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/ISED Test Report

Includes NCEE Labs report R20160216-29-01C and its amendment in full

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

Product: **SenseTag, M/N QAGET100**

Test Report No: **R20160216-29-01D**

Approved By:

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

DATE: **27 July 2017**

Total Pages: **57**

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	NA	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 11.12.2.4	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(f), RSS-247 Issue 1 Section 5.2.2 ANSI C63.10, Section 11.10.2	Power Spectral Density	Pass	Meets the requirement
FCC Part 15.247(f), ANSI C63.10, Section 7.7.2, 7.7.3, 7.7.4 RSS-247 Issue 1, Section 5.3	Carrier frequency separation, number of hopping channels, Time of Occupancy	Pass	Meets the requirement

1.2 Description of amendment

Section 4.3.3 was corrected to show the BW in kHz. Section 4.2.2)g) was modified to state that all 3 orthogonal axis were tested. Section 4.3 measurements were repeated with a lower RBW.
Section 4.6.2 was modified to state that the method for peak PSD was used
A photo of the 3rd test axis was added to Annex A.
The first paragraph under Section 4.6.2 was changed to show that Peak PSD measurements were added and replaced the average PSD measurements.
Section 4.4.6 was modified to state 10MHz RBW was used to measure peak power from plots 7-9.
Values in Section 3.4 were corrected.

2.0 Description

2.1 Equipment under test

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

EUT Received Date: 10 August 2016
EUT Tested Dates: 10 August 2016 – 12 September 2016
Bandwidth measurements: 25 January 2017

PRODUCT	SenseTag
MODEL	QAGET100
SERIAL NUMBER	07160013 (Used for all continuous transmit tests) 07160006(Used for PSD Measurements) 07160011 (Used for hop count measurements)
POWER SUPPLY	1.5 VDC (AA BATTERY)
ANTENNA TYPE	PCB

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 frequencies below:

Channel	Frequency
1	902.3
2	908.6
3	914.9

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	1654	02 Aug 2016	02 Aug 2017
EMCO Horn Antenna**	3115	6416	25 Jan 2016	25 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*
Mini Circuits 1700 – 5000Mhz High Pass Filter***	15542	31618	16 June 2016*	16 June 2017*

*Internal Characterization
**Used for radiated measurements above 1GHz
***Used for measurements from 1 GHz - 6GHz
****Used for measurements above 3 GHz

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 internal to the EUT on a PCB.

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 all 3 orthogonal axis. The position that produced the highest emissions was the X-axis and it 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

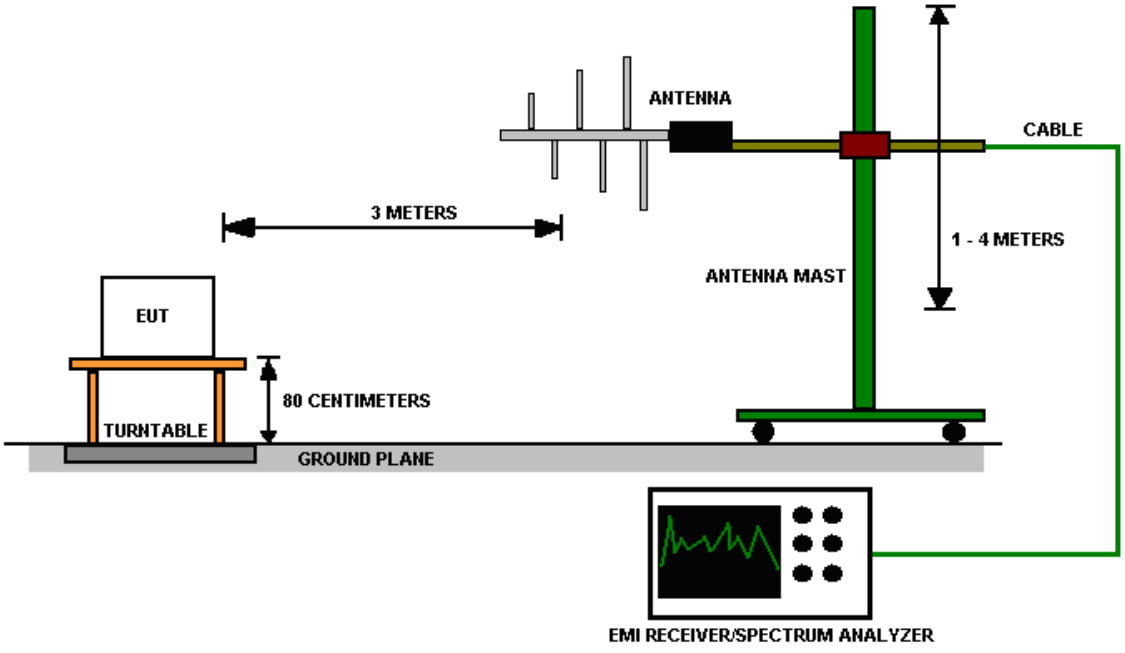


Figure 1 - Radiated Emissions Test Setup

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 1.5 VDC (1 x AA BATTERY battery) and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

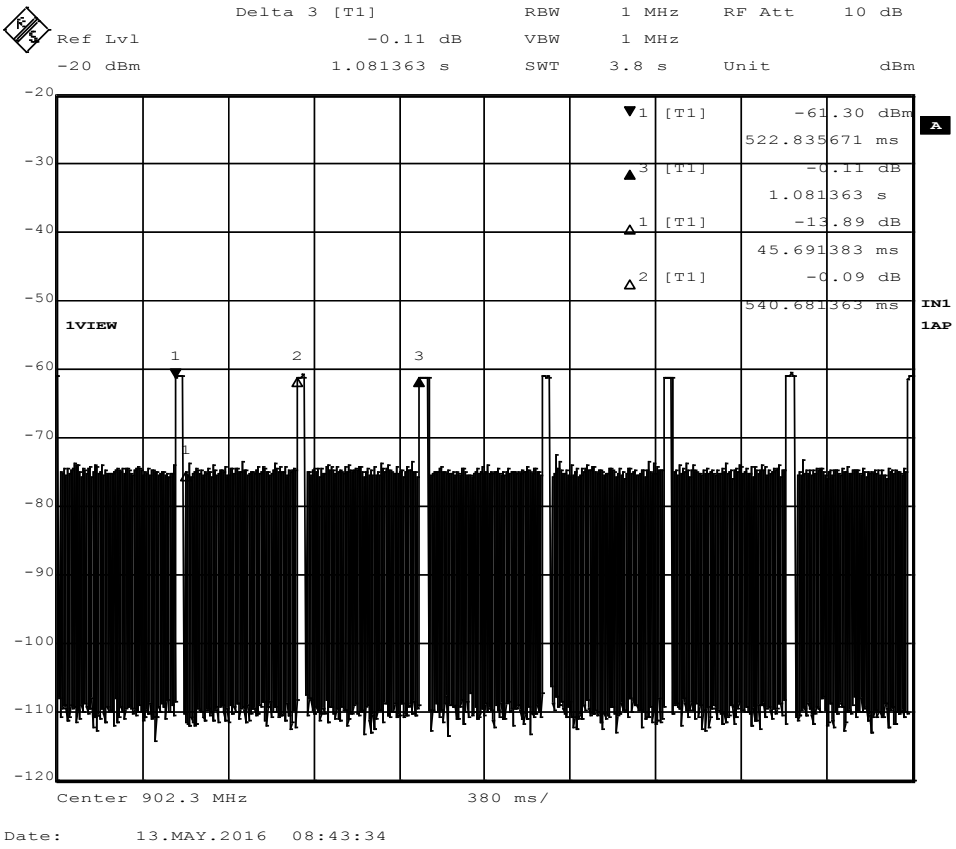


Figure 2 –Duty Cycle

Transmit time per period = 45.69 ms (delta marker in Figure 2)
Period time = 100 ms (Maximum usable, actual = 540.68 ms in Figure 2)
Duty cycle = Transmit time / period = 45.69 / 100 = 0.4569
Averaging factor = 20 × log(duty cycle) = 20 × log(0.4569) = -6.80

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	SenseTag	MODE	Receive
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

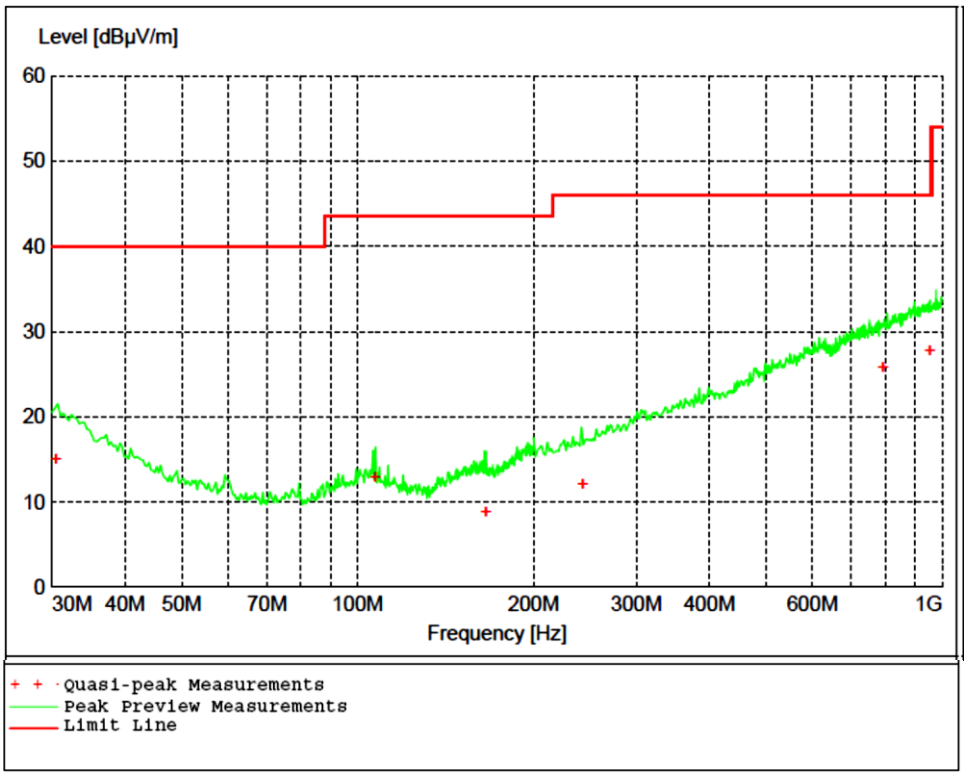


Figure 3 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.480000	15.04	40.00	25.00	399	244	HORI
107.280000	12.90	43.50	30.60	400	231	VERT
165.720000	8.82	43.50	34.70	136	58	VERT
242.640000	12.00	46.00	34.00	327	360	HORI
793.380000	25.70	46.00	20.30	220	269	HORI
954.300000	27.74	46.00	18.30	111	177	VERT

Table 2 - Radiated Emissions Peak Measurements, Receive

Frequency	Peak Level	Avg Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1792.600000	34.68	54.00	19.30	100	314	VERT
2698.600000	35.97	54.00	18.00	388	101	HORI
3607.600000	39.51	54.00	14.50	100	293	VERT
4514.600000	41.07	54.00	12.90	398	89	HORI
5411.400000	41.81	54.00	12.20	99	36	VERT

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

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	SenseTag	MODE	Low Channel
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

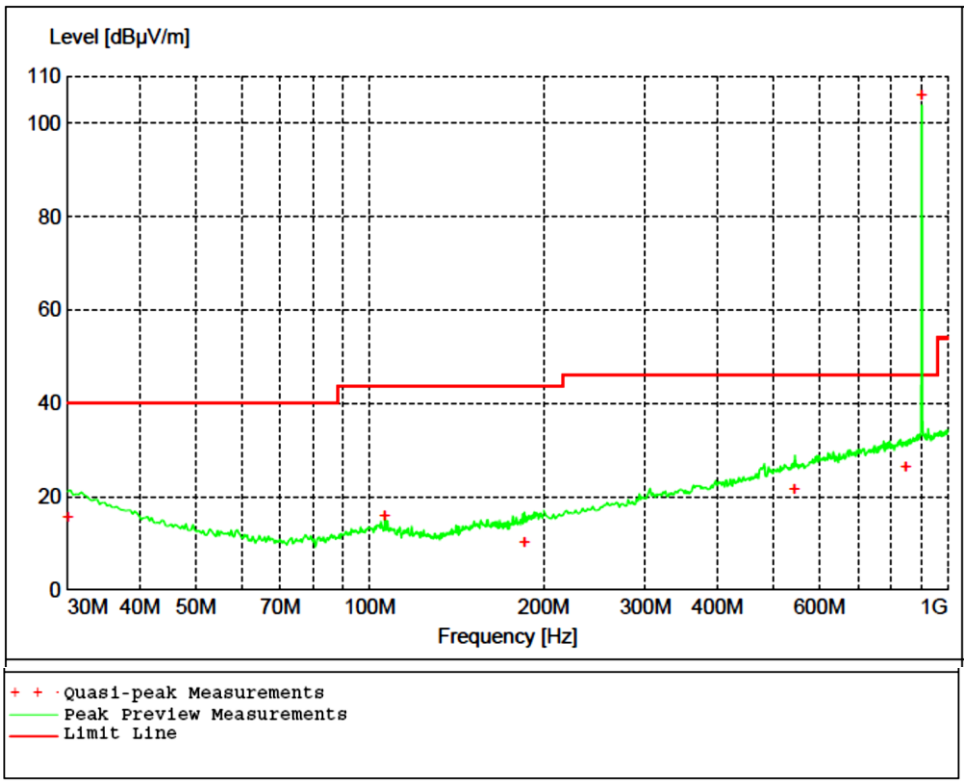


Figure 4 - Radiated Emissions Plot, Low Channel

Table 3 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.000000	15.60	40.00	24.40	121	320	VERT
106.260000	15.71	43.50	27.80	115	136	VERT
185.580000	10.26	43.50	33.30	173	182	HORI
543.720000	21.53	46.00	24.50	400	70	VERT
847.320000	26.41	46.00	19.60	400	268	VERT
902.300000	105.98	NA	NA	130	161	VERT

Table 4 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1804.680000	47.11	54.00	6.89	129	141	VERT
2707.000000	47.35	54.00	6.65	338	359	VERT
3609.200000	38.53	54.00	15.47	100	70	HORI
4511.600000	40.24	54.00	13.76	99	262	HORI
5413.800000	41.39	54.00	12.61	100	292	HORI
6315.600000	41.49	54.00	12.51	100	160	VERT
7218.600000	43.09	54.00	10.91	106	125	VERT
8120.200000	49.57	54.00	4.43	197	164	VERT
9022.400000	45.82	54.00	8.18	99	211	HORI

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 5 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1804.680000	53.91	74.00	20.09	129	141	VERT
2707.000000	54.15	74.00	19.85	338	359	VERT
3609.200000	45.33	74.00	28.67	100	70	HORI
4511.600000	47.04	74.00	26.96	99	262	HORI
5413.800000	48.19	74.00	25.81	100	292	HORI
6315.600000	48.29	74.00	25.71	100	160	VERT
7218.600000	49.89	74.00	24.11	106	125	VERT
8120.200000	56.37	74.00	17.63	197	164	VERT
9022.400000	52.62	74.00	21.38	99	211	HORI

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	SenseTag	MODE	Mid Channel
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

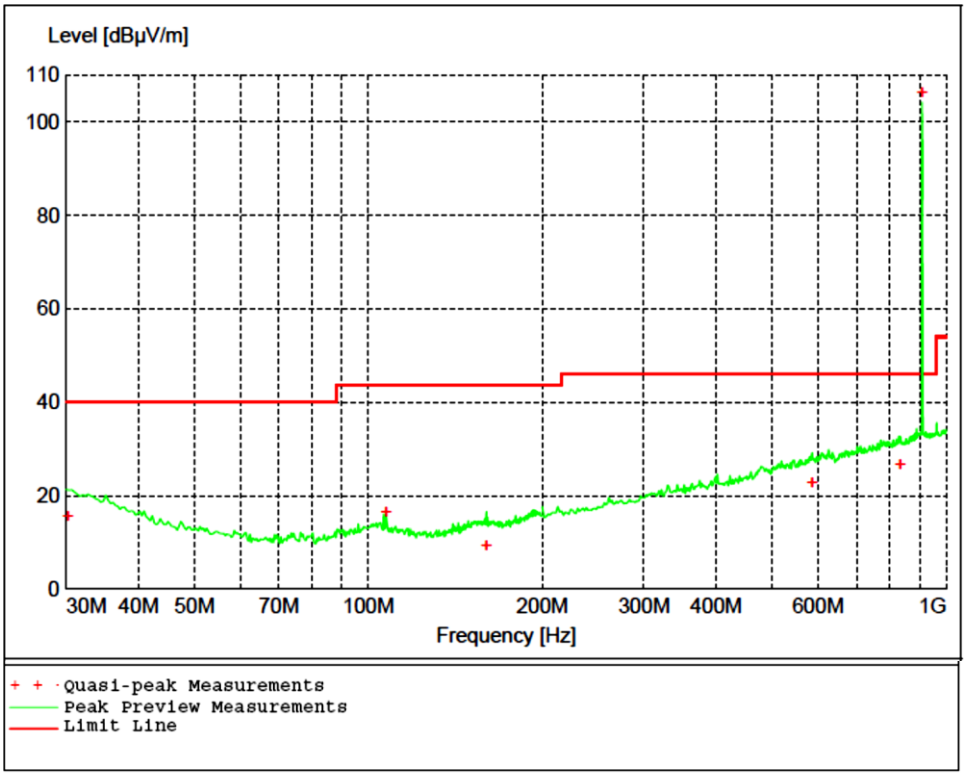


Figure 5 - Radiated Emissions Plot, Mid Channel

Table 6 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.180000	15.47	40.00	24.50	399	231	VERT
107.280000	16.38	43.50	27.10	102	317	VERT
160.140000	9.19	43.50	34.30	98	197	HORI
586.140000	22.76	46.00	23.20	100	99	VERT
833.400000	26.68	46.00	19.30	159	24	VERT
908.640000	106.17	NA	NA	136	161	VERT

