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Amended

FCC/ISED Test Report

Prepared for: **Digital Monitoring Products**

Address: **2500 North Partnership Blvd.**
Springfield, MO 6582

Product: **1100 - 900MHz Wireless Transceiver**

Test Report No: **R20180226-21-01A**

Approved by:

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

DATE: **18 June 2018**

Total Pages: **45**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	4 May 2018	Original – NJohnson Prepared by KVepuri
A	18 June 2018	Band edge measurements section was modified to include field strength measurements compared to 15.209 limits. Added note about testing in hopping mode This report contains NCEE Labs report R20180226-21-01 and its amendment in full. -NJ

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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested to meet the following regulatory requirements:

(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	Pass	Meets the requirement of the limit.
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	Pass	Meets the requirement of the limit.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary

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

EUT	1100XH
EUT Received	4/19/2018
EUT Tested	4/19/2018 - 5/1/2018
Serial No.	PC-0114 R5
Operating Band	900.0 – 928.0 MHz
Device Type	FHSS
Power Supply	I.T.E. Power Supply MN: MGT-12500-SPS Input: 100-240 VAC 50/60Hz 0.2A Output: 12 VDC 0.5A

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	905.6
Middle	915.0
High	924.4

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
2	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	30 Jan 2018	30 Jan 2019
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2018
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2019*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2019*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	25 Jul 2017	25 Jul 2018
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2019*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2019*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2019*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2019*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2019*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2019*

*Internal Characterization

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

3.4 TEST SOFTWARE

MANUFACTURER	Software	Version No.	TESTS
Rohde & Schwarz	ES-K1	1.60	Transmitter Spurious Emissions Receiver Spurious Emissions Conducted Emissions

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 on bench 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:

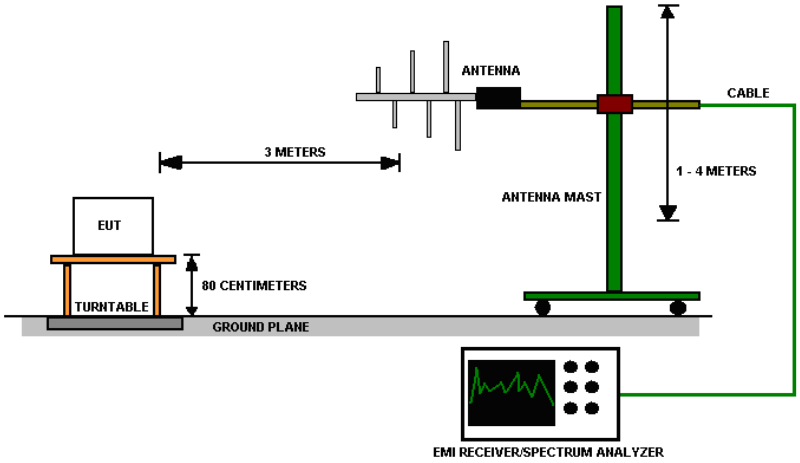

Figure 1 - Radiated Emissions Test Setup, 30MHz – 1GHz

EUT operating conditions:

The EUT was powered by 12 VDC unless specified. The duty cycle was only tested on the mid channel as it will be identical for all channels.

Test results:

