Company: Tehama Wireless

Test of: TW-191-R Diversity Repeater

To: FCC CFR 47 Part 15 Subpart C 15.247 (DTS)

Report No.: TEHA05-U2 Rev A Radiated

RADIATED TEST REPORT

RADIATED TEST REPORT

FROM

MiCOM Labs
opening wireless markets

Test of: Tehama Wireless TW-191-R Diversity Repeater

to

To: FCC CFR 47 Part 15 Subpart C 15.247 (DTS)

Test Report Serial No.: TEHA05-U2 Rev A Radiated

This report supersedes: None

Applicant:	Tehama Wireless 2607 7th St. Suite G Berkeley California 94710 United States
Product Function:	Wireless signal repeater
Issue Date:	1st May 2015

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.
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Pleasanton California 94566
USA
Phone: +1 (925) 462-0304
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A2LA ACCREDITED
TESTING CERT #2381.01

MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

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1. ACCREDITATION, LISTINGS & RECOGNITION

1.1. TESTING ACCREDITATION

MiCOM Labs, Inc. is an accredited Electrical testing laboratory per the international standard ISO/IEC 17025:2005. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.01. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-01.pdf

American Association for Laboratory Accreditation

Accredited Laboratory

A2LA has accredited

MICOM LABS

Pleasanton, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 28th day of February 2014.

President & CEO
For the Accreditation Council
Certificate Number 2381.01
Valid to November 30, 2015

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

1.2. RECOGNITION

MiCOM Labs, Inc has widely recognized wireless testing capabilities. Our international recognition includes Conformity Assessment Body designation by APEC MRA countries. MiCOM Labs test reports are accepted globally.

Country	Recognition Body	Status	Phase	Identification No.
USA	Federal Communications Commission (FCC)	TCB	-	US0159 Listing #: 102167
Canada	Industry Canada (IC)	FCB	APEC MRA 2	US0159 Listing #: 4143A-2 4143A-3
Japan	MIC (Ministry of Internal Affairs and Communication)	CAB	APEC MRA 2	RCB 210
	VCCI	--	--	A-0012
Europe	European Commission	NB	EU MRA	NB 2280
Australia	Australian Communications and Media Authority (ACMA)	CAB	APEC MRA 1	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)	CAB	APEC MRA 1	
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)	CAB	APEC MRA 1	
Singapore	Infocomm Development Authority (IDA)	CAB	APEC MRA 1	
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)	CAB	APEC MRA 1	
Vietnam	Ministry of Communication (MIC)	CAB	APEC MRA 1	

EU MRA – European Union Mutual Recognition Agreement.
NB – Notified Body
APEC MRA – Asia Pacific Economic Community Mutual Recognition Agreement. Recognition agreement under which test lab is accredited to regulatory standards of the APEC member countries.

Phase I - recognition for product testing
Phase II – recognition for both product testing and certification

1.3. PRODUCT CERTIFICATION

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard ISO/IEC 17065:2012. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.02. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-02.pdf

United States of America – Telecommunication Certification Body (TCB)
Industry Canada – Certification Body, CAB Identifier – US0159
Europe – Notified Body (NB), NB Identifier - 2280
Japan – Recognized Certification Body (RCB), RCB Identifier - 210

2. DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft #1	10th March 2015	
Draft #2	22nd April 2015	
Rev A	1st May 2015	Initial Release
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In the above table the latest report revision will replace all earlier versions.

3. TEST RESULT CERTIFICATE

Manufacturer:	Tehama Wireless 2607 7th St. Suite G Berkeley California 94710, USA	**Tested By:**	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566, USA
Model:	TW-191-R	**Telephone:** **Fax:**	+1 925 462 0304 +1 925 462 0306
Type Of Equipment:	900 MHz Wireless signal repeater		
S/N's:	E2000017		
Test Date(s):	9th February – 3rd March 2015	**Website:**	www.micomlabs.com

STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 15 Subpart C 15.247 (DTS)	EQUIPMENT COMPLIES

MiCOM Labs, Inc. tested the equipment mentioned in accordance with the requirements set forth in the above standards. Test results indicate that the equipment tested is capable of demonstrating compliance with the requirements as documented within this report.

Notes:

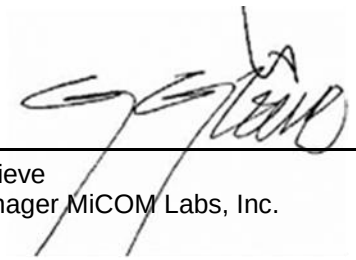
1. This document reports conditions under which testing was conducted and the results of testing performed.

2. Details of test methods used have been recorded and kept on file by the laboratory.

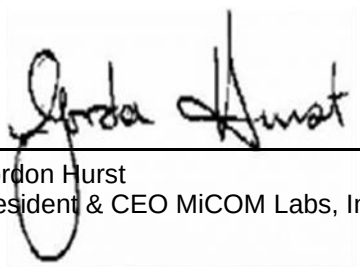
3. Test results apply only to the item(s) tested.

A2LA ACCREDITED
TESTING CERT #2381.01

Approved & Released for MiCOM Labs, Inc. by:



Graeme Grieve
Quality Manager MiCOM Labs, Inc.



Gordon Hurst
President & CEO MiCOM Labs, Inc.

4. REFERENCES AND MEASUREMENT UNCERTAINTY

4.1. Normative References

REF.	PUBLICATION	YEAR	TITLE
I	KDB 644545 D01 v01r02	Oct 31 2013	Guidance for IEEE 802.11ac Old rules.
II	662911	Oct 31 2013	Guidance for measurement of output emission of devices that employ single transmitter with multiple outputs or systems with multiple transmitters operating simultaneously in the same frequency band
III	558074 D01	June 6,2014	DTS Meas Guidance v03r02 Guidance for performing compliance measurements on Digital Transmission Systems (DTS) operating under section 15.247.
IV	558074 D02	June 5,2014	DTS Part 15.247 Old Rule. Guidance for performing compliance measurements on Digital Transmission Systems (DTS) operating under section 15.247.
V	A2LA	April 2014	Reference to A2LA Accreditation Status – A2LA Advertising Policy
VI	ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
VII	ANSI C63.4	2014	American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
VIII	CISPR 22	2008	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
IX	ETSI TR 100 028	2001-12	Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics
X	FCC 47 CFR Part 15.247	2014	CFR Title 47 Part 15.247 – Radio Frequency Devices; Subpart C – Intentional Radiators
XI	ICES-003	Issue 5 2012	Spectrum Management and Telecommunications; Interference-Causing Equipment Standard. Information Technology Equipment (ITE) – Limits and methods of measurement.
XII	M 3003	Edition 3 Nov. 2012	Expression of Uncertainty and Confidence in Measurements
XIII	RSS-210 Annex 8	2010	Radio Standards Specification 210; License-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
XIV	RSS-Gen	2010	General Requirements and Information for the Certification of Radiocommunication Equipment
XV	KDB 644545 D02 v01	June 7th 2012	Alternative Guidance for IEEE 802.11ac and pre-ac Device emissions testing, old rules.
XVI	KDB 644545 D03	August 14th 2014	Guidance for IEEE 802.11ac New Rules v01
XVII	FCC 47 CFR Part 2.1033	2014	FCC requirements and rules regarding photographs and test setup diagrams.

4.2. Test and Uncertainty Procedure

Conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, listed in the Normative References section of this report.

Measurement uncertainty figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95 % in accordance with UKAS document M 3003 listed in the Normative References section of this report.

