



CERTIFICATION TEST REPORT

Report Number. : 12212365-E2V3

Applicant : RACHIO INC,
1321 15 ST.
DENVER, CO 80202, U.S.A.

Model : RACHFLOW

FCC ID : 2AOTB-RFLOW

ISED ID : 23555-RFLOW

EUT Description : WIRELESS FLOW METER

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C
ISED RSS-247 ISSUE 2
ISED RSS-GEN ISSUE 4

Date Of Issue:

May 09, 2018

Prepared by:

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NVLAP LAB CODE 200065-0

Revision History

<u>Rev.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
V1	04/20/18	Initial Issue	--
V2	05/01/18	Updated Sections 5.5 & 5.6	Vien Tran
V3	05/09/18	Revised section 9 and 9.1	Vien Tran

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: RACHIO, INC.
1321 15 ST
DENVER, CO 80202, U.S.A.

EUT DESCRIPTION: WIRELESS FLOW METER

MODEL: RACHFLOW

SERIAL NUMBER: 001 (Radiated Sample) & 002 (Conducted Sample)

DATE TESTED: April 11 to 12, 2018

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 4	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

Approved & Released For
UL Verification Services Inc. By:

Prepared By:



FRANK IBRAHIM
OPERATIONS LEADER
UL Verification Services Inc.

Ray Li
EMC ENGINEER
UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, RSS-GEN Issue 4, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
<input checked="" type="checkbox"/> Chamber A	<input type="checkbox"/> Chamber D
<input type="checkbox"/> Chamber B	<input type="checkbox"/> Chamber E
<input type="checkbox"/> Chamber C	<input type="checkbox"/> Chamber F
	<input type="checkbox"/> Chamber G
	<input type="checkbox"/> Chamber H

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers A through C are covered under Industry Canada company address code 2324B with site numbers 2324B -1 through 2324B-3, respectively. Chambers D through H are covered under Industry Canada company address code 22541 with site numbers 22541 -1 through 22541-5, respectively.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://ts.nist.gov/standards/scopes/2000650.htm>.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Radiated Disturbance, 1000 to 18000 MHz	4.32 dB
Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Radiated Disturbance, 26000 to 40000 MHz	5.24 dB
Occupied Channel Bandwidth	± 0.39 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is a Wireless Flow Meter which is operating in frequency range 903.8-922.2MHz and powered by two AA batteries, 3VDC.

5.2. MAXIMUM OUTPUT PEAK POWER

The transmitter has a maximum conducted peak output power as follows:

Frequency Range (MHz)	Mode	Peak Output Power (dBm)	Peak Output Power (mW)
903.8 - 922.2	Normal	9.17	8.26

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a SMD chip antenna, with a maximum gain of -0.5dBi.

5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was 9
The test utility software used during testing was Tera Term Ver 4.93.

5.5. WORST-CASE CONFIGURATION AND MODE

Radiated emission from 9KHz to 1000 MHz was performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Radiated emission from 1000MHz to 18GHz was performed with the EUT set to transmit at the Mid channel as worst-case scenario; after low and high channels were investigated.

The EUT must be mounted in Y-orientation (Stand). Therefore, all final radiated testing was performed with the EUT and antenna in Y-orientation (Stand).

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

N/A

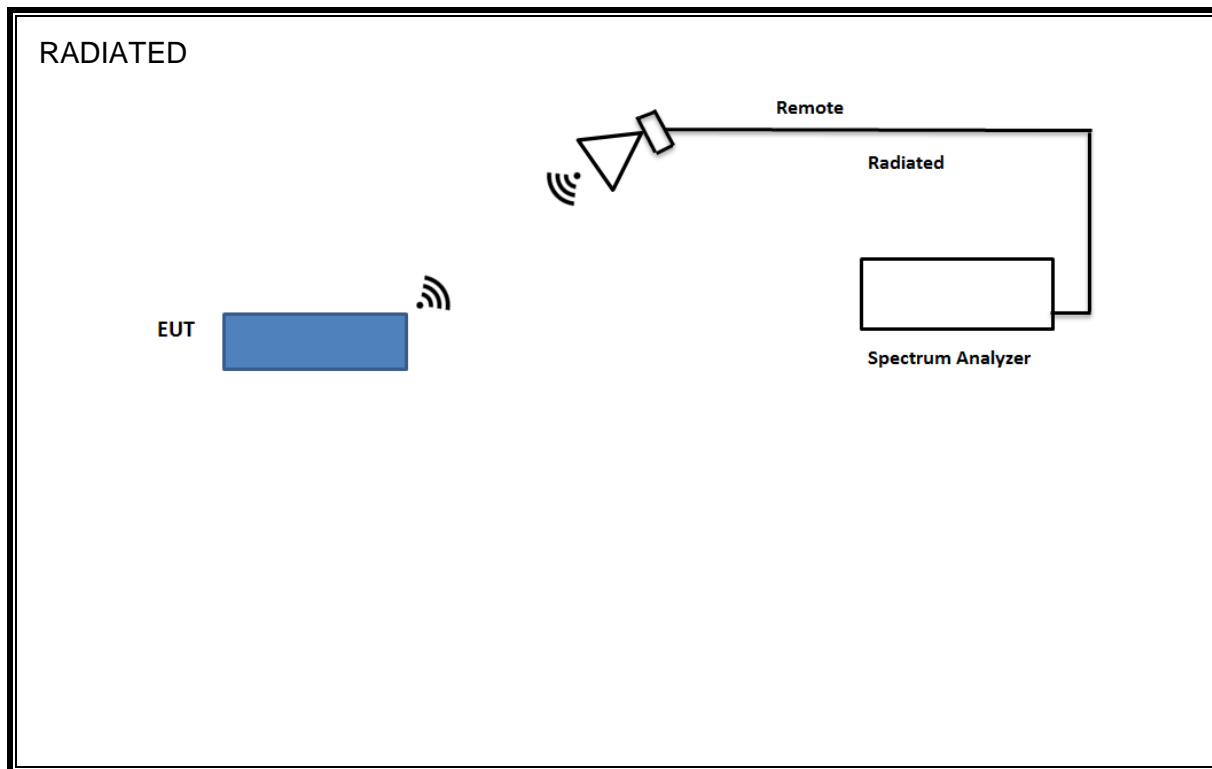
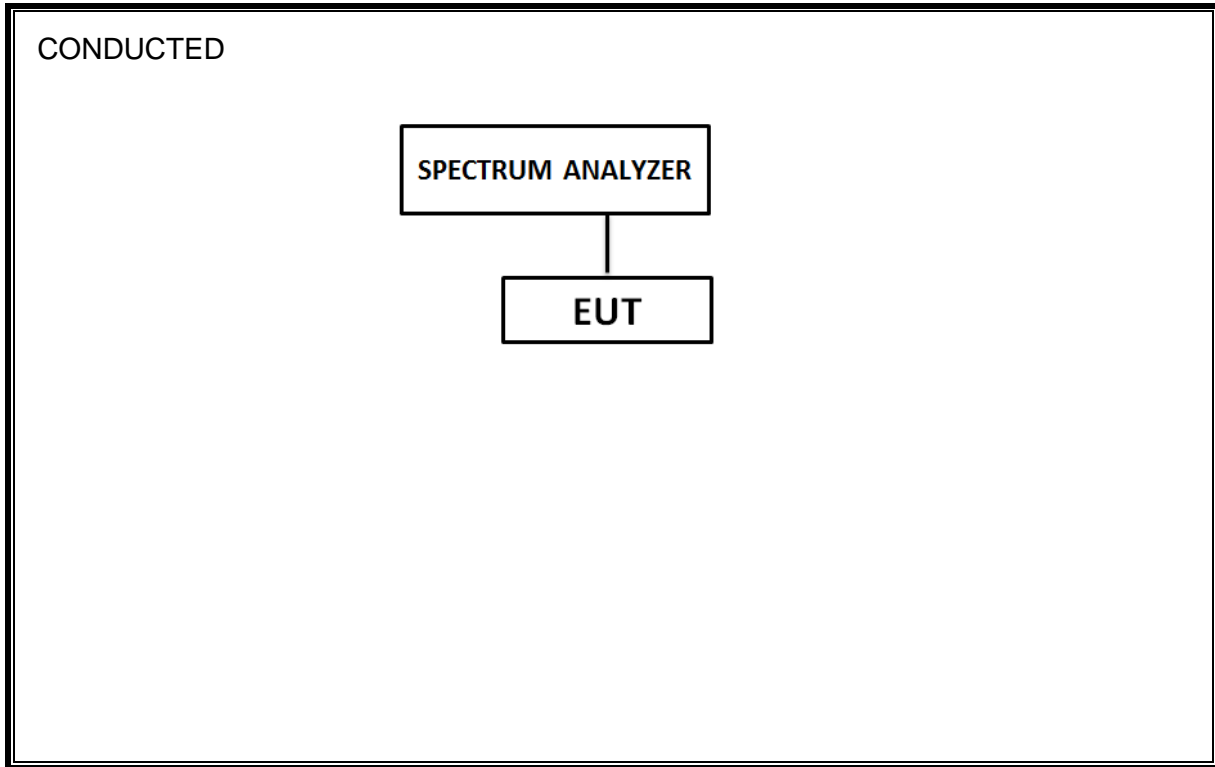
I/O CABLES

