TEST REPORT

Report Number: 103758643MPK-002
Project Number: G103758643
January 29, 2019

Testing performed on the
SmartBypass™
Model Number: SmartBypass 2000

FCC ID: QPS01006

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:** January 29, 2019
Anderson Soungpanya

Reviewed by: _____ **Date:** January 29, 2019
Krishna K Vemuri

Report No. 103758643MPK-002	
Equipment Under Test:	SmartBypass™
Trade Name:	Smart Wires, Inc.
Model Number(s):	SmartBypass 2000
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:	January 14 - 21, 2019

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 2.4GHz 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:

The SmartBypass™ builds upon the proven success of the bypass systems used in the PowerLine Guardian® and SmartBypass™ 390 products. The SmartBypass is used to control and protect a Power Guardian 700 or SmartValve™ by providing rapid bypass of those products during fault conditions. Under normal operation, it enables operators to manually bypass a Power Guardian 700 or a SmartValve, or it can switch them in series with the transmission line. When in series with the line, the Power Guardian 700 can inject its reactance to maintain the desired level of power flow. When in series with the line, a SmartValve can inject its controllable reactance for power flow control. The SmartBypass can operate at line currents of thousands of amps during normal bypass operation and withstand different fault current levels depending on the model. The SmartBypass models are differentiated by continuous current rating and maximum fault current rating. For example, the SmartBypass 4000-63 is rated for continuous line currents up to 4000 A RMS and fault currents of up to 63 kA RMS for 1 second. The SmartBypass provides telemetry when operating in monitoring mode or injection mode.

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

Information about the 2.4 GHz radio is presented below:

Applicant	Smart Wires, Inc.
Model No.	SmartBypass 2000
FCC Identifier	QPS01006
Type of Transmission	Frequency Hopping Spread Spectrum
Rated RF Output	15.08 dBm
Antenna(s) & Gain	Internal Antenna, Gain: 4.0 dBi
Frequency Range	2436.000000 – 2461.493774 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: January 09, 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: January 14, 2019

Test completion date: January 21, 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 Meas Guidance v05), 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 2.4 GHz band			
Test Channel		Frequency, MHz	Tested
Low	0	2436.000000	√
Middle	32	2448.949219	√
High	63	2461.493774	√
Hopping Mode	0-63	2436.000000 - 2461.493774	√

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

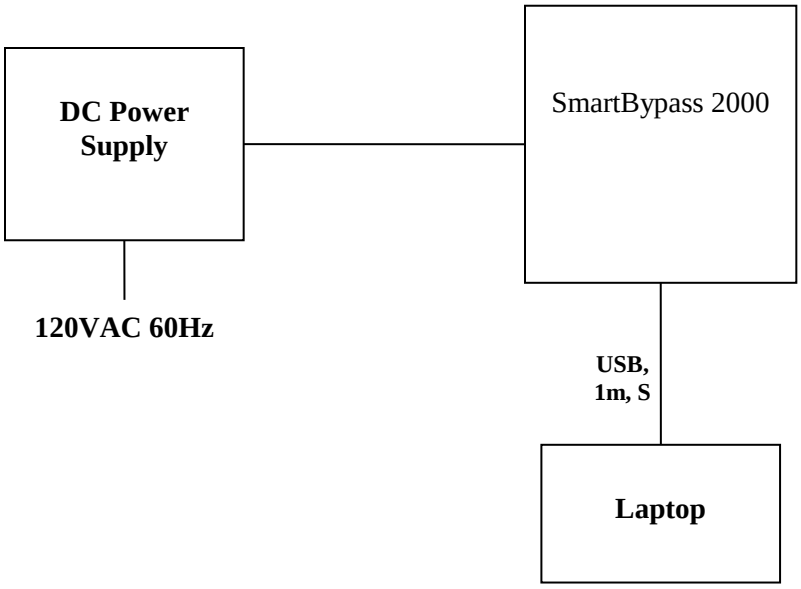
3.1 Support Equipment

Description	Manufacturer	Model Number
Laptop	DELL	Latitude 5480
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	23318-002-09-00-0-1

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 table. 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 (~1656 pounds) to safely lift onto a 1.5m table for testing above 1GHz. Arrangements were made to safely put on a table 1m above the ground plane for radiated testing.

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 = 11

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 v05 & 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.

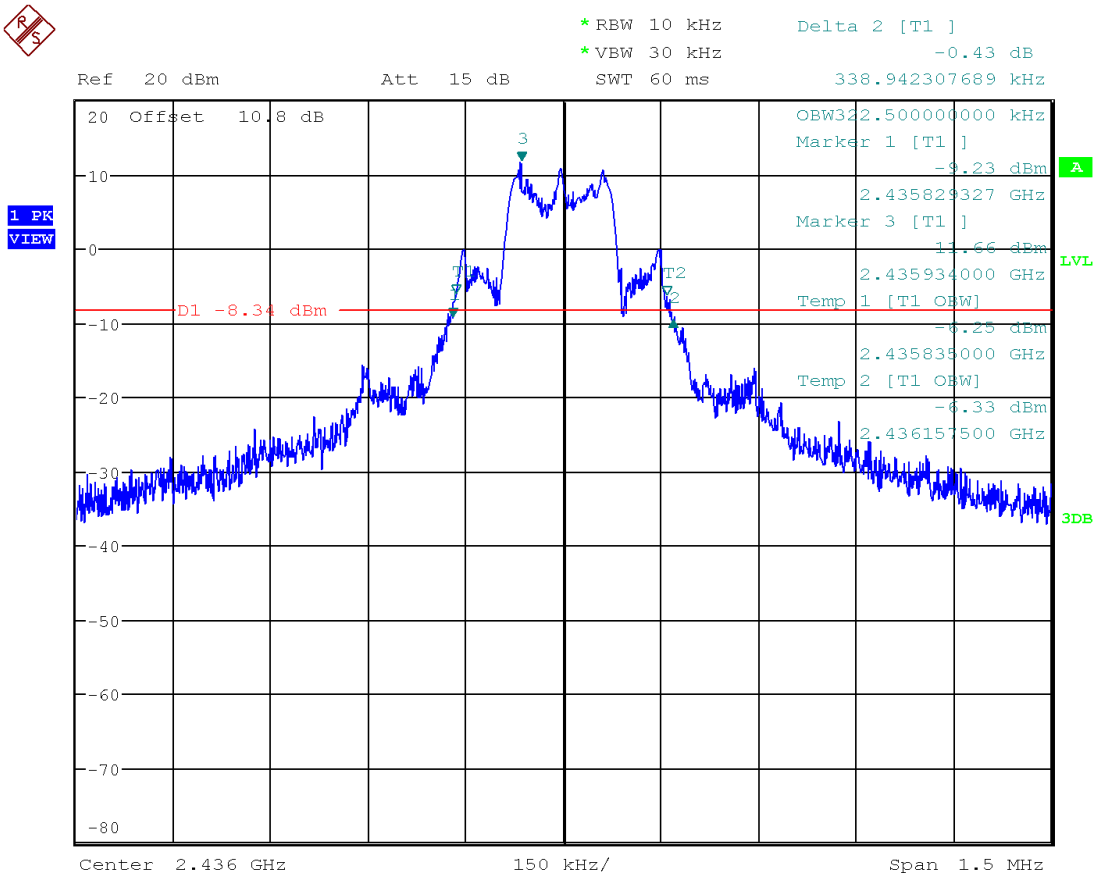
Tested By	Test Date
Anderson Soungpanya	January 18, 2019

4.1.2 Test Result

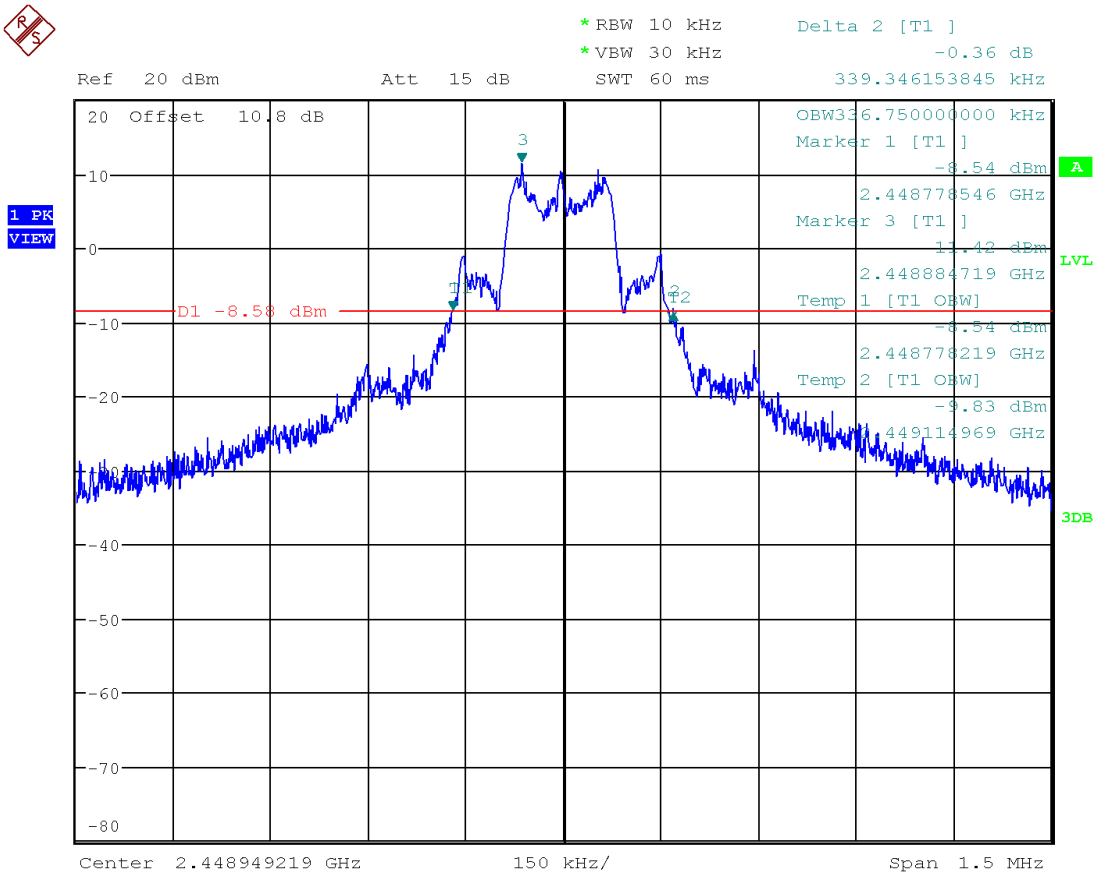
Frequency MHz	20 dB FCC Bandwidth, kHz	99% Bandwidth, kHz	Plot #
2436.000000	338.942	322.500	1.1
2448.949219	339.346	336.750	1.2
2461.493774	344.980	327.750	1.3

Results	Complies

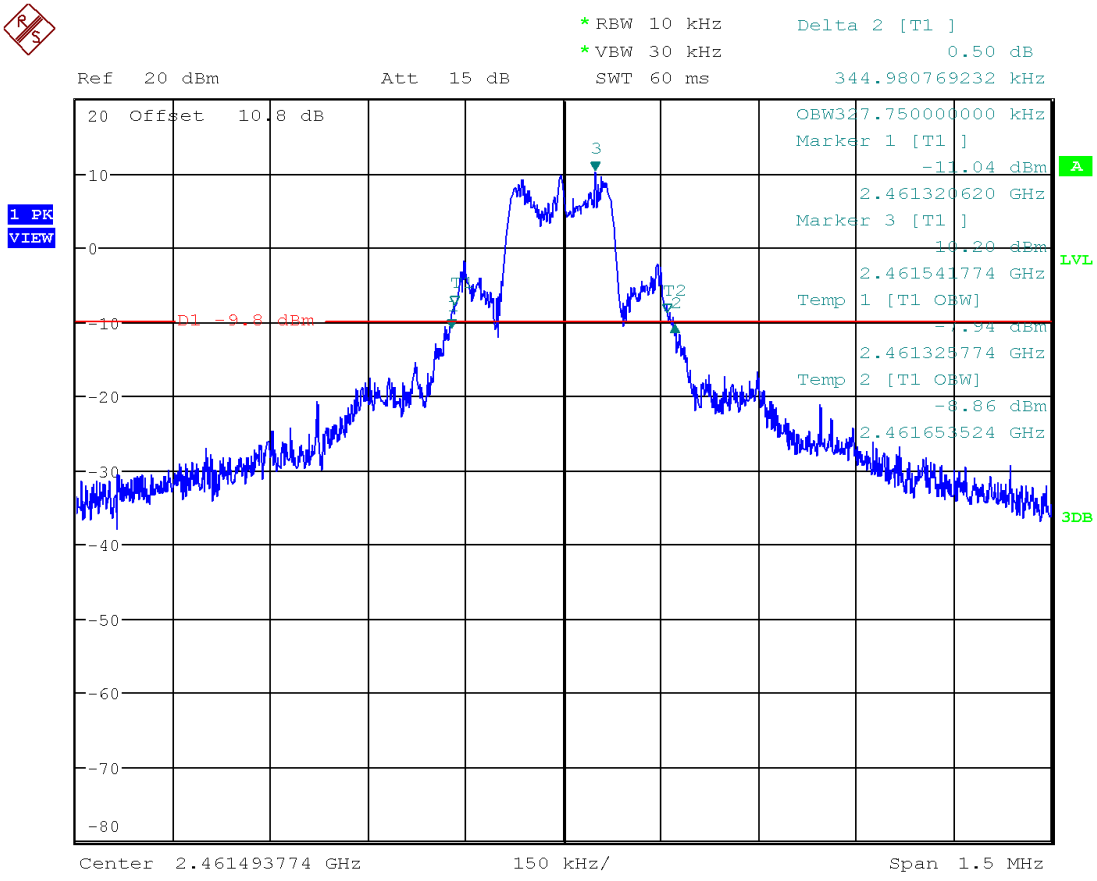
Plot 1. 1 – 20dB Bandwidth and 99% Bandwidth Low Channel



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



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



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 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

4.2.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 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	January 18, 2019

