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Amended

FCC/ISED Test Report

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

Product: **SenseTag**

Test Report No: **R20190919-20-E1A**

Approved By:

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

DATE: **14 May 2020**

Total Pages: **57**

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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 5, Section 8.3	Unique Antenna Requirement	Pass	Meets the requirement
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	NA	Meets the requirement
FCC Part 15.209 RSS-Gen Issue 5, 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 2 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 2 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 2 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 2 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 2 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 2, Section 5.3	Carrier frequency separation, number of hopping channels, Time of Occupancy	Pass	Meets the requirement

2.0 Description

2.1 Equipment under test

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

EUT Received Date: 20 September 2019
EUT Tested Dates:
20 September 2019 – 26 February 2020
10 August 2016 – 12 September 2016 (Section 4.7)

PRODUCT	SenseTag
MODEL	QAG
SERIAL NUMBER	09190002
POWER SUPPLY	1.5 VDC (AAA 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
Lowest	902.3
Middle	908.6
High	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 5**
5. **Industry Canada RSS-247 Issue 2**

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
Software Version 1.60	ESK-1	2575	N/A	N/A
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2020*****
Keysight MXE Signal Analyzer	N9038A	MY59050109	23 Apr 2019	23 Apr 2021
Keysight EXA Signal Analyzer	N9010A	MY56070862	14 Dec 2018	14 Dec 2020
SunAR RF Motion	JB1	A082918-1	15 Oct 2018	15 Oct 2020
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	25 Jul 2019	25 Jul 2020
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*
Mini Circuits 1700 – 5000Mhz High Pass Filter***	15542	31618	09 Mar 2018*	09 Mar 2020*

*Internal Characterization
**Used for radiated measurements above 1GHz
***Used for measurements from 1 GHz - 6GHz
****Used for measurements above 3 GHz
*****No measurements were performed with this instrument after the calibration due date

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 both the horizontal and vertical orientation. 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

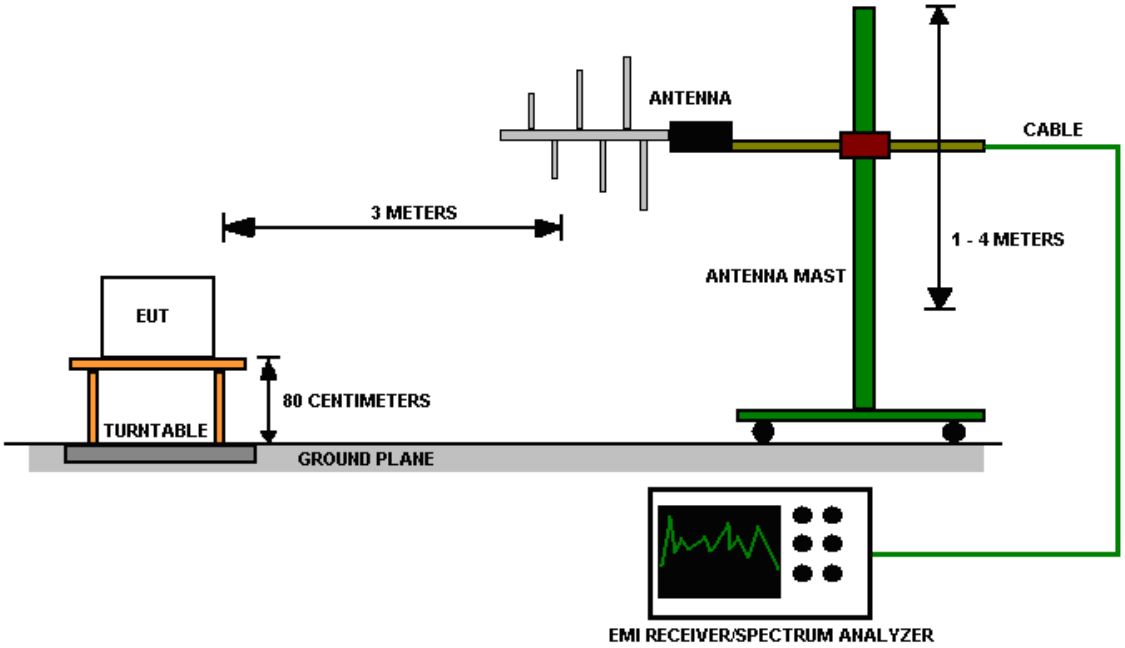


Figure 1 - Radiated Emissions Test Setup

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

4.2.6 Test results

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

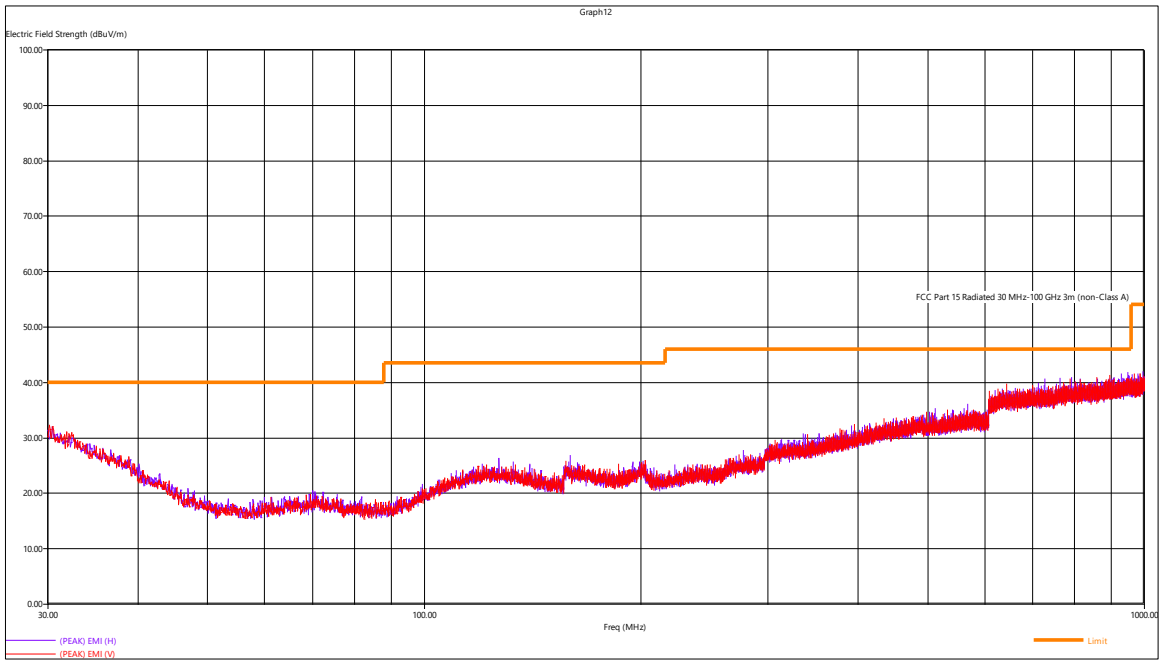


Figure 2 - Radiated Emissions Plot, Receive

All the measurements were found to be at least 6dB below the limit.

EUT MODULE	SenseTag	MODE	Channel 4
INPUT POWER	1.5 VDC (AAA Battery)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

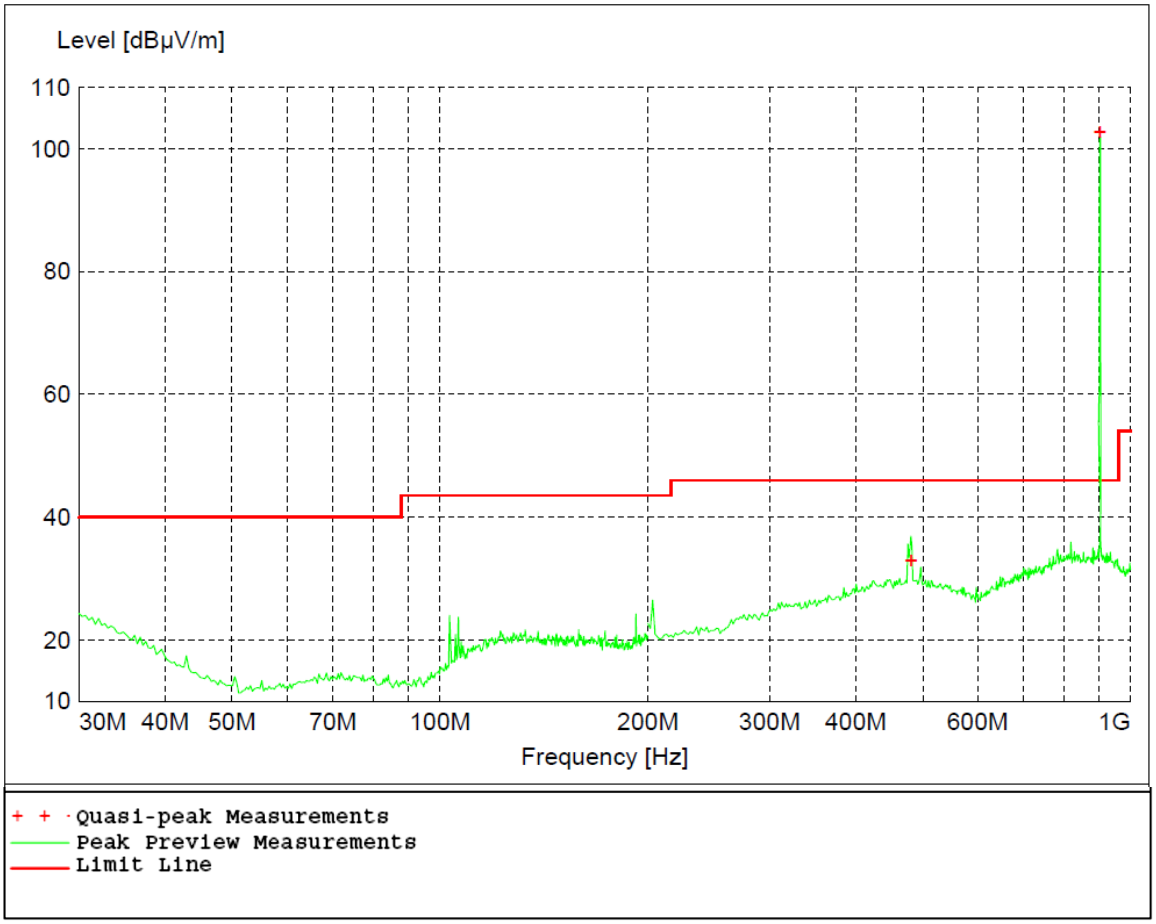


Figure 3 - Radiated Emissions Plot, Lowest Channel

Table 1 - Radiated Emissions Quasi-peak Measurements, Channel 4

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
481.20	33.05	46.00	12.90	103.00	277.00	V
902.28	102.80	N/A	N/A	200.00	322.00	H

Table 2 - Radiated Emissions Peak Measurements vs Average Limit, Channel 4

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1803.73	36.55	53.98	17.43	169.00	358.00	H
2437.74	44.50	53.98	9.48	126.00	134.00	V
2705.50	36.73	53.98	17.25	160.00	196.00	H
7218.50	52.24	53.98	1.74	200.00	33.00	V
8121.00*	56.70	73.98	17.28	199.00	282.00	V
9023.00	50.68	53.98	3.30	399.00	359.00	V

*Peak limit is compared for this frequency. Average measurement shown in table below.

Table 3 - Radiated Emissions Average Measurements, Channel 4

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
8121.00	51.73	53.98	2.25	389	0	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	SenseTag	MODE	Channel 5
INPUT POWER	1.5 VDC (AAA Battery)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

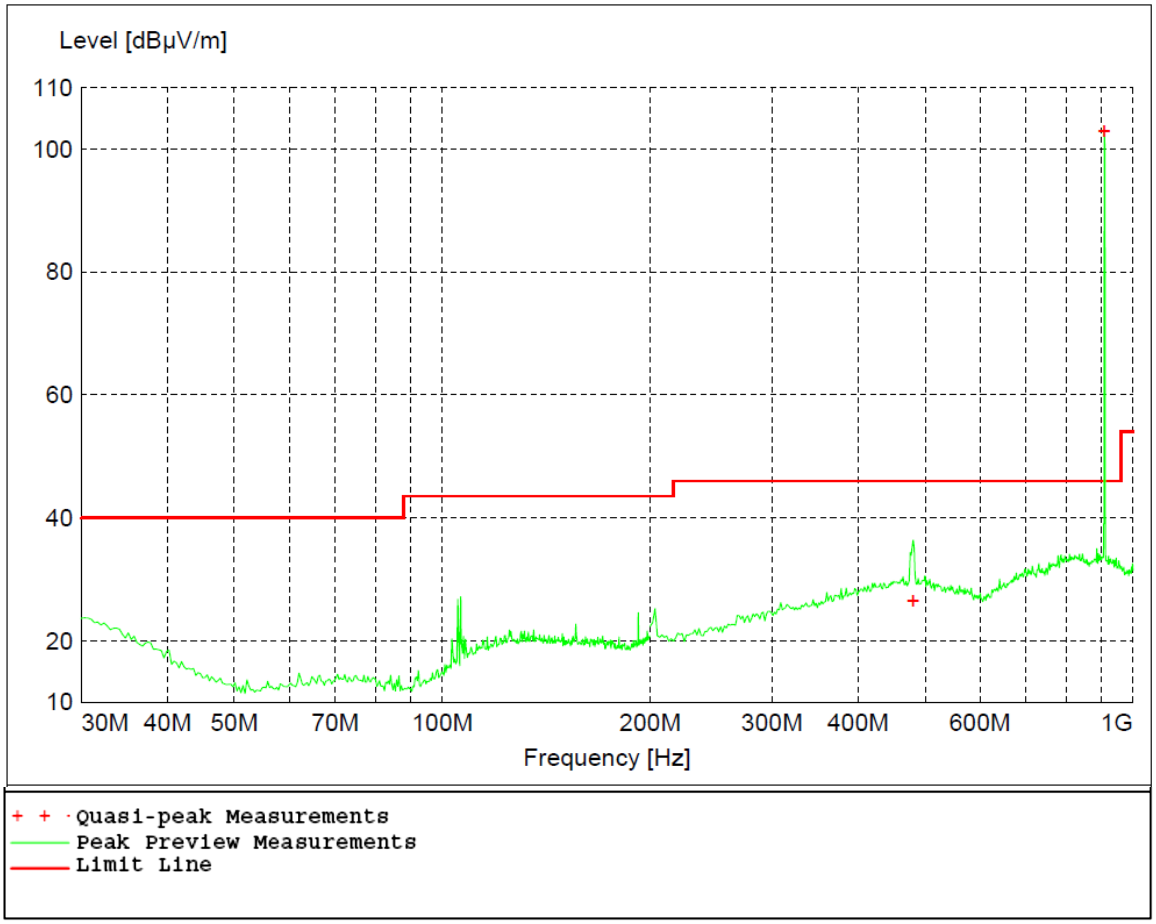


Figure 4 - Radiated Emissions Plot, Middle Channel

Table 4 - Radiated Emissions Quasi-peak Measurements, Channel 5

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
480.90	26.57	46.00	19.40	101.00	2.00	V
908.64	102.98	NA	NA	200.00	322.00	H

Table 5 - Radiated Emissions Peak Measurements, Channel 5

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1880.00	48.84	73.98	25.14	98	299	VERT
2725.80	47.02	73.98	26.96	117	218	HORI
3634.40	49.85	73.98	24.13	190	226	VERT
4543.20	45.98	73.98	28.00	126	197	HORI
6359.80	50.73	73.98	23.25	224	263	VERT
7268.60	58.09	73.98	15.89	126	41	VERT
8177.60	59.16	73.98	14.82	100	330	VERT
9085.80	59.23	73.98	14.75	224	314	VERT

Table 6 - Radiated Emissions Average Measurements, Channel 5

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1880.00	41.58	53.98	12.40	98	299	VERT
2725.80	42.08	53.98	11.90	117	218	HORI
3634.40	44.84	53.98	9.14	190	226	VERT
4543.20	32.76	53.98	21.22	126	197	HORI
6359.80	43.49	53.98	10.49	224	263	VERT
7268.60	52.39	53.98	1.59	126	41	VERT
8177.00	50.39	53.98	3.59	278	290	VERT
9085.80	51.95	53.98	2.03	224	314	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.

