TEST REPORT

Report Number: 103948971MPK-001
Project Number: G103948971
Original Issue: December 29, 2019
Revision Date: January 10, 2020

Testing performed on the
SmartBypass™
Model Number: SmartBypass 2000-63

FCC ID: QPS01008
IC ID: 22326-01008

to
FCC Part 15 Subpart C (15.247)
Industry Canada RSS-247 Issue 2
FCC Part 15 Subpart B
Industry Canada ICES-003

For

Smart Wires, Inc.

Test Performed by:	Test Authorized by:
Intertek	Smart Wires, Inc.
1365 Adams Court	3292 Whipple Rd.
Menlo Park, CA 94025 USA	Union City, CA 94587 USA

Prepared by: ______________________ **Date:** December 29, 2019
Anderson Soungpanya

Reviewed by: ______________________ **Date:** December 29, 2019
Krishna K Vemuri

Report No. 103948971MPK-001	
Equipment Under Test:	SmartBypass™
Trade Name:	Smart Wires, Inc.
Model Number(s):	SmartBypass 2000-63
Applicant:	Smart Wires, Inc.
Contact:	Karamjit Singh
Address:	Smart Wires, Inc. 3292 Whipple Rd. Union City, CA 94587
Country:	USA
Tel. Number:	(510) 952-2668
Email:	karamjit.singh@smartwires.com
Applicable Regulation:	FCC Part 15 Subpart C (15.247) Industry Canada RSS-247 Issue 2 FCC Part 15, Subpart B Industry Canada ICES-003 Issue 6
Date of Test:	November 18 – December 10, 2019

Original: We attest to the accuracy of this report:

Anderson Soungpanya
Project Engineer

Krishna K Vemuri
Engineering Team Lead

Revision: We attest to the accuracy of this report:

Anderson Soungpanya
Project Engineer

Krishna K Vemuri
Engineering Team Lead

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1.0 Introduction

This report is designed to show compliance of the 900 MHz transceiver with the requirements of FCC Part 15 Subpart C (15.247) and RSS-247. This test report covers only the FHSS radio.

1.1 Summary of Tests

TEST	Reference FCC	Reference Industry Canada	RESULTS
RF Output Power	15.247(b)	RSS-247, 5.4.2	Complies
20-dB Bandwidth	15.247(a)(1)	RSS-247, 5.1.1	Complies
Channel Separation	15.247(a)(1)	RSS-247, 5.1.2	Complies
Number of Hopping Channels	15.247(a)(1)	RSS-247, 5.14	Complies
Average Channel Occupancy Time	15.247(a)(1)	RSS-247, 5.14	Complies
Out-of-Band Antenna Conducted Emission	15.247(d)	RSS-247, 5.5	Complies
Transmitter Radiated Emissions	15.247(d), 15.209, 15.205	RSS-GEN	Complies
RF Exposure	15.247(i)	RSS-102	Complies
AC Conducted Emission	15.207	RSS-GEN	Complies
Antenna Requirement	15.203	RSS-GEN	Complies (Professional Installation)
Radiated Emission	15.109	RSS-GEN	Complies
AC Line Conducted Emission	15.107	RSS-GEN	Complies

2.0 General Description

2.1 Product Description

Smart Wires, Inc. supplied the following description of the EUT:

Smart Wires' SmartBypass technology is designed to protect other Smart Wires series compensation devices. The SmartBypass does this by automatically activating switches to carry the transmission line current during line faults or when operators desire to manually bypass the series compensation. The SmartBypass technology builds on the protection used in other Smart Wires products. The SmartBypass is installed on a single-phase basis, meaning that for most transmission deployments, there will be an equal number of units per phase.

For more information, see user's manual provided by the manufacturer.

Information about the 900 MHz radio is presented below:

Applicant	Smart Wires, Inc.
Model No.	SmartBypass 2000-63
FCC Identifier	QPS01008
IC Identifier	22326-01008
Type of Transmission	Frequency Hopping Spread Spectrum
Rated RF Output	22.46 dBm or 176.198 mW
Antenna(s) & Gain	Internal Antenna, Gain: 1.15 dBi
Frequency Range	902.400 – 926.944 MHz
Number of Channel(s)	64
Modulation Type	2-FSK
Applicant Name & Address	Smart Wires, Inc. 3292 Whipple Rd. Union City, CA 94587 USA

EUT receive date: November 18, 2019

EUT receive condition: The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.

Test start date: November 18, 2019

Test completion date: December 10, 2019

The test results in this report pertain only to the item tested.

2.2 Related Submittal(s) Grants

None.

2.3 Test Methodology

Antenna conducted measurements were performed according to the FCC documents "Guidance for Performing Compliance Measurement on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System devices Operating under §15.247" (KDB 558074 D01 15.247 Meas Guidance v05r02), RSS-247 Issue 2, ANSI C63.10: 2013 and RSS-GEN Issue 5.

Radiated emissions and AC mains conducted emissions measurements were performed according to the procedures in ANSI C63.10: 2013 & ANSI C63.4-2014. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this report.

All other measurements were made in accordance with the procedures in part 2 of CFR 47.

Following is the channel test plan:

Channels in 900 MHz band			
Test Channel		Frequency, MHz	Tested
Low	0	902.400	√
Middle	32	914.867	√
High	63	926.944	√
Hopping Mode	0-63	902.400 - 926.944	√

2.4 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

3.0 System Test Configuration

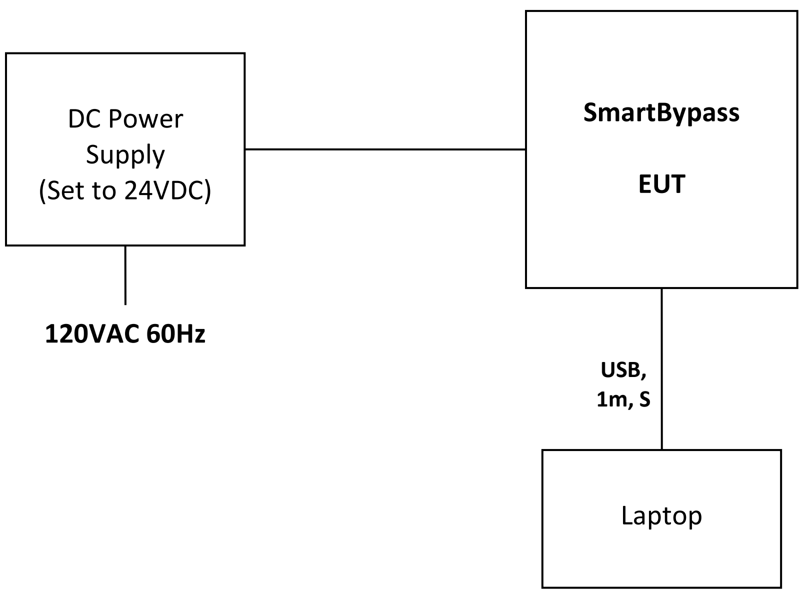
3.1 Support Equipment

Description	Manufacturer	Model Number
Laptop	DELL	Latitude 7490
DC Power Supply	Exetech	D30030012

3.2 Block Diagram of Test Setup

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
Communication Device	Smart Wires, Inc.	SmartBypass 2000-63	3919-004-20-50-06-1

Antenna was removed and co-axial connector with a cable was installed for Conducted Measurements.



S = Shielded	**F** = With Ferrite
U = Unshielded	**m** = Length in Meters

3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive platform15cm off the ground. The EUT is attached to peripherals and they are connected and operational (as typical as possible). The EUT is wired to transmit full power. During testing, all cables are manipulated to produce worst-case emissions.

The SmartBypass' size and weight were excessive (~2600 pounds) to safely lift onto an 80cm or 1.5m table for testing. Arrangements were made to safely test it as a floor standing unit.

3.4 Mode of Operation During Test

During transmitter testing, the transmitter was setup to transmit continuously at maximum RF power on the low channel, middle channel, high channel and with hopping channels enabled.

The Maximum power allowed by the manufacturer's provided GUI is RF Power = 22

3.5 Modifications Required for Compliance

Intertek installed no modifications during compliance testing in order to bring the product into compliance.

3.6 Additions, Deviations and Exclusions from Standards

No additions, deviations or exclusions from the standard were made.

4.0 Emissions Measurement Results

4.1 20dB Bandwidth, and 99% Occupied Bandwidth
FCC Rule 15.247(a)(1)

4.1.1 Procedure

The Procedure described in the FCC Publication 558074 D01 Meas Guidance v05r02 & Section 7.8.7 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the 20dB bandwidth.

- Span = Approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
- RBW = 1% of the 20 dB bandwidth
- VBW = 3 x RBW
- Sweep = Auto
- Detector function = Peak
- Trace = Max hold

The EUT should be transmitting at its maximum data rate. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Use the marker delta function to measure 20 dB down one side of the emission. Reset the marker-delta function, and move the marker to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the 20 dB bandwidth of the emission. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

For 99% power bandwidth measurement, the bandwidth was determined by using the built-in 99% occupied bandwidth function of the spectrum analyzer.

The antenna port of the EUT was connected to the input of a spectrum analyzer (SA). For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. A Peak output reading was taken, a Display line was drawn for 20dB lower than Peak level. The 20dB bandwidth was determined from where the channel output spectrum intersected the display line.

Tested By	Test Date
Anderson Soungpanya	November 18, 2019

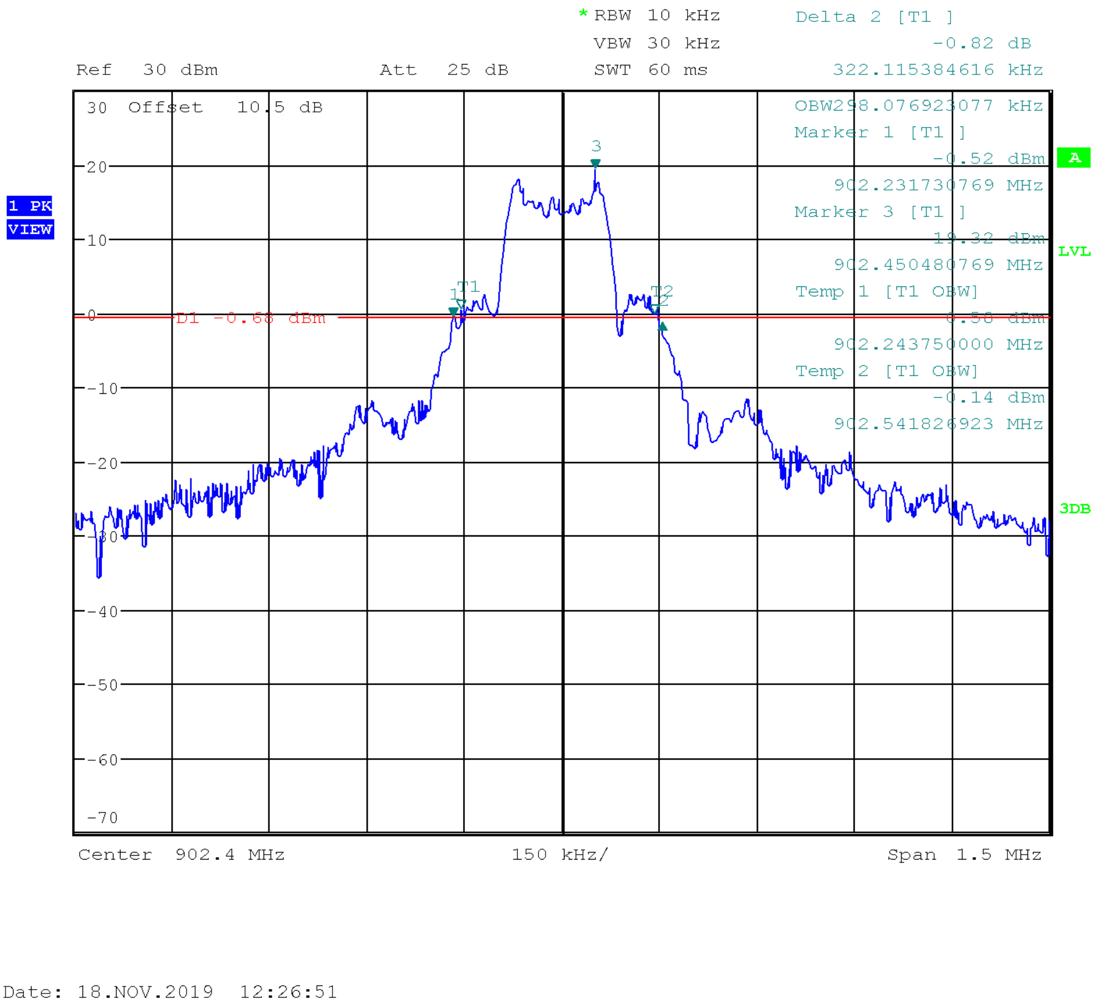
4.1.2 Test Result

Frequency MHz	20 dB FCC Bandwidth, kHz	99% Bandwidth, kHz	Plot #
902.400	322.115	298.077	1.1
914.867	322.116	295.673	1.2
926.944	317.308	300.481	1.3

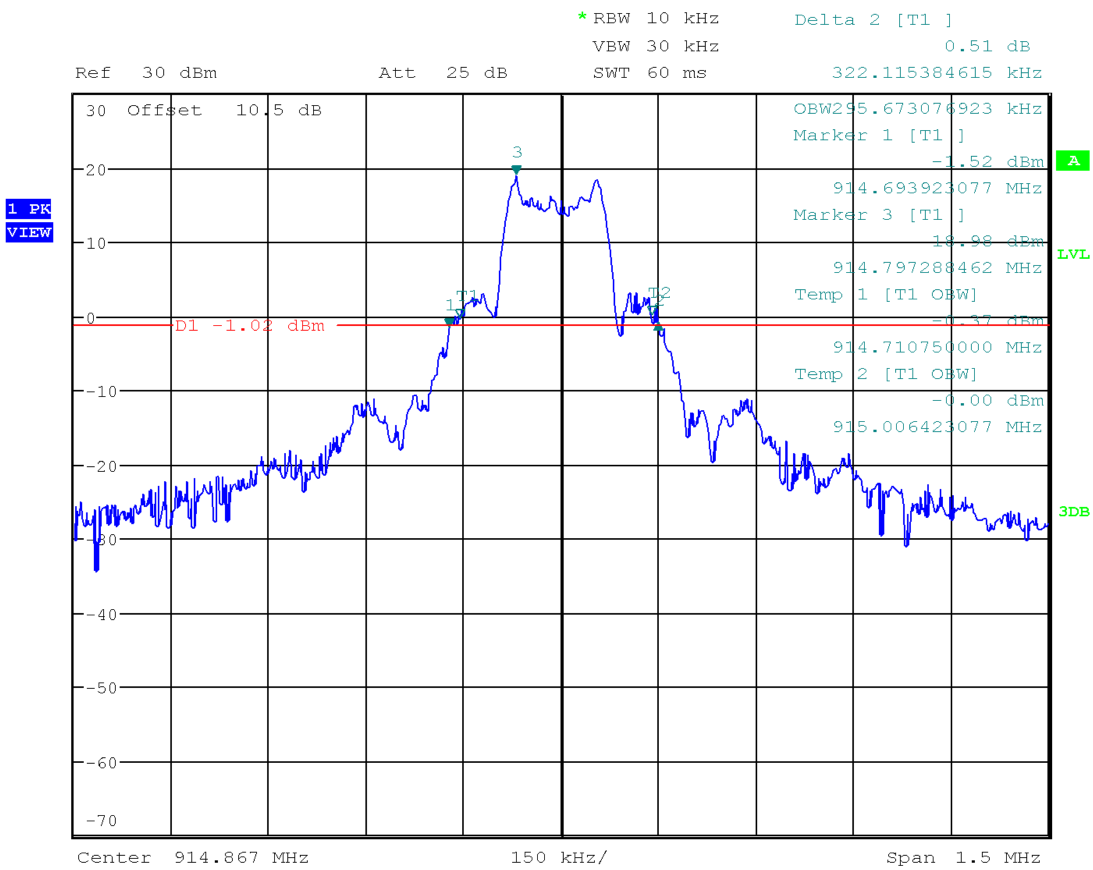
For frequency hopping systems operating in the 902-928 MHz band, the maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Results	Complies

Plot 1. 1 – 20dB Bandwidth and 99% Bandwidth Low Channel

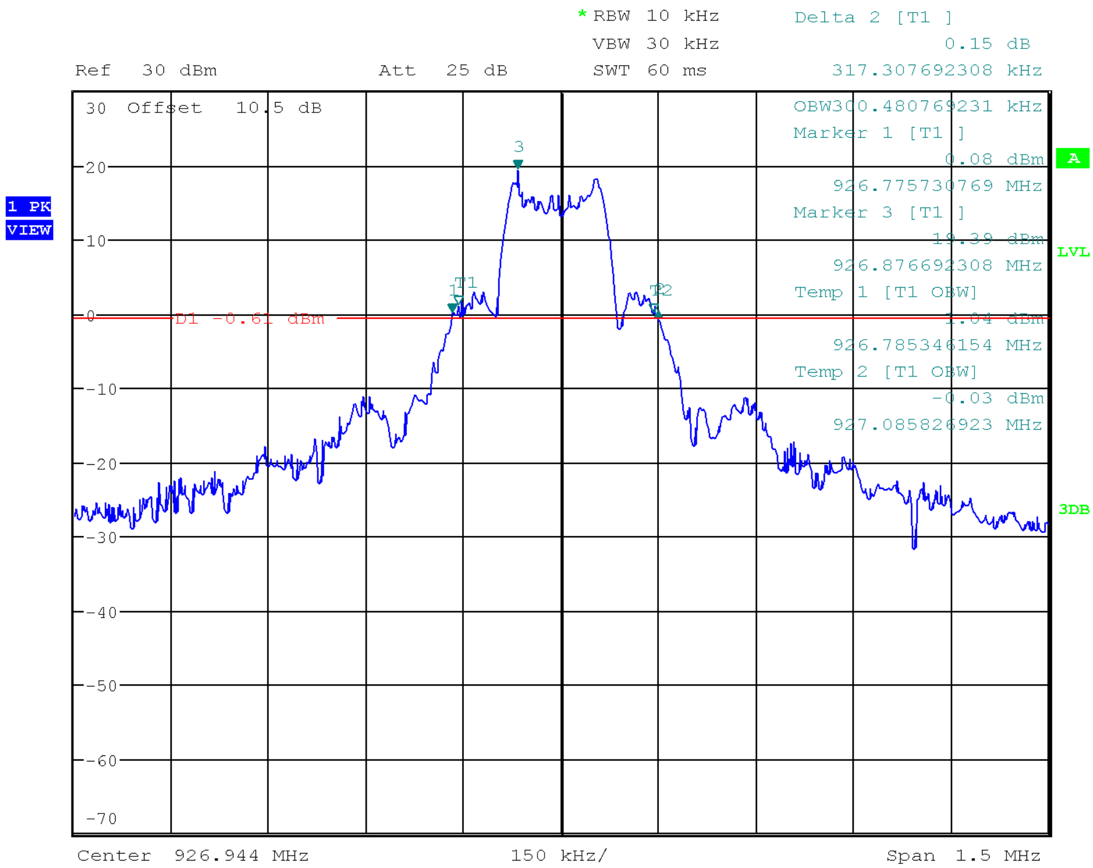


Plot 1. 2 – 20dB Bandwidth and 99% Bandwidth Middle Channel



Date: 18.NOV.2019 11:41:05

Plot 1. 3 – 20dB Bandwidth and 99% Bandwidth High Channel



Date: 18.NOV.2019 11:58:34

4.2 Conducted Output Power at Antenna Terminals FCC Rule 15.247(b)(1)

4.2.1 Requirement

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels

4.2.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05r02 was used. Specifically, Section 7.8.5 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the RF Output Power.

- Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
- RBW > the 20 dB bandwidth of the emission being measured
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power (see the NOTE above regarding external attenuation and cable loss). The limit is specified in one of the subparagraphs of this Section. Submit this plot.

The antenna port of the EUT was connected to the input of a spectrum analyzer. Power was read directly from the spectrum analyzer and cable loss correction was added to the reading to obtain the power at the antenna terminals.

