RHEIN TECH LABORATORIES, INC.

Engineering Solutions & Electromagnetic Compatibility Services

Limited Modular Approval Certification Application Report
FCC Part 15.247 & ISED RSS-247

Test Lab:	Applicant:
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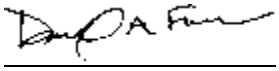
Model #/HVIN	223150	**Test Report Date**	May 5, 2022
FCC ID	UE3SX7023EXT	**RTL Work Order #**	2021093
IC	7044A-SX7023EXT	**RTL Quote**	QRTL21-093A

American National Standard Institute	ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC Classification	DSS: Part 15 Spread Spectrum Transmitter
FCC Rule Part(s)/ Guidance	FCC 15.247:Operation within the bands 902 – 928 MHz, 2400.0 – 2483.5 MHz, and 5725 – 5850 MHz (10/01/2020)
ISED Canada	RSS-247 Issue 2: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices (02-2017) RSS-Gen Issue 5: General Requirements for Compliance of Radio Apparatus, Amendment 1, and Amendment 2 (02-2021)

Frequency Range (MHz)	Output Power (mW)	Frequency Tolerance (%)	Emission Designator
902.4 – 927.6	588.8	N/A	326KF7D

I, the undersigned, hereby declare that the equipment tested and referenced in this report conforms to the identified standard(s) as described in this test report. No deviations from, additions to, or exclusions from, the applicable parts of ANSI 63.10, FCC Part 2, FCC Part 15, ISED RSS-247, and ISED RSS-Gen.

Signature:  Date: May 5, 2022

Name: Desmond A. Fraser Position: President

This report may not be reproduced, except in full, without the written approval of Rhein Tech Laboratories, Inc., and Banner Engineering Corporation. The test results relate only to the item(s) tested. Replaces Test Report R1.1.

These test(s) are accredited under Rhein Tech Laboratories, Inc. ISO/IEC 17025 accreditation issued by ANAB. Refer to certificate and scope of accreditation AT-1445.

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1 General Information

1.1 Scope

Applicable standards:

- FCC Part 15.247: Operation within the bands 902–928 MHz, 2400.0–2483.5 MHz, and 5725-5850 MHz
- ISED RSS-247 Issue 2: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- ISED RSS-Gen Issue 5: General Requirements for Compliance of Radio Apparatus

1.2 Description of EUT

Equipment Under Test	Radio Module
Model Name / Model #/HVIN	SX7023EXT / 223150
Power Supply	AC Adapter
Modulation Type	GFSK
Frequency Range	902-928 MHz
Antenna	2 dBi Monopole, 5 dBi Monopole, 6 dBi Dipole

1.3 Test Facility

The open area test site and conducted measurement facility used to collect the radiated data is located at 360 Herndon Parkway, Suite 1400, Herndon, Virginia 20170.

1.4 Related Submittal(s)/ Grant(s)

This is an original certification application for Limited Modular Approval for Banner Engineering Corporation Model SX7023EXT; Model#/HVIN: 223150, FCC ID: UE3SX7023EXT, IC: 7044A-SX7023EXT.

1.5 Modification(s) to EUT

No modifications were made to the EUT in order to achieve compliance.

1.6 Deviation(s) from Standard(s)

No deviation(s) from test method(s) and/ or standard(s).

1.7 Acronyms Used in this Document

ATO	-	Average Time of Occupancy
AVG	-	Average
BE	-	Band Edge
CFS	-	Carrier Frequency Separation
EUT	-	Equipment Under Test
FHSS	-	Frequency Hopping Spread Spectrum
LBE	-	Lower Band Edge
LISN	-	Line Impedance Stabilization Network
OBW	-	Occupied Channel Bandwidth
PK	-	Peak
QPK	-	Quasi-Peak
RBE	-	Restricted Band Edge
SCF	-	Site Correction Factor
UBE	-	Upper Band Edge

2 Test Information

2.1 Exercising the EUT

The EUT was provided power (115 VAC, 60 Hz) through the provided AC adapter. The EUT was tested to various modes shown below:

- Low Power: FMPCT 28, Right Rotary 9, A, B and C for hopping (25)
- Normal Power: FMPCT 44, Right Rotary 1, 2, 3 and 0 for hopping (51)
- Receive/ Standby: DIP Switch 7 ON, DIP Switch 8 OFF, FMPCT 44, Right Rotary N/A

For all tests, the EUT was operated in its most EMC-sensitive configuration.

2.2 Description of Test Mode(s)

In accordance with FCC Part 15.31(m), the following frequencies were tested:

Table 2-1: Test Frequency and Modes

Channel (#)	Frequency (MHz)
Low	902.4
Middle	915.2
High	927.6

2.3 Test Result Summary

Table 2-2: Test Result Summary

Test	FCC Reference	ISED Reference	Result
AC Power Conducted Emissions	Part 15.207	RSS-Gen: 8.8	Pass
Radiated Emissions	Part 15.209	RSS-247: 5.5 RSS-Gen: 8.9 / 8.10	Pass
Carrier Frequency Separation	Part 15.247(a)(1)	RSS-247: 5.1(b)	Pass
Occupied Channel Bandwidth: 20 dB and 99%	Part 15.247(a)(1)(i)	RSS-247: 5.1(c) RSS-Gen: 6.7	Pass
Hopping Characteristics	Part 15.247(a)(1)(i)	RSS-247: 5.1(c)	Pass
Maximum Peak Power Output	Part 15.247(b)(2)	RSS-247: 5.4(a) RSS-Gen: 6.12	Pass
Antenna Conducted Spurious Emissions	Part 15.247(d)	RSS-247: 5.5 RSS-Gen: 6.13	Pass
Band Edge Measurement	Part 15.247(d)	RSS-247: 5.5	Pass

2.4 Test System Details

The test samples were received on August 25, 2021. The FCC identifiers for all applicable equipment and cable descriptions used in the tested system are identified in the following table.

Table 2-3: Equipment Under Test

RTL Barcode	Part	Manufacturer	Model	Serial Number	Cable Description
23908	Antenna: 6 dBi Dipole	L-Com	HGV-906U	N/A	N/A
23909	Antenna: 5 dBi Monopole	Sensonix	BWA-905-C	N/A	N/A
23911	Antenna: 2 dBi Monopole	Sensonix	BWA-902-C	3076908	N/A
23913	Transceiver 1	Banner	223150	165317-155647-1604P	Shielded I/O, Power
23915	Transceiver 2	Banner	223150	366749-155633-1919P	Shielded I/O, Power
23917	AC Adapter	CUI Inc.	SMI24-24	N/A	N/A

Table 2-4: Auxiliary Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Cable Description
23912	USB Converter	Banner	BWA-HW-006	N/A	N/A

2.5 Test Configuration

Figure 2-1: Configuration of Tested System, Conducted Emissions

3 Peak Power – FCC 15.247(b)(2); ISED RSS-247 5.4(a), RSS-Gen 6.12

3.1 Peak Power Test Procedure

The peak powers were measured using a 50 Ω SA. The following settings were used:

Span:	5 times the OBW 20 dB	
RBW:	>OBW 20 dB	
VBW:	>RBW	
Sweep:	Auto	
Detector:	Peak	
Trace:	Max Hold	The trace was allowed to stabilize, and the peak function was used to mark the peak of the emission

3.2 Peak Power Limits

For FHSS operating in the band 902 – 928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

3.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Peak Power: ±0.8dB

3.4 Peak Power Test Data

Table 3-1: Peak Power Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
08/31/2021	23.1	31	101.1
09/01/2021	23.3	36	101.1

Notes: 4.0 W ≈ 36.0 dBm 1.0 W ≈ 30.0 dBm 0.25 W ≈ 24.0 dBm

Table 3-2: Peak Power Test Result, Low Power, FMPCT 28

Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
902.4	23.6	24.0	-0.4
915.2	23.7	24.0	-0.3
927.6	23.7	24.0	-0.3

Table 3-3: Peak Power Test Result, Normal Power, FMPCT 44

Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
902.4	27.7	30.0	-2.3
915.2	27.7	30.0	-2.3
927.6	27.6	30.0	-2.4

Note: The highest antenna gain assembly (6 dBi Dipole) shall be used for E.I.R.P power.

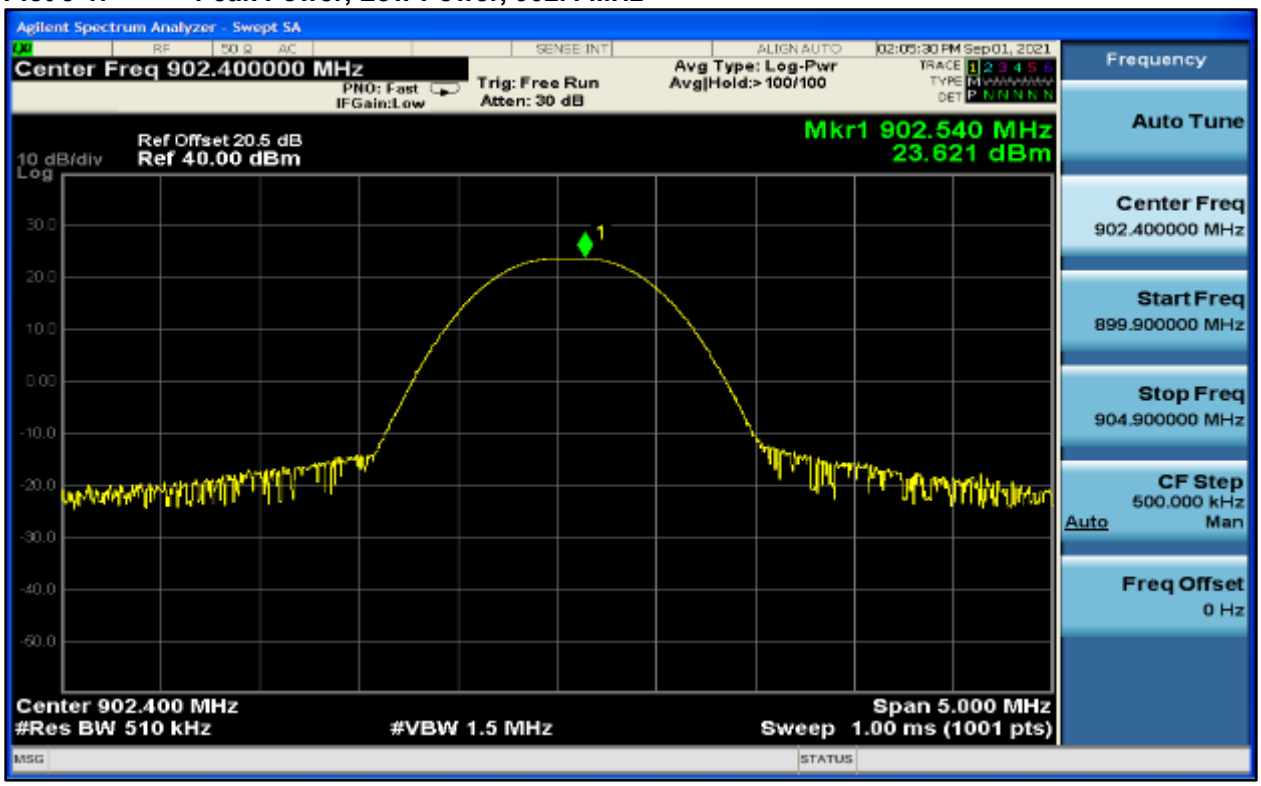
Table 3-4: E.I.R.P Test Result, Low Power, FMPCT 28

Frequency (MHz)	Peak Power (E.I.R.P dBm)	Limit (dBm)	Margin (dB)
902.4	29.6	30.0	-0.4
915.2	29.7	30.0	-0.3
927.6	29.7	30.0	-0.3

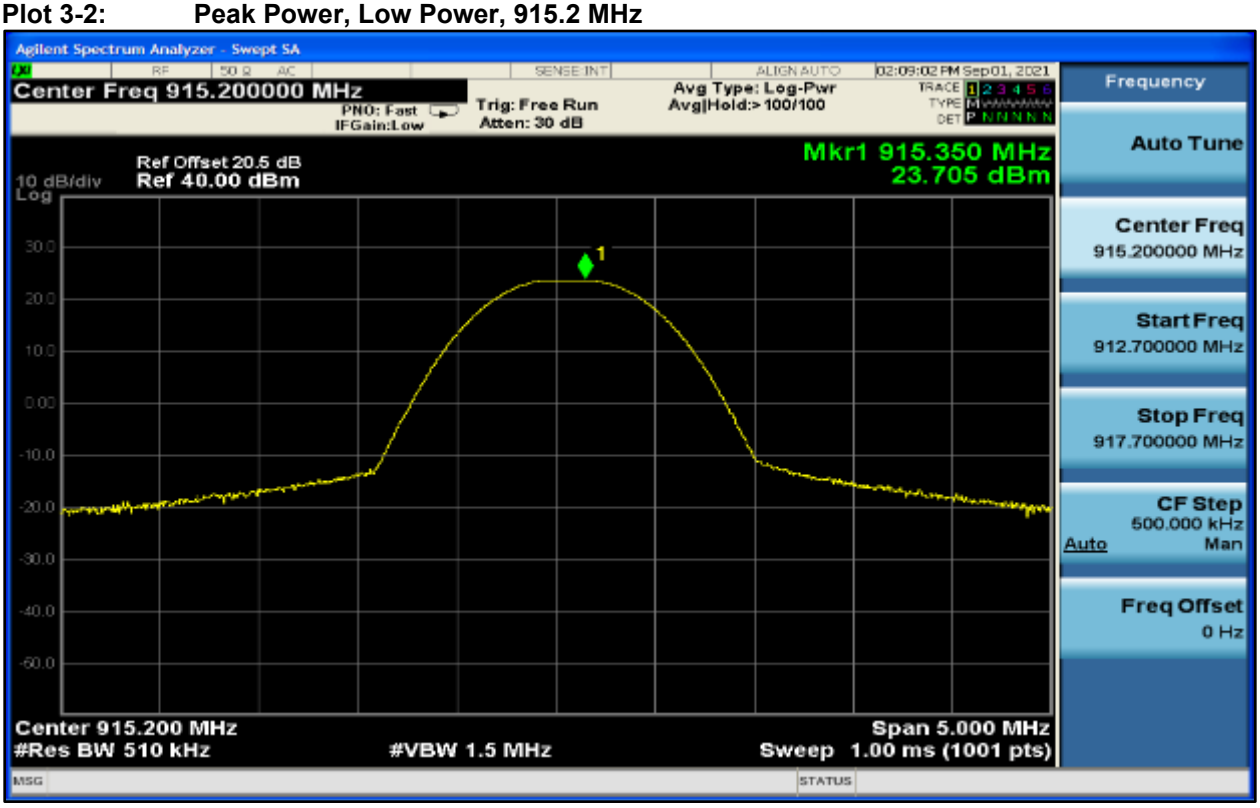
Table 3-5: E.I.R.P Test Result, Normal Power, FMPCT 44

Frequency (MHz)	Peak Power (E.I.R.P dBm)	Limit (dBm)	Margin (dB)
902.4	33.7	36.0	-2.3
915.2	33.7	36.0	-2.3
927.6	33.6	36.0	-2.4

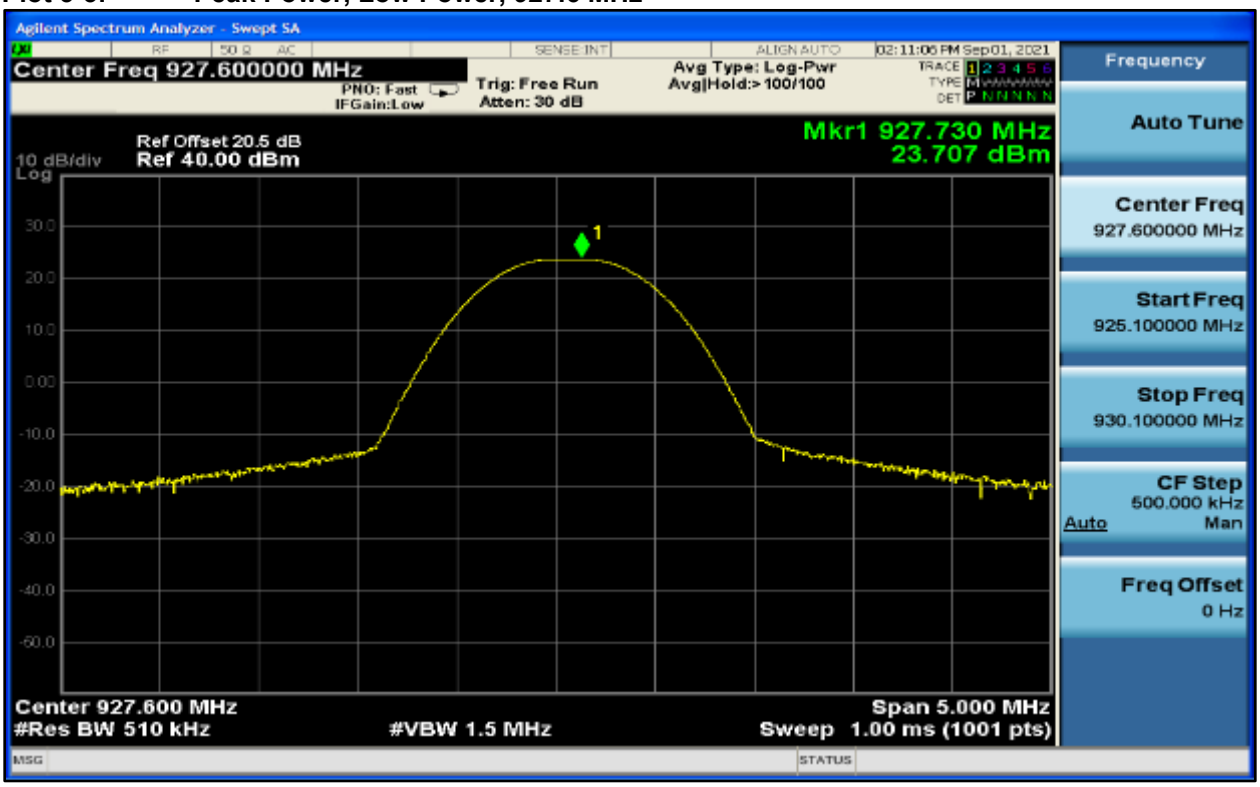
Plot 3-1: Peak Power, Low Power, 902.4 MHz



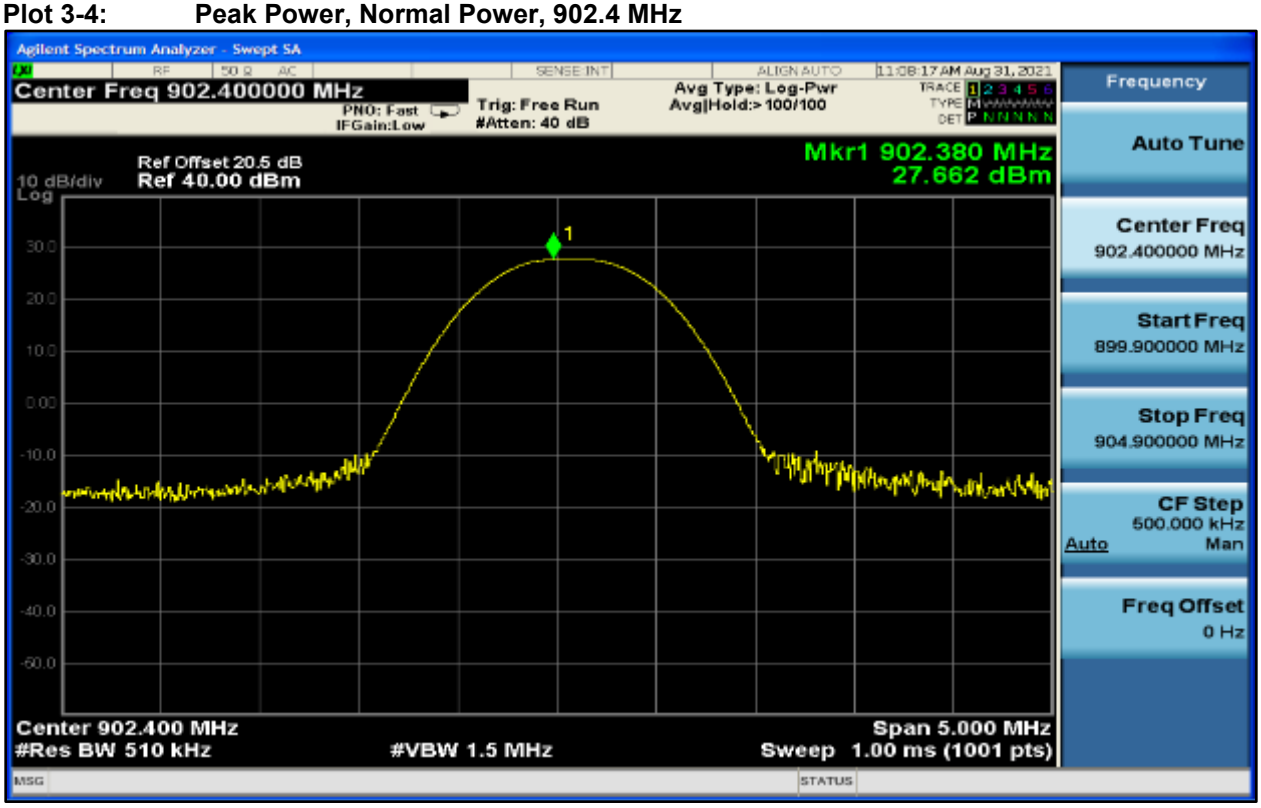
Plot 3-2: Peak Power, Low Power, 915.2 MHz



