The Nebraska Center for Excellence in Electronics
4740 Discovery Drive
Lincoln, NE 68521
Phone: 402.323.6233
Fax: 402.323.6238
www.nceelabs.com

Amended

FCC/IC Test Report

Includes NCEE Labs report R20160216-29-02

Client: **Communications Systems Solutions**
6030 S. 58th St. STE C
Lincoln, NE 68516

Product: **Gateway, M/N QAGGW1000**

Test Report No: **R20160216-29-02A**

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **6 January 2017**

Total Pages: **54**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Tables of Figures
Table of Tables

Table of Figures

Figure **Page**

Table of Tables

Table **Page**

1.0 Summary of test results

1.1 Test Results

The EUT has been tested according to the following specifications:

APPLIED STANDARDS: FCC Part 15, Subpart C Industry Canada RSS-Gen Issue 4, RSS-247 Issue 1			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC Part 15.203 RSS-Gen Issue 4, Section 8.3	Unique Antenna Requirement	Pass	Meets the requirement
FCC Part 15.207 RSS-Gen Issue 4, Section 8.8	Conducted Emissions	Complies	Meets the requirement
FCC Part 15.209 RSS-Gen Issue 4, Section 8.9 ANSI C63.10, Section 6.5, 6.6	Radiated Emissions	Pass	Meets the requirement
FCC Part 15.247(a)(1) RSS-247 Issue 1 Section 5.2.1 ANSI C63.10, Section 11.8.1	Minimum Bandwidth,	Pass	Meets the requirement
FCC Part 15.247(b), RSS-247 Issue 1 Section 5.4.2 ANSI C63.10, Section 11.9.1.1	Maximum Peak Output Power,	Pass	Meets the requirement
FCC Part 15.247(c) RSS-247 Issue 1 Section 5.5 ANSI C63.10, Section 6.5, 6.6	Transmitter Radiated Emissions,	Pass	Meets the requirement
FCC Part 15.247(c) RSS-247 Issue 1 Section 5.5 ANSI C63.10, Section 6.10.6.2, 11.11, 11.12, 11.13	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement
FCC Part 15.247(a), RSS-247 Issue 1 Section 5.2.2 ANSI C63.10, Section 11.10.2	Power Spectral Density	Pass	Meets the requirement

1.2 Reason for amendment – Section 4.5.1 was modified to state the correct frequency band. Section 4.2.2)g) was modified to state that all 3 orthogonal axis were tested. A note was added below measurement plots to indicate detector used.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was a wireless gateway which is intended to communicate with numerous remote ear tags placed on cattle.

EUT Received Date: 12 May 2016
EUT Tested Dates: 13 May 2016 – 29 June 2016

PRODUCT	Gateway
MODEL NUMBER	QAGGW1000
SERIAL NUMBER	09015002
POWER SUPPLY	120 VAC / 60 Hz
ANTENNA TYPE	Antenna 1: Type: Monopole Manufacturer: Laird M/N FG9026 Antenna 2: Type: Panel Manufacturer: L-Com M/N: HG913HSP-120

NOTE:
1. For more detailed features description, please refer to the manufacturer's specifications or User's Manual.

2.2 Laboratory description

All testing was performed at the NCEE Lincoln facility. Laboratory environmental conditions varied slightly throughout the tests:

Relative humidity of 52 ± 4%
Temperature of 23 ± 3° Celsius

2.3 Description of test modes

The EUT operates on, and was tested at the lowest possible operating frequency, the highest and one in the middle. It was set to transmit continuously.

2.4 Applied standards and regulations

The EUT uses digital modulation and operates in the 902 MHz to 928 MHz band. According to the specifications of the manufacturer, it must comply with the requirements of the following standards and regulations:

1. **ANSI C63.10:2013**
2. **FCC Part 15, Subpart C (15.247)**
3. **FCC Part 15, Subpart C (15.207 and 15.209)**
4. **Industry Canada RSS-Gen Issue 4**
5. **Industry Canada RSS-247 Issue 1**

All test items have been performed and recorded as per the above.

2.5 Description of support units

None

2.6 Configuration of system under test

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on Low, Mid and High Channels.

3.0 Test equipment used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	08 Feb 2016	08 Feb 2017
EMCO Biconilog Antenna	3142B	1647	23 Jun 2015	23 Jun 2016
EMCO Horn Antenna*	3115	6416	25 Jan 2016	25 Jan 2018
EMCO Horn Antenna****	3116	2576	26 Jan 2016	26 Jan 2018
Rohde & Schwarz Preamplifier**	TS-PR18	3545700803	14 Dec 2015*	14 Dec 2016*
Trilithic High Pass Filter****	6HC330	23042	14 Dec 2015*	14 Dec 2016*
Rohde & Schwarz LISN	ESH3-Z5	100023	27 Jan 2016	27 Jan 2017
Mini Circuits 1700 – 5000Mhz High Pass Filter***	15542	31618	16 June 2016*	16 June 2017*

All radiated emissions testing was performed between June 1 and June 23, 2016
All other tests were performed between May 13 and June 29, 2016

*Internal Characterization
**Used for radiated measurements above 1GHz
***Used for measurements from 1 GHz - 6GHz
****Used for measurements above 6GHz
*****Used for measurements above 18GHz

4.0 Detailed results

4.1 Unique antenna requirement

4.1.1 Standard applicable

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

4.1.2 Antenna description

The antenna is external to the EUT and it has reverse polarity connectors on it.

4.2 Radiated emissions

4.2.1 Limits for radiated emissions measurements

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (μV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on peak detector values with duty cycle correction, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

4.2.2 Test procedures

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was measured in both the horizontal and vertical orientation rotated 360 degrees in each orientation so that all three orthogonal planes were measured. It was found that the vertical position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, The video bandwidth was 1MHz for peak measurements and 10Hz for average measurements. A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

4.2.3 Deviations from test standard

No deviation.

4.2.4 Test setup

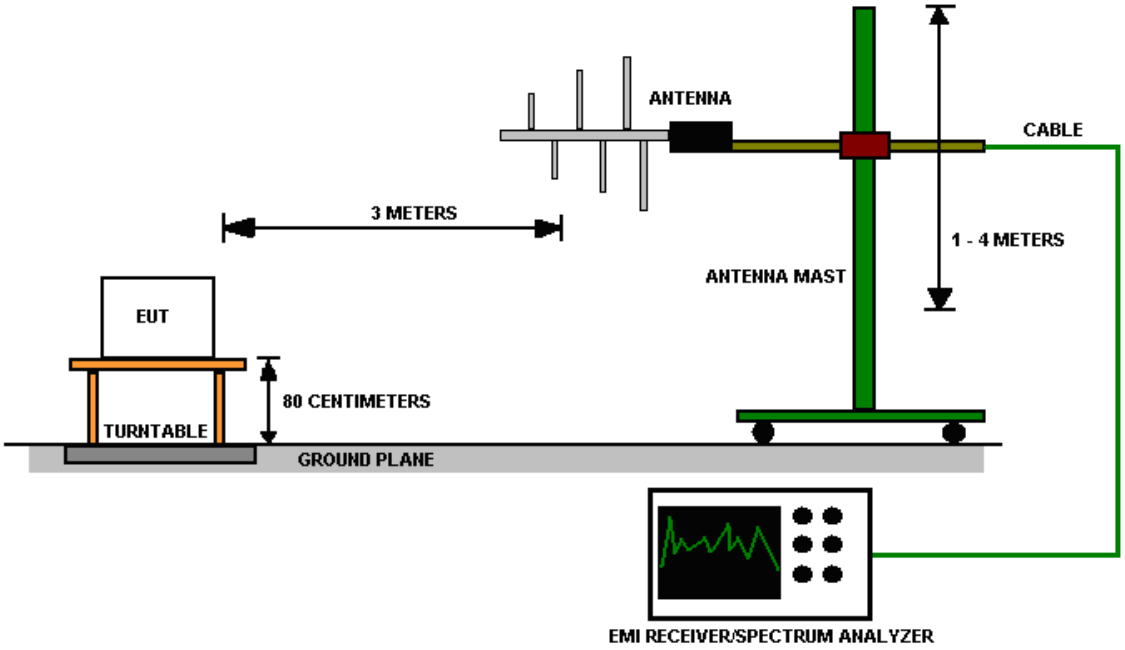


Figure 1 - Radiated Emissions Test Setup

For the actual test configuration, please refer to Appendix A for photographs of the test configuration.

4.2.5 EUT operating conditions

The EUT was powered by 120 VAC 60 Hz unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

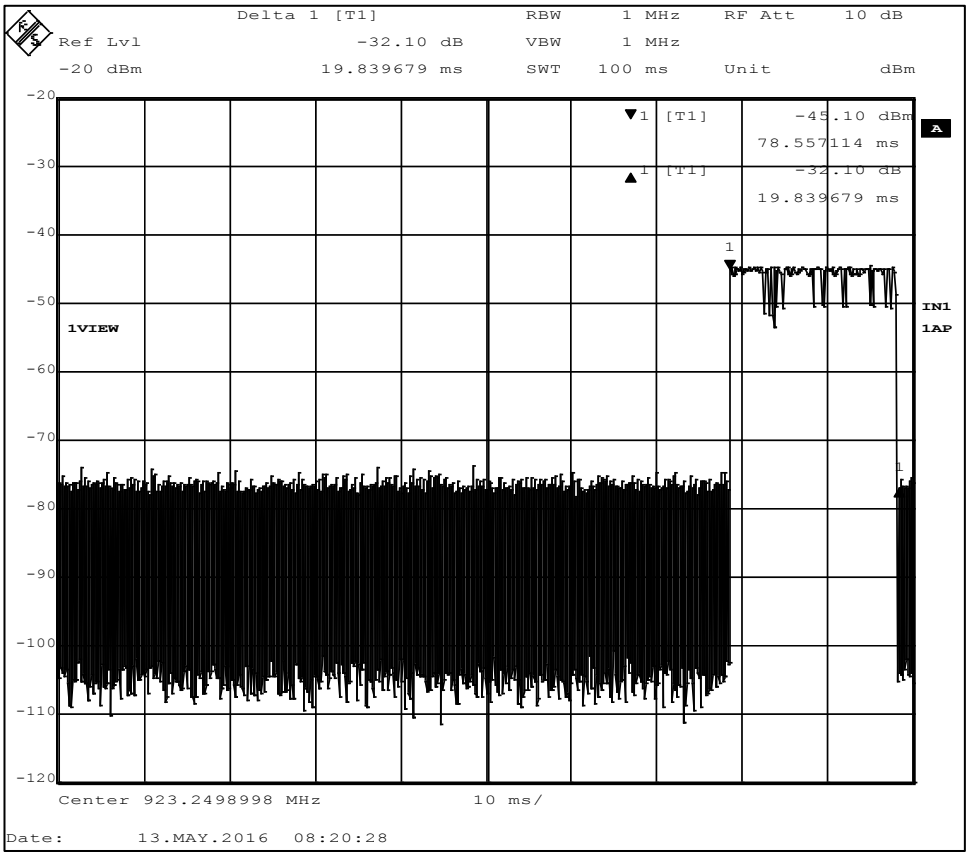


Figure 2 –ON Time

19.84 seconds

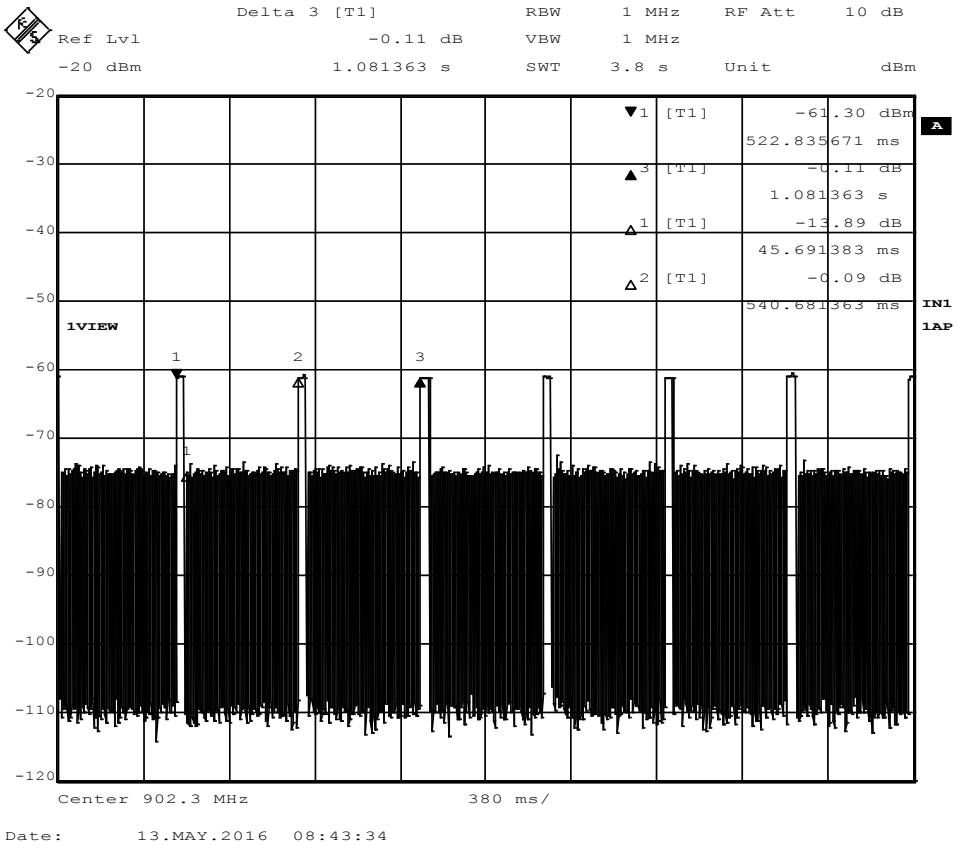


Figure 3 –Period
540.68 ms

Transmit time per period = 19.84 ms (delta marker in Figure 2)
Period time = 100 ms (Maximum usable, actual = 540.68 ms in Figure 3)
Duty cycle = Transmit time / period = 19.84 / 100 = 0.1983
Averaging factor = 20 × log(duty cycle) = 20 × log(0.1984) = -14.05

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle above.