N/A

TEST SETUP

The EUT was connected to the host laptop via an USB cable for the parameter setting purposes such as channel, power. During testing, that support equipment was removed and the EUT tested as stand-alone unit

SETUP DIAGRAM FOR TESTS



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment List					
Description	Manufacturer	Model	T Number	Cal Date	Cal Due
Amplifier, 1 to 18 GHz	Miteq	AMF4D-01000800-30-29P	T1573	04/03/2018	04/03/2019
Amplifier, 10KHz to 1GHz, 32dB	Agilent	8447D	15	08/14/2017	08/14/2018
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	862	06/09/2017	06/09/2018
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences	JB3	130	10/16/2017	10/16/2018
Antenna, Active Loop 9kHz-30MHz	COM-POWER	AL-130R	PRE0165308 (MET No)	12/13/2017	12/13/2018
Amplifier, 1-8GHz,35dB	Miteq	AMF-4D-010008000-30-29P	T1573	04/03/2018	04/03/2019
Filter, HPF 3.0GHz	Micro-Tronics	HPM17543	T486	04/03/2018	04/03/2019
Power Meter, P-series, 50MHz to 18GHz	Agilent	N1911A	T413	06/22/2018	06/22/2019
Power Meter, P-series single channel	Agilent	N911A	T1269	04/05/2018	04/05/2019
PXA Spectrum Analyzer, 3Hz to 44GHz	Agilent	N9030A	906	02/16/2018	02/16/2019

Test Software List			
Description	Manufacturer	Model	Test Software
Radiated Software	UL	UL EMC	Ver 9.5, Dec 01, 2016
Antenna Port Software	UL	UL RF	Ver 9.1, January 25, 2018

7. MEASUREMENT METHODS

On Time and Duty Cycle: KDB 558074 D01 v04, Section 6.

6 dB BW: KDB 558074 D01 v04, Section 8.1.

99% BW: ANSI C63.10-2013, Section 6.9.3.

Output Power: KDB 558074 D01 v04, Section 9.2.3.1.

Power Spectral Density: KDB 558074 D01 v04, Section 10.3.

Out-of-band emissions in non-restricted bands: KDB 558074 D01 v04, Section 11.1 (b).

Out-of-band emissions in restricted bands: KDB 558074 D01 v04, Section 12.1.

Band-edge: KDB 558074 D01 v04, Section 12.1

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

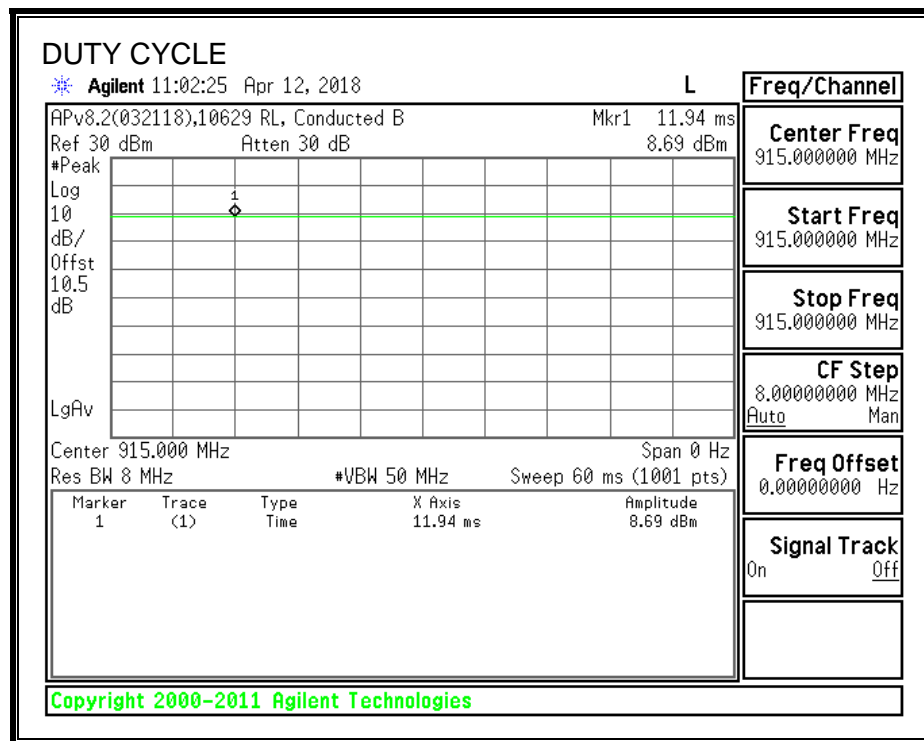
PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
915MHz	100	100	1.000	100.00%	0.00	0.010

