

Report on the Radio Testing  
For  
Dyson Technology Ltd  
on  
RB03 Dyson 360 VISNAV  
Report no. TRA-047957-45-05B  
25<sup>th</sup> May 2021

RF915 7.0



Report Number: TRA-047957-45-05B  
Issue: B

REPORT ON THE RADIO TESTING OF A  
Dyson Technology Ltd  
RB03 Dyson 360 VISNAV  
WITH RESPECT TO SPECIFICATION  
FCC 47CFR 15.247

TEST DATE: 2020/06/05 - 2020/12/10

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Approved by:

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Radio Senior Test Engineer

Date: 25<sup>th</sup> May 2021

Disclaimers:

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

RF915 7.0

## 1 Revision Record

| <i>Issue Number</i> | <i>Issue Date</i>           | <i>Revision History</i>          |
|---------------------|-----------------------------|----------------------------------|
| A                   | 13 <sup>th</sup> April 2021 | Original                         |
| B                   | 25 <sup>th</sup> May 2021   | Update after certification check |
|                     |                             |                                  |

## 2 Summary

|                             |                                                                                                                                                          |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEST REPORT NUMBER:         | TRA-047957-45-05B                                                                                                                                        |
| WORKS ORDER NUMBER:         | TRA-047957-03                                                                                                                                            |
| PURPOSE OF TEST:            | USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J. |
| TEST SPECIFICATION:         | 47CFR15.247                                                                                                                                              |
| EQUIPMENT UNDER TEST (EUT): | RB03 Dyson 360 VISNAV                                                                                                                                    |
| FCC IDENTIFIER:             | QVHRB03001                                                                                                                                               |
| EUT SERIAL NUMBER:          | not applicable                                                                                                                                           |
| MANUFACTURER/AGENT:         | Dyson Technology Ltd                                                                                                                                     |
| ADDRESS:                    | Tetbury Hill<br>Malmesbury<br>Wiltshire<br>SN16 0RP<br>United Kingdom                                                                                    |
| CLIENT CONTACT:             | Neil Taylor<br>☎ 01666834364<br>✉ neil.taylor@dyson.com                                                                                                  |
| ORDER NUMBER:               | 6000061185                                                                                                                                               |
| TEST DATE:                  | 2020/06/05 - 2020/12/10                                                                                                                                  |
| TESTED BY:                  | D Garvey / A Tosif / A Longley<br>Element                                                                                                                |

## 2.1 Test Summary

| Test Method and Description                                                       |      | Requirement Clause | Applicable to this equipment        | Result / Note |
|-----------------------------------------------------------------------------------|------|--------------------|-------------------------------------|---------------|
|                                                                                   |      | 47CFR15            |                                     |               |
| Radiated spurious emissions (restricted bands of operation and cabinet radiation) |      | 15.205             | <input checked="" type="checkbox"/> | PASS          |
| AC power line conducted emissions                                                 |      | 15.207             | <input checked="" type="checkbox"/> | PASS          |
| Occupied bandwidth                                                                |      | 15.247(a)(2)       | <input checked="" type="checkbox"/> | PASS          |
| Conducted carrier power                                                           | Peak | 15.247(b)(3)       | <input checked="" type="checkbox"/> | PASS          |
|                                                                                   | Max. |                    | <input type="checkbox"/>            |               |
| Conducted / radiated RF power out-of-band                                         |      | 15.247(d)          | <input checked="" type="checkbox"/> | PASS          |
| Power spectral density, conducted                                                 |      | 15.247(e)          | <input checked="" type="checkbox"/> | PASS          |

### Notes:

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

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

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

### 3 Contents

|      |                                                    |    |
|------|----------------------------------------------------|----|
| 1    | Revision Record .....                              | 3  |
| 2    | Summary.....                                       | 4  |
| 2.1  | Test Summary.....                                  | 5  |
| 3    | Contents.....                                      | 6  |
| 4    | Introduction .....                                 | 8  |
| 5    | Test Specifications .....                          | 9  |
| 5.1  | Normative References .....                         | 9  |
| 5.2  | Deviations from Test Standards.....                | 9  |
| 6    | Glossary of Terms .....                            | 10 |
| 7    | Equipment Under Test .....                         | 11 |
| 7.1  | EUT Identification.....                            | 11 |
| 7.2  | System Equipment.....                              | 11 |
| 7.3  | EUT Mode of Operation.....                         | 11 |
| 7.4  | EUT Radio Parameters.....                          | 11 |
| 7.5  | EUT Description .....                              | 11 |
| 8    | Modifications .....                                | 12 |
| 9    | EUT Test Setup .....                               | 13 |
| 9.1  | Block Diagram .....                                | 13 |
| 9.2  | General Set-up Photograph.....                     | 13 |
| 9.3  | Measurement software .....                         | 15 |
| 10   | General Technical Parameters.....                  | 16 |
| 10.1 | Normal Conditions.....                             | 16 |
| 10.2 | Varying Test Conditions.....                       | 16 |
| 11   | Radiated emissions.....                            | 17 |
| 11.1 | Definitions .....                                  | 17 |
| 11.2 | Test Parameters.....                               | 17 |
| 11.3 | Test Limit .....                                   | 17 |
| 11.4 | Test Method.....                                   | 18 |
| 11.5 | Test Set-up Photograph.....                        | 19 |
| 11.6 | Test Equipment .....                               | 19 |
| 11.7 | Test Results.....                                  | 20 |
| 12   | AC power-line conducted emissions .....            | 31 |
| 12.1 | Definition.....                                    | 31 |
| 12.2 | Test Parameters.....                               | 31 |
| 12.3 | Test Limit .....                                   | 31 |
| 12.4 | Test Method.....                                   | 31 |
| 12.5 | Test Set-up Photograph.....                        | 32 |
| 12.6 | Test Equipment .....                               | 32 |
| 12.7 | Test Results.....                                  | 33 |
| 13   | Occupied Bandwidth .....                           | 34 |
| 13.1 | Definition.....                                    | 34 |
| 13.2 | Test Parameters .....                              | 34 |
| 13.3 | Test Limit .....                                   | 34 |
| 13.4 | Test Method.....                                   | 35 |
| 13.5 | Test Equipment .....                               | 35 |
| 13.6 | Test Results.....                                  | 36 |
| 14   | Maximum peak conducted output power .....          | 38 |
| 14.1 | Definition.....                                    | 38 |
| 14.2 | Test Parameters .....                              | 38 |
| 14.3 | Test Limit .....                                   | 38 |
| 14.4 | Test Method.....                                   | 39 |
| 14.5 | Test Equipment .....                               | 39 |
| 14.6 | Test Results.....                                  | 39 |
| 15   | Out-of-band and conducted spurious emissions ..... | 42 |
| 15.1 | Definition.....                                    | 42 |
| 15.2 | Test Parameters .....                              | 42 |
| 15.3 | Test Limit .....                                   | 42 |
| 15.4 | Test Method.....                                   | 43 |
| 15.5 | Test Equipment .....                               | 43 |
| 15.6 | Test Results.....                                  | 44 |

|      |                               |    |
|------|-------------------------------|----|
| 16   | Power spectral density .....  | 46 |
| 16.1 | Definition .....              | 46 |
| 16.2 | Test Parameters .....         | 46 |
| 16.3 | Test Limit .....              | 46 |
| 16.4 | Test Method .....             | 47 |
| 16.5 | Test Equipment .....          | 47 |
| 16.6 | Test Results .....            | 47 |
| 17   | Measurement Uncertainty ..... | 50 |

## 4 Introduction

This report TRA-047957-45-05B presents the results of the Radio testing on a Dyson Technology Ltd, RB03 Dyson 360 VISNAV to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Dyson Technology Ltd by Element, at the address detailed below.

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

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

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

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

Element is accredited for the above sites under the US-UK MRA, designation numbers:

UK2007 Hull

UK2020 Skelmersdale

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

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

## 7 Equipment Under Test

### 7.1 EUT Identification

- Name: RB03 Dyson 360 VISNAV
- Serial Number: not applicable
- Model Number: RB03
- Software Revision: Not Applicable
- Build Level / Revision Number: Not Applicable

### 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 EUT was transmitting continuously with modulation on bottom, middle and top channels, as required.

### 7.4 EUT Radio Parameters

|                                |                                    |
|--------------------------------|------------------------------------|
| <b>Frequency of operation:</b> | 2402 MHz – 2480 MHz                |
| <b>Modulation type:</b>        | GFSK                               |
| <b>Nominal Supply Voltage:</b> | 5.0 Vdc from internal power supply |
| <b>Antenna Type:</b>           | Integral PCB                       |
| <b>Antenna Gain:</b>           | 5.0 dBi                            |

### 7.5 EUT Description

The EUT is an autonomous Vacuum Cleaning Robot and Dock that has Bluetooth Low Energy, 2.4 GHz Wi-Fi and 5 GHz Wi-Fi Radios. This test report only covers testing of the Bluetooth Low Energy.

## **8 Modifications**

No modifications were performed during this assessment.

## 9 EUT Test Setup

### 9.1 Block Diagram

The following diagram shows basic EUT interconnections:



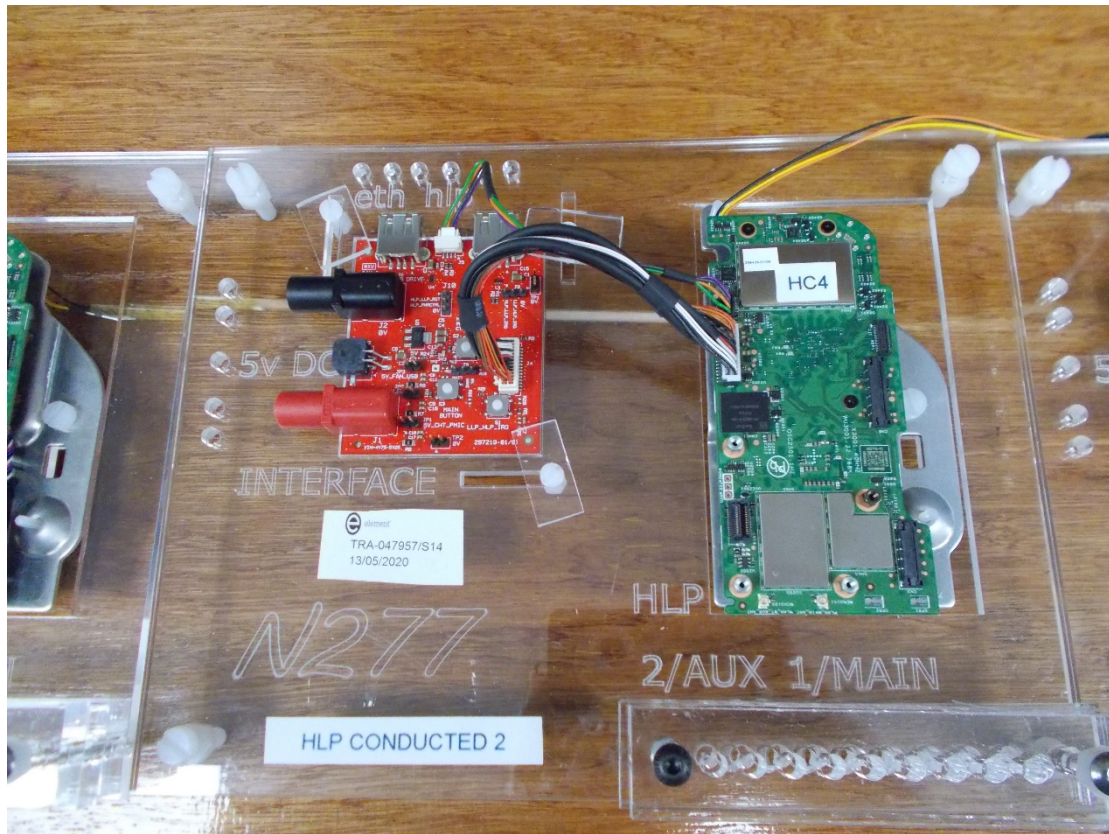
### 9.2 General Set-up Photograph

The following photographs shows basic EUT radiated set-up:





The following photograph shows the conducted sample:



### 9.3 Measurement software

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

Element Emissions R5 (See Note)

Note:

The version of the Element software used is recorded in the results sheets contained within this report.

## 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 5 Vdc from an internal power supply which was powered from a 14.8 Vdc fully charged battery, with charging station connected to 110 Vac, 60 Hz, from the mains. For conducted testing, 5 Vdc was supplied from desktop power supply.