Table 7 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1817.500000	47.19	54.00	6.81	386	295	VERT
2719.500000	46.86	54.00	7.14	271	280	HORI
3634.200000	38.70	54.00	15.30	100	118	HORI
4543.000000	40.88	54.00	13.12	187	172	HORI
5451.600000	39.74	54.00	14.26	100	182	HORI
6359.600000	37.44	54.00	16.56	99	152	HORI
7268.400000	44.41	54.00	9.59	183	178	VERT
8177.800000	49.39	54.00	4.61	163	160	VERT
9085.800000	45.84	54.00	8.16	100	199	HORI

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, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1817.500000	53.99	74.00	20.01	386	295	VERT
2719.500000	53.66	74.00	20.34	271	280	HORI
3634.200000	45.50	74.00	28.50	100	118	HORI
4543.000000	47.68	74.00	26.32	187	172	HORI
5451.600000	46.54	74.00	27.46	100	182	HORI
6359.600000	44.24	74.00	29.76	99	152	HORI
7268.400000	51.21	74.00	22.79	183	178	VERT
8177.800000	56.19	74.00	17.81	163	160	VERT
9085.800000	52.64	74.00	21.36	100	199	HORI

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	SenseTag	MODE	High Channel
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

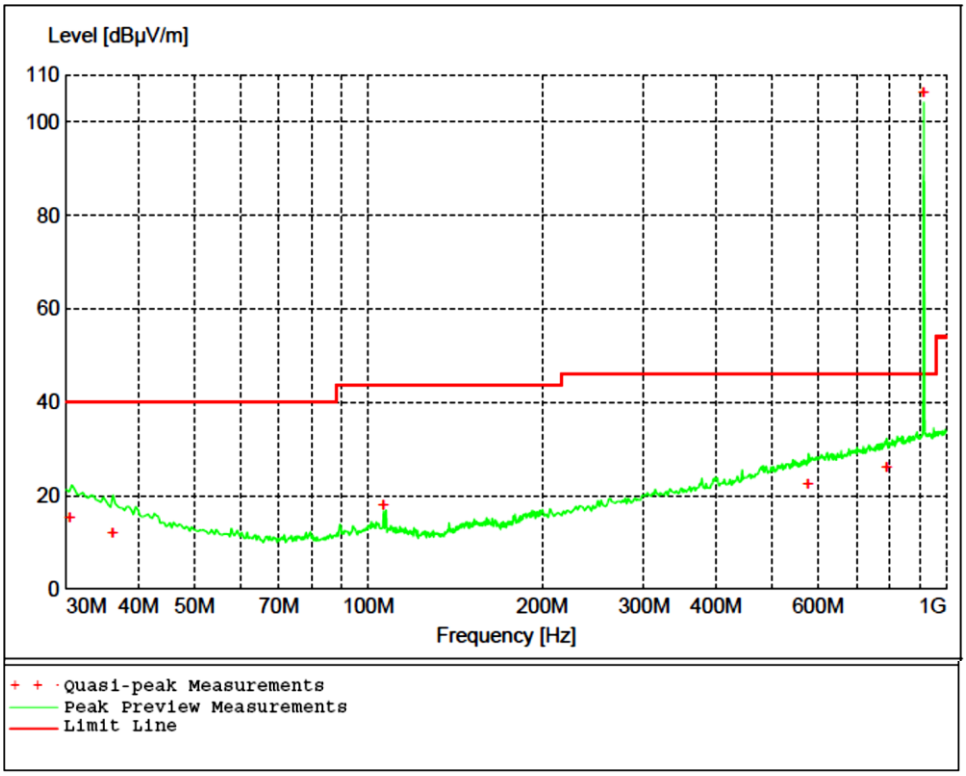


Figure 6 - Radiated Emissions Plot, High Channel

Table 9 - Radiated Emissions Quasi-peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.420000	15.23	40.00	24.80	240	249	VERT
36.120000	12.05	40.00	28.00	310	90	VERT
106.260000	17.93	43.50	25.60	113	354	VERT
577.200000	22.52	46.00	23.50	149	326	VERT
789.360000	25.88	46.00	20.10	100	46	VERT
914.900000	106.25	NA	NA	129	160	VERT

*Unrestricted band. Required to be 20dB below fundamental

Table 10 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1829.500000	47.46	54.00	6.54	371	328	VERT
2746.000000	46.93	54.00	7.07	150	263	HORI
3659.800000	39.00	54.00	15.00	100	107	HORI
4574.400000	42.00	54.00	12.00	190	167	HORI
5489.200000	40.42	54.00	13.58	100	173	VERT
6404.600000	41.92	54.00	12.08	100	153	VERT
7318.800000	47.02	54.00	6.98	177	170	VERT
8234.200000	50.33	54.00	3.67	173	152	VERT
9149.600000	47.38	54.00	6.62	100	189	HORI

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, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1829.500000	54.26	74.00	19.74	371	328	VERT
2746.000000	53.73	74.00	20.27	150	263	HORI
3659.800000	45.80	74.00	28.20	100	107	HORI
4574.400000	48.80	74.00	25.20	190	167	HORI
5489.200000	47.22	74.00	26.78	100	173	VERT
6404.600000	48.72	74.00	25.28	100	153	VERT
7318.800000	53.82	74.00	20.18	177	170	VERT
8234.200000	57.13	74.00	16.87	173	152	VERT
9149.600000	54.18	74.00	19.82	100	189	HORI

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 and occupied bandwidth are reported for reference only, as the system is categorized under hybrid system.

4.3.2 Test procedures

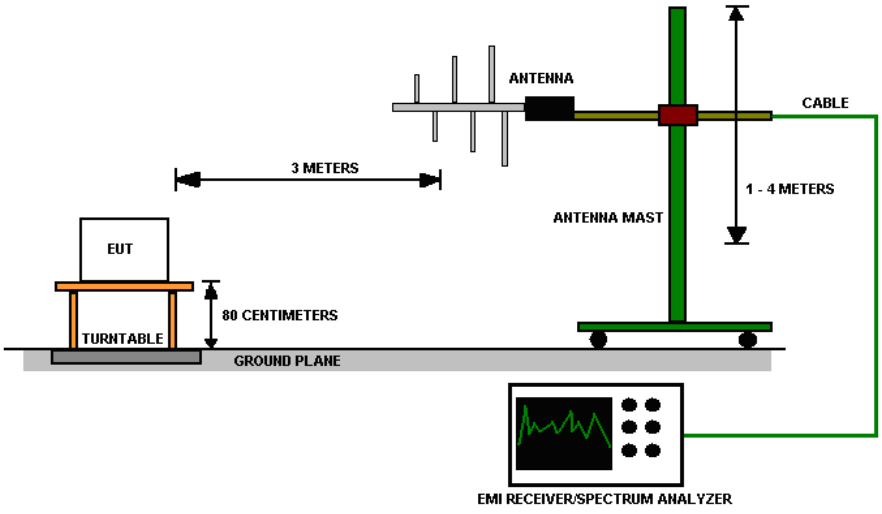
The method from ANSI C63.10, Section 11.8.1 was used.

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 10 kHz RBW (1-5% OBW) and 30 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 1 MHz 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



4.3.5 EUT operating conditions

The EUT was powered by 1.5 VDC (1 x AA BATTERY) 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	SenseTag	MODE	Continuous Transmit
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	20 dB and 99% Occupied BW (kHz)
Low	902.3	161.93
Mid	908.6	163.53
High	914.8	161.12

REMARKS:
None

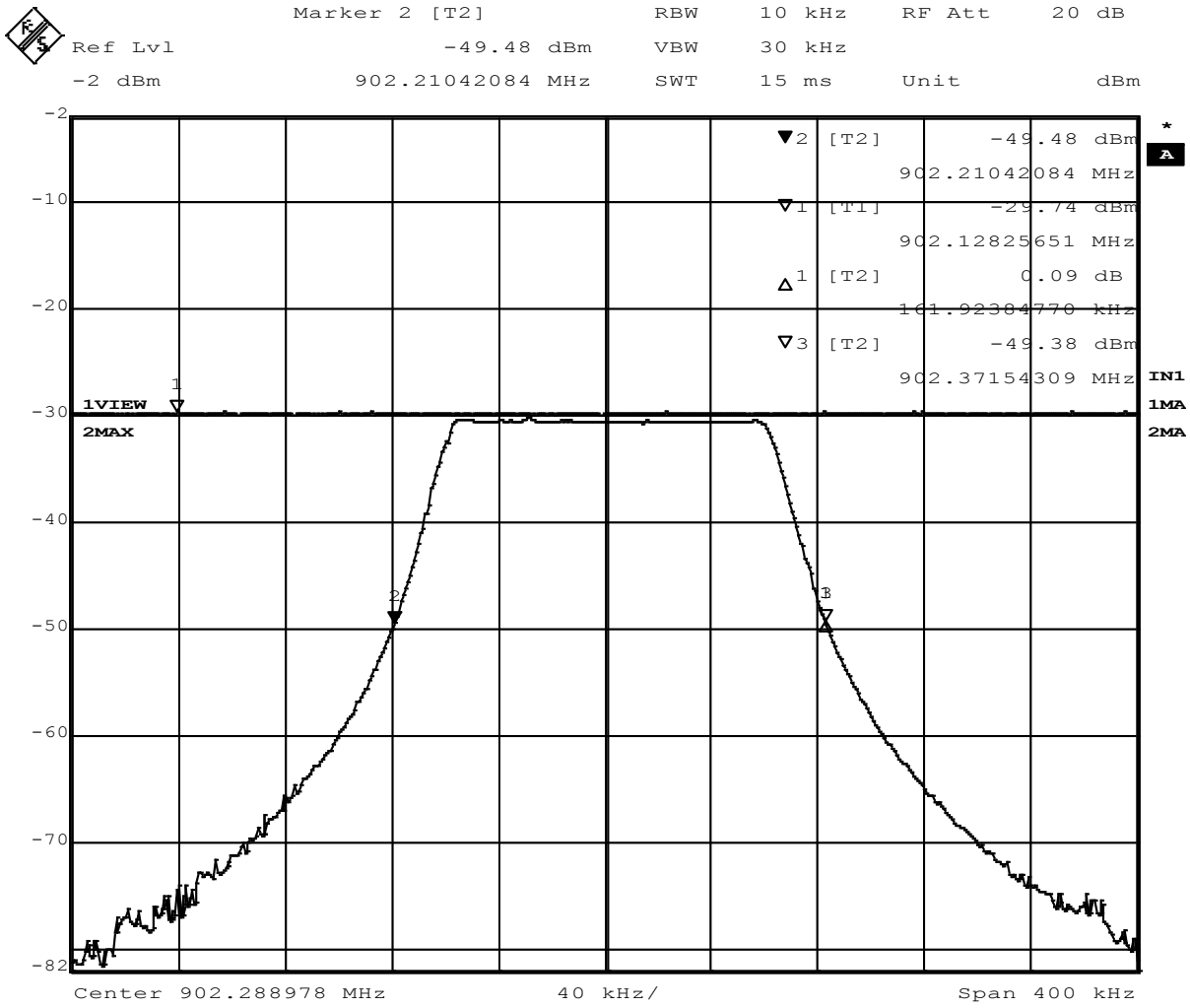


Figure 7 - 20dB Bandwidth, Low Channel

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

In this case, the 10 MHz RBW and 10 kHz peaks were the same.

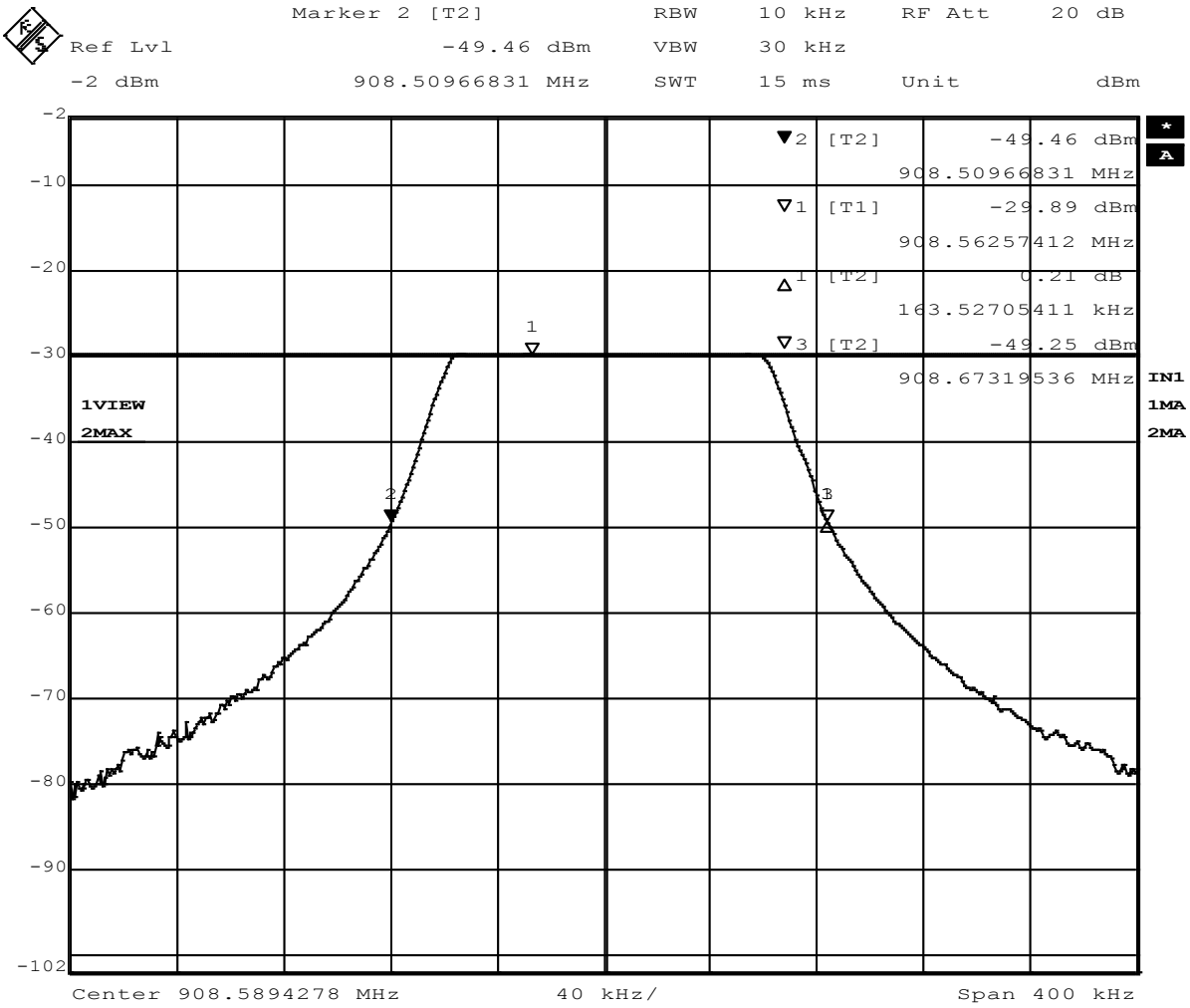


Figure 8 – 20 dB Occupied Bandwidth, Mid Channel

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

In this case, the 10 MHz RBW and 10 kHz peaks were the same.

.