DUTY CYCLE PLOTS



8.2. 6 dB BANDWIDTH

LIMITS

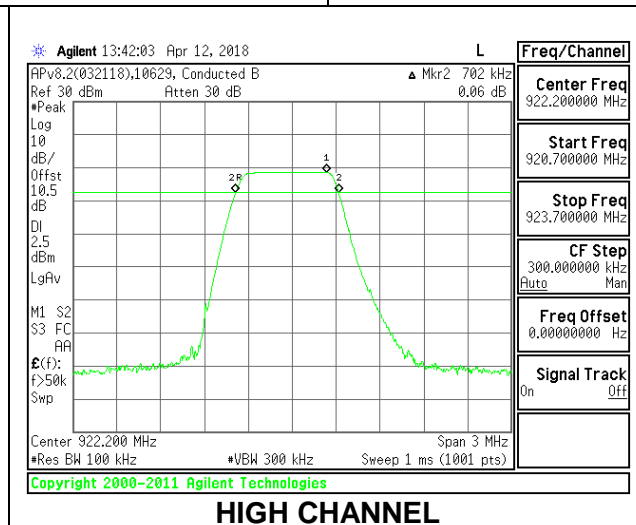
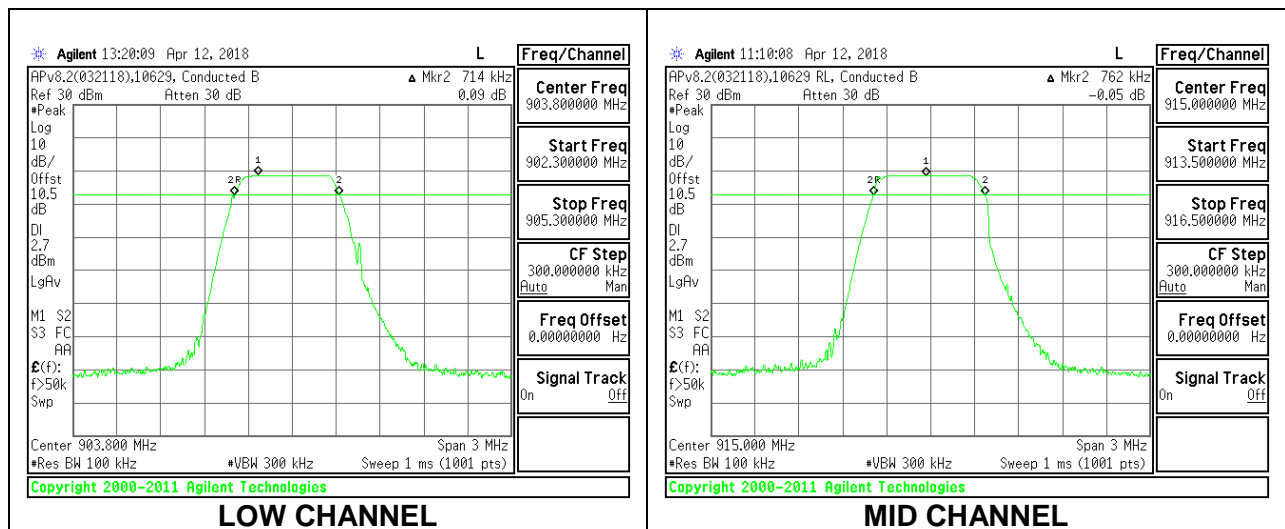
FCC §15.247 (a) (2)

ISED RSS-247 Clause 5.2 (a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	903.8	0.714	0.5
Mid	915.0	0.762	0.5
High	922.2	0.702	0.5



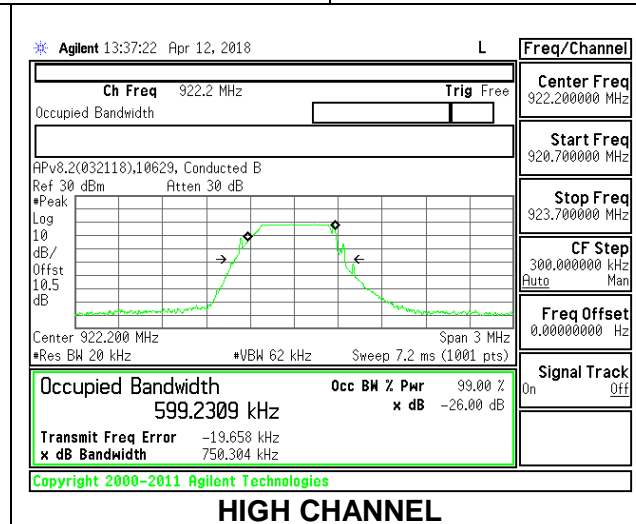
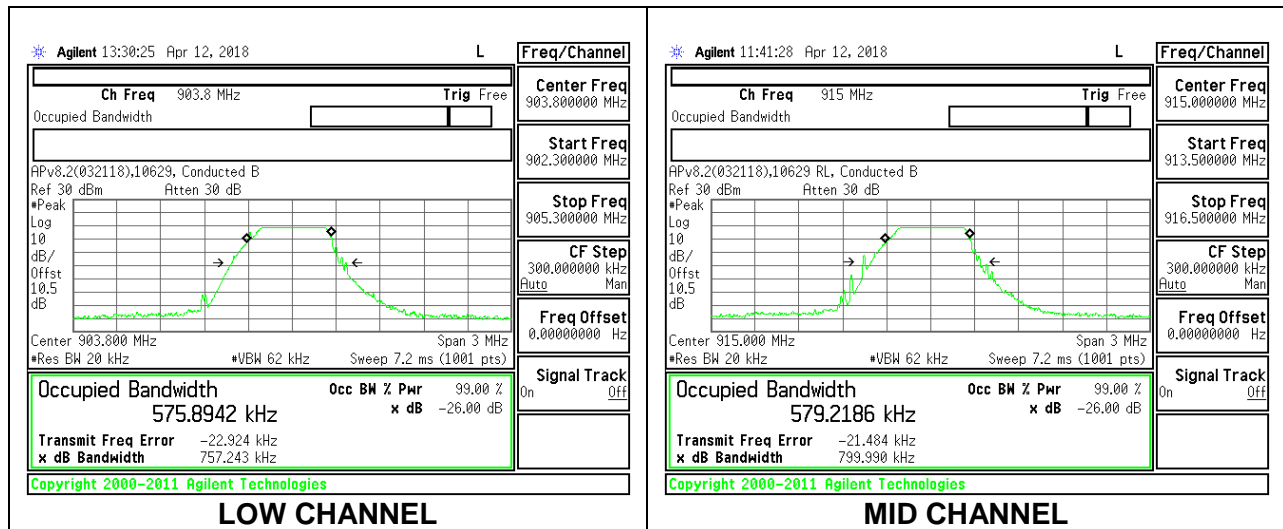
8.3. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

