

Report on the Radio Testing
For
Pektron Group Ltd
on
Lordstown Motors Bluetooth Key
Report no. TRA-056845-47-00B
23rd August 2022

RF915 8.0



0026

Report Number: TRA-056845-47-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
Pektron Group Ltd
Lordstown Motors Bluetooth Key
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 20th June 2022 to 23rd August 2022

Tested by: Steven Hodgkinson

Written by:

Steven Hodgkinson
Michael Else
Radio test engineer

Approved by:

Daniel Winstanley
Senior radio test engineer

Date: 23rd August 2022

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	27 TH July 2022	Original
B	23 rd August 2022	Radiated spurious emissions 9kHz to 30 MHz Pre-scans added.

2 Summary

TEST REPORT NUMBER:	TRA-056845-47-00B
WORKS ORDER NUMBER:	TRA-056845-00
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	Lordstown Motors Bluetooth Key
FCC IDENTIFIER:	AQO017
MANUFACTURER/AGENT:	Pektron Group Ltd
ADDRESS:	Alfreton Road Derby Derbyshire DE21 4AP United Kingdom
CLIENT CONTACT:	Richard Jones ☎ 01332832424 ext 382 ✉ rjones@pektron.co.uk
TEST DATE:	20 th June 2022 to 23 rd August 2022
TESTED BY:	Steven Hodgkinson Element

2.1 Test Summary

Test Method and Description		Requirement Clause 47CFR15	Applicable to this equipment	Result / Note
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.247 (d)	☒	Pass
AC power line conducted emissions		15.207	☐	Note 1
Occupied bandwidth		15.247 (a) (2)	☒	Pass
Conducted carrier power	Peak	15.247 (b) (3)	☒	Pass
	Max.		☐	
Out of band emissions		15.247 (d)	☒	Pass
Power spectral density		15.247 (e)	☒	Pass
Calculation of duty correction		-	☐	N/A

Specific Note:

1. The EUT is a battery powered device.

General 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-058645-00B presents the results of the Radio testing on a Pektron Group Ltd, Lordstown Motors Bluetooth Key to specification 47CFR15 Radio Frequency Devices. The testing was carried out for Pektron Group Ltd by Element, at the address 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:

The test laboratory is accredited for the above sites under the US-UK MRA,

Designation number(s):

Element Hull UK2007
Element Skelmersdale UK2020

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: Lordstown Motors Bluetooth Key
- Serial Number: N/A
- Model Number: 0841G01
- Software Revision: P0841A1.8.13
- Build Level / Revision Number: A-0841G01

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.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

The test samples provided had client installed test software, which allowed The test modes to be selected via a button press.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2402 MHz to 2480 MHz
Modulation type(s):	GFSK
Occupied channel bandwidth(s):	682 kHz
Channel spacing:	1 MHz
Declared output power(s):	1.0 dBm
Nominal Supply Voltage:	3.0 Vdc
Duty cycle:	96.6%

7.4.2 Antennas

Type:	Chip Antenna
Gain:	2.5 dBi

7.5 EUT Description

The EUT is a Keyfob incorporating a BTLE 2.4 GHz radio with TX and RX capabilities, the EUT also has a LF 125 kHz radio with RX only capability.

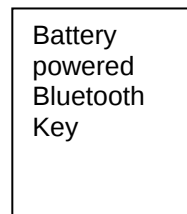
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

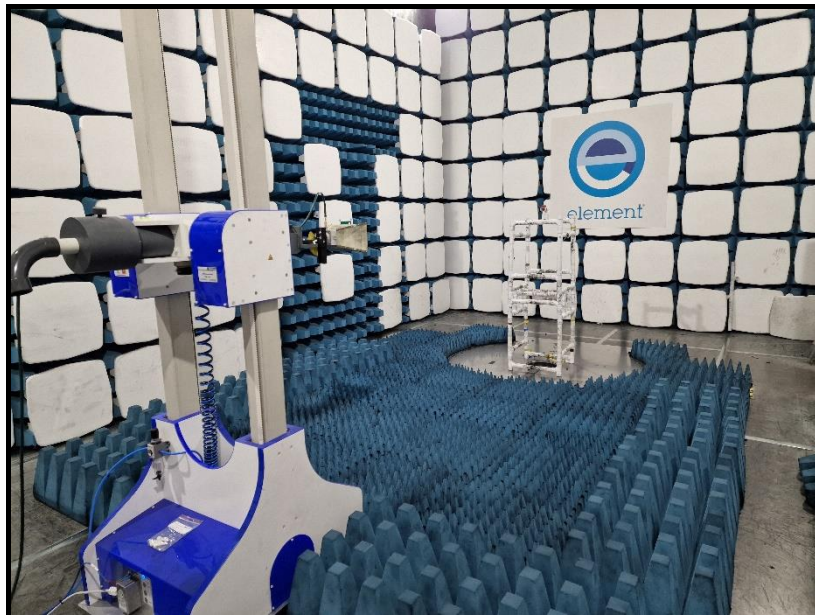
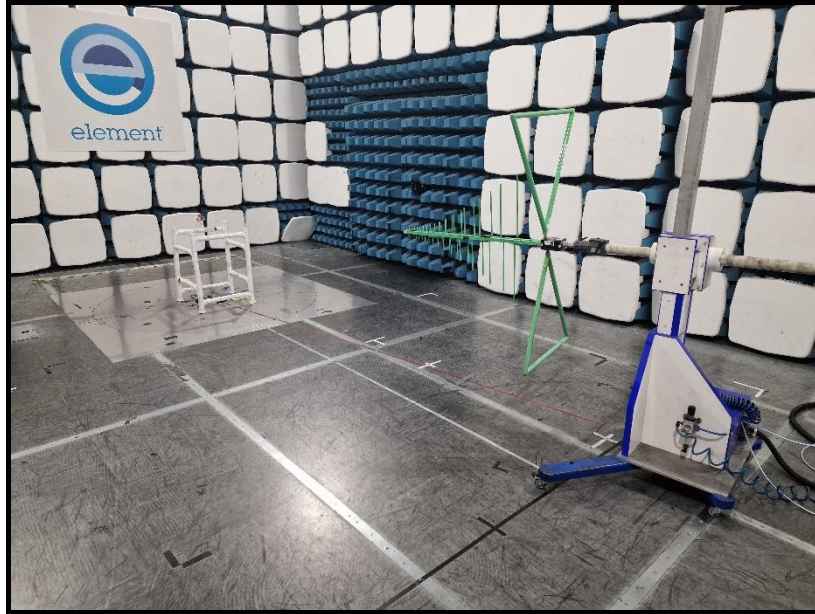
9.1 Block Diagram

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:



9.3 *Measurement software*

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5
Element Transmitter Bench Test

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.0 Vdc battery

10.2 Varying Test Conditions

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

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

	Category	Nominal	Variation
☐	Mains	110 Vac +/-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 Skelmersdale
Test Chamber:	Radio Chamber 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402 MHz/2440 MHz/2480 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: CISPR average and Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 55 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 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)	Field Strength (dB$\mu\text{V/m}$ at 3 m)
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

On frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function. On frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit.

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:

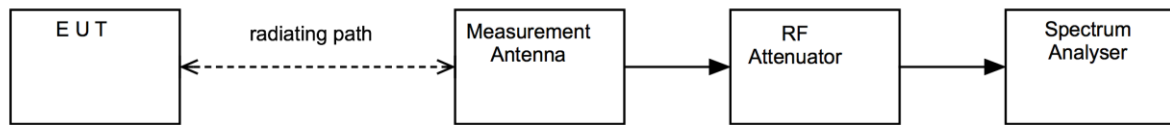
$$FS = PR + CL + AF - PA + DC - CF$$

$$\text{Factor} = CL + AF - PA$$

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);

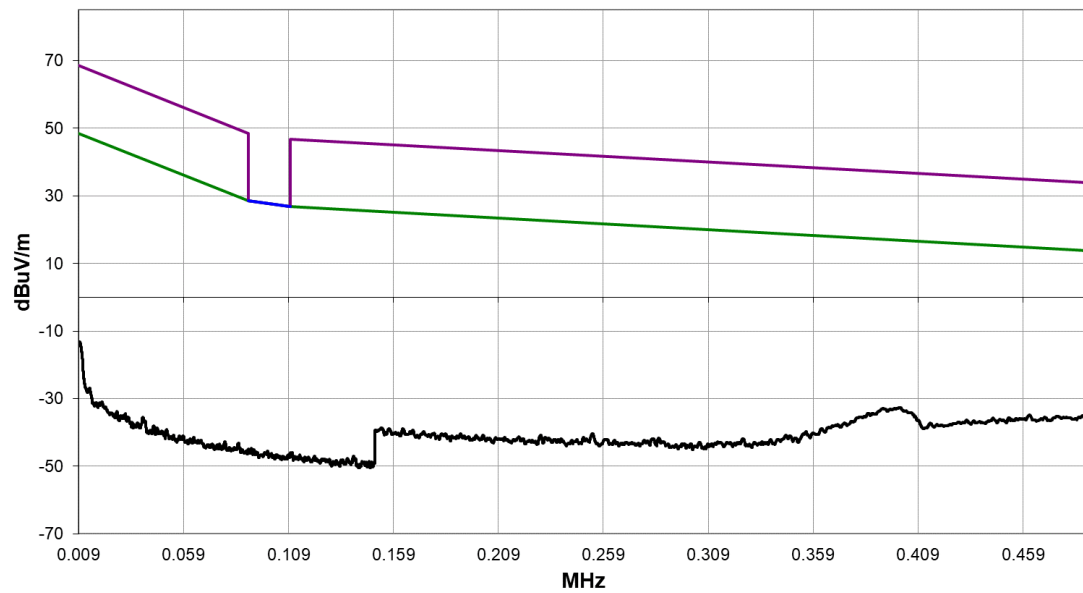
This field strength value is then compared with the regulatory limit.

Figure i Test Setup**11.5 Test Equipment**

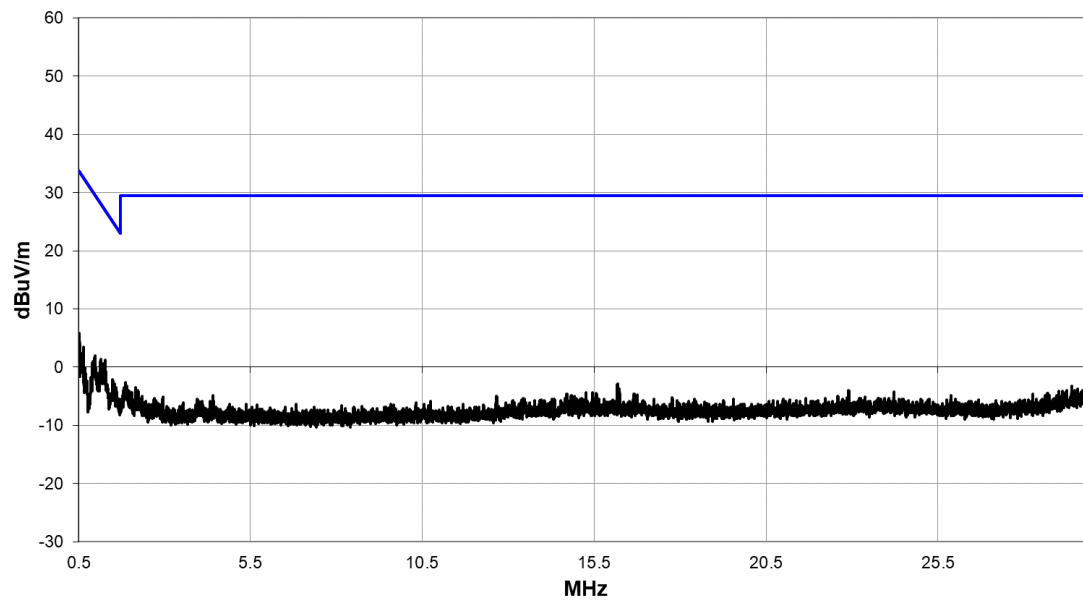
Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required
Chamber 1	Rainford EMC	ATS	U387	2023-10-24
Radio Chamber - PP	Rainford EMC	ATS	REF940	2023-11-06
Pre Amp	AMETEK	LNA6901	U711	2023-03-14
Bilog	Chase	CBL6112B	U093	2023-09-15
1-18GHz Horn	EMCO	3115	L139	2024-07-01
Pre Amp	Agilent	8449B	L572	2022-10-29
Spectrum Analyser	R&S	FSU26	U405	2023-04-21
Bilog	Chase	CBL6112	U420	2023-01-28
Horn 18-26GHz (&U330)	Flann	20240-20	L300	2024-06-30
EMI Receiver	R&S	ESR7	U456	2023-01-25