4.2.6 Test results

EUT MODULE	Gateway	MODE	Receive, Antenna 1
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

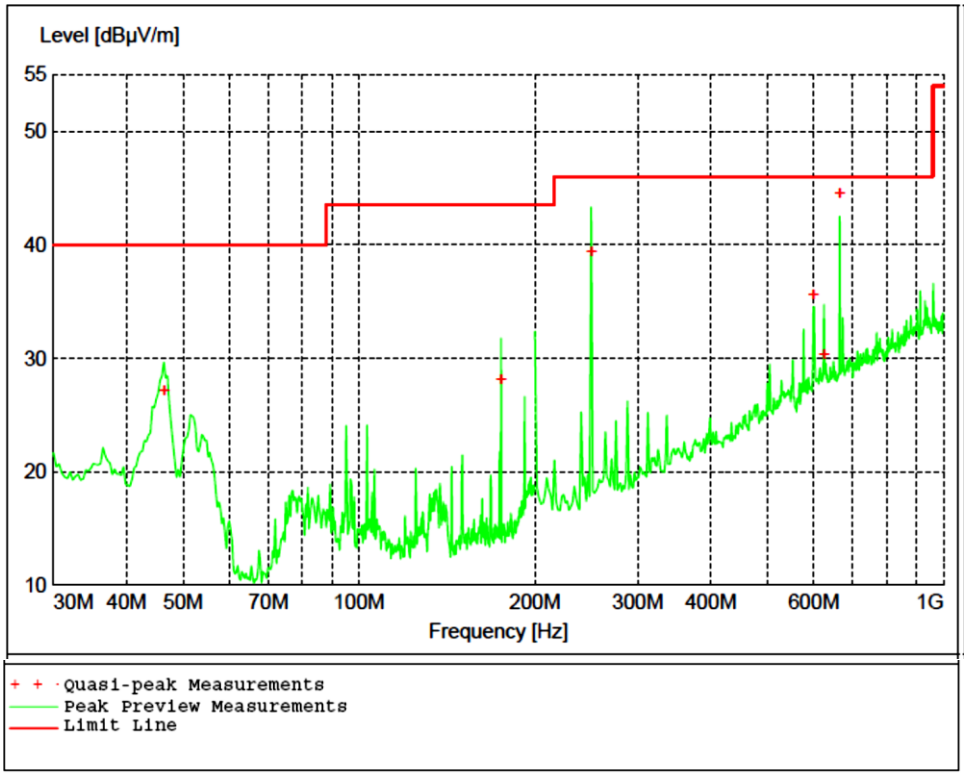


Figure 4 - Radiated Emissions Plot, Receive, Antenna 1

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive, Antenna 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
46.500000	27.08	40.00	12.90	100	67	VERT
175.020000	28.14	43.50	15.40	186	288	HORI
250.020000	39.34	46.00	6.70	100	324	VERT
599.640000	35.59	46.00	10.40	126	89	HORI
625.080000	30.27	46.00	15.70	112	92	HORI
664.980000	44.57	46.00	1.40	119	236	HORI

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 2 - Radiated Emissions Peak Measurements, Receive, Antenna 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1463.000000	43.76	54.00	10.20	123	332	VERT
1852.400000	36.25	54.00	17.70	336	55	VERT
2778.400000	38.01	54.00	16.00	396	360	VERT
3715.200000	40.32	54.00	13.70	100	142	VERT
4628.800000	41.31	54.00	12.70	397	243	VERT
5545.800000	43.01	54.00	11.00	134	356	HORI

Note: peak measurements are compliant with the average limit, so average measurements are not required.

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

EUT MODULE	Gateway	MODE	Transmit, Channel1, Antenna 1
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

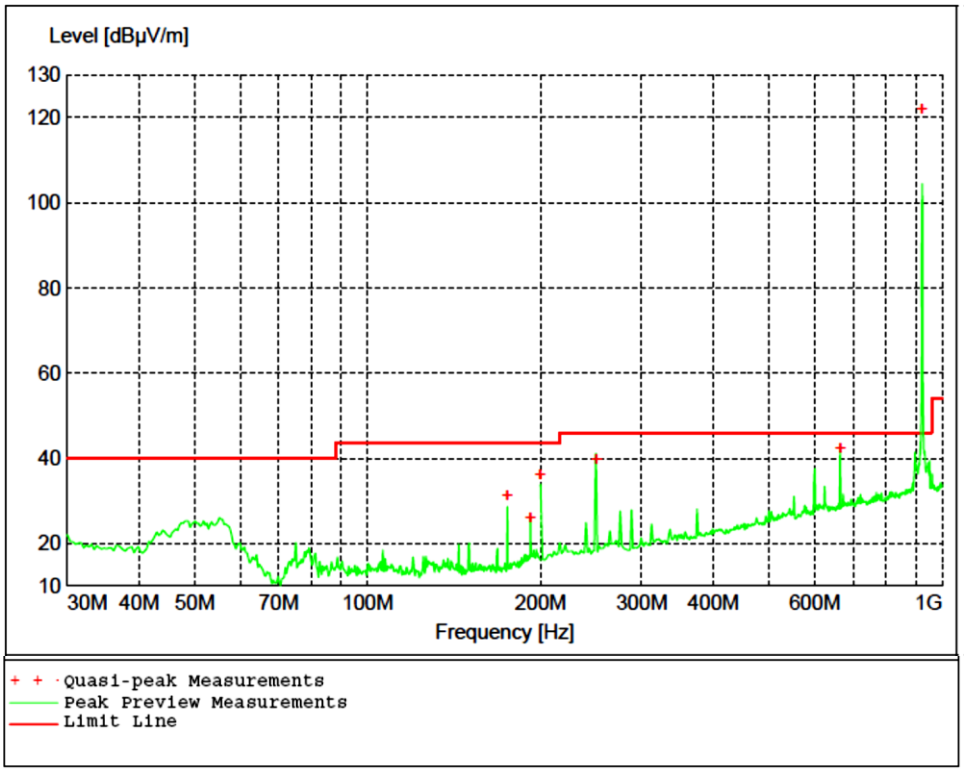


Figure 5 - Radiated Emissions Plot, Channel 1

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 3 - Radiated Emissions Quasi-peak Measurements, Antenna 1, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
175.140000	31.15	43.50	12.40	102	346	VERT
192.000000	25.87	43.50	17.60	104	354	VERT
199.860000	36.02	43.50	7.50	100	360	VERT
250.010000	39.81	46.00	6.20	193	228	HORI
664.980000	42.22	46.00	3.80	100	360	VERT
923.300000	121.84	NA	NA	131	6	VERT

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 4 - Radiated Emissions Average Measurements, Antenna 1, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1846.400000	50.75	54.00	3.25	183	317	VERT
2770.000000	38.27	54.00	15.73	160	209	VERT
3693.200000	36.13	54.00	17.87	100	263	VERT
4616.000000	31.78	54.00	22.22	101	354	HORI
5538.800000	32.58	54.00	21.42	204	150	VERT
6463.000000	38.25	54.00	15.75	99	346	VERT
7386.400000	39.06	54.00	14.94	183	109	VERT
8310.000000	38.52	54.00	15.48	186	93	VERT
9234.200000	39.15	54.00	14.85	183	31	VERT

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle in Figure 2.

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 5 - Radiated Emissions Peak Measurements, Antenna 1, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1846.400000	64.80	74.00	9.20	183	317	VERT
2770.000000	52.32	74.00	21.68	160	209	VERT
3693.200000	50.18	74.00	23.82	100	263	VERT
4616.000000	45.83	74.00	28.17	101	354	HORI
5538.800000	46.63	74.00	27.37	204	150	VERT
6463.000000	52.30	74.00	21.70	99	346	VERT
7386.400000	53.11	74.00	20.89	183	109	VERT
8310.000000	52.57	74.00	21.43	186	93	VERT
9234.200000	53.20	74.00	20.80	183	31	VERT

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

EUT MODULE	Gateway	MODE	Transmit, Channel 2, Antenna 1
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

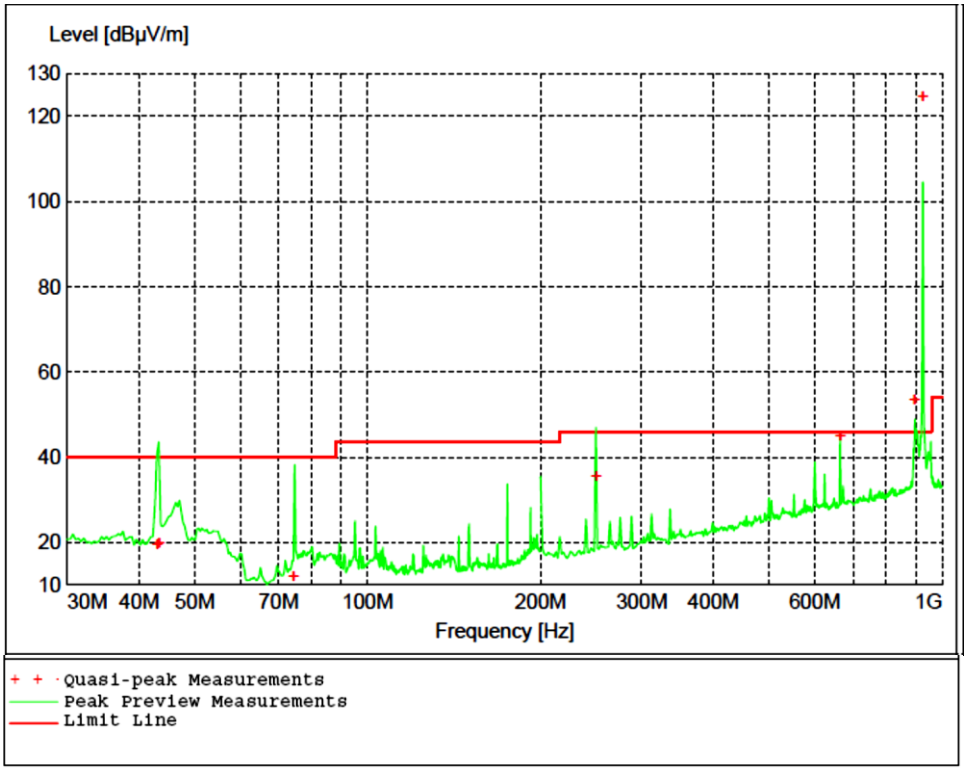


Figure 6 - Radiated Emissions Plot, Channel 2

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 6 - Radiated Emissions Quasi-peak Measurements, Antenna 1, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.020000	19.55	40.00	20.50	99	112	VERT
43.380000	19.85	40.00	20.10	101	360	VERT
74.340000	11.86	40.00	28.10	161	102	VERT
250.080000	35.29	46.00	10.70	99	268	HORI
664.980000	44.95	46.00	1.00	119	133	HORI
895.980000	53.32	NA	NA	109	223	VERT
925.620000	124.56	NA	NA	117	132	VERT

Table 7 - Radiated Emissions Average Measurements, Antenna 1, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1851.200000	50.05	54.00	3.95	142	10	VERT
2776.600000	33.07	54.00	20.93	100	243	VERT
3702.600000	35.24	54.00	18.76	100	56	VERT
4628.000000	31.32	54.00	22.68	99	360	VERT
5544.600000	30.12	54.00	23.88	350	65	HORI
6479.200000	36.14	54.00	17.86	194	175	VERT
7404.800000	34.49	54.00	19.51	101	322	VERT
8330.000000	37.38	54.00	16.62	200	282	VERT
9254.000000	39.93	54.00	14.07	151	306	VERT

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle in Figure 2.

