

Report on the Radio Testing

For

Vicon Motion Systems Ltd

on

IMeasureU

Report no. TRA-037525-01-45-01B

5th January 2018

RF915 4.0

Report Number: TRA-037525-01-45-01B
Issue: B

REPORT ON THE RADIO TESTING OF A
Vicon Motion Systems Ltd
IMeasureU

WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATE: From 17-10-2017 to 1-11-2017

Written by:

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Radio Test Engineer

Approved by:

J. Charters
Department Manager (Radio)

Date: 5th January 2018

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
- [2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

RF915 4.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2 nd November 2017	Original
B	5th January 2018	Update to ISED ID

2 Summary

TEST REPORT NUMBER:	TRA-037525-01-45-01B
WORKS ORDER NUMBER	TRA-037525-01
PURPOSE OF TEST:	<p>USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.</p> <p>Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.</p>
TEST SPECIFICATION(S):	47CFR15.247 & RSS-247
EQUIPMENT UNDER TEST (EUT):	IMeasureU
FCC IDENTIFIER:	DMR-IMUAP1
IC ID	11323A-IMUAP1
EUT SERIAL NUMBER:	1800
MANUFACTURER/AGENT:	Vicon Motion Systems Ltd
ADDRESS:	<p>Unit 6 Oxford Industrial Park Mead Road Yarnton OXFORD OX5 1QU United Kingdom</p>
CLIENT CONTACT:	<p>Tom Shannon  TPS01865 781398  thomas.shannon@omg3d.com</p>
ORDER NUMBER:	PO:POR011551
TEST DATE:	From 17-10-2017 to 1-11-2017

TESTED BY:

A. L. Y. Wong
Radio Test Engineer
Element

2.1 Test Summary

Test Method and Description		Requirement Clause		Applicable to this equipment	Result / Note
		RSS	47CFR15		
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		Gen, 8.10	15.205	<input checked="" type="checkbox"/>	PASS
AC power line conducted emissions		Gen, 8.8	15.207	<input checked="" type="checkbox"/>	PASS
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	<input checked="" type="checkbox"/>	PASS
Conducted carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	<input type="checkbox"/>	PASS
	Max.			<input checked="" type="checkbox"/>	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	<input checked="" type="checkbox"/>	PASS
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	<input checked="" type="checkbox"/>	PASS
Calculation of duty correction		-	15.35(c)	<input type="checkbox"/>	Not applicable

Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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4 Introduction

This report TRA-037525-01-45-01B presents the results of the Radio testing on a Vicon Motion Systems Ltd, IMU Sensor to specification 47CFR15 Radio Frequency Devices and RSS-247 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for Vicon Motion Systems Ltd by Element, at the address detailed below.

<input checked="" type="checkbox"/> Element Hull	<input type="checkbox"/> Element Skelmersdale
Unit E	Unit 1
South Orbital Trading Park	Pendle Place
Hedon Road	Skelmersdale
Hull	West Lancashire
HU9 1NJ	WN8 9PN
UK	UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

IC Registration Number(s):

Element Hull	3483A
Element North West	3930B

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 *Normative References*

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- Industry Canada RSS-247, Issue 2, February 2017 – Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- Industry Canada RSS-Gen, Issue 4, November 2014 – General Requirements for Compliance of Radio Apparatus

5.2 *Deviations from Test Standards*

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada
ITU	International Telecommunication Union
LBT	Listen Before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: IMU Sensor
- Serial Number: 1800
- Model Number: V1
- Software Revision: Compliance Testing
- Build Level / Revision Number: Preproduction

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Laptop computer (TRA-037525-S4)

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmitter tests was as follows:-

A laptop connected via USB to set the required channels for testing.

For PLCE tests, the EUT was set to transmit at middle channel whilst its charging battery.

7.3.2 Reception

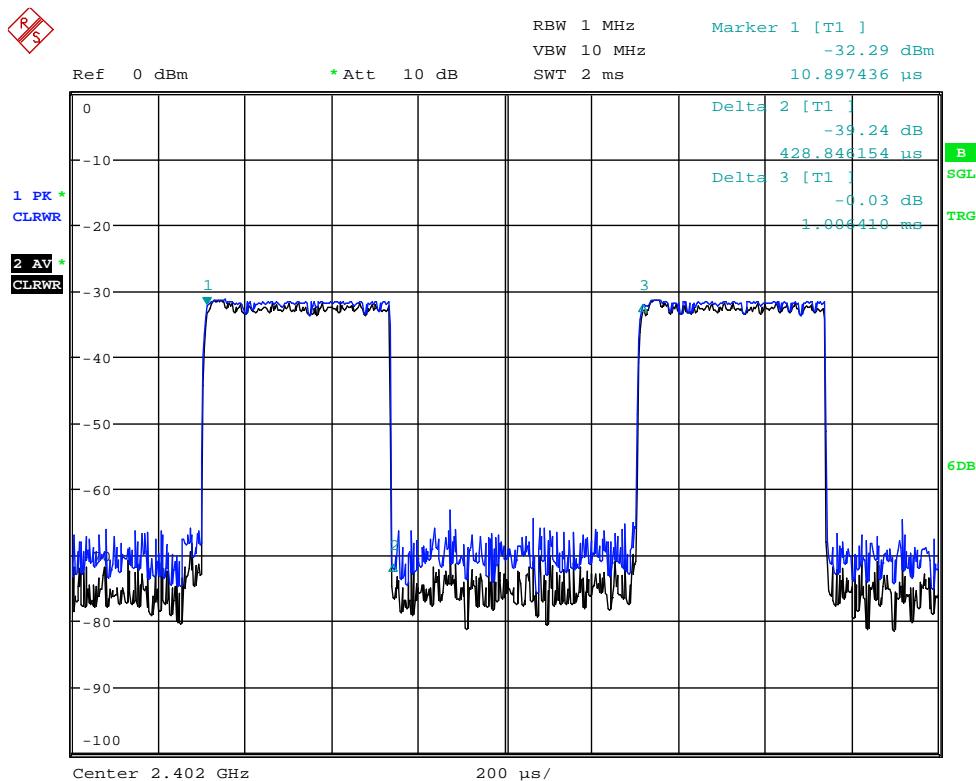
Receiver test was not carried out.

Please refer to EMC report TRA-037525-36-02A Report for unintentional emissions testing.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2402-2480 MHz
Modulation type(s):	GFSK
Occupied channel bandwidth(s):	2 MHz
Channel spacing:	2 MHz
ITU emission designator(s):	1M63F1D
Declared output power(s):	+ 4 dbm
Warning against use of alternative antennas in user manual (yes/no):	Not applicable
Nominal Supply Voltage:	5 V
Frequency stability:	< 30 ppm
Location of notice for license exempt use:	Label / user manual / both
Method of prevention of use on non-US / non-Canadian frequencies:	Secure Firmware
Test Duty cycle:	42.6%



7.4.2 Antennas

Type:	SMD
Frequency range:	2400-2480 MHz
Impedance:	50 Ω
SWR:	2:1
Gain:	0.8 dBi Peak / -1.9 dBi Average
Polarisation:	Horizontal
Beam width:	Integral PCB
Connector type:	Not applicable
Length:	2 mm
Weight:	Negligible
Environmental limits:	-40 °C to +85 °C
Mounting:	Not applicable

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	None
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	No
Fixed pt-mpt operations (yes/no):	No
Simultaneous tx (yes/no):	No

7.5 EUT Description

The device is a small body-worn sensor designed to monitor athletic activities and report this information to a phone or computer etc. via Bluetooth.

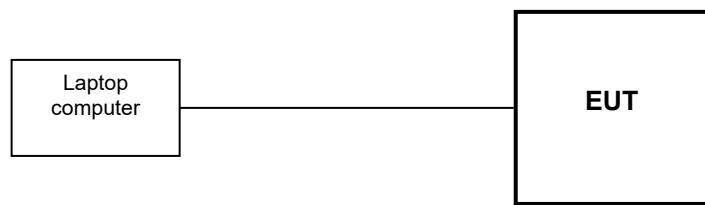
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 *Block Diagram*

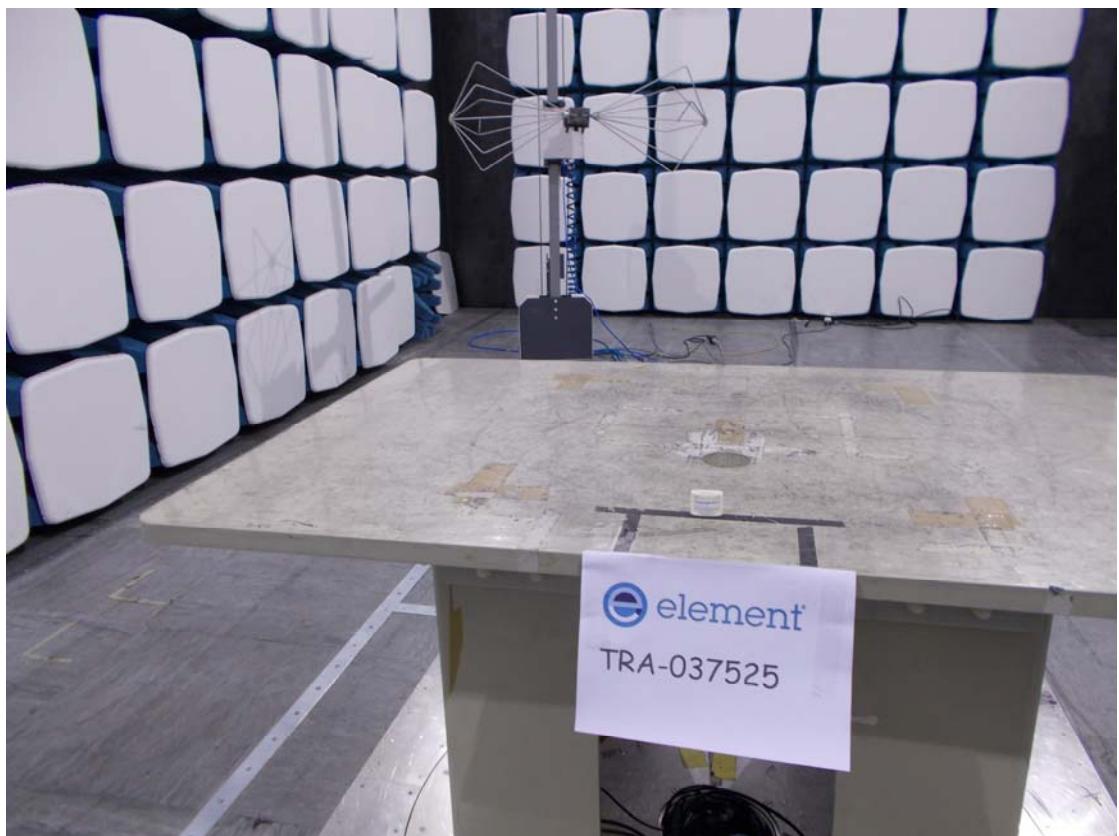
The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



