for the Bottom Channel (Single and Multicarrier):

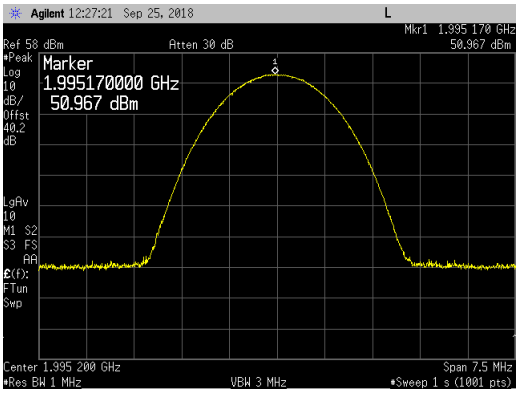
Carrier Power -Port 1 – 1995.2MHz_Peak



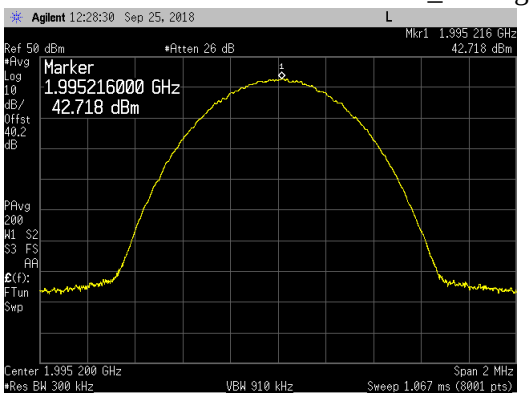
Carrier Power -Port 1 – 1995.2MHz_Average



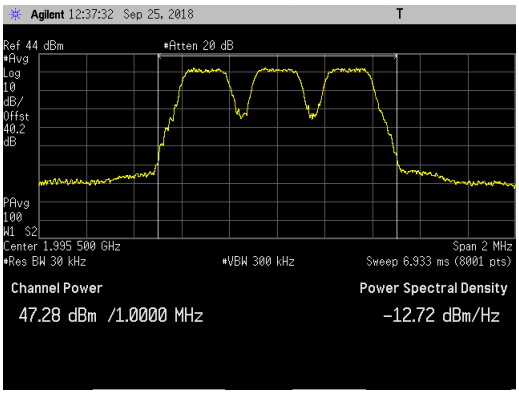
Carrier Power -Port 2 – 1995.2MHz_Peak



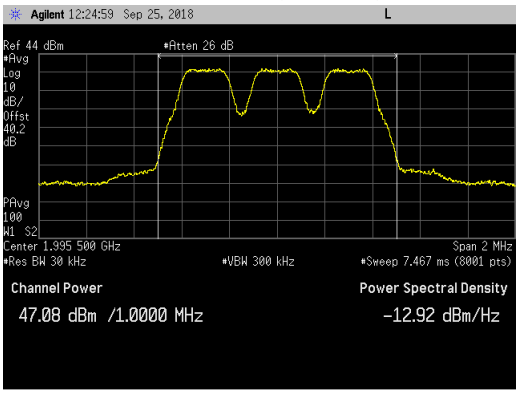
Carrier Power -Port 2 – 1995.2MHz_Average



Port Pwr_Port 1_1995.2, 1995.5, 1995.8MHz_Ave

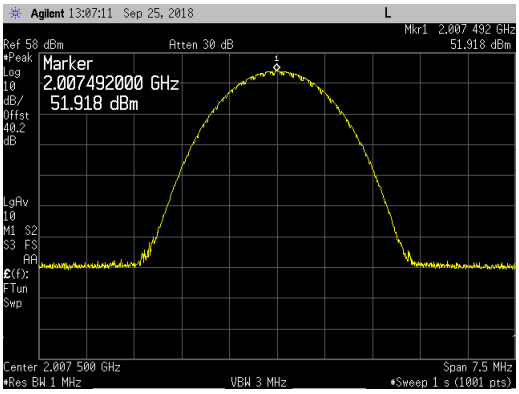


Port Pwr_Port 2_1995.2, 1995.5, 1995.8MHz _Ave

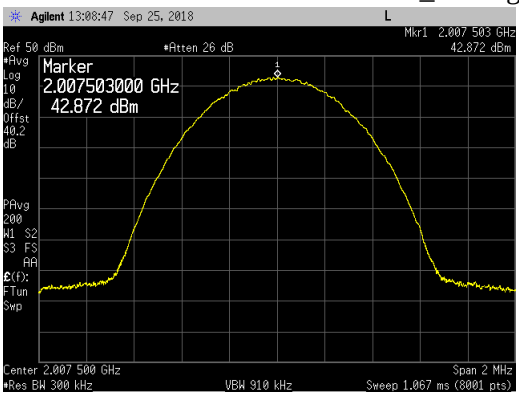


Power Plots at Antenna Ports 1 and 2 for the Middle Channel (Single and Multicarrier):

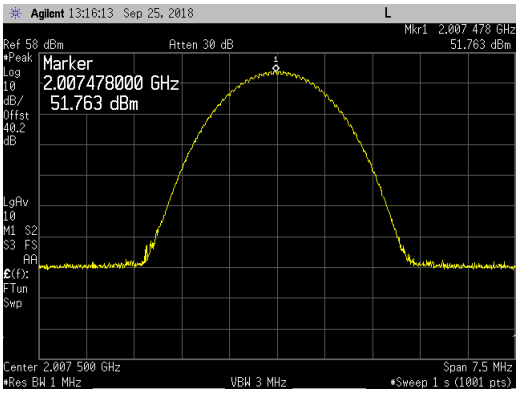
Carrier Power -Port 1 – 2007.5MHz_Peak



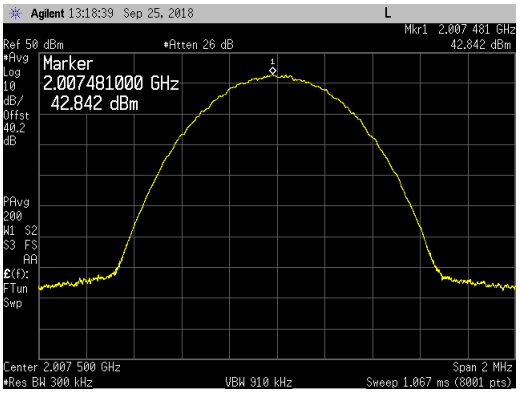
Carrier Power -Port 1 – 2007.5MHz_Average



