Report on the Radio Testing

For

Pektron Group Ltd

on

Lordstown Motors Bluetooth Key

Report no. TRA-056845-47-00B

23rd August 2022

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: Digitally signed by Michael Else Date: 2022.08.23 11:22:57 +01'00'

Steven Hodgkinson
Michael Else
Radio test engineer

Daniel Winstanley
Senior radio test engineer

Approved by:

Date: 23rd August 2022

# 1 Revision Record

| *Issue Number* | *Issue Date* | *Revision History* |
|---|---|---|
| A | 27TH July 2022 | Original |
| B | 23rd August 2022 | Radiated spurious emissions 9kHz to 30 MHz Pre-scans added. |

## 2 Summary

| | |
|---|---|
| TEST REPORT NUMBER: | TRA-058645-47-00B |
| 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<br>Derby<br>Derbyshire<br>DE21 4AP<br>United Kingdom |
| CLIENT CONTACT: | Richard Jones<br>☎ 01332832424 ext 382<br>✉ rjones@pektron.co.uk |
| TEST DATE: | 20th June 2022 to 23rd August 2022 |
| TESTED BY: | Steven Hodgkinson<br>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).

# 3 Contents

# 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
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:

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.

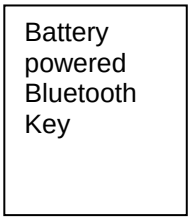
# 8 Modifications

No modifications were performed during this assessment.

# 9 EUT Test Setup

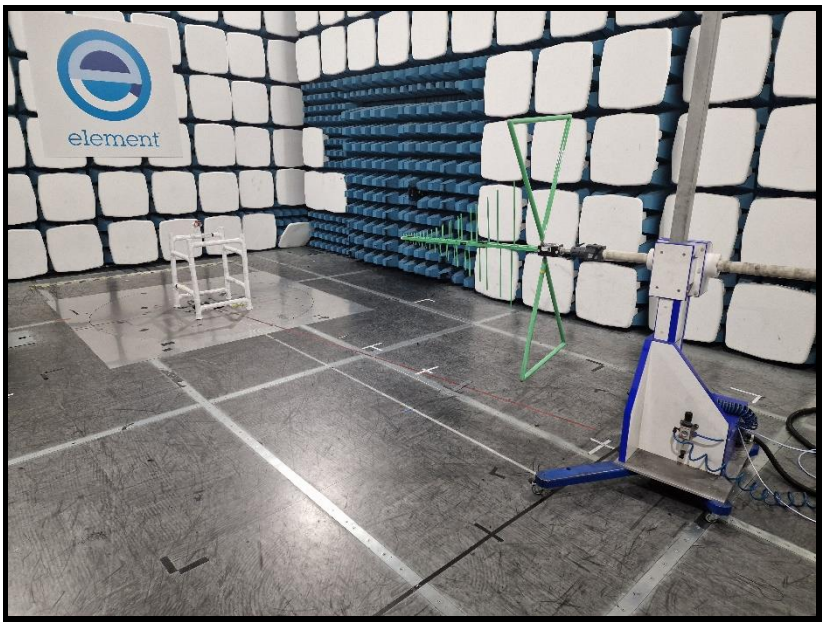
## *9.1 Block Diagram*

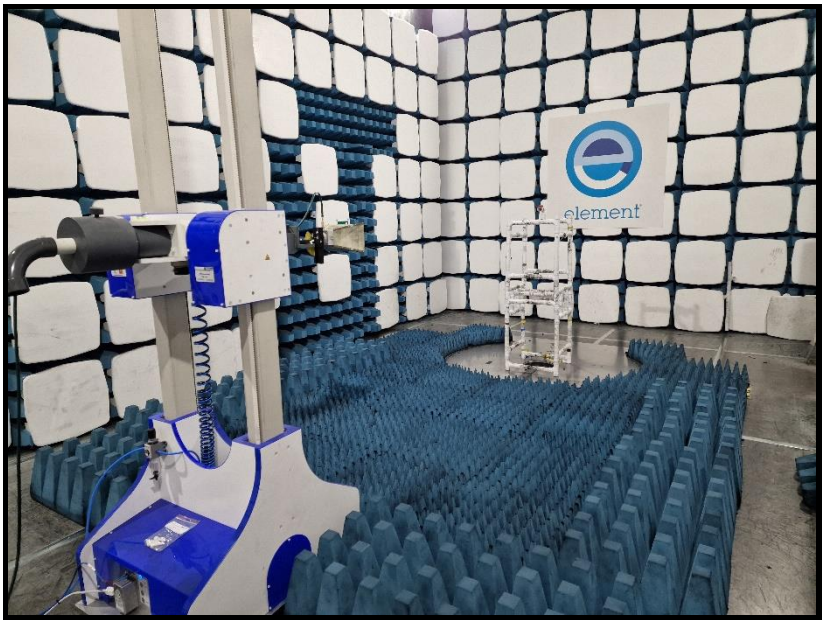
The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



### *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 ºC to +35 ºC (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 (µV/m at 3 m)* | *Field Strength (dBµV/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:

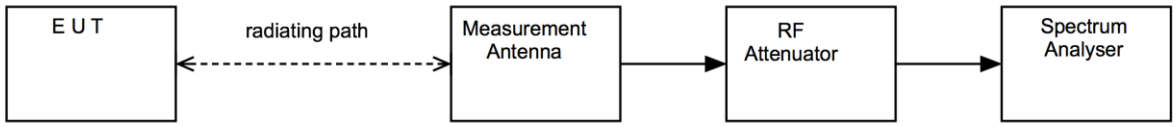
$$FS = PR + CL + AF – PA + DC – CF$$
$$Factor = CL+AF-PA$$

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**

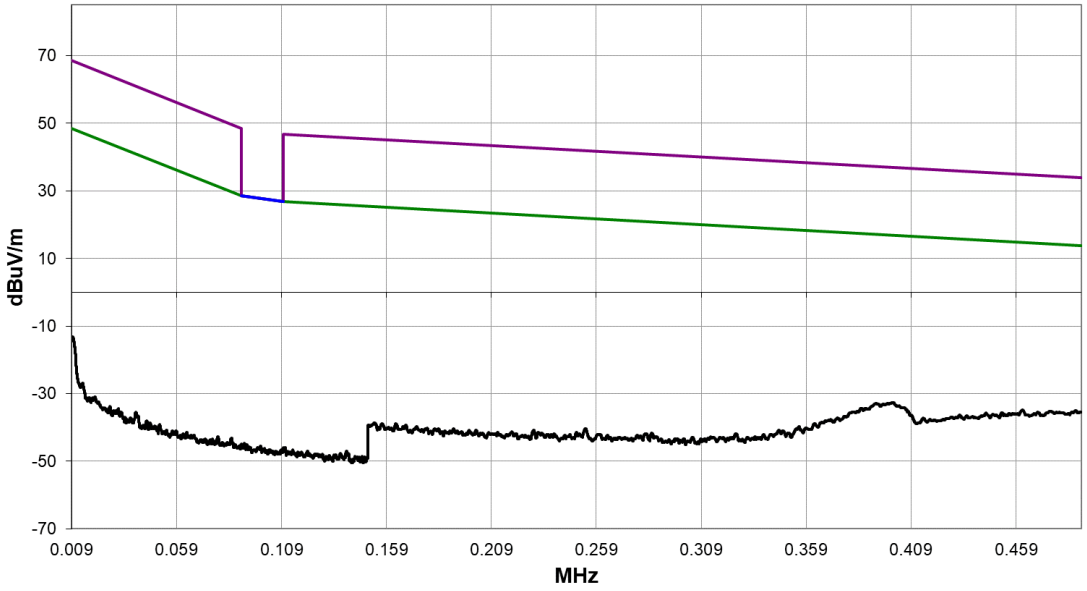



### *11.5 Test Equipment*

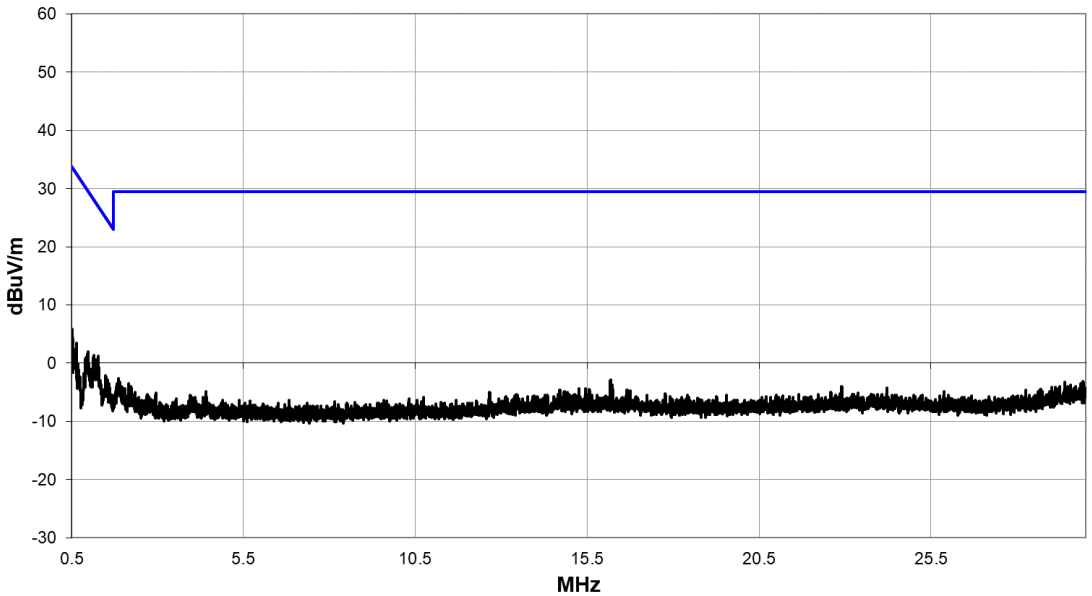
| Equipment Description | Manufacturer | Equipment Type | Element No | Due For Calibration |
|---|---|---|---|---|
| Radiated Test Software | Element | Emissions R5 | REF9000 | Cal not required |
| Chamber 1 | Rainford EMC | ATS | U387 | 2023-10-24 |
| Radio Chamber - PP | Rainford EMC | ATS | REF940 | 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*

