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Submittal Application Report

for
Grant of Certification

Model: 02-0084-10
2405-2470 MHz
Broadband Digital Transmission System
FCC ID: 2ABOY-02008410
IC: 12222A-02008410

FOR

Elecsys International Corporation

846 N Mart-Way Court
Olathe, KS 66061

Test Report Number: 180820
FCC Site Registration: US5305
IC Test Site Registration: 3041A-1

Authorized Signatory: Scot D Rogers
Scot D. Rogers

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Testing
NVLAP Lab Code 200087-0

ROGERS LABS, INC.

4405 West 259th Terrace
Louisburg, KS 66053
Phone / Fax (913) 837-3214

Engineering Test Report for Grant of Certification Application

FOR

Broadband Digital Transmission System CFR 47, PART 15C - Paragraph 15.247 Industry Canada RSS-247 Issue 2

License Exempt Intentional Radiator

For

Elecsys International Corporation

846 N Mart-Way Court
Olathe, KS 66061

Broadband Digital Transmission System

Model: 02-0084-10
Frequency Range 2405-2470 MHz
FCC: 2ABOY-02008410
IC: 12222A-02008410

Test Date: August 20, 2018

Certifying Engineer: Scot D Rogers

Scot D. Rogers
Rogers Labs, Inc.
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Louisburg, KS 66053
Telephone/Facsimile: (913) 837-3214

Table of Contents

Revisions

Revision 1 Issued September 17, 2018

Forward

The following information is submitted for consideration in obtaining Grant of Certification for License Exempt Digital Transmission System Intentional Radiator operating under 47 CFR Paragraph 15.247 and RSS-247 Issue 2 Digital Modulation transmitter module operation in the 2405-2470 MHz band.

Name of Applicant: Elecsys International Corporation FRN: 0019011998
846 N Mart-Way Court
Olathe, KS 66061

Model: 02-0084-10

FCC ID: 2ABOY-02008410 IC: 12222A-02008410

Frequency Range: 2405-2470 MHz

Operating Power: Peak power 0.120 Watts, 99% OBW 2,500.0 kHz

Opinion / Interpretation of Results

Tests Performed	Margin (dB)	Results
Restricted Frequency Bands 15.205, RSS-GEN 8.10	-8.7	Complies
AC Line Conducted 15.207, RSS-GEN 7.2.4	-31.5	Complies
Radiated Emissions 15.209, RSS-GEN 7.2.5	-11.1	Complies
Harmonic Emissions per 15.247, RSS-247	-4.4	Complies
Peak Power Spectral Density per 15.247, RSS-247	-1.3	Complies

Equipment Tested

Equipment	Model	Serial Number	FCC I.D.
EUT	02-0084-10	ENG11	2ABOY-02008410
Dev Board	Dev Board	Dev1	N/A
DC Supply	BK1670A	N96131 3540	N/A
Dell Studio XPS	921LBN1	N/A	N/A

Test results in this report relate only to the items tested.

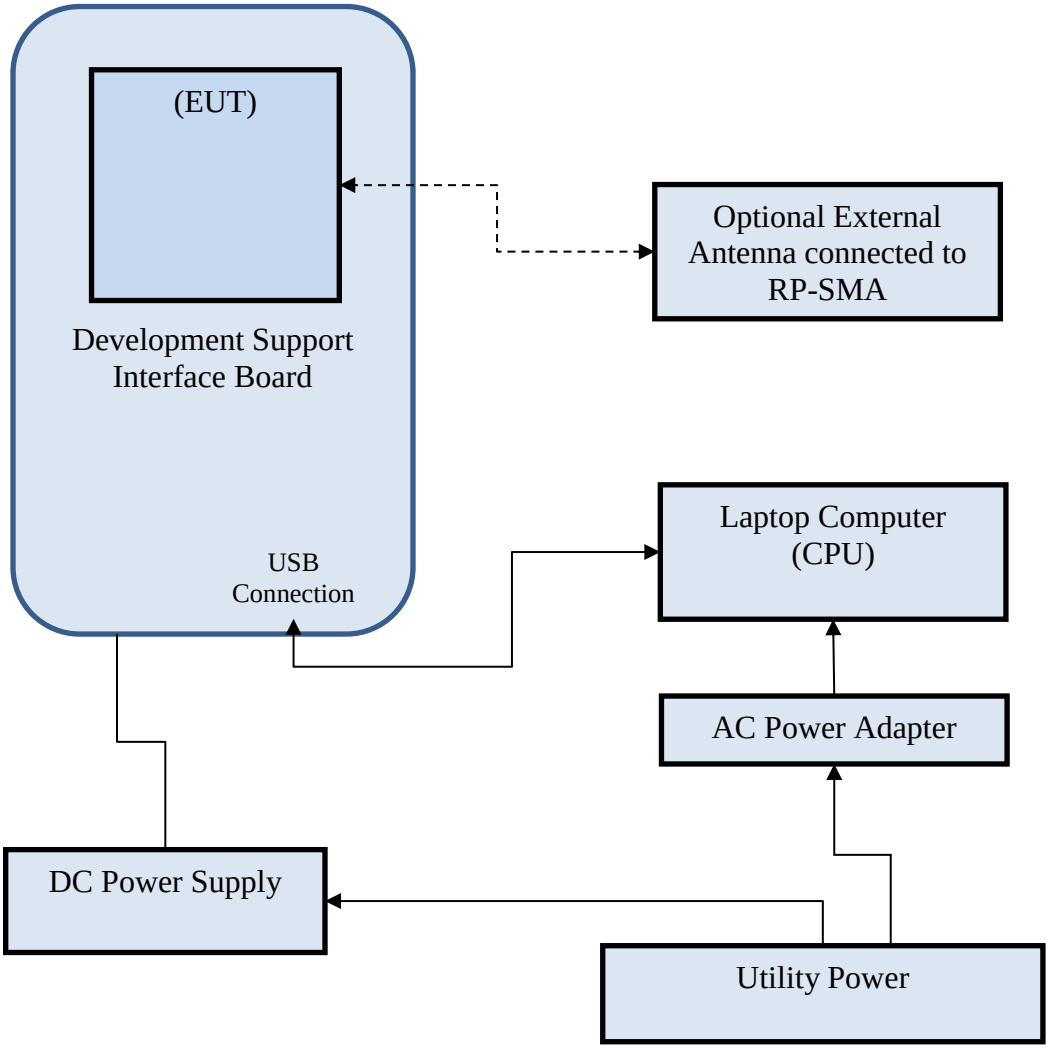
Equipment Function and Configuration

The EUT is a 2405-2470 MHz Digital Transmission System modem module for incorporation into industrial system monitoring equipment. The design provides communications between compatible IEEE 802.15.4 equipment. The design provides operational capabilities across the 2405-2470 MHz frequency band. The EUT offers broadband wireless connectivity to transmit and receive data between remote devices. The design utilizes integral surface mounted Dielectric Ceramic PIFA (1.5-dBi) antenna and provides connector for use with authorized external antenna configuration connected to reverse polarity SMA port. External antennas tested and authorized for use include a Dipole (2.3-dBi) and Omni directional (4-dBi). The EUT requires 9 Vdc power input supplied from installation system.

For testing purposes, the EUT transceiver module was placed on the manufacturer supplied development interface test board. This configuration provided power and communications to the EUT. The interface board was powered from a bench top DC power supply and connected to a laptop computer for transmitter communications and control. The laptop computer was used to communicate and send commands to the EUT module.

The design provides no other interfacing options than those presented in this report. The RP-SMA connector allowed testing of transmitter performance at the antenna port. For testing purposes, the 02-0084-10 test sample was configured to transmit pseudo random data packets at maximum rates receiving power from the support development board. As requested by the manufacturer the equipment was tested for emissions compliance using the available configurations with the worst-case data presented. Test results in this report relate only to the products described in this report.

Equipment Configuration



Applicant Company information

Applicants Company	Elecsys International Corporation (Elecsys Corporation)
Applicants Address	846 N Mart-Way Court, Olathe, KS 66061
FCC Identifier	2ABOY-02008410
Industry Canada Identifier	12222A-02008410
Manufacturer Company	Elecsys International Corporation (Elecsys Corporation)
Manufacturer Address	846 N Mart-Way Court, Olathe, KS 66061

Equipment information

Product Marketing Name (PMN): The PMN is the name or model number under which the product will be marketed/offered for sale in Canada. If the product has PMN, it must be provided.	02-0084-10
Unique Product Number (UPN): The applicant made up of a maximum of 11 alphanumeric characters (A-Z, 0-9), assigns the UPN.	12222A-02008410
Hardware Version Identification Number (HVIN): The HVIN identifies hardware specifications of a product version. The HVIN replaces the ISED Model Number in the legacy E-filing System. An HVIN is required for all products for certification applications.	02-0084-10
Host Marketing Name (HMN) (if applicable): The HMN is the name or model number of a final product, which contains a certified radio module.	
Brand Name	
Model Number	02-0084-10
Test Rule Part(s)	47 CFR Parts 15C, 15.247, and RSS-247
Test Frequency Range	2405-2470 MHz
Project Number	180820
Submission Type	Certification

Support Equipment

Support Development Interface Board	Elecsys International Corporation, Dev Board
DC Power supply	BK Precision, BK1670A
Laptop Computer	Dell model, Studio XPS

Table for Filed Antennas

Ant.	Brand	Model Name	P/N	Antenna Type	Connector	Gain (dBi)
1	Togals	2.4GHz 1.5dBi Peak Gain Dielectric Ceramic PIFA	PA.12	Integral	N/A	1.5
2	Togals	2.4GHz 2.3dBi Screw mount Dipole Antenna	GW.11.A153	Dipole	RP-SMA	2.3
3	Togals	4dBi 2.4GHz Omni-Directional	WS.-2B.205111	Omni Directional	RP-SMA	4.0

Product Details

Items	Description
Product Type	IEEE 802.15.4 2.4 GHz
Radio Type	Transceiver
Power Type	Direct Current power provided from installation system
Modulation	IEEE 802.15.4 QPSK
Frequency Range	2405-2470 MHz

Application for Certification

(1) Manufacturer: Elecsys International Corporation
846 N Mart-Way Court
Olathe, KS 66061

(2) Identification: Model: 02-0084-10
FCC I.D.: 2ABOY-02008410 IC: 12222A-02008410

(3) Instruction Book:
Refer to Exhibit for Instruction Manual.