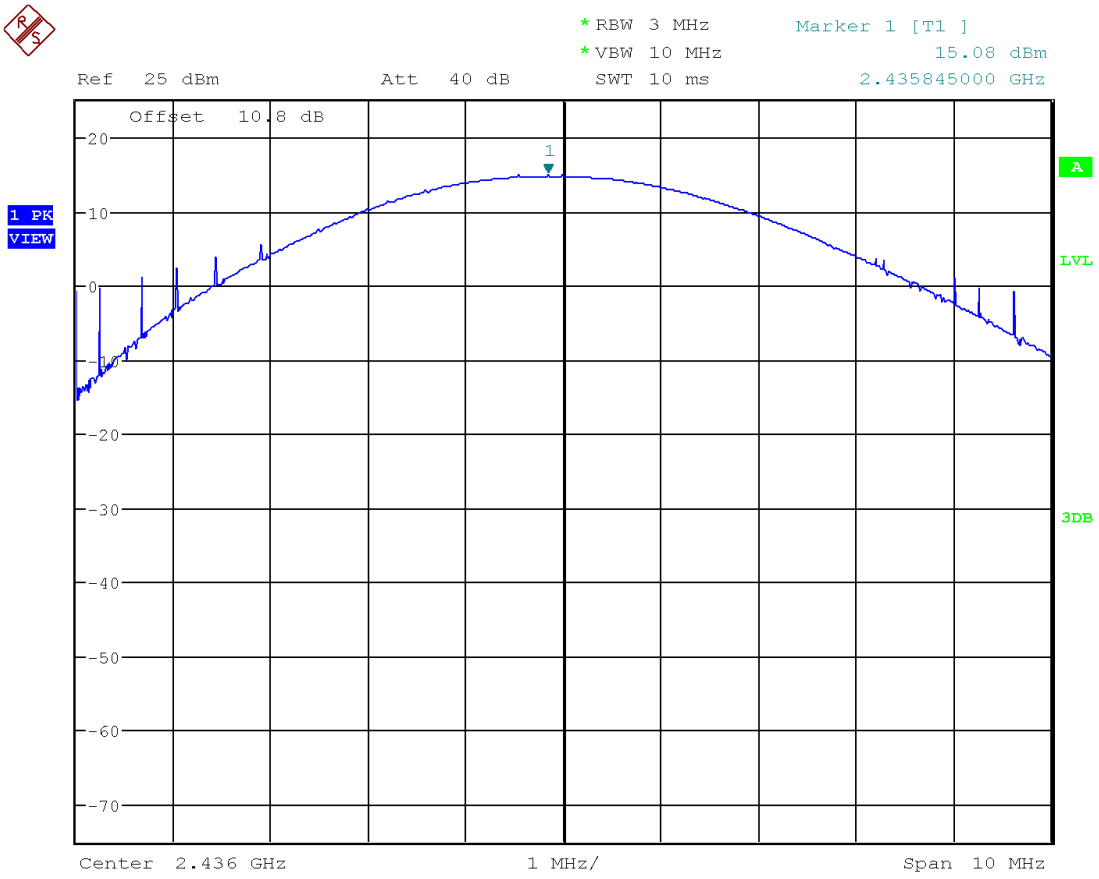
4.3.3 Test Result

Refer to the following plots for the test result:

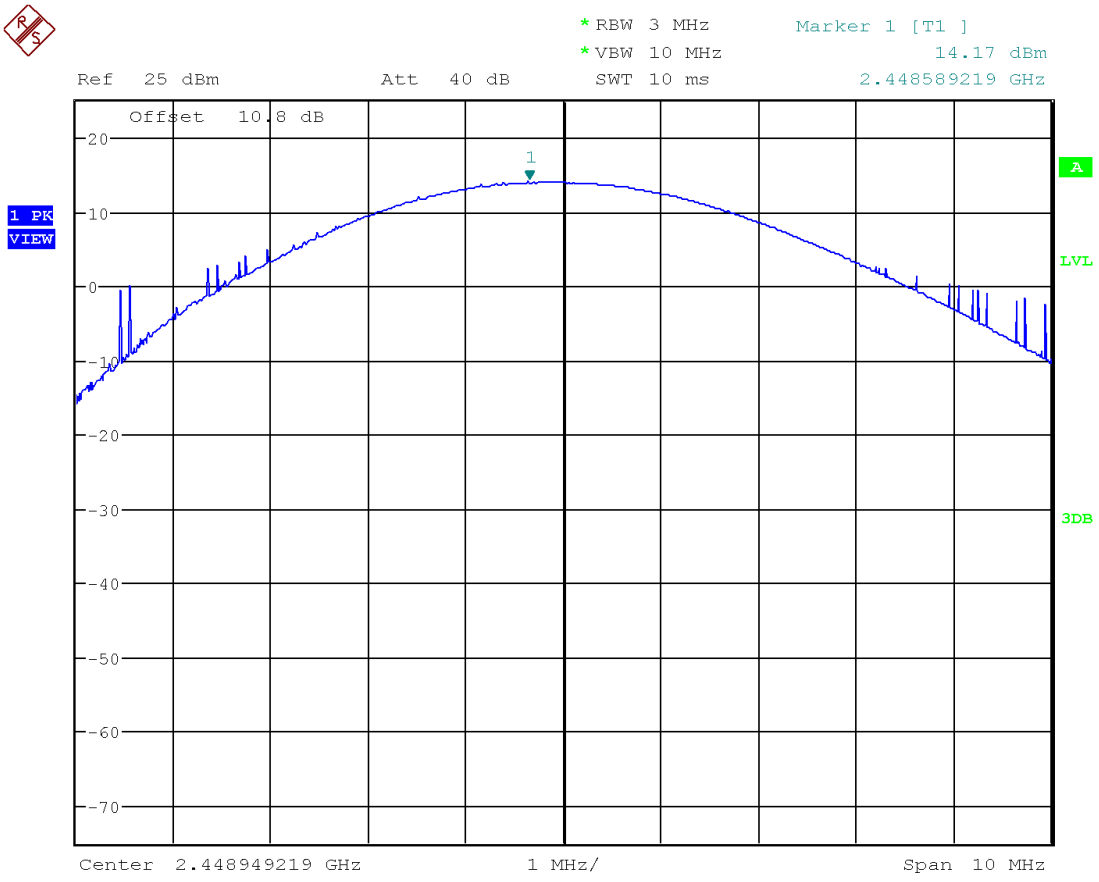
Frequency MHz	Conducted Peak Power dBm	Conducted Peak Power mW	Plot #
2436.000000	15.08	32.211	2.1
2448.949219	14.17	26.122	2.2
2461.493774	13.52	22.491	2.3

Results	64 Channels used; Complies

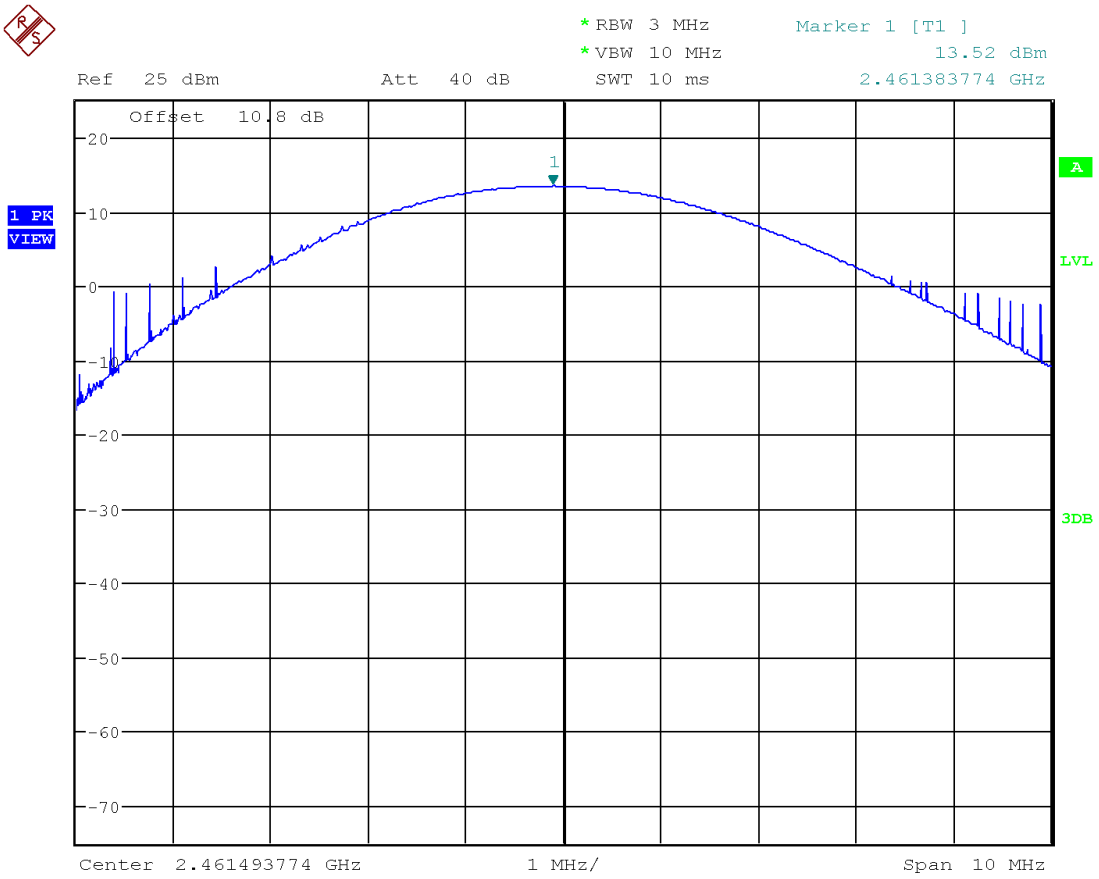
Plot 2. 2 – Output Power Low Channel



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 v05 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

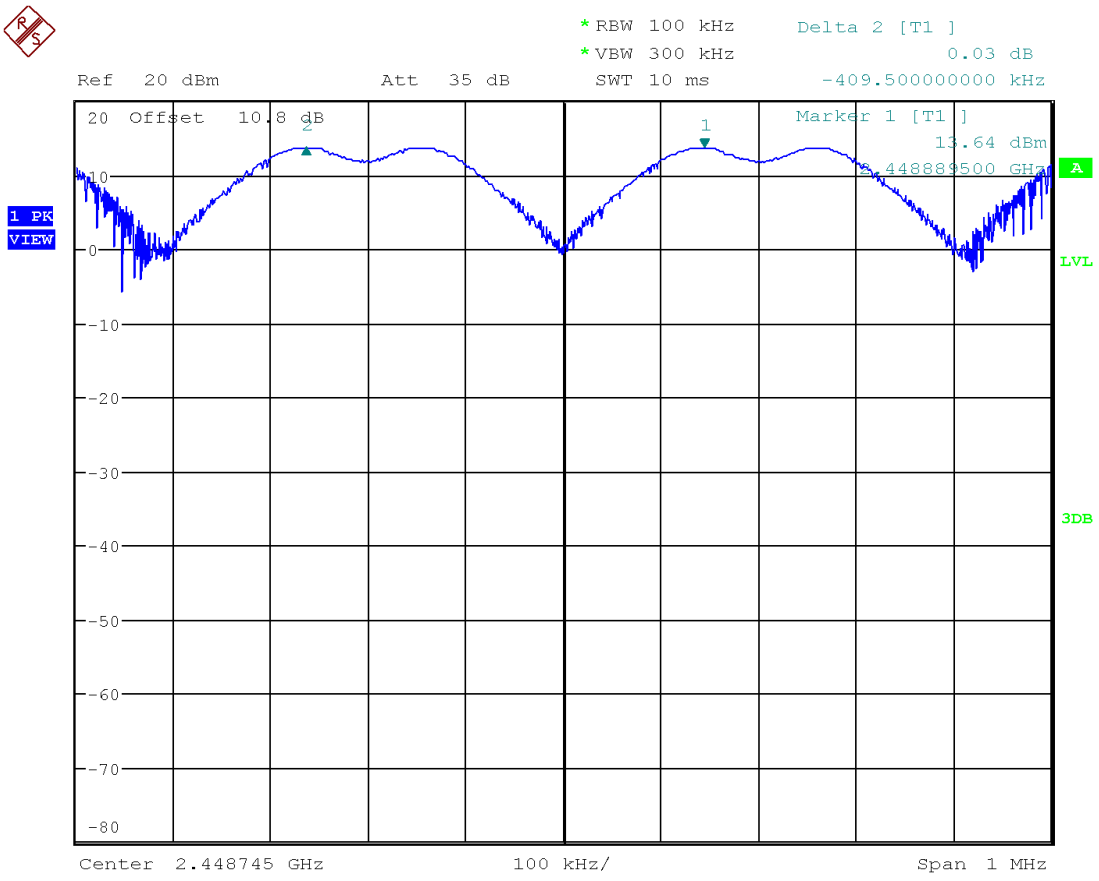
Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Tested By	Test Date
Anderson Soungpanya	January 18, 2019

4.3.3 Test Result

The worst case 20dB Bandwidth is 344.980 kHz, therefore the minimum Carrier Frequency Separation shall be greater than two thirds of 344.980 kHz (229.99 kHz). The measured channel separation is 409.500 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.