### 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:

|                                     | <b>Category</b>       | <b>Nominal</b>  | <b>Variation</b> |
|-------------------------------------|-----------------------|-----------------|------------------|
| <input type="checkbox"/>            | Mains                 | 110 V ac +/-2 % | 85 % and 115 %   |
| <input checked="" type="checkbox"/> | Internal Power Supply | 5 Vdc           | 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 Hull                                                 |
| Test Chamber:             | Wireless Lab 3                                               |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 6.5 and 6.6                         |
| EUT Frequencies Measured: | 2402 MHz / 2440 MHz / 2480 MHz                               |
| EUT Channel Bandwidths:   | 2 MHz                                                        |
| Deviations From Standard: | None                                                         |
| Measurement BW:           | 30 MHz to 1 GHz: 120 kHz<br>Above 1 GHz: 1 MHz               |
| Measurement Detector:     | Up to 1 GHz: quasi-peak<br>Above 1 GHz: RMS average and Peak |

#### **Environmental Conditions (Normal Environment)**

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 42 % RH  | 20 % RH to 75 % RH (as declared) |
| Supply: 5 Vdc      | As declared                      |

### 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**

| <b>Frequency<br/>(MHz)</b> | <b>Field Strength<br/>(<math>\mu\text{V/m}</math> at 3 m)</b> |
|----------------------------|---------------------------------------------------------------|
| 30 to 88                   | 100                                                           |
| 88 to 216                  | 150                                                           |
| 216 to 960                 | 200                                                           |
| Above 960                  | 500                                                           |

## 11.4 Test Method

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

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

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

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

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

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

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

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBμV;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

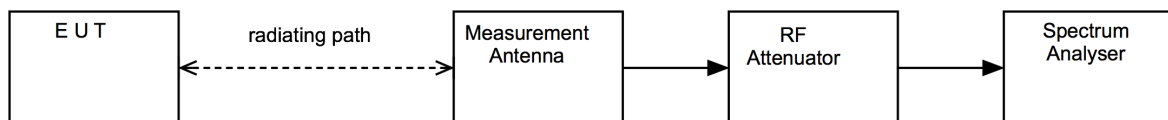
PA is the pre-amplifier gain in dB (where used);

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

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

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

**Figure i Test Setup**



### 11.5 Test Set-up Photograph



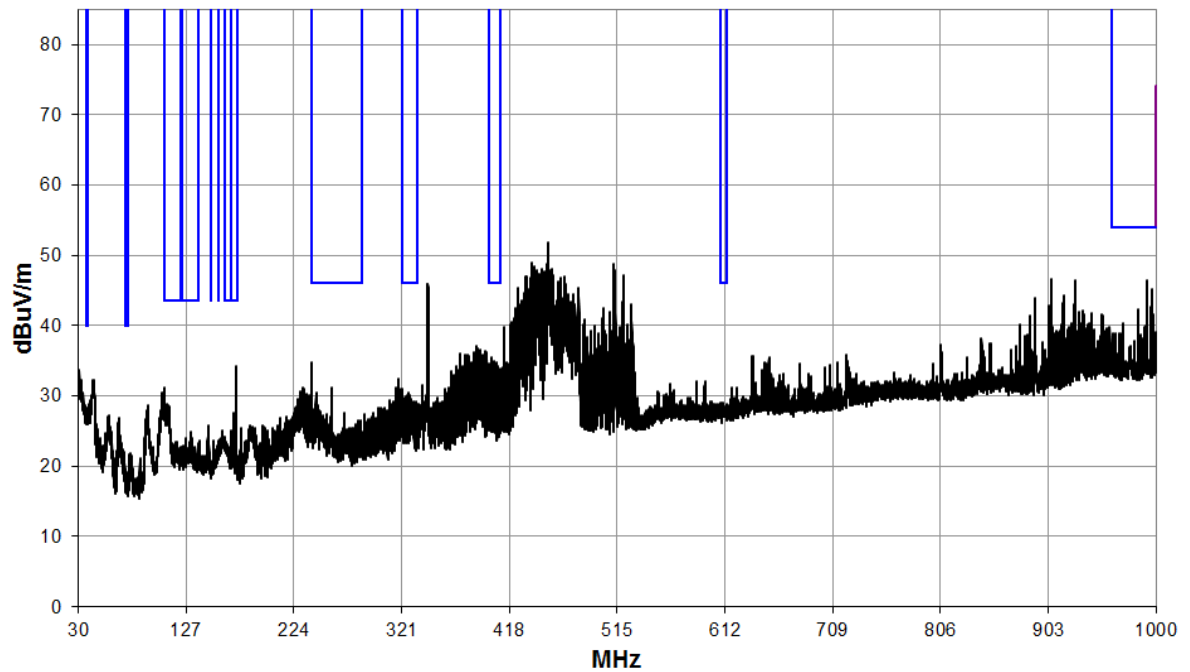
### 11.6 Test Equipment

| Equipment Type        | Manufacturer | Equipment Description  | Element No | Due For Calibration |
|-----------------------|--------------|------------------------|------------|---------------------|
| Ferrite Lined Chamber | Rainford     | Chamber                | REF2259    | 2022-08-03          |
| EMI Test Receiver     | R&S          | ESW26                  | REF2235    | 2021-08-31          |
| Bilog Antenna         | Chase        | CBL6111B               | REF2218    | 2021-10-23          |
| Horn Antenna          | A Info Inc   | LB-10180-NF            | REF2241    | 2022-07-13          |
| LB-90-25-C2-SF        | A Info Inc   | Horn Antenna           | REF2243    | 2022-07-17          |
| LB-62-25-C-SF         | A Info Inc   | Horn Antenna           | REF2244    | 2022-07-17          |
| LB-180400-25-C-KF     | A Info Inc   | Horn Antenna           | REF2246    | 2022-07-28          |
| Emissions R5          | Element      | Radiated Test Software | REF9000    | Cal not required    |

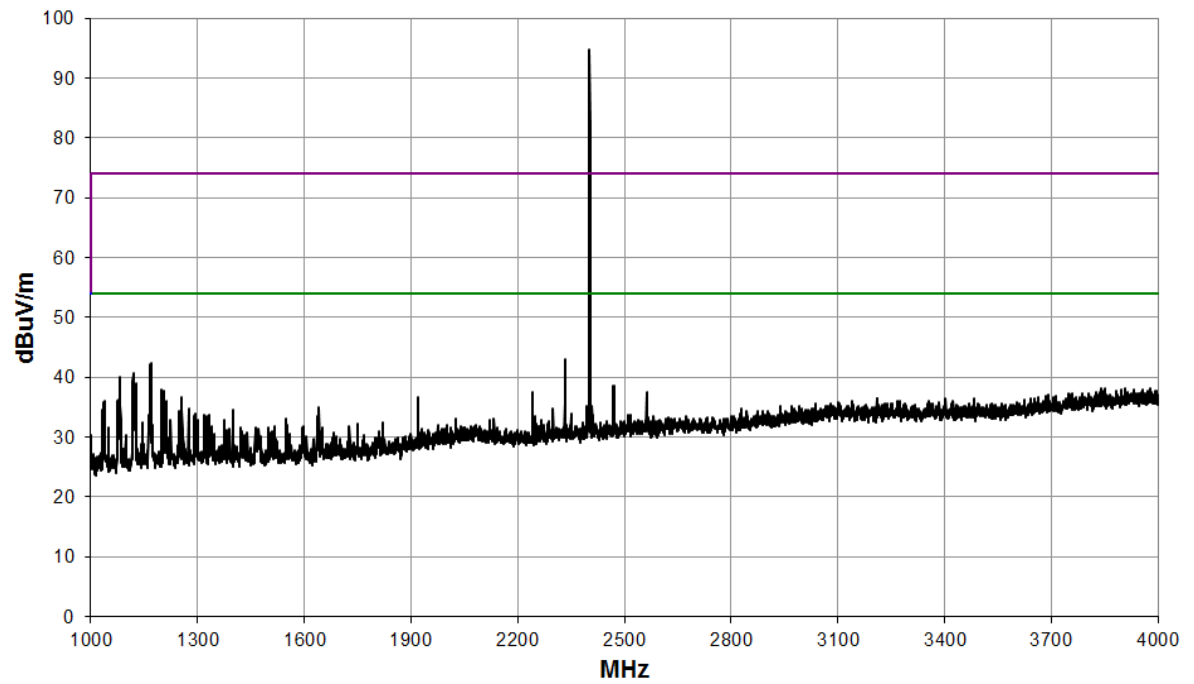
## 11.7 Test Results

| BLE; Power Setting: 4; Channel: 0; Frequency: 2402 MHz |             |                        |                 |                       |                   |                        |                               |                         |                       |              |
|--------------------------------------------------------|-------------|------------------------|-----------------|-----------------------|-------------------|------------------------|-------------------------------|-------------------------|-----------------------|--------------|
| Detector                                               | Freq. (MHz) | Meas'd Emission (dBμV) | Cable Loss (dB) | Antenna Factor (dB/m) | Pre-amp Gain (dB) | Duty Cycle Corr'n (dB) | Distance Extrap'n Factor (dB) | Field Strength (dBμV/m) | Field Strength (μV/m) | Limit (μV/m) |
| AV                                                     | 1169.5      | 10.7                   | 2.5             | 24.6                  | 0.0               | 0.0                    | 0.0                           | 37.8                    | 77.6                  | 500          |
| AV                                                     | 4803.9      | -1.4                   | 5.4             | 33.3                  | 0.0               | 0.0                    | 0.0                           | 37.3                    | 73.3                  | 500          |
| Peak emissions are not within 20 dB of the limit.      |             |                        |                 |                       |                   |                        |                               |                         |                       |              |