(4) Description of Circuit Functions:
Refer to Exhibit of Operational Description.

(5) Block Diagram with Frequencies:
Refer to Exhibit of Operational Description.

(6) Report of Measurements:
Report of measurements follows in this Report.

(7) Photographs: Construction, Component Placement, etc.:
Refer to Exhibit for photographs of equipment.

(8) List of Peripheral Equipment Necessary for operation. The equipment operates from direct current power received from the installation support system. The EUT provides onboard PIFA as well as well as connection point for reverse polarity SMA connector (RP-SMA). All power and communication interfaces are availed though the onboard pin connectors. During testing, the EUT was powered from a DC power supply which powered the development board.

(9) Transition Provisions of 47 CFR 15.37 are not requested

(10) Not Applicable. The unit is not a scanning receiver.

(11) Not Applicable. The EUT does not operate in the 59 – 64 GHz frequency band.

(12) The equipment is not software defined and this section is not applicable.

(13) Applications for certification of U-NII devices in the 5.15-5.35 GHz and the 5.47-5.85 GHz bands must include a high-level operational description of the security procedures that control the radio frequency operating parameters and ensure that unauthorized modifications cannot be made. Not applicable to this filing.

(14) Contain at least one drawing or photograph showing the test set-up for each of the required types of tests applicable to the device for which certification is requested. These drawings or photographs must show enough detail to confirm other information contained in the test report. Any photographs used must be focused originals without glare or dark spots and must clearly show the test configuration used. This information is provided in this report and Test Setup Exhibits provided with the application filing.

Applicable Standards & Test Procedures

The following information is submitted in accordance e-CFR Title 47 dated August 20, 2018, Part 2, Subpart J, Paragraphs 2.907, 2.911, 2.913, 2.925, 2.926, 2.1031(b), and applicable parts of paragraph 15, Part 15C Paragraph 15.247 and Industry Canada RSS-247 Issue 2 and RSS-Gen Issue 5. Test procedures used are the established Methods of Measurement of Radio-Noise Emissions as described in ANSI C63.10-2013, KDB 558074 D01 v04, RSS-247 Issue 2, and RSS-GEN Issue 5.

Equipment Testing Procedures

AC Line Conducted Emission Test Procedure

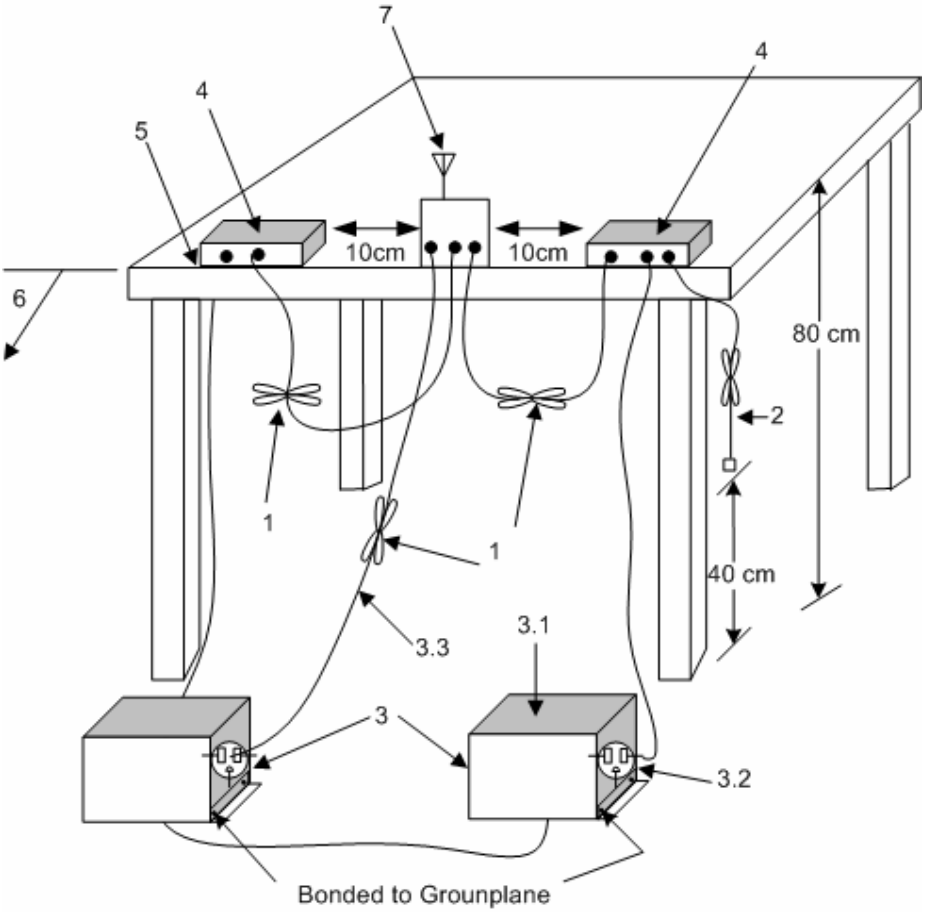
Testing for the AC line-conducted emissions was performed as defined in ANSI C63.10-2013. The test setup, including the EUT, was arranged in the test configurations as presented during testing. The test configuration was placed on a 1 x 1.5-meter wooden bench, 0.8 meters high located in a screen room. The power lines of the system were isolated from the power source using a standard LISN with a 50-µHy choke. EMI was coupled to the spectrum analyzer through a 0.1 µF capacitor internal to the LISN. The LISN was positioned on the floor beneath the wooden bench supporting the EUT. The power lines and cables were draped over the back edge of the table. Refer to diagram one showing typical test arrangement and photographs in exhibits for EUT placement used during testing.

Radiated Emission Test Procedure

Radiated emission testing was performed as required and specified in ANSI C63.10-2013 and referenced KDB documents. The EUT was placed on a rotating 0.9 x 1.2-meter platform, elevated as required above the ground plane at a distance of 3 meters from the FSM antenna. EMI energy was maximized by equipment placement, raising and lowering the FSM antenna, changing the antenna polarization, and by rotating the turntable. Each emission was maximized before data was taken using a spectrum analyzer. The frequency spectrum from 9 kHz to 25,000 MHz was searched for during preliminary investigation. Refer to diagrams two and three showing typical test arrangement and photographs in the test setup exhibits for specific EUT placement during testing.

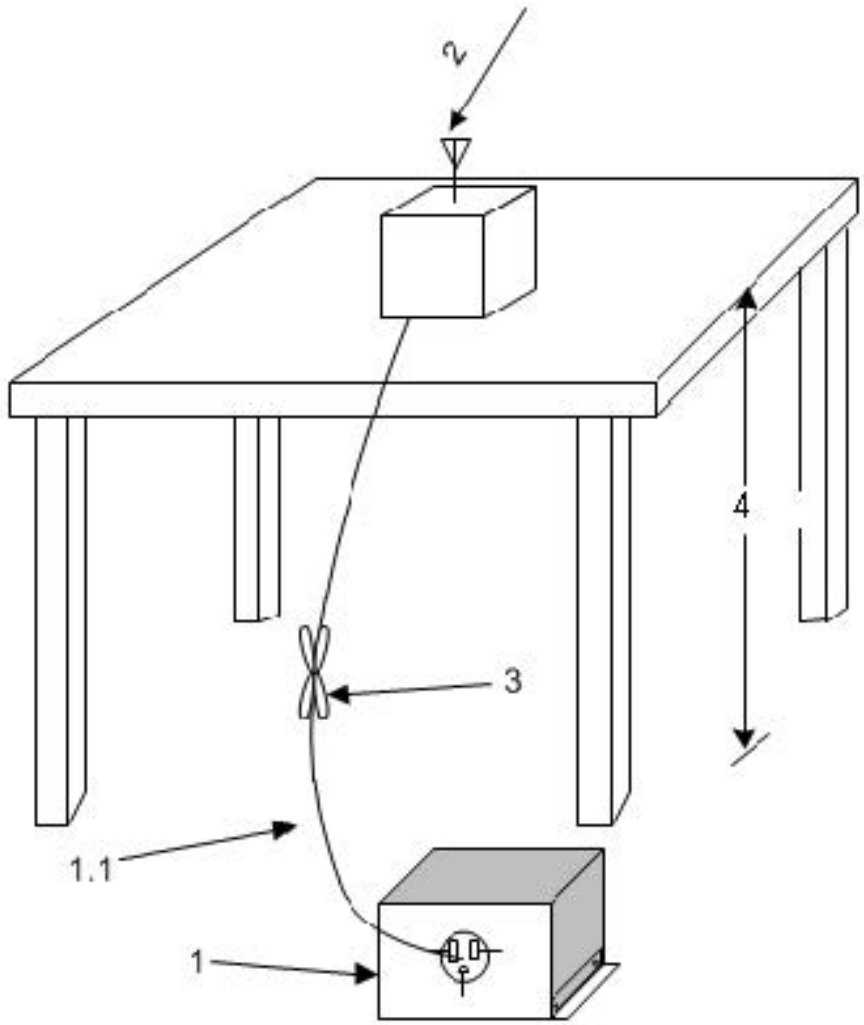
Antenna Port Conducted Emission Test Procedure