Tested By	Test Date
Anderson Soungpanya	November 18, 2019

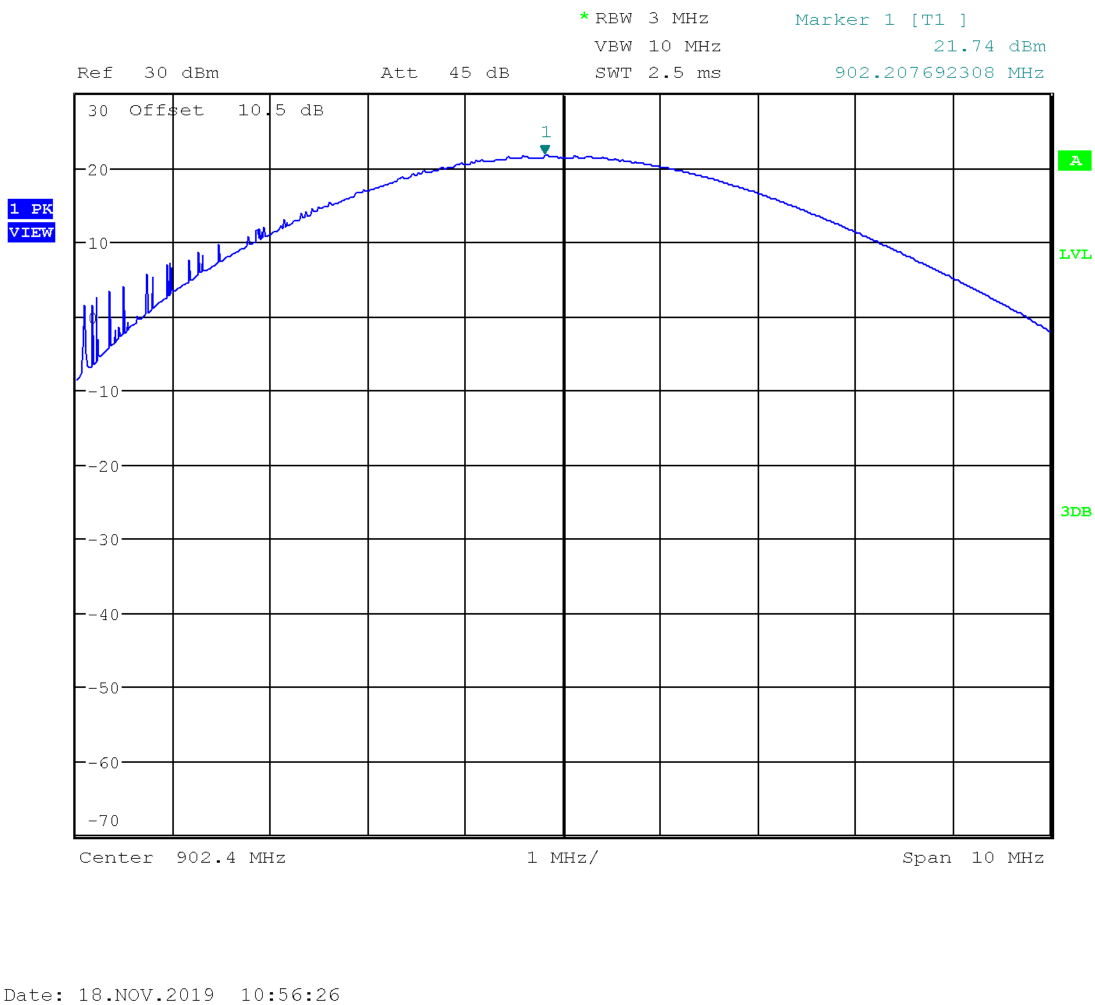
4.2.3 Test Result

Refer to the following plots for the test result:

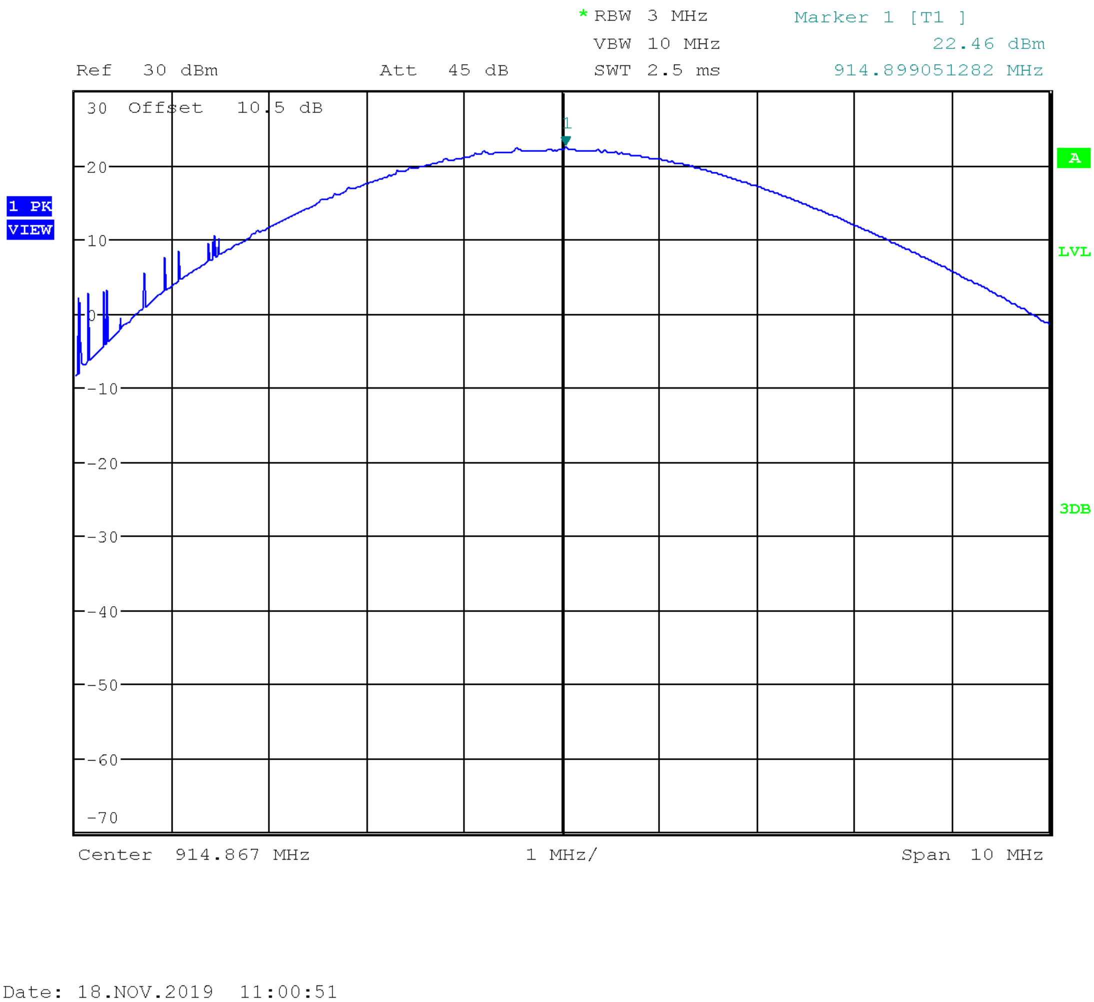
Frequency MHz	Conducted Peak Power dBm	Conducted Peak Power mW	Plot #
902.400	21.74	149.279	2.1
914.867	22.46	176.198	2.2
926.944	22.21	166.341	2.3

Results	Complies

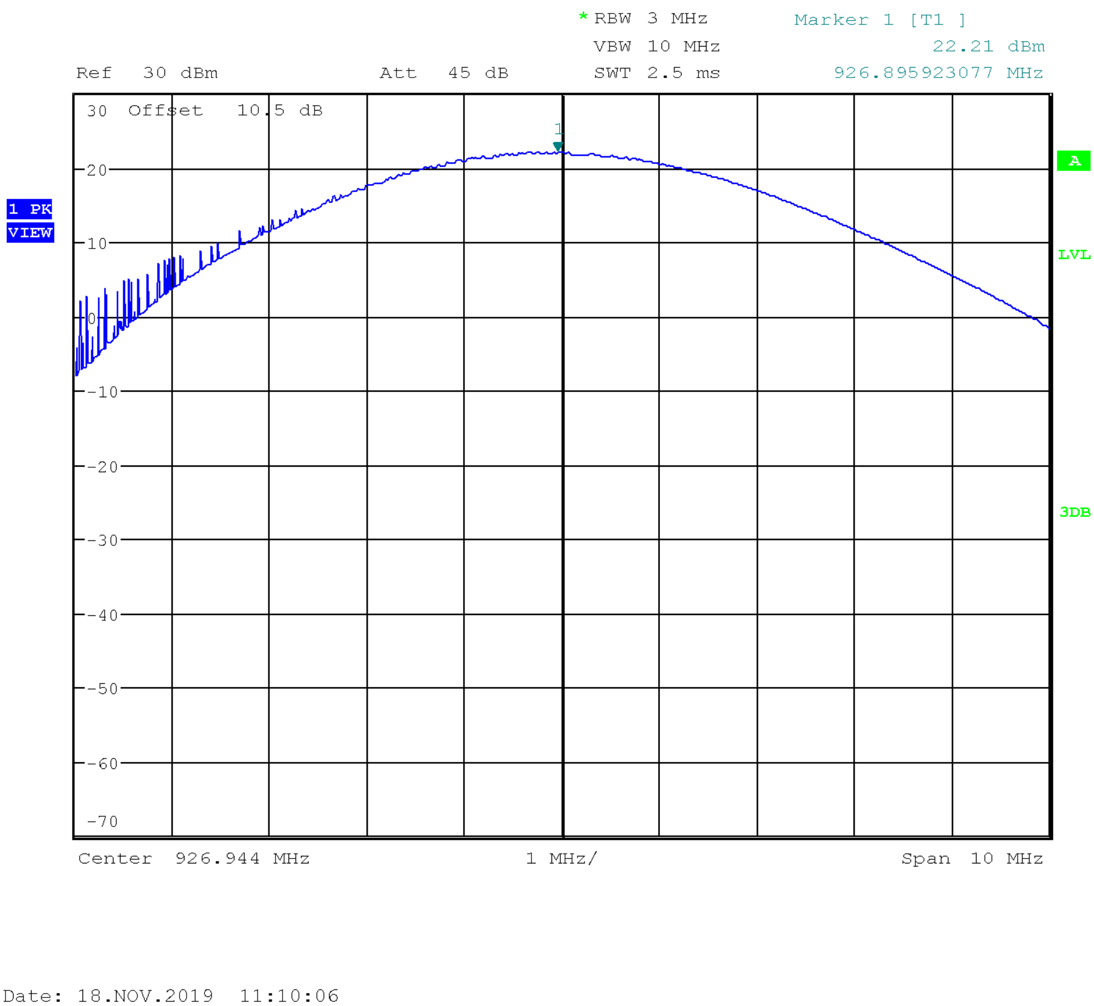
Plot 2. 2 – Output Power Low Channel



Plot 2. 2 – Output Power Middle Channel



Plot 2. 3 – Output Power High Channel



4.3 Carrier Frequency Separation
FCC 15.247 (a)(1)

4.3.1 Requirement

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

4.3.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05r02 was used. Specifically, Section 7.8.2 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Carrier Frequency Separation.

- The EUT must have its hopping function enabled
- Span = wide enough to capture the peaks of two adjacent channels
- Resolution (or IF) Bandwidth (RBW) = 1% of the span
- Video (or Average) Bandwidth (VBW) = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

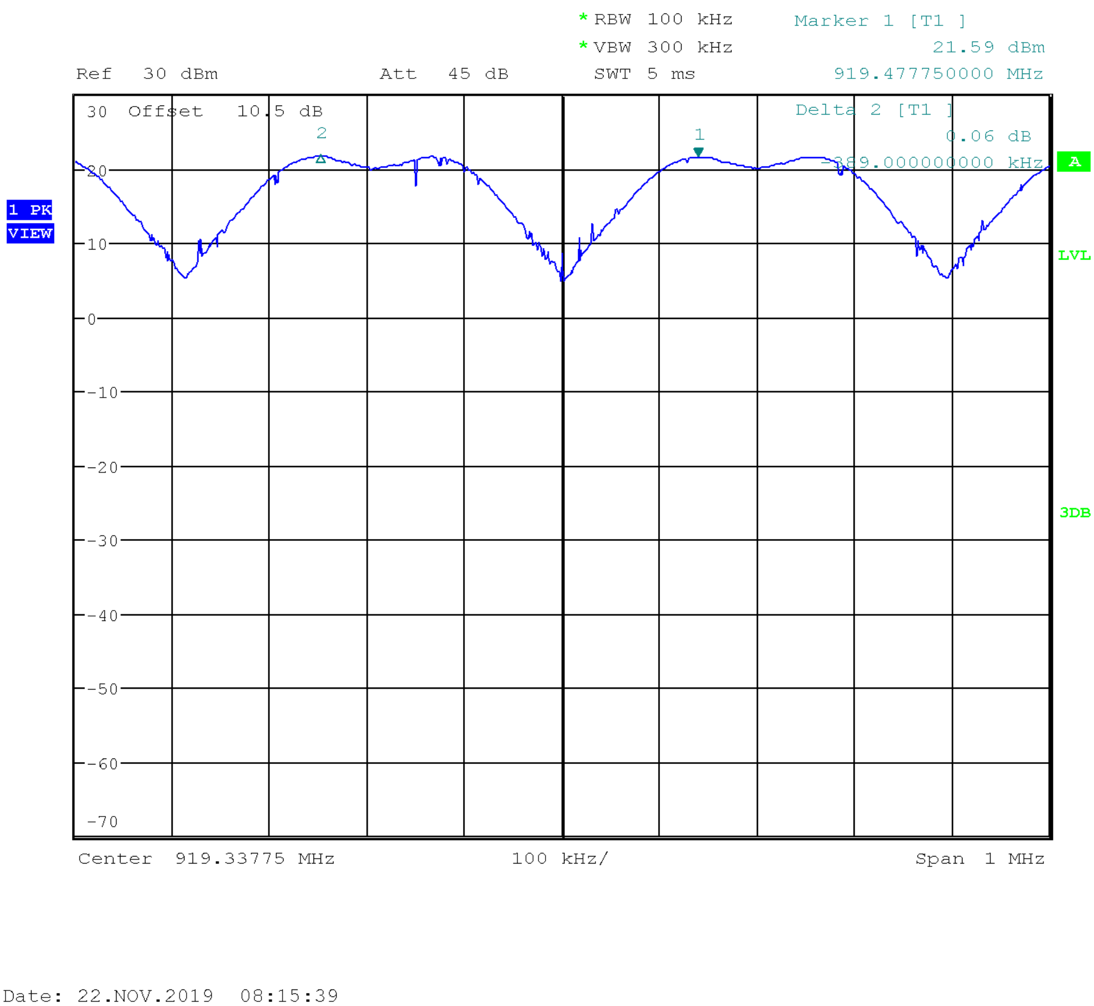
Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Tested By	Test Date
Anderson Soungpanya	November 22, 2019

4.3.3 Test Result

The worst case 20dB Bandwidth is 322.116 kHz, therefore the minimum Carrier Frequency Separation shall be greater than 322.116 kHz. The measured channel separation is 389.0 kHz. Carrier Frequency Separation meets the minimum requirement. Please refer to spectrum analyzer Plot 3.1 below for the test result.

Plot 3.1– Channel Separation



Results	Complies

4.4 Number of Channels
FCC 15.247 (a)(1)(iii)

4.4.1 Requirement

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

4.4.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05r02 was used. Specifically, Section 7.8.3 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Number of Channels.

- The EUT must have its hopping function enabled.
- Span = the frequency band of operation
- RBW = 1% of the span
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

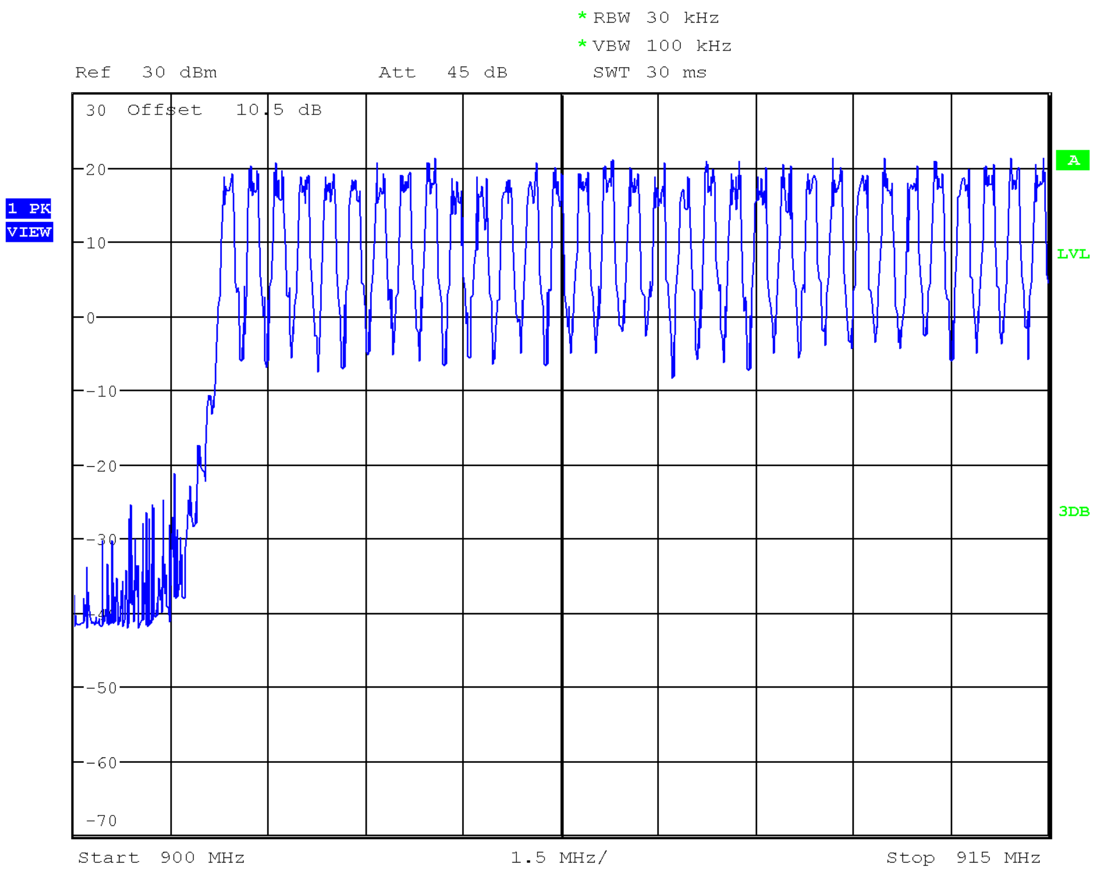
Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies.

With the analyzer set to MAX HOLD, readings were taken once channels were filled in. The channel peaks were recorded and compared to the minimum number of channels required in the regulation.

