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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	Hub Device
Model Number:	A01SG100
FCC ID:	2AKAAA01SG100
IC Certification Number:	22125-A01SG100
Manufacturer:	Ag Growth International

REVISION HISTORY

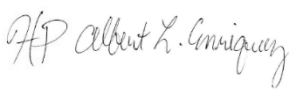
Date	Report Number	Rev #	Details	Author's Initials
Dec 13, 2016	E10819-1603_AGI-Hub	0.0	Draft Test Report	HZ
Dec 20, 2016	E10819-1603_AGI-Hub	0.1	Draft Test Report Update	HZ
Dec 21, 2016	E10819-1603_AGI-Hub	1.0	Final Test Report	HZ
All previous versions of this report have been superseded by the latest dated revision as listed in the above table.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 16SH10271.

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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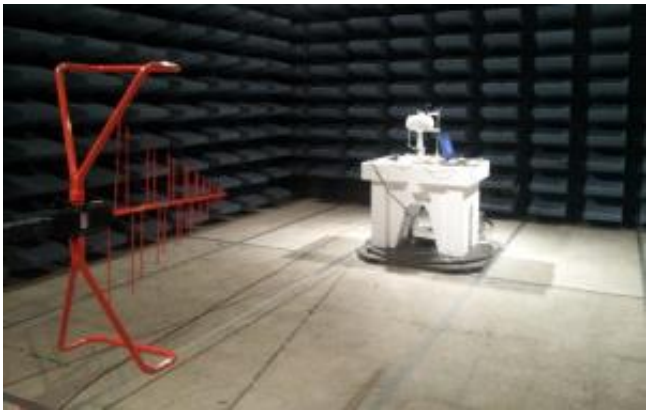
QAI EMC ACCREDITATION

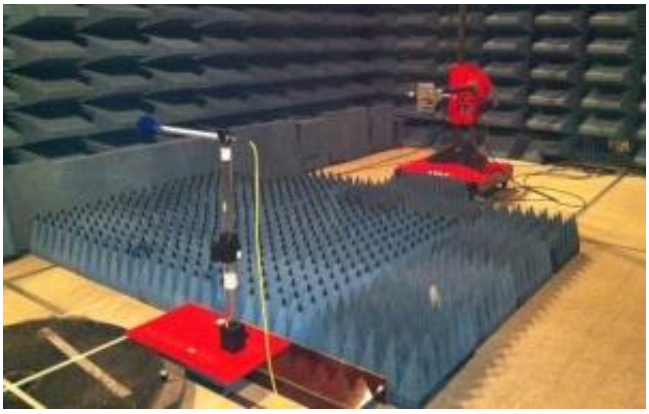
QAI EMC is your one-stop regulatory compliance partner for electromagnetic compatibility (EMC) and electromagnetic interference (EMI). Products are tested to the latest and applicable EMC/EMI requirements for domestic and international markets. QAI EMC goes above and beyond being a testing facility—we 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 "Hub 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 16SH10271:

- **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 "Hub 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	Hub 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 collects data from Transmitters via 900MHz link, and periodically relays all collected data to Internet/Cloud via either Cellular link or 2.4GHz WiFi link (one or the other, not both simultaneously). The enclosure is a plastic custom-made case.
FRN	0026010561
FCC ID	2AKAAA01SG100
IC Certification Number	22125-A01SG100
Manufacturer	Ag Growth International
Model No.	A01SG100
Serial No.	Sample 1: 203 | Sample 2: 205

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

Pre-approved Modules Information

This host device has following pre-approved modules along with the Bluetooth Low Energy (2400-2483.5MHz) and LORA (902-928MHz). The following Wi-Fi and Cellular modules does not transmit simultaneously with each other or the other radios. Both pre-approved modules were installed in the host device as per the instructions provided in their grants certificates.

Module or Product	FCC ID	IC Number
Wi-Fi Module inside Hub Unit	XF6-RS9113SB	8407A-RS9113SB
Cellular Module inside Hub Unit	RI7HE910	5131A-HE910

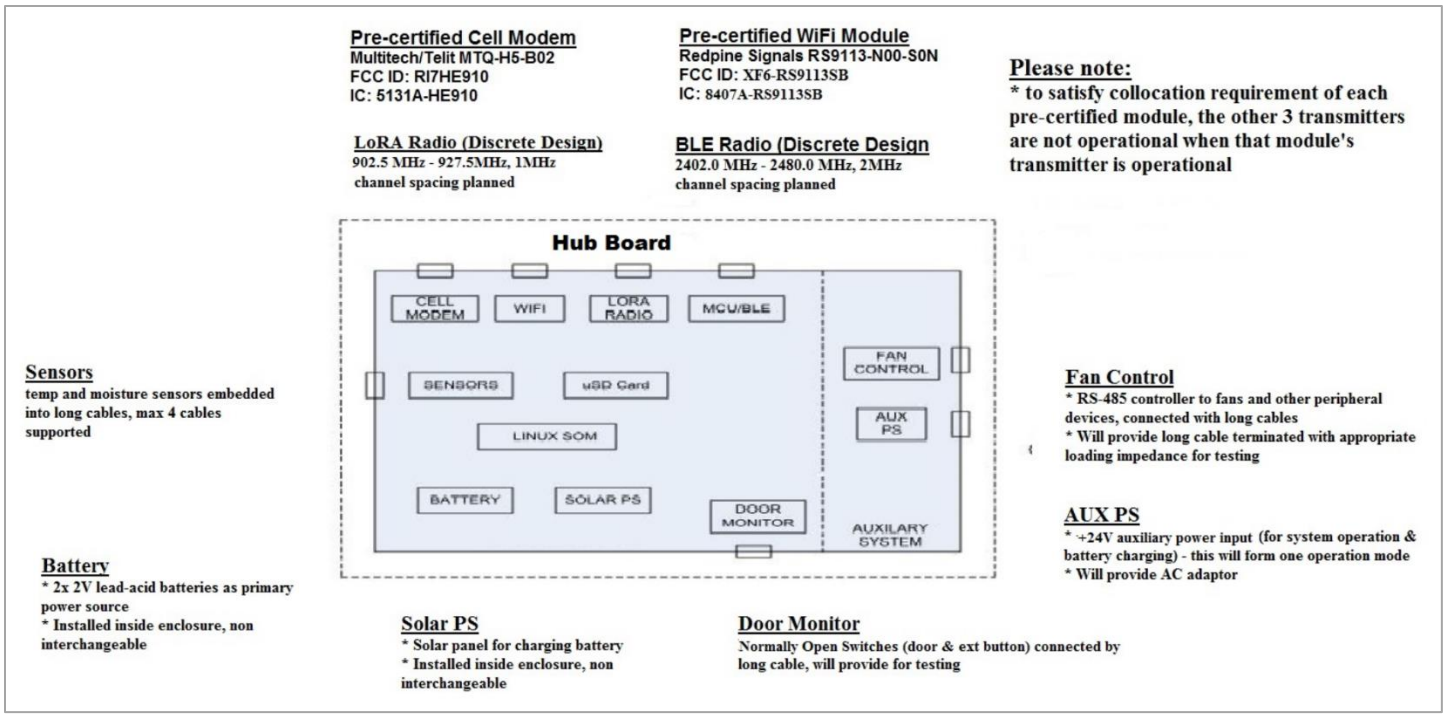
Antenna Information

Item #	Qty	Description	Manufacturer	Manufacturer's Part #	Value	Type	Rating	Comments
1	4	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	2	2.4GHz Antenna	LSR	001-0010	2.4GHz, +2.0dBi	RPSMA(F) omni whip	IP67	One for BLE, one for WiFi Module
6	1	Cellular Module Antenna	Laird	MAF94301	cellular heptaband, 1-3dBi	RPSMA(F) omni whip	Non-waterproof, -30C to +50C	

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 – Hub 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	-5.75	20.68	14.93	30	15.07
Middle	915.0	-5.9	20.71	14.81	30	15.19
High	927.5	-6.12	20.71	14.59	30	15.41

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	14.93	2	16.93
Middle	915.0	14.81	2	16.81
High	927.5	14.59	2	16.59

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	14.93	8	22.93
Middle	915.0	14.81	8	22.81
High	927.5	14.59	8	22.59

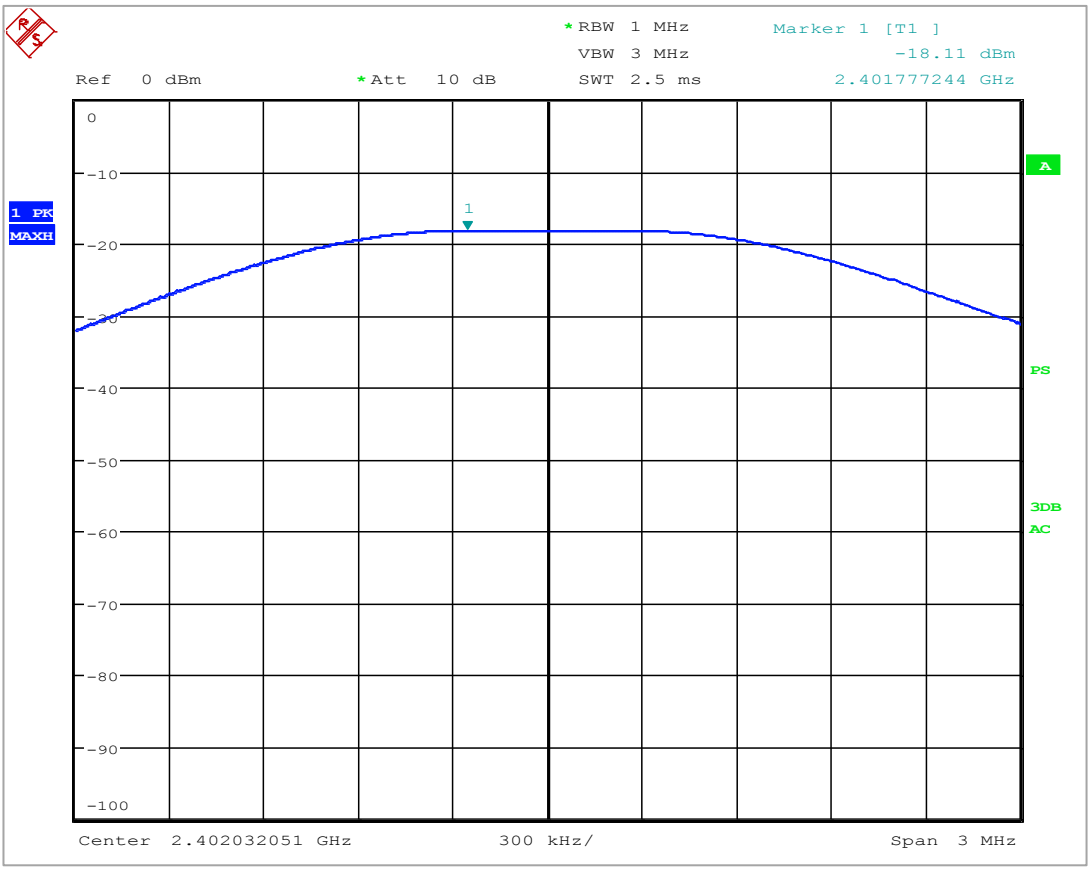
BLE Radio (2400-2483.5 MHz) Data and Plot

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

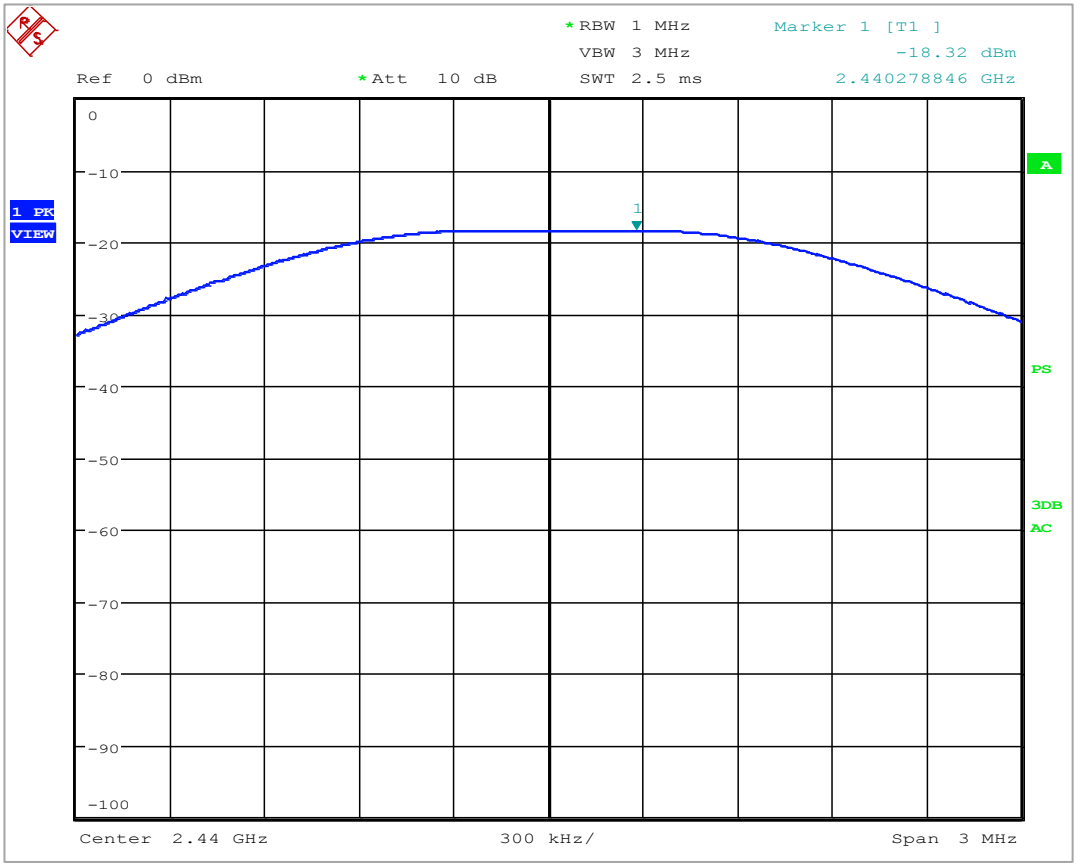
Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Cable Loss with 30dB Attenuator (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	-18.12	21.14	3.02	30	26.98
Middle	2440	-18.32	21.18	2.86	30	27.14
High	2480	-18.54	21.18	2.64	30	27.36

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

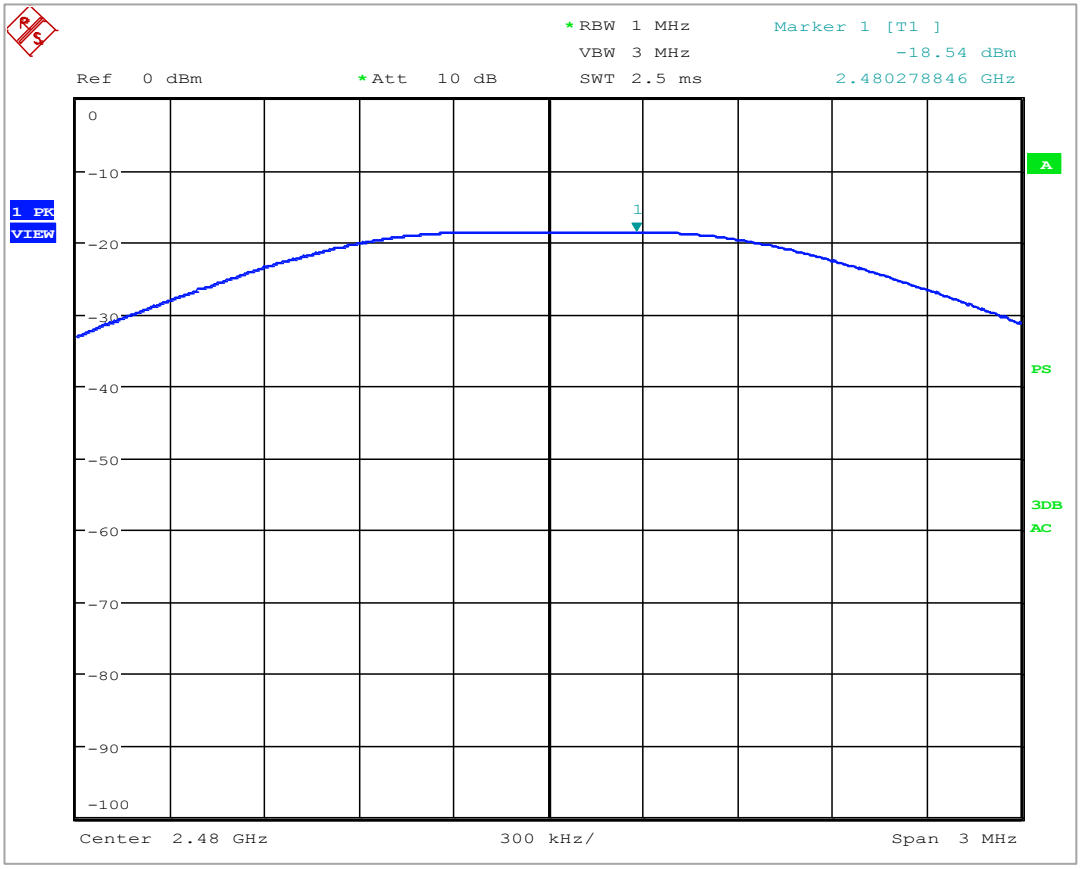
Channel	Frequency (MHz)	Corrected Peak Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)
Low	2402	3.02	2	5.02
Middle	2440	2.86	2	4.86
High	2480	2.64	2	4.64



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 1, 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:

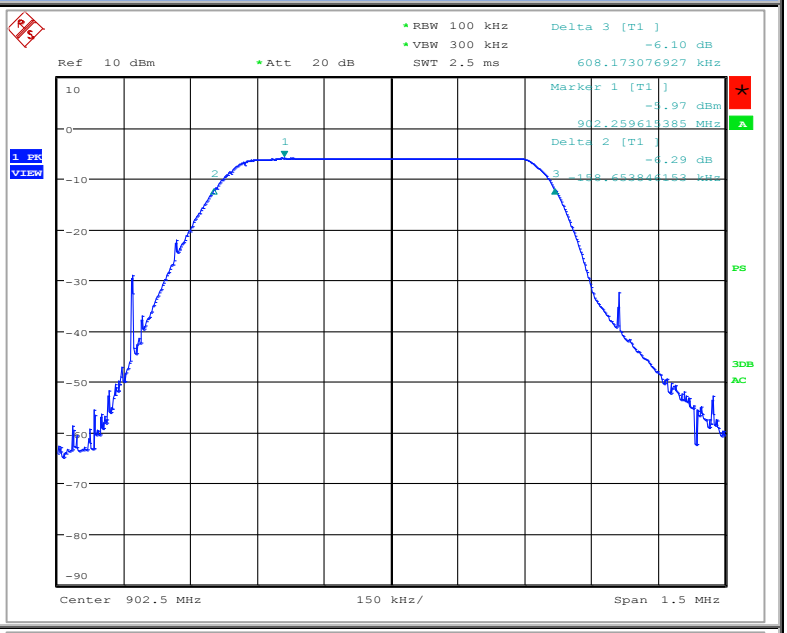
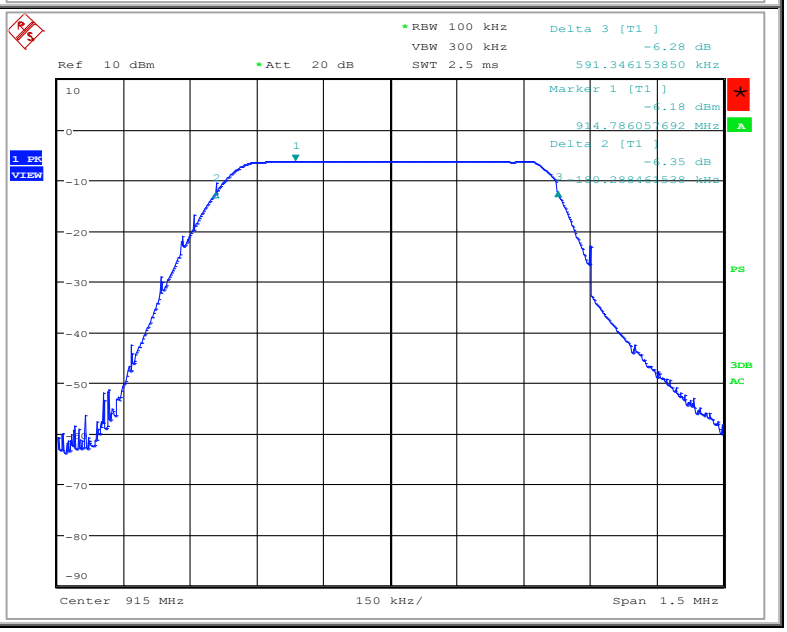
The EUT complies with the applicable standard.