RESULTS

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	903.8	0.5759
Mid	915.0	0.5792
High	922.2	0.5992



8.4. OUTPUT PEAK POWER

LIMITS

FCC §15.247

ISED RSS-247 Clauses 5.4 (d)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt, based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

DIRECTIONAL ANTENNA GAIN

There is only one transmitter output therefore the directional gain is equal to the antenna gain.

RESULTS

Tested By:	10629 RL
Date:	4/12/2018

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	IC Power Limit (dBm)	IC EIRP Limit (dBm)	Max Power (dBm)
Low	903.8	-0.50	30.00	30	36	30.00
Mid	915	-0.50	30.00	30	36	30.00
High	922.2	-0.50	30.00	30	36	30.00

Duty Cycle CF (dB)	0.00	Included in Calculations of Corr'd Power
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Results

Channel	Frequency (MHz)	Chain 0 Meas Peak Power (dBm)	Total Corr'd Peak Power (dBm)	Power Limit (dBm)	Margin (dB)
Low	903.8	9.17	9.17	30.00	-20.83
Mid	915	9.14	9.14	30.00	-20.86
High	922.2	9.03	9.03	30.00	-20.97

8.5. POWER SPECTRAL DENSITY

LIMITS

FCC §15.247

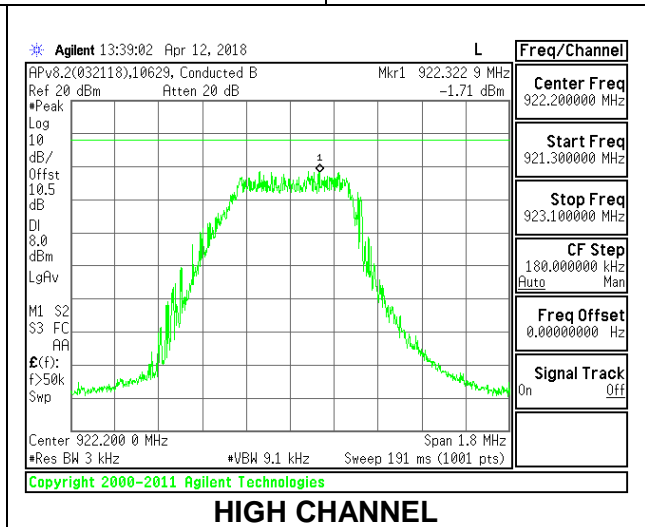
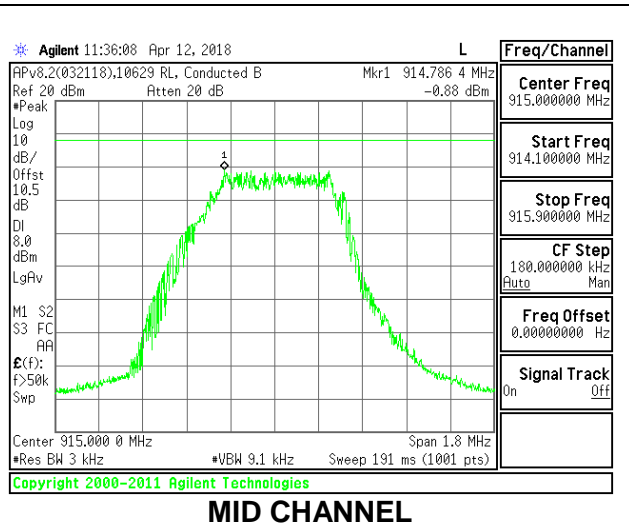
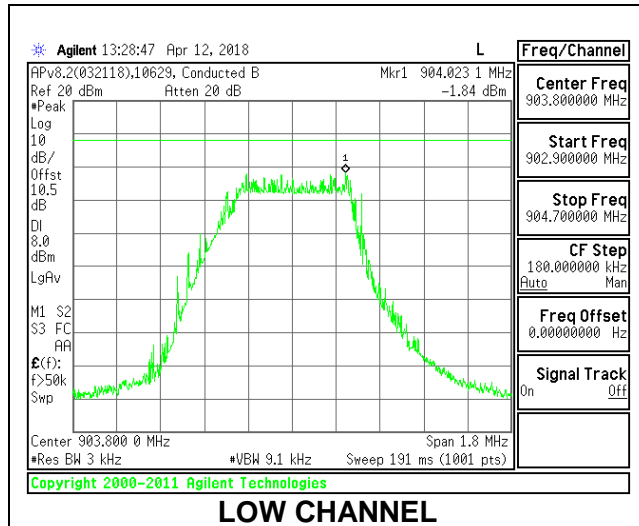
ISED RSS-247 Clause 5.2 (b)

RESULTS

Tested By	10629 RL
Date:	4/12/2018

Duty Cycle CF (dB)	0.00	Included in Calculations of Corr'd PSD
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Channel	Frequency (MHz)	Chain 0 Meas (dBm)	Total Corr'd PSD (dBm)	Limit (dBm)	Margin (dB)
Low	903.8	-1.84	-1.84	8.0	-9.8
Mid	915.0	-1.71	-1.71	8.0	-9.7
High	922.2	-1.71	-1.71	8.0	-9.7



