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Amended

FCC/ISED Test Report

Prepared for: **Johnson Outdoors**

Address: **1531 E. Madison Ave.**
Mankato, MN 56001

Product: **CoPilot Remote Transmitter**

Test Report No: **R20171114-20A**

Approved By:

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

DATE: **26 January 2018**

Total Pages: **25**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	25 January 2018	Original – NJohnson Prepared by KVepuri
A	296 January 2018	Added a note under Figure 2 to explain the limit line shown in the plot. Added a limit and verdict to the results in Section 4.4. Includes NCEE Labs report R20171114-20 and its amendment in full.

CONTENTS

TABLES OF FIGURES

Figure Number **Page**

TABLE OF TABLES

Table Number **Page**

1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS-Gen, Issue 4, Section 6.10	Duty Cycle Momentary operation	Pass
FCC Part 15.231(a) RSS-210, Issue 9	Bandwidth	Pass
FCC Part 15.231(a) RSS Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.231(a) (unrestricted) RSS-210, Issue 9	Transmitter Radiated Emissions	Pass
FCC Part 15.209, 15.231(a) RSS-210, Issue 9	Band Edge Measurement	Pass

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a wireless remote used to control trolling motors.

EUT	CoPilot Remote Transmitter
EUT Received	11/10/2017
EUT Tested	11/16/2017 - 1/5/2018
Serial No.	2394040
Operating Band	433.92 MHz
Device Type	DTS
Power Supply	Battery: CR2032 3V

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
1	433.92

This is the only channel the EUT operates in.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the only channel it transmits in.

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

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*
Rohde & Schwarz LISN	ESH3-Z5	100023	23 Jan 2017	23 Jan 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

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Duty cycle measurements were not performed. Peak detector measurements were compliant with average limits so it was not necessary. Momentary operation did not change from the original grant (FCC ID: M05COPLT) as declared by manufacturer. So these measurements were not repeated.

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:

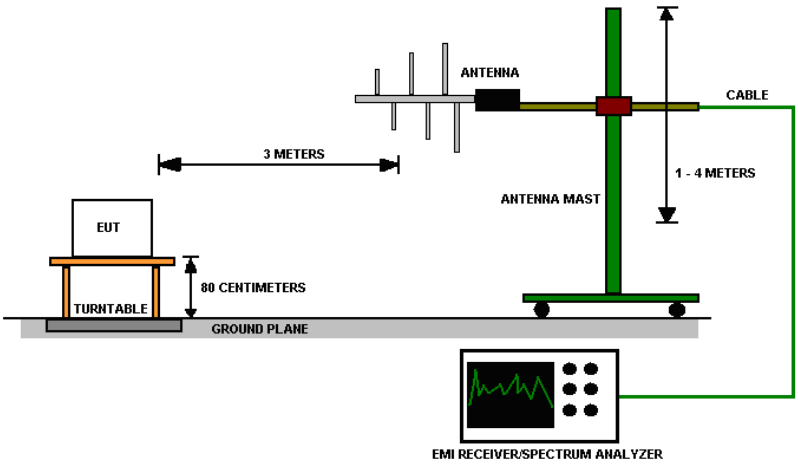

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by a CR2032, 3 VDC battery, unless specified and set to transmit continuously on the only channel it operates in.

Test results:

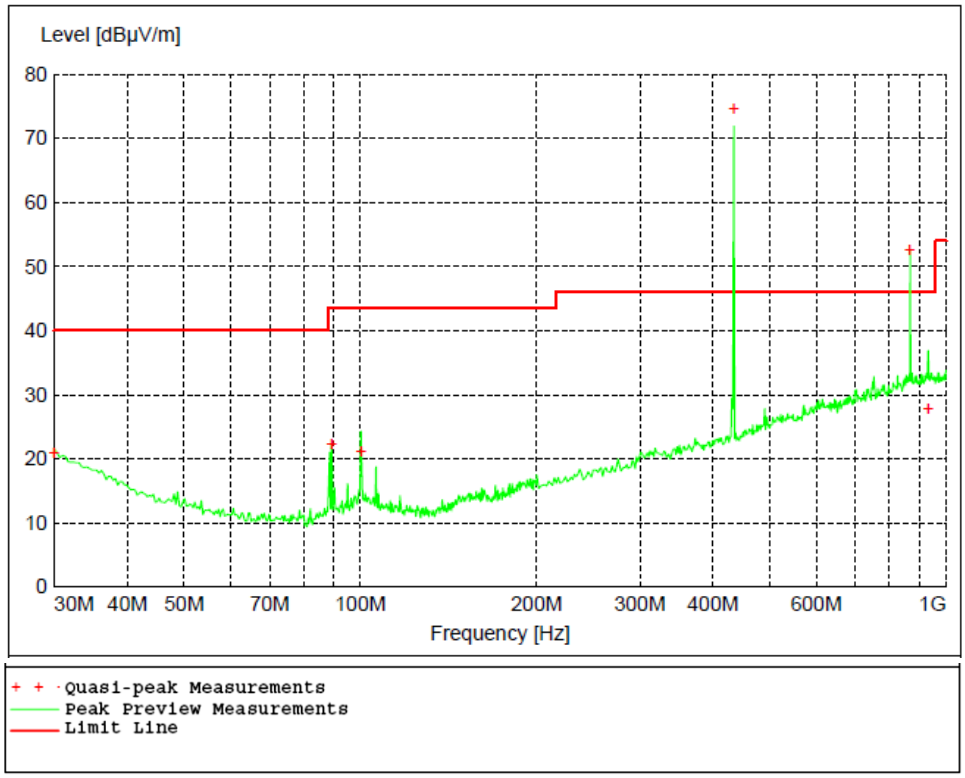

Figure 2 - Radiated Emissions Plot

Note: the red limit line is for restricted bands for Part 15.205 only. For emissions outside of these bands, the limit line shown in the plot does not apply.

Table 1 - Radiated Emissions Quasi-peak Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
30.000000	21.08	40.00	18.90	351	189	VERT	Y
89.280000	22.32	43.50	21.20	390	153	HORI	Y
100.260000	21.27	43.50	22.30	339	99	HORI	Y
433.920000	74.66*	80.83	6.17	129	75	VERT	Y
867.960000	51.55	59.83**	8.23	109	315	HORI	Y
933.060000	27.80	46.00	18.20	281	38	VERT	Y

*Fundamental

** From FCC Part 15.231(b)

Table 2 - Radiated Emissions Peak Measurements vs. Average Limit

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1303.000000	53.19	54.00	0.81	163	331	VERT	Y
1736.000000	43.33	54.00	10.70	130	231	HORI	Y
2169.600000	47.69	54.00	6.30	140	99	VERT	Y
2604.000000	49.39	54.00	4.60	143	82	VERT	Y
3037.800000	51.07	54.00	2.90	190	353	HORI	Y
3471.400000	43.57	54.00	10.40	187	94	VERT	Y
3906.000000	48.30	54.00	5.70	146	82	VERT	Y
4340.000000	45.23	54.00	8.80	127	67	VERT	Y

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

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, Annex G.2

Limits of bandwidth measurements:
The maximum allowed peak output power per Part 15.231 (a) is 80.83dBµV/m for 433.92MHz at 3m test distance.

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 3 MHz RBW and 10 MHz VBW. The RBW was set to a value larger than the occupied BW.

Deviations from test standard:
No deviation.

Test setup:

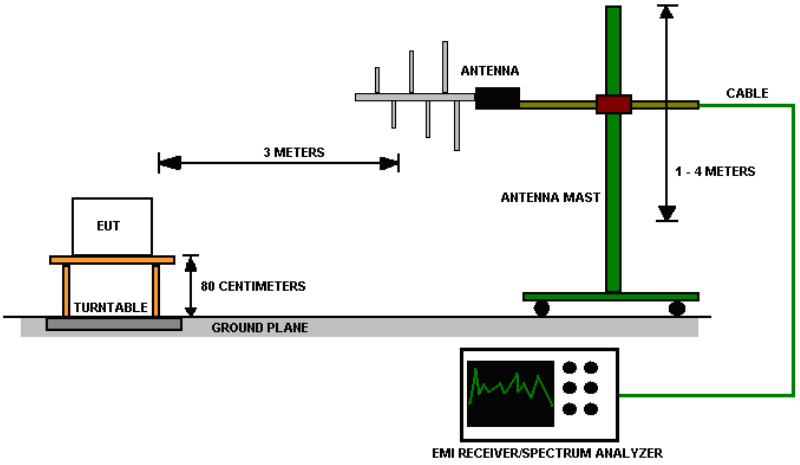

Figure 3 - Radiated Emissions Test Setup

EUT operating conditions:
The EUT was powered by a CR2032, 3 VDC battery, unless specified and set to transmit continuously on the only channel it operates in.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBµV/m)	Method	RESULT
Low	433.92	75.58	Radiated	PASS