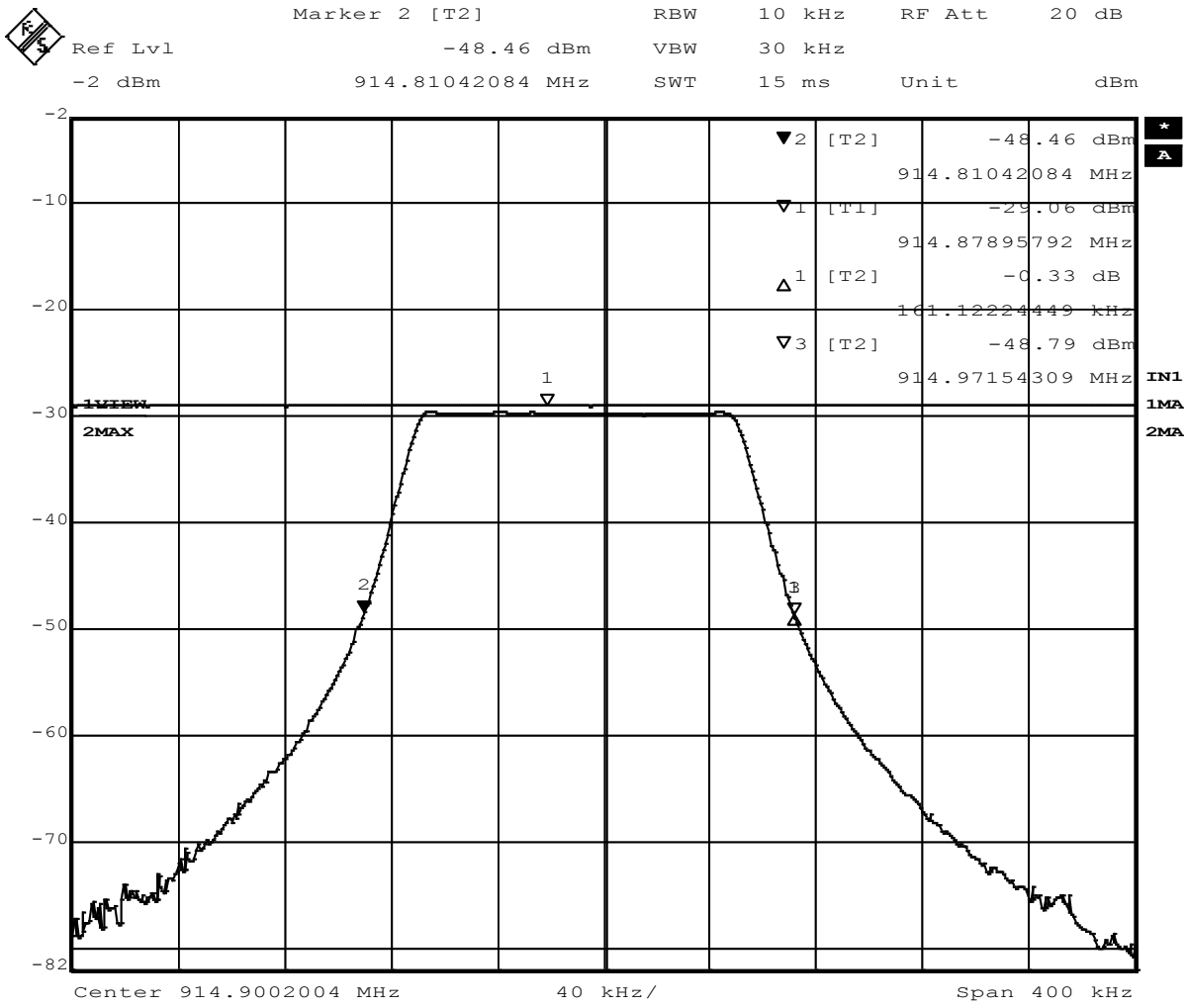


Figure 9 – 20 dB Occupied Bandwidth, High Channel

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

In this case, the 10 MHz RBW and 10 kHz peaks were the same.

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

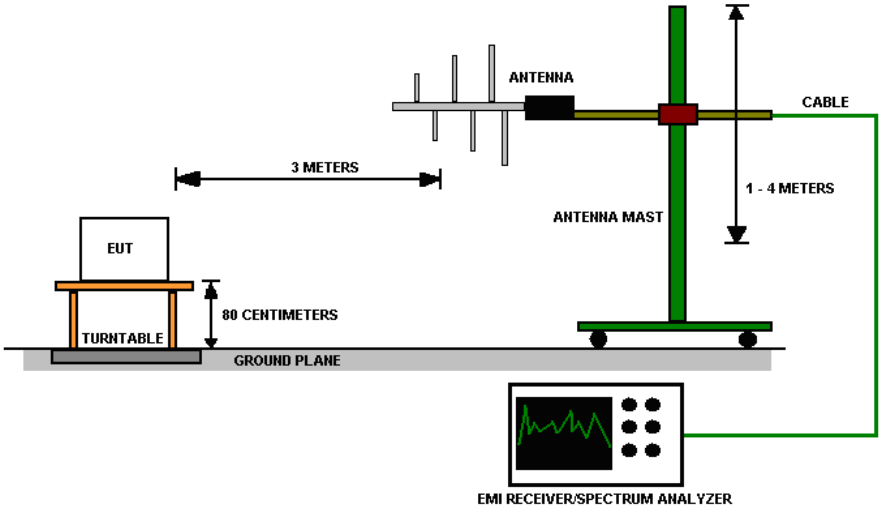
The method from ANSI C63.10 Section 11.12.2.4 was used.

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 10 MHz RBW and 10 MHz VBW.

4.4.3 Deviations from test standard

No deviation.

4.4.4 Test setup



4.4.5 EUT operating conditions

See Section 2.6

4.4.5 EUT operating conditions

The EUT was powered by 1.5 VDC (1 x AA BATTERY) 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	SenseTag	MODE	Continuous Transmit
INPUT POWER	1.5 VDC (AA BATTERY)	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
Low	902.3	10.63	30	PASS
Mid	908.6	10.48	30	PASS
High	914.9	11.31	30	PASS

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

$$\text{EIRP Peak} = P + AF + CF + 3mF_{50\Omega}$$

P = Maximized measurements from Figures 7 - 9. It was Measured at 3m and indicated by marker 1 and measured with 10MHz RBW as indicated by trace 1. Trace 1 was placed in “max hold” mode with an RBW of 10 MHz. The trace was placed in “view” mode, holding it on the screen. The RBW was then changed to 10 kHz for BW measurements as indicated on the screencap.

AF = Antenna factor = 23.9 dB

CF = Cable factor = 4.7 dB

$3mF_{50\Omega}$ = Conversion from 3m field strength in dBm to dBi (EIRP) in a 50Ω measurement system = 11.77 dB

REMARKS:
None

4.5 Bandedges

4.5.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (900 – 928 MHz band)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 method from ANSI C63.10 Section 6.10.6.2 was used.

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 1.5 VDC (1 x AA BATTERY) 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	SenseTag	MODE	Continuous Transmit
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest In-Band Emissions
10kHz 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	-58.06	-30.39	27.67	20.0	PASS
3	928	-62.27	-29.17	33.10	20.0	PASS

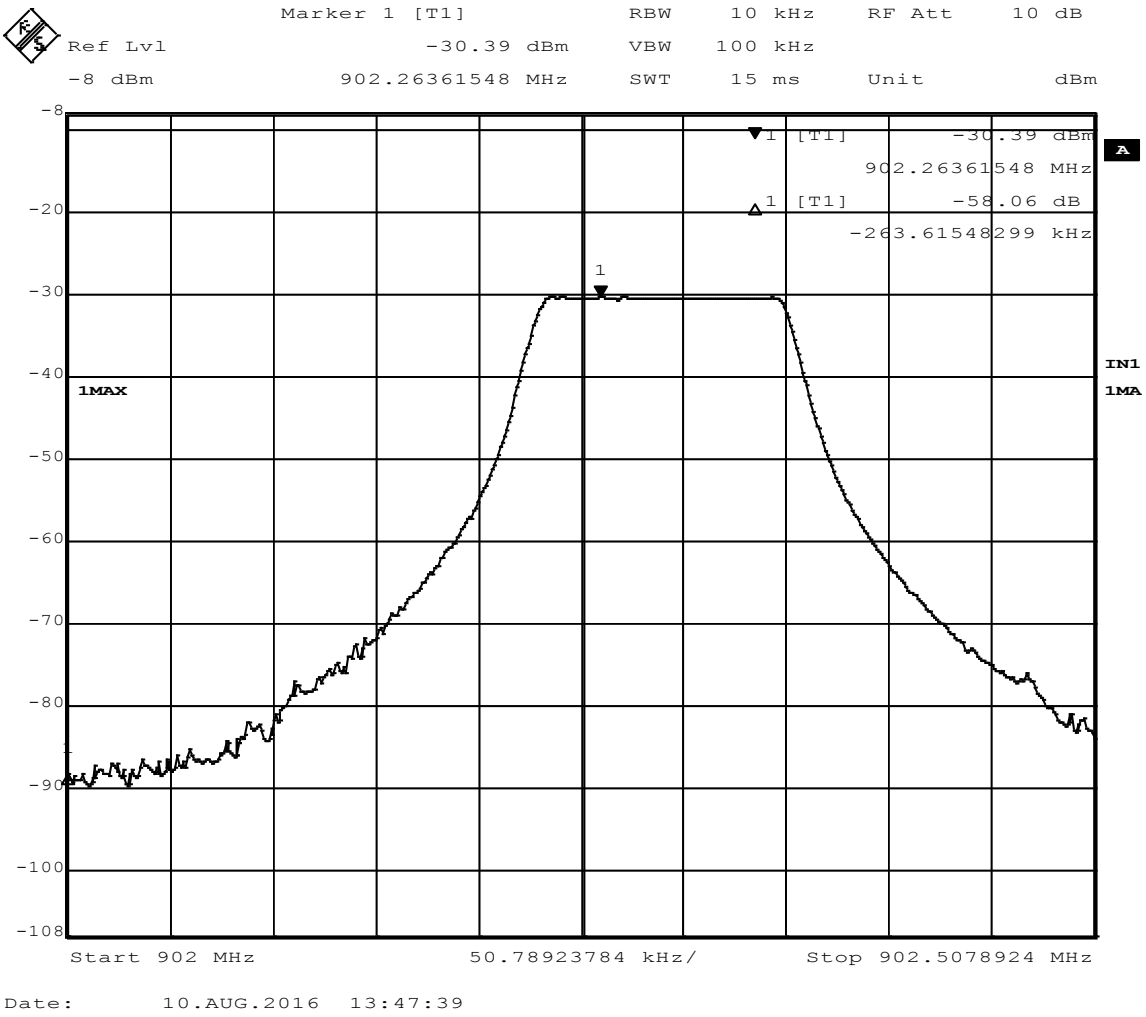


Figure 10 - Band-edge Measurement, Low Channel

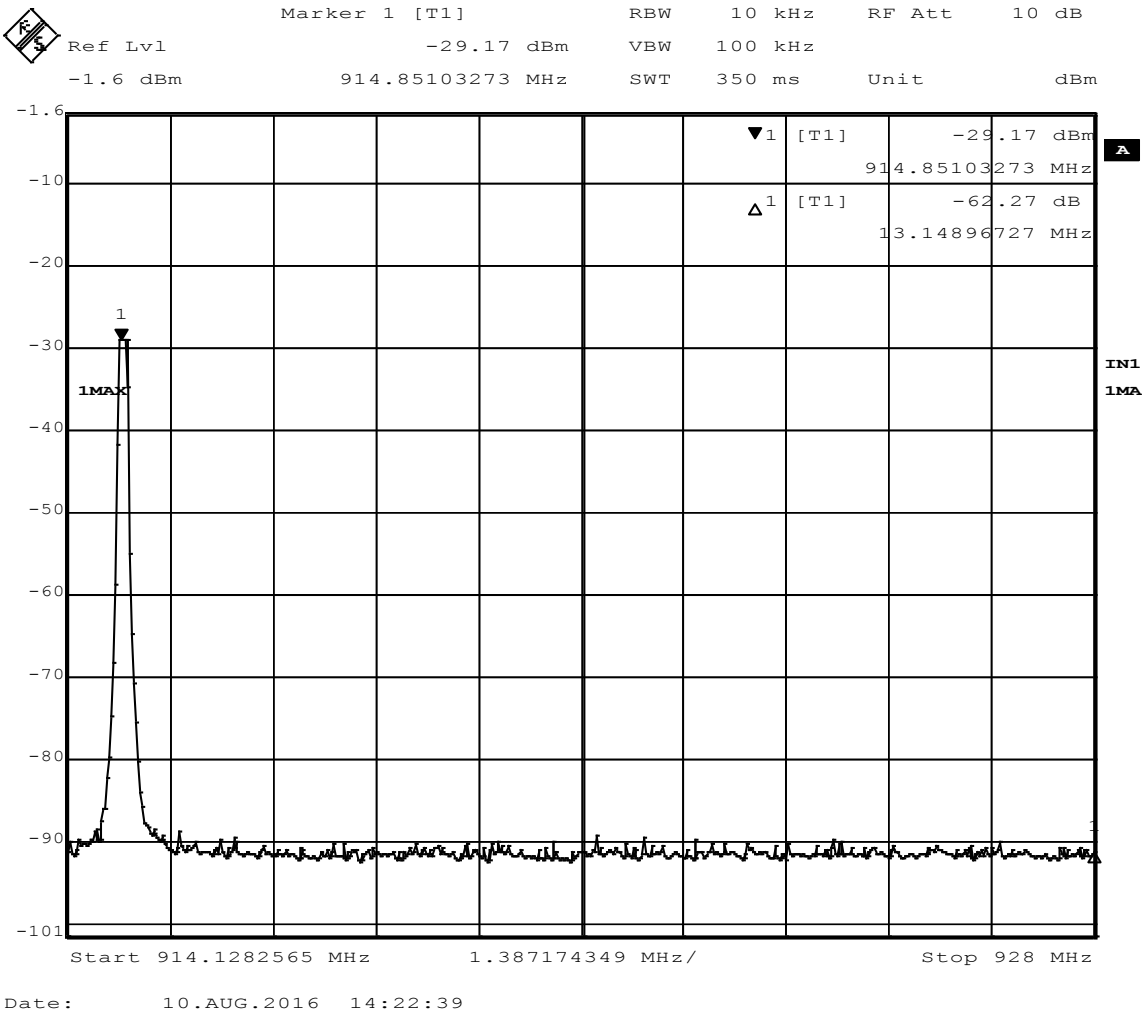


Figure 11 - Band-edge Measurement, High Channel

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

The method from ANSI C63.10 Section 11.10.2, Method PKPSD was used for PSD measurements.

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 power spectral density was measured using the peak detector and recorded at the frequency with the highest emission. The trace was allowed to fully stabilize in max hold. The sweep was set to auto couple, as per C63.10-2013, Section 11.10.2.

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 1.5 VDC (1 x AA BATTERY) 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	SenseTag	MODE	Continuous Transmit
INPUT POWER	1.5 VDC (AA BATTERY)	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	902.34	2.72	8.00	PASS
2	908.64	3.70	8.00	PASS
3	914.82	4.35	8.00	PASS

All measurements were taken from Figures 12 – 14 of this section.

$$\text{EIRP PSD Peak} = P + AF + CF + 3mF_{50\Omega}$$

P = Maximized measurements from Figures 12 – 14. Measured at 3m and indicated by marker 1

AF = Antenna factor = 23.9 dB

CF = Cable factor = 4.7 dB

$3mF_{50\Omega}$ = Conversion from 3m field strength in dBm to dBi (EIRP) in a 50Ω measurement system = 11.77 dB