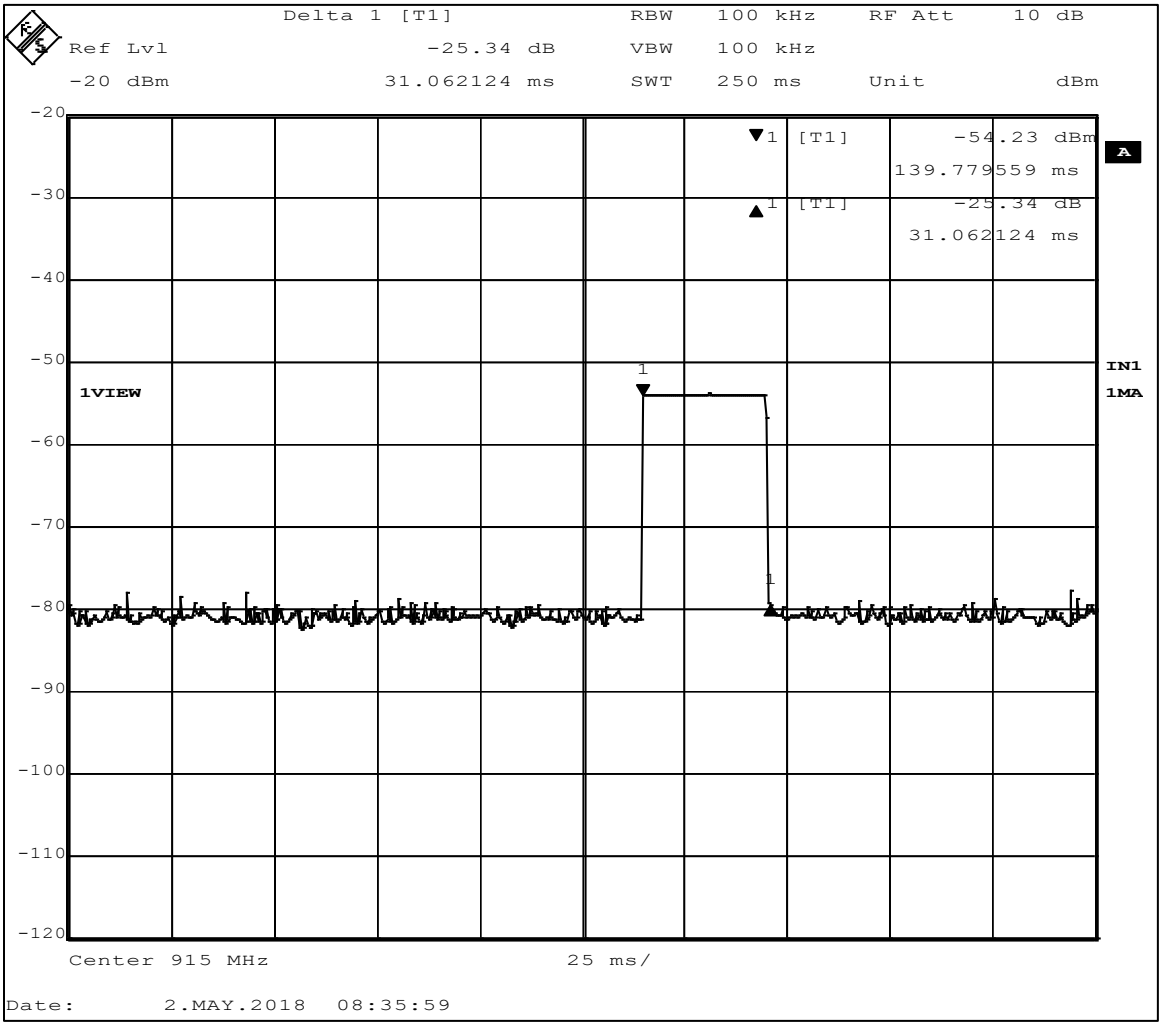

Figure 2 – Duty Cycle

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

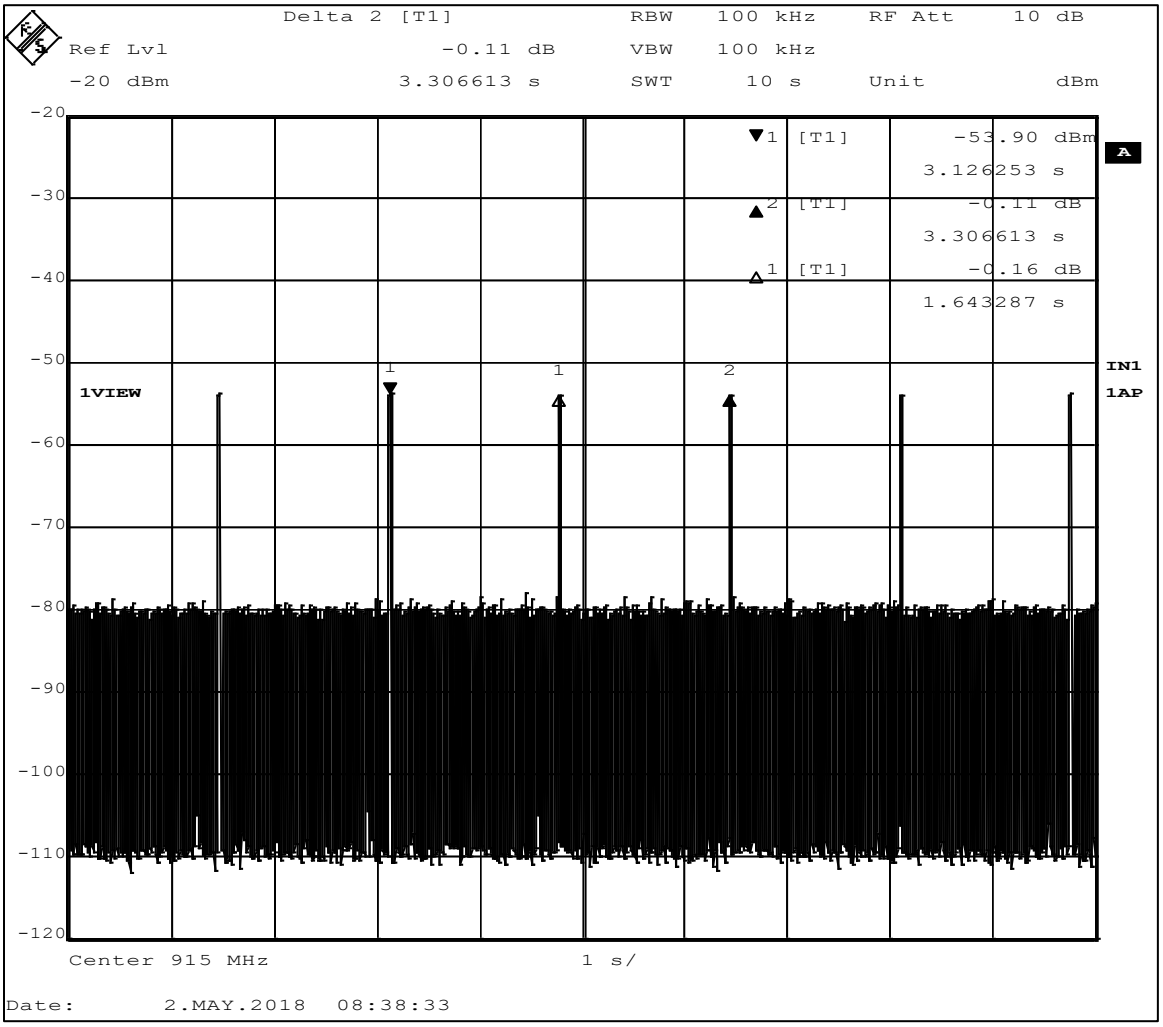

Figure 3 – Maximum Pulse Width

Duty cycle correction factor = 20*log(31.06)/100) = -10.16 dB

On time = 31.06 ms per Figure 2

Period = 100 ms (Figure 3 shows greater than 1 s; maximum 100ms was used)

*Note that these measurements were done in the hopping mode provided by the manufacturer and they consider that this is the worst case for duty cycle.

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:

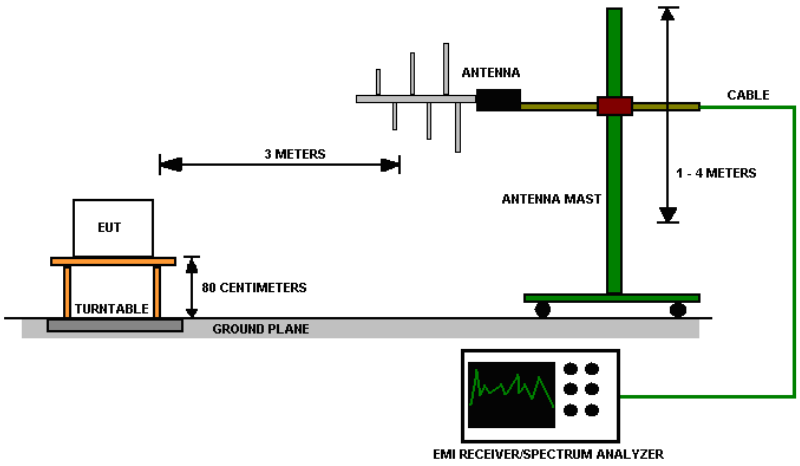

Figure 4 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 12 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:

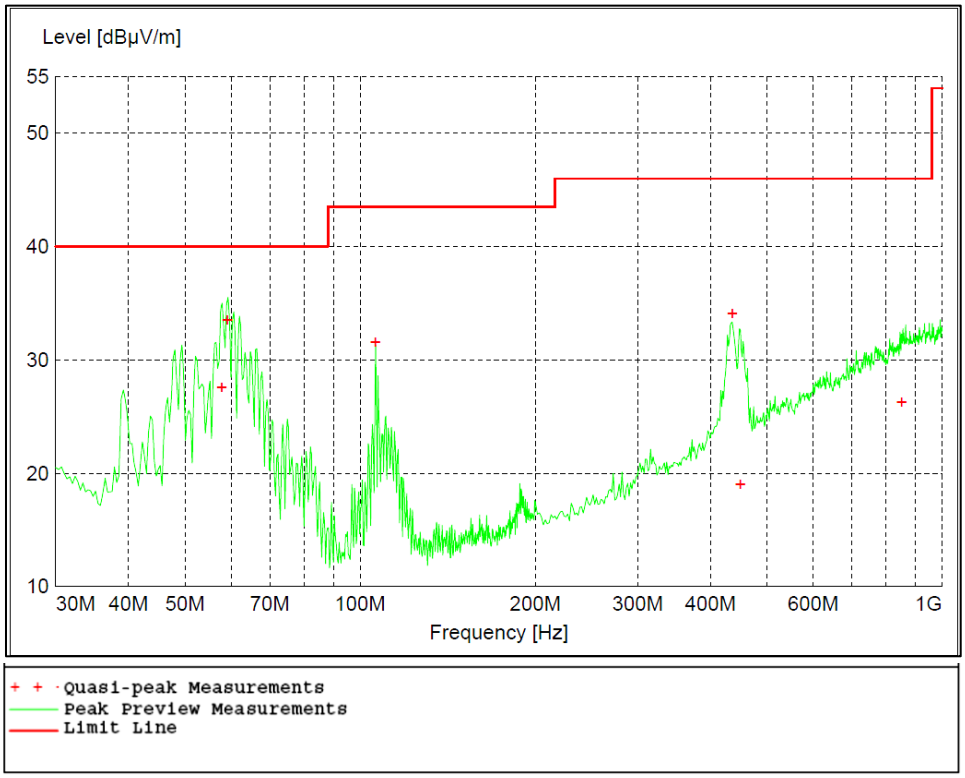

Figure 5 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
57.900000	27.52	40.00	12.50	141	261	VERT	Y
59.160000	33.52	40.00	6.50	115	169	VERT	Y
106.260000	31.54	43.50	12.00	102	190	VERT	Y
436.140000	34.04	46.00	12.00	143	10	VERT	Y
450.060000	19.01	46.00	27.00	100	22	HORI	Y
852.240000	26.25	46.00	19.70	233	169	HORI	Y

Table 2 - Radiated Emissions Peak Measurements Vs Average Limit, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2744.200000	34.22	54.00	19.80	398	266	HORI	Y
4426.000000	39.08	54.00	14.90	100	146	VERT	Y
5921.800000	45.18	54.00	8.80	398	32	HORI	Y
9002.400000	44.12	54.00	9.90	187	287	HORI	Y

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

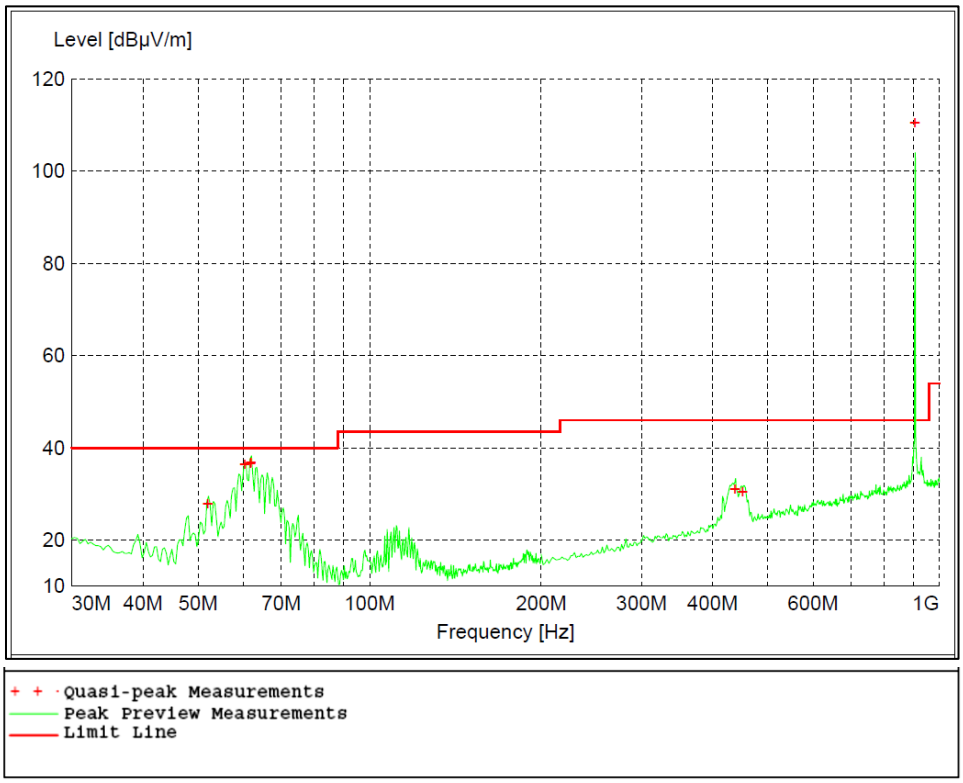

Figure 6 - Radiated Emissions Plot, Low Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
52.020000	27.91	40.00	12.10	100	0	VERT	Y
60.420000	36.30	40.00	3.70	100	232	VERT	Y
61.860000	36.46	40.00	3.50	115	177	VERT	Y
61.920000	36.72	40.00	3.30	115	161	VERT	Y
437.700000	31.01	46.00	15.00	99	341	HORI	Y
451.560000	30.48	46.00	15.50	100	12	HORI	Y
905.600000	110.51*	NA	NA	123	192	VERT	Y

*peak measurement

Table 4 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1811.200000	41.56	54.00	12.44	175	141	VERT	Y
2717.000000	25.23	54.00	28.77	163	334	HORI	Y
3622.400000	33.71	54.00	20.29	272	105	HORI	Y
4526.800000	32.06	54.00	21.94	398	0	VERT	Y
5427.600000	32.74	54.00	21.26	386	327	VERT	Y
6322.600000	33.15	54.00	20.85	344	171	VERT	Y
7244.800000	33.00	54.00	21.00	351	95	VERT	Y
8146.000000	35.36	54.00	18.64	259	50	VERT	Y
9074.000000	35.14	54.00	18.86	348	248	HORI	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 10.16 dB was used.