Table 8 - Radiated Emissions Peak Measurements, Antenna 1, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1851.200000	64.10	74.00	9.90	142	10	VERT
2776.600000	47.12	74.00	26.88	100	243	VERT
3702.600000	49.29	74.00	24.71	100	56	VERT
4628.000000	45.37	74.00	28.63	99	360	VERT
5544.600000	44.17	74.00	29.83	350	65	HORI
6479.200000	50.19	74.00	23.81	194	175	VERT
7404.800000	48.54	74.00	25.46	101	322	VERT
8330.000000	51.43	74.00	22.57	200	282	VERT
9254.000000	53.98	74.00	20.02	151	306	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

EUT MODULE	Gateway	MODE	Transmit, Channel 3, Antenna 1
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

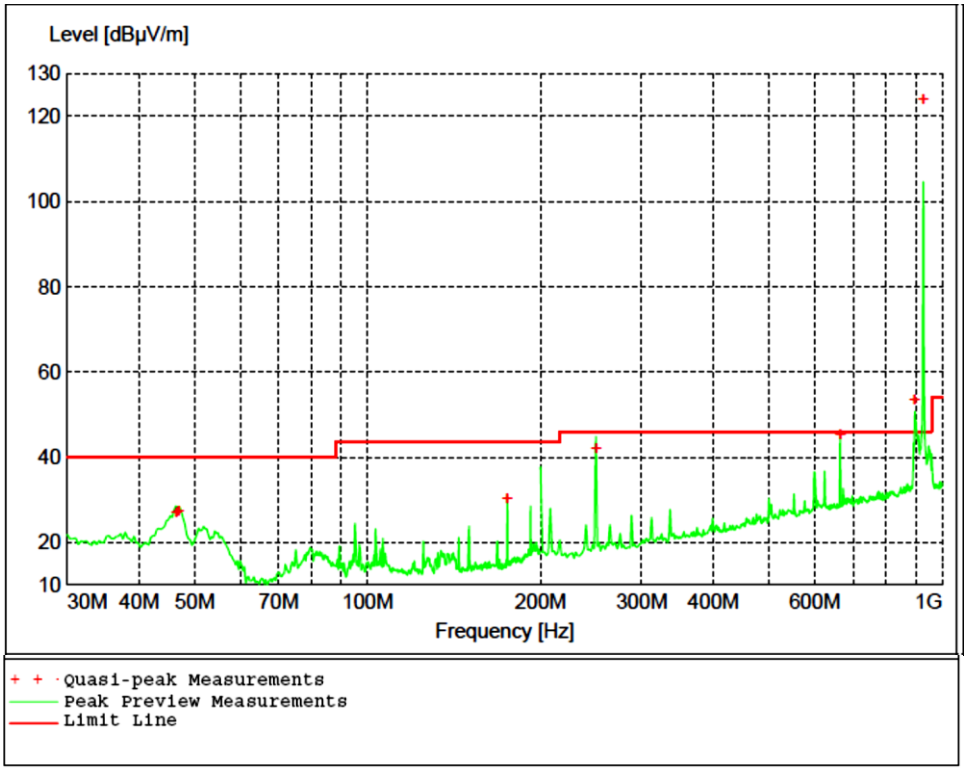


Figure 7 - Radiated Emissions Plot, Channel 3

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 9 - Radiated Emissions Quasi-peak Measurements, Antenna 1, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
46.500000	26.87	40.00	13.10	99	73	VERT
46.920000	27.16	40.00	12.80	98	74	VERT
175.020000	30.15	43.50	13.40	101	71	VERT
250.020000	41.87	46.00	4.10	193	148	VERT
664.980000	45.20	46.00	0.80	122	131	HORI
895.980000	53.29	103.87*	50.58	106	223	VERT
927.540000	123.87	NA	NA	117	132	VERT

*Unrestricted band. Required to be 20dB below fundamental

Table 10 - Radiated Emissions Average Measurements, Antenna 1, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1855.000000	49.25	54.00	4.75	200	9	VERT
2782.200000	31.68	54.00	22.32	100	245	VERT
3710.000000	35.54	54.00	18.46	183	163	VERT
4637.400000	31.00	54.00	23.00	111	187	HORI
5565.800000	30.96	54.00	23.04	252	65	VERT
6493.000000	31.48	54.00	22.52	168	263	VERT
7420.000000	36.40	54.00	17.60	100	319	VERT
8349.400000	34.29	54.00	19.71	236	270	VERT
9276.400000	36.86	54.00	17.14	204	187	VERT

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle in Figure 2.

Table 11 - Radiated Emissions Peak Measurements, Antenna 1, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1855.000000	63.30	74.00	10.70	200	9	VERT
2782.200000	45.73	74.00	28.27	100	245	VERT
3710.000000	49.59	74.00	24.41	183	163	VERT
4637.400000	45.05	74.00	28.95	111	187	HORI
5565.800000	45.01	74.00	28.99	252	65	VERT
6493.000000	45.53	74.00	28.47	168	263	VERT
7420.000000	50.45	74.00	23.55	100	319	VERT
8349.400000	48.34	74.00	25.66	236	270	VERT
9276.400000	50.91	74.00	23.09	204	187	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

EUT MODULE	Gateway	MODE	Receive, Antenna 2
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

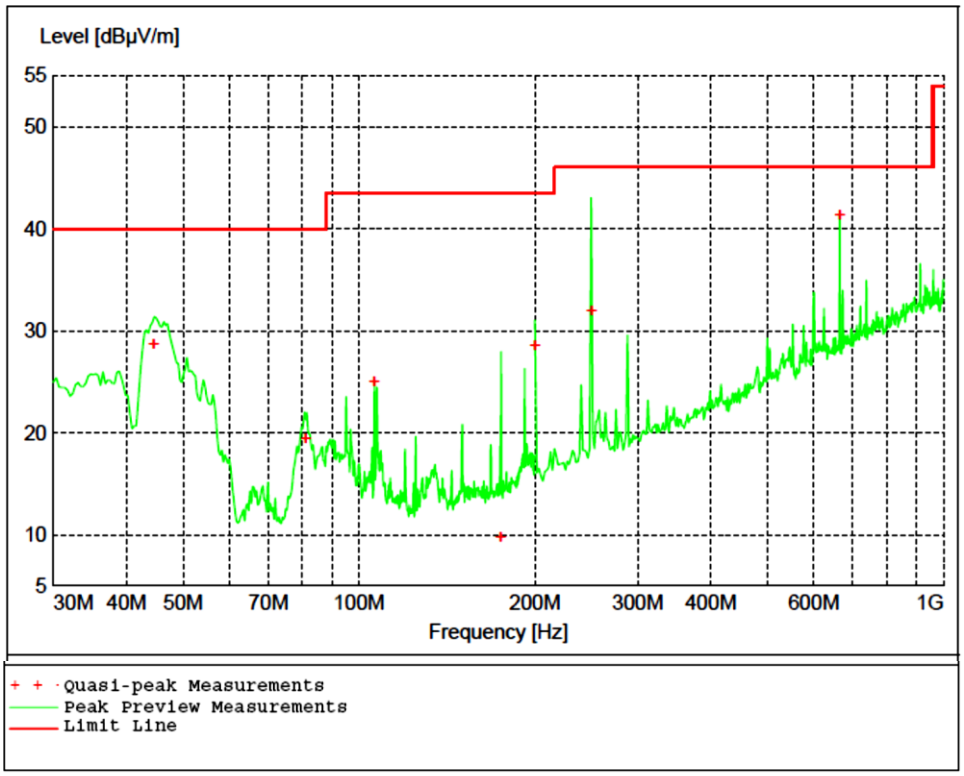


Figure 8 - Radiated Emissions Plot, Receive, Antenna 2

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 12 - Radiated Emissions Quasi-peak Measurements, Receive, Antenna 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
44.520000	28.66	40.00	11.30	100	99	VERT
81.120000	19.42	40.00	20.60	100	112	VERT
106.320000	25.01	43.50	18.50	100	17	VERT
174.840000	9.74	43.50	33.80	180	185	VERT
199.980000	28.49	43.50	15.00	148	111	HORI
250.080000	31.93	46.00	14.10	100	355	VERT
664.980000	41.24	46.00	4.80	100	218	VERT

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 13 - Radiated Emissions Peak Measurements, Receive, Antenna 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1849.400000	35.54	54.00	18.50	99	165	VERT
2768.800000	37.42	54.00	16.60	100	155	VERT
3718.000000	40.47	54.00	13.50	399	359	VERT
4621.000000	41.02	54.00	13.00	400	239	VERT
5555.400000	43.12	54.00	10.90	138	236	VERT

Note: peak measurements are compliant with the average limit, so average measurements are not required.

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

EUT MODULE	Gateway	MODE	Transmit, Channel1, Antenna 2
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

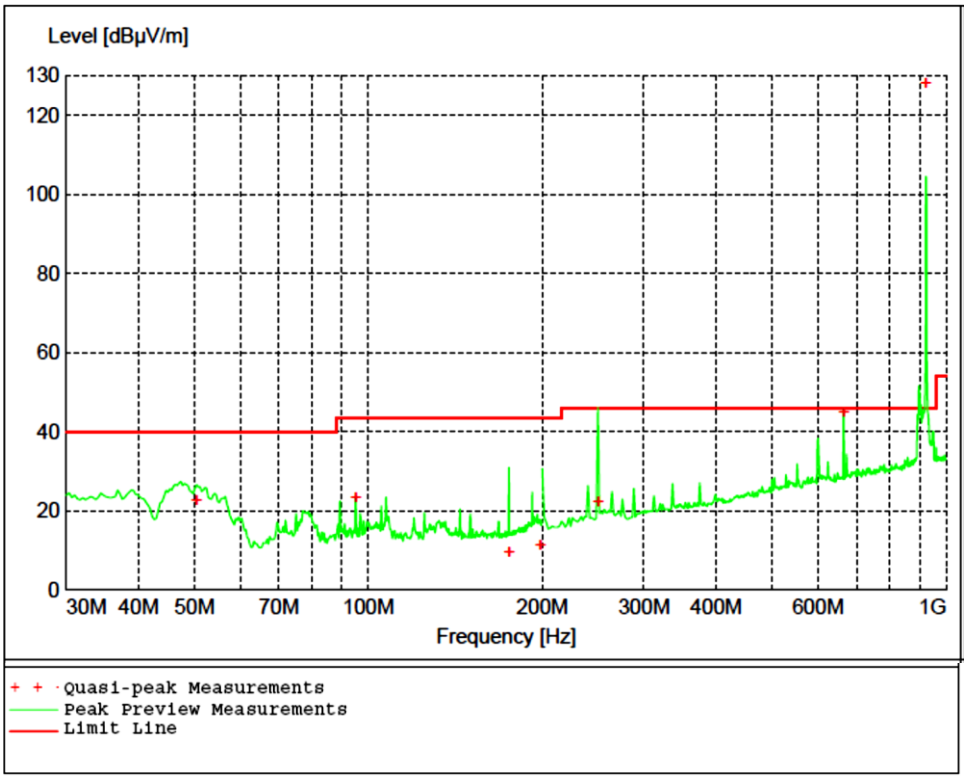


Figure 9 - Radiated Emissions Plot, Antenna 2, Channel 1

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 14 - Radiated Emissions Quasi-peak Measurements, Antenna 2, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
50.460000	22.77	40.00	17.20	100	273	VERT
95.100000	23.42	43.50	20.10	100	107	VERT
175.320000	9.44	43.50	34.10	400	267	HORI
198.600000	11.34	43.50	32.20	143	138	HORI
250.200000	22.15	46.00	23.90	100	2	HORI
664.980000	44.85	46.00	1.20	100	97	HORI
923.300000	127.99	46.00	-82.00	153	216	HORI

Table 15 - Radiated Emissions Average Measurements, Antenna 2, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1846.600000	46.64	54.00	7.36	160	46	VERT
2770.000000	28.31	54.00	25.69	100	230	HORI
3692.800000	37.26	54.00	16.74	173	322	VERT
4616.200000	35.13	54.00	18.87	197	223	VERT
5539.200000	31.93	54.00	22.07	237	267	HORI
6462.200000	31.42	54.00	22.58	100	329	VERT
7387.600000	38.40	54.00	15.60	206	355	VERT
8309.400000	35.82	54.00	18.18	220	157	HORI
9233.200000	40.06	54.00	13.94	115	100	VERT

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle in Figure 2.

