

Report on the Radio Testing

For

Pektron Group Limited

on

BTLE Keyfob

Report no. TRA-051982-47-00B

18 May 2021

RF915 7.0



Report Number: TRA-051982-47-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
Pektron Group Limited
BTLE Keyfob
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2021-02-22 to 2021-02-24

Written by:



Steven Garwell
Radio Test Engineer

Approved by:

Date: 18 May 2021

Daniel Winstanley
Senior - Radio 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 | 2021-04-19 | Original |
| B | 2021-05-18 | Added antenna gain, amended FCC ID |

2 Summary

TEST REPORT NUMBER: TRA-051982-47-00B

WORKS ORDER NUMBER: TRA-051982-02

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: FCC 47CFR 15.247

FCC ID: AQQ013

EQUIPMENT UNDER TEST (EUT): BTLE Keyfob

EUT SERIAL NUMBER: AB10000108 (Radiated)
AB10000109 (Conducted)

MANUFACTURER/AGENT: Pektron Group Limited

ADDRESS: Alfreton Road
Derby
Derbyshire
DE21 4AP
United Kingdom

CLIENT CONTACT: Richard Jones
☎ 01332832424 ext 382
✉ rjones@pektron.co.uk

ORDER NUMBER: PROJ-00000632

TEST DATE: 2021-02-22 to 2021-02-24

TESTED BY: Steven Garwell, Michael Else
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 type="checkbox"/> | Note 1 |
| Occupied bandwidth | 15.247(a)(2) | <input type="checkbox"/> | Pass |
| Conducted carrier power | Peak | <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 |
| Calculation of duty correction | 15.35(c) | <input checked="" type="checkbox"/> | - |

Note 1: Not applicable, not connected to the mains.

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-051982-47-00B presents the results of the Radio testing on a Qualcomm Technologies International Ltd., BTLE Keyfob to specification 47CFR15 Radio Frequency Devices - Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.

The testing was carried out for Pektron Group Limited, by Element, at the address detailed below.

| | |
|--|--|
| <input type="checkbox"/> Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK | <input checked="" 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:

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

Designation number(s):

| | |
|----------------------|--------|
| Element Hull | UK2007 |
| Element Skelmersdale | UK2020 |

IC Registration Number(s):

| | |
|----------------------|-------|
| Element Hull | 3483A |
| Element Skelmersdale | 3930B |

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

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 *Normative References*

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

5.2 *Deviations from Test Standards*

There were no deviations from the test standard.

6 Glossary of Terms

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

7 Equipment Under Test

7.1 EUT Identification

- Name: BTLE Keyfob
- Model Number: A-0820G01
- Serial Number: AB10000108 (Radiated) / AB10000109 (Conducted)
- Software Versions: Bootloader: P0820B1.1.0, / Application: P0820A1.7.0
- Hardware Version: Production

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

No additional support equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmit tests was as follows:-

The EUT was transmitting modulated carrier on the frequencies indicated.

7.4 EUT Radio Parameters

| | |
|--------------------------------|-------------------------------|
| Frequency of operation: | 2402 MHz – 2480 MHz |
| Modulation: | GFSK |
| Declared output power: | ≤10.0 dBm |
| Antenna type: | WLA.01 Ceramic SMD |
| Antenna gain: | 2.5 dBi |
| Nominal supply voltage: | 3 Vdc from a CR2032 coin cell |

7.5 EUT Description

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

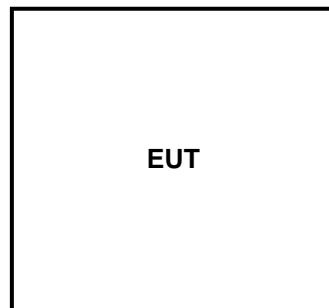
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

