

EMC Test Report

Project Number: 4191450

Report Number: 4191450EMC02 **Revision Level:** 0

Client: Michelin Americas Research Co.

Equipment Under Test: Industrial TPMS Receiver

Model Name: Antenne Active

Model Number: AA-V2.0

FCC ID: FI5-EX1-01

IC ID: 5056A-EX101

Applicable Standards: FCC Part 15 Subpart C, § 15.247
RSS-247, Issue 2, February 2017
RSS-GEN, Issue 4, November 2014
ANSI C63.10: 2013

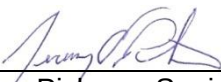
Report issued on: 27 September 2017

Test Result: Compliant

Tested by:


Martin Taylor, Project Engineer

Reviewed by:


Jeremy Pickens, Senior EMC Engineer

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.

This document is issued by the Company under its General Conditions of Service accessible at <http://www.sgs.com/en/Terms-and-Conditions.aspx>. Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.

Table of Contents

1	SUMMARY OF TEST RESULTS	4
1.1	MODIFICATIONS REQUIRED FOR COMPLIANCE	4
2	GENERAL INFORMATION	5
2.1	CLIENT INFORMATION	5
2.2	TEST LABORATORY	5
2.3	GENERAL INFORMATION OF EUT	5
2.4	OPERATING MODES AND CONDITIONS	5
2.5	EUT CONNECTION BLOCK DIAGRAM – CONDUCTED MEASUREMENTS	6
2.6	EUT CONNECTION BLOCK DIAGRAM – RADIATED MEASUREMENTS	6
2.7	SYSTEM CONFIGURATIONS	7
2.8	CABLE LIST	7
3	BANDWIDTH	8
3.1	TEST RESULT	8
3.2	TEST METHOD	8
3.3	TEST SITE	8
3.4	TEST EQUIPMENT	8
3.5	TEST DATA	8
4	OUTPUT POWER	10
4.1	TEST RESULT	10
4.2	TEST METHOD	10
4.3	TEST SITE	10
4.4	TEST EQUIPMENT	10
4.5	TEST DATA	11
5	POWER SPECTRAL DENSITY	12
5.1	TEST RESULT	12
5.2	TEST METHOD	12
5.3	TEST SITE	12
5.4	TEST EQUIPMENT	12
5.5	TEST DATA	13
6	CONDUCTED SPURIOUS EMISSIONS / BAND EDGE	14
6.1	TEST RESULT	14
6.2	TEST METHOD	14
6.3	TEST SITE	14
6.4	TEST EQUIPMENT	14
6.5	TEST DATA – DTS BAND EDGE	15
6.6	TEST DATA – CONDUCTED SPURIOUS EMISSIONS	16
7	FIELD STRENGTH OF SPURIOUS RADIATION	17
7.1	TEST RESULT	17
7.2	TEST METHOD	17
7.3	TEST SITE	17
7.4	TEST EQUIPMENT	18
7.5	TEST DATA – PEAK PLOTS	19
7.6	TEST DATA – TABULAR DATA	26
8	RADIATED EMISSIONS AT BAND EDGE / RESTRICTED BAND	27
8.1	TEST RESULT	27
8.2	TEST METHOD	27



8.3 TEST SITE 27

8.4 TEST EQUIPMENT 27

8.5 TEST DATA – RESTRICTED BAND EDGE 28

9 REVISION HISTORY 29

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, Class A	15.107, 15.207	RSS-GEN S8.8	N/A (2)

(1) The device uses an internal chip antenna. It is not replaceable by the end user.

(2) Not Applicable. The EUT does not connect to the AC mains.

1.1 Modifications Required for Compliance

None

2 General Information

2.1 Client Information

Name: Michelin Americas Research Co.
Address: 515 Michelin Rd
City, State, Zip, Country: Greenville, SC 29605, 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: Industrial TPMS Receiver
Model Name: Antenne Active
Model Number: AA-V2.0
Serial Number: Not labeled

Frequency Range: 2402-2480MHz
Data Modes: Bluetooth Low Energy
Antenna: Surface Mount Antenna (-2.8dB)

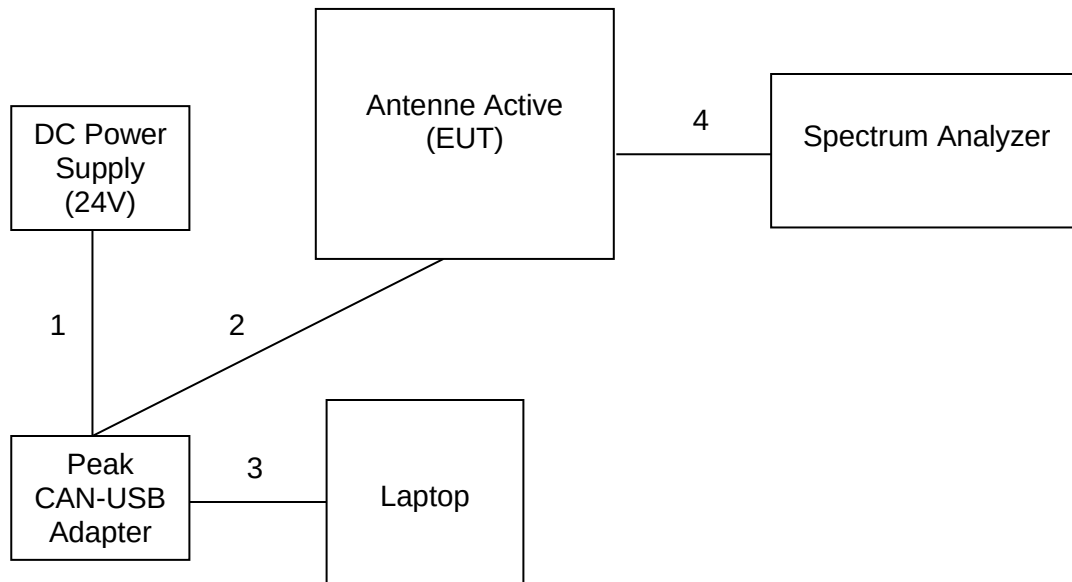
Rated Voltage: 24Vdc
Test Voltage: 24Vdc

Sample Received Date: 10 August 2017
Dates of testing: 12-16 September 2017

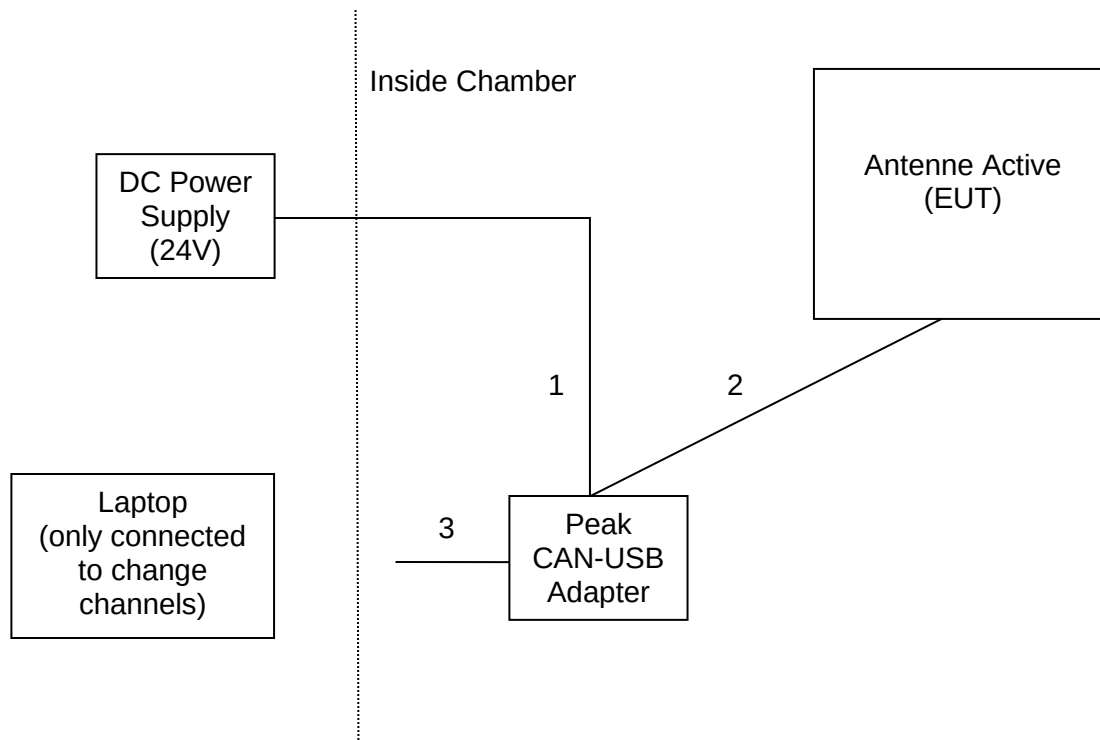
2.4 Operating Modes and Conditions

Continuous traffic was generated using test commands. Where the duty cycle measured below 99% and an RMS detector was employed, corrections of $10 \cdot \log(1/D)$ 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

Manufacturer	Description	Model Number	Serial Number
Michelin	Antenne Active (EUT)	AA-V2.0	Not labeled
Peak System	PCAN-USB Adapter	IPEH-002021-214994	Not labeled

2.8 Cable List

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
1	DC Power	PCAN-USB DB9 Port	Lab DC Power Supply	0.65	No	No
2	CAN	PCAN-USB DB9 Port	Antenne Active (EUT)	10.18	No	No
3	USB	PCAN-USB	Laptop Computer	0.70	No	Yes
4	RF (coax)	EUT BLE Antenna Trace	Spectrum Analyzer	0.20	No	Yes

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: 23.7 °C
 Relative Humidity: 49.4 %
 Atmospheric Pressure: 98.2 kPa

