Engineering Solutions & Electromagnetic Compatibility Services

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

Test Lab:		Applicant:	
Rhein Tech Laboratories, Inc. Phone: 703-689 0368 360 Herndon Parkway www.rheintech.com Suite 1400 atcbinfo@rheintech.com Herndon, VA 20170		Banner Engineering Corporation 9714 10th Avenue North Minneapolis, MN 55441	
FCC ID **IC**	UE3SX243 7044A-SX243	**Test Report Date**	April 6, 2020
Platform	N/A	**RTL Work Order #**	2019159DSS
Model	SX243	**RTL Quote Number**	QRTL19-159A

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)	FCC Rules Part 15.247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz (10-01-18)
ISED Standards	RSS-247 Issue 2: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices RSS-Gen Issue 5: General Requirements for Compliance of Radio Apparatus
Digital Interface Information	Digital Interface was found to be compliant

Frequency Range (MHz)	Output Power (mW) Peak Conducted	Frequency Tolerance	Emission Designator
2402 – 2479	97.7	N/A	3M77F7D

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 modifications were made to the equipment during testing in order to achieve compliance with these standards. Furthermore, there was no deviation from, additions to, or exclusions from, the applicable parts of FCC Part 2, FCC Part 15, ANSI C63.10, and ISED RSS-247 and RSS-Gen.

Signature: _____ Date: April 6, 2020

Typed/Printed Name: Desmond A. Fraser Position: President

These tests are accredited and meet the requirements of ISO/IEC 17025 as verified by ANAB. Refer to certificate and scope of accreditation AT-1445. This replaces Report R0.0.

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.

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1 General Information

1.1 Scope

Applicable Standards:

- FCC Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz.
- ISED RSS-247: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-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	SX243
Power Supply	AC Adapter
Modulation Type	FSK
Frequency Range	2402 – 2479 MHz
Antenna	External +2.0 dBi

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. This site has been fully described in a report and approved by the Federal Communications Commission to perform AC line conducted and radiated emissions testing (ANSI C63.10-2013).

1.4 Related Submittal(s)/Grant(s)

This is an original certification application for Limited Modular Approval for Banner Engineering Corporation Model/HVIN: SX243, FCC ID: UE3SX243, IC: 7044A-SX243.

1.5 Modifications

The EUT must contain revision 'U' of firmware.

1. The lowest channel center frequency for 250 kbps was moved up 200 kHz; now 2402.2 MHz. All 26 other channels matched legacy settings.

2. The number of channels for 1 and 2 Mbps was reduced to 15 channels. The lowest channel frequency is 2403 MHz, and the highest channel frequency is 2468 MHz.

The manufacturer will implement the RF bias and power levels equivalent to those provided by the rotary switch settings used in Section 2.2.

2 Test Information

2.1 Description of Test Modes

In accordance with FCC 15.31(m), and because the EUT utilizes an operating band greater than 10 MHz, the following frequencies were tested:

250 kbps – Low (2402.2 MHz), Middle (2440 MHz), High (2479 MHz)
1000 kbps – Low (2403 MHz), Middle (2440 MHz), High (2468 MHz)
2000 kbps – Low (2403 MHz), Middle (2440 MHz), High (2468 MHz)

2.2 EUT Exercise Description

The SX243 module was installed on a representative host PCB with DC voltage regulation performed on the host according to manufacturer guidelines. Two rotary switches were used to configure the channels, rates, and modes of the unit. The internal DIP switch 7 was turned 'ON' for all tests. The '-PARNT' value was set to '00015' for all tests.

For receive mode, the left rotary switch was set to '3'. For transmit mode, the left rotary switch was set to '0' and the right rotary was set to the following:

'0'	-	250 kbps Hopping
'1'	-	250 kbps at 2402.2 MHz
'2'	-	250 kbps at 2440 MHz
'3'	-	250 kbps at 2479 MHz
'4'	-	1000 kbps Hopping
'5'	-	1000 kbps at 2403 MHz
'6'	-	1000 kbps at 2440 MHz
'7'	-	1000 kbps at 2468 MHz
'8'	-	2000 kbps Hopping
'9'	-	2000 kbps at 2403 MHz
'A'	-	2000 kbps at 2440 MHz
'B'	-	2000 kbps at 2468 MHz

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

2.3 Test Result Summary

Table 2-1: Test Result Summary – FCC Part 15, ISED RSS-247, RSS-Gen

Test	FCC Reference	ISED Reference	Result
AC Power Conducted Emissions	15.207	RSS-Gen 8.8	Pass
Radiated Emissions	15.209	RSS-247 5.5; RSS-Gen 8.9, 8.10	Pass
Maximum Peak Power Output	15.247(b)(1)	RSS-247 5.4(b), RSS-Gen 6.12	Pass
Antenna Conducted Spurious Emissions	15.247(d)	RSS-247 5.5, RSS-Gen 6.13	Pass
Carrier Frequency Separation	15.247(a)(1)	RSS-247 5.1(b)	Pass
Band Edge Measurement	15.247(d)	RSS-247 5.5	Pass
20 dB Bandwidth	15.247(a)(1)	RSS-247 5.1(a)	Pass
Hopping Characteristics	15.247(a)(1)(iii)	RSS-247 5.1(d)	Pass
Average Time of Occupancy	15.247(a)(1)(iii)	RSS-247 5.1(d)	Pass
99% Bandwidth	N/A	RSS-Gen 6.7/ TRC-43	N/A

2.4 Test System Details

The test samples were received on September 30, 2019. The FCC identifiers for all applicable equipment, plus descriptions of all cables used in the tested system, are identified in the following tables. The transceiver models are electrically identical.

Table 2-2: Equipment Under Test (EUT)

Part	Manufacturer	Model #/ HVIN	Serial Number	FCC ID	Cable Description	RTL Bar Code
Transceiver 1	Banner Engineering Corp.	SX243	129011. 149936.1045E	UE3SX243	Unshielded Power	23474
Transceiver 2	Banner Engineering Corp.	SX243	N/A	UE3SX243	Unshielded Power	23475

Table 2-3: Support Equipment

Part	Manufacturer	Model #	Serial Number	FCC ID	Cable Description	RTL Bar Code
Laptop	ASUS	N550J	F2N0CY33003 607G	N/A	Unshielded	N/A
AC Adapter	CUI Inc.	SMI24-24	SMI24-24-V-P5	N/A	Unshielded	23486
Omni, ½ wave dipole, swivel	Banner Engineering Corp.	BWA-202-C	77816	N/A	N/A	23477

2.5 Configuration of Tested System

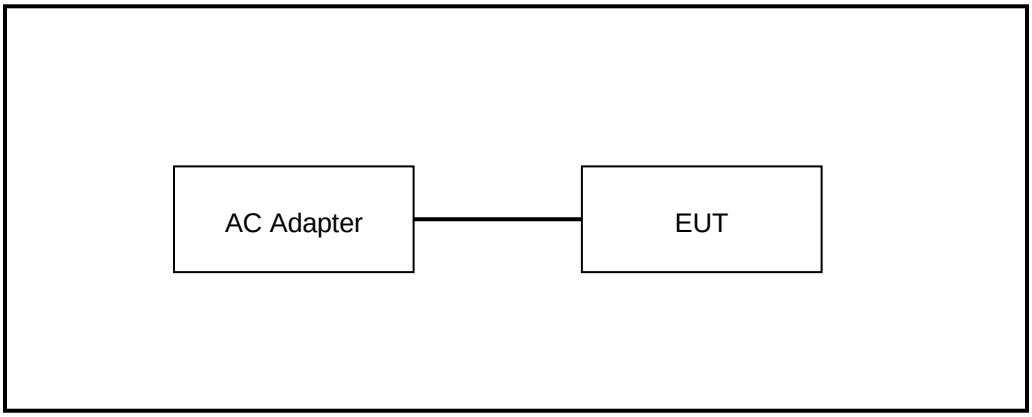


Figure 2-1: Configuration of System Under Test

3 Peak Output Power – FCC 15.247(b)(1); ISED RSS-247 5.4(b), RSS-Gen 6.12

3.1 Power Output Test Procedure

A conducted power measurement of the EUT was taken using an Agilent Technologies Analyzer. The following settings were used:

1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel (4 MHz used)
2) RBW >20 dB bandwidth of the emission being measured (1 MHz used)
3) VBW ≥RBW (3 MHz used)
4) Sweep: Auto
5) Detector function: Peak
6) Trace: Max hold. The trace was allowed to stabilize, and the marker-to-peak function was used to set the marker to the peak of the emission.

3.2 Measurement Uncertainty

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

Peak Output Power: ±0.8 dB

3.3 Power Output Test Results

Table 3-1: Power Output Environmental Factors

Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
09/30/2019	74.2	36	100.8
10/31/2019	73.8	35	100.8

Table 3-2: Power Output Test Data

Rate (kbps)	Peak Power (dBm)		
	Low Channel	Mid Channel	High Channel
250	17.9	19.1	19.4
1000	18.8	19.6	19.6
2000	18.6	19.5	19.9

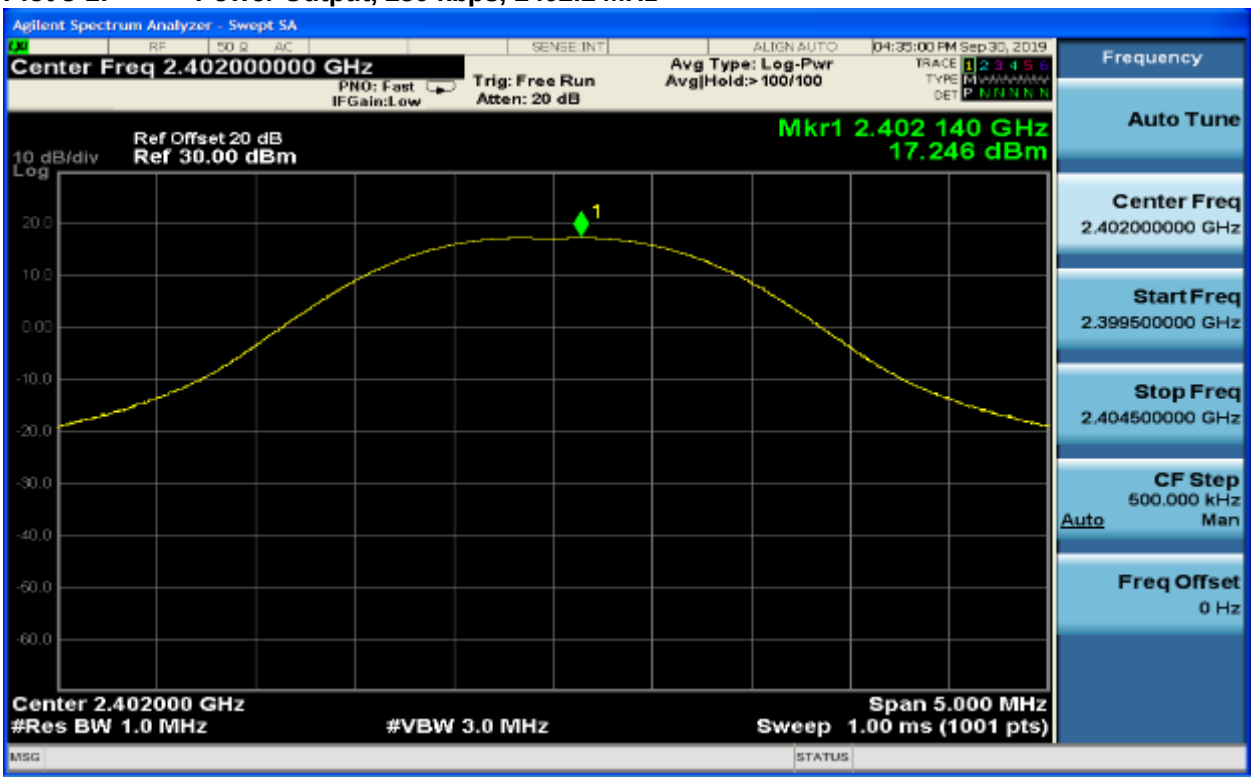
Note: DIP switch 7 had to be turned 'ON' and the '-PARNT' value had to be changed to '00015' in order to bring the power level down below the limit.

Table 3-3: Power Output Test Result

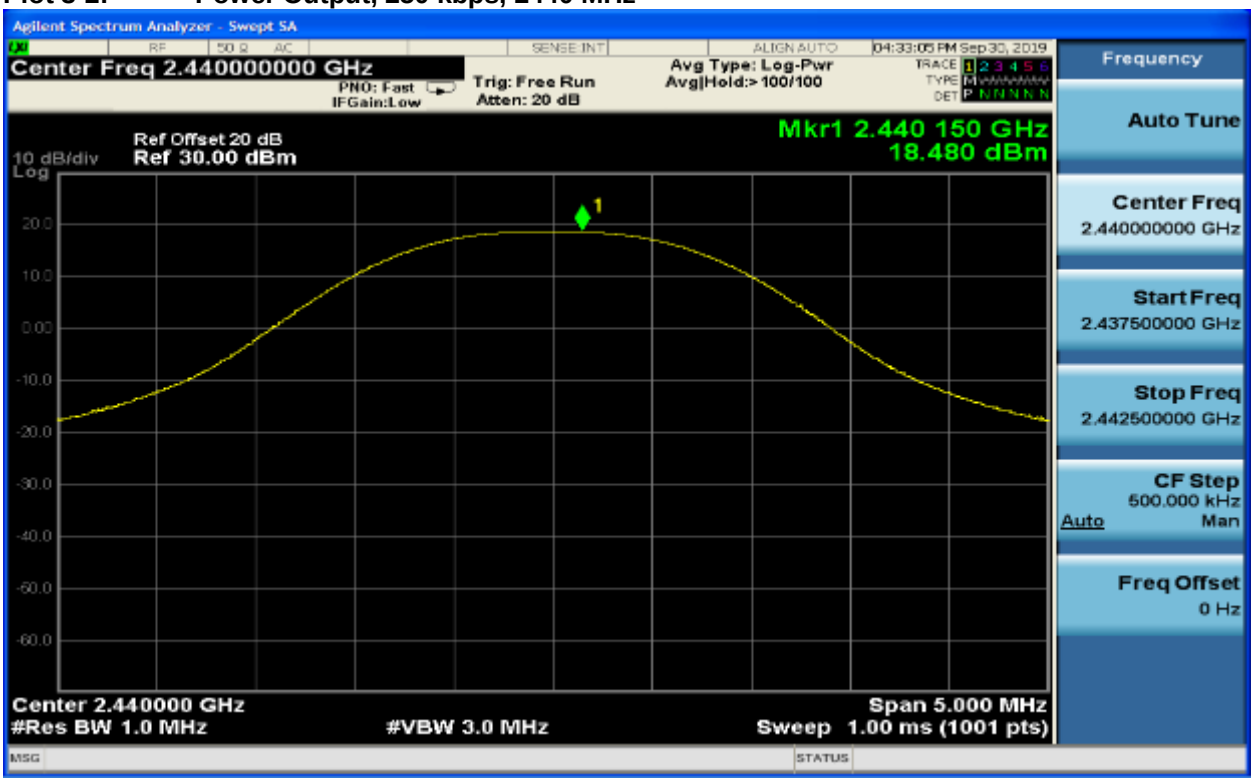
Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)	Result (Pass / Fail)
2402.2 / 2403	18.8	21.0	-2.2	Pass
2440	19.6	21.0	-1.4	Pass
2468 / 2479	19.9	21.0	-1.1	Pass

Note: 19.9 dBm ≈ 97.7 mW

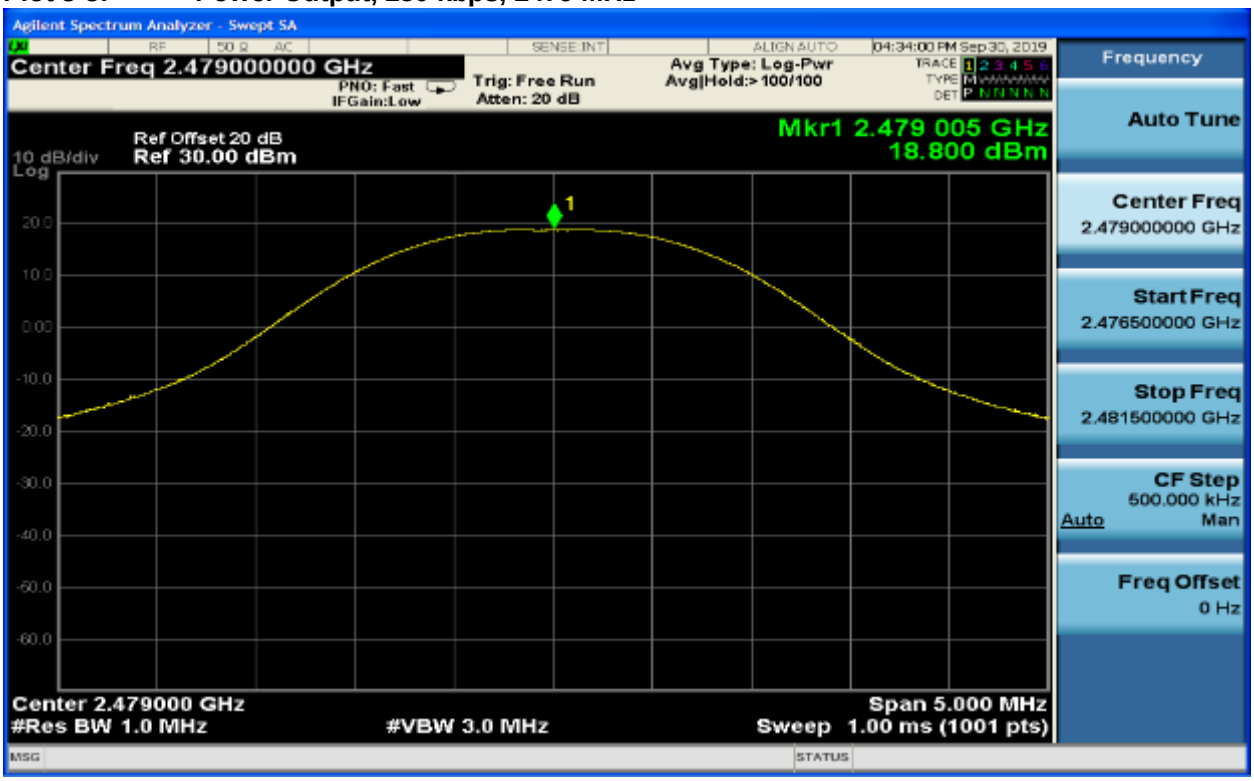
Plot 3-1: Power Output, 250 kbps, 2402.2 MHz



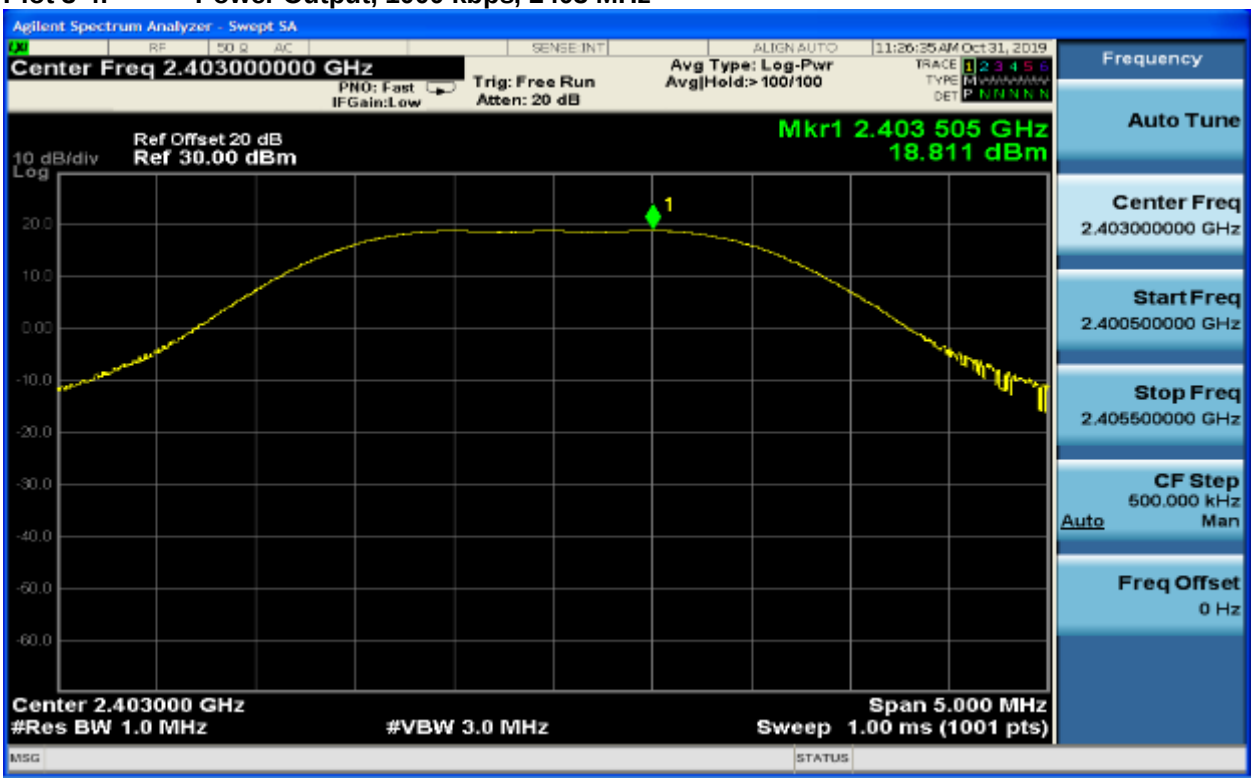
Plot 3-2: Power Output, 250 kbps, 2440 MHz



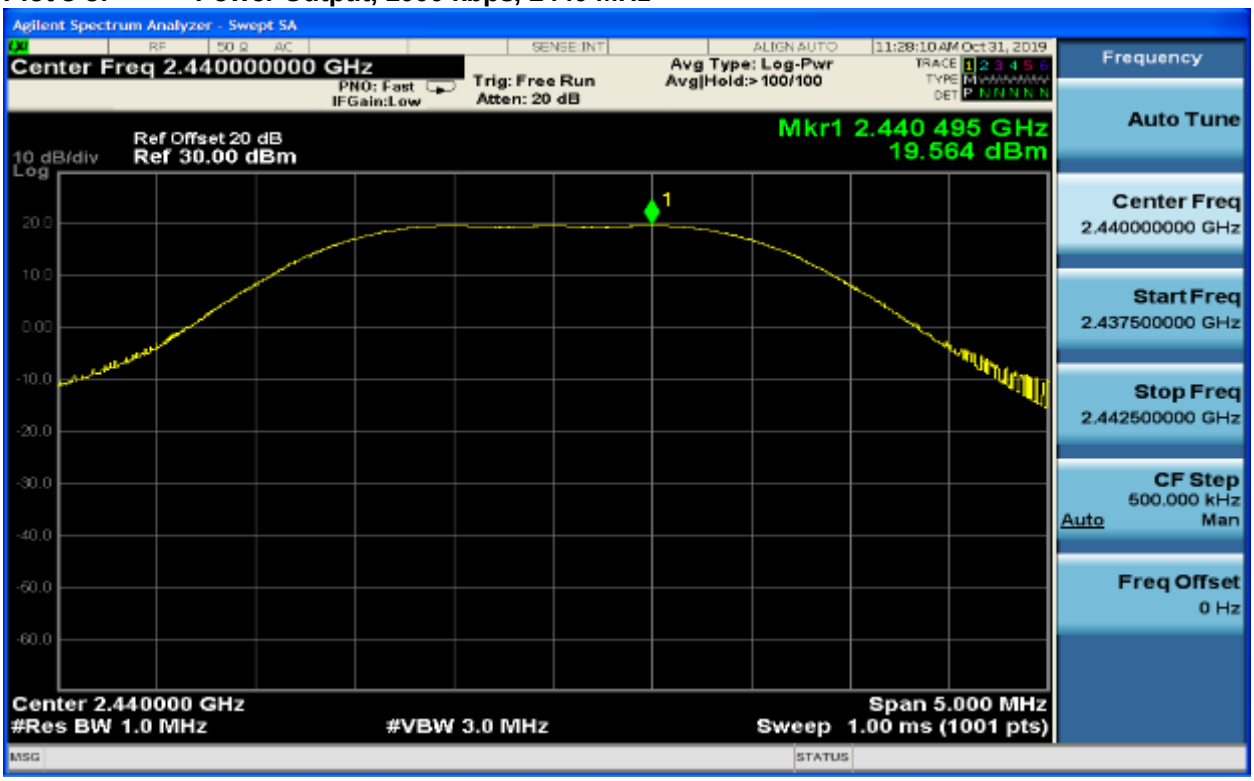
Plot 3-3: Power Output, 250 kbps, 2479 MHz



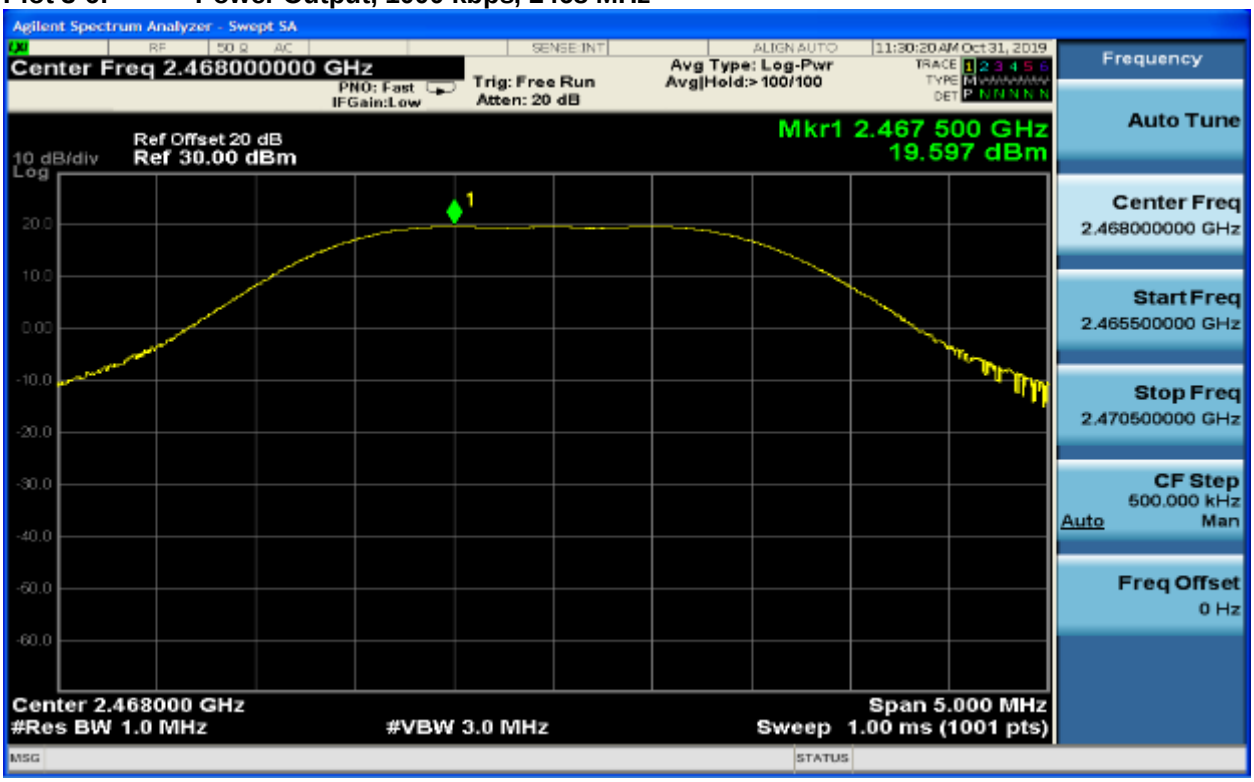
Plot 3-4: Power Output, 1000 kbps, 2403 MHz



