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ELECTROMAGNETIC COMPATIBILITY TEST REPORT

PREPARED FOR AG GROWTH INTERNATIONAL
BY QAI LABORATORIES

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Applicable Test Standards:	FCC CFR 47 Part 15 - Subpart B and Subpart C ICES-003 Issue 6 RSS-247 Issue 1 RSS-Gen Issue 4

Equipment Tested	Transmitter Device
Model Number:	A02SG100
FCC ID:	2AKAAA02SG100
IC Certification Number:	22125-A02SG100
Manufacturer:	Ag Growth International

REVISION HISTORY

Date	Report Number	Rev #	Details	Author's Initials
Dec 20, 2016	E10819-1604_AGI-Transmitter	0.0	Draft Test Report	HZ
Dec 21, 2016	E10819-1604_AGI-Transmitter	1.0	Final Test Report	HZ

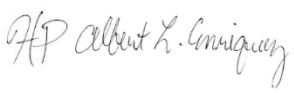
All previous versions of this report have been superseded by the latest dated revision as listed in the above table. Please dispose of all previous electronic and paper printed revisions accordingly.

REPORT AUTHORIZATION

The data documented in this report is for the test equipment provided by Ag Growth International. Tests were conducted on the sample equipment as requested by Ag Growth International for the purpose of demonstrating compliance with FCC CFR 47 Part 15 - Subpart B and Subpart C, ICES-003 Issue 6, RSS-247 Issue 1, and RSS-Gen Issue 4 as agreed upon by Ag Growth International as per Quote 16SH10272.

Ag Growth International is responsible for the tested product configuration, continued product compliance, and for the appropriate auditing of subsequent products as required. This report may comprise partial list of tests that are required for FCC or IC Declaration of Conformity and can only be produced by the manufacturer.

This is to certify that the following report is true and correct to the best of our knowledge.



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QAI FACILITIES

Founded in 1994 by a group of experienced certification and testing experts, QAI is an independent third-party testing, inspection and certification organization which serves the building industry, government and individuals with cost effective solutions through our in-house capabilities / services, and an established world-wide network of qualified affiliates. To help get your product to market, trust the provider that many leading global manufacturers do: QAI.

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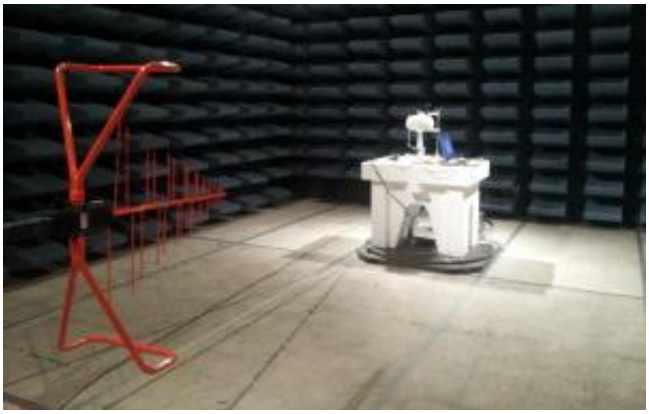
QAI EMC ACCREDITATION

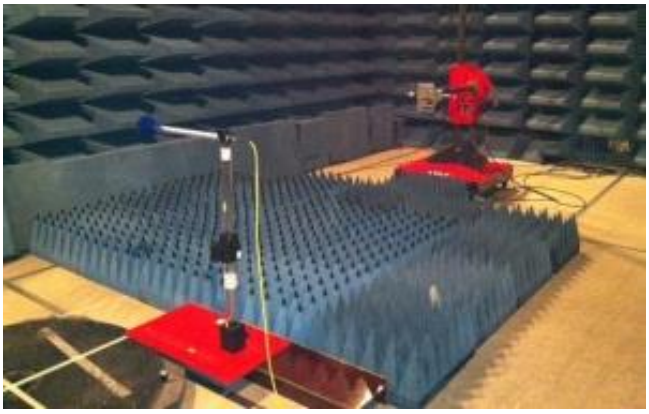
QAI EMC is your one-stop regulatory compliance partner for electromagnetic compatibility (EMC) and electromagnetic interference (EMI). Products are tested to the latest and applicable EMC/EMI requirements for domestic and international markets. QAI EMC goes above and beyond being a testing facility—we are your regulatory compliance partner. QAI EMC has the capability to perform RF Emissions and Immunity for all types of electronics manufacturing including Industrial, Scientific, Medical, Information Technology, Telecom, Wireless, Automotive, Marine and Avionics.

EMC Laboratory Location	FCC Designation (3m SAC)	IC Registration (3m SAC)	A2LA Certificate
Burnaby, BC Canada	CA9543	21146-1	3657.02

Headquarters & EMC Laboratory in Burnaby, BC



3 m Semi-Anechoic Chamber (SAC) in Burnaby, BC



3 m Semi-Anechoic Chamber (SAC) in Burnaby, BC

10 m Open Area Test Site (OATS) in British Columbia, Canada

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Section I: EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this report is to demonstrate and document the compliance of "Transmitter Device" as per Sections 1.2 & 1.3.

1.2 Scope

The information documented in this report is based on the test methods and levels as per Quote 16SH10272:

- **FCC CFR 47 Part 15 –** Radio Frequency Devices, Subpart B – Unintentional Radiators
- **FCC CFR 47 Part 15 –** Radio Frequency Devices, Subpart C – Intentional Radiators
    - 15.247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5875 MHz
    - Radiated Spurious Emissions to be measured during the pre-scan
- **ICES-003 Issue 6 –** Information Technology Equipment (Including Digital Apparatus) - Limits and Methods of Measurement
- **RSS-247 Issue 1 –** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- **RSS-Gen Issue 4 –** General Requirements and Information for the Certification of Radio Apparatus

The tests documented in this report were performed in accordance with ANSI C63.4-2014, ANSI C63.10-2013, RSS-Gen Issue 4 and FCC KDB 558074 D01 DTS Meas Guidance v03r05.

1.3 Summary of Results

The following tests demonstrate the testimony to "FCC and IC" Mark Electromagnetic compatibility testing for "Transmitter Device" manufactured by Ag Growth International.

The following testing was performed pursuant to the FCC and IC Radio and RF Emissions Standards:

Test or Measurement	Applicable FCC and IC Standard	Description	Performance Criteria
Antenna Requirement	FCC CFR 47 Part 15.203 RSS-Gen Issue 4	Reversed SMA connector used at antenna port	Complies
RF Peak Power Output	FCC CFR 47 Part 15.247 RSS-247 Issue 1	Maximum peak conducted output power shall not exceed 1 W. Except as provided in Section RSS 210 A8.4 (5), the e.i.r.p. shall not exceed 4 W.	Complies
Occupied Bandwidth (6dB Bandwidth)	FCC CFR 47 Part 15.247 RSS-247 Issue 1 RSS-Gen Issue 4	The minimum -6 dB bandwidth shall be at least 500 kHz.	Complies
99% Occupied Bandwidth	FCC CFR 47 Part 15.247 RSS-247 Issue 1 RSS-Gen Issue 4	The difference between the two recorded frequencies is the 99% occupied bandwidth.	Complies
Power Spectral Density	FCC CFR 47 Part 15.247 RSS-247 Issue 1	The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8dBm in any 3kHz band during any time interval of continuous transmission	Complies
Out-of-Band Emissions (Band Edge)	FCC CFR 47 Part 15.247 RSS-247 Issue 1	In any 100kHz bandwidth outside the frequency band in which the digitally modulated device is operating, the RF power that is produced shall be at least 20dB.	Complies
Conducted Spurious Emissions	FCC CFR 47 Part 15.247 RSS-247 Issue 1	In any 100 kHz bandwidth outside the frequency band in which the digitally modulated device is operating, the RF power that is produced shall be at least 20dB.	Complies
Radiated Spurious Emissions – Transmit Mode	FCC CFR 47 Part 15.247 FCC CFR 47 Part 15.209 FCC CFR 47 Part 15.205 RSS-247 Issue 1 RSS-Gen Issue 4	The radiated emissions were measured from 30MHz to 1GHz and 1GHz to 25GHz frequency ranges while in transmit mode.	Complies
Radiated Spurious Emissions – Receive Mode	FCC CFR 47 Part 15.247 (d) FCC CFR 47 Part 15.209 (a) ICES-003 Issue 6 RSS-Gen Issue 4	The radiated emissions were measured from 30MHz to 1GHz and 1GHz to 25GHz frequency ranges while in receive mode.	Complies
AC Mains Conducted Emissions	FCC CFR 47 Part 15.207 ICES-003 Issue 6 RSS-Gen Issue 4	The Conducted Emissions are measured on the phase and Neutral Power lines in the 0.15 - 30.0 MHz range.	Complies
Duty Cycle Correction Factor	FCC CFR 47 Part 15.35 (d) ICES-003 Issue 6	Measurement and Calculation for duty cycle correction as stated in the standards.	Complies
Frequency Stability	FCC CFR 47 Part 15.215(c) RSS-Gen Issue 4	Ensure the normal functionality despite temperature fluctuations	Complies
RF Exposure	FCC CFR 47 §1.1310 RSS-102 Section 2.5.2	RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm	Complies

Section II: GENERAL INFORMATION

2.1 Product Description

The information provided in this section is for the Equipment Under Test (EUT) and the corresponding Auxiliary Equipment needed to perform the tests as complete system.

Equipment Under Test (EUT) Information

EUT	Transmitter Device
Functional Description	Two 2.0V lead-acid internally-mounted batteries as primary power source, charged by internally-mounted solar panel or +24VDC wall adaptor (AUX PS). DUT monitors and collects temperature and humidity data using long string of sensor cables (max of 4 supported), and relays monitored data using 2.4GHz BLE link to other BLE devices. DUT also relays collected data to Hubs via 900MHz link. The enclosure is a plastic custom-made case.
FRN	0026010561
FCC ID	2AKAAA02SG100
IC Certification Number	22125-A02SG100
Manufacturer	Ag Growth International
Model No.	A02SG100
Serial No.	Sample 1: 201 | Sample 2: 203

Frequency Band	LORA Radio	902-928 MHz
	BLE Radio	2400-2483.5 MHz
Transmit Power	LORA Radio	15dBm
	BLE Radio	4dBm
Modulation	LORA Radio	Propriety non-FHSS
	BLE Radio	GFSK
Test Channels	LORA Radio	Low – 902.5MHz Mid – 915MHz High – 927.5MHz
	BLE Radio	Low – 2402MHz Mid – 2440MHz High – 2480MHz
Antenna Type and Gain	LORA Radio Type- RPSMA(F) omni whip	2dBi
	LORA Radio Type- N-Female omni whip	8dBi
	BLE Radio Type- RPSMA(F) omni whip	2dBi

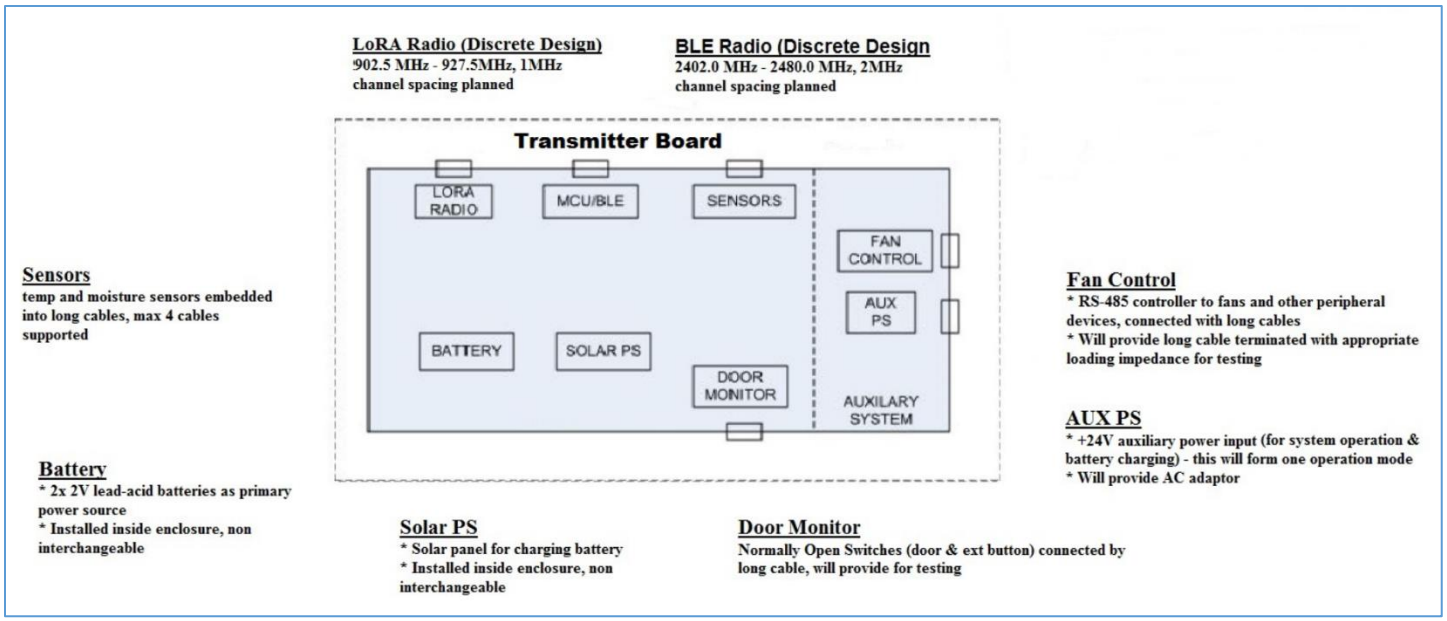
Antenna Information

Item #	Qty	Description	Manufacturer	Manufacturer's Part #	Value	Type	Rating	Comments
1	2	PCB-to-Antenna Cable Assembly	LSR	080-0013		U.FL to RPSMA(F) bulkhead	Waterproof	One per radio
2	1	LORA Antenna	Nearson	S1551AH-915S	915MHz, +2.0dBi	RPSMA(F) omni whip	IP67	
3	1	LORA Antenna (optional high-gain)	Laird	OD9-8	915MHz, +8.0dBi	N-Female omni whip	Waterproof	
4	1	RF Cable for Optional LORA Antenna	Generic	Generic	5ft	N-Male-to-RPSMA(M)		
5	1	2.4GHz Antenna	LSR	001-0010	2.4GHz, +2.0dBi	RPSMA(F) omni whip	IP67	

Auxiliary Equipment Information

Equipment	Manufacturer	Product Description	Model No.
Auxiliary 1	Bel Power Solutions	80W DIN Rail Switching Power Supply	LDN80-24
Auxiliary 2	Ag Growth International, OPI	Sensor Cable Network	Bin Configuration 6013
Auxiliary 3	Ag Growth International	Fan Control/RS485 cable, 80ft	Generic
Auxiliary 4	Ag Growth International	+24V Aux Power Cable, 150ft	Generic
Auxiliary 5	Ag Growth International	Cable assembly with 3 door switches connected in parallel, 150ft	Generic
Auxiliary 6	Ag Growth International	External pushbutton cable, 9in	generic

EUT Block Diagram



EUT Photo

EUT – Transmitter Device

2.2 Environmental Conditions

The equipment under test was operated and tested under the following environmental conditions:

Parameter	Conditions
Location	Indoors
Temperature	22-28ºC
Relative Humidity	39.7 - 54.4%

2.3 Measurement Uncertainty

Parameter	Uncertainty
Radiated Emissions, 30MHz-1GHz	± 2.40 dB
Radiated Emissions, 1GHz-40GHz	± 2.48 dB
Radio Frequency	±1,5 x 10-5 MHz
Total RF Power Conducted	±1.36 dB
Spurious Emissions, Conducted	±1.36 dB
RF Power Density, Conducted	±1.36 dB
Temperature	±1ºC
Humidity	±5 %
DC and low frequency voltages	±3 %

2.4 Worst Test Case

Worst-case orientation was determined during the preliminary testing. The final radiated emissions were performed in the worst-case orientation.

2.5 Sample Calculations of Emissions Data

Radiated and conducted emissions were performed using EMC32 software developed by Rohdes & Schwarz. Transducer factors like Antenna factors, Cable Losses and Amplifier gains were stored in the test templates which are used to perform the emissions measurements. After test is finished, data is generated from the EMC32 consisting of product details, emission plots and final data tables as shown below.

Frequency (MHz)	Quasi-Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
42.663900	33.0	1000.000	120.000	100.0	H	70.0	13.2	7.5	40.5

Quasi Peak reading shown in the table above is already corrected by the software using correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

Corr.(dB) = Antenna factor + Cable loss

Or

Corr.(dB) = Antenna factor + Cable Loss - Amp gain (if pre-amplifier was used)

The final Quasi peak reading shown in the data is calculated by the software using following equation:

Corrected Quasi Peak(dBµV/m) = Raw Quasi Peak Reading + Antenna factor + Cable loss

To obtain the final Quasi-Peak or Average reading during power line conducted emissions, transducer factors are included in the final measurement as shown below.

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	44.3	1000.000	9.000	0.6	21.7	66.0

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	27.2	1000.000	9.000	0.6	28.8	56.0

Note: *Data shown above are sample data and are not relevant to the EUT's actual data.*

Quasi Peak or Average reading shown in above table is already corrected by the software using the correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

Corr.(dB) = Antenna factor + Cable loss

The final Quasi peak or Average reading shown in the data is calculated by the software using following equation:

Corr. Quasi Peak/Average Reading (dBµV) = Raw Quasi Peak/Average Reading + Antenna factor + Cable loss

The allowable margin from the limits, as per the standards, were calculated for both radiated and conducted emissions:

Margin(dB) = Limit – Quasi-Peak or Average reading

2.6 Test Equipment List

The tables below contain all the equipment used by QAI Laboratories in conducting all tests on the Equipment Under Test (EUT) as per Section 1.3.

Emissions Test Equipment

Manufacturer	Model	Description	Serial No.	Calibration Due Date
Sunol Sciences	SM46C	Turntable	051204-2	N/A
Sunol Sciences	TWR95	Mast	TREML0001	N/A
Sunol Sciences	JB3	Biconilog Antenna 30MHz – 3GHz	A120106	24-Sep-2017
Sunol Sciences	DRH-118	Horn Antenna 1GHz-18GHz	A050905	10-Mar-2019
ETS Lindgren	3160-09	Horn Antenna 18GHz-26.5GHz	9701-1071	30-Aug-2017
ETS Lindgren	3160-10	Horn Antenna 26.5GHz-40.0GHz	9708-1075	30-Aug-2017
ETS Lindgren	6502	Active Loop Antenna 10kHz – 30MHz	2178	21-Aug-2017
ETS Lindgren	2165	Turntable	00043677	N/A
ETS Lindgren	2125	Mast	00077487	N/A
Rohde & Schwarz	ESU40	EMI Receiver	100011	20-Nov-2017
Fischer	FCC-LISN-50-25-2-08	LISN (150kHz-30MHz)	2041	19-Nov-2018
ETS Lindgren	S201	5-meter Semi-Anechoic Chamber	1030	N/A
AH Systems	PAM118	Amplifier 10KHz-18GHz	189	Conditional Use
California Instruments	PACS-1	Harmonics and flicker analyzer	72569	18 July 2018
California Instruments	OMNI 1-18 I	Programmable Impedance Flicker test	-	18 July 2018
California Instruments	3001ix	Power supply	HK52117	18 July 2018

Note: *Equipment listed above have a 3 years calibration interval.*

Measurement Software List

Manufacturer	Model	Version	Description
Rhode & Schwarz	EMC 32	6.20.0	Emissions Test Software
ETS-Lindgren	Tile7	7.3.15	Emissions Test Software

Section III: REQUIREMENTS FOR THE US MARKET (FCC) & THE CANADIAN MARKET (IC) - Exigences pour le Marché Canadien

3.1 Antenna Requirements

Date Performed:

November 25, 2016

Test Standard:

- FCC CFR 47 Part 15.203
- RSS-Gen Issue 4

Applicable Regulation:

The purpose of this requirement is to make certain that no other antenna, except for that provided by the responsible party, shall be used with the Equipment-Under-Test (EUT) as defined in FCC CFR 47 Part 15.203 & RSS-Gen Issue 4:

> "An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited." … "the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded."

Modifications:

No modification was required to comply for this test.

Final Result:

A reversed SMA connector was used at the antenna port. The EUT meets the antenna requirement.

3.2 RF Peak Power Output

Date Performed:

December 1-7, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- RSS-247 Issue 1

Test Method:

- FCC KDB 558074 D01 DTS Meas Guidance v03r05

Test Requirement:

For systems employing digital modulation techniques operating in the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz, the maximum peak conducted output power shall not exceed 1 W (30dBm). Except as provided in RSS 210 Section A8.4 (5), the e.i.r.p. shall not exceed 4 W.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

The following are measurement methods used on each radio as per FCC KDB 558074 D01 DTS Meas Guidance v03r05:

- LORA Radio (902-928 MHz) – Power meter was used for this radio therefore there was no plots generated
- BLE Radio (2400-2483.5 MHz) – Section 9.1.1: RBW ≥ DTS bandwidth

Modifications:

No modification was required to comply for this test.

Final Result:

The EUT complies with the applicable standard.

Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

Table 1: Conducted output power measurements (LORA Radio: 902-928 MHz)

Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Cable Loss with 30dB Attenuator (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	902.5	-6.07	20.68	14.61	30	15.39
Middle	915.0	-6.4	20.71	14.31	30	15.69
High	927.5	-6.6	20.71	14.11	30	15.89

Table 2: E.I.R.P. measurements (LORA Radio with Nearson S1551AH-915S 915MHz, +2.0dBi omni whip Antenna)

Channel	Frequency (MHz)	Corrected Peak Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)
Low	902.5	14.61	2	16.61
Middle	915.0	14.31	2	16.31
High	927.5	14.11	2	16.11

Table 3: E.I.R.P. measurements (LORA Radio with Laird OD9-8 Gain 8dBi N-Female omni whip)

Channel	Frequency (MHz)	Corrected Peak Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)
Low	902.5	14.61	8	22.61
Middle	915.0	14.31	8	22.31
High	927.5	14.11	8	22.11

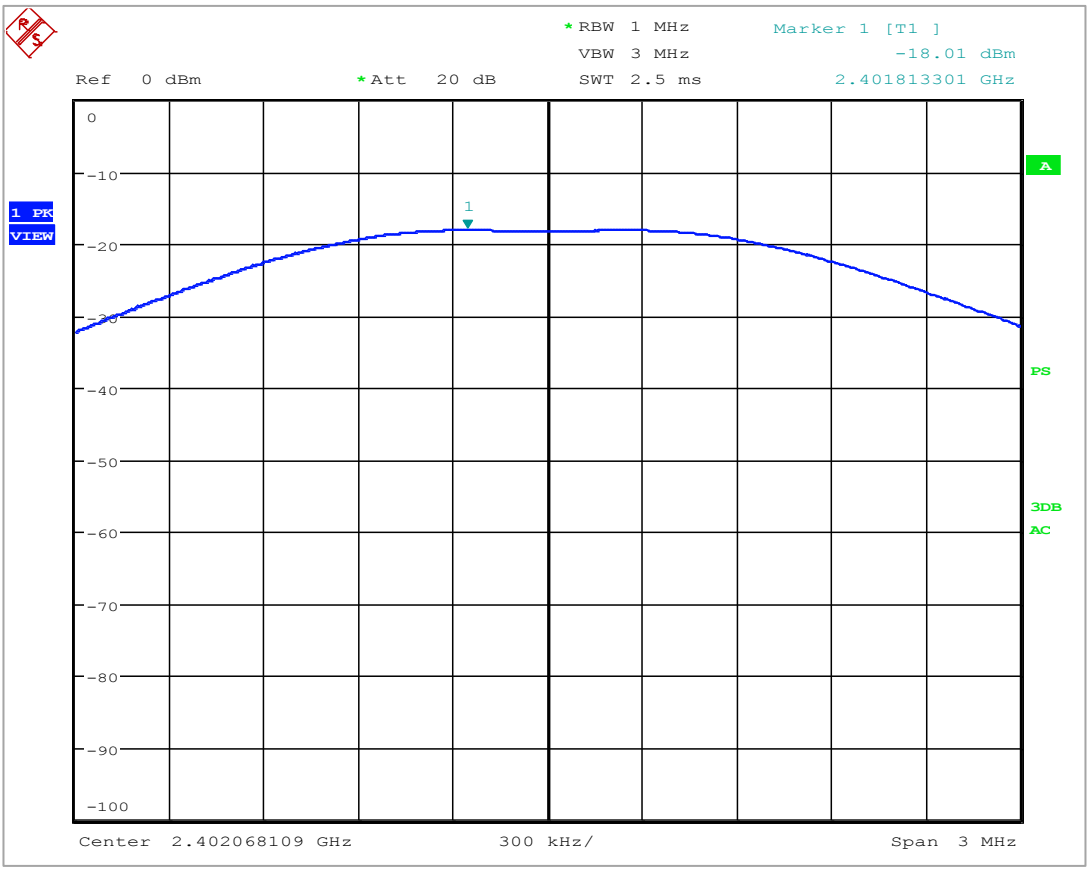
BLE Radio (2400-2483.5 MHz) Data and Plot

