

Report on the Radio Testing

For

Vicon Motion Systems Ltd

on

BlueTrident V2

Report no. TRA-042784-10-47-01B

4 February 2019

RF915 6.0



Report Number: TRA-042784-10-47-01B
Issue: A

REPORT ON THE RADIO TESTING OF A
Vicon Motion Systems Ltd
BlueTrident V2
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 4th-6th December 2018

Written by:

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Date: 4 February 2019

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

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	20 December 2019	Original
A	4 February 2019	Updates to TCB request

2 Summary

TEST REPORT NUMBER:	TRA-042784-10-47-01B
WORKS ORDER NUMBER:	TRA-042784-00
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. .
TEST SPECIFICATION(S):	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	BlueTrident V2
FCC IDENTIFIER:	DMR-IMUAP2
EUT SERIAL NUMBER:	1007
MANUFACTURER/AGENT:	Vicon Motion Systems Ltd
ADDRESS:	Unit 6 Oxford Industrial Park Mead Road Yarnton OXFORD OX5 1QU United Kingdom
CLIENT CONTACT:	Tom Shannon ☎ TPS01865 781398 ✉ thomas.shannon@omg3d.com
ORDER NUMBER:	Por012352
TEST DATE:	4th-6th December 2018
TESTED BY:	S Hodgkinson, David Garvey Element

2.1 Test Summary

Test Method and Description		Requirement Clause	Applicable to this equipment	Result / Note
		47CFR15		
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	☒	Pass
AC power line conducted emissions		15.207	☒	Pass
Occupied bandwidth		15.247(a)(2)	☒	Pass
Conducted carrier power	Peak	15.247(b)(3)	☒	Pass
	Max.		☐	
Conducted / radiated RF power out-of-band		15.247(d)	☒	Pass
Power spectral density, conducted		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).

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4 Introduction

This report TRA-042784-10-47-01B presents the results of the Radio testing on a Vicon Motion Systems Ltd, BlueTrident V2 to specification 47CFR15 Radio Frequency Devices

The testing was carried out for Vicon Motion Systems Ltd 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 Skelmersdale West Lancashire WN8 9PN UK
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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.

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: BlueTrident V2
- Serial Number: 1007
- Model Number: V2
- Software Revision: V1.0
- Build Level / Revision Number: Pre-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.

Dell Precision Test Laptop, Samsung SM-T710

7.3 EUT Mode of Operation

The EUT In the first instance was connected via Bluetooth to the Samsung Tablet. Using the BLE check App, the EUT was placed into DTM mode, which then allowed connection to the test laptop via USB.

7.3.1 Transmission

The mode of operation for Transmitter tests was as follows...

The channels and modulation where selected via the Client software, and operating at the client advised output power of +8 dBm.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2400 MHz- 2483.5 MHz
Modulation type(s):	GFSK
Declared output power(s):	+8 dBm
Nominal Supply Voltage:	+5 Vdc Via USB port whilst under test
Nominal Supply Voltage:	Normal Mode: Battery operated 3.0-4.2 Vdc
Duty cycle:	15.6

7.4.2 Antennas

Type:	Antenova Antenna A10192 627-1016-ND
Frequency range:	2.4 GHz-2.5 GHz
Impedance:	50 Ω
Gain:	0.8 dBi
Polarisation:	Linear
Mounting:	PCB

7.5 EUT Description

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

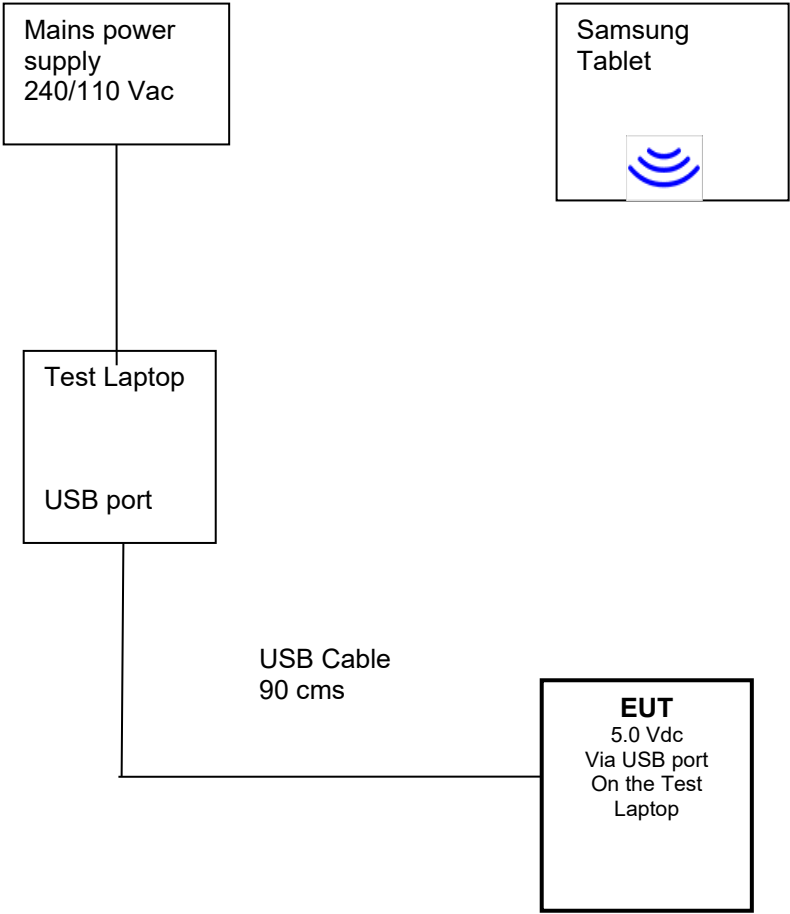
8 Modifications

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:



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. 5.0 Vdc from the USB Port on the test Laptop.

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:

	Category	Nominal	Variation
☒	Mains	110 V ac +/-2 %	85 % and 115 %
☒	Battery	New battery	N/A

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 Element Hull
Test Chamber:	Wireless Lab 3
Test Standard and Clause:	RSS-Gen 8.8 ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402 MHz / 2442 MHz / 2480 MHz
EUT Channel Bandwidths:	1 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: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc	

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 ($\mu\text{V/m}$ 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 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;

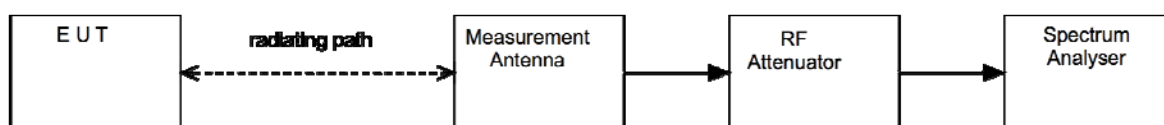
PA is the pre-amplifier gain in dB (where used);

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

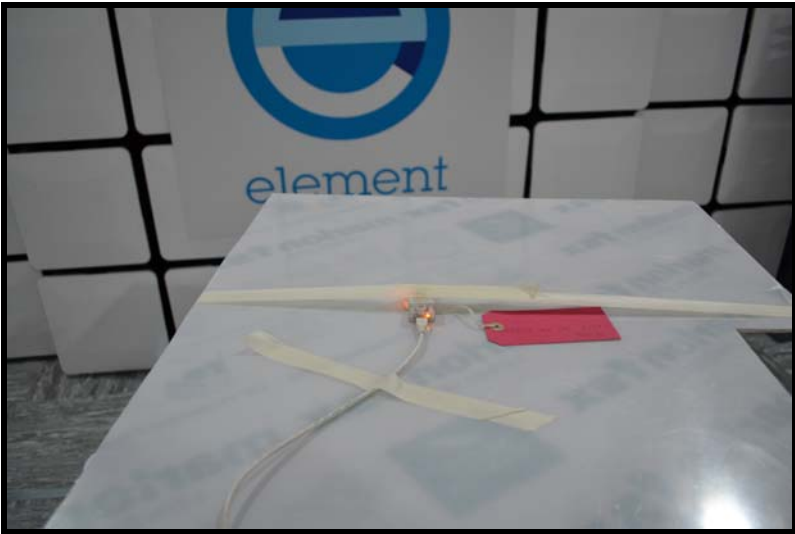
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph



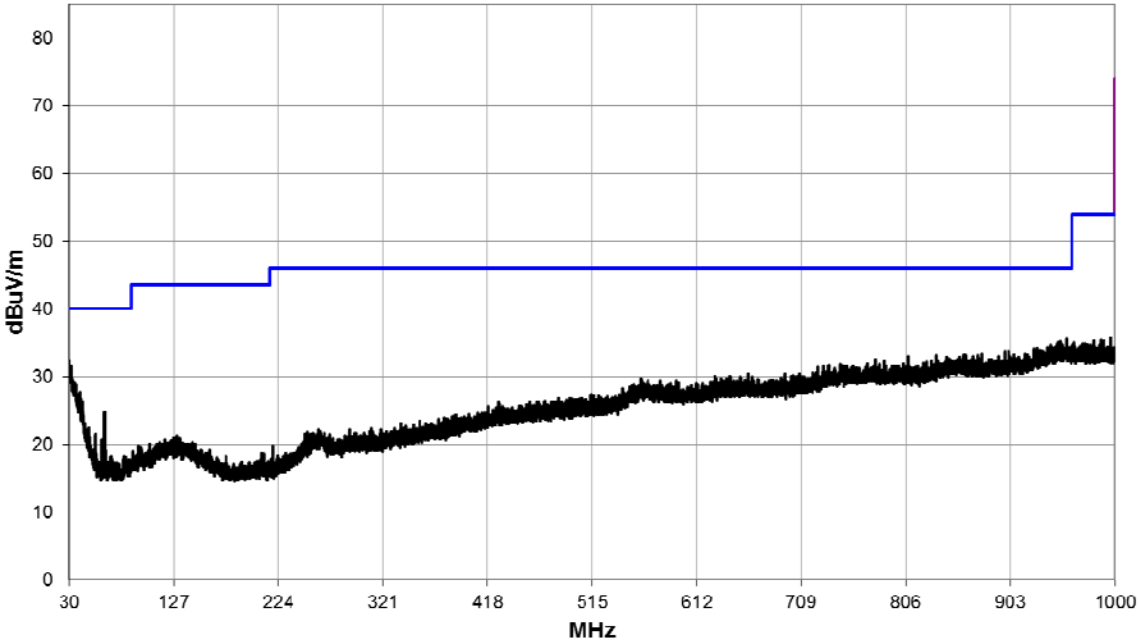
11.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Ferrite Lined Chamber	Rainford	Chamber	REF2259	2020-08-03
ESW26	R&S	EMI Test Receiver	REF2235	2019-07-23
CBL6111B	Chase	Bilog Antenna	REF2218	2019-11-06
LB-10180-NF	A Info Inc	Horn Antenna	REF2241	2020-07-13
LB-90-25-C2-SF	A Info Inc	Horn Antenna	REF2243	2020-07-16
LB-62-25-C-SF	A Info Inc	Horn Antenna	REF2244	2020-07-16
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2020-07-25

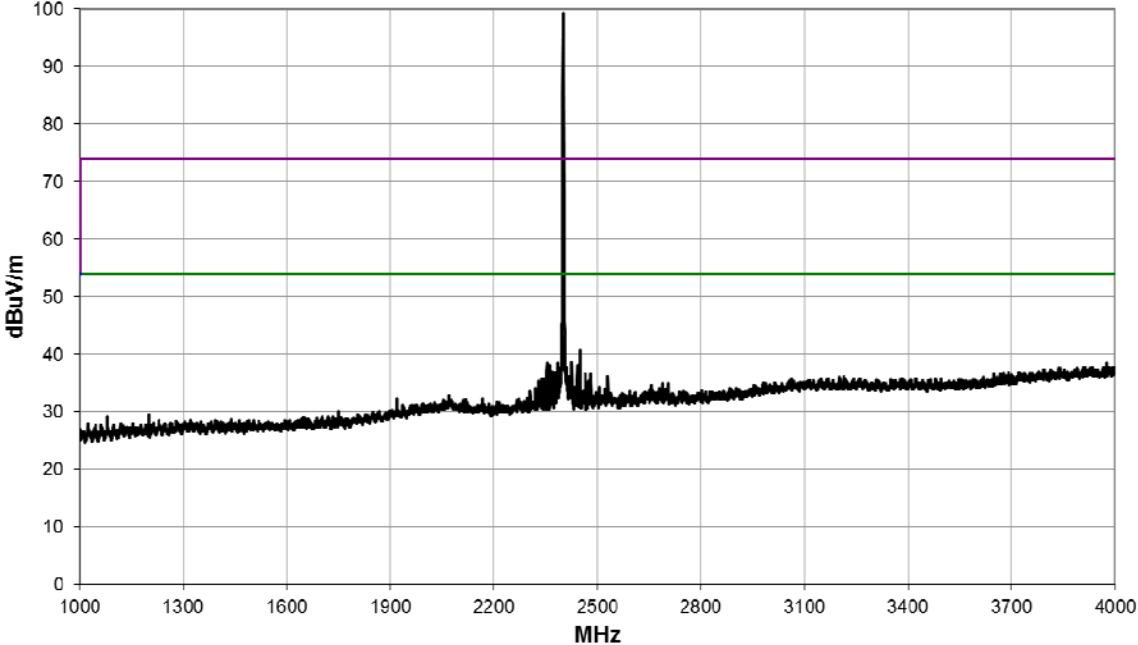
11.7 Test Results

Power: +8 dBm; Channel: low 2402 MHz										
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)
PK	No Significant emissions within 20dB of the limit									
Av	No Significant emissions within 20dB of the limit									

