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Amended

FCC/ISED Test Report

Prepared for: **Inovonics**

Address: **397 S. Taylor Ave.**
Louisville, CO 80027

Product: **EN1550EP**

Test Report No: **R20171106-27-01A**

Approved by:

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

DATE: **7 December 2017**

Total Pages: **51**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	29 November 2017	Original – NJohnson Prepared by KVepuri
A	7 December 2017	Changed Pages 1 and 7 to show the product name as “EN1550EP” per client request. This report includes NCEE Labs report R20171106-27-01 and its amendment in full. -NJ

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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-Gen, Issue 4
(3) ISED RSS-247, Issue 2

SUMMARY			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	PCB antenna
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	Pass	Pulsed emissions duty cycle was applied
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	NA	The EUT has no receiver functionality
FCC 15.247(a)(1)(i) RSS-247, 5.1(c)	Minimum Bandwidth, Limit: Min. 250kHz	Pass	Meets the requirement of the limit.
FCC 15.247(b)(1) RSS-247, 5.1	Maximum Peak Output Power, Limit: Max. 24 dBm	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-247, 5.5	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247(a) (1) (i) RSS-247, 5.1(c)	Frequency hopping system, Limit: Max. 0.4 Seconds in 10 Second Period	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205 RSS-Gen, 8.9 RSS-247, 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	NA	Not applicable. Battery power only, no charger.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a wireless FHSS transmitter. It has transmit capabilities only.

EUT	EN1550EP
EUT Received	11/14/2017
EUT Tested	11/15/2017 - 11/28/2017
Serial No.	12680133 (Used for the radio measurements) & 12680120 (Used for all other tests)
Operating Band	900.0 – 928.0 MHz
Device Type	FHSS
Power Supply	3 VDC Battery (CR123A)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low	902.4
Middle	914.8
High	927.6

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, highest and one channel in the middle.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:
Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Karthik Vepuri	EMC Test Engineer	Testing
3	Nic Johnson	Technical Manager	Review of Results

Notes:
All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	24 Jan 2017	24 Jan 2018
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2018
EMCO Horn Antenna	3115	6416	25 Jan 2016	25 Jan 2018
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	9 Feb 2017*	9 Feb 2018*
Trilithic High Pass Filter	6HC330	23042	9 Feb 2017*	9 Feb 2018*
Mini Circuits 1700 – 5000Mhz High Pass Filter***	15542	31618	9 Feb 2017*	9 Feb 2018*
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Feb 2017*	09 Feb 2018*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Feb 2017*	09 Feb 2018*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Feb 2017*	09 Feb 2018*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Feb 2017*	09 Feb 2018*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Feb 2017*	09 Feb 2018*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Feb 2017*	09 Feb 2018*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Feb 2017*	09 Feb 2018*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Feb 2017*	09 Feb 2018*

*Internal Characterization

Notes:
All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: ANSI C63.10:2013, Section 7.5

Limits for duty cycle:

As shown in FCC Part 15.35(b), and RSS-Gen, Section 6.1, for frequencies above 1000MHz, the field strength limits are based on average detector, 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.

(c) Unless otherwise specified, *e.g.,* §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

Test procedures:

Because the EUT did not have provisions for making conducted measurements, the duty cycle was measured in a 10m semi-anechoic chamber with the test receiver set to “Zero span” mode.

All field strength or power measurements shown in these plots are arbitrary and only the times and levels of the EUT relative to the remote are considered for compliance.

Deviations from test standard:

No deviation.

Test setup:

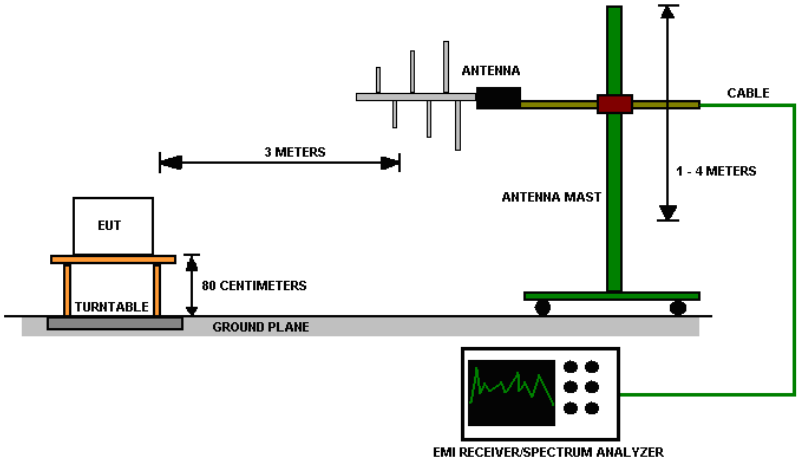

Figure 1 - Radiated Emissions Test Setup, 30MHz – 1GHz

EUT operating conditions:

The EUT was powered by 3 VDC unless specified. The duty cycle was only tested on the mid channel as it will be identical for all channels.

The EUT will only transmit often when the internal spring is triggered physically. In order to measure the maximum possible duty cycle an operator was standing next to the EUT and was flicking this spring during the test.

Test results:

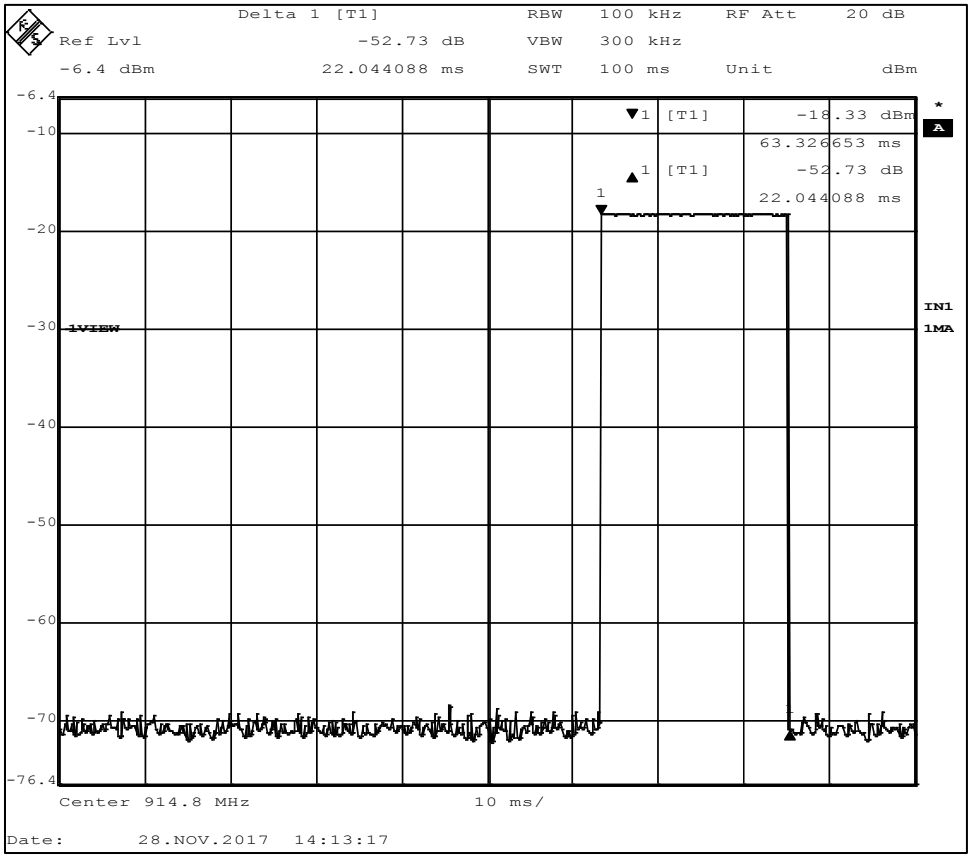

Figure 2 – Duty Cycle

Maximum of 1 pulse can occur in any 100 ms window on any one frequency channel.

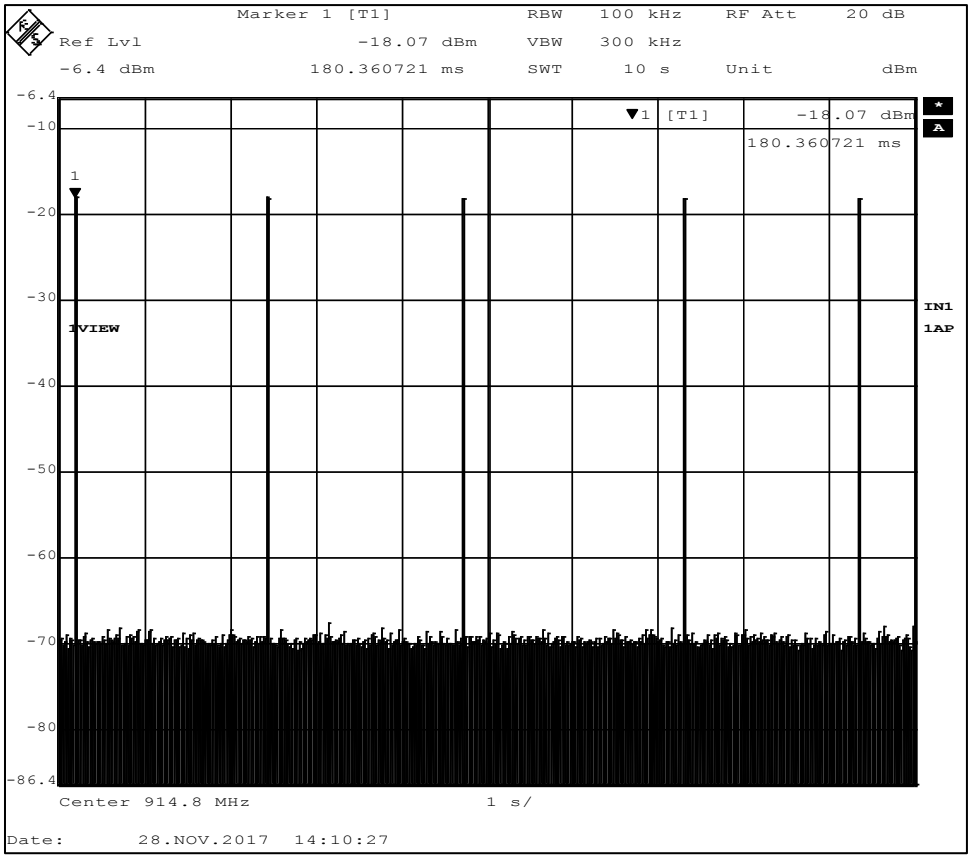

Figure 3 – Maximum Pulse Width

Duty cycle correction factor = 20*log(22.04)/100) = -13.14 dB

On time = 22.04 ms per Figure 2

Period = 100 ms (Figure 3 shows greater than 2 s; maximum 100ms was used)

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013, Section 6.5, 6.6

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 average detector, 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.