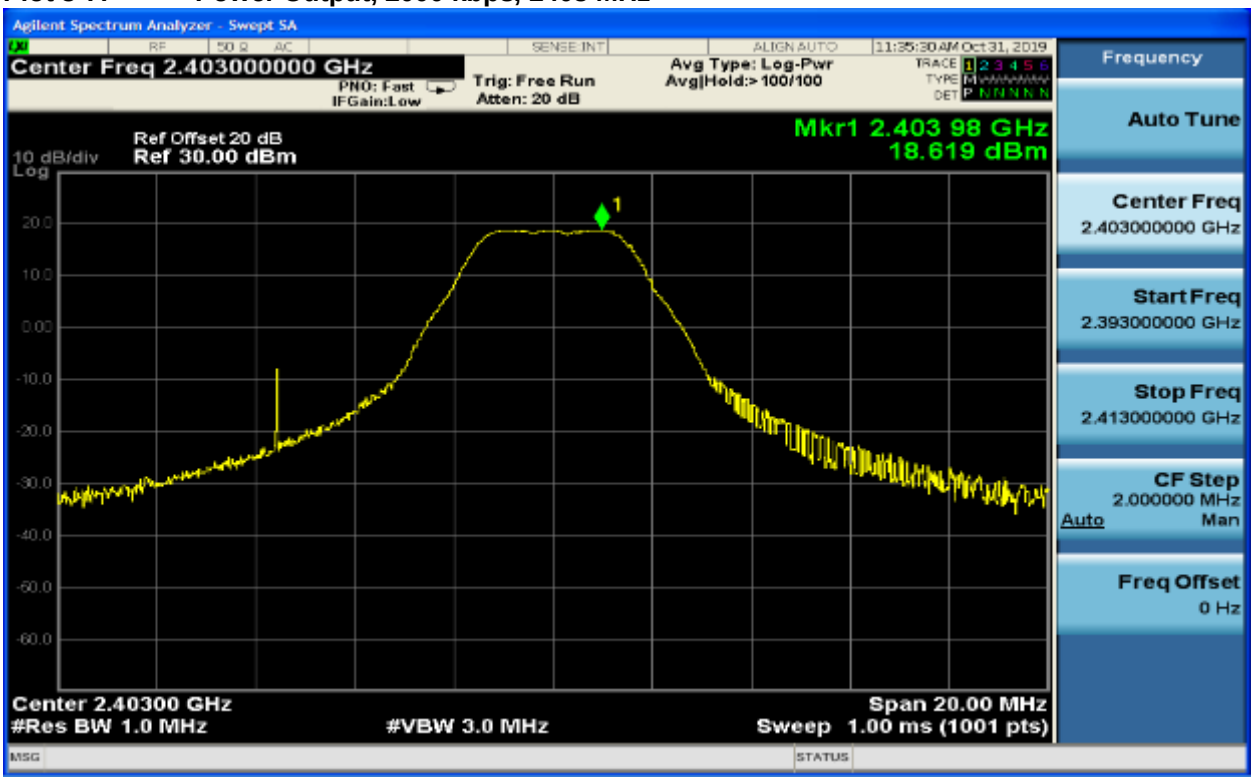
Plot 3-5: Power Output, 1000 kbps, 2440 MHz



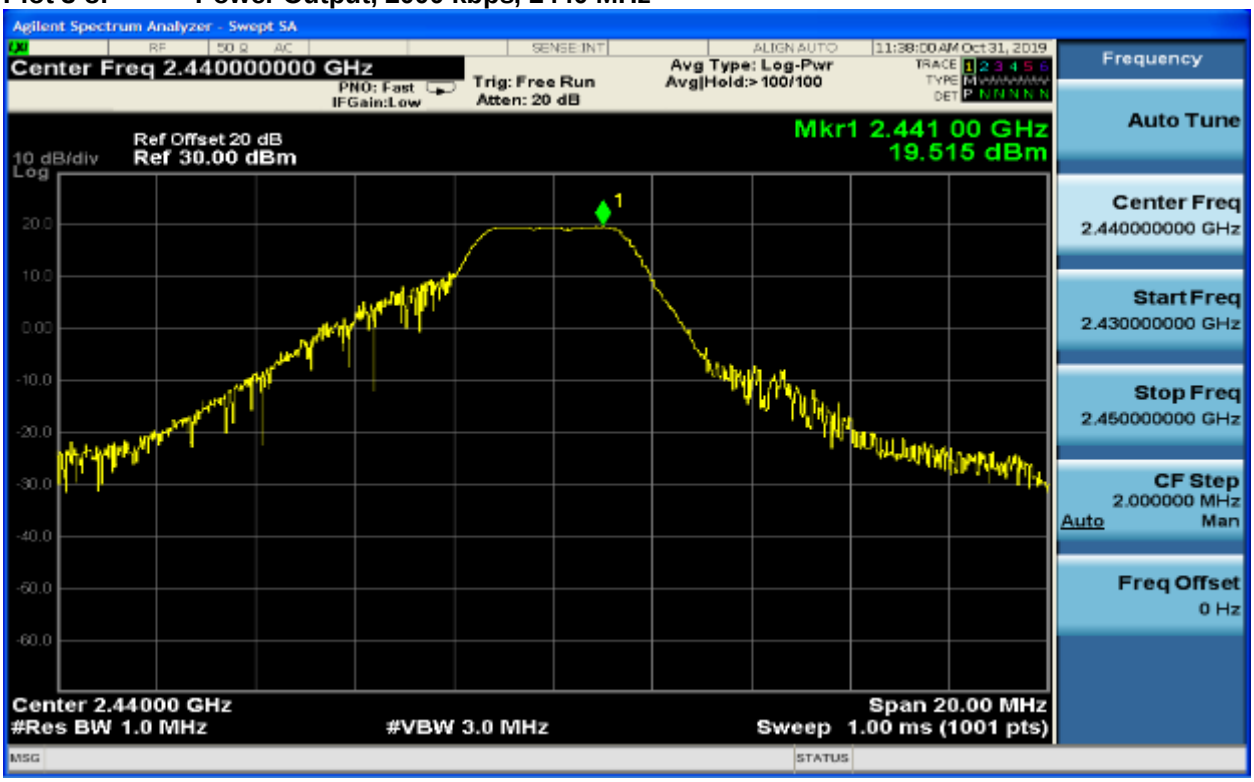
Plot 3-6: Power Output, 1000 kbps, 2468 MHz



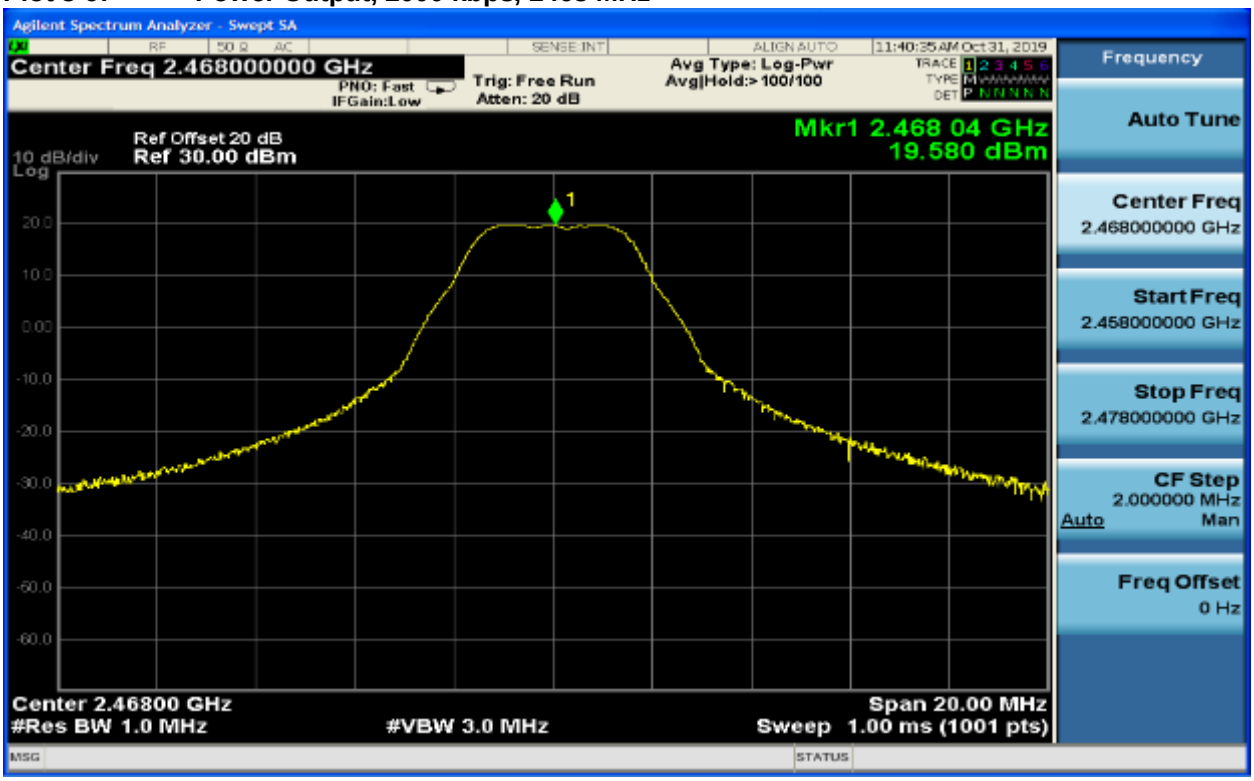
Plot 3-7: Power Output, 2000 kbps, 2403 MHz



Plot 3-8: Power Output, 2000 kbps, 2440 MHz



Plot 3-9: Power Output, 2000 kbps, 2468 MHz



Result: Pass

Test Personnel:

Khue Do		September 30, 2019 October 31, 2019
EMC Test Engineer	Signature	Dates of Test

Table 3-4: Power Output Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

4 Compliance with the Band Edge – FCC 15.247(d); ISED RSS-247 5.5

4.1 Band Edge Test Procedure

Radiated emissions measurements were made on the three/ten-meter, open-field test site. The EUT was placed on a nonconductive turntable 1.5 meters above the ground plane.

At each Lower Band Edge (LBE) and Upper Band Edge (UBE), the EUT was rotated 360°, and the antenna was raised and lowered from 1 to 4 meters in order to determine the emission's maximum level. Measurements were taken using both horizontal and vertical antenna polarizations. For emissions above 1000 MHz, emissions are measured using the average and peak detectors function with a minimum resolution bandwidth of 1 MHz. No video filter less than 10 times the resolution bandwidth was used. The highest emission amplitudes relative to the appropriate limit were measured and recorded in this report.

Plots were taken with a suitable span to encompass the peak of the fundamental, and traces to hopping and non-hopping modes. The measurement was performed from the highest peak in the restricted band (within 2 MHz), and the average result was compared to the restricted band limit (54 dBµV/m). An offset was used to reference the site correction factor, amplifier factor, and cable factor.

Average calculations were obtained from the peak and duty cycle measurements. Please refer to Section 10 for the duty cycle measurements. Below is the equation used to calculate the average emission.

*Average = Peak + (20 * LOG10(DC))*

4.2 Measurement Uncertainty

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

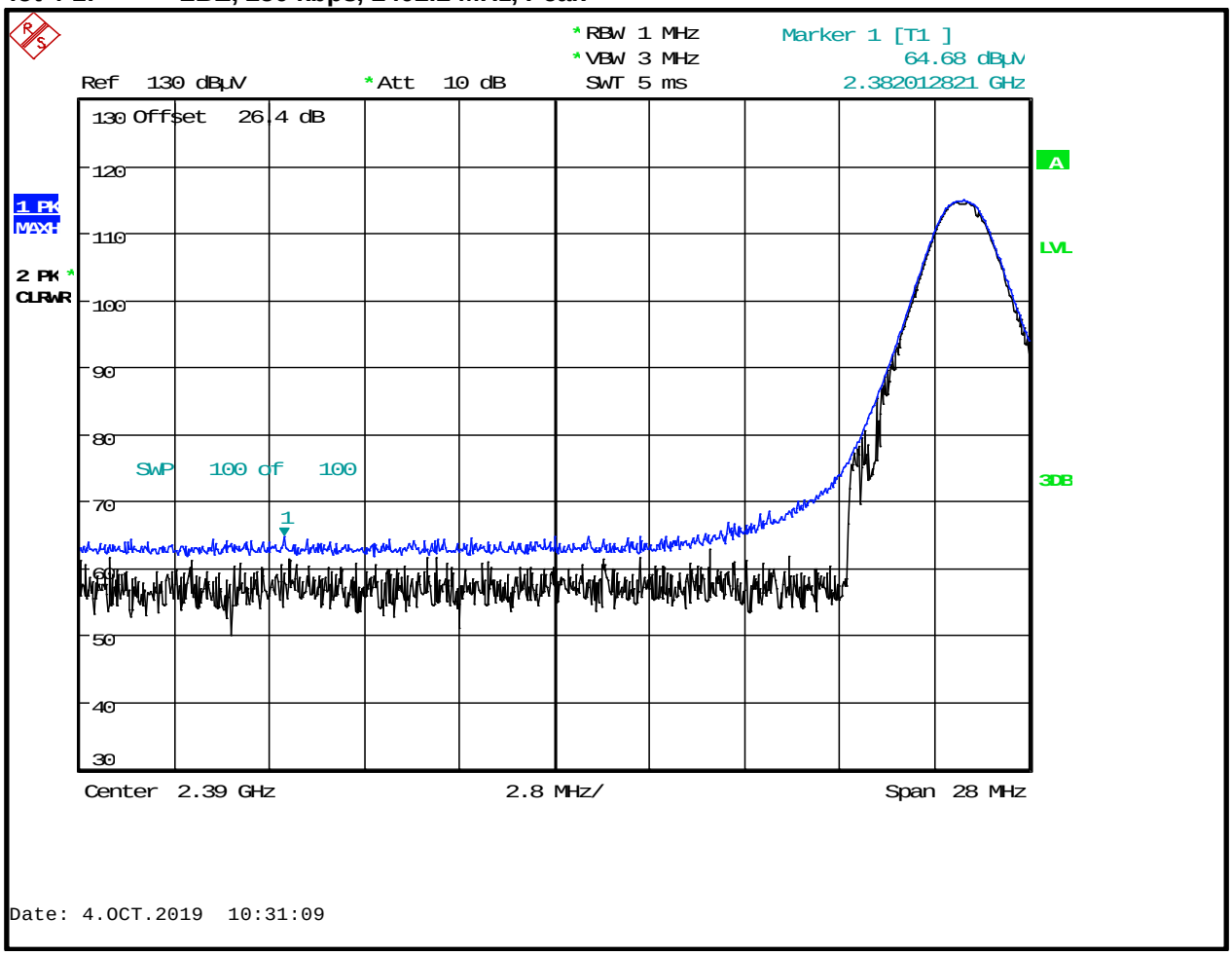
Band Edge: ±4.5 dB

4.3 Restricted Band Edge Test Results

Table 4-1: Restricted Band Edge Environmental Factors

Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
10/04/2019	62.0	48	99.6
11/01/2019	53.9	67	101.5

Plot 4-1: LBE, 250 kbps, 2402.2 MHz, Peak



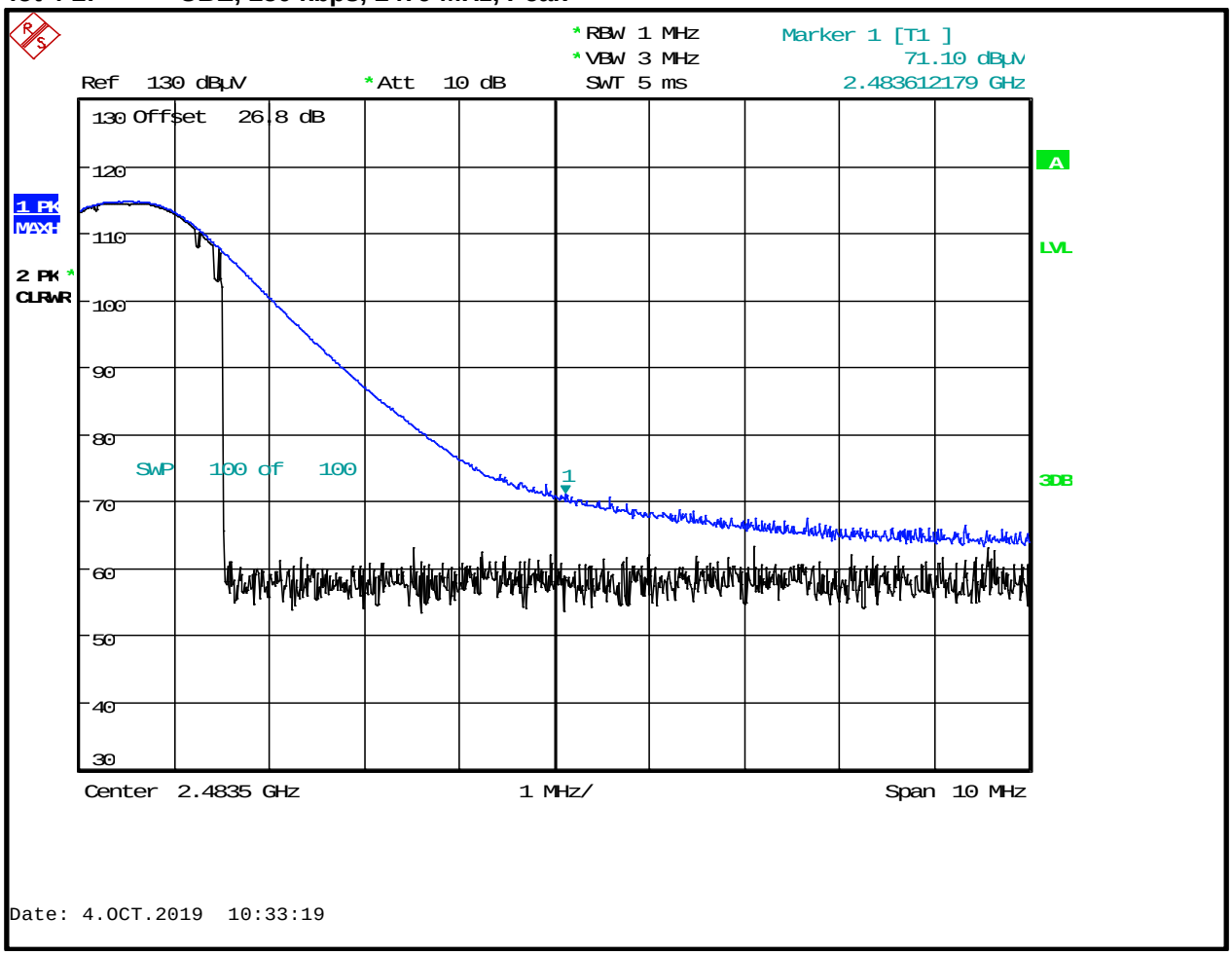
Measured Peak = 64.7 dBµV/m Duty Cycle = 0.126

Calculated Average = 64.7 dBµV/m + (20 * LOG10(0.126)) = 46.7 dBµV/m

Table 4-2: LBE, 250 kbps, 2402 MHz, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2386.276	46.7	54.0	-7.3	Pass

Plot 4-2: UBE, 250 kbps, 2479 MHz, Peak



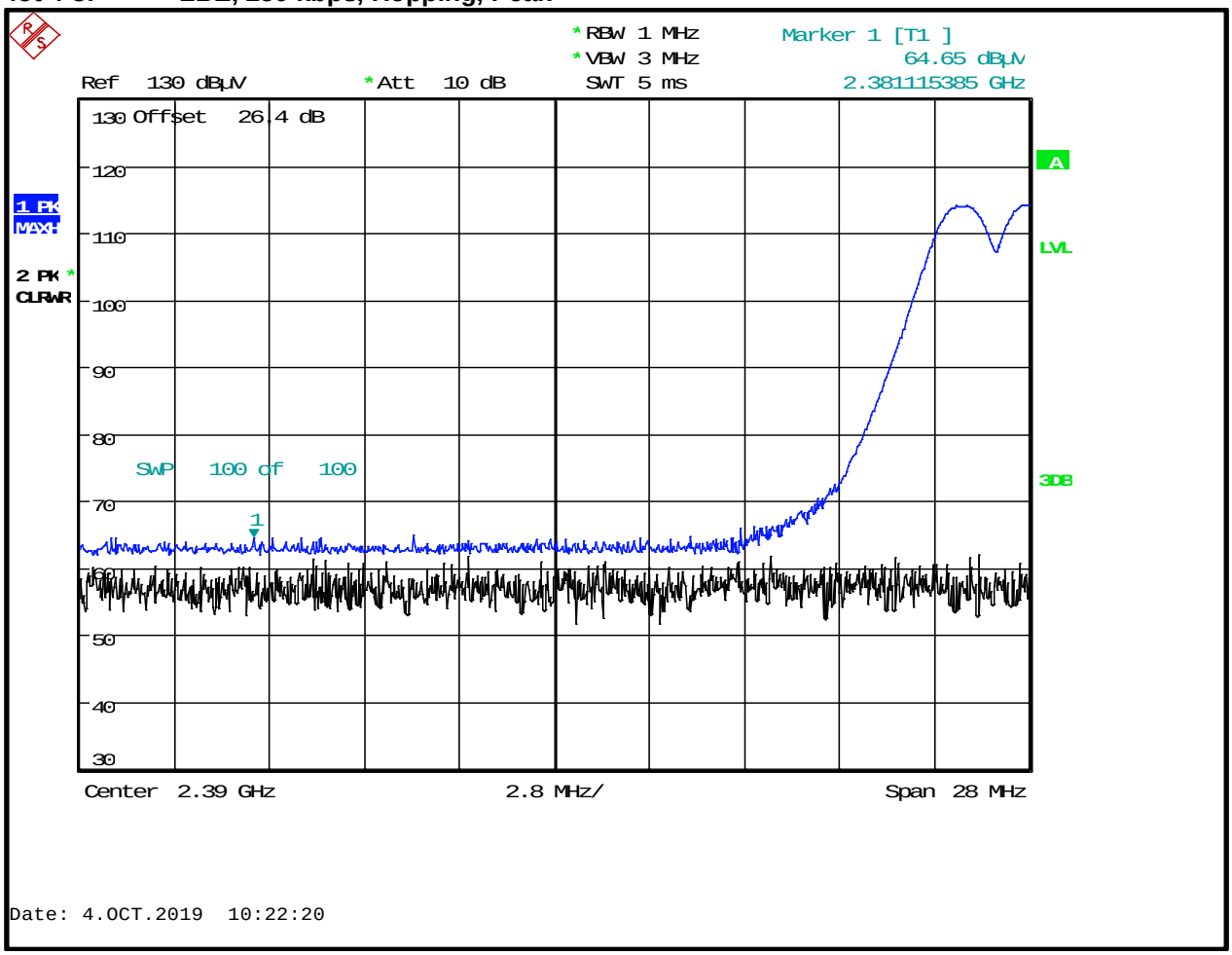
Measured Peak = 71.1 dBµV/m Duty Cycle = 0.126

Calculated Average = 71.1 dBµV/m + (20 * LOG10(0.126)) = 53.1 dBµV/m

Table 4-3: UBE, 250 kbps, 2479 MHz, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2483.612	53.1	54.0	-0.9	Pass

Plot 4-3: LBE, 250 kbps, Hopping, Peak



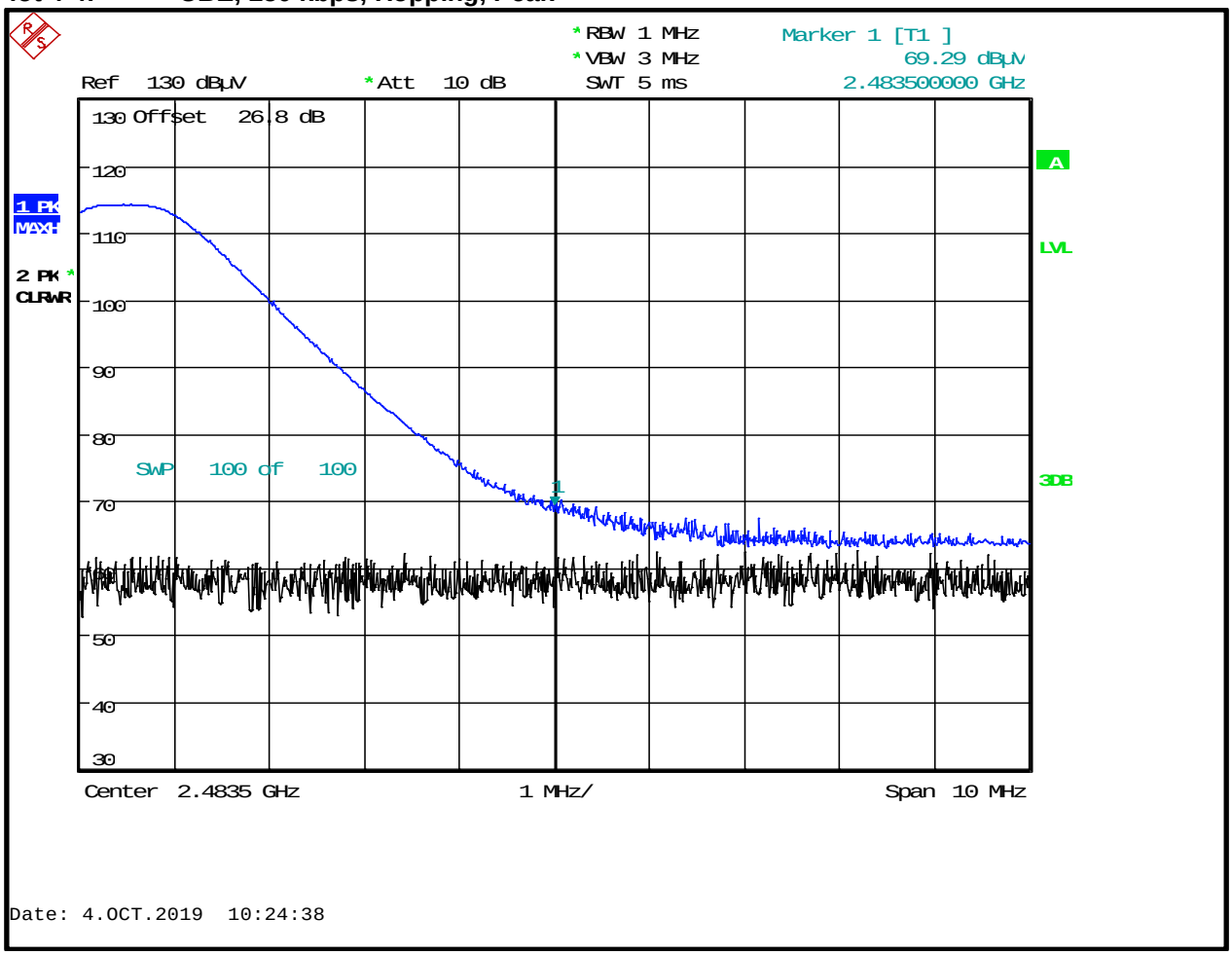
Measured Peak = 64.7 dBµV/m Duty Cycle = 0.126

Calculated Average = 64.7 dBµV/m + (20 * LOG10(0.126)) = 46.7 dBµV/m

Table 4-4: LBE, 250 kbps, Hopping, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2386.276	46.7	54.0	-7.3	Pass

Plot 4-4: UBE, 250 kbps, Hopping, Peak



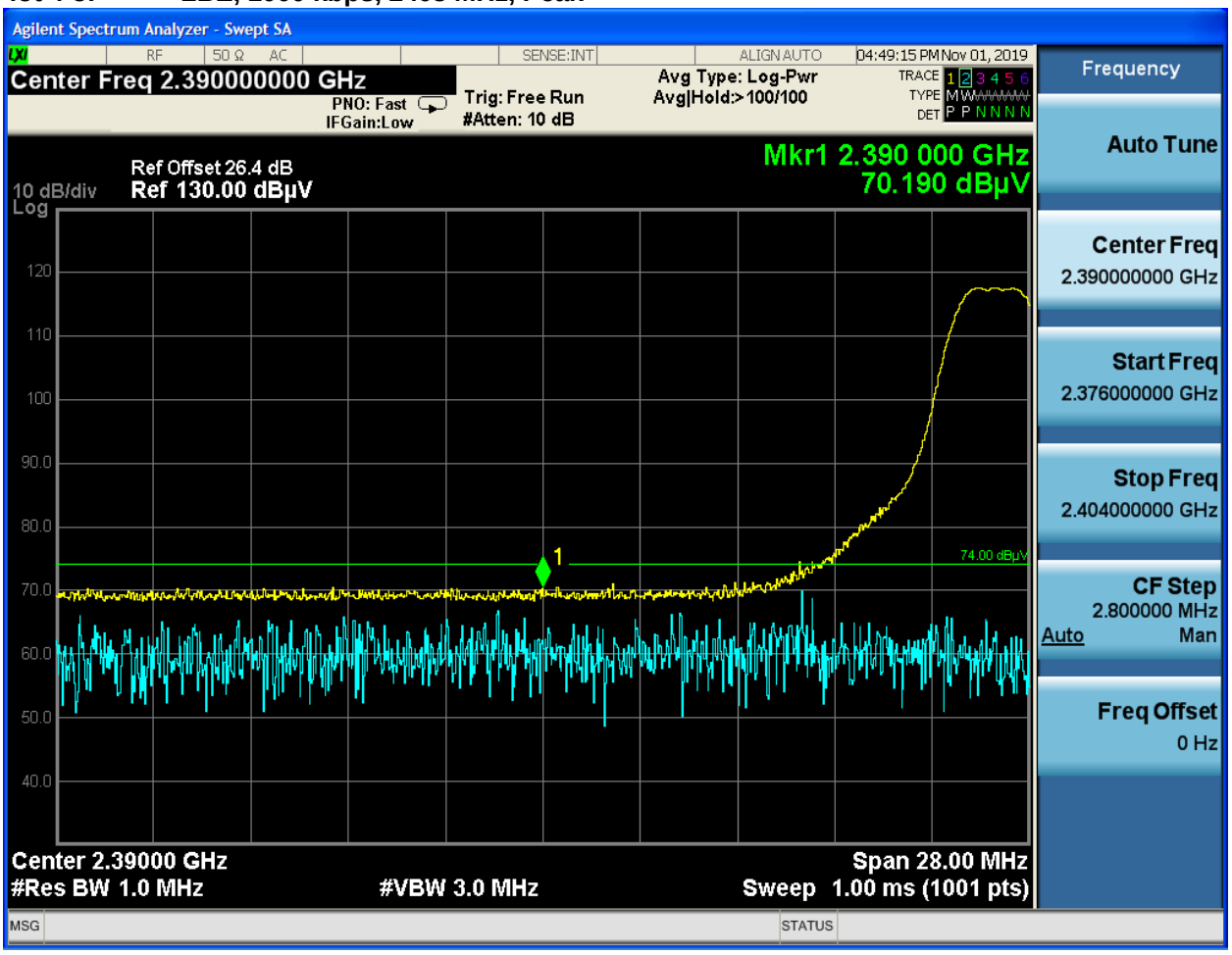
Measured Peak = 69.3 dBµV/m Duty Cycle = 0.126