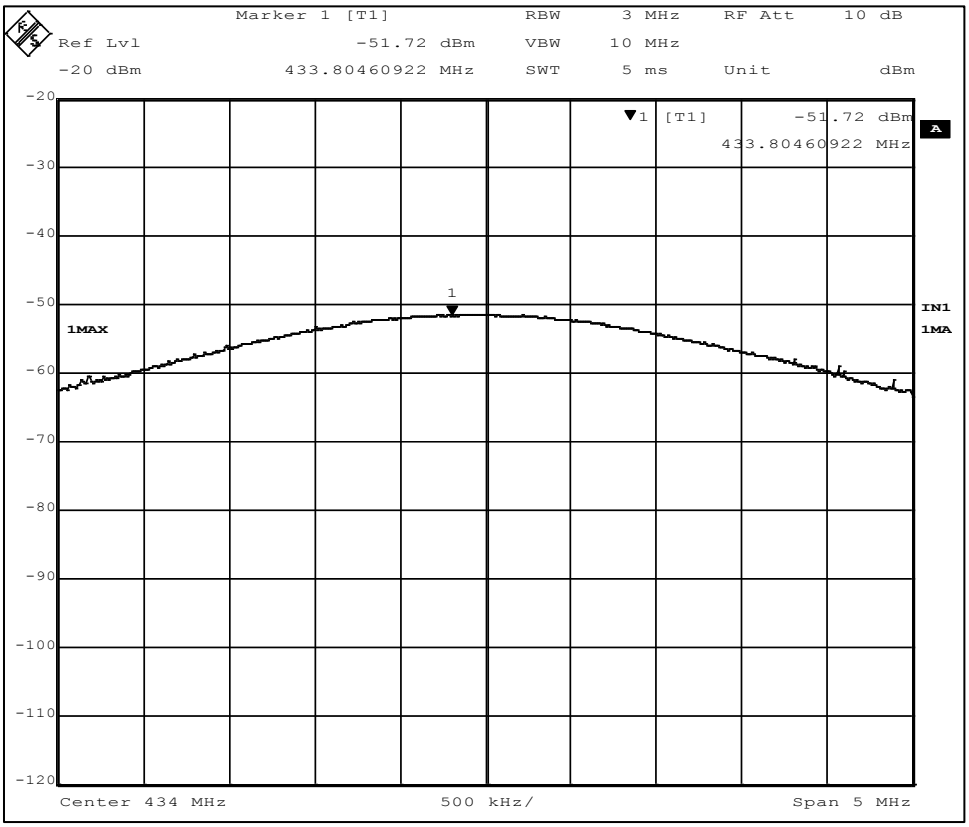

Figure 4 – Output Power

Peak Output Power at 3m = -51.72 dBm + 107 + CL + AF = 75.58 dBµV/m

CL = cable loss = 3.3 dB
AF = antenna factor = 17 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system

4.4 BANDWIDTH

Test Method: ANSI C63.10, Section 6.9

Limits of bandwidth measurements:
The 99% occupied bandwidth is displayed. The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. In this case the limit is 108.48 as the center frequency is 433.92 MHz.

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 5 kHz RBW and 20 kHz VBW.

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.

Deviations from test standard:
No deviation.

Test setup:

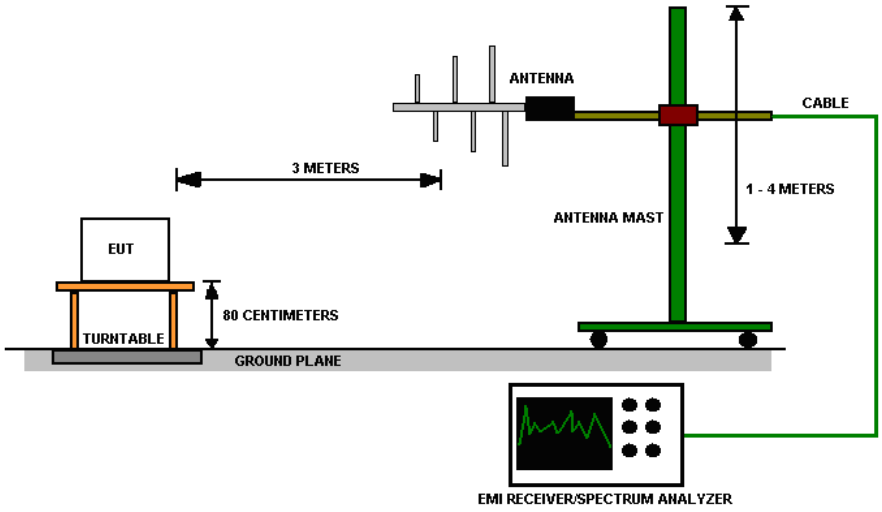

Figure 5 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by a CR2032, 3 VDC battery, unless specified and set to transmit continuously on the only channel it operates in.

Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)	Max Limit 0.25% of center frequency MHz	Verdict
1	433.92	92.58	1.08 MHz	PASS

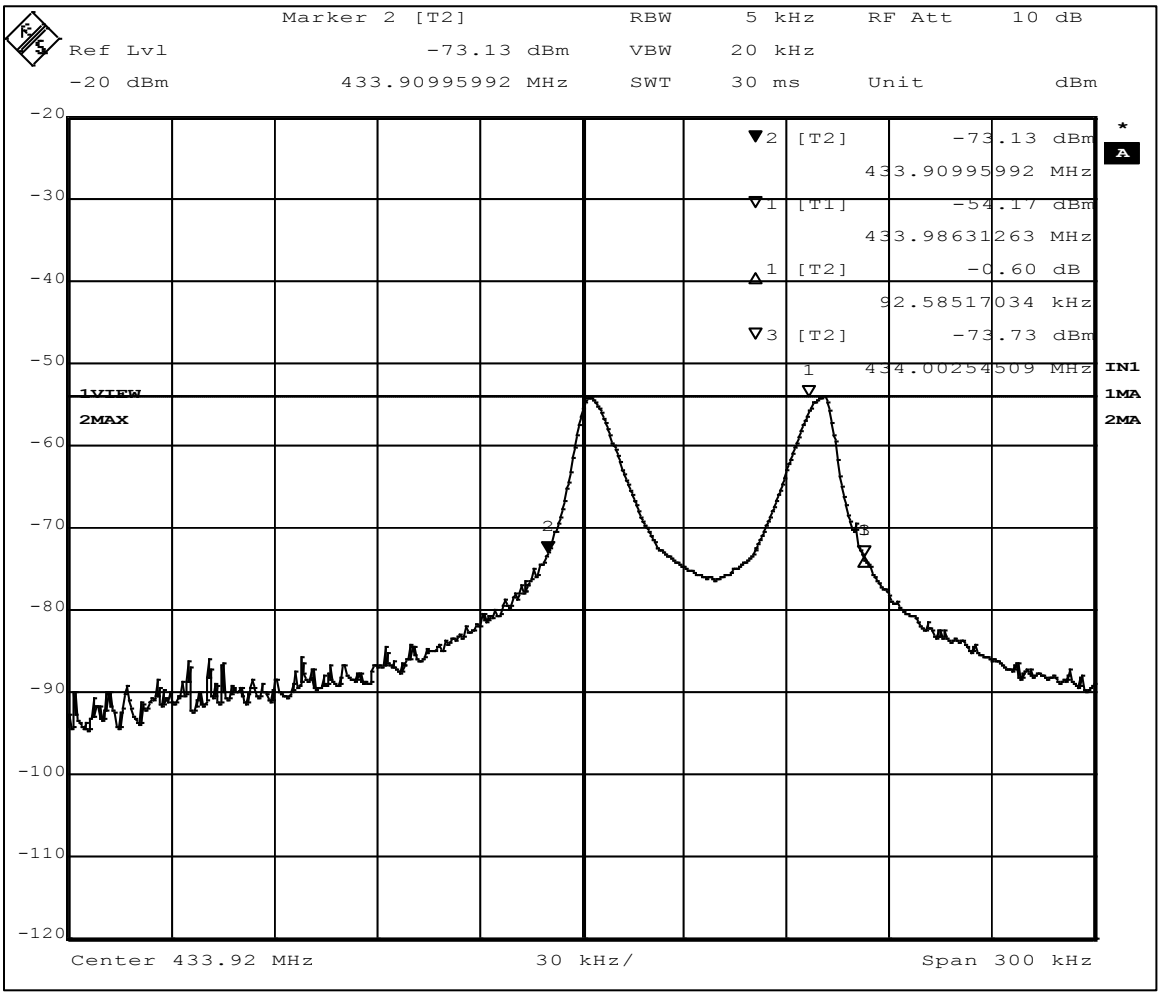

Figure 6 - 99% Occupied Bandwidth

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen. The trace on the bottom was made with a 5 kHz RBW.

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 (260 - 470 MHz), 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 *4.2*. The EUT was oriented as to produce the maximum emission levels. 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:
See Section 4.3

EUT operating conditions:
The EUT was powered by a CR2032, 3 VDC battery, unless specified and set to transmit continuously on the only channel it operates in.

Test results:

Highest Out of Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (peak) dBµV/m	Limit dBµV/m	Margin dB	Result
1	260.00	18.32	46.00 (restricted)	27.68	PASS
1	410.00	23.23	52.04* (unrestricted)	28.81	PASS
1	470.00	24.35	52.04* (unrestricted)	27.69	PASS
1	608.00	27.77	46.00 (restricted)	18.23	PASS

1. Results taken from tabular data in Figure 2 on page 14
2. Peak measurements were compared to quasi-peak limit
3. The nearest restricted band edge and band edge from 15.231 were tested.

*limit based on FCC Part 15.231(a) for spurious emissions in unrestricted bands for a transmitter operating at 433.92 MHz.

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