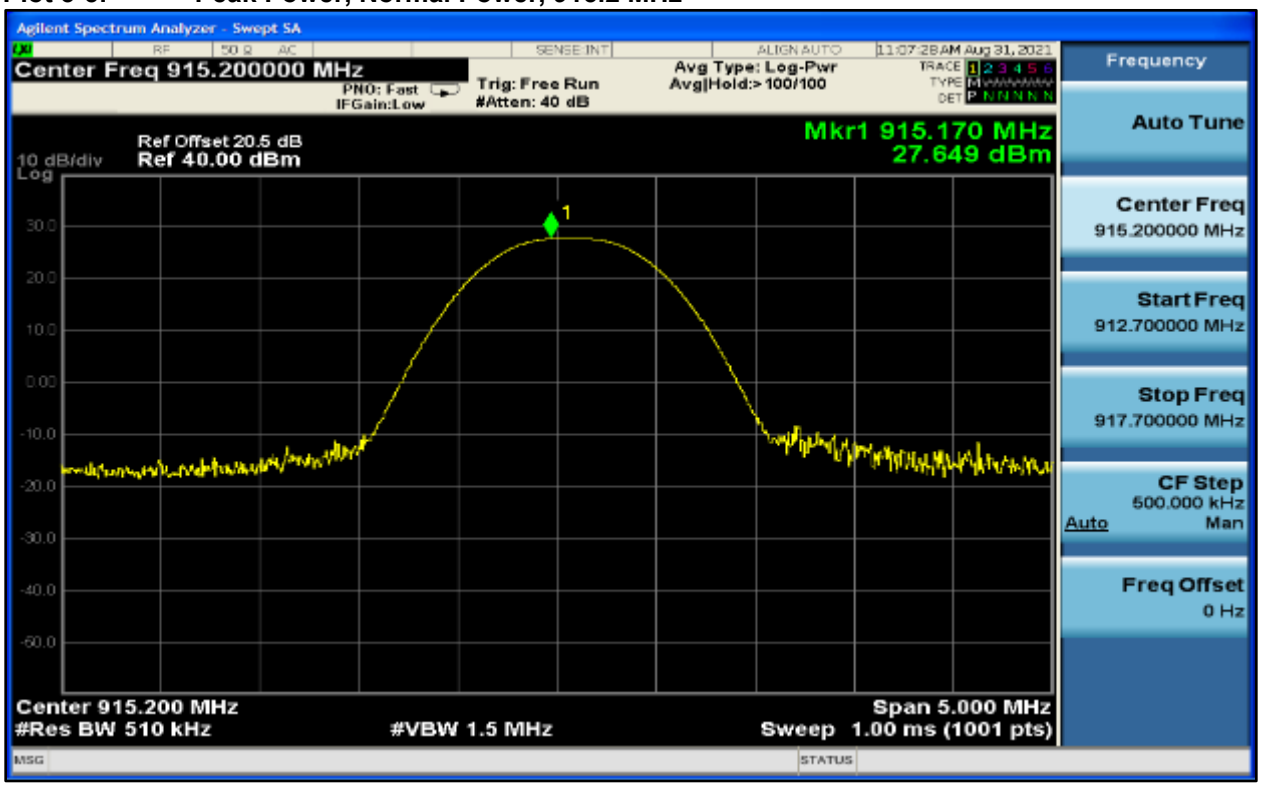
Plot 3-3: Peak Power, Low Power, 927.6 MHz



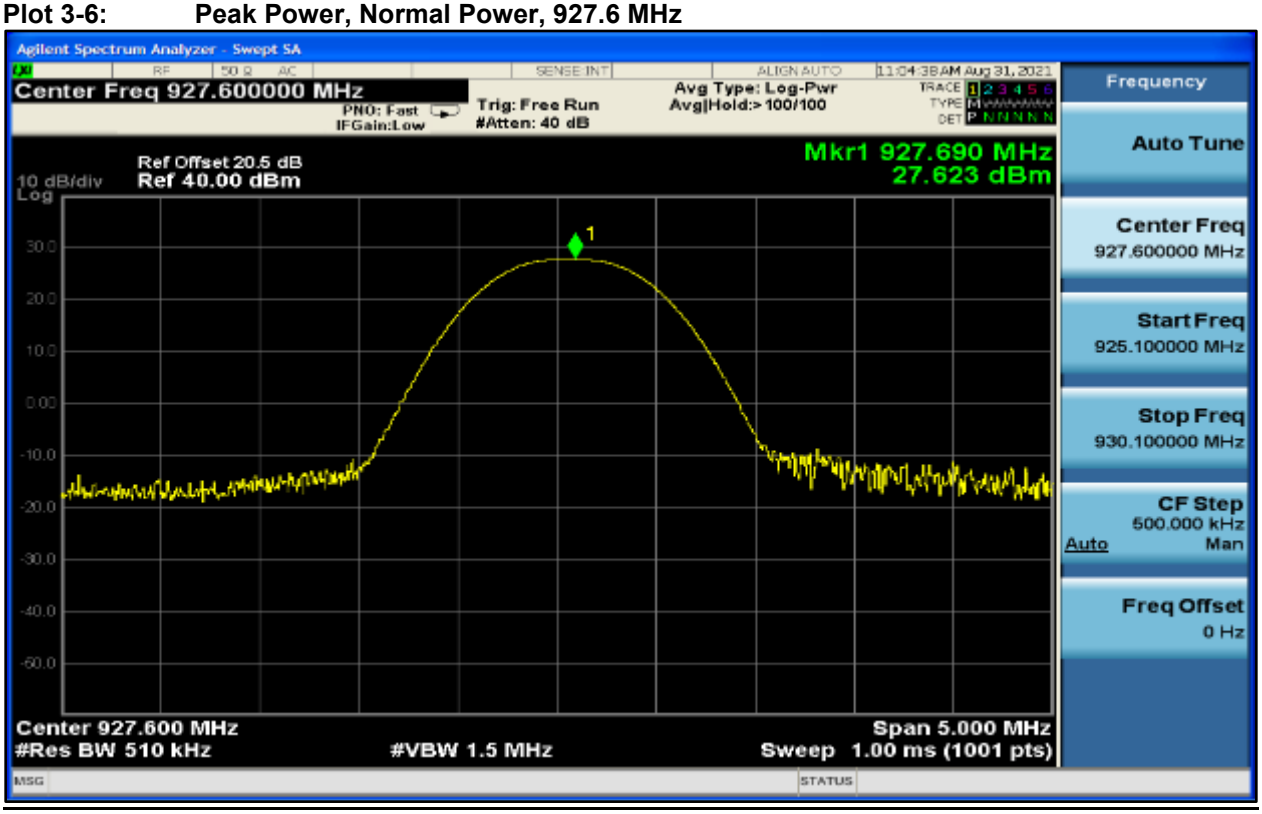
Plot 3-4: Peak Power, Normal Power, 902.4 MHz



Plot 3-5: Peak Power, Normal Power, 915.2 MHz



Plot 3-6: Peak Power, Normal Power, 927.6 MHz



Result: Pass

Table 3-6: Peak Power Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021, September 1, 2021
EMC Test Engineer	**Signature**	**Dates of Test**

4 Conducted Emissions – FCC Part 15.207; ISED RSS-Gen 8.8

4.1 Conducted Emissions Test Procedure

The powerline conducted emissions measurement were performed in a Series 81 Type shielded enclosure manufactured by Rayproof. The EUT was assembled on a wooden table 80 cm high. Power was fed to the EUT through a 50 Ω/ 50 µH Line Impedance Stabilization Network (LISN). The EUT LISN was fed power through an AC filter box on the outside of the shielded enclosure. The filter box and EUT LISN housing are bonded to the ground plane of the shielded enclosure. A second LISN, the peripheral LISN, provides isolation for the EUT test peripherals. This peripheral LISN was also fed AC power. A metal power outlet box, which is bonded to the ground plane and electrically connected to the peripheral LISN, powers a DC power supply which powers the EUT.

The spectrum analyzer (SA) was connected to the AC line through an isolation transformer. The 50 Ω output of the LISN was connected to the SA input through a Solar 100 kHz high-pass filter. The filter is used to prevent overload of the SA from noise below 100 kHz. Conducted emission levels were measured on each current-carrying line with the SA operating in the CISPR quasi-peak (QPK) mode or peak (PK) mode if applicable.

The SA's 6 dB bandwidth was set to 9 kHz. Video bandwidth (VBW) filter less than 10 times the resolution bandwidth (RBW) is not used. Average (AVG) measurements are performed in linear mode using a 10 kHz RBW, 1 Hz VBW, and by increasing the sweep time in order to obtain a calibrated measurement. The emission spectrum was scanned from 150 kHz to 30 MHz. The highest emission amplitudes relative to the appropriate limits were measured and recorded.

4.2 Conducted Emissions Limits

Table 4-1: Conducted Emissions Limits per FCC Part 15.207

Frequency (MHz)	Quasi-Peak (dBµV)	Average (dBµV)
0.15 – 0.50	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50

4.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

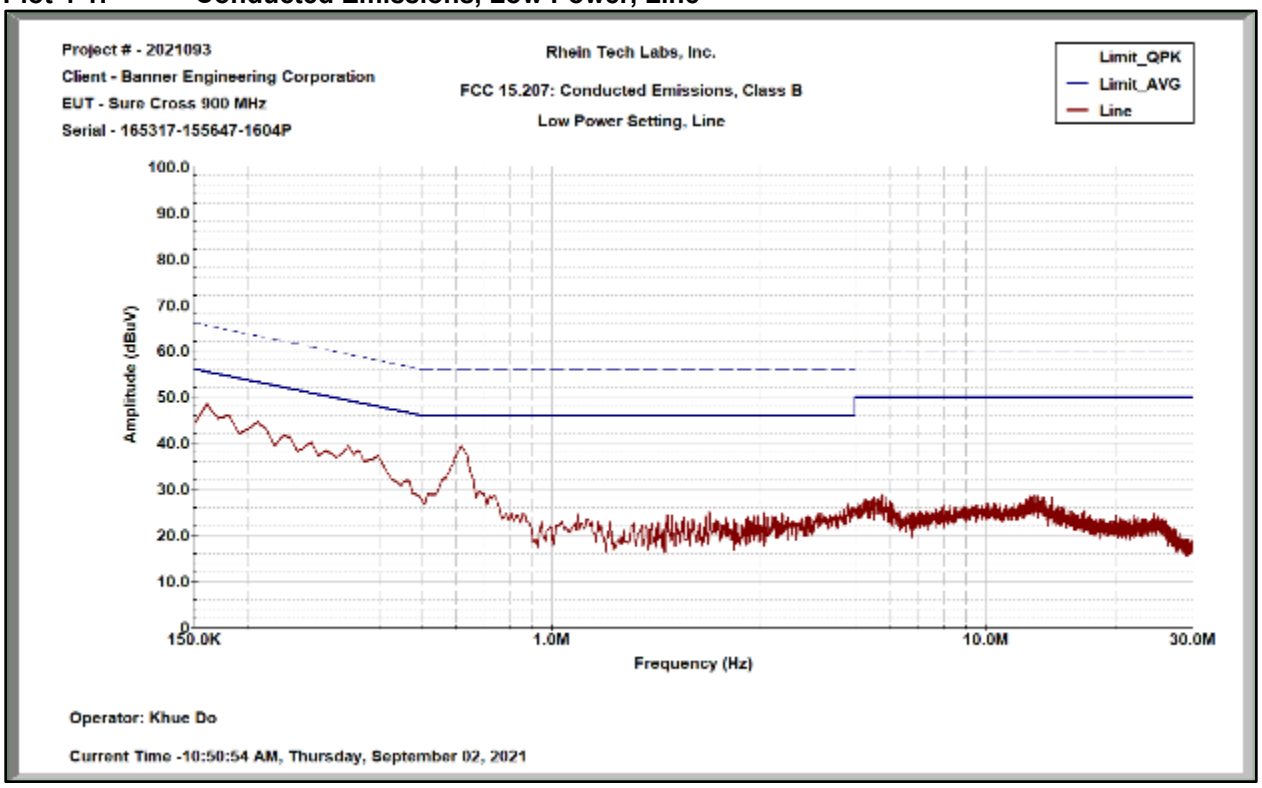
Conducted Emissions: ±3.6 dB

4.4 Conducted Emissions Test Data

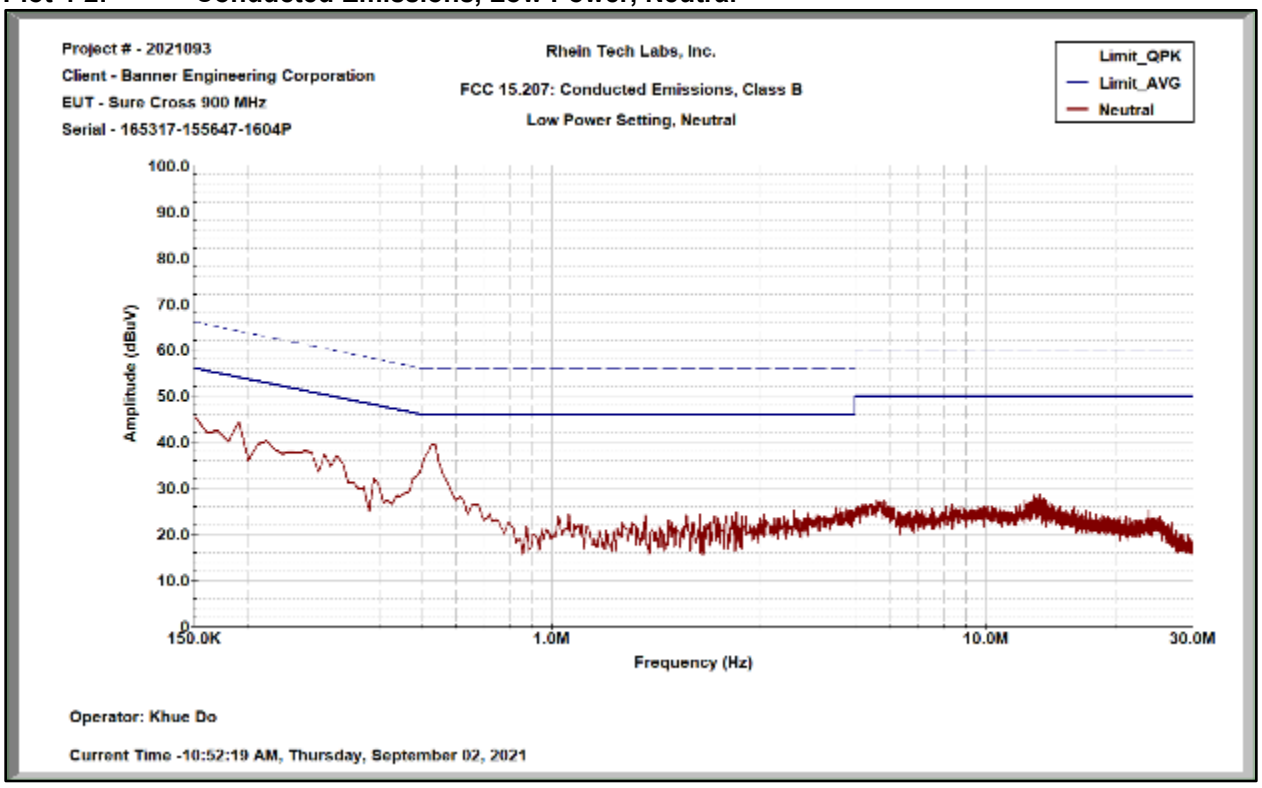
Table 4-2: Conducted Emissions Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
09/02/2021	23.3	32	101.1
09/13/2021	23.2	35	101.0

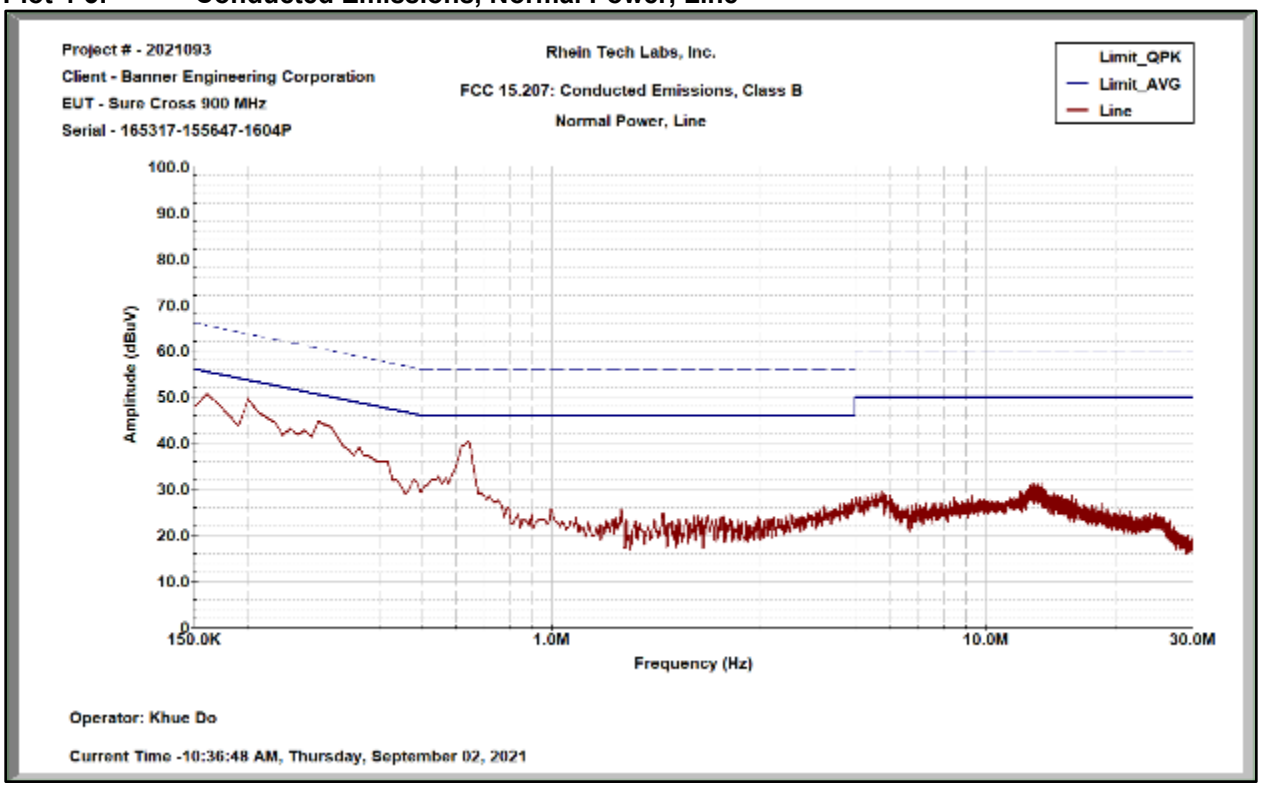
Plot 4-1: Conducted Emissions, Low Power, Line



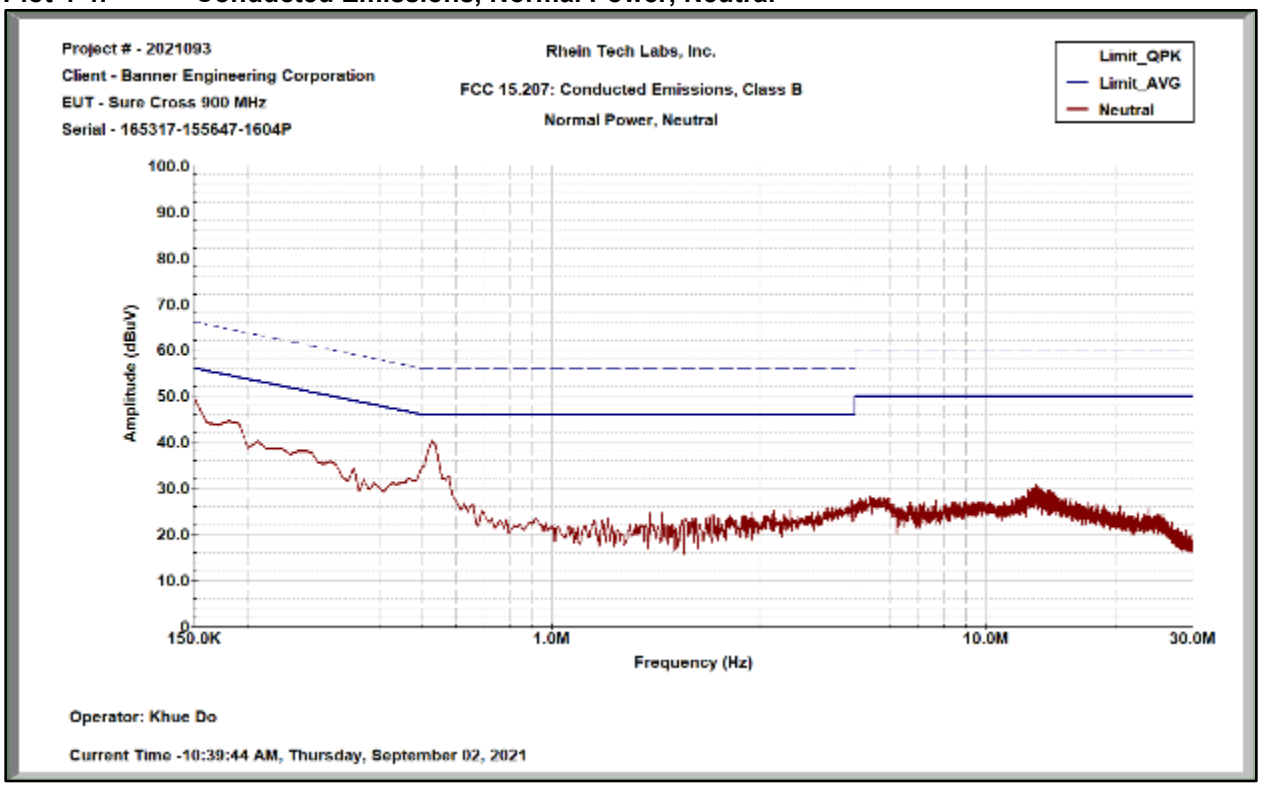
Plot 4-2: Conducted Emissions, Low Power, Neutral