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	Channel 6
INPUT POWER	1.5 VDC (AAA Battery)	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

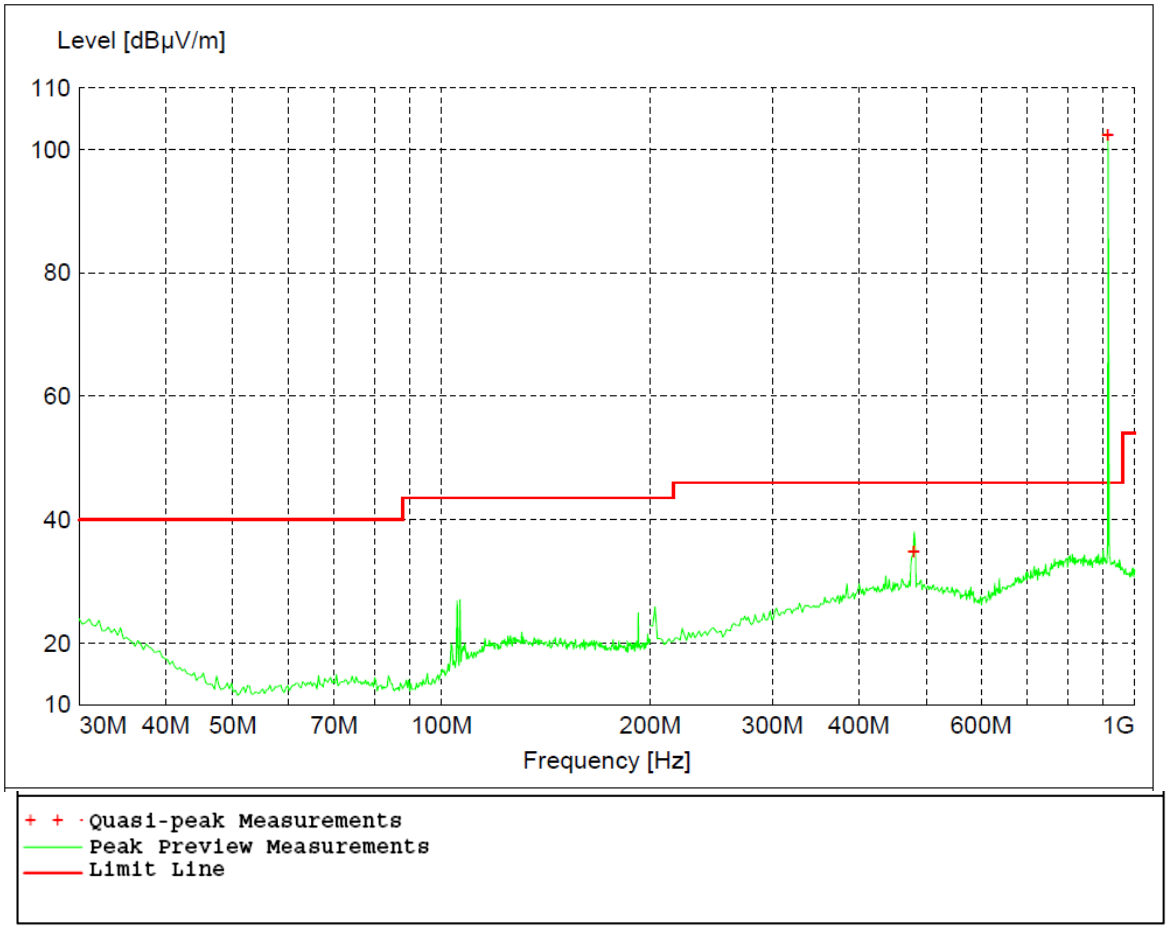


Figure 5 - Radiated Emissions Plot, Highest Channel

Table 7 - Radiated Emissions Quasi-peak Measurements, Channel 6

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
479.76	34.84	46.00	11.20	99.00	88.00	V
914.94	102.48	NA	NA	196.00	327.00	H

*Unrestricted band. Required to be 20dB below fundamental

Table 8 - Radiated Emissions Peak Measurements vs Average Limit, Channel 6

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1830.00	42.47	53.98	11.51	135	359	H
2744.50	45.42	53.98	8.56	178	246	H
4574.50	44.50	53.98	9.48	134	299	V
6404.00	45.37	53.98	8.61	334	99	V
7319.00	47.99	53.98	5.99	104	399	V
8234.00	49.41	53.98	4.57	284	100	V
9149.50	50.72	53.98	3.26	196	200	V

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

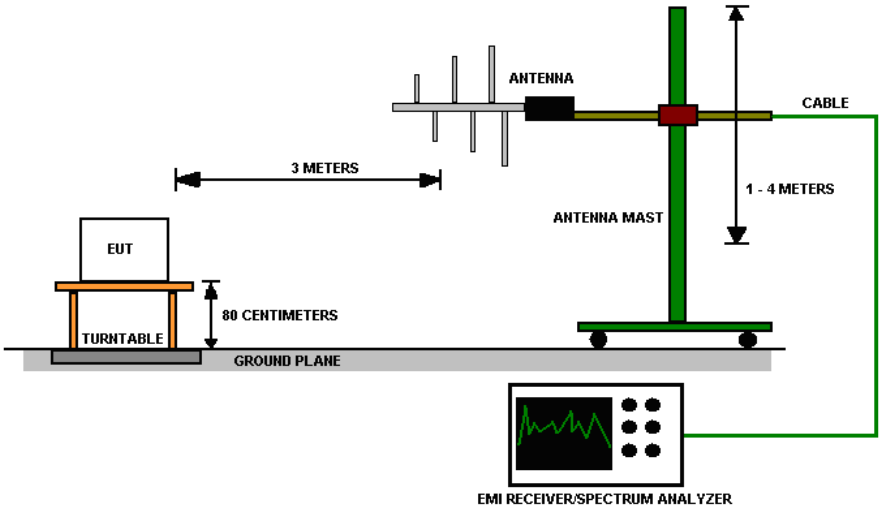
The method from ANSI C63.10, Section 11.8.1 was used.

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 1 MHz VBW.
The 6dB 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 AAA 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 (AAA Battery)	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri, FLane, AInamura

CHANNEL	CHANNEL FREQUENCY (MHz)	6dB BW (kHz)
Lowest	902.3	260.7
Middle	908.6	262.4
Highest	914.9	258.2

REMARKS:
None

CHANNEL	CHANNEL FREQUENCY (kHz)	20 dB and 99% Occupied BW (kHz)
Lowest	902.3	312.23
Middle	908.6	314.35
Highest	914.9	307.88

REMARKS:
None

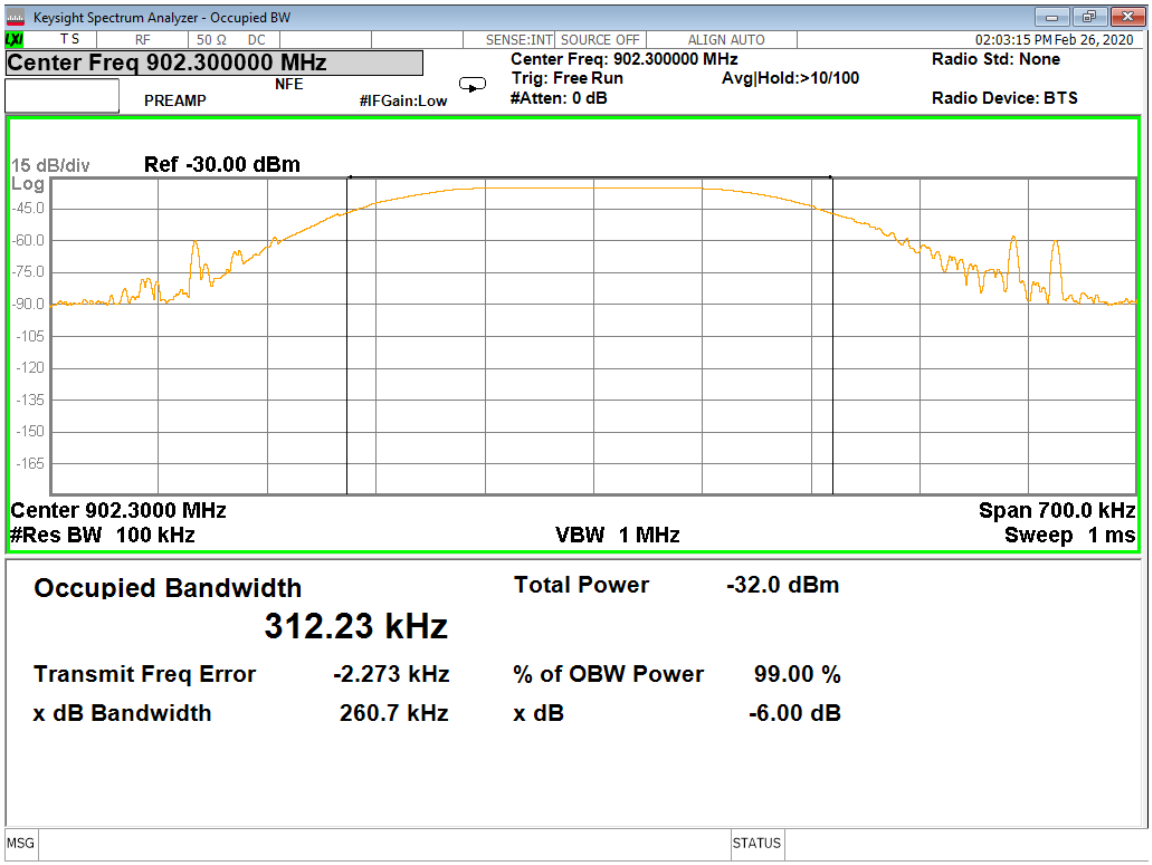


Figure 6 - Bandwidth, Low Channel

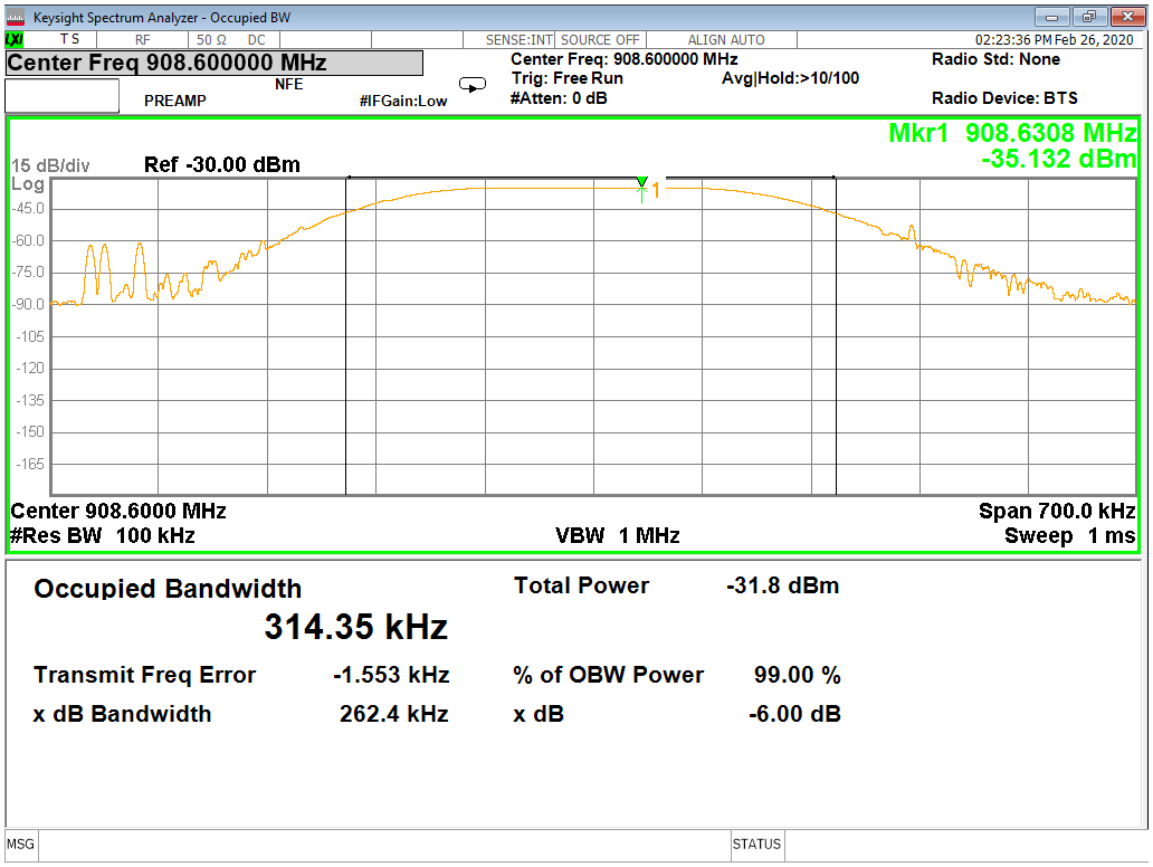


Figure 7 - Bandwidth, Middle Channel

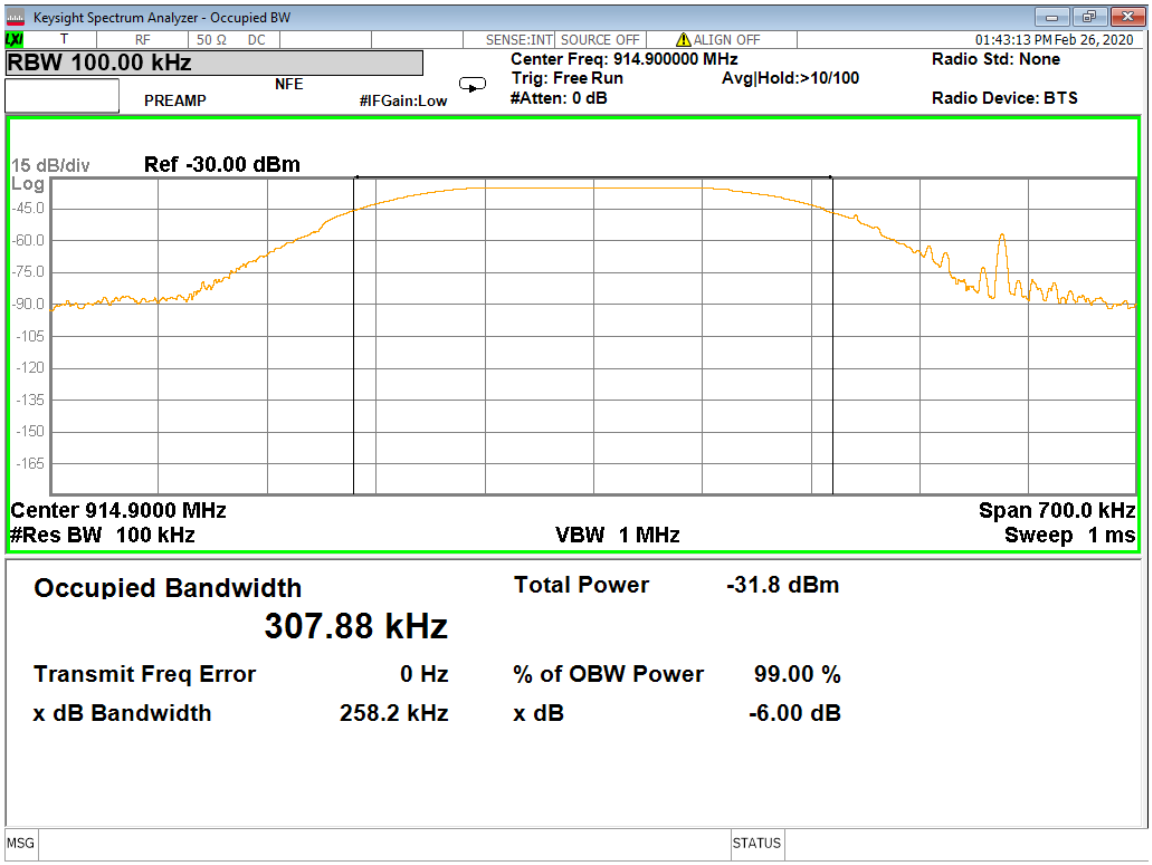


Figure 8 - Bandwidth, High Channel

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

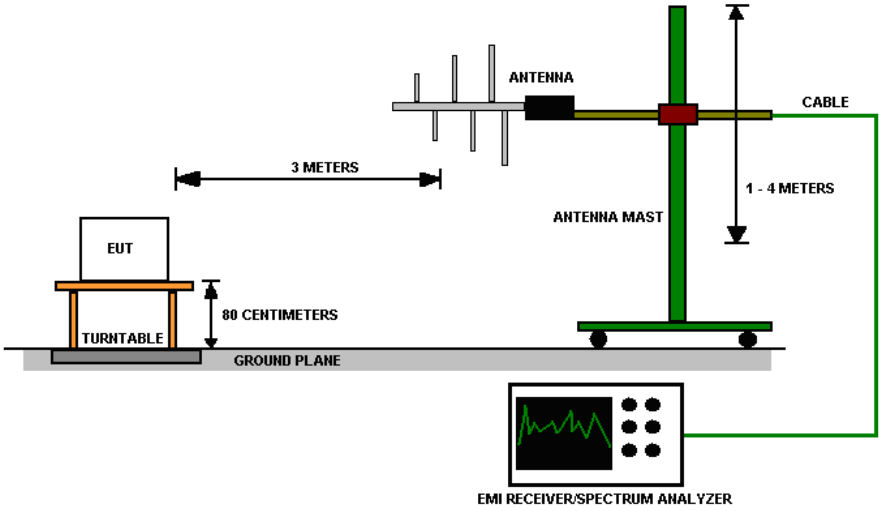
The method from ANSI C63.10 Section 7.8.5 was used.

