Test of WHERETAG III STHO

To: FCC 47 CFR Part 15.209; FCC 15.247 & IC RSS-210

Test Report Serial No.: ETSD17-A2 Rev A

MiCOMLabs

opening wireless markets

TEST REPORT

FROM

MiCOMLabs

Test of WHERETAG III STHO

To

FCC 47 CFR Part 15.209; FCC 15.247 & IC RSS-210

Test Report Serial No.: ETSD17-A2 Rev A

This report supersedes: None

Manufacturer: WHERENET CORP.
2858 De La Cruz Blvd,
Santa Clara,
California 95050, USA

Product Function: RFID or Real Time Location System

Copy No: pdf **Issue Date:** 19th May 2009

This Test Report is Issued Under the Authority of;

MiCOM Labs, Inc.
440 Boulder Court, Suite 200
Pleasanton, CA 94566 USA
Phone: +1 (925) 462-0304
Fax: +1 (925) 462-0306
www.micomlabs.com

ACCREDITED

CERTIFICATE #2381.01

MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

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ACCREDITATION, LISTINGS & RECOGNITION

ACCREDITATION

MiCOM Labs, Inc. an accredited laboratory complies with the international standard EN ISO/IEC 17025. 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

THE 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 18 June 2005*).

Presented this 26th day of February 2008.

President
For the Accreditation Council
Certificate Number 2381.01
Valid to November 30, 2009

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

LISTINGS

MiCOM Labs test facilities are listed by the following organizations;

<u>North America</u>

United States of America

Federal Communications Commission (FCC) Listing #: 102167

Canada

Industry Canada (IC) Listing #: 4143A

<u>Japan Registration</u>

VCCI Membership Number: 2959

- Radiation 3 meter site; Registration No. R-2881
- Line Conducted, Registration Nos. C-3181 & T-1470
- Emissions; Registration Nos. C-3180 & T-1469

RECOGNITION

APEC MRA (Asia-Pacific Economic Community Mutual Recognition Agreement)

Conformity Assessment Body (CAB) – MiCOM Labs

Test data generated by MiCOM Labs is accepted in the following countries under the APEC MRA.

Country	Recognition Body	Phase	CAB Identification No.
Australia	Australian Communications and Media Authority (ACMA)	I	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)	I	
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)	I	
Singapore	Infocomm Development Authority (IDA)	I	
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)	I I	

DOCUMENT HISTORY

Document History		
Revision	**Date**	**Comments**
Draft		
Rev A	19th May 2009	Initial release.

1. TEST RESULT CERTIFICATE

Manufacturer:	WHERENET CORP. 2858 De La Cruz Blvd, Santa Clara, California 95050, USA	Tested By:	MiCOM Labs, Inc. 440 Boulder Court Suite 200 Pleasanton California, 94566, USA
EUT:	WHERETAG III STHO	Telephone:	+1 925 462 0304
Model:	TFF-1015	Fax:	+1 925 462 0306
S/N:	19044557		
Test Date(s):	24th March & 29th April, 2009	Website:	www.micomlabs.com

STANDARD(S)	TEST RESULTS
FCC 47 CFR Part 15.209; FCC 15.247 & IC RSS-210	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.

ACCREDITED

CERTIFICATE #2381.01

Approved & Released for MiCOM Labs, Inc. by:

Graeme Grieve
Quality Manager MiCOM Labs,

Gordon Hurst
President & CEO MiCOM Labs, Inc.

2. REFERENCES AND MEASUREMENT UNCERTAINTY

2.1. Normative References

Ref.	Publication	Year	Title
(i)	FCC 47 CFR Part 15.247	2007	Code of Federal Regulations
(ii)	Industry Canada RSS-210	Issue 7 June 2007	Low Power License-Exempt Radiocommunication Devices (All Frequency Bands)
(iii)	Industry Canada RSS-Gen	Issue 2 June 2007	General Requirements and Information for the Certification of Radiocommunication Equipment.
(iv)	ANSI C63.4	2003	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
(v)	CISPR 22/ EN 55022	1997 1998	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
(vi)	M 3003	Edition 1 Dec. 1997	Expression of Uncertainty and Confidence in Measurements
(vii)	LAB34	Edition 1 Aug 2002	The expression of uncertainty in EMC Testing
(viii)	ETSI TR 100 028	2001	Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics
(ix)	A2LA	14th September '05	Reference to A2LA Accreditation Status – A2LA Advertising Policy

2.2. Test and Uncertainty Procedures

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.

3. PRODUCT DETAILS AND TEST CONFIGURATIONS

3.1. Technical Details

Details	Description
Purpose:	To test WhereNet's WHERETAG III STHO for compliance to FCC 15.247 and RSS-210 to support a Class B permissive change.
Applicant:	WHERENET CORP. 2858 De La Cruz Blvd, Santa Clara, California 95050, USA
Manufacturer:	Same as applicant.
Laboratory performing the tests:	MiCOM Labs, Inc. 440 Boulder Court, Suite 200 Pleasanton, California 94566 USA
Test report reference number:	ETSD17-A2 REV A
Date EUT received:	29th April, 2009
Standard(s) applied:	FCC 47 CFR Part 15.209; FCC 15.247 & IC RSS-210
Dates of test (from - to):	3/24/2009 and 4/29/2009
No of Units Tested:	1
Type of Equipment:	RFID or Real Time Location System
Manufacturers Trade Name:	WHERENET CORP.
Model:	TFF-1015
Location for use:	Indoor / Outdoor Use
Declared Frequency Range(s):	Transmitter: 2400-2483 MHz / Receiver:114-127 KHz
Type of Modulation:	DSSS = 2441.75 MHz, OOK= 2446.5 MHz
EUT Duty Cycle	Duty Cycle: 2.49% (ON 2.55 mS, OFF 100 mS)
Declared Nominal Output Power:	16dBm
EUT Modes of Operation:	Test Mode 1 for DSSS: normal 56-bit message that repeats forever. 100% Duty Cycle Test Mode 2 for OOK: normal transmit message that repeats forever. 100% Duty Cycle
Transmit/Receive Operation:	Transmit: DSSS = 2441.75 MHz, OOK= 2446.5 MHz Receive: 114-127 KHz
Rated Input Voltage and Current:	12 V DC Nomimal 65 mA with transmitter turned off; 250mA with transmitter turned on; 3 Watts (tx on)
Operating Temperature Range:	-30 °C to +65 °C
Microprocessor(s) Model:	ST Microelectronics P/N ST92F150JDV1T6
Clock/Oscillator(s):	30.5MHz 32KHz 4MHZ
Frequency Stability:	+/- 1 ppm
Equipment Dimensions:	5”x1”x2.5”
Weight:	4oz (113g)
Primary function of equipment:	RFID or Real Time Location System

3.2. Scope of Test Program

The scope of the test program was to test the WHERETAG III STHO to FCC Part 15.247, previously certified under FCC ID: NSQTFF-1015S. This report is to show compliance (supporting a Class B permissive change) to FCC 47 CFR Part 15.209; FCC 15.247 & IC RSS-210 utilizing a new antenna system.