Test procedures:

a. The EUT was placed on the top of a rotating table 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. The table was 0.8m high for measurements form 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

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 maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

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, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

Test setup:

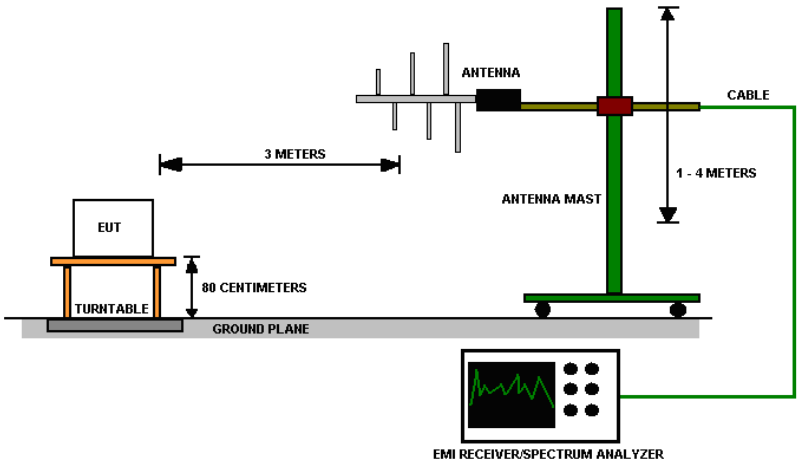

Figure 4 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

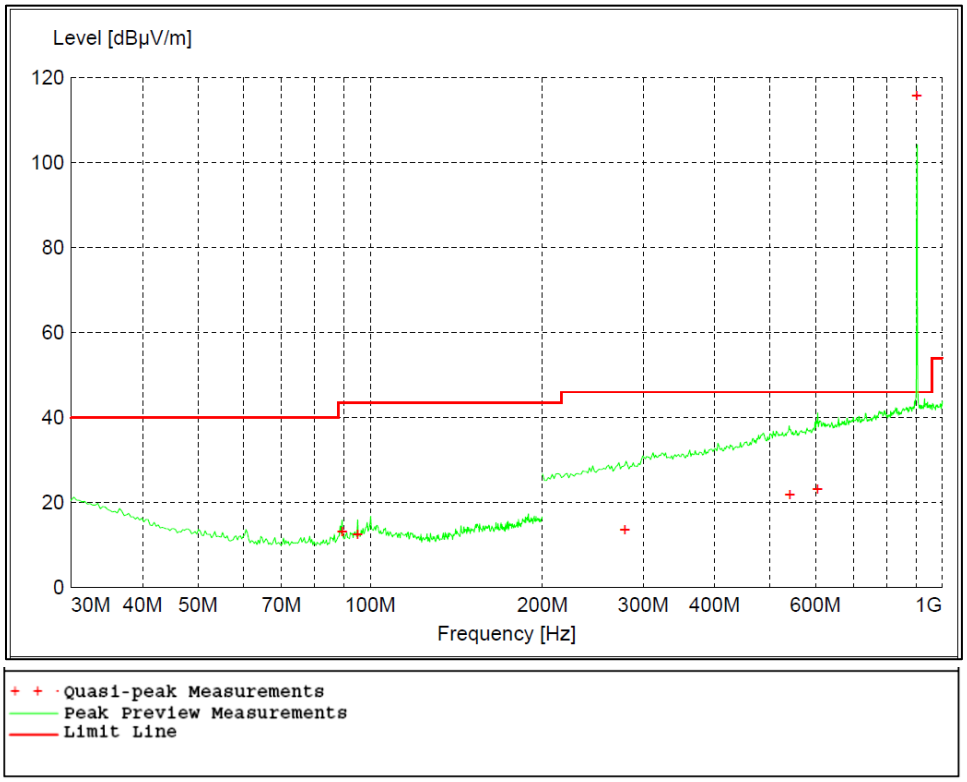

Figure 5 - Radiated Emissions Plot, Low Channel

Note: break at 200 MHz is due to attenuation being added to protect receiver from fundamental

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
89.340000	13.17	43.50	30.30	308	352	VERT	Y
95.100000	12.41	43.50	31.10	399	292	HORI	Y
278.880000	13.66	46.00	32.30	148	360	VERT	Y
541.440000	21.75	46.00	24.30	360	0	HORI	Y
605.400000	23.21	46.00	22.80	303	270	HORI	Y
902.400000	115.72	46.00	-69.70	126	358	HORI	Y

Table 2 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.800000	32.73	54.00	21.27	206	180	VERT	Y
2707.200000	36.15	54.00	17.85	167	63	HORI	Y
3609.600000	43.13	54.00	10.87	190	89	VERT	Y
4511.800000	27.95	54.00	26.05	399	256	VERT	Y
5414.400000	44.02	54.00	9.98	204	121	VERT	Y
6316.600000	32.77	54.00	21.23	177	215	VERT	Y
7219.200000	32.27	54.00	21.73	256	307	VERT	Y
8118.800000	33.47	54.00	20.53	400	33	HORI	Y
9046.200000	34.03	54.00	19.97	144	18	HORI	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 13.14 dB was used.

Table 3 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.800000	45.87	74.00	28.13	206	180	VERT	Y
2707.200000	49.29	74.00	24.71	167	63	HORI	Y
3609.600000	56.27	74.00	17.73	190	89	VERT	Y
4511.800000	41.09	74.00	32.91	399	256	VERT	Y
5414.400000	57.16	74.00	16.84	204	121	VERT	Y
6316.600000	45.91	74.00	28.09	177	215	VERT	Y
7219.200000	45.41	74.00	28.59	256	307	VERT	Y
8118.800000	46.61	74.00	27.39	400	33	HORI	Y
9046.200000	47.17	74.00	26.83	144	18	HORI	Y

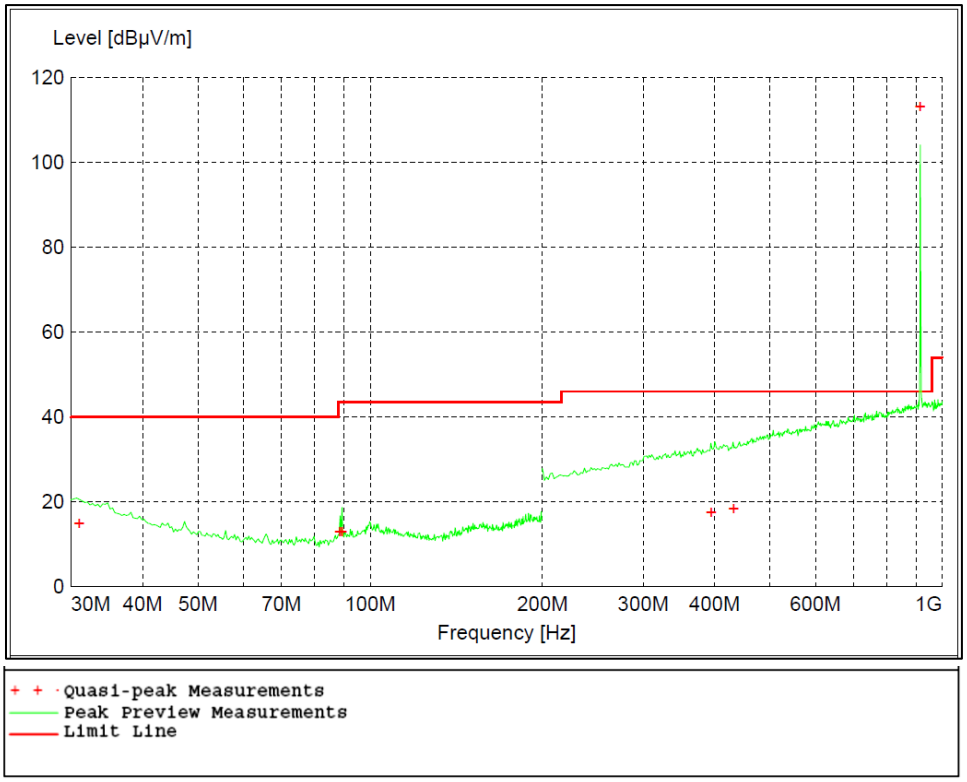

Figure 6 - Radiated Emissions Plot, Mid Channel

Note: break at 200 MHz is due to attenuation being added to protect receiver from fundamental

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
31.020000	14.90	40.00	25.10	172	90	VERT	Y
88.500000	12.85	43.50	30.70	102	268	HORI	Y
89.280000	13.01	43.50	30.50	102	349	HORI	Y
394.740000	17.52	46.00	28.50	185	153	VERT	Y
431.760000	18.25	46.00	27.70	99	239	HORI	Y
914.800000	112.99	46.00	-67.00	130	357	HORI	Y

Table 5 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1724.800000	24.23	54.00	29.77	144	360	VERT	Y
1829.600000	22.17	54.00	31.83	157	55	VERT	Y
2744.400000	39.17	54.00	14.83	160	280	HORI	Y
3659.200000	47.13	54.00	6.87	190	95	HORI	Y
4574.000000	45.73	54.00	8.27	211	58	HORI	Y
5488.800000	43.28	54.00	10.72	167	301	VERT	Y
6387.800000	31.04	54.00	22.96	233	119	VERT	Y
7318.400000	36.43	54.00	17.57	119	60	VERT	Y
8211.400000	33.90	54.00	20.10	399	29	VERT	Y
9132.200000	34.49	54.00	19.51	99	275	VERT	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 13.14dB was used.