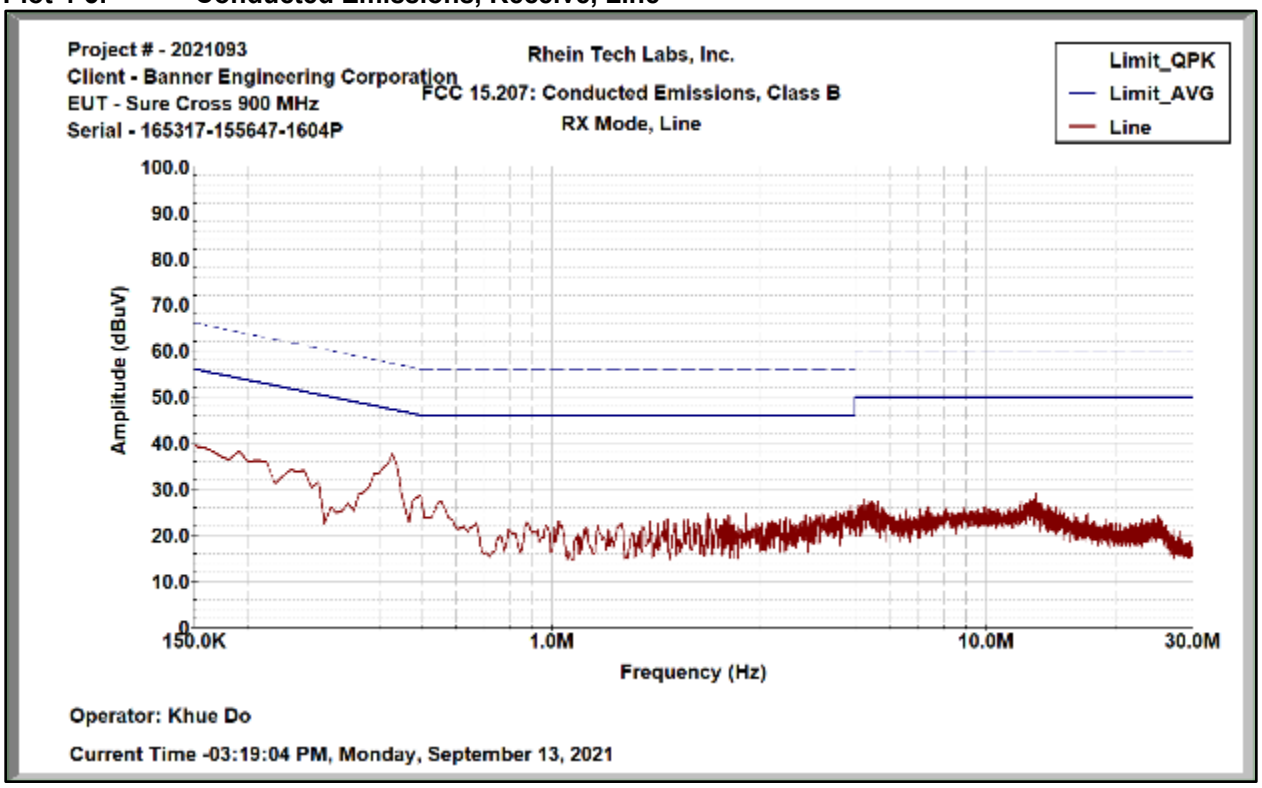
Plot 4-3: Conducted Emissions, Normal Power, Line



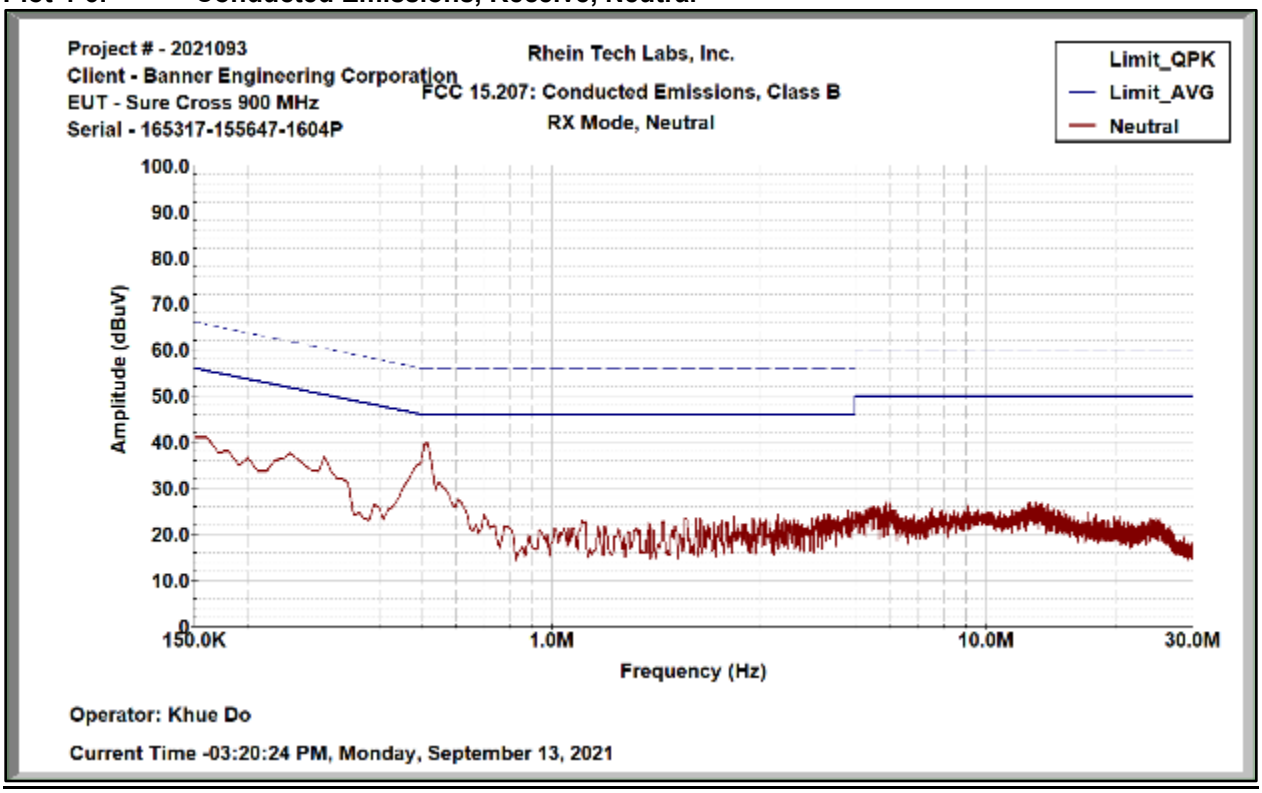
Plot 4-4: Conducted Emissions, Normal Power, Neutral



Plot 4-5: Conducted Emissions, Receive, Line



Plot 4-6: Conducted Emissions, Receive, Neutral



Result: Pass

Table 4-3: Conducted Emissions Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
900728	High Pass Filter	Solar Electronics Co.	Type 8130	947305	04/30/2023
900930	Spectrum Analyzer Display	Hewlett Packard	85662A	3144A20839	N/A
900931	Spectrum Analyzer (100 Hz – 22 GHz)	Hewlett Packard	8566B	3138A07771	02/06/2023
900969	Quasi Peak Adapter	Hewlett Packard	85650A	2412A00414	N/A
901083	16A LISN	AFJ International	LS16	16010020080	02/16/2023
Test Software	TILE! Test Software	Quantum Change	TILE! 7	7.1.3.20	N/A

Test Personnel:

Khue N. Do		September 2 & 13, 2021
EMC Test Engineer	**Signature**	**Dates of Test**

5 Radiated Emissions – FCC Part 15.209; ISED RSS-247 5.5, RSS-Gen 8.9/ 8.10

5.1 Radiated Emissions Test Procedure

Before final measurements of radiated emissions were made on the OATS, the EUT was scanned indoors at 1- and 3-meter distances. This was done in order to determine its emissions spectrum signature. The physical arrangement of the test system and associated cabling was varied in order to determine the effect on the EUT's emissions in amplitude, direction, and frequency. This process was repeated during final radiated emissions measurements on the OATS, at each frequency, in order to ensure that maximum amplitudes were attained.

Final radiated emissions measurements were made on the OATS. The EUT was placed on a non-conductive turntable 0.8 m (for frequencies < 1 GHz)/ 1.5 m (for frequencies > 1 GHz) above the ground plane. The spectrum was examined from 9 kHz to 10 GHz.

At each frequency, the EUT was rotated 360°, and the antenna was raised and lowered between 1 and 4 meters in order to determine the emission's maximum level. Measurements were taken using both horizontal and vertical antenna polarization. For frequencies between 30 and 1000 MHz, the SA 6 dB bandwidth was set to 120 kHz, and the SA was operated in the CISPR QPK detection mode. For emissions above 1 GHz, measurements were taken using the AVG detector functions with a minimum RBW of 1 MHz. No VBW less than 10 times the RBW was used. The highest emission amplitudes relative to the appropriate limit were measured and recorded.

5.2 Radiated Emissions Limits

Table 5-1: Radiated Emissions Limits per FCC Part 15.209

Frequency (MHz)	Field Strength (µV/m)	Measure Distance (m)
0.009 – 0.490	2400/ f (kHz)	300
0.490 – 1.705	2400/ f (kHz)	30
1.705 – 30.000	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

As shown in 15.35(b), for frequencies above 1 GHz, the field strength limits are based on AVG detector, however, the PK field strength of any emission shall not exceed the maximum permitted AVG limits specified above by more than 20 dB under any circumstances of modulation.

5.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Radiated Emissions: ±4.6 dB

5.4 Radiated Emissions Test Data

Table 5-2: Radiated Emissions Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
09/07/2021	22.8	65	100.2
09/08/2021	24.4	62	99.9
09/09/2021	21.2	76	99.9
09/10/2021	20.5	62	99.9
09/21/2021	23.4	76	102.5
09/22/2021	23.9	90	101.7

Only Normal Power mode was investigated. Low Power mode harmonics were spot checked. No harmonics from Low Power were higher than Normal Power mode.

The EUT was tested both in-host (inside enclosure), and stand-alone (outside enclosure).

Average levels were obtained through Peak level corrections. Please see Section 8 for Duty Cycle. The following equation was used to calculate the correction.

Correction (dB) = 20 * LOG DC (%))

Low Power Correction = -22.3 dB
Normal Power Correction = -28.4 dB

5.4.1 Harmonics/Spurious - In-Host, Normal Power Test Data

Table 5-3: In-Host, Normal Power, 2 dBi Monopole, 902.4 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	33.1	54.0	-20.9	Pass
3609.6	H	1.5	34.3	54.0	-19.7	Pass
4512.0	V	1.5	30.5	54.0	-23.5	Pass
5414.4	H	1.5	28.6	54.0	-25.4	Pass
8121.6	V	1.5	22.3	54.0	-31.7	Pass
9024.0	V	1.5	19.3	54.0	-34.7	Pass

Table 5-4: In-Host, Normal Power, 2 dBi Monopole, 902.4 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	61.5	74.0	-12.5	Pass
3609.6	H	1.5	62.7	74.0	-11.3	Pass
4512.0	V	1.5	58.9	74.0	-15.1	Pass
5414.4	H	1.5	57.0	74.0	-17.0	Pass
8121.6	V	1.5	50.7	74.0	-23.3	Pass
9024.0	V	1.5	47.7	74.0	-26.3	Pass

Table 5-5: In-Host, Normal Power, 2 dBi Monopole, 915.2 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	35.4	54.0	-18.6	Pass
3660.8	H	1.5	32.0	54.0	-22.0	Pass
4576.0	V	1.5	29.7	54.0	-24.3	Pass
7321.6	H	1.5	23.6	54.0	-30.4	Pass
8236.8	V	1.5	31.7	54.0	-22.3	Pass
9152.0	V	1.5	28.1	54.0	-25.9	Pass

Table 5-6: In-Host, Normal Power, 2 dBi Monopole, 915.2 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	63.8	74.0	-10.2	Pass
3660.8	H	1.5	60.4	74.0	-13.6	Pass
4576.0	V	1.5	58.1	74.0	-15.9	Pass
7321.6	H	1.5	52.0	74.0	-22.0	Pass
8236.8	V	1.5	60.1	74.0	-13.9	Pass
9152.0	V	1.5	56.5	74.0	-17.5	Pass

Table 5-7: In-Host, Normal Power, 2 dBi Monopole, 927.6 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	29.2	54.0	-24.8	Pass
3710.4	V	1.5	19.1	54.0	-34.9	Pass
4638.0	V	1.5	21.4	54.0	-32.6	Pass
7420.8	V	1.5	17.4	54.0	-36.6	Pass
8348.4	V	1.5	23.2	54.0	-30.8	Pass

Table 5-8: In-Host, Normal Power, 2 dBi Monopole, 927.6 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	57.6	74.0	-16.4	Pass
3710.4	V	1.5	47.5	74.0	-26.5	Pass
4638.0	V	1.5	49.8	74.0	-24.2	Pass
7420.8	V	1.5	45.8	74.0	-28.2	Pass
8348.4	V	1.5	51.6	74.0	-22.4	Pass

Table 5-9: In-Host, Normal Power, 5 dBi Monopole, 902.4 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	35.5	54.0	-18.5	Pass
3609.6	H	1.5	27.7	54.0	-26.3	Pass
4512.0	V	1.5	32.1	54.0	-21.9	Pass
5414.4	V	1.5	31.0	54.0	-23.0	Pass
8121.6	V	1.5	23.5	54.0	-30.5	Pass
9024.0	H	1.5	21.2	54.0	-32.8	Pass

Table 5-10: In-Host, Normal Power, 5 dBi Monopole, 902.4 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	63.9	74.0	-10.1	Pass
3609.6	H	1.5	56.1	74.0	-17.9	Pass
4512.0	V	1.5	60.5	74.0	-13.5	Pass
5414.4	V	1.5	59.4	74.0	-14.6	Pass
8121.6	V	1.5	51.9	74.0	-22.1	Pass
9024.0	H	1.5	49.6	74.0	-24.4	Pass

Table 5-11: In-Host, Normal Power, 5 dBi Monopole, 915.2 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	V	1.5	37.4	54.0	-16.6	Pass
3660.8	H	1.5	24.0	54.0	-30.0	Pass
4576.0	H	1.5	31.5	54.0	-22.5	Pass
7321.6	V	1.5	30.3	54.0	-23.7	Pass
8236.8	V	1.5	24.5	54.0	-29.5	Pass
9152.0	H	1.5	19.7	54.0	-34.3	Pass

Table 5-12: In-Host, Normal Power, 5 dBi Monopole, 915.2 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	V	1.5	65.8	74.0	-8.2	Pass
3660.8	H	1.5	52.4	74.0	-21.6	Pass
4576.0	H	1.5	59.9	74.0	-14.1	Pass
7321.6	V	1.5	58.7	74.0	-15.3	Pass
8236.8	V	1.5	52.9	74.0	-21.1	Pass
9152.0	H	1.5	48.1	74.0	-25.9	Pass

Table 5-13: In-Host, Normal Power, 5 dBi Monopole, 927.6 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	30.3	54.0	-23.7	Pass
3710.4	H	1.5	17.7	54.0	-36.3	Pass
4638.0	H	1.5	23.8	54.0	-30.2	Pass
7420.8	V	1.5	22.1	54.0	-31.9	Pass
8348.4	H	1.5	13.9	54.0	-40.1	Pass

Table 5-14: In-Host, Normal Power, 5 dBi Monopole, 927.6 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	58.7	74.0	-15.3	Pass
3710.4	H	1.5	46.1	74.0	-27.9	Pass
4638.0	H	1.5	52.2	74.0	-21.8	Pass
7420.8	V	1.5	50.5	74.0	-23.5	Pass
8348.4	H	1.5	42.3	74.0	-31.7	Pass

Table 5-15: In-Host, Normal Power, 6 dBi Dipole, 902.4 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	32.6	54.0	-21.4	Pass
3609.6	H	1.5	25.9	54.0	-28.1	Pass
4512.0	V	1.5	32.2	54.0	-21.8	Pass
5414.4	V	1.5	36.4	54.0	-17.6	Pass
8121.6	H	1.5	27.5	54.0	-26.5	Pass
9024.0	H	1.5	20.4	54.0	-33.6	Pass

Table 5-16: In-Host, Normal Power, 6 dBi Dipole, 902.4 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	61.0	74.0	-13.0	Pass
3609.6	H	1.5	54.3	74.0	-19.7	Pass
4512.0	V	1.5	60.6	74.0	-13.4	Pass
5414.4	V	1.5	64.8	74.0	-9.2	Pass
8121.6	H	1.5	55.9	74.0	-18.1	Pass
9024.0	H	1.5	48.8	74.0	-25.2	Pass

Table 5-17: In-Host, Normal Power, 6 dBi Dipole, 915.2 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	32.6	54.0	-21.4	Pass
3660.8	H	1.5	25.3	54.0	-28.7	Pass
4576.0	H	1.5	31.8	54.0	-22.2	Pass
7321.6	V	1.5	26.2	54.0	-27.8	Pass
8236.8	H	1.5	25.9	54.0	-28.1	Pass
9152.0	H	1.5	19.2	54.0	-34.8	Pass

Table 5-18: In-Host, Normal Power, 6 dBi Dipole, 915.2 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	61.0	74.0	-13.0	Pass
3660.8	H	1.5	53.7	74.0	-20.3	Pass
4576.0	H	1.5	60.2	74.0	-13.8	Pass
7321.6	V	1.5	54.6	74.0	-19.4	Pass
8236.8	H	1.5	54.3	74.0	-19.7	Pass
9152.0	H	1.5	47.6	74.0	-26.4	Pass

Table 5-19: In-Host, Normal Power, 6 dBi Dipole, 927.6 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	28.8	54.0	-25.2	Pass
3710.4	V	1.5	14.9	54.0	-39.1	Pass
4638.0	H	1.5	23.3	54.0	-30.7	Pass
7420.8	V	1.5	15.5	54.0	-38.5	Pass
8348.4	V	1.5	13.4	54.0	-40.6	Pass

Table 5-20: In-Host, Normal Power, 6 dBi Dipole, 927.6 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	57.2	74.0	-16.8	Pass
3710.4	V	1.5	43.3	74.0	-30.7	Pass
4638.0	H	1.5	51.7	74.0	-22.3	Pass
7420.8	V	1.5	43.9	74.0	-30.1	Pass
8348.4	V	1.5	41.8	74.0	-32.2	Pass

5.4.2 Harmonics/Spurious, Stand-Alone, Normal Power Test Data

Table 5-21: Stand-alone, Normal Power, 2 dBi Monopole, 902.4 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	32.9	54.0	-21.1	Pass
3609.6	H	1.5	34.9	54.0	-19.1	Pass
4512.0	H	1.5	30.0	54.0	-24.0	Pass
5414.4	H	1.5	30.8	54.0	-23.2	Pass
8121.6	H	1.5	23.3	54.0	-30.7	Pass
9024.0	H	1.5	32.6	54.0	-21.4	Pass

Table 5-22: Stand-alone, Normal Power, 2 dBi Monopole, 902.4 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	61.3	74.0	-12.7	Pass
3609.6	H	1.5	63.3	74.0	-10.7	Pass
4512.0	H	1.5	58.4	74.0	-15.6	Pass
5414.4	H	1.5	59.2	74.0	-14.8	Pass
8121.6	H	1.5	51.7	74.0	-22.3	Pass
9024.0	H	1.5	61.0	74.0	-13.0	Pass

Table 5-23: Stand-alone, Normal Power, 2 dBi Monopole, 915.2 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	35.0	54.0	-19.0	Pass
3660.8	H	1.5	36.1	54.0	-17.9	Pass
4576.0	H	1.5	29.9	54.0	-24.1	Pass
7321.6	H	1.5	26.0	54.0	-28.0	Pass
8236.8	H	1.5	22.8	54.0	-31.2	Pass
9152.0	H	1.5	33.6	54.0	-20.4	Pass

Table 5-24: Stand-alone, Normal Power, 2 dBi Monopole, 915.2 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	63.4	74.0	-10.6	Pass
3660.8	H	1.5	64.5	74.0	-9.5	Pass
4576.0	H	1.5	58.3	74.0	-15.7	Pass
7321.6	H	1.5	54.4	74.0	-19.6	Pass
8236.8	H	1.5	51.2	74.0	-22.8	Pass
9152.0	H	1.5	62.0	74.0	-12.0	Pass

Table 5-25: Stand-alone, Normal Power, 2 dBi Monopole, 927.6 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	V	1.5	29.5	54.0	-24.5	Pass
3710.4	H	1.5	23.2	54.0	-30.8	Pass
4638.0	H	1.5	23.2	54.0	-30.8	Pass
7420.8	H	1.5	15.8	54.0	-38.2	Pass
8348.4	H	1.5	18.3	54.0	-35.7	Pass

Table 5-26: Stand-alone, Normal Power, 2 dBi Monopole, 927.6 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	V	1.5	57.9	74.0	-16.1	Pass
3710.4	H	1.5	51.6	74.0	-22.4	Pass
4638.0	H	1.5	51.6	74.0	-22.4	Pass
7420.8	H	1.5	44.2	74.0	-29.8	Pass
8348.4	H	1.5	46.7	74.0	-27.3	Pass