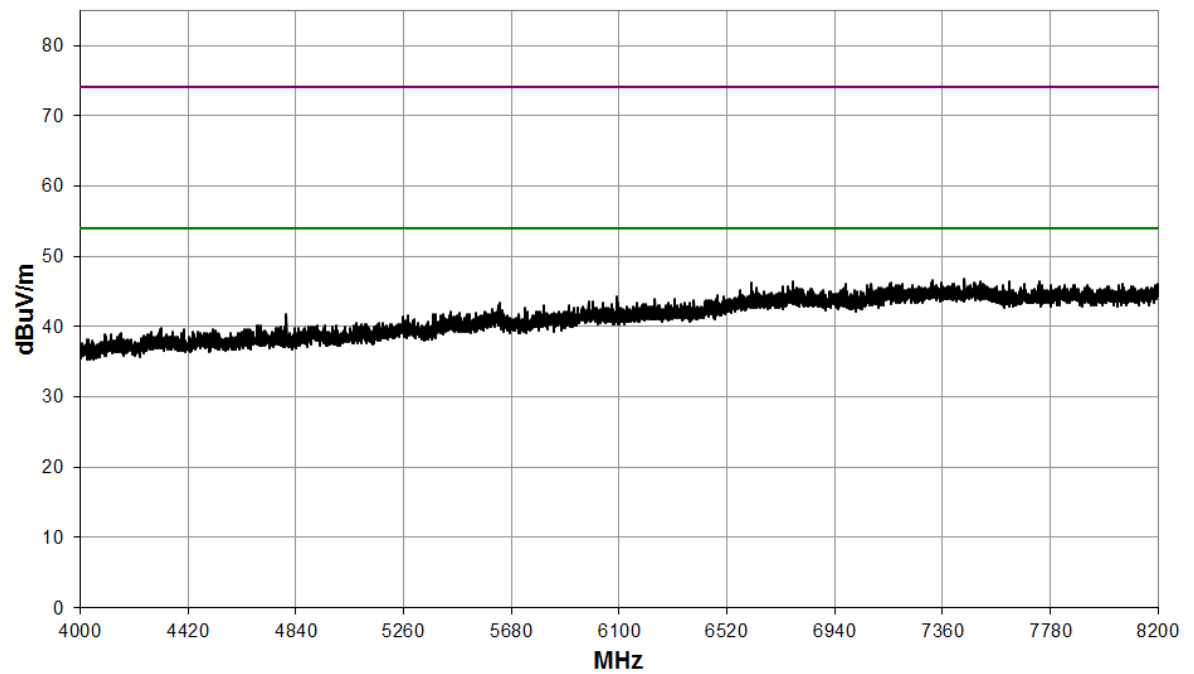
30 MHz to 1 GHz



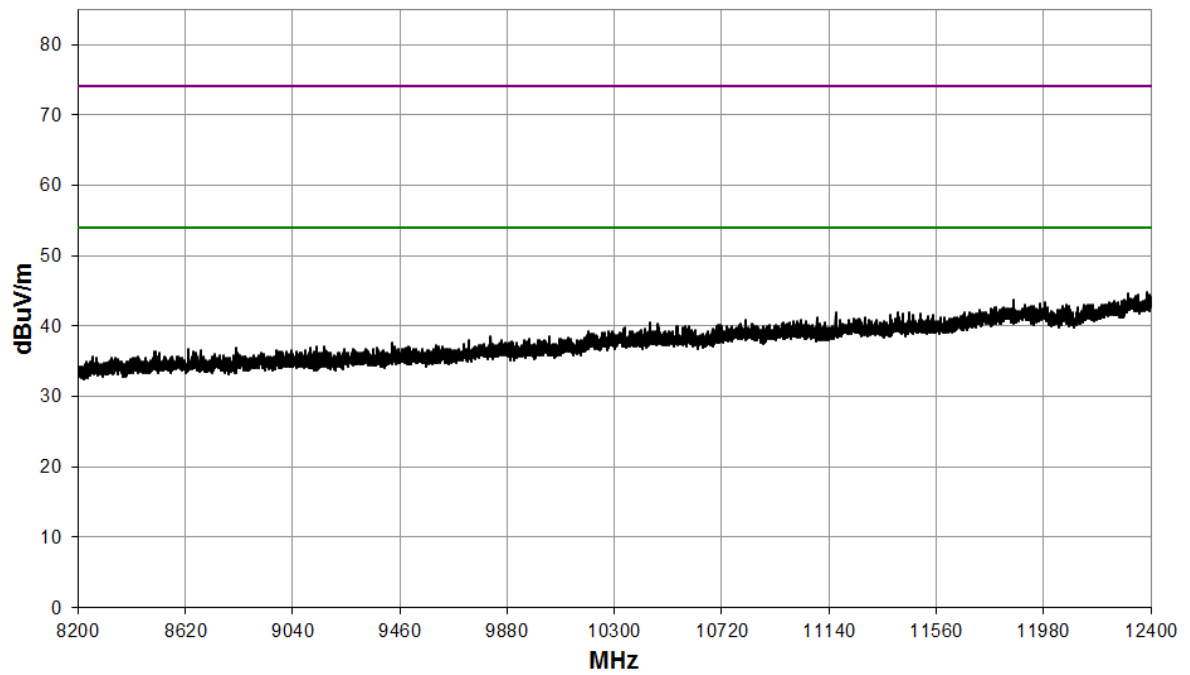
## 1 GHz to 4 GHz



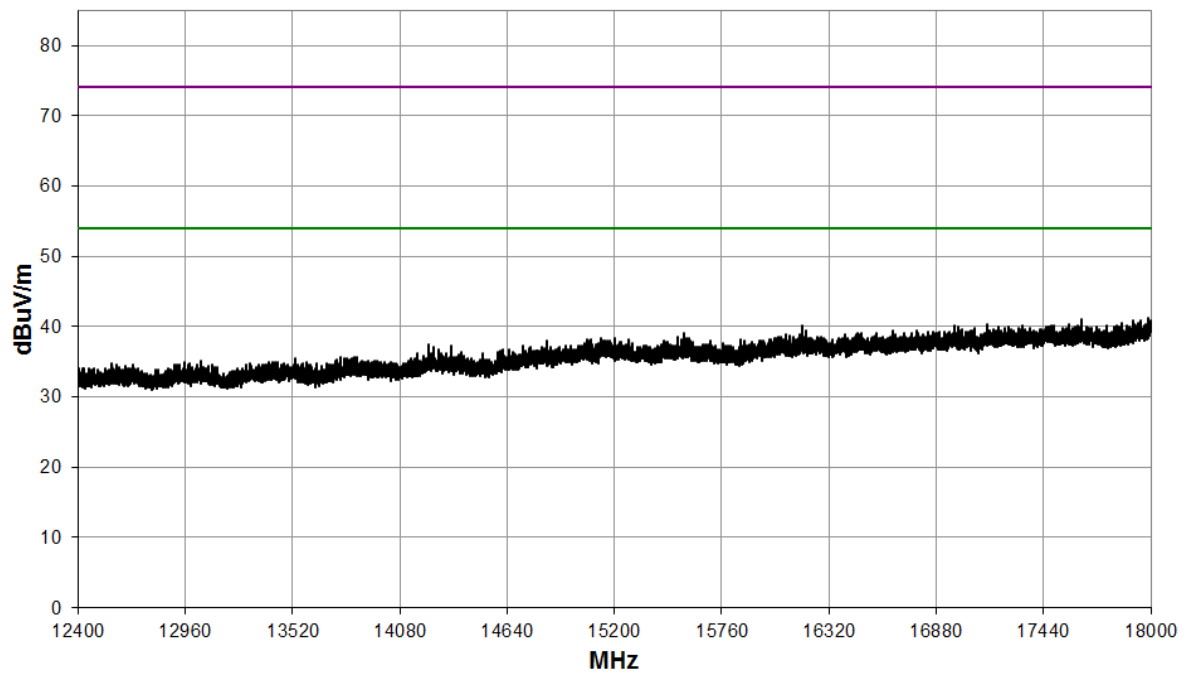
## 4 GHz to 8.2 GHz



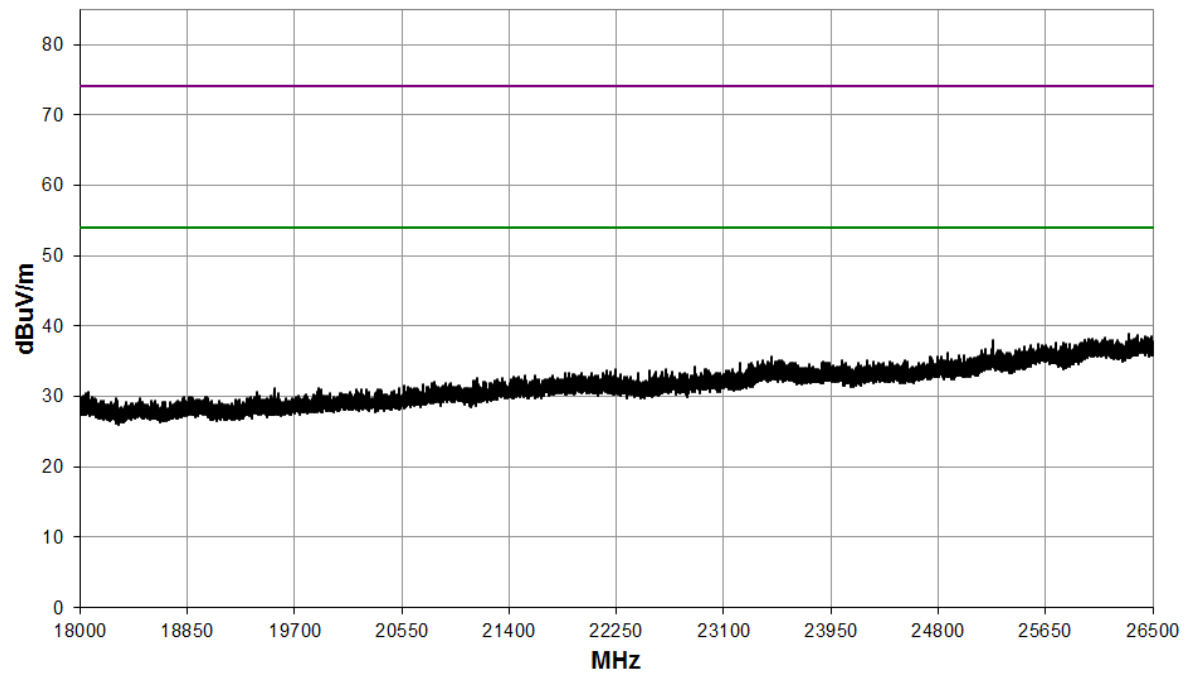
## 8.2 GHz to 12.4 GHz



## 12.4 GHz to 18 GHz

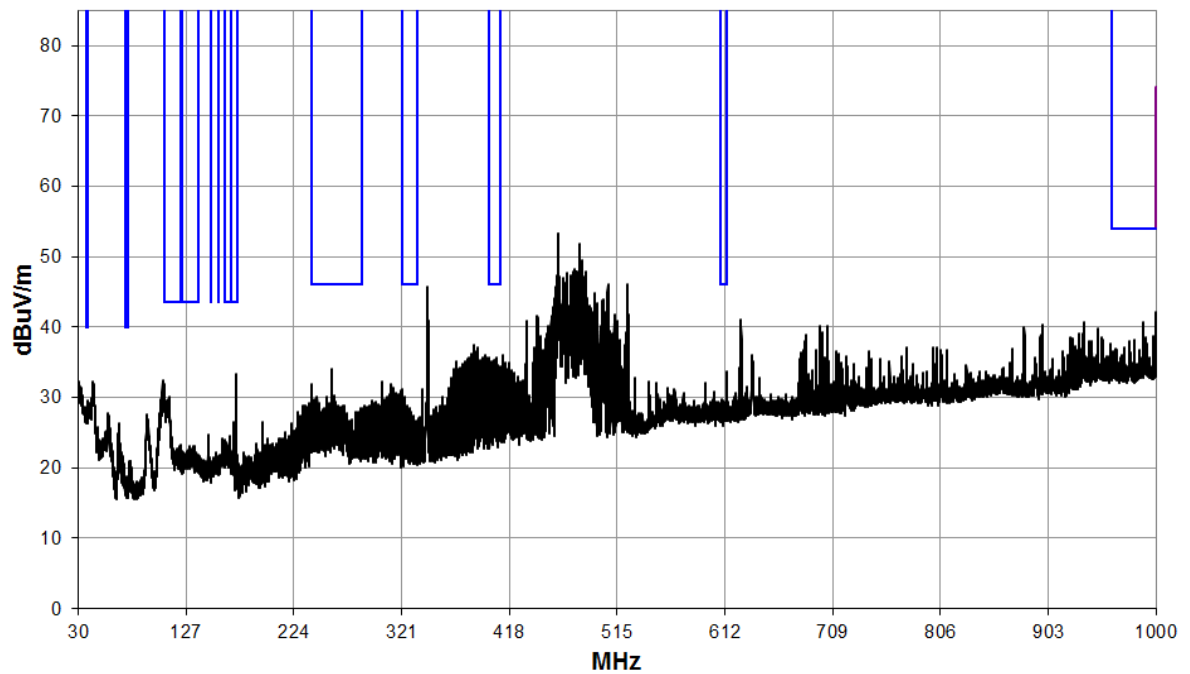


18 GHz to 26.5 GHz

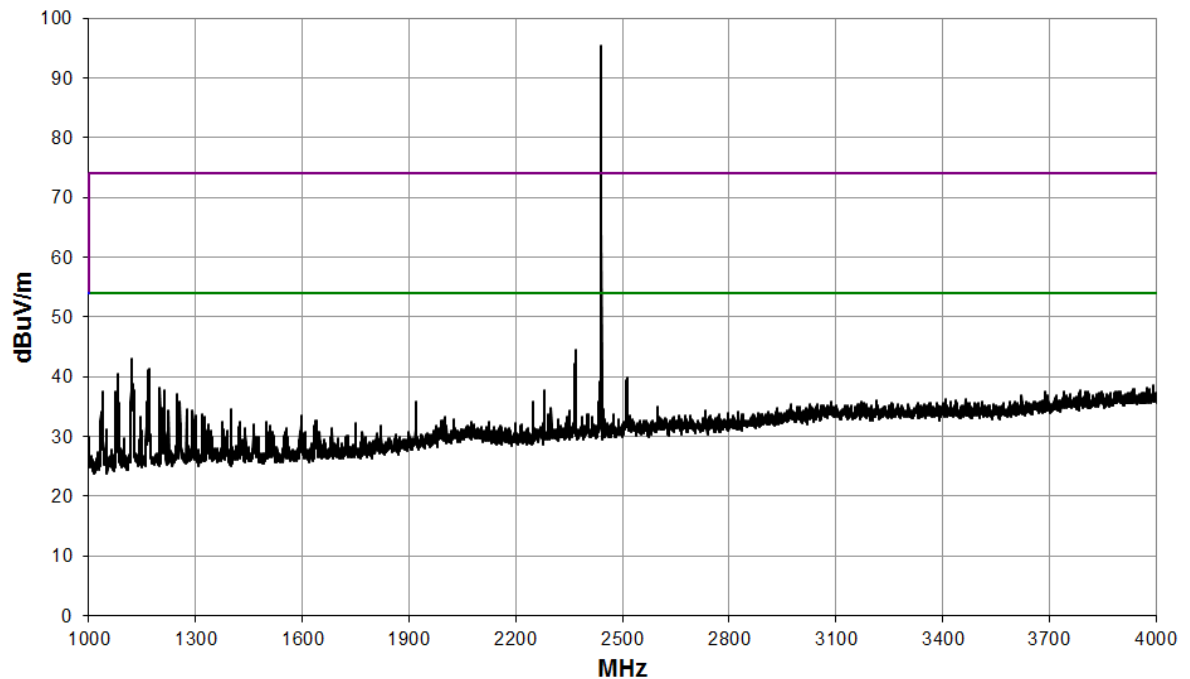


| BLE; Power Setting: 4; Channel: 19; Frequency: 2440 MHz |             |                        |                 |                       |                   |                        |                               |                         |                       |              |
|---------------------------------------------------------|-------------|------------------------|-----------------|-----------------------|-------------------|------------------------|-------------------------------|-------------------------|-----------------------|--------------|
| Detector                                                | Freq. (MHz) | Meas'd Emission (dBμV) | Cable Loss (dB) | Antenna Factor (dB/m) | Pre-amp Gain (dB) | Duty Cycle Corr'n (dB) | Distance Extrap'n Factor (dB) | Field Strength (dBμV/m) | Field Strength (μV/m) | Limit (μV/m) |
| AV                                                      | 1169.5      | 10.7                   | 2.5             | 24.6                  | 0.0               | 0.0                    | 0.0                           | 37.8                    | 77.6                  | 500          |
| AV                                                      | 4879.9      | 0.9                    | 5.4             | 33.3                  | 0.0               | 0.0                    | 0.0                           | 39.6                    | 95.5                  | 500          |
| Peak emissions are not within 20 dB of the limit.       |             |                        |                 |                       |                   |                        |                               |                         |                       |              |

