Report on the Radio Testing

For

ViCentra BV

on

Kaleido Insulin Pump Handset

Report no. TRA-032498-02-45-01A

4th November 2017

RF915 4.0

Report Number: TRA-032498-02-45-01A
Issue: A

REPORT ON THE RADIO TESTING OF A
ViCentra BV
Kaleido Insulin Pump Handset
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATE: From 12-9-2017 to 3-11-2017

Written by: A Wong

A. L. Y. Wong
Radio Test Engineer

Approved by:

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Reason: I am approving this document
Date: 2017.12.20 13:43:15 Z

J. Charters
Department Manager (Radio)

Date: 4th November 2017

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Company Reg No. 02536659

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	4th November 2017	Original

2 Summary

TEST REPORT NUMBER:	TRA-032498-02-45-01A
WORKS ORDER NUMBER	TRA-032498-02
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J. 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.
TEST SPECIFICATION(S):	47CFR15.247 & RSS-247
EQUIPMENT UNDER TEST (EUT):	Kaleido Insulin Pump Handset
FCC IDENTIFIER:	2ALNZ300118
EUT SERIAL NUMBER:	TRA-032498-S85 and TRA-032498-S86
MANUFACTURER/AGENT:	ViCentra BV
ADDRESS:	Kanaalweg 17B2 Utrecht 3526 KL Netherlands
CLIENT CONTACT:	John Tullett ☎ +31 (0) 88 3232 871 ✉ john.tullett@vicentra.com
ORDER NUMBER:	PO:PF2441
TEST DATE:	From 12-9-2017 to 3-11-2017
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	☒	*PASS*
AC power line conducted emissions		Gen, 8.8	15.207	☒	*PASS*
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	☒	*PASS*
Conducted carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	☒	*PASS*
	Max.			☐	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	☒	*PASS*
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	☒	*PASS*
Calculation of duty correction		-	15.35(c)	☒	*PASS*

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).

3 Contents

4 Introduction

This report TRA-032498-02-45-01A presents the results of the Radio testing on a ViCentra BV, Kaleido Insulin Pump Handset 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 ViCentra BV by Element, at the address(es) detailed below.

☒ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☐ Element Skelmersdale
Unit 1
Pendle Place
Skemersdale
West Lancashire
WN8 9PN
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 1, May 2015 – 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: Kaleido Insulin Pump Handset
- Serial Number: TRA-032498-S85 and TRA-032498-S86
- Model Number: 5060431041350
- Software Revision: Compliance test with RF power setting the same as production versionNot Applicable
- Build Level / Revision Number: Production

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.

A laptop computer was connected via USB connection to combo box provided.

7.3 EUT Mode of Operation

7.3.1 Transmission

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

Vicentra Radio Test Monitor 0.0.0.1 was installed on a laptop computer, connected to a Combo box with flying leads to EUT, was used to set power level, channel and data rate for testing.

7.3.2 Reception

Receiver mode was not tested.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2400-2480 MHz
Modulation type(s):	Bluetooth
Occupied channel bandwidth(s):	1-2 MHz
Channel spacing:	2 MHz
ITU emission designator(s):	1M2DXF
Declared output power(s):	0 dBm
Warning against use of alternative antennas in user manual (yes/no):	Yes
Nominal Supply Voltage:	3.6 V
Frequency stability:	+/- 40 ppm
Location of notice for license exempt use:	Label & user manual
Method of prevention of use on non-US / non-Canadian frequencies:	Secure Firmware
Duty cycle:	< 10 %

7.4.2 Antennas

Type:	Printed on PCB (Copper Trace)
Frequency range:	2400-2480 MHz
Impedance:	50 Ω
Polarisation:	In the plane of PCB
Beam width:	Not measured
Connector type:	N / A
Length:	32 mm (straightened length)
Environmental limits:	-20 to 55 ºC
Mounting:	N / A

7.4.3 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	No
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	N / A
Fixed pt-mpt operations (yes/no):	No
Simultaneous tx (yes/no):	N / A

7.5 EUT Description

The handset is for communicating to insulin pump, one pump at a time, using a wireless connection. It will keep track of the insulin deliveries.

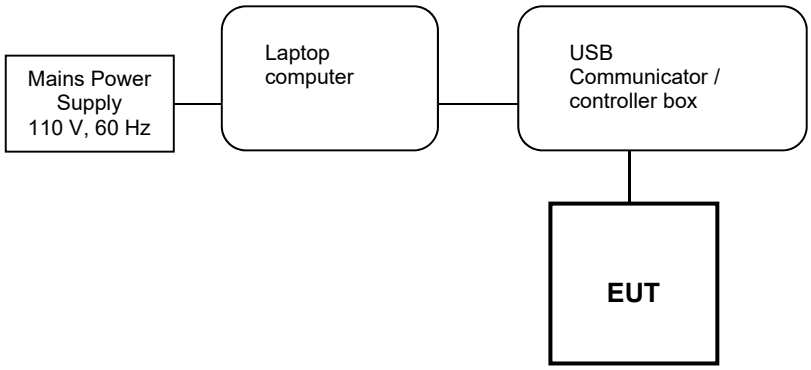
8 Modifications

No modifications were performed during this assessment.

EUT Test Setup

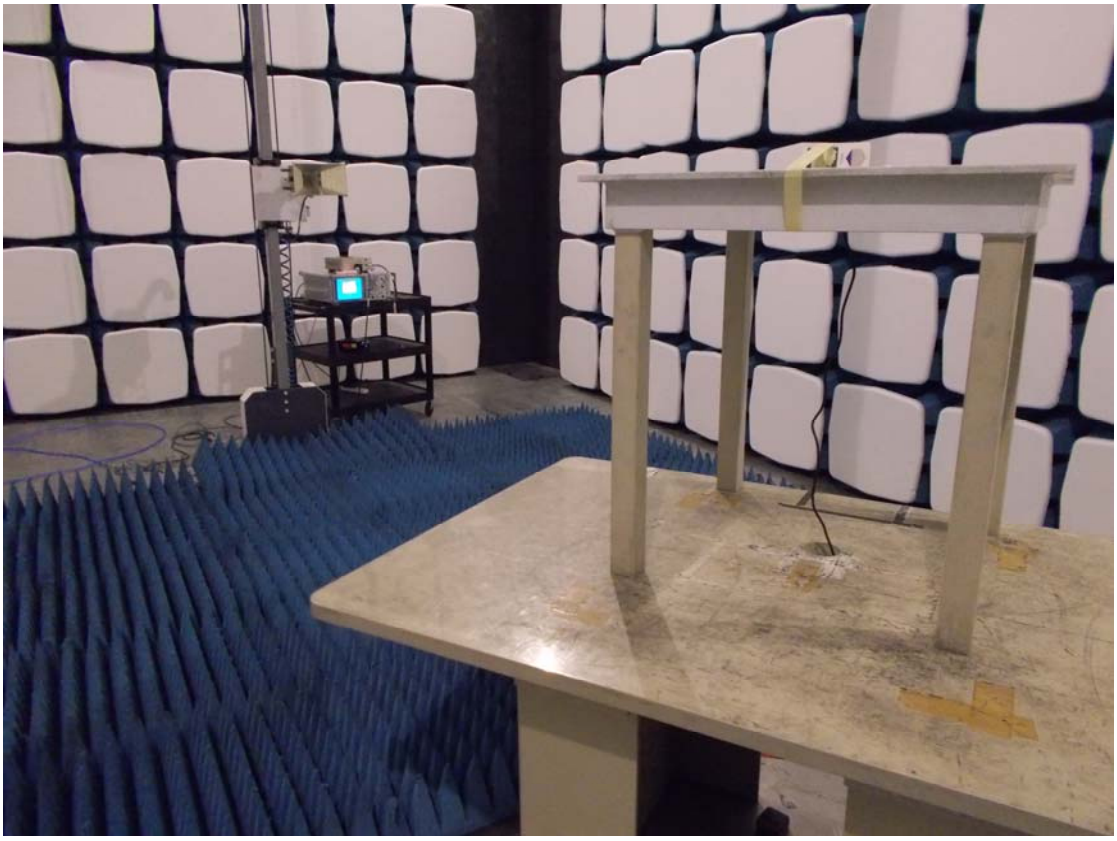
8.1 Block Diagram

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



8.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9 General Technical Parameters

9.1 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. 3.6V dc from an internal LiPo Rechargeable battery.

9.2 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:

	Category	***Nominal***	***Variation***
☐	Mains	110 V ac +/-2 %	85 % and 115 %
☒	Battery	3.6V LiPo Ion	3.6 – 4.2 V

10 Radiated emissions

10.1 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.

10.2 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:	1 MHz for 1 Mbps / 2 MHz for 2 Mbps
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 ºC to +35 ºC (as declared)
Humidity: 43 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 V dc	Via Computer USB port

10.3 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

10.4 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 dBµV/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 dBµV;
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);

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

Figure i Test Setup

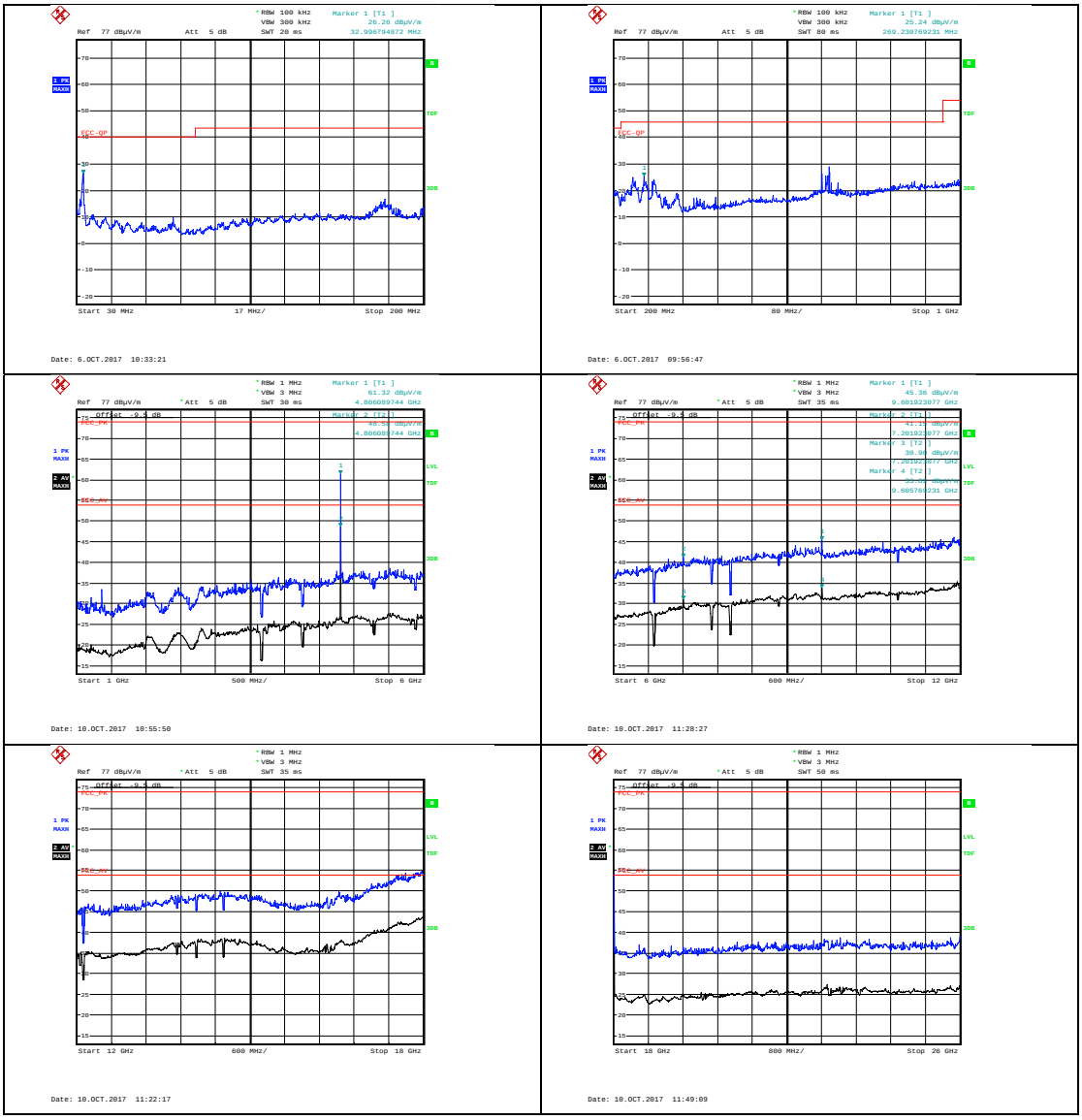
10.5 Test Set-up Photograph

10.6 Test Equipment

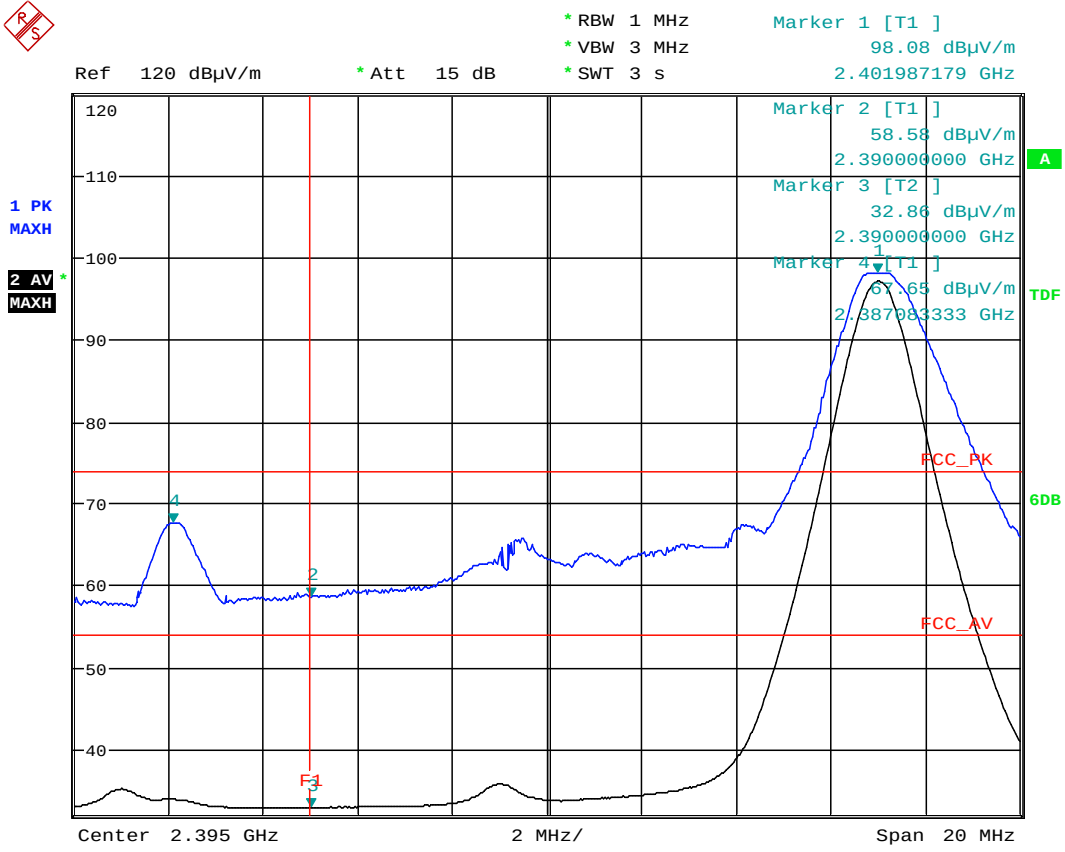
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	27/04/2018
310	Sonoma	Pre-Amp (9kHz – 1GHz)	REF927	30/06/2018
8449B	Agilent	Pre-Amp (1 – 26.5GHz)	REF913	02/02/2018
Cable	AtlanTec	Short SMA RF Cable	REF2165	09/12/2017
Bandstop filter	Unknown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