Laptop only used for setup

9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 5 V LiPo rechargeable battery.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	<i>Category</i>	<i>Nominal</i>	<i>Variation</i>
<input type="checkbox"/>	Mains		85 % and 115 %
<input checked="" type="checkbox"/>	Battery	5 V	Fully charged battery

11 Radiated emissions

11.1 Definitions

Spurious emissions

Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	Low / Mid / High (2402 / 2440 / 2480 MHz)
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	Field Strength (µV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dB μ V/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB μ V;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

PA is the pre-amplifier gain in dB (where used);

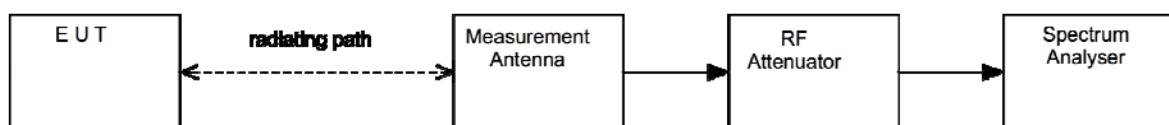
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

CF is the distance factor in dB (where measurement distance different to limit distance);

DC correction factor in this case is added to the average value due to a <98% duty cycle. See ANSI C63.10 2013 Section 11.12.2.5.2 i) 1) for calculation of duty cycle correction.

This field strength value is then compared with the regulatory limit.

Figure i Test Setup



11.5 Test Set-up Photograph

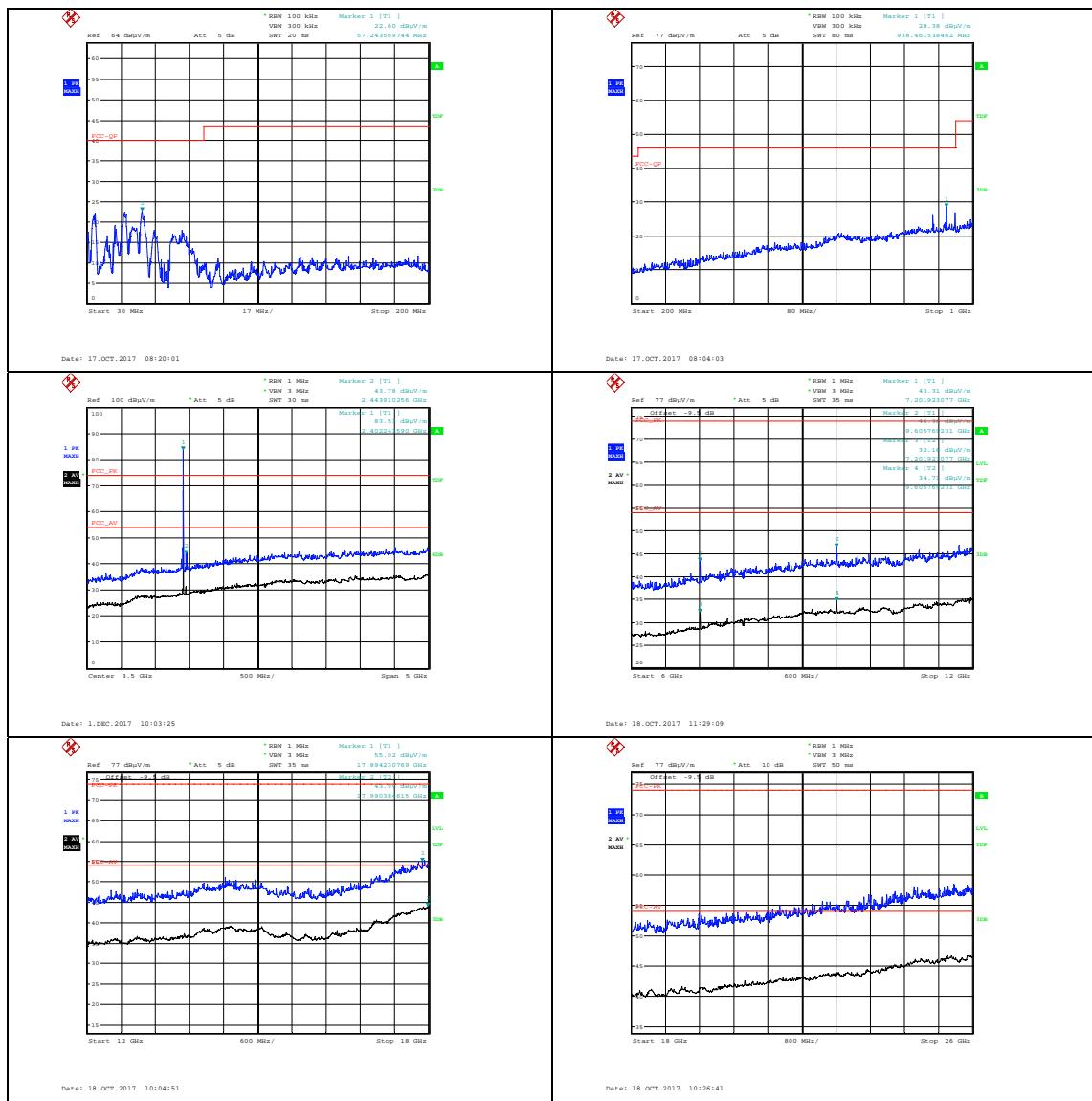


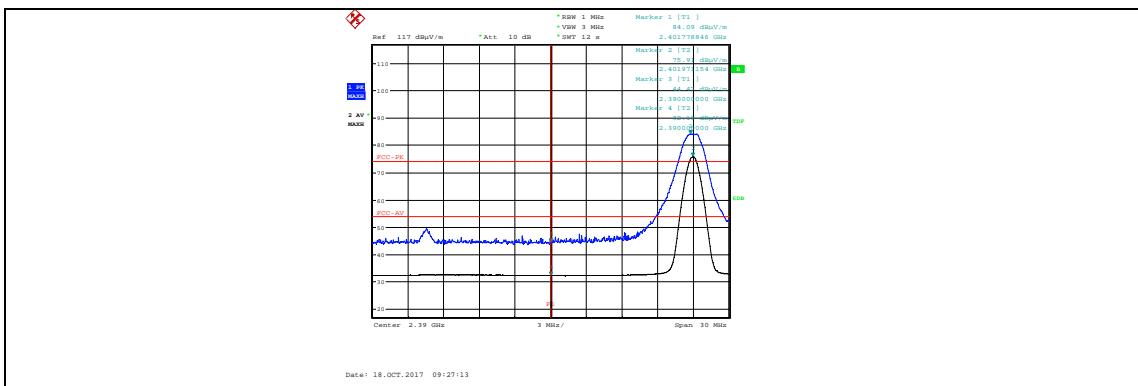
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	27/04/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2184	27/03/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2185	27/03/2018
3115	EMCO	Horn Antenna	RFG129	09/02/2018
310	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
Cable	AtlanTec	Short SMA RF Cable	REF2165	09/12/2017
Bandstop filter	Unknown	2.4 GHz ISM bandstop filter	REF2158	Cal before use
3146	EMCO	Log Periodic Antenna	RFG191	17/05/2019
Antenna	Q-Par	Horn Antenna	RFG630	24/11/2017
3109	EMCO	Biconical Antenna	RFG095	17/05/2019
1-18GHz Horn	EMCO	3115	L139	25/09/2019
Spectrum Analyser	R&S	FSU46	U281	19/06/2018
Pre Amp	Agilent	8449B	L572	07/02/2018
2.4G Band Stop Filter	BSC	SN 4478	U543	27/02/2019

