FCC/IC Test Report

Prepared for: **Inovonics Wireless Corp.**

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

Product: **W3-CO**

Test Report No: **R20170718-22-01**

Approved By:

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iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **13 September 2017**

Total Pages: **48**

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TESTING LABORATORY
CERTIFICATE NO. 1953.01

NCEE Labs
FCC/IC Test Report

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1.0   Summary of test results

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1.0 Summary of test results
1.1 Test Results
The EUT has been tested according to the following specifications:

SUMMARY			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	Internal Antenna
FCC 15.209 RSS-Gen, 7.1.2	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, 5.4	Maximum Peak Output Power, Limit: Max. 24 dBm	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9	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 RSS-247, 5.5 RSS-Gen, 8.9	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.

2.0   Description
2.1   Equipment under test

The Equipment Under Test (EUT) was a CO detector and FHSS transmitter. It operates from 902 to 928 MHz and has transmit capabilities only.

EUT Received Date: 16 August 2017
EUT Tested Dates: 17 August 2017 – 8 September 2017,

MODEL	W3-CO
Serial No.	154954 (Used in Continuous Transmit Mode) 154335 (Standard user code)
POWER SUPPLY	3 VDC (CR123A)
ANTENNA TYPE	Antenna is not user replaceable

NOTE: 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 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 $32 \pm 4\%$
Temperature of $22 \pm 3°$ Celsius

2.3   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.

2.4   Applied standards

The EUT is a frequency hopping device operating in the 902 MHz to 928 MHz amateur band. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

FCC Part 15, Subpart C; 15.209 and 15.247
Industry Canada, RSS-247, Issue 2
Industry Canada, RSS-Gen, Issue 4
ANSI C63.10:2013
ANSI C63.4:2014

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 the lowest, highest and one channel in the middle.

3.0 Test equipment used

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	3141	1212	26 Jan 2017	26 Jan 2018
EMCO Horn Antenna	3115	6416	25 Jan 2016	25 Jan 2018
EMCO Horn Antenna	3116	2576	26 Jan 2016	26 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*
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   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 on the EUT is an antenna on the PCB so it's not user replaceable.

4.2   Radiated emissions

Test Method: ANSI C63.10, Section(s) 6.5, 6.6

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 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.

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4.2.2 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.

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.

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4.2.3 Deviations from test standard

No deviation.

4.2.4 Test setup
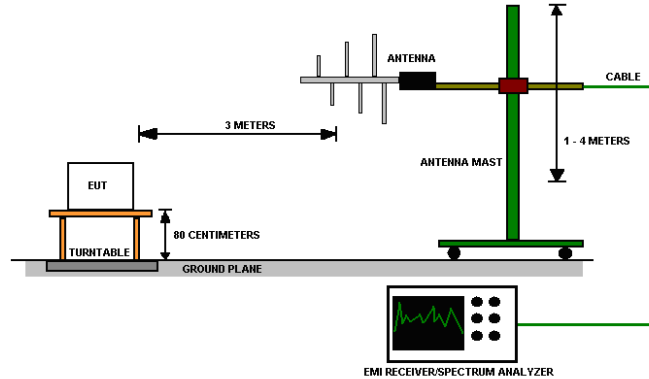
Figure 1 - Radiated Emissions Test Setup

The EUT was tested in all 3 orthogonal axis to meet the requirements from ANSI C63.10:2013, Section 5.10.1 and Annex H.2.

For measurements above 1GHz, the antenna was pointed in the direction of the EUT.

4.2.5 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.

4.2.6 Test results

EUT MODULE	W3-CO	MODE	Receive
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 10GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3°C	TECHNICIAN	KVepuri
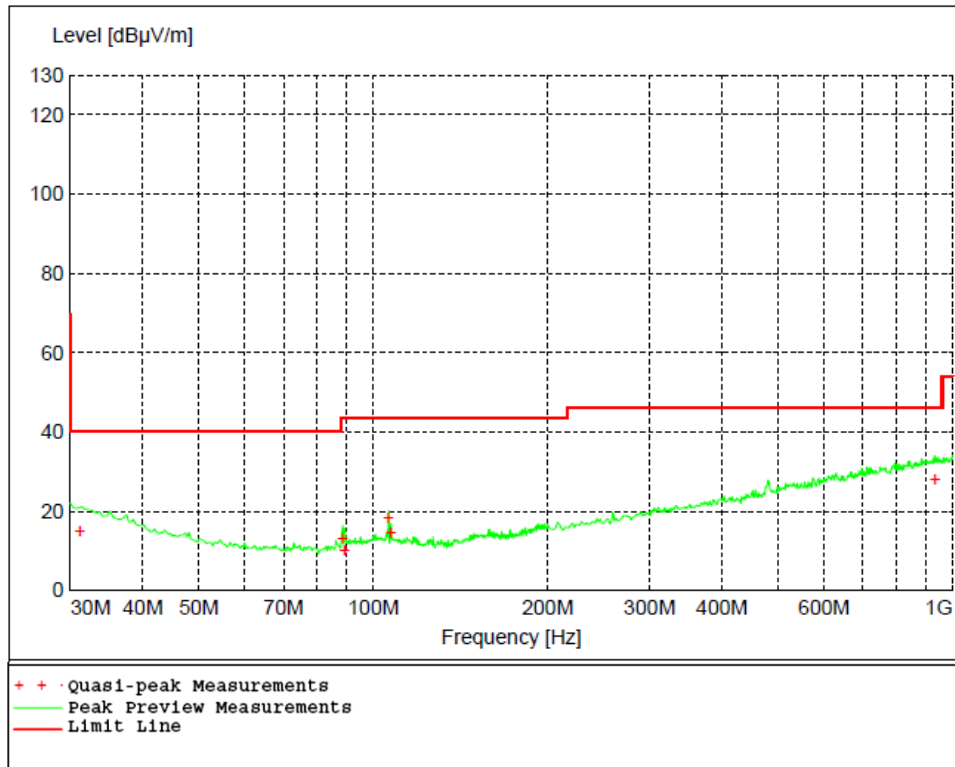
Figure 2 - Radiated Emissions Plot, Receive Mode

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 both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive Mode

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
31.140000	15.19	40.00	24.80	371	136	HORI	X
88.500000	13.35	43.50	30.20	288	274	VERT	X
89.280000	10.28	43.50	33.20	220	280	HORI	X
106.260000	18.56	43.50	25.00	117	360	HORI	X
107.280000	14.57	43.50	29.00	267	165	HORI	X
932.580000	27.99	46.00	18.00	349	319	VERT	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.

Table 2 - Radiated Emissions Average Measurements, Receive Mode

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1827.400000	33.13	54.00	20.90	200	67	VERT	X
2739.000000	36.40	54.00	17.60	200	186	HORI	X
3662.400000	38.78	54.00	15.20	200	215	HORI	X
4576.800000	41.57	54.00	12.40	200	200	VERT	X
5946.000000	46.43	54.00	7.60	200	332	VERT	X
8461.000000	47.75	54.00	6.20	200	217	VERT	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.

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| EUT MODULE	W3-CO	MODE	Transmit, Low Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 10GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri
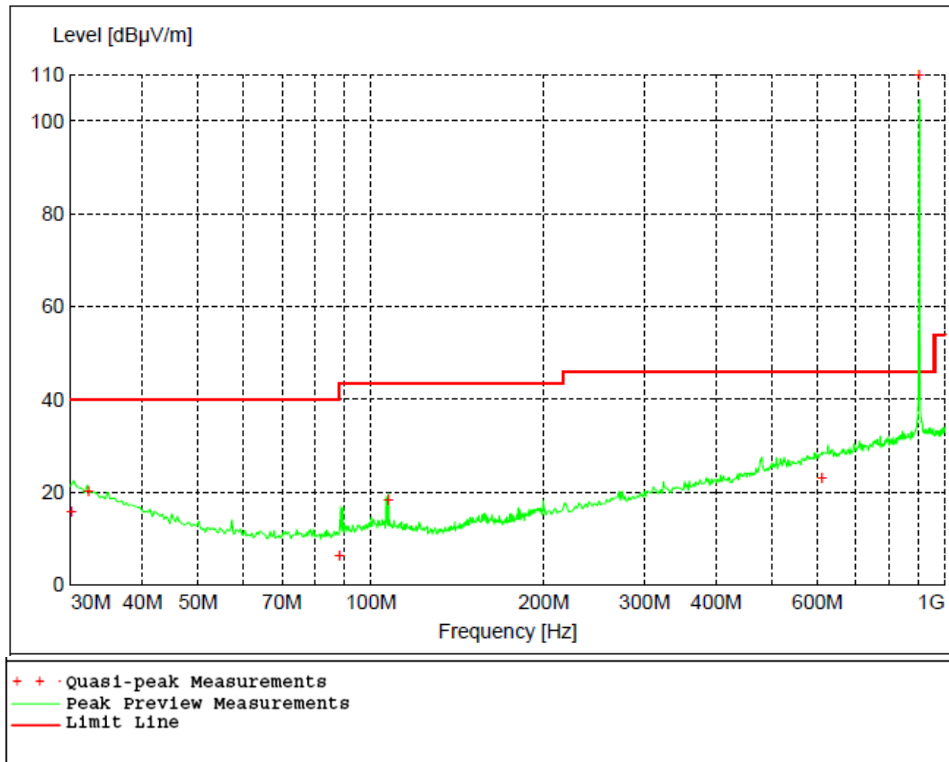
Figure 3 - Radiated Emissions Plot, Low Channel

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 both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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.		
30.060000	15.81	40.00	24.20	100	20	VERT	X
32.220000	20.41	40.00	19.60	145	48	HORI	X
88.260000	6.58	43.50	36.90	98	223	VERT	X
107.280000	18.45	43.50	25.10	102	324	HORI	X
611.520000	23.07	46.00	22.90	337	111	VERT	X
902.400000	109.93	NA	NA	100	195	HORI	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.

