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Application For Grant of Certification

47CFR Paragraph 15.247 FHSS and Industry Canada RSS-GEN Issue 5 and RSS-247 Issue 2

HVIN: MPRXFH5

902.5-927.5 MHz (DSSS)
Frequency Hopping Spread Spectrum
License Exempt Intentional Radiator

FCC ID: FIHMPRXFH5P15
IC: 1584A-MPRXFH5R247

Transcore

Amtech Technology Center
8600 Jefferson Street, NE
Albuquerque, NM 87113

FCC Designation: US5305
ISED Registration: 3041A

Test Report Number: 220525

Test Date: May 25, 2022

Authorized Signatory: Scot D Rogers
Scot D. Rogers

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Revisions

Revision 1 Isued June 15, 2022

Executive Summary

License Exempt Digital Transmission System Intentional Radiator operating under Title 47 of the Code of Federal Regulations (47CFR) Paragraph 15.247 and Industry Canada RSS-247 Issue 2 and RSS-GEN Issue 5, Frequency Hopping Spread Spectrum (FHSS) or Direct Sequence Spread Spectrum (DSS) transmitter operations in the 2400-2483.5 MHz frequency band.

Name of Applicant: Transcore
Amtech Technology Center
8600 Jefferson Street, NE
Albuquerque, NM 87113

HVIN: MPRXFH5 PMN: MPRXFH

FCC ID: FIHMPRXFH5P15 IC: 1584A-MPRXFH5R247

Operating Frequency Range: 902.5-927.5 MHz

Operation Direct Sequence Spread Spectrum (DSS) communication

Antenna Port Conducted Power Watts	99% OBW (kHz)	20-dB OBW (kHz)
1.00	488	197

This report addresses EUT Operations as Direct Sequence Spread Spectrum transmitter. Note, the device provides for use with antenna gains not exceeding 14 dBi. The transmitter power must be reduced to comply with maximum e.i.r.p. levels of 36 dBm.

Opinion / Interpretation of Results

Tests Performed	Margin (dB)	Results
Restricted Bands 47CFR 15.205, RSS-210 4.1	-14.9	Complies
AC Line Emissions as per 47CFR 15.207, RSS-GEN 8.8	-20.0	Complies
Unwanted Radiated Emissions 47CFR 15.247, RSS-247	-62.2	Complies
Harmonic Emissions per 47CFR 15.247, RSS-210 B.10	-11.9	Complies

Tests performed include
47CFR
§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20-dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20-dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

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

(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)).

RSS-247 Issue 2

5.1 Frequency hopping systems (FHS)

FHSs employ a spread spectrum technology in which the carrier is modulated with coded information in a conventional manner, causing a conventional spreading of the radio frequency (RF) energy around the carrier frequency. The carrier frequency is not fixed, but changes at fixed intervals under the direction of a coded sequence.

FHSs are not required to employ all available hopping frequencies during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the requirements in this section in case the transmitter is presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of frequency hopping equipment and must distribute its transmissions over the minimum number of hopping channels specified in this section.

Incorporation of intelligence into an FHS that enables it to recognize other users of the band and to avoid occupied frequencies is permitted provided that the FHS does it individually and independently chooses or adapts its hopset. The coordination of FHSs in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

The following applies to FHSs in each of the three bands:

a) The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

b) FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

c) For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

d)FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

e)FHSs operating in the band 5725-5850 MHz shall use at least 75 hopping channels. The maximum20 dB bandwidth of the hopping channel shall be 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30-second period.

Equipment Tested

Model: MPRXFH5

Transcore
Amtech Technology Center
8600 Jefferson Street, NE
Albuquerque, NM 87113

Equipment	HVIN	Serial Number
EUT (Single Port)	MPRXFH5	21104849
EUT (4-Port)	MPRXFH5	21230053
DC Communications interface	Manufacturer provided	N/A
Computer	Dell E6520	6CB35Q1

Test results in this report relate only to the items tested

Software Version: 1.11MH1

The software provides ability to adjust power from 30 dBm to 15 dBm in 1 dB steps. The power level of the design is nominal 1.0 watts (30 dBm) for authorized FHSS operation in the 902-928 MHz band operating specifically in the 902.5-927.5 MHz frequency band.

Antenna List

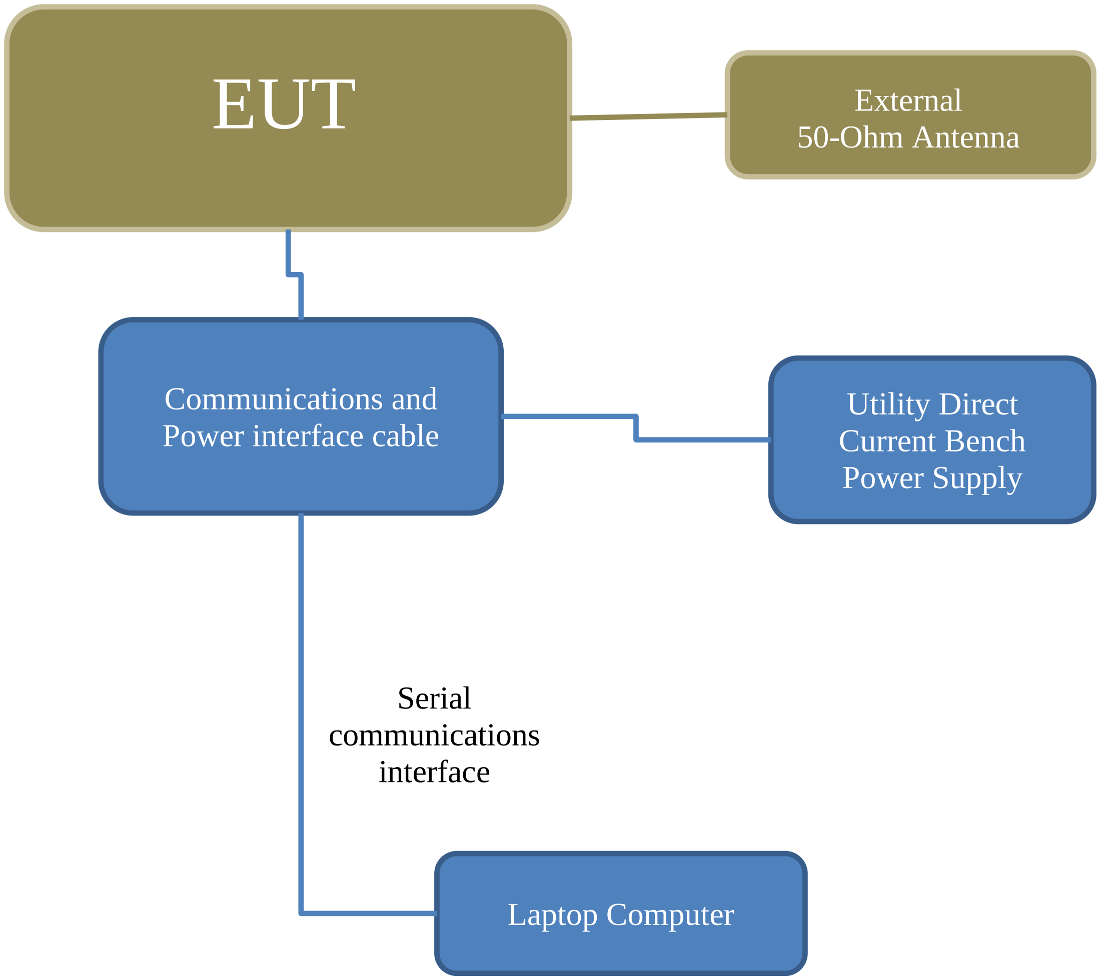
Antenna options for this transmitter are included in the User Guide and range from -30 to 14 dBi. Use of antennas with gain exceeding 6 dBi requires power reduction which may include cable loss for length of cable between transmitter and antenna location.

Manufacture	Part Number	Polarization	Gain (dBi)	Min line Loss Required (dB)
Huber Suhner	1309.17.0111/85018546	Circular	5.50	0.00
Kathrein	52010087	Circular	11.00	5.00
Kathrein	52010249	Linear	11.00	5.00
Kathrein	52010092	Circular	-30.00	0.00
Laird	S9028P	Linear	8.00	2.00
Laird	S9025PR	Circular	5.50	0.00
MARS Antennas & RF Systems LTD.	MA-IS91-T2	Linear	10.50	4.50
Mobile Mark	PN6-915RCP-1C-WHT-6	RH Circular	6.00	0.00
Mobile Mark	PN6-915LCP-1C-WHT-6	LH Circular	6.00	0.00
Mobile Mark	PL8-915RCP-1Y-WHT-12	RH Circular	8.00	2.00
Mobile Mark	HD7-915RCP-BLK	RH Circular	7.00	1.00
MTI Wireless Edge LTD.	MT-263007/TRH/A/K	Circular	11.50	5.50
TransCore	AA3152 Universal Toll Antenna	Linear	14.00	8.00
TransCore	AA3237	Linear	6.00	0.00
TransCore	AA3110	Linear	12.50	6.50
TransCore	AA3153	Linear	10.50	4.50
MTI Wireless Edge LTD.	MT-26024/TRH/A/K	RH Circular	7.50	1.50

Equipment Function

The EUT is a fixed mounted Direct Sequence Spread Spectrum (DSS) transmitter. The design provides the ability to read and report Radio-Frequency Identification Tags used in the Intelligent Transportation Systems Radio Service. The system operates from direct current power covering the input power range of 12-110 V_{dc}. The power and communications interface cable provides serial interface for communications with other digital equipment. The manufacturer provided test software on the device which allowed testing personnel operational control of the transmitter for testing purposes. The software provided ability to operate the transmitter both in hopping mode as well as on single channel at 100% duty cycle for testing purposes. Two test samples were provided for testing, 1) device has single antenna port and 2) a multiplexed version providing four-ports of which only a single port is operational at any time. The test samples were loaded with manufacturer software Version 1.11MH1. The EUT was arranged as described by the manufacturer emulating typical use configurations for testing purposes. The EUT offers no other interface connections than those documented in the configuration options presented. During testing all interface connections were appropriately terminated. As requested by the manufacturer and required by regulations, 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



Application for Certification

(1) Manufacturer: Transcore
Amtech Technology Center
8600 Jefferson Street, NE
Albuquerque, NM 87113

(2) Identification: M/N: MPRXFH5
FCC ID: FIHMPRXFH5P15 IC: 1584A-MPRXFH5R247

(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 covering the input range 12-110 Vdc. The EUT provides serial interface connection for communications as presented in this filing.

(9) Transition Provisions of 47CFR 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.

Applicable Standards

The following information is submitted in accordance with the eCFR (electronic Title 47 Code of Federal Regulations) (47CFR), dated May 25, 2022: Part 2, Subpart J, Part 15C Paragraph 15.247, 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 Direct Sequence Spread Spectrum Transmitter.

Equipment Testing Procedures

AC Line Conducted Emission Test Procedure

The device operates on direct current power only. Therefore, AC line conducted emission testing was performed on the power source for the computer (digital device). Testing for the AC line-conducted emissions were performed as required in 47CFR 15C, RSS-GEN, RSS-247 Issue 2 and specified 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 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 the test setup exhibit for EUT placement used during testing.