Table 5 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1811.200000	51.72	74.00	22.28	175	141	VERT	Y
2717.000000	35.39	74.00	38.61	163	334	HORI	Y
3622.400000	43.87	74.00	30.13	272	105	HORI	Y
4526.800000	42.22	74.00	31.78	398	0	VERT	Y
5427.600000	42.90	74.00	31.10	386	327	VERT	Y
6322.600000	43.31	74.00	30.69	344	171	VERT	Y
7244.800000	43.16	74.00	30.84	351	95	VERT	Y
8146.000000	45.52	74.00	28.48	259	50	VERT	Y
9074.000000	45.30	74.00	28.70	348	248	HORI	Y

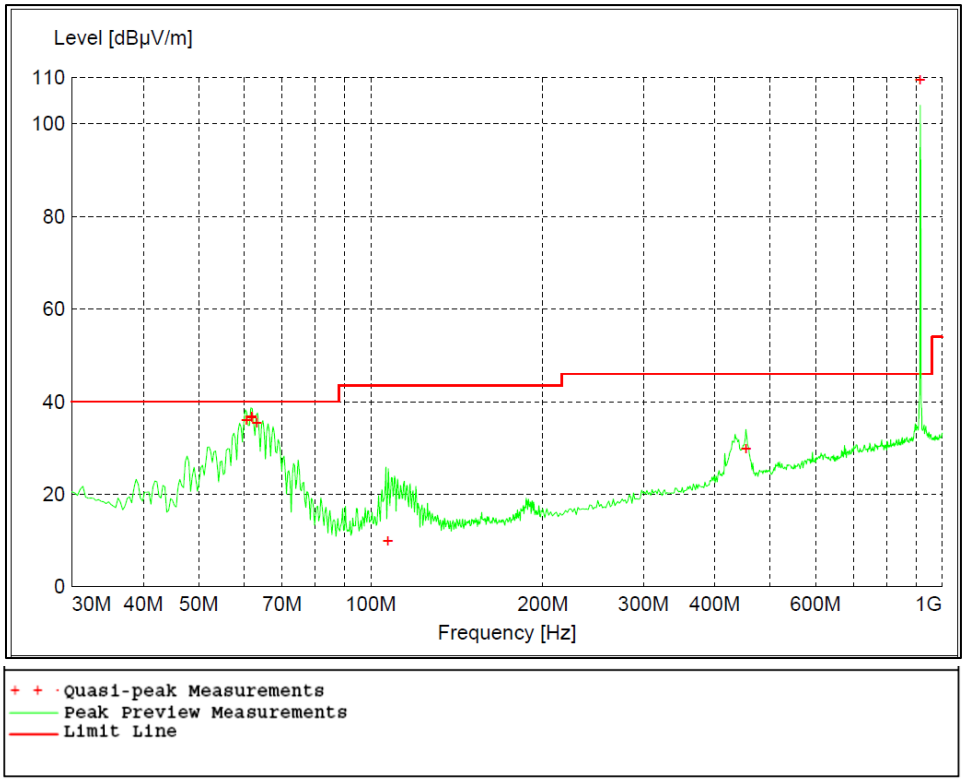

Figure 7 - Radiated Emissions Plot, Mid Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
60.600000	36.01	40.00	4.00	115	231	VERT	Y
61.920000	36.75	40.00	3.30	102	169	VERT	Y
61.980000	36.53	40.00	3.50	100	164	VERT	Y
63.240000	35.44	40.00	4.60	107	162	VERT	Y
107.220000	9.85	43.50	33.70	102	163	VERT	Y
454.080000	29.71	46.00	16.30	100	15	HORI	Y
915.000000	109.43*	NA	NA	122	194	VERT	Y

*peak measurement

Table 7 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1830.000000	43.05	54.00	10.95	173	139	VERT	Y
2739.600000	24.91	54.00	29.09	320	358	VERT	Y
3660.000000	33.81	54.00	20.19	99	170	VERT	Y
4569.000000	30.57	54.00	23.43	398	121	VERT	Y
5490.000000	32.36	54.00	21.64	313	285	HORI	Y
6394.600000	32.57	54.00	21.43	313	60	VERT	Y
7294.800000	31.38	54.00	22.62	101	3	VERT	Y
8215.600000	34.71	54.00	19.29	163	256	VERT	Y
9138.000000	35.05	54.00	18.95	208	246	HORI	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 10.16 dB was used.

Table 8 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1830.000000	53.21	74.00	20.79	173	139	VERT	Y
2739.600000	35.07	74.00	38.93	320	358	VERT	Y
3660.000000	43.97	74.00	30.03	99	170	VERT	Y
4569.000000	40.73	74.00	33.27	398	121	VERT	Y
5490.000000	42.52	74.00	31.48	313	285	HORI	Y
6394.600000	42.73	74.00	31.27	313	60	VERT	Y
7294.800000	41.54	74.00	32.46	101	3	VERT	Y
8215.600000	44.87	74.00	29.13	163	256	VERT	Y
9138.000000	45.21	74.00	28.79	208	246	HORI	Y

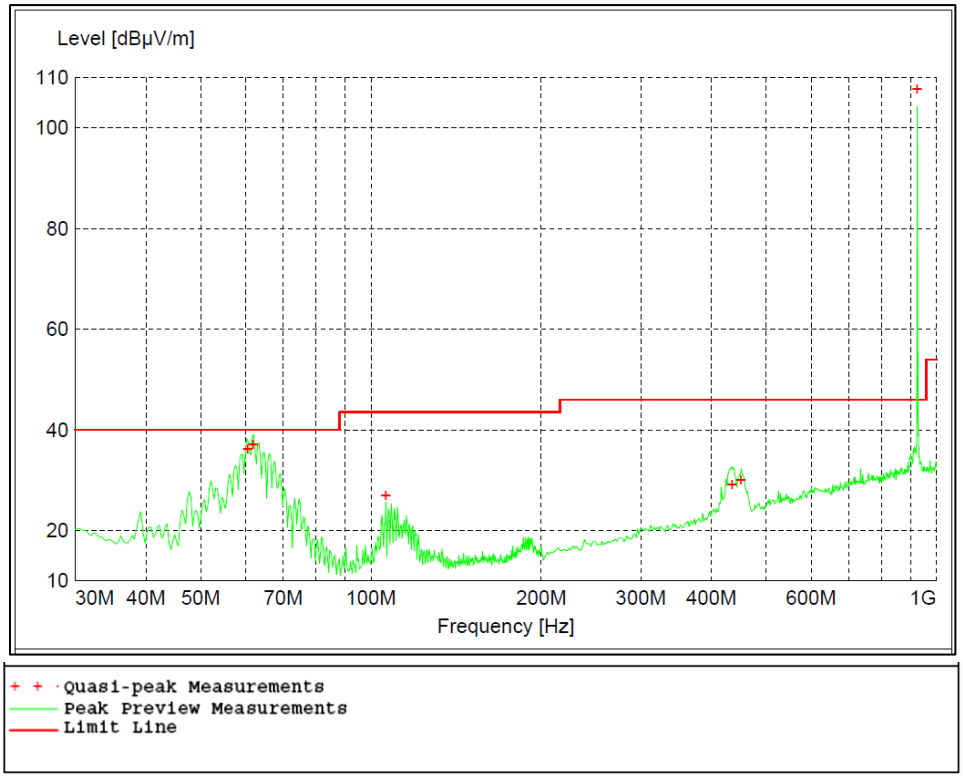

Figure 8 - Radiated Emissions Plot, High Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
30.540000	15.22	40.00	24.80	102	360	VERT	Y
259.980000	43.20	46.00	2.80	100	277	HORI	Y
312.000000	35.47	46.00	10.50	100	104	HORI	Y
768.360000	38.51	46.00	7.50	102	173	HORI	Y
820.380000	42.96	46.00	3.00	100	195	HORI	Y
924.400000	96.95*	NA	NA	396	190	HORI	Y

*peak measurement

Table 10 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1848.800000	43.21	54.00	10.79	115	185	VERT	Y
3697.800000	33.32	54.00	20.68	100	163	VERT	Y
4615.400000	31.12	54.00	22.88	354	317	HORI	Y
5540.800000	32.36	54.00	21.64	99	51	HORI	Y
6483.800000	32.97	54.00	21.03	392	0	VERT	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 2, and 3. 10.16 dB was used.