Calculated Average = 69.3 dBµV/m + (20 * LOG10(0.126)) = 51.3 dBµV/m

Table 4-5: UBE, 250 kbps, Hopping, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2483.500	51.3	54.0	-2.7	Pass

Plot 4-5: LBE, 1000 kbps, 2403 MHz, Peak



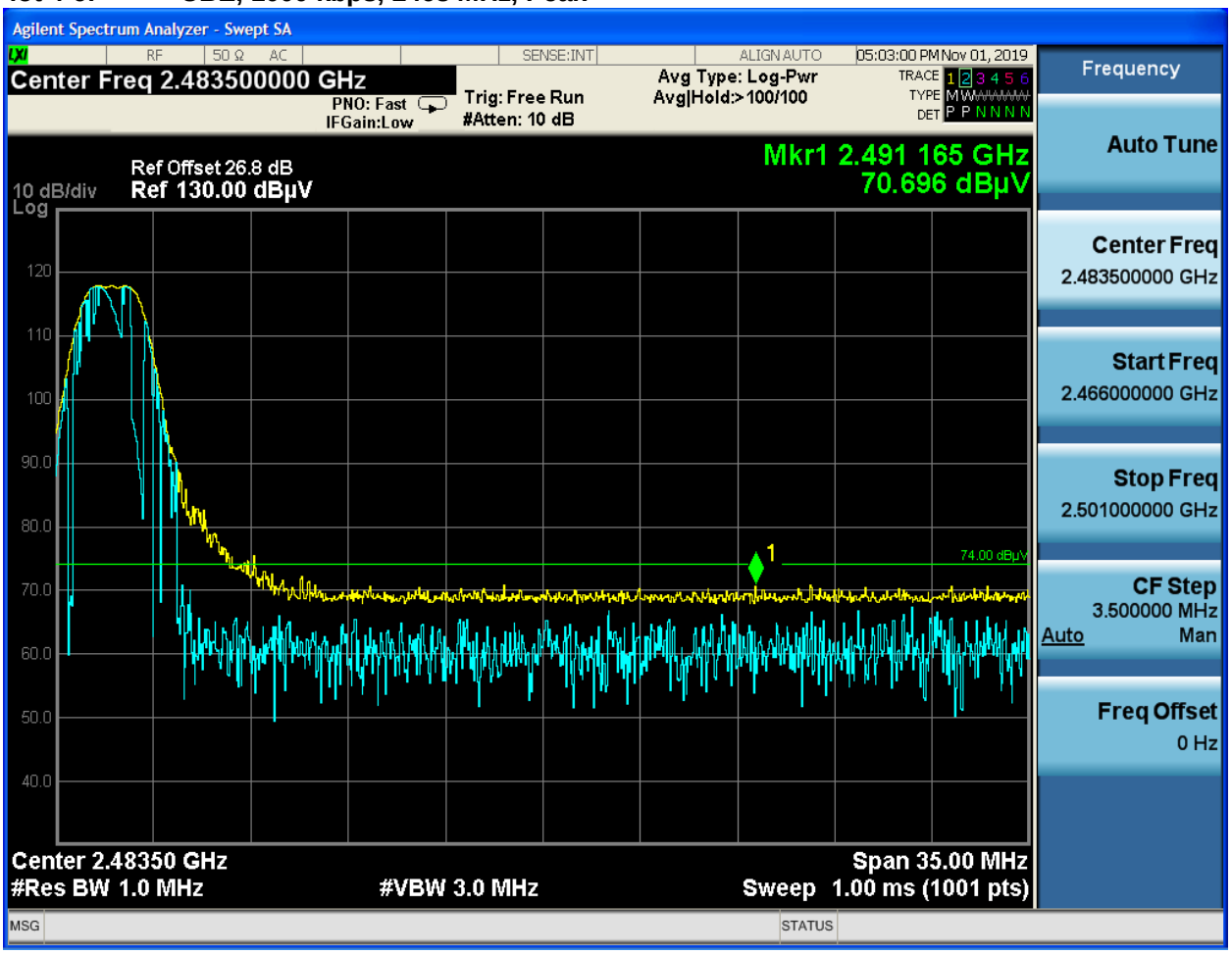
Measured Peak = 70.2 dBµV/m Duty Cycle = 0.067

Calculated Average = 70.2 dBµV/m + (20 * LOG10(0.067)) = 46.7 dBµV/m

Table 4-6: LBE, 1000 kbps, 2403 MHz, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2439.000	46.7	54.0	-7.3	Pass

Plot 4-6: UBE, 1000 kbps, 2468 MHz, Peak



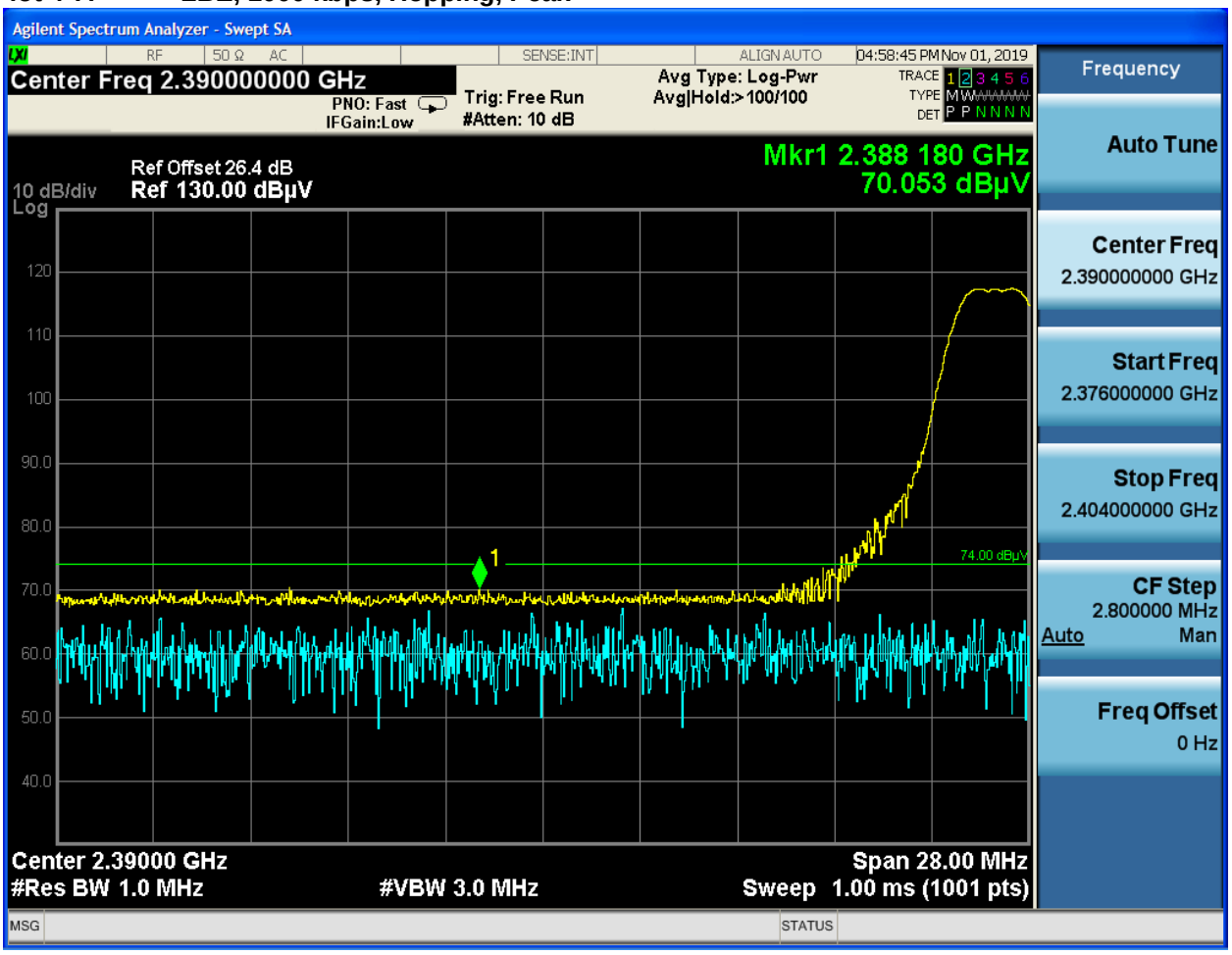
Measured Peak = 70.7 dBµV/m Duty Cycle = 0.067

Calculated Average = 70.7 dBµV/m + (20 * LOG10(0.067)) = 47.2 dBµV/m

Table 4-7: UBE, 1000 kbps, 2468 MHz, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2491.165	47.2	54.0	-6.8	Pass

Plot 4-7: LBE, 1000 kbps, Hopping, Peak



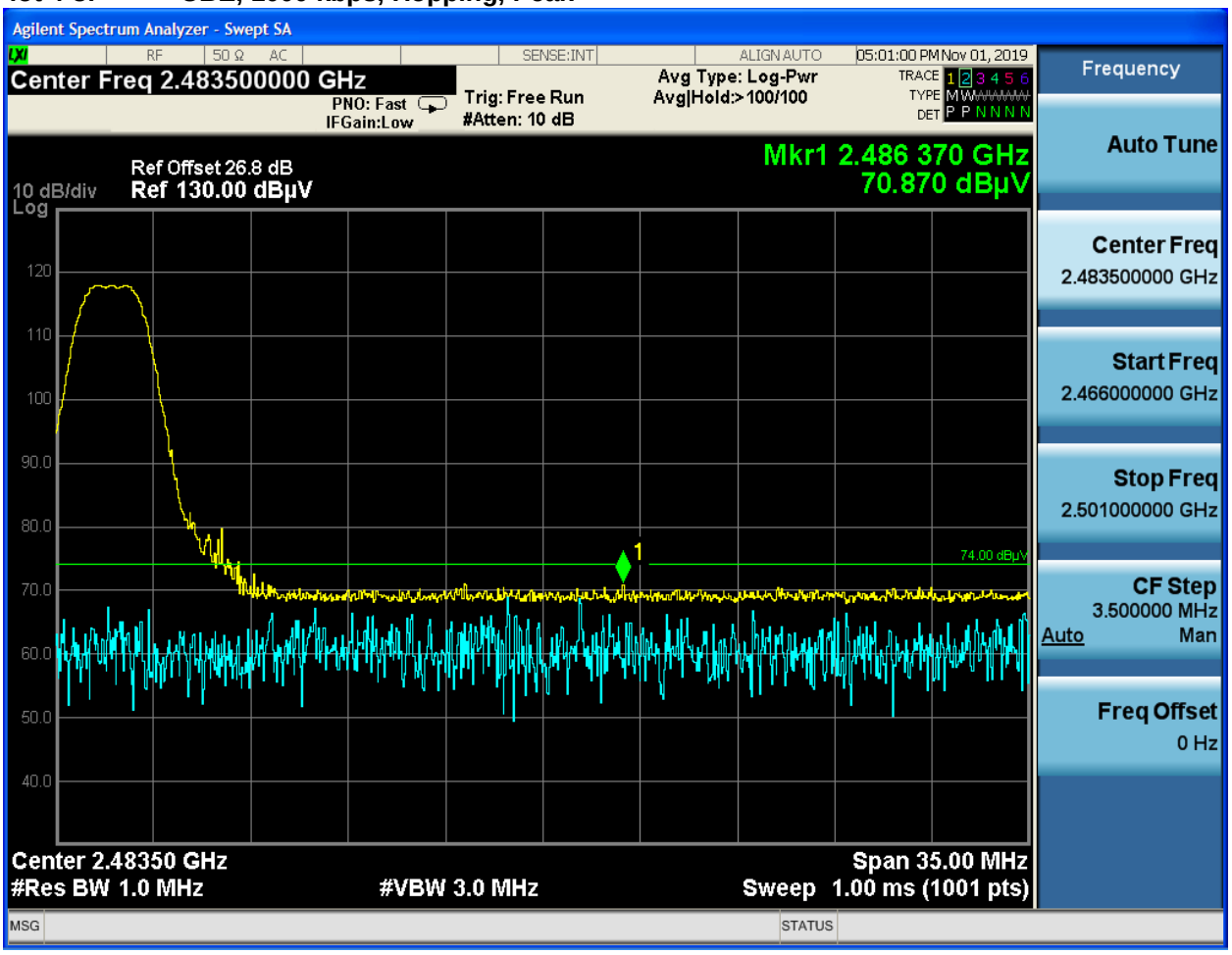
Measured Peak = 70.1 dBµV/m Duty Cycle = 0.067

Calculated Average = 70.1 dBµV/m + (20 * LOG10(0.067)) = 46.6 dBµV/m

Table 4-8: LBE, 1000 kbps, Hopping, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2388.180	46.6	54.0	-7.4	Pass

Plot 4-8: UBE, 1000 kbps, Hopping, Peak



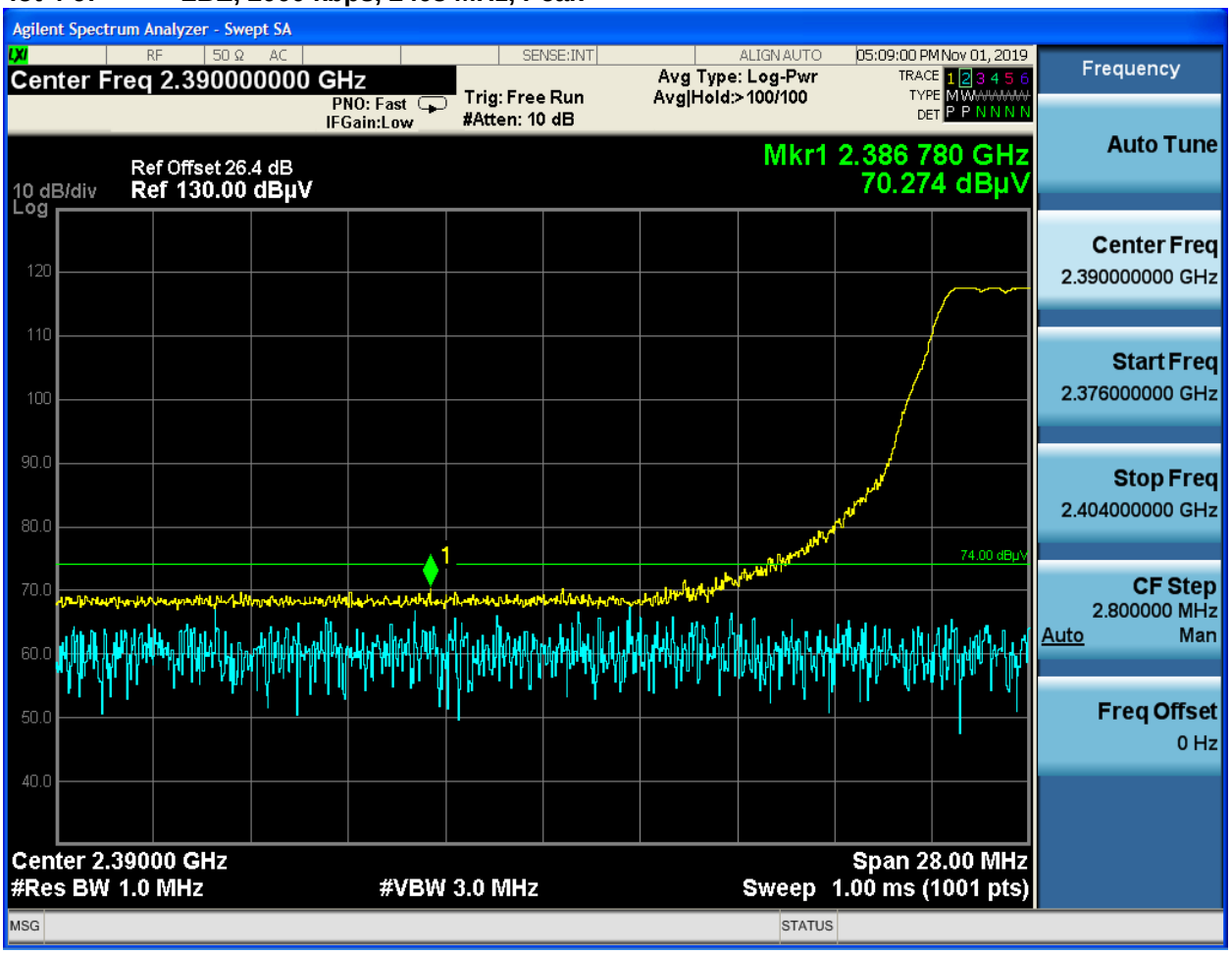
Measured Peak = 70.9 dBµV/m Duty Cycle = 0.067

Calculated Average = 70.9 dBµV/m + (20 * LOG10(0.067)) = 47.4 dBµV/m

Table 4-9: UBE, 1000 kbps, Hopping, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2486.370	47.4	54.0	-6.6	Pass

Plot 4-9: LBE, 2000 kbps, 2403 MHz, Peak



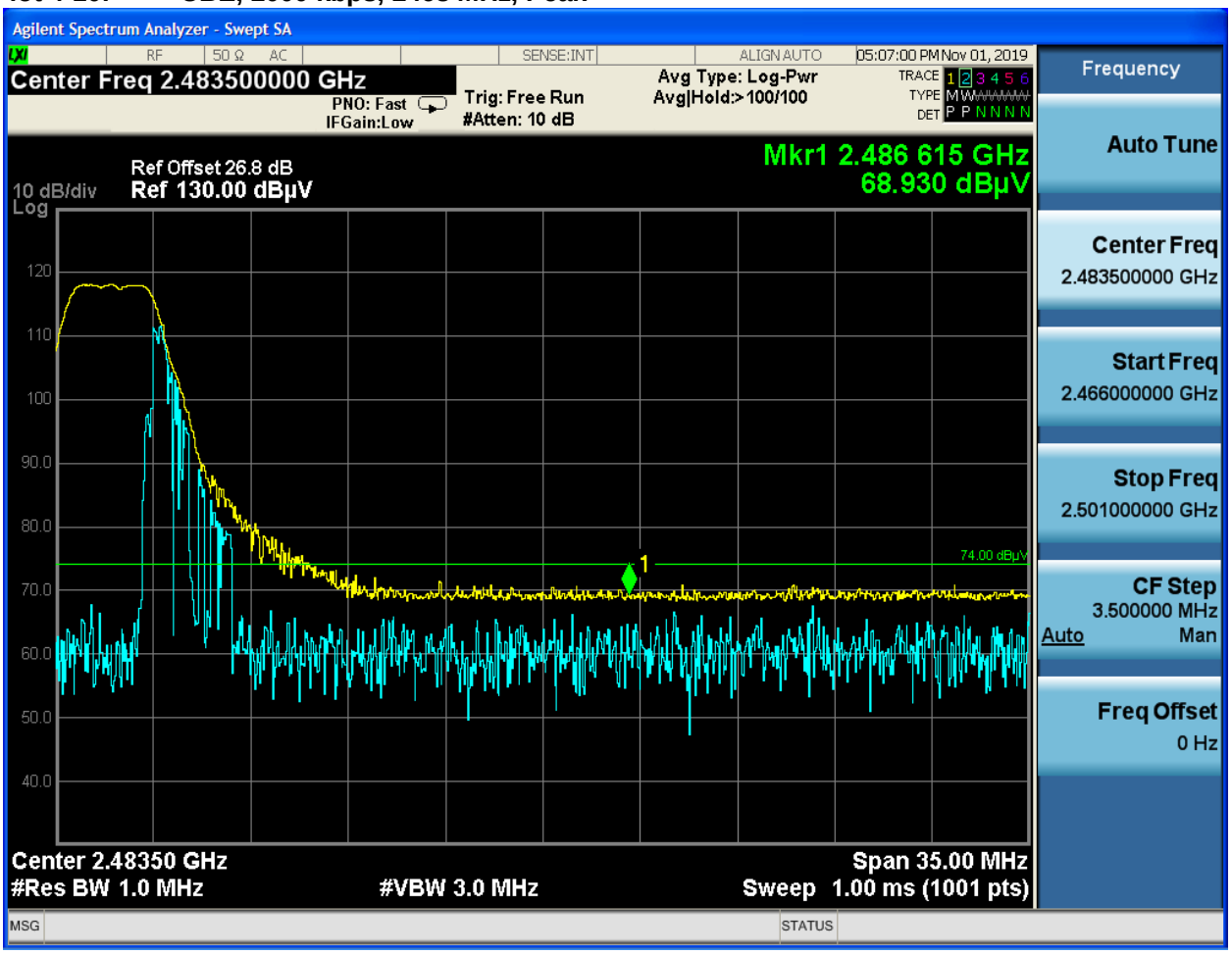
Measured Peak = 70.3 dBµV/m Duty Cycle = 0.036

Calculated Average = 70.3 dBµV/m + (20 * LOG10(0.036)) = 41.4 dBµV/m

Table 4-10: LBE, 2000 kbps, 2403 MHz, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2386.780	41.4	54.0	-12.6	Pass

Plot 4-10: UBE, 2000 kbps, 2468 MHz, Peak



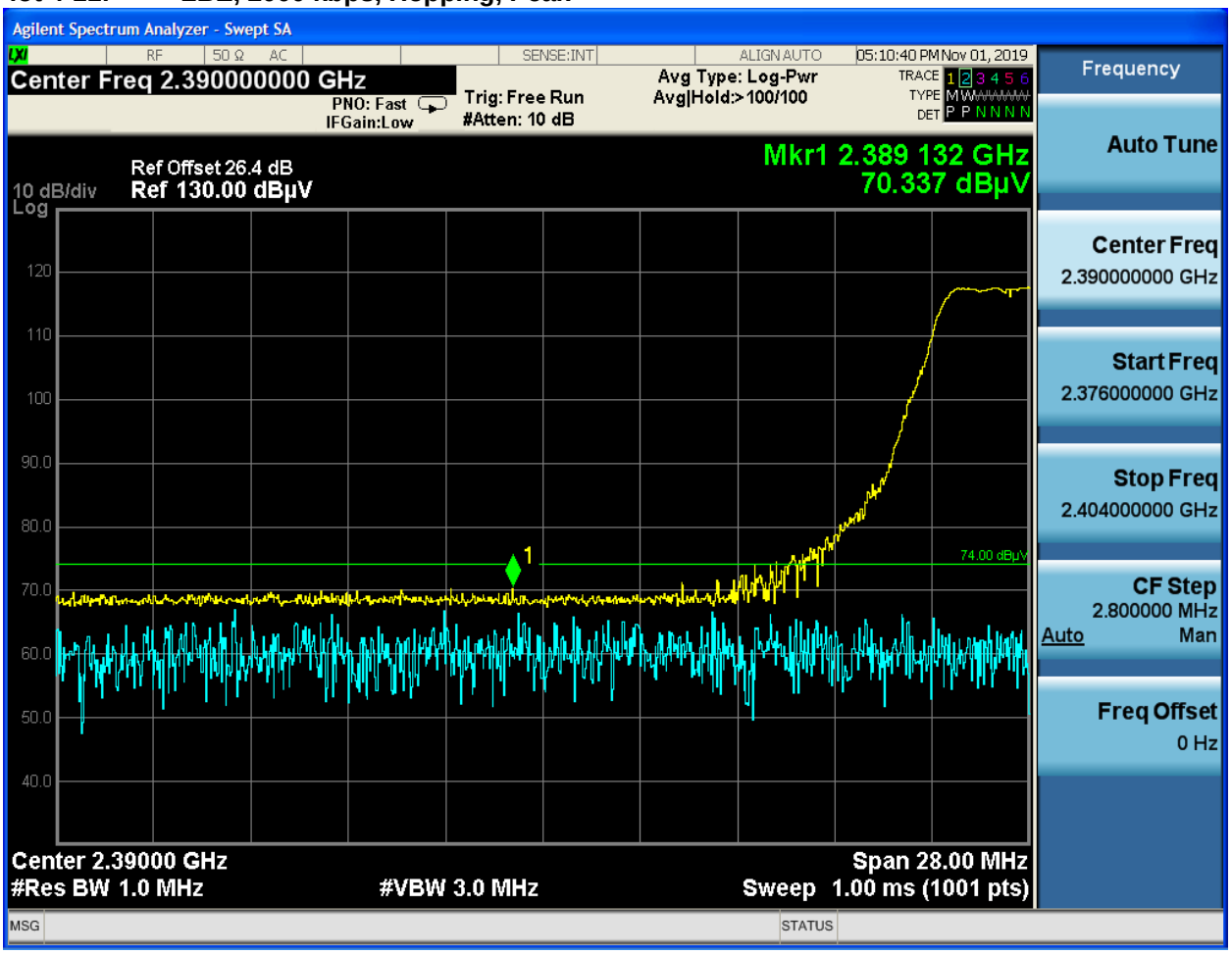
Measured Peak = 68.9 dBµV/m Duty Cycle = 0.036

Calculated Average = 68.9 dBµV/m + (20 * LOG10(0.036)) = 40.0 dBµV/m

Table 4-11: UBE, 2000 kbps, 2468 MHz, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2486.615	40.0	54.0	-14.0	Pass

Plot 4-11: LBE, 2000 kbps, Hopping, Peak



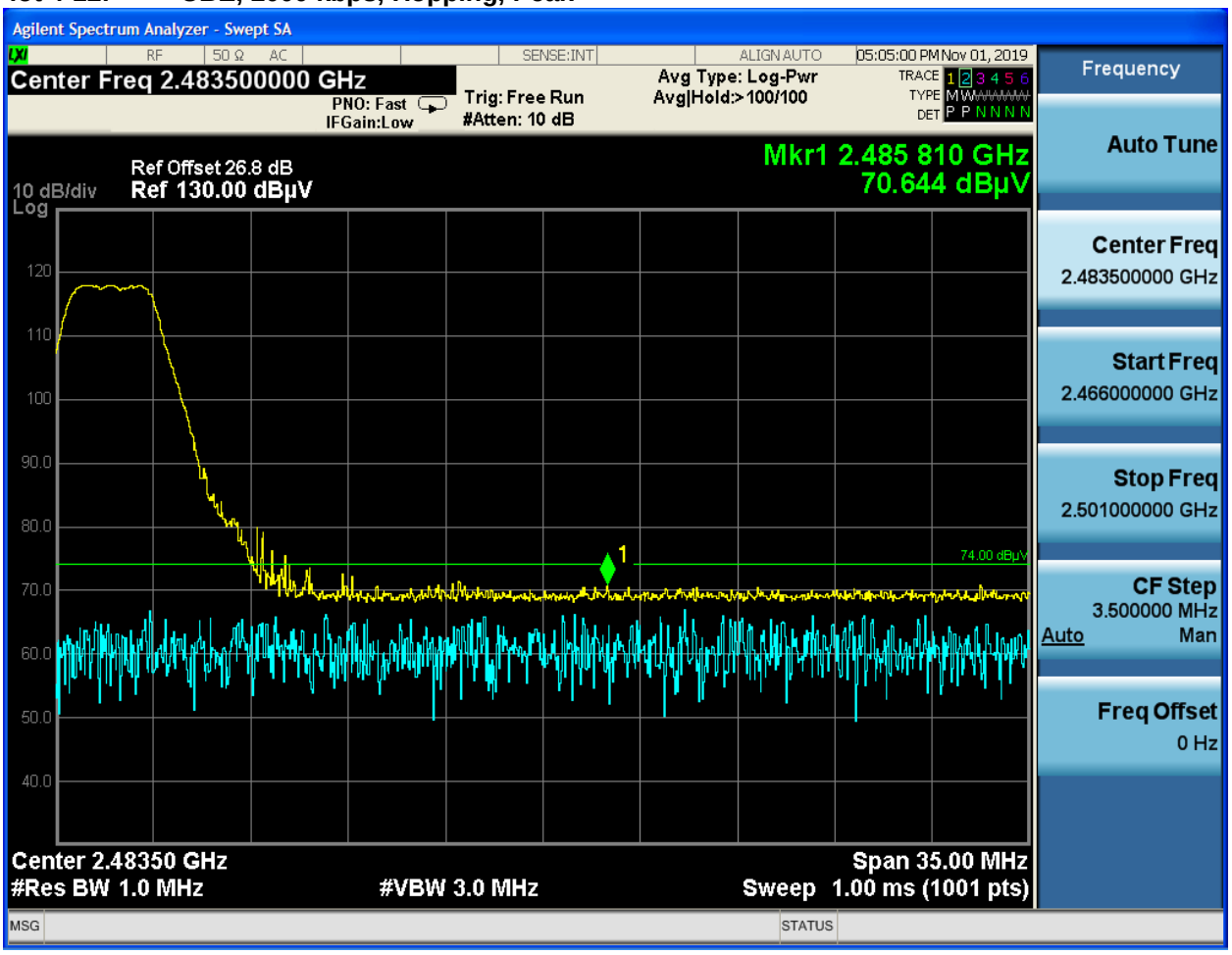
Measured Peak = 70.3 dBµV/m Duty Cycle = 0.036

Calculated Average = 70.3 dBµV/m + (20 * LOG10(0.036)) = 41.4 dBµV/m

Table 4-12: LBE, 2000 kbps, Hopping, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2389.132	41.4	54.0	-12.6	Pass

Plot 4-12: UBE, 2000 kbps, Hopping, Peak



Measured Peak = 70.6 dBµV/m Duty Cycle = 0.036

Calculated Average = 70.6 dBµV/m + (20 * LOG10(0.036)) = 41.7 dBµV/m

Table 4-13: UBE, 2000 kbps, Hopping, Average

Frequency (MHz)	Average Power (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result (Pass / Fail)
2485.810	41.7	54.0	-12.3	Pass

Result: Pass

Test Personnel:

Khue Do		October 4, 2019 November 1, 2019
EMC Test Engineer	Signature	Dates of Test

Table 4-14: Band Edge Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
900772	EMCO	3161-02	Horn Antenna (2 – 4 GHz)	9804-1044	05/17/2021
901581	Rohde & Schwarz	FSU 1166.1660.50	Spectrum Analyzer (20 Hz – 50 GHz)	200106	04/26/2021
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021
901723	Hewlett Packard	8449B	Preamplifier (1 – 26.5 GHz)	3008A00762	09/03/2020

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

5.1 Antenna Conducted Spurious Emissions Test Procedures

Antenna spurious emissions per FCC 15.247(d) were measured from the EUT antenna port using a 50-ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 100 kHz for below 1 GHz. Resolution bandwidth of 1 MHz and video bandwidth of 3 MHz were used for frequencies above 1 GHz. The modulated carrier was identified at 2440 MHz.