Table 5-27: Stand-alone, Normal Power, 5 dBi Monopole, 902.4 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	35.4	54.0	-18.6	Pass
3609.6	H	1.5	28.4	54.0	-25.6	Pass
4512.0	H	1.5	31.2	54.0	-22.8	Pass
5414.4	V	1.5	33.1	54.0	-20.9	Pass
8121.6	H	1.5	24.8	54.0	-29.2	Pass
9024.0	H	1.5	35.2	54.0	-18.8	Pass

Table 5-28: Stand-alone, Normal Power, 5 dBi Monopole, 902.4 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	63.8	74.0	-10.2	Pass
3609.6	H	1.5	56.8	74.0	-17.2	Pass
4512.0	H	1.5	59.6	74.0	-14.4	Pass
5414.4	V	1.5	61.5	74.0	-12.5	Pass
8121.6	H	1.5	53.2	74.0	-20.8	Pass
9024.0	H	1.5	63.6	74.0	-10.4	Pass

Table 5-29: Stand-alone, Normal Power, 5 dBi Monopole, 915.2 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	38.5	54.0	-15.5	Pass
3660.8	H	1.5	31.2	54.0	-22.8	Pass
4576.0	H	1.5	31.3	54.0	-22.7	Pass
7321.6	H	1.5	30.1	54.0	-23.9	Pass
8236.8	H	1.5	25.9	54.0	-28.1	Pass
9152.0	H	1.5	36.9	54.0	-17.1	Pass

Table 5-30: Stand-alone, Normal Power, 5 dBi Monopole, 915.2 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	66.9	74.0	-7.1	Pass
3660.8	H	1.5	59.6	74.0	-14.4	Pass
4576.0	H	1.5	59.7	74.0	-14.3	Pass
7321.6	H	1.5	58.5	74.0	-15.5	Pass
8236.8	H	1.5	54.3	74.0	-19.7	Pass
9152.0	H	1.5	65.3	74.0	-8.7	Pass

Table 5-31: Stand-alone, Normal Power, 5 dBi Monopole, 927.6 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	32.7	54.0	-21.3	Pass
3710.4	H	1.5	22.8	54.0	-31.2	Pass
4638.0	H	1.5	24.6	54.0	-29.4	Pass
7420.8	H	1.5	19.3	54.0	-34.7	Pass
8348.4	H	1.5	17.5	54.0	-36.5	Pass

Table 5-32: Stand-alone, Normal Power, 5 dBi Monopole, 927.6 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	61.1	74.0	-12.9	Pass
3710.4	H	1.5	51.2	74.0	-22.8	Pass
4638.0	H	1.5	53.0	74.0	-21.0	Pass
7420.8	H	1.5	47.7	74.0	-26.3	Pass
8348.4	H	1.5	45.9	74.0	-28.1	Pass

Table 5-33: Stand-alone, Normal Power, 6 dBi Dipole, 902.4 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	32.2	54.0	-21.8	Pass
3609.6	H	1.5	27.5	54.0	-26.5	Pass
4512.0	H	1.5	33.7	54.0	-20.3	Pass
5414.4	H	1.5	35.6	54.0	-18.4	Pass
8121.6	H	1.5	24.0	54.0	-30.0	Pass
9024.0	H	1.5	36.4	54.0	-17.6	Pass

Table 5-34: Stand-alone, Normal Power, 6 dBi Dipole, 902.4 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2707.2	H	1.5	60.6	74.0	-13.4	Pass
3609.6	H	1.5	55.9	74.0	-18.1	Pass
4512.0	H	1.5	62.1	74.0	-11.9	Pass
5414.4	H	1.5	64.0	74.0	-10.0	Pass
8121.6	H	1.5	52.4	74.0	-21.6	Pass
9024.0	H	1.5	64.8	74.0	-9.2	Pass

Table 5-35: Stand-alone, Normal Power, 6 dBi Dipole, 915.2 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	30.0	54.0	-24.0	Pass
3660.8	H	1.5	27.0	54.0	-27.0	Pass
4576.0	H	1.5	33.2	54.0	-20.8	Pass
7321.6	H	1.5	27.3	54.0	-26.7	Pass
8236.8	H	1.5	22.8	54.0	-31.2	Pass
9152.0	H	1.5	35.2	54.0	-18.8	Pass

Table 5-36: Stand-alone, Normal Power, 6 dBi Dipole, 915.2 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2745.6	H	1.5	58.4	74.0	-15.6	Pass
3660.8	H	1.5	55.4	74.0	-18.6	Pass
4576.0	H	1.5	61.6	74.0	-12.4	Pass
7321.6	H	1.5	55.7	74.0	-18.3	Pass
8236.8	H	1.5	51.2	74.0	-22.8	Pass
9152.0	H	1.5	63.6	74.0	-10.4	Pass

Table 5-37: Stand-alone, Normal Power, 6 dBi Dipole, 927.6 MHz, Average

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	22.9	54.0	-31.1	Pass
3710.4	H	1.5	19.2	54.0	-34.8	Pass
4638.0	V	1.5	22.5	54.0	-31.5	Pass
7420.8	H	1.5	15.4	54.0	-38.6	Pass
8348.4	H	1.5	17.1	54.0	-36.9	Pass

Table 5-38: Stand-alone, Normal Power, 6 dBi Dipole, 927.6 MHz, Peak

Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2782.8	H	1.5	51.3	74.0	-22.7	Pass
3710.4	H	1.5	47.6	74.0	-26.4	Pass
4638.0	V	1.5	50.9	74.0	-23.1	Pass
7420.8	H	1.5	43.8	74.0	-30.2	Pass
8348.4	H	1.5	45.5	74.0	-28.5	Pass

5.4.3 Radiated Emissions, Digital Unintentional/Receiver

Table 5-39: Radiated Emissions, Digital Unintentional/Receiver, 2 dBi Monopole

Emission Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Table Azimuth (°)	QPK Raw (dBµV)	SCF (dB/m)	QPK Corrected (dBµV/m)	QPK Limit (dBµV/m)	QPK Margin (dB)
134.859	H	1.0	225	49.4	-19.5	29.9	43.5	-13.6
144.100	H	1.0	315	43.3	-18.9	24.4	43.5	-19.1
207.736	H	4.0	180	44.9	-16.5	28.4	43.5	-15.1
285.124	H	3.0	0	50.0	-14.0	36.0	46.0	-10.0
309.814	V	1.0	90	35.2	-12.8	22.4	46.0	-23.6
504.734	V	1.0	0	34.8	-6.4	28.4	46.0	-17.6
826.712	V	1.0	90	34.6	0.8	35.4	46.0	-10.6

Table 5-40: Radiated Emissions, Digital Unintentional/Receiver, 5 dBi Monopole

Emission Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Table Azimuth (°)	QPK Raw (dBµV)	SCF (dB/m)	QPK Corrected (dBµV/m)	QPK Limit (dBµV/m)	QPK Margin (dB)
134.859	V	1.0	0	46.8	-19.5	27.3	43.5	-16.2
144.100	V	1.0	0	40.6	-18.9	21.7	43.5	-21.8
207.842	V	1.0	180	45.5	-16.5	29.0	43.5	-14.5
285.124	V	1.0	0	40.9	-14.0	26.9	46.0	-19.1
309.714	V	1.0	90	38.3	-12.8	25.5	46.0	-20.5
504.734	H	1.0	180	38.5	-6.4	32.1	46.0	-13.9
826.712	V	1.0	90	37.1	0.8	37.9	46.0	-8.1

Table 5-41: Radiated Emissions, Digital Unintentional/Receiver, 6 dBi Dipole

Emission Frequency (MHz)	Antenna Polarity (H / V)	Antenna Height (m)	Table Azimuth (°)	QPK Raw (dBµV)	SCF (dB/m)	QPK Corrected (dBµV/m)	QPK Limit (dBµV/m)	QPK Margin (dB)
134.859	V	1.0	0	46.5	-19.5	27.0	43.5	-16.5
144.100	H	1.0	0	42.7	-18.9	23.8	43.5	-19.7
207.800	V	1.0	180	44.2	-16.5	27.7	43.5	-15.8
285.124	H	1.5	90	38.4	-14.0	24.4	46.0	-21.6
309.714	V	1.0	90	37.8	-12.8	25.0	46.0	-21.0
504.734	H	2.0	180	38.2	-6.4	31.8	46.0	-14.2
826.712	V	1.0	180	38.2	0.8	39.0	46.0	-7.0

Result: Pass

Table 5-42: Radiated Emissions Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
900321	Horn Antenna (4.0 – 8.2 GHz)	EMCO	3161-03	9528-1020	08/05/2024
900323	Horn Antenna (8.2 – 12.4 GHz)	EMCO	3160-07	9605-1024	08/05/2024
900772	Horn Antenna (2 – 4 GHz)	EMCO	3161-02	9804-1044	08/05/2024
900905	Preamplifier (10 MHz – 2 GHz)	Rhein Tech Laboratories, Inc.	PR-1040	1006	09/15/2021
900930	Spectrum Analyzer Display	Hewlett Packard	85662A	3144A20839	N/A
900931	Spectrum Analyzer (100 Hz – 22 GHz)	Hewlett Packard	8566B	3138A07771	02/06/2023
900932	Preamplifier (1 – 26.5 GHz)	Hewlett Packard	8449B OPT H02	3008A00505	02/16/2022
900969	Quasi Peak Adapter	Hewlett Packard	85650A	2412A00414	N/A
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022
901669	Bilog Antenna (26 MHz – 6 GHz)	ETS-Lindgren	3142E	00166065	04/24/2022
N/A	Test Software	Rhein Tech Laboratories, Inc.	RTL Emission	Version 1.1.4	N/A

Test Personnel:

Khue N. Do		September 7 – 10, 21 – 22, 2021
EMC Test Engineer	**Signature**	**Dates of Test**

6 Carrier Frequency Separation – FCC 15.247(a)(1); ISED RSS-247 5.1(b)

6.1 Carrier Frequency Separation Test Procedure

The carrier frequency separation (CFS) was measured using a 50 Ω SA. The following settings were used:

Span:	2 MHz	Center:	Enough to cover two adjacent channels
RBW:	10 kHz	Sweep:	Auto
VBW:	30 kHz	Detector:	Peak
Attenuation:	10 dB	Trace:	Max Hold

6.2 Carrier Frequency Separation Limits

FHSS shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the OBW 20 dB of the hopping channel, whichever is greater.

6.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Carrier Frequency Separation: $\pm 1.0 \times 10^{-6}$ Hz

6.4 Carrier Frequency Separation Test Data

Table 6-1: Carrier Frequency Separation Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
8/31/2021	23.1	31	101.1
4/11/2022	22.2	28	101.1

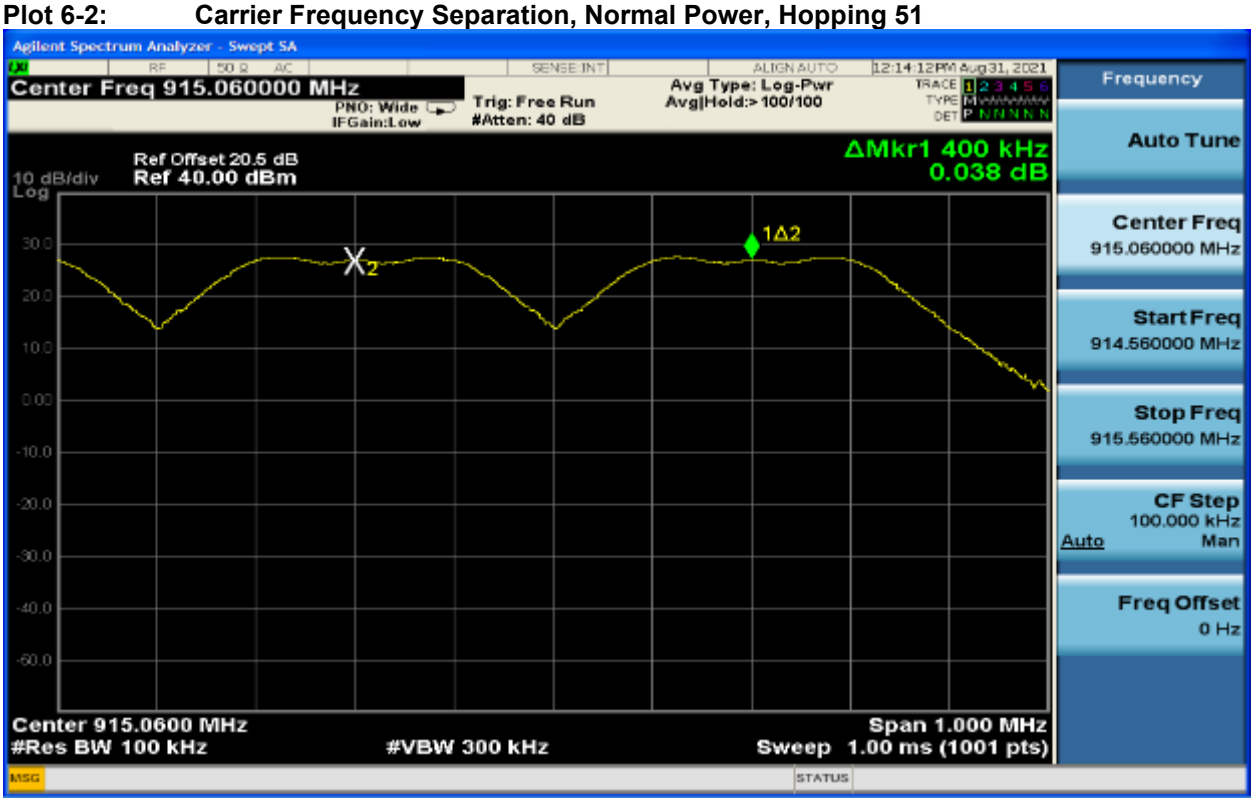
Table 6-2: Carrier Frequency Separation Test Result

Frequency (MHz)	CFS (kHz)	Limit (kHz)	Result
903.46	800.0	352.2	Pass
915.06	400.0	349.6	Pass

Notes: The 20 dB OBW is greater than 25 kHz. Low Power was set to Hop on 25 channels (Right Rotary C). Normal power was set to Hop on 51 channels (Right Rotary 0).

Plot 6-1: Carrier Frequency Separation, Low Power, Hopping 25

Plot 6-2: Carrier Frequency Separation, Normal Power, Hopping 51



Result: Pass

Table 6-3: Carrier Frequency Separation Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021 April 11, 2022
EMC Test Engineer	**Signature**	**Dates of Test**

7 Occupied Channel Bandwidth – FCC 15.247(a)(1)(i); ISED RSS-247 5.1(c), RSS-Gen 6.7

7.1 Occupied Bandwidth Test Procedure

The OBW 99% were measured using a 50 Ω SA. The following settings were used:

Span: 1.5 to 5.0 times the OBW
RBW: 1% to 5% of the OBW
VBW: 3 times RBW
Sweep: Auto
Detector: Peak
Trace: Max Hold
Reference: Peak of emission must be more than [10 log(OBW / RBW)] below the reference level

The measurements were repeated a few times until the RBW and VBW are in compliance with the above requirement.

7.2 Occupied Bandwidth Limits

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

7.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Occupied Bandwidth: $\pm 1.0 \times 10^{-6}$ Hz

7.4 Occupied Bandwidth Test Data

Table 7-1: Occupied Bandwidth Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
8/31/2021	23.1	31	101.1

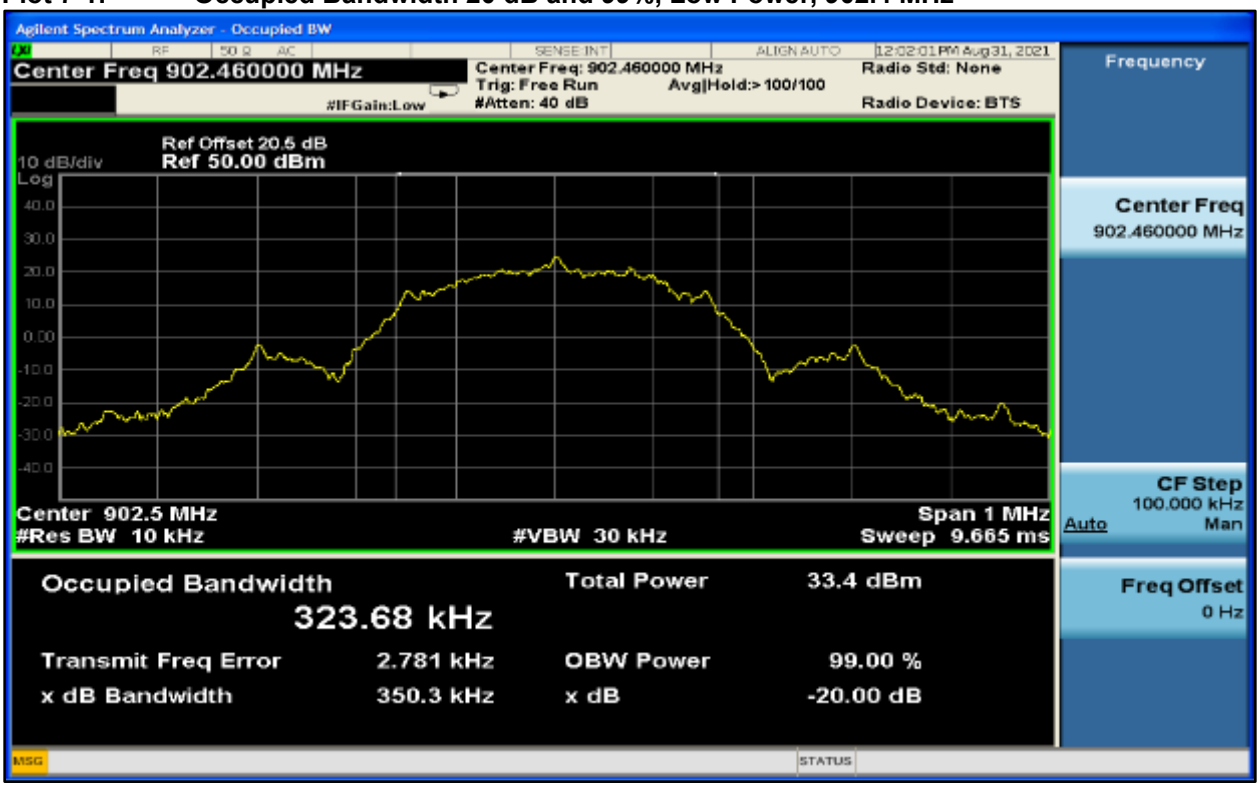
Table 7-2: Occupied Bandwidth Low Power

Frequency (MHz)	OBW 99% (kHz)	OBW 20 dB (kHz)	OBW 20 dB Limit (kHz)	Result
902.4	323.680	350.300	500.000	Pass
915.2	322.750	349.500	500.000	Pass
927.6	326.160	352.200	500.000	Pass

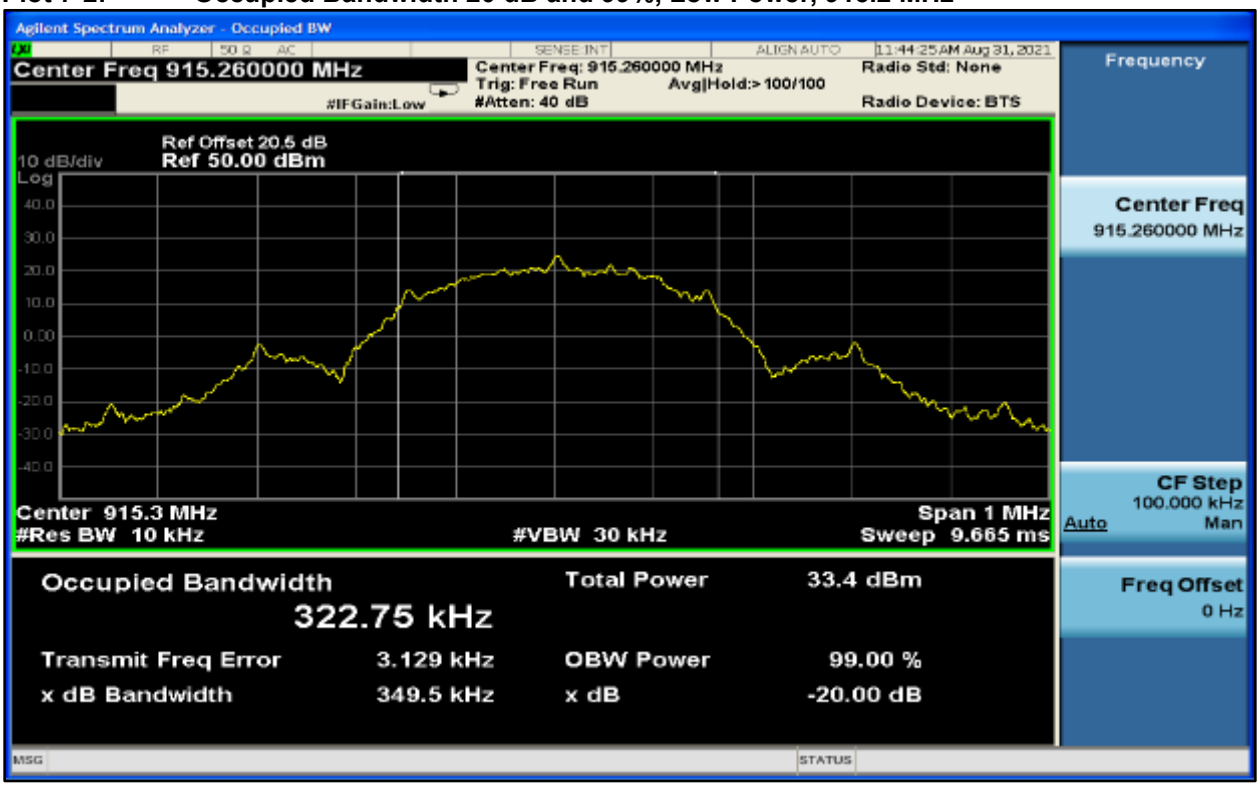
Table 7-3: Occupied Bandwidth Normal Power