Table 6 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1724.800000	37.37	74.00	36.63	144	360	VERT	Y
1829.600000	35.31	74.00	38.69	157	55	VERT	Y
2744.400000	52.31	74.00	21.69	160	280	HORI	Y
3659.200000	60.27	74.00	13.73	190	95	HORI	Y
4574.000000	58.87	74.00	15.13	211	58	HORI	Y
5488.800000	56.42	74.00	17.58	167	301	VERT	Y
6387.800000	44.18	74.00	29.82	233	119	VERT	Y
7318.400000	49.57	74.00	24.43	119	60	VERT	Y
8211.400000	47.04	74.00	26.96	399	29	VERT	Y
9132.200000	47.63	74.00	26.37	99	275	VERT	Y

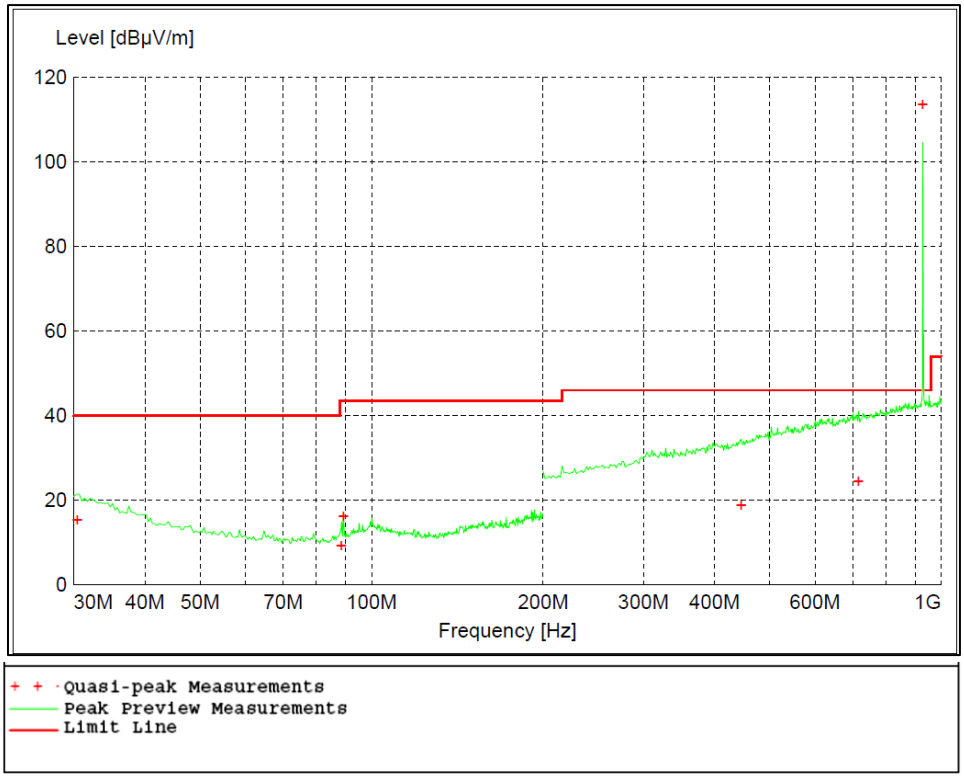

Figure 7 - Radiated Emissions Plot, High Channel

Note: break at 200 MHz is due to attenuation being added to protect receiver from fundamental

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
30.420000	15.23	40.00	24.80	383	260	HORI	Y
88.500000	9.11	43.50	34.40	324	360	HORI	Y
89.280000	16.20	43.50	27.30	308	248	VERT	Y
445.440000	18.71	46.00	27.30	100	304	HORI	Y
714.900000	24.51	46.00	21.50	213	9	HORI	Y
927.600000	113.59	46.00	-67.60	123	0	HORI	Y

Table 8 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1855.200000	30.41	54.00	23.59	197	199	VERT	Y
2782.800000	40.29	54.00	13.71	160	286	HORI	Y
3710.400000	47.50	54.00	6.50	157	101	VERT	Y
4638.000000	47.23	54.00	6.77	200	60	HORI	Y
5565.600000	40.82	54.00	13.18	200	55	VERT	Y
6499.400000	30.63	54.00	23.37	158	312	VERT	Y
7403.400000	29.93	54.00	24.07	291	358	VERT	Y
8346.200000	33.55	54.00	20.45	187	85	HORI	Y
9276.400000	32.73	54.00	21.27	362	9	HORI	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 13.14dB was used.

Table 9 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1855.200000	43.55	74.00	30.45	197	199	VERT	Y
2782.800000	53.43	74.00	20.57	160	286	HORI	Y
3710.400000	60.64	74.00	13.36	157	101	VERT	Y
4638.000000	60.37	74.00	13.63	200	60	HORI	Y
5565.600000	53.96	74.00	20.04	200	55	VERT	Y
6499.400000	43.77	74.00	30.23	158	312	VERT	Y
7403.400000	43.07	74.00	30.93	291	358	VERT	Y
8346.200000	46.69	74.00	27.31	187	85	HORI	Y
9276.400000	45.87	74.00	28.13	362	9	HORI	Y

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.
5. The EUT was measured in all 3 orthagonal axis. It was found that the Y-axis produced the highest emissions, and this orientation was used for all testing. See the test setup photo exhibit for details on the orientations.

4.3 PEAK OUTPUT POWER

Test Method: ANSI C63.10, Section(s) 7.8.5

Limits of bandwidth measurements:
The peak EIRP was measured using a 1 MHz RBW. For an FHSS system with 25 channels, the output power is required to be less than 250 mW or 24 dBm.

EIRP was calculated from field strength measurements using ANSI C63.10:2013, Section 9.5, Equation (22). The field strength was measured at a 3m distance and maximized.

Test procedures:
All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 1 MHz RBW and 3 MHz VBW.

The EUT was maximized in all 3 orthogonal positions in a similar manner as described in Section 4.2.

Deviations from test standard:
No deviation.

Test setup:

See Section 4.2

EUT operating conditions:
The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	Method	RESULT
Low	902.4	20.68	EIRP	PASS
Middle	914.8	20.03	EIRP	PASS
High	927.6	18.80	EIRP	PASS

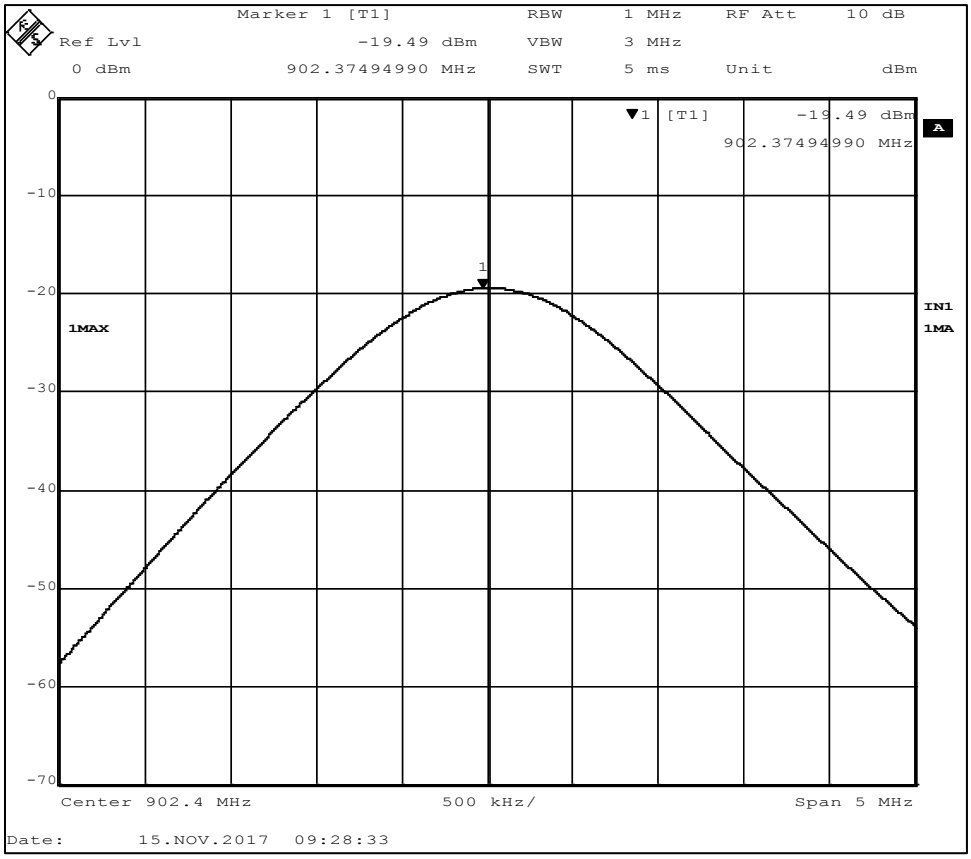

Figure 8 – Output Power, Low Channel. -19.49 dBm

Maximum power = -19.49 dBm + 107 + CL + AF - 95.23 = 20.68 dBm*
CL = cable loss = 4.70 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

