NVLAP Lab Code 200087-0

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CFR47, PART 15C - Intentional Radiators
CFR47 Paragraph 15.247 and
Industry Canada RSS-247 Issue 2 and RSS-GEN Issue 5

Application For Grant of Certification

Product Marketing Name (PMN): Aranet4 HOME

2402-2480 MHz (DTS)
Digital Transmission System

FCC ID: W9Z-A4MK2HOME
IC: 8855A-A4MK2HOME

SAF Tehnika AS

24a, Ganibu dambis
Riga Latvia LV-1005

FCC Designation: US5305
ISED Registration: 3041A-1

Test Report Number: 210416

Test Date: April 16, 2021

Authorized Signatory: Scot D Rogers
Scot D. Rogers

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Revisions

Revision 1 Issued May 29, 2021

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Executive Summary

The following information is submitted for consideration in obtaining Grant of Certification for License Exempt Digital Transmission System Intentional Radiator operating under Code of Federal Regulations Title 47 (CFR47) Part 15C paragraph 15.247, Industry Canada RSS-247 Issue 2, and RSS-GEN Issue 5, operation in the 2400 – 2483.5 MHz band.

Name of Applicant: SAF Tehnika AS
24a, Ganibu dambis
Riga Latvia LV-1005

PMN: Aranet4 HOME

HVIN: TDSPC0H3.002, TDSPC0H3.003, and TDSPC0H3.004

FCC ID: W9Z-A4MK2HOME IC: 8855A-A4MK2HOME

Frequency Range: operation in the 2402-2480 MHz band

Operational communication modes

Mode	Power (Watts)	99% OBW (kHz)	6-dB OBW (kHz)
1, BLE (1Mb)	0.003	1,072.8	811.2
2, BLE (2Mb)	0.002	2,112.5	1,450.0

This report addresses EUT Operations as Digital Transmission System using transmitter modulations in modes 1 and 2.

Opinion / Interpretation of Results

Tests Performed	Margin (dB)	Results
Emissions 15.205, RSS-GEN, RSS-247	-7.7	Complies
Emissions as per 47CFR 15.207, RSS-GEN 8.8	N/A	Complies
Radiated Emissions 47 CFR 15.209, RSS-GEN 8.9	-14.8	Complies
Harmonic Emissions per CFR47 15.247, RSS-247	-4.1	Complies
Power Spectral Density per CFR47 15.247, RSS-247	-16.8	Complies

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Equipment Tested

PMN: Aranet4 HOME

HVIN: TDSPC0H3.002, TDSPC0H3.003, and TDSPC0H3.004

SAF Tehnika AS
24a, Ganibu dambis
Riga Latvia LV-1005

Equipment	Model / PN	Serial Number
EUT 1 (Production design)	Aranet4 HOME	05128
EUT 2 (Integral antenna, modified test software)	Aranet4 HOME	05127
EUT 3 (Integral antenna, modified test software)	Aranet4 HOME	0512B
EUT 4 (modified antenna port and test software)	Aranet4 HOME	05129
EUT 5 (modified antenna port and test software)	Aranet4 HOME	0512A

Notes: Sample 1 provided as production design. Samples 2 and 3 are identical transmitter using two different sensors. These samples were provided for radiated emissions testing with modified software for testing purposes. The test software provided continuous transmission on defined channels. Samples 4 and 5 are identical transmitter using two different sensors. These samples were provided with modified antenna connection for antenna port conducted emissions testing and modified software for testing purposes. The test software provided continuous transmission on defined channels.

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

- Software version of "typical" Aranet4 HOME: v0.4.5 and higher
- Software version of "modified for testing" Aranet4 HOME: v0.4.4-4-gc220537

Antenna: PIFA (0 dBi)

Operational communication modes

Mode	Transmitter Operation
1	BLE (1Mb)
2	BLE (2Mb)

Test results in this report relate only to the items tested. Worst-case configuration data recorded in this report.

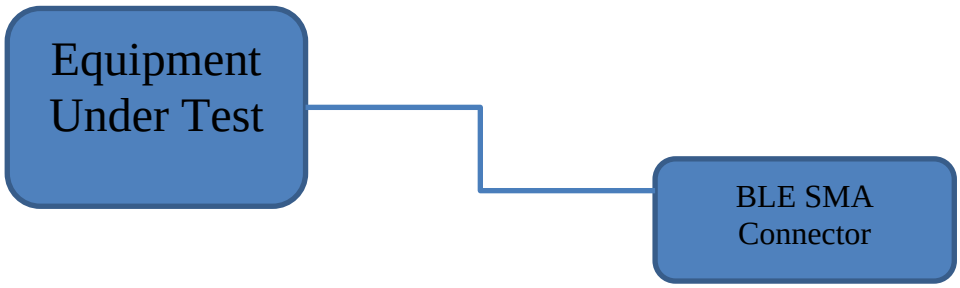
Equipment Function

The Equipment Under Test (EUT) provides sensor circuitry to monitor environmental conditions. The design may be provided using different CO_2 sensors interfaced with the identical transmitter board. Identification of the different sensors are provided under the different Hardware Version Identification Numbers (HVIN): TDSPC0H3.002, TDSPC0H3.003, and TDSPC0H3.004 (note: Numbers "0" are numeric zeros). The design incorporates radio transceiver providing wireless interface operation with compatible 2402-2480 MHz BLE (Bluetooth® Low Energy) equipment. Five test samples were provided for testing. One sample representative of end product with integral antenna system. Two samples were provided with production integral antenna and modified test software for radiated emissions testing. And two samples were provided with modified antenna connector and test software. These samples were modified by replacing the integral antenna with 50-ohm RF connection port. BLE operates as Digital Transmission System across the 2402-2480 MHz band. Each operational mode was tested for compliance as documented in this report. The design operates from two (2) LR6 (AA) replaceable batteries only and offers no provision for alternate power source. Samples provided with the special test software provided testing personnel the capability to operate the transmitter in defined modes and channels. Test samples with test software provided transmit operation on lowest, middle, and highest operating channels. The test software provided operation of the transmitter at 100% duty cycle for testing. For testing purposes, each test sample received power from new replaceable LR6 batteries and configured to operate in available modes. 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

1) EUT #1 operating from replaceable LR6 (AA) internal battery

2) EUT #2 (Antenna Port Unit) operating from replaceable LR6 (AA) internal battery



Applicable Standards & Test Procedures

The following information is submitted in accordance with the eCFR Code of Federal Regulations Title 47 (47CFR), dated April 16, 2021: Part 2, Subpart J, Part 15C Paragraph 15.247, 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. This report documents compliance for the EUT operations as Digital Transmission Systems operation.

Tests performed include
47CFR
15.247 (a) (2) Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.
(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one-Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.
(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).
(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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.2 Digital transmission systems

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz

a)The minimum 6 dB bandwidth shall be 500 kHz.

b)The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d),(i.e., the power spectral density shall be determined using the same method as is used to determine the conducted output power).

5.4 Transmitter output power and equivalent isotropically radiated power (e.i.r.p.) requirements

d) For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

5.5 Unwanted emissions

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Application for Certification

(1) Manufacturer: SAF Tehnika AS
24a, Ganibu dambis
Riga Latvia LV-1005

(2) Identification: PMN: Aranet4 HOME HVIN: TDSPC0H3.002, TDSPC0H3.003, and TDSPC0H3.004

FCC ID: W9Z-A4MK2HOME IC: 8855A-A4MK2HOME

(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 supplied from replaceable LR6 (AA) batteries and provides no other interface options as presented in this filing. The EUT offers no other connection ports than those presented in this filing.

(9) Transition Provisions of CFR47 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. This requirement is not applicable to his DTS device.

(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.

Testing Procedures

AC Line Conducted Emission Test Procedure

The design operates solely from direct current power provided from LR6 (AA) 1.5-volt batteries. The design offers no provision for connection with Utility AC power system and is therefore exempt from AC Line conducted emissions testing.