Tested By	Test Date
Anderson Soungpanya	November 22, 2019

4.4.3 Test Result

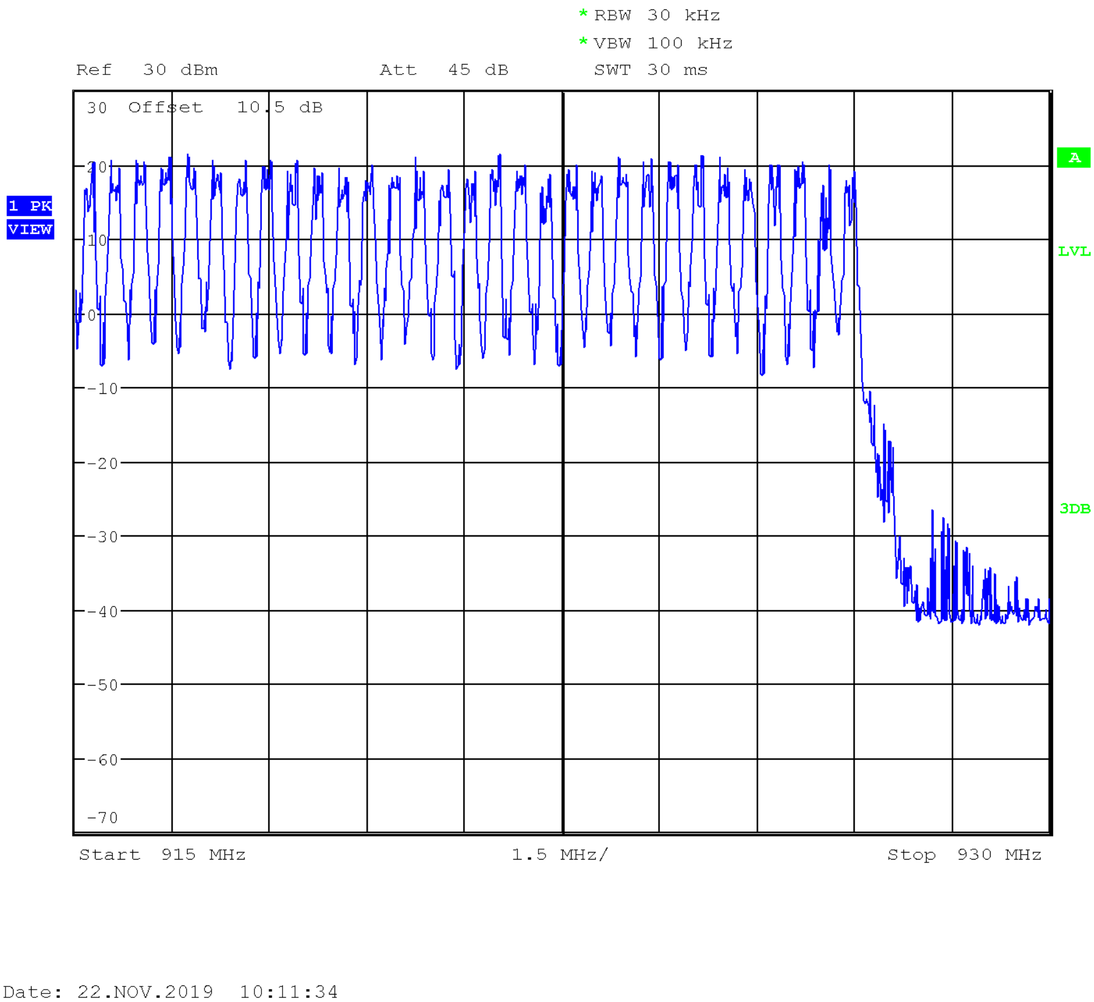
Plot 4.1 - Number of hopping channels, 900 - 915MHz



Date: 22.NOV.2019 09:23:48

4.4.3 Test Result (Continued)

Plot 4.2 - Number of hopping channels, 915 - 930MHz



Results	Complies, 64 Channels

4.5 Average Channel Occupancy Time
FCC 15.247(a)(1)

4.5.1 Requirement

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

4.5.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05r02 was used. Specifically, Section 7.8.4 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Average Channel Occupancy Time.

- The EUT must have its hopping function enabled.
- Span = zero span, centered on a hopping channel
- RBW = 1 MHz
- VBW = 3 x RBW
- Sweep = as necessary to capture the entire dwell time per hopping channel
- Detector function = peak
- Trace = max hold

If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. An oscilloscope may be used instead of a spectrum analyzer.

The spectrum analyzer center frequency was set to one of the known hopping channels, the SPAN was set to ZERO SPANS, and the TRIGGER was set to VIDEO. The time duration of the transmission so captured was measured with the MARKER DELTA function.

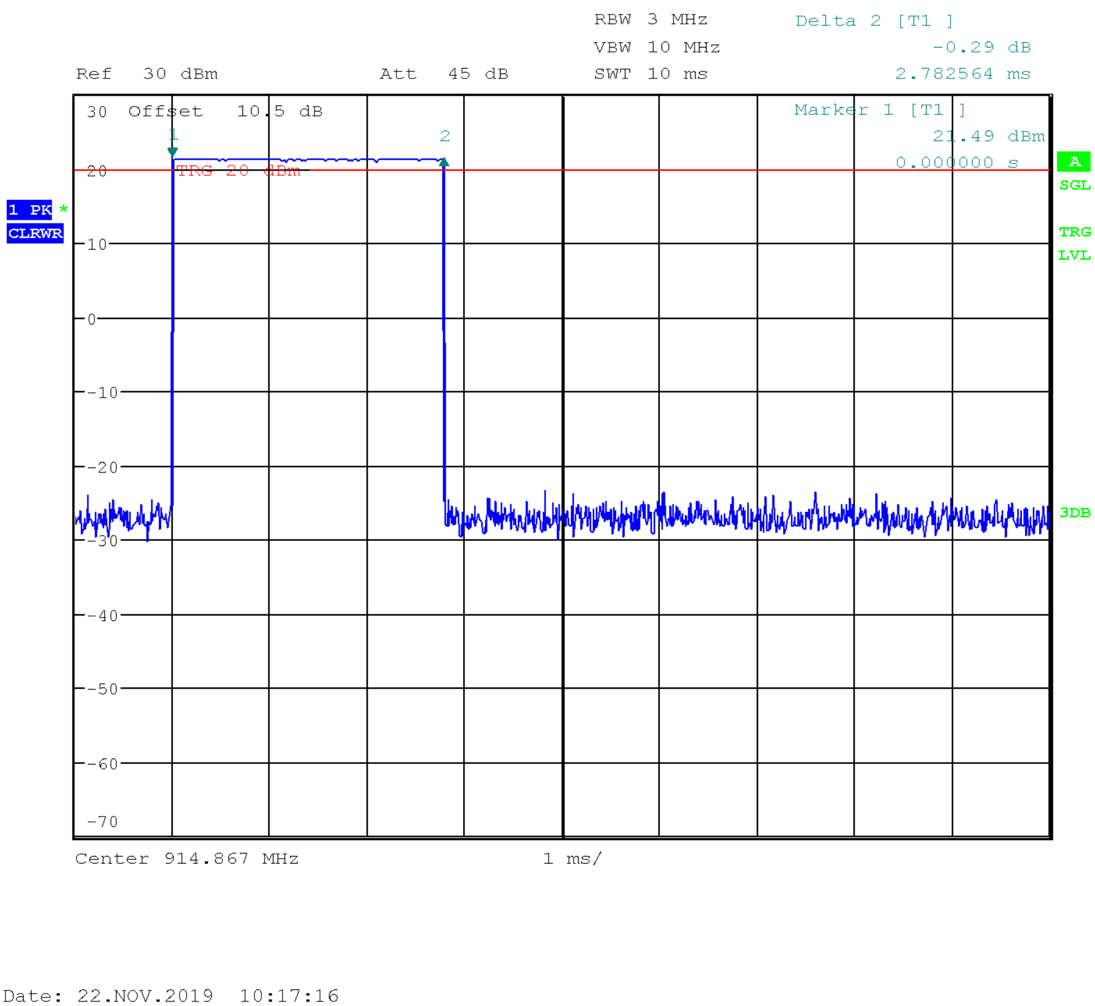
Tested By	Test Date
Anderson Soungpanya	November 22, 2019

4.5.3 Test Results

No. of Burst in 10 seconds	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
9	2.783	25.047	400

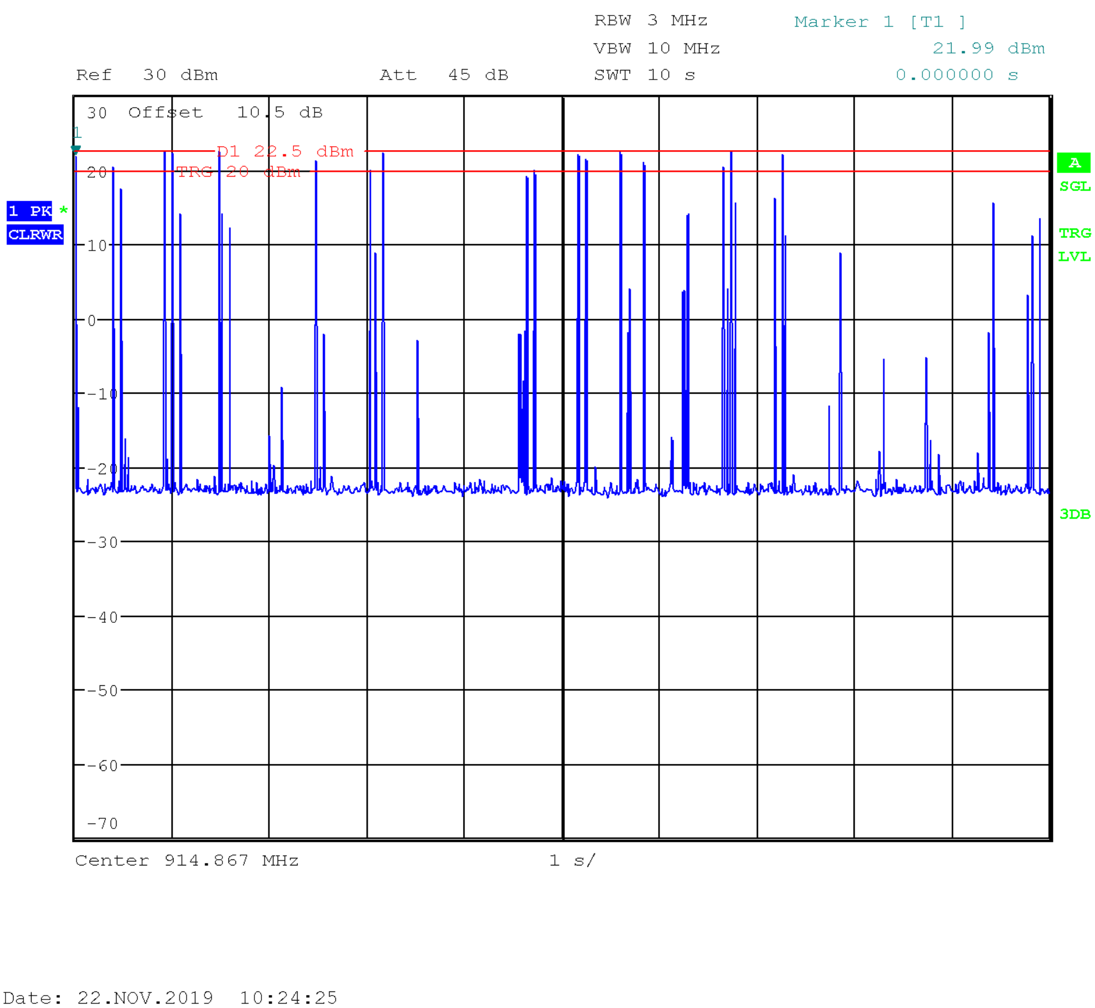
The 20-dB bandwidth of the hopping channel is greater than 250 kHz, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

Burst Time



4.5.3 Test Results (Continued)

Number of Burst in 10 seconds



Results	Complies

4.6 Out-of-Band Conducted Emissions
FCC 15.247(d)

4.6.1 Requirement

In any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

4.6.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05r02 was used. Specifically, Section 7.8.8 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Out-of-Band Conducted Emissions.

- Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic.
- RBW = 100 kHz
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified in this Section.

A spectrum analyzer was connected to the antenna port of the transmitter. Analyzer Resolution Bandwidth was set to 100 kHz. For each channel investigated, the in-band and out-of-band emission measurements were performed. The out-of-band emissions were measured from 30 MHz to 26 GHz.

Tested By	Test Date
Anderson Soungpanya	November 22, 2019

4.6.3 Test Result

Refer to the following plots and out-of-band conducted spurious emissions at the Band-Edge, Table 4.1 & 4.2 for the test results:

Table 4.1

Frequency MHz	Description	Plot #
902.400	Scan 30 MHz – 10 GHz	4.1
914.867	Scan 30 MHz – 10 GHz	4.2
926.944	Scan 30 MHz – 10 GHz	4.3

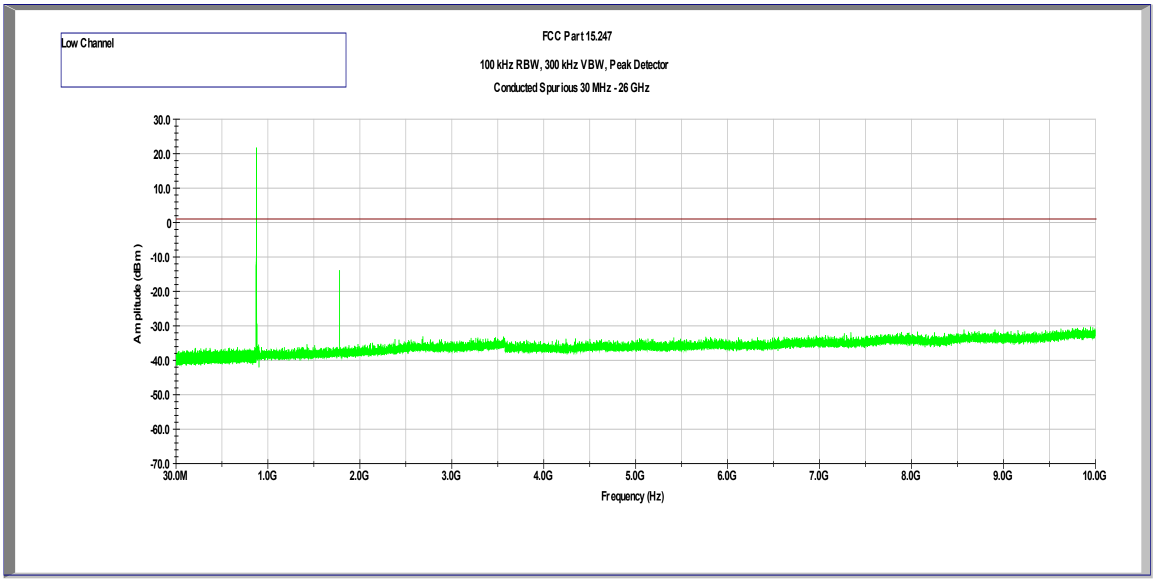
Out-of-Band Conducted Spurious Emissions at the Band-Edge:

Table 4.2

Channel	Frequency MHz	Out-band emissions margin to In-band emissions	Plot #
0	902.400	Complies, Greater than 20dB	4.4
Hopping	Low Band Edge	Complies, Greater than 20dB	4.5
63	926.944	Complies, Greater than 20dB	4.6
Hopping	High Band Edge	Complies, Greater than 20dB	4.7