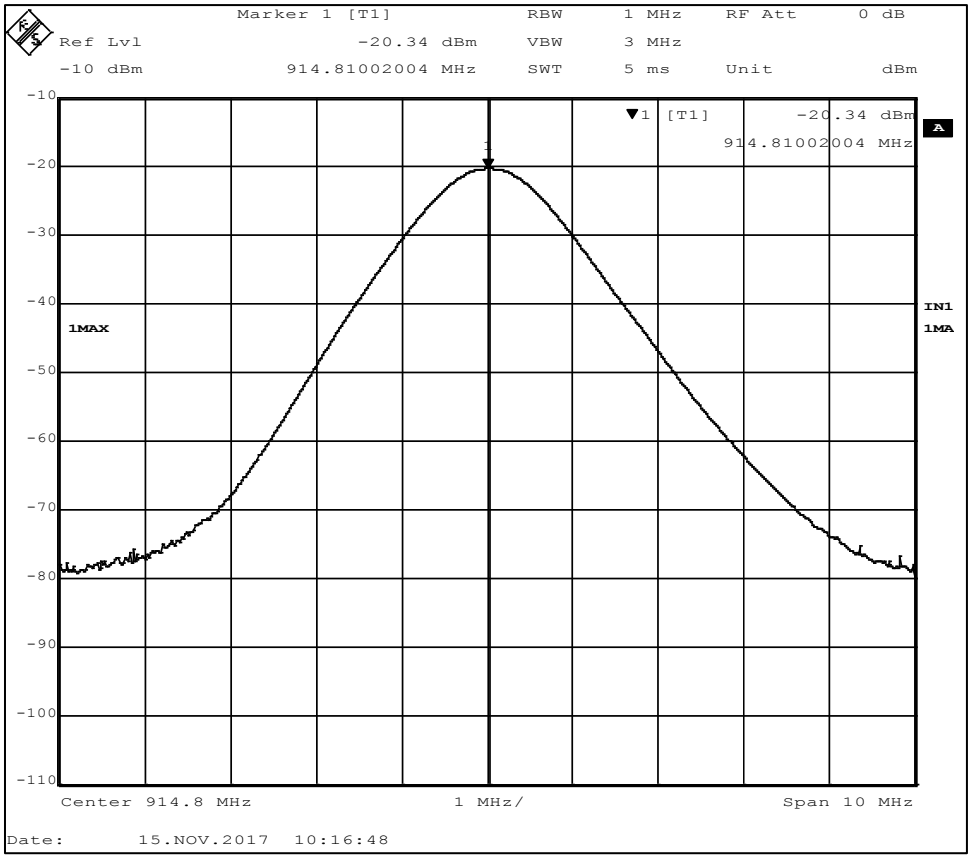

Figure 9 - Output Power, Mid Channel

Maximum power = -20.34 dBm + 107 + CL + AF - 95.23 = 20.03 dBm
CL = cable loss = 4.80 dB
AF = antenna factor = 23.80 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

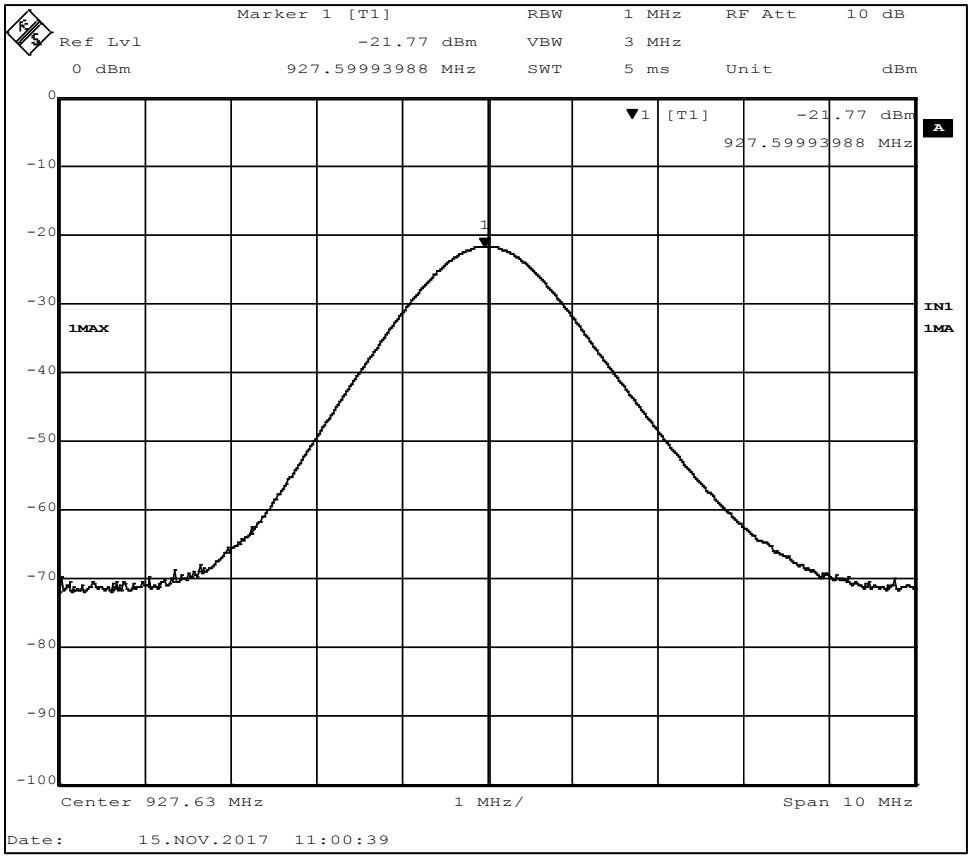

Figure 10 - Output Power, High Channel

Maximum power = -21.77 dBm + 107 + CL + AF - 95.23 = 18.80 dBm
CL = cable loss = 4.90 dB
AF = antenna factor = 23.90 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

4.4 BANDWIDTH

Test Method: ANSI C63.10, Section(s) 6.9.2

Limits of bandwidth measurements:
From FCC Part 15.247 (1) (i) and RSS-247 5.1(c)

The maximum allowed 20 dB bandwidth of the hopping channel is 250 kHz.

Test procedures:
Bandwidth measurement was 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 300 kHz VBW.

The 20 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 20dB.

Test setup:

All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually. See Section 4.3 for more details.

Deviations from test standard:
No deviation.

Test setup:

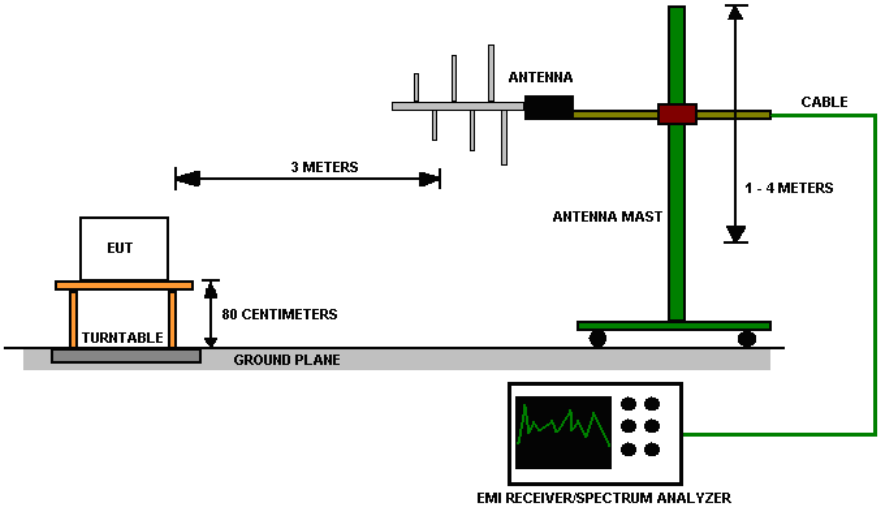

Figure 11 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

20 dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	20dB BW (kHz)
Low	902.40	316.63
Mid	914.80	316.63
High	927.75	320.64

*The limit is 250 kHz minimum. The measurements were conducted at 100 kHz RBW and 300 kHz VBW according to FCC Report and Order FCC 14-208 from December 30, 2014, Paragraph 83.

