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Amended Test Report

FCC Part 25/RSS-170

Includes NCEE Labs report R20151212-20-02B and its amendment in full

Client: **Appareo Systems**
1810 NDSU Research Circle N.
Fargo, ND 58102

EUT: **Gateway**

FCC ID: **2AETC-153103**
IC: **12021A-1535103**

Test Report No.: **R20141212-20-02C**

Approved By:

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EMC Test Engineering Manager/Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

Date: **21 March 2016**

Total Pages: **38**

Revision Page

Rev. No.	Date	Description
Original	20 November 2015	Original – NJohnson Prepared by KVepuri
A	11 February 2016	Added standard reference section to Section 1. Repeated emissions mask measurements with 1kHz RBW and bandwidth correction. Added spurious emissions measurements in the 1559 – 1605 MHz band
B	18 February 2016	Table 3 was added to show compliance with FCC Part 15.212(f) and (g). The measurements were taken for original measurements and no additional measurements were performed. A note was added below Figures 1 – 9 to clarify how the limits were chosen and what the margins are. –NJ.
C	21 March 2016	A note was added below Figures 1 – 9 to clarify how the limits were chosen and what the margins are. –NJ

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1 Summary of Test Results

The equipment under test (EUT) was tested for compliance to FCC CFR 47 Part 2, FCC CFR 47 Part 25 and IC RSS-170, Issue 3. The test method used was TIA-603-D.

47 CFR FCC Rule Part and IC Rule Part	Description	Result
§2.1055, §25.202(d) RSS 170, Section 5.2 TIA-603-D Section 2.2.2	Frequency Stability	Compliant
§25.204 § RSS 170, Section 5.3 TIA-603-D Section 2.2.1	RF Output Power	Compliant
§ 2.1047(d)	Occupied Bandwidth	Compliant
§ 2.1053, §25.202(f) RSS 170, Section 5.4.3.1 TIA-603-D Section 2.2.13, 2.2.14	Emissions Limitations	Compliant
§25.216 RSS 170, Section 5.4.3 TIA-603-D Section 2.1.1, 2.2.12	Field Strength of Spurious Radiation	Compliant

2 EUT Description

The Equipment Under Test (EUT) was the GW03 Gateway from Appareo Systems, LLC. The device functions as a wireless hub for Agricultural vehicles.

2.1 Equipment under Test (EUT)

EUT Received Date: 20 October 2015
EUT Tested Date: 20 October 2015 - 11 February 2016

PRODUCT	Gateway
PART NUMBER	153510-000003
POWER INPUT	12 VDC/14 VDC
NUMBER OF CHANNELS	1
MAXIMUM OUTPUT POWER	3.89 dBW
ANTENNA TYPE	External Antenna
SERIAL NUMBER OF TEST UNIT	B0009 (radiated emissions unit) B0001 (Duty cycle measurement unit)
POWER SUPPLY	Battery powered, 12V

2.2 Testing Location

All testing was performed at the NCEE Lincoln facility, which is an A2LA accredited EMC test laboratory accredited per scope 1953.01.

2.3 EUT Setup

The EUT was powered by 12VDC from a battery power supply. A 30 dB physical attenuator is used to make conducted measurements.

3 Test Results

3.1 Frequency Tolerance

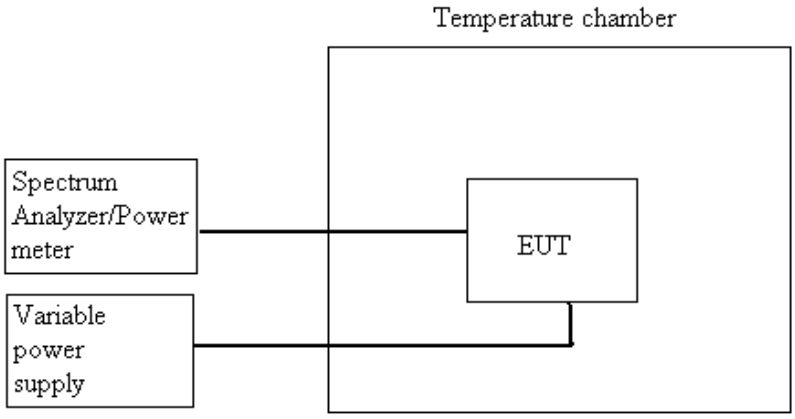
Test: FCC Part 2.1055 and 25.202(d)
RSS-170, Clause 5.2

Test Description:

Conducted power was measured on a spectrum analyzer with resolution bandwidth and video bandwidth set to 100 kHz. The EUT is supplied by 12 VDC. This input voltage was varied by (+/-)20% for the highest and lowest temperature setting. Measurements were performed at the highest and lowest voltages. Voltage variations of ±10% were performed at -30°C. The temperature was varied from -40°C to 75°C in 10°C steps.

CFR Paragraphs 2.1055 and 87.133 require a minimum deviation of 10 ppm or 0.001%.

Test Setup:



Test Equipment Used

Serial #	*Manufacturer*	*Model*	*Description*	*Last Cal*
100007	Rohde & Schwarz	ESI7	EMI Test Receiver	6/22 /2015
N/A	Mini-Circuits	NAT-10-60	10dB Attenuator	CNR
N/A	BIRD	N/A	6B Attenuator	CNR
2130154	Omega	iTHX-SD	Temperature Meter	6/22/2015
NCEE1	Russells	NCEE1	Thermal chamber	CNR*

*Calibration Not Required – temperature was measured with a calibrated probe.

Table 1 – 1616.0208033 MHz Frequency Stability

Temperature (°C)	Input Voltage (VDC)	Center Frequency (MHz)	Change (kHz)	Spec Limit - 10ppm (+/- kHz)	Percent
-40.0	8.1	1616.022044	1.24	1.616022	0.00006%
-40.0	12.0	1616.021840	1.04	1.616022	0.00008%
-40.0	16.0	1616.022044	1.24	1.616022	0.00008%
-30.0	12.0	1616.022044	1.24	1.616022	0.00005%
-20.0	12.0	1616.021640	0.84	1.616022	0.00006%
-10.0	12.0	1616.021840	1.04	1.616022	0.00006%
0.0	12.0	1616.021840	1.04	1.616022	0.00009%
10.0	12.0	1616.022244	1.44	1.616022	0.00009%
20.0	12.0	1616.022244	1.44	1.616022	0.00006%
30.0	12.0	1616.021840	1.04	1.616022	0.00006%
40.0	12.0	1616.021840	1.04	1.616022	0.00006%
50.0	12.0	1616.021840	1.04	1.616022	0.00006%
60.0	12.0	1616.021840	1.04	1.616022	0.00008%
70.0	12.0	1616.022044	1.24	1.616022	0.00008%
75.0	12.0	1616.022044	1.24	1.616022	0.00000%

Table 2 – 1625.979167 MHz Frequency Stability

Temperature (°C)	Input Voltage (VDC)	Center Frequency (MHz)	Change (kHz)	Spec Limit - 10ppm (+/- kHz)	Percent
-40.0	8.1	1625.980360	1.19	1.62598	0.00005%
-40.0	12.0	1625.979960	0.79	1.62598	0.00007%
-40.0	16.0	1625.980360	1.19	1.62598	0.00008%
-30.0	12.0	1625.980501	1.33	1.625981	0.00006%
-20.0	12.0	1625.980160	0.99	1.62598	0.00006%
-10.0	12.0	1625.978160	1.01	1.625978	0.00006%
0.0	12.0	1625.980160	0.99	1.62598	0.00007%
10.0	12.0	1625.980360	1.19	1.62598	0.00006%
20.0	12.0	1625.980160	0.99	1.62598	0.00009%
30.0	12.0	1625.980560	1.39	1.625981	0.00007%
40.0	12.0	1625.980360	1.19	1.62598	0.00006%
50.0	12.0	1625.980160	0.99	1.62598	0.00006%
60.0	12.0	1625.980160	0.99	1.62598	0.00009%
70.0	12.0	1625.980560	1.39	1.625981	0.00010%
75.0	12.0	1625.980760	1.59	1.625981	0.00000%

3.2 Emissions Limitation

Test: FCC Part 2.1053 and 25.202(f) RSS-170 5.4.3.1

Result: *Complies* Date: 23 October 2015 - 11 February 2016

Test Description
For emissions measurements, the EUT was connected to a spectrum analyzer via a cable and 30dB attenuator. The resolution bandwidth was set to 1kHz (masks), 3kHz (for other measurements) and the video bandwidth was set to 10kHz. A peak detector was used in max hold mode to capture the peak power.

Test Environment
Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:
Relative humidity of 30 ± 5%; Temperature of 20 ± 2º C

Emission limitations (from FCC CFR 47, 25.202(f))
The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (1) through (4) .

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;

(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;

(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;

(4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (1), (2) and (3) of this section.

On any frequency removed from the center of the assigned channel by more than 250 percent at least: 43 + 10 log (P) dB

Test Setup
The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 1 kHz for Masks and 3 kHz for other measurements. Sufficient scans were taken to show any out of band emissions up to the 10^{th} harmonic. The test setup can be seen in Figures 2 through 4 of appendix A.

Test Equipment Used

Serial #	*Manufacturer*	*Model*	*Description*	*Last Cal.*
100037	Rohde & Schwarz	ESIB26	EMI Test Receiver	20 Jan 2015
100007	Rohde & Schwarz	ESI7	EMI Test Receiver	22 Jun 2015
BG1808	Weinschel	48-30-43	30dB Attenuator	CNR

Test Results

The spurious emissions at the antenna terminals were found to comply.

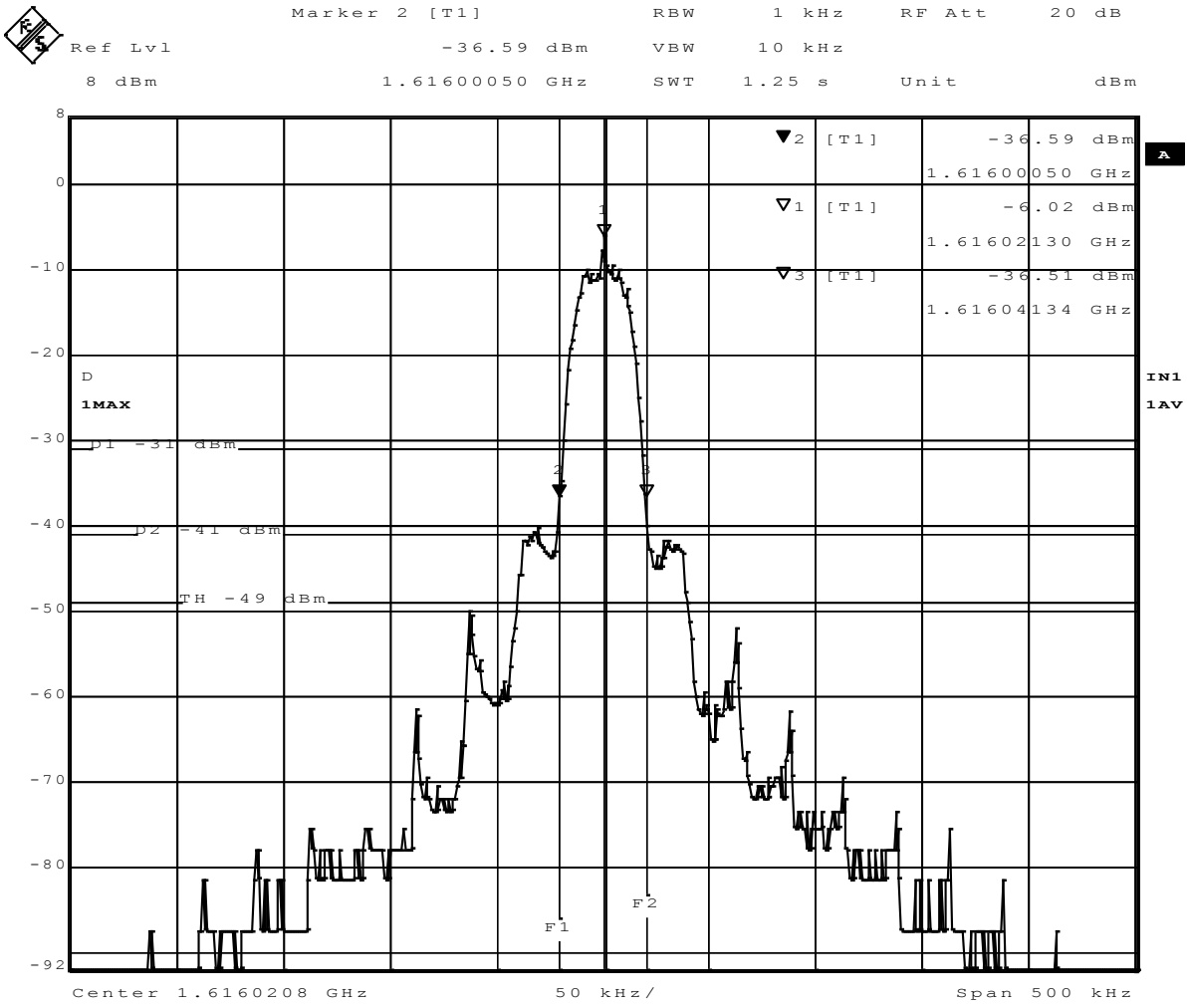


Figure 1 - Emissions Mask-1, 1616.0208033 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 50% of authorized band width and the spectrum of the radio is within these lines at -31 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) and RSS-170 Section 5.4.2.1 i.e. 50 Percent of authorized bandwidth. A 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.61599997 GHz
F2= 1.616041637 GHz

Marker 2 Margin = 5.59 dB
Marker 3 Margin = 5.51 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.94 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.94 dBc.