5.2 Measurement Uncertainty

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

Conducted Spurious Emissions: ±0.8 dB

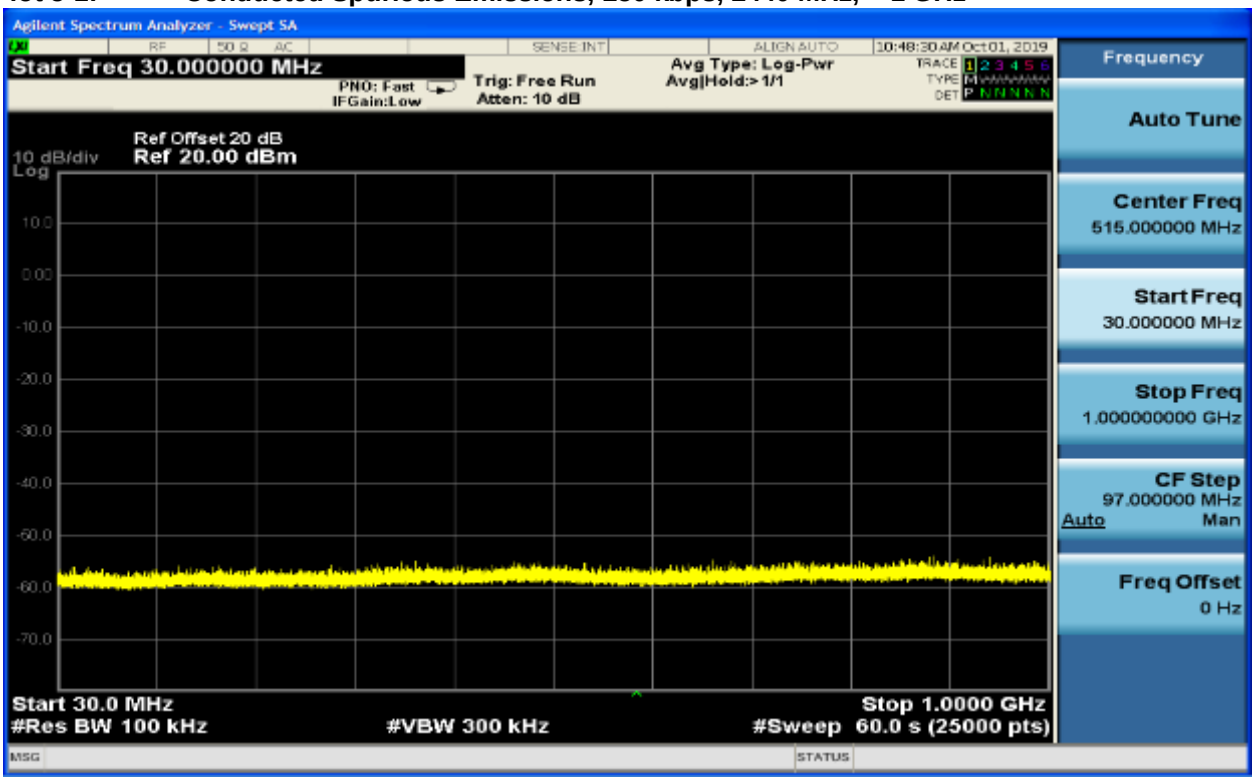
5.3 Conducted Spurious Emissions Test Results

Table 5-1: Conducted Spurious Emissions Environmental Factors

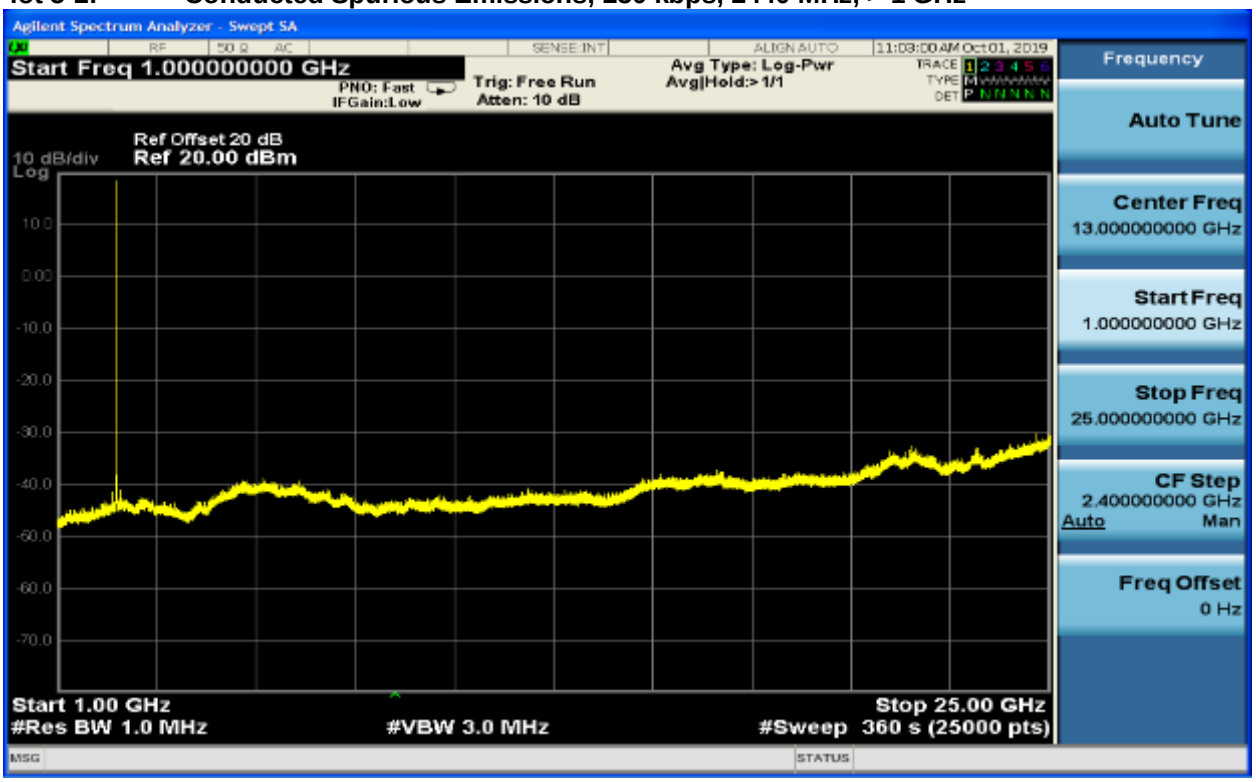
Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
10/01/2019	74.5	37	100.8

No harmonics or spurs were found within 20 dB (note that reported powers are peak) of the carrier level from the carrier to the 10th harmonic of the carrier frequency.

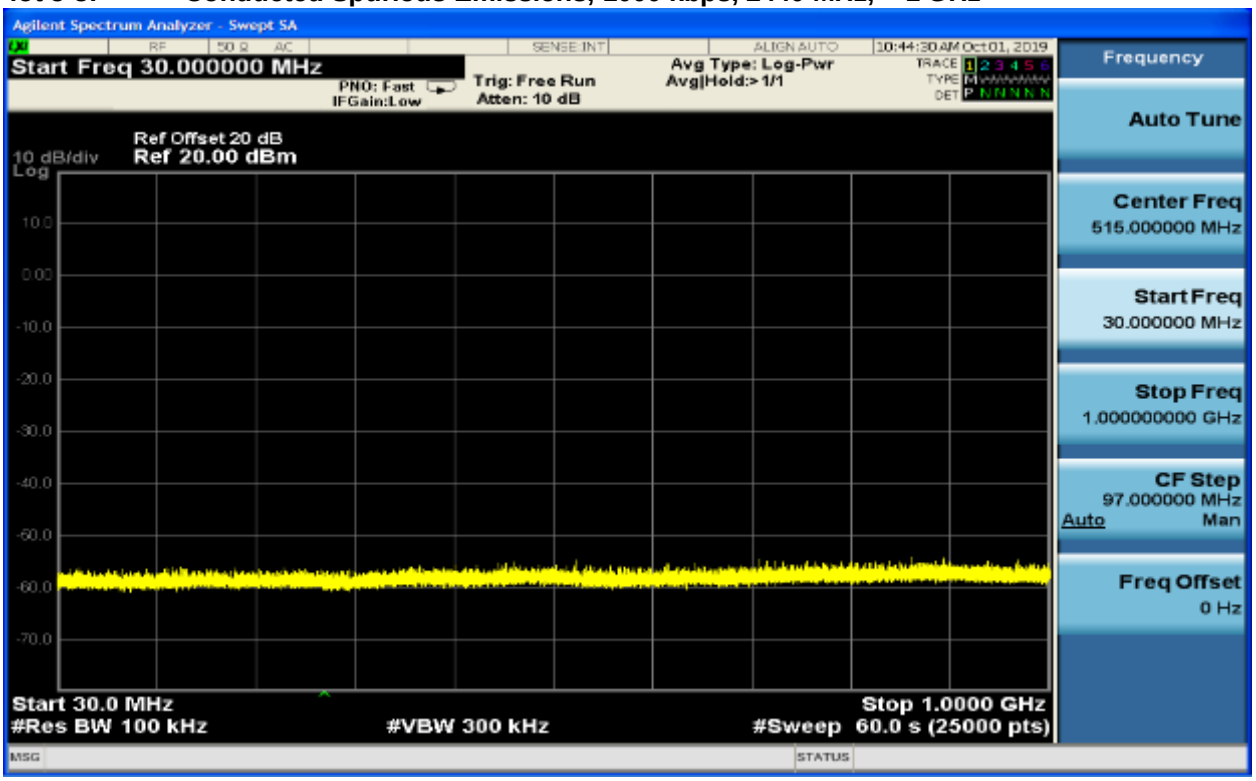
Plot 5-1: Conducted Spurious Emissions, 250 kbps, 2440 MHz, < 1 GHz



Plot 5-2: Conducted Spurious Emissions, 250 kbps, 2440 MHz, > 1 GHz

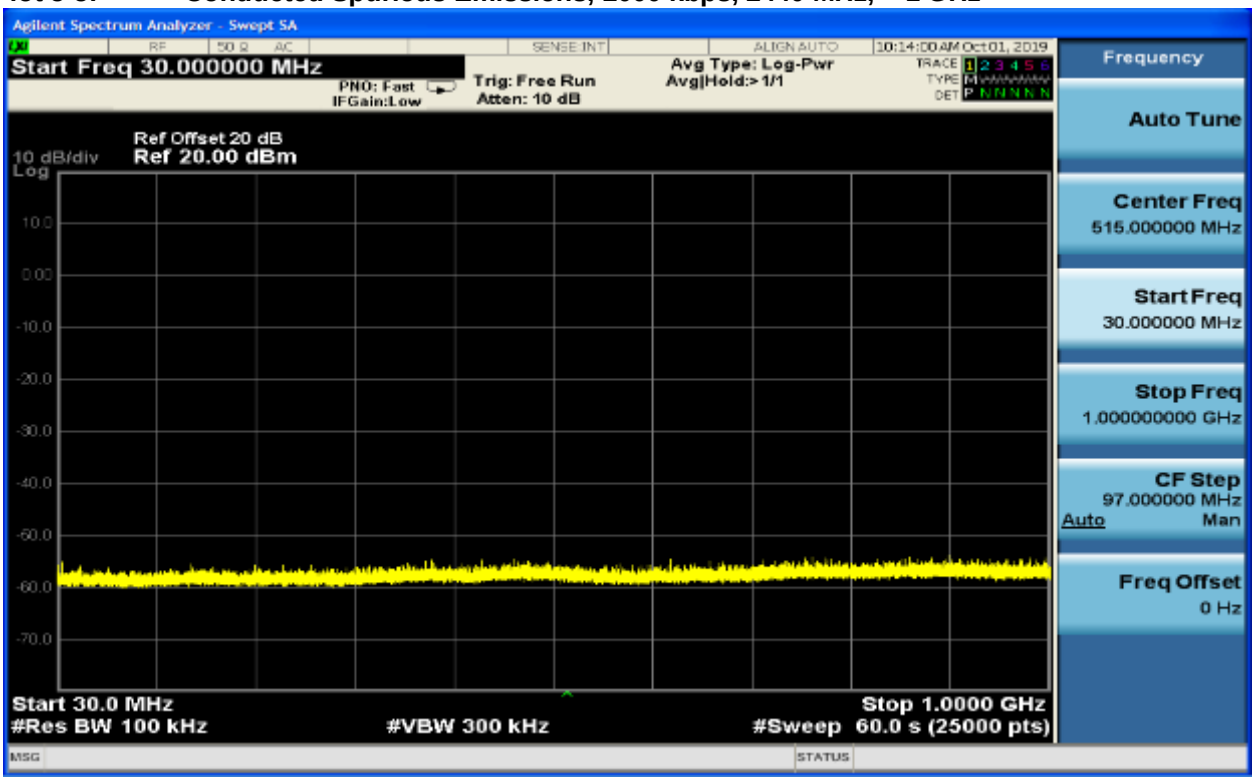


Plot 5-3: Conducted Spurious Emissions, 1000 kbps, 2440 MHz, < 1 GHz

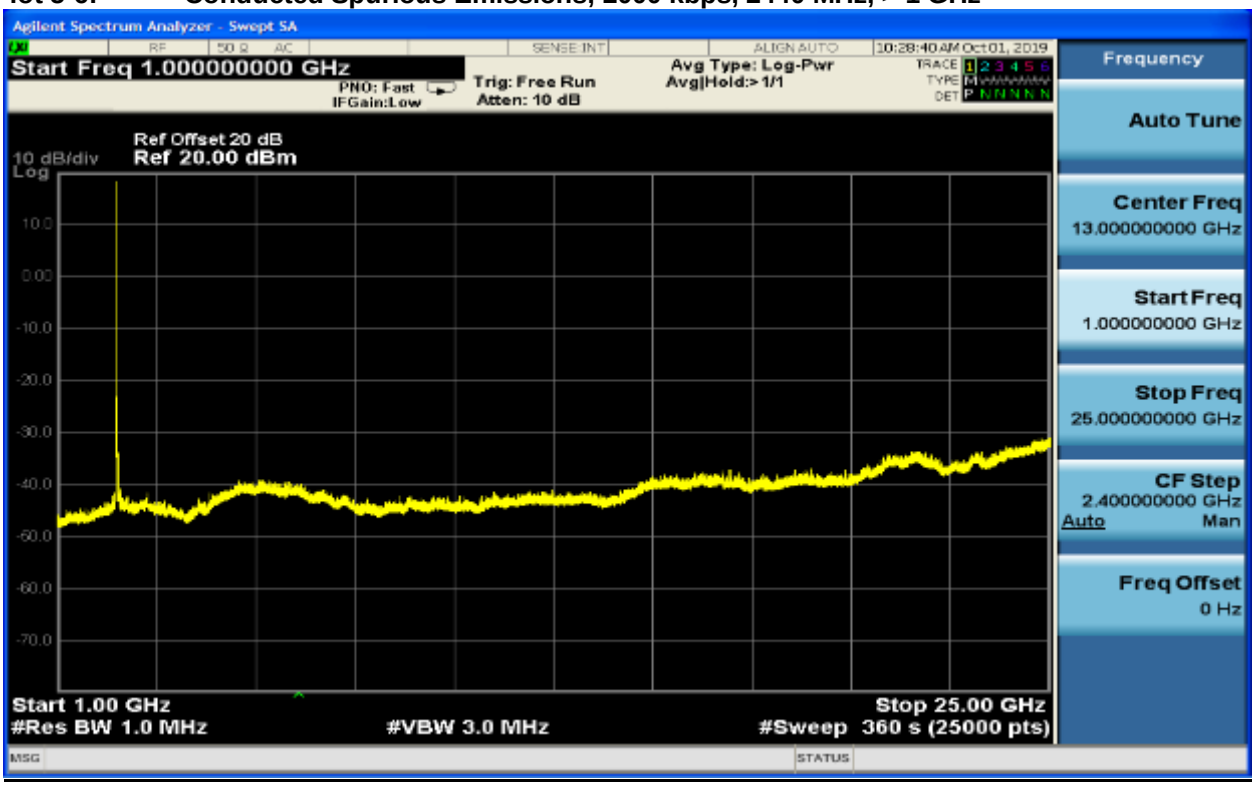


Plot 5-4: Conducted Spurious Emissions, 1000 kbps, 2440 MHz, > 1 GHz

Plot 5-5: Conducted Spurious Emissions, 2000 kbps, 2440 MHz, < 1 GHz



Plot 5-6: Conducted Spurious Emissions, 2000 kbps, 2440 MHz, > 1 GHz



Result: Pass

Test Personnel:

Khue Do		October 1, 2019
EMC Test Engineer	Signature	Date of Test

Table 5-2: Conducted Spurious Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

6 20 dB Bandwidth – FCC 15.247(a)(1)); ISED RSS-247 5.1(a)

6.1 20 dB Bandwidth Test Procedure

The minimum 20 dB bandwidths per FCC 15.247 were measured using a 50-ohm spectrum analyzer. The carrier was adjusted on the analyzer so that it was displayed entirely on the spectrum analyzer. The sweep time was set to auto and allowed through several sweeps with the max hold function used in peak detector mode. The resolution bandwidth was set to 100 kHz, and the video bandwidth set at 300 kHz. The minimum 20 dB bandwidths were measured using the spectrum analyzer delta marker set 20 dB down from the peak of the carrier.

6.2 Measurement Uncertainty

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

20 dB Bandwidth: $\pm 1.0 * 10^{-6}$ Hz

6.3 20 dB Bandwidth Test Results

Table 6-1: 20 dB Bandwidth Environmental Factors

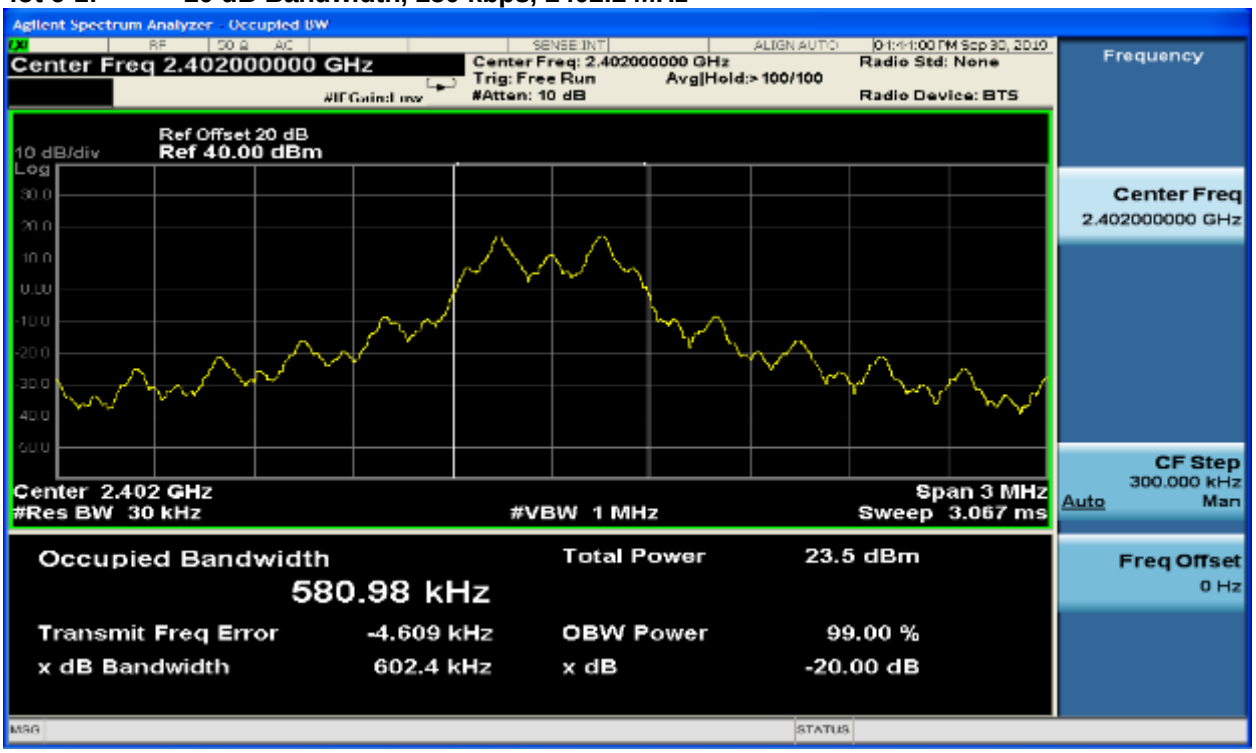
Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
09/30/2019	74.2	36	100.8
10/31/2019	73.2	26	100.8

Table 6-2: 20 dB Bandwidth Test Data

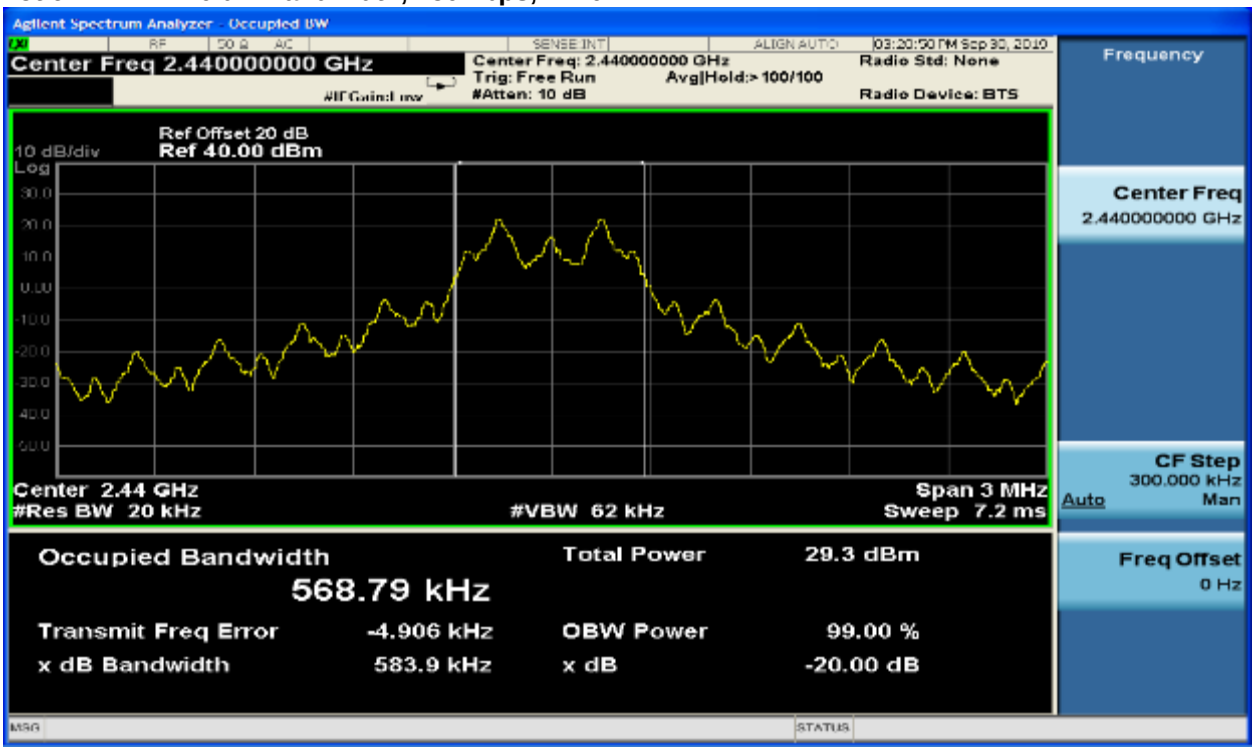
Rate (kbps)	20 dB Bandwidth (MHz)		
	Low Channel	Mid Channel	High Channel
250	0.603	0.584	0.586
1000	2.077	2.078	2.078
2000	4.128	4.138	4.128

6.4 20 dB Bandwidth Plots

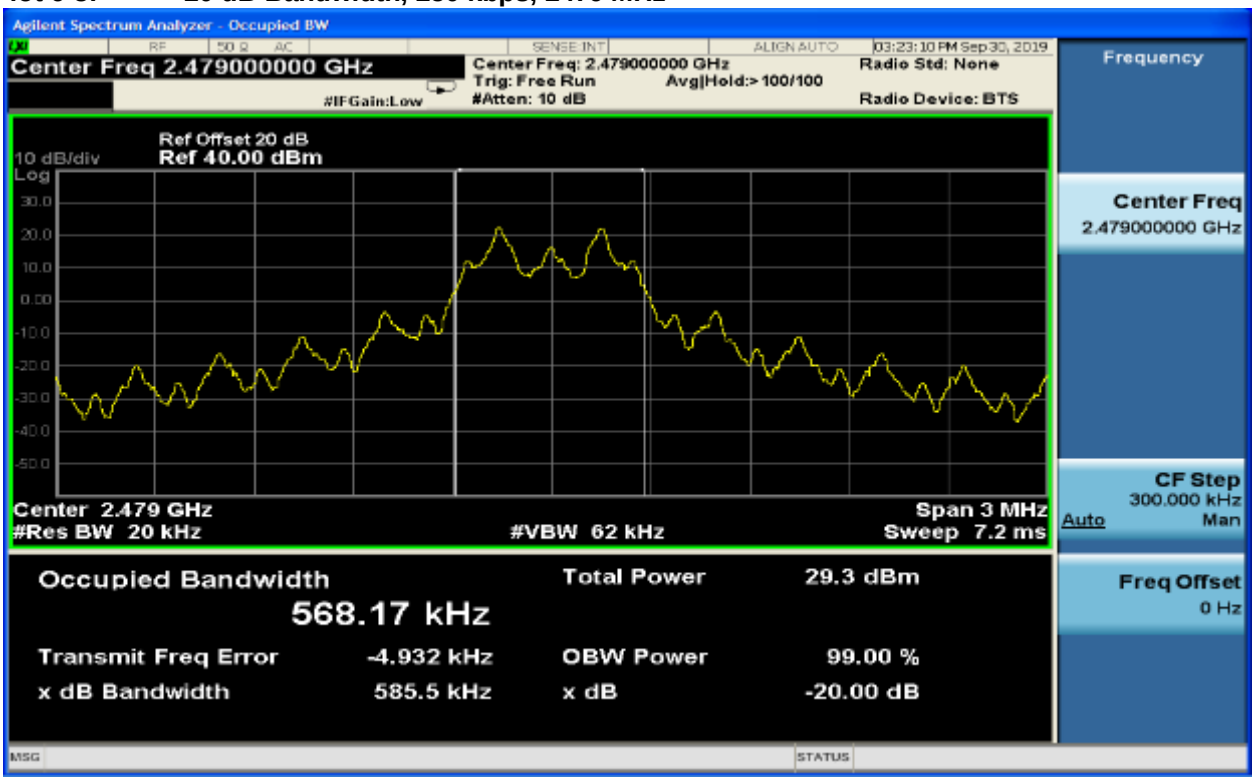
Plot 6-1: 20 dB Bandwidth, 250 kbps, 2402.2 MHz