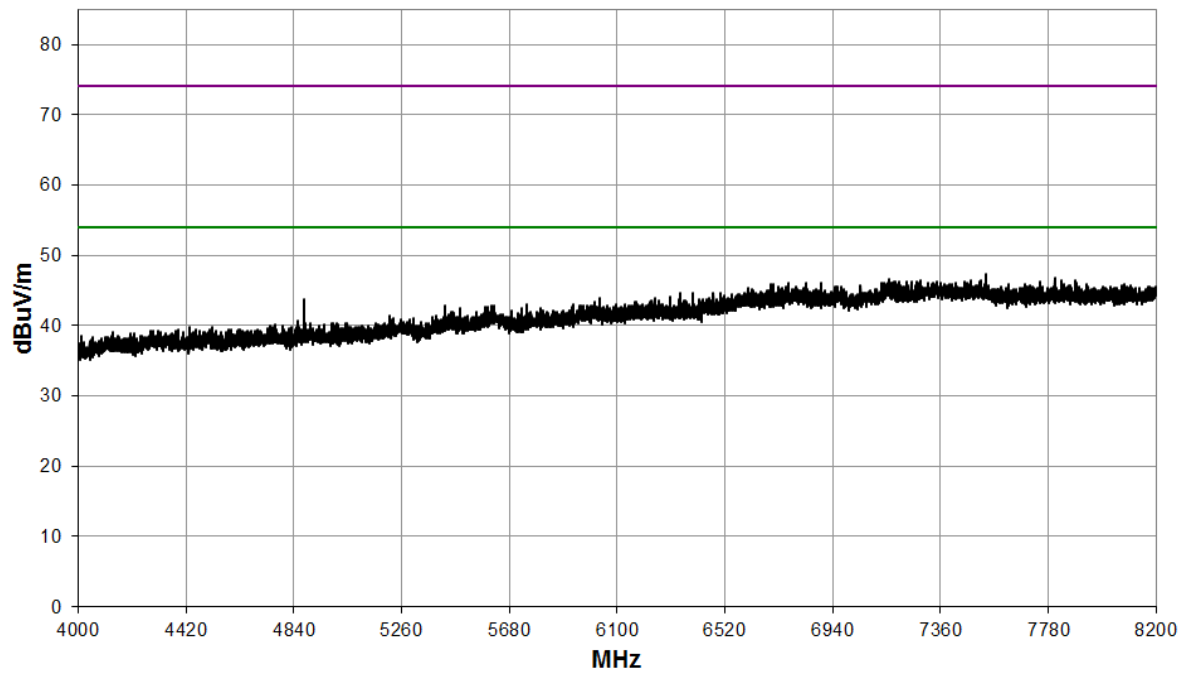
## 30 MHz to 1 GHz



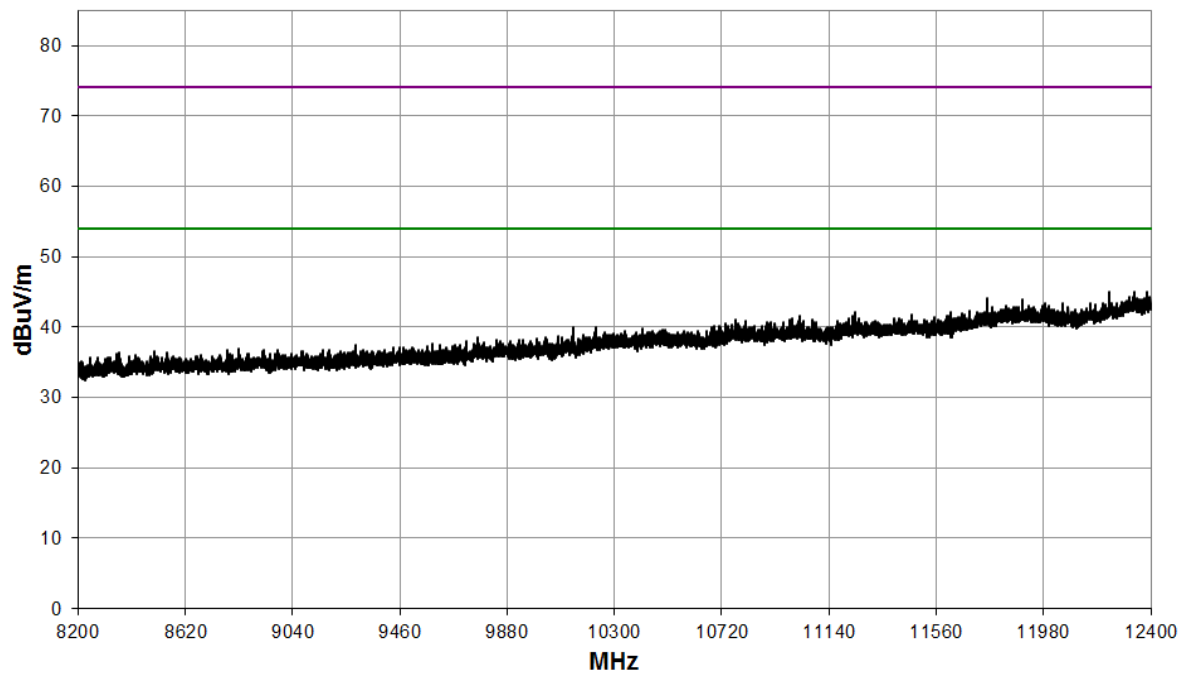
## 1 GHz to 4 GHz



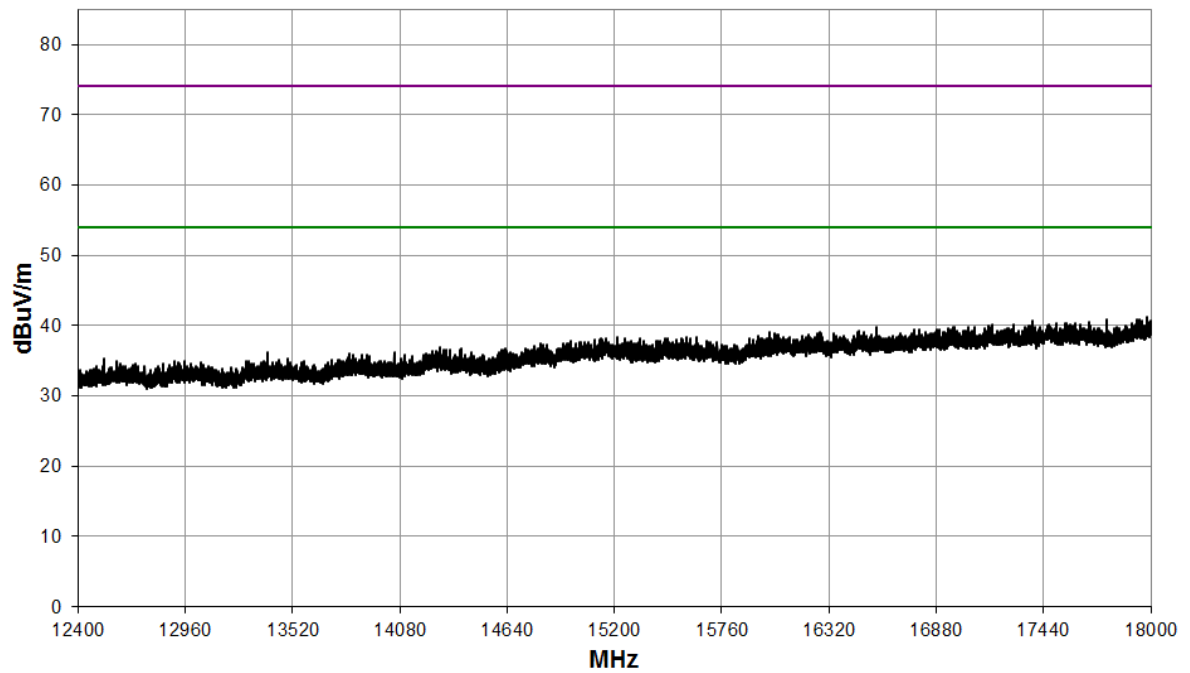
## 4 GHz to 8.2 GHz



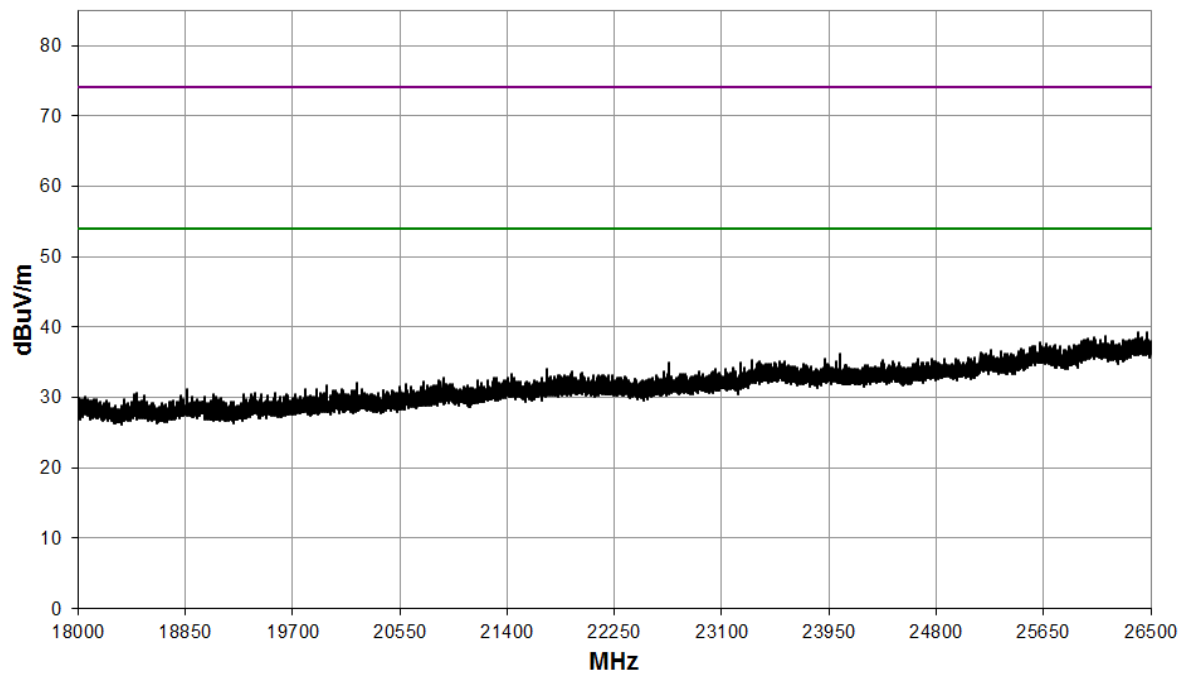
## 8.2 GHz to 12.4 GHz



## 12.4 GHz to 18 GHz

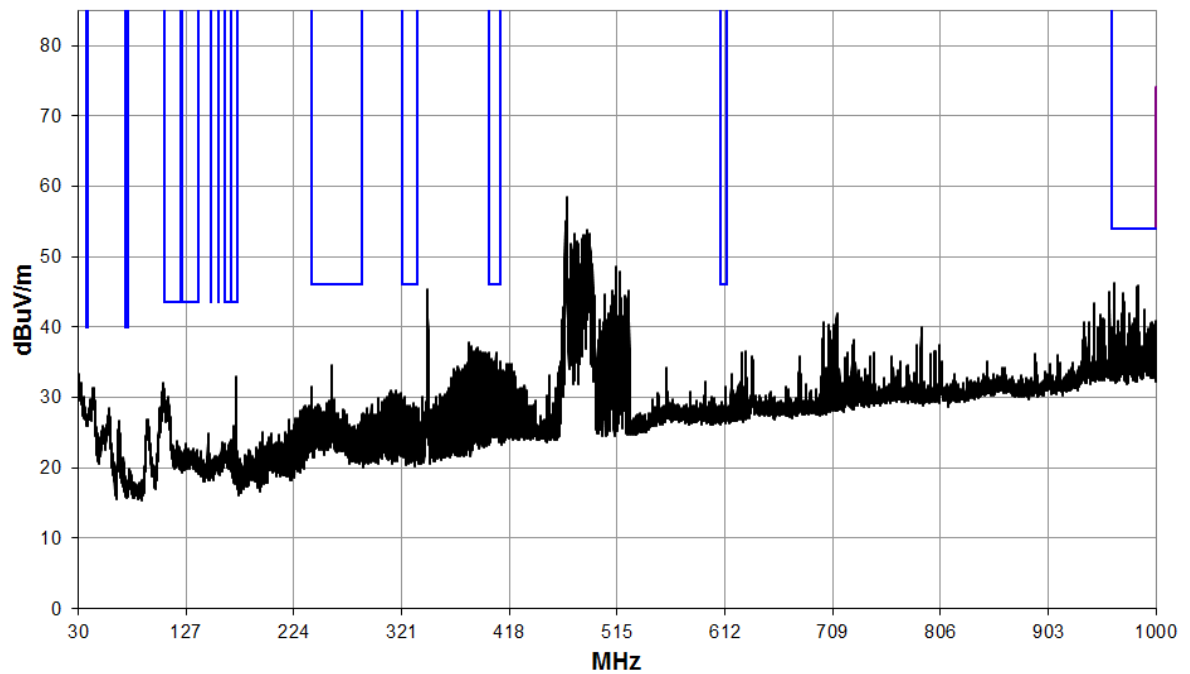


## 18 GHz to 26.5 GHz

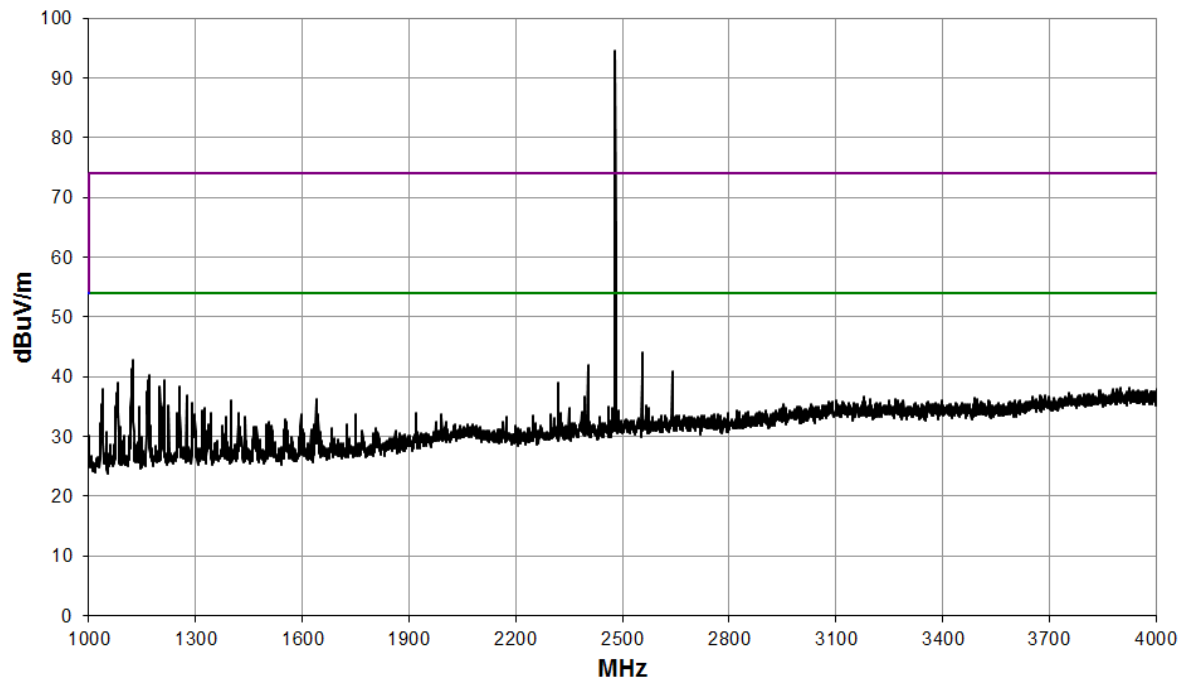


| BLE; Power Setting: 4; Channel: 39; Frequency: 2480 MHz |             |                        |                 |                       |                   |                        |                               |                         |                       |              |
|---------------------------------------------------------|-------------|------------------------|-----------------|-----------------------|-------------------|------------------------|-------------------------------|-------------------------|-----------------------|--------------|
| Detector                                                | Freq. (MHz) | Meas'd Emission (dBμV) | Cable Loss (dB) | Antenna Factor (dB/m) | Pre-amp Gain (dB) | Duty Cycle Corr'n (dB) | Distance Extrap'n Factor (dB) | Field Strength (dBμV/m) | Field Strength (μV/m) | Limit (μV/m) |
| AV                                                      | 1169.5      | 10.7                   | 2.5             | 24.6                  | 0.0               | 0.0                    | 0.0                           | 37.8                    | 77.6                  | 500          |
| AV                                                      | 4959.9      | -0.9                   | 5.5             | 33.3                  | 0.0               | 0.0                    | 0.0                           | 37.9                    | 78.5                  | 500          |
| Peak emissions are not within 20 dB of the limit.       |             |                        |                 |                       |                   |                        |                               |                         |                       |              |