The WHERETAG III STHO primary function is as a RFID or Real Time Location System. It consists of multiple radios that do not operate simultaneously, each utilizing their own antenna.

The EUT utilizes two (2) transmissions modes on individual fixed frequencies:

DSSS Mode @ 2441.75 MHz

OOK Mode @ 2446.5 MHz

The WHERETAG III STHO is available in 4 variations. Only one configuration was tested.

Model: TFF-1015-08AB (Bottom connector, RS422)

Model: TFF-1015-08AA (Bottom connector, RS232)

Model: TFF-1015-09AA (End connector, RS232)

Model: TFF-1015-09AB (End connector, RS422)

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

Type (EUT/ Support)	Equipment Description (Including Brand Name)	Mfr	Model No.	Serial No.
EUT	WHERETAG III STHO RFID or Real Time Location System	WhereNet	TFF-1015 (Bottom connector RS422)	TBD
Support	Laptop for EUT configuration	Dell	D610	--
Support	RSS 232 to 422 converter	--	--	--
Support	HP 6274B DC Power Supply - 12V DC	Hewlett Packard	6274B	--

3.4. Antenna Details

Antenna Type	Gain (dBi)	Manufacturer	Model No.	Serial No.
Mono-pole (at center position)	4.5	WhereNet	22810	--
Mono-pole (at outer position)	7.0	WhereNet	22810	--

NOTE: Insertion Loss of 1 foot RF cable between DUT and antenna is 0.5 dB

3.5. Cabling and I/O Ports

Number and type of I/O ports

1. Power/Serial RS422 with maximum cable length of 46 feet
2. SMA with maximum cable length less than 10 feet.

3.6. Test Configurations

List of test configurations

1. Test Mode 1 for DSSS: normal 56-bit message that repeats forever.
2. Test Mode 2 for OOK: normal transmit message that repeats forever.

3.7. Equipment Modifications

The following modifications were required to bring the equipment into compliance:

1. Ferrite added (5 Loops) to antenna cable internal to EUT. Fair-Rite part number 2643665802 was used.

3.8. Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:

1. NONE

3.9. Subcontracted Testing or Third Party Data

1. NONE

4. TEST SUMMARY

List of Measurements

The following table represents the list of measurements required under the **FCC CFR47 Part 15.247** and **Industry Canada RSS-210** and **Industry Canada RSS-Gen.**

Section(s)	Test Items	Description	Condition	Result	Test Report Section
15.247(a)(2) **A8.2(1)** **4.4**	6 dB and 99 % Bandwidths	≥ 500 kHz	Conducted	Not Tested	5.1.1
15.247(b)(3) **15.31(e)** **A8.4(4)**	Peak Output Power Voltage Variation	Shall not exceed 1W Variation of supply voltage 85 % -115 %	Conducted	Complies	5.1.2
15.247(e) **A8.2**	Peak Power Spectral Density	Shall not be greater than +8 dBm in any 3 kHz band	Conducted	Not Tested	5.1.3
15.247(i) **5.5**	Maximum Permissible Exposure	Exposure to radio frequency energy levels	Conducted	Not Tested	5.1.4
15.247(d) **15.205 /** **15.209** **A8.5** **2.2** **4.7**	Spurious Emissions (30MHz - 26 GHz)	The radiated emission in any 100 kHz of out-band shall be at least 20 dB below the highest in-band spectral density	Conducted	Not Tested	5.1.5

List of Measurements (continued)

The following table represents the list of measurements required under the **FCC CFR47 Part 15.247**, **Industry Canada RSS-210,** and **Industry Canada RSS-Gen.**

Section(s)	Test Items	Description	Condition	Result	Test Report Section
15.247(d) **15.205 /** **15.209** **A8.5** **2.2** **2.6** **4.7**	Radiated Emissions	Restricted Bands	Radiated	Complies	5.1.6
	Transmitter Radiated Spurious Emissions, Peak Emissions, Band Edge	Emissions above 1 GHz		Complies	*5.1.6.1*
Industry Canada only **RSS-Gen §4.8, §6**	Receiver Radiated Spurious Emissions	Emissions above 1 GHz		Not Tested	*5.1.6.2*
15.205 / **15.209** **2.2**	Radiated Spurious Emissions	Emissions <1 GHz (30M-1 GHz)	Radiated	Complies	*5.1.6.3*
15.207 **7.2.2**	AC Wireline Conducted Emissions 150 kHz– 30 MHz	Conducted Emissions	Conducted	Not Applicable Device dc powered	*5.1.7*

Note 1: *Test results reported in this document relate only to the items tested*
Note 2: *The required tests demonstrated compliance as per client declaration of test configuration, monitoring methodology and associated pass/fail criteria*
Note 3: *Section - Equipment Modifications highlights the equipment modifications that were required to bring the product into compliance with the above test matrix*

5. TEST RESULTS

5.1. Device Characteristics

5.1.1. 6 dB and 99 % Bandwidth

6 dB and 99 % Bandwidth Not Tested

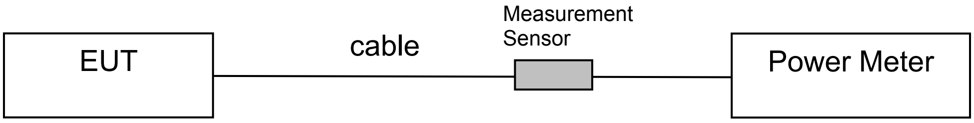
5.1.2. Peak Conducted Output Power

FCC, Part 15 Subpart C §15.247(b)(3), §15.31(e)
Industry Canada RSS-210 §A8.4(4)

Test Procedure

The transmitter terminal of EUT was connected to the input of the Power Meter sensor. Cable loss was accounted for in Power Meter settings. Measurements were made while EUT was operating in a continuous transmission mode i.e. 100 % duty cycle at the appropriate center frequency.

Test Measurement Set up



Measurement set up for Transmitter Peak Output Power

15.247 (c) Operation with directional antenna gains greater than 6 dBi

(1) Fixed point –to-point operation:

(i) Systems operating in the 2400 – 2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

EUT parameters:

Test Mode 2 for OOK: normal transmit message that repeats forever; 12V DC; OOK frequency = 2446.5 MHz; Power Level = Maximum; 100% Duty Cycle

Antenna Type	Gain (dBi)	Antenna Gain >6dBi (dB)	Max. Allowable Peak Power (dBm)	Maximum EIRP (dBm)	Peak Power Measurement (dBm)
Mono-pole (at center position)	4.5	No	30	36	10.66
Mono-pole (at outer position)	7.0	Yes	29	36	10.66

EUT parameters:

Test Mode 1 for DSSS: normal 56-bit message that repeats forever; 12V DC; DSSS frequency = 2441.75 MHz; Power Level = Maximum; 100% Duty Cycle

Antenna Type	Gain (dBi)	Antenna Gain >6dBi (dB)	Max. Allowable Peak Power (dBm)	Maximum EIRP (dBm)	Peak Power Measurement (dBm)
Mono-pole (at center position)	4.5	No	30	36	14.81
Mono-pole (at outer position)	7.0	Yes	29	36	14.81

Specification
Limits

§15.247 (b) The maximum peak output power of the intentional radiator shall not exceed the following:

> **§15.247 (b) (3)** For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands: 1.0 watt.