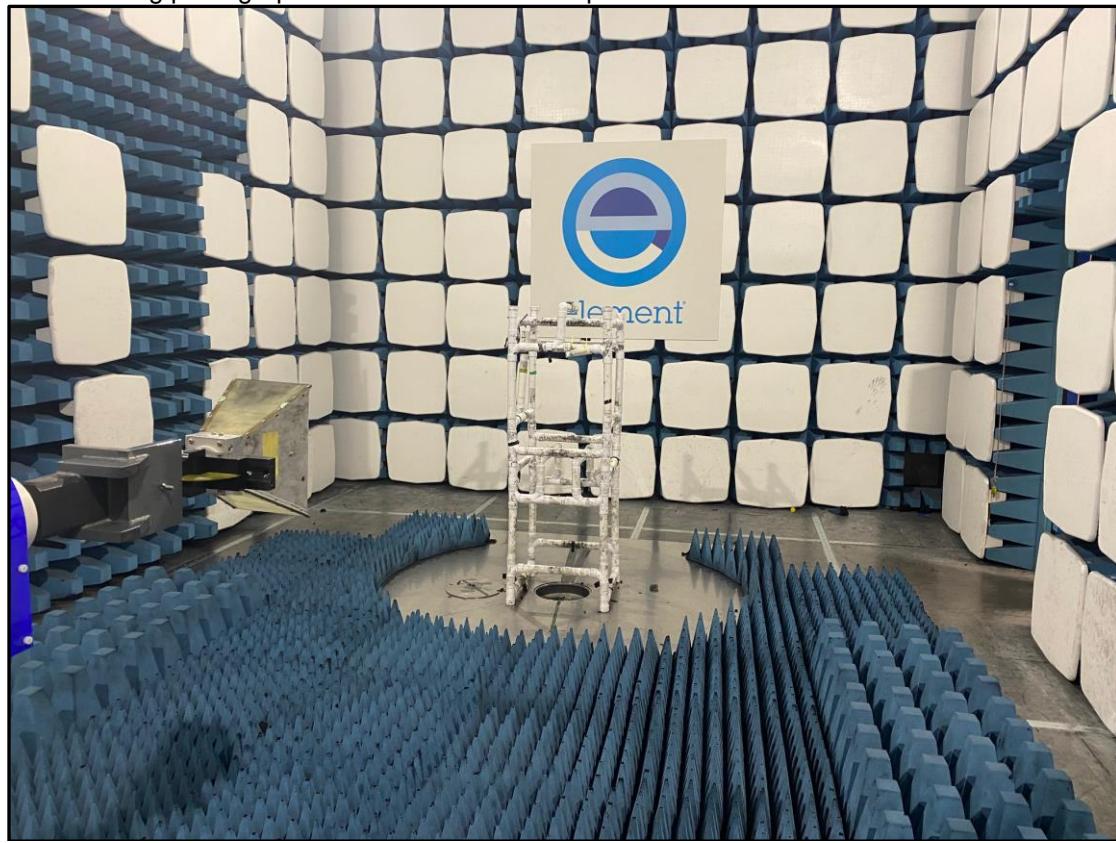
9.1 *Block Diagram*

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



General Set-up Photograph

The following photograph shows basic EUT set-up:



9.2 Measurement software

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

Element Emissions R5 (See Note)
Element Transmitter Bench Test (See Note)
ETS Lindgren EMPower V1.0.4.2

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 3 Vdc from a CR2032 coin cell battery.

11 Radiated emissions

11.1 Definitions

Spurious emissions

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

Restricted bands

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

| | |
|---------------------------|--|
| Test Location: | Element Skelmersdale |
| Test Chamber: | SK03 radio chamber |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 6.5 and 6.6 |
| Frequencies Measured: | 2402 MHz / 2440 MHz / 2480 MHz |
| EUT Channel Bandwidths: | 1 MHz |
| Deviations From Standard: | None |
| Measurement BW: | 30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz |
| Measurement Detector: | Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak |

Environmental Conditions (Normal Environment)

| | |
|--------------------|----------------------------------|
| Temperature: 24 °C | +15 °C to +35 °C (as declared) |
| Humidity: 37 % RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3 Vdc | 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 (µV/m at 3 m) |
|-----------------|------------------------------|
| 30 to 88 | 100 |
| 88 to 216 | 150 |
| 216 to 960 | 200 |
| Above 960 | 500 |

11.4 Test Method

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

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

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

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

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

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

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

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

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB μ V;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

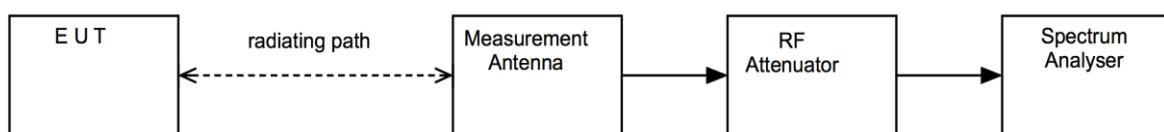
PA is the pre-amplifier gain in dB (where used);