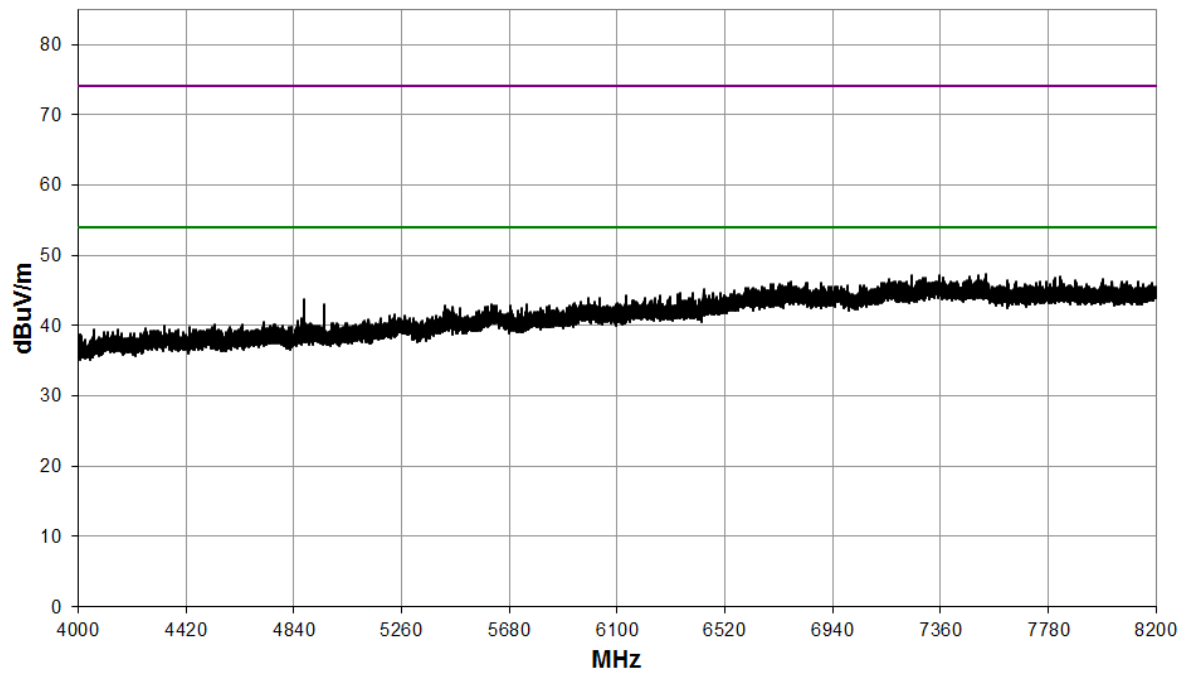
## 30 MHz to 1 GHz



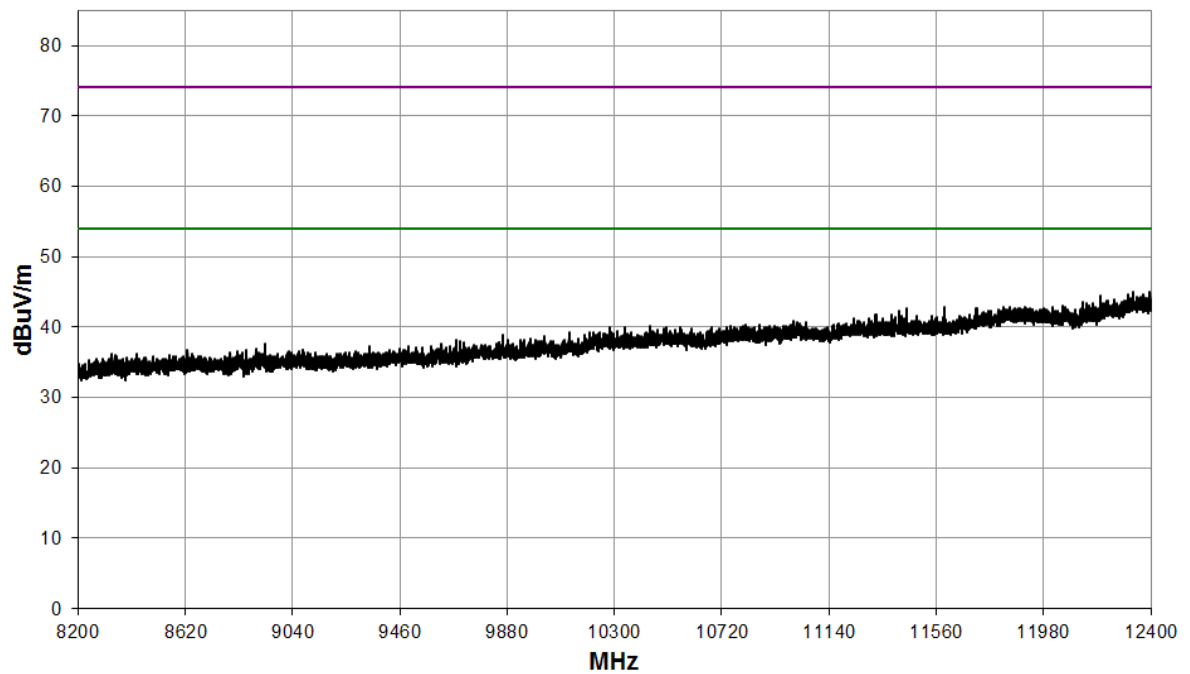
## 1 GHz to 4 GHz



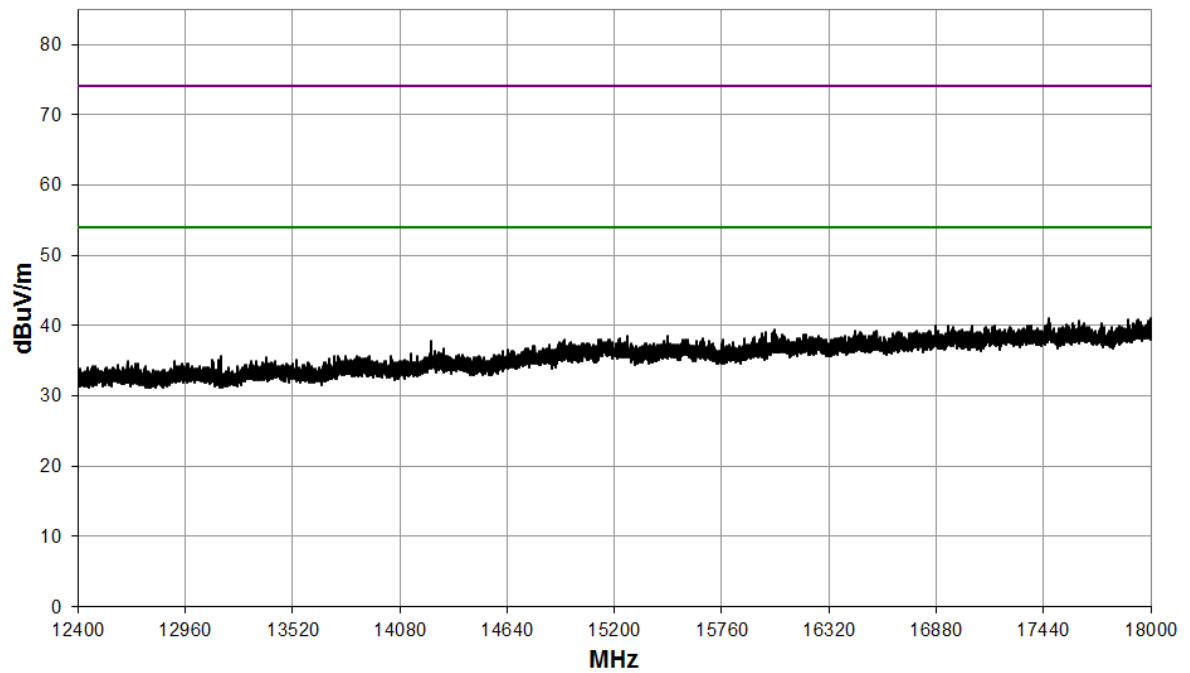
## 4 GHz to 8.2 GHz



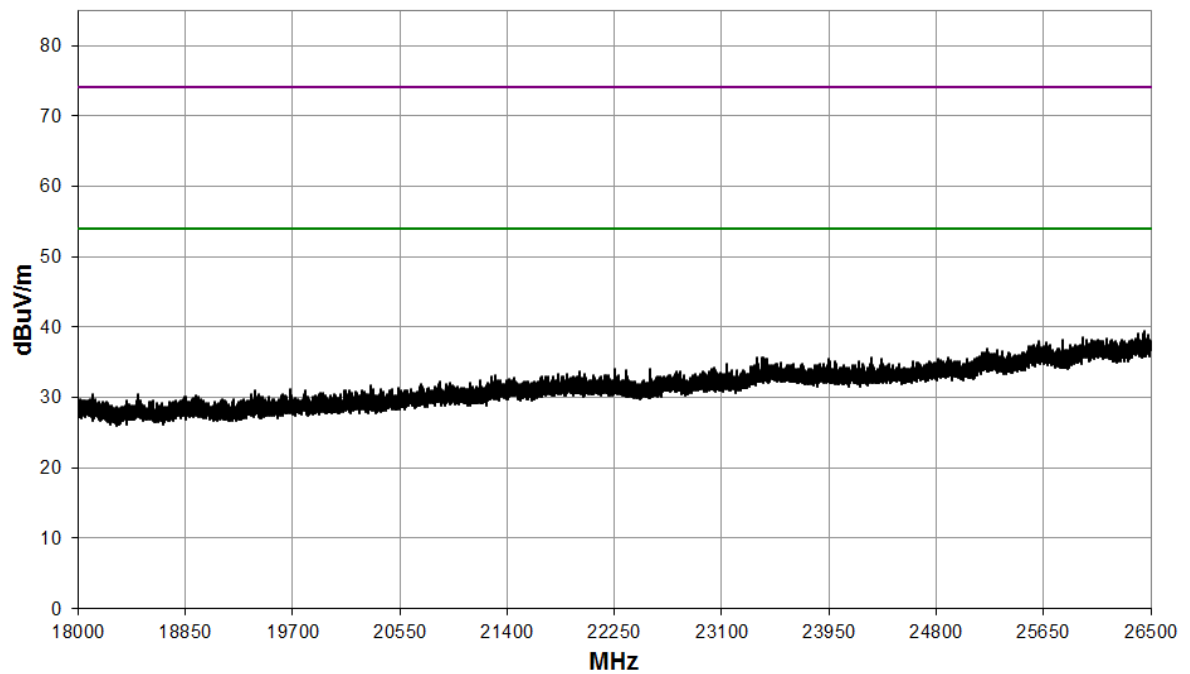
## 8.2 GHz to 12.4 GHz



## 12.4 GHz to 18 GHz



## 18 GHz to 26.5 GHz





## 12 AC power-line conducted emissions

### 12.1 Definition

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

### 12.2 Test Parameters

|                           |                              |
|---------------------------|------------------------------|
| Test Location:            | Element Hull                 |
| Test Chamber:             | Screen Room 2                |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 6.2 |
| EUT Channels:             | 2440 MHz                     |
| Deviations From Standard: | None                         |
| Measurement Detectors:    | Quasi-Peak and Average       |

### Environmental Conditions (Normal Environment)

|                    |                                   |
|--------------------|-----------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared)    |
| Humidity: 40 % RH  | 20 % RH to 75 % RH (as declared)  |
| Supply: 110 Vac    | 110 V ac $\pm 10$ % (as declared) |

### 12.3 Test Limit

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

**Table 3 – AC Power Line Conducted Emission Limits**

| Frequency<br>(MHz) | Conducted limit<br>(dB $\mu$ V) |           |
|--------------------|---------------------------------|-----------|
|                    | Quasi-Peak                      | Average** |
| 0.15 to 0.5        | 66 to 56*                       | 56 to 46* |
| 0.5 to 5           | 56                              | 46        |
| 5 to 30            | 60                              | 50        |

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

\*\*A linear average detector is required.

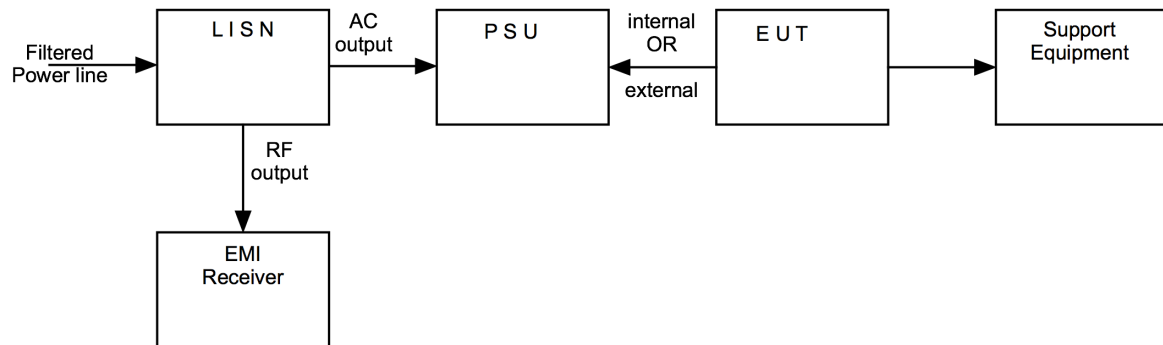
### 12.4 Test Method

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

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

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

**Figure ii Test Setup**



### 12.5 Test Set-up Photograph

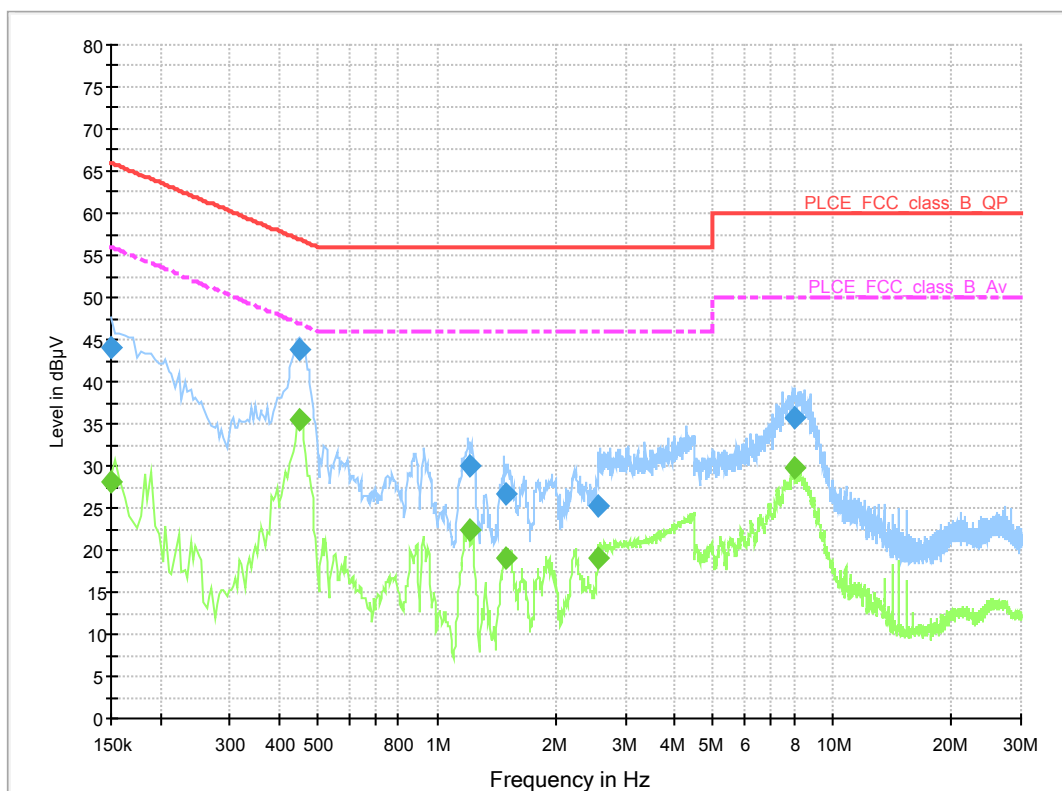


### 12.6 Test Equipment

| Equipment Type     | Manufacturer | Equipment Description | Element No | Due For Calibration |
|--------------------|--------------|-----------------------|------------|---------------------|
| Measuring Receiver | R&S          | ESHS10                | RFG125     | 2021-01-22          |
| LISN               | R&S          | ESH3-Z5               | RFG732     | 2021-05-18          |
| Pulse Limiter      | R&S          | ESH3-Z2               | RFG680     | 2021-06-09          |