§15.31 (e) For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

§ RSS-210 A8.4(4) For systems employing digital modulation techniques operating in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands the maximum peak conducted power shall not exceed 1 watt.

Laboratory Measurement Uncertainty for Power Measurements

Measurement uncertainty	±1.33 dB

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-01 'Measuring RF Output Power'	0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117

5.1.3. Peak Power Spectral Density

FCC, Part 15 Subpart C §15.247(e)
Industry Canada RSS-210 §A8.2

Peak Power Spectral Density Not Tested.

Specification
Peak Power Spectral Density Limits

§15.247(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than +8 dBm in any 3 kHz band during any time interval of continuous transmission **RSS-210 §A8.2(2)** The transmitter power spectral density (into the antenna) shall not be greater than +8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0 second duration.

Laboratory Measurement Uncertainty for Spectral Density

Measurement uncertainty	±1.33 dB

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-01 'Measuring RF Output Power'	0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117

5.1.4. Maximum Permissible Exposure

FCC, Part 15 Subpart C §15.247(i)
Industry Canada RSS-Gen §5.5

Maximum Permissible Exposure Levels Not Calculated

Specification

Maximum Permissible Exposure Limits

§15.247(i) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency levels in excess of the Commission's guidelines. **FCC §1.1310** Limit = 1mW / cm^2 from 1.310 Table 1 **RSS-Gen §5.5** Before equipment certification is granted, the applicable requirements of RSS-102 shall be met.

Laboratory Measurement Uncertainty for Power Measurements

Measurement uncertainty	±1.33 dB

5.1.5. Conducted Spurious Emissions

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

Conducted Spurious Emissions Not Tested.

Specification

Limits Band-Edge

Lower Limit Band-edge	Upper Limit Band-edge	Limit below highest level of desired power
2,400 MHz	2,483.5 MHz	≥ 20 dB

§15.247(d) and RSS-210 §A8.5 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 radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

§15.247(d)
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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section §15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(a)).

RSS-210 §A8.5 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Tables 2 and 3 is not required. In addition, radiated emissions which fall in the restricted bands of Table 1 must also comply with the radiated emission limits specified in Tables 2 and 3.

RSS-Gen §4.7
The search for unwanted emissions shall be from the lowest frequency internally generated or used in the device (local oscillator, intermediate of carrier frequency), or from 30 MHz , whichever is the lowest frequency, to the 5^{th} harmonic of the highest frequency generated without exceeding 40 GHz.

Laboratory Measurement Uncertainty for Conducted Spurious Emissions

Measurement uncertainty	±2.37 dB

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-05 'Measurement of Spurious Emissions'	0088, 0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117.

5.1.6. <u>Radiated Emissions</u>

5.1.6.1. Transmitter Radiated Spurious Emissions (above 1 GHz)

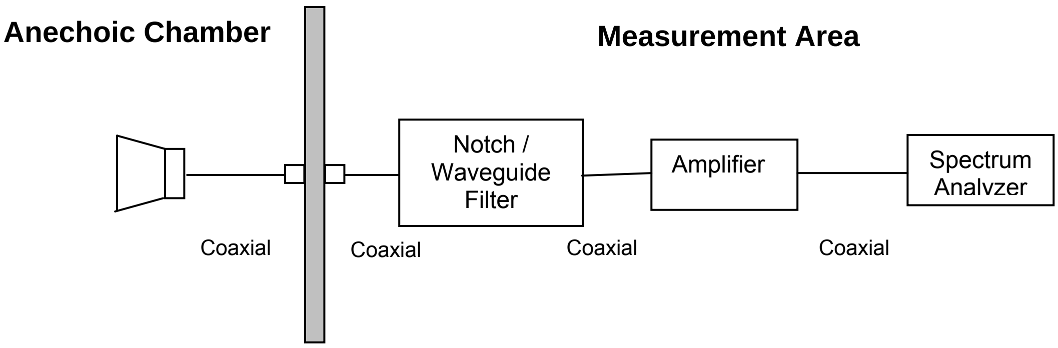
FCC, Part 15 Subpart C §15.247(d) 15.205; 15.209
Industry Canada RSS-210 §A8.5, §2.2, §2.6
Industry Canada RSS-Gen §4.7

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 GHz 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.

The product was initially tested to find worst case orientation for the maximization of spurious emissions. Worst case orientation was used for all emission testing.

Test Measurement Set up



Measurement set up for Radiated Emission Test

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

During the radiated emission test a linear power supply was used to power the device under test. Voltage delivered to the device was +12 Vdc.

DSSS EUT parameters:

Test Mode 1 for DSSS: normal 56-bit message that repeats forever; 12V DC; DSSS frequency = 2441.75 MHz; Power Level = 3; Nominal (14.04 dBm); 100% Duty Cycle

TABLE OF RESULTS – +12 Vdc

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB	PASS/ FAIL
4883.479	68.05	4.52	-8.74	63.83	Peak Max	V	98	92	74	-10.17	PASS
7336.673	48.26	5.45	-2.97	50.74	Peak Max	V	151	234	74	-23.26	PASS
4914.053	63.29	4.55	-8.74	59.09	Peak Max	H	107	0	74	-14.91	PASS
13417.84	45.57	7.45	-2.27	50.75	Peak Max	H	127	89	74	-23.25	PASS
2309.173	60.51	2.91	-10.52	52.91	Peak Max	V	143	136	74	-21.09	PASS
7336.673	36.9	5.45	-2.97	39.39	Average Max	V	151	234	54	-14.61	PASS
4914.053	52.08	4.55	-8.74	47.89	Average Max	V	99	92	54	-6.11	PASS
13417.84	32.29	7.45	-2.27	37.47	Average Max	V	121	281	54	-16.53	PASS
2309.173	47.01	2.91	-10.52	39.4	Average Max	V	143	136	54	-14.6	PASS
4883.479*	66.2	4.52	-8.74	61.98	Average Max	V	98	92	--	--	--
Note 1:	=63.83 + (-31.87) = 31.96 dBuV								54	-22.04	PASS