Table 4: Conducted output power measurements (BLE Radio: 2400-2483.5 MHz)

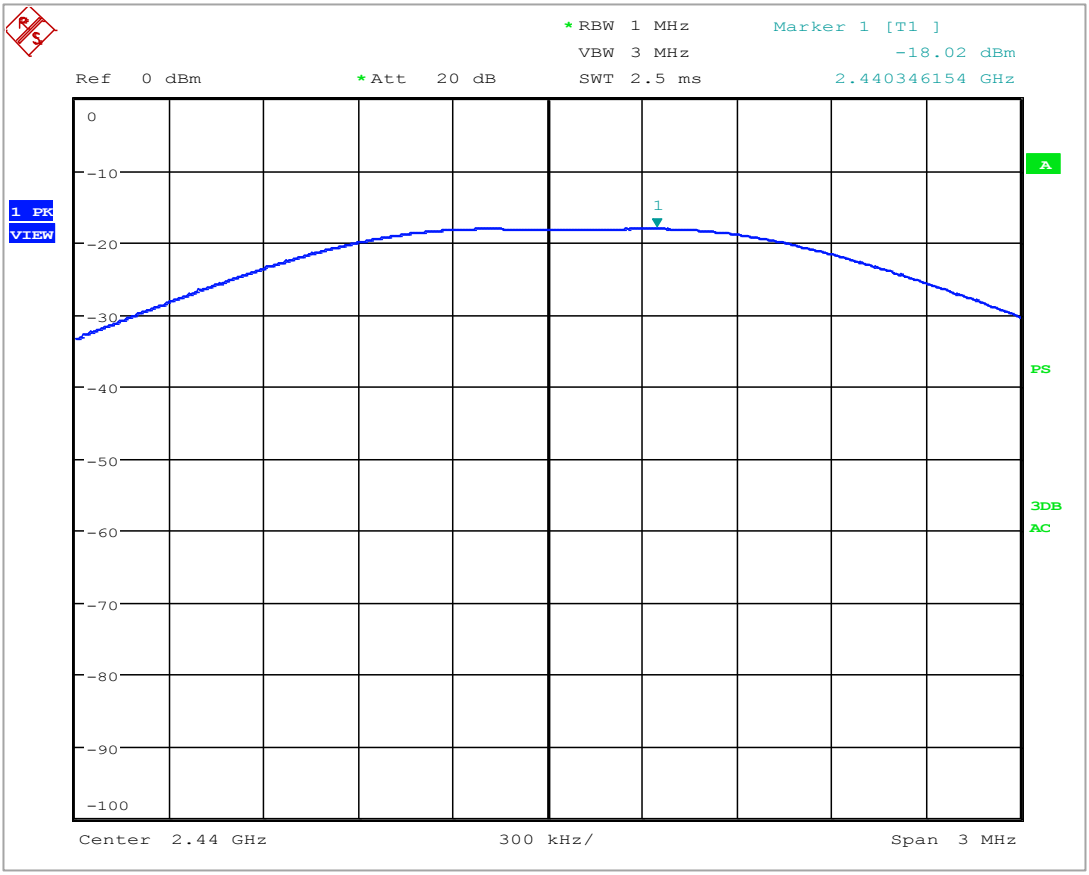
Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Cable Loss with 30dB Attenuator (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	-18.01	21.14	3.13	30	26.87
Middle	2440	-18.02	21.18	3.16	30	26.84
High	2480	-18.33	21.18	2.85	30	27.15

Table 5: E.I.R.P. measurements (BLE Radio: 2400-2483.5 MHz)

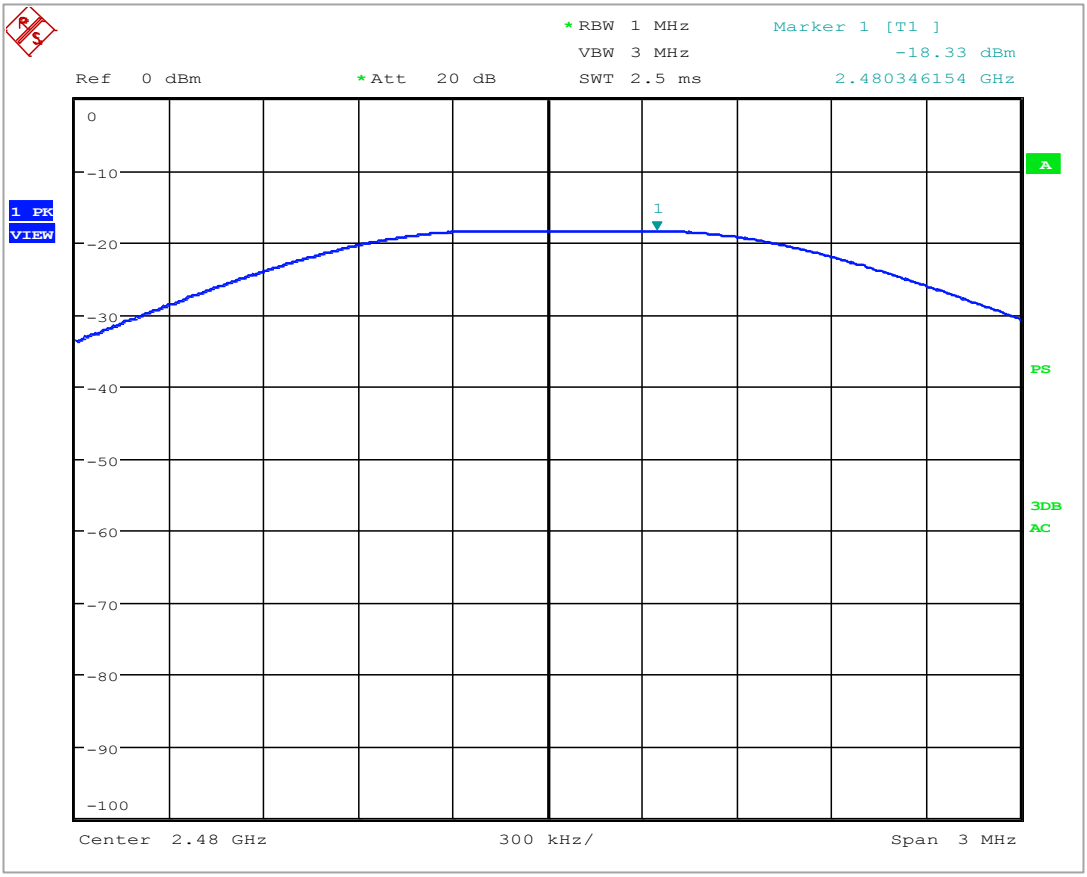
Channel	Frequency (MHz)	Corrected Peak Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)
Low	2402	3.13	2	5.13
Middle	2440	3.16	2	5.16
High	2480	2.85	2	4.85



Plot 1: Peak Output Power – Low Channel (BLE Radio: 2400-2483.5 MHz)



Plot 2: Peak Output Power – Middle Channel (BLE Radio: 2400-2483.5 MHz)



Plot 3: Peak Output Power – High Channel (BLE Radio: 2400-2483.5 MHz)

3.3 6dB Occupied Bandwidth

Date Performed:

December 7, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- RSS-247 Issue 1
- RSS-Gen Issue 4

Test Method:

- ANSI C63.10-2013

Test Requirement:

The minimum 6dB bandwidth shall be at least 500kHz.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

As called in ANSI C63.10-2013.

Modifications:

No modification was required to comply for this test.

Final Result:

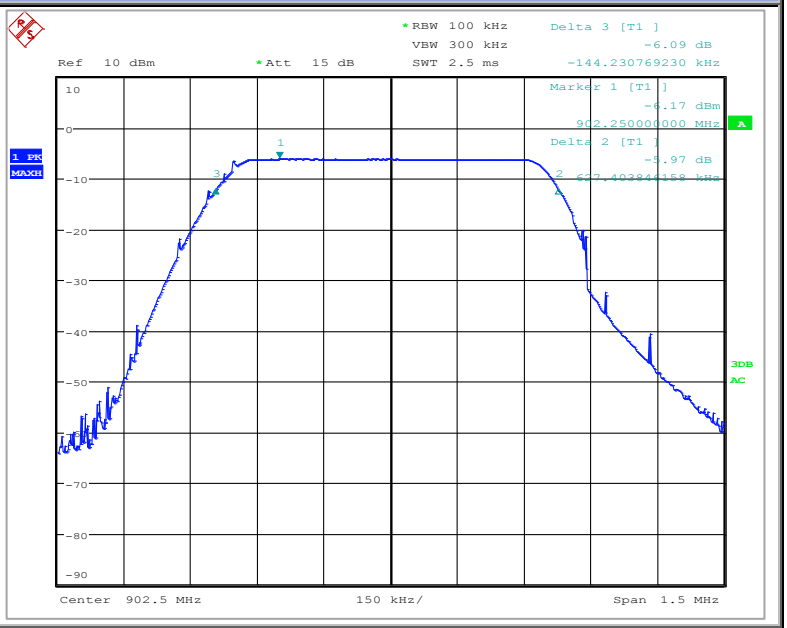
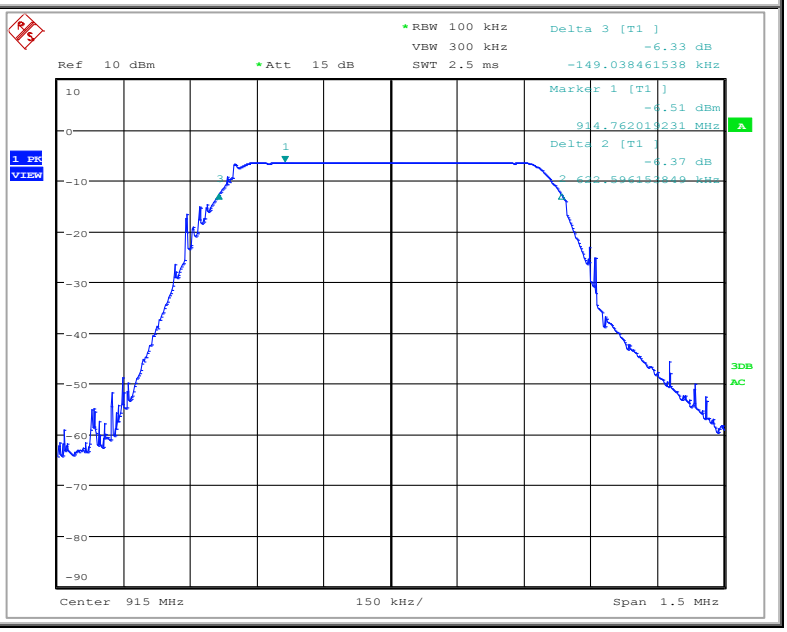
The EUT complies with the applicable standard.

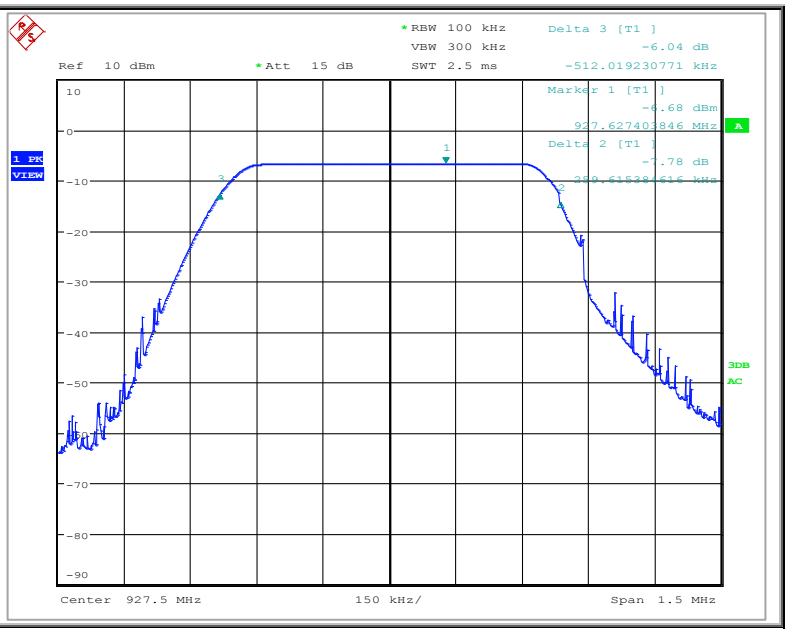
Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

Table 6: 6dB Occupied Bandwidth Data (LORA Radio: 902-928 MHz)

Channel	Frequency (MHz)	6dB Bandwidth (kHz)	Limit (kHz)
Low	902.5	771.6	>500
Middle	915.0	771.64	>500
High	927.5	771.64	>500

Channel	Plot
Low	
Middle	

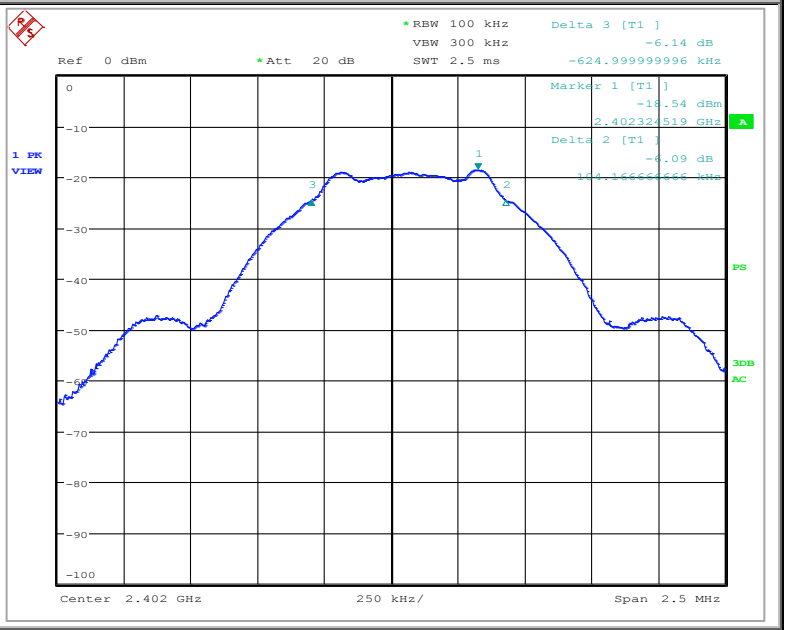
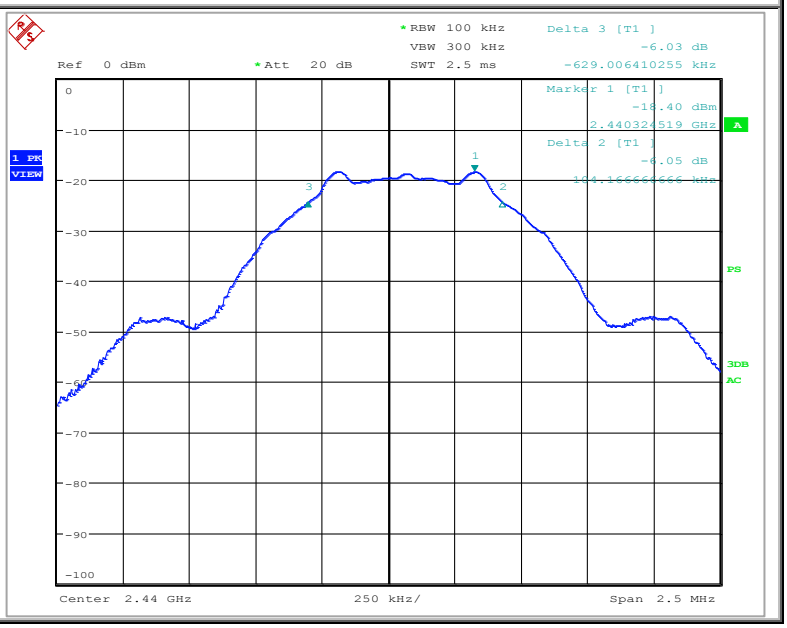
High	

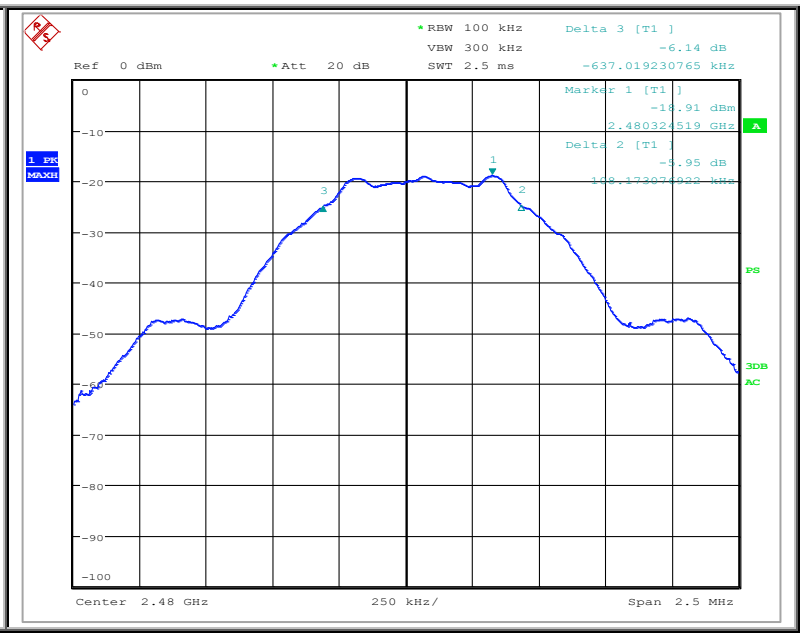
Plot 4: 6dB Occupied Bandwidth Plot (LORA Radio: 902-928 MHz)

BLE Radio (2400-2483.5 MHz) Data and Plot

Table 7: 6dB Occupied Bandwidth Data (BLE Radio: 2400-2483.5 MHz)

Channel	Frequency (MHz)	6dB Bandwidth (kHz)	Limit (kHz)
Low	2402	729.1	>500
Middle	2440	733.18	>500
High	2480	745.19	>500

Channel	Plot
Low	
Middle	

High	

Plot 5: 6dB Occupied Bandwidth Plot (BLE Radio: 2400-2483.5 MHz)

3.4 99% Occupied Bandwidth

Date Performed:

December 7, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- RSS-247 Issue 1
- RSS-Gen Issue 4

Test Method:

- ANSI C63.10 2013

Test Setup:

RSS-Gen Issue 4: Section 6.6 – A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

Measurement Method:

As called in ANSI C63.10-2013.

Modifications:

No modification was required to comply for this test.

Final Result:

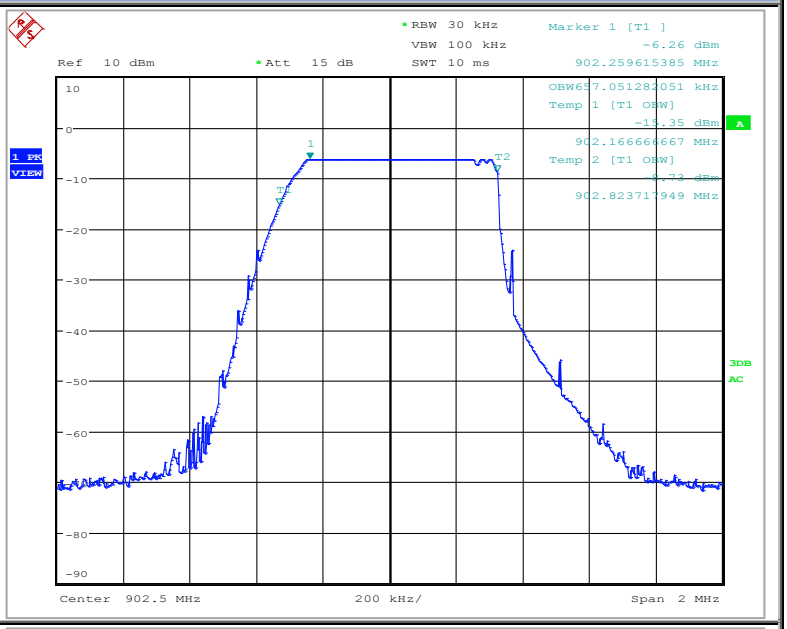
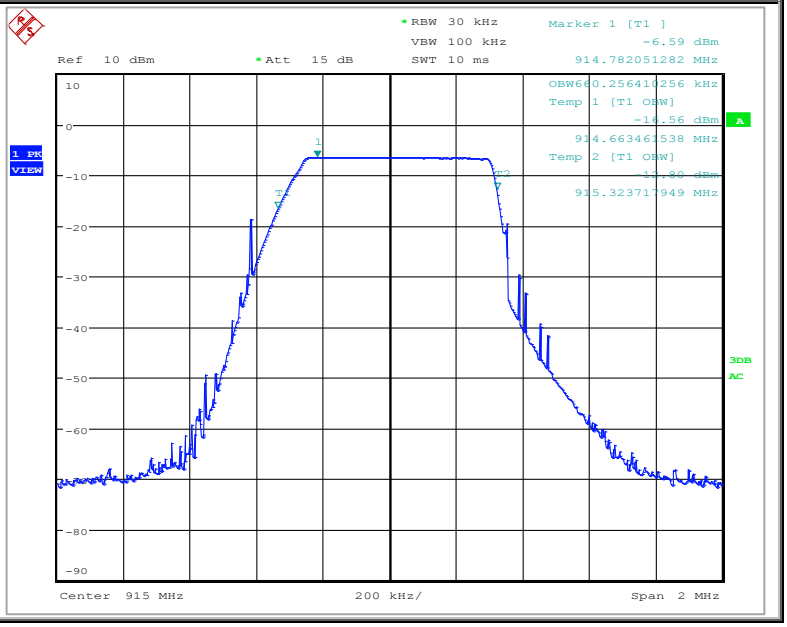
Complies with the applicable standard.