The EUT was assembled as required for operation placed on a benchtop. This configuration provided the ability to connect test equipment to the provided test antenna port Antenna Port conducted emissions testing was performed on the test sample as required in the regulations and specified in ANSI C63.10-2013. Testing was completed on a laboratory bench in a shielded room. The active antenna port of the unlicensed wireless device was connected to appropriate attenuation and the spectrum analyzer. Refer to diagram four showing typical test arrangement and photographs in the test setup exhibits for specific EUT placement during testing.



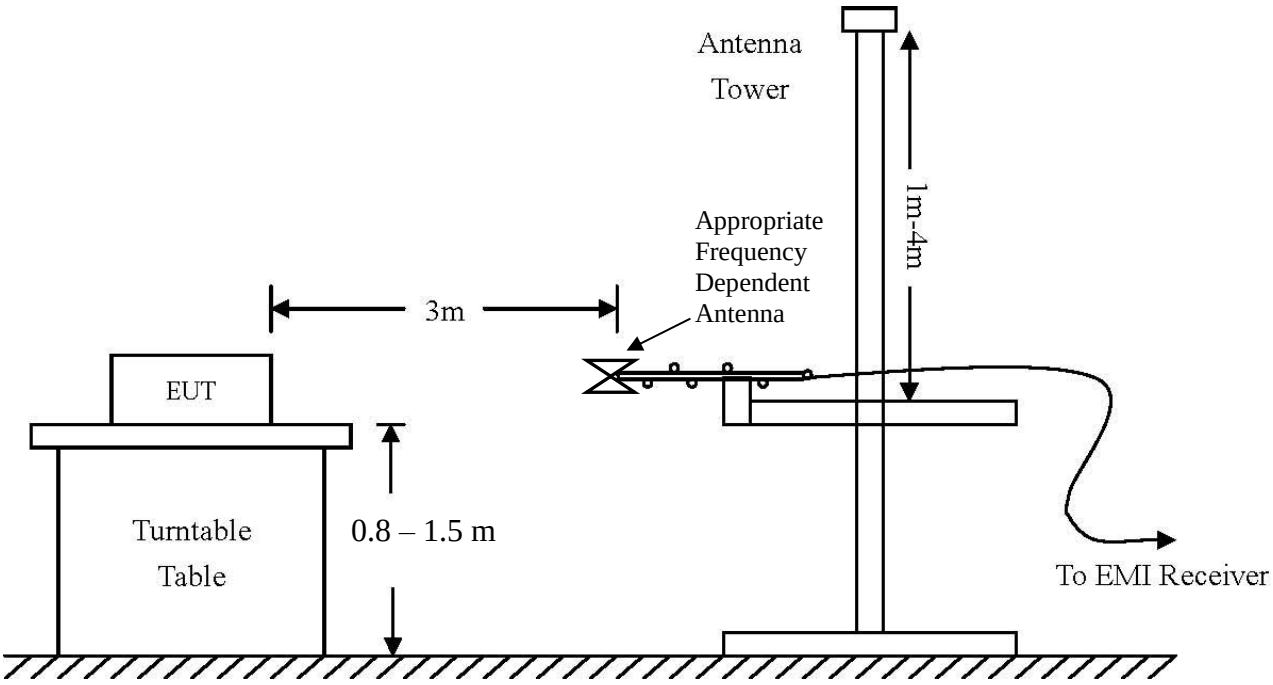
1. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 cm to 40 cm long see (see 6.2.3.2).
2. The I/O cables that are not connected to an accessory shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m (see 6.2.2).
3. EUT connected to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω loads. LISN may be placed on top of, or immediately beneath, reference ground plane (see 6.2.2 and 6.2.3).
   3.1 All other equipment powered from additional LISN(s).
   3.2 Multiple-outlet strip can be used for multiple power cords of non-EUT equipment.
   3.3 LISN at least 80 cm from nearest part of EUT chassis
4. Non-EUT components of EUT system being tested
5. Rear of EUT, including peripherals, shall all be aligned and flush with edge of tabletop (see 6.2.3.2).
6. Edge of tabletop shall be 40 cm removed from a vertical conducting plane that is bonded to the ground plane (see 6.2.2 for options).
7. Antenna may be integral or detachable. If detachable, the antenna shall be attached for this test.

Diagram 1 Test arrangement for Conducted emissions



1. A LISN is optional for radiated measurements between 30 MHz and 1000 MHz but not allowed for measurements below 30 MHz and above 1000 MHz (see 6.3.1). If used, then connect EUT to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω loads. The LISN may be placed on top of, or immediately beneath, the reference ground plane (see 6.2.2 and 6.2.3.2).
   1.1 LISN spaced at least 80 cm from nearest part of EUT chassis.
2. Antenna can be integral or detachable, depending on the EUT (see 6.3.1).
3. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 cm to 40 cm long (see 6.3.1).
4. For emission measurements at or below 1 GHz, the table height shall be 80 cm. For emission measurements above 1 GHz, the table height shall be 1.5 m for measurements, except as otherwise specified (see 6.3.1 and 6.6.3.1).

Diagram 2 Test arrangement for radiated emissions of tabletop equipment



Frequency: 9 kHz-30 MHz	Frequency: 30 MHz- 1 GHZ	Frequency: Above 1 GHz
Loop Antenna	Broadband Biconilog	Horn
RBW = 9 kHz	RBW = 120 kHz	RBW = 1 MHz
VBW = 30 kHz	VBW = 120 kHz	VBW = 1 MHz
Sweep time = Auto	Sweep time = Auto	Sweep time = Auto
Detector = PK, QP	Detector = PK, QP	Detector = PK, AV
Antenna Height 1m	Antenna Height 1-4m	Antenna Height 1-4m

Diagram 3 Test arrangement for radiated emissions tested on Open Area Test Site (OATS)