Table 11 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1848.800000	53.37	74.00	20.63	115	185	VERT	Y
3697.800000	43.48	74.00	30.52	100	163	VERT	Y
4615.400000	41.28	74.00	32.72	354	317	HORI	Y
5540.800000	42.52	74.00	31.48	99	51	HORI	Y
6483.800000	43.13	74.00	30.87	392	0	VERT	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 C63.10-2013, Section(s) 7.8.5

Limits of bandwidth measurements:
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 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 12 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	905.60	15.96	EIRP	PASS
Middle	915.00	15.64	EIRP	PASS
High	924.40	13.55	EIRP	PASS

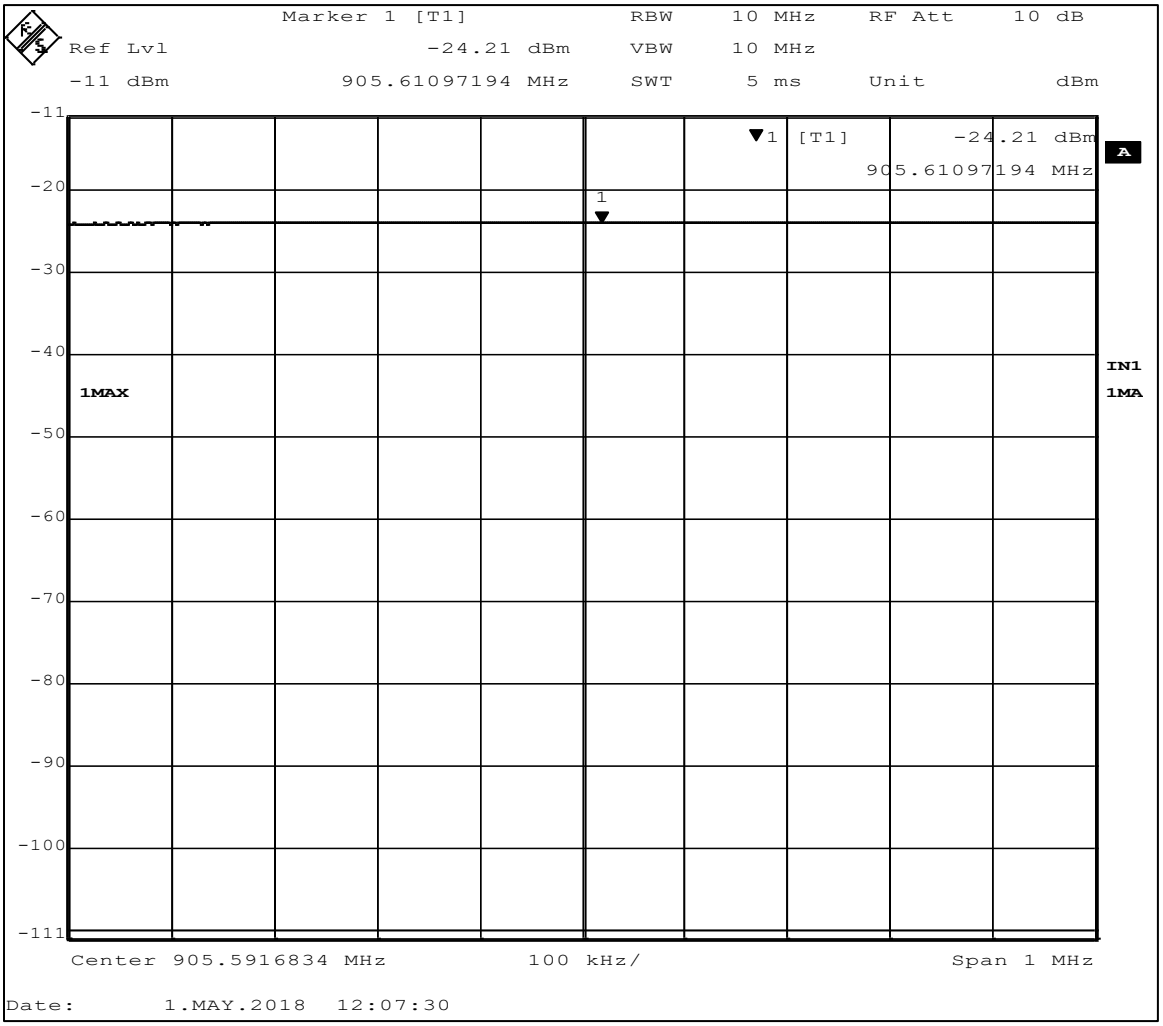

Figure 9 – Output Power, Low Channel

Maximum power = -24.21 dBm + 107 + CL + AF - 95.23 = 15.96 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.

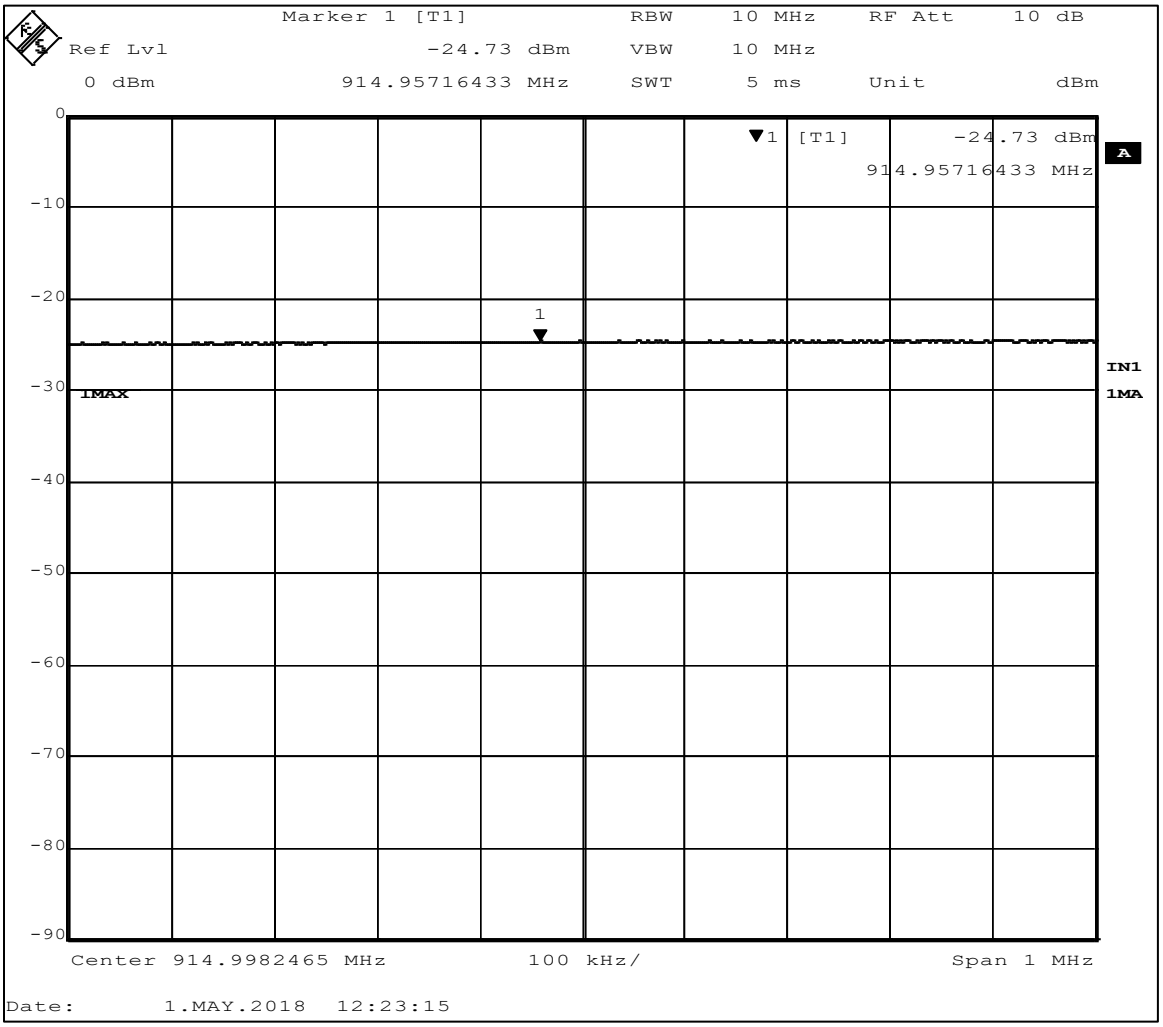

Figure 10 - Output Power, Mid Channel

Maximum power = -24.73 dBm + 107 + CL + AF - 95.23 = 15.64 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.