Table 4 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.800000	53.33	NA*	NA*	163	195	VERT	X
2707.200000	51.71	54.00	2.29	210	0	VERT	X
3609.600000	49.99	54.00	4.01	197	321	VERT	X
4512.000000	46.57	54.00	7.43	100	294	HORI	X
5414.400000	50.38	54.00	3.62	163	324	HORI	X
6316.800000	46.21	54.00	7.79	197	18	HORI	X
7219.000000	43.16	54.00	10.84	254	359	VERT	X
8121.800000	41.11	54.00	12.89	308	133	VERT	X
9042.800000	41.26	54.00	12.74	133	73	VERT	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
*Unrestricted band
Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6 and 9.

Table 5 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1804.800000	58.83	NA*	NA*	163	195	VERT	X
2707.200000	57.21	74.00	16.79	210	0	VERT	X
3609.600000	55.49	74.00	18.51	197	321	VERT	X
4512.000000	52.07	74.00	21.93	100	294	HORI	X
5414.400000	55.88	74.00	18.12	163	324	HORI	X
6316.800000	51.71	74.00	22.29	197	18	HORI	X
7219.000000	48.66	74.00	25.34	254	359	VERT	X
8121.800000	46.61	74.00	27.39	308	133	VERT	X
9042.800000	46.76	74.00	27.24	133	73	VERT	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
*Unrestricted band
Average measurement values = Peak measurement values – averaging factor (-5.5 dB). See Figures 6 and 7 for details.

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| EUT MODULE	W3-CO	MODE	Transmit, Mid Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 10GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3°C	TECHNICIAN	KVepuri
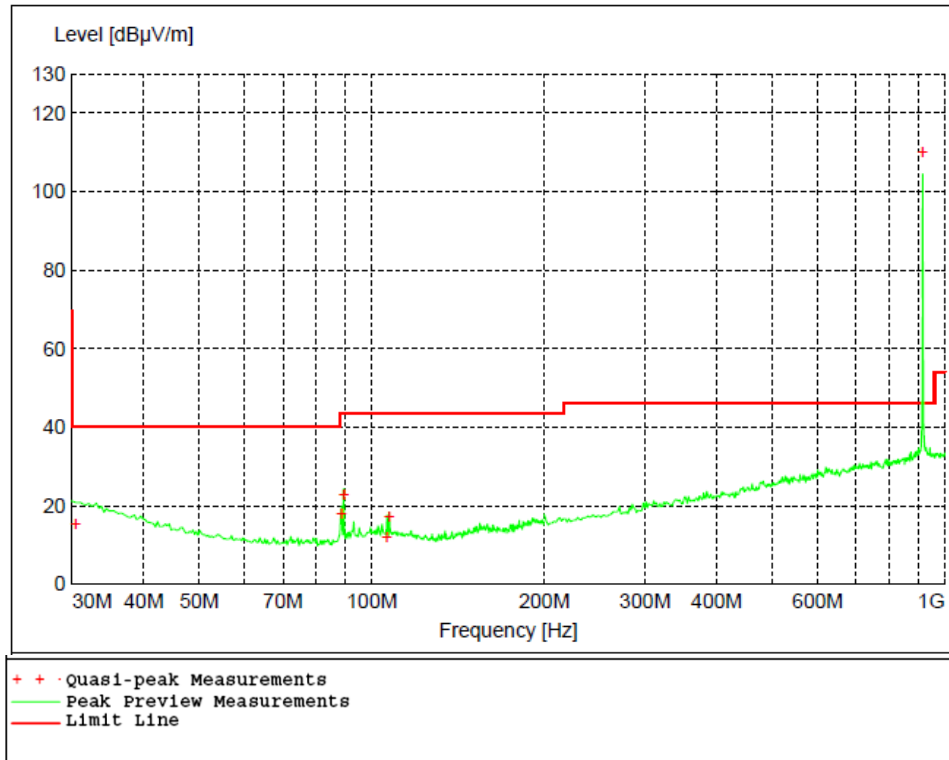
Figure 4 - Radiated Emissions Plot, Mid Channel

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 both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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.		
30.420000	15.60	40.00	24.40	210	256	HORI	X
88.500000	18.19	43.50	25.30	295	265	VERT	X
89.340000	23.08	43.50	20.40	302	241	VERT	X
106.320000	12.18	43.50	31.30	370	360	HORI	X
107.280000	17.17	43.50	26.40	136	360	VERT	X
914.760000	110.13	NA	NA	126	199	VERT	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.

Table 7 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1829.600000	51.92	NA*	NA*	170	349	VERT	X
2744.400000	47.09	54.00	6.91	157	15	VERT	X
3659.200000	50.44	54.00	3.56	197	334	VERT	X
4574.000000	48.74	54.00	5.26	211	350	HORI	X
5488.800000	52.20	54.00	1.80	170	324	HORI	X
6403.600000	45.54	54.00	8.46	204	23	HORI	X
7318.400000	42.90	54.00	11.10	197	359	HORI	X
8233.400000	45.02	54.00	8.98	133	355	HORI	X
9169.600000	40.97	54.00	13.03	114	208	HORI	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
*Unrestricted band
Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6 and 9.

Table 8 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1829.600000	57.42	NA*	NA*	170	349	VERT	X
2744.400000	52.59	74.00	21.41	157	15	VERT	X
3659.200000	55.94	74.00	18.06	197	334	VERT	X
4574.000000	54.24	74.00	19.76	211	350	HORI	X
5488.800000	57.70	74.00	16.30	170	324	HORI	X
6403.600000	51.04	74.00	22.96	204	23	HORI	X
7318.400000	48.40	74.00	25.60	197	359	HORI	X
8233.400000	50.52	74.00	23.48	133	355	HORI	X
9169.600000	46.47	74.00	27.53	114	208	HORI	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
*Unrestricted band
Average measurement values = Peak measurement values – averaging factor (-5.5 dB).
See Figures 6 and 9 for details.

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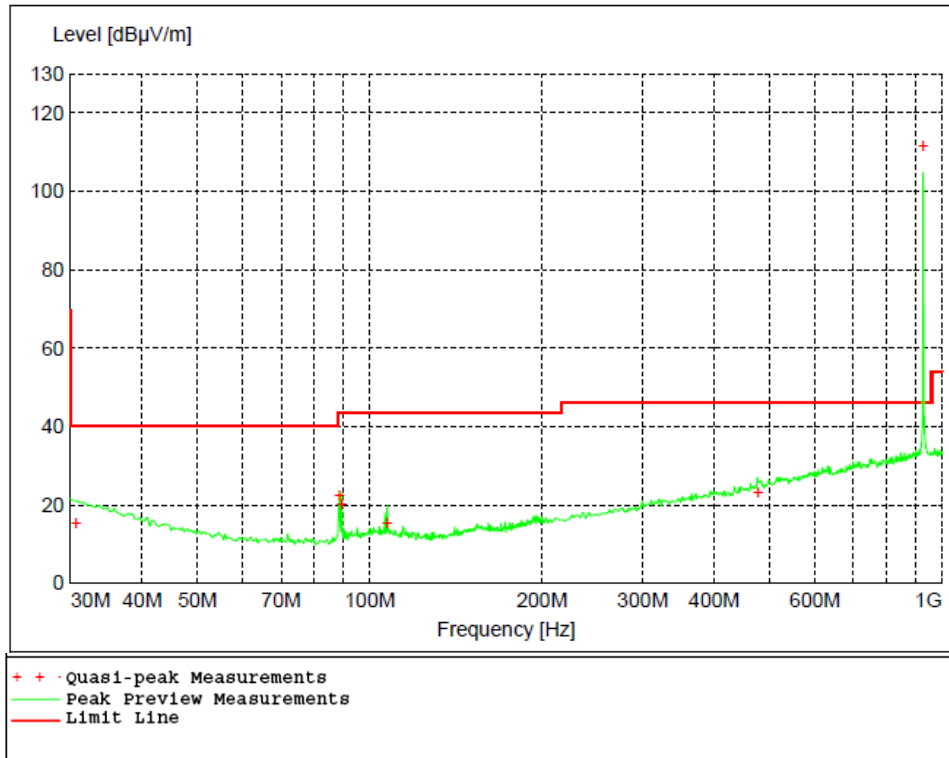| EUT MODULE	W3-CO	MODE	Transmit, High Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 10GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3⁰C	TECHNICIAN	KVepuri

Figure 5 - Radiated Emissions Plot, High Channel

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 both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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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.		
30.660000	15.45	40.00	24.50	400	177	HORI	X
88.500000	22.71	43.50	20.80	305	357	VERT	X
89.340000	20.23	43.50	23.30	102	360	HORI	X
107.340000	15.37	43.50	28.10	400	206	HORI	X
477.240000	23.47	46.00	22.50	223	330	VERT	X
927.600000	111.70	NA	NA	126	195	VERT	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.

Table 10 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1855.200000	52.13	NA*	NA*	197	355	VERT	X
2782.800000	45.81	54.00	8.19	157	143	VERT	X
3710.400000	48.83	54.00	5.17	210	334	VERT	X
4638.000000	49.06	54.00	4.94	206	349	HORI	X
5565.600000	52.00	54.00	2.00	177	325	HORI	X
6493.200000	45.33	54.00	8.67	180	340	HORI	X
7420.800000	42.58	54.00	11.42	163	345	HORI	X
8360.600000	41.19	54.00	12.81	247	15	VERT	X
9278.800000	40.88	54.00	13.12	106	185	HORI	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
*Unrestricted band
Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6 and 9.