5. PRODUCT DETAILS AND TEST CONFIGURATIONS

5.1. Technical Details

Details	Description
Purpose:	Test of the Tehama Wireless TW221 to FCC CFR 47 Part 15 Subpart C 15.247 (DTS) and IC RSS-210 Annex 8
Applicant:	Tehama Wireless 2607 7th St. Suite G Berkeley California 94710 USA
Manufacturer:	As Applicant
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court, Pleasanton, California 94566 USA
Test report reference number:	TEHA05-U2
Date EUT received:	6th February 2015
Standard(s) applied:	FCC CFR 47 Part 15 Subpart C 15.247 (DTS)
Dates of test (from - to):	9th to 10th February 2015
No of Units Tested:	1
Type of Equipment:	900 MHz Wireless signal repeater
Product Trade Name:	Tehama Wireless Design Group
Model(s):	TW-191-R
Location for use:	Indoor
Declared Frequency Range(s):	902 - 928 MHz;
Hardware Rev	TW-221-FAB-V3
Software Rev	3277M
Type of Modulation:	GFSK
EUT Modes of Operation:	FHSS: 902 - 928 MHz:
Declared Nominal Output Power (Ave):	+20.00 dBm
Transmit/Receive Operation:	Transceiver - Simplex
System Beam Forming:	This device has no beam-forming capability
Rated Input Voltage and Current:	AC/ DC adaptor (adaptor sold with unit) Input: AC 120/240V 50-60 Hz Output: 12Vdc, 450 mA
Operating Temperature Range:	Declared Range 0°C to 50°C
ITU Emission Designator:	173KF1D
Equipment Dimensions:	127mm x 127mm x 49mm / 5.0" x 5.0" x 1.9" (W x D x H)
Weight:	0.213 kg
Primary function of equipment:	Wireless signal repeater
Secondary function of equipment:	None provided

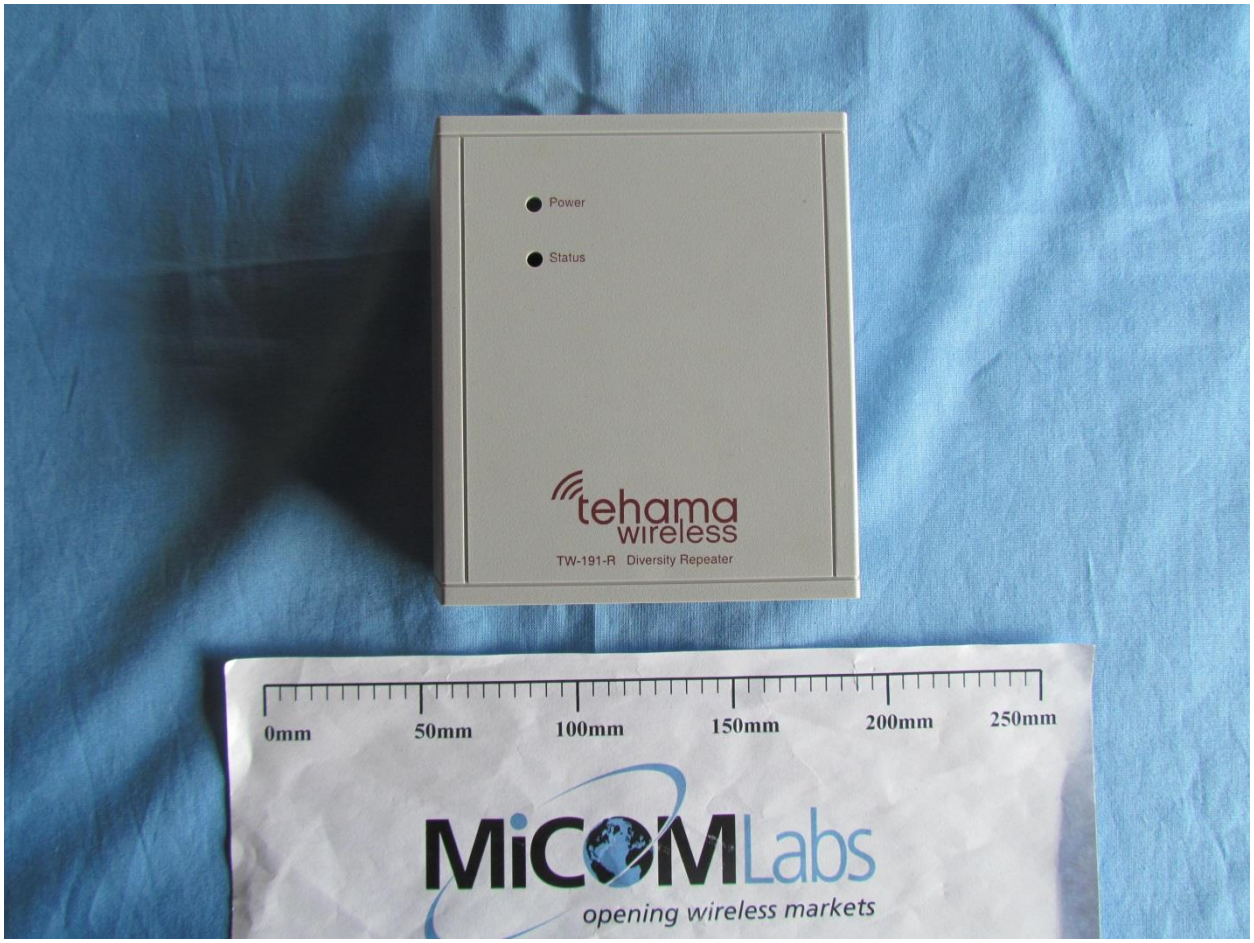
5.2. Scope Of Test Program

Tehama Wireless TW-191-R Diversity Repeater

The scope of the test program was to test the Tehama Wireless TW221 FHSS Diversity Repeater in the frequency range 902 - 928 MHz; for compliance against FCC CFR 47 Part 15 Subpart C 15.247 (DTS) specifications.

FCC CFR 47 Part 15 Subpart C 15.247 (DTS)

Tehama Wireless TW-191-R Diversity Repeater



Front Face

5.3. Equipment Model(s) and Serial Number(s)

Type (EUT/ Support)	Equipment Description (Including Brand Name)	Mfr	Model No.	Serial No.
EUT	900 MHz Wireless signal repeater	Tehama	TW221	E2000017
Support	Laptop PC	IBM	Thinkpad	None

5.4. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
Integral #1	Tehama Wireless	PCB	PCB	2.5	-	360	-	902 - 928
Integral #2	Tehama Wireless	PCB	PCB	2.5	-	360	-	902 - 928

BF Gain - Beamforming Gain
Dir BW - Directional BeamWidth
X-Pole – Cross Polarization

5.5. Cabling and I/O Ports

Number and type of I/O ports

1. Audio stereo jack 3.5mm (3 pins UART), 1m length cable
2. 6 Vdc jack connector, maximum 3m length cable

5.6. Test Configurations

Testing was performed to determine the highest power level versus bit rate. The variant with the highest power was used to exercise the product.