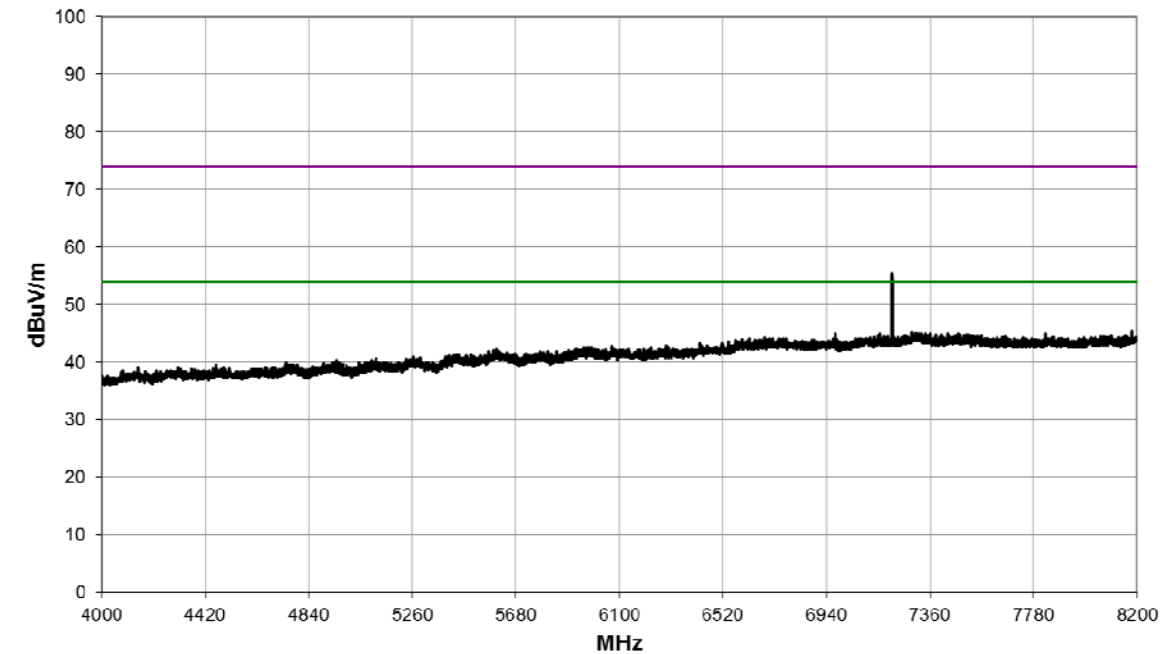
30 MHz to 1 GHz



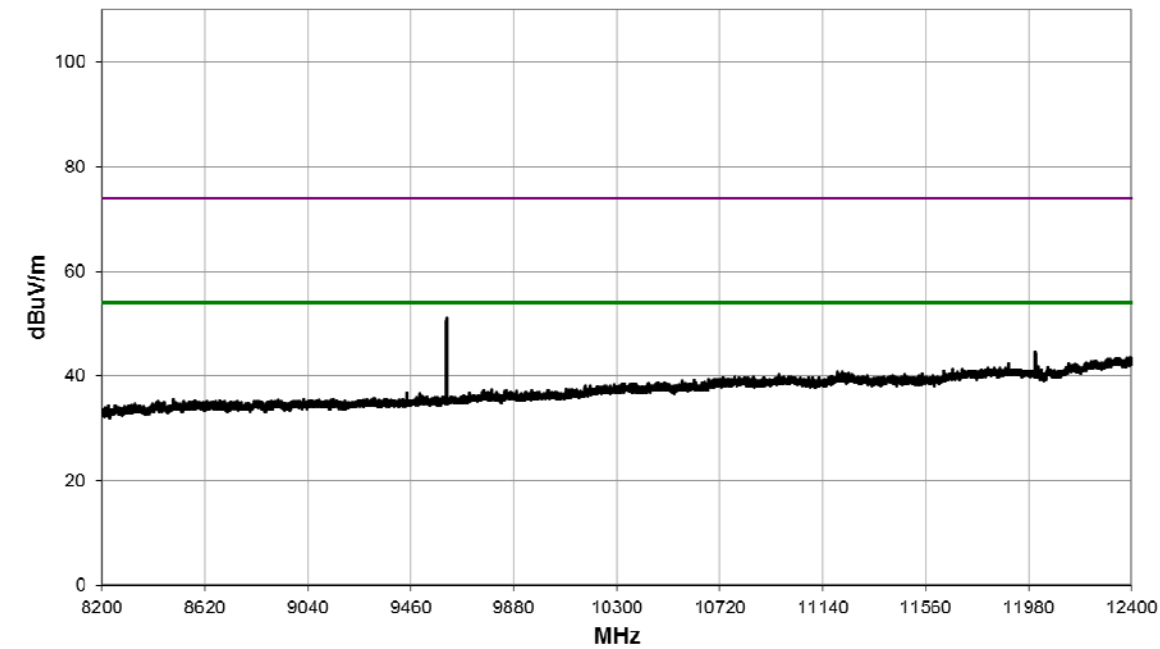
1 GHz to 4 GHz



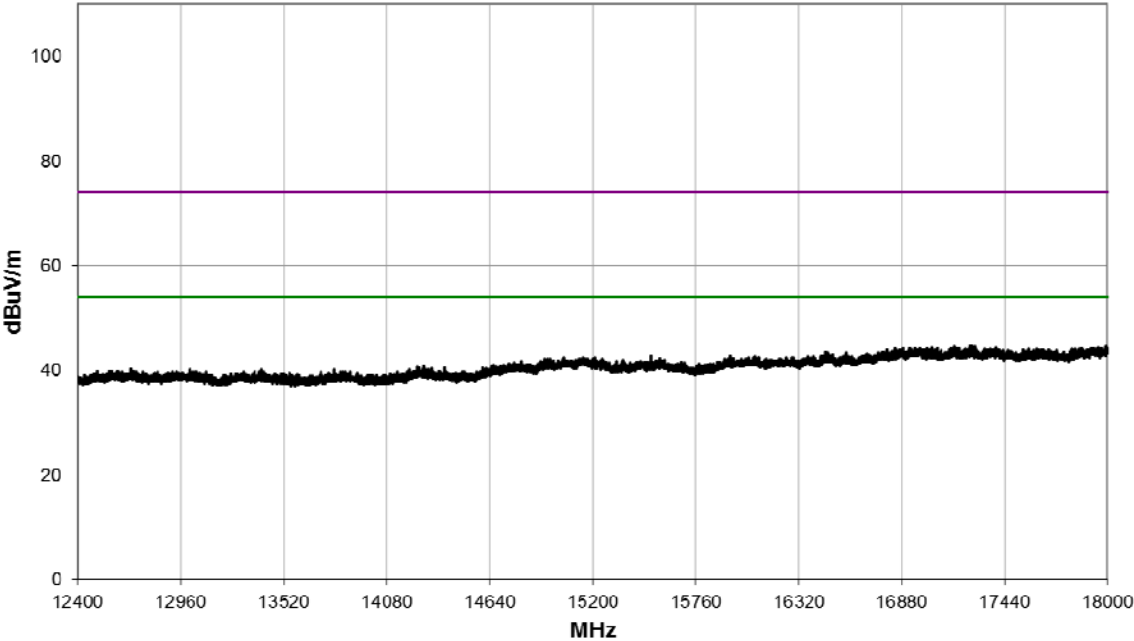
4 GHz to 8.2 GHz



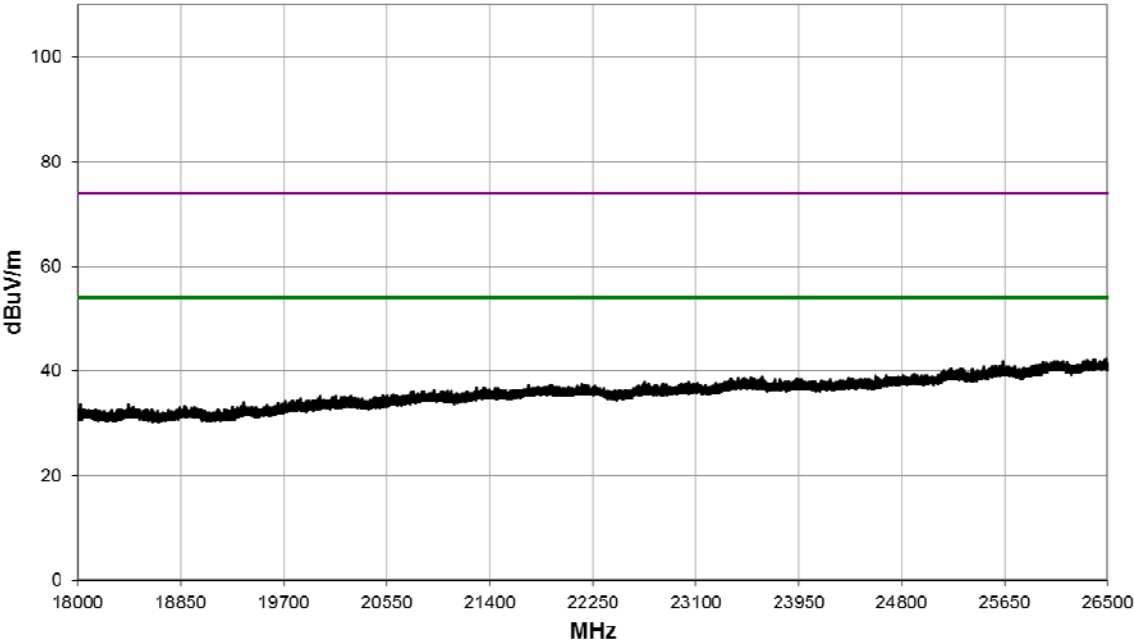
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