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 3 MHz RBW and 3 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 AAA 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 (AAA Battery)	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri,FLane, AInamura

Maximum peak output power

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	PEAK POWER LIMIT (dBm)	EIRP PEAK POWER OUTPUT (mW)	RESULT
Lowest	902.3	8.80	30	7.59	PASS
Middle	908.6	8.03	30	6.35	PASS
Highest	914.9	8.05	30	6.38	PASS

E_{Meas} = Maximized measurements from Figures 10 – 12. Measured at 3m and indicated by marker 1 = raw value from plot + 107 (dBm to dBuV) + AF + CF

AF = Antenna factor = 26.30 dB

CF = Cable factor = 5.06 dB

From ANSI C63.10 Equation 9.5:

$$EIRP = E_{Meas} + 20\log(d_{meas}) - 104.7$$

REMARKS:
None

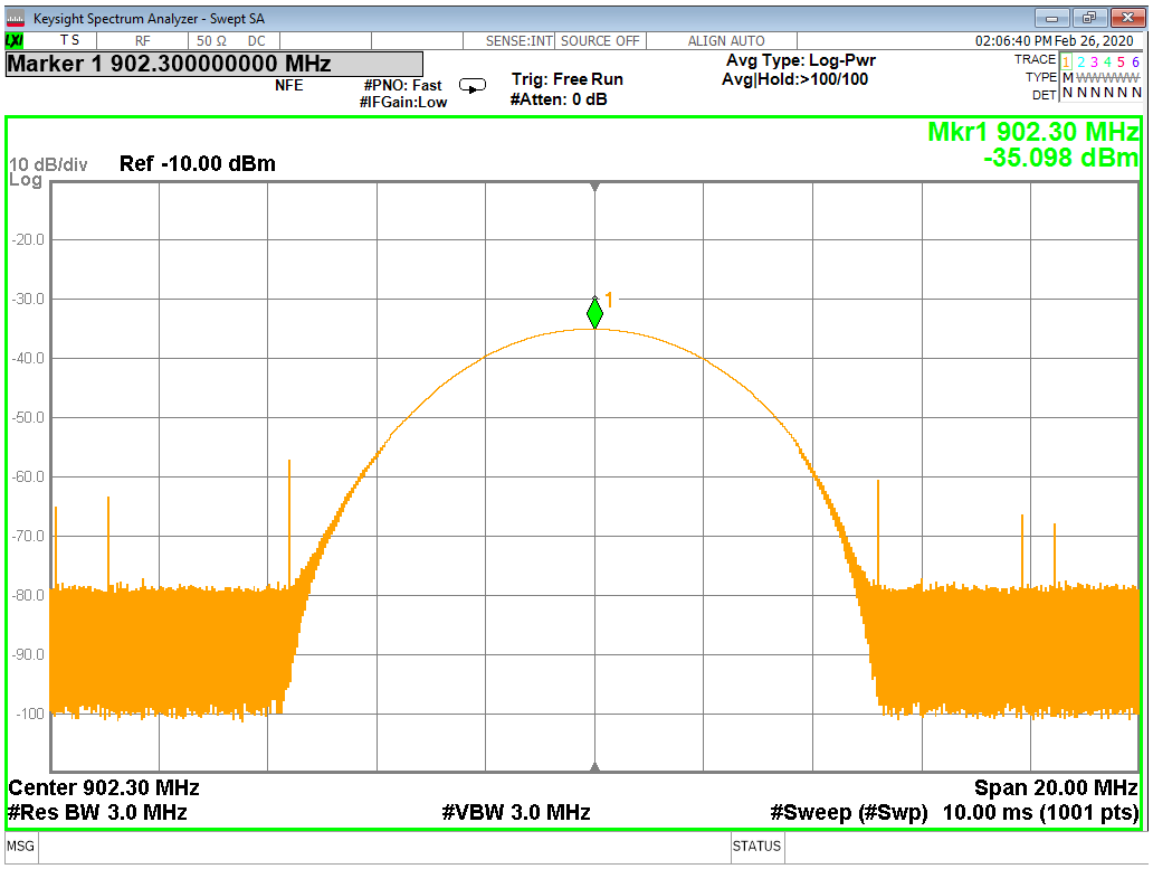


Figure 9 – Peak Output Power, Low Channel

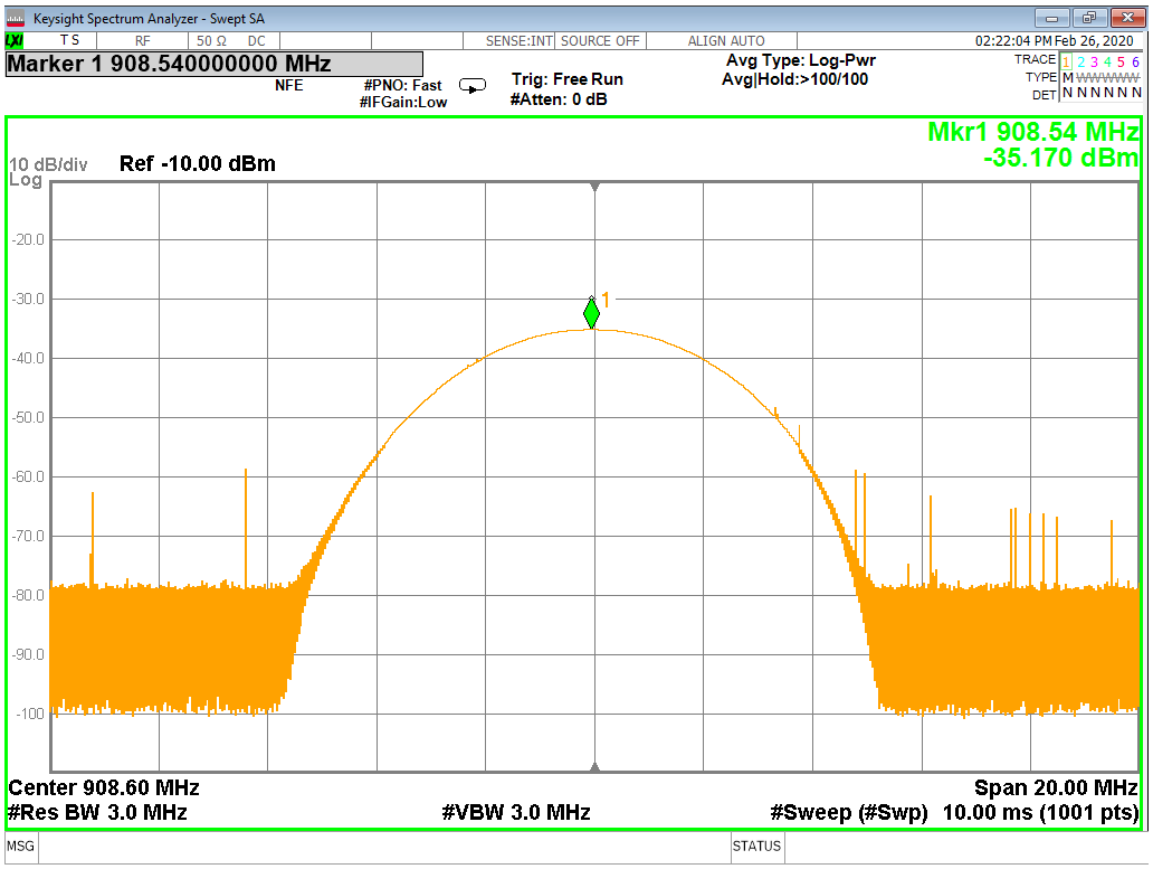


Figure 10 – Peak Output Power, Mid Channel

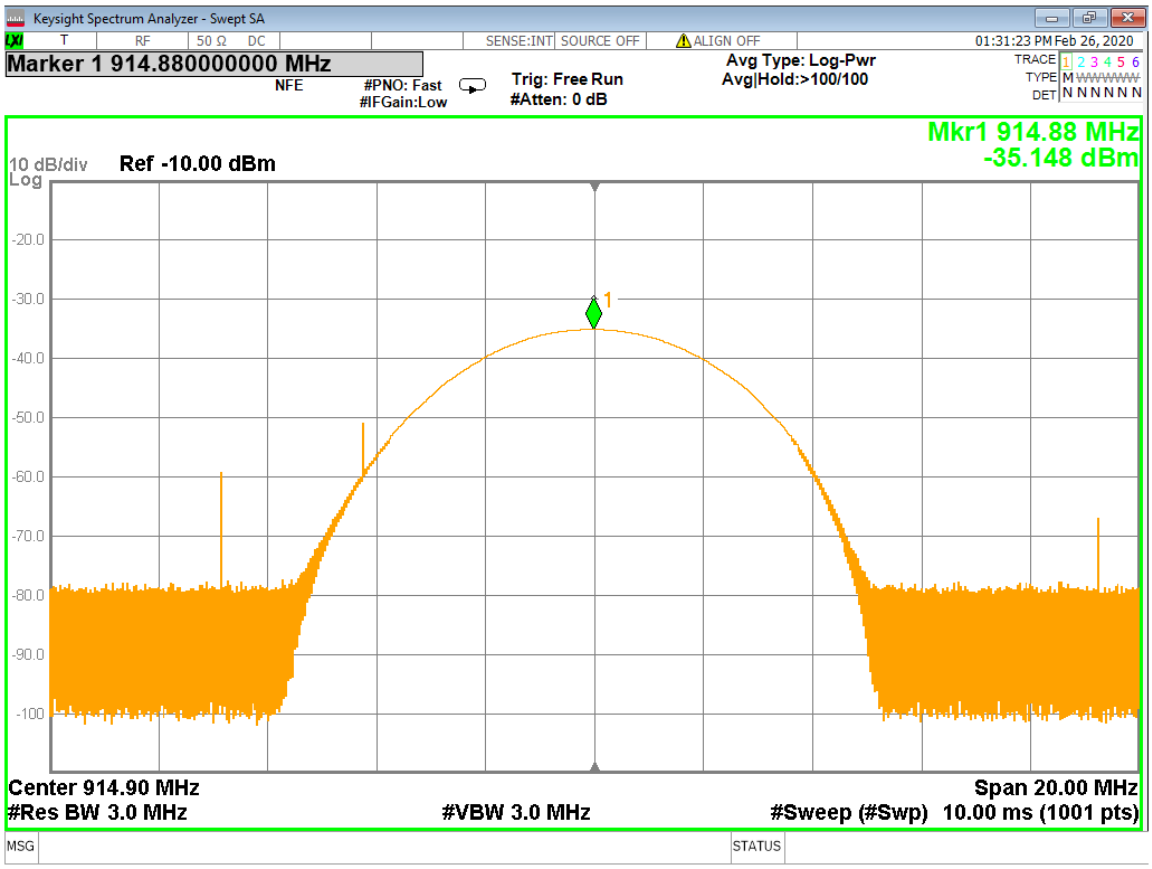


Figure 11 – Peak Output Power, High Channel

4.5 Bandedges

4.5.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (2400.0MHz – 2483.5MHz), 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 AAA 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 (AAA Battery)	FREQUENCY RANGE	902 MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	52 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest In-Band Emissions
100kHz 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
Low, Continuous (unrestricted)	902.30	-87.142	-35.120	52.022	20.0	PASS
High, Continuous (unrestricted)	928.00	-94.013	-35.115	58.898	20.0	PASS

*Minimum delta = [highest fundamental peak field strength from Section 4.2] – [Part 15.209 radiated emissions limit.]

From Section 4.2

Fundamental peak field strength at Low /m Channel = 102.80 dBuV @ 3m
Fundamental peak field strength at High channel = 102.48 dBuV @ 3m

Low Channel minimum delta = 102.80 – 54.00 = 48.80
High Channel minimum delta = 102.48 – 54.00 = 48.48

