FCC Testing of the Damerell Consulting Ltd Industrial BLE Tag. Model: Conneq 2 In accordance with FCC 47 CFR Part 15C

Prepared for: Damerell Consulting Ltd
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United Kingdom

FCC ID: 2AN53-CONNEQ2

Product Service

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Date: December 2017
Document Number: 75939662-03 | Issue: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Steven White	08 December 2017	
Authorised Signatory	Matthew Russell	08 December 2017	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT
The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15C. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Mohamed Toubella	08 December 2017	
	Graeme Lawler	08 December 2017	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2016 for the tests detailed in section 1.3.

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Product Service

Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	08 December 2017

Table 1

1.2 Introduction

Applicant	Damerell Consulting Ltd
Manufacturer	Damerell Consulting Ltd
Model Number(s)	Conneq 2
Serial Number(s)	048518 and 048524
Hardware Version(s)	V3
Software Version(s)	3.5
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2016
Order Number Date	Proforma Invoice 05-July-2017
Date of Receipt of EUT	01-November-2017
Start of Test	01-November-2017
Finish of Test	08-November-2017
Name of Engineer(s)	Mohamed Toubella and Graeme Lawler
Related Document(s)	ANSI C63.10 (2013) KDB 558074 D01 DTS Meas Guidance v04

Product Service

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C is shown below.

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration and Mode: Bluetooth Low Energy - Transmit				
2.1	15.247 (a)(2)	Emission Bandwidth	Pass	ANSI C63.10 (2013)
2.2	15.247 (b)(3)	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013)
2.3	15.247 (d) and 15.205	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)
2.4	15.205	Restricted Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.247 (d)	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.6	15.247 (e)	Power Spectral Density	Pass	ANSI C63.10 (2013)

Table 2

Product Service

1.4 Application Form

EQUIPMENT DESCRIPTION	
Model Name/Number	Conneq 2
Part Number	BLE-I
Hardware Version	V3
Software Version	3.5
FCC ID (if applicable)	2AN53-CONNEQ2
Industry Canada ID (if applicable)	
Technical Description (Please provide a brief description of the intended use of the equipment)	Industrial Low Energy Bluetooth tag used for tagging outdoor and indoor assets, i.e. bed frames , plant equipment , cable drums

Types of Modulations used by the Equipment
☐ FHSS
☒ Other forms of modulation
In case of FHSS Modulation
In case of non-Adaptive Frequency Hopping equipment:
Number of Hopping Frequencies:
In case of Adaptive Frequency Hopping Equipment:
Maximum number of Hopping Frequencies:
Minimum number of Hopping Frequencies:
Dwell Time:
Adaptive / non-adaptive equipment:
☐ non-adaptive Equipment
☒ adaptive Equipment without the possibility to switch to a non-adaptive mode
☐ adaptive Equipment which can also operate in a non-adaptive mode
In case of adaptive equipment:
The maximum Channel Occupancy Time implemented by the equipment: 0.625µS
☐ The equipment has implemented an LBT based DAA mechanism
In case of equipment using modulation different from FHSS:
☐ The equipment is Frame Based equipment
☐ The equipment is Load Based equipment
☐ The equipment can switch dynamically between Frame Based and Load Based equipment
The CCA time implemented by the equipment: µs
☒ The equipment has implemented an non-LBT based DAA mechanism
☐ The equipment can operate in more than one adaptive mode

In case of non-adaptive Equipment:
The maximum RF Output Power (e.i.r.p.): dBm
The maximum (corresponding) Duty Cycle: %
Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):

In case of non-adaptive Equipment:	
The worst case operational mode for each of the following tests:	
RF Output Power: 8dBm	
Power Spectral Density:	
Duty cycle, Tx-Sequence, Tx-gap:	
Accumulated Transmit Time, Frequency Occupation & Hopping Sequence (only for FHSS equipment):	
Hopping Frequency Separation (only for FHSS equipment):	
Medium Utilisation:	
Adaptivity & Receiver Blocking:	
Nominal Channel Bandwidth:	
Transmitter unwanted emissions in the OOB domain:	
Transmitter unwanted emissions in the spurious domain:	
Receiver spurious emissions:	
The different transmit operating modes (tick all that apply):	
☐	Operating mode 1: Single Antenna Equipment
☒	Equipment with only 1 antenna
☐	Equipment with 2 diversity antennas but only 1 antenna active at any moment in time
☐	Smart Antenna Systems with 2 or more antennas, but operating in a (legacy) mode where only 1 antenna is used. (e.g. IEEE 802.11™ [i.3] legacy mode in smart antenna systems)
☐	Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming
☐	Single spatial stream / Standard throughput / (e.g. IEEE 802.11™ [i.3] legacy mode)
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 3
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 4
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 5
NOTE: Add more lines if more channel bandwidths are supported.	
☐	Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming
☐	Single spatial stream / Standard throughput (e.g. IEEE 802.11™ [i.3] legacy mode)
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 3
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 4
☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 5
NOTE: Add more lines if more channel bandwidths are supported.	

In case of Smart Antenna Systems:
The number of Receive chains:
The number of Transmit chains:
☐ symmetrical power distribution
☐ asymmetrical power distribution
In case of beam forming, the maximum (additional) beam forming gain: dB
NOTE: The additional beam forming gain does not include the basic gain of a single antenna.
Operating Frequency Range(s) of the equipment:
Operating Frequency Range 1: 2400 MHz to 2483.5 MHz
Operating Frequency Range 2: MHz to MHz
Operating Frequency Range 3: MHz to MHz
NOTE: Add more lines if more Frequency Ranges are supported.
Nominal Channel Bandwidth(s):
Nominal Channel Bandwidth1: 1 MHz
Nominal Channel Bandwidth2: MHz
Nominal Channel Bandwidth3: MHz
Nominal Channel Bandwidth4: MHz
Nominal Channel Bandwidth5: MHz
NOTE: Add more lines if more channel bandwidths are supported.
Type of Equipment (stand-alone, combined, plug-in radio device, etc.):
☒ Stand-alone
☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)
☐ Plug-in radio device (Equipment intended for a variety of host systems)
☐ Other
The normal and extreme operating conditions that apply to the equipment:
Normal operating conditions (if applicable):
Operating temperature: °C
Other (please specify if applicable):
Extreme operating conditions:
Operating temperature range: Minimum -20 °C to Maximum 60 °C
Other (please specify if applicable): Minimum °C to Maximum °C
Details provided are for the:
☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:			
Antenna Type:			
☒ Integral Antenna (information to be provided in case of conducted measurements)			
Antenna Gain: 0 dBi			
If applicable, additional beamforming gain (excluding basic antenna gain): dB			
☐ Temporary RF connector provided			
☐ No temporary RF connector provided			
☐ Dedicated Antennas (equipment with antenna connector)			
☐ Single power level with corresponding antenna(s)			
☐ Multiple power settings and corresponding antenna(s)			
Number of different Power Levels: 1			
Power Level 1: 8 dBm			
Power Level 2: dBm			
Power Level 3: dBm			
NOTE 1: Add more lines in case the equipment has more power levels.			
NOTE 2: These power levels are conducted power levels (at antenna connector).			
For each of the Power Levels, provide the intended antenna assemblies, their corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beamforming gain (Y) if applicable			
Power Level 1: dBm			
Number of antenna assemblies provided for this power level:			
Assembly #	**Gain (dBi)**	**e.i.r.p (dBm)**	**Part number or model number**
1			
2			
3			
4			
NOTE: Add more rows in case more antenna assemblies are supported for this power level.			
Power Level 2: dBm			
Number of antenna assemblies provided for this power level:			
Assembly #	**Gain (dBi)**	**e.i.r.p (dBm)**	**Part number or model number**
1			
2			
3			
4			
NOTE: Add more rows in case more antenna assemblies are supported for this power level.			
Power Level 3: dBm			
Number of antenna assemblies provided for this power level:			
Assembly #	**Gain (dBi)**	**e.i.r.p (dBm)**	**Part number or model number**
1			
2			
3			
4			
NOTE: Add more rows in case more antenna assemblies are supported for this power level.			