## 12.7 Test Results

| AC power-line conducted emissions, Transmit mode |                 |           |               |                            |             |                |
|--------------------------------------------------|-----------------|-----------|---------------|----------------------------|-------------|----------------|
| Results measured using the average detector      |                 |           |               |                            |             |                |
| Reference Number                                 | Frequency (MHz) | Conductor | Result (dBuV) | Specification Limit (dBuV) | Margin (dB) | Result Summary |
| 1                                                | 0.150           | L1        | 28.1          | 56.0                       | 27.9        | PASS           |
| 2                                                | 0.449           | L1        | 35.5          | 46.9                       | 11.4        | PASS           |
| 3                                                | 1.209           | L1        | 22.5          | 46.0                       | 23.6        | PASS           |
| 4                                                | 1.493           | L1        | 19.1          | 46.0                       | 26.9        | PASS           |
| 5                                                | 2.565           | L1        | 19.0          | 46.0                       | 27.0        | PASS           |
| 6                                                | 8.001           | L1        | 29.7          | 50.0                       | 20.3        | PASS           |
| Results measured using the quasi-peak detector   |                 |           |               |                            |             |                |
| Reference Number                                 | Frequency (MHz) | Conductor | Result (dBuV) | Specification Limit (dBuV) | Margin (dB) | Result Summary |
| 1                                                | 0.150           | L1        | 9.7           | 65.6                       | 21.8        | PASS           |
| 2                                                | 0.449           | L1        | 9.8           | 62.3                       | 13.1        | PASS           |
| 3                                                | 1.209           | L1        | 9.9           | 57.0                       | 26.0        | PASS           |
| 4                                                | 1.493           | L1        | 10.0          | 56.0                       | 29.4        | PASS           |
| 5                                                | 2.565           | L1        | 10.1          | 56.0                       | 30.7        | PASS           |
| 6                                                | 8.001           | L1        | 11.0          | 60.0                       | 24.3        | PASS           |



## 13 Occupied Bandwidth

### 13.1 Definition

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

### 13.2 Test Parameters

|                             |                                    |
|-----------------------------|------------------------------------|
| Test Location:              | Element Hull                       |
| Test Chamber:               | Wireless Laboratory 1              |
| Test Standard and Clause:   | FCC: ANSI C63.10-2013, Clause 11.8 |
| EUT Frequencies Measured:   | 2402 MHz / 2440 MHz / 2480 MHz     |
| EUT Channel Bandwidths:     | 2 MHz                              |
| EUT Test Modulations:       | GFSK                               |
| Deviations From Standard:   | None                               |
| Measurement BW:             | 100 kHz                            |
| Spectrum Analyzer Video BW: | 300 kHz                            |
| Measurement Span:           | 3 MHz                              |
| Measurement Detector:       | Peak                               |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 40 % RH  | 20 % RH to 75 % RH (as declared) |
| Supply: 5 Vdc      | As declared                      |

### 13.3 Test Limit

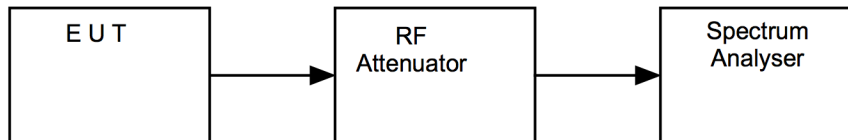
The minimum -6 dB bandwidth shall be at least 500 kHz.

### 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**

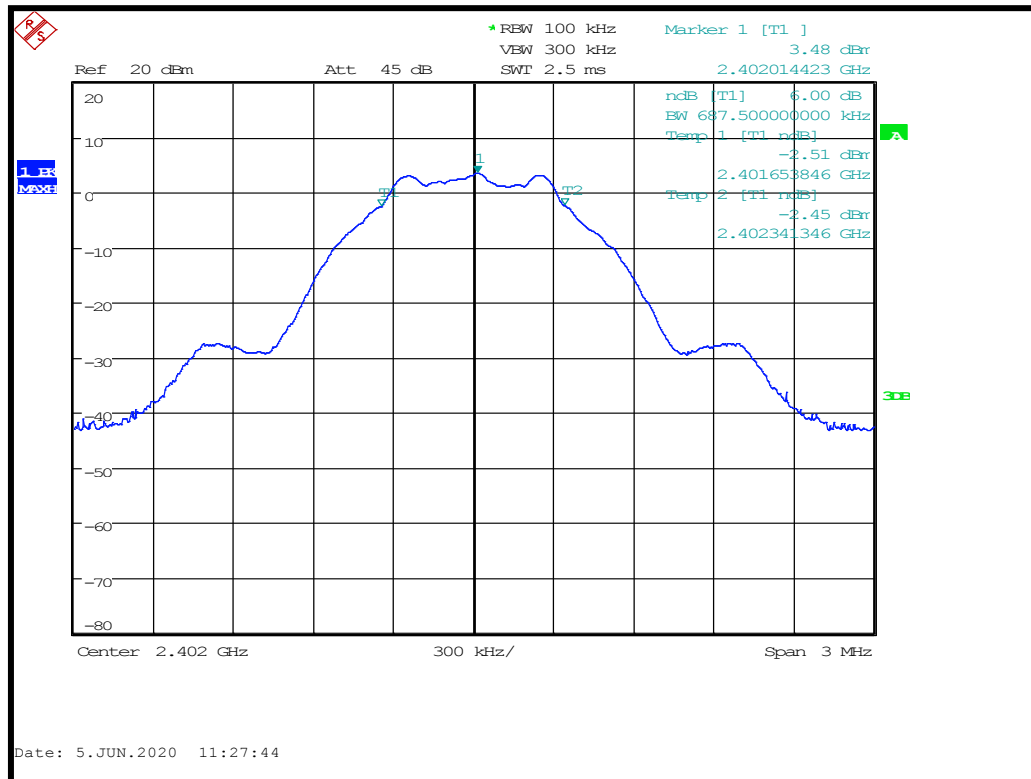


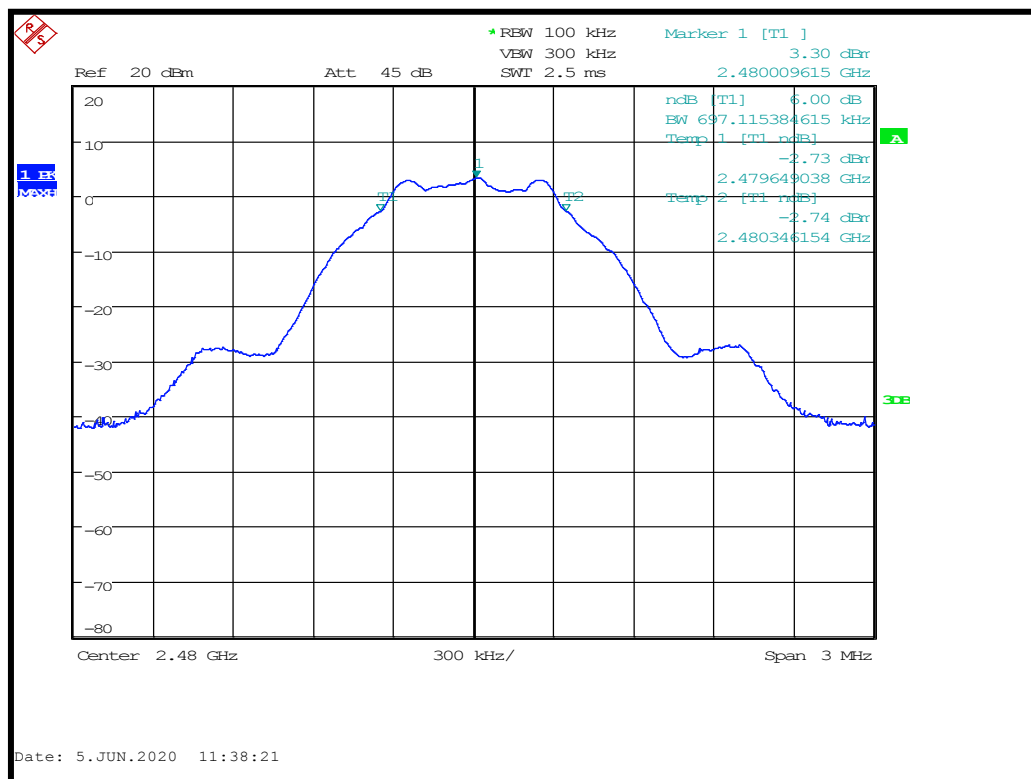
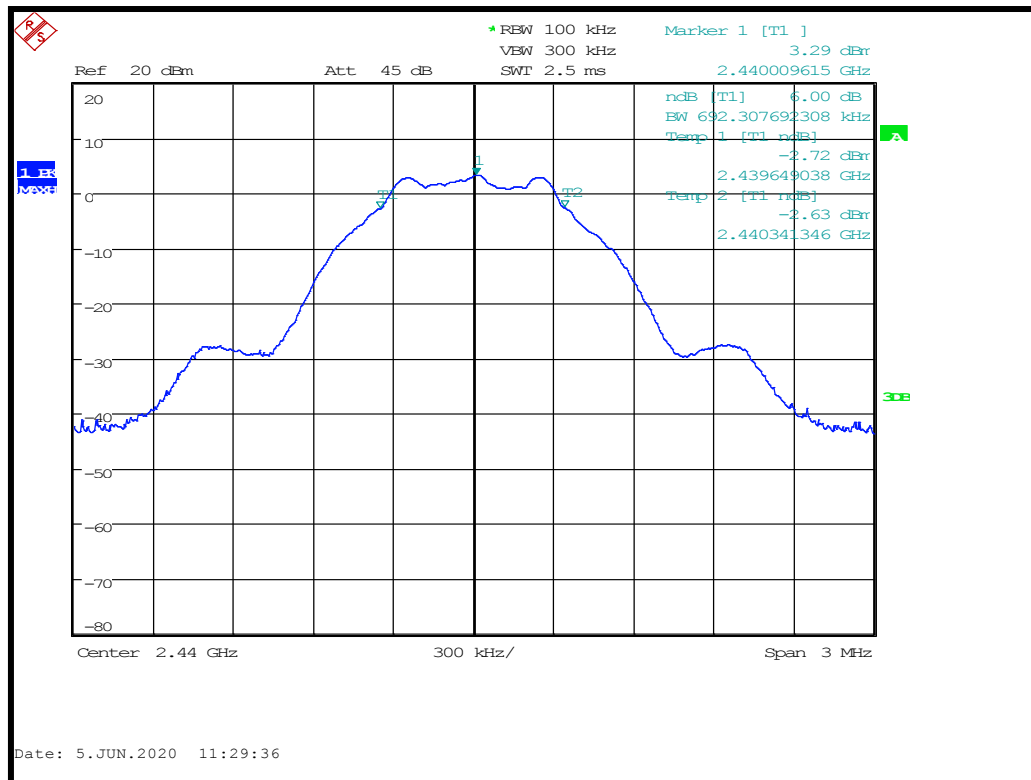
### 13.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|----------------|--------------|-----------------------|------------|---------------------|
| FSU26          | R&S          | Spectrum Analyser     | U405       | 2021-07-17          |
| LT30-2         | Farnell      | Power Supply          | RFG035     | Cal with REF887     |
| 34405A         | Agilent      | Multimeter            | REF887     | 2021-10-21          |

### 13.6 Test Results

| FCC 15.247. Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4 |             |             |                     |        |
|---------------------------------------------------------------------|-------------|-------------|---------------------|--------|
| Channel Frequency (MHz)                                             | $F_L$ (MHz) | $F_H$ (MHz) | 6dB Bandwidth (kHz) | Result |
| 2402                                                                | 2401.653846 | 2402.341346 | 687.500000000       | PASS   |
| 2440                                                                | 2439.649038 | 2440.341346 | 692.307692308       | PASS   |
| 2480                                                                | 2479.649038 | 2480.346154 | 697.115384615       | PASS   |





## 14 Maximum peak conducted output power

### 14.1 Definition

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

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

### 14.2 Test Parameters

|                                         |                                                                                                 |
|-----------------------------------------|-------------------------------------------------------------------------------------------------|
| Test Location:                          | Element Hull                                                                                    |
| Test Chamber:                           | Wireless Laboratory 1                                                                           |
| Test Standard and Clause:               | ANSI C63.10-2013, Clause 11.9.1                                                                 |
| EUT Frequencies Measured:               | 2402 MHz / 2440 MHz / 2480 MHz                                                                  |
| EUT Channel Bandwidths:                 | 2 MHz                                                                                           |
| Deviations From Standard:               | None                                                                                            |
| Measurement BW:                         | 3 MHz                                                                                           |
| Spectrum Analyzer Video BW:             | 10 MHz                                                                                          |
| Measurement Detector:                   | Peak                                                                                            |
| Voltage Extreme Environment Test Range: | Mains Power = 85 % and 115 % of Nominal (FCC only requirement);<br>Battery Power = new battery. |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 40 % RH  | 20 % RH to 75 % RH (as declared) |

### 14.3 Test Limit

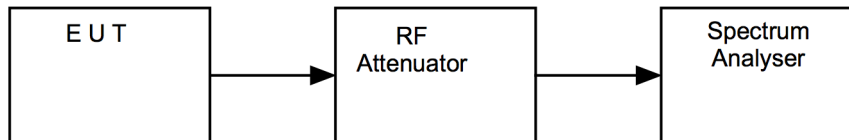
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