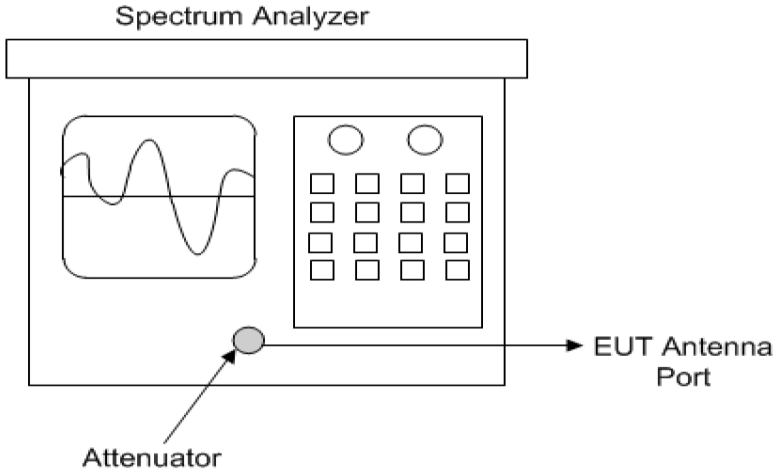


Diagram 4 Test arrangement for Antenna Port Conducted emissions

List of Test Equipment

Equipment	Manufacturer	Model (SN)	Band	Cal Date(m/d/y)	Due
☒ LISN	FCC	FCC-LISN-50-2-10(1PA) (160611)	.15-30MHz	5/2/2018	5/2/2019
☐ LISN	Compliance Design	FCC-LISN-2.Mod.cd,	.15-30MHz	10/24/2017	10/24/2018
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(303073)	9kHz-40 GHz	10/24/2017	10/24/2018
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303069)	9kHz-40 GHz	10/24/2017	10/24/2018
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303071)	9kHz-40 GHz	10/24/2017	10/24/2018
☒ Cable	Belden	RG-58 (L1-CAT3-11509)	9kHz-30 MHz	10/24/2017	10/24/2018
☒ Cable	Belden	RG-58 (L2-CAT3-11509)	9kHz-30 MHz	10/24/2017	10/24/2018
☐ Antenna	ARA	BCD-235-B (169)	20-350MHz	10/24/2017	10/24/2018
☐ Antenna	EMCO	3147 (40582)	200-1000MHz	10/24/2017	10/24/2018
☒ Antenna	ETS-Lindgren	3117 (200389)	1-18 GHz	5/2/2018	5/2/2020
☐ Antenna	Com Power	AH-118 (10110)	1-18 GHz	10/24/2017	10/24/2019
☒ Antenna	Com Power	AH-840 (101046)	18-40 GHz	5/15/2017	5/15/2019
☒ Antenna	Com Power	AL-130 (121055)	.001-30 MHz	10/24/2017	10/24/2018
☒ Antenna	Sunol	JB-6 (A100709)	30-1000 MHz	10/24/2017	10/24/2018
☒ Analyzer	Rohde & Schwarz	ESU40 (100108)	20Hz-40GHz	5/2/2018	5/2/2019
☐ Analyzer	Rohde & Schwarz	ESW44 (101534)	20Hz-44GHz	12/22/2017	12/22/2018
☐ Analyzer	Rohde & Schwarz	FS-Z60, 90, 140, and 220	40GHz-220GHz	12/22/2017	12/22/2019
☐ Analyzer	HP	8591EM (3628A00871)	9kHz-1.8GHz	5/2/2018	5/2/2019
☐ Analyzer	HP	8562A (3051A05950)	9kHz-125GHz	5/2/2018	5/2/2019
☐ Analyzer	HP External Mixers	11571, 11970	25GHz-110GHz	5/2/2018	5/2/2019
☒ Amplifier	Com-Power	PA-010 (171003)	100Hz-30MHz	10/24/2017	10/24/2018
☒ Amplifier	Com-Power	CPPA-102 (01254)	1-1000 MHz	10/24/2017	10/24/2018
☒ Amplifier	Com-Power	PAM-118A (551014)	0.5-18 GHz	10/24/2017	10/24/2018
☒ Power Meter	Agilent	N1911A with N1921A	0.05-40 GHz	5/2/2018	5/2/2019
☐ Generator	Rohde & Schwarz	SMB100A6 (100150)	20Hz-6 GHz	5/2/2018	5/2/2019
☐ Generator	Rohde & Schwarz	SMBV100A6 (260771)	20Hz-6 GHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	BRC50722 (009).9G notch	30-1800 MHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	HPM50114 (017)1.5G HPF	30-18000 MHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	HPM50117 (063) 3G HPF	30-18000 MHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	HPM50105 (059) 6G HPF	30-18000 MHz	5/2/2018	5/2/2019
☒ RF Filter	Micro-Tronics	BRM50702 (172) 2G notch	30-1800 MHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	BRC50703 (G102) 5G notch	30-1800 MHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	BRC50705 (024) 5G notch	30-1800 MHz	5/2/2018	5/2/2019
☐ RF Filter	Micro-Tronics	BRC17663 (001) 9G notch	30-1800 MHz	5/2/2018	5/2/2019
☐ Attenuator	Fairview	SA6NFNF100W-14 (1625)	30-1800 MHz	5/2/2018	5/2/2019
☒ Attenuator	Mini-Circuits	VAT-3W2+ (1735)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1436)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	Mini-Circuits	VAT-3W2+ (14362)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1445)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	Mini-Circuits	VAT-3W2+ (14452)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	Mini-Circuits	VAT-6W2+ (1438)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	Mini-Circuits	VAT-6W2+ (1736)	30-6000 MHz	5/2/2018	5/2/2019
☐ Attenuator	JFW Industries	50FH-010-10 (1)	30-18000 MHz	5/2/2018	5/2/2019
☒ Weather station	Davis	6312 (A70927D44N)		10/24/2017	10/24/2018

Test Site Locations

Conducted EMI	AC power line conducted emissions testing was performed in a shielded screen room located at Rogers Labs, Inc., Louisburg, KS
Radiated EMI	The radiated emissions tests were performed at the 3 meters, Open Area Test Site (OATS) located at Rogers Labs, Inc., Louisburg, KS
Site Registration	FCC Site Designation US5305, Industry Canada Registration: 3041A-1
Accreditation	NVLAP Accreditation Lab Code 200087-0

Units of Measurements

Conducted EMI	Data is in dBµV; dB referenced to one microvolt
Radiated EMI	Data is in dBµV/m; dB/m referenced to one microvolt per meter

Sample Calculation:

RFS = Radiated Field Strength, FSM = Field Strength Measured
A.F. = Receive antenna factor, Gain = amplification gains and/or cable losses
RFS (dBµV/m @ 3m) = FSM (dBµV) + A.F. (dB) - Gain (dB)

Environmental Conditions

Ambient Temperature	23.3° C
Relative Humidity	43%
Atmospheric Pressure	1007.1 mb

Intentional Radiators

As per 47 CFR part 15 subpart C, and Industry Canada RSS-247, Issue 2, the following information is submitted for consideration and demonstration of compliance with regulation and standards.

Antenna Requirements

The EUT provides on board SMT PIFA antenna as well as reverse polarity SMA (RP-SMA) connector for use with authorized antennas as documented in this application. The antenna complies with the unique antenna connection requirements. The requirements of 15.203 are fulfilled there are no deviations or exceptions to the specification.

Restricted Bands of Operation

Spurious emissions falling in the restricted frequency bands of operation were measured at the on the OATS. The EUT utilizes frequency, determining circuitry, which generates harmonics falling in restricted bands. Emissions were investigated at the antenna port and OATS, using appropriate antennas or pyramidal horns, amplification stages, and spectrum analyzer. Peak and average amplitudes of frequencies above 1000 MHz were compared to the required limits with worst-case data presented below. Test procedures of ANSI C63.10-2013 were used during testing. No other significant emission was observed which fell into the restricted bands of operation. Computed radiated emission values account for measured radiated field strength, receive antenna correction factor, amplifier gain stage, and test system cable losses.

Table 1 General Radiated Emissions in Restricted Bands Data (PIFA worst-case)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
2390.0	71.0	N/A	37.9	66.5	N/A	35.0	54.0
2483.5	68.4	N/A	40.6	67.2	N/A	37.4	54.0
4810.0	49.8	N/A	35.2	47.4	N/A	34.4	54.0
4880.0	50.1	N/A	35.6	47.8	N/A	34.6	54.0
4940.0	52.8	N/A	36.1	50.0	N/A	34.8	54.0
7215.0	50.9	N/A	38.0	50.4	N/A	37.9	54.0
7320.0	51.5	N/A	38.6	51.7	N/A	38.7	54.0
7410.0	51.1	N/A	38.2	51.4	N/A	38.2	54.0
12025.0	57.3	N/A	44.2	56.9	N/A	43.9	54.0
12200.0	58.0	N/A	45.1	58.3	N/A	45.1	54.0
12350.0	58.3	N/A	45.3	58.5	N/A	45.2	54.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Table 2 General Radiated Emissions in Restricted Bands Data (Dipole worst-case)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
2390.0	61.6	N/A	34.1	72.0	N/A	38.6	54.0
2483.5	54.5	N/A	36.0	60.2	N/A	38.6	54.0
4810.0	48.4	N/A	34.7	47.1	N/A	34.4	54.0
4880.0	48.2	N/A	34.8	47.8	N/A	34.7	54.0
4940.0	47.7	N/A	34.6	49.4	N/A	35.2	54.0
7215.0	51.9	N/A	38.4	50.5	N/A	38.0	54.0
7320.0	51.5	N/A	38.7	52.1	N/A	38.8	54.0
7410.0	51.4	N/A	38.3	51.2	N/A	38.3	54.0
12025.0	57.5	N/A	44.0	57.1	N/A	43.9	54.0
12200.0	58.0	N/A	45.1	57.6	N/A	45.1	54.0
12350.0	58.3	N/A	45.1	58.2	N/A	45.1	54.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Table 3 General Radiated Emissions in Restricted Bands Data (Omni worst-case)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
2390.0	61.6	N/A	37.8	70.8	N/A	37.3	54.0
2483.5	54.5	N/A	38.2	59.1	N/A	37.8	54.0
4810.0	48.4	N/A	34.2	49.3	N/A	34.8	54.0
4880.0	48.2	N/A	34.3	49.3	N/A	34.8	54.0
4940.0	47.7	N/A	34.6	47.6	N/A	34.7	54.0
7215.0	51.9	N/A	38.2	51.0	N/A	38.1	54.0
7320.0	51.5	N/A	38.7	51.4	N/A	38.7	54.0
7410.0	51.4	N/A	38.9	51.5	N/A	38.3	54.0
12025.0	57.5	N/A	44.3	56.3	N/A	44.1	54.0
12200.0	58.0	N/A	45.1	58.4	N/A	45.1	54.0
12350.0	58.3	N/A	45.2	57.6	N/A	45.2	54.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Summary of Results for Radiated Emissions in Restricted Bands

The EUT demonstrated compliance with the emissions requirements of 47 CFR 15.205, RSS-GEN and RSS-247, Issue 2 Intentional Radiators. The EUT provided a worst-case minimum margin of -8.7 dB below the emissions requirements in restricted frequency bands. Peak, Quasi-peak, and average amplitudes were checked for compliance with the regulations. Worst-case emissions are reported with other emissions found in the restricted frequency bands at least 20 dB below the requirements.