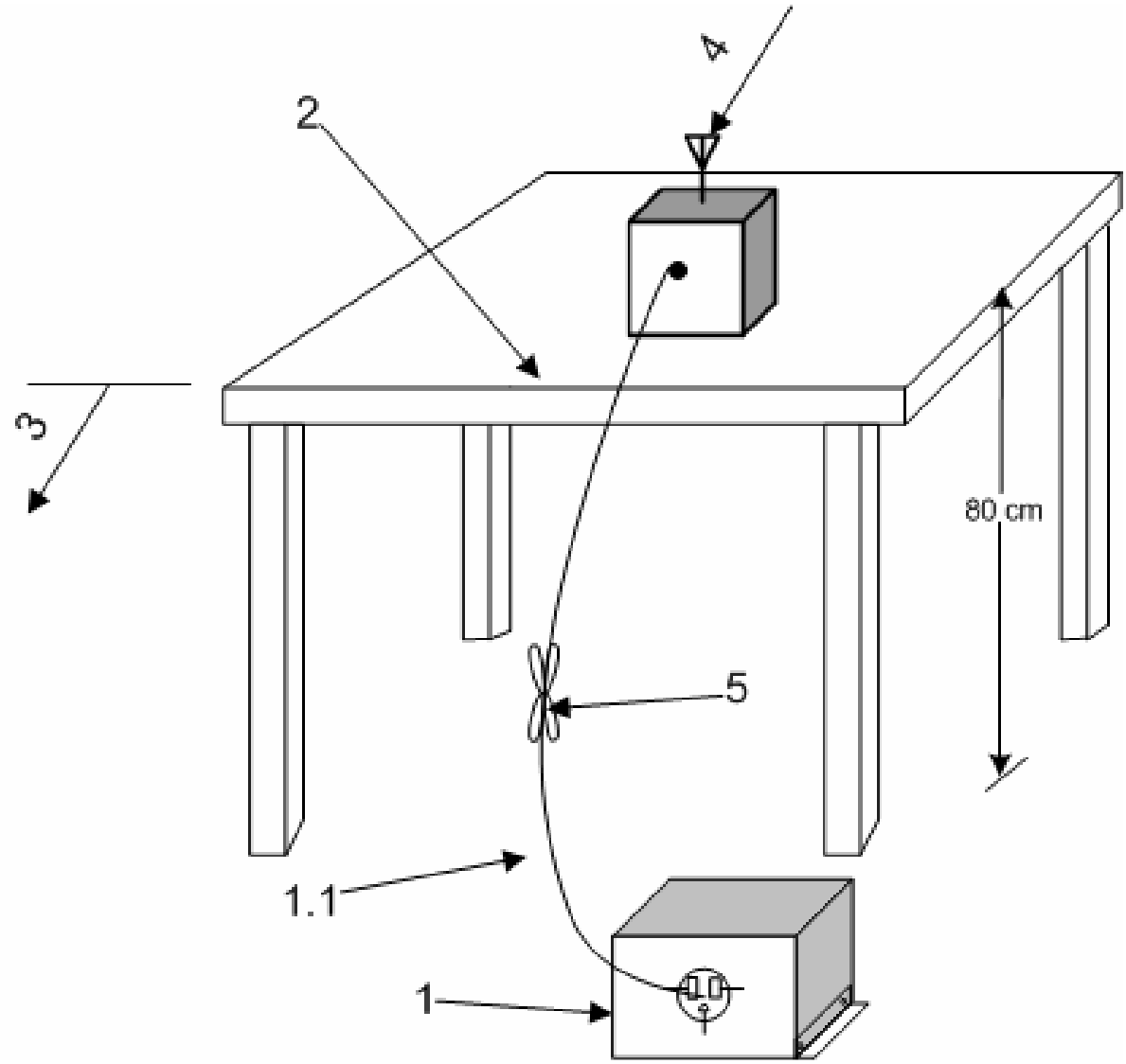
Radiated Emission Test Procedure

Radiated emissions testing was performed as required in CFR47 15C, RSS-247 Issue 2, RSS-GEN and specified in ANSI C63.10-2013. 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 permitting orientation in three orthogonal axes, raising, and lowering the FSM antenna, changing the antenna polarization, and by rotating the turntable. Each emission was maximized before data was taken and recorded. The frequency spectrum from 9 kHz to 25,000 MHz was searched for emissions during preliminary investigation. Refer to diagrams one and two showing typical test setup. Refer to photographs in the test setup exhibits for specific EUT placement during testing.

Antenna Port Conducted Emission Test Procedure

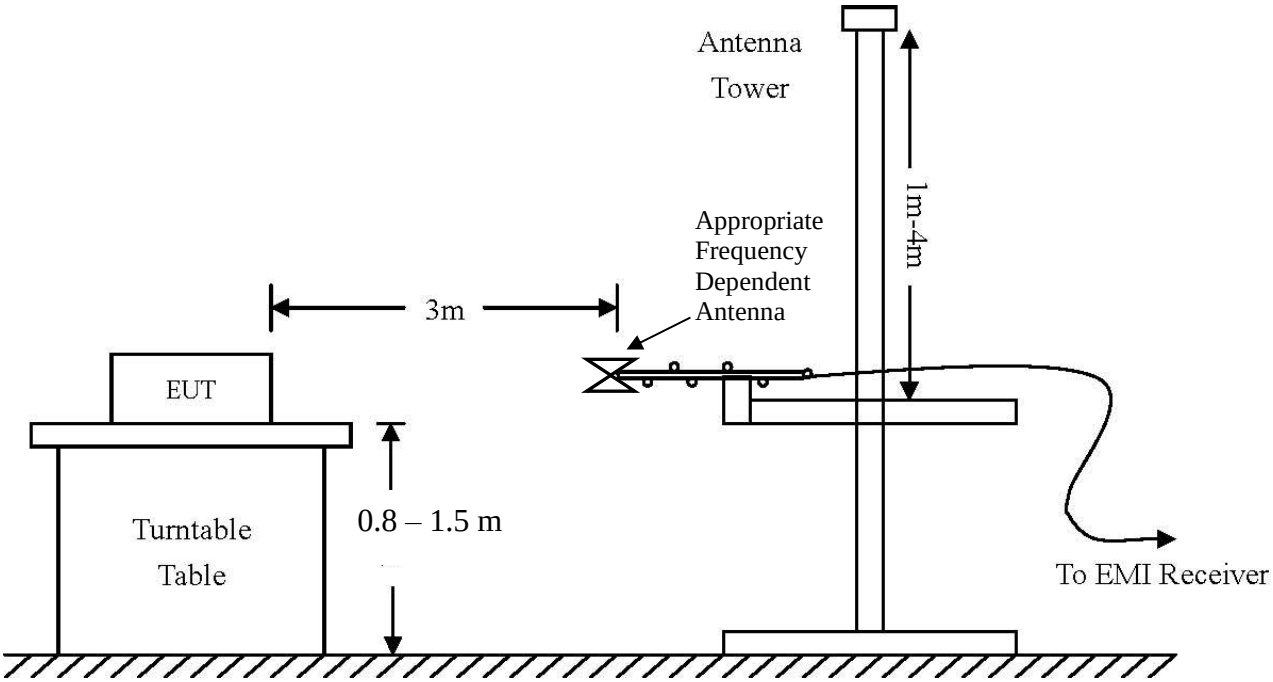
The EUT was assembled as required for operation and placed on a benchtop. This configuration provided the ability to connect test equipment to the provided test antenna port Antenna Port conducted emissions testing was performed as presented in this document and specified in ANSI C63.10-2013. Testing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

Diagram 1 Test arrangement for radiated emissions of tabletop equipment



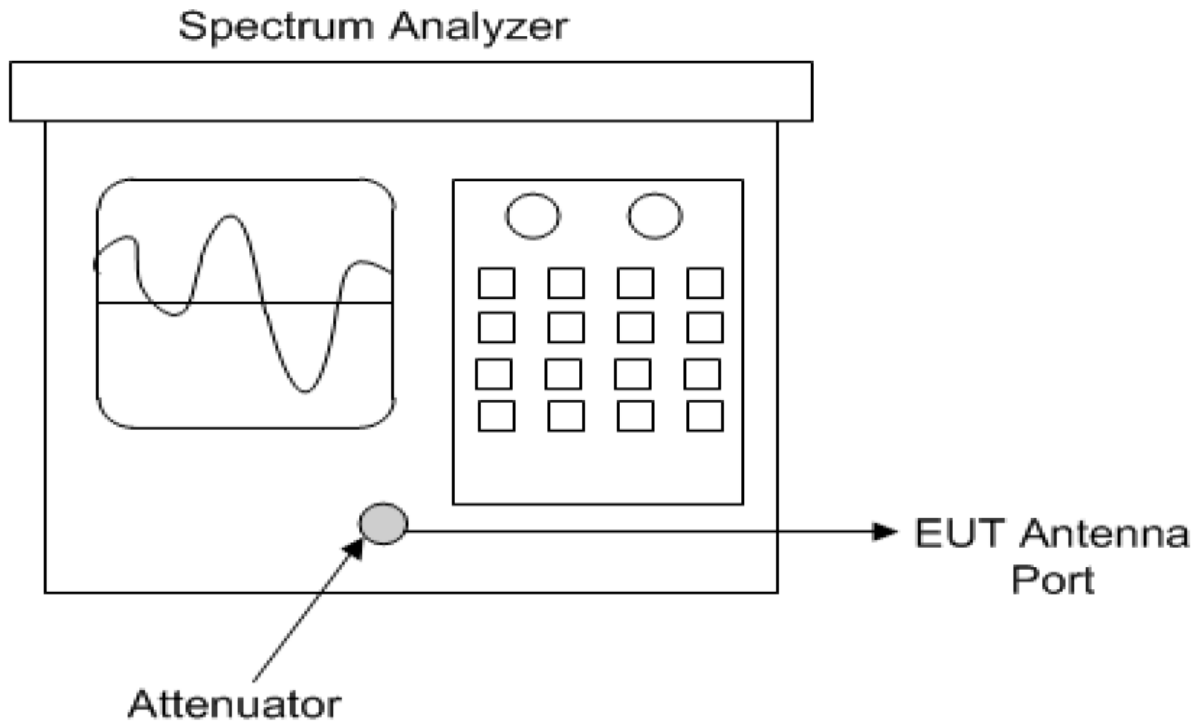
1—A LISN is optional for radiated measurements between 30 MHz and 1000 MHz but not allowed for measurements below 30 MHz and above 1000 MHz (see 6.3.1). If used, then connect EUT to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω loads. The LISN may be placed on top of, or immediately beneath, the reference ground plane (see 6.2.2 and 6.2.3.2).
1.1—LISN spaced at least 80 cm from the nearest part of the 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 tested on Open Area Test Site (OATS)



AC Line Conducted Emissions (0.150 -30 MHz)		
RBW	AVG. BW	Detector Function
9 kHz	30 kHz	Peak / Quasi Peak
Emissions (30-1000 MHz)		
RBW	AVG. BW	Detector Function
120 kHz	300 kHz	Peak / Quasi Peak
Emissions (Above 1000 MHz)		
RBW	Video BW	Detector Function
100 kHz	100 kHz	Peak
1 MHz	1 MHz	Peak / Average

Diagram 3 Test arrangement for Antenna Port Conducted emissions



Test Site Locations

Conducted EMI	AC line conducted emissions testing performed in a shielded screen room located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Antenna port	Antenna port conducted emissions testing was performed in a shielded screen room located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Radiated EMI	The radiated emissions tests were performed at the 3 meters, Open Area Test Site (OATS) located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Registered Site information:	FCC Site: US5305, ISED: 3041A, CAB Identifier: US0096
NVLAP Accreditation	Lab code 200087-0

Units of Measurements

Conducted EMI Data presented in dBµV; dB referenced to one microvolt

Antenna port Conducted Data is in dBm; dB referenced to one milliwatt

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

Note: Radiated limit may be expressed for measurement in dBµV/m when the measurement is taken at a distance of 3 or 10 meters. Data taken for this report was taken at distance of 3 meters. Sample calculation demonstrates corrected field strength reading for Open Area Test Site using the measurement reading and correcting for receive antenna factor, cable and test system losses, and amplifier gains.