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

4.4.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 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

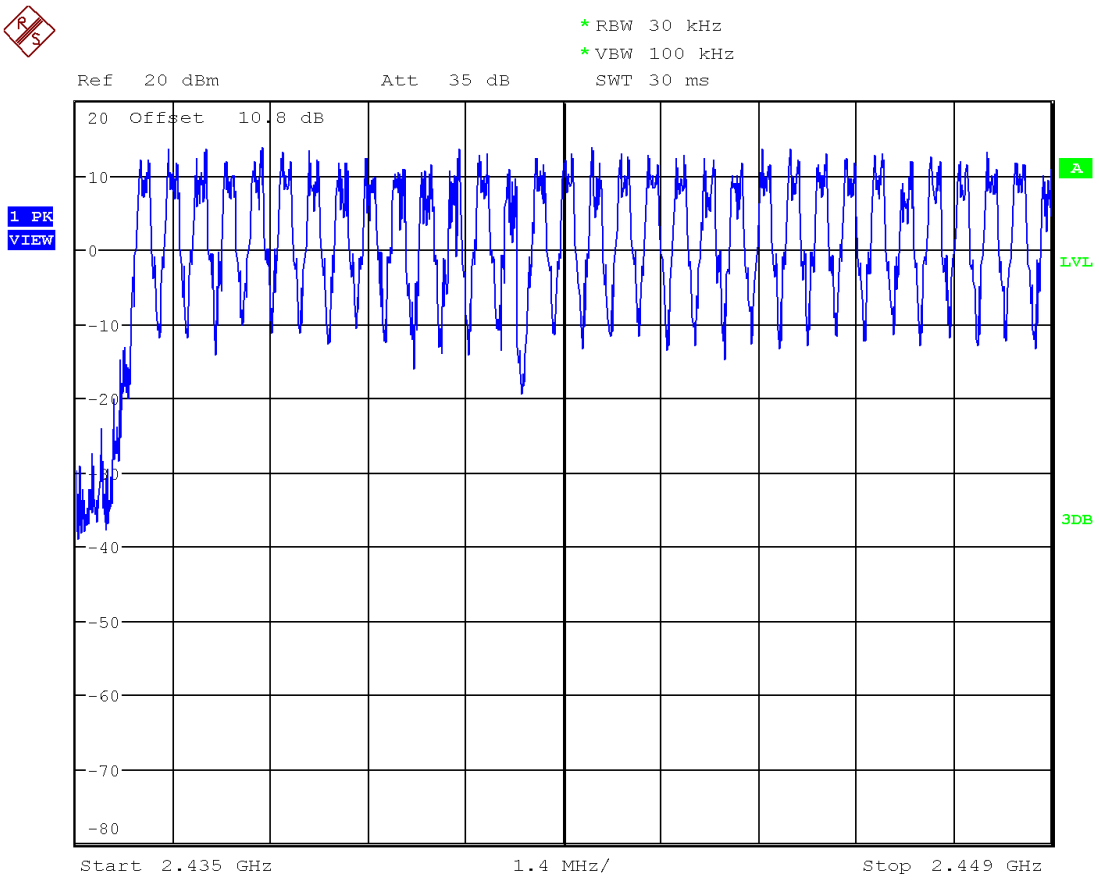
Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies.

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	January 18, 2019

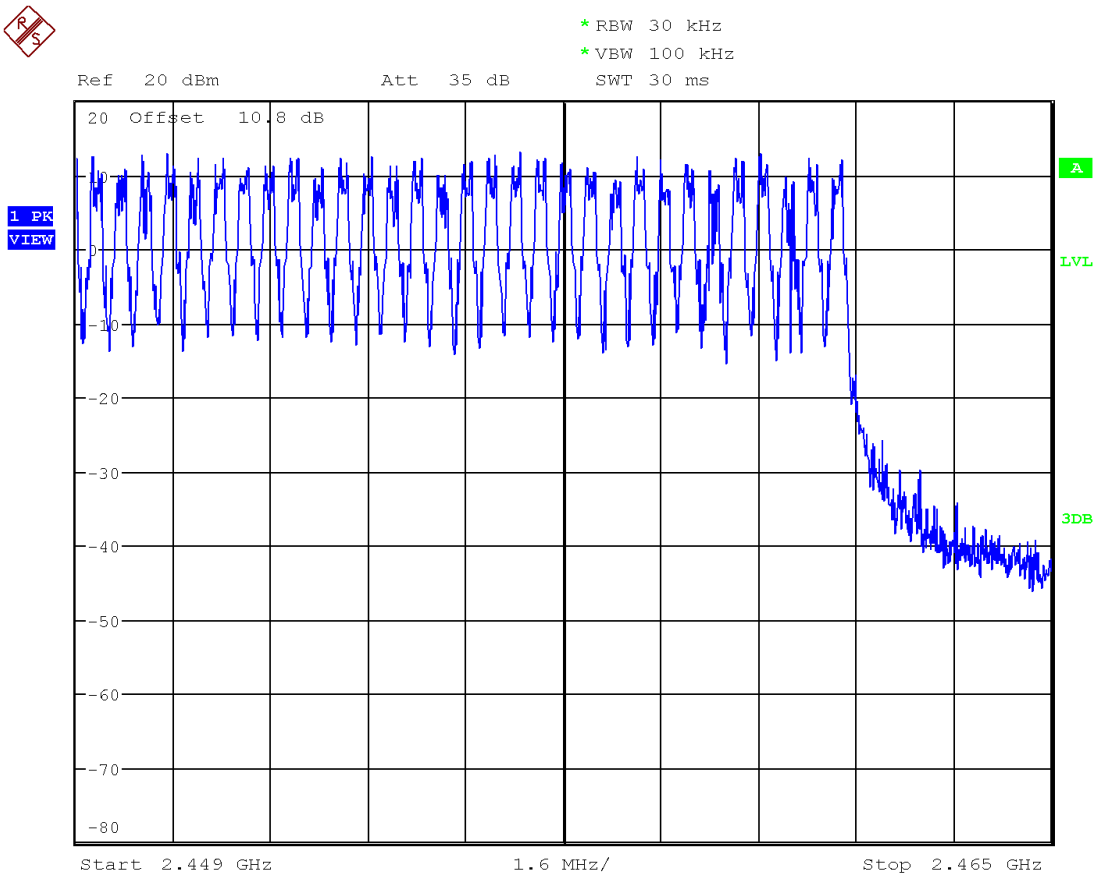
4.4.3 Test Result

Plot 4.1 - Number of hopping channels, 2435 – 2449 MHz



4.4.3 Test Result (Continued)

Plot 4.2 - Number of hopping channels, 2449 – 2465 MHz



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.

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

4.5.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 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.

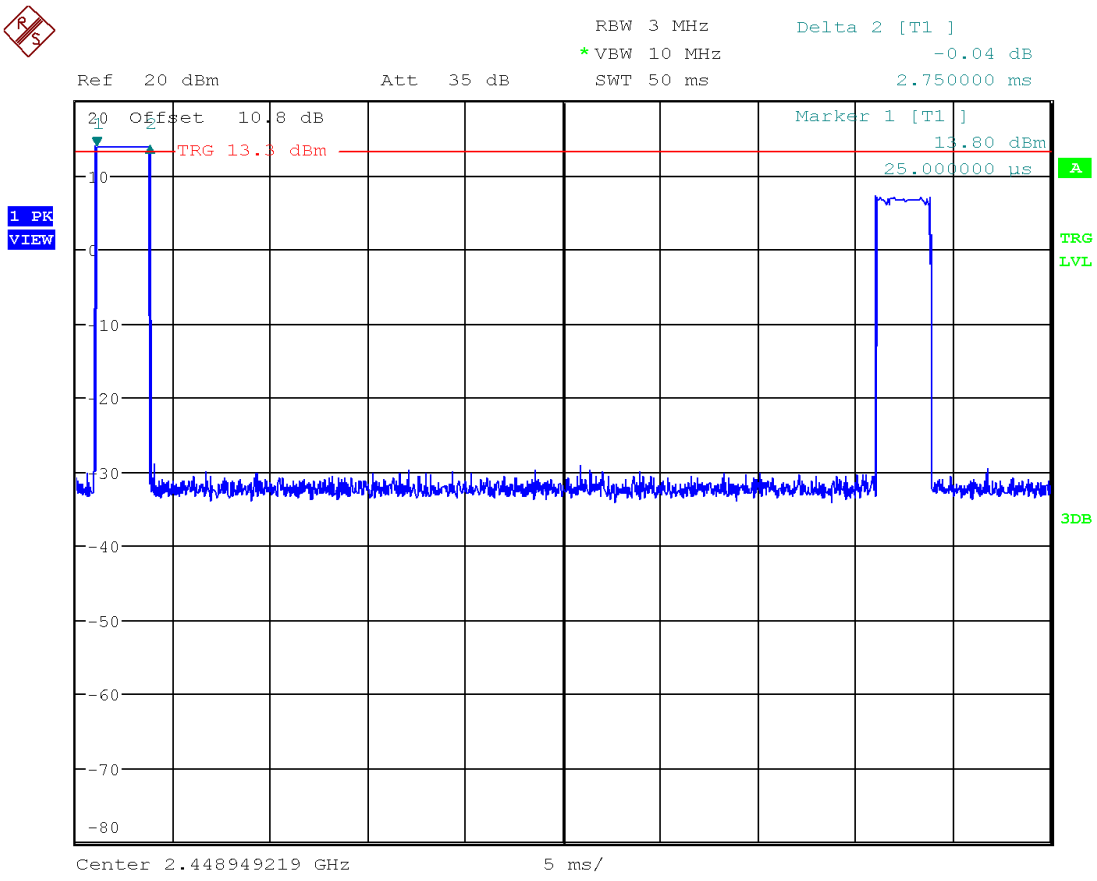
Tested By	Test Date
Anderson Soungpanya	January 18, 2019

4.5.3 Test Results

No. of Burst in 5.12 seconds	Burst On Time (ms)	Dwell Time (ms) (Burst Time * No. of Burst * 5)	Dwell Time limit (ms)
5	2.75	68.75	400

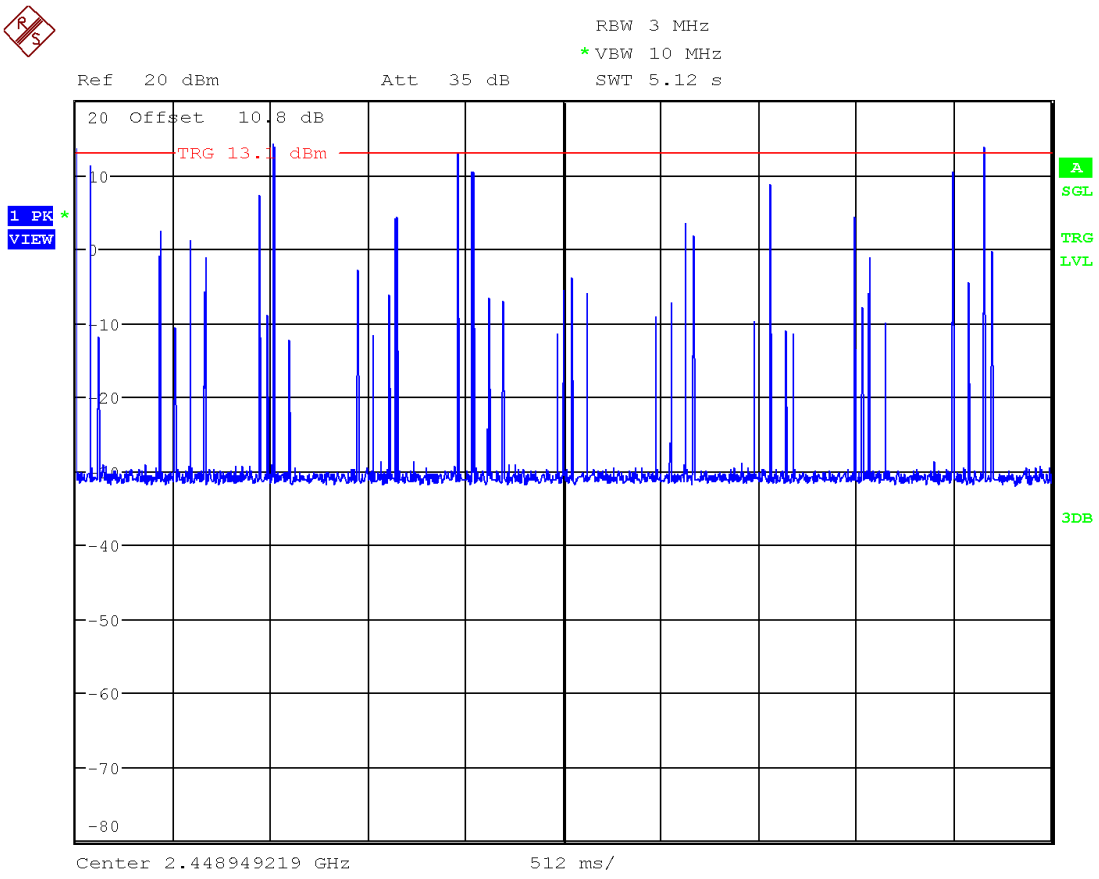
The 20-dB bandwidth of the hopping channel is greater than 250 kHz, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a period of the number of channels multiplied by 0.4 second (25.6 seconds).