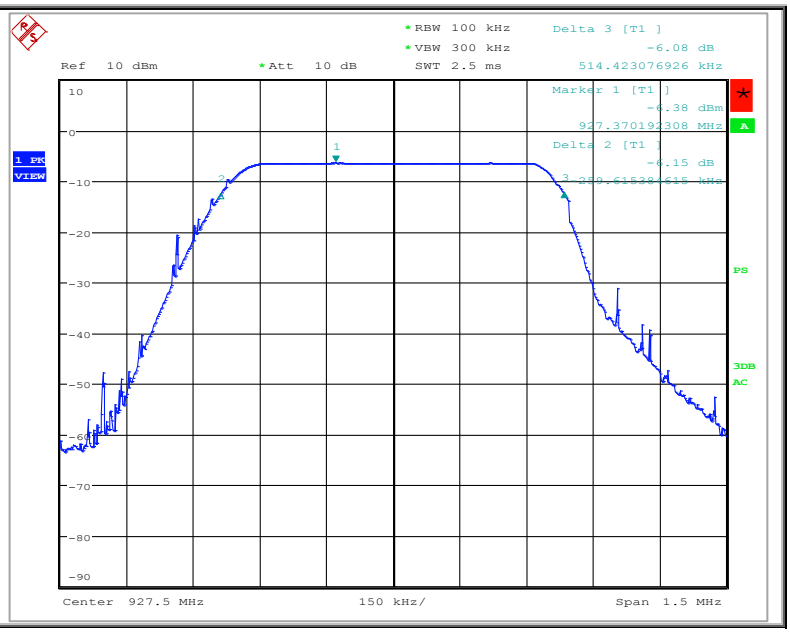
Measurement Data and Plot:

[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	766.8	>500
Middle	915.0	771.6	>500
High	927.5	774.38	>500

Channel	Plot
Low	
Middle	

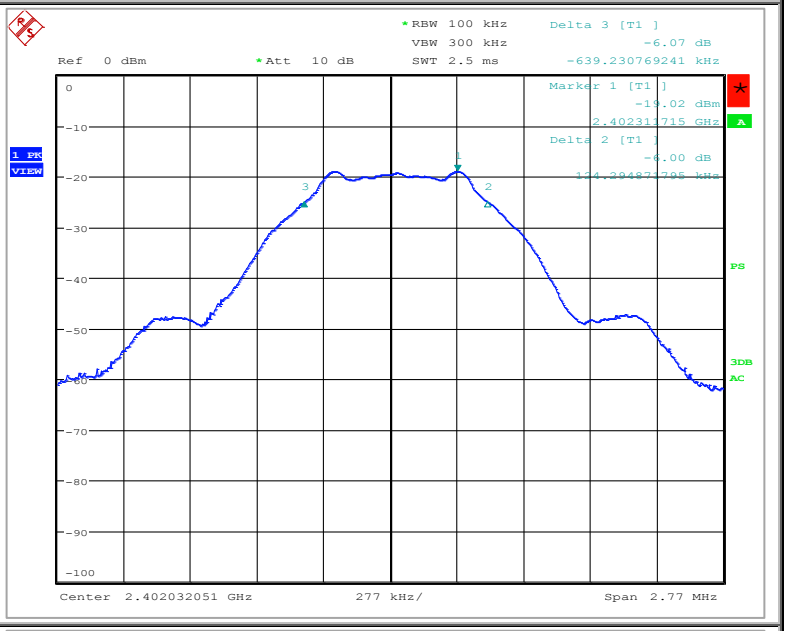
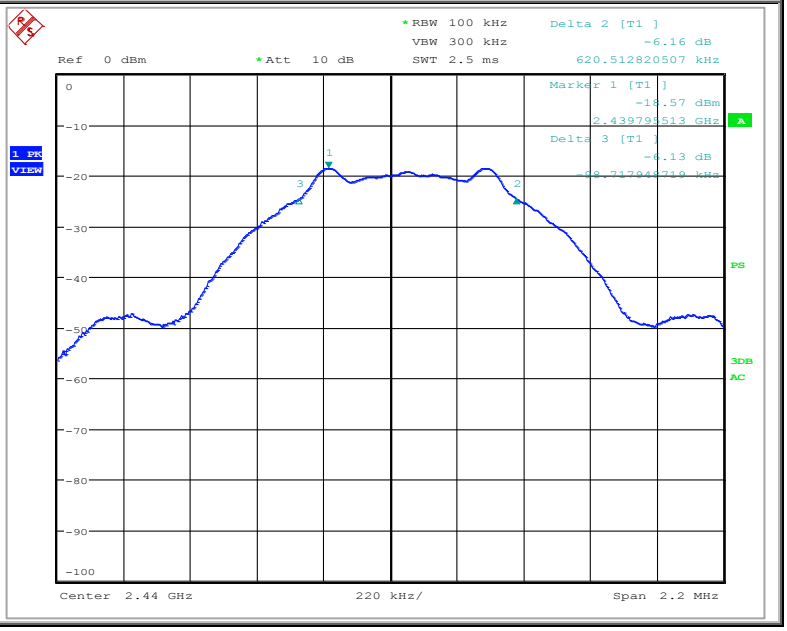
High	

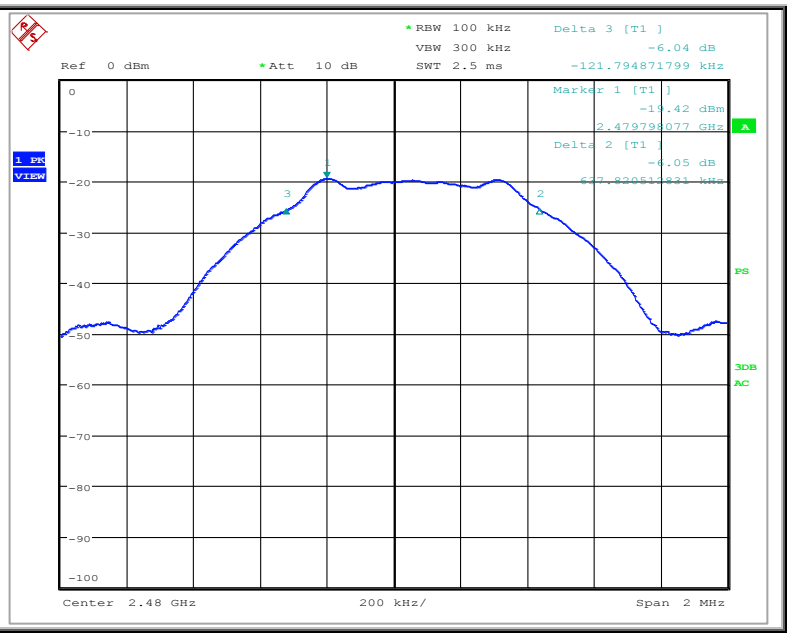
Plot 4: 6dB Occupied Bandwidth Plot (LORA Radio: 902-928 MHz)

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	763.4	>500
Middle	2440	719.2	>500
High	2480	759.5	>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 1-7, 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:

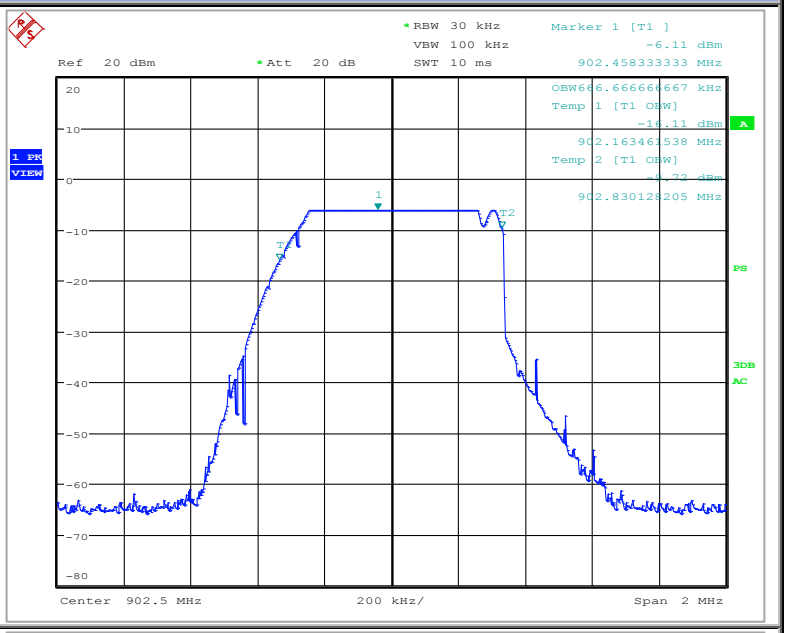
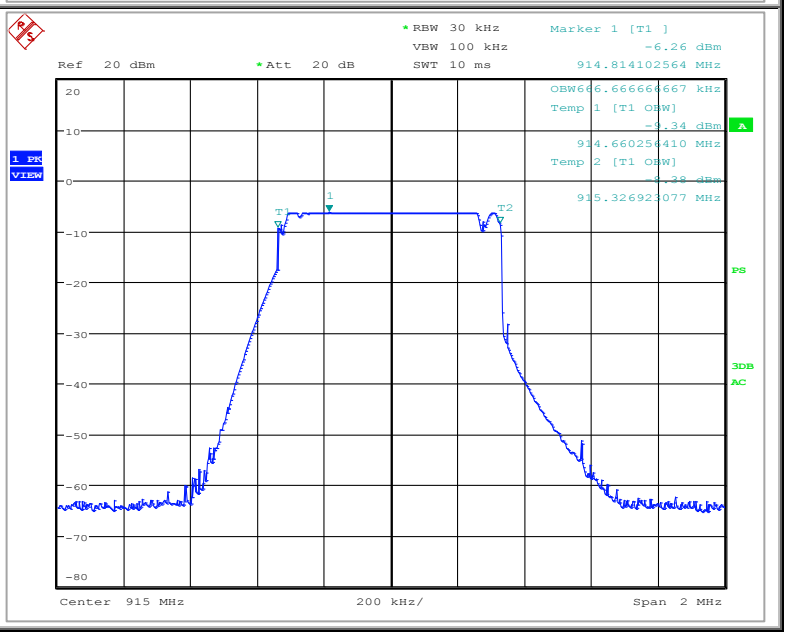
Complies with the applicable standard.

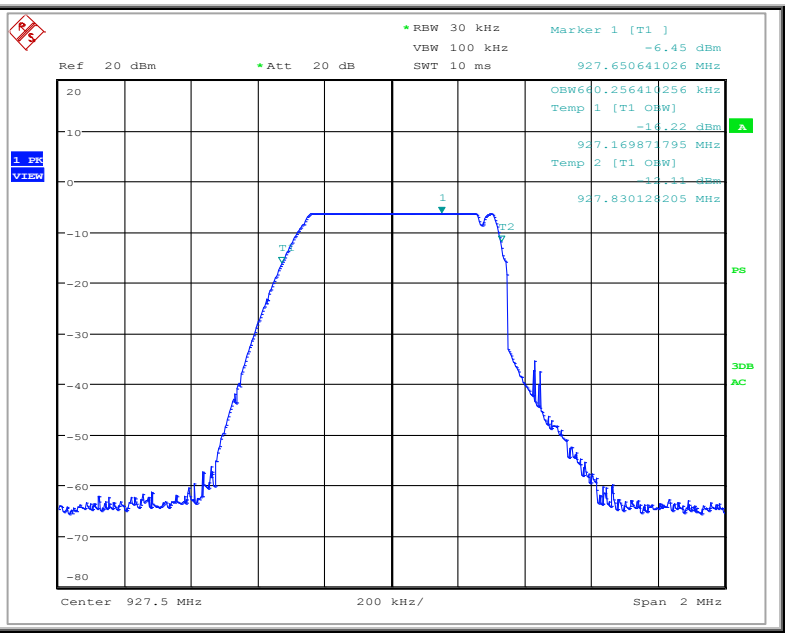
Measurement Data and Plot:

[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	666.6
Middle	915.0	666.6
High	927.5	660.256

Channel	Plot
Low	
Middle	

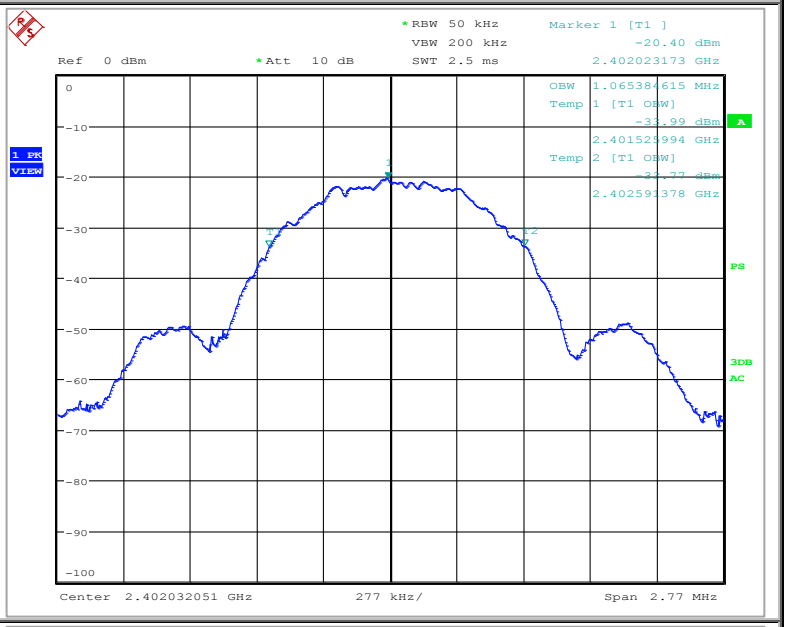
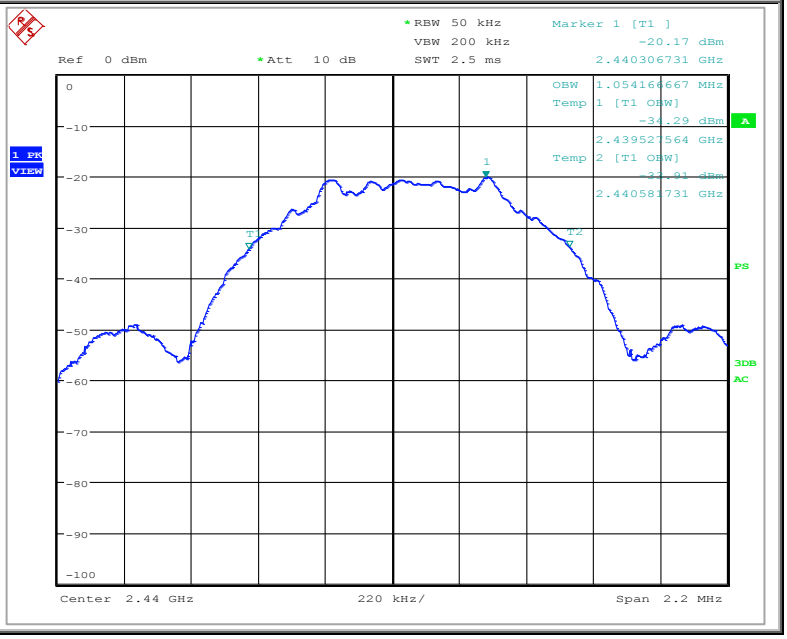
High	

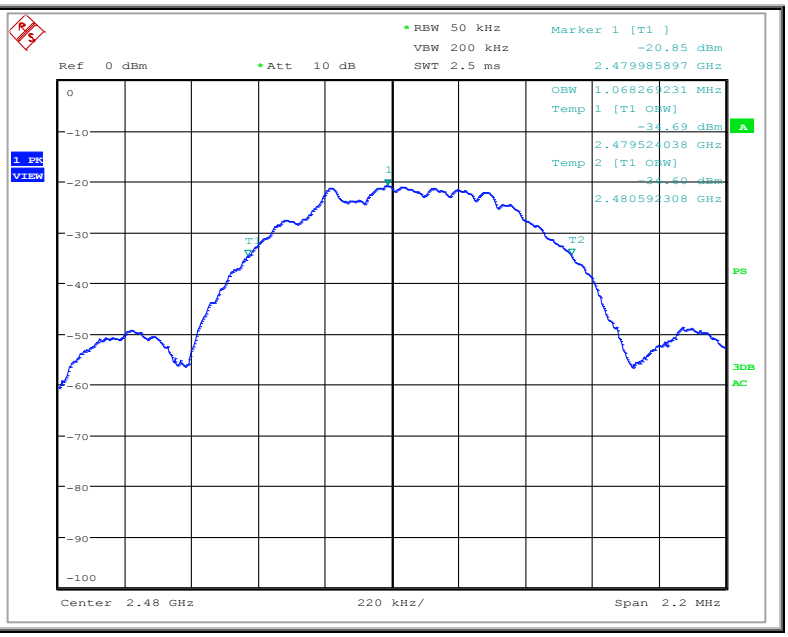
Plot 6: 99% Occupied Bandwidth Plot (LORA Radio: 902-928 MHz)

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	1.065
Middle	2440	1.054
High	2480	1.068

Channel	Plot
Low	
Middle	

High	

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

3.5 Power Spectral Density

Date Performed:

November 25 - December 1, 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:

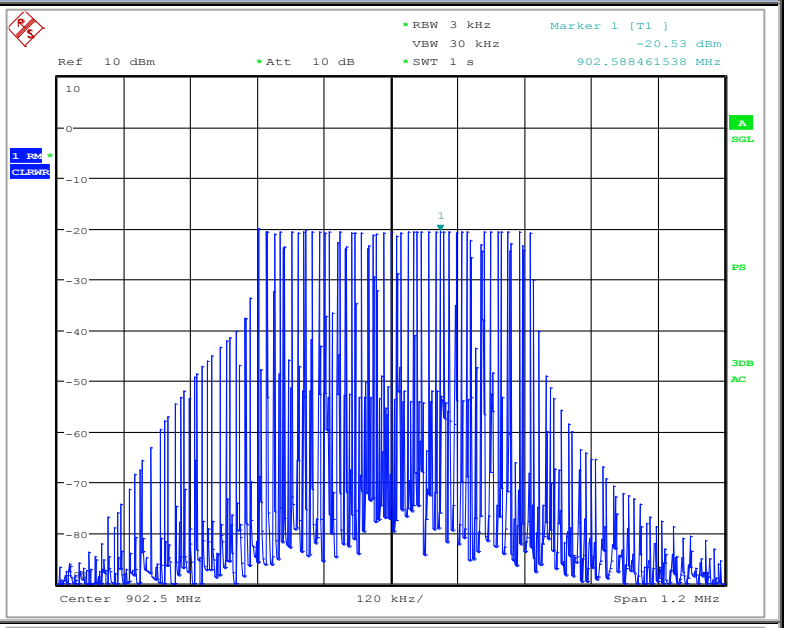
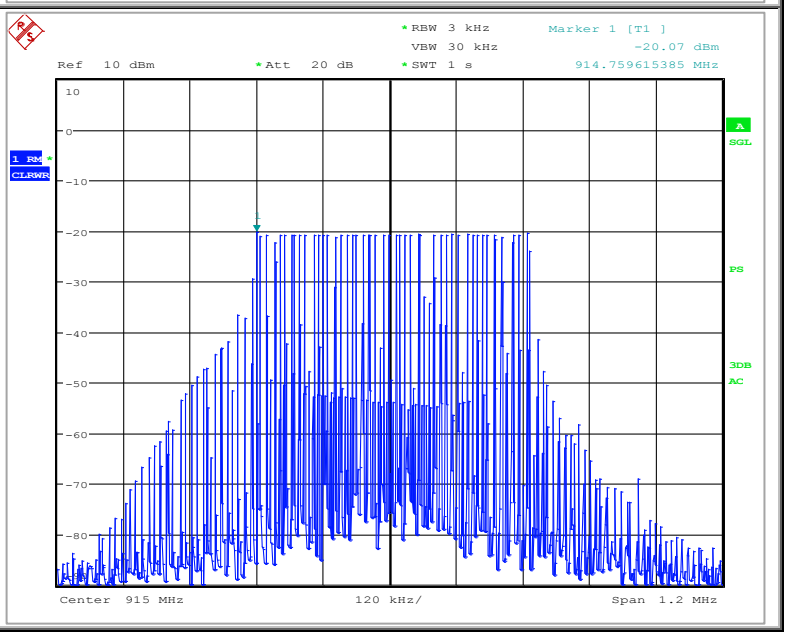
The EUT complies with the applicable standard.

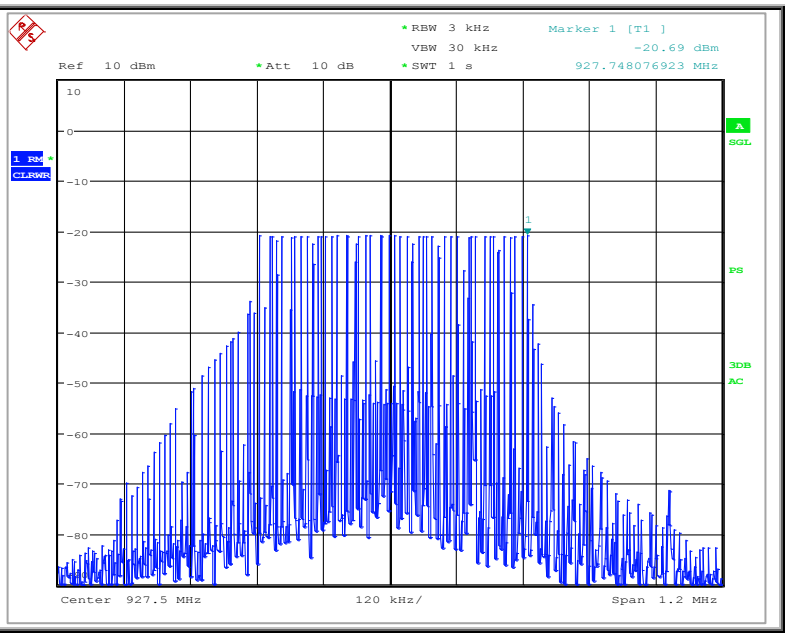
Measurement Data and Plot:

[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	-20.13	20.68	0.55	8	7.45
Middle	915.0	-20.07	20.71	0.64	8	7.36
High	927.5	-20.69	20.71	0.02	8	7.98

Channel	Plot
Low	
Middle	

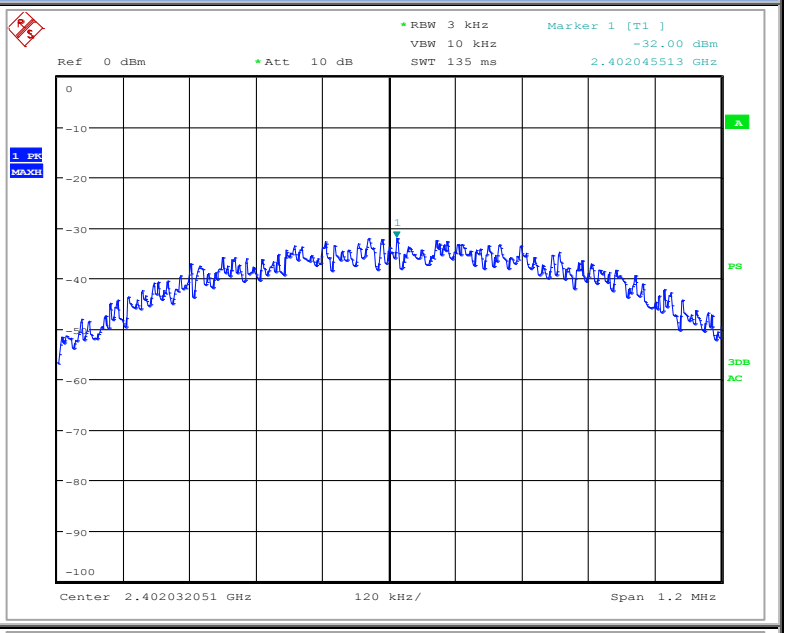
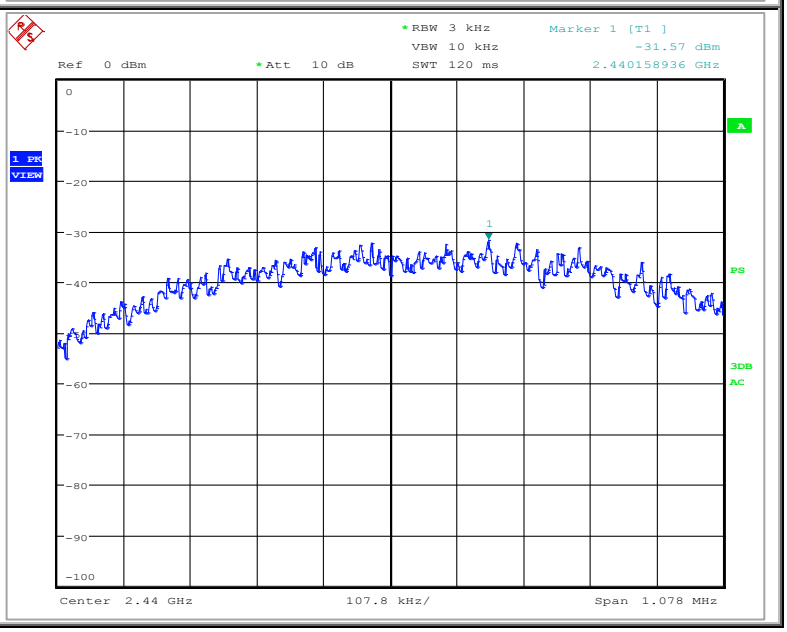
High	

