EMC Test Report

Project Number: 4219718
Report Number: 4219718EMC02 **Revision Level:** 0

Client: Johnson Controls Inc
Equipment Under Test: Wireless Thermostat
Model: SiO2
FCC ID: OEJGLASWIFI
IC ID: 279A-GLASWIFI

Applicable Standards: FCC Part 15 Subpart C, § 15.247
RSS-247, Issue 2
ANSI C63.10: 2013
RSS-GEN, Issue 4

Report issued on: 31 October 2017
Test Result: Compliant

Tested by: _____
Jeremy Pickens, Senior EMC Engineer

Reviewed by: _____
David Schramm, Operations Manager

Remarks: This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

Table of Contents

1 Summary of Test Results

Test Description	Test Specification		Test Result
Bandwidth	15.247(d)	RSS-247 S5.2 (1) RSS-GEN S6.6	Compliant
Transmitter Output Power	15.247(b)(3)	RSS-247 S5.4 (4)	Compliant
Power Spectral Density	15.247(e)	RSS-247 S5.2 (2)	Compliant
Conducted Spurious Emissions / Band Edge	15.247(d)	RSS-247 S5.5	Compliant
Radiated Spurious Emissions / Restricted Bands	15.35(b),15.209	RSS-GEN S6.13 RSS-GEN S8.10	Compliant
Antenna Requirement	15.203	RSS-GEN S8.3	Compliant (1)
AC Powerline Conducted Emissions	15.107, 15.207	RSS-GEN S8.8	Compliant

1) Internal PCB trace antenna

1.1 *Modifications Required for Compliance*

None

2 General Information

2.1 *Client Information*

Name:	Johnson Controls Inc
Address:	507 East Michigan Street
City, State, Zip, Country:	Milwaukee, WI 53202, USA

2.2 *Test Laboratory*

Name:	SGS North America, Inc.
Address:	620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country:	Suwanee, GA 30024, USA
Accrediting Body:	A2LA
Type of lab:	Testing Laboratory
Certificate Number:	3212.01

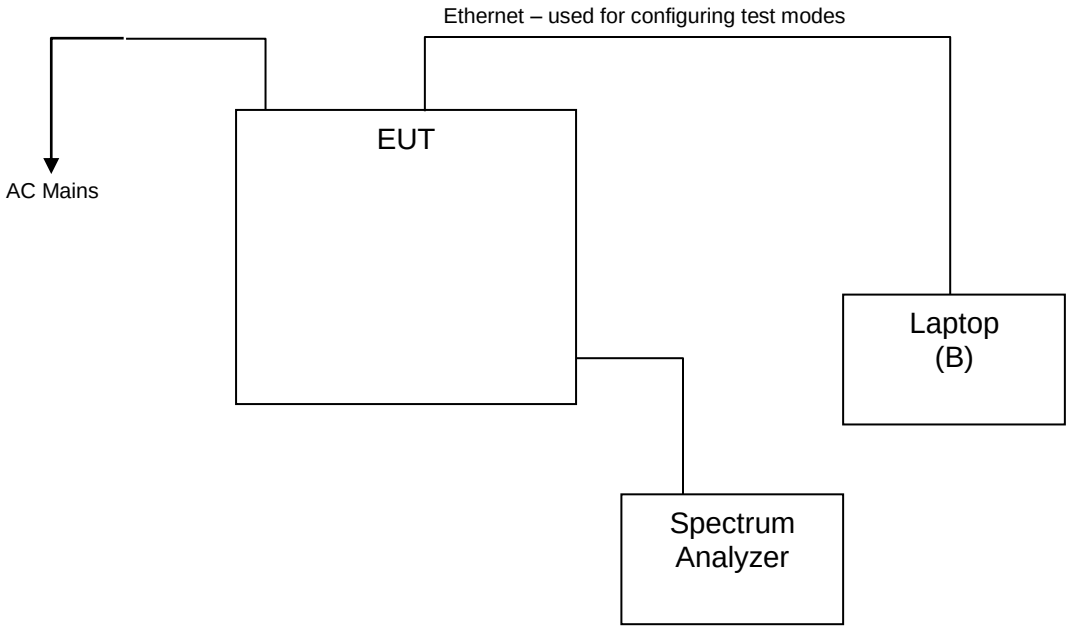
2.3 *General Information of EUT*

Type of Product:	Wireless Thermostat
Model Number:	SiO2
Serial Number:	173800048
Frequency Range:	2402-2480MHz
Data Modes:	Bluetooth Low Energy
Antenna:	Internal, 3.34 dBi Max Gain
Rated Voltage:	24Vac, 60Hz
Test Voltage:	24Vac, 60Hz
Sample Received Date:	18 October 2017
Dates of testing:	18 - 31 October 2017

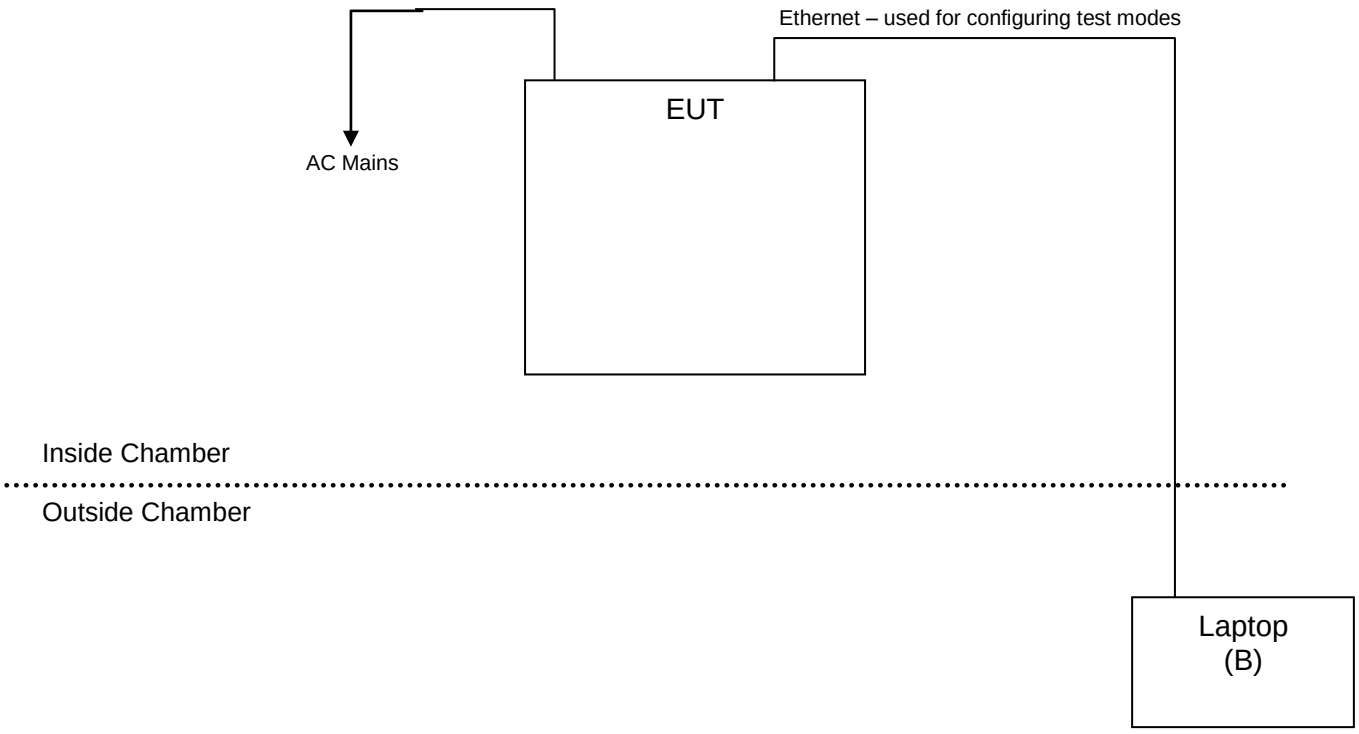
2.4 *Operating Modes and Conditions*

Continuous traffic was generated using test commands. Where the duty cycle measured below 99% and an RMS detector was employed, corrections of 10*LOG(1/D) were applied according to KDB publication 558074 D01 DTS Meas Guidance v04 .

2.5 *EUT Connection Block Diagram – Conducted Measurements*



2.6 *EUT Connection Block Diagram – Radiated Measurements*



2.7 *System Configurations*

Device reference	Manufacturer	Description	Model Number	Serial Number
A	Johnson Controls	Wireless Thermostat	SiO2	173800048
B	Dell	Laptop	Latitude ES420	11033846857

3 Bandwidth

3.1 *Test Result*

Test Description	Test Specification		Test Result
6 dB bandwidth / 99% OBW	15.247(d)	RSS-247 S5.2 (1) RSS-GEN S6.6	Compliant

3.2 *Test Method*

The procedures from ANSI C63.10: 2013 clause 11.8 and 558074 D01 DTS Meas Guidance v04 were used to determine the 6 dB bandwidth and 99% OBW.

3.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	21.7 °C
Relative Humidity:	42.0 %
Atmospheric Pressure:	98.8 kPa

3.4 *Test Equipment*

Test End Date: 19-Oct-2017 Tester: JOP

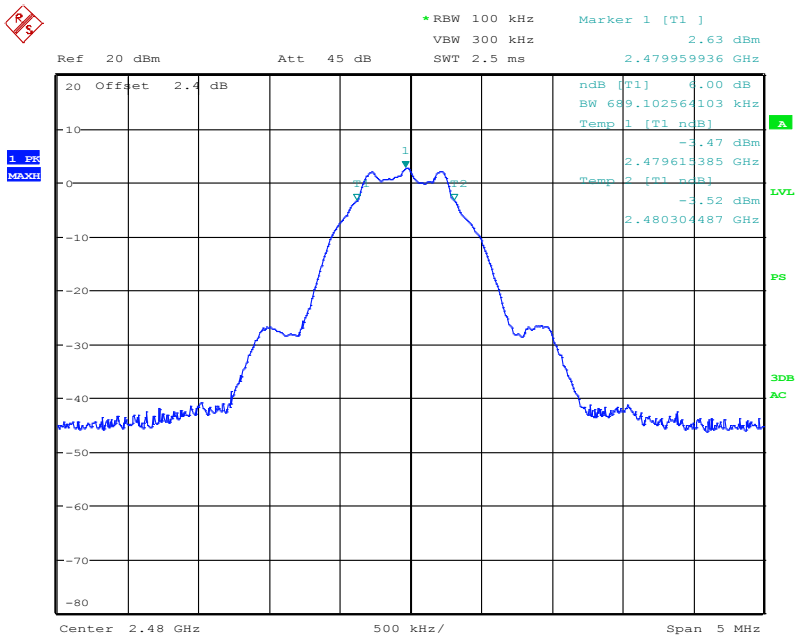
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018

Note: The equipment calibration period is 1 year.