Sample Calculation:

RFS = Radiated Field Strength, FSM = Field Strength Measured

A.F. = Receive antenna factor, Losses = attenuators/cable losses, Gain = amplification gains

RFS (dBµV/m @ 3m) = FSM (dBµV) + A.F. (dB/m) + Losses (dB) - Gain (dB)

Environmental Conditions

Ambient Temperature 22.4° C

Relative Humidity 26%

Atmospheric Pressure 1025.4 mb

Statement of Modifications and Deviations

No modifications to the EUT were required for the unit to demonstrate compliance with CFR47 Part 15C, RSS-247 Issue 2, and RSS-GEN Issue 5 emission requirements. There were no deviations to the specifications.

Intentional Radiators

The following information is submitted in support demonstration of compliance with the requirements of CFR47, Paragraph 15 Subpart C, paragraph 15.247, Industry Canada RSS-247 Issue 2, and RSS-GEN Issue 5.

Antenna Requirements

The EUT incorporates integral antenna system and offers no provision for connection to alternate antenna system. The antenna connection point complies with the unique antenna connection requirements. 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 OATS. The EUT utilizes frequency, determining circuitry, which generates harmonics falling in the restricted bands. Emissions were investigated at the OATS, using appropriate antennas or pyramidal horns, amplification stages, and a 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 emission values consider the received radiated field strength, receive antenna correction factor, amplifier gain stage, and test system cable losses.

Table 1 Harmonic Radiated Emissions in Restricted Bands Worst-case

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)	Horizontal Margin (dB)	Vertical Margin (dB)
2390.0	53.2	34.7	53.7	34.4	54.0	-19.3	-19.6
2483.5	61.6	39.2	63.6	40.8	54.0	-14.8	-13.2
4804.0	54.1	37.8	50.2	36.7	54.0	-16.2	-17.3
4880.0	54.9	36.1	51.3	35.9	54.0	-17.9	-18.1
4960.0	53.4	36.4	51.8	36.3	54.0	-17.6	-17.7
7206.0	52.0	39.5	52.6	39.6	54.0	-14.5	-14.4
7320.0	53.4	39.6	53.7	39.7	54.0	-14.4	-14.3
7440.0	52.6	39.6	53.2	39.7	54.0	-14.4	-14.3
12010.0	58.1	45.7	59.3	45.8	54.0	-8.3	-8.2
12200.0	59.9	46.3	58.8	46.3	54.0	-7.7	-7.7
12400.0	58.9	45.8	59.2	45.7	54.0	-8.2	-8.3

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

Summary of Results for Radiated Emissions in Restricted Bands

The EUT demonstrated compliance with the radiated emissions requirements of CFR47 Paragraph 15, Subpart 15C, RSS-247 Issue 2, and RSS-GEN Issue 5 emission requirements. The EUT worst-case operations demonstrated a minimum radiated emission margin of -7.7 dB below the 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 EMI Procedure

The design operates solely from direct current power provided from replaceable LR6 (AA) batteries. The design offers no provision for connection with the Utility AC power system and is therefore exempt from AC Line conducted emissions testing

General Radiated Emissions Procedure

The EUT was arranged in a typical equipment configuration and operated through all available mode during testing. 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 measurements were performed. Final data was taken with the EUT located on the OATS at 3 meters distance 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 and mixers above 1 GHz, notch filters and appropriate amplifiers and external mixers were utilized.

Table 2 General Radiated Emissions Data

Frequency (MHz)	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Limit @ 3m (dBµV/m)	Horizontal Margin (dB)	Vertical Margin (dB)
64.0	22.8	18.5	27.6	25.2	40.0	-21.5	-14.8
112.1	30.3	23.3	28.3	23.7	40.0	-16.7	-16.3
128.1	20.9	15.3	20.5	14.4	40.0	-24.7	-25.6
144.1	25.3	19.5	27.9	18.8	40.0	-20.5	-21.2
160.1	30.2	15.8	19.6	13.3	40.0	-24.2	-26.7
176.2	22.7	17.3	22.8	17.0	40.0	-22.7	-23.0
208.0	18.5	13.4	17.7	13.0	40.0	-26.6	-27.0

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

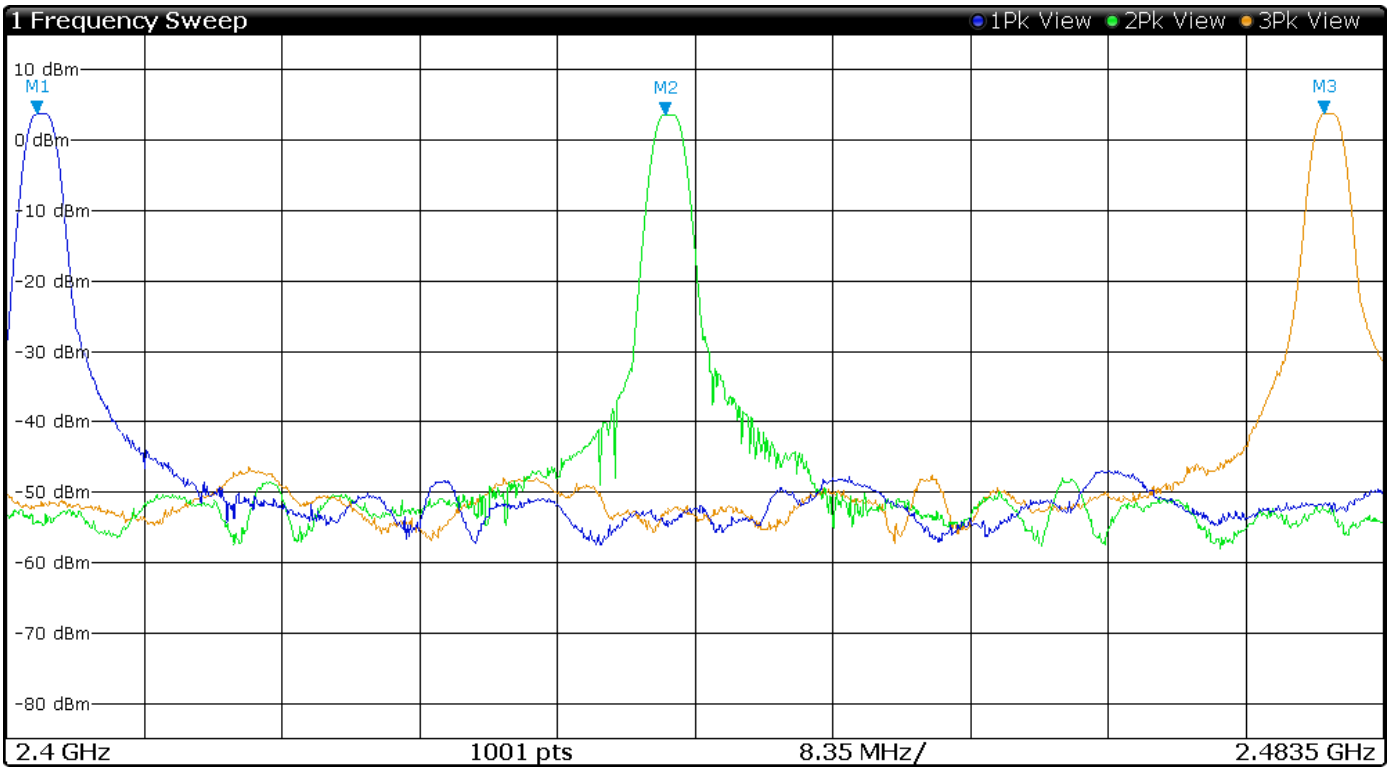
Summary of Results for General Radiated Emissions

The EUT demonstrated compliance with the radiated emissions requirements of CFR47 Paragraph 15.209, RSS-247 Issue 2 and RSS-GEN Issue 5 emission requirements. The EUT demonstrated a minimum margin of -14.8 dB below the requirements. Other emissions were present with amplitudes at least 20 dB below the Limits.