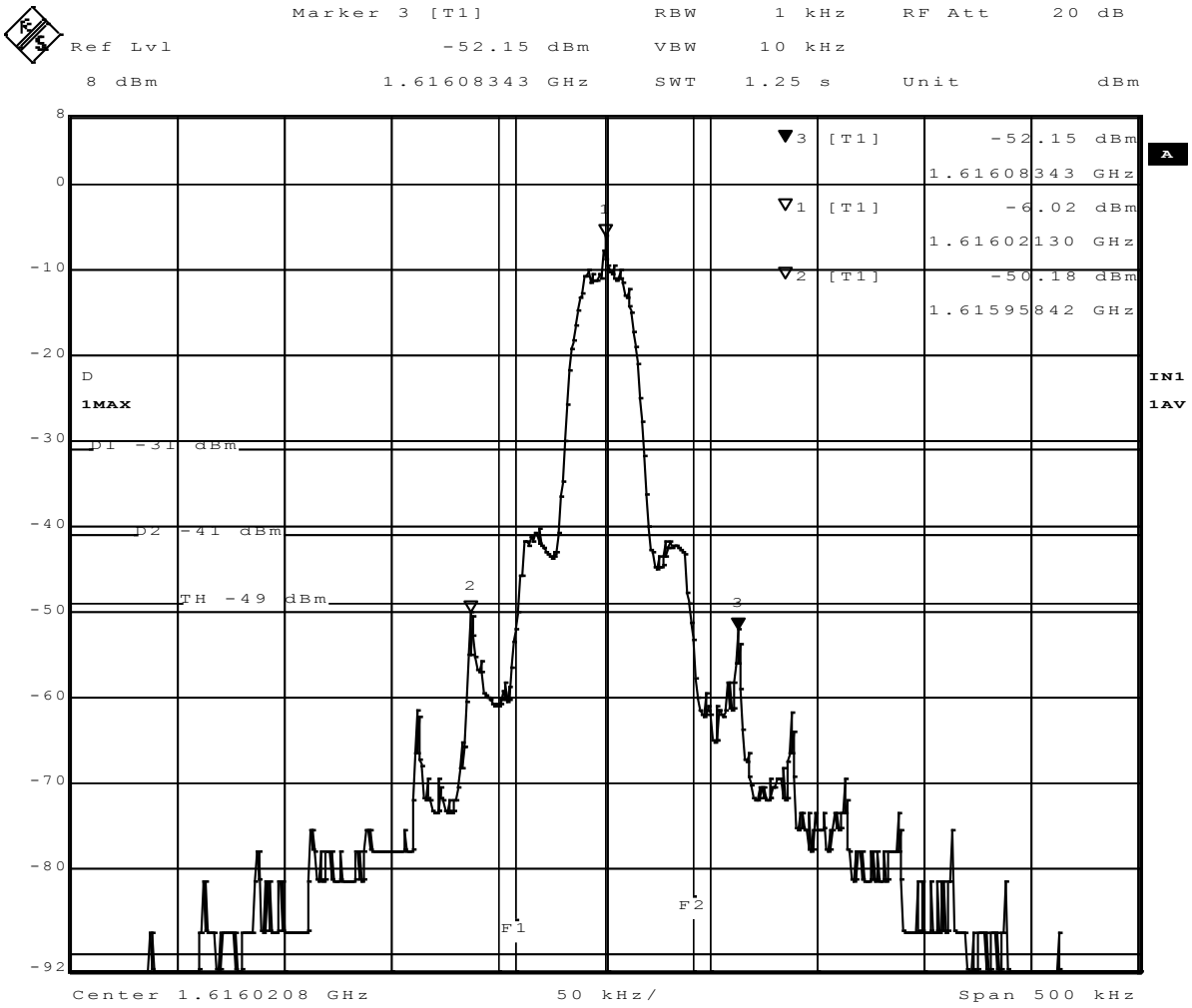


Figure 2 - Emissions Mask-2, 1616.0208033 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 100% of authorized band width and the spectrum of the radio is within these lines at -41 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) and RSS-170 Section 5.4.2.1 i.e. 50 Percent of authorized bandwidth. A 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.615979136 GHz
F2= 1.61606247 GHz

Marker 2 Margin = 9.18 dB
Marker 3 Margin = 11.15 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.94 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.94 dBc.

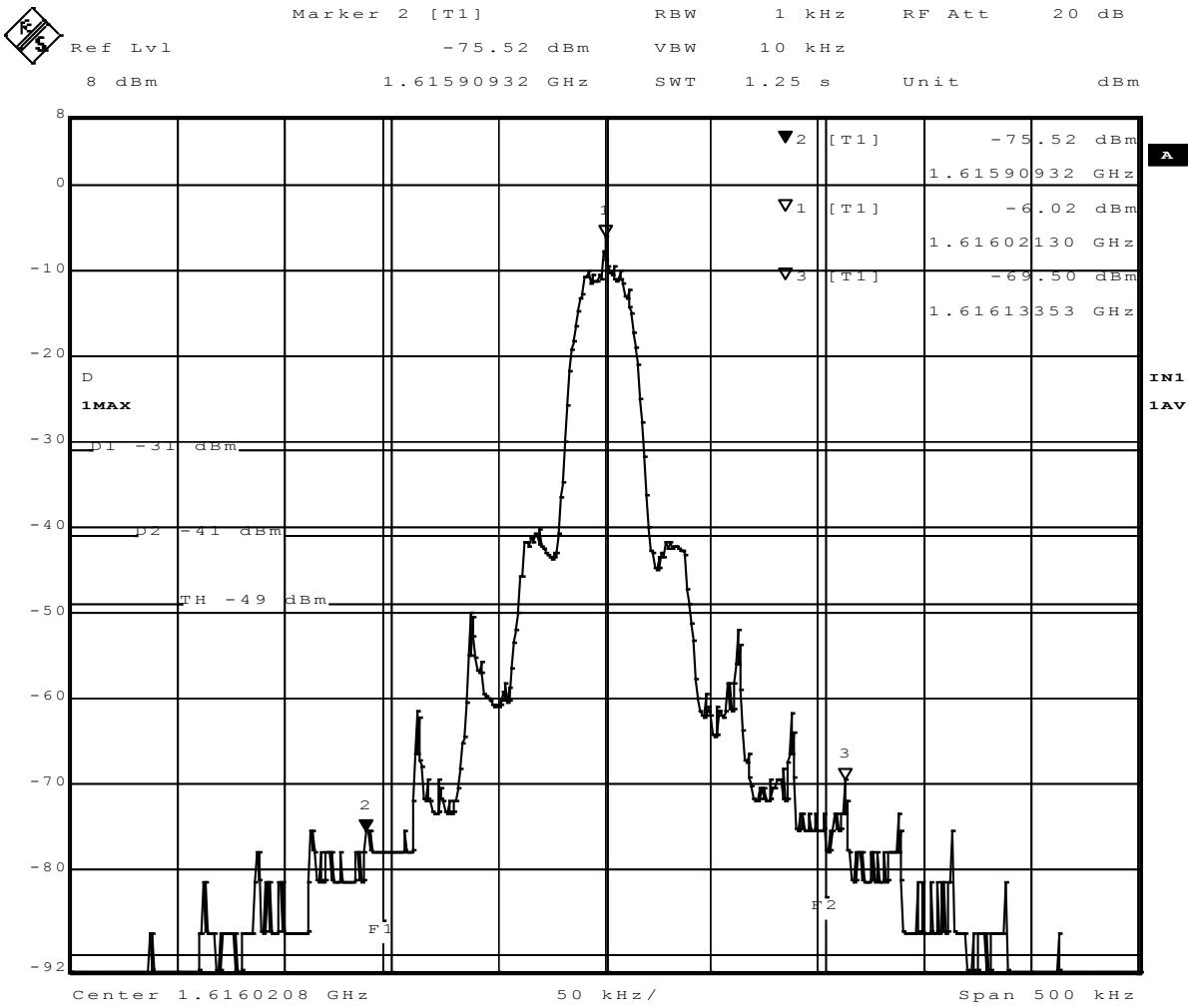


Figure 3 - Emissions Mask-3, 1616.0208033 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 250% of authorized band width and the spectrum of the radio is within these lines at -49 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) and RSS-170 Section 5.4.2.1 i.e. 50 Percent of authorized bandwidth. A 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.615916636 GHz
F2= 1.616124971 GHz

Marker 2 Margin = 26.52 dB
Marker 3 Margin = 20.50 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.94 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.94 dBc.

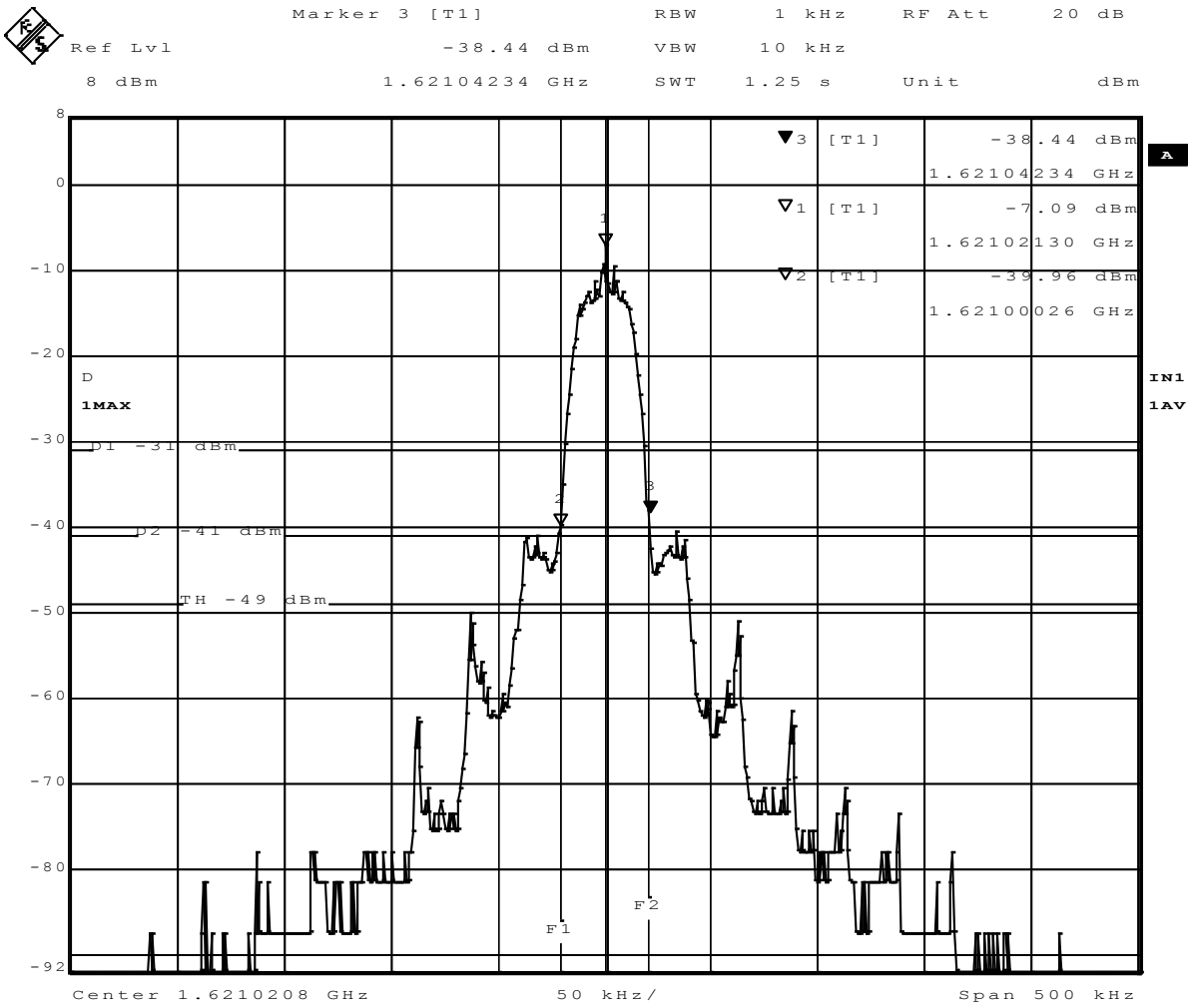


Figure 4 - Emissions Mask-1, 1621.0208033 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 50% of authorized band width and the spectrum of the radio is within these lines at -31 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) and RSS-170 Section 5.4.2.1 i.e. 50 Percent of authorized bandwidth. A 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.62099997 GHz
F2= 1.621041637 GHz

Marker 2 Margin = 8.96 dB
Marker 3 Margin = 7.44 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.81 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.81 dBc.