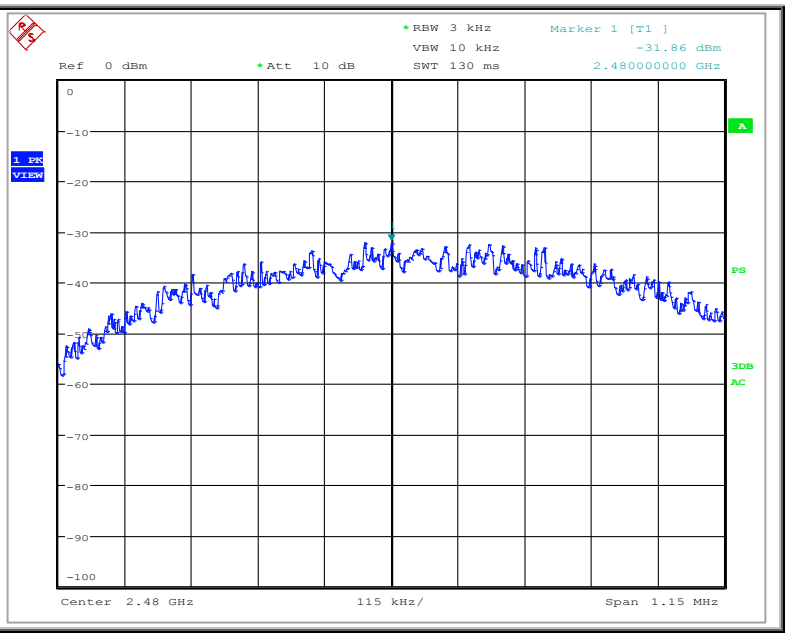
Plot 8: Power Spectral Density Plot (LORA Radio: 902-928 MHz)

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	-32	21.14	-10.86	8	18.86
Middle	2440	-31.57	21.18	-10.39	8	18.39
High	2480	-31.86	21.18	-10.68	8	18.68

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:

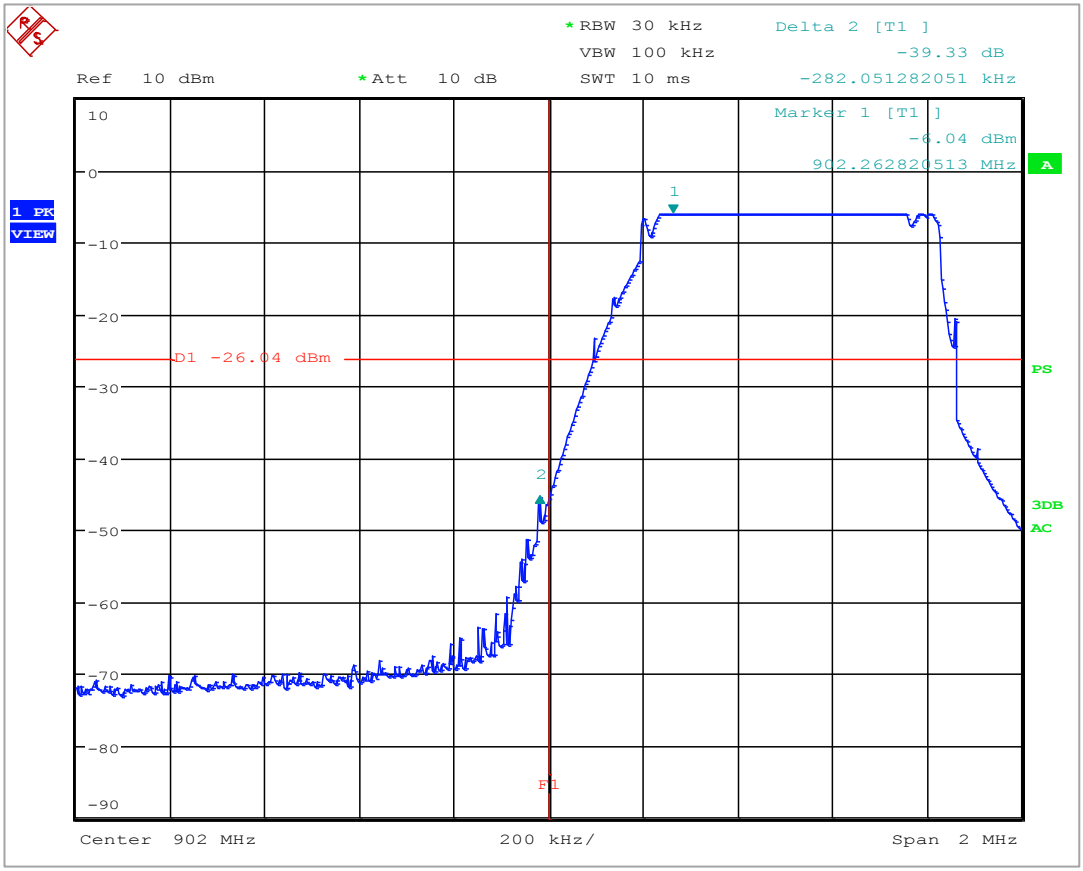
No modification was required to comply for this test.

Final Result:

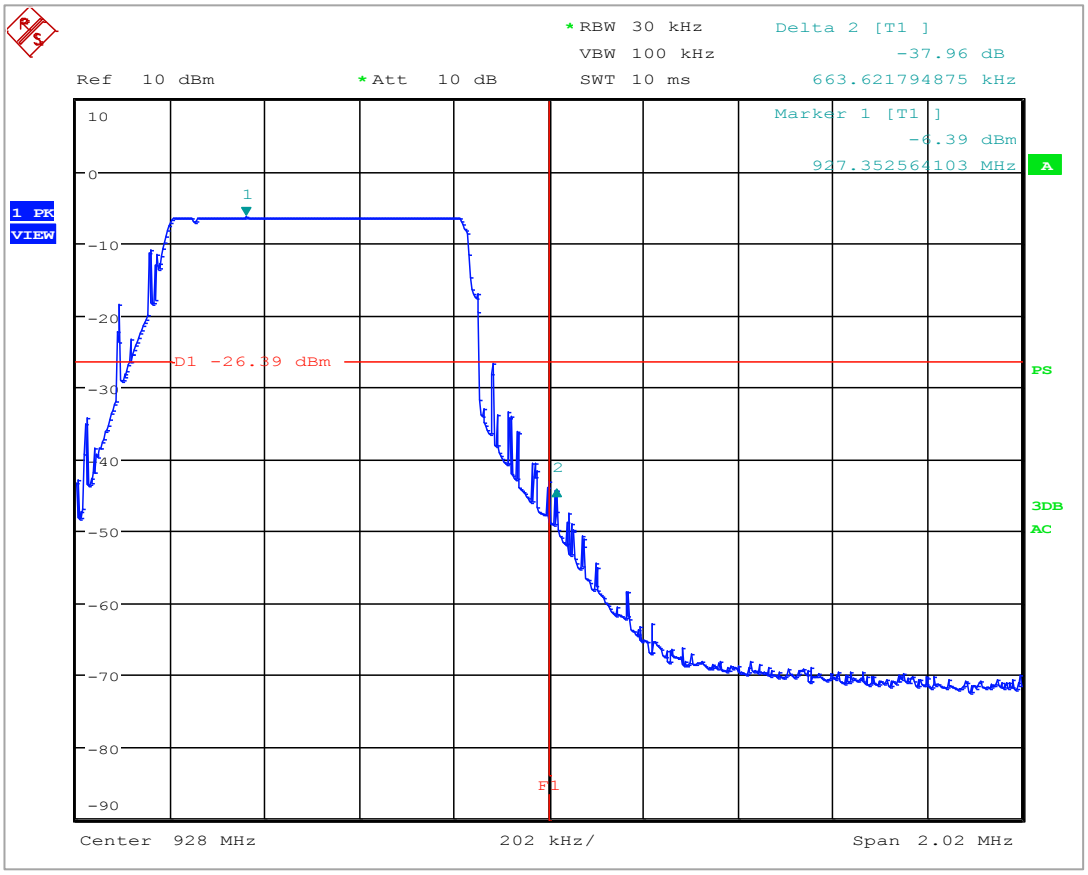
The EUT complies with the applicable standard.

Measurement Data and Plot:

LORA Radio (902-928 MHz) Data and Plot

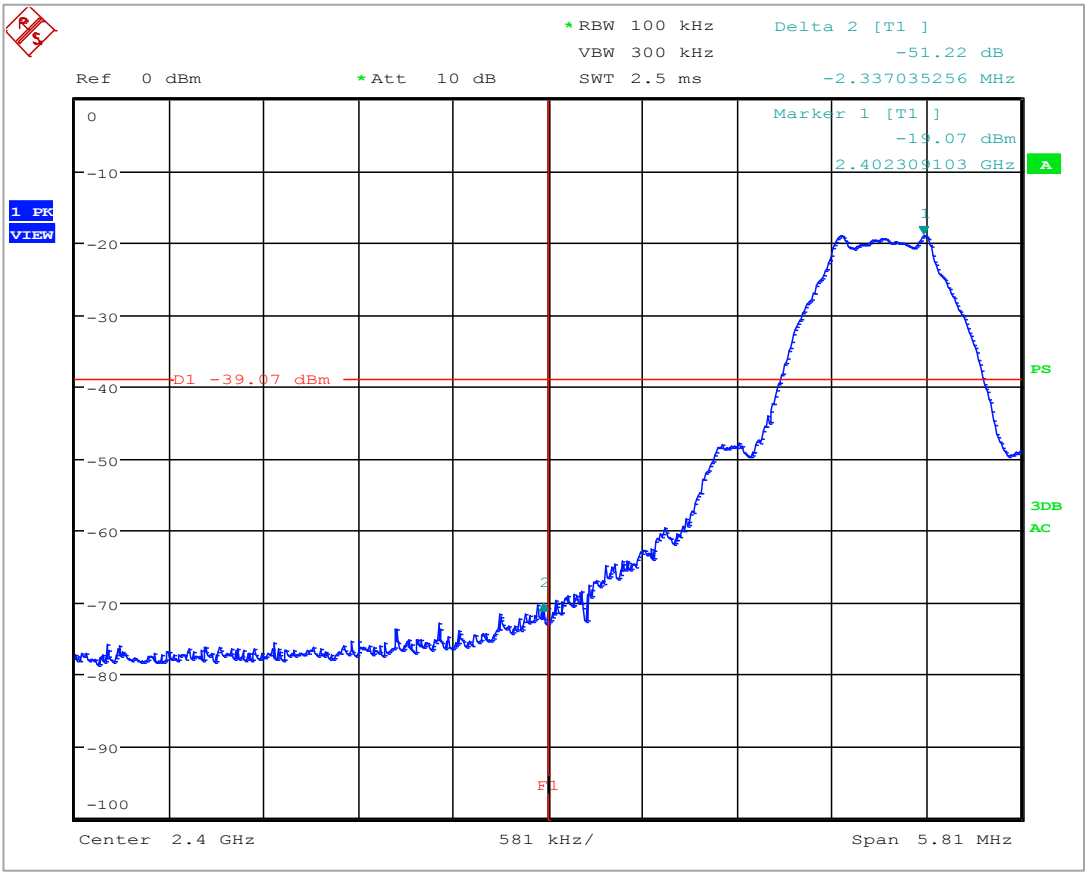


Plot 10: Band Edge Plot at Channel Low (LORA Radio: 902-928 MHz)

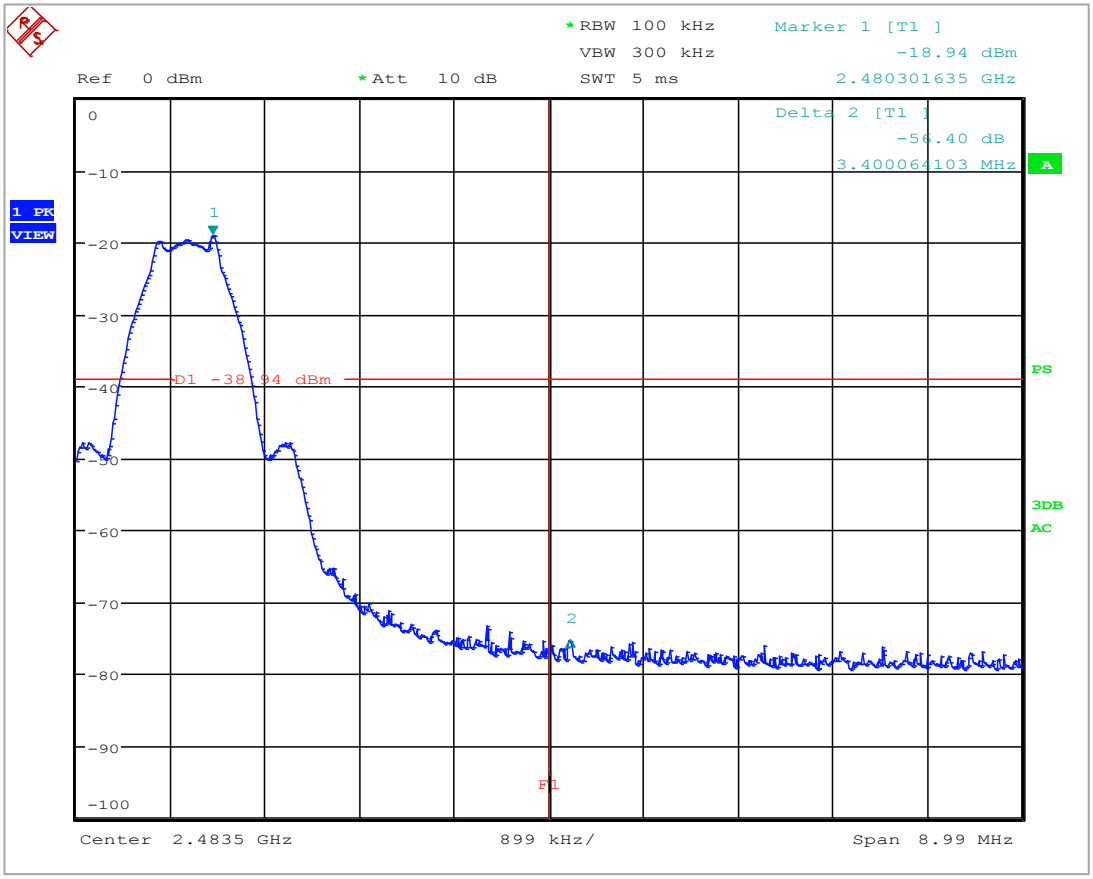


Plot 11: Band Edge Plot at Channel High (LORA Radio: 902-928 MHz)

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:

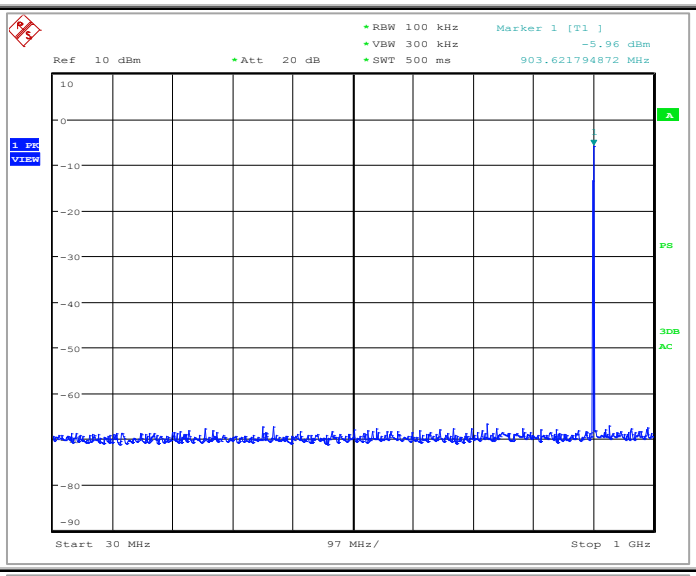
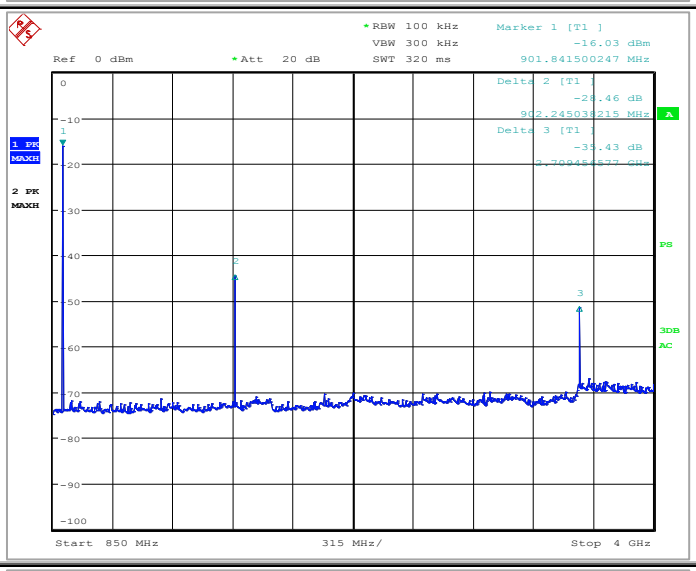
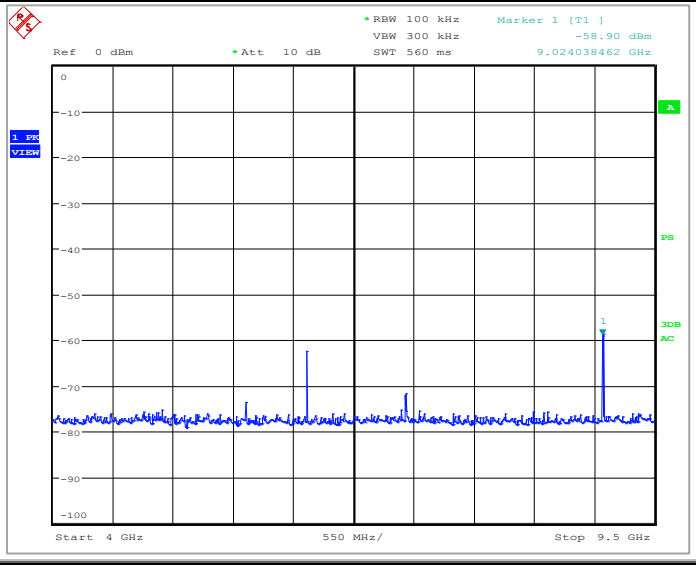
The EUT complies with the applicable standard. Conducted spurious emissions were measured up to tenth harmonic of the fundamental frequency.

Measurement Data and Plot:

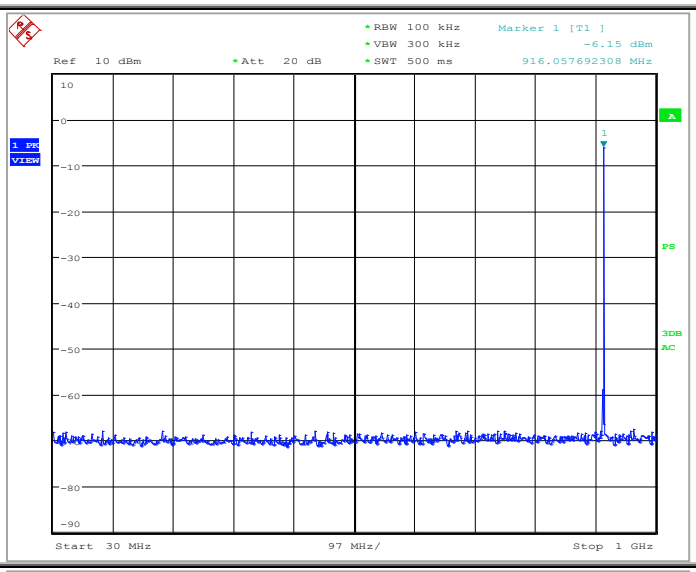
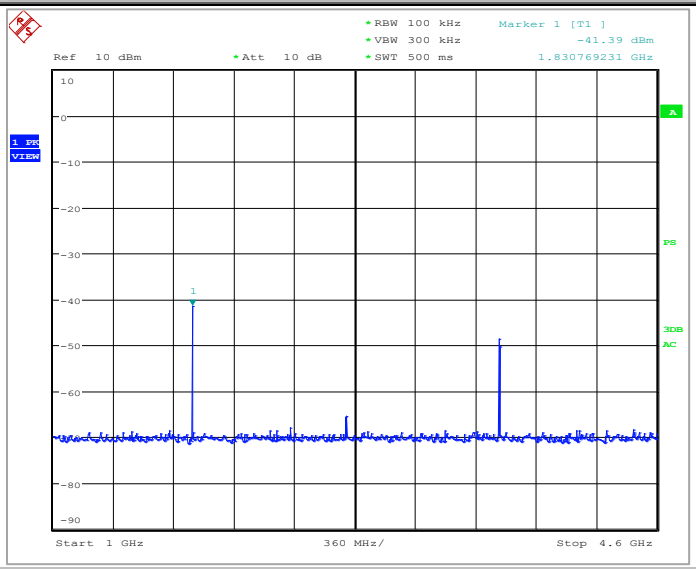
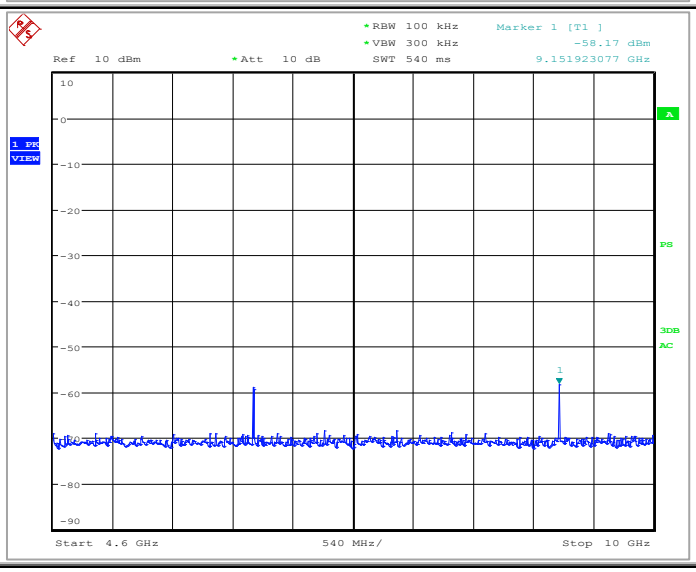
LORA Radio (902-928 MHz) Data and Plot