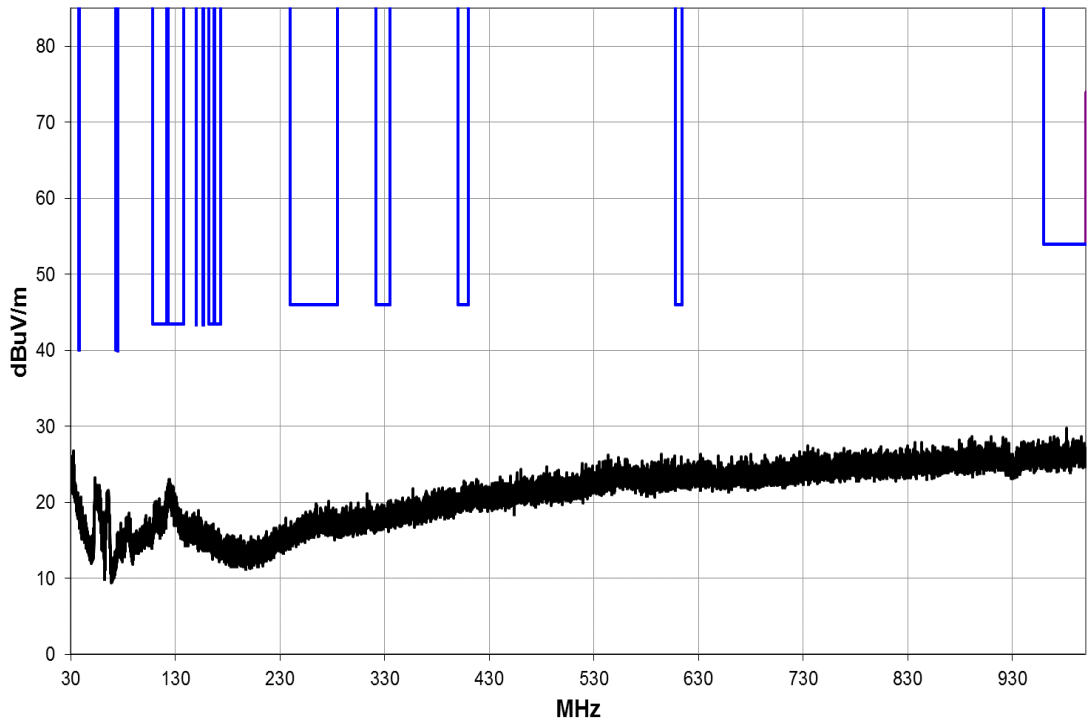
2402 MHz 9 kHz-490 kHz



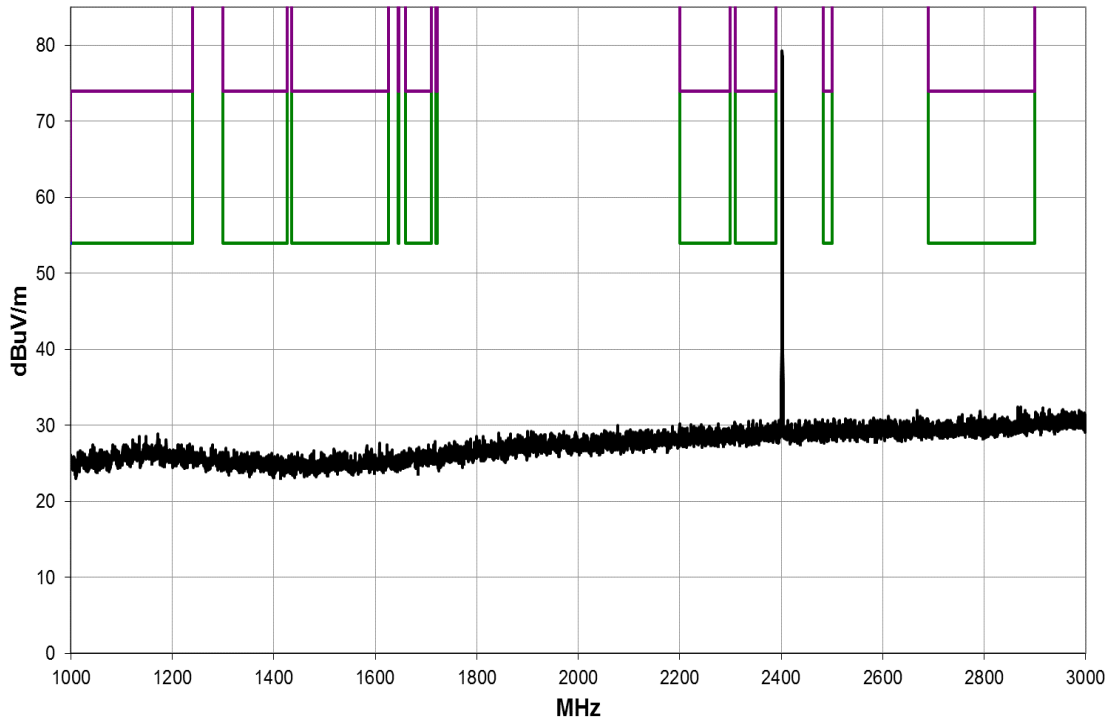

2402 MHz 490 kHz-30 MHz



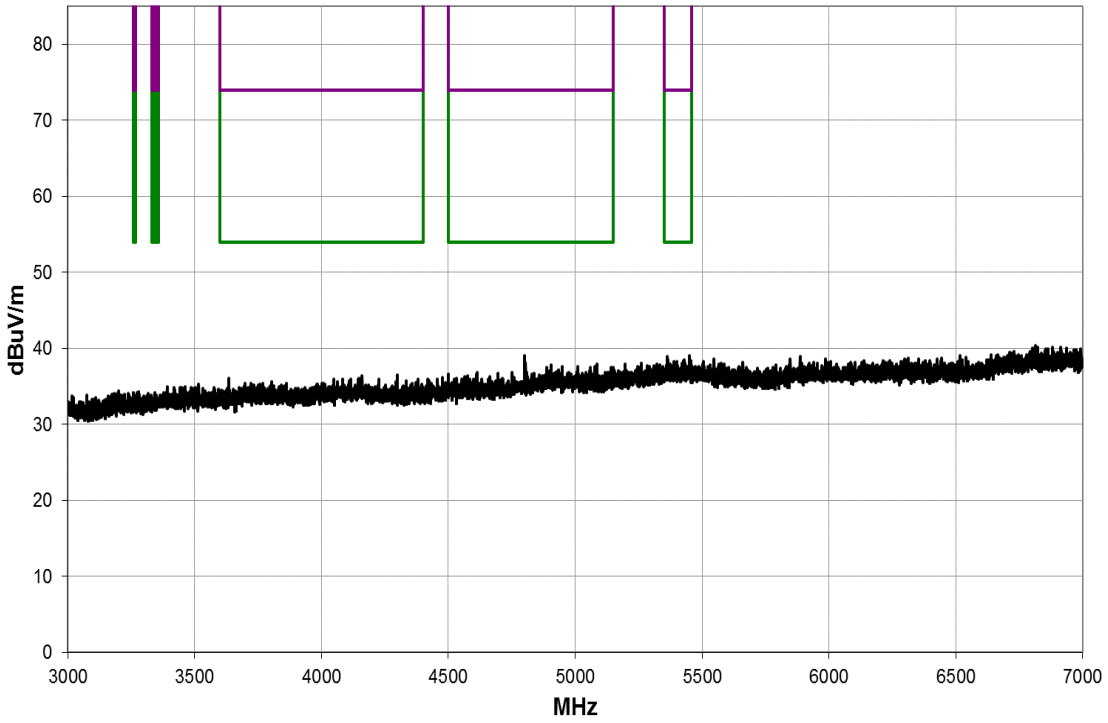
2402 MHz 30 MHz-1 GHz



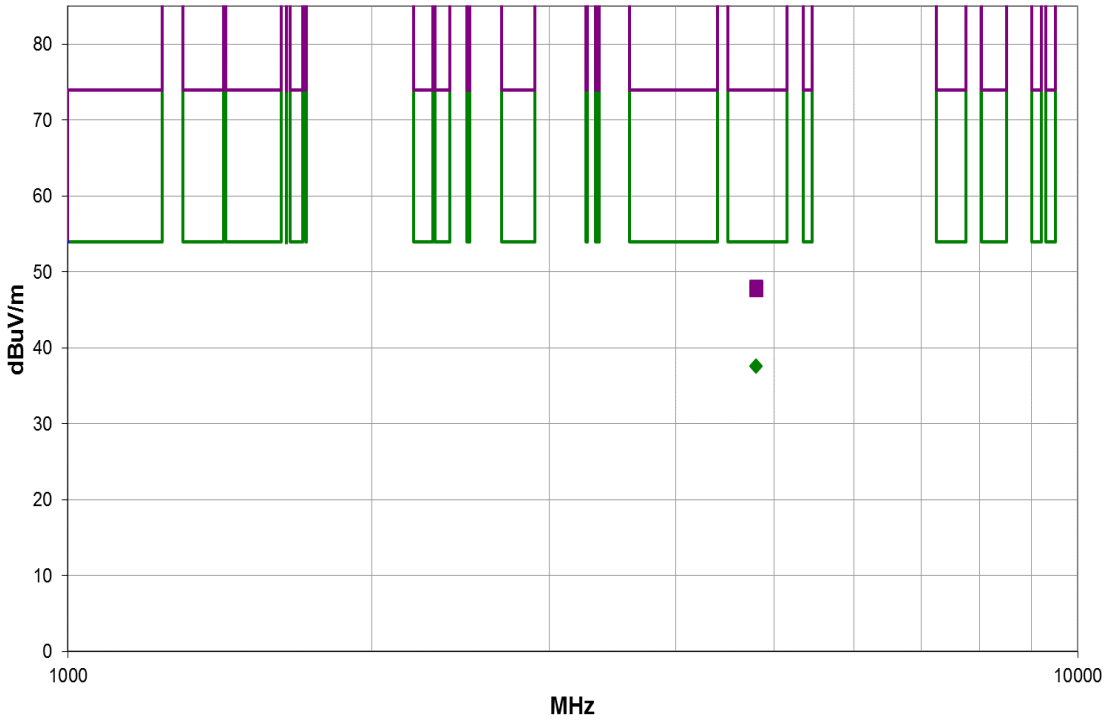

2402 MHz 1 GHz-3 GHz



## 2402 MHz 3 GHz-7 GHz

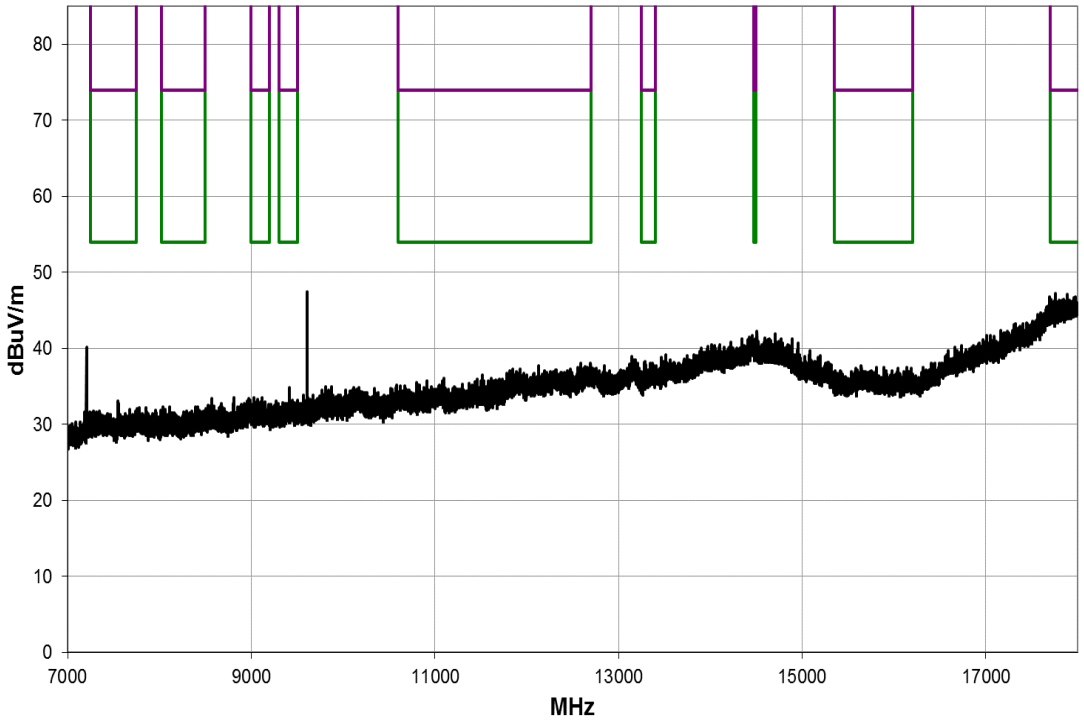



## 2402 MHz 3 GHz-7 GHz Maximised

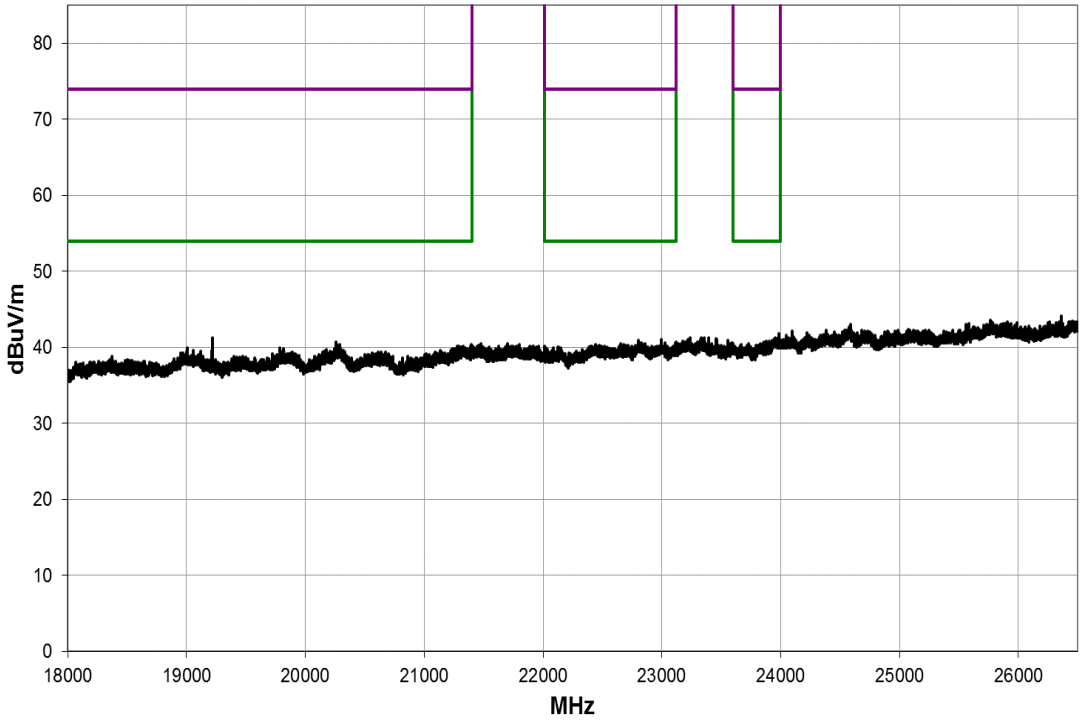



| Freq (MHz) | Amplitude (dBuV) | Factor (dB/m) | Antenna Height (meters) | Azimuth (degrees) | Test Distance (meters) | External Attenuation (dB) | Polarity/ Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | |

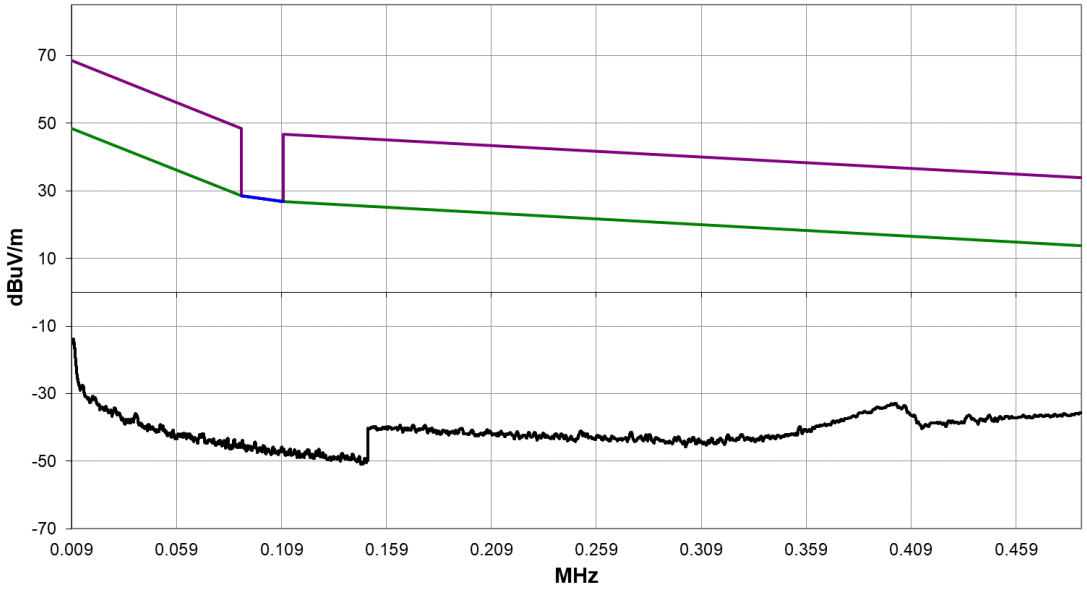
2402 MHz 7 GHz-18 GHz



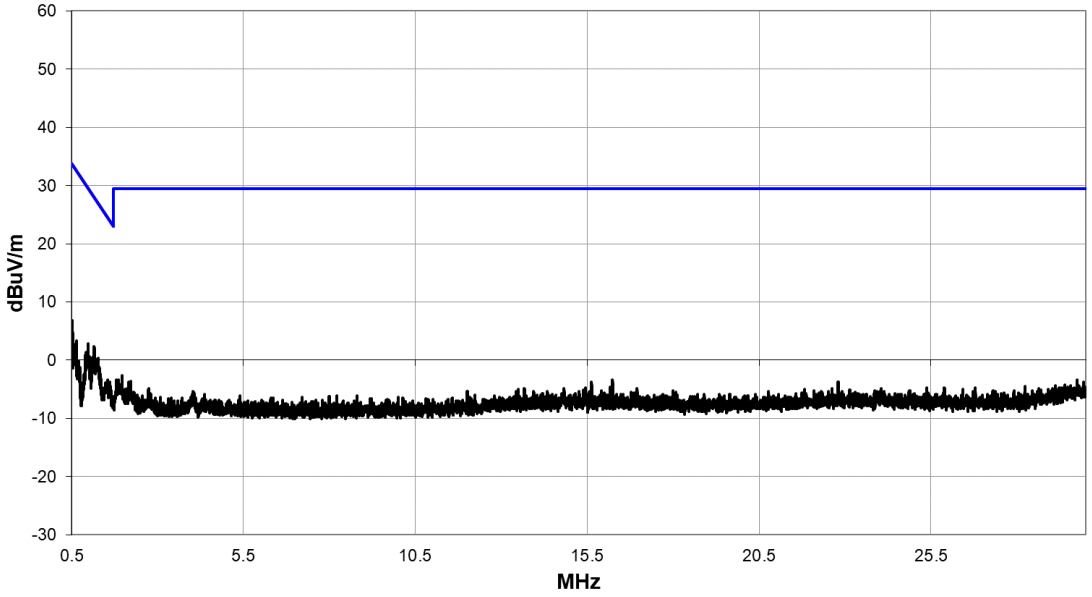

2402 MHz 18 GHz-26.5 GHz



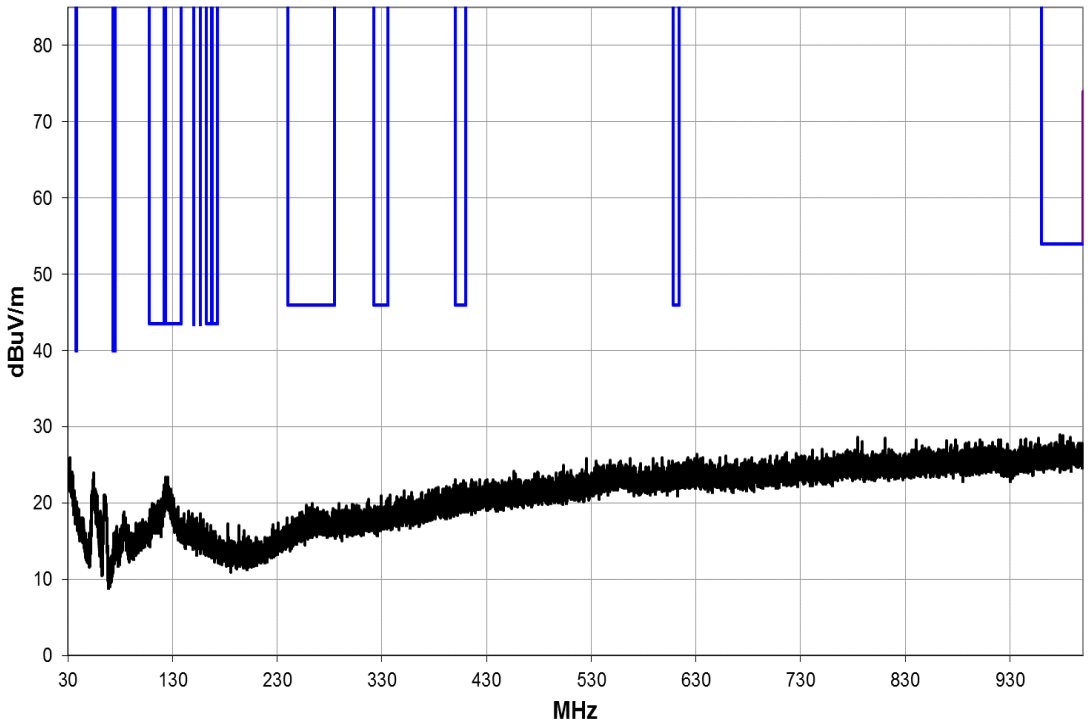
2440 MHz 9 kHz-490 MHz



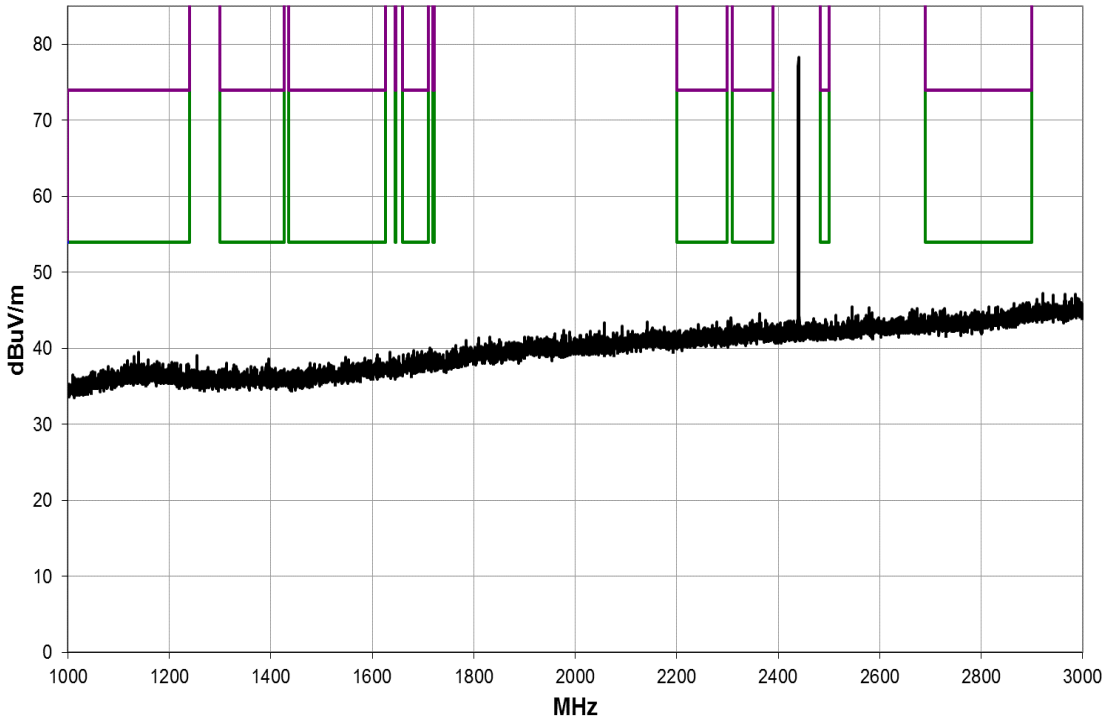

2440 MHz 490 kHz-30 MHz



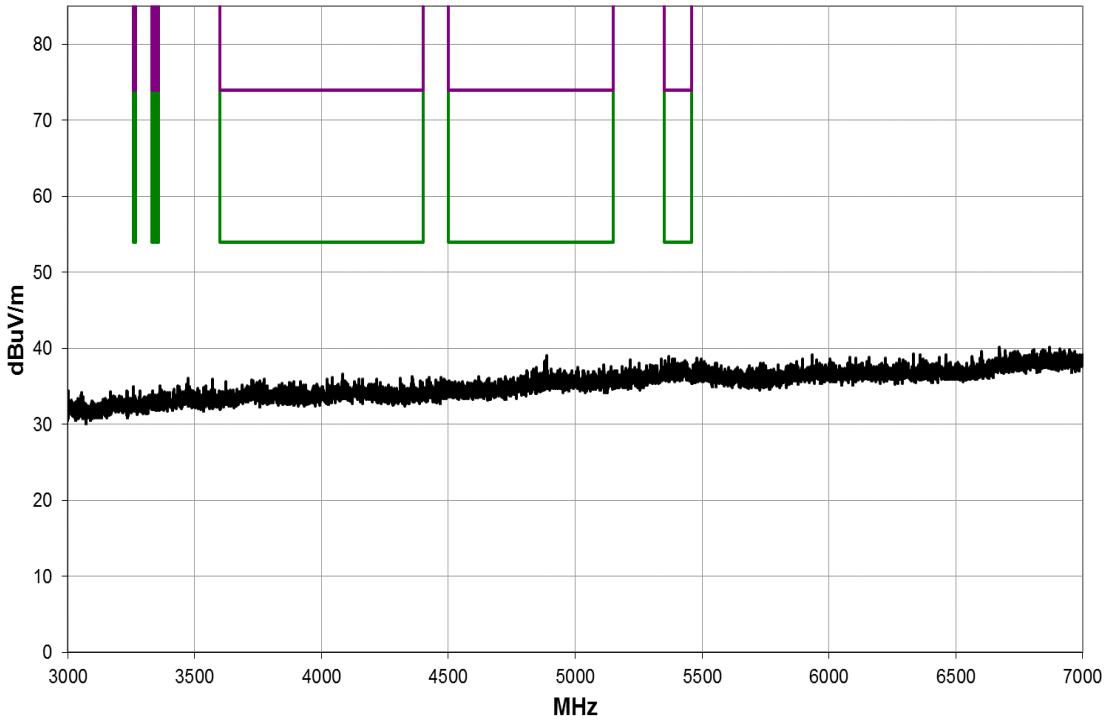
2440 MHz 30 MHz-1 GHz



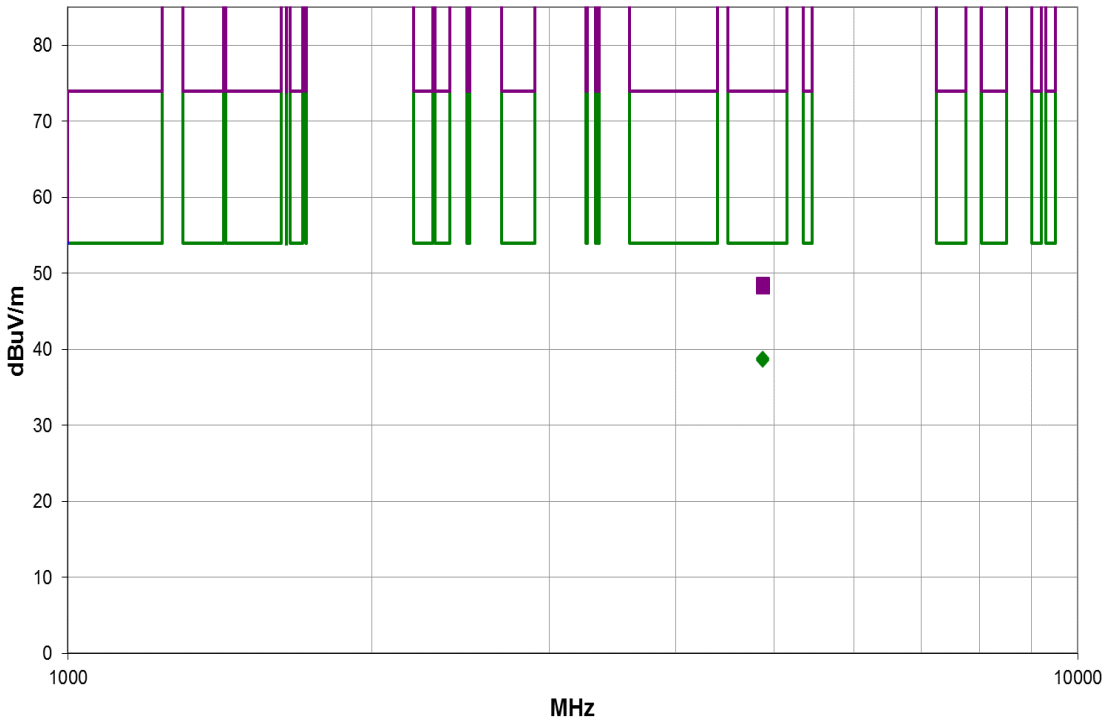

2440 MHz 1 GHz-3 GHz



2440 MHz 3 GHz-7 GHz

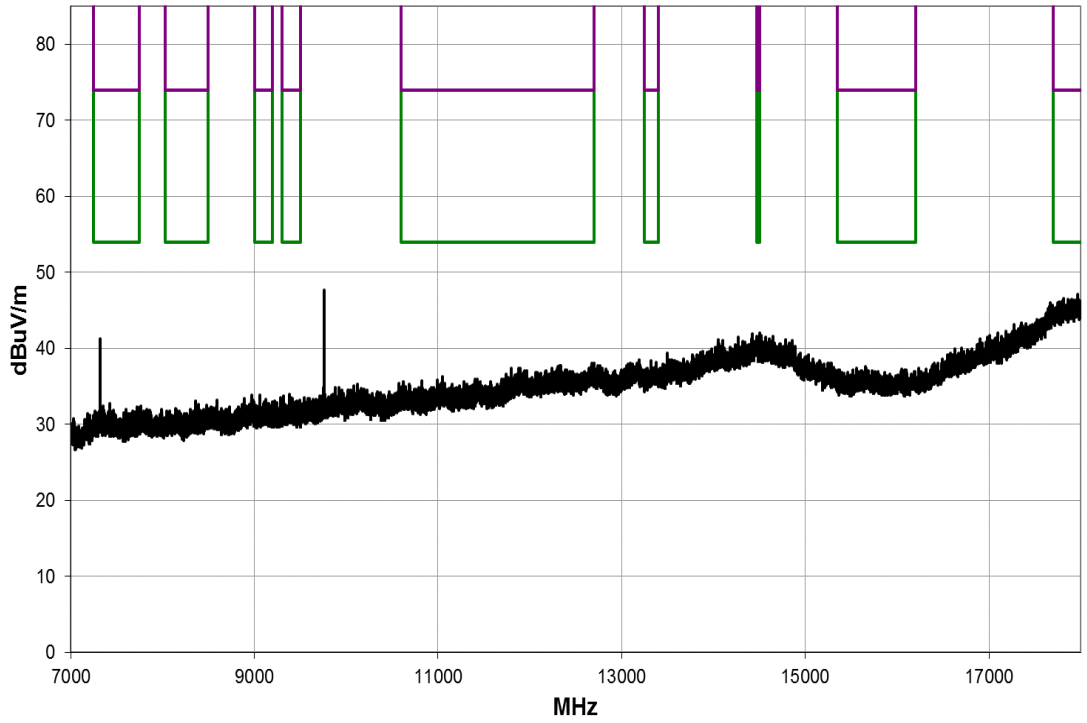



2440 MHz 3 GHz-7 GHz Maximised

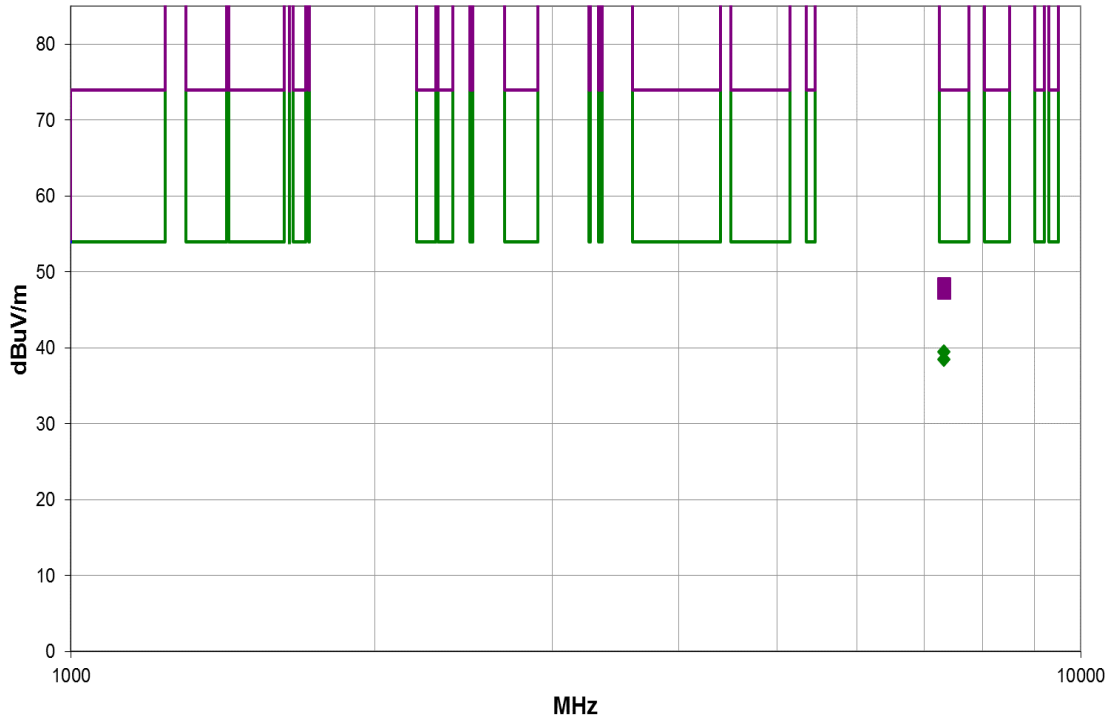