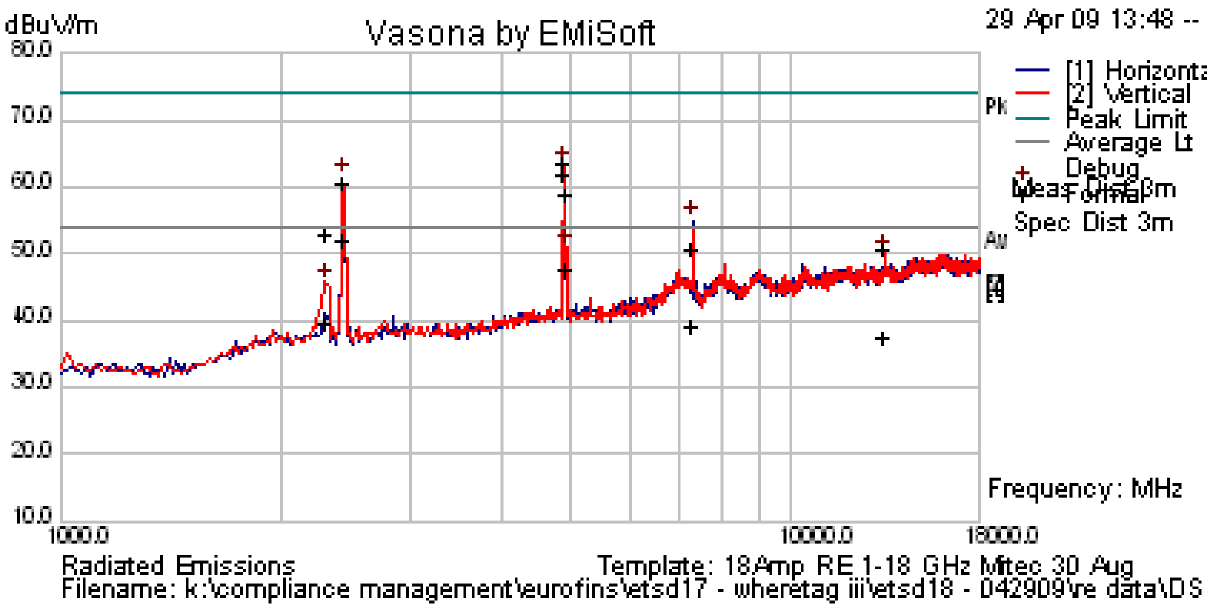
* Note 1: Restricted band emissions, average value calculation: Peak value + 20 Log (duty cycle); Peak value + 20 Log (0.0255); Peak Value + (-31.87 dB)

Manufacturer's Declared Operational Duty Cycle: 2.55% (ON 2.55 mS, WINDOW 100 mS) where 100mS is the measurement period.

Per FCC's Digital Transmission Systems, Measurements and Procedures Public Notice DA 00-705 Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems. Average value of emission is calculated by the following equation;

Peak value +20 Log (duty cycle)
20 Log (0.0255) = -31.87 dB

DSSS Channel 2441.75 MHz Radiated Emissions



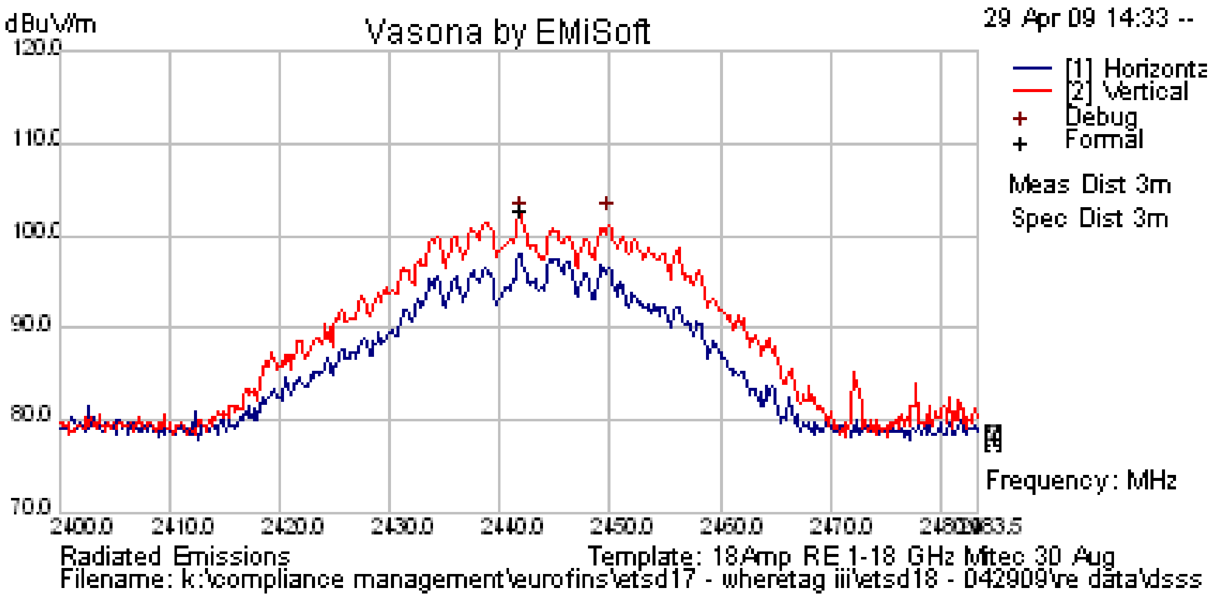
EUT parameters:

Test Mode 1 for DSSS: normal 56-bit message that repeats forever; 12V DC; DSSS frequency = 2441.75 MHz; Power Level = 3; Nominal (14.04 dBm); 100% Duty Cycle

TABLE OF RESULTS – +12 Vdc

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB
2449.7	57.0	12.98	32.37	102.35	Peak	V	100	10	--	--
	Peak Emissions = 102.35 dBuV/m									

DSSS Channel 2441.75 MHz Peak Emission

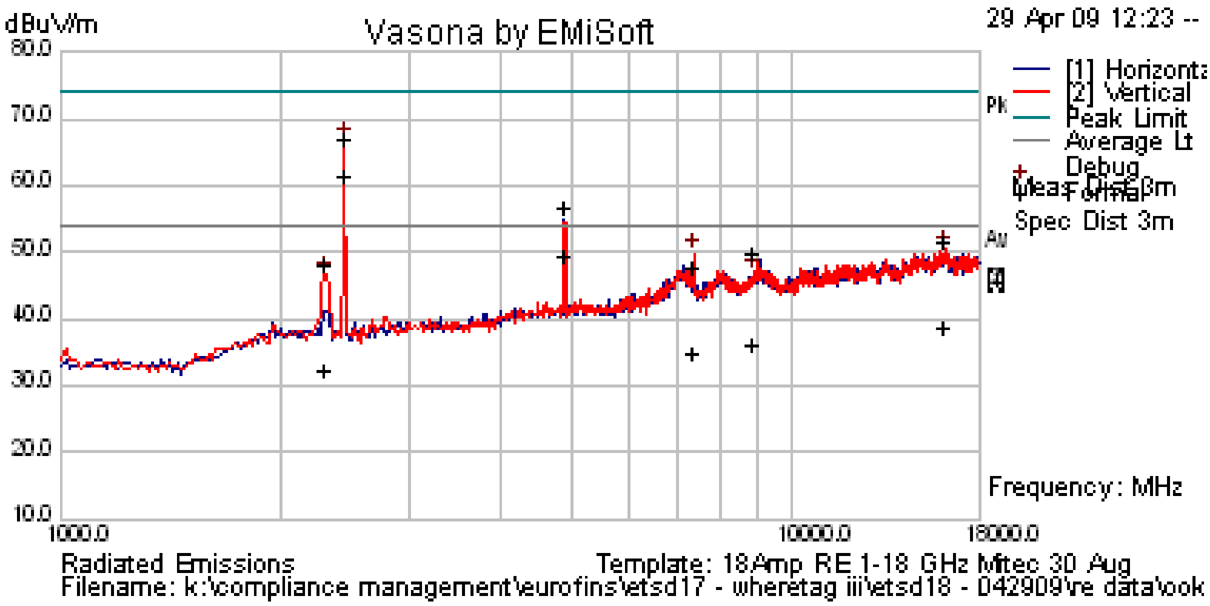


OOK EUT parameters:

Test Mode 2 for OOK: normal transmit message that repeats forever; 12V DC; OOK frequency = 2446.5 MHz; P Power Level = 3; Nominal (14.04 dBm)

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB	PASS/ FAIL
2309.654	40.11	2.91	-10.52	32.5	Average Max	V	98	192	54	-21.5	Pass
2309.654	55.86	2.91	-10.52	48.25	Peak Max	V	98	192	74	-25.75	Pass
2446.472	68.95	2.98	-10.57	61.35	Average Max	V	98	99	--	--	FUND
2446.472	74.54	2.98	-10.57	66.94	Peak Max	V	98	99	--	--	FUND
4892.841	53.52	4.53	-8.73	49.32	Average Max	H	99	0	54	-4.68	Pass
4892.841	60.8	4.53	-8.73	56.6	Peak Max	H	99	0	74	-17.4	Pass
7336.673	45.16	5.45	-2.97	47.64	Peak Max	V	142	233	74	-26.36	Pass
7336.673	32.32	5.45	-2.97	34.8	Average Max	V	142	233	54	-19.2	Pass
8891.725	31.01	6.14	-0.77	36.38	Average Max	V	111	143	54	-17.62	Pass
8891.725	44.49	6.14	-0.77	49.87	Peak Max	H	139	136	74	-24.13	Pass
16160.32	30.22	8.96	-0.47	38.71	Average Max	V	134	332	54	-15.29	Pass
16160.32	43.12	8.96	-0.47	51.61	Peak Max	H	143	49	74	-22.39	Pass

OOK Channel 2446.5 MHz Radiated Emissions



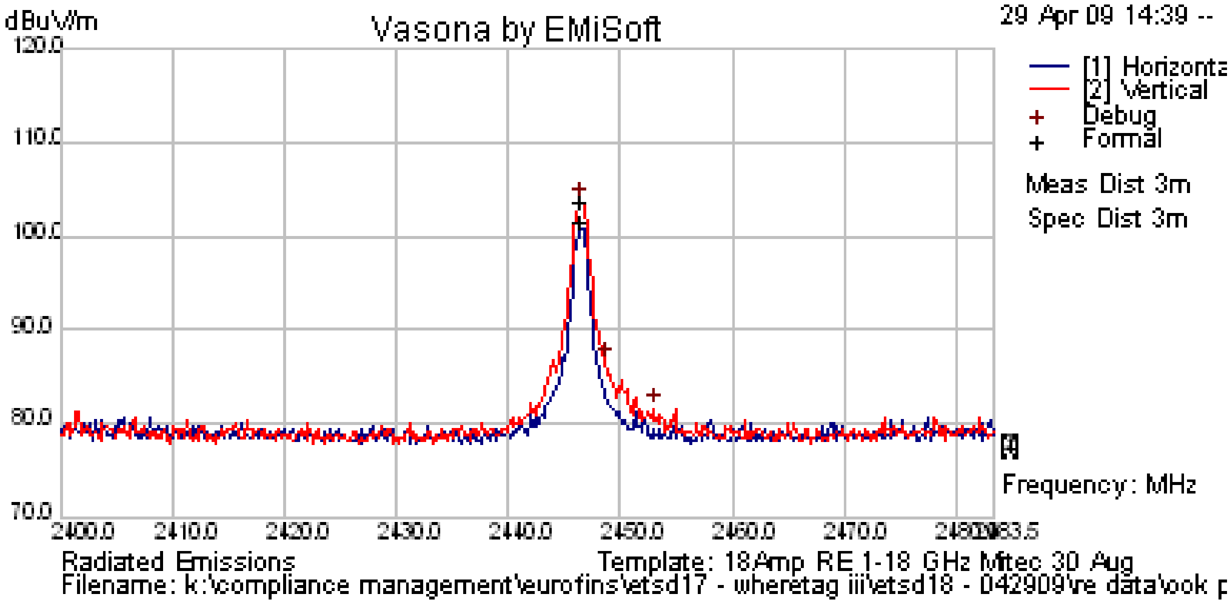
OOK EUT parameters:

Test Mode 2 for OOK: normal transmit message that repeats forever; 12V DC; OOK frequency = 2446.5 MHz; Power Level = 3; Nominal (14.04 dBm)

TABLE OF RESULTS – +12 Vdc

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB
2446.448	58.4	12.98	32.37	103.7	Peak	V	100	0	--	--
	Peak Emissions = 103.7 dBuV/m									

OOK Channel 2446.5 MHz Peak Emission



Specification Limits

FCC §15.247(d) and RSS-210 §A8.5 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 radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

FCC §15.247(d)
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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section §15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(a)).

IC RSS-210 §A8.5 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Tables 2 and 3 is not required. In addition, radiated emissions which fall in the restricted bands of Table 1 must also comply with the radiated emission limits specified in Tables 2 and 3.

IC RSS-Gen §4.7
The search for unwanted emissions shall be from the lowest frequency internally generated or used in the device (local oscillator, intermediate of carrier frequency), or from 30 MHz , whichever is the lowest frequency, to the 5^{th} harmonic of the highest frequency generated without exceeding 40 GHz.

FCC §15.205 (a) Except as shown in paragraph (d) of 15.205 (a), only spurious emissions are permitted in any of the frequency bands listed.

FCC §15.205 (a) Except as shown in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

FCC §15.209 (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 (μV/m)	Field Strength (dBμV/m)	Measurement Distance (meters)
30-88	100	40.0	3
88-216	150	43.5	3
216-960	200	46.0	3
Above 960	500	54.0	3

Laboratory Measurement Uncertainty for Radiated Emissions

Measurement uncertainty	+5.6/ -4.5 dB

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-03 'Measurement of Radiated Emissions'	0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312

5.1.6.2. Receiver Radiated Spurious Emissions (above 1 GHz)

Receiver Radiated Spurious Emissions (above 1 GHz) Not Tested.

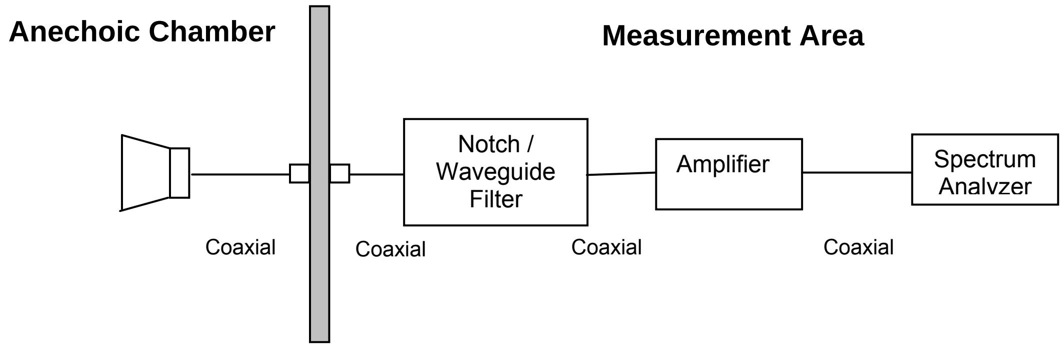
Industry Canada RSS-Gen §4.8, §6

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.