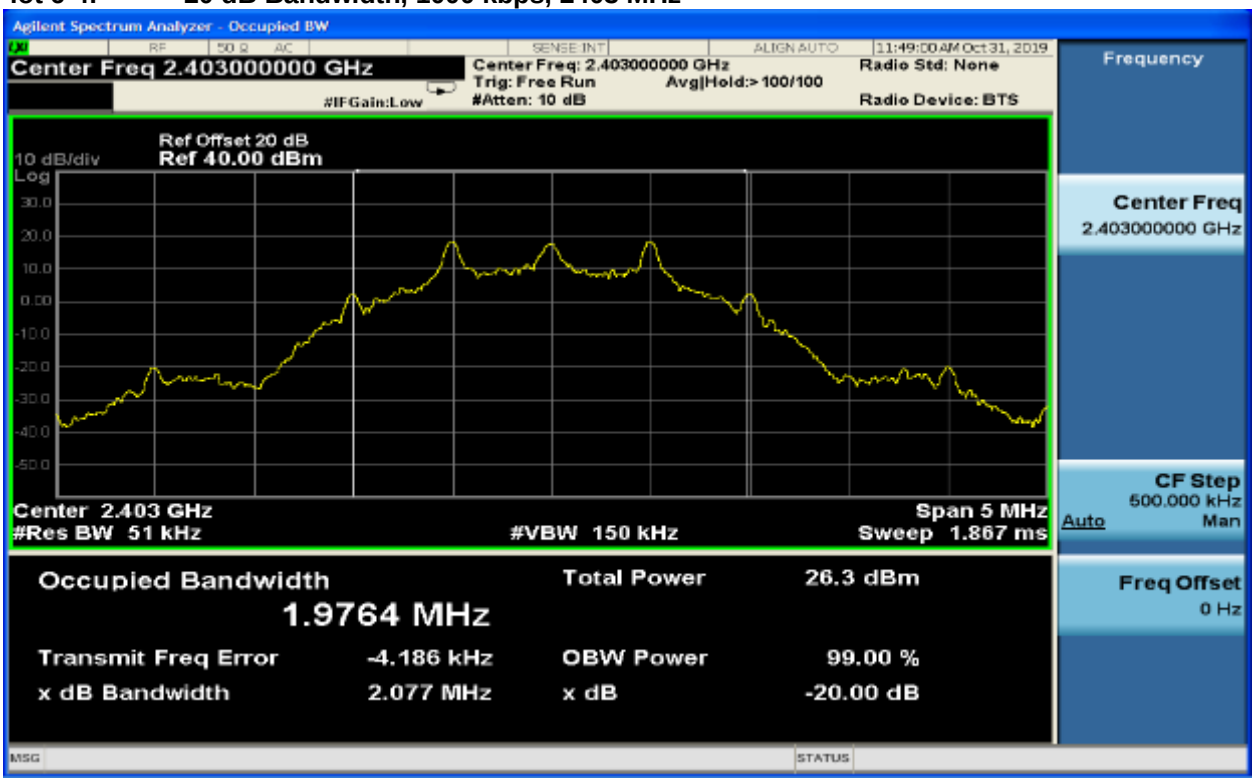
Plot 6-2: 20 dB Bandwidth, 250 kbps, 2440 MHz



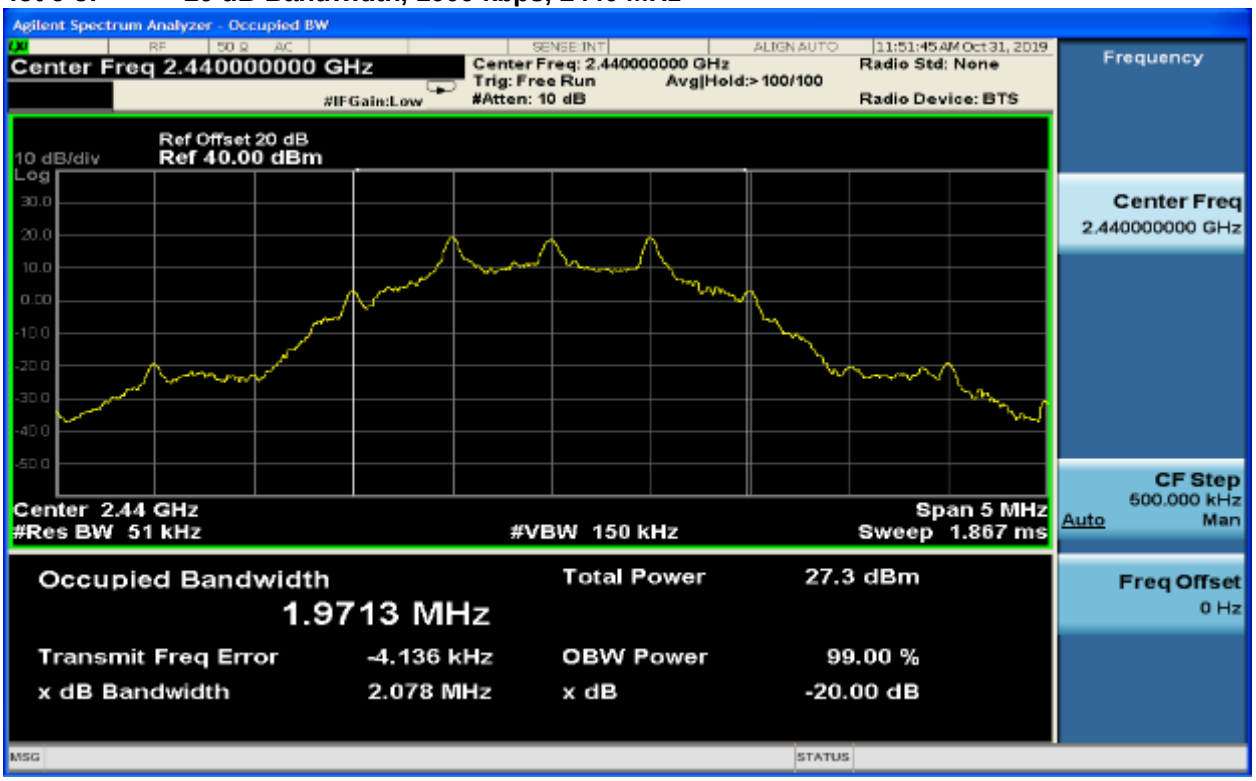
Plot 6-3: 20 dB Bandwidth, 250 kbps, 2479 MHz



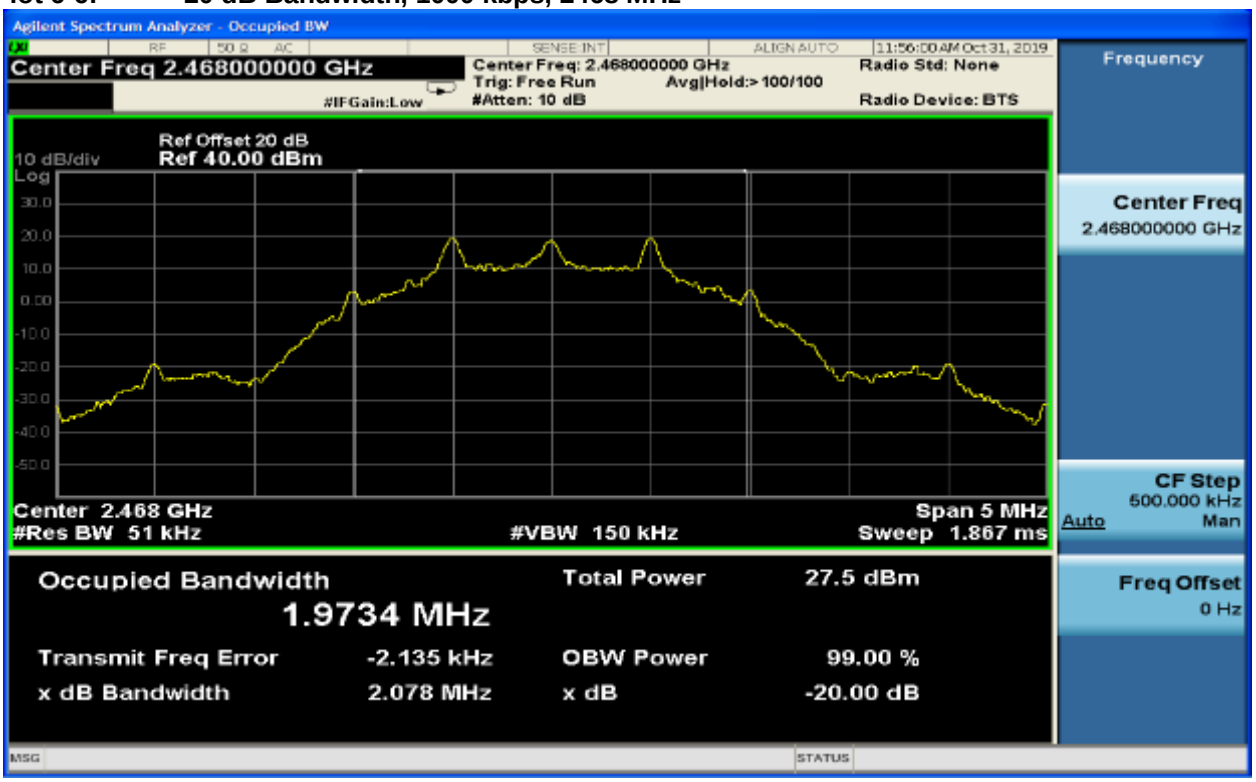
Plot 6-4: 20 dB Bandwidth, 1000 kbps, 2403 MHz



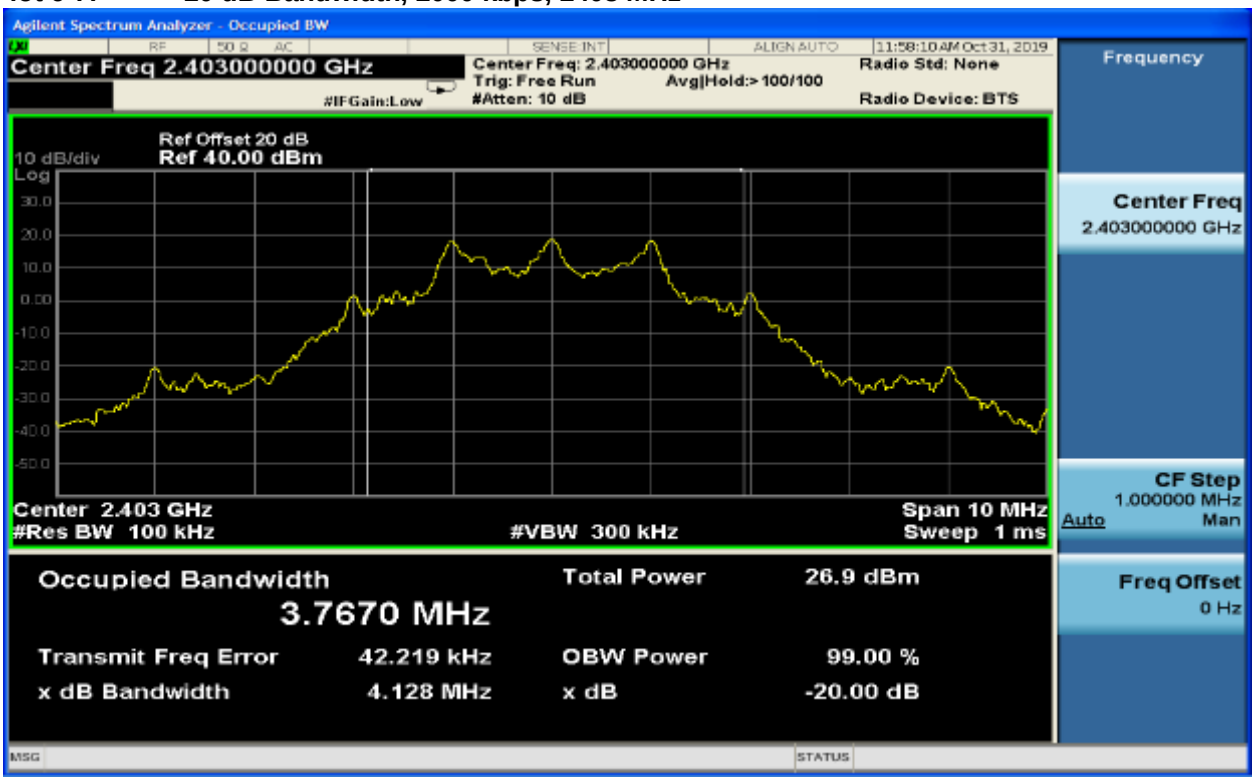
Plot 6-5: 20 dB Bandwidth, 1000 kbps, 2440 MHz



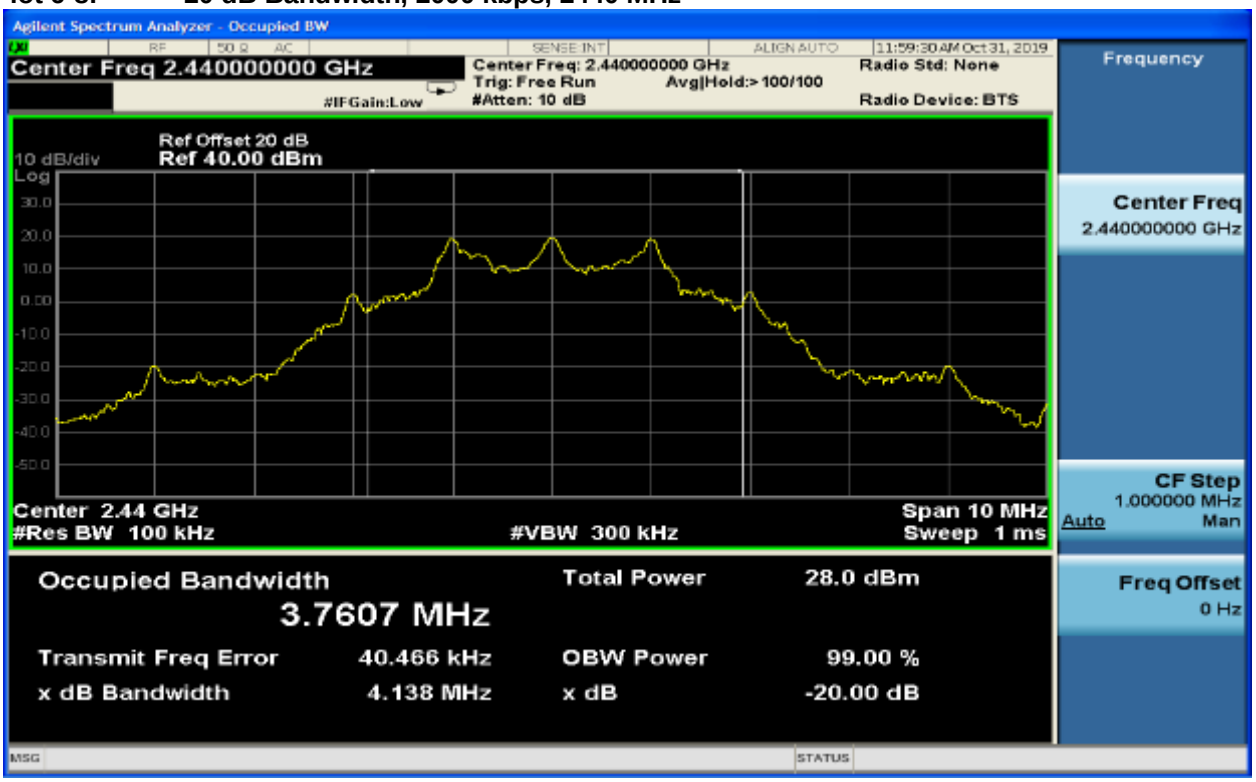
Plot 6-6: 20 dB Bandwidth, 1000 kbps, 2468 MHz



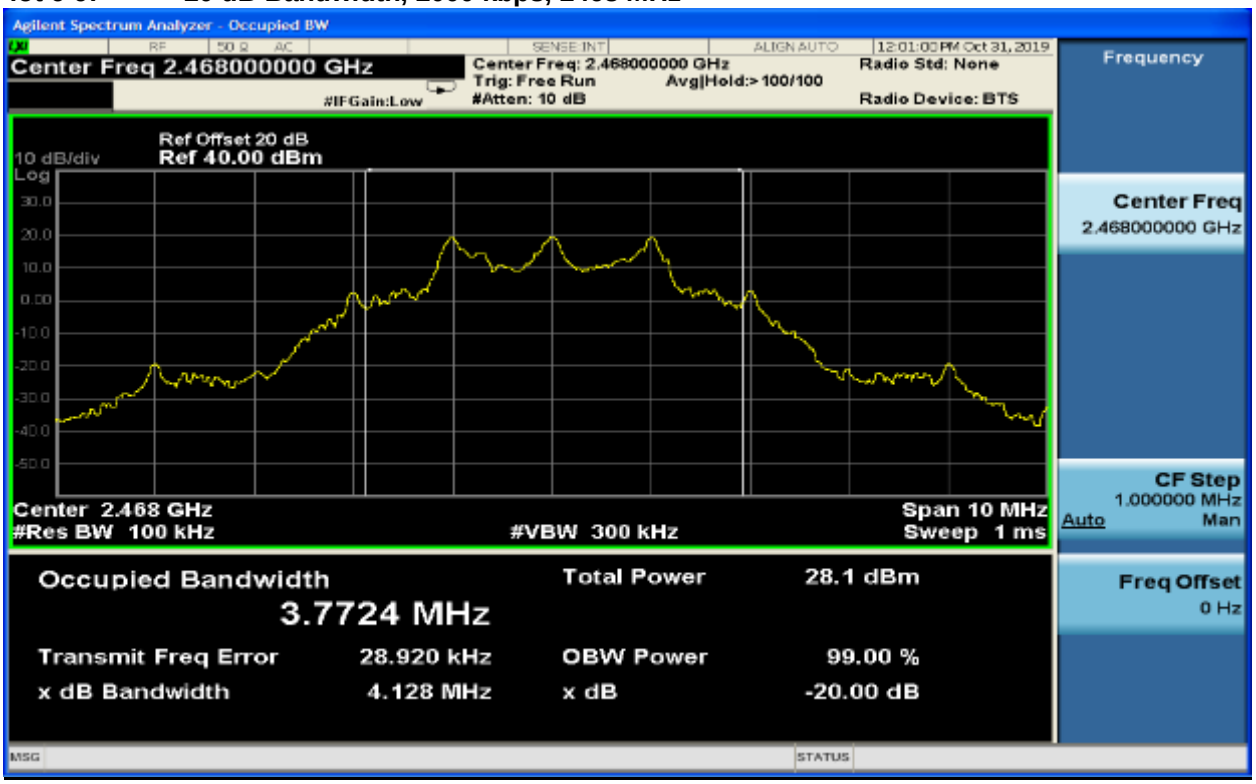
Plot 6-7: 20 dB Bandwidth, 2000 kbps, 2403 MHz



Plot 6-8: 20 dB Bandwidth, 2000 kbps, 2440 MHz



Plot 6-9: 20 dB Bandwidth, 2000 kbps, 2468 MHz



Result: Pass

Test Personnel:

Khue Do		September 30, 2019 October 31, 2019
EMC Test Engineer	Signature	Dates of Test

Table 6-3: 20 dB Bandwidth Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

7 Occupied Bandwidth – ISED RSS-Gen 6.7

7.1 99% Bandwidth Test Procedure

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to "Sample". However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or "Max Hold") may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

7.2 Measurement Uncertainty

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

99% Bandwidth: $\pm 1.0 * 10^{-6}$ Hz

7.3 99% dB Bandwidth Test Results

Table 7-1: 99% Bandwidth Environmental Factors

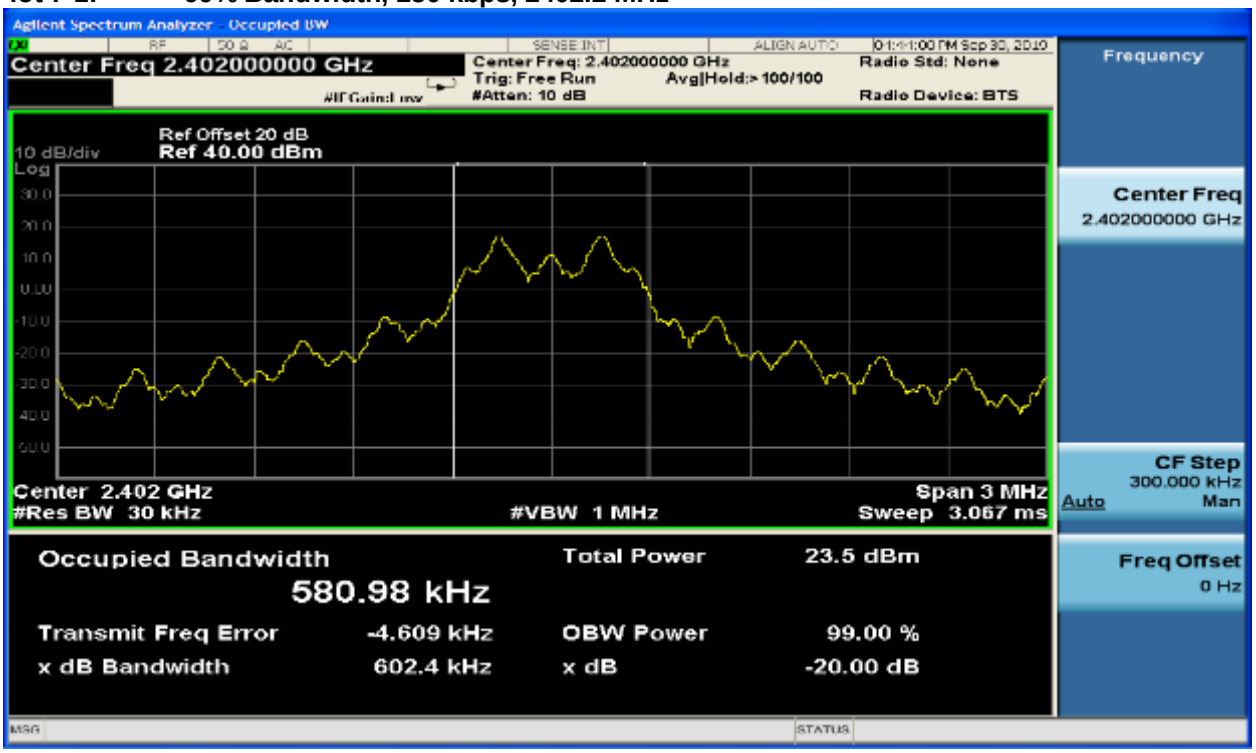
Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
09/30/2019	74.2	36	100.8
10/31/2019	73.2	26	100.8

Table 7-2: 99% Bandwidth Test Data

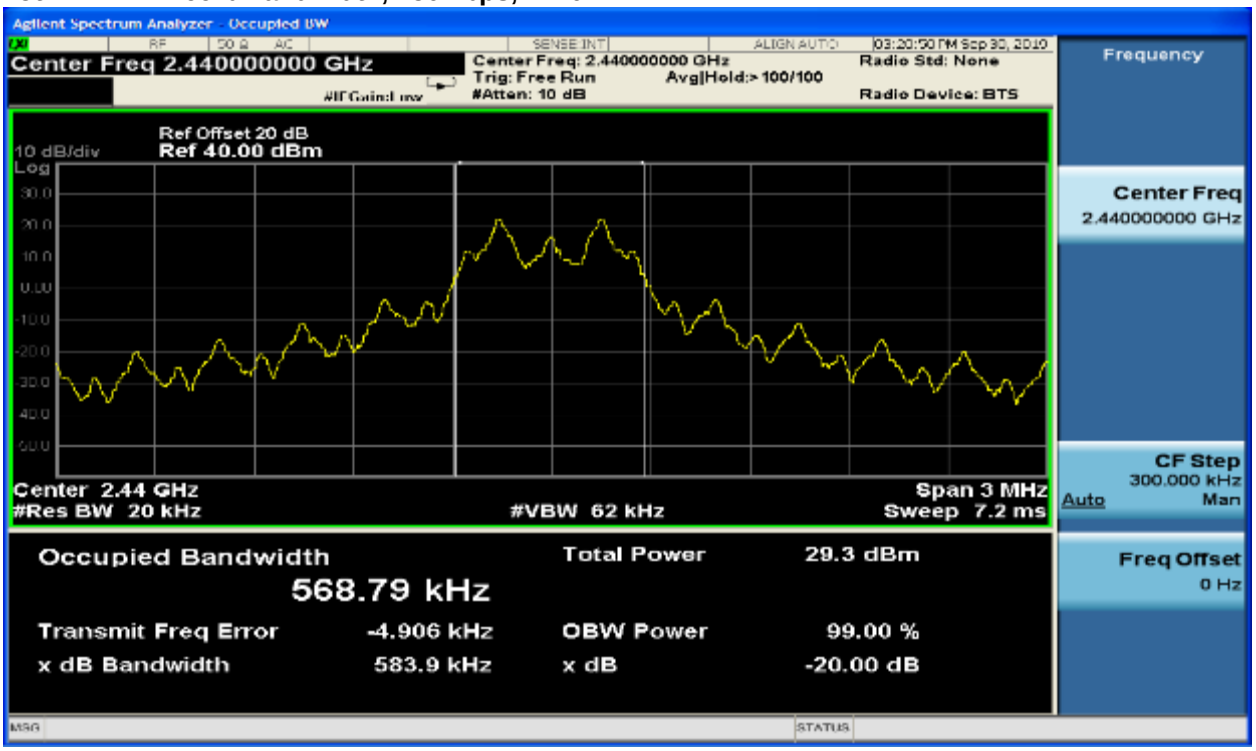
Rate (kbps)	99% Bandwidth (MHz)		
	Low Channel	Mid Channel	High Channel
250	0.582	0.569	0.568
1000	1.976	1.971	1.973
2000	3.767	3.761	3.772

7.4 99% Bandwidth Plots

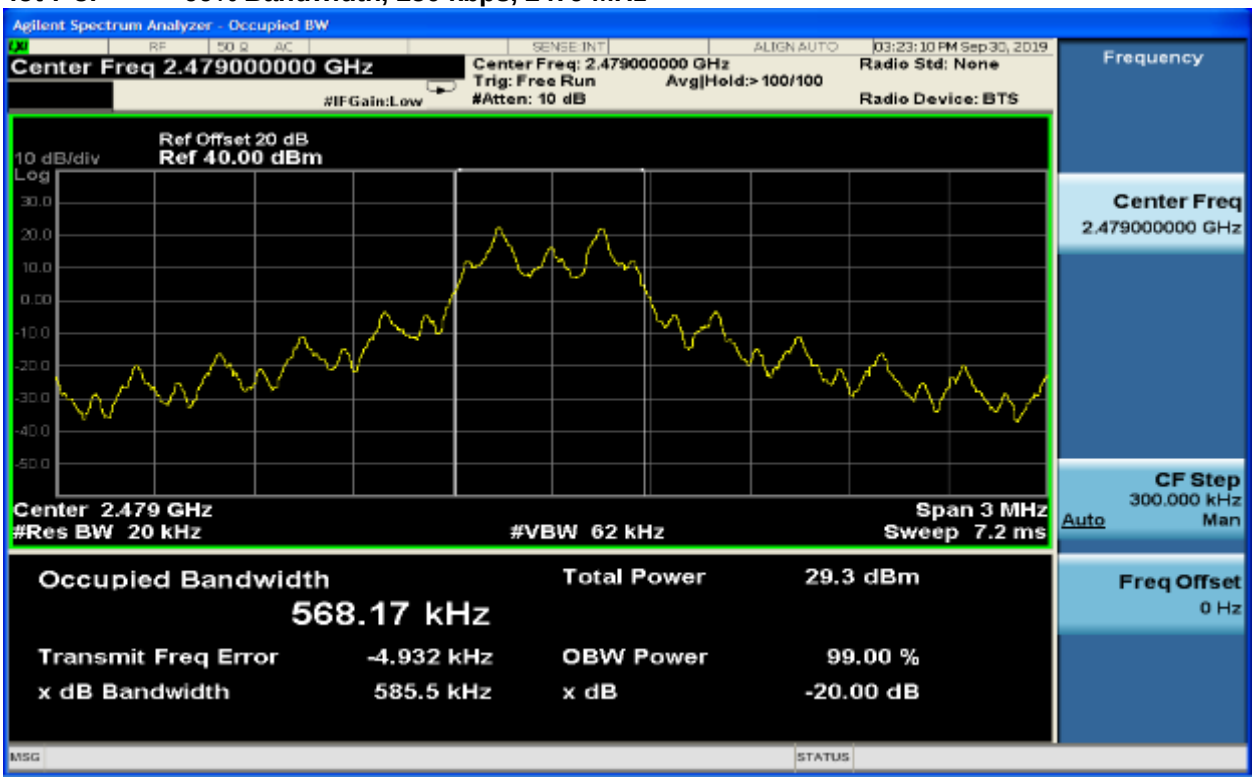
Plot 7-1: 99% Bandwidth, 250 kbps, 2402.2 MHz