Operation in the Band 2400 – 2483.5 MHz

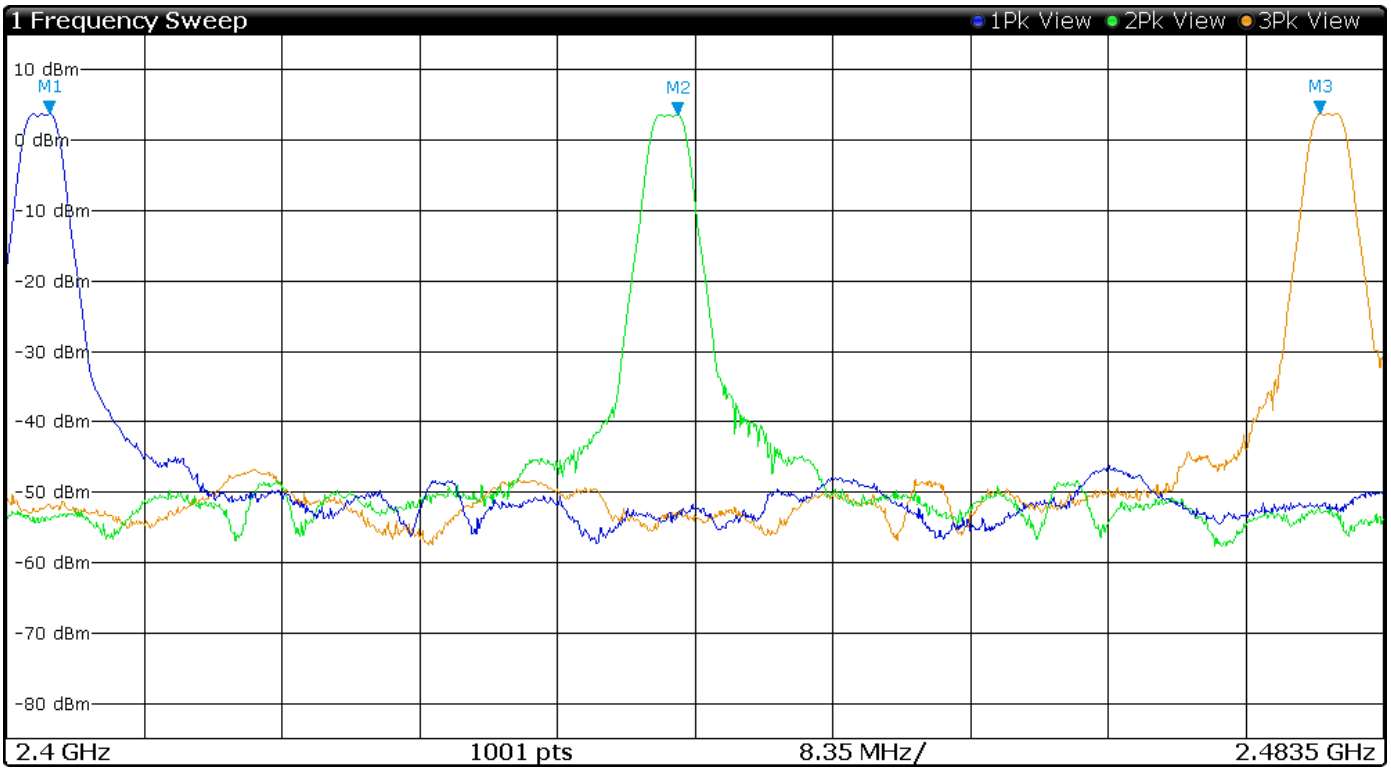
Test procedures of ANSI C63.10-2013 paragraph 6, and KDB 558074 v05r02 were used during transmitter testing. Test sample #2 was provided for testing antenna port conducted emissions. This sample was modified by replacing the internal antenna with a 50-ohm antenna port connector and attenuator for testing purposes. The transmitter peak and average power was measured at the antenna port using a wideband RF power meter as described in ANSI C63.10-2013 and KDB 558074. Average power measured did not include any time intervals during which the transmitter was off or transmitting at a reduced power level. The Power Spectral Density (PSD) was measured as required in ANSI C63.10-2013 and KDB 558074. DTS Emission bandwidth was measured as required in ANSI C63.10-2013 and KDB 558074. The amplitude of each harmonic and general radiated emission was measured on the OATS at distance of 3 meters from the FSM antenna (radiated emission testing was performed on sample #1 representative of production equipment with integral antenna). The EUT was positioned on supporting turntable elevated as required above the ground plane, at a distance of 3 meters from the FSM antenna. Radiated emission investigations were performed from 9 kHz to 25,000 MHz. Each radiated emission was maximized by varying the FSM antenna height and polarization, and by rotating the turntable. The worst-case amplitude of each emission was then recorded from the analyzer display. The peak and quasi-peak amplitude of frequencies below 1000 MHz were measured using a spectrum analyzer. The peak and average amplitude of frequencies above 1000 MHZ were measured using a spectrum analyzer. A Loop antenna was used for measuring emissions from 0.009 to 30 MHz, Biconilog Antenna for 30 to 1000 MHz, Double-Ridge, and/or Pyramidal Horn Antennas from 1 GHz to 25 GHz. Radiated Emissions were measured in dBµV/m @ 3 meters. Plots were taken of transmitter performance (using sample #2) for reference in this and other documentation displaying compliance with the specifications.

Figure 1 Plot of Transmitter Operation in 2402-2480 MHz Mode 1



Type	Ref	Trace	X-Value	Y-Value
M1		1	2.402 GHz	3.7 dBm
M2		2	2.44 GHz	3.6 dBm
M3		3	2.48 GHz	3.8 dBm

Figure 2 Plot of Transmitter Operation in 2402-2480 MHz Mode 2



Type	Ref	Trace	X-Value	Y-Value
M1		1	2.403 GHz	3.7 dBm
M2		2	2.441 GHz	3.6 dBm
M3		3	2.48 GHz	3.8 dBm