Test Measurement Set up



Measurement set up for Radiated Emission Test

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

Specification

Receiver Radiated Spurious Emissions

Industry Canada RSS-Gen §4.8,
The search for spurious emissions shall be from the lowest frequency internally generated or used in the receiver (e.g. local oscillator, intermediate or carrier frequency), or 30 MHz, whichever is the higher, to at least 3 times the highest tunable or local oscillator frequency, whichever is the higher, without exceeding 40 GHz.

RSS-Gen §6
The following receiver spurious emission limits shall be complied with;

a. If a radiated measurement is made, all spurious emissions hall comply with the limits of Table 1.

Frequency (MHz)	Field Strength (μV/m)	Field Strength (dBμV/m)	Measurement Distance (meters)
30-88	100	40.0	3
88-216	150	43.5	3
216-960	200	46.0	3
Above 960	500	54.0	3

Laboratory Measurement Uncertainty for Radiated Emissions

Measurement uncertainty	+5.6/ -4.5 dB

Traceability

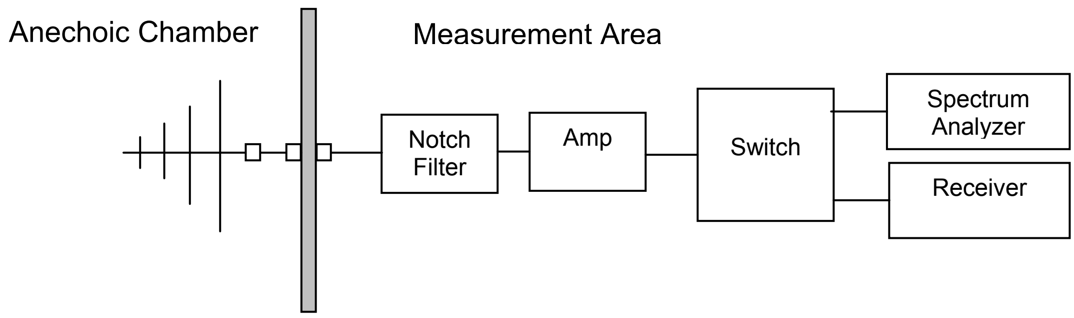
Method	Test Equipment Used
Measurements were made per work instruction WI-03 ‘Measurement of Radiated Emissions’	0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312

5.1.6.3. Radiated Spurious Emissions (30M - 1GHz)

FCC, Part 15 Subpart C §15.205/ §15.209
Industry Canada RSS-210 §2.2

Test Procedure
Preliminary radiated emissions are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarity. The emissions are recorded with a spectrum analyzer in peak hold mode. Emissions closest to the limits are measured in the quasi-peak mode with a CISPR compliant receiver. Only the highest emissions relative to the limit are listed.

Test Measurement Set up



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 51.5dBμV; 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 = 36.3dBμV/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 = 100μV/m
48 dBμV/m = 250μV/m

During the radiated emission test a linear power supply was used to power the device under test. Voltage delivered to the device was +12 Vdc.

Measurement Results for Spurious Emissions (30 MHz – 1 GHz)

Ambient conditions.
Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

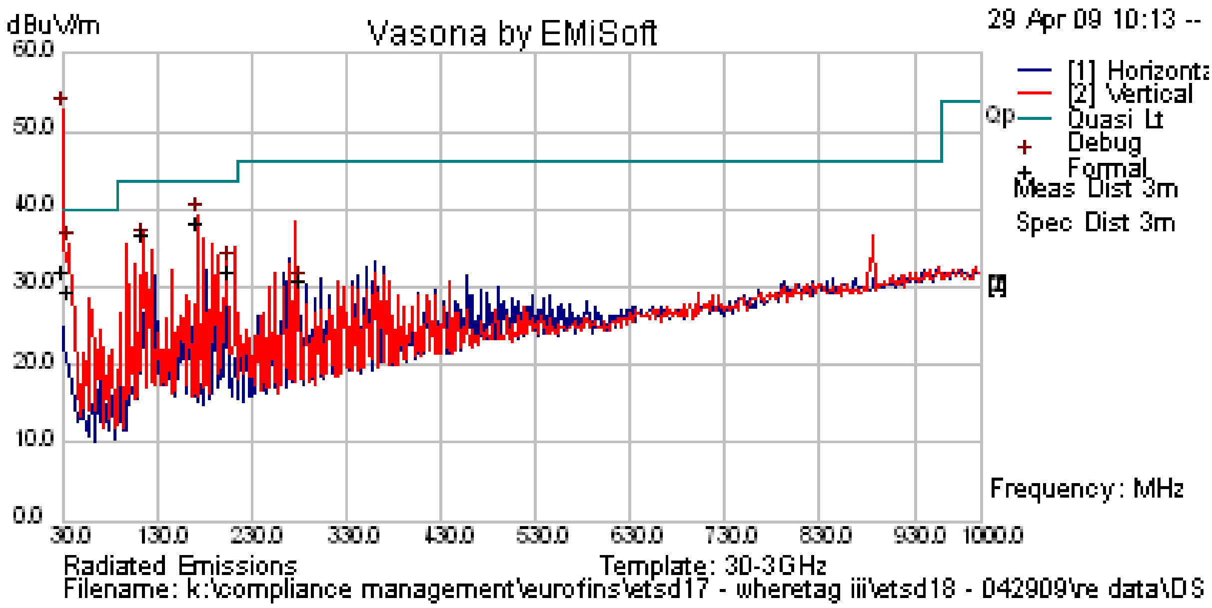
DSSS EUT parameters:

Test Mode 1 for DSSS: normal 56-bit message that repeats forever; 12V DC; DSSS frequency = 2441.75 MHz; Power Level = 3; Nominal (14.04 dBm); 100% Duty Cycle

TABLE OF RESULTS – +12 Vdc

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB	PASS/ FAIL
30.509	38.56	3.38	-10.02	31.93	Quasi Max	V	149	228	40	-8.07	Pass
171.992	52.99	4.6	-19.26	38.34	Quasi Max	V	147	7	43.5	-5.16	Pass
35.983	40.13	3.5	-14.37	29.25	Quasi Max	V	103	352	40	-10.75	Pass
115.987	50.22	4.27	-17.61	36.88	Quasi Max	V	98	25	43.5	-6.62	Pass
203.995	46.34	4.77	-19.06	32.06	Quasi Max	V	98	354	43.5	-11.44	Pass
279.996	42.9	5.11	-17.15	30.86	Quasi Max	H	101	267	46	-15.14	Pass

