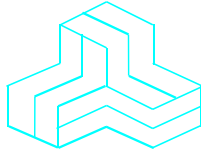


ENGINEERING TEST REPORT



Sub-1GHz Narrowband Transceiver

Model: NRWRANGEX

FCC ID: 2AFYY-NRWRANGEX

Applicant:

Embedded Sense Inc
5502 Timberlea Blvd.
Mississauga, ON L4W 2T7

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.249
Operating in the Frequency Band 902 – 928 MHz

UltraTech's File No.: 17EMSI056_FCC15249

This Test report is Issued under the Authority of
Tri M. Luu
Vice President of Engineering
UltraTech Group of Labs

Date: November 27, 2017

Report Prepared by: Santhosh Fernandez

Tested by: Mr. Hung Trinh

Issued Date: November 27, 2017

Test Dates: December 4-7, 2016

- The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.
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Website: www.ultratech-labs.com, Email: vic@ultratech-labs.com, Email: tri@ultratech-labs.com



1309



46390-2049



AT-1945



SL2-IN-E-
1119R



Korea
KCC-RRR

CA2049

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.249
Title:	Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15 – Radio Frequency Devices
Purpose of Test:	Equipment Certification for Low Power Licensed-Exempt Transmitters operating in the Frequency Band 902-928 MHz.
Test Procedures:	▪ ANSI C63.4 ▪ ANSI C63.10
Environmental Classification:	[x] Commercial, industrial or business environment [x] Residential environment

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2017	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz
ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
CISPR 22	2008-09,Ed 6	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
CISPR 16-1-1 +A1 +A2	2006 2006 2007	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-1-2 +A1 +A2	2003 2004 2006	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances

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File #: 17EMSI056_FCC15249

November 27, 2017

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Embedded Sense Inc
Address:	5155 Spectrum Way Mississauga, ON L4W 5A1 CANADA
Contact Person:	Mr. Frank Gerlach Phone #: 905-282-1750 Fax #: 905-282-9691 Email Address: fgerlach@embeddedsense.com

MANUFACTURER	
Name:	Embedded Sense Inc.
Address:	5155 Spectrum Way Mississauga, ON L4W 5A1 CANADA
Contact Person:	Mr. Frank Gerlach Phone #: 905-282-1750 Fax #: 905-282-9691 Email Address: fgerlach@embeddedsense.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Product Name:	Sub-1GHz Narrowband Transceiver
Model Name or Number:	NRWRANGEX
Serial Number:	Test Sample
Type of Equipment:	Low Power Communication Device Transmitter
Input Power Supply:	3.0 V DC
Primary User Functions of EUT:	narrow band transceiver

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	• Mobile • Fixed
Intended Operating Environment:	▪ Commercial, industrial or business environment ▪ Residential environment
Power Supply Requirement:	3.0 VDC
RF Output Power Rating:	92.99 dBµV/m Peak at 3m distance
Operating Frequency Range:	903.00 to 927.00 MHz
20 dB Bandwidth:	21.55 KHz
RF Output Impedance:	50 Ohm
Modulation Type:	2-FSK
Antenna Connector Type:	Integral PCB Antenna

RECEIVER	
Power Supply Requirement:	3.0 VDC
Operating Frequency Range:	903.00-927.00MHz
RF Input Impedance:	50 Ohm
Oscillator Frequency(ies):	26MHz

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Antenna Type	Maximum Gain (dBi)
Integral PCB Antenna	0.0

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
No I/O port.				

2.6. ANCILLARY EQUIPMENT

The EUT is a split module RF transceiver, the RF circuitry portion of the module. For the controller portion, the EUT was interfaced with a proprietary controller board, an Occupancy Sensor V4A, which is one of the intended controllers to be used in deployment.

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 °C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3.0 V DC

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements.
Special Test Software:	Special software provided by the Applicant to operate the EUT at each channel frequency continuously. For example, the transmitter will be operated at each of the lowest, middle and highest frequencies individually continuously during testing.
Special Hardware Used:	For the controller portion, the EUT was interface with a proprietary controller board, an Occupancy Sensor V4A.
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	903.00 - 927.00 MHz
Frequency(ies) Tested:	903 MHz, 915 MHz and 927 MHz
RF Power Output:	92.99 dBµV/m Peak at 3m distance
Normal Test Modulation:	2-FSK
Modulating Signal Source:	Internal

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes
15.207(a)	Power Line Conducted Emissions	Yes
15.215(c)	20 dB Bandwidth	Yes
15.249(a), 15.209, 15.205	Transmitter Radiated Emissions, Harmonic Emissions	Yes

* The EUT complies with the requirement; it employs an integral antenna.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

EXHIBIT 5. TEST DATA

5.1. POWERLINE CONDUCTED Emissions @ FCC PART 15, SUBPART B, PARA.15.107(A)

5.1.1. Limits

The equipment shall meet the limits of the following table:

Test Frequency Range (MHz)	CLASS B LIMITS		Measuring Bandwidth
	Quasi-Peak (dB μ V)	Average* (dB μ V)	
0.15 to 0.5	66 to 56*	56 to 46*	RBW = 9 kHz VBW $\geq$ 9 kHz for QP VBW = 10 Hz for Average
0.5 to 5	56	46	RBW = 9 kHz VBW $\geq$ 9 kHz for QP VBW = 10 Hz for Average
5 to 30	60	50	RBW = 9 kHz VBW $\geq$ 9 kHz for QP VBW = 10 Hz for Average

* Decreasing linearly with logarithm of frequency

5.1.2. Method of Measurements

Refer to Ultratech Test Procedures ULTR-P001-2004 & ANSI C63.4 for method of measurements.