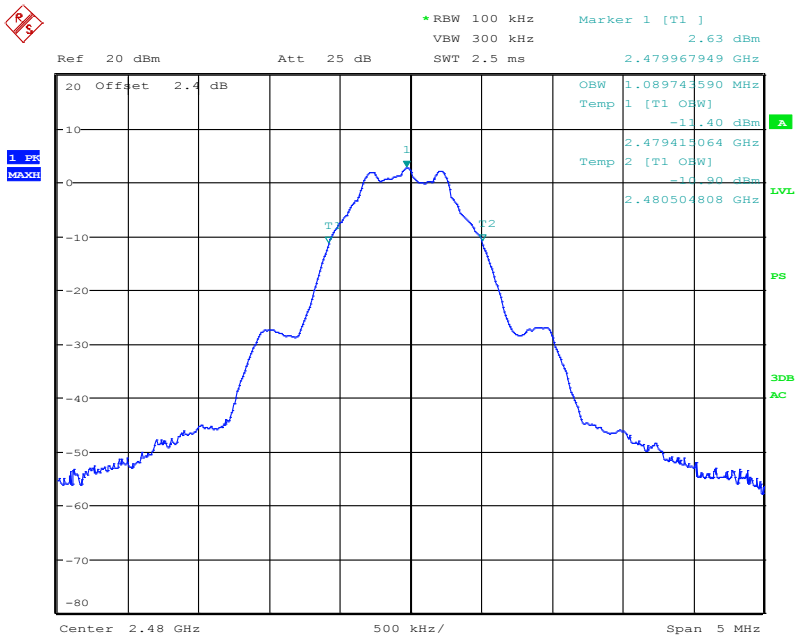
3.5 *Test Data*

Protocol	Channel	6dB Bandwidth (MHz)	Occupied Bandwidth (99%) (MHz)
BLE	0	0.680	1.085
BLE	19	0.683	1.085
BLE	39	0.689	1.090

Sample Plots:



Date: 19.OCT.2017 11:09:20



Date: 19.OCT.2017 11:10:51

4 Output Power

4.1 *Test Result*

Test Description	Test Specification		Test Result
Peak Output Power	15.247(b)(3)	RSS-247 S5.4 (4)	Compliant

4.2 *Test Method*

Fundamental peak power measurements were recorded using the procedures from ANSI C63.10: 2013 clause 11.9 and KDB 558074 D01 Measurement Guidance v04.

Limit

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. For using antennas with greater than 6dBi of gain, the limit is reduced in dB by the amount the gain exceeds 6dBi (e.g. for a 7.4dBi antenna, the limit is reduced from 30dBm to 28.6dBm)

4.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	21.7 °C
Relative Humidity:	42.0 %
Atmospheric Pressure:	98.8 kPa

4.4 *Test Equipment*

Test End Date: 19-Oct-2017 Tester: JOP

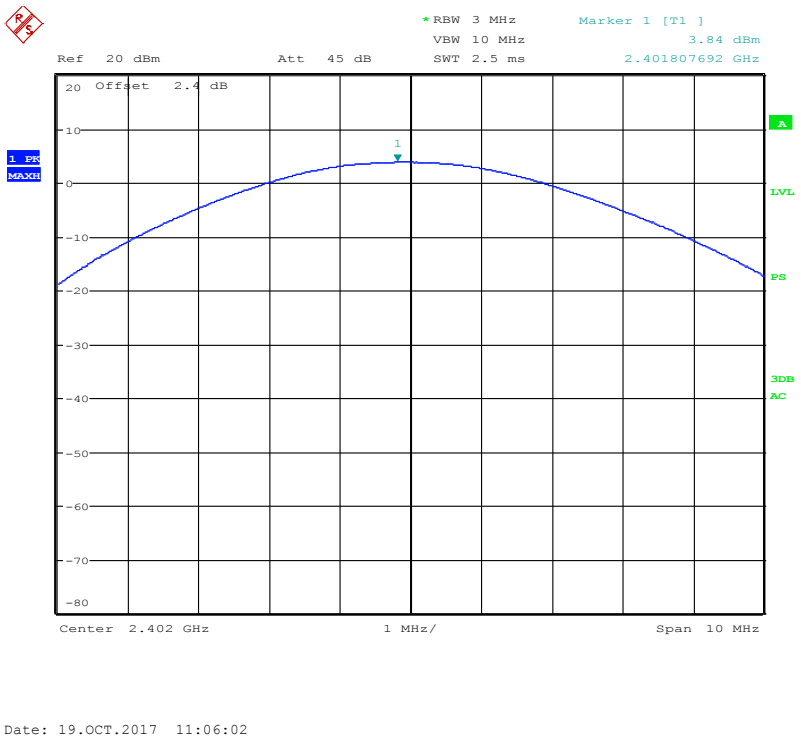
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018

Note: The equipment calibration period is 1 year.

4.5 *Test Data*

Protocol	Channel	Peak Power (dBm)	Limit (dBm)	Margin (dB)
BLE	0	3.84	30	-26.16
BLE	19	3.68	30	-26.32
BLE	39	3.37	30	-30.74

Sample Plot:



5 Power Spectral Density

5.1 *Test Result*

Test Description	Test Specification		Test Result
Power Spectral Density	15.247(e)	RSS-247 S5.2 (2)	Compliant

5.2 *Test Method*

Power spectral density measurements were recorded using the procedures from ANSI C63.10: 2013 clause 11.10 and KDB 558074 D01 Measurement Guidance v04.

Limit
The limit is 8 dBm.

5.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	21.7 °C
Relative Humidity:	42.0 %
Atmospheric Pressure:	98.8 kPa

5.4 *Test Equipment*

Test End Date: 19-Oct-2017 Tester: JOP

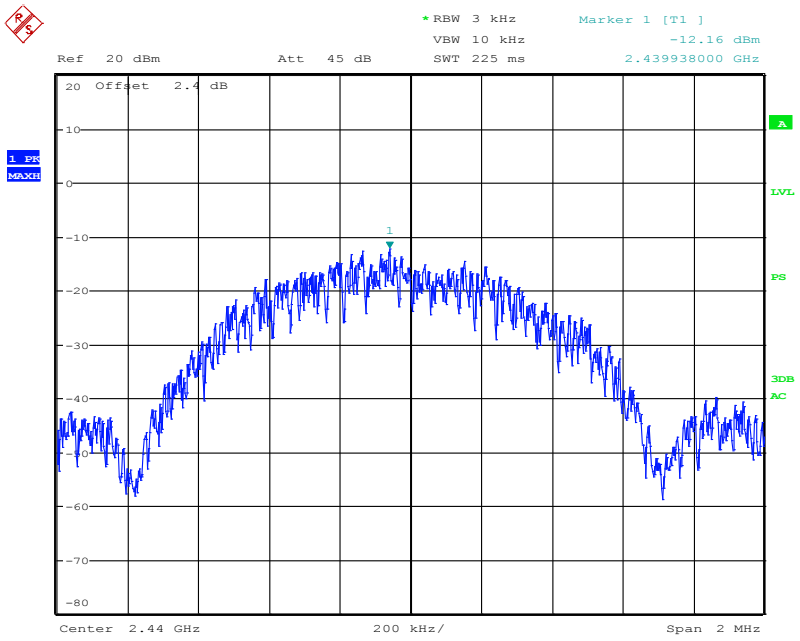
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018

Note: The equipment calibration period is 1 year.

5.5 *Test Data*

Protocol	Channel	Peak PSD (dBm)	Limit (dBm)	Margin (dB)
BLE	0	-12.02	8	-20.02
BLE	19	-12.16	8	-20.16
BLE	39	-12.47	8	-20.47

Sample Plot:



6 Conducted Spurious Emissions / Band Edge

6.1 *Test Result*

Test Description	Test Specification		Test Result
Conducted Spurious Emissions	15.247(d)	RSS-247 S5.5	Compliant

6.2 *Test Method*

Spurious emissions in non-restricted frequency bands were recorded using the methods defined in ANSI C63.10: 2013 clause 11.11 and KDB 558074 D01 Measurement Guidance v04.

Lowest, middle, and highest channels were investigated.

Because the maximum conducted peak output power was used to determine compliance with the output power limits, the limit in any 100 kHz band outside of the authorized band is 20 dB below the maximum in-band peak level.

6.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	21.7 °C
Relative Humidity:	42.0 %
Atmospheric Pressure:	98.8 kPa

6.4 *Test Equipment*

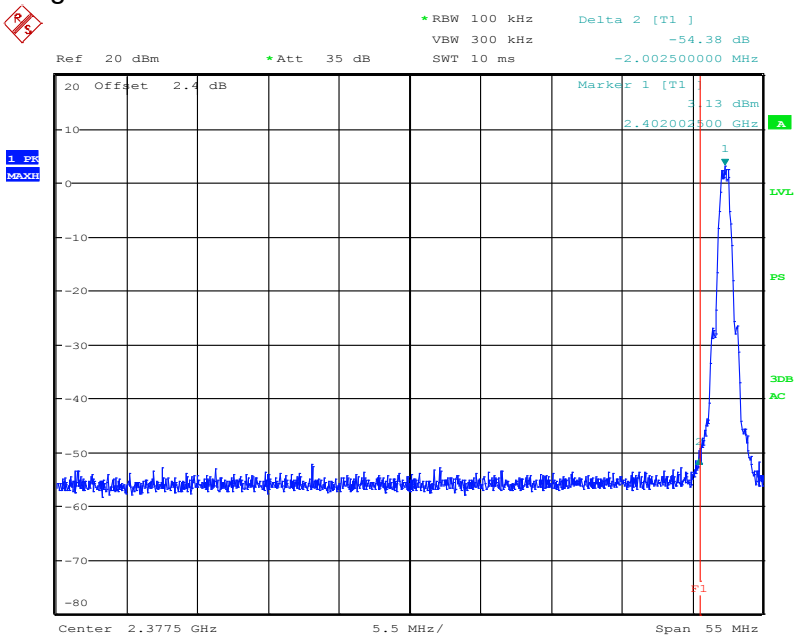
Test End Date: 19-Oct-2017 Tester: JOP

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018

Note: The equipment calibration period is 1 year.

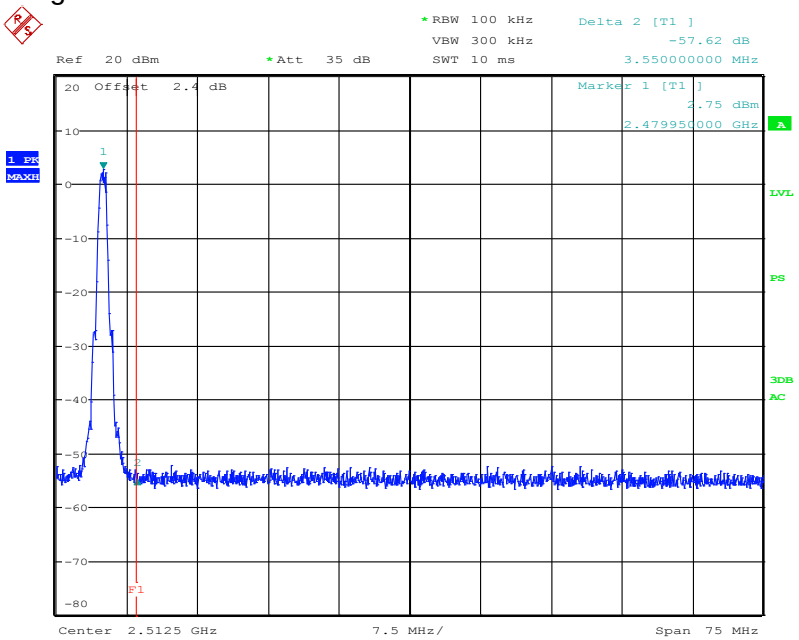
6.5 *Test Data – DTS Band Edge*

BLE - Lower band edge:



Date: 19.OCT.2017 11:22:38

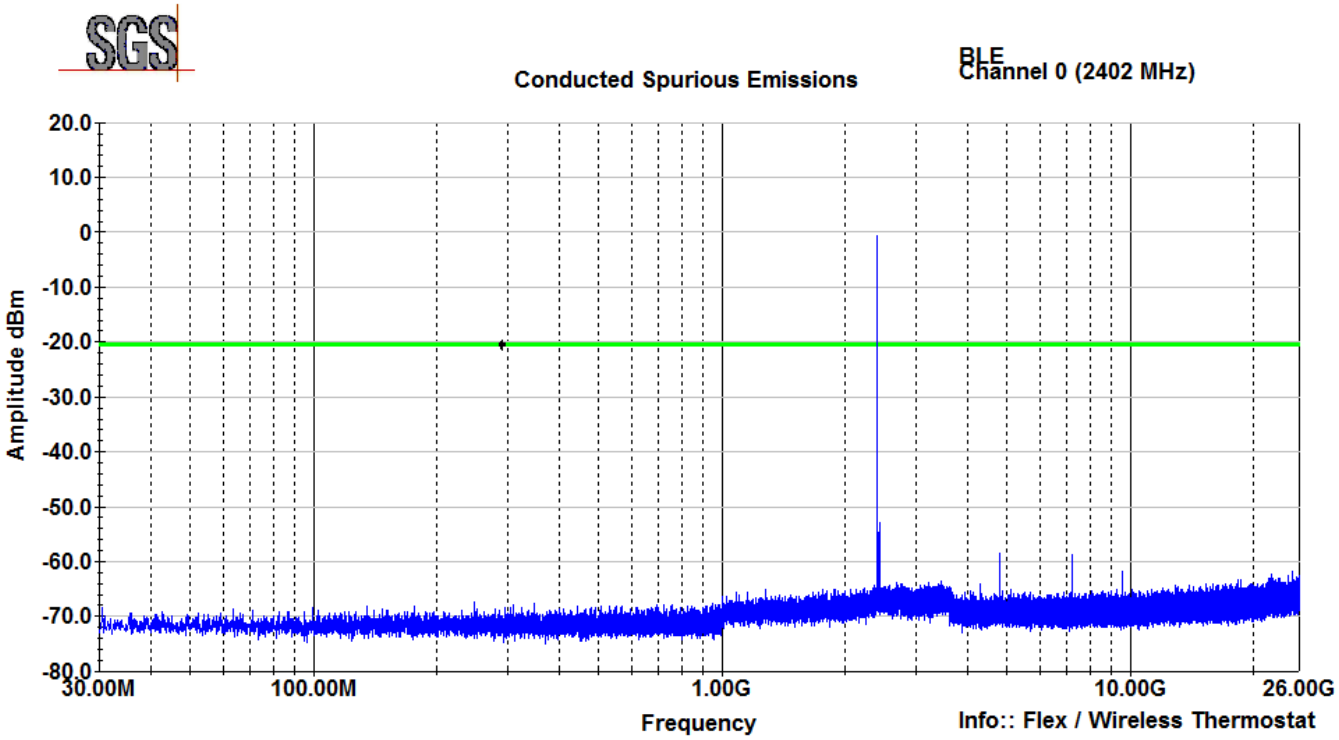
BLE - Upper band edge:



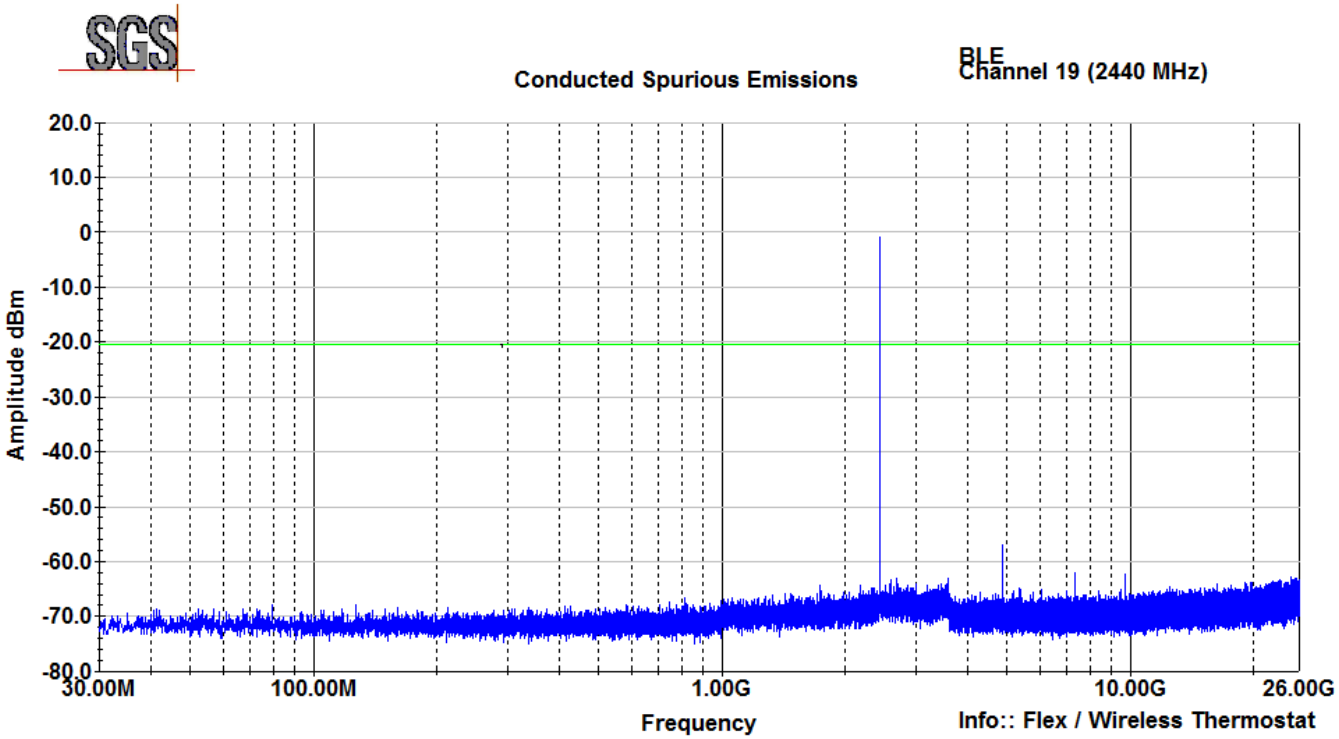
Date: 19.OCT.2017 11:21:35

6.6 *Test Data – Conducted Spurious Emissions*

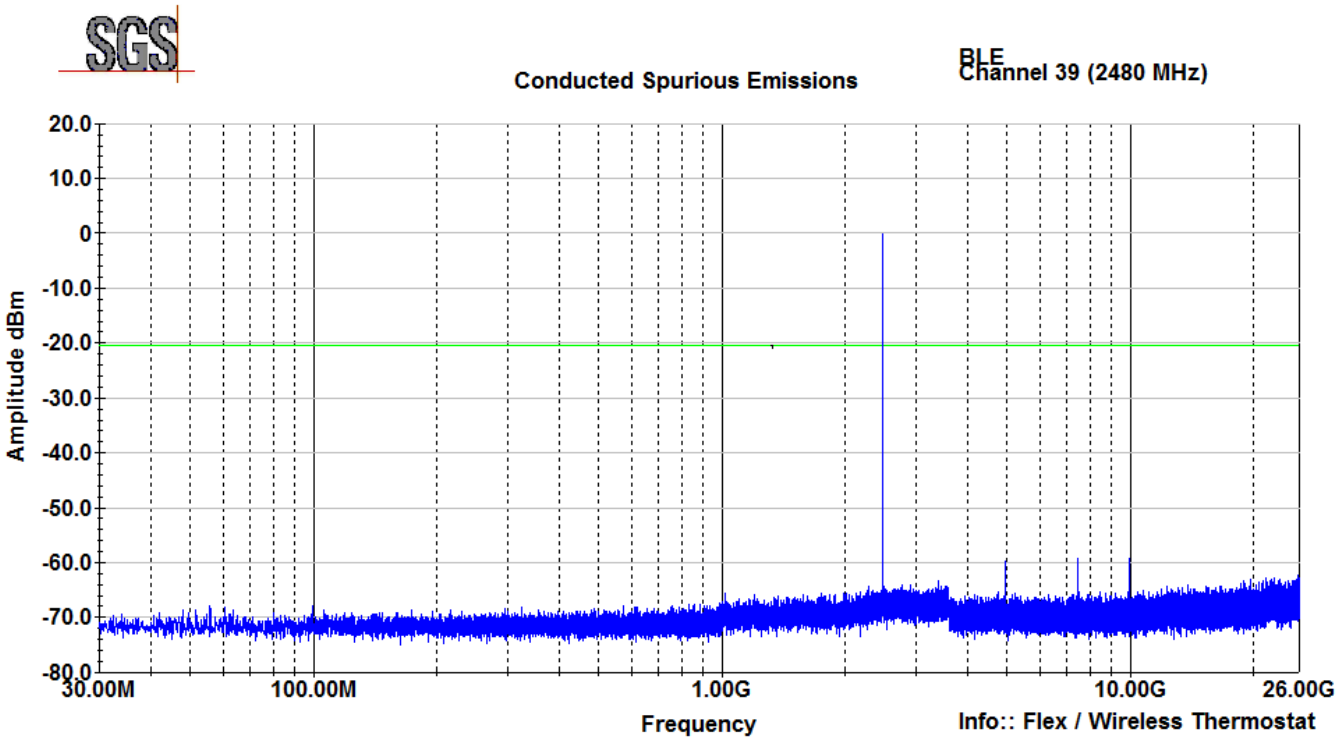
Conducted Spurs – Channel 0



Conducted Spurs – Channel 19



Conducted Spurs – Channel 39



7 Field Strength of Spurious Radiation

7.1 *Test Result*

Test Description	Test Specification		Test Result
Spurious Emissions	15.247 (d) and 15.209	RSS-247 S5.5	Compliant

7.2 *Test Method*

The measurement methods defined in ANSI C63.10: 2013 were used.

Lowest, middle, and highest channels were investigated – the device was commanded to continuously transmit on channels 0, 19, and 39.