#### 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**

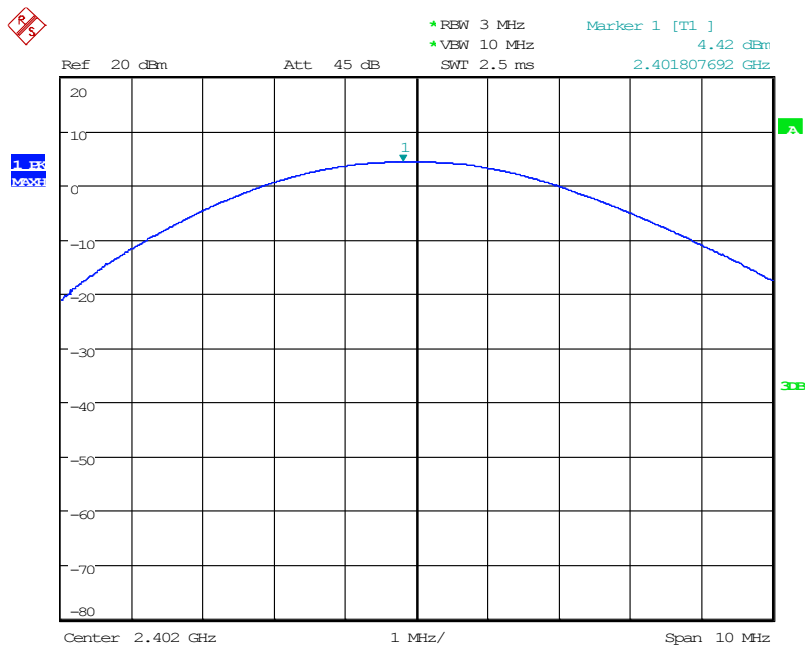


#### 14.5 Test Equipment

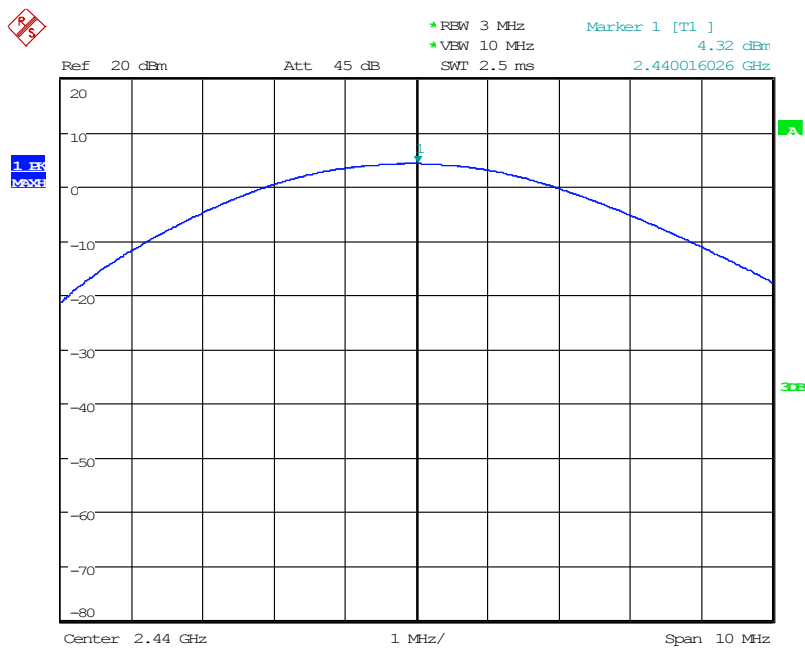
| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|----------------|--------------|-----------------------|------------|---------------------|
| FSU26          | R&S          | Spectrum Analyser     | U405       | 2021-07-17          |
| LT30-2         | Farnell      | Power Supply          | RFG035     | Cal with REF887     |
| 34405A         | Agilent      | Multimeter            | REF887     | 2021-10-21          |

#### 14.6 Test Results

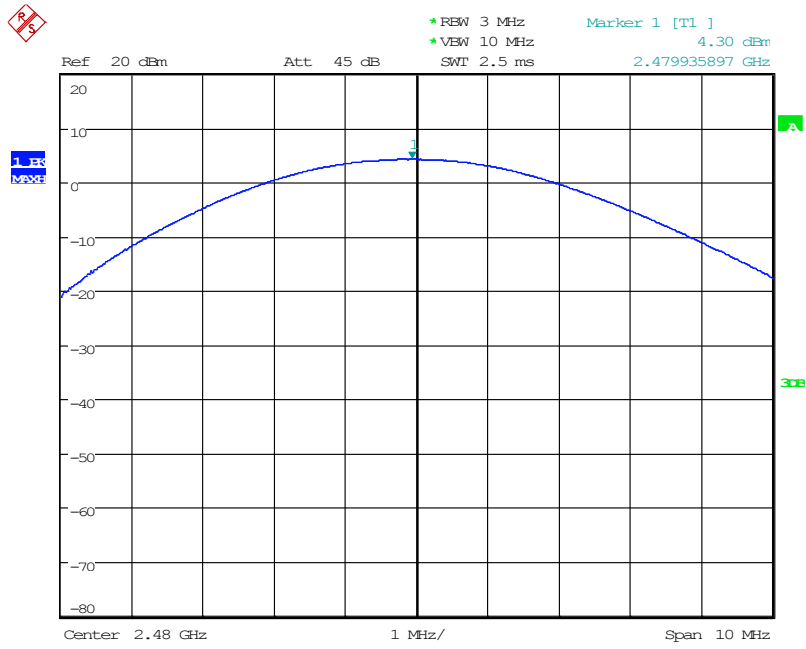
| <i>Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4</i> |                             |                        |                   |               |
|----------------------------------------------------------------|-----------------------------|------------------------|-------------------|---------------|
| <i>Channel Frequency (MHz)</i>                                 | <i>Analyzer Level (dBm)</i> | <i>Cable loss (dB)</i> | <i>Power (mW)</i> | <i>Result</i> |
| 2402                                                           | 4.4                         | 0.8                    | 3.3               | PASS          |
| 2440                                                           | 4.3                         | 0.8                    | 3.2               | PASS          |
| 2480                                                           | 4.3                         | 0.8                    | 3.2               | PASS          |



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Date: 5.JUN.2020 11:58:15

## 15 Out-of-band and conducted spurious emissions

### 15.1 Definition

#### *Out-of-band emission.*

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

#### *Spurious emission.*

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

### 15.2 Test Parameters

|                             |                                |
|-----------------------------|--------------------------------|
| Test Location:              | Element Hull                   |
| Test Chamber:               | Wireless Laboratory 1          |
| Test Standard and Clause:   | ANSI C63.10-2013, Clause 11.11 |
| EUT Frequencies Measured:   | 2402 MHz / 2440 MHz / 2480 MHz |
| EUT Channel Bandwidths:     | 2 MHz                          |
| Deviations From Standard:   | None                           |
| Measurement BW:             | 100 kHz                        |
| Spectrum Analyzer Video BW: | 300 kHz                        |
| Measurement Detector:       | Peak                           |
| Measurement Range:          | 9 kHz to 26.5 GHz              |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 40 % RH  | 20 % RH to 75 % RH (as declared) |
| Supply: 5 Vdc      | As declared                      |

### 15.3 Test Limit

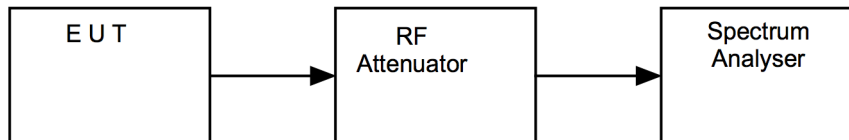
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

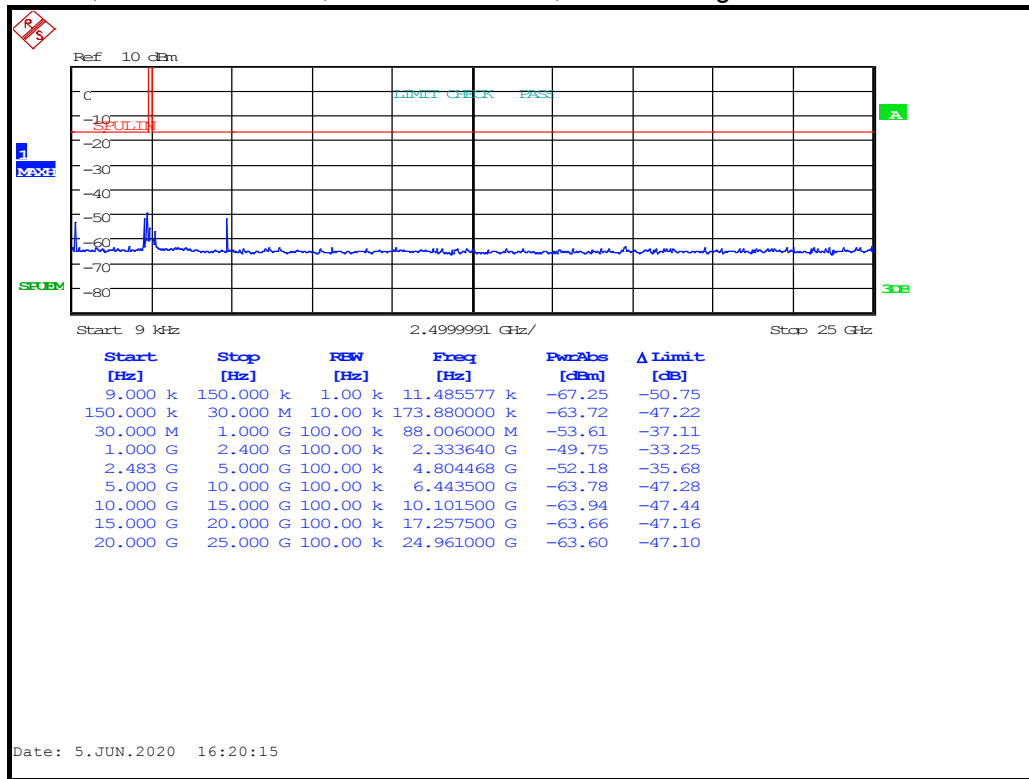


#### 15.5 Test Equipment

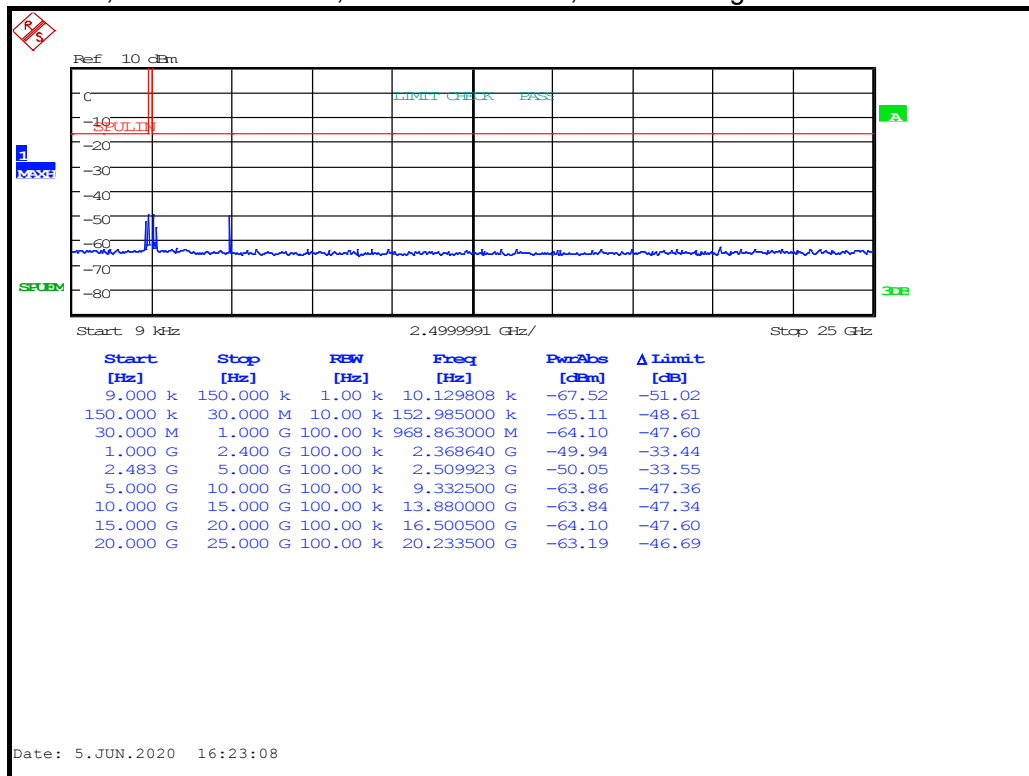
| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|----------------|--------------|-----------------------|------------|---------------------|
| FSU26          | R&S          | Spectrum Analyser     | U405       | 2021-07-17          |
| LT30-2         | Farnell      | Power Supply          | RFG035     | Cal with REF887     |
| 34405A         | Agilent      | Multimeter            | REF887     | 2021-10-21          |

## 15.6 Test Results

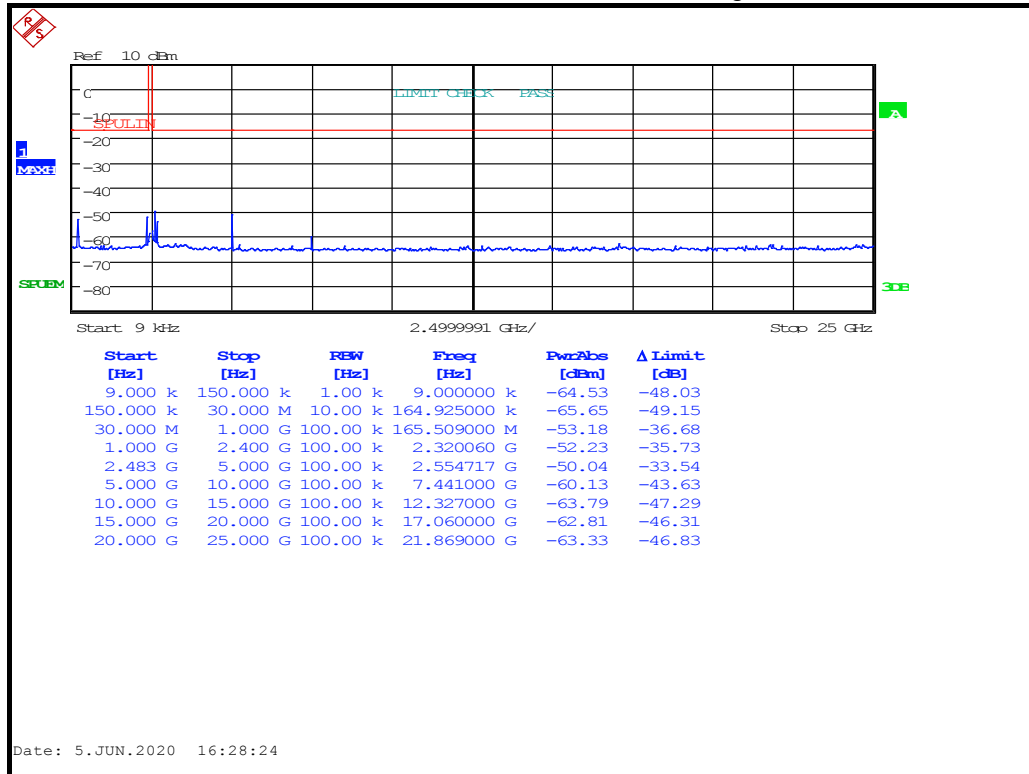
Channel 0; Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4