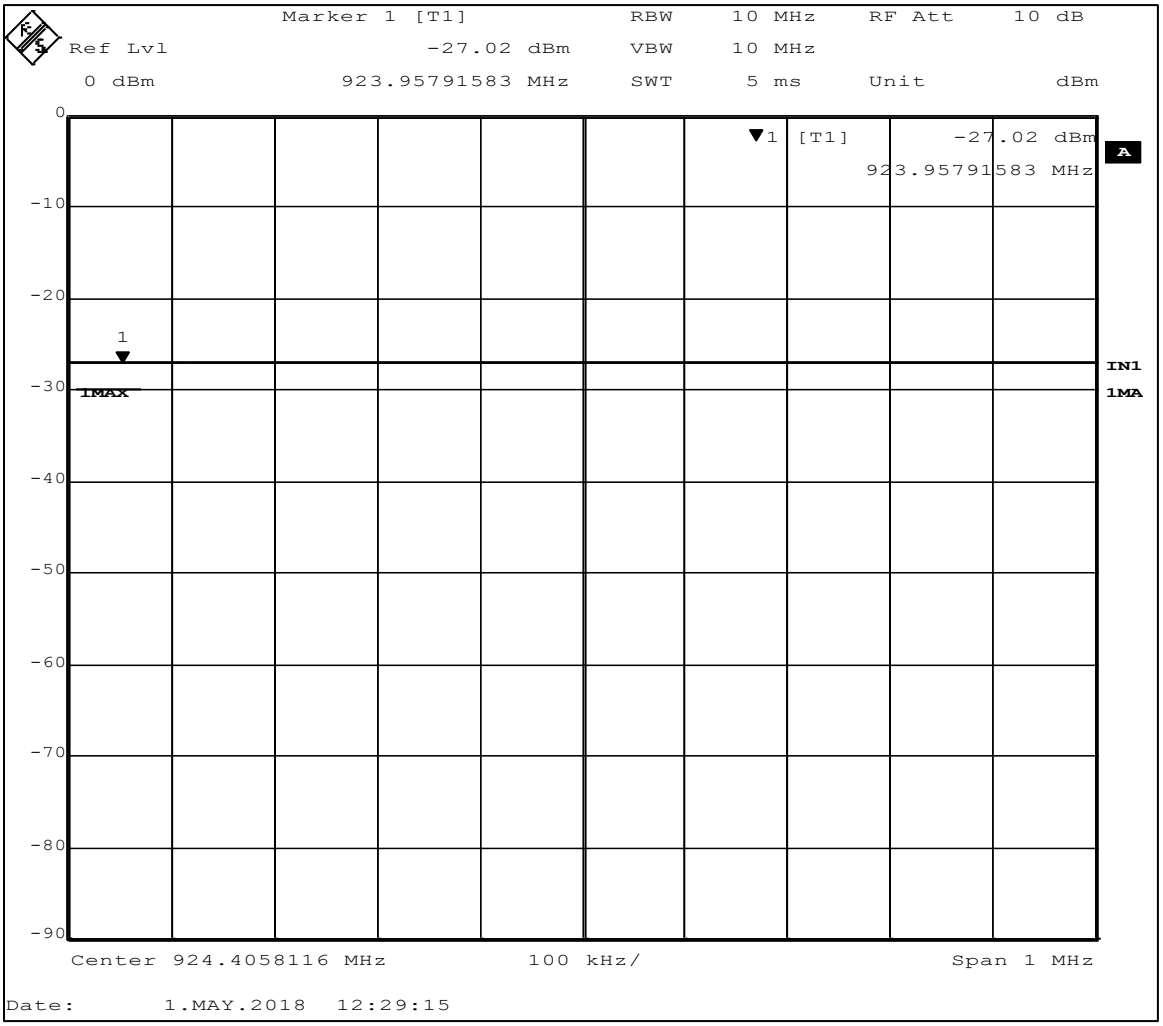

Figure 11 - Output Power, High Channel

Maximum power = -27.02 dBm + 107 + CL + AF - 95.23 = 13.55 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 C63.10-2013, 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 500 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:

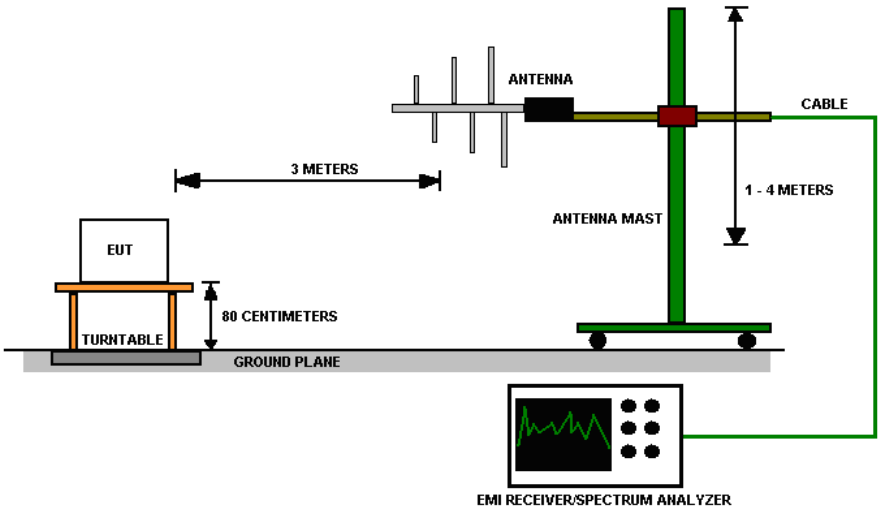

Figure 12 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by 12 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)	RESULT
Low	905.60	71.14	PASS
Mid	915.00	71.64	PASS
High	924.40	71.64	PASS