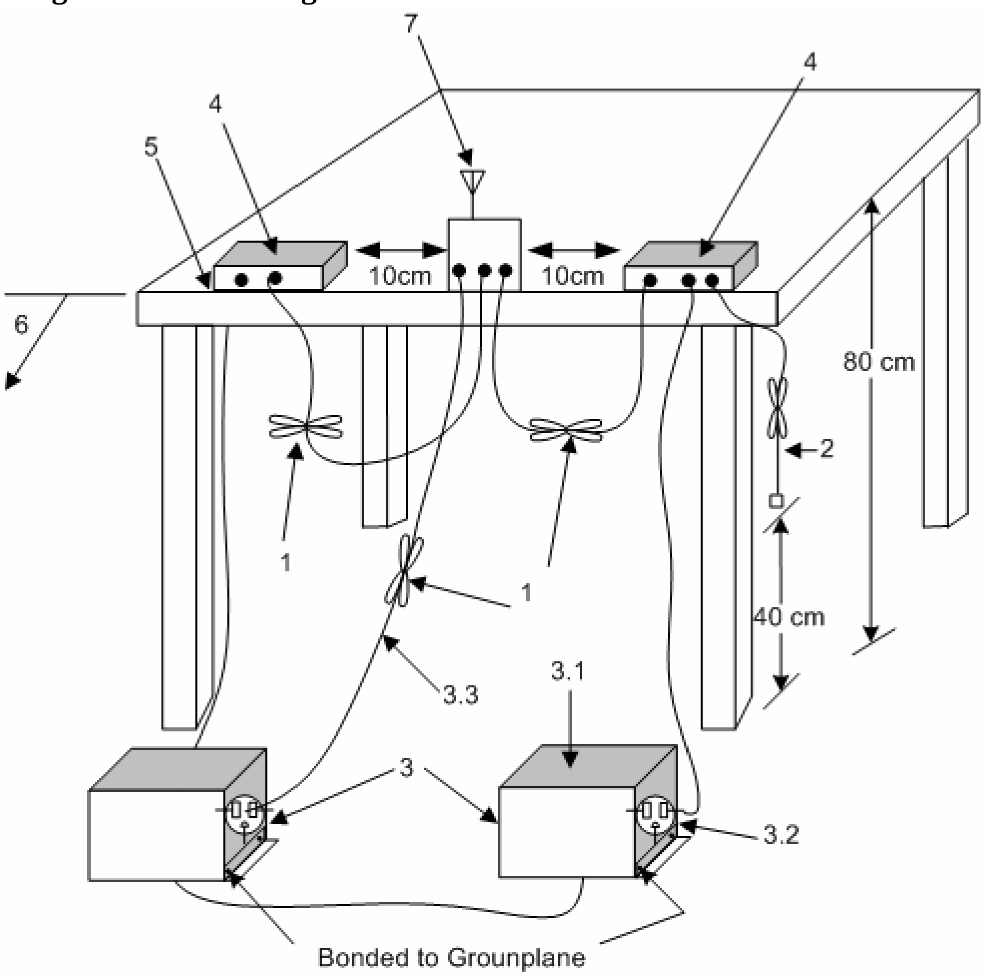
Radiated Emission Test Procedure

Radiated emissions testing was performed as required in 47CFR 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 10,000 MHz was searched for emissions during preliminary investigation. Refer to diagrams two and three showing typical test setup. Refer to photographs in the test setup exhibits for specific EUT placement during testing.

Antenna Port Conducted Emission Test Procedure

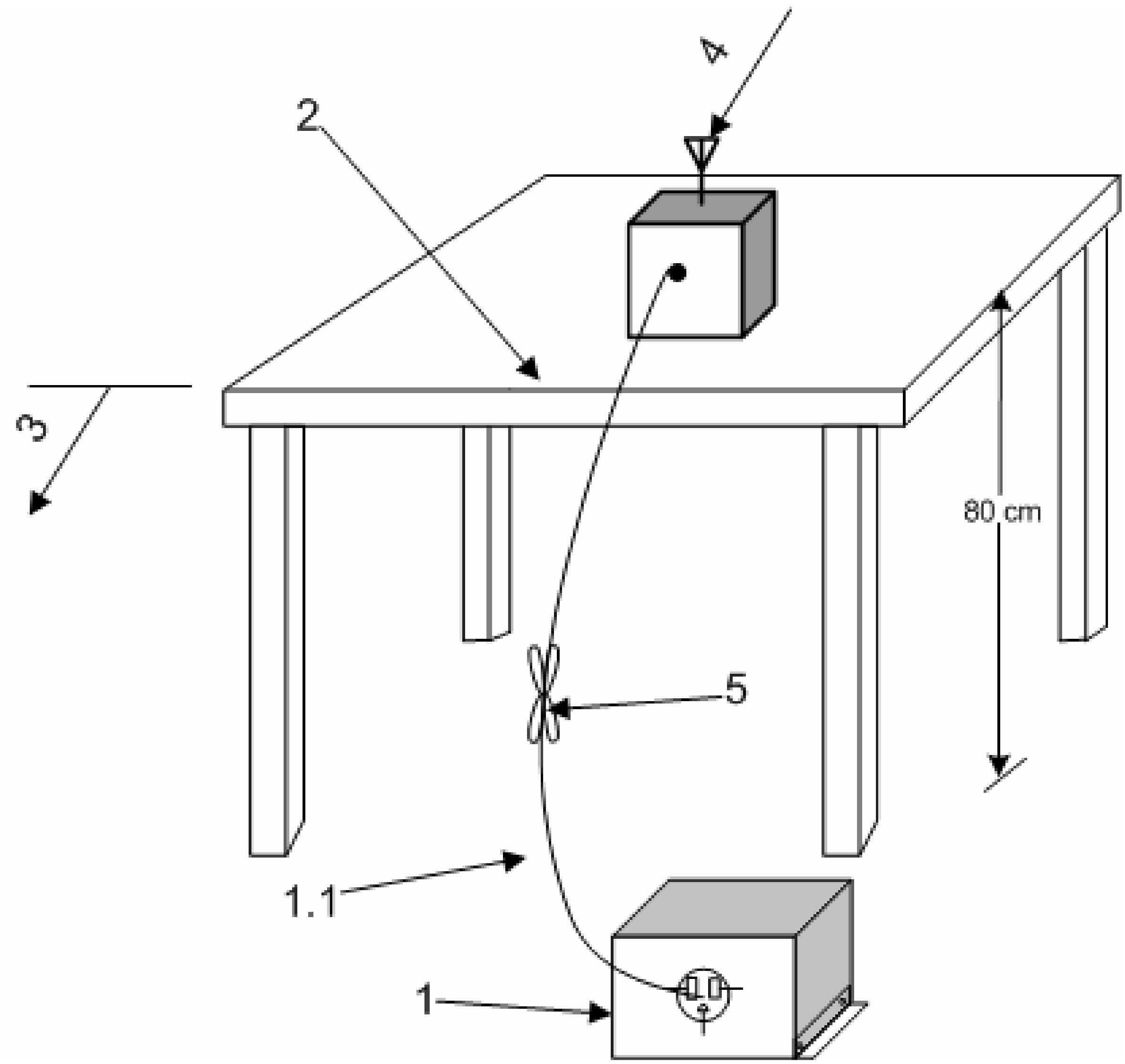
The EUT was assembled as required for operation and placed on a benchtop. This configuration provided the ability to connect test equipment to the provided test antenna port Antenna Port conducted emissions testing was performed as presented in this document and specified in ANSI C63.10-2013. Testing 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 four showing typical test arrangement and photographs in the test setup exhibits for specific EUT placement during testing.

Diagram 1 Test arrangement for Conducted emissions



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 6.2.3.1).
2. 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 can 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 rear of tabletop (see 6.2.3.1).
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 2 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 3 Test arrangement for radiated emissions tested on Open Area Test Site (OATS)

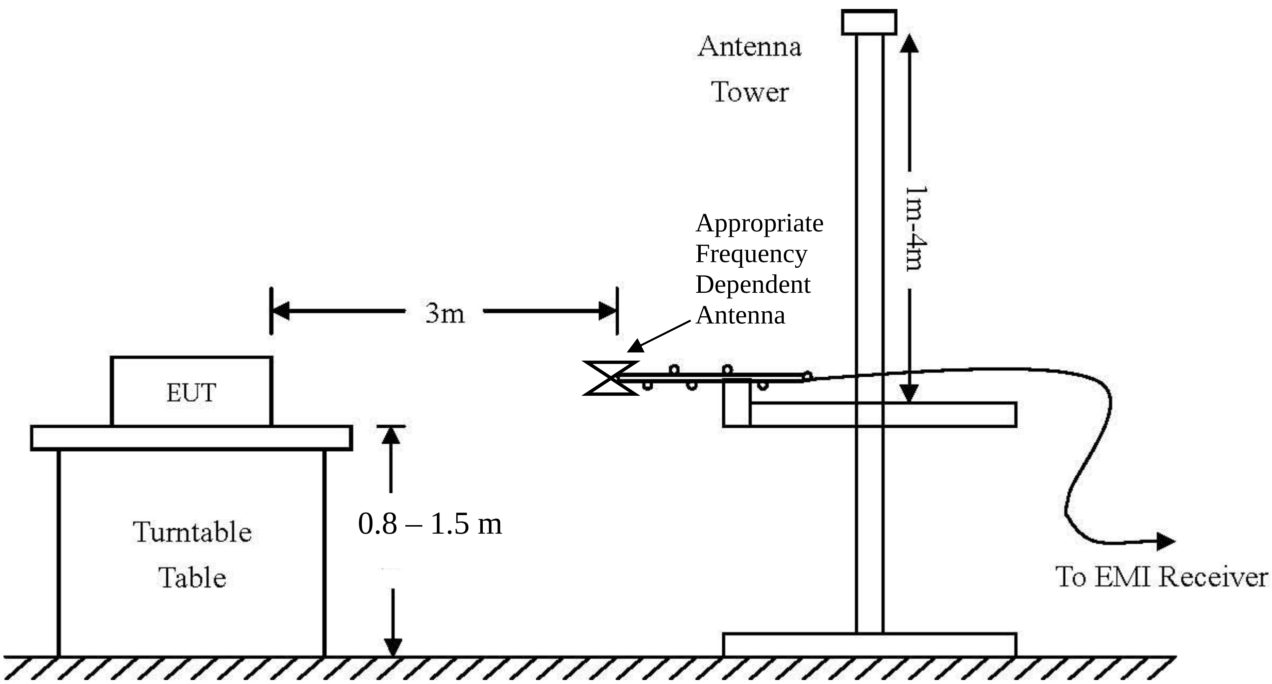
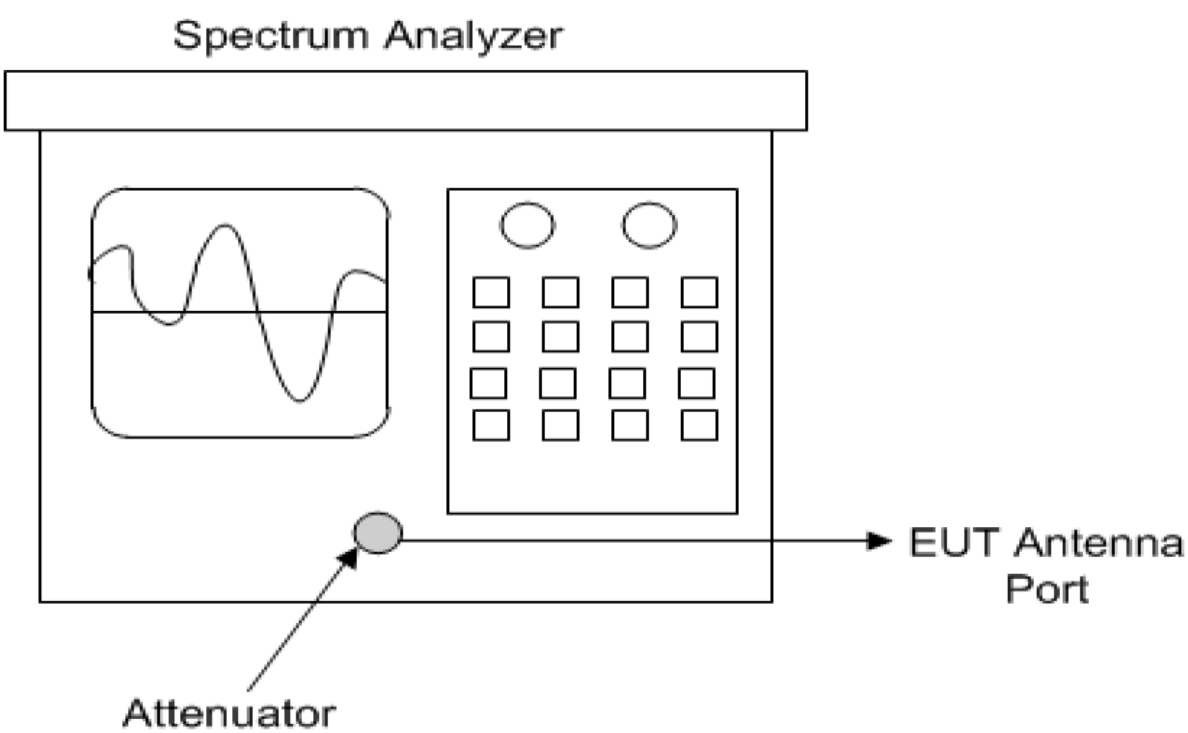