Figure 3 Plot of Transmitter Emissions Low Band Edge Mode 1

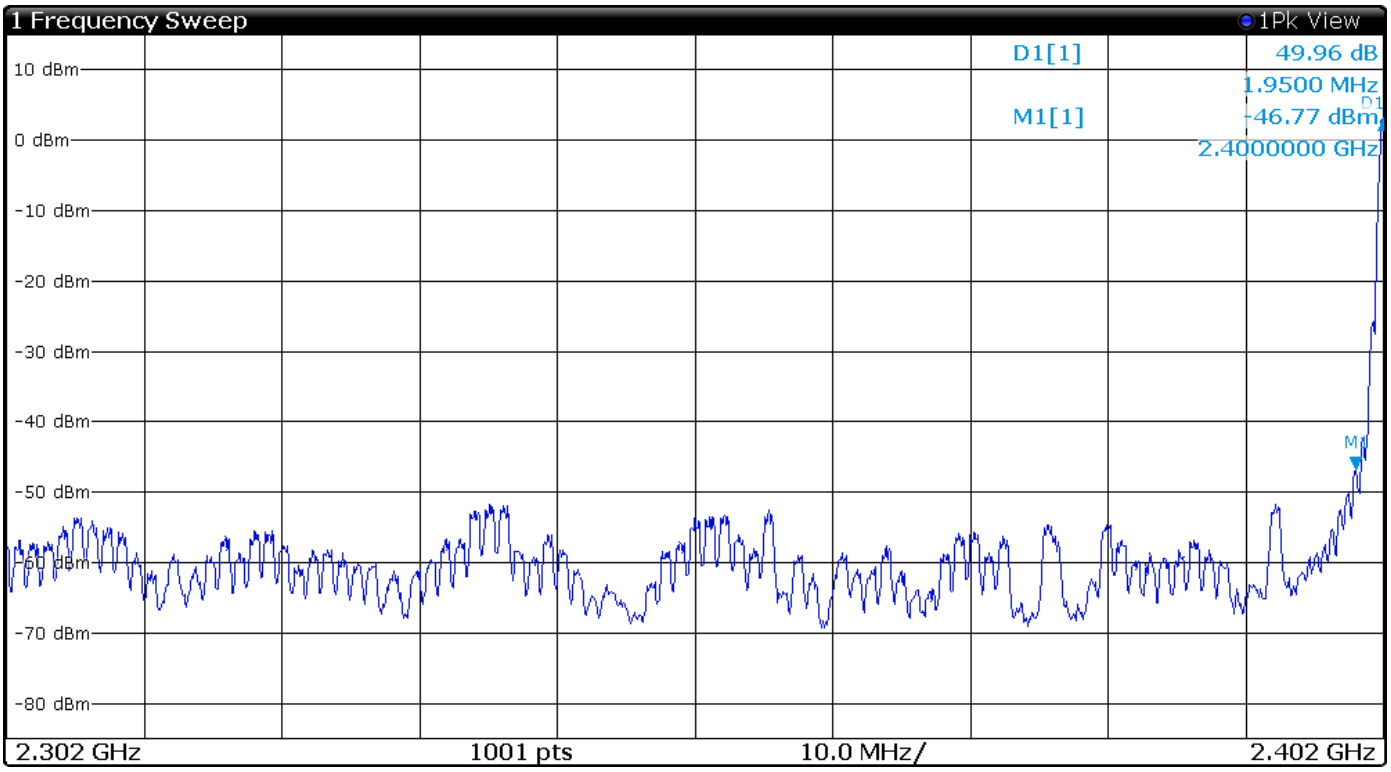


Figure 4 Plot of Transmitter Emissions Low Band Edge Mode 2

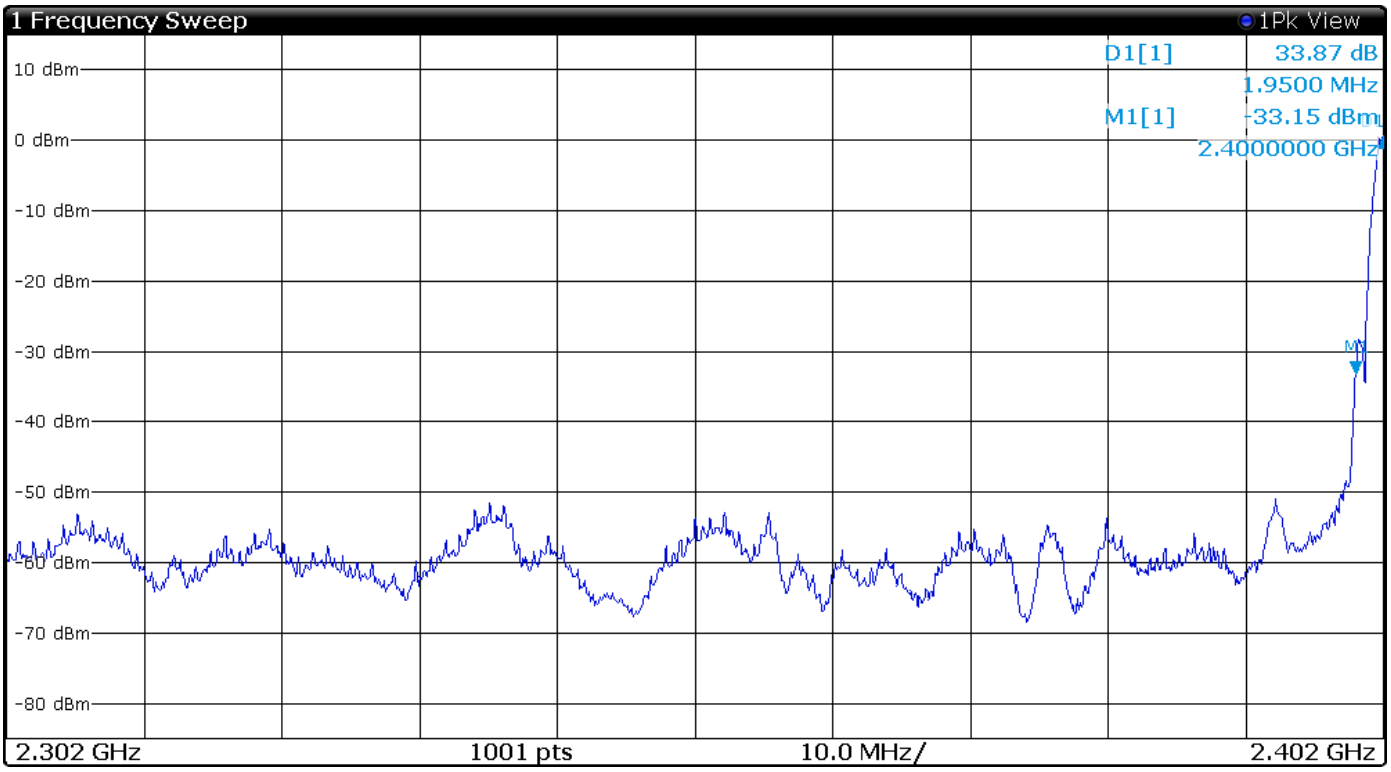


Figure 5 Plot of Transmitter Emissions High Band Edge Mode 1

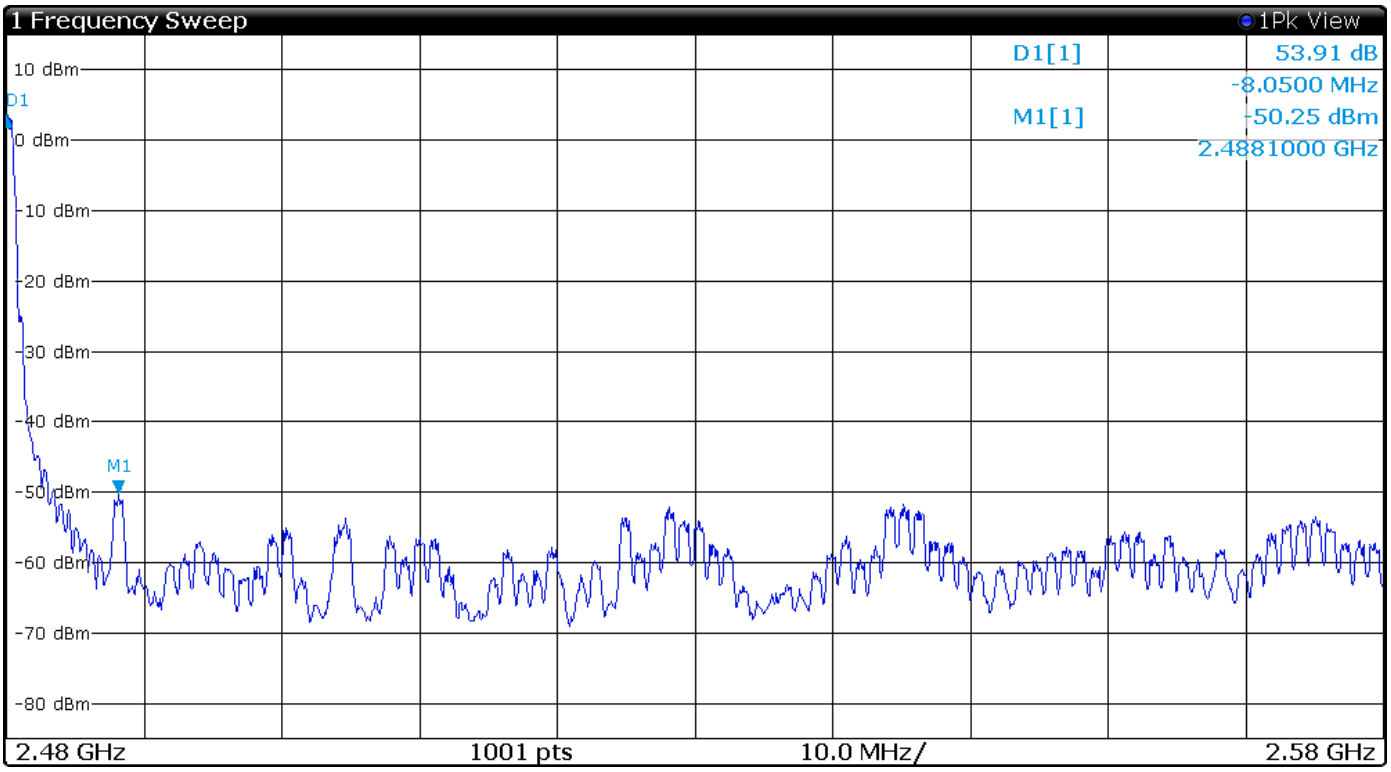


Figure 6 Plot of Transmitter Emissions High Band Edge Mode 2

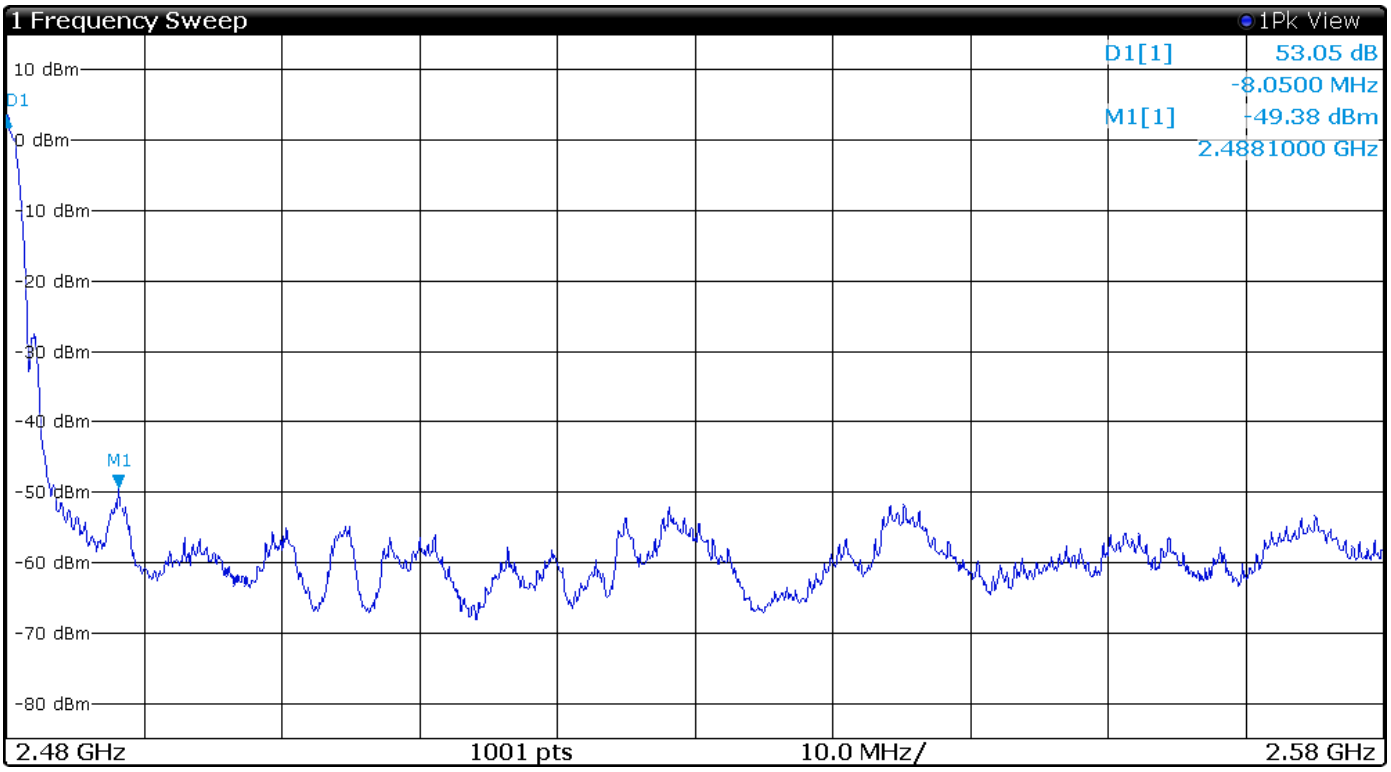
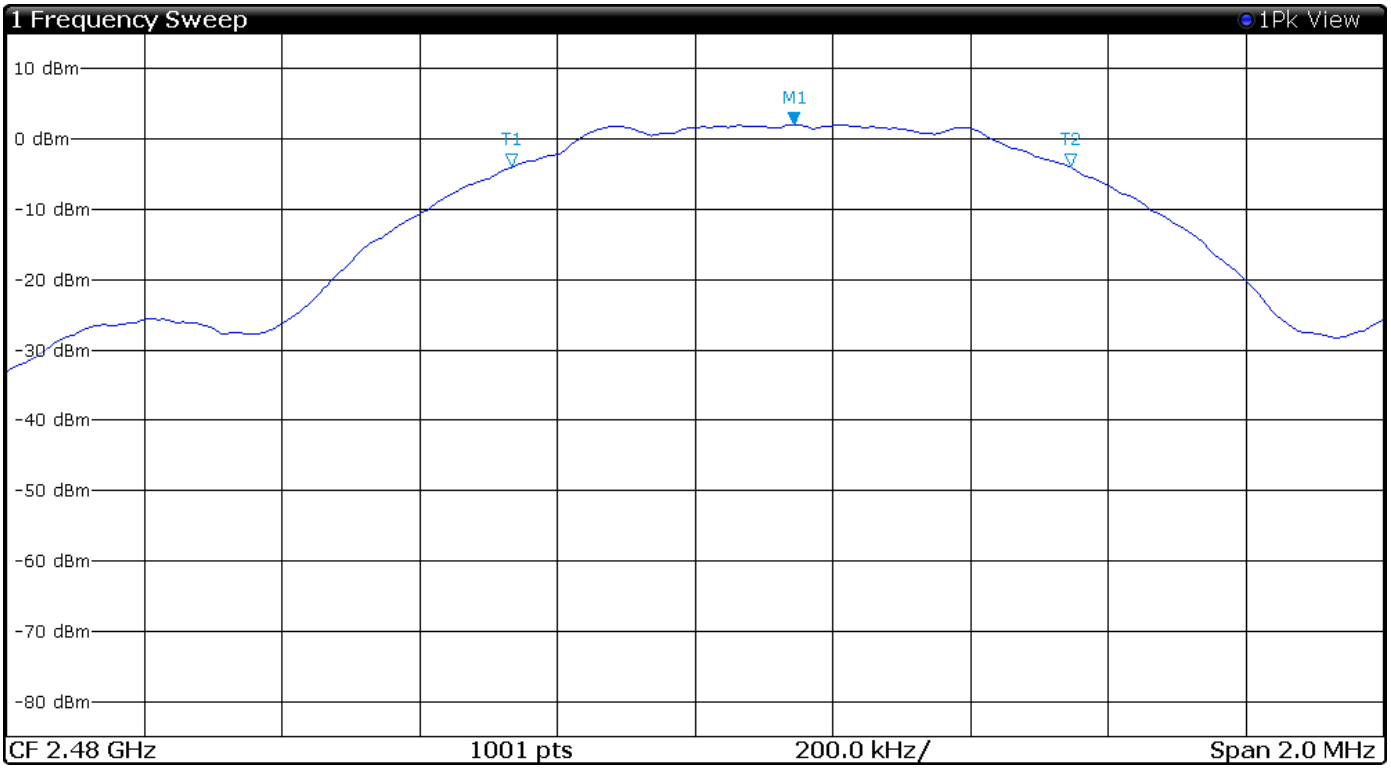
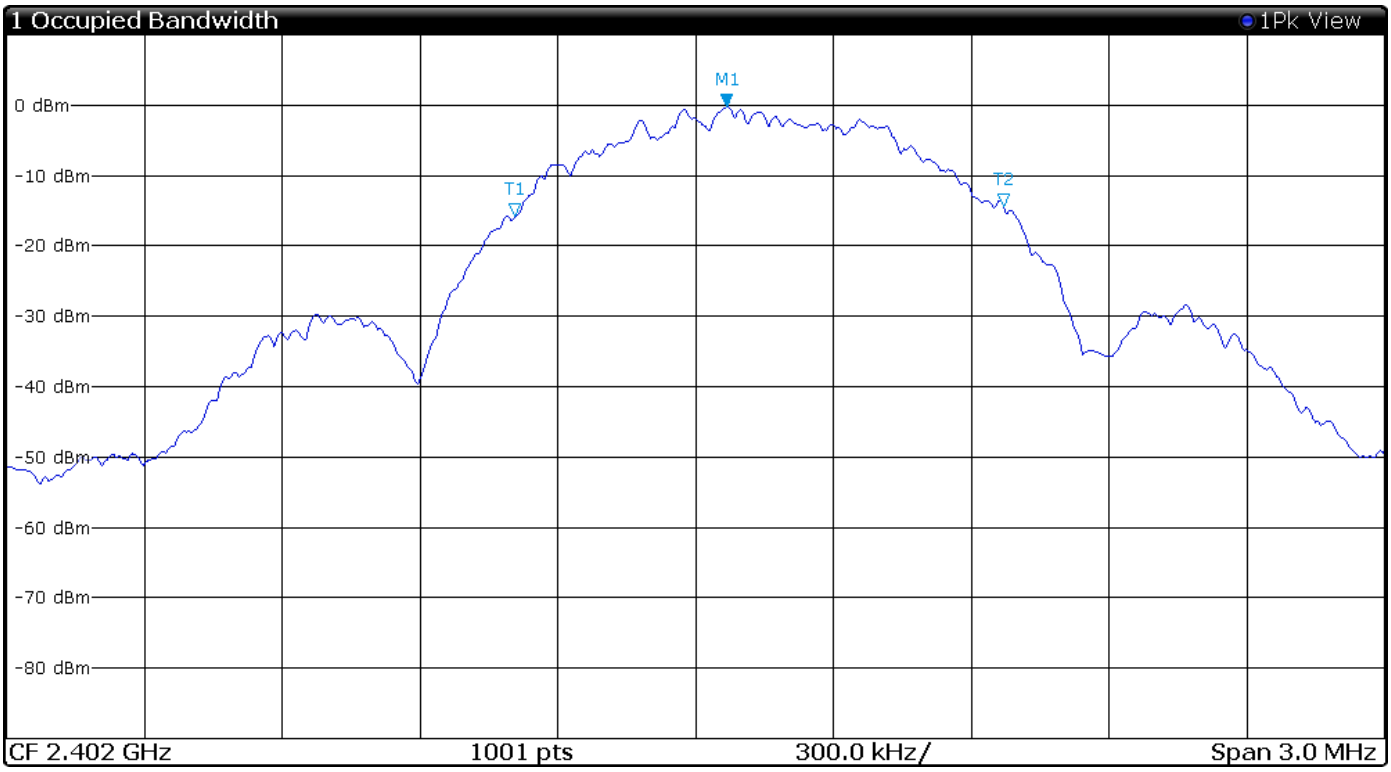