| Freq (MHz) | Amplitude (dBuV) | Factor (dB/m) | Antenna Height (meters) | Azimuth (degrees) | Test Distance (meters) | External Attenuation (dB) | Polarity/ Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

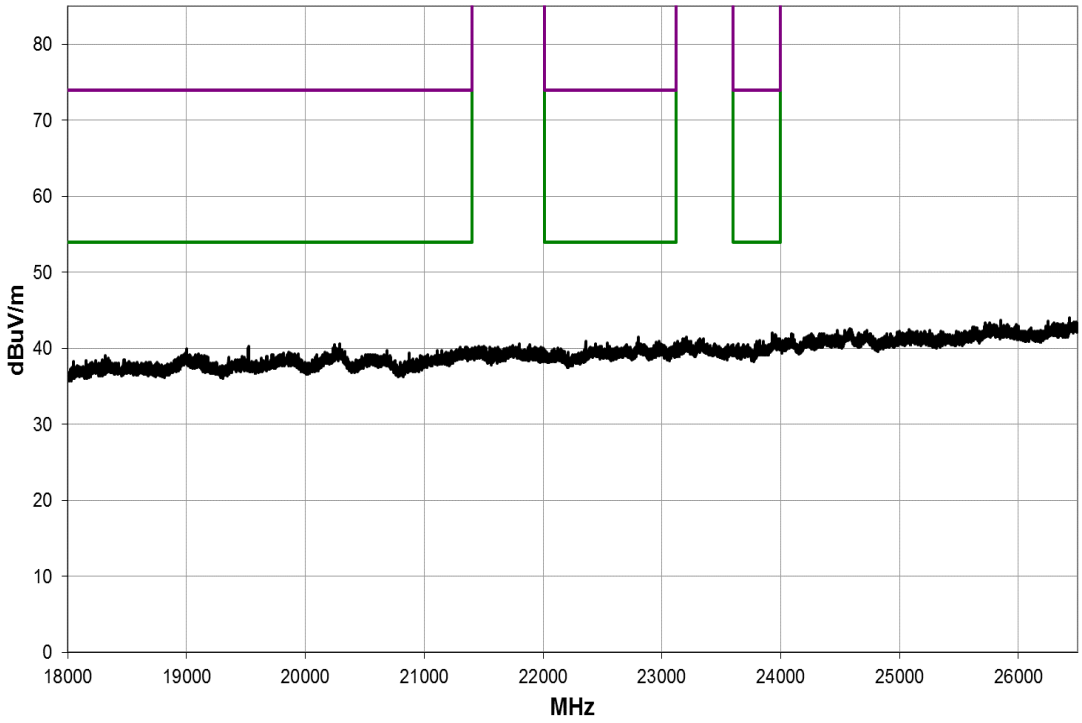



## 2440 MHz 7 GHz-18 GHz Maximised

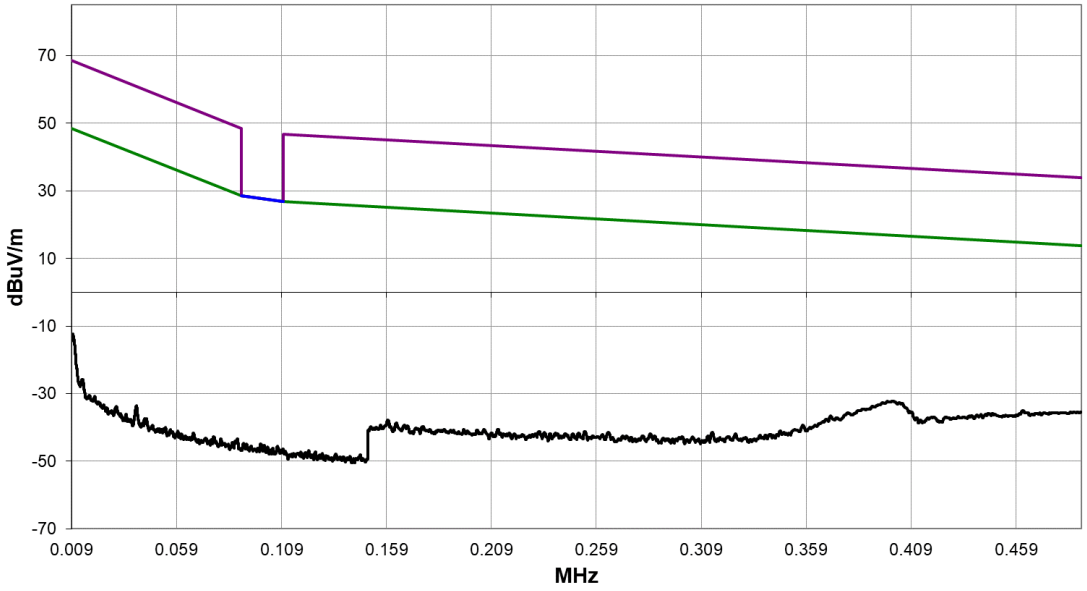



| Freq (MHz) | Amplitude (dBuV) | Factor (dB/m) | Antenna Height (meters) | Azimuth (degrees) | Test Distance (meters) | External Attenuation (dB) | Polarity/ Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | |

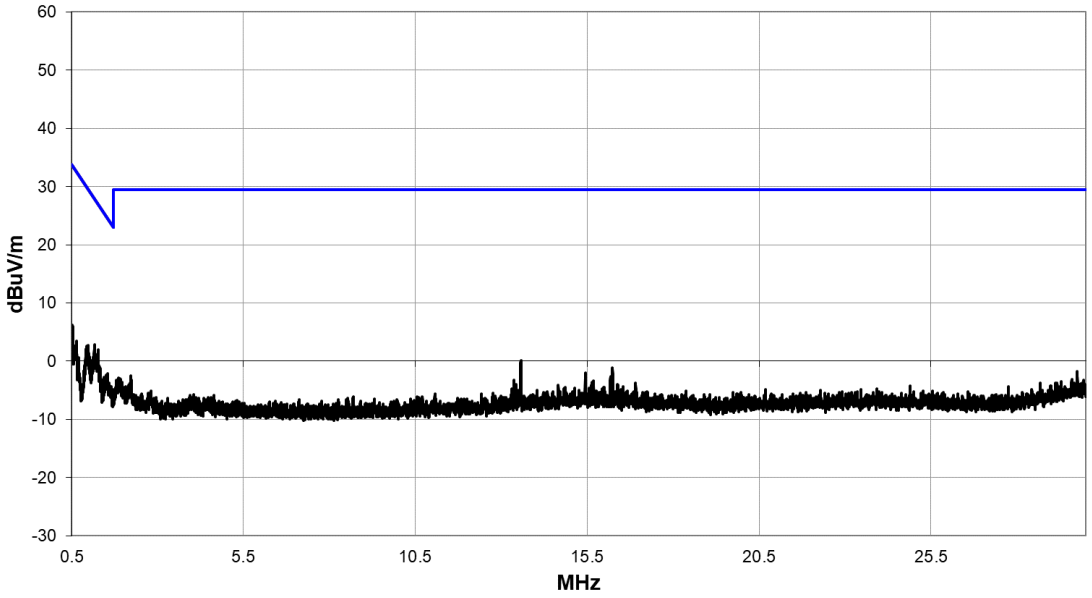
2440 MHz 18 GHz-26.5 GHz



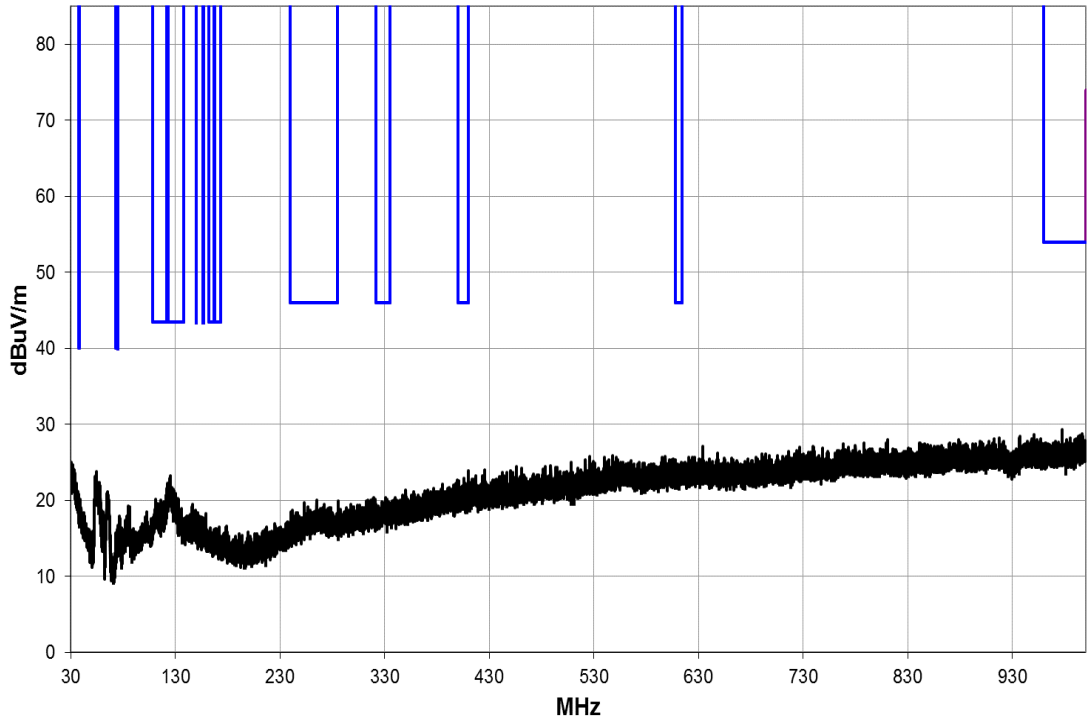
2480 MHz 9 kHz-490 MHz



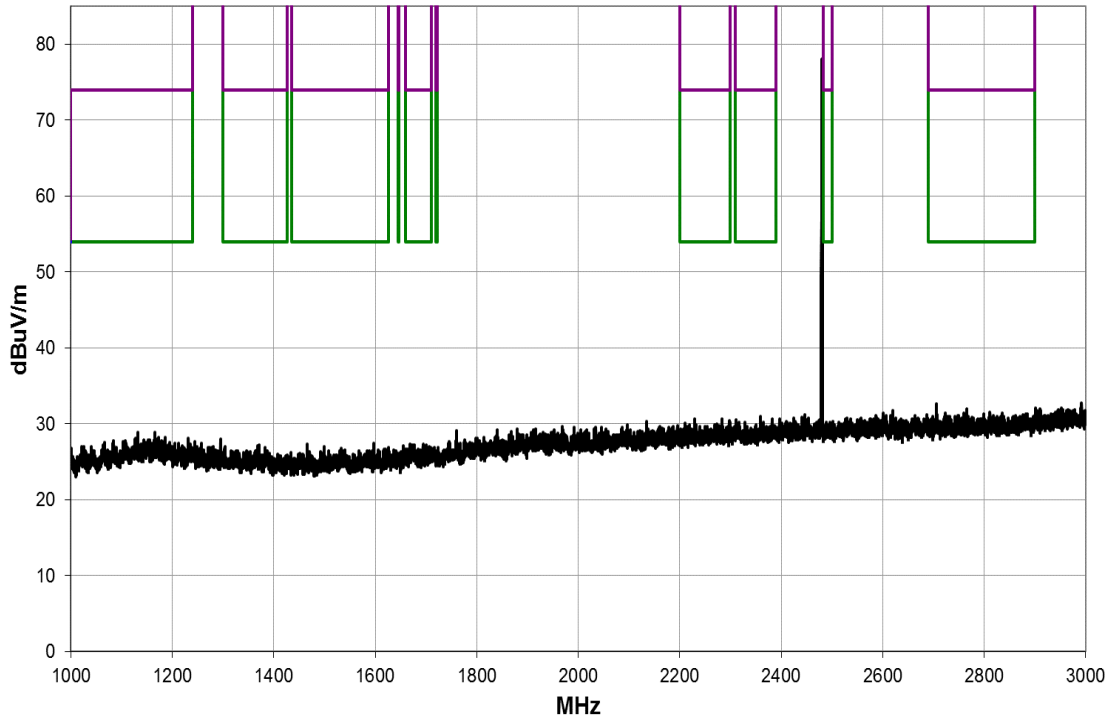

2480 MHz 490 kHz-30 MHz



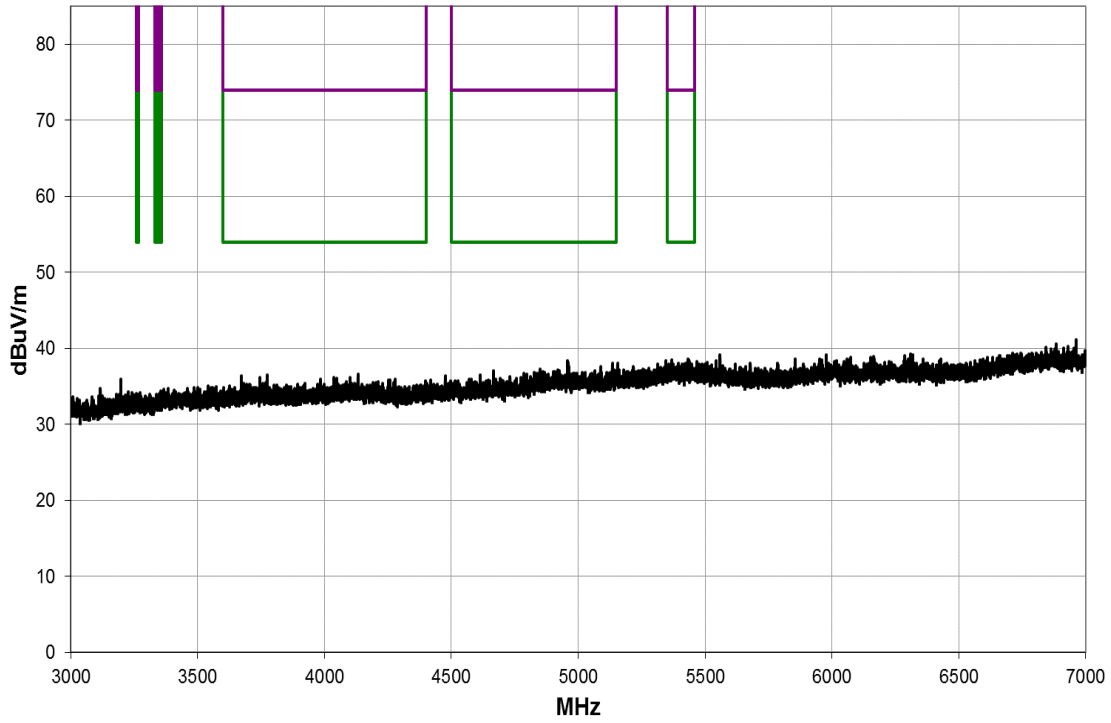
2480 MHz 30 MHz-1 GHz



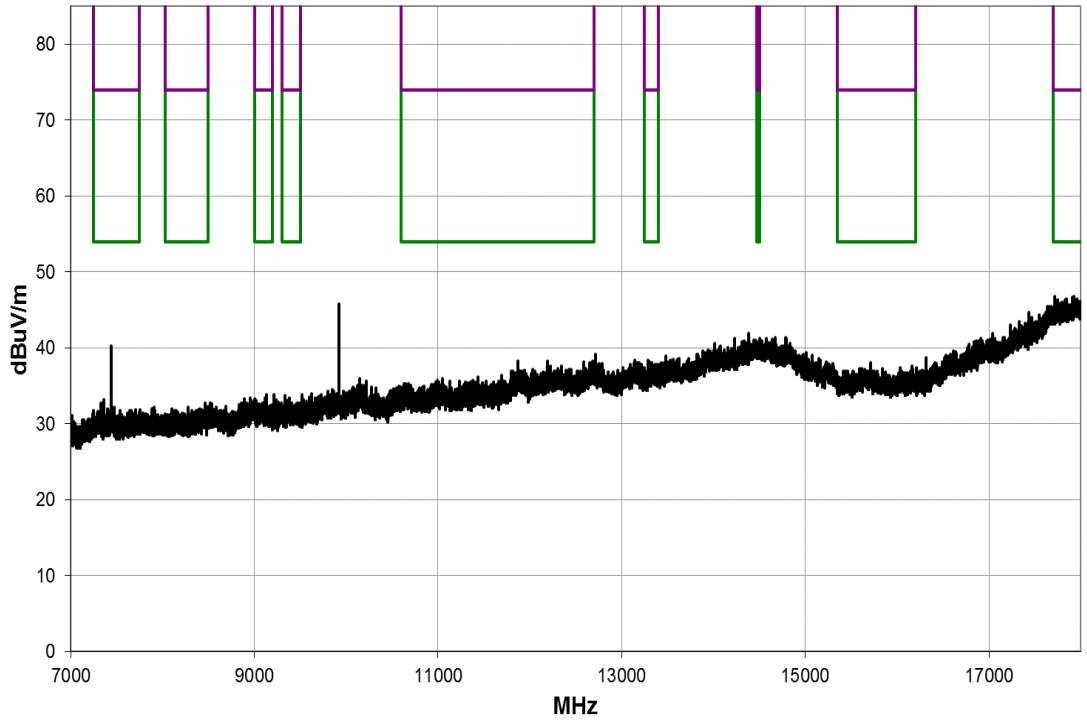

2480 MHz 1 GHz- 3 GHz



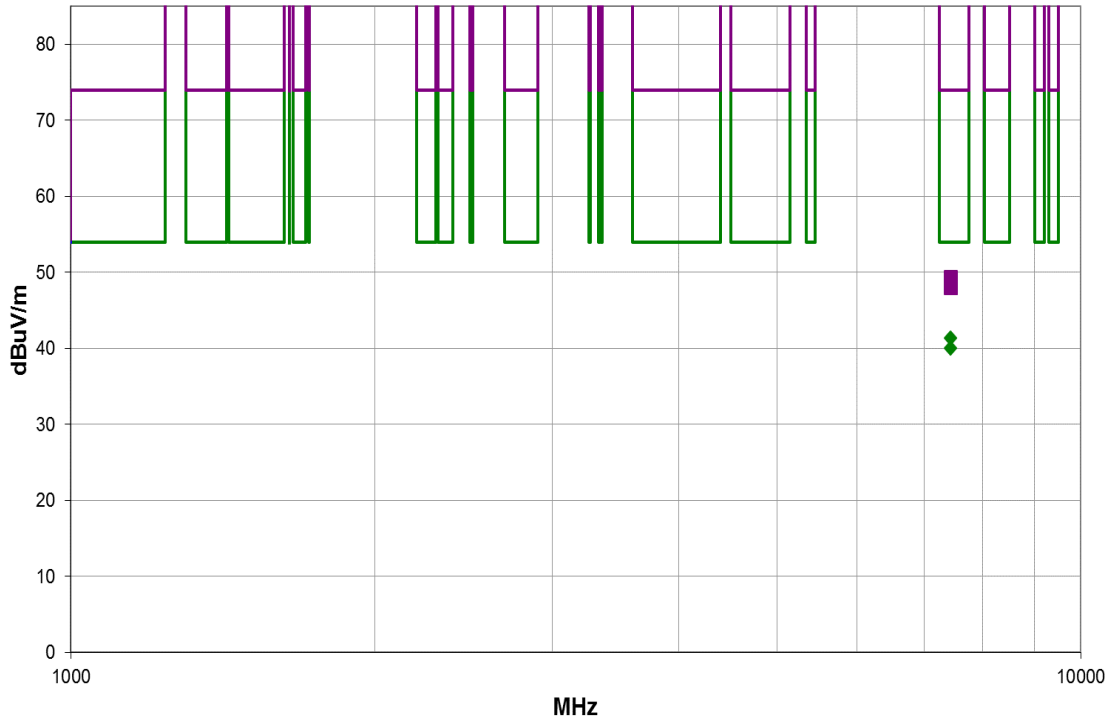
2480 MHz 3 GHz-7 GHz




2480 MHz 7 GHz-18 GHz

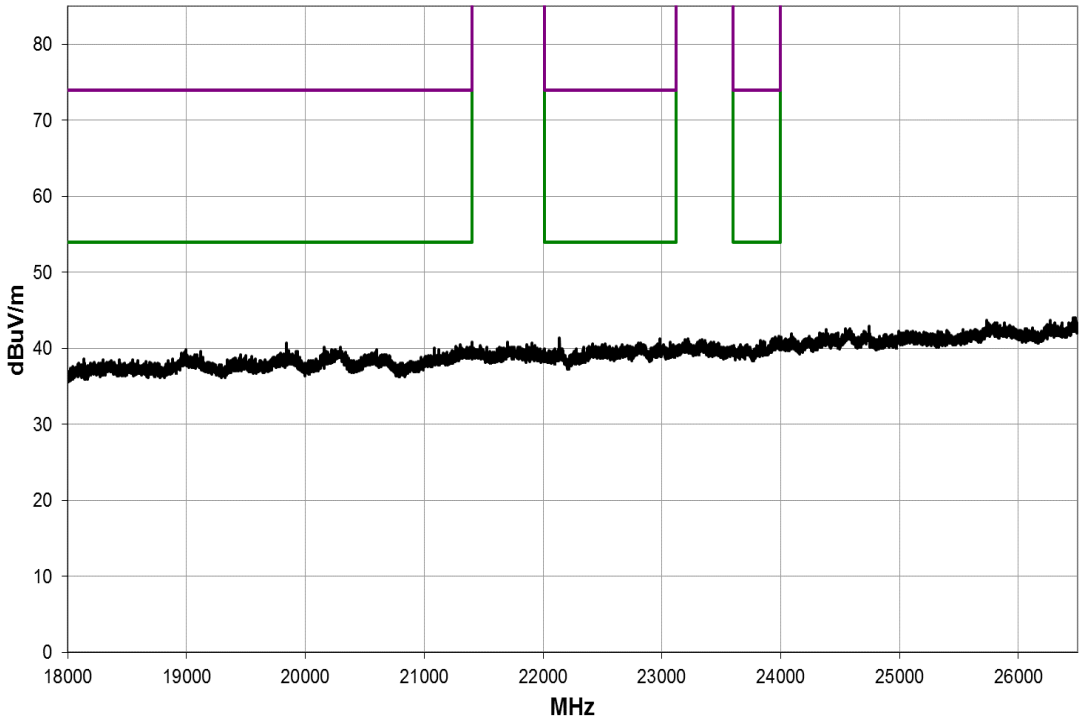


## 2480 MHz 7 GHz-18 GHz Maximised



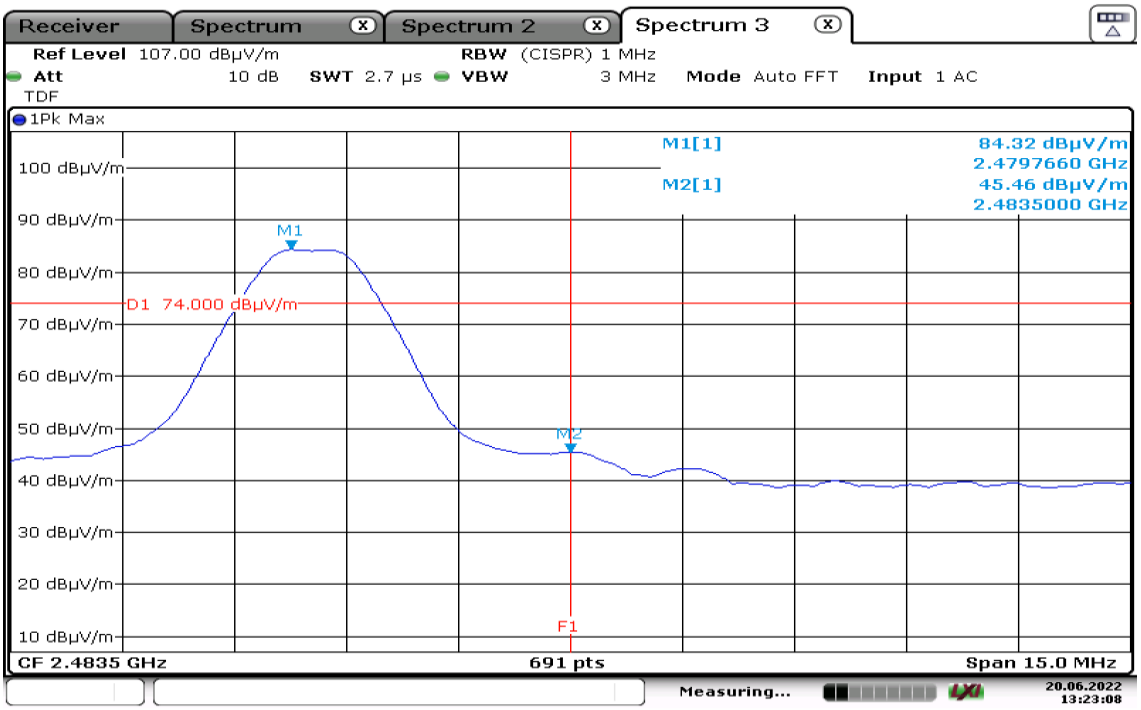

| Freq (MHz) | Amplitude (dBuV) | Factor (dB/m) | Antenna Height (meters) | Azimuth (degrees) | Test Distance (meters) | External Attenuation (dB) | Polarity/ Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

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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 ºC to +35 ºC (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.