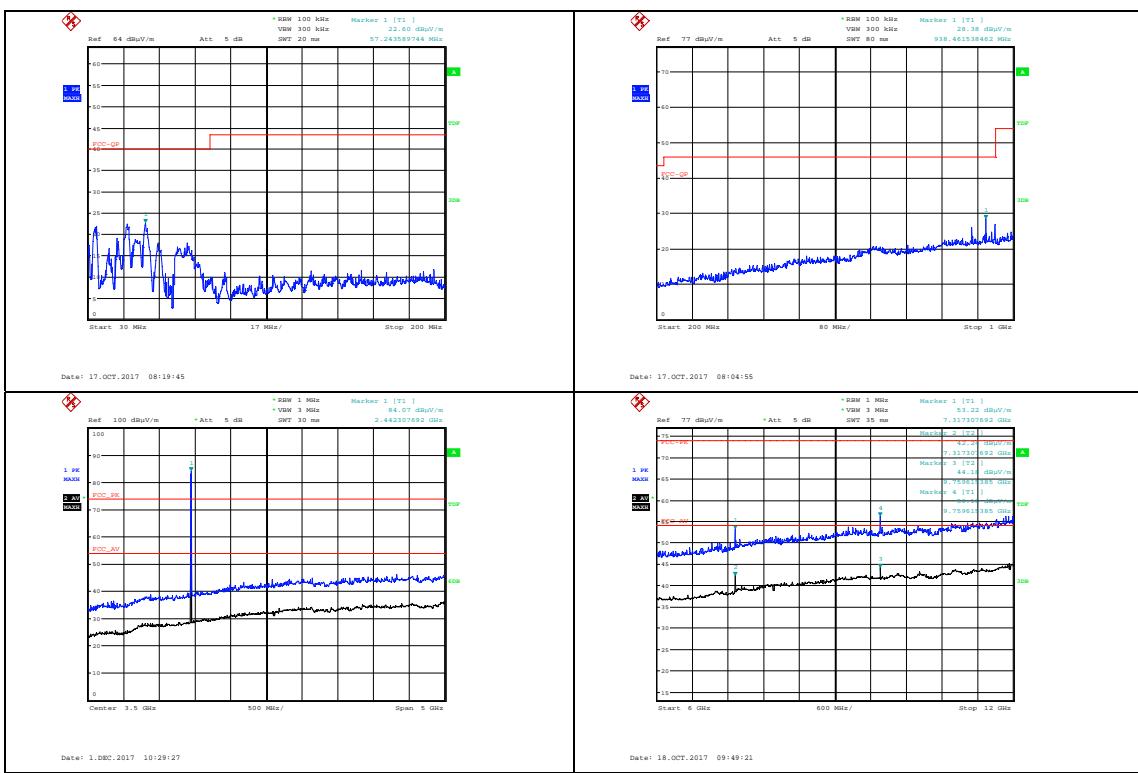
11.7 Test Results

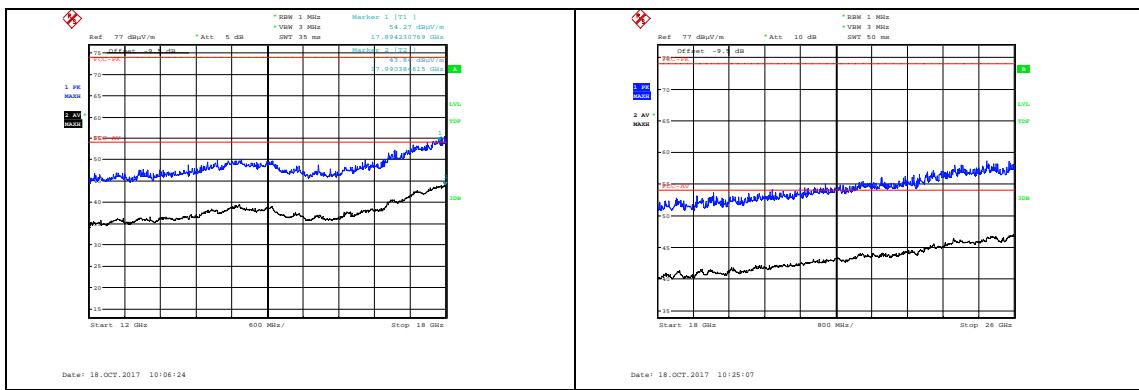
Max. Power Setting: +4 dBm; Channel Frequency: 2402 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dB μ V)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dB μ V/m)	Field Strength (μ V/m)	Limit (μ V/m)
No emission detected within 10 dB of limit lines.										



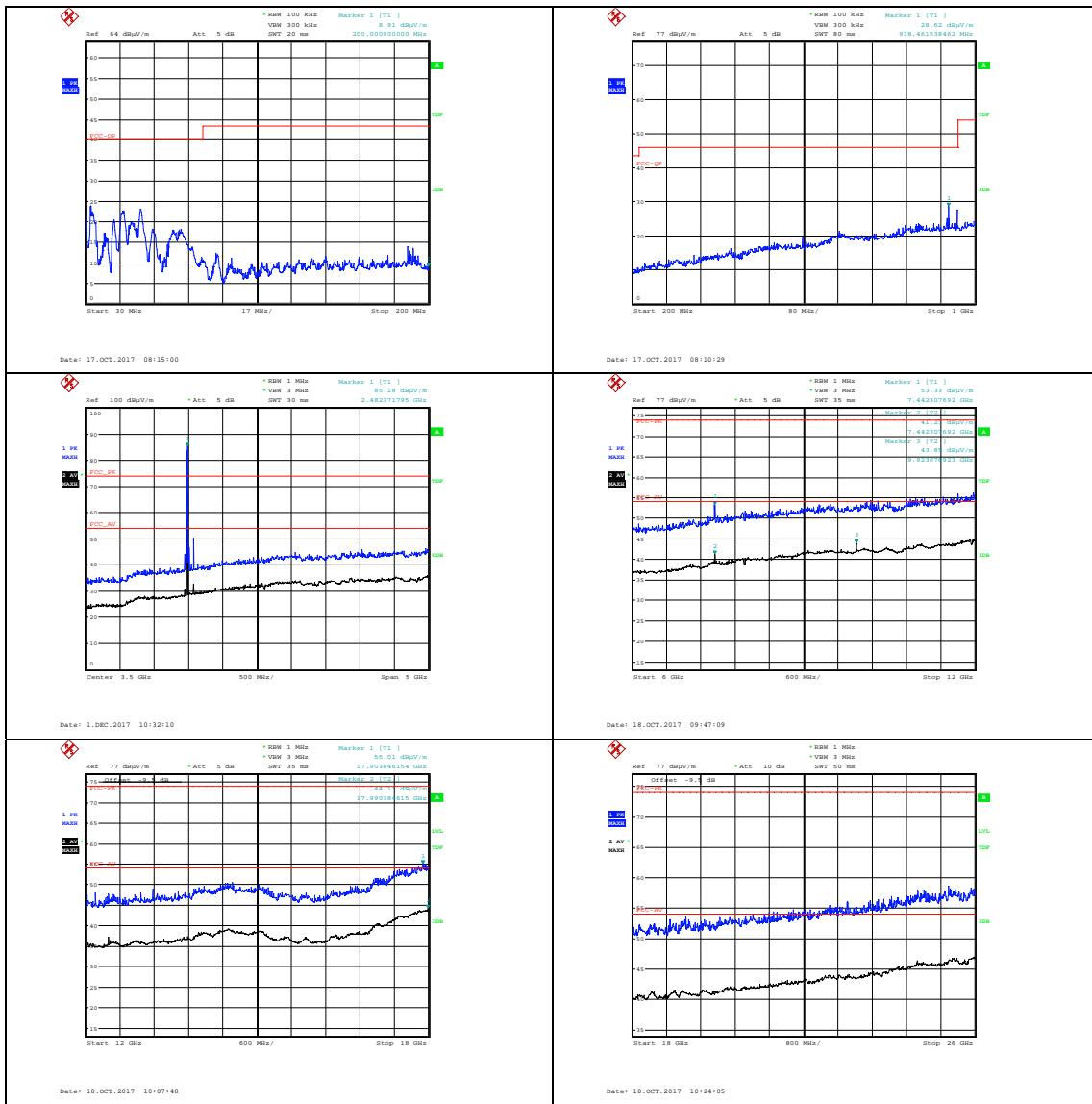


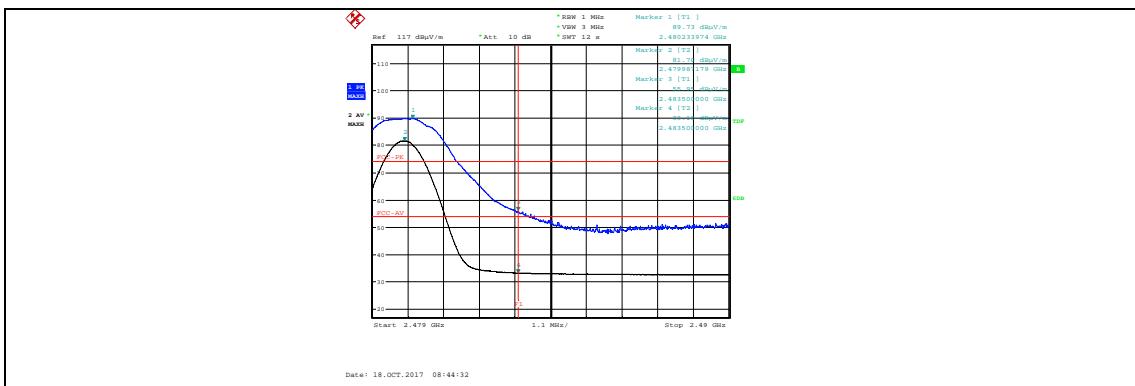
Max. Power Setting: +4 dBm; Channel Frequency: 2440 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dB μ V)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dB μ V/m)	Field Strength (μ V/m)	Limit (μ V/m)
Pk	4880.00	46.15	4.60	33.30	36.21	0.00	0.00	47.84	246.60	5000
Av	4880.00	35.00	4.60	33.30	36.21	3.70	0.00	40.39	104.65	500
Pk	7320.00	55.78	6.60	36.90	36.65	0.00	0.00	62.63	1354.10	5000
Av	7320.00	42.34	6.60	36.90	36.65	3.70	0.00	52.89	441.30	500





Max. Power Setting: +4 dBm; Channel Frequency: 2480 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dB μ V)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dB μ V/m)	Field Strength (μ V/m)	Limit (μ V/m)
Pk	4960.00	49.55	4.60	33.30	36.23	0.00	0.00	51.22	363.92	5000
Av	4960.00	37.30	4.60	33.30	36.23	3.70	0.00	42.67	136.06	500
Pk	7440.00	53.86	6.20	37.00	36.68	0.00	0.00	60.38	1044.72	5000
Av	7440.00	40.35	6.20	37.00	36.68	3.70	0.00	50.57	337.86	500





12 AC power-line conducted emissions

12.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Screen Room 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	Mid (2440 MHz)
EUT Channel Bandwidths:	2 MHz
EUT Modulation:	GFSK
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 54 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 V ac	110 V ac ±10 % (as declared)

12.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3.

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	Conducted limit (dB μ V)	
	Quasi-Peak	Average**
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.