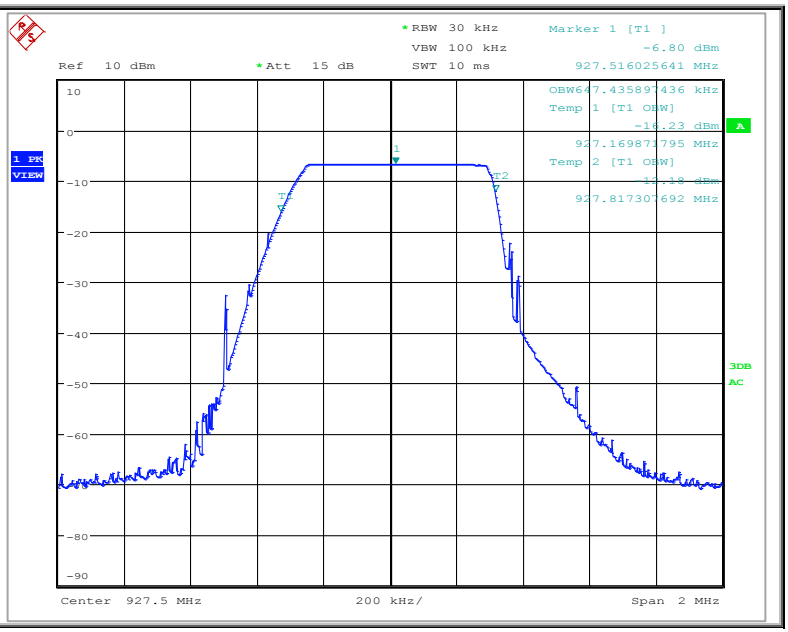
Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

Table 8: 99% Occupied Bandwidth Data (LORA Radio: 902-928 MHz)

Channel	Frequency (MHz)	99% Bandwidth (kHz)
Low	902.5	657.05
Middle	915.0	660.256
High	927.5	647.43

Channel	Plot
Low	
Middle	

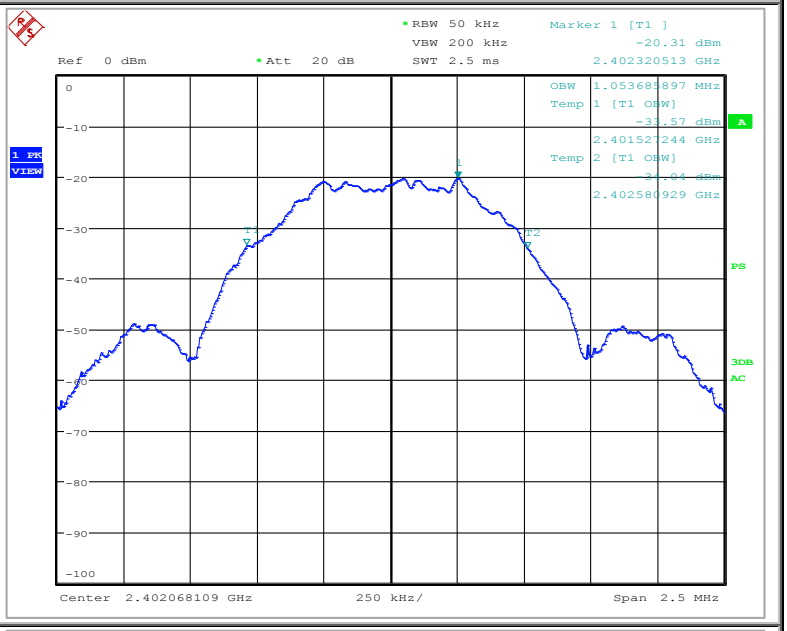
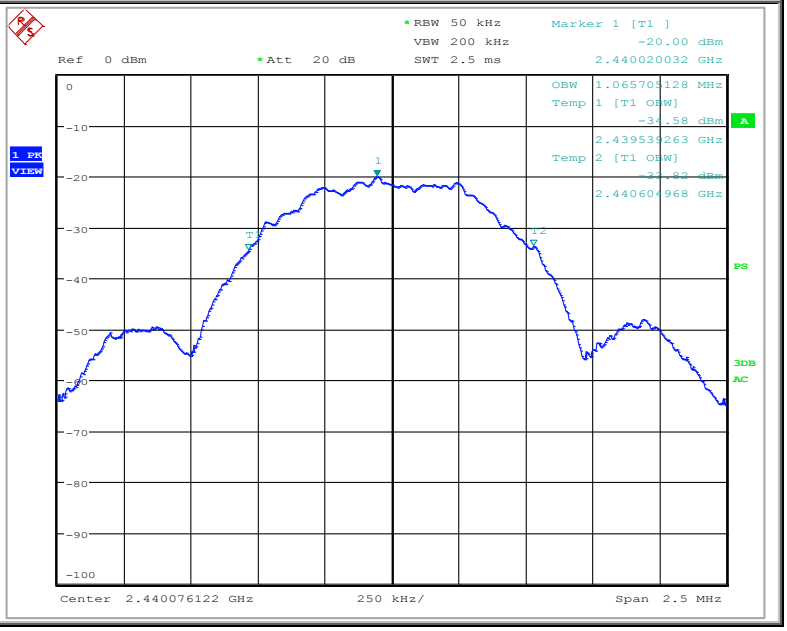
High	

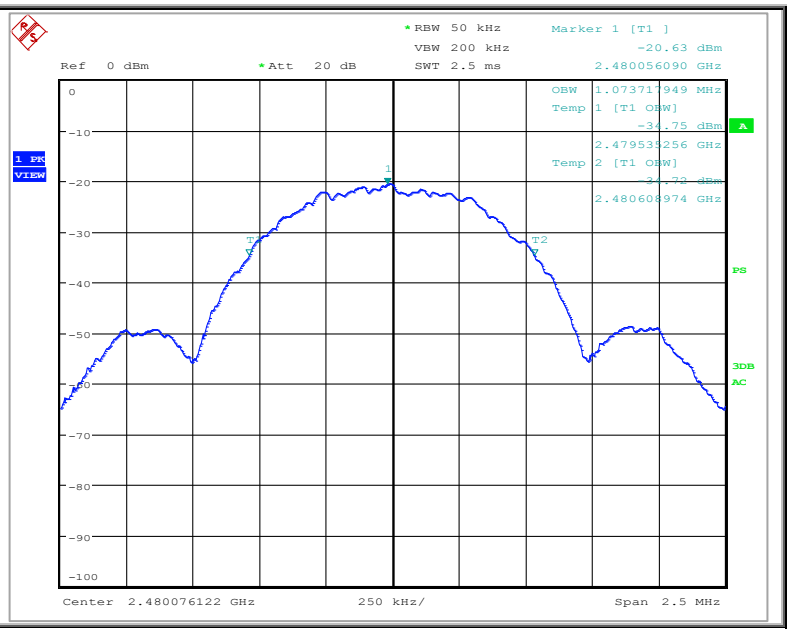
Plot 6: 99% Occupied Bandwidth Plot (LORA Radio: 902-928 MHz)

BLE Radio (2400-2483.5 MHz) Data and Plot

Table 9: 99% Occupied Bandwidth Data (BLE Radio: 2400-2483.5 MHz)

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2402	1.053
Middle	2440	1.065
High	2480	1.078

Channel	Plot
Low	
Middle	

High	

Plot 7: 99% Occupied Bandwidth Plot (BLE Radio: 2400-2483.5 MHz)

3.5 Power Spectral Density

Date Performed:

December 7, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- RSS-247 Issue 1

Test Method:

- FCC KDB 558074 D01 DTS Meas Guidance v03r05

Test Requirement:

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission. The power spectral density was determined using the same method as is used to determine the conducted output power).

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

The following are measurement methods used on each radio as per FCC KDB 558074 D01 DTS Meas Guidance v03r05:

- LORA Radio (902-928 MHz) – Section 10.4: Method AVGPSD-1 Alternative (RMS detection with slow sweep speed and EUT transmitting continuously at full power)
- BLE Radio (2400-2483.5 MHz) – 10.2: Method PKPSD (peak PSD)

Modifications:

No modification was required to comply for this test.

Final Result:

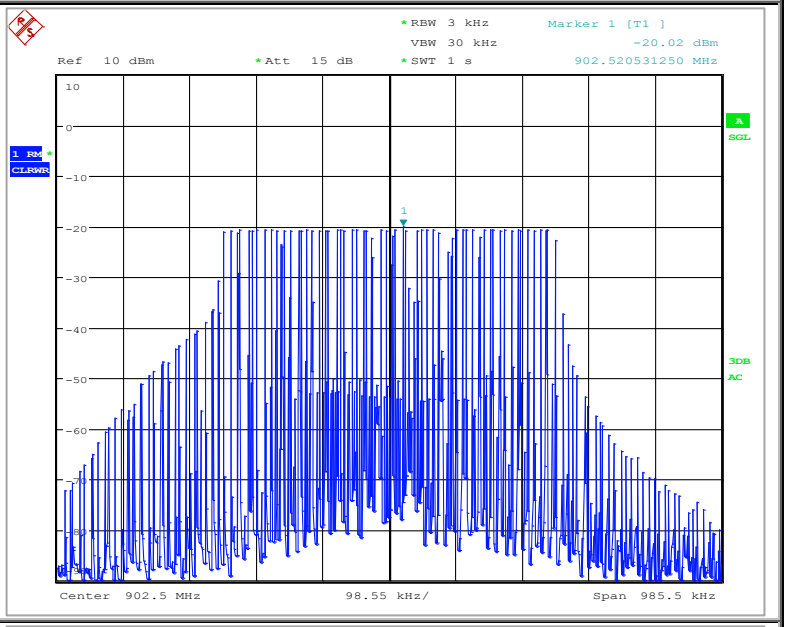
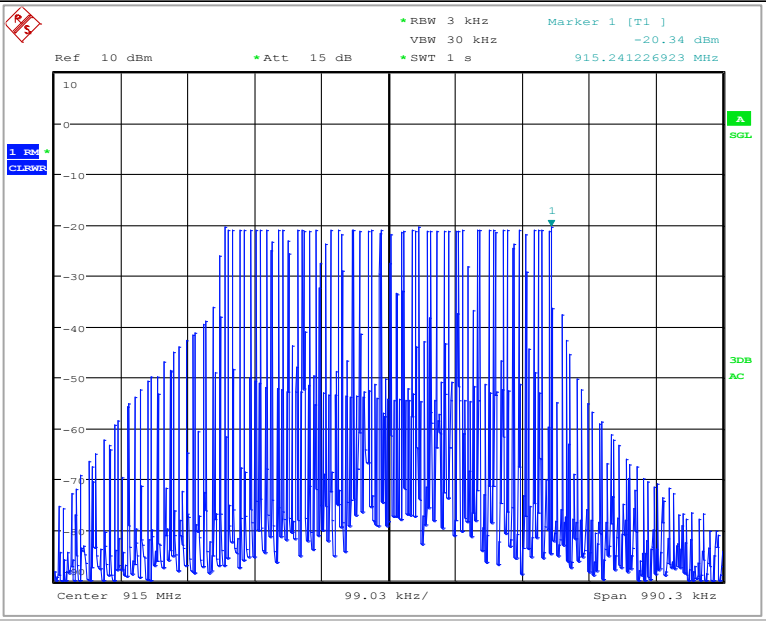
The EUT complies with the applicable standard.

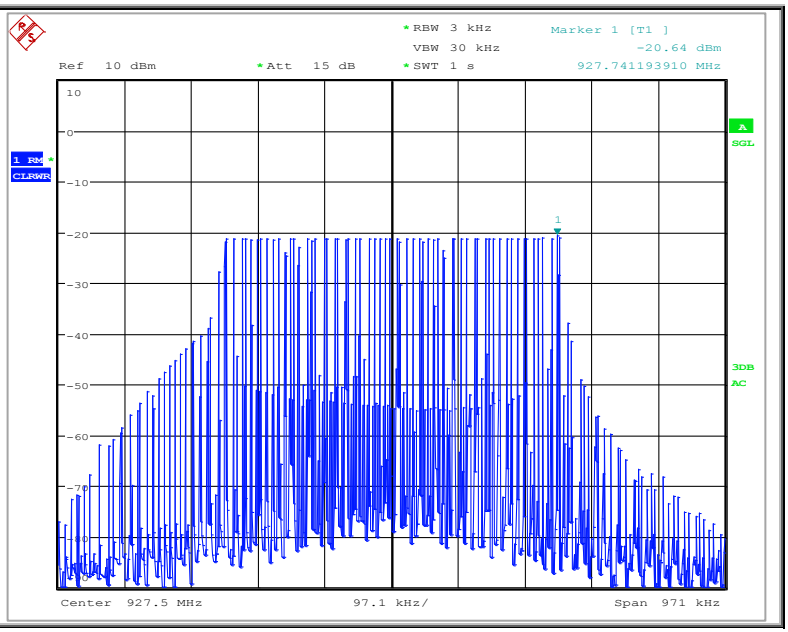
Measurement Data and Plot:

[LORA Radio (902-928 MHz) Data and Plot]

Table 10: Power Spectral Density Data (LORA Radio: 902-928 MHz)

Channel	Frequency (MHz)	Measured PSD (dBm)	Cable Loss with 30dB Attenuator (dB)	Corrected PSD (dBm)	Limit (dBm)	Margin (dB)
Low	902.5	-20.02	20.68	0.66	8	7.34
Middle	915.0	-20.34	20.71	0.37	8	7.63
High	927.5	-20.64	20.71	0.07	8	7.93

Channel	Plot
Low	
Middle	

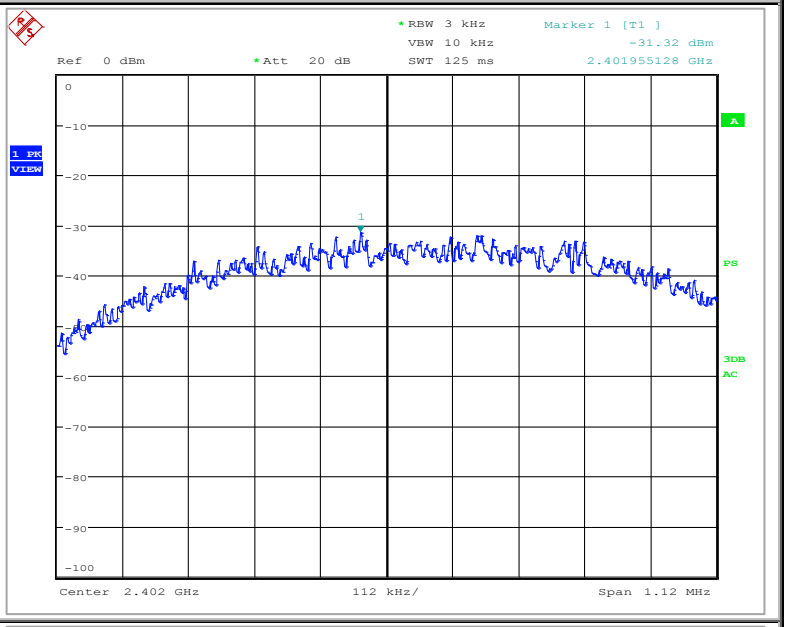
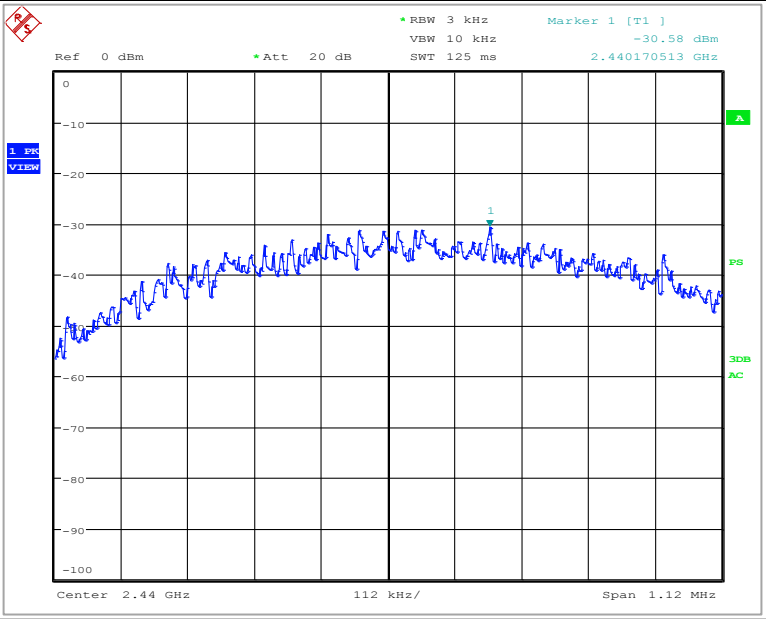
High	

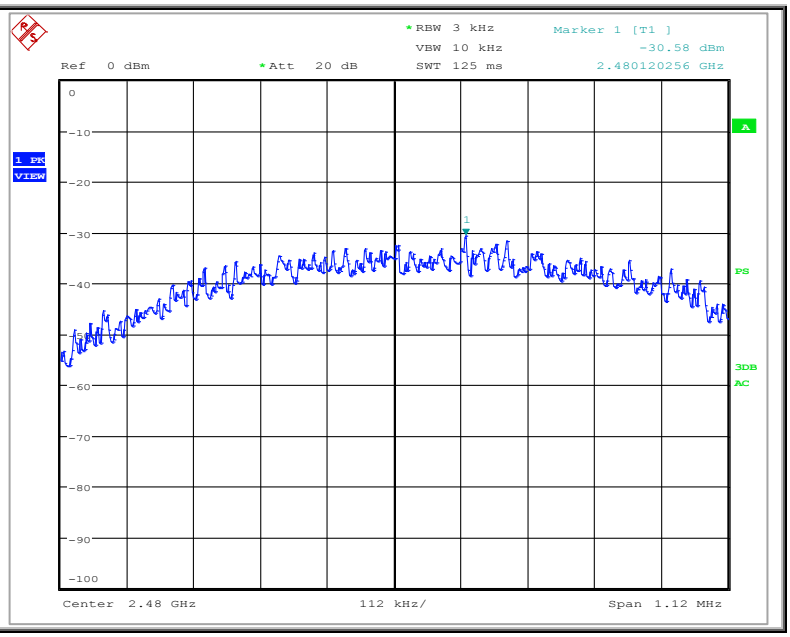
Plot 8: Power Spectral Density Plot (LORA Radio: 902-928 MHz)

BLE Radio (2400-2483.5 MHz) Data and Plot

Table 11: Power Spectral Density Data (BLE Radio: 2400-2483.5 MHz)

Channel	Frequency (MHz)	Measured PSD (dBm)	Cable Loss with 30dB Attenuator (dB)	Corrected PSD (dBm)	Limit (dBm)	Margin (dB)
Low	2402	-31.32	21.14	-10.18	8	18.18
Middle	2440	-30.58	21.18	-9.4	8	17.4
High	2480	-30.58	21.18	-9.4	8	17.4

Channel	Plot
Low	
Middle	

High	

Plot 9: Power Spectral Density Plot (BLE Radio: 2400-2483.5 MHz)

3.6 Out of Band Emissions (Band Edge)

Date Performed:

November 25 - December 1, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- RSS-247 Issue 1

Test Method:

- ANSI C63.10-2013

Test Requirement:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section A8.4 (4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in Rss-Gen Issue 4 is not required.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

The measurement method used for both radios was Section 6.10.6.2 Marker-delta Method of ANSI C63.10-2013 standard.

Modifications:

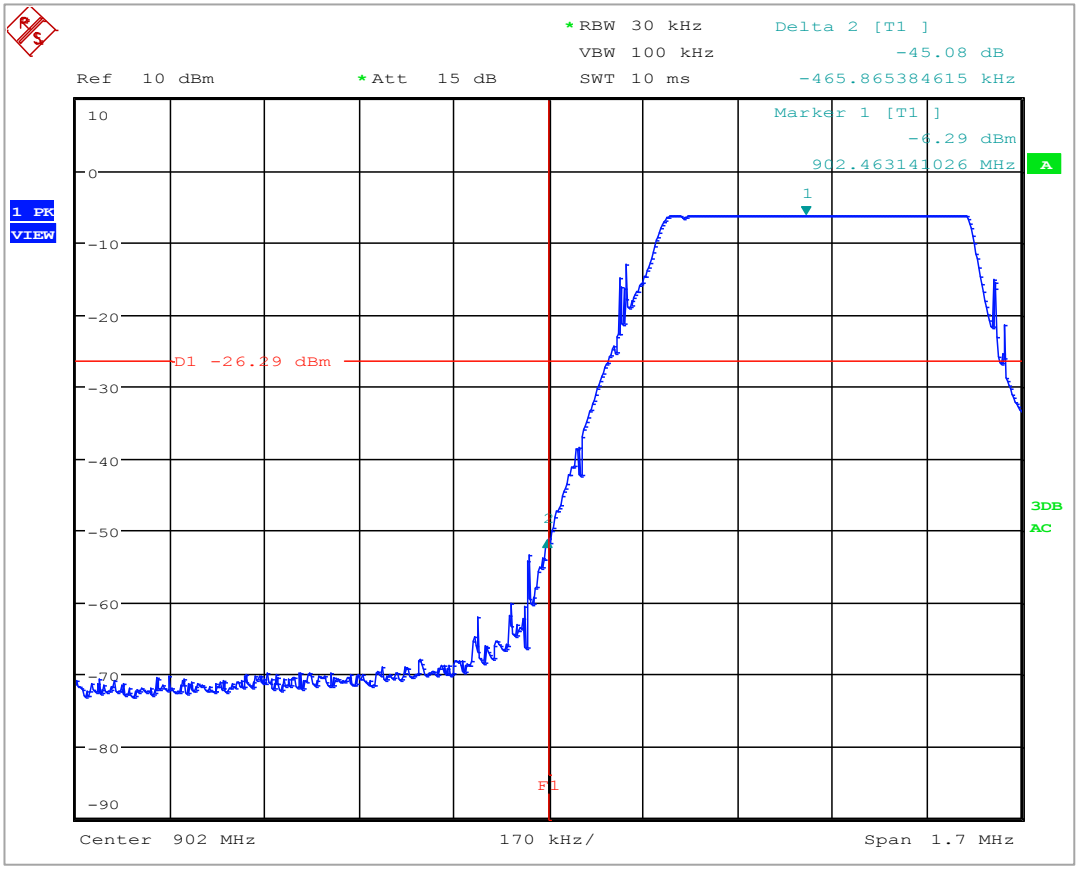
No modification was required to comply for this test.

Final Result:

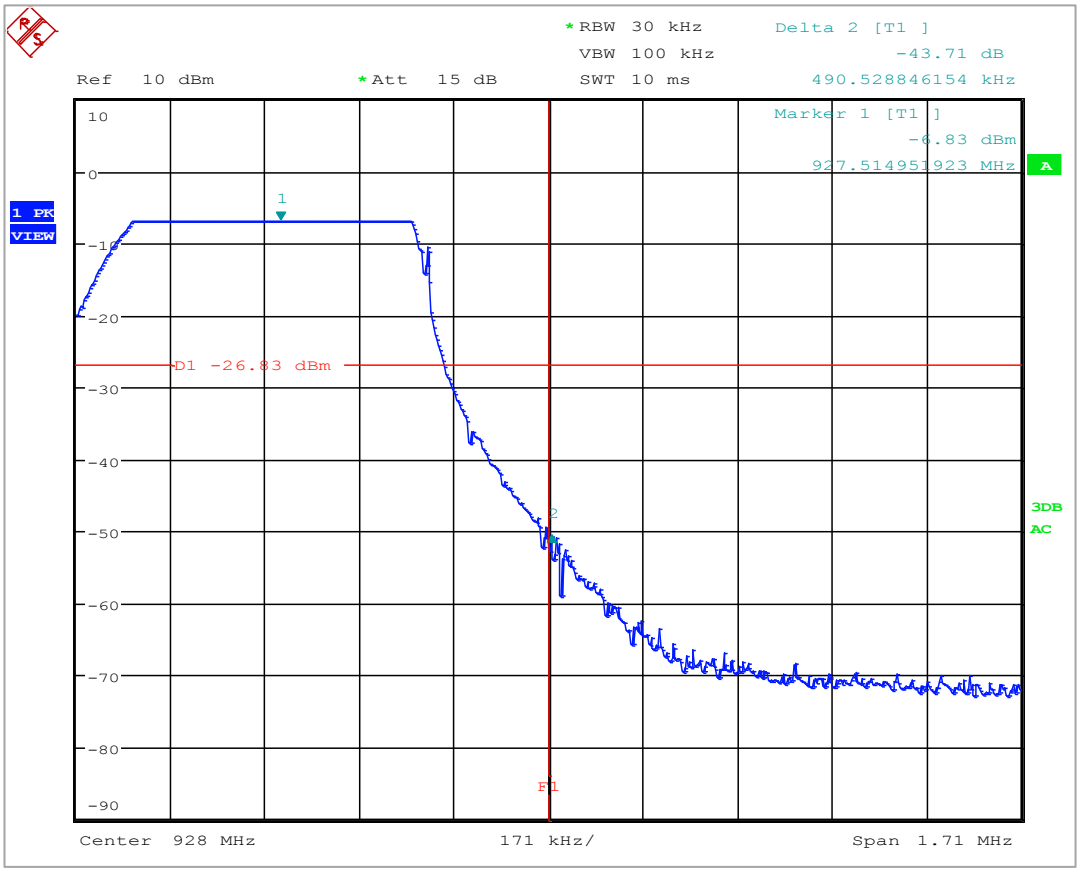
The EUT complies with the applicable standard.

Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

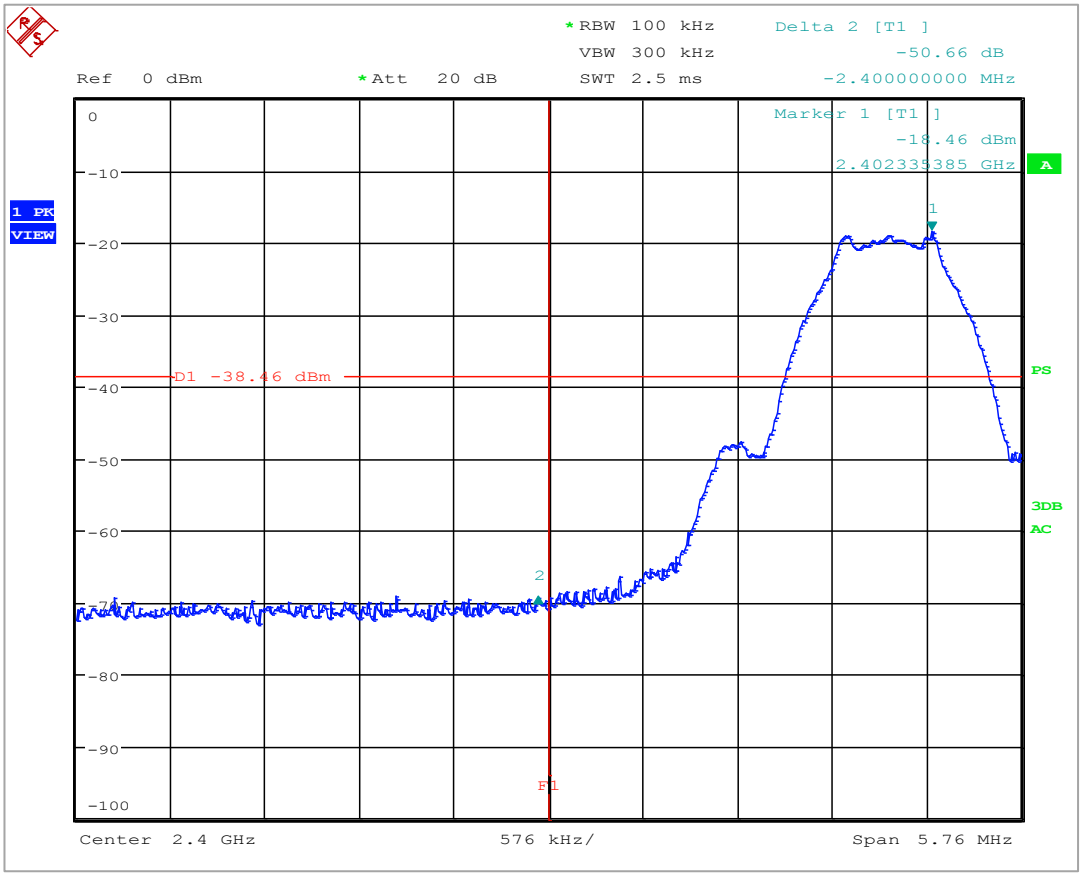


Plot 10: Band Edge Plot at Channel Low (LORA Radio: 902-928 MHz)

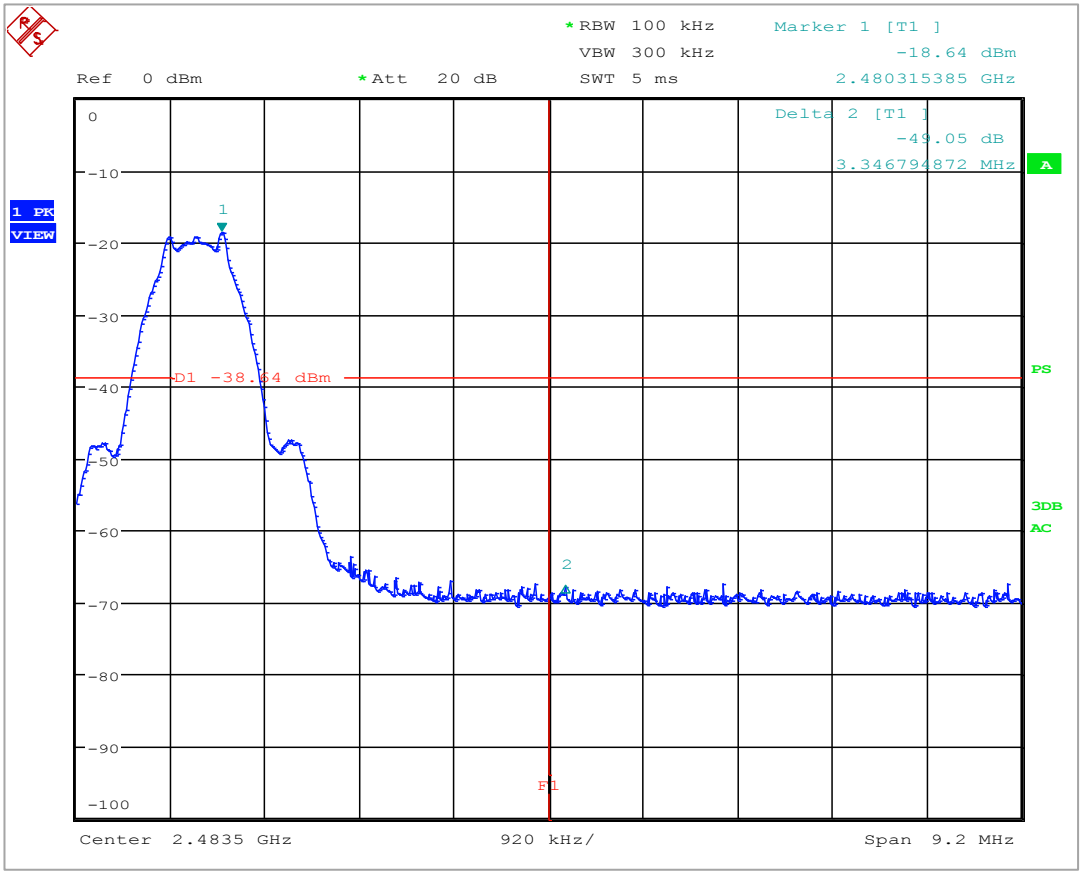


Plot 11: Band Edge Plot at Channel High (LORA Radio: 902-928 MHz)

BLE Radio (2400-2483.5 MHz) Data and Plot



Plot 12: Band Edge Plot at Channel Low (BLE Radio: 2400-2483.5 MHz)



Plot 13: Band Edge Plot at Channel High (BLE Radio: 2400-2483.5 MHz)

3.7 Conducted Spurious Emissions

Date Performed:

December 1-7, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- RSS-247 Issue 1

Test Method:

- FCC KDB 558074 D01 DTS Meas Guidance v03r05

Test Requirement:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Modifications:

No modification was required to comply for this test.

Final Result:

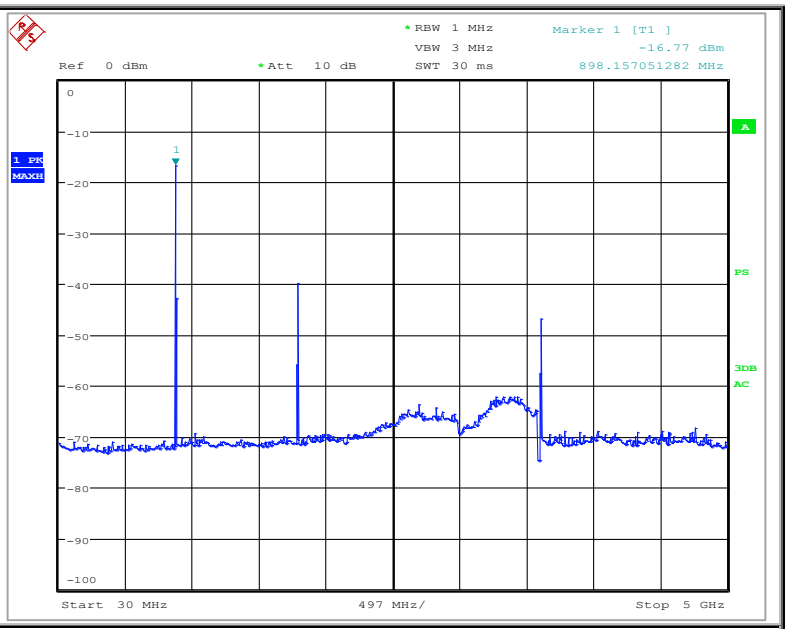
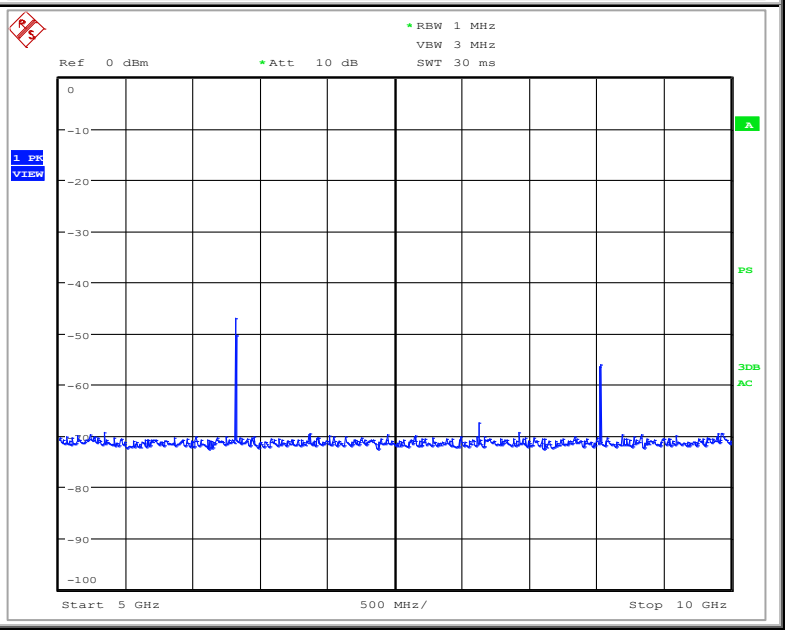
The EUT complies with the applicable standard. Conducted spurious emissions were measured up to tenth harmonic of the fundamental frequency.

Measurement Data and Plot:

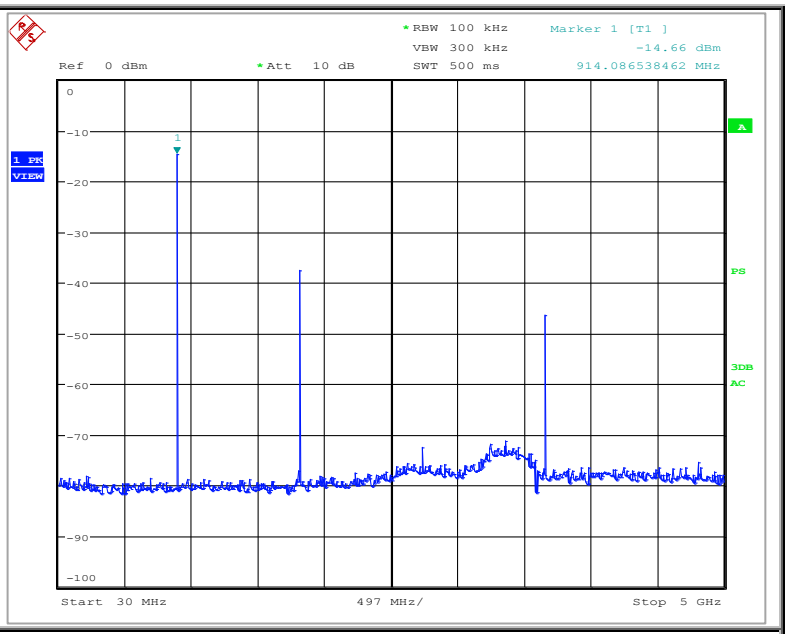
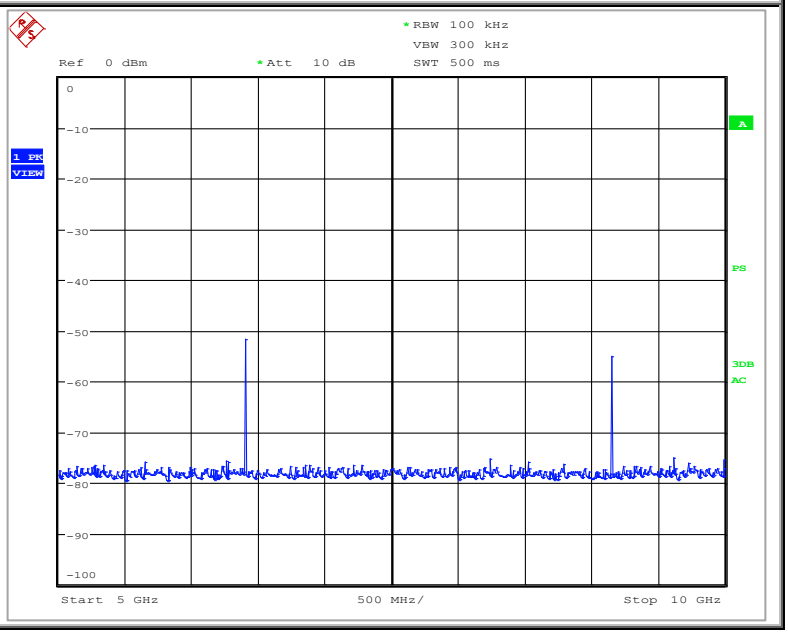
LORA Radio (902-928 MHz) Data and Plot

Table 12: Conducted Spurious Emissions Data (LORA Radio: 902-928 MHz)

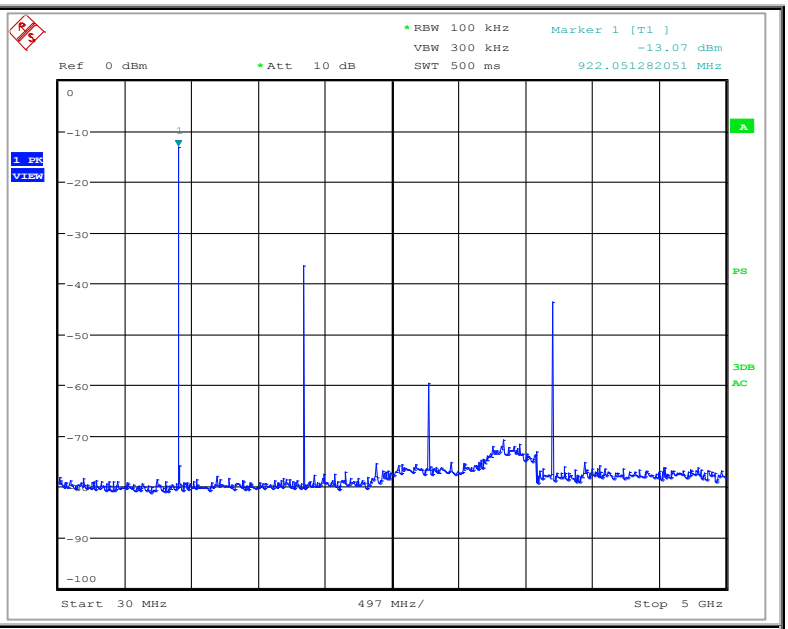
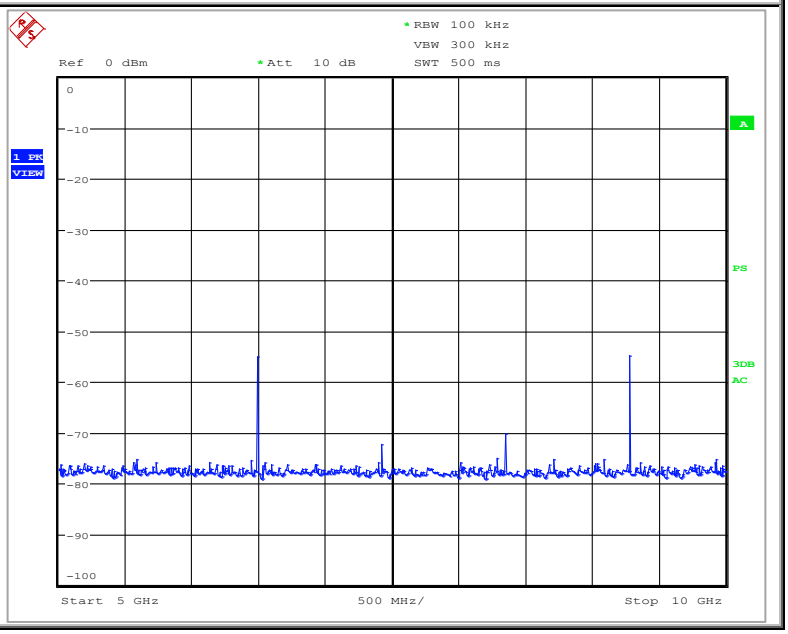
Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Loss (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low Channel 902.5MHz	1805	-39.76	0.96	-38.8	-5.58	33.22
	2707.8	-62.63	1.66	-60.97	-5.58	55.39
	3610	-46.25	1.67	-44.58	-5.58	39
	4512	-65.29	2.94	-62.35	-5.58	56.77
	5415.8	-69.22	5.63	-63.59	-5.58	58.01
	6317.5	-46.88	3.39	-43.49	-5.58	37.91
	7220	-69.02	3.79	-65.23	-5.58	59.65
	8122.5	-65.54	3.28	-62.26	-5.58	56.68
	9025	-55.1	4	-51.1	-5.58	45.52
Mid Channel 915MHz	1830	-37.59	1.13	-36.46	-5.91	30.55
	2745	-63.11	1.38	-61.73	-5.91	55.82
	3660	-45.6	1.73	-43.87	-5.91	37.96
	4575	-66.73	3.25	-63.48	-5.91	57.57
	5490	-68.57	4.66	-63.91	-5.91	58
	6405	-50.75	3.14	-47.61	-5.91	41.7
	7320	-67.7	2.71	-64.99	-5.91	59.08
	8235	-68.17	3.76	-64.41	-5.91	58.5
	9150	-53.77	3.69	-50.08	-5.91	44.17
Hi Channel 927.5MHz	1855	-36.43	0.85	-35.58	-6.08	29.5
	2782.5	-57.19	1.73	-55.46	-6.08	49.38
	3710	-43.15	1.92	-41.23	-6.08	35.15
	4637.5	-69.47	3.17	-66.3	-6.08	60.22
	5565	-68.06	3.66	-64.4	-6.08	58.32
	6492.5	-54	3.2	-50.8	-6.08	44.72
	7420	-65.4	2.45	-62.95	-6.08	56.87
	8347.5	-65.04	3.71	-61.33	-6.08	55.25
	9275	-53.77	3.52	-50.25	-6.08	44.17

Frequency Span: 30MHz-5GHz	
Frequency Span: 5GHz-10GHz	

Plot 14: Conducted Spurious Emissions Plot – Low Channel (LORA Radio: 902-928 MHz)

Frequency Span: 30MHz-5GHz	
Frequency Span: 5GHz-10GHz	

Plot 15: Conducted Spurious Emissions Plot – Mid Channel (LORA Radio: 902-928 MHz)

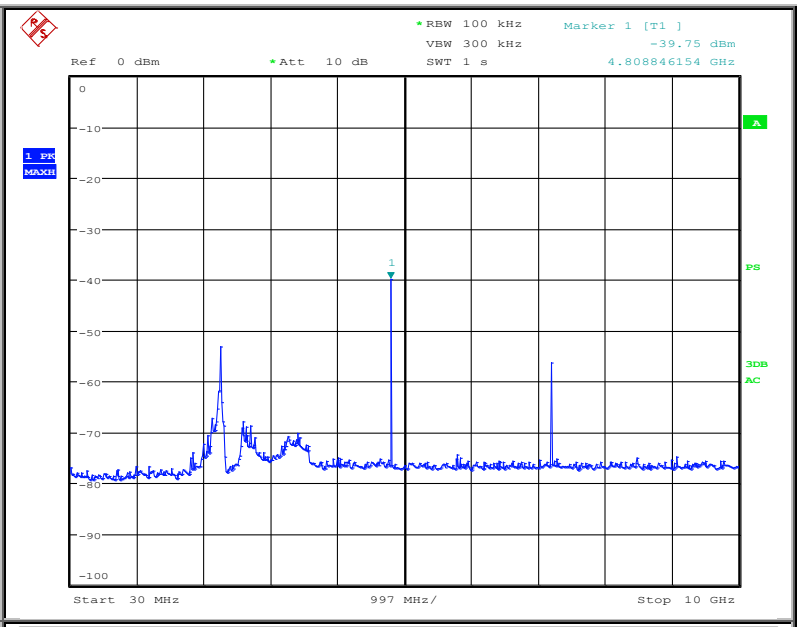
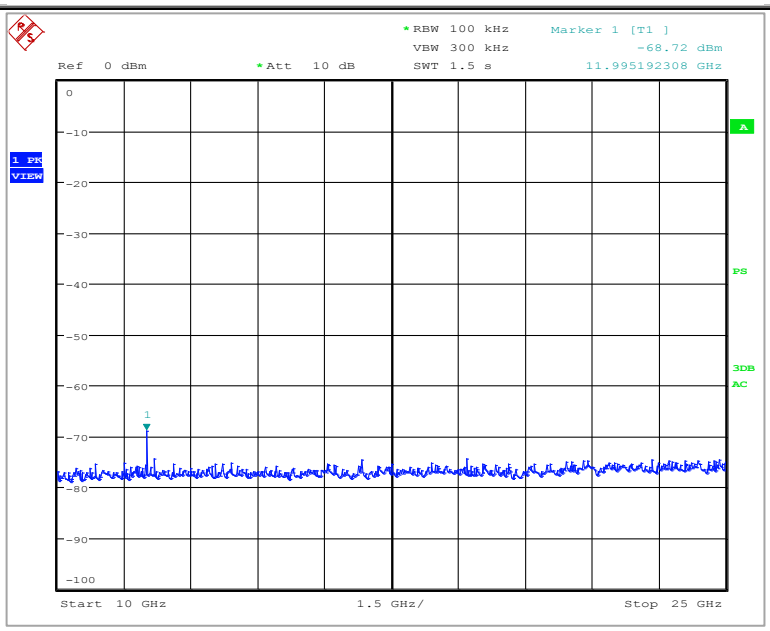
Frequency Span: 30MHz-5GHz	
Frequency Span: 5GHz-10GHz	

Plot 16: Conducted Spurious Emissions Plot – Hi Channel (LORA Radio: 902-928 MHz)

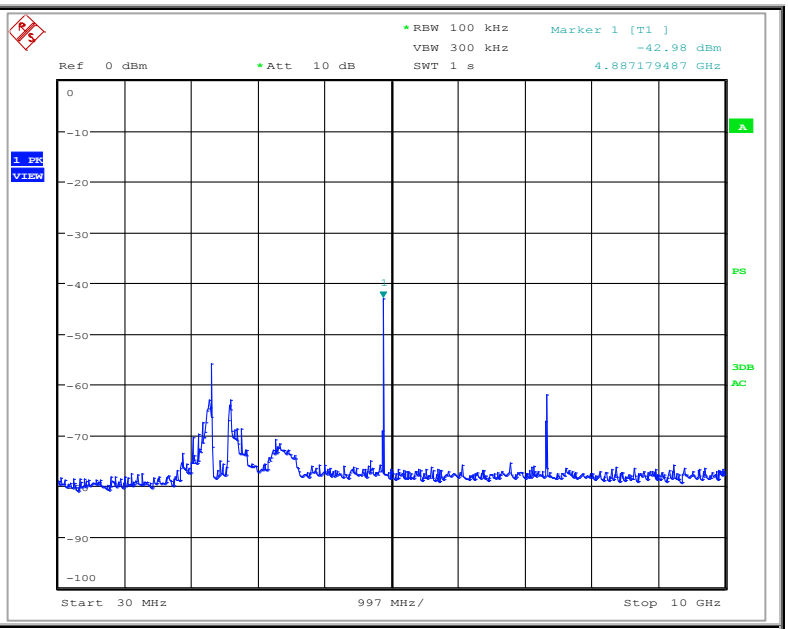
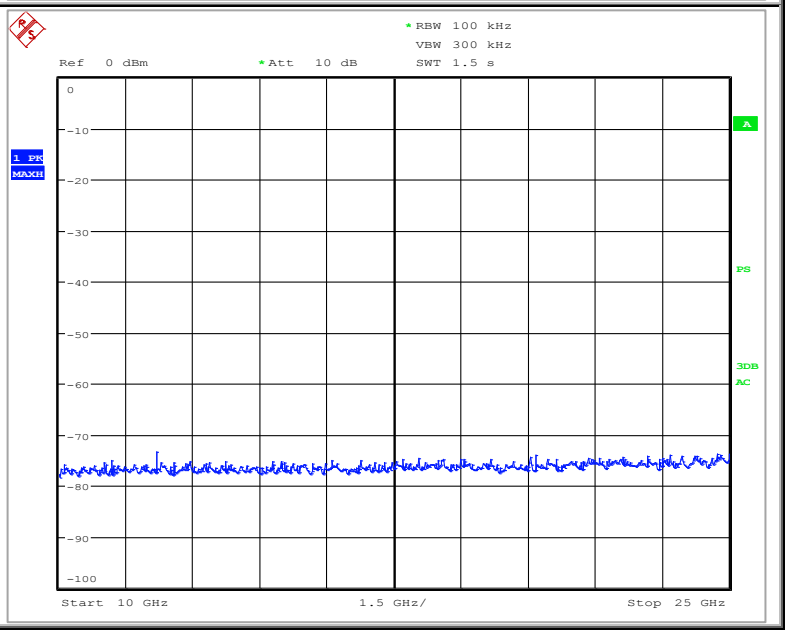
BLE Radio (2400-2483.5 MHz) Data and Plot

Table 13: Conducted Spurious Emissions Data (BLE Radio: 2400-2483.5 MHz)

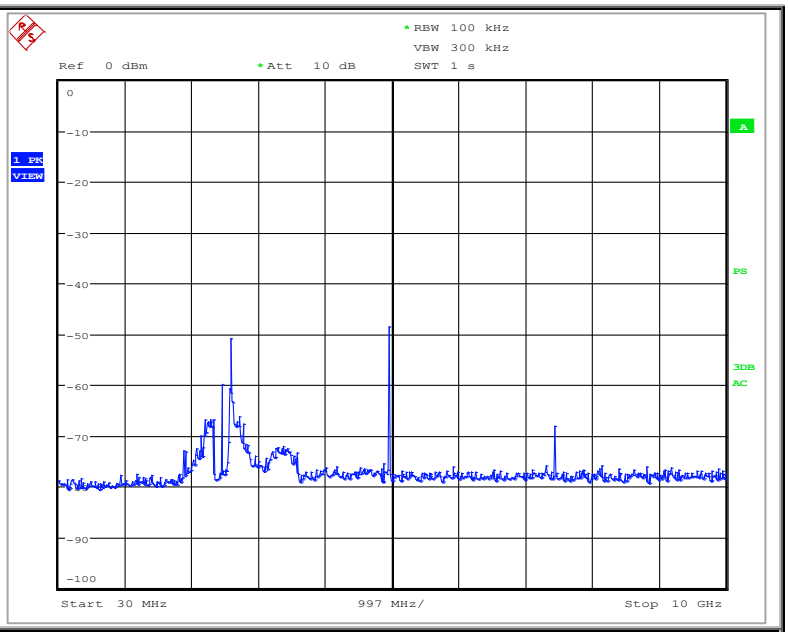
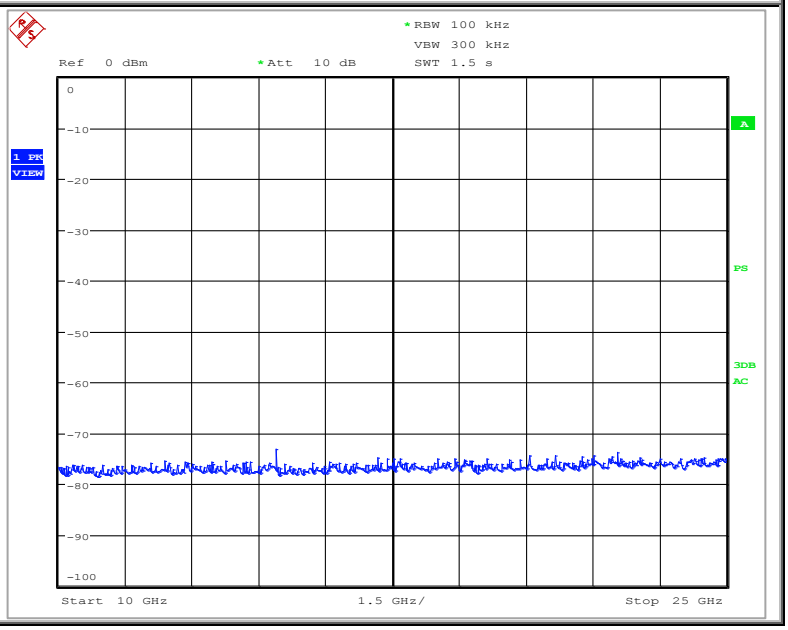
Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Loss (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low Channel 2402MHz	4804	-39.33	2.26	-37.07	-17.5	19.57
	7206	-55.77	2.44	-53.33	-17.5	35.83
	9608	-75	3.91	-71.09	-17.5	53.59
	12010	-64.65	4.74	-59.91	-17.5	42.41
	14412	-75.73	8.76	-66.97	-17.5	49.47
	16814	-70.91	8.53	-62.38	-17.5	44.88
Mid Channel 2440MHz	4880	-42.35	2.84	-39.51	-17.43	22.08
	7320	-59.34	3.12	-56.22	-17.43	38.79
	9760	-75	4.73	-70.27	-17.43	52.84
	12200	-71.32	4.69	-66.63	-17.43	49.2
	14640	-74	9.36	-64.64	-17.43	47.21
	17080	-73.13	8.58	-64.55	-17.43	47.12
Hi Channel 2480MHz	4960	-46.46	2.23	-44.23	-17.65	26.58
	7440	-66.1	3.15	-62.95	-17.65	45.3
	9920	-75.7	4.46	-71.24	-17.65	53.59
	12400	-72.5	4.65	-67.85	-17.65	50.2
	14880	-68.09	8.54	-59.55	-17.65	41.9
	17360	-73.6	7.74	-65.86	-17.65	48.21

Frequency Span: 30MHz-10GHz	
Frequency Span: 10GHz-25GHz	

Plot 17: Conducted Spurious Emissions Plot – Low Channel (BLE Radio: 2400-2483.5 MHz)

Frequency Span: 30MHz-10GHz	
Frequency Span: 10GHz-25GHz	

Plot 18: Conducted Spurious Emissions Plot – Mid Channel (BLE Radio: 2400-2483.5 MHz)

Frequency Span: 30MHz-10GHz	
Frequency Span: 10GHz-25GHz	

Plot 19: Conducted Spurious Emissions Plot – Hi Channel (BLE Radio: 2400-2483.5 MHz)

3.8 Radiated Spurious Emissions Transmit Mode

Date Performed:

November 26 – December 5, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- FCC CFR 47 Part 15.209
- FCC CFR 47 Part 15.205
- RSS-247 Issue 1
- RSS-Gen Issue 4

Test Method:

- ANSI C63.10:2013

Test Requirement:

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 20 dB below the level of the fundamental or to the general field strength limits listed in Rss-Gen Issue 4, whichever is less stringent.