3.4 Test Equipment

Test End Date: 16-Sep-2017

Tester: MT

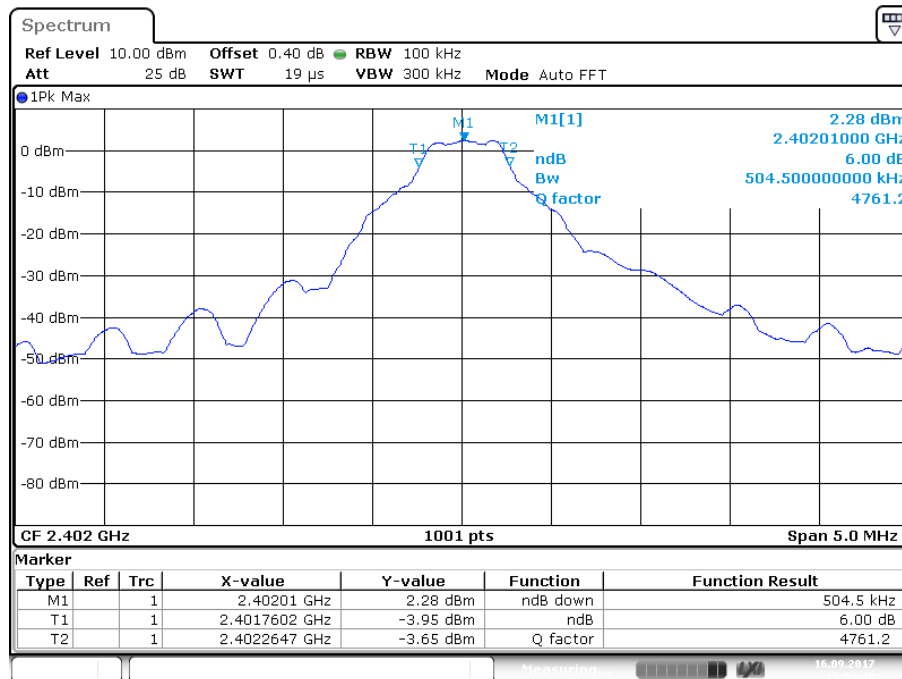
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	B085749	8-Oct-2017

Note: The equipment calibration period is 1 year except for the FSV which is on a 2 year cycle.

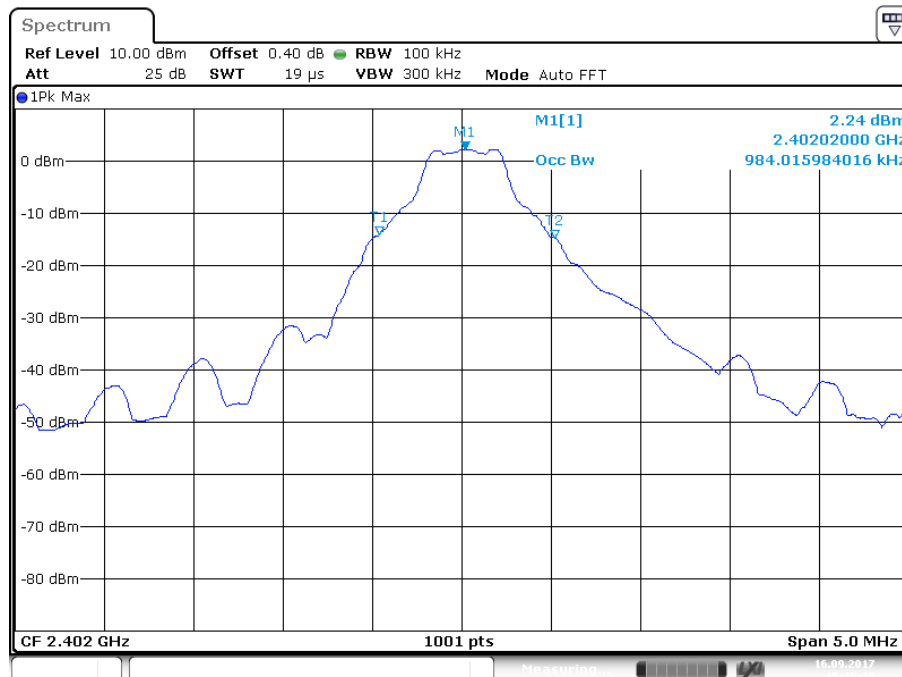
3.5 Test Data

Protocol	Channel	6dB Bandwidth (MHz)	Occupied Bandwidth (99%) (MHz)
BLE	0	0.505	0.984
BLE	19	0.520	0.974
BLE	39	0.500	1.014

Sample Plots:



Date: 16.SEP.2017 15:03:49



Date: 16.SEP.2017 15:15:21

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 Meas 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: 22.8 °C
 Relative Humidity: 51.2 %
 Atmospheric Pressure: 98.2 kPa

4.4 Test Equipment

Test End Date: 16-Sep-2017

Tester: MT

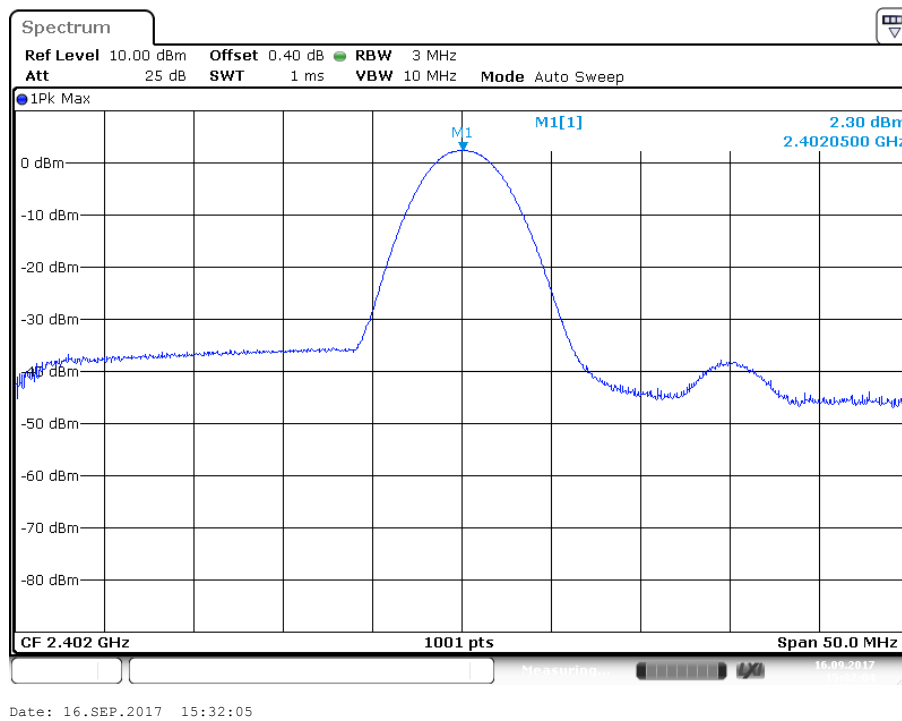
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	B085749	8-Oct-2017

Note: The equipment calibration period is 1 year except for the FSV which is on a 2 year cycle.

4.5 Test Data

Protocol	Channel	Peak Power (dBm)	Limit (dBm)	Margin (dB)
BLE	0	2.30	30	-27.70
BLE	19	2.37	30	-27.63
BLE	39	1.80	30	-28.2

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 Meas Guidance v04.

Limit

The limit is 8 dBm / 3 kHz.

5.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.4 °C
 Relative Humidity: 49.9 %
 Atmospheric Pressure: 98.1 kPa

5.4 Test Equipment

Test End Date: 16-Sep-2017

Tester: MT

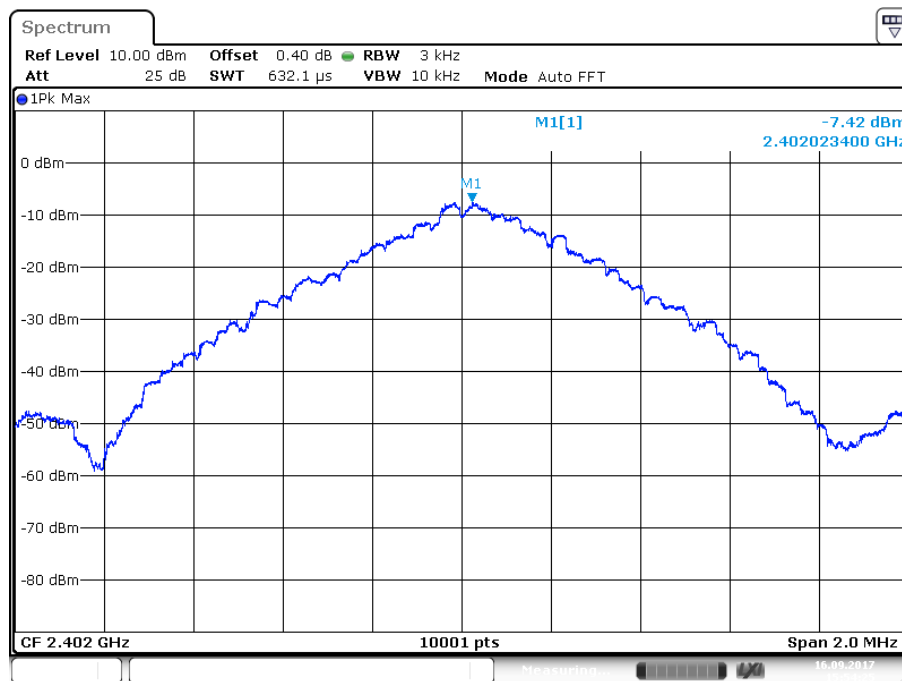
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	B085749	8-Oct-2017

Note: The equipment calibration period is 1 year except for the FSV which is on a 2 year cycle.