8.6. CONDUCTED SPURIOUS EMISSIONS LIMITS

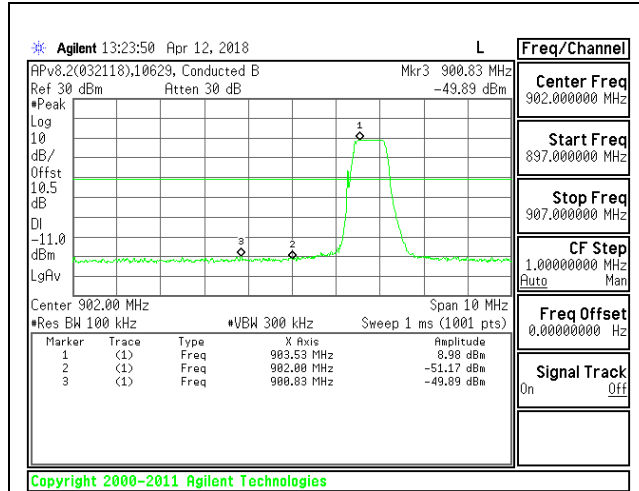
LIMITS

FCC §15.247 (d)

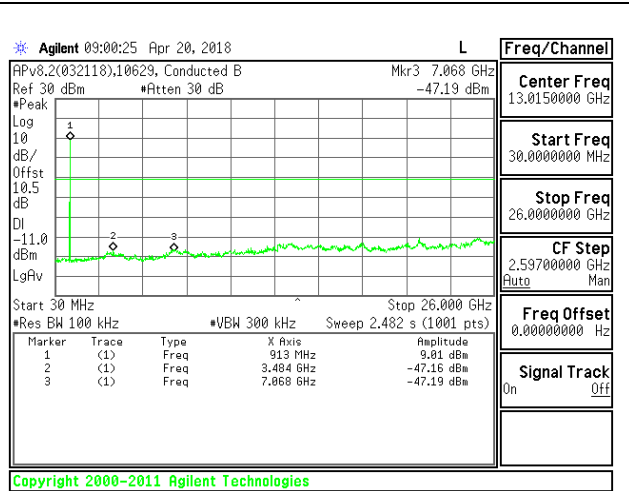
ISED RSS-247 Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

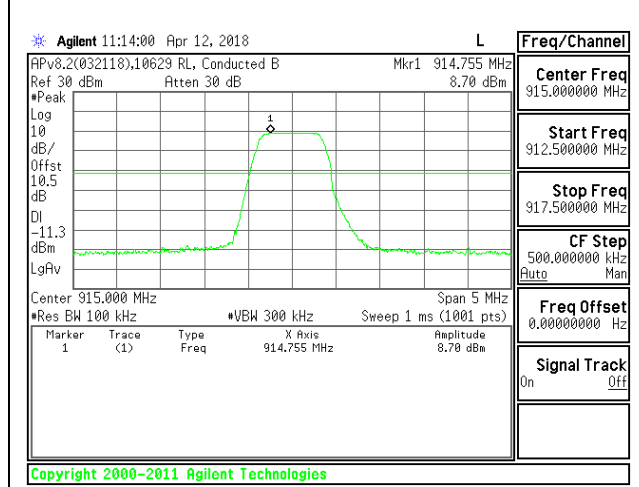
RESULTS



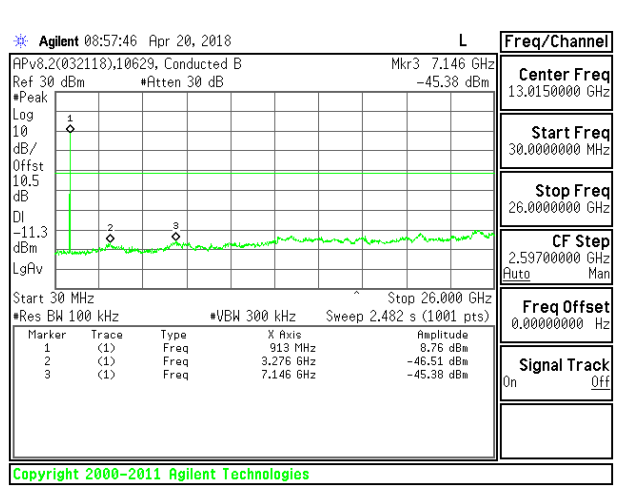
LOW CHANNEL BANDEDGE



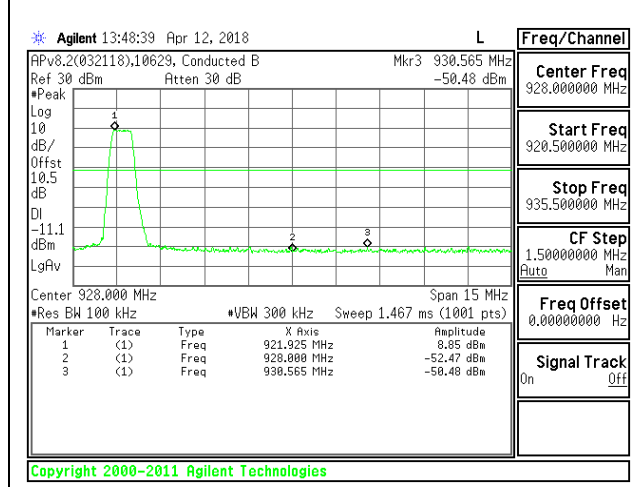
OUT-OF-BAND LOW CHANNEL



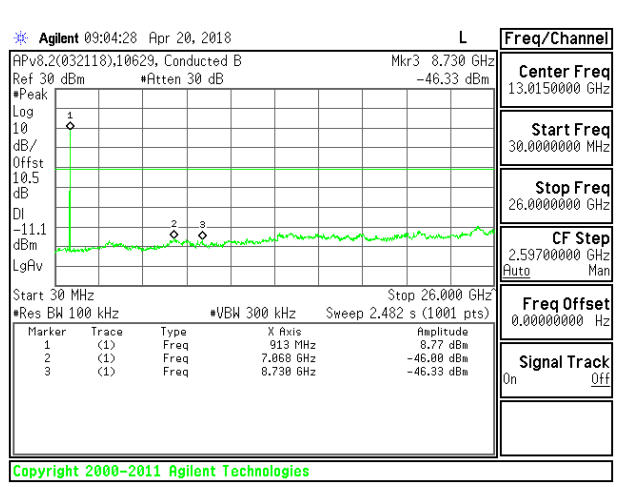
IN-BAND REFERENCE LEVEL



OUT-OF-BAND MID CHANNEL



HIGH CHANNEL BANDEDGE



OUT-OF-BAND HIGH CHANNEL

9. RADIATED TEST RESULTS

LIMITS

FCC 15.205 and FCC 15.209

IC RSS-210
IC RSS-GEN Clause 8.9 (Transmitter)
IC RSS-GEN Clause 7 (Receiver)