Diagram 4 Test arrangement for Antenna Port Conducted emissions



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 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	22.8° C
Relative Humidity	49 %
Atmospheric Pressure	1010.3 mb

Statement of Modifications and Deviations

No modifications to the EUT were required for the equipment to demonstrate compliance with the 47CFR Part 15C, Industry Canada 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 supporting compliance with the requirements of 47CFR, Subpart C, paragraph 15.247, Industry Canada RSS-247 Issue 2, and RSS-GEN Issue 5.

Antenna Requirements

The design is distributed and marketed through authorized dealers and installers to specific industrial, commercial, and governmental applications. Professional installation by the dealer or authorized installer is required. The equipment is professionally installed in secure locations which provide restricted access. Installers are responsible to ensure output power is reduced as required by the antenna selection and requirements. 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 antenna port. 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 Restricted Frequency Radiated Emissions Data

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)
2707.5	48.4	37.9	47.7	39.1	54.0	-16.1	-14.9
2745.0	45.3	33.8	45.5	33.8	55.0	-21.2	-21.2
2782.5	45.8	33.5	45.6	33.0	56.0	-22.5	-23.0
3610.0	47.7	34.1	47.5	34.5	57.0	-22.9	-22.5
3660.0	46.3	32.6	45.9	32.8	58.0	-25.4	-25.2
3710.0	46.1	33.5	46.1	33.3	59.0	-25.5	-25.7
4512.5	46.7	33.6	46.3	33.6	60.0	-26.4	-26.4
4575.0	48.1	35.6	48.4	35.6	61.0	-25.4	-25.4
4637.5	48.6	36.1	48.9	36.1	62.0	-25.9	-25.9
5415.0	49.2	36.4	49.1	36.4	63.0	-26.6	-26.6
5490.0	50.4	37.3	51.6	37.3	64.0	-26.7	-26.7
5565.0	50.3	37.8	50.5	37.8	65.0	-27.2	-27.2

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.

Results for Restricted Bands Radiated Emissions

The EUT demonstrated compliance with the radiated emissions requirements of 47CFR Part 15C and RSS-247 Issue 2 Intentional Radiator requirements. The EUT demonstrated a worst-case minimum margin of -14.9 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 EMI

The EUT was arranged in typical AC power equipment configurations for AC Line Conducted emissions testing. Testing was performed with the EUT 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. Testing for the AC line-conducted emissions were the procedures of ANSI C63.10-2013 paragraph 6. The AC power adapter or CPU providing power to the EUT was connected to the LISN for AC line-conducted emissions testing. 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 those 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 was 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 frequencies of each of the emissions, which demonstrated the highest amplitudes. 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 data was recorded with maximum conducted emissions levels.

Refer to figures one and two for plots of applicable configuration, EUT – USB Computer interface AC Line conducted emissions.

Figure 1 AC Line Conducted EMI line 1 (EUT – Computer)

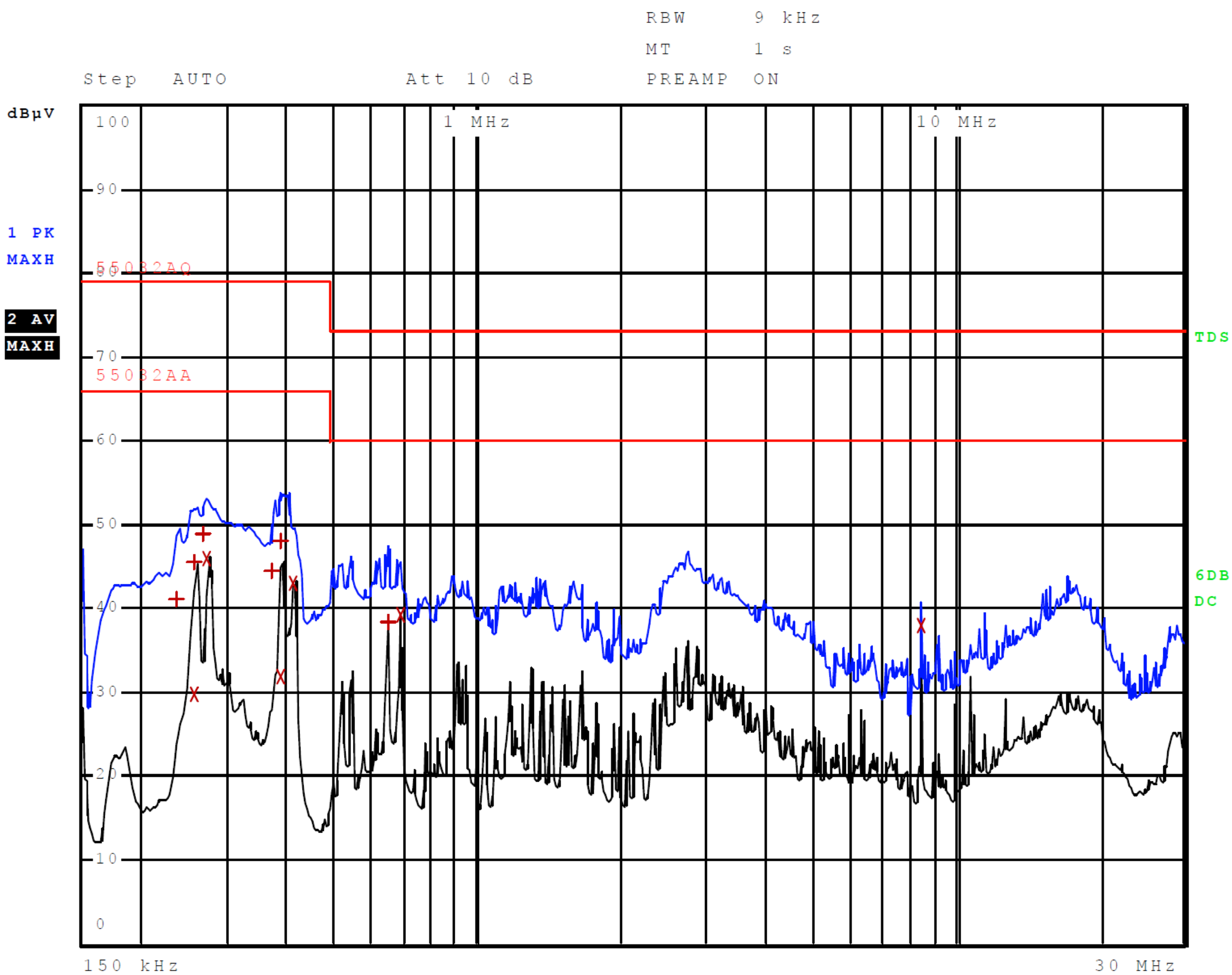


Figure 2 AC Line Conducted EMI line 2 (EUT – Computer)