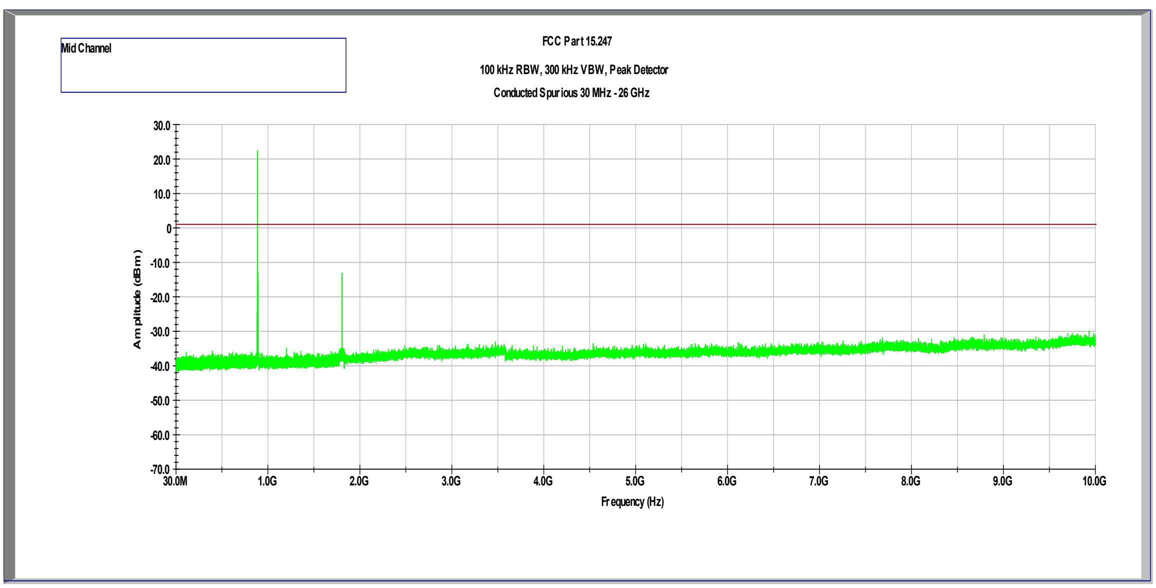
Plot 4.1

Transmitter Spurious, Low Channel



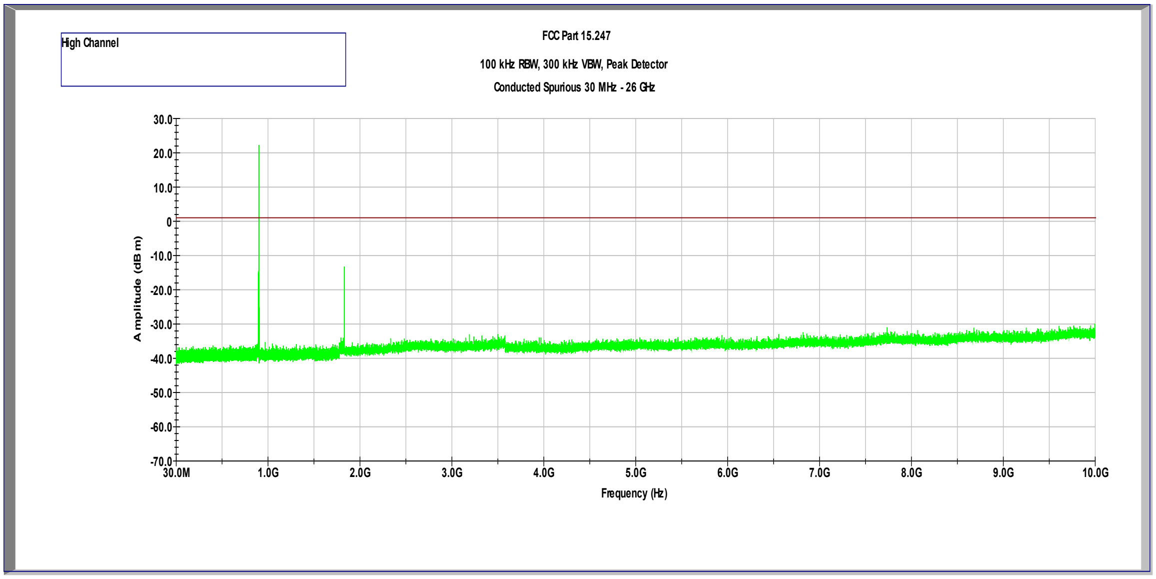
Plot 4.2

Transmitter Spurious, Middle Channel



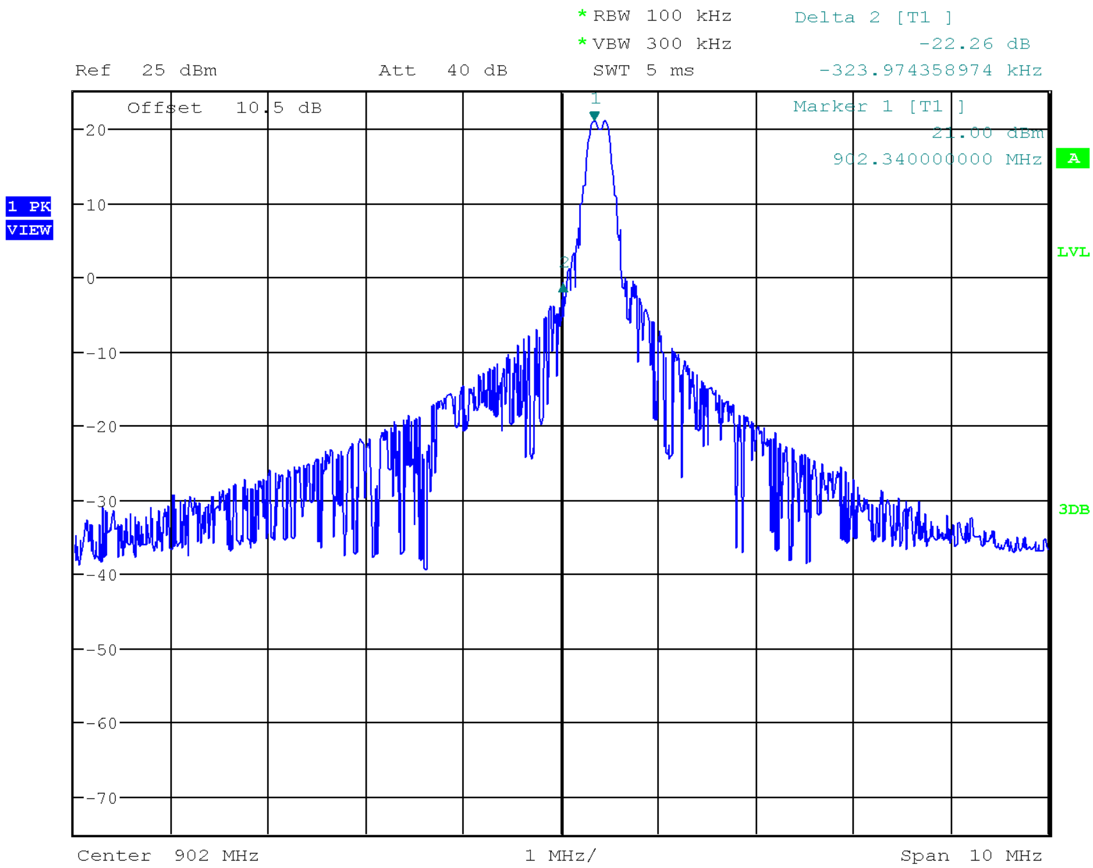
Plot 4.3

Transmitter Spurious, High Channel



Plot 4.4

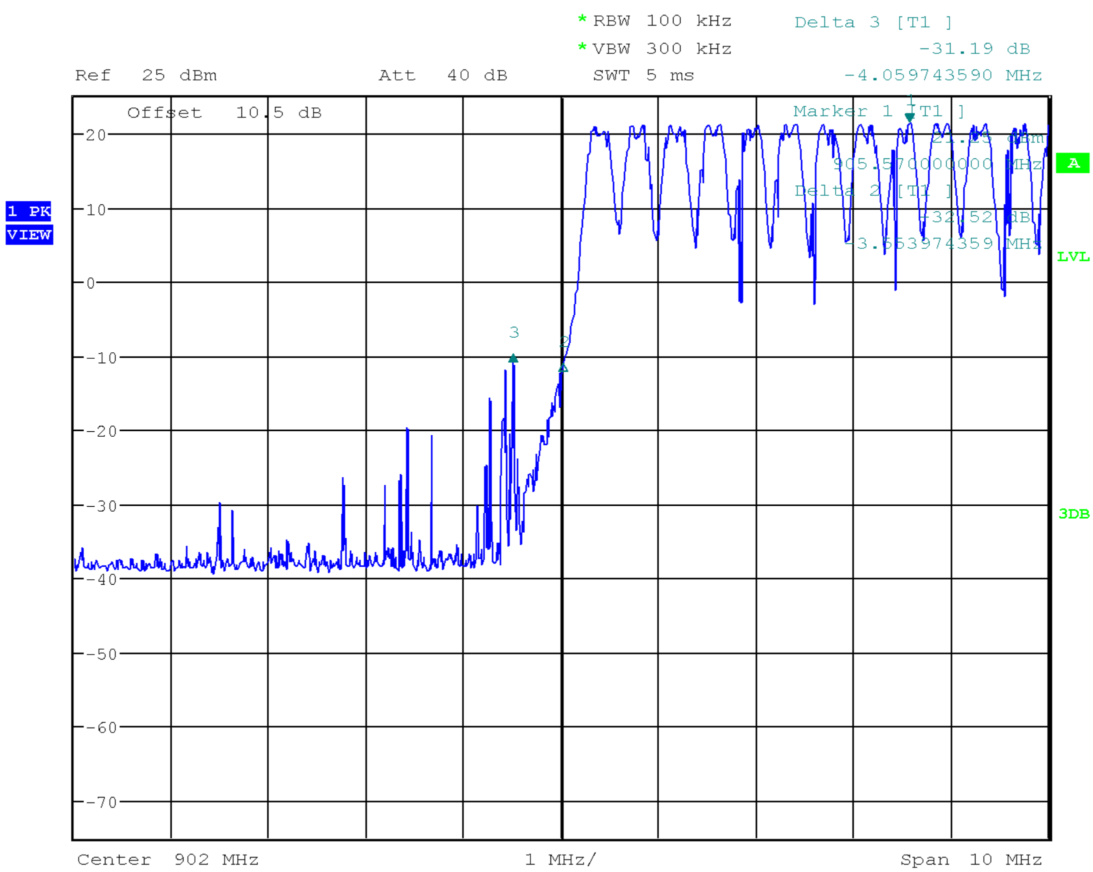
Conducted Band Edge, Low Channel



Date: 21.NOV.2019 12:08:14

Plot 4.11

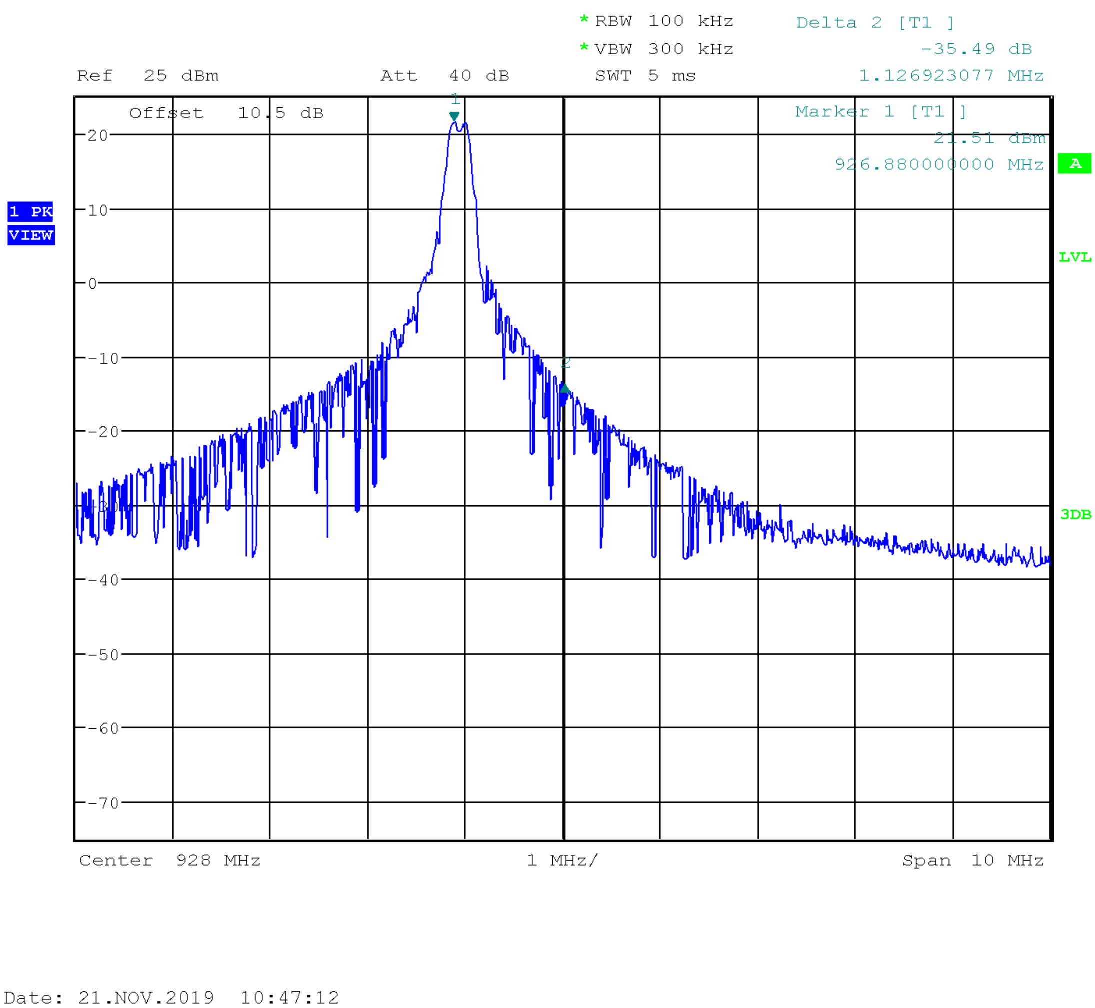
Conducted Band Edge (Hopping)



Date: 21.NOV.2019 12:36:44

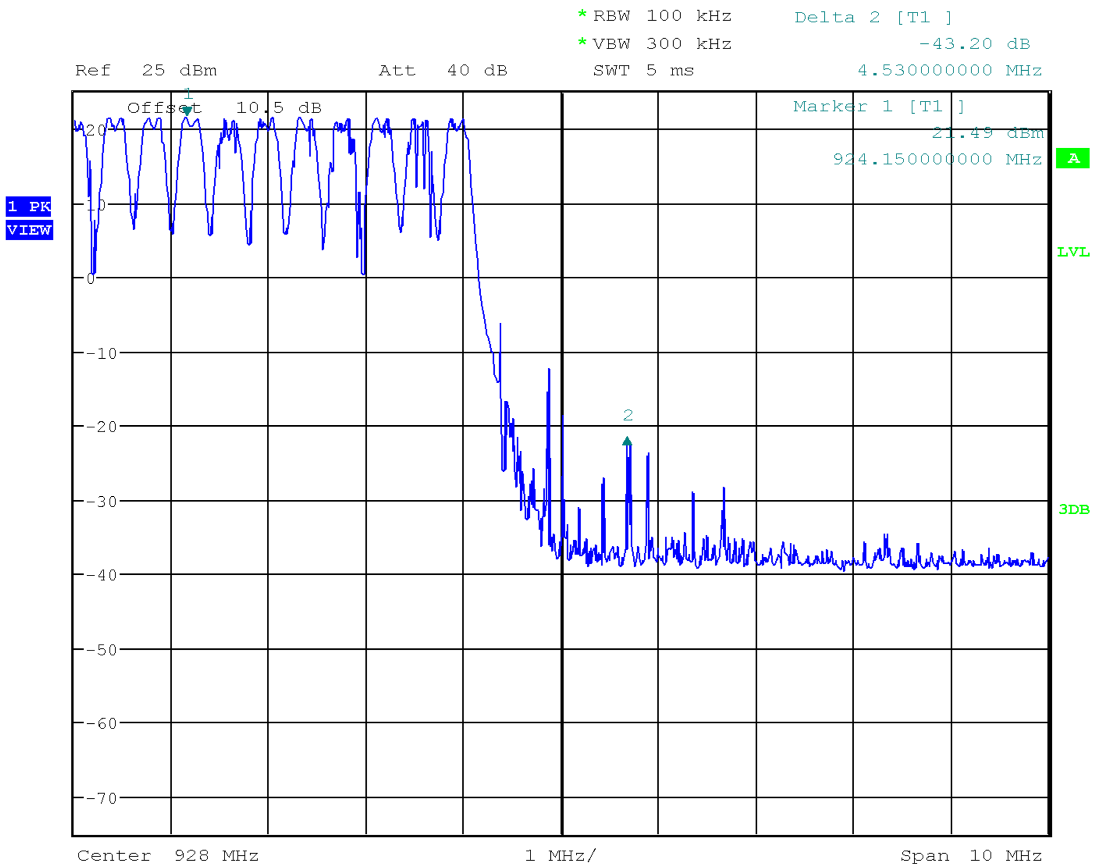
Plot 4.12

Conducted Band Edge, High Channel



Plot 4.13

Conducted Band Edge (Hopping)



Date: 21.NOV.2019 12:54:39

Results	Complies

4.7 Transmitter Radiated Emissions
FCC Rules: 15.247(d), 15.209, 15.205; RSS-247, 5.5;

4.7.1 Requirement

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

For out of band radiated emissions (except for frequencies in restricted bands), in any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

4.7.2 Procedure

Radiated emission measurements were performed from 30 MHz to 10 GHz according to the procedure described in ANSI C63.10: 2013. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz. Above 1000 MHz Peak and Average measurements were performed.

If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Radiated emissions are taken at 3 meters for frequencies above 1 GHz and at 10 meters for frequencies below 1 GHz.

Measurements are made with a preamp from 30 MHz to 10 GHz.

Measurements may be made with a Peak Detector and compared to QP limits for 30 MHz – 1 GHz and Average limits for 1 GHz – 10 GHz.

Radiated measurements were performed in the nominal orientation of the EUT. Out-of-Band Radiated Spurious Emissions Measurements were performed with a 50-ohm load on the antenna port.

4.7.3 Field Strength Calculation

Field Strength Calculation

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:

FS = RA + AF + CF – AG; if measurement is performed at a distance other than specified in the rule, a Distance Correction Factor (DCF) shall be added.

Where FS = Field Strength in dB(μV/m)
RA = Receiver Amplitude (including preamplifier) in dB(μV); AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB; AG = Amplifier Gain in dB

Assume a receiver reading of 52.0 dB(μV) is obtained. The antennas factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving field strength of 32 dB(μV/m). This value in dB(μV/m) was converted to its corresponding level in μV/m.
RA = 52.0 dB(μV)
AF = 7.4 dB(1/m)
CF = 1.6 dB
AG = 29.0 dB
FS = 52.0+7.4+1.6-29.0 = 32 dB(μV/m).
Level in μV/m = Common Antilogarithm [(32 dBμV/m)/20] = 39.8 μV/m.

4.7.4 Antenna-port conducted measurements

Antenna-port conducted measurements may also be used as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case spurious emissions is required.

4.7.5 General Procedure for conducted measurements in restricted bands

a) Measure the conducted output power (in dBm) using the detector specified for determining quasi-peak, peak, and average conducted output power, respectively.

b) Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)

c) Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).

d) For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (*e.g.*, Watts, mW).

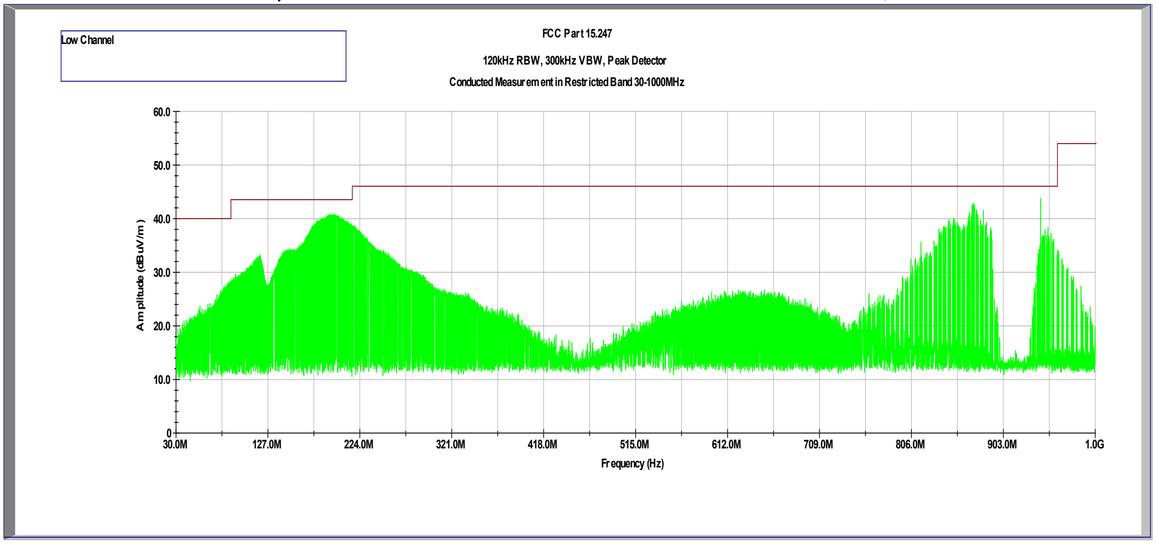
e) Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:
E = EIRP – 20log D + 104.8+DCF (DCF for Average measurements)
where:
E = electric field strength in dBμV/m,
EIRP = equivalent isotropic radiated power in dBm
D = specified measurement distance in meters.
DCF = Duty Cycle Correction Factor
f) Compare the resultant electric field strength level to the applicable limit.
g) Perform radiated spurious emission test

4.7.6 Test Results

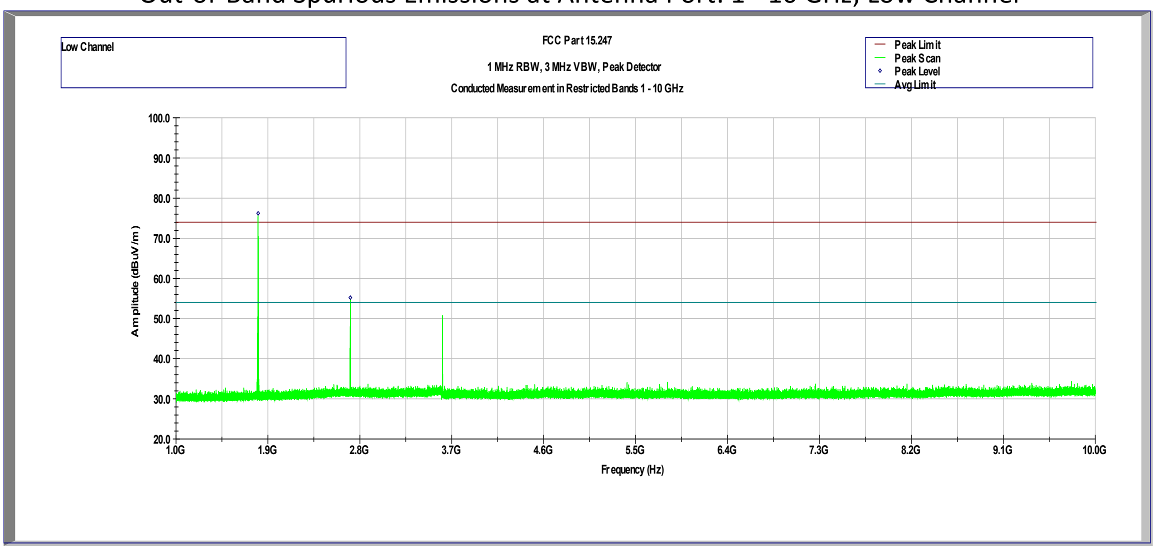
Tested By	Test Date
Anderson Soungpanya	November 26 – December 10, 2019

A notch filter was used for Out-of-Band Conducted Spurious Emissions at the Antenna Port when scanned from 30MHz to 1GHz. These measurements were performed with the consideration of path losses and the addition of a 2dBi Antenna.

Out-of-Band Spurious Emissions at Antenna Port: 30 MHz - 1 GHz; Low Channel



Out-of-Band Spurious Emissions at Antenna Port: 1 - 10 GHz; Low Channel



Frequency[1]	Peak Amplitude	Peak Limit[2]	Results
GHz	dB(µV/m)	dB(µV/m)	
1.8041	76.2	99.69 (-20dBc)	Pass

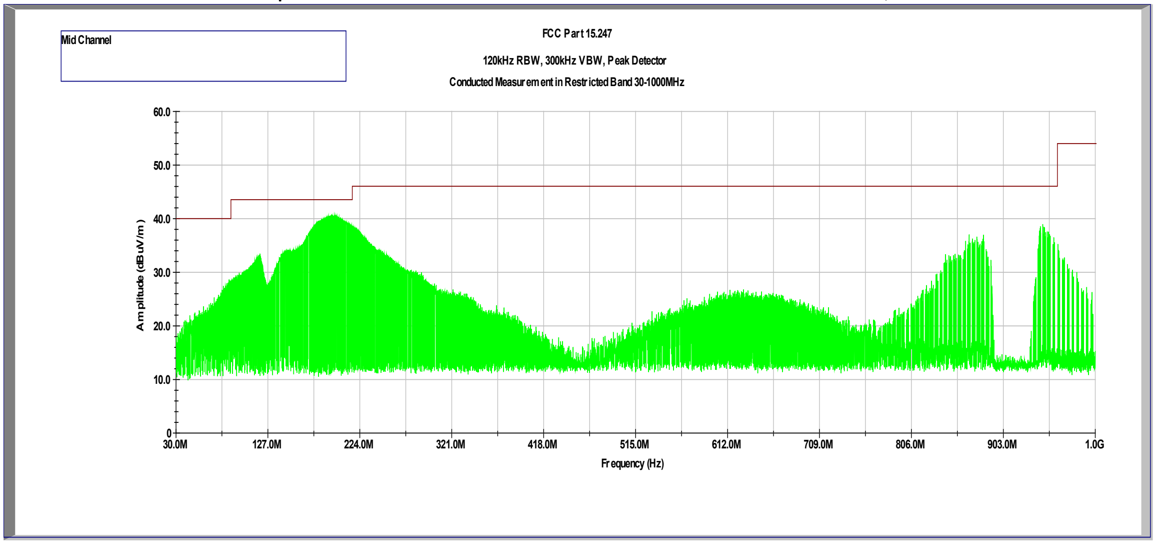
[1] Spurious emission frequencies does not fall under the restricted bands of 15.205, therefore the 15.209 limits does not apply to these frequencies.