In measuring unwanted emissions, the spectrum shall be investigated from 30 MHz or the lowest radio frequency signal generated in the equipment, whichever is lower, without going below 9 kHz, up to at least the frequency if the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. **Unwanted emissions falling into restricted bands of shall comply with the limits specified below**

Frequency (MHz)	Field Strength	
	uV/m @ 3-m	Calculated dBµV/m at 3m
30 – 88	100	49.5
88 - 216	150	54.0
216 - 960	200	56.9
960 - 1000	500	60.0

FCC PART 15.205-RESTRICTED BANDS OF OPERATION

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1] 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

*** - note FCC-specific .**

Canada-specific frequency ranges in MHz – 3.020-3.026, 5.677–5.683, 121.94-123.0. 149.9-150.05, 162.0125-167.17, 167.72-173.2, 1300-1427, 2483.5-2500, 3500-3600,

(2) Above 38,6 GHz

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in § 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in § 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in § 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in § 15.35 apply to these measurements.

RESTRICTED FREQUENCY BANDS (RSS-GEN ISSUE 4)

MHz
0.090-0.110
2.1735-2.1905
3.020-3.026
4.125-4.128
4.17725-4.17775
4.20725-4.20775
5.677-5.683
6.215-6.218
6.26775-6.26825
6.31175-6.31225
8.291-8.294
8.362-8.366
8.37625-8.38675
8.41425-8.41475
12.29-12.293
12.51975-12.52025
12.57675-12.57725
13.36-13.41
16.42-16.423
16.69475-16.69525
16.80425-16.80475
25.5-25.67
37.5-38.25
73-74.6
74.8-75.2
108-138
156.52475-156.52525
156.7-156.9

MHz
240-285
322-335.4
399.9-410
608-614
960-1427
1435-1626.5
1645.5-1646.5
1660-1710
1718.8-1722.2
2200-2300
2310-2390
2655-2900
3260-3267
3332-3339
3345.8-3358
3500-4400
4500-5150
5350-5460
7250-7750
8025-8500

GHz
9.0-9.2
9.3-9.5
10.6-12.7
13.25-13.4
14.47-14.5
15.35-16.2
17.7-21.4
22.01-23.12
23.6-24.0
31.2-31.8
36.43-36.5
Above 38.6

Note: Certain frequency bands listed in Table 3 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in the 200– and 300– series RSSs, such as RSS-210 and RSS-310, which contain the requirements that apply to licence-exempt radio apparatus.

Test Setup:

The EUT was tested in our 3 m SAC and was positioned on the center of the turntable. The transmitter was set for continuous transmission. The lowest, middle and highest channels in the 902-928 MHz and 2400-2483.5 MHz bands were measured for all radiated emissions 10kHz to 18 GHz. The EUT was pre-scanned in 3 different orthogonal orientations and was found to radiate highest when placed flat on the table top as indicated in the test photos.

Measurement Method:

ANSI C63.10:2013 radiated emissions procedure was followed to demonstrate the compliance of both radios.

Modifications:

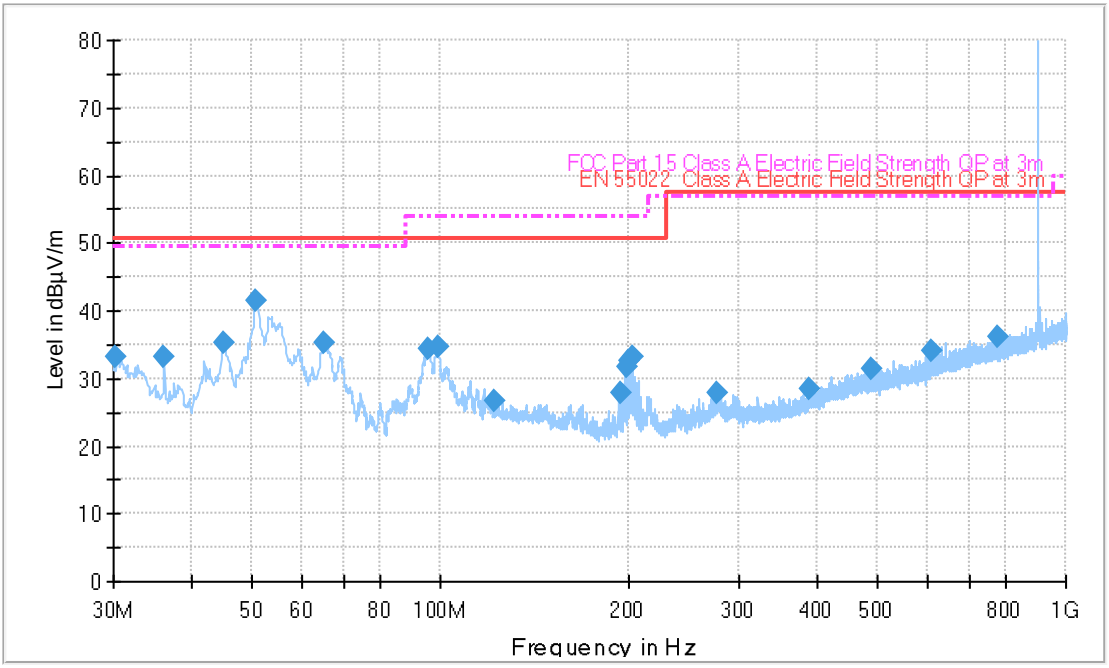
No modification was required to comply for this test.

Final Result:

The EUT complies with the applicable standard.

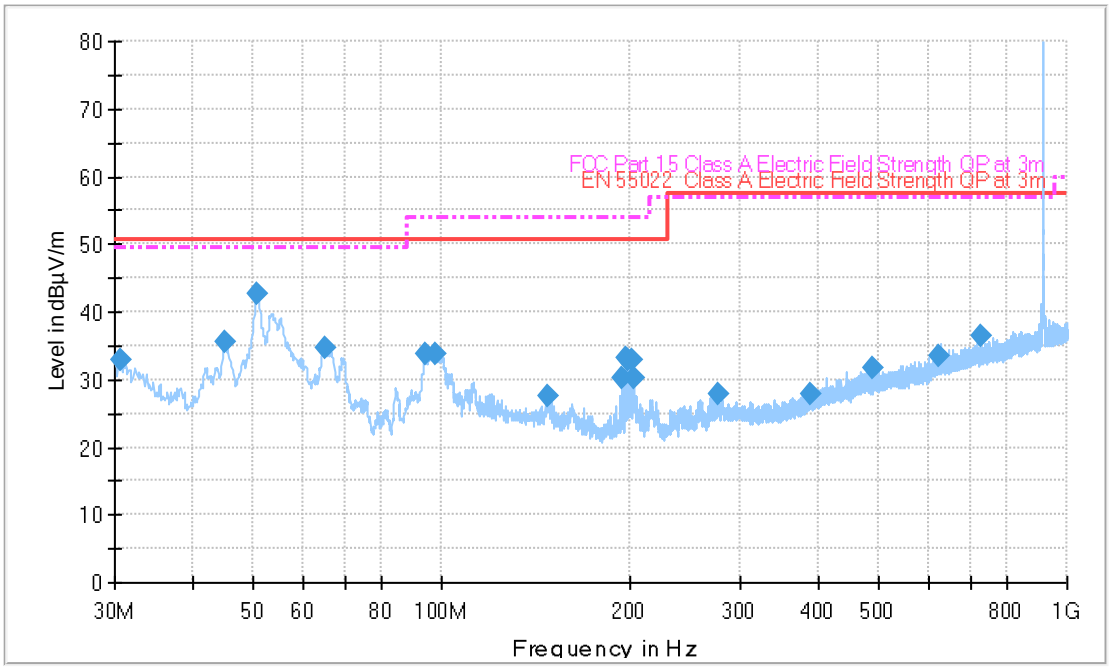
Measurement Data and Plot:

LORA Radio with Nearson S1551AH-915S 915MHz, +2.0dBi omni whip Antenna(902-928 MHz) Data and Plot



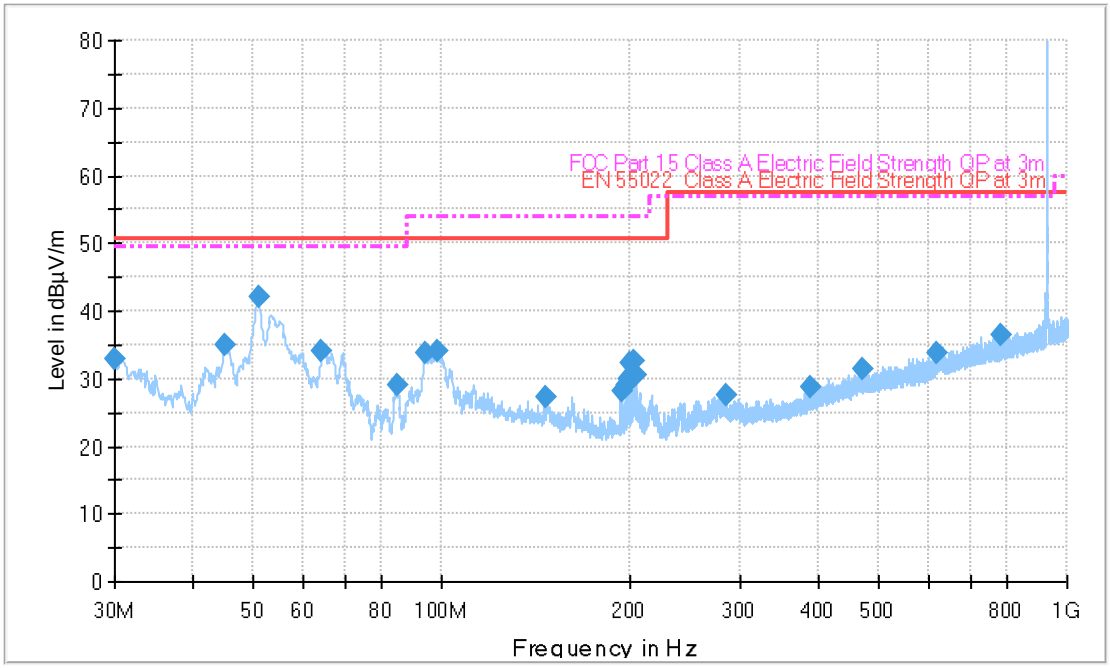
Plot 20: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 30-1000MHz

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



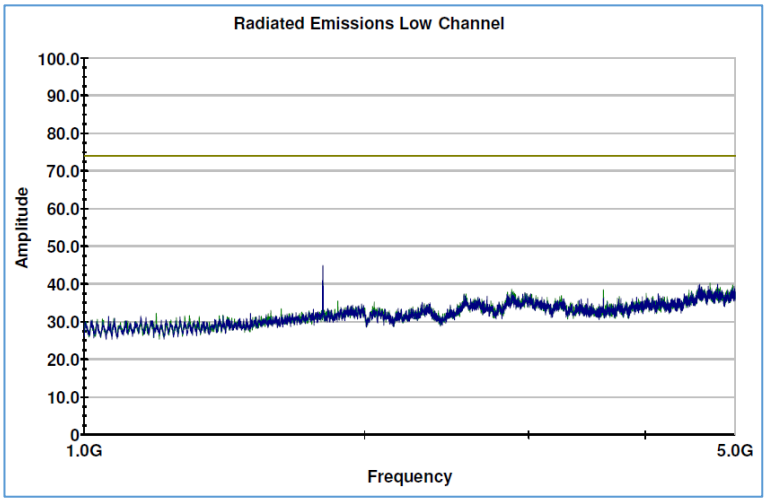
Plot 21: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 30-1000MHz

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*

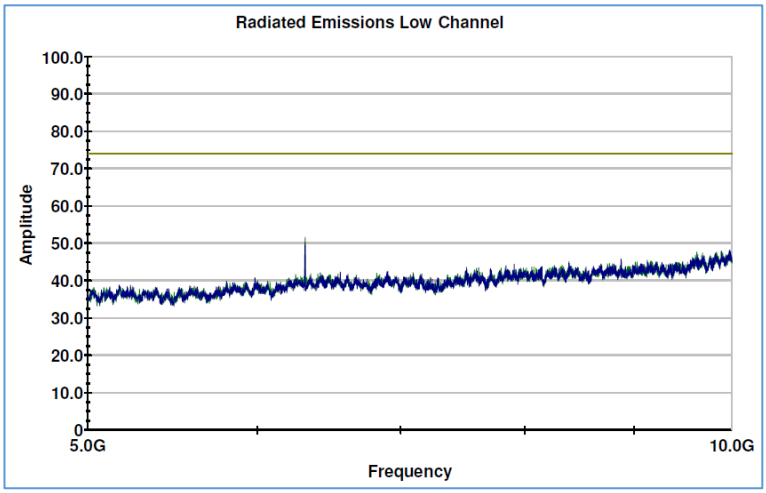


Plot 22: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 30-1000MHz

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



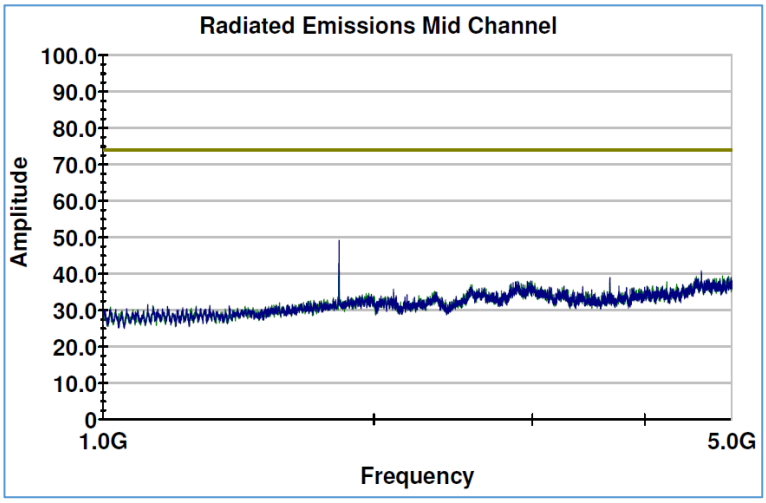
Plot 23: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 1-5GHz



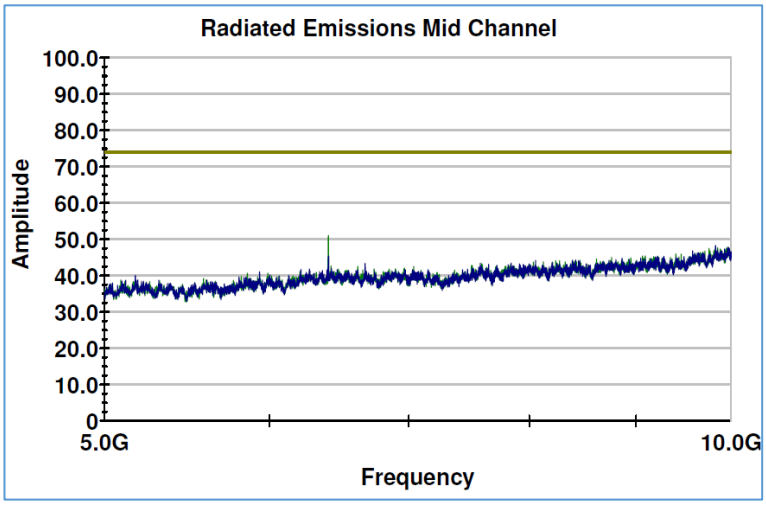
Plot 24: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 5-10GHz

Table 14: TX Mode (Low Channel) – Radiated Spurious Emissions Data: 1-10GHz (LORA Radio Type- RPSMA(F) omni whip)

Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
1805	51.7	46.5	V	321.5	108	30.5	-34.6	47.6	42.4	94	76.2	46.4	33.8
1805	47.6	36.5	H	321	100	30.5	-34.6	43.5	32.4	94	76.2	50.5	43.8
2707.5	46.7	35	V	32.6	208	33	-32.8	46.9	35.2	74	54	27.1	18.8
2707.5	46.6	33.7	H	360	203	33	-32.8	46.8	33.9	74	54	27.2	20.1
3610	46.7	33.3	V	100	160	33.2	-31	48.9	35.5	74	54	25.1	18.5
3610	44.9	31.5	H	0	150	33.2	-31	47.1	33.7	74	54	26.9	20.3
5415.5	41.2	25.4	H	0	150	34.5	-25.4	50.3	34.5	74	54	23.7	19.5
6317.5	49.2	38.8	V	346	140	35.6	-26.6	58.2	47.8	94	76.2	35.8	28.4
6317.5	49.1	39	H	0	180	35.6	-26.6	58.1	48	94	76.2	35.9	28.2
9025	45	31.8	V	15	150	36.3	-24.1	57.2	44	74	54	16.8	10
9025	46.1	32.1	H	345	168	36.3	-24.1	58.3	44.3	74	54	15.7	9.7



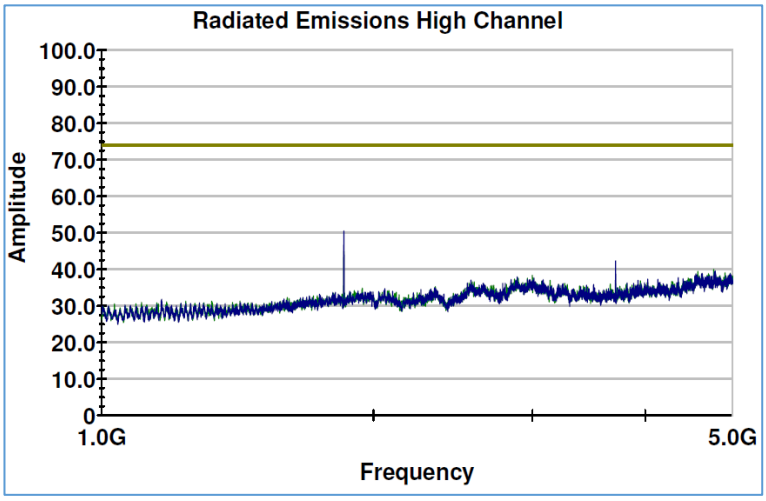
Plot 25: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 1-5GHz



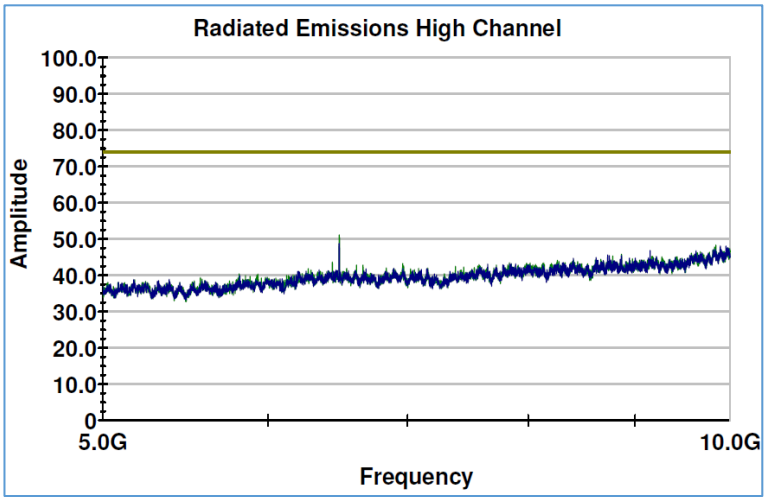
Plot 26: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 5-10GHz

Table 15: TX Mode (Mid Channel) – Radiated Spurious Emissions Data: 1-10GHz

Freq. (MHz)	Raw Pk (dBuV/ m)	Raw Ave. (dBuV/ m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/ m)	Corr. Ave. (dBuV/ m)	Peak Limit (dBuV/ m)	Ave Limit (dBuV/ m)	Peak Margin (dB)	Average Margin (dB)
1830	53.8	49.4	V	60	220	30.5	-33.6	50.7	46.3	94	76.2	43.3	29.9
1830	47.9	37.1	H	330	100	30.5	-33.6	44.8	34	94	76.2	49.2	42.2
2745	46	33.3	V	300	230	33	-32.1	46.9	34.2	74	54	27.1	19.8
2745	47.1	34.6	H	267	230	33	-32.1	48	35.5	74	54	26	18.5
3660	45	32.7	V	330	220	33.2	-31	47.2	34.9	74	54	26.8	19.1
3660	44.5	31.3	H	220	230	33.2	-31	46.7	33.5	74	54	27.3	20.5
5490	41.6	28	H	0	160	34.5	-27.7	48.4	34.8	94	76.2	45.6	41.4
6405	50.2	39.2	V	130	258	35.6	-25.6	60.2	49.2	94	76.2	33.8	27
6405	51.7	40.9	H	0	215	35.6	-25.6	61.7	50.9	94	76.2	32.3	25.3
9150	45.6	31.5	V	0	150	36.3	-25.2	56.7	42.6	74	54	17.3	11.4
9150	44.7	30.5	H	340	232	36.3	-25.2	55.8	41.6	74	54	18.2	12.4