Radiated Spurious Emissions 30 MHz to 1 GHz



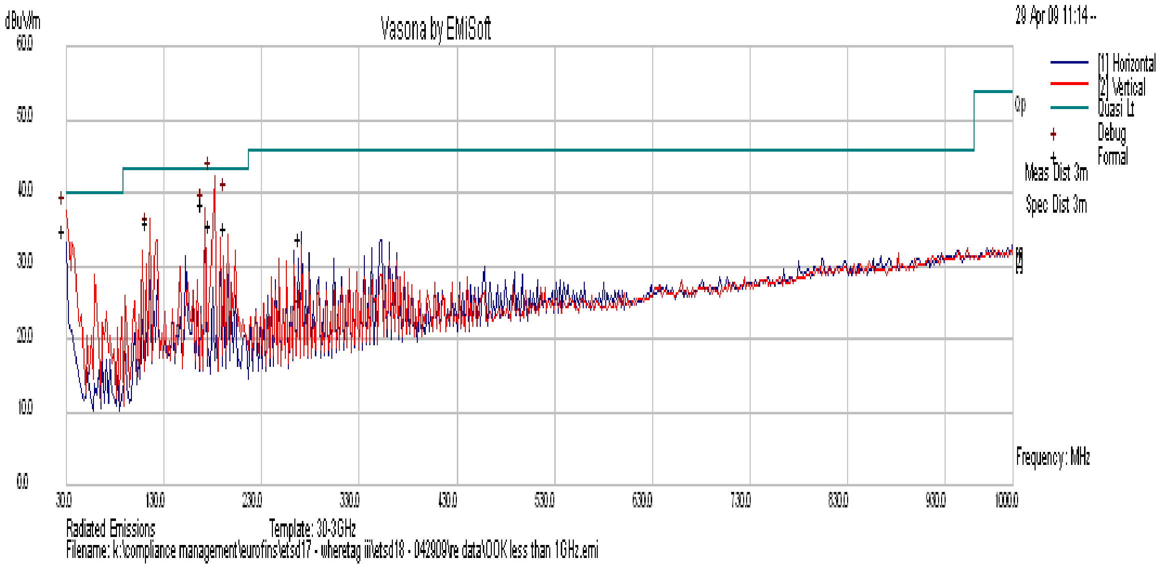
OOK EUT parameters:

Test Mode 2 for OOK: normal transmit message that repeats forever; 12V DC; OOK frequency = 2446.5 MHz; Power Level = 3; Nominal (14.04 dBm)

TABLE OF RESULTS – +12 VDC

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB	PASS/ FAIL
179.991	50.73	4.65	-19.6	35.78	Quasi Max	V	198	353	43.5	-7.72	Pass
30.51	41.36	3.38	-10.02	34.73	Quasi Max	V	108	298	40	-5.27	Pass
195.987	48.61	4.73	-18.18	35.16	Quasi Max	V	166	355	43.5	-8.34	Pass
171.984	52.99	4.6	-19.26	38.33	Quasi Max	V	211	38	43.5	-5.17	Pass
115.984	49.45	4.27	-17.61	36.11	Quasi Max	V	106	0	43.5	-7.39	Pass
271.982	45.95	5.07	-17.28	33.75	Quasi Max	H	113	123	46	-12.25	Pass

Radiated Spurious Emissions 30 MHz to 1 GHz



Specification

Limits

§15.205 (a) Except as shown in paragraph (d) of 15.205 (a), only spurious emissions are permitted in any of the frequency bands listed.

§15.205 (a) Except as shown in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (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.

§15.209 (a) and **RSS-Gen §2.2** Limit Matrix

Frequency(MHz)	Field Strength (μV/m)	Field Strength (dBμV/m)	Measurement Distance (meters)
30-88	100	40.0	3
88-216	150	43.5	3
216-960	200	46.0	3
Above 960	500	54.0	3

Laboratory Measurement Uncertainty for Radiated Emissions

Measurement uncertainty	+5.6/ -4.5 dB

Traceability

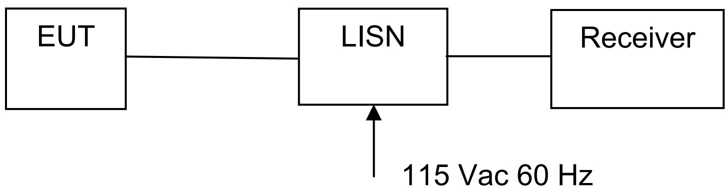
Method	Test Equipment Used
Measurements were made per work instruction WI-03 ‘Measurement of Radiated Emissions’	0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312

5.1.7. AC Wireline Conducted Emissions (150 kHz – 30 MHz)

FCC, Part 15 Subpart C §15.207
Industry Canada RSS-Gen §7.2.2

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.

Test Measurement Set up



Measurement set up for AC Wireline Conducted Emissions Test

Measurement Results for AC Wireline Conducted Emissions (150 kHz – 30 MHz)

D.C. operated Device; No test required.

Specification

Limit

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator 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 μΩ line impedance stabilization network (LISN), see §15.207 (a) matrix below. 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.

RSS-Gen §7.2.2
The radio frequency voltage that is conducted back into the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in the table below. The tighter limit applies at the frequency range boundaries.

§15.207 (a) and **RSS-Gen §7.2.2** Limit Matrix
The lower limit applies at the boundary between frequency ranges

Frequency of Emission (MHz)	Conducted Limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency

Laboratory Measurement Uncertainty for Conducted Emissions

Measurement uncertainty	±2.64 dB

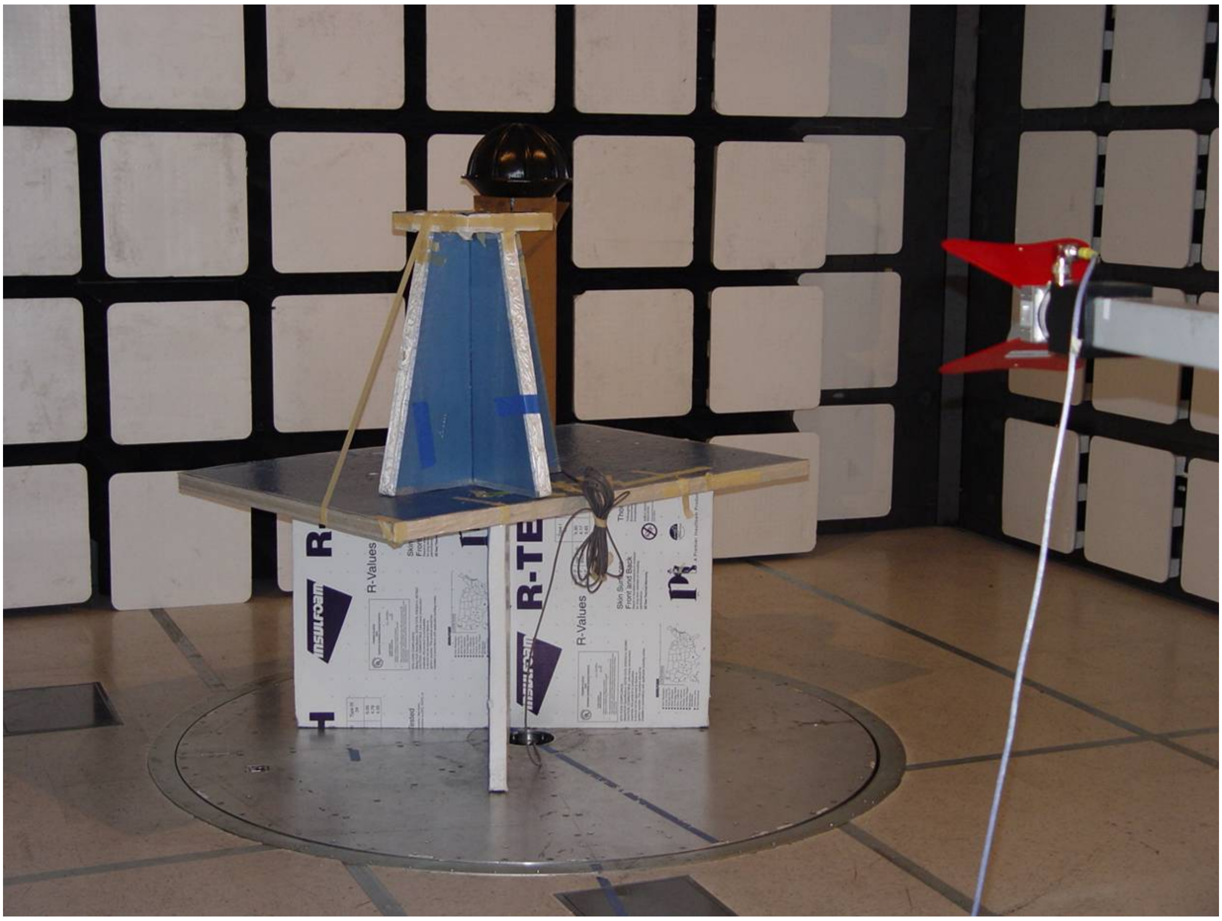
Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-EMC-01 'Measurement of Conducted Emissions'	0158, 0184, 0193, 0190, 0293, 0307