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 v05 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	January 18, 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

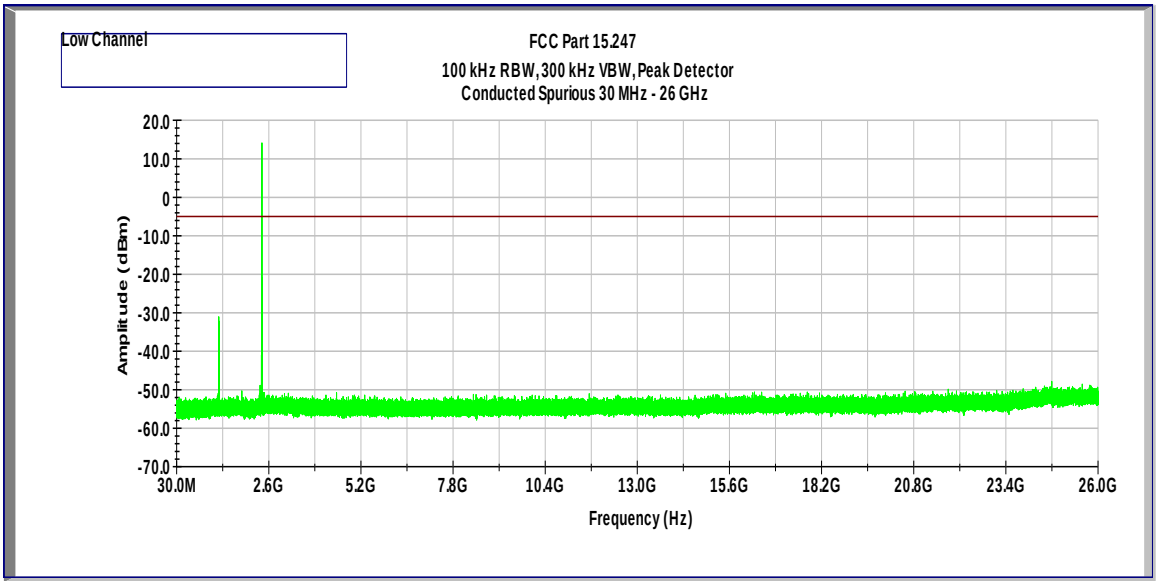
Frequency MHz	Description	Plot #
2436.000000	Scan 30 MHz – 26 GHz	4.1
2448.949219	Scan 30 MHz – 26 GHz	4.2
2461.493774	Scan 30 MHz – 26 GHz	4.3

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

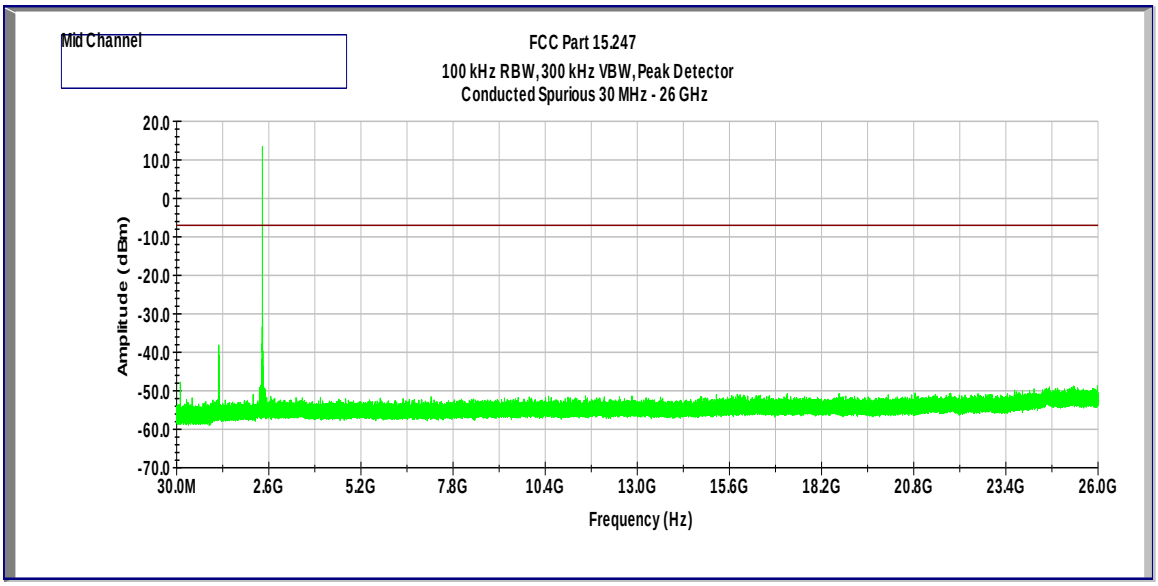
Table 4.2

Channel	Frequency MHz	Out-band emissions margin to In-band emissions	Plot #
0	2436.000000	Complies	4.4
Hopping	Low Band Edge	Complies	4.5
63	2461.493774	Complies	4.6
Hopping	High Band Edge	Complies	4.7

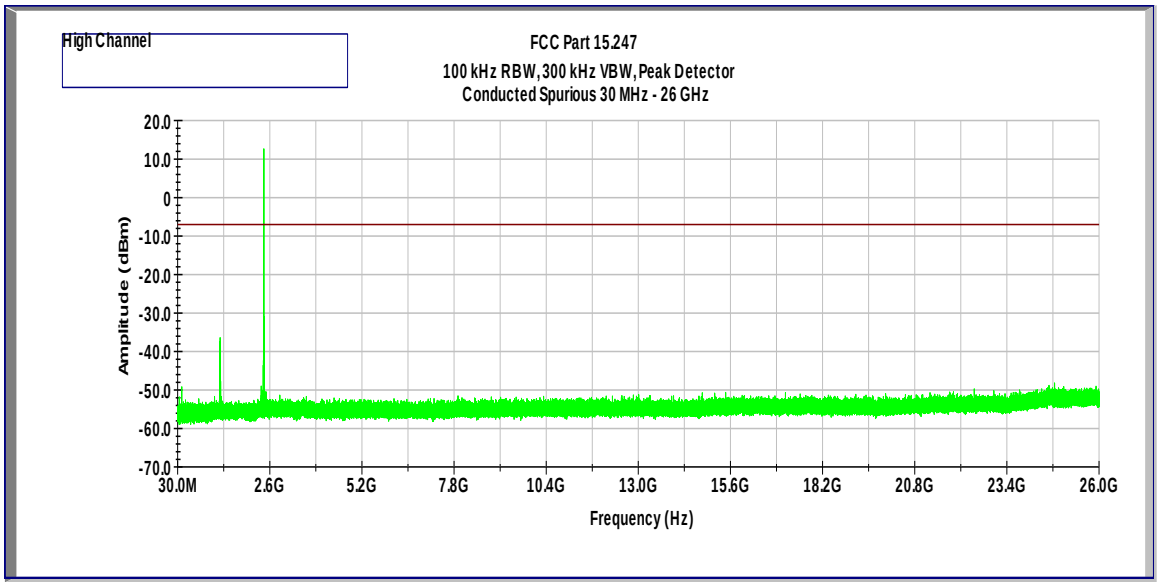
Plot 4.1
Transmitter Spurious, Low Channel



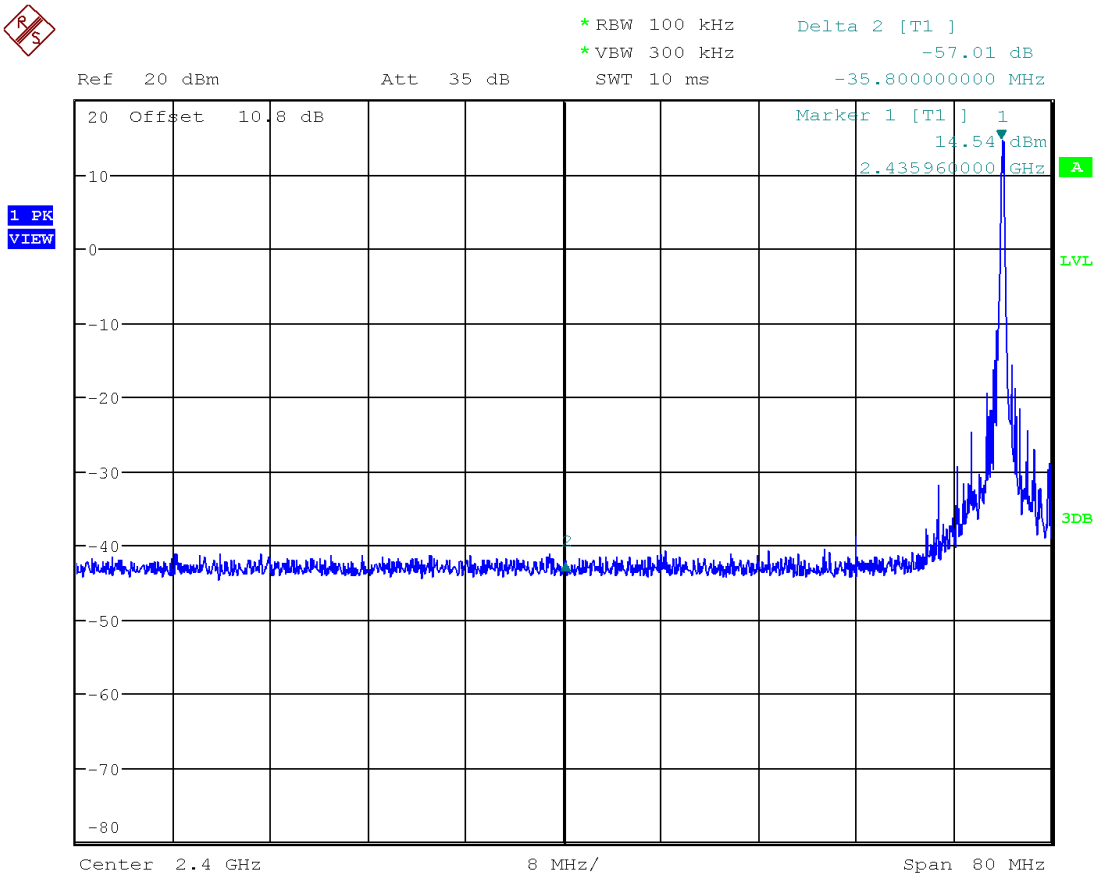
Plot 4.2
Transmitter Spurious, Middle Channel



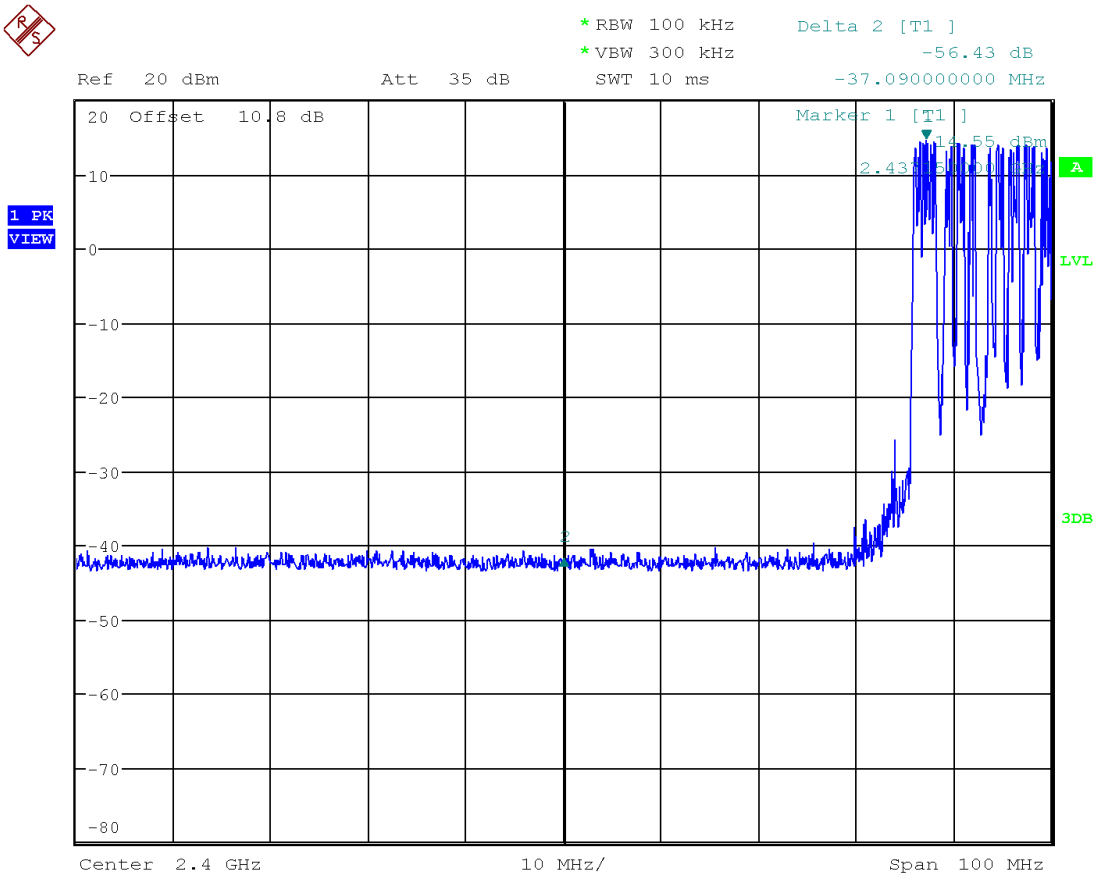
Plot 4.3
Transmitter Spurious, High Channel



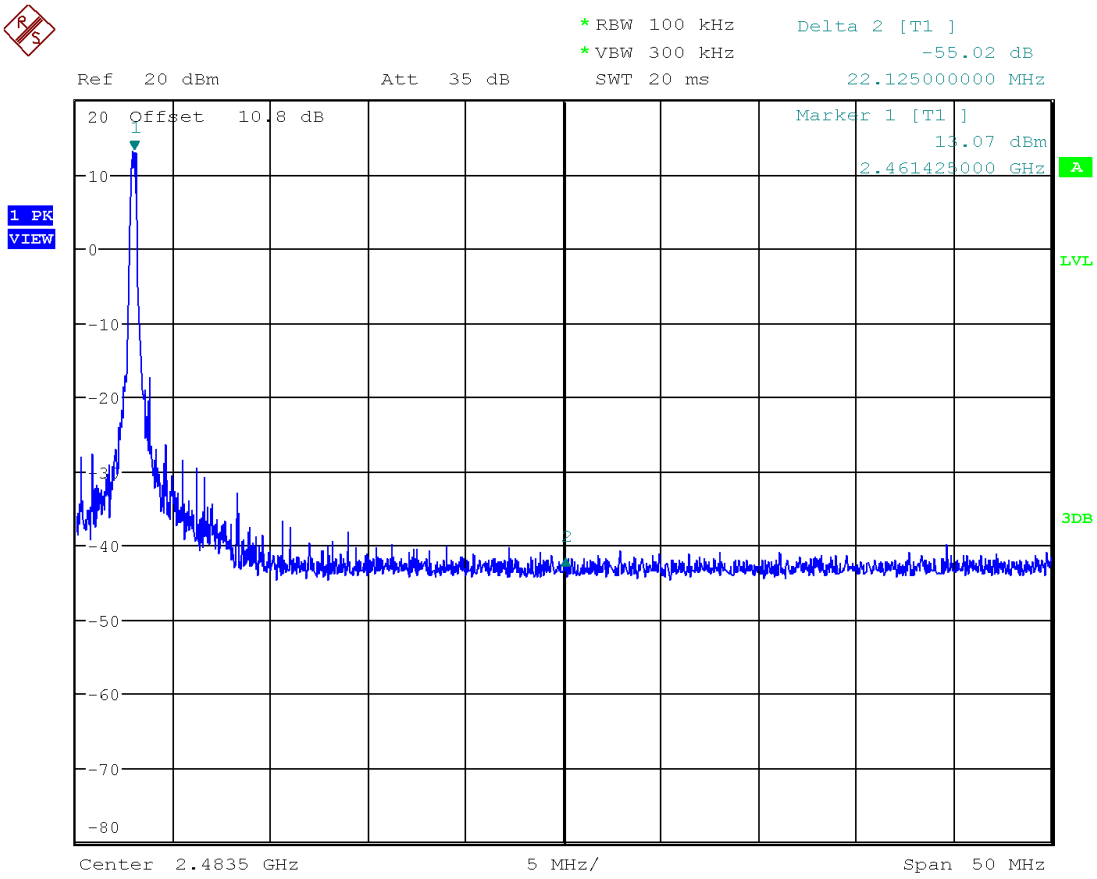
Plot 4.4
Conducted Band Edge, Low Channel