Test distance:

9k to 30 MHz – Near field prescan to determine if there were any emissions.
30 to 1000 MHz - The EUT to measurement antenna distance was 3 meters
1 to 18 GHz - The EUT to measurement antenna distance was 3 meters
18 to 26 GHz - The EUT to measurement antenna distance was 3 meter

Limits within restricted bands of operation:

Frequency	Limits(1)		Peak Limits dBuV/m
	Microvolts/m	dBuV/m	
30 - 88 MHz	100	40 (2)	--
88 - 216 MHz	150	43.5 (2)	--
216 - 960 MHz	200	46 (2)	--
960 - 1000 MHz	500	54 (2)	--
1 - 40 GHz	500	54 (3)	74

(1) These limits are applicable to emissions outside of the intentional transmit frequency band.
(2) Quasi-peak limit
(3) Average limit

7.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.5 °C
Relative Humidity: 44.2 %
Atmospheric Pressure: 97.8 kPa

7.4 *Test Equipment*

Test End Date: 31-Oct-2017 Tester: JOP

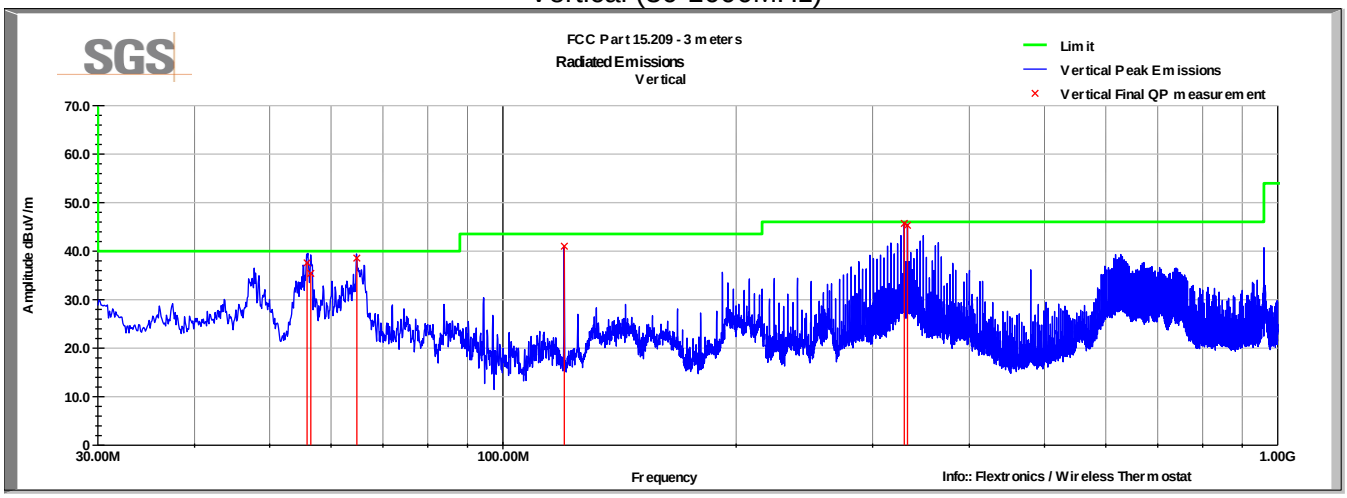
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU8	ROHDE & SCHWARZ	B085759	25-Jul-2018
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
ANTENNA, BILOG	CBL 6143A	TESEQ	B085931	6-Dec-2017
RF CABLE	SF106	HUBER & SUHNER	B079661	25-Jul-2018
RF CABLE	SF106	HUBER & SUHNER	B079713	24-Jul-2018
RF CABLE	SF106	HUBER & SUHNER	B079659	25-Jul-2018
RF CABLE	SUCOFLEX 100	HUBER & SUHNER	B108523	24-Jul-2018
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	B094463	22-Feb-2018
ANTENNA, DRG HORN (MEDIUM)	3117	ETS LINDGREN	B079691	27-Jul-2018
HORN(SMALL)	LB-180400-20-C-KF	A-INFO	15007	21-Mar-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018
RF CABLE	SF102	HUBER & SUHNER	B079824	26-Jul-2018
LOW NOISE AMPLIFIER	NSP1840-HG	MITEQ	B087572	28-Jul-2018

Note: The equipment calibration period is 1 year.

7.5 *Test Data – Peak Plots*

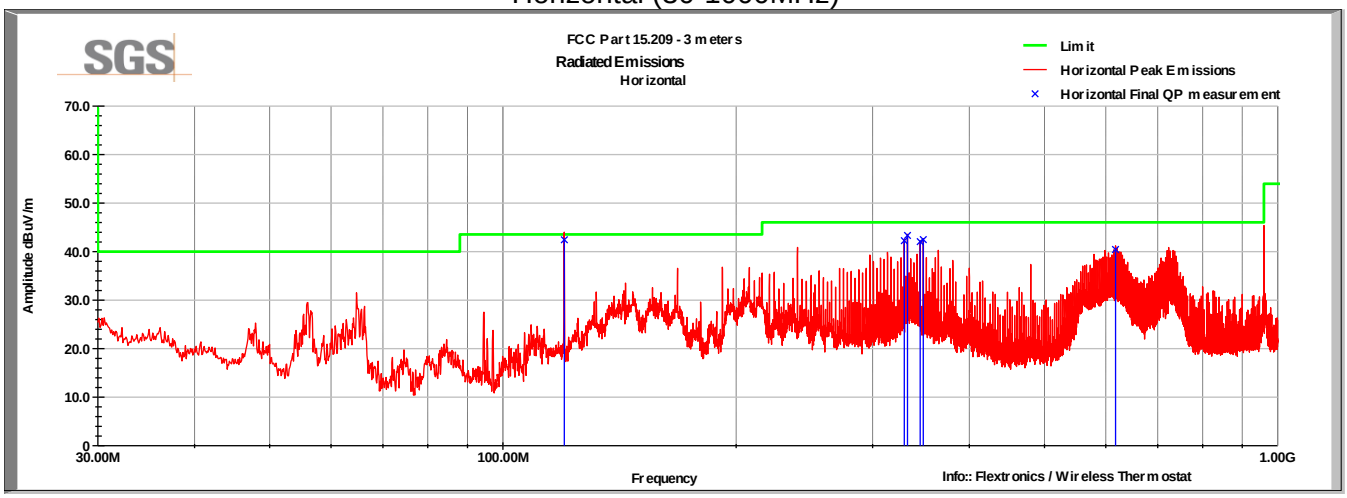
No emissions were detected in the range 9kHz to 30MHz.

BLE Channel 0
Vertical (30-1000MHz)



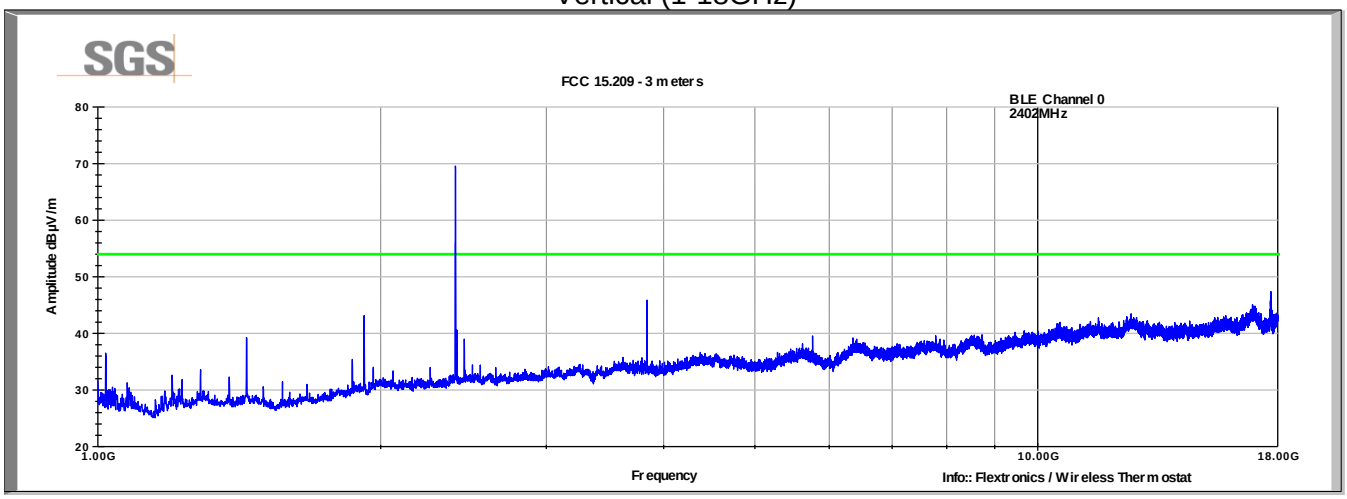
Below 1GHz, there was no discernible difference among the different transmit channels.

BLE Channel 0
Horizontal (30-1000MHz)



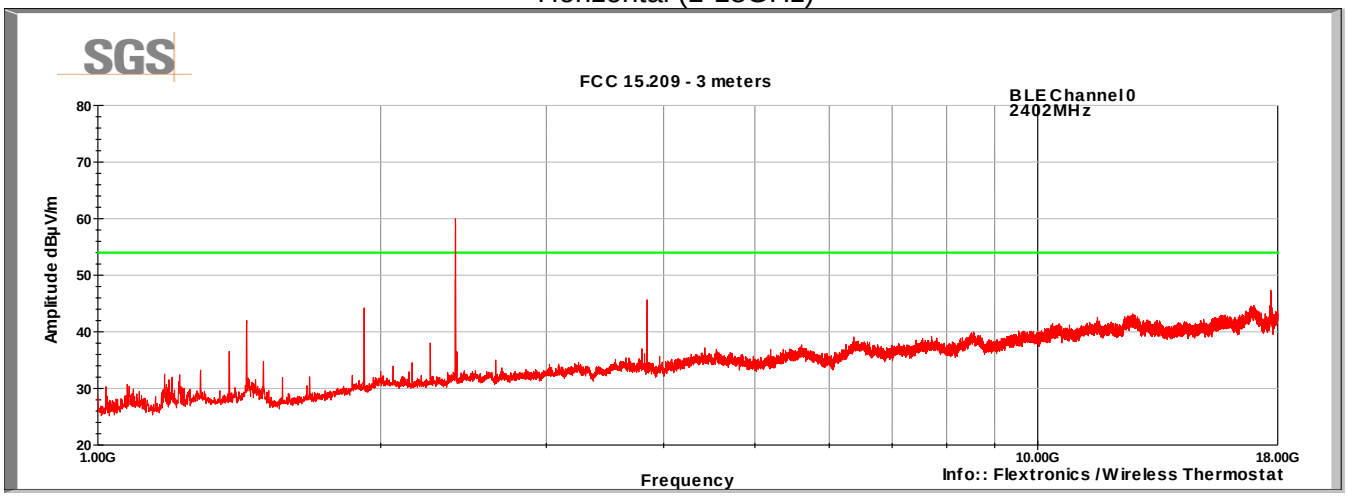
Below 1GHz, there was no discernible difference among the different transmit channels.