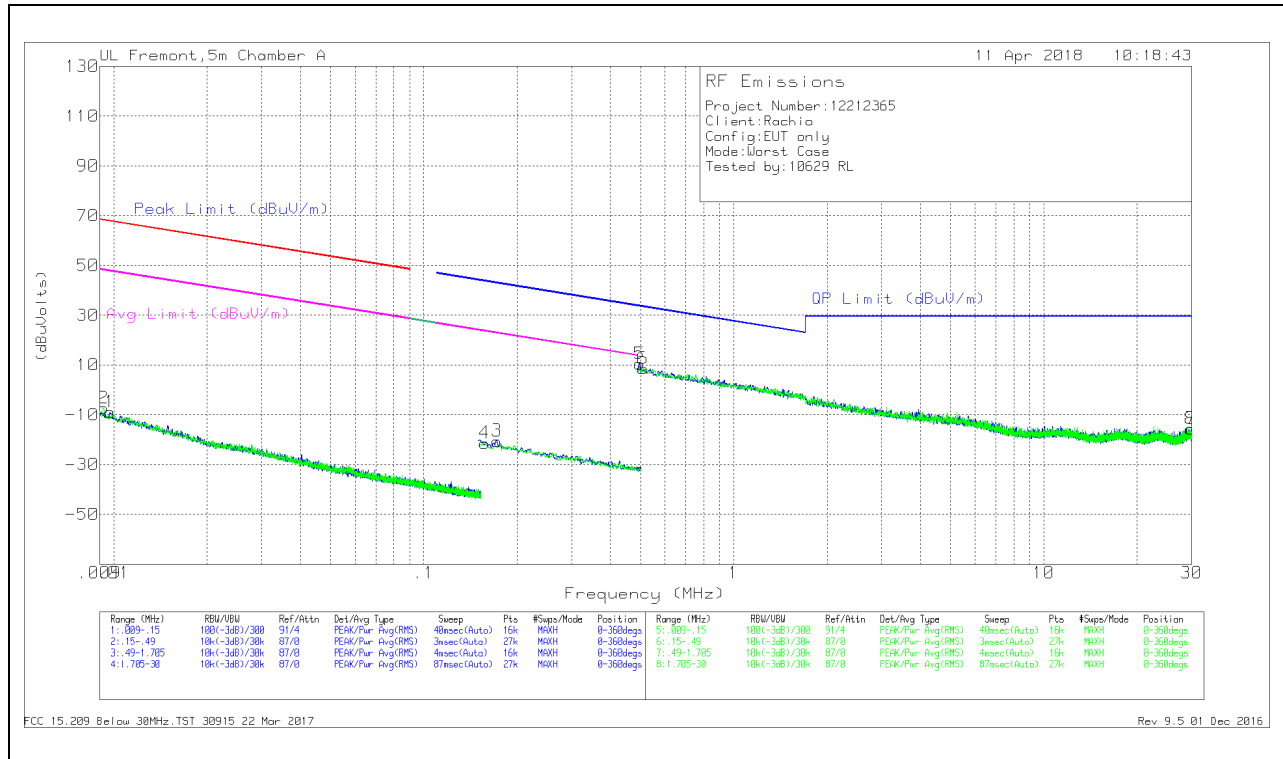
(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

RESULTS

9.1. TRANSMITTER RADIATED EMISIONS 9 kHz TO 30 MHz



NOTE: KDB 414788 OATS and Chamber Correlation Justification

- Based on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.
- OATs and chamber correlation testing had been performed and chamber measured test result is the worst-case test result.