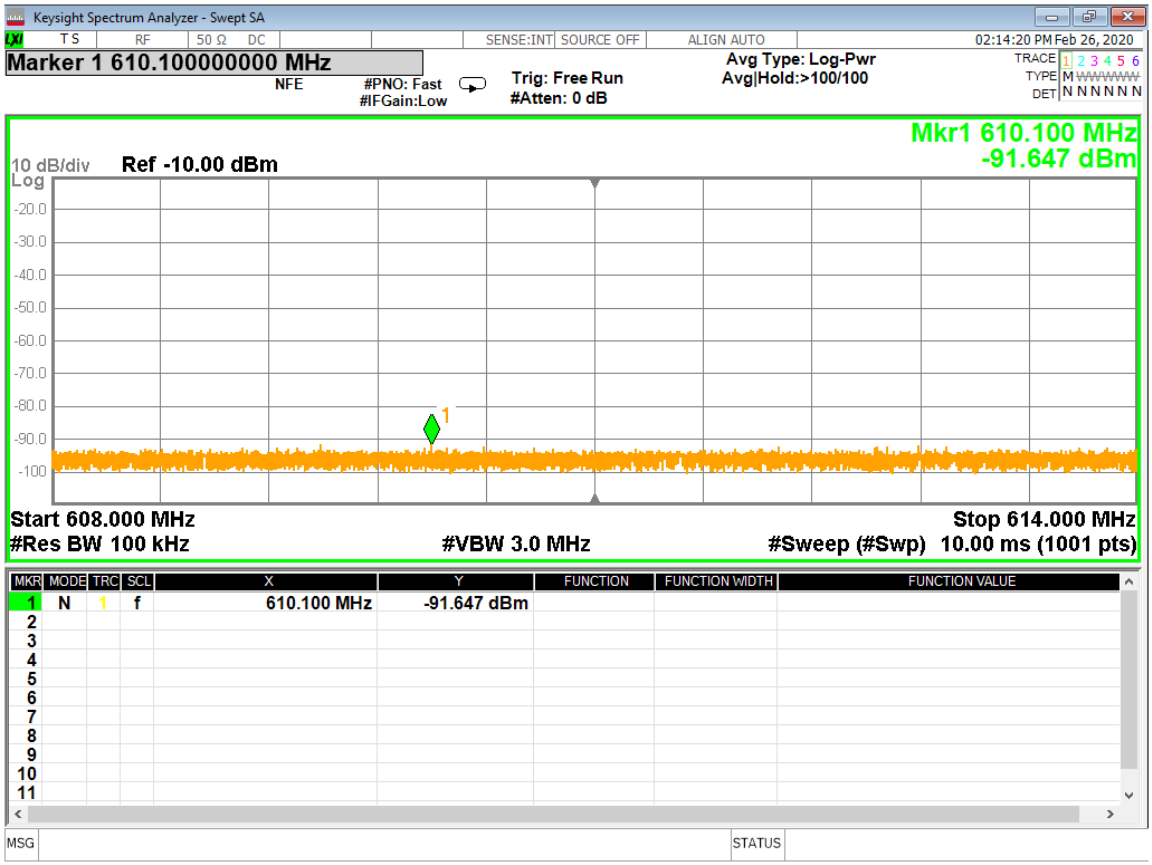


Figure 12 - Band-edge Measurement, Restricted, Low Channel

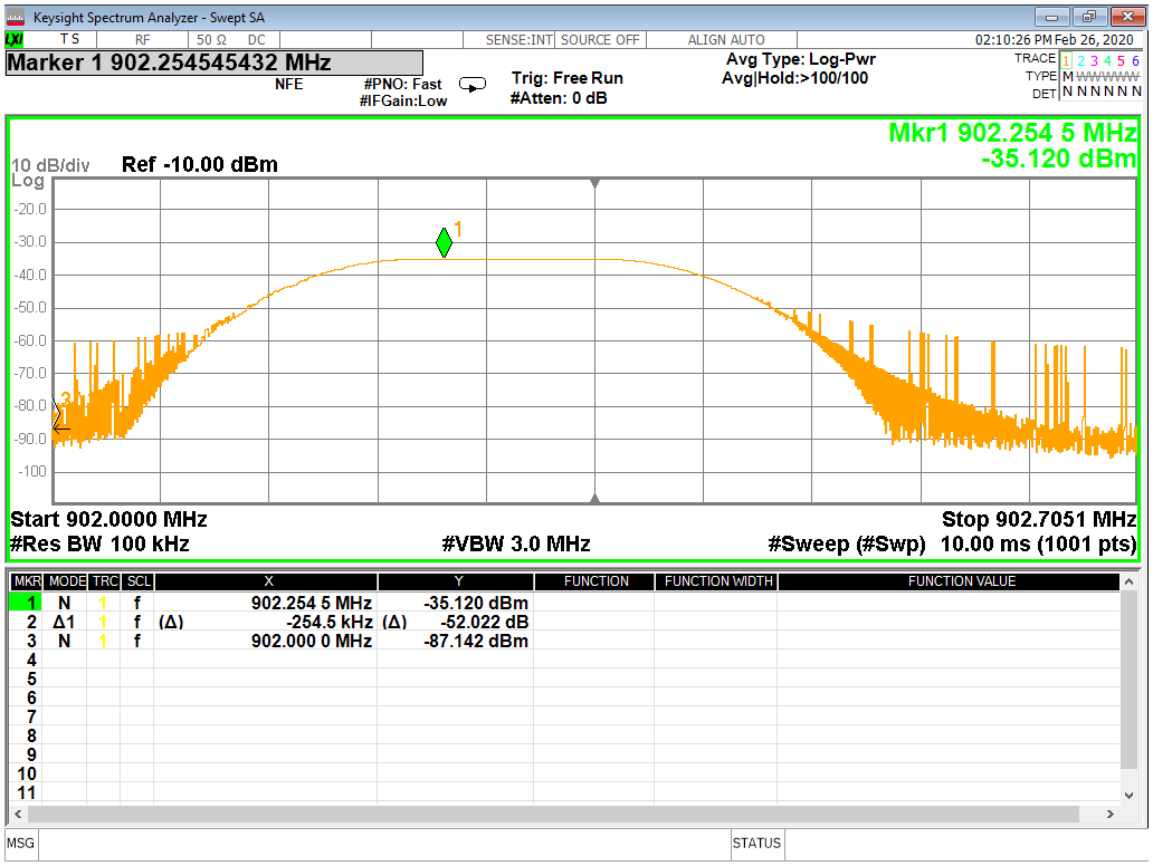


Figure 13 - Band-edge Measurement, Unrestricted, Low Channel

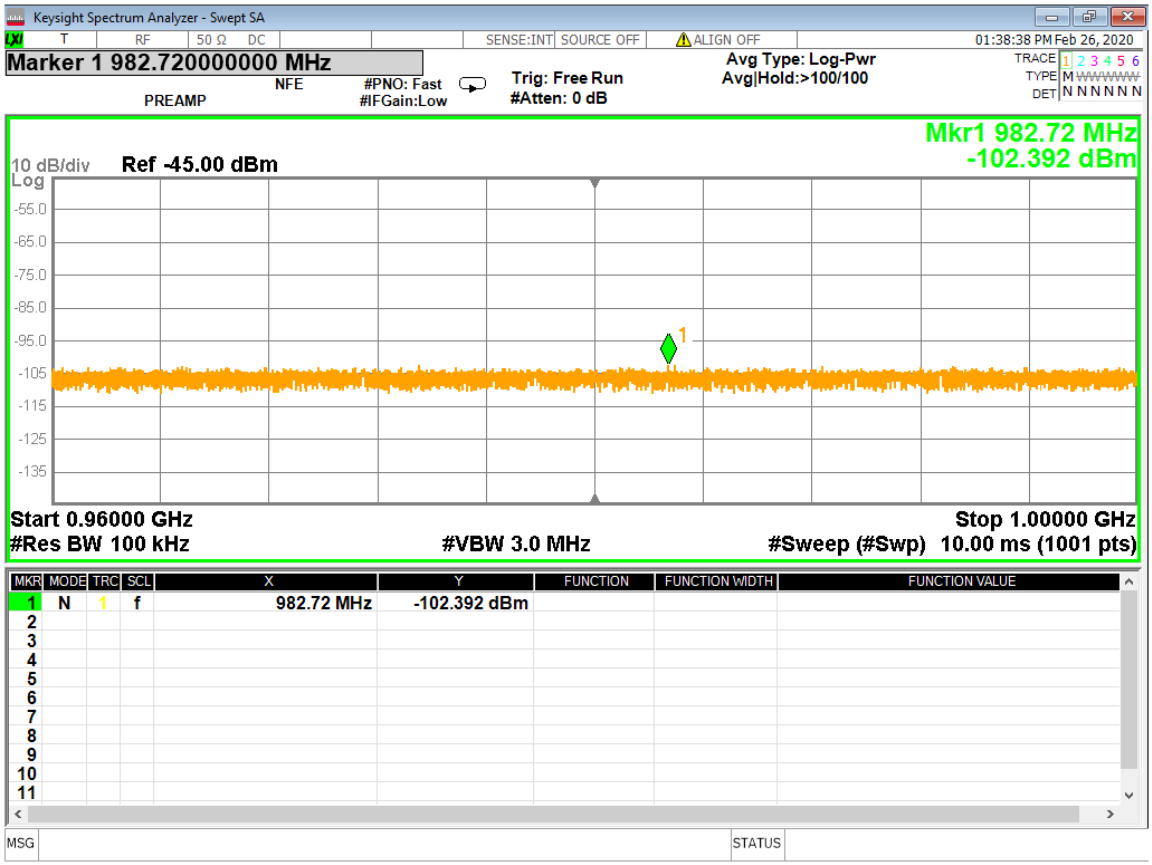


Figure 14 - Band-edge Measurement, Restricted, High Channel

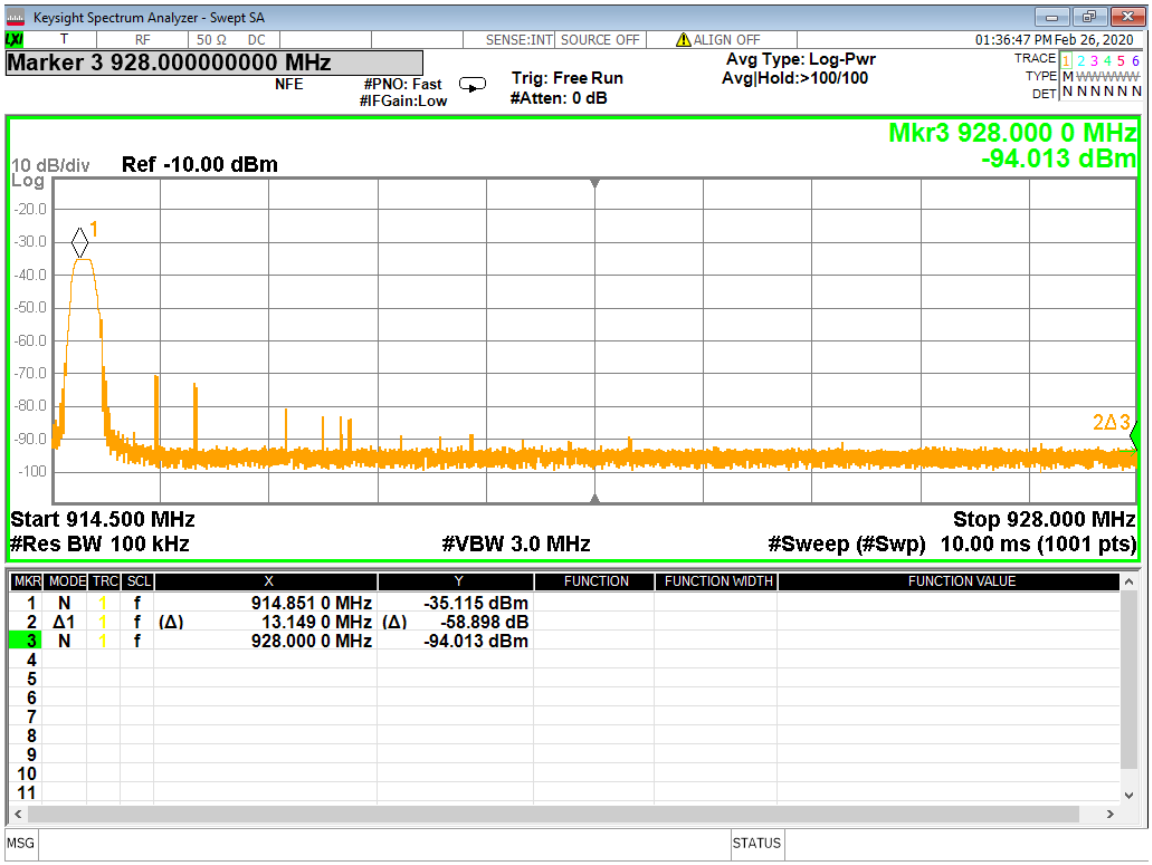


Figure 15 - Band-edge Measurement, Unrestricted, High Channel

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 11.10.3 was used.

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 and recorded at the frequency with the highest emission. The trace averaging over 100 traces was carried out. Number of measurement points are 500 which matches the requirement. The sweep was set to auto couple, as per C63.10-2013, Section 11.10.3

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 AAA 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 (AAA 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	0.397	8.00	PASS
2	908.64	1.28	8.00	PASS
3	914.82	1.16	8.00	PASS

All measurements were taken from Figures 15 – 17 of this section.

E_{Meas} = Maximized measurements from Figures 10 – 12. Measured at 3m and indicated by marker 1 = raw value from plot + 107 (dBm to dBuV) + AF + CF

AF = Antenna factor = 26.30 dB

CF = Cable factor = 5.06 dB

From ANSI C63.10 Equation 9.5:

$$EIRP = E_{Meas} + 20\log(d_{meas}) - 104.7$$

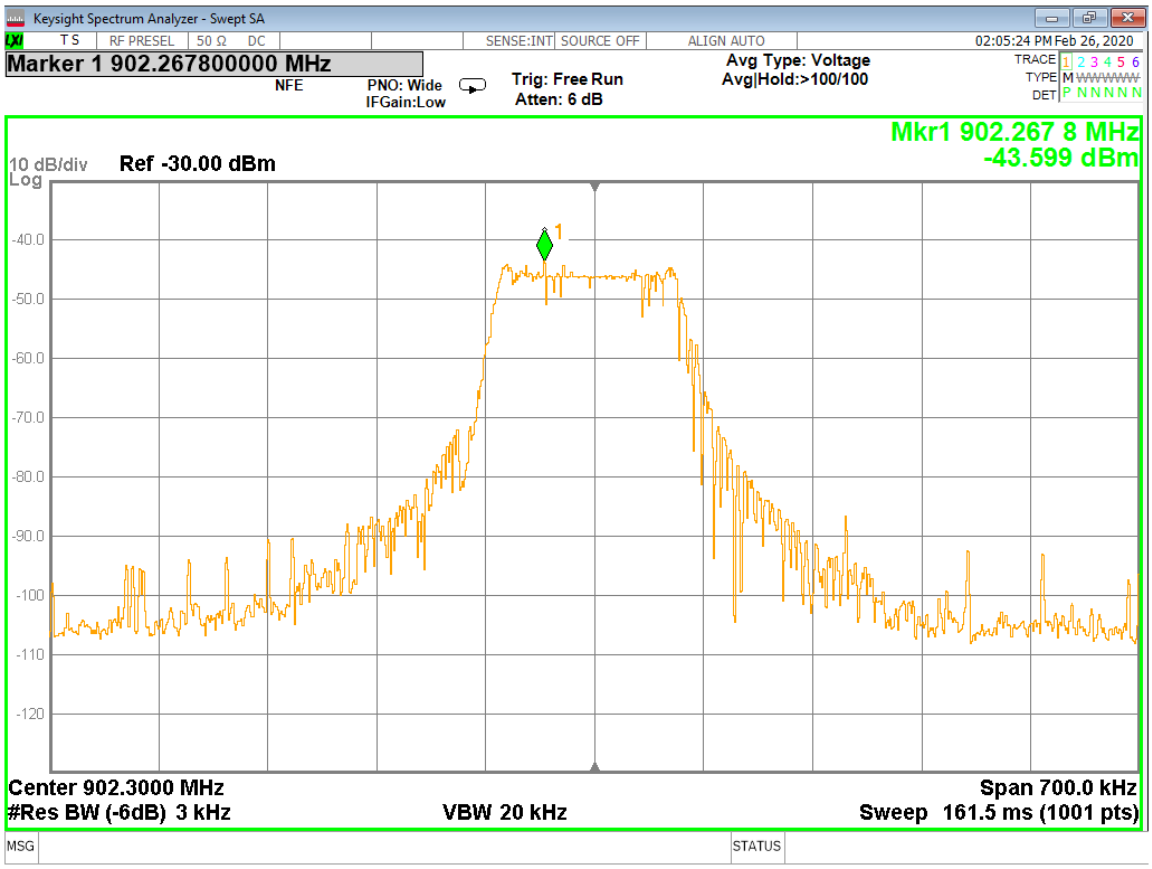


Figure 16 - Power Spectral Density Measurement, Low Channel

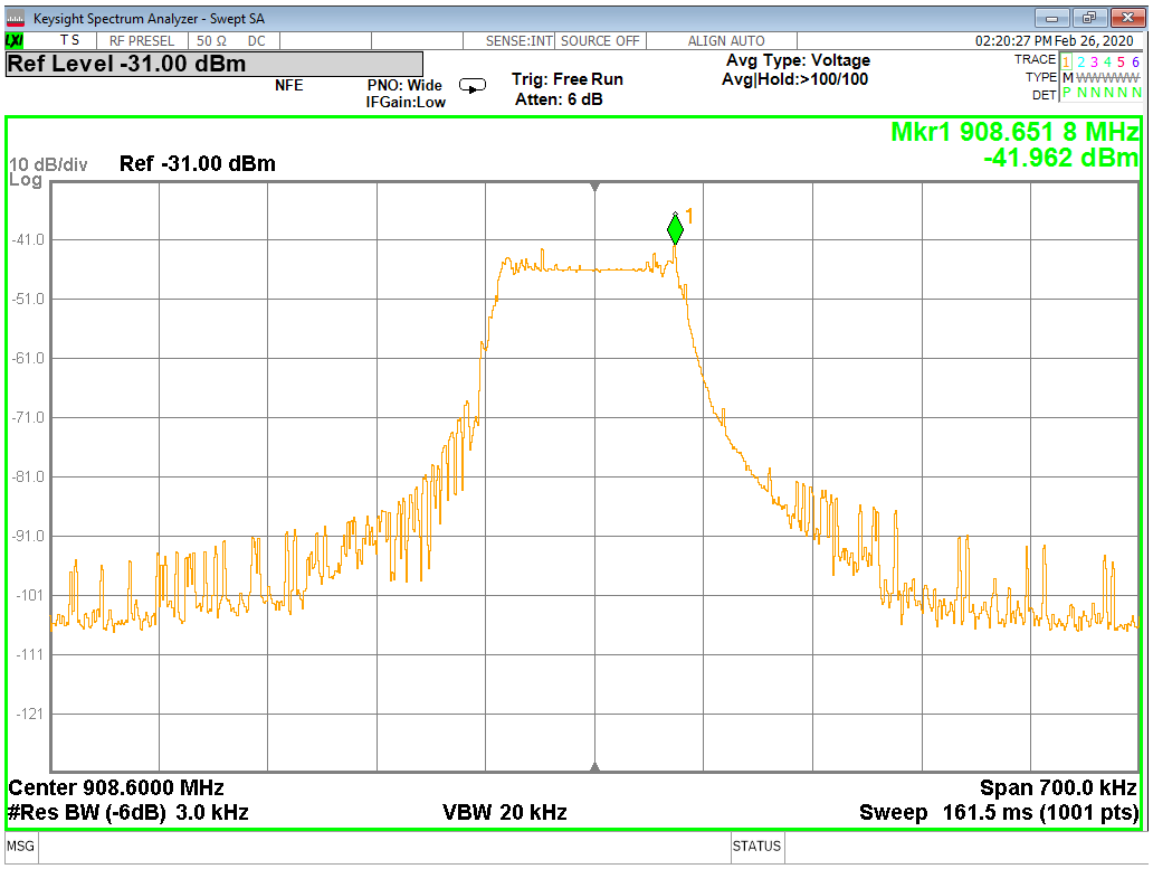


Figure 17 - Power Spectral Density Measurement, Mid Channel

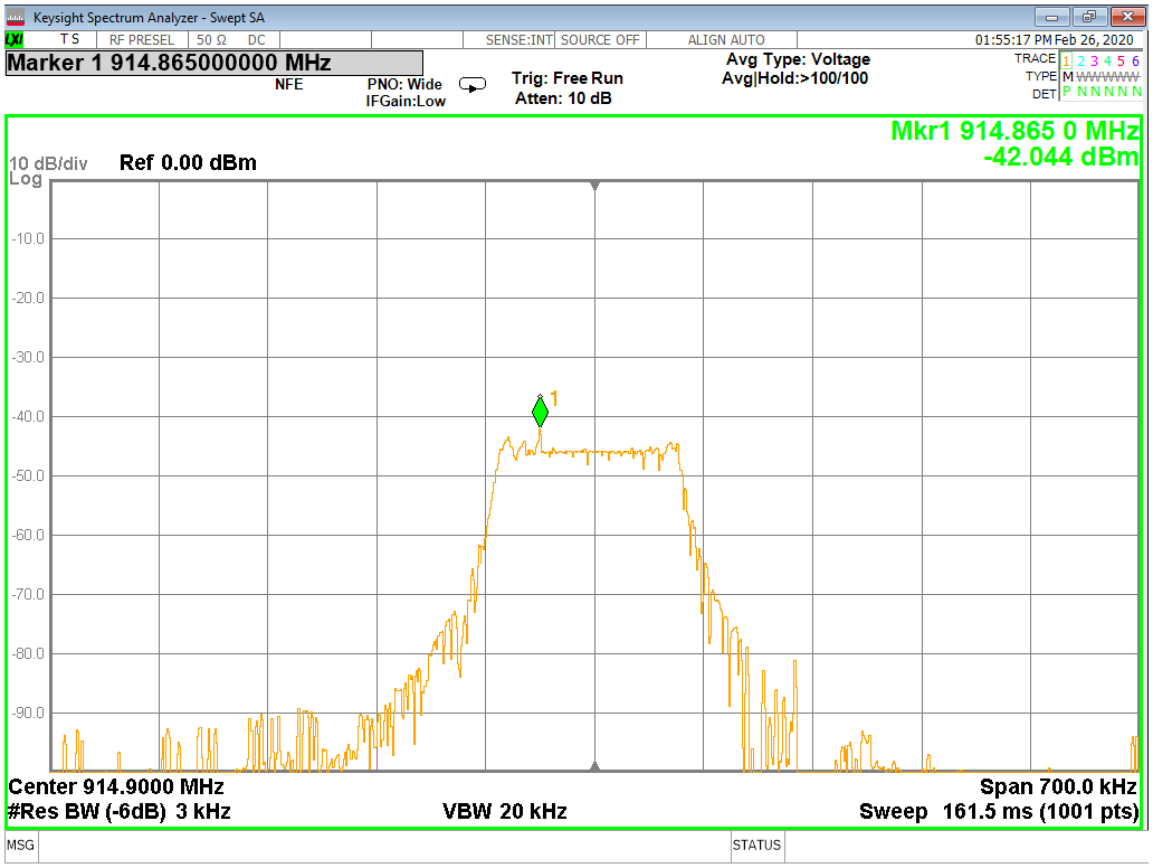


Figure 18 - Power Spectral Density Measurement, High Channel

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 data in this section were taken from a previous version of the transmitter. No changes were made to the software that would affect these parameters

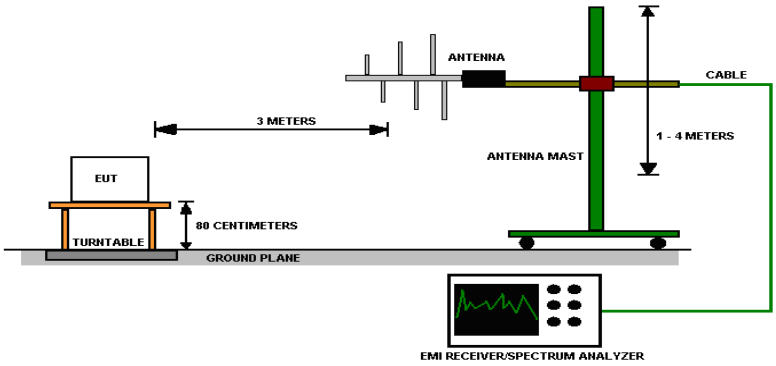
The method from ANSI C63.10 Section 7.7.2, 7.7.3 and 7.7.4 were used.

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 AAA 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. Note that these measurements were done on previous version of the same product and manufacturer declared that this section won't be affected by the changes made to the EUT.