BLE Channel 0
Vertical (1-18GHz)



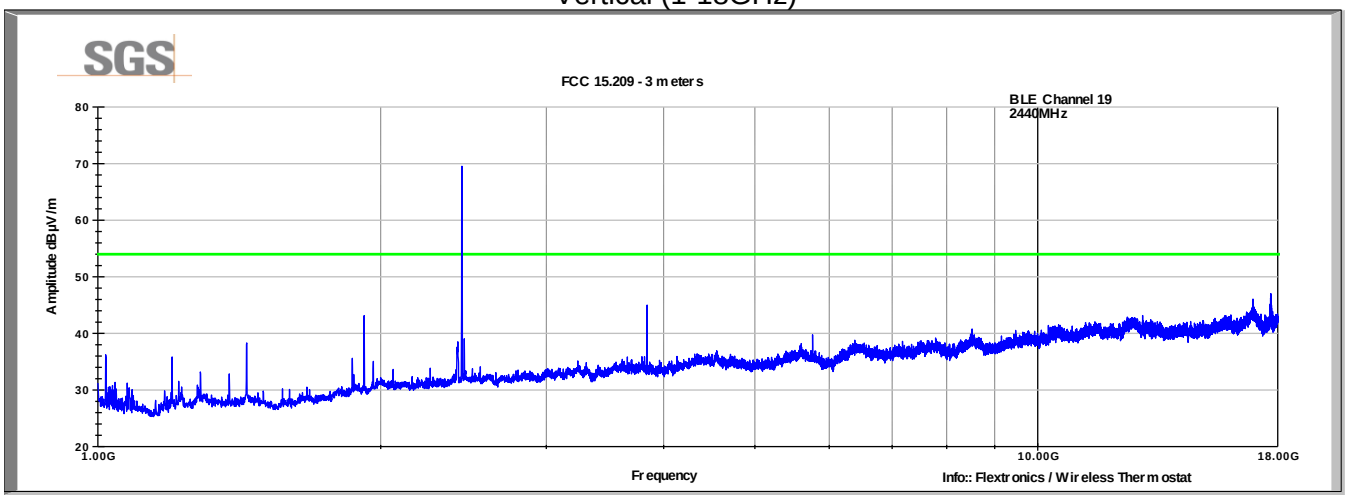
Antenna port was terminated into 50-Ohms

BLE Channel 0
Horizontal (1-18GHz)



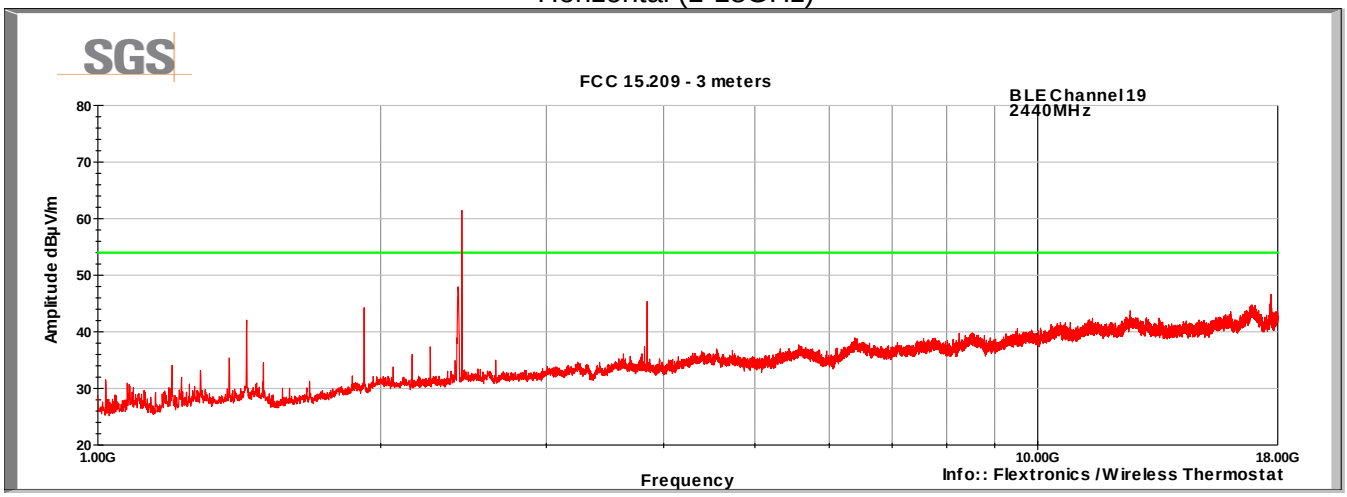
Antenna port was terminated into 50-Ohms

BLE Channel 19
Vertical (1-18GHz)



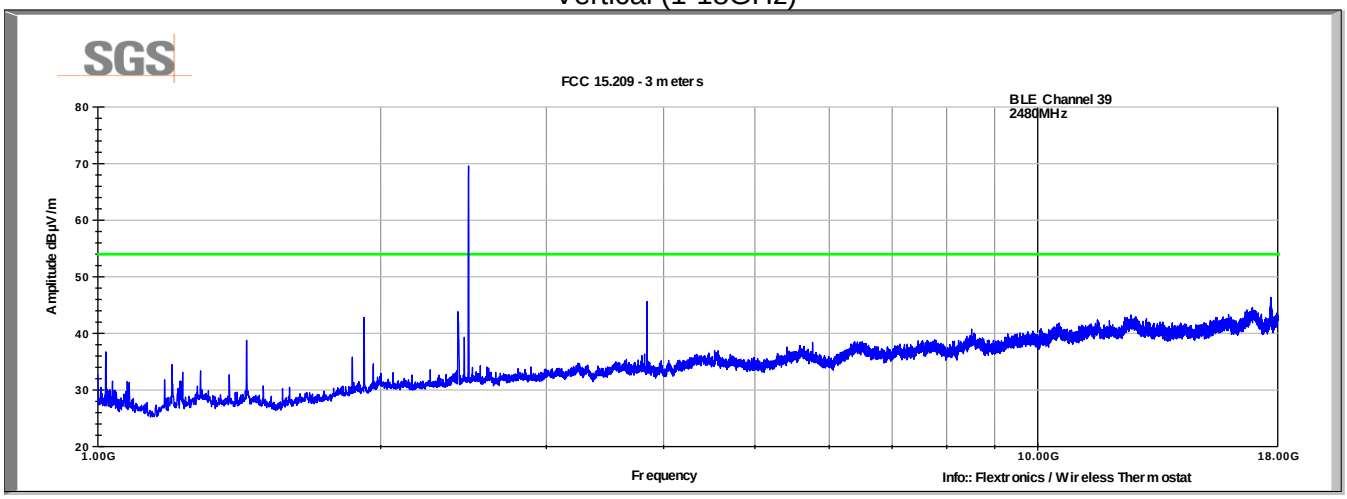
Antenna port was terminated into 50-Ohms

BLE Channel 19
Horizontal (1-18GHz)



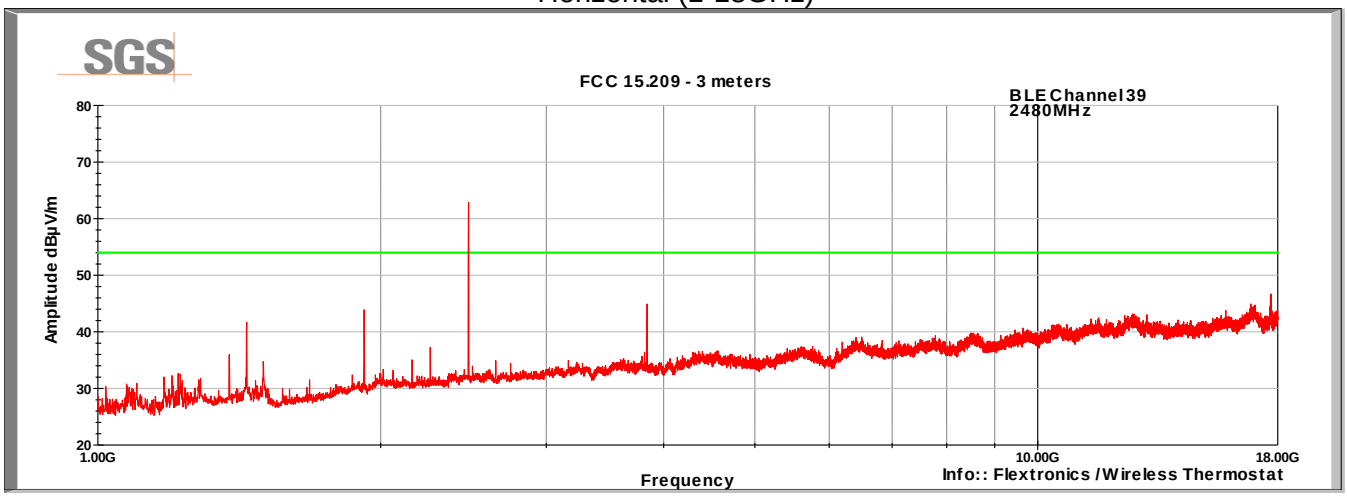
Antenna port was terminated into 50-Ohms

BLE Channel 39
Vertical (1-18GHz)



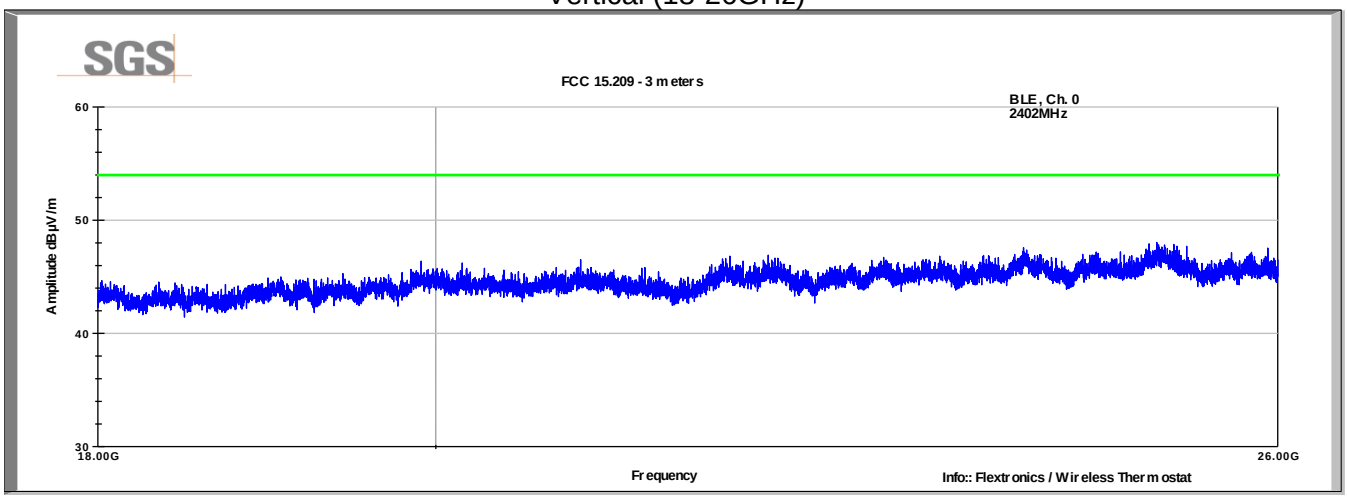
Antenna port was terminated into 50-Ohms

BLE Channel 39
Horizontal (1-18GHz)