Operational Mode(s) (802.11a/b/g/n/ac)	Data Rate with Highest Power MBit/s	Channel Frequency (MHz)		
		Low	Mid	High
902 - 928 MHz				
FHSS	25 KBit/s	903.00	914.90	926.00

Results for the above configurations are provided in this report

5.7. Equipment Modifications

The following modifications were required to bring the equipment into compliance:
1. NONE

5.8. Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:
1. NONE

6. TEST SUMMARY

List of Measurements

Test Header	Result	Data Link
(i) 15.205 Restricted Band Emissions	Not Tested	-
(ii) 15.205 Restricted Band-Edge Emissions	Not Tested	-
15.247(d) Emissions	-	-
(2) Radiated Emissions	Complies	-
(3) 15.209 Digital Emissions (0.03 - 1 GHz)	Complies	View Data

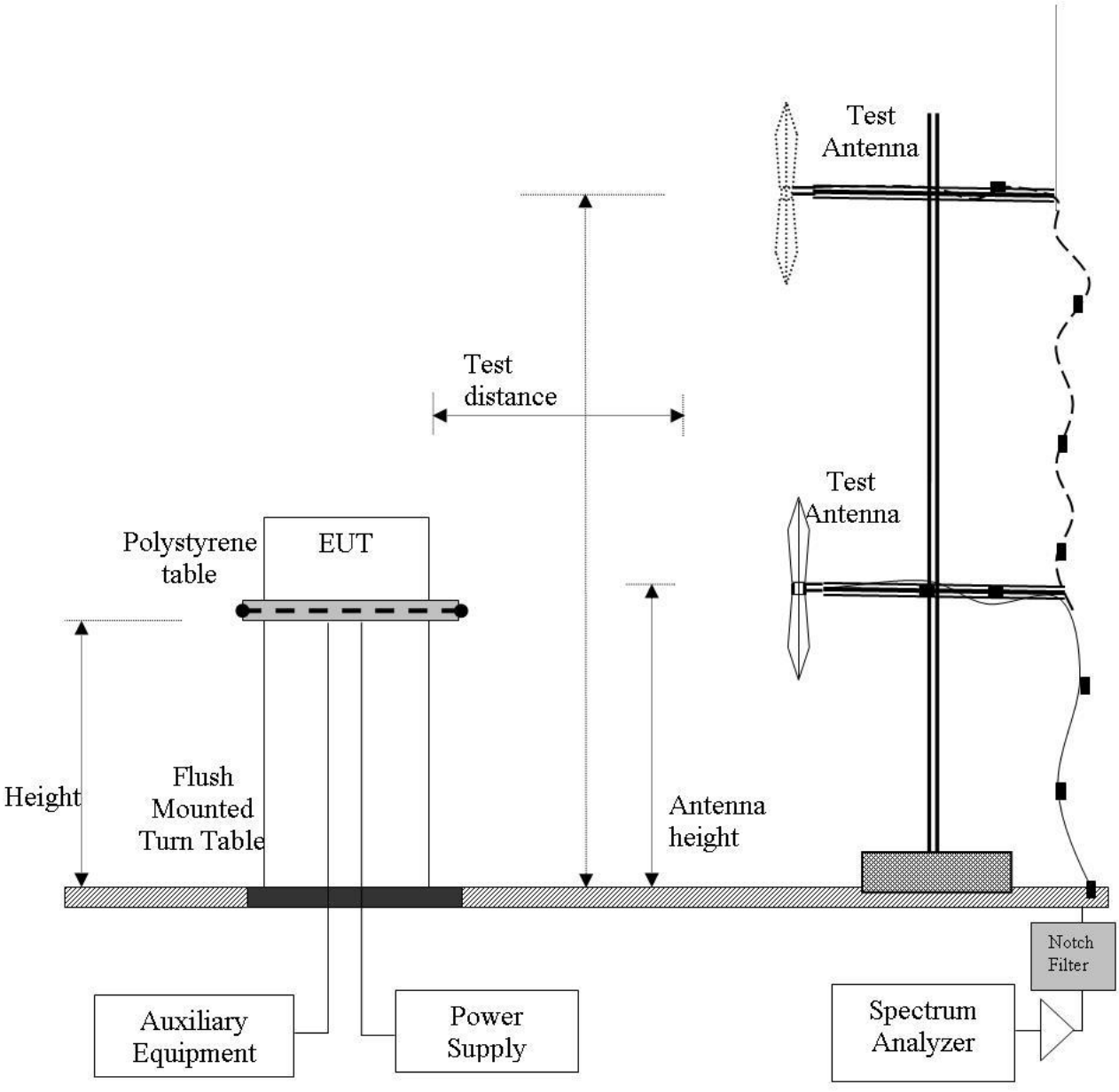
7. TEST EQUIPMENT CONFIGURATION(S)

Radiated

The following tests were performed using the Radiated test set-up shown in the diagram below.

1. Transmitter Radiated Spurious Emissions (above 1 GHz);
2. Transmitter Radiated Spurious Emissions (below 1 GHz);
3. Digital Emissions (below 1 GHz);