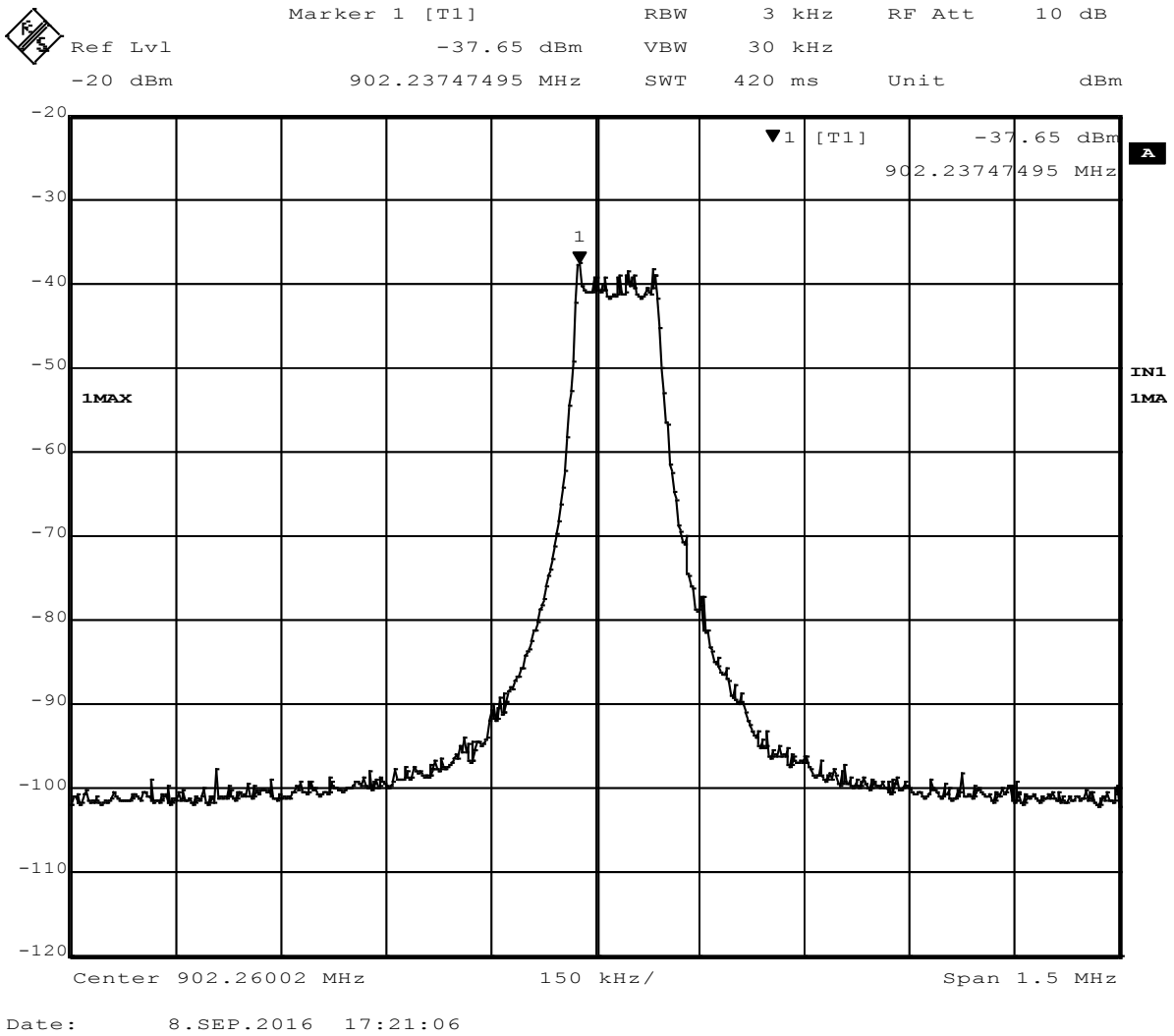


Figure 12 - Power Spectral Density Measurement, Low Channel

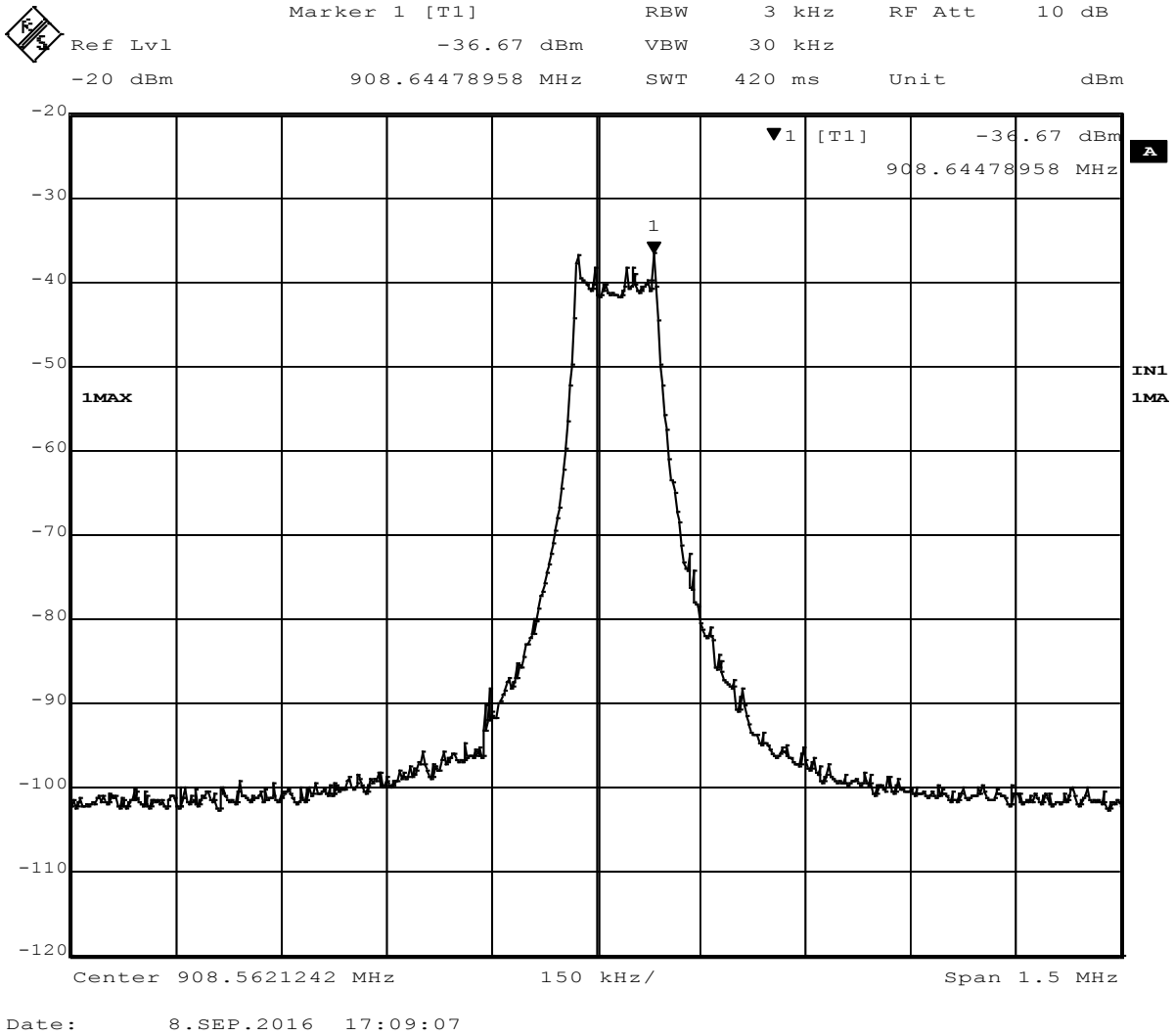


Figure 13 - Power Spectral Density Measurement, Mid Channel

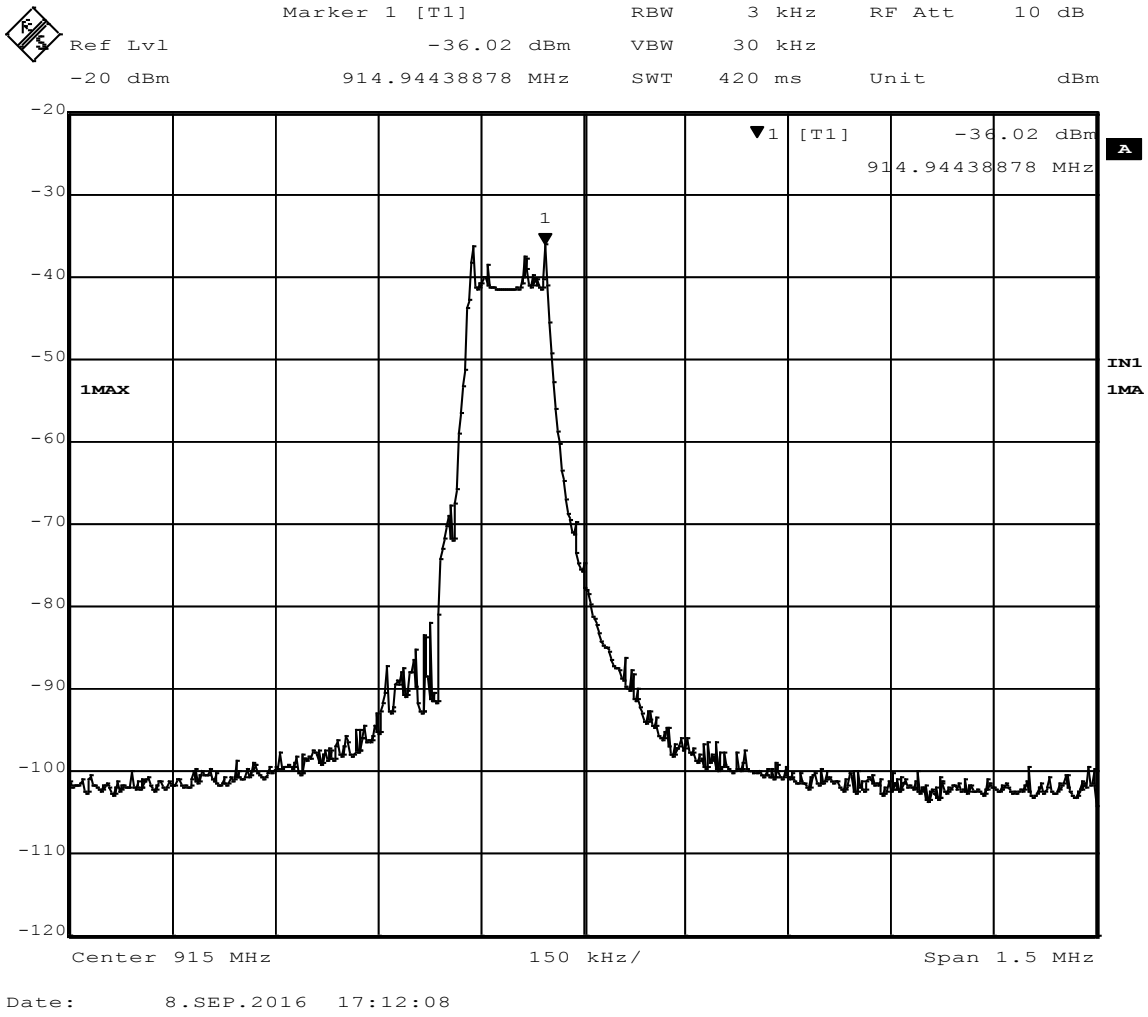


Figure 14 - Power Spectral Density Measurement, High Channel

4.7 Carrier frequency separation, Number of hopping channels, Time of Occupancy

4.7.1 Limits for Time of Occupancy

Average time of occupancy on any frequency not to exceed 0.4 seconds

4.7.2 Test procedures

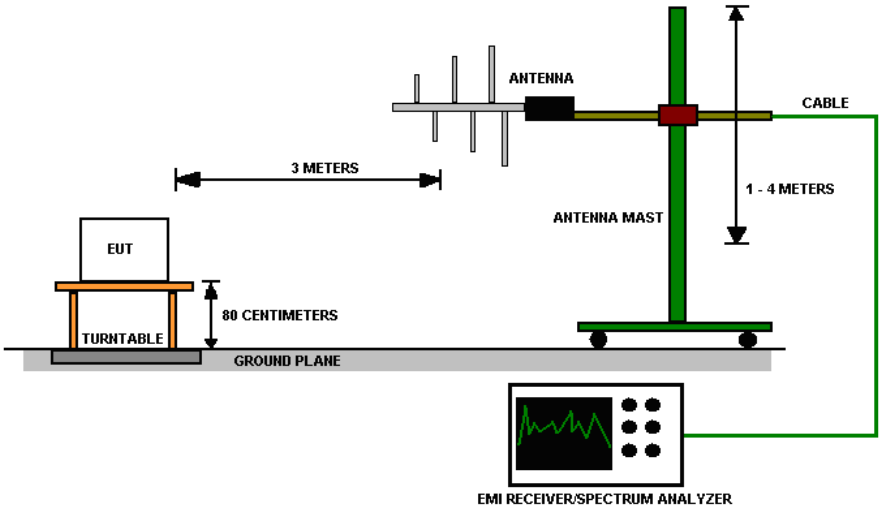
The method from ANSI C63.10 Section 7.7.2, 7.7.3 and 7.7.4 were used.

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 10 kHz RBW and 30 kHz VBW.

4.7.3 Deviations from test standard

No deviation.

4.7.4 Test setup



4.7.5 EUT operating conditions

The EUT was powered by 1.5 VDC (1 x AA BATTERY) unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.7.6 Test results

EUT MODULE	SenseTag	MODE	Continuous Hop
INPUT POWER	1.5 VDC (AA BATTERY)	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

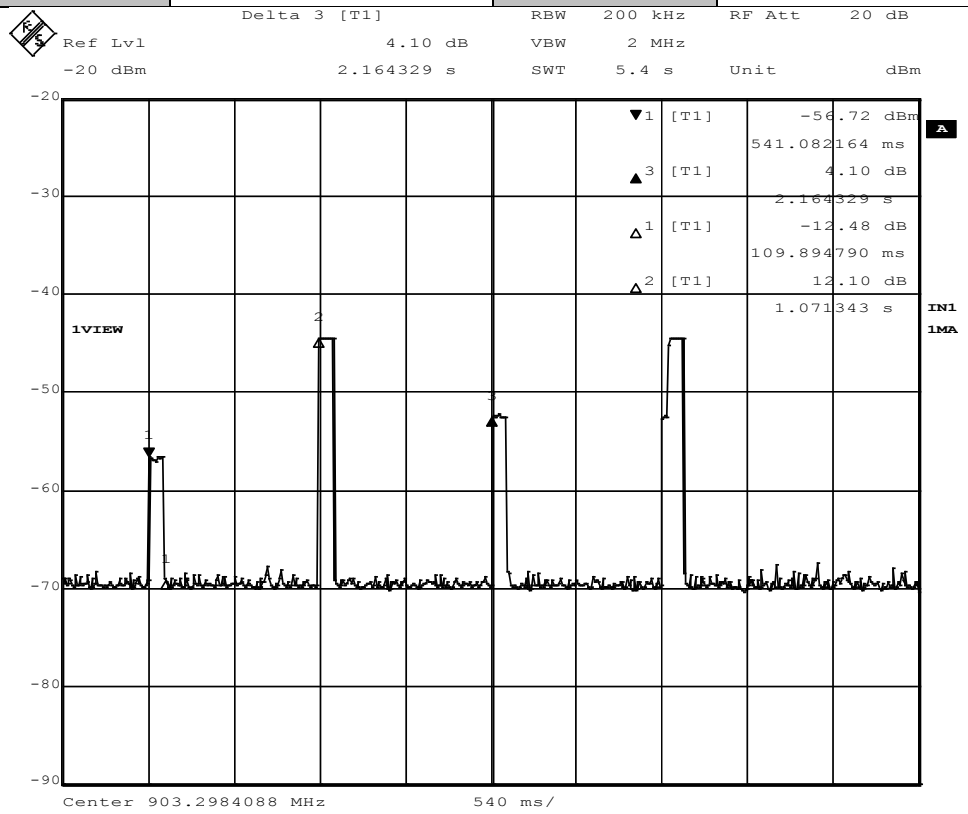


Figure 15 – Time of Occupancy (109.98 ms per Hop - Pass)

Max = 0.4 sec

Frequency Separation

Block	Block FREQ (MHz)	Hop 1 -2 Seperation (kHz)	Hop 2-3 Seperation (kHz)	Hop 3-4 Seperation (kHz)	Hop 4-5 Seperation (kHz)	Hop 5-6 Seperation (kHz)	Hop 6-7 Seperation (kHz)	Hop 7-8 Seperation (kHz)
A	902.3-903.7	200.40	200.40	200.40	204.40	200.40	200.40	200.40
B	903.9-905.3	200.40	200.40	200.40	196.40	200.40	200.40	200.40
C	905.5-906.9	200.40	200.40	200.40	205.41	200.40	200.40	200.40
D	907.1-908.5	200.40	200.40	200.40	195.40	200.40	200.40	200.40
E	908.7-910.1	202.80	198.40	202.80	193.98	202.80	198.40	202.80
F	910.3-911.7	200.40	200.40	200.40	200.40	200.40	200.40	200.40
G	911.9-913.3	202.80	201.20	200.40	197.60	202.80	201.20	200.40
H	913.5-914.9	202.80	198.40	202.80	198.40	202.80	198.40	202.80

Frequency Block	Channel	Frequency in MHz		Frequency Block	Channel	Frequency in MHz
Block A	0	902.3		Block E	32	908.7
	1	902.5			33	908.9
	2	902.7			34	909.1
	3	902.9			35	909.3
	4	903.1			36	909.5
	5	903.3			37	909.7
	6	903.5			38	909.9
	7	903.7			39	910.1
Block B	8	903.9		Block F	40	910.3
	9	904.1			41	910.5
	10	904.3			42	910.7
	11	904.5			43	910.9
	12	904.7			44	911.1
	13	904.9			45	911.3
	14	905.1			46	911.5
	15	905.3			47	911.7
Block C	16	905.5		Block E	48	911.9
	17	905.7			49	912.1
	18	905.9			50	912.3
	19	906.1			51	912.5
	20	906.3			52	912.7
	21	906.5			53	912.9
	22	906.7			54	913.1
	23	906.9			55	913.3
Block D	24	907.1		Block F	56	913.5
	25	907.3			57	913.7
	26	907.5			58	913.9
	27	907.7			59	914.1
	28	907.9			60	914.3
	29	908.1			61	914.5
	30	908.3			62	914.7
	31	908.5			63	914.9