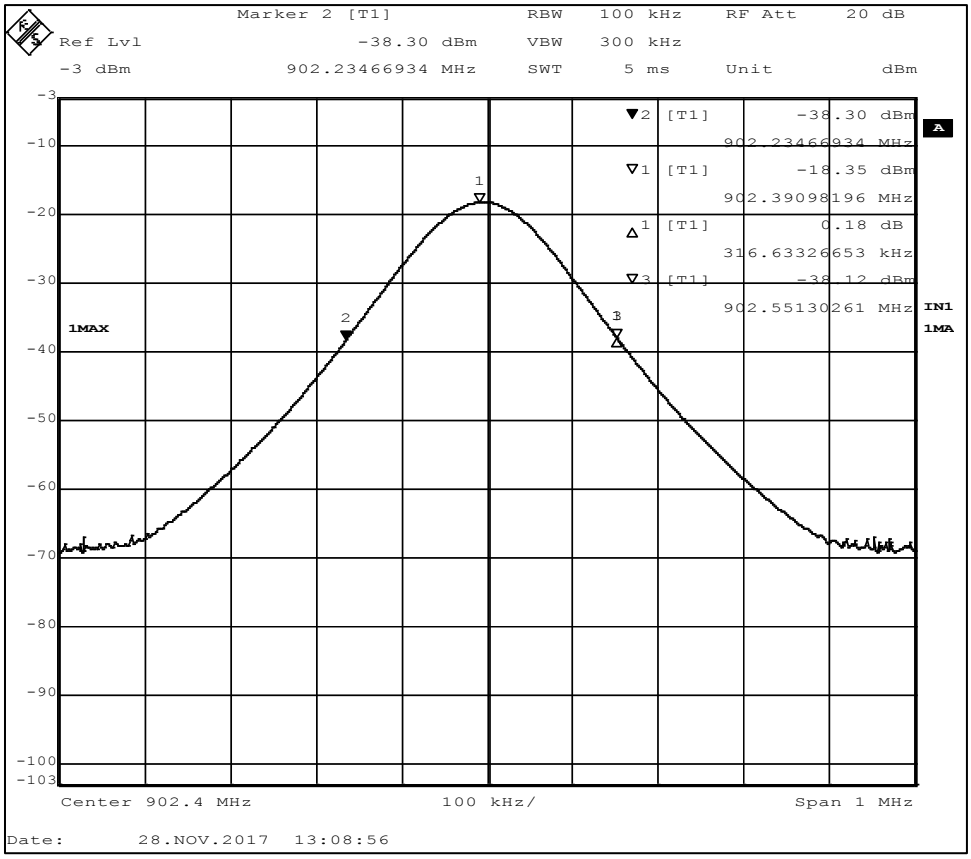

Figure 12 – 20 dB Bandwidth, Low Channel. 316.63 kHz

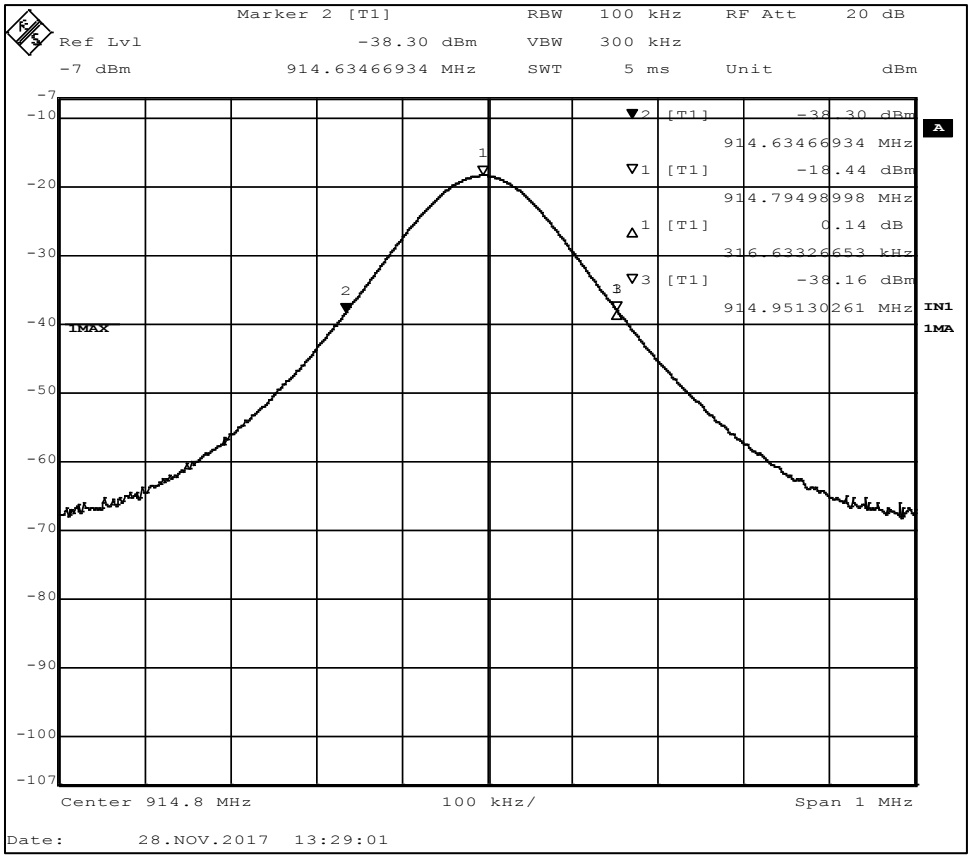

Figure 13 - 20 dB Bandwidth, Mid Channel, 316.63 kHz

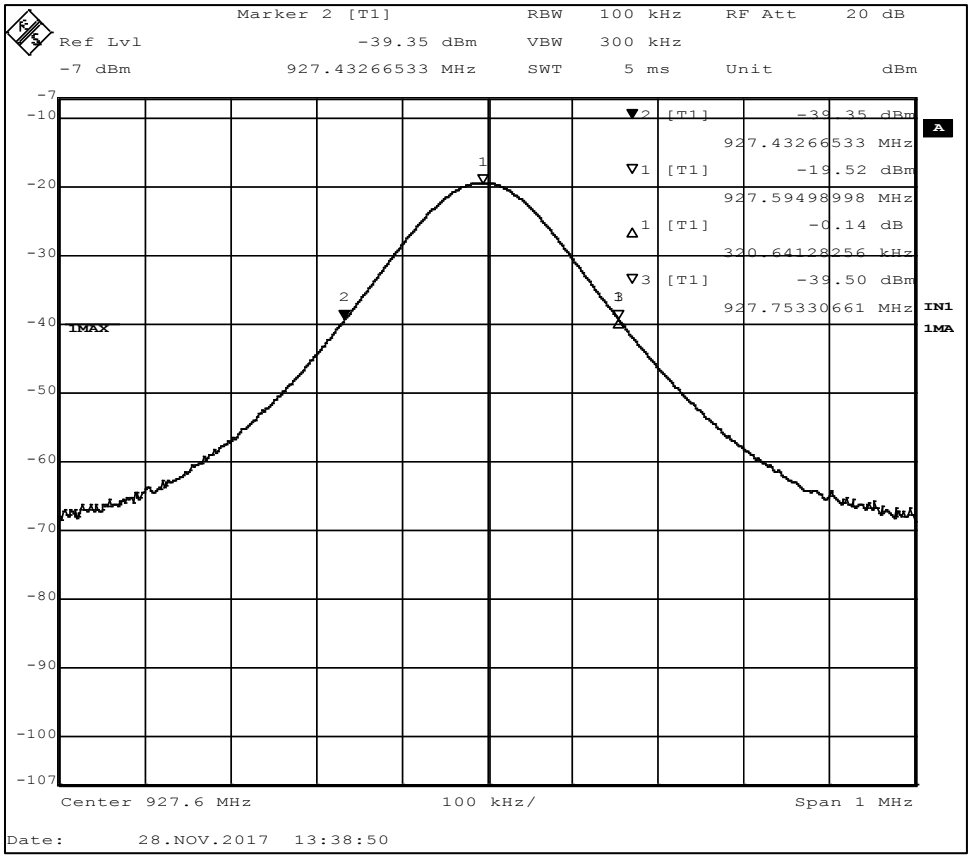

Figure 14 - 20 dB Bandwidth, High Channel, 320.64 kHz

4.5 BANDEDGES

Test Method: ANSI C63.10, Section(s) 6.10.6

Limits of bandedge measurements:
For emissions outside of the allowed band of operation (902 – 928MHz), 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.

Test procedures:
The EUT was tested in the same method as described in section *4.4 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

Deviations from test standard:
No deviation.

Test setup:
All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually.

EUT operating conditions:
The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Highest Out of Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low, Continuous	614.0	-109.14	-18.43	90.71	69.72	PASS
High, Continuous	960.0	-103.84	-18.70	85.14	67.59	PASS
Low Hopping	614.0	-107.99	-19.05	88.94	69.72	PASS
High, Hopping	960.0	-103.19	-19.69	83.50	67.59	PASS

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

From Section 4.2

Fundamental average field strength at 902.4MHz for low channel = 115.72 dBµV/m
Fundamental average field strength at 927.6MHz for high channel = 113.59 dBµV/m

Low channel minimum delta = 115.72 – 46.0 dBµV/m = 69.72 dBc
High channel minimum delta = 113.59 – 46.0 dBµV/m = 67.59 dBc

Measurements do not include correction factors and are intended to be relative measurements only.

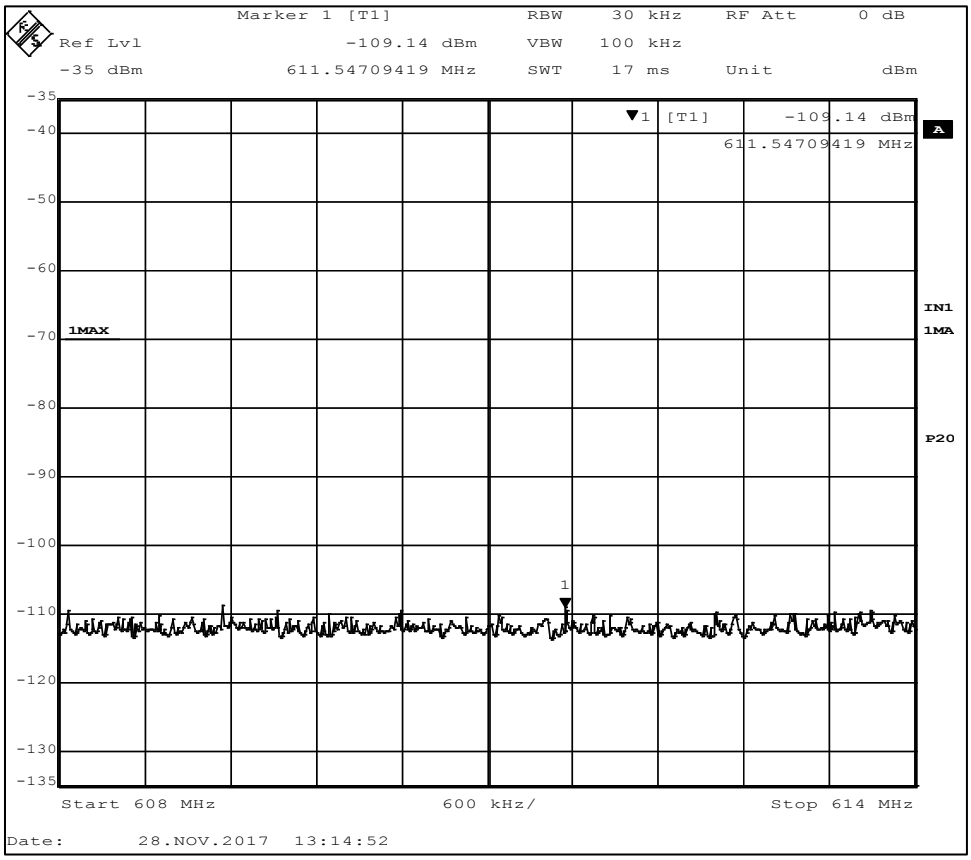

Figure 15 - Band-edge Measurement, Low Channel, Restricted Frequency, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