[2] Limit is based on EIRP of 22.46dBm + 2 dBi Antenna. 24.46dBm EIRP is Converted to a dBuV/m Limit at 3m using: dBuV/m = EIRP – 20Log(D) + 104.77 - 20. Where (D)istance is 3m.

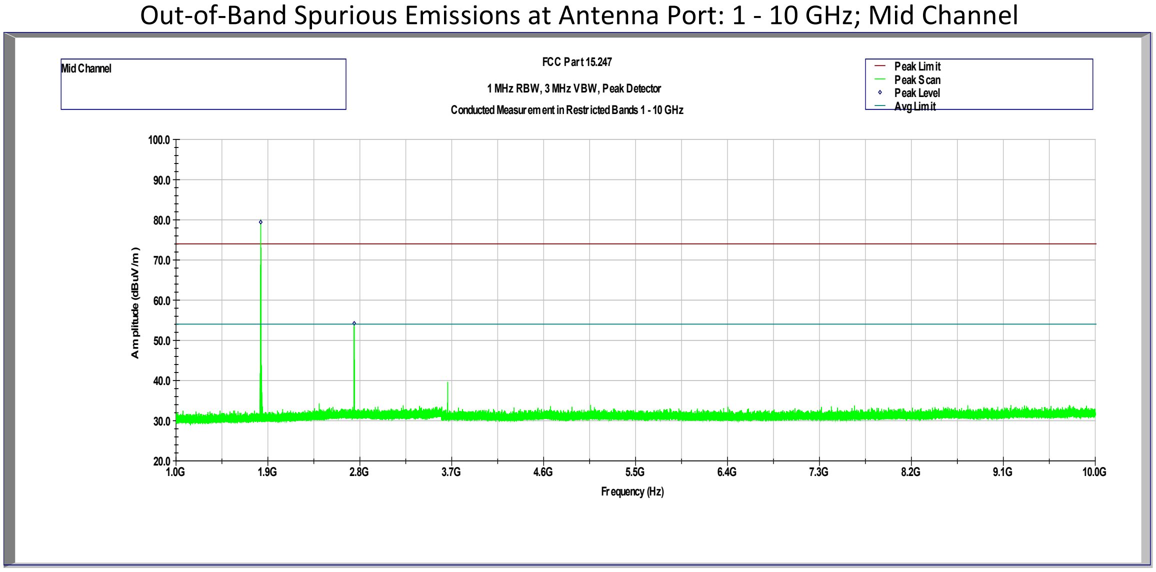
Frequency[3]	Peak Amplitude	Peak Limit	Duty Cycle Correction	Avg Amplitude	Avg Limit	Results
GHz	dB(µV/m)	dB(µV/m)	dB	dB(µV/m)	dB(µV/m)	
2.7070	55.2	74.0	-20.0	35.2	54.0	Pass

[3] The spurious identified in table above are compliant with 15.209 Average limit (54dBuV/m) by subtracting the Duty Cycle Correction Factor of 20dB to the Peak Amplitude (See Annex A for Duty Cycle calculation).

Out-of-Band Spurious Emissions at Antenna Port: 30 MHz - 1 GHz; Mid Channel



Out-of-Band Spurious Emissions at Antenna Port: 1 - 10 GHz; Mid Channel



Frequency[1]	Peak Amplitude	Peak Limit[2]	Results
GHz	dB(µV/m)	dB(µV/m)	
1.82968	79.4	99.69 (-20dBc)	Pass

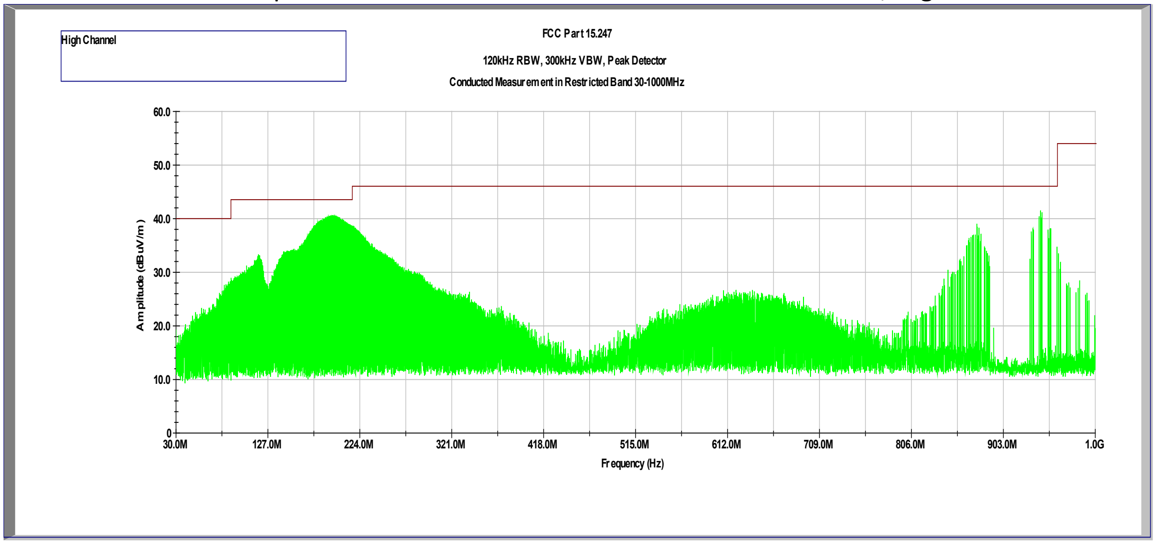
[1] Spurious emission frequencies does not fall under the restricted bands of 15.205, therefore the 15.209 limits does not apply to these frequencies.

[2] Limit is based on EIRP of 22.46dBm + 2 dBi Antenna. 24.46dBm EIRP is Converted to a dBuV/m Limit at 3m using: dBuV/m = EIRP – 20Log(D) + 104.77 - 20. Where (D)istance is 3m.

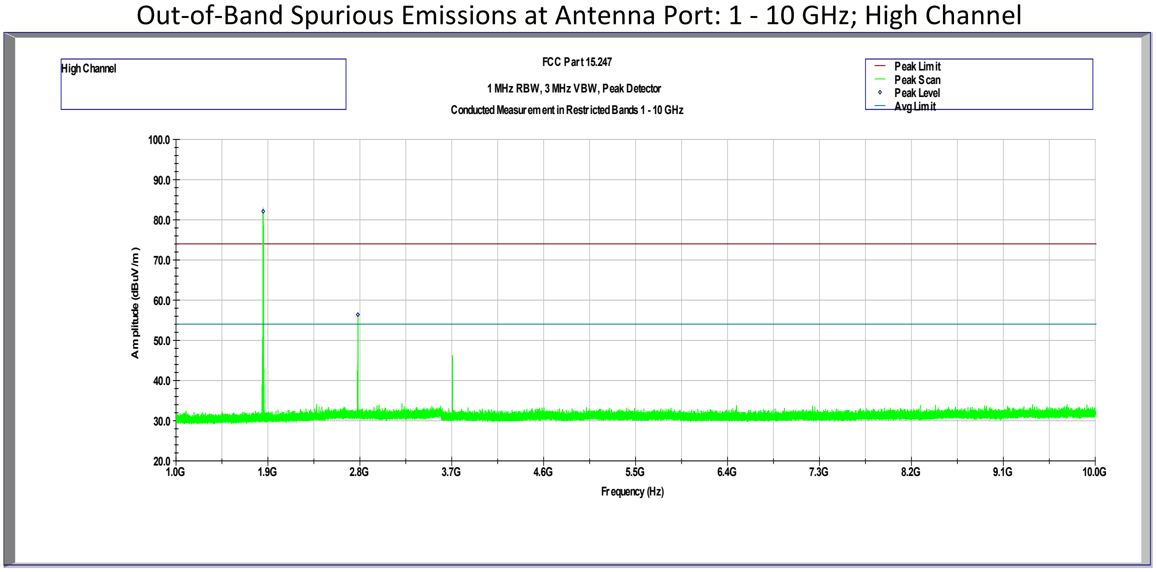
Frequency[3]	Peak Amplitude	Peak Limit	Duty Cycle Correction	Avg Amplitude	Avg Limit	Results
GHz	dB(µV/m)	dB(µV/m)	dB	dB(µV/m)	dB(µV/m)	
2.74462	54.2	74.0	-20.0	34.2	54.0	Pass

[3] The spurious identified in table above are compliant with 15.209 Average limit (54dBuV/m) by subtracting the Duty Cycle Correction Factor of 20dB to the Peak Amplitude (See Annex A for Duty Cycle calculation).

Out-of-Band Spurious Emissions at Antenna Port: 30 MHz - 1 GHz; High Channel



Out-of-Band Spurious Emissions at Antenna Port: 1 - 10 GHz; High Channel



Frequency[1]	Peak Amplitude	Peak Limit[2]	Results
GHz	dB(µV/m)	dB(µV/m)	
1.8535	82.1	99.69 (-20dBc)	Pass

[1] Spurious emission frequencies does not fall under the restricted bands of 15.205, therefore the 15.209 limits does not apply to these frequencies.

[2] Limit is based on EIRP of 22.46dBm + 2 dBi Antenna. 24.46dBm EIRP is Converted to a dBuV/m Limit at 3m using: dBuV/m = EIRP – 20Log(D) + 104.77 - 20. Where (D)istance is 3m.

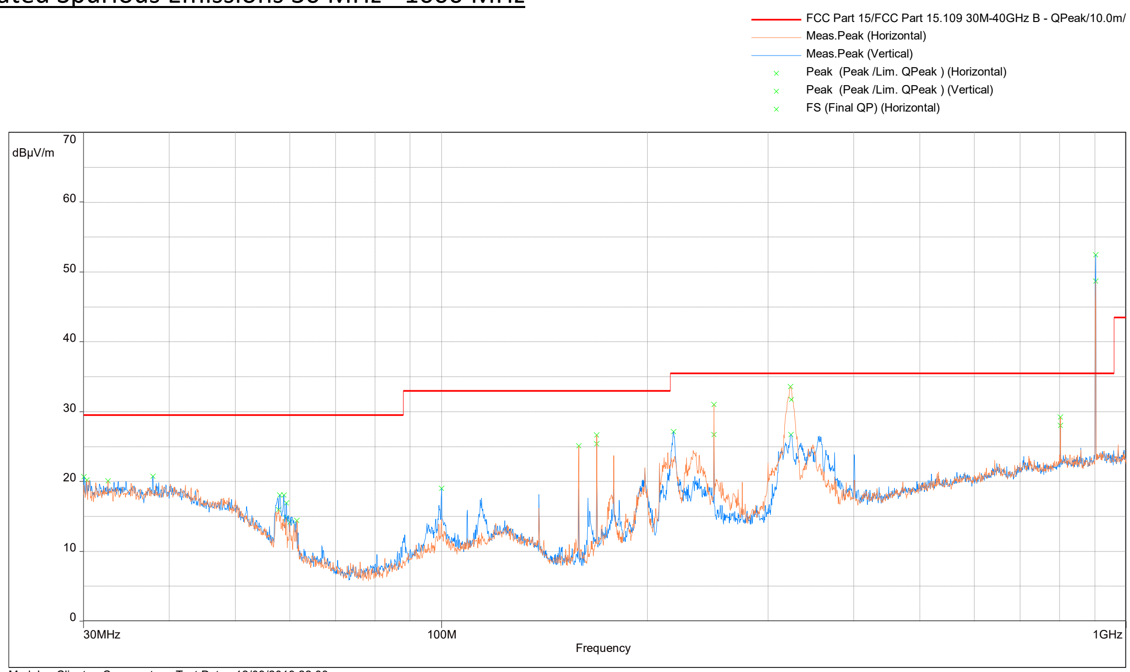
Frequency[3]	Peak Amplitude	Peak Limit	Duty Cycle Correction	Avg Amplitude	Avg Limit	Results
GHz	dB(µV/m)	dB(µV/m)	dB	dB(µV/m)	dB(µV/m)	
2.7808	56.4	74.0	-20.0	36.4	54.0	Pass

[3] The spurious identified in table above are compliant with 15.209 Average limit (54dBuV/m) by subtracting the Duty Cycle Correction Factor of 20dB to the Peak Amplitude (See Annex A for Duty Cycle calculation).

Out-of-Band Radiated Spurious Emissions

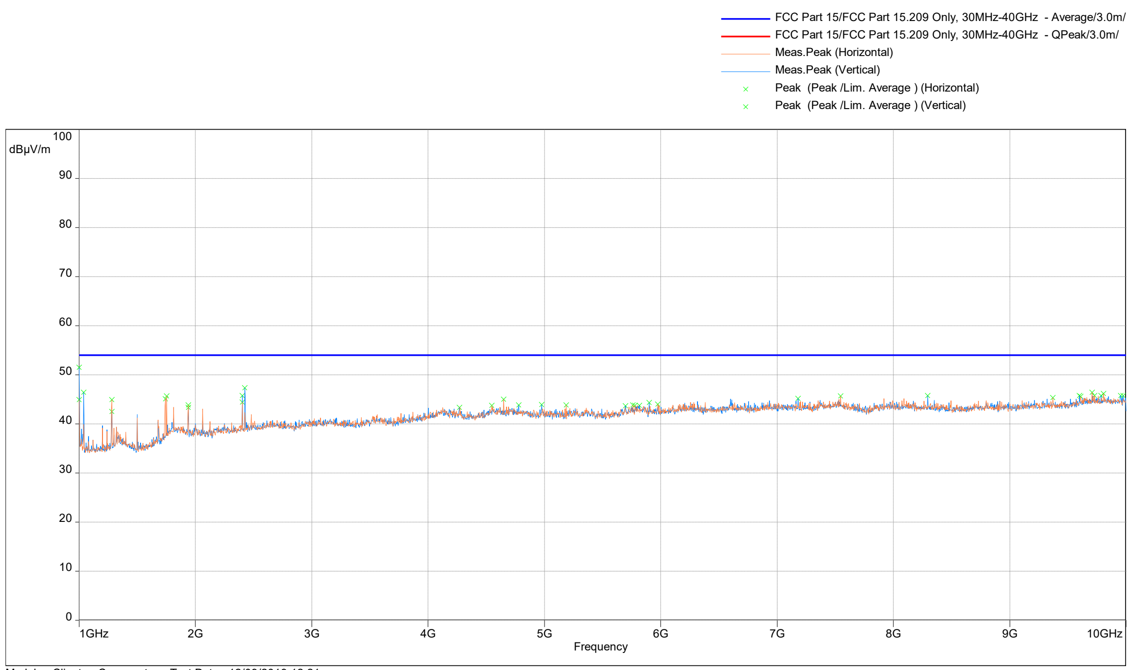
Test Results: 15.209 Radiated Spurious Emissions Low Channel, Tx at 902.400MHz

Radiated Spurious Emissions 30 MHz - 1000 MHz



Model: ; Client: ; Comments: ; Test Date: 12/09/2019 22:33

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg & Limit



Model: ; Client: ; Comments: ; Test Date: 12/09/2019 12:21

Test Results: 15.209 Radiated Spurious Emissions Low Channel, Tx at 902.400MHz

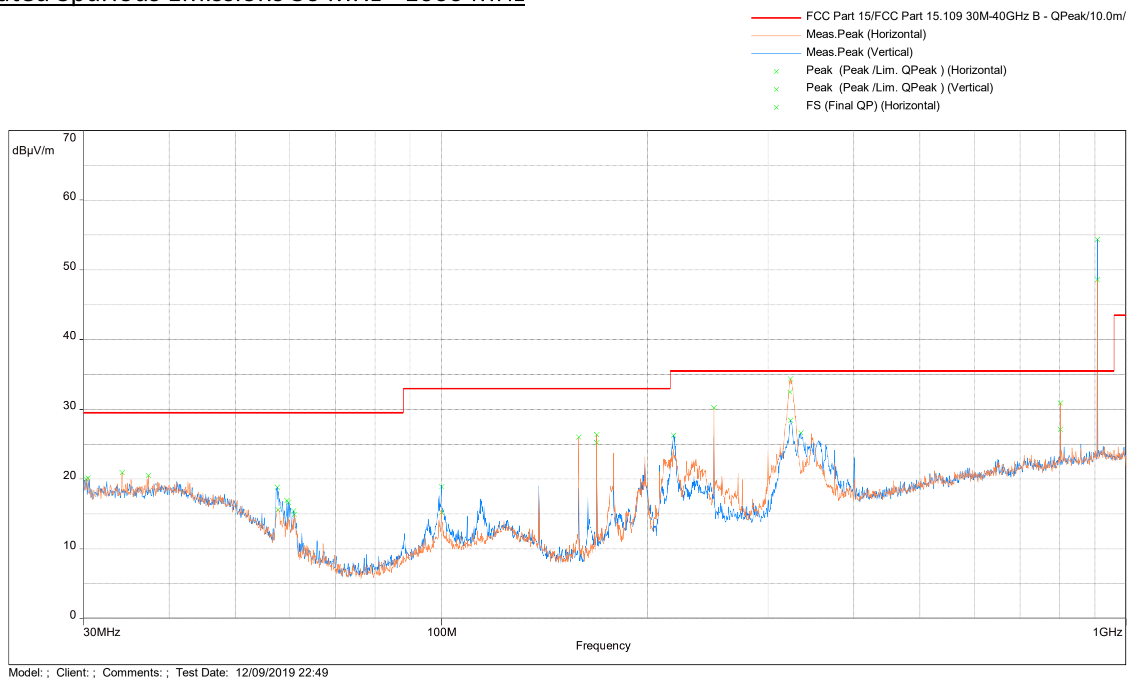
Frequency	FS @10m	Limit@10m	Margin	Height	Angle	Polarization	Correction
MHz	(dBµV/m)	(dBµV/m)	(dB)	(m)	(°)		(dB)
168.581	26.63	33.00	-6.37	4.00	21	Horizontal	-15.17
168.581	25.42	33.00	-7.58	1.00	227	Vertical	-15.17
249.996	30.97	35.50	-4.53	4.00	74	Horizontal	-11.83
324.195	31.72	35.50	-3.78	4.00	61	Horizontal	-9.48
801.829	29.21	35.50	-6.29	1.02	52	Horizontal	-1.64
Frequency	**FS @3m**	**Limit@3m**	**Margin**	**Height**	**Angle**	**Polarization**	**Correction**
MHz	**(dBµV/m)**	**(dBµV/m)**	**(dB)**	**(m)**	**(°)**		**(dB)**
1001.596	31.75	54.00	-22.25	1.00	137	Vertical	-17.98
2425.600	47.35	54.00	-6.65	1.49	240	Vertical	-14.94

Note: Raw Amplitude = FS - Correction (Antenna Factor + Cable Factor – Preamp Factor)