Calculation of Conducted Emission Voltage (dB μ V):

This is calculated by adding the L.I.S.N factor, Cable loss factor, and Attenuator factor to the measured reading. The basic equation with a sample calculation is as follows:

$$\text{Voltage (dB}\mu\text{V)} = \text{RA} + \text{AF} + \text{CF} + \text{LF}$$

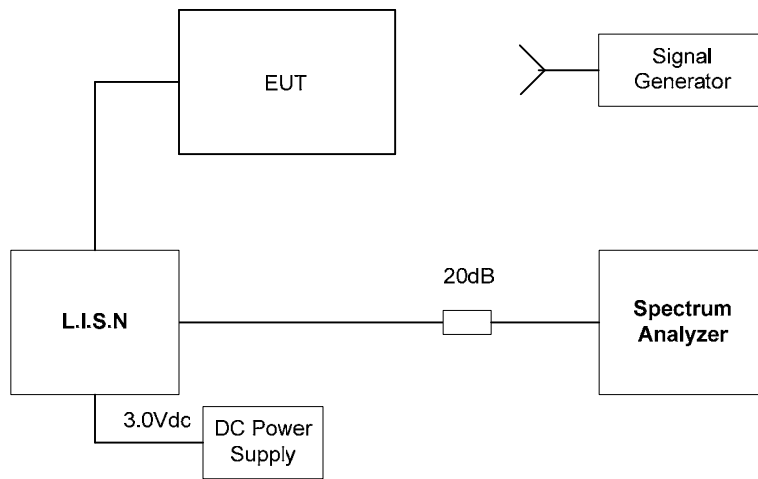
Where

RA	=	Receiver/Analyzer Reading in dB μ V
AF	=	Attenuation Factor in dB
CF	=	Cable loss Factor in dB
LF	=	L.I.S.N Factor in dB

5.1.3. Test Instruments

Refer to Exhibit 6 for Test Instruments & Measurement Uncertainty

5.1.4. Test Arrangement



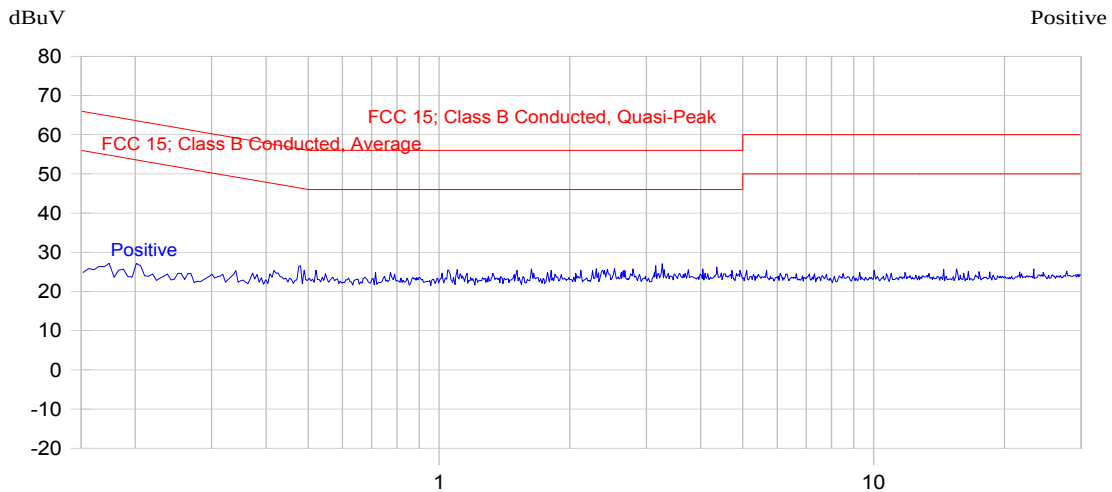
5.1.5. Test Equipment list

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Agilent	E7401A	US40240432	9 kHz–1.5 GHz	Apr 14, 2017
Attenuator	Pasternack	PE7010-20	7	DC–2 GHz	Mar 26, 2017
L.I.S.N	Schwarzbeck	NSLK8127	8127276	0.10 -30 MHz	Jun 24, 2017
Signal Generator	Hewlett Packard	8648C	3443U00391	100 kHz – 3200 MHz	2 Feb 2017
DC Power Supply	Xantrex	HPD 60-5SX	63903	0-60 VDC	-

5.1.6. Test Results

The emissions were scanned from 150 kHz to 30 MHz at AC mains Terminal via a LISN, and all emissions less than 20 dB below the limits were recorded.