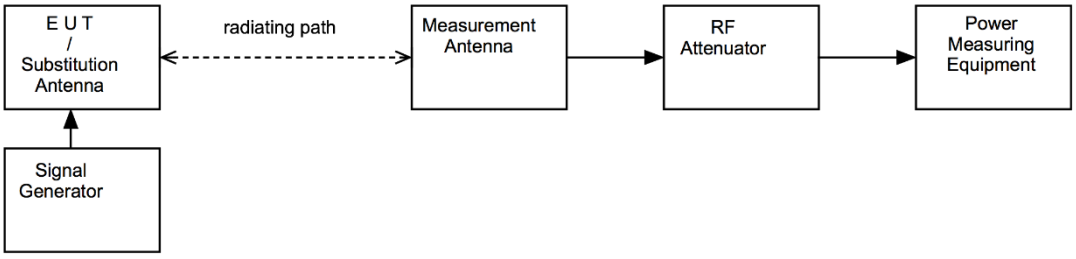
The duty cycle correction factor, DC, shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as:

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* ≥ 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**

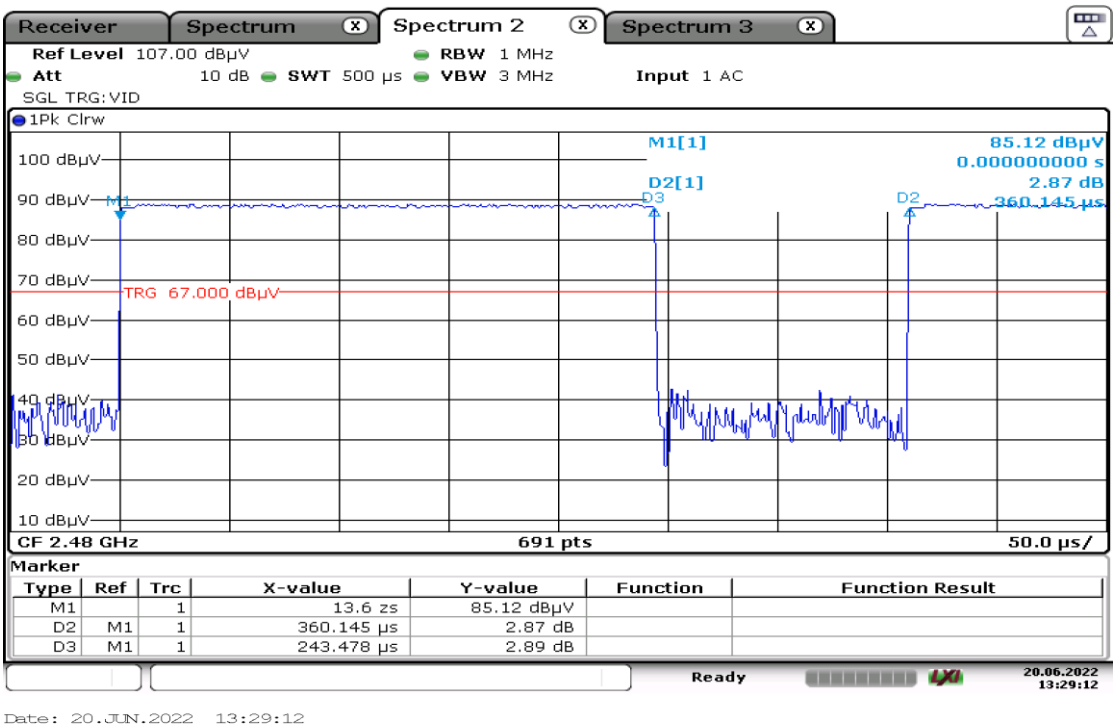



### *12.5 Test Equipment*

| 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÷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 ºC to +35 ºC (as declared) |
| Humidity: 55 % RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3.0 Vdc | |

## *13.3 Test Limit*

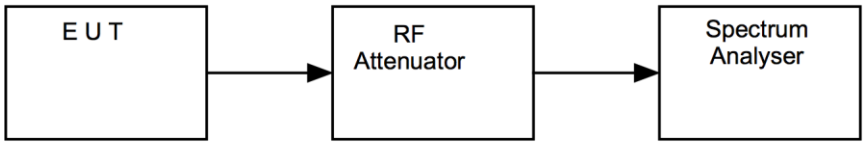
The minimum -6 dB bandwidth shall be at least 500 kHz.

### *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**



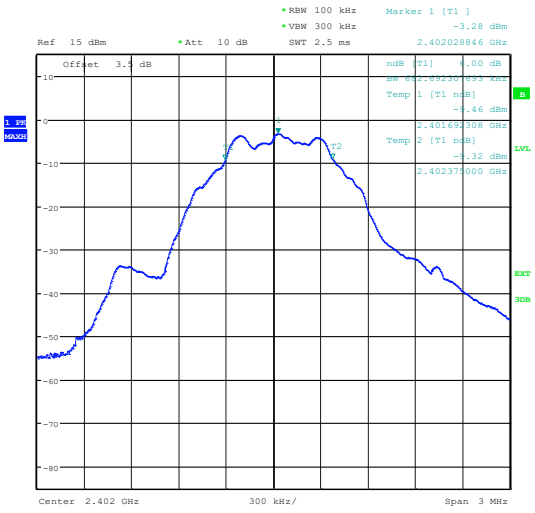

### *13.5 Test Equipment*

| 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 |

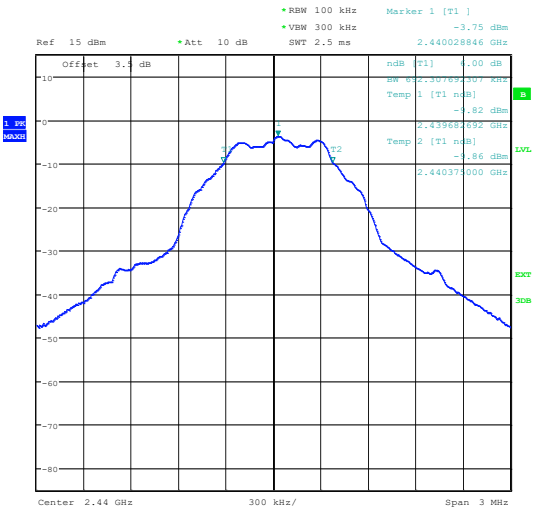
## *13.6 Test Results*

| *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 |

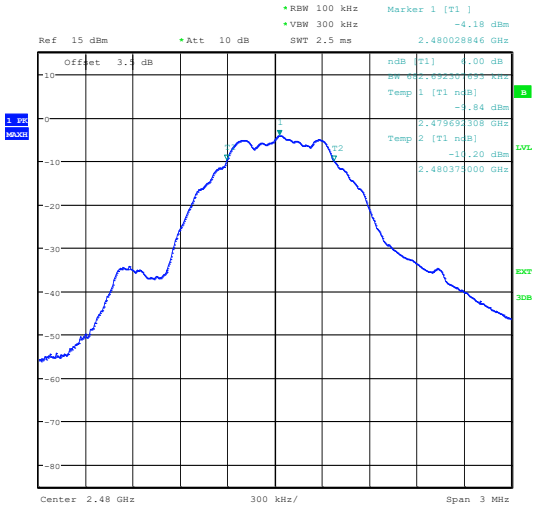
2402 MHz




2440 MHz




2480 MHz



# 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 ºC to +35 ºC (as declared) |
| Humidity: 55 % RH | 20 % RH to 75 % RH (as declared) |

## *14.3 Test Limit*

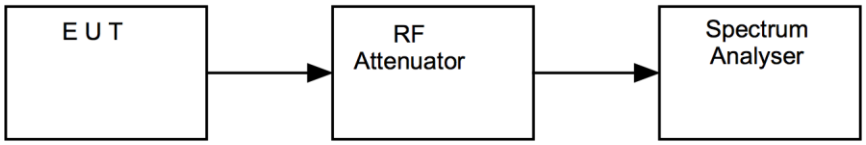
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

### *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*

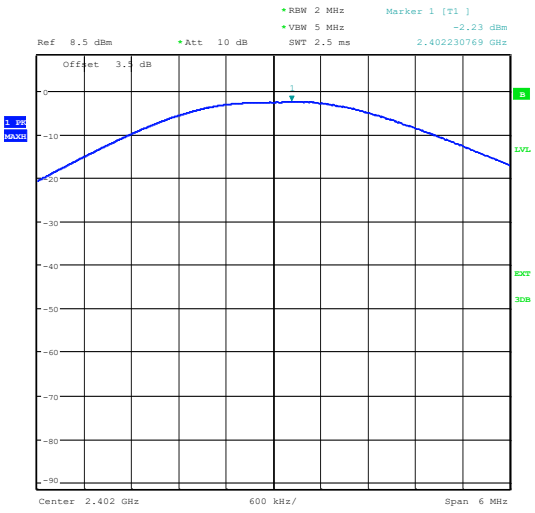
| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|---|---|---|---|---|
| Spectrum Analyser | R&S | FSU46 | REF910 | 22/12/2022 |
| Attenuator | AtlanTecRF Microwave | 3 dB | U637 | Cal in use |

### *14.6 Test Results*

FCC

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

## 2402 MHz

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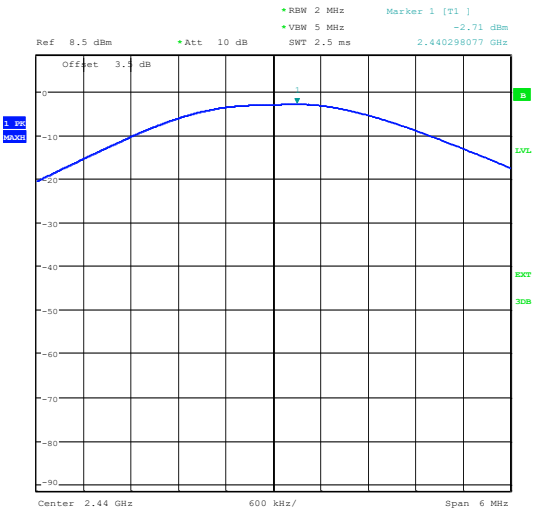
## 2440 MHz

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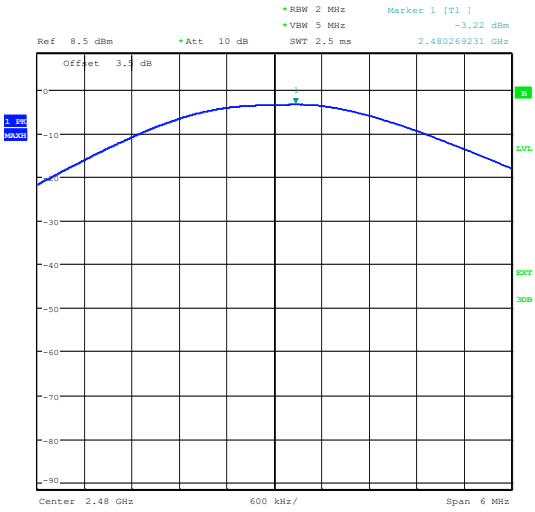
## 2480 MHz

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# 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 ºC to +35 ºC (as declared) |
| Humidity: 55% RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3.0 Vdc | |

## *15.3 Test Limit*

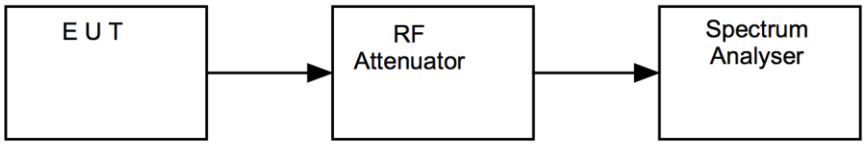
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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



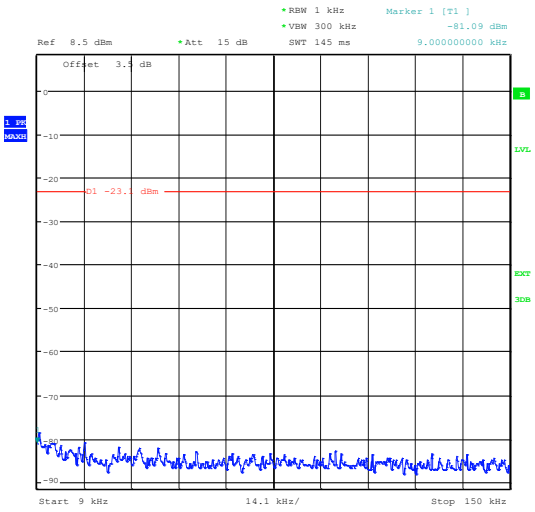

### *15.5 Test Equipment*

| 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

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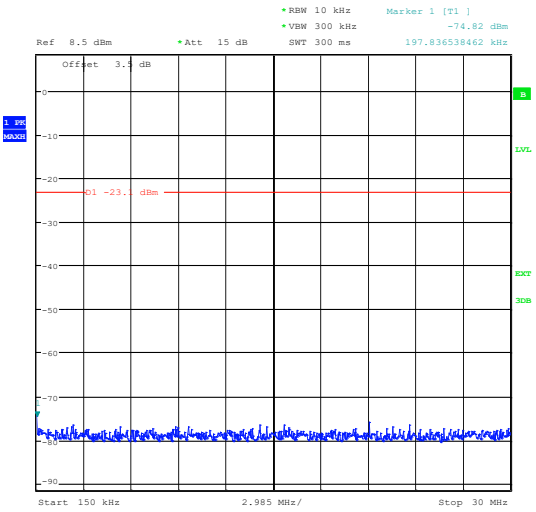
150 kHz - 30 MHz