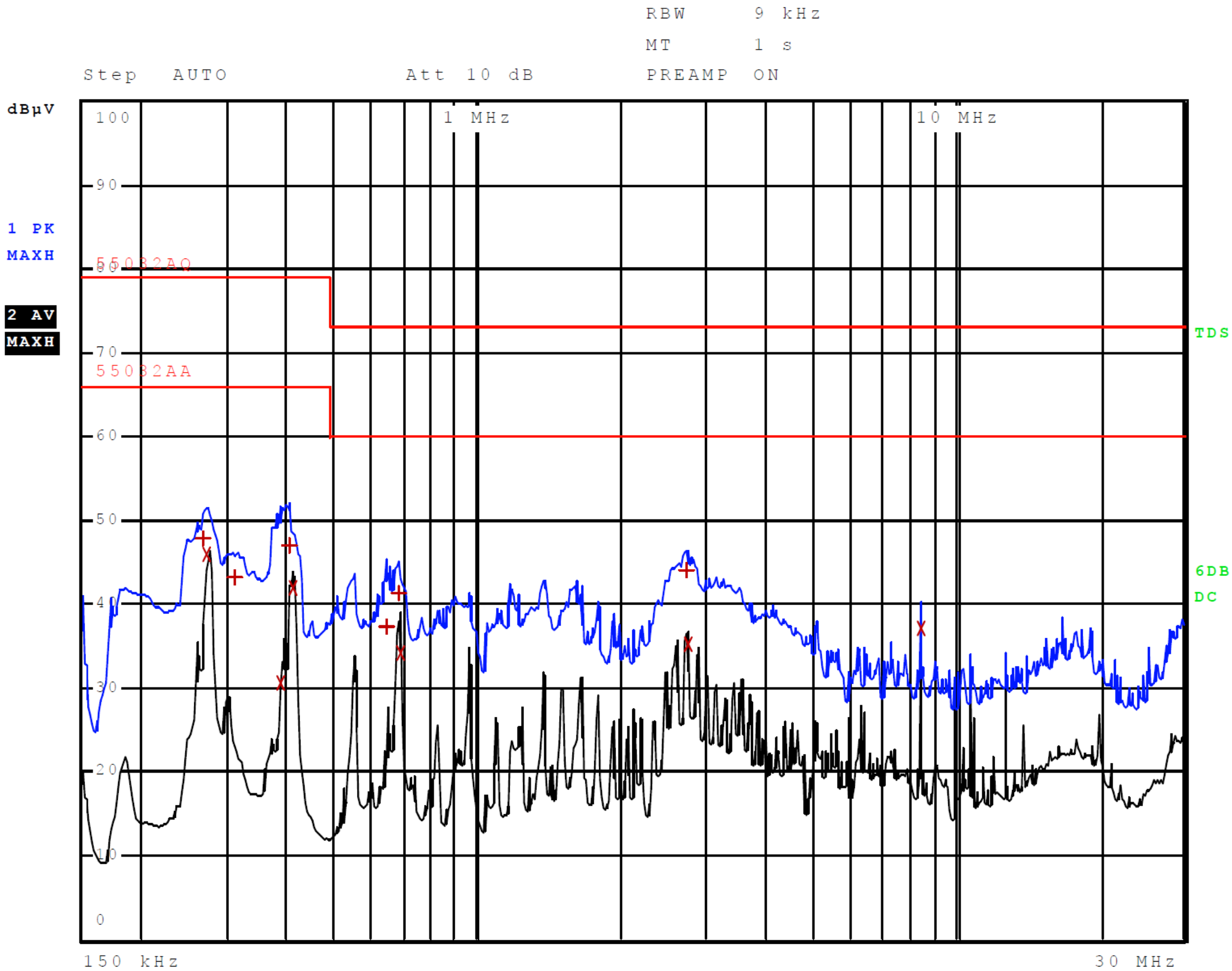


Table 2 AC Line Conducted EMI Data L1 (EUT – Computer)

Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
1	238.000000000 kHz	41.02	Quasi Peak	-37.98
1	258.000000000 kHz	45.45	Quasi Peak	-33.55
2	258.000000000 kHz	29.77	Average	-36.23
1	270.000000000 kHz	48.87	Quasi Peak	-30.13
2	274.000000000 kHz	45.83	Average	-20.17
1	374.000000000 kHz	44.38	Quasi Peak	-34.62
1	386.000000000 kHz	48.10	Quasi Peak	-30.90
2	390.000000000 kHz	31.79	Average	-34.21
2	414.000000000 kHz	42.93	Average	-23.07
1	646.000000000 kHz	38.41	Quasi Peak	-34.59
2	690.000000000 kHz	39.28	Average	-20.72
2	8.455900000 MHz	37.97	Average	-22.03

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

Table 3 AC Line Conducted EMI Data L2 (EUT – Computer)

Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
1	270.000000000 kHz	47.75	Quasi Peak	-31.25
2	274.000000000 kHz	45.98	Average	-20.02
1	314.000000000 kHz	43.11	Quasi Peak	-35.89
2	390.000000000 kHz	30.60	Average	-35.40
1	402.000000000 kHz	46.99	Quasi Peak	-32.01
2	410.000000000 kHz	41.93	Average	-24.07
1	642.000000000 kHz	37.22	Quasi Peak	-35.78
1	682.000000000 kHz	41.20	Quasi Peak	-31.80
2	690.000000000 kHz	34.11	Average	-25.89
1	2.734000000 MHz	43.91	Quasi Peak	-29.09
2	2.754000000 MHz	35.14	Average	-24.86
2	8.459900000 MHz	37.17	Average	-22.83

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

Results for AC Line Conducted EMI

The EUT demonstrated compliance with the AC Line Conducted Emissions requirements of 47CFR Part 15C and other applicable emissions requirements. The EUT-CPU configuration worst-case configuration demonstrated a minimum margin of -20.0 dB below the requirement. Other emissions were present with amplitudes at least 20 dB below the limit and worst-case amplitudes recorded.

Unwanted Radiated Emissions

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.

Out of band emissions requirement for DSS equipment:
47CFR 15.247 (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)).

RSS-247 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.

Table 4 Unwanted 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)
35.3	39.7	33.8	45.1	41.1	105.0	-71.2	-63.9
40.0	35.7	30.8	42.7	37.3	105.0	-74.2	-67.7
66.9	32.0	28.6	40.9	36.6	105.0	-76.4	-68.4
69.6	34.5	29.6	45.4	41.3	105.0	-75.4	-63.7
70.8	34.7	29.6	46.3	42.8	105.0	-75.4	-62.2
72.4	38.3	33.0	43.0	40.3	105.0	-72.0	-64.7
73.5	38.8	33.4	41.1	38.8	105.0	-71.6	-66.2
129.4	35.9	30.6	39.7	31.4	105.0	-74.4	-73.6
132.7	36.9	29.5	32.2	38.0	105.0	-75.5	-67.0
164.5	37.7	32.7	36.3	32.3	105.0	-72.3	-72.7
168.0	41.2	38.2	39.1	35.4	105.0	-66.8	-69.6
180.0	47.2	38.2	37.1	28.3	105.0	-66.8	-76.7
192.0	47.0	42.5	41.3	36.9	105.0	-62.5	-68.1

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.

Results for Unwanted Radiated Emissions

The EUT demonstrated compliance with the radiated emissions requirements of 47CFR Part 15C paragraph 15.209, RSS-247 Issue 2, and RSS-GEN Issue 5 Intentional Radiators. The EUT configuration demonstrated a minimum margin of -62.2 dB below the requirements. Other emissions were present with amplitudes at least 20 dB below the Limits.

Operation in the Band 902 – 928 MHz

Test procedures of ANSI C63.10-2013 and KDB 558074 D01 15.247 Meas Guidance v05 were used during transmitter testing. The transmitter peak power was measured at the antenna port as described in ANSI C63.10-2013. The 20-dB and 99% emission bandwidths were measured as described in C63.10-2013. The channel separation and the number of hopping channels were measured at the antenna port as described in C63.10-2013. The system utilizes at least 15 channels with average time of occupancy on any channel not exceeding 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. The transmitter radiated spurious and general emissions were measured on an open area test site @ 3 meters. During radiated emissions measurements, the EUT sample #1 was placed on a turntable elevated as required above the ground plane at a distance of 3 meters from the measurement antenna. The amplitude of each emission was then recorded from the measurement results. The test system gains and losses were accounted for in the measurement results presented. The amplitude of each radiated emission was maximized by equipment orientation and placement on the turn table, raising and lowering the FSM (Field Strength Measuring) antenna, changing the FSM antenna polarization, and by rotating the turntable. 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 10 GHz. Emissions were measured in dBµV/m @ 3 meters.

Requirement: For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Time on channel: The design resides on channel 2 times in a 10 second period. Transmitting each time for 100 mS which equates to an average time of occupancy of (2 * 100 mS) 200 mS.

The 200 mS average time of occupancy demonstrates compliance with requirement of less than 400 mS in 10 second period. Additional Frequency Hopping detail may be found in the operational description exhibits.

Refer to figures three through twelve showing plots taken of the 902.5-927.5 MHz Direct Sequence Spread Spectrum operation displaying compliance with the specifications.