Table 11 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1855.200000	57.63	NA*	NA*	197	355	VERT	X
2782.800000	51.31	74.00	22.69	157	143	VERT	X
3710.400000	54.33	74.00	19.67	210	334	VERT	X
4638.000000	54.56	74.00	19.44	206	349	HORI	X
5565.600000	57.50	74.00	16.50	177	325	HORI	X
6493.200000	50.83	74.00	23.17	180	340	HORI	X
7420.800000	48.08	74.00	25.92	163	345	HORI	X
8360.600000	46.69	74.00	27.31	247	15	VERT	X
9278.800000	46.38	74.00	27.62	106	185	HORI	X

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
*Unrestricted band
Average measurement values = Peak measurement values – averaging factor (-5.5 dB). See Figures 6 and 7 for details.
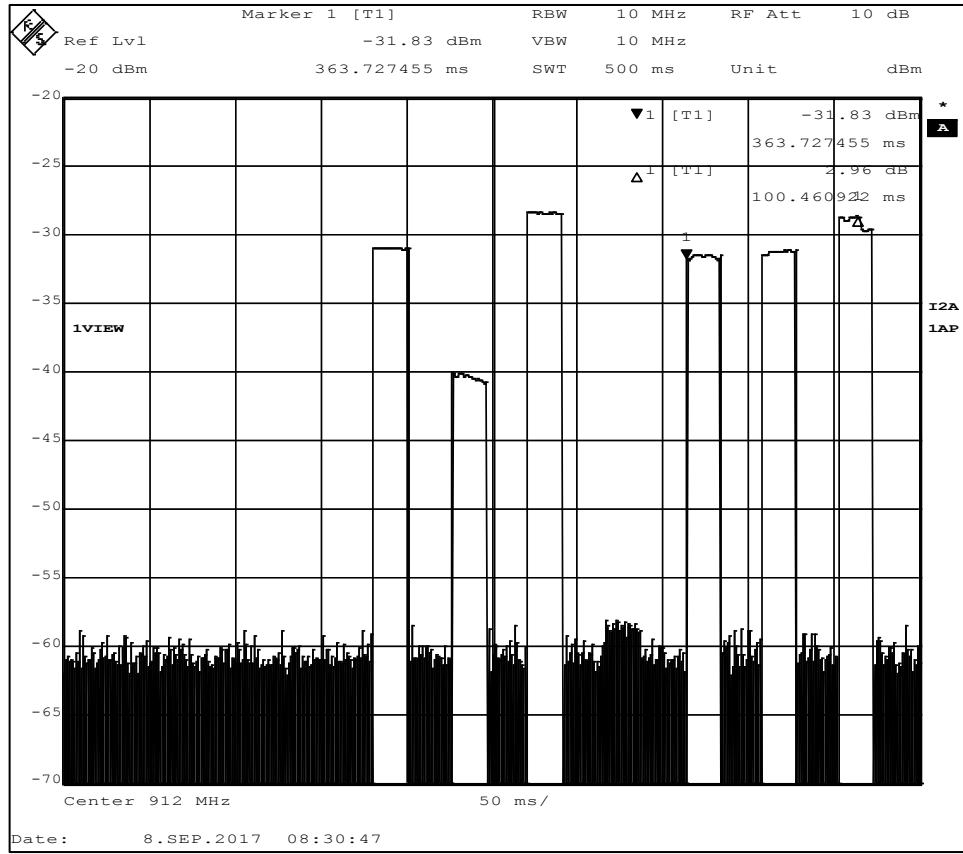
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Figure 6 – Period

A maximum of 2.5 pulses can occur in any 100 ms window

The pulse train seen above is the result of manually triggering the transmitter using test Hush function and manufacturer believes that this will produce the worst case duty cycle.
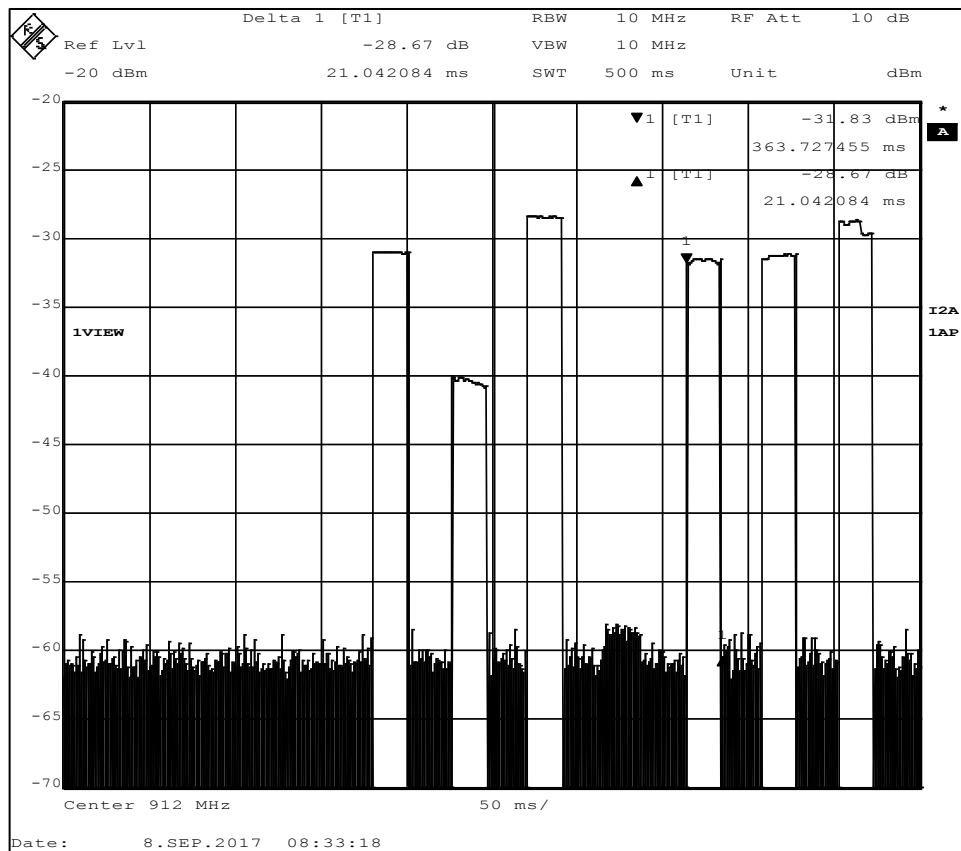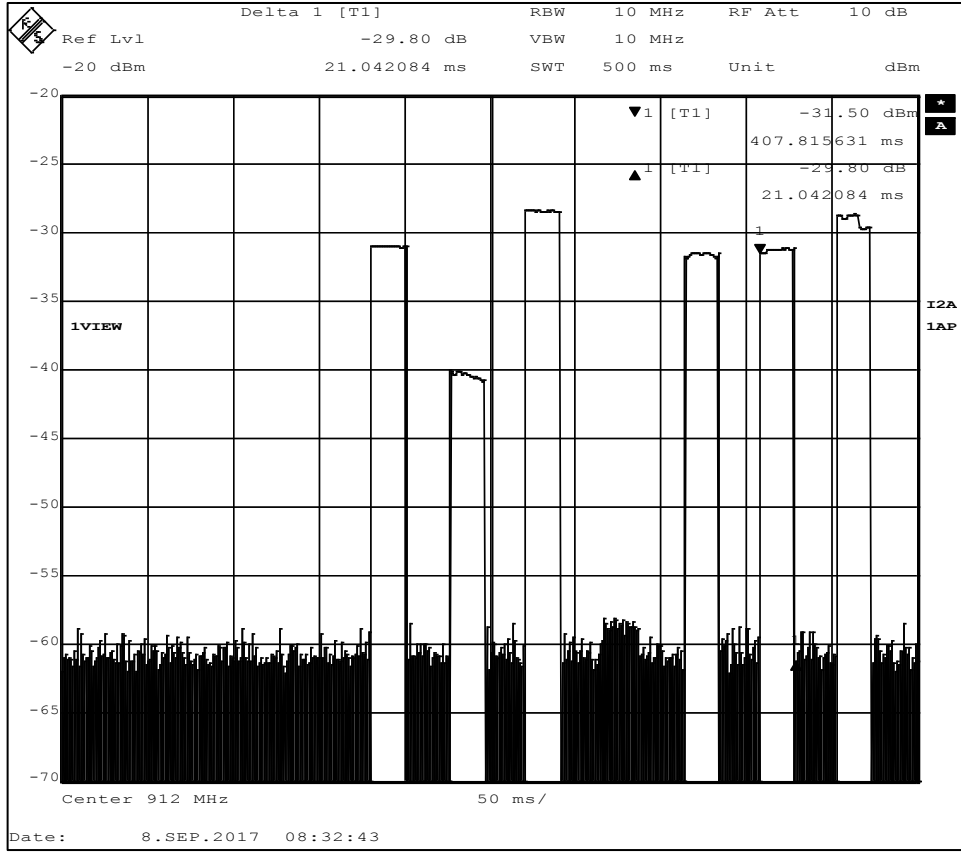
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Figure 7 – Maximum Pulse Width, Pulse 1

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Figure 8 – Maximum Pulse Width, Pulse 2