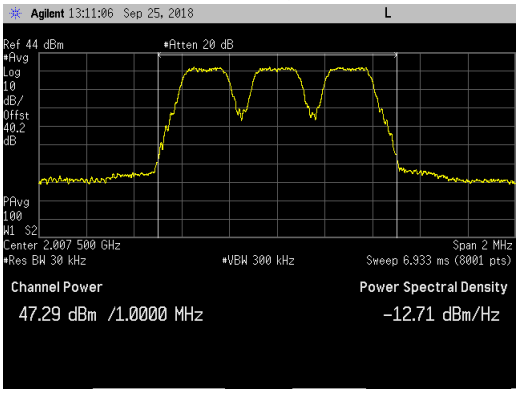
Carrier Power -Port 2 – 2007.5MHz _Peak



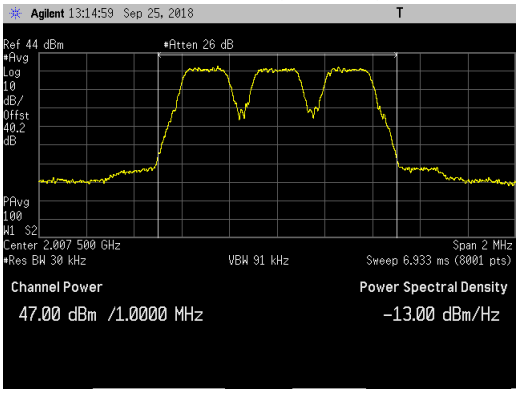
Carrier Power -Port 2 – 2007.5MHz _Average



Port Pwr_Port 1_2007.2, 2007.5, 2007.8MHz_Ave

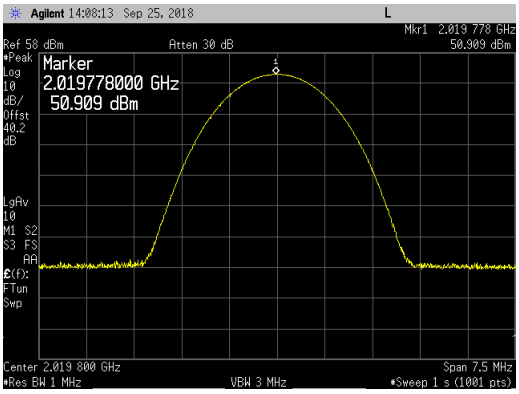


Port Pwr_Port 2_2007.2, 2007.5, 2007.8MHz _Ave

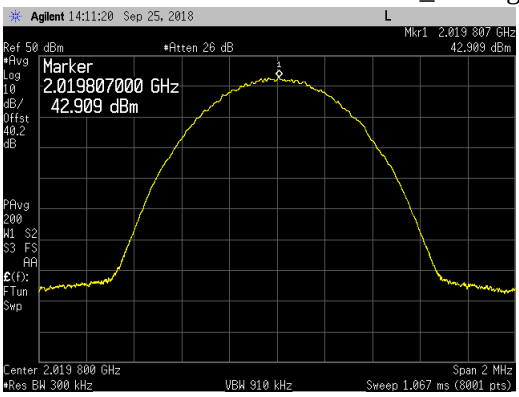


Power Plots at Antenna Ports 1 and 2 for the Top Channel (Single and Multicarrier):

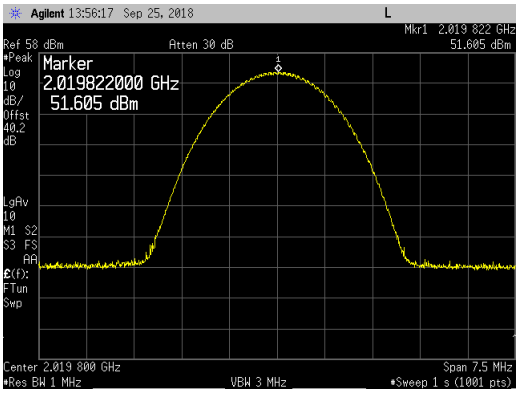
Carrier Power -Port 1 – 2019.8MHz_Peak



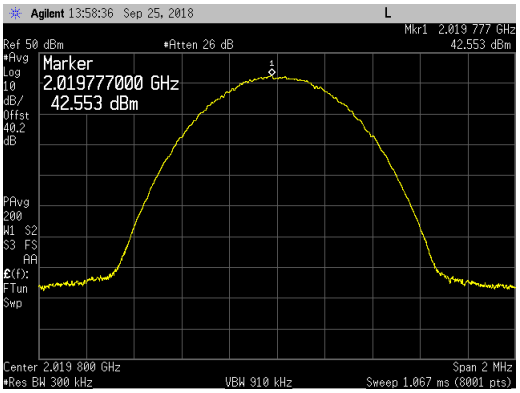
Carrier Power -Port 1 – 2019.8MHz_Average



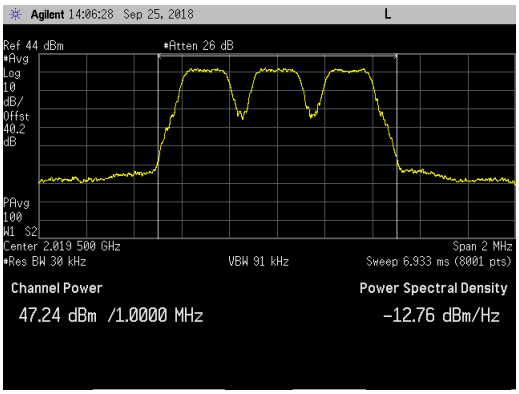
Carrier Power -Port 2 – 2019.8MHz _Peak



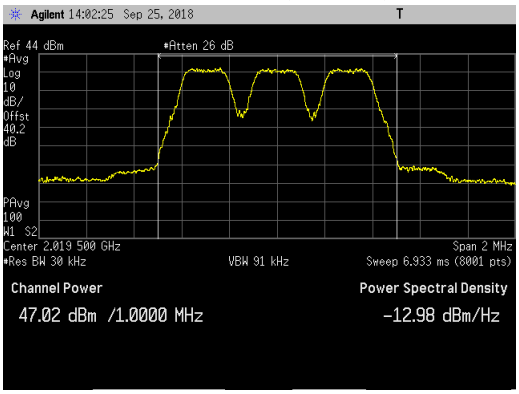
Carrier Power -Port 2 – 2019.8MHz _Average



Port Pwr_Port 1_2019.2, 2019.5, 2019.8MHz_Ave



Port Pwr_ Port 2_2019.2, 2019.5, 2019.8MHz _Ave



Emission Bandwidth (26 dB down and 99%)

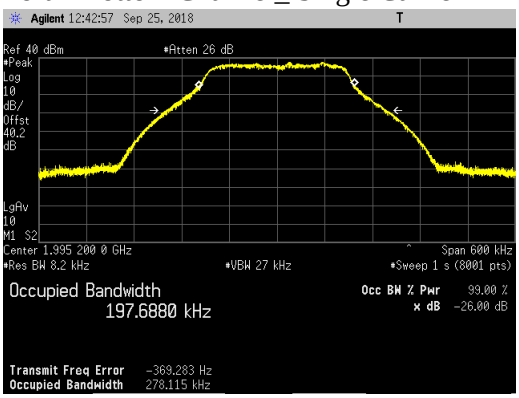
Emission bandwidth measurements were made at antenna ports 1&2 on the bottom, middle and top channels. The AHLJA was operated at maximum RF output power for NB-IoT stand-alone single carrier (QPSK). The results are provided in the following table. The largest emission bandwidth is highlighted.