11.6 Test Results

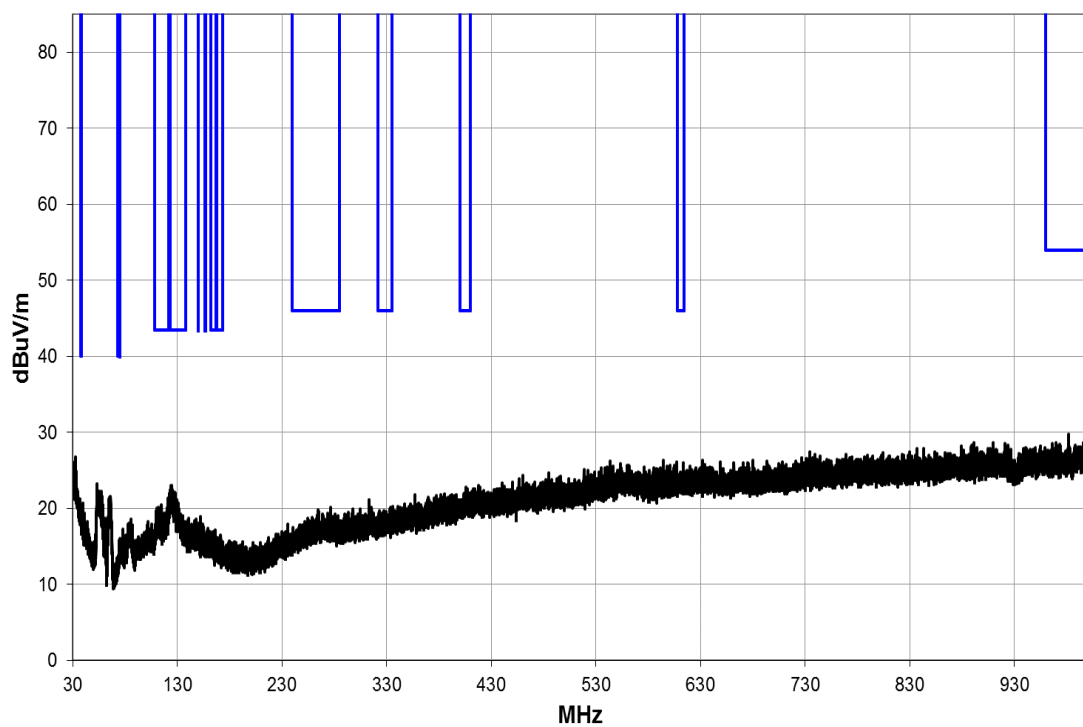
2402 MHz 9 kHz-490 kHz



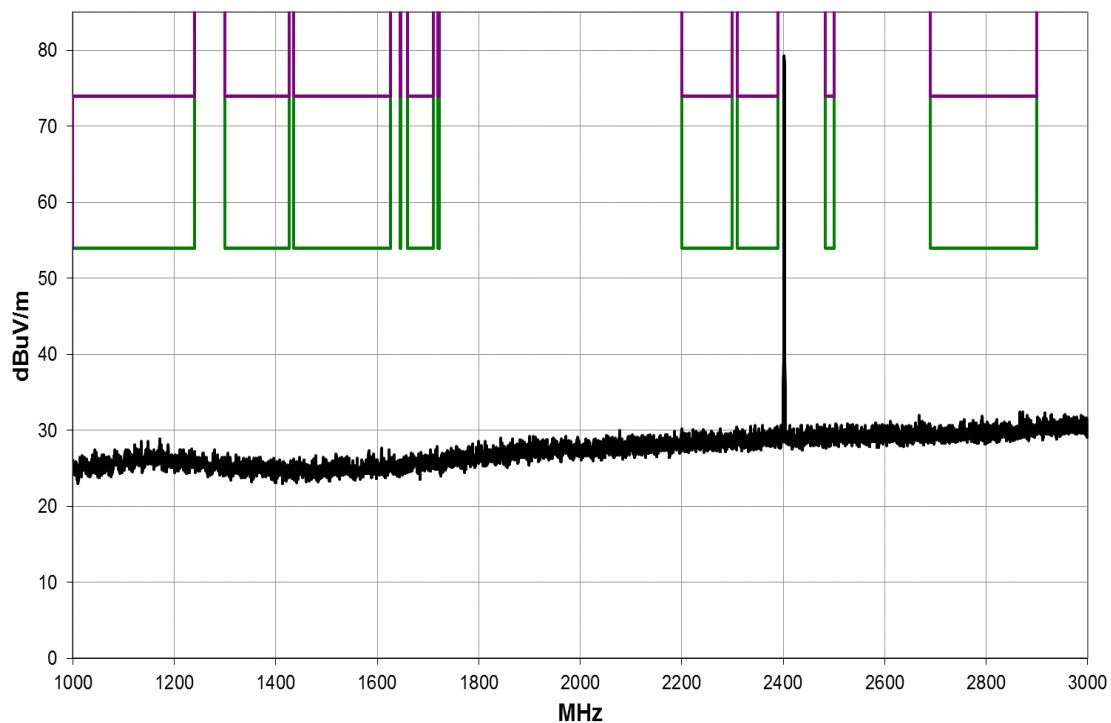
2402 MHz 490 kHz-30 MHz



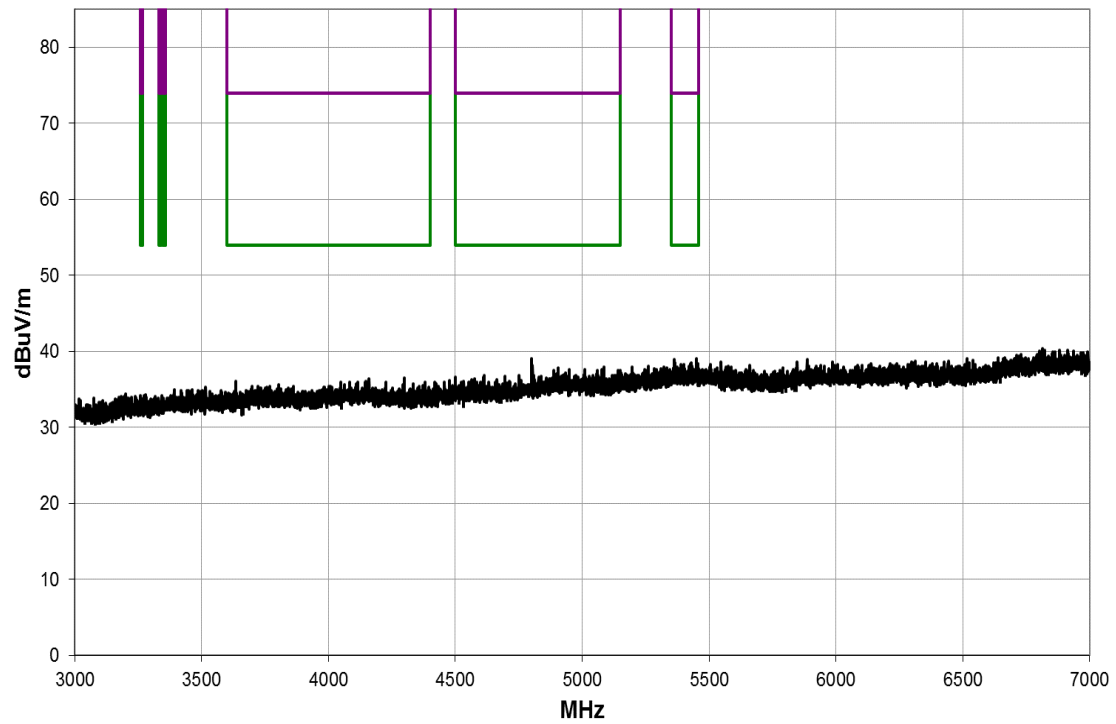
2402 MHz 30 MHz-1 GHz



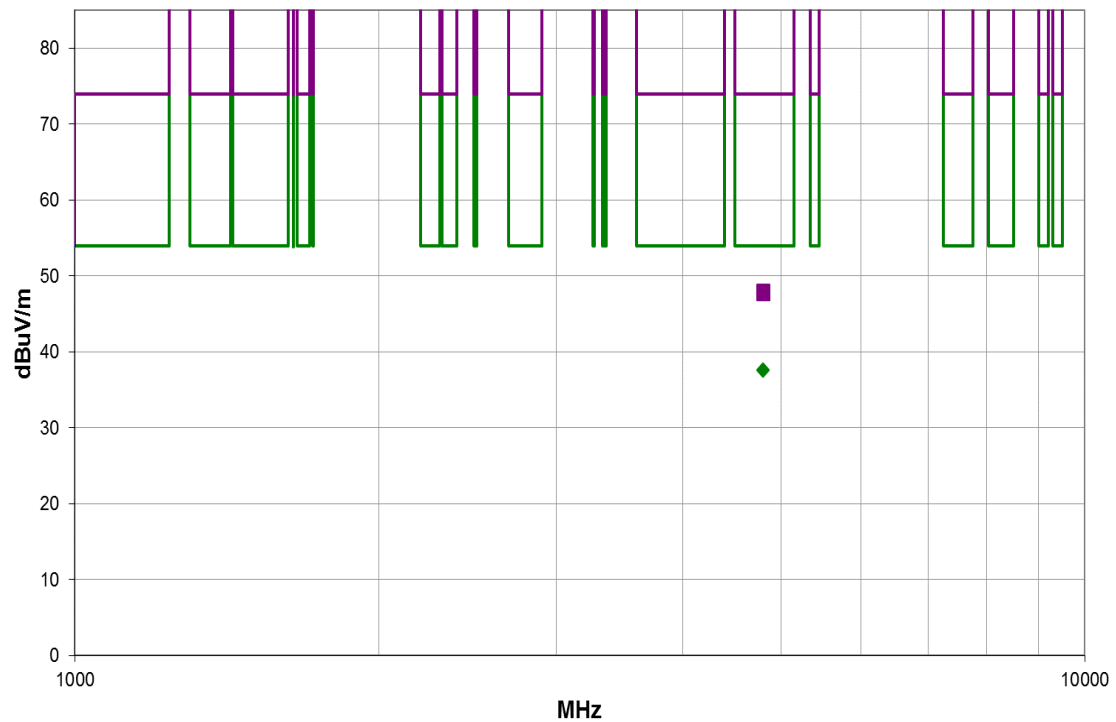
2402 MHz 1 GHz-3 GHz



2402 MHz 3 GHz-7 GHz

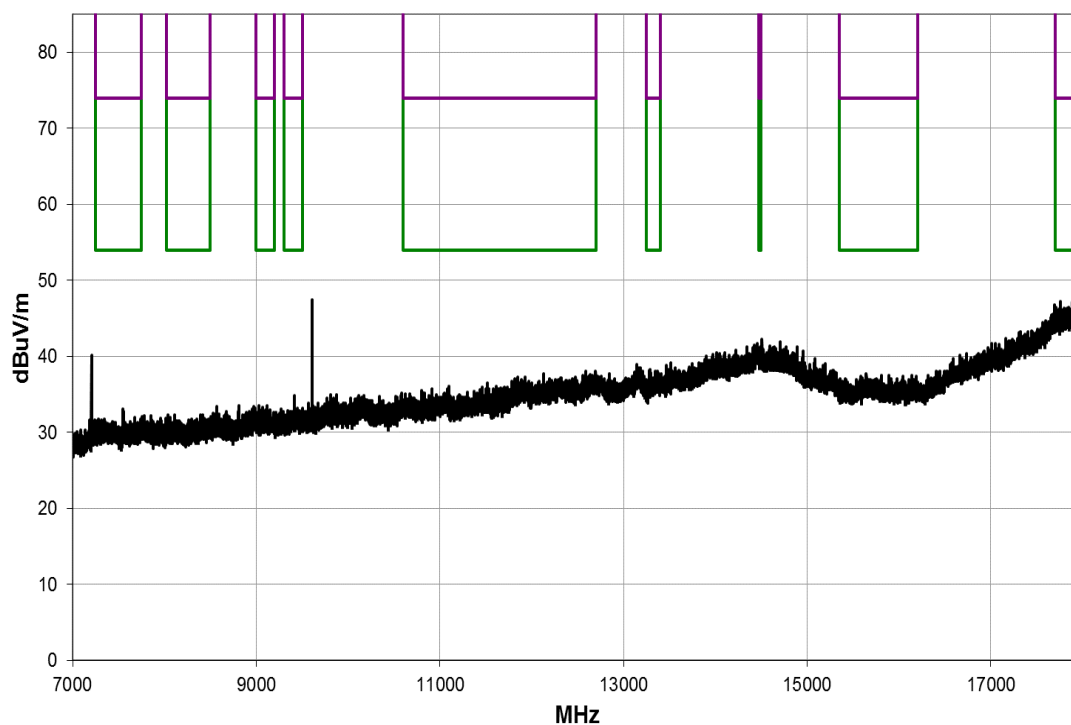


2402 MHz 3 GHz-7 GHz Maximised

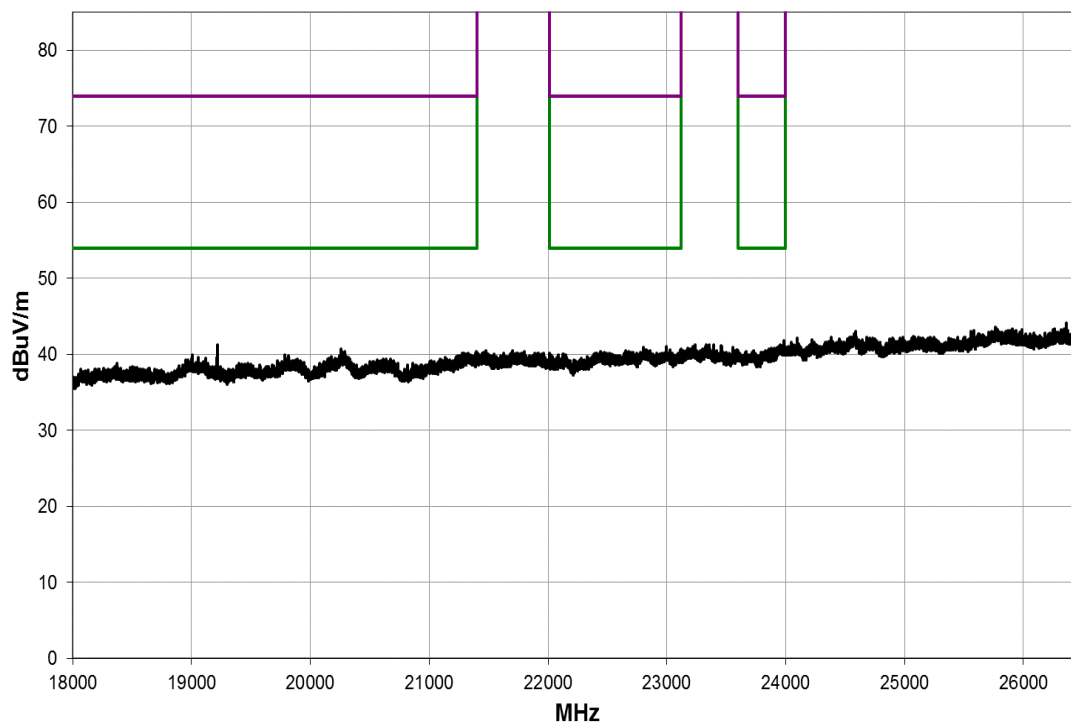


Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
4804.383	32.0	2.1	1.0	24.1	3.0	0.0	Horz	AV	0.0	37.5	54.0	-19.9	3.4 DCCF
4804.399	32.0	2.1	1.0	66.9	3.0	0.0	Horz	AV	0.0	37.5	54.0	-19.9	3.4 DCCF
4803.642	45.8	2.1	1.0	24.1	3.0	0.0	Horz	PK	0.0	47.9	74.0	-26.1	
4804.616	45.6	2.1	1.0	66.9	3.0	0.0	Horz	PK	0.0	47.7	74.0	-26.3	