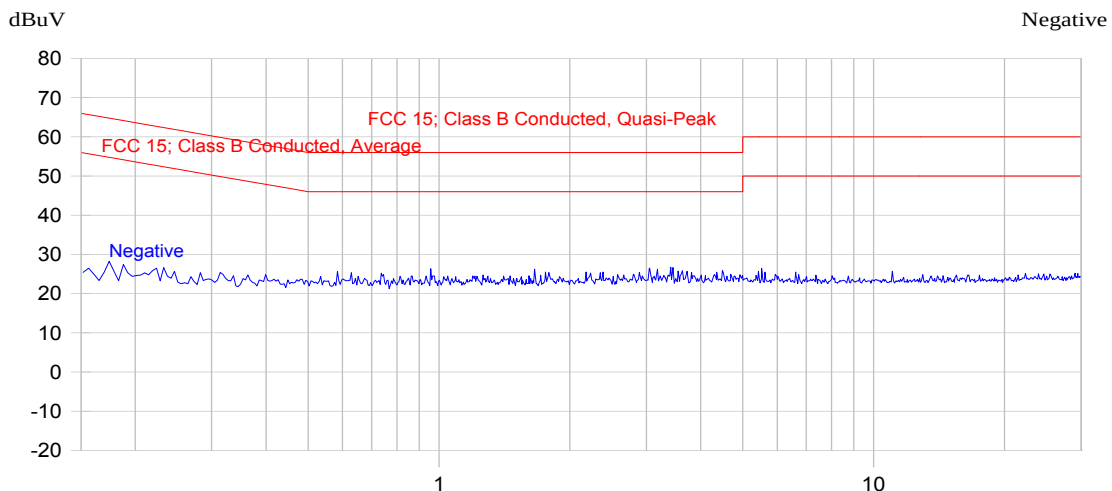
3V Dc Positive Line-Tx



12/7/2016 9:29:34 AM (Start = 0.15, Stop = 30.00) MHz

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.206	37.4	33.2	-30.1	27.9	-25.5	Positive
0.471	35.0	29.6	-26.9	23.9	-22.6	Positive
1.628	35.0	29.2	-26.8	23.8	-22.2	Positive

3V Dc Negative Line-Tx



12/7/2016 9:21:42 AM (Start = 0.15, Stop = 30.00) MHz

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.164	37.7	32.4	-32.8	26.6	-28.6	Negative
0.185	38.6	32.8	-31.5	27.4	-26.8	Negative
0.961	34.2	29.3	-26.7	23.7	-22.3	Negative

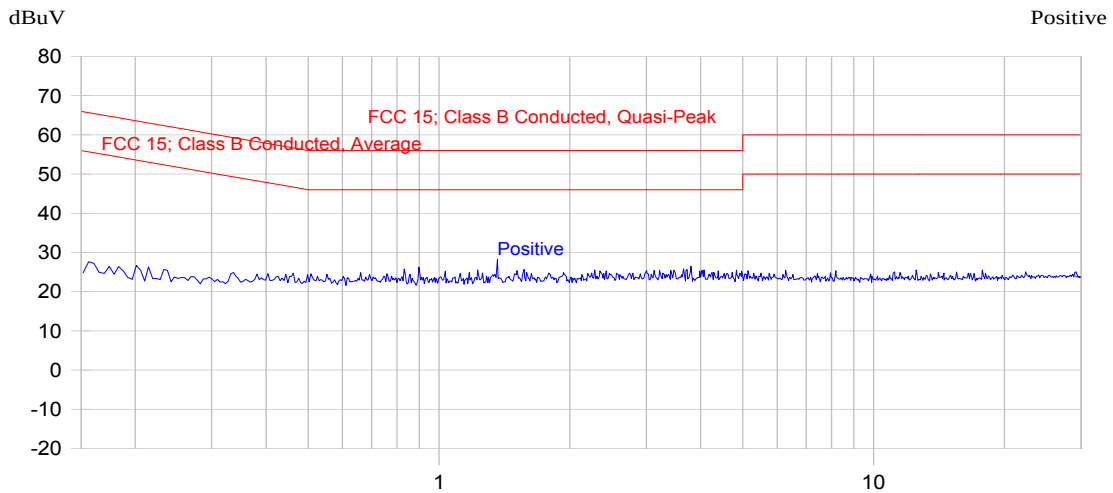
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3V Dc Positive Line-Rx