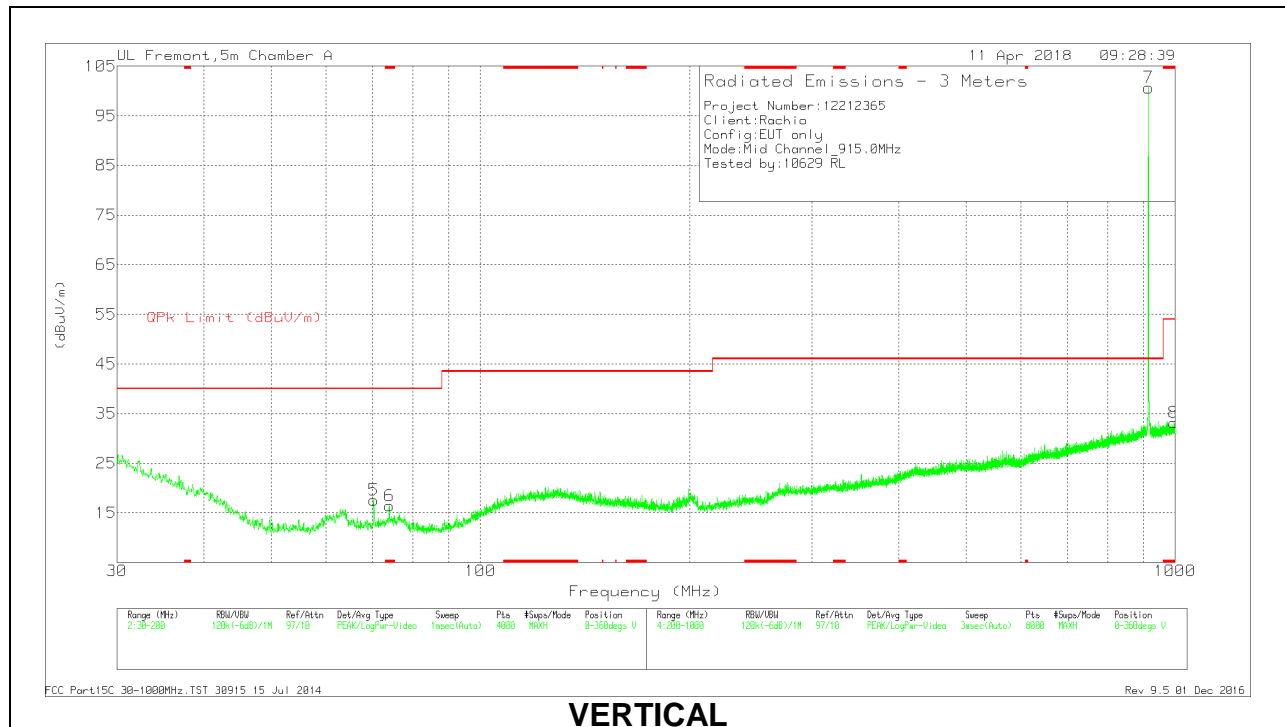
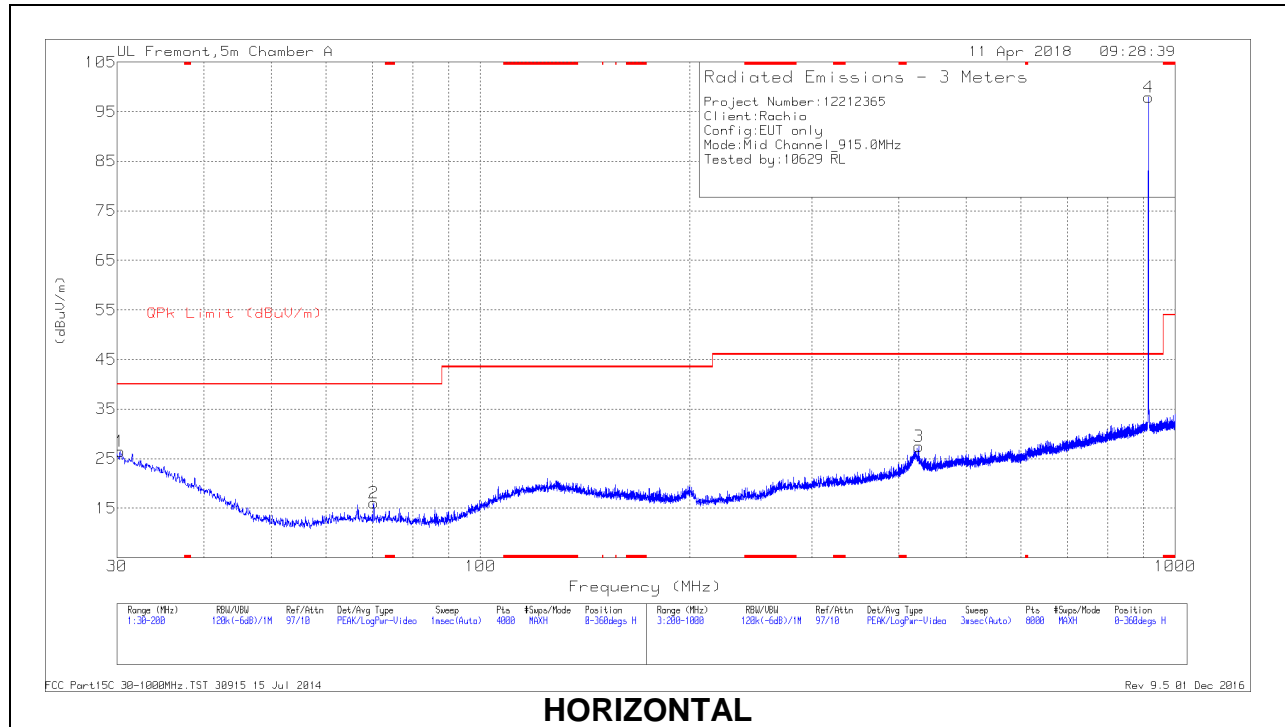
Radiated Emissions

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr 300m	Corrected Reading (dBuV olts)	Peak Limit (dBuV/m)	Margin (dB)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Avg Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
2	.00926	52.94	Pk	19.6	.1	-80	-7.36	68.25	-75.61	48.25	-55.61	-	-	-	-	0-360
1	.00972	51.87	Pk	19	.1	-80	-9.03	67.83	-76.86	47.83	-56.86	-	-	-	-	0-360
4	.15722	47.48	Pk	11	.1	-80	-21.42	-	-	-	-	43.69	-65.11	23.69	-45.11	0-360
3	.17205	48.33	Pk	11	.1	-80	-20.57	-	-	-	-	42.91	-63.48	22.91	-43.48	0-360

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr 30m	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
5	.49566	39.19	Pk	11.1	.1	-40	10.39	33.7	-23.31	0-360
6	.50949	37.39	Pk	11.1	.1	-40	8.59	33.46	-24.87	0-360
8	29.78197	13.82	Pk	9.7	.8	-40	-15.68	29.5	-45.18	0-360
7	29.96065	13.86	Pk	9.7	.8	-40	-15.64	29.5	-45.14	0-360

Pk - Peak detector

9.2. TRANSMITTER RADIATED EMISSIONS 30 TO 1000 MHz



Radiated Emissions

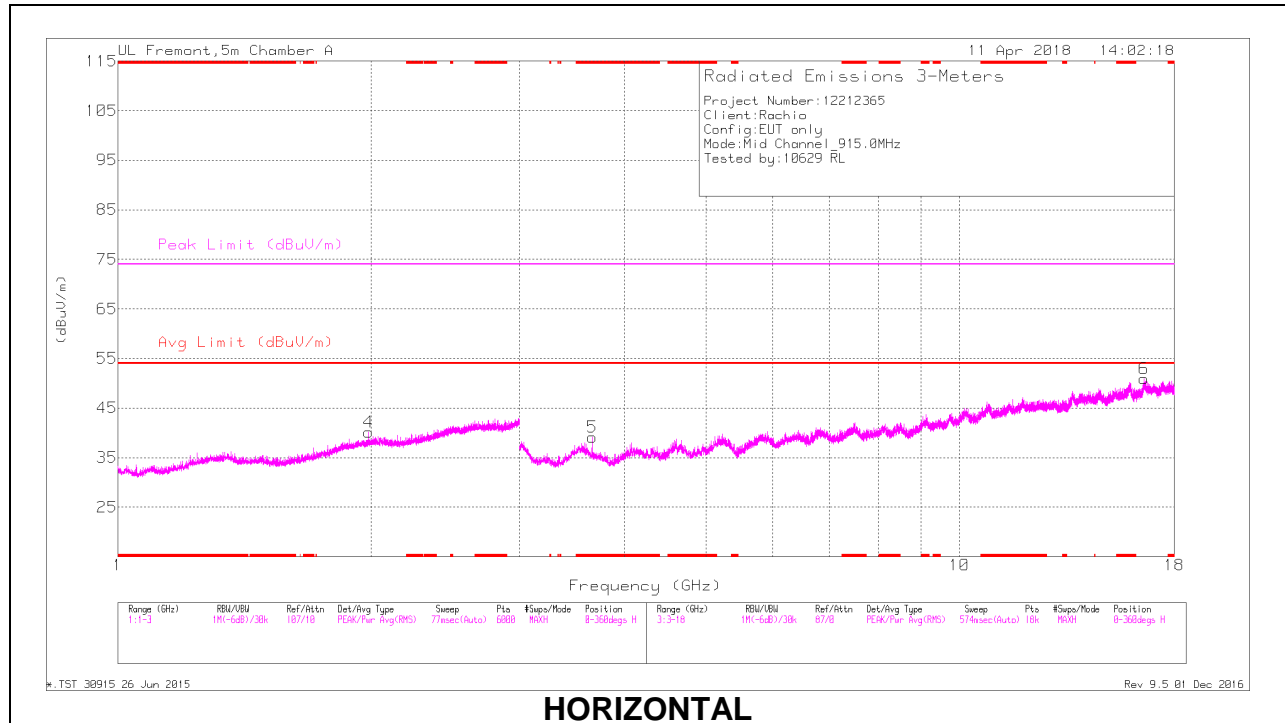
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T130 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
6	73.9564	31.08	Pk	12	-26.7	16.38	40	-23.62	0-360	100	V
8	996.5035	28.46	Pk	27.2	-22.5	33.16	53.97	-20.81	0-360	200	V
1	30.2976	28.74	Pk	25	-27.3	26.44	40	-13.56	0-360	100	H
5	70.2154	32.13	Pk	12.1	-26.7	17.53	40	-22.47	0-360	100	V
2	70.2579	30.71	Pk	12.1	-26.7	16.11	40	-23.89	0-360	100	H
3	427.4296	32.13	Pk	20.5	-25.1	27.53	46.02	-18.49	0-360	200	H
*4	915.393	94.34	Pk	26.5	-22.9	97.94	-	-	0-360	101	H
*7	915.443	97.06	Pk	26.5	-22.9	100.66	-	-	0-360	200	V