Figure 7 Plot of 6-dB Occupied Bandwidth Mode 1



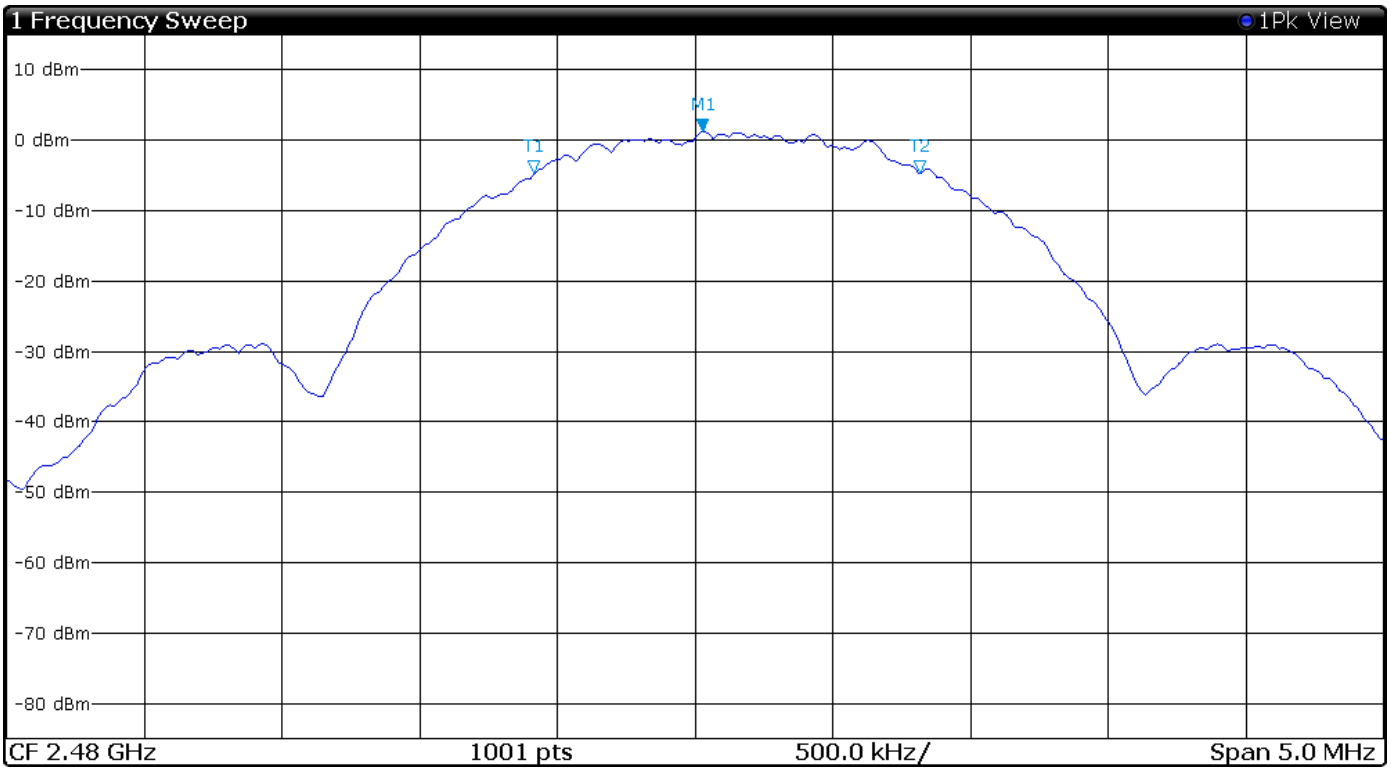
Type	Ref	Trace	X-Value	Y-Value	Function	Func Result
M1		1	2.48 GHz	2.1 dBm	ndB	6 dB
T1		1	2.48 GHz	-3.9 dBm	ndB down BW	811.2 kHz
T2		1	2.481 GHz	-4 dBm	Q Factor	3057