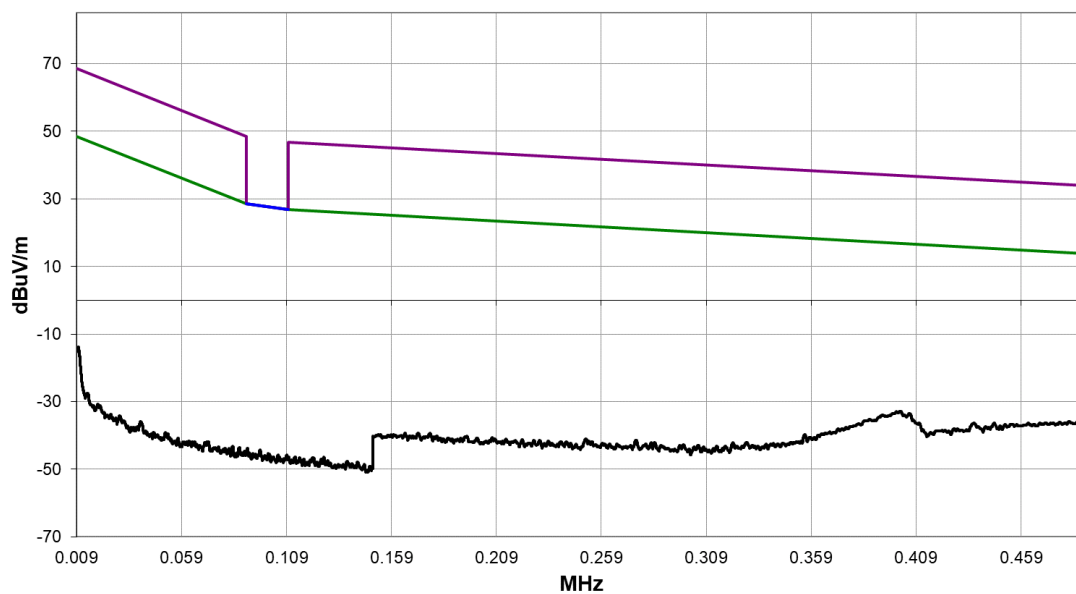
2402 MHz 7 GHz-18 GHz



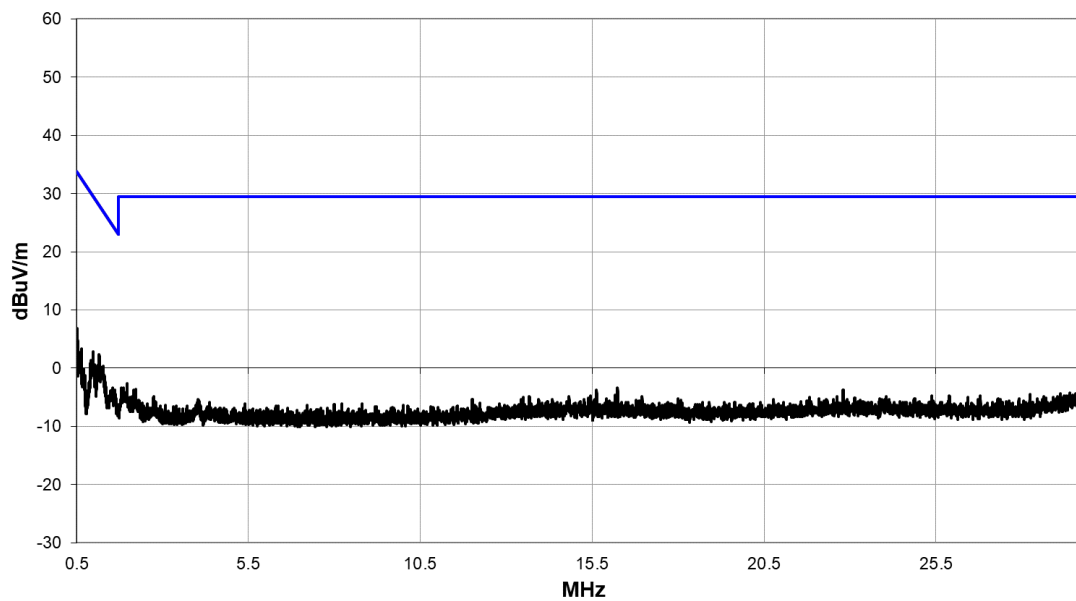
2402 MHz 18 GHz-26.5 GHz



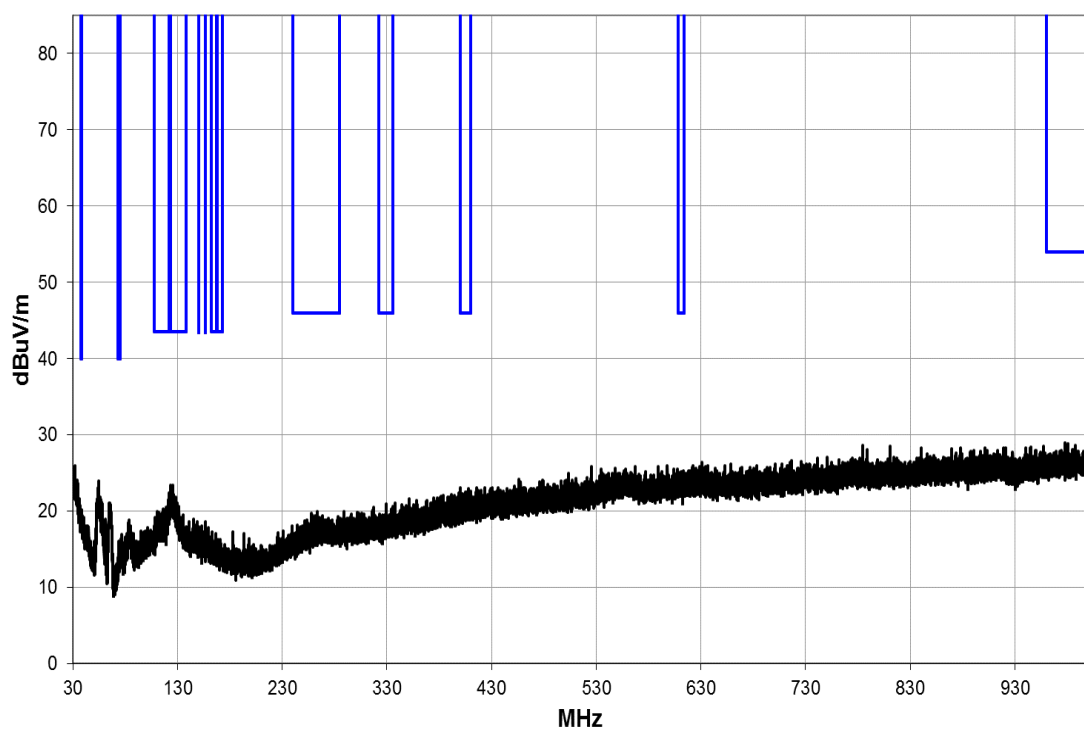
2440 MHz 9 kHz-490 MHz



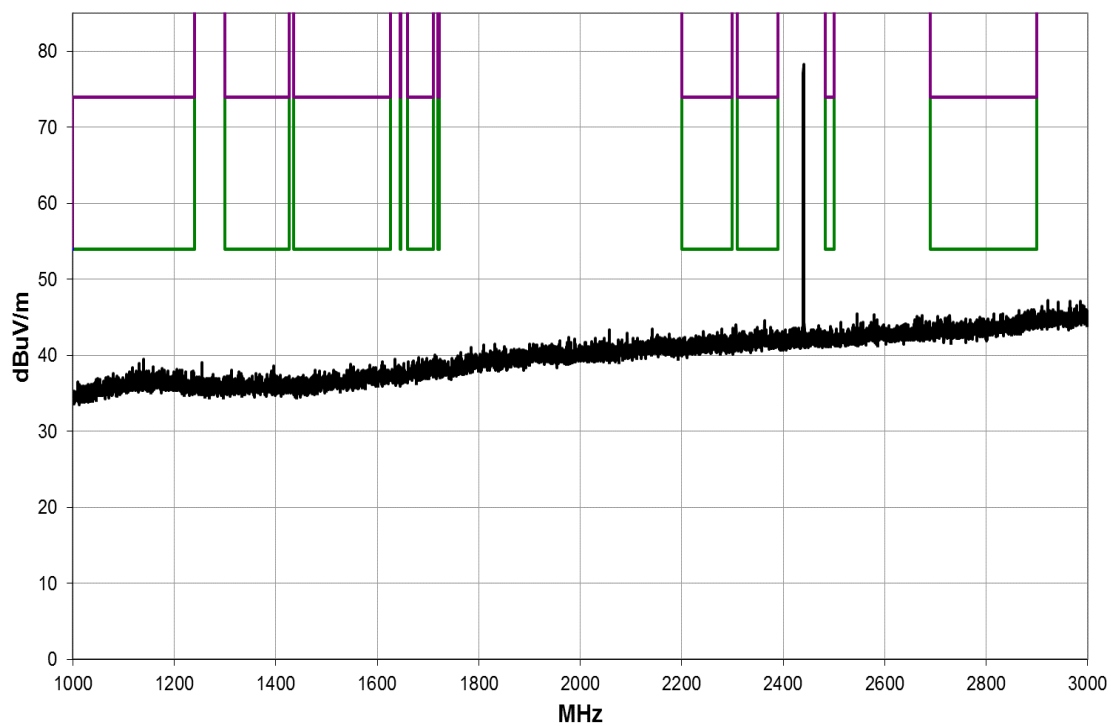
2440 MHz 490 kHz-30 MHz



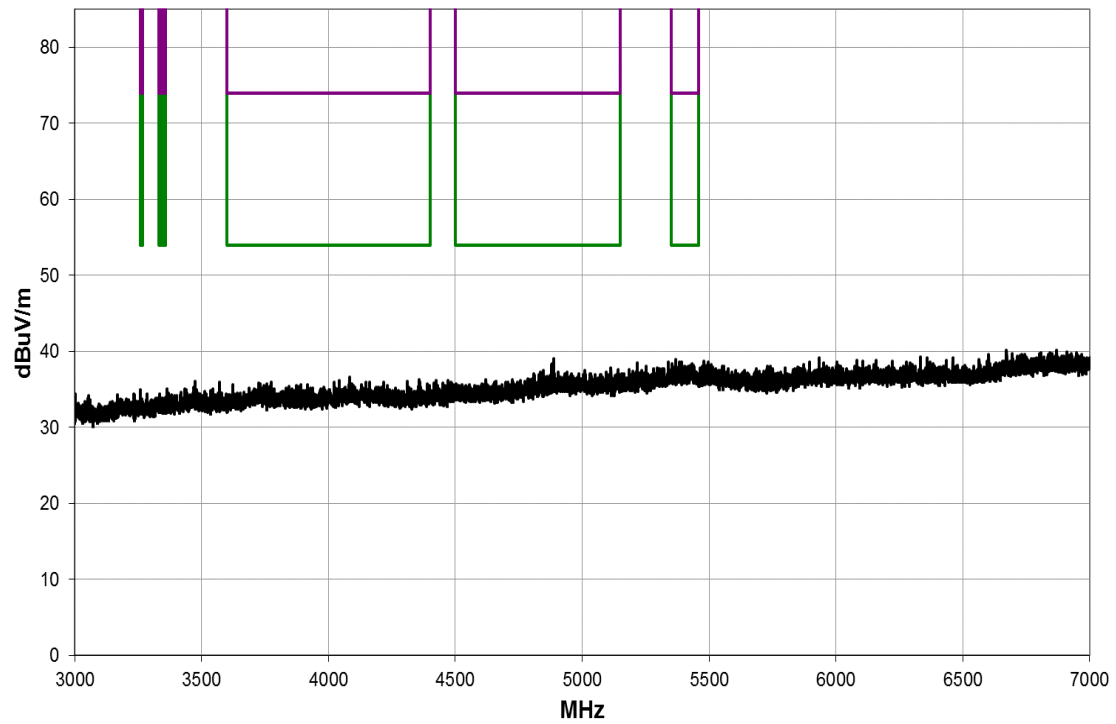
2440 MHz 30 MHz-1 GHz



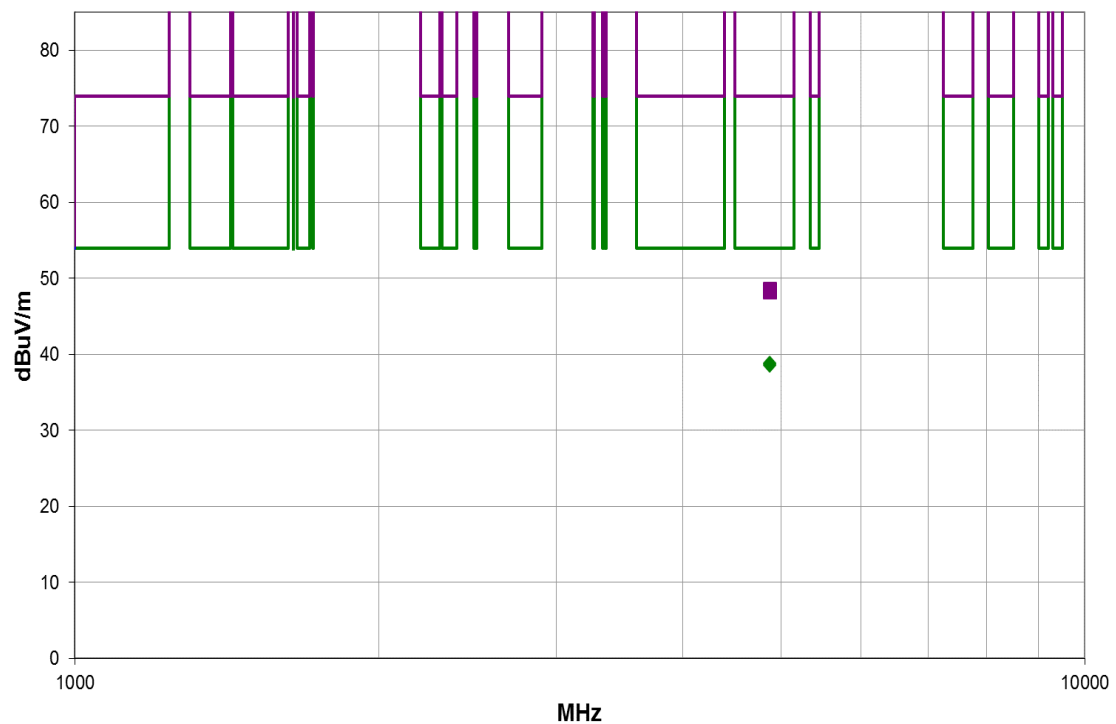
2440 MHz 1 GHz-3 GHz



2440 MHz 3 GHz-7 GHz

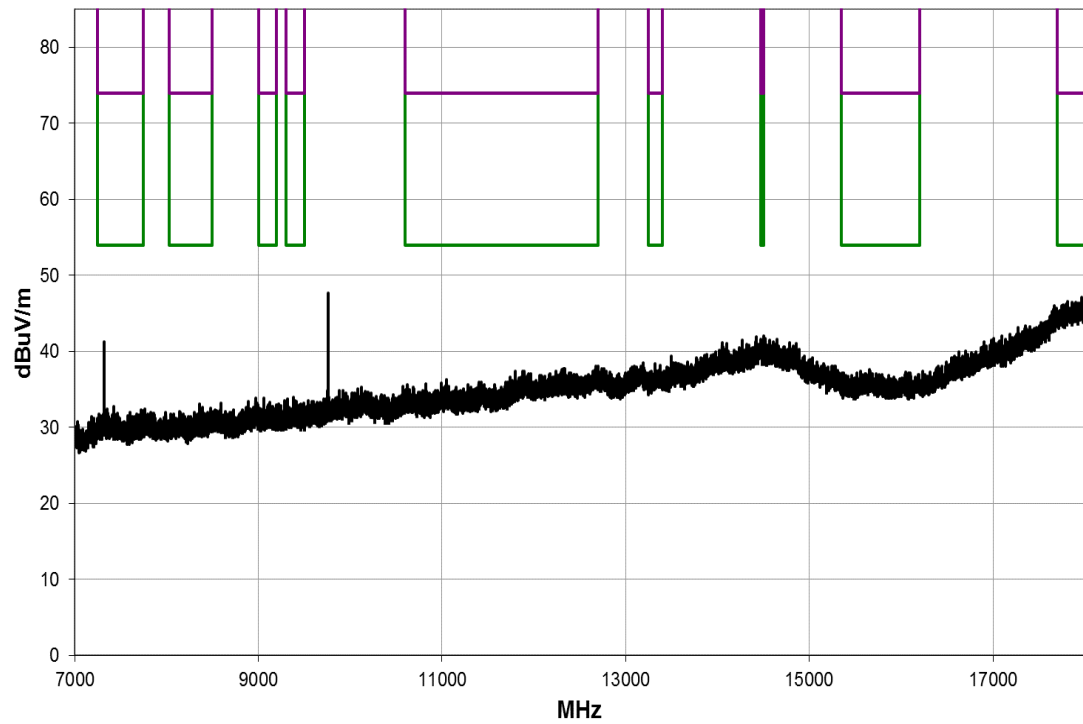


2440 MHz 3 GHz-7 GHz Maximised

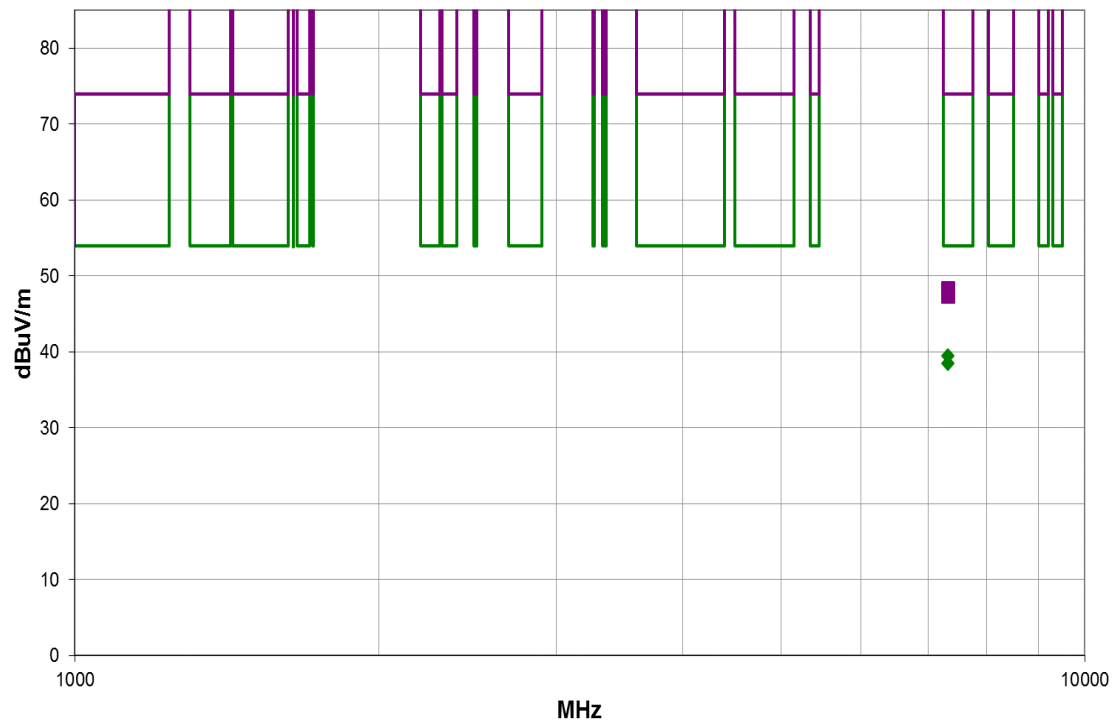


Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
4880.441	33.0	2.4	1.5	17.9	3.0	0.0	Horz	AV	0.0	38.8	54.0	-15.2	3.4 DCCF
4880.449	32.7	2.4	1.5	48.0	3.0	0.0	Horz	AV	0.0	38.5	54.0	-15.5	3.4 DCCF
4880.790	46.1	2.4	1.5	17.9	3.0	0.0	Horz	PK	0.0	48.5	74.0	-25.5	
4880.649	45.9	2.4	1.5	48.0	3.0	0.0	Horz	PK	0.0	48.3	74.0	-25.7	

2440 MHz 7 GHz-18 GHz

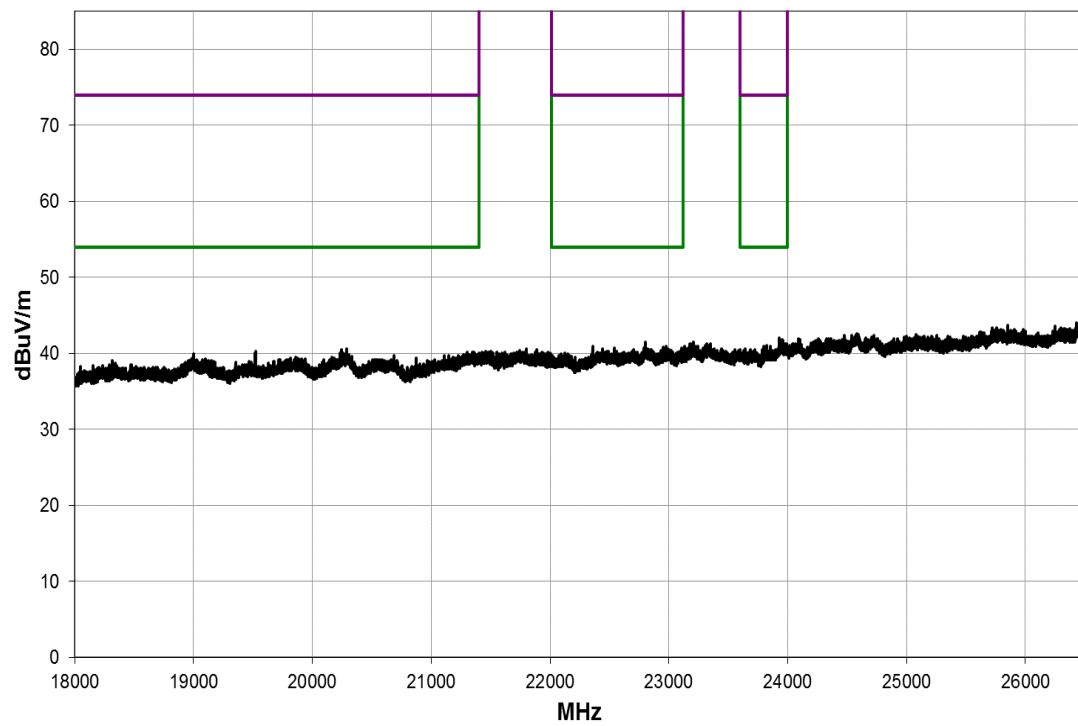


2440 MHz 7 GHz-18 GHz Maximised

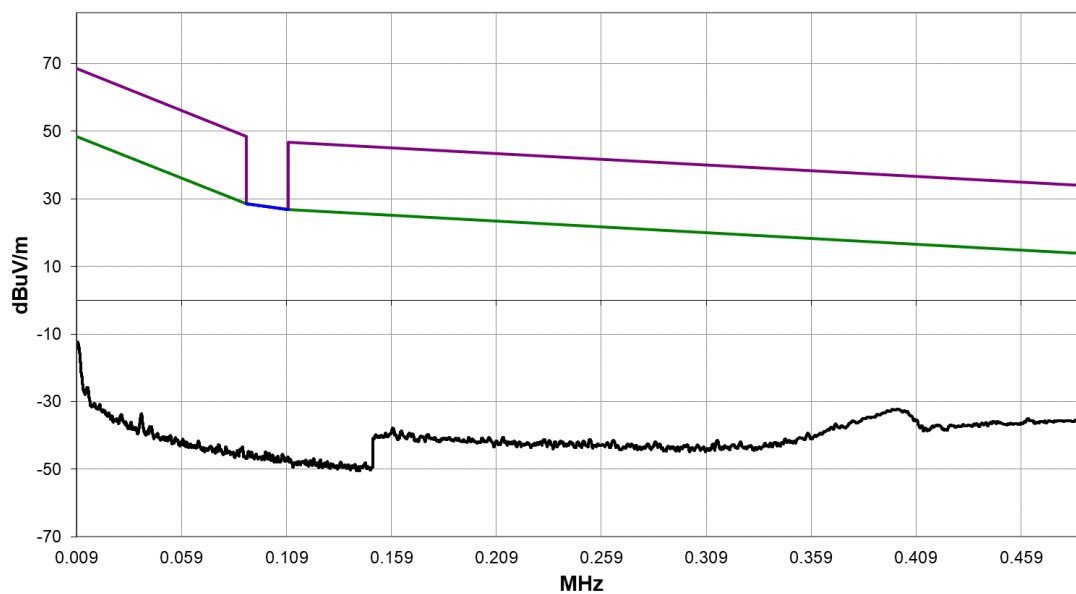


Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7320.799	38.9	6.6	1.5	189.0	1.0	0.0	Vert	AV	-9.5	39.4	54.0	-14.6	3.4 DCCF
7320.799	37.9	6.6	1.5	-0.1	1.0	0.0	Horz	AV	-9.5	38.4	54.0	-15.6	3.4 DCCF
7320.932	51.2	6.6	1.5	189.0	1.0	0.0	Vert	PK	-9.5	48.3	74.0	-25.7	
7319.110	50.3	6.6	1.5	-0.1	1.0	0.0	Horz	PK	-9.5	47.4	74.0	-26.6	

