

Report on the Radio Testing

For

Schrader Electronics Ltd

on

Schrader BLE TPMS

Report no. TRA-056478-45-02A

20th January 2023

Report Number: TRA-056478-45-02A
Issue: A

REPORT ON THE RADIO TESTING OF A
Schrader Electronics Ltd
Schrader BLE TPMS
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2022-10-10 to 2022-10-12

Tested by: D Garvey

Written by: 

D Garvey
Radio Test Engineer

Approved by:

Date: 20th January 2023

D Winstanley
Radio Senior Test Engineer

Disclaimers:

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

1 Revision Record

| <i>Issue Number</i> | <i>Issue Date</i> | <i>Revision History</i> |
|---------------------|-------------------|-------------------------|
| A | 20th January 2023 | Original |
| | | |

2 Summary

TEST REPORT NUMBER: TRA-056478-45-02A

WORKS ORDER NUMBER: TRA-056478-05

PURPOSE OF TEST: Certification

TEST SPECIFICATION: 47CFR15.247

EQUIPMENT UNDER TEST (EUT): Schrader BLE TPMS

FCC IDENTIFIER: MRXSCHEB

EUT SERIAL NUMBER: Not Stated

MANUFACTURER/AGENT: Schrader Electronics Ltd

ADDRESS: 11 Technology Park
Belfast Road
Antrim
Co. Antrim
BT41 1QS
Ireland

CLIENT CONTACT: Zoe Gourley
☎ 02894 482 536
✉ zgourley@sensata.com

ORDER NUMBER: 6808900051451

TEST DATE: 2022-10-10 to 2022-10-12

TESTED BY: D Garvey
Element

2.1 Test Summary

| <i>Test Method and Description</i> | | <i>Requirement Clause 47CFR15</i> | <i>Applicable to this equipment</i> | <i>Result / Note</i> |
|-----------------------------------------------------------------------------------|------|-----------------------------------|-------------------------------------|----------------------|
| Radiated spurious emissions (restricted bands of operation and cabinet radiation) | | 15.247 (d) | <input checked="" type="checkbox"/> | Pass |
| AC power line conducted emissions | | 15.207 | <input type="checkbox"/> | Note 1 |
| 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"/> | |
| Out of band emissions | | 15.247 (d) | <input checked="" type="checkbox"/> | Pass |
| Power spectral density | | 15.247 (e) | <input checked="" type="checkbox"/> | Pass |
| Calculation of duty correction | | - | <input type="checkbox"/> | Note 2 |

Specific Note:

1. The EUT is a battery powered device.
2. No duty cycle correction was required

General Notes:

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

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

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

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4 Introduction

This report TRA-056478-45-02A presents the results of the Radio testing on a Schrader Electronics Ltd, Schrader BLE TPMS to specification 47CFR15 Radio Frequency Devices.

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

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

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

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

Throughout this report EUT denotes equipment under test.

FCC Site Listing:

Element Hull is accredited for the above sites under the US-UK MRA, Designation number UK2007.

The test site requirements of ANSI C63.4-2014 are met up to 1 GHz.

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: Schrader BLE TPMS
- Serial Number: Not Stated
- Model Number: SCHEB
- Software Revision: 1
- Build Level / Revision Number: 1

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.

7.4 EUT Radio Parameters

7.4.1 General

| | |
|--------------------------------|--------------------------|
| Frequency of operation: | 2402 MHz – 2480 MHz |
| Declared output power: | 0 dBm |
| Antenna type and gain: | Integral Antenna 1.7 dBi |
| Nominal Supply Voltage: | 3 Vdc |
| Duty Cycle: | 100 % |

7.5 EUT Description

The EUT is a bicycle TPMS that updates tyre pressure intermittently over BLE

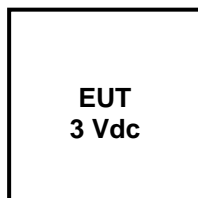
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

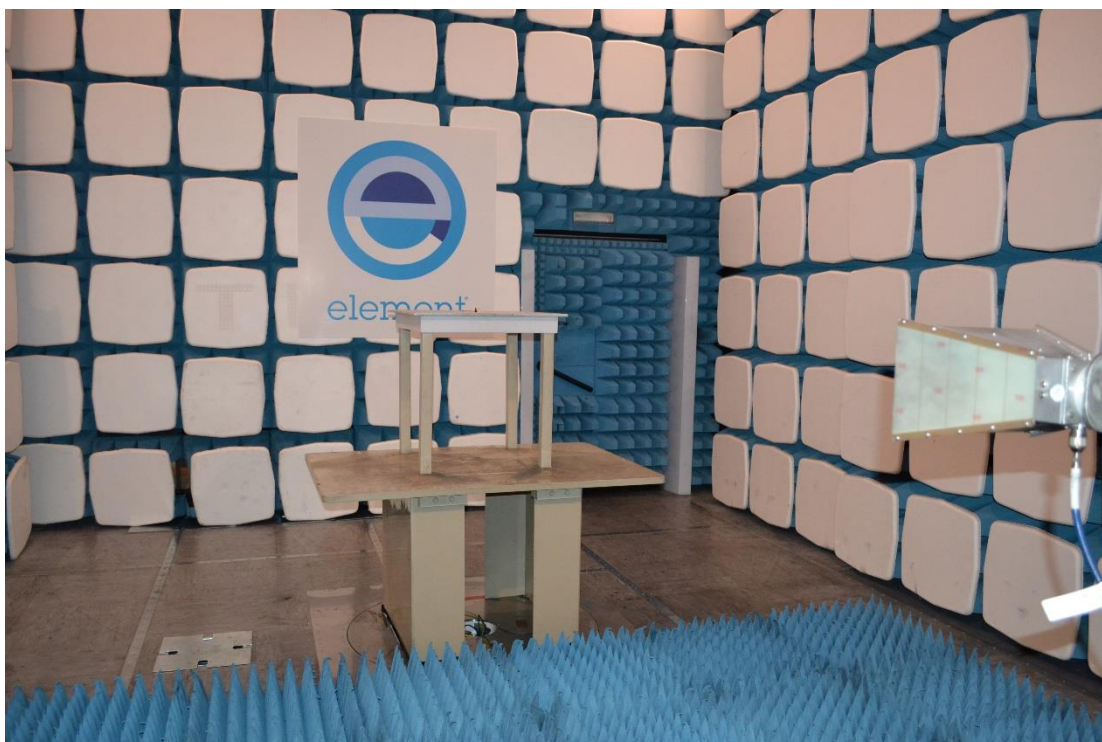
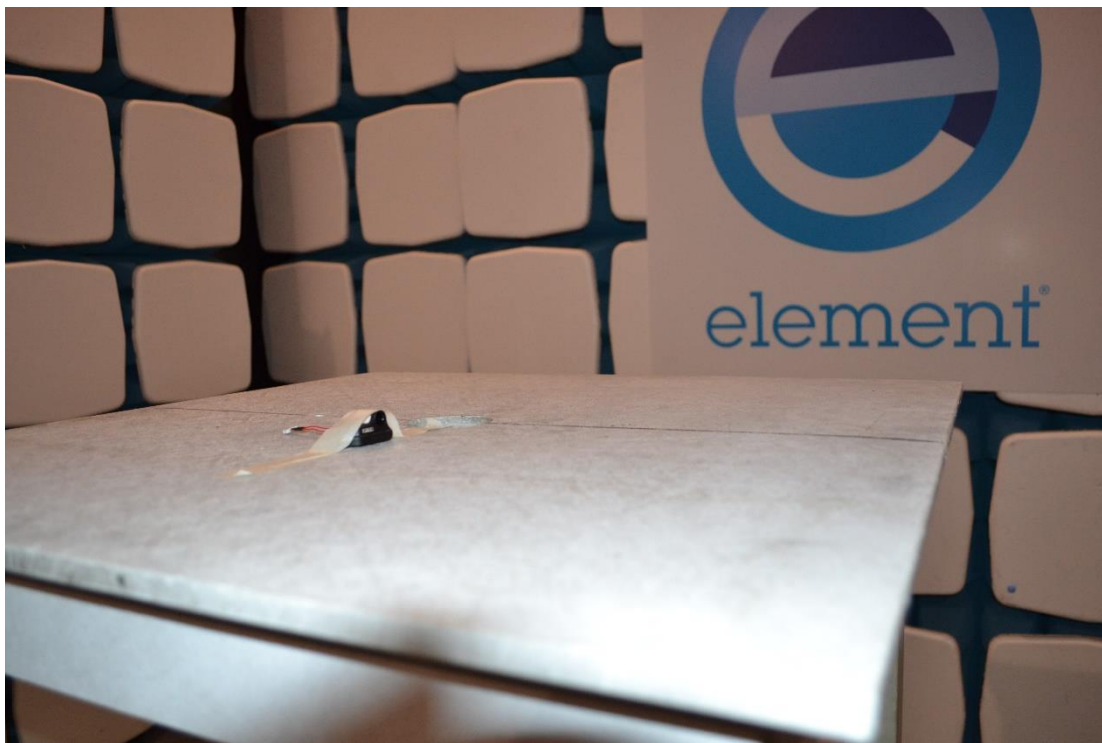
9.1 *Block Diagram*

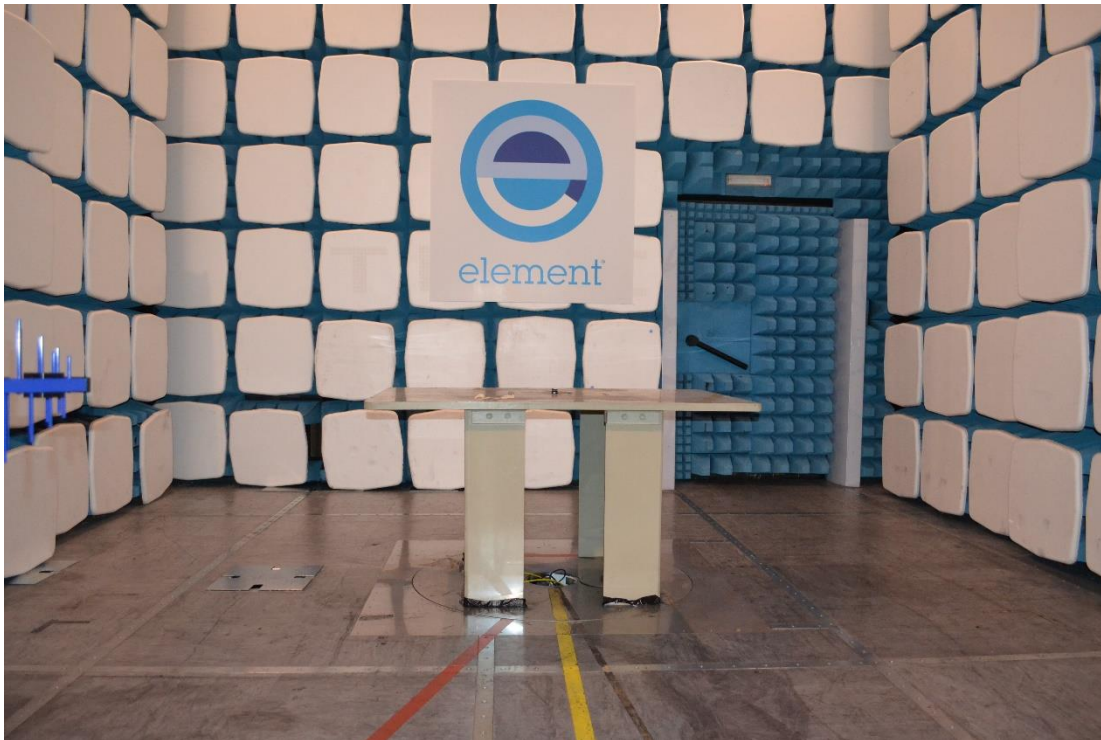
The following diagram shows basic EUT interconnections:



9.2 General Set-up Photograph

The following 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

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 Vdc from a lithium 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 |
|-------------------------------------|-----------------|----------------|------------------|
| <input type="checkbox"/> | Mains | 110 Vac +/-2 % | 85 % and 115 % |
| <input checked="" type="checkbox"/> | 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 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 |
| 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: 21 °C | +15 °C to +35 °C (as declared) |
| Humidity: 45 % RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3 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

| Frequency (MHz) | Field Strength ($\mu\text{V}/\text{m}$ at 3 m) | Field Strength (dB $\mu\text{V}/\text{m}$ 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 dB μ V/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 dB μ V;

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);

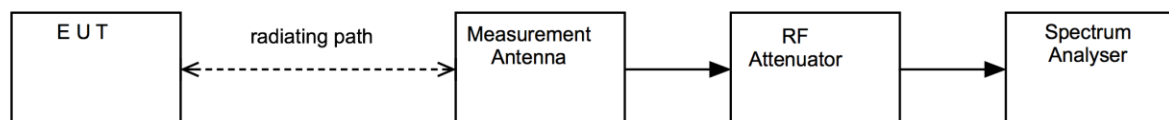
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

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

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

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

Figure i Test Setup



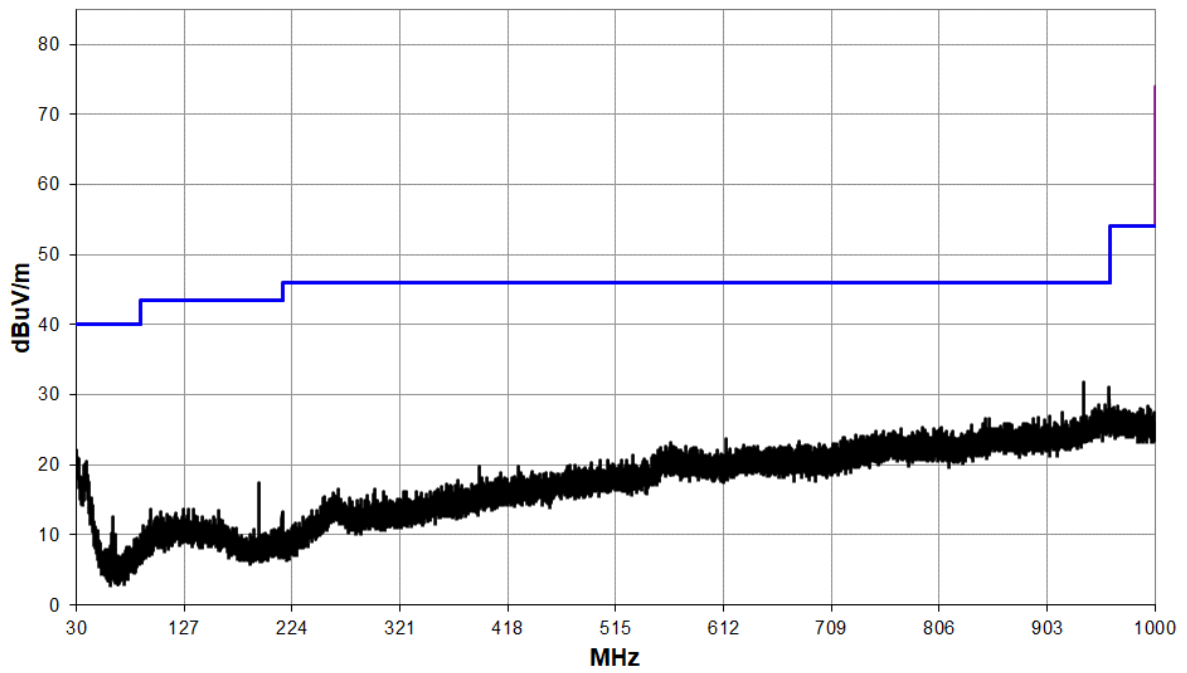
11.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|-------------------------|---------------------|------------------------------|-------------------|----------------------------|
| Ferrite Lined Chamber | Rainford | Chamber | REF886 | 2024-06-15 |
| Spectrum Analyser | R&S | FSU50 | U544 | 2022-11-12 |
| CBL6111D | TESEQ | Bilog Antenna | REF2385 | 2024-06-24 |
| 3115 | EMCO | Horn Antenna | RFG129 | 2024-01-24 |
| LB-62-25-C-SF | A Info Inc | Horn Antenna | REF2244 | 2024-07-11 |
| QSH20S20S | Q-Par | Horn Antenna | RFG629 | 2023-11-17 |
| Pre-Amp (9 kHz – 1 GHz) | Sonoma | 310 | REF2389 | 2023-09-02 |
| Pre-Amp (1 – 26.5 GHz) | Agilent | 8449B | REF913 | 2023-03-24 |
| Emissions R5 | Element | Radiated Test Software | REF9000 | Cal not required |
| 4478 | BSC | Band Stop Filter | REF2158 | Calibrate in use |
| AFH-07000 | AtlanTecRF | High Pass Filter | REF2240 | Calibrate in use |

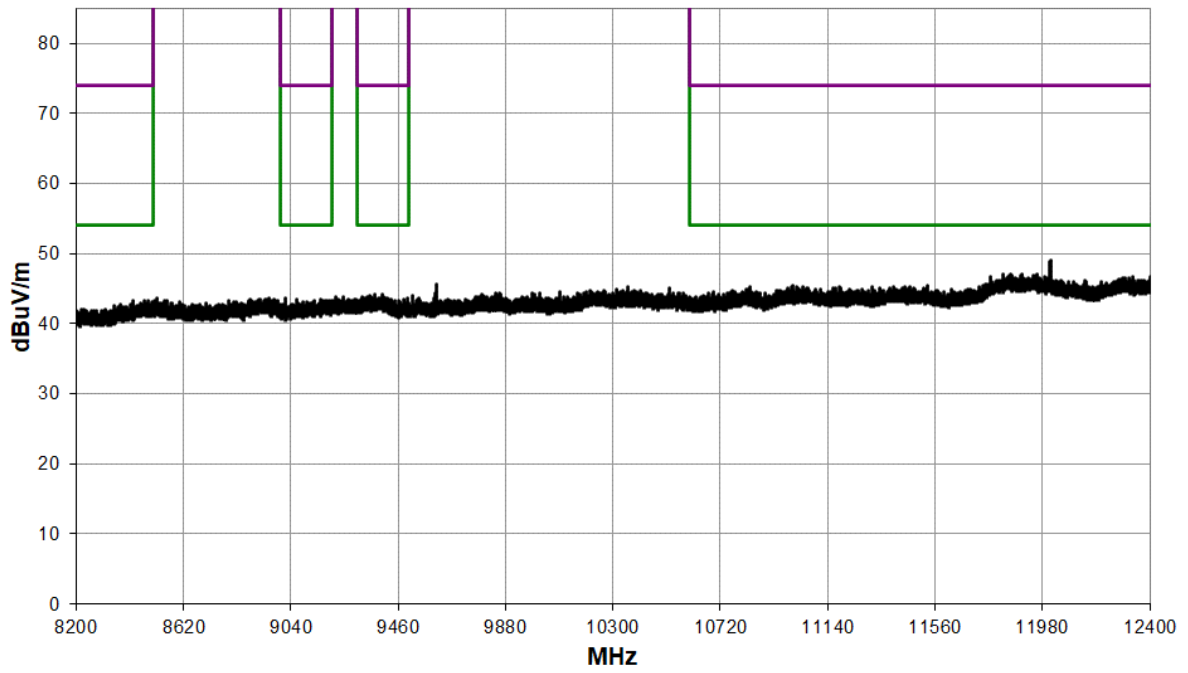
11.6 Test Results

| Frequency: 2402 MHz; Power Setting: Default; Modulation: GFSK; Data rate: 1 Mbps | | | | | | | | |
|----------------------------------------------------------------------------------|-------------|------------------------|-------------|------------------------|-------------------------------|-------------------------|----------------|-------------|
| Detector | Freq. (MHz) | Meas'd Emission (dBµV) | Factor (dB) | Duty Cycle Corr'n (dB) | Distance Extrap'n Factor (dB) | Field Strength (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
| QP | 936.0 | 29.5 | 0.4 | 0.0 | 0.0 | 29.9 | 46.0 | -16.1 |
| PK | 4803.4 | 58.2 | 2.4 | 0.0 | 0.0 | 60.6 | 74.0 | -13.4 |
| AV | 4803.6 | 50.1 | 2.4 | 0.0 | 0.0 | 52.5 | 54.0 | -1.5 |
| AV | 12008.9 | 34.1 | 11.7 | 0.0 | 0.0 | 45.8 | 54.0 | -8.2 |
| PK | 12011.2 | 48.0 | 11.6 | 0.0 | 0.0 | 59.6 | 74.0 | -14.4 |