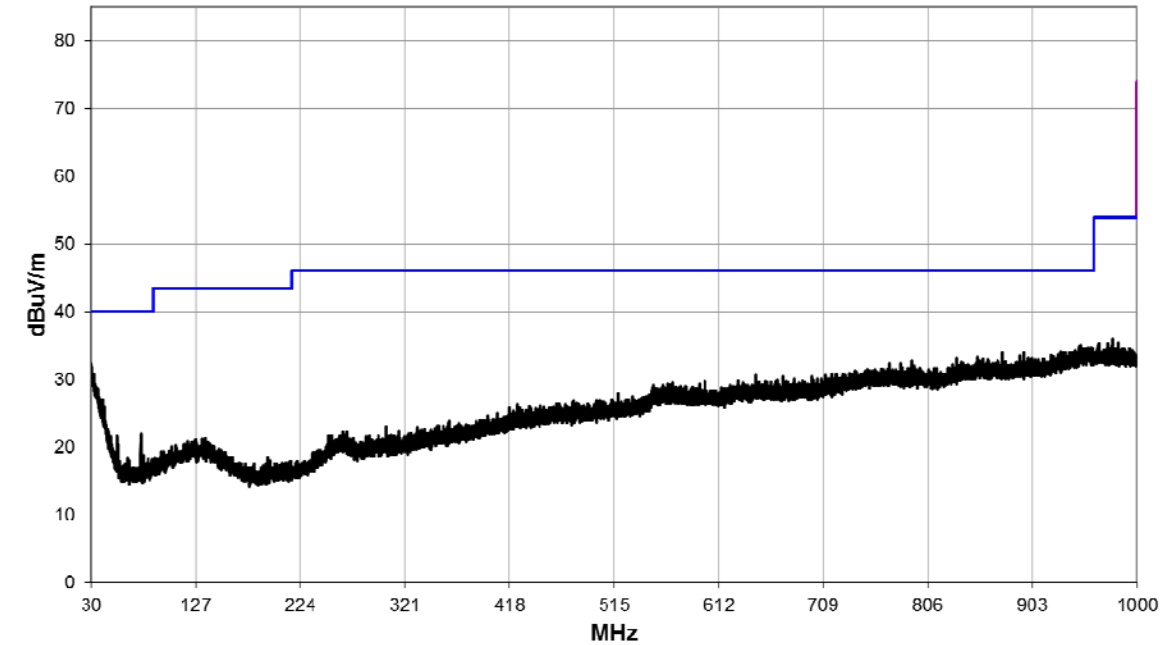


18 GHz to 26.5 GHz

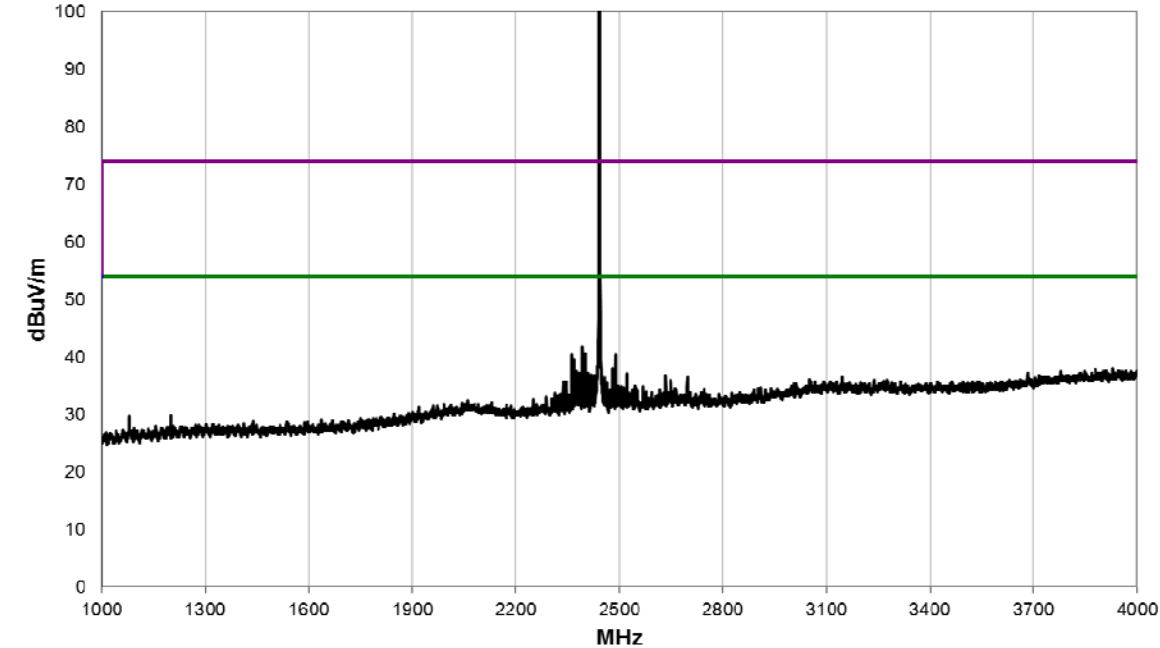


Power: +8 dBm; Channel: mid 2442 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)& Filter	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
AV	7325.5	38.66	7.2	36.5	36.6	15.6	-9.54	51.82	389.9	500
PK	7325.7	56.80	7.2	36.5	36.6	-	-9.54	54.36	522.4	5000

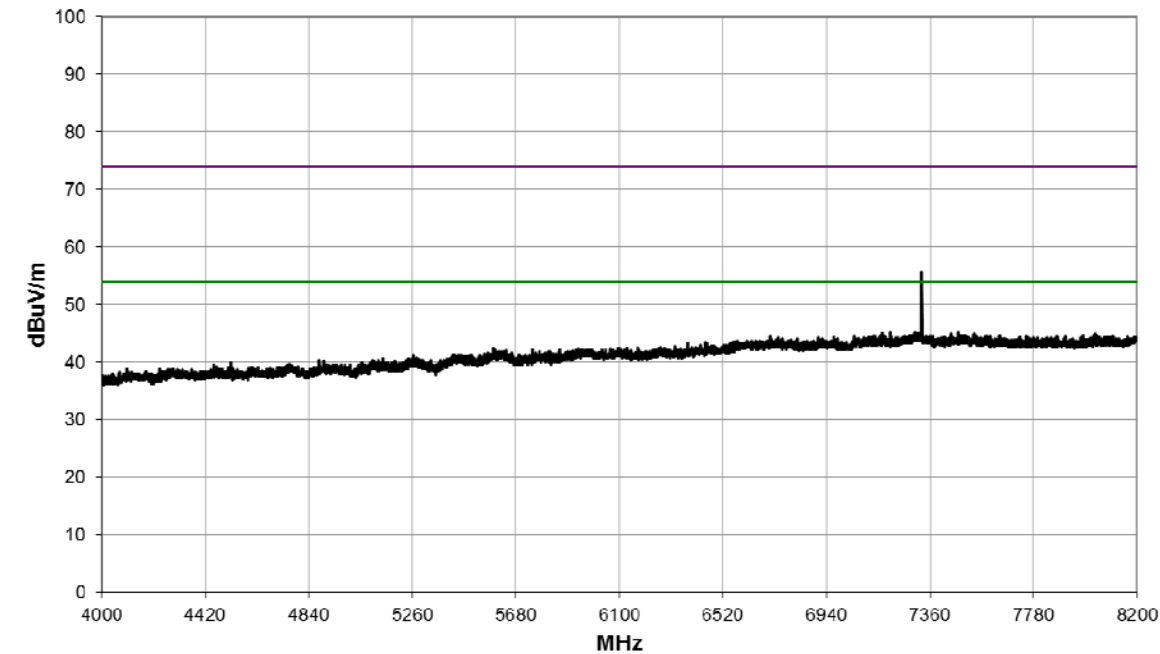
30 MHz to 1 GHz



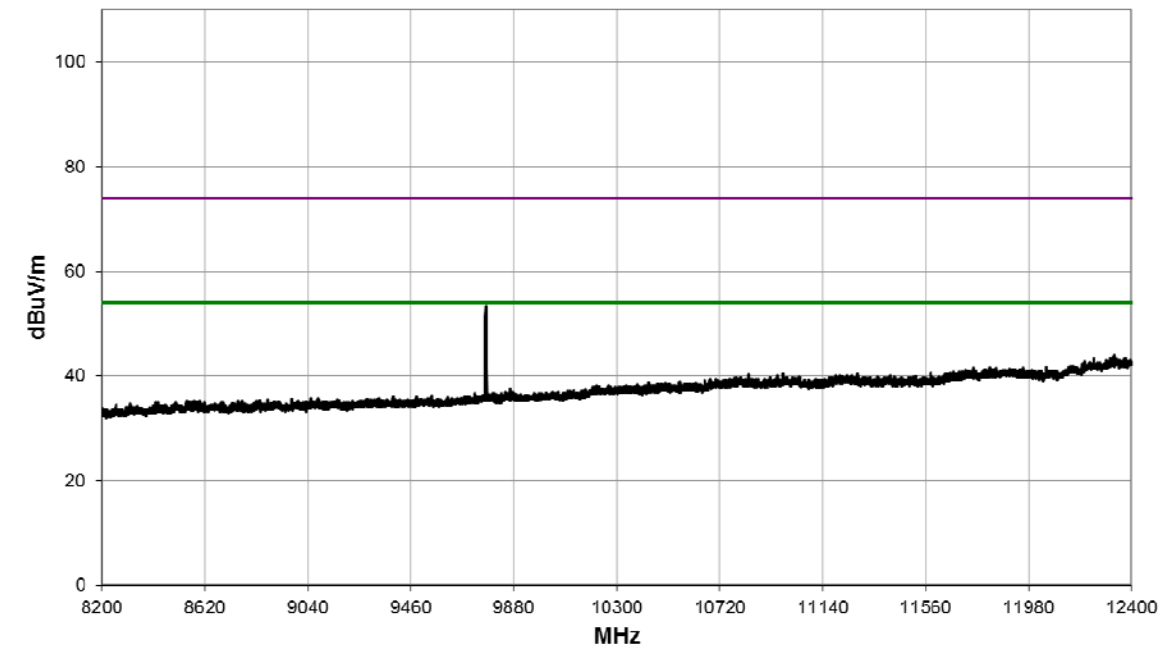
1 GHz to 4 GHz



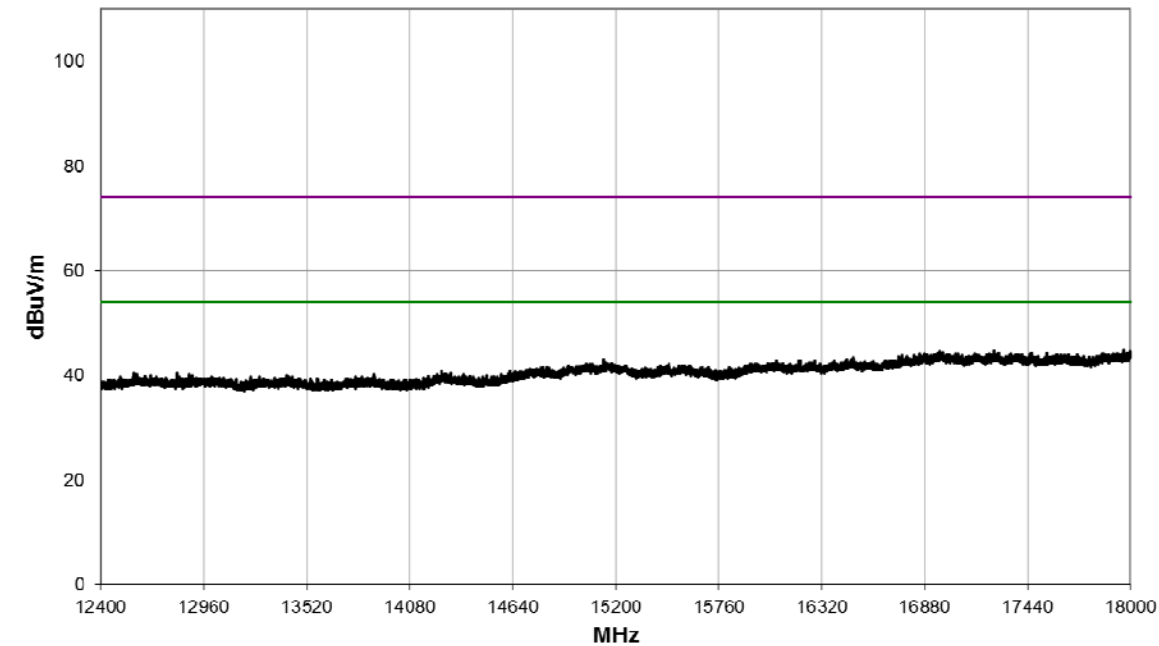
4 GHz to 8.2 GHz



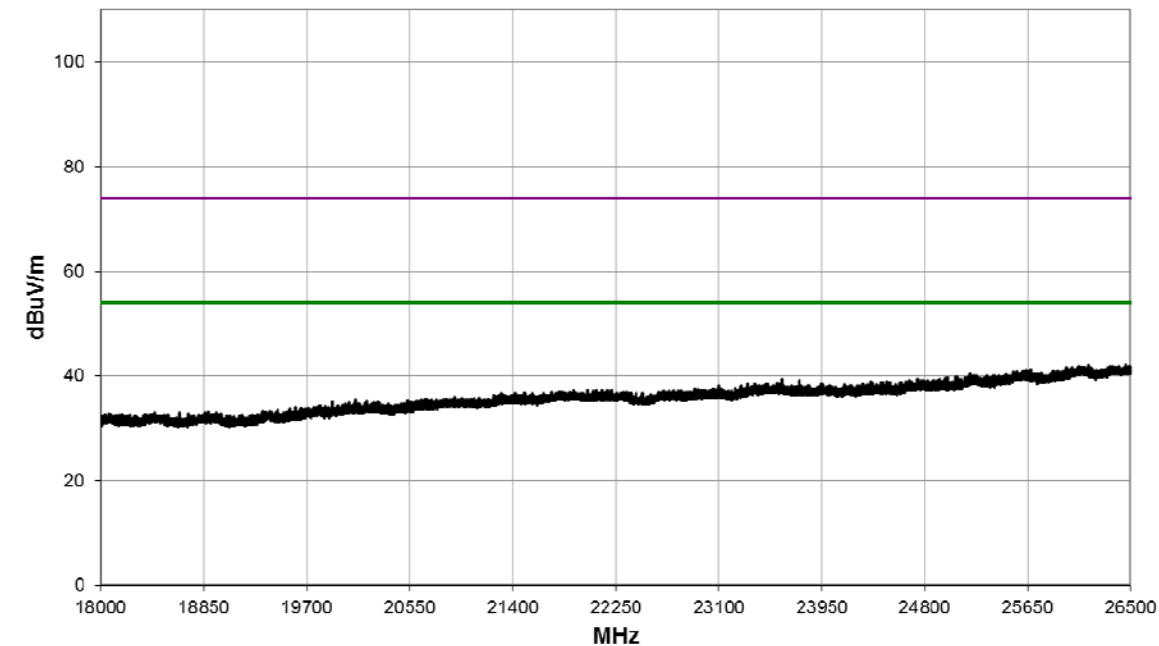
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