The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:		
Details provided are for the:		
☒	stand-alone equipment	
☐	combined (or host) equipment	
☐	test jig	
Supply Voltage	☐ AC mains State AC voltage	V
	☐ DC State DC voltage	V
In case of DC, indicate the type of power source		
☐	Internal Power Supply	
☐	External Power Supply or AC/DC adapter	
☒	Battery	
☐	Other:	
Describe the test modes available which can facilitate testing:		
PC based test tool that allowed the tester to select channels and put the Tag in to the required test modes.		
The equipment type (e.g. Bluetooth®, IEEE 802.11™ [i.3] IEEE 802.15.4™ [i.4], proprietary, etc.):		
BLE Tag		
If applicable, the statistical analysis referred in clause 5.4.1 q)		
To be provided as separate attachment		
If applicable, the statistical analysis referred in clause 5.4.1 r)		
To be provided as separate attachment		
Geo-location capability supported by the equipment:		
☐ Yes		
☐	The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user.	
☒ No		
Describe the minimum performance criteria that apply to the equipment (see clause 4.3.1.12.3 or 4.3.2.11.3)		
Combination for testing (see clause 5.3.2.3 of EN 300 328 V21.1)		
From all combinations of conducted power settings and intended antenna assembly(ies) specified in clause 5.4.1 m), specify the combination resulting in the highest e.i.r.p. for the radio equipment. Unless otherwise specified in ETSI EN 300 328, this power setting is to be used for testing against the requirements of ETSI EN 300 328. In case there is more than one such conducted power setting resulting in the same (highest) e.i.r.p. level, the highest power setting is to be used for testing. See also ETS EN 300 328, clause 5.3.2.3		
Highest overall e.i.r.p. value: 8 dBm		
Corresponding Antenna assembly gain: 0 dBi		Antenna Assembly #:
Corresponding conducted power setting: 8 dBm (also the power level to be used for testing)		Listed as Power Setting #:
Additional information provided by the applicant		
Modulation		
ITU Class(es) of emission: G1D		
Can the transmitter operate unmodulated? ☐ Yes	☐ No	

Duty Cycle	
The transmitter is intended for:	
☒	Continuous duty
☐	Intermittent duty
☐	Continuous operation possible for testing purposes
About the UUT	
☒	The equipment submitted are representative production models
☐	If not, the equipment submitted are pre-production models?
☐	If pre-production equipment are submitted, the final production equipment will be identical in all respects with the equipment tested
☐	If not, supply full details
☐	The equipment submitted is CE marked
Additional items and/or supporting equipment provided	
☐	Spare batteries (e.g. for portable equipment)
☐	Battery charging device
☐	External Power Supply or AC/DC adapter
☐	Test Jig or interface box
☒	RF test fixture (for equipment with integrated antennas)
☒	Host System
	Manufacturer DCL
	Model UART to USB klrads to allow direct control from host PC
	Model Name
☐	Combined equipment
	Manufacturer
	Model
	Model Name
☐	User Manual
☐	Technical documentation (Handbook and circuit diagrams)

I hereby declare that the information supplied is correct and complete.

Name: Will Damerell Position held: Director
Date: 27/09/2017

1.5 Product Information

1.5.1 Technical Description

Industrial Low Energy Bluetooth tag used for tagging outdoor and indoor assets, i.e. bed frames, plant equipment, cable drums.

1.6 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.7 EUT Modification Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Serial Number: 048518			
0	As supplied by the customer	Not Applicable	Not Applicable
Serial Number: 048524			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 3

1.8 Test Location

TÜV SÜD Product Service conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: Bluetooth Low Energy - Transmit		
Emission Bandwidth	Mohamed Toubella	UKAS
Maximum Conducted Output Power	Mohamed Toubella	UKAS
Spurious Radiated Emissions	Graeme Lawler	UKAS
Restricted Band Edges	Graeme Lawler	UKAS
Authorised Band Edges	Graeme Lawler	UKAS
Power Spectral Density	Mohamed Toubella	UKAS

Table 4

Office Address:

Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Emission Bandwidth

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(2)

2.1.2 Equipment Under Test and Modification State

Conneq 2, S/N: 048524 - Modification State 0

2.1.3 Date of Test

28-November-2017

2.1.4 Test Method

The test was performed in accordance with KDB 558074 D01, clause 8.2.

2.1.5 Environmental Conditions

Ambient Temperature	24.2 °C
Relative Humidity	45.5 %

2.1.6 Test Results

Bluetooth Low Energy - Transmit

Modulation/Packet Type: GFSK/DH1

Frequency (MHz)	6 dB Bandwidth (MHz)
2402	680.1
2442	684.8
2480	689.3

Table 5

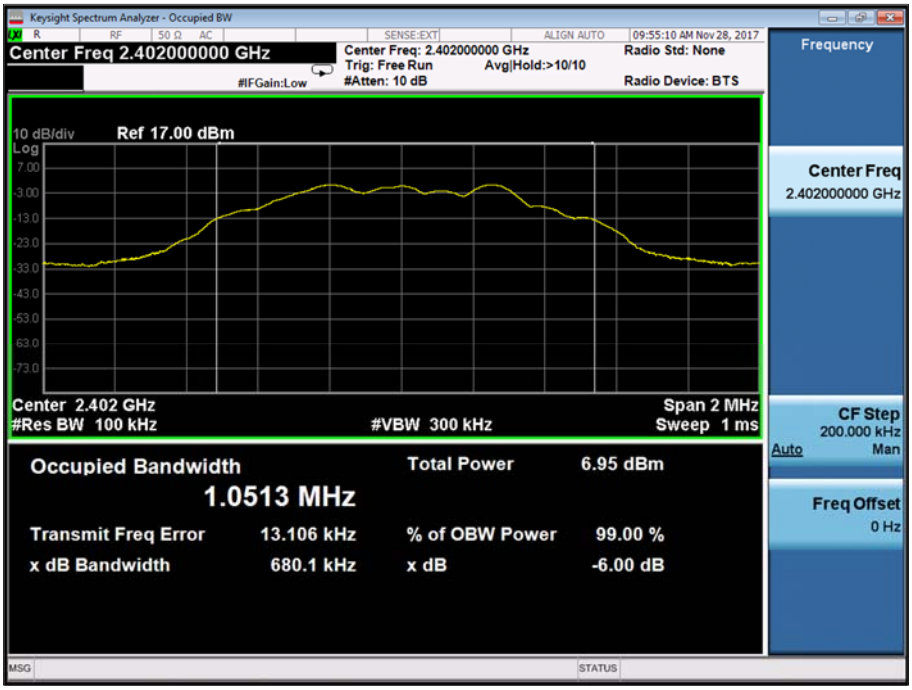

Figure 1 - 2402 MHz

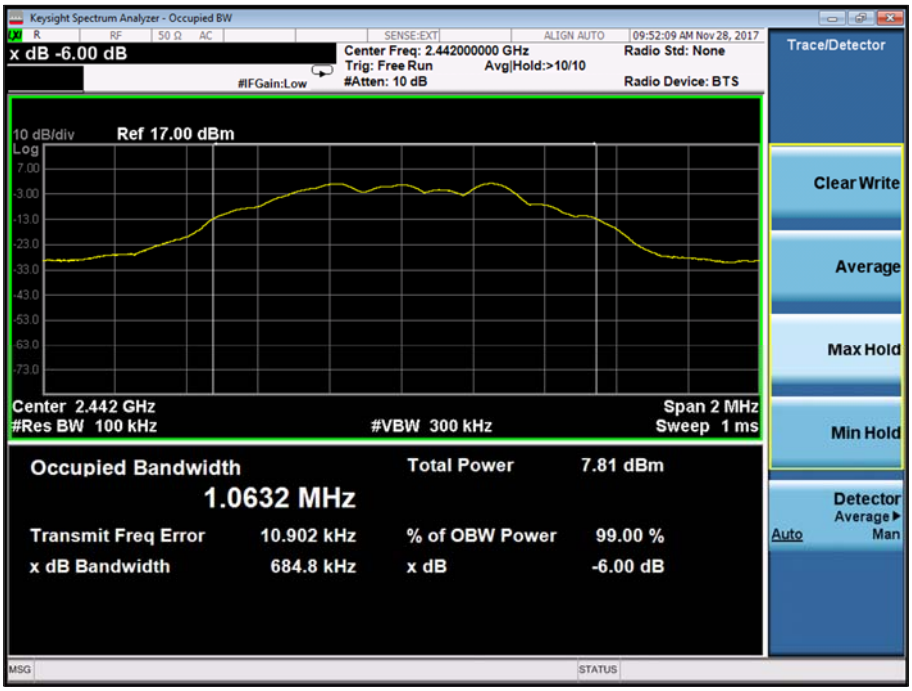

Figure 2 - 2442 MHz

Figure 3 - 2480 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(2)

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

2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Power Supply Unit	Hewlett Packard	6253A	441	-	O/P Mon
Multimeter	Fluke	79 Series III	498	12	09-Aug-2018
Hygrometer	Rotronic	I-1000	3220	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	19-Sep-2018
EMI Receiver	Keysight Technologies	N9038A MXE	4629	12	13-Sep-2018

Table 6

O/P Mon – Output Monitored using calibrated equipment

2.2 Maximum Conducted Output Power

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)(3)

2.2.2 Equipment Under Test and Modification State

Conneq 2, S/N: 048524 - Modification State 0

2.2.3 Date of Test

01-November-2017

2.2.4 Test Method

The test was performed in accordance with KDB 558074 D01, clause 9.1.1.

2.2.5 Environmental Conditions

Ambient Temperature	24.2 °C
Relative Humidity	45.5 %

2.2.6 Test Results

Bluetooth Low Energy - Transmit

Frequency (MHz)	Output Power	
	(dBm)	(mW)
2402	2.9	1.95
2442	3.1	2.04
2480	3.3	2.14

Table 7

FCC 47 CFR Part 15, Limit Clause 15.247 (b)

The maximum peak conducted output power of the intentional radiator shall not exceed the following:

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

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt.