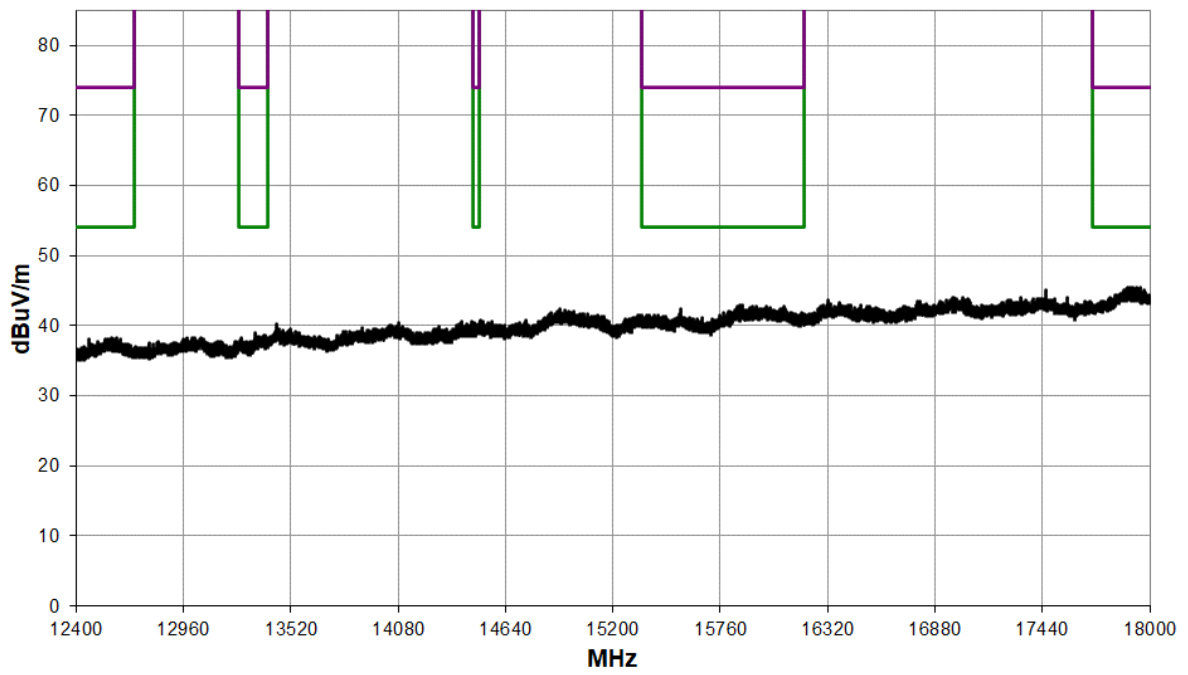
30 MHz to 1 GHz



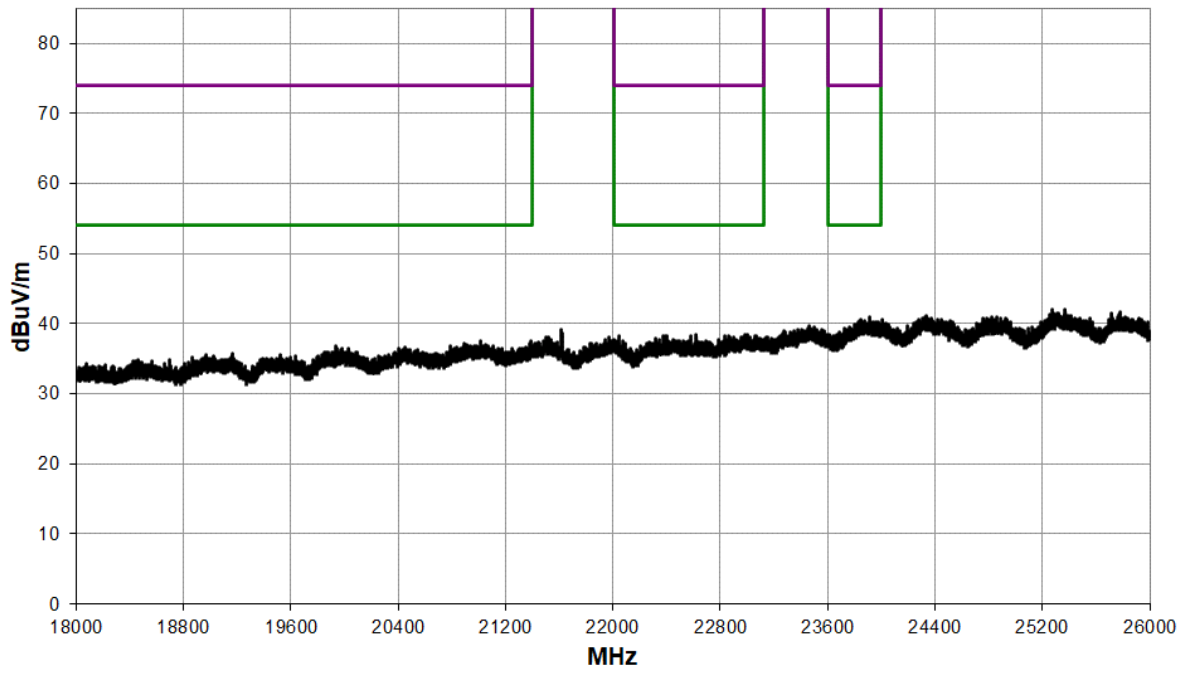
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

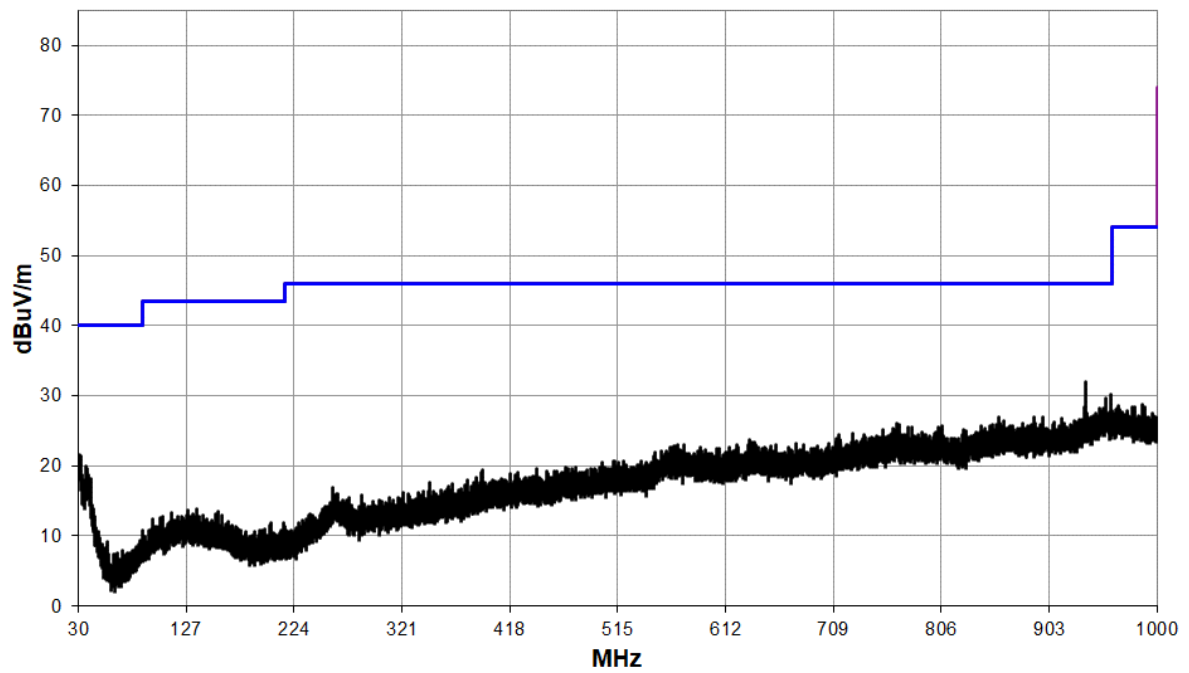


18 GHz to 26 GHz

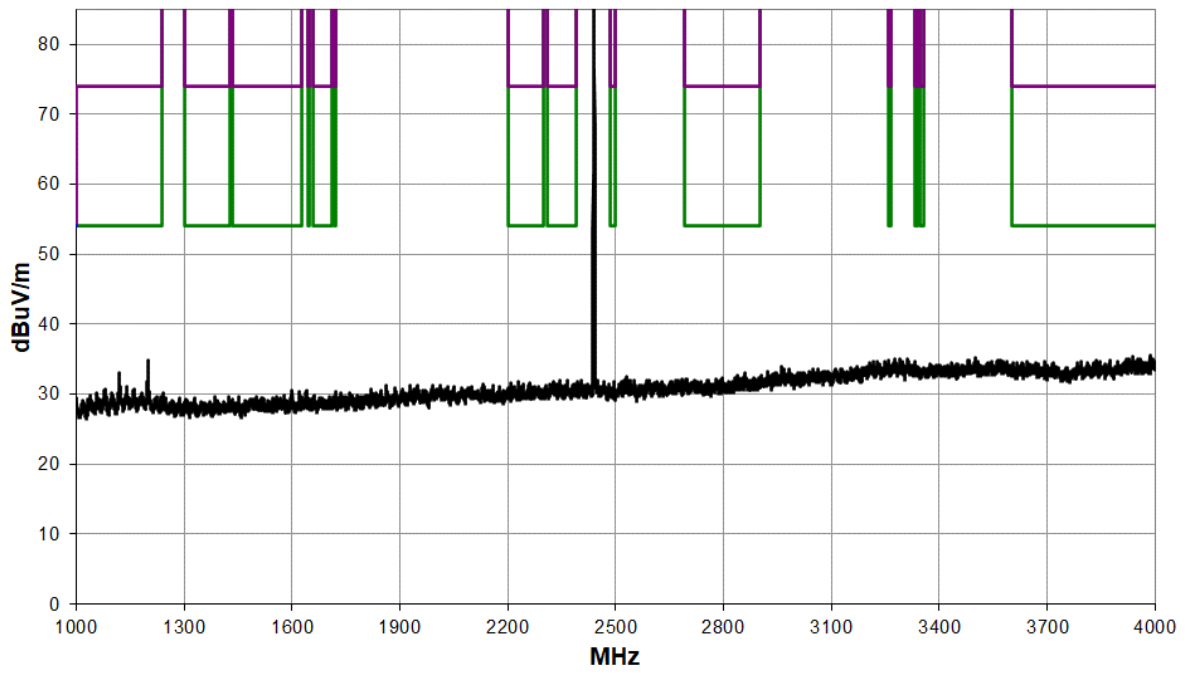


| Frequency: 2440 MHz; Power Setting: Default; Modulation: GFSK; Data rate: 1 Mbps | | | | | | | | |
|----------------------------------------------------------------------------------|-------------|------------------------|-------------|------------------------|-------------------------------|-------------------------|----------------|-------------|
| Detector | Freq. (MHz) | Meas'd Emission (dBµV) | Factor (dB) | Duty Cycle Corr'n (dB) | Distance Extrap'n Factor (dB) | Field Strength (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
| QP | 936.0 | 29.5 | 0.4 | 0.0 | 0.0 | 29.9 | 46.0 | -16.1 |
| AV | 4879.5 | 50.1 | 2.6 | 0.0 | 0.0 | 52.7 | 54.0 | -1.3 |
| PK | 4879.6 | 57.8 | 2.6 | 0.0 | 0.0 | 60.4 | 74.0 | -13.6 |
| PK | 7319.3 | 53.3 | 7.8 | 0.0 | 0.0 | 61.1 | 74.0 | -12.9 |
| AV | 7319.3 | 44.5 | 7.8 | 0.0 | 0.0 | 52.3 | 54.0 | -1.7 |