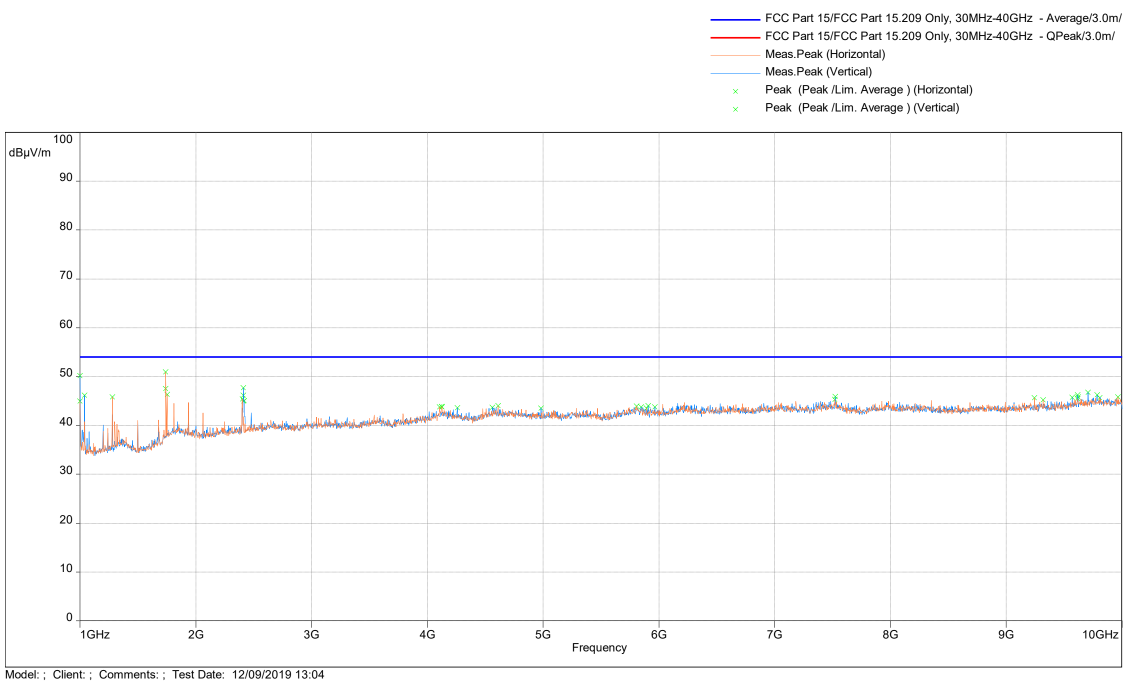
Results	Complies

Test Results: 15.209 Radiated Spurious Emissions Mid Channel, Tx at 914.867MHz

Radiated Spurious Emissions 30 MHz - 1000 MHz



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg & Limit



Test Results: 15.209 Radiated Spurious Emissions Mid Channel, Tx at 914.867MHz

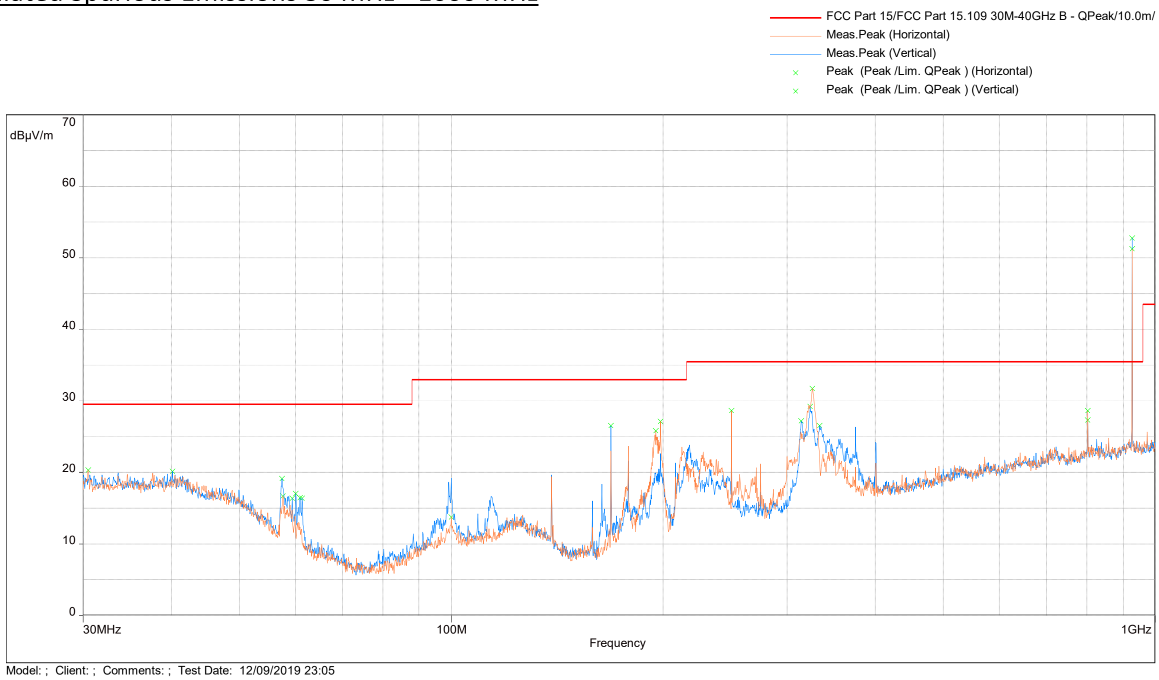
Frequency MHz	FS @10m (dBµV/m)	Limit@10m (dBµV/m)	Margin (dB)	Height (m)	Angle (°)	Polarization	Correction (dB)
168.581	26.37	33.00	-6.63	4.00	18	Horizontal	-15.17
249.996	30.25	35.50	-5.25	4.00	69	Horizontal	-11.83
322.993	32.47	35.50	-3.03	3.92	61	Horizontal	-9.50
801.829	30.90	35.50	-4.60	1.02	293	Horizontal	-1.64
Frequency MHz	**FS @3m (dBµV/m)**	**Limit@3m (dBµV/m)**	**Margin (dB)**	**Height (m)**	**Angle (°)**	**Polarization**	**Correction (dB)**
1000.000	50.18	54.00	-3.82	1.02	134	Vertical	-17.98
1739.200	47.57	54.00	-6.43	1.48	57	Horizontal	-16.89
1740.400	50.91	54.00	-3.09	2.48	57	Horizontal	-16.86
2409.400	47.74	54.00	-6.26	1.02	197	Vertical	-15.04

Note: Raw Amplitude = FS - Correction (Antenna Factor + Cable Factor – Preamp Factor)

Results	Complies

Test Results: 15.209 Radiated Spurious Emissions High Channel, Tx at 926.944MHz

Radiated Spurious Emissions 30 MHz - 1000 MHz



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg & Limit

Test Results: 15.209 Radiated Spurious Emissions High Channel, Tx at 926.944MHz

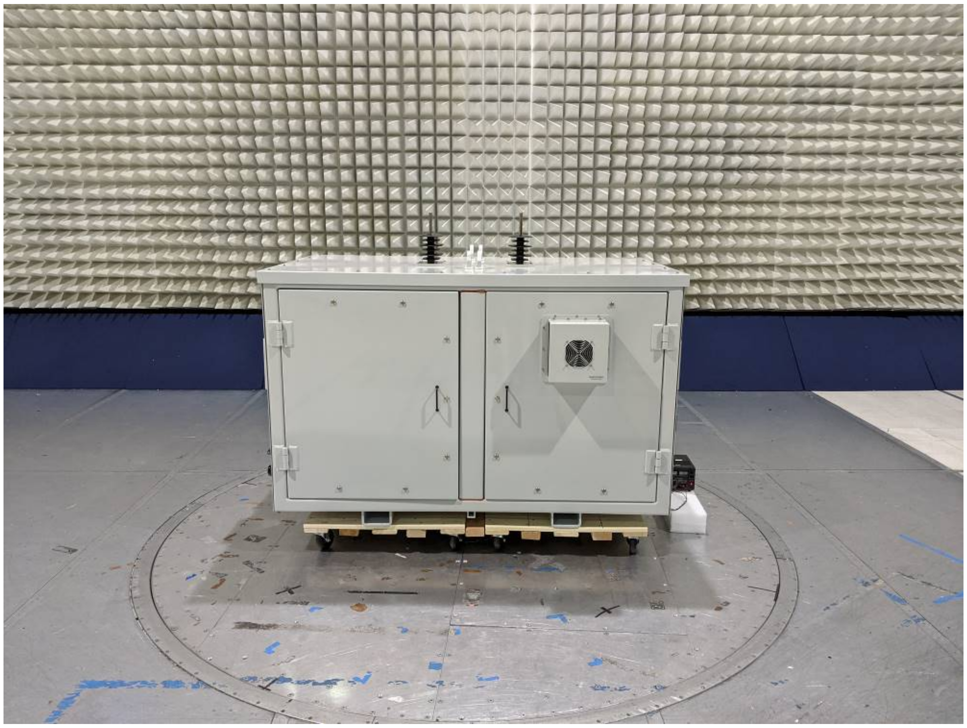
Frequency	**FS @10m**	**Limit@10m**	**Margin**	**Height**	**Angle**	**Polarization**	**Correction**
MHz	**(dBµV/m)**	**(dBµV/m)**	**(dB)**	**(m)**	**(°)**		**(dB)**
168.581	26.55	33.00	-6.45	1.00	229	Vertical	-15.17
198.327	27.14	33.00	-5.86	2.52	15	Horizontal	-14.30
249.996	28.61	35.50	-6.89	2.52	66	Horizontal	-11.83
323.360	29.21	35.50	-6.29	1.00	336	Vertical	-9.50
325.818	31.74	35.50	-3.76	2.52	15	Horizontal	-9.40
801.829	28.59	35.50	-6.91	1.02	96	Horizontal	-1.64
Frequency	**FS @3m**	**Limit@3m**	**Margin**	**Height**	**Angle**	**Polarization**	**Correction**
MHz	**(dBµV/m)**	**(dBµV/m)**	**(dB)**	**(m)**	**(°)**		**(dB)**
1000.000	48.85	54.00	-5.15	1.01	336	Vertical	-17.98
2409.700	48.55	54.00	-5.45	2.49	185	Vertical	-15.03

Note: Raw Amplitude = FS - Correction (Antenna Factor + Cable Factor – Preamp Factor)

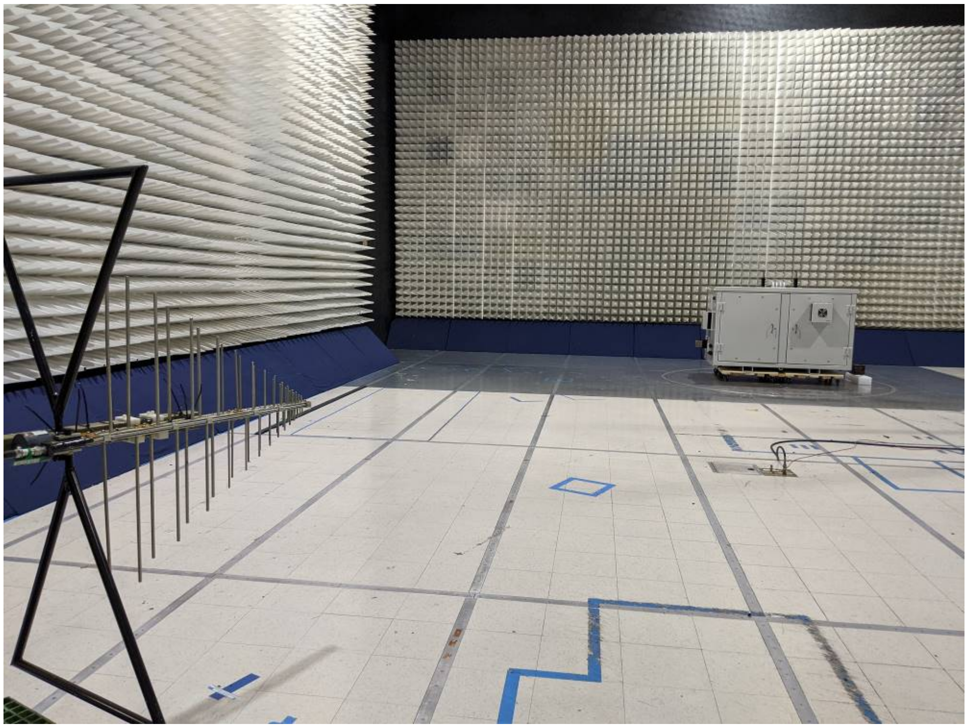
Results	Complies

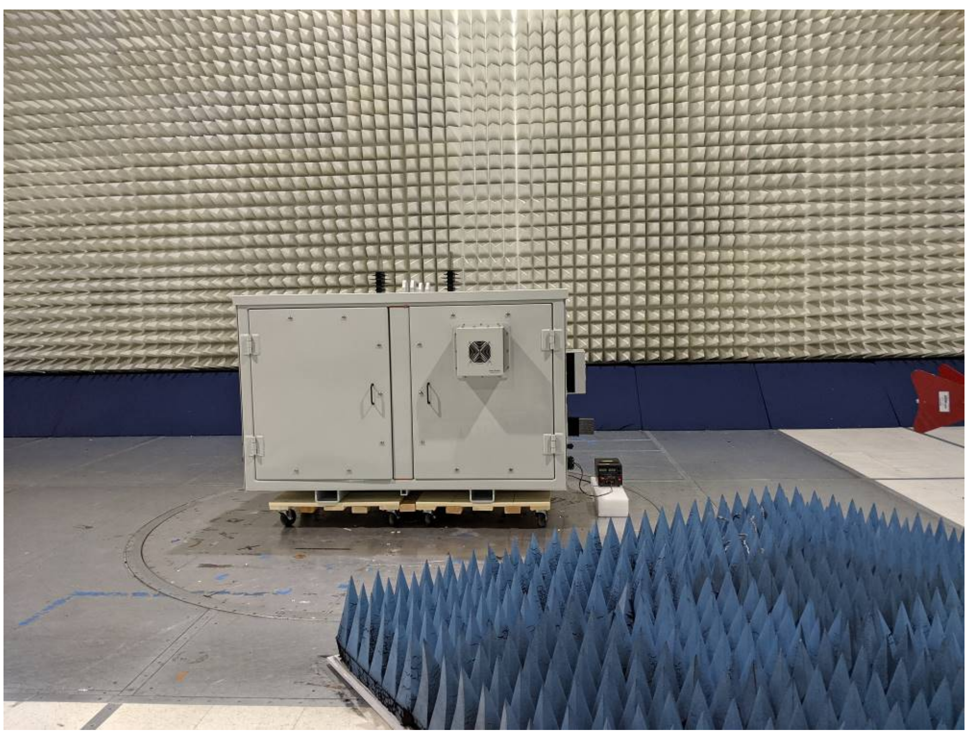
4.7.7 Test Setup Photographs

The following photographs show the testing configurations used.



4.7.5 Test Setup Photographs (Continued)





4.8 Digital Radiated Emissions

FCC Ref: 15.109, ICES 003

4.8.1 Requirement

Limits for Electromagnetic Radiated Emissions FCC Section 15.109(b), ICES 003*, RSS GEN

Frequency (MHz)	Class A at 10m dB(μV/m)	Class B at 3m dB(μV/m)
30-88	39	40.0
88-216	43.5	43.5
216-960	46.4	46.0
Above 960	49.5	54.0

* According to FCC Part 15.109(g) an alternative to the radiated emission limits shown above, digital devices may be shown to comply with the limit of CISPR Pub. 22

4.8.2 Procedures

Measurements are conducted with a quasi-peak detector instrument in the frequency range of 30 MHz to 1000 MHz and with the average detector instrument in the frequency range above 1000 MHz. The measuring receiver meets the requirements of Section One of CISPR 16 and the measuring antenna correlates to a balanced dipole.

Measurements of the radiated field are made with the antenna located at a distance of 10 meters from the EUT. If the field-strength measurements at 10m cannot be made because of high ambient noise level or for other reasons, measurements of Class B equipment may be made at a closer distance, for example 3m. An inverse proportionality factor of 20 dB per decade should be used to normalize the measured data or limit line to the specified distance for determining compliance.

The antenna is adjusted between 1m and 4m in height above the ground plane for maximum meter reading at each test frequency.

The antenna-to-EUT azimuth is varied during the measurement to find the maximum field-strength readings.

The antenna-to-EUT polarization (horizontal and vertical) is varied during the measurements to find the maximum field-strength readings.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for a larger EUT.

Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material.

Equipment setup for radiated disturbance tests followed the guidelines of ANSI C63.4: 2014

4.8.3 Test Results

Radiated emission measurements were performed from 30 MHz to 1000 MHz. The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

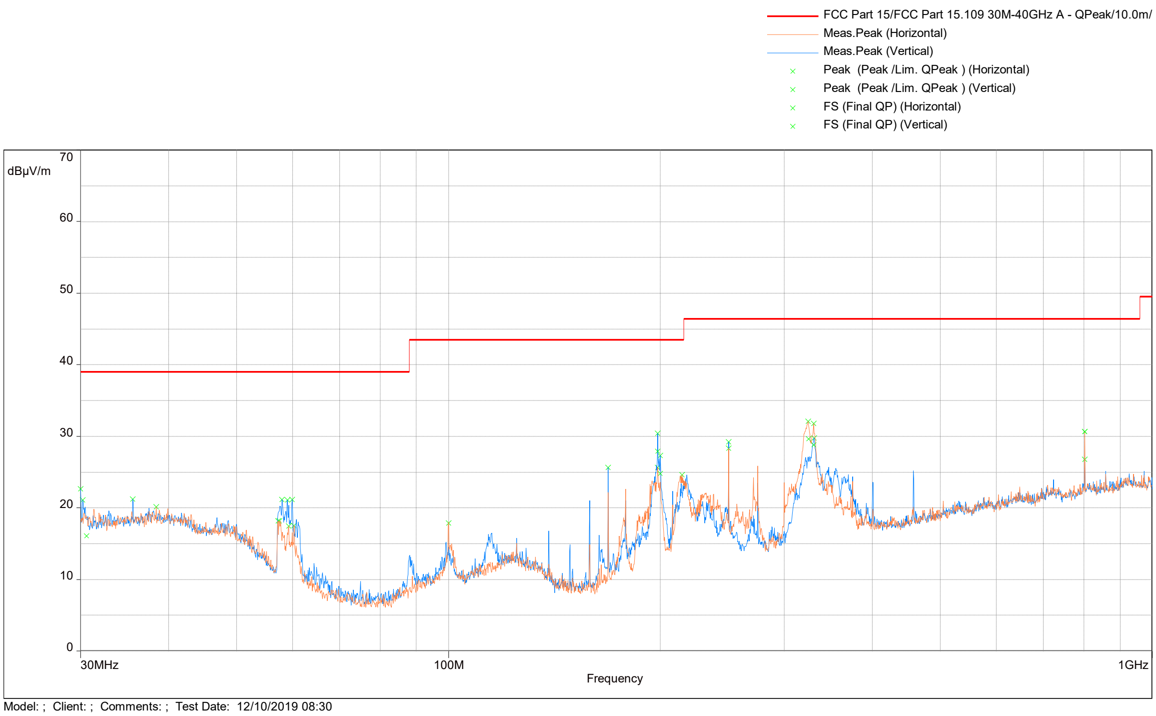
An inverse proportionality factor of 20 dB per decade was used to normalize the limit line of 30MHz to 1000MHz to the specified distance for determining compliance

Note: Radiated emission measurements were performed up to 18GHz.