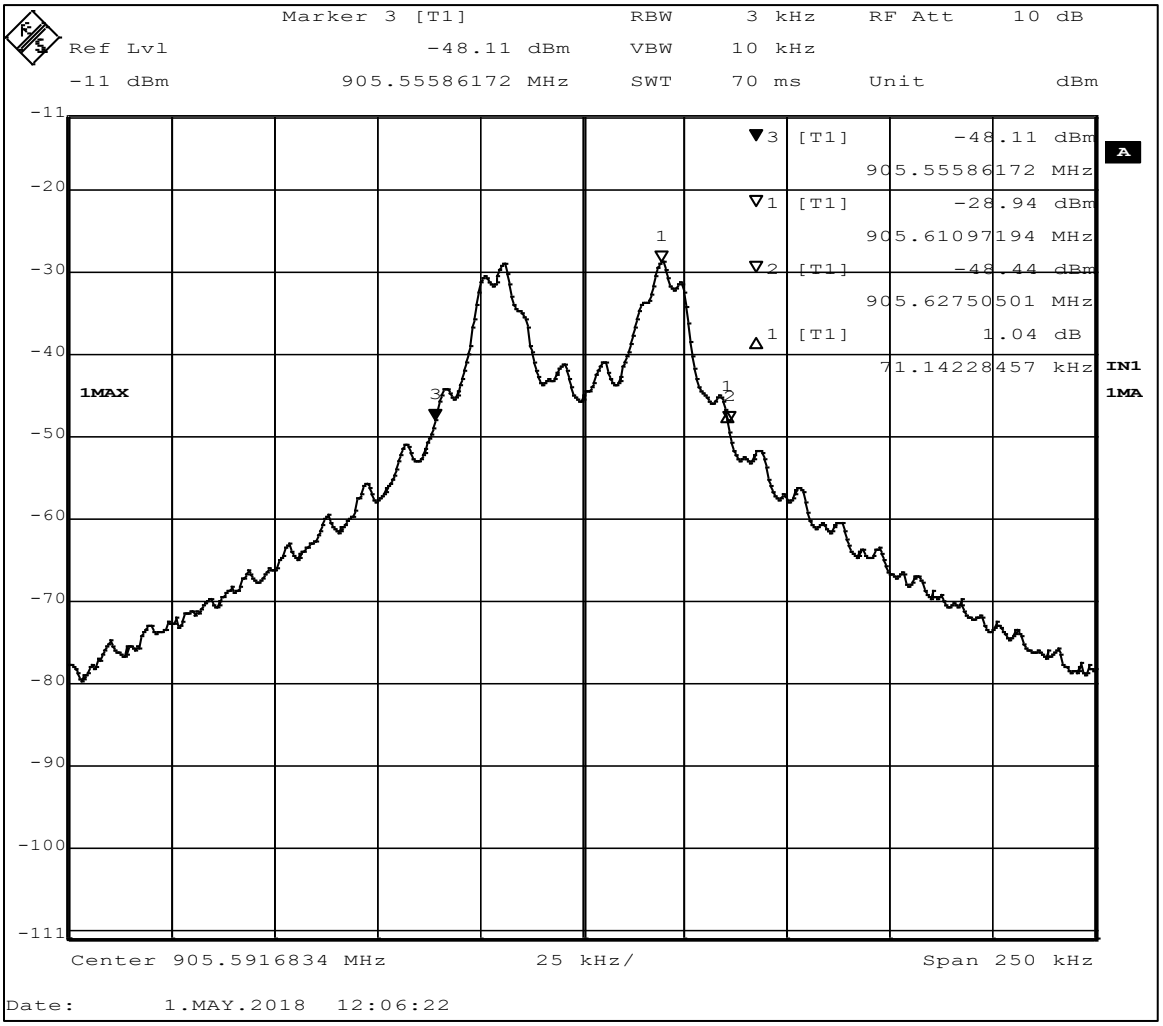

Figure 13 – 20 dB Bandwidth, Low Channel. 71.14 kHz

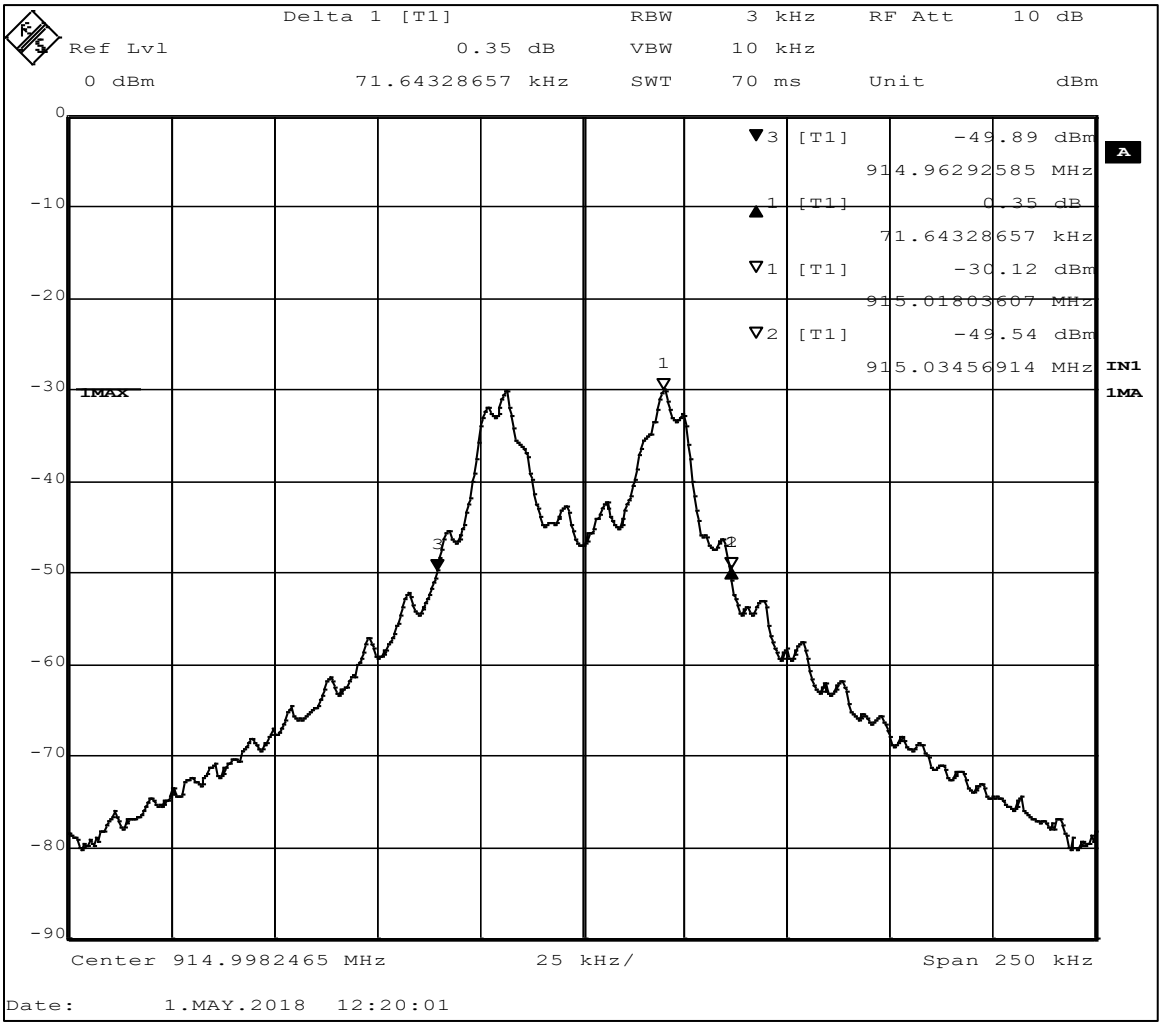

Figure 14 - 20 dB Bandwidth, Mid Channel, 71.64 kHz

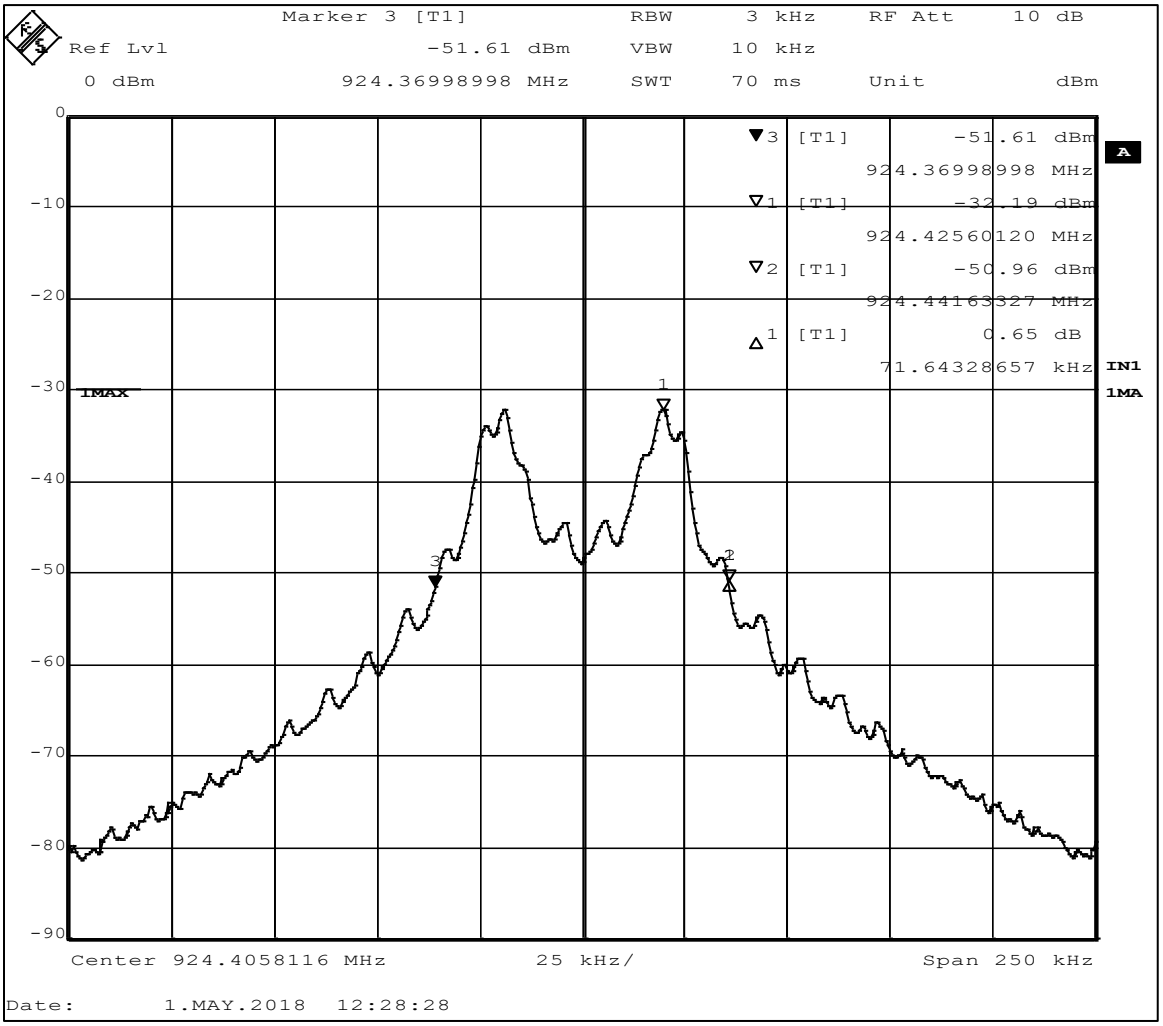

Figure 15 - 20 dB Bandwidth, High Channel, 71.64 kHz

4.5 BANDEDGES

Test Method: ANSI C63.10-2013, 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.

EUT operating conditions:
The EUT was powered by 12 VDC unless specified and set to transmit continuously on the lowest frequency channel, and the highest frequency channel.

Test results:

Highest Out of Band Emissions, restricted band

CHANNEL	Band edge /Measurement Frequency (MHz)	Level dBµV/m	Limit dBµV/m	Margin	Result
Low, Continuous	902.0	40.30	46.0	5.70	PASS
High, Continuous	928.0	39.16	46.0	6.84	PASS

Note: bandedges were also measured in hopping mode. The results were identical to these in continuous mode.

The band edge measurements shown are the closest restricted band edges from the fundamental frequency.

Measurements were taken from data in report section 4.2.