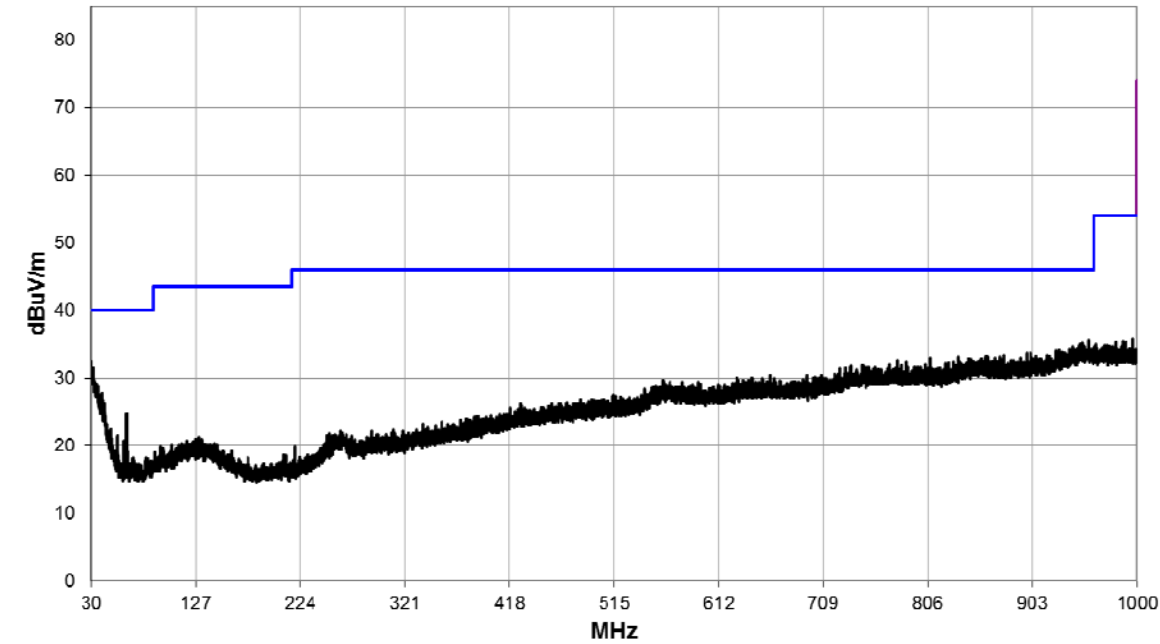


18 GHz to 26.5 GHz

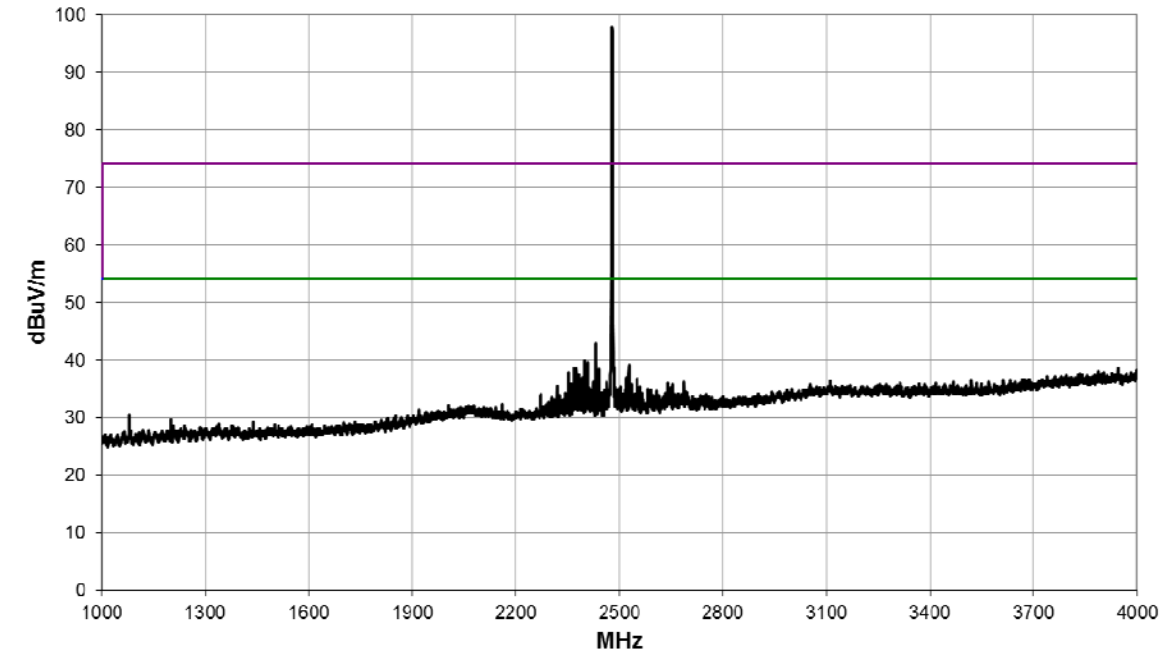


Power: +8 dBm; Channel: high 2480 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Cable Loss (dB) & Filter	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Limit (µV/m)
AV	7439.5	39.38	7.2	36.6	36.7	15.6	-9.54	52.54	423.6	500
PK	7439.2	59.53	7.2	36.6	36.7	-	-9.54	57.09	715.3	5000