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

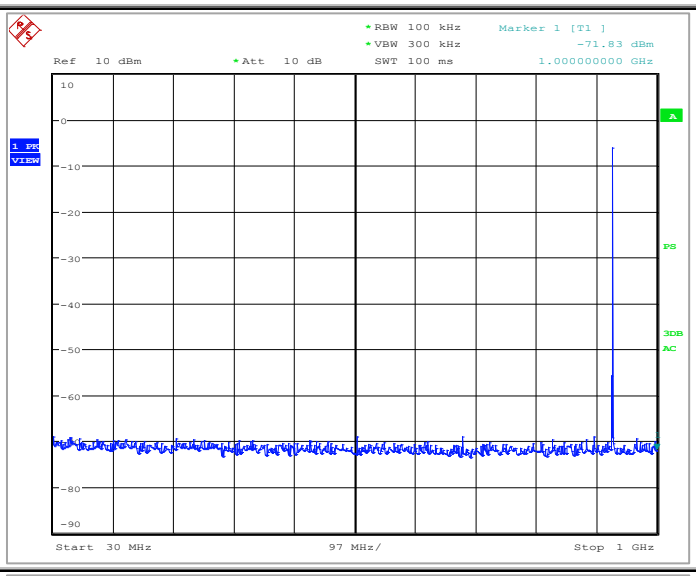
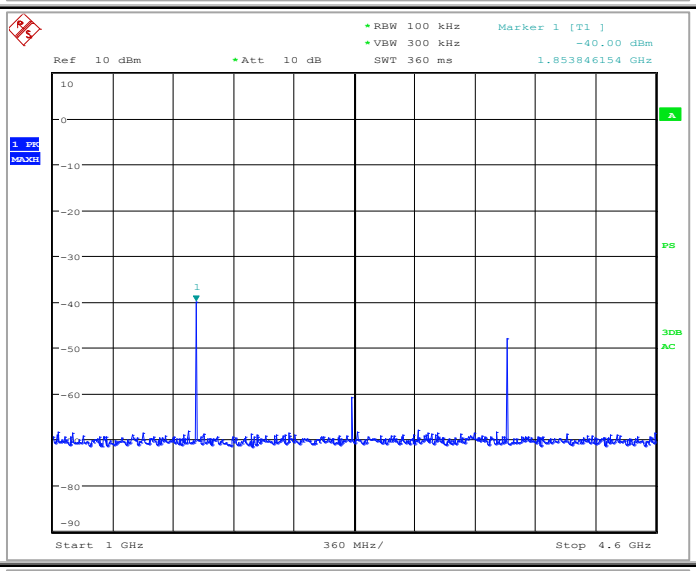
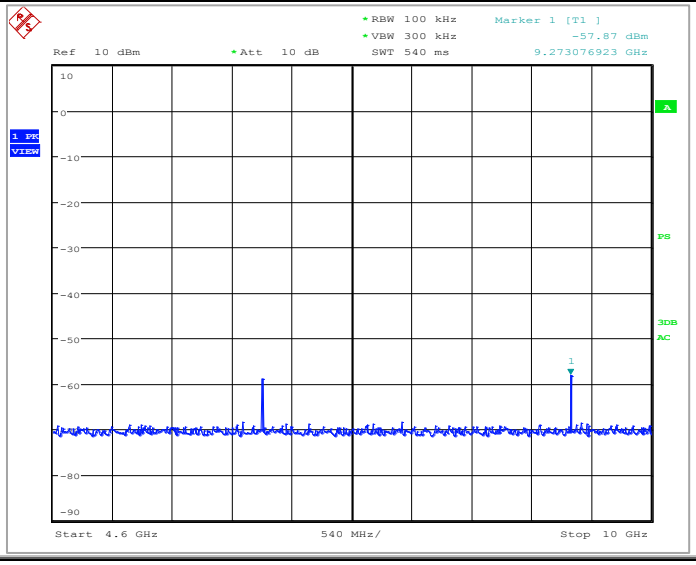
Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Loss (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low Channel 902.5MHz	1805	-44.72	0.96	-43.76	-5.37	38.39
	2707.8	-76	1.66	-74.34	-5.37	68.97
	3610	-51.57	1.67	-49.9	-5.37	44.53
	4512	-72.12	2.94	-69.18	-5.37	63.81
	5415.8	-65.42	5.63	-59.79	-5.37	54.42
	6317.5	-59.09	3.39	-55.7	-5.37	50.33
	7220	-64.82	3.79	-61.03	-5.37	55.66
	8122.5	-68	3.28	-64.72	-5.37	59.35
	9025	-54.6	4	-50.6	-5.37	45.23
Mid Channel 915MHz	1830	-40.97	1.13	-39.84	-5.41	34.43
	2745	-62.79	1.38	-61.41	-5.41	56
	3660	-48.5	1.73	-46.77	-5.41	41.36
	4575	-73.1	3.25	-69.85	-5.41	64.44
	5490	-64.87	4.66	-60.21	-5.41	54.8
	6405	-57.08	3.14	-53.94	-5.41	48.53
	7320	-64.8	2.71	-62.09	-5.41	56.68
	8235	-65.46	3.76	-61.7	-5.41	56.29
	9150	-56.18	3.69	-52.49	-5.41	47.08
Hi Channel 927.5MHz	1855	-40.14	0.85	-39.29	-5.64	33.65
	2782.5	-60.7	1.73	-58.97	-5.64	53.33
	3710	-47.8	1.92	-45.88	-5.64	40.24
	4637.5	-69.5	3.17	-66.33	-5.64	60.69
	5565	-65.8	3.66	-62.14	-5.64	56.5
	6492.5	-58.04	3.2	-54.84	-5.64	49.2
	7420	-65.6	2.45	-63.15	-5.64	57.51
	8347.5	-66.1	3.71	-62.39	-5.64	56.75
	9275	-56.65	3.52	-53.13	-5.64	47.49

Frequency Span: 30MHz-1GHz	
Frequency Span: 850MHz-4GHz	
Frequency Span: 4GHz-9GHz	

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

Frequency Span: 30MHz-1GHz	
Frequency Span: 1GHz-4.6GHz	
Frequency Span: 4.6GHz-10GHz	

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

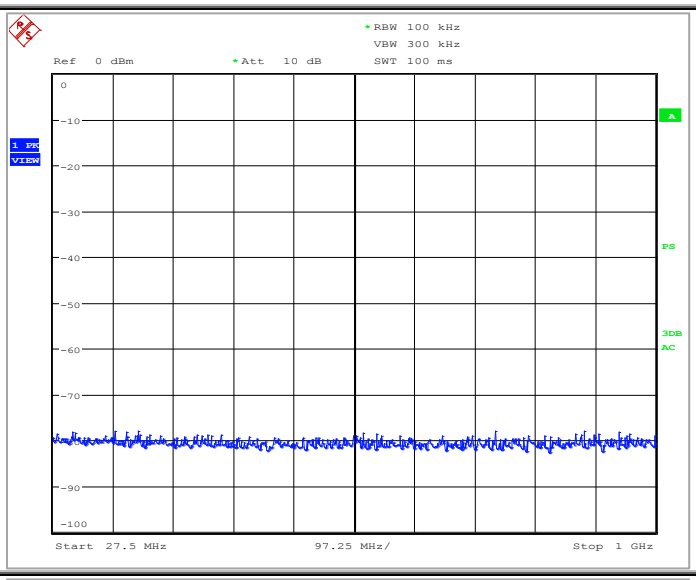
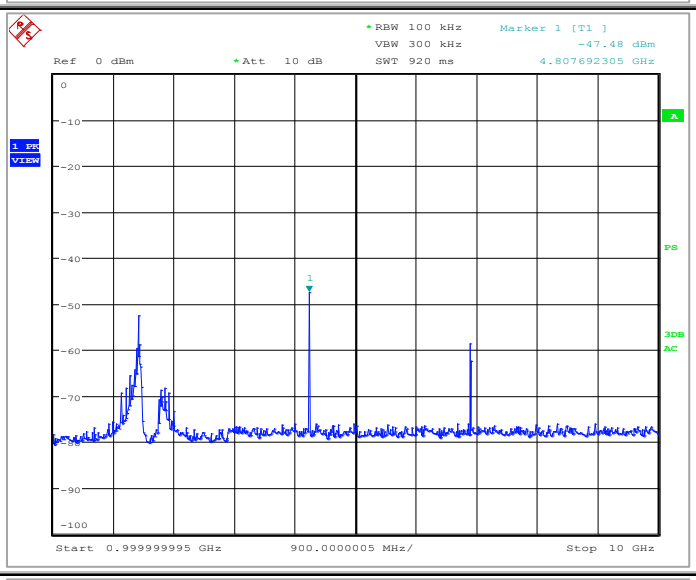
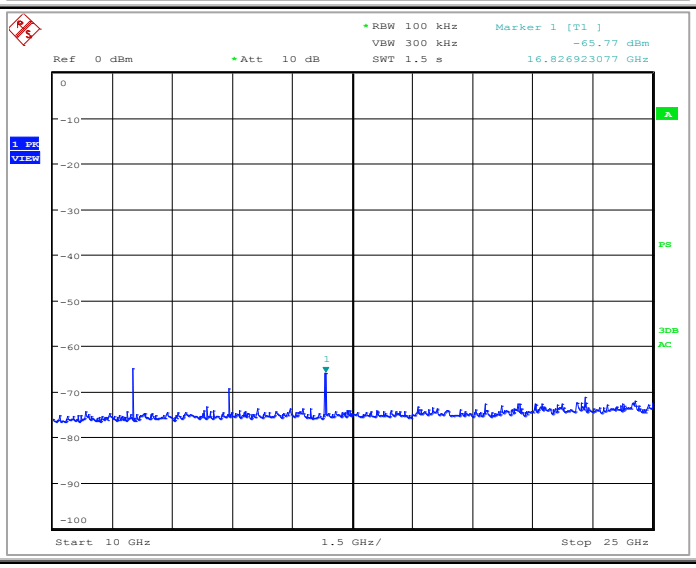
Frequency Span: 30MHz-1GHz	
Frequency Span: 1GHz-4.6GHz	
Frequency Span: 4.6GHz-10GHz	

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

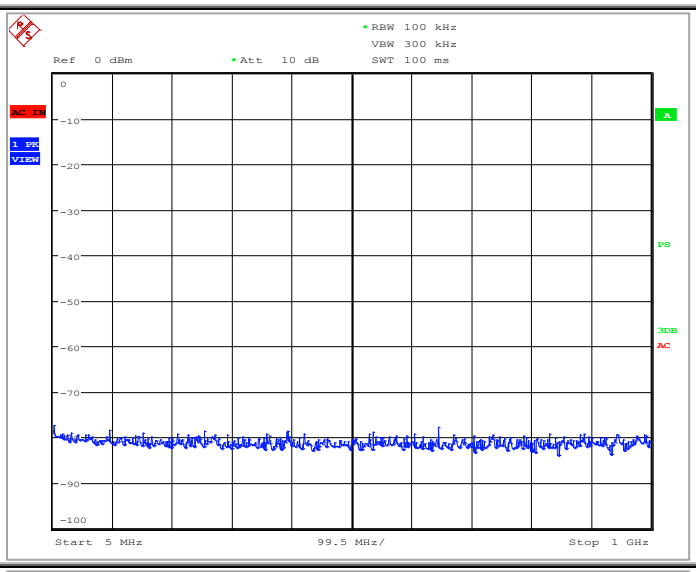
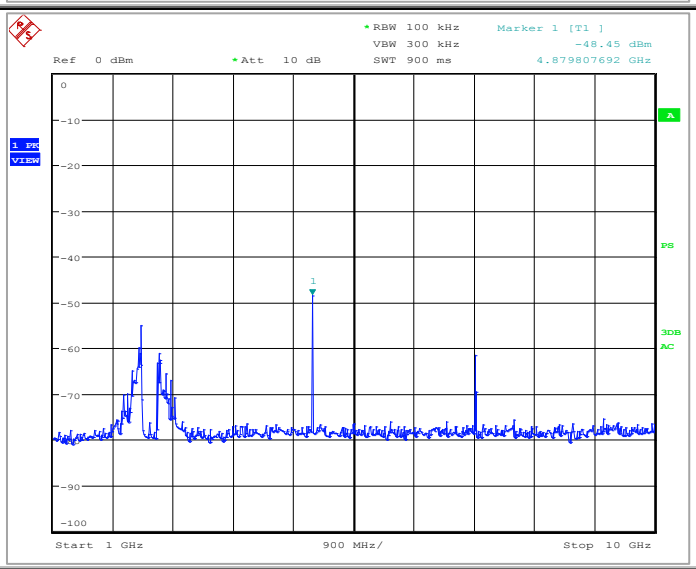
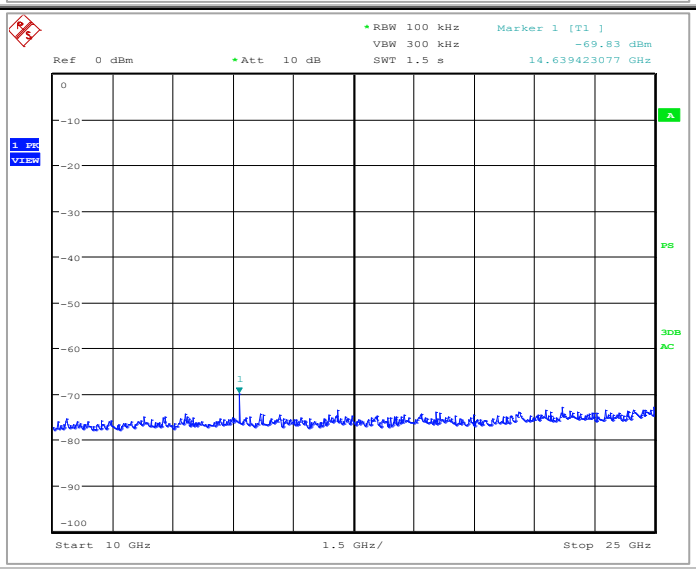
BLE Radio (2400-2483.5 MHz) Data and Plot

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

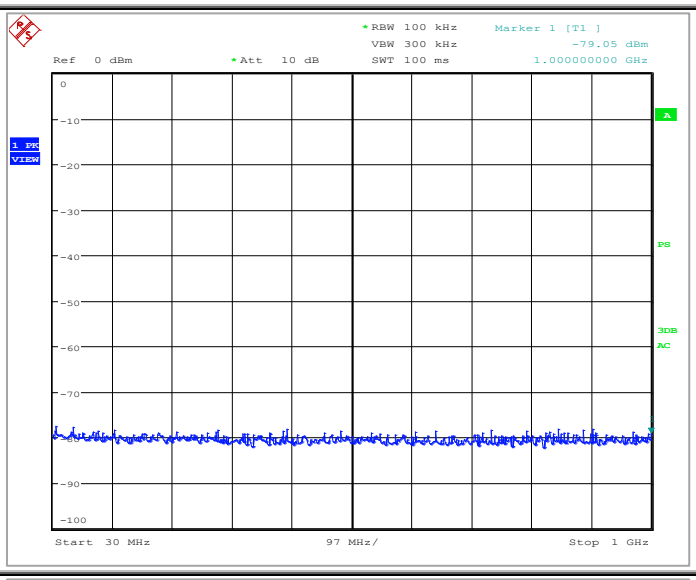
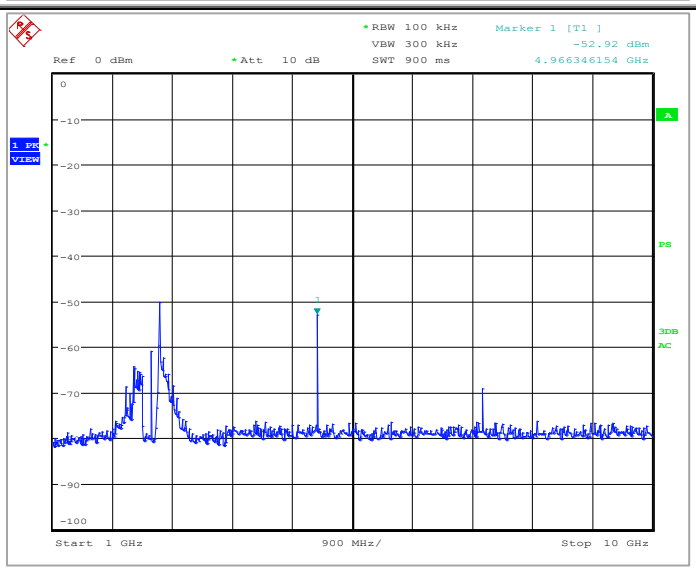
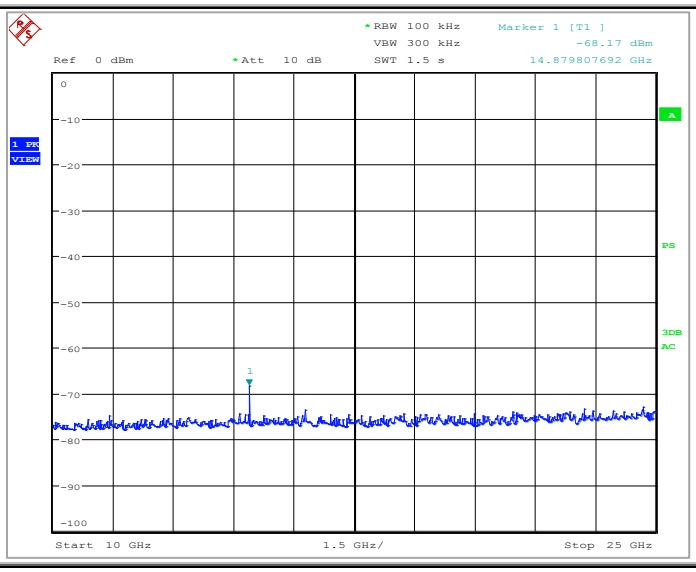
Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Loss (dB)	Corrected Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
Low Channel 2402MHz	4804	-44.19	2.26	-41.93	-17.8	24.13
	7206	-57.69	2.44	-55.25	-17.8	37.45
	9608	-75.2	3.91	-71.29	-17.8	53.49
	12010	-64.88	4.74	-60.14	-17.8	42.34
	14412	-67.7	8.76	-58.94	-17.8	41.14
	16814	-63.79	8.53	-55.26	-17.8	37.46
Mid Channel 2440MHz	4880	-45.85	2.84	-43.01	-17.43	25.58
	7320	-58.67	3.12	-55.55	-17.43	38.12
	9760	-74	4.73	-69.27	-17.43	51.84
	12200	-72.46	4.69	-67.77	-17.43	50.34
	14640	-66.5	9.36	-57.14	-17.43	39.71
	17080	-70.26	8.58	-61.68	-17.43	44.25
Hi Channel 2480MHz	4960	-49.9	2.23	-47.67	-17.65	30.02
	7440	-65.56	3.15	-62.41	-17.65	44.76
	9920	-74.97	4.46	-70.51	-17.65	52.86
	12400	-74.97	4.65	-70.32	-17.65	52.67
	14880	-63.94	8.54	-55.4	-17.65	37.75
	17360	-70.8	7.74	-63.06	-17.65	45.41

Frequency Span: 30MHz-1GHz	
Frequency Span: 1GHz-10GHz	
Frequency Span: 10GHz-25GHz	

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

Frequency Span: 30MHz-1GHz	
Frequency Span: 1GHz-10GHz	
Frequency Span: 10GHz-25GHz	

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

Frequency Span: 30MHz-1GHz	
Frequency Span: 1GHz-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 21 – 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:

- FCC KDB 558074 D01 DTS Meas Guidance v03r05

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 Bluetooth low energy (with LSR 2dBi antenna) and Lora radio (with Nearson 2dBi antennas).

When LORA Radio (902-928MHz) was tested with Laird OD9-8 antenna compliance to restricted bands was demonstrated as per procedure defined in clause 12.2 of FCC guidance document 558074 D01 DTS, conducted measurements were performed with proper impedance matching and an additional radiated test for cabinet/case spurious emissions performed. The general procedure was used as follows:

a) Measure the conducted output power (in dBm) using the detector specified (see 12.2.2, 12.2.3, and 12.2.4 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
b) Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
c) Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).
d) For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
e) Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:

$$E = EIRP - 20\log D + 104.8$$

where:

E = electric field strength in dBμV/m,
EIRP = equivalent isotropic radiated power in dBm
D = specified measurement distance in meters.

f) Compare the resultant electric field strength level to the applicable limit.
g) Perform radiated spurious emission test

Additional consideration was given to unwanted emissions radiating from the EUT cabinet, control circuits, power leads, or intermediate circuit elements by performing a radiated test to ensure that emissions emanating from the EUT cabinet (rather than the antenna port) also comply with the applicable limits.

For these cabinet radiated spurious emission measurements the EUT transmit antenna was replaced with a 50 Ohm termination matching the nominal impedance of the antenna.

The measurement results are obtained as described below:

$$E\ [dB\mu V/m] = \text{Un-Corrected Value} + ATOT$$

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

A proper impedance matching was ensured and an additional radiated test for cabinet/case spurious emissions was executed

Modifications:

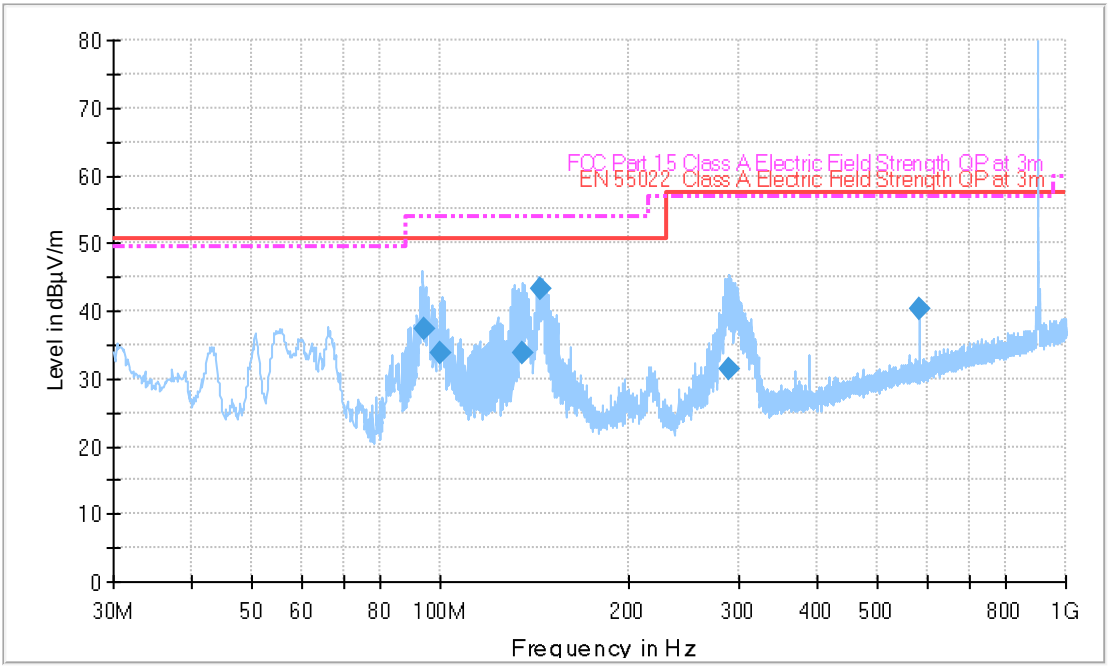
No modification was required to comply for this test.