Figure 16 – Frequency Blocks Used

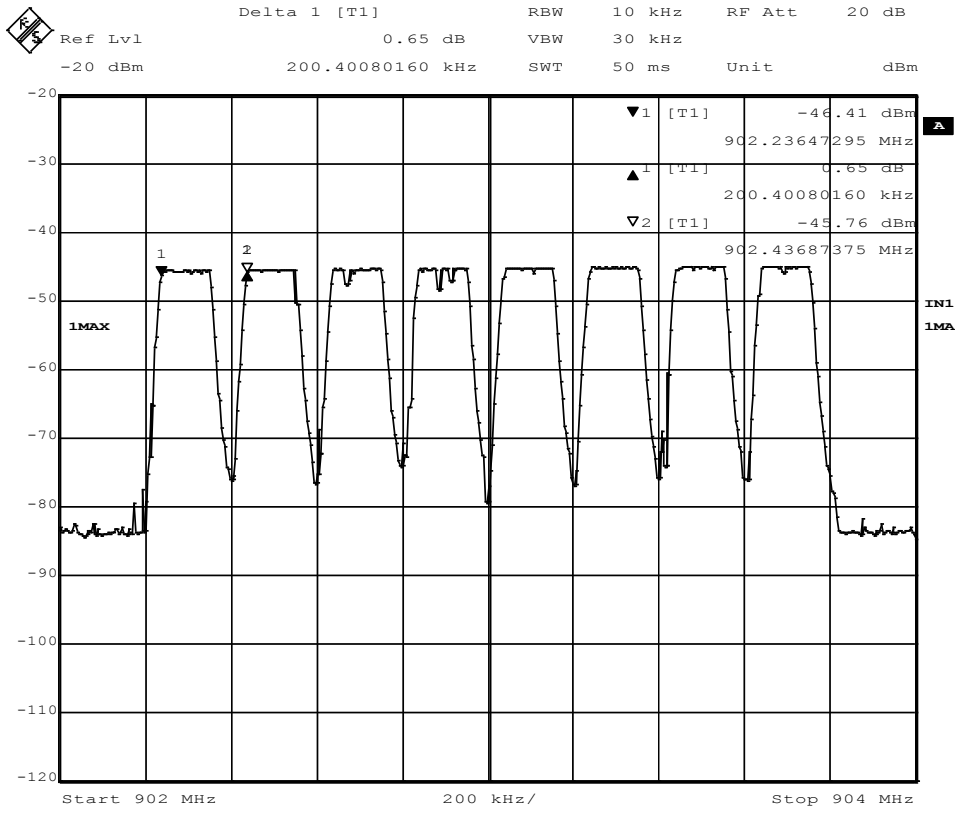


Figure 17 – Number of Hops Block A(8 Hops)

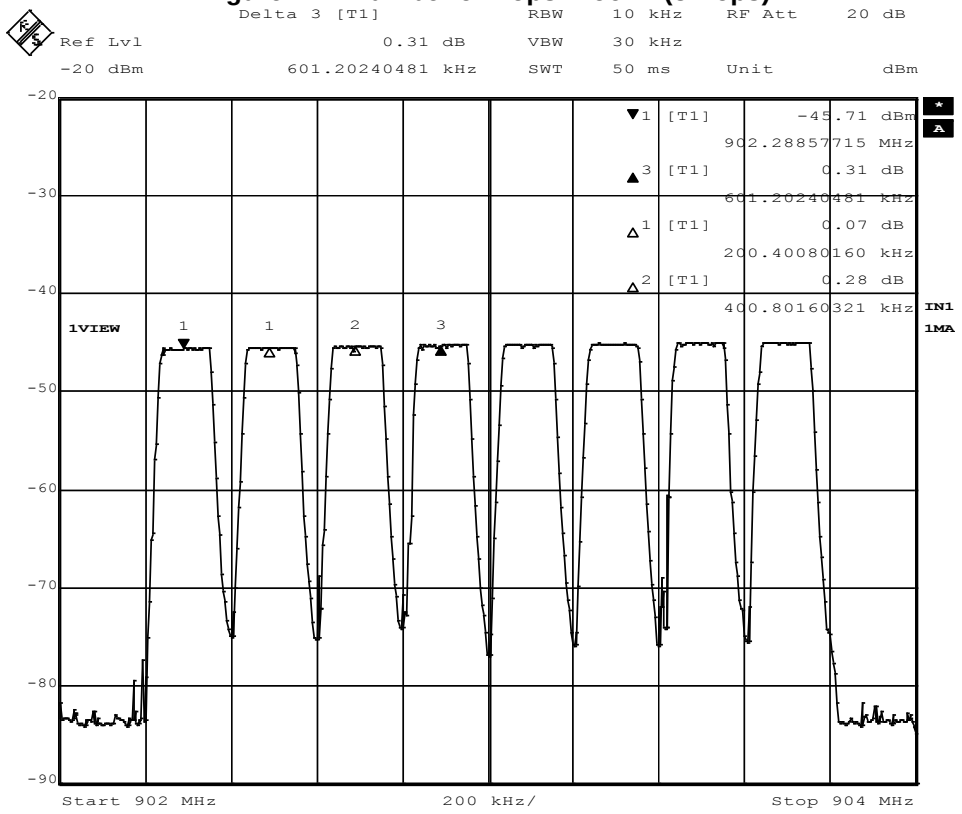


Figure 18 – Hop Separation Block A (1-4)

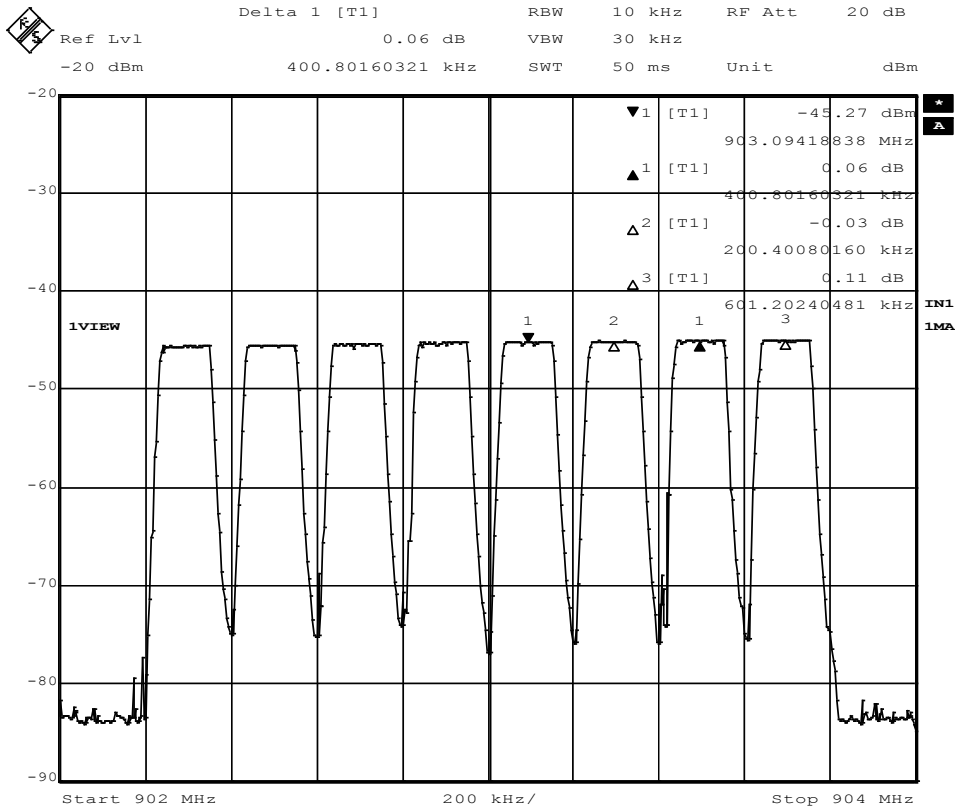


Figure 19 – Hop Separation Block A (4-8)

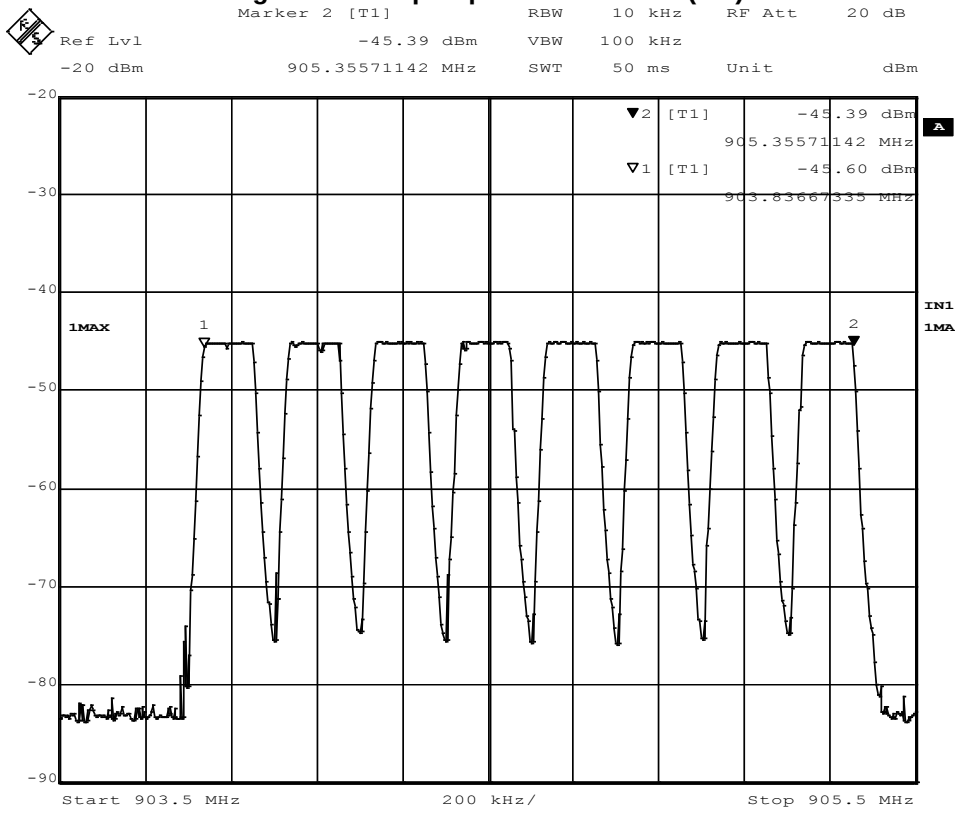


Figure 20 – Number of Hops Block B(8 Hops)

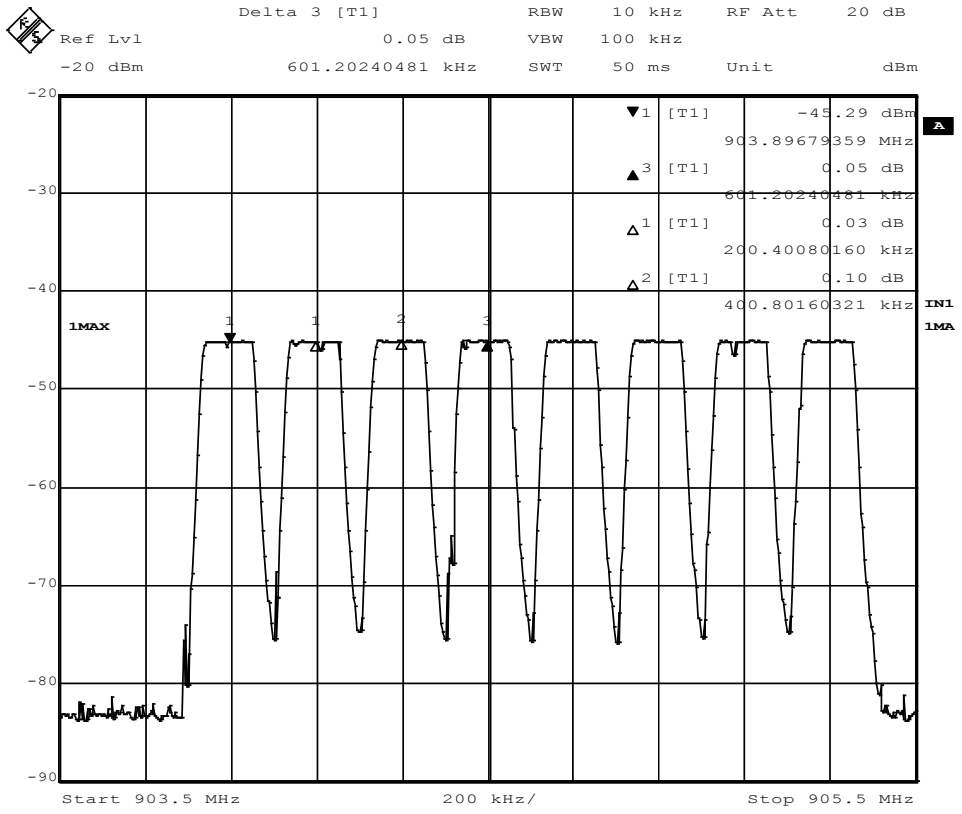


Figure 21 – Hop Separation Block B (1-4)

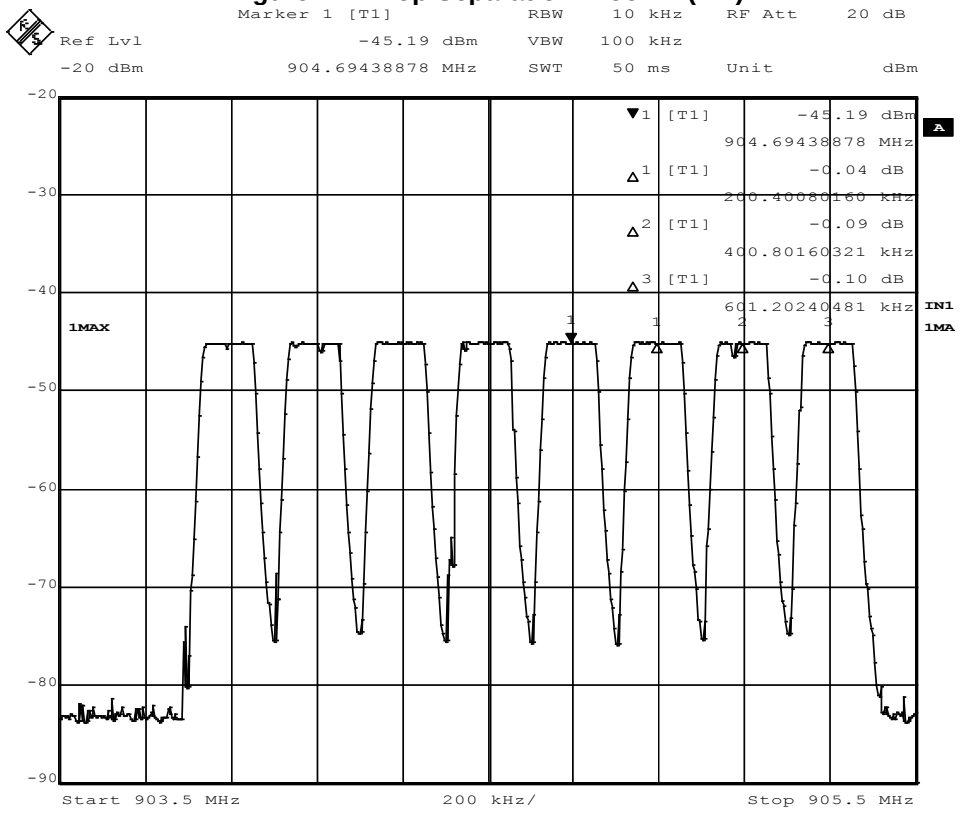


Figure 22 – Hop Separation Block B (4-8)

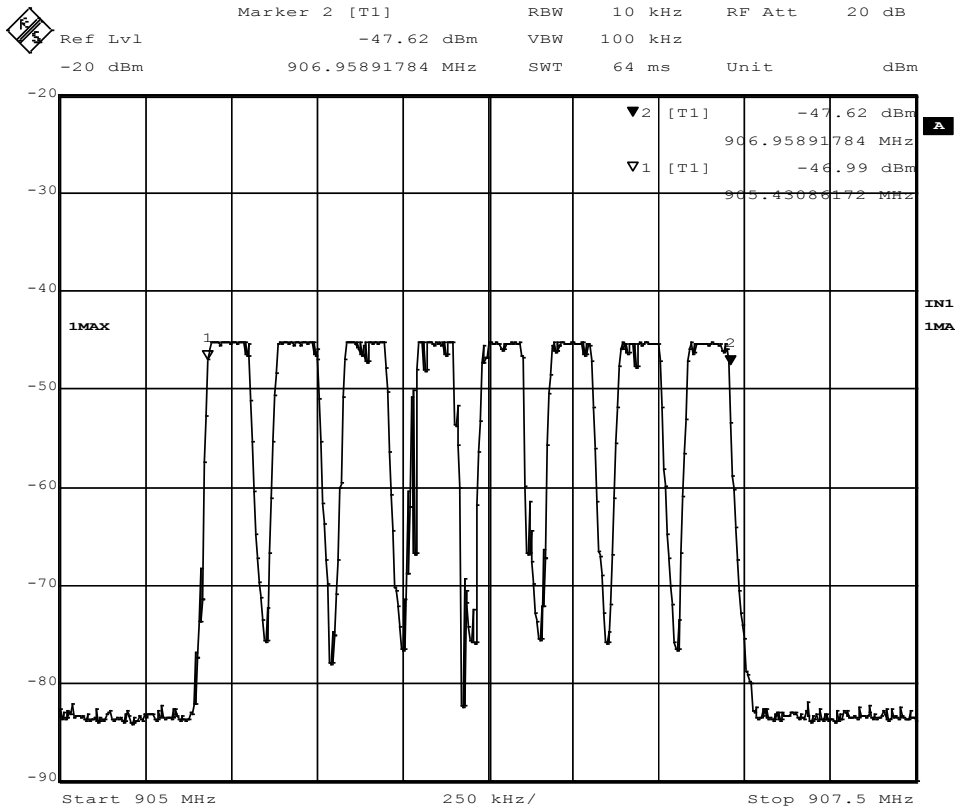


Figure 23 – Number of Hops Block C (8 Hops)