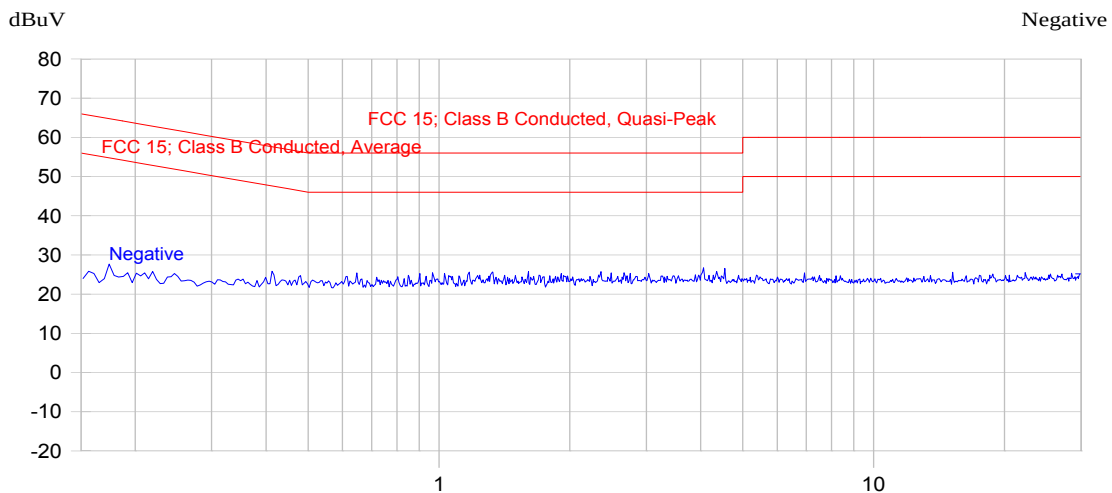


12/7/2016 9:38:14 AM

(Start = 0.15, Stop = 30.00) MHz

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
1.362	28.3	--	-27.7	--	-17.7	Positive

3V Dc Negative Line -Rx



12/7/2016 9:43:49 AM

(Start = 0.15, Stop = 30.00) MHz

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.173	38.7	34.5	-30.3	29.5	-25.3	Negative
0.411	34.3	29.4	-28.3	23.8	-23.8	Negative

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5.2. OCCUPIED BANDWIDTH [§15.215(c)]

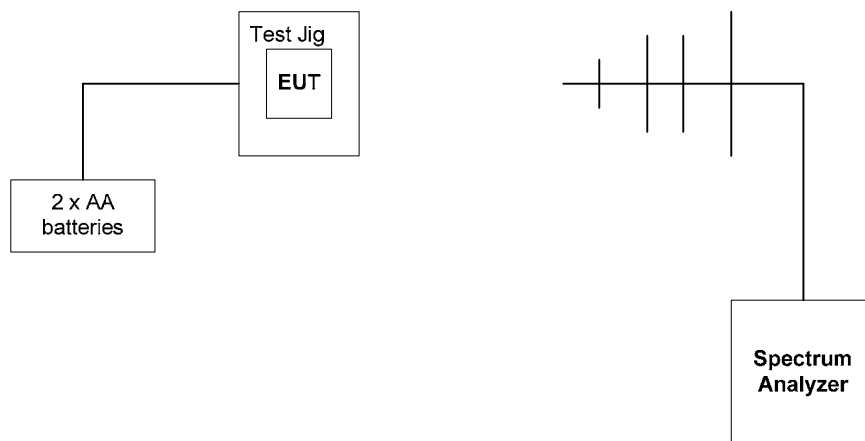
5.2.1. Limit(s)

The fundamental emission must be in the authorized bandwidth.

5.2.2. Method of Measurements

ANSI C63.10

5.2.3. Test Arrangement



5.2.4. Test Equipment list

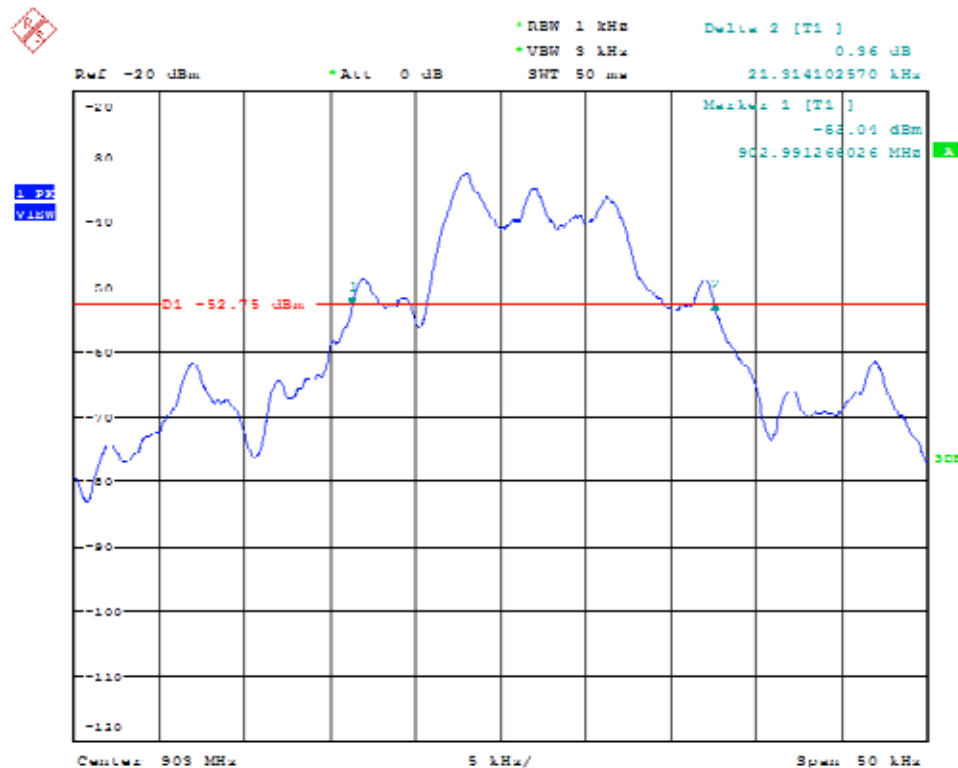
Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 21, 2018
Log Periodic	ETS-Lindgren	3148	23845	200 – 2000 MHz	Jul 20, 2018

5.2.5. Test Data

Frequency (MHz)	20 dB Bandwidth (kHz)
903	21.31
915	21.63
927	21.39

See the following plots for detailed measurements.