Figure 3 Plot of Transmitter Emissions Operation in 902.5-927.5 MHz

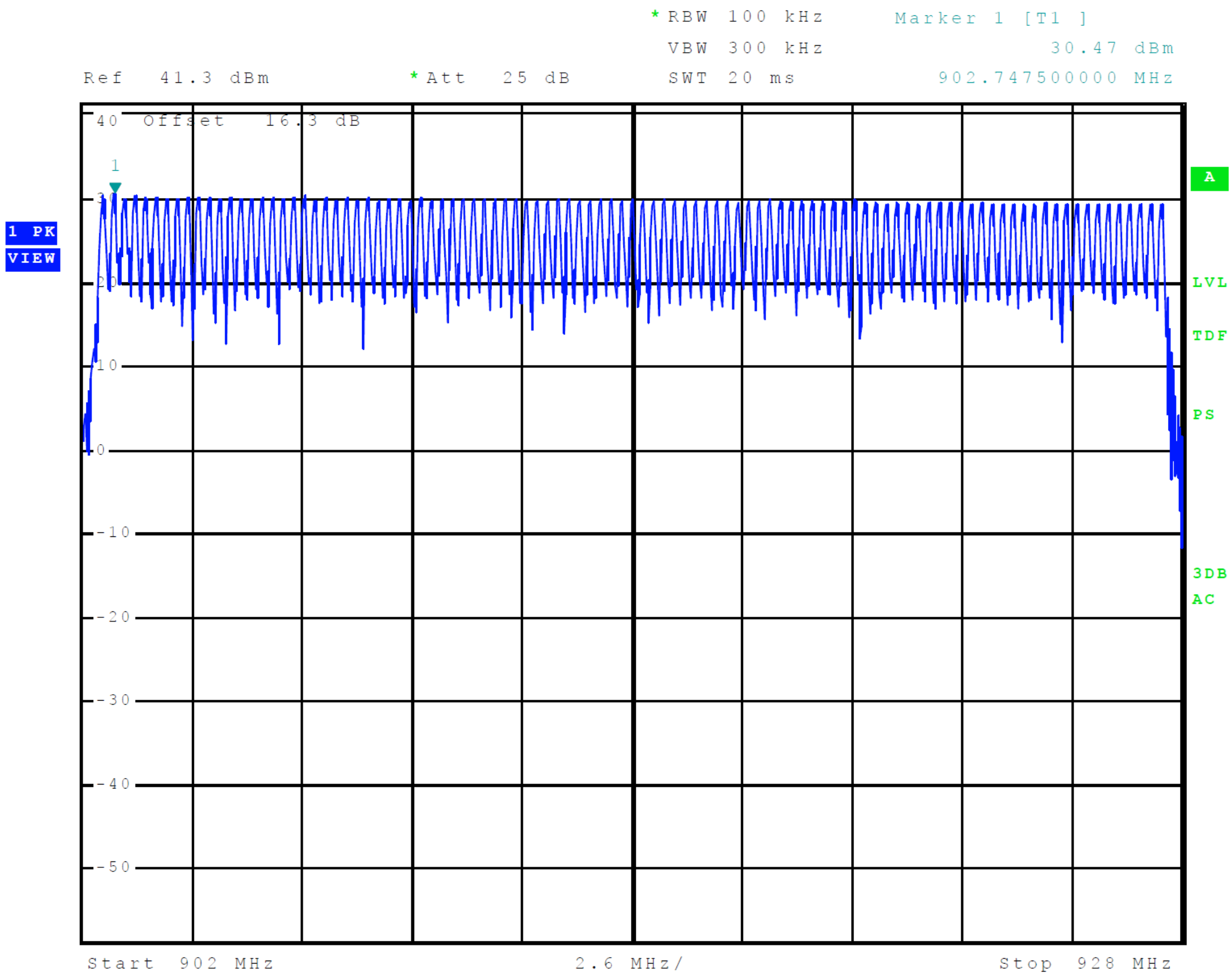


Figure 4 Plot of Transmitter Emissions 20-dB Occupied Bandwidth

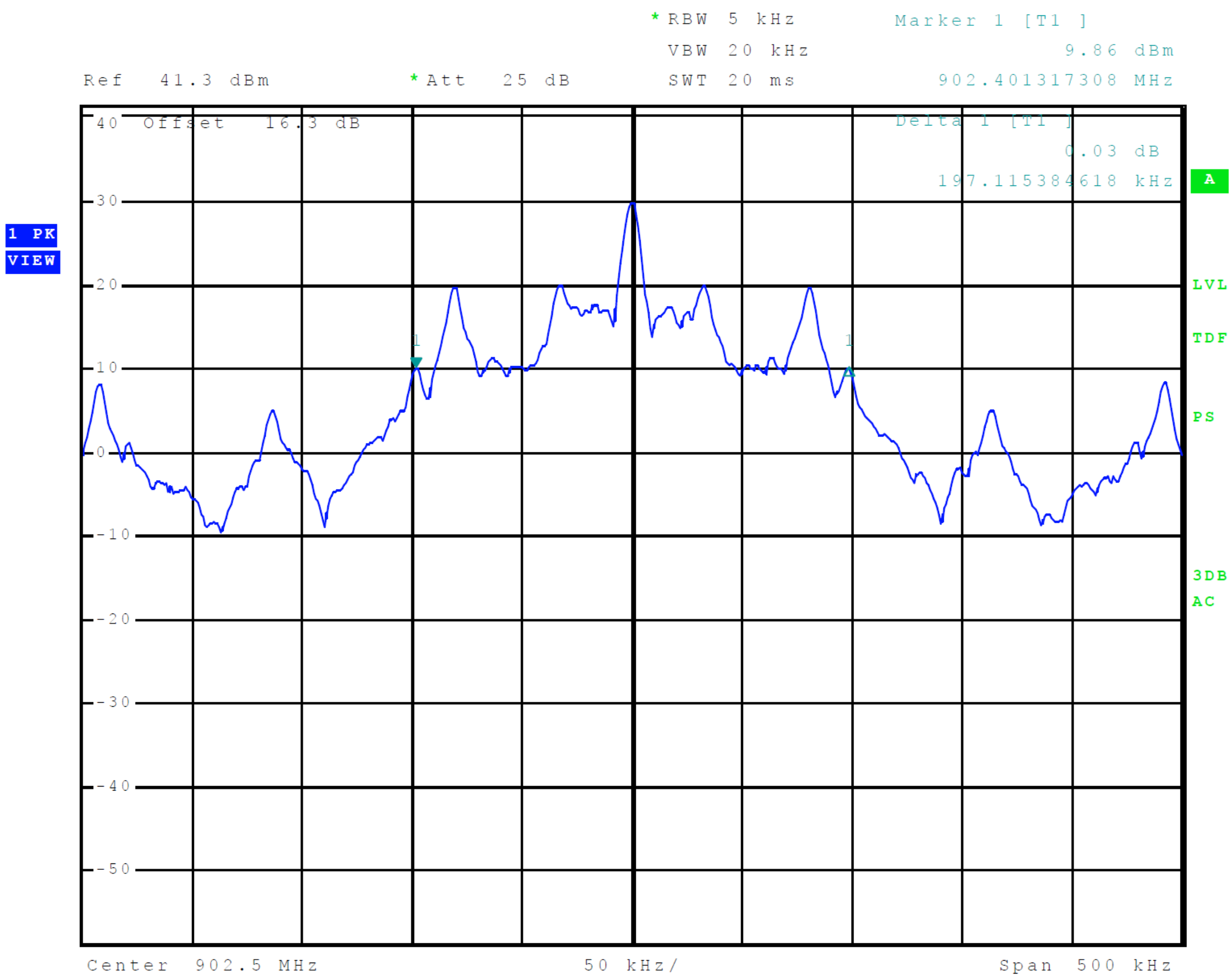


Figure 5 Plot of Transmitter Emissions 99% Occupied Bandwidth

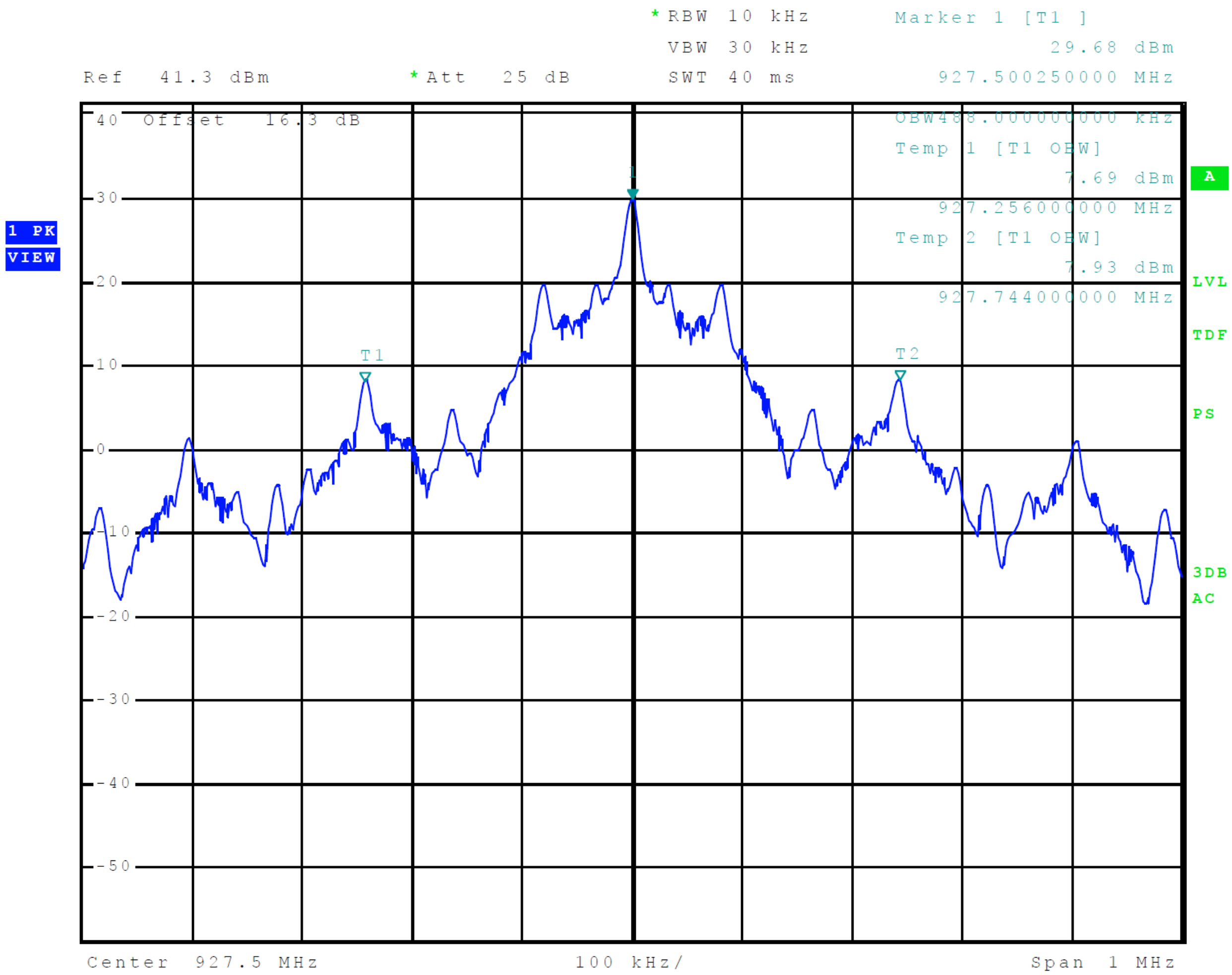


Figure 6 Plot of Number of Hopping Channels

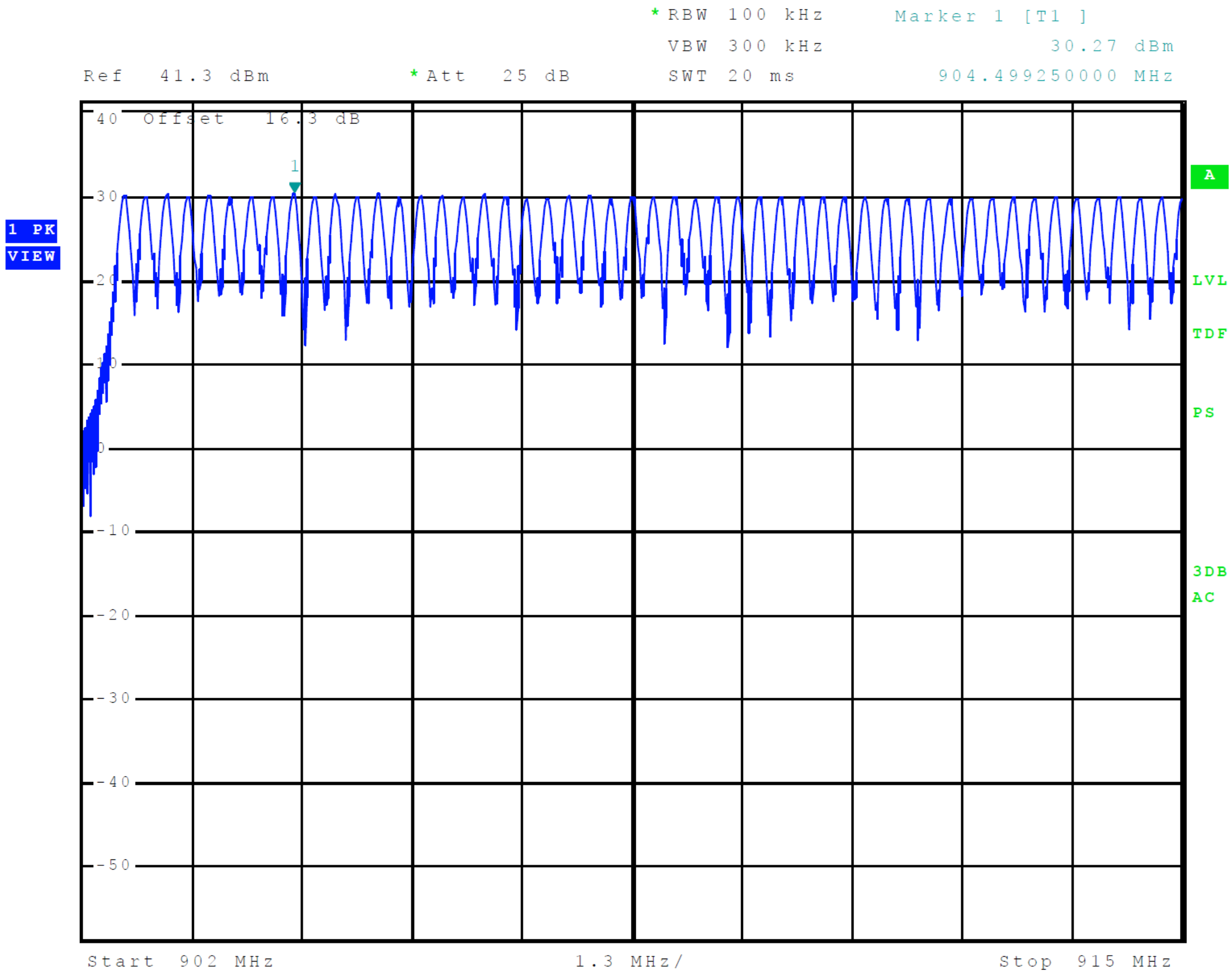


Figure 7 Plot of Number of Hopping Channels

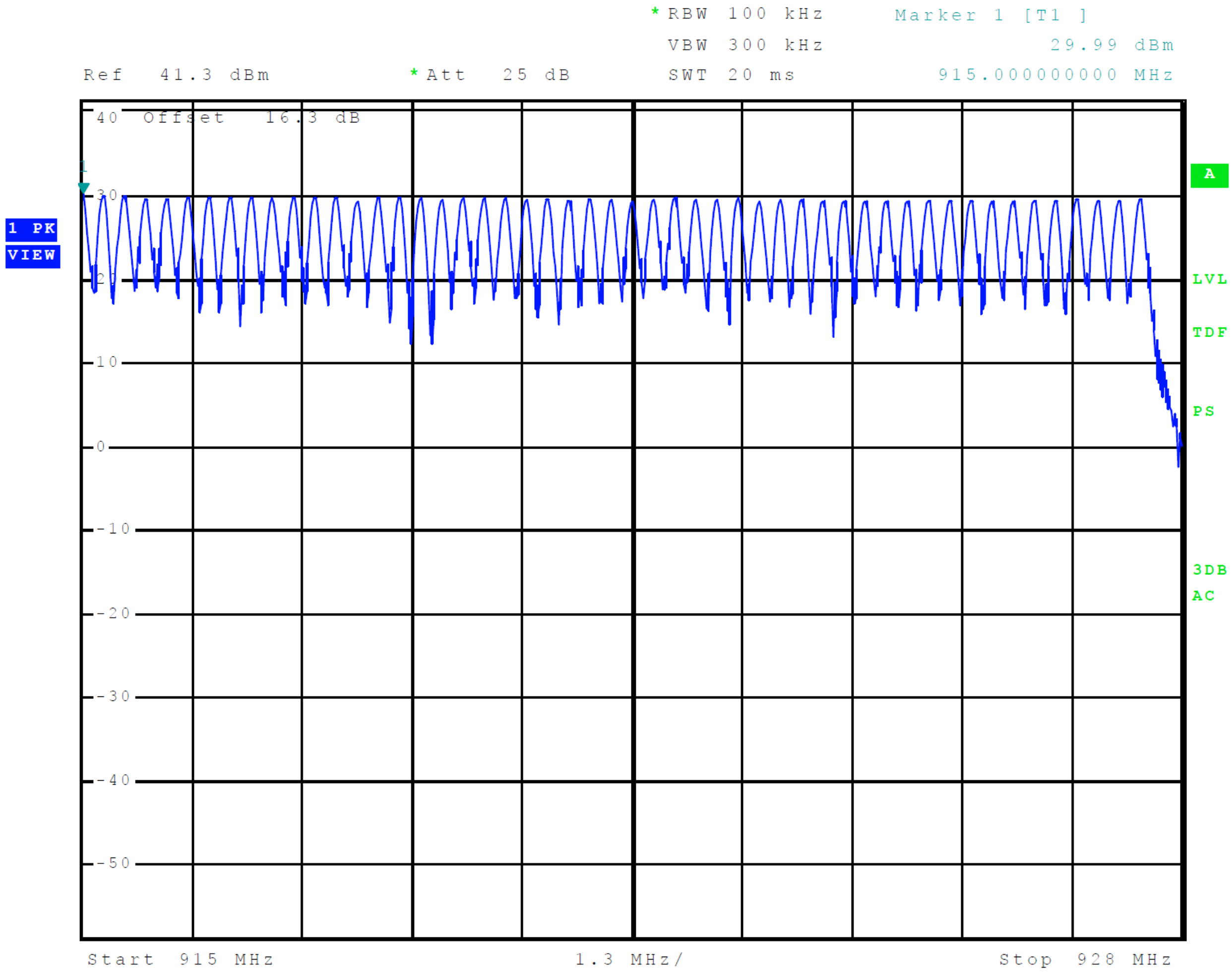


Figure 8 Plot of Channel Separation

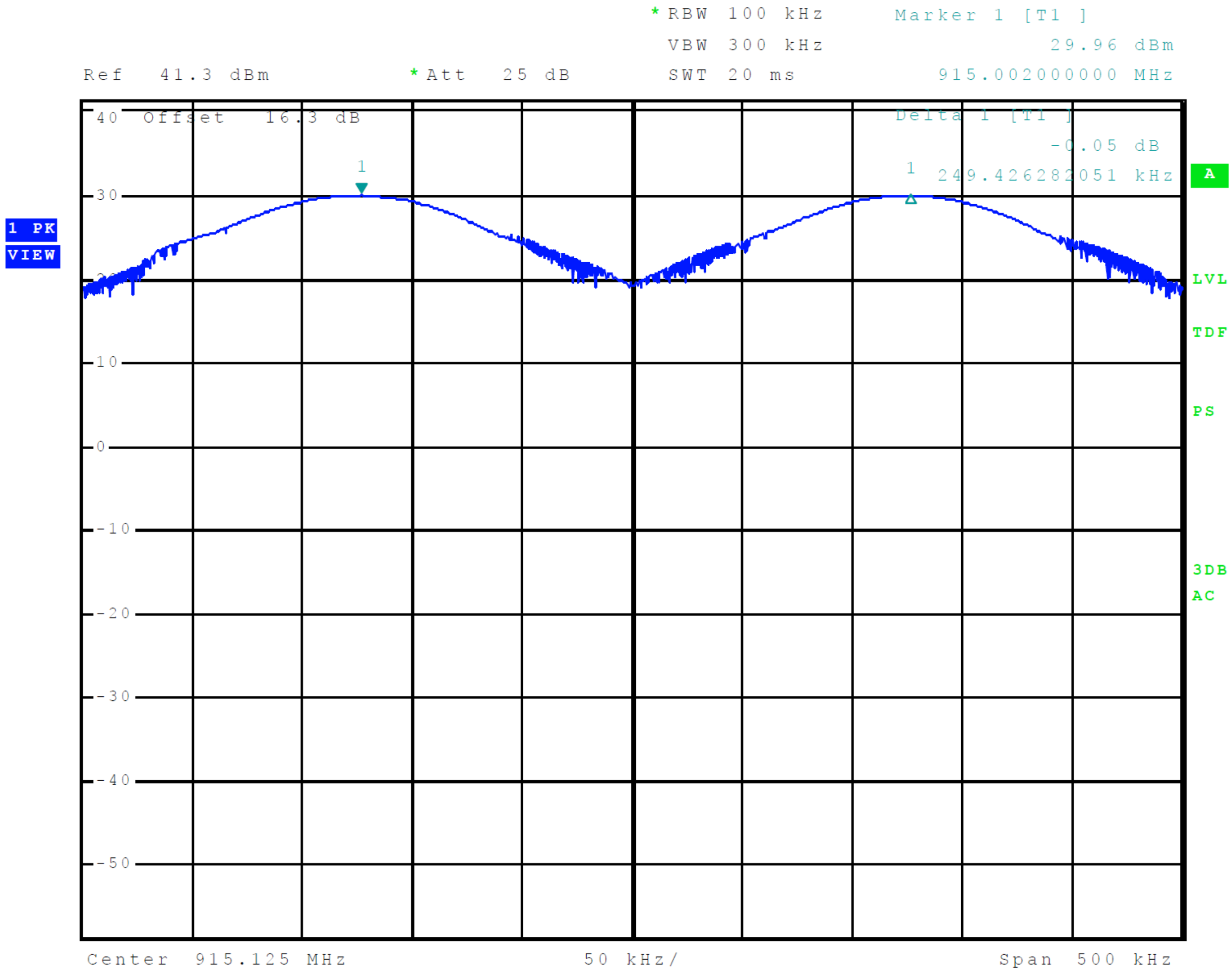


Figure 9 Plot of Dwell time On Channel

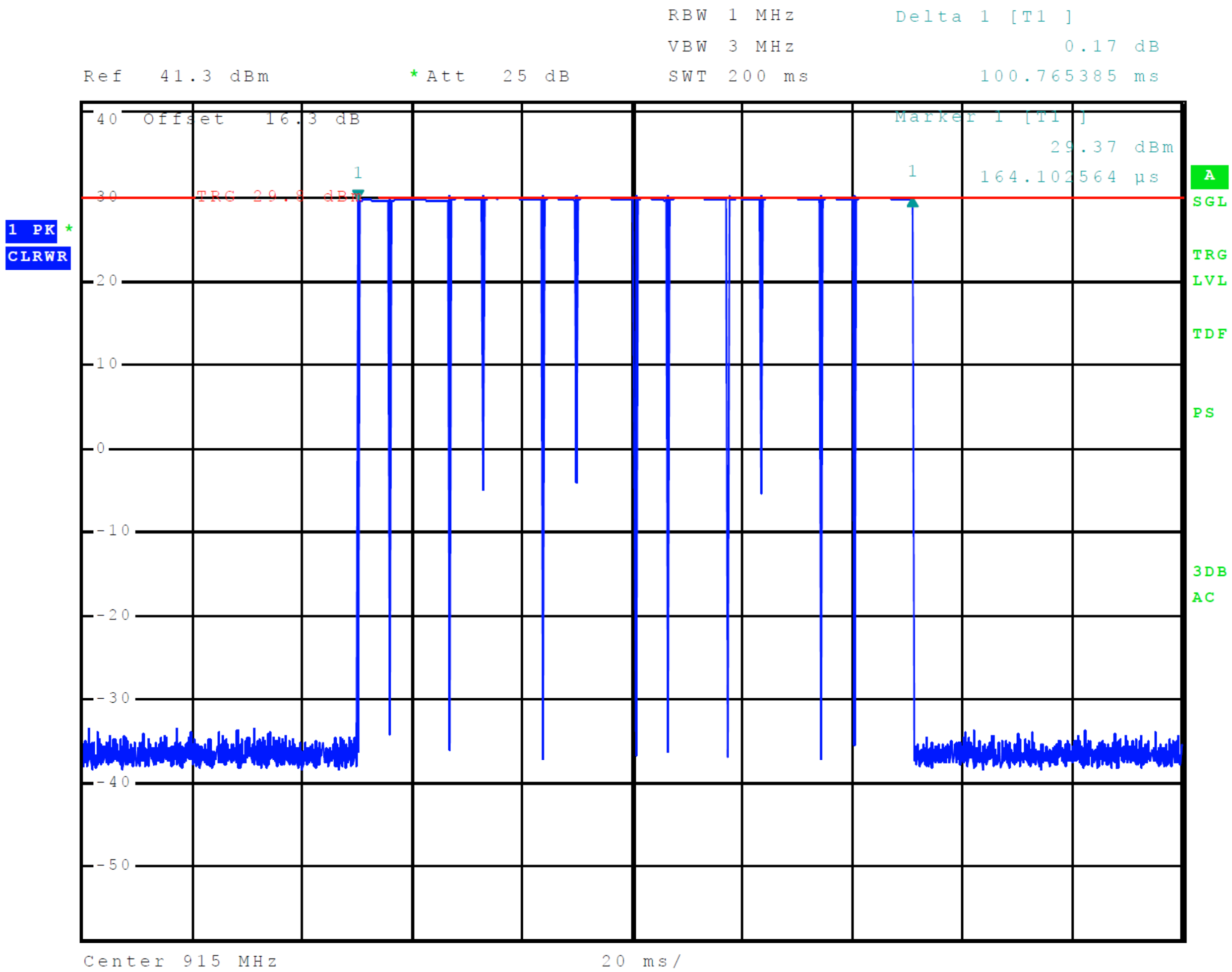


Figure 10 Plot of Number of Times on Channel over 10 Second Period

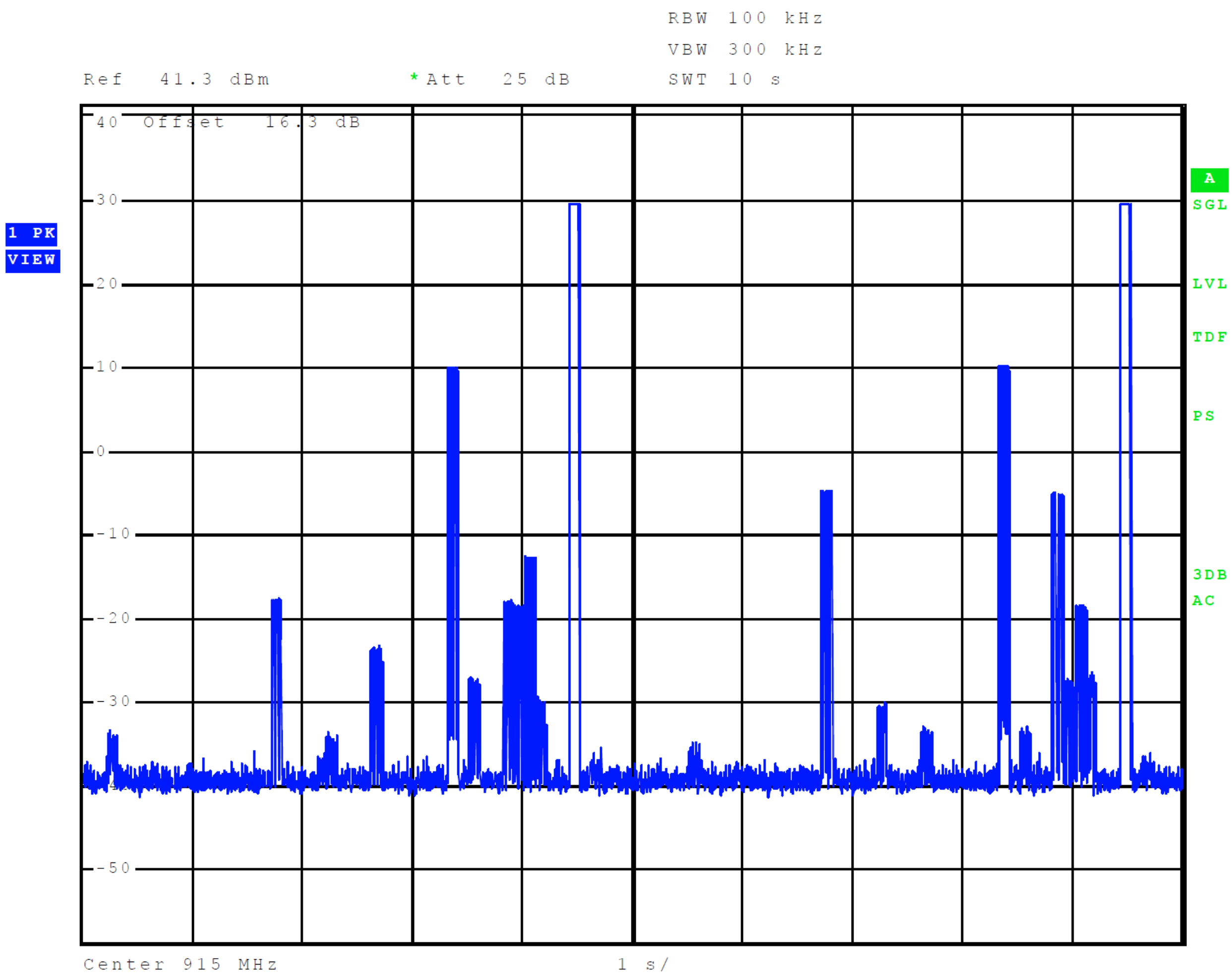


Figure 11 Plot of Transmitter Emissions Low Band Edge

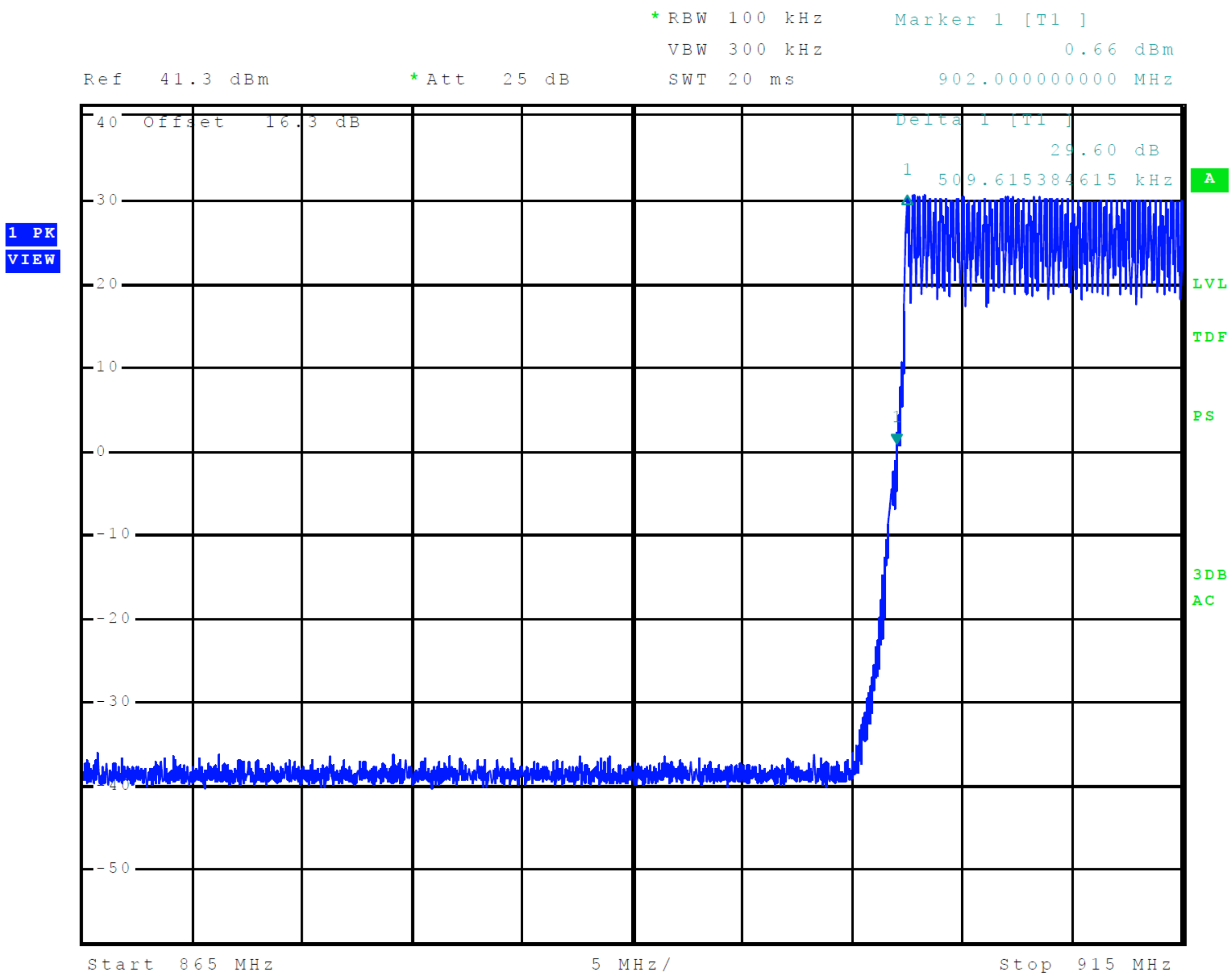


Figure 12 Plot of Transmitter Emissions High Band Edge

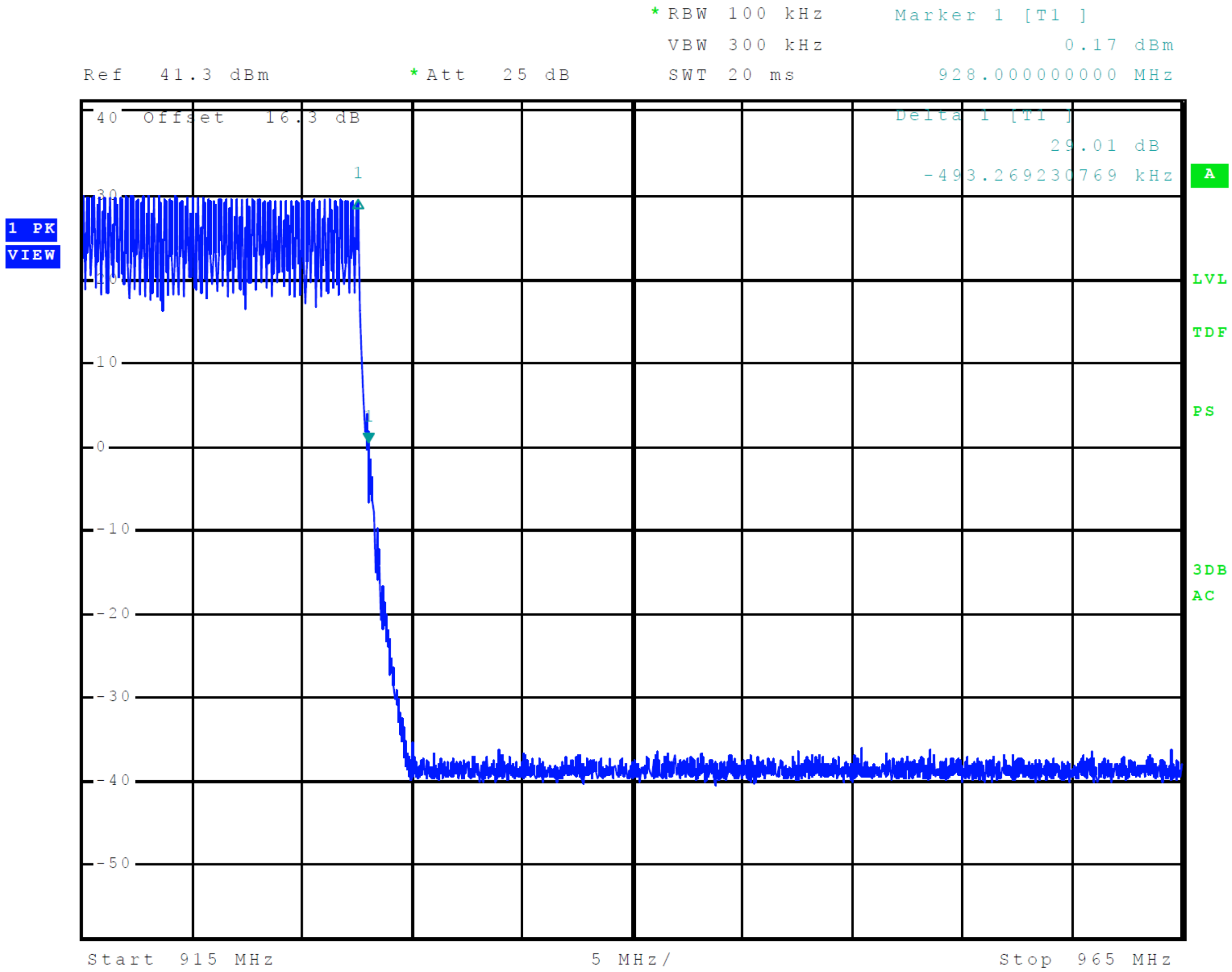


Table 7 Transmitter Radiated Emissions

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)
902.5	--	--	--	--	--	--	--
1805.00	42.1	28.3	42.3	30.0	54.0	-25.7	-24.0
2707.50	48.4	37.9	47.7	39.1	54.0	-16.1	-14.9
3610.00	47.7	34.1	47.5	34.5	54.0	-19.9	-19.5
4512.50	46.7	33.6	46.3	33.6	54.0	-20.4	-20.4
5415.00	49.2	36.4	49.1	36.4	54.0	-17.6	-17.6
6317.50	53.3	39.0	52.9	39.8	54.0	-15.0	-14.2
915.0	--	--	--	--	--	--	--
1830.00	42.1	28.5	41.3	28.6	54.0	-25.5	-25.4
2745.00	45.3	33.8	45.5	33.8	54.0	-20.2	-20.2
3660.00	46.3	32.6	45.9	32.8	54.0	-21.4	-21.2
4575.00	48.1	35.6	48.4	35.6	54.0	-18.4	-18.4
5490.00	50.4	37.3	51.6	37.3	54.0	-16.7	-16.7
6405.00	52.6	39.4	54.0	42.1	54.0	-14.6	-11.9
927.5	--	--	--	--	--	--	--
1855.00	41.6	28.9	44.4	33.5	54.0	-25.1	-20.5
2782.50	45.8	33.5	45.6	33.0	54.0	-20.5	-21.0
3710.00	46.1	33.5	46.1	33.3	54.0	-20.5	-20.7
4637.50	48.6	36.1	48.9	36.1	54.0	-17.9	-17.9
5565.00	50.3	37.8	50.5	37.8	54.0	-16.2	-16.2
6492.50	52.1	39.1	53.0	40.6	54.0	-14.9	-13.4

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.

Table 8 Transmitter Antenna Port Conducted Data

Frequency MHz	Antenna Port Average Output Power (Watts)	99% Occupied Bandwidth (kHz)	20-dB Occupied Bandwidth (kHz)
Mode 1 BT BR			
902.5	1.00	486.0	197.2
915.0	0.99	487.0	196.3