10.7 Test Results

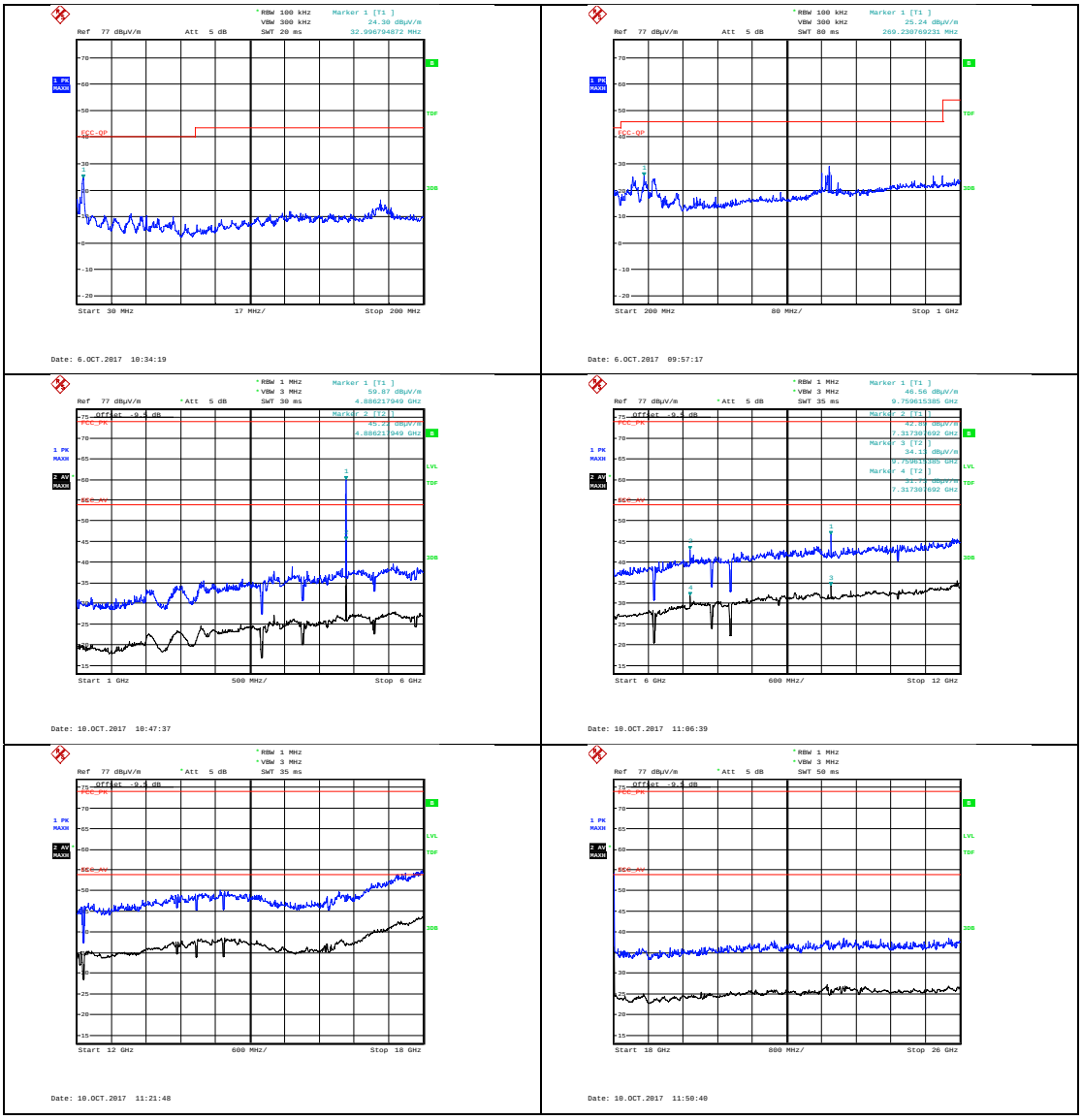
Power Setting: 0 dBm; Channel: 2402 MHz; Data Rate: 1 Mbps										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
Any	No Significant emissions with in 10dB of the limit.									



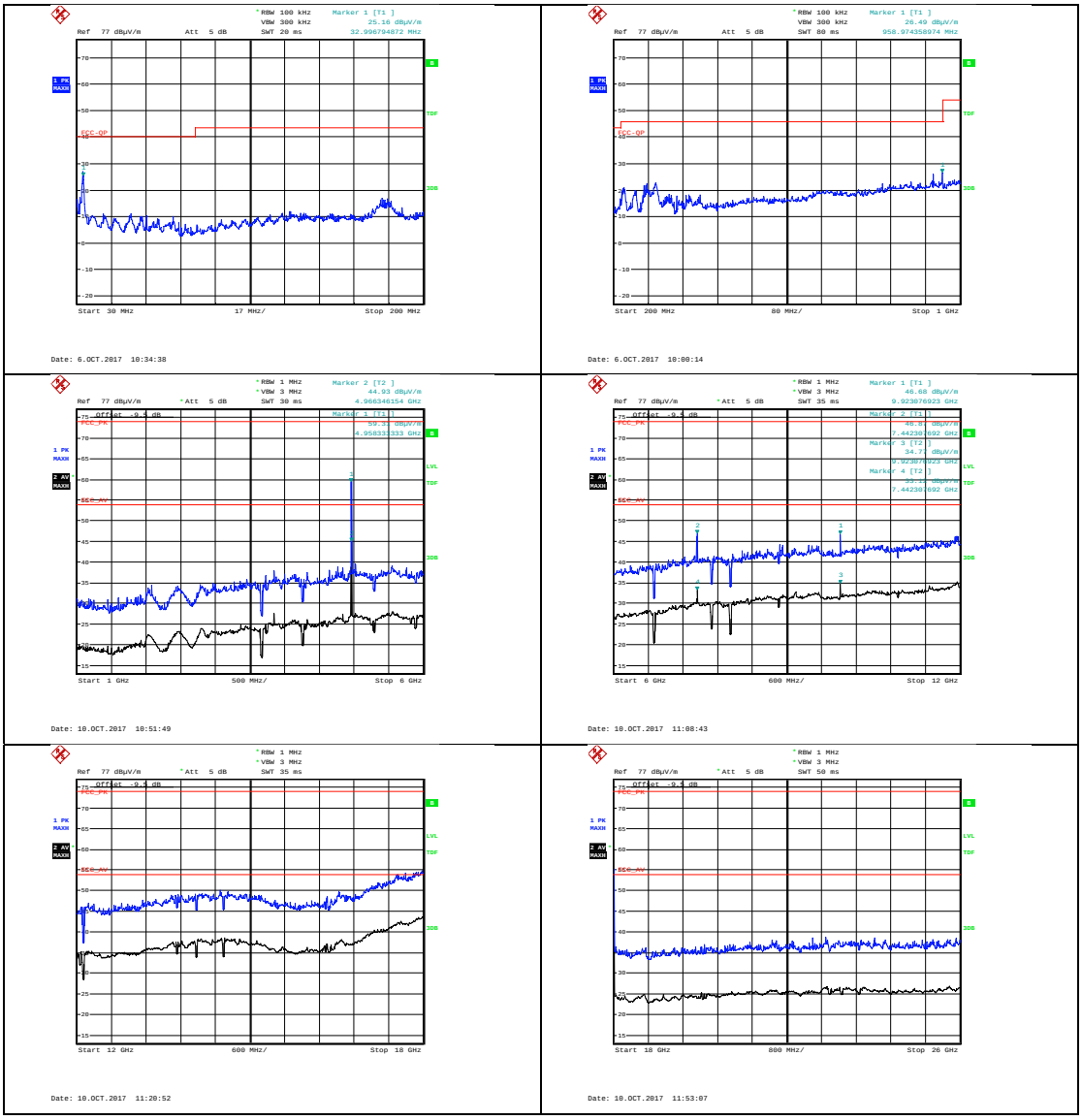
Lower Band Edge: Bluetooth LE 1 M bps



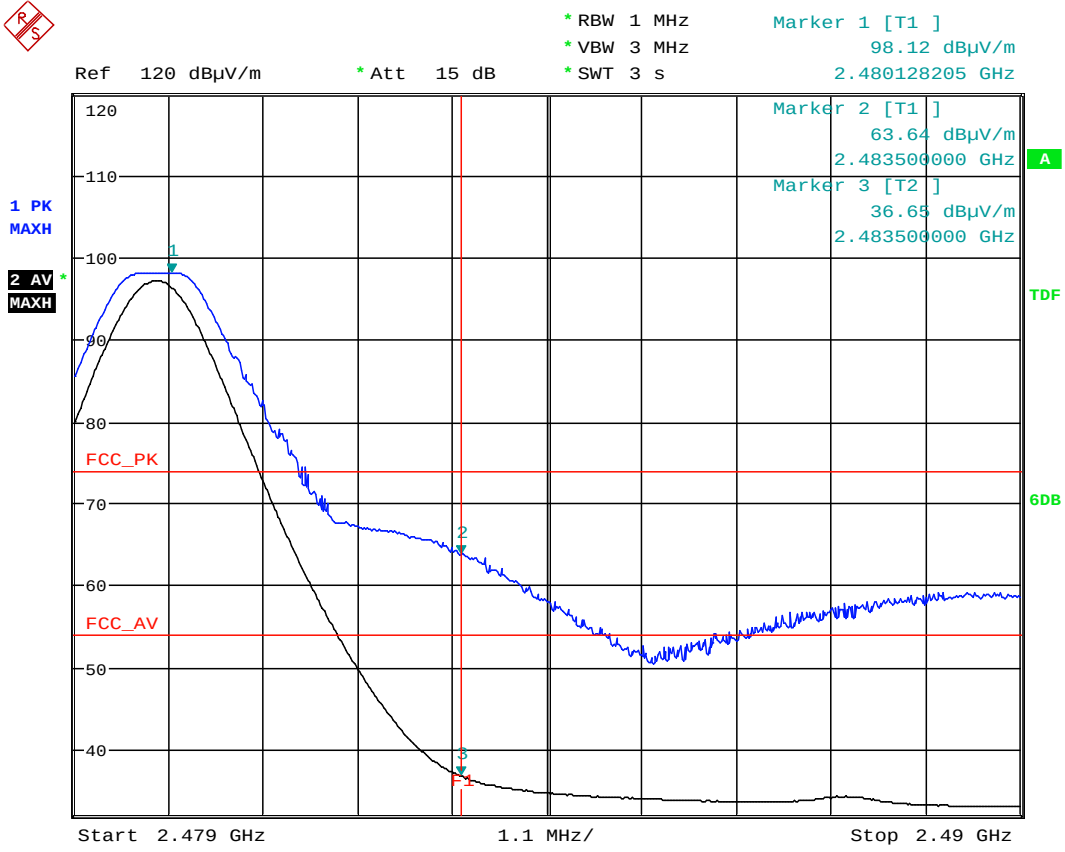
Power Setting: 0 dBm; Channel: 2440 MHz; Data Rate: 1 Mbps										
Detector	**Freq. (MHz)**	**Meas'd Emission (dBµV)**	**Cable Loss (dB)**	**Antenna Factor (dB/m)**	**Pre-amp Gain (dB)**	**Duty Cycle Corr'n (dB)**	**Distance Extrap'n Factor (dB)**	**Field Strength (dBµV/m)**	**Field Strength (µV/m)**	**Limit (µV/m)**
Any	No Significant emissions with in 10dB of the limit.									



Power Setting: 0 dBm; Channel: 2480 MHz; Data Rate: 1 Mbps										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
Any	No Significant emissions with in 10dB of the limit.									