5.5 Test Data

Protocol	Channel	Peak PSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
BLE	0	-7.42	8	-15.42
BLE	19	-6.92	8	-14.92
BLE	39	-8.77	8	-16.77

Sample Plot:



Date: 16.SEP.2017 15:54:26

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 Meas 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: 23.7 °C
 Relative Humidity: 49.1 %
 Atmospheric Pressure: 98.0 kPa

6.4 Test Equipment

Test End Date: 16-Sep-2017

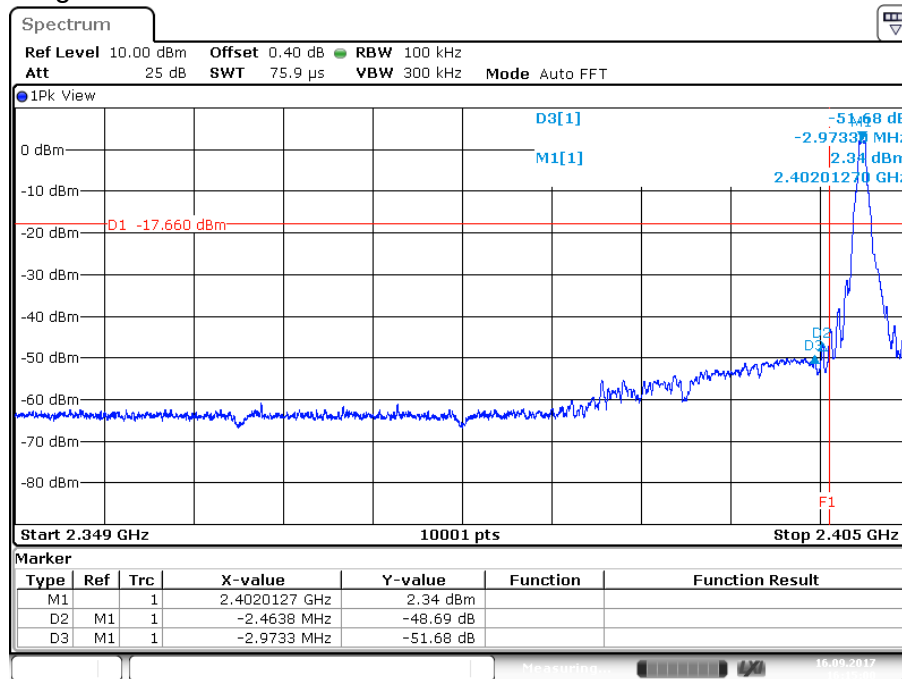
Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	B085749	8-Oct-2017

Note: The equipment calibration period is 1 year except for the FSV which is on a 2 year cycle.

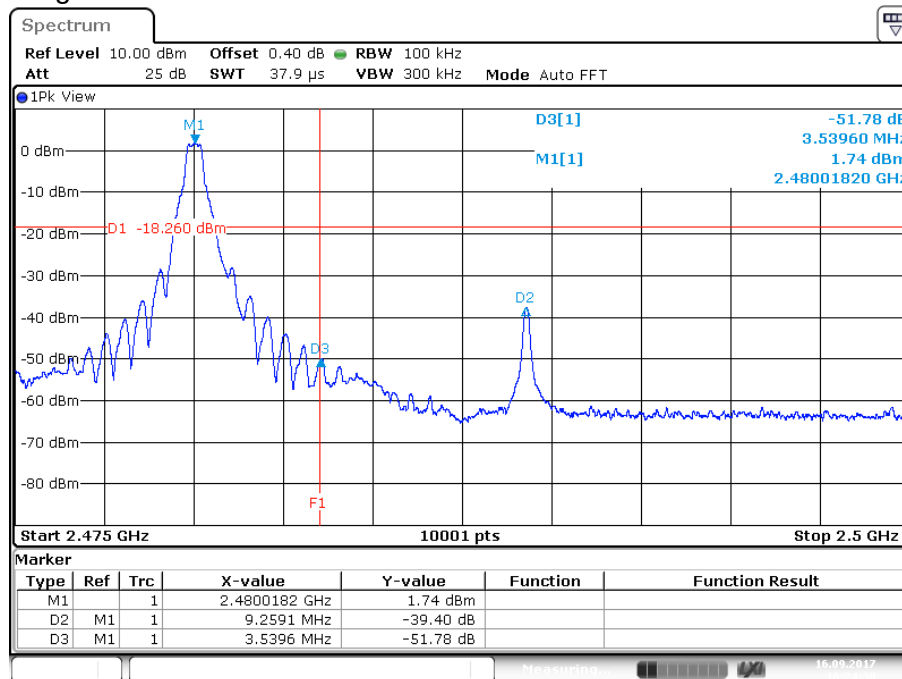
6.5 Test Data – DTS Band Edge

BLE - Lower band edge:



Date: 16.SEP.2017 16:15:01

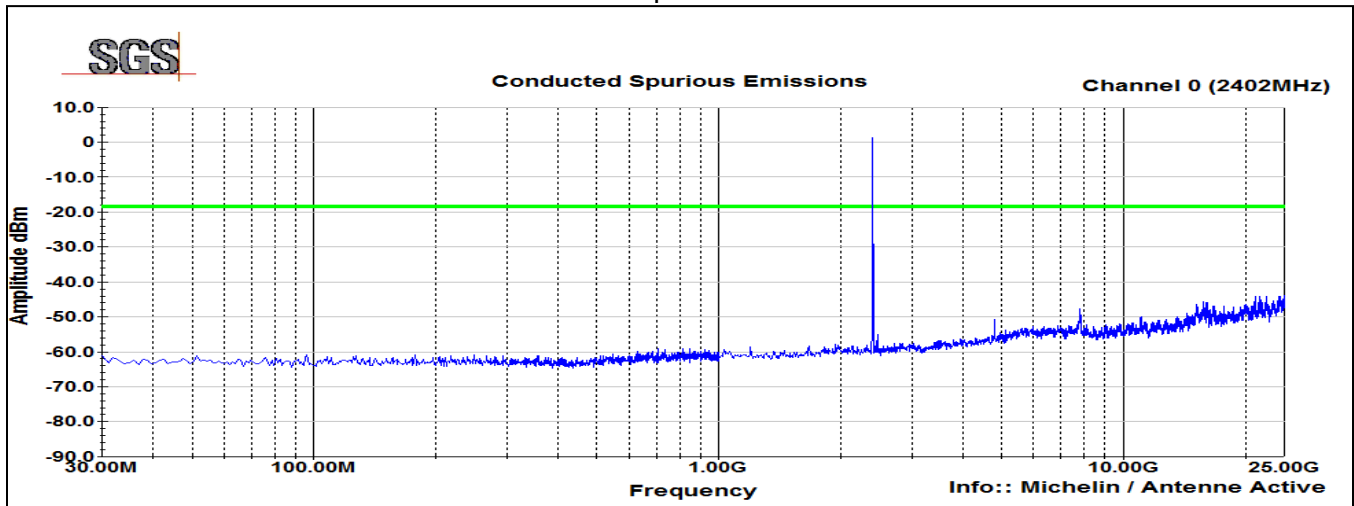
BLE - Upper band edge:



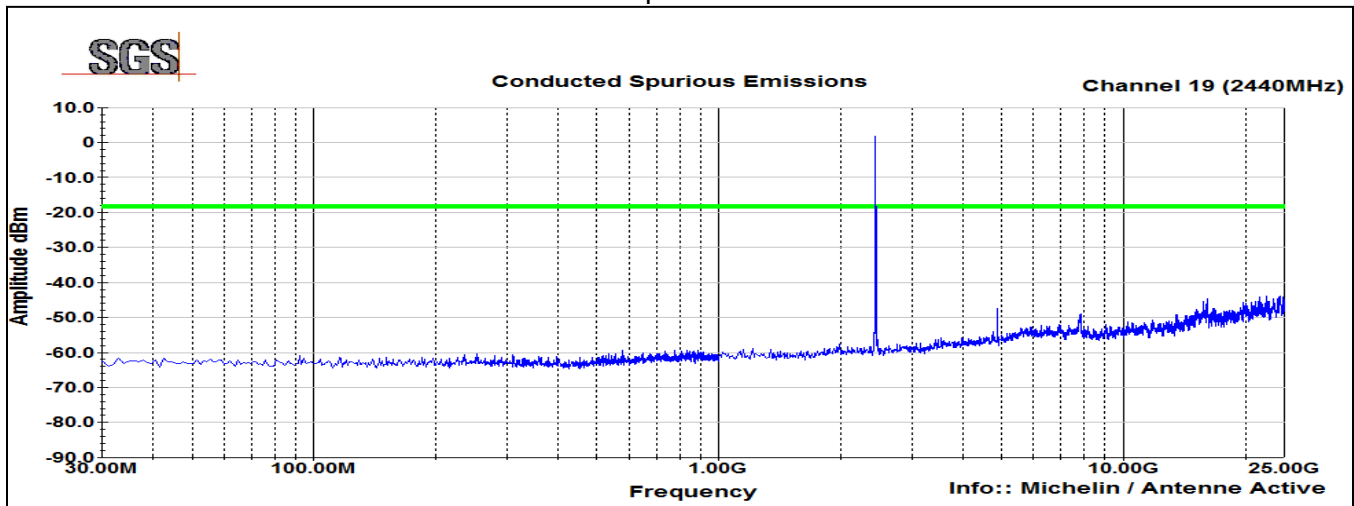
Date: 16.SEP.2017 16:24:31

6.6 Test Data – Conducted Spurious Emissions

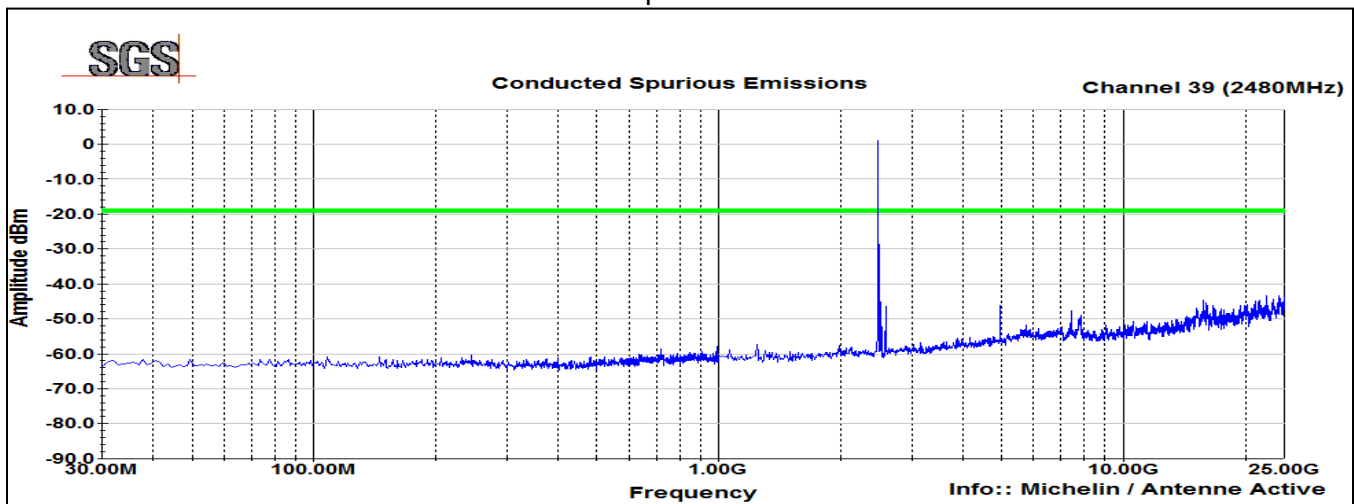
Conducted Spurs – Channel 0



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 and KDB 558074 D01 Meas Guidance v04 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: 22.0 – 23.8 °C
- Relative Humidity: 45.6 – 59.9 %
- Atmospheric Pressure: 97.5 – 97.8 kPa