927.5	0.97	488.0	196.3

Results for Operation in the Band 902 – 928 MHz Intentional Radiator

The EUT demonstrated compliance with the radiated emissions requirements of 47CFR Paragraph 15.247, Industry Canada RSS-247 Issue 2, and RSS-GEN Issue 5. The antenna port conducted output power measured was 1.00 Watts. The unit utilizes 79 hopping channels with the average time of occupancy less than 0.4 seconds over the required time. The EUT worst-case configuration demonstrated minimum radiated harmonic emission margin of -11.9 dB below the limit. No other radiated emissions were found in the restricted bands less than 20 dB below limits than those recorded in this report. Other emissions were present with amplitudes at least 20 dB below the limits.

Annex

- Annex A Measurement Uncertainty Calculations
- Annex B Test Equipment
- Annex C Rogers Qualifications
- Annex D Laboratory 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 Test Equipment

Equipment	Manufacturer	Model (SN)	Band	Cal Date(m/d/y)	Due
☒ LISN	FCC	FCC-LISN-50-25-10(1PA) (160611)	.15-30MHz	3/29/2022	3/29/2023
☒ LISN: Fischer Custom Communications Model: FCC-LISN-50-16-2-08				3/29/2022	3/29/2023
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(303073)	9kHz-40 GHz	10/14/2021	10/14/2022
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303069)	9kHz-40 GHz	10/14/2021	10/14/2022
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303070)	9kHz-40 GHz	10/14/2021	10/14/2022
☒ Cable	Belden	RG-58 (L1-CAT3-11509)	9kHz-30 MHz	10/14/2021	10/14/2022
☐ Cable	Belden	RG-58 (L2-CAT3-11509)	9kHz-30 MHz	10/14/2021	10/14/2022
☒ Antenna	Com Power	AL-130 (121055)	.001-30 MHz	10/14/2021	10/14/2022
☐ Antenna:	EMCO	6509	.001-30 MHz	10/14/2020	10/14/2022
☐ Antenna	ARA	BCD-235-B (169)	20-350MHz	10/14/2021	10/14/2022
☐ Antenna:	Schwarzbeck Model	VHBB 9124 (1468)	30-200MHz	10/14/2020	10/14/2022
☒ Antenna	Sunol	JB-6 (A100709)	30-1000 MHz	10/14/2021	10/14/2022
☐ Antenna	ETS-Lindgren	3147 (40582)	200-1000MHz	10/14/2020	10/14/2022
☐ Antenna:	Schwarzbeck Model:	VULP 9118 (A-534)	200-1000MHz	10/14/2020	10/14/2022
☒ 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	4/6/2021	4/6/2023
☒ Analyzer	Rohde & Schwarz	ESU40 (100108)	20Hz-40GHz	3/9/2022	3/9/2023