Antenna Port	RF Channel	Emission Bandwidth (MHz)	
		26dB	99%
Port 1	Bottom Channel	278.115	197.6880
	Middle Channel	277.411	196.8116
	Top Channel	279.344	197.6519
Port 2	Bottom Channel	**293.222**	**201.9194**
	Middle Channel	278.297	197.8375
	Top Channel	278.131	197.9972

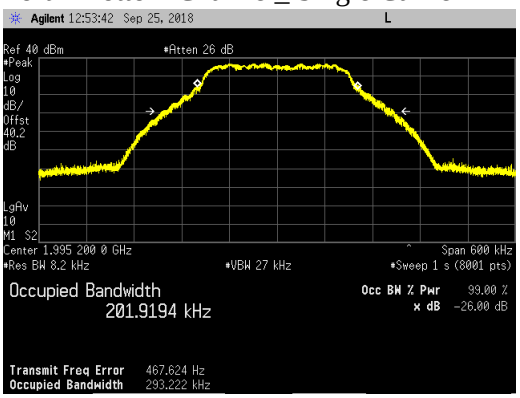
Emission bandwidth measurement data are provided in the following pages.

Emission Bandwidth Plots at Antenna Ports 1 and 2 for the Bottom, Middle and Top Frequency Channels:

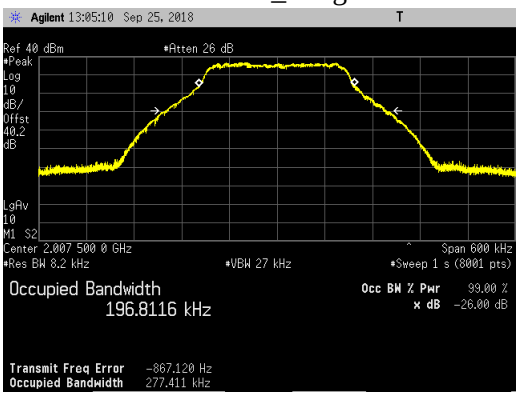
Port 1 Bottom Channel_ Single Carrier



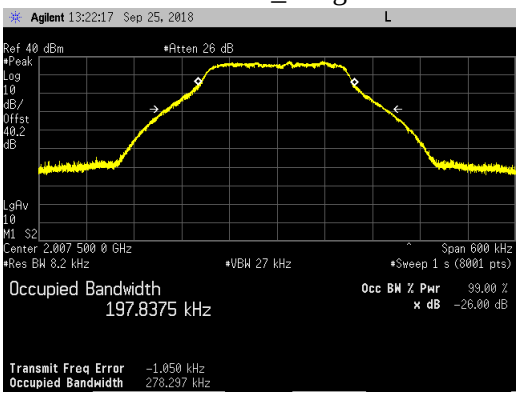
Port 2 Bottom Channel_ Single Carrier



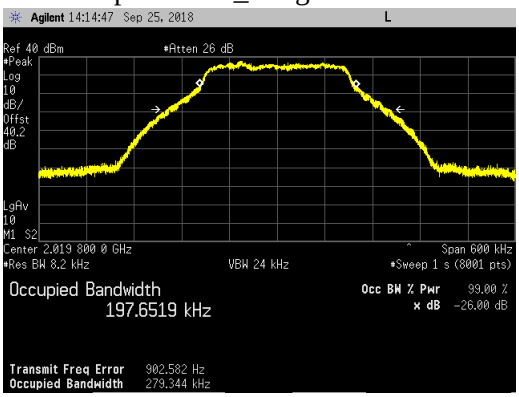
Port 1 Middle Channel_ Single Carrier



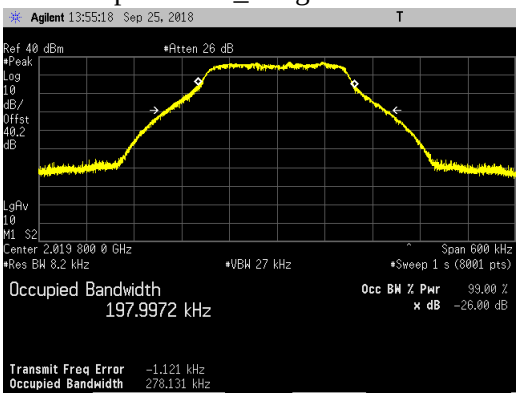
Port 2 Middle Channel_ Single Carrier



Port 1 Top Channel_ Single Carrier



Port 2 Top Channel_ Single Carrier



Antenna Port Conducted Band Edge

Conducted band edge measurements were made at RRH antenna port 1. The RRH was operated at maximum power with a single carrier at the band edge frequencies. Measurements were also performed with three carriers (with minimum spacing between carrier frequencies) per antenna port on the bottom and top channels. Three carriers are required to produce maximum port power output. The maximum single carrier power output is 20 watts while the maximum port power output is 60 watts for ports 1&2.

Another multicarrier test case based upon KDB 971168 D03v01 using three carriers per antenna port was performed with two carriers (with minimum spacing between carrier frequencies) at the lower band edge and a third carrier (with maximum spacing between the other two carrier frequencies) at the upper band edge.

The power of any emission outside of the authorized operating frequency range cannot exceed -13 dBm as specified in section 27.53(h)(1) and FCC DA 13-2409 items 25 and 47.

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 measured emission bandwidth (3kHz) per 27.53(h)(3) and FCC DA 13-2409 items 25&47 was used. In the 1 to 2MHz frequency range outside the band edge (i.e.: 1993 to 1994MHz and 2021 to 2022MHz bands) the RBW was set to 1% of the measured emission bandwidth (3kHz) and the power integrated over 1MHz. In the 2MHz to 22MHz frequency range outside the band edge (i.e.: 1973 to 1993MHz and 2022 to 2042MHz 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.