Frequency (MHz)	OBW 99% (kHz)	OBW 20 dB (kHz)	OBW 20 dB Limit (kHz)	Result
902.4	324.130	349.600	500.000	Pass
915.2	324.410	349.100	500.000	Pass
927.6	325.800	349.400	500.000	Pass

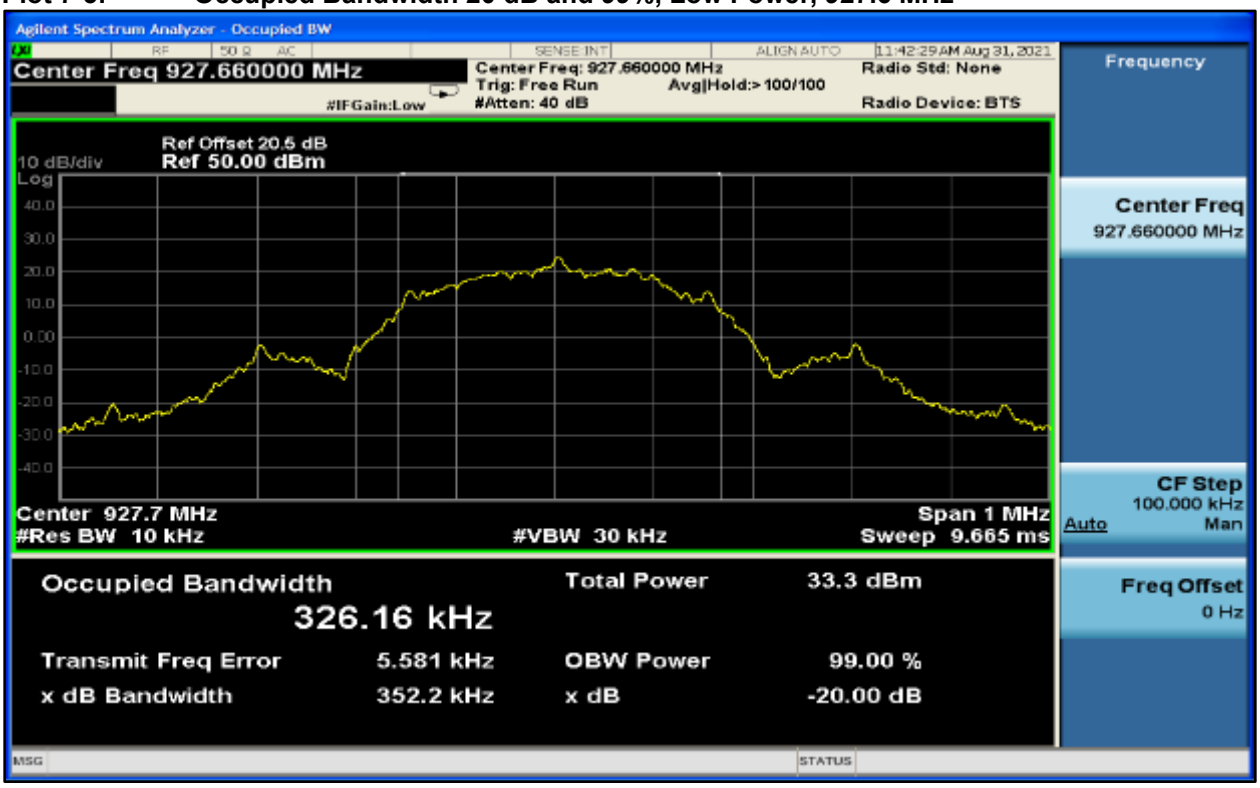
Plot 7-1: Occupied Bandwidth 20 dB and 99%, Low Power, 902.4 MHz



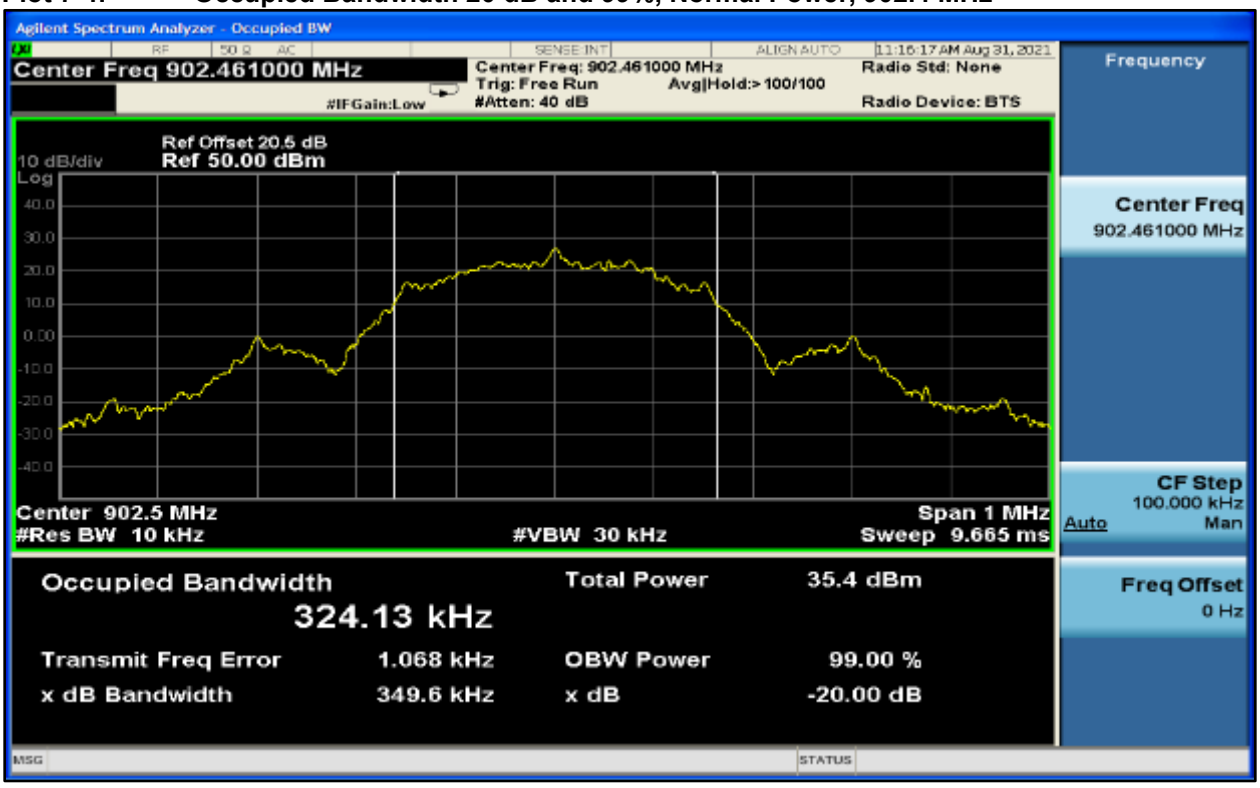
Plot 7-2: Occupied Bandwidth 20 dB and 99%, Low Power, 915.2 MHz



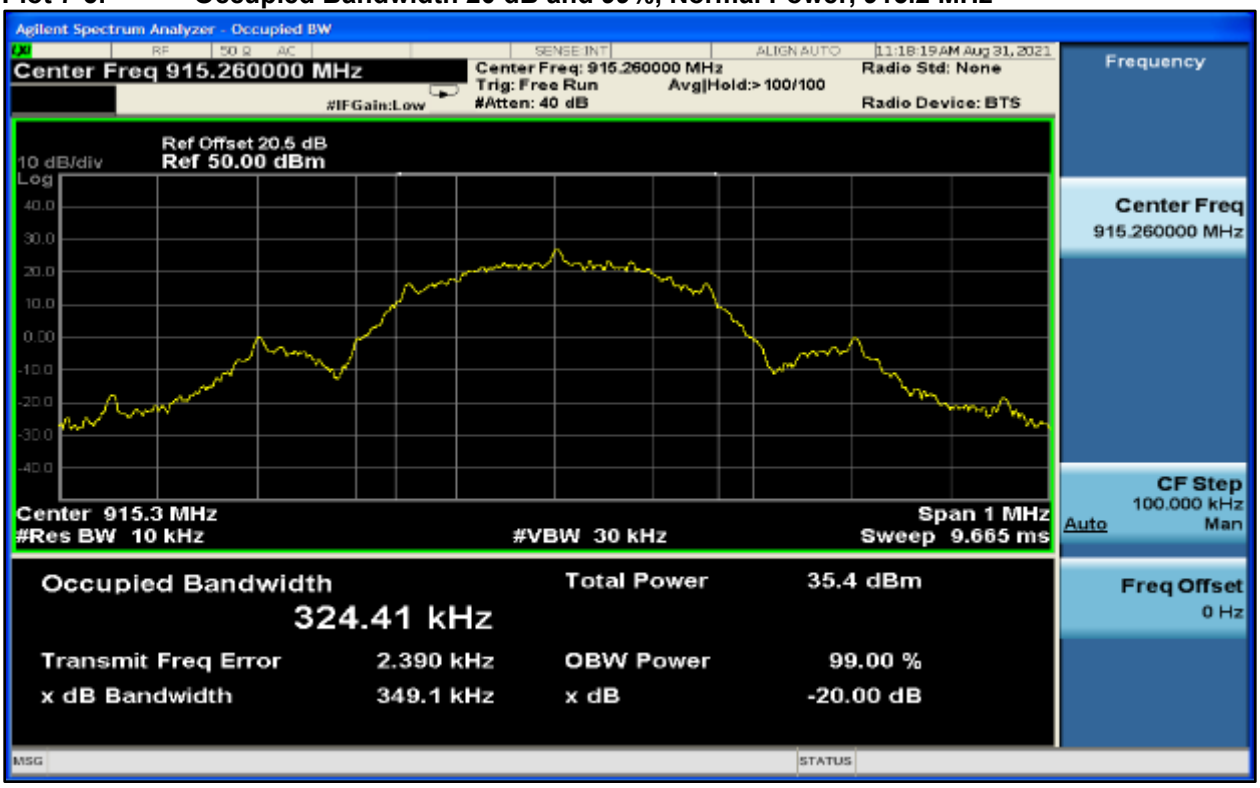
Plot 7-3: Occupied Bandwidth 20 dB and 99%, Low Power, 927.6 MHz



Plot 7-4: Occupied Bandwidth 20 dB and 99%, Normal Power, 902.4 MHz



Plot 7-5: Occupied Bandwidth 20 dB and 99%, Normal Power, 915.2 MHz



Plot 7-6: Occupied Bandwidth 20 dB and 99%, Normal Power, 927.6 MHz

Result: Pass

Table 7-4: Occupied Bandwidth Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021
EMC Test Engineer	**Signature**	**Date of Test**

8 Hopping Characteristics – FCC 15.247(a)(1)(i); ISED RSS-247 5.1(c)

8.1 Hopping Characteristics Test Procedure

The hopping characteristics were measured using a 50 Ω SA. The span was set large enough to observe all of the hopping channels employed. Each distinct individual frequency was counted and recorded.

The SA gate function was used to determine the pulse width using the gate start and stop times, with a zero span. The sweep time was adjusted to capture a single pulse. The delta response of the gate was used to measure the dwell time/ duration of the pulse.

The sweep time was then changed to 0.4 seconds times the number of hopping channels employed. The number of pulses present within this new time window was counted and recorded. The product of the pulse duration and the number of pulses in the new time window is the average time of occupancy (ATO).

8.2 Hopping Characteristics Limits

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.

8.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Hopping Characteristics: $\pm 1.0 \times 10^{-6}$ Hz

8.4 Hopping Characteristics Test Data

Table 8-1: Hopping Characteristics Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
8/31/2021	23.1	31	101.1
9/13/2021	23.2	35	101.0
4/11/2022	22.2	28	101.1

Notes: Since 20 dB OBW is greater than 250 kHz, the system shall use at least 25 channels and the ATO shall not be greater than 0.4 s within a 10 s period.

Low Power was set to Hop on 25 channels (Right Rotary C). Normal power was set to Hop on 51 channels (Right Rotary 0).

Pulse Duration (s) = Sum ON time of pulses (s)

ATO (s) = (Pulse Duration (s)) x (# of Pulses in 10 s Window)

Table 8-2: Hopping Channels, Low Power

# of Channels (N)	Limit (#)	Result
25	≥25	Pass

Table 8-3: Hopping Channels, Normal Power

# of Channels (N)	Limit (#)	Result
51	≥50	Pass

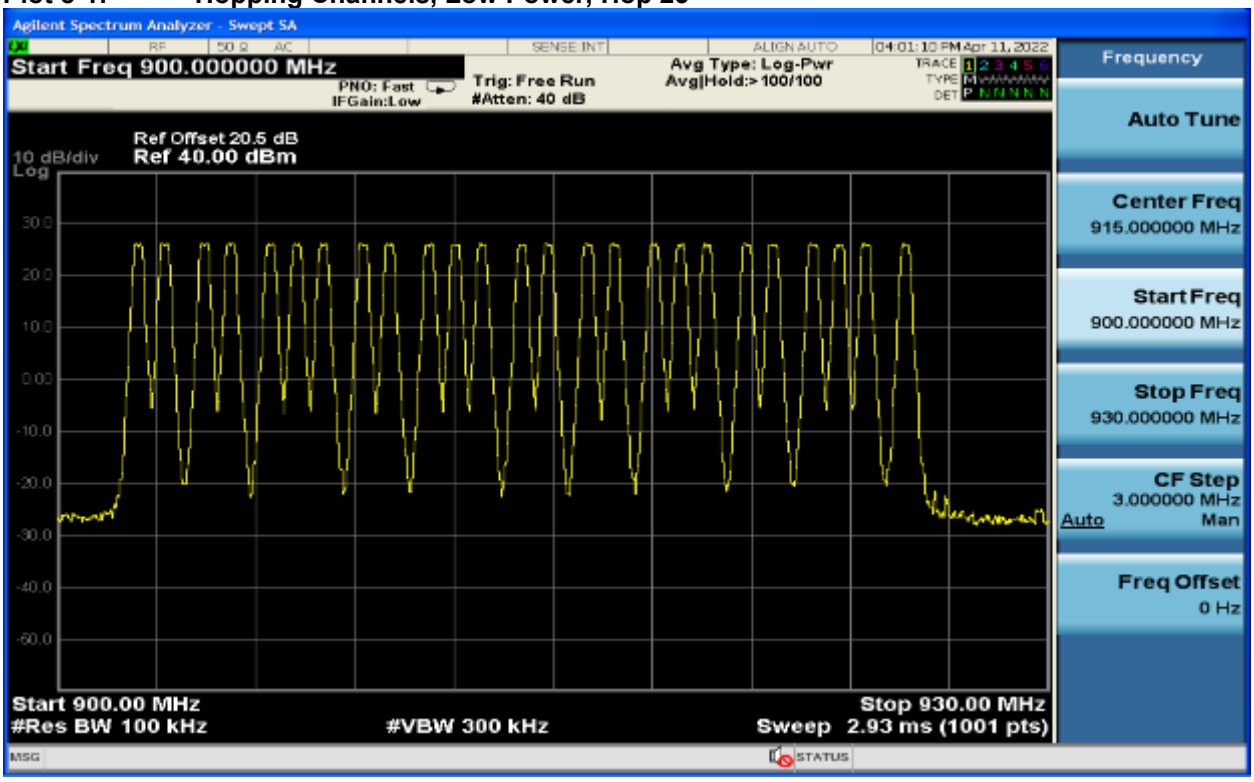
Table 8-4: ATO, Low Power

Pulse Duration (ms)	# of Pulses in Period	ATO (ms)	Limit (ms)	Result
3.841	30	115.23	400.000	Pass

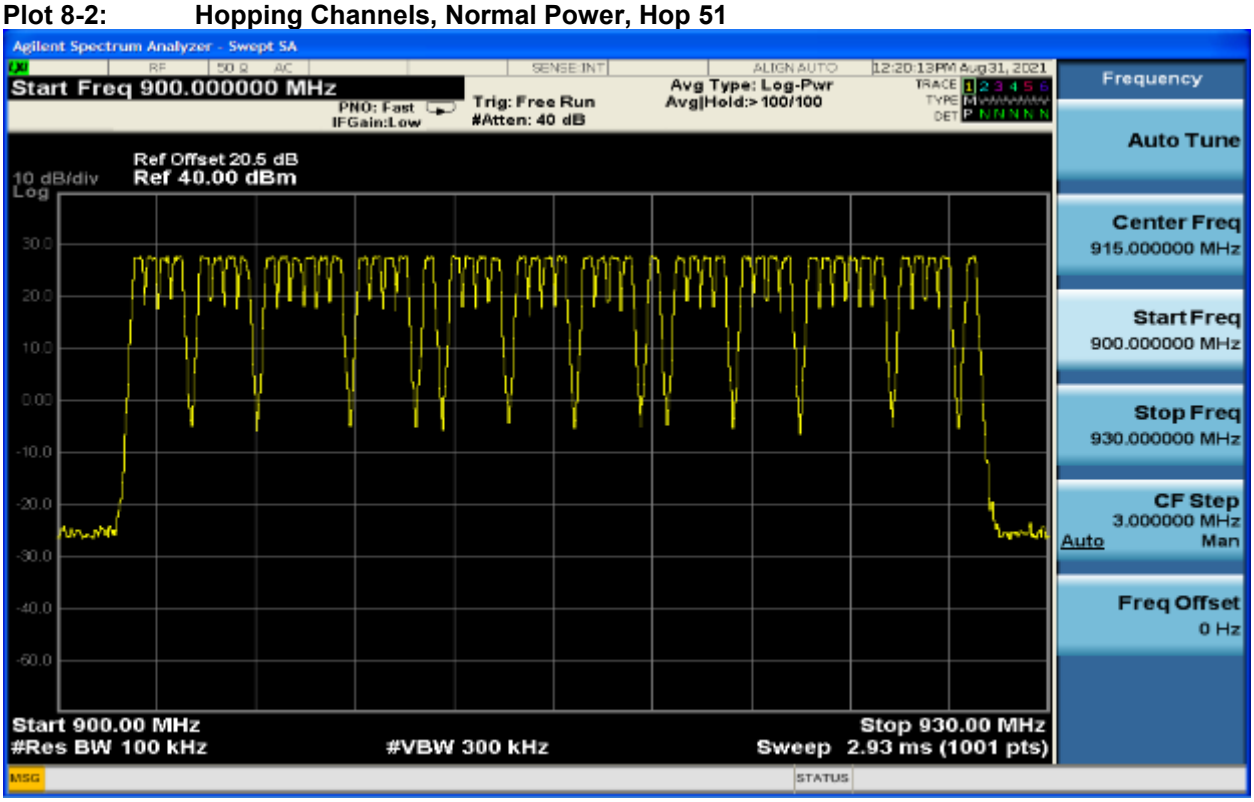
Table 8-5: ATO, Normal Power

Pulse Duration (ms)	# of Pulses in Period	ATO (ms)	Limit (ms)	Result
3.800	13	49.400	400.000	Pass

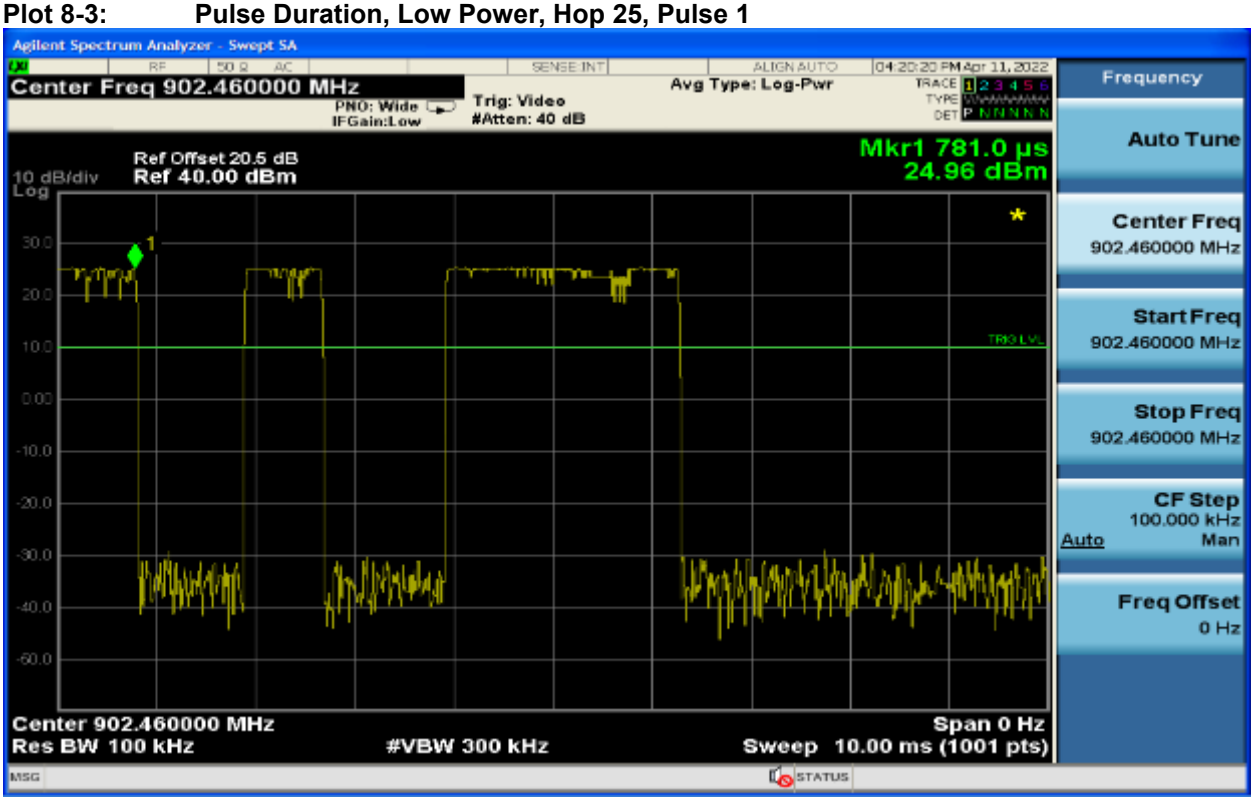
Plot 8-1: Hopping Channels, Low Power, Hop 25