4.7.6 Test results

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

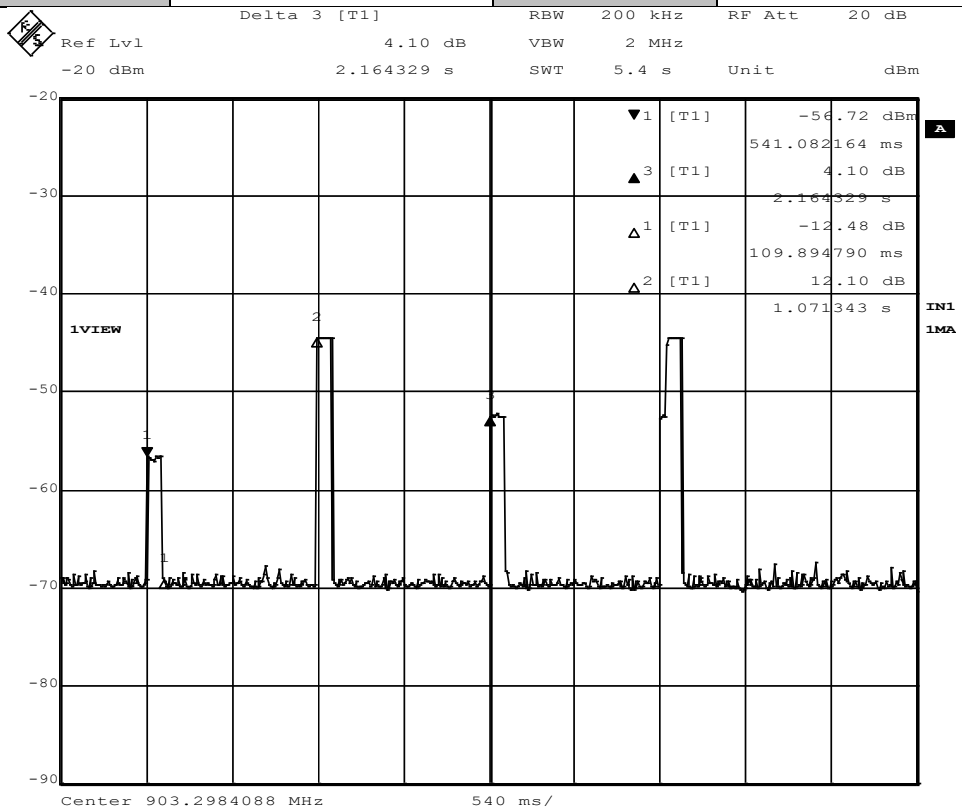


Figure 19 – Time of Occupancy (109.98 ms per Hop - Pass)

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 20 – Frequency Blocks Used

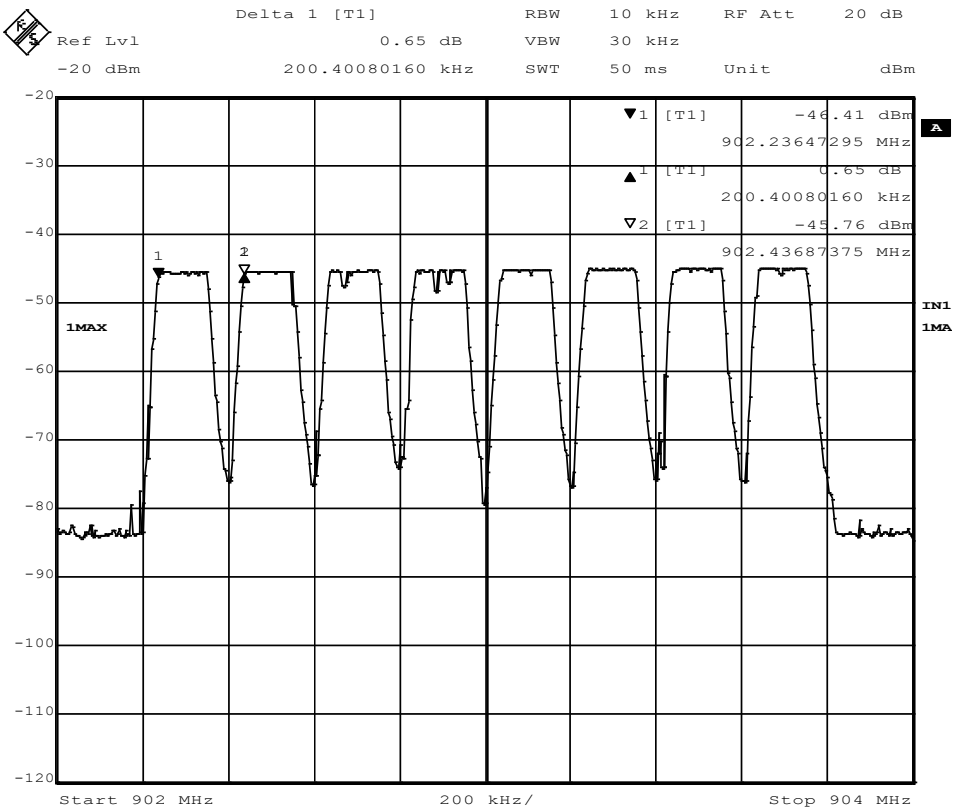


Figure 21 – Number of Hops Block A(8 Hops)

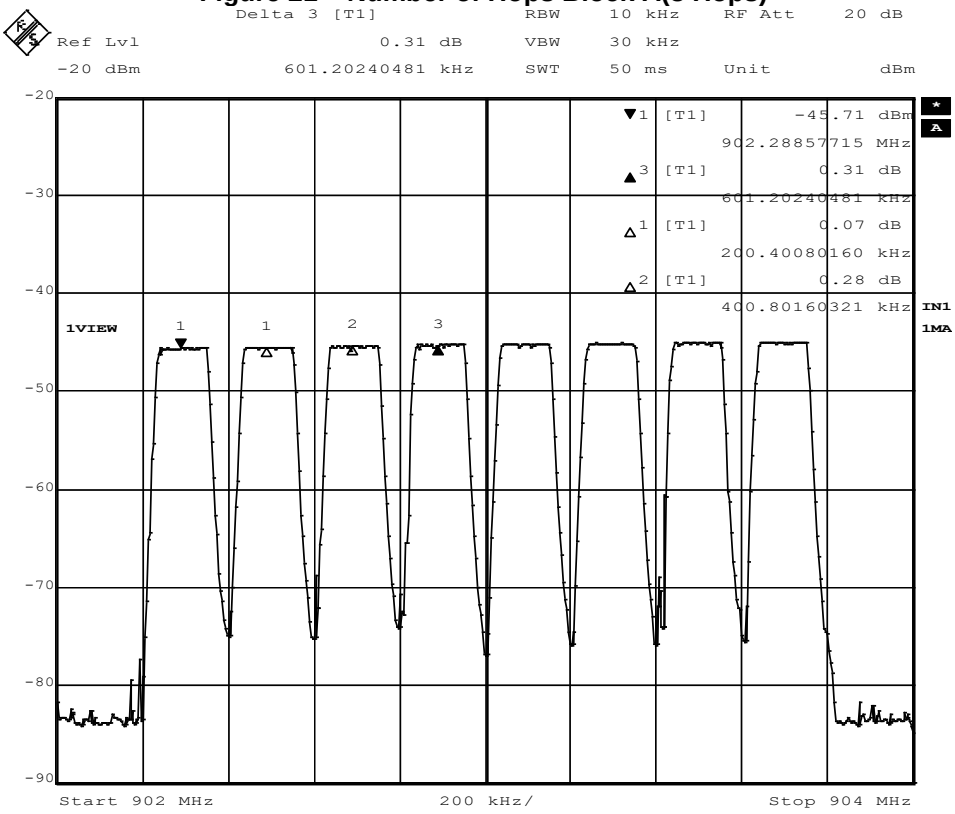


Figure 22 – Hop Separation Block A (1-4)

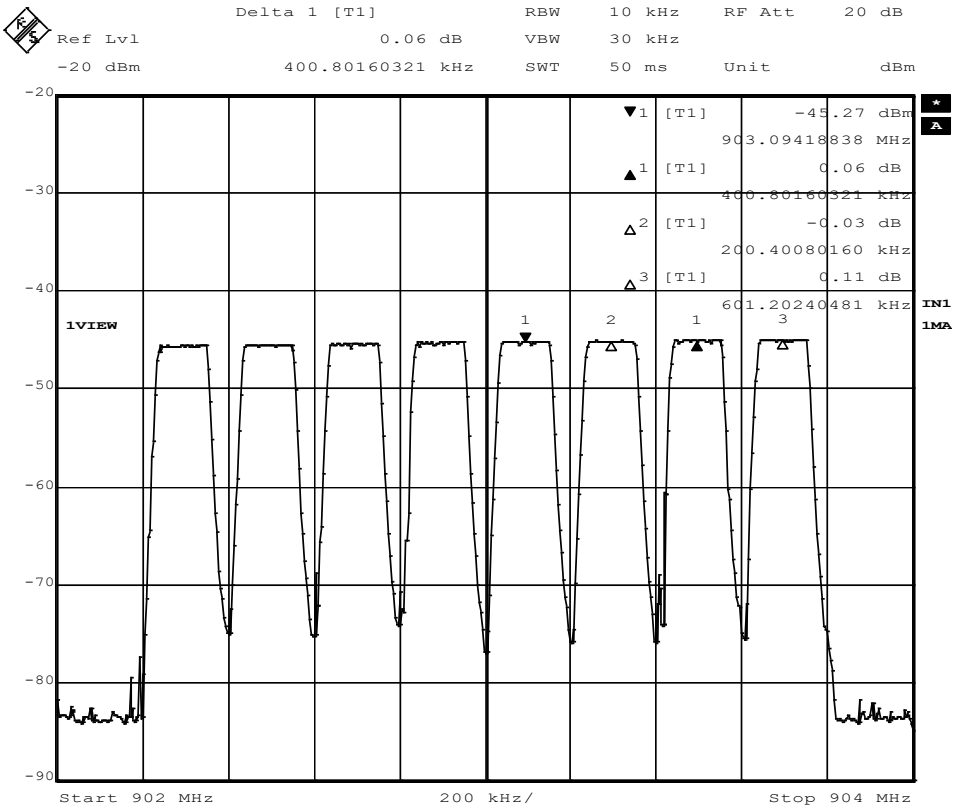


Figure 23 – Hop Separation Block A (4-8)

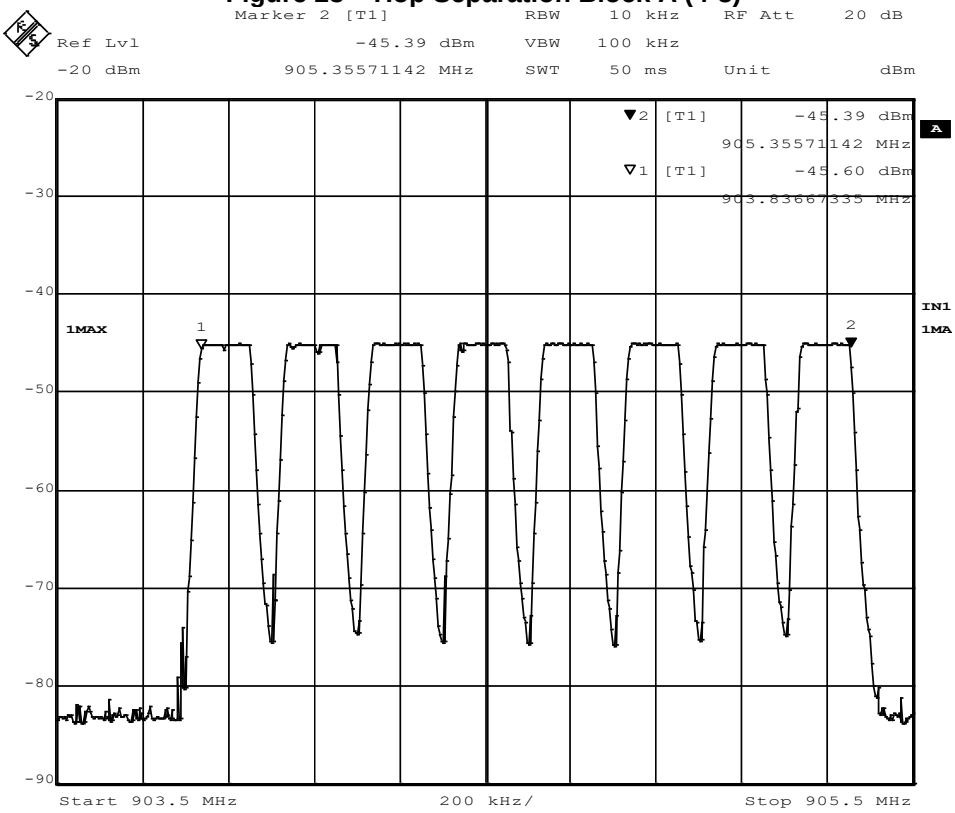


Figure 24 – Number of Hops Block B(8 Hops)

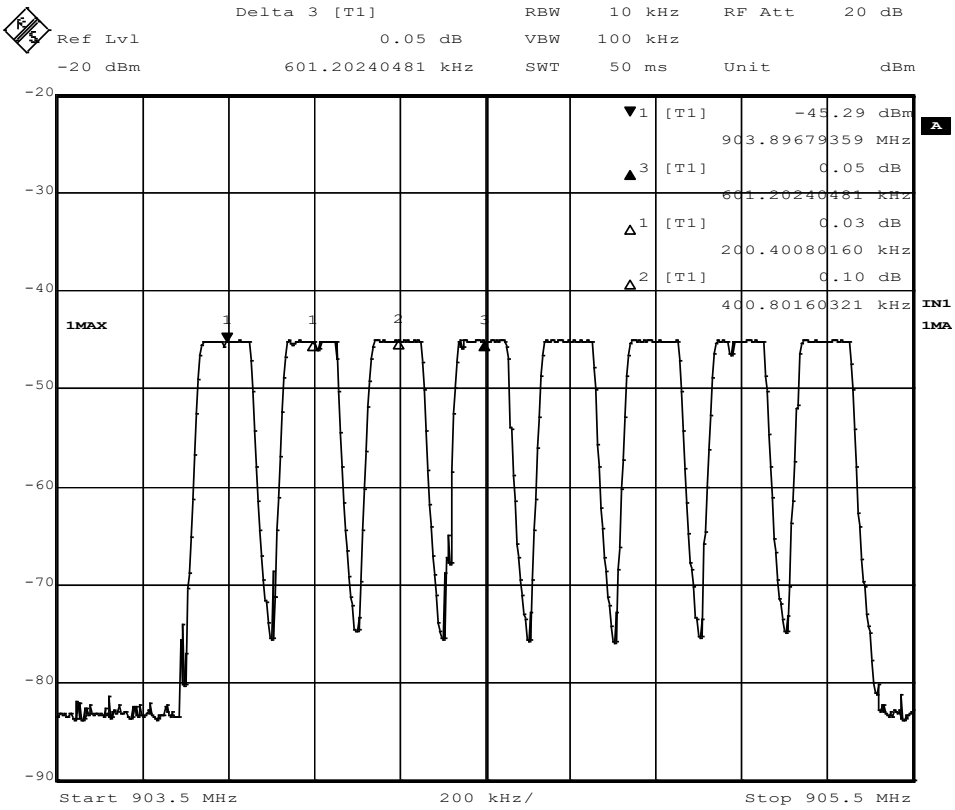


Figure 25 – Hop Separation Block B (1-4)

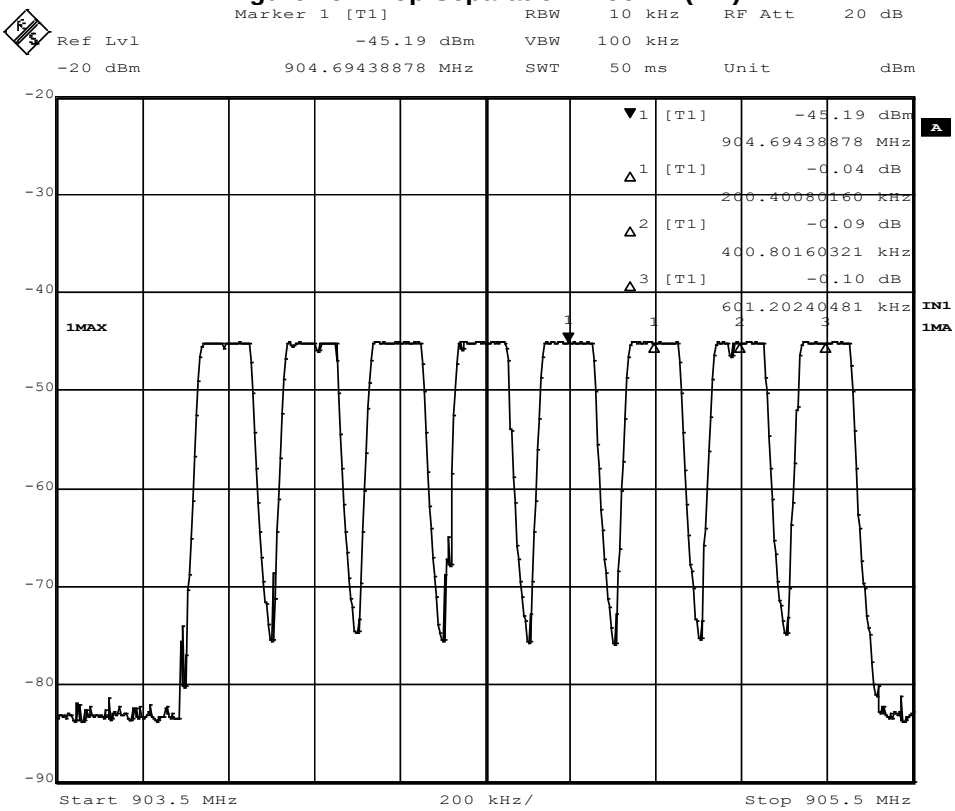


Figure 26 – Hop Separation Block B (4-8)