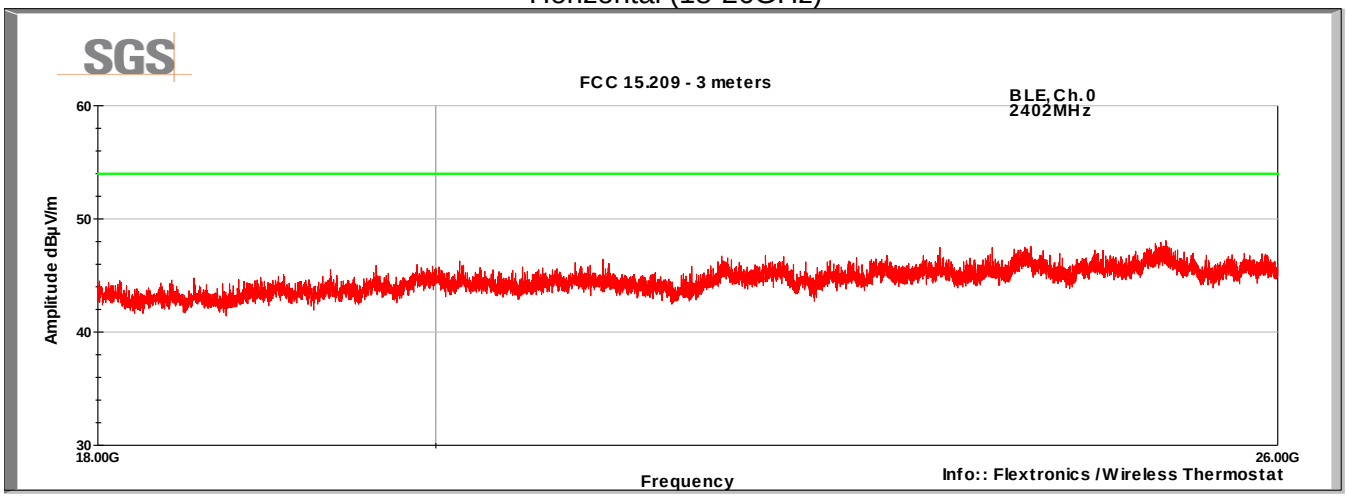


Antenna port was terminated into 50-Ohms

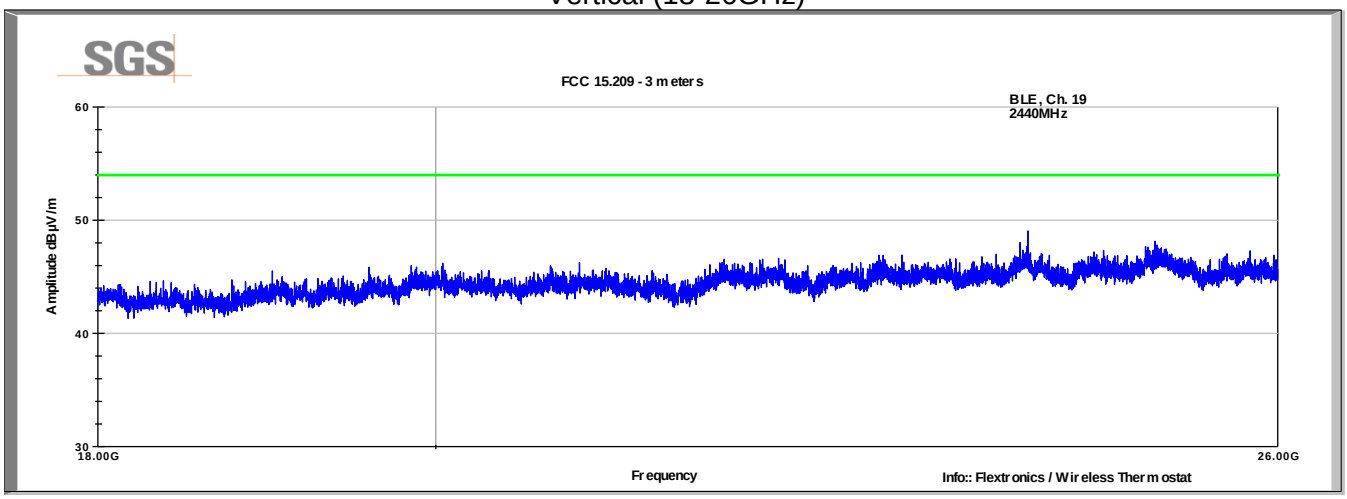
BLE Channel 0
Vertical (18-26GHz)



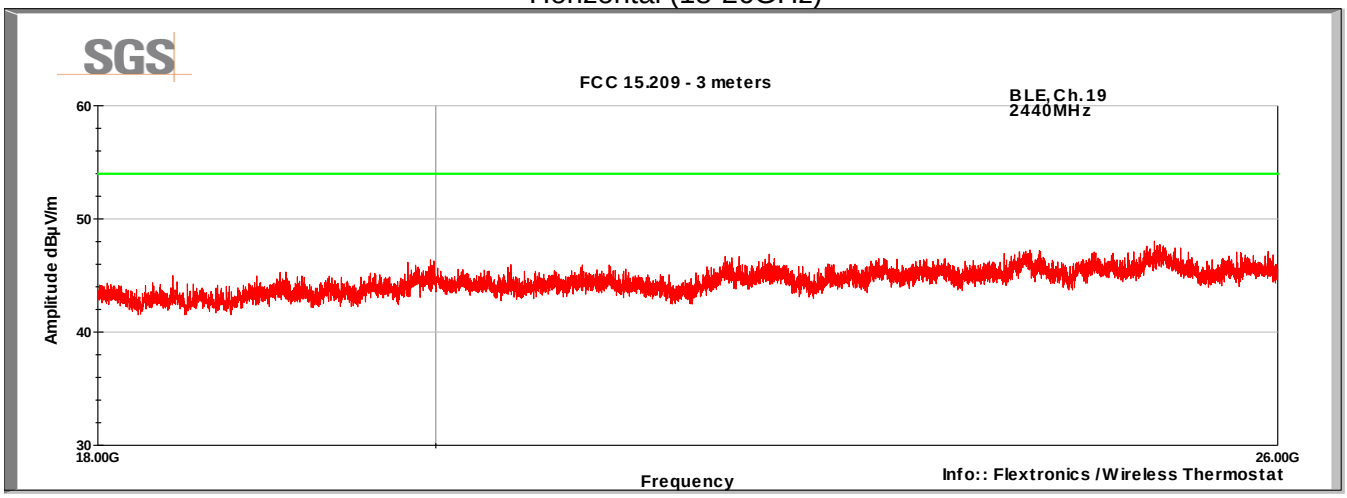
BLE Channel 0
Horizontal (18-26GHz)



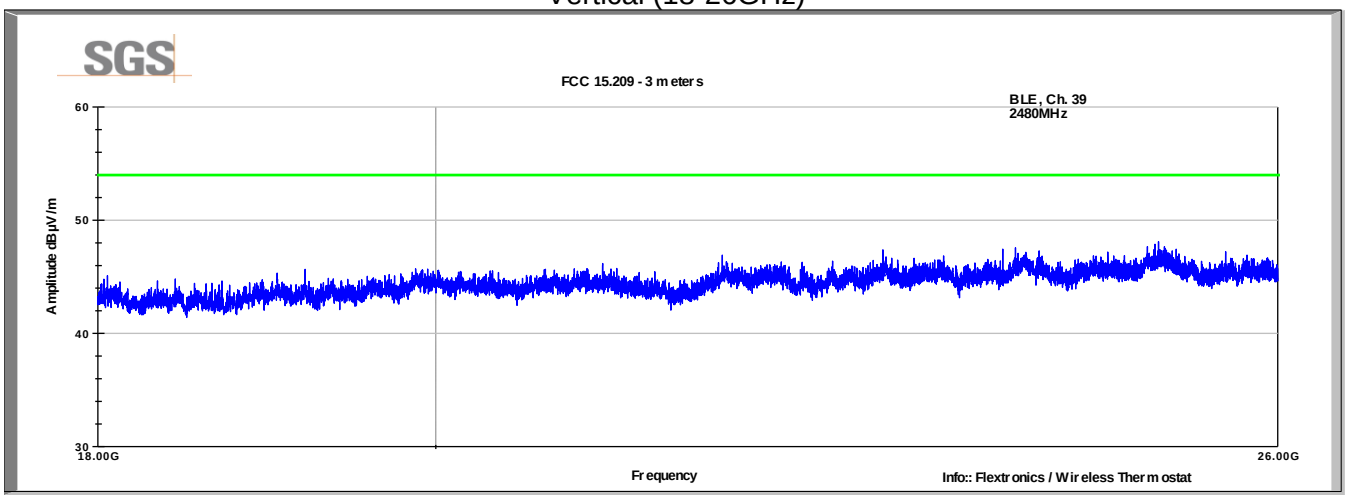
BLE Channel 19
Vertical (18-26GHz)



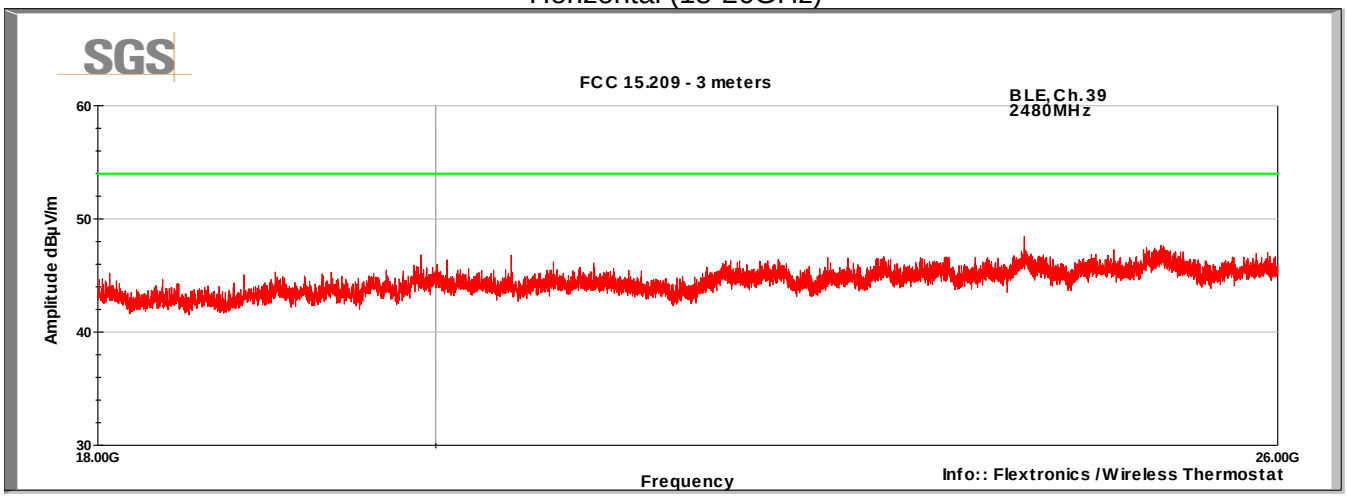
BLE Channel 19
Horizontal (18-26GHz)



BLE Channel 39
Vertical (18-26GHz)



BLE Channel 39
Horizontal (18-26GHz)



7.6 *Test Data – Tabular Data*

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
55.89	57.4	V	230.0	127.0	12.3	0.7	32.9	37.6	40.0	-2.4
56.50	55.5	V	240.0	100.0	12.1	0.7	32.9	35.4	40.0	-4.6
64.78	61.1	V	313.0	100.0	9.8	0.7	33.1	38.6	40.0	-1.4
120.02	60.3	V	0.0	198.0	13.4	1.0	33.7	41.0	43.5	-2.5
329.60	62.7	V	315.0	175.0	14.7	1.8	33.5	45.7	46.0	-0.3
332.80	62.4	V	308.0	158.0	14.6	1.8	33.5	45.3	46.0	-0.7
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
120.02	61.7	H	266.0	260.0	13.4	1.0	33.7	42.4	43.5	-1.1
329.60	59.3	H	145.0	345.0	14.7	1.8	33.5	42.3	46.0	-3.8
332.80	60.4	H	139.0	307.0	14.6	1.8	33.5	43.3	46.0	-2.7
345.59	58.7	H	134.0	318.0	15.0	1.8	33.5	42.1	46.0	-4.0
348.79	59.0	H	134.0	308.0	15.2	1.8	33.5	42.5	46.0	-3.6
617.59	52.0	H	0.0	295.0	19.2	2.5	33.2	40.4	46.0	-5.6
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

No spurious emissions above 1GHz were within 10dB of the limit.