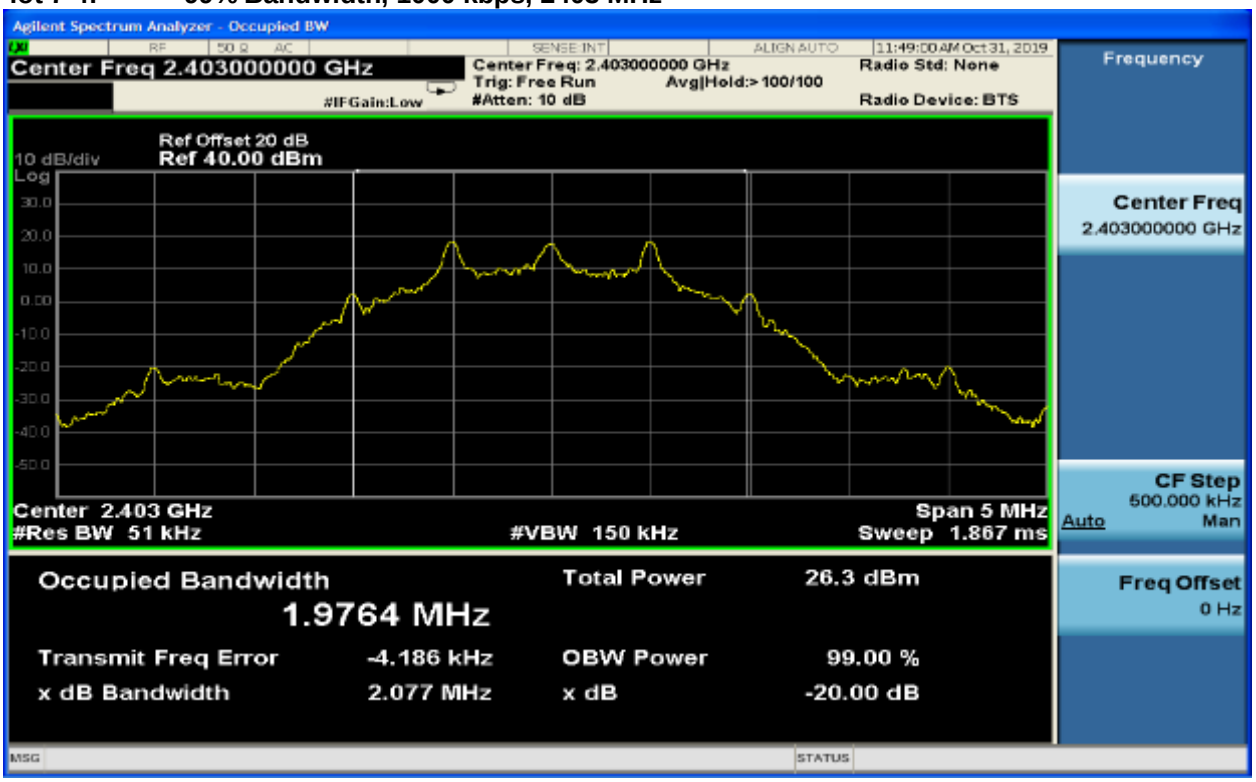
Plot 7-2: 99% Bandwidth, 250 kbps, 2440 MHz



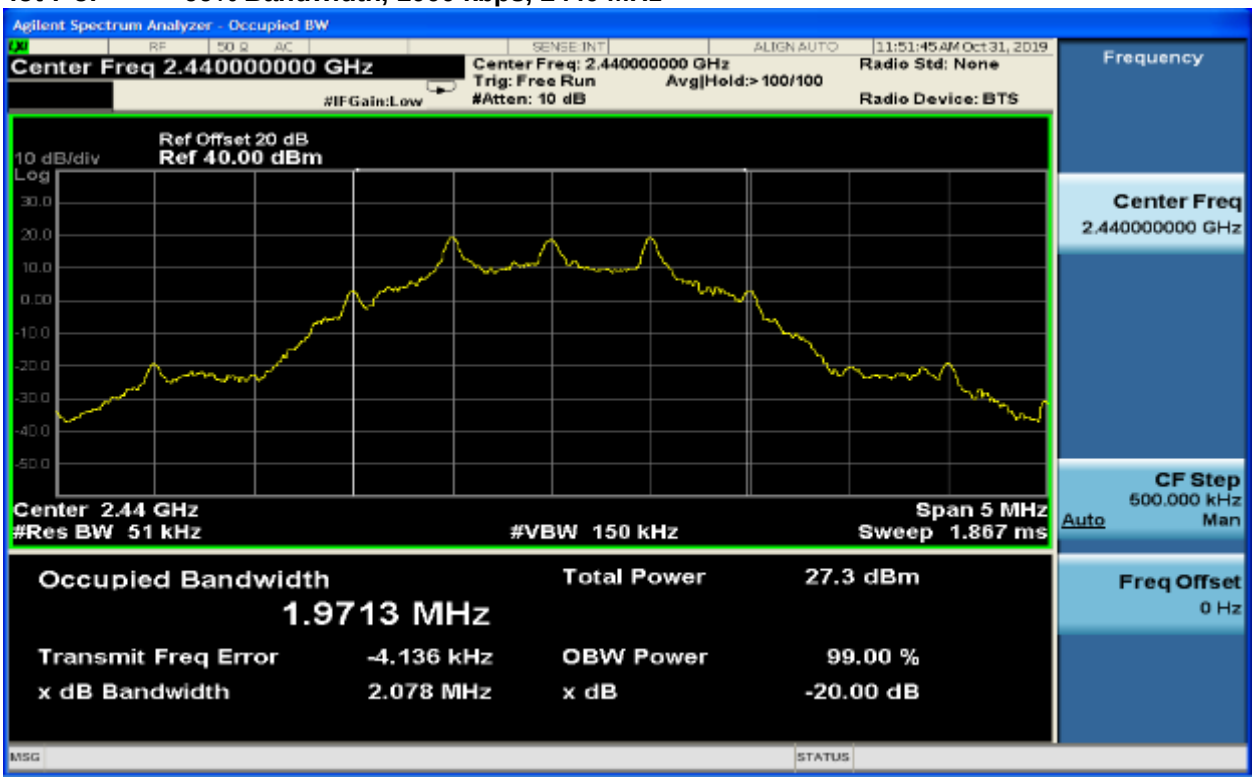
Plot 7-3: 99% Bandwidth, 250 kbps, 2479 MHz



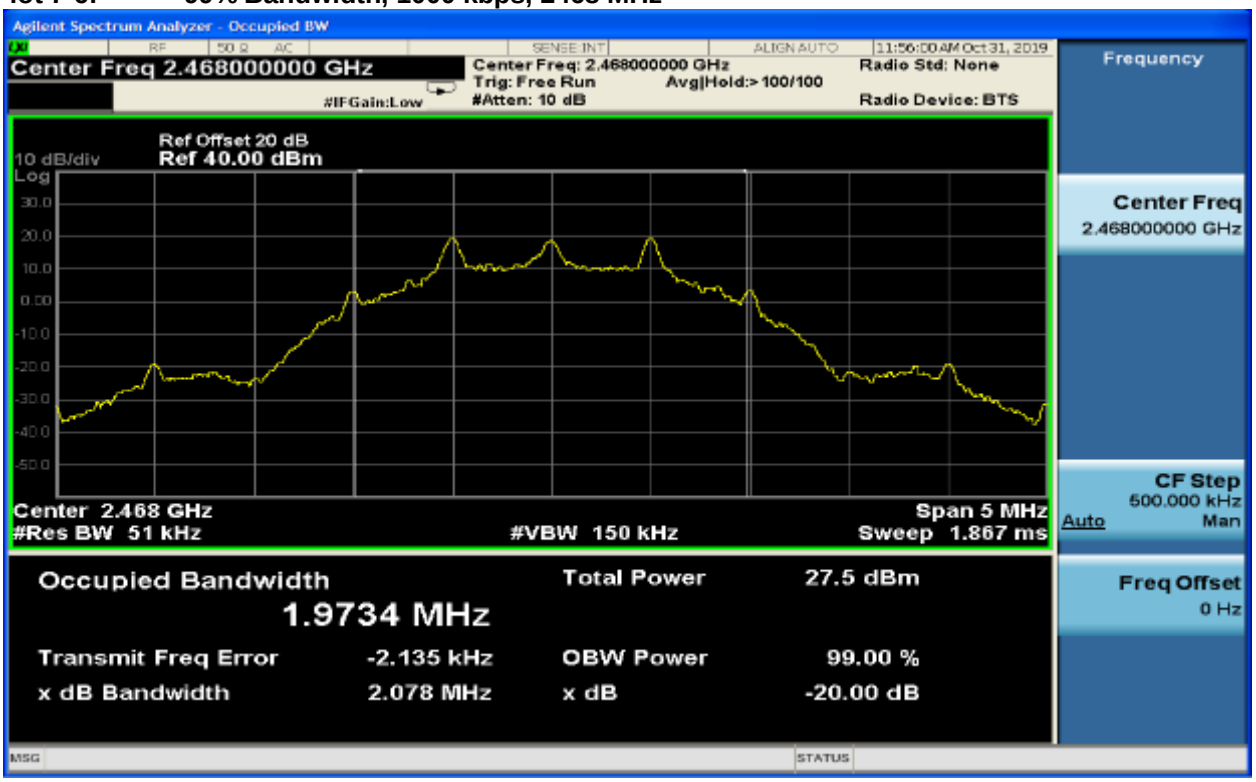
Plot 7-4: 99% Bandwidth, 1000 kbps, 2403 MHz



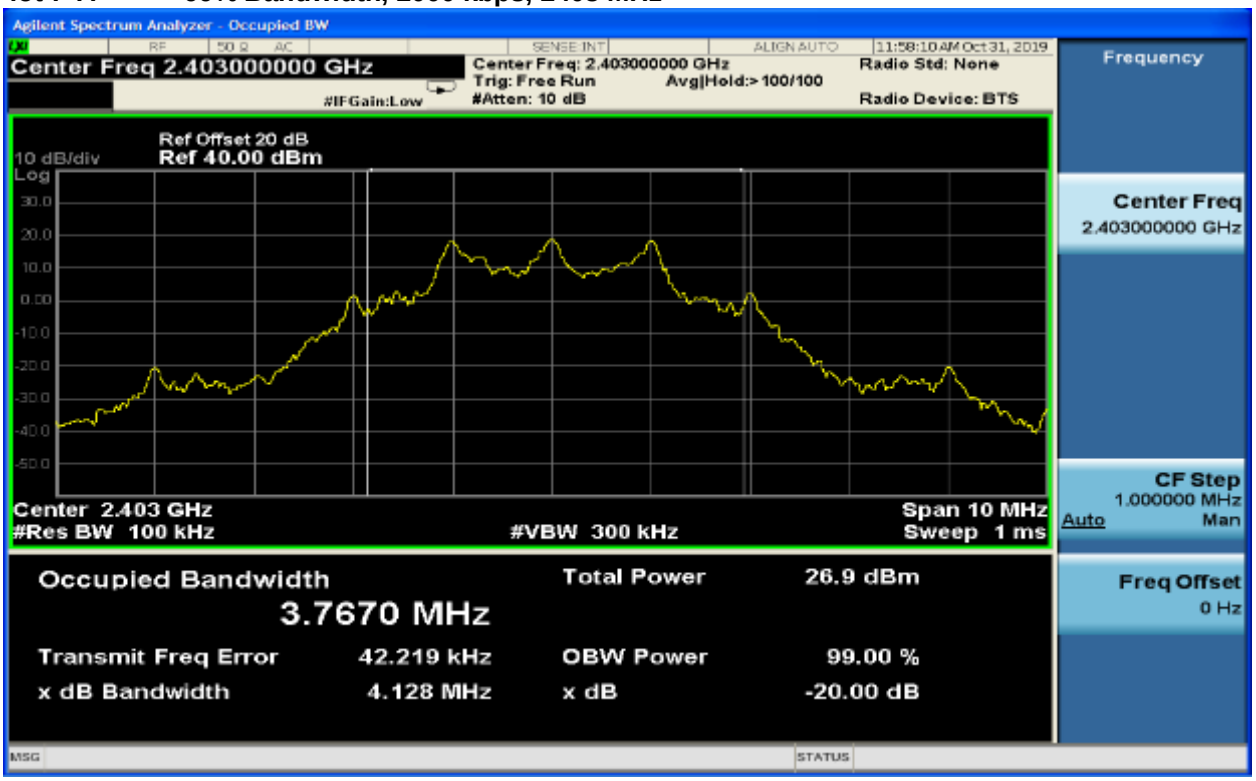
Plot 7-5: 99% Bandwidth, 1000 kbps, 2440 MHz



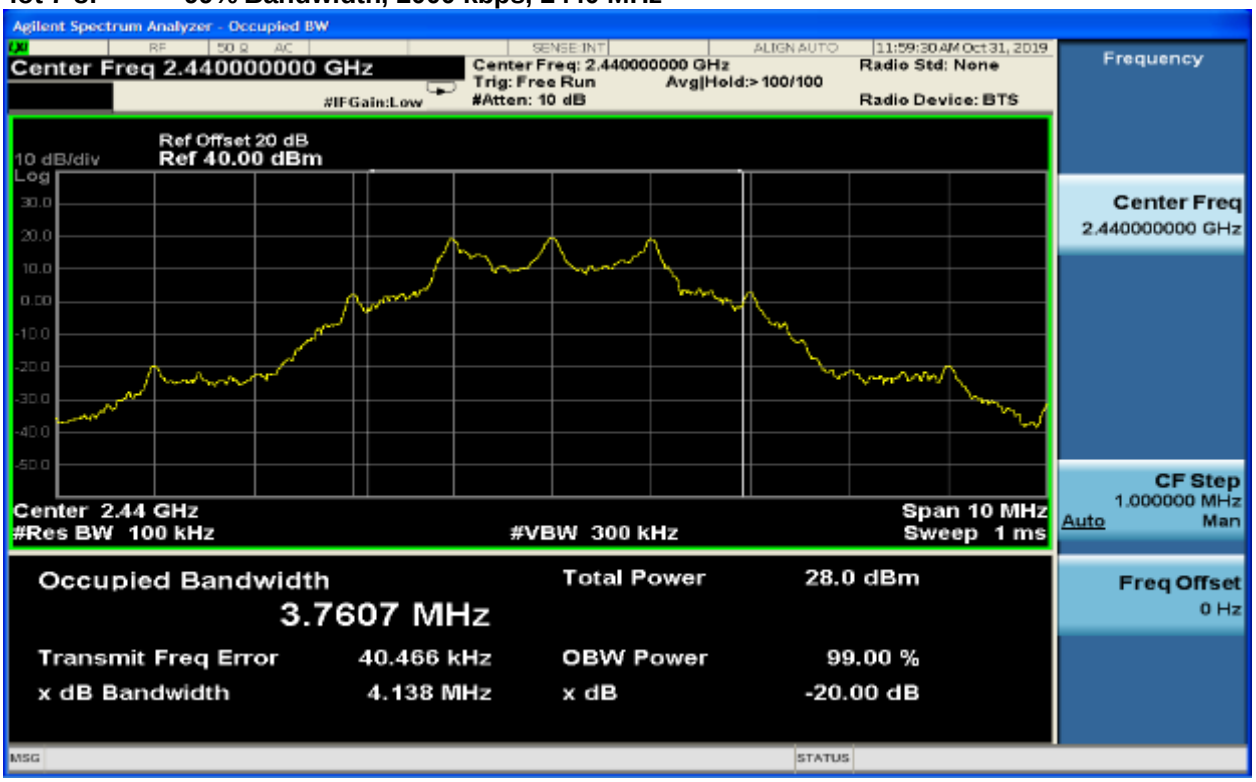
Plot 7-6: 99% Bandwidth, 1000 kbps, 2468 MHz



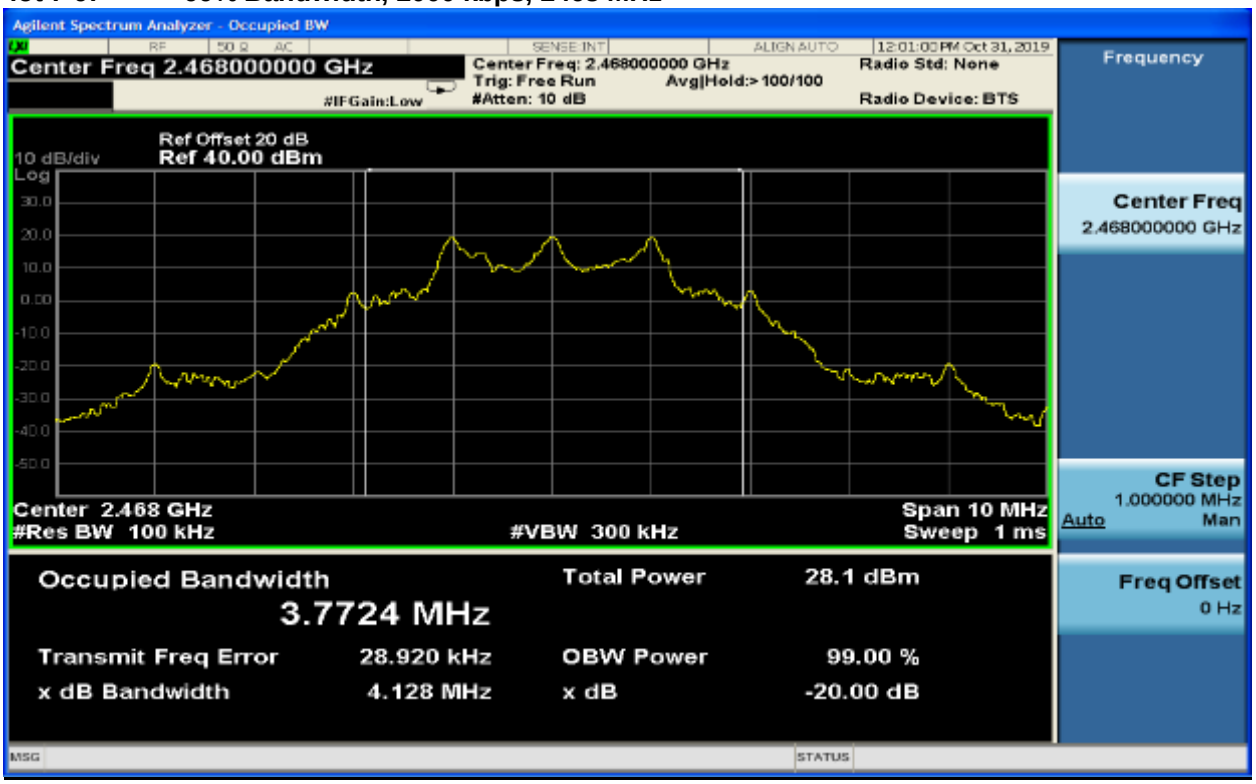
Plot 7-7: 99% Bandwidth, 2000 kbps, 2403 MHz



Plot 7-8: 99% Bandwidth, 2000 kbps, 2440 MHz



Plot 7-9: 99% Bandwidth, 2000 kbps, 2468 MHz



Result: Pass

Test Personnel:

Khue Do		September 30, 2019 October 31, 2019
EMC Test Engineer	Signature	Dates of Test

Table 7-3: 99% Bandwidth Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

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

8.1 Carrier Frequency Separation Test Procedure

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

8.2 Measurement Uncertainty

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

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

8.3 Carrier Frequency Separation Test Results

Table 8-1: Carrier Frequency Separation Environmental Factors

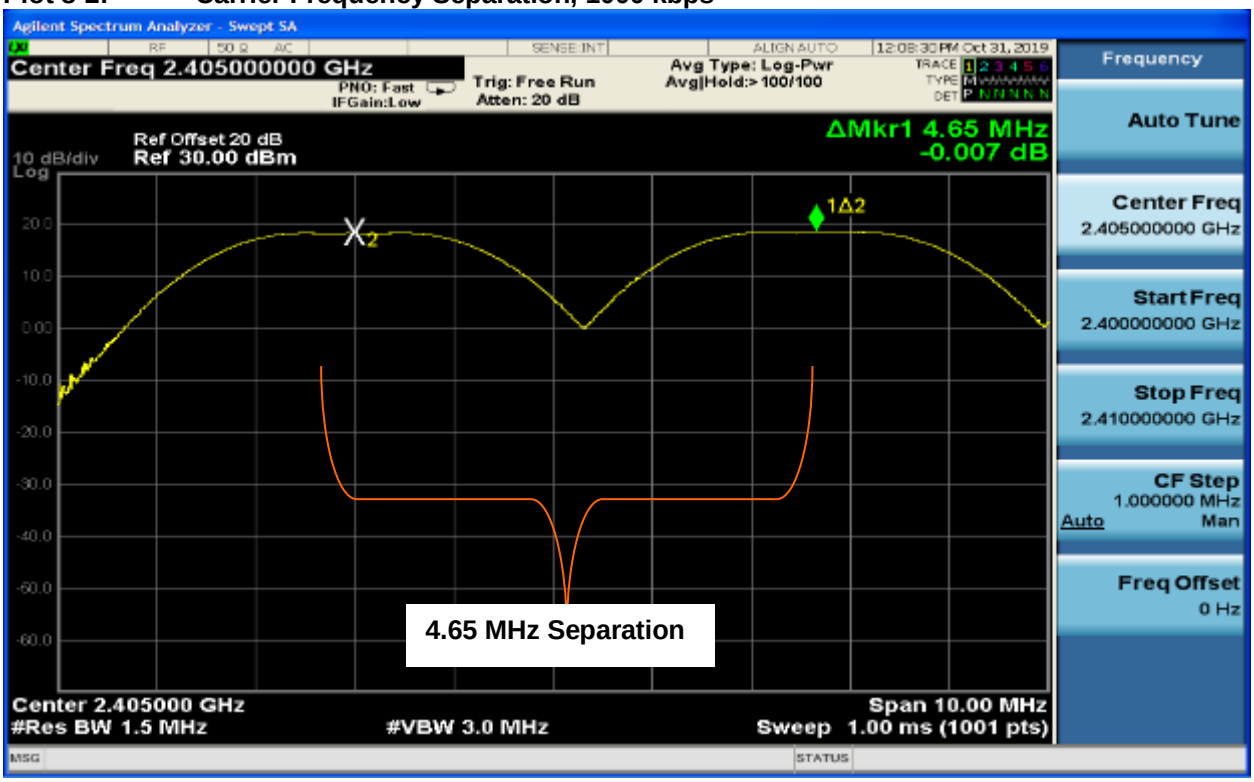
Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
09/30/2019	74.2	36	100.8
10/31/2019	73.2	26	100.8

Table 8-2: Carrier Frequency Separation Test Data

Rate (kbps)	Separation (MHz)	Minimum Limit (MHz)	Result (Pass / Fail)
250	2.000	0.402	Pass
1000	4.650	1.385	Pass
2000	4.650	2.759	Pass

Plot 8-1: Carrier Frequency Separation, 250 kbps

Plot 8-2: Carrier Frequency Separation, 1000 kbps



Plot 8-3: Carrier Frequency Separation, 2000 kbps

Result: Pass

Test Personnel:

Khue Do		September 30, 2019 October 31, 2019
EMC Test Engineer	Signature	Dates of Test

Table 8-3: Carrier Frequency Separation Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

9 Hopping Characteristics – FCC 15.247(a)(1)(iii); ISED RSS-247 5.1(d)

9.1 Hopping Characteristics Test Procedure

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 is used.

9.2 Measurement Uncertainty

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

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

9.3 Number of Hopping Channels Test Results

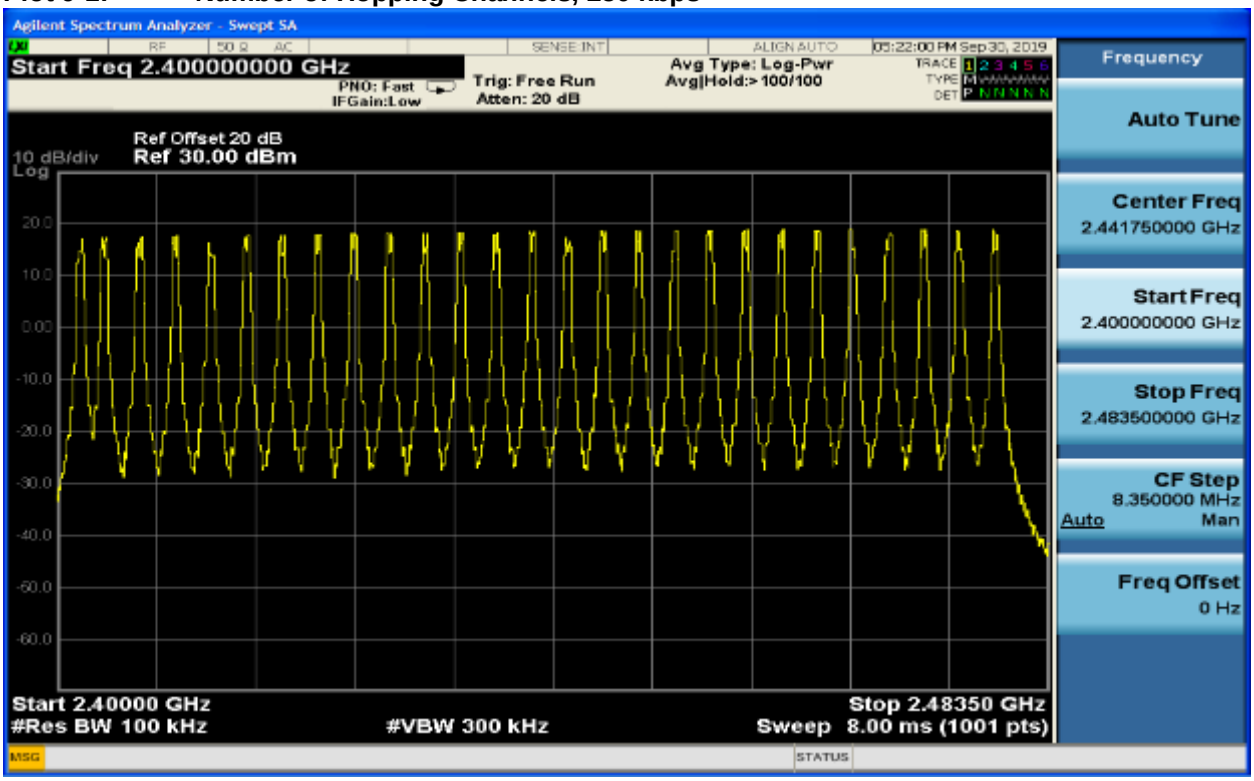
Table 9-1: Number of Hopping Channels Environmental Factors

Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
09/30/2019	74.2	36	100.8
10/31/2019	73.2	26	100.8

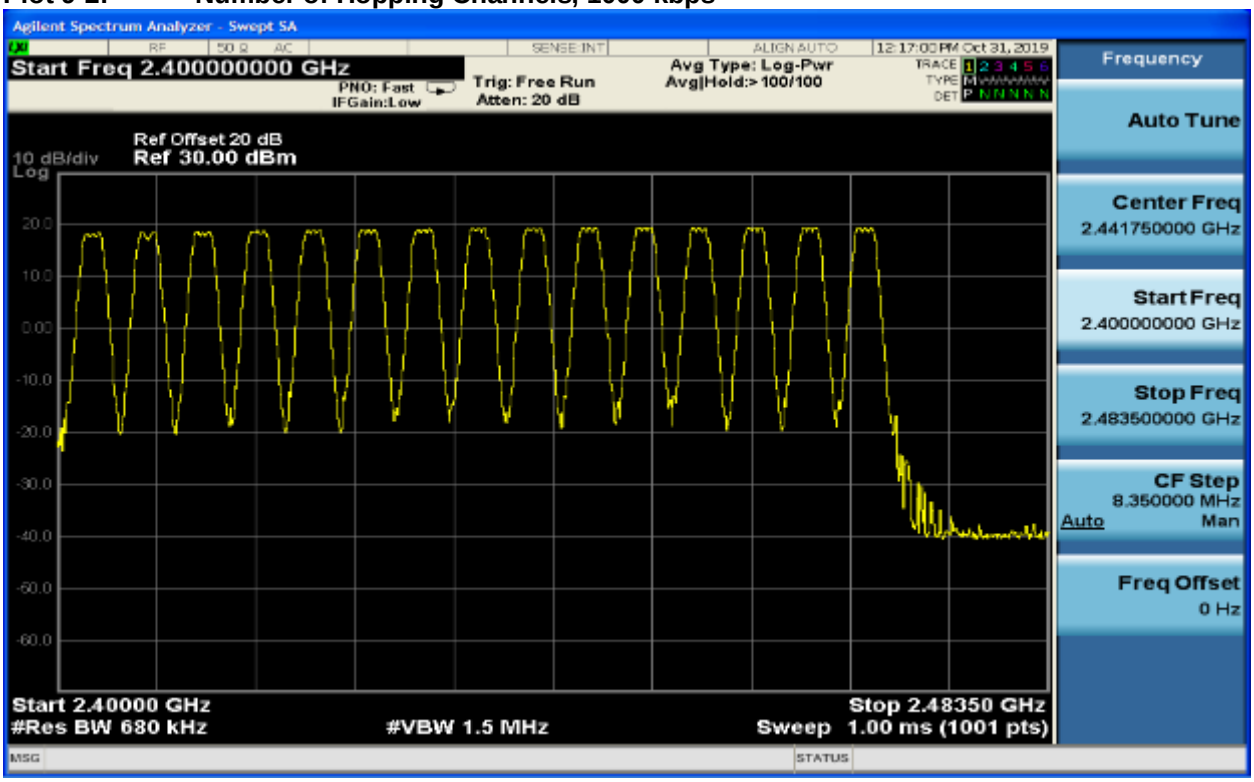
Table 9-2: Number of Hopping Channels Test Data