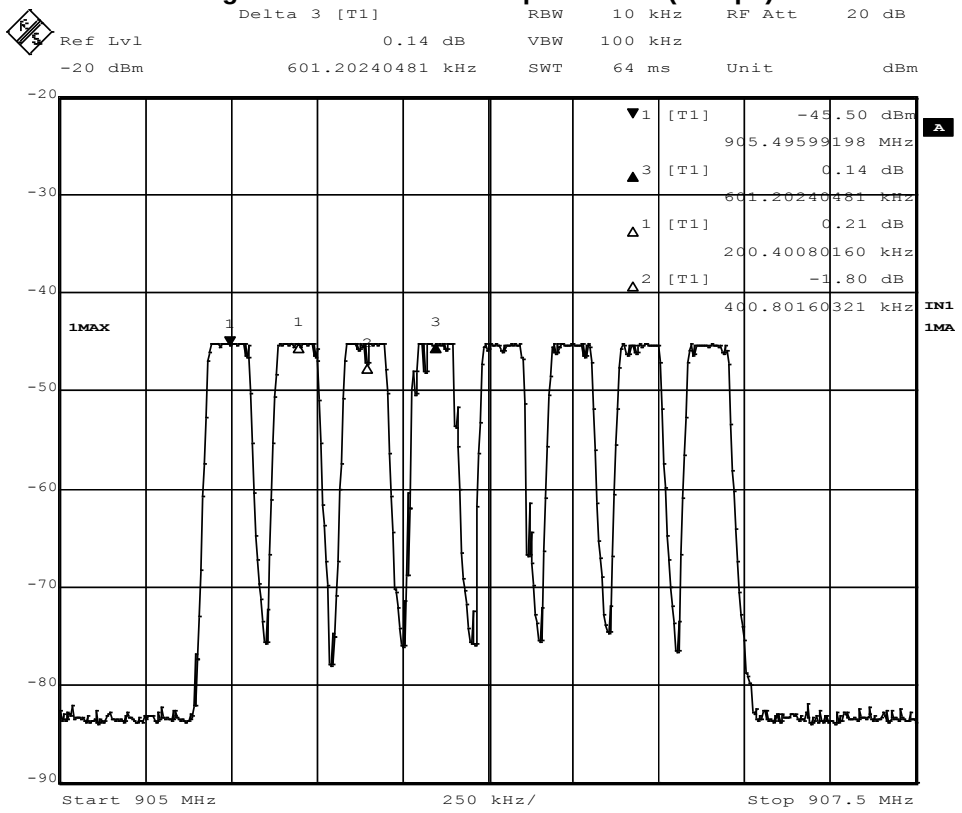


Figure 24 – Hop Separation Block C (1-4)

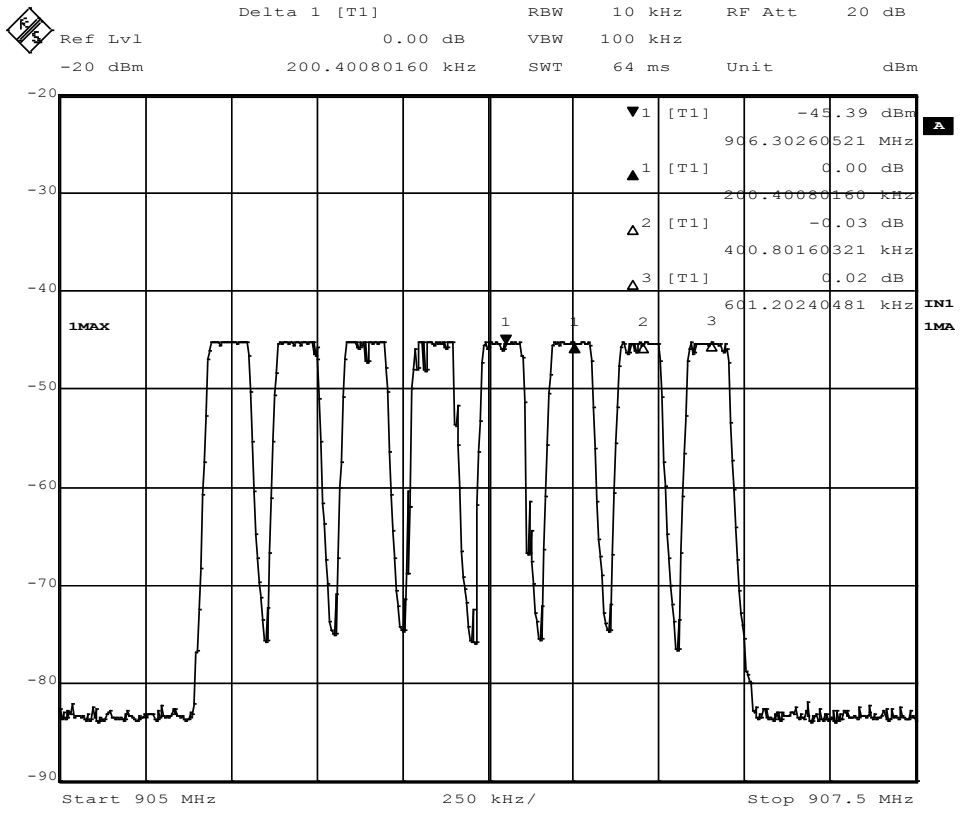


Figure 25 – Hop Separation Block C (4-8)

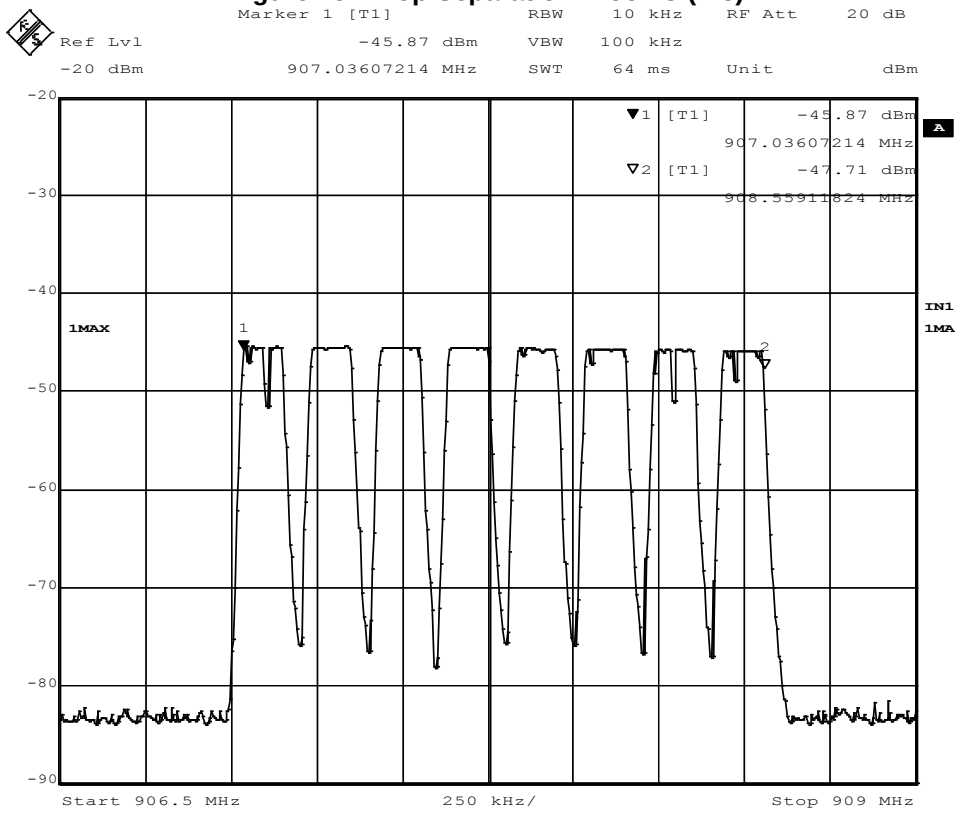


Figure 26 – Number of Hops Block D (8 Hops)

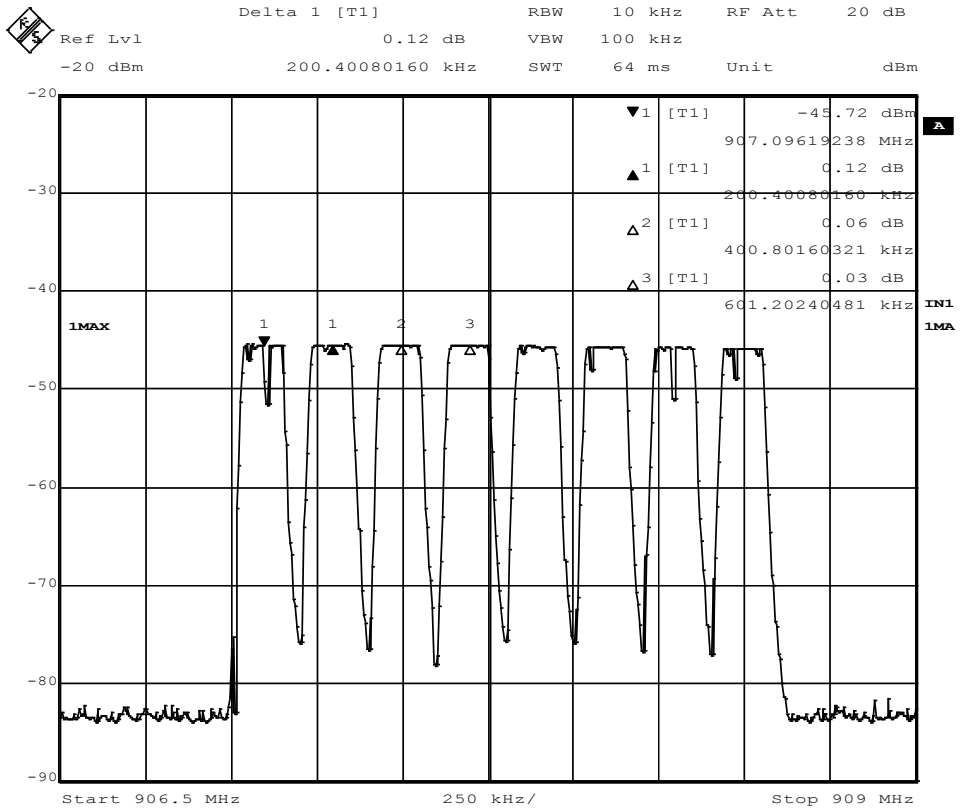


Figure 27 – Hop Separation Block D (1-4)

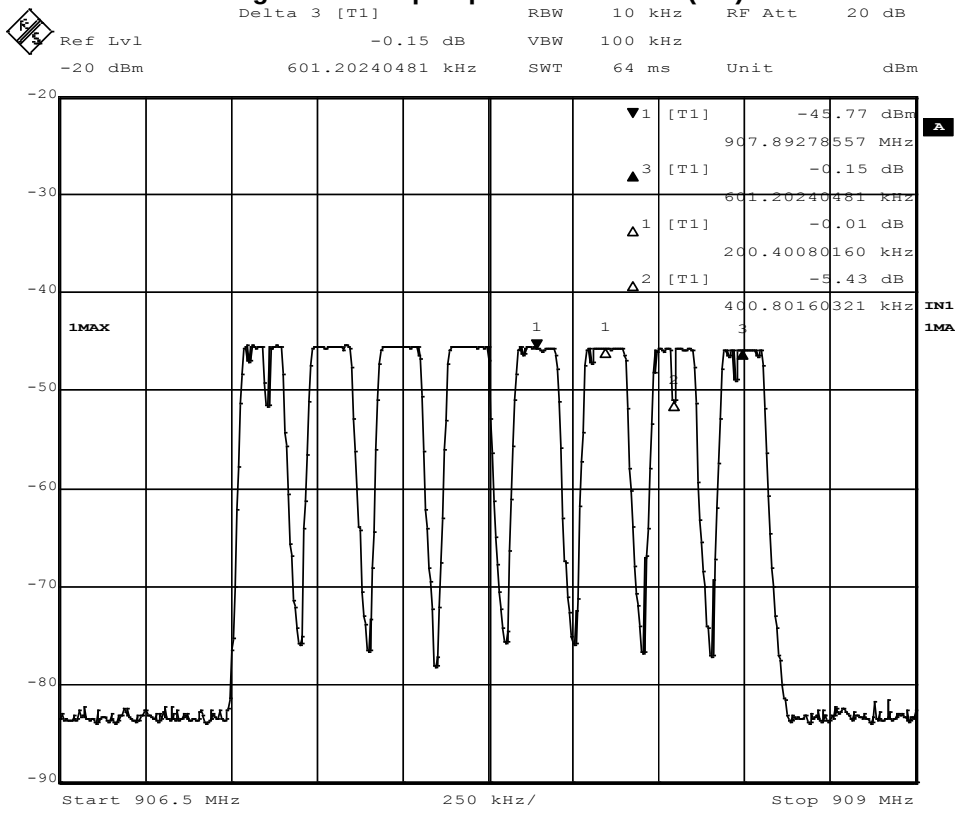


Figure 28 – Hop Separation Block D (4-8)

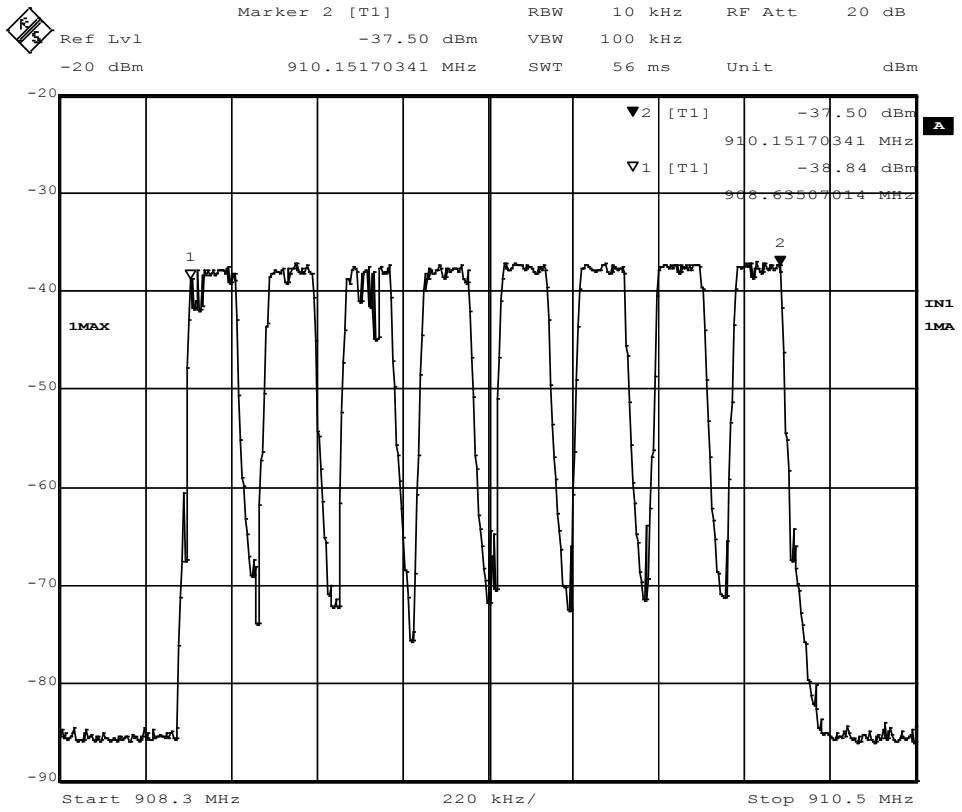


Figure 29 – Number of Hops Block E (8 Hops)

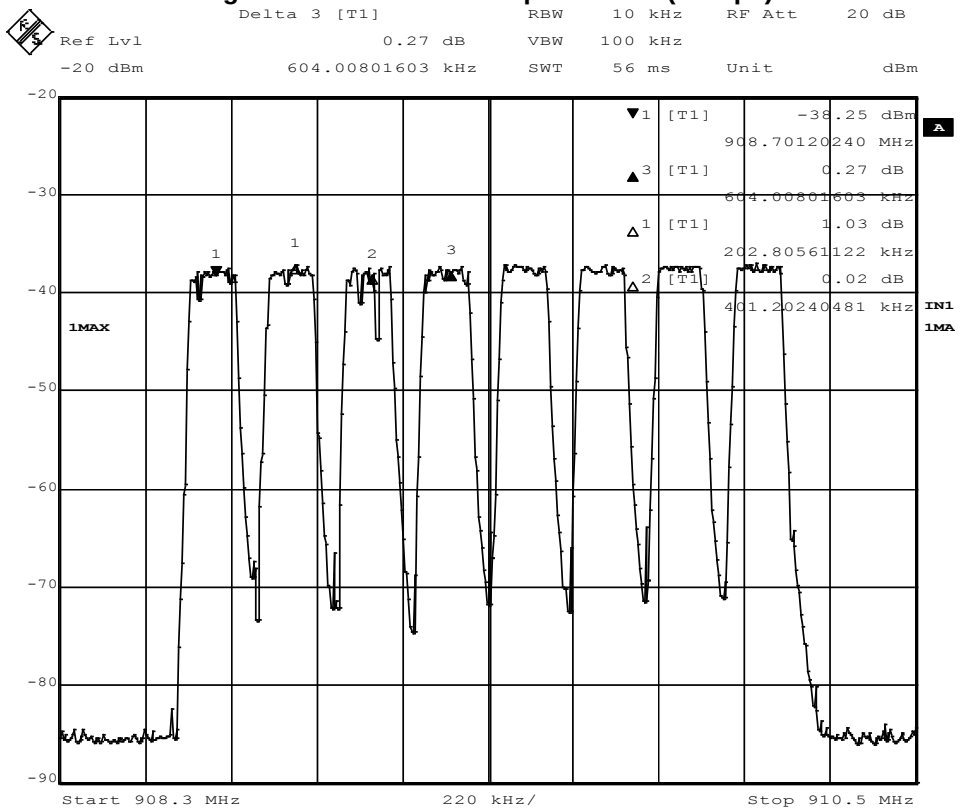


Figure 30 – Hop Separation Block E (1-4)