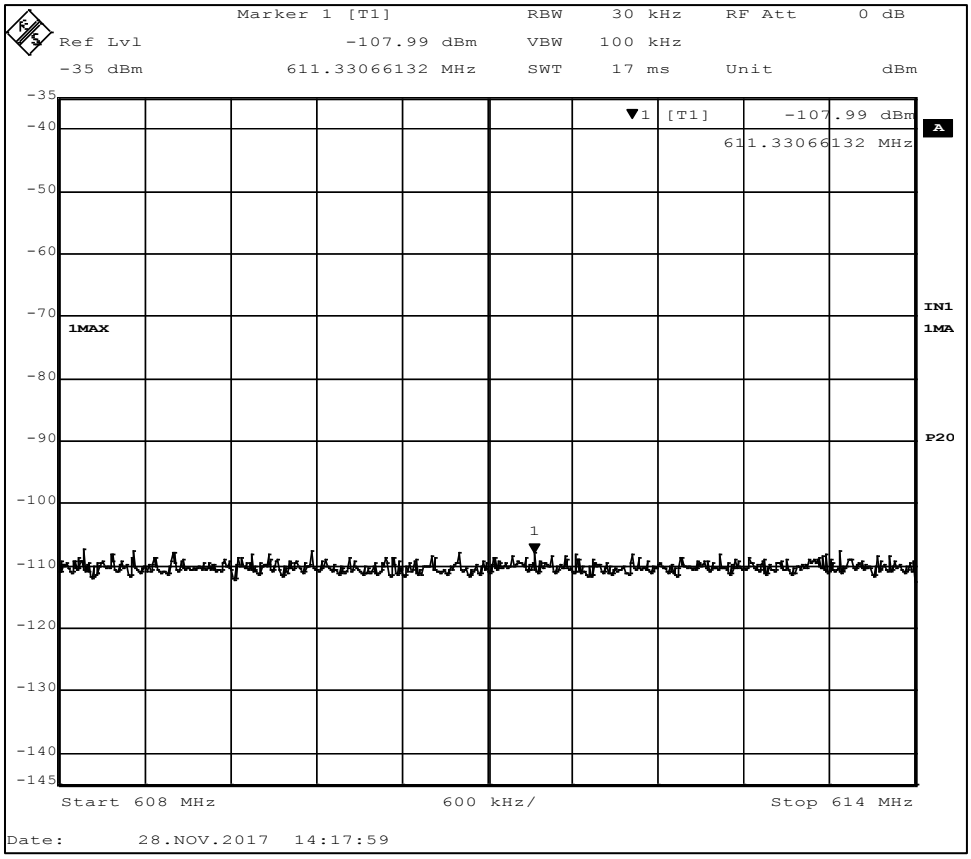

Figure 16 - Band-edge Measurement, Low Channel, Restricted Frequency, Hopping

The plot shows an uncorrected measurement, used for relative measurements only.

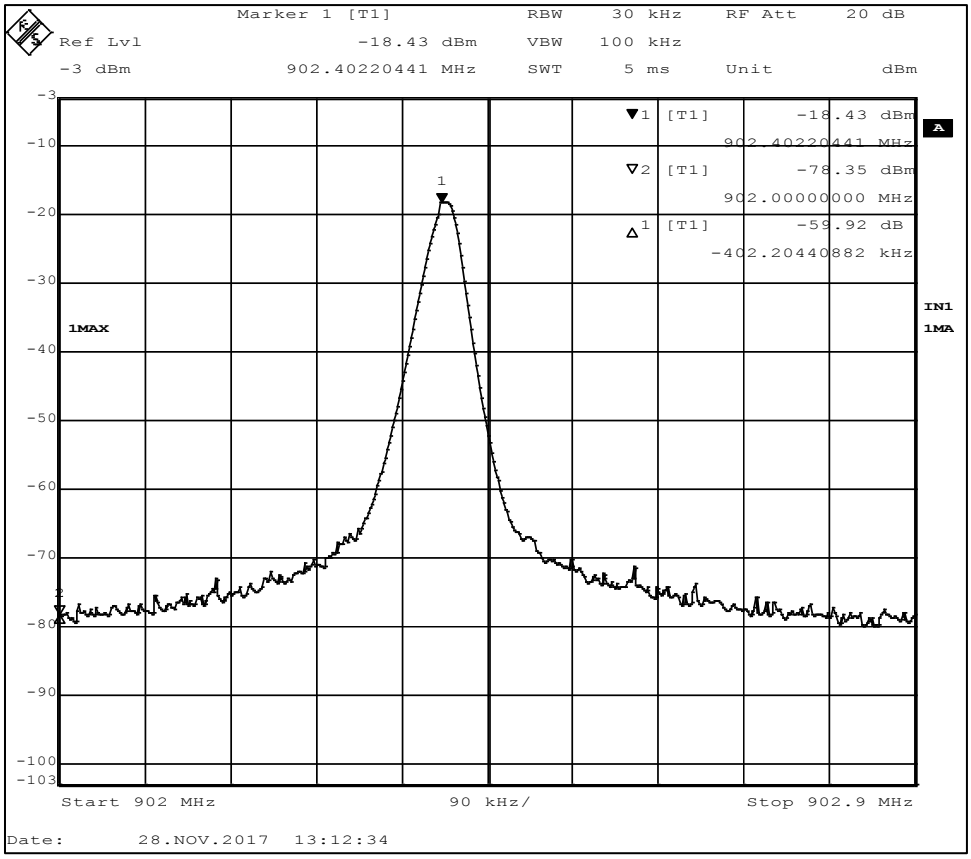

Figure 17 - Band-edge Measurement, Low Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 59.92 dB > 20 dB minimum

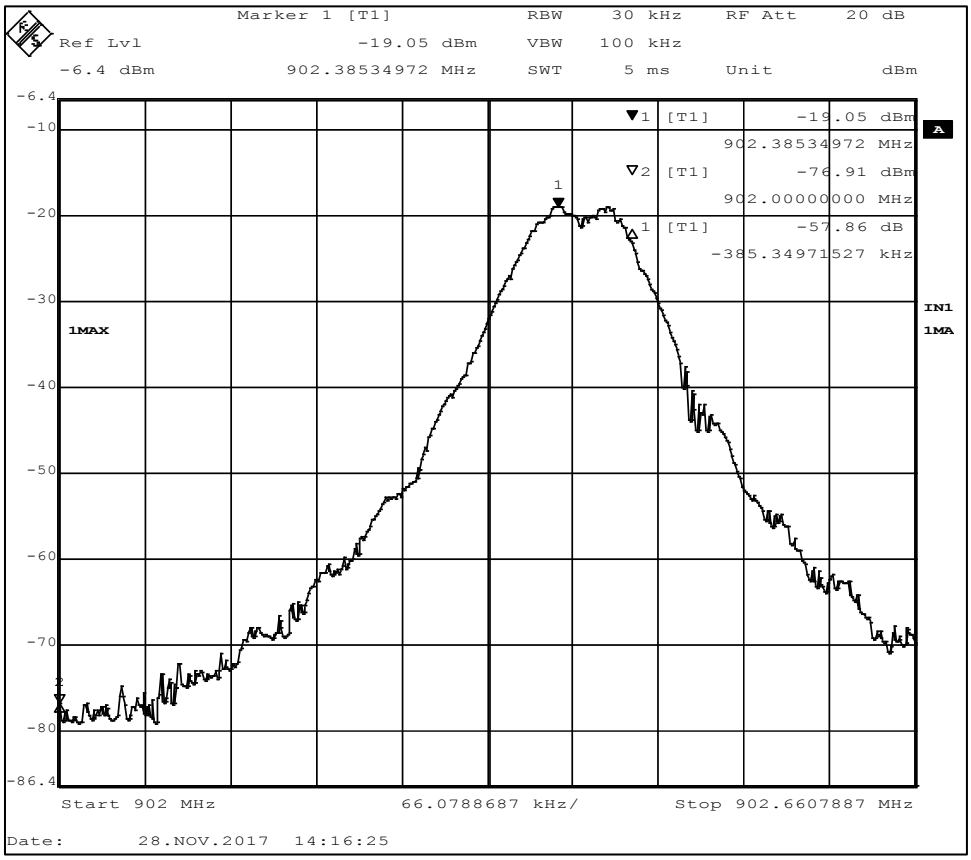

Figure 18 - Band-edge Measurement, Low Channel, Fundamental, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.
Delta = 57.86 dB > 20 dB minimum

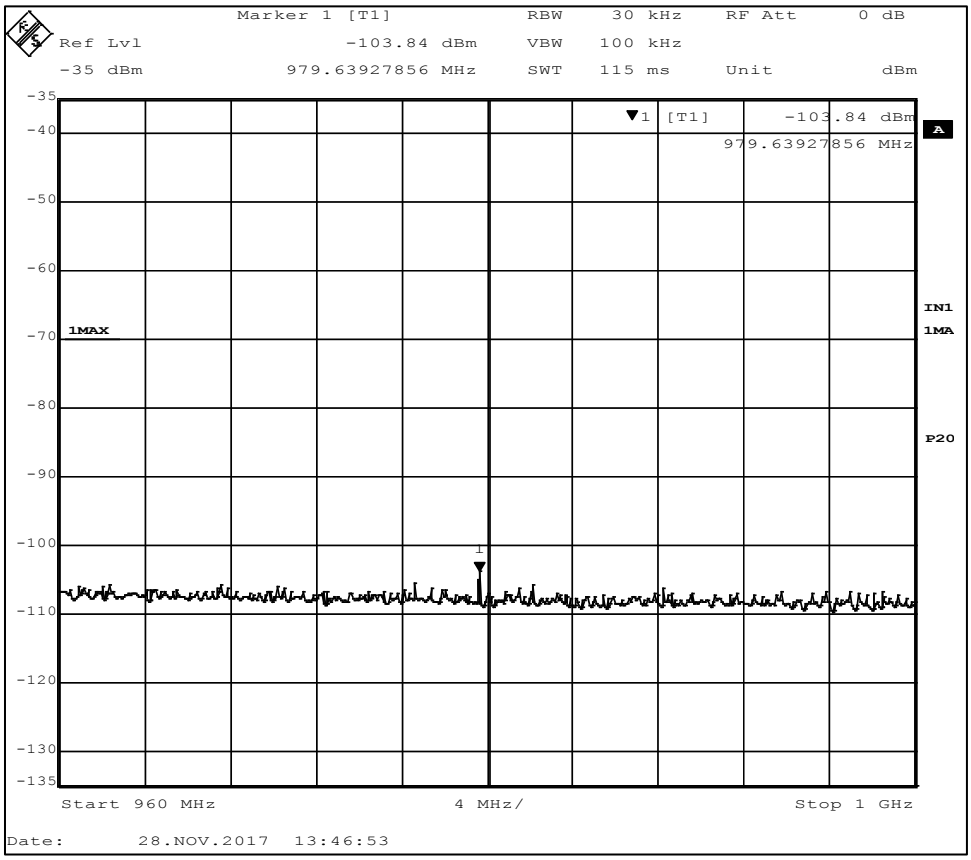

Figure 19 - Band-edge Measurement, High Channel, Restricted Frequency, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