8 Radiated Emissions at Band Edge / Restricted Band

8.1 *Test Result*

Test Description	Test Specification		Test Result
Spurious Emissions	15.205 / 15.209	RSS-GEN S8.9 / 8.10	Compliant

8.2 *Test Method*

Field strength measurements were performed at the restricted band edges of 2390MHz and 2483.5MHz for each modulation. Measurements were made using the conducted methods defined in Section 12 of FCC publication D01 DTS Meas Guidance v04. Conducted measurements across the entire band were used for showing compliance in all other restricted bands applying the same methods.

Offset Calculations:
Offset calculations so that conducted measurements on the spectrum analyzer in dBµV represent field strength measurements in dBµV/m.

Offset = -20Log(D) + 104.8 - 107 + CL + DC + AG
$Offset_{3m}$ = -11.7 + CL + DC + AG

D = 3m	Distance
CL = 1.1 dB	Cable Loss
DC = 1.9 dB (64.4%)	Duty Cycle Correction Factor
AG = 3.34 dB	Antenna Gain

Offset = -5.4 dB

8.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	21.7 °C
Relative Humidity:	42.0 %
Atmospheric Pressure:	98.8 kPa

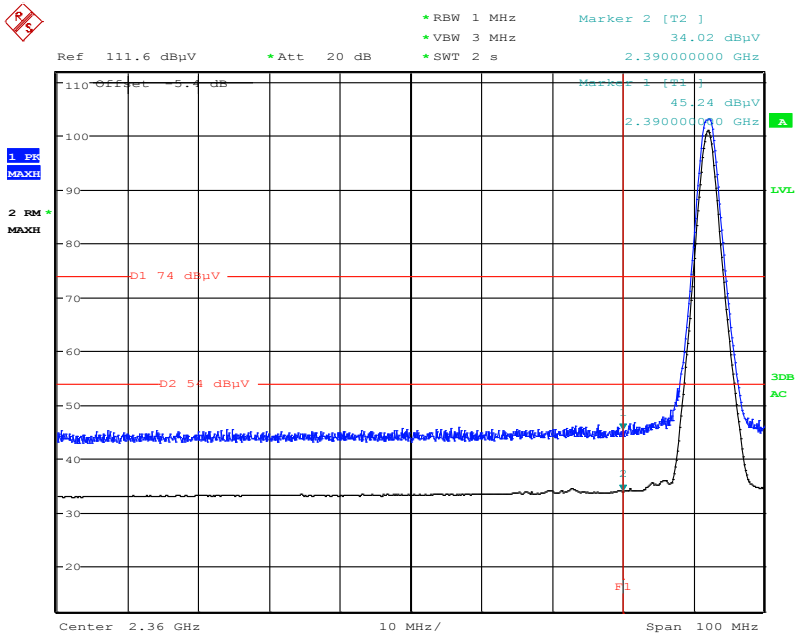
8.4 *Test Equipment*

Test End Date: 19-Oct-2017 Tester: JOP

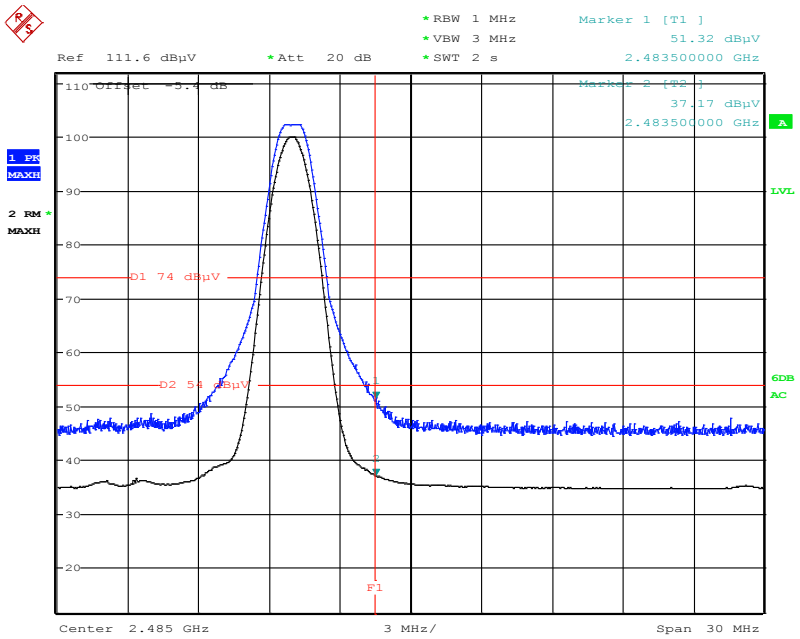
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
RF CABLE	SF102	HUBER & SUHNER	B079823	26-Jul-2018
FILTER, BAND REJECT (2450MHZ)	BRM50709	MICRO-TRONICS	B079790	27-Jul-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018

Note: The equipment calibration period is 1 year.