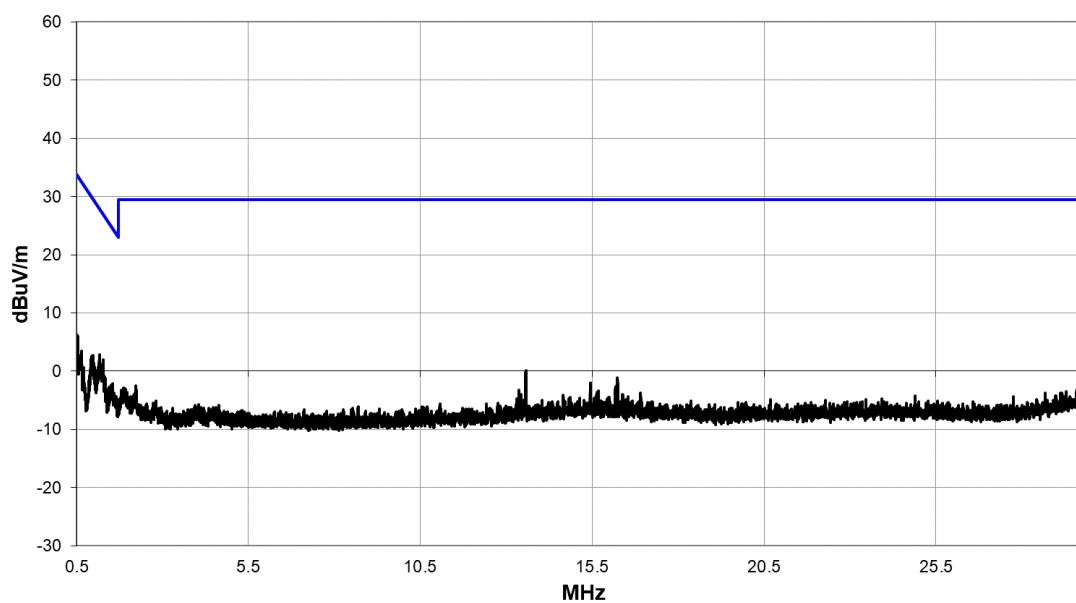
2440 MHz 18 GHz-26.5 GHz



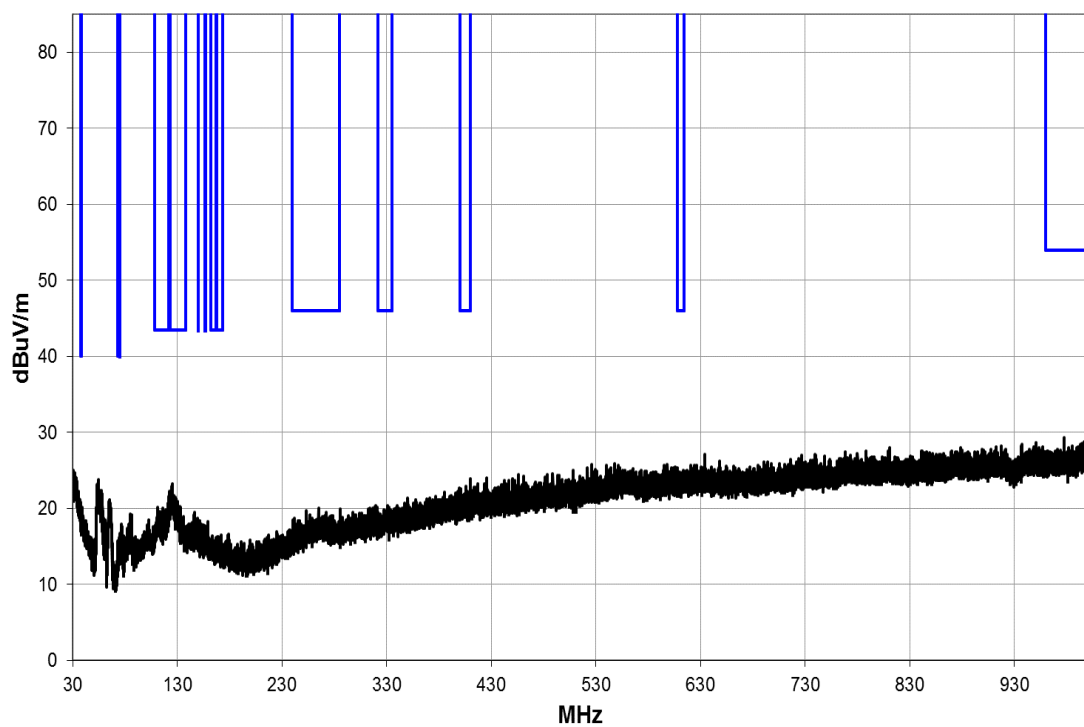
2480 MHz 9 kHz-490 MHz



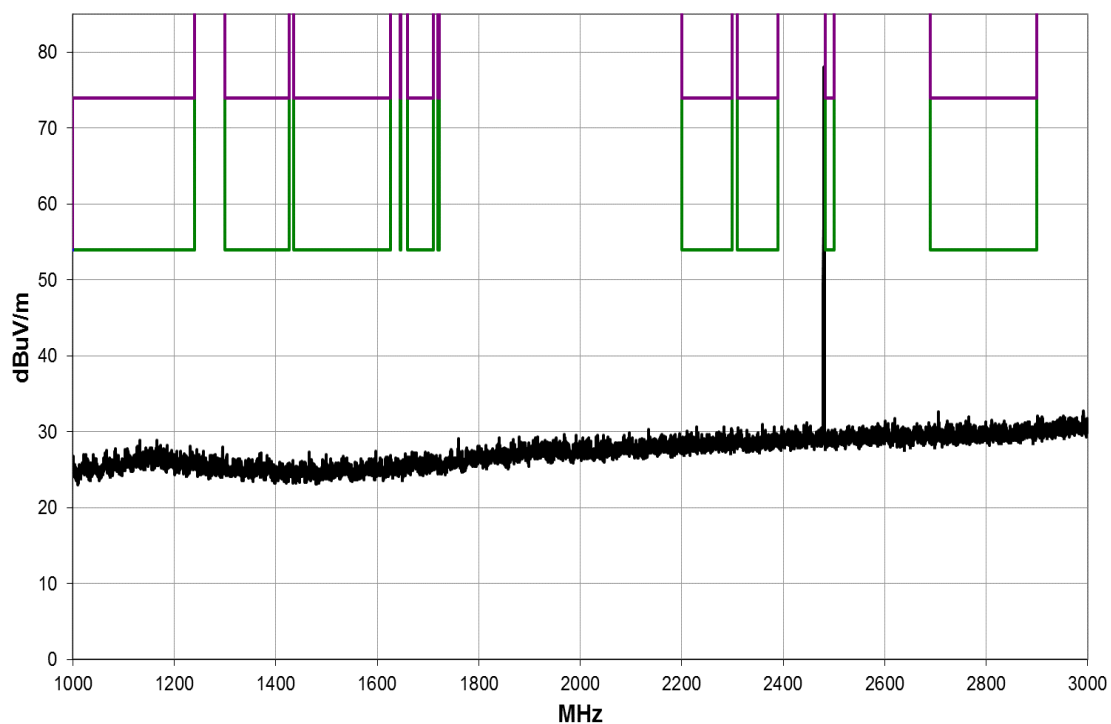
2480 MHz 490 kHz-30 MHz



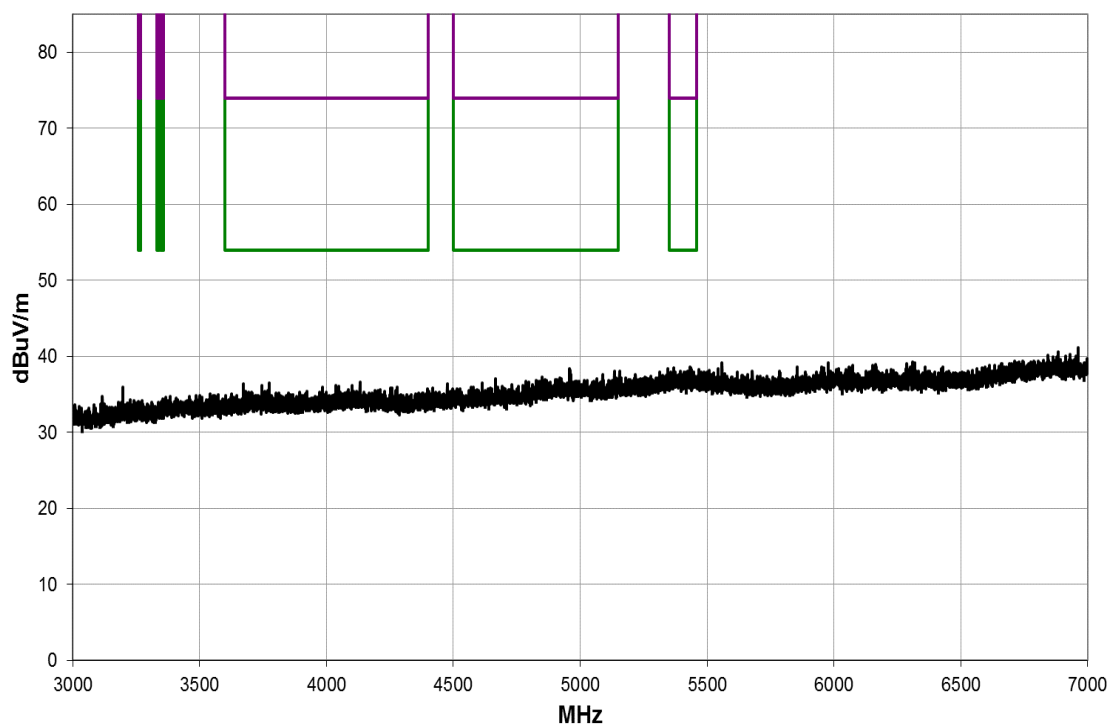
2480 MHz 30 MHz-1 GHz



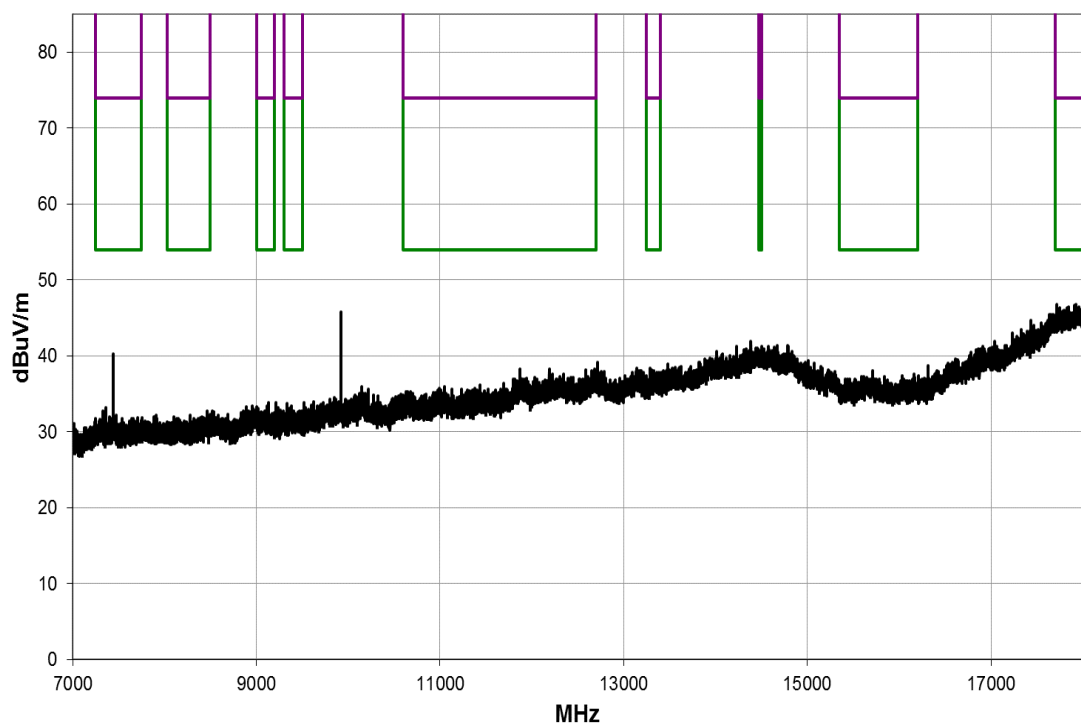
2480 MHz 1 GHz- 3 GHz



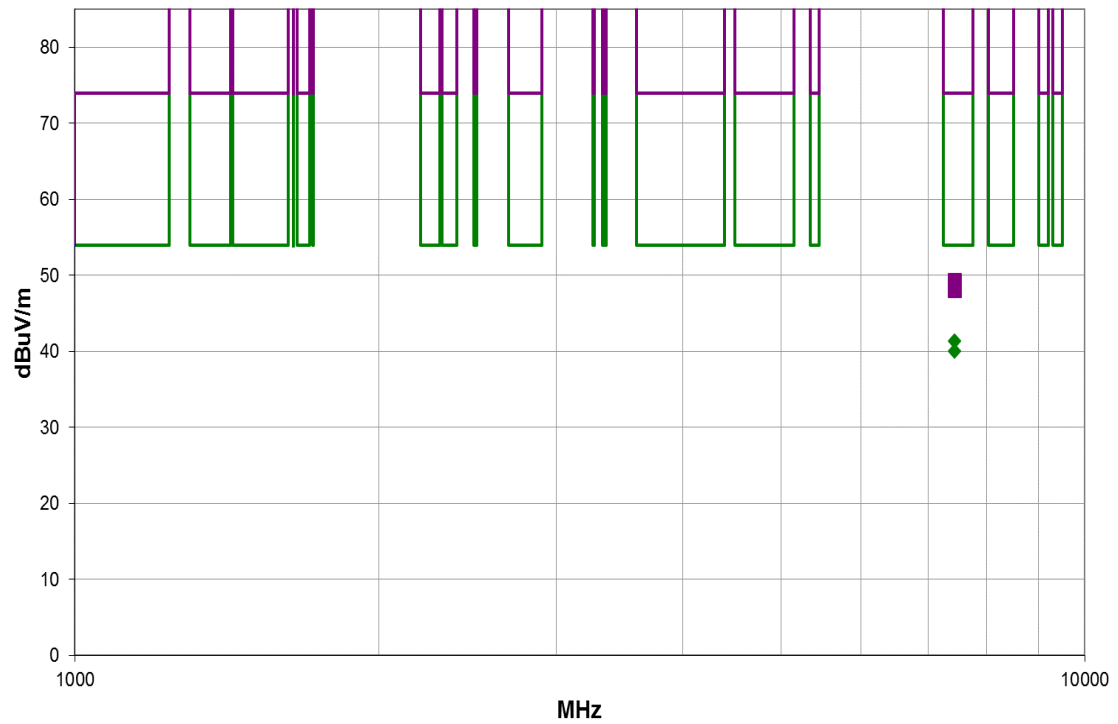
2480 MHz 3 GHz-7 GHz



2480 MHz 7 GHz-18 GHz

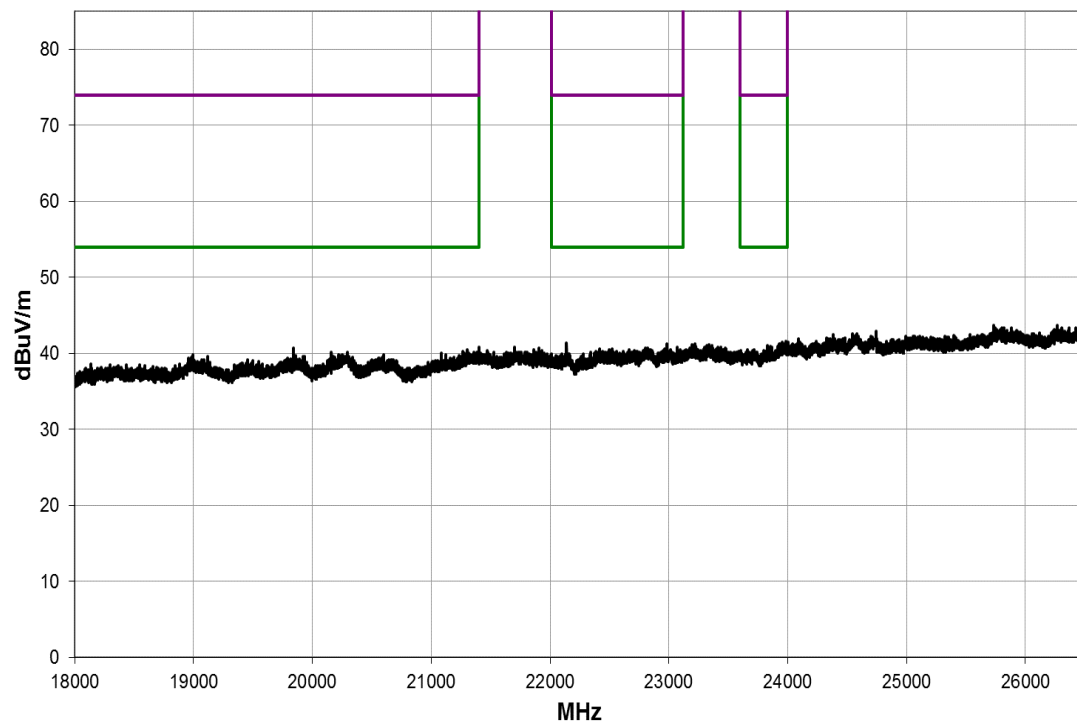


2480 MHz 7 GHz-18 GHz Maximised



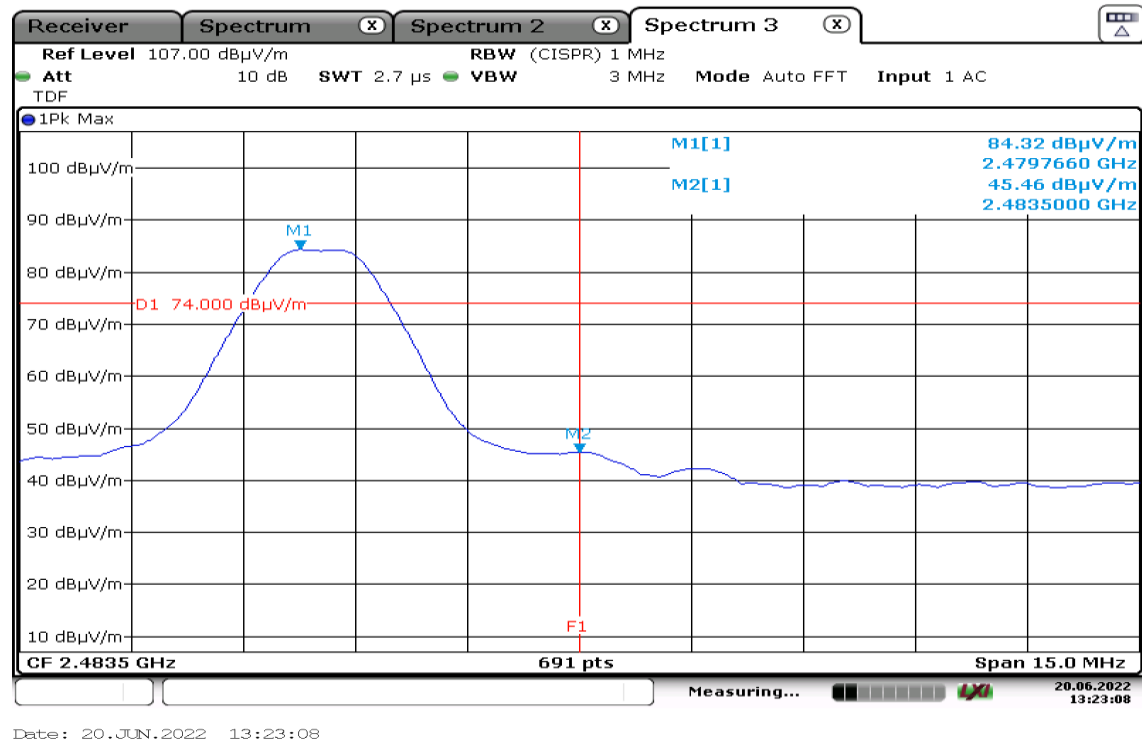
Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7440.790	40.8	6.6	1.45	149.0	1.0	0.0	Horz	AV	-9.5	41.3	54.0	-12.7	3.4 DCCF
7440.799	39.5	6.6	1.47	78.9	1.0	0.0	Vert	AV	-9.5	40.0	54.0	-14.0	3.4 DCCF
7439.235	52.2	6.6	1.45	149.0	1.0	0.0	Horz	PK	-9.5	49.3	74.0	-24.7	
7439.726	51.0	6.6	1.47	78.9	1.0	0.0	Vert	PK	-9.5	48.1	74.0	-25.9	

2480 MHz 18 GHz-26 .5 GHz



Note: All maximised Peak emissions, are lower than the average limit.

Upper bandedge Peak



Upper bandedge Average

Peak measurement is lower than the average limit, therefore the band edge measurement meets the average requirement by default.

12 Duty Cycle

12.1 Definition

The ratio of the sum of all pulse durations to the total period, during a specified period of operation.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Standard and Clause:	Radio Chamber SK03
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 22°C	+15 °C to +35 °C (as declared)
Humidity: 55% RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

N/A.

12.4 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 measured

[1] Single antenna output devices

Duty was measured at the antenna port / at a distance of 3 m.

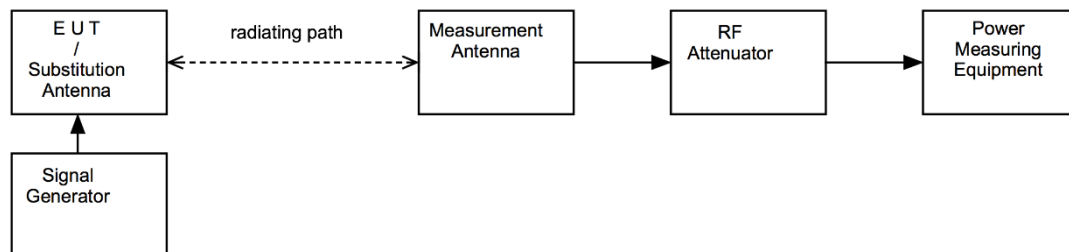
[2] Multiple antenna output devices

Duty was measured as the combination of all ports simultaneously / at a distance of 3 m.

The duty cycle correction factor, DC, shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as:

- 1) If power averaging (rms) mode was used in step f), then the applicable correction factor is $[10 \log (1 / D)]$, where D is the duty cycle.
- 2) If linear voltage averaging mode was used in step f), then the applicable correction factor is $[20 \log (1 / D)]$, where D is the duty cycle.
- 3) If a specific emission is demonstrated to be continuous ($D \geq 98\%$) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Figure vii Test Setup

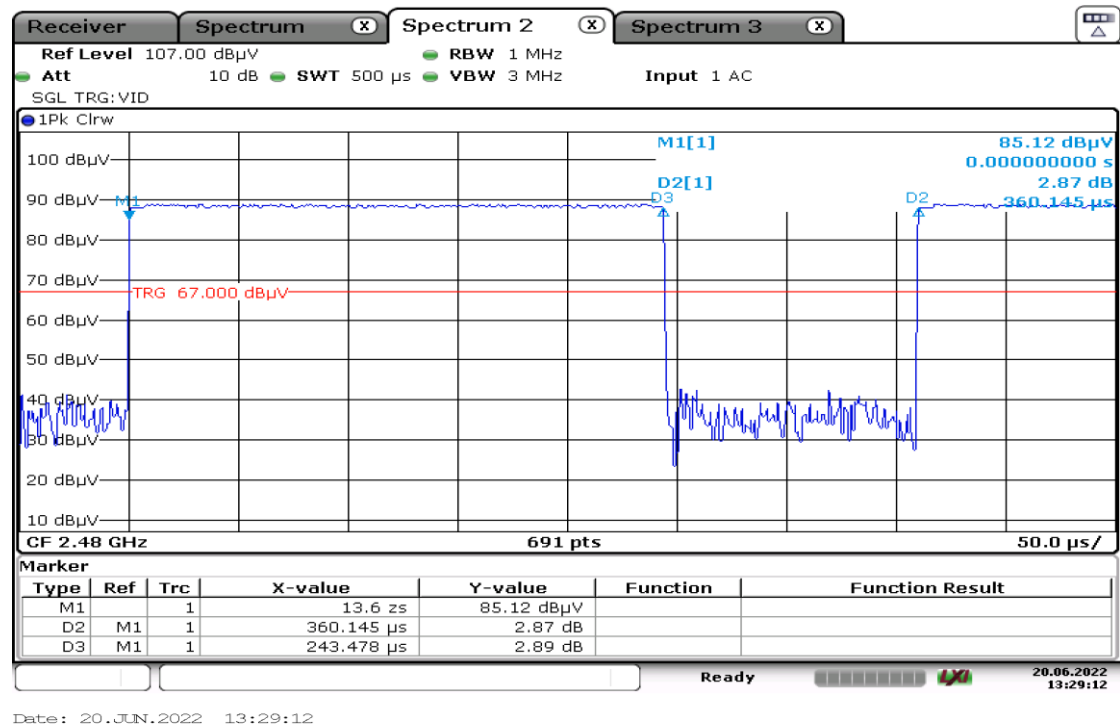


12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
LNA6901	AMETEK	Pre Amp	U711	2023-03-14