Rate (kbps)	# of Channels (N)	Minimum Limit (N)	Result (Pass / Fail)
250	27	15	Pass
1000	15	15	Pass
2000	15	15	Pass

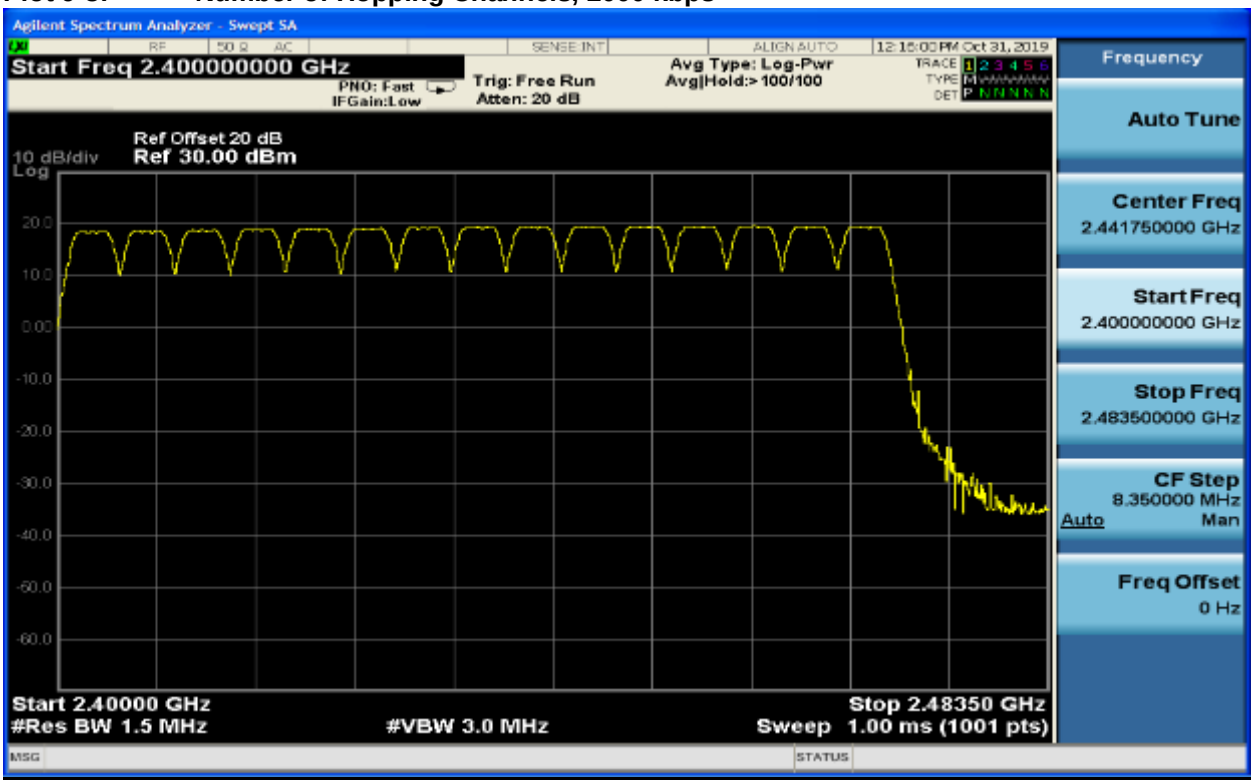
Plot 9-1: Number of Hopping Channels, 250 kbps



Plot 9-2: Number of Hopping Channels, 1000 kbps



Plot 9-3: Number of Hopping Channels, 2000 kbps



Result: Pass

Test Personnel:

Khue Do		September 30, 2019 October 31, 2019
EMC Test Engineer	Signature	Dates of Test

Table 9-3: Number of Hopping Channels Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

9.4 Average Time of Occupancy

The spectrum analyzer gate function was used to determine the pulse width using the gate start and stop times, with a zero span at 2441 MHz to capture a pulse from the device under test. The delta response was used to measure the dwell time for this pulse. The sweep was then set to single sweep for 31.6 s.

The number of pulses in 31.6 s varied depending on the packet type.

The average time of occupancy (ATO) in the above period (31.6 s) is equal to the number of pulses multiplied by the dwell time, which meets the limit as defined by 15.247(a)(1)(iii) of 0.4 seconds.

9.5 Average Time of Occupancy Test Results

Table 9-4: ATO Environmental Factors

Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
09/30/2019	74.2	36	100.8
10/31/2019	73.2	26	100.8

Table 9-5: ATO Test Data

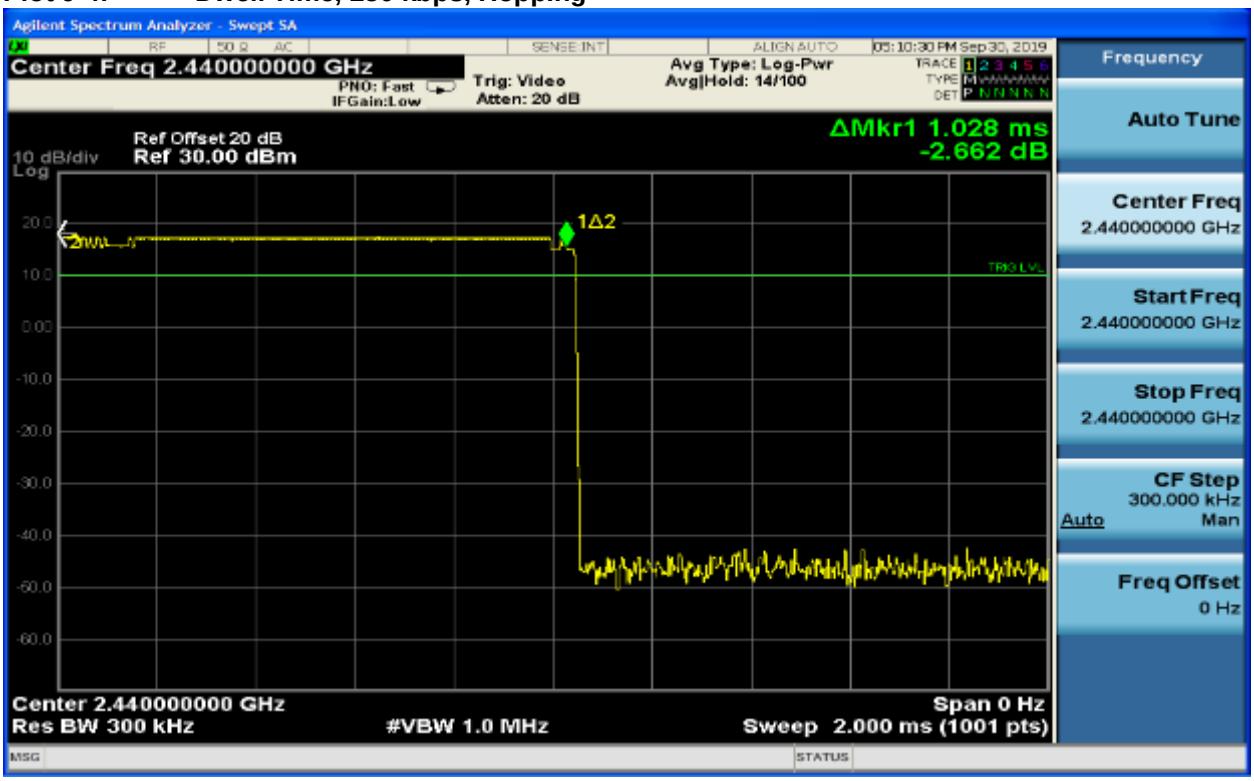
Rate (kbps)	Dwell (ms)	# of Pulses in Window (N)	ATO (ms)	Limit (ms)	Result (Pass / Fail)
250	1.028	4	4.1	400.0	Pass
1000	0.280	40	11.2	400.0	Pass
2000	0.150	47	7.1	400.0	Pass

Note: Window = Number of channels * 400 ms

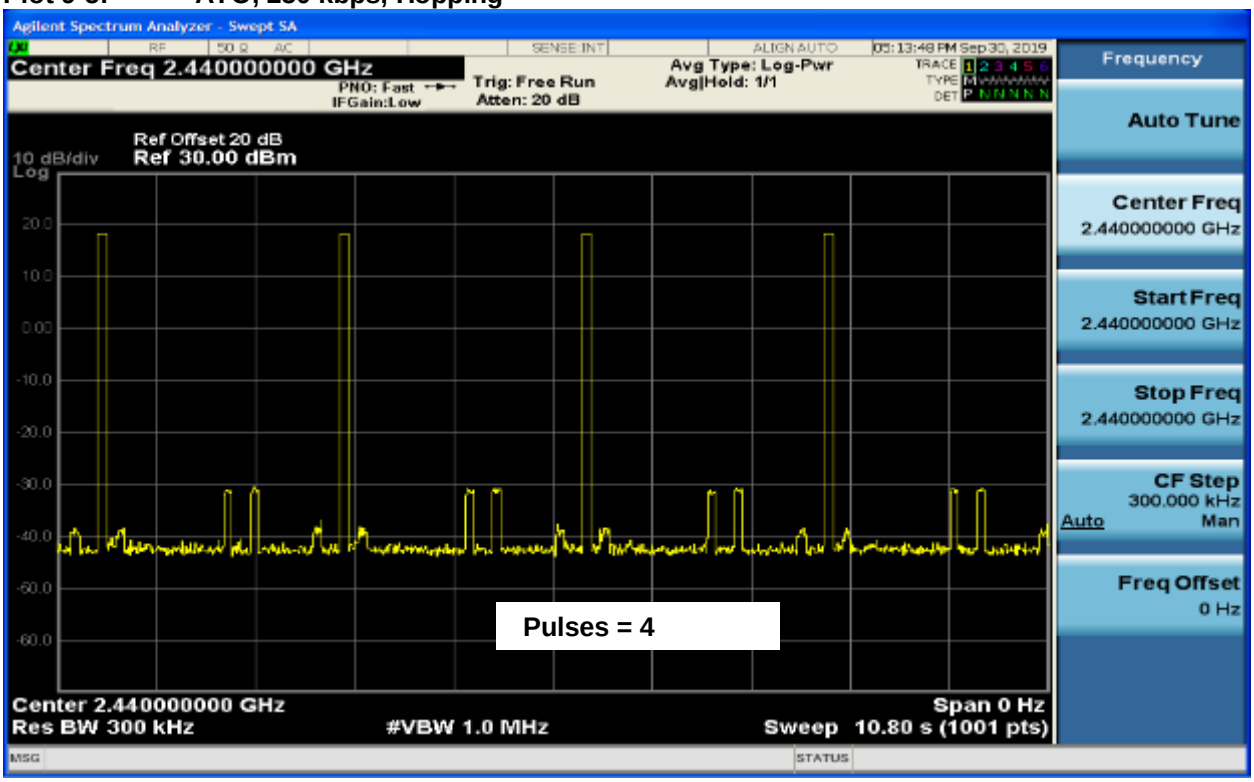
Window = 27 * 400 ms = 10.8 s for 250 kbps

Window = 15 * 400 ms = 6.0 s for 1 Mbps and 2 Mbps

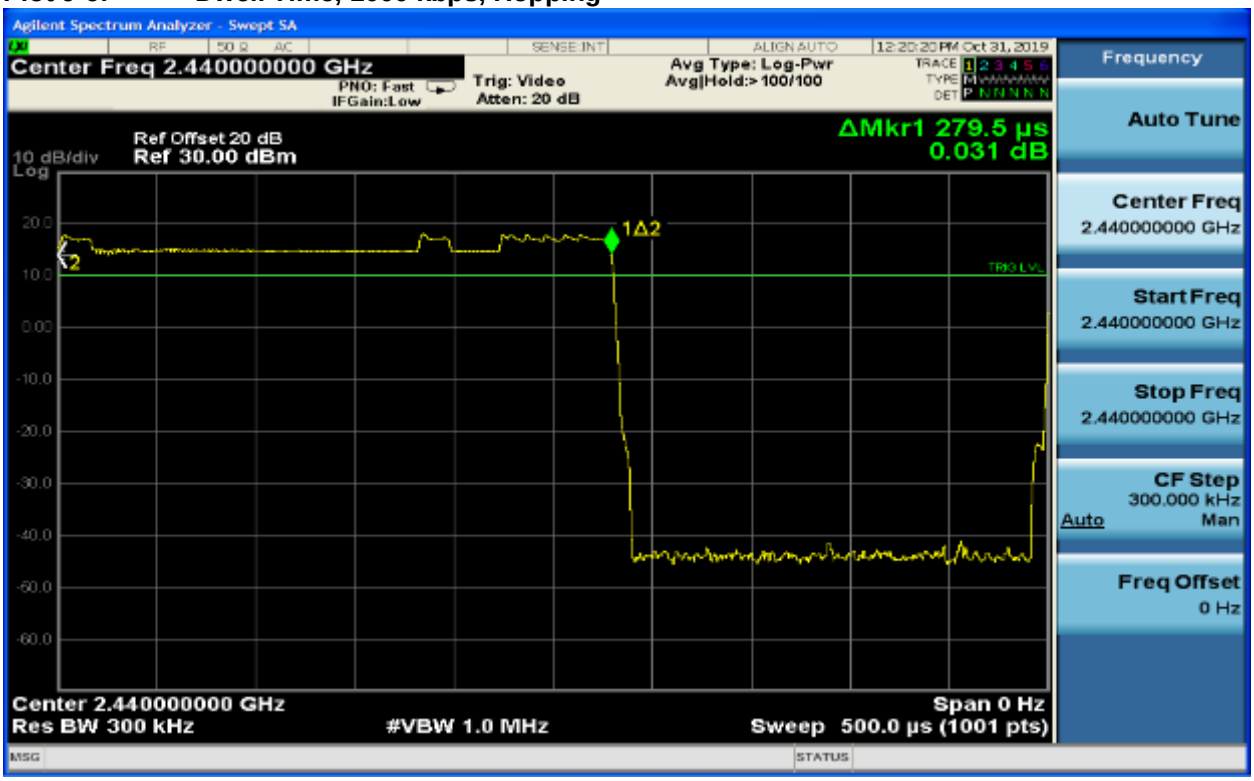
Plot 9-4: Dwell Time, 250 kbps, Hopping



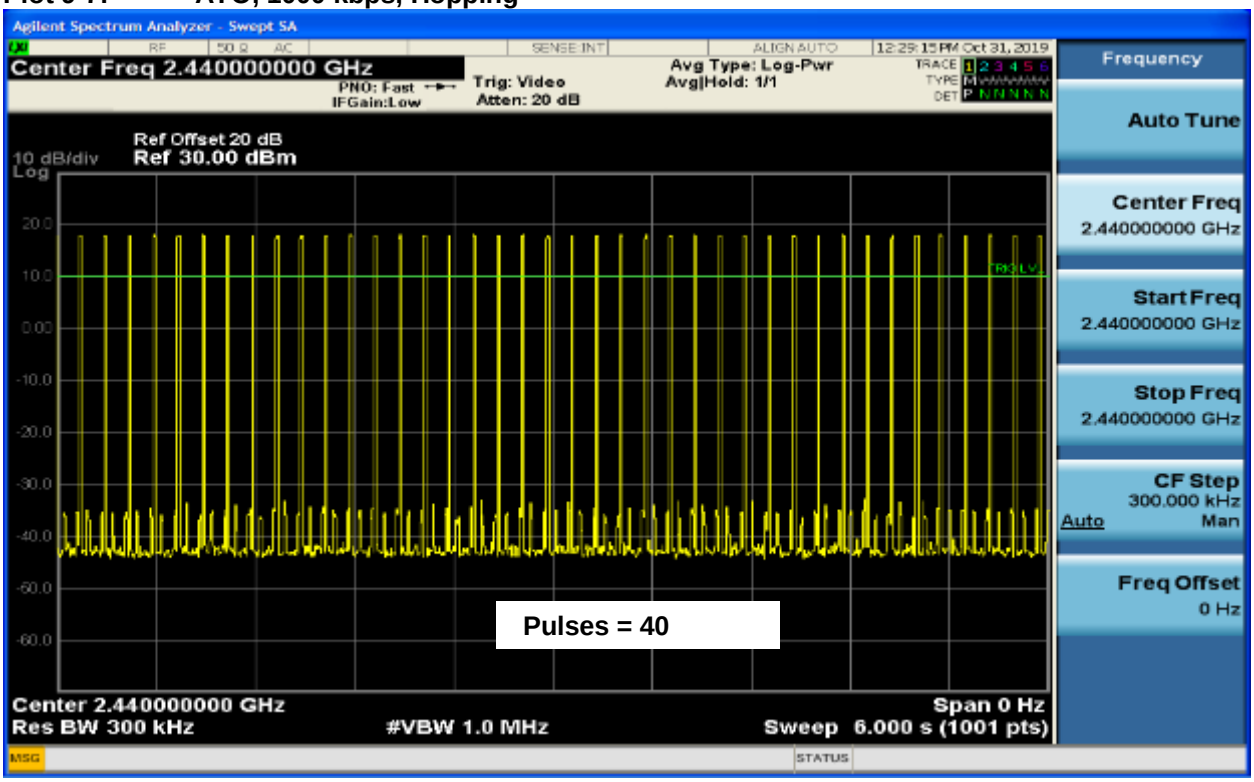
Plot 9-5: ATO, 250 kbps, Hopping



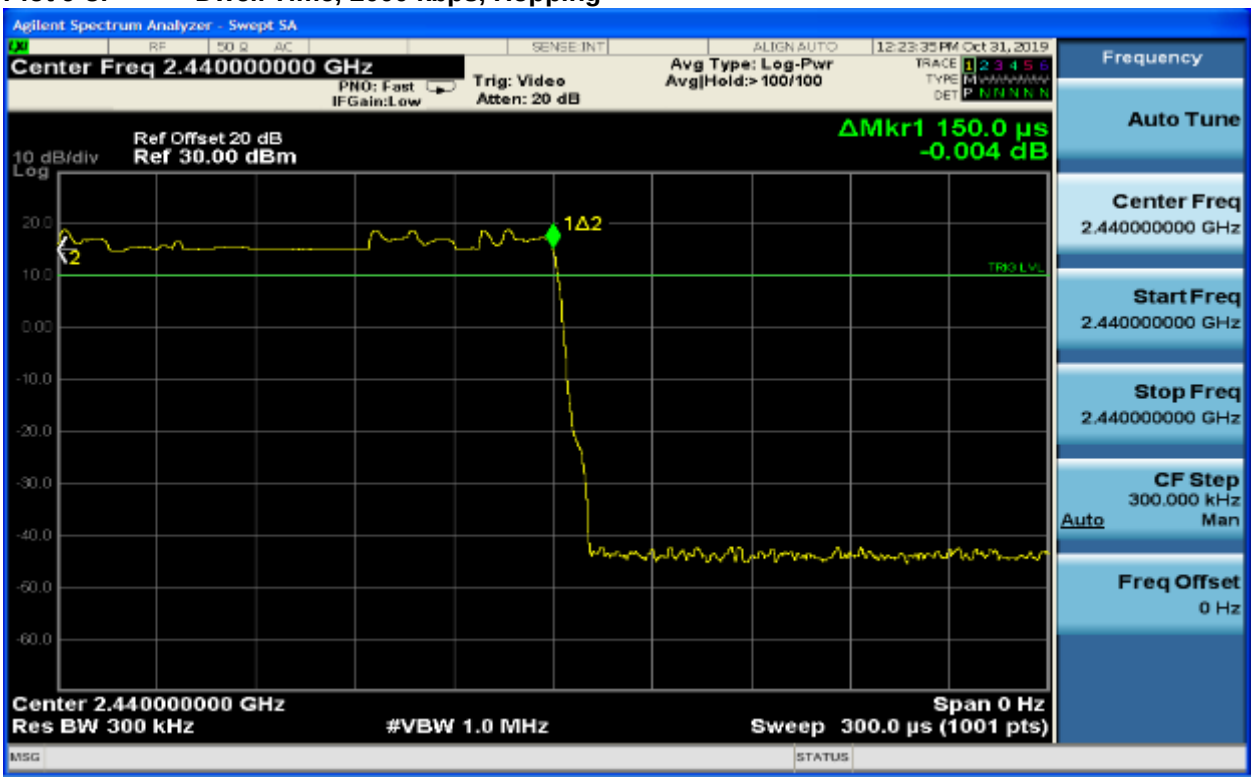
Plot 9-6: Dwell Time, 1000 kbps, Hopping



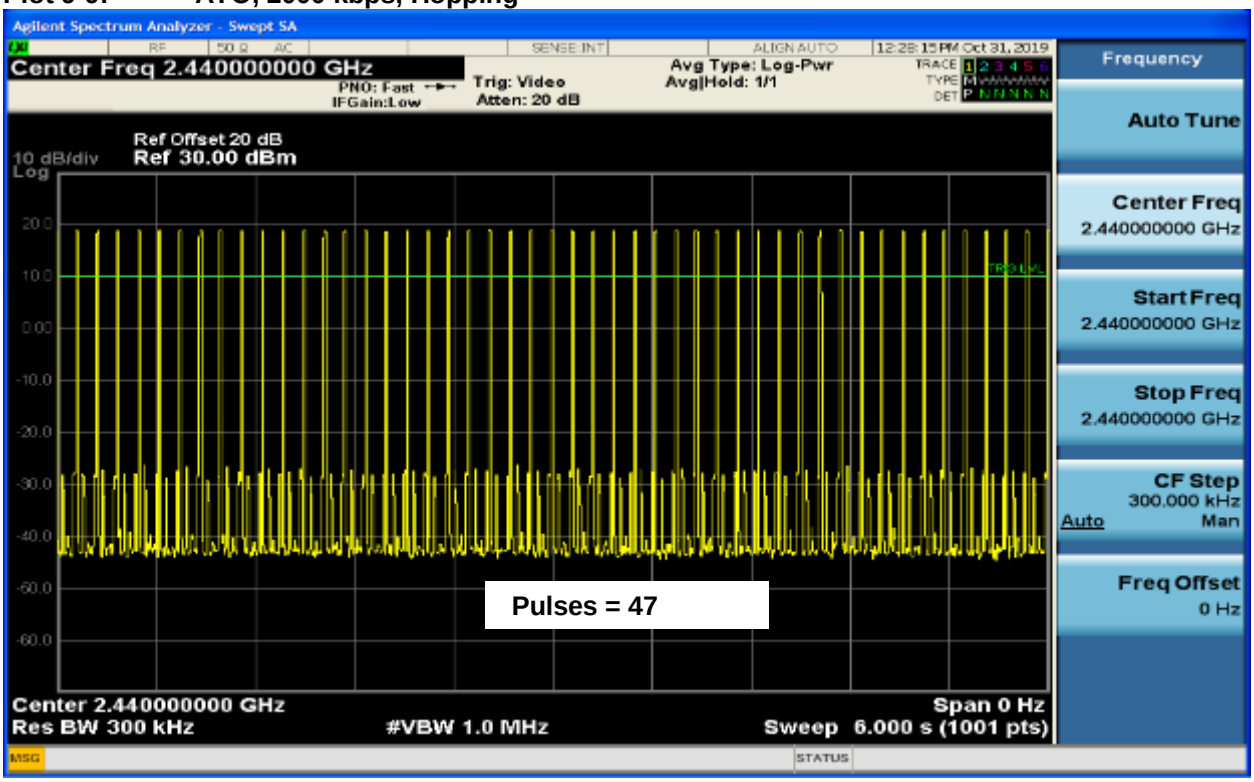
Plot 9-7: ATO, 1000 kbps, Hopping



Plot 9-8: Dwell Time, 2000 kbps, Hopping



Plot 9-9: ATO, 2000 kbps, Hopping



Result: Pass

Test Personnel:

Khue Do		September 30, 2019 October 31, 2019
EMC Test Engineer	Signature	Dates of Test

Table 9-6: ATO Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901583	Agilent Technologies	EXA N9010A	Signal Analyzer (9 kHz – 26.5 GHz)	MY51250846	02/06/2021

10 Duty Cycle

The EUT was set to hopping mode for normal use operation. The spectrum analyzer gate function was used to determine the pulse width using the gate start and stop times, with a zero span to capture a pulse from the device under test. The sweep was then set to single sweep for 100 ms.

The Duty Cycle in the above period (100 ms) is equal to the number of pulses multiplied by the dwell time, then divided by 100 ms. Please refer to Section 9 for dwell time.