Table 16 - Radiated Emissions Peak Measurements, Antenna 2, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1846.600000	60.69	74.00	13.31	160	46	VERT
2770.000000	42.36	74.00	31.64	100	230	HORI
3692.800000	51.31	74.00	22.69	173	322	VERT
4616.200000	49.18	74.00	24.82	197	223	VERT
5539.200000	45.98	74.00	28.02	237	267	HORI
6462.200000	45.47	74.00	28.53	100	329	VERT
7387.600000	52.45	74.00	21.55	206	355	VERT
8309.400000	49.87	74.00	24.13	220	157	HORI
9233.200000	54.11	74.00	19.89	115	100	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

EUT MODULE	Gateway	MODE	Transmit, Channel2, Antenna 2
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

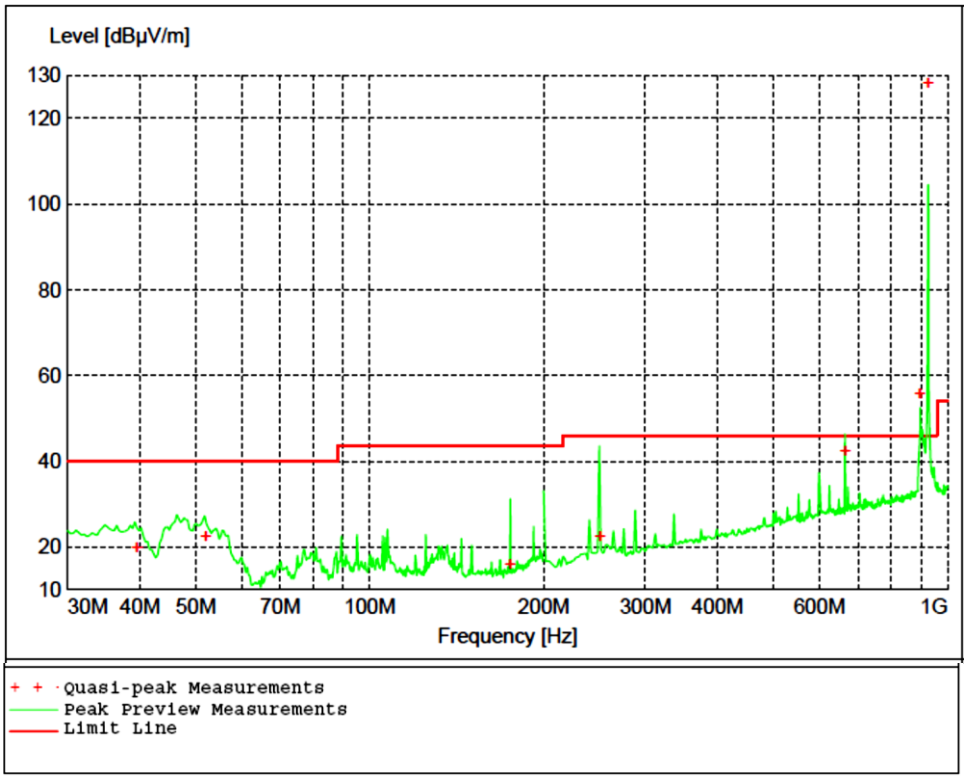


Figure 10 - Radiated Emissions Plot, Channel 2

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 17 - Radiated Emissions Quasi-peak Measurements, Antenna 2, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
39.540000	19.90	40.00	20.10	101	112	VERT
52.080000	22.30	40.00	17.70	99	336	VERT
175.080000	15.74	43.50	27.80	149	170	HORI
250.320000	22.45	46.00	23.60	112	0	VERT
664.980000	42.36	46.00	2.60	100	345	HORI
895.980000	55.69	46.00	-9.70	112	182	HORI
925.620000	128.14	46.00	-82.10	153	211	HORI

Table 18 - Radiated Emissions Average Measurements, Antenna 2, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1851.200000	50.59	54.00	3.41	106	87	HORI
2776.800000	34.61	54.00	19.39	204	211	HORI
3702.200000	34.59	54.00	19.41	173	322	VERT
4628.000000	35.07	54.00	18.93	251	245	HORI
5557.000000	28.92	54.00	25.08	264	317	VERT
6477.800000	30.94	54.00	23.06	100	329	VERT
7404.000000	36.73	54.00	17.27	200	354	VERT
8332.600000	37.88	54.00	16.12	190	89	VERT
9256.800000	38.13	54.00	15.87	206	14	VERT

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle in Figure 2.

Table 19 - Radiated Emissions Peak Measurements, Antenna 2, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1851.200000	64.64	74.00	9.36	106	87	HORI
2776.800000	48.66	74.00	25.34	204	211	HORI
3702.200000	48.64	74.00	25.36	173	322	VERT
4628.000000	49.12	74.00	24.88	251	245	HORI
5557.000000	42.97	74.00	31.03	264	317	VERT
6477.800000	44.99	74.00	29.01	100	329	VERT
7404.000000	50.78	74.00	23.22	200	354	VERT
8332.600000	51.93	74.00	22.07	190	89	VERT
9256.800000	52.18	74.00	21.82	206	14	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

EUT MODULE	Gateway	MODE	Transmit, Channel3, Antenna 2
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

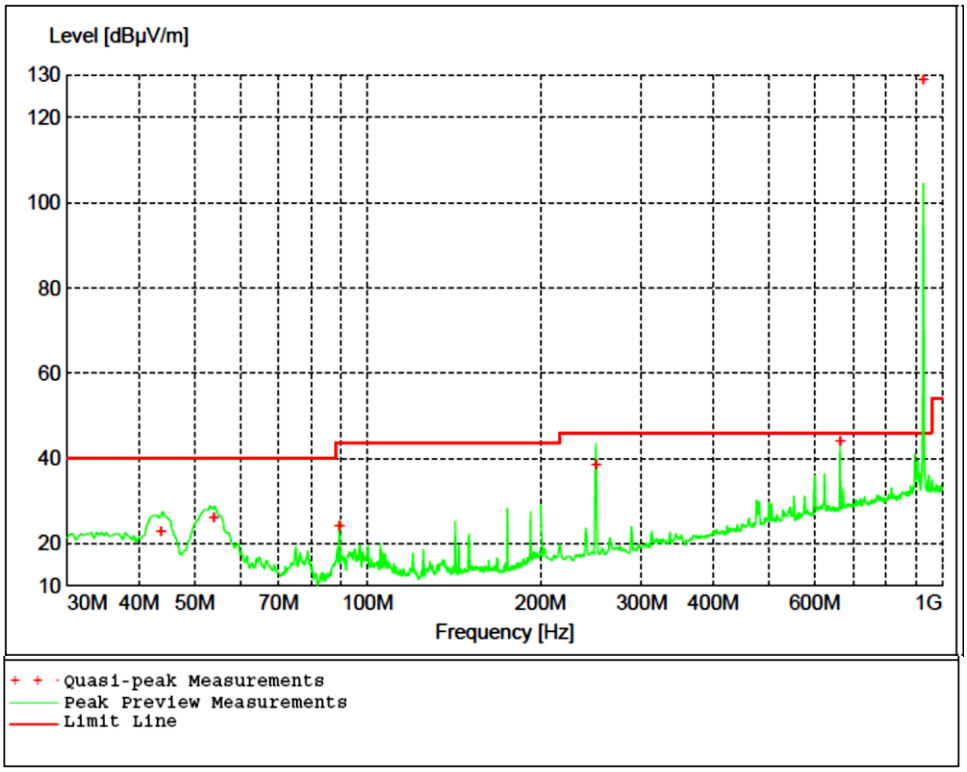


Figure 11 - Radiated Emissions Plot, Antenna 2, Channel 3

In the results of the plot EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 20 - Radiated Emissions Quasi-peak Measurements, Antenna 2, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.680000	22.78	40.00	17.20	100	256	VERT
54.060000	26.07	40.00	13.90	99	273	VERT
89.280000	23.97	43.50	19.50	134	33	VERT
249.960000	38.47	46.00	7.50	213	101	VERT
664.980000	43.88	46.00	2.10	100	0	VERT
927.480000	128.70	46.00	-82.70	176	194	HORI

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 21 - Radiated Emissions Average Measurements, Antenna 2, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1855.200000	49.80	54.00	4.20	194	46	VERT
2782.000000	35.25	54.00	18.75	197	199	HORI
3709.800000	33.27	54.00	20.73	200	53	HORI
4637.400000	38.33	54.00	15.67	206	298	HORI
5565.200000	34.88	54.00	19.12	267	224	HORI
6494.000000	30.97	54.00	23.03	301	19	VERT
7419.800000	33.54	54.00	20.46	190	334	VERT
8345.400000	39.56	54.00	14.44	217	58	VERT
9275.400000	40.33	54.00	13.67	264	355	VERT

Note: Average measurements are calculated by taking the peak measurements and applying the averaging factor based on the measured duty cycle in Figure 2.

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

Table 22 - Radiated Emissions Peak Measurements, Antenna 2, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1855.200000	63.85	74.00	10.15	194	46	VERT
2782.000000	49.30	74.00	24.70	197	199	HORI
3709.800000	47.32	74.00	26.68	200	53	HORI
4637.400000	52.38	74.00	21.62	206	298	HORI
5565.200000	48.93	74.00	25.07	267	224	HORI
6494.000000	45.02	74.00	28.98	301	19	VERT
7419.800000	47.59	74.00	26.41	190	334	VERT
8345.400000	53.61	74.00	20.39	217	58	VERT
9275.400000	54.38	74.00	19.62	264	355	VERT

In the results in the table, the EUT was oriented vertically. Both horizontal and vertical orientations were tested and the vertical position was the worse-case.

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

4.3 Bandwidth

4.3.1 Limits of bandwidth measurements

The 6dB bandwidth of the signal must be greater than 500 kHz

4.3.2 Test procedures

The transmitter output was connected to the spectrum analyzer directly. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW. The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

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.

4.3.3 Deviations from test standard

No deviation.

4.3.4 Test setup

The cable used to go from the spectrum analyzer to the EUT had a loss of 0.25dB. This was not taken into account on the plot below because it is a relative measurement.

4.3.5 EUT operating conditions

The EUT was powered by 120 VAC/60 Hz unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.3.6 Test results

EUT MODULE	Gateway	MODE	Continous Transmit
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	6dB BW (kHz)	6dB Limit Min (kHz)	RESULT
1	923.3	616.2	500.00	PASS
2	925.6	631.3	500.00	PASS
3	927.5	621.2	500.00	PASS

REMARKS:
None

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
1	923.3	851.7
2	925.6	836.7
3	927.5	836.7