7.4 Test Equipment

30MHz to 1GHz

Test End Date: 13-Sep-2017

Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
ANTENNA, BILOG	CBL 6143A	TESEQ	B085931	6-Dec-2017
RF CABLE	SF106	HUBER & SUHNER	B079712	24-Jul-2018
RF CABLE	UC-N-MM-275	MAURY MICROWAVE	17015	25-Jul-2018
RF CABLE	SUCOFLEX 100	HUBER & SUHNER	B108523	24-Jul-2018
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	B094463	22-Feb-2018
EMI TEST RECEIVER	ESU8	ROHDE & SCHWARZ	B085759	25-Jul-2018

Note: The equipment calibration period is 1 year.

1 to 18GHz

Test End Date: 14-Sep-2017

Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	3117	ETS LINDGREN	B079699	16-May-2018
RF CABLE	SF106	HUBER & SUHNER	B079716	24-Jul-2018
RF CABLE	104PE	HUBER & SUHNER	B079793	24-Jul-2018
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	15003	28-Jul-2018
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018

Note: The equipment calibration period is 1 year.

18 to 26GHz

Test End Date: 14-Sep-2017

Tester: MT

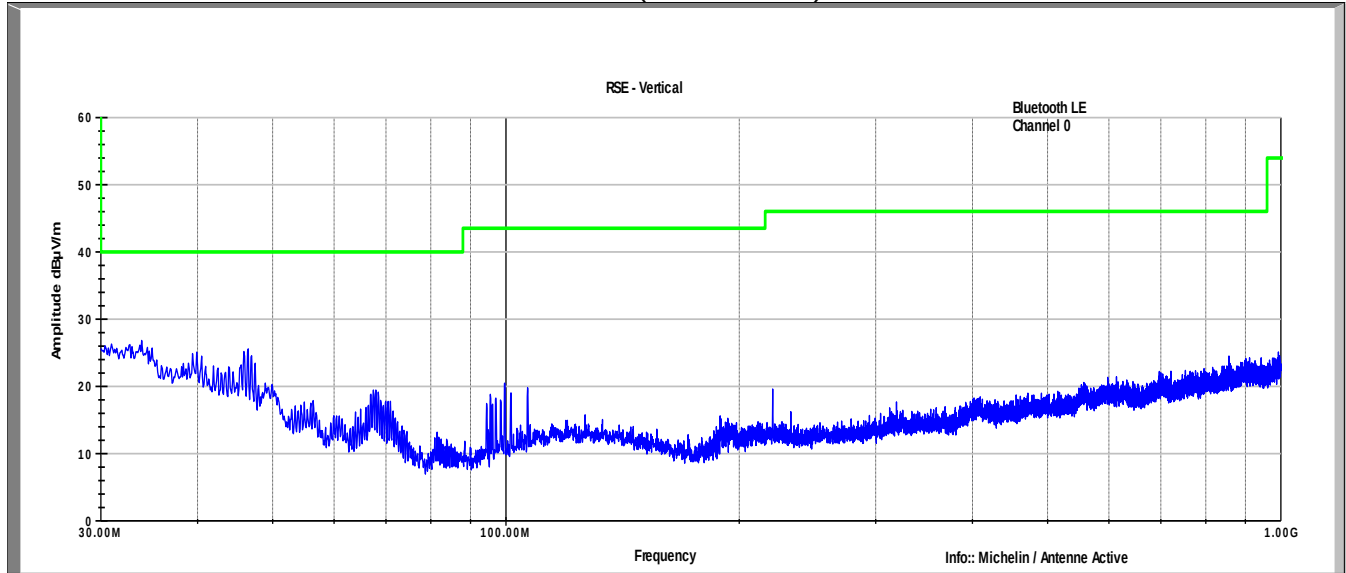
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
HORN(SMALL)	LB-180400-20-C-KF	A-INFO	15007	21-Mar-2018
RF CABLE	SF102	HUBER & SUHNER	B079822	27-Jul-2018
RF CABLE	SF102	HUBER & SUHNER	B079824	26-Jul-2018
LOW NOISE AMPLIFIER	NSP1840-HG	MITEQ	B087572	28-Jul-2018
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018

Note: The equipment calibration period is 1 year.

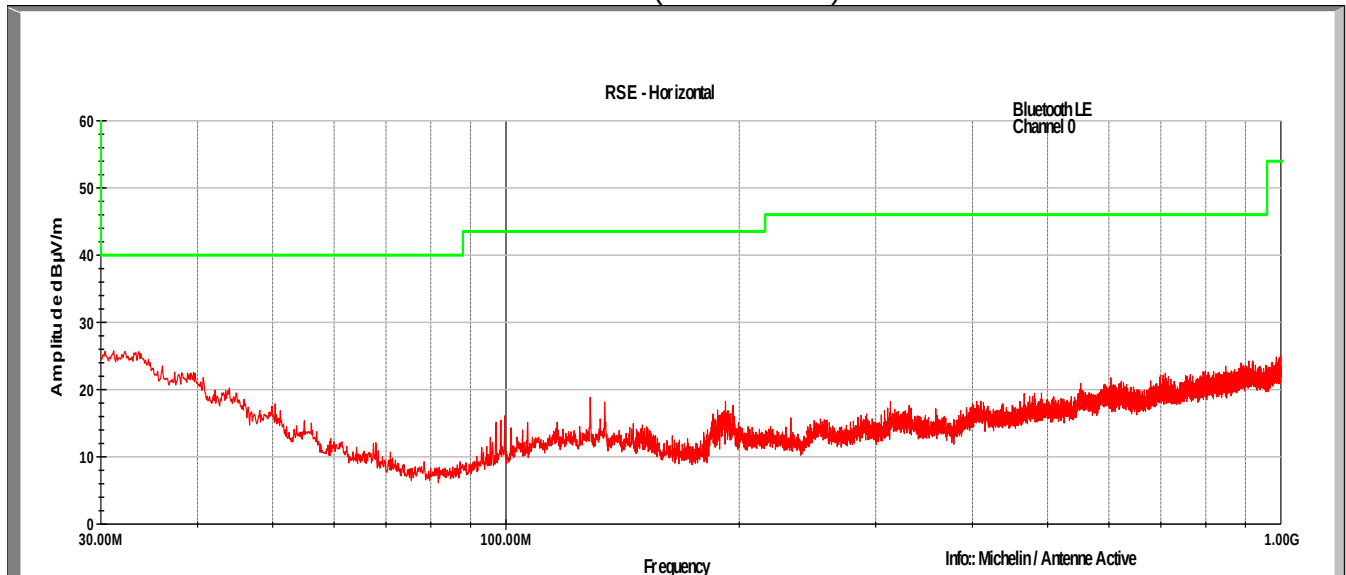
7.5 Test Data – Peak Plots

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

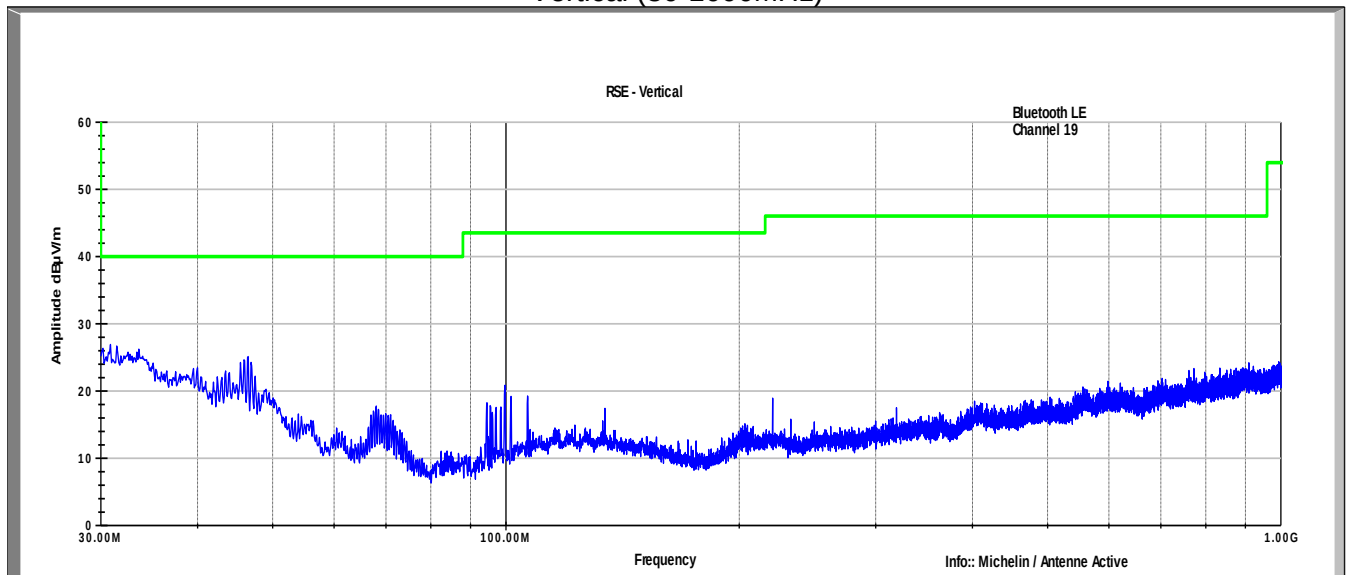
BLE Channel 0
 Vertical (30-1000MHz)