CBL6112B	Chase	Bilog	U093	2021-09-25
3115	EMCO	1-18GHz Horn	L139	2023-07-27
8449B	Agilent	Pre Amp	L572	2022-10-29

12.6 Test Results

Modulation: GFSK;				
Test Environment		TxOn time (ms)	Frame Period (ms)	Calculated Factor (dB)
V _{nominal}	T _{nominal}	0.243478	0.360145	3.4



$$20 \log (0.360145 \div 0.243478) = 3.4$$

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.

The 99% emission bandwidth is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	6 dB Bandwidth: ANSI C63.10-2013, Clause 11.8
Frequencies Measured:	2402 MHz / 2440 MHz/ 2480 MHz
EUT Channel Bandwidths:	1 MHz
EUT Test Modulations:	GFSK
Deviations from Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22.5 °C	+15 °C to +35 °C (as declared)
Humidity: 55 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

13.3 Test Limit

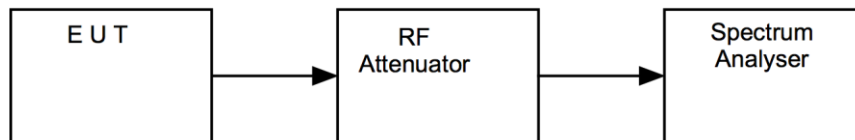
The minimum -6 dB bandwidth shall be at least 500 kHz.

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



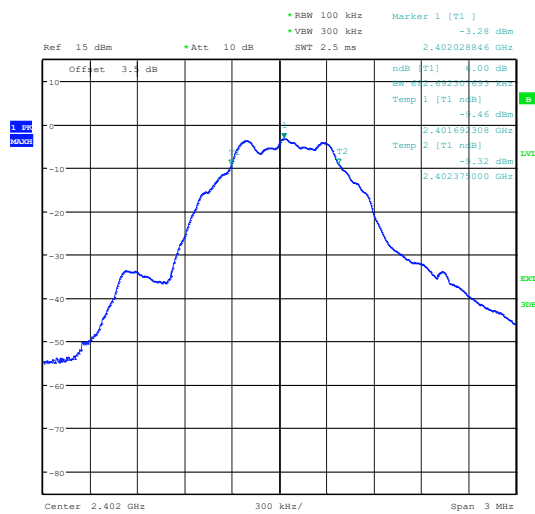
13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	22/12/2022
Attenuator	AtlanTecRF Microwave	3 dB	U637	Cal in use

13.6 Test Results

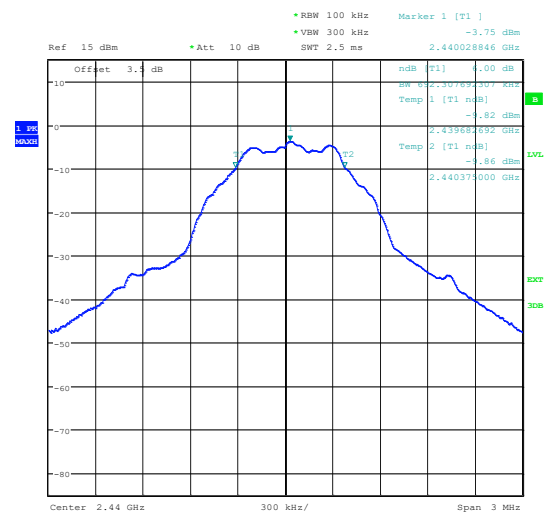
Bandwidth Type: 6 dB; Modulation: GFSK; Power setting: Default				
Frequency (MHz)	F_L (MHz)	F_H (MHz)	Bandwidth (kHz)	Result
2402	2401.692308	2402.375000	682.692	PASS
2440	2439.682692	2440.375000	692.308	PASS
2480	2479.692308	2480.375000	682.692	PASS

2402 MHz



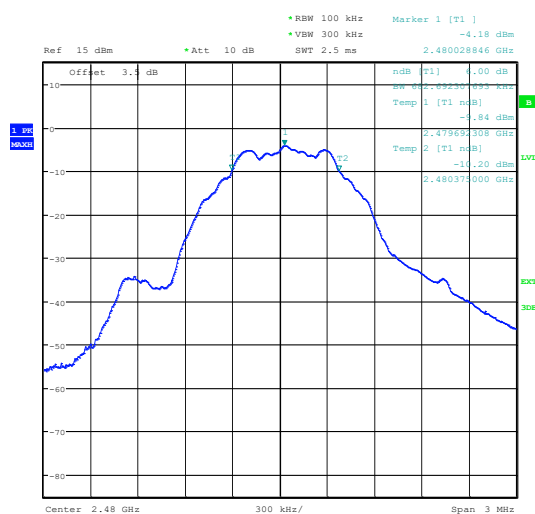
Date: 23.JUN.2022 11:26:46

2440 MHz



Date: 23.JUN.2022 11:33:29

2480 MHz



Date: 23.JUN.2022 11:32:46

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.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
Frequencies Measured:	2402 MHz/ 2440 MHz/ 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations from Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 22.5 °C	+15 °C to +35 °C (as declared)
Humidity: 55 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

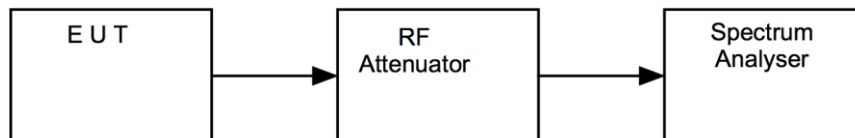
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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

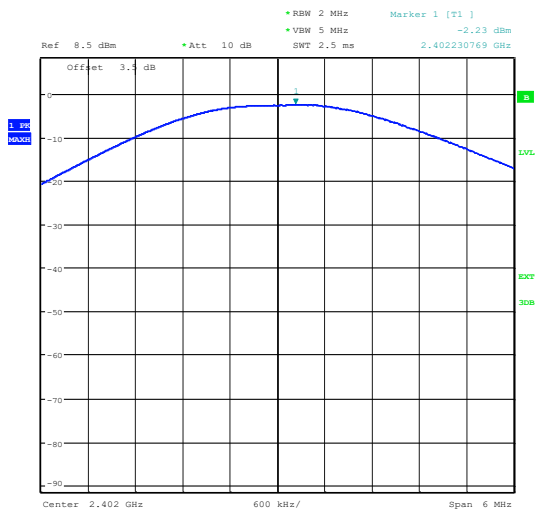
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	22/12/2022
Attenuator	AtlanTecRF Microwave	3 dB	U637	Cal in use

14.6 Test Results

FCC

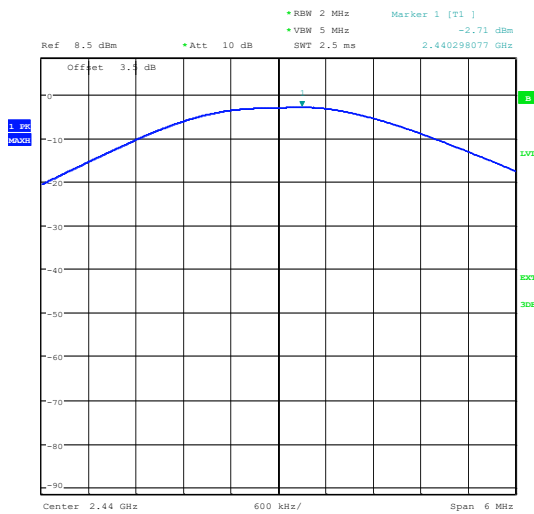
<i>Modulation: GFSK; Power setting: Default</i>			
<i>Frequency (MHz)</i>	<i>Maximum peak conducted output power</i>		<i>Result</i>
	<i>(dBm)</i>	<i>(W)</i>	
2402	-2.23	0.00059	Pass
2440	-2.71	0.00053	Pass
2480	-3.22	0.00047	Pass