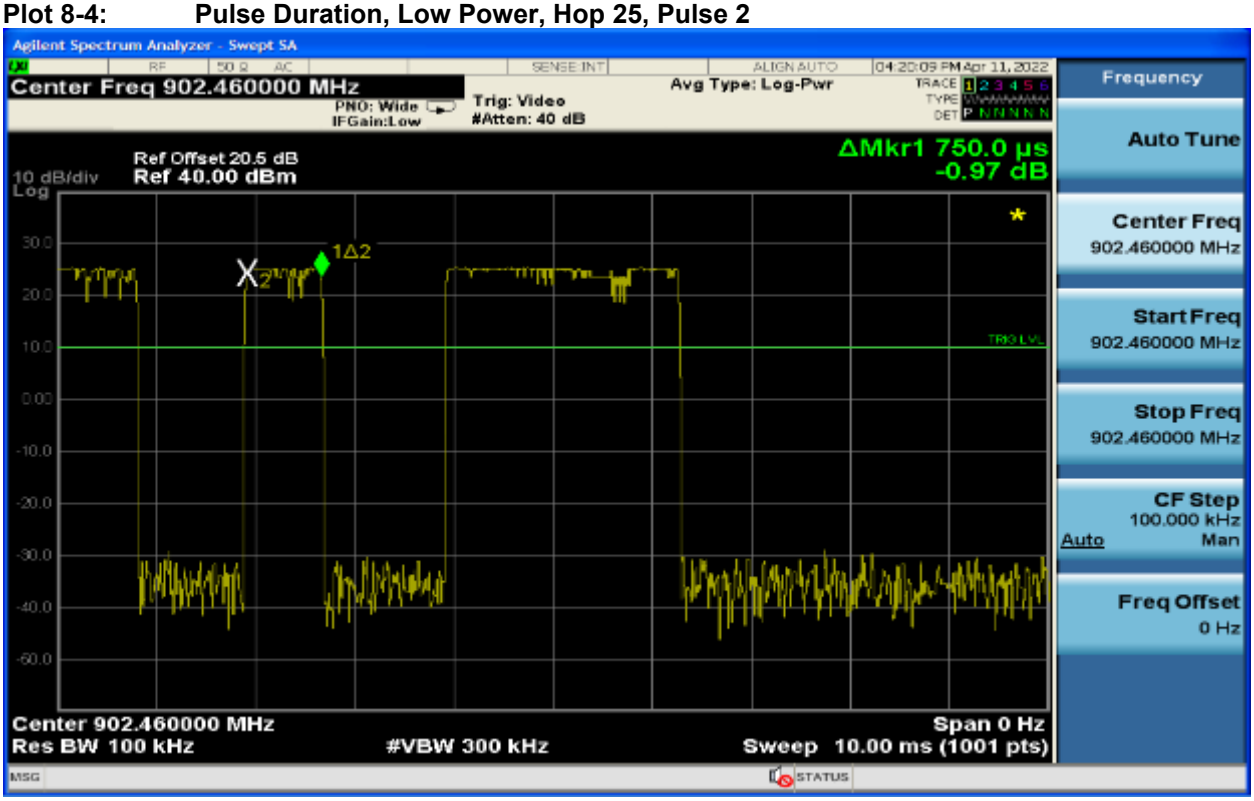
Plot 8-2: Hopping Channels, Normal Power, Hop 51



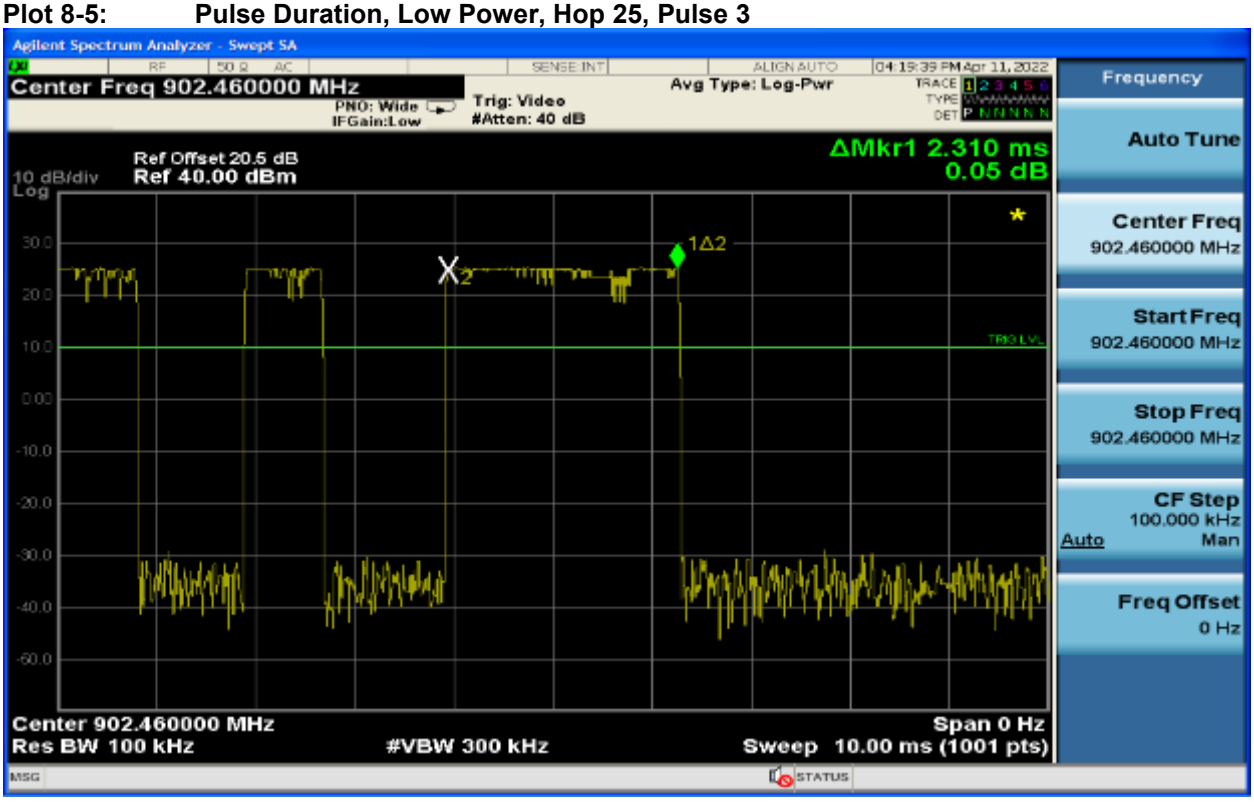
Plot 8-3: Pulse Duration, Low Power, Hop 25, Pulse 1



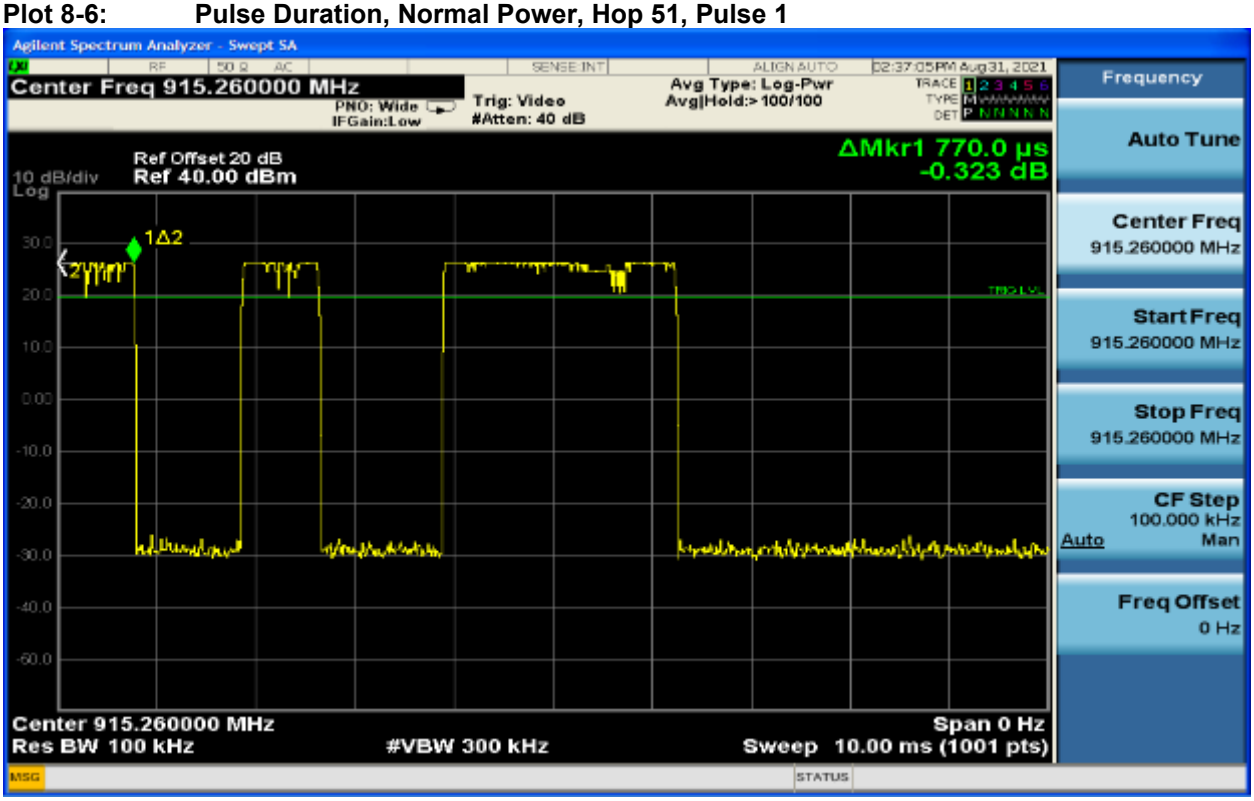
Plot 8-4: Pulse Duration, Low Power, Hop 25, Pulse 2



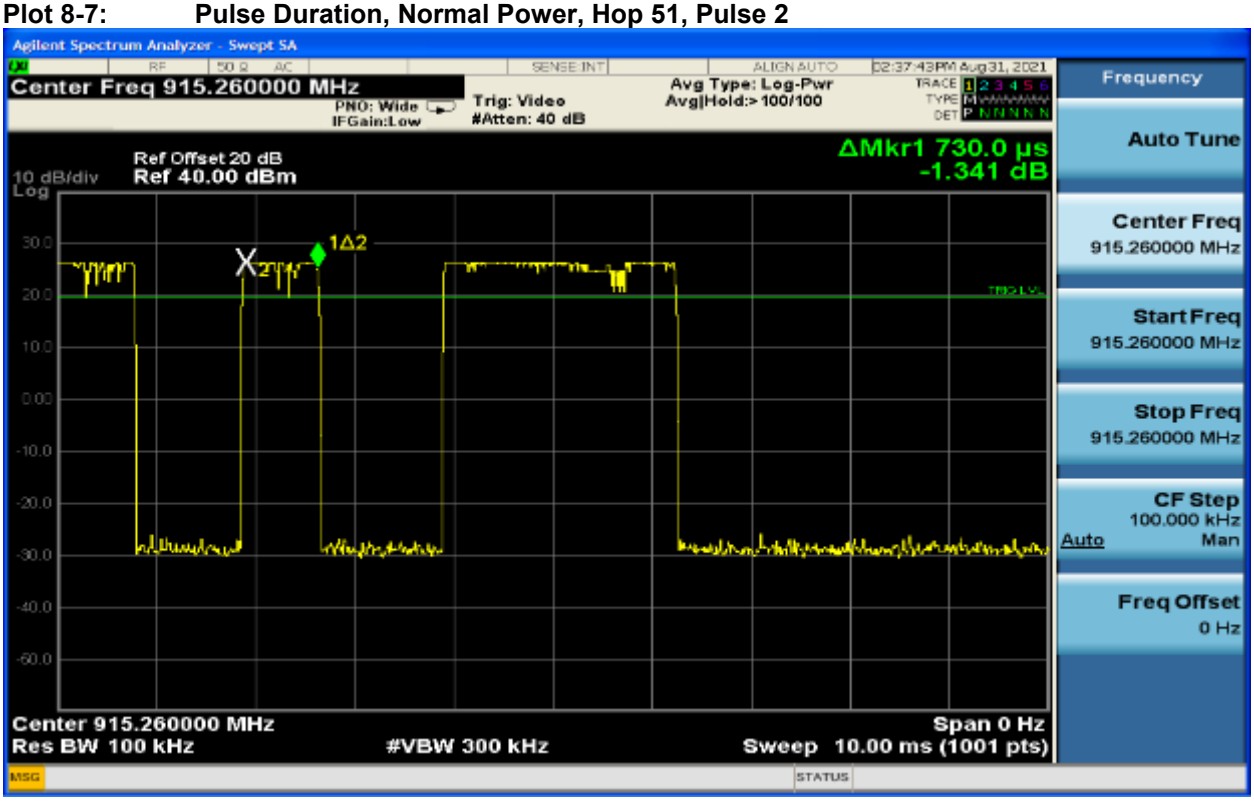
Plot 8-5: Pulse Duration, Low Power, Hop 25, Pulse 3



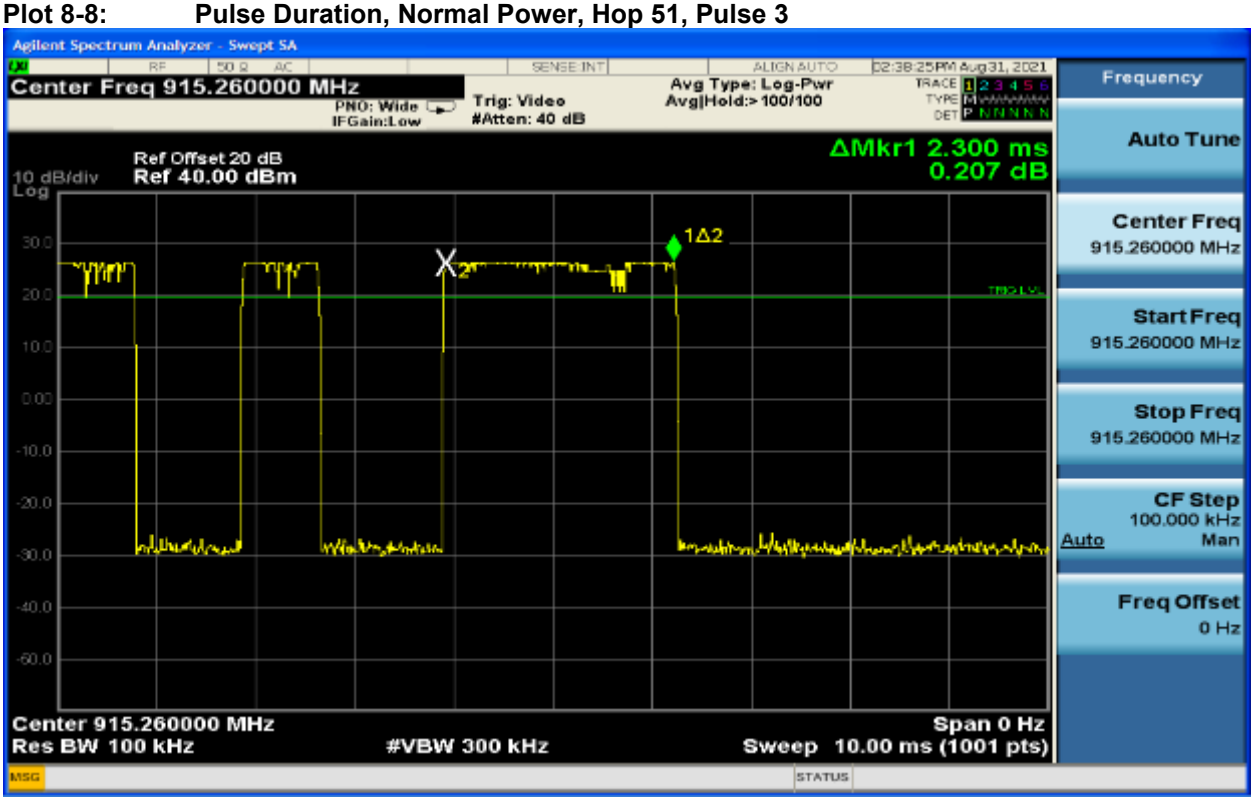
Plot 8-6: Pulse Duration, Normal Power, Hop 51, Pulse 1



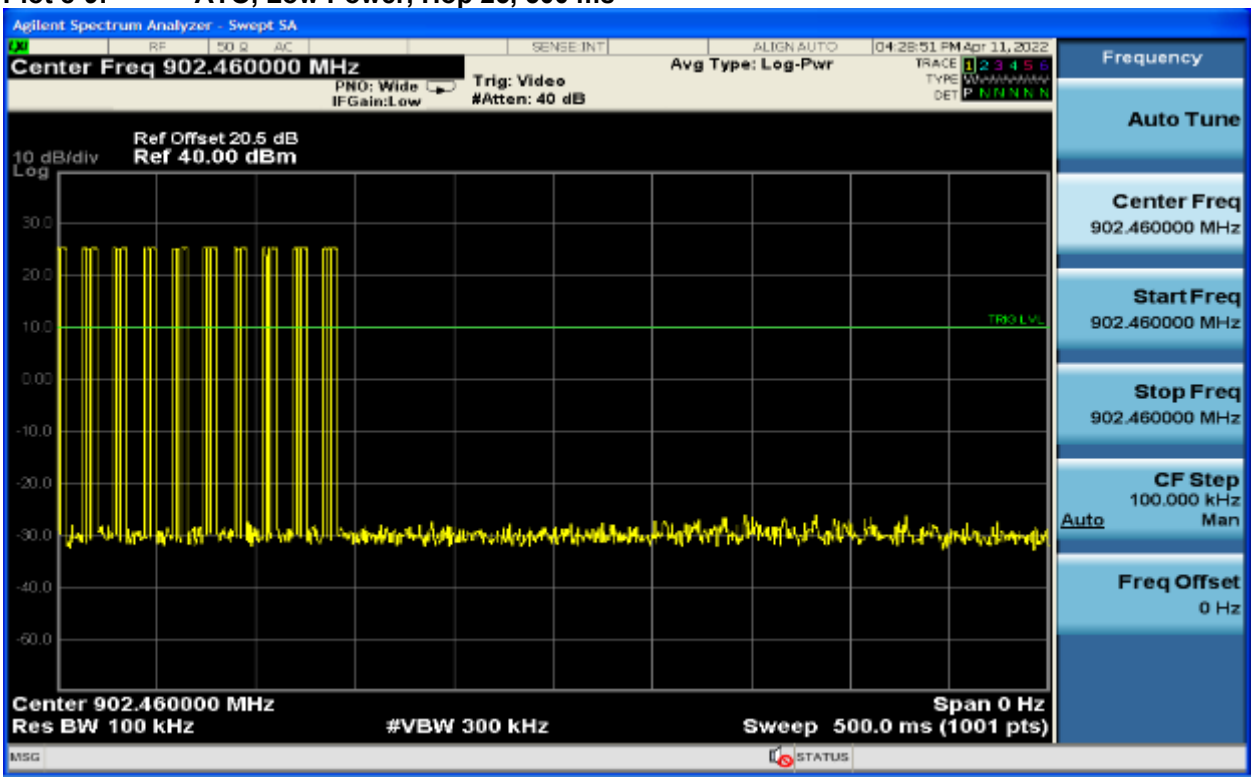
Plot 8-7: Pulse Duration, Normal Power, Hop 51, Pulse 2