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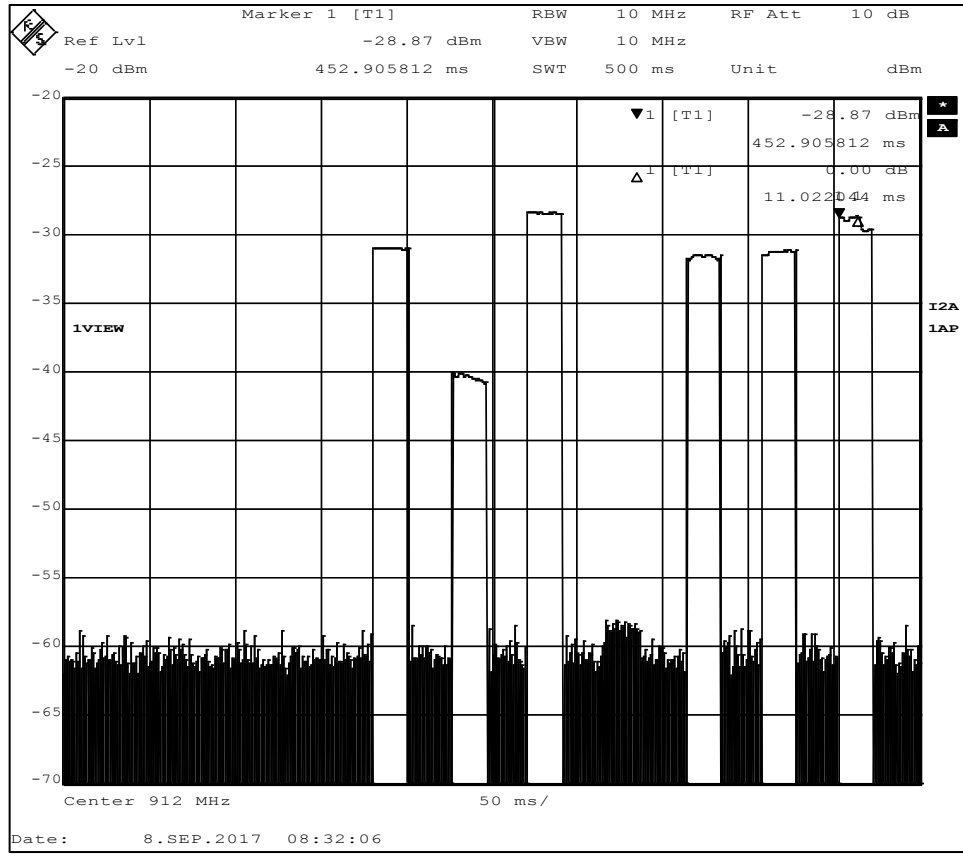Prepared for Inovonics Wireless Corp.

Figure 9 – Maximum Pulse Width, Pulse 3

The delta measurement shown above is based on the end of the 100ms period as first measured in Figure 6.

Duty cycle correction factor = 20*log (21.04+21.04+11.02) =20*log (53.10/100) = -5.50 dB

Note 1: 100ms is the longest allowed period per FCC Part 15.35

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4.3   Output Power

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

4.3.1 Limits of bandwidth measurements
The peak EIRP was measured using a 500 kHz 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. The EUT was placed on an 80cm foam table.

4.3.2 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 100 kHz RBW and 300 kHz VBW.

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

4.3.3 Deviations from test standard
No deviation

4.3.4 Test setup
See Section 4.2.4

4.3.5 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.

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4.3.6 Test results

EUT MODULE	W3-CO	MODE	Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	902MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Peak EIRP

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	EIRP LIMIT (dBm)	RESULT
Low	902.4	15.93	24.00	PASS
Mid	914.8	14.92	24.00	PASS
High	927.6	15.05	24.00	PASS

EIRP was calculated from field strength measurements using ANSI C63.10:2013, Section 9.5, Equation (22). A peak detector was used in "Max Hold" mode.

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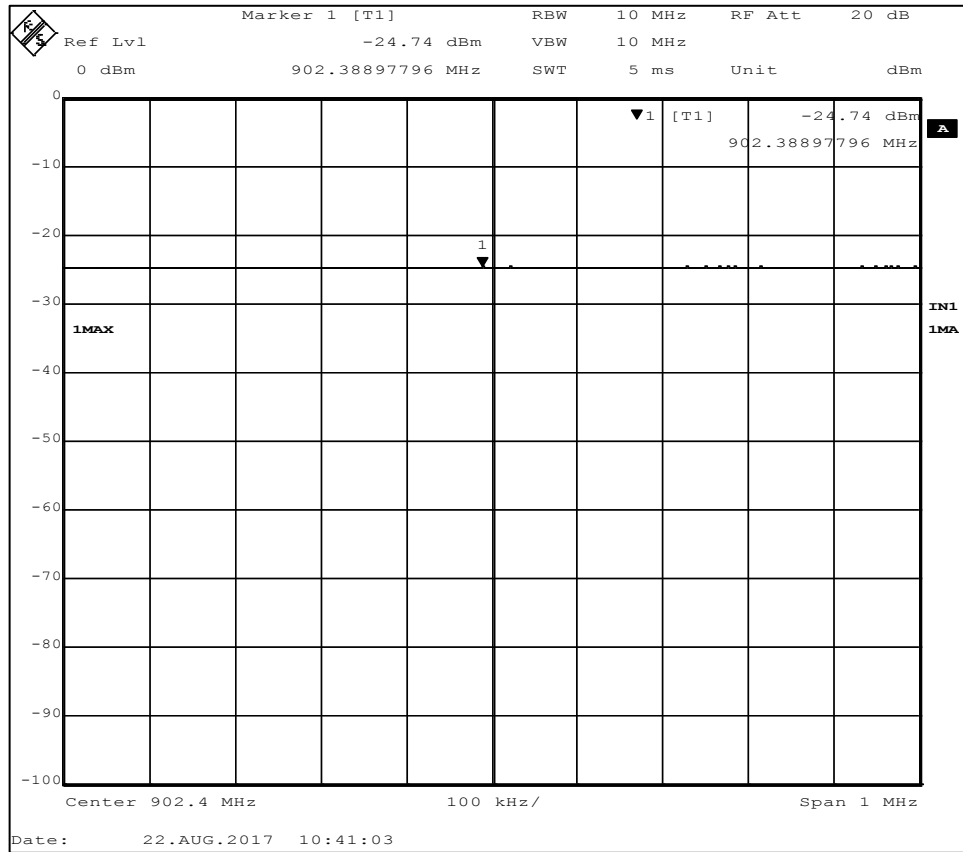Prepared for Inovonics Wireless Corp.

Figure 10 – Output Power, Low Channel

Maximum power = -24.74 dBm + 107 + CL + AF - 95.23 = 15.93 dBm

CL = cable loss = 4.70 dB
AF = antenna factor = 24.20 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.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.
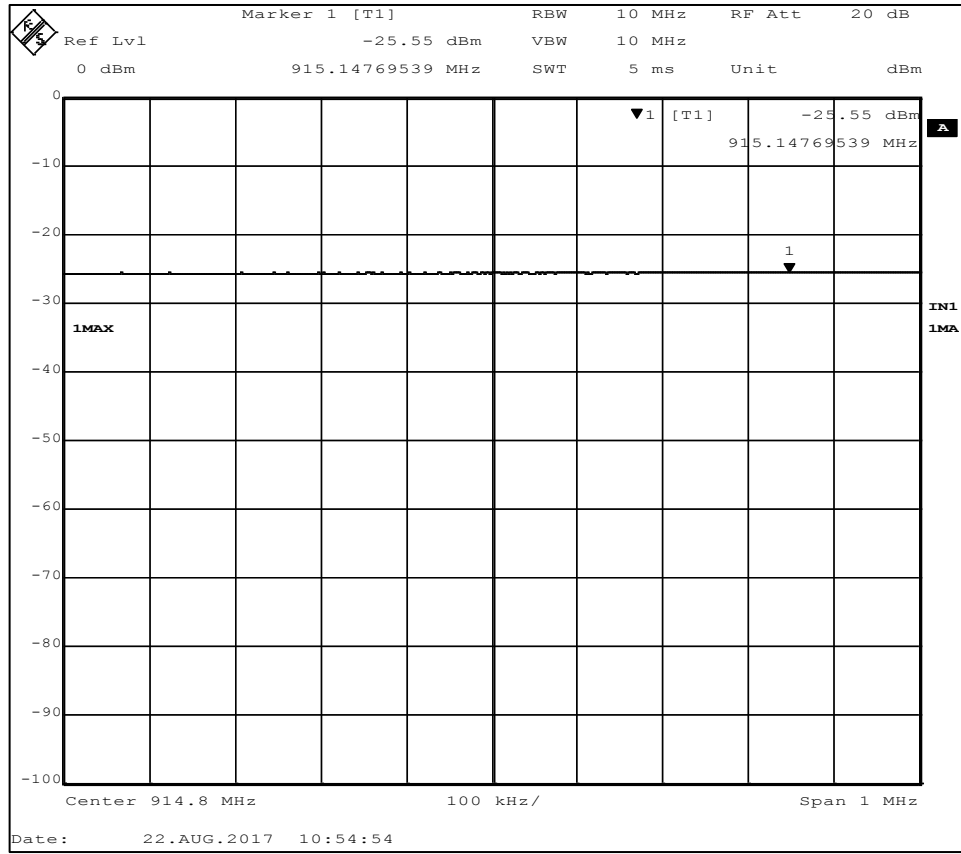
Figure 11 – Output Power, Mid Channel

Maximum power = -25.55 dBm + 107 + CL + AF - 95.23 = 14.92 dBm*

CL = cable loss = 4.80 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.