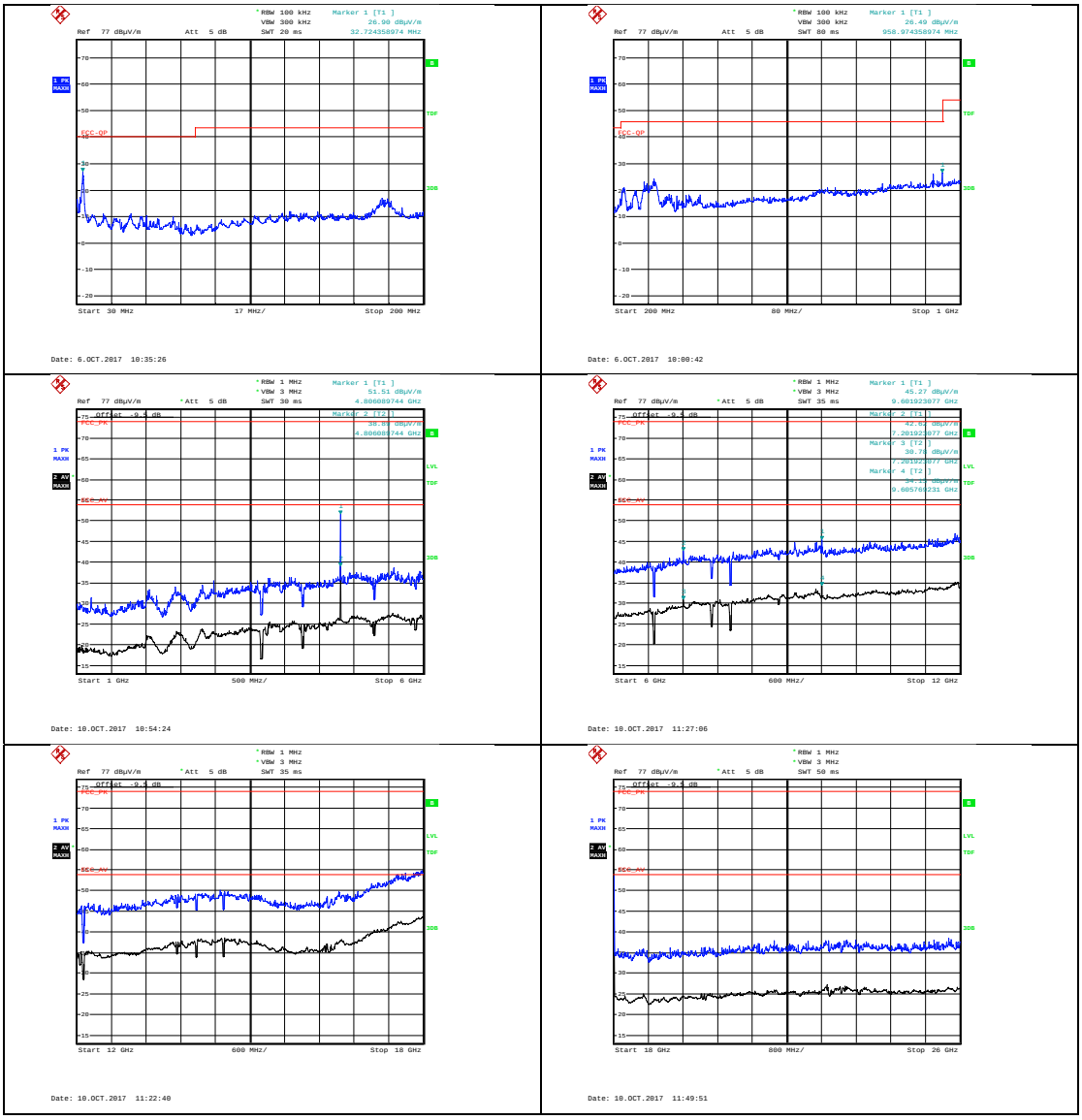


Upper Band Edge: Bluetooth LE 1 Mbps

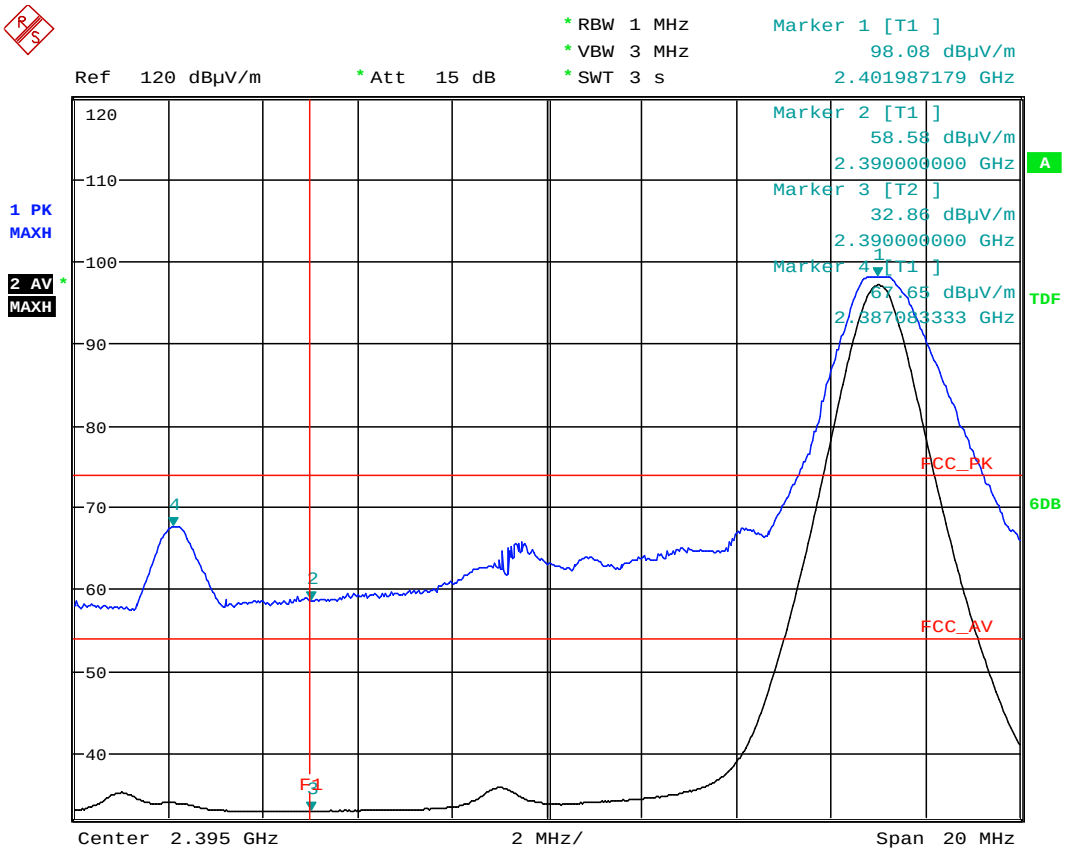


Date: 10.OCT.2017 10:15:48

Power Setting: 0 dBm; Channel: 2402 MHz; Data Rate: 2 Mbps										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
Any	No Significant emissions with in 10dB of the limit.									