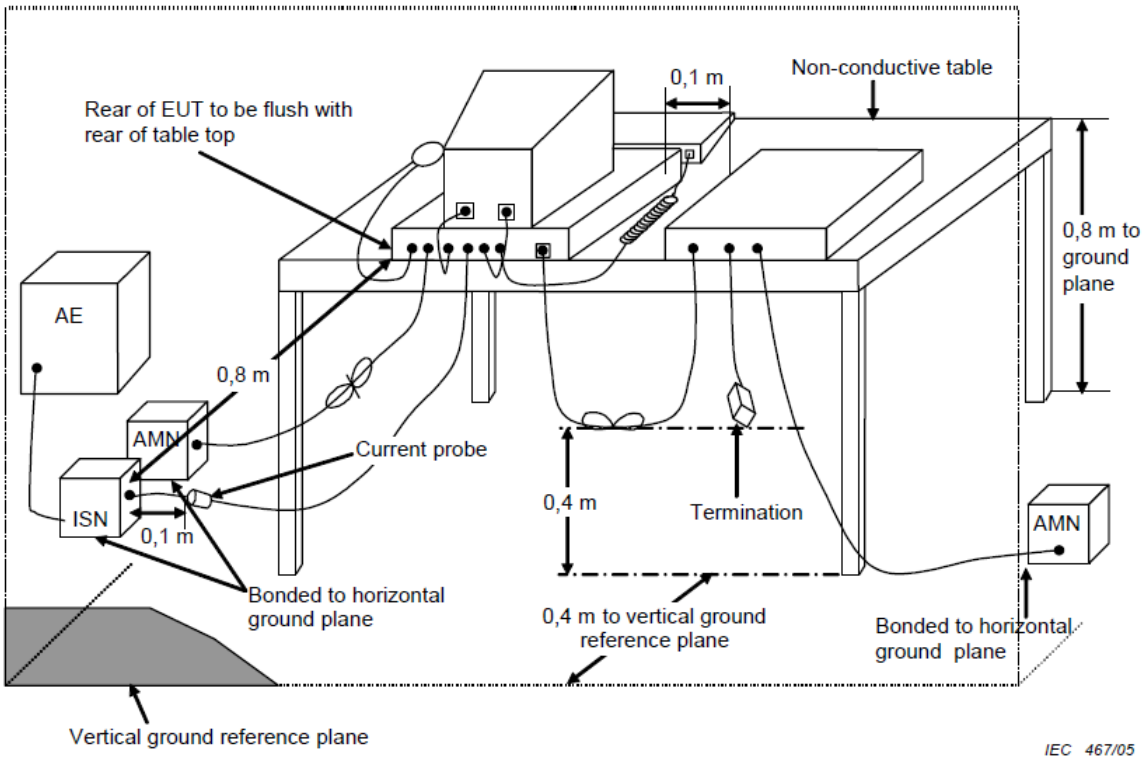
Test Measurement Set up



Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
158	Barometer/ Thermometer	Control Co.	4196	E2846	6 Dec '15
287	EMI Receiver	Rhode & Schwarz	ESIB40	100201	31 Jul 15
310	SMA Cable	Micro-Coax	UFA210A-0-0787-3G03G0	209089-001	N/A
312	SMA Cable	Micro-Coax	UFA210A-1-1181-3G0300	209092-001	N/A
338	30 - 3000 MHz Antenna	Sunol	JB3	A052907	14 Aug '15
393	Low Pass Filter 1050MHz	Minicircuits	WLFX-1050		N/A
396	Notch Filter 2.4G	Microtronics	BRM50701		N/A
397	Preamp 10-2500 MHz	MiCOM Labs		0397	23 Oct '15
399	Horn Antenna 1-18G	ETS	3117	00154575	10 Oct '15
406	Preamp 1-18 GHz	MiCOM Labs		0406	30 May '15
411	Mast/Turntable Control	Sunol Sciences	SC98V	060199-1D	N/A
413	Mast Controller	Sunol Sciences	TWR95-4	030801-3	N/A
415	Turntable Controller	Sunol Sciences		0415	N/A
416	Gigabit Ethernet Filter	ETS	260366	0416	N/A
502	EMC Test Software	EMISoft	Vasona	5.0051	N/A

AC Wireline Conducted

The following tests were performed using the AC Wireline Conducted test set-up shown in the diagram below.



Measurement set up for Conducted Disturbance at Mains Terminals

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
158	Barometer/ Thermometer	Control Co.	4196	E2846	6 Dec '15
190	LISN (two-line V-network)	Rhode & Schwarz	ESH3Z5	836679/006	12 Sep 2015
193	Receiver 20 Hz to 7 GHz	Rhode & Schwarz	ESI 7	838496/007	14 Jan 2016
307	BNC Cable	Megaphase	1689 1GVT4	15F50B002	N/A
502	EMC Test Software	EMISoft	Vasona	5.0051	N/A

8. TEST RESULTS

8.1. Emissions

8.1.1. Radiated Emissions

FCC, Part 15 Subpart C §15.247(d) 15.205; 15.209
Industry Canada RSS-210 §A8.5, §2.2, §2.6
Industry Canada RSS-Gen §4.7

Test Procedure

Radiated emissions above 1 GHz are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarities. The emissions are recorded and maximized as a function of azimuth by rotation through 360° with a spectrum analyzer in peak hold mode. Depending on the frequency band spanned a notch filter and waveguide filter was used to remove the fundamental frequency. The highest emissions relative to the limit are listed for each frequency spanned.

All measurements on any frequency or frequencies over 1 MHz are based on the use of measurement instrumentation employing an average detector function. All measurements above 1 GHz were performed using a minimum resolution bandwidth of 1 MHz.

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data.

FS = R + AF + CORR - FO

where: FS = Field Strength
R = Measured Spectrum analyzer Input Amplitude
AF = Antenna Factor
CORR = Correction Factor = CL – AG + NFL
CL = Cable Loss
AG = Amplifier Gain
FO = Distance Falloff Factor
NFL = Notch Filter Loss or Waveguide Loss

For example:
Given receiver input reading of 51.5 dBμV; Antenna Factor of 8.5 dB; Cable Loss of 1.3 dB; Falloff Factor of 0 dB, an Amplifier Gain of 26 dB and Notch Filter Loss of 1 dB. The Field Strength of the measured emission is:

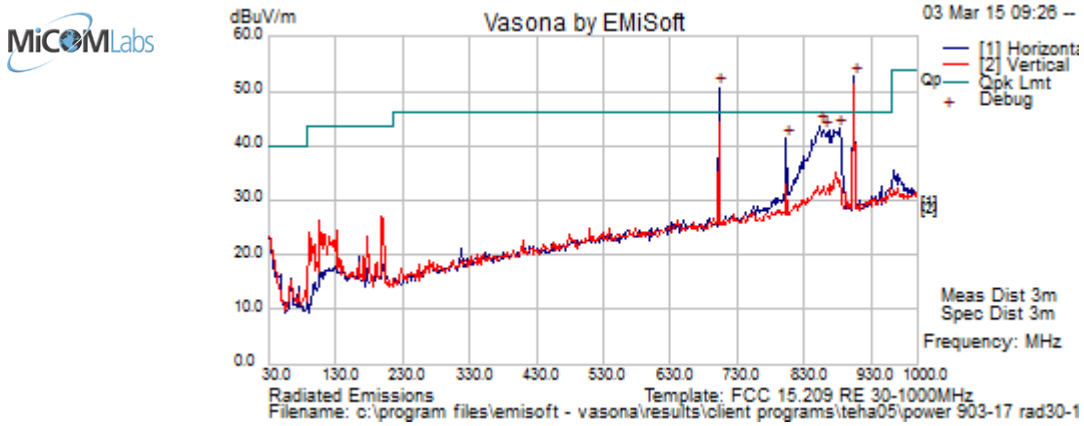
FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3 dBμV/m

Conversion between dBμV/m (or dBμV) and μV/m (or μV) are done as:
Level (dBμV/m) = 20 * Log (level (μV/m))
40 dBμV/m = 100 μV/m
48 dBμV/m = 250 μV/m

Client declared Time Averaged Duty Cycle Correction Factor (DCCF)
Maximum transmit time within 100mS period
Transmit Time: 23.68mS
Correction Factor: 20 * Log (23.68/100) = -12.51 dB
Corrected Value = Measured Value (dB) – 12.51 (dB)
Level (dBµV/m) = Raw + Cable Loss + AF + Correction Factor

8.1.1.1. Radiated Spurious < 1 G

Test Freq.	903 MHz CH 0	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	14.5
Freq. Range	30 - 1000 MHz	**Rel. Hum.(%)**	45
Power Setting	Min (5)	**Press. (mBars)**	1005
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		

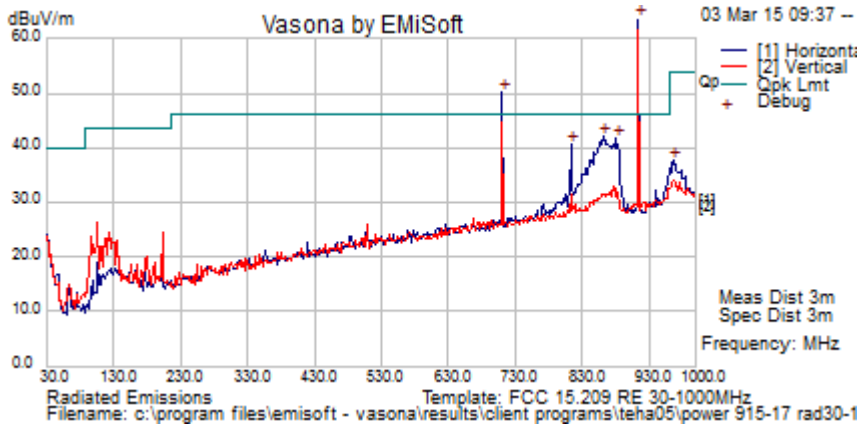


Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
904.749	53.9	6.3	-7.5	52.8	Peak [Scan]	H						FUND
702.58517	54.6	5.9	-9.9	50.6	Peak [Scan]	H						NRB
854.208	45.6	6.2	-8.1	43.7	Peak [Scan]	H						NRB
883.086	44.6	6.3	-8.0	42.9	Peak [Scan]	H						NRB
860.340	44.5	6.2	-8.1	42.6	Peak [Scan]	H						NRB
803.667	44.0	6.1	-8.8	41.3	Peak [Scan]	H						NRB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	NRB = Non-Restricted Band. Limit = 68.23 dBuV/m; RB = Restricted Band. Limits per 15.205