2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Power Supply Unit	Hewlett Packard	6253A	441	-	O/P Mon
Multimeter	Fluke	79 Series III	498	12	09-Aug-2018
Attenuator (10dB, 50W)	Aeroflex / Weinschel	47-10-34	3166	12	20-Oct-2018
Hygrometer	Rotronic	I-1000	3220	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	19-Sep-2018
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	06-Oct-2018

Table 8

O/P Mon – Output Monitored using calibrated equipment

2.3 Spurious Radiated Emissions

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.205

2.3.2 Equipment Under Test and Modification State

Conneq 2, S/N: 048518 - Modification State 0

2.3.3 Date of Test

06-November-2017 to 08-November-2017

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10-2013 clause 6.3, 6.5 and 6.6.

For frequencies > 1 GHz, plots for average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.3 to characterize the EUT. Where emissions were detected, final average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.2.

The plots shown are the characterization of the EUT. The limits on the plots represent the most stringent case for restricted bands, (74/54 dBuV/m) when compared to 20 dBc outside restricted bands. The limits shown have been used as a threshold to determine where further measurements are necessary. Where results are within 10 dB of the limits shown on the plots, further investigation was carried out and reported in results tables.

The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

For frequencies > 18 GHz, the measurement distance was reduced to 1 meter and the limit line was increased by 20*LOG(3/1) = 9.54 dB.

2.3.5 Environmental Conditions

Ambient Temperature	20.9 - 22.0 °C
Relative Humidity	29.0 - 30.0 %

2.3.6 Test Results

Bluetooth Low Energy - Transmit

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
30.293	30.3	40.0	-9.7	0	1.00	Horizontal
31.893	29.6	40.0	-10.4	0	1.00	Vertical
34.486	28.5	40.0	-11.5	0	1.00	Horizontal
788.939	32.3	46.0	-13.7	0	1.00	Horizontal
827.831	32.7	46.0	-13.3	0	1.00	Horizontal
960.000	33.9	46.0	-12.1	0	1.00	Horizontal

Table 9 - 2402 MHz - 30 MHz to 1 GHz Emissions Results

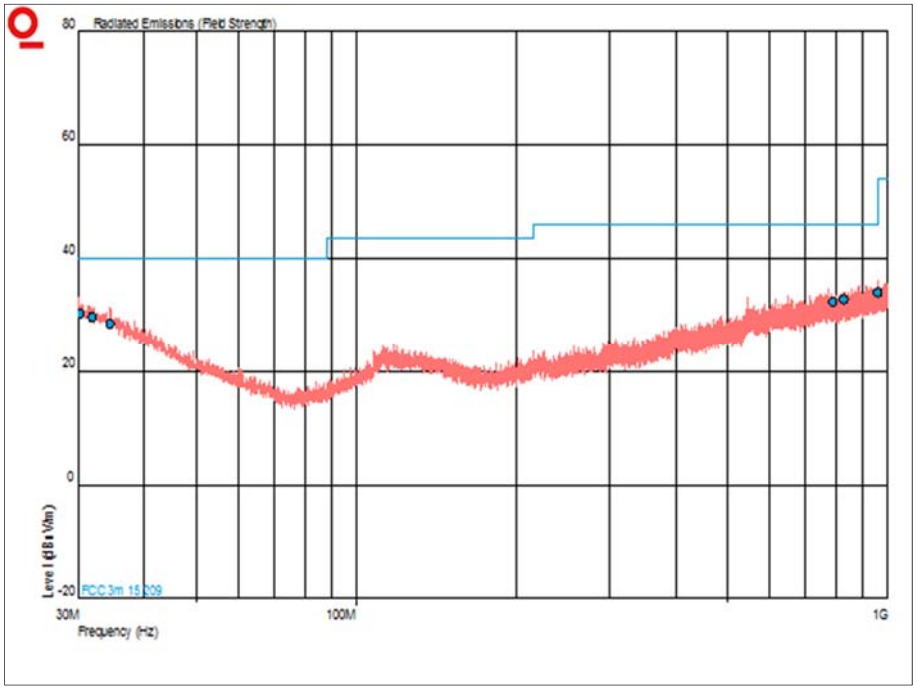

Figure 4 – 2402 MHz - 30 MHz to 1 GHz - Horizontal and Vertical

Frequency (GHz)	Result (dBµV/m)		Limit (dBµV/m)		Margin (dBµV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 10 - 2402 MHz - 1 GHz to 25 GHz Emissions Results

*No emissions were detected within 10 dB of the limit.