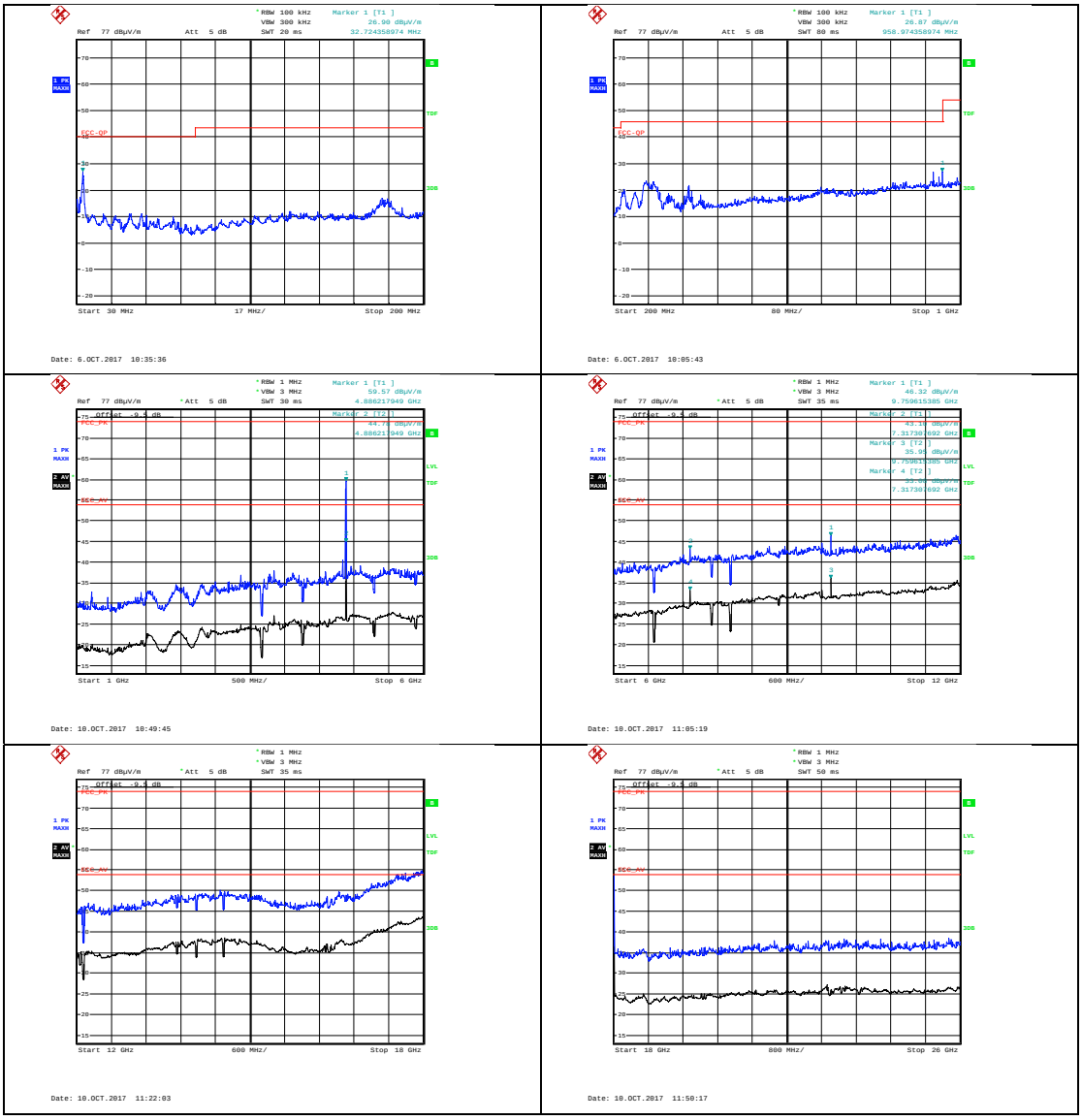


Lower Band Edge: Bluetooth LE 2 M bps

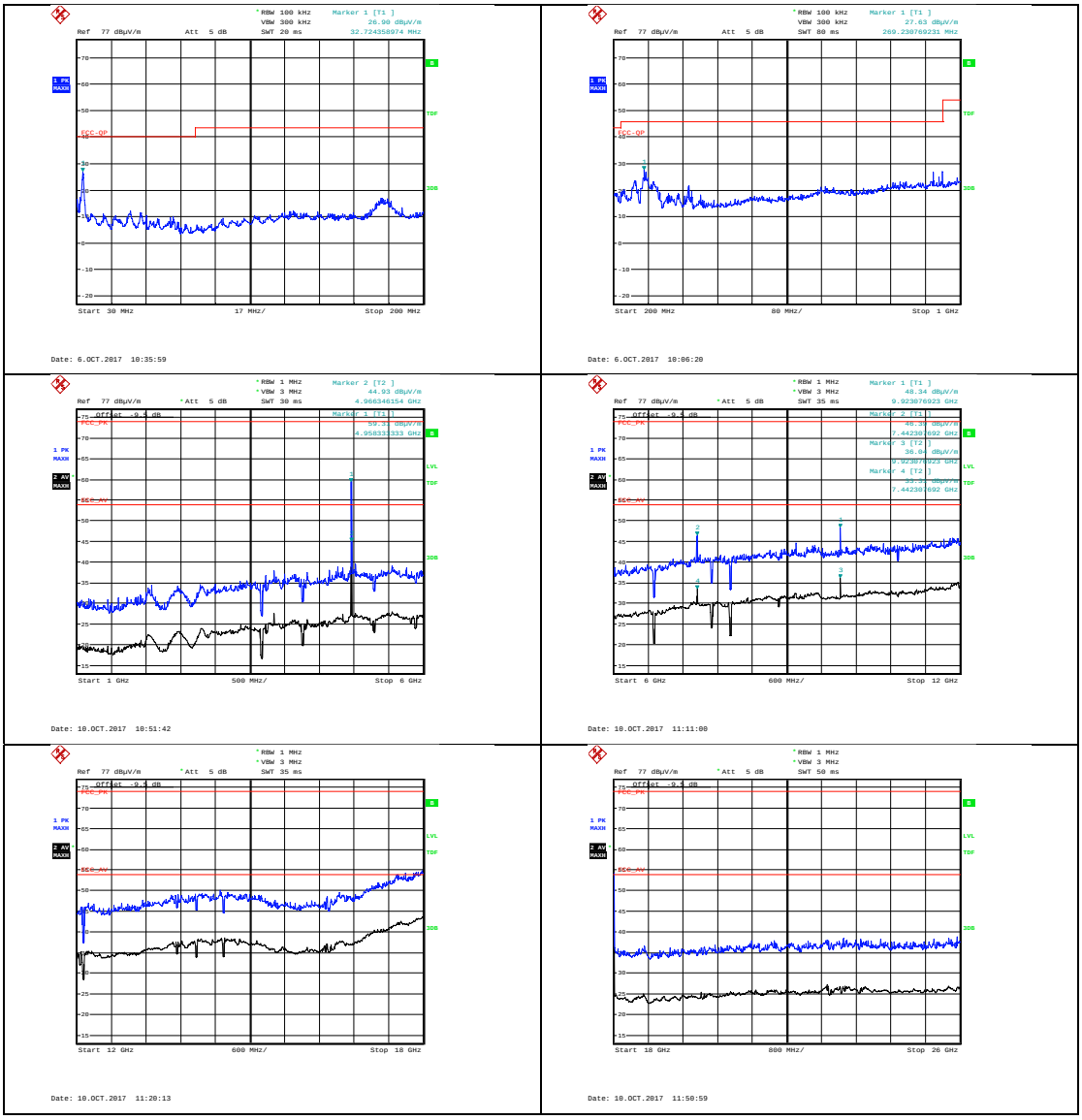


Date: 10.OCT.2017 10:01:56

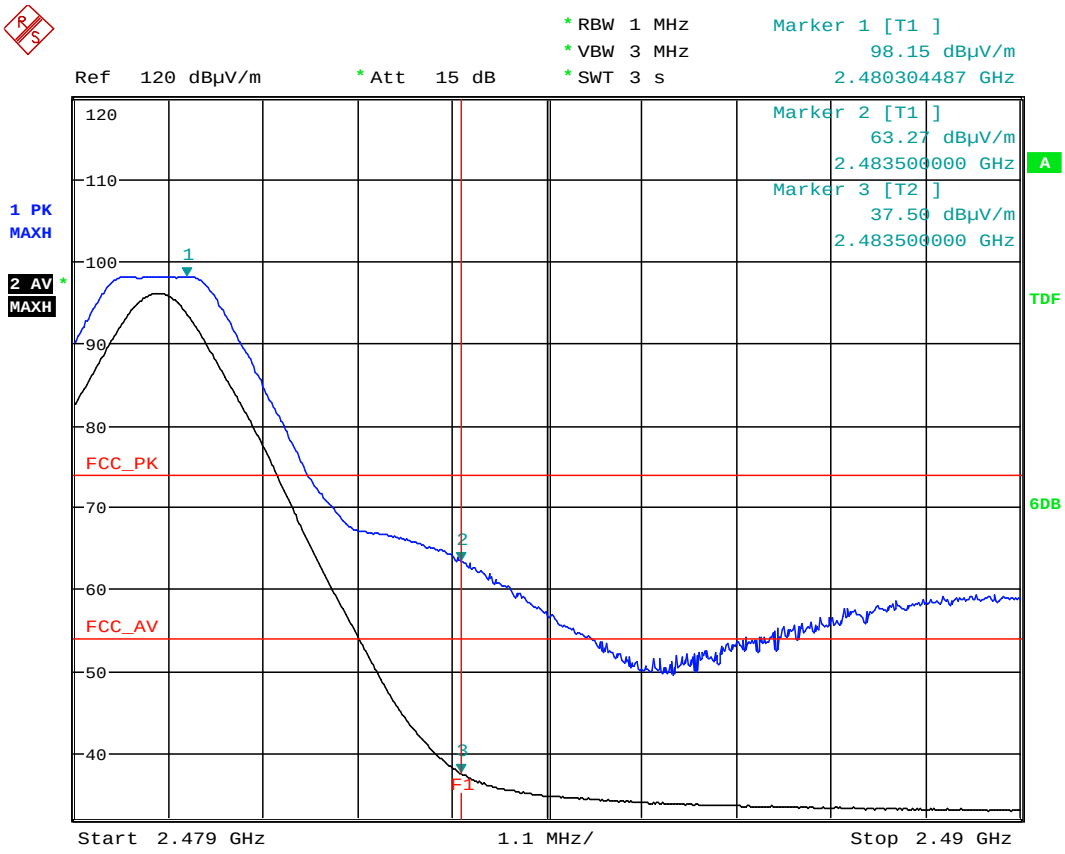
Power Setting: 0 dBm; Channel: 2440 MHz; Data Rate: 2 Mbps										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
Any	No Significant emissions with in 10dB of the limit.									



Power Setting: 0 dBm; Channel: 2480 MHz; Data Rate: 2 Mbps										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
Any	No Significant emissions with in 10dB of the limit.									



Upper Band Edge: Bluetooth LE 2 Mbps



Date: 10.OCT.2017 10:17:32

11 AC power-line conducted emissions

11.1 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.

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Hull Lab 5
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels / Frequencies Measured:	EUT communicating with Insulin Pump over BTLE link.
EUT Channel Bandwidths:	1.5 MHz
EUT Modulation:	BTLE
Deviations From Standard:	None
Measurement BW:	9 kHz
Measurement Detectors:	Quasi-Peak and Average

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 V ac	110 V ac ±10 % (as declared)

11.3 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 (dBµV)***	
	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.

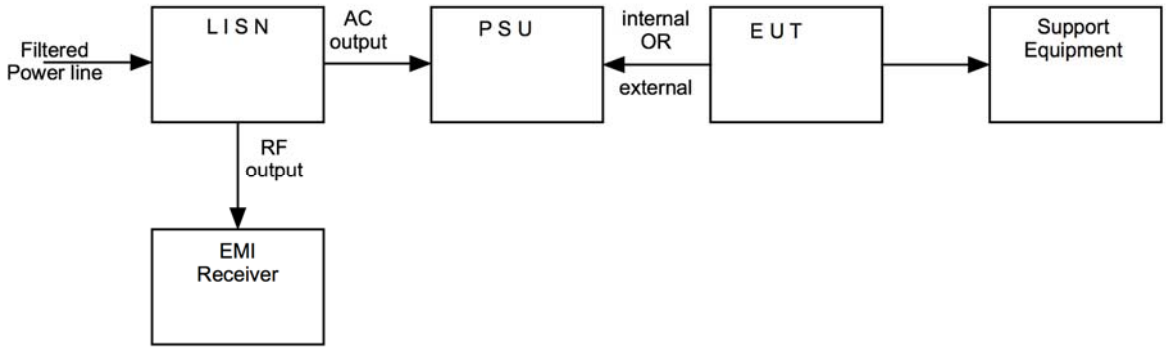
11.4 Test Method

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



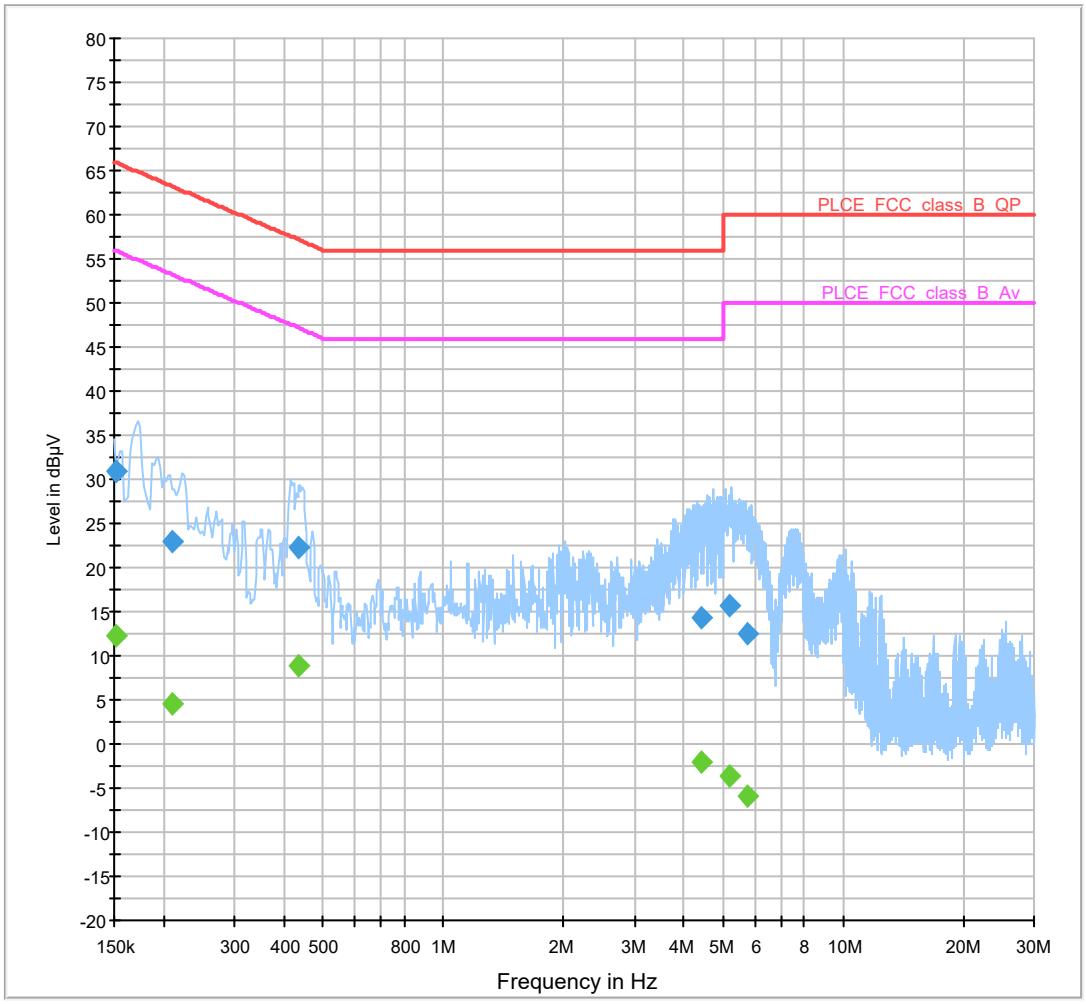
11.5 Test Set-up Photograph

11.6 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	Lab 5	H705	N / A
Analyser/Receiver	R&S	ESCI 7	H715	11/10/2017
Vertical Ground Reference Plane	Element	2.5m x 2m	H737	N / A

11.7 Test Results

Conducted Emissions Test Data – Kaleido Handset



The above plot is generated from a combined live and neutral Peak hold preview scan. The Blue markers above are a maximised Quasi-peak detector, the Green markers above are the maximised Average detector required for the formal assessment; the above emissions are listed in table format below.

The above plot shows a number of formal average measurement between 150 kHz and 300 kHz and between 4 MHz and 6 MHz that are significantly below the preview peak hold. These emissions were manually investigated for a minimum time period of 60 seconds. During this time period the emissions were found to occur at several intervals in a 15 second period and therefore considered a fluctuating spurious emissions in nature as per the guidelines in CISPR16-2-3 and therefore deemed a pass result.

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.151750	31.0	15000.0	9.000	GND	L1	0.3	34.9	65.9
0.210675	23.0	15000.0	9.000	GND	L1	0.3	40.2	63.2
0.431825	22.3	15000.0	9.000	GND	L1	0.3	34.9	57.2
4.424475	14.3	15000.0	9.000	GND	L1	0.6	41.7	56.0
5.164000	15.7	15000.0	9.000	GND	L1	0.6	44.3	60.0
5.781500	12.5	15000.0	9.000	GND	L1	0.7	47.5	60.0

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.151750	12.4	15000.0	9.000	GND	L1	0.3	43.5	55.9
0.210675	4.4	15000.0	9.000	GND	L1	0.3	48.7	53.2
0.431825	8.8	15000.0	9.000	GND	L1	0.3	38.4	47.2
4.424475	-2.0	15000.0	9.000	GND	L1	0.6	48.0	46.0
5.164000	-3.7	15000.0	9.000	GND	L1	0.6	53.7	50.0
5.781500	-5.9	15000.0	9.000	GND	L1	0.7	55.9	50.0

This test measures conducted noise that may be present on an EUT's power supply cable. This test ensures the protection of broadcast and telecommunication services used in the vicinity of the EUT.

The test setup used complies with all the dimension requirements set out in ANSI C63.4:2014. Reference is made to company procedure RTP1029 and RTP1002. Measurement instrumentation used meets the requirements of CISPR16-1-1:2010 or CISPR 16-1-2:2006 as appropriate, and uncertainties of CISPR 16-4-2:2011. Expanded laboratory uncertainties Ulab are less than or equal to CISPR 16-4-2:2011 cispr Table 1. Therefore no compensation is required to the actual measured level in determining compliance with the applied limit.

An initial scan is carried out in order to establish a frequency list that is attributable to the EUT, using automated R&S EMC32 measurement software. Receiver/analyser scan speed and bandwidth adjustments where applicable are in accordance with the reference standard, appropriate to the intercepted signal being resolved. Any emissions measurements that fall within 20 dBµV of the Average or Quasi-Peak limit line

12 Occupied Bandwidth

12.1 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.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	2402, 2440, 2480 MHz
EUT Channel Bandwidths:	Nominally 1 MHz for 1 Mbps / 2 MHz for 2 Mbps
EUT Test Modulations:	GFSK
Deviations From Standard:	None
Measurement BW: (FCC requirement: 100 kHz)	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	2.5 / 4.0 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 19-24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 39-47 %RH	20%RH to 75%RH (as declared)
Supply: 5 Vdc	Via USB port of a support laptop