Test Freq.	915 MHz CH 30	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	14.5
Freq. Range	30 - 1000 MHz	**Rel. Hum.(%)**	45
Power Setting	Min (5)	**Press. (mBars)**	1005
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		

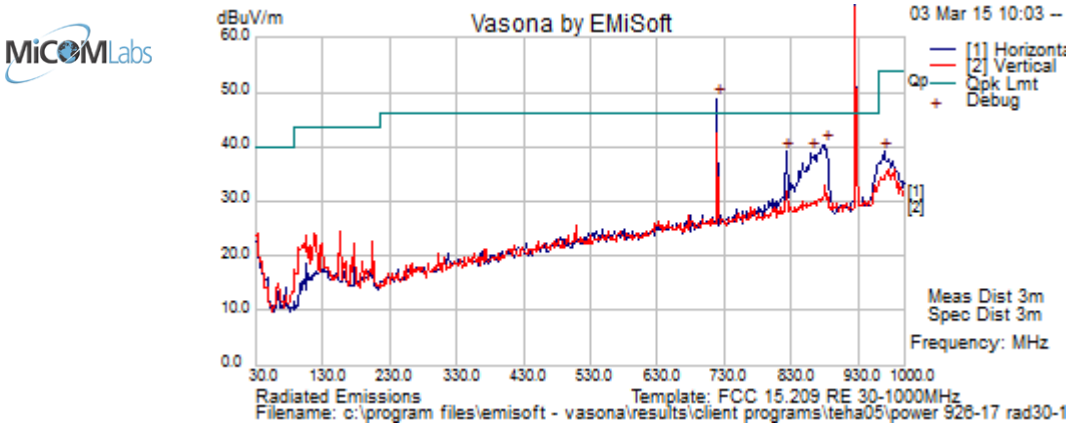


Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
914.469	64.7	6.4	-7.6	63.5	Peak [Scan]	H						FUND
710.360721	54.0	5.9	-9.7	50.2	Peak [Scan]	H						NRB
861.984	43.8	6.3	-8.1	42.0	Peak [Scan]	H						NRB
813.386774	43.0	6.1	-8.5	40.7	Peak [Scan]	H						NRB
881.440	43.5	6.3	-8.0	41.8	Peak [Scan]	H						NRB
967.008	38.1	6.5	-6.9	37.7	Peak [Scan]	H	99	-1	54	-16.28	Pass	RB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	NRB = Non-Restricted Band. Limit = 68.23 dBuV/m; RB = Restricted Band. Limits per 15.205

Test Freq.	926 MHz CH 59	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	14.5
Freq. Range	30 - 1000 MHz	**Rel. Hum.(%)**	45
Power Setting	Min (5)	**Press. (mBars)**	1005
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2			

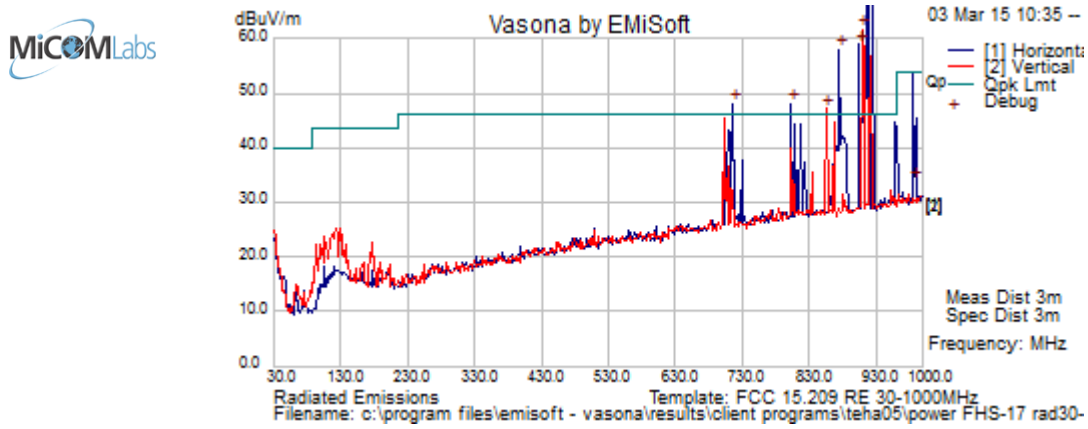


Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
926.132	67.0	6.4	-7.4	66.0	Peak [Scan]	H						FUND
720.08016	52.5	5.9	-9.6	48.8	Peak [Scan]	H						NRB
881.423	42.1	6.3	-8.0	40.4	Peak [Scan]	H						NRB
823.099	41.2	6.2	-8.2	39.2	Peak [Scan]	H						NRB
860.212	40.7	6.2	-8.1	38.9	Peak [Scan]	H						NRB
968.873	39.4	6.5	-6.8	39.1	Peak [Scan]	H	98	-1	54	-14.89	Pass	RB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	NRB = Non-Restricted Band. Limit = 68.23 dBuV/m; RB = Restricted Band. Limits per 15.205

Test Freq.	FHSS 903-926	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	14.5
Freq. Range	30 - 1000 MHz	**Rel. Hum.(%)**	45
Power Setting	Max (2)	**Press. (mBars)**	1005
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		



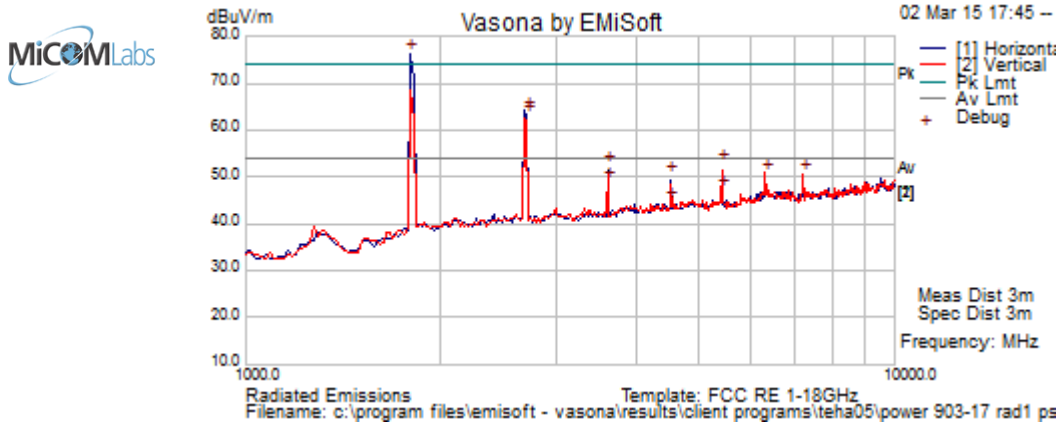
Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
916.413	69.7	6.4	-7.6	68.5	Peak [Scan]	H						FUND
920.300601	69.0	6.4	-7.6	67.9	Peak [Scan]	H						FUND
924.188	67.6	6.5	-7.5	66.5	Peak [Scan]	H						FUND
910.581162	62.9	6.4	-7.5	61.7	Peak [Scan]	V						FUND
904.749	60.2	6.3	-7.5	59.0	Peak [Scan]	H						FUND
986.459	33.9	6.5	-6.6	33.8	Quasi Peak.	H	100	0	54	-20.2	Pass	RB
875.591	59.7	6.3	-8.0	58.0	Peak [Scan]	H						NRB
716.192	51.9	5.9	-9.7	48.1	Peak [Scan]	H						NRB
803.667	50.8	6.1	-8.8	48.1	Peak [Scan]	H						NRB
856.152	49.0	6.2	-8.1	47.1	Peak [Scan]	V						NRB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	NRB = Non-Restricted Band. Limit = 68.23 dBuV/m; RB = Restricted Band. Limits per 15.205