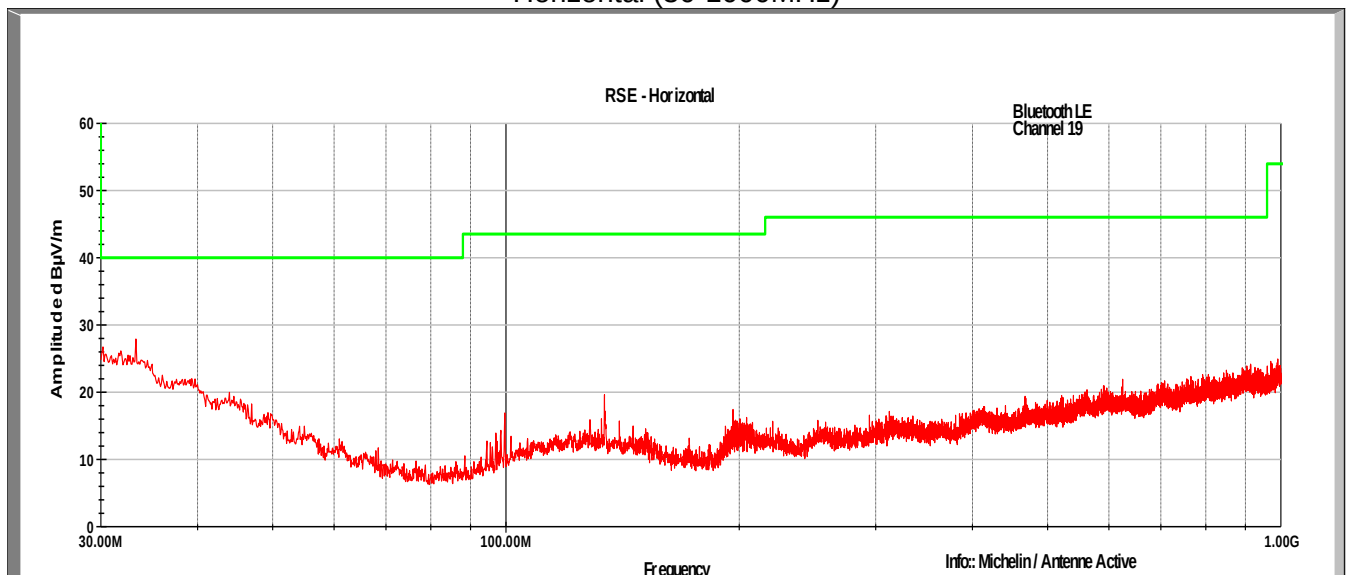
BLE Channel 0
 Horizontal (30-1000MHz)



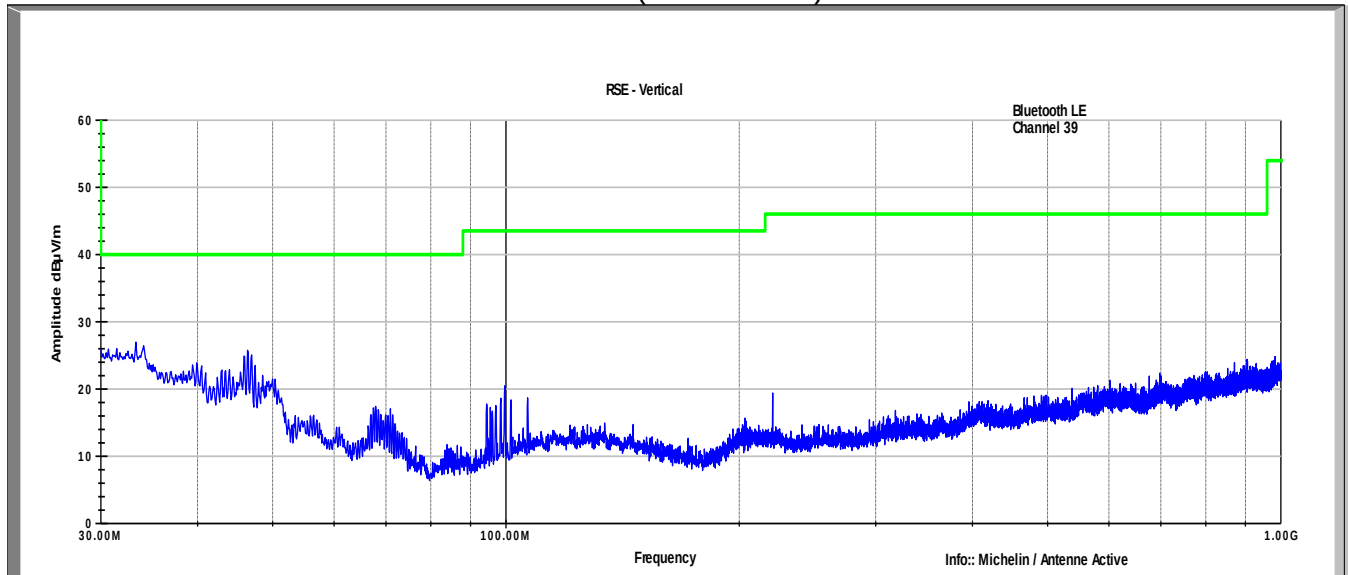
BLE Channel 19 Vertical (30-1000MHz)



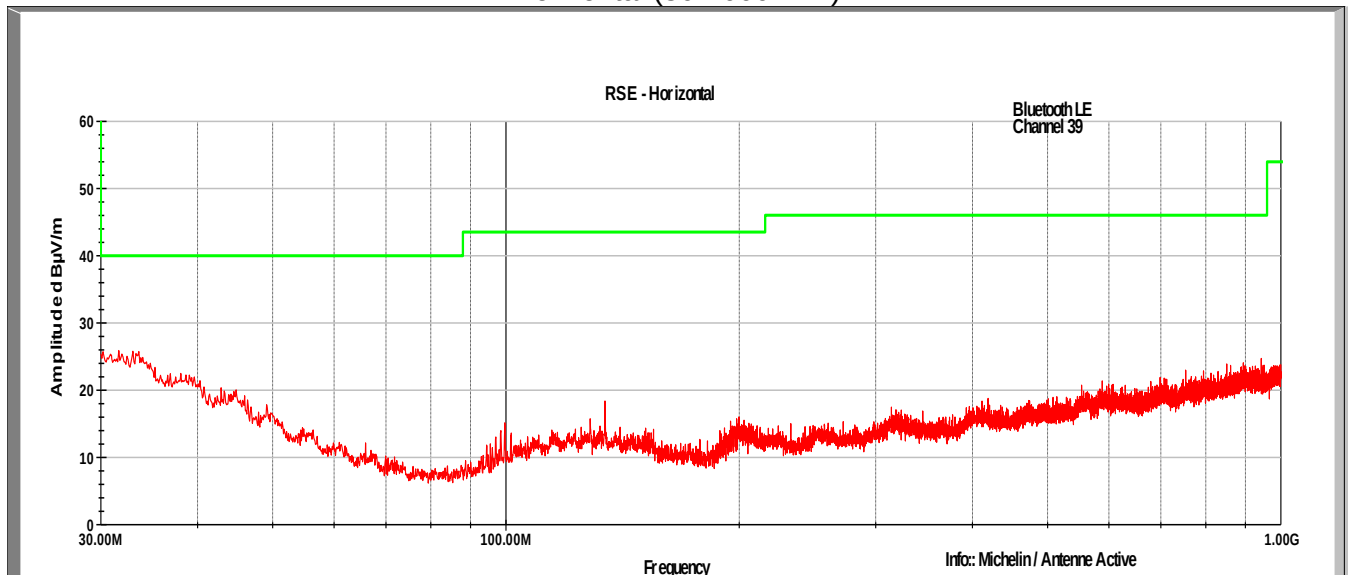
BLE Channel 19 Horizontal (30-1000MHz)



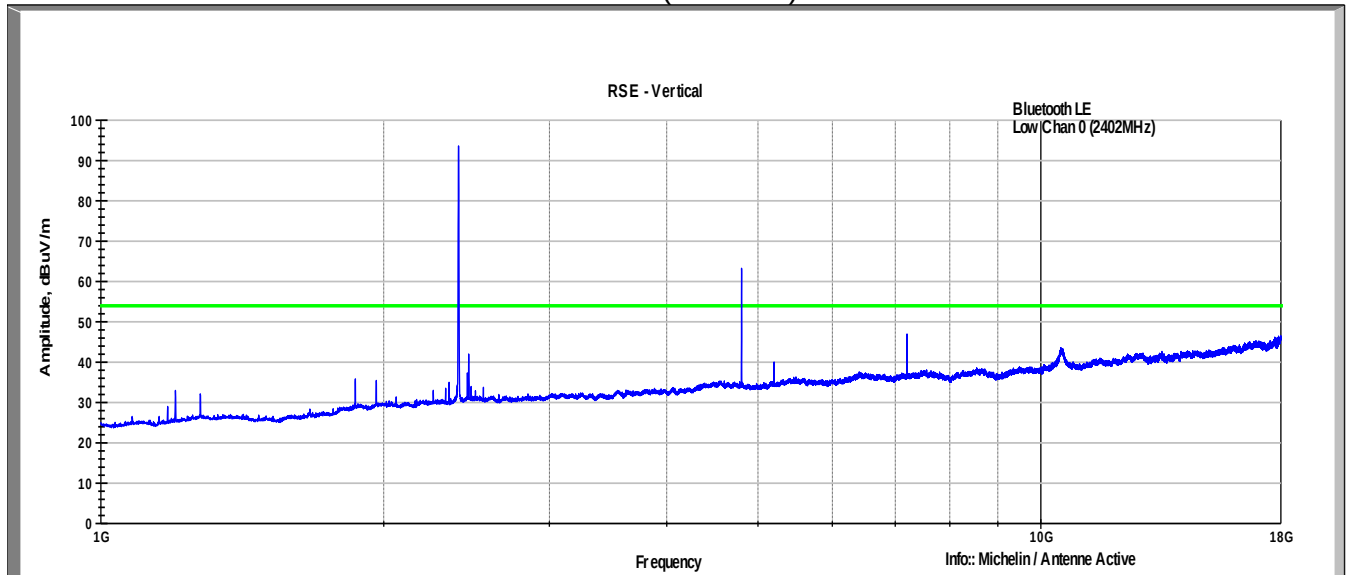
BLE Channel 39
 Vertical (30-1000MHz)