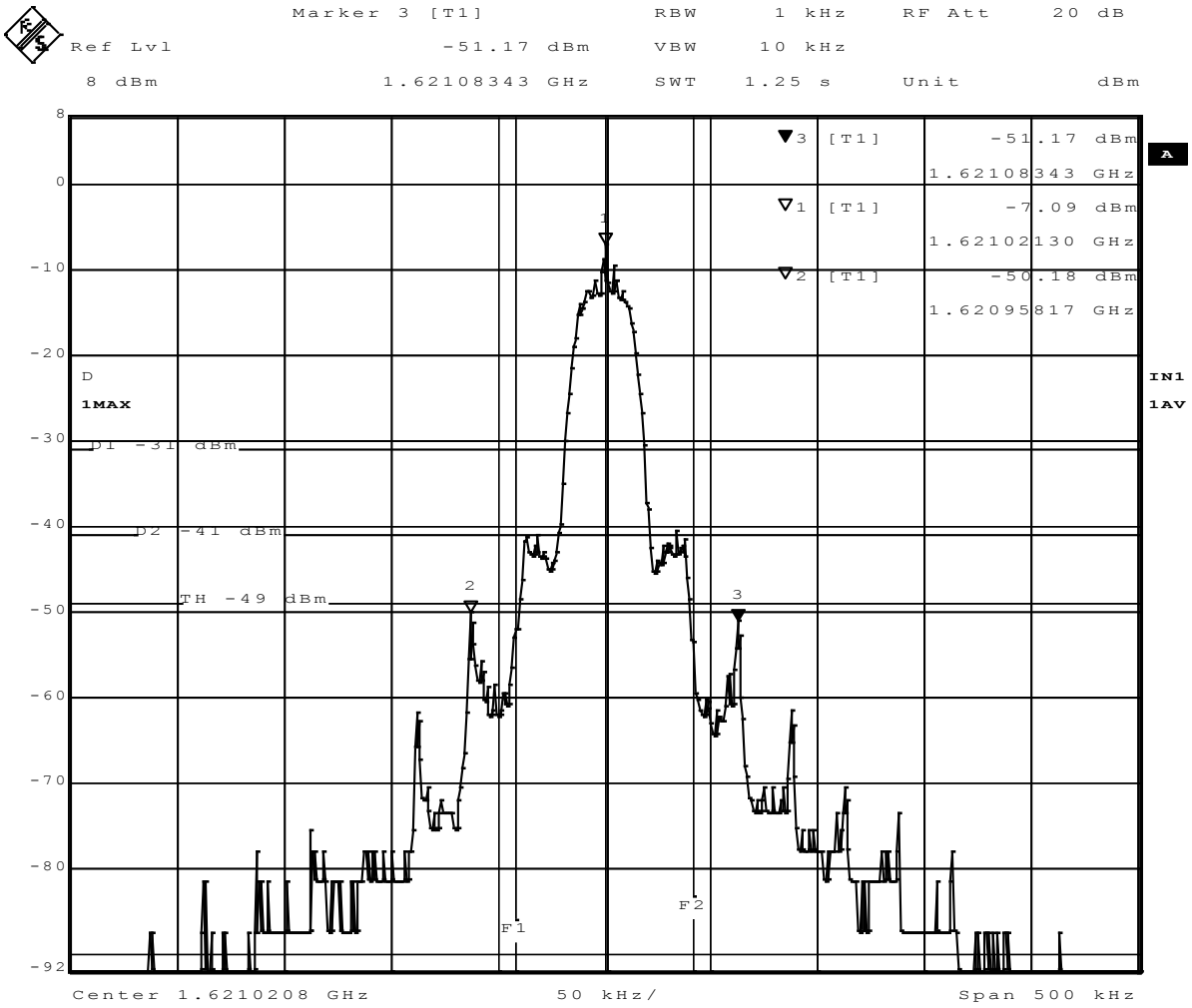


Figure 5 - Emissions Mask-2, 1621.0208033 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 100% of authorized band width and the spectrum of the radio is within these lines at -41 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) and RSS-170 Section 5.4.2.1 i.e. 50 Percent of authorized bandwidth. A 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.620979136 GHz
F2= 1.62106247 GHz

Marker 2 Margin = 9.18 dB
Marker 3 Margin = 10.17 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.81 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.81 dBc.

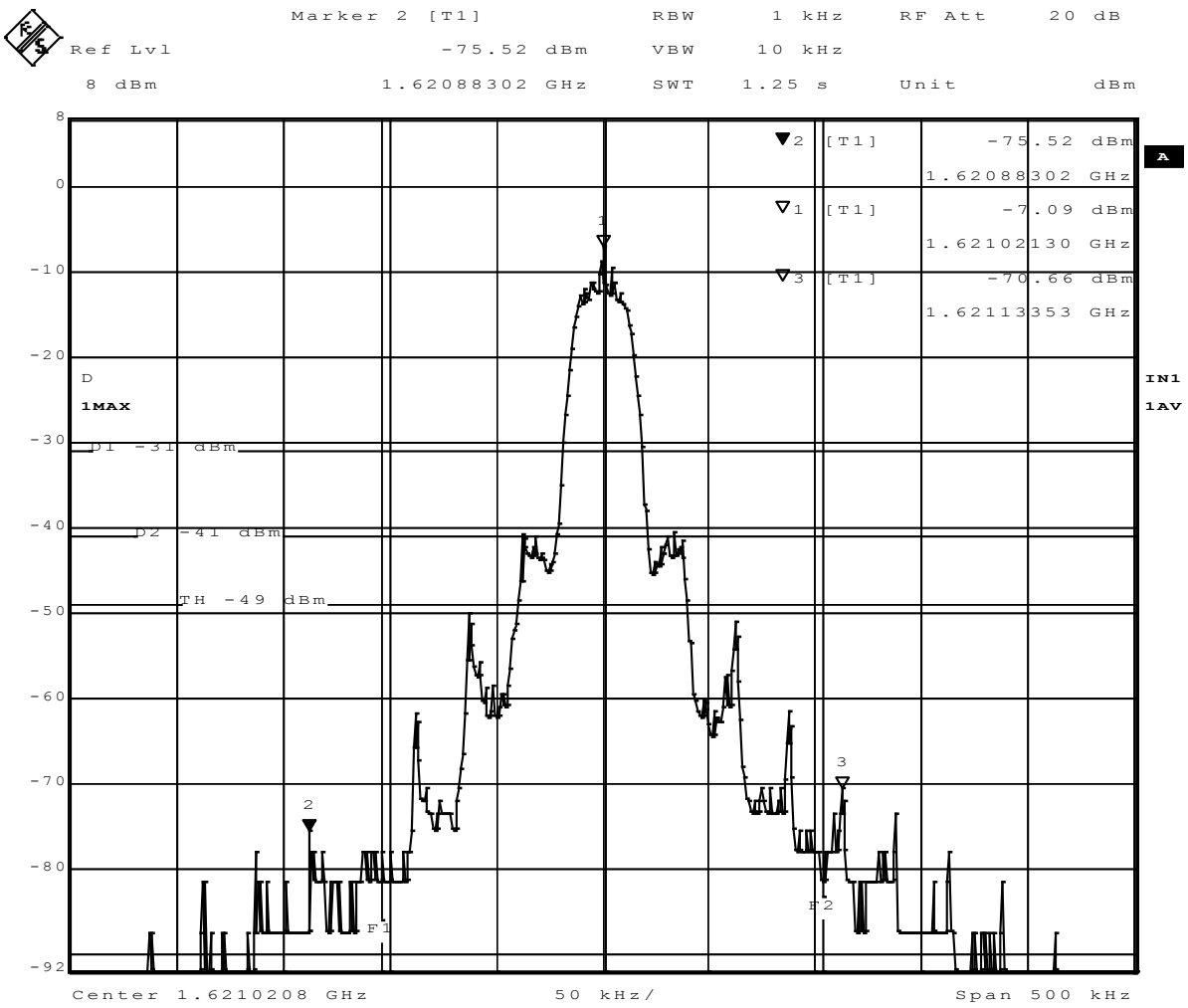


Figure 6 - Emissions Mask-3, 1621.0208033 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 250% of authorized band width and the spectrum of the radio is within these lines at -49 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) i.e. 250 Percent of authorized bandwidth. 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.620916636 GHz
F2= 1.621124971 GHz

Marker 2 Margin = 26.52
Marker 3 Margin = 21.66

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.81 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.81 dBc.

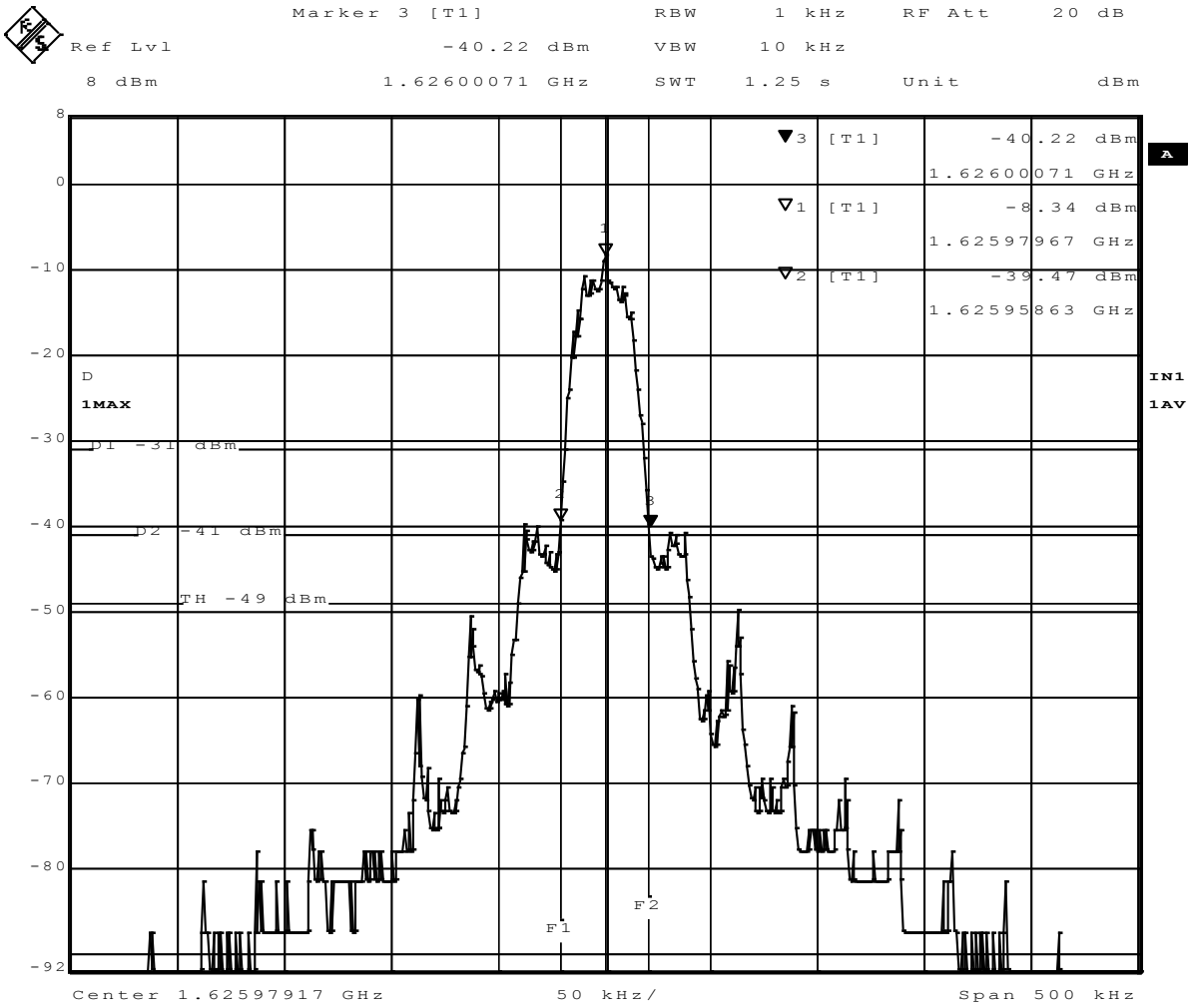


Figure 7 - Emissions Mask-1, 1625.979167 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 50% of authorized band width and the spectrum of the radio is within these lines at -31 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) i.e. 50 Percent of authorized bandwidth. 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.625958334 GHz
F2= 1.626000001 GHz