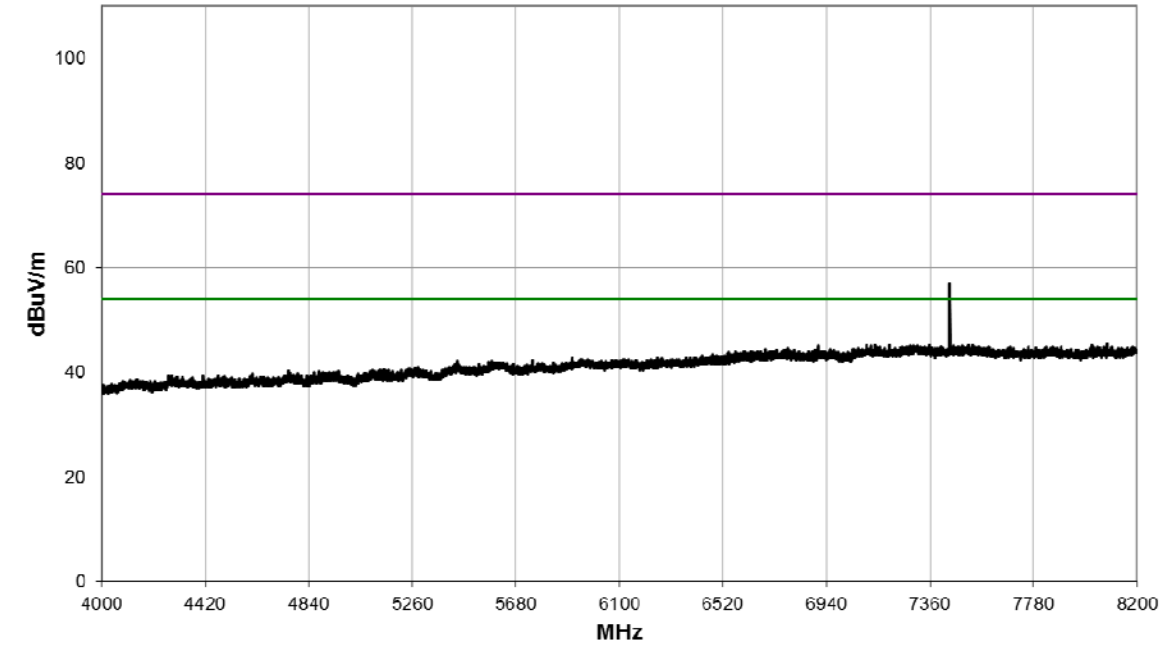
30 MHz to 1 GHz



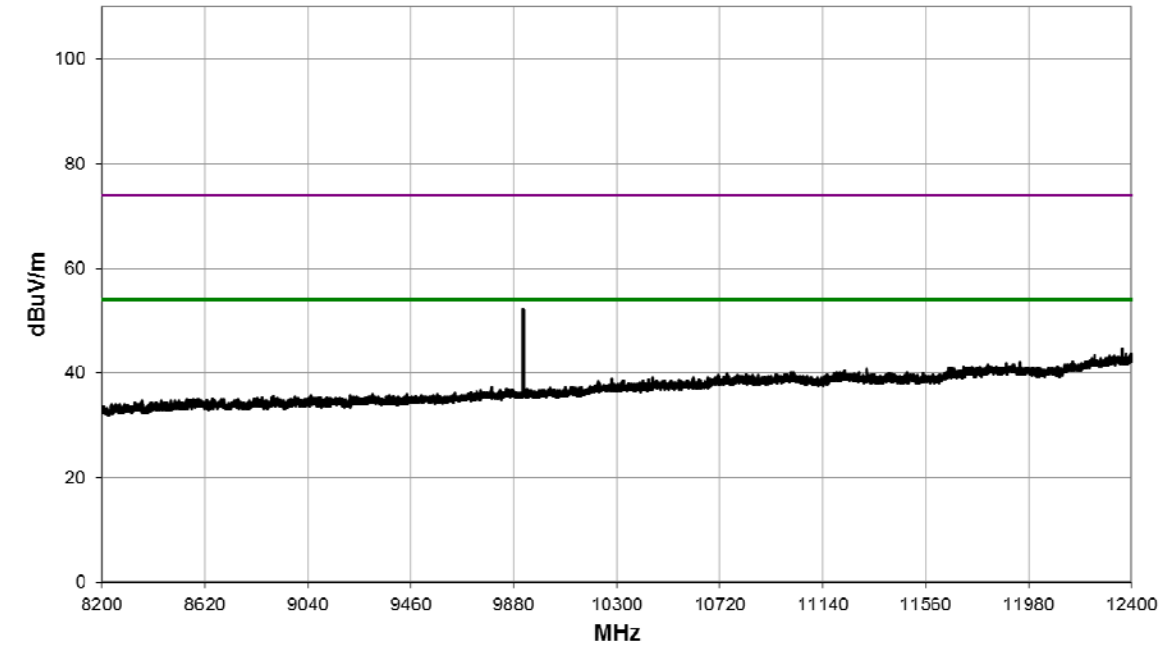
1 GHz to 4 GHz



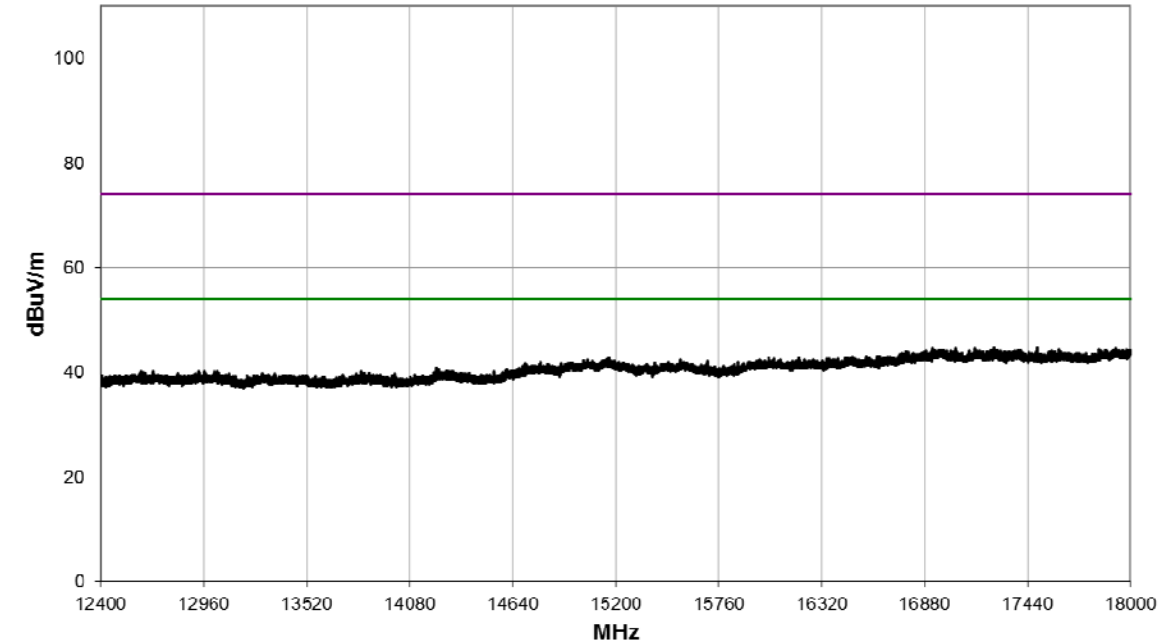
4 GHz to 8.2 GHz



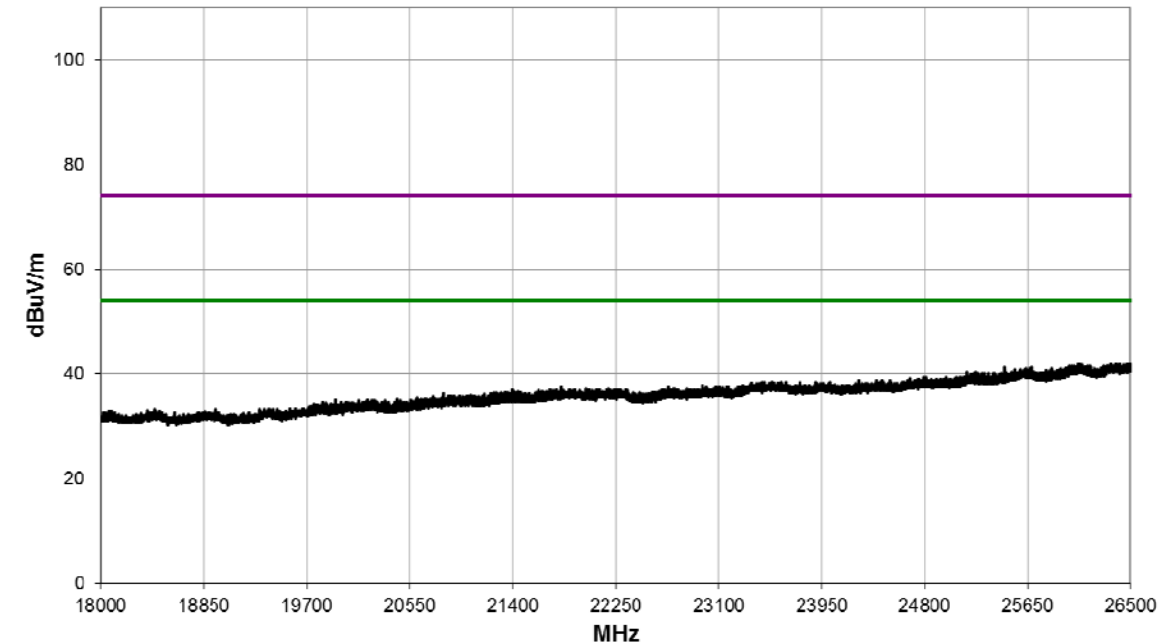
8.2 GHz to 12.4 GHz



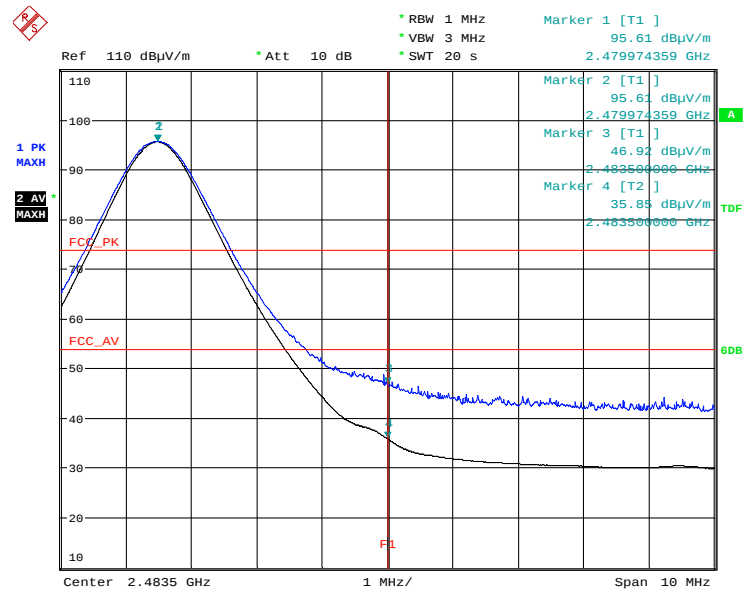
12.4 GHz to 18 GHz



18 GHz to 26.5 GHz



Upper band edge plots



Date: 6.DEC.2018 16:45:46

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 Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channel :	Mid
EUT Channel Bandwidths:	1 MHz
EUT Modulation:	GFSK
Deviations From Standard:	None
Measurement BW:	10kHz
Measurement Detectors:	Quasi-Peak and Average,

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 42 % RH	20 % RH to 75 % RH (as declared)
Supply: 110 Vac	

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.

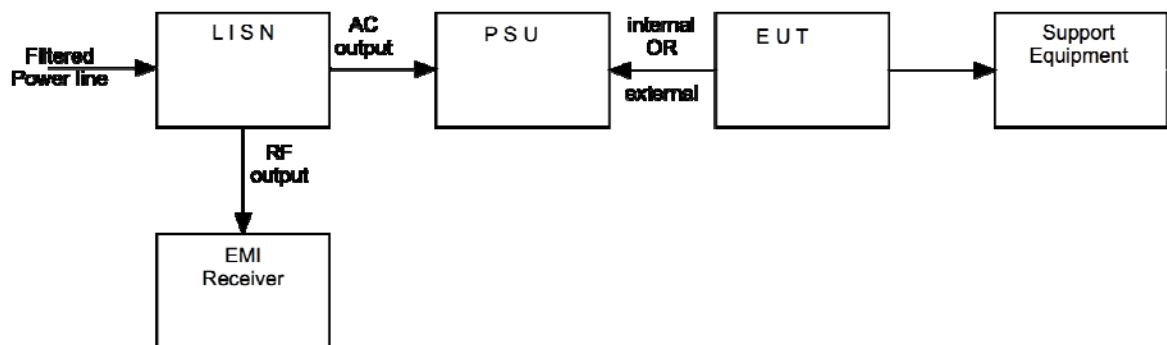
12.4 Test Method

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

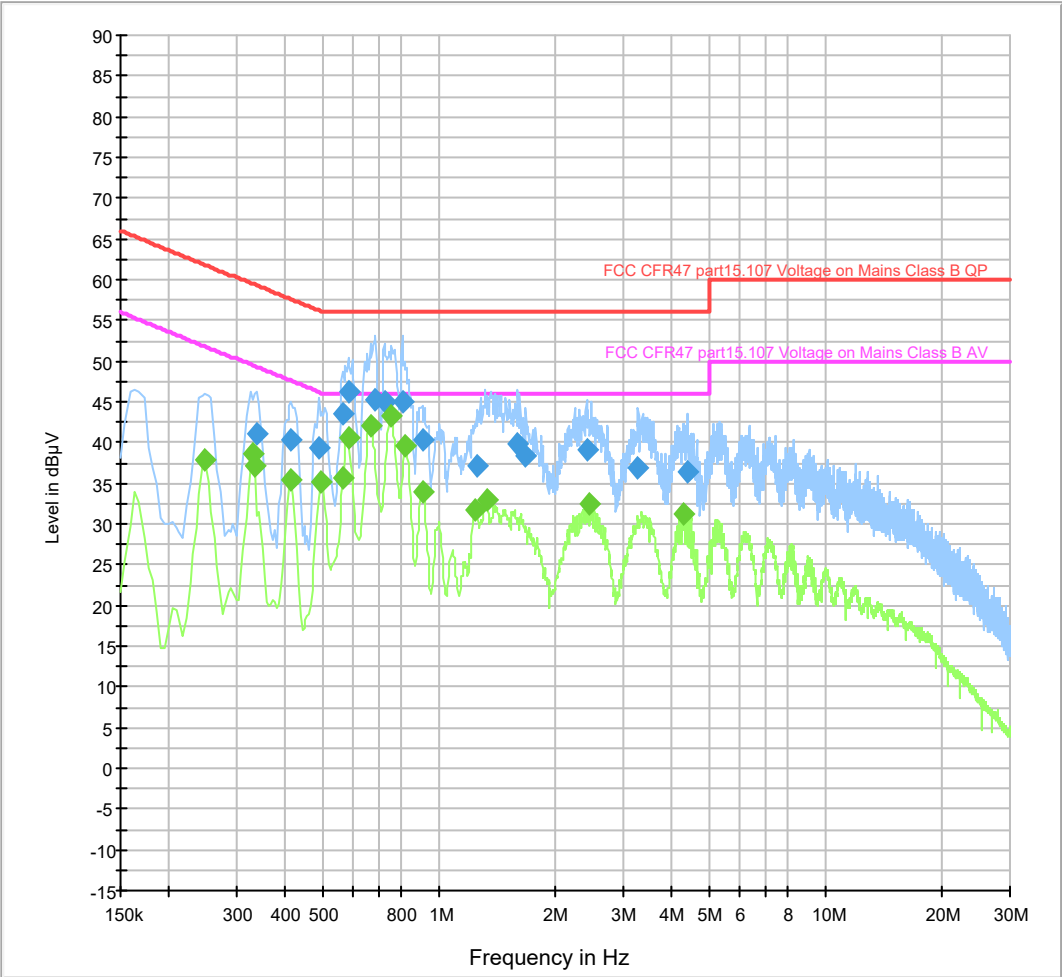


12.6 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
ESHS10	R&S	Receiver	U003	2019-09-21
ESH3-Z5.831.5	R&S	Lisn	U195	2019-09-12

12.7 Test Results

Conducted emissions on Mains 9kHz-30MHz ESHS10 + UH195+UH443PL



Frequency (MHz)	QuasiPeak (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)	Comment
0.339000	41.2	2000.0	10.000	GN	N	10.1	18.0	59.2	Pass
0.415500	40.3	2000.0	10.000	GN	L1	10.1	17.2	57.5	Pass
0.487500	39.4	2000.0	10.000	GN	L1	10.1	16.8	56.2	Pass
0.564000	43.5	2000.0	10.000	GN	L1	10.1	12.5	56.0	Pass
0.582000	46.3	2000.0	10.000	GN	L1	10.1	9.7	56.0	Pass
0.685500	45.2	2000.0	10.000	GN	N	10.1	10.8	56.0	Pass
0.721500	44.9	2000.0	10.000	GN	N	10.1	11.1	56.0	Pass
0.802500	45.0	2000.0	10.000	GN	N	10.1	11.0	56.0	Pass
0.906000	40.3	2000.0	10.000	GN	L1	10.1	15.7	56.0	Pass
1.248000	37.2	2000.0	10.000	GN	N	10.1	18.8	56.0	Pass
1.599000	39.9	2000.0	10.000	GN	L1	10.1	16.1	56.0	Pass
1.680000	38.3	2000.0	10.000	GN	L1	10.1	17.7	56.0	Pass
2.404500	39.0	2000.0	10.000	GN	L1	10.2	17.0	56.0	Pass
3.277500	37.0	2000.0	10.000	GN	L1	10.2	19.0	56.0	Pass
4.402500	36.5	2000.0	10.000	GN	L1	10.3	19.5	56.0	Pass

Frequency (MHz)	Average (dBμV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)	Comment
0.249000	37.8	2000.0	10.000	GN	L1	10.1	14.0	51.8	Pass
0.330000	38.6	2000.0	10.000	GN	L1	10.1	10.9	49.5	Pass
0.334500	37.2	2000.0	10.000	GN	L1	10.1	12.1	49.3	Pass
0.415500	35.3	2000.0	10.000	GN	L1	10.1	12.2	47.5	Pass
0.496500	35.1	2000.0	10.000	GN	L1	10.1	11.0	46.1	Pass
0.564000	35.7	2000.0	10.000	GN	L1	10.1	10.3	46.0	Pass
0.582000	40.6	2000.0	10.000	GN	L1	10.1	5.4	46.0	Pass
0.667500	42.0	2000.0	10.000	GN	L1	10.1	4.0	46.0	Pass
0.748500	43.4	2000.0	10.000	GN	L1	10.1	2.6	46.0	Pass
0.820500	39.7	2000.0	10.000	GN	L1	10.1	6.3	46.0	Pass
0.906000	33.8	2000.0	10.000	GN	L1	10.1	12.2	46.0	Pass
1.239000	31.6	2000.0	10.000	GN	L1	10.1	14.4	46.0	Pass
1.324500	32.9	2000.0	10.000	GN	L1	10.1	13.1	46.0	Pass
2.436000	32.4	2000.0	10.000	GN	L1	10.2	13.6	46.0	Pass
4.312500	31.2	2000.0	10.000	GN	L1	10.3	14.8	46.0	Pass

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 Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	FCC: ANSI C63.10-2013, Clause 11.8
EUT frequencies:	2402 / 2440 / 2480
EUT Channel Bandwidths:	701.923 kHz, 692.308 kHz, 697.116 kHz
EUT Test Modulations:	LE 1M PHY 1Mb/s
Deviations From Standard:	None
Measurement BW:	100kHz
FCC requirement: 100 kHz)	
Spectrum Analyzer Video BW:	300kHz
(requirement at least 3x RBW)	
Measurement Span:	3MHz
(requirement 2 to 5 times OBW)	
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 5.0 Vdc	

13.3 Test Limit

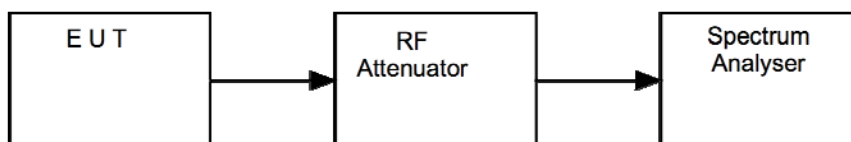
The minimum -6 dB bandwidth shall be at least 500 kHz.

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.