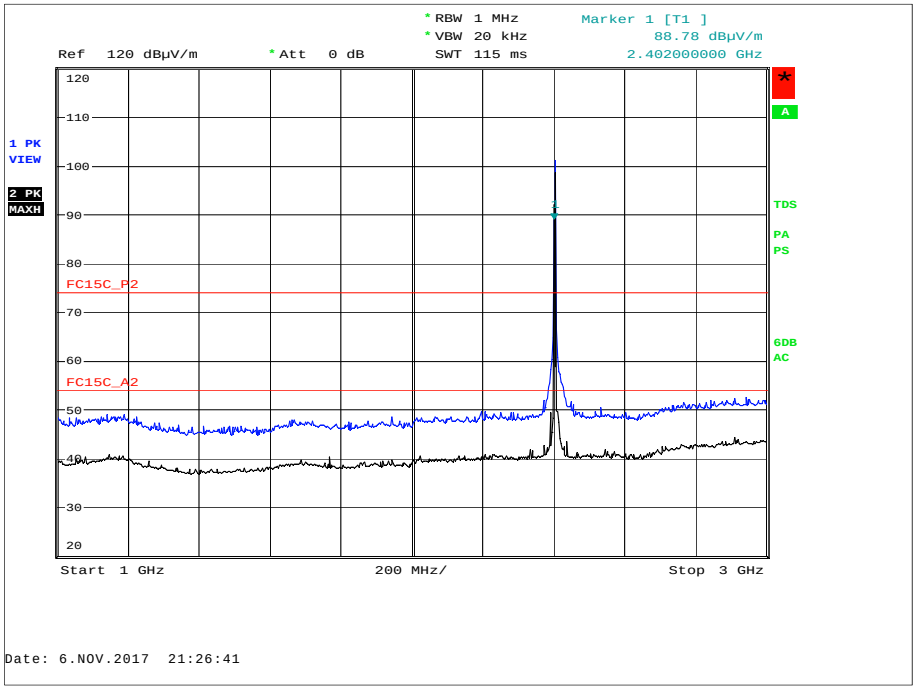

Figure 5 - 2402 MHz - 1 GHz to 3 GHz - Horizontal and Vertical

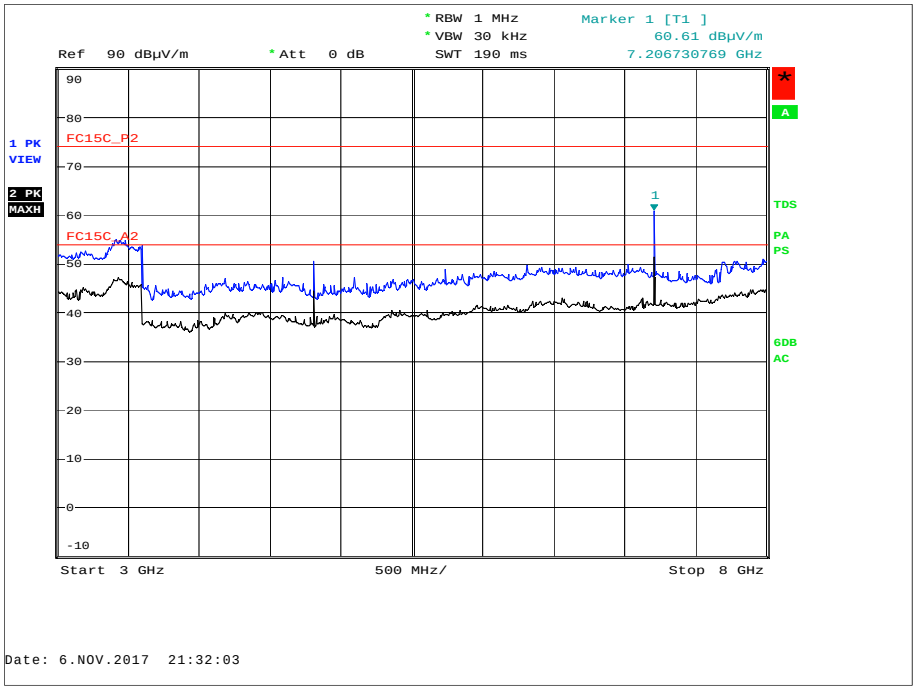

Figure 6 - 2402 MHz - 3 GHz to 8 GHz - Horizontal and Vertical

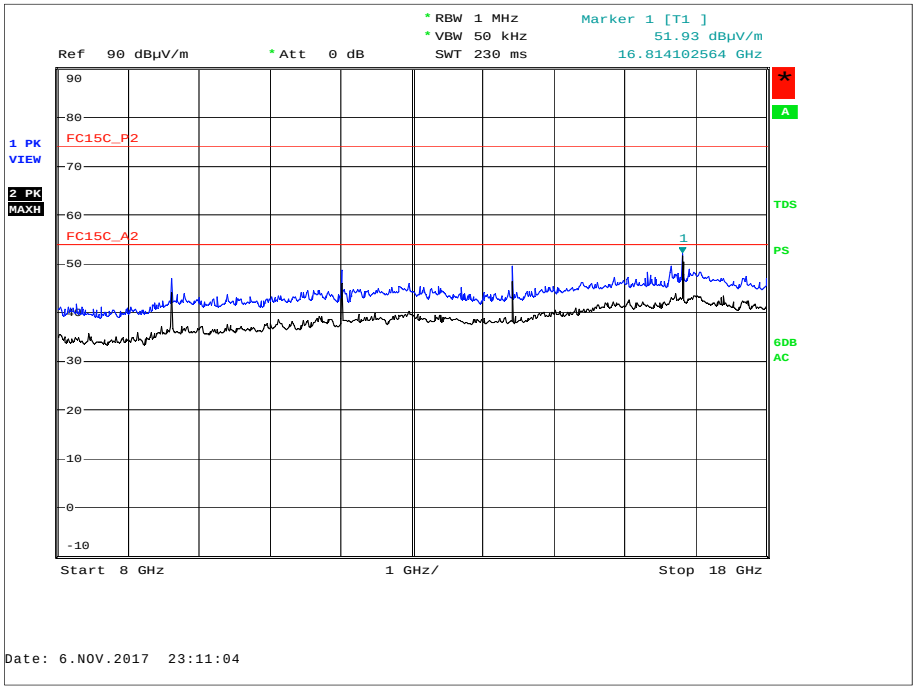

Figure 7 - 2402 MHz - 8 GHz to 18 GHz - Horizontal and Vertical

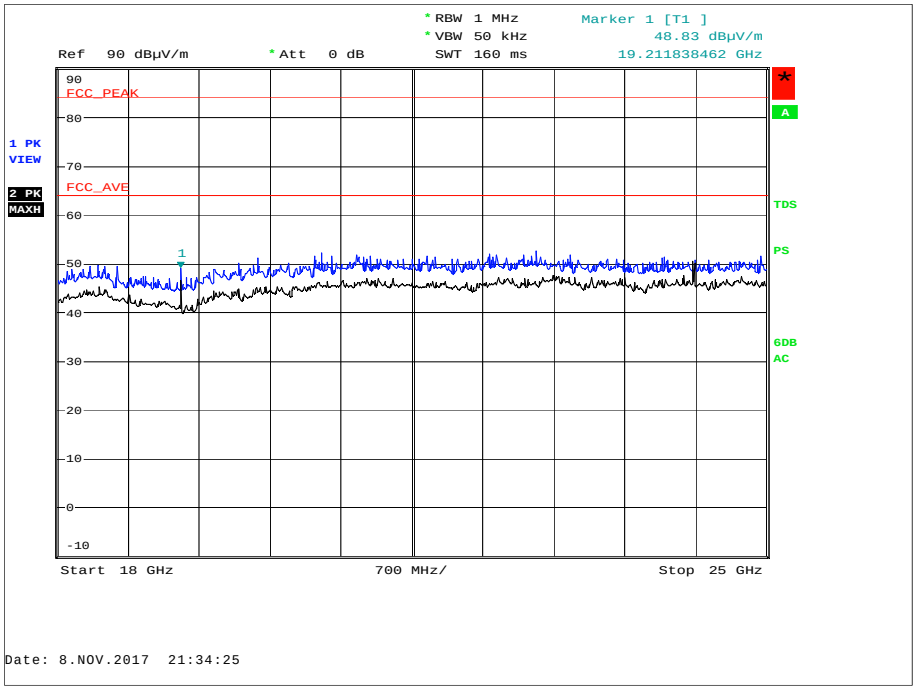

Figure 8 - 2402 MHz - 18 GHz to 25 GHz - Horizontal and Vertical

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
30.196	30.5	40.0	-9.5	0	1.00	Vertical
32.100	29.5	40.0	-10.5	0	1.00	Vertical
36.327	27.5	40.0	-12.5	0	1.00	Vertical
794.877	32.2	46.0	-13.8	0	1.00	Vertical
889.043	33.2	46.0	-12.8	0	1.00	Vertical
960.000	33.9	46.0	-12.1	0	1.00	Vertical

Table 11 - 2442 MHz - 30 MHz to 1 GHz Emissions Results

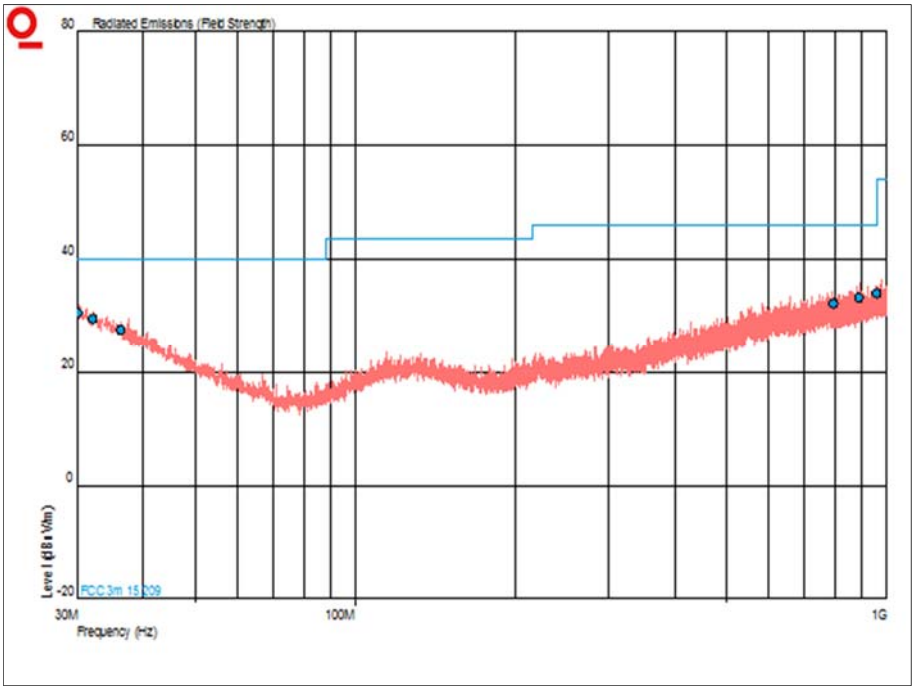

Figure 9 – 2442 MHz - 30 MHz to 1 GHz - Horizontal and Vertical

Frequency (GHz)	Result (dBµV/m)		Limit (dBµV/m)		Margin (dBµV/m)	
	Peak	Average	Peak	Average	Peak	Average
7.325330	66.70	49.25	73.98	53.98	7.28	4.73

Table 12 - 2442 MHz - 1 GHz to 25 GHz Emissions Results

No other emissions were detected within 10 dB of the limit.