Final Result:

The EUT complies with the applicable standard.

Measurement Data and Plot:

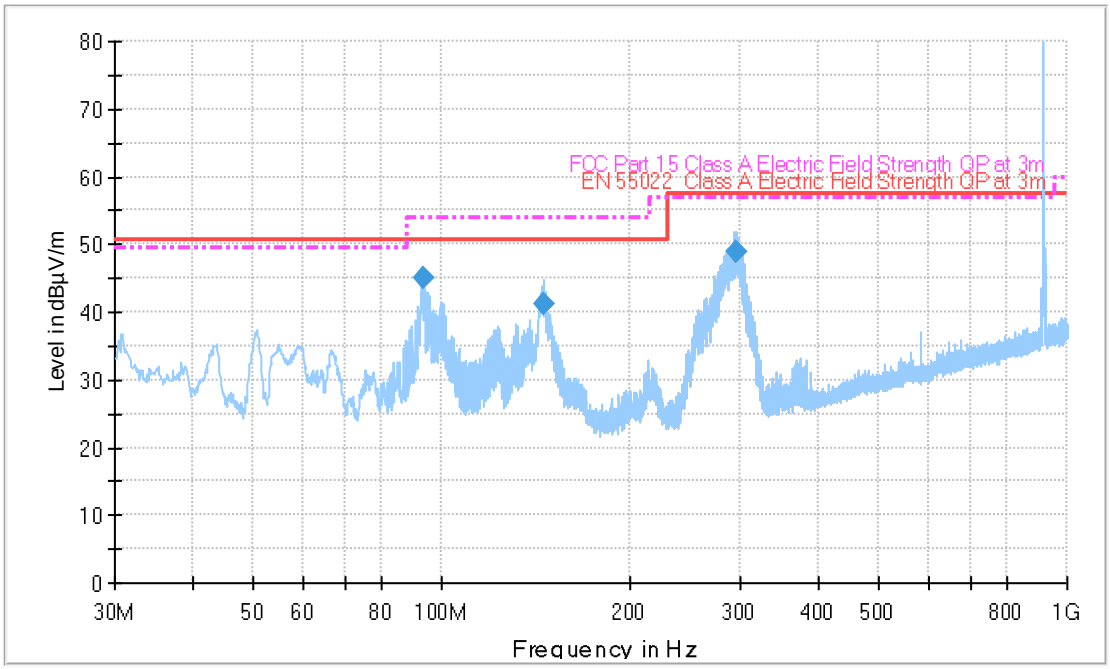
LORA Radio with Nearson S1551AH-915S 915MHz, +2.0dBi omni whip Antenna(902-928 MHz) Data and Plot



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

Table 14: TX Mode (Low Channel) – Radiated Spurious Emissions Data: 30-1000MHz

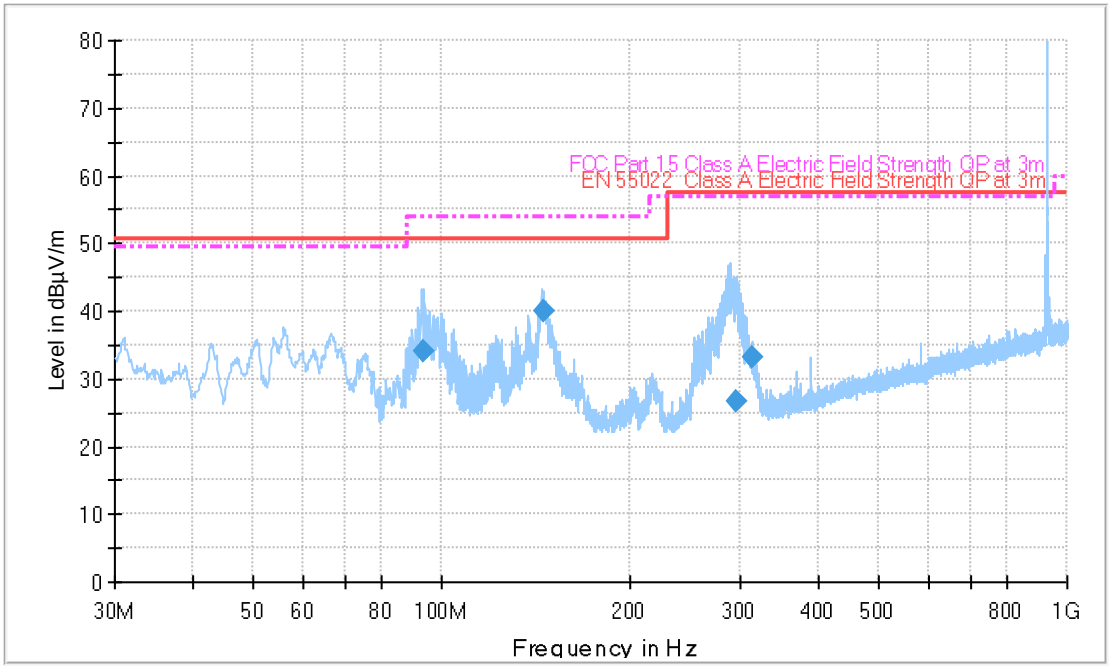
Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
94.039650	37.3	1000.000	120.000	100.0	V	330.0	15.7	16.7	54.0
99.961800	33.8	1000.000	120.000	100.0	V	0.0	17.1	20.2	54.0
135.136700	33.9	1000.000	120.000	100.0	V	349.0	20.6	20.1	54.0
144.494400	43.1	1000.000	120.000	312.0	H	330.0	20.3	10.9	54.0
289.515650	31.4	1000.000	120.000	207.0	V	205.0	21.0	25.5	56.9
585.030900	40.4	1000.000	120.000	100.0	V	342.0	27.2	16.5	56.9



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

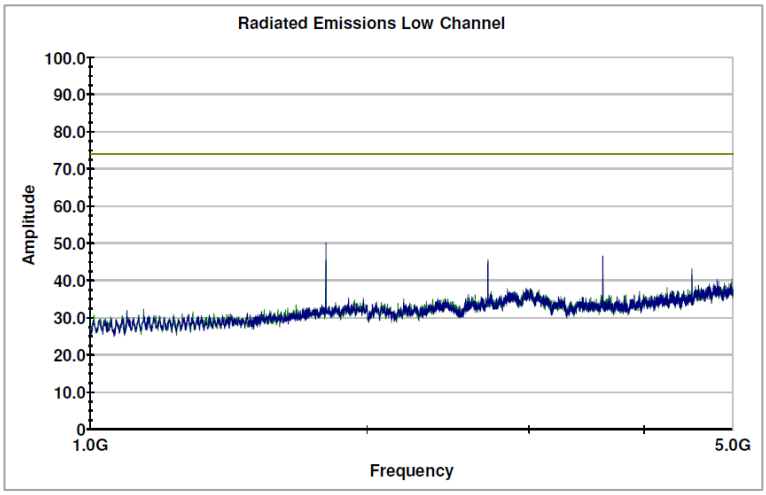
Table 15: TX Mode (Mid Channel) – Radiated Spurious Emissions Data: 30-1000MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
93.721250	45.1	1000.000	120.000	320.0	H	232.0	15.6	8.9	54.0
145.115250	41.2	1000.000	120.000	227.0	H	66.0	20.2	12.8	54.0
296.021500	48.8	1000.000	120.000	148.0	H	321.0	21.0	8.1	56.9

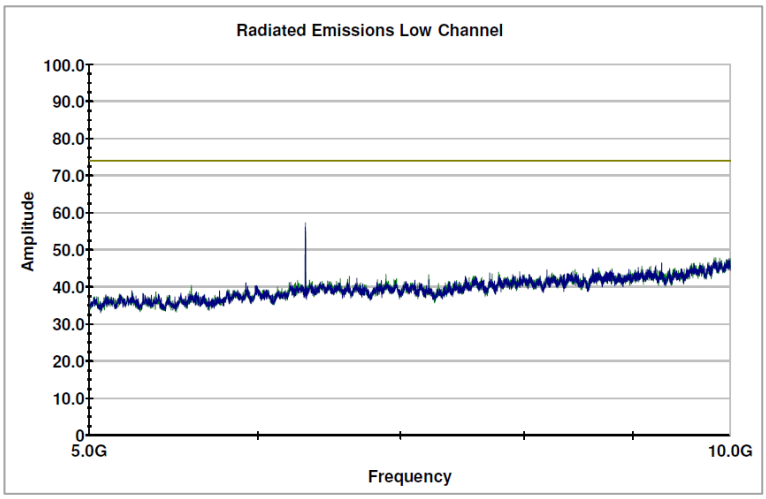


Plot 22: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 30-1000MHz

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



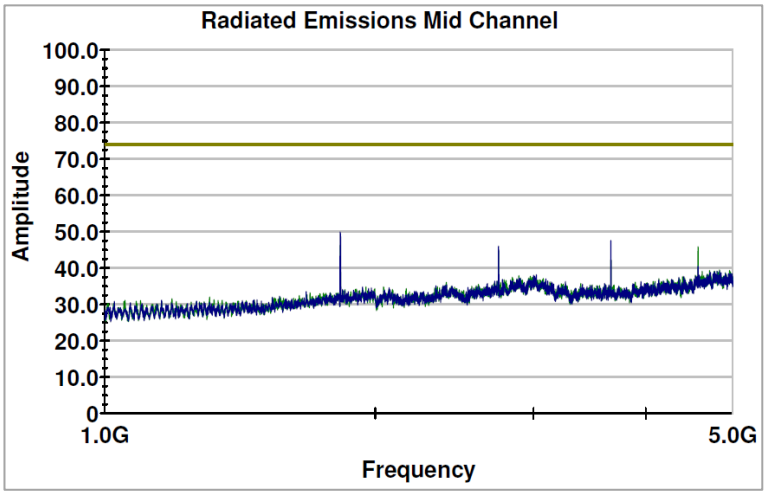
Plot 23: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 1-5GHz



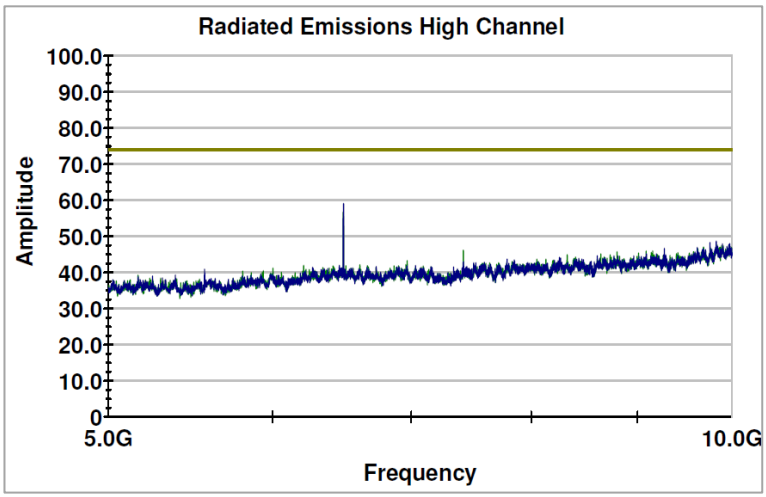
Plot 24: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 5-10GHz

Table 16: 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	56.7	51.9	V	0	160	30.5	-34.6	52.6	47.8	94.3	83.3	41.7	35.5
1805	56.6	53.7	H	50	190	30.5	-34.6	52.5	49.6	94.3	83.3	41.8	33.7
2707.5	53.3	48.7	V	0	230	33	-32.8	53.5	48.9	74	54	20.5	5.1
2707.5	52	45	H	0	150	33	-32.8	52.2	45.2	74	54	21.8	8.8
3610	49.3	41.3	V	50	100	33.2	-31	51.5	43.5	74	54	22.5	10.5
3610	50.8	43.6	H	50	200	33.2	-31	53	45.8	74	54	21	8.2
4512	42.5	33	V	20	200	33.9	-29.2	47.2	37.7	74	54	26.8	16.3
4512	43.1	31.6	H	0	150	33.9	-29.2	47.8	36.3	74	54	26.2	17.7
5415.5	43.2	33	V	40	165	34.5	-25.4	52.3	42.1	74	54	21.7	11.9
5415.5	42.3	31	H	0	180	34.5	-25.4	51.4	40.1	74	54	22.6	13.9
6317.5	50.6	40	V	330	200	35.6	-26.6	59.6	49	94.3	83.3	34.7	34.3
6317.5	51.7	42.1	H	340	220	35.6	-26.6	60.7	51.1	94.3	83.3	33.6	32.2
9025	45.5	31.5	V	40	230	36.3	-24.1	57.7	43.7	74	54	16.3	10.3
9025	45.8	33	H	347	220	36.3	-24.1	58	45.2	74	54	16	8.8



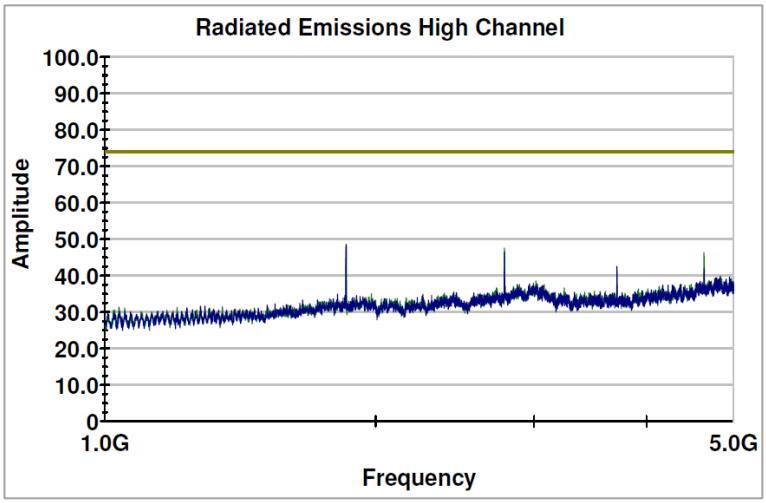
Plot 25: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 1-5GHz



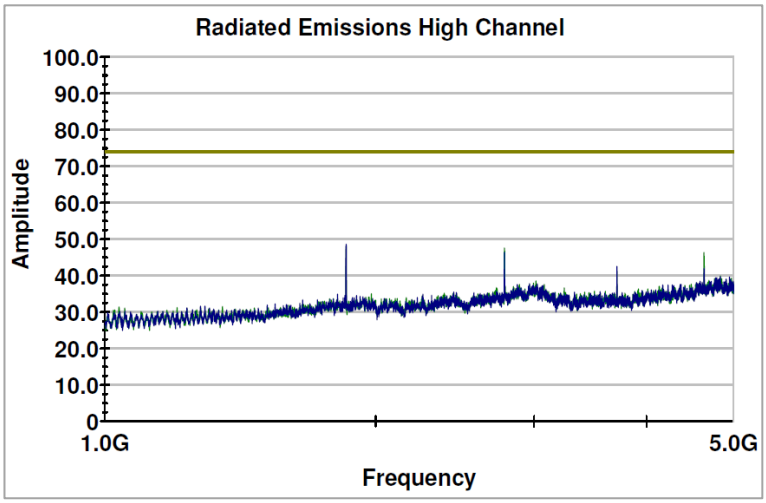
Plot 26: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 5-10GHz

Table 17: 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	56.2	52.5	V	340	230	30.5	-33.6	53.1	49.4	95.1	84.5	42	35.1
1830	54.8	50.6	H	340	210	30.5	-33.6	51.7	47.5	95.1	84.5	43.4	37
2745	52.8	46.5	V	0	230	33	-32.1	53.7	47.4	74	54	20.3	6.6
2745	51.6	44.3	H	10	215	33	-32.1	52.5	45.2	74	54	21.5	8.8
3660	45	35.7	V	0	160	33.2	-31	47.2	37.9	74	54	26.8	16.1
3660	46.5	40	H	340	200	33.2	-31	48.7	42.2	74	54	25.3	11.8
4575	43.6	31.5	V	0	150	33.9	-29.6	47.9	35.8	74	54	26.1	18.2
4575	44	32.5	H	0	180	33.9	-29.6	48.3	36.8	74	54	25.7	17.2
5490	43.7	32.6	V	340	150	34.5	-27.7	50.5	39.4	95.1	84.5	44.6	45.1
5490	45.3	36	H	10	250	34.5	-27.7	52.1	42.8	95.1	84.5	43	41.7
6405	53	43.5	V	55	170	35.6	-25.6	63	53.5	95.1	84.5	32.1	31
6405	51.3	39	H	340	110	35.6	-25.6	61.3	49	95.1	84.5	33.8	35.5
9150	45.6	33.5	V	350	210	36.3	-25.2	56.7	44.6	74	54	17.3	9.4



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

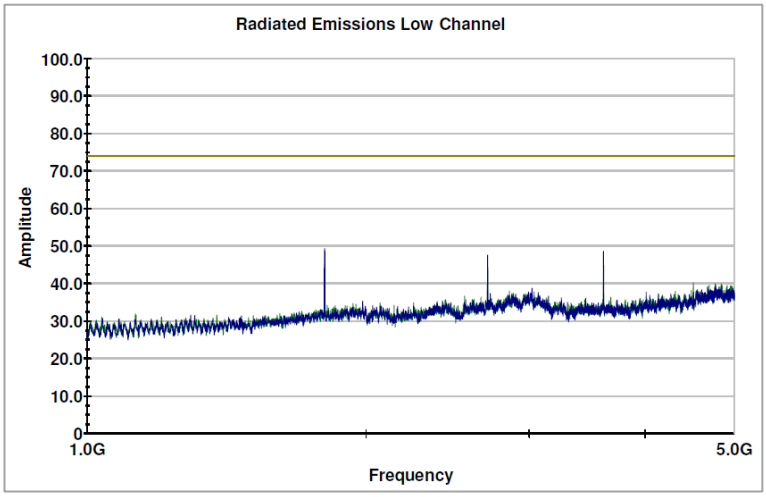


Plot 28: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 5-10GHz

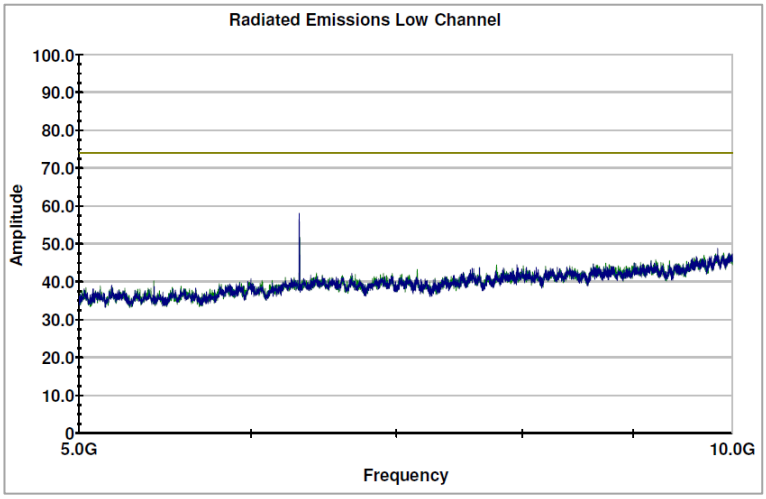
Table 18: TX Mode (High Channel) – Radiated Spurious Emissions Data: 1-10GHz

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	57.3	53.6	V	90	250	30.5	-33.3	54.5	50.8	96.4	86.2	41.9	35.4
1855	54.3	48.7	H	50	160	30.5	-33.3	51.5	45.9	96.4	86.2	44.9	40.3
2782.5	49.5	43	V	50	140	33	-31.7	50.8	44.3	74	54	23.2	9.7
2782.5	48.1	40.8	H	330	230	33	-31.7	49.4	42.1	74	54	24.6	11.9
3710	44.7	35	V	50	240	33.2	-30	47.9	38.2	74	54	26.1	15.8
3710	45.1	37	H	70	230	33.2	-30	48.3	40.2	74	54	25.7	13.8
5565	44.8	33.7	V	40	140	34.5	-27.8	51.5	40.4	96.4	86.2	44.9	45.8
5565	48.2	37.1	H	330	200	34.5	-27.8	54.9	43.8	96.4	86.2	41.5	42.4
6492.5	51.8	42.5	V	50	170	35.6	-26.4	61	51.7	96.4	86.2	35.4	34.5
6492.5	52.8	43.6	H	350	230	35.6	-26.4	62	52.8	96.4	86.2	34.4	33.4

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



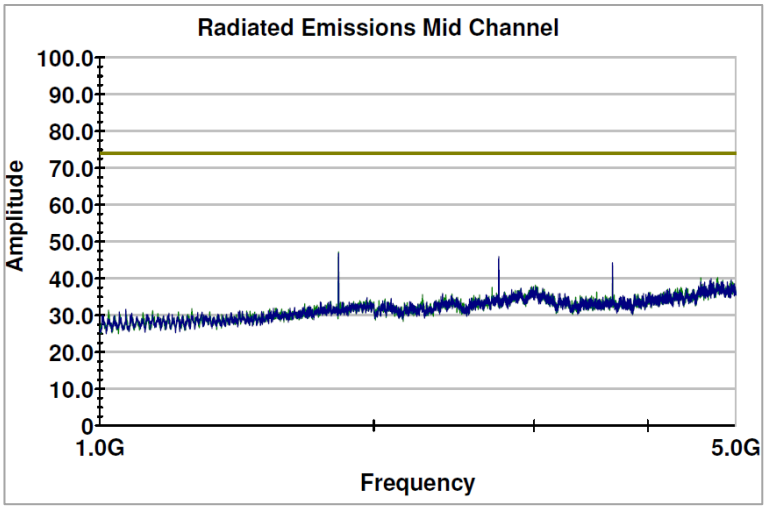
Plot 29: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 1-5GHz (LORA Radio Type- N-Female omni whip)