REMARKS:
None

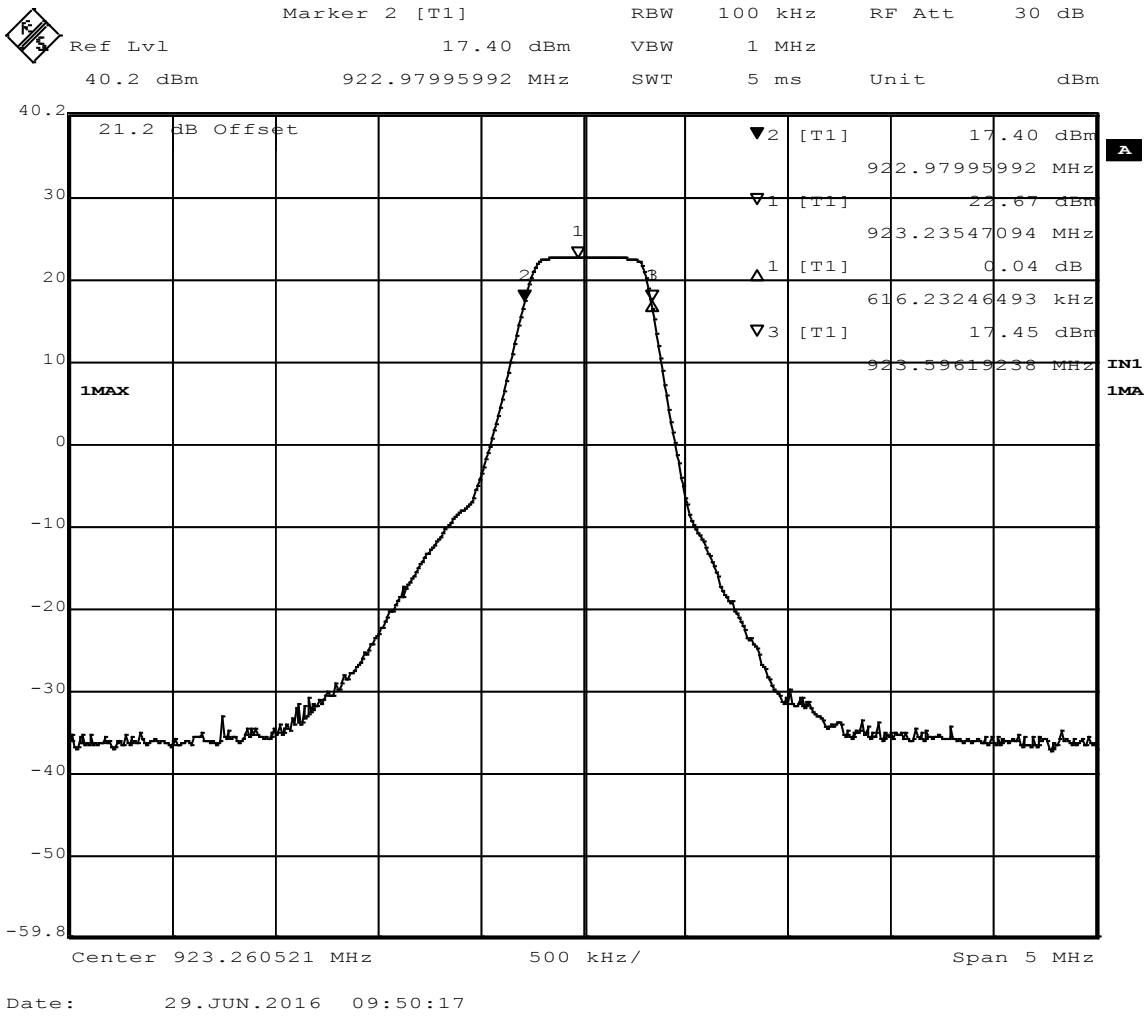


Figure 12 - 6dB Bandwidth, Low Channel

Detector = Max peak, max hold

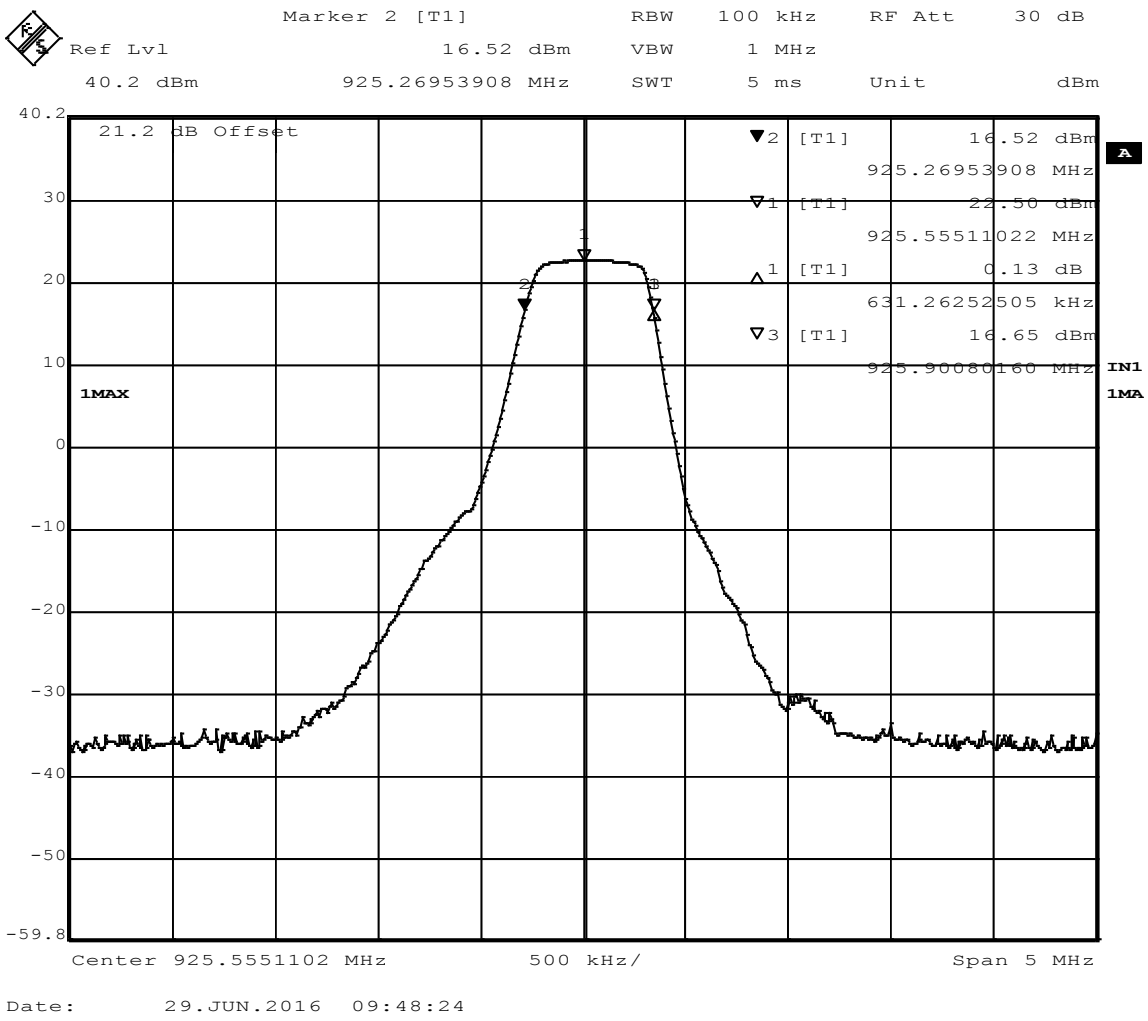


Figure 13 - 6dB Bandwidth, Middle Channel

Detector = Max peak, max hold

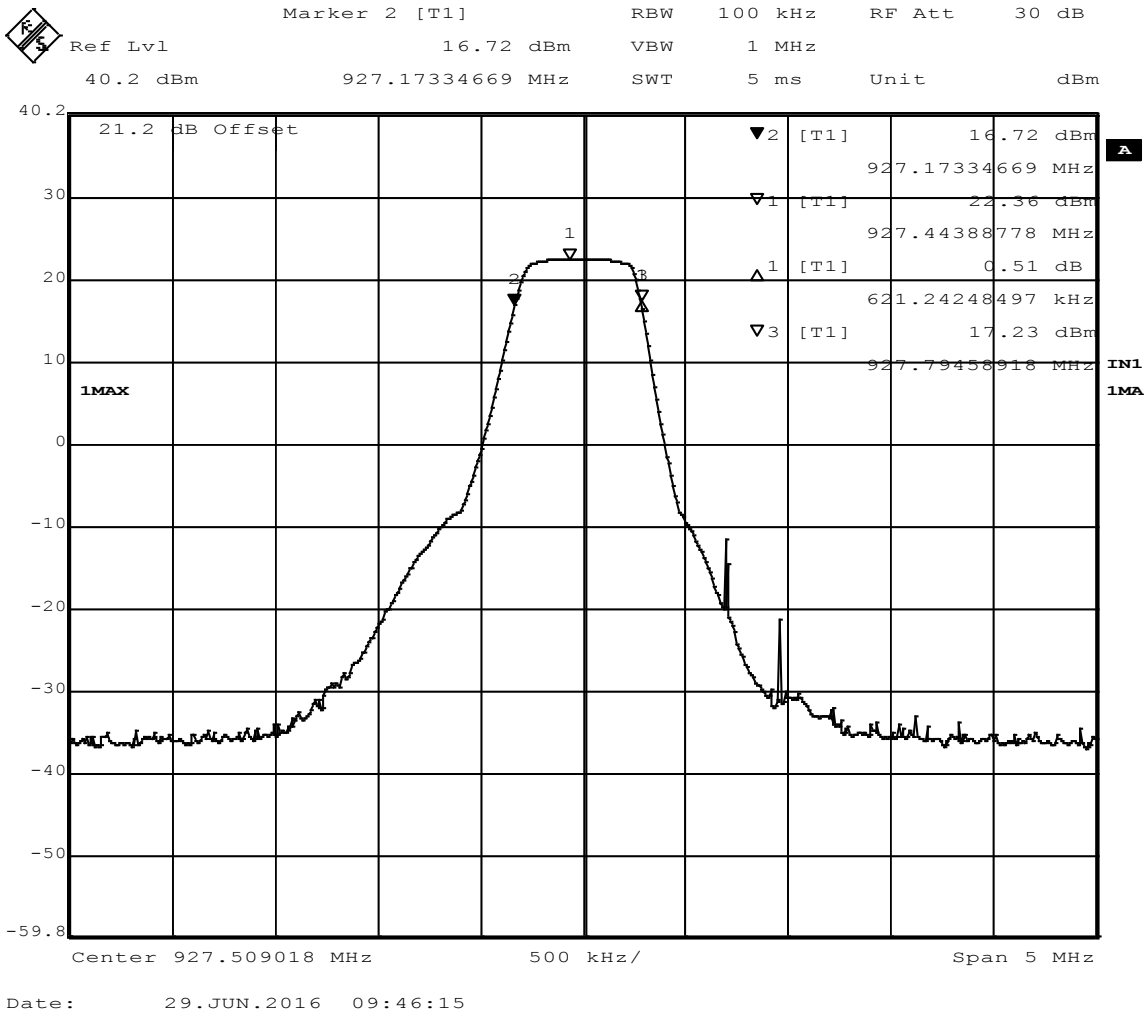


Figure 14 - 6dB Bandwidth, High Channel

Detector = Max peak, max hold

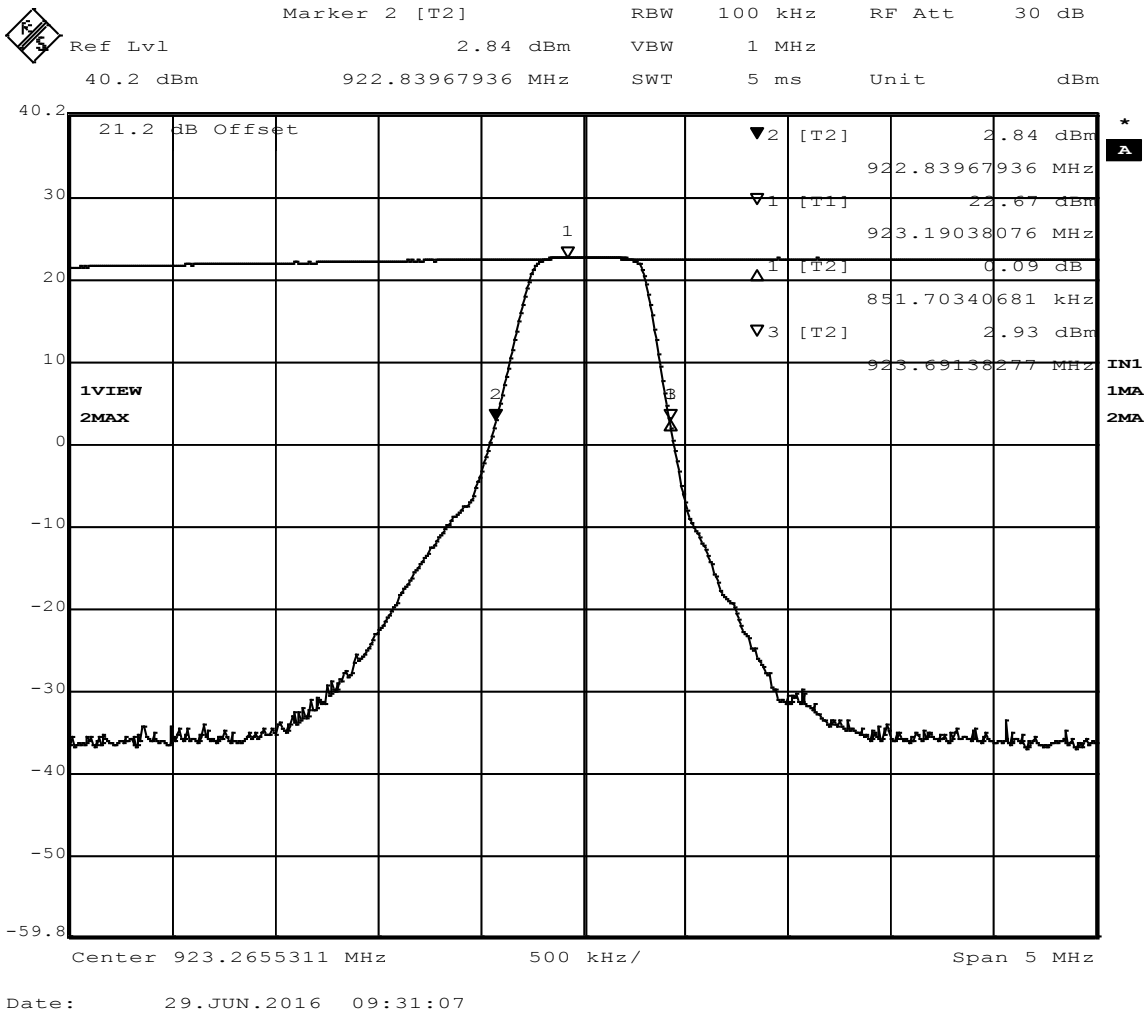


Figure 15 - 99% Occupied Bandwidth, Low Channel

Detector = Max peak, max hold

Note: The upper trace was measured with a 10 MHz RBW and overlaid on the trace showing a 100 kHz RBW. The 99% occupied BW is shown as the points on the 100 kHz trace 20dB below the highest point on the 10 MHz RBW trace.

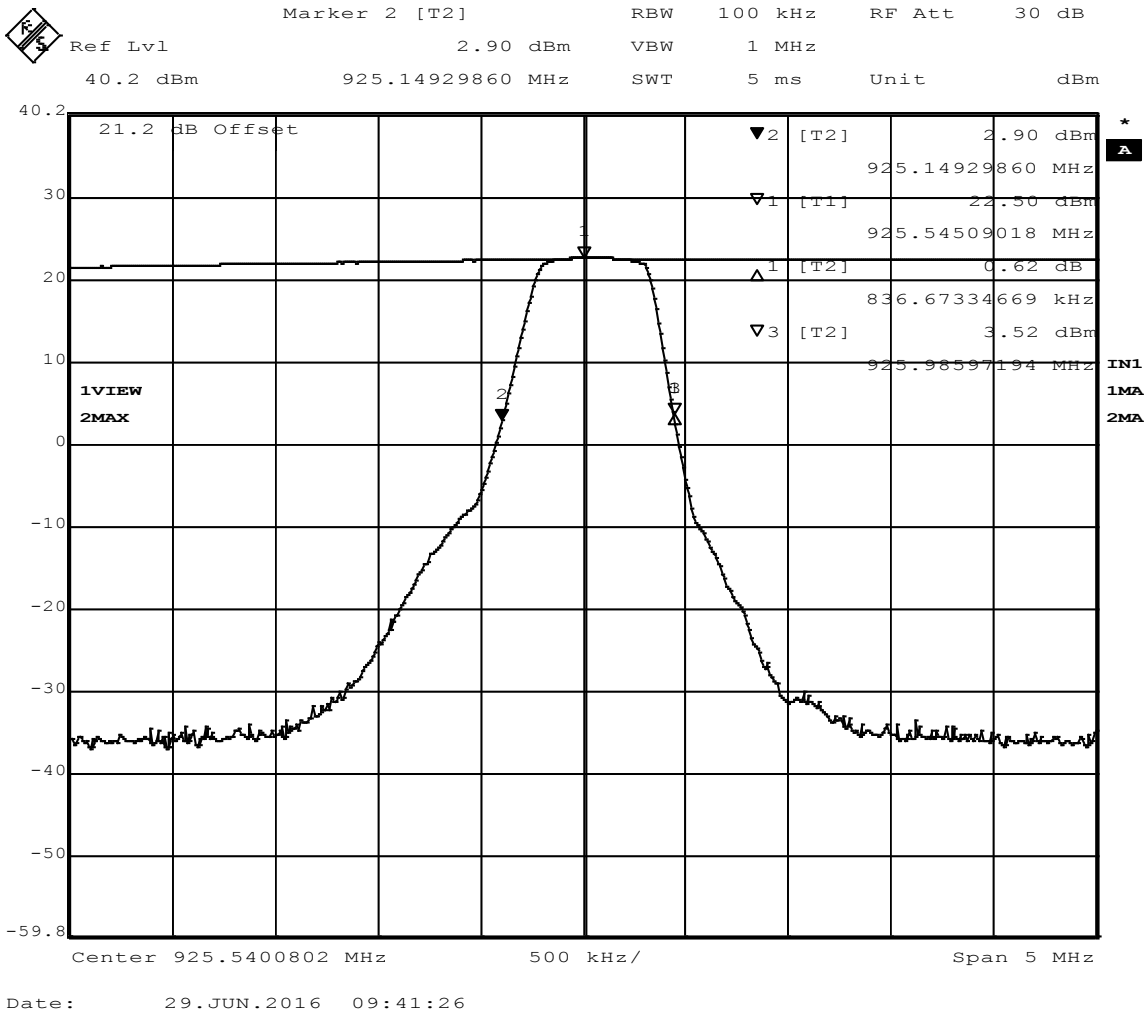


Figure 16 - 99% Occupied Bandwidth, Mid Channel

Detector = Max peak, max hold

Note: The upper trace was measured with a 10 MHz RBW and overlaid on the trace showing a 100 kHz RBW. The 99% occupied BW is shown as the points on the 100 kHz trace 20dB below the highest point on the 10 MHz RBW trace.