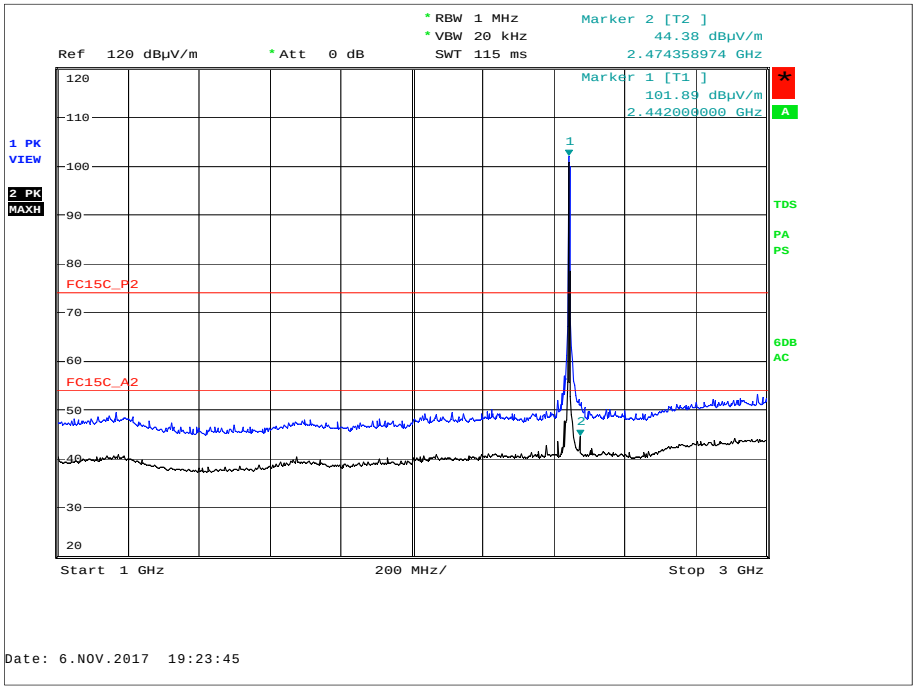

Figure 10 - 2442 MHz - 1 GHz to 3 GHz - Horizontal and Vertical

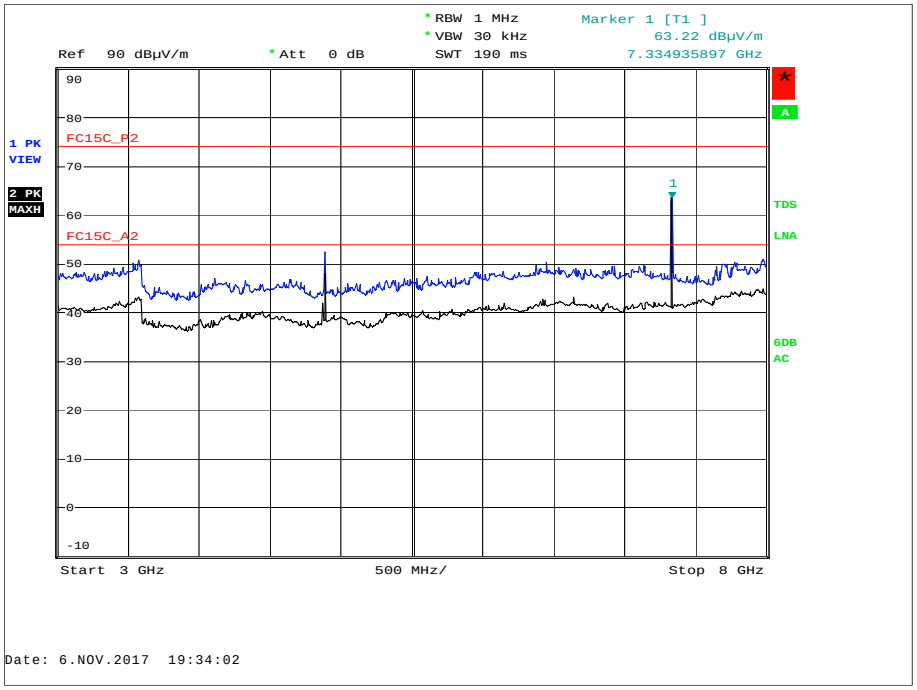

Figure 11 - 2442 MHz - 3 GHz to 8 GHz - Horizontal and Vertical

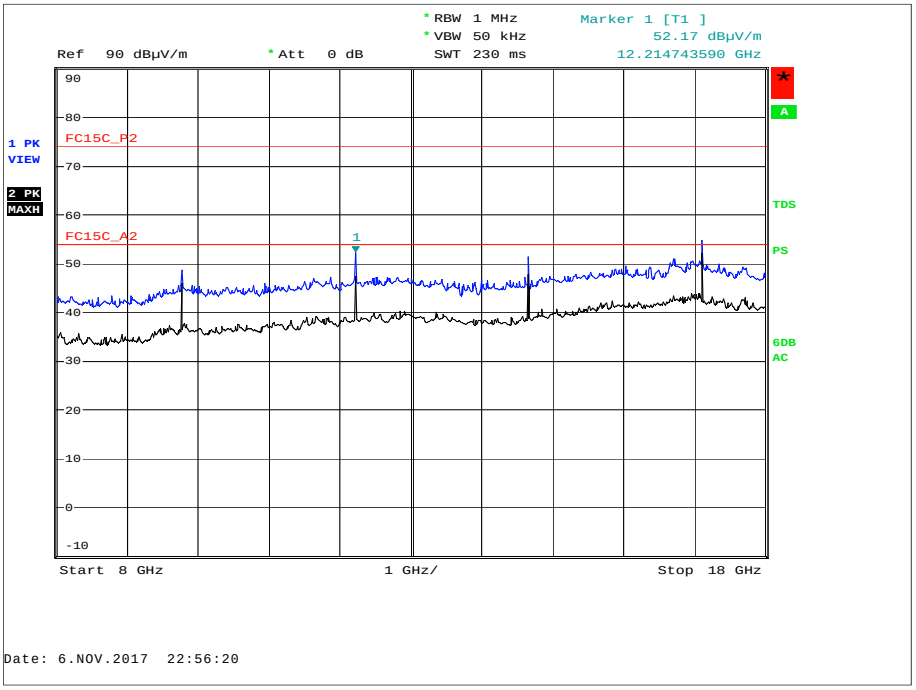

Figure 12 - 2442 MHz - 8 GHz to 18 GHz - Horizontal and Vertical

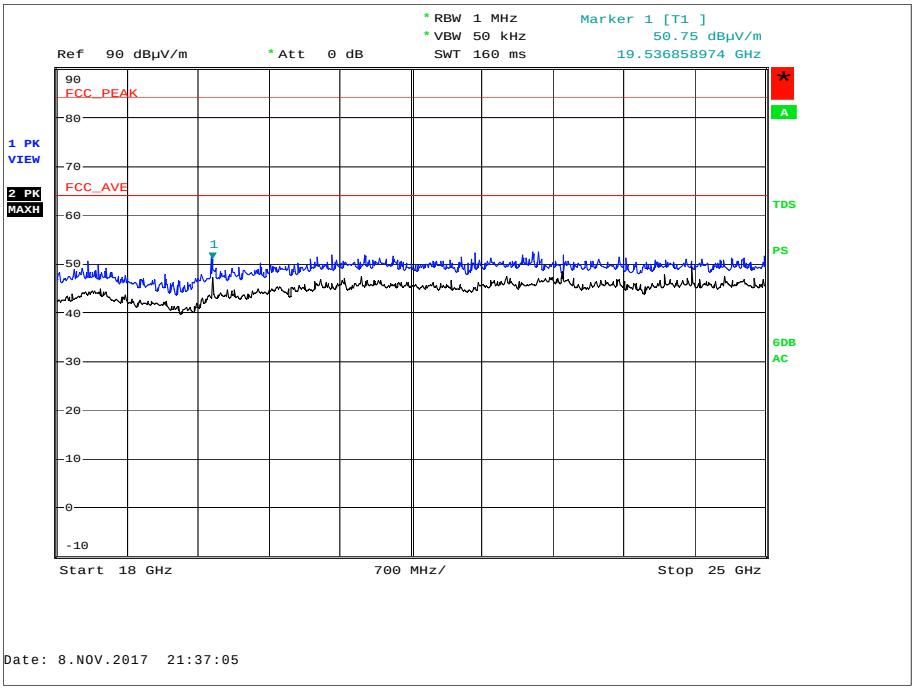

Figure 13 - 2442 MHz - 18 GHZ to 25 GHz - Horizontal and Vertical

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
30.342	30.2	40.0	-9.8	0	1.00	Horizontal
31.377	29.8	40.0	-10.2	0	1.00	Vertical
32.647	29.1	40.0	-10.9	0	1.00	Horizontal
738.540	32.2	46.0	-13.8	0	1.00	Vertical
845.733	32.8	46.0	-13.2	0	1.00	Vertical
960.000	33.9	46.0	-12.1	0	1.00	Vertical

Table 13 - 2480 MHz - 30 MHz to 1 GHz Emissions Results

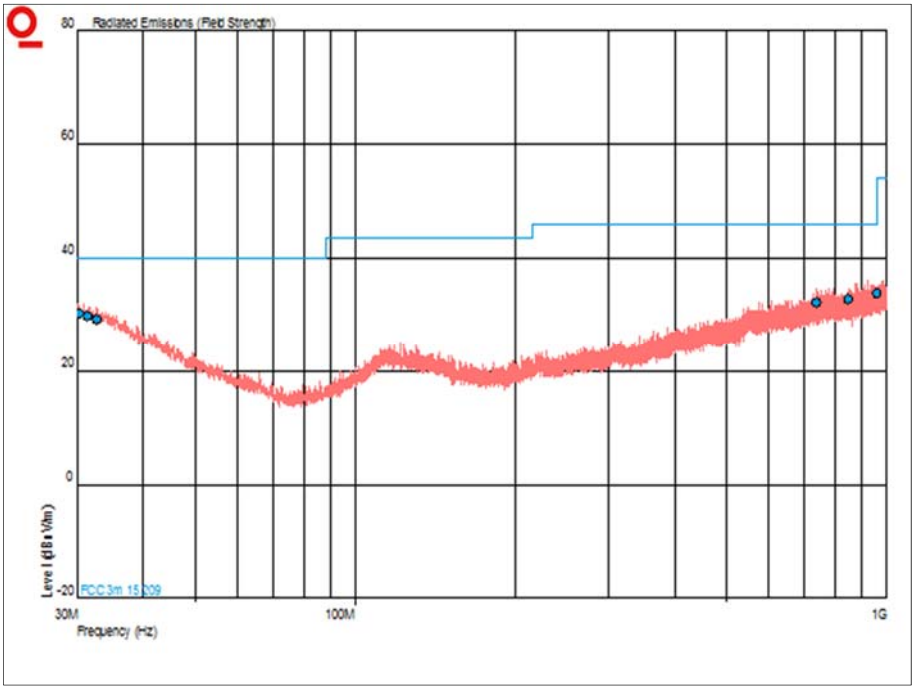

Figure 14 – 2480 MHz - 30 MHz to 1 GHz - Horizontal and Vertical

Frequency (GHz)	Result (dBµV/m)		Limit (dBµV/m)		Margin (dBµV/m)	
	Peak	Average	Peak	Average	Peak	Average
7.439758	67.23	49.83	73.98	53.98	6.75	4.15

Table 14 - 2480 MHz - 1 GHz to 25 GHz Emissions Results

No other emissions were detected within 10 dB of the limit.