**A linear average detector is required.

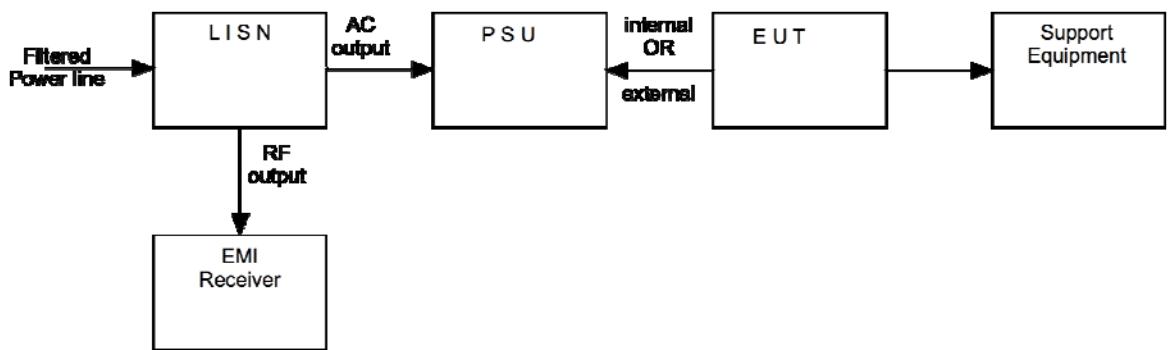
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



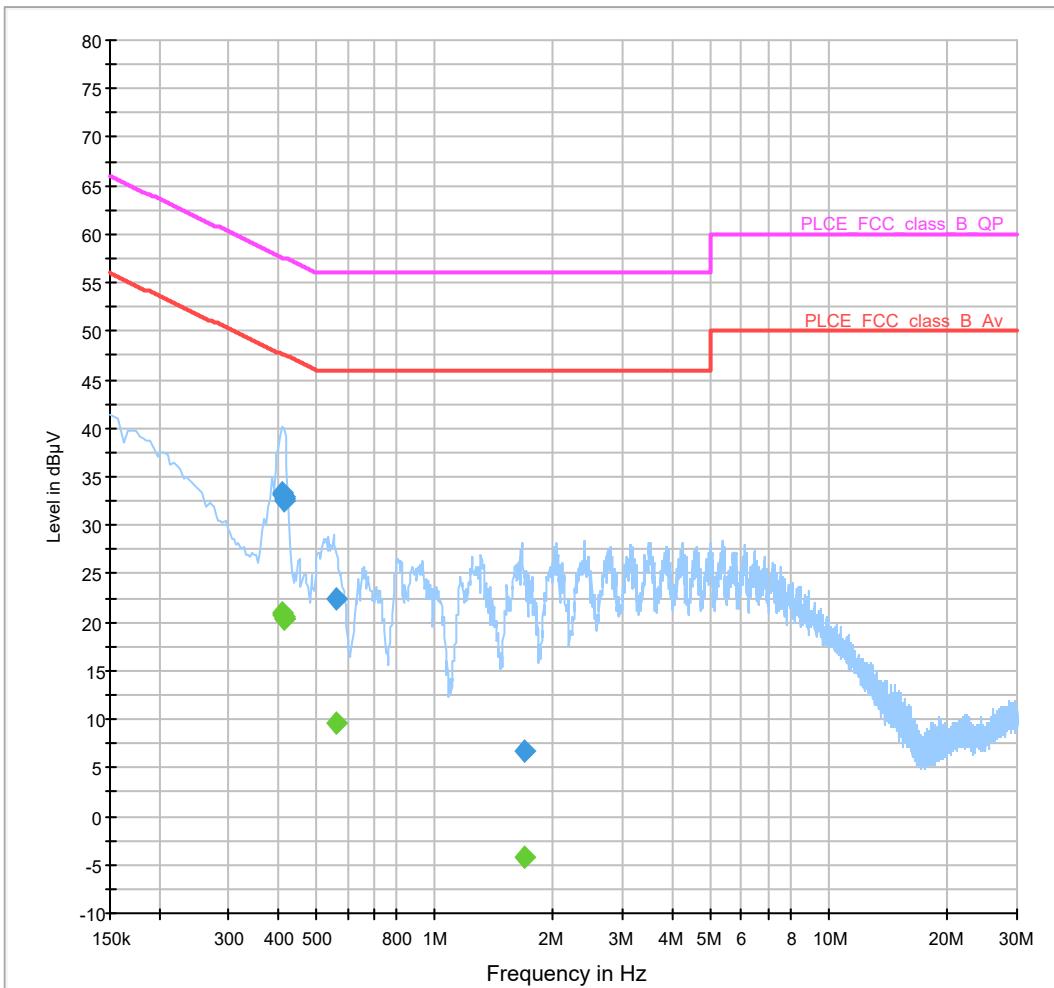
12.5 Test Set-up Photograph



12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
LISN	R&S	ESH3-Z5	H189	7/8/2018
Pulse Limiter	R&S	ESH3-Z2	H674	6/4/2018
RF Chamber (Line Conducted Site)	Belling Lee	Screen Room 2	H705	N / A
Analyser/Receiver	R&S	ESHS10	RFG125	12/12/2017
Vertical Ground Reference Plane	Element	2.5m x 2m	H737	N / A

12.7 Test Results



Frequency (MHz)	QuasiPeak (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.409000	33.2	15000.0	10.000	GND	L1	10.4	24.5	57.7
0.411000	33.4	15000.0	10.000	GND	L1	10.4	24.2	57.6
0.413000	32.9	15000.0	10.000	GND	L1	10.4	24.7	57.6
0.413000	32.7	15000.0	10.000	GND	L1	10.4	24.9	57.6
0.413000	32.6	15000.0	10.000	GND	L1	10.4	25.0	57.6
0.565000	22.4	15000.0	10.000	GND	L1	10.4	33.6	56.0
1.691000	6.6	15000.0	10.000	GND	L1	10.5	49.4	56.0

Frequency (MHz)	Average (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.409000	20.7	15000.0	10.000	GND	L1	10.4	27	47.7
0.411000	21.0	15000.0	10.000	GND	L1	10.4	26.6	47.6
0.413000	20.5	15000.0	10.000	GND	L1	10.4	27.2	47.6
0.413000	20.4	15000.0	10.000	GND	L1	10.4	27.2	47.6
0.413000	20.4	15000.0	10.000	GND	L1	10.4	37.2	47.6
0.565000	9.6	15000.0	10.000	GND	L1	10.4	36.4	46.0
1.691000	-4.2	15000.0	10.000	GND	L1	10.5	50.2	46.0

13 Occupied Bandwidth

13.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 2
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	Low / Mid / High (2402 / 2440 / 2480 MHz)
EUT Channel Bandwidths:	2 MHz
EUT Test Modulations:	Bluetooth LE GFSK PRBS9 Payload 37
Deviations From Standard:	None
Measurement BW: (IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	IC: 50 kHz / FCC: 100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	200 kHz / 300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	

13.3 Test Limit

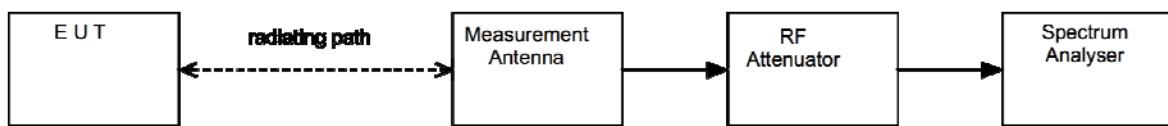
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iii Test Setup