☒ Analyzer	Rohde & Schwarz	ESW44 (101534)	20Hz-44GHz	1/18/2022	1/18/2023
☐ 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	10/14/2021	10/14/2022
☒ Amplifier	Com-Power	CPPA-102 (01254)	1-1000 MHz	10/14/2021	10/14/2022
☒ Amplifier	Com-Power	PAM-118A (551014)	0.5-18 GHz	10/14/2021	10/14/2022
☐ Amplifier	Com-Power	PAM-840A (461328)	18-40 GHz	10/14/2021	10/14/2022
☐ Power Meter	Agilent	N1911A with N1921A	0.05-40 GHz	3/29/2022	3/29/2023
☐ Generator	Rohde & Schwarz	SMB100A6 (100150)	20Hz-6 GHz	3/29/2022	3/29/2023
☐ Generator	Rohde & Schwarz	SMBV100A6 (260771)	20Hz-6 GHz	3/29/2022	3/29/2023
☐ RF Filter	Micro-Tronics	BRC50722 (009).9G notch	30-18000 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	HPM50114 (017)1.5G HPF	30-18000 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	HPM50117 (063) 3G HPF	30-18000 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	HPM50105 (059) 6G HPF	30-18000 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	BRM50702 (172) 2G notch	30-18000 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	BRC50703 (G102) 5G notch	30-18000 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	BRC50705 (024) 5G notch	30-18000 MHz	4/6/2021	4/6/2023
☒ Attenuator	Fairview	SA6NFNF100W-40 (1625)	30-18000 MHz	3/29/2022	3/29/2023
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1436)	30-6000 MHz	3/29/2022	3/29/2023
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1445)	30-6000 MHz	3/29/2022	3/29/2023
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1735)	30-6000 MHz	3/29/2022	3/29/2023
☐ Attenuator	Mini-Circuits	VAT-6W2+ (1438)	30-6000 MHz	3/29/2022	3/29/2023
☐ Attenuator	Mini-Circuits	VAT-6W2+ (1736)	30-6000 MHz	3/29/2022	3/29/2023
☒ Weather station	Davis	6312 (A81120N075)		11/4/2021	11/4/2022

List of Test Equipment			Calibration Date (m/d/y)	Due
☐ Antenna:	Schwarzbeck Model VHBB 9124 (01468)		10/14/2020	10/14/2022
☐ Antenna:	Schwarzbeck Model: VULP 9118 A (VULP 9118 A-856)		10/14/2020	10/14/2022
☐ Frequency Counter: Leader LDC-825 (8060153			3/29/2022	4/6/2023
☐ ISN: Com-Power Model ISN T-8			3/29/2022	3/29/2023
☐ LISN	Compliance Design	FCC-LISN-2.Mod.cd,(126) .15-30MHz	10/14/2021	10/14/2022
☐ LISN: Com-Power Model LI-220A			10/14/2020	10/14/2022