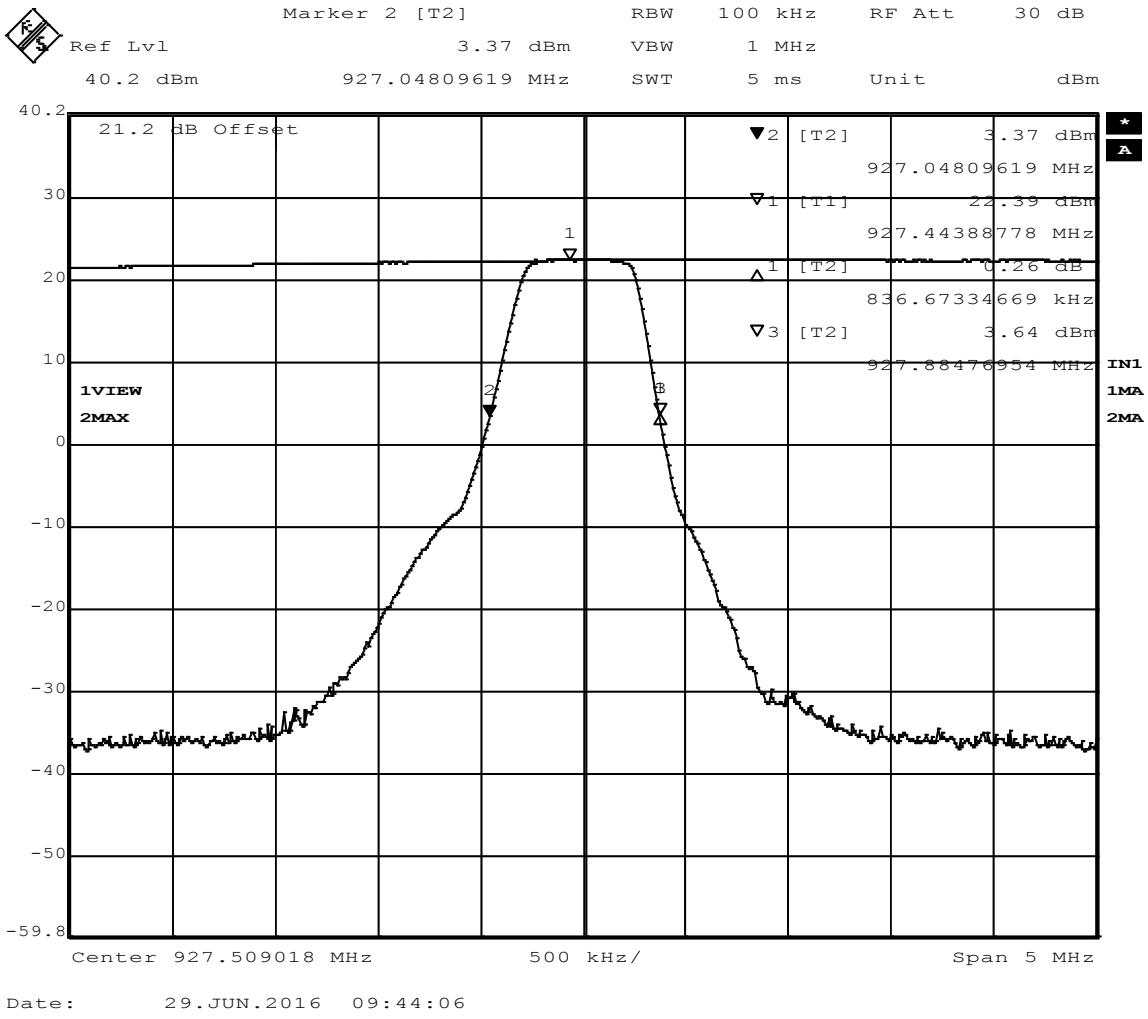


Figure 17 - 99% Occupied Bandwidth, High Channel

Detector = Max peak, max hold

Note: The upper trace was measured with a 10 MHz RBW and overlaid on the trace showing a 100 kHz RBW. The 99% occupied BW is shown as the points on the 100 kHz trace 20dB below the highest point on the 10 MHz RBW trace.

4.4 *Maximum peak output power*

4.4.1 Limits of power measurements

The maximum peak output power allowed is 30dBm.

4.4.2 Test procedures

Test procedure from ANSI C63.10:2013, Section 11.9.1.1.

1. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable.

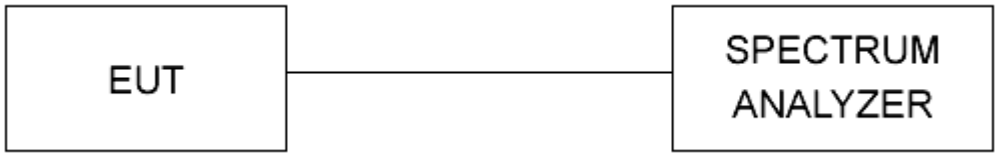
2. The channel power function of the spectrum analyzer was used to calculate the cumulative power output per MHz over the range of the set channel bandwidth. The channel bandwidth was set to 30MHz.

3. The resolution bandwidth was set to 10MHz and the video bandwidth was set to 10MHz to capture the maximum amount of signal. The analyzer used a peak detector in max hold mode. This represented the maximum output power.

4.4.3 Deviations from test standard

No deviation.

4.4.4 Test setup



The cable used to go from the spectrum analyzer to the EUT had a loss of 0.25dB. The plot shows the uncorrected value. The corrected value was recorded from this plot with 0.25dB added.

4.4.5 EUT operating conditions

See Section 2.6

4.4.5 EUT operating conditions

The EUT was powered by 120 VAC/60 Hz unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.4.6 Test results

EUT MODULE	Gateway	MODE	Continuous Transmit
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Maximum peak output power

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	PEAK POWER LIMIT (dBm)	RESULT
1	923.30	22.67	23.00*	PASS
2	925.60	22.50	23.00*	PASS
3	927.50	22.39	23.00*	PASS

All measurements were taken from the 99% occupied bandwidth screen captures in Section 4.3.

*Note: the EUT can be sold with an optional antenna with 13 dBi of gain. Per FCC Part 15.247 (4)(c), the peak power limit must be reduced by the amount the antenna gain exceeds 6 dBi.

30 dBm (limit) – (13 dBi – 6 dB) = 23 dBm

REMARKS:
None

4.5 Bandedges

4.5.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (902.0MHz – 928.0MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

4.5.2 Test procedures

The EUT was tested in the same method as described in section *4.3 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30 kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a peak detector. The highest emissions level beyond the bandedge was measured and recorded. If the out of band emissions do not fall within a restricted band from 15.205, then it is required that the out of band emission be 20dB below that of the fundamental emission level. If the out of band emission falls with a restricted band from 15.205, then it is required that the emission be below the limits from 15.209.

4.5.3 Deviations from test standard

No deviation.

4.5.4 Test setup

See Section 4.4

4.5.5 EUT operating conditions

The EUT was powered by a 120 VAC/ 60 Hz unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.5.6 Test results

EUT MODULE	Gateway	MODE	Cont. Transmit
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest In-Band Emissions
30kHz RBW, Marker-Delta method from ANSI C63.10, Section 6.10.6

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest in-band level (dBm)	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	902	-47.34	21.62	68.67	20.0	PASS
3	928	-18.26	21.33	39.59	20.0	PASS

Measurements in the restricted bands defined in part 15.205 are covered in Section 4.2. In all cases the results are reported unless they were at least 10 dB below the applicable limit.