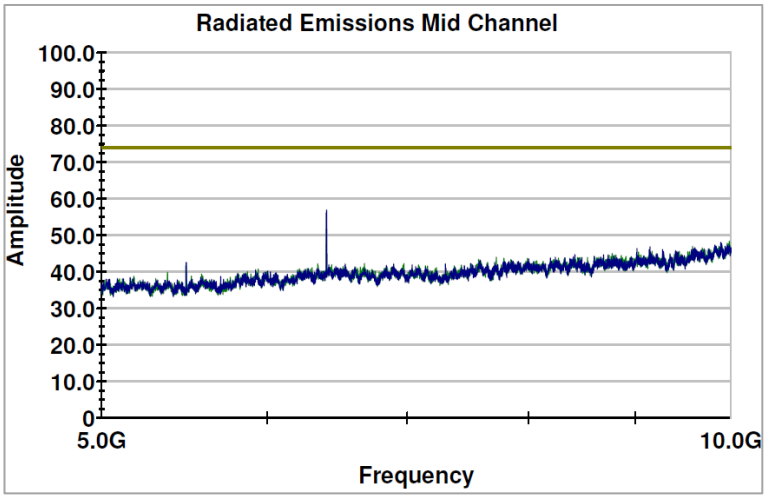
Plot 30: TX Mode (Low Channel) – Radiated Spurious Emissions Plot: 5-10GHz (LORA Radio Type- N-Female omni whip)

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

Freq. (MHz)	Raw Peak (dBm)	Raw Average (dBm)	Loss (dB)	Corrected Peak (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Pk E-field Strength at 3m (dBuV/m)	Ave E-field Strength at 3m (dBuV/m)	Pk Limit (dBuV/m)	Pk Margin (dBuV/m)	Ave Limit (dBuV/m)	Ave Margin (dBuV/m)
2707.8	-66.5	-77	1.66	-64.84	8	-56.84	38.42	27.92	74	35.58	54	26.08
3610	-49.86	-55.75	1.67	-48.19	8	-40.19	55.07	49.18	74	18.93	54	4.82
4512	-66.57	-78.1	2.94	-63.63	8	-55.63	39.63	28.1	74	34.37	54	25.9
5415.8	-65.42	-78.5	5.63	-59.79	8	-51.79	43.47	30.39	74	30.53	54	23.61
7220	-64.82	-78.13	3.79	-61.03	8	-53.03	42.23	28.92	74	31.77	54	25.08
8122.5	-68	-75	3.28	-64.72	8	-56.72	38.54	31.54	74	35.46	54	22.46
9025	-54.6	-68.35	4	-50.6	8	-42.6	52.66	38.91	74	21.34	54	15.09



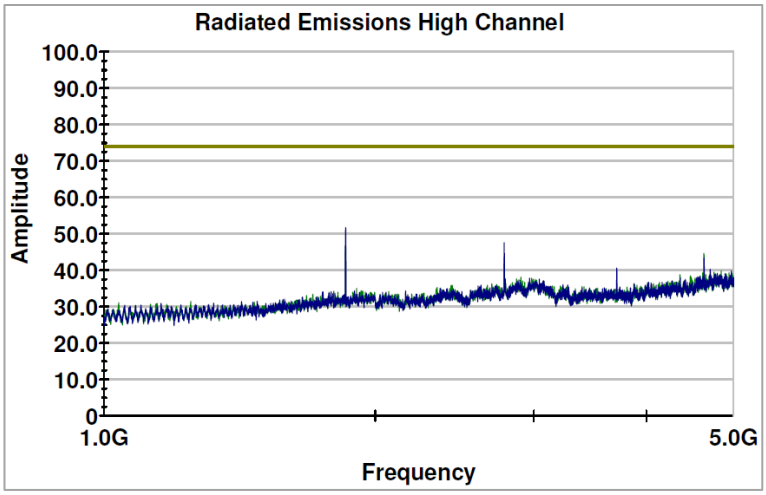
Plot 31: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 1-5GHz (LORA Radio Type- N-Female omni whip)



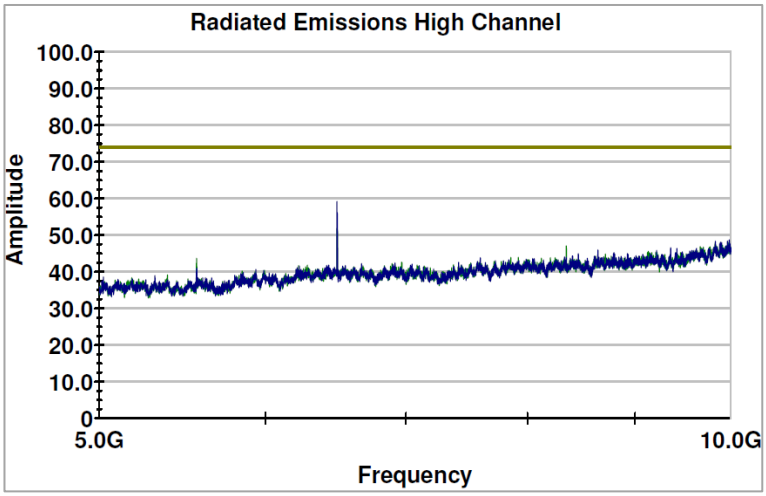
Plot 32: TX Mode (Mid Channel) – Radiated Spurious Emissions Plot: 5-10GHz (LORA Radio Type- N-Female omni whip)

Table 20: TX Mode (Mid Channel) – Radiated Spurious Emissions Data: 1-10GHz (LORA Radio Type- N-Female omni whip)

Freq. (MHz)	Raw Peak (dBm)	Raw Average (dBm)	Loss (dB)	Corrected Peak (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Pk E-field Strength at 3m (dBuV/m)	Ave E-field Strength at 3m (dBuV/m)	Pk Limit (dBuV/m)	Pk Margin (dBuV/m)	Ave Limit (dBuV/m)	Ave Margin (dBuV/m)
2745	-62.79	-70.6	1.38	-61.41	8	-53.41	41.85	34.04	74	32.15	54	19.96
3660	-48.5	-54.7	1.73	-46.77	8	-38.77	56.49	50.29	74	17.51	54	3.71
4575	-73.1	-78.2	3.25	-69.85	8	-61.85	33.41	28.31	74	40.59	54	25.69
7320	-64.8	-75.1	2.71	-62.09	8	-54.09	41.17	30.87	74	32.83	54	23.13
8235	-65.46	-77	3.76	-61.7	8	-53.7	41.56	30.02	74	32.44	54	23.98
9150	-54	-67.2	3.69	-50.31	8	-42.31	52.95	39.75	74	21.05	54	14.25



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

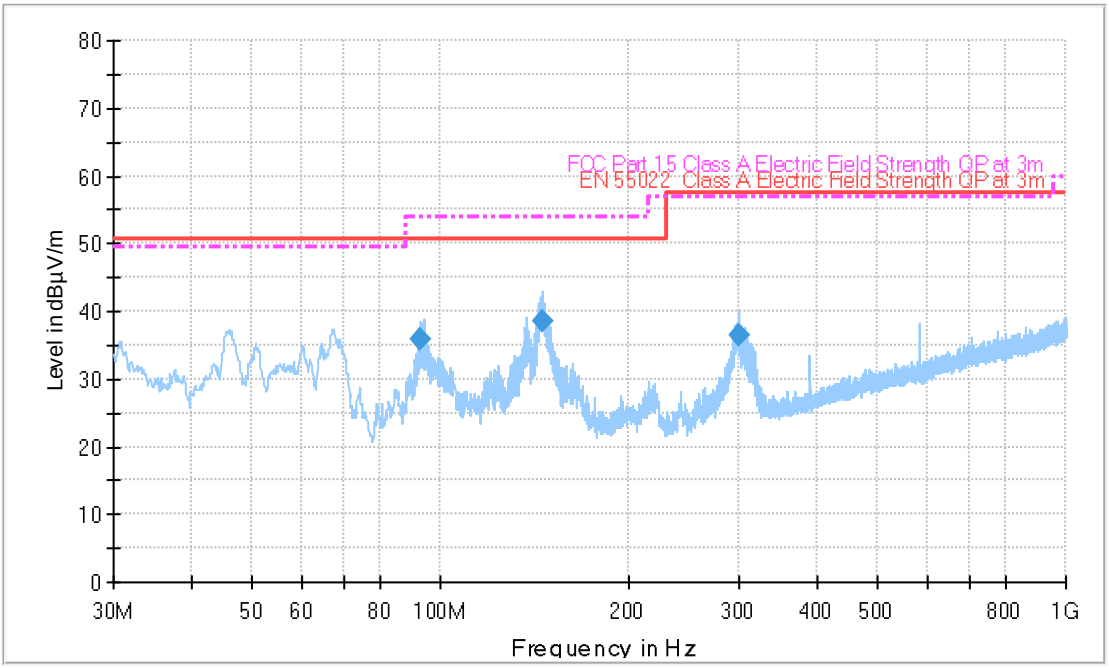


Plot 34: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 5-10GHz (LORA Radio Type- N-Female omni whip)

Table 21: TX Mode (High Channel) – Radiated Spurious Emissions Data: 1-10GHz (LORA Radio Type- N-Female omni whip)

Freq. (MHz)	Raw Peak (dBm)	Raw Average (dBm)	Loss (dB)	Corrected Peak (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Pk E-field Strength at 3m (dBuV/m)	Ave E-field Strength at 3m (dBuV/m)	Pk Limit (dBuV/m)	Pk Margin (dBuV/m)	Ave Limit (dBuV/m)	Ave Margin (dBuV/m)
2782.5	-60.7	-64.9	1.73	-58.97	8	-50.97	44.29	40.09	74	29.71	54	13.91
3710	-47.8	-52.88	1.92	-45.88	8	-37.88	57.38	52.3	74	16.62	54	1.7
4637.5	-69.5	-78.2	3.17	-66.33	8	-58.33	36.93	28.23	74	37.07	54	25.77
7420	-65.6	-77.06	2.45	-63.15	8	-55.15	40.11	28.65	74	33.89	54	25.35
8347.5	-66.1	-78.38	3.71	-62.39	8	-54.39	40.87	28.59	74	33.13	54	25.41

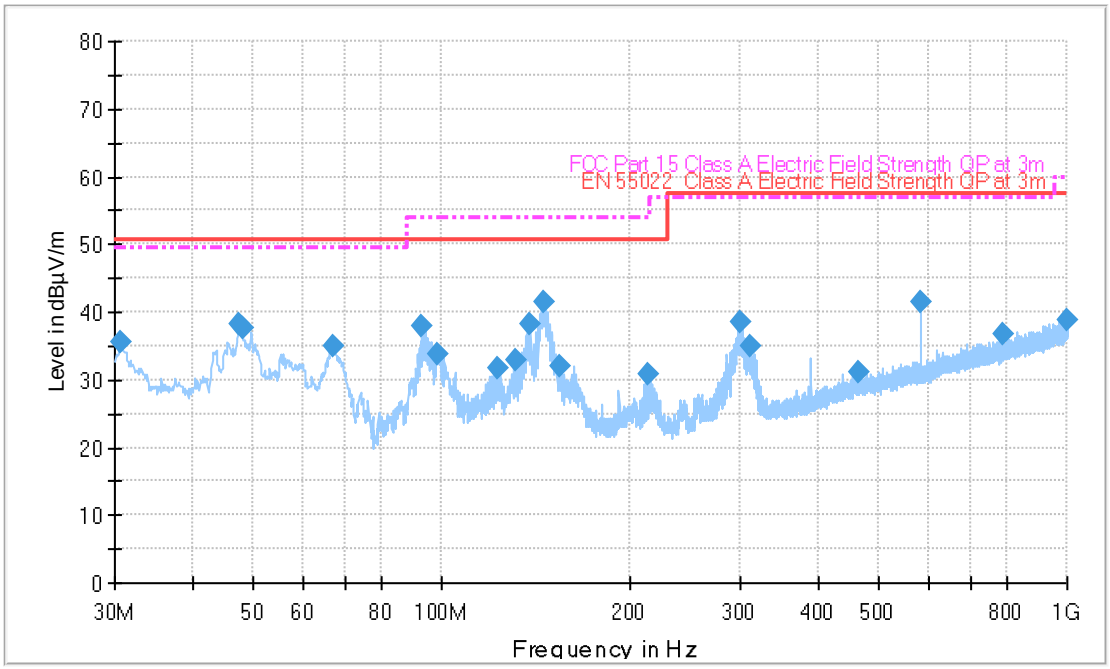
BLE Radio (2400-2483.5 MHz) Data and Plot



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

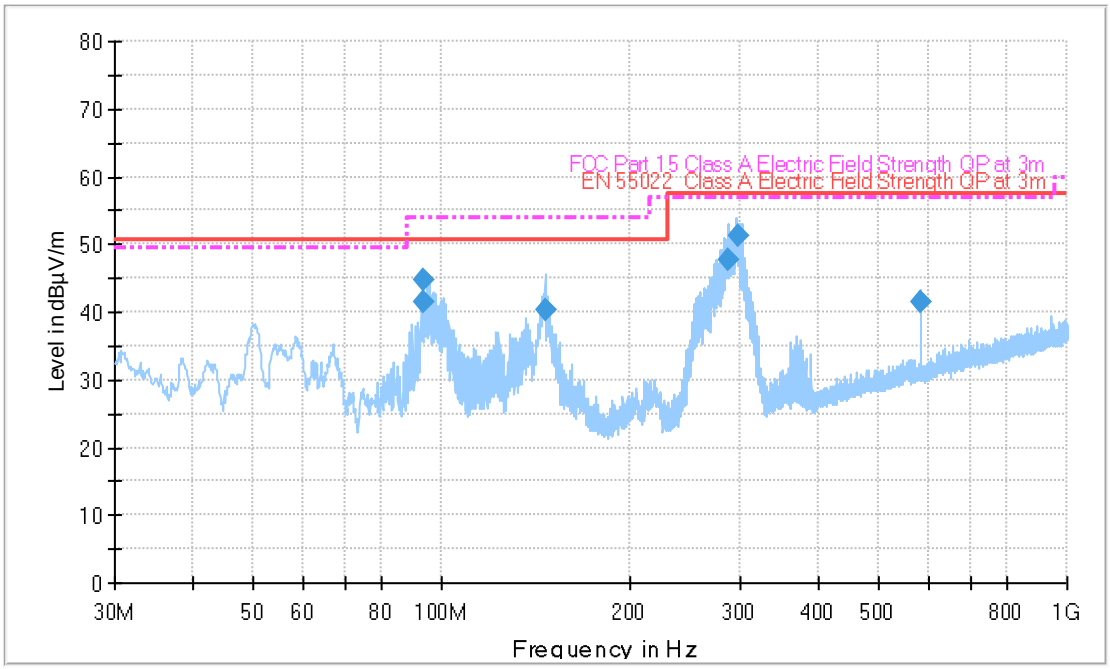
Table 22: TX Mode (Low Channel) – Radiated Spurious Emissions Data: 30-1000MHz (BLE Radio)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
93.104900	36.0	1000.000	120.000	358.0	H	232.0	15.4	18	54.0
145.554800	38.4	1000.000	120.000	171.0	H	66.0	20.2	15.6	54.0
300.356400	36.3	1000.000	120.000	100.0	H	318.0	21.1	20.6	56.9



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

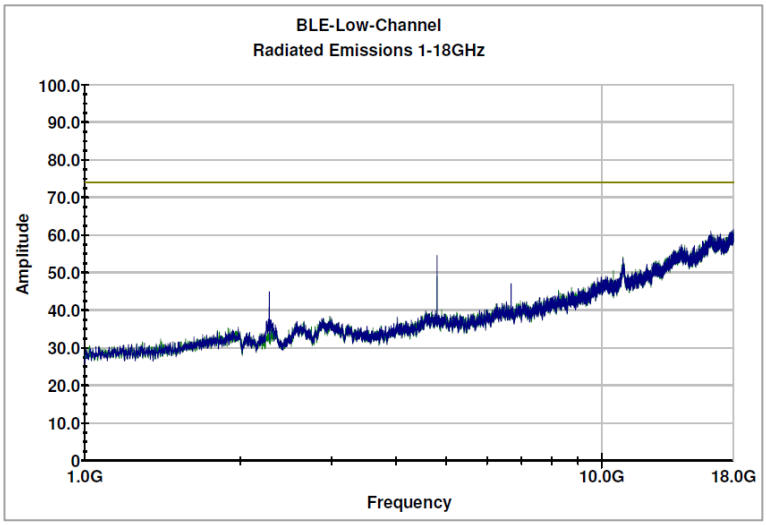
Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



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

Table 23: TX Mode (High Channel) – Radiated Spurious Emissions Data: 30-1000MHz (BLE Radio)

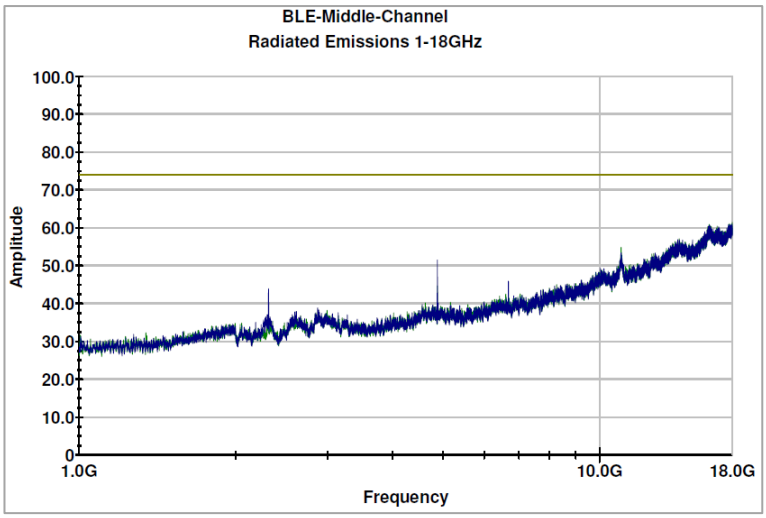
Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
93.724350	44.6	1000.000	120.000	350.0	H	153.0	15.6	9.4	54.0
93.726550	41.4	1000.000	120.000	328.0	H	308.0	15.6	12.6	54.0
146.310250	40.4	1000.000	120.000	232.0	H	1.0	20.2	13.6	54.0
288.155850	47.7	1000.000	120.000	100.0	H	303.0	21.0	9.2	56.9
297.113200	51.3	1000.000	120.000	100.0	H	230.0	21.1	5.6	56.9
585.021000	41.5	1000.000	120.000	100.0	V	337.0	27.2	15.4	56.9



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

Table 24: TX Mode (Low Channel) – Radiated Spurious Emissions Data: 1-18GHz (BLE Radio)

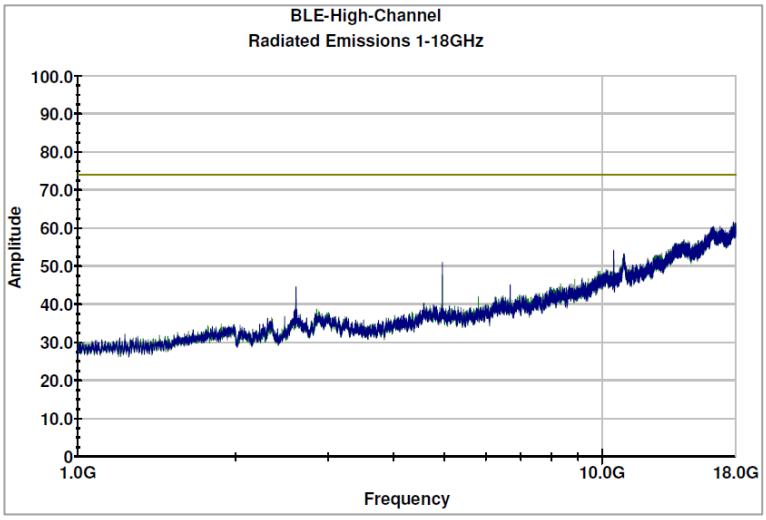
Freq. (MHz)	Raw Pk (dBuV/m)	Raw Ave. (dBuV/m)	Ant. Pol. (V/H)	Turn-table (degree)	Ant Ht (cm)	Ant factor (dB/m)	System Loss/ Gain (dB)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
4804	51.2	48	V	180.9	102	34.1	-30.3	55	51.8	74	54	19	2.2
4804	49.1	43	H	100	156.4	34.1	-30.3	52.9	46.8	74	54	21.1	7.2



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

Table 25: 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)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
4880	51.3	47.2	V	199	116.3	34.1	-30.3	55.1	51	74	54	18.9	3
4880	50.3	45.9	H	246.9	156.8	34.1	-30.3	54.1	49.7	74	54	19.9	4.3

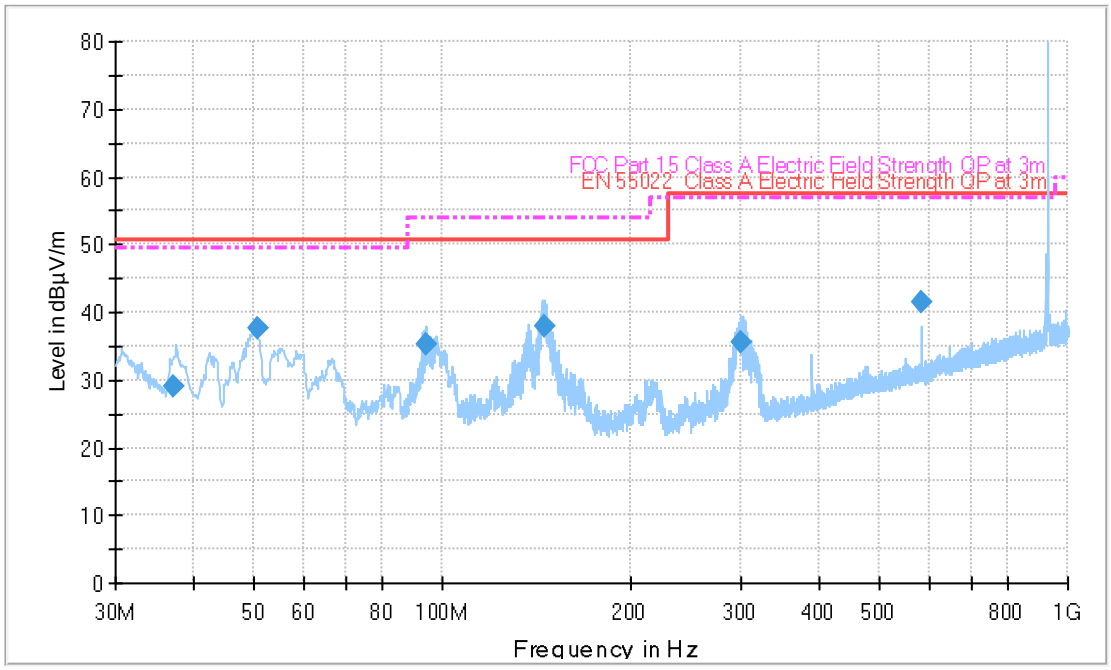


Plot 40: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 1-18GHz (BLE Radio)