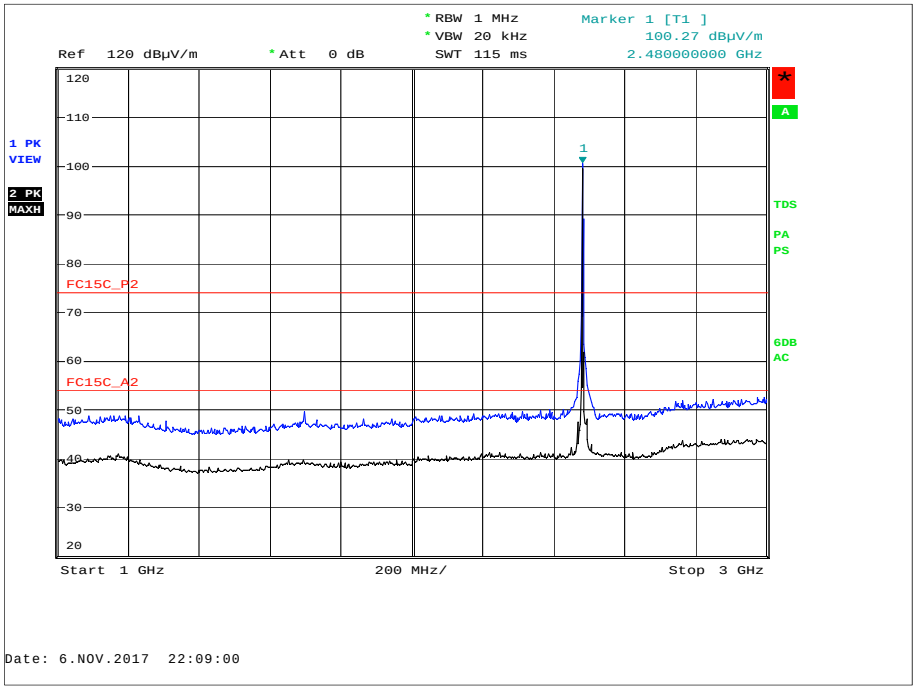

Figure 15 - 2480 MHz - 1 GHz to 3 GHz - Horizontal and Vertical

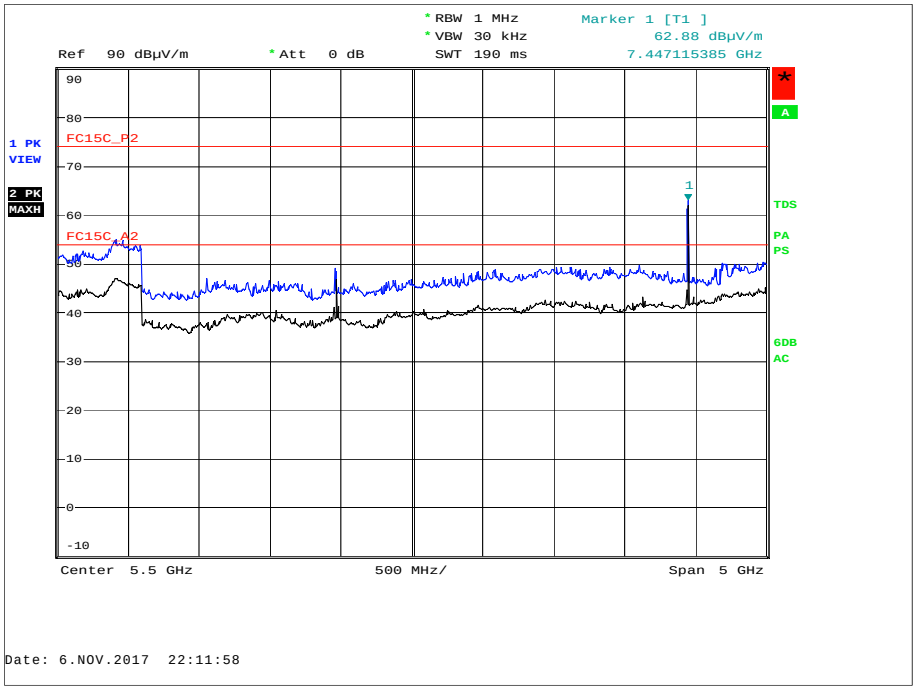

Figure 16 - 2480 MHz - 3 GHz to 8 GHz - Horizontal and Vertical

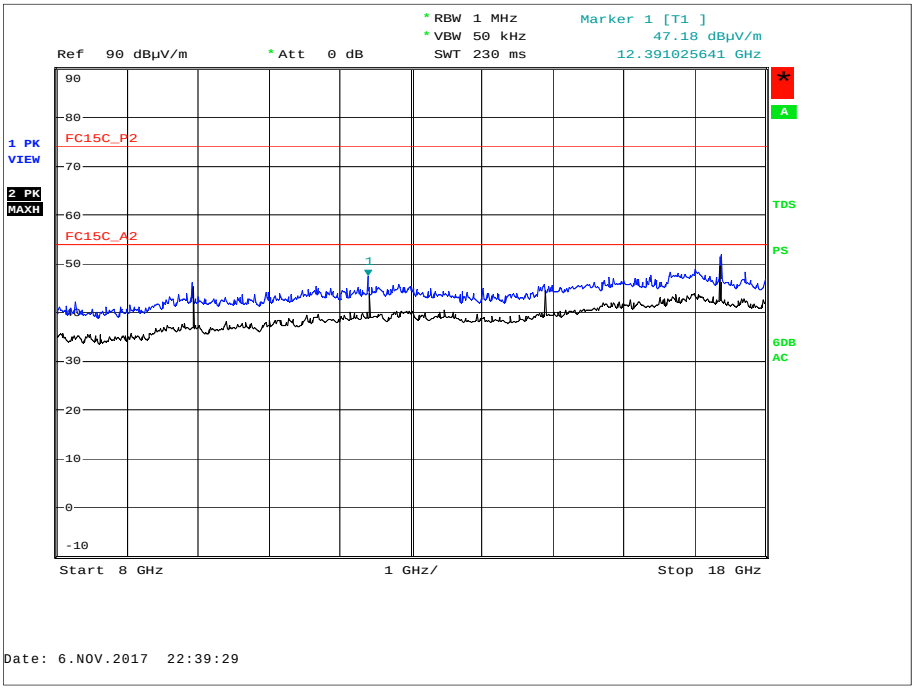

Figure 17 - 2480 MHz - 8 GHZ to 18 GHz - Horizontal and Vertical

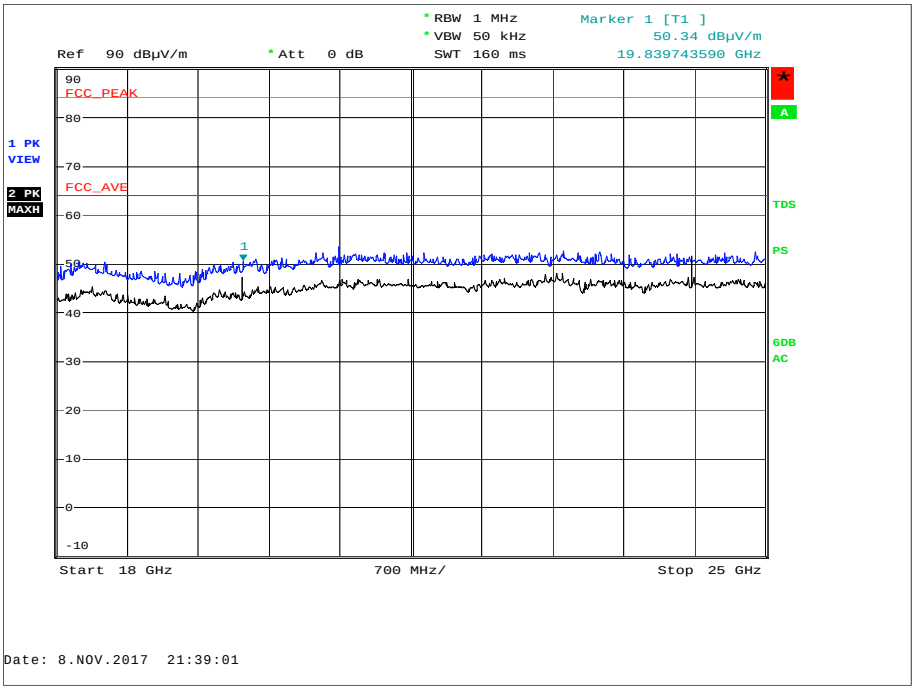

Figure 18 - 2480 MHz - 18 GHz to 25 GHz - Horizontal and Vertical

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator 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 the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in 15.209(a).