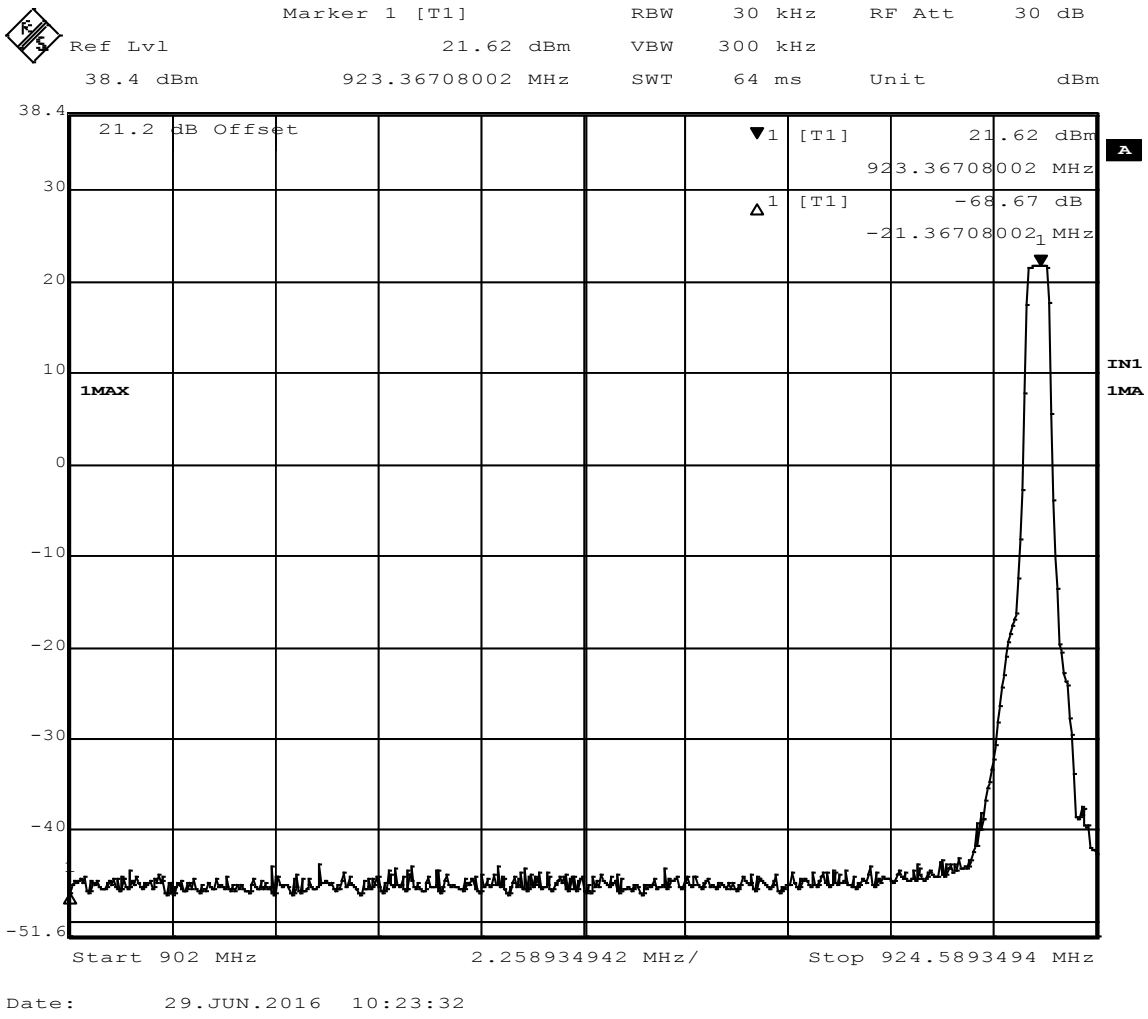


Figure 18 - Band-edge Measurement, Low Channel

Detector = Max peak, max hold

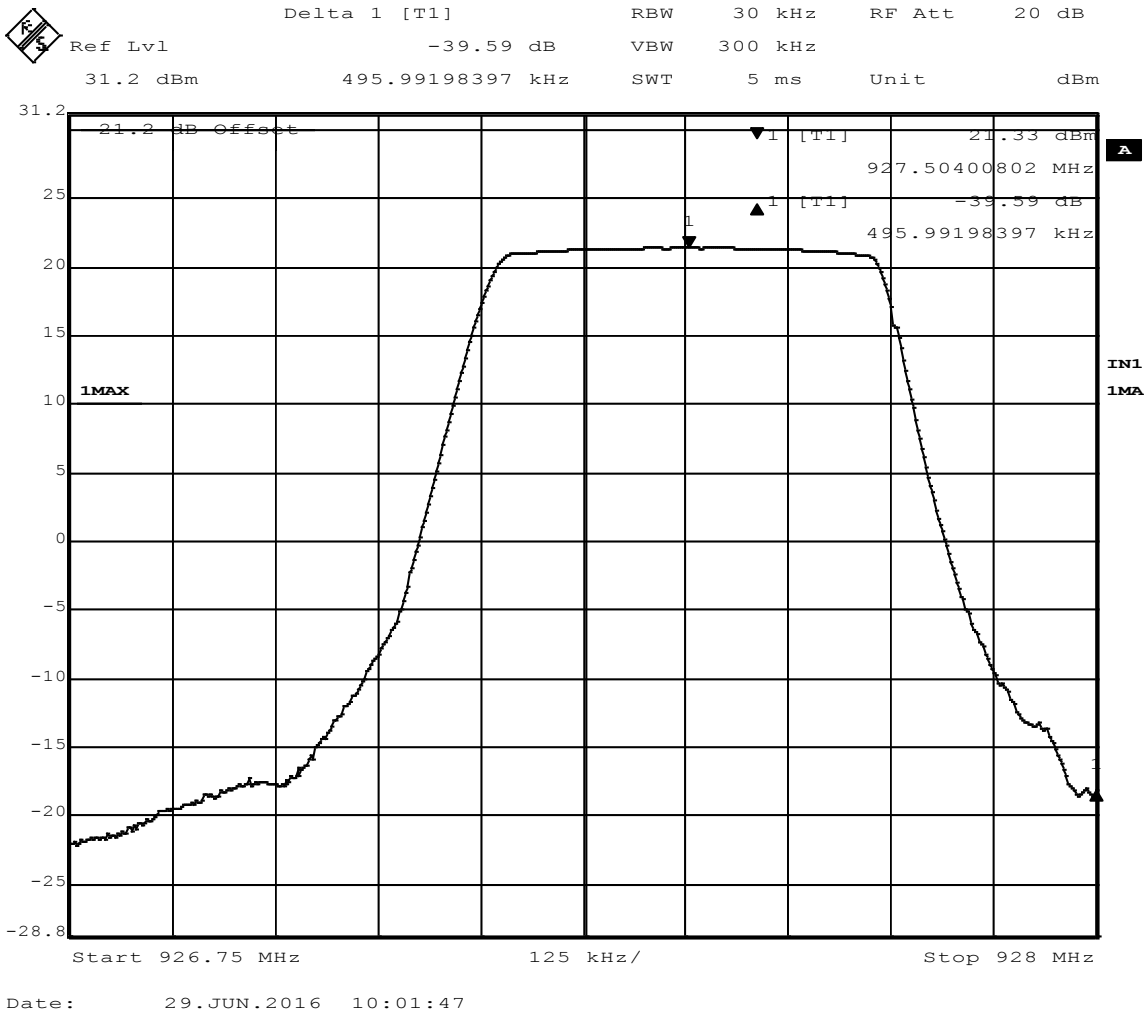


Figure 19 - Band-edge Measurement, High Channel

Detector = Max peak, max hold

4.6 Power Spectral Density

4.6.1 Power spectral density measurements

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.6.2 Test procedures

Test procedure from ANSI C63.10:2013, Section 11.10.2.

All measurements were taken at a distance of 3m from the EUT. The spectrum analyzer was set to 3 kHz RBW and 30 kHz VBW, the sweep time was set to auto. The power spectral density was measured and recorded at the frequency with the highest emission. The sweep time is allowed to be longer than span/3KHz for a full response of the mixer in the spectrum analyzer.

See Annex B for an example of how the EIRP is calculated in order to report maximum power output.

4.6.3 Deviations from test standard

No deviation.

4.6.4 Test setup

See section 4.3

4.6.5 EUT operating conditions

The EUT was powered by a 120 VAC / 60 Hz unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

EUT MODULE	Gateway	MODE	Cont. Transmit
INPUT POWER	120 VAC 60 Hz	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	MAXIMUM POWER LIMIT (dBm)	RESULT
1	923.00	5.00	8.00	PASS
2	925.60	4.76	8.00	PASS
3	927.50	4.55	8.00	PASS