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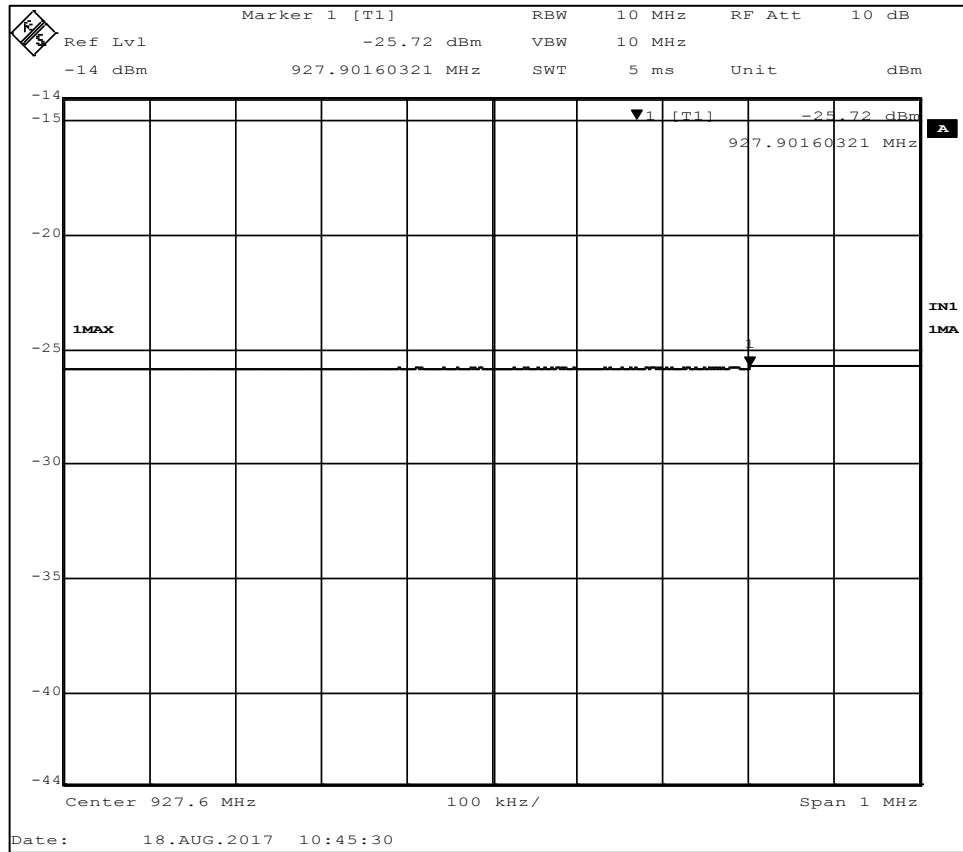resolution bandwidth and saved on the screen.

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Figure 12 – Output Power, High Channel

Maximum power = -25.72 dBm + 107 + CL + AF - 95.23 = 15.05 dBm*

CL = cable loss = 4.90 dB
AF = antenna factor = 24.10 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.

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

4.4   Bandwidth

Test Method: ANSI C63.10, Section(s) 6.9, 7.8.5

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

If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

4.4.2 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 100 kHz RBW and 300 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 100 kHz 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.

4.4.3 Deviations from test standard
No deviation

4.3.4 Test setup
See Section 4.2.4

4.4.5 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.

4.4.6 Test results

EUT MODULE	W3-CO	MODE	Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	902MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
Low	902.4	320.64
Mid	914.8	320.64
High	927.6	322.65

*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.

REMARKS:
None

EIRP was calculated from field strength measurements using ANSI C63.10:2013, Section 9.5, Equation (22).

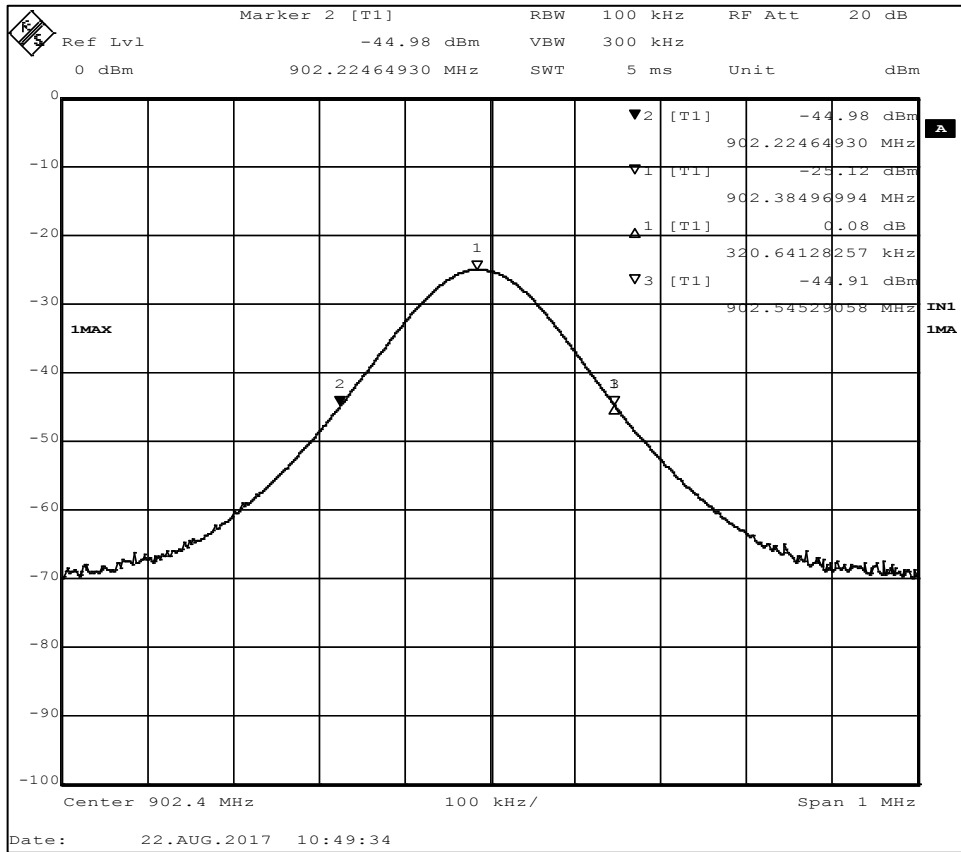All measurements were taken from the 99% occupied bandwidth screen captures.

REMARKS:
None

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Figure 13 - 99% Occupied Bandwidth, Low Channel. 320.64 kHz

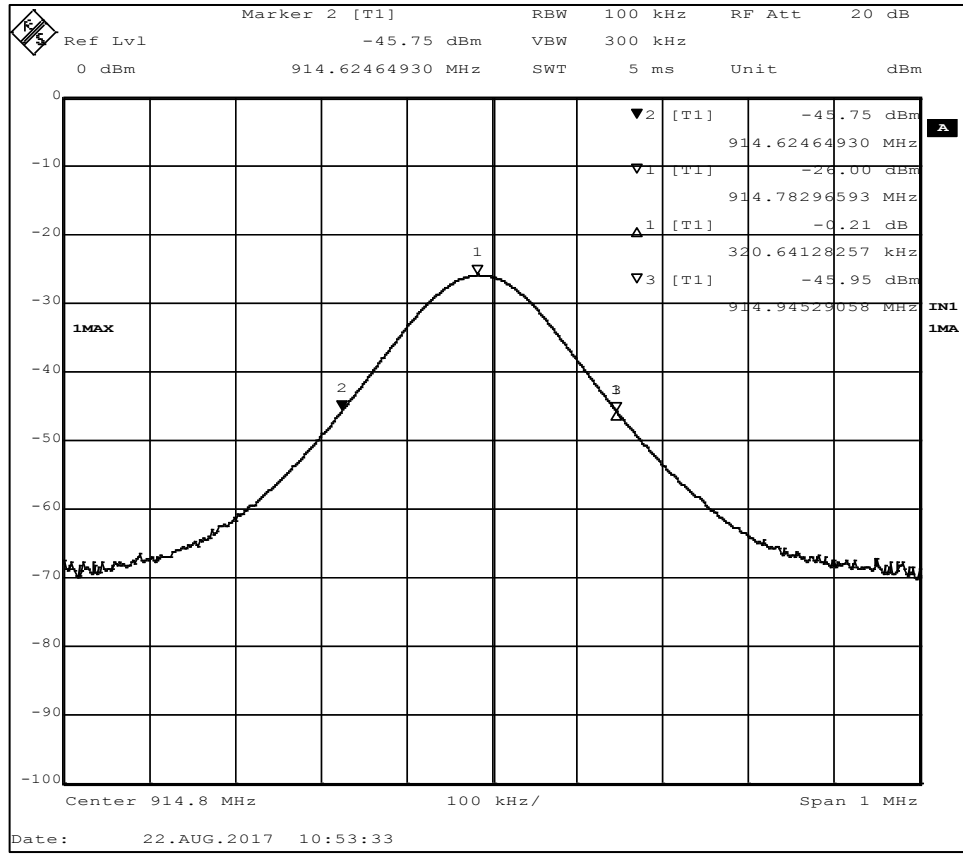The plot shows an uncorrected measurement, used for relative measurements only.