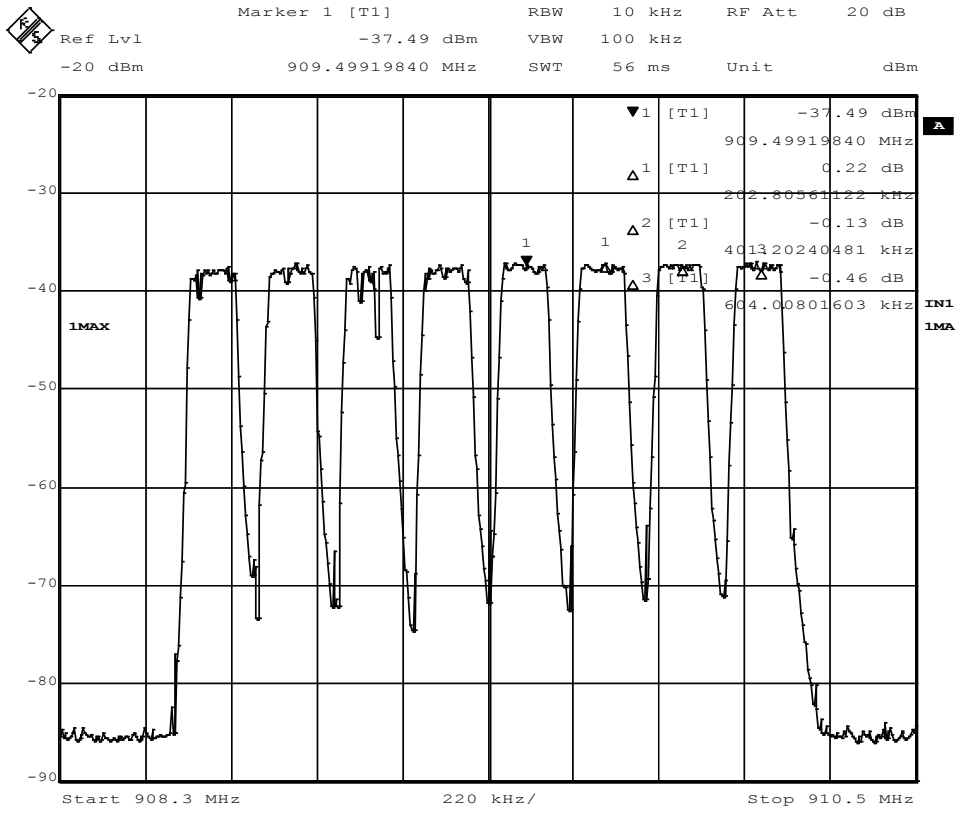


Figure 31 – Hop Separation Block E (4-8)

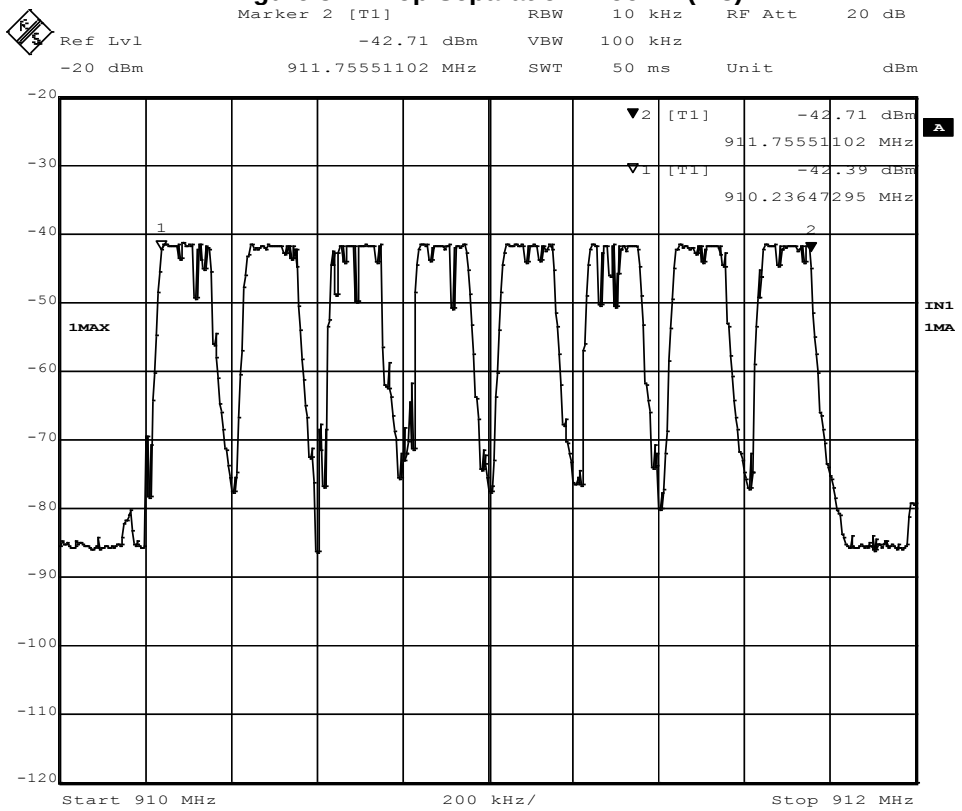


Figure 32 – Number of Hops Block F (8 Hops)

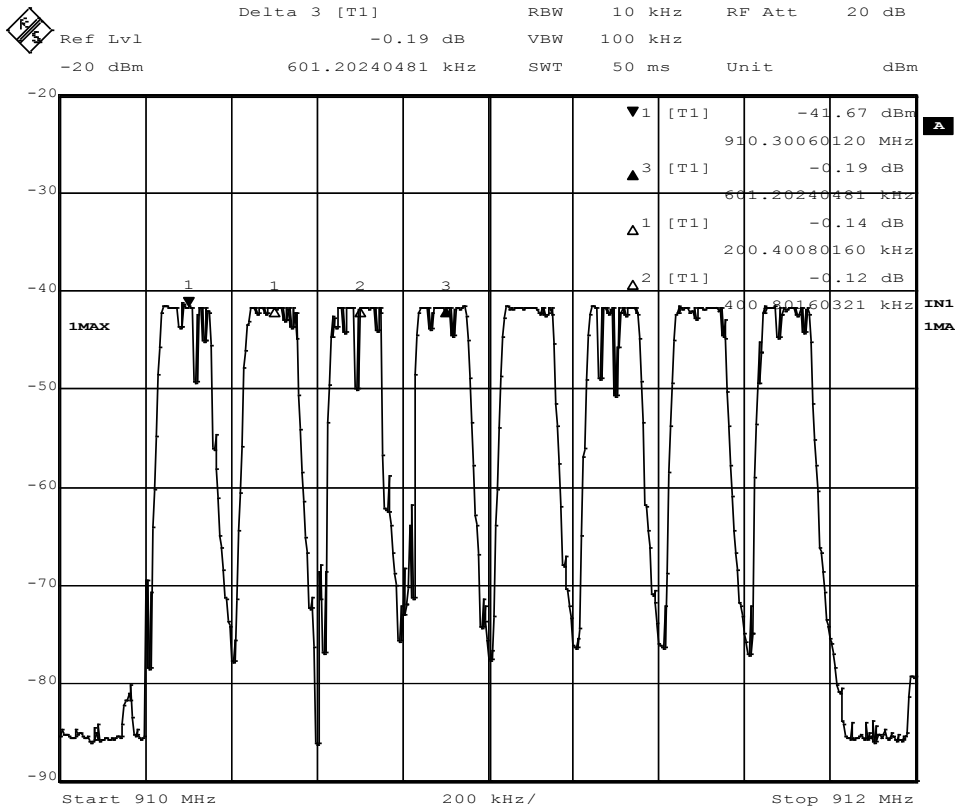


Figure 33 – Hop Separation Block F (1-4)

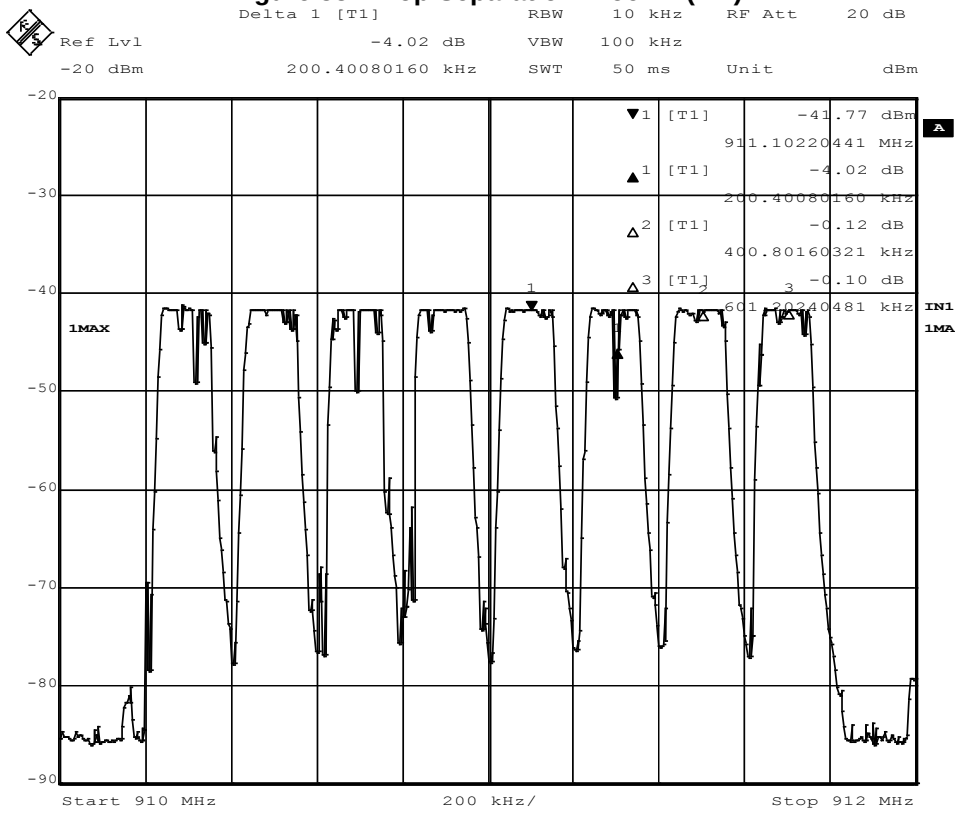


Figure 34 – Hop Separation Block F (4-8)

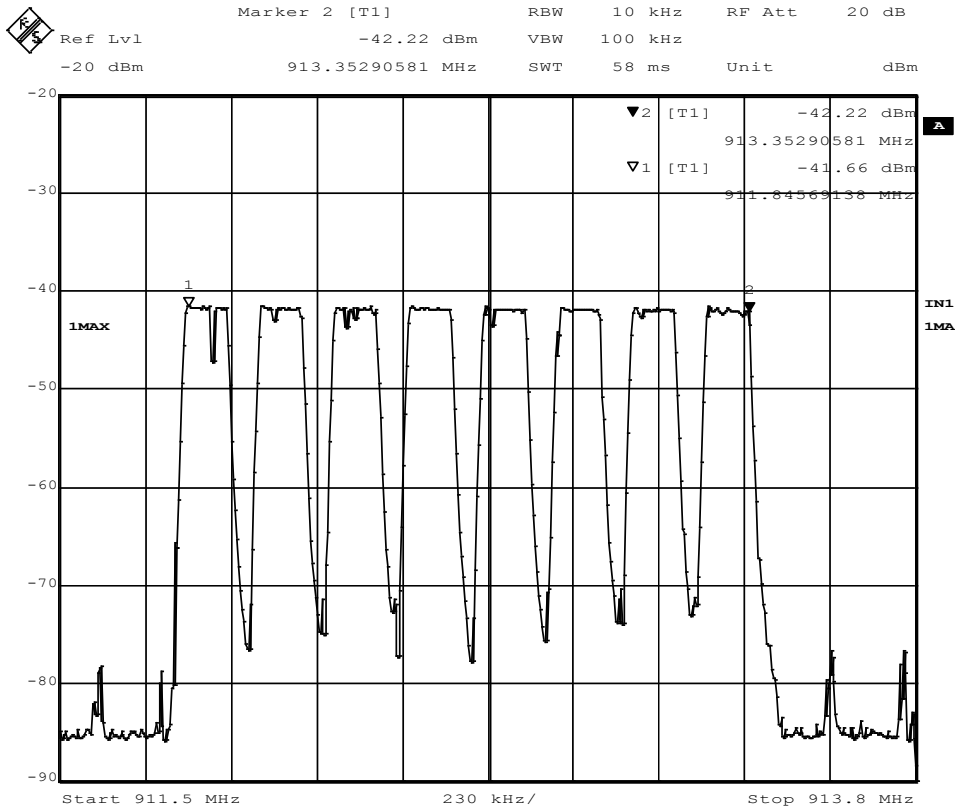


Figure 35 – Number of Hops Block G (8 Hops)

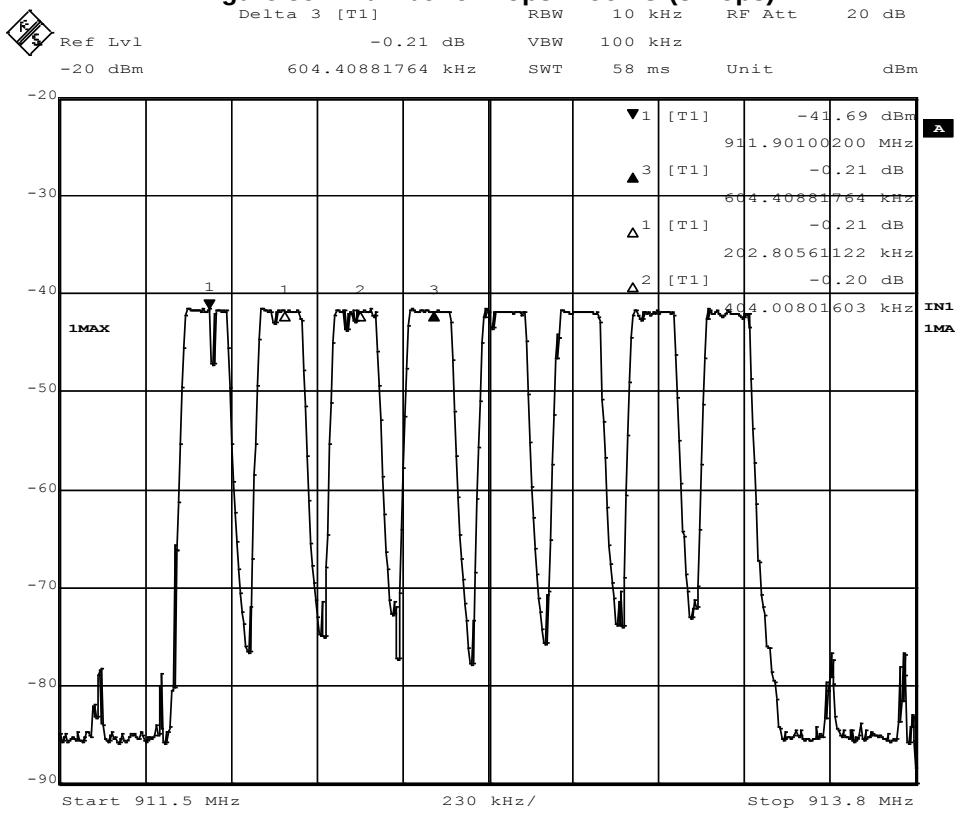


Figure 36 – Hop Separation Block G (1-4)