Tested By	Test Date
Anderson Soungpanya	December 09 - 10, 2019

4.8.3 Test Results (Continued)

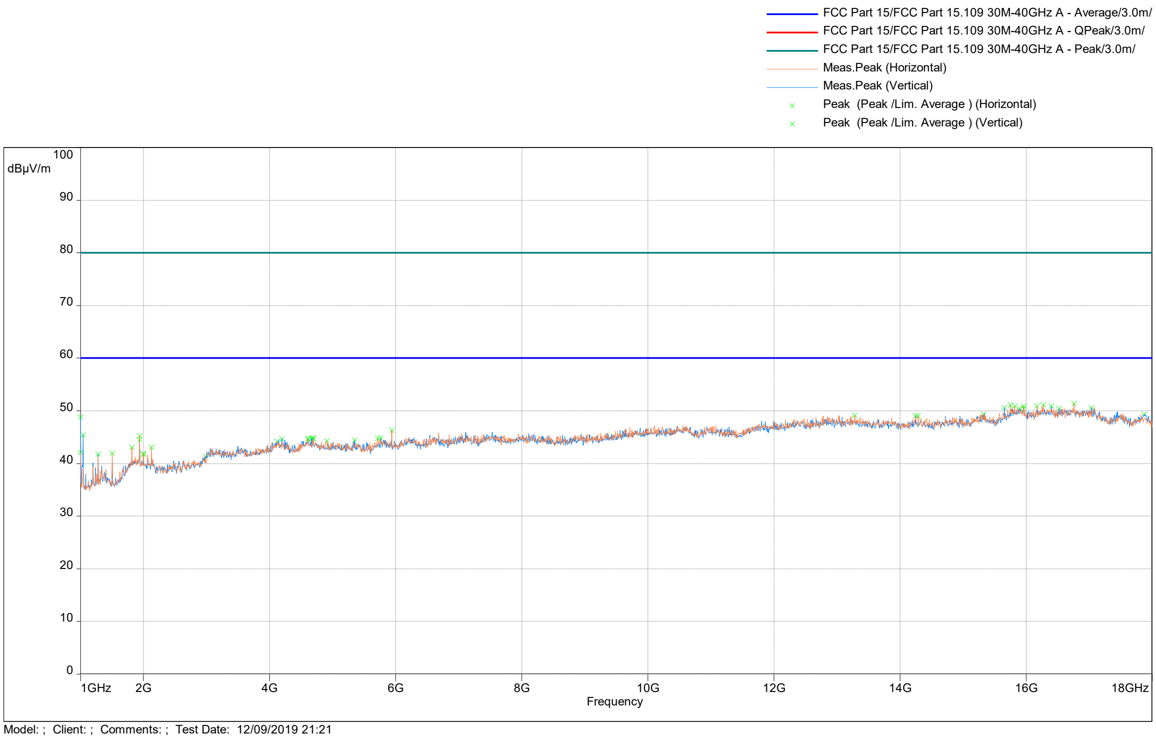
Radiated Emissions 30 MHz – 1000, FCC Part 15B: Class A



Frequency MHz	FS@10m dB(µV/m)	Limit @10m dB(uV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity	RA (dBuV)	Correction (dB)
30.586	16.05	39.0	-22.95	178	3.96	Vertical	22.75	-6.76
198.347	27.90	43.5	-15.60	3	1.00	Vertical	42.20	-14.30
199.992	24.82	43.5	-18.68	352	1.04	Vertical	39.10	-14.28
324.991	29.63	46.4	-16.77	68	3.96	Horizontal	39.08	-9.40
330.413	28.81	46.4	-17.59	351	4.00	Horizontal	38.00	-9.20
801.831	30.66	46.4	-15.74	262	1.58	Horizontal	32.30	-1.64
Result:	Complies by 15.60 dB							

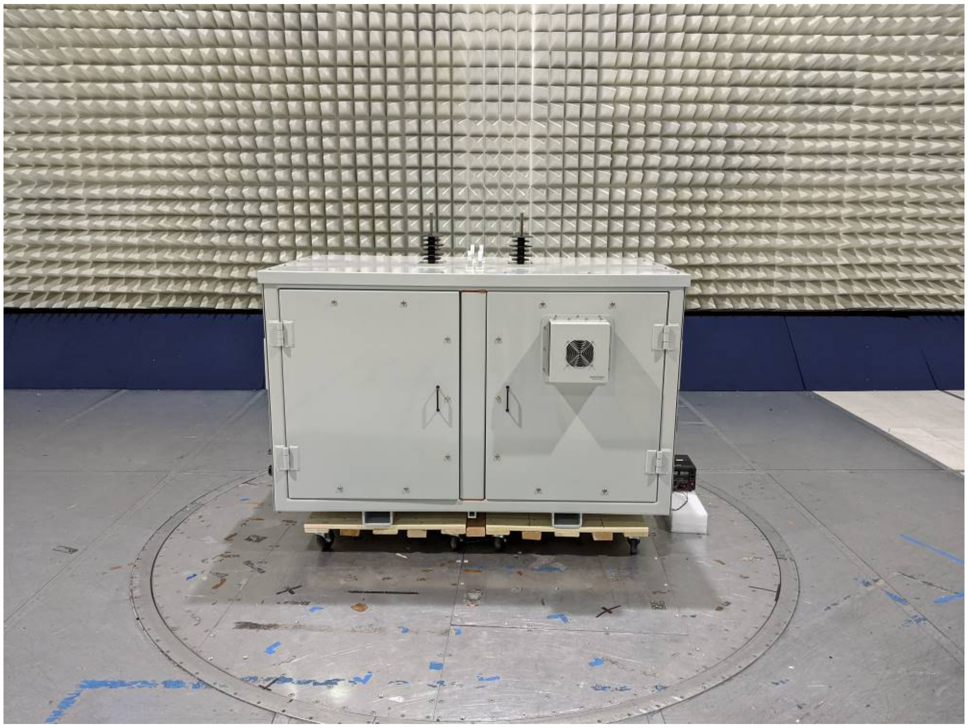
4.8.3 Test Results (Continued)

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg Limit

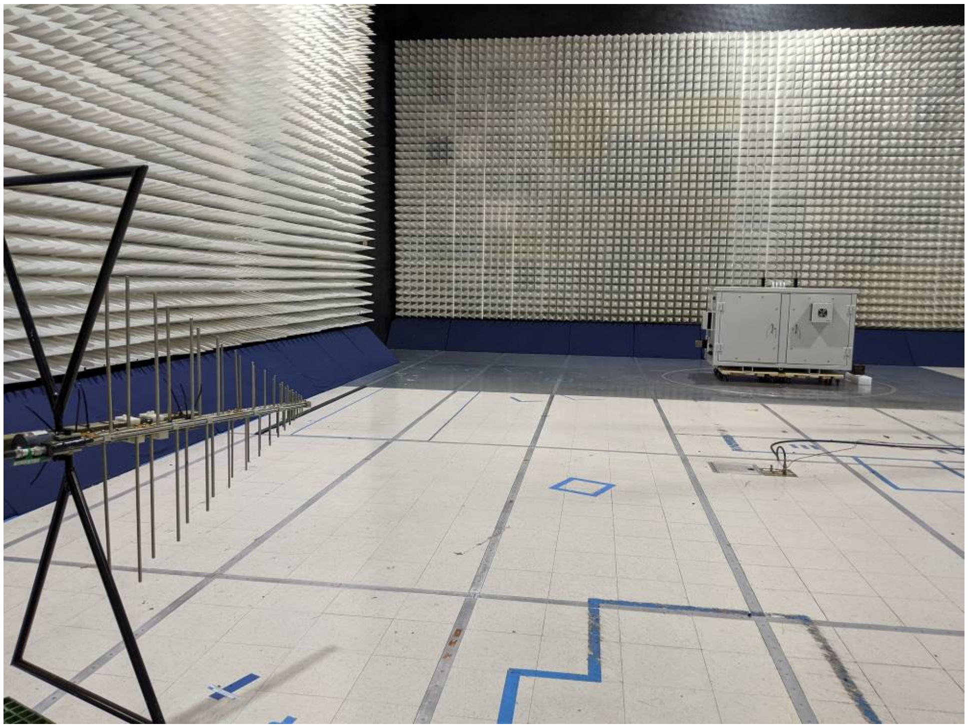


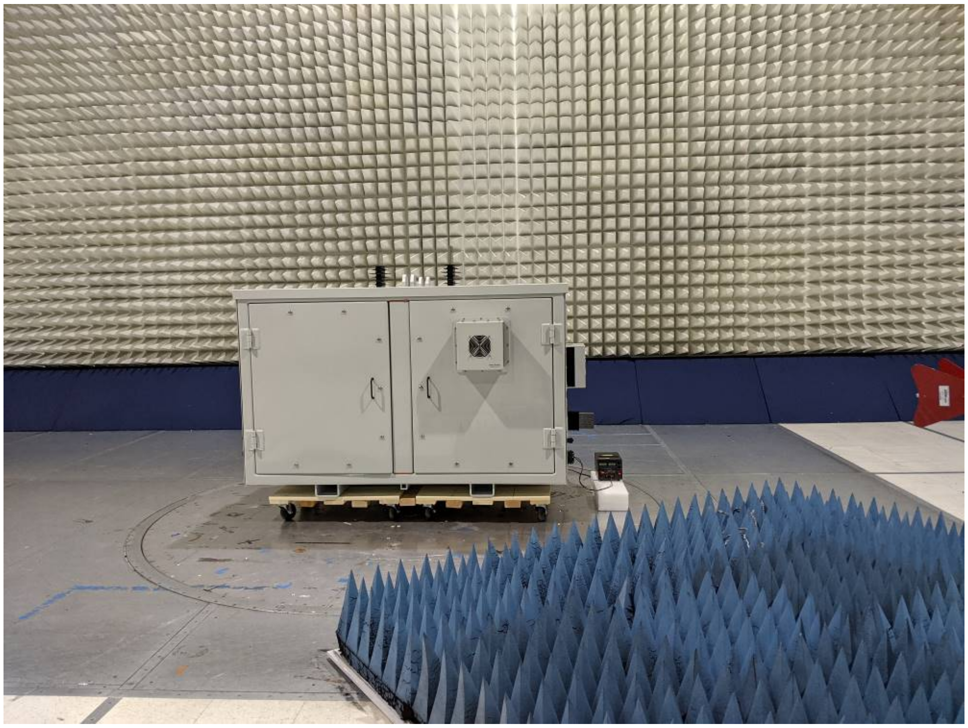
Results	Complies

4.8.4 Test Configuration Photographs



4.8.4 Test Setup Photographs (Continued)





4.9 AC Line Conducted Emission
FCC: 15.207, 15.107; RSS-GEN;

4.9.1 Requirement

Frequency Band MHz	Class B Limit dB(µV)		Class A Limit dB(µV)	
	Quasi-Peak	Average	Quasi-Peak	Average
0.15-0.50	66 to 56 *	56 to 46 *	79	66
0.50-5.00	56	46	73	60
5.00-30.00	60	50	73	60

*Note: *Decreases linearly with the logarithm of the frequency*
At the transition frequency the lower limit applies.

4.9.2 Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide a defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage and also to provide isolation of the circuit under test from the ambient noise on the power lines. An AMN as defined in CISPR 16 shall be used.

The EUT is located so that the distance between the boundary of the EUT and the closest surface of the AMN is 0.8m.

Where a flexible mains cord is provided by the manufacturer, this shall be 1m long or if in excess of 1m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0.4m in length.

The EUT is arranged and connected with cables terminated in accordance with the product specification.

Conducted disturbance is measured between the phase lead and the reference ground, and between the neutral lead and the reference ground. Both measured values are reported.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. A vertical, metal reference plane is placed 0.4m from the EUT. The vertical metal reference-plane is at least 2m by 2m. The EUT shall be kept at least 0.8m from any other metal surface or other ground plane not being part of the EUT. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for larger EUT.

Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

Equipment setup for conducted disturbance tests followed the guidelines of ANSI C63.4:2014 and ANSI C63.10:2013.

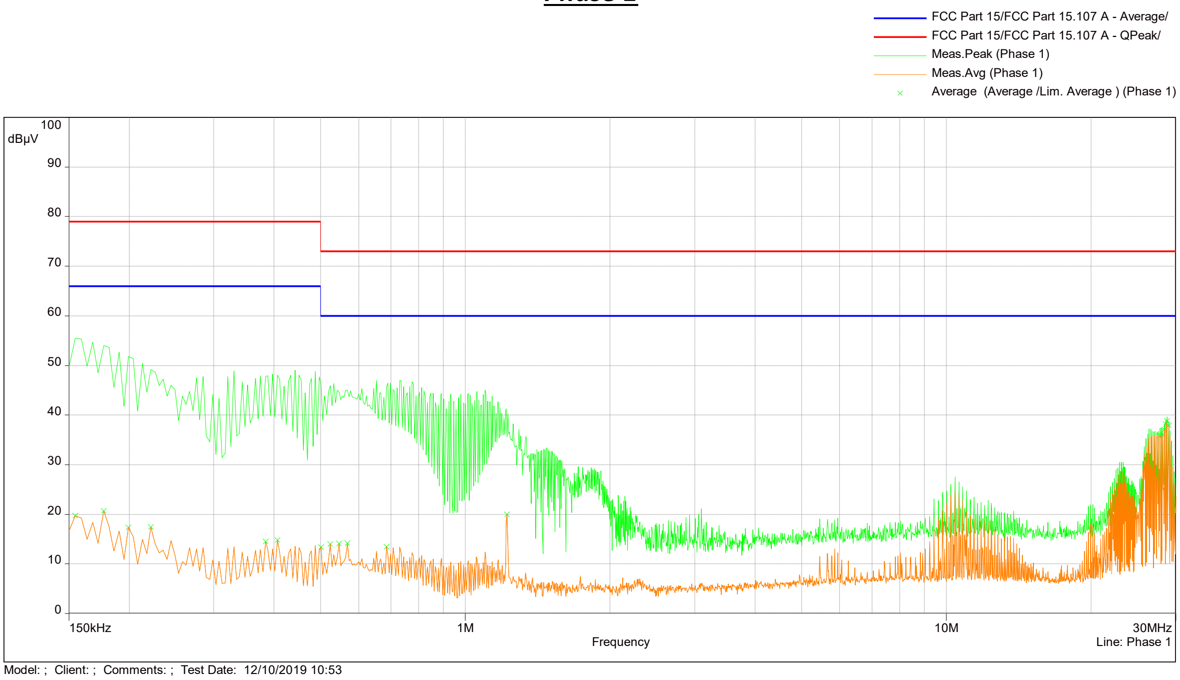
4.9.3 Test Results

Tested By	Test Date
Anderson Soungpanya	December 10, 2019

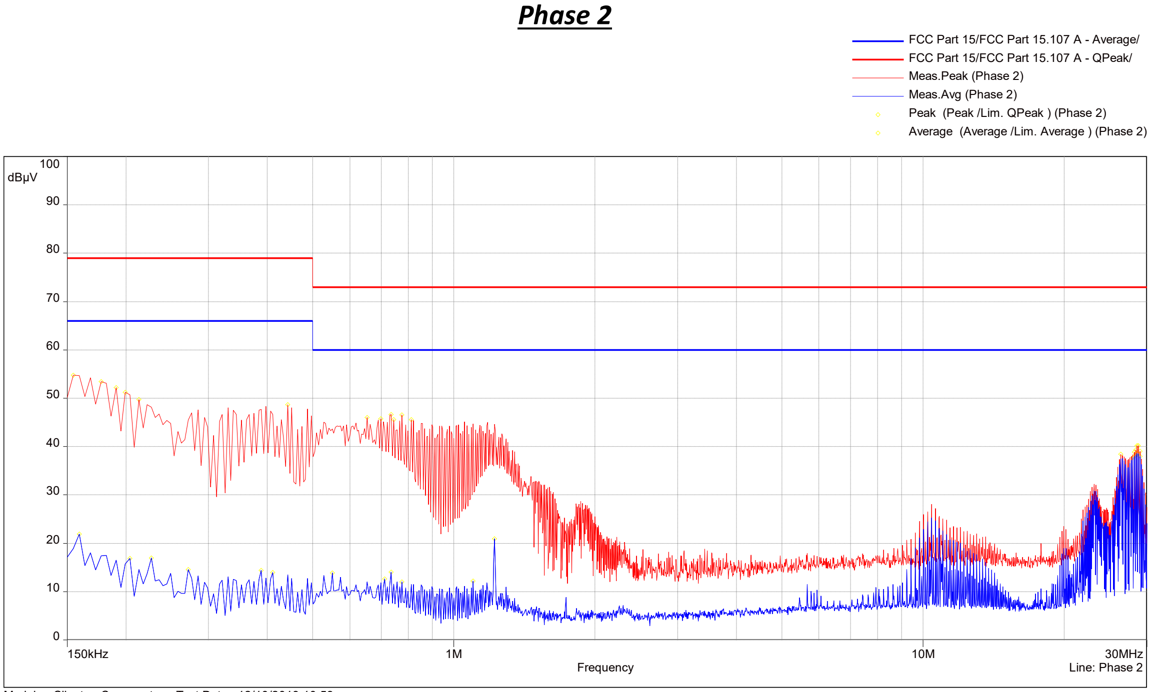
4.9.3 Test Results (Continued)

Conducted Emissions 120VAC 60Hz, FCC Part 15.107

Phase 1



Phase 2



4.9.3 Test Results (Continued)

Quasi Peak Table					
Frequency (MHz)	QPeak (dBµV)	Lim. QPeak (dBµV)	QPeak-Lim (dB)	Phase	Correction (dB)
0.155	55.47	79.00	-23.53	Phase 1	10.72
0.155	54.79	79.00	-24.21	Phase 2	10.72
0.168	54.74	79.00	-24.26	Phase 1	10.72
0.177	53.47	79.00	-25.53	Phase 2	10.71
0.177	54.03	79.00	-24.97	Phase 1	10.71
0.191	52.72	79.00	-26.28	Phase 1	10.70
0.191	52.20	79.00	-26.80	Phase 2	10.70
0.200	51.24	79.00	-27.76	Phase 2	10.69
0.200	51.85	79.00	-27.15	Phase 1	10.69
0.533	46.36	73.00	-26.64	Phase 1	10.68
0.654	46.03	73.00	-26.97	Phase 2	10.70
0.654	47.01	73.00	-25.99	Phase 1	10.70
0.690	46.40	73.00	-26.60	Phase 1	10.70
0.699	45.79	73.00	-27.21	Phase 2	10.71
0.699	46.48	73.00	-26.52	Phase 1	10.71
0.735	46.68	73.00	-26.32	Phase 2	10.71
0.735	47.00	73.00	-26.00	Phase 1	10.71
0.744	45.55	73.00	-27.45	Phase 2	10.71
0.776	46.72	73.00	-26.28	Phase 1	10.70
0.776	46.55	73.00	-26.45	Phase 2	10.70
0.812	45.56	73.00	-27.44	Phase 2	10.71
26.412	38.43	73.00	-34.57	Phase 2	11.67
27.987	37.48	73.00	-35.52	Phase 1	11.70
28.190	37.41	73.00	-35.59	Phase 1	11.70
28.199	38.90	73.00	-34.10	Phase 2	11.70
28.388	38.15	73.00	-34.85	Phase 1	11.70
28.397	39.32	73.00	-33.68	Phase 2	11.70
28.586	39.10	73.00	-33.90	Phase 1	11.70
28.595	40.21	73.00	-32.79	Phase 2	11.70
28.784	39.63	73.00	-33.37	Phase 1	11.70
28.797	40.18	73.00	-32.82	Phase 2	11.70
28.982	38.59	73.00	-34.41	Phase 1	11.70
28.995	39.08	73.00	-33.92	Phase 2	11.70

4.9.3 Test Results (Continued)

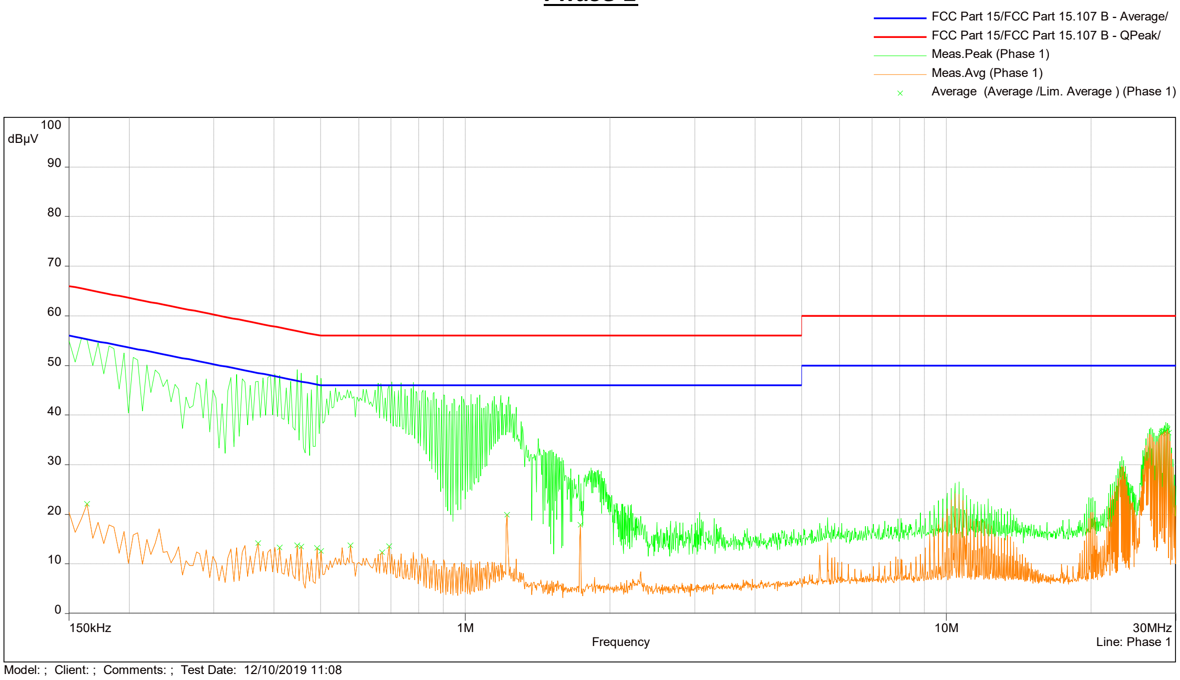
Average Table					
Frequency (MHz)	AVG (dBµV)	Lim. Average (dBµV)	AVG-Lim (dB)	Phase	Correction (dB)
0.155	19.69	66.00	-46.31	Phase 1	10.72
0.159	21.96	66.00	-44.04	Phase 2	10.71
0.177	20.66	66.00	-45.34	Phase 1	10.71
0.222	17.45	66.00	-48.55	Phase 1	10.69
0.227	16.95	66.00	-49.05	Phase 2	10.67
0.411	13.93	66.00	-52.07	Phase 2	10.69
0.501	13.42	60.00	-46.58	Phase 1	10.68
0.524	13.95	60.00	-46.05	Phase 1	10.68
0.546	14.11	60.00	-45.89	Phase 1	10.66
0.551	13.84	60.00	-46.16	Phase 2	10.66
0.569	14.15	60.00	-45.85	Phase 1	10.68
0.686	13.49	60.00	-46.51	Phase 1	10.71
0.713	12.63	60.00	-47.37	Phase 2	10.70
0.735	14.06	60.00	-45.94	Phase 2	10.71
0.776	12.04	60.00	-47.96	Phase 2	10.70
1.100	12.22	60.00	-47.78	Phase 2	10.71
1.221	20.94	60.00	-39.06	Phase 2	10.71
1.221	19.97	60.00	-40.03	Phase 1	10.71
27.789	35.92	60.00	-24.08	Phase 1	11.69
28.001	37.74	60.00	-22.26	Phase 2	11.70
28.190	35.94	60.00	-24.06	Phase 1	11.70
28.199	38.02	60.00	-21.98	Phase 2	11.70
28.388	37.03	60.00	-22.97	Phase 1	11.70
28.397	38.36	60.00	-21.64	Phase 2	11.70
28.586	38.18	60.00	-21.82	Phase 1	11.70
28.595	38.64	60.00	-21.36	Phase 2	11.70
28.784	38.81	60.00	-21.19	Phase 1	11.70
28.797	38.55	60.00	-21.45	Phase 2	11.70
28.982	37.92	60.00	-22.08	Phase 1	11.70
28.995	38.02	60.00	-21.98	Phase 2	11.70