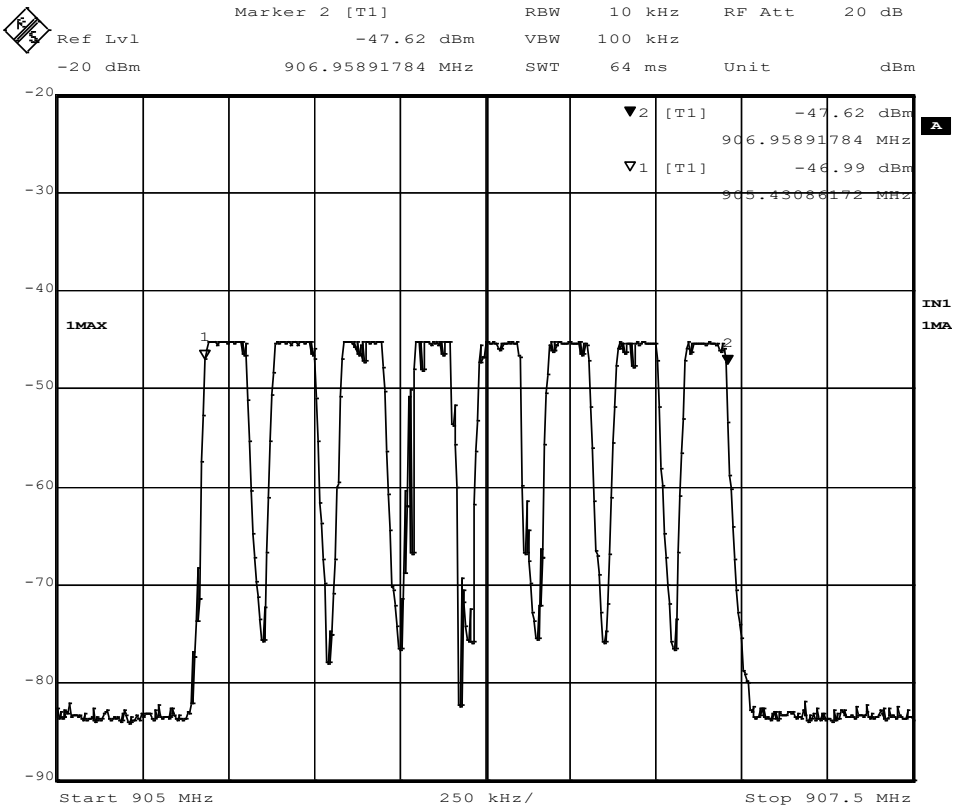


Figure 27 – Number of Hops Block C (8 Hops)

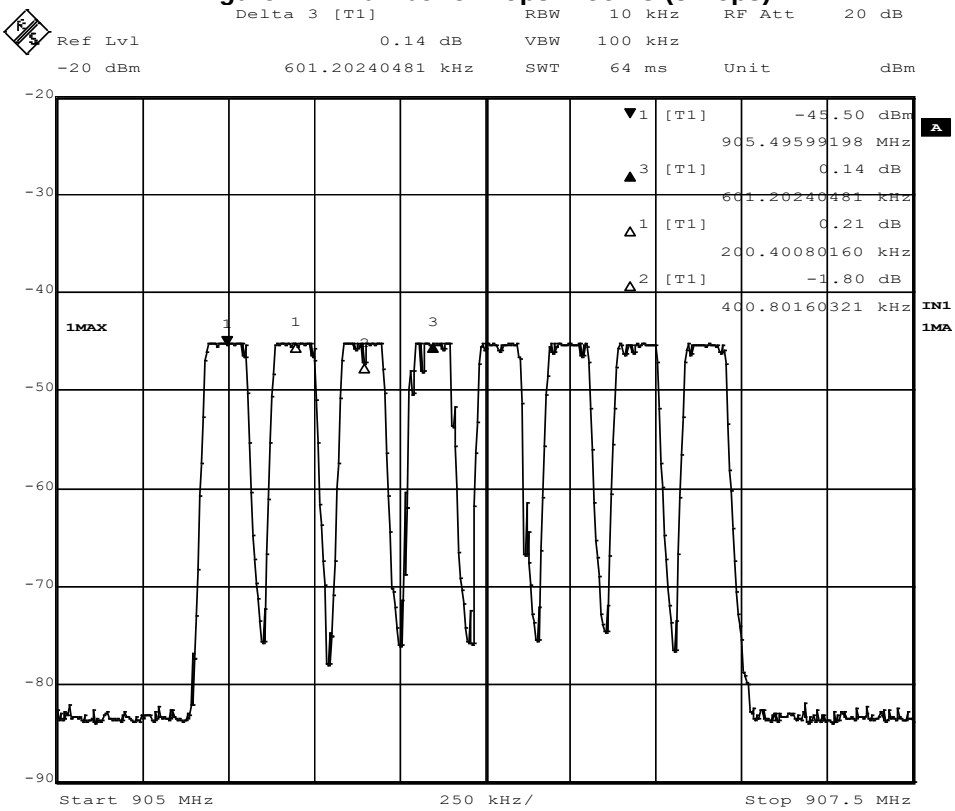


Figure 28 – Hop Separation Block C (1-4)

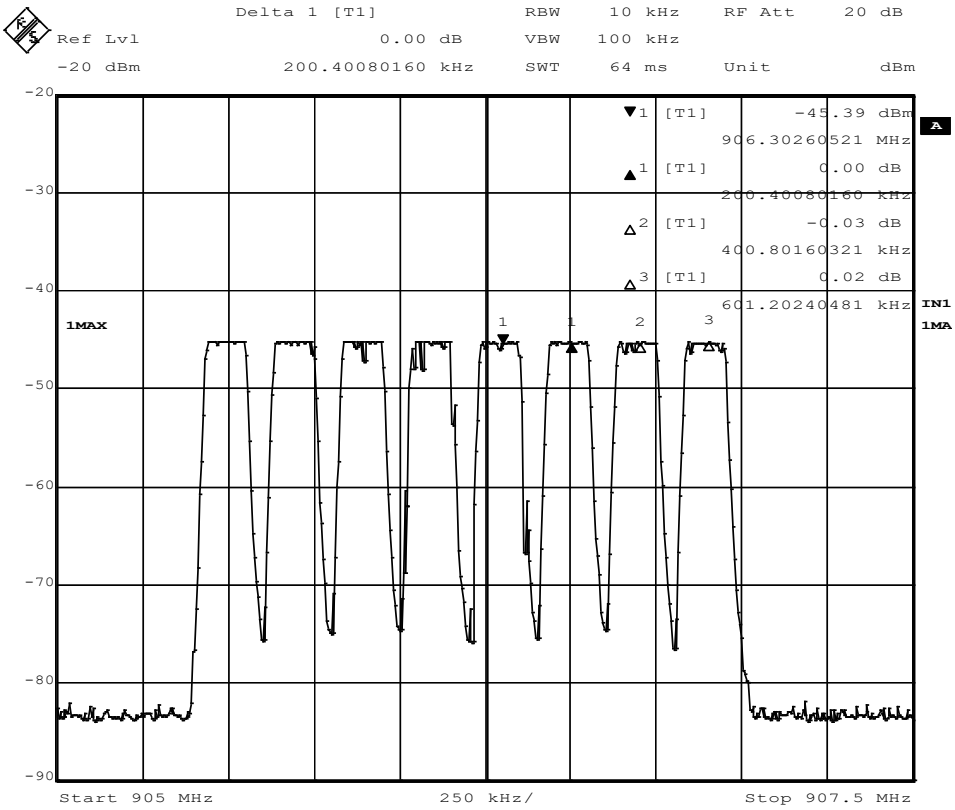


Figure 29 – Hop Separation Block C (4-8)

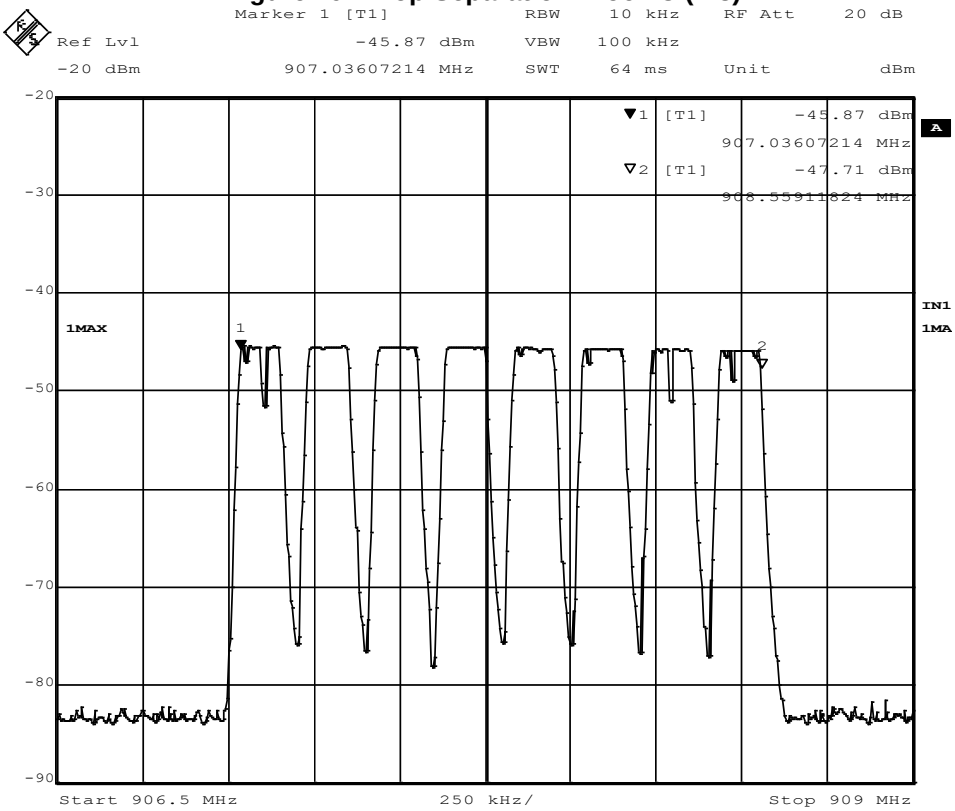


Figure 30 – Number of Hops Block D (8 Hops)

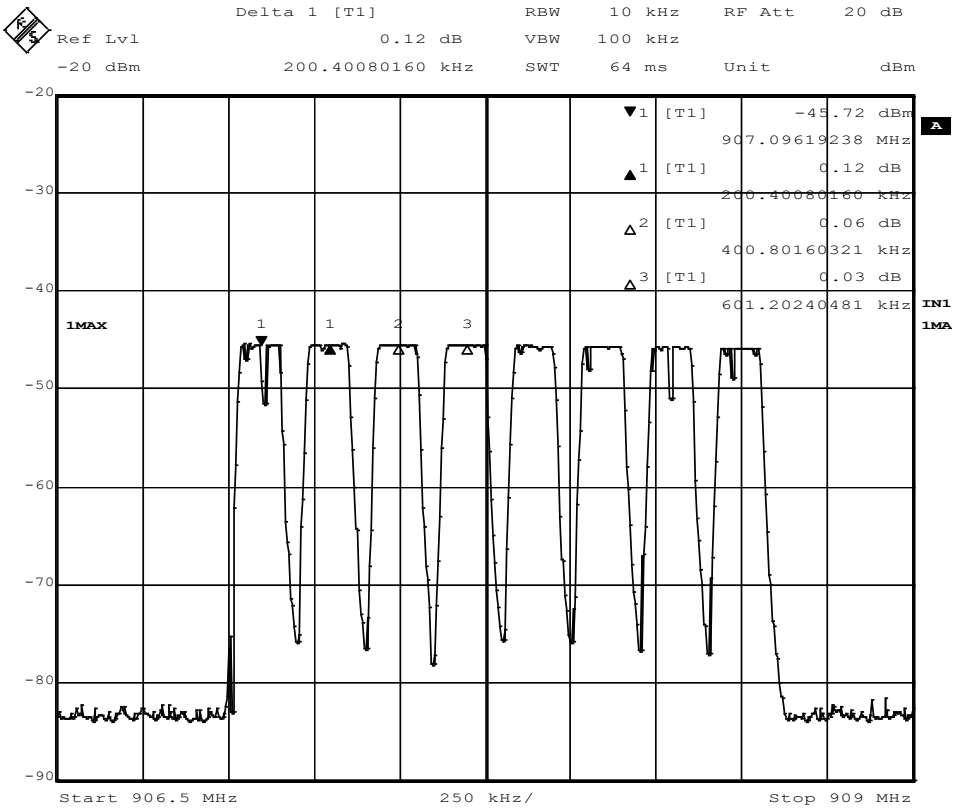


Figure 31 – Hop Separation Block D (1-4)

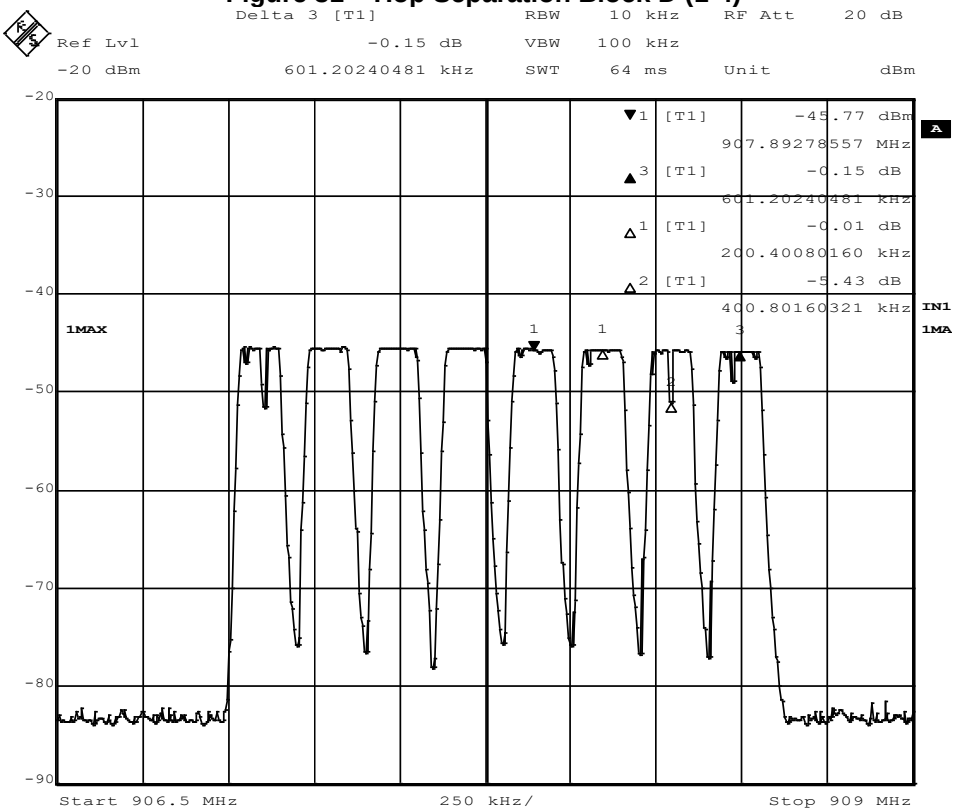


Figure 32 – Hop Separation Block D (4-8)

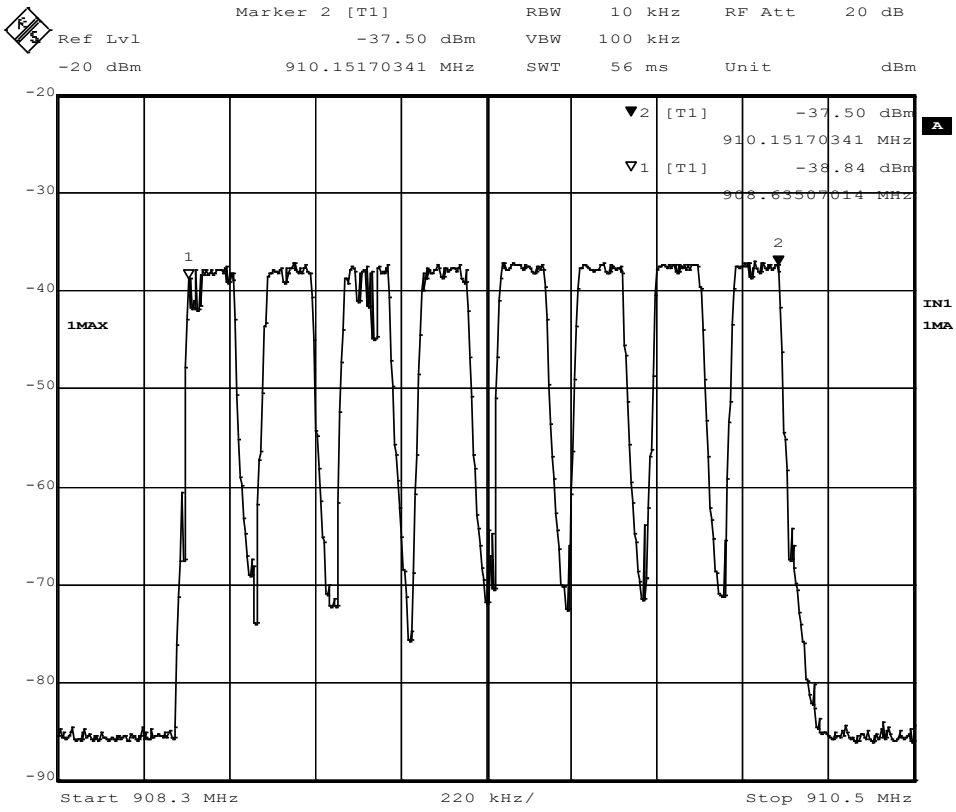


Figure 33 – Number of Hops Block E (8 Hops)