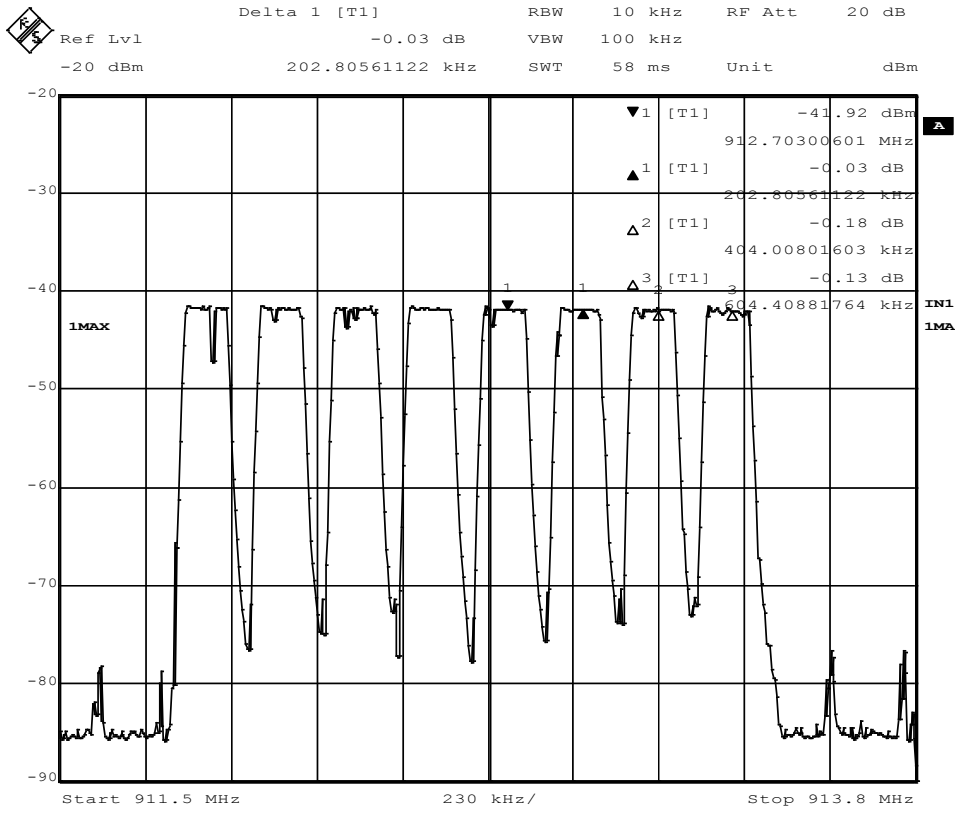


Figure 37 – Hop Separation Block G (4-8)

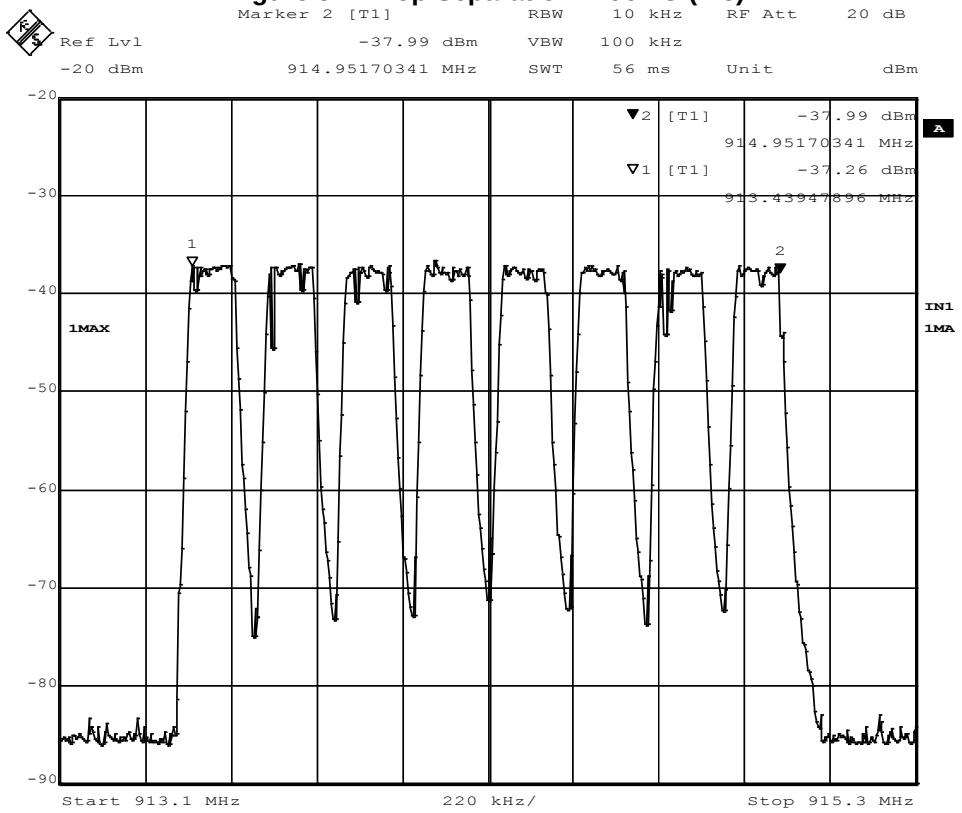


Figure 38 – Number of Hops Block H (8 Hops)

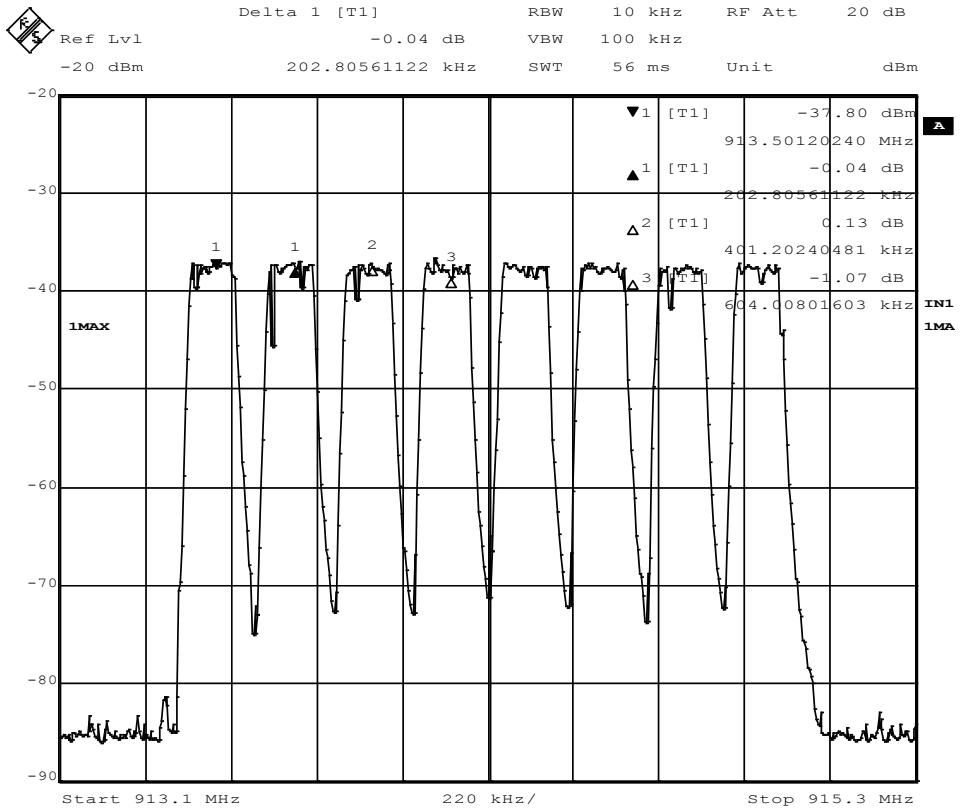


Figure 39 – Hop Separation Block H (1-4)

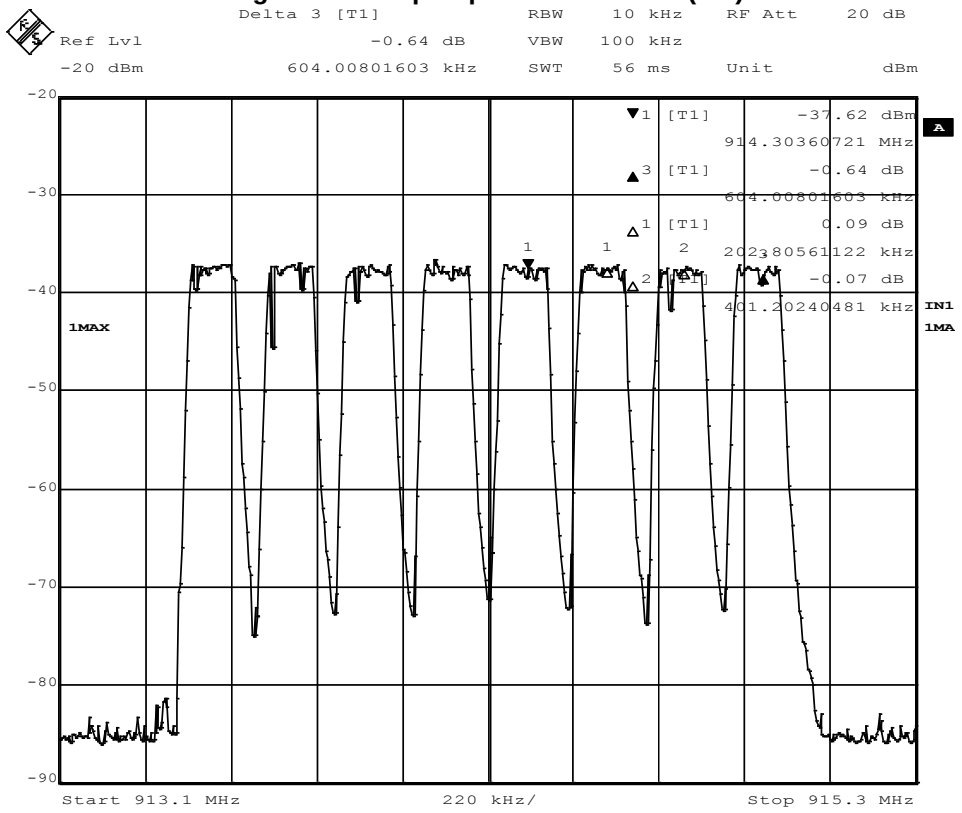


Figure 40 – Hop Separation Block H (4-8)

Appendix A: Test Photos

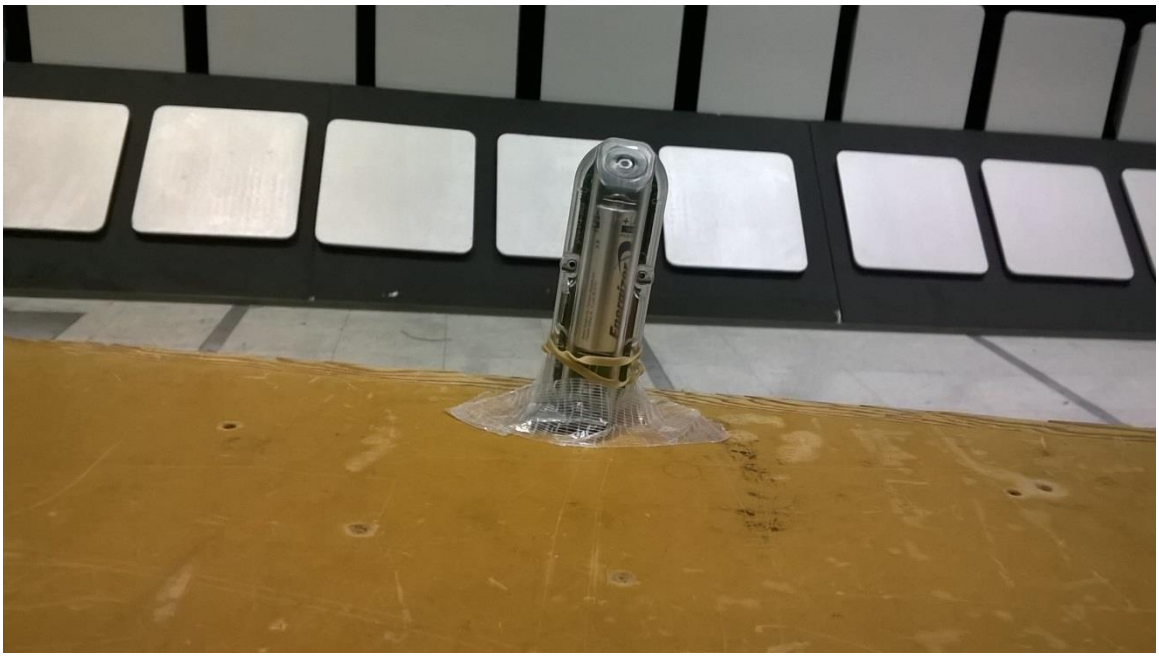


Figure 41 – Radiated Emissions Test Setup, Vertical, 30MHz – 1GHz

Figure 42 - Radiated Emissions Test Setup, Vertical, 30MHz – 1GHz

Figure 43 – Radiated Emissions Test Setup, Y-axis, 30MHz – 1GHz

Figure 44 - Radiated Emissions Test Setup, Z-axis, 30MHz – 1GHz

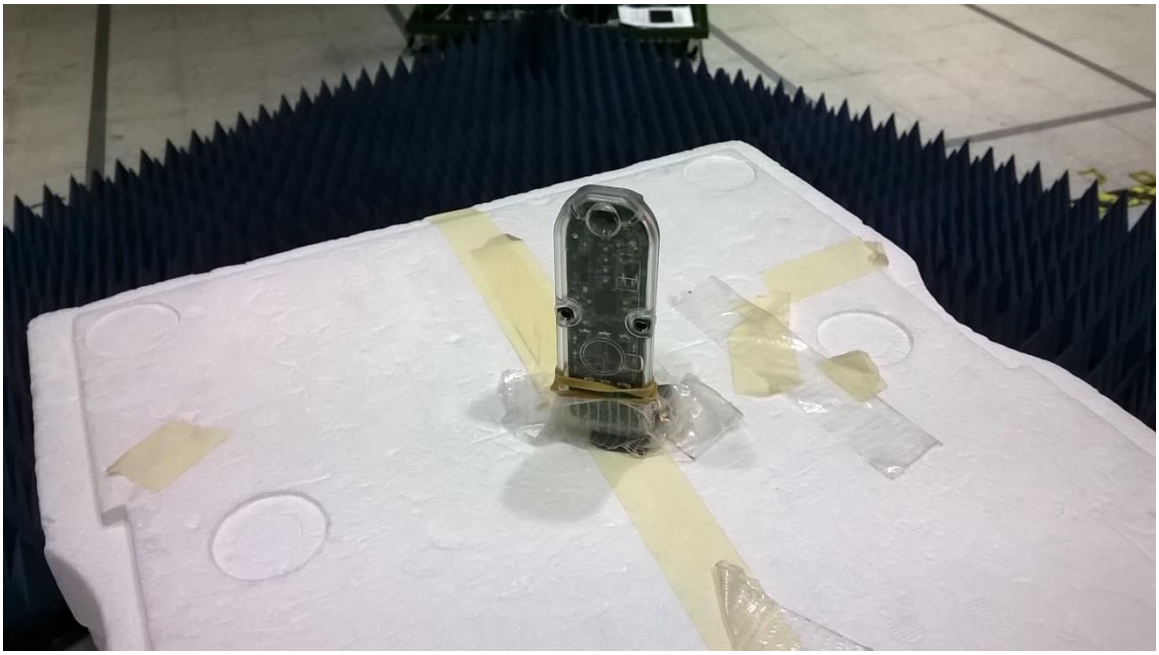


Figure 45 - Radiated Emissions Test Setup, X-axis, 1GHz – 25GHz

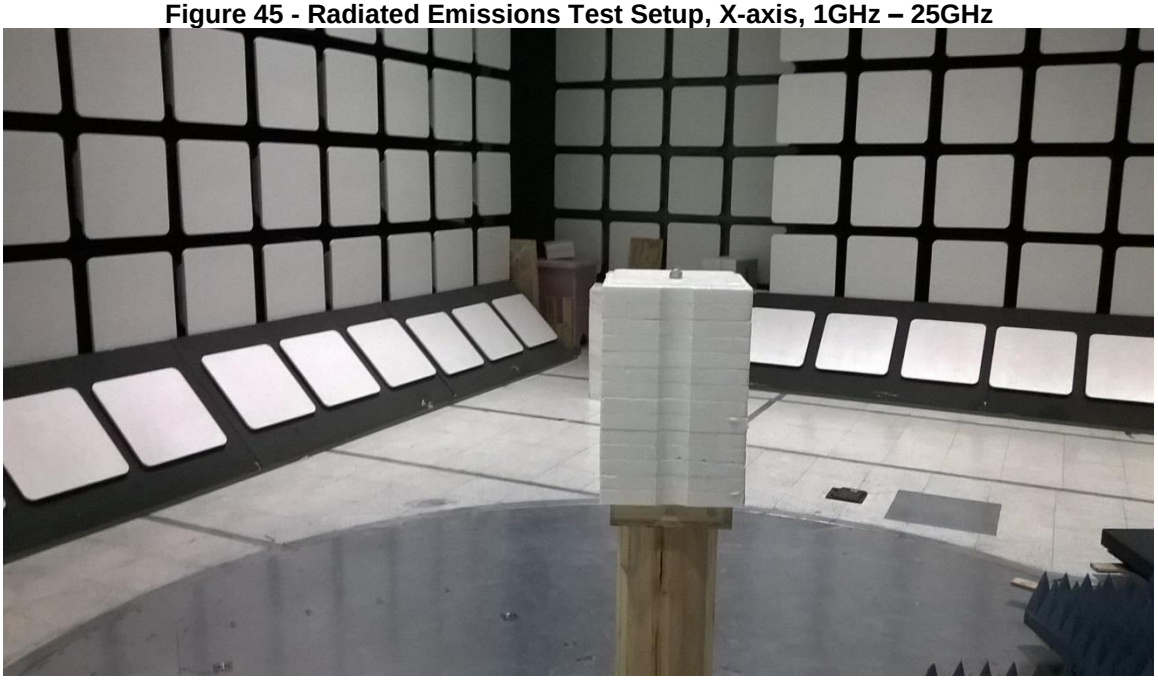


Figure 46 - Radiated Emissions Test Setup, Y-axis, 1GHz – 25GHz

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%.