2402 MHz



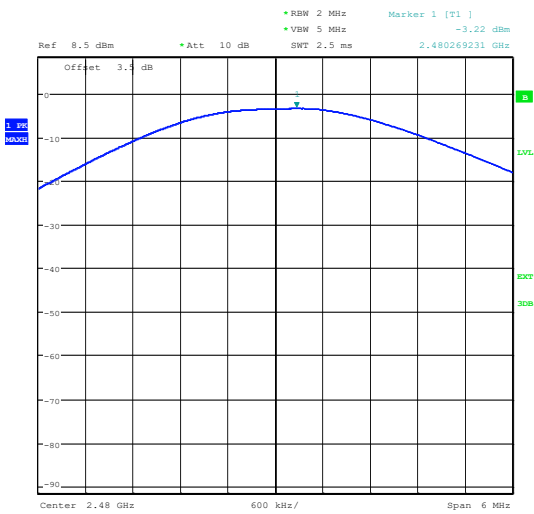
Date: 23.JUN.2022 13:22:18

2440 MHz



Date: 23.JUN.2022 13:22:48

2480 MHz



Date: 23.JUN.2022 13:23:19

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
Frequencies Measured:	2402 MHz / 2440 MHz/ 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations from Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 22.5 °C	+15 °C to +35 °C (as declared)
Humidity: 55% RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

15.3 Test Limit

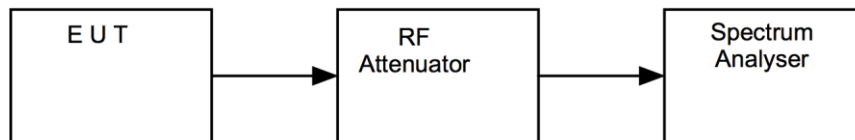
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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



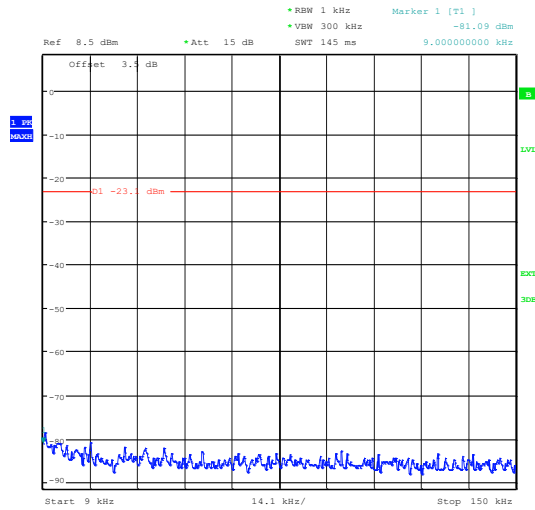
15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	22/12/2022
Attenuator	AtlanTecRF Microwave	3 dB	U637	Cal in use