Plot 5.2.5.1. 20 dB Bandwidth, 903 MHz



Date: 2.FEB.2017 14:13:02

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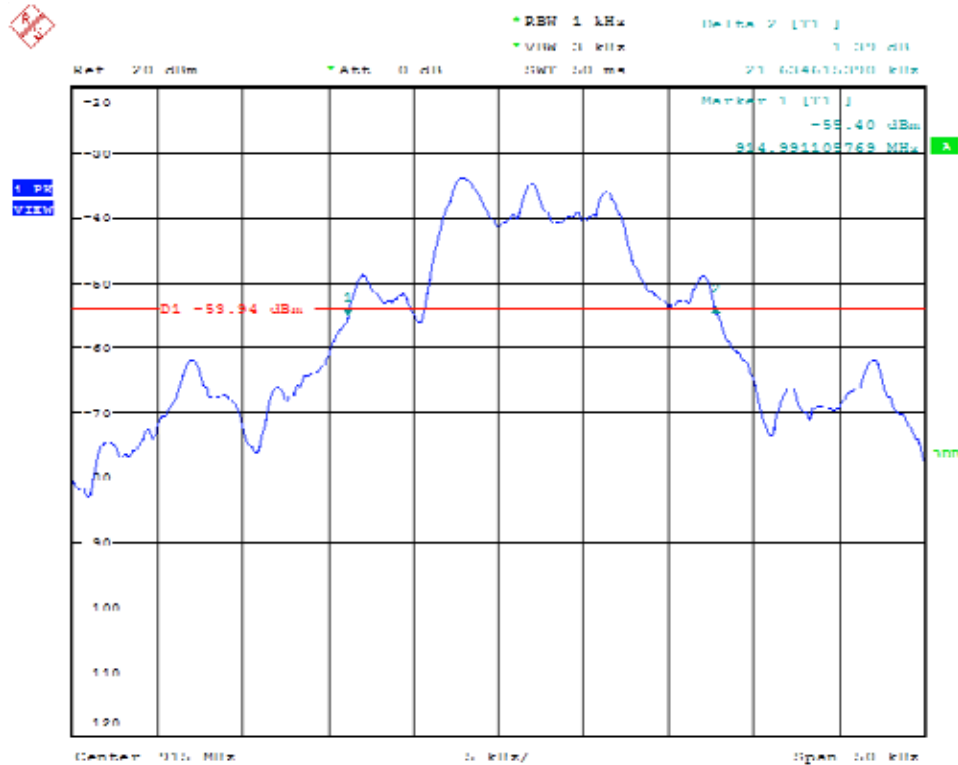
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

File #: 17EMSI056_FCC15249

November 27, 2017

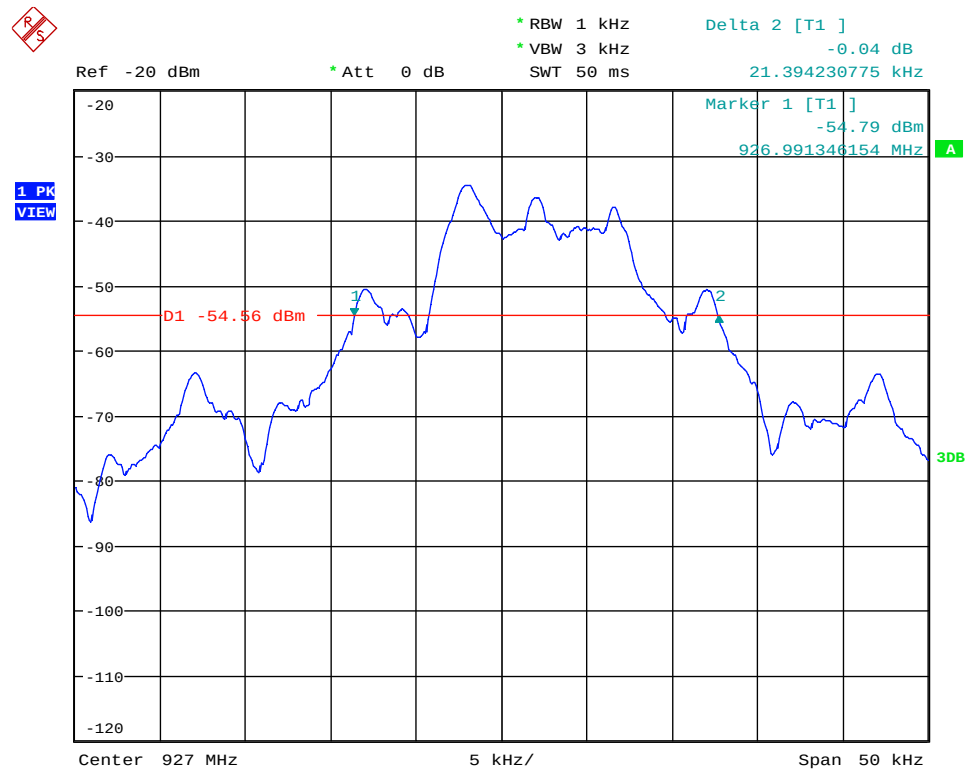
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.2.5.2. 20 dB Bandwidth, 915 MHz