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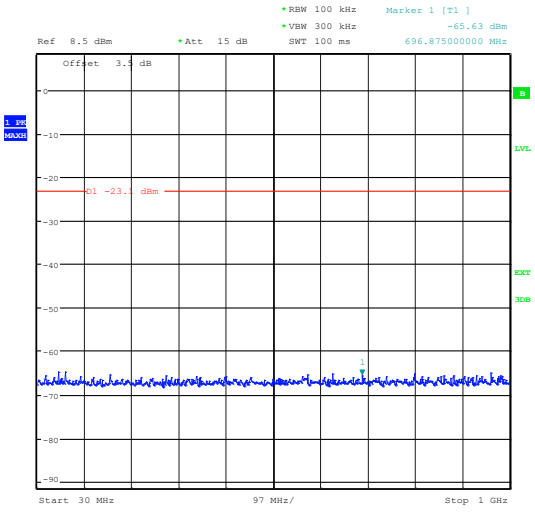
30 MHz - 1GHz

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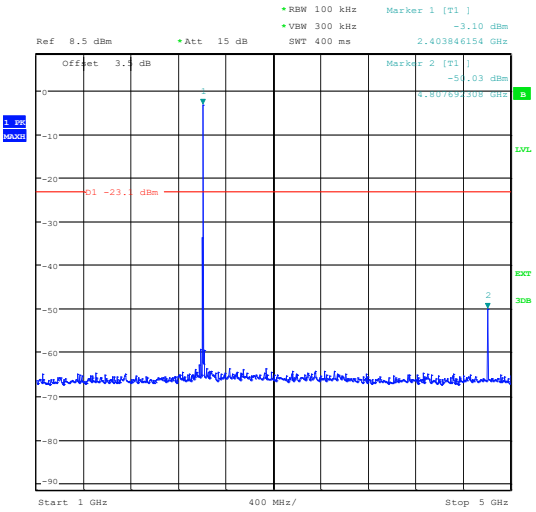
1 GHz - 5 GHz

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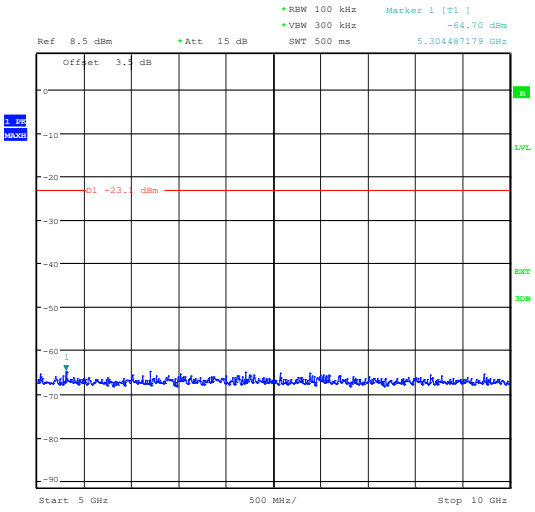
## 5 GHz – 10 GHz

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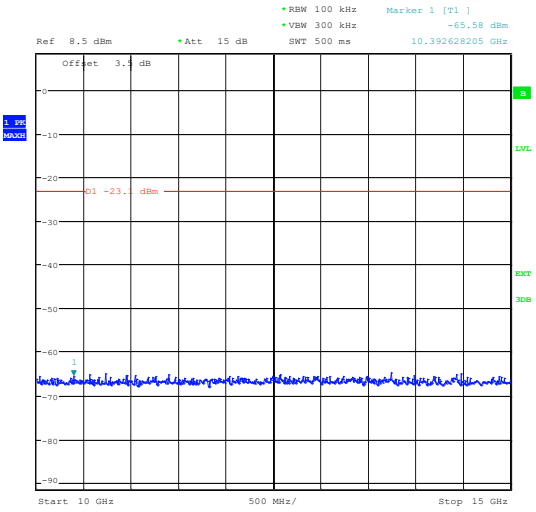
## 10 GHz - 15 GHz

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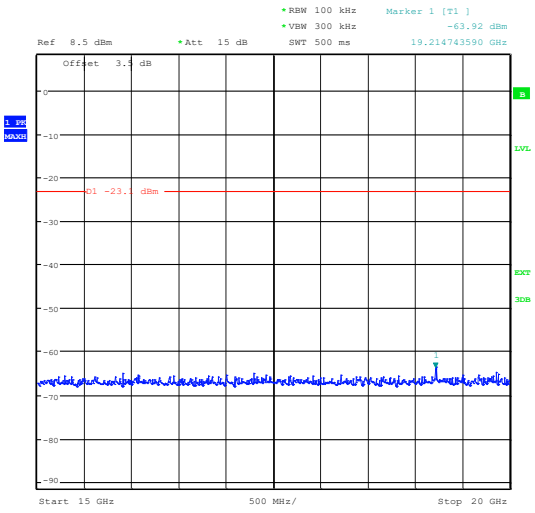
## 15 GHz – 20 GHz

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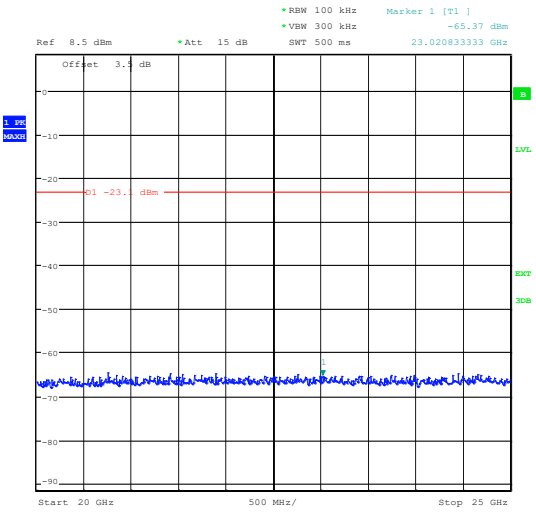
## 20 GHz – 25 GHz

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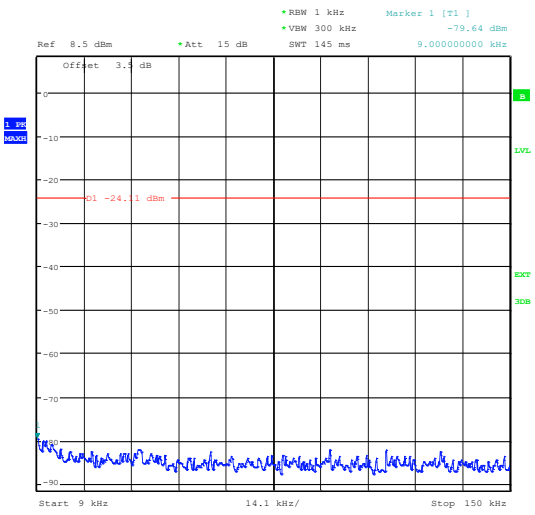
## 2440 MHz

### 9 kHz - 150 kHz

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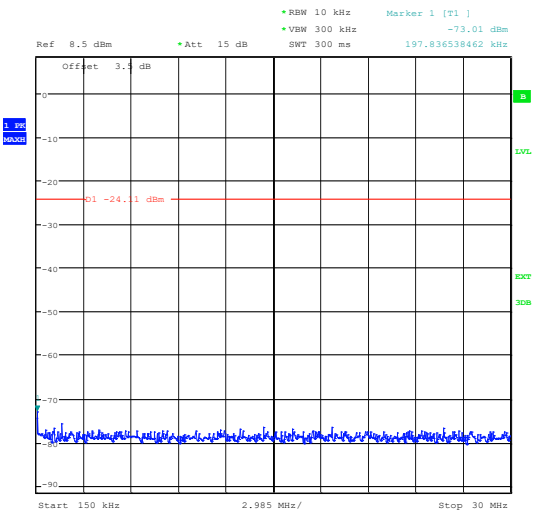
### 150 kHz - 30 MHz

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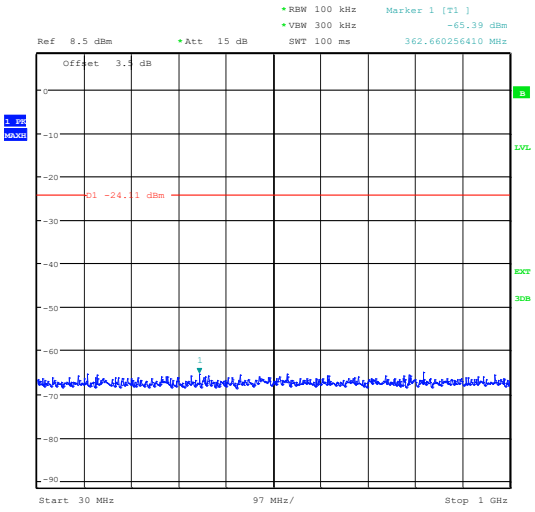
### 30 MHz - 1GHz

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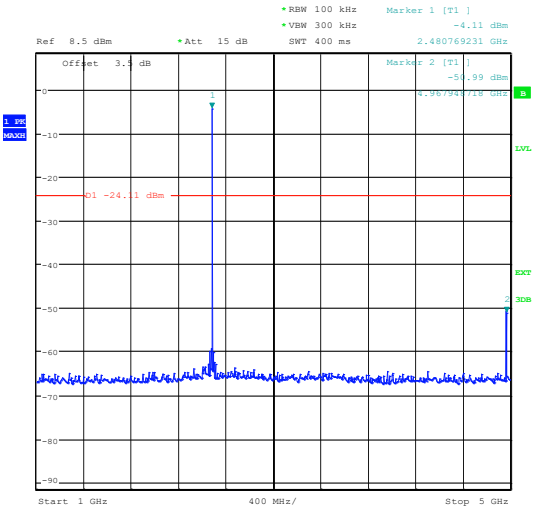
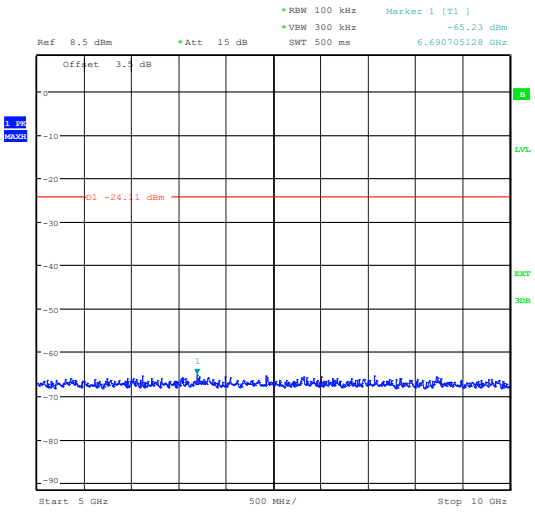
### 1 GHz - 5 GHz




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

## 5 GHz – 10 GHz

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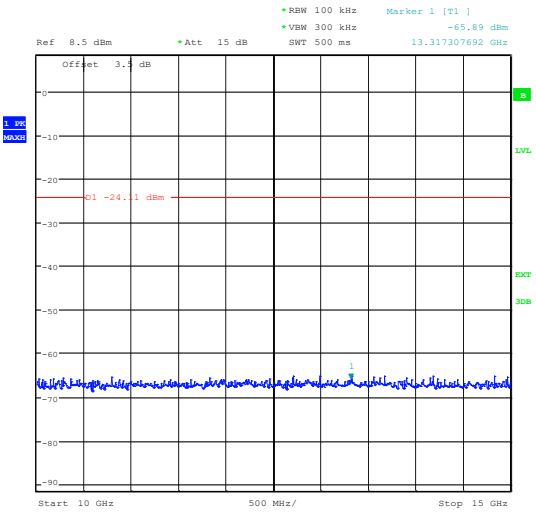
## 10 GHz - 15 GHz

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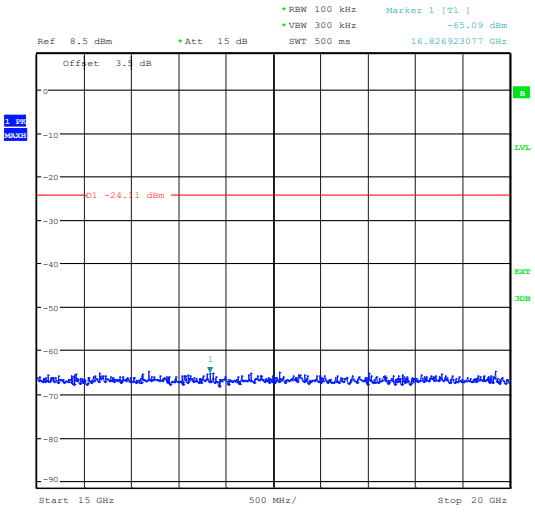
## 15 GHz – 20 GHz

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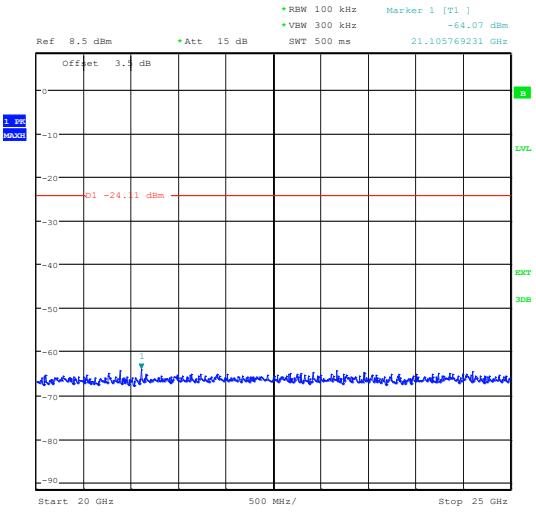
## 20 GHz – 25 GHz