15.6 Test Results

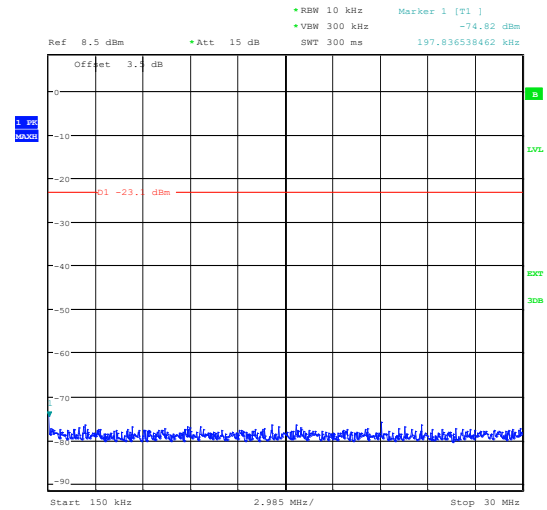
2402 MHz

9 kHz - 150 kHz



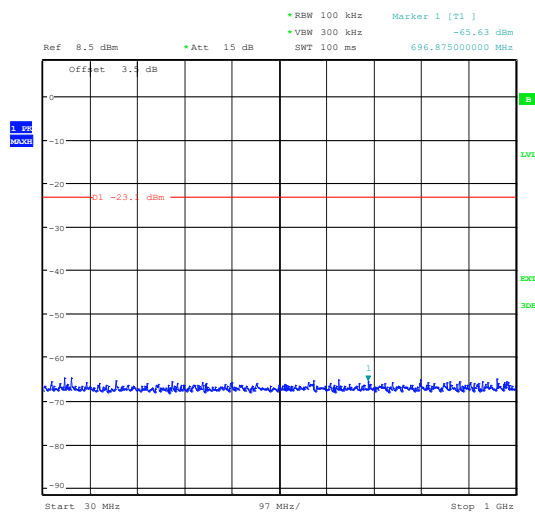
Date: 23.JUN.2022 14:08:18

150 kHz - 30 MHz



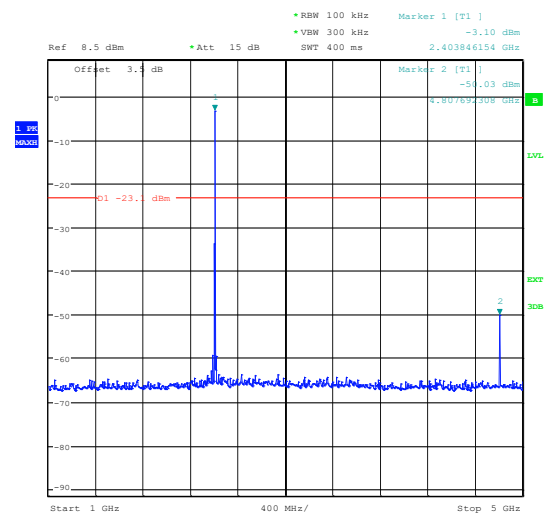
Date: 23.JUN.2022 14:08:55

30 MHz - 1GHz



Date: 23.JUN.2022 14:07:49

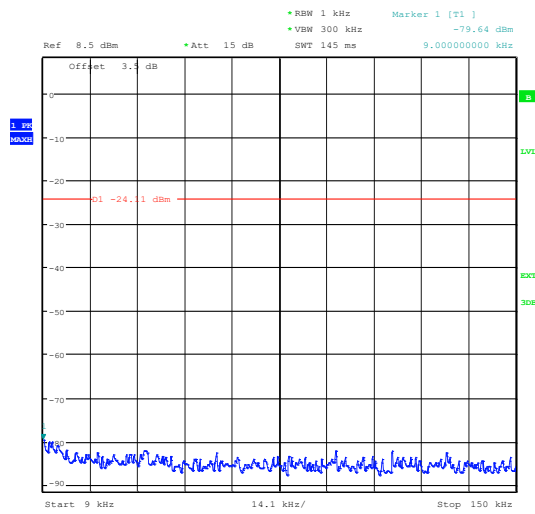
1 GHz - 5 GHz



Date: 23.JUN.2022 14:03:36

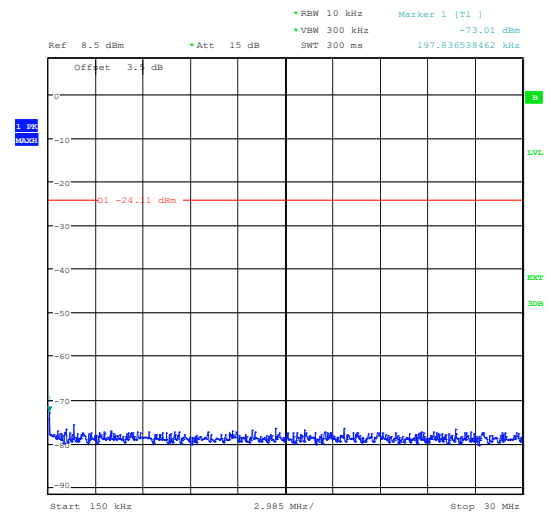
2440 MHz

9 kHz - 150 kHz



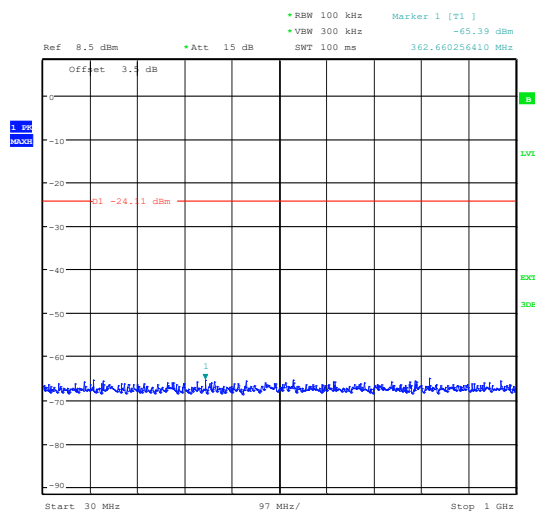
Date: 23.JUN.2022 14:18:11

150 kHz - 30 MHz



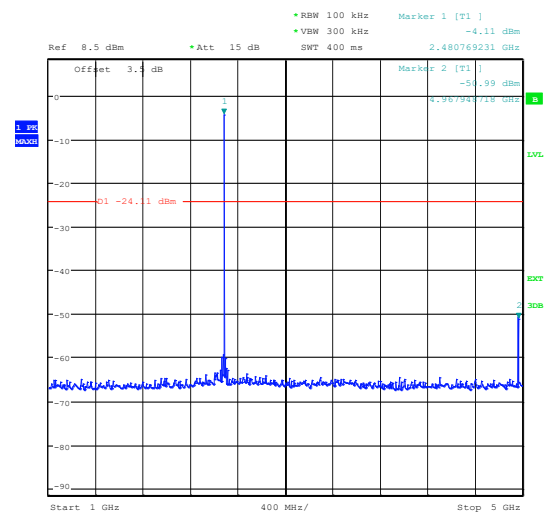
Date: 23.JUN.2022 14:18:59

30 MHz - 1GHz



Date: 23.JUN.2022 14:17:37

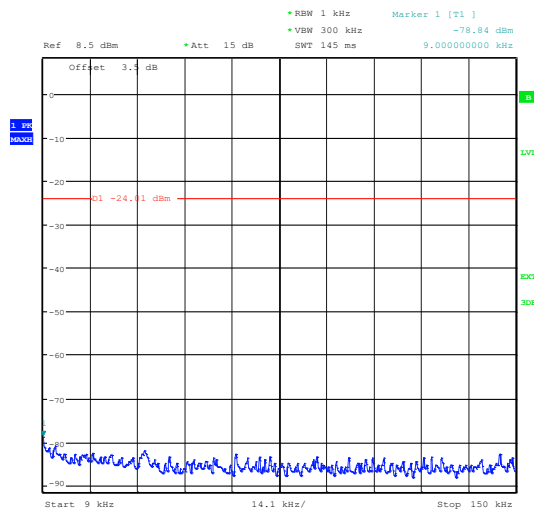
1 GHz - 5 GHz



Date: 23.JUN.2022 14:11:48

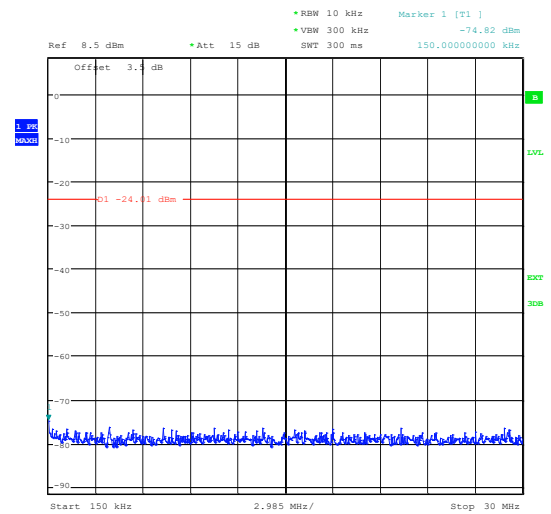
2480 MHz

9 kHz - 150 kHz



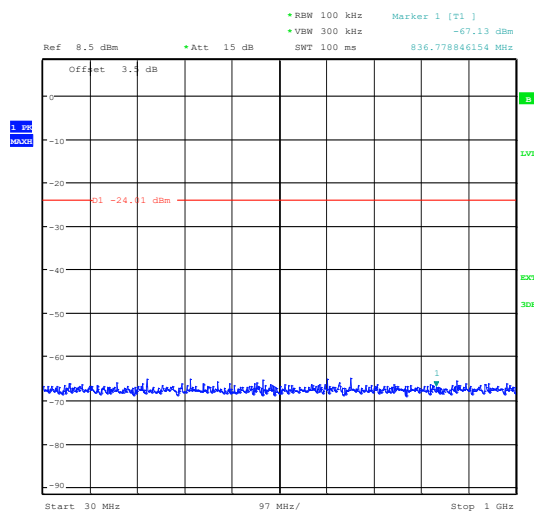
Date: 23.JUN.2022 14:37:53

150 kHz - 30 MHz



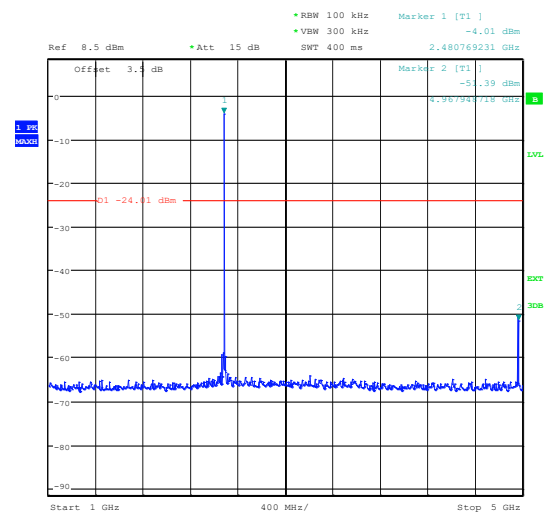
Date: 23.JUN.2022 14:38:22

30 MHz - 1GHz

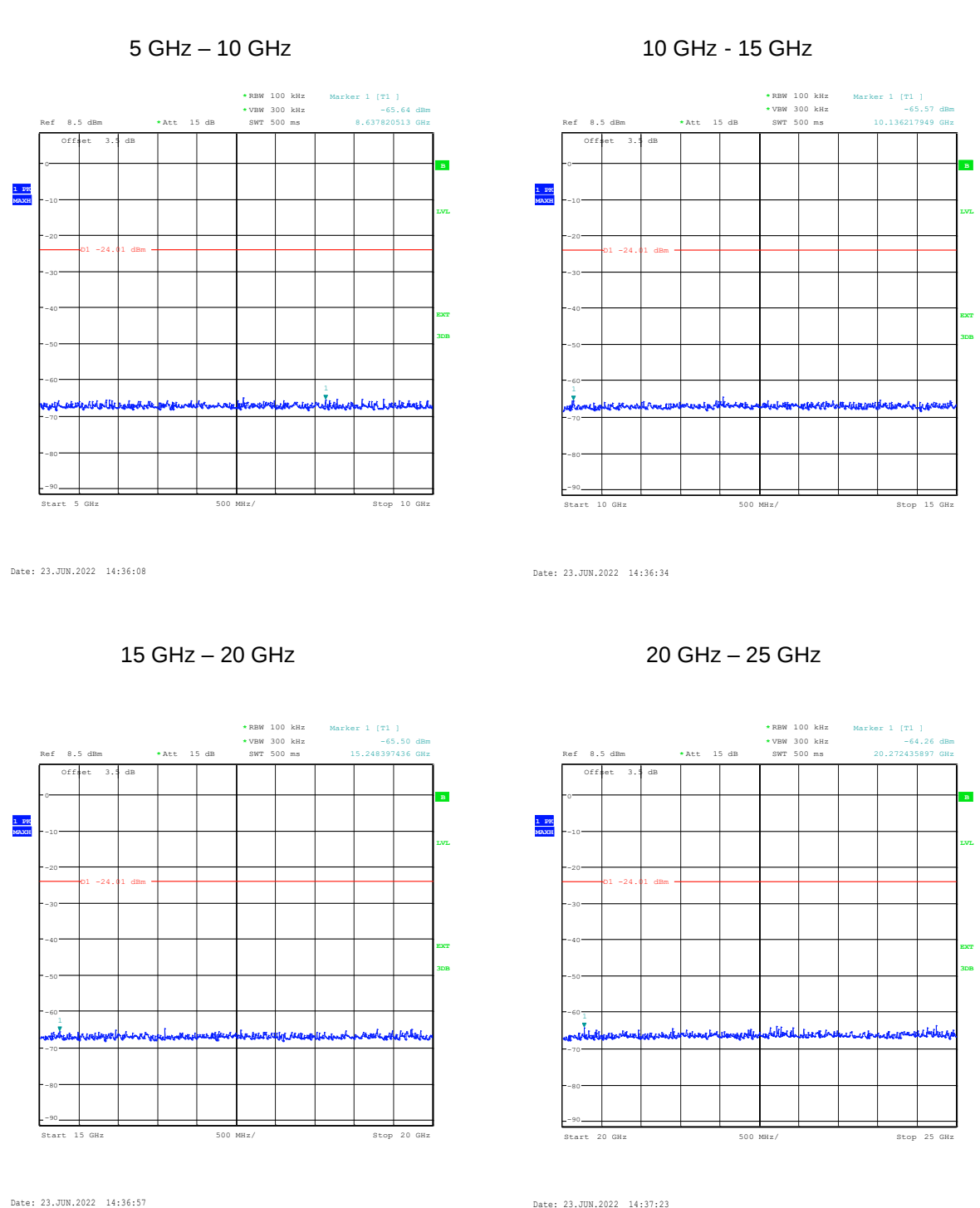


Date: 23.JUN.2022 14:39:31

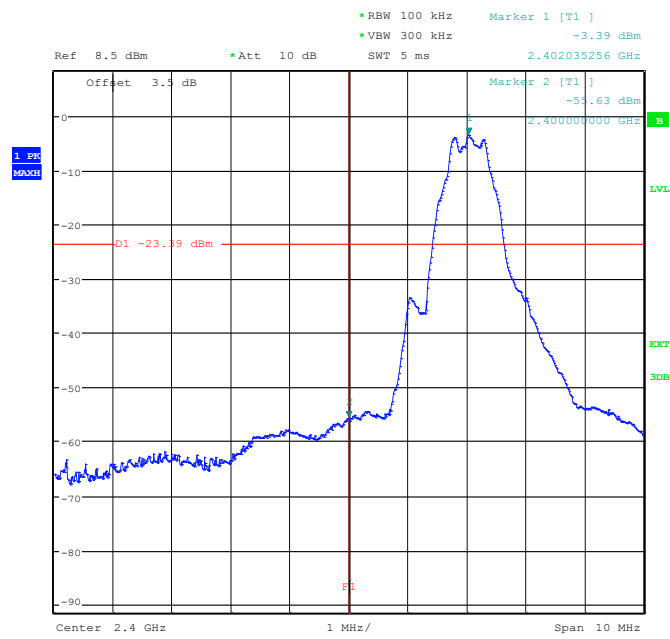
1 GHz - 5 GHz



Date: 23.JUN.2022 14:35:44

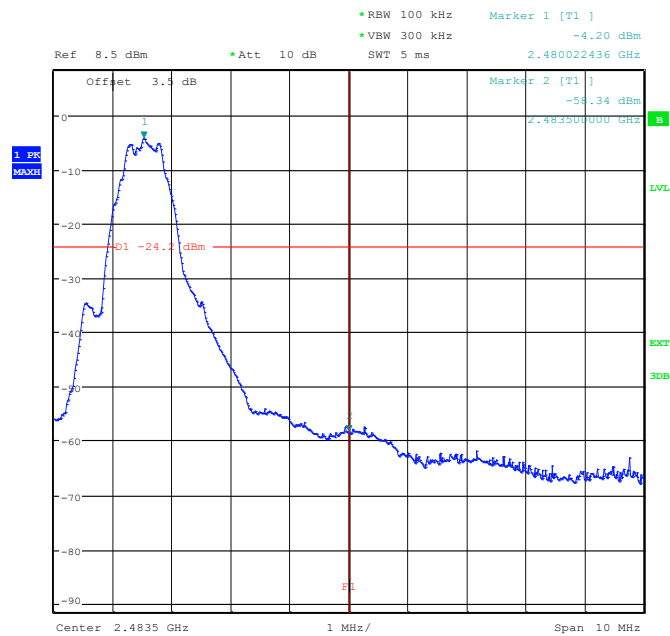


Lower bandege



Date: 23.JUN.2022 13:47:50

Upper bandege



Date: 23.JUN.2022 13:49:48

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
Frequencies Measured:	2402 MHz / 2440 MHz / 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations from Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1.05 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22.5 °C	+15 °C to +35 °C (as declared)
Humidity: 55 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

16.3 Test Limit

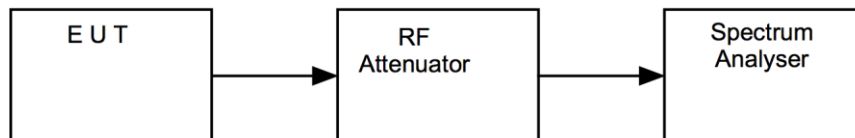
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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



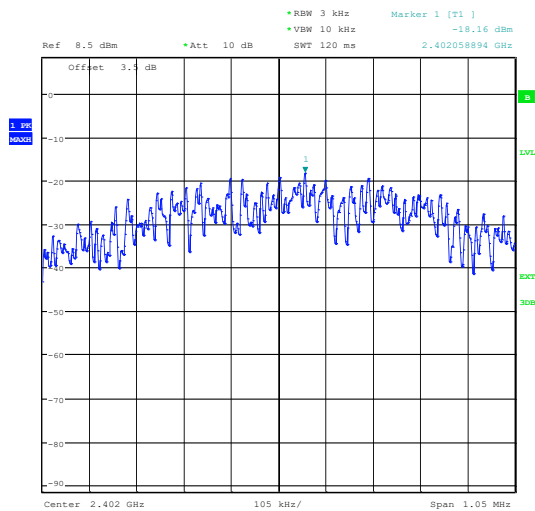
16.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU46	REF910	22/12/2022
Attenuator	AtlanTecRF Microwave	3 dB	U637	Cal in use

16.6 Test Results

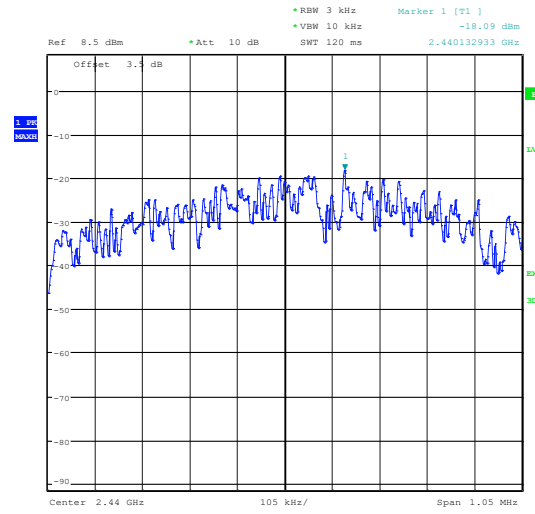
Modulation: GFSK; Power setting: Default		
Channel Frequency (MHz)	Power (dBm)	Result
2402	-18.16	PASS
2440	-18.09	PASS
2480	-19.13	PASS

2402 MHz



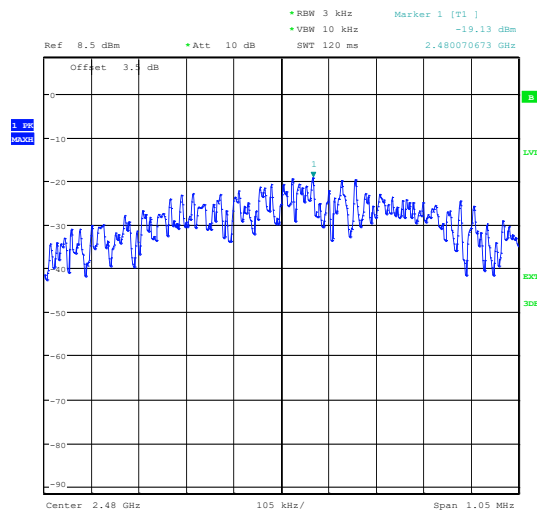
Date: 23.JUN.2022 15:01:28

2440 MHz



Date: 23.JUN.2022 15:02:07

2480 MHz



Date: 23.JUN.2022 15:02:40

17 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Test/Measurement	Budget Number	MU
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connector) Dare RPR3006W Power Head	MU4001	0.9 dB
Carrier Power and PSD - Spectrum Analysers	MU4004	0.9 dB
Adjacent Channel Power	MU4002	1.9 dB
Transmitter conducted spurious emissions	MU4041	0.9 dB
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	2.4 dB
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	2.5 dB
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	2.4 dB
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	3.7 dB
Effective Radiated Power	MU4021	4.7 dB
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	5.3 dB
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	5.1 dB
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	2.7 dB