Date: 2.FEB.2017 14:40:40

Plot 5.2.5.3. 20 dB Bandwidth, 927 MHz



Date: 2.FEB.2017 14:47:15

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File #: 17EMSI056_FCC15249

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All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.3. FUNDAMENTAL FIELD STRENGTH AND HARMONIC EMISSIONS (RADIATED at 3m) [47 CFR §§ 15.249(a), 15.209 & 15.205]

5.3.1. Limit(s)

(a) The Field Strength of emissions from intentional radiators operated within 902–928 MHz band shall comply with the following:

Fundamental Frequency	Field Strength of Fundamental (mV/m)	Field Strength of Harmonics (µV/m)
902–928 MHz	50	500

(c) Field strength limits specified at a distance of 3 meters.

(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For point-to-point operation under paragraph (b) of this section, the peak field strength shall not exceed 2500 millivolts/meter at 3 meters along the antenna azimuth.

- The fundamental frequency shall not fall within any restricted frequency band specified in 15.205. All other emissions that fall in the restricted bands shall not exceed the general radiated emission limits specified in 15.209(a).

47 CFR 15.205 – Restricted Bands of Operation

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
¹ 0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	(2)
13.36–13.41.			

¹Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.

²Above 38.6

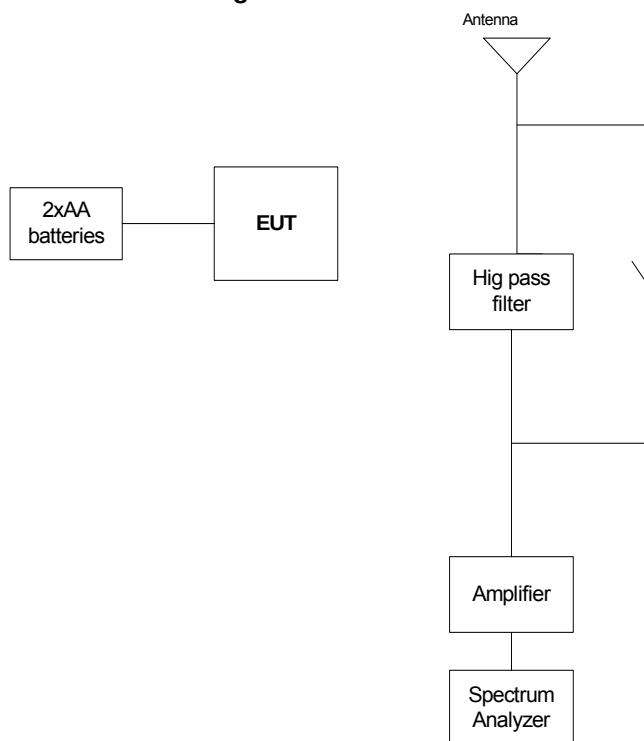
47 CFR 15.209(a) - Field Strength Limits within Restricted Frequency Bands		
Frequency (MHz)	Field Strength Limits ($\mu\text{V/m}$)	Distance (Meters)
0.009 - 0.490	2,400 / F (KHz)	300
0.490 - 1.705	24,000 / F (KHz)	30
1.705 - 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

5.3.2. Method of Measurements

ANSI C63.10 and ANSI C63.4 for measurement methods.

5.3.3. Spurious Radiated Emissions

5.3.3.1. Test Arrangement



5.3.3.2. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	May 8, 2017
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 21, 2018
RF Amplifier	Com-Power	PAM-0118A	551016	0.5 – 18 GHz	Jul 17, 2017
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	May 5, 2017
Biconilog	Emco	3142	9601-1005	26-1000 MHz	May 12, 2018
Horn Antenna	Emco	3155	5955	1 – 18 GHz	Apr 21, 2017
High Pass Filter	K & L	11SH10-1500/T8000	2	Cut off 900 MHz	Cal on use

Remark(s):

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions @ 3m distance.
- The following test results are the worst-case measurements.