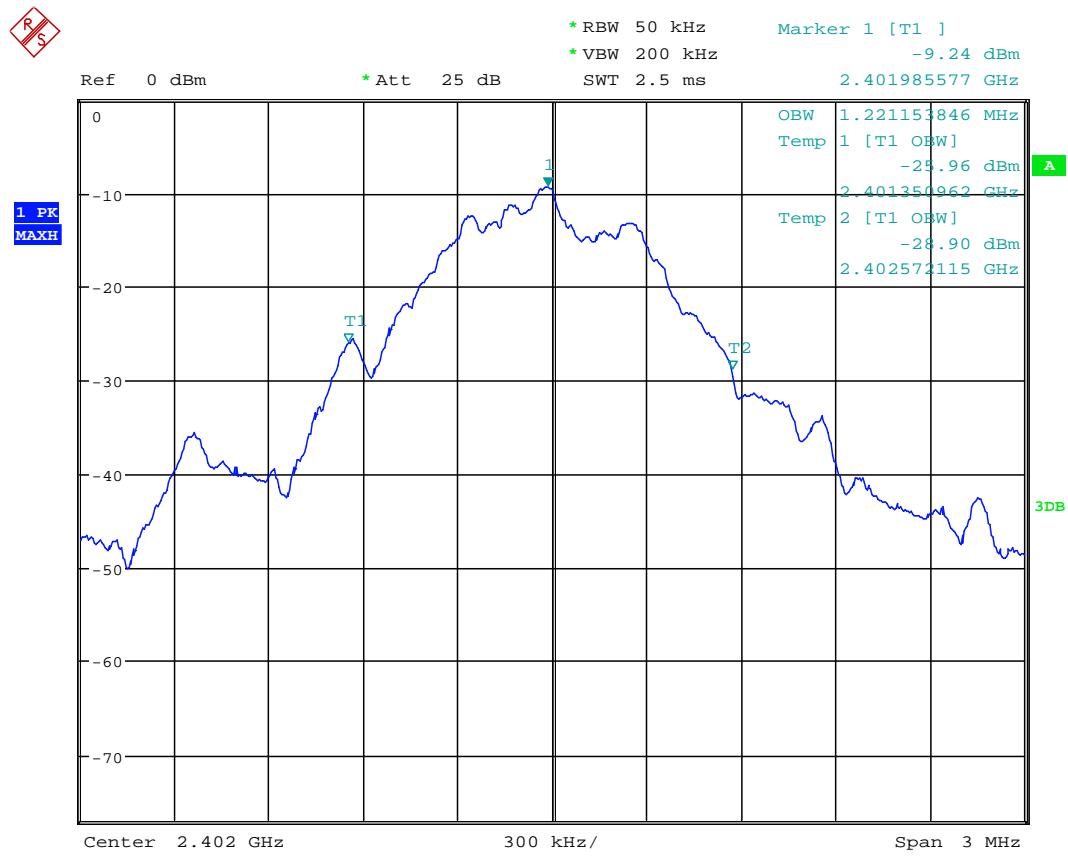


13.5 Test Equipment

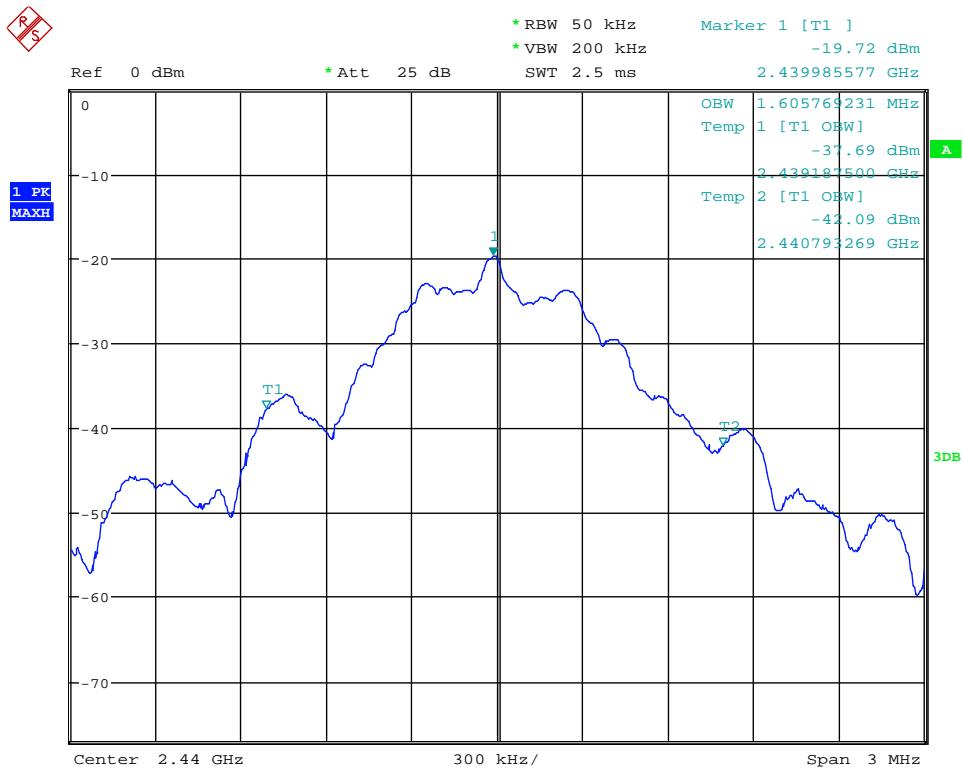
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	27/04/2018
10m 3.5mm	Rosenberger	Cable	REF937	01/02/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2184	27/03/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2185	27/03/2018
3115	EMCO	Horn Antenna	RFG129	09/02/2018
ATS	Rainford	Ferrite Lined Chamber	REF886	24/07/2018

13.6 Test Results

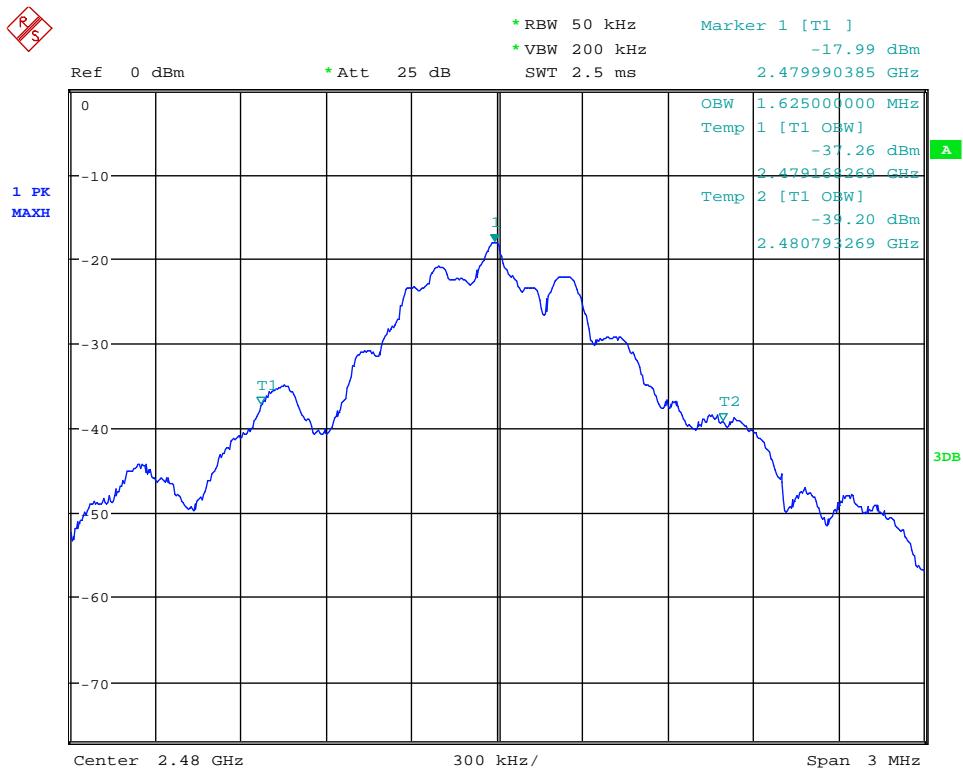
RSS-210 99%OBW				
Modulation: Bluetooth LE; Data rate: PRBS9 Payload37;				
Power setting: +4 dBm				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	99 % OBW (kHz)	Result
2402	2401.350962	2402.572115	1221.153846	Information only
2440	2439.187500	2440.793269	1605.769231	Information only
2480	2479.168269	2480.793269	1625.000000	Information only



Date: 19.OCT.2017 13:36:20

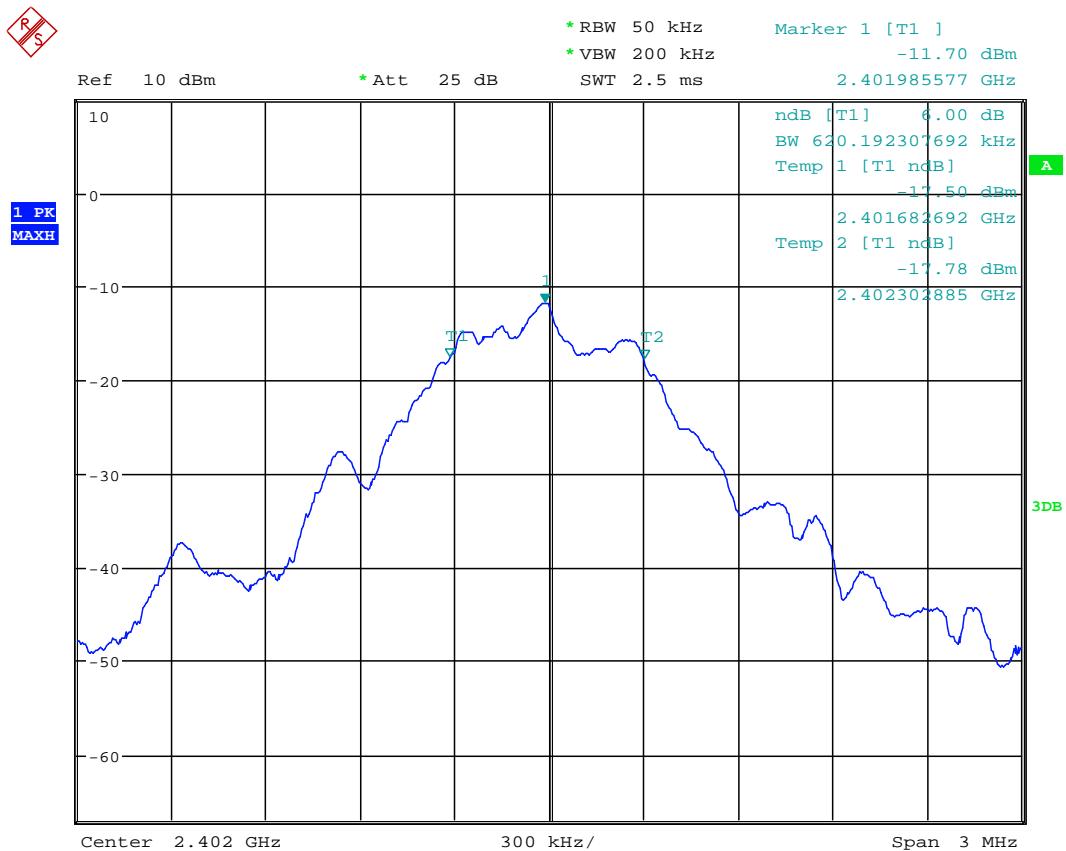


Date: 19.OCT.2017 13:26:18



Date: 19.OCT.2017 13:19:43

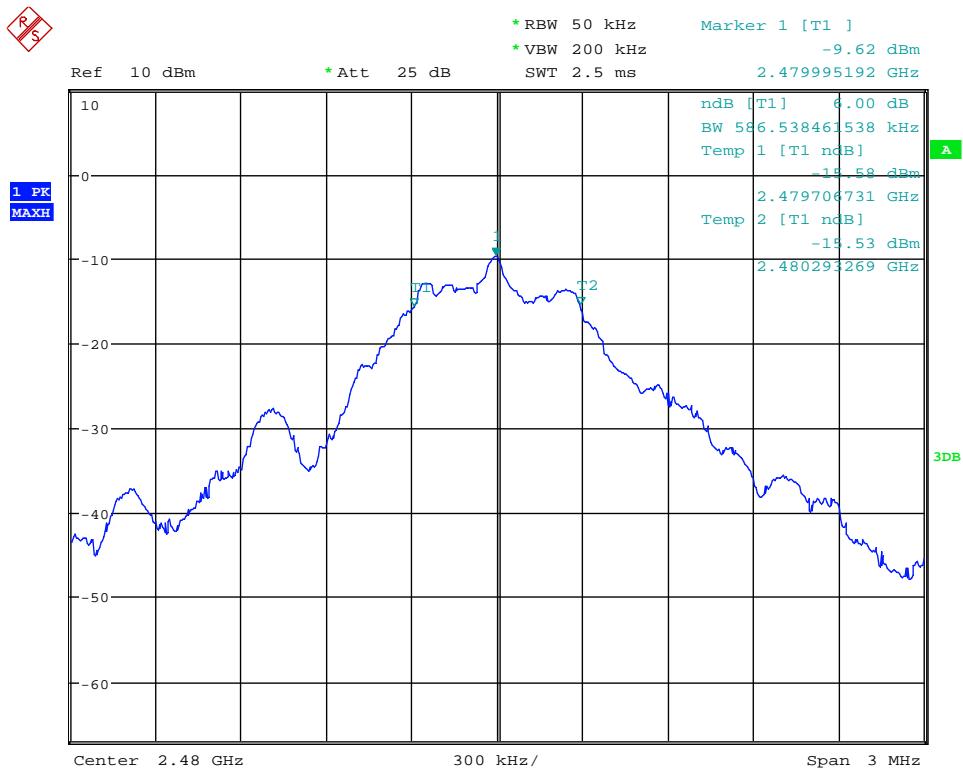
RSS 247. Modulation: Bluetooth LE; Data rate: PRBS9 Payload37; Power setting: +4 dBm				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2402	2401.682692	2402.302885	620.192	PASS
2440	2439.687500	2440.298077	610.577	PASS
2480	2479.706731	2480.293269	586.538	PASS