8.1.1.2. Radiated Spurious > 1 G (Restricted Band Emissions)

Test Freq.	903 MHz CH 0	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	17.5
Freq. Range	1 - 10 GHz	**Rel. Hum.(%)**	40
Power Setting	Min (5)	**Press. (mBars)**	997
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		



Formally measured emission peaks

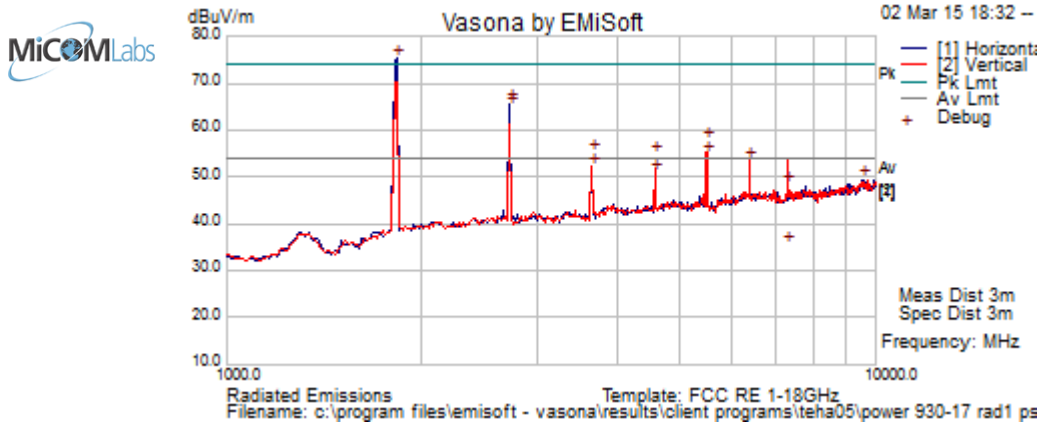
Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
1793.587	86.8	3.4	-13.8	76.4	Peak [Scan]	H	150	0	54	22.37	Fail	NRB
2708.999	71.4	4.2	-11.4	64.2	Peak Max	H	105	148	74	-9.8	Pass	RB
2708.999	70.5	4.2	-11.4	63.3	Average Max	H	105	148	54	9.29	Pass*	DCCF = -3.2
3611.990	58.9	4.9	-11.1	52.7	Peak Max	H	133	339	74	-21.35	Pass	RB
3611.990	55.5	4.9	-11.1	49.2	Average Max	H	133	339	54	-4.8	Pass	RB
4515.014	50.9	5.5	-11.5	44.8	Average Max	H	127	67	54	-9.2	Pass	RB
4515.014	56.4	5.5	-11.5	50.3	Peak Max	H	127	67	74	-23.7	Pass	RB
5417.936	57.9	6.0	-11.2	52.8	Peak Max	V	141	-1	74	-21.2	Pass	RB
5417.936	52.3	6.0	-11.2	47.2	Average Max	V	141	-1	54	-6.8	Pass	RB
6320.641	52.7	6.6	-8.3	51.0	Peak [Scan]	V	100	0	54	-3.0	Pass	NRB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	DC= Duty Cycle Correction; RB = Restricted Band. Limits per 15.205

*Emission passes with addition of DCCF – Duty Cycle Correction Factor -12.5 dB

Test Freq.	915 MHz CH 30	**Engineer**	JMH

Variant	FHSS 33 KHz	**Temp (ºC)**	17.5
Freq. Range	1 - 10 GHz	**Rel. Hum.(%)**	40
Power Setting	Min (5)	**Press. (mBars)**	997
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		



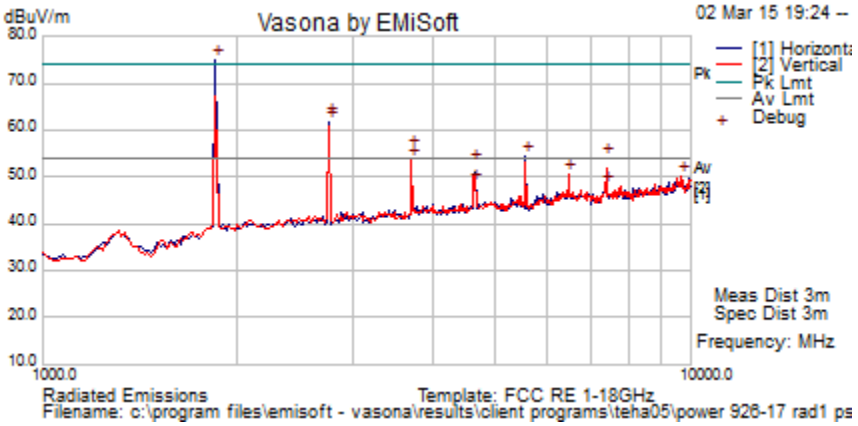
Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
1829.659	85.4	3.4	-13.5	75.3	Peak [Scan]	H	150	0	54	21.26	Fail	NRB
2740.519	71.9	4.2	-11.4	64.7	Average Max	H	100	144	54	10.74	Pass*	DCCF = -1.8
2740.519	72.8	4.2	-11.4	65.7	Peak Max	H	100	144	74	-8.32	Pass	RB
3653.970	58.4	4.9	-11.1	52.2	Average Max	V	156	10	54	-1.78	Pass	RB
3653.970	61.1	4.9	-11.1	54.9	Peak Max	V	156	10	74	-19.06	Pass	RB
4567.447	56.7	5.5	-11.4	50.8	Average Max	V	110	353	54	-3.2	Pass	RB
4567.447	60.4	5.5	-11.4	54.5	Peak Max	V	110	353	74	-19.5	Pass	RB
5480.999	59.7	6.1	-11.2	54.5	Average Max	V	153	14	54	0.5	Pass*	DCCF = -12.0
5480.999	62.7	6.1	-11.2	57.6	Peak Max	V	153	14	74	-16.4	Pass	RB
7312.625	48.2	7.2	-7.3	48.1	Peak Max	V	125	290	74	-25.9	Pass	RB
7312.625	35.3	7.2	-7.3	35.3	Average Max	V	125	290	54	-18.8	Pass	RB
6392.786	54.8	6.7	-8.1	53.4	Peak [Scan]	V	150	0	54	-0.6	Pass	NRB
9531.062	47.0	8.4	-5.9	49.5	Peak [Scan]	H	150	0	54	-4.5	Pass	Noise

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	DC= Duty Cycle Correction; RB = Restricted Band. Limits per 15.205

*Emission passes with addition of DCCF – Duty Cycle Correction Factor -12.5 dB

Test Freq.	926 MHz CH 59	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	19
Freq. Range	1 - 10 GHz	**Rel. Hum.(%)**	40
Power Setting	Min (5)	**Press. (mBars)**	1006
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		