Figure 8 Plot of 99% Occupied Bandwidth Mode 1



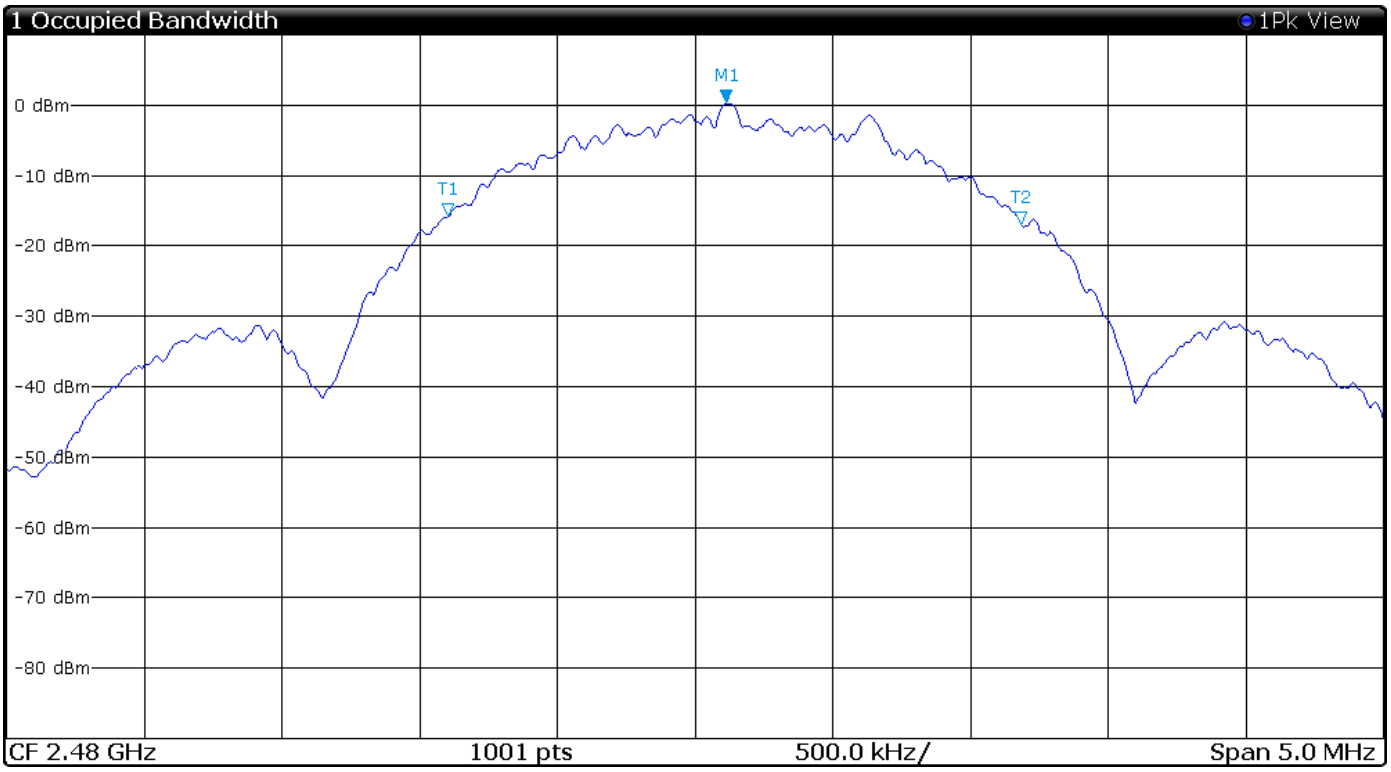
Type	Ref	Trace	X-Value	Y-Value	Function	Func Result
M1		1	2.402 GHz	-0.2 dBm	Occ Bw	
T1		1	2.402 GHz	-15.8 dBm	Occ Bw Centroid	
T2		1	2.403 GHz	-14.5 dBm	Occ Bw Freq Offset	

Figure 9 Plot of 6-dB Occupied Bandwidth Mode 2



Type	Ref	Trace	X-Value	Y-Value	Function	Func Result
M1		1	2.48 GHz	1.3 dBm	ndB	6 dB
T1		1	2.479 GHz	-4.7 dBm	ndB down BW	1.399 MHz
T2		1	2.481 GHz	-4.7 dBm	Q Factor	1773

Figure 10 Plot of 99% Occupied Bandwidth Mode 2



Type	Ref	Trace	X-Value	Y-Value	Function	Func Result
M1		1	2.48 GHz	0.3 dBm	Occ Bw	2.082 MHz
T1		1	2.479 GHz	-15.8 dBm	Occ Bw Centroid	2.48 GHz
T2		1	2.481 GHz	-17 dBm	Occ Bw Freq Offset	141.9 kHz

Figure 11 Plot of Transmitter Power Spectral Density Mode 1

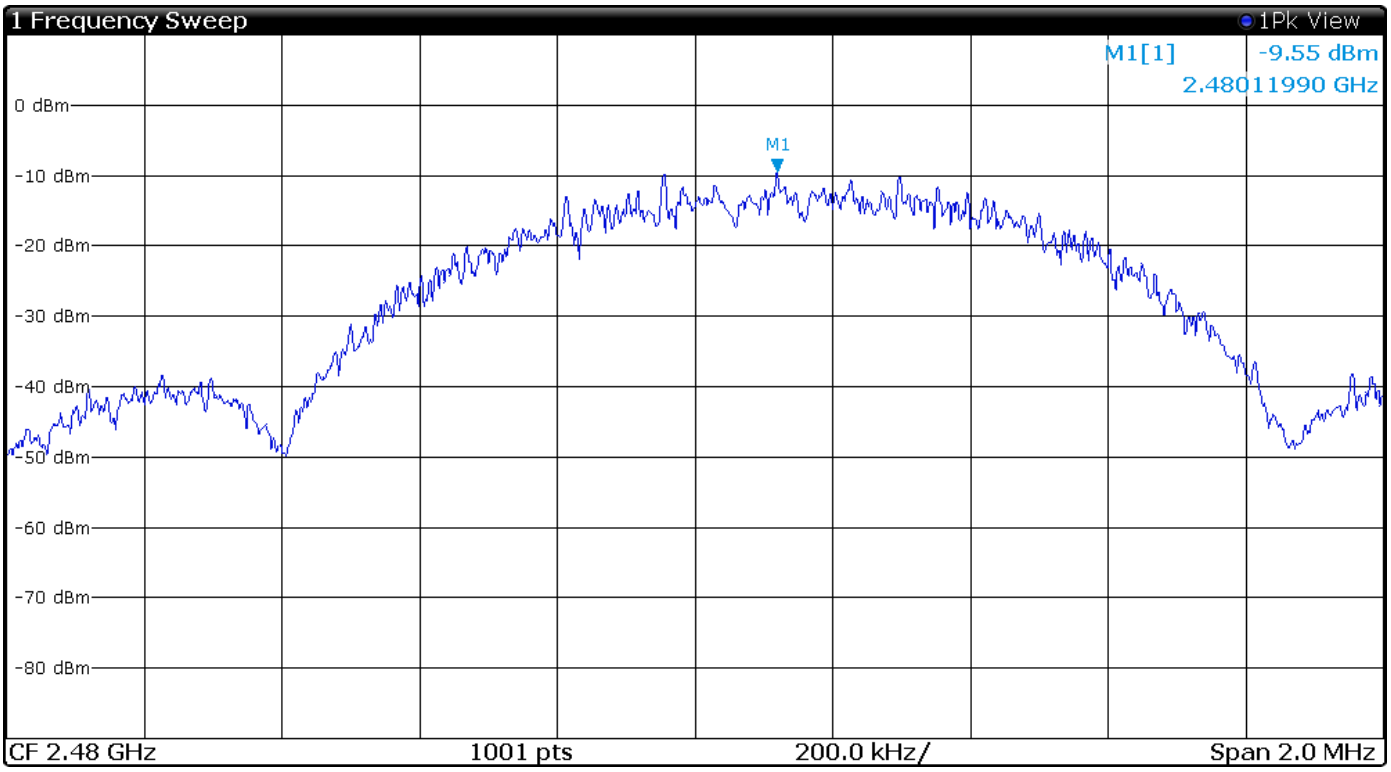
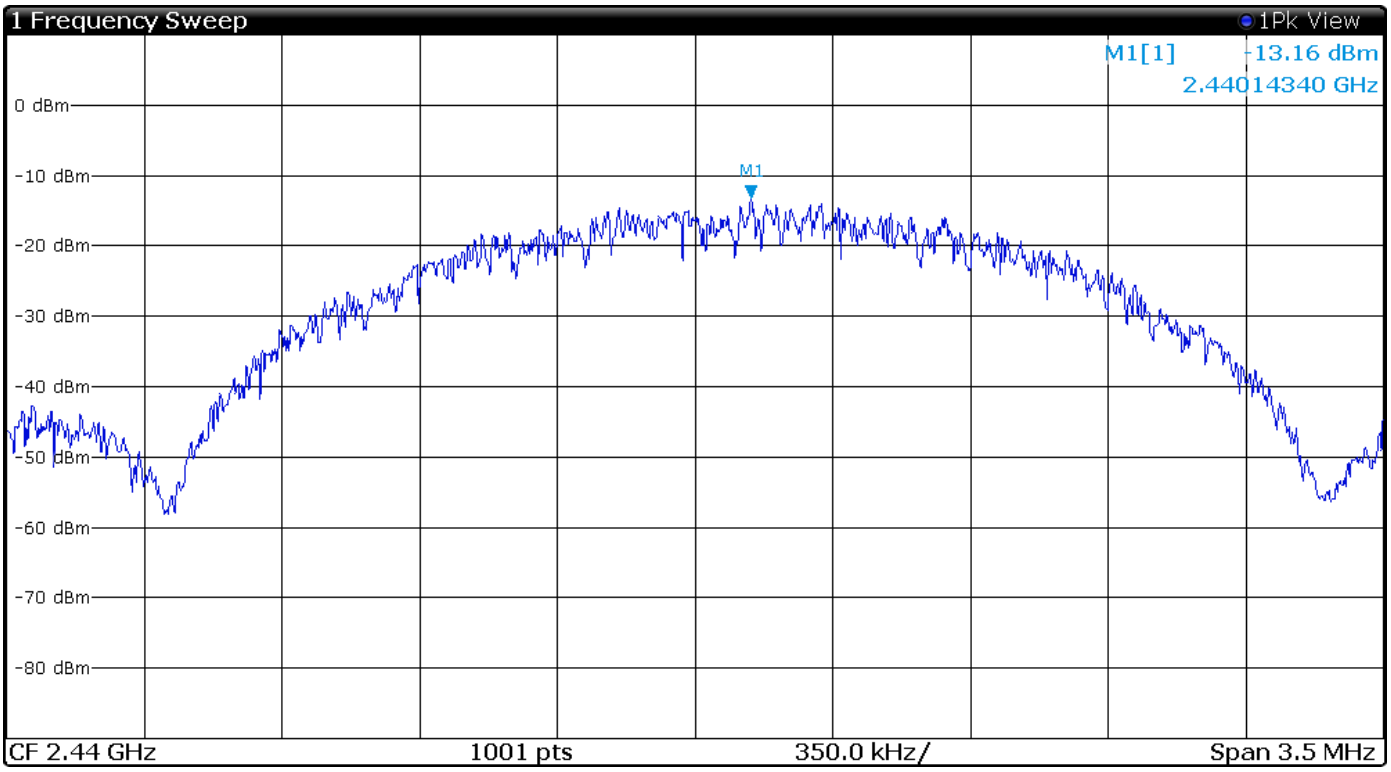