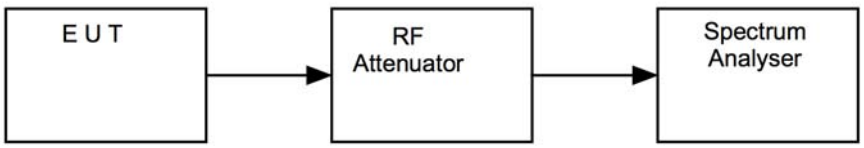
Test Limits

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

12.3 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

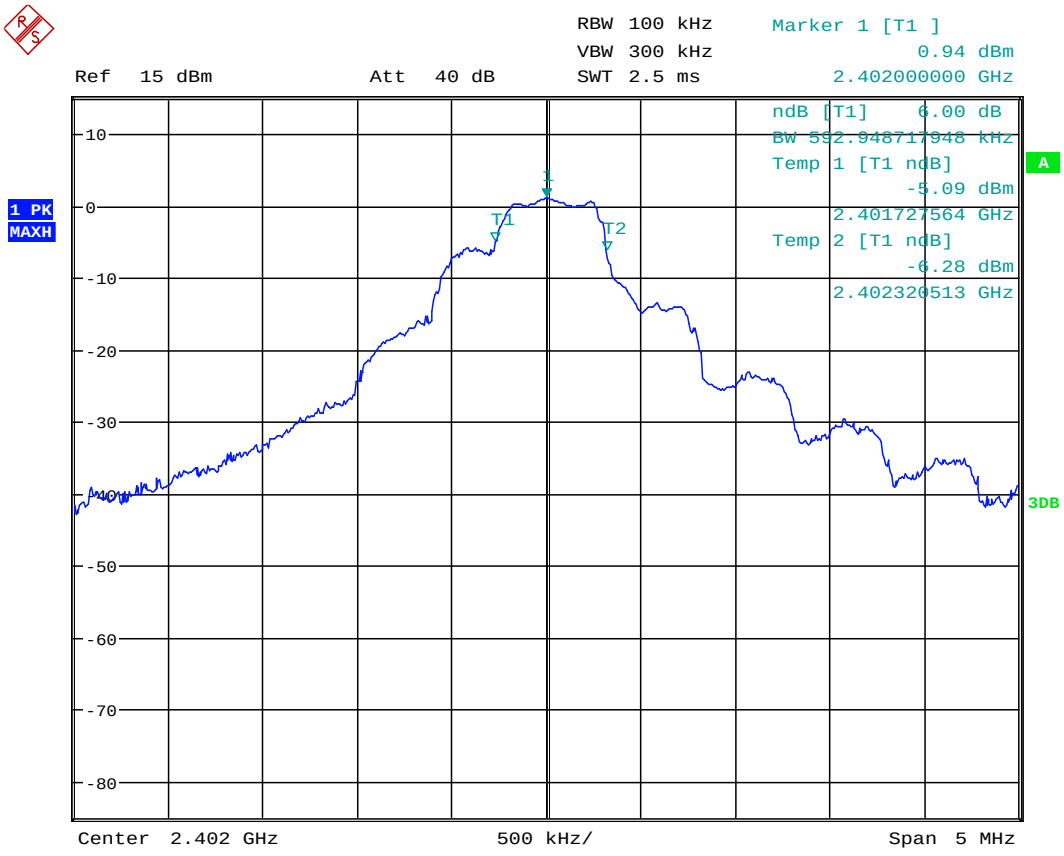


12.4 Test Equipment

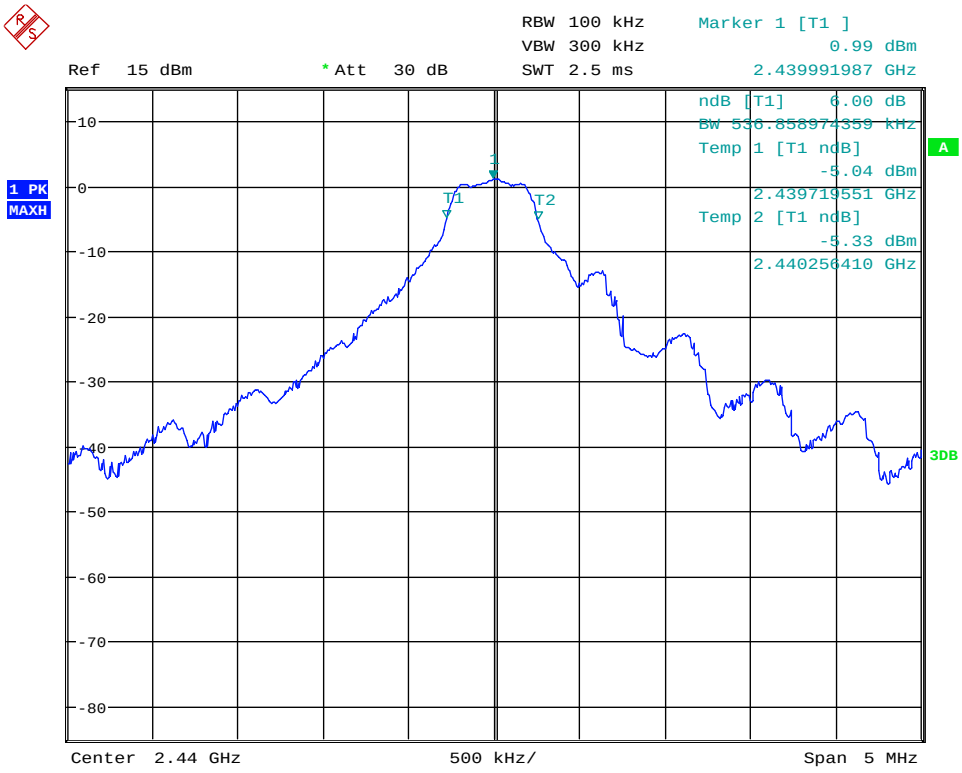
Equipment Description	Manufacturer	Equipment Type	Element No	Last Cal Calibration	Calibration Period	Due For Calibration
Spectrum Analyser	R&S	FSU50	U544	27/04/2017	12	27/04/2018

12.5 Test Results

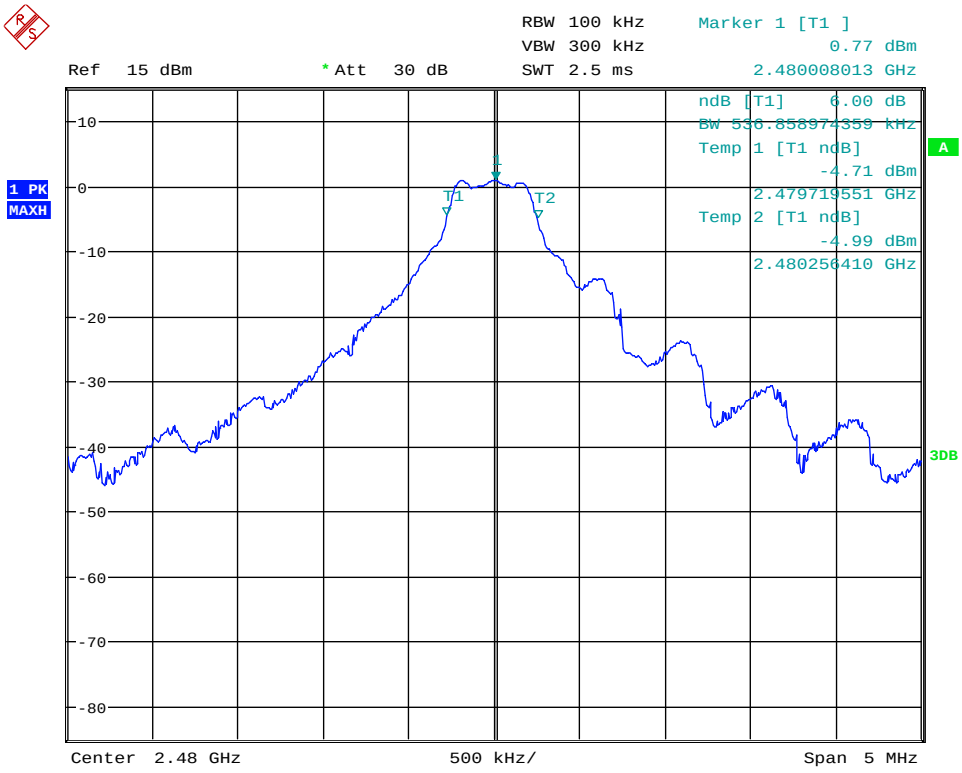
Modulation: GFSK ; Data rate: 1Mbit/s; Power setting: 0 dBm				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2402	2401.728	2402.321	592.949	PASS
2440	2439.720	2440.256	536.859	PASS
2480	2479.720	2480.256	536.859	PASS



Date: 2.NOV.2017 14:01:45

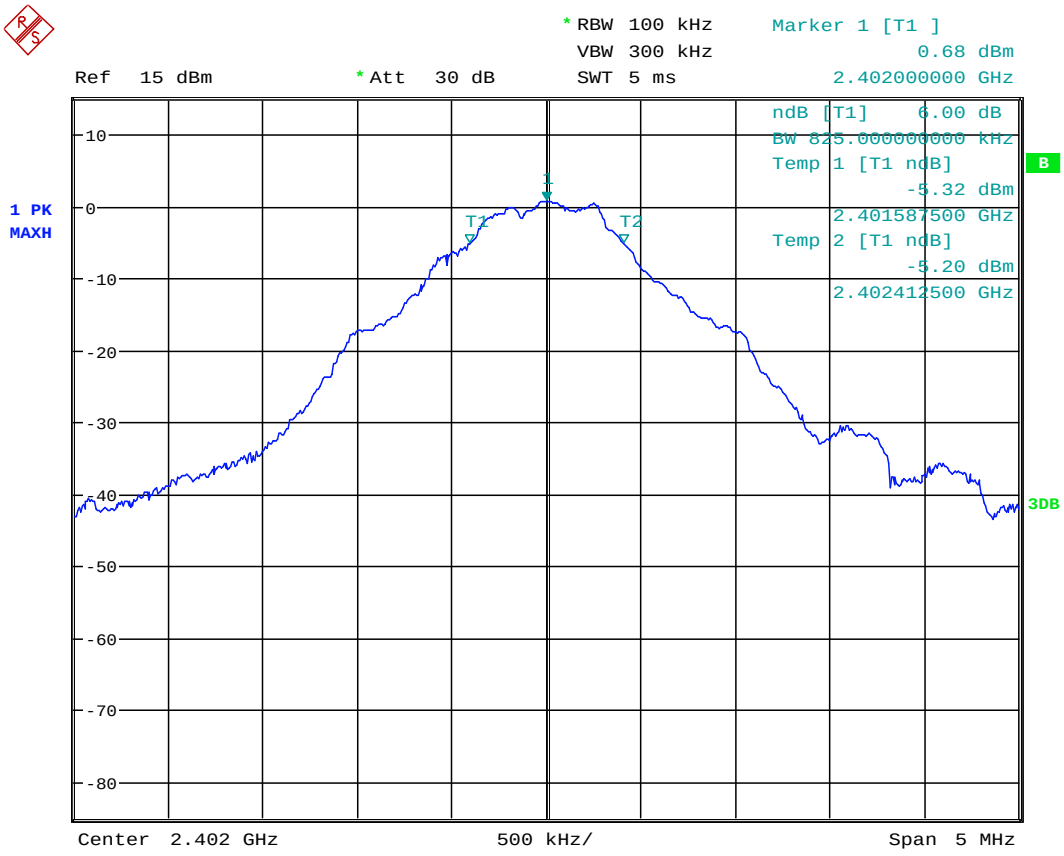


Date: 2.NOV.2017 14:05:23

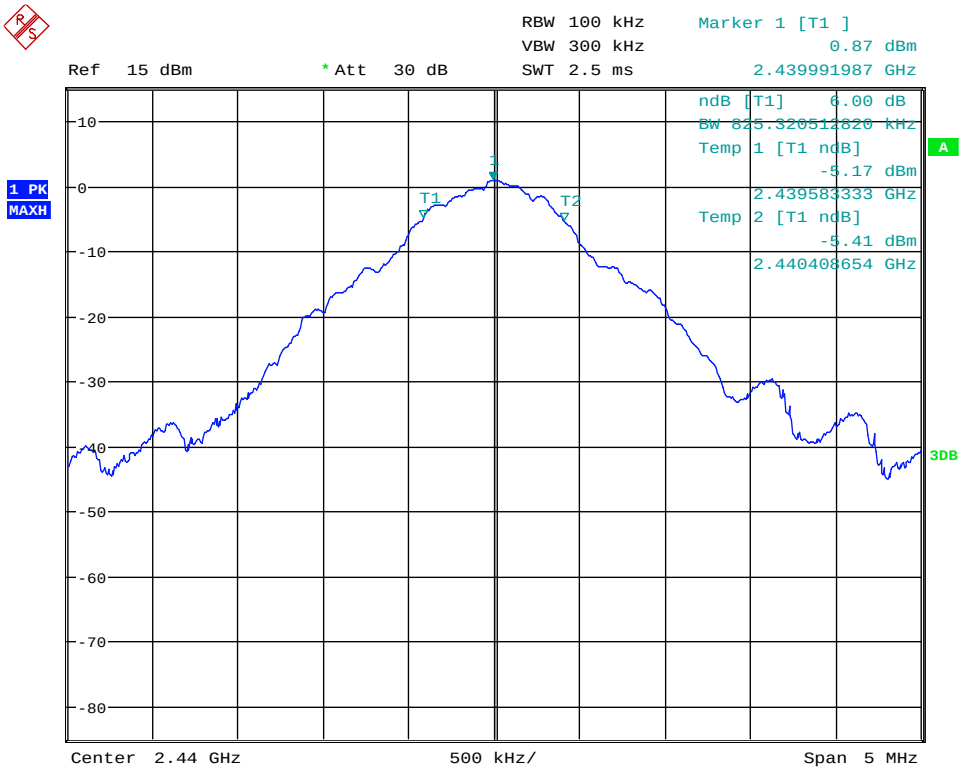


Date: 2.NOV.2017 14:18:25

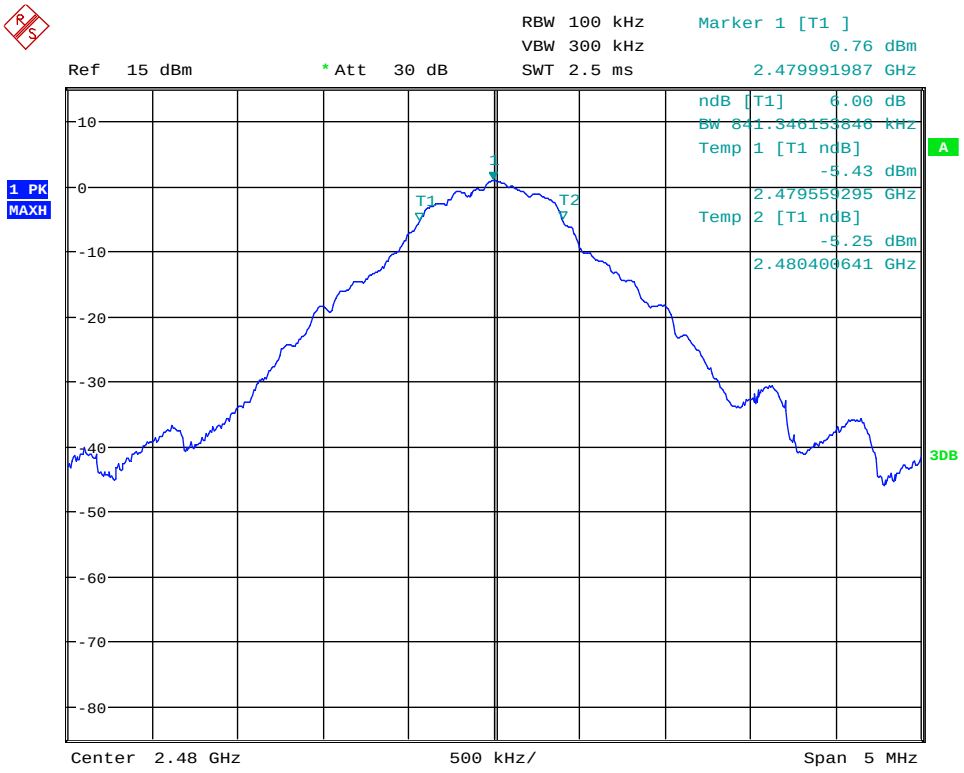
Modulation: GFSK ; Data rate: 2Mbit/s; Power setting: 0 dBm				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**6dB Bandwidth (kHz)**	**Result**
2402	2401.588	2402.413	825.000	PASS
2440	2439.583	2440.409	825.321	PASS
2480	2479.559	2480.401	841.346	PASS



Date: 2.NOV.2017 12:55:24



Date: 2.NOV.2017 14:13:57



Date: 2.NOV.2017 14:16:15

13 Maximum peak conducted output power

13.1 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.