Table 26: 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)	Corr. Pk (dBuV/m)	Corr. Ave. (dBuV/m)	Peak Limit (dBuV/m)	Ave Limit (dBuV/m)	Peak Margin (dB)	Average Margin (dB)
4960	46	36.3	V	176.3	167	34.1	-30.9	49.2	39.5	74	54	24.8	14.5
4960	45.9	36.6	H	277.6	235.3	34.1	-30.9	49.1	39.8	74	54	24.9	14.2

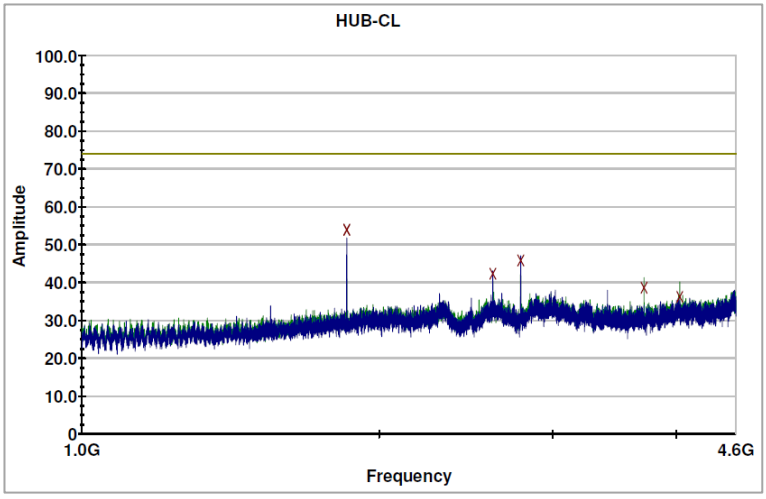
Collocation Radiated Spurious Emissions Test Data and Plot



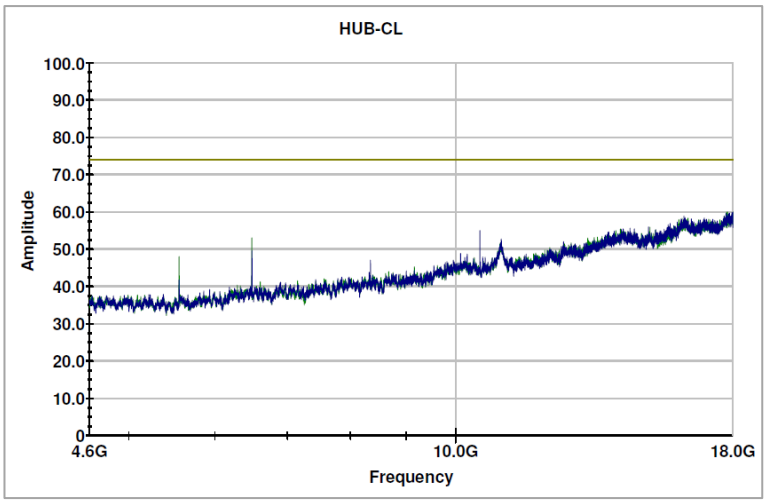
Plot 41: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 30-1000MHz (LORA and BLE are ON)

Table 27: TX Mode (High Channel) – Radiated Spurious Emissions Data: 30-1000MHz (LORA and BLE are ON)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
37.092700	29.1	1000.000	120.000	100.0	V	230.0	22.1	20.4	49.5
50.547600	37.6	1000.000	120.000	100.0	V	47.0	15.4	11.9	49.5
94.073450	35.3	1000.000	120.000	345.0	H	151.0	15.7	18.7	54.0
145.596400	37.9	1000.000	120.000	171.0	H	320.0	20.2	16.1	54.0
299.808350	35.5	1000.000	120.000	122.0	H	233.0	21.1	21.4	56.9
584.993650	41.5	1000.000	120.000	100.0	V	341.0	27.2	15.4	56.9



Plot 42: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 1-4.6GHz (LORA and BLE are ON)



Plot 43: TX Mode (High Channel) – Radiated Spurious Emissions Plot: 4.6-18GHz (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 21, 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).

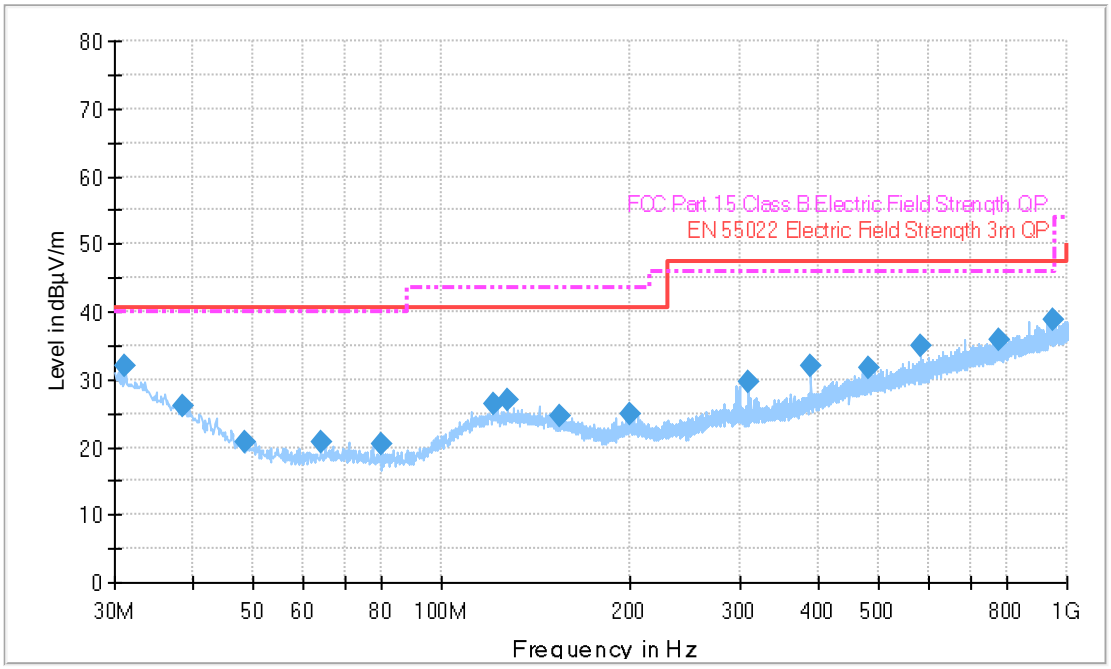
Modifications:

No modification was required to comply for this test.

Final Result:

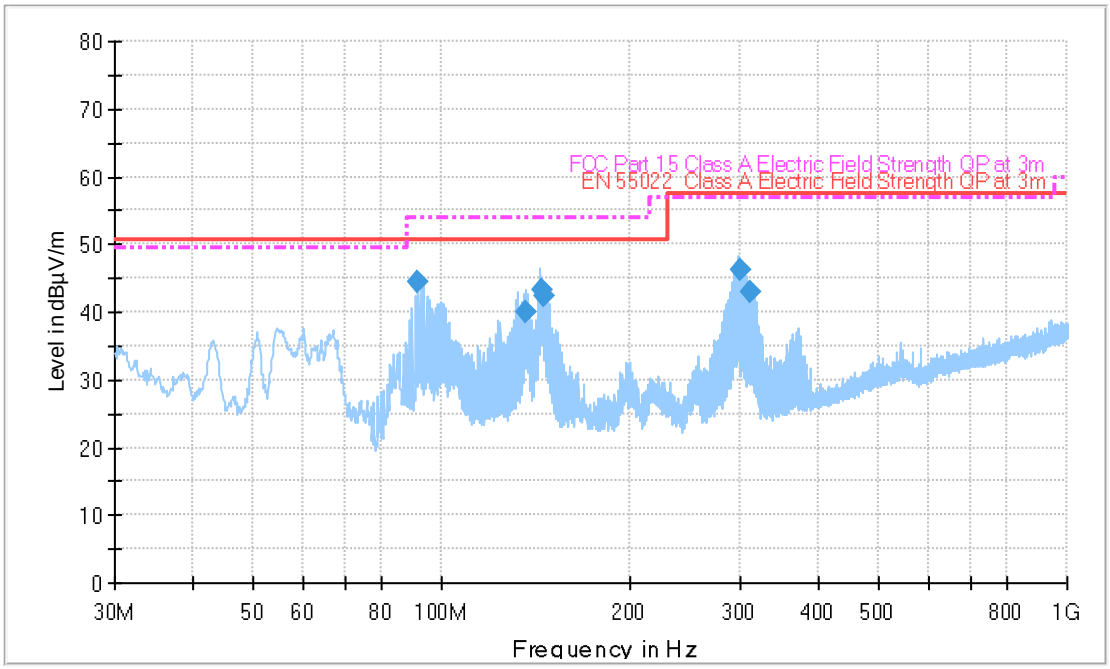
The EUT complies with the applicable standard.

Measurement Data and Plot:



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

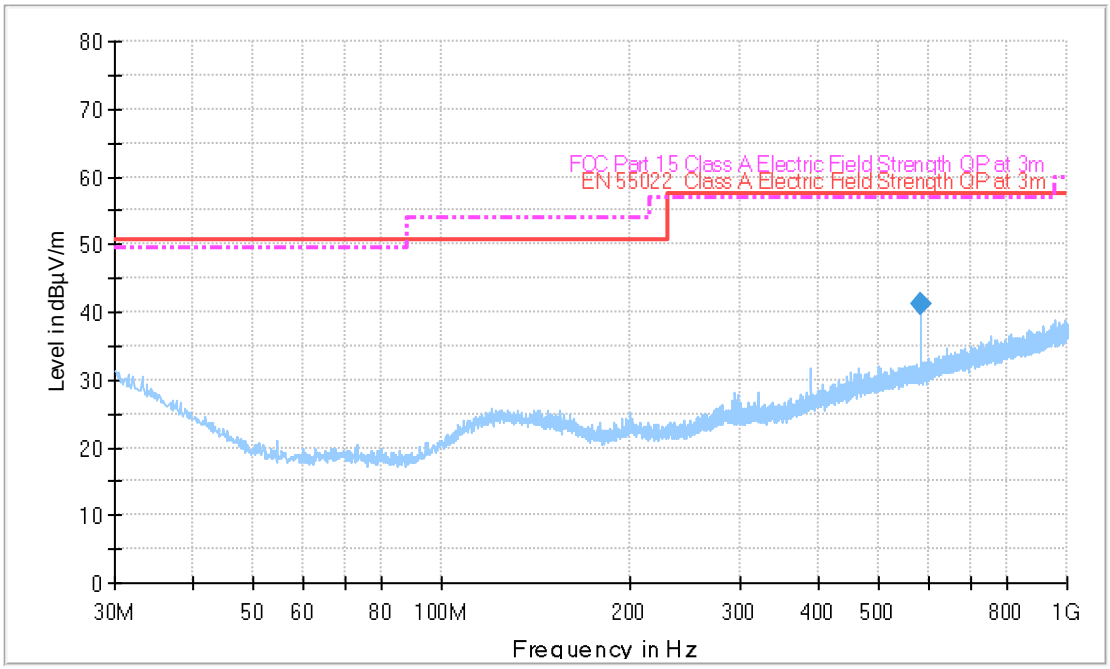
Note: *Quasi-peaks were 20dB or greater below the limit line and were not included in this report.*



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

Table 28: Radiated Spurious Emissions Data: 30-1000MHz (Power Supply was used – Standby Mode)

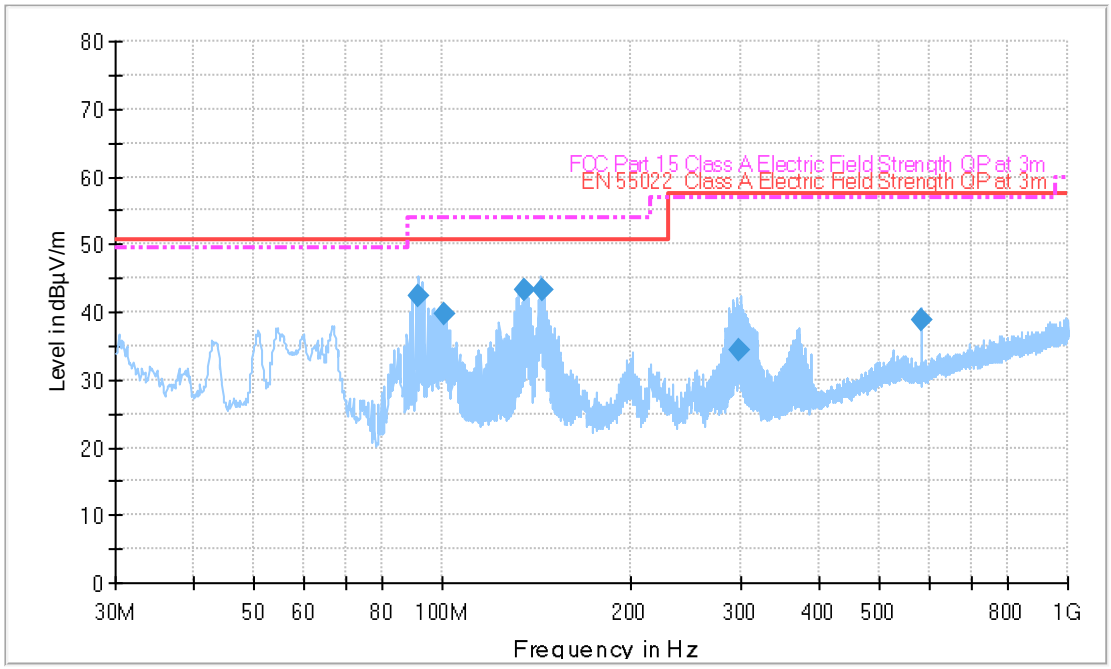
Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
91.756150	44.5	1000.000	120.000	100.0	V	168.0	15.1	9.5	54.0
136.122250	40.0	1000.000	120.000	100.0	V	237.0	20.6	14	54.0
144.970400	43.1	1000.000	120.000	207.0	H	0.0	20.2	10.9	54.0
145.965800	42.4	1000.000	120.000	171.0	H	0.0	20.2	11.6	54.0
299.880750	46.1	1000.000	120.000	100.0	H	229.0	21.1	10.8	56.9
310.658150	42.8	1000.000	120.000	100.0	H	234.0	21.3	14.1	56.9



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

Table 29: Radiated Spurious Emissions Data: 30-1000MHz (Battery was used – Receive Mode – LORA and BLE are ON)

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
584.990350	41.3	1000.000	120.000	123.0	V	169.0	27.2	15.6	56.9



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

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

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
91.757050	42.4	1000.000	120.000	135.0	V	180.0	15.1	11.6	54.0
100.653200	39.7	1000.000	120.000	280.0	H	81.0	17.3	14.3	54.0
135.181150	43.2	1000.000	120.000	220.0	H	60.0	20.6	10.8	54.0
145.043000	43.2	1000.000	120.000	158.0	H	1.0	20.2	10.8	54.0
299.006650	34.3	1000.000	120.000	170.0	V	196.0	21.1	22.6	56.9
585.033550	38.8	1000.000	120.000	100.0	V	322.0	27.2	18.1	56.9

3.10 AC Mains Conducted Emissions

Date Performed:

November 23, 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.

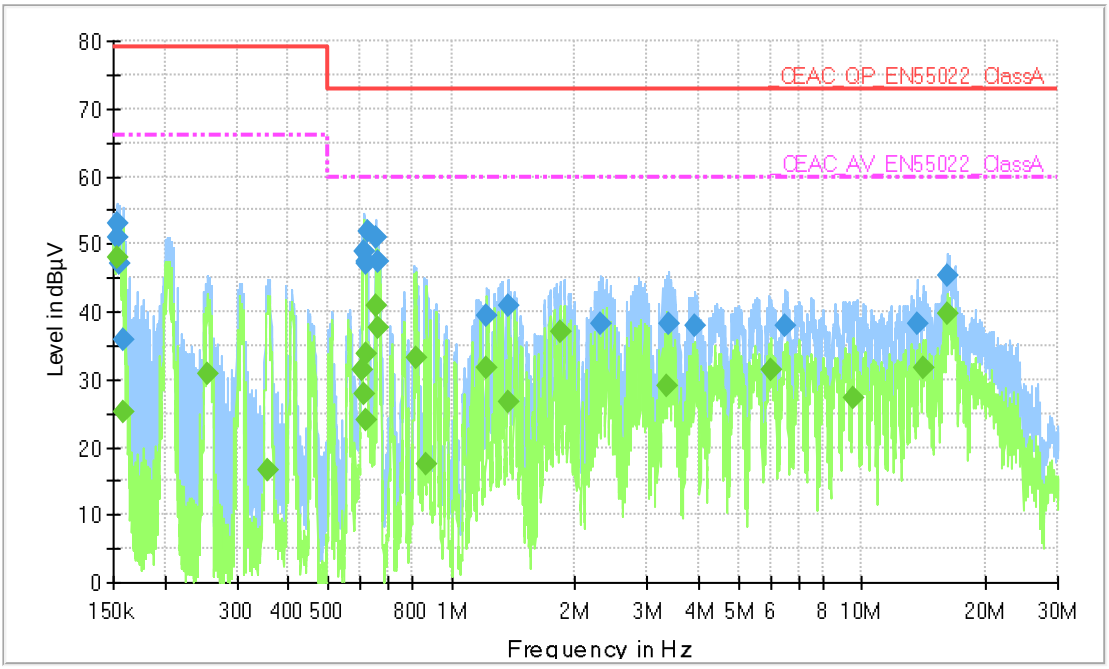
Modifications:

No modification was required to comply for this test.

Final Result:

The EUT complies with the applicable standard.

Measurement Data and Plot:



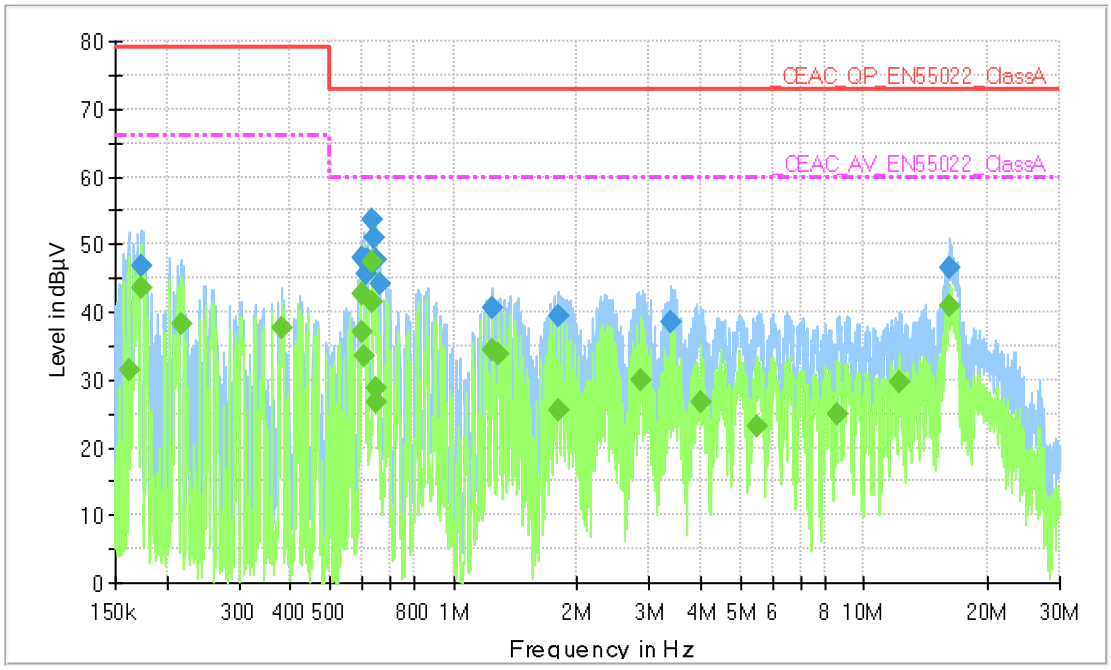
Plot 48: AC Mains Conducted Emissions Plot (Both Radios ON at High Channel) – Line 1

Table 31: Quasi-peak Data of AC Mains Conducted Emissions (Both Radios ON at High Channel) – Line 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.152723	53.1	1000.000	9.000	GND	10.5	25.9	79.0
0.153795	50.9	1000.000	9.000	GND	10.5	28.1	79.0
0.154875	47.1	1000.000	9.000	GND	10.5	31.9	79.0
0.159112	35.8	1000.000	9.000	GND	10.5	43.2	79.0
0.612735	48.9	1000.000	9.000	GND	10.4	24.1	73.0
0.618271	47.5	1000.000	9.000	GND	10.4	25.5	73.0
0.620748	47.0	1000.000	9.000	GND	10.4	26.0	73.0
0.623235	51.9	1000.000	9.000	GND	10.4	21.1	73.0
0.651255	51.0	1000.000	9.000	GND	10.4	22.0	73.0
0.660432	47.3	1000.000	9.000	GND	10.4	25.7	73.0
1.222418	39.4	1000.000	9.000	GND	10.4	33.6	73.0
1.375438	40.9	1000.000	9.000	GND	10.4	32.1	73.0
2.318854	38.2	1000.000	9.000	GND	10.5	34.8	73.0
3.396965	38.1	1000.000	9.000	GND	10.5	34.9	73.0
3.911074	38.0	1000.000	9.000	GND	10.5	35.0	73.0
6.504912	37.9	1000.000	9.000	GND	10.6	35.1	73.0
13.700437	38.2	1000.000	9.000	GND	10.6	34.8	73.0
16.200008	45.4	1000.000	9.000	GND	10.6	27.6	73.0

Table 32: Average Data of AC Mains Conducted Emissions (Both Radios ON at High Channel) – Line 1

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.152723	47.9	1000.000	9.000	GND	10.5	18.1	66.0
0.159112	25.1	1000.000	9.000	GND	10.5	40.9	66.0
0.254518	30.8	1000.000	9.000	GND	10.4	35.2	66.0
0.357523	16.5	1000.000	9.000	GND	10.4	49.5	66.0
0.607855	31.3	1000.000	9.000	GND	10.4	28.7	60.0
0.612735	27.8	1000.000	9.000	GND	10.4	32.2	60.0
0.618271	23.9	1000.000	9.000	GND	10.4	36.1	60.0
0.620748	33.8	1000.000	9.000	GND	10.4	26.2	60.0
0.651255	40.9	1000.000	9.000	GND	10.4	19.1	60.0
0.662415	37.7	1000.000	9.000	GND	10.4	22.3	60.0
0.815490	33.3	1000.000	9.000	GND	10.4	26.7	60.0
0.867624	17.6	1000.000	9.000	GND	10.4	42.4	60.0
1.222418	31.7	1000.000	9.000	GND	10.4	28.3	60.0
1.375438	26.6	1000.000	9.000	GND	10.4	33.4	60.0
1.836071	37.1	1000.000	9.000	GND	10.5	22.9	60.0
3.356465	29.1	1000.000	9.000	GND	10.5	30.9	60.0
5.999032	31.5	1000.000	9.000	GND	10.5	28.5	60.0
9.567431	27.3	1000.000	9.000	GND	10.6	32.7	60.0
14.131583	31.6	1000.000	9.000	GND	10.6	28.4	60.0
16.216208	39.8	1000.000	9.000	GND	10.6	20.2	60.0