Band 70 Carrier Frequency Carrier Power and Port Power	**Port 1 (dBm)**	
	Lower	**Upper**
Single Carrier at Bottom Channel (1995.2MHz)/Top Channel (2019.8MHz) 20W per Carrier and 20W per Port	-23.007	-26.661
Three Carriers at BCs (1995.2, 1995.5, 1995.8MHz)/TCs (2019.2, 2019.5, 2019.8MHz) 20W per Carrier and 60W per Port	-20.113	-21.618
Three Carriers at BCs (1995.2 and 1995.5MHz) and at TC (1995.8MHz) 20W per Carrier and 60W per Port	-22.767	-26.800

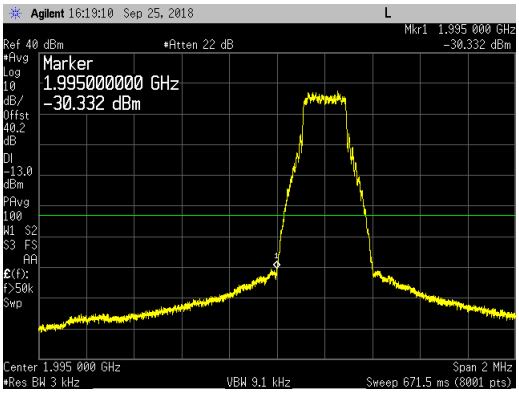
The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.

Conducted band edge measurements are provided in the following pages.

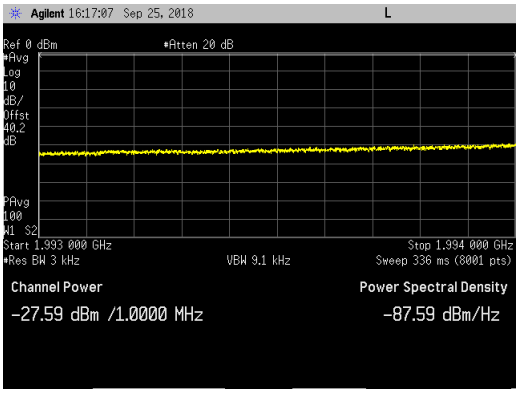
Band 70 Single Carrier at 20W/Carrier and 20W/Port -Lower and Upper Band Edge Plots:

Carrier at Bottom Channel (1995.2MHz)

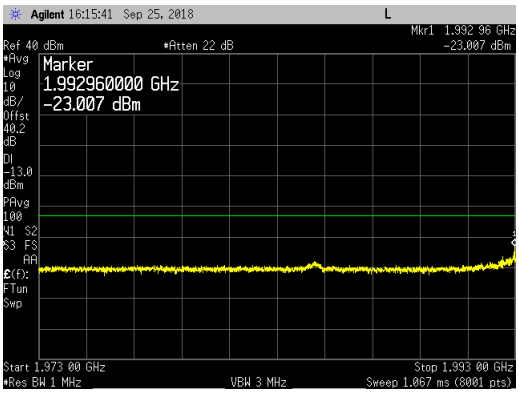
Port 1_LBE_1994 to 1996MHz



Port 1_LBE_1993 to 1994MHz

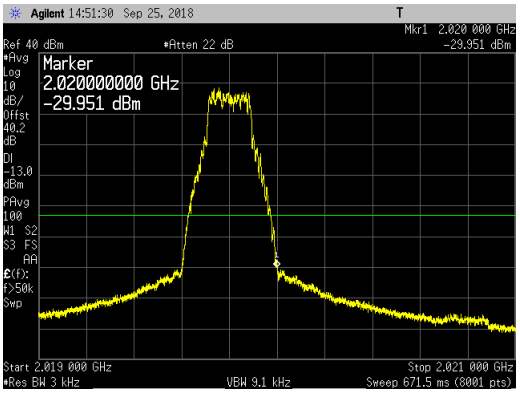


Port 1_LBE_1973 to 1993MHz

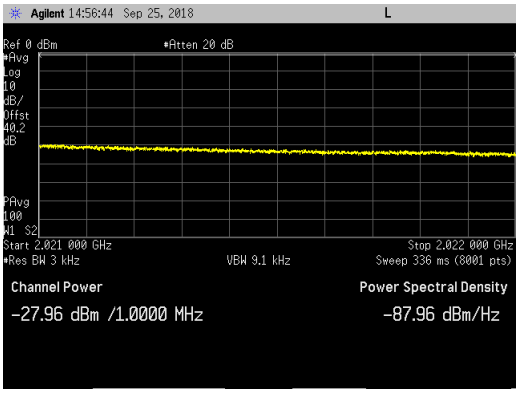


Carrier at Top Channel (2019.8MHz)

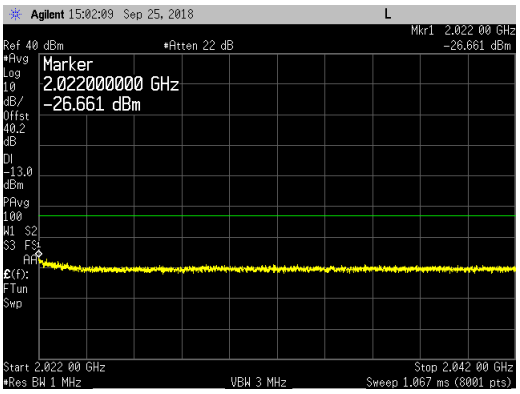
Port 1_UBE_2019 to 2021MHz



Port 1_UBE_2021 to 2022MHz



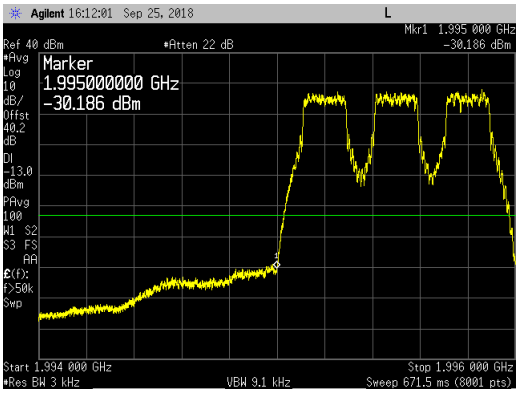
Port 1_UBE_2022 to 2042MHz



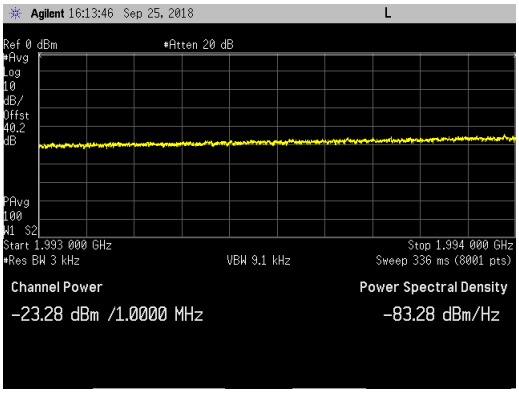
Band 70 Three Carriers at 20W/Carrier and 60W/Port -Lower and Upper Band Edge Plots:

Carriers at BCs (1995.2, 1995.5, 1995.8MHz)