13.2 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:	1 MHz for 1 Mbps / 2 MHz for 2 Mbps
Deviations From Standard:	None
Measurement BW:	3 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement);

Environmental Conditions (Normal Environment)

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

13.3 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.

13.4 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

13.5 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	Teleydyne	K-Type RF coaxial cable	REF2184	27/03/2018
Cable	Teleydyne	K-Type RF coaxial cable	REF2185	27/03/2018
3115	EMCO	Horn Antenna	RFG129	09/02/2018

13.6 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: 1 Mbps; Power setting: 0 dBm					
Channel Frequency (MHz)	***Peak Field Strength (dBµV/m)***	***Distance (m)***	***Power (W)***	***Limit (W)***	***Result***
2402	98.61	3	0.00218	1	PASS
2440	101.26	3	0.00401	1	PASS
2480	98.49	3	0.00212	1	PASS

Modulation: Bluetooth LE; Data rate: 2 Mbps; Power setting: 0 dBm					
Channel Frequency (MHz)	***Peak Field Strength (dBµV/m)***	***Distance (m)***	***Power (W)***	***Limit (W)***	***Result***
2402	98.63	3	0.00219	1	PASS
2440	99.27	3	0.00254	1	PASS
2480	98.51	3	0.00213	1	PASS

14 Out-of-band and conducted spurious emissions

14.1 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.

14.2 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:	1 MHz for 1 Mbps / 2 MHz for 2 Mbps
Deviations From Standard:	None
Measurement BW:	1 / 10 / 100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 / 30 / 300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 25 GHz

Environmental Conditions (Normal Environment)

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

14.3 Test Limit

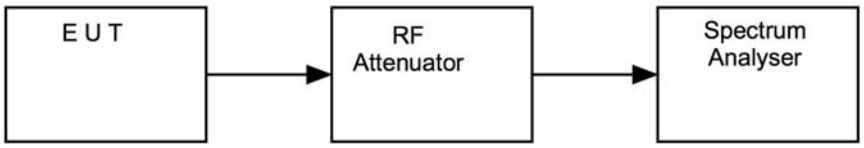
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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.

14.4 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

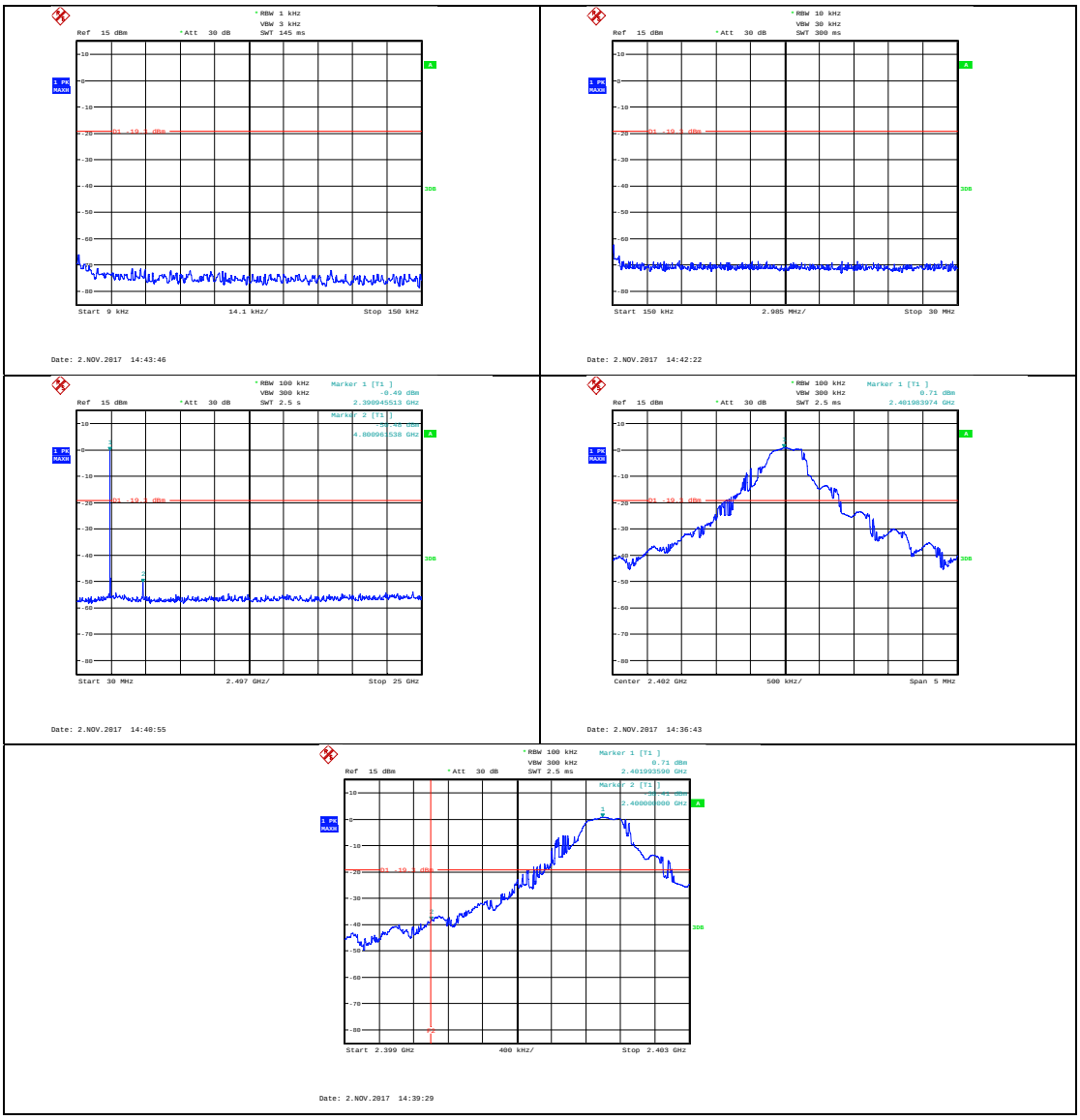


14.5 Test Equipment

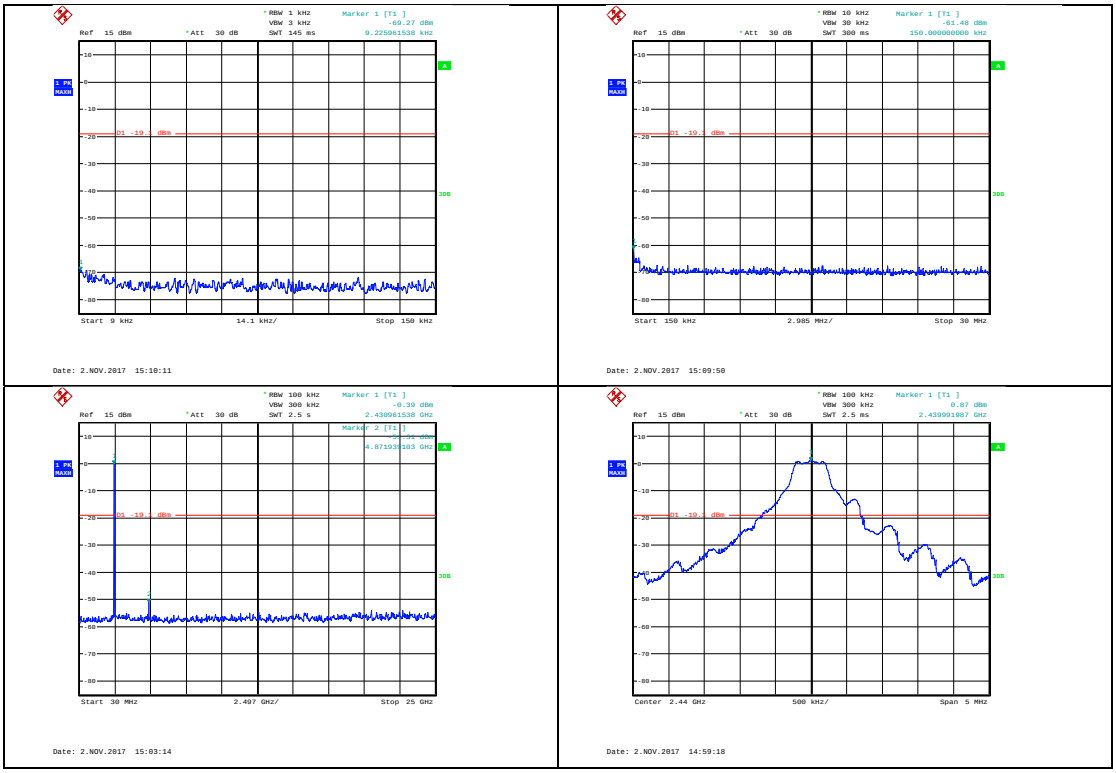
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU50	U544	27/04/2017	12	27/04/2018

14.6 Test Results

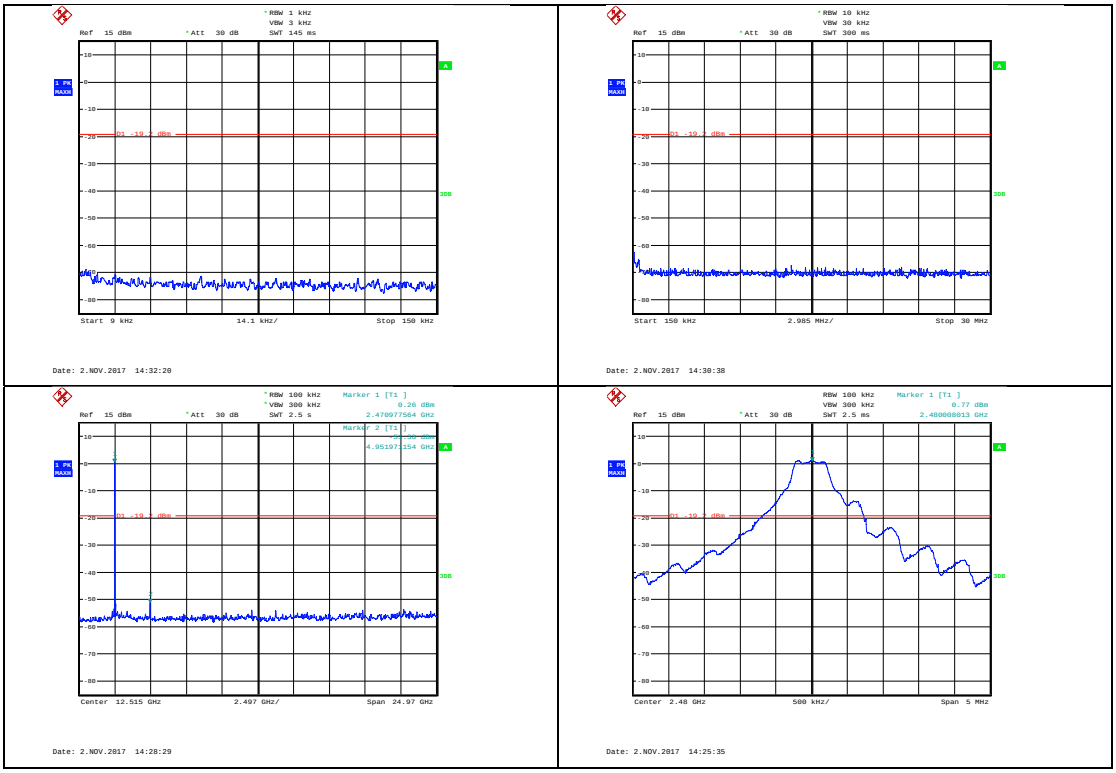
Modulation: GFSK; Data rate: 1 Mbps; Power setting: 0 dBm						
Channel Frequency	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
Low	2402	0.71	0.71	N/A	N/A	N/A
No Significant emissions with in 10dB of the limit.						PASS