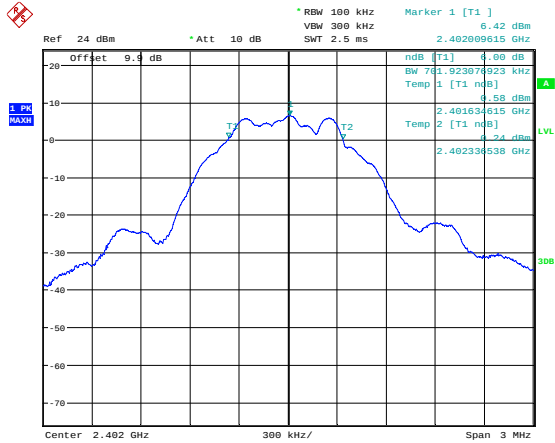
Figure iii Test Setup



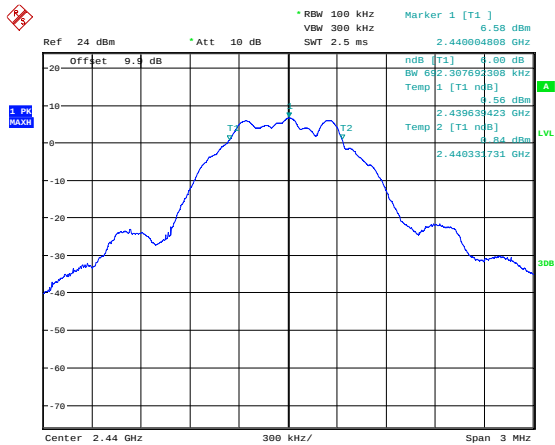
13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2019-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	Cal In use

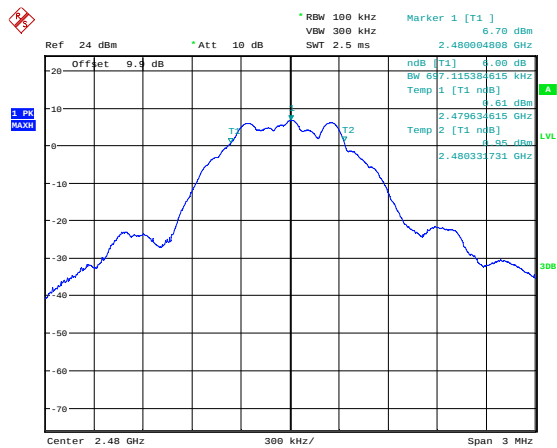
FCC 15.247. Data rate: 1Mb/s Power setting: +8dBm				
Channel Frequency (MHz)	F _L (MHz)	F _H (MHz)	6dB Bandwidth (kHz)	Result
2402	2401.634615	2402.336538	701.923	PASS
2440	2439.639423	2440.331731	692.307	PASS
2480	2479.634615	2480.331731	697.115	PASS



Date: 4.DEC.2018 09:14:09



Date: 4.DEC.2018 09:17:50



Date: 4.DEC.2018 09:28:03

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 Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT frequencies:	2402 / 2440 / 2480
EUT Channel Bandwidths:	701.923 kHz, 692.308 kHz, 697.116 kHz
Deviations From Standard:	None
Measurement BW:	1MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

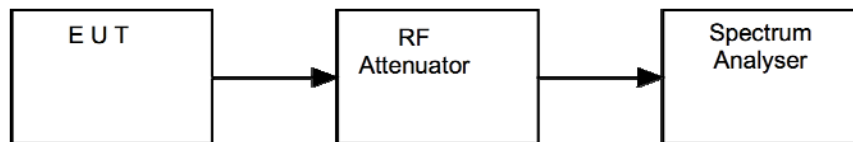
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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



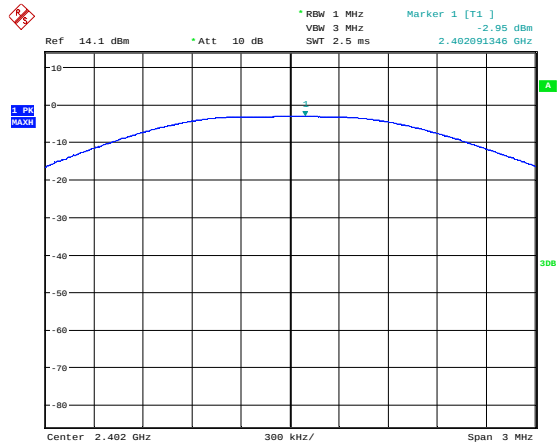
14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2019-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	Cal In use

14.6 Test Results

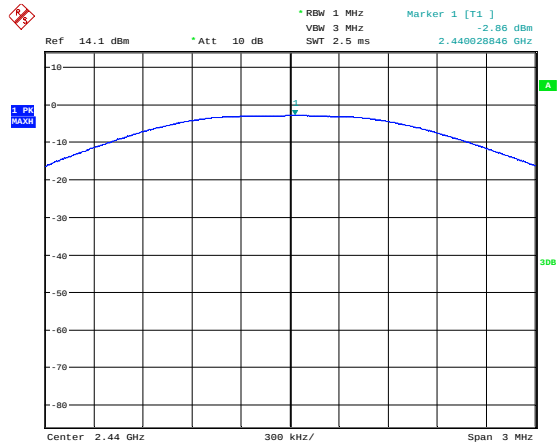
<i>Modulation: GFSK; Data rate: 1Mb/s; Power setting: +8dBm</i>					
<i>Channel Frequency (MHz)</i>	<i>Analyzer Level (dBm)</i>	<i>Cable loss (dB)</i>	<i>Power (dBm)</i>	<i>(mW)</i>	<i>Result</i>
2402.00	-2.95	10.2	7.25	5.30	PASS
2440.00	-2.86	10.2	7.34	5.42	PASS
2480.00	-2.69	10.2	7.51	5.63	PASS

Bottom channel 2402MHz



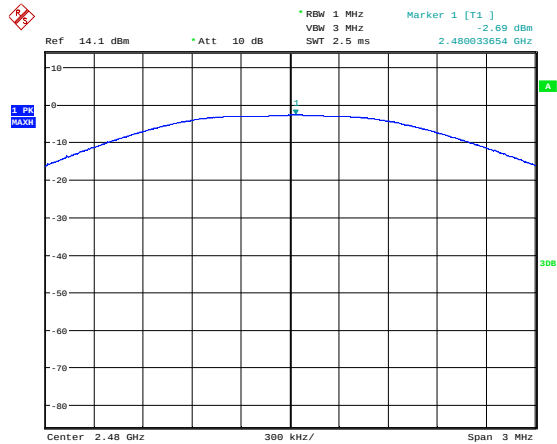
Date: 5.DEC.2018 07:57:03

Middle channel 2440MHz



Date: 5.DEC.2018 07:58:24

Top channel 2480MHz



Date: 5.DEC.2018 08:00:03

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 Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT frequencies :	2402 / 2440 / 2480
EUT Channel Bandwidths:	701.923 kHz, 692.308 kHz, 697.116 kHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300
Measurement Detector:	Peak
Measurement Range:	30 MHz to 25GHz

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 5.0 Vdc	

15.3 Test Limit

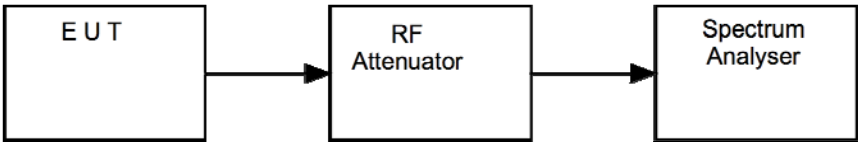
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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



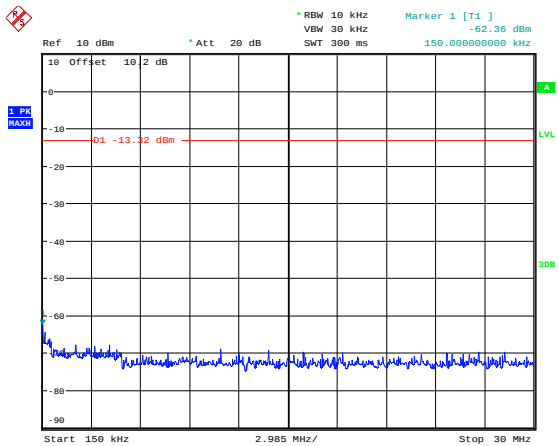
15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2019-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	Cal In use

15.6 Test Results

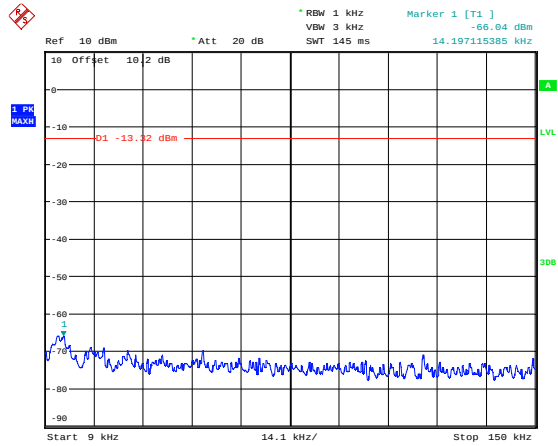
2402 MHz Modulation: GFSK; Data rate: 1Mb/s; Power setting: +8dBm						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
2402	No Significant emissions within 20dB of the limit					PASS

9 kHz-150 kHz



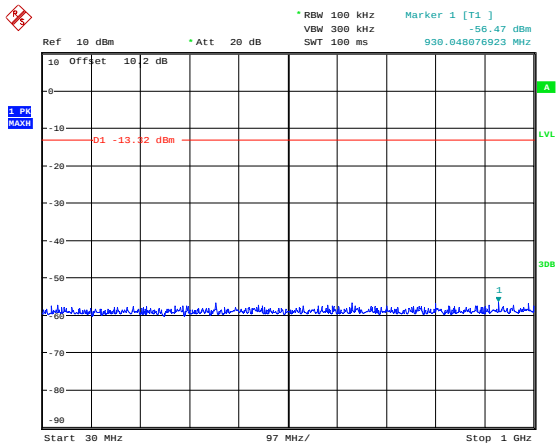
Date: 5.DEC.2018 09:28:49

150 kHz-30 MHz



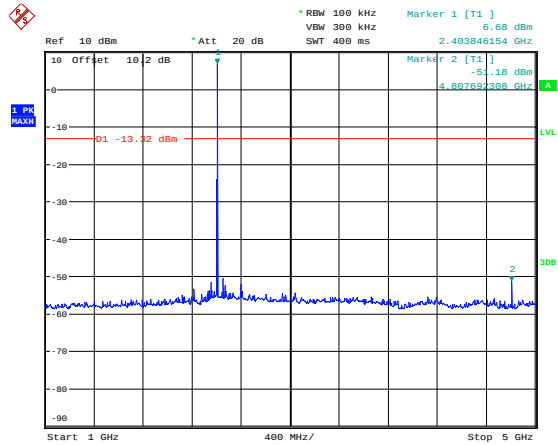
Date: 5.DEC.2018 09:28:24

30 MHz-1 GHz



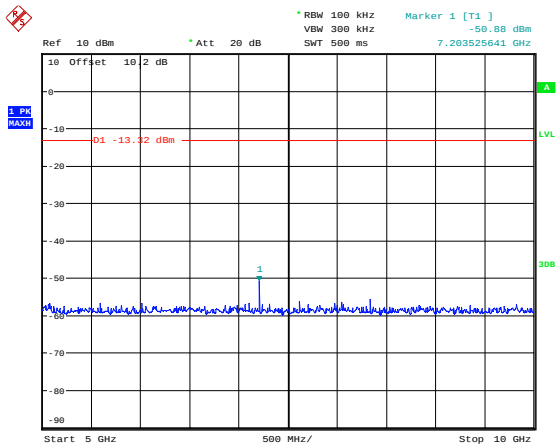
Date: 5.DEC.2018 09:28:08

1 GHz-5 GHz



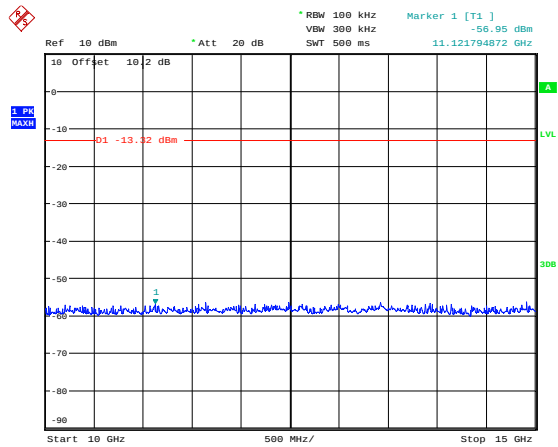
Date: 5.DEC.2018 09:28:06

5 GHz-10 GHz



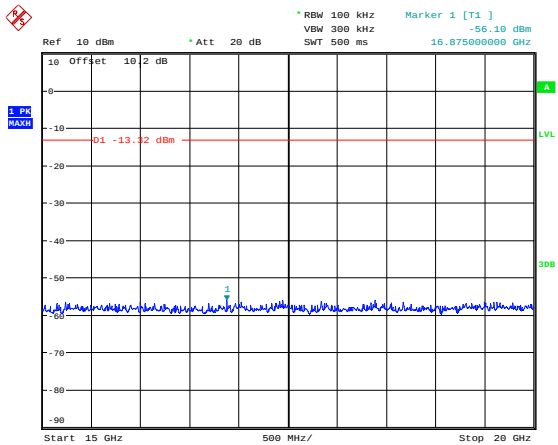
Date: 5.DEC.2018 09:29:36

10 GHz-15 GHz



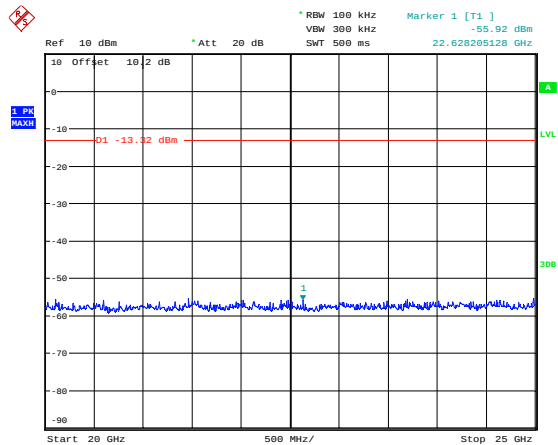
Date: 5.DEC.2018 09:30:01

15 GHz-20 GHz



Date: 5.DEC.2018 09:30:25

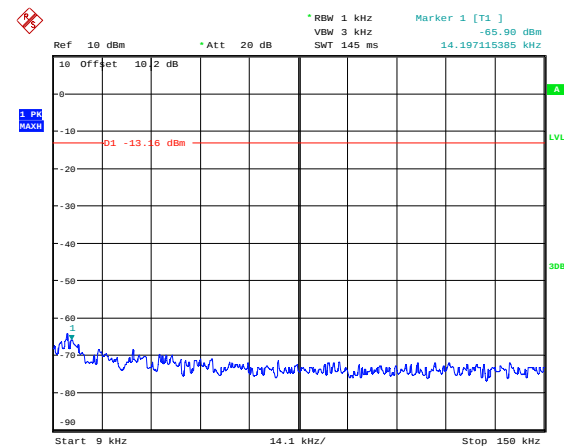
20 GHz-25 GHz



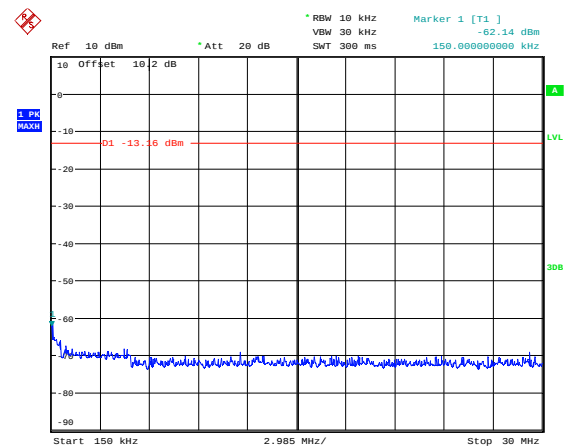
Date: 5.DEC.2018 09:30:51

2440 MHz Modulation: GFSK; Data rate: 1Mb/s; Power setting: +8dBm						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
2440	No Significant emissions within 20dB of the limit					PASS