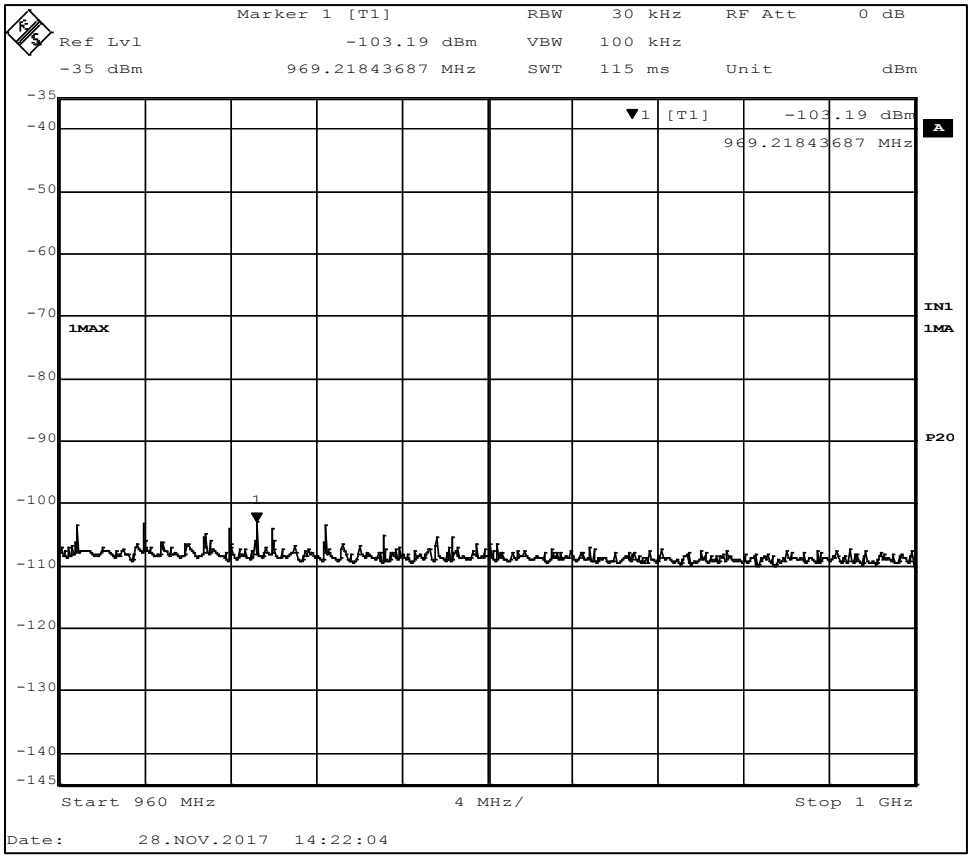

Figure 20 - Band-edge Measurement, High Channel, Restricted Frequency, Hopping

The plot shows an uncorrected measurement, used for relative measurements only.

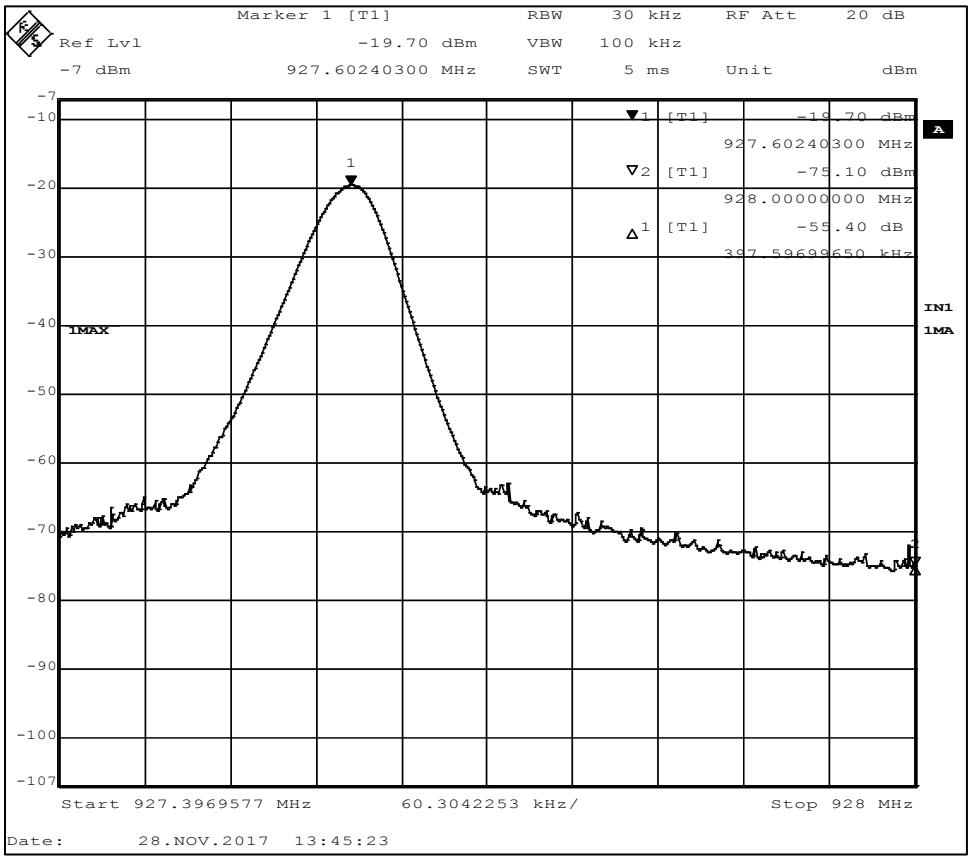

Figure 21 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 55.40 dB > 20 dB minimum

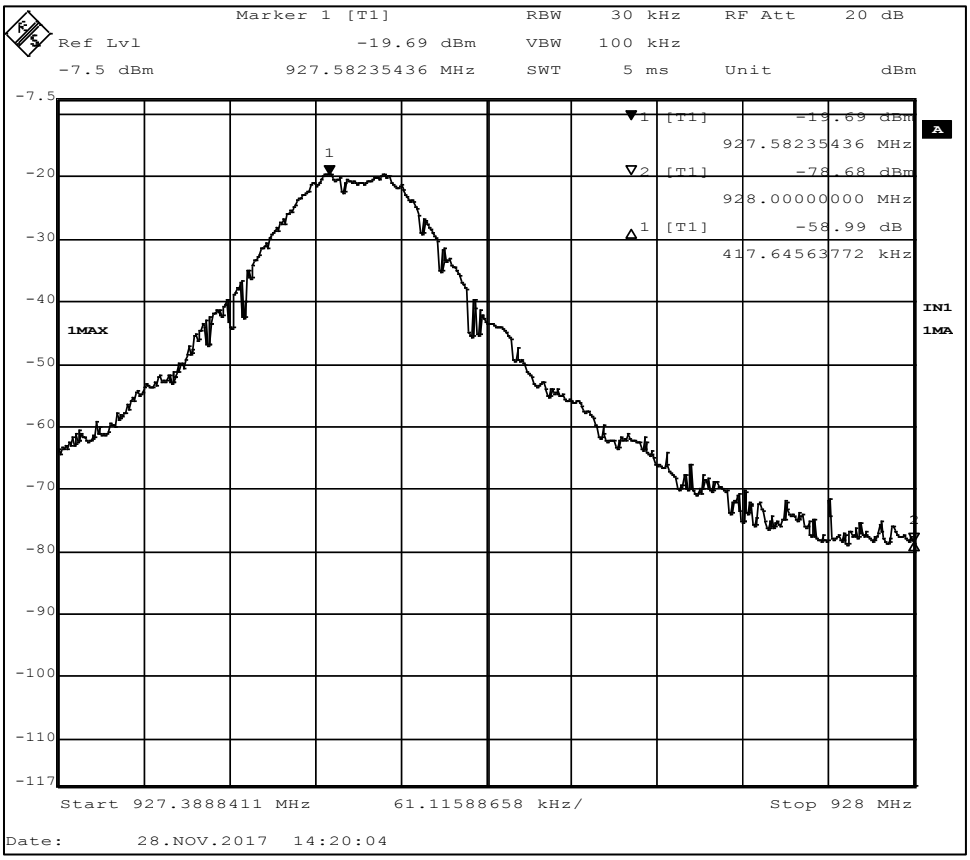

Figure 22 - Band-edge Measurement, High Channel, Fundamental, Hopping Transmit

The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 58.99 dB > 20 dB minimum

4.6 CARRIER FREQUENCY SEPERATION, NUMBER OF HOPPING CHANNELS, TIME OF OCCUPANCY

Test Method: ANSI C63.10, Section 7.8.2, 7.8.3, 7.8.4

Limits for Time of Occupancy

Average time of occupancy on any frequency, not to exceed 0.4 seconds within a 10 second period.

Test procedures:
The method from FCC DA 00-705

All measurements were taken at a distance of 3m from the EUT.

Test setup:
All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually.