Figure 12 Plot of Transmitter Power Spectral Density Mode 2



Transmitter Emissions Data

Table 3 Transmitter Radiated Emissions Worst-case

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)	Horizontal Margin (dB)	Vertical Margin (dB)
2402.0	--	--	--	--	--	--	--
4804.0	54.1	37.8	50.2	36.7	54.0	-16.2	-17.3
7206.0	52.0	39.5	52.6	39.6	54.0	-14.5	-14.4
9608.0	55.1	42.1	55.3	42.2	54.0	-11.9	-11.8
12010.0	58.1	45.7	59.3	45.8	54.0	-8.3	-8.2
14412.0	61.7	48.9	62.2	49.0	54.0	-5.1	-5.0
16814.0	62.4	49.6	62.5	49.5	54.0	-4.4	-4.5
2440.0	--	--	--	--	--	--	--
4880.0	54.9	36.1	51.3	35.9	54.0	-17.9	-18.1
7320.0	53.4	39.6	53.7	39.7	54.0	-14.4	-14.3
9760.0	55.3	42.4	55.4	42.6	54.0	-11.6	-11.4
12200.0	59.9	46.3	58.8	46.3	54.0	-7.7	-7.7
14640.0	62.4	49.1	61.9	49.2	54.0	-4.9	-4.8
17080.0	62.0	49.2	62.1	49.3	54.0	-4.8	-4.7
2480.0	--	--	--	--	--	--	--
4960.0	53.4	36.4	51.8	36.3	54.0	-17.6	-17.7
7440.0	52.6	39.6	53.2	39.7	54.0	-14.4	-14.3
9920.0	55.7	42.6	55.5	42.7	54.0	-11.4	-11.3
12400.0	58.9	45.8	59.2	45.7	54.0	-8.2	-8.3
14880.0	61.3	48.2	61.9	48.2	54.0	-5.8	-5.8
17360.0	63.1	49.9	62.8	49.8	54.0	-4.1	-4.2

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

Table 4 Transmitter Antenna Port Conducted Data modes 5, 6, and 7

Frequency MHz	Antenna Port Average Output Power (Watts)	99% Occupied Bandwidth (kHz)	6-dB Occupied Bandwidth (kHz)	Peak Power Spectral Density (dBm)
Mode 1				
2402.0	0.003	1,072.8	795.2	-10.1
2440.0	0.002	1,062.3	799.2	-9.6
2480.0	0.003	1,069.4	811.2	-8.8
Mode 2				
2402.0	0.002	2,083.3	1,350.0	-12.7
2440.0	0.002	2,099.4	1,370.0	-11.9
2480.0	0.002	2,112.5	1,450.0	-13.1

Summary of Results for Transmitter Radiated Emissions of Intentional Radiator

The EUT demonstrated compliance with the radiated and conducted emission requirements of CFR47 Subpart 15C Paragraph 15.247, RSS-247 Issue 2 and RSS-GEN Issue 5 emission requirements for Digital Transmission Systems. Highest average output power measured at the antenna port was 0.003 Watts. The highest peak power spectral density measured at the antenna port presented a minimum margin of -16.8 dB below the requirements. The EUT demonstrated a minimum margin of -4.1 dB below the harmonic emissions 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.

Annex

- Annex A Measurement Uncertainty Calculations
- Annex B Test Equipment
- 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 Additional Test Equipment

Equipment	Manufacturer	Model (SN)	Band	Cal Date(m/d/y)	Due
☐ LISN	FCC	FCC-LISN-50-25-10(1PA) (160611)	.15-30MHz	4/21/2020	4/21/2021
☐ LISN	Compliance Design	FCC-LISN-2.Mod.cd,(126)	.15-30MHz	10/14/2020	10/14/2021
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(303073)	9kHz-40 GHz	10/14/2020	10/14/2021
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303069)	9kHz-40 GHz	10/14/2020	10/14/2021
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303070)	9kHz-40 GHz	10/14/2020	10/14/2021
☐ Cable	Belden	RG-58 (L1-CAT3-11509)	9kHz-30 MHz	10/14/2020	10/14/2021
☐ Cable	Belden	RG-58 (L2-CAT3-11509)	9kHz-30 MHz	10/14/2020	10/14/2021
☒ Antenna	Com Power	AL-130 (121055)	.001-30 MHz	10/14/2020	10/14/2021
☐ Antenna:	EMCO	6509	.001-30 MHz	10/14/2020	10/14/2022
☐ Antenna	ARA	BCD-235-B (169)	20-350MHz	10/14/2020	10/14/2021
☐ Antenna:	Schwarzbeck Model	VHBB 9124 (9124-627)		4/21/2020	4/21/2021
☒ Antenna	Sunol	JB-6 (A100709)	30-1000 MHz	10/14/2020	10/14/2021
☐ Antenna	ETS-Lindgren	3147 (40582)	200-1000MHz	10/14/2020	10/14/2022
☐ Antenna:	Schwarzbeck Model:	VULP 9118 A (VULP 9118 A-534)		4/21/2020	4/21/2021
☒ Antenna	ETS-Lindgren	3117 (200389)	1-18 GHz	4/21/2020	4/21/2022
☐ Antenna	Com Power	AH-118 (10110)	1-18 GHz	10/14/2020	10/14/2022
☒ Antenna	Com Power	AH-840 (101046)	18-40 GHz	4/21/2020	4/21/2021
☒ Analyzer	Rohde & Schwarz	ESU40 (100108)	20Hz-40GHz	3/2/2021	3/2/2022
☒ Analyzer	Rohde & Schwarz	ESW44 (101534)	20Hz-44GHz	1/12/2021	1/12/2022
☐ Analyzer	Rohde & Schwarz	FS-Z60, 90, 140, and 220	40GHz-220GHz	12/22/2017	12/22/2027
☒ Amplifier	Com-Power	PA-010 (171003)	100Hz-30MHz	10/14/2020	10/14/2021
☒ Amplifier	Com-Power	CPPA-102 (01254)	1-1000 MHz	10/14/2020	10/14/2021
☒ Amplifier	Com-Power	PAM-118A (551014)	0.5-18 GHz	10/14/2020	10/14/2021
☒ Amplifier	Com-Power	PAM-840A (461328)	18-40 GHz	10/14/2020	10/14/2021
☐ Power Meter	Agilent	N1911A with N1921A	0.05-40 GHz	4/21/2020	4/21/2021
☐ Generator	Rohde & Schwarz	SMB100A6 (100150)	20Hz-6 GHz	4/21/2020	4/21/2021
☐ Generator	Rohde & Schwarz	SMBV100A6 (260771)	20Hz-6 GHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC50722 (009).9G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	HPM50114 (017)1.5G HPF	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	HPM50117 (063) 3G HPF	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	HPM50105 (059) 6G HPF	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRM50702 (172) 2G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC50703 (G102) 5G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC50705 (024) 5G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Fairview	SA6NFNF100W-40 (1625)	30-18000 MHz	4/21/2020	4/18/2021
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1436)	30-6000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1445)	30-6000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1735)	30-6000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Mini-Circuits	VAT-6W2+ (1438)	30-6000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Mini-Circuits	VAT-6W2+ (1736)	30-6000 MHz	4/21/2020	4/21/2021
☒ Weather station	Davis	6312 (A81120N075)		11/4/2020	11/4/2021

List of Test Equipment				Calibration	Date (m/d/y)	Due
☐ Frequency Counter: Leader LDC-825 (8060153					4/21/2020	4/21/2021
☐ LISN: Com-Power Model LI-220A					10/14/2020	10/14/2021
☐ LISN: Com-Power Model LI-550C					10/14/2020	10/14/2021
☐ ISN: Com-Power Model ISN T-8					4/21/2020	4/21/2021
☐ LISN: Fischer Custom Communications Model: FCC-LISN-50-16-2-08					4/21/2020	4/21/2021
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303072)	9kHz-40 GHz		10/14/2020	10/14/2021
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L1M)(281183)	9kHz-40 GHz		10/14/2020	10/14/2021
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L4M)(281184)	9kHz-40 GHz		10/14/2020	10/14/2021
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(317546)	9kHz-40 GHz		10/14/2020	10/14/2021
☐ Cable	Time Microwave	4M-750HF290-750 (4M)	9kHz-24 GHz		10/14/2020	10/14/2021
☐ RF Filter	Micro-Tronics	BRC17663 (001) 9.3-9.5 notch	30-1800 MHz		4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC19565 (001) 9.2-9.6 notch	30-1800 MHz		10/16/2018	4/21/2021
☐ Analyzer	HP	8562A (3051A05950)	9kHz-125GHz		4/21/2020	4/21/2021
☐ Analyzer	HP External Mixers	11571, 11970	25GHz-110GHz		4/18/2015	4/18/2025
☐ Analyzer	HP	8591EM (3628A00871)			4/21/2020	4/21/2021
☐ Wave Form Generator Keysight		33512B (MY57400128)			4/21/2020	4/21/2021
☐ Antenna: Solar 9229-1 & 9230-1					2/22/2021	2/22/2022
☐ CDN: Com-Power Model CDN325E					10/14/2020	10/14/2021
☐ Injection Clamp Luthi Model EM101					10/14/2020	10/14/2021
☐ Oscilloscope Scope: Tektronix MDO 4104					2/22/2021	2/22/2022
☐ EMC Transient Generator HVT TR 3000					2/22/2021	2/22/2022
☐ AC Power Source (Ametech, California Instruments)					2/22/2021	2/22/2022
☐ Field Intensity Meter: EFM-018					2/22/2021	2/22/2022
☐ ESD Simulator: MZ-15					2/22/2021	2/22/2022
☐ R.F. Power Amp ACS 230-50W					not required	
☐ R.F. Power Amp EIN Model: A301					not required	
☐ R.F. Power Amp A.R. Model: 10W 1010M7					not required	
☐ R.F. Power Amp A.R. Model: 50U1000					not required	
☐ Tenney Temperature Chamber					not required	
☒ Shielded Room					not required	

Annex C Rogers Qualifications

Scot D. Rogers, Engineer

Rogers Labs, Inc.

Mr. Rogers has 35 years' experience in the field of electronics. Work experience includes working 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.

Annex D Laboratory Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2017

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 17025:2017. 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).

2021-02-19 through 2022-03-31
Effective Dates

For the National Voluntary Laboratory Accreditation Program