Plot 27: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 1-5GHz

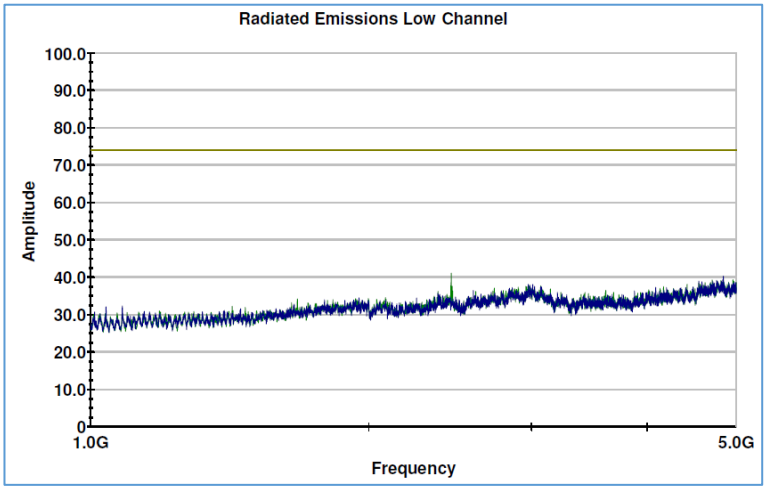


Plot 28: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 5-10GHz

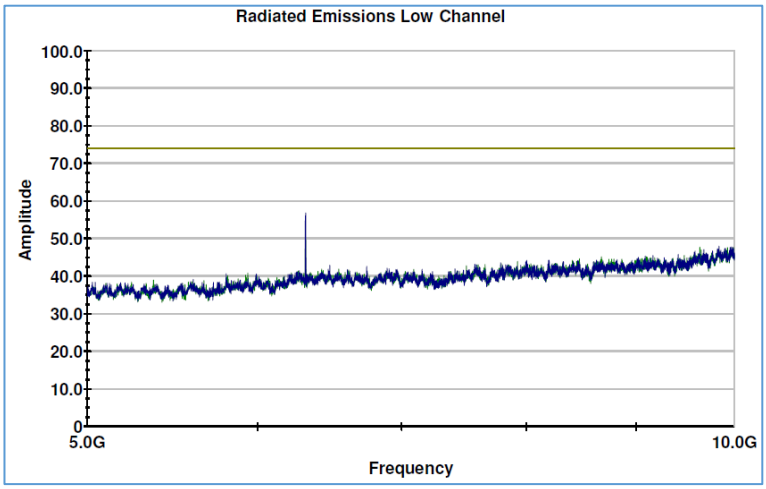
Table 16: TX Mode (High Channel) – Radiated Spurious Emissions Data: 1-10GHz

Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
1855	55.5	52	V	20	230	30.5	-33.3	52.7	49.2	95.3	77.5	42.6	28.3
1855	50	41.3	H	0	230	30.5	-33.3	47.2	38.5	95.3	77.5	48.1	39
2782.5	47	33.6	V	0	300	33	-31.7	48.3	34.9	74	54	25.7	19.1
2782.5	47.6	34.5	H	0	100	33	-31.7	48.9	35.8	74	54	25.1	18.2
3710	44.3	33	V	230	250	33.2	-30	47.5	36.2	74	54	26.5	17.8
3710	43.3	29.6	H	0	220	33.2	-30	46.5	32.8	74	54	27.5	21.2
5565	42.5	28.7	V	0	180	34.5	-27.8	49.2	35.4	95.3	77.5	46.1	42.1
5565	43.8	29.8	H	0	100	34.5	-27.8	50.5	36.5	95.3	77.5	44.8	41
6492.5	47.6	35.5	V	0	200	35.6	-26.4	56.8	44.7	95.3	77.5	38.5	32.8
6492.5	46.9	33.4	H	83	200	35.6	-26.4	56.1	42.6	95.3	77.5	39.2	34.9

LORA Radio with Laird OD9-8_Gain 8dBi N-Female omni whip (902-928 MHz) Data and Plot



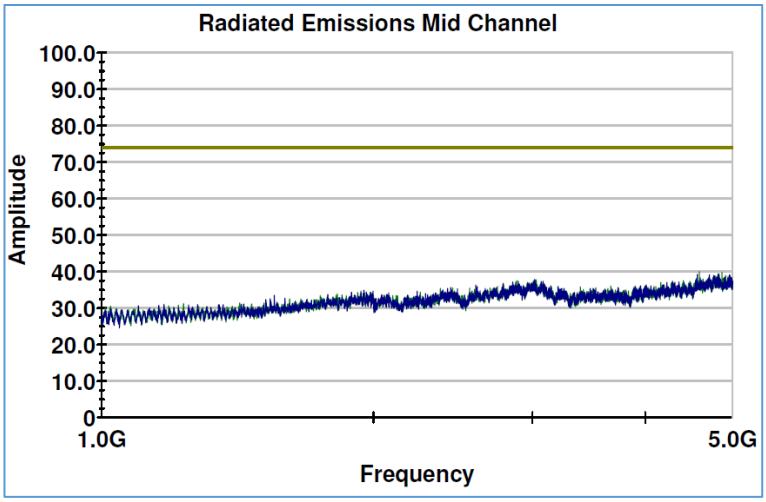
Plot 29: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 1-5GHz (LORA Radio Type- N-Female omni whip)



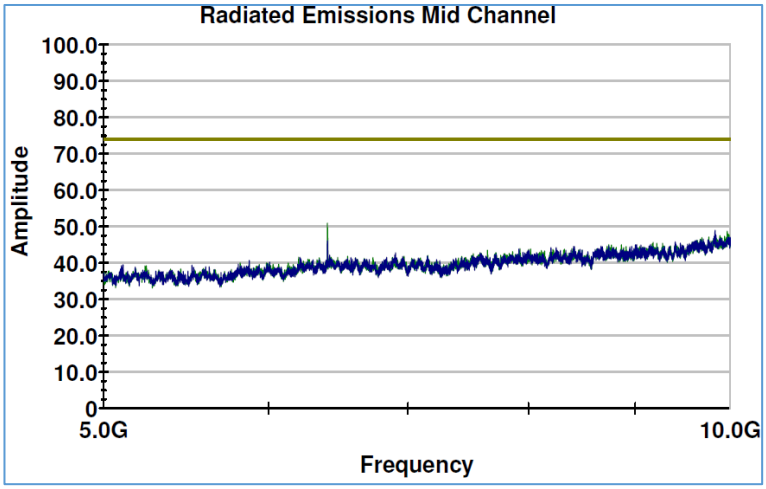
Plot 30: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 5-10GHz (LORA Radio Type- N-Female omni whip)

Table 17: TX Mode (Low Channel) – Radiated Spurious Emissions Data: 1-10GHz (LORA Radio Type- N-Female omni whip)

Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
1805	56.9	54.6	V	0	313	30.5	-34.6	52.8	50.5	74	54	40.3	32.5
1805	50.8	46	H	30	300	30.5	-34.6	46.7	41.9	74	54	46.4	41.1
3610	48.4	42.4	V	340	310	33.2	-31	50.6	44.6	74	54	23.4	9.4
3610	47.1	35.5	H	15	290	33.2	-31	49.3	37.7	74	54	24.7	16.3
6317.5	51.6	49.2	V	50	180	35.6	-26.6	60.6	58.2	74	54	32.5	24.8
6317.5	52.6	48.5	H	45	100	35.6	-26.6	61.6	57.5	74	54	31.5	25.5



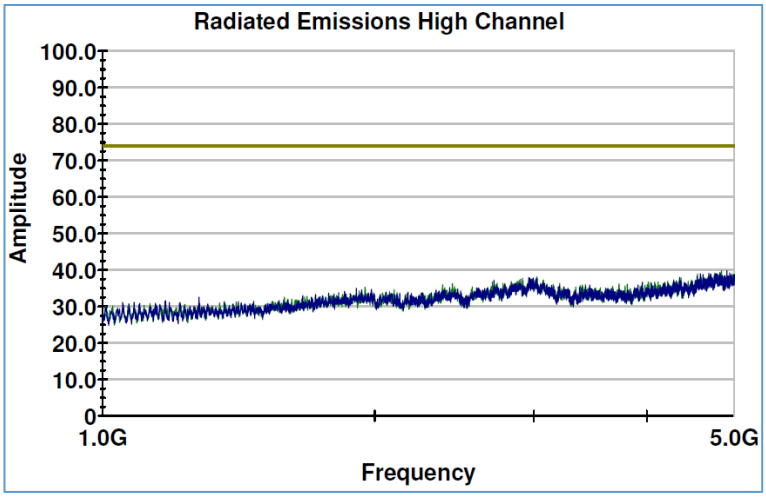
Plot 31: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 1-5GHz (LORA Radio Type- N-Female omni whip)



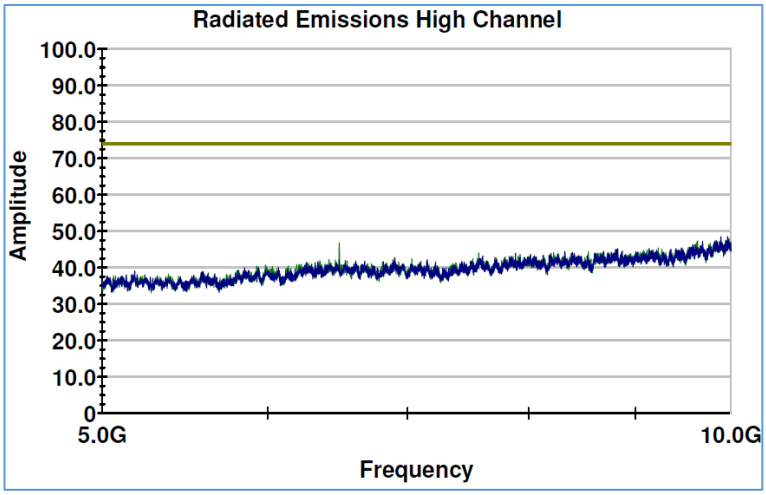
Plot 32: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 5-10GHz (LORA Radio Type- N-Female omni whip)

Table 18: TX Mode (Mid Channel) – Radiated Spurious Emissions Data: 1-10GHz (LORA Radio Type- N-Female omni whip)

Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
1830	58.4	56.8	V	0	313	30.5	-33.6	55.3	53.7	94.5	84.5	39.2	30.8
1830	52	48.2	H	30	300	30.5	-33.6	48.9	45.1	94.5	84.5	45.6	39.4
3660	47.7	41.7	V	340	310	33.2	-31	49.9	43.9	74	54	24.1	10.1
3660	44.5	34	H	15	290	33.2	-31	46.7	36.2	74	54	27.3	17.8
6405	47.8	42.5	V	50	168	35.6	-25.6	57.8	52.5	94.5	84.5	36.7	32
6405	51.1	47.4	H	45	100	35.6	-25.6	61.1	57.4	94.5	84.5	33.4	27.1



Plot 33: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 1-5GHz (LORA Radio Type- N-Female omni whip)

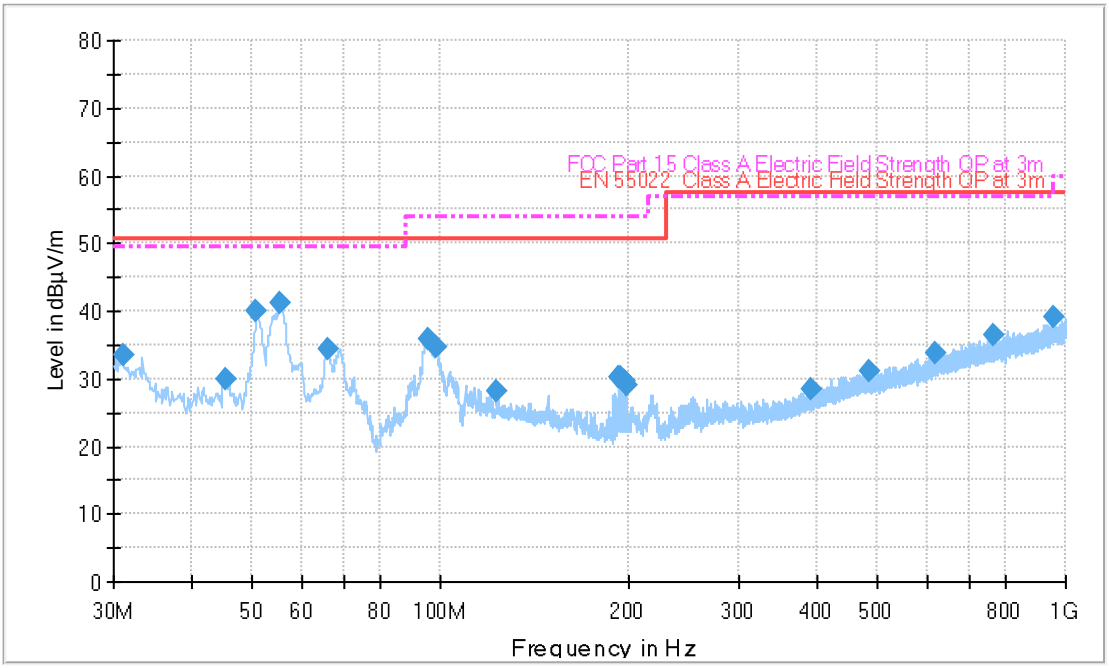


Plot 34: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 5-10GHz (LORA Radio Type- N-Female omni whip)

Table 19: TX Mode (High Channel) – Radiated Spurious Emissions Data: 1-10GHz (LORA Radio Type- N-Female omni whip)

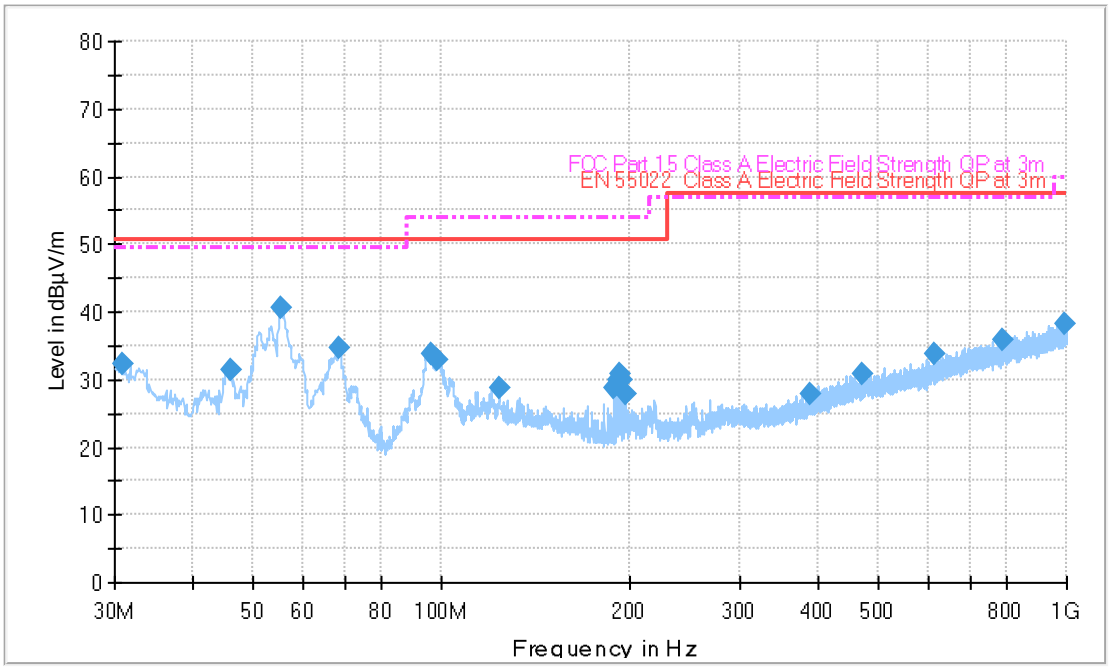
Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
1855	59.4	58.2	V	0	313	30.5	-33.3	56.6	55.4	94.1	84.1	37.5	28.7
1855	54.4	51.1	H	30	300	30.5	-33.3	51.6	48.3	94.1	84.1	42.5	35.8
3710	47.7	42.8	V	340	310	33.2	-30	50.9	46	74	54	23.1	8
3710	44.5	35.1	H	15	290	33.2	-30	47.7	38.3	74	54	26.3	15.7
6492.5	47.3	43.3	V	50	168	35.6	-26.4	56.5	52.5	94.1	84.1	37.6	31.6
6492.5	50.8	47.4	H	47.8	150	35.6	-26.4	60	56.6	94.1	84.1	34.1	27.5

BLE Radio (2400-2483.5 MHz) Data and Plot



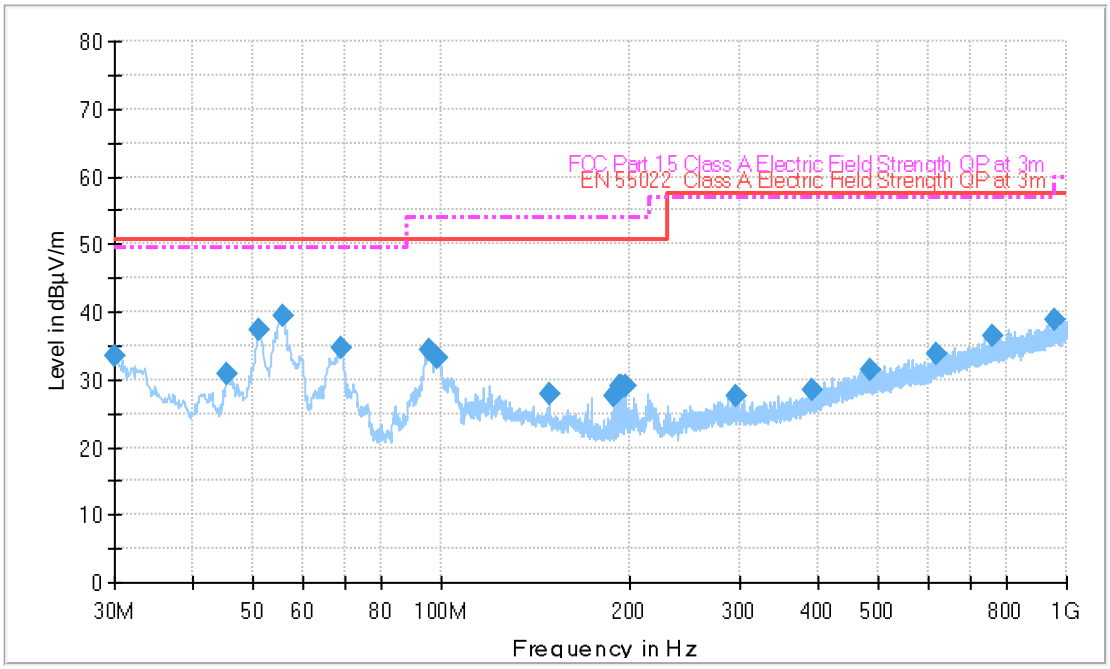
Plot 35: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 30-1000MHz (BLE Radio)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



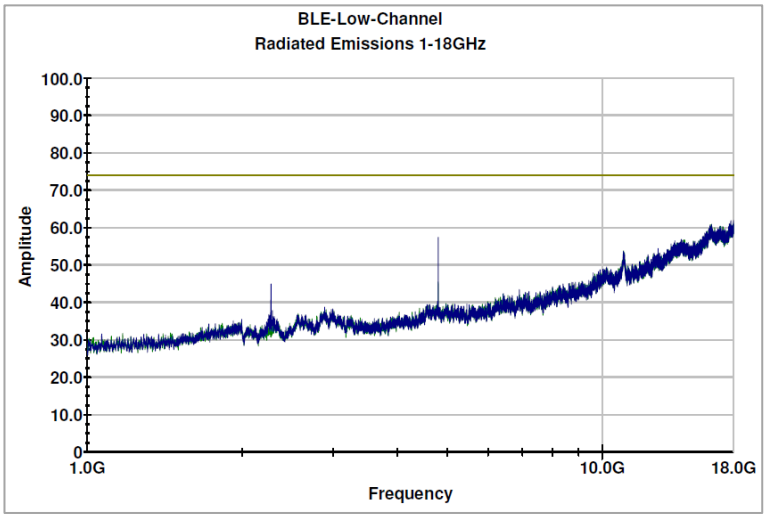
Plot 36: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 30-1000MHz (BLE Radio)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



Plot 37: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 30-1000MHz (BLE Radio)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*

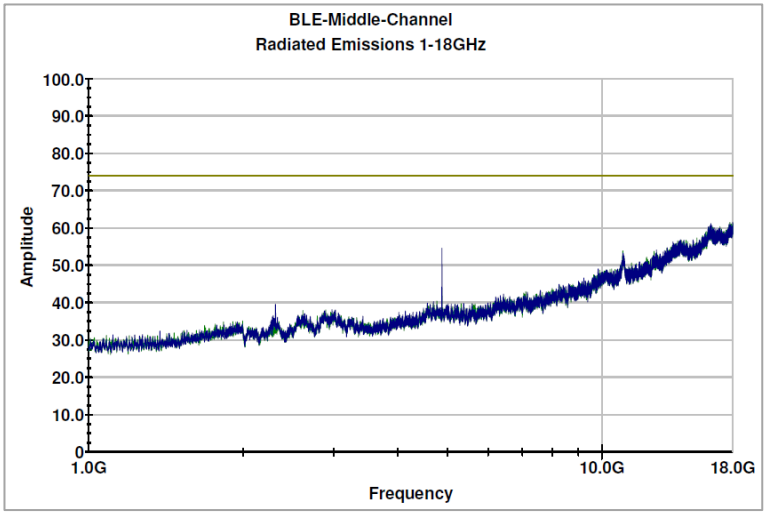


Plot 38: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 1-18GHz (BLE Radio)

Table 20: TX Mode (Low Channel) – Radiated Spurious Emissions Data: 1-18GHz (BLE Radio)

Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Duty Cycle Corr. Factor (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Ave. Margin (dB)
4804	53.9	49.7	V	180.9	102	34.1	-30.3	20	57.7	37.7	74	54	16.3	16.3
4804	48.6	42.2	H	100	156.4	34.1	-30.3	20	52.4	32.4	74	54	21.6	21.6
7206	46.4	34.8	V	0	220	35.6	-26.7	20	55.3	35.3	74	54	18.7	18.7
7206	46.8	34.4	H	113	200	35.6	-26.7	20	55.7	35.7	74	54	18.3	18.3

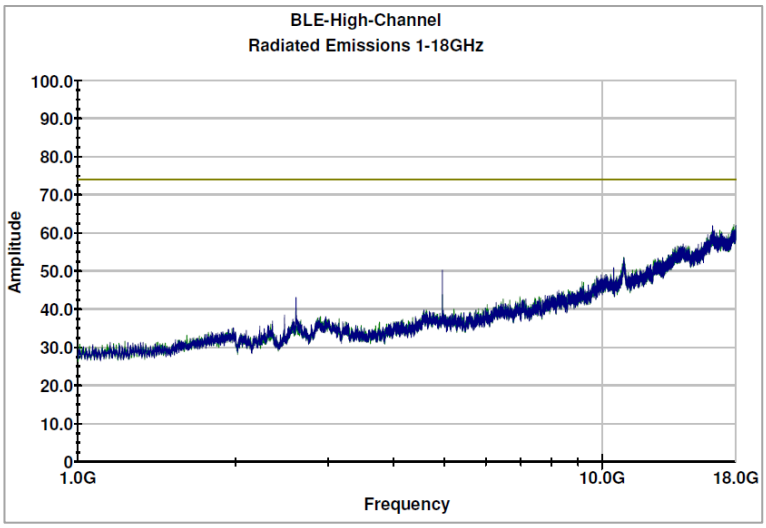
Note: *Bluetooth low energy radio has very low duty cycle due to which measured duty cycle correction factor is high i.e. -49.84dB (see part 3.11 of this report). However, in above data 20dB of duty cycle correction factor is used to demonstrate the compliance for reference.*



Plot 39: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 1-18GHz (BLE Radio)

Table 21: TX Mode (Mid Channel) – Radiated Spurious Emissions Data: 1-18GHz (BLE Radio)

Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Duty Cycle Corr. Factor (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Ave. Margin (dB)
4880	53.2	48.9	V	168.4	100	34.1	-30.3	20	57	37	74	54	17	17
4880	48.7	42.2	H	348.5	100	34.1	-30.3	20	52.5	32.5	74	54	21.5	21.5
7320	45.9	34.4	V	322.1	100	35.6	-27.2	20	54.3	34.3	74	54	19.7	19.7
7320	45.3	33.6	H	338.7	100	35.6	-27.2	20	53.7	33.7	74	54	20.3	20.3
Note: *Bluetooth low energy radio has very low duty cycle due to which measured duty cycle correction factor is high i.e. -49.84dB (see part 3.11 of this report). However, in above data 20dB of duty cycle correction factor is used to demonstrate the compliance for reference.*														

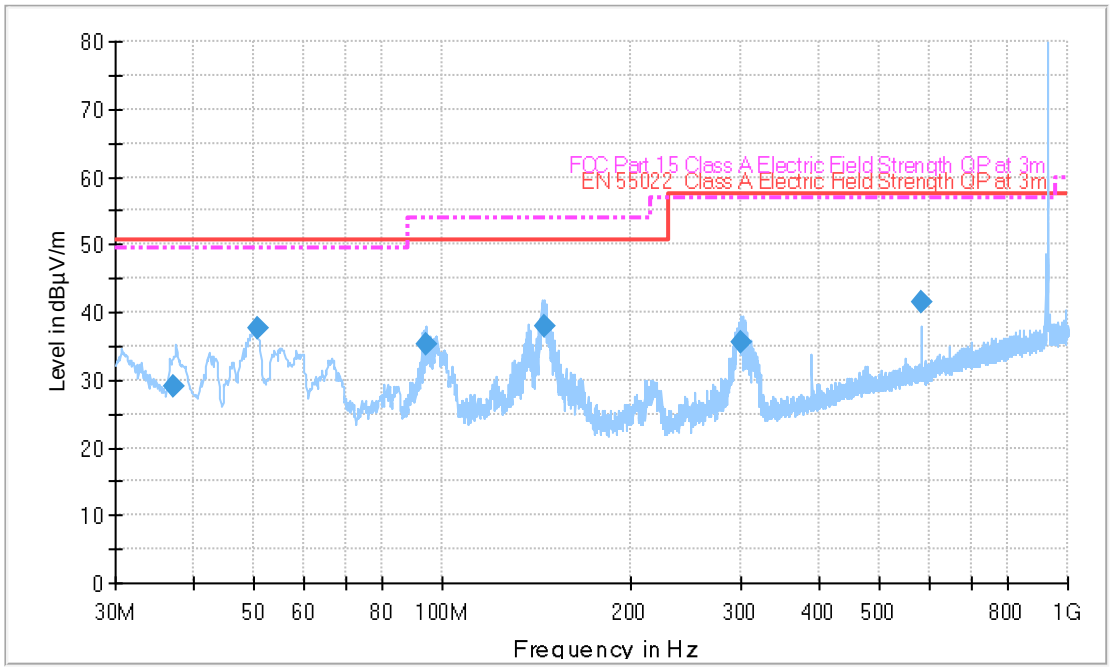


Plot 40: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 1-18GHz (BLE Radio)