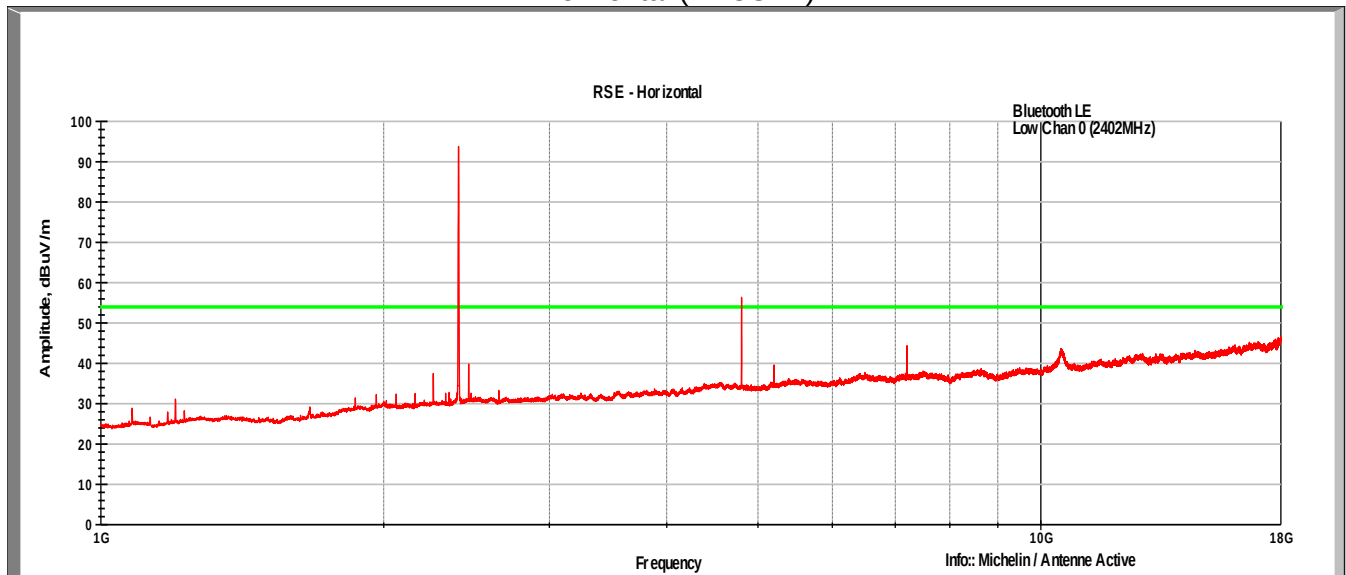
BLE Channel 39
 Horizontal (30-1000MHz)



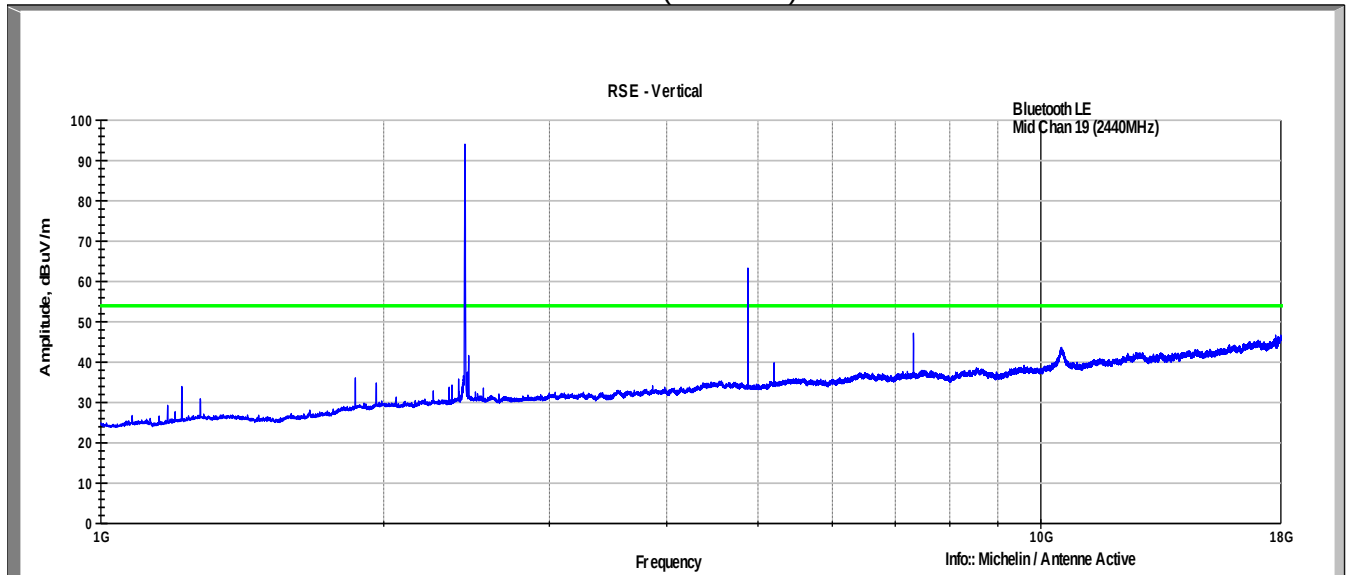
BLE Channel 0 Vertical (1-18GHz)



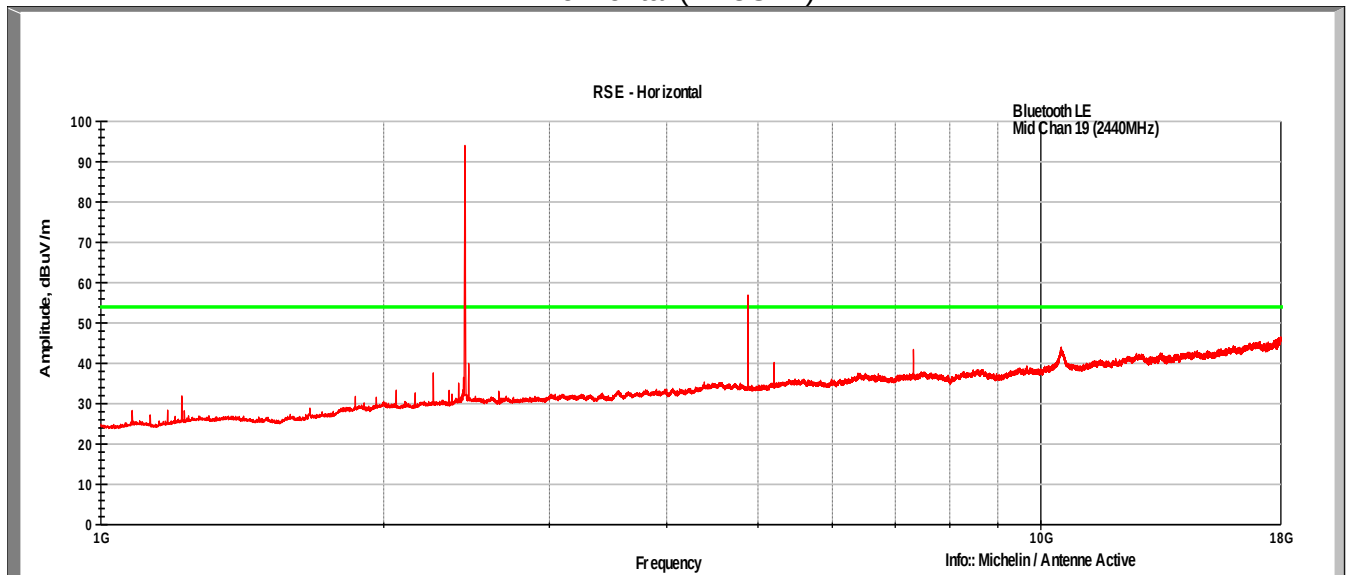
BLE Channel 0 Horizontal (1-18GHz)



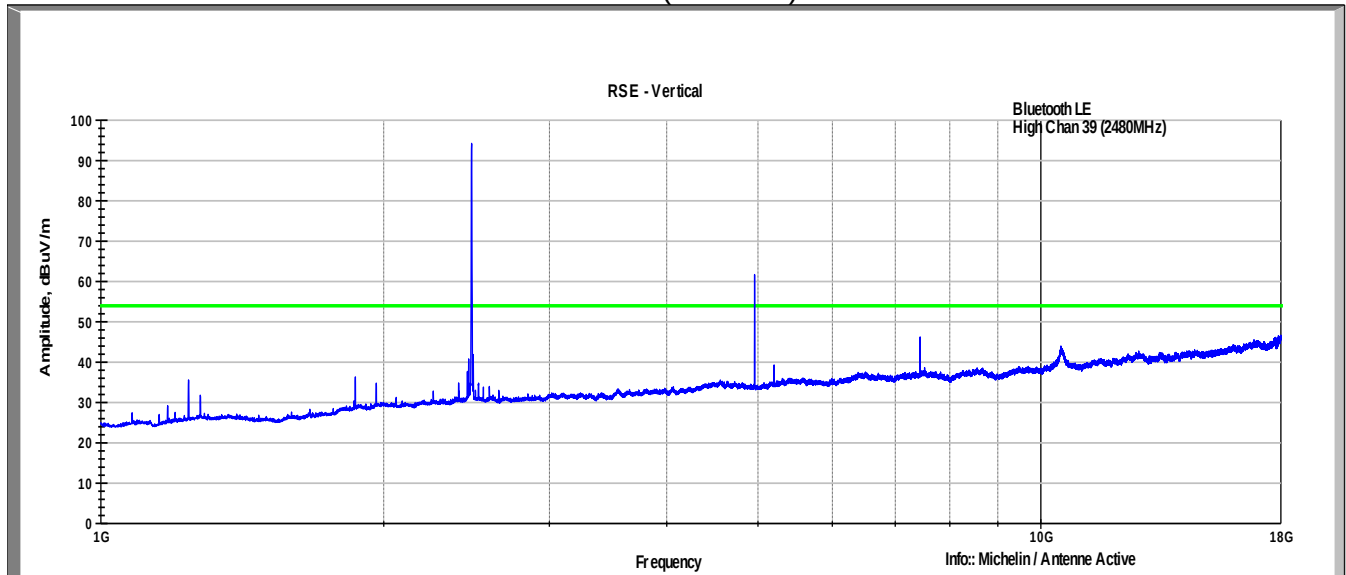
BLE Channel 19 Vertical (1-18GHz)