8.5 *Test Data – Restricted Band Edge*



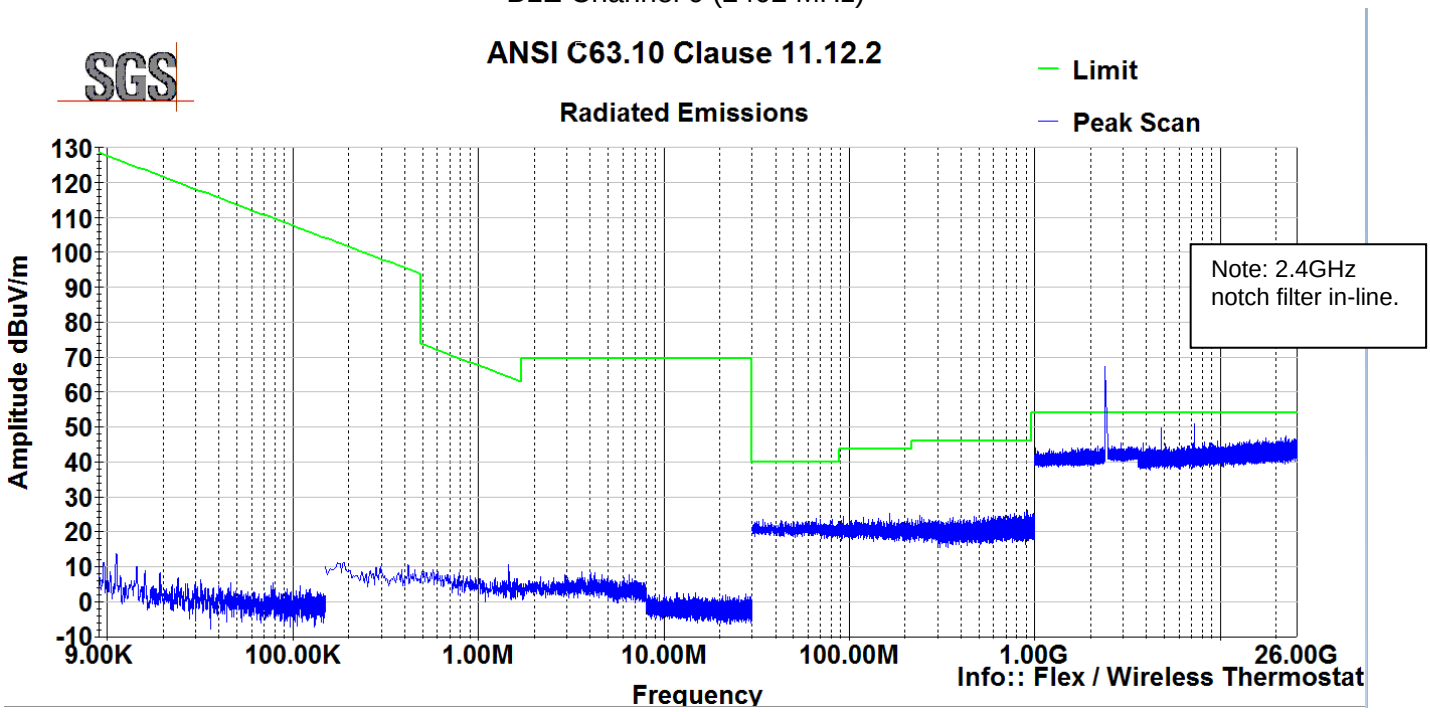
Date: 19.OCT.2017 11:54:15



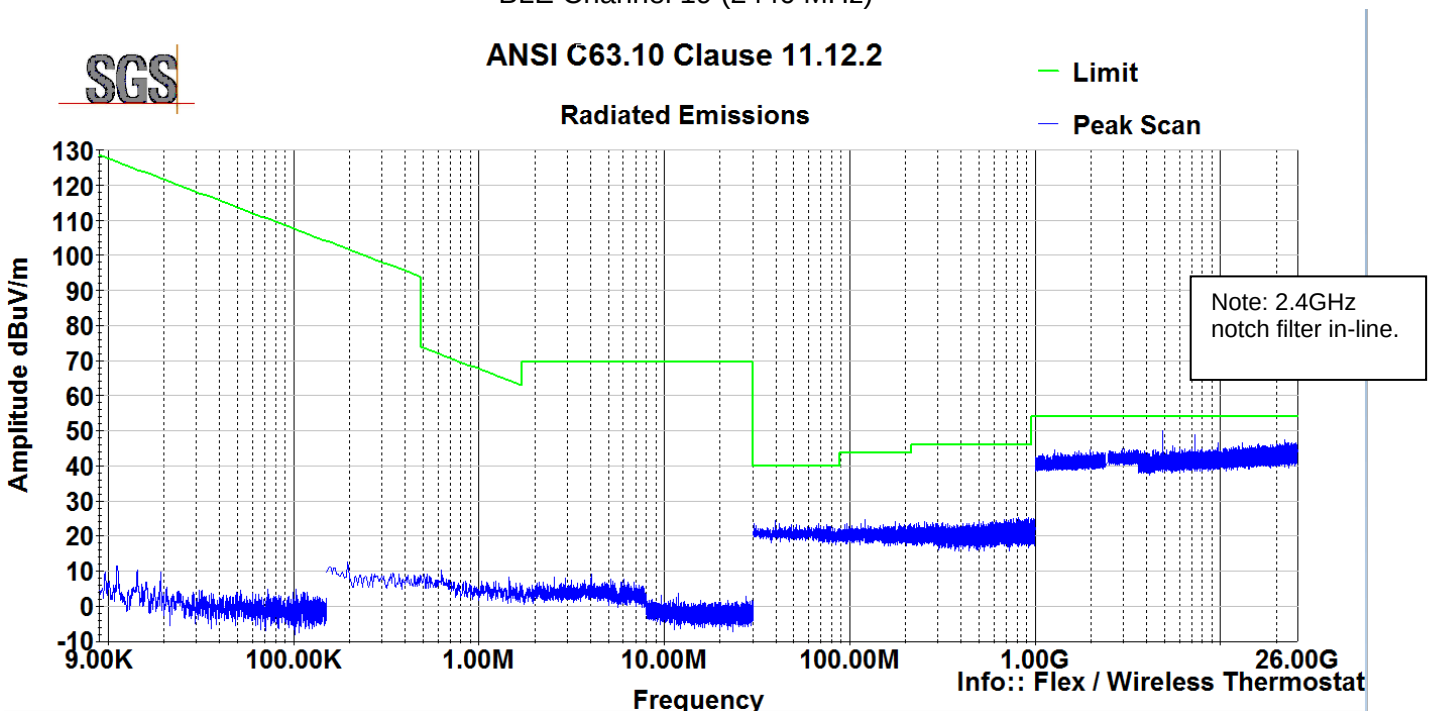
Date: 19.OCT.2017 11:56:33

8.6 *Test Data – Restricted Bands*

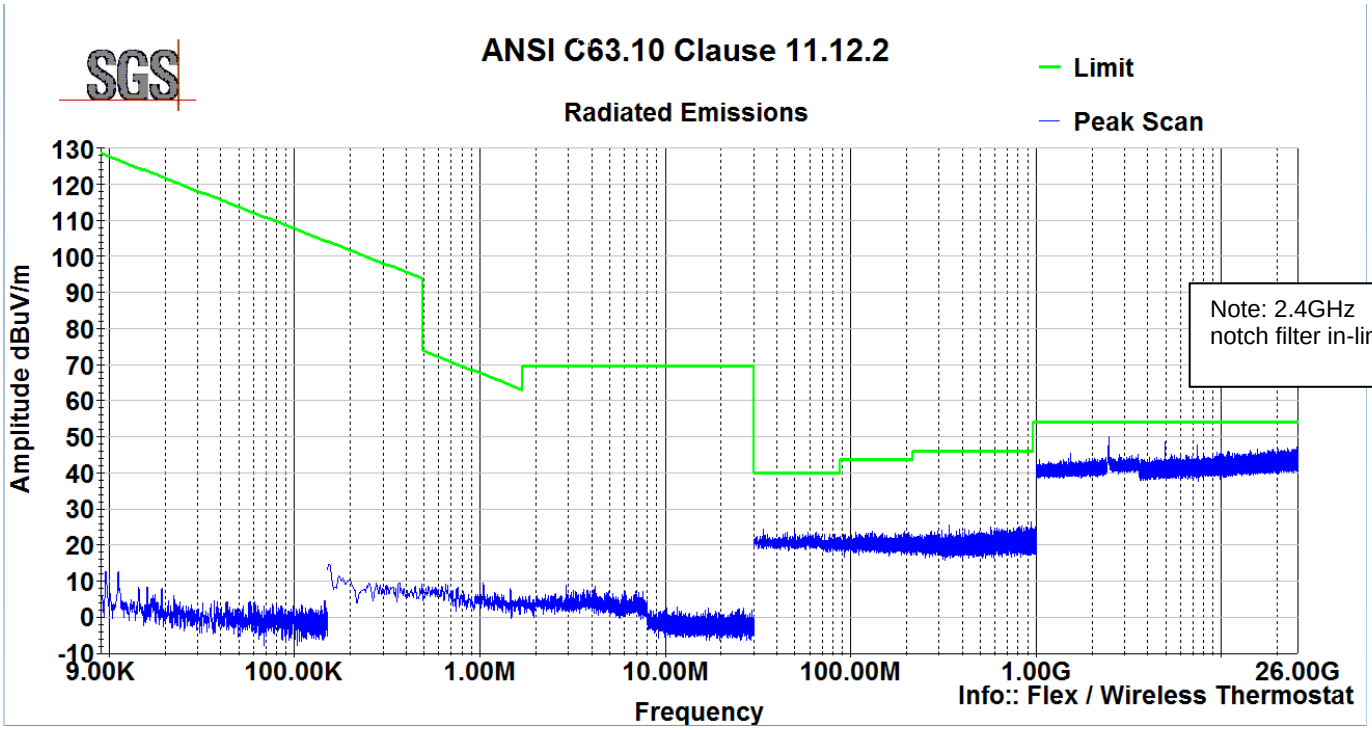
BLE Channel 0 (2402 MHz)



BLE Channel 19 (2440 MHz)



BLE Channel 39 (2480 MHz)



9 Conducted Emissions

9.1 *Test Result*

Test Description	Basic Standards	Test Result
Conducted Emissions, Class B	RSS-GEN, Issue 4 ANSI C63.4:2014	Compliant

9.2 *Test Method*

With the receivers resolution bandwidth was set to 9 kHz the exploratory scans were performed over the measuring frequency range (0.15MHz to 30MHz) using a max hold mode incorporating a Peak detector and Average detector and using the TILE! software. The final test data was measured using a Quasi-Peak detector and Average detector and compared against the limits indicated in the table below.

Frequency Range	Class A Limits (dBuV)	Class B Limits (dBuV) CISPR
0.15 to 0.5 MHz	Avg 66 QP 79	Avg 56 to 46 QP 66 to 56
0.5 to 5 MHz	Avg 60 QP 73	Avg 46 Pk 56
5 to 30 MHz	Avg 60 QP 73	Avg 50 Pk 60

9.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions
Temperature: 23.5°C
Relative Humidity: 42.8%

9.4 *Test Equipment*

Test End Date: 17-Oct-2017 Tester: JOP

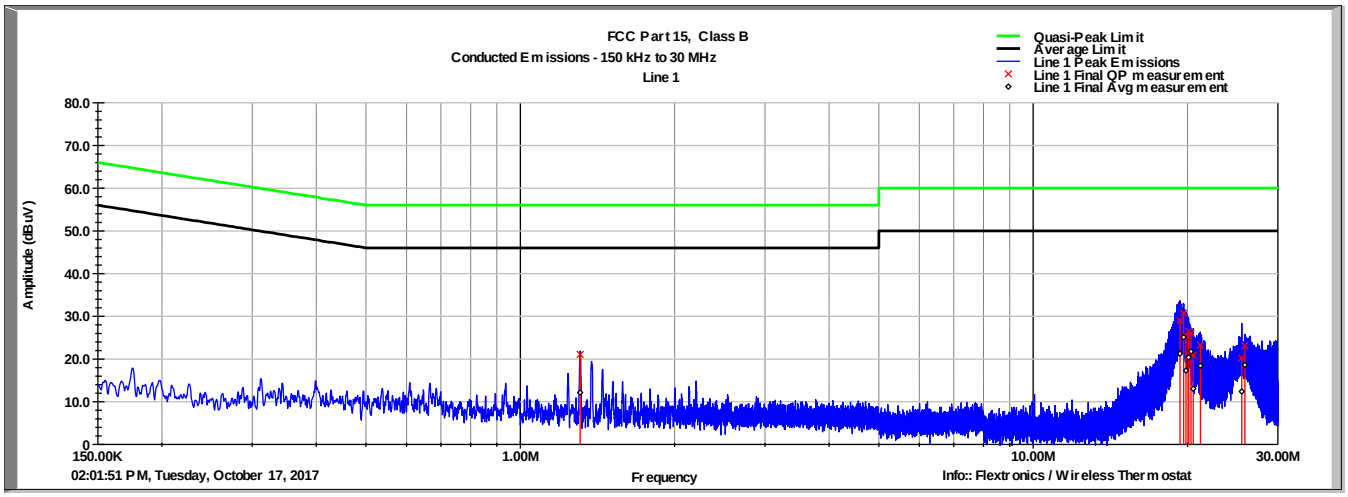
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
LINE IMPEDANCE STABILIZATION NETWORK	NNB 51	TESEQ	B087573	16-Nov-2017
RF CABLE	CBL-25FT-NMNM	MINI-CIRCUITS	B094941	25-Jul-2018

Note: The equipment calibration period is 1 year.

Software:
“Conducted Emissions” TILE! profile dated Dec 2015

9.5 *Test Data*

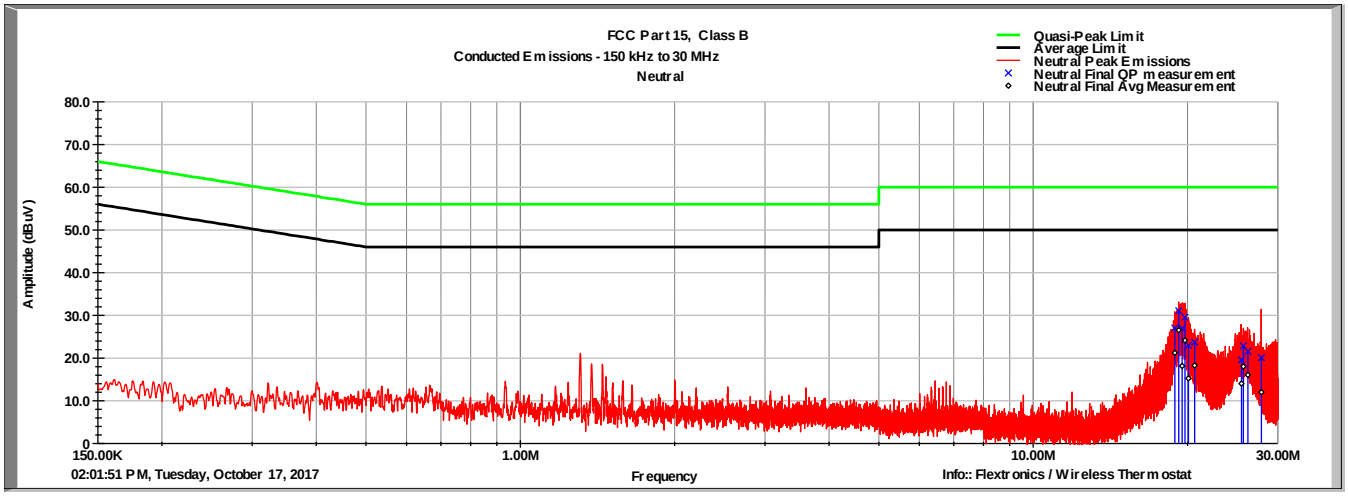
Line 1 Conducted Emissions Plot 150-30MHz



Line 1 Conducted Emissions Data 150-30MHz

Frequency MHz	QP Value dBuV	QP Limit dBuV	QP Margin dB	Avg Value dBuV	Avg Limit dBuV	Avg Margin dB
1.308	21.1	56.0	-34.9	12.1	46.0	-33.9
19.335	29.0	60.0	-31.0	21.3	50.0	-28.7
19.655	30.7	60.0	-29.3	25.1	50.0	-24.9
19.860	25.4	60.0	-34.6	17.3	50.0	-32.7
20.098	26.4	60.0	-33.6	20.4	50.0	-29.6
20.313	26.1	60.0	-33.9	21.8	50.0	-28.2
20.520	20.9	60.0	-39.1	13.0	50.0	-37.0
21.189	23.2	60.0	-36.8	18.4	50.0	-31.6
25.520	20.2	60.0	-39.8	12.4	50.0	-37.6
25.878	23.1	60.0	-36.9	18.6	50.0	-31.4

Neutral Conducted Emissions Plot 150-30MHz



Neutral Conducted Emissions Data 150-30MHz

Frequency MHz	QP Value dBuV	QP Limit dBuV	QP Margin dB	Avg Value dBuV	Avg Limit dBuV	Avg Margin dB
18.893	27.0	60.0	-33.0	21.2	50.0	-28.8
19.225	31.0	60.0	-29.0	26.5	50.0	-23.5
19.528	27.0	60.0	-33.0	18.1	50.0	-31.9
19.771	29.6	60.0	-30.4	24.1	50.0	-25.9
20.084	23.0	60.0	-37.0	15.2	50.0	-34.8
20.646	23.7	60.0	-36.3	18.3	50.0	-31.7
25.482	19.6	60.0	-40.4	14.0	50.0	-36.0
25.695	22.8	60.0	-37.2	18.0	50.0	-32.0
26.224	21.6	60.0	-38.4	16.0	50.0	-34.0
27.865	20.1	60.0	-39.9	12.0	50.0	-38.0

10 Revision History

Revision Level	Description of changes	Revision Date
0	Initial release	31 October 2017