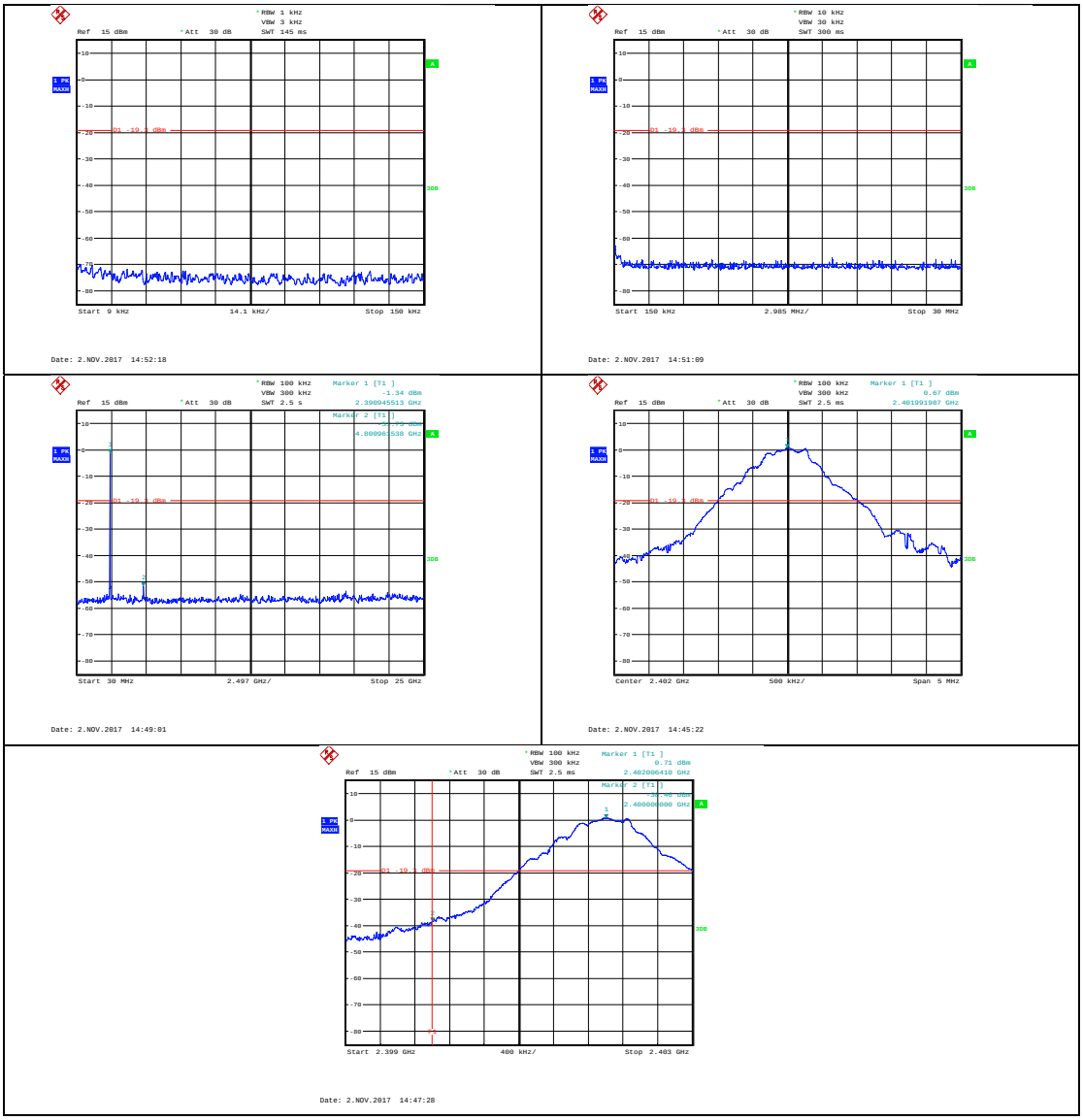
Modulation: GFSK; Data rate: 1 Mbps; Power setting: 0 dBm						
Channel Frequency	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
Mid	2440	0.87	0.87	N/A	N/A	N/A
No Significant emissions with in 10dB of the limit.						PASS



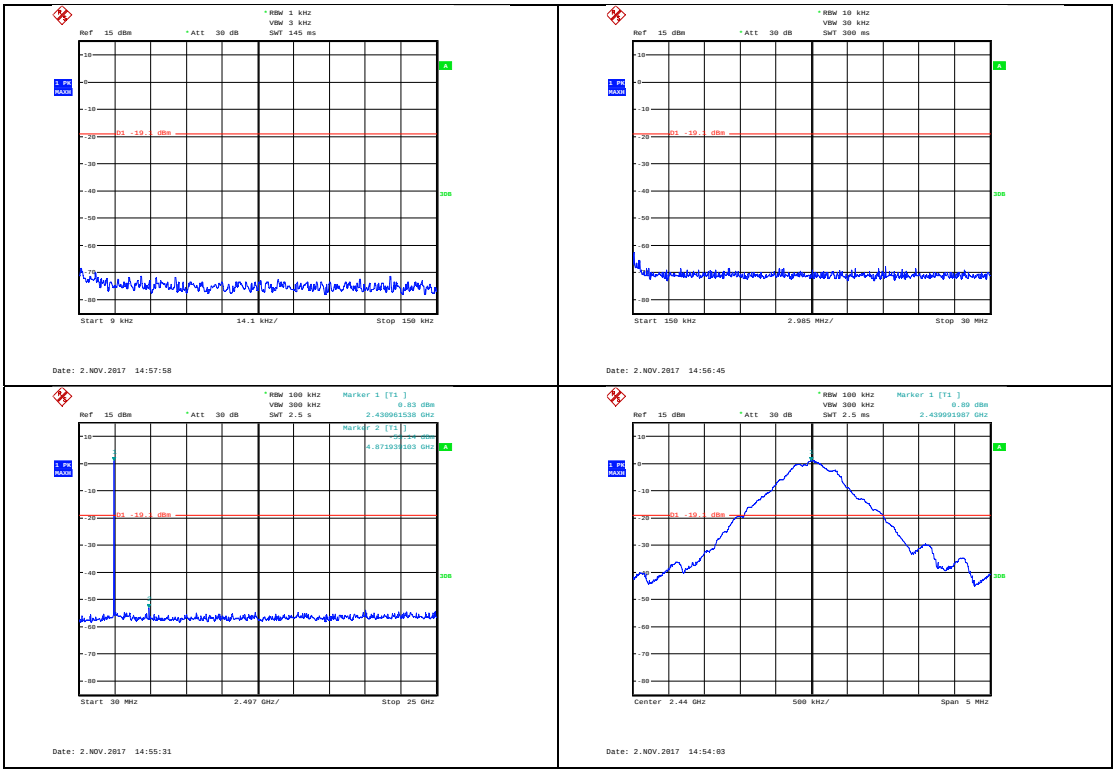
Modulation: GFSK; Data rate: 1 Mbps; Power setting: 0 dBm						
Channel Frequency	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
High	2480	0.77	0.77	N/A	N/A	N/A
No Significant emissions with in 10dB of the limit.						PASS



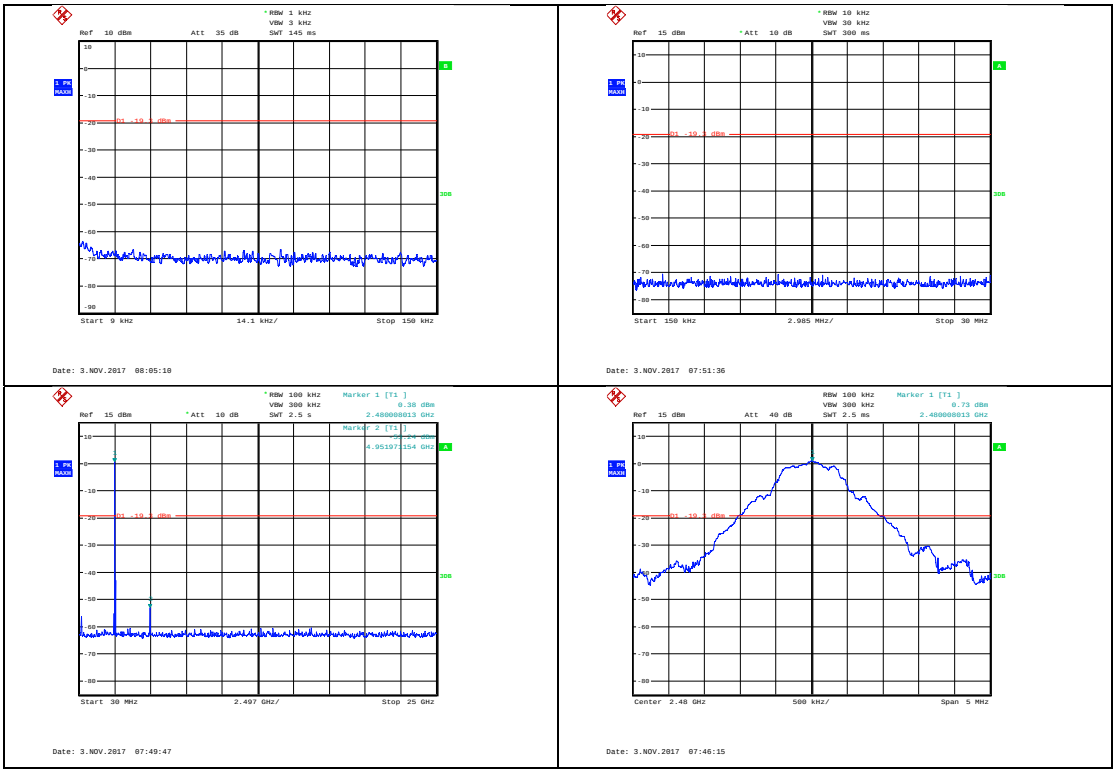
Modulation: GFSK; Data rate: 2 Mbps; Power setting: 0 dBm						
Channel Frequency	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
Low	2402	0.67	0.67	N/A	N/A	N/A
No Significant emissions with in 10dB of the limit.						PASS



Modulation: GFSK; Data rate: 2 Mbps; Power setting: 0 dBm						
Channel Frequency	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
Mid	2440	0.89	0.89	N/A	N/A	N/A
No Significant emissions with in 10dB of the limit.						PASS



Modulation: GFSK; Data rate: 2 Mbps; Power setting: 0 dBm						
Channel Frequency	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
High	2480	0.73	0.73	N/A	N/A	N/A
No Significant emissions with in 10dB of the limit.						PASS



15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	Low / Mid / High
EUT Channel Bandwidths:	1 MHz for 1 Mbps / 2 MHz for 2 Mbps
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: 19-24 °C	+15 ºC to +35 ºC (as declared)
Humidity: 39-47 %RH	20%RH to 75%RH (as declared)
Supply: 5 Vdc	Via USB port of a support laptop

15.3 Test Limit

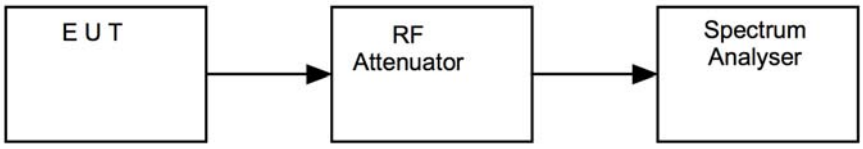
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 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

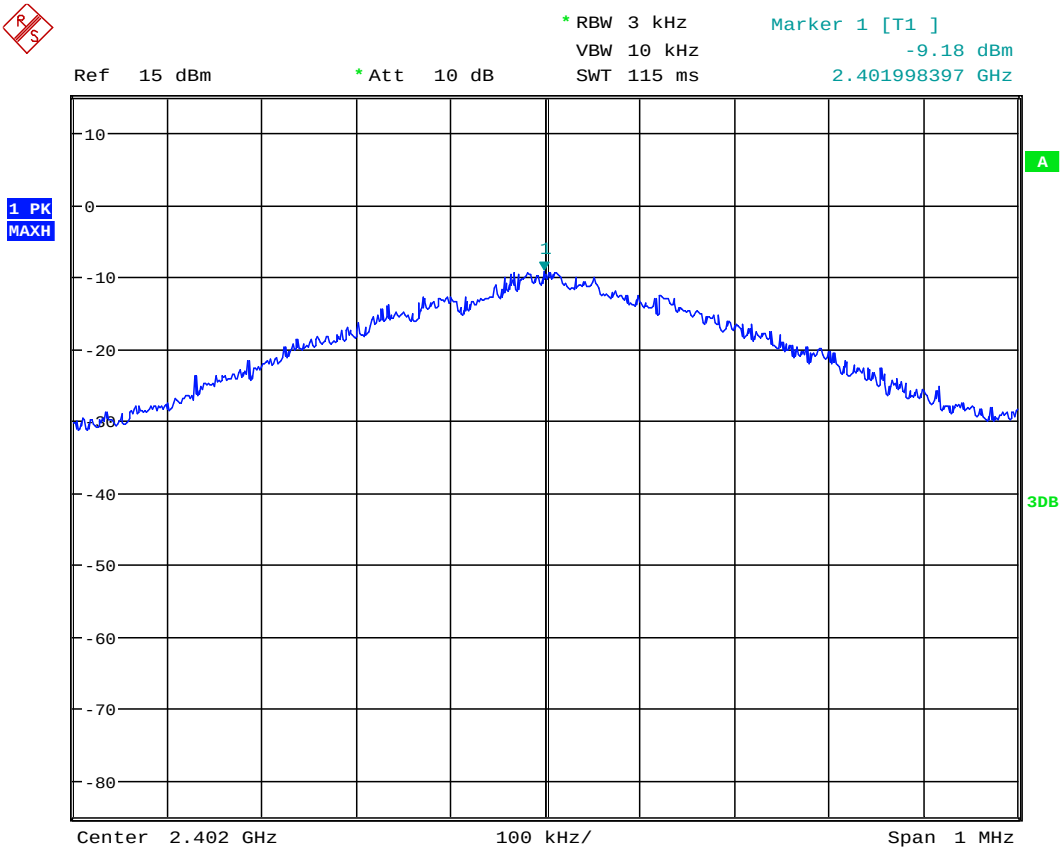


15.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU50	U544	27/04/2017	12	27/04/2018

15.6 Test Results

Modulation: GFSK; Data rate: 1 Mbps; Power setting: 0 dBm				
Channel Frequency (MHz)	**Analyzer Level (dBm)**	**Cable loss (dB)**	**Power (dBm)**	**Result**
2402	-9.18	0.3	-8.88	PASS
2440	-9.45	0.3	-9.15	PASS
2480	-9.55	0.3	-9.25	PASS