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

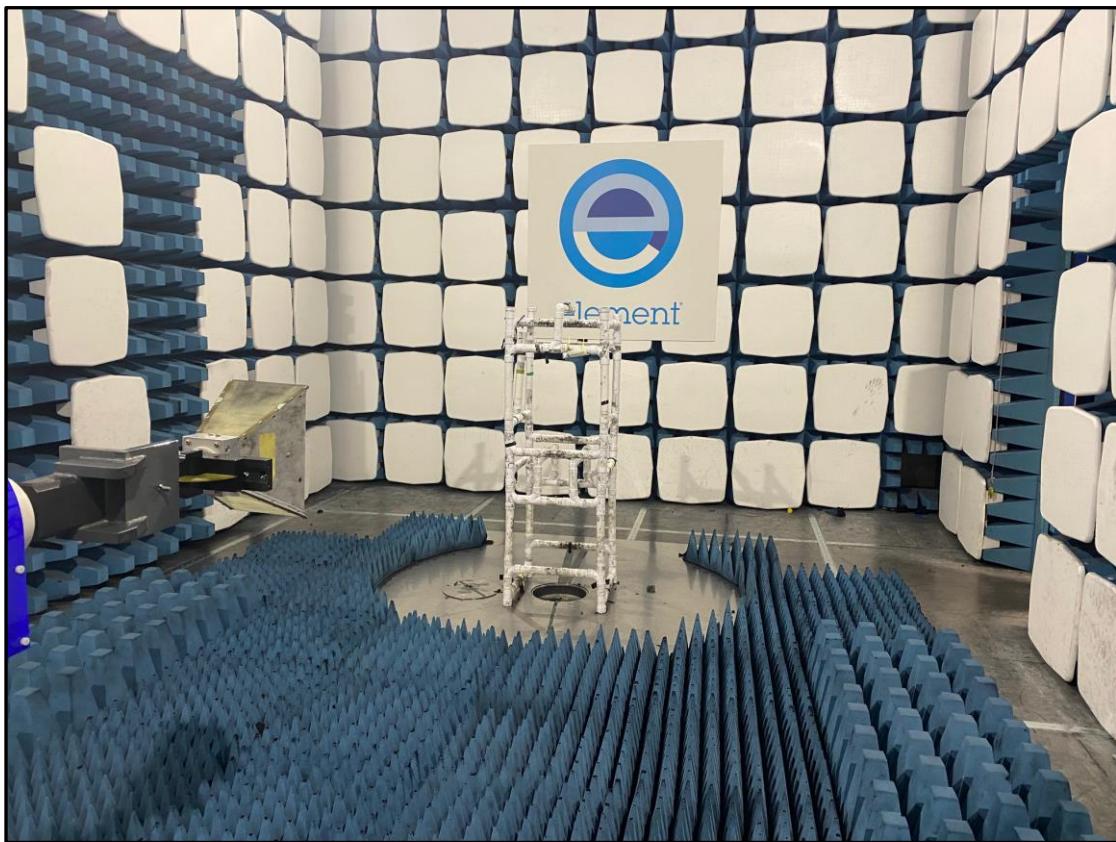
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph

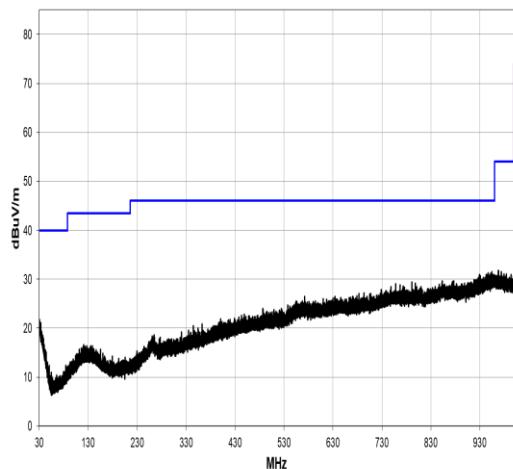


11.6 Test Equipment

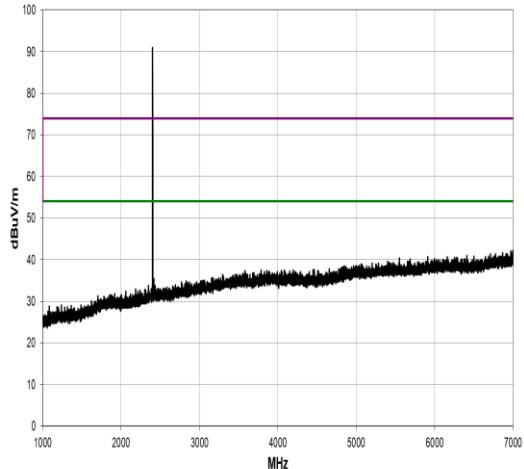
| Equipment Description | Manufacturer | Equipment Type | Element No | Due For Calibration |
|-----------------------|--------------------|----------------|------------|---------------------|
| Spectrum Analyser | R&S | FSU26 | U405 | 2021-07-17 |
| Bilog | Chase | CBL611/A | U573 | 2021-09-19 |
| 1-18GHz Horn | EMCO | 3115 | L139 | 2021-07-16 |
| PreAmp | Watkins Johnson | 6201-69 | U372 | 2022-03-01 |
| Pre Amp | Agilent | 8449B | L572 | 2021-10-19 |
| Horn 18-26GHz (&U330) | Flann | 20240-20 | L300 | 2022-04-23 |
| High Pass Filter | Atlantic Microwave | AFH-07000 | U558 | 2022-01-30 |
| Radio Chamber - PP | Rainford EMC | ATS | REF940 | 2021-12-09 |

11.7 Test Results

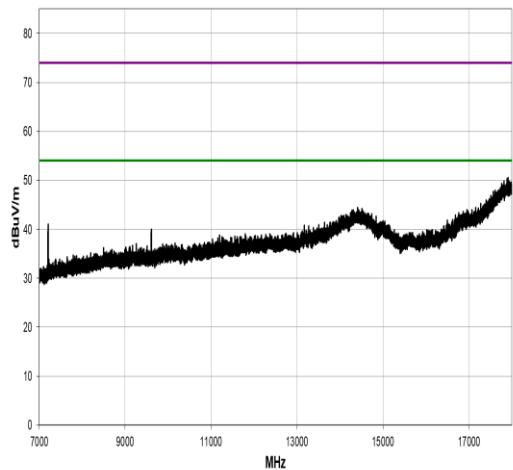
Bottom Channel 2402 MHz – BLE1



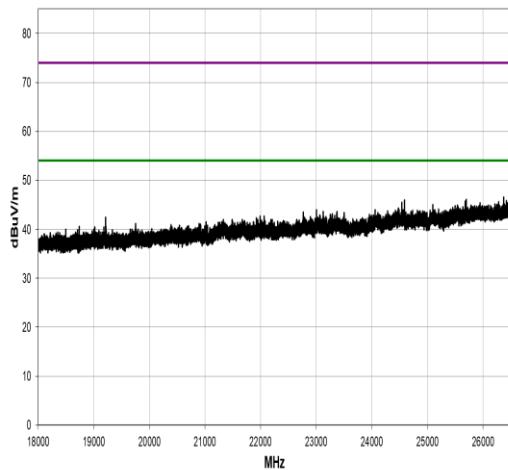
30 MHz to 1 GHz



1 GHz to 7 GHz



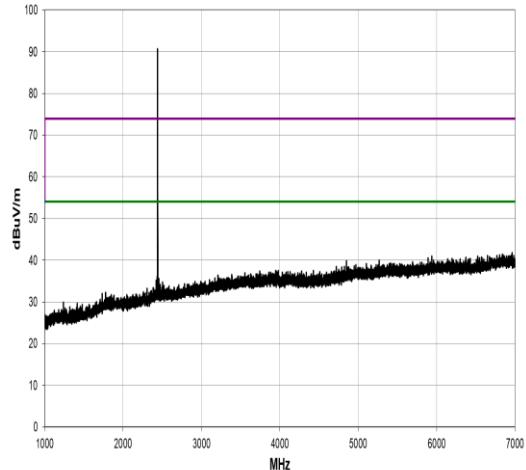
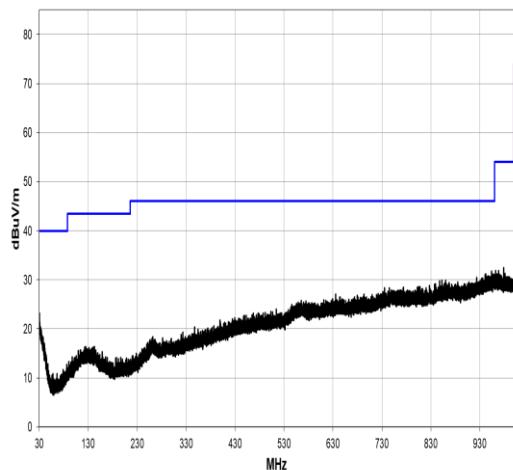
7 GHz to 18 GHz