Table 22: TX Mode (High Channel) – Radiated Spurious Emissions Data: 1-18GHz (BLE Radio)

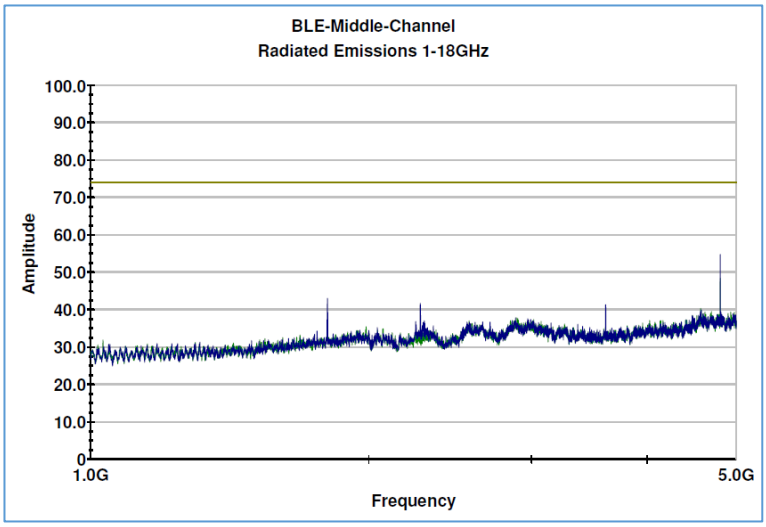
Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Duty Cycle Corr. Factor (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Ave. Margin (dB)
4960	49.9	45	V	11.7	112.3	34.1	-30.9	20	53.1	33.1	74	54	20.9	20.9
4960	47.1	39.5	H	341.8	100	34.1	-30.9	20	50.3	30.3	74	54	23.7	23.7
7440	44.4	31	V	0	100	35.6	-26.7	20	53.3	33.3	74	54	20.7	20.7
7440	45.5	32.6	H	148.3	223.2	35.6	-26.7	20	54.4	34.4	74	54	19.6	19.6
Note: *Bluetooth low energy radio has very low duty cycle due to which measured duty cycle correction factor is high i.e. -49.84dB (see part 3.11 of this report). However, in above data 20dB of duty cycle correction factor is used to demonstrate the compliance for reference.*														

Collocation Radiated Spurious Emissions Test Data and Plot

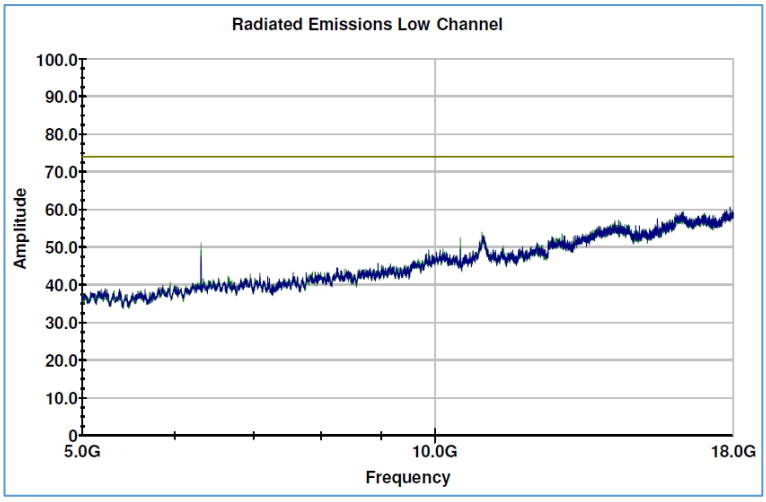


Plot 41: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 30-1000MHz (LORA and BLE are ON)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



Plot 42: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 1-5GHz (LORA and BLE are ON)



Plot 43: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 5-18GHz (LORA and BLE are ON)

Final Result for Collocation Data:

There were no intermodulation frequencies detected during the simultaneous transmission of the two radio modules. Peaks showing in the plots are harmonics of the fundamental frequencies.

3.9 Radiated Spurious Emissions Receive Mode

Date Performed:

November 26, 2016

Test Standard:

- FCC CFR 47 Part 15.247
- FCC CFR 47 Part 15.209
- ICES-003 Issue 6
- RSS-Gen Issue 4

Test Method:

- ANSI C63.4-2014

Test Requirement:

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 20 dB below the level of the fundamental or to the general field strength limits listed in Rss-Gen Issue 4, whichever is less stringent.

In measuring unwanted emissions, the spectrum shall be investigated from 30 MHz or the lowest radio frequency signal generated in the equipment, whichever is lower, without going below 9 kHz, up to at least the frequency if the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

Unwanted emissions falling into restricted bands of shall comply with the limits specified below

Frequency (MHz)	Field Strength	
	uV/m @ 3-m	Calculated dBµV/m at 3m
30 – 88	100	49.5
88 - 216	150	54.0
216 - 960	200	56.9
960 - 1000	500	60.0

Test Setup:

The EUT was tested in our 3 m SAC and was positioned on the center of the turntable. The transmitter was set for continuous transmission. The lowest, middle and highest channels in the 902-928 MHz and 2400-2483.5 MHz band were measured for all radiated emissions 10kHz to 18 GHz. The EUT was pre-scanned in 3 different orthogonal orientations and was found to radiate highest when placed flat on the table top as indicated in the test photos.

Measurement Method:

Measurements were made using spectrum analyser and receiver, 200Hz RBW average detector for the frequency range 9-150KHz; 9kHz RBW average detector for the Frequency range 150kHz to 30MHz; 120kHz RBW quasi-peak detector using the appropriate antennas, amplifiers and filters.

The measurement results are obtained as described below:

E [dBµV/m] = Un-Corrected Value + ATOT

Where ATOT is total correction factor including cable loss, antenna factor and preamplifier gain (ATOT = LCABLES + AF - AMP).

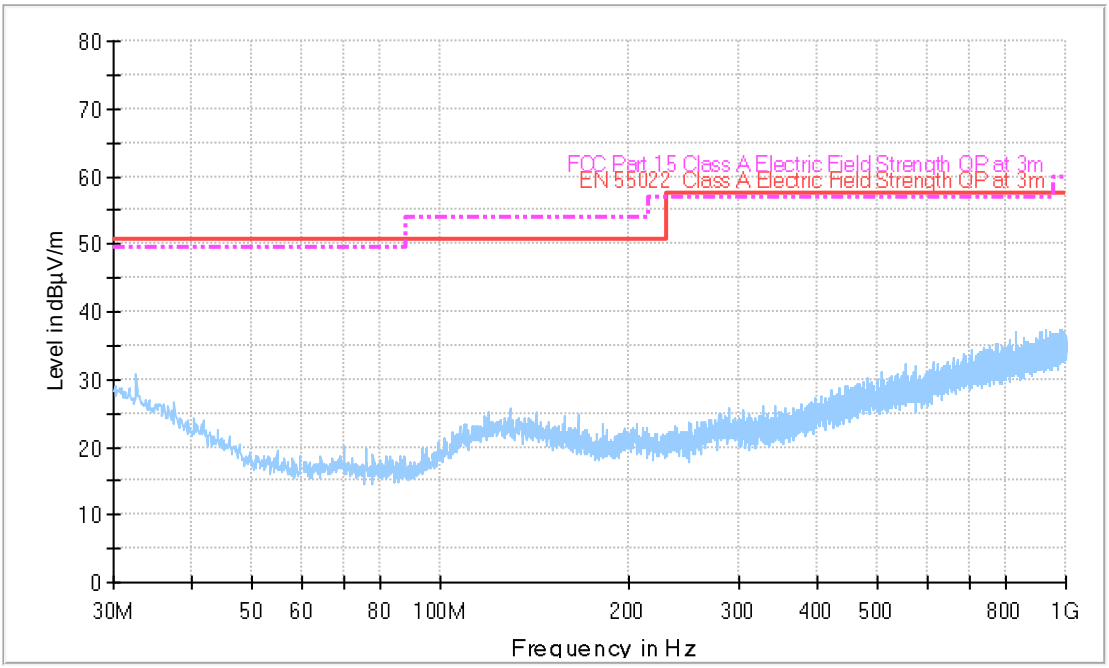
Modifications:

No modification was required to comply for this test.

Final Result:

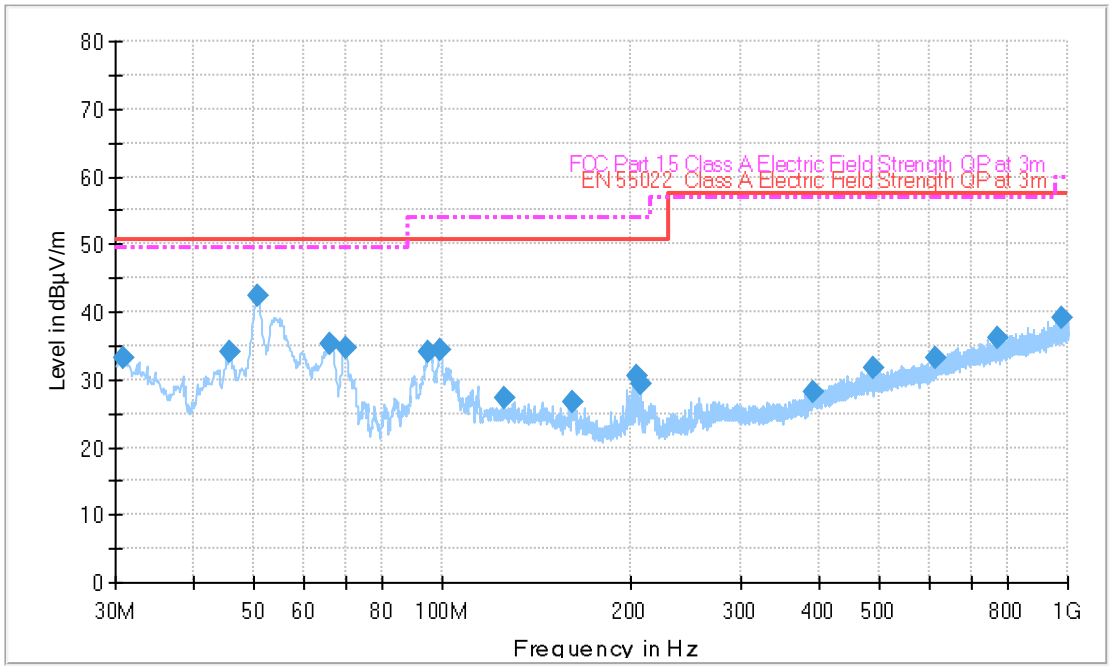
The EUT complies with the applicable standard.

Measurement Data and Plot:



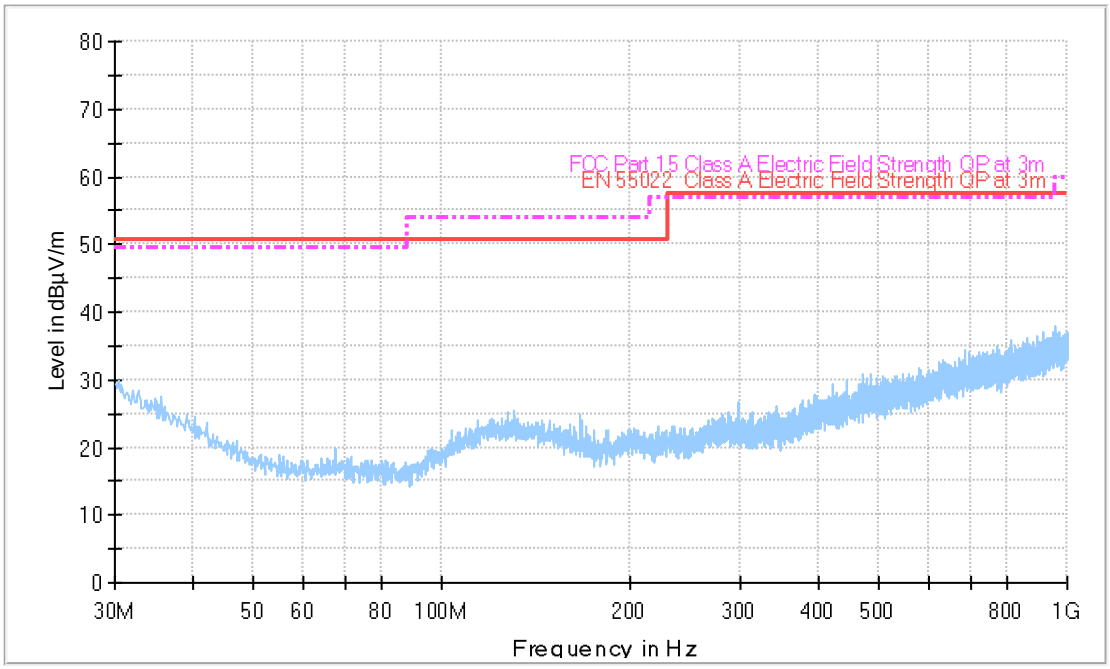
Plot 44: Radiated Spurious Emissions Plot: 30-1000MHz (Battery was used – Standby Mode)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



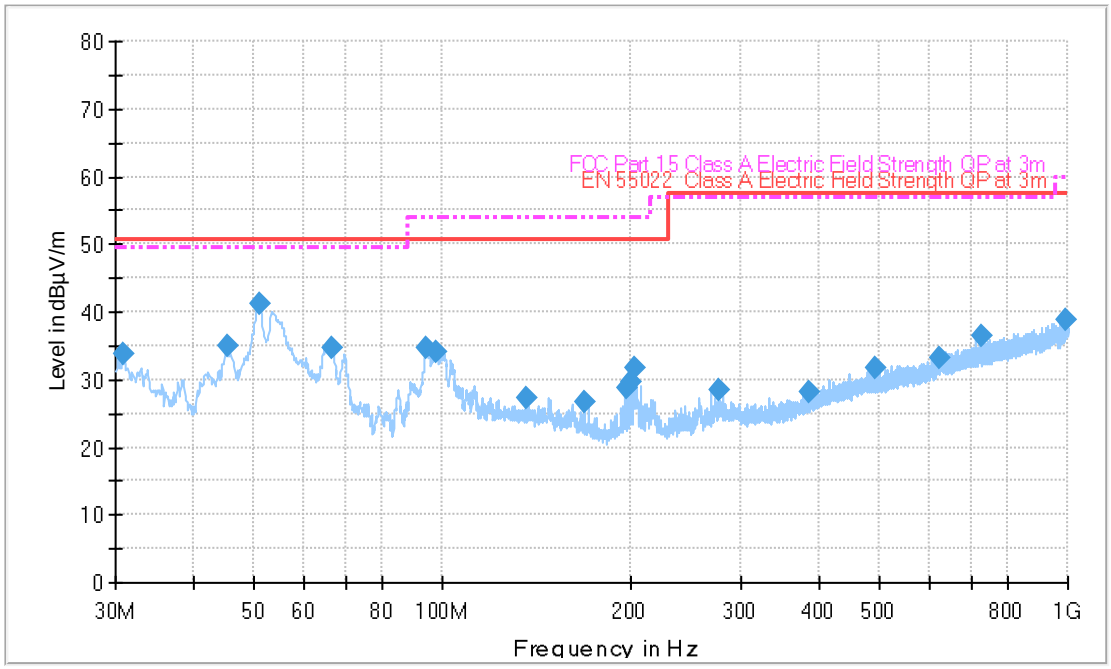
Plot 45: Radiated Spurious Emissions Plot: 30-1000MHz (Power Supply was used – Standby Mode)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



Plot 46: Radiated Spurious Emissions Plot: 30-1000MHz (Battery was used – Receive Mode – LORA and BLE are ON)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



Plot 47: Radiated Spurious Emissions Plot: 30-1000MHz (Power Supply was used – Receive Mode – LORA and BLE are ON)

Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*

3.10 AC Mains Conducted Emissions

Date Performed:

December 15, 2016

Test Standard:

- FCC CFR 47 Part 15.207
- ICES-003 Issue 6
- RSS-Gen Issue 4

Test Method:

- ANSI C63.4-2014

Test Requirement:

Class A Limit

Frequency (MHz)	Conducted Limit (dBµV)	
	Quasi-Peak	Average
0.15 - 0.50	79	66
0.5 - 30	73	60
Note 1 The lower limit shall apply at the transition frequencies		

Test Setup:

The EUT was connected to the conducted emissions LISN apparatus.

Measurement Method:

Measurements were made using a test receiver with 9 kHz bandwidth, CISPR Quasi-Peak and Average detector.

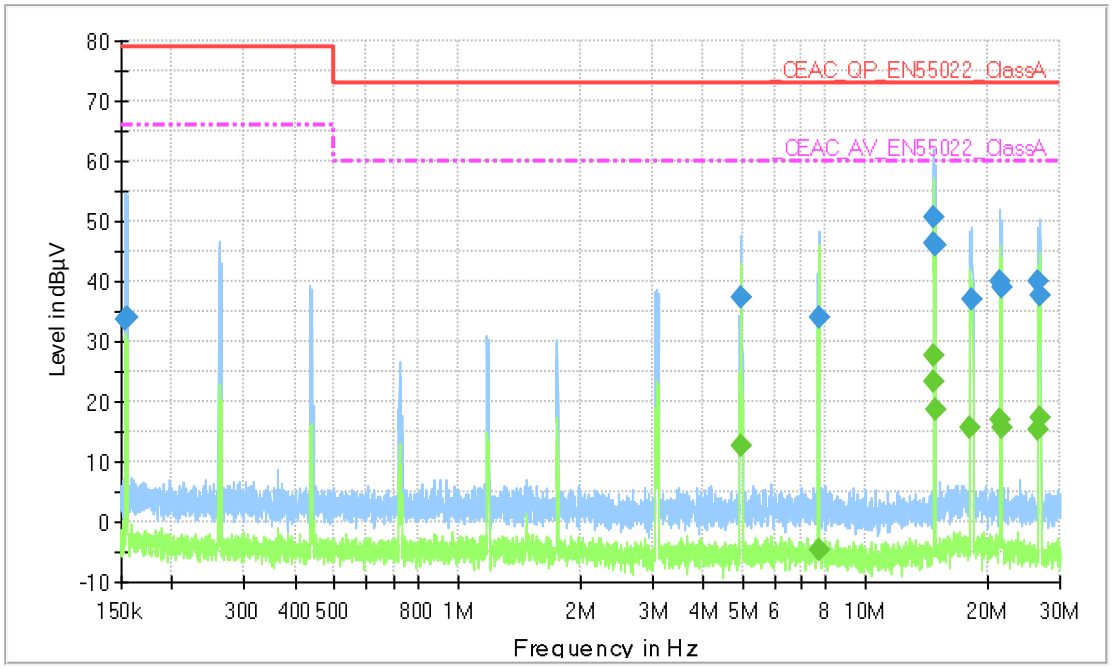
Modifications:

No modification was required to comply for this test.

Final Result:

The EUT complies with the applicable standard.

Measurement Data and Plot:



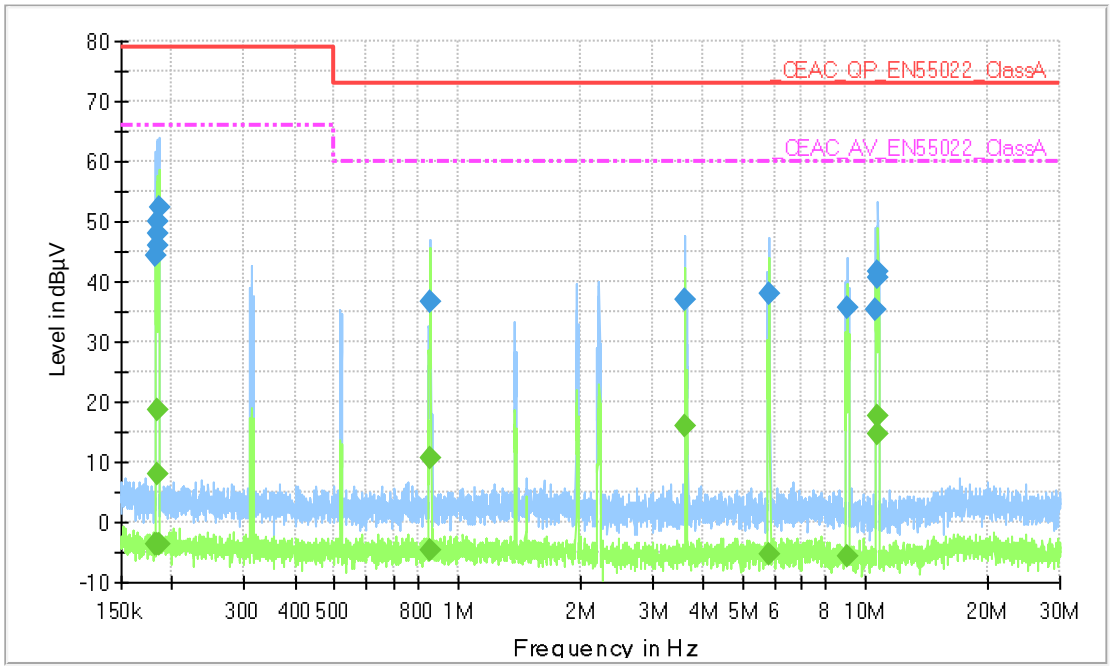
Plot 48: AC Mains Conducted Emissions Plot (Both Radios ON at Low Channel) – Line 1

Table 23: Quasi-peak Data of AC Mains Conducted Emissions (Both Radios ON at Low Channel) – Line 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.153488	33.7	1000.000	9.000	GND	10.5	45.3	79.0
0.155030	33.9	1000.000	9.000	GND	10.5	45.1	79.0
4.956469	37.5	1000.000	9.000	GND	10.5	35.5	73.0
7.725076	33.9	1000.000	9.000	GND	10.6	39.1	73.0
14.663974	46.3	1000.000	9.000	GND	10.6	26.7	73.0
14.766930	50.5	1000.000	9.000	GND	10.6	22.5	73.0
14.870609	46.1	1000.000	9.000	GND	10.7	26.9	73.0
18.300910	37.0	1000.000	9.000	GND	10.7	36.0	73.0
21.342487	39.9	1000.000	9.000	GND	10.7	33.1	73.0
21.535340	39.1	1000.000	9.000	GND	10.7	33.9	73.0
26.571663	40.0	1000.000	9.000	GND	10.8	33.0	73.0
26.678109	37.8	1000.000	9.000	GND	10.8	35.2	73.0

Table 24: Average Data of AC Mains Conducted Emissions (Both Radios ON at Low Channel) – Line 1

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
4.951517	12.7	1000.000	9.000	GND	10.5	47.3	60.0
7.717359	-4.7	1000.000	9.000	GND	10.6	64.7	60.0
14.663974	23.3	1000.000	9.000	GND	10.6	36.7	60.0
14.766930	27.7	1000.000	9.000	GND	10.6	32.3	60.0
14.870609	18.7	1000.000	9.000	GND	10.7	41.3	60.0
18.100802	15.5	1000.000	9.000	GND	10.7	44.5	60.0
21.342487	17.1	1000.000	9.000	GND	10.7	42.9	60.0
21.535340	15.8	1000.000	9.000	GND	10.7	44.2	60.0
26.571663	15.5	1000.000	9.000	GND	10.8	44.5	60.0
26.678109	17.4	1000.000	9.000	GND	10.8	42.6	60.0



Plot 49: AC Mains Conducted Emissions Plot (Both Radios ON at Low Channel) – Line 2

Table 25: Quasi-peak Data of AC Mains Conducted Emissions (Both Radios ON at Low Channel) – Line 2

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.182644	44.4	1000.000	9.000	GND	10.5	34.6	79.0
0.183192	46.1	1000.000	9.000	GND	10.5	32.9	79.0
0.183742	47.9	1000.000	9.000	GND	10.5	31.1	79.0
0.184478	50.1	1000.000	9.000	GND	10.5	28.9	79.0
0.185032	52.2	1000.000	9.000	GND	10.5	26.8	79.0
0.857279	36.8	1000.000	9.000	GND	10.4	36.2	73.0
3.621363	36.9	1000.000	9.000	GND	10.5	36.1	73.0
5.810195	37.9	1000.000	9.000	GND	10.5	35.1	73.0
9.046634	35.8	1000.000	9.000	GND	10.6	37.2	73.0
10.618047	35.4	1000.000	9.000	GND	10.6	37.6	73.0
10.671244	41.5	1000.000	9.000	GND	10.6	31.5	73.0
10.767670	40.8	1000.000	9.000	GND	10.6	32.2	73.0

Table 26: Average Data of AC Mains Conducted Emissions (Both Radios ON at Low Channel) – Line 2

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.182644	-3.7	1000.000	9.000	GND	10.5	69.7	66.0
0.183192	18.7	1000.000	9.000	GND	10.5	47.3	66.0
0.183926	7.8	1000.000	9.000	GND	10.5	58.2	66.0
0.184478	-3.6	1000.000	9.000	GND	10.5	69.6	66.0
0.185217	-3.7	1000.000	9.000	GND	10.5	69.7	66.0
0.857279	10.5	1000.000	9.000	GND	10.4	49.5	60.0
0.859854	-4.8	1000.000	9.000	GND	10.4	64.8	60.0
3.621363	16.0	1000.000	9.000	GND	10.5	44.0	60.0
5.810195	-5.3	1000.000	9.000	GND	10.5	65.3	60.0
9.046634	-5.7	1000.000	9.000	GND	10.6	65.7	60.0
10.671244	17.7	1000.000	9.000	GND	10.6	42.3	60.0
10.767670	14.6	1000.000	9.000	GND	10.6	45.4	60.0

3.11 Duty Cycle Correction Factor

Date Performed:

December 7, 2016

Test Standard:

- FCC CFR 47 Part 15.35 (d)
- ICES-003 Issue 6

Test Method:

- ANSI C63.10-2013

Measurement Method:

The FCC regulations provide an allowance for correcting pulsed transmissions when the limits are expressed in terms of an average, and the average measurement may be derived from the peak pulse amplitude corrected for the duty cycle.