5.3.3.3. Test Data

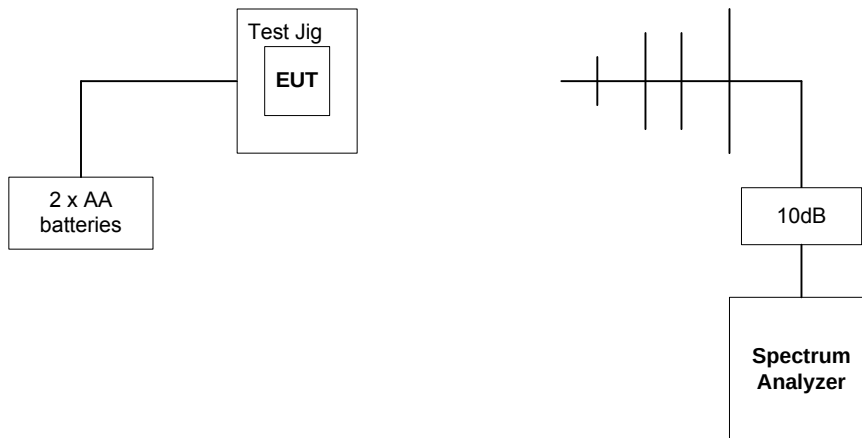
Fundamental Frequency:		903 MHz					
Frequency Test Range:		30 MHz – 10 GHz					
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit of Fundamental / Harmonics (dBµV/m)	Limit 15.209 (dBµV/m)	Margin (dB)	Pass/Fail
903	92.99	--	H	94.0	--	-1.01	PASS
903	92.06	--	V	94.0	--	-1.94	PASS
1806	45.82	33.59	H	54.00	54.00	-8.18	PASS
1806	46.78	32.35	V	54.00	54.00	-7.22	PASS
3612	47.38	36.62	H	54.00	54.00	-6.62	PASS
3612	46.78	35.14	V	54.00	54.00	-7.22	PASS
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

Fundamental Frequency:		915 MHz					
Frequency Test Range:		30 MHz – 10 GHz					
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit of Fundamental / Harmonics (dBµV/m)	Limit 15.209 (dBµV/m)	Margin (dB)	Pass/Fail
915	91.34		V	94.00	--	-2.66	PASS
915	90.54		H	94.00	--	-3.46	PASS
1830	45.27	33.47	V	54.00	54.00	-8.73	PASS
1830	44.69	31.67	H	54.00	54.00	-9.31	PASS
3660	47.87	36.06	V	54.00	54.00	-6.13	PASS
3660	46.91	35.50	H	54.00	54.00	-7.09	PASS
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

Fundamental Frequency:		927 MHz					
Frequency Test Range:		30 MHz – 10 GHz					
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit of Fundamental / Harmonics (dBµV/m)	Limit 15.209 (dBµV/m)	Margin (dB)	Pass/Fail
927	91.33		V	94.00	--	-2.67	PASS
927	90.45		H	94.00	--	-3.55	PASS
1854	46.08	32.37	V	54.00	54.00	-7.92	PASS
1854	43.33	31.74	H	54.00	54.00	-10.67	PASS
3708	47.20	35.28	V	54.00	54.00	-6.8	PASS
3708	47.66	33.7	H	54.00	54.00	-6.34	PASS
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