☐ LISN: Com-Power Model LI-550C			10/14/2020	10/14/2022
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303072) 9kHz-40 GHz	10/14/2021	10/14/2022
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L1M)(281183) 9kHz-40 GHz	10/14/2021	10/14/2022
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L4M)(281184) 9kHz-40 GHz	10/14/2021	10/14/2022
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(317546)9kHz-40 GHz	10/14/2021	10/14/2022
☐ Cable	Time Microwave	4M-750HF290-750 (4M) 9kHz-24 GHz	10/14/2021	10/14/2022
☐ RF Filter	Micro-Tronics	BRC17663 (001) 9.3-9.5 notch 30-1800 MHz	4/6/2021	4/6/2023
☐ RF Filter	Micro-Tronics	BRC19565 (001) 9.2-9.6 notch 30-1800 MHz	10/14/2021	10/14/2023
☐ Analyzer	HP	8562A (3051A05950) 9kHz-125GHz	3/29/2022	3/29/2023
☐ Wave Form Generator Keysight		33512B (MY57400128)	3/29/2022	3/29/2023
☐ Antenna: Solar 9229-1 & 9230-1			2/22/2022	2/22/2023
☐ CDN: Com-Power Model CDN325E			10/14/2021	10/14/2022
☐ Injection Clamp Luthi Model EM101			10/14/2021	10/14/2022
☐ Oscilloscope Scope: Tektronix MDO 4104			2/22/2022	2/22/2023
☐ EMC Transient Generator HVT TR 3000			2/22/2022	2/22/2023
☐ AC Power Source (Ametech, California Instruments)			2/22/2022	2/22/2023
☐ Field Intensity Meter: EFM-018			2/22/2022	2/22/2023
☐ ESD Simulator: MZ-15			2/22/2022	2/22/2023
☐ 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	
☒ Temperature Chamber			not required	
☒ Shielded Room			not required	

Annex C Rogers Qualifications

Scot D. Rogers, Engineer

Rogers Labs, Inc.

Mr. Rogers has approximately 35 years' experience in the field of electronics. Working experience includes six years working in the automated controls industry and 6 years working with the design, development and testing of radio communications and electronic equipment.

Positions Held:

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

Educational Background:

Bachelor of Science Degree in Electrical Engineering from Kansas State University

Bachelor of Science Degree in Business Administration Kansas State University

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).

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA

2022-03-22 through 2023-03-31
Effective Dates

For the National Voluntary Laboratory Accreditation Program