Marker 2 Margin = 8.47 dB
Marker 3 Margin = 9.22 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.81 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.81 dBc.
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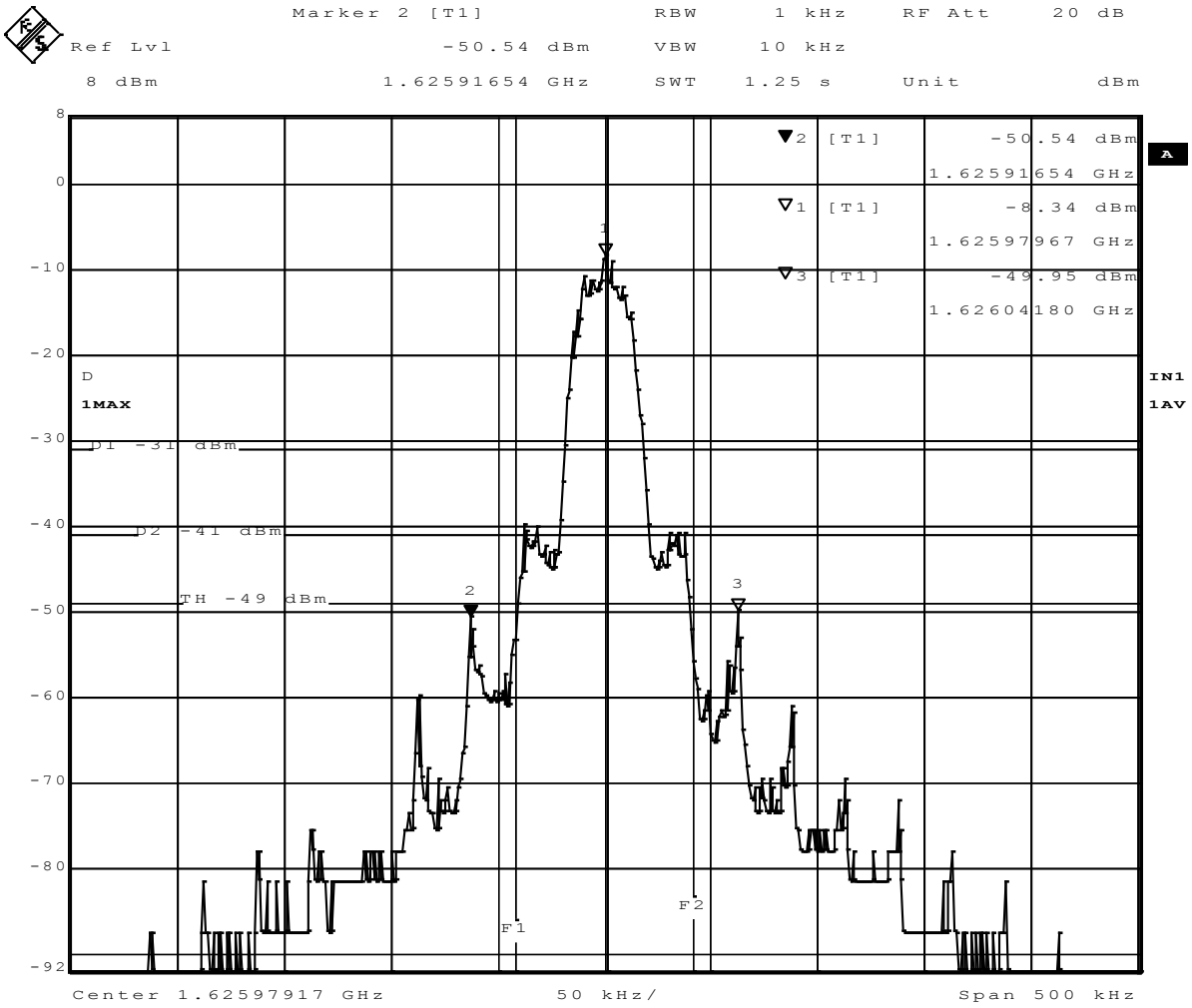

Figure 8 - Emissions Mask-2, 1625.979167 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 100% of authorized band width and the spectrum of the radio is within these lines at -41 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) i.e. 100 Percent of authorized bandwidth. 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.6259375 GHz
F2= 1.626020834 GHz

Marker 2 Margin = 9.54 dB
Marker 3 Margin = 8.95 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges.

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.81 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.81 dBc.

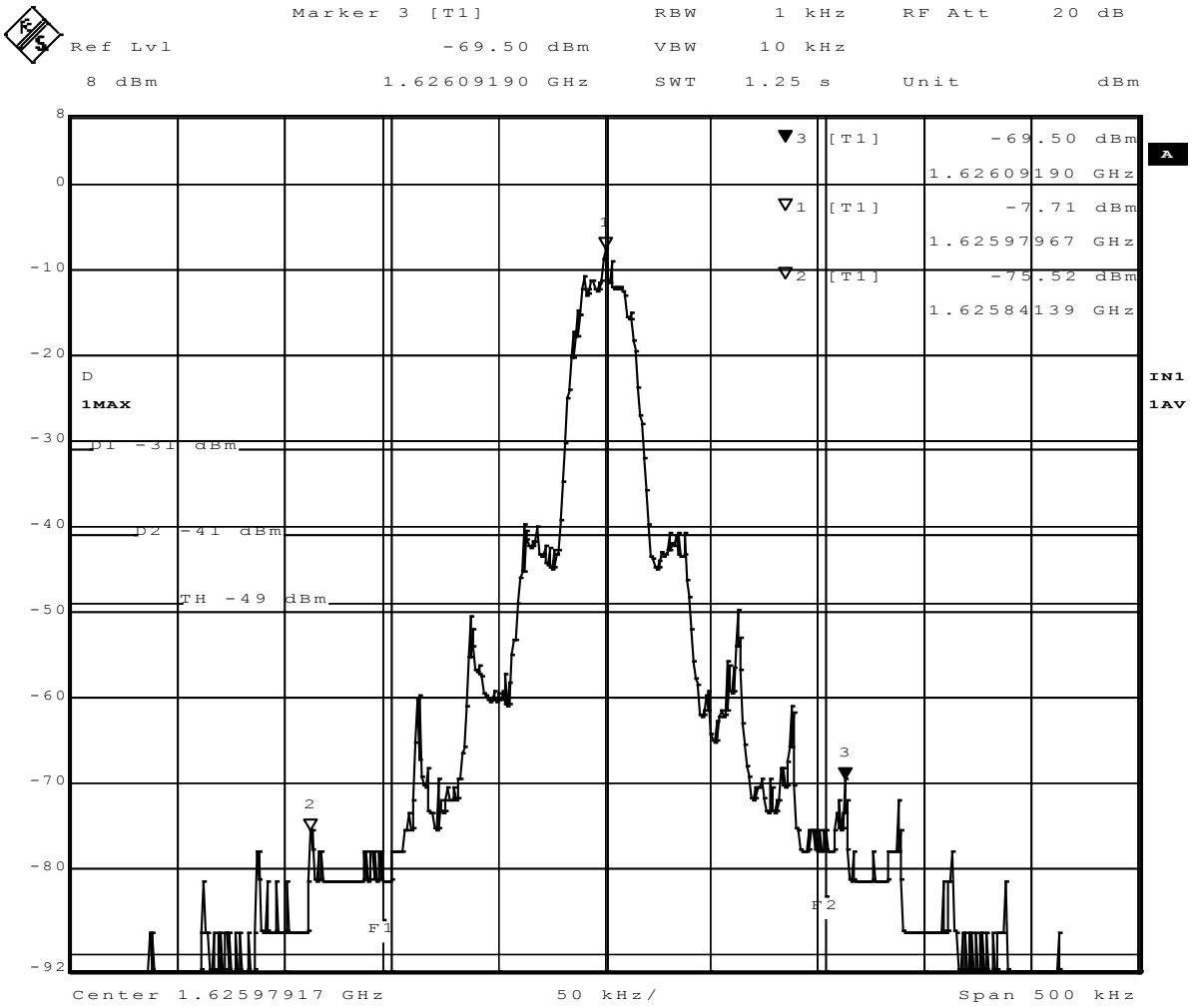

Figure 9 - Emissions Mask-3, 1625.979167 MHz

*The Authorized Band width is 41.667 kHz. Note that vertical lines F1 and F2 on the graph represent 250% of authorized band width and the spectrum of the radio is within these lines at -49 dBm, fulfilling the requirement in FCC CFR 47, 25.202(f (1)) i.e. 250 Percent of authorized bandwidth. A 6dB correction to convert 1 kHz RBW to 4 kHz RBW was applied to the horizontal limits.

F1= 1.625875 dB
F2= 1.626083335 dB

Marker 2 Margin = 26.52 dB
Marker 3 Margin = 20.50 dB

1kHz to 4kHz conversion = 10log(1/4) = -6.0 dB
1kHz resolution bandwidth was used to get higher frequency resolution at the band edges

The reference levels used are in dBc as compared to a power value of 0 dBm. 30 dB of attenuation was used, so the actual reference value was 30 dBm. The maximum conducted output power was measured to be 32.81 dBm (as seen in Section 3.3). Because this value is higher than the reference value used, the margin will be an additional 2.81 dBc.

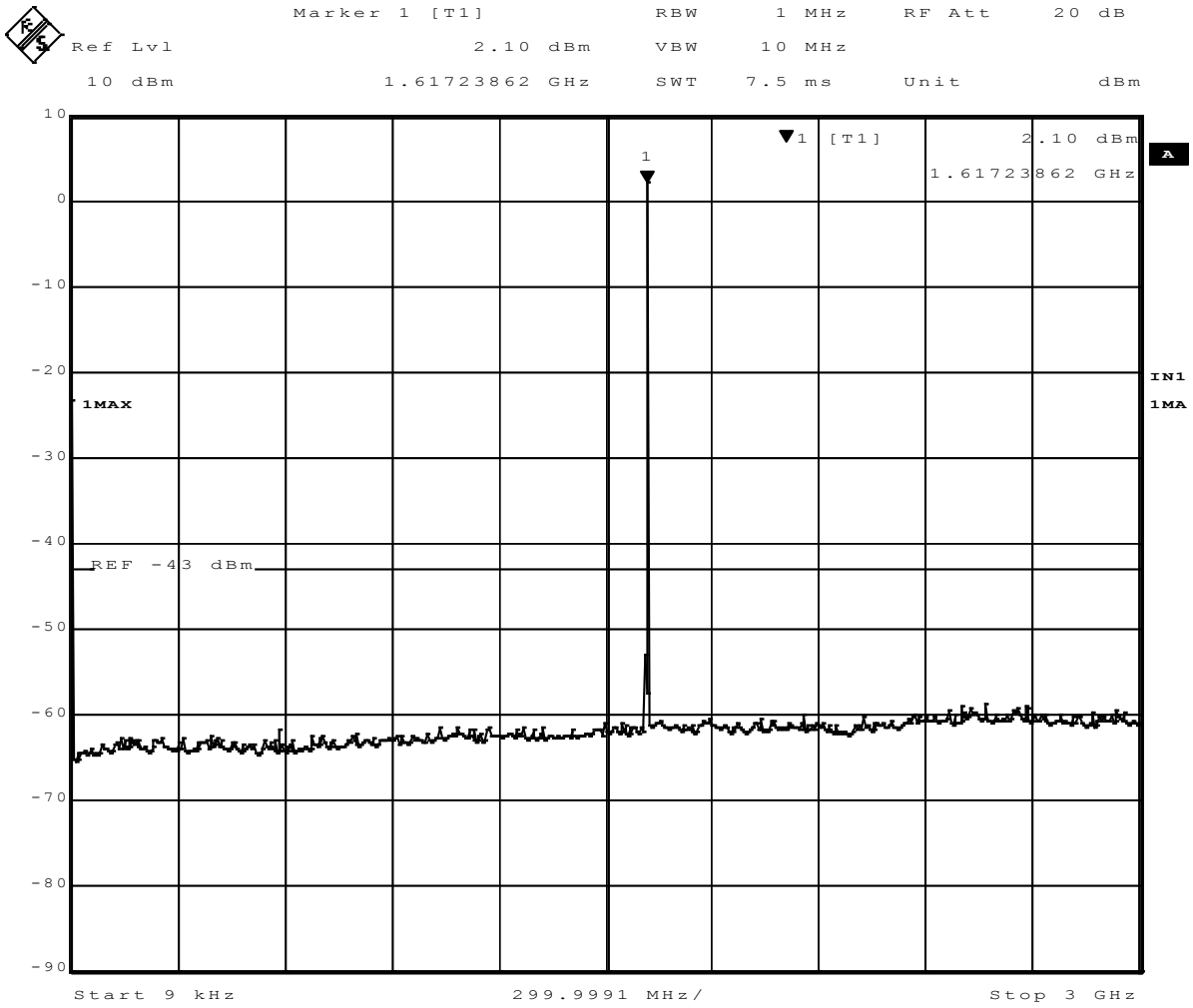

Figure 10 – Spurious Emissions at Antenna Terminals, 1616.0208033 MHz, 1-3 GHz
*cable loss + attenuation = 30.49 dB