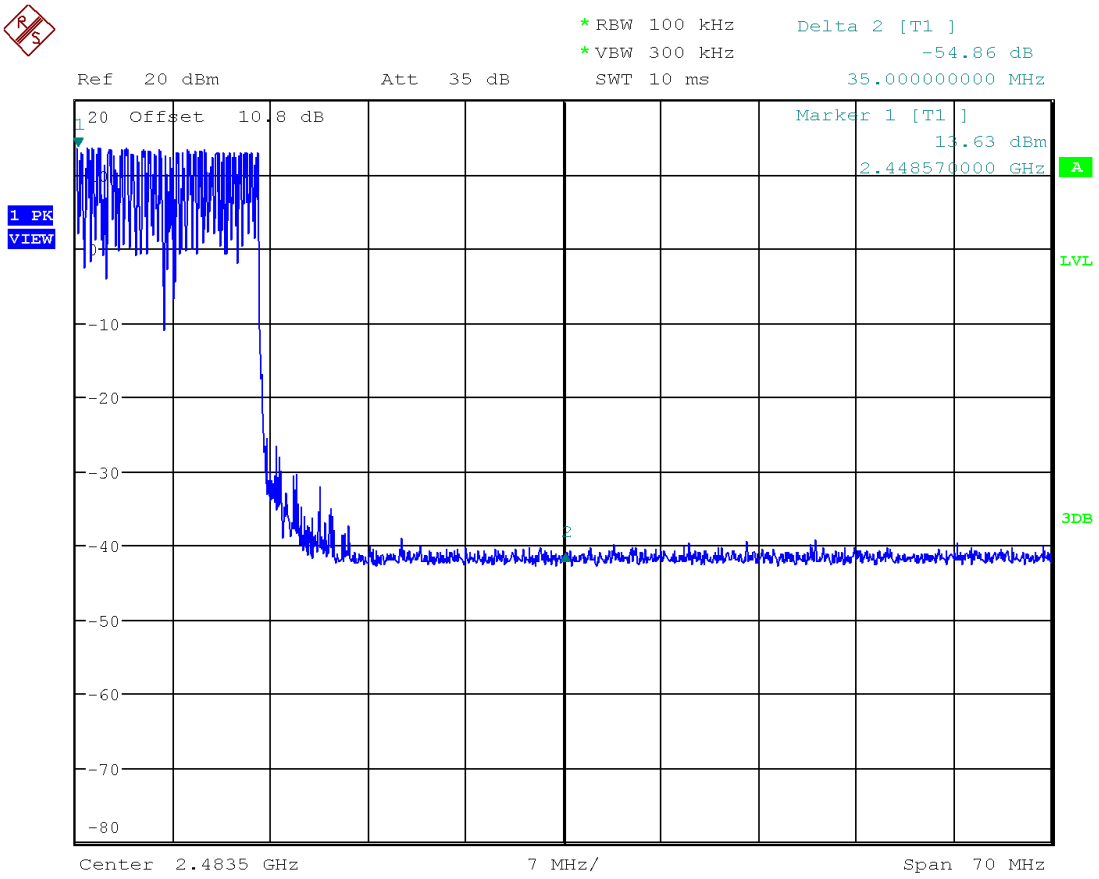
Plot 4.11
Conducted Band Edge (Hopping)



Plot 4.12
Conducted Band Edge, High Channel



Plot 4.13
Conducted Band Edge (Hopping)



Results	Complies

4.7 Transmitter Radiated Emissions
FCC Rule 15.247(d), 15.209, 15.205

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 10,000 MHz. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz.

The EUT is placed on a plastic turntable that is 1.5 m in height above 1 GHz and 80cm below 1GHz. 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

All measurements were made with a Peak Detector and compared to QP limits for 30MHz – 1GHz and Average or Peak limits for 1GHz – 26 GHz where applicable.

Data is included of the worst-case configuration (the configuration which resulted in the highest emission levels).

EUT was tested with Antenna in place.

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 Test Results

The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

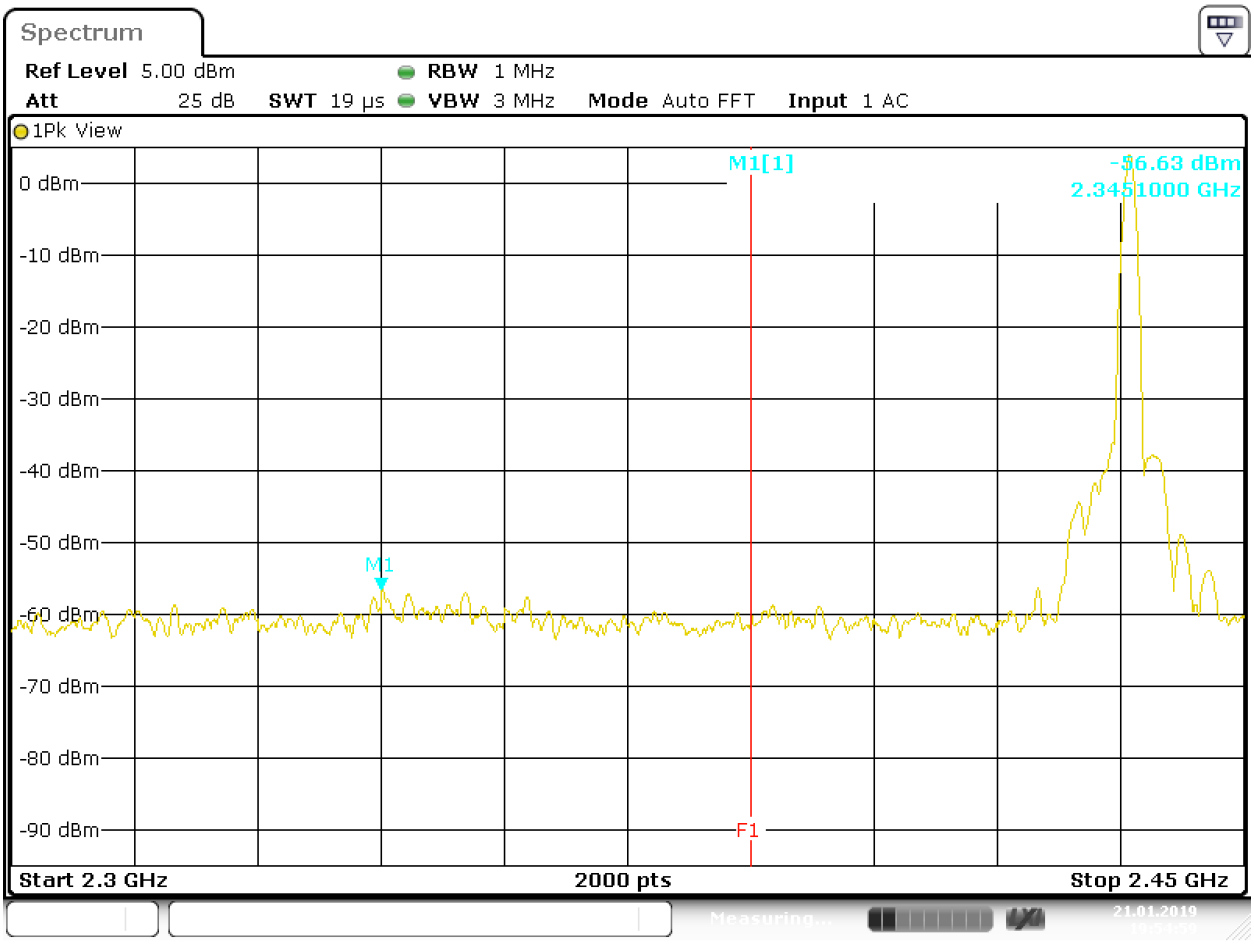
Radiated emission measurements were performed up to 26 GHz. No other emissions were detected above the noise floor which is at least 10 dB below the limit.

4.7.4 Test Results (Continued)

Test Results: 15.209/15.205 Radiated Restricted Band Emissions

Tested By	Test Date
Anderson Soungpanya	January 21, 2019

Conducted Out-of-Band Spurious Emissions at the Band Edge – Tx @ Low Channel, Peak



Date: 21.JAN.2019 19:55:00

Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
GHz	dB(µV/m)	dB(µV/m)	dB		
2.34510	53.40	54	-0.60	Peak	Pass

Corrected Amplitude (dBµV/m) = Eo – DCF + 104.77

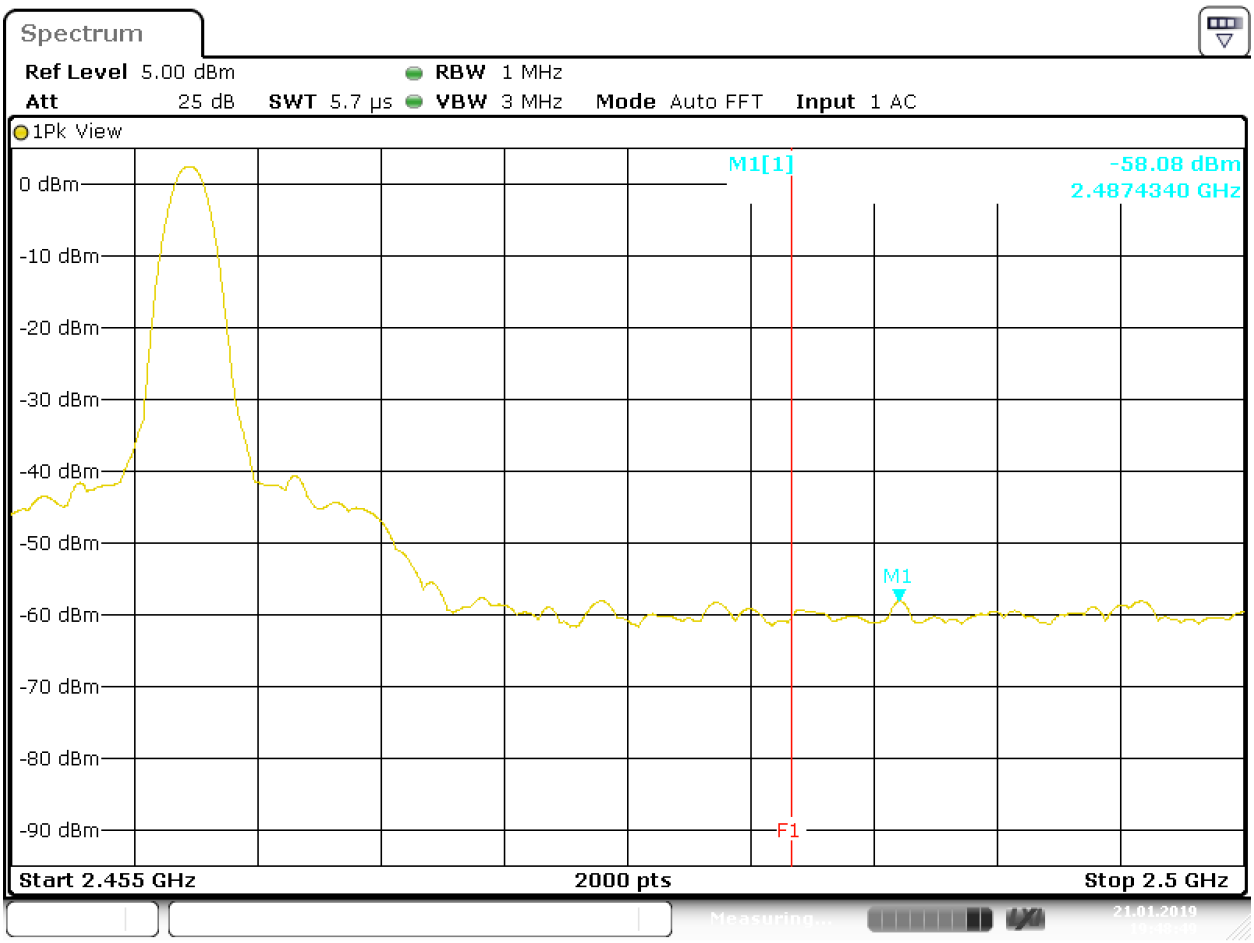
Measured: **-56.63** dBm; Antenna Gain: **4.00** dBi; Cable Loss: **10.80** dB

Eo = -41.83 dB (Measured + Antenna Gain + Cable Loss with Attenuator)

DCF at 3m = 20Log (3) = **9.54**

Corrected Amplitude (dBµV/m) = **53.40**

Conducted Out-of-Band Spurious Emissions at the Band Edge – Tx @ High Channel, Peak



Date: 21.JAN.2019 19:48:49

Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
GHz	dB(µV/m)	dB(µV/m)	dB		
2.487434	51.95	54	-2.05	Peak	Pass

Corrected Amplitude (dBµV/m) = Eo – DCF + 104.77

Measured: **-58.08** dBm; Antenna Gain: **4.00** dBi; Cable Loss: **10.80** dB

Eo = -43.28 dB (Measured + Antenna Gain + Cable Loss with Attenuator)