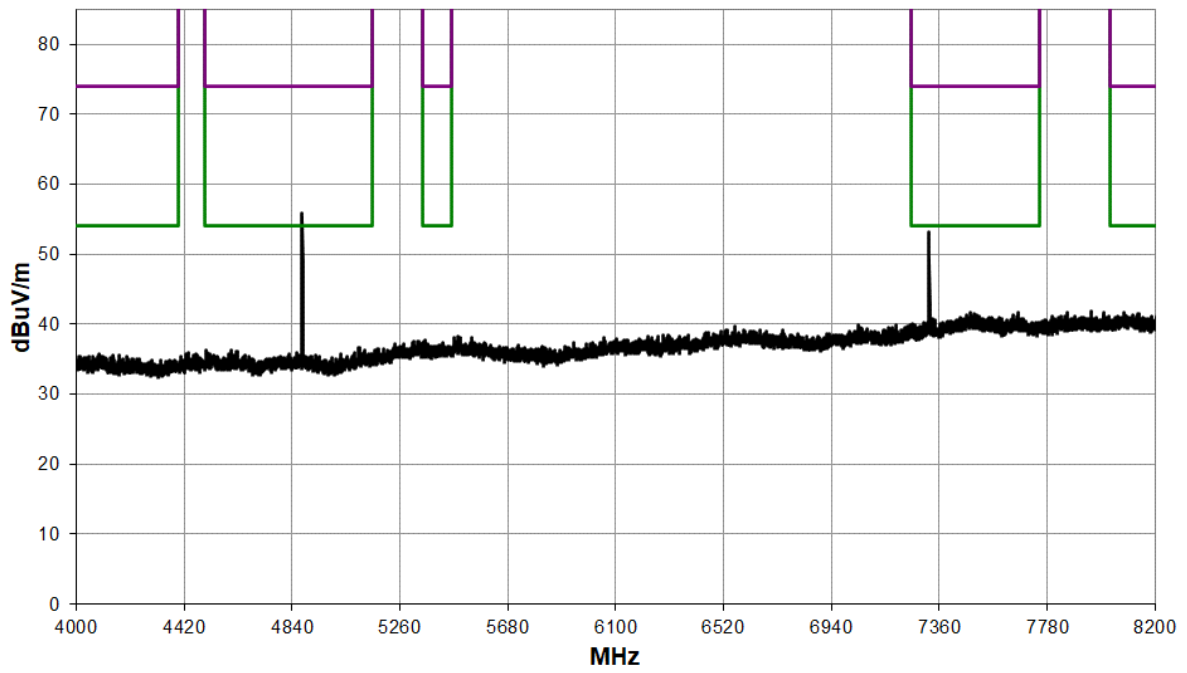
30 MHz to 1 GHz



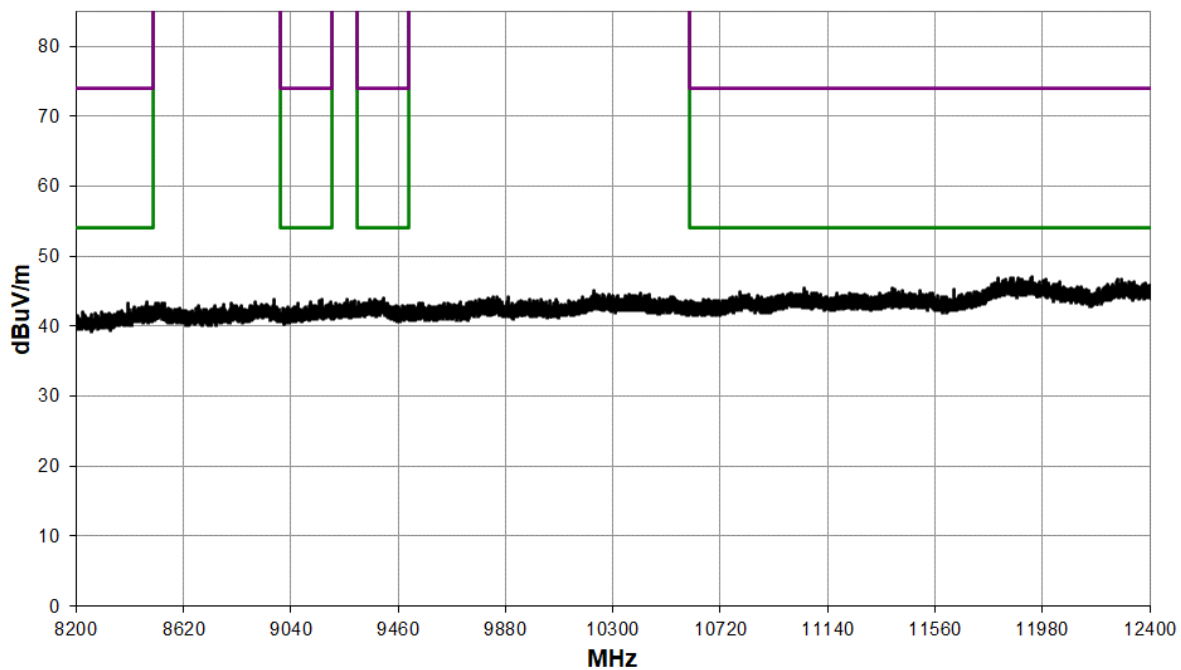
1 GHz to 4 GHz



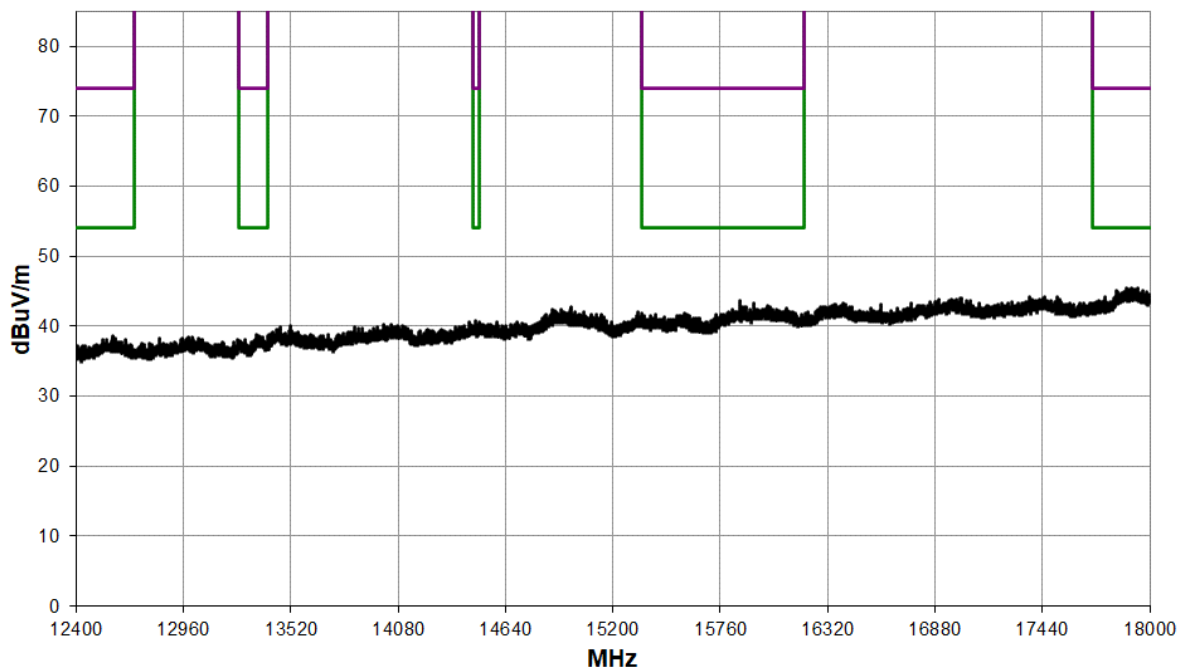
4 GHz to 8.2 GHz



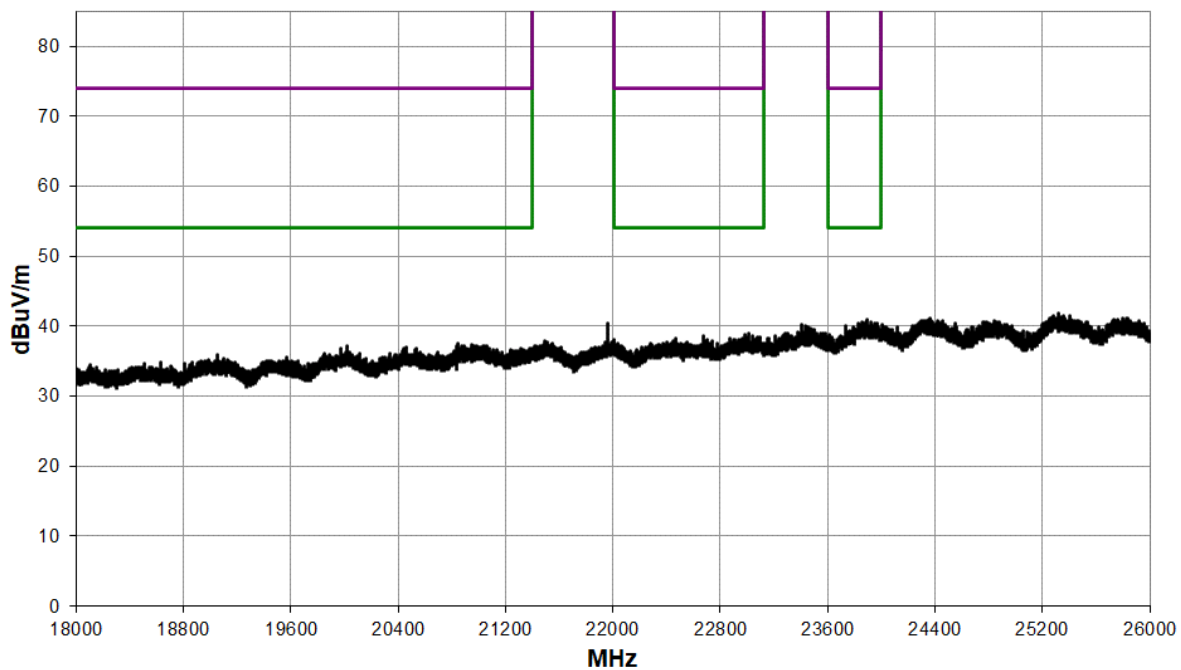
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz

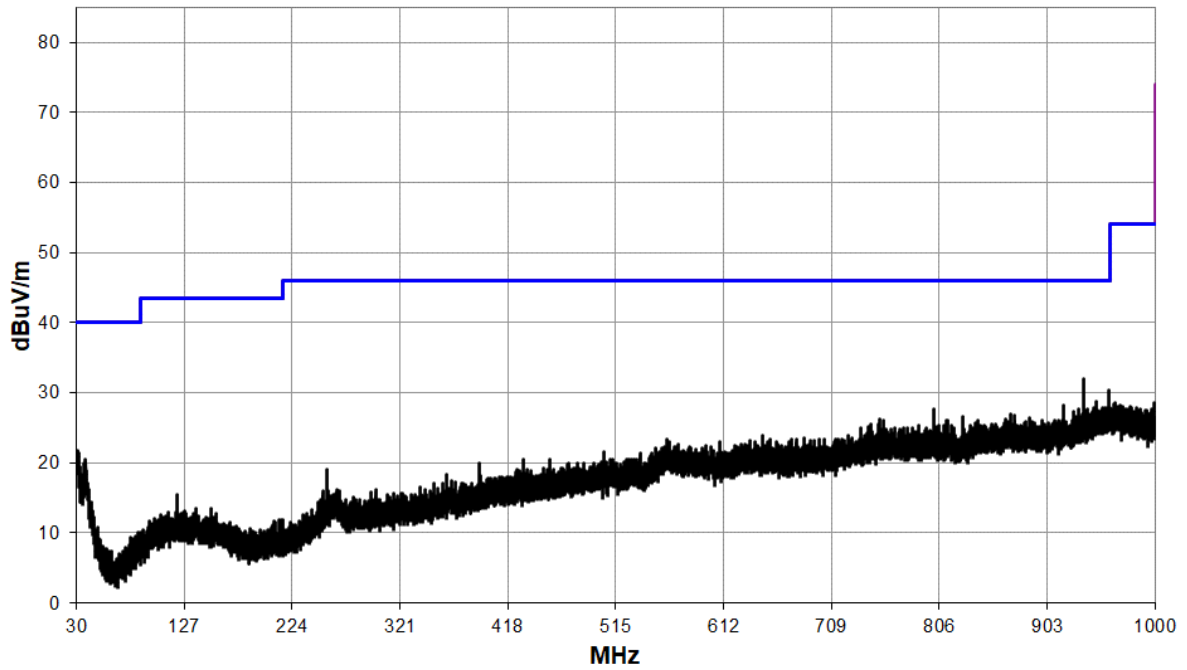


18 GHz to 26 GHz

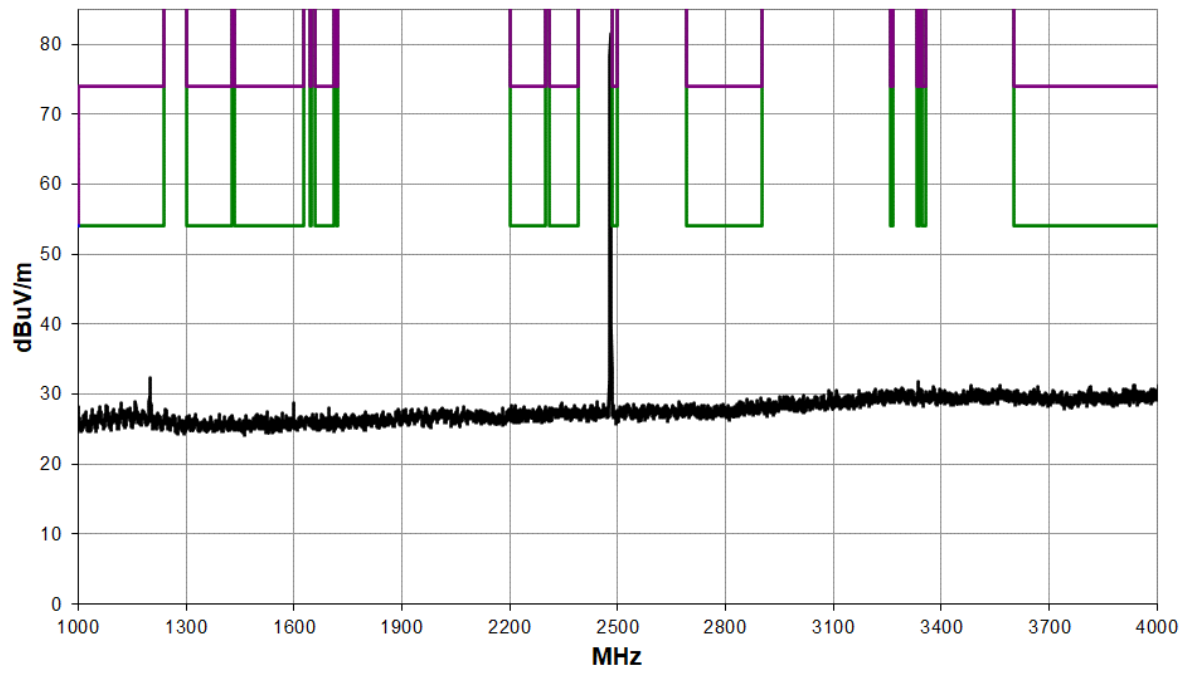


| Frequency: 2480 MHz; Power Setting: Default; Modulation: GFSK; Data rate: 1 Mbps | | | | | | | | |
|----------------------------------------------------------------------------------|-------------|------------------------|-------------|------------------------|-------------------------------|-------------------------|----------------|-------------|
| Detector | Freq. (MHz) | Meas'd Emission (dBµV) | Factor (dB) | Duty Cycle Corr'n (dB) | Distance Extrap'n Factor (dB) | Field Strength (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
| QP | 936.0 | 29.5 | 0.4 | 0.0 | 0.0 | 29.9 | 46.0 | -16.1 |
| AV | 4960.5 | 50.8 | 2.7 | 0.0 | 0.0 | 53.5 | 54.0 | -0.5 |
| PK | 4959.5 | 57.5 | 2.7 | 0.0 | 0.0 | 60.2 | 74.0 | -13.8 |
| AV | 7439.3 | 44.7 | 7.7 | 0.0 | 0.0 | 52.4 | 54.0 | -1.6 |
| PK | 7439.3 | 53.7 | 7.7 | 0.0 | 0.0 | 61.4 | 74.0 | -12.6 |