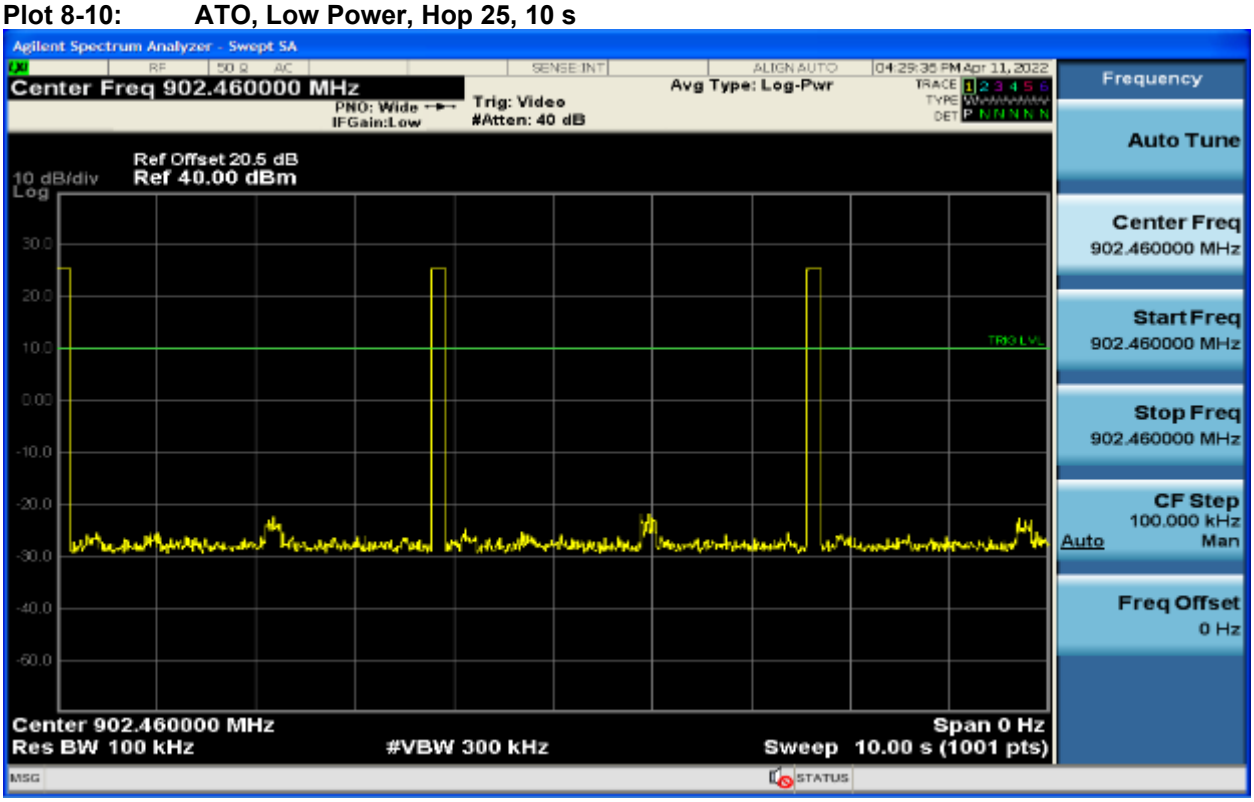
Plot 8-8: Pulse Duration, Normal Power, Hop 51, Pulse 3



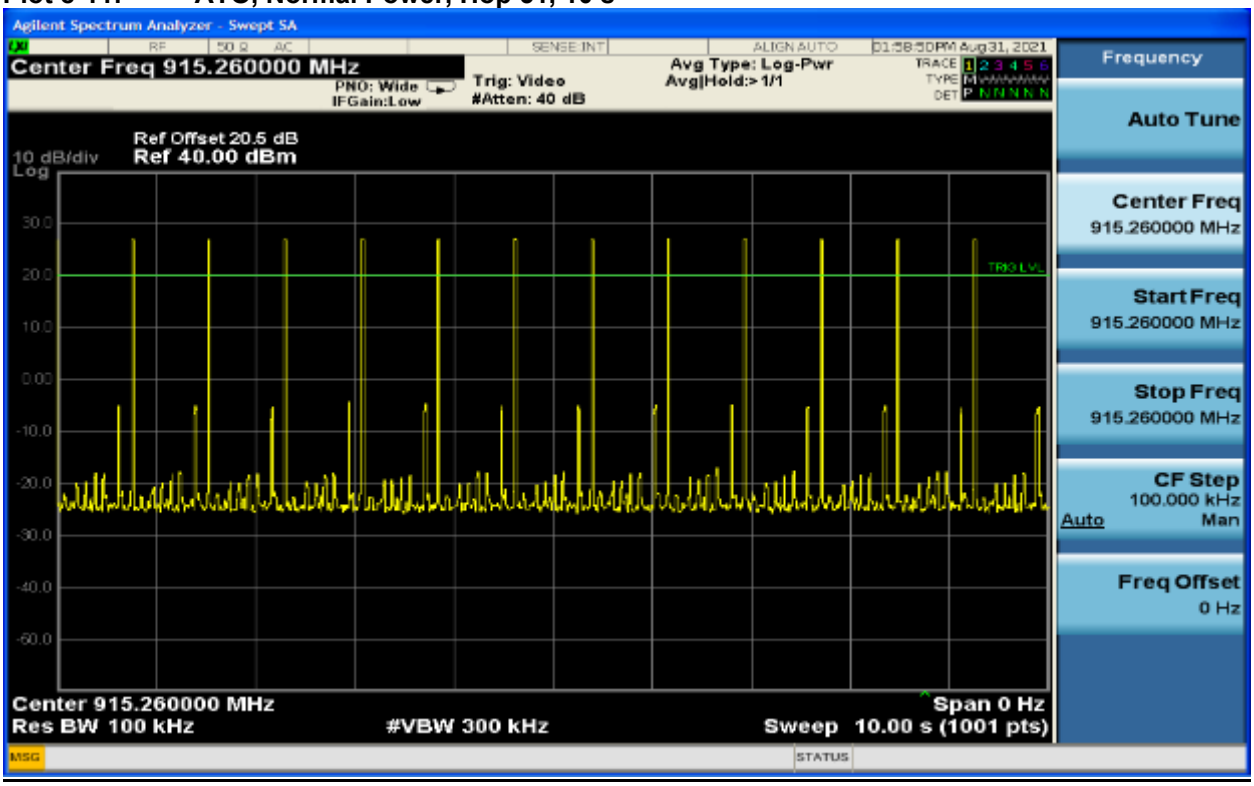
Plot 8-9: ATO, Low Power, Hop 25, 500 ms



Plot 8-10: ATO, Low Power, Hop 25, 10 s



Plot 8-11: ATO, Normal Power, Hop 51, 10 s



Result: Pass

Table 8-6: Hopping Characteristics Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021, September 13, 2021 April 11, 2022
EMC Test Engineer	**Signature**	**Dates of Test**

9 Duty Cycle

9.1 Duty Cycle Test Procedure

Center: Center of RF Signal
Span: 0 Hz
Sweep Time: 100 ms
Trigger: At least one period of pulse train

The duty cycle is then determined by dividing the total maximum “ON time” by the period of the pulse train over 100 ms.

9.2 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

DC: $\pm 1.0 \times 10^{-6}$ Hz

9.3 Duty Cycle Test Data

Table 9-1: Duty Cycle Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
8/31/2021	23.1	31	101.1
9/13/2021	23.2	35	101.0
4/11/2022	22.2	28	101.1

Low Power was set to Hop on 25 channels (Right Rotary C).
Normal power was set to Hop on 51 channels (Right Rotary 0).

Pulse Duration – see Section 7

Duty Cycle (%) = (# of Pulses in X ms Window) x (Pulse Duration)

The Duty Cycle shall be used for average emissions correction. The following equation was used to determine the correction:

Average Emission (dBµV/m) = Peak Emission (dBµV/m) + (20 * LOG(DC (%)))

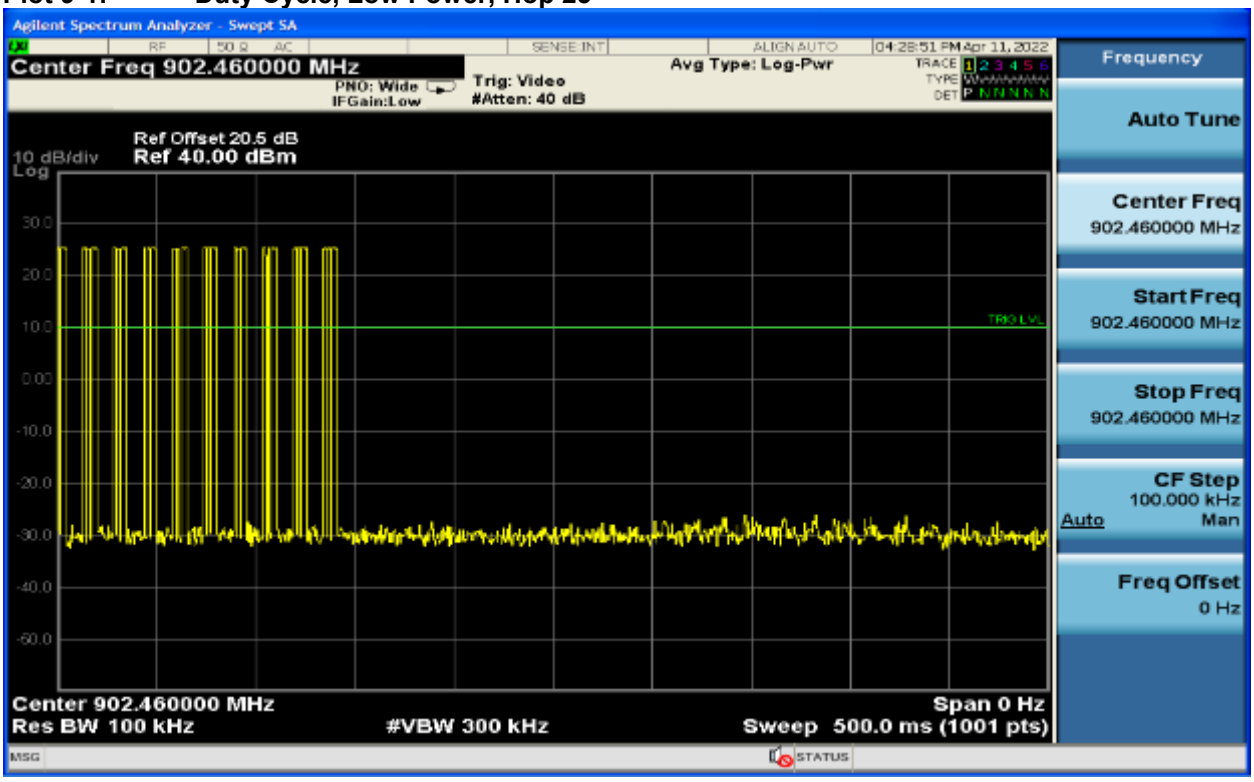
Table 9-2: Duty Cycle, Low Power

Pulse Duration (ms)	# of Pulses in Period	Duty Cycle (%)	Correction (dB)
3.841	10	7.682	-22.3

Table 9-3: Duty Cycle, Normal Power

Pulse Duration (ms)	# of Pulses in Period	Duty Cycle (%)	Correction (dB)
3.800	1	3.800	-28.4

Plot 9-1: Duty Cycle, Low Power, Hop 25



Plot 9-2: Duty Cycle, Normal Power, Hop 51

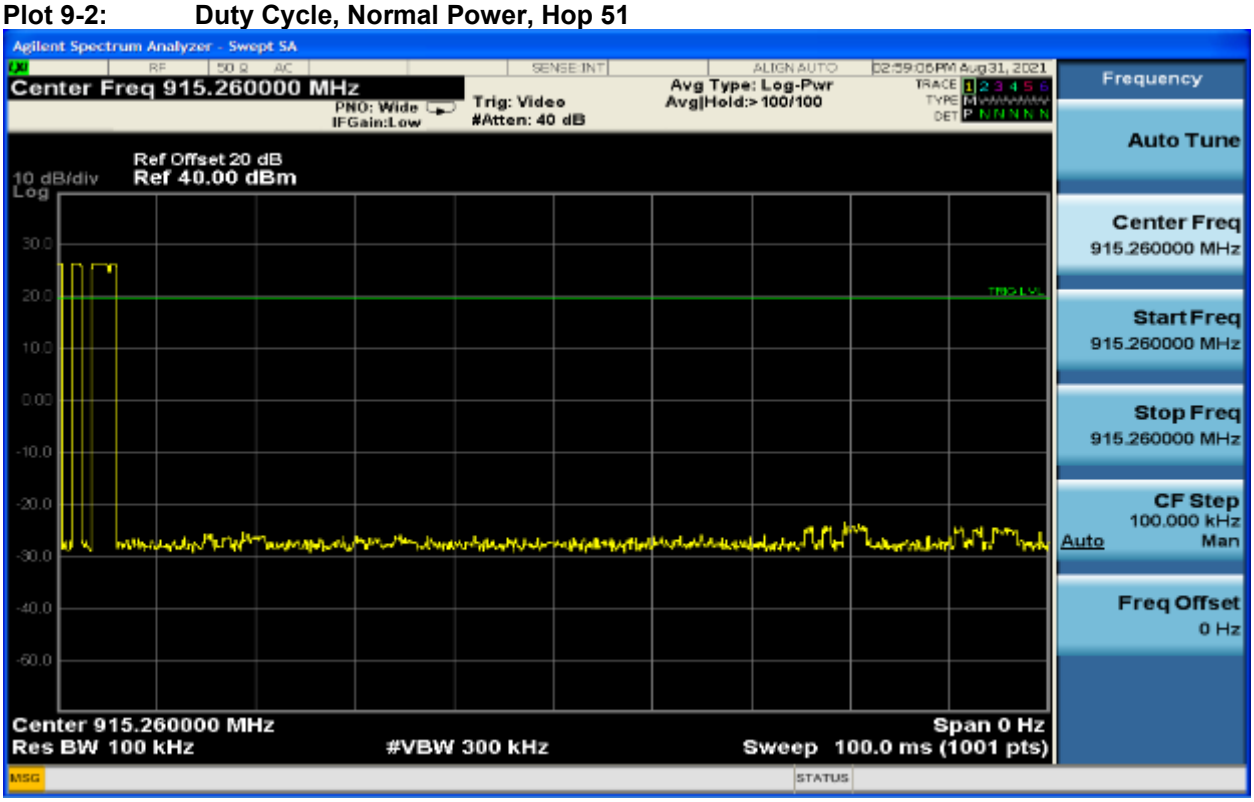


Table 9-4: Duty Cycle Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021, September 13, 2021 April 11, 2022
EMC Test Engineer	**Signature**	**Dates of Test**

10 Antenna Conducted Spurious – FCC 15.247(d); ISED RSS-247 5.5, RSS-Gen 6.13

10.1 Antenna Conducted Spurious Test Procedure

The antenna spurious emissions were measured from the EUT antenna port using a 50 Ω SA. The following settings were used:

Span:	30 MHz to 1 GHz, 1 GHz to 10 GHz	Sweep:	Auto
Detector:	Peak	Trace:	Max Hold
30 MHz to 1 GHz		1 GHz to 10 GHz	
RBW:	100 kHz	RBW:	100 kHz
VBW:	300 kHz	VBW:	300 kHz

10.2 Antenna Conducted Spurious Limits

Harmonics and spurious emissions from the antenna port shall not exceed 20 dB below the measured peak carrier.

10.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Antenna Conducted Spurious: ±0.8 dB

10.4 Antenna Conducted Spurious Test Data

Table 10-1: Antenna Conducted Spurious Environmental Conditions

Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
8/31/2021	23.1	31	101.1
9/9/2021	23.4	30	101.1

Notes: Low Power (low, middle, high channels), Normal Power (low, middle, high channels) and Receive mode were tested.

No harmonics nor spurious were found within 20 dB of the limit from the carrier to the 10th harmonic of the carrier frequency. Per FCC 2.1051, no emissions are being reported.

Result: Pass

Table 10-2: Antenna Conducted Spurious Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021, September 9, 2021
EMC Test Engineer	**Signature**	**Dates of Test**

11 Band Edge – FCC 15.247(d); ISED RSS-247 5.5

11.1 Band Edge Test Procedure

The antenna spurious emissions were measured from the EUT antenna port using a 50 Ω SA. The following settings were used:

Span:	Wide enough to capture the emission
Reference:	Peak of emission must be more than [10 log(OBW / RBW)] below the reference level
Attenuation:	Auto (at least 10 dB)
Sweep:	Coupled
RBW:	100 kHz
VBW:	300 kHz
Detector:	Peak
Trace:	Max Hold

11.2 Band Edge Limits

Spurious emissions from the antenna port shall not exceed 20 dB below the measured carrier.

11.3 Measurement Uncertainty

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2.

Band Edge: ±4.6 dB

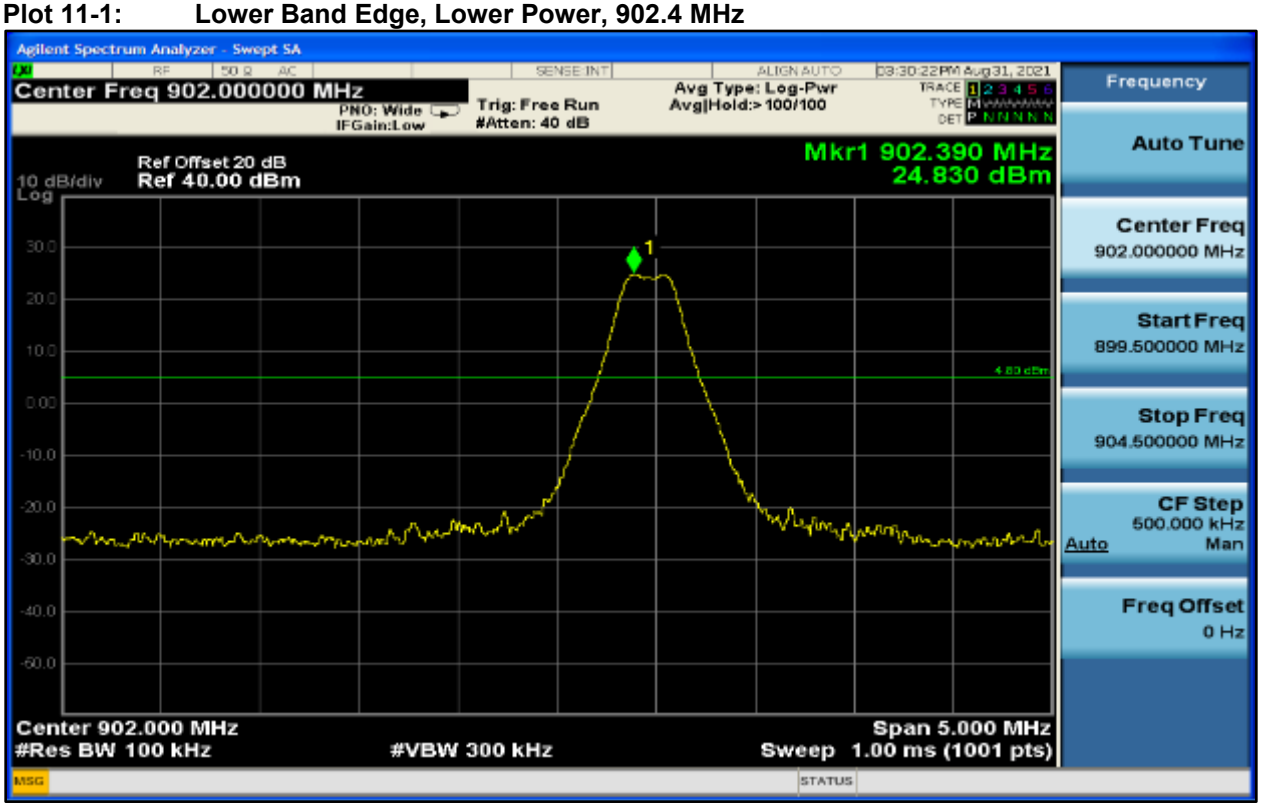
11.4 Band Edge Test Data

Table 11-1: Band Edge Environmental Conditions

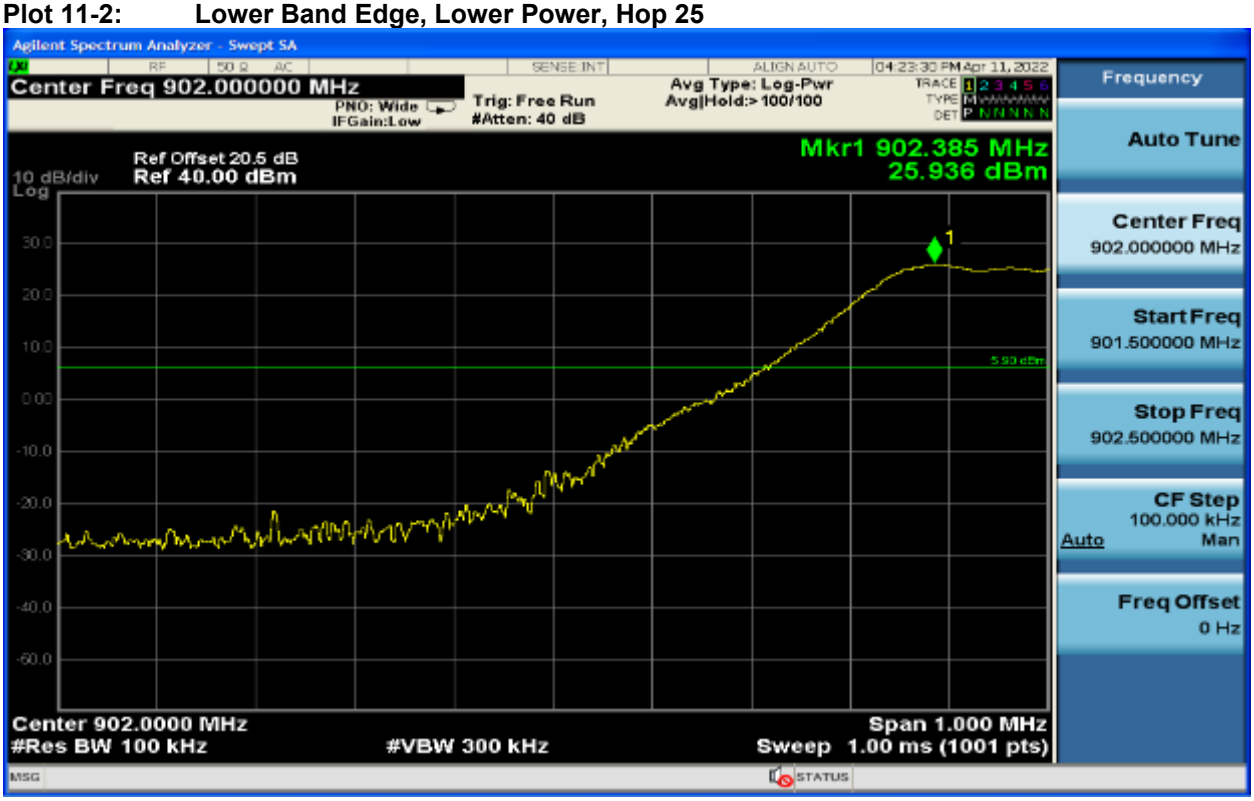
Date	Temperature (°C)	Humidity (%)	Pressure (kPa)
8/31/2021	23.1	31	101.1
4/11/2022	22.2	28	101.1

Notes: Testing was performed for both single channel and hopping. The low and high channels of Low Power and Normal Power mode were tested.