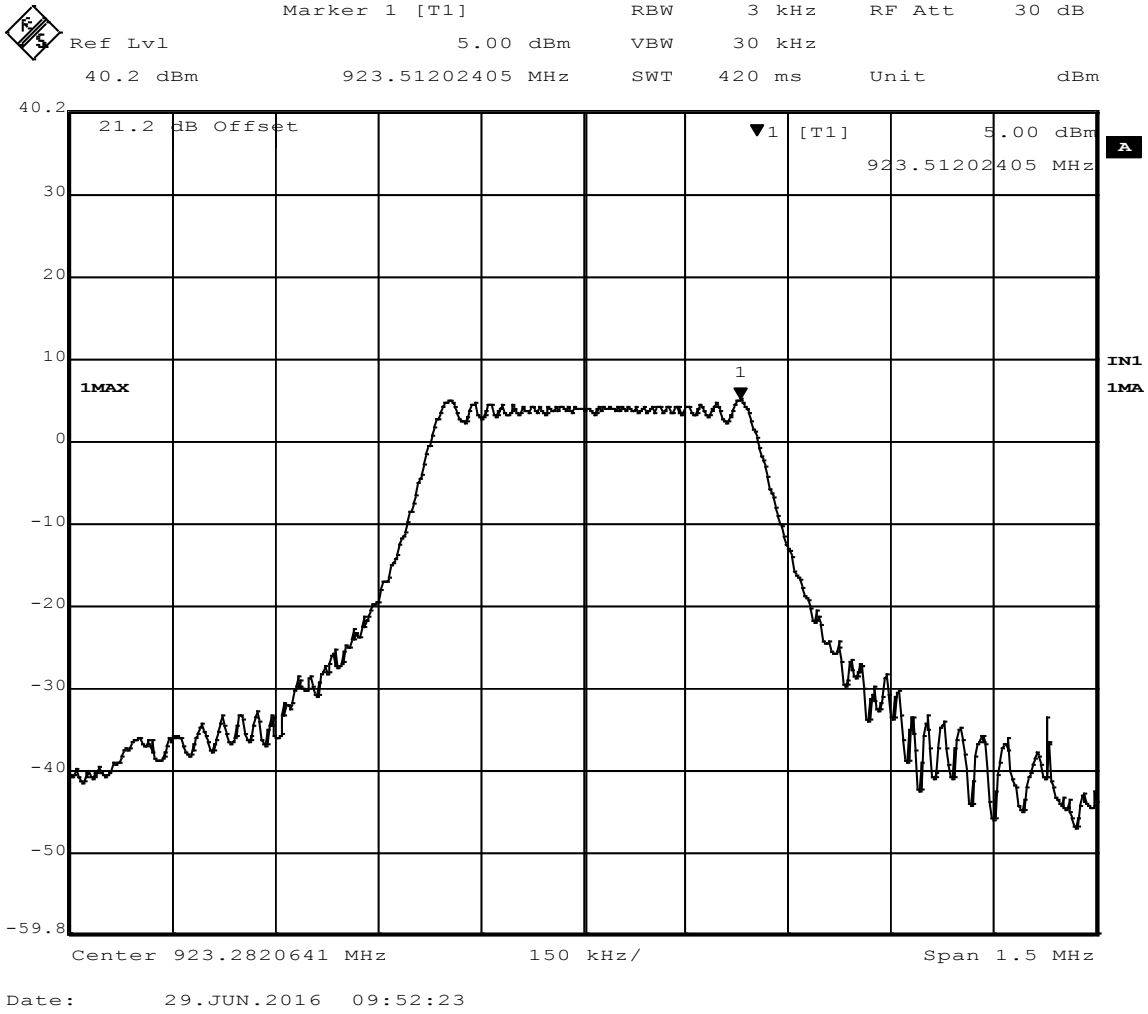


Figure 20 - Power Spectral Density Measurement, Low Channel

Detector = Max peak, max hold

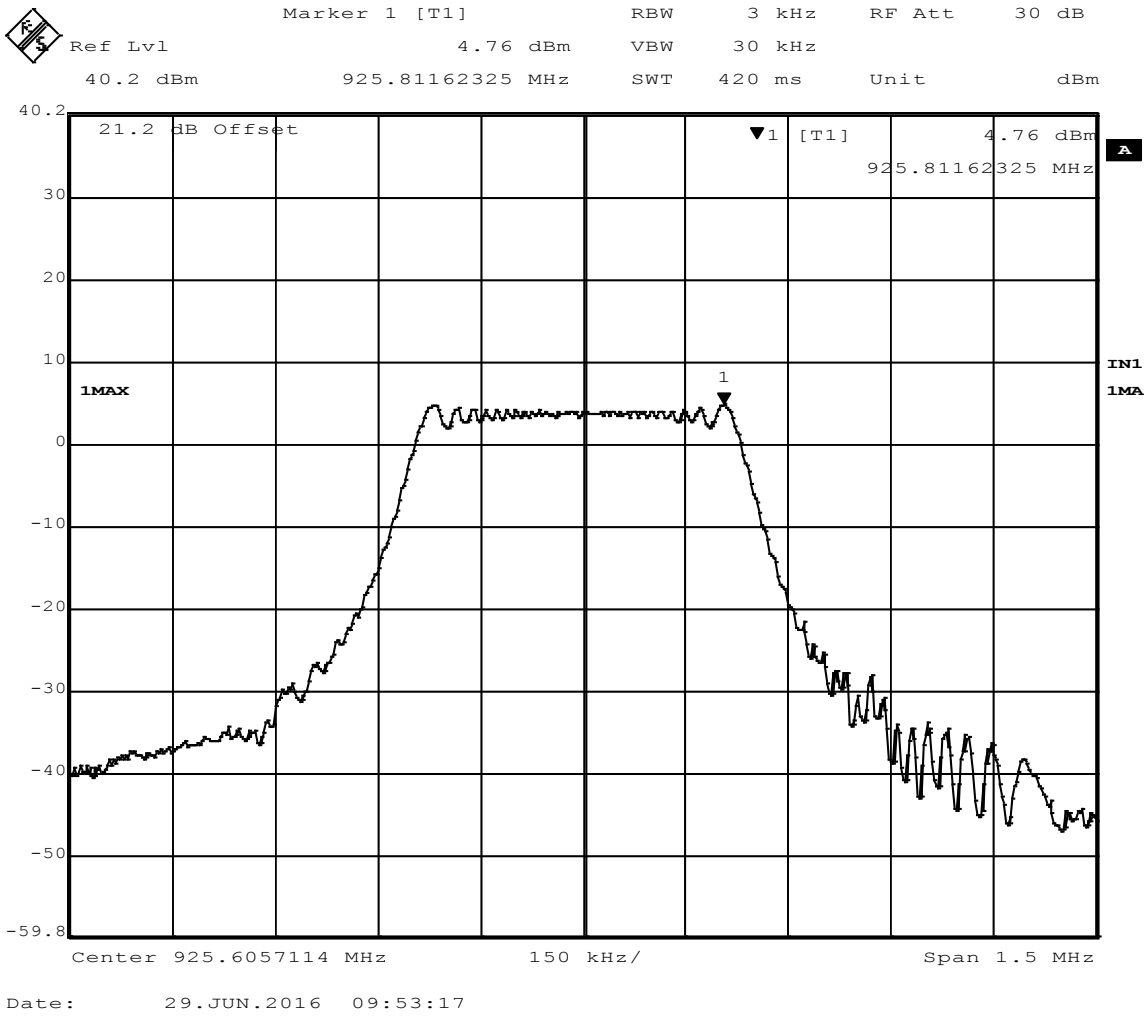


Figure 21 - Power Spectral Density Measurement, Mid Channel

Detector = Max peak, max hold

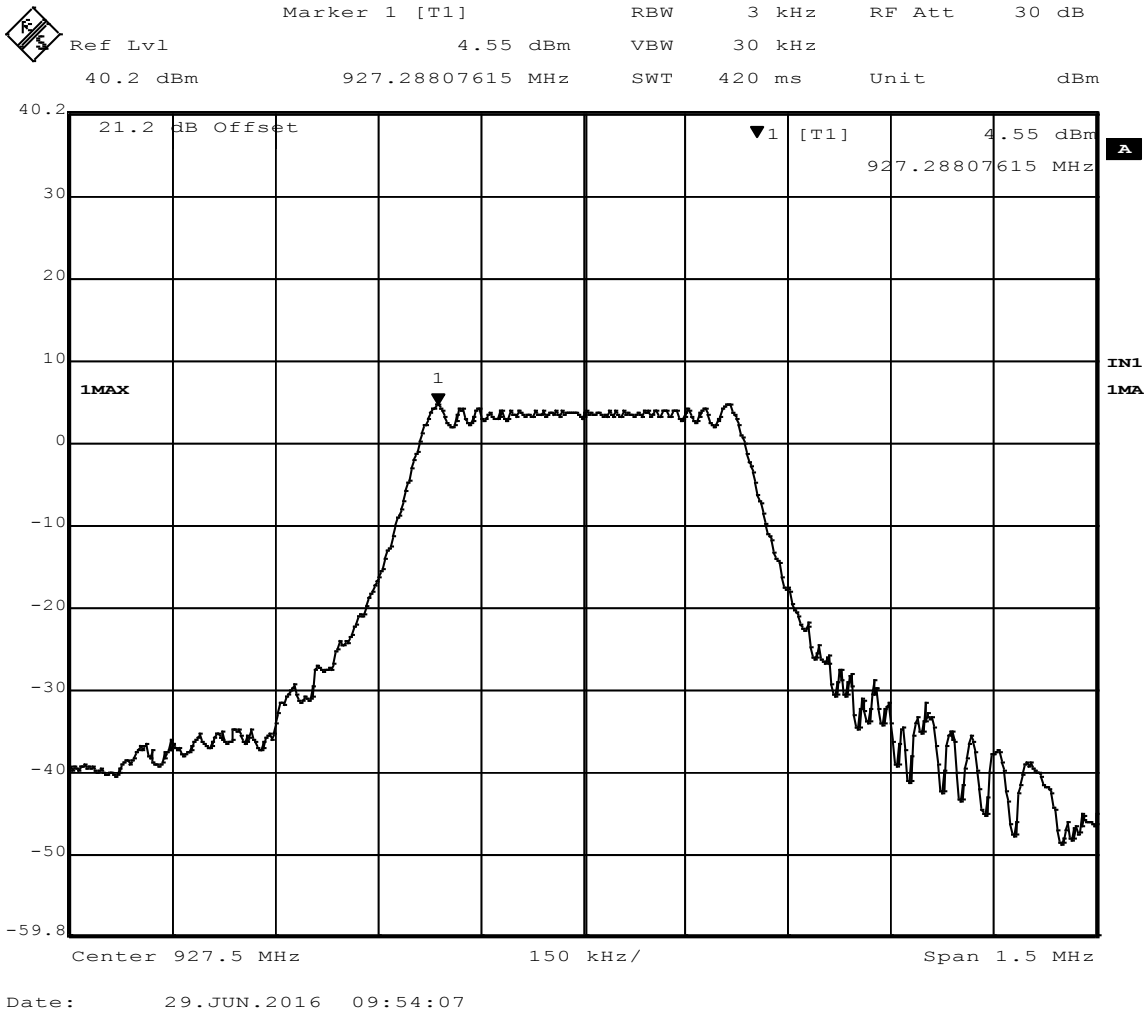


Figure 22 - Power Spectral Density Measurement, High Channel

Detector = Max peak, max hold

Appendix A: Test Photos

Figure 23 –Antenna 1 used for all tests, Laird MN:FG9026

Figure 24 –Antenna 2 used for all tests, L-com MN: HG913HSP-120

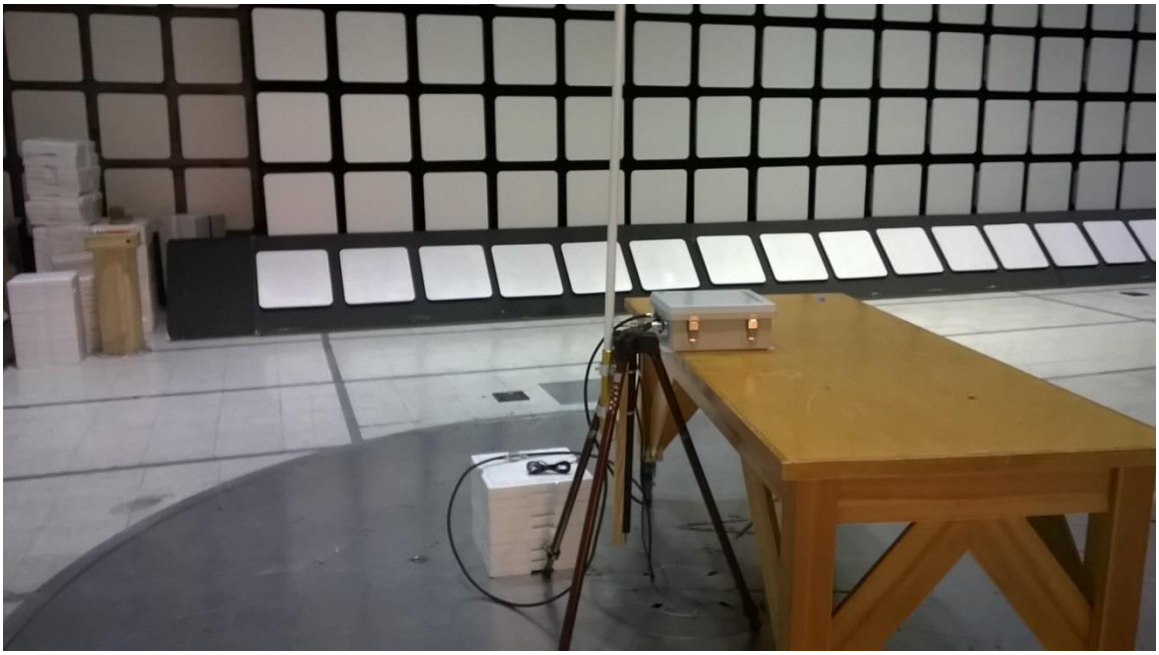


Figure 25 – Radiated Emissions Test Setup, Antenna 1

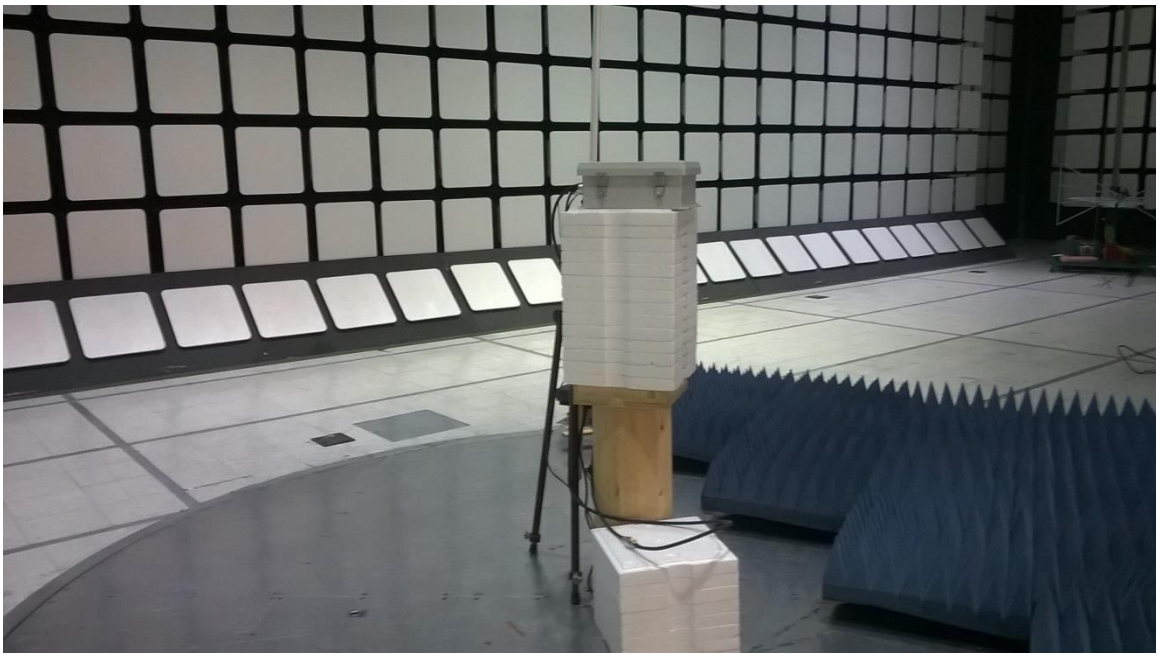


Figure 26 - Radiated Emissions Test Setup, Antenna 1

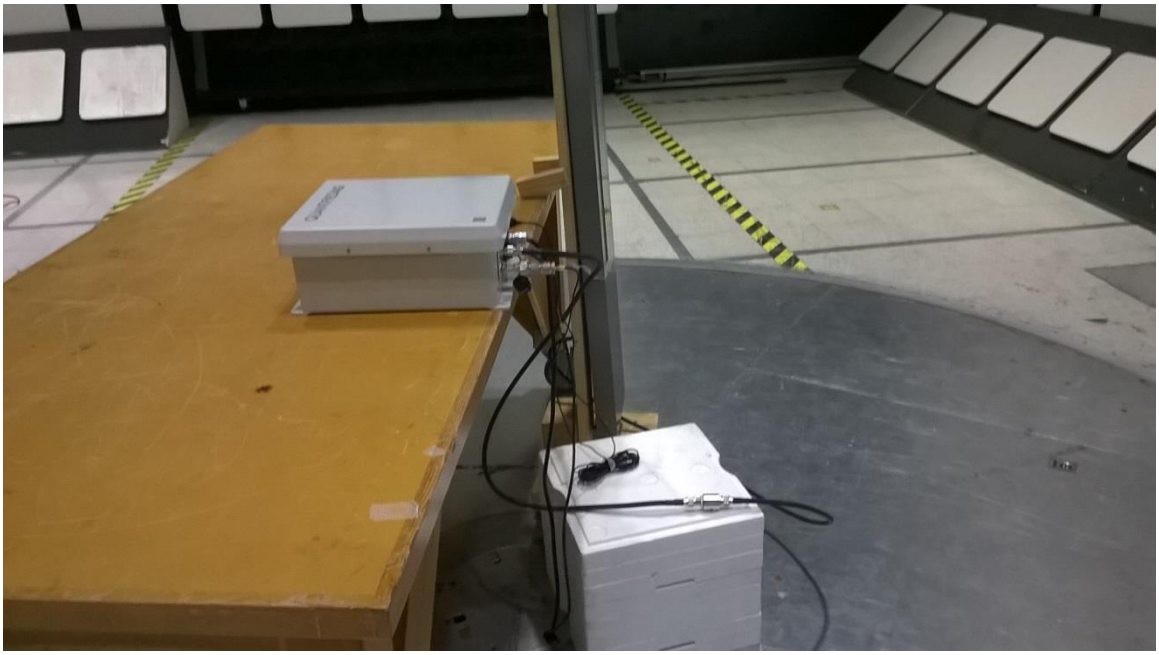


Figure 27 - Radiated Emissions Test Setup, Antenna 2

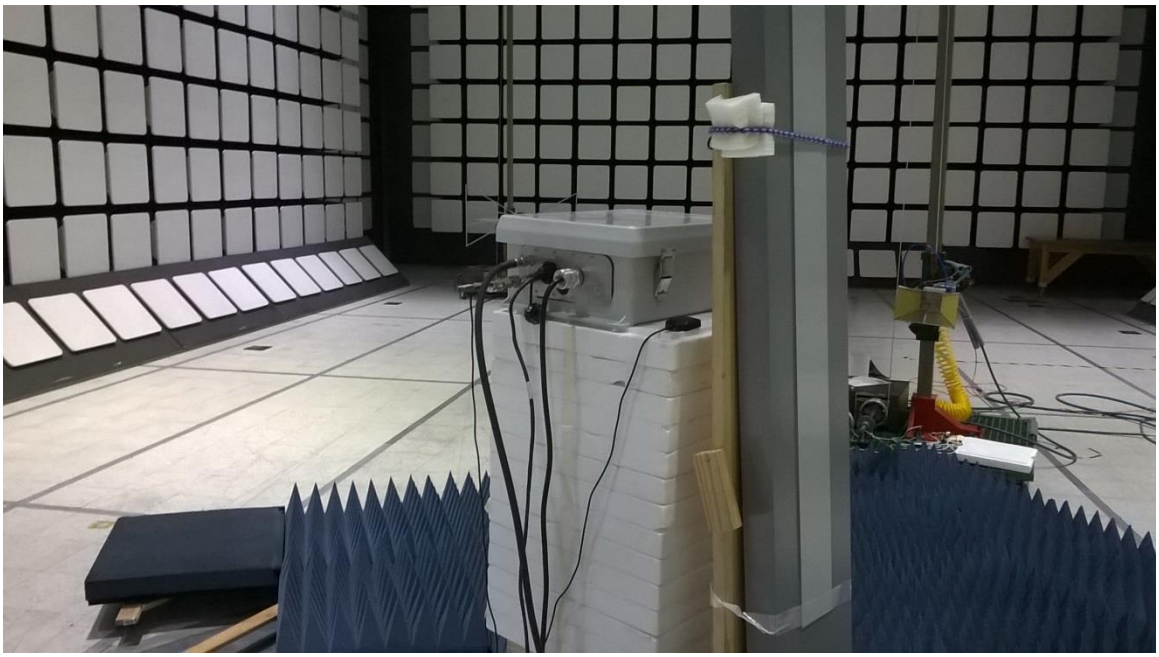


Figure 28 - Radiated Emissions Test Setup, Antenna 2

Appendix B: Sample Calculation

Field Strength Calculation

The field strength is calculated 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 = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 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

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Stregnth (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

Power (watts) = 10^[Power (dBm)/10] x 1000

Field Strength (dBµV/m) = Field Stregth (dBm) = 107 (for 50Ω measurement systems)

Field Stregnth (V/m) = 10^[Field Stregnth (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator

Annex C – Measurement Uncertainty

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

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

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