DCF at 3m = 20Log (3) = **9.54**

Corrected Amplitude (dBµV/m) = **51.95**

Tested By	Test Date
Anderson Soungpanya	January 14 – 18, 2019

15.209 Out-of-Band Radiated Spurious Emissions, 2436.000000MHz

Radiated Spurious Emissions 30 MHz – 26 GHz

Frequency (MHz)	Channel No.	10m Measured Data dB(uV/m)	10m Limit dB(uV/m)	Margin (dB)	Detector	Antenna Polarization	Turntable Degree	Antenna Height (cm)
163.82	0	25.51	29.5	-3.99	QP	H	265	108
244.08	0	28.17	33	-4.83	QP	V	95	110
613.52	0	32.34	35.5	-3.16	QP	V	294	110
Frequency (MHz)	**Channel No.**	**3m Measured Data dB(uV/m)**	**3m Limit dB(uV/m)**	**Margin (dB)**	**Detector**	**Antenna Polarization**	**Turntable Degree**	**Antenna Height (cm)**
1217.60	0	52.05	54	-1.95	AVE	V	74	115
		53.12	74	-20.88	PK			
3653.70	0	51.48	54	-2.52	AVE	V	64	107
		52.01	74	-21.99	PK			
4872.00	0	34.80	54	-19.20	AVE	V	40	122
		42.73	74	-31.27	PK			
7308.00	0	34.96	54	-19.04	AVE	V	309	165
		44.15	74	-29.85	PK			
9744.00	0	38.19	54	-15.81	AVE	V	143	188
		45.91	74	-28.09	PK			
12180.00	0	35.77	54	-18.23	AVE	V	346	124
		46.54	74	-27.46	PK			
14616.00	0	35.12	54	-18.88	AVE	V	57	164
		48.18	74	-25.82	PK			
17052.00	0	37.92	54	-16.08	AVE	V	159	191
		50.45	74	-23.55	PK			
19488.00	0	42.78	54	-11.22	AVE	V	139	180
		52.44	74	-21.56	PK			
21924.00	0	42.31	54	-11.69	AVE	V	22	104
		53.21	74	-20.79	PK			
24360.00	0	43.79	54	-10.21	AVE	V	321	198
		54.64	74	-19.36	PK			

Results	Complies

4.7.4 Test Results (Continued)

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2448.949219 MHz

Radiated Spurious Emissions 30 MHz – 26 GHz

Frequency (MHz)	Channel No.	10m Measured Data dB(uV/m)	10m Limit dB(uV/m)	Margin (dB)	Detector	Antenna Polarization	Turntable Degree	Antenna Height (cm)
163.83	32	25.79	29.5	-3.71	QP	H	354	106
244.12	32	29.15	33	-3.85	QP	V	285	101
613.52	32	31.76	35.5	-3.74	QP	V	165	109
Frequency (MHz)	Channel No.	3m Measured Data dB(uV/m)	3m Limit dB(uV/m)	Margin (dB)	Detector	Antenna Polarization	Turntable Degree	Antenna Height (cm)
1224.40	32	52.56	54	-1.44	AVE	V	90	103
		53.03	74	-20.97	PK			
3672.97	32	50.75	54	-3.25	AVE	V	78	108
		51.37	74	-22.63	PK			
4897.92	32	34.86	54	-19.14	AVE	V	322	117
		42.81	74	-31.19	PK			
7346.88	32	35.02	54	-18.98	AVE	V	139	140
		44.23	74	-29.77	PK			
9795.84	32	38.18	54	-15.82	AVE	V	281	168
		45.89	74	-28.11	PK			
12244.80	32	35.75	54	-18.25	AVE	V	341	159
		46.52	74	-27.48	PK			
14693.76	32	35.07	54	-18.93	AVE	V	49	108
		48.42	74	-25.58	PK			
17142.72	32	38.10	54	-15.90	AVE	V	261	152
		50.41	74	-23.59	PK			
19591.68	32	43.07	54	-10.93	AVE	V	310	193
		52.80	74	-21.20	PK			
22040.64	32	42.60	54	-11.40	AVE	V	194	111
		53.58	74	-20.42	PK			
24489.60	32	44.09	54	-9.91	AVE	V	40	135
		55.02	74	-18.98	PK			

Results	Complies

4.7.4 Test Results (Continued)

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2461.493774 MHz

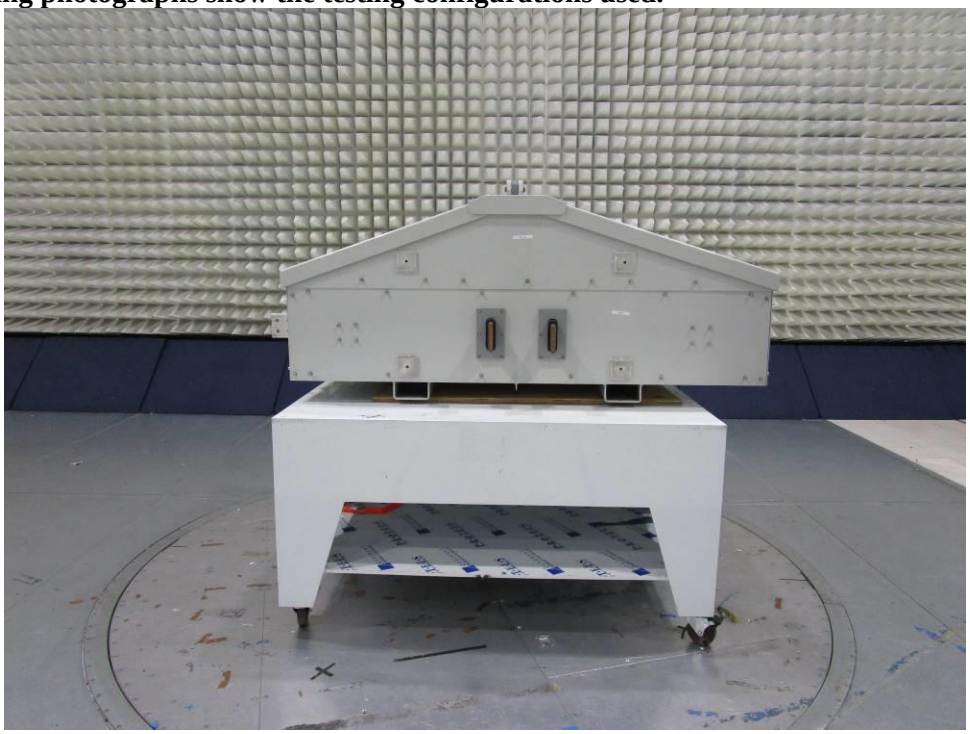
Radiated Spurious Emissions 30 MHz – 26 GHz

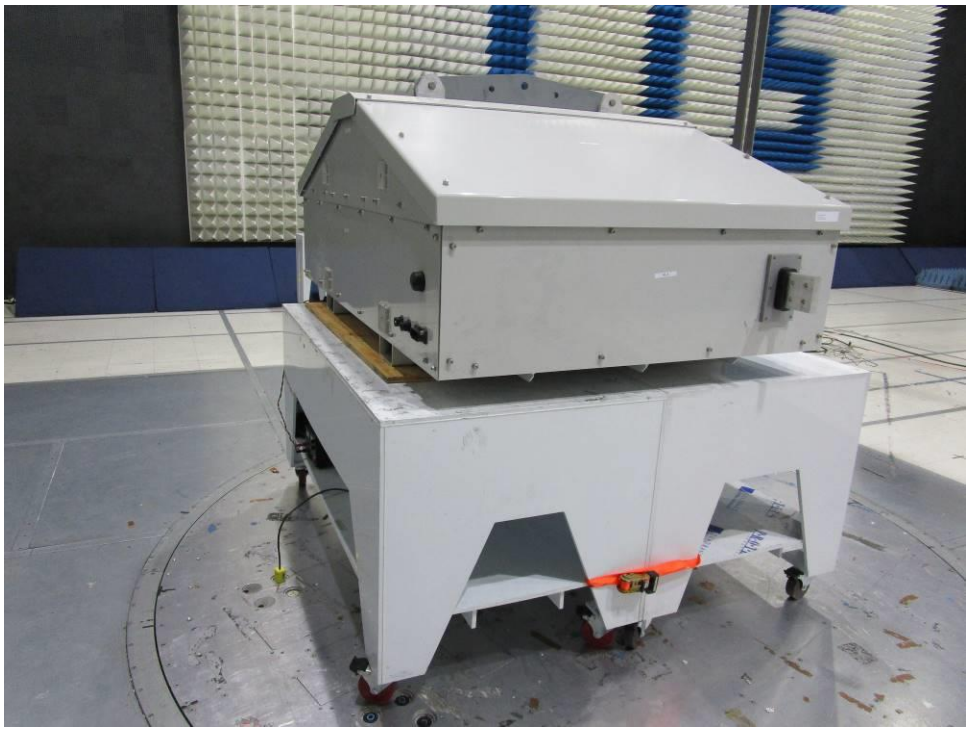
Frequency (MHz)	Channel No.	Measured Data (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Antenna Polarization	Turntable Degree	Antenna Height (cm)
163.83	63	26.15	29.5	-3.35	QP	V	11	100
240.72	63	28.99	33	-4.01	QP	H	152	103
613.55	63	30.86	35.5	-4.64	QP	V	242	115
Frequency (MHz)	Channel No.	3m Measured Data dB(uV/m)	3m Limit dB(uV/m)	Margin (dB)	Detector	Antenna Polarization	Turntable Degree	Antenna Height (cm)
1230.63	63	51.98	54	-2.02	AVE	V	74	109
		52.78	74	-21.22	PK			
3692.23	63	49.66	54	-4.34	AVE	V	77	111
		50.15	74	-23.85	PK			
4923.03	63	34.90	54	-19.10	AVE	V	205	179
		42.86	74	-31.14	PK			
7384.55	63	35.06	54	-18.94	AVE	V	112	198
		44.27	74	-29.73	PK			
9846.06	63	38.12	54	-15.88	AVE	V	353	193
		45.83	74	-28.17	PK			
12307.58	63	35.82	54	-18.18	AVE	V	133	196
		46.60	74	-27.40	PK			
14769.09	63	35.09	54	-18.91	AVE	V	57	102
		48.76	74	-25.24	PK			
17230.61	63	38.08	54	-15.92	AVE	V	55	153
		50.10	74	-23.90	PK			
19692.12	63	43.13	54	-10.87	AVE	V	312	139
		52.87	74	-21.13	PK			
22153.64	63	42.66	54	-11.34	AVE	V	116	111
		53.65	74	-20.35	PK			
24615.15	63	44.15	54	-9.85	AVE	V	330	122
		55.09	74	-18.91	PK			

Results	Complies

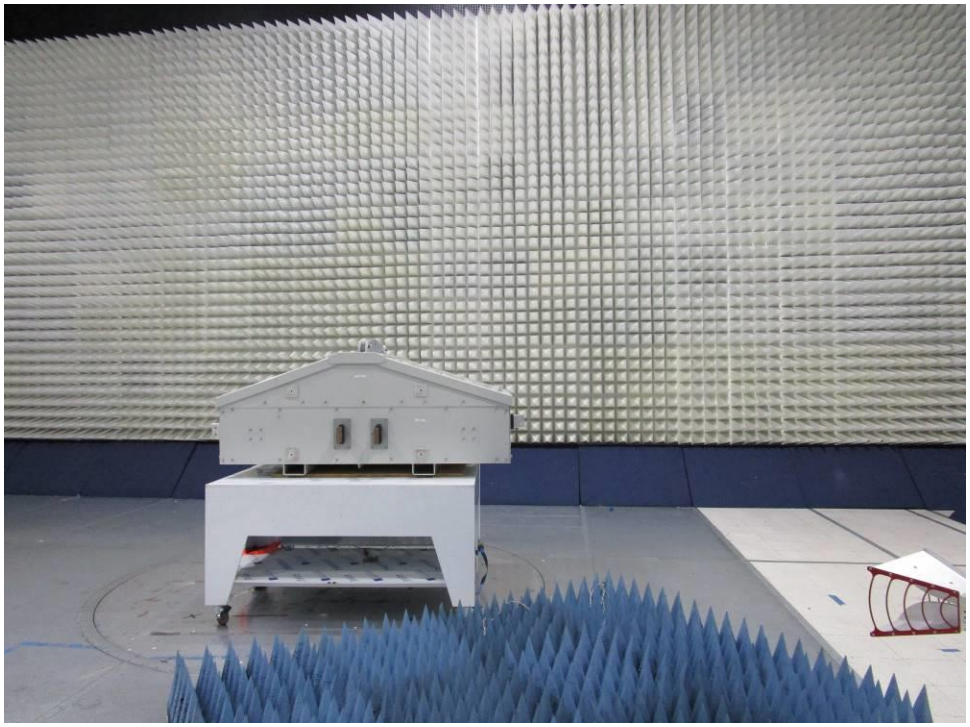
4.7.5 Test Setup Photographs

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.