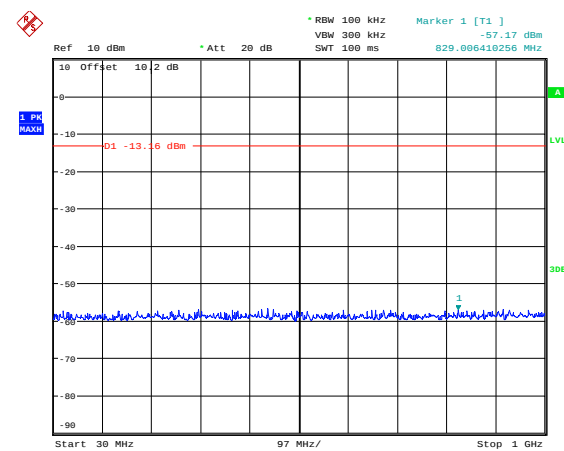
9 kHz-150 kHz



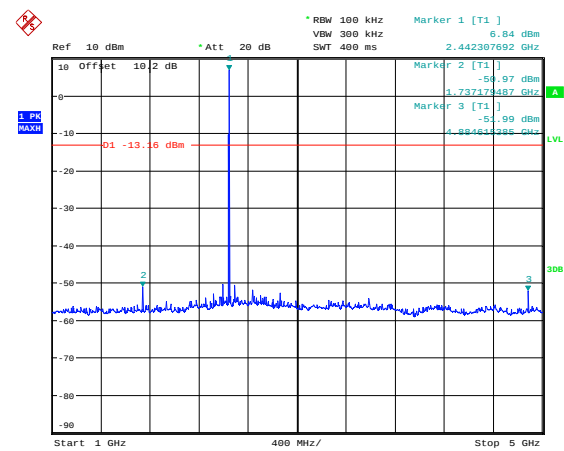
150 kHz-30 MHz



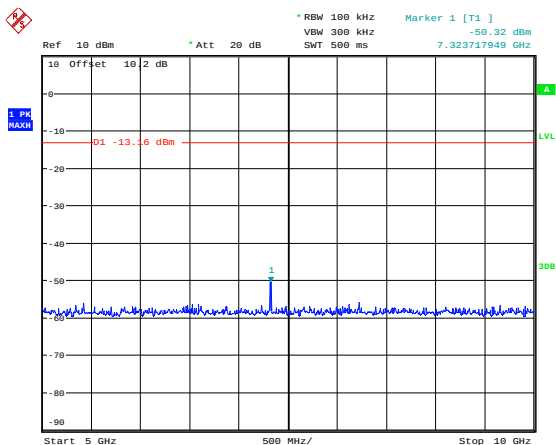
30 MHz- 1 GHz



1 GHz-5 GHz

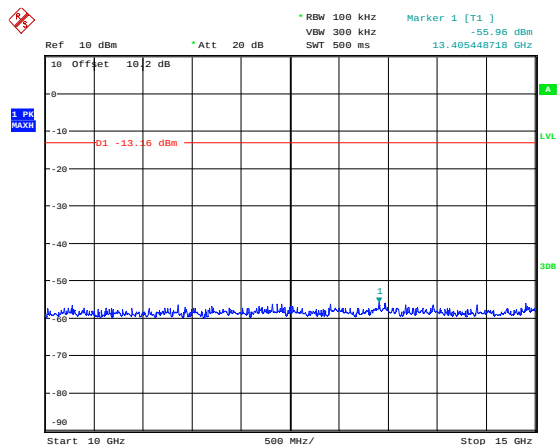


5 GHz-10 GHz



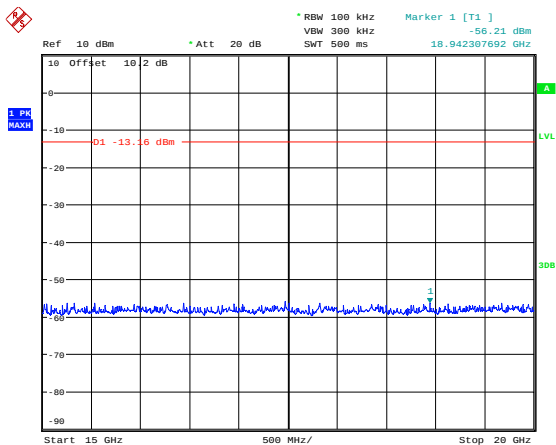
Date: 5.DEC.2018 09:38:44

10 GHz-15 GHz



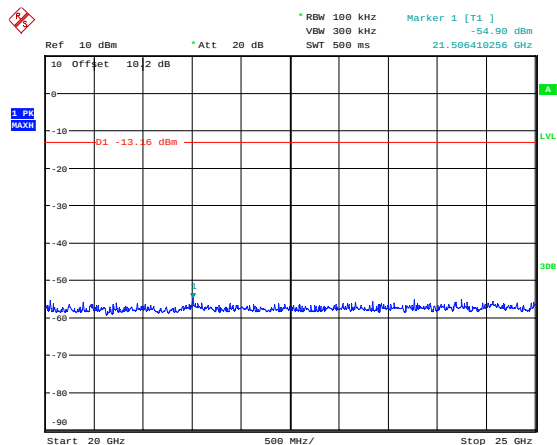
Date: 5.DEC.2018 09:39:13

15 GHz-20 GHz



Date: 5.DEC.2018 09:39:35

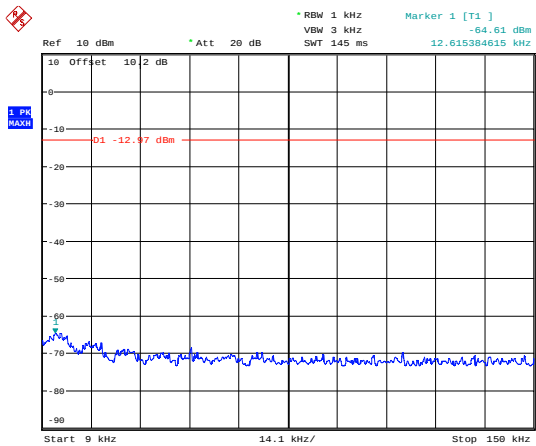
20 GHz-25 GHz



Date: 5.DEC.2018 09:40:01

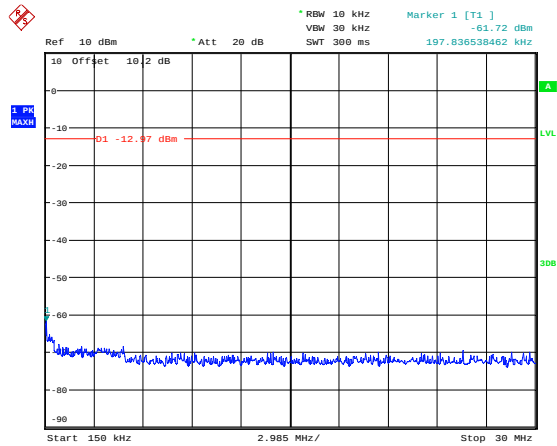
2480 MHz Modulation: GFSK; Data rate: 1Mb/s; Power setting: +8dBm						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
2480	No Significant emissions within 20dB of the limit					PASS