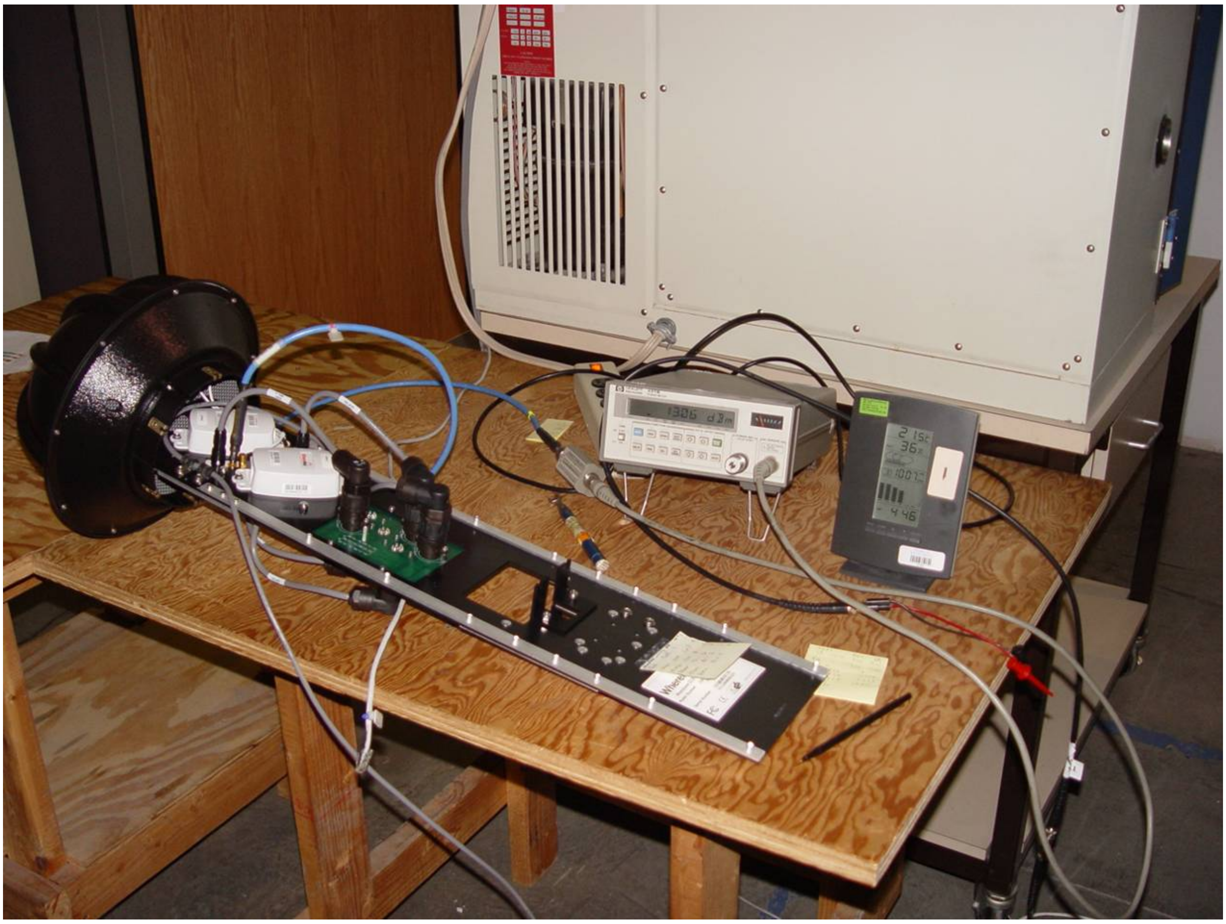
6. PHOTOGRAPHS

6.1. Radiated Emissions ≤ 1 GHz

6.2. Radiated Emissions ≥ 1 GHz



6.3. Conducted Power Measurement Test Set-Up



7. TEST EQUIPMENT DETAILS

Asset #	Instrument	Manufacturer	Part #	Serial #
0088	Spectrum Analyzer	Hewlett Packard	8564E	3410A00141
0104	1-18GHz Horn Antenna	The Electro-Mechanics Company	3115	9205-3882
0134	Amplifier	Com Power	PA 122	181910
0158	Barometer /Thermometer	Control Co.	4196	E2846
0193	EMI Receiver	Rhode & Schwartz	ESI 7	838496/007
0252	SMA Cable	Megaphase	Sucoflex 104	None
0304	2.4GHzHz Notch Filter	Micro-Tronics	--	001
0310	2m SMA Cable	Micro-Coax	UFA210A-0-0787-3G03G0	209089-001
0312	3m SMA Cable	Micro-Coax	UFA210A-1-1181-3G0300	209092-001
0313	Coupler	Hewlett Packard	86205A	3140A01285
0314	30dB N-Type Attenuator	ARRA	N9444-30	1623
0070	Power Meter	Hewlett Packard	437B	3125U11552
0116	Power Sensor	Hewlett Packard	8485A	3318A19694
0117	Power Sensor	Hewlett Packard	8487D	3318A00371
0184	Pulse Limiter	Rhode & Schwartz	ESH3Z2	357.8810.52
0190	LISN	Rhode & Schwartz	ESH3Z5	836679/006
0293	BNC Cable	Megaphase	1689 1GVT4	15F50B001
0307	BNC Cable	Megaphase	1689 1GVT4	15F50B002

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