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Figure 14 - 99% Occupied Bandwidth, Mid Channel, 320.64 kHz

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

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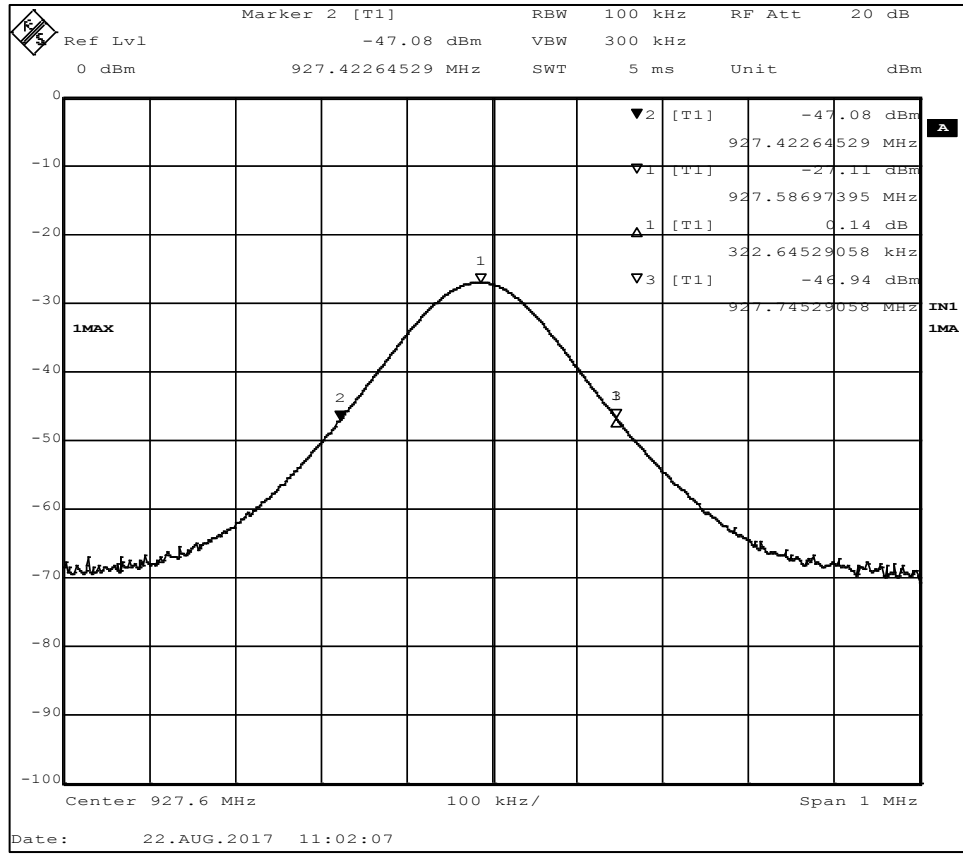Prepared for Inovonics Wireless Corp.

Figure 15 - 99% Occupied Bandwidth, High Channel, 322.65 kHz

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

4.5   Bandedges

Test Method: ANSI C63.10, Section(s) 6.10.5.2

4.5.1   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.

4.5.2   Test procedures

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 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.

4.5.3   Deviations from test standard

No deviation.

4.5.4   Test setup

See Section 4.3

4.5.5   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.

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4.4.6 Test results

EUT MODULE	W3-CO	MODE	Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	902MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

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
1	902	-103.67	-20.20	83.47	63.93	PASS
3	928	-93.93	-23.20	70.73	65.70	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 902MHz for low channel = 109.93 dBµV/m
Fundamental peak field strength at 928MHz for high channel = 111.70 dBµV/m

    Channel 1 minimum delta = 109.93 - 46.0 dBµV/m = 63.93 dBc
    Channel 3 minimum delta = 111.70 - 46.0 dBµV/m = 65.70 dBc

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

The field strength values at the band edges meet the spurious emissions requirements of Part 15.209 and also meet the requirement to be 20dB below the maximum fundamental field strength requirement.

The restricted bands at 614 MHz and 960 MHz where investigated in Section 4.2 of this test report and found to be at least 20 dB below the limits of FCC Part 15.209.
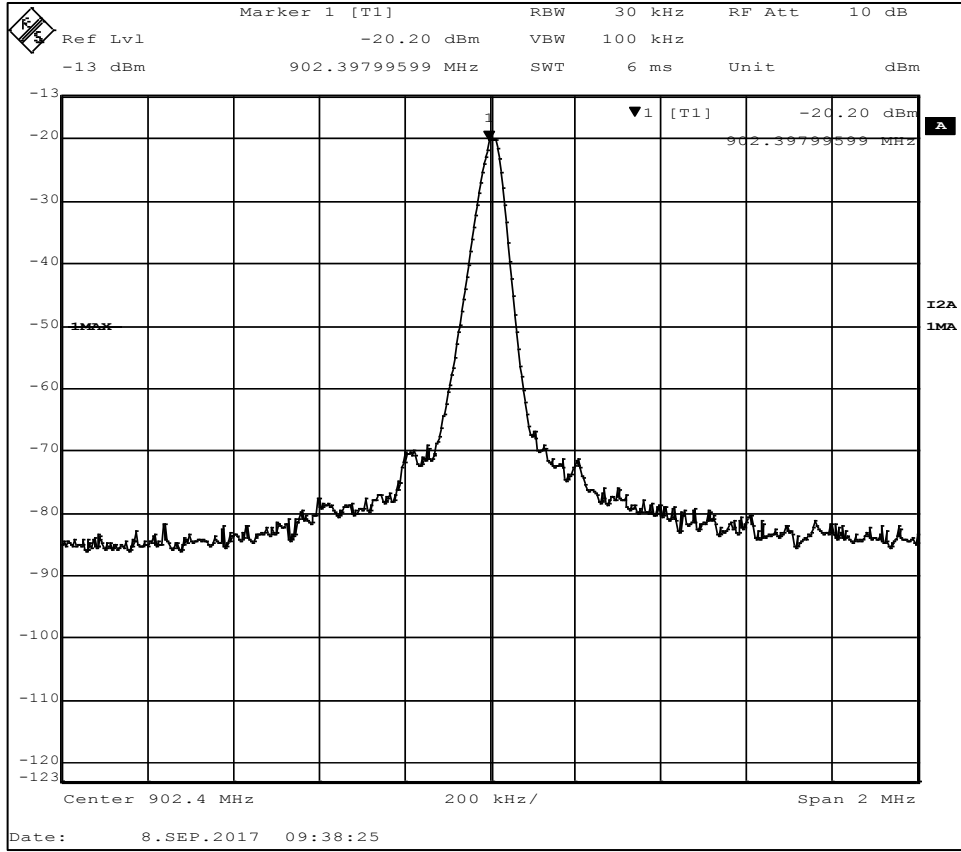
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Figure 16 - Band-edge Measurement, Low Channel, Restricted Frequency
The plot shows an uncorrected measurement, used for relative measurements only.
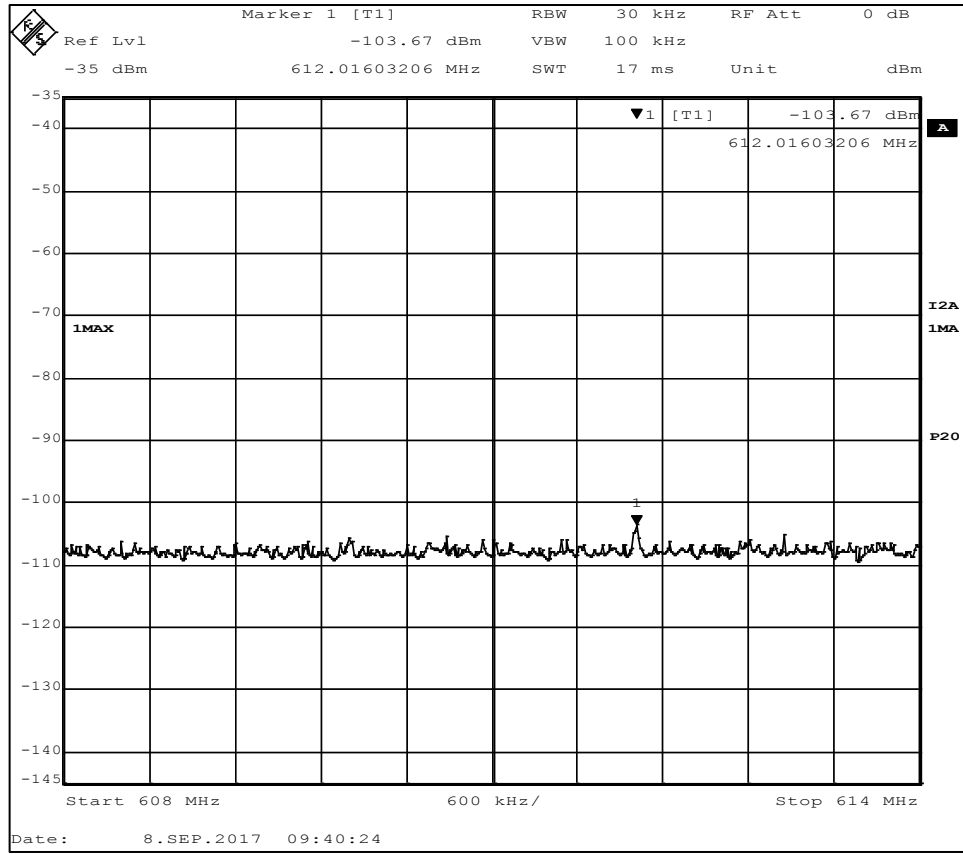
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Figure 17 - Band-edge Measurement, Low Channel, Restricted Frequency
The plot shows an uncorrected measurement, used for relative measurements
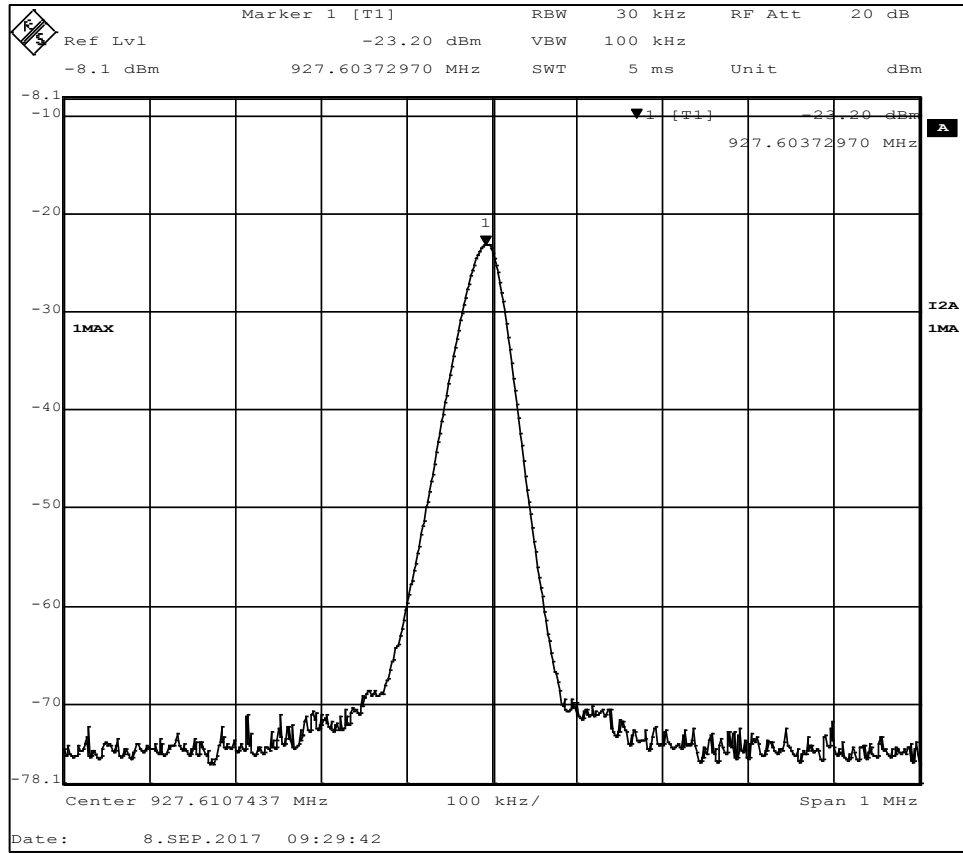only.