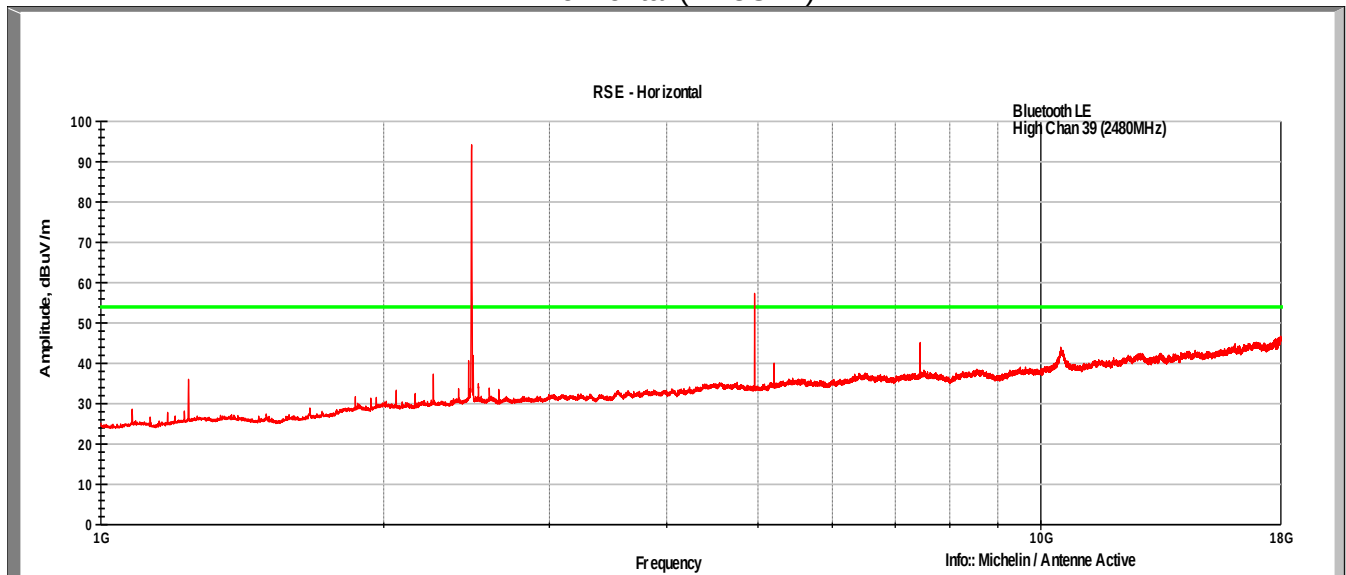
BLE Channel 19 Horizontal (1-18GHz)



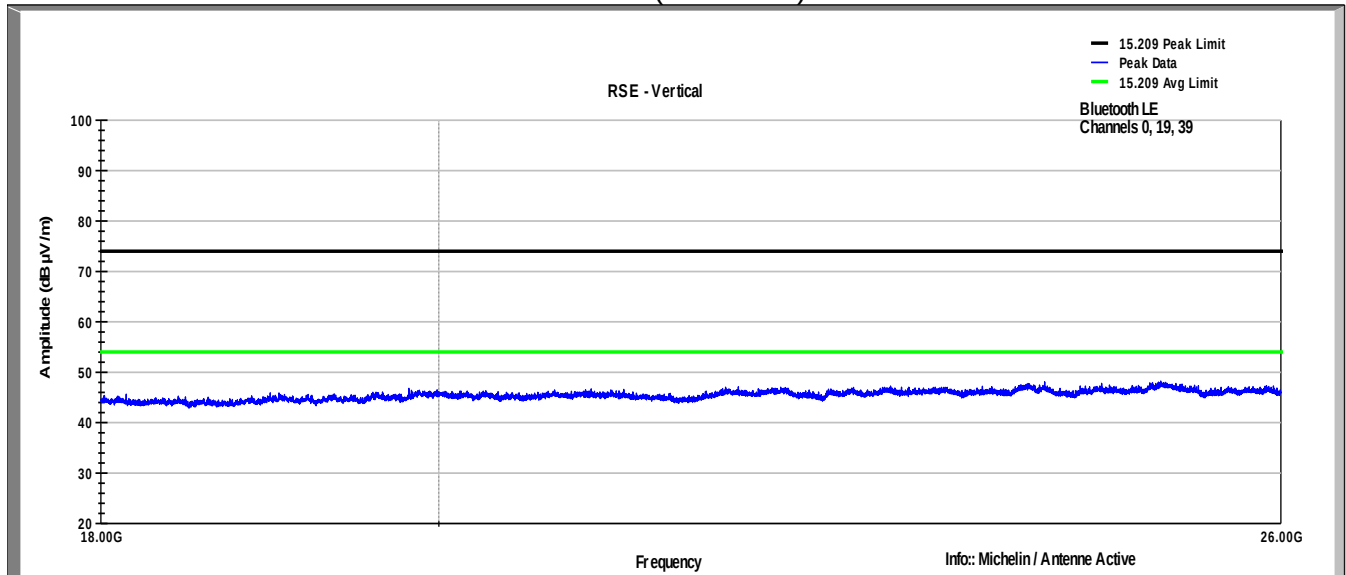
BLE Channel 39 Vertical (1-18GHz)



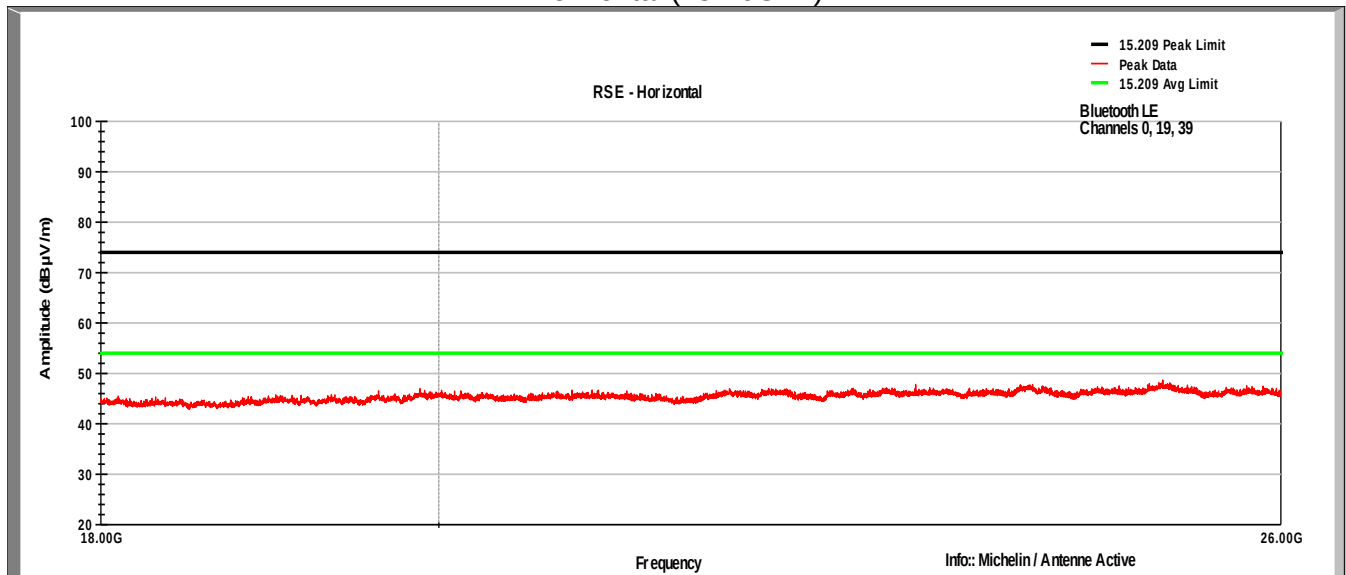
BLE Channel 39 Horizontal (1-18GHz)



BLE Channels 0, 19, 39
 Vertical (18-26GHz)



BLE Channels 0, 19, 39
 Horizontal (18-26GHz)



7.6 Test Data – Tabular Data

Frequency MHz	Raw Meas (dBuV/m)	Polarity (V/H)	Correction (dB)	Corr Value dBuV/m	Limit (dBuV/m)	Margin (dB)
Channel 0 (2402MHz)						
4804.0	63.3	V	-28.45	34.85	54.0	-19.15
4804.0	56.3	H	-28.45	27.85	54.0	-26.15
Channel 19 (2440MHz)						
4880.0	63.3	V	-28.45	34.85	54.0	-19.15
4880.0	56.8	H	-28.45	28.35	54.0	-25.65
Channel 39 (2480MHz)						
4960.0	61.7	V	-28.45	33.25	54.0	-20.75
4960.0	57.3	H	-28.45	28.85	54.0	-25.15

Note: Correction is for duty cycle which was determined in accordance with KDB 558074 D01 Meas Guidance v04 Clause 12.2.5.2. Tests were performed using a maximum achievable duty cycle of 96.6% for which a correction factor of 0.15dB was added to get to the levels that would have been measured had the tests been performed using 100% duty cycle. Then a duty cycle reduction of -28.6dB was included since a duty cycle of less than 0.138% was measured with the EUT in normal Bluetooth LE operation. As stated in KDB 558074 D01 Meas Guidance v04 Clause 12.2.5.2 i) 4), duty cycle reduction as defined in 15.35(c) may be applied to a DTS device if the following 4 conditions are met:

- 1) The unwanted emission is temporally related to the fundamental emission
- 2) The unwanted emission falls into a restricted frequency band
- 3) The maximum duty cycle used in determining the reduction factor is “hardwired” such that under no condition can it be changed or modified by either the device or the end user; and
- 4) A documented justification for use of Section 15.35(c), including the measurements used to determine the worst-case duty cycle, must be included in the test report.