Date: 20.OCT.2017 09:09:13

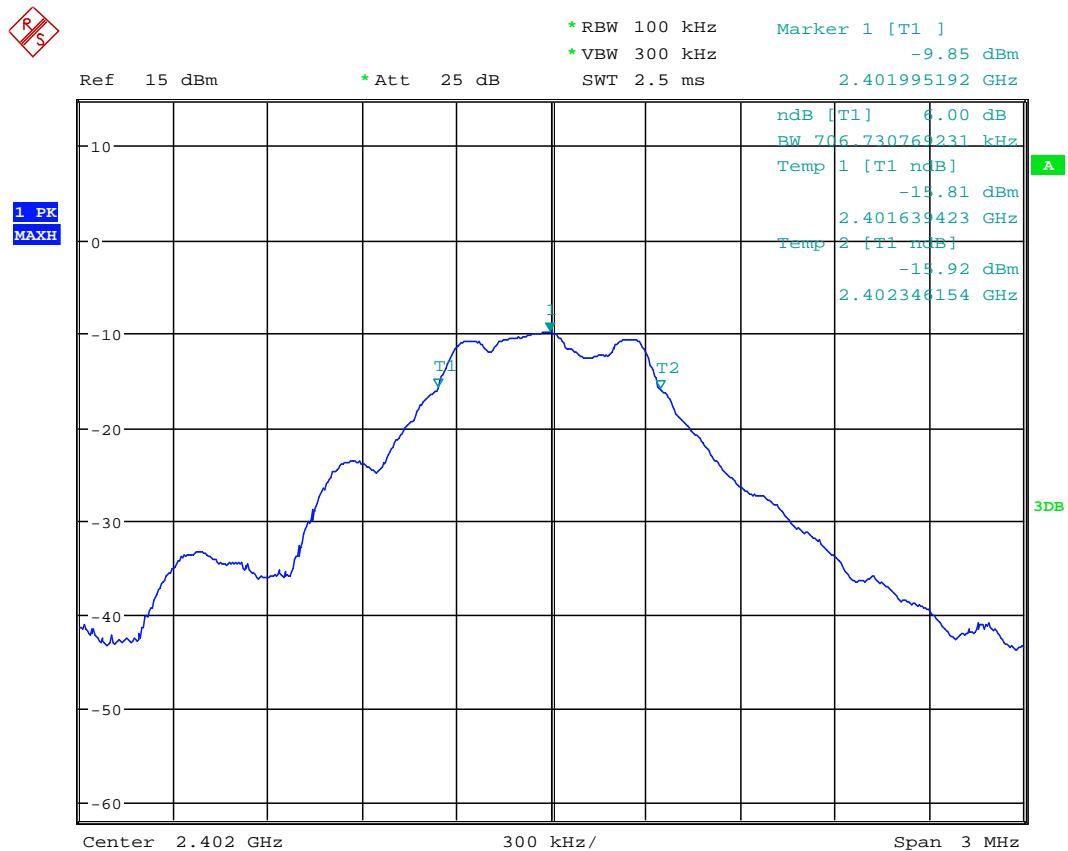


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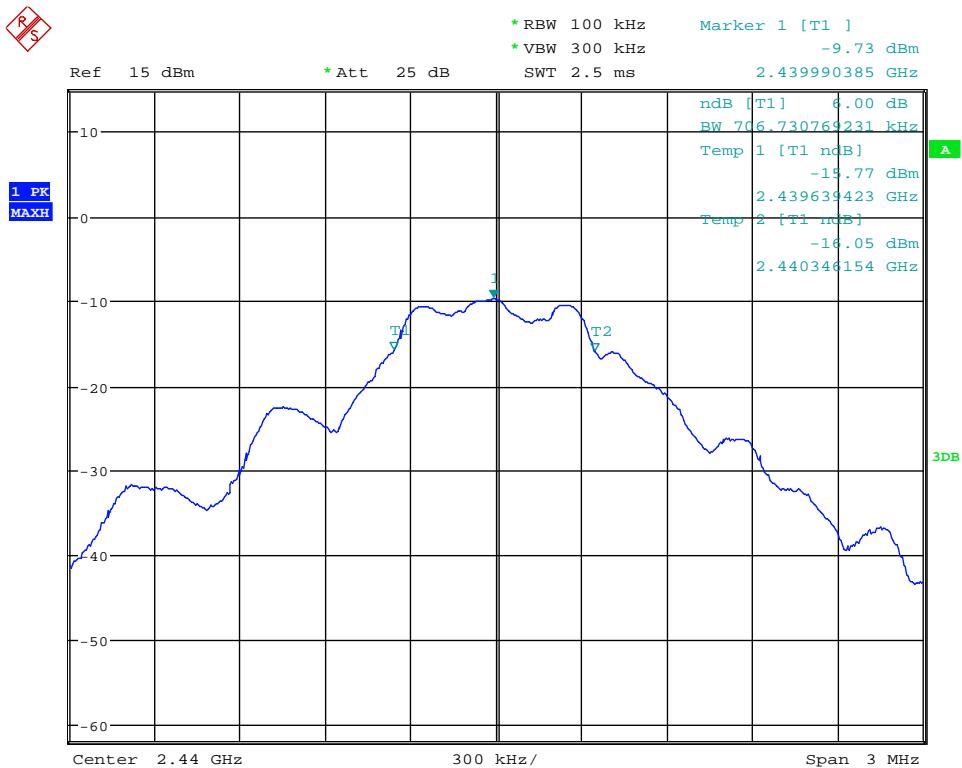


Date: 20.OCT.2017 09:04:00

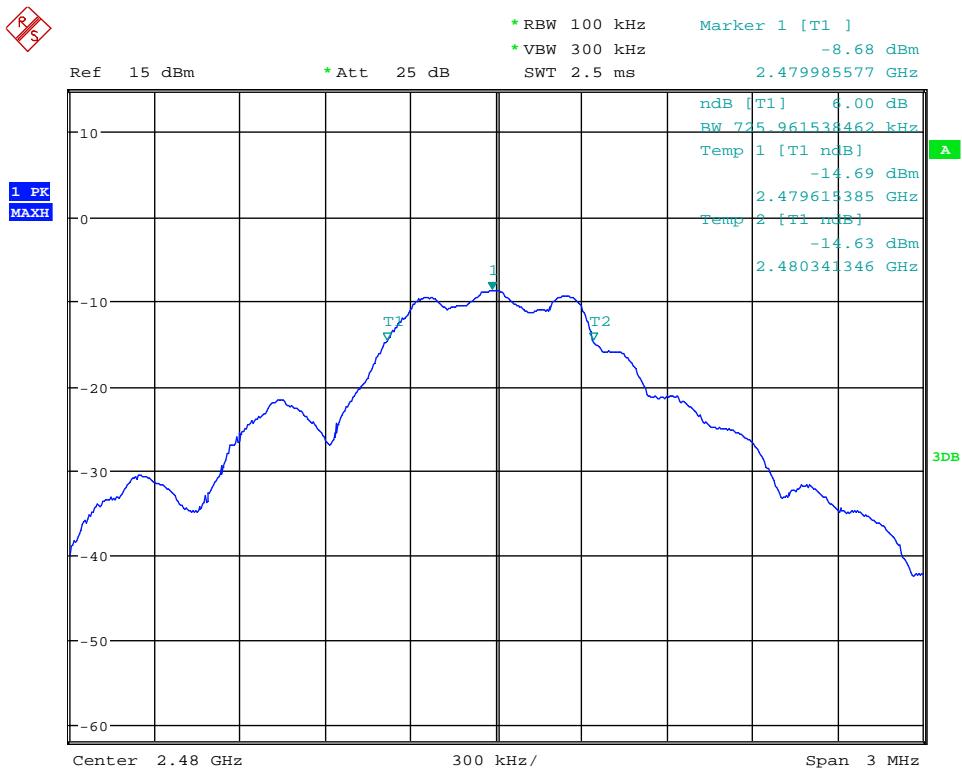
FCC 15.247. Modulation: Bluetooth LE; Data rate: PRBS9 Payload37; Power setting: +4 dBm				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2402	2401.639423	2402.346154	706.731	PASS
2440	2439.639423	2440.346154	706.731	PASS
2480	2479.615385	2480.341346	725.962	PASS



Date: 19.OCT.2017 14:43:45



Date: 19.OCT.2017 14:33:16



Date: 19.OCT.2017 14:30:15

14 Maximum peak conducted output power

14.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels / Frequencies Measured:	Low / Mid / High (2402 / 2440 / 2480 MHz)
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	3 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak & Average
Voltage Extreme Environment Test Range:	Fully Charged Battery 5V d.c.

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

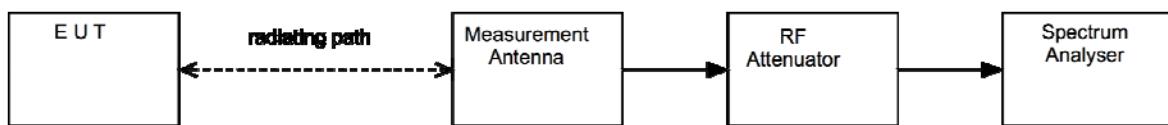
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iv Test Setup



14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	27/04/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2184	27/03/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2185	27/03/2018
3115	EMCO	Horn Antenna	RFG129	09/02/2018
310	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
Cable	AtlanTec	Short SMA RF Cable	REF2165	09/12/2017
Bandstop filter	Unknown	2.4 GHz ISM bandstop filter	REF2158	Cal before use
3146	EMCO	Log Periodic Antenna	RFG191	17/05/2019
Antenna	Q-Par	Horn Antenna	RFG630	24/11/2017
3109	EMCO	Biconical Antenna	RFG095	17/05/2019

14.6 Test Results

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

$$TP = (FS \times D)^2 / (30 \times G)$$

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain.