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	2.7 dB
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz	MU4037	4.7 dB
Radiated Spurious Emissions 1-18 GHz	MU4032	4.5 dB
E Field Emissions 18GHz to 26 GHz	MU4024	3.2 dB
E Field Emissions 26GHz to 40 GHz	MU4025	3.3 dB
E Field Emissions 40GHz to 50 GHz	MU4026	3.5 dB
E Field Emissions 50GHz to 75 GHz	MU4027	3.6 dB
E Field Emissions 75GHz to 110 GHz	MU4028	3.6 dB
Radiated Magnetic Field Emissions	MU4031	2.3 dB
Frequency Measurements		
Frequency Deviation	MU4022	0.316 kHz
Frequency error using CMTA test set	MU4023	113.441 Hz
Frequency error using GPS locked frequency source	MU4045	0.0413 ppm
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	3.87 %
Transmitter Mask Amplitude	MU4039	1.3 dB
Transmitter Mask Frequency	MU4040	2.59 %
Time Domain Measurements		
Transmission Time	MU4038	4.40 %
Dynamic Frequency Selection (DFS) Parameters)		
DFS Analyser - Measurement Time	MU4006	679 μ s
DFS Generator - Frequency Error	MU4007	92 Hz
DFS Threshold Conducted	MU4008	1.3 dB
DFS Threshold Radiated	MU4009	3.2 dB

Test/Measurement	Budget Number	MU
Receiver Parameters		
EN300328 Receiver Blocking	MU4010	1.1 dB
EN301893 Receiver Blocking	MU4011	1.1 dB
EN303340 Adjacent Channel Selectivity	MU4012	1.1 dB
EN303340 Overloading	MU4013	1.1 dB
EN303340 Receiver Blocking	MU4014	1.1 dB
EN303340 Receiver Sensitivity	MU4015	0.9 dB
EN303372-1 Image Rejection	MU4016	1.4 dB
EN303372-1 Receiver Blocking	MU4017	1.1 dB
EN303372-2 Adjacent Channel Selectivity	MU4018	1.1 dB
EN303372-2 Dynamic Range	MU4019	0.9 dB
Receiver Blocking Talk Mode Conducted	MU4033	1.2 dB
Receiver Blocking Talk Mode- radiated	MU4034	3.4 dB
Rx Blocking, listen mode, blocking level	MU4035	3.2 dB
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	3.4 dB
Adjacent Sub Band Selectivity	MU4003	4.2 dB

18 RF Exposure

General SAR test reduction & exclusion guidance

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 frequencies in the range 100 MHz to 6 GHz, and for test separation distance of ≤ 50 mm, is determined as follows.

$$\text{SAR Exclusion Threshold (SARET)} = (\text{NT} \times \text{TSD}_A) / \sqrt{f_{\text{GHz}}}$$

Where,

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

TSD_A = Minimum Test separation distance or 50 mm (whichever is lower)

f_{GHz} = Transmit frequency in GHz

<i>Channel Frequency (MHz)</i>	<i>Maximum Conducted Power (mW)</i>	<i>SAR Exclusion Threshold at 5 mm (mW)</i>	<i>SAR Evaluation</i>
2402	0.6	9.7	Not Required
2440	0.5	9.6	Not Required
2480	0.5	9.5	Not Required

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

MPE Calculation

Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20 cm separation specified under FCC rules may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than the power density limit, as required under FCC rules.

Equation from IEEE C95.1

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

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Channel Frequency (MHz)	EIRP (mW)	Power density limit (S) (mW/cm²)	Distance (R) cm required to be less than the power density limit
2402	1.10	1.0	0.296
2440	0.95	1.0	0.283
2480	0.85	1.0	0.283