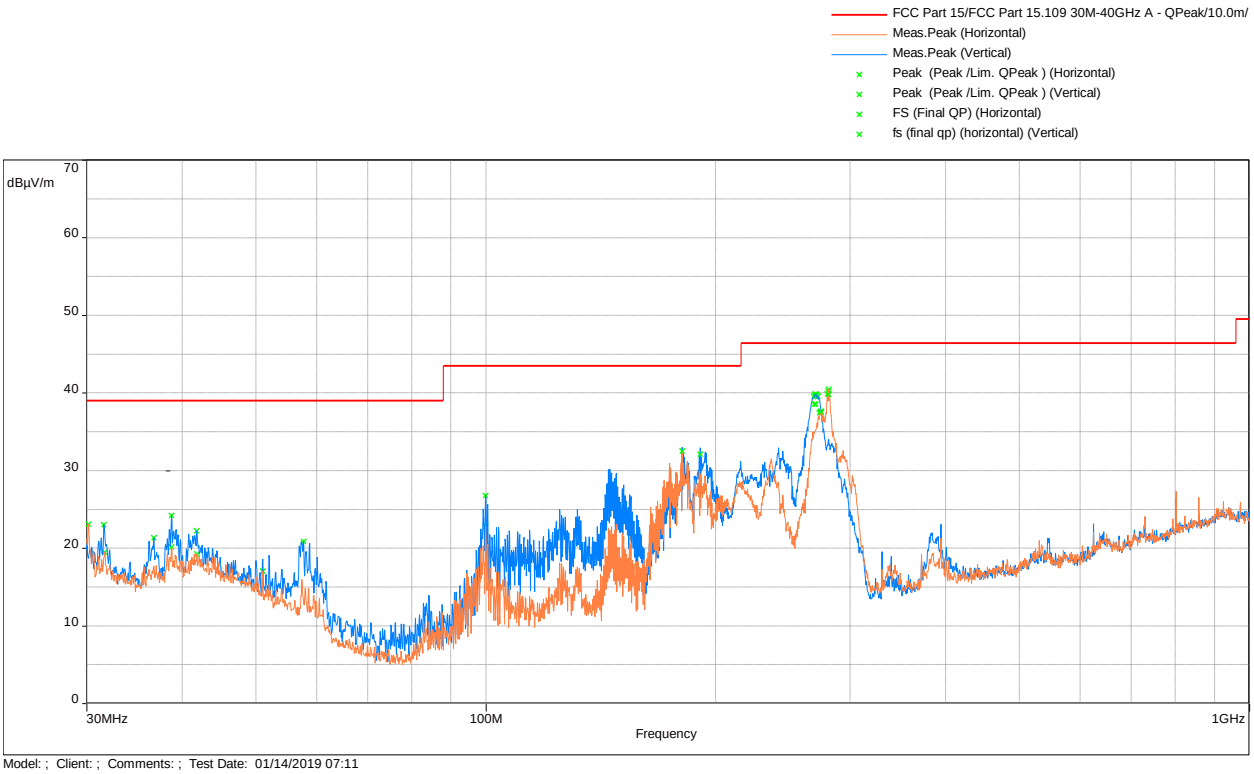
An inverse proportionality factor of 20 dB per decade was used to normalize the limit line of 30MHz to 1000MHz to the specified distance for determining compliance

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

Tested By	Test Date
Anderson Soungpanya	January 14 - 15, 2019

4.8.3 Test Results (Continued)

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

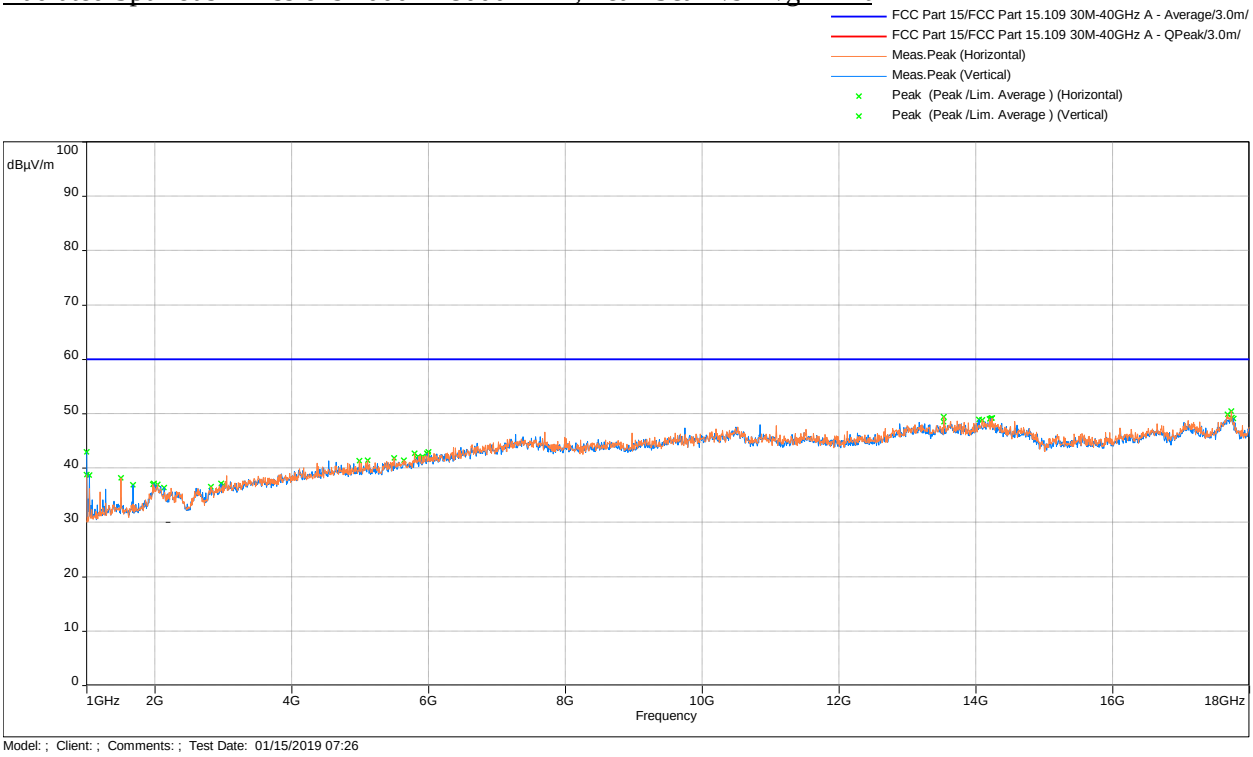


Model: ; Client: ; Comments: ; Test Date: 01/14/2019 07:11

Frequency MHz	FS dBµV/m	Limit dBµV/m	Margin (dB)	Azimuth (deg)	Height (m)	Polarity	RA (dBµV)	Correction (dB)
274.046	37.53	46.4	-8.87	53	2.66	Horizontal	50.83	-13.30
281.299	39.77	46.4	-6.63	52	2.10	Horizontal	53.34	-13.58
180.762	32.47	43.5	-11.03	151	1.04	Vertical	49.85	-17.38
190.935	32.05	43.5	-11.45	104	1.08	Vertical	48.90	-16.85
269.421	38.55	46.4	-7.85	265	4.00	Vertical	51.68	-13.12
270.579	38.53	46.4	-7.87	262	3.84	Vertical	51.66	-13.17
Result:	Complies by 6.63 dB							

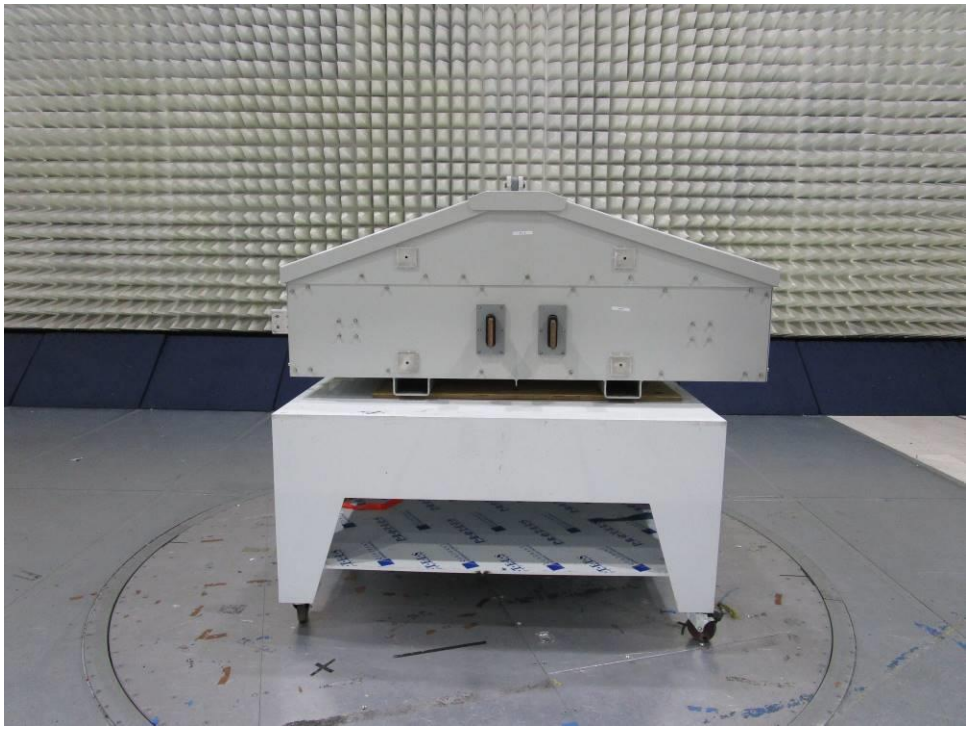
4.8.3 Test Results

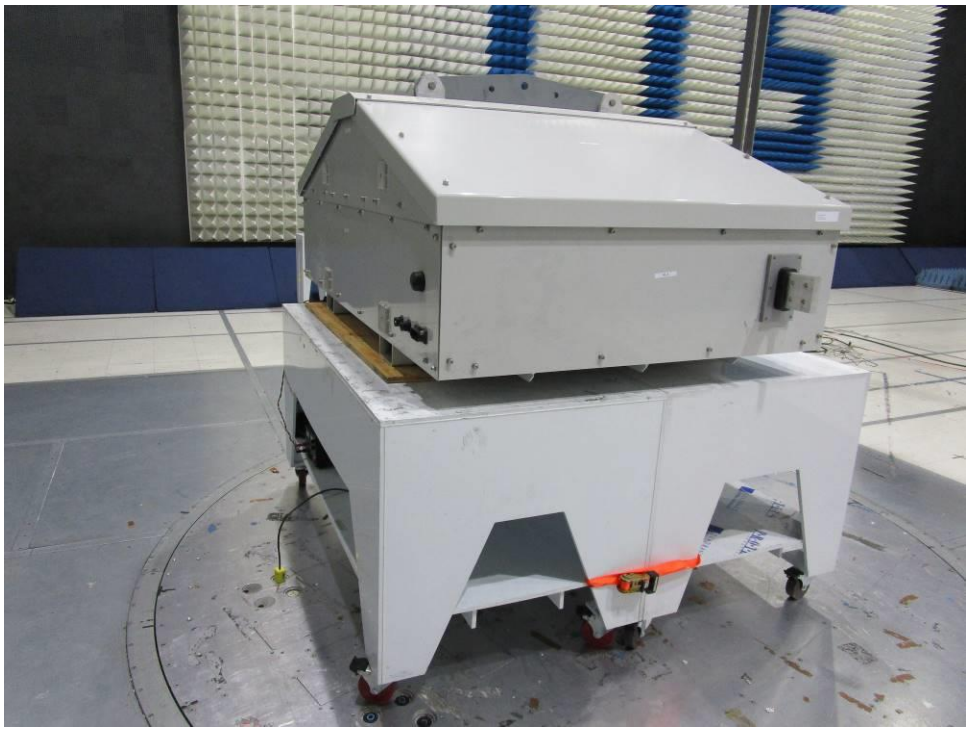
Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg Limit



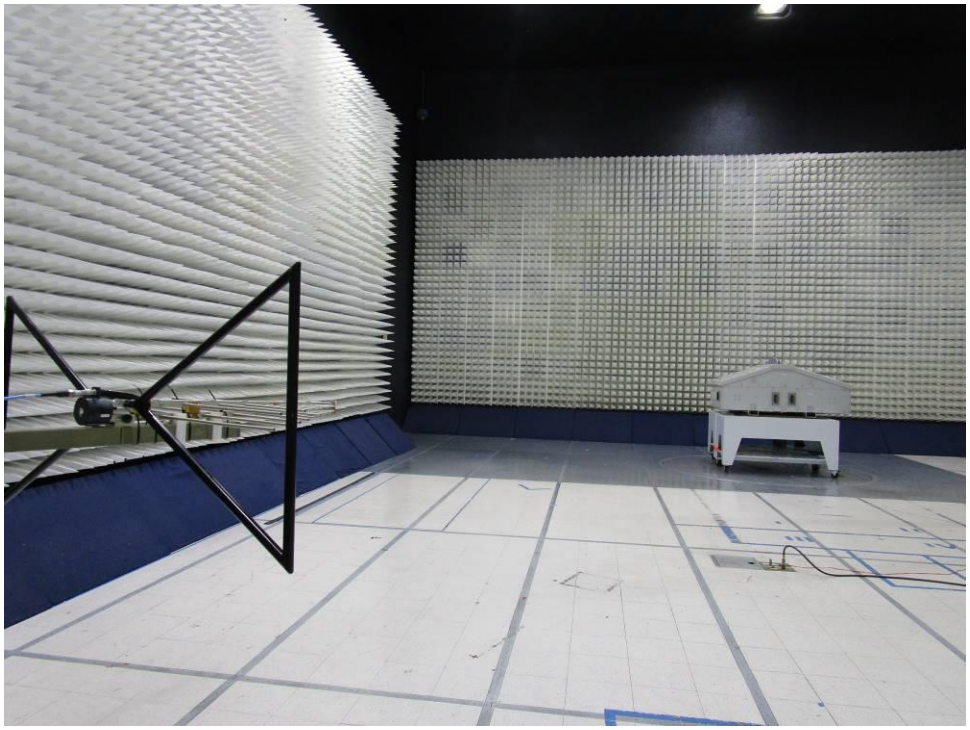
Results	Complies

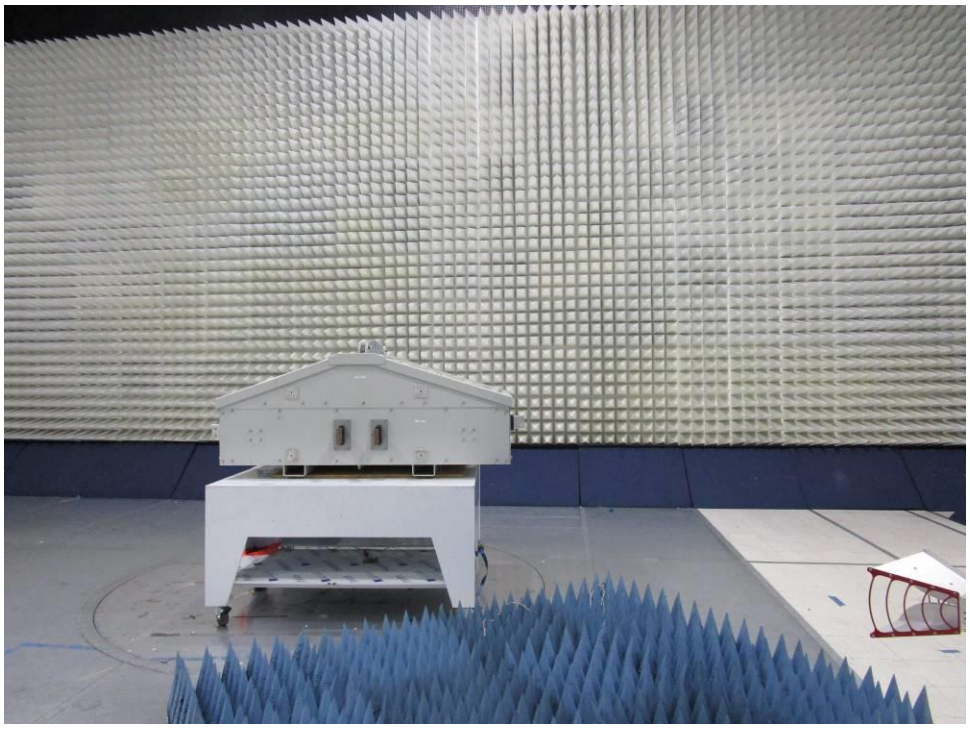
4.8.4 Test Configuration Photographs





4.7.5 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.