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

Test Method: ANSI C63.10-2013, Section 7.8.2, 7.8.3, 7.8.4

Limits for Time of Occupancy

Average time of occupancy on any frequency should not to exceed 0.4 seconds within a 20 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 12 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:

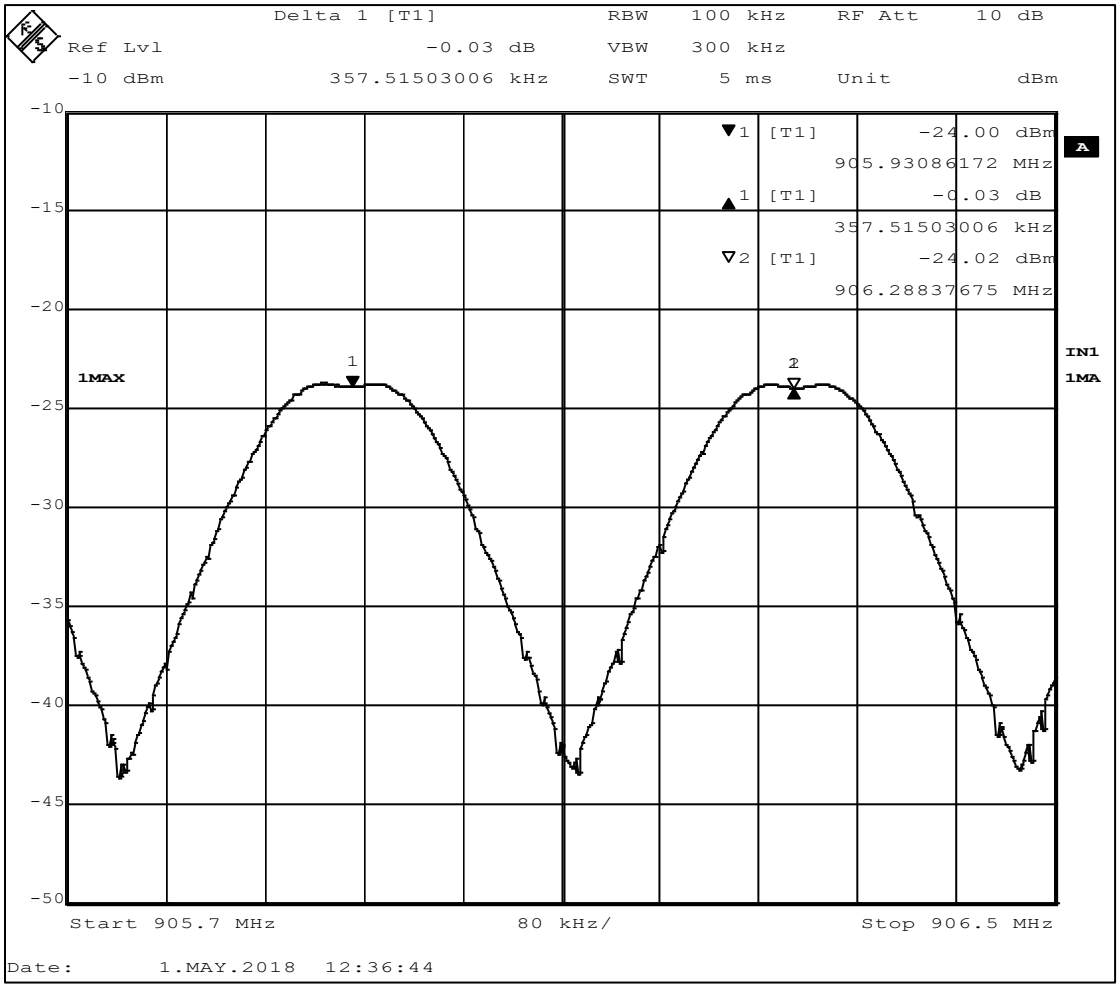

Figure 16 – Frequency Separation, 357.52 kHz

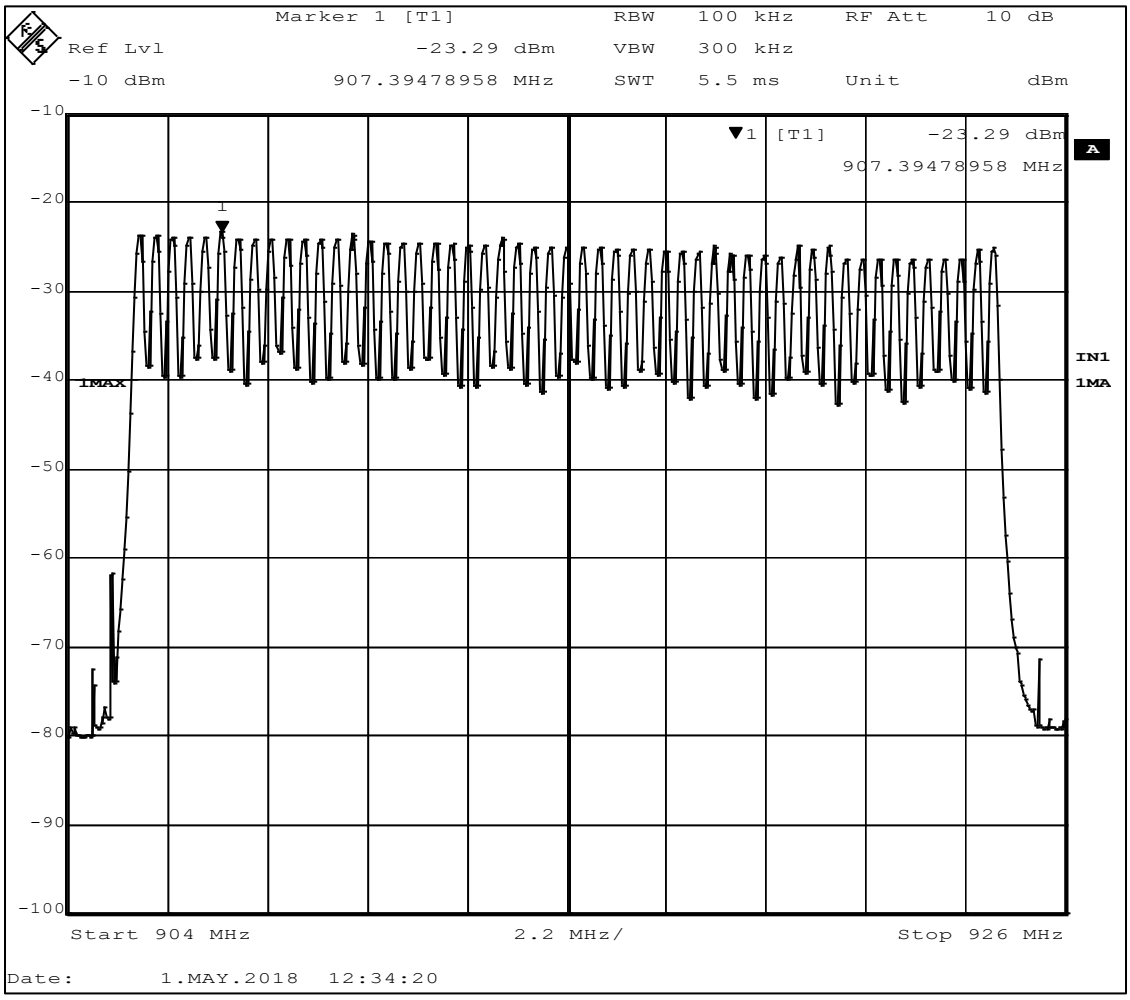

Figure 17 – Hop Count, 53 Hops

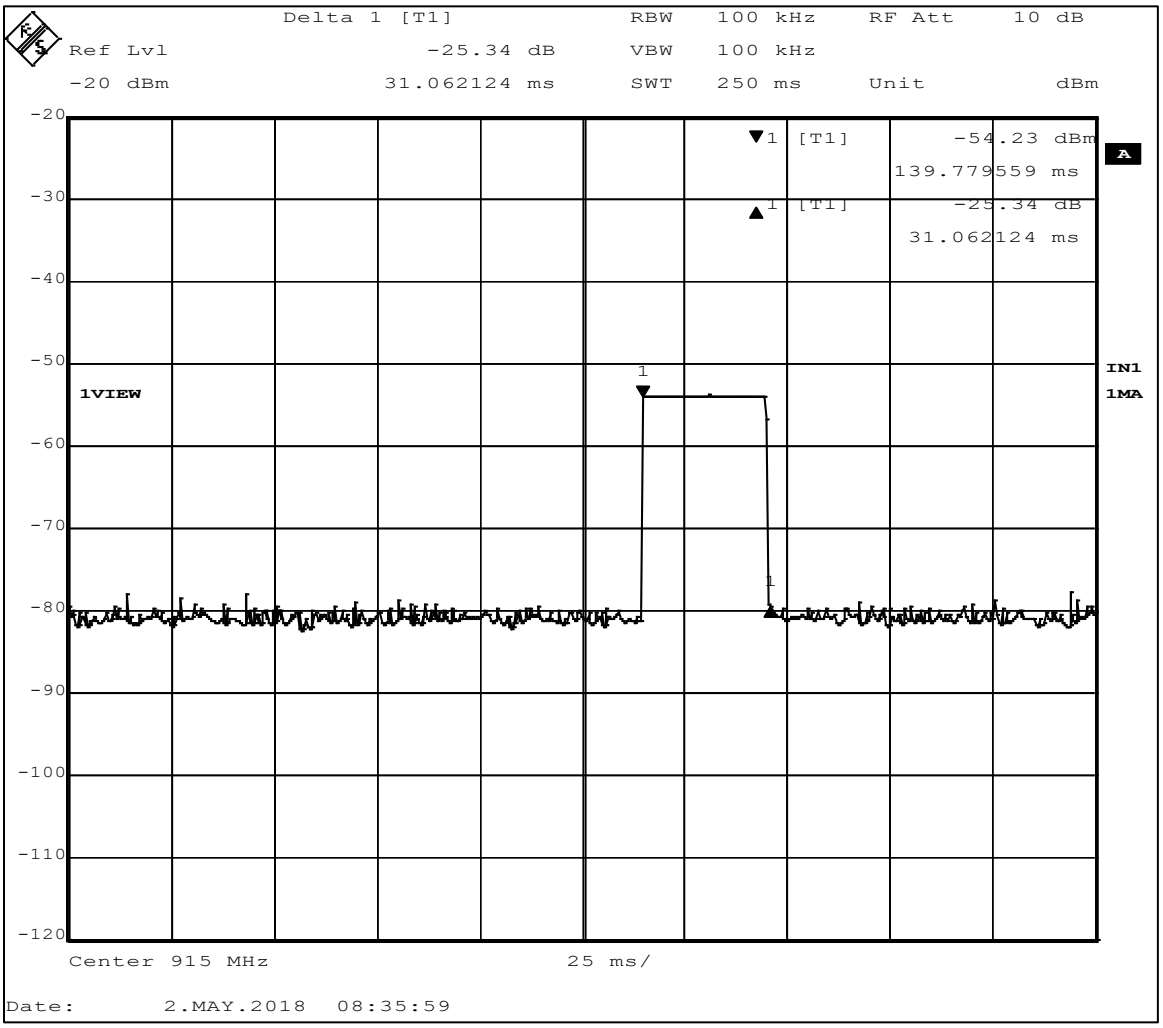

Figure 18 – Time of Occupancy, On Time

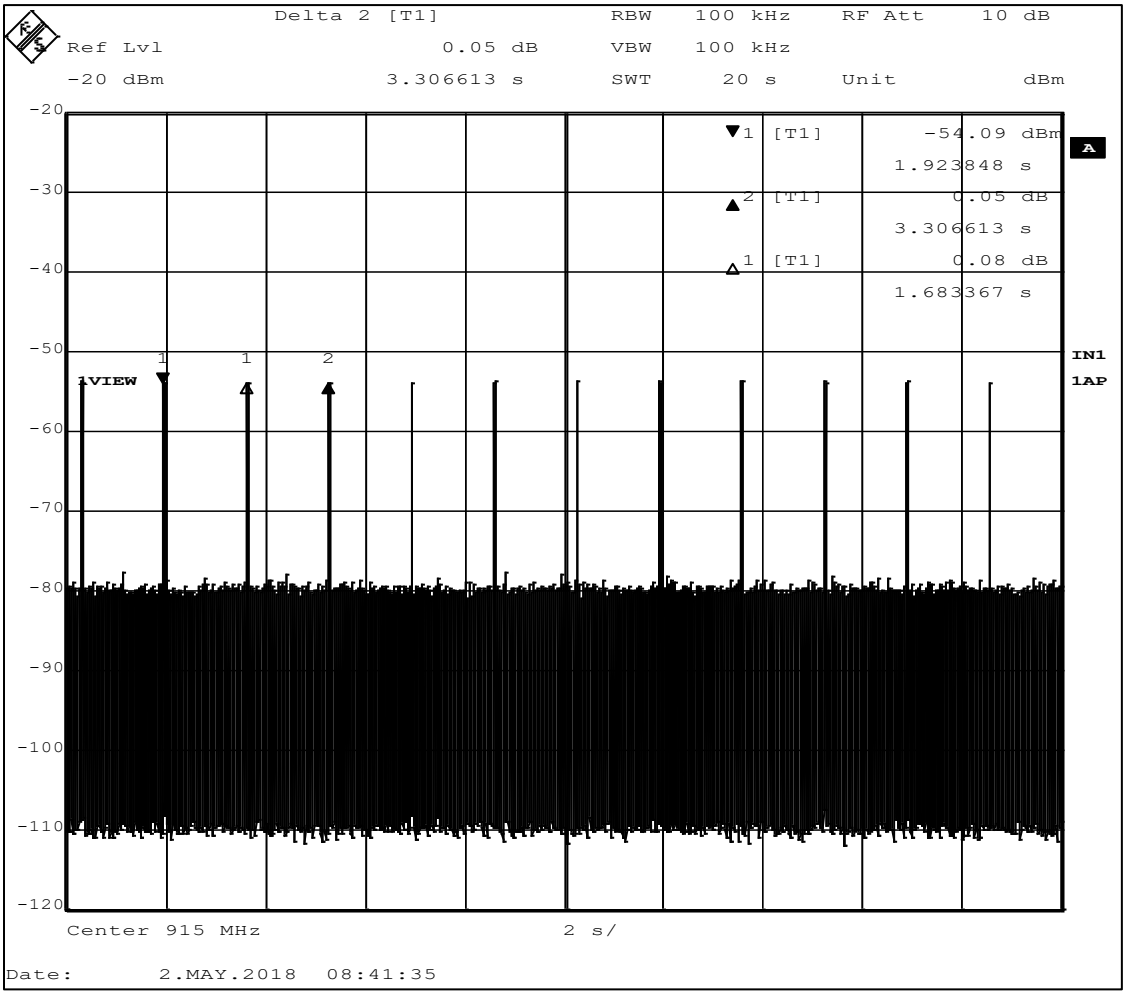

Figure 19 – Time of Occupancy, Period

*Maximum of 12 transmissions can occur in a given channel in any 20 s so the average time of occupancy is 31.06 ms x 12 =372.72 ms = 0.372 s < 0.4 s – Pass

4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz.
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

Test Procedures:

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

EUT operating conditions:
The EUT was powered by 12 VDC unless specified and set to transmit continuously on the Middle channel of its operating range.