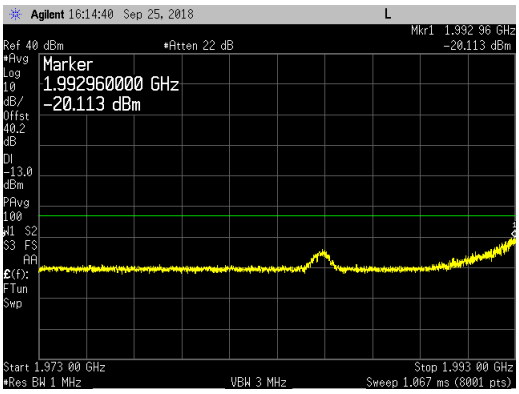
Port 1_LBE_1994 to 1996MHz



Port 1_LBE_1993 to 1994MHz

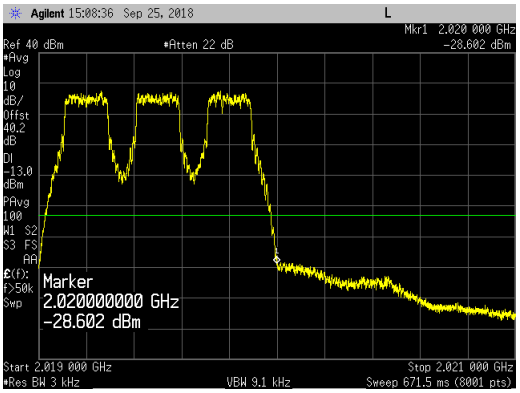


Port 1_LBE_1973 to 1993MHz

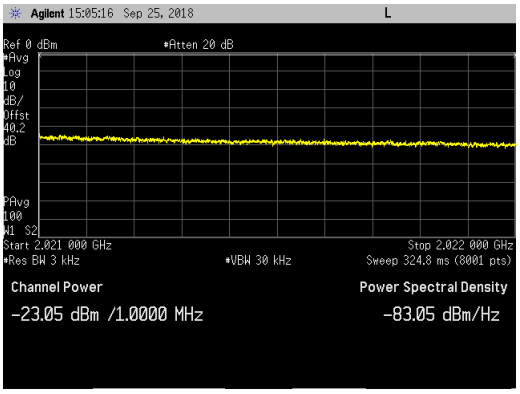


Carriers at TCs (2019.2, 2019.5, 2019.8MHz)

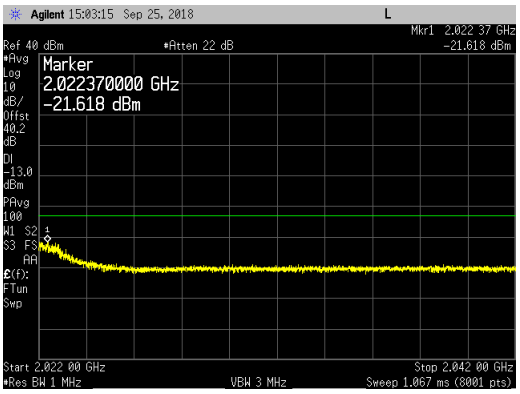
Port 1_UBE_2019 to 2021MHz



Port 1_UBE_2021 to 2022MHz



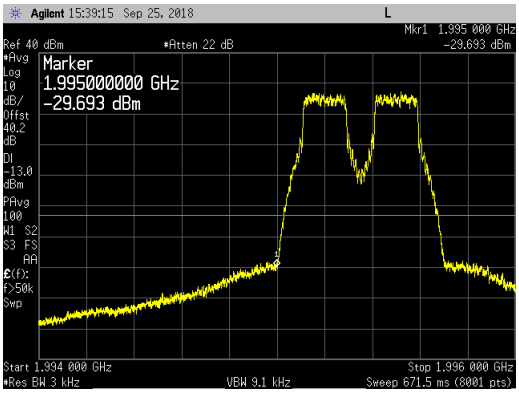
Port 1_UBE_2022 to 2042MHz



Band 70 Three Carriers at 20W/Carrier and 60W/Port -Lower and Upper Band Edge Plots:

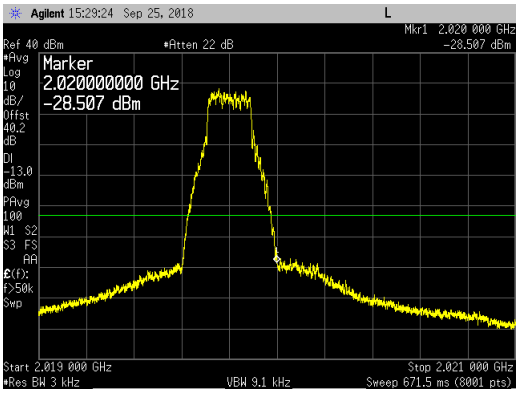
Carriers at 1995.2, 1995.5, 2019.8MHz

Port 1_LBE_1994 to 1996MHz

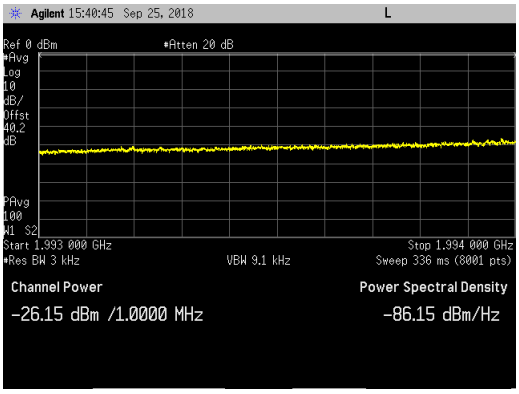


Carriers at 1995.2, 1995.5, 2019.8MHz

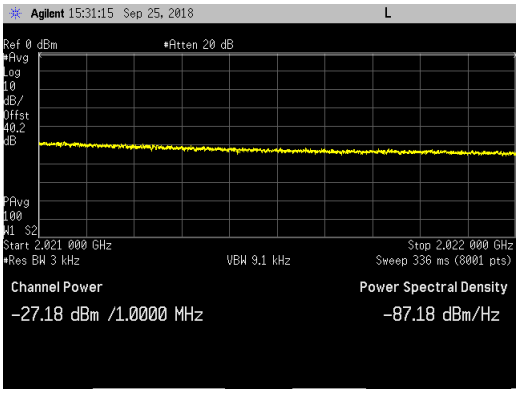
Port 1_UBE_2019 to 2021MHz



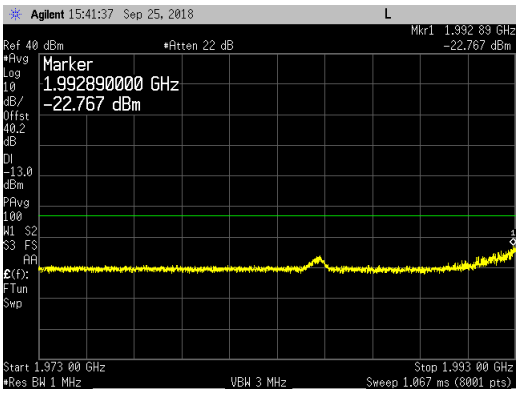
Port 1_LBE_1993 to 1994MHz



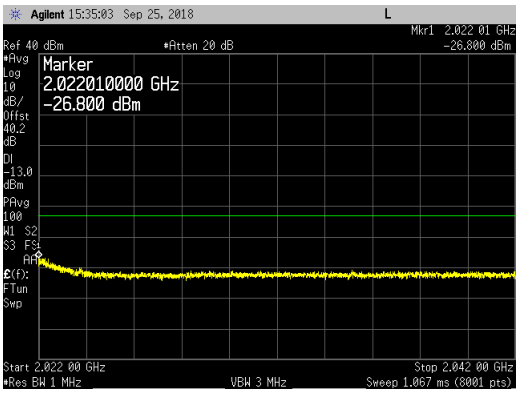
Port 1_UBE_2021 to 2022MHz



Port 1_LBE_1973 to 1993MHz



Port 1_UBE_2022 to 2042MHz



Transmitter Antenna Port Conducted Emissions

Transmitter conducted emission measurements were made at RRH antenna port 1. Measurements were performed over the 9kHz to 21GHz frequency range. The RRH was operated at maximum power with a single carrier on the Band 70 middle channel (2007.5MHz). Measurements were also performed with three carriers (with minimum spacing between carrier frequencies) per antenna port on the middle channels (2007.2, 2007.5, 2007.8MHz). Three carriers are required to produce maximum port power output. The maximum single carrier power output is 20 watts while the maximum port power output is 60 watts for ports 1&2. Another multicarrier test case based upon KDB 971168 D03v01 using three carriers per antenna port was performed with two carriers (with minimum spacing between carrier frequencies) at the lower band edge (1995.2 & 1995.5MHz) and a third carrier (with maximum spacing between the other two carrier frequencies) at the upper band edge (2019.8MHz).

The power of any emission outside of the authorized operating frequency range cannot exceed -13 dBm for a 1MHz resolution bandwidth as specified in section 27.53(h)(1 & 3) and FCC DA 13-2409 items 25& 47. 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 20MHz to 3GHz frequency range). Measurements for the 20MHz to 3GHz 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 –43dBm to correct for a spectrum analyzer RBW of 1kHz versus required RBW of 1MHz [i.e.: -43dBm = -13dBm -10log(1000kHz/1kHz)]. The limit for the 150kHz to 20MHz frequency range was adjusted to –33dBm to correct for a spectrum analyzer RBW of 10kHz versus required RBW of 1MHz [i.e.: -33dBm = -13dBm -10log(1000kHz/10kHz)]. The required limit of -13dBm with a RBW of ≥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	8.8dB
150kHz to 20MHz	10kHz	30kHz	8001	Peak	Auto	50 Sweeps	8.8dB
20MHz to 3000MHz	1MHz	3MHz	8001	Average	Auto	Note 2	40.2dB
3GHz to 6GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	40.1dB
6GHz to 21GHz	2MHz	6MHz	8001	Peak	Auto	50 Sweeps	28.0dB

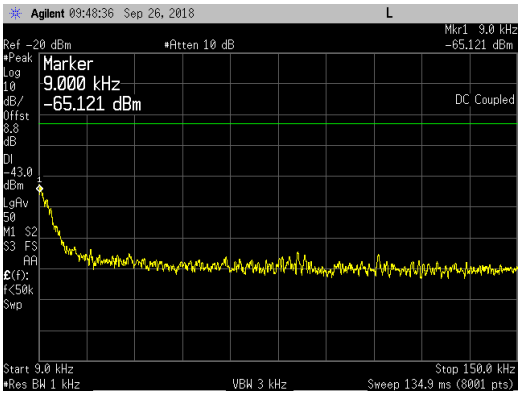
Note 1: The total measurement RF path loss of the test setup (attenuators, filters and test cables) is accounted for by the spectrum analyzer reference level offset.
Note 2: Max Hold not used and instead measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces.

A high pass filter was used to reduce measurement instrumentation noise floor for the frequency range above 6GHz. A low pass filter was used to reduce instrumentation noise for the frequency ranges below 20MHz. The total measurement RF path loss of the test setup (attenuators, low pass filter and test cables) as shown in the table is accounted for by the spectrum analyzer reference level offset. The display line on

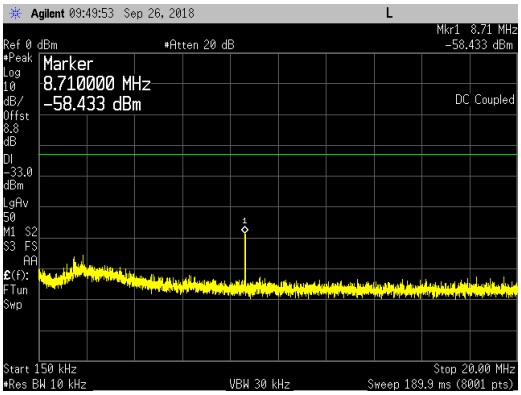
the plots reflects the required limit. Conducted spurious emission plots/measurements are provided in the following pages.

Band 70 Single Carrier at Middle Channel (2007.5MHz) with 20W/Carrier and 20W/Port:

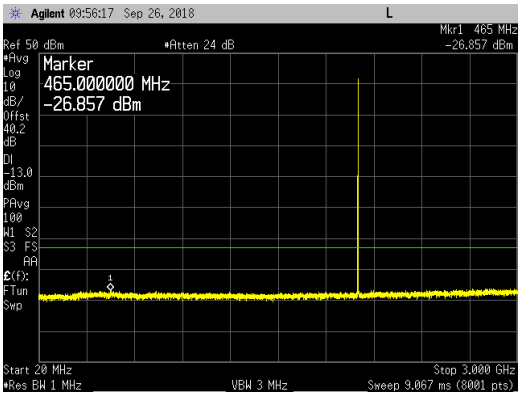
9kHz to 150kHz



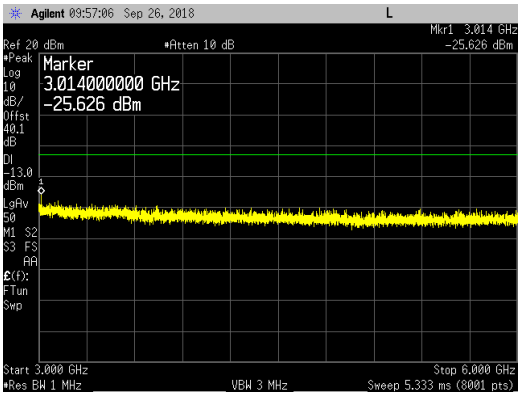
150kHz to 20MHz



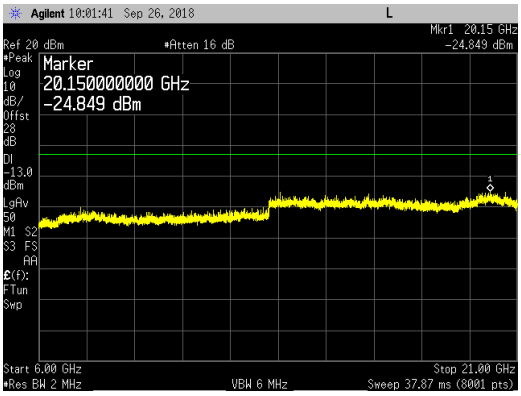
20MHz to 3000MHz



3GHz to 6GHz

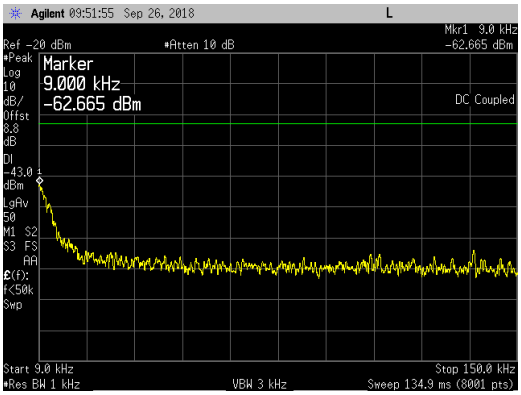


6GHz to 21GHz

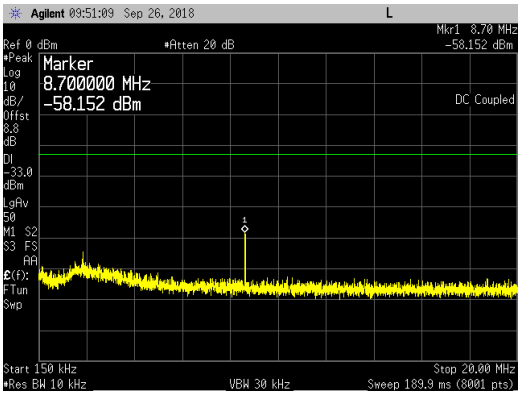


Band 70 Three Carriers at Middle Chs (2007.2, 2007.5, 2007.8MHz) with 20W/Carrier and 60W/Port:

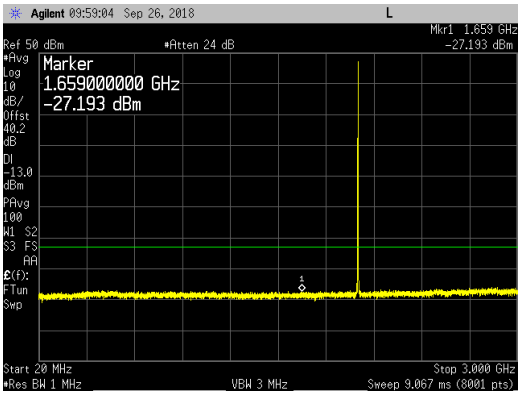
9kHz to 150kHz



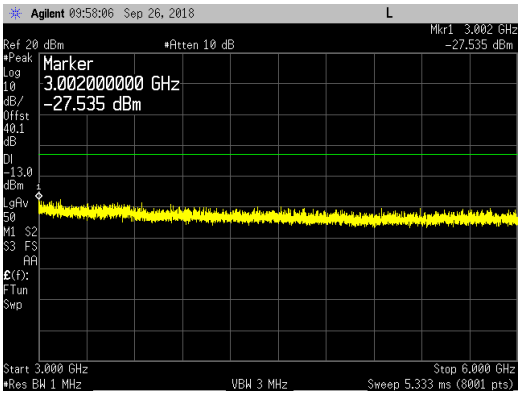
150kHz to 20MHz



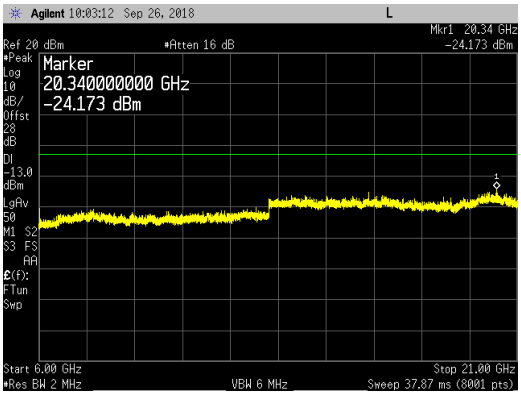
20MHz to 3000MHz



3GHz to 6GHz

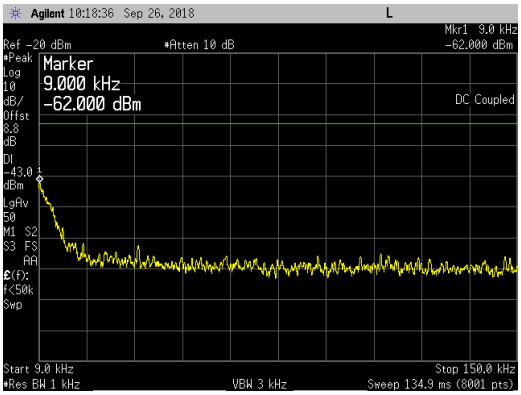


6GHz to 21GHz

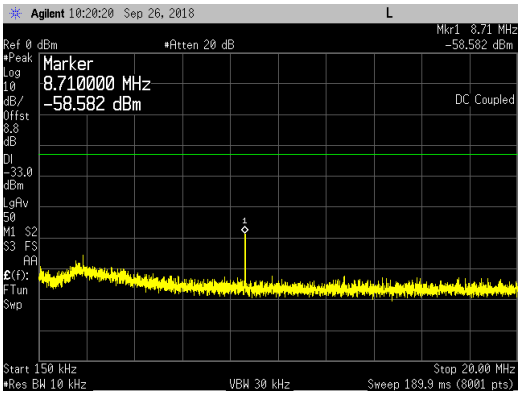


Band 70 Three Carriers at BCs (1995.2 & 1995.5MHz) & TC (2019.8MHz) with 20W/Carrier and 60W/Port:

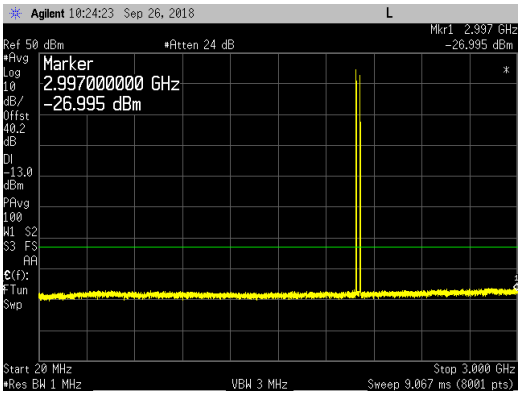
9kHz to 150kHz



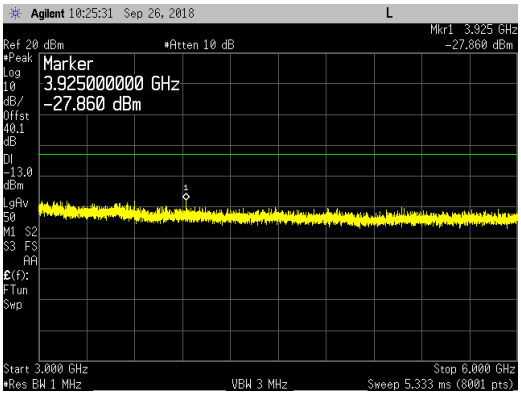
150kHz to 20MHz



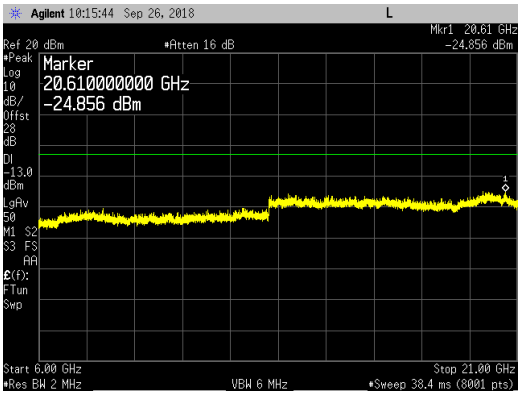
20MHz to 3000MHz



3GHz to 6GHz

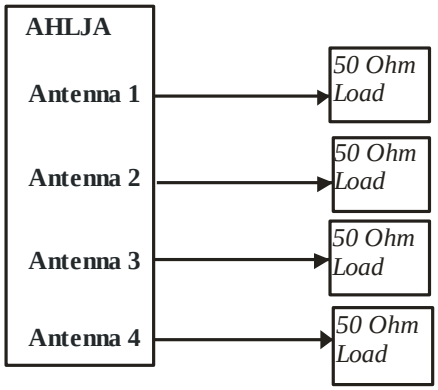


6GHz to 21GHz



Transmitter Radiated Spurious Emissions

During radiated emission testing all antenna ports of the base station were terminated with 50ohm termination blocks as shown in the diagram below.



See ANSI C63.26-2015 paragraph 5.1 for details of test setup requirements. Based on antenna port conducted spurious emissions tests results, preliminary scans for radiated spurious emissions were performed in 30MHz – 21GHz frequency range.

One radiated emission test configuration (with the RRH fan assembly and RRH AC Power Supply options) were used to prove compliance for both 3GPP Band 29 and the 3GPP Band 70 frequency bands. The Band 29 IoT carriers were enabled on the bottom and top frequency channels at maximum power (20 watts per carrier and 40 watts per antenna port) on Antenna ports 3 & 4. The Band 70 IoT carriers were enabled on the bottom, middle and top frequency channels at maximum power (20 watts per carrier and 60 watts per antenna port) on Antenna ports 1 & 2. The RRH antenna ports are to be terminated using RF cables/loads. Final maximized radiated emissions are measured in these modes. The carrier configuration for the radiated emission testing is provided below.

Frequency Band	Antenna Port	EARFCN	Transmit Frequency	Carrier Power
Band 70	1	13113 (Bottom Channel)	1995.2 MHz	20 Watts
Band 70	1	13116 (Bottom Channel +3)	1995.5 MHz	20 Watts
Band 70	1	13359 (Top Channel)	2019.8 MHz	20 Watts
Band 70	2	13233 (Middle Channel -3)	2007.2 MHz	20 Watts
Band 70	2	13236 (Middle Channel)	2007.5 MHz	20 Watts
Band 70	2	13239 (Middle Channel +3)	2007.8 MHz	20 Watts
Band 29	3	11133 (Bottom Channel)	722.2 MHz	20 Watts
Band 29	3	11189 (Top Channel)	727.8 MHz	20 Watts
Band 29	4	11133 (Bottom Channel)	722.2 MHz	20 Watts
Band 29	4	11189 (Top Channel)	727.8 MHz	20 Watts

Antenna Ports and Band 29/70 Carriers at Maximum Power (20W/carrier)

Radiated spurious emission plots/measurement results are in Appendix A.

Frequency Stability/Accuracy

Measurement methods are detailed in KDB 971168 D01v03r01 section 9 and ANSI C63.26-2015. Section 27.54 defines the frequency deviation limit as follows: "The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation." Carrier frequency stability of the EUT at extreme temperatures and voltages was measured. The frequency stability was measured as follows:

(1) EUT transmitting with NB-IoT stand-alone carriers at the bottom and top frequency channels (1995.2 and 2019.8MHz) on port 1 at maximum carrier power.
(2) The EUT temperature was stabilized at each temperature step (for a minimum of 30 minutes) prior to frequency accuracy/band edge measurements measurement.
(3) RF conducted emissions measurements were performed at the lower and upper band edges to insure regulatory compliance (< -13dBm) – as detailed in the band edge measurement section.

The nominal operating voltage of the product is declared as 48VDC for the DC power configuration. The nominal operating voltage of the product is declared as 120VAC for the AC power configuration. The band edge measurement results are listed below for extreme voltages and temperatures.

Extreme Voltages:

Percentage of Rated Supply	DC Voltage (VDC)	Band Edge Readings (dBm) at 20°C	
		Lower	Upper
85%	40.8	-31.1	-31.3
100%	48.0	-30.8	-31.9
115%	55.2	-32.4	-32.5
Percentage of Rated Supply	**AC Voltage (VAC)**	**Band Edge Readings (dBm) at 20°C**	
		Lower	**Upper**
85%	102.0	-31.9	-32.9
100%	120.0	-32.4	-30.8
115%	138.0	-32.4	-31.1

Extreme Temperatures:

Temperature	Band Edge Readings (dBm) at 48VDC		Band Edge Readings (dBm) at 120VAC	
	Lower	Upper	Lower	Upper
-30 °C	-32.6	-32.5	-30.9	-31.5
-20 °C	-31.4	-31.2	**-29.4**	-30.9
-10 °C	-31.2	-32.2	-30.5	-31.1
0 °C	-30.9	-31.7	-32.4	-31.5
10 °C	-32.9	-30.5	-31.8	-31.4
20 °C	-32.5	-32.2	-29.9	-31.6
30 °C	-30.7	-32.0	-30.5	-29.8
40 °C	-32.6	-31.9	-30.9	-30.7
50 °C	**-30.4**	-31.9	-29.9	-30.3

Based on the results above, the highest recorded band edge measurement (-30.4dBm for DC power configuration and -29.4dBm for AC power configuration) ensures that the transmitted signal remains in its authorized frequency block at extreme voltages and temperatures. The results above are deemed sufficient to demonstrate the RRH meets regulatory frequency stability requirements.

End of Report