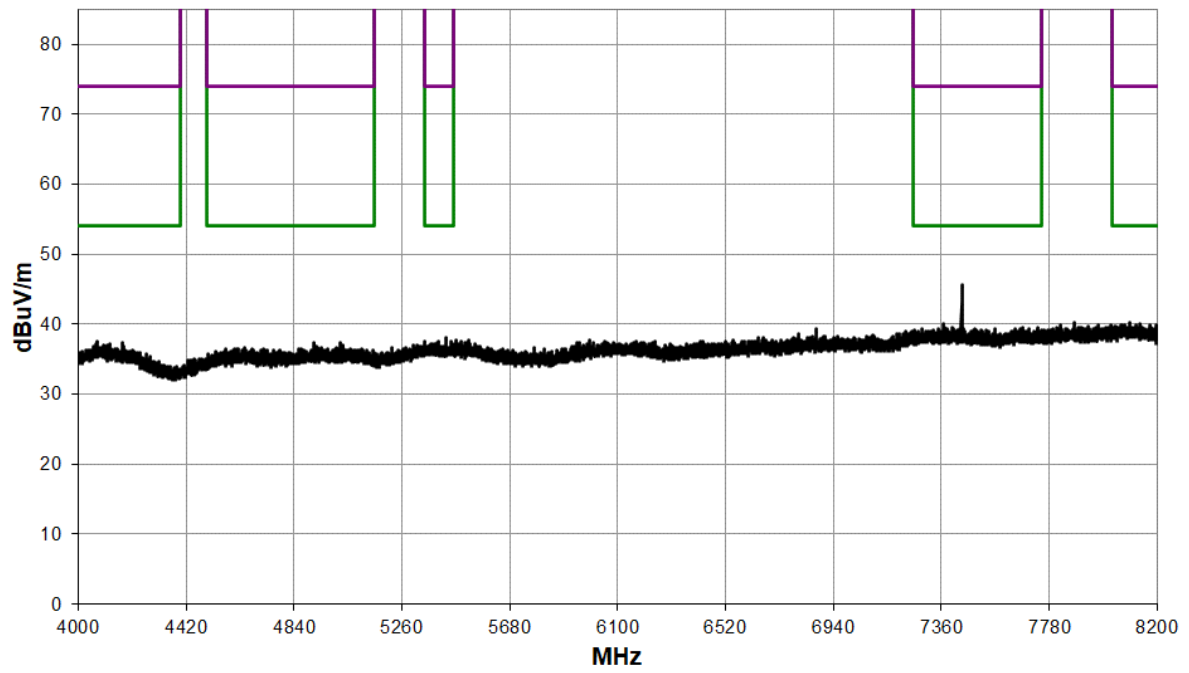
30 MHz to 1 GHz



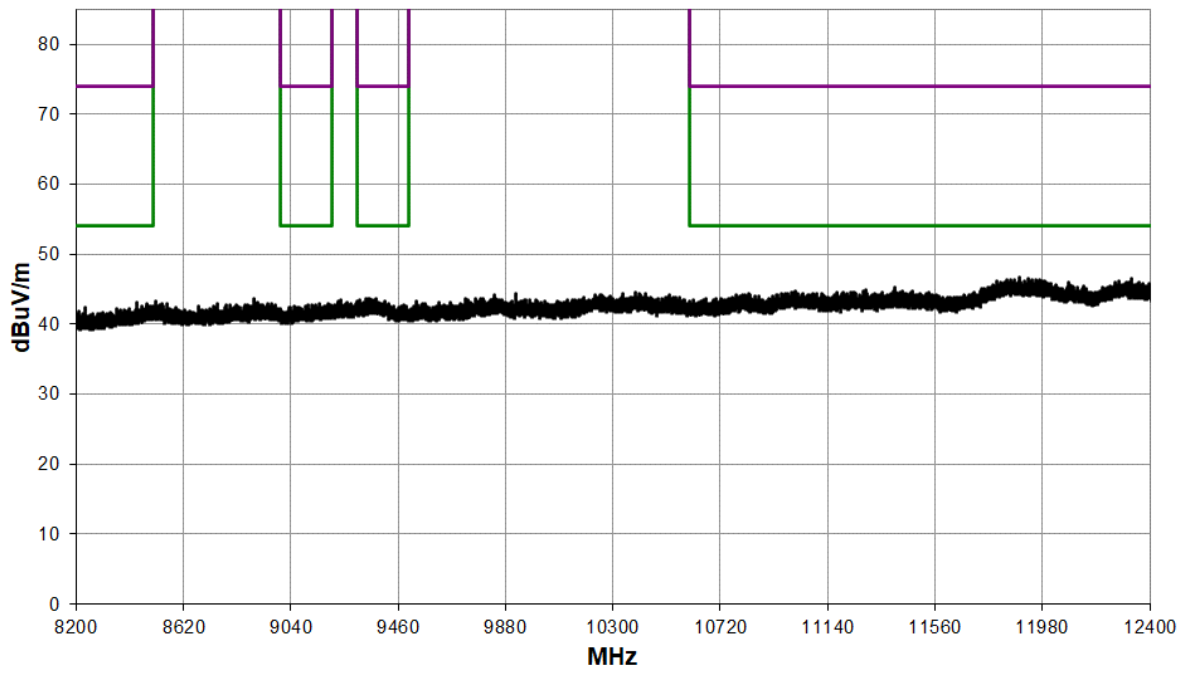
1 GHz to 4 GHz



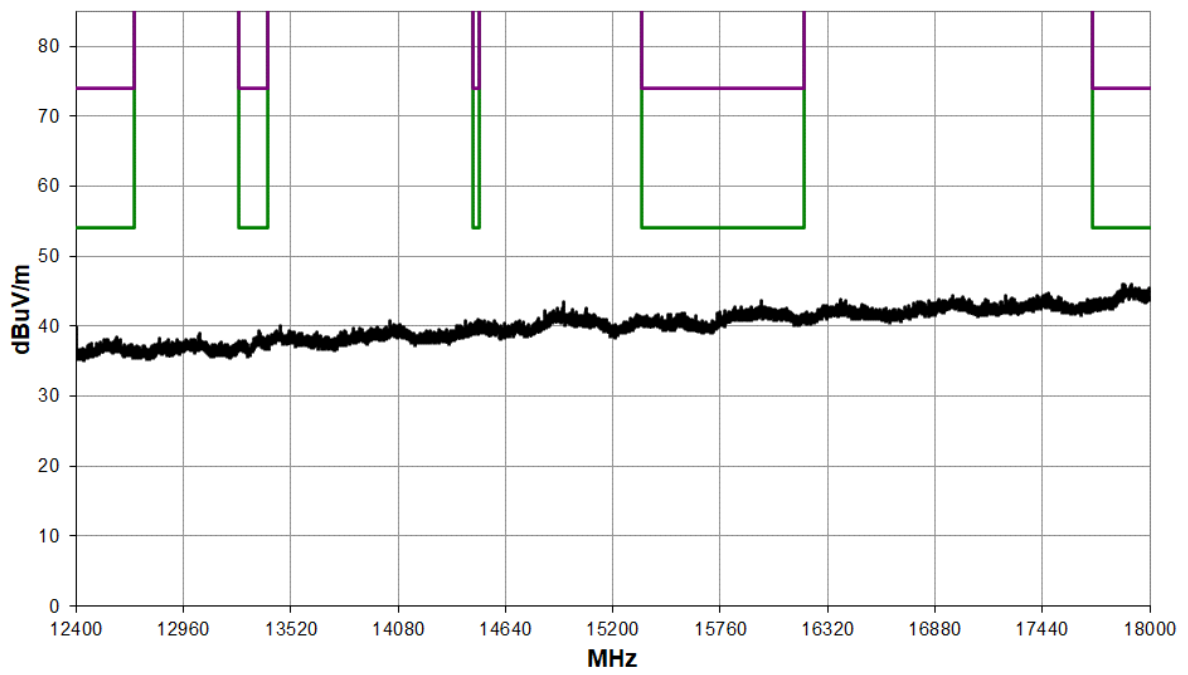
4 GHz to 8.2 GHz



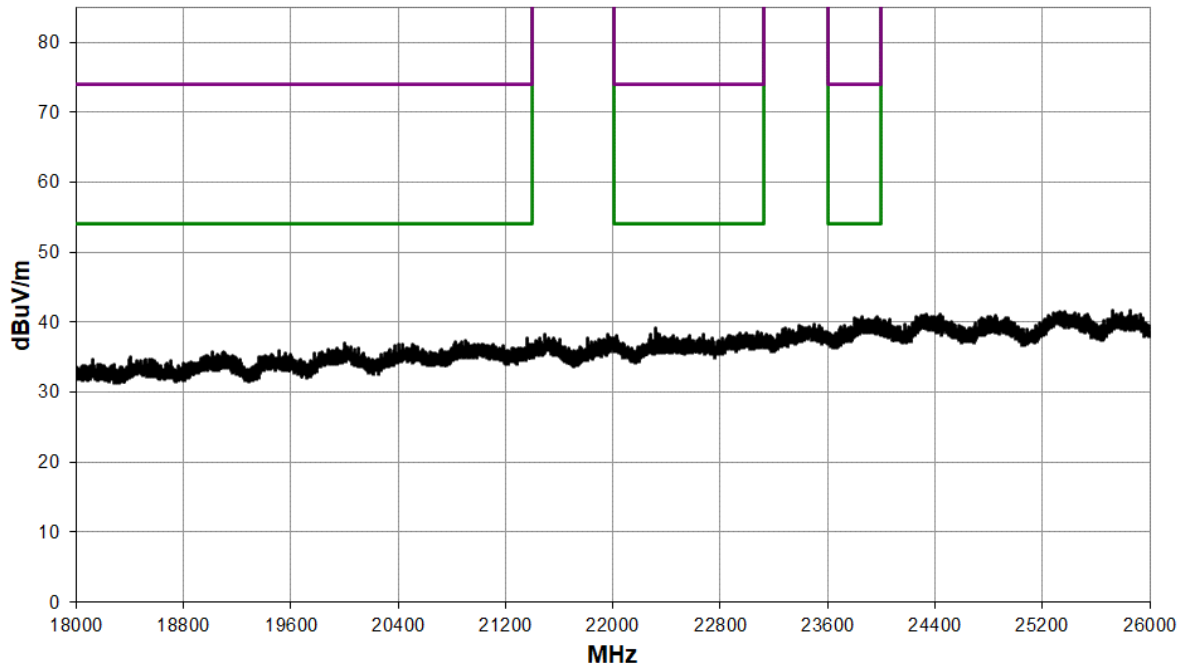
8.2 GHz to 12.4 GHz



12.4 GHz to 18 GHz



18 GHz to 26 GHz



Band Edge



Element

*RBW 1 MHz

Marker 1 [T1]

*VBW 3 MHz

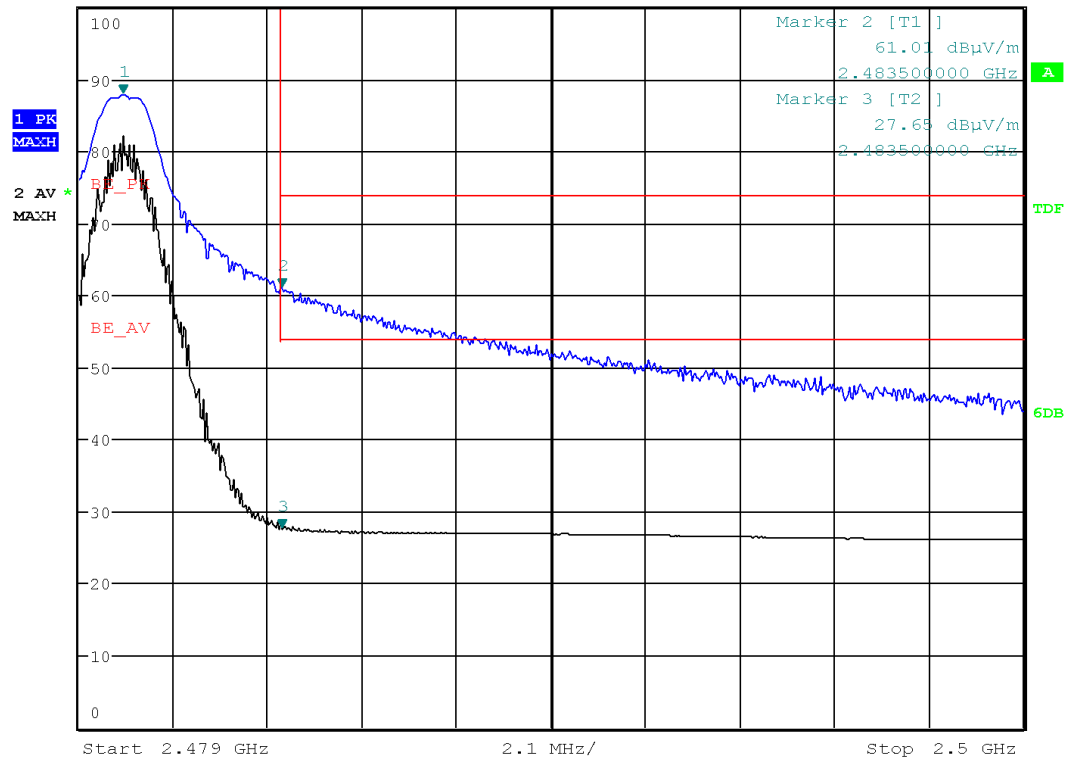
87.90 dBuV/m

Ref 100 dBuV/m

*Att 0 dB

*SWT 60 s

2.479980000 GHz



Date: 11.OCT.2022 15:33:05

12 Occupied Bandwidth

12.1 Definition

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

12.2 Test Parameters

| | |
|---------------------------|--------------------------------|
| Test Location: | Element Hull |
| Test Chamber: | Wireless Lab 2 |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.8 |
| EUT Frequencies Measured: | 2402 MHz / 2440 MHz / 2480 MHz |
| EUT Channel Bandwidths: | 2 MHz |
| EUT Test Modulations: | BLE |
| Deviations From Standard: | None |
| Measurement Detector: | Peak |

Environmental Conditions (Normal Environment)

| | |
|--------------------|--------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared) |
| Humidity: 45 %RH | 20 %RH to 75 %RH (as declared) |
| Supply: 3 Vdc | As declared |

12.3 Test Limit

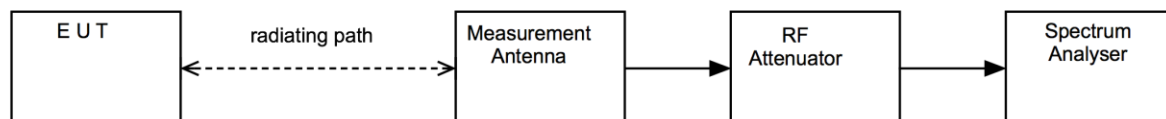
The minimum -6 dB bandwidth shall be at least 500 kHz.