AC Line Conducted Emissions Procedure

The EUT was arranged in a typical equipment configuration and placed on a 1 x 1.5-meter wooden bench 80 cm above the conducting ground plane, floor of a screen room. The bench was positioned 40 cm away from the wall of the screen room. The LISN was positioned on the floor of the screen room 80-cm from the rear of the EUT. The manufacturer supplied AC/DC adapter was connected to the LISN and provided direct current power to the unit or POE and powered the test sample. A second LISN was positioned on the floor of the screen room 80-cm from the rear of the supporting equipment of the EUT. All power cords except the power supply providing power to the EUT were then powered from the second LISN. EMI was coupled to the spectrum analyzer through a 0.1 μf capacitor, internal to the LISN. Power line conducted emissions testing were carried out individually for each current carrying conductor of the EUT. The excess length of lead between the system and the LISN receptacle was folded back and forth to form a bundle not exceeding 40 cm in length. The screen room, conducting ground plane, analyzer, and LISN were bonded together to the protective earth ground. Preliminary testing was performed to identify the frequency of each emission displaying the highest amplitude. The cables were repositioned to obtain maximum amplitude of measured EMI level. Once the worst-case configuration was identified, plots were made of the EMI from 0.15 MHz to 30 MHz then the data was recorded with maximum conducted emissions levels.

Refer to figures one and two for plots of the AC Line Conducted emissions of the benchtop DC power supply providing power to the EUT.

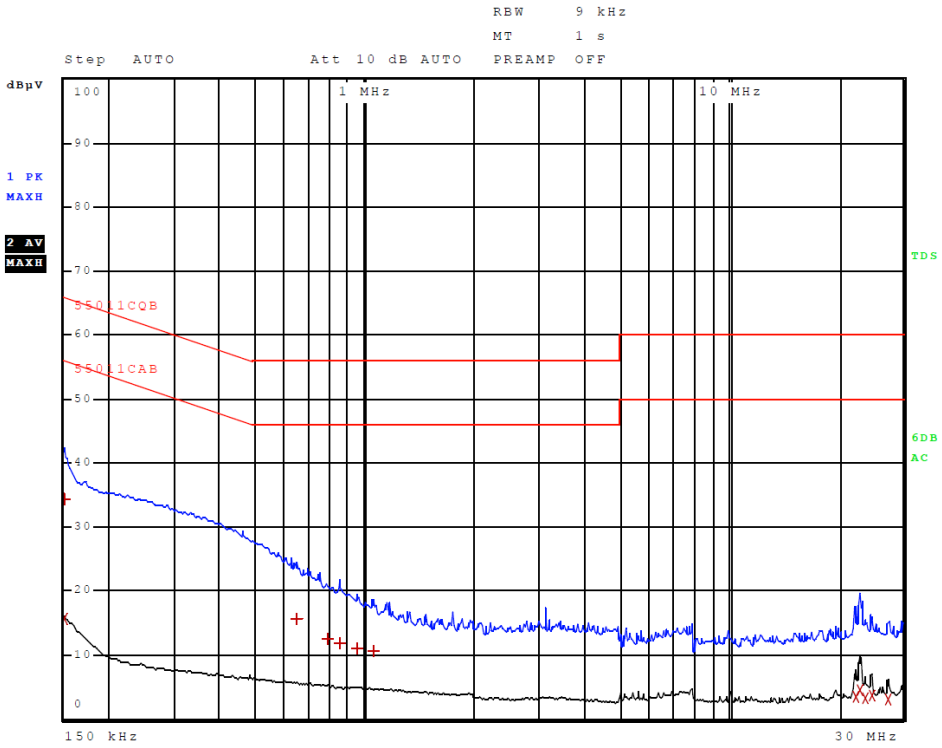


Figure 1 AC Line Conducted Emissions Line 1

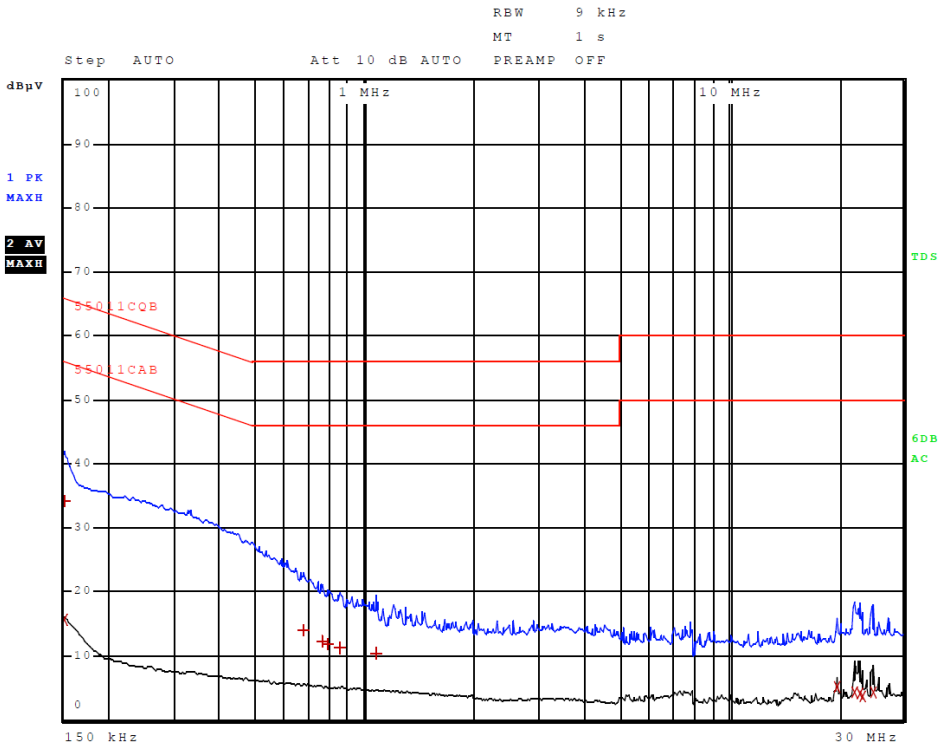


Figure 2 AC Line Conducted Emissions Line 2

Table 4 AC Line Conducted Emissions Data Line 1

Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
2	150.000000000 kHz	15.73	Average	-40.27
1	150.000000000 kHz	34.42	Quasi Peak	-31.58
1	650.000000000 kHz	15.61	Quasi Peak	-40.39
1	786.000000000 kHz	12.47	Quasi Peak	-43.53
1	854.000000000 kHz	11.79	Quasi Peak	-44.21
1	954.000000000 kHz	10.93	Quasi Peak	-45.07
1	1.050000000 MHz	10.60	Quasi Peak	-45.40
2	22.196000000 MHz	3.54	Average	-46.46
2	22.836000000 MHz	4.52	Average	-45.48
2	23.588000000 MHz	3.22	Average	-46.78
2	24.676000000 MHz	3.64	Average	-46.36
2	27.400000000 MHz	3.09	Average	-46.91

Other emissions present had amplitudes at least 20 dB below the limit.

Table 5 AC Line Conducted Emissions Data Line 2

Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
2	150.000000000 kHz	15.60	Average	-40.40
1	150.000000000 kHz	34.19	Quasi Peak	-31.81
1	674.000000000 kHz	14.01	Quasi Peak	-41.99
1	762.000000000 kHz	12.19	Quasi Peak	-43.81
1	790.000000000 kHz	11.94	Quasi Peak	-44.06
1	854.000000000 kHz	11.20	Quasi Peak	-44.80
1	1.074000000 MHz	10.36	Quasi Peak	-45.64
2	19.712000000 MHz	5.25	Average	-44.75
2	22.188000000 MHz	4.31	Average	-45.69
2	22.848000000 MHz	4.03	Average	-45.97
2	23.196000000 MHz	3.59	Average	-46.41
2	24.836000000 MHz	4.24	Average	-45.76

Other emissions present had amplitudes at least 20 dB below the limit.

Summary of Results for AC Line Conducted Emissions

The EUT test system demonstrated compliance to the conducted emissions requirements of 47 CFR 15.207, RSS-247 Issue 2 and RSS-GEN. The EUT demonstrated minimum margin of –31.5 dB below the limit. Measurements were taken using the peak, quasi peak, and average, measurement function for each emissions amplitude and were below the limits stated in the specification. Other emissions were present with recorded data representing worst-case amplitudes.

General Radiated Emissions Procedure

The EUT was arranged in typical equipment configurations and operated through all available modes with worst-case data recorded. Preliminary testing was performed in a screen room with the EUT positioned 1 meter from the FSM. Radiated emissions measurements were performed to identify the frequencies, which produced the highest emissions. Each radiated emission was then maximized at the OATS location before final radiated emissions measurements were performed. Final data was taken with the EUT located at the OATS at a distance of 3 meters between the EUT and the receiving antenna. The frequency spectrum from 9 kHz to 25,000 MHz was searched for general radiated emissions. Measured emission levels were maximized by EUT placement on the table, rotating the turntable through 360 degrees, varying the antenna height between 1 and 4 meters above the ground plane and changing antenna position between horizontal and vertical polarization. Antennas used were Loop from 9 kHz to 30 MHz, Broadband Biconical from 30 to 200 MHz, Biconilog from 30 to 1000 MHz, Log Periodic from 200 MHz to 1 GHz and or Double Ridge or pyramidal horns from 1 GHz to 25 GHz, notch filters, and appropriate amplifiers were used during investigation and testing.