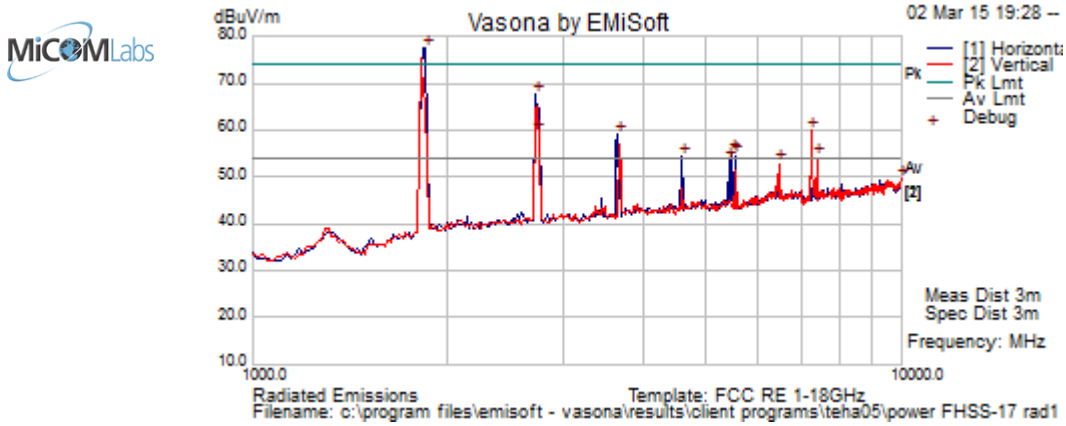
Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
1847.695	85.2	3.4	-13.5	75.1	Peak [Scan]	H						NRB
2778.019	70.1	4.2	-11.3	63.0	Peak Max	H	99	155	74	-10.98	Pass	RB
2778.019	69.1	4.2	-11.3	62.0	Average Max	H	99	155	54	8.01	Pass*	w/DC = -4.5
3704.008	62.2	4.9	-10.9	56.1	Peak Max	V	151	349	74	-17.88	Pass	RB
3704.008	59.8	4.9	-10.9	53.8	Average Max	V	151	349	54	-0.22	Pass	RB
4629.929	58.9	5.5	-11.3	53.2	Peak Max	H	101	338	74	-20.85	Pass	RB
4629.929	54.2	5.5	-11.3	48.5	Average Max	H	101	338	54	-5.6	Pass	RB
7408.016	54.3	7.3	-7.2	54.4	Peak Max	V	100	74	74	-19.6	Pass	RB
7408.016	48.0	7.3	-7.2	48.1	Average Max	V	100	74	54	-5.9	Pass	RB
5563.126	59.7	6.1	-11.2	54.6	Peak [Scan]	H						NRB
6482.966	52.0	6.7	-7.9	50.8	Peak [Scan]	V						NRB
9675.351	47.9	8.6	-6.2	50.3	Peak [Scan]	V						NRB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	DC= Duty Cycle Correction; RB = Restricted Band. Limits per 15.205

*Emission passes with addition of DCCF – Duty Cycle Correction Factor -12.5 dB

Test Freq.	FHSS 903-926	**Engineer**	JMH
Variant	FHSS 33 KHz	**Temp (ºC)**	19
Freq. Range	1 - 10 GHz	**Rel. Hum.(%)**	40
Power Setting	Min (5)	**Press. (mBars)**	1006
Antenna	Integral	**Duty Cycle (%)**	100
Test Notes 1	EUT SN E2000017		
Test Notes 2	EUT Operational Duty Cycle: 23.68mS per 100mS window Correction Factor = 20 * LOG (23.68 / 100), Correction Factor = -12.51dB		



Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
1847.695	87.6	3.4	-13.5	77.5	Peak [Scan]	H						NRB
2731.463	74.7	4.2	-11.4	67.6	Peak.	H	100	148	74	-6.4	Pass	RB
2731.462	66.7	4.2	-11.4	59.5	Average.	H	100	148	54	5.5	Pass*	DCCF = -7.0
7258.51703	60.0	7.2	-7.3	59.9	Peak [Scan]	V	100	0	54	5.87	Pass*	DCCF = -6.2
3651.303	65.3	4.9	-11.1	59.1	Peak [Scan]	H	150	0	54	5.1	Pass*	DCCF = -7.4
4589.178	60.2	5.5	-11.4	54.3	Peak [Scan]	H	100	0	54	0.33	Pass*	DCCF = -12.2
7402.806	54.0	7.3	-7.2	54.1	Peak [Scan]	V	150	0	54	0.1	Pass*	DCCF = -12.4
5418.838	58.6	6.0	-11.2	53.4	Peak [Scan]	H	100	0	54	-0.58	Pass*	DCCF = -13.0
5472.946	60.1	6.1	-11.2	54.9	Peak [Scan]	H						NRB
5527.054	59.6	6.1	-11.2	54.5	Peak [Scan]	H						NRB
6482.966	54.0	6.7	-7.9	52.8	Peak [Scan]	V						NRB
9981.964	46.1	8.7	-5.3	49.5	Peak [Scan]	V						NRB

Legend:	TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission
	DC= Duty Cycle Correction; RB = Restricted Band. Limits per 15.205

Emission passes with addition of DCCF – Duty Cycle Correction Factor -12.5 dB

8.1.2. Digital Emissions (0.03 - 1 GHz)

Radiated Test Conditions for Radiated Digital Emissions (0.03 – 1 GHz)			
Standard:	FCC CFR 47:15.247	**Ambient Temp. (ºC):**	20.0 - 24.5
Test Heading:	Digital Emissions	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	15.209	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Radiated Digital Emissions (0.03 – 1 GHz)
Testing 30M-1 GHz was performed in a 3-meter anechoic chamber using a CISPR compliant receiver. Preliminary radiated emissions were measured on every azimuth and with the receiving antenna in both horizontal and vertical polarizations. To further maximize emissions the receive antenna was varied between 1 and 4 meters. The emissions are recorded with receiver in peak hold mode. Emissions closest to the limits are measured in the quasi-peak mode with the tuned receiver using a bandwidth of 120 kHz. Only the highest emissions relative to the limit are listed.

Test configuration and setup for Radiated Spurious and Band-Edge Measurement were per the Radiated Test Set-up specified in this document.

Field Strength Calculation
The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. In this test facility, the Antenna Factor, Cable Loss, and Amplifier Gains are loaded into the Rohde & Schwarz Receiver and the corrected field strength can be read directly on the receiver.

FS = R + AF + CORR

where:
FS = Field Strength
R = Measured Receiver Input Amplitude
AF = Antenna Factor
CORR = Correction Factor = CL – AG + NFL
CL = Cable Loss
AG = Amplifier Gain

For example:
Given a Receiver input reading of 51.5dBmV; Antenna Factor of 8.5dB; Cable Loss of 1.3dB; Falloff Factor of 0dB, an Amplifier Gain of 26dB and Notch Filter Loss of 1dB. The Field Strength of the measured emission is:

FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3dBmV/m

Conversion between dBmV/m (or dBmV) and mV/m (or mV) are done as:

Level (dBmV/m) = 20 * Log (level (mV/m))

40 dBmV/m = 100mV/m
48 dBmV/m = 250mV/m

Limits for Radiated Digital Emissions (0.03 – 1 GHz)