Pk - Peak detector

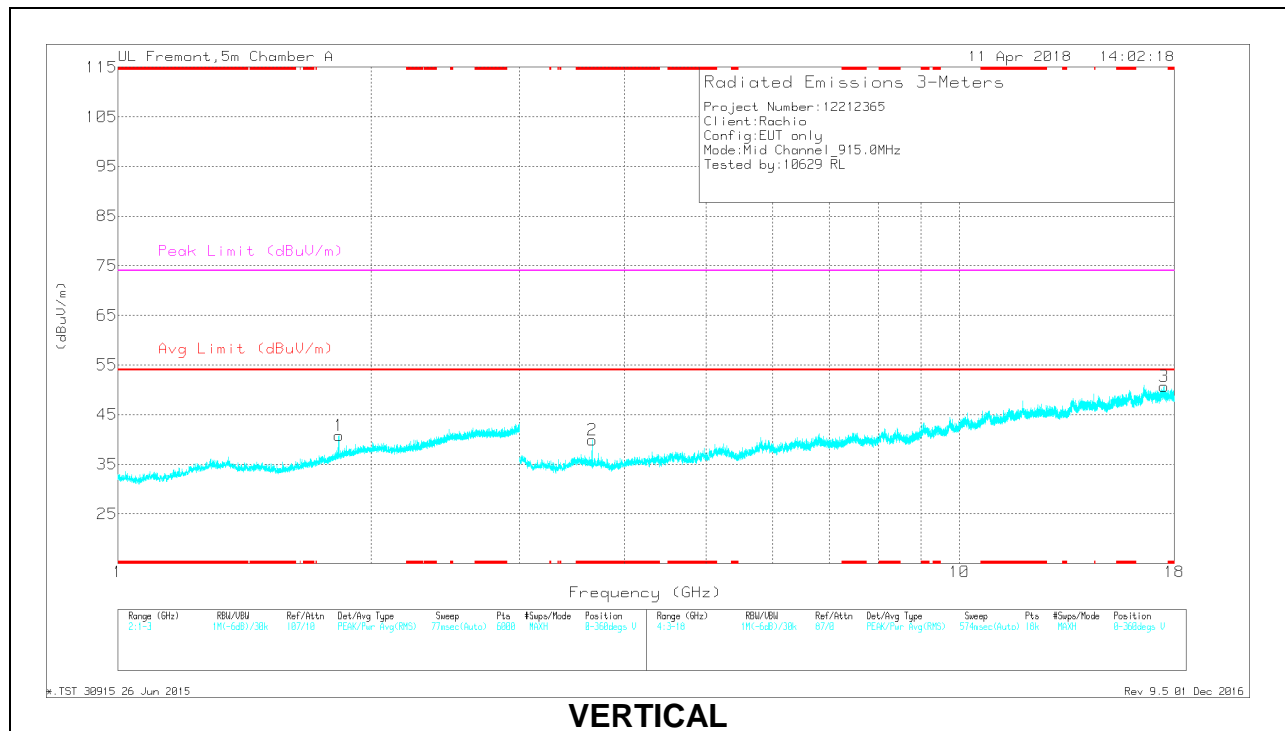
*Fundamental 915.0MHz

9.3. TRANSMITTER RADIATED EMISSIONS 1 TO 18 GHz

HARMONICS AND SPURIOUS EMISSIONS WORST-CASE MID CHANNEL (915 MHz)



HORIZONTAL



VERTICAL

Radiated Emissions

Marker	Frequenc y (GHz)	Meter Reading (dBuV)	Det	AF T862 (dB/m)	Amp/Cbl/Fitr/ Pad (dB)	Correcte d Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
5	* 3.66	39.39	PK2	32.9	-27.7	44.59	-	-	74	-29.41	174	103	H
	* 3.66	29.05	MAv1	32.9	-27.7	34.25	54	-19.75	-	-	174	103	H
2	* 3.661	40.19	PK2	32.9	-27.7	45.39	-	-	74	-28.61	121	207	V
	* 3.66	29.73	MAv1	32.9	-27.7	34.93	54	-19.07	-	-	121	207	V
1	1.83	33.63	Pk	30.6	-23.4	40.83	-	-	-	-	0-360	200	V
4	1.985	32.04	Pk	31.4	-23.3	40.14	-	-	-	-	0-360	199	H
6	16.581	26.09	Pk	41.4	-16.6	50.89	-	-	-	-	0-360	199	H
3	17.505	27.69	Pk	41.2	-18.2	50.69	-	-	-	-	0-360	200	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 Pk – Peak detector
 PK2 - KDB558074 Method: Maximum Peak
 MAv1 - KDB558074 Option 1 Maximum RMS Average