12.4 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

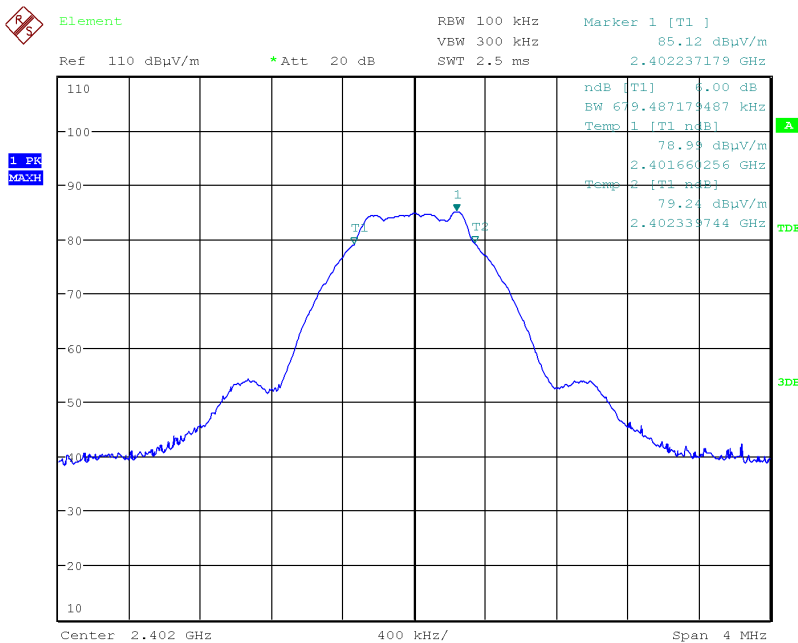


12.5 Test Equipment

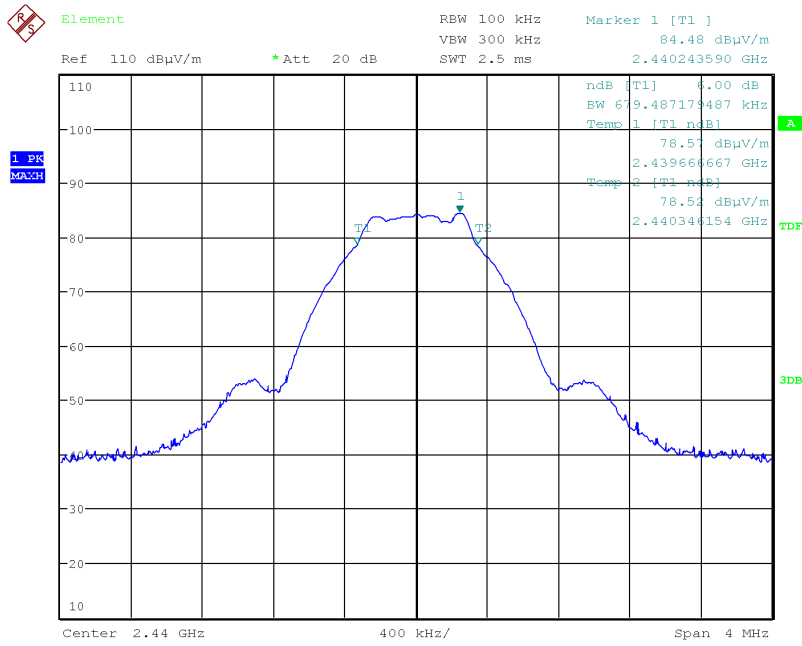
| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|------------------------|--------------|-----------------------|------------|---------------------|
| Ferrite Lined Chamber | Rainford | Chamber | REF886 | 2024-06-15 |
| Spectrum Analyser | R&S | FSU50 | U544 | 2022-11-12 |
| 3115 | EMCO | Horn Antenna | RFG129 | 2024-01-24 |
| Pre-Amp (1 – 26.5 GHz) | Agilent | 8449B | REF913 | 2023-03-24 |

12.6 Test Results

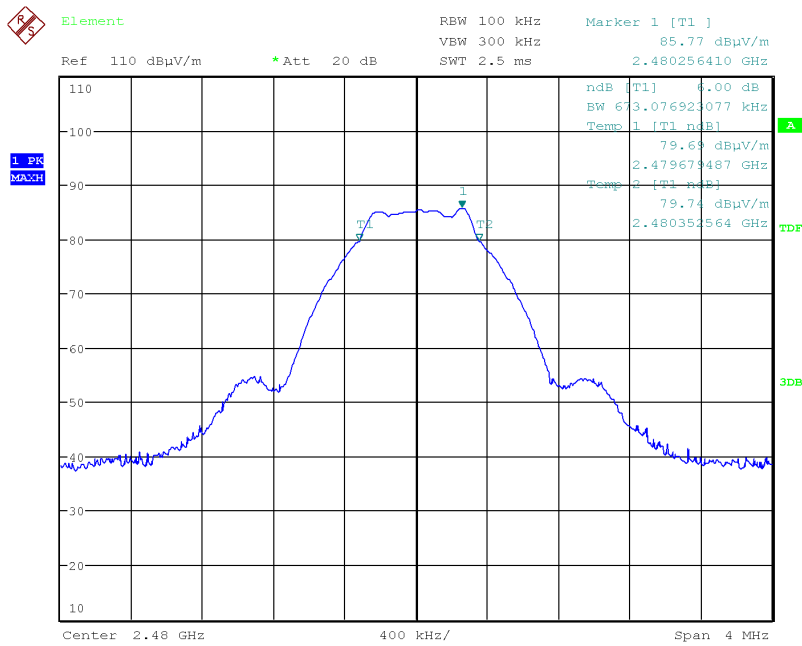
| Bandwidth Type: 6 dB; Modulation: GFSK; Data rate: 1 Mbps; Power setting: default | | | | |
|-----------------------------------------------------------------------------------|----------------------|----------------------|-----------------|--------|
| Frequency (MHz) | F _L (MHz) | F _H (MHz) | Bandwidth (kHz) | Result |
| 2402 | 2401.660256 | 2402.339744 | 679.487179487 | PASS |
| 2440 | 2439.666667 | 2440.346154 | 679.487179487 | PASS |
| 2480 | 2479.679487 | 2480.352564 | 673.076923077 | PASS |



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13 Maximum peak conducted output power

13.1 Definition

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

13.2 Test Parameters

| | |
|-----------------------------------------|---------------------------------|
| Test Location: | Element Hull |
| Test Chamber: | Wireless Lab 2 |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.9.1 |
| EUT Frequencies Measured: | 2402 MHz, 2440 MHz & 2480 MHz |
| Deviations From Standard: | None |
| Measurement Detector: | Peak |
| Voltage Extreme Environment Test Range: | Battery Power = new battery. |

Environmental Conditions (Normal Environment)

| | |
|--------------------|--------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared) |
| Humidity: 45 %RH | 20 %RH to 75 %RH (as declared) |

13.3 Test Limit

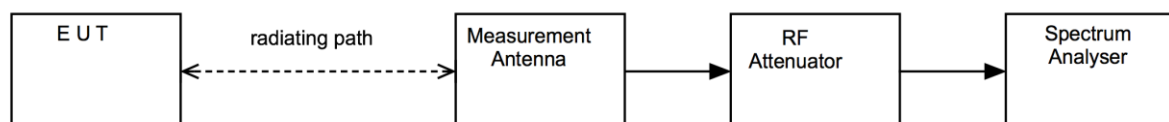
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

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

Figure iv Test Setup



13.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|------------------------|---------------------|------------------------------|-------------------|----------------------------|
| Ferrite Lined Chamber | Rainford | Chamber | REF886 | 2024-06-15 |
| Spectrum Analyser | R&S | FSU50 | U544 | 2022-11-12 |
| 3115 | EMCO | Horn Antenna | RFG129 | 2024-01-24 |
| Pre-Amp (1 – 26.5 GHz) | Agilent | 8449B | REF913 | 2023-03-24 |
| Emissions R5 | Element | Radiated Test Software | REF9000 | Cal not required |

13.6 Test Results

The following formula was used to convert field strength (E) in volts/metre to conducted output power in watts:

$$\text{Conducted Output Power} = (E \times d)^2 / (30 \times G)$$

Where,

E is the electric field strength in V/m

d is the measurement distance in meters (m)

G is the antenna numerical gain referenced to isotropic gain

| 2.4 GHz BLE; Power Setting: Default | | | | | | |
|--------------------------------------------|----------------------------------------------------|----------------------------------|---------------------|-----------------------|------------------------------------------------|---------------|
| Frequency (MHz) | Peak Field Strength (dBμV/m) | Peak Field Strength (V/m) | Distance (m) | Numerical Gain | Maximum peak conducted output power (W) | Result |
| 2402 | 87.9 | 0.02483 | 3.0 | 1.48 | 0.000125 | Pass |
| 2440 | 86.3 | 0.02065 | 3.0 | 1.48 | 0.000087 | Pass |
| 2480 | 87.9 | 0.02483 | 3.0 | 1.48 | 0.000125 | Pass |

Note: Duty cycle is 100%

14 Out-of-band and conducted spurious emissions

14.1 Definition

Out-of-band emission.

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

Spurious emission.

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

14.2 Test Parameters

| | |
|-----------------------------|--------------------------------|
| Test Location: | Element Hull |
| Test Chamber: | Wireless Lab 2 |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.11 |
| EUT 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: | 300 kHz |
| Measurement Detector: | Peak |
| Measurement Range: | 30 MHz to 26.5 GHz |

Environmental Conditions (Normal Environment)

| | |
|--------------------|--------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared) |
| Humidity: 45 %RH | 20 %RH to 75 %RH (as declared) |
| Supply: 3 Vdc | As declared |

14.3 Test Limit

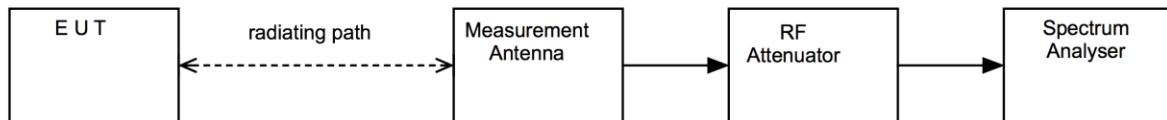
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) / RSS-Gen is not required.