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Figure 18 - Band-edge Measurement, High Channel, Restricted Frequency
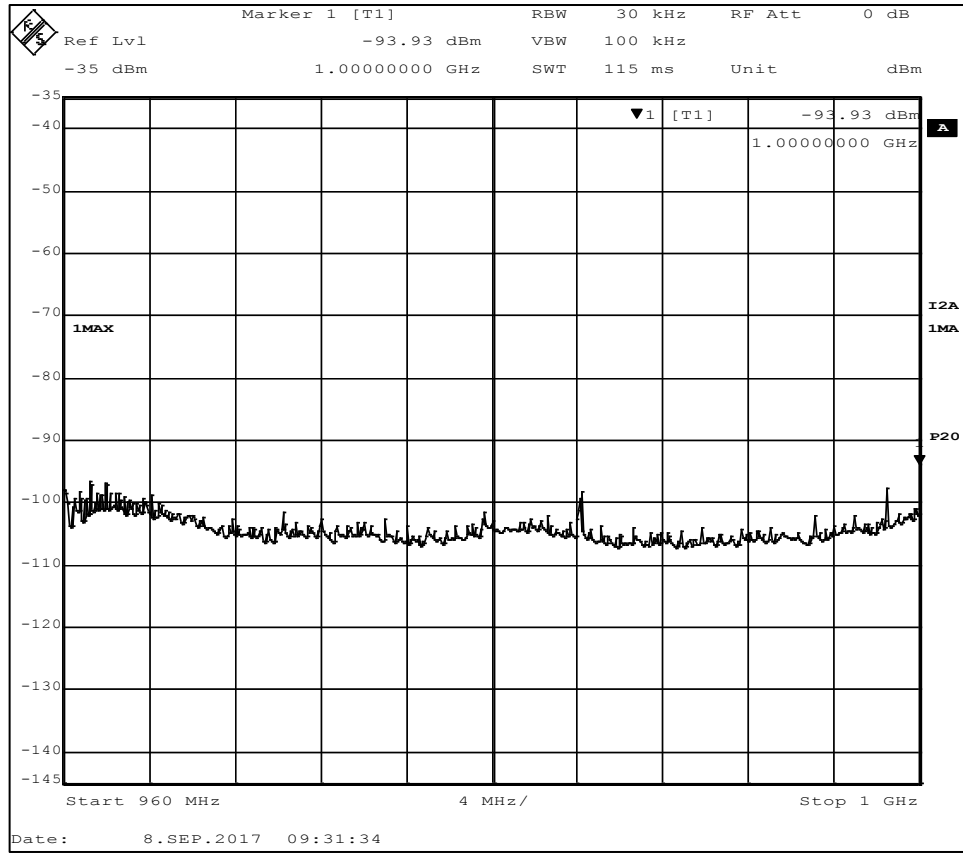The plot shows an uncorrected measurement, used for relative measurements only.

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Figure 19 - Band-edge Measurement, High Channel, Restricted Frequency
The plot shows an uncorrected measurement, used for relative measurements
only.

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

4.6.1   Limits for Time of Occupancy

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

4.6.2   Test procedures

The method from FCC DA 00-705

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

4.6.3   Deviations from test standard

No deviation.

4.6.4   Test setup
See Section 4.2.4

4.7.5   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.

4.6.6   Test results

EUT MODULE	W3-CO	MODE	Continuous Hop
INPUT POWER	3 VDC	FREQUENCY RANGE	902MHz – 928 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

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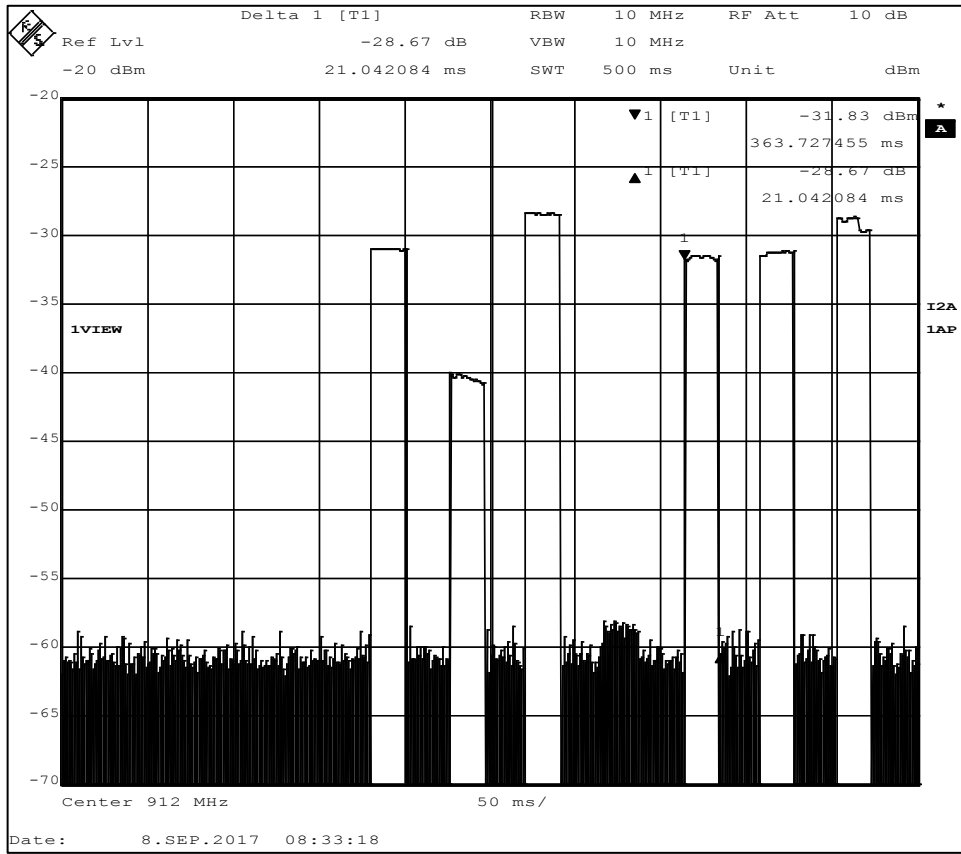
Figure 20 – Time of Occupancy (21.04 ms per Hop - Pass)

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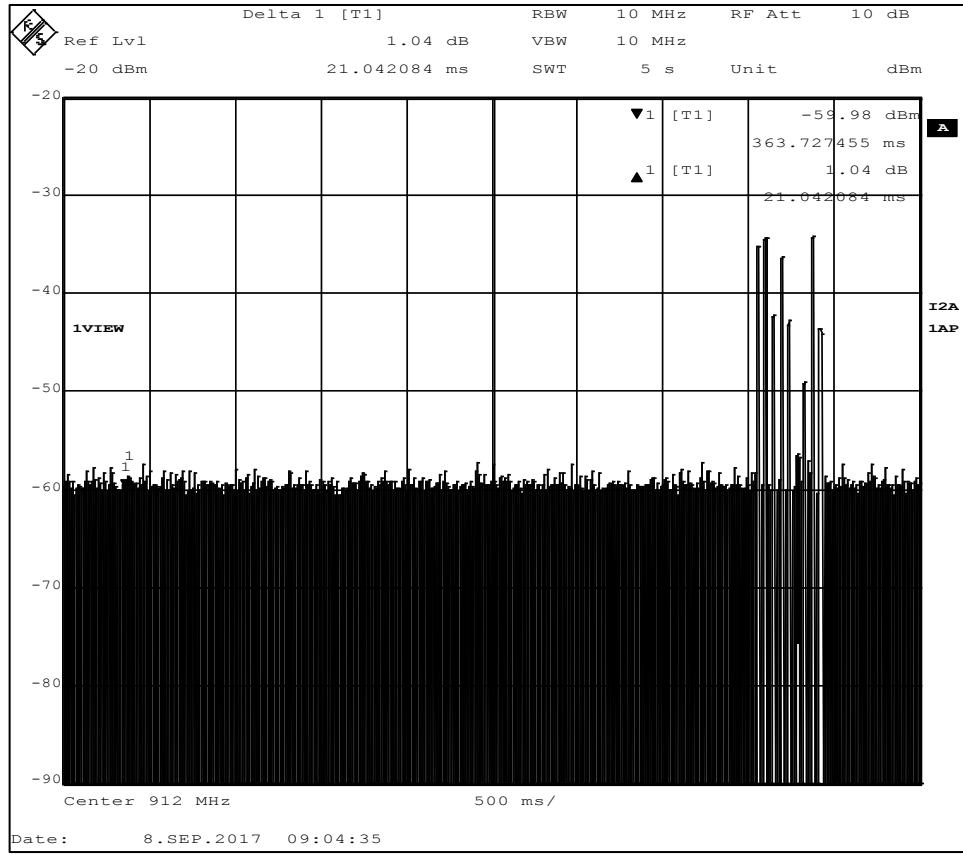**Figure 21 – Time of Occupancy - Period**
(Max – 8 peaks in 5 seconds window)