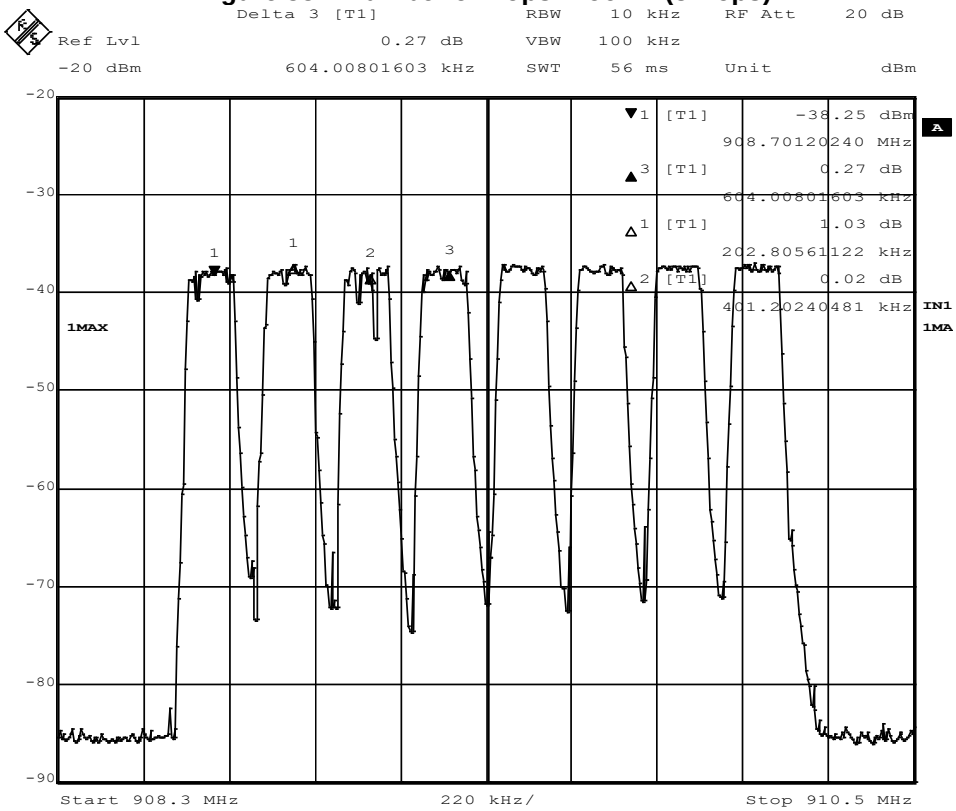


Figure 34 – Hop Separation Block E (1-4)

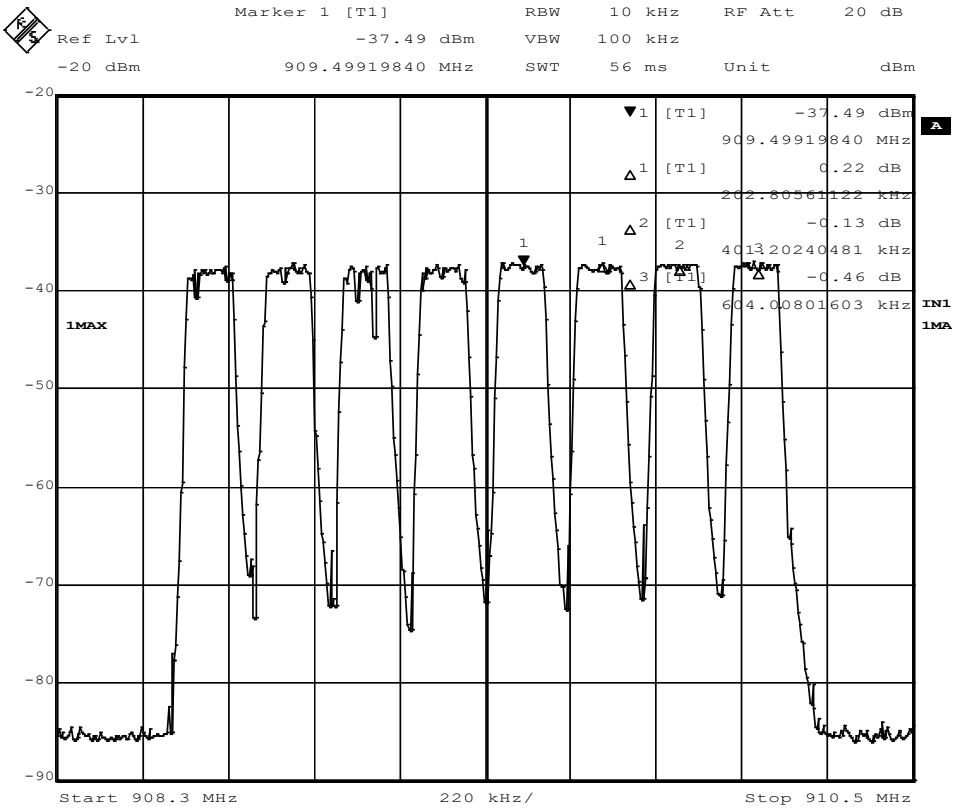


Figure 35 – Hop Separation Block E (4-8)

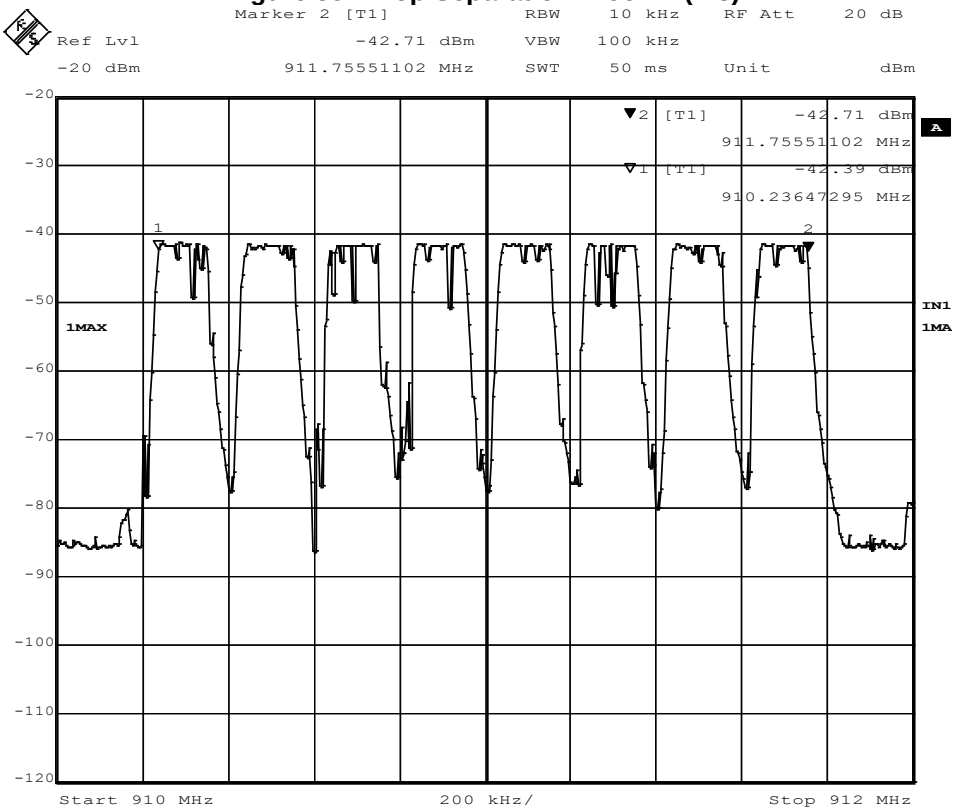


Figure 36 – Number of Hops Block F (8 Hops)

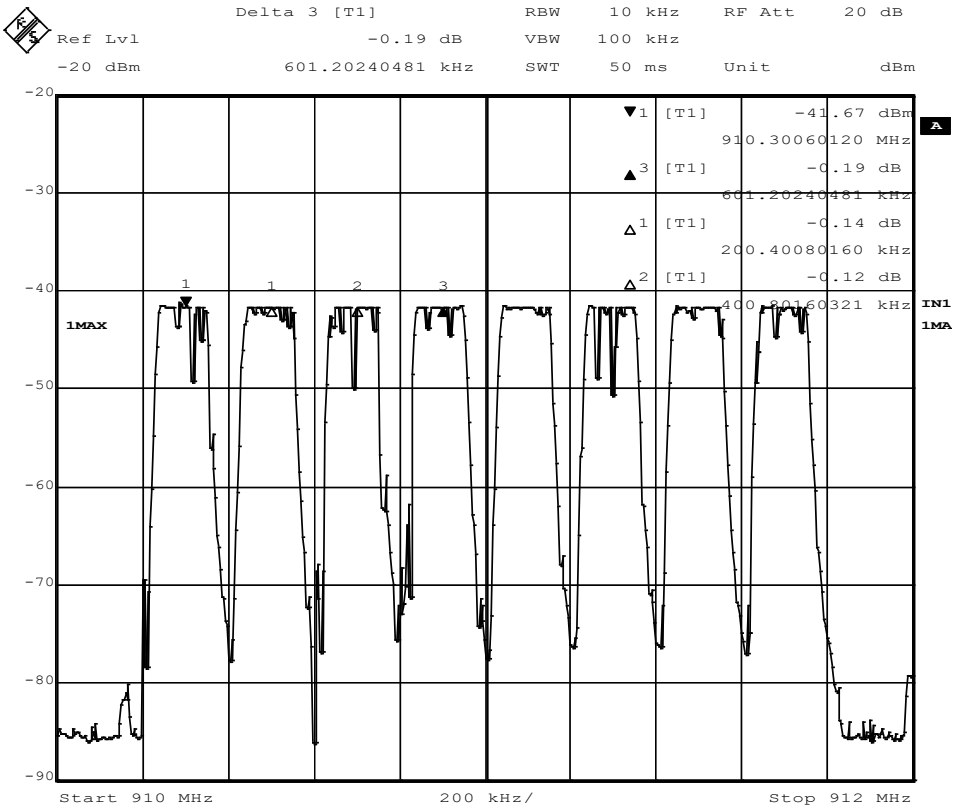


Figure 37 – Hop Separation Block F (1-4)

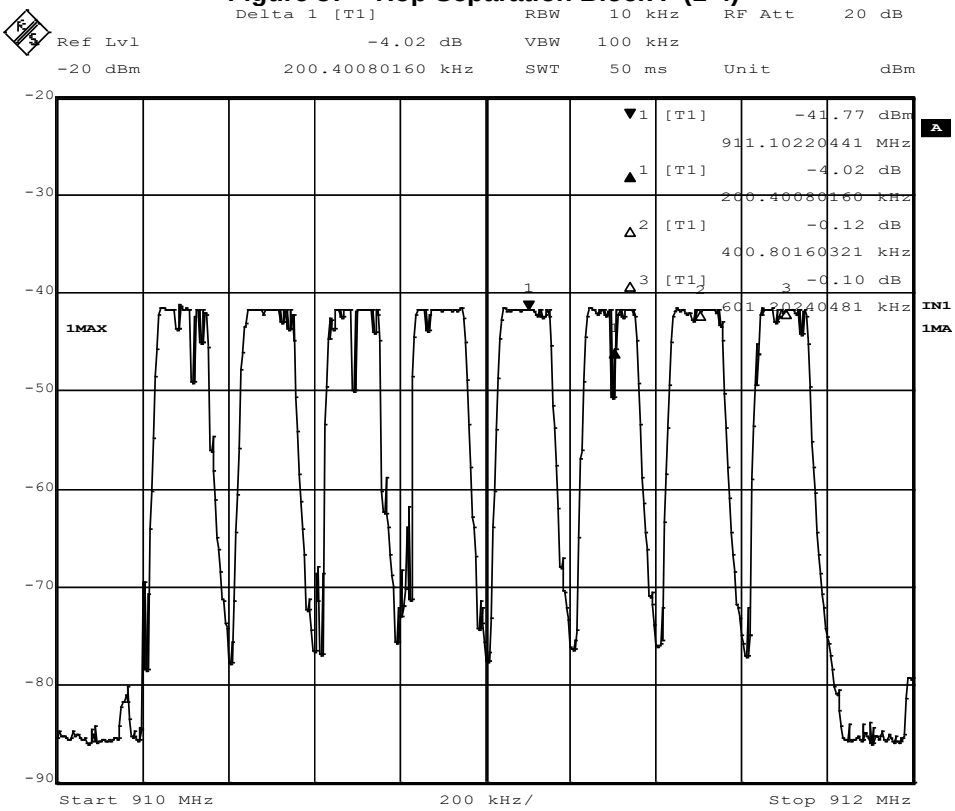


Figure 38 – Hop Separation Block F (4-8)

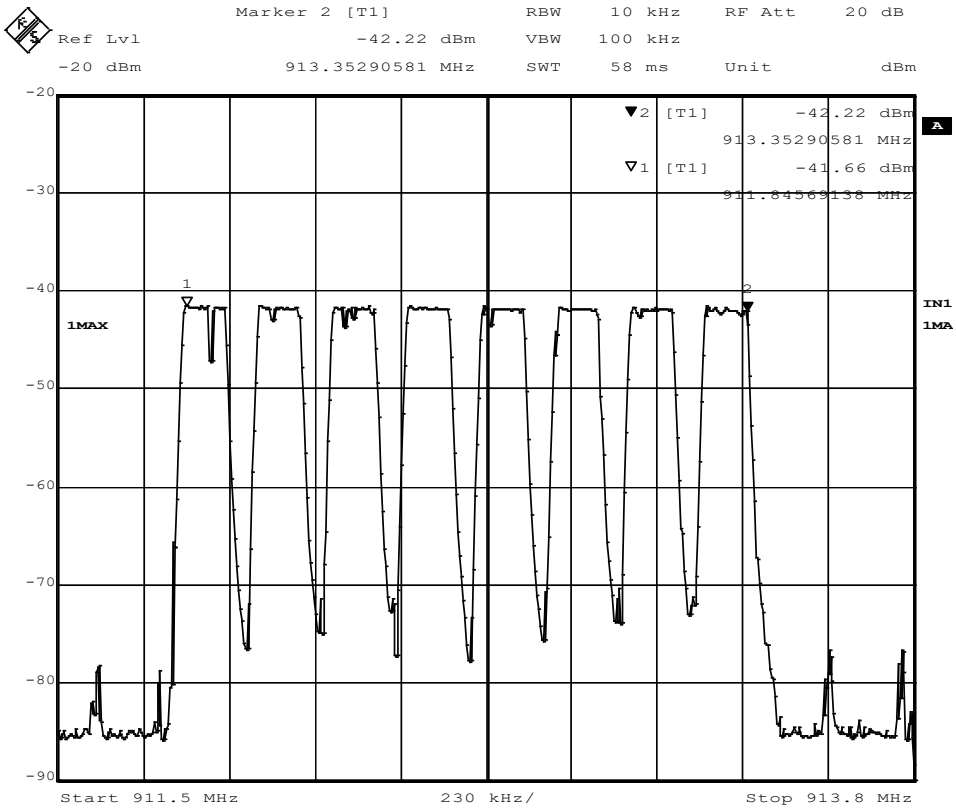


Figure 39 – Number of Hops Block G (8 Hops)

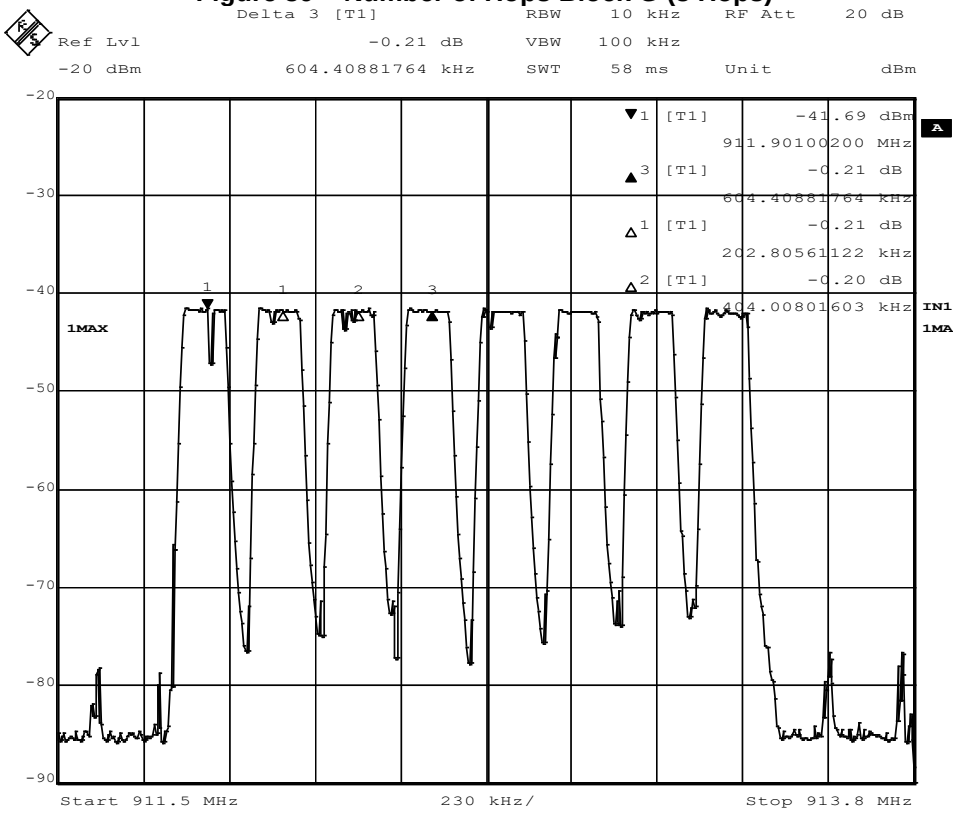


Figure 40 – Hop Separation Block G (1-4)