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

Table 33: Quasi-peak Data of AC Mains Conducted Emissions (Both Radios ON at High Channel) – Line 2

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.174262	46.8	1000.000	9.000	GND	10.5	32.2	79.0
0.601208	48.0	1000.000	9.000	GND	10.4	25.0	73.0
0.608462	47.8	1000.000	9.000	GND	10.4	25.2	73.0
0.612122	45.8	1000.000	9.000	GND	10.4	27.2	73.0
0.613347	47.7	1000.000	9.000	GND	10.4	25.3	73.0
0.615804	47.8	1000.000	9.000	GND	10.4	25.2	73.0
0.631386	53.7	1000.000	9.000	GND	10.4	19.3	73.0
0.642205	51.1	1000.000	9.000	GND	10.4	21.9	73.0
0.647361	47.8	1000.000	9.000	GND	10.4	25.2	73.0
0.663741	44.3	1000.000	9.000	GND	10.4	28.7	73.0
1.248348	40.5	1000.000	9.000	GND	10.4	32.5	73.0
1.803333	39.5	1000.000	9.000	GND	10.5	33.5	73.0
3.380031	38.6	1000.000	9.000	GND	10.5	34.4	73.0
16.248657	46.4	1000.000	9.000	GND	10.6	26.6	73.0

Table 34: Average Data of AC Mains Conducted Emissions (Both Radios ON at High Channel) – Line 2

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.161677	31.3	1000.000	9.000	GND	10.5	34.7	66.0
0.173047	43.6	1000.000	9.000	GND	10.5	22.4	66.0
0.216254	38.3	1000.000	9.000	GND	10.4	27.7	66.0
0.382668	37.7	1000.000	9.000	GND	10.4	28.3	66.0
0.597017	42.6	1000.000	9.000	GND	10.4	17.4	60.0
0.600608	37.1	1000.000	9.000	GND	10.4	22.9	60.0
0.606641	33.5	1000.000	9.000	GND	10.4	26.5	60.0
0.632017	47.5	1000.000	9.000	GND	10.4	12.5	60.0
0.636454	41.4	1000.000	9.000	GND	10.4	18.6	60.0
0.644778	28.7	1000.000	9.000	GND	10.4	31.3	60.0
0.649305	26.8	1000.000	9.000	GND	10.4	33.2	60.0
1.248348	34.5	1000.000	9.000	GND	10.4	25.5	60.0
1.290209	33.9	1000.000	9.000	GND	10.4	26.1	60.0
1.806942	25.4	1000.000	9.000	GND	10.5	34.6	60.0
2.866143	29.9	1000.000	9.000	GND	10.5	30.1	60.0
3.998027	26.8	1000.000	9.000	GND	10.5	33.2	60.0
5.488432	23.1	1000.000	9.000	GND	10.5	37.0	60.0
8.614245	25.0	1000.000	9.000	GND	10.6	35.0	60.0
12.164078	29.5	1000.000	9.000	GND	10.6	30.5	60.0
16.248657	41.0	1000.000	9.000	GND	10.6	19.0	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:

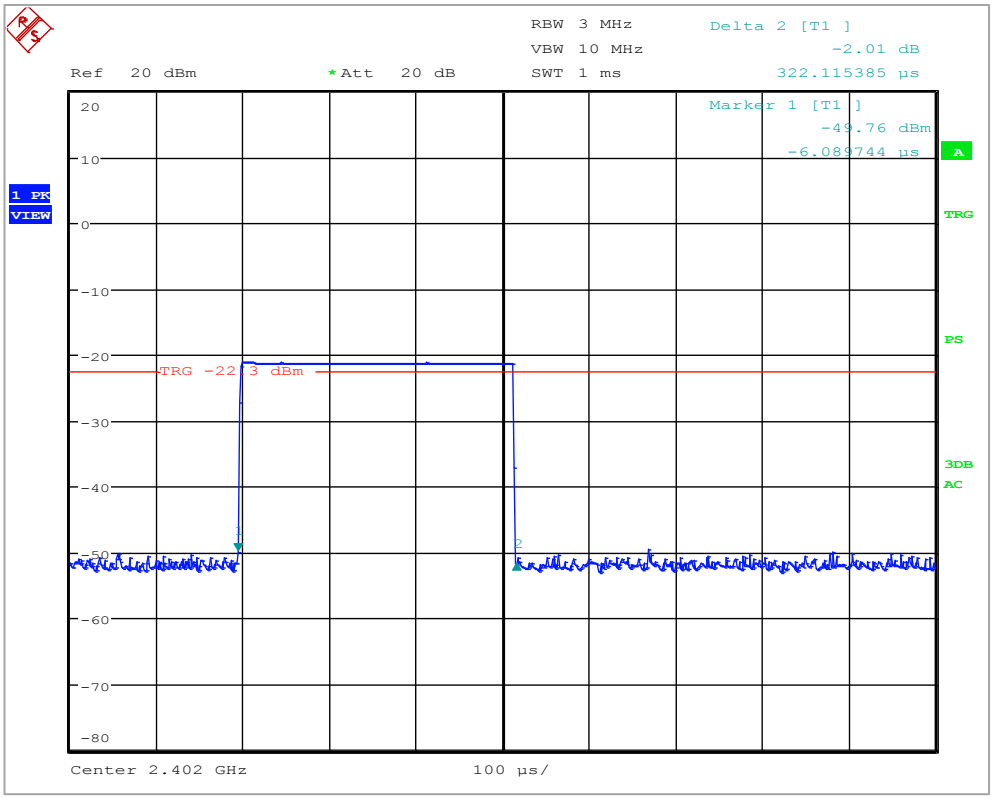
The EUT complies with the applicable standard.

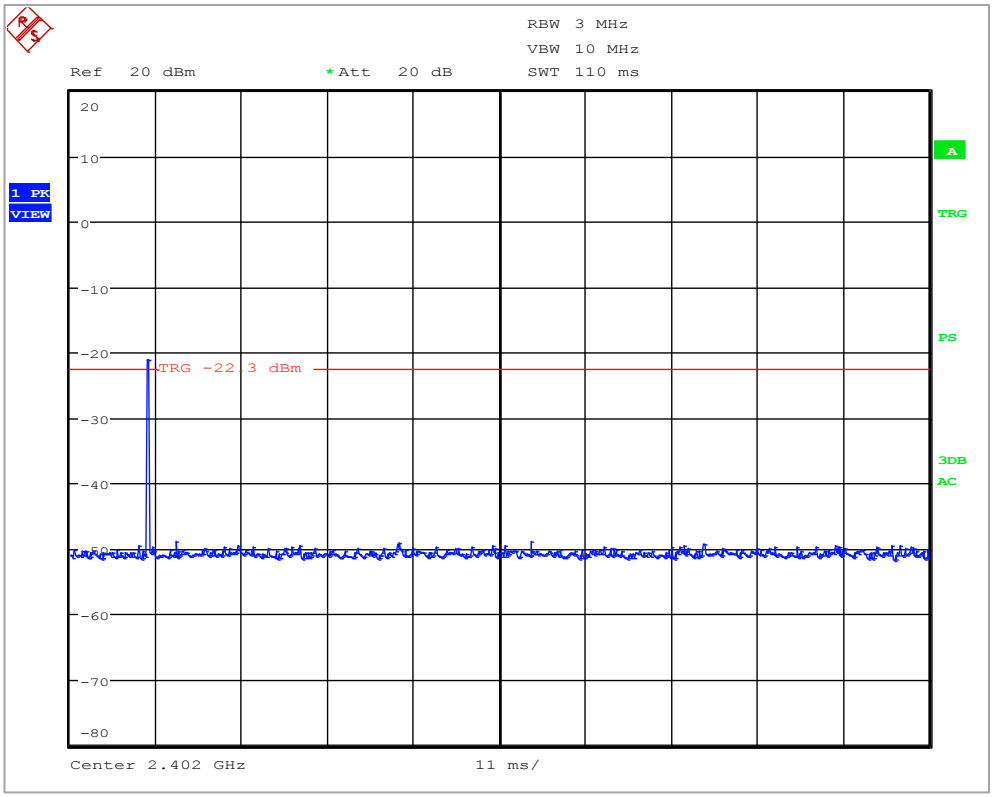
Measurement Data and Plot:

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.*

BLE Radio (2400-2483.5 MHz) Data and Plot





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 35: 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 36: Frequency Stability Data (LORA Radio: 902-928 MHz)

Temperature (°C)	Channel	Frequency (MHz)	Offset (MHz)	PPM
-40	Low	902.4927	-0.0108	-11.97
	Mid	914.992	-0.0123	-13.44
	High	927.4903	-0.0115	-12.40
20	Low	902.5035	0	0.00
	Mid	915.0043	0	0.00
	High	927.5018	0	0.00
50	Low	902.4954	-0.0081	-8.98
	Mid	914.9999	-0.0044	-4.81
	High	927.4928	-0.009	-9.70

BLE Radio (2400-2483.5 MHz) Data and Plot

Table 37: Frequency Stability Data (BLE Radio: 2400-2483.5 MHz)

Temperature (°C)	Channel	Frequency (MHz)	Offset (MHz)	PPM
-40	Low	2402.0291	-0.0086	-3.58
	Mid	2440.0491	-0.0086	-3.52
	High	2480.0011	-0.0115	-4.64
20	Low	2402.0377	0	0.00
	Mid	2440.0577	0	0.00
	High	2480.0126	0	0.00
50	Low	2402.0245	-0.0132	-5.50
	Mid	2440.0345	-0.0232	-9.51
	High	2480.0021	-0.0105	-4.23

3.13 RF Exposure Evaluation

Date Performed:

December 8, 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: Hub Device
Model: A01SG100

Module Identifier:

The host product contains the following modules:

Module or Product	FCC ID	IC ID	Model Name	Grant Status	Manufacturer
Hub unit	2AKAAA01SG100	22125-A01SG100	A01SG100		AGI
WiFi module inside Hub unit	XF6-RS9113SB	8407A-RS9113SB	n/a	Pre-approved	Redpine Signals Inc
Cellular module inside Hub unit	RI7HE910	5131A-HE910	n/A	Pre-approved	Telit Communications S.p.A.

Antenna Description:

Description	Manufacturer	Manufacturer's Part #	Value	Type
LORA Antenna	Nearson	S1551AH-915S	915MHz, +2.0dBi	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
Cellular Module Antenna	Laird	MAF94301	cellular heptaband, 1-3dBi	RPSMA(F) omni whip

Operating Modes/Configuration:

The operating modes/product configurations considered are:

1. Simultaneous transmission of only Bluetooth Low Energy (2400-2483.5MHz) and LORA 902-928MHz modules are allowed.
2. Pre-approved Wi-Fi and 3G modules are not configured to transmit simultaneously with any other 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 3.02dBm when the EUT was operated at 2402MHz.

Frequency (MHz)	Peak Output power (dBm)	Max Gain (dBi)	EIRP (dBm)	EIRP (mW)
2402	3.02	2	5.02	3.176874071

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

As per above equation power density at 20cm = $\frac{3.1768}{4x3.14x20x20}$ =0.000632 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 3.17mW which is far below the exemption limit 2.67W 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 14.93dBm when the EUT was operated at 902.5MHz.

Frequency (MHz)	Peak Output power (dBm)	Max Gain (dBi)	EIRP (dBm)	EIRP (mW)
902.5	14.93	2	16.93	49.3173804

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

As per above equation power density at 20cm = $\frac{49.3173}{4x3.14x20x20}$ =0.00982 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 49.3173mW at 902 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 was14.93dBm when the EUT was operated at 902.5MHz.

Frequency (MHz)	Peak Output power (dBm)	Max Gain (dBi)	EIRP (dBm)	EIRP (mW)
902.5	14.93	8	22.93	196.3360277

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

As per above equation power density at 20cm = $\frac{196.336}{4x3.14x20x20}$ =0.0391mW/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 196.336mW at 902 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	3.02	2	5.02	3.17687	0.322	0.0102295	2.03613E-06	1	2.036E-06
LORA 902-928MHz	14.93	2	16.93	49.3174	100	49.31738	0.009816358	1	0.0098164
MPE Total of Collocated Transmitters									0.0098184

Total MPE of collocated transmitters is 0.0098184 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	3.02	2	5.02	3.17687	0.322	0.0102295	2.03613E-06	1	2.036E-06
LORA 902-928MHz	14.93	8	22.93	196.336	100	196.33603	0.039079623	1	0.0390796
MPE Total of Collocated Transmitters									0.0390817

Total MPE of collocated transmitters is 0.039712 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 (below 1GHz) Test Setup

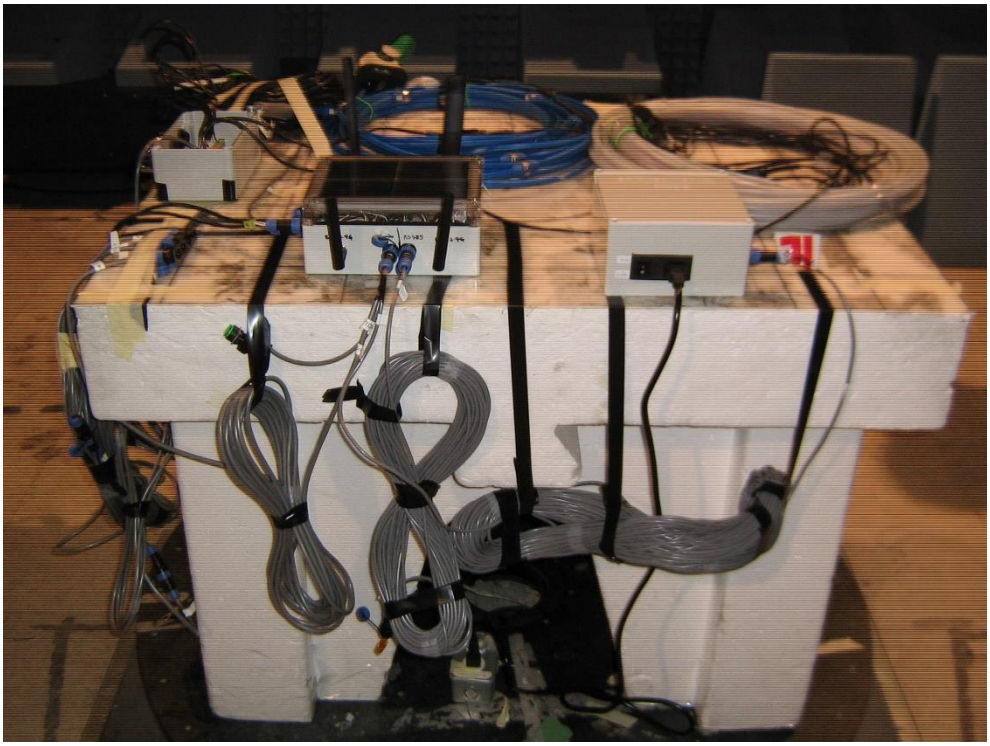


Figure 2: Radiated Emissions (below 1GHz close-up view) Test Setup

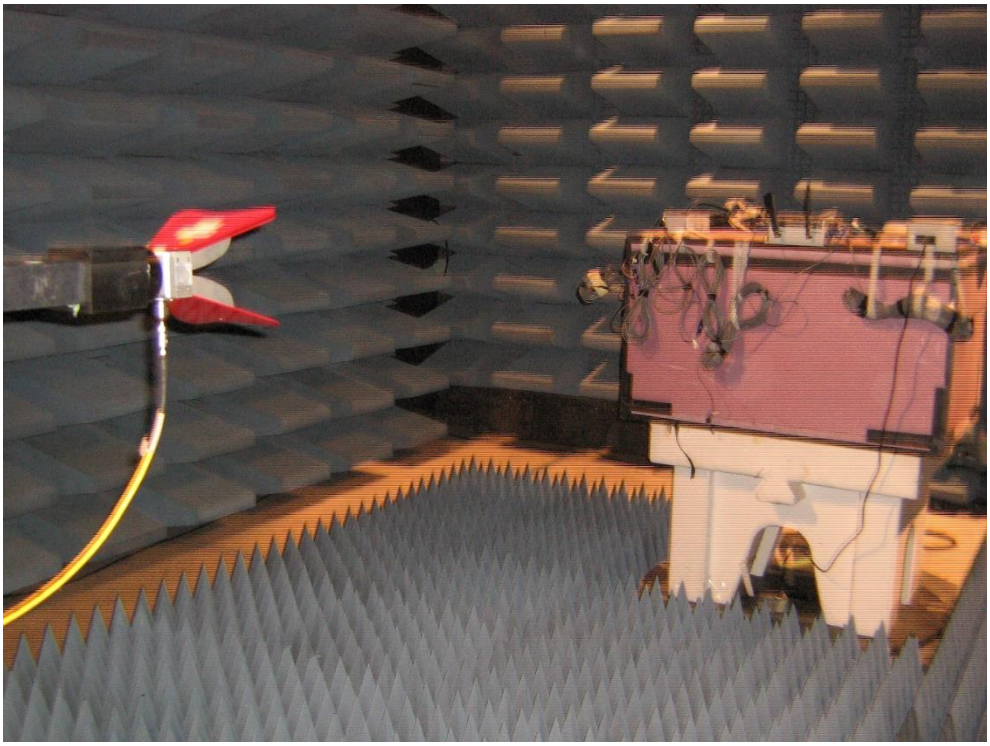


Figure 3: Radiated Emissions (above 1GHz) Test Setup

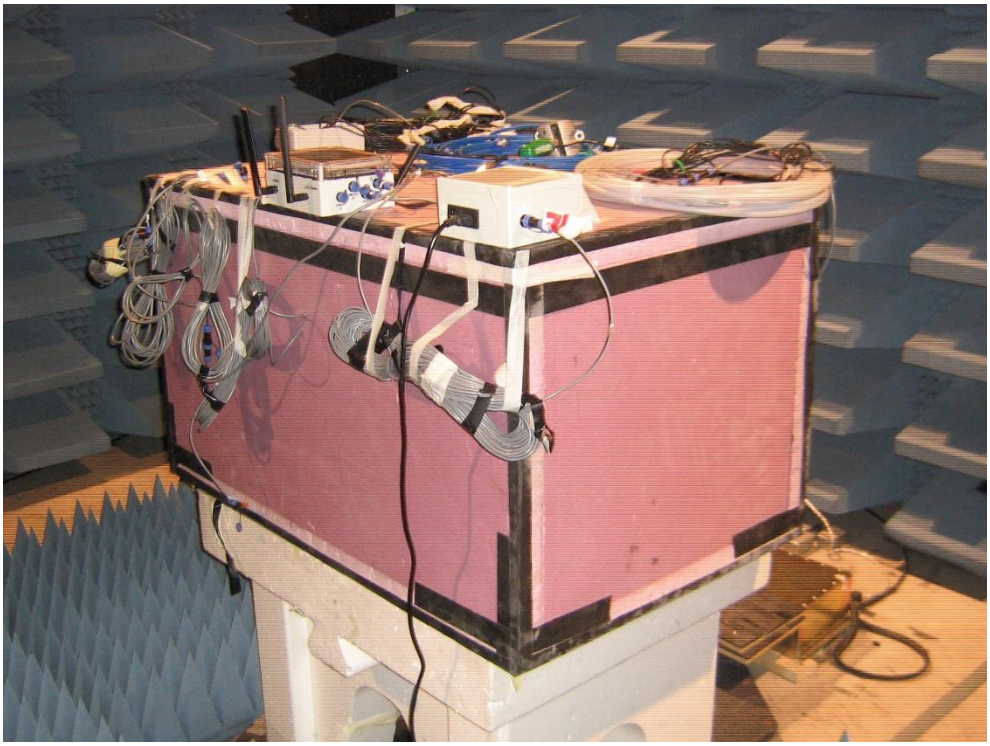


Figure 4: Radiated Emissions (above 1GHz close-up view) Test Setup

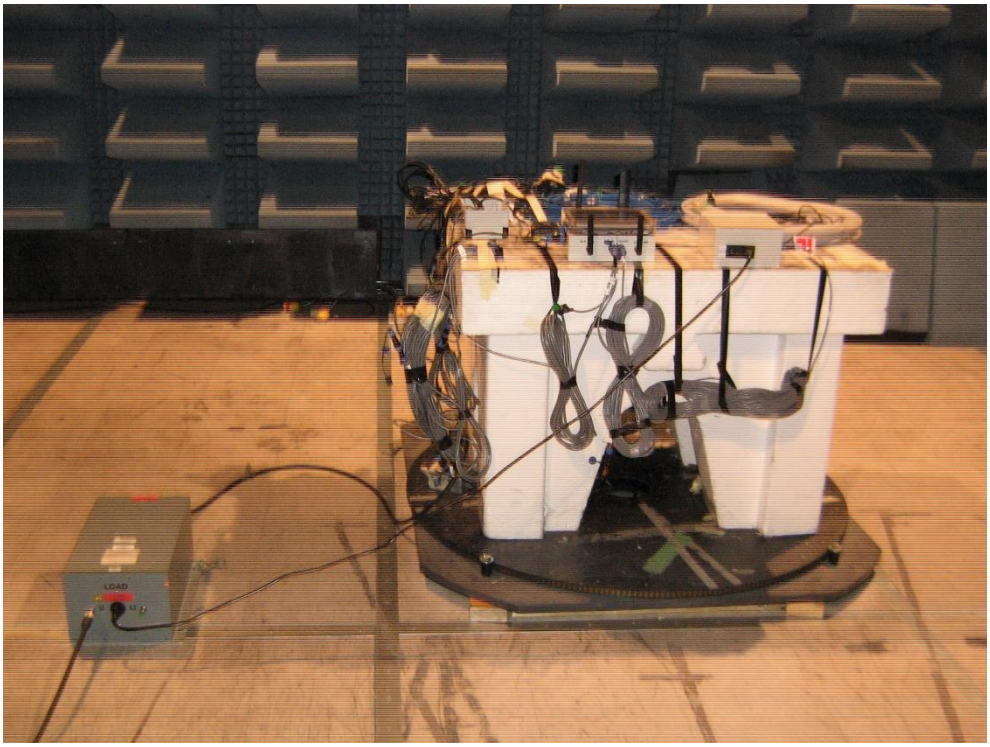


Figure 5: Conducted Emissions Test Setup

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