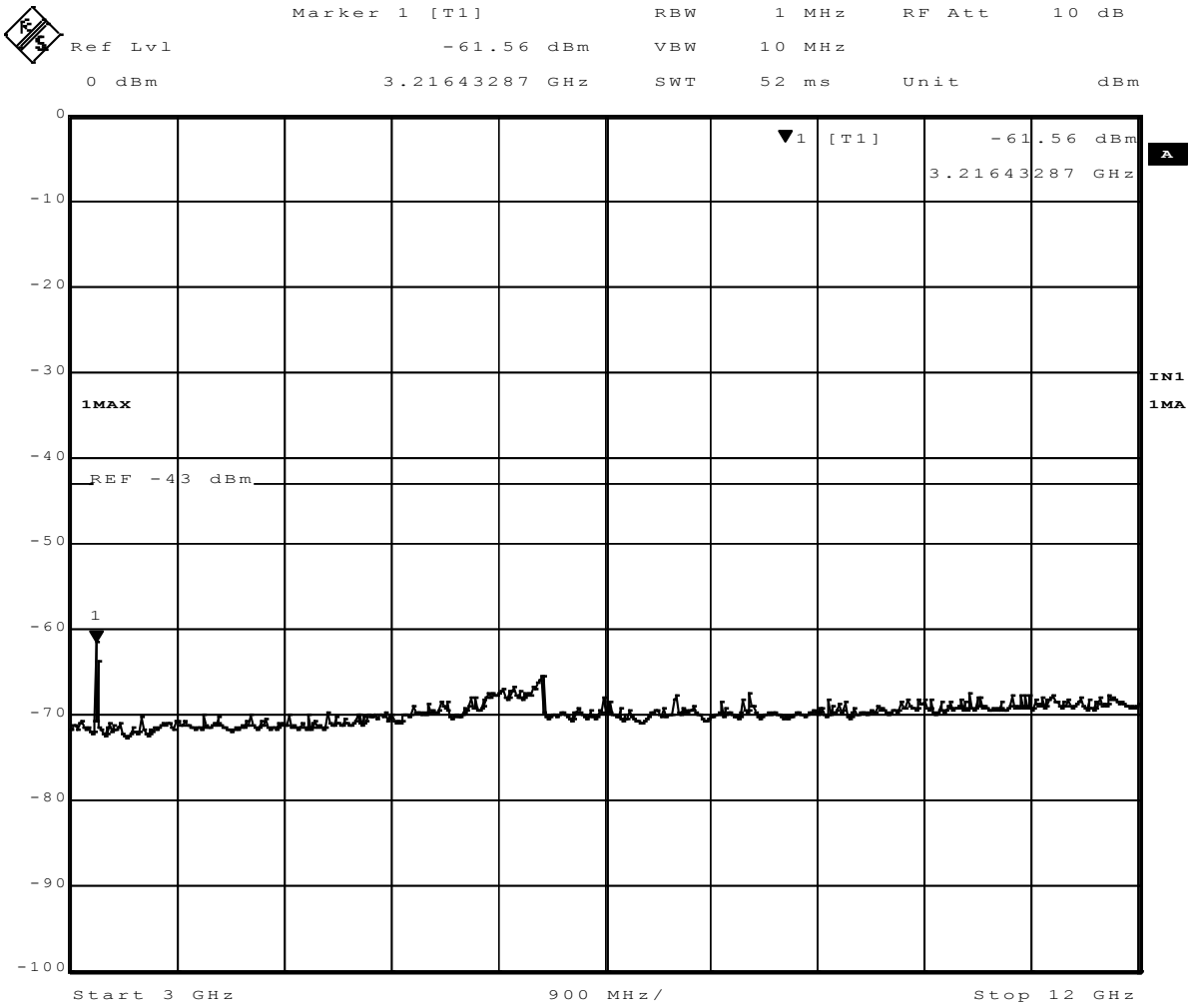

Figure 11 – Spurious Emissions at Antenna Terminals, 1616.0208033 MHz, 3 - 20 GHz
*cable loss + attenuation = 30.87 dB

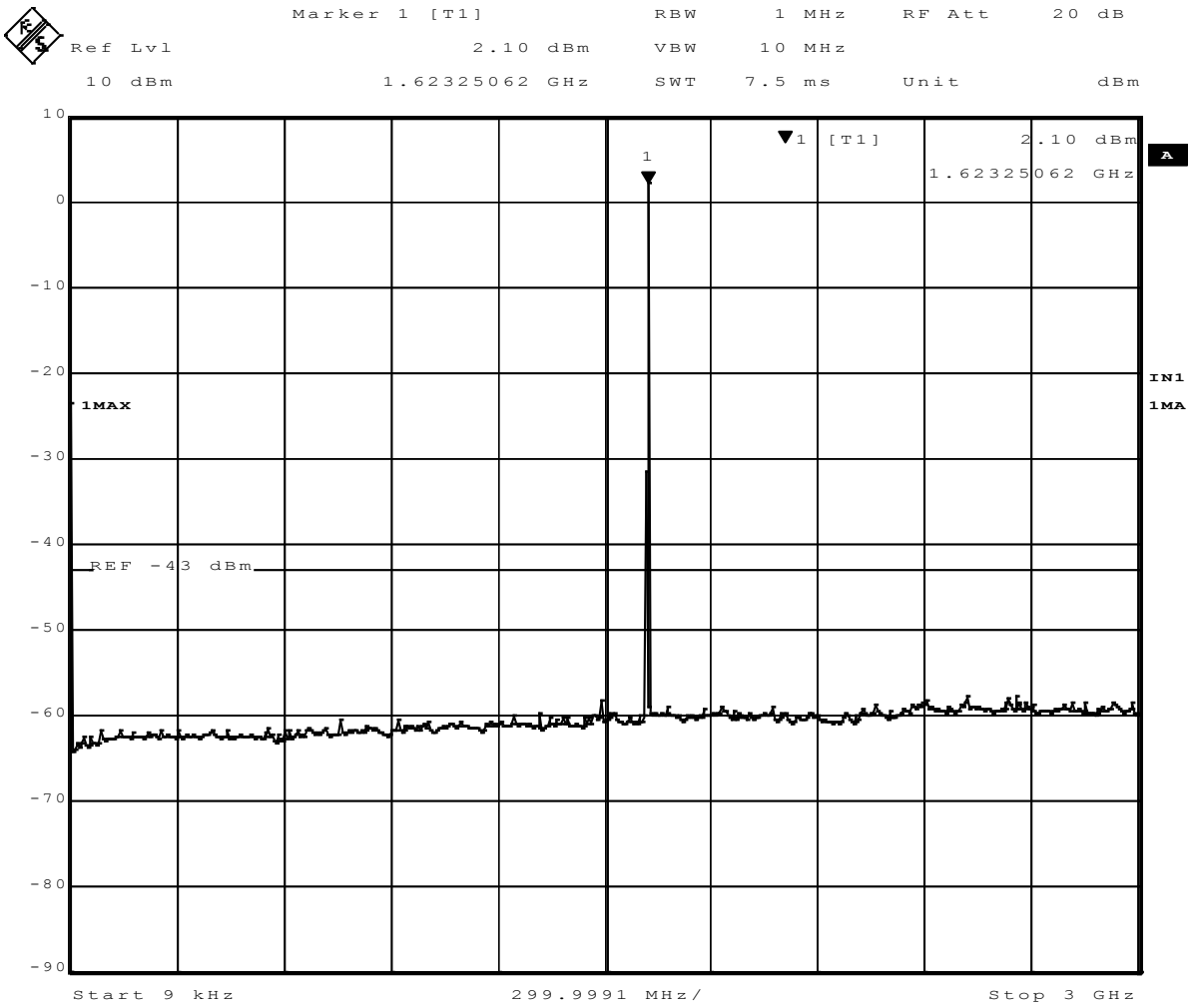

Figure 12 – Spurious Emissions at Antenna Terminals, 1621.0208033 MHz, 1-3 GHz
*cable loss + attenuation = 30.49 dB

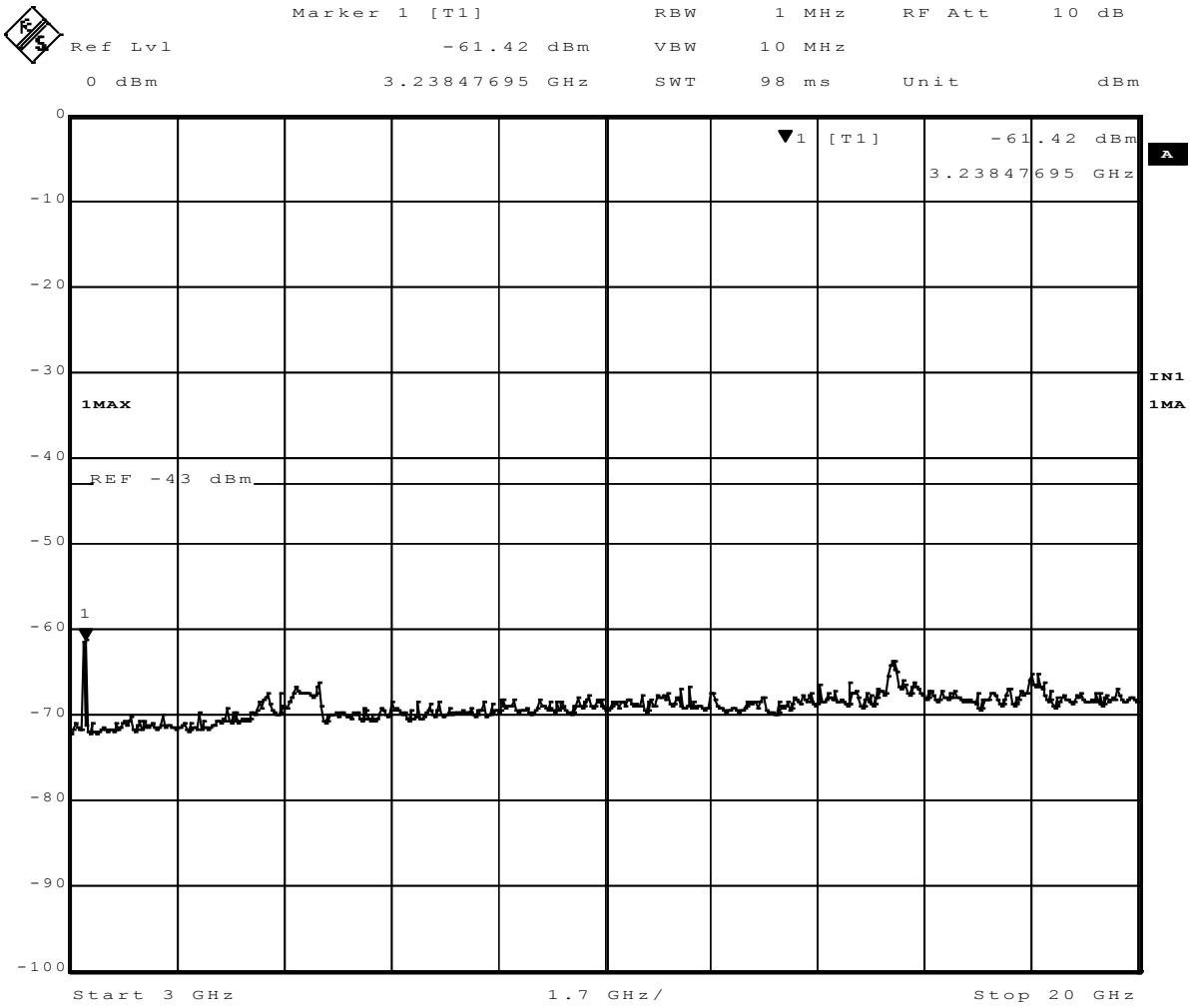

Figure 13 – Spurious Emissions at Antenna Terminals, 1621.0208033 MHz, 3 - 20 GHz
*cable loss + attenuation = 30.87 dB