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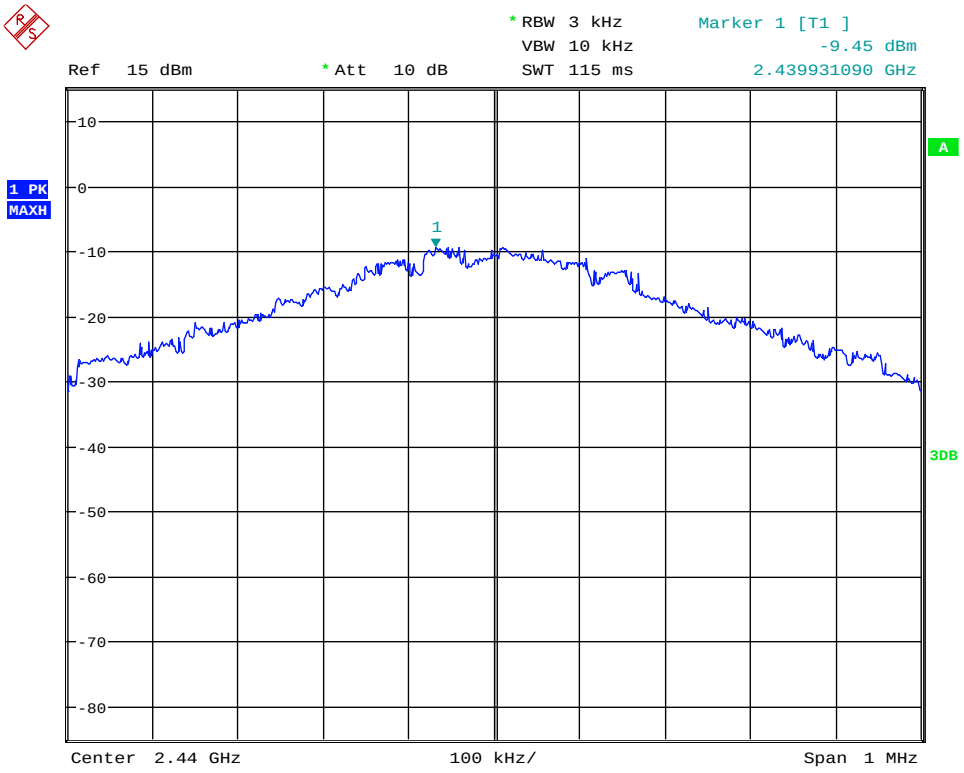
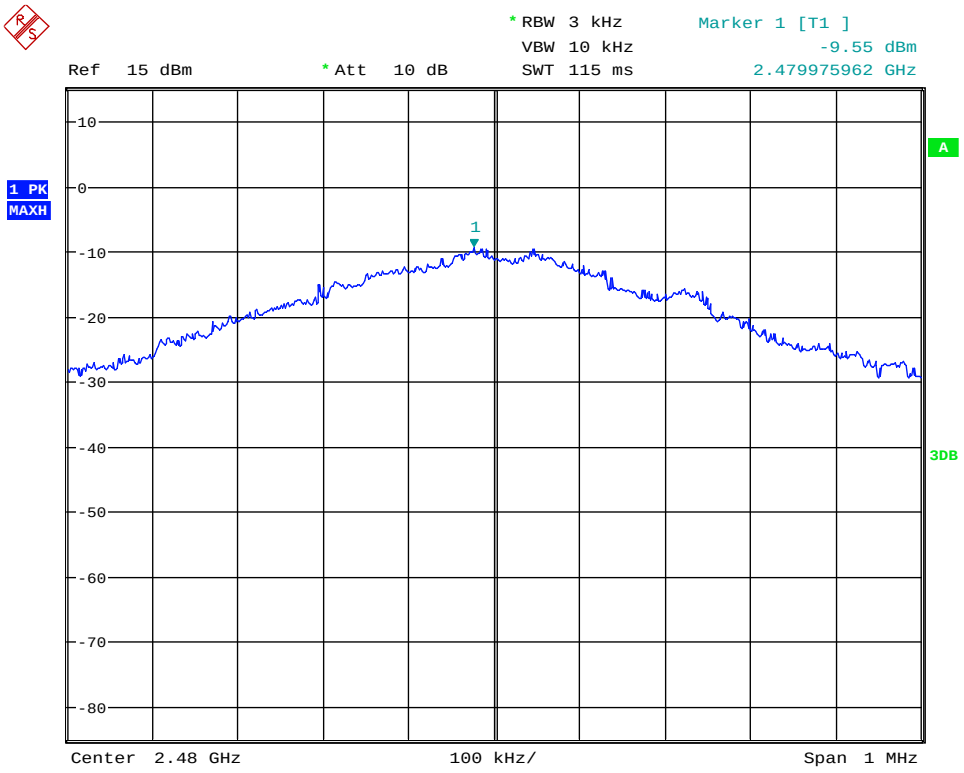
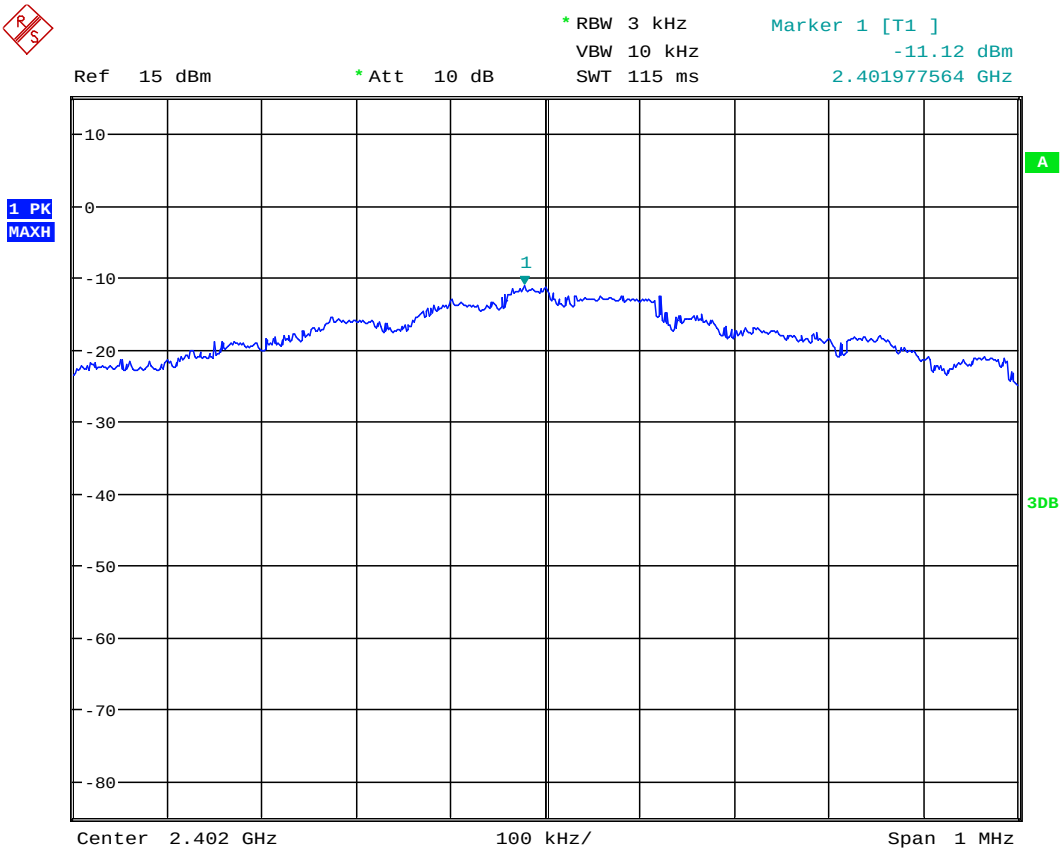


Date: 3.NOV.2017 08:13:24

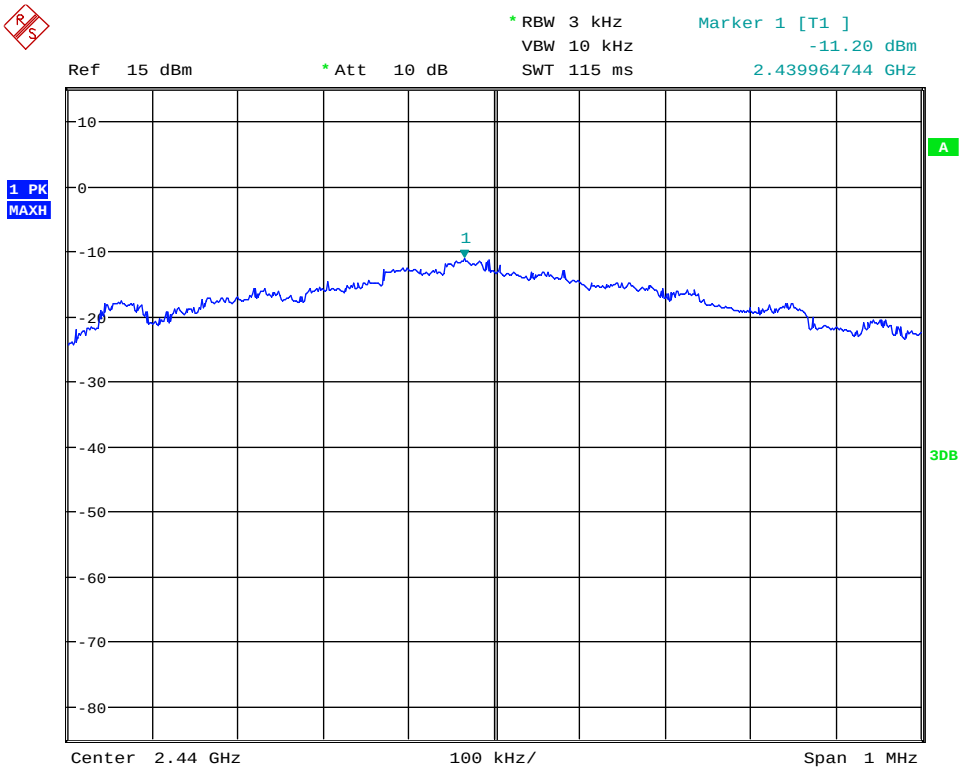


Date: 3.NOV.2017 08:11:01

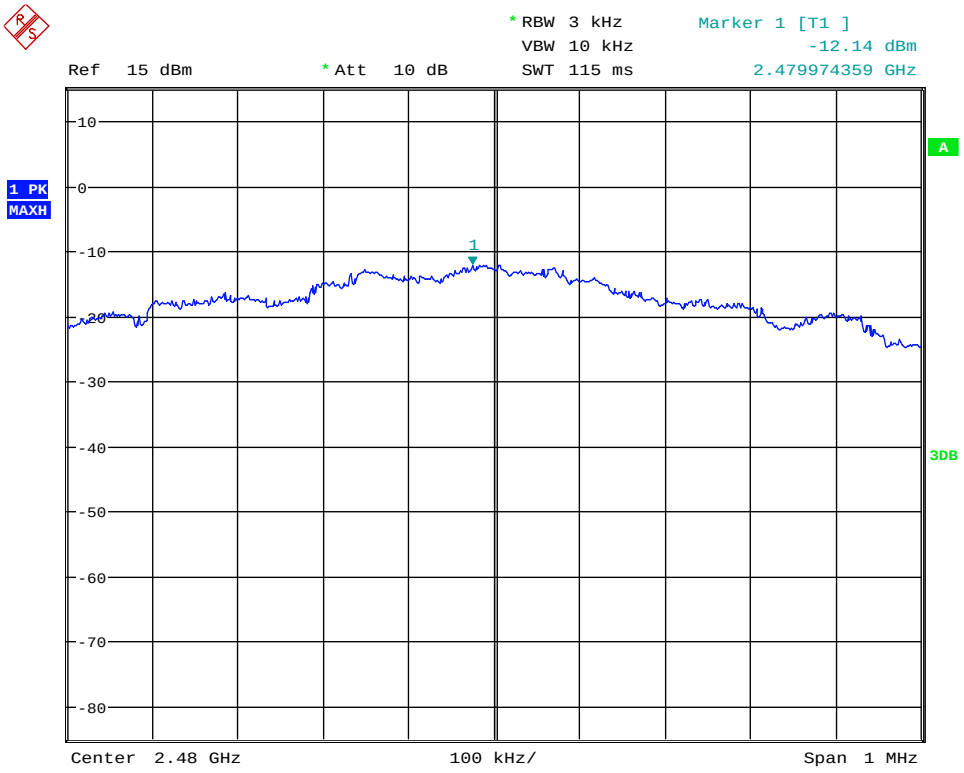
Modulation: GFSK; Data rate: 2 Mbps; Power setting: 0 dBm				
Channel Frequency (MHz)	**Analyzer Level (dBm)**	**Cable loss (dB)**	**Power (dBm)**	**Result**
2402	-11.12	0.3	-10.82	PASS
2440	-11.20	0.3	-10.90	PASS
2480	-12.14	0.3	-11.84	PASS



Date: 3.NOV.2017 08:17:20



Date: 3.NOV.2017 08:14:52



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16 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**
Uncertainty in test result (18 GHz to 26 GHz) = **3.2 dB**
Uncertainty in test result (26 GHz to 40 GHz) = **3.3 dB**
Uncertainty in test result (40 GHz to 50 GHz) = **3.5 dB**
Uncertainty in test result (50 GHz to 75 GHz) = **3.6 dB**

[6] Power spectral density

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

17 RF Exposure

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) * √ 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 x TSDA) / √ 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 TSDA is 5mm.

Operating Frequency 2.405 GHz

SARET = [(3.0 x 5) / √2.402]
SARET = 9.68 mW

Operating Frequency 2.440 GHz

SARET = [(3.0 x 5) / √2.440]
SARET = 9.60 mW

Operating Frequency 2.480 GHz

SARET = [(3.0 x 5) / √2.480]
SARET = 9.53 mW

Channel Frequency (MHz)	Max. Output Power (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
2402	2.19	9.68	Not Required
2440	4.01	9.60	Not Required
2480	2.13	9.53	Not Required

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