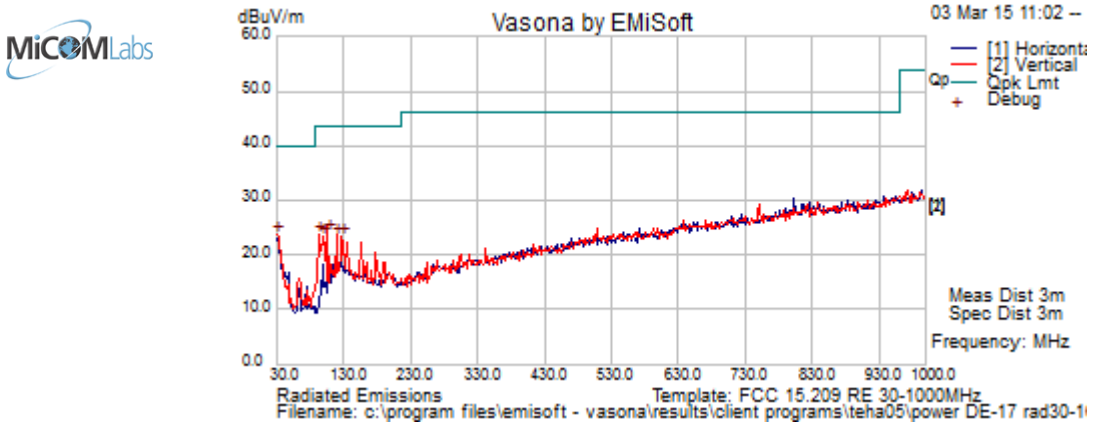
(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength		Measurement Distance (m)
	µV/m (microvolts/meter)	dBµV/m (dB microvolts/meter)	
0.009-0.490	2400/F(kHz)	--	300
0.490-1.705	24000/F(kHz)	--	30
1.705-30.0	30	29.5	30
30-88	100**	40	3
88-216	150**	43.5	3
216-960	200**	46.0	3
Above 960	500	54.0	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. (b) In the emission table above, the tighter limit applies at the band edges. (c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency. (d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector. (e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part. (f) In accordance with §15.33(a), in some cases the emissions from an intentional radiator must be measured to beyond the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator because of the incorporation of a digital device. If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in §15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in §15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit. Emissions which must be measured above the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator and which fall within the restricted bands shall comply with the general radiated emission limits in §15.109 that are applicable to the incorporated digital device. (g) Perimeter protection systems may operate in the 54-72 MHz and 76-88 MHz bands under the provisions of this section. The use of such perimeter protection systems is limited to industrial, business and commercial applications.

8.1.2.3. Digital Emissions (0.03-1 GHz)

EUT	TW-221-R	**Engineer**	JMH
Variant	Digital Emissions	**Temp (ºC)**	17
Freq. Range	30 MHz - 1000 MHz	**Rel. Hum.(%)**	41
Standard Limit	FCC Class B	**Press. (mBars)**	1005
Support Equip	None		
Test Notes	EUT SN E2000017		



Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail	Comments
30.591	30.4	3.4	-10.1	23.7	Peak [Scan]	V	98	-1	40	-16.3	Pass	
106.006	39.8	3.9	-19.6	24.080	Peak [Scan]	V	98	-1	43.5	-19.4	Pass	
92.493	43.2	3.8	-23.5	23.6	Peak [Scan]	V	98	-1	43.5	-19.9	Pass	
127.498	36.4	4.0	-17.1	23.3	Peak [Scan]	V	98	-1	43.5	-20.2	Pass	
119.519	36.6	4.0	-17.4	23.2	Peak [Scan]	V	98	-1	43.5	-20.3	Pass	
97.805	41.1	3.9	-21.9	23.1	Peak [Scan]	V	98	-1	43.5	-20.4	Pass	

Legend:	DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency
	TRNS= Transient Emission, Brbnd= Broadband emission

8.1.3. Conducted Disturbance at Mains Terminal (150 kHz – 30 MHz)

Standard Reference

FCC, Part 15 Subpart C §15.107

Test Procedure

The EUT is configured in accordance with ANSI C63.4. The conducted emissions are measured in a shielded room with a spectrum analyzer in peak hold in the first instance. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9 kHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

If the average limit is met when using a quasi-peak detector receiver, the EUT shall be deemed to meet both limits and measurement with the average detector receiver is unnecessary.

If the reading of the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the higher reading shall be recorded with the exception of any brief isolated high reading which shall be ignored.

Specification

Conducted Disturbance at Mains Terminal – Digital Apparatus

FCC, Part 15 Subpart B §15.107
(a) Except for Class A digital devices, for equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the band edges.

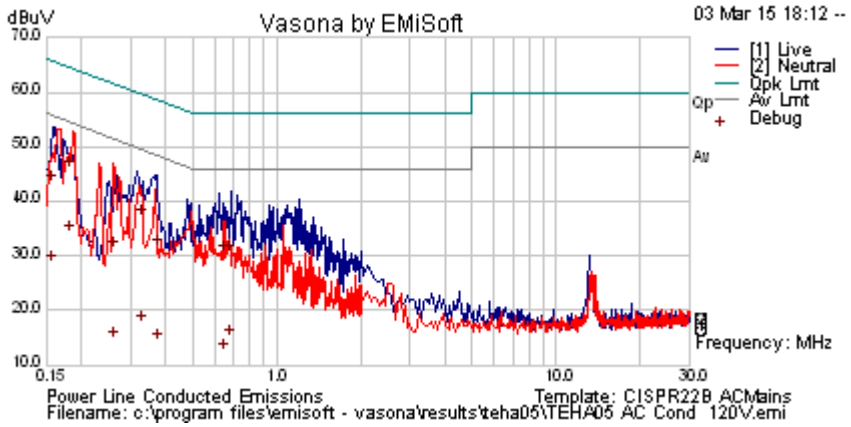
(b) For a Class A digital device that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms LISN. Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Industry Canada ICES-003
Class A: An ITE meeting the conditions for Class A operation defined in Section 2.2 shall comply with the Class A conducted limits.

Class B: An ITE that does not meet the conditions for Class A operation shall comply with the Class B conducted limits.

8.1.3.4. Conducted Disturbance at Mains Terminal (150 kHz – 30 MHz)

Model Number	TW-221-R	**Engineer**	JMH
Variant	AC Wireline 120Vac 60 Hz	**Temp (ºC)**	17
Freq. Range	0.150 MHz - 30 MHz	**Rel. Hum.(%)**	37
Power Setting	N/A	**Press. (mBars)**	1003
Antenna			
Test Notes 1	EUT SN E2000017		
Test Notes 2	Class B Limits		



Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass /Fail	Comments
0.156	18.4	9.9	0.1	28.3	Average	Live	55.68	-27.4	Pass	
0.156	33.2	9.9	0.1	43.2	Quasi Peak	Live	65.68	-22.5	Pass	
0.181	35.7	9.9	0.1	45.7	Quasi Peak	Live	64.46	-18.8	Pass	
0.181	23.8	9.9	0.1	33.8	Average	Live	54.46	-20.7	Pass	
0.258	21.1	9.9	0.1	31.1	Quasi Peak	Neutral	61.49	-30.4	Pass	
0.258	4.5	9.9	0.1	14.5	Average	Neutral	51.49	-37.0	Pass	
0.324	27.0	9.9	0.1	37.0	Quasi Peak	Live	59.6	-22.6	Pass	
0.324	7.3	9.9	0.1	17.3	Average	Live	49.6	-32.3	Pass	
0.370	4.3	9.9	0.1	14.2	Average	Neutral	48.5	-34.3	Pass	
0.370	21.3	9.9	0.1	31.2	Quasi Peak	Neutral	58.5	-27.3	Pass	
0.636	2.4	10.0	0.1	12.4	Average	Live	46	-33.6	Pass	
0.636	20.2	10.0	0.1	30.2	Quasi Peak	Live	56	-25.8	Pass	
0.677	20.3	10.0	0.1	30.4	Quasi Peak	Live	56	-25.7	Pass	
0.677	4.8	10.0	0.1	14.8	Average	Live	46	-31.2	Pass	

Legend:	DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency
	NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band

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