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

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

Figure v Test Setup



14.5 Test Equipment

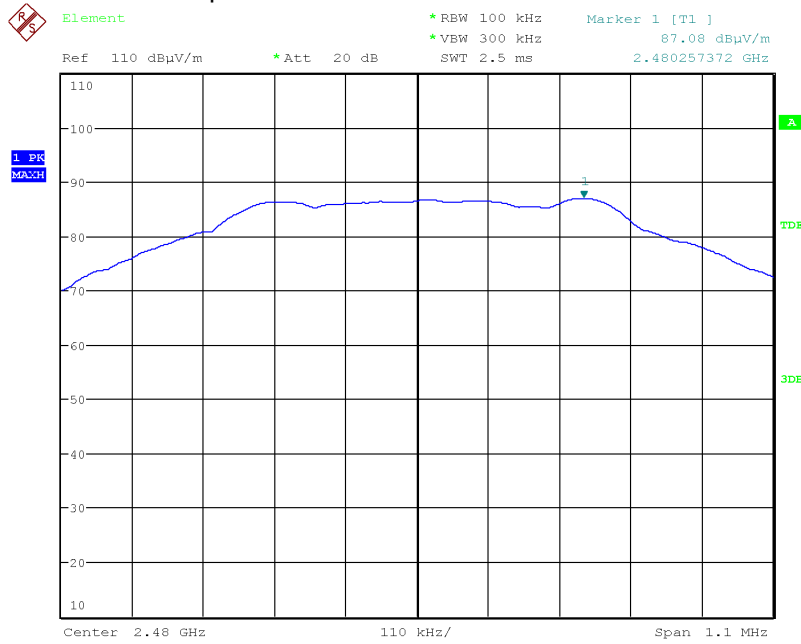
| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|------------------------|---------------------|------------------------------|-------------------|----------------------------|
| Ferrite Lined Chamber | Rainford | Chamber | REF886 | 2024-06-15 |
| Spectrum Analyser | R&S | FSU50 | U544 | 2022-11-12 |
| 3115 | EMCO | Horn Antenna | RFG129 | 2024-01-24 |
| Pre-Amp (1 – 26.5 GHz) | Agilent | 8449B | REF913 | 2023-03-24 |

14.6 Test Results

| Modulation: BLE; Data rate: 1 Mbps; Power setting: Default | | | | | | |
|------------------------------------------------------------|--------------------------|------------------------------|------------------------------------------|---------------------------------------|-------------|--------|
| Channel Frequency (MHz) | Emission Frequency (MHz) | Peak Field Strength (dBuV/m) | Fundamental peak field strength (dBuV/m) | 20 dBc Level Limit for plots (dBuV/m) | Margin (dB) | Result |
| 2402 | 7206.7 | 50.2 | 87.1 | 67.1 | -16.9 | Pass |
| 2402 | 9609.0 | 37.3 | 87.1 | 67.1 | -29.8 | Pass |
| 2402 | 21618 | 51.7 | 87.1 | 67.1 | -15.4 | Pass |
| 2440 | 21962.0 | 53.2 | 87.1 | 67.1 | -13.9 | Pass |

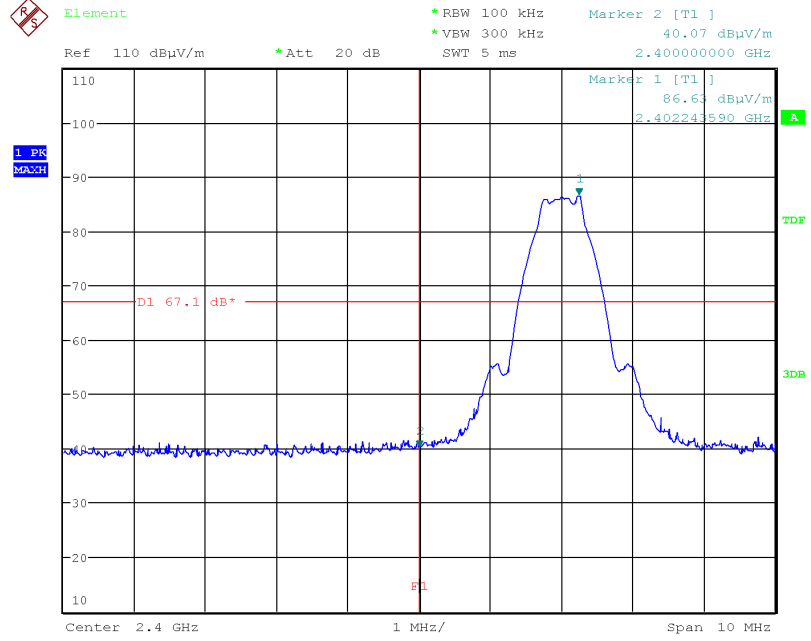
The frequencies recorded were determine from the scans in section 11.6

Reference Level plot: 100 kHz PSD



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Band Edge



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15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

| | |
|--------------------------------------|--------------------------------|
| Test Location: | Element Hull |
| Test Chamber: | Wireless Lab 3 |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.10 |
| EUT Channels / 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: | 300 kHz |
| Measurement Detector: | Peak |

Environmental Conditions (Normal Environment)

| | |
|--------------------|--------------------------------|
| Temperature: 21 °C | +15 °C to +35 °C (as declared) |
| Humidity: 45 %RH | 20 %RH to 75 %RH (as declared) |
| Supply: 3 Vdc | As declared |

15.3 Test Limit

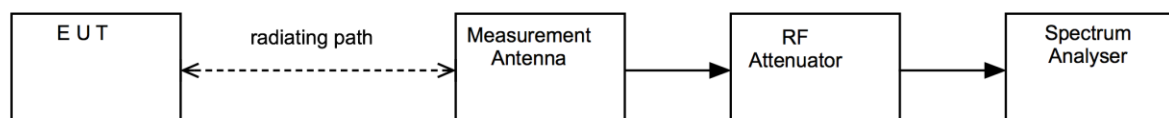
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

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

Figure vi Test Setup



15.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|------------------------|---------------------|------------------------------|-------------------|----------------------------|
| Ferrite Lined Chamber | Rainford | Chamber | REF886 | 2024-06-15 |
| Spectrum Analyser | R&S | FSU50 | U544 | 2022-11-12 |
| 3115 | EMCO | Horn Antenna | RFG129 | 2024-01-24 |
| Pre-Amp (1 – 26.5 GHz) | Agilent | 8449B | REF913 | 2023-03-24 |

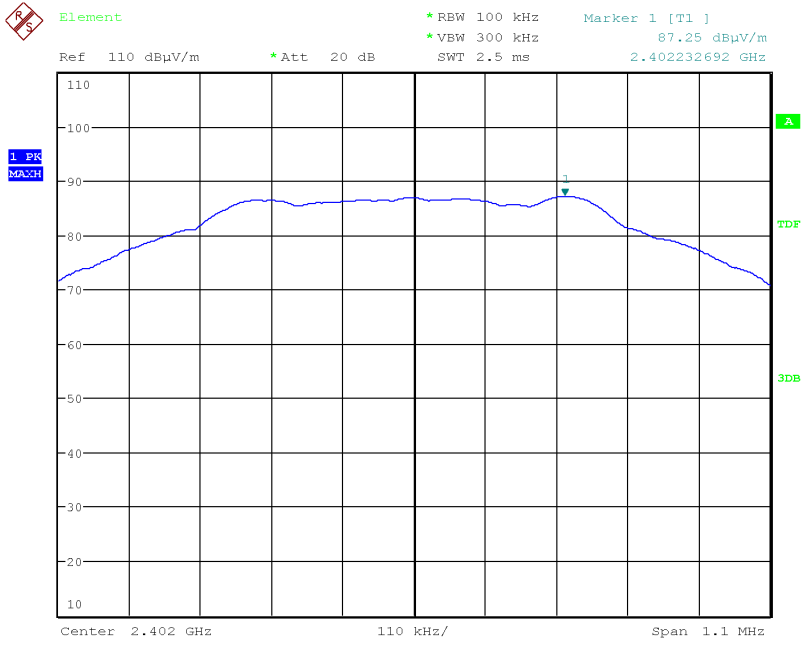
15.6 Test Results

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

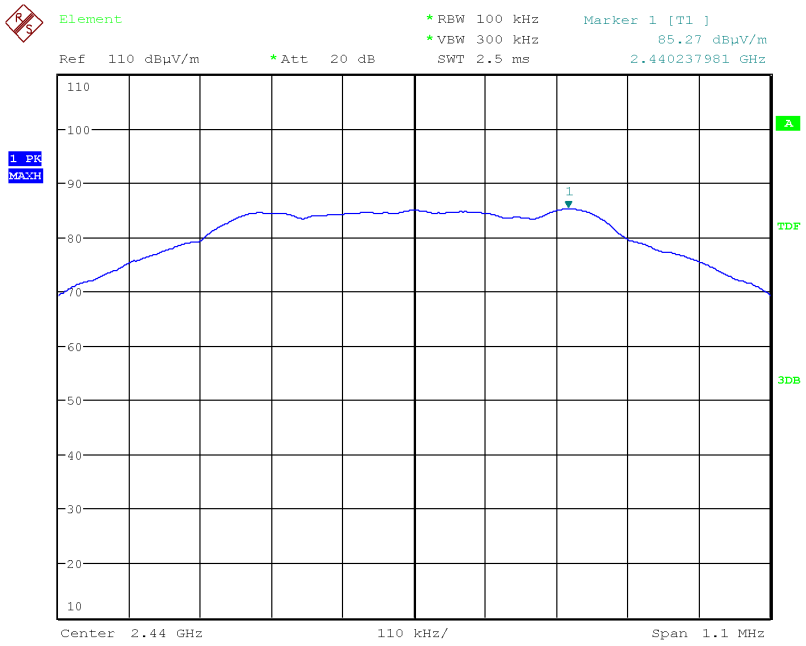
$$TP = (FS \times D)^2 / (30 \times G)$$

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain.

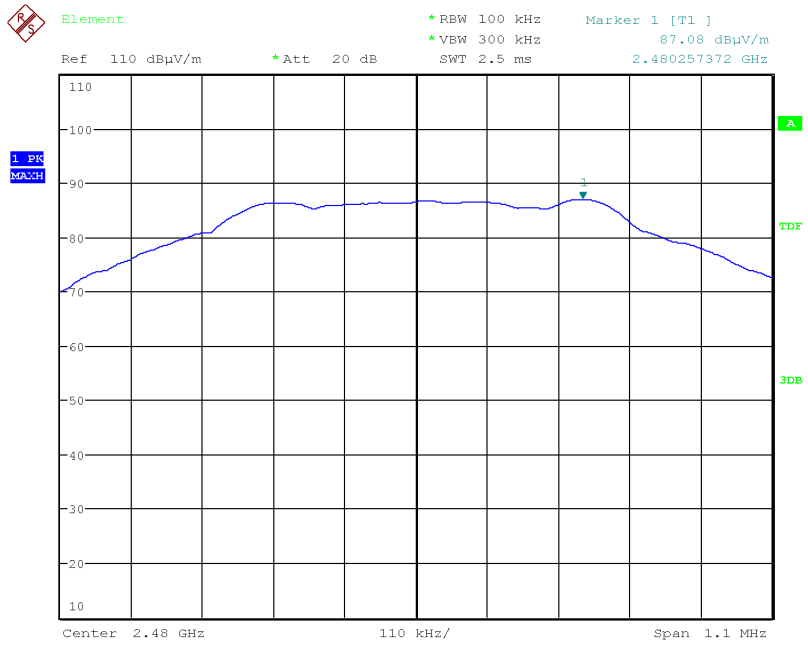
| 2.4 GHz BLE; Power Setting: Default | | | | | |
|--------------------------------------------|-------------------------------------|---------------------|-----------------------|-----------------------|---------------|
| Frequency (MHz) | Peak Field Strength (dBµV/m) | Distance (m) | Numerical Gain | Max. PSD (dBm) | Result |
| 2402 | 87.25 | 3 | 1.7 | -9.68 | Pass |
| 2440 | 85.27 | 3 | 1.7 | -11.66 | Pass |
| 2480 | 87.08 | 3 | 1.7 | -9.85 | Pass |



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16 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

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

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