2.3.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna 18-40GHz (Double Ridge Guide)	Link Microtek Ltd	AM180HA-K-TU2	230	24	12-Feb-2018
Antenna (Bilog)	Schaffner	CBL6143	287	24	18-Apr-2018
Pre-Amplifier	Phase One	PS04-0086	1533	12	31-Jul-2018
18GHz - 40GHz Pre-Amplifier	Phase One	PSO4-0087	1534	12	23-Jan-2018
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Hygrometer	Rotronic	HYGROPALM 1	2338	12	24-Oct-2018
Comb Generator	Schaffner	RSG1000	3034	-	TU
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	12	02-May-2018
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo Gmbh	TAM 4.0-P	3916	-	TU
Mast Controller	maturo Gmbh	NCD	3917	-	TU
Hygropalm Temperature and Humidity Meter	Rotronic	HP21	4410	12	04-May-2018
Suspended Substrate Highpass Filter	Advance Power Components	11SH10-3000/X18000-O/O	4411	12	22-May-2018
Cable (Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4526	6	17-Sep-2017
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	04-Nov-2017
Cable (Rx, SMAm-SMAm 0.5m)	Scott Cables	SLSLL18-SMSM-00.50M	4528	6	Op Mon
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	17-Feb-2018
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	17-Feb-2018

Table 15

TU - Traceability Unscheduled
O/P Mon – Output Monitored using calibrated equipment

2.4 Restricted Band Edges

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205

2.4.2 Equipment Under Test and Modification State

Conneq 2, S/N: 048518 - Modification State 0

2.4.3 Date of Test

06-November-2017

2.4.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5.

Plots for average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.3. These are shown for information purposes and were used to determine the worst case measurement point. Final average measurements were then taken in accordance with ANSI C63.10 clause 4.1.4.2.2. to obtain the measurement result recorded in the test results tables.

The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

2.4.5 Environmental Conditions

Ambient Temperature	22.0 °C
Relative Humidity	30.0 %

2.4.6 Test Results

Bluetooth Low Energy - Transmit

Modulation	Frequency (MHz)	Measured Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK	2402	2390.0	62.94	46.87
GFSK	2480	2483.5	68.32	46.27