Table 6 General Radiated Emissions from EUT Data (PIFA Highest Emissions)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
166.3	20.5	15.4	N/A	19.6	14.0	N/A	40.0
183.8	21.6	16.0	N/A	20.4	14.9	N/A	40.0
185.3	22.8	18.9	N/A	21.3	16.9	N/A	40.0
186.4	19.3	14.0	N/A	22.7	18.4	N/A	40.0
188.8	23.0	18.2	N/A	20.9	15.3	N/A	40.0
191.4	25.9	22.0	N/A	21.6	17.0	N/A	40.0
272.3	31.1	27.2	N/A	24.1	18.2	N/A	47.0
367.5	34.1	29.1	N/A	29.0	24.1	N/A	47.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Table 7 General Radiated Emissions from EUT Data (External Antenna worst-case)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
155.4	26.8	22.4	N/A	32.0	27.0	N/A	40.0
165.6	34.0	28.6	N/A	28.6	24.8	N/A	40.0
169.3	32.0	28.1	N/A	26.6	22.0	N/A	40.0
170.9	32.2	28.9	N/A	28.1	24.0	N/A	40.0
173.2	29.1	24.9	N/A	30.1	26.6	N/A	40.0
184.1	32.2	27.9	N/A	27.3	23.3	N/A	40.0
229.5	32.5	27.9	N/A	24.1	19.8	N/A	40.0
276.2	27.6	23.0	N/A	27.5	23.1	N/A	47.0
375.7	33.5	27.6	N/A	29.4	24.8	N/A	47.0
441.1	35.3	32.1	N/A	29.5	24.9	N/A	47.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Summary of Results for General Radiated Emissions

The EUT demonstrated compliance with the radiated emissions requirements of 47 CFR part 15 and Industry Canada RSS-247 Issue 2 Intentional Radiators. The EUT worst-case configuration demonstrated a minimum margin of -11.1 dB below the requirements. Other emissions were present with amplitudes at least 20 dB below the Limits.

Operation in the 2400-2483.5 MHz Frequency Band

Antenna port conducted emissions were measured in a screen room. Radiated emissions were measured on the Open Area Test Site (OATS) at a three-meter distance. Production equipment design of the EUT provides RP-SMA connection to antenna port. Radiated emissions measurements were performed on the production design test sample as documented in this report. Radiated emissions were tested using the documented antenna configurations with the module placed on the supporting development board. The module was tested in the open without any additional shielding around the module. Testing procedures defined in publications ANSI C63.10-2013and KDB 558074 D01 DTS Meas Guidance v04 were utilized during compliance testing. The EUT was placed on a turntable elevated as required above the ground plane at a distance of 3 meters from the FSM antenna located on the OATS during radiated emissions testing. The peak and quasi-peak amplitude of the frequencies below 1000 MHz were measured using a spectrum analyzer / EMC receiver. The peak and average amplitude of emissions above 1000 MHz were measured using a spectrum analyzer / EMC receiver. Emissions data was recorded from the measurement results. Data presented reflects measurement result corrected to account for measurement system gains and losses. Antenna conducted measurements were made on the test sample at the antenna port RF connection. Plots were made of transmitter performance for reference purposes. Refer to figures three through eight for plots of antenna port conducted performance.

1. The transmitter's maximum peak power was measured as specified in KDB's 558074 9.1
2. Emission DTS Bandwidth was measured as specified in KDB 558074 paragraph 8
3. Peak Power Spectral Density was measured as specified in KDB 558074 10.2
4. Unwanted Radiated Emissions were measured as specified in KDB 558074 paragraph 11 and specified in ANSI C63-10 at a 3-meters distance located on the OATS.
5. Radiated Emissions Levels in restricted bands were measured as specified in KDB 558074 paragraph 12 and ANSI C63-10 at a 3-meters distance located on the OATS.
6. Band-Edge measurements were performed as specified in KDB 558074 paragraph 13