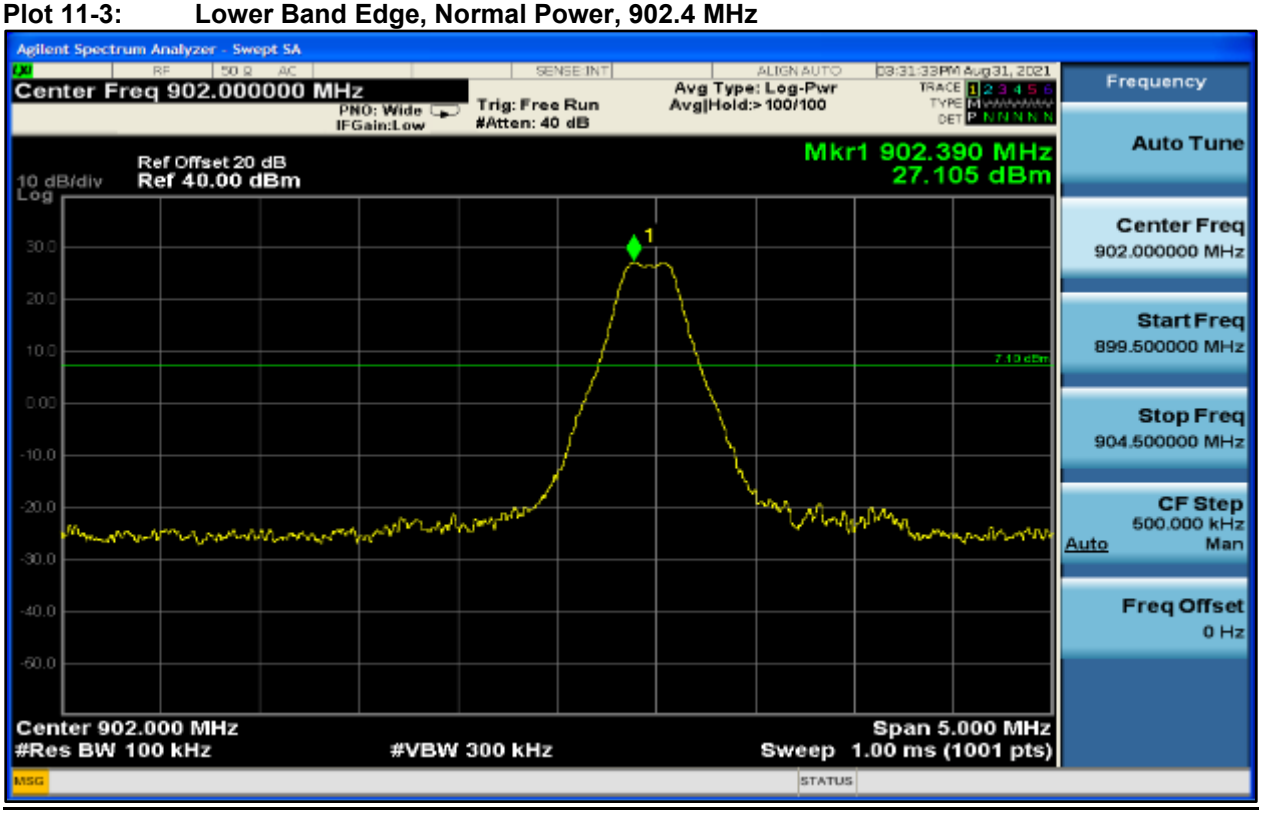
Plot 11-1: Lower Band Edge, Lower Power, 902.4 MHz



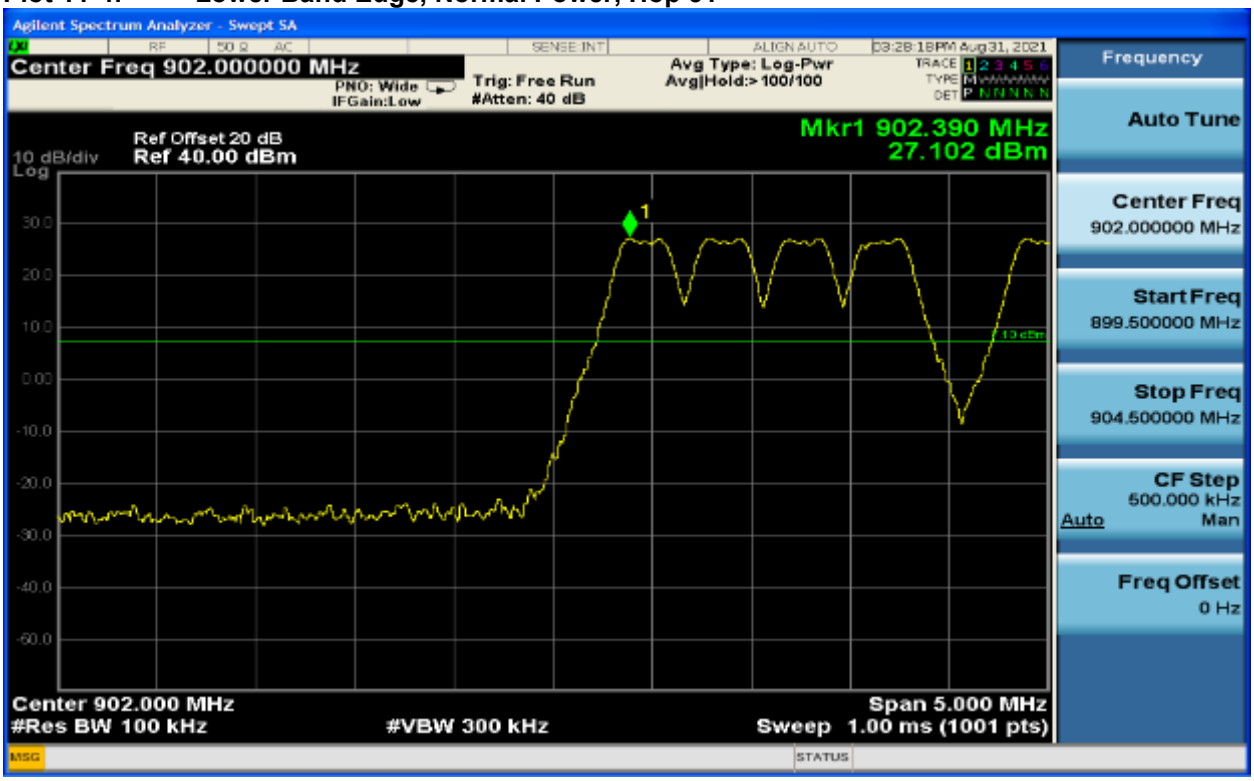
Plot 11-2: Lower Band Edge, Lower Power, Hop 25



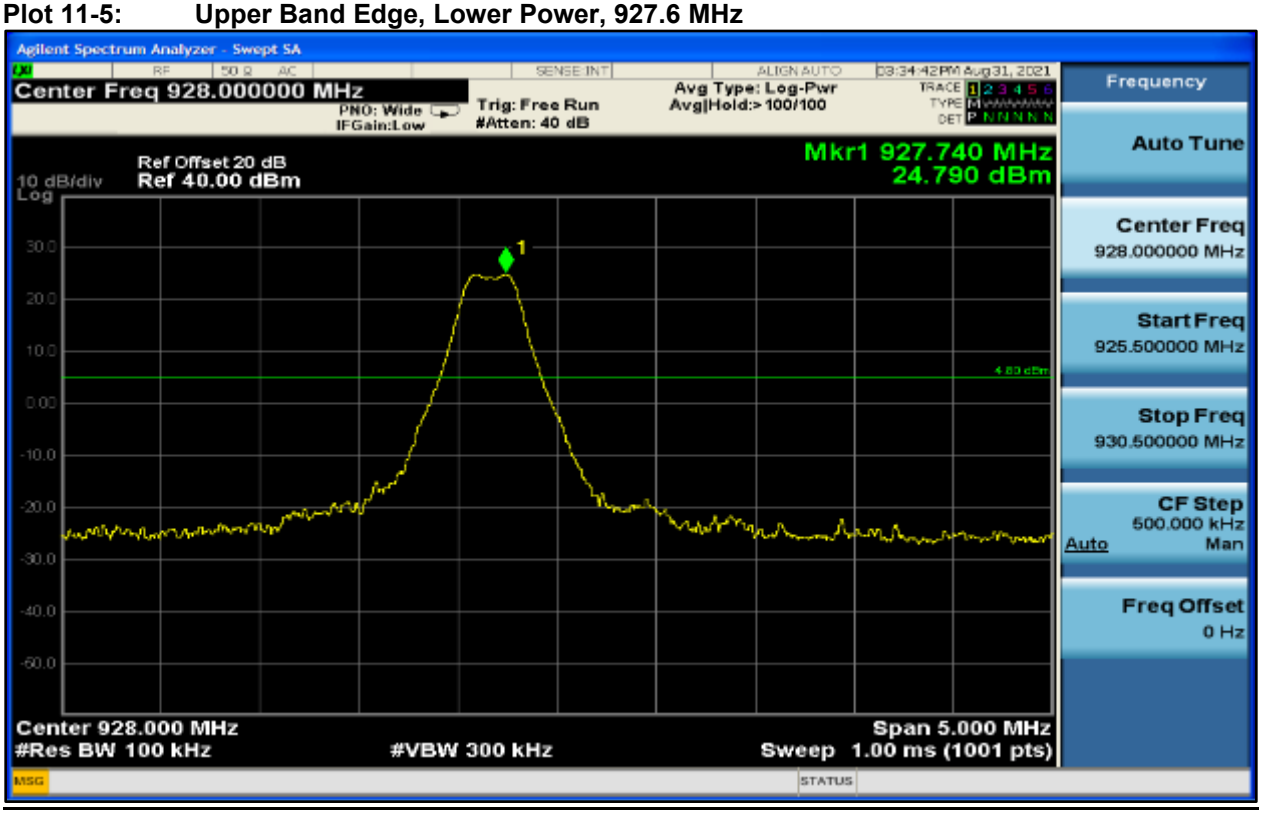
Plot 11-3: Lower Band Edge, Normal Power, 902.4 MHz



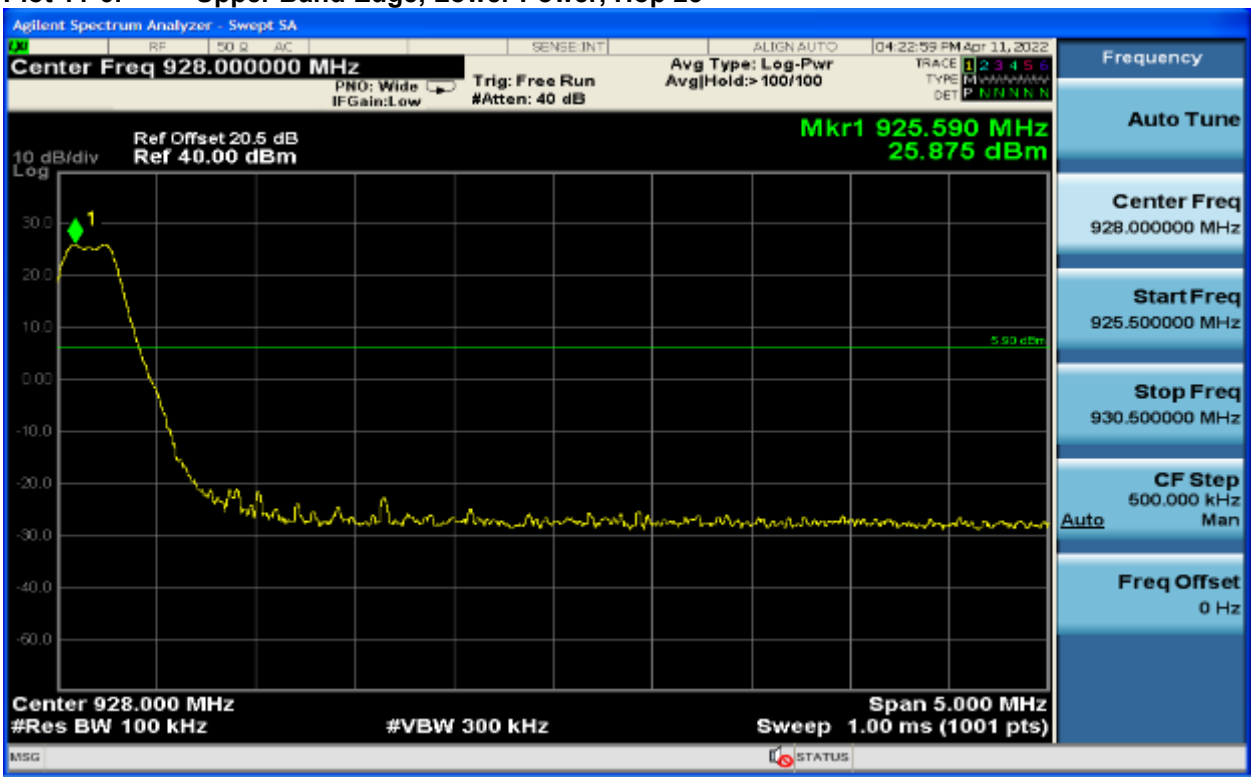
Plot 11-4: Lower Band Edge, Normal Power, Hop 51



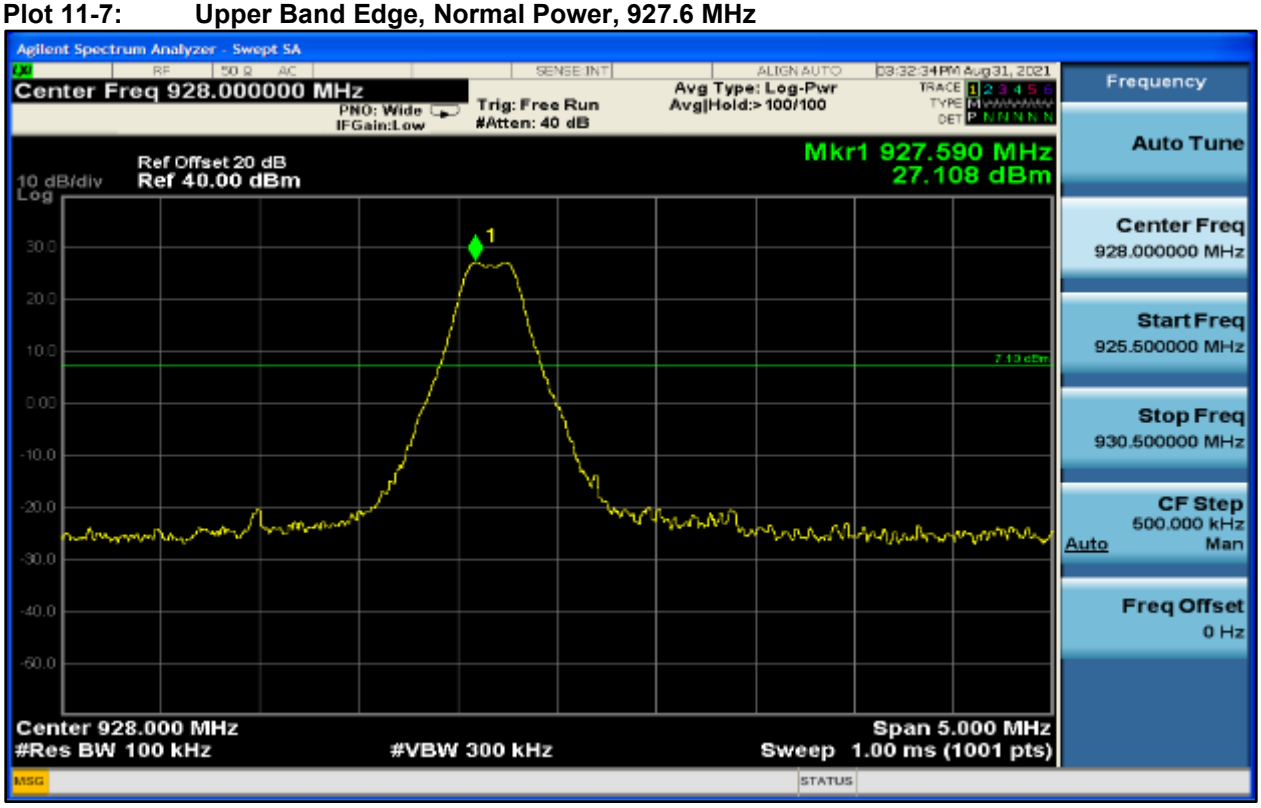
Plot 11-5: Upper Band Edge, Lower Power, 927.6 MHz



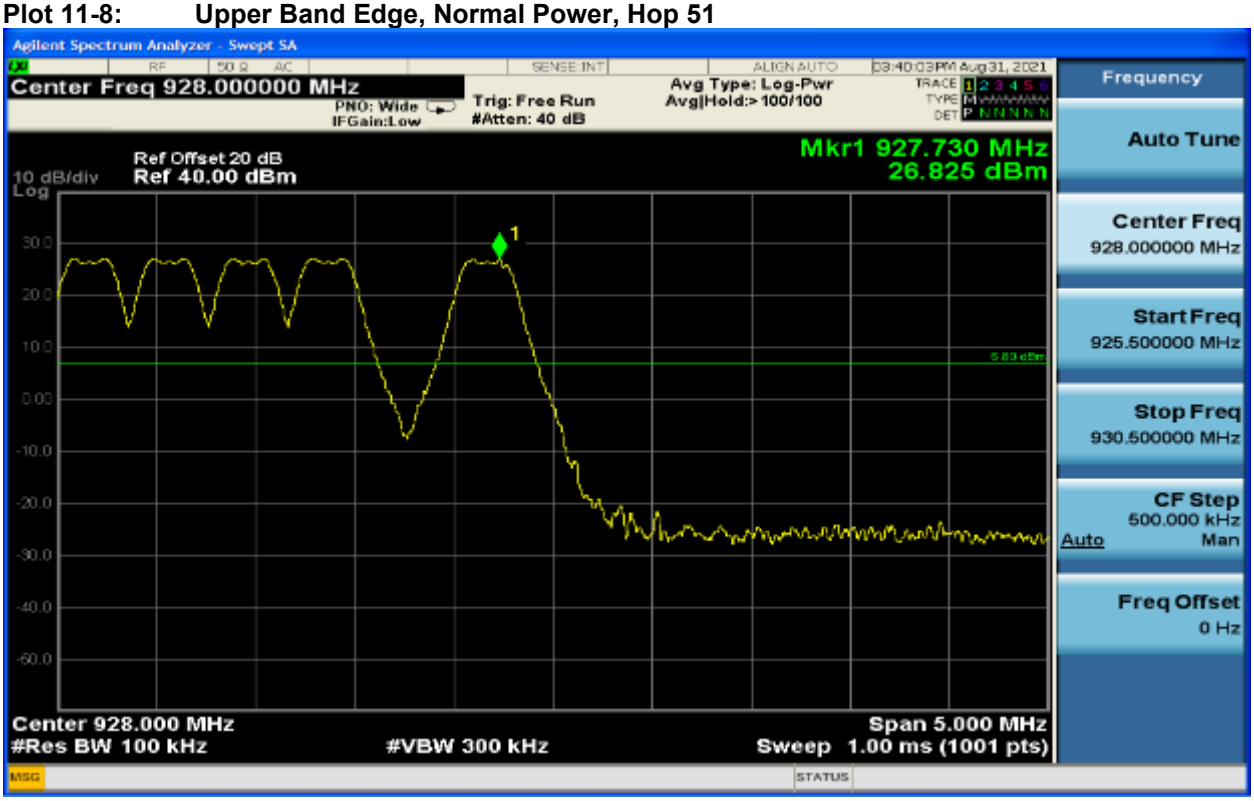
Plot 11-6: Upper Band Edge, Lower Power, Hop 25



Plot 11-7: Upper Band Edge, Normal Power, 927.6 MHz



Plot 11-8: Upper Band Edge, Normal Power, Hop 51



Result: Pass

Table 11-2: Band Edge Test Equipment

RTL Barcode	Part	Manufacturer	Model	Serial Number	Calibration Due Date
901524	Attenuator 20 dB (DC – 4 GHz)	MA/Com	2082-6174-20	N/A	09/20/2022
901583	EXA Signal Analyzer (10 Hz – 26.5 GHz)	Agilent	N9010A	MY51250846	03/18/2022

Test Personnel:

Khue N. Do		August 31, 2021 September 9, 2021 April 11, 2022
EMC Test Engineer	**Signature**	**Dates of Test**

12 Conclusion

The data presented in this report shows that the EUT as tested, Banner Engineering Corporation SX7023EXT Module , Model #/HVIN: 223150, FCC ID: UE3SX7023EXT, IC: 7044A-SX7023EXT, complies with the applicable requirements of FCC Rules and Regulations Part 2 and 15, and ISED RSS-247 and RSS-Gen for Limited Modular Approval.