Test Results:

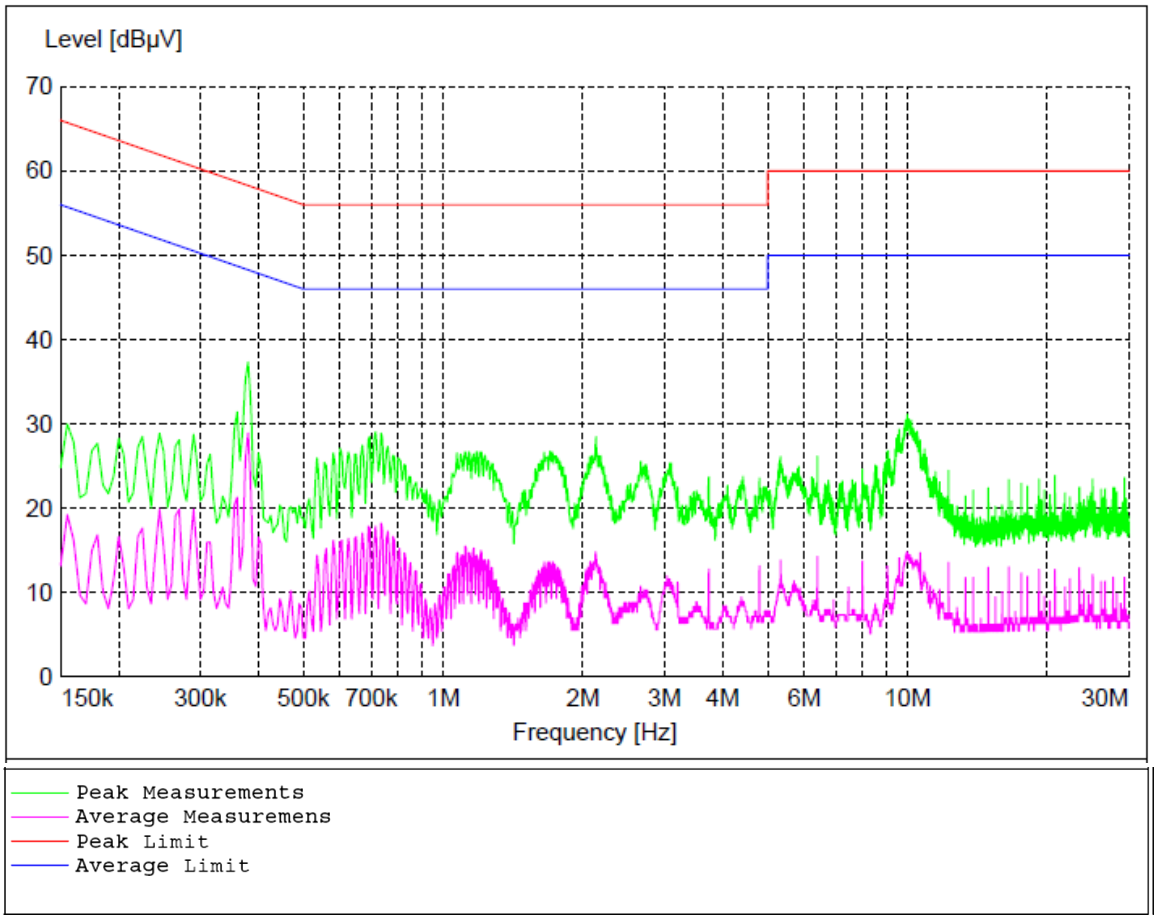

Figure 20 - Conducted Emissions Plot

All measurements were found to be at least 10dB below the applicable limit.

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.

Conducted Emissions

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

FS = R + IL – (-CF)

where V = Conducted Emissions Voltage Measurement

R = Receiver reading in dBμV
IL = LISN Insertion Loss
CF = Cable Attenuation Factor

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

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

The 53.90 dBμV/m value can be mathematically converted to its corresponding level in μV/m.
Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 495.45 μV/m
*Note: NCEE Labs uses the Rohde and Schwarz ES-K1 software package. In this software, all cable losses are listed as negative. This is why cable loss is subtracting in the preceding equations.

Margin is calculated by taking the limit and subtracting the Field

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