5.3.4. Band edge Emissions

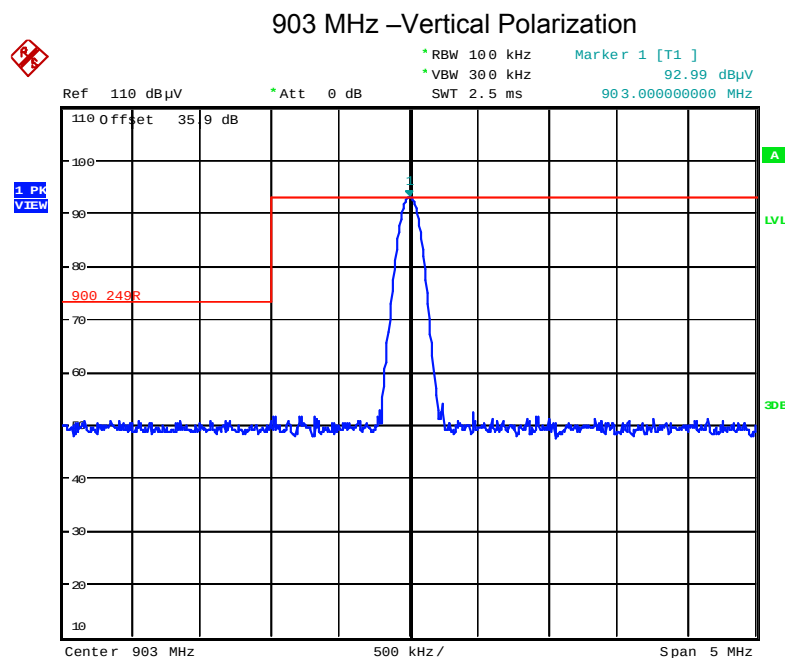
5.3.4.1. Test Arrangement



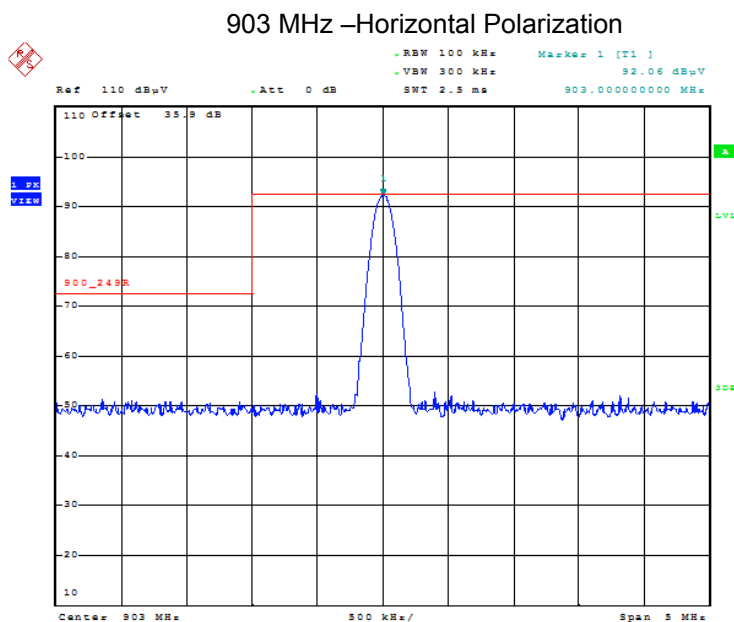
5.3.5. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 21, 2018
Attenuator	Pasternack	PE7024-10	4	DC–26.5 GHz	Cal on use
Log Periodic	ETS-Lindgren	3148	23845	200 – 2000 MHz	Jul 20, 2018

5.3.5.1. Test Data



Date: 4.DEC.2016 06:03:35



Date: 4.DEC.2016 05:40:46

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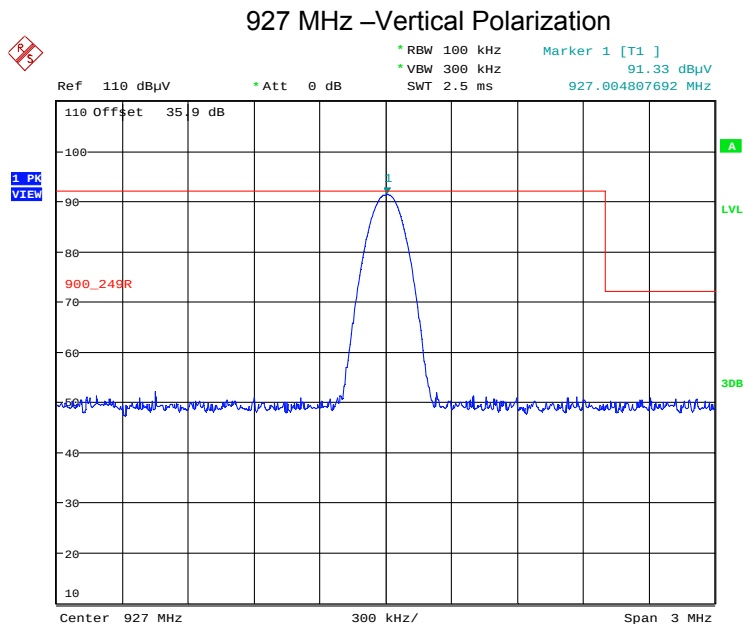
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4

Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

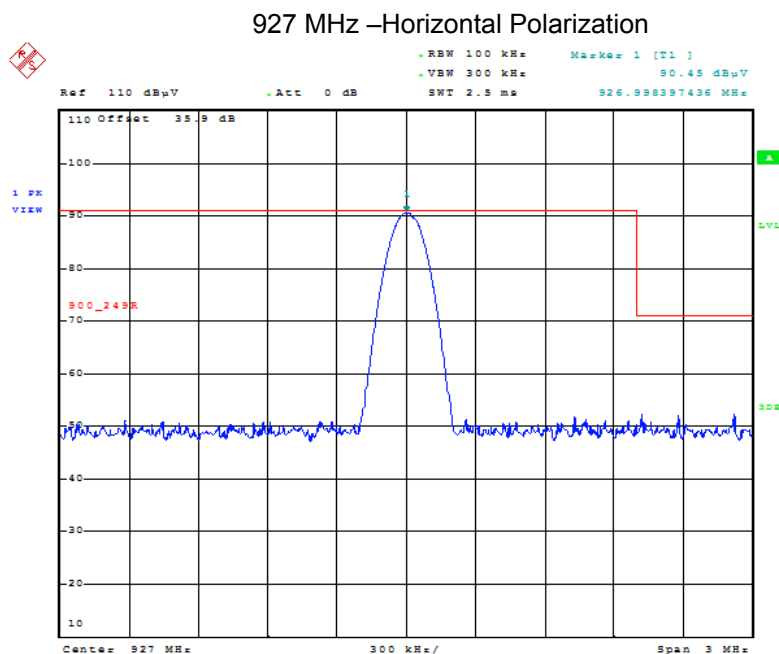
File #: 17EMSI056_FCC15249

November 27, 2017

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)



Date: 4.DEC.2016 06:27:22



Date: 4.DEC.2016 06:22:12

ULTRATECH GROUP OF LABS

3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4

Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

File #: 17EMSI056_FCC15249

November 27, 2017

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

EXHIBIT 6. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

6.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.39	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.79	± 5.2

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.39	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.78	± 5.2

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.87	Under consideration
U	Expanded uncertainty U: $U = 2u_c(y)$	± 3.75	Under consideration