These conditions are all met. Duty cycle calculations are located in Appendix A.

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 KDB 558074 D01 DTS Meas Guidance v04.

Offset Calculations:

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

$$\text{Offset} = -20\log(D) + 104.8 - 107 + \text{CL} + \text{DC} + \text{AG}$$

$$\text{Offset}_{3m} = -11.7 + \text{CL} + \text{DC} + \text{AG}$$

D = 3m	Distance
CL = 0.4 dB	Cable Loss
DC = 0.15 dB (96.6%)	Duty Cycle Correction Factor
AG = 2 dB*	Antenna Gain

$$\text{Offset} = -9.2 \text{ dB}$$

- The actual antenna gain was calculated to be -2.8dBi. 2 dB correction is the minimum allowed by the test method.

8.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.3 °C
Relative Humidity:	49.8 %
Atmospheric Pressure:	98.0 kPa

8.4 Test Equipment

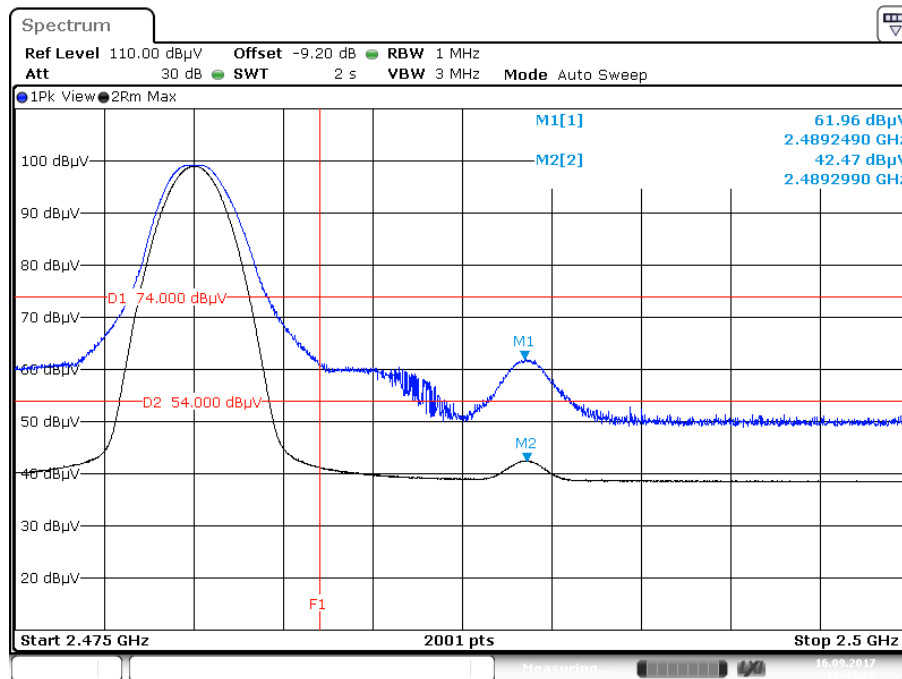
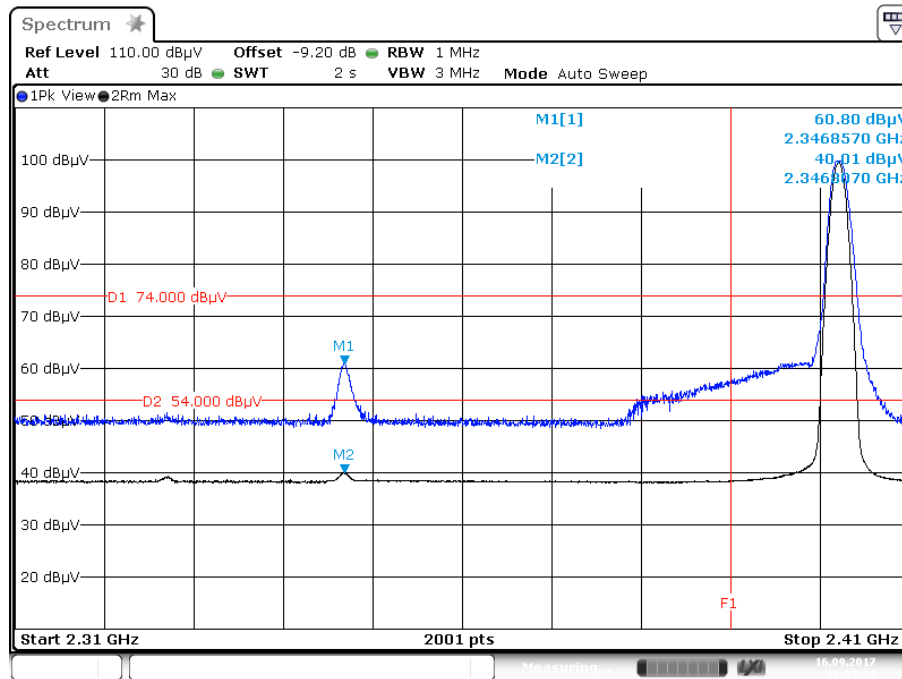
Test End Date: 16-Sep-2017

Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	B085749	8-Oct-2017

Note: The equipment calibration period is 1 year except for the FSV30 which is on a 2-year cycle.

8.5 Test Data – Restricted Band Edge

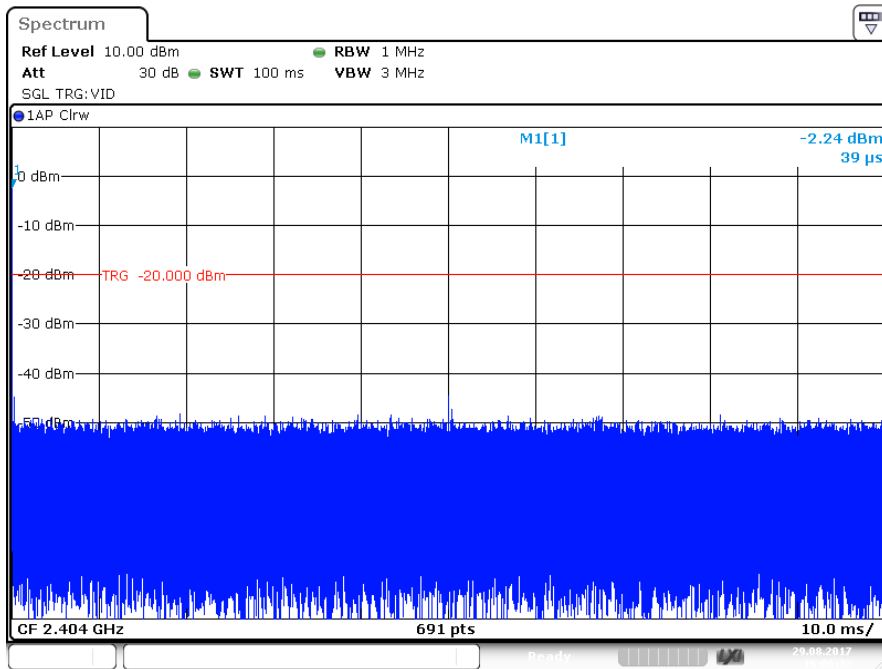


9 Revision History

Revision Level	Description of changes	Revision Date
0	Initial release	27 September 2017

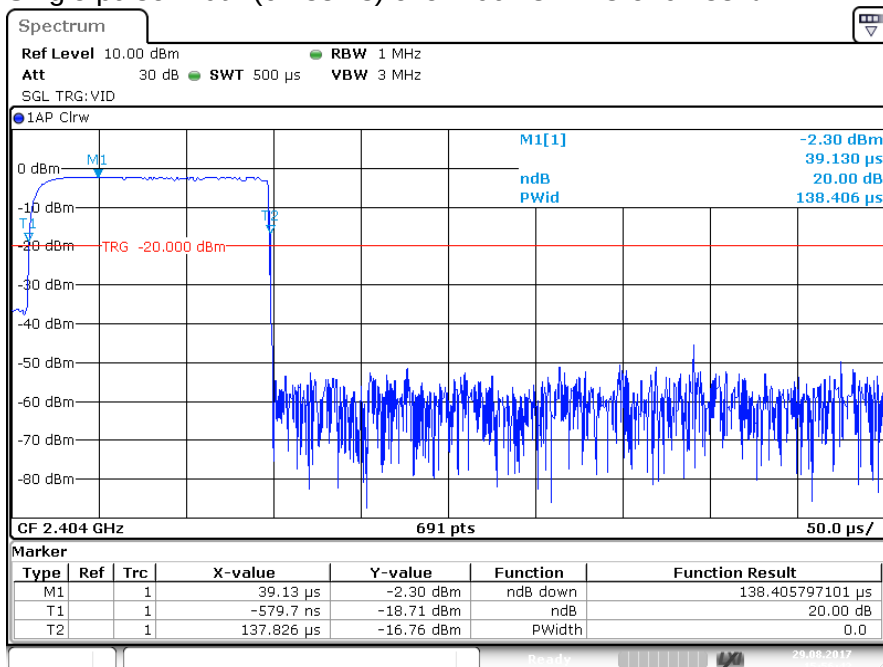
Appendix A: Duty-Cycle Calculations

These plots were taken with the device in its normal functional state with the nRF51 chipset linked to a companion device.



Date: 29.AUG.2017 16:06:32

Single pulse-width (0.138ms) over 100ms = DC of 0.138%



Date: 29.AUG.2017 15:56:42