9 kHz-150 kHz



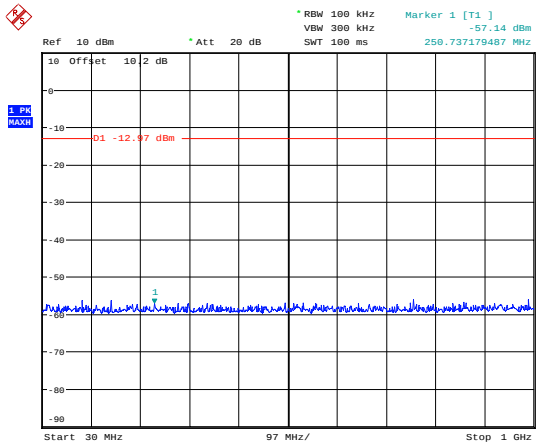
Date: 5.DEC.2018 10:27:29

150 kHz-30 MHz



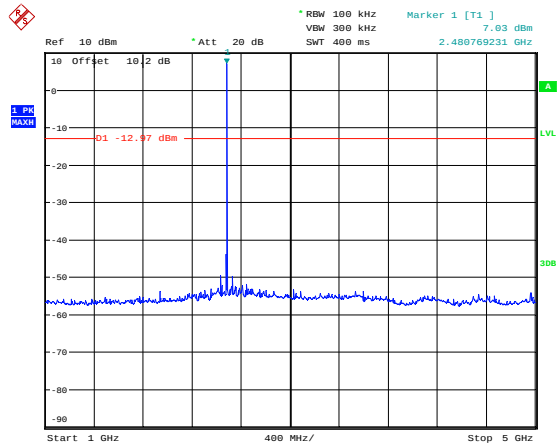
Date: 5.DEC.2018 10:28:14

30 MHz-1 GHz



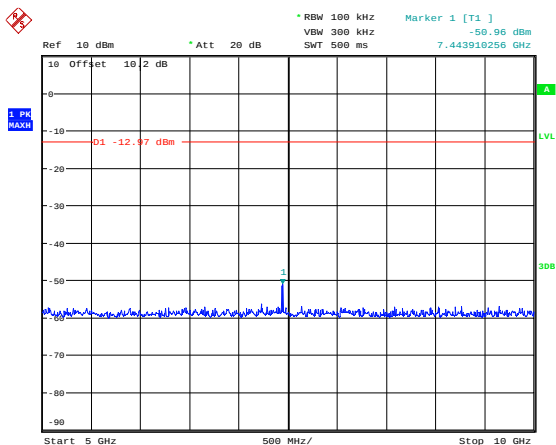
Date: 5.DEC.2018 10:28:44

1 GHz-5 GHz



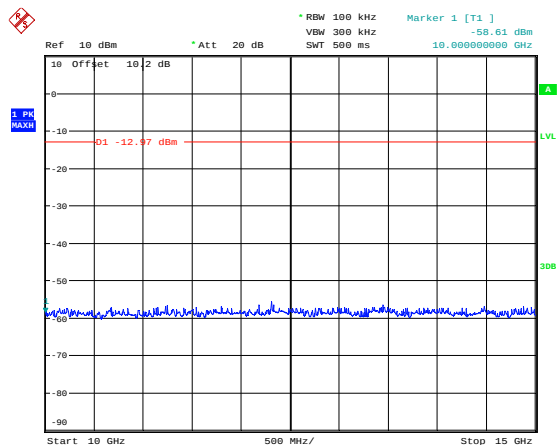
Date: 5.DEC.2018 10:09:19

5 GHz-10 GHz



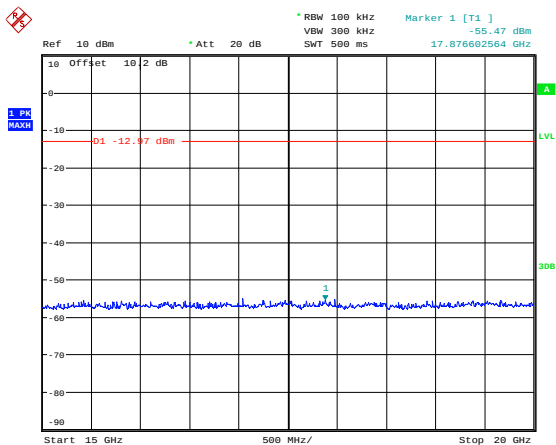
Date: 5.DEC.2018 10:09:40

10 GHz-15 GHz



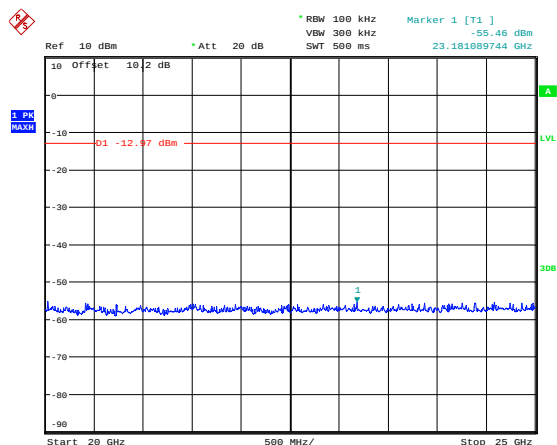
Date: 5.DEC.2018 10:10:01

15 GHz-20 GHz



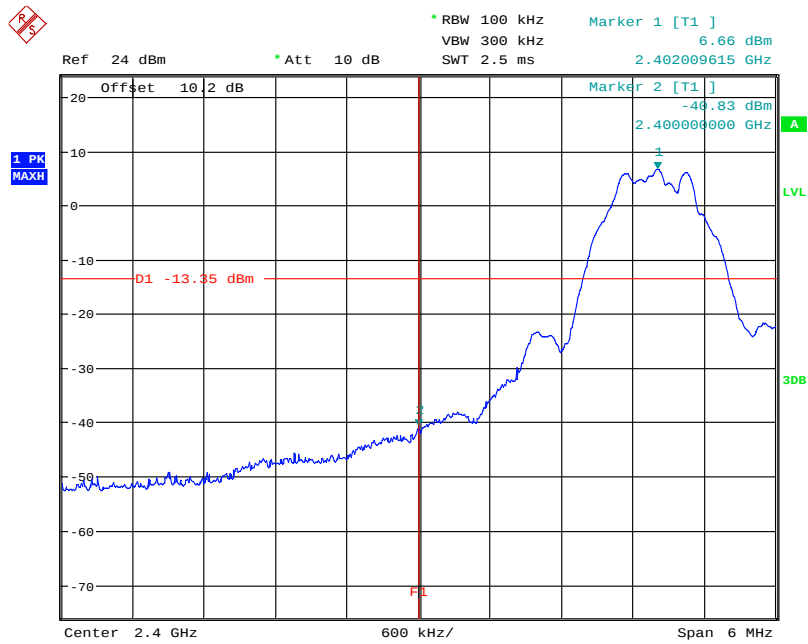
Date: 5.DEC.2018 10:19:35

20 GHz-25 GHz



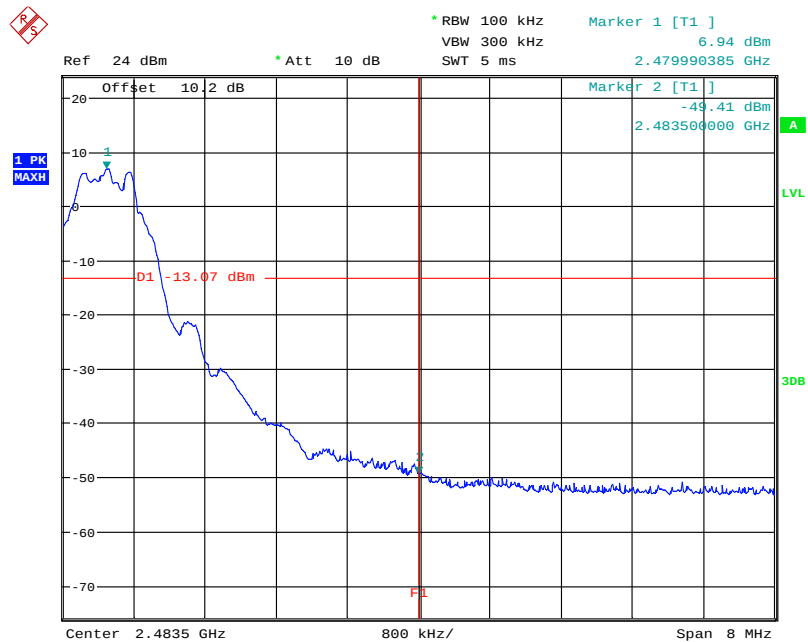
Date: 5.DEC.2018 10:20:13

Lower Bandedge



Date: 5.DEC.2018 09:04:39

Upper Bandedge



Date: 5.DEC.2018 09:14:39

16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	2402 / 2440 / 2480
EUT Channel Bandwidths:	701.923 kHz,692.308 kHz,697.116 kHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300
Measurement Span: (requirement 1.5 times Channel BW)	1MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 5.0 Vdc	

16.3 Test Limit

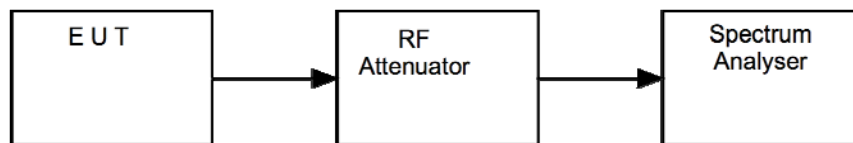
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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



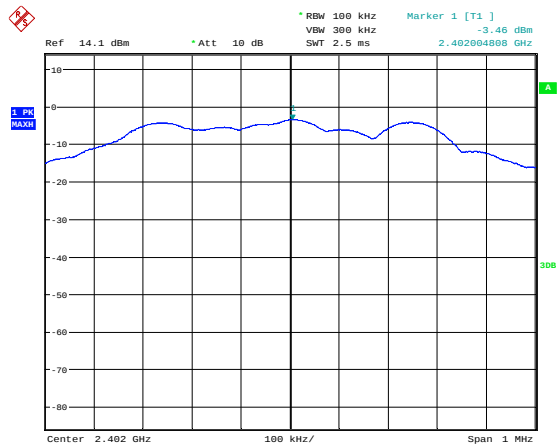
16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2019-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	Cal In use

16.6 Test Results

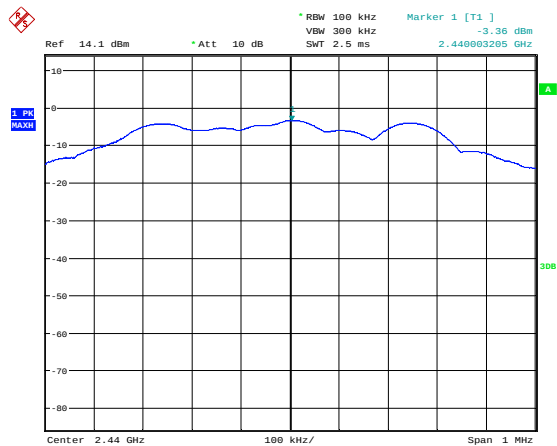
<i>Modulation: GFSK; Data rate: 1Mb/s; Power setting: +8dBm</i>				
<i>Channel Frequency (MHz)</i>	<i>Analyzer Level (dBm)</i>	<i>Cable loss (dB)</i>	<i>Power (dBm)</i>	<i>Result</i>
2402	-3.46	10.2	6.74	PASS
2440	-3.36	10.2	6.84	PASS
2480	-3.20	10.2	7.00	PASS

PSD Bottom Channel



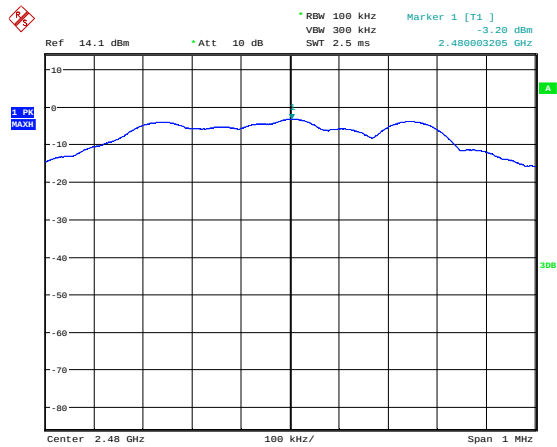
Date: 5.DEC.2018 08:02:35

PSD Middle Channel



Date: 5.DEC.2018 08:05:51

PSD Top Channel



Date: 5.DEC.2018 08:09:14

17 Duty Cycle

17.1 Definition

The ratio of the sum of all pulse durations to the total period, during a specified period of operation. The duty cycle is determined on the basis of one complete pulse train for pulse trains not exceeding 100 milliseconds. Where the pulse train exceeds 100 milliseconds, the duty cycle is determined on the basis of the 100 millisecond interval with the highest average value of emission.

17.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.5
EUT Frequencies Measured:	2402 / 2440 / 2480
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 5.0 Vdc	

17.3 Test Limit

N/A.
Note, the maximum duty cycle correction factor which may be used is 20 dB.

17.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, the duty of the EUT was calculated from the sum of total on and off times over the observation period.

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

[1] Single antenna output devices

Duty was measured at the antenna port

[2] Multiple antenna output devices

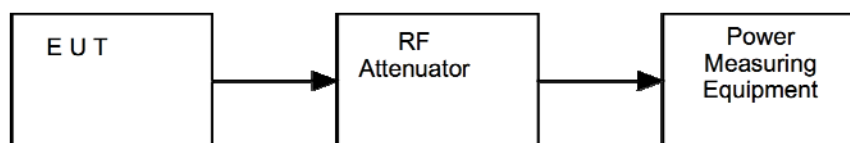
Duty was measured as the combination of all ports simultaneously

The duty cycle correction factor, DC, is used to adjust peak emissions (voltage) to give an average value and is calculated by:

$$20 \log 1 \div D$$

$$(T_{on} + T_{off}) \div T_{on}$$

Figure vii Test Setup



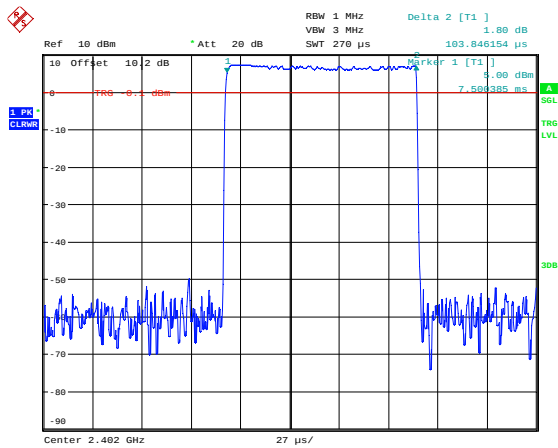
17.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU50	R&S	Spectrum Analyser	U544	2019-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	Cal In use

17.6 Test Results

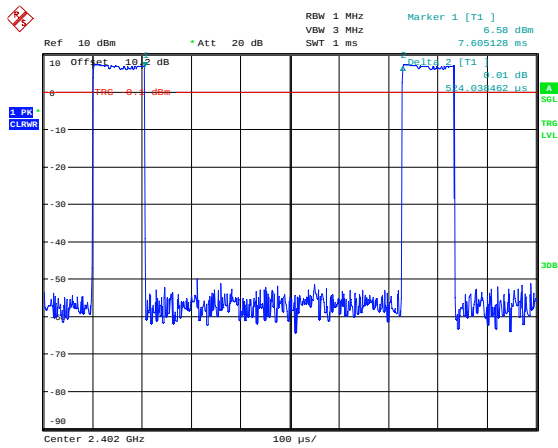
2402 MHz; Modulation: GFSK; Data rate: 1Mb/s							
Test Environment		Total TxOn time (μs)	Tx off Period (μs)	Tx On + Tx off (μs)	$D = \frac{\text{Tx On}}{\text{Tx On} + \text{Tx off}}$	1/D	Calculated Factor
V _{nominal}	T _{nominal}	103.84	524.03	627.87	0.1654	6.04	15.62

Tx on



Date: 5.DEC.2018 12:46:43

Tx off



Date: 5.DEC.2018 13:19:57

18 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) = **4.75 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **0.93 dB**

[5] Conducted 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**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **3.11 dB**

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**

Uncertainty in test result (Pershore OATS) = **4.26 dB**

19 RF Exposure

RADIO FREQUENCY RADIATION EXPOSURE

KDB 447498

47 CFR §§1.1307 and 2.1091

Radio frequency radiation exposure evaluation.

Mobile devices that operate under CFR47 Part 90 are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more for FCC requirements.

Prediction of MPE limit at a given distance

$$S = \frac{EIRP}{4 \pi R^2} \text{ re - arranged} \quad R = \sqrt{\frac{EIRP}{S 4 \pi}}$$

where:

S = power density

R = distance to the centre of radiation of the antenna

ERP = EUT Maximum power

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (S) (mW/cm ²)	Distance (R) cm required to be less than (S) mW/cm ²
2402	6.4	1	0.72
2440	6.5	1	0.72
2480	6.8	1	0.74

Result: Pass

LIMITS

FCC LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Averaging Time E ² , H ² or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f ₂)*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	280/f	2.19/f	-	6
10-30	28	2.19/f	-	6
30-300	28	0.073	2	6
300-1500	$1.585 f^{0.5}$	$0.0042 f^{0.5}$	f/150	6
1500-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$