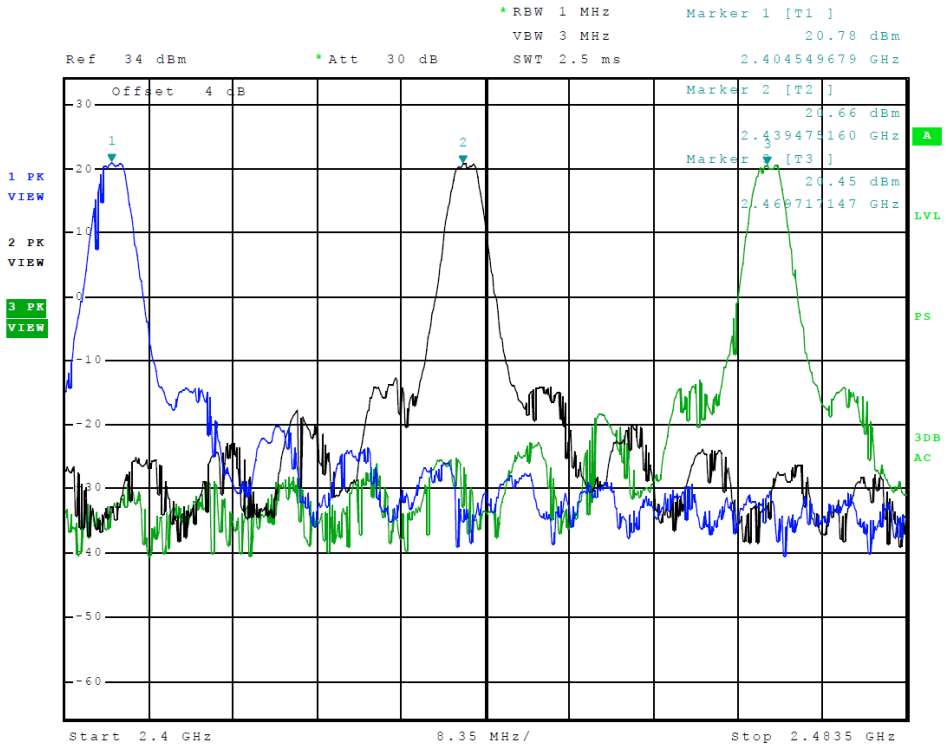


Figure 3 Plot of Transmitter Emissions Across Operational Band

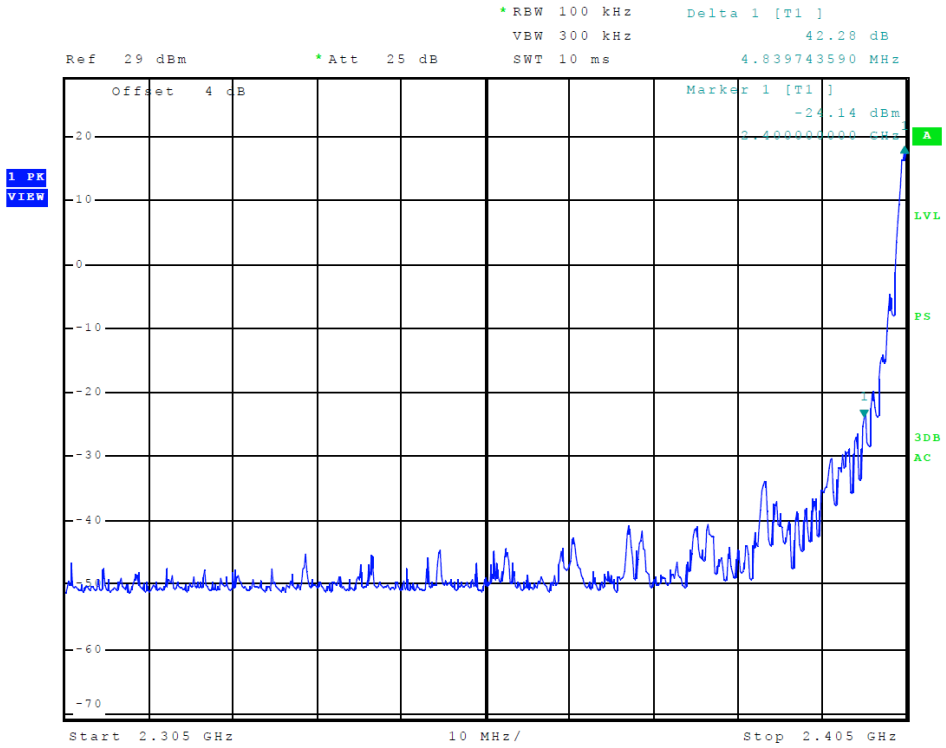


Figure 4 Plot of Transmitter Emissions Low Band Edge

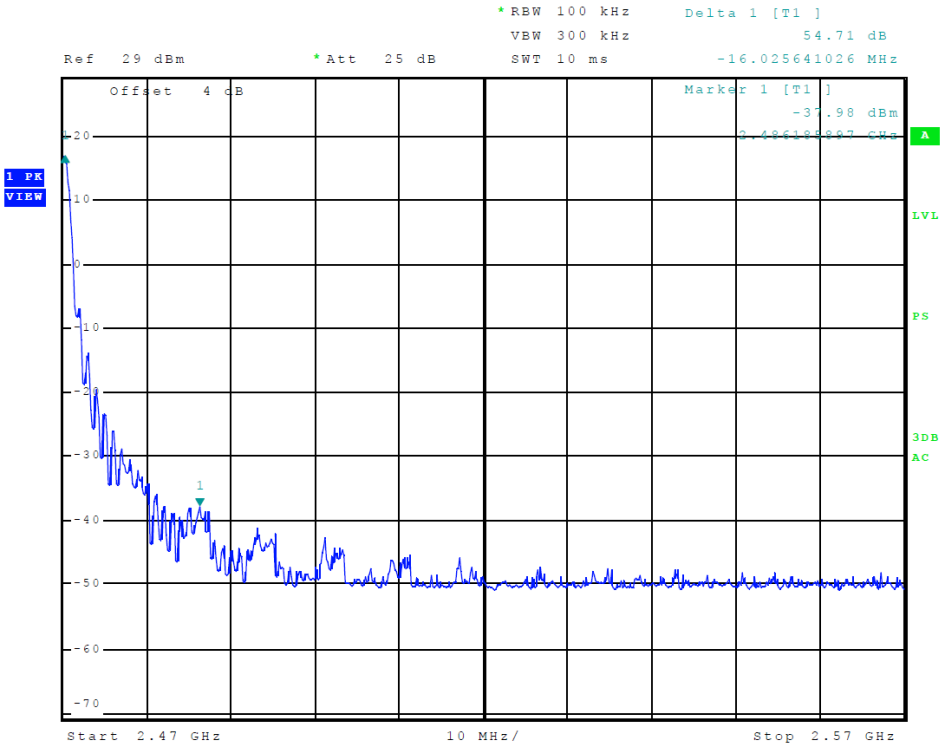


Figure 5 Plot of Transmitter Emissions High Band Edge

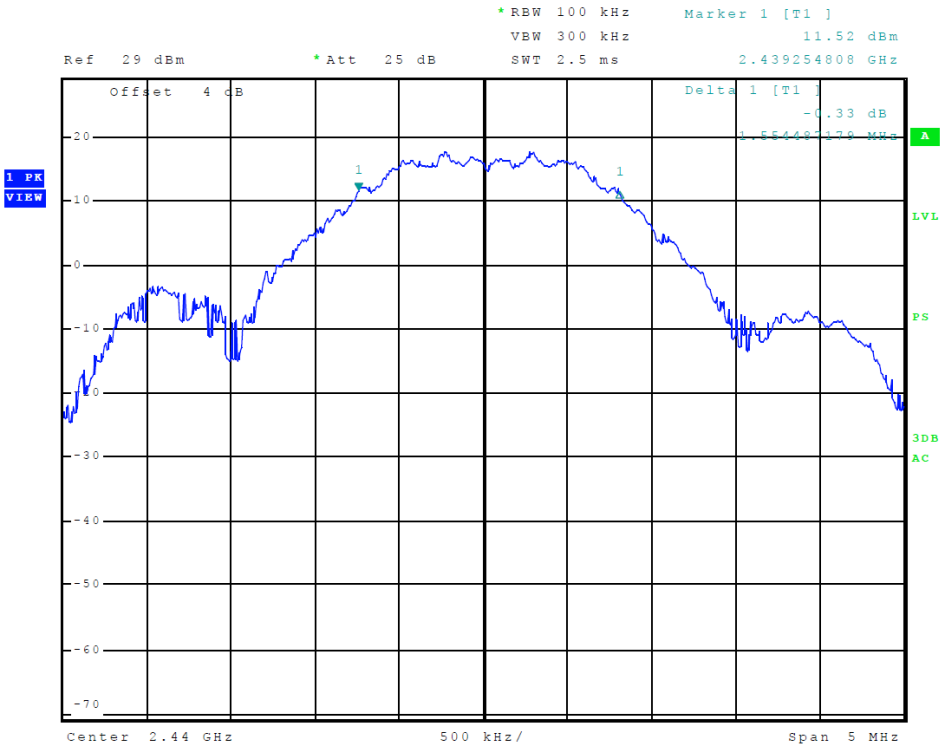


Figure 6 Plot of Transmitter Emission 6-dB Occupied Band Width

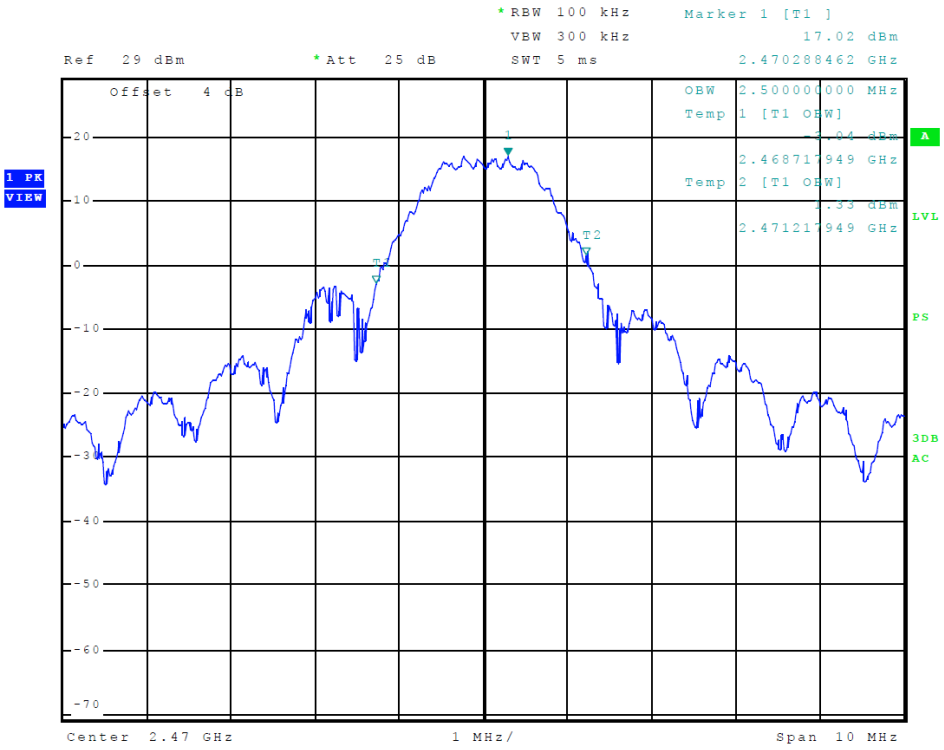


Figure 7 Plot of Transmitter Emission 99% Occupied Band Width

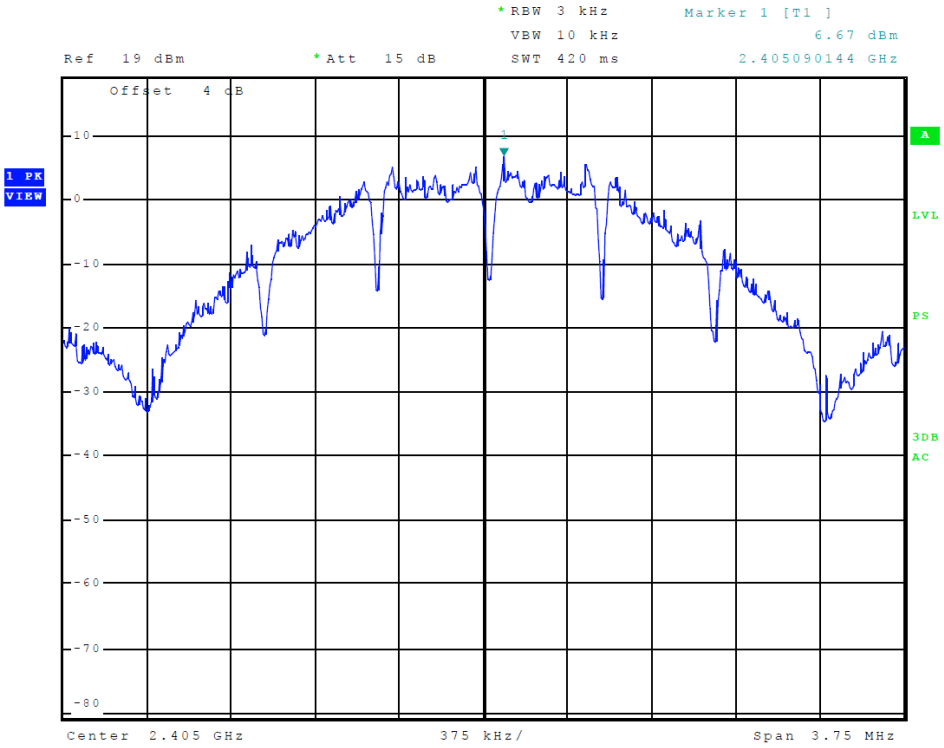


Figure 8 Plot of Transmitter Emission Peak Power Spectral Density

Transmitter Emissions Data

Table 8 Transmitter Radiated Emissions (PIFA)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
2405.0	-	-	-	-	-
4810.0	49.8	35.2	47.4	34.4	54.0
7215.0	50.9	38.0	50.4	37.9	54.0
9620.0	53.4	41.0	54.2	41.0	54.0
12025.0	57.3	44.2	56.9	43.9	54.0
14430.0	58.5	45.9	58.3	45.8	54.0
16835.0	61.3	48.9	62.0	48.9	54.0
2440.0	-	-	-	-	-
4880.0	50.1	35.6	47.8	34.6	54.0
7320.0	51.5	38.6	51.7	38.7	54.0
9760.0	53.5	40.9	53.7	40.9	54.0
12200.0	58.0	45.1	58.3	45.1	54.0
14640.0	60.4	47.1	59.7	47.2	54.0
17080.0	62.5	49.5	62.5	49.5	54.0
2470.0	-	-	-	-	-
4940.0	52.8	36.1	50.0	34.8	54.0
7410.0	51.1	38.2	51.4	38.2	54.0
9880.0	54.2	41.2	54.2	41.3	54.0
12350.0	58.3	45.3	58.5	45.2	54.0
14820.0	60.0	47.1	59.8	47.1	54.0
17290.0	61.5	48.6	61.2	48.7	54.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range of 30-1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Table 9 Transmitter Radiated Emissions (Dipole)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
2405.0	-	-	-	-	-
4810.0	48.4	34.7	47.1	34.4	54.0
7215.0	51.9	38.4	50.5	38.0	54.0
9620.0	54.1	41.0	54.0	41.2	54.0
12025.0	57.5	44.0	57.1	43.9	54.0
14430.0	58.8	45.9	58.3	45.9	54.0
16835.0	62.6	49.0	62.2	48.9	54.0
2440.0	-	-	-	-	-
4880.0	48.2	34.8	47.8	34.7	54.0
7320.0	51.5	38.7	52.1	38.8	54.0
9760.0	53.5	41.0	53.5	40.9	54.0
12200.0	58.0	45.1	57.6	45.1	54.0
14640.0	60.2	47.0	60.1	47.0	54.0
17080.0	62.7	49.5	62.4	49.5	54.0
2470.0	-	-	-	-	-
4940.0	47.7	34.6	49.4	35.2	54.0
7410.0	51.4	38.3	51.2	38.3	54.0
9880.0	54.1	41.4	54.0	41.4	54.0
12350.0	58.3	45.1	58.2	45.1	54.0
14820.0	61.4	47.5	60.3	47.5	54.0
17290.0	62.0	49.1	61.8	49.1	54.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range of 30-1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Table 10 Transmitter Radiated Emissions (Omni)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
2405.0	-	-	-	-	-
4810.0	47.5	34.2	49.3	34.8	54.0
7215.0	51.2	38.2	51.0	38.1	54.0
9620.0	54.1	41.0	54.0	41.0	54.0
12025.0	57.1	44.3	56.3	44.1	54.0
14430.0	58.4	45.9	58.8	45.9	54.0
16835.0	61.5	48.8	62.3	48.9	54.0
2440.0	-	-	-	-	-
4880.0	47.4	34.3	49.3	34.8	54.0
7320.0	51.2	38.7	51.4	38.7	54.0
9760.0	54.1	41.1	54.5	41.1	54.0
12200.0	58.3	45.1	58.4	45.1	54.0
14640.0	60.4	47.3	60.2	47.3	54.0
17080.0	62.3	49.6	62.6	49.6	54.0
2470.0	-	-	-	-	-
4940.0	47.6	34.6	47.6	34.7	54.0
7410.0	52.7	38.9	51.5	38.3	54.0
9880.0	54.3	41.4	54.0	41.4	54.0
12350.0	58.0	45.2	57.6	45.2	54.0
14820.0	60.8	47.3	59.7	47.3	54.0
17290.0	62.2	49.0	61.7	49.0	54.0

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range of 30-1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Table 11 Transmitter Power and Emissions

Frequency MHz	Conducted Output Power (Watts)	99% Occupied Bandwidth kHz	6-dB Occupied Bandwidth kHz	Power Spectral Density dBm
2405.0	0.120	2,435.9	1,522.4	6.7
2440.0	0.116	2,467.9	1,554.5	6.2
2470.0	0.111	2,500.0	1,530.4	6.4

Summary of Results for Transmitter Radiated Emissions of Intentional Radiator

The EUT demonstrated compliance with the radiated emissions requirements of 47 CFR Part 15.247 and Industry Canada RSS-247. The highest conducted peak power measured 0.120 Watts. The worst-case peak power spectral density provided a minimum margin of -1.3 dB below the 3 kHz PSD requirements. The minimum radiated harmonic emission provided -4.4 dB margin below requirements. There were no other significantly measurable emissions in the restricted bands other than those recorded in this report. Other emissions were present with amplitudes at least 20 dB below the requirements. There were no other deviations or exceptions to the requirements.

Statement of Modifications and Deviations