Modulation: GFSK; Data rate: 1 Mbps; Power setting: +4 dBm					
Channel Frequency (MHz)	Peak Field Strength (dB μ V/m)	Distance (m)	Antenna Gain (dBi)	Max. Power (mW)	Result
2402	85.74	3	Included	0.113	PASS
2440	86.05	3	Included	0.121	PASS
2480	90.79	3	Included	0.360	PASS

15 Out-of-band and conducted spurious emissions

15.1 Definition

Out-of-band emission.

Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

Spurious emission.

Emission on a frequency or frequencies that are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency conversion products, but exclude out-of-band emissions.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	

15.3 Test Limit

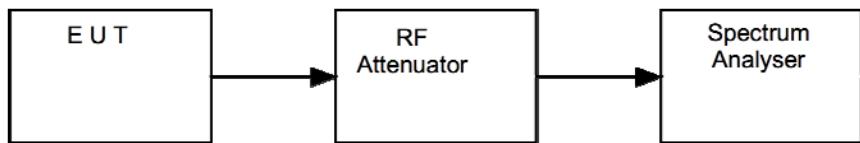
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) / RSS-Gen is not required.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure v Test Setup



15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	27/04/2018

15.6 Test Results

Modulation: GFSK; Power setting: +4 dBm						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	-20 dB offset (dBm)	Limit (dBm)	Margin (dB)	Result
2402	2402	-25.08	-45.08	N/A	N/A	PASS
2402	0.052	-49.01	N/A	-45.08	-3.93	PASS
2402	0.110	-47.81	N/A	-45.08	-2.73	PASS
2402	3.212	-52.43	N/A	-45.08	-7.35	PASS
2402	7192.869	-56.90	N/A	-45.08	-11.82	PASS

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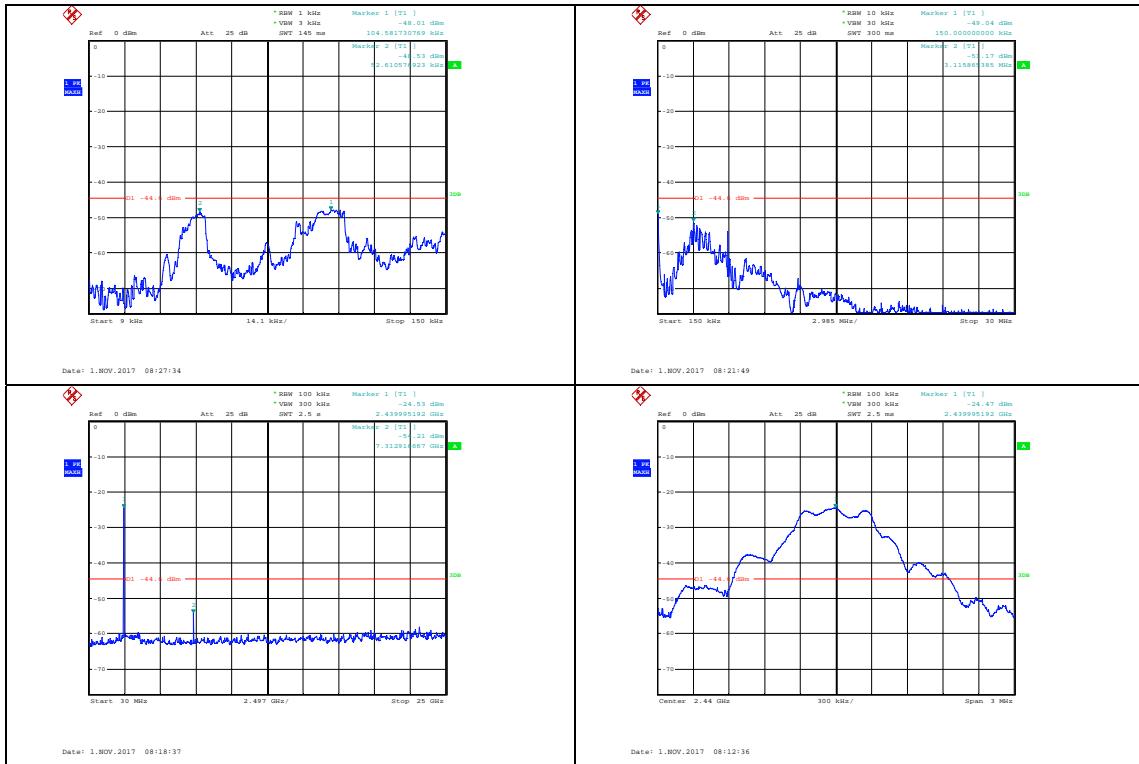
Date: 1.NOV.2017 08:47:54

Date: 1.NOV.2017 08:43:21

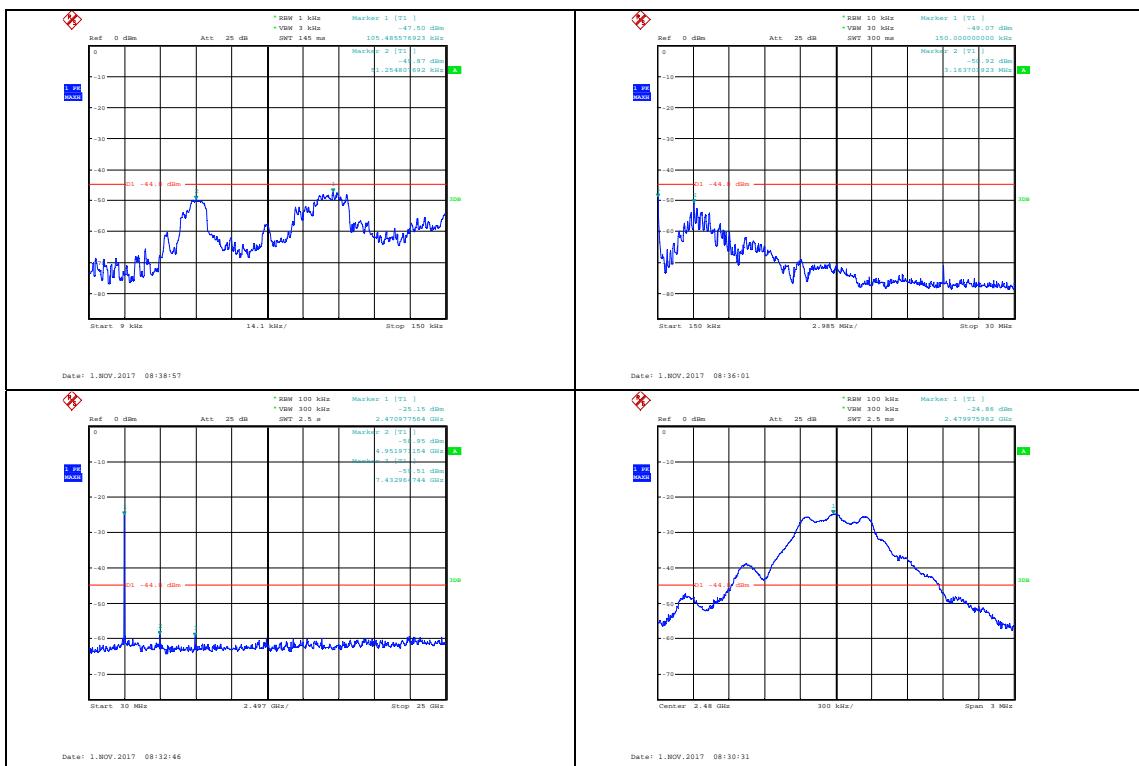
Date: 1.NOV.2017 08:41:44

Date: 1.NOV.2017 08:45:49

Modulation: GFSK; Power setting: +4 dBm						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	-20 dB offset (dBm)	Limit (dBm)	Margin (dB)	Result
2440	2440	-24.47	-44.47	N/A	N/A	PASS
2440	0.053	-48.53	N/A	-44.47	-3.45	PASS
2440	3.12	-51.17	N/A	-44.47	-6.09	PASS
2440	7312.917	-54.21	N/A	-44.47	-9.13	PASS



Modulation: GFSK; Power setting: +4 dBm						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	-20 dB offset (dBm)	Limit (dBm)	Margin (dB)	Result
2480	2480	-24.86	-44.8	N/A	N/A	PASS
2480	0.051	-49.87	N/A	-44.8	-4.79	PASS
2480	3.164	-50.92	N/A	-44.8	-5.84	PASS
2480	4951.971	-58.95	N/A	-44.8	-13.87	PASS
2480	7432.965	-59.51	N/A	-44.8	-14.43	PASS



16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Laboratory 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	Low / Mid / High (2402 / 2440 / 2480 MHz)
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	

16.3 Test Limit

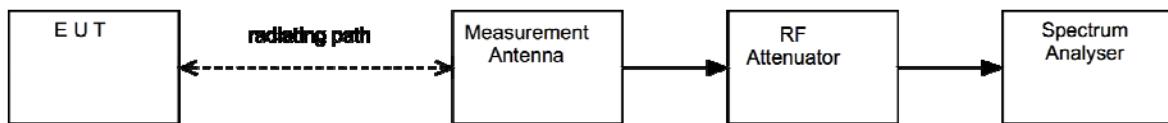
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure vi Test Setup



16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	27/04/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2184	27/03/2018
Cable	Teledyne	K-Type RF coaxial cable	REF2185	27/03/2018
Horn Antenna	EMCO	1-18 GHz	RFG129	09/02/2018