EUT operating conditions:
The EUT was powered by 3VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

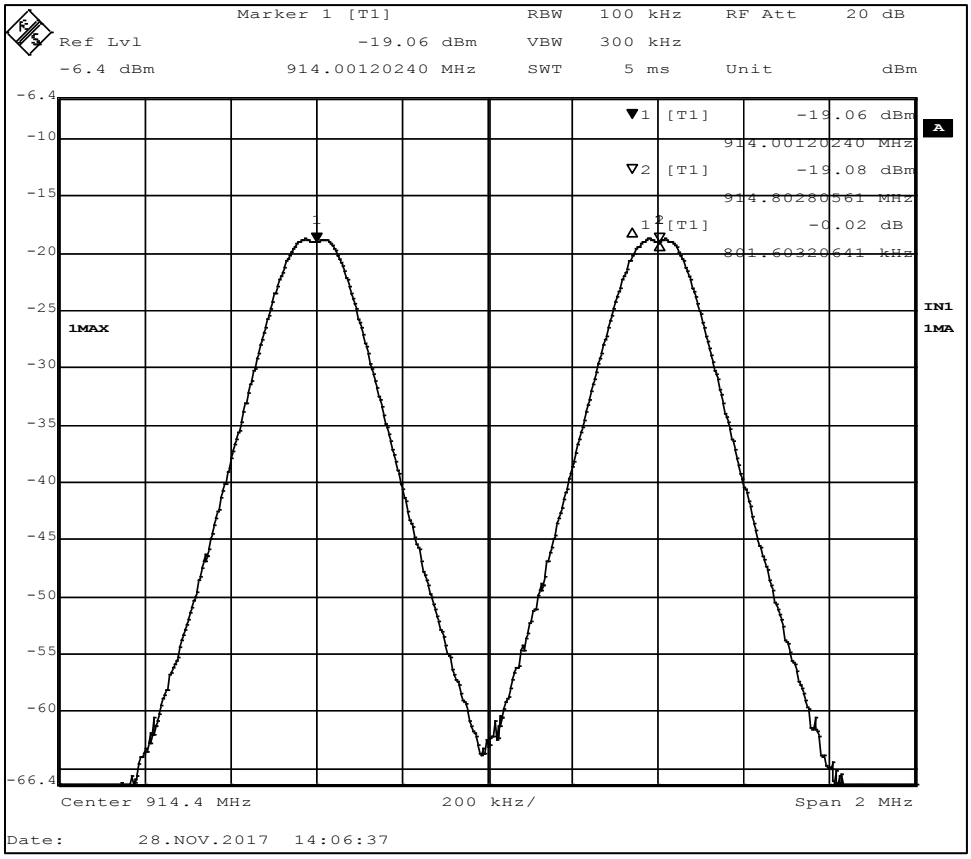

Figure 23 – Frequency Separation, 801.60 kHz

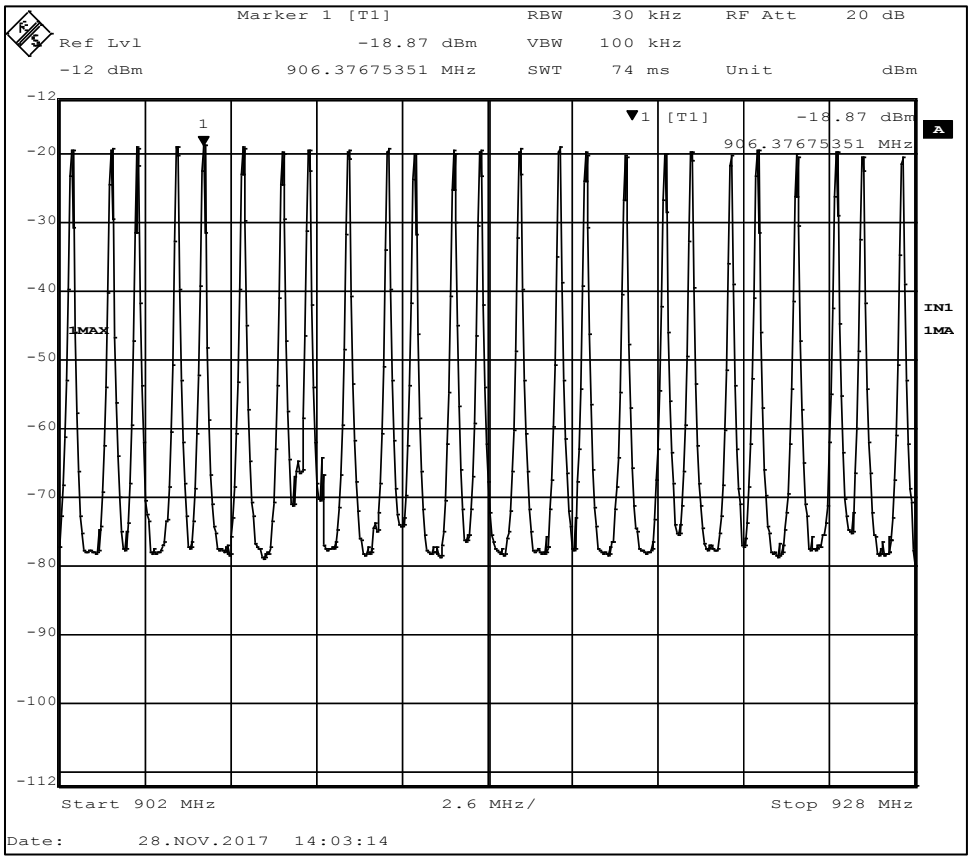

Figure 24 – Hop Count, 25 Hops

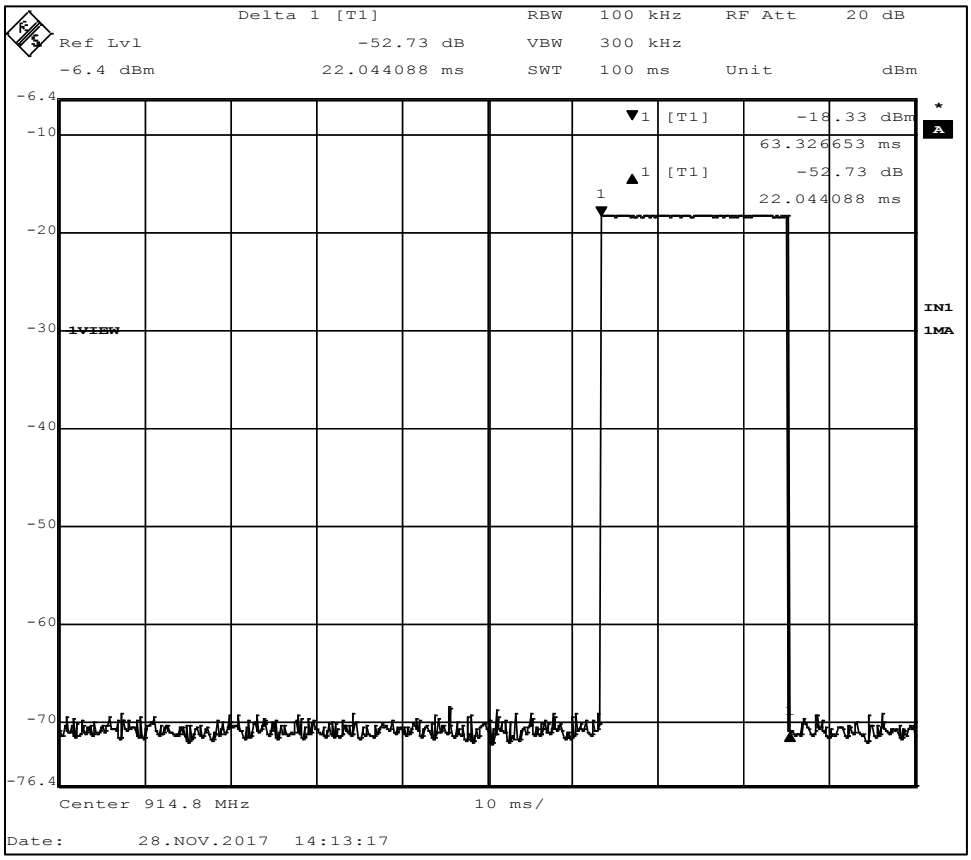

Figure 25 – Time of Occupancy, On Time

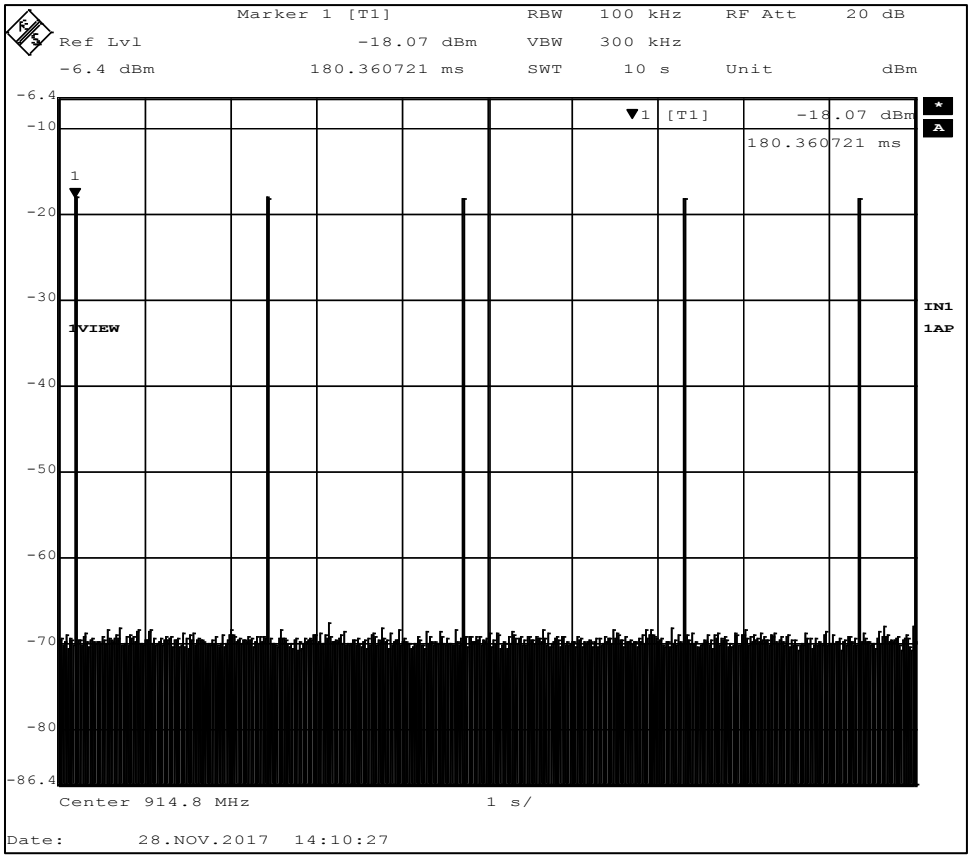

Figure 26 – Time of Occupancy, Period

*Maximum of 5 transmissions can occur in a given channel in any 10 s so the average time of occupancy is 22.04 ms x 5 =110.2 ms = 0.11 s < 0.4 s - Pass

APPENDIX A: 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 Strength (V/m) x antenna distance (m)]^2 / 30

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

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

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

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

10log(10^9) is the conversion from micro to milli

APPENDIX B – 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%.

REPORT END