Results: Complies by 21.19 dB

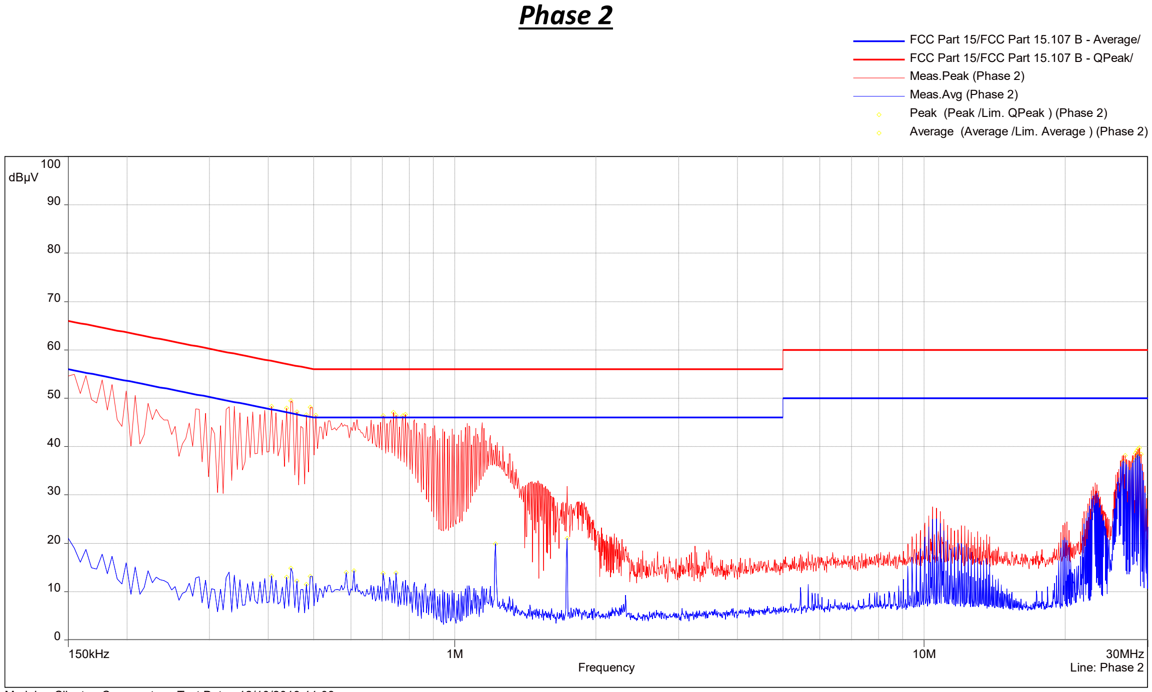
4.9.3 Test Results (Continued)

Conducted Emissions 120VAC 60Hz, FCC Part 15.207

Phase 1



Phase 2



4.9.3 Test Results (Continued)

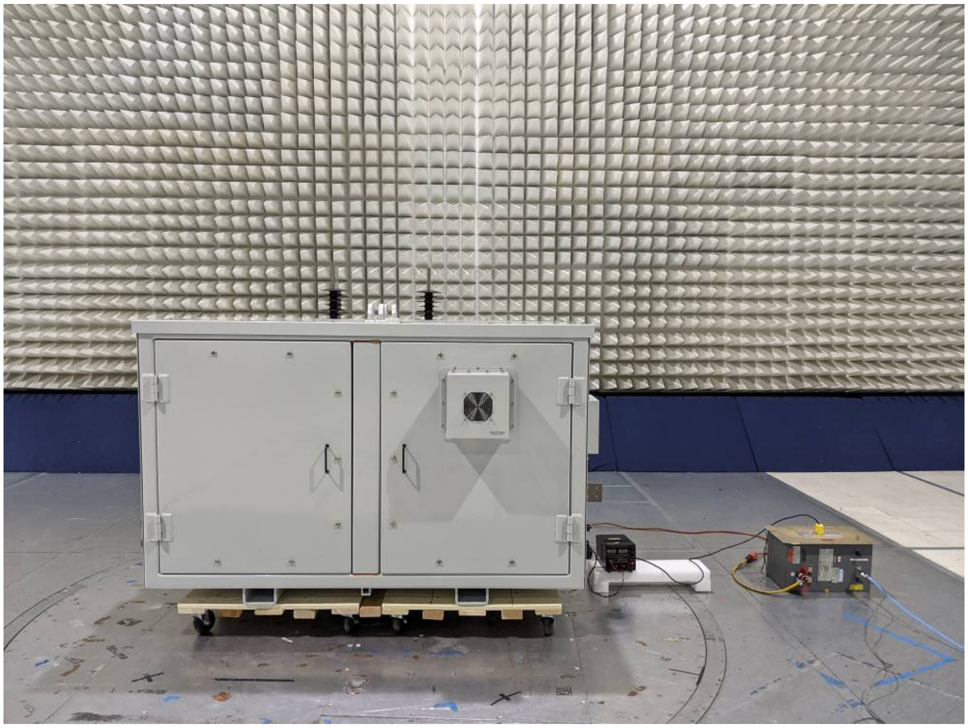
Quasi Peak Table					
Frequency (MHz)	QPeak (dBµV)	Lim. QPeak (dBµV)	QPeak-Lim (dB)	Phase	Correction (dB)
0.393	47.93	58.00	-10.07	Phase 1	10.68
0.402	48.29	57.81	-9.52	Phase 1	10.67
0.407	48.31	57.72	-9.41	Phase 2	10.68
0.411	48.05	57.63	-9.58	Phase 1	10.69
0.438	47.94	57.10	-9.16	Phase 2	10.68
0.447	49.18	56.93	-7.76	Phase 1	10.68
0.447	49.48	56.93	-7.45	Phase 2	10.68
0.456	48.45	56.77	-8.32	Phase 1	10.68
0.461	47.19	56.68	-9.49	Phase 2	10.68
0.483	46.54	56.29	-9.75	Phase 2	10.69
0.492	48.17	56.13	-7.97	Phase 2	10.69
0.492	48.05	56.13	-8.08	Phase 1	10.69
0.501	47.43	56.00	-8.57	Phase 1	10.68
0.506	46.47	56.00	-9.53	Phase 2	10.67
0.659	46.44	56.00	-9.56	Phase 1	10.70
0.668	46.40	56.00	-9.60	Phase 1	10.70
0.704	46.40	56.00	-9.60	Phase 2	10.71
0.704	46.75	56.00	-9.25	Phase 1	10.71
0.735	46.53	56.00	-9.47	Phase 1	10.71
0.740	47.07	56.00	-8.93	Phase 2	10.71
0.749	46.48	56.00	-9.52	Phase 2	10.70
0.776	46.40	56.00	-9.60	Phase 2	10.70
0.780	46.59	56.00	-9.41	Phase 1	10.70
0.785	46.64	56.00	-9.36	Phase 2	10.69
28.203	38.63	60.00	-21.37	Phase 2	11.70
28.401	39.03	60.00	-20.97	Phase 2	11.70
28.401	37.89	60.00	-22.11	Phase 1	11.70
28.599	38.52	60.00	-21.48	Phase 1	11.70
28.599	39.47	60.00	-20.53	Phase 2	11.70
28.797	39.78	60.00	-20.22	Phase 2	11.70
28.802	38.39	60.00	-21.61	Phase 1	11.70

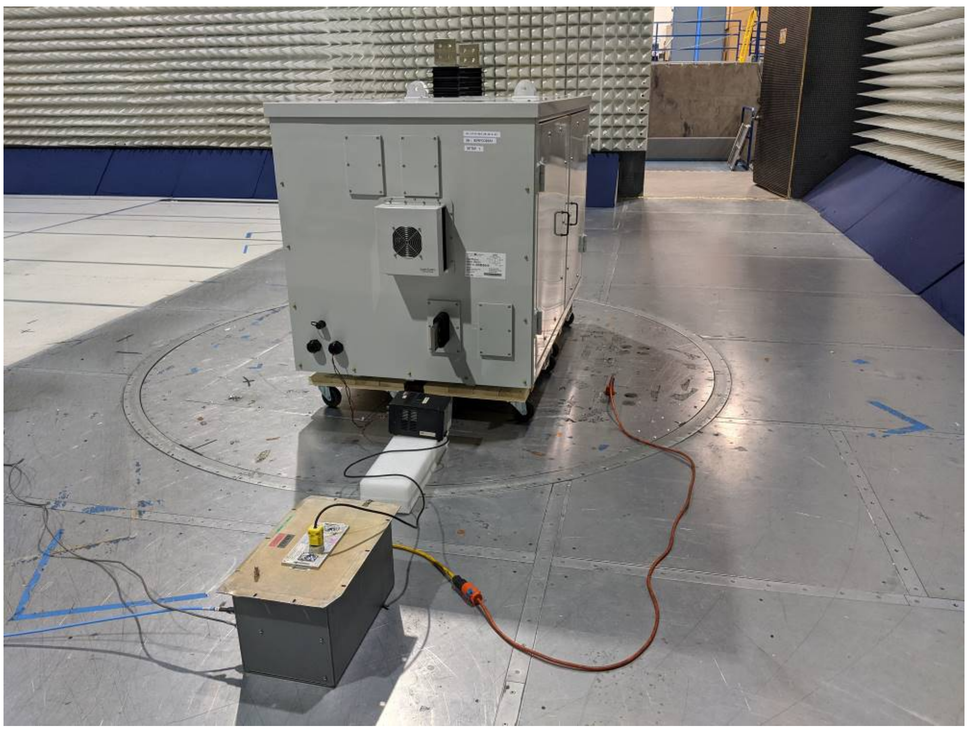
4.9.3 Test Results (Continued)

Average Table					
Frequency (MHz)	AVG (dBµV)	Lim. Average (dBµV)	AVG-Lim (dB)	Phase	Correction (dB)
0.164	22.11	55.28	-33.17	Phase 1	10.72
0.411	13.30	47.63	-34.33	Phase 1	10.69
0.438	12.95	47.10	-34.15	Phase 2	10.68
0.447	13.76	46.93	-33.17	Phase 1	10.68
0.447	14.89	46.93	-32.04	Phase 2	10.68
0.456	13.44	46.77	-33.32	Phase 1	10.68
0.461	12.19	46.68	-34.49	Phase 2	10.68
0.483	11.50	46.29	-34.79	Phase 2	10.69
0.492	13.17	46.13	-32.96	Phase 1	10.69
0.609	14.28	46.00	-31.72	Phase 2	10.69
0.672	12.34	46.00	-33.66	Phase 1	10.70
0.695	13.53	46.00	-32.47	Phase 1	10.70
1.221	19.87	46.00	-26.13	Phase 1	10.71
1.221	19.86	46.00	-26.14	Phase 2	10.71
1.734	17.88	46.00	-28.12	Phase 1	10.75
1.734	21.07	46.00	-24.93	Phase 2	10.75
26.615	37.01	50.00	-12.99	Phase 2	11.67
28.005	36.23	50.00	-13.77	Phase 1	11.70
28.005	37.17	50.00	-12.83	Phase 2	11.70
28.203	36.41	50.00	-13.59	Phase 1	11.70
28.203	37.67	50.00	-12.33	Phase 2	11.70
28.401	36.67	50.00	-13.33	Phase 1	11.70
28.401	38.15	50.00	-11.85	Phase 2	11.70
28.599	36.65	50.00	-13.35	Phase 1	11.70
28.599	38.44	50.00	-11.56	Phase 2	11.70
28.797	37.99	50.00	-12.01	Phase 2	11.70
28.802	37.13	50.00	-12.87	Phase 1	11.70
29.000	36.42	50.00	-13.58	Phase 1	11.70

Results: Complies by 7.45 dB

4.9.4 Test Configuration Photographs





5.0 List of Test Equipment and Software

Measurement equipment used for emission compliance testing utilized the equipment on the following list:

Equipment Description	Manufacturer	Model/ Type	Asset No.	Monthly Cal Interval	Cal Due
EMI Receiver	Rohde and Schwarz	ESR	ITS 01607	12	10/23/20
EMI Receiver	Rohde and Schwarz	ESU40	ITS 00961	12	11/07/20
Spectrum Analyzer	Rohde and Schwarz	FSU	ITS 00913	12	03/26/20
Active Horn Antenna	ETS-Lindgren	3117-PA	ITS 01636	12	01/17/20
BI-Log Antenna	Antenna Research	LPB-2513	ITS 00355	12	04/24/20
Pre-Amplifier	Sonoma Instrument	310N	ITS 00415	12	04/104/20
Horn Antenna (10-40 GHz)	ETS-Lindgren	3116C	ITS 01376	12	02/15/20
Pre-Amplifier (18-40GHz)	Miteq	TTA1840-35-S-M	ITS 01393	12	02/08/20
LISN	FCC	FCC-LISN-PA-NEMA-5-15	ITS 00551	12	11/13/20
RF Cable	Megaphase	TM40-K1K1-59	ITS 01657	12	11/11/20
RF Cable	Megaphase	EMC1-K1K1-236	ITS 01537	12	02/20/20
RF Cable	TRU Corporation	TRU CORE 300	ITS 01330	12	05/09/20
RE Cable	TRU Corporation	TRU CORE 300	ITS 01465	12	08/27/20
RE Cable	TRU Corporation	TRU CORE 300	ITS 01470	12	08/27/20
Transient Limiter	COM-POWER	LIT-153A	ITS 01452	12	08/30/20
Notch Filter	Micro-Tronics	BRC50722	ITS 01170	12	03/18/20
High Pass Filter	Micro-Tronics	HPM50144-02	ITS 01722	12	11/11/20
Attenuator	Mini Circuits	FSCM99899	ITS 01582	12	10/07/20

Software used for emission compliance testing utilized the following:

Name	Manufacturer	Version	Template/Profile
Tile	Quantum Change	3.4.K.22	Conducted Spurious_30M-26GHz Conducted Restricted Band Edge_Avg Conducted Restricted Band Edge_Peak Conducted Restricted Band_30M-1GHz Conducted Restricted Band_1-26GHz
BAT-EMC	Nexio	3.16.0.64	Smartwires_G103948971.bpp
RS Commander	Rohde Schwarz	1.6.4	Not Applicable (Screen grabber)

Total Quality. Assured.

6.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G103948971	AS	KV	December 29, 2019	Original Document
1.1 / G103948971	AS	KV	January 10, 2020	Added additional tabular data into section 4.7.6

Annex A - Duty Cycle Measurement

A.1 Procedure

<u>ANSI C63.10:2013; Section 7.5</u>

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval. The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in Equation:

$$\delta \text{ (dB)} = 20 \log (\Delta)$$

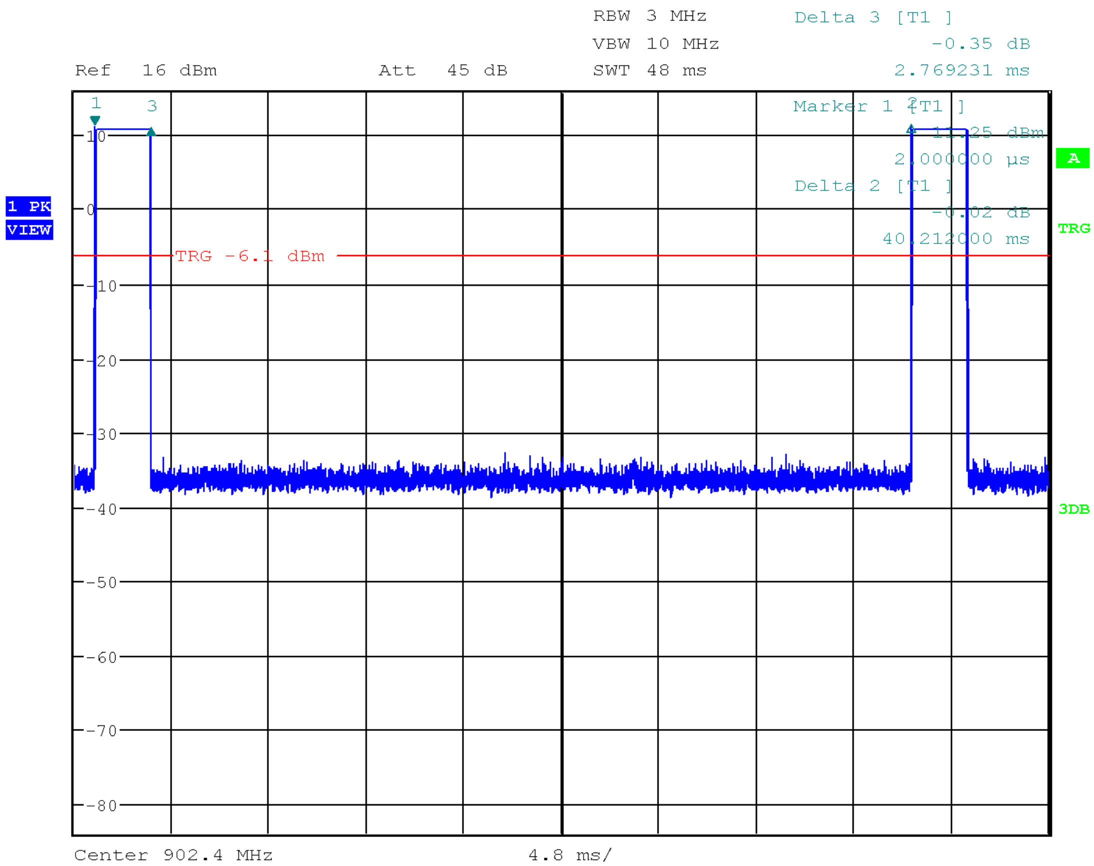
where

δ is the duty cycle correction factor (dB)
Δ is the duty cycle (dimensionless)

This correction factor may then be subtracted from the peak pulse amplitude (in dB) to find the average emission. This correction may be applied to all emissions that demonstrate the same pulse timing characteristics as the fundamental emission (e.g., the fundamental and harmonic emissions). In cases where the pulse train is truly random or pseudo random, some regulatory agencies may accept a declaration by the manufacturer of the worst-case value of t_{ON}.

When the duty cycle correction factor is calculated to be less than -20.0 dB, -20.0 dB is used to find the average emission.

A.2 Test Results



Date: 25.NOV.2019 09:05:12

Duty Cycle: DC = 2.769/40.212 = 0.0689 or 6.89%

Duty Cycle Correction Factor **δ (dB)** = 20 log (0.0689) = -23.23 dB

END OF REPORT