No modifications to the EUT were required for the test configuration to demonstrate compliance with the 47 CFR Part 15C paragraph 15.247 and Industry Canada RSS-247 emissions requirements. There were no deviations or modifications to the specifications.

Annex

- Annex A Measurement Uncertainty Calculations
- Annex B Rogers Labs Test Equipment List
- Annex C Rogers Qualifications
- Annex D Rogers Labs Certificate of Accreditation

Annex A Measurement Uncertainty Calculations

The measurement uncertainty was calculated for all measurements listed in this test report according To CISPR 16–4. Result of measurement uncertainty calculations are recorded below. Component and process variability of production devices similar to those tested may result in additional deviations. The manufacturer has the sole responsibility of continued compliance.

Measurement	Expanded Measurement Uncertainty $U_{(lab)}$
3 Meter Horizontal 0.009-1000 MHz Measurements	4.16
3 Meter Vertical 0.009-1000 MHz Measurements	4.33
3 Meter Measurements 1-18 GHz	5.14
3 Meter Measurements 18-40 GHz	5.16
10 Meter Horizontal Measurements 0.009-1000 MHz	4.15
10 Meter Vertical Measurements 0.009-1000 MHz	4.32
AC Line Conducted	1.75
Antenna Port Conducted power	1.17
Frequency Stability	1.00E-11
Temperature	1.6˚C
Humidity	3%

Annex B Rogers Labs Test Equipment List

List of Test Equipment	Calibration Date (m/d/y)	Due
Antenna: Schwarzbeck Model: BBA 9106/VHBB 9124 (9124-627)	5/2/2018	5/2/2019
Antenna: Schwarzbeck Model: VULP 9118 A (VULP 9118 A-534)	5/2/2018	5/2/2019
Antenna: EMCO 6509	10/24/2016	10/24/2018
Antenna: EMCO 3143 (9607-1277) 20-1200 MHz	5/2/2018	5/2/2019
Antenna: EMCO Dipole Set 3121C	2/23/2018	2/23/2019
Antenna: C.D. B-101	2/23/2018	2/23/2019
Antenna: Solar 9229-1 & 9230-1	2/23/2018	2/23/2019
Cable: Belden 8268 (L3)	10/24/2017	10/24/2018
Cable: Time Microwave: 4M-750HF290-750	10/24/2017	10/24/2018
Frequency Counter: Leader LDC-825 (8060153	5/2/2018	5/2/2019
Oscilloscope Scope: Tektronix 2230	2/23/2018	2/23/2019
Wattmeter: Bird 43 with Load Bird 8085	2/23/2018	2/23/2019
Power Supplies: Sorensen SRL 20-25, SRL 40-25, DCR 150, DCR 140	2/23/2018	2/23/2019
R.F. Generator: SMB100A6 s/n 100623	5/2/2018	5/2/2019
R.F. Generator: SBMBV100A s/n: 260771	5/2/2018	5/2/2019
R.F. Generators: HP 606A, HP 8614A, HP 8640B	2/23/2018	2/23/2019
R.F. Power Amp 65W Model: 470-A-1010	2/23/2018	2/23/2019
R.F. Power Amp 50W M185- 10-501	2/23/2018	2/23/2019
R.F. Power Amp A.R. Model: 10W 1010M7	2/23/2018	2/23/2019
R.F. Power Amp EIN Model: A301	2/23/2018	2/23/2019
LISN: Compliance Eng. Model 240/20	5/2/2018	15/50/19
LISN: Fischer Custom Communications Model: FCC-LISN-50-16-2-08	5/2/2018	5/2/2019
Audio Oscillator: H.P. 201CD	2/23/2018	2/23/2019
ESD Test Set 2010i	2/23/2018	2/23/2019
Oscilloscope Scope: Tektronix MDO 4104	2/23/2018	2/23/2019
EMC Transient Generator HVT TR 3000	2/23/2018	2/23/2019
AC Power Source (Ametech, California Instruments)	2/23/2018	2/23/2019
Fast Transient Burst Generator Model: EFT/B-101	2/23/2018	2/23/2019
Field Intensity Meter: EFM-018	2/23/2018	2/23/2019
KEYTEK Ecat Surge Generator	2/23/2018	2/23/2019
ESD Simulator: MZ-15	2/23/2018	2/23/2019
Shielded Room not required		

Annex C Rogers Qualifications

Scot D. Rogers, Engineer

Rogers Labs, Inc.

Mr. Rogers has approximately 27 years' experience in the field of electronics. Engineering experience includes six years in the automated controls industry and remaining years working with the design, development and testing of radio communications and electronic equipment.

Positions Held

Systems Engineer:	A/C Controls Mfg. Co., Inc.	6 Years
Electrical Engineer:	Rogers Consulting Labs, Inc.	5 Years
Electrical Engineer:	Rogers Labs, Inc.	Current

Educational Background

1) Bachelor of Science Degree in Electrical Engineering from Kansas State University.

2) Bachelor of Science Degree in Business Administration Kansas State University.

3) Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming.

Scot D Rogers
Scot D. Rogers

Annex D Rogers Labs Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 200087-0

Rogers Labs, Inc.
Louisburg, KS

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Electromagnetic Compatibility & Telecommunications

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

2018-02-21 through 2019-03-31
Effective Dates

For the National Voluntary Laboratory Accreditation Program