As detailed in 47 CFR Part 15.35(c), the correction factor of a transmission is a 100 ms capture of a characteristic pulse train of "on time". In the event that the pulse train is greater than 100 ms, the 100 ms pulse train captured must include a representation of worst-case "on time" pulses.

Modifications:

No modification was required to comply for this test.

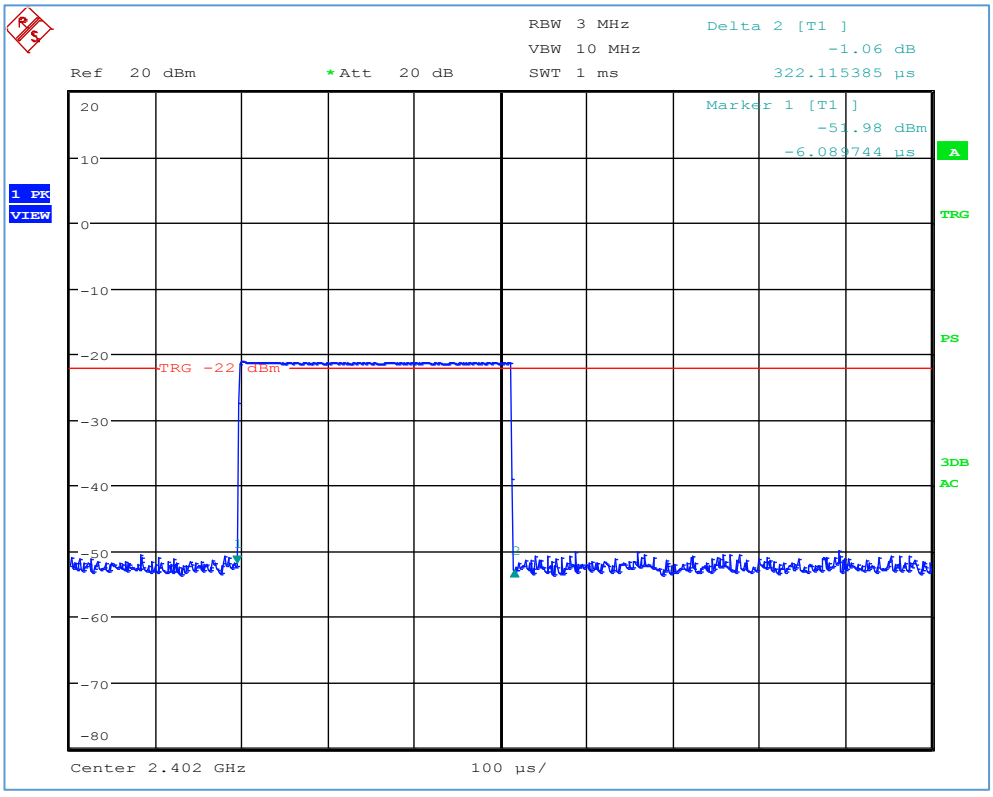
Final Result:

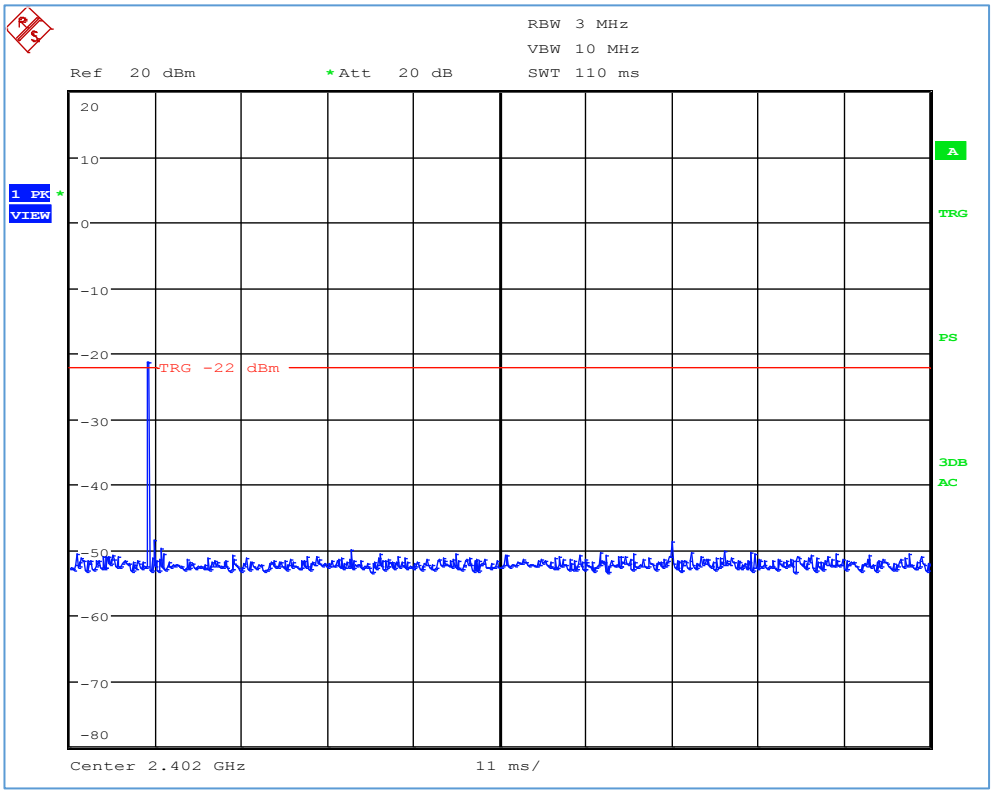
The EUT complies with the applicable standard.

Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

Note: *Lora Radio has a 100% Duty Cycle. Plots and data are not included in this section.*





Plot 50: Duty Cycle Correction Factor Plot

Equation used to calculate Duty Cycle Correction Factor:

$$20 \log\left(\frac{Ton\ in\ ms}{100ms}\right) \qquad \text{unit in } \mathbf{dB}$$

Table 27: Duty Cycle Correction Factor Data

Ton (ms)	0.322115385
Duty Cycle Correction Factor	-49.84 dB

3.12 Frequency Stability

Date Performed:

December 9, 2016

Test Standard:

- FCC CFR 47 Part 15.215(c)
- RSS-Gen Issue 4

Test Method:

- ANSI C63.10 2013

Test Setup:

FCC (15.215(c)): The 20dB bandwidth must remain within the designated frequency band over the expected variations in temperature and voltage range.

Rss-Gen Issue 4 (8.8): Transmitter frequency stability for licence-exempt radio apparatus shall be measured in accordance with Section 6.11. For licence-exempt radio apparatus, the frequency stability shall be measured at temperatures of -20°C (-4°F), +20°C (+68°F) and +50°C (+122°F) instead of at the temperatures specified in Section 6.11. If the frequency stability of the licence-exempt radio apparatus is not specified in the applicable standard (RSS), measurement of the frequency stability is not required provided that the occupied bandwidth of the licence-exempt radio apparatus lies entirely outside the restricted bands and the prohibited TV bands of 54-72 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz and 614-806 MHz.

Modifications:

No modification was required to comply for this test.

Performance:

Complies with the applicable standard.

Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

Table 28: Frequency Stability Data (LORA Radio: 902-928 MHz)

Temperature (°C)	Channel	Frequency (MHz)	Offset (MHz)	PPM
-40	Low	902.4927	-0.012	-13.30
	Mid	914.992	-0.0141	-15.41
	High	927.4903	-0.0121	-13.05
20	Low	902.5035	0	0.00
	Mid	915.0043	0	0.00
	High	927.5018	0	0.00
50	Low	902.4954	-0.0052	-5.76
	Mid	914.9999	-0.0035	-3.83
	High	927.4928	-0.0031	-3.34

BLE Radio (2400-2483.5 MHz) Data and Plot

Table 29: Frequency Stability Data (BLE Radio: 2400-2483.5 MHz)

Temperature (°C)	Channel	Frequency (MHz)	Offset (MHz)	PPM
-40	Low	2402.0291	-0.007	-2.91
	Mid	2440.0491	-0.0085	-3.48
	High	2480.0011	-0.022	-8.87
20	Low	2402.0377	0	0.00
	Mid	2440.0577	0	0.00
	High	2480.0126	0	0.00
50	Low	2402.0245	-0.0138	-5.75
	Mid	2440.0345	-0.0076	-3.11
	High	2480.0021	-0.0134	-5.40

3.13 RF Exposure Evaluation

Date Performed:

December 15, 2016

Test Standard:

- FCC CFR 47 §1.1310
- RSS-102 Section 2.5.2

Test Requirement:

FCC CFR 47 §1.1310:

"Radiofrequency radiation exposure limits for General Population/Uncontrolled Exposure at Frequency range 1500 - 100000 MHz: 1.0 mW/cm^2"

RSS-102 Section 2.5.2:

"RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

-at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1.31 x 10-2 f^0.6834 W (adjusted for tune-up tolerance), where f is in MHz

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived."

Host Product:

Internal Product Name: Transmitter Device
Model: A02SG100

Antenna Description:

Description	Manufacturer	Manufacturer's Part #	Value	Type
LORA Antenna	Nearson	S1551AH-915S	915MHz, +2.0dBif	RPSMA(F) omni whip
LORA Antenna (optional high-gain)	Laird	OD9-8	915MHz, +8.0dBi	N-Female omni whip
RF Cable for Optional LORA Antenna	Generic	Generic	5ft	N-Male-to-RPSMA(M)
2.4GHz Antenna Wifi and BLE	LSR	001-0010	2.4GHz, +2.0dBi	RPSMA(F) omni whip

Operating Modes/Configuration:

This unit allows simultaneous transmission of Bluetooth Low Energy (2400-2483.5MHz) and LORA 902-928MHz modules.

All operating modes assume an antenna to person distance of >20cm.

RF Exposure Evaluation Bluetooth Low Energy (BLE):

Maximum peak conducted output power measured for BLE was 3.16dBm when the EUT was operated at 2440MHz.

Frequency (MHz)	Peak Output power (dBm)	Max Gain (dBi)	EIRP (dBm)	EIRP (mW)
2440	3.16	2	5.16	3.280952931

Power Density = $\frac{EIRP}{4\pi r2}$ mW/cm^2

As per above equation power density at 20cm = $\frac{3.2809}{4x3.14x20x20}$ =0.0006 mW/cm^2 which is far below far below the limit 1.0 mW/cm^2 as per FCC 47 CFR §2.1091 & §1.1310

As per **RSS-102 Section 2.5.2:**

> *"RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:*

- *at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1.31 x 10-2 f^0.6834 W (adjusted for tune-up tolerance), where f is in MHz*

As per above equation *source-based, time-averaged maximum e.i.r.p. of the device is equal to or less 2.705W.*

EIRP of this EUT is 3.2809mW which is far below the exemption limit 2.705W as per RSS-102 Section 2.5.2.

RF Exposure Evaluation LORA (902-928MHz) with Nearson with RPSMA(F) omni whip:

Maximum peak conducted output power measured for this module was 14.61dBm when the EUT was operated at 902.5MHz.

Frequency (MHz)	Peak Output power (dBm)	Max Gain (dBi)	EIRP (dBm)	EIRP (mW)
902.5	14.61	2	16.61	45.81418867

Power Density = $\frac{EIRP}{4\pi r2}$ mW/cm^2

As per above equation power density at 20cm = $\frac{45.814}{4x3.14x20x20}$ =0.009 mW/cm^2 which is far below far below the limit 1.0 mW/cm^2 as per FCC 47 CFR §2.1091 & §1.1310

As per **RSS-102 Section 2.5.2:**

> *"RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:*

- *at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1.31 x 10-2 f^0.6834 W (adjusted for tune-up tolerance), where f is in MHz*

As per above equation *source-based, time-averaged maximum e.i.r.p. of the device is equal to or less 2.67W.*

EIRP of this EUT is 45.814mW at 902.5 MHz which is far below the exemption limit 1.37W as per RSS-102 Section 2.5.2.

RF Exposure Evaluation LORA (902-928MHz) with Laird with N-Female omni whip

Maximum peak conducted output power measured for this module was14.61dBm when the EUT was operated at 902.5MHz.

Frequency (MHz)	Peak Output power (dBm)	Max Gain (dBi)	EIRP (dBm)	EIRP (mW)
902.5	14.61	8	22.61	182.389

Power Density = $\frac{EIRP}{4\pi r2}$ mW/cm^2

As per above equation power density at 20cm = $\frac{182.389}{4x3.14x20x20}$ =0.0363 mW/cm^2 which is far below far below the limit 1.0 mW/cm^2 as per FCC 47 CFR §2.1091 & §1.1310

As per **RSS-102 Section 2.5.2:**

> *"RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:*

- *at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1.31 x 10-2 f^0.6834 W (adjusted for tune-up tolerance), where f is in MHz*

As per above equation *source-based, time-averaged maximum e.i.r.p. of the device is equal to or less 1.37W.*

EIRP of this EUT is 182.389mW at 902.5 MHz which is far below the exemption limit 1.37W as per RSS-102 Section 2.5.2.

MPE Co-location Calculation

Formulas

1. Average power density for each transmitter at 20 cm, Seq, is calculated using the following formula:

$$S_{eq} = \frac{P \cdot G}{4\pi \cdot r^2} \times \eta$$

Where
P is the peak power conducted into the antenna
G is the peak antenna gain
Ƞ is the duty cycle of transmissions
R = 20 cm

Then the ratio Seq/Slimit is calculated for all applied limits, where Slim is the limit at the frequency of interest, as specified in section 6. This essentially converts the power densities into unit-less values representing the portion of the power density limit generated by individual transmitters.

Finally, it must be ensured that the sum of all worst case power densities of all active transmitters do not exceed the limits, even if they are far below the limits for the single transmitter. The ratios for all the transmitters calculated in step 2 are summed together in all possible combinations of transmitters such that

$$\sum_{1}^{n} \frac{S_{eq\,n}}{S_{\lim n}} = \frac{S_{eq\,1}}{S_{\lim 1}} + \frac{S_{eq\,2}}{S_{\lim 2}} + \cdots + \frac{S_{eq\,n}}{S_{\lim n}} \leq 1$$

RF Exposure Evaluation of Collocated Bluetooth Low Energy and LORA 902-928MHz transmitter using 2dBi antenna

Modules	Peak Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Duty Cycle (%)	EIRP Adjusted with Duty Cycle	Power Density (Seq) (mw/Cm2)	Slimit (mw/Cm2)	Seq/Slimit (mw/Cm2)
Bluetooth Low energy	3.16	2	5.16	3.28095	0.322	0.0105647	2.10284E-06	1	2.103E-06
LORA 902-928MHz	14.61	2	16.61	45.8142	100	45.814189	0.009119066	1	0.0091191
MPE Total of Collocated Transmitters									0.0091212

Total MPE of collocated transmitters is 0.0091212 which is far below far below the limit of 1.0 when used with the antennas specified.

RF Exposure Evaluation of Collocated Bluetooth Low Energy with 2dBi antenna and LORA 902-928MHz transmitter using 8dBi antenna (Laird with N-Female omni whip)

Modules	Peak Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Duty Cycle (%)	EIRP Adjusted with Duty Cycle	Power Density (Seq) (mw/Cm2)	Slimit (mw/Cm2)	Seq/Slimit (mw/Cm2)
Bluetooth Low energy	3.16	2	5.16	3.28095	0.322	0.0105647	2.10284E-06	1	2.103E-06
LORA 902-928MHz	14.61	8	22.61	182.39	100	182.38957	0.036303656	1	0.0363037
MPE Total of Collocated Transmitters									0.0363058

Total MPE of collocated transmitters is 0.0363058 which is far below far below the limit of 1.0 when used with the antennas specified.

Appendix A: TEST SETUP PICTURES

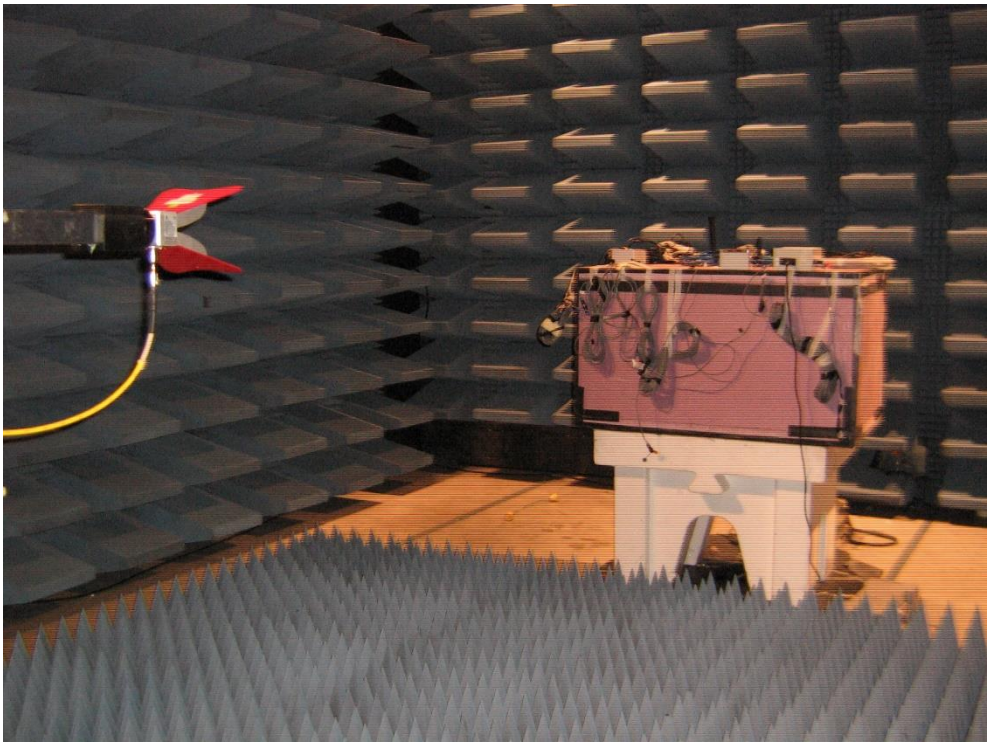


Figure 1: Radiated Emissions (above 1GHz) Test Setup

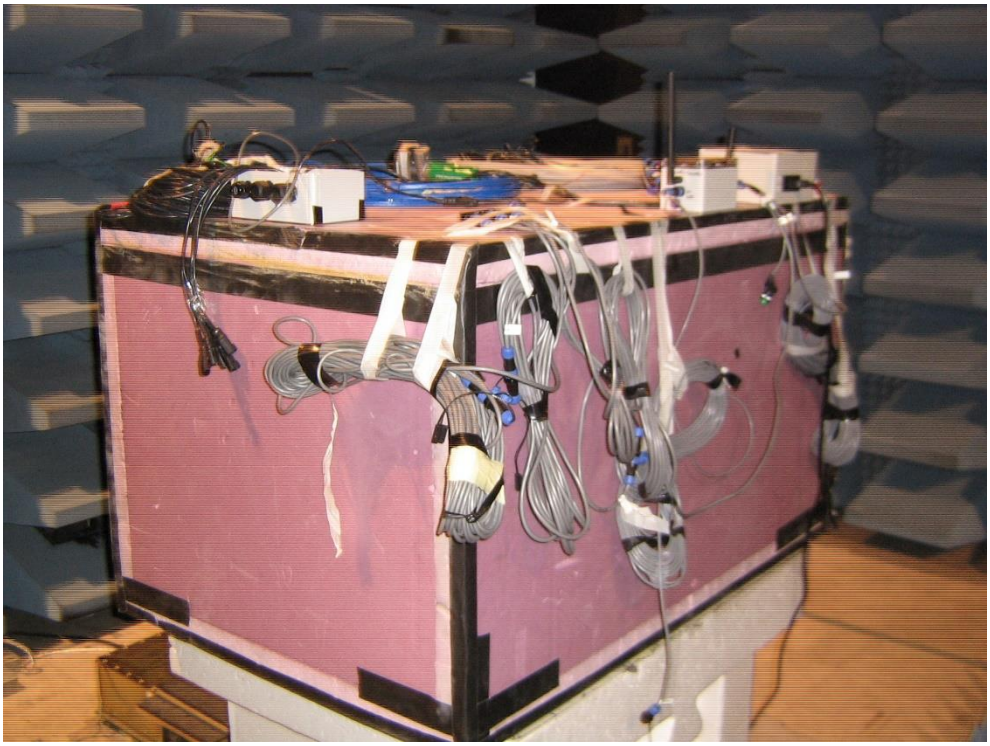


Figure 2: Radiated Emissions (above 1GHz close-up view) Test Setup

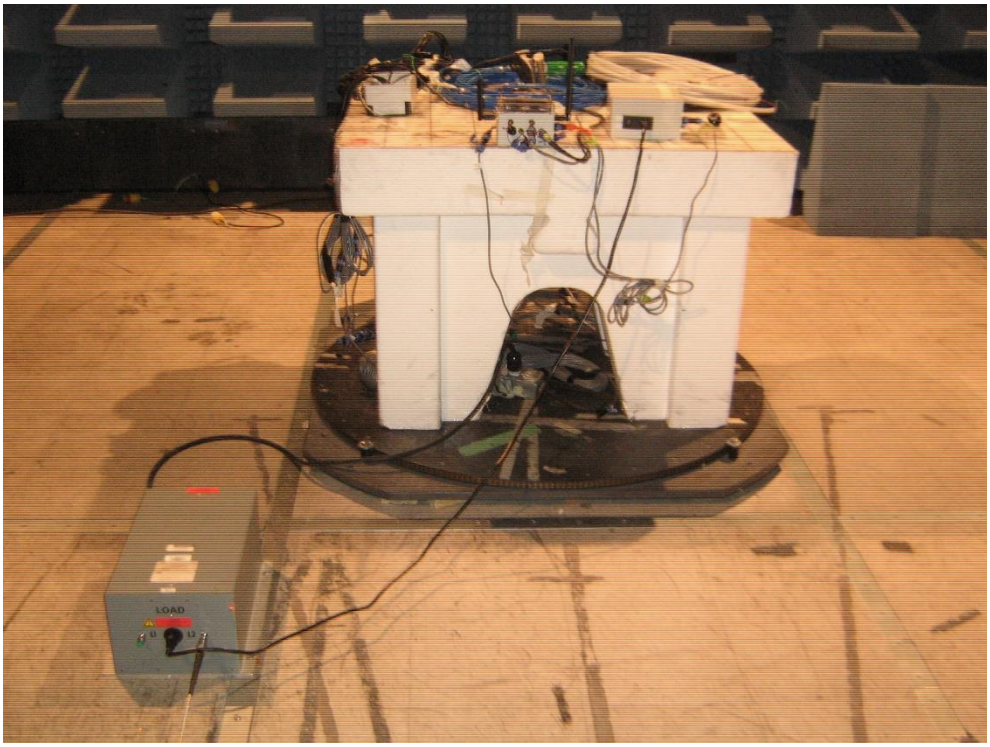


Figure 3: Conducted Emissions Test Setup

Appendix B: ABBREVIATIONS

Abbreviation	Definition
AC	Alternating Current
DC	Direct Current
E.I.R.P.	Equivalent Isotropically Radiated Power
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EUT	Equipment Under Test
FCC	Federal Communications Commission
IC	Industry Canada
ICES	Interference-Causing Equipment Standard
LISN	Line Impedance Stabilizing Network
OATS	Open Area Test Site
RF	Radio Frequency
RMS	Root-Mean-Square
RSS	Radio Standards Specifications
SAC	Semi-Anechoic Chamber

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END OF REPORT