Note: included for resolution purposes

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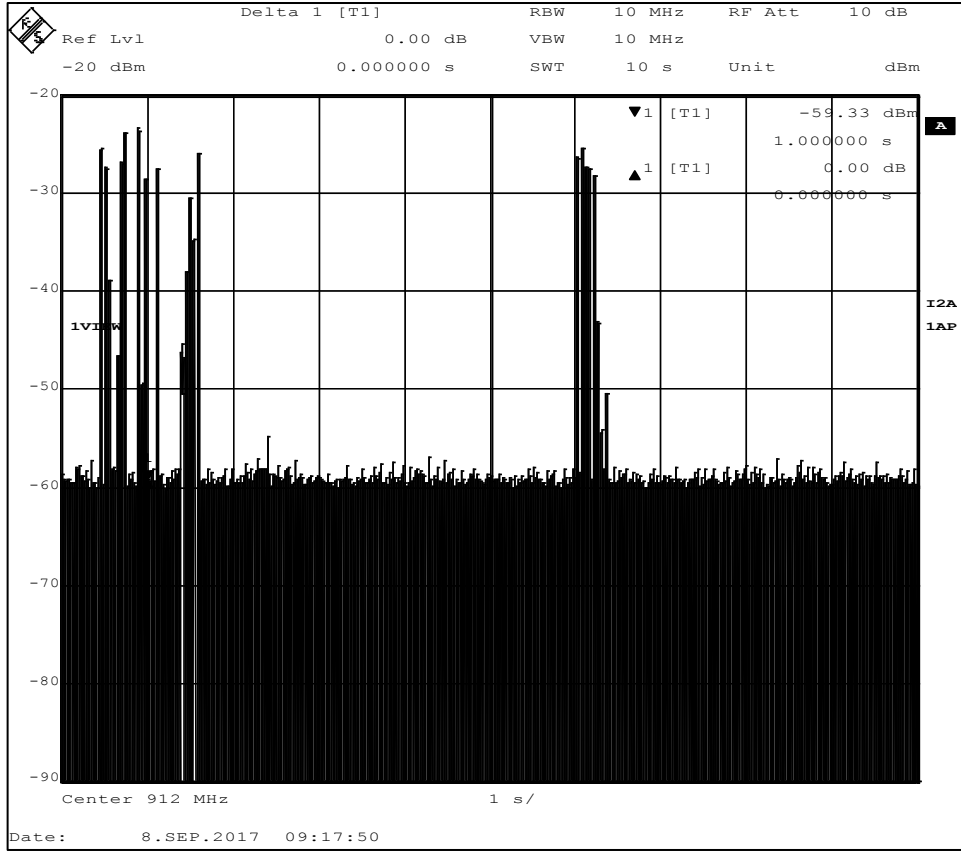Prepared for Inovonics Wireless Corp.

Figure 22 – Time of Occupancy - Period
(Max – 16 peaks with 21.04 ms ON time in 10 seconds window)

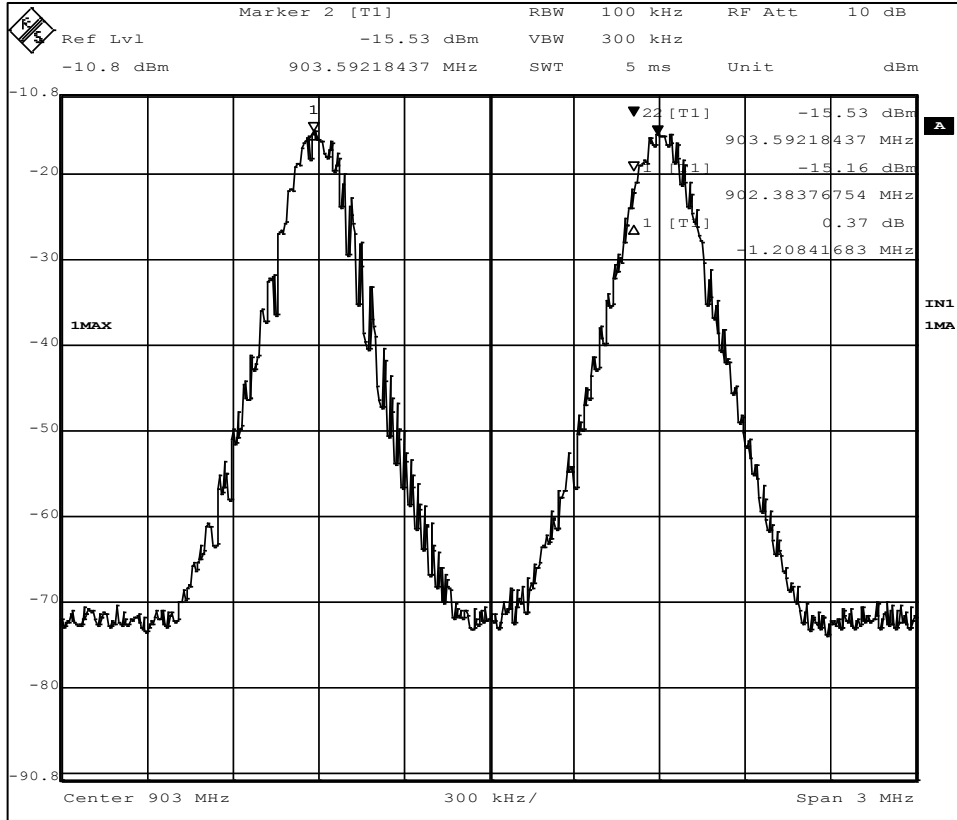Max = 0.4 sec in 10 sec window > (21.04*16 = 336.64 ms=0.34 sec)

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Figure 23 – Frequency Separation (1.208 MHz)

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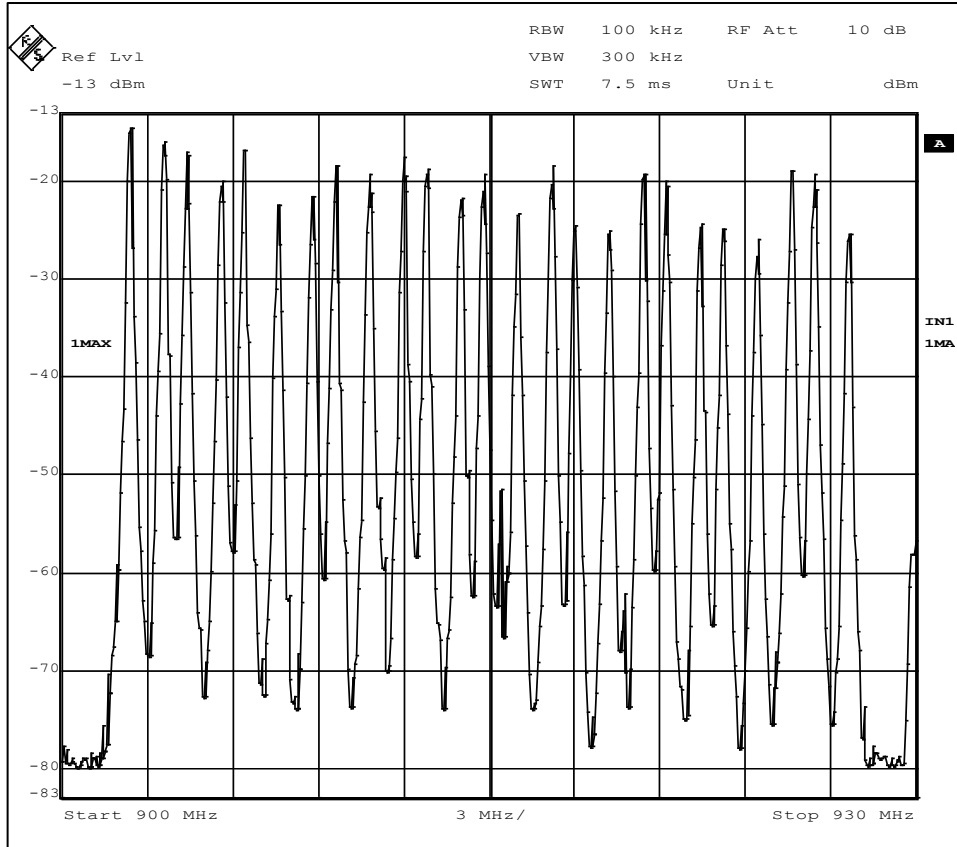
Figure 24 – Hopping Channel Count (25 Channels)

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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.

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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 x Gain (numeric)]

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

Field Strength (dBµV/m) = Field Strength (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 x d^2)/30 = FS [(d^2)/30] = FS [0.3}

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

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

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Annex 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	150kHz – 18GHz	±3.30 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

CISPR 16-4-2:2011 was used to calculate the above values.