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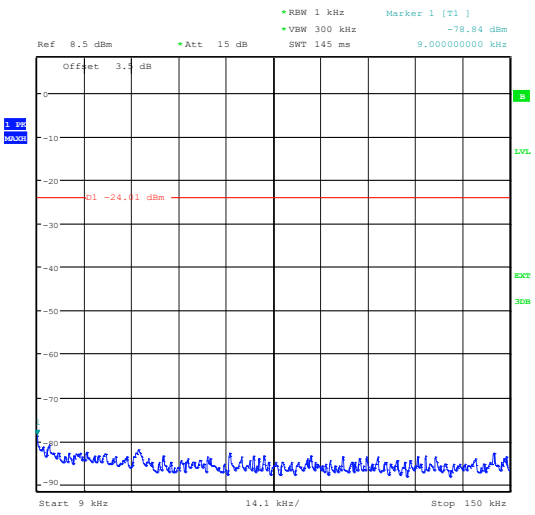
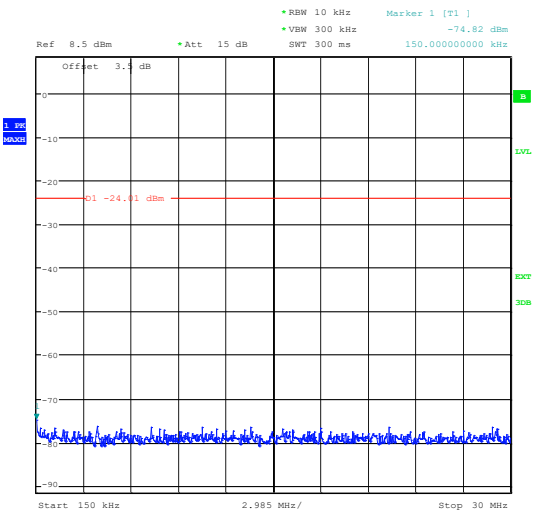
## 2480 MHz

### 9 kHz - 150 kHz




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

### 150 kHz - 30 MHz

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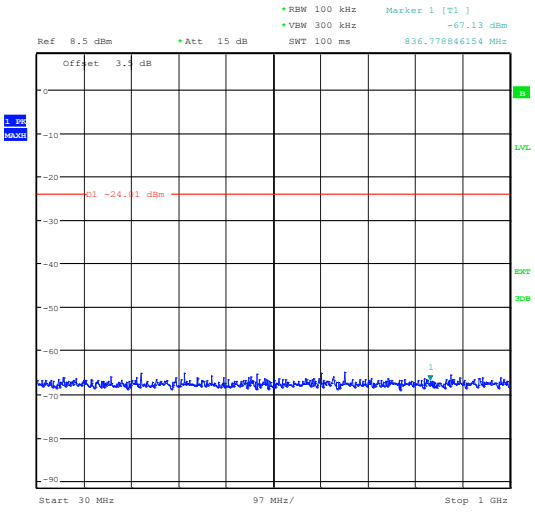
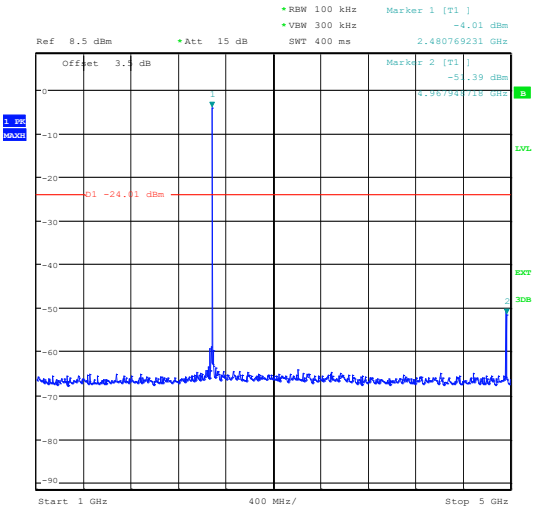
### 30 MHz - 1GHz




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

### 1 GHz - 5 GHz

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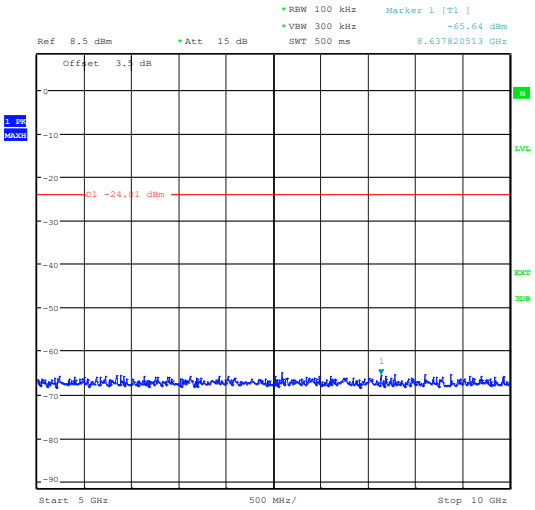
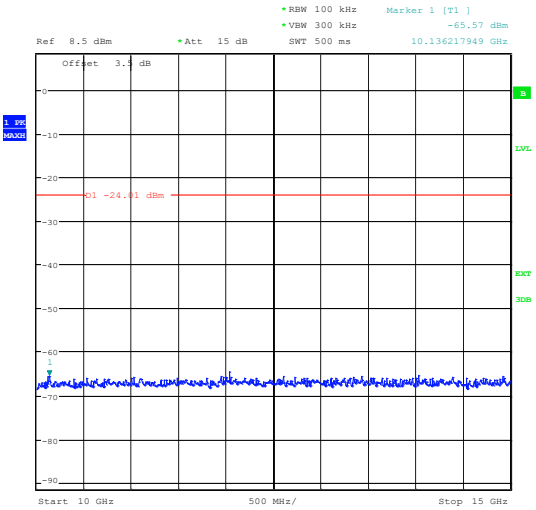
## 5 GHz – 10 GHz



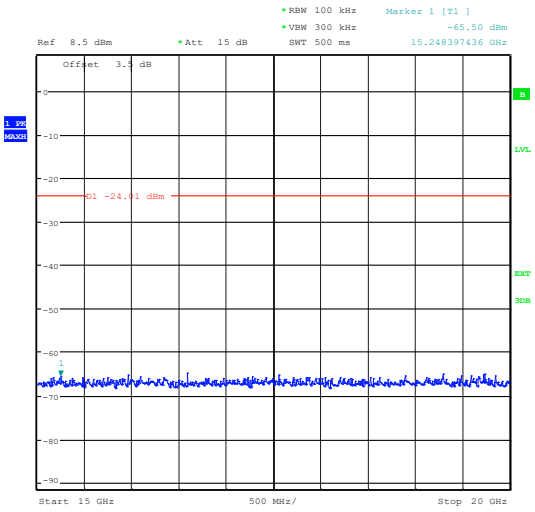

Date: 23.JUN.2022 14:36:08

## 10 GHz - 15 GHz



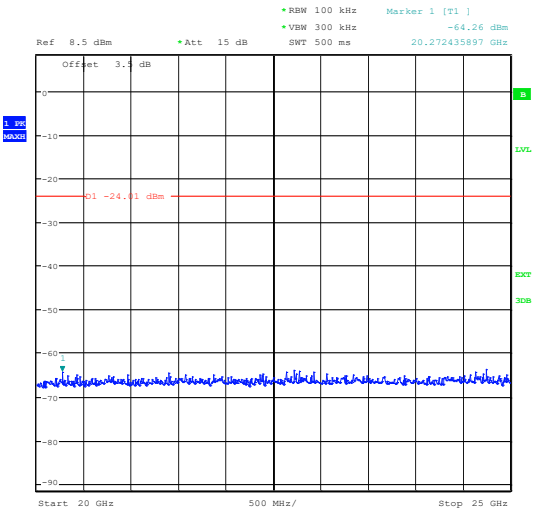

Date: 23.JUN.2022 14:36:34

## 15 GHz – 20 GHz




Date: 23.JUN.2022 14:36:57

## 20 GHz – 25 GHz

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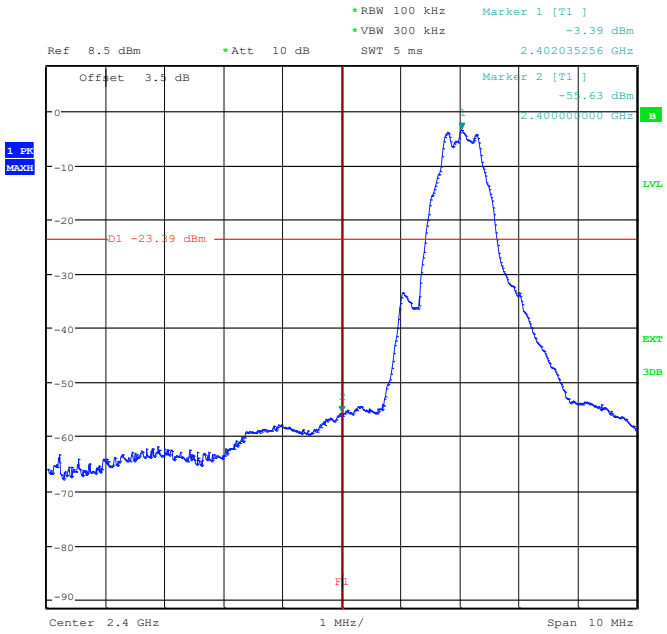
## Lower bandege

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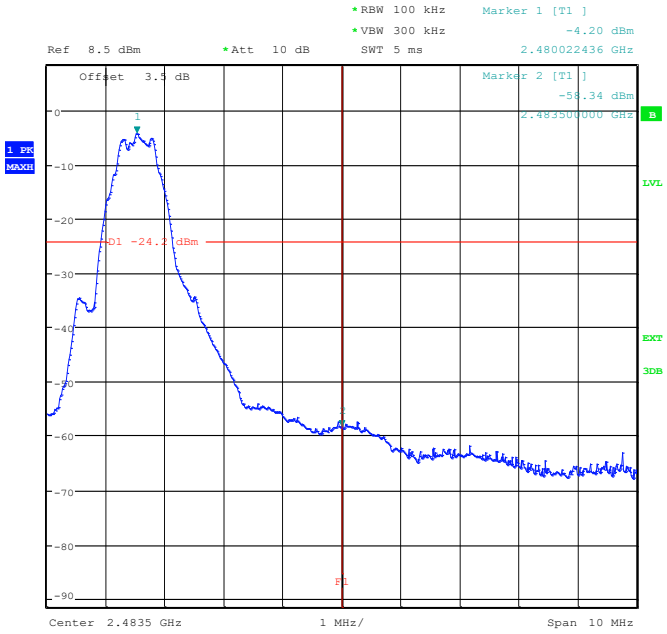
## Upper bandege

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# 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:<br>(requirement at least 3x RBW) | 10 kHz |
| Measurement Span:<br>(requirement 1.5 times Channel BW) | 1.05 MHz |
| Measurement Detector: | Peak |

**Environmental Conditions (Normal Environment)**

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

## *16.3 Test Limit*

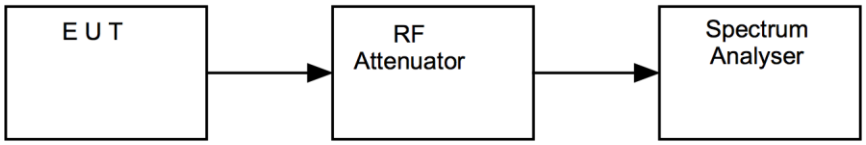
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

### *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**



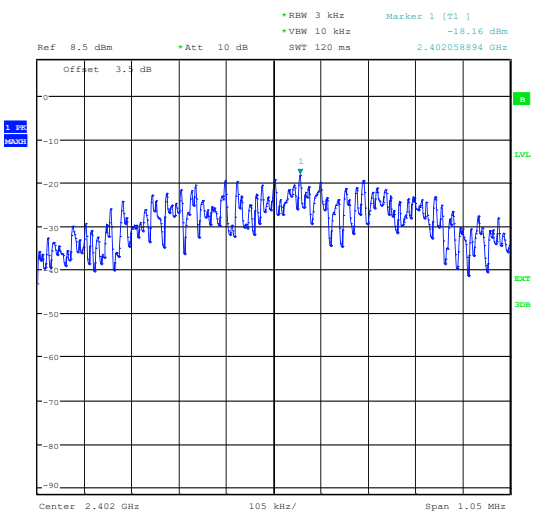

### *16.5 Test Equipment*

| 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

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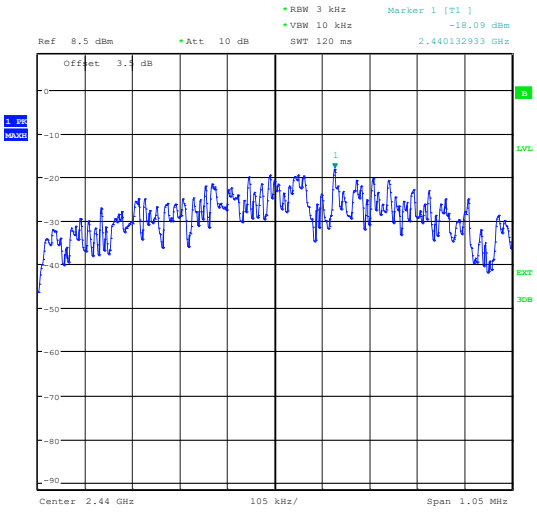
2440 MHz

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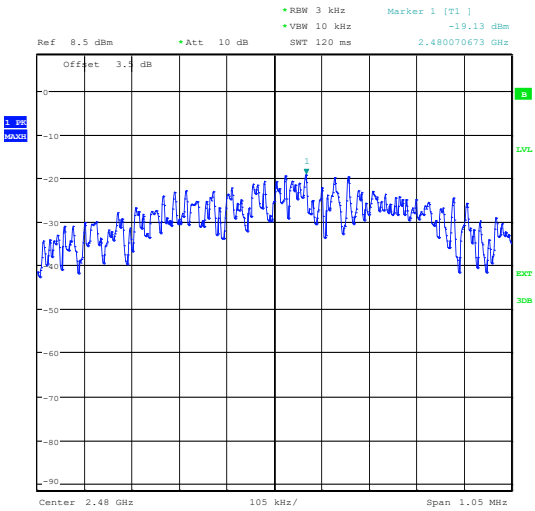
2480 MHz




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 connecter) 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 µs** |
| 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.

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

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

| ***Channel Frequency (MHz)*** | ***Maximum Conducted Power (mW)*** | ***SAR Exclusion Threshold at 5 mm (mW)*** | ***SAR Evaluation*** |
|---|---|---|---|
| 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

$$S = \frac{EIRP}{4\pi R^2} \quad \text{re-arranged } R = \sqrt{\frac{EIRP}{S4\pi}}$$

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) ($mW/cm^2$)*** | ***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 |