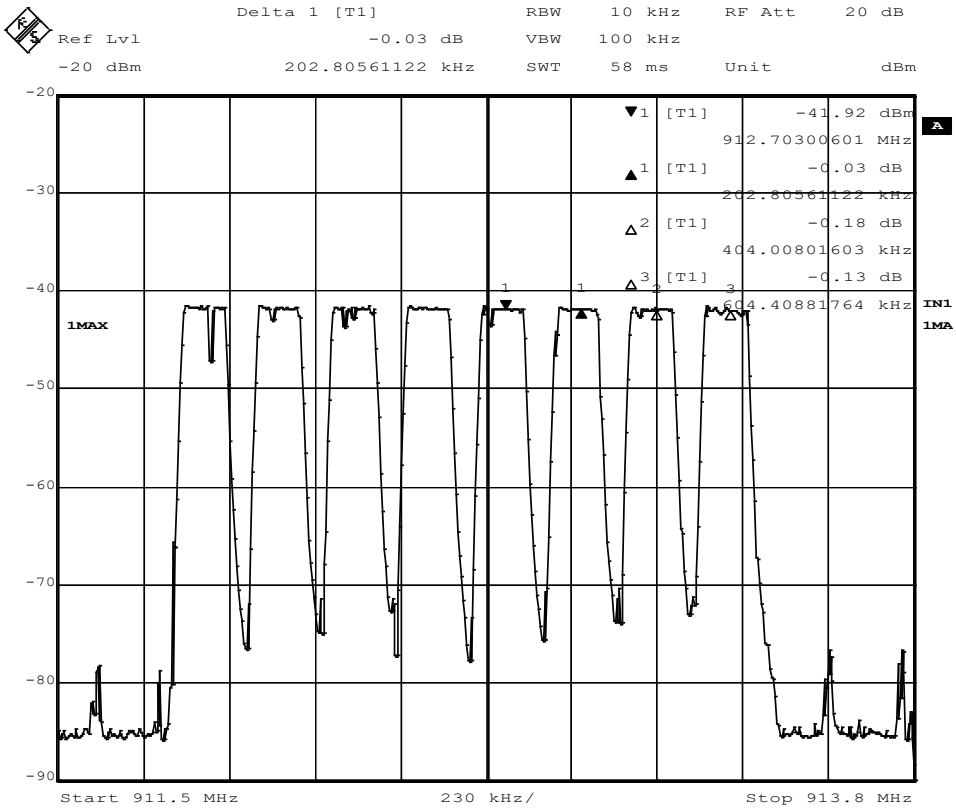


Figure 41 – Hop Separation Block G (4-8)

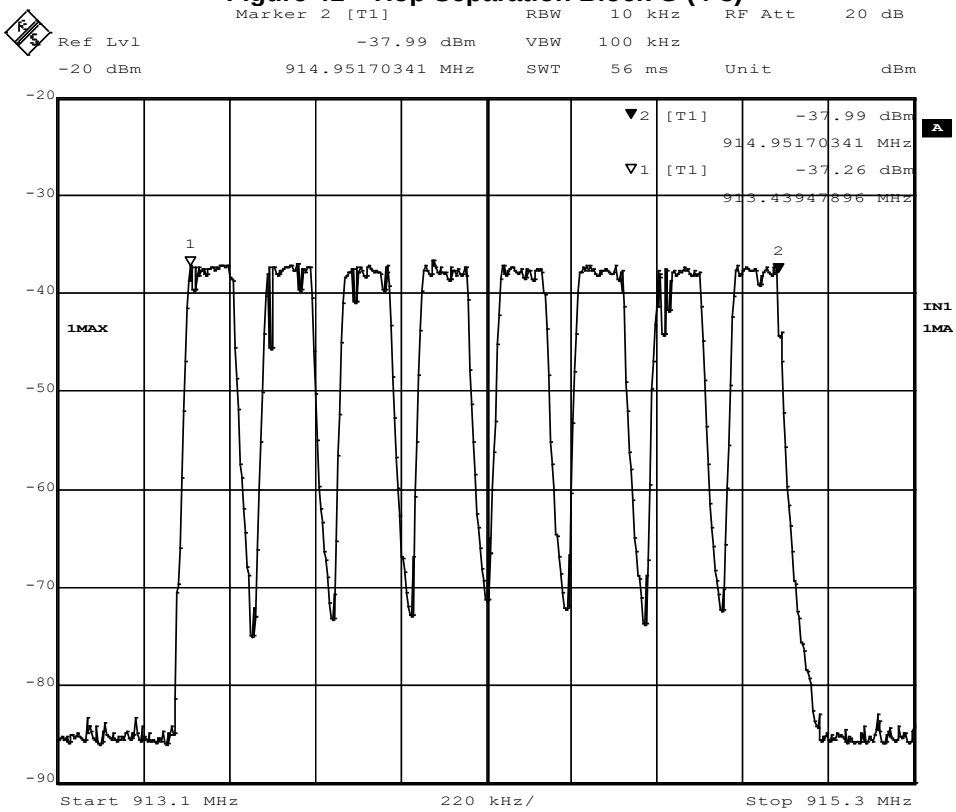


Figure 42 – Number of Hops Block H (8 Hops)

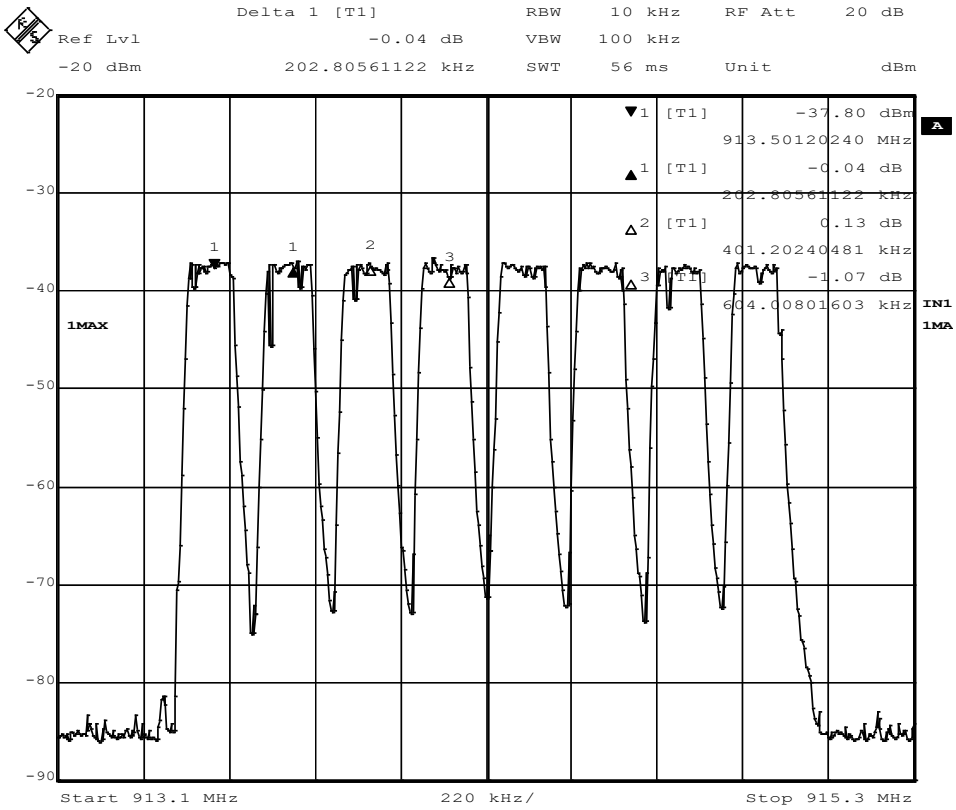


Figure 43 – Hop Separation Block H (1-4)

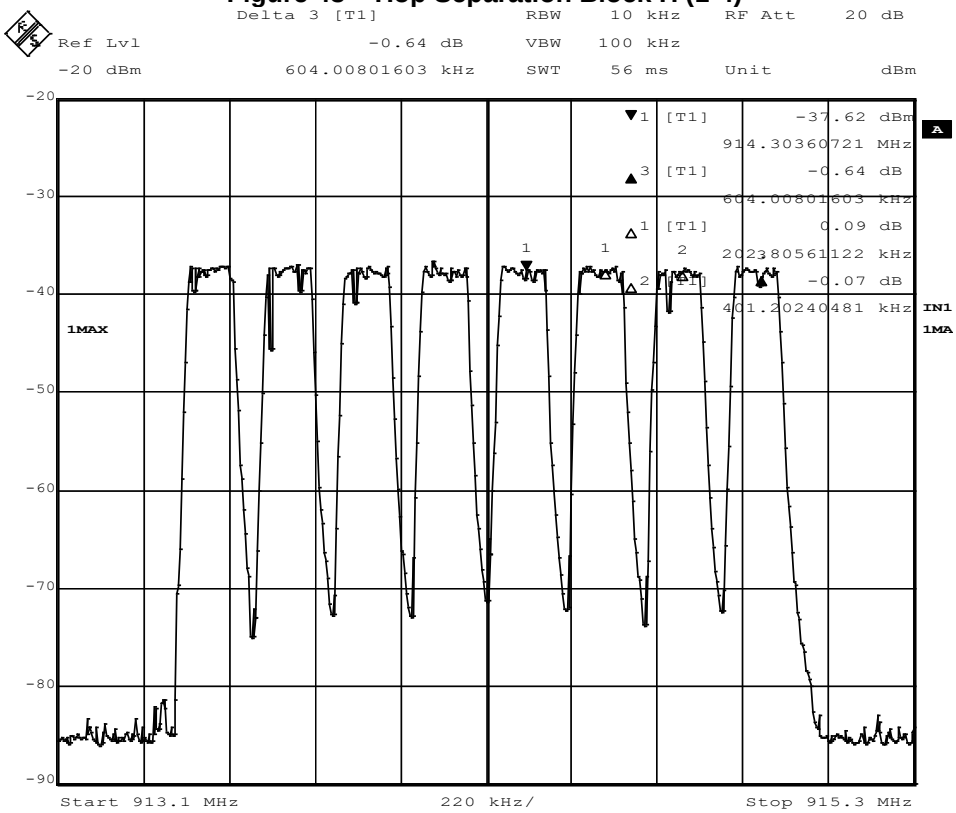


Figure 44 – Hop Separation Block H (4-8)

Appendix A: Test Photos

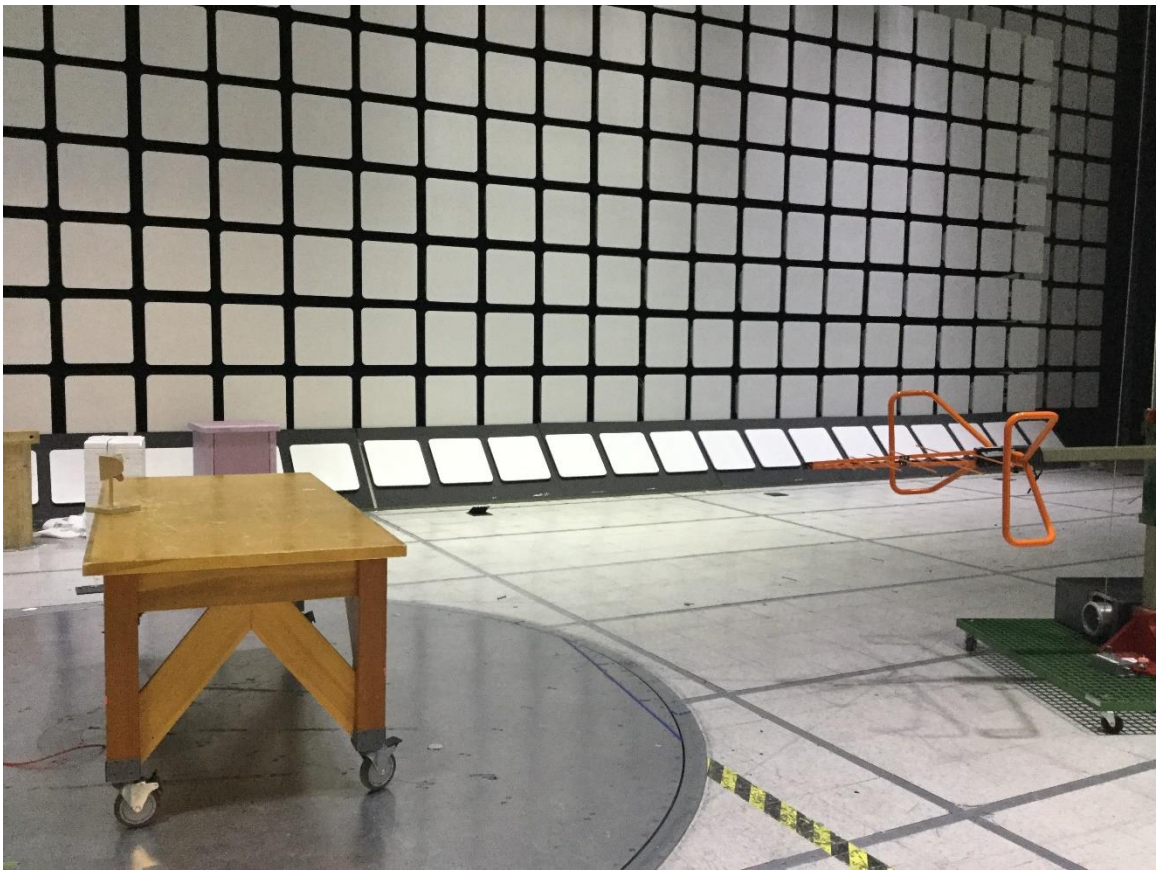


Figure 45 – Radiated Emissions Test Setup, 30MHz – 1GHz

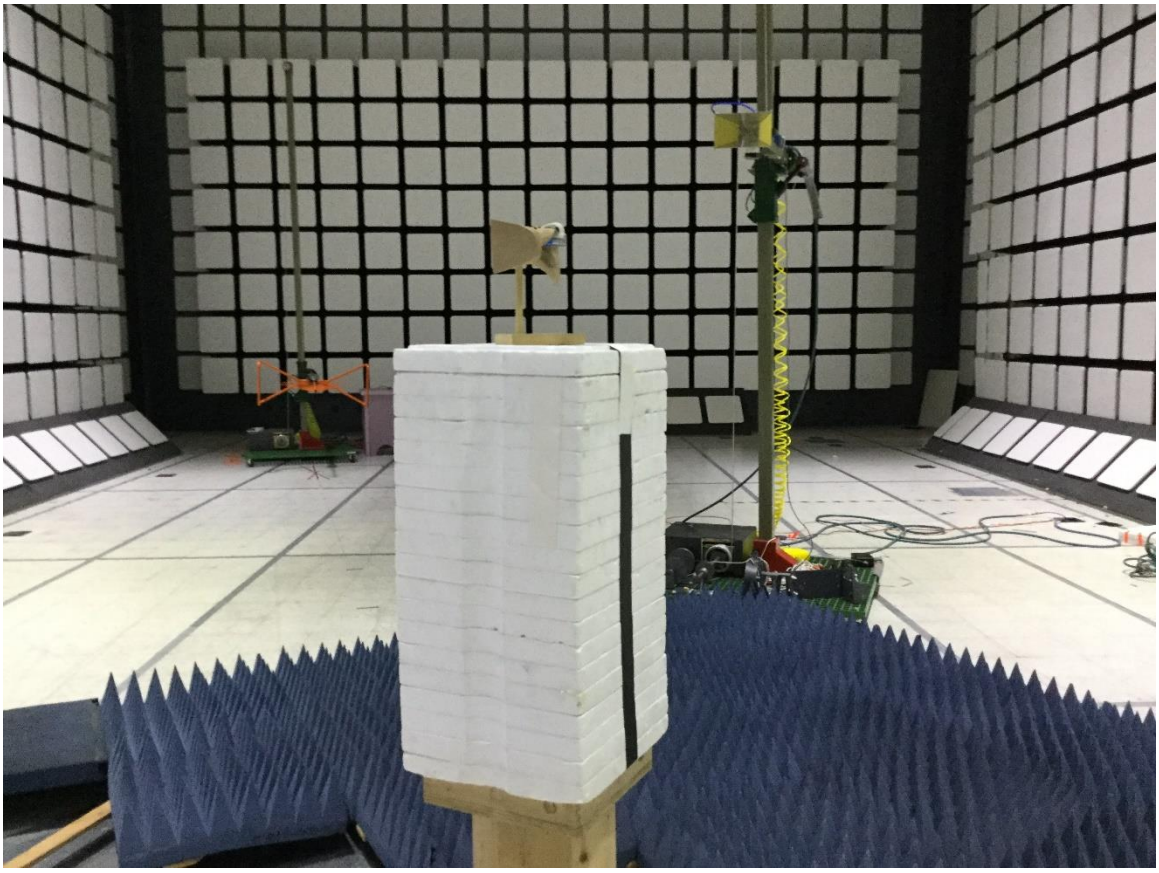


Figure 46 - Radiated Emissions Test Setup, Vertical, 1GHz – 25GHz

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%.