10.1 Measurement Uncertainty

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

Duty Cycle: $\pm 1.0 * 10^{-6}$ Hz

10.2 Duty Cycle Test Results

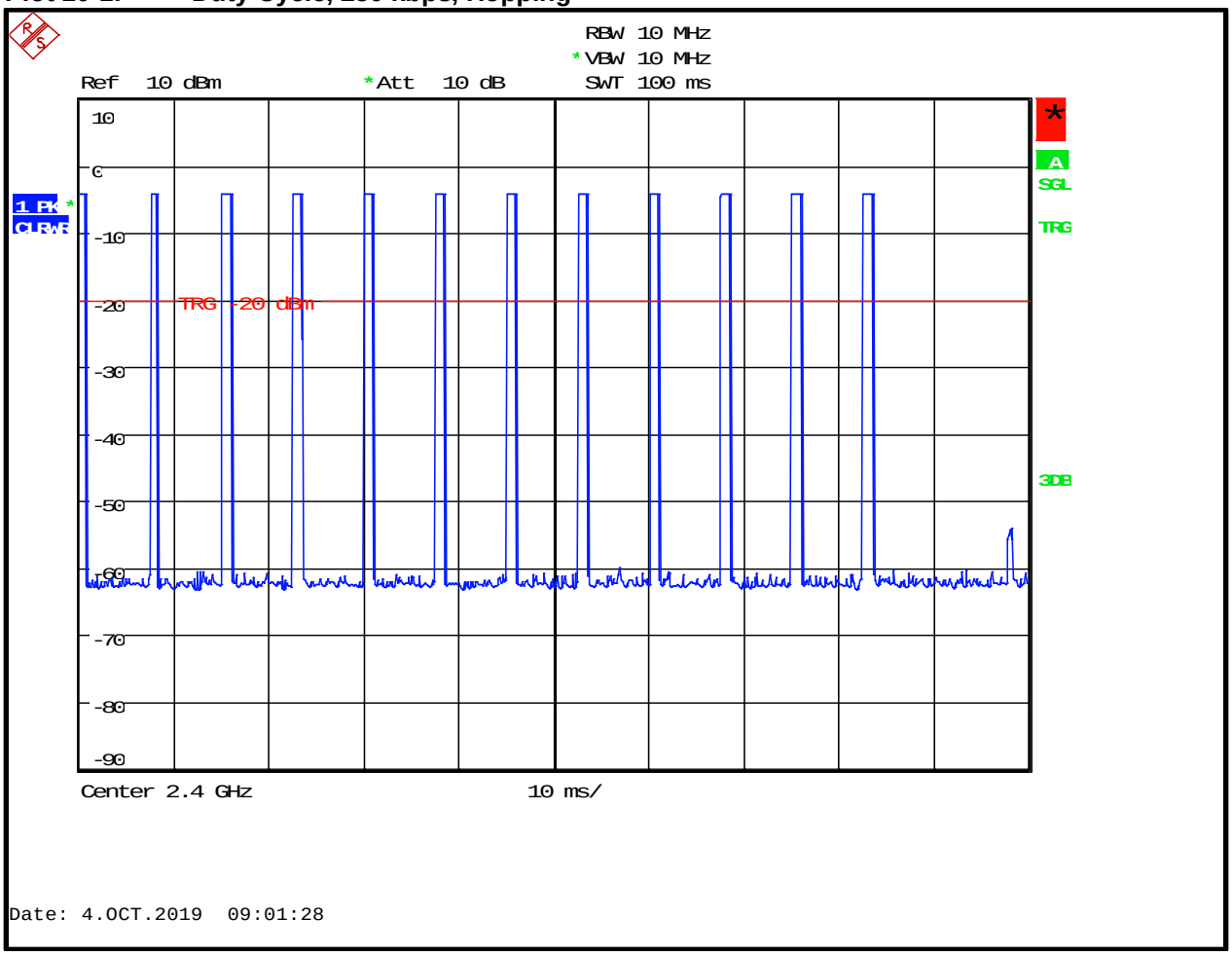
Table 10-1: Duty Cycle Environmental Factors

Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
10/04/2019	75.5	39	100.8
10/31/2019	73.2	26	100.8

Table 10-2: Duty Cycle Data

Rate (kbps)	Number of Pulses (N)	Duty Cycle (%)
250	12	0.123
1000	24	0.067
2000	24	0.036

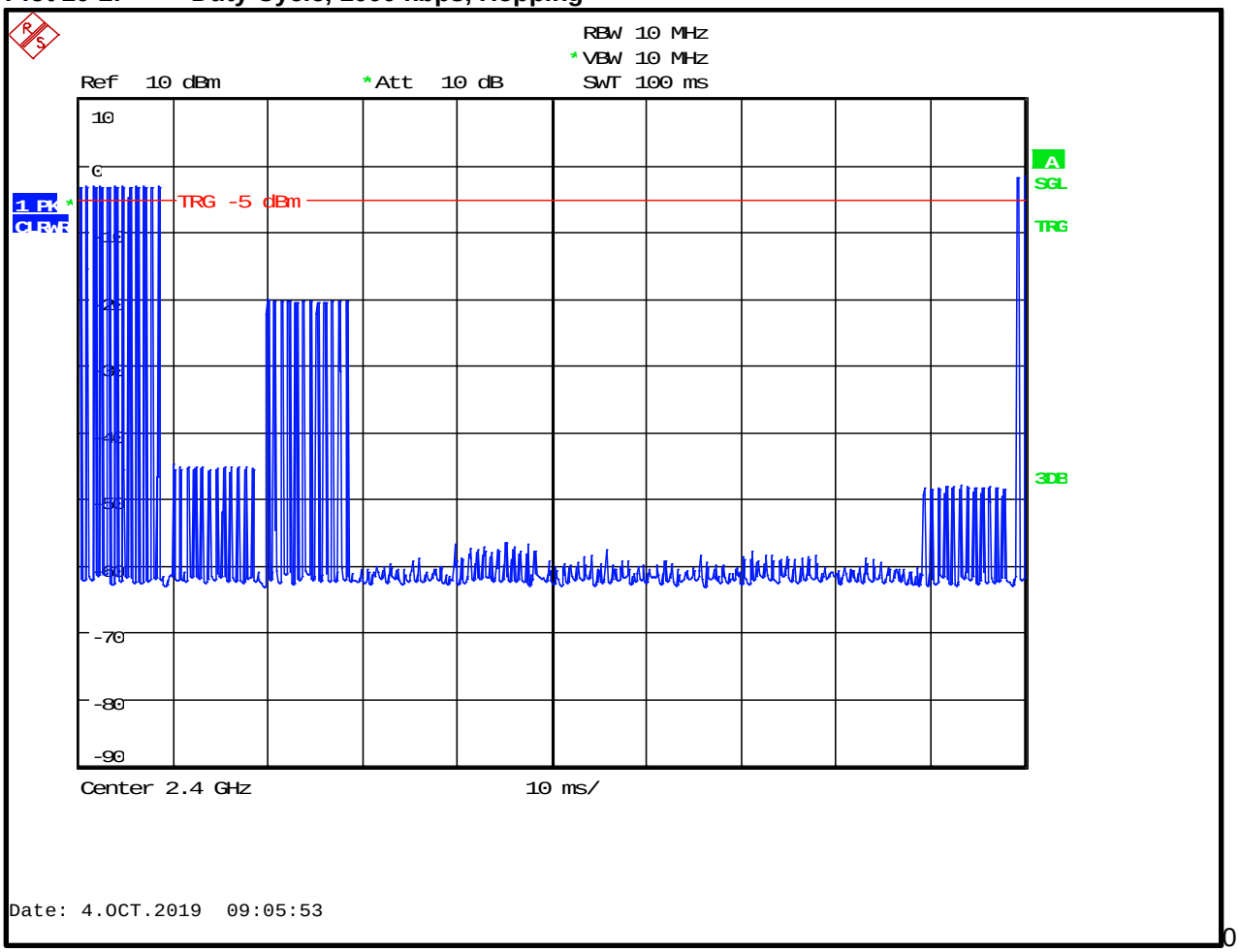
Plot 10-1: Duty Cycle, 250 kbps, Hopping



Number of Pulses: 12

Duty Cycle = (1.028 ms * 12) / 100 ms = 0.123

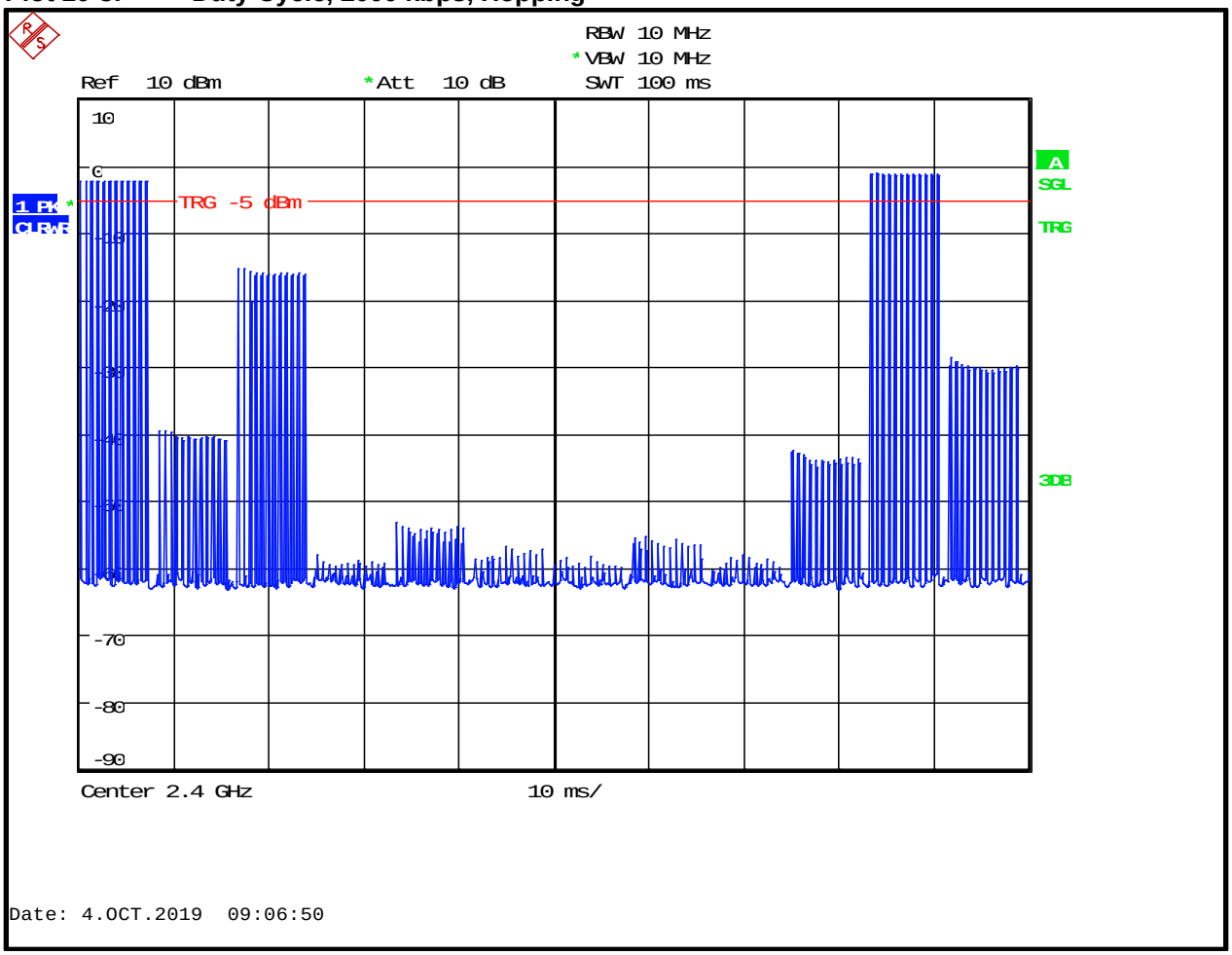
Plot 10-2: Duty Cycle, 1000 kbps, Hopping



Number of Pulse = 24

Duty Cycle = (0.280 ms * 24) / 100 ms = 0.067

Plot 10-3: Duty Cycle, 2000 kbps, Hopping



Number of Pulse = 24

Duty Cycle = (0.150 ms * 24) / 100 ms = 0.036

Test Personnel:

Khue Do		October 4, 2019 October 21, 2019
EMC Test Engineer	Signature	Dates of Test

Table 10-3: Duty Cycle Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901521	MA/COM	2082-6174-20	Attenuator, 20 dB (DC – 4 GHz)	N/A	08/07/2020
901581	Rohde & Schwarz	FSU 1166.1660.50	Spectrum Analyzer (20 Hz – 50 GHz)	200106	04/26/2021

11 AC Conducted Emissions – FCC 15.207; ISED RSS-Gen 8.8

The power line conducted emission measurements were performed in a type shielded enclosure. The EUT was placed on a wooden table. Power was fed to the EUT through a 50-ohm/50 microhenry Line Impedance Stabilization Network (LISN). The EUT LISN was fed power through an AC filter box mounted on 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's auxiliary equipment. This peripheral LISN was also fed AC power.

The spectrum analyzer was connected to the AC line through an isolation transformer. The 50-ohm output of the EUT LISN was connected to the spectrum analyzer input through a Solar 100 kHz high-pass filter. The filter is used to prevent overload of the spectrum analyzer from noise below 100 kHz. Conducted emission levels were measured on each current-carrying line with the spectrum analyzer operating in the CISPR quasi-peak mode (or peak mode if applicable). The analyzer's 6 dB bandwidth was set to 9 kHz. Video filter less than 10 times the resolution bandwidth is not used. Average measurements are performed in linear mode using a 10 kHz resolution bandwidth, a 1 Hz video bandwidth, by increasing the sweep time in order to obtain a calibrated measurement. The emission spectrum was scanned from 150 kHz to 30 MHz.

11.1 Test Limits

Table 11-1: Conducted Emission Limits per 15.207

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

11.2 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

11.3 Conducted Emissions Test Data

Table 11-2: Conducted Emissions Environmental Factors

Date	Temperature (°F)	Humidity (%)	Atmospheric Pressure (kPa)
10/10/2019	73.4	31	100.8

Plot 11-1: Conducted Emissions – Phase

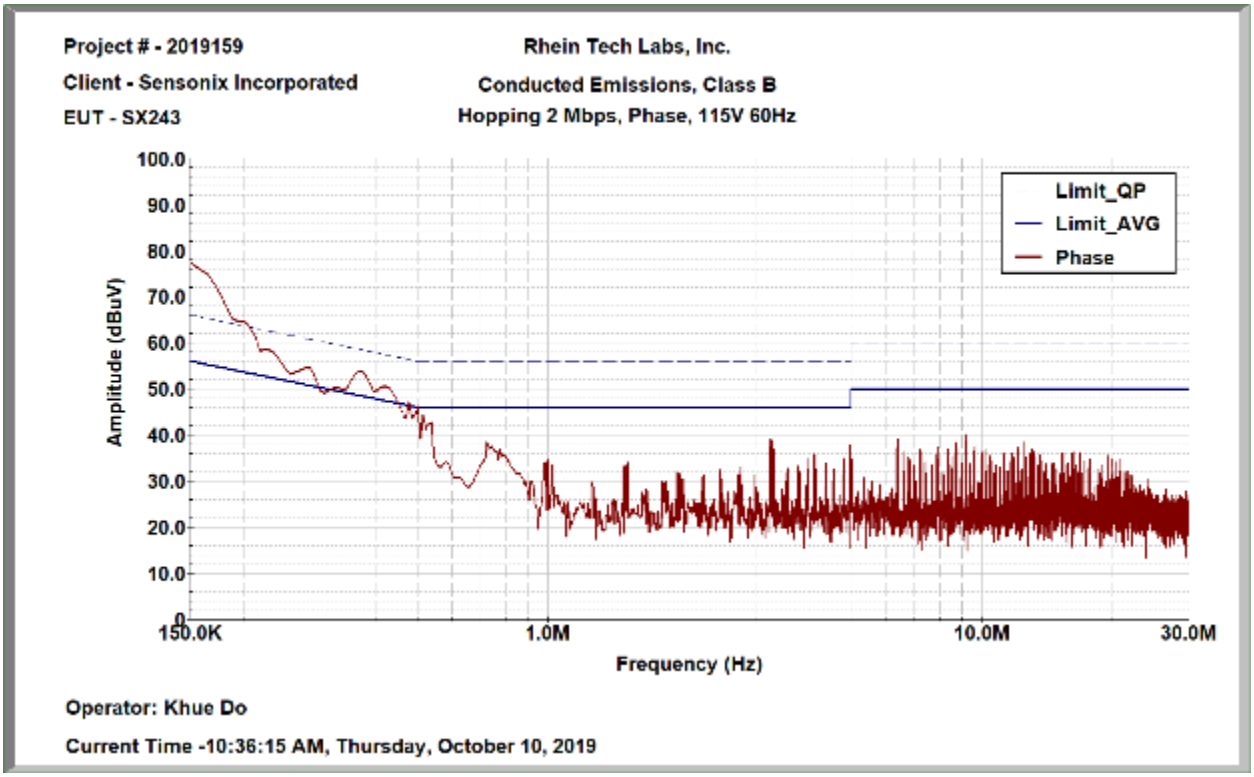


Table 11-3: Conducted Emissions Data, Phase

Frequency (MHz)	Detector	Raw Level (dBµV/m)	SCF (dB/m)	Corrected (dBµV/m)	Limit (dBµV/m)	Margin (dB)
0.150	PK	47.1	0.1	47.2	66.0	-18.8
0.150	AVG	25.3	0.1	25.4	56.0	-30.6

Plot 11-2: Conducted Emissions – Neutral

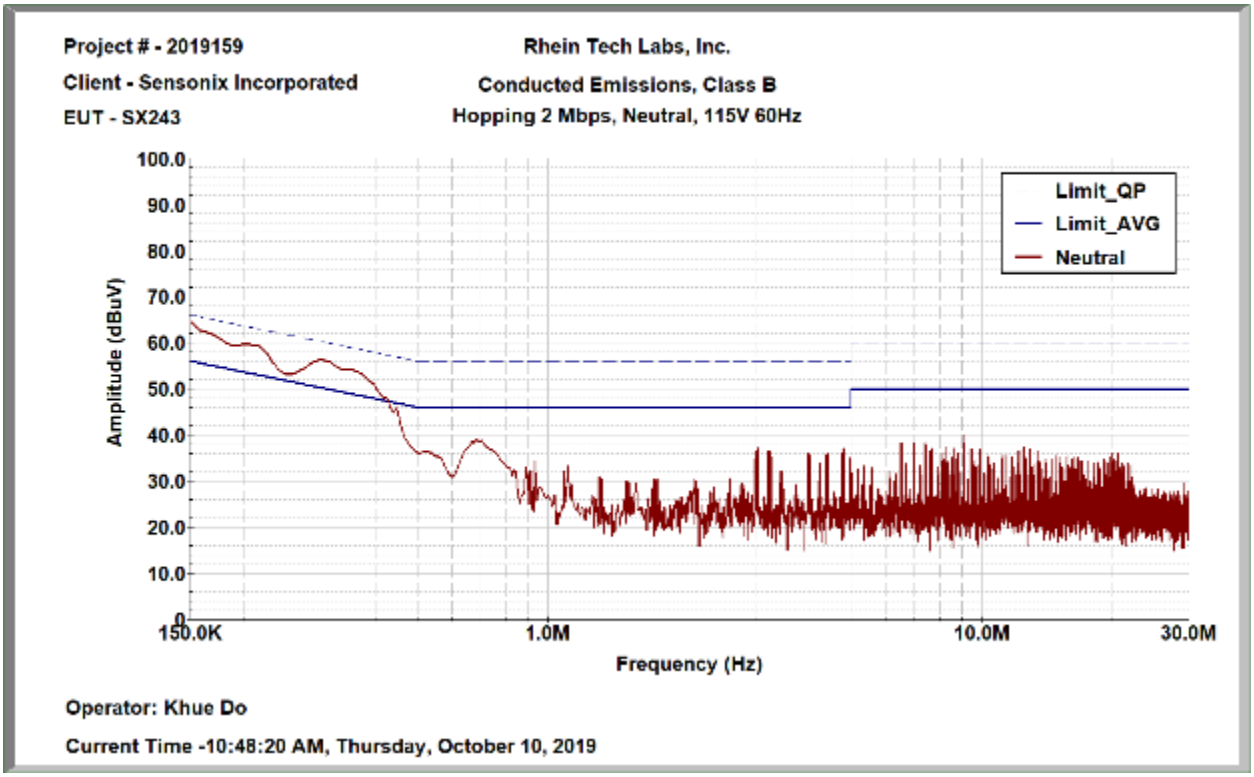


Table 11-4: Conducted Emissions Data, Neutral

Frequency (MHz)	Detector	Raw Level (dBµV/m)	SCF (dB/m)	Corrected (dBµV/m)	Limit (dBµV/m)	Margin (dB)
0.150	PK	47.4	0.1	47.5	66.0	-18.5
0.150	AVG	25.4	0.1	25.5	56.0	-30.5

Result: Pass

Test Personnel:

Khue Do		October 10, 2019
EMC Test Engineer	Signature	Date of Test

Table 11-5: Conducted Emissions Test Equipment

RTL Asset #	Part Type	Manufacturer	Model	Serial Number	Calibration Due Date
900339	Quasi-Peak Adapter	Hewlett Packard	85650A	2521A00743	04/24/2020
900728	Filter	Solar	Type 8130-7.0	N/A	04/24/2020
900930	Spectrum Analyzer Display	Hewlett Packard	85662A	3144A20839	N/A
900931	Spectrum Analyzer (100 Hz – 22 GHz)	Hewlett Packard	8566B	3138A07771	04/24/2020
901083	16A LISN	AFJ International	LS16/110VAC	16010020080	02/13/2021
N/A	Test software	ETS-Lindgren	TILE! 7.1.3.20	N/A	N/A

12 Radiated Emissions – FCC 15.209; ISED RSS-247 5.5; RSS-Gen 8.9, 8.10

12.1 Radiated Emissions Measurements

Before final radiated emissions measurements were made on the OATS, the EUT was scanned indoors at both one and three meter distances. This was done in order to determine its emission spectrum signal. 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 emission measurements on the OATS, at each frequency, in order to ensure that maximum emission amplitudes were measured. Final radiated emissions measurements were made on the OATS at a distance of 3 meters. The EUT was placed on a non-conductive turntable. At each frequency, the EUT was rotated 360°, and the antenna was raised and lowered from 1 to 4 meters in order to determine the emissions maximum levels. Measurements were taken using both horizontal and vertical antenna polarization. The spectrum analyzer's 6 dB bandwidth was set to 120 kHz for frequencies below 1 GHz and 1 MHz for frequencies above 1 GHz. No video filter less than 10 times the resolution bandwidth was used. The highest emission amplitudes relative to the appropriate limit were measured and recorded in this report.

12.2 Test Limits

Table 12-1: Radiated Emission Limits per 15.209

Frequency (MHz)	Field Strength (µV/m)	Measure Distance (m)
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

Notes: 100 µV/m ≈ 40.0 dBµV/m 150 µV/m ≈ 43.5 dBµV/m

200 µV/m ≈ 46.0 dBµV/m 500 µV/m ≈ 54.0 dBµV/m

12.3 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

12.4 Field Strength Calculations

The field strength is calculated by adding the antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FI(dBµV/m) = SAR(dBµV) + SCF(dB/m)
FI = Field Intensity
SAR = Spectrum Analyzer Reading
SCF = Site Correction Factor

The Site Correction Factor (SCF) used in the above equation is determined empirically, and is expressed in the following equation:

SCF(dB/m) = - PG(dB) + AF(dB/m) + CL(dB)

SCF = Site Correction Factor
PG = Pre-amplifier Gain
AF = Antenna Factor
CL = Cable Loss

The field intensity in microvolts per meter can then be determined according to the following equation:

$$FI(\mu V/m) = 10^{FI(dB\mu V/m)/20}$$

For example, assume a signal at a frequency of 125 MHz has a received level measured as 49.3 dBµV. The total Site Correction Factor (antenna factor plus cable loss minus preamplifier gain) for 125 MHz is -11.5 dB/m. The actual radiated field strength is calculated as follows:

49.3 dBµV – 11.5 dB = 37.8 dBµV/m

$$10^{37.8/20} = 10^{1.89} = 77.6\ \mu V/m$$

12.5 Radiated Emissions Test Results – Standalone Module

Table 12-2: Harmonics, 250 kbps, 2402 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4804.400	15.0	33.5	48.5	74.0	-25.5
12011.000	5.9	44.1	50.0	74.0	-24.0
19217.600	0.5	53.3	53.8	74.0	-20.2

Table 12-3: Harmonics, 250 kbps, 2402 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4804.400	13.2	33.5	46.7	54.0	-7.3
12011.000	-3.3	44.1	40.8	54.0	-13.2
19217.600	-5.4	53.3	47.9	54.0	-6.1

Table 12-4: Harmonics, 250 kbps, 2440 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4880.000	16.6	33.5	50.1	74.0	-23.9
7320.000	12.9	35.8	48.7	74.0	-25.3
12200.000	7.3	44.1	51.4	74.0	-22.6
19520.000	-3.4	53.6	50.2	74.0	-23.8

Table 12-5: Harmonics, 250 kbps, 2440 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4880.000	14.3	33.5	47.8	54.0	-6.2
7320.000	10.9	35.8	46.7	54.0	-7.3
12200.000	-0.4	44.1	43.7	54.0	-10.3
19520.000	-10.0	53.6	43.6	54.0	-10.4

Table 12-6: Harmonics, 250 kbps, 2479 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4958.000	14.6	33.7	48.3	74.0	-25.7
7437.000	7.3	35.9	43.2	74.0	-30.8
12395.000	7.0	44.2	51.2	74.0	-22.8
19832.000	-2.5	53.7	51.2	74.0	-22.8
22311.000	1.5	55.7	57.2	74.0	-16.8

Table 12-7: Harmonics, 250 kbps, 2479 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4958.000	13.0	33.7	46.7	54.0	-7.3
7437.000	3.8	35.9	39.7	54.0	-14.3
12395.000	-0.6	44.2	43.6	54.0	-10.4
19832.000	-9.7	53.7	44.0	54.0	-10.0
22311.000	-4.5	55.7	51.2	54.0	-2.8

Table 12-8: Harmonics, 1000 kbps, 2403 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4806.000	14.7	33.5	48.2	74.0	-25.8
12015.000	6.7	44.1	50.8	74.0	-23.2
19224.000	-2.3	53.3	51.0	74.0	-23.0

Table 12-9: Harmonics, 1000 kbps, 2403 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4806.000	12.8	33.5	46.3	54.0	-7.7
12015.000	-2.7	44.1	41.4	54.0	-12.6
19224.000	-8.1	53.3	45.2	54.0	-8.8

Table 12-10: Harmonics, 1000 kbps, 2440 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4880.000	14.0	33.5	47.5	74.0	-26.5
7320.000	12.8	35.8	48.6	74.0	-25.4
12200.000	7.8	44.1	51.9	74.0	-22.1
19520.000	-3.2	53.6	50.4	74.0	-23.6

Table 12-11: Harmonics, 1000 kbps, 2440 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4880.000	12.3	33.5	45.8	54.0	-8.2
7320.000	10.5	35.8	46.3	54.0	-7.7
12200.000	0.1	44.1	44.2	54.0	-9.8
19520.000	-10.1	53.6	43.5	54.0	-10.5

Table 12-12: Harmonics, 1000 kbps, 2468 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4936.000	13.2	33.6	46.8	74.0	-27.2
7404.000	9.8	35.9	45.7	74.0	-28.3
12340.000	7.7	44.3	52.0	74.0	-22.0
19744.000	-2.2	53.7	51.5	74.0	-22.5
22212.000	-1.1	55.5	54.4	74.0	-19.6

Table 12-13: Harmonics, 1000 kbps, 2468 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4936.000	11.0	33.6	44.6	54.0	-9.4
7404.000	6.6	35.9	42.5	54.0	-11.5
12340.000	0.6	44.3	44.9	54.0	-9.1
19744.000	-8.2	53.7	45.5	54.0	-8.5
22212.000	-7.9	55.5	47.6	54.0	-6.4

Table 12-14: Harmonics, 2000 kbps, 2403 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4806.000	14.8	33.5	48.3	74.0	-25.7
12015.000	6.7	44.1	50.8	74.0	-23.2
19224.000	-3.5	53.3	49.8	74.0	-24.2

Table 12-15: Harmonics, 2000 kbps, 2403 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4806.000	13.0	33.5	46.5	54.0	-7.5
12015.000	-2.4	44.1	41.7	54.0	-12.3
19224.000	-10.3	53.3	43.0	54.0	-11.0

Table 12-16: Harmonics, 2000 kbps, 2440 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4880.000	14.0	33.5	47.5	74.0	-26.5
7320.000	12.1	35.8	47.9	74.0	-26.1
12200.000	8.1	44.1	52.2	74.0	-21.8
19520.000	-4.0	53.6	49.6	74.0	-24.4

Table 12-17: Harmonics, 2000 kbps, 2440 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4880.000	12.3	33.5	45.8	54.0	-8.2
7320.000	9.6	35.8	45.4	54.0	-8.6
12200.000	0.1	44.1	44.2	54.0	-9.8
19520.000	-10.5	53.6	43.1	54.0	-10.9

Table 12-18: Harmonics, 2000 kbps, 2468 MHz, Peak, Standalone Module

Frequency (MHz)	Peak Detector (dBµV/m)	SCF (dB/m)	Peak Corrected (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
4936.000	14.1	33.6	47.7	74.0	-26.3
7404.000	10.2	35.9	46.1	74.0	-27.9
12340.000	8.3	44.3	52.6	74.0	-21.4
19744.000	-2.3	53.7	51.4	74.0	-22.6
22212.000	-1.3	55.5	54.2	74.0	-19.8

Table 12-19: Harmonics, 2000 kbps, 2468 MHz, Average, Standalone Module

Frequency (MHz)	Average Detector (dBµV/m)	SCF (dB/m)	Average Corrected (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4936.000	12.7	33.6	46.3	54.0	-7.7
7404.000	6.8	35.9	42.7	54.0	-11.3
12340.000	1.1	44.3	45.4	54.0	-8.6
19744.000	-8.3	53.7	45.4	54.0	-8.6
22212.000	-6.8	55.5	48.7	54.0	-5.3

Result: Pass

Test Personnel:

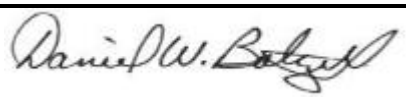
Dan Baltzell		April 2, 2020
EMC Test Engineer	Signature	Date of Test

Table 12-20: Radiated Emissions Test Equipment

RTL Asset #	Part Type	Manufacturer	Model	Serial Number	Calibration Due Date
900321	Horn Antennas (4.0 – 8.2 GHz)	EMCO	3161-03	9508-1020	05/17/2021
900323	Horn Antennas (8.2 – 12.4 GHz)	EMCO	3160-7	9605-1054	05/17/2021
900356	Horn Antenna (12.4 – 18.0 GHz)	EMCO	3160-08	9607-1044	05/17/2021
900711	Horn Antenna (75 – 110 GHz)	ATM	10-443-6R	8051905-1	04/07/2022
900712	Horn Antenna (50 – 75 GHz)	ATM	15-443-6R	8051805-1	04/07/2022
900772	Horn Antenna (2 – 4 GHz)	EMCO	3161-02	9804-1044	05/17/2021
900791	Bilog Antenna (30 – 2000 MHz)	Chase	CBL6111B	N/A	10/04/2020
900905	Preamplifier (10 – 2000 MHz)	Rhein Tech Laboratories	PR-1040	1006	08/29/2020
900913	RF Filter Section (100 kHz – 6.5 GHz)	Hewlett Packard	85462A	3325A00159	05/14/2021
900914	EMI Receiver Section (9 kHz – 6.5 GHz)	Hewlett Packard	85460A	3330A00107	05/14/2021
901218	Horn Antenna (18.0 – 26.5 GHz)	EMCO	3160-09	960281-003	05/05/2021
901256	Horn Antenna (40 – 60 GHz)	ATM	19-443-6R	8041704-01	04/04/2020
901303	Horn Antenna (26.5 – 40.0 GHz)	EMCO	3160-10	960452-007	05/15/2021
901581	Spectrum Analyzer (20 Hz – 50 GHz)	Rhode & Schwarz	1166.1660.50	200106	06/26/2021
901583	Signal Analyzer (10 Hz – 26.5 GHz)	Agilent Technologies	EXA N9010A	MY51250846	02/06/2021
901723	Preamplifier (1 – 26.5 GHz)	Hewlett Packard	8449B	3008A00762	09/03/2020
N/A	Test Software	Rhein Tech Laboratories	RTL Emission 1.1.4	N/A	N/A
901592	SMK RF Cables 20'	Insulated Wire Inc.	KPS-1503-3600-KPR	NA	01/29/2021

13 Conclusion

The data in this measurement report shows that the EUT as tested, Banner Engineering Corp., Model SX243, FCC ID: UE3SX243, IC: 7044A-SX243, complies with the applicable requirements of FCC Parts 2 and 15 and ISED RSS-247 and RSS-Gen for Limited Modular Approval.