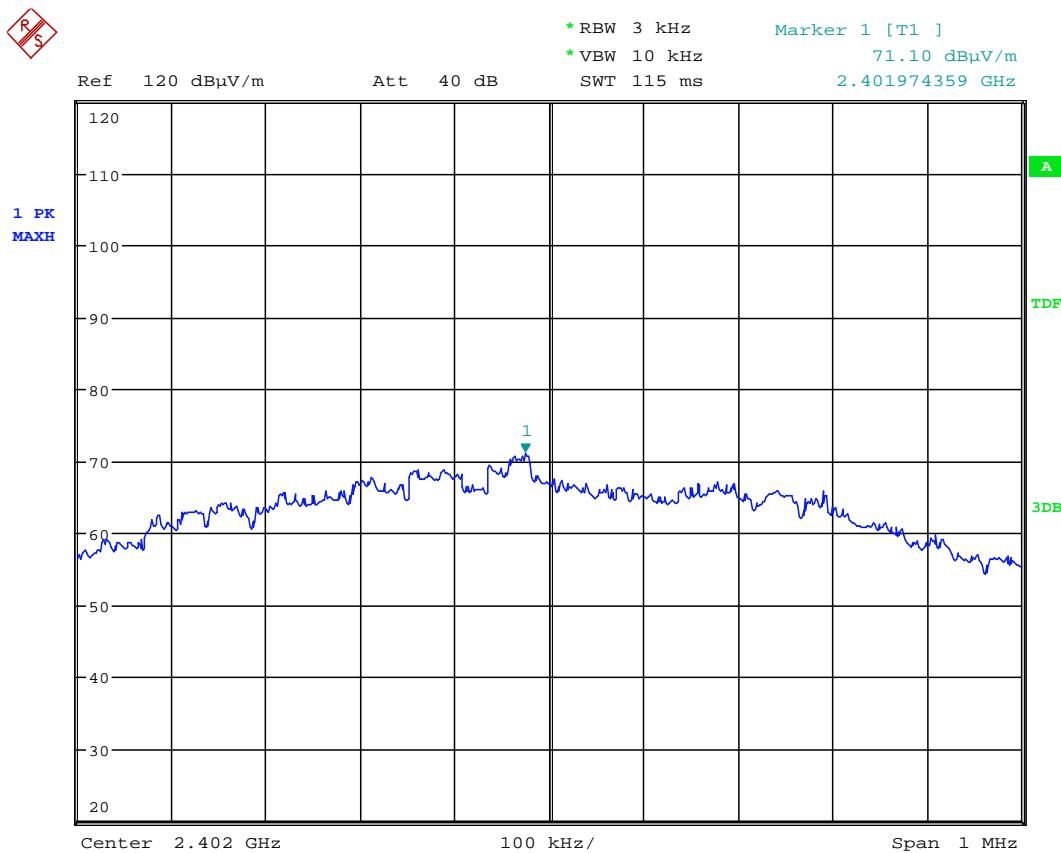
16.6 Test Results

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

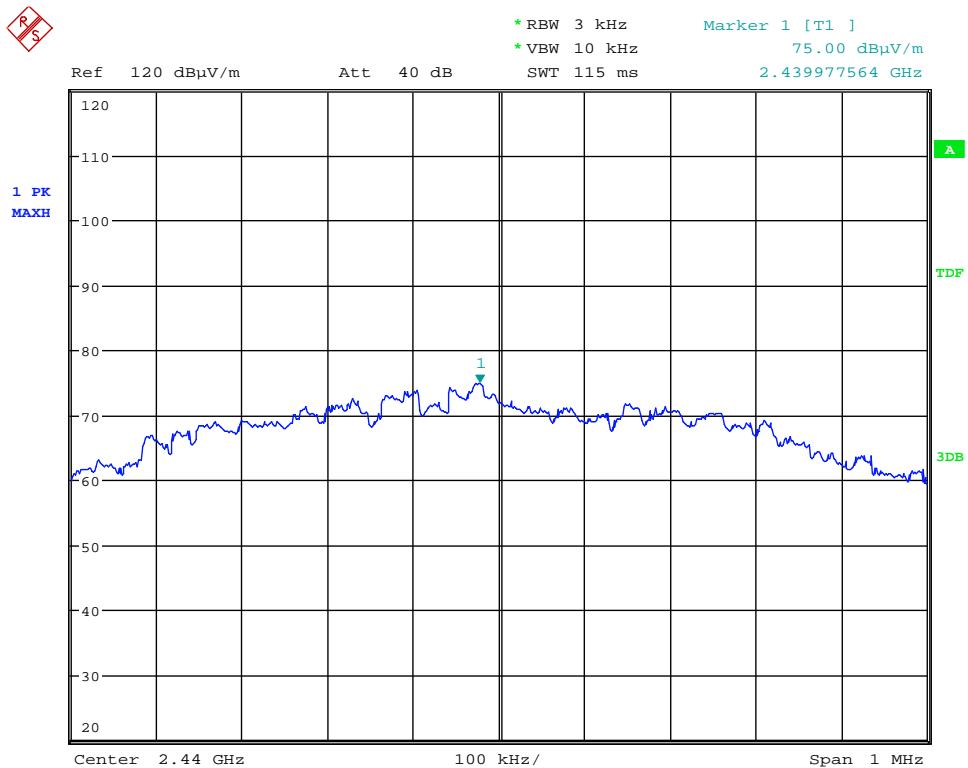
$$TP = (FS \times D)^2 / (30 \times G)$$

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain.

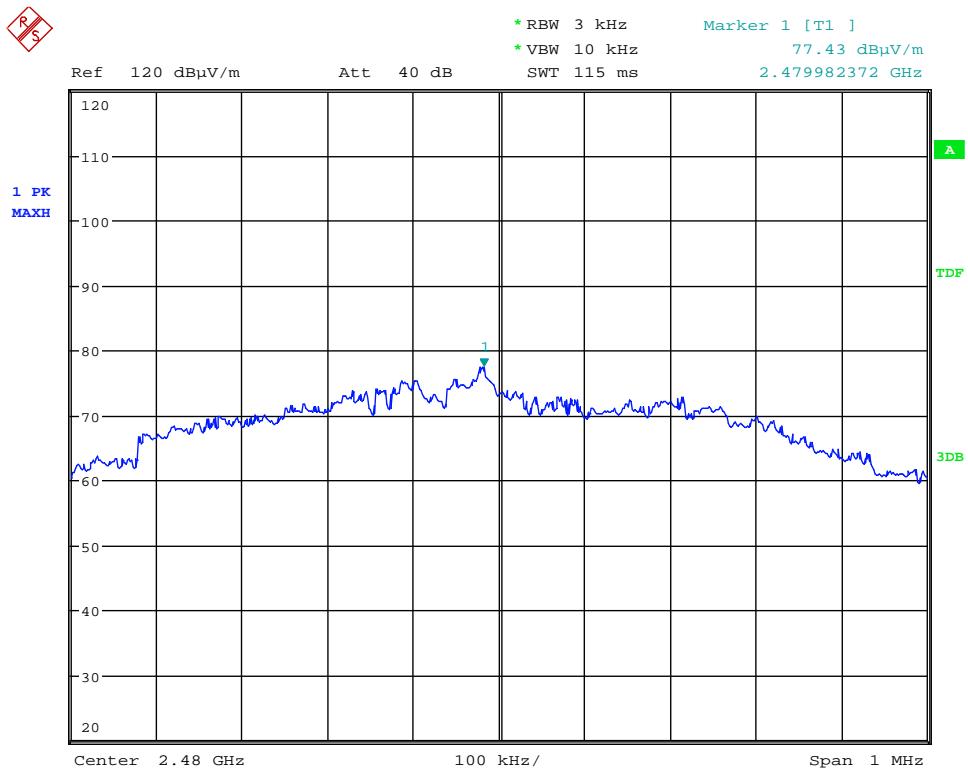
Modulation: Bluetooth LE; Data rate: Test PRBS9 Payload 37; Power setting: +4 dBm					
Channel Frequency (MHz)	Peak Field Strength (dB μ V/m)	Distance (m)	Antenna Gain (dBi)	Max. Power EIRP (dBm)	Result
2402	71.10	3	Included	-24.13	PASS
2440	75.00	3	Included	-20.23	PASS
2480	77.43	3	Included	-17.80	PASS



Date: 18.OCT.2017 09:28:43



Date: 18.OCT.2017 09:31:05



Date: 18.OCT.2017 08:46:56

17 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **1.08 dB**

[5] Conducted / radiated RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**
Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**
Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[6] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **2.48 dB**

18 RF Exposure Technical Brief

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR Exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

The SAR Test Exclusion Threshold for operation in the 2400 – 2483.5 MHz band will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

$$NT = [(MP/TSDA) * \sqrt{fGHz}]$$

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)

MP = Max Power of channel (mW) (inc tune up)

TSDA = Min Test separation Distance or 50mm (whichever is lower) = 5mm (in this case)

We can transpose this formula to allow us to find the maximum power of a channel allowed and compare this to the measured maximum power.

$$= [(NT \times TSA) / \sqrt{fGHz}]$$

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSDB - 50mm) * 10\}$$

Where:

TSDB = Min Test separation Distance (mm) = 50

Note: Step 2 is not required here as the TSA is 5mm.

Operating Frequency 2.402 GHz

$$\begin{aligned} SARET &= [(3.0 \times 5) / \sqrt{2.402}] \\ SARET &= 9.68 \text{ mW} \end{aligned}$$

Operating Frequency 2.440 GHz

$$\begin{aligned} SARET &= [(3.0 \times 5) / \sqrt{2.440}] \\ SARET &= 9.60 \text{ mW} \end{aligned}$$

Operating Frequency 2.480 GHz

$$\begin{aligned} SARET &= [(3.0 \times 5) / \sqrt{2.480}] \\ SARET &= 9.53 \text{ mW} \end{aligned}$$

Channel Frequency (MHz)	Max. Output Power (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
2402	0.113	9.68	Not Required
2440	0.121	9.60	Not Required
2480	0.360	9.53	Not Required

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

RSS-102 issue 5

2.5.1 Exemption Limits for Routine Evaluation – SAR Evaluation

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance.

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold at distance of ≤ 5 mm (mW)	SAR Evaluation
2402	0.113	4.26	Exempt
2440	0.121	4.05	Exempt
2480	0.360	3.94	Exempt

EIRP values are measured radiated power.