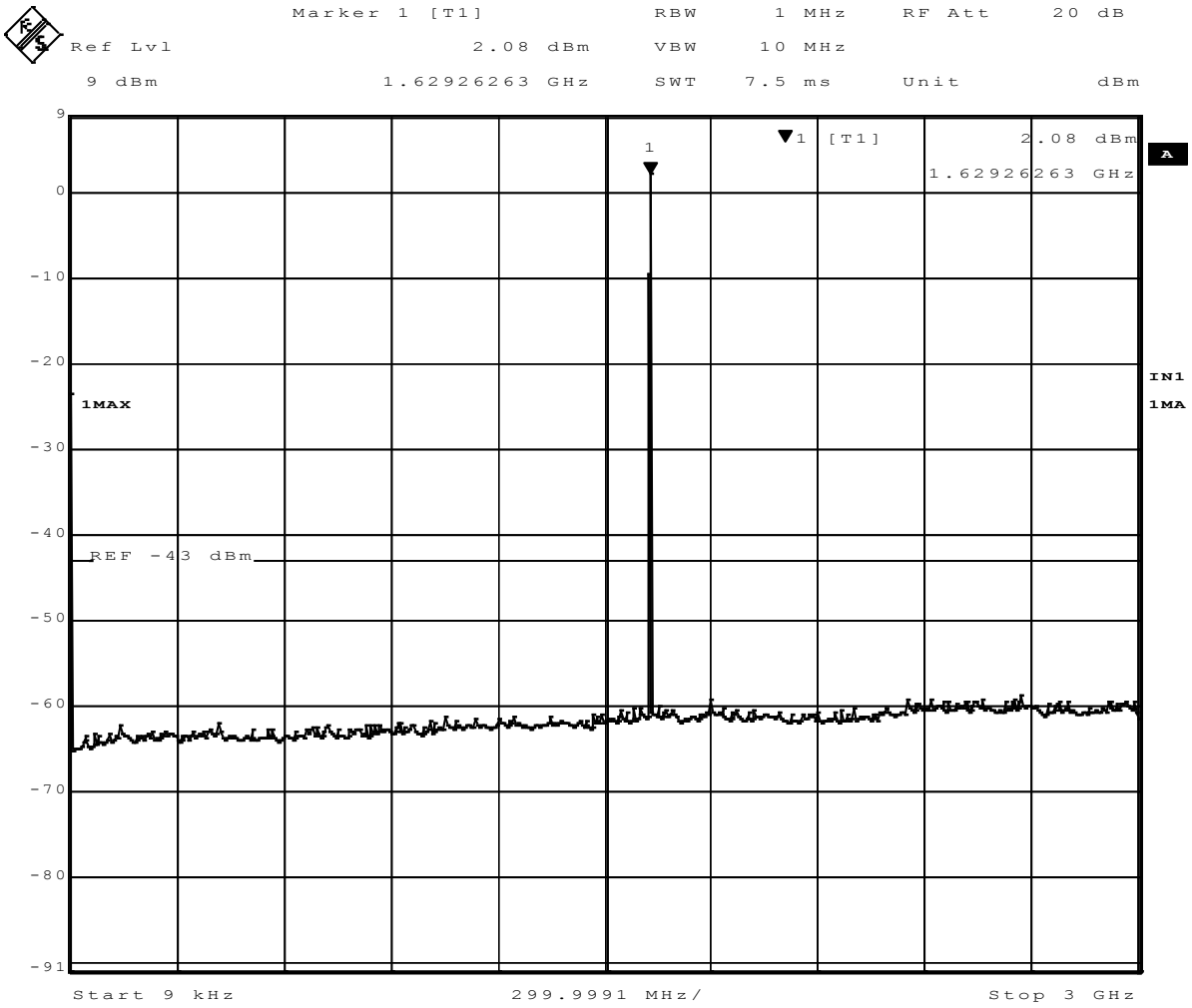

Figure 14 – Spurious Emissions at Antenna Terminals, 1625.979167 MHz, 1-3 GHz
*cable loss + attenuation = 30.49 dB

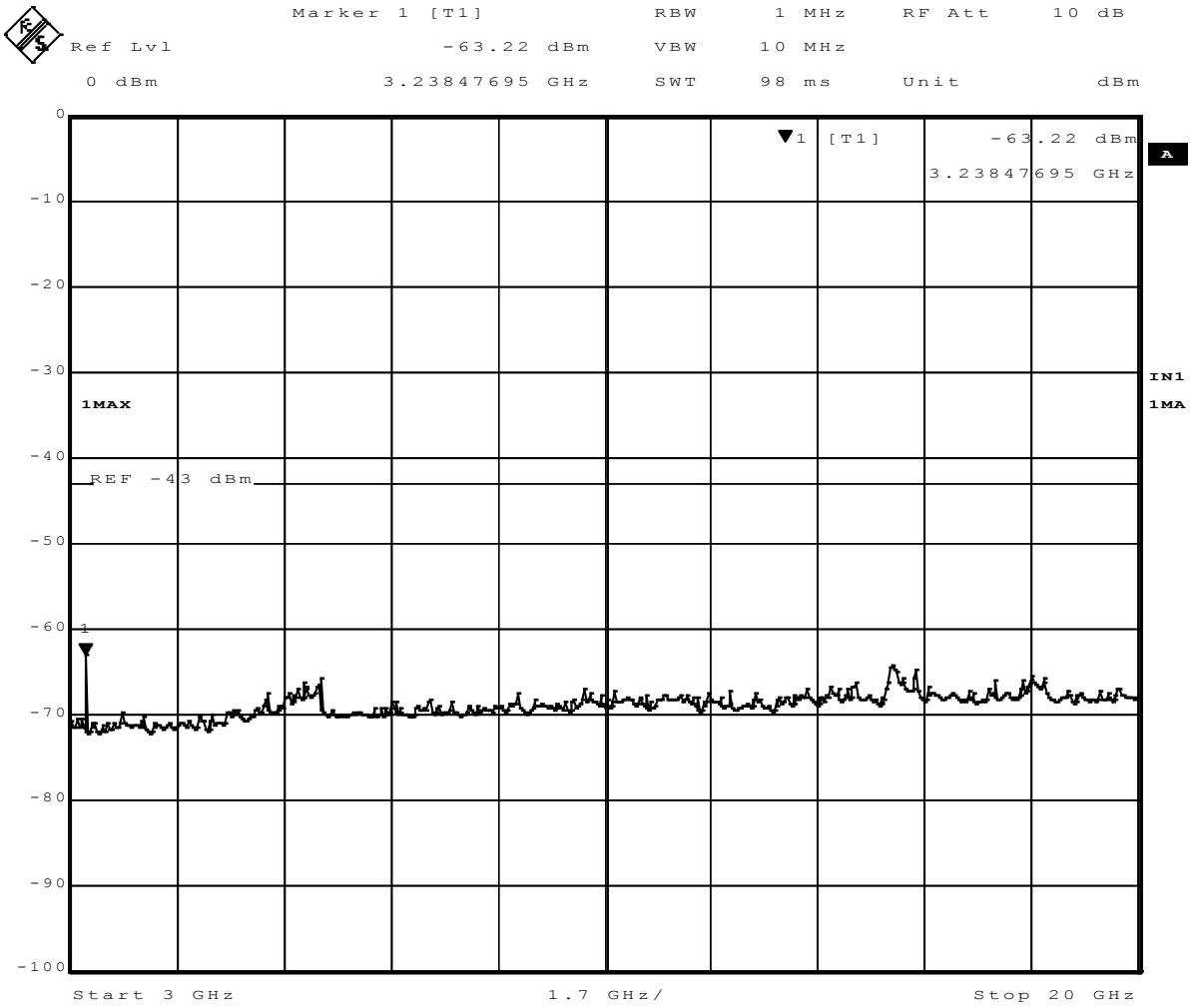

Figure 15 – Spurious Emissions at Antenna Terminals, 1625.979167 MHz, 3 - 20 GHz
*cable loss + attenuation = 30.87 dB

3.3 RF Output Power and EIRP

Test: FCC Part 25.204
RSS-170, Clause 5.3

Test Result: *Complies* Date: 20 November 2015

Test Description
For conducted power, the EUT was connected to a spectrum analyzer via a cable and 30dB attenuator. The resolution bandwidth was set to 10MHz to capture the entire signal. A peak detector was used in max hold mode to capture the peak power.

Test Environment
Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 30 ± 5%
Temperature of 22 ± 2º C

Test Setup
The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuators. The spectrum analyzer was used to make power measurements using bandwidth filter large enough to capture the entire bandwidth of the signal.

Test Equipment Used

Serial #	*Manufacturer*	*Model*	*Description*	*Last Cal.*
100037	Rohde & Schwarz	ESIB26	EMI Test Receiver	20 Jan 2015
BG1808	Weinschel	48-30-43	30dB Attenuator	CNR

Test Results

The power measurements were found to comply

Conducted Power and EIRP Results
FCC 25.204 and RSS-170, Clause 5.3

Frequency	Uncorrected Measurement	Cable and Attenuation Correction Factor	Corrected Measurement	Corrected Measurement	EIRP
MHz	dBm	dB	dBm	W	dBi
1616.0208033	2.45	30.49	32.94	1.9679	7.39
1621.0208033	2.32	30.49	32.81	1.9099	7.15
1625.9791670	2.32	30.49	32.81	1.9099	7.15

Corrected measurement = Uncorrected measurement + cable correction factor + Attenuation
Values from occupied bandwidth measurement plots in section 3.2.

EIRP = conducted power + antenna gain (3.5 dBi)

3.4 Field Strength Spurious Emission

Test: §25.216 § RSS 5.4.3

Result: *Complies* Date: 18 November 2015

Test Description
The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. The test was performed by placing the EUT Horizontally. The frequency range up to tenth harmonic of the fundamental frequency was investigated.

The EUT was then removed and the replaced with a substitution antenna of the same model as the receiving antenna. A signal generator was connected to the substitution antenna by a non-radiating cable. The absolute levels of the spurious emissions were measured by the substitution. Spurious emissions in dB = 10 log (TXpwr in Watts/0.001) which is the absolute level.

The limit is -70dBW or -40dBm. The RBW was 1MHz.
And

Test Environment
Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 30 ± 5%
Temperature of 22 ± 2º C

Test Setup
The transmitter was placed on a wooden turntable, and it was transmitting into a 50ohm load which was also placed on the turntable. The test setup can be seen in Figure 1 of appendix A.