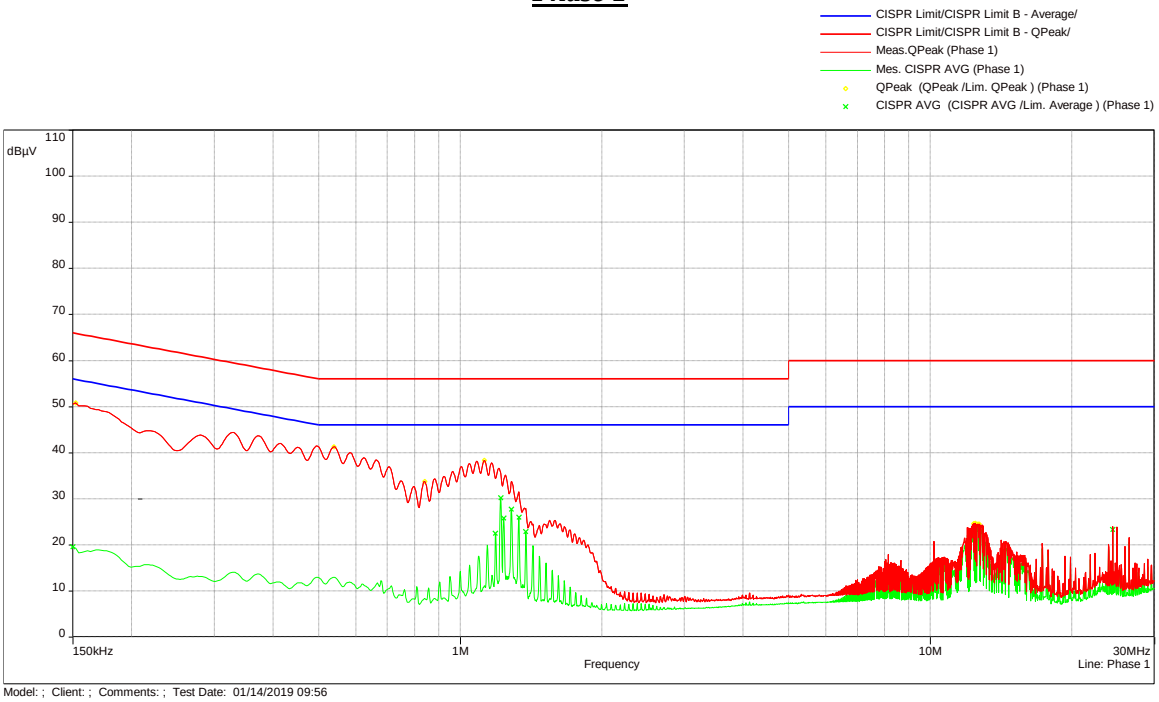
4.9.3 Test Results

Tested By	Test Date
Anderson Soungpanya	January 14, 2019

4.9.3 Test Results (Continued)

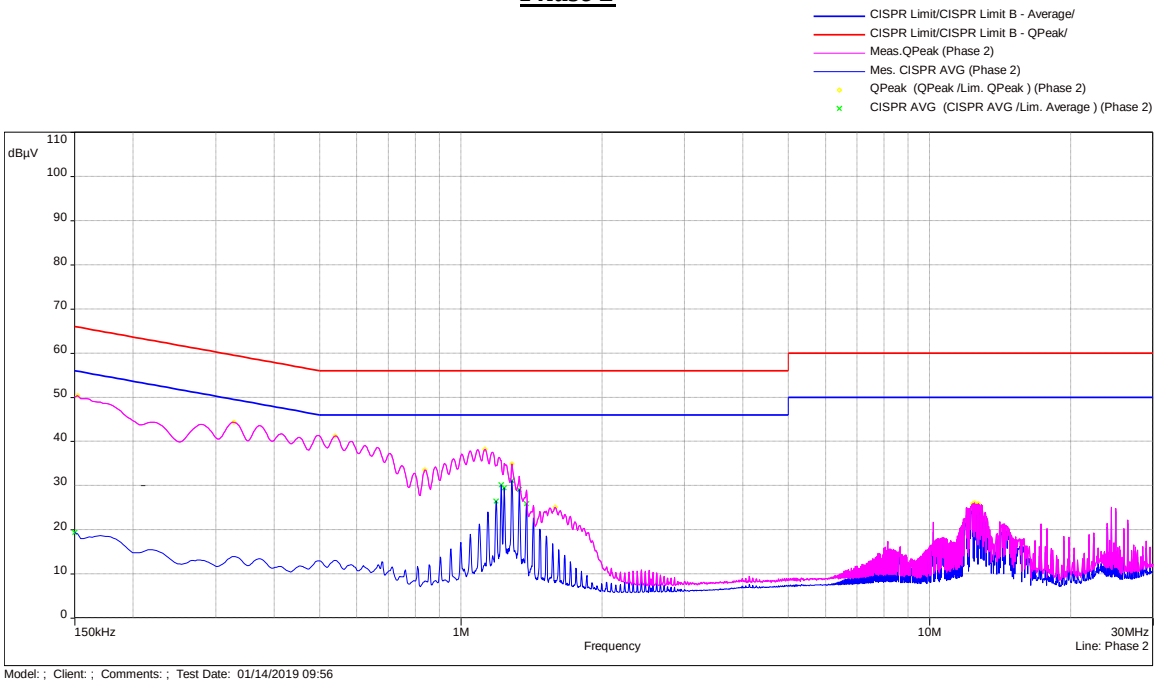
Conducted Emissions 120VAC 60Hz, FCC Part 15.207/15.107

Phase 1



Model: ; Client: ; Comments: ; Test Date: 01/14/2019 09:56

Phase 2



Model: ; Client: ; Comments: ; Test Date: 01/14/2019 09:56

4.9.3 Test Results (Continued)

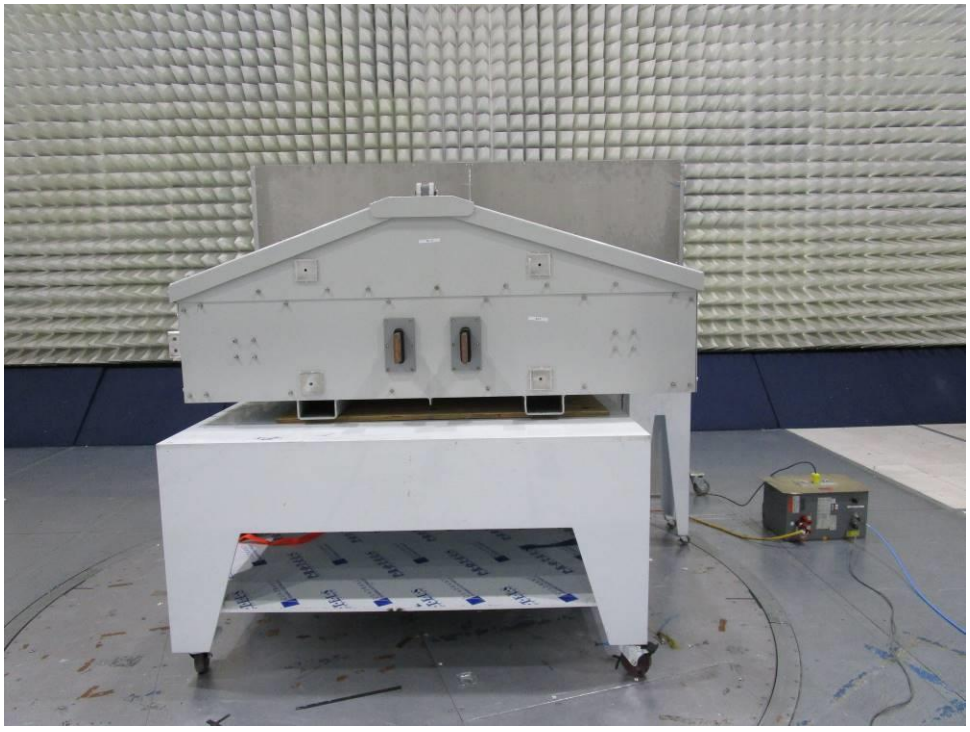
Quasi Peak Table					
Frequency (MHz)	QPeak (dBµV)	Lim. QPeak (dBµV)	QPeak-Lim (dB)	Phase	Correction (dB)
0.152	50.33	65.88	-15.55	Phase 2	11.55
0.152	50.83	65.88	-15.05	Phase 1	11.55
0.328	44.33	59.51	-15.18	Phase 2	11.57
0.539	41.23	56.00	-14.77	Phase 2	11.60
0.539	41.26	56.00	-14.74	Phase 1	11.60
0.839	33.50	56.00	-22.50	Phase 2	11.64
0.841	33.76	56.00	-22.24	Phase 1	11.64
1.127	38.31	56.00	-17.69	Phase 1	11.63
1.127	38.18	56.00	-17.82	Phase 2	11.63
1.286	34.88	56.00	-21.12	Phase 2	11.65
1.590	25.06	56.00	-30.94	Phase 2	11.69
12.381	25.90	60.00	-34.10	Phase 2	12.01
12.381	24.61	60.00	-35.39	Phase 1	12.01
12.428	24.57	60.00	-35.43	Phase 1	12.01
12.428	25.85	60.00	-34.15	Phase 2	12.01
12.476	26.00	60.00	-34.00	Phase 2	12.02
12.476	24.70	60.00	-35.30	Phase 1	12.02
12.620	25.79	60.00	-34.21	Phase 2	12.03
12.620	24.44	60.00	-35.56	Phase 1	12.03
12.667	25.79	60.00	-34.21	Phase 2	12.03
12.667	24.42	60.00	-35.58	Phase 1	12.03
12.714	24.47	60.00	-35.53	Phase 1	12.03
12.714	25.86	60.00	-34.14	Phase 2	12.03

4.9.3 Test Results (Continued)

Average Table					
Frequency (MHz)	AVG (dBµV)	Lim. Average (dBµV)	AVG-Lim (dB)	Phase	Correction (dB)
0.150	19.51	56.00	-36.49	Phase 1	11.55
0.150	19.33	56.00	-36.67	Phase 2	11.55
1.190	22.47	46.00	-23.53	Phase 1	11.63
1.190	26.48	46.00	-19.52	Phase 2	11.63
1.221	30.16	46.00	-15.84	Phase 1	11.64
1.221	30.12	46.00	-15.88	Phase 2	11.64
1.239	25.78	46.00	-20.22	Phase 1	11.64
1.239	29.50	46.00	-16.50	Phase 2	11.64
1.286	31.14	46.00	-14.86	Phase 2	11.65
1.286	27.71	46.00	-18.29	Phase 1	11.65
1.334	29.06	46.00	-16.94	Phase 2	11.67
1.334	25.92	46.00	-20.08	Phase 1	11.67
1.381	22.84	46.00	-23.16	Phase 1	11.66
1.381	25.85	46.00	-20.15	Phase 2	11.66
12.381	24.61	50.00	-25.39	Phase 2	12.01
12.381	23.34	50.00	-26.66	Phase 1	12.01
12.428	24.79	50.00	-25.21	Phase 2	12.01
12.428	23.49	50.00	-26.51	Phase 1	12.01
12.476	24.60	50.00	-25.40	Phase 2	12.02
12.620	25.09	50.00	-24.91	Phase 2	12.03
12.620	23.71	50.00	-26.29	Phase 1	12.03
12.667	24.84	50.00	-25.16	Phase 2	12.03
12.667	23.48	50.00	-26.52	Phase 1	12.03
12.761	24.94	50.00	-25.06	Phase 2	12.03
12.761	23.51	50.00	-26.49	Phase 1	12.03

Results: Complies by 14.74 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	ESR7	ITS 01607	12	10/23/19
EMI Receiver	Rohde and Schwarz	ESU40	ITS 00961	12	10/26/19
Horn Antenna	ETS-Lindgren	3115	ITS 00982	12	02/08/19
Pre-Amplifier	ETS-Lindgren	3117-PA	ITS 01365	12	10/04/19
BI-Log Antenna	Antenna Research	LPB-2513	ITS 00355	12	02/21/19
Pre-Amplifier	Sonoma Instrument	310N	ITS 00942	12	01/26/19
Horn Antenna (10-40 GHz)	ETS-Lindgren	3116C	ITS 01376	12	04/25/19
Pre-Amplifier (18-40GHz)	Miteq	TTA1840-35-S-M	ITS 01393	12	01/19/19
LISN	FCC	FCC-LISN-PA-NEMA-5-15	ITS 00551	12	10/04/19
RF Cable	Megaphase	EMC1-K1K1-236	ITS 01538	12	06/25/19
RF Cable	Megaphase	TM40-K1K1-59	ITS 01657	12	06/26/19
RF Cable	TRU Corporation	TRU CORE 300	ITS 00465	12	08/16/19
RF Cable	TRU Corporation	TRU CORE 300	ITS 01470	12	08/16/19
Transient Limiter	COM-POWER	LIT-153A	ITS 01452	12	06/21/19
Notch Filter	Micro-Tronics	BRM50702	ITS 01166	12	03/10/19
Attenuator	Mini Circuits	FSCM99899	ITS 01582	12	10/07/19

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
BAT-EMC	Nexio	3.16.0.64	Smartwires_Bypass_G103758643.bpp
RS Commander	Rohde Schwarz	1.6.4	Not Applicable (Screen grabber)

6.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G103758643	AS	KV	January 29, 2019	Original Document

END OF REPORT