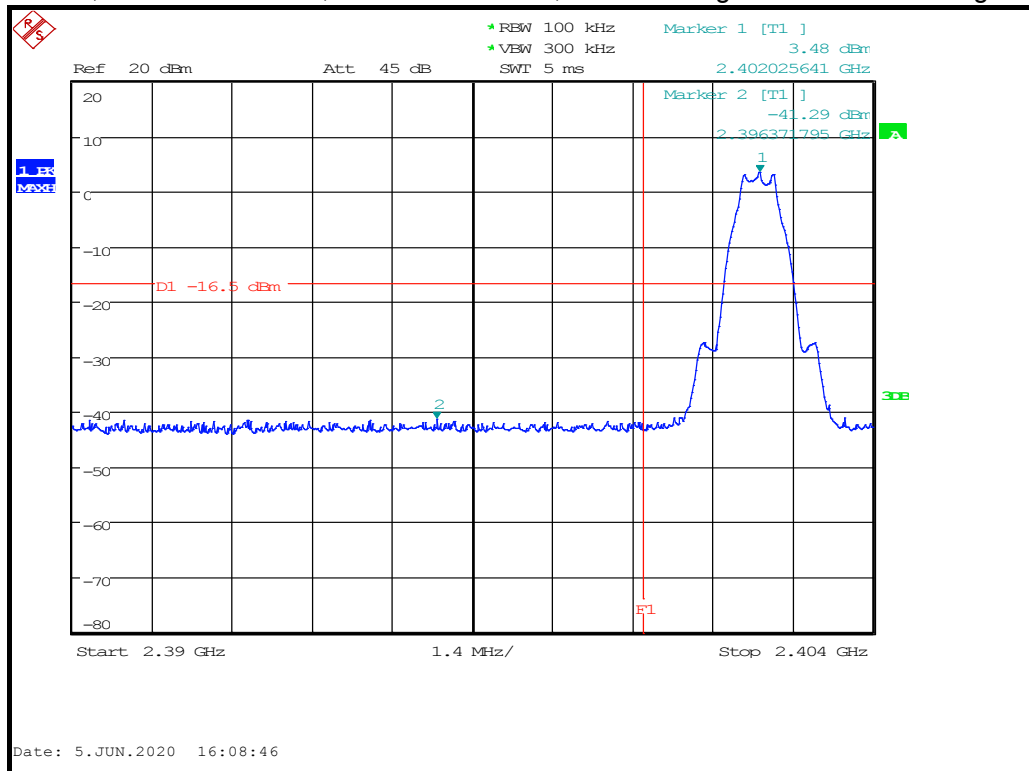
Channel 19; Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4



Channel 39; Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4



Channel 0; Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4 – Lower Band Edge



## 16 Power spectral density

### 16.1 Definition

The power per unit bandwidth.

### 16.2 Test Parameters

|                             |                                |
|-----------------------------|--------------------------------|
| Test Location:              | Element Hull                   |
| Test Chamber:               | Wireless Laboratory 1          |
| Test Standard and Clause:   | ANSI C63.10-2013, Clause 11.10 |
| EUT Frequencies Measured:   | 2402 MHz / 2440 MHz / 2480 MHz |
| EUT Channel Bandwidths:     | 2 MHz                          |
| Deviations From Standard:   | None                           |
| Measurement BW:             | 3 kHz                          |
| Spectrum Analyzer Video BW: | 10 kHz                         |
| Measurement Span:           | 1.5 MHz                        |
| Measurement Detector:       | Peak                           |

### Environmental Conditions (Normal Environment)

|                    |                                  |
|--------------------|----------------------------------|
| Temperature: 22 °C | +15 °C to +35 °C (as declared)   |
| Humidity: 38 % RH  | 20 % RH to 75 % RH (as declared) |
| Supply: 5 Vdc      | As declared                      |

### 16.3 Test Limit

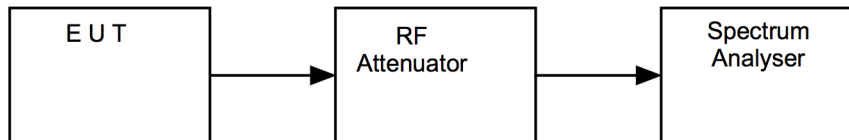
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

#### 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**

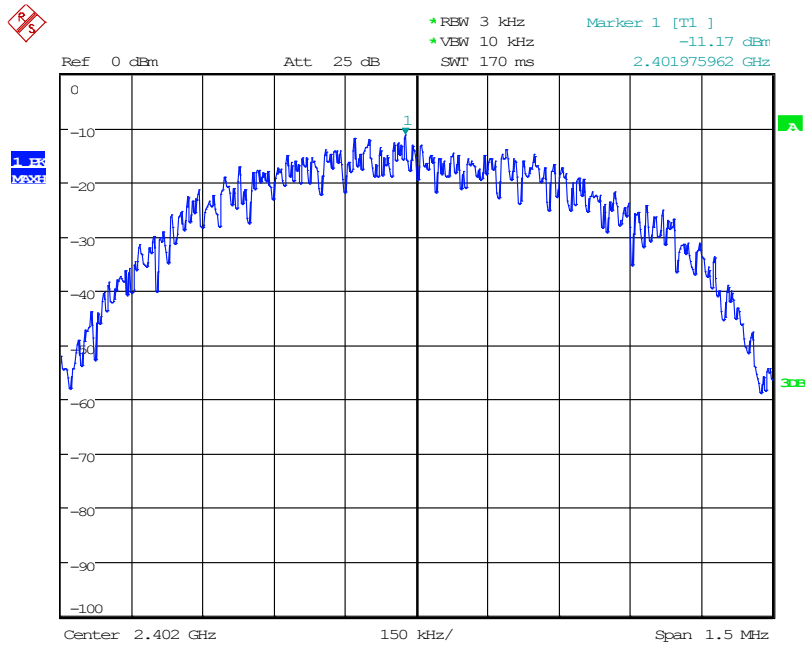


#### 16.5 Test Equipment

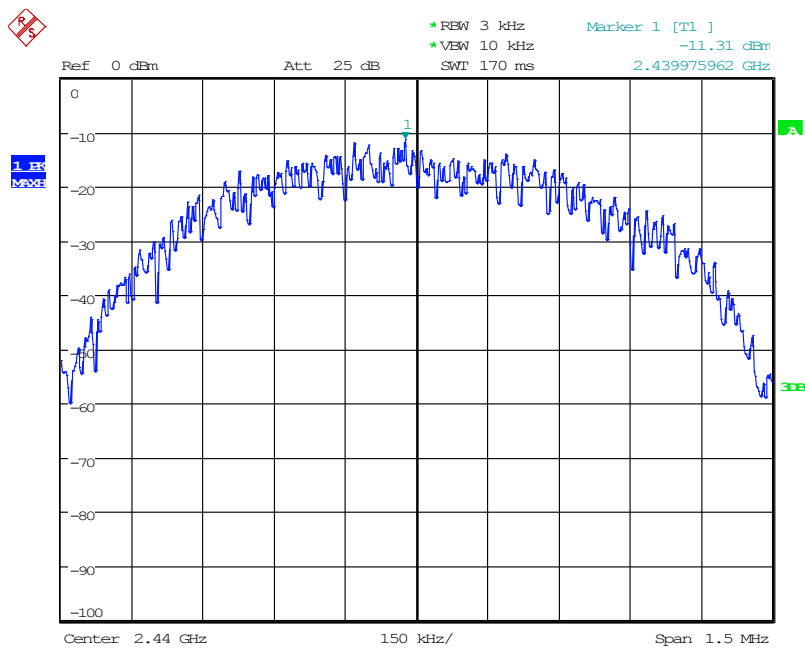
| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|----------------|--------------|-----------------------|------------|---------------------|
| FSU26          | R&S          | Spectrum Analyser     | U405       | 2021-07-17          |
| LT30-2         | Farnell      | Power Supply          | RFG035     | Cal with REF887     |
| 34405A         | Agilent      | Multimeter            | REF887     | 2021-10-21          |

#### 16.6 Test Results

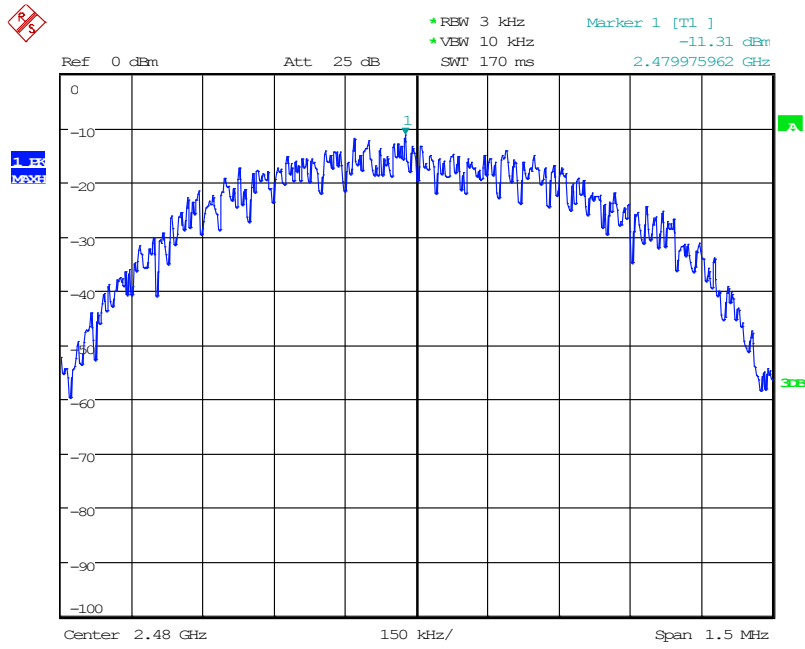
| <b>Modulation: GFSK; Data rate: 1 Mbit/s; Power setting: 4</b> |                                  |                        |                         |               |
|----------------------------------------------------------------|----------------------------------|------------------------|-------------------------|---------------|
| <b>Channel Frequency (MHz)</b>                                 | <b>Analyzer Level (dBm/3kHz)</b> | <b>Cable loss (dB)</b> | <b>Power (dBm/3kHz)</b> | <b>Result</b> |
| 2402                                                           | -11.2                            | 0.8                    | -10.4                   | PASS          |
| 2440                                                           | -11.3                            | 0.8                    | -10.5                   | PASS          |
| 2480                                                           | -11.3                            | 0.8                    | -10.5                   | PASS          |



Date: 5.JUN.2020 16:54:10



Date: 5.JUN.2020 16:55:33



Date: 5.JUN.2020 16:57:00

## 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.*

| Reference No. | Parameter                   | Description                                                                                    | Value                                        | Unit |
|---------------|-----------------------------|------------------------------------------------------------------------------------------------|----------------------------------------------|------|
| 1             | Adjacent Channel Power      | Uncertainty in test result                                                                     | Error! Not a valid link.                     | dB   |
| 2             | Carrier Power               | Uncertainty in test result (Power Meter)<br><br>Uncertainty in test result (Spectrum Analyser) | <b>0.070</b><br><br>Error! Not a valid link. | dB   |
| 3             | Effective Radiated Power    | Uncertainty in test result                                                                     | <b>4.71</b>                                  | dB   |
| 4             | Radiated Spurious Emissions | Uncertainty in test result<br>30 MHz to 1 GHz<br><br>1 GHz to 18 GHz                           | <b>4.75</b><br><br><b>4.46</b>               | dB   |
| 5             | Maximum Frequency Error     | Uncertainty in test result (CMTA)                                                              | <b>113.441</b>                               | Hz   |

| Reference No. | Parameter                                                              | Description                                                                                                                                                                                                                                                                                                                                                                                | Value                                                                                                                     | Unit    |
|---------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------|
| 6             | Radiated Emissions, Field Strength OATS 9 kHz – 110 GHz Electric Field | Uncertainty in test result (9 kHz – 30 MHz)<br>Uncertainty in test result (30 MHz – 1 GHz)<br>Uncertainty in test result (1 GHz – 18 GHz)<br>Uncertainty in test result (18 GHz – 26 GHz)<br>Uncertainty in test result (26 GHz – 40 GHz)<br>Uncertainty in test result (40 GHz – 50 GHz)<br>Uncertainty in test result (50 GHz – 75 GHz)<br>Uncertainty in test result (75 GHz – 110 GHz) | <div>2.3</div> <div>4.75</div> <div>4.46</div> <div>3.2</div> <div>3.3</div> <div>3.5</div> <div>3.6</div> <div>3.6</div> | dB      |
| 7             | Frequency Deviation                                                    | Uncertainty in test result                                                                                                                                                                                                                                                                                                                                                                 | 3.7                                                                                                                       | %       |
| 8             | Magnetic Field Emissions                                               | Uncertainty in test result                                                                                                                                                                                                                                                                                                                                                                 | 2.3                                                                                                                       | dB      |
| 9             | Conducted Spurious                                                     | Uncertainty in test result Up to 26 GHz                                                                                                                                                                                                                                                                                                                                                    | 0.921                                                                                                                     | dB      |
| 10            | Channel Bandwidth                                                      | Uncertainty in test result                                                                                                                                                                                                                                                                                                                                                                 | Error! Not a valid link.                                                                                                  | %       |
| 11            | Spectrum Mask Measurements                                             | Uncertainty in test result (frequency)<br>Uncertainty in test result (amplitude)                                                                                                                                                                                                                                                                                                           | <div>2.59</div> <div>1.32</div>                                                                                           | %<br>dB |
| 12            | Adjacent Sub Band Selectivity                                          | Uncertainty in test result                                                                                                                                                                                                                                                                                                                                                                 | 1.24                                                                                                                      | dB      |
| 13            | Receiver Blocking – Listen Mode, Radiated                              | Uncertainty in test result                                                                                                                                                                                                                                                                                                                                                                 | 3.23                                                                                                                      | dB      |

| Reference No. | Parameter                                | Description                | Value       | Unit |
|---------------|------------------------------------------|----------------------------|-------------|------|
| 14            | Receiver Blocking – Talk Mode, Radiated  | Uncertainty in test result | <b>3.36</b> | dB   |
| 15            | Receiver Blocking – Talk Mode, Conducted | Uncertainty in test result | <b>1.24</b> | dB   |
| 16            | Receiver Threshold                       | Uncertainty in test result | <b>3.42</b> | dB   |
| 17            | Transmission Time Measurement            | Uncertainty in test result | <b>4.40</b> | %    |
| 18            | AC power line conducted emissions        | Uncertainty in test result | <b>3.42</b> | dB   |