Test Results
The radiated spurious emissions were found to comply

Test Equipment Used

Serial #	*Manufacturer*	*Model*	*Description*	*Last Cal*
83467	Rohde & Schwarz	SML20	Signal Generator	9/17/14
100037	Rohde & Schwarz	ESIB26	EMI Test Receiver	1/26 /2015
N/A	RES-NET	RCX51SF	50 ohm Load	CNR
1647	EMCO	3141B	Bicon Antenna	6/23/2015
1654	EMCO	3141B	Bicon Antenna	1/26/2015
6415	EMCO	3115	DRG Horn	1/20/2015
6416	EMCO	3115	DRG Horn	1/14/2014
2575	Rohde & Schwarz	EMSK1	Software v.1.20	N/A

Radiated Spurious Emission Measurements

Frequency	Pre-scan Level	Antenna Height	Angle	Pol.	Signal Generator Level	Transmit Antenna Gain	Transmit Cable loss	Level	Limit	Margin
MHz	dBµV/m	cm	deg.		dBm	dBi	dB	dBm	dBm	
1616.0208033 MHz										
49.26	12.54	99	298	V	-77.00	0.27	1.20	-77.93	-40.00	34.93
69.54	16.33	196	266	V	-77.10	1.17	1.30	-77.23	-40.00	34.23
140.04	26.60	98	276	V	-76.10	3.30	1.70	-74.50	-40.00	31.50
150.00	34.93	101	239	V	-66.50	2.86	1.80	-65.44	-40.00	22.44
299.76	45.13	100	200	V	-57.70	3.60	2.70	-56.80	-40.00	13.80
448.68	30.36	100	30	V	-69.80	3.58	3.30	-69.52	-40.00	26.52
1559.00	25.13*	100	251	V	-71.02	8.53	6.00	-73.55	-70.00	3.55
3235.40	39.68	395	117	H	-60.00	9.11	8.60	-59.50	-40.00	16.50
4844.00	42.45	331	36	V	-61.00	12.41	10.60	-59.19	-40.00	16.19
1621.0208033 MHz										
47.58	17.81	129	360	V	-69.30	0.22	1.20	-67.88	-40.00	24.88
70.32	20.40	156	128	V	-72.70	1.17	1.30	-70.23	-40.00	27.23
139.98	29.46	100	278	V	-72.80	3.30	1.70	-67.80	-40.00	24.80
150.00	34.92	100	283	V	-66.60	2.86	1.80	-61.94	-40.00	18.94
232.38	30.95	101	274	V	-74.10	3.73	2.40	-67.97	-40.00	24.97
298.74	45.00	99	202	V	-57.90	3.60	2.70	-51.60	-40.00	8.60
1559.00	25.45*	100	251	V	-70.98	8.53	6.00	-73.51	-70.00	3.51
3245.80	26.84	297	237	H	-59.10	9.11	8.60	-58.60	-40.00	15.60
4876.20	28.85	100	348	H	-62.00	12.41	10.60	-60.19	-40.00	17.19
1625.979167 MHz										
69.54	17.39	115	94	V	-77.10	1.17	1.30	-74.63	-40.00	31.63
97.26	23.93	112	280	V	-70.70	1.27	1.40	-68.03	-40.00	25.03
139.98	23.39	216	290	V	-79.50	3.30	1.70	-74.50	-40.00	31.50
150.00	34.45	99	297	V	-67.00	2.86	1.80	-62.34	-40.00	19.34
233.16	30.31	104	269	V	-75.20	3.73	2.40	-69.07	-40.00	26.07
299.76	44.65	99	209	V	-58.30	3.60	2.70	-52.00	-40.00	9.00
1559.00	25.12*	100	251	V	-70.56	8.53	6	-73.09	-70.00	3.09
3256.60	40.49	342	271	V	-59.10	9.11	8.60	-58.60	-40.00	15.60
4878.40	42.24	394	144	V	-62.00	12.41	10.60	-60.19	-40.00	17.19

*System noise floor

Rx mode

Frequency	Pre-scan	Antenna Height	Angle	Pol.	Signal Generator Level	Transmit Antenna Gain	Transmit	Level	Limit	Margin
MHz	Level	cm	ge		dBm	dBi	Cable loss (dB)	dBm	dBm	dB
55.86	19.89	100	0	V	-70.40	0.50	1.20	-68.70	-50.00	15.70
70.62	16.76	132	79	V	-77.10	1.21	1.30	-74.59	-50.00	21.59
144.00	28.10	100	111	V	-74.20	3.18	1.70	-69.32	-50.00	16.32
150.00	34.75	100	229	V	-66.70	2.86	1.80	-62.04	-40.00	19.04
299.70	44.20	100	202	V	-58.70	3.60	2.70	-52.40	-40.00	9.40
448.62	30.48	100	185	V	-69.80	3.58	3.30	-62.92	-40.00	19.92

Carrier-off mode (FCC Part 25.216(i))

Frequency	Pre-scan	Antenna Height	Angle	Pol.	Signal Generator Level	Transmit Antenna Gain	Transmit	Level	Limit	Margin
Hz	Level	cm	Deg		dBm	dBi	Cable loss (dB)		dBm	dB
1559	20.30*	100	251	V	-79.21	8.53	6.00	-81.74	-50.00**	31.74
1610	21.00*	100	300	H	-78.25	8.53	6.00	-80.78	-50.00**	30.78

*System noise floor
**Limit = -80.00 dBW = -50.00 dBm

Table 3 - Measurements according to FCC Part 15.212(f) and (g)

1616.0208033 MHz

Frequency	Level	Limit	Margin
MHz	dBW	dBW	dB
1605.00	-80.79	-80.00	0.79
1606.00	-80.05	-68.00	12.05
1607.00	-80.89	-56.00	24.89
1608.00	-80.87	-44.00	36.87
1609.00	-80.71	-32.00	48.71
1610.00	-80.09	-20.00	60.09

1621.0208033 MHz

Frequency	Level	Limit	Margin
MHz	dBW	dBW	dB
1605.00	-80.87	-80.00	0.87
1606.00	-80.85	-68.00	12.85
1607.00	-81.47	-56.00	25.47
1608.00	-81.74	-44.00	37.74
1609.00	-80.42	-32.00	48.42
1610.00	-80.57	-20.00	60.57

1625.979167 MHz

Frequency	Level	Limit	Margin
MHz	dBW	dBW	dB
1605.00	-81.19	-80.00	1.19
1606.00	-80.99	-68.00	12.99
1607.00	-80.01	-56.00	24.01
1608.00	-80.06	-44.00	36.06
1609.00	-80.29	-32.00	48.29
1610.00	-80.75	-20.00	60.75

Note: the limits shown are for discrete emissions of less than 700 Hz bandwidth according to FCC Part 15.212(g). The bandwidth of the emissions was not measured, so the lowest limits were used. For FCC Part 15.212(g) the limits are 10 dB higher, so the margins would increase by 10 dB. These measurements are intedned to show compliance with both parts using the lowest limit.

3.5 Occupied Bandwidth

Test: FCC Part 2.1049
RSS-Gen, Clause 4.6.1

Result: *Complies* Date: 20 November 2015

Test Description
The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 1 MHz VBW. The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 100kHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

Test Environment
Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 30 ± 5%
Temperature of 22 ± 2º C

Test Setup
The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 2 kHz. Sufficient scans were taken to show any out of band emissions up to the 10th harmonic. The test setup can be seen in Figures 2 through 4 of appendix A.

Test Equipment Used

Serial #	*Manufacturer*	*Model*	*Description*	*Last Cal.*
100037	Rohde & Schwarz	ESIB26	EMI Test Receiver	1/20/2015
BG1808	Weinschel	48-30-43	30dB Attenuator	CNR

Test Results
The spurious emissions at the antenna terminals were found to comply.

Channel Frequency	99% Occupied Bandwidth
MHz	kHz
1616.0208033	32.06
1621.0208033	32.06
1625.979167	33.06