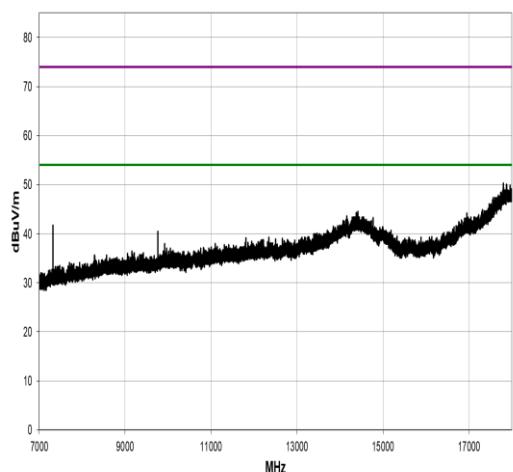
18 GHz TO 26.5 GHz

| Freq (MHz) | Amplitude (dBuV) | Factor (dB) | Antenna Height (meters) | Azimuth (degrees) | Duty Cycle Correction Factor (dB) | External Attenuation (dB) | Polarity/Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) |
|------------|------------------|-------------|-------------------------|-------------------|-----------------------------------|---------------------------|--------------------------|----------|--------------------------|-------------------|----------------------|------------------------|
| 9608.883 | 34.9 | 9.8 | 1.5 | 92.9 | 3.4 | 0.0 | Vert | AV | -9.5 | 38.6 | 54.0 | -15.4 |
| 7206.575 | 39.5 | 7.7 | 1.5 | 198.0 | 3.4 | 0.0 | Horz | AV | -9.5 | 41.1 | 54.0 | -12.9 |
| 7206.592 | 42.8 | 7.7 | 1.31 | 181.0 | 3.4 | 0.0 | Vert | AV | -9.5 | 44.4 | 54.0 | -9.6 |
| 9608.825 | 36.1 | 9.8 | 1.5 | 13.1 | 3.4 | 0.0 | Horz | AV | -9.5 | 39.8 | 54.0 | -14.2 |
| 7206.808 | 54.0 | 7.7 | 1.31 | 181.0 | | 0.0 | Vert | PK | -9.5 | 52.2 | 74.0 | -21.8 |
| 9608.958 | 50.3 | 9.8 | 1.5 | 13.1 | | 0.0 | Horz | PK | -9.5 | 50.6 | 74.0 | -23.4 |
| 7206.317 | 51.5 | 7.7 | 1.5 | 198.0 | | 0.0 | Horz | PK | -9.5 | 49.7 | 74.0 | -24.3 |
| 9609.042 | 49.0 | 9.8 | 1.5 | 92.9 | | 0.0 | Vert | PK | -9.5 | 49.3 | 74.0 | -24.7 |

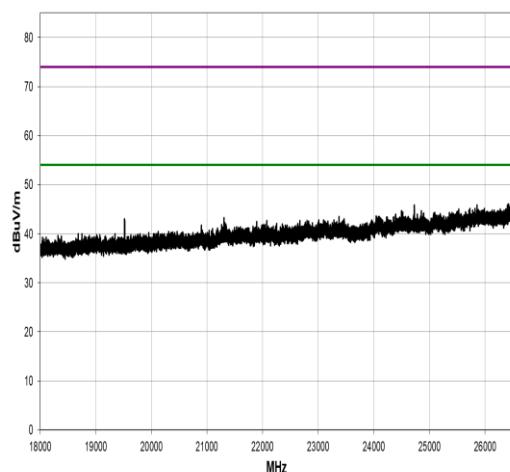
Middle Channel 2440 MHz – BLE1



30 MHz to 1 GHz



1 GHz to 7 GHz

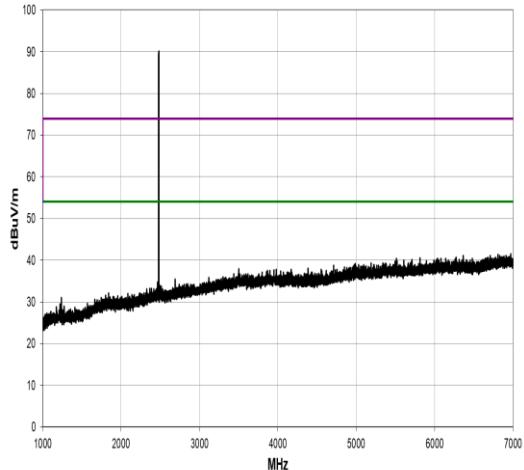
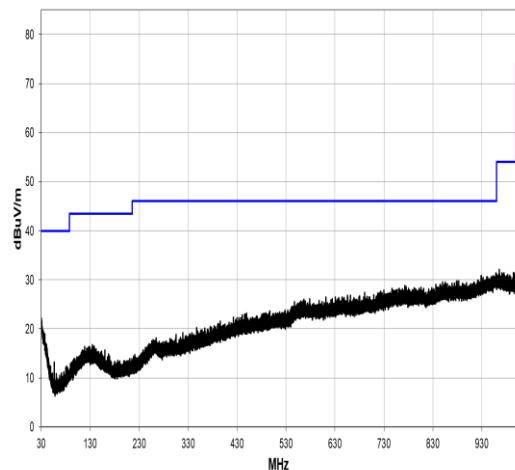


7 GHz to 18 GHz

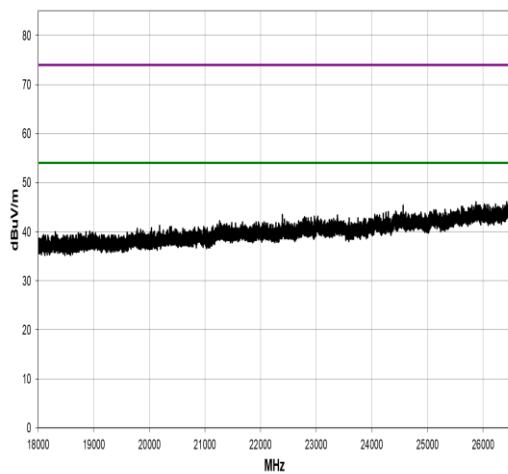
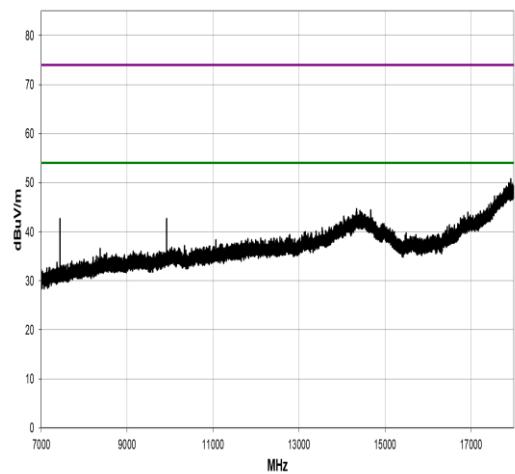
18 GHz to 26.5 GHz

| Freq (MHz) | Amplitude (dBuV) | Factor (dB) | Antenna Height (meters) | Azimuth (degrees) | Duty Cycle Correction Factor (dB) | External Attenuation (dB) | Polarity/Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) |
|------------|------------------|-------------|-------------------------|-------------------|-----------------------------------|---------------------------|--------------------------|----------|--------------------------|-------------------|----------------------|------------------------|
| 7320.583 | 42.4 | 7.9 | 1.31 | 182.1 | 3.4 | 0.0 | Vert | AV | -9.5 | 44.2 | 54.0 | -9.8 |
| 9760.817 | 38.3 | 9.8 | 1.5 | 25.1 | 3.4 | 0.0 | Horz | AV | -9.5 | 42.0 | 54.0 | -12.0 |
| 7320.575 | 40.1 | 7.9 | 1.54 | 200.0 | 3.4 | 0.0 | Horz | AV | -9.5 | 41.9 | 54.0 | -12.1 |
| 9760.842 | 36.7 | 9.8 | 1.5 | 106.0 | 3.4 | 0.0 | Vert | AV | -9.5 | 40.4 | 54.0 | -13.6 |
| 9761.075 | 51.5 | 9.8 | 1.5 | 25.1 | | 0.0 | Horz | PK | -9.5 | 51.8 | 74.0 | -22.2 |
| 7319.158 | 53.2 | 7.9 | 1.31 | 182.1 | | 0.0 | Vert | PK | -9.5 | 51.6 | 74.0 | -22.4 |
| 9758.875 | 50.1 | 9.8 | 1.5 | 106.0 | | 0.0 | Vert | PK | -9.5 | 50.4 | 74.0 | -23.6 |
| 7319.125 | 51.8 | 7.9 | 1.54 | 200.0 | | 0.0 | Horz | PK | -9.5 | 50.2 | 74.0 | -23.8 |

Top Channel 2480 MHz – BLE1



30 MHz to 1 GHz

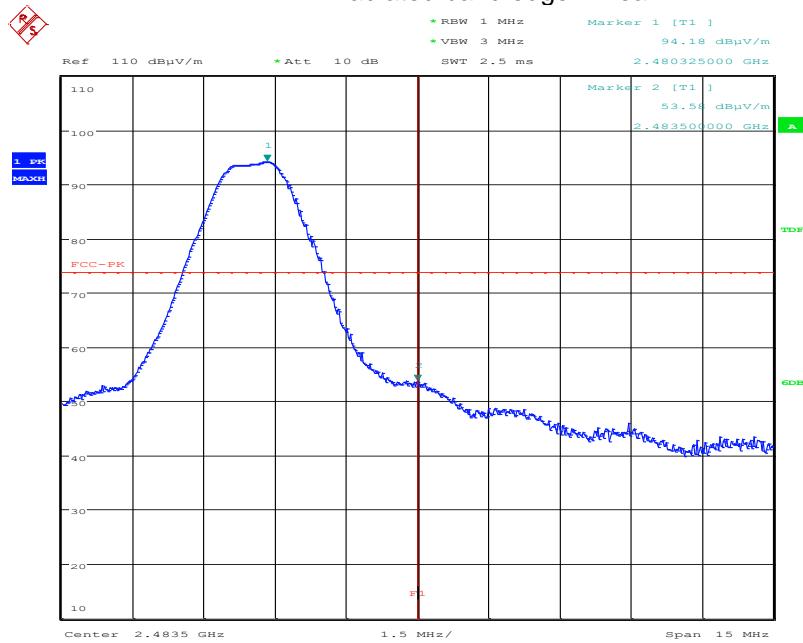


7 GHz to 18 GHz

18 GHz to 26.5 GHz

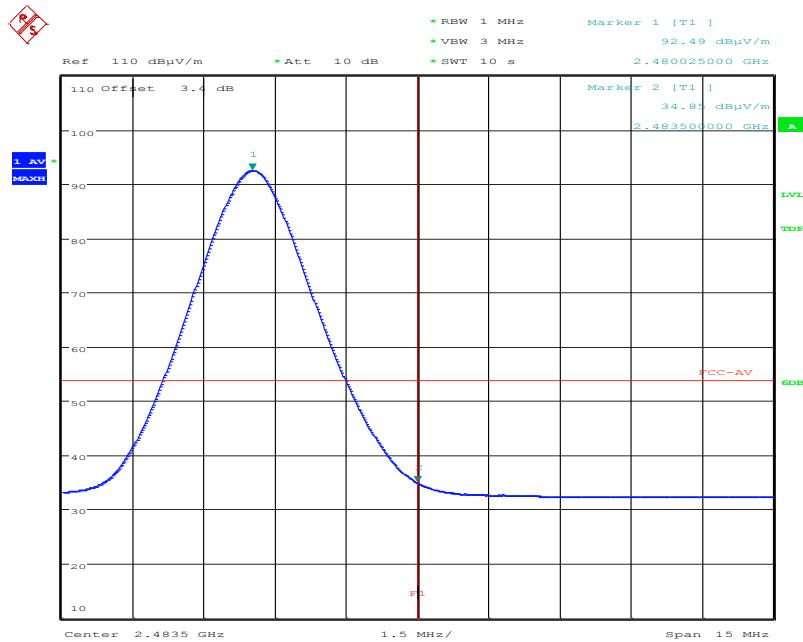
| Freq (MHz) | Amplitude (dBuV) | Factor (dB) | Antenna Height (meters) | Azimuth (degrees) | Duty Cycle Correction Factor (dB) | External Attenuation (dB) | Polarity/Transducer Type | Detector | Distance Adjustment (dB) | Adjusted (dBuV/m) | Spec. Limit (dBuV/m) | Compared to Spec. (dB) |
|------------|------------------|-------------|-------------------------|-------------------|-----------------------------------|---------------------------|--------------------------|----------|--------------------------|-------------------|----------------------|------------------------|
| 9920.783 | 40.5 | 10.0 | 1.34 | 30.9 | 3.4 | 0.0 | Horz | AV | -9.5 | 44.4 | 54.0 | -9.6 |
| 7440.550 | 43.2 | 8.1 | 1.34 | 2.0 | 3.4 | 0.0 | Horz | AV | -9.5 | 45.2 | 54.0 | -8.8 |
| 7440.533 | 41.2 | 8.1 | 1.58 | 102.9 | 3.4 | 0.0 | Vert | AV | -9.5 | 43.2 | 54.0 | -10.8 |
| 9920.800 | 38.5 | 10.0 | 1.5 | 66.9 | 3.4 | 0.0 | Vert | AV | -9.5 | 42.4 | 54.0 | -11.6 |
| 9921.133 | 53.4 | 10.0 | 1.34 | 30.9 | | 0.0 | Horz | PK | -9.5 | 53.9 | 74.0 | -20.1 |
| 7440.567 | 54.0 | 8.1 | 1.34 | 2.0 | | 0.0 | Horz | PK | -9.5 | 52.6 | 74.0 | -21.4 |
| 9918.767 | 51.6 | 10.0 | 1.5 | 66.9 | | 0.0 | Vert | PK | -9.5 | 52.1 | 74.0 | -21.9 |
| 7439.025 | 52.9 | 8.1 | 1.58 | 102.9 | | 0.0 | Vert | PK | -9.5 | 51.5 | 74.0 | -22.5 |

BLE1 radiated band edge – Peak



Date: 22.FEB.2021 16:49:38

BLE1 radiated band edge – Average



Date: 22.FEB.2021 16:48:22

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

Environmental Conditions (Normal Environment)

| | |
|--------------------|----------------------------------|
| Temperature: 24 °C | +15 °C to +35 °C (as declared) |
| Humidity: 37 % RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3 Vdc | 3 Vdc (as declared) |

12.3 Test Limit

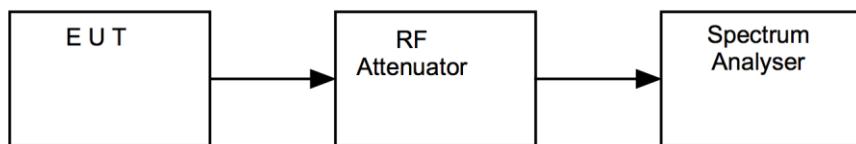
The minimum -6 dB bandwidth shall be at least 500 kHz.

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

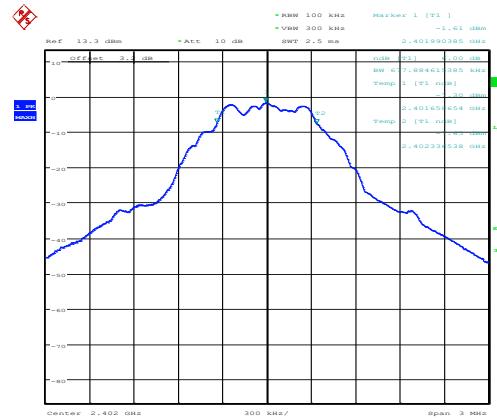


12.5 Test Equipment

| <i>Equipment</i> | | <i>Equipment</i> | <i>Element</i> | <i>Due For</i> |
|-------------------|-----------------------|--------------------|----------------|--------------------|
| <i>Type</i> | <i>Manufacturer</i> | <i>Description</i> | <i>No</i> | <i>Calibration</i> |
| Spectrum Analyser | R&S | FSU46 | REF910 | 2021-11-16 |
| Attenuator | AtlanTechRF Microwave | 3dB SMA | U639 | Cal in use |