Table 16 - Restricted Band Edge Results

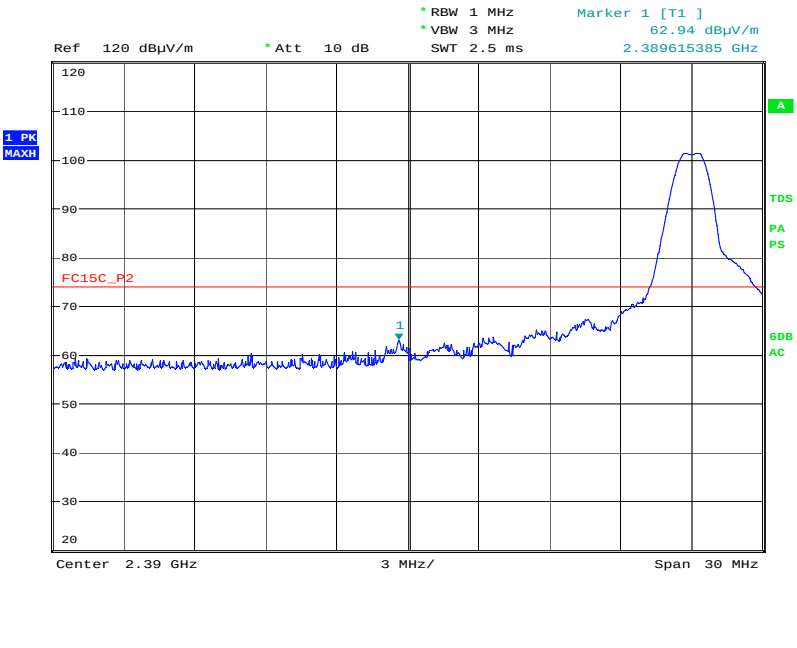

Figure 19 - GFSK - 2402 MHz - Measured Frequency 2390.0 MHz - Peak

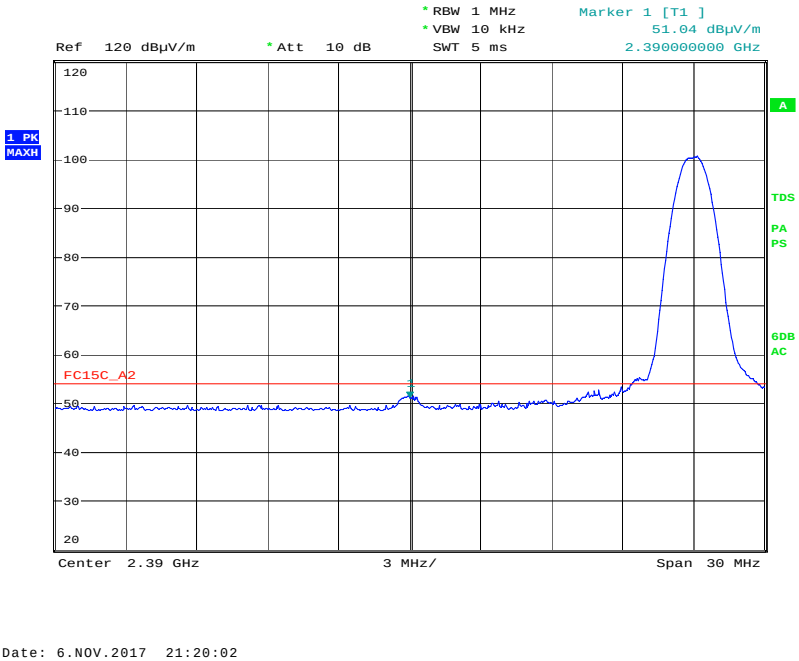

Figure 20 - GFSK - 2402 MHz - Measured Frequency 2390.0 MHz – Average

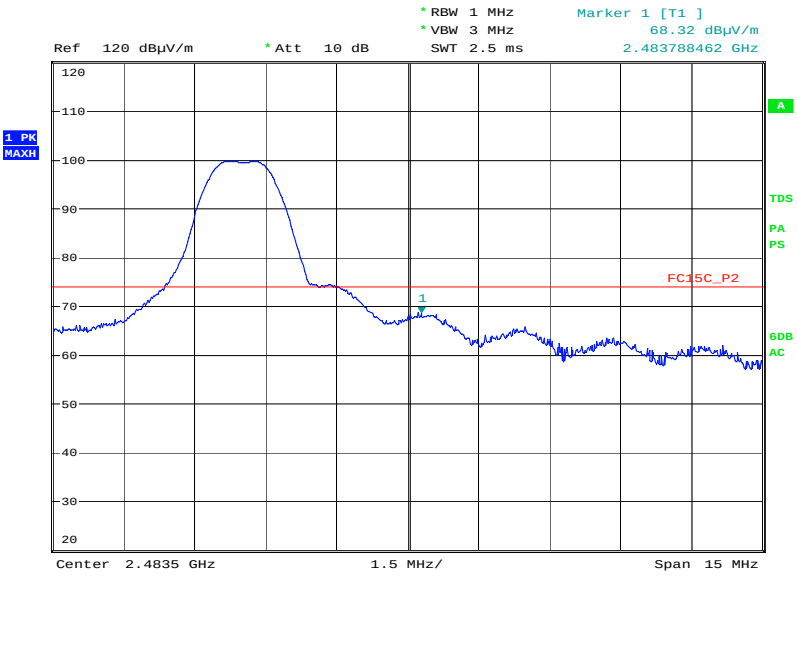

Figure 21 - GFSK - 2480 MHz - Measured Frequency 2483.5 MHz - Peak

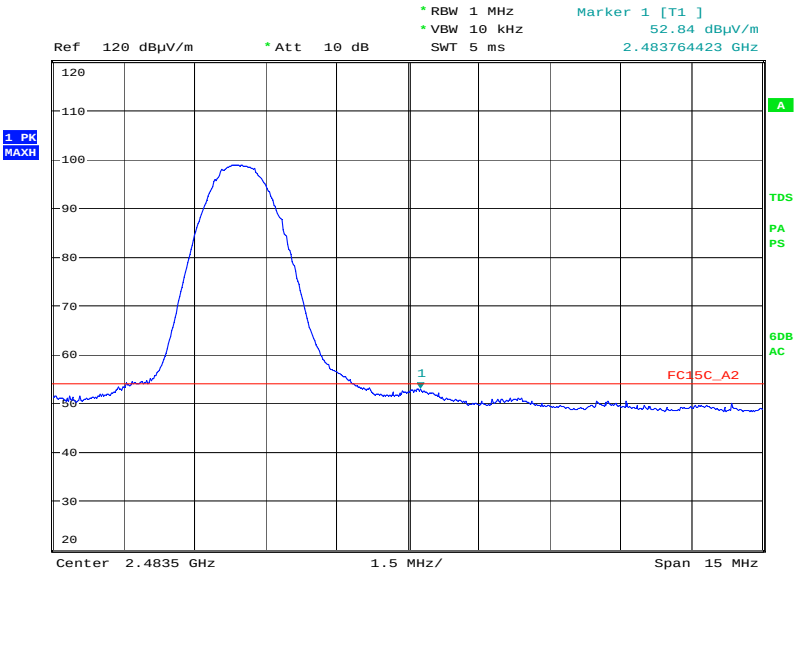

Figure 22 - GFSK - 2480 MHz - Measured Frequency 2483.5 MHz - Average

FCC 47 CFR Part 15, Limit Clause 15.205

	Peak (dBµV/m)	Average (dBµV/m)
Restricted Bands of Operation	74	54

Table 17

2.4.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	12	02-May-2018
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo Gmbh	TAM 4.0-P	3916	-	TU
Mast Controller	maturo Gmbh	NCD	3917	-	TU
Hygropalm Temperature and Humidity Meter	Rotronic	HP21	4410	12	04-May-2018
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	O/P Mon
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	17-Feb-2018

Table 18

TU - Traceability Unscheduled
O/P Mon – Output Monitored using calibrated equipment

2.5 Authorised Band Edges

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d)

2.5.2 Equipment Under Test and Modification State

Conneq 2, S/N: 048518 - Modification State 0

2.5.3 Date of Test

06-November-2017

2.5.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.4.

The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

2.5.5 Environmental Conditions

Ambient Temperature	22.0 °C
Relative Humidity	30.0 %

2.5.6 Test Results

Bluetooth Low Energy - Transmit

Modulation	Frequency (MHz)	Measured Frequency (MHz)	Level (dBc)
GFSK	2402	2400.0	-43.17
GFSK	2480	2483.5	-44.99

Table 19

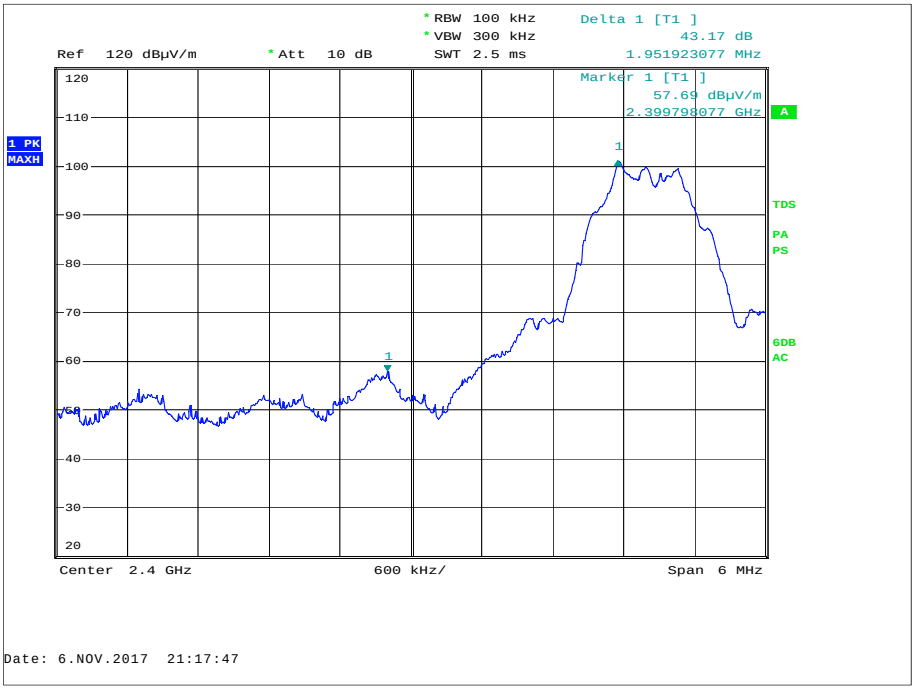

Figure 23 - GFSK - 2402 MHz - Measured Frequency 2400.0 MHz

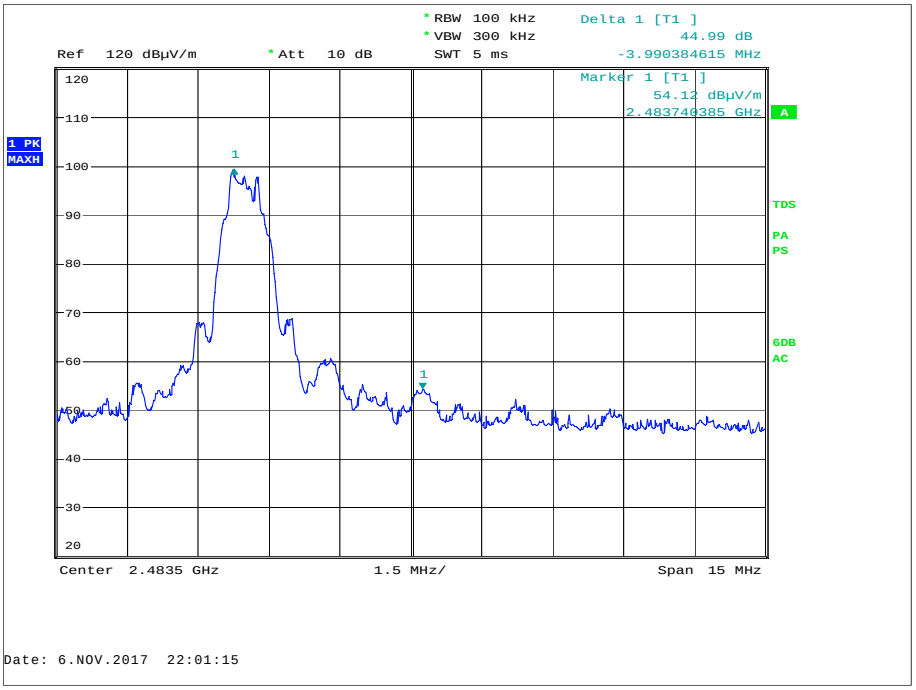

Figure 24 - GFSK - 2480 MHz - Measured Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

20 dB below the fundamental measured in a 100 kHz bandwidth using a peak detector. If the transmitter complies with the conducted power limits, based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB below the fundamental instead of 20 dB.

2.5.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	12	02-May-2018
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo Gmbh	TAM 4.0-P	3916	-	TU
Mast Controller	maturo Gmbh	NCD	3917	-	TU
Hygropalm Temperature and Humidity Meter	Rotronic	HP21	4410	12	04-May-2018
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	O/P Mon
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	17-Feb-2018

Table 20

TU - Traceability Unscheduled
O/P Mon – Output Monitored using calibrated equipment

2.6 Power Spectral Density

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (e)

2.6.2 Equipment Under Test and Modification State

Conneq 2, S/N: 048524 - Modification State 0

2.6.3 Date of Test

01-November-2017

2.6.4 Test Method

The test was performed in accordance with KDB 558074 D01, clause 10.2.

2.6.5 Environmental Conditions

Ambient Temperature	24.2 °C
Relative Humidity	54.5 %

2.6.6 Test Results

Bluetooth Low Energy - Transmit

Modulation/Packet Type: GFSK/DH1

Frequency (MHz)	Power Spectral Density (dBm)
2402	-5.045
2442	-5.723
2480	-6.509

Table 21

FCC 47 CFR Part 15, Limit Clause 15.247 (e)

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Power Supply Unit	Hewlett Packard	6253A	441	-	O/P Mon
Multimeter	Fluke	79 Series III	498	12	09-Aug-2018
Attenuator (10dB, 50W)	Aeroflex / Weinschel	47-10-34	3166	12	20-Oct-2018
Hygrometer	Rotronic	I-1000	3220	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	19-Sep-2018
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	06-Oct-2018

Table 22

O/P Mon – Output Monitored using calibrated equipment

3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Emission Bandwidth	± 33.078 kHz
Maximum Conducted Output Power	± 0.70 dB
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.1 dB 1 GHz to 40 GHz: ± 6.3 dB
Restricted Band Edges	30 MHz to 1 GHz: ± 5.1 dB 1 GHz to 40 GHz: ± 6.3 dB
Authorised Band Edges	Conducted: ± 3.08 dB Radiated: 30 MHz to 1 GHz: ± 5.1 dB Radiated: 1 GHz to 40 GHz: ± 6.3 dB
Power Spectral Density	± 0.96 dB

Table 23