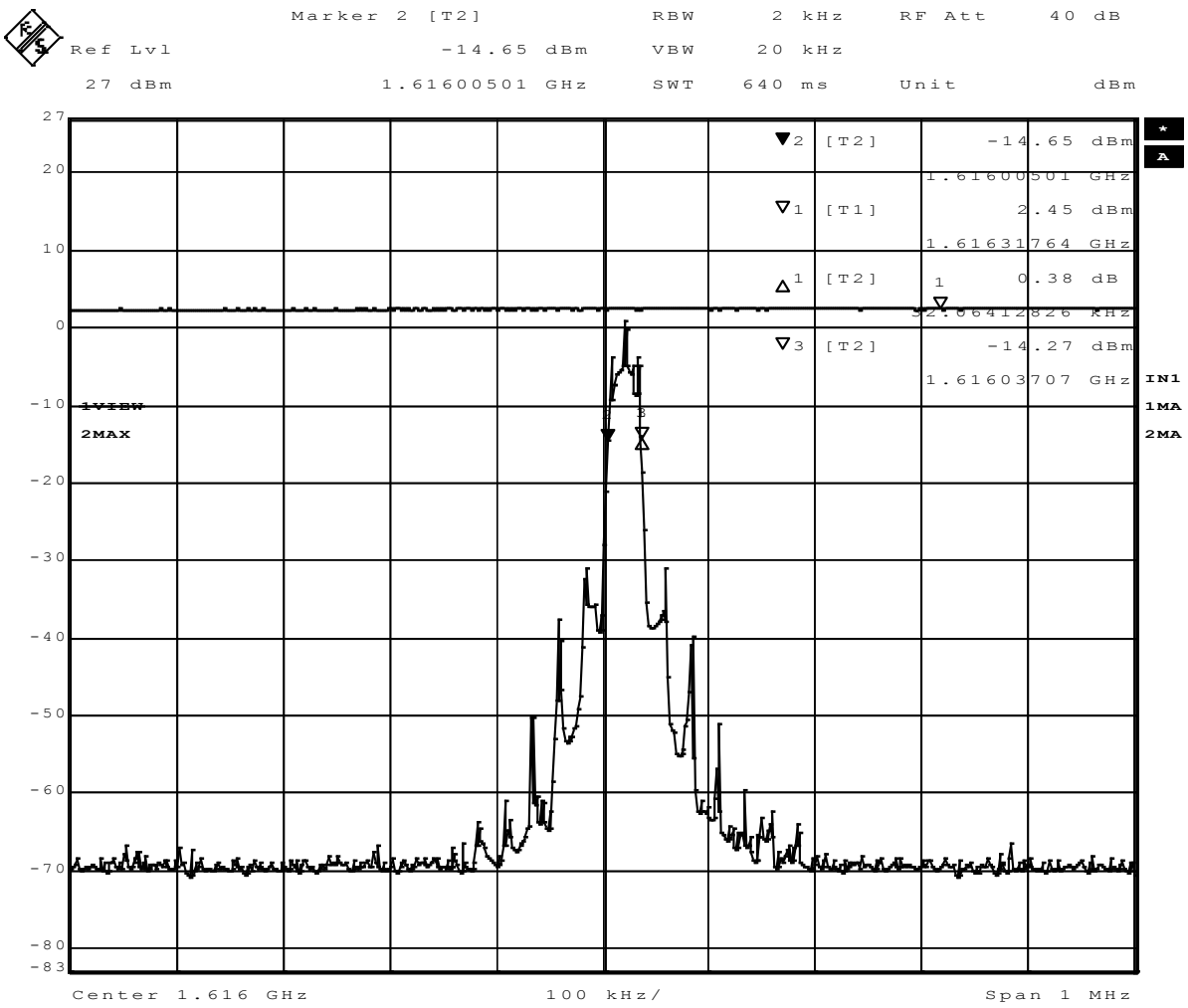

Figure 16 - 99% Occupied Bandwidth, 1616.0208033 MHz

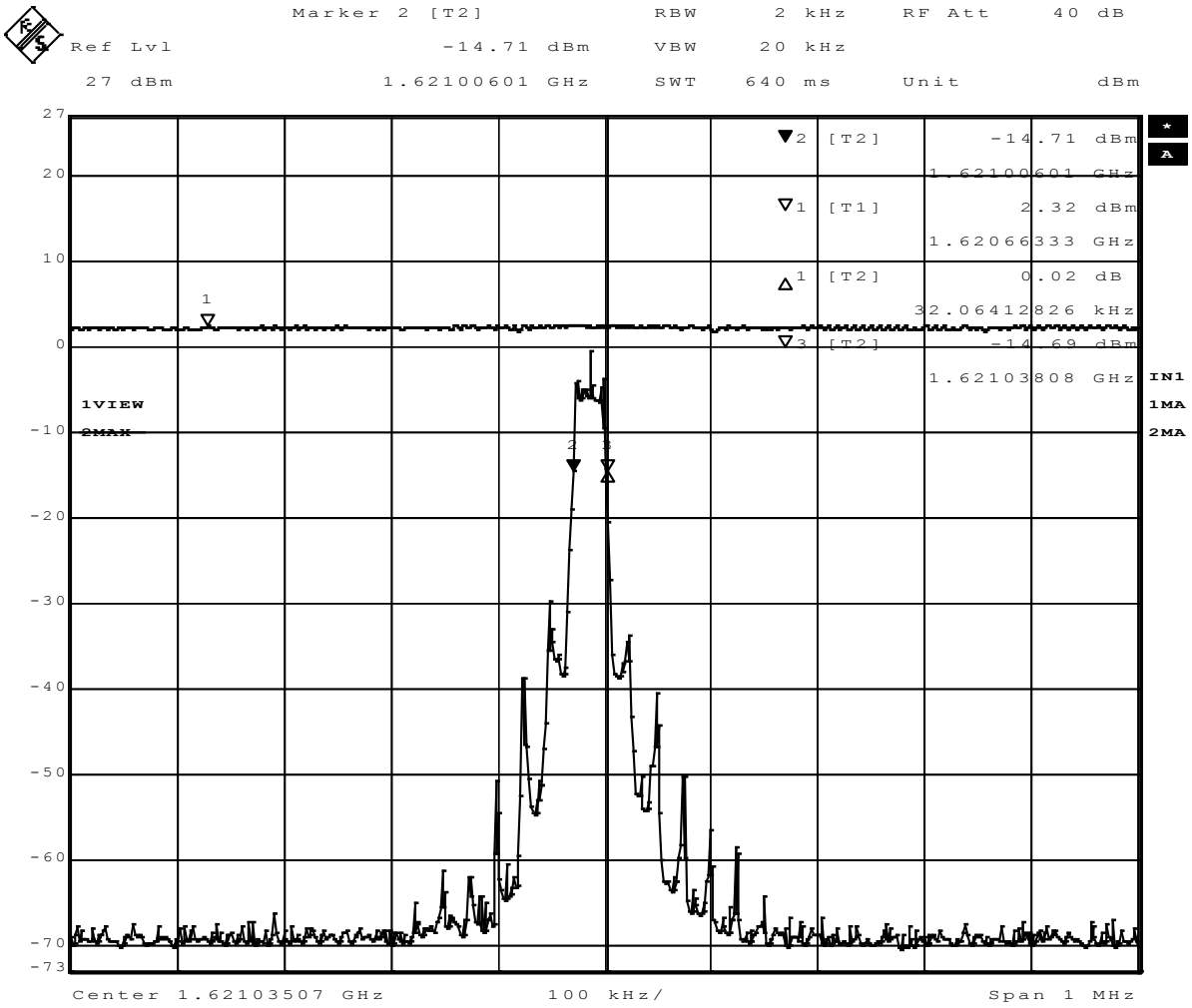

Figure 17 -, 99% Occupied Bandwidth, 1621.0208033 MHz

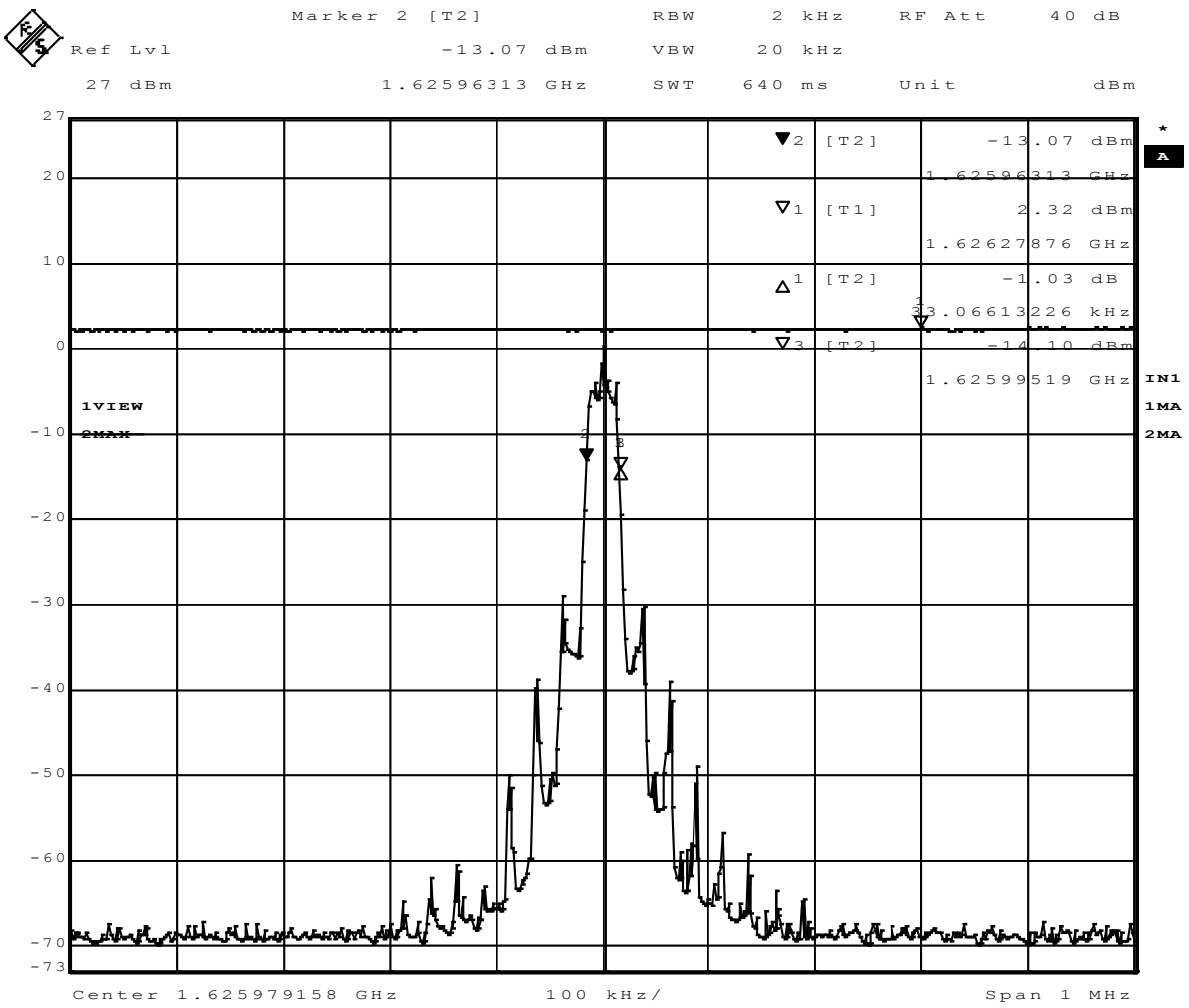

Figure 18 - 99% Occupied Bandwidth, 1625.979167 MHz

3.6 Modulation Characteristics

Test: FCC Part 2.1047(d)

Result: *Complies* Date: 20 November 2015

Test Description
The bandwidth was measured to support the following description of the modulation provided by the manufacturer:

The acquisition channel uses differently encoded binary phase shift keyed (DE-BPSK) with 40% square root raised cosine pulse shaping. The burst rate on these channels is 25 kbps.

The sync channel uses 25 kpbps DE-BPSK on the uplink and 50 kbps DE-QPSK on the downlink. Both with 40% square root raised cosine pulse shaping.

Traffic, broadcast, and ring alert channels use differently encoded quaternary phase shift keyed (DE-QPSK) modulation with 40% square root raised cosine pulse shaping. The burst transmission rate is 25kps or 50 kbps. The phase of the QPSK symbol states relative to the carrier phase is (Symbol State/Phase in deg): 00/0, 01/+90, 11/180.

Test Environment
Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:
Relative humidity of 30 ± 5%
Temperature of 22 ± 2º C

Test Setup
The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuation.

Test Equipment Used

Serial #	*Manufacturer*	*Model*	*Description*	*Last Cal.*
100037	Rohde & Schwarz	ESIB26	EMI Test Receiver	1/20/2015
BG1808	Weinschel	48-30-43	30dB Attenuator	CNR

Test Results
Time and frequency domain plots have been provided to have been provided to support the manufacturer's stated modulation characteristics.

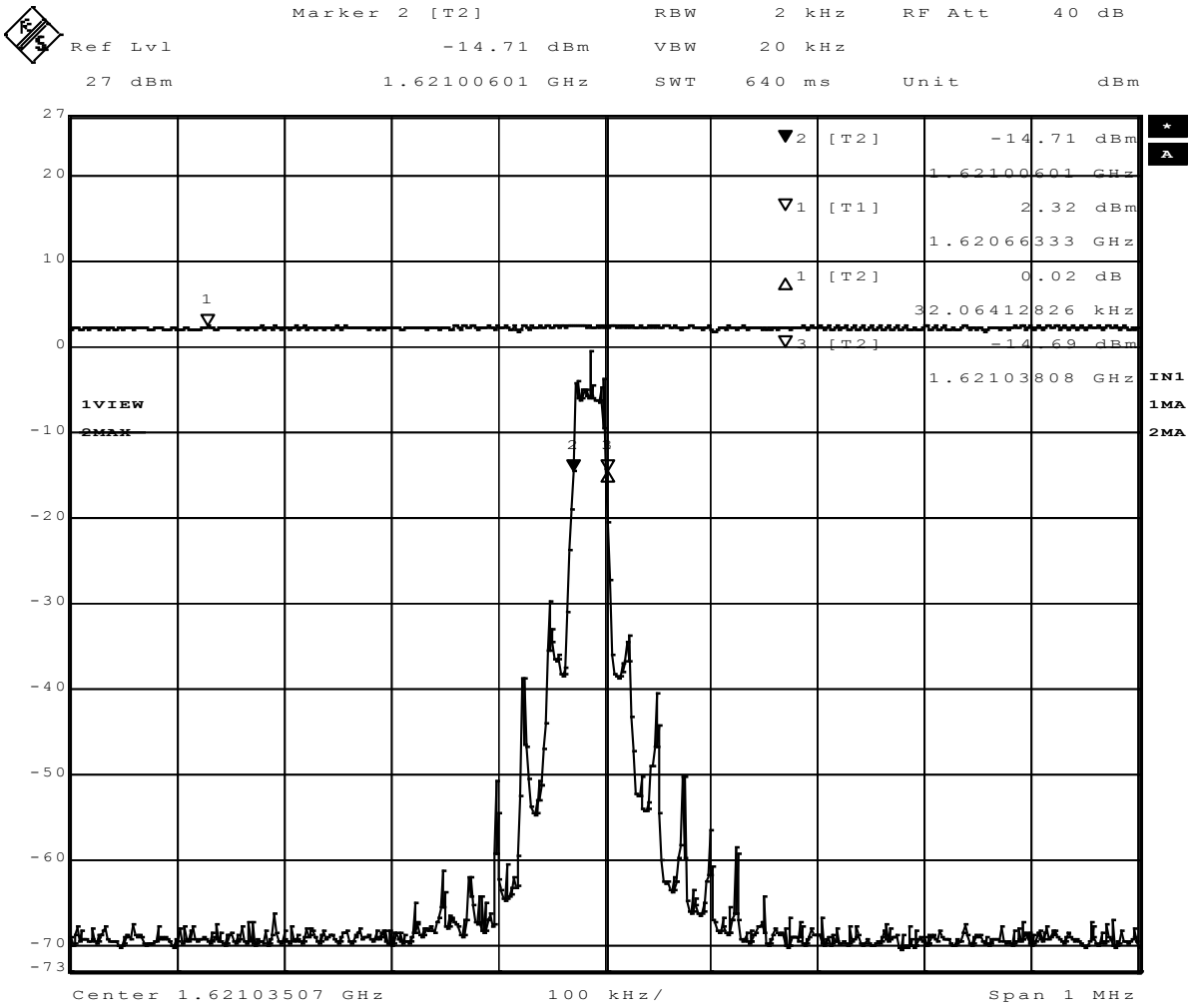

Figure 19 -, 99% Modulation Characteristics, 1621.0208033 MHz

Annex A – Sample Field Strength Calculation

Radiated Emissions

The field strength is calculated in decibels (dB) by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = R + AF – (-CF + AG)

where FS = Field Strength

R = Receiver Amplitude Receiver reading in dBμV

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Preamplifier Amplifier Gain

Assume a receiver reading of 55.00 dBμV is obtained. The Antenna Factor of 12.00 and a Cable Factor of 1.10 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.10 dBμV/m.

FS = 55.00 + 12.00 – (-1.10 + 20.00) = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20] = 254.1 μV/m

Conducted Emissions

Receiver readings are compared directly to the conducted emissions limits in decibels (dB) by adding the cable loss and LISN insertion loss to the receiver reading. The basic equations with a sample calculation are as follows;

FS = R + IL – (-CF)

where V = Conducted Emissions Voltage Measurement

R = Receiver reading in dBμV

IL = LISN Insertion Loss

CF = Cable Attenuation Factor

Assume a receiver reading of 52.00 dBμV is obtained. The LISN insertion loss of 0.80 dB and a Cable Factor of 1.10 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

V = 52.00 + 0.80 – (-1.10) = 53.90 dBμV/m

The 53.90 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20] = 495.45 μV/m

*Note: NCEE Labs uses the Rohde and Schwarz ES-K1 software package. In this software, all cable losses are listed as negative. This is why cable loss is subtracting in the preceding equations.

Margin is calculated by taking the limit and subtracting the Field

Annex B – Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value
Emissions limits, radiated	30MHz - 1GHz	±3.82 dB
Emissions limits, radiated	1GHz - 18GHz	±4.44 dB
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB
Power Limits	9kHz – 18GHz	±1.0 dB
Frequency Tolerance	9kHz – 18GHz	±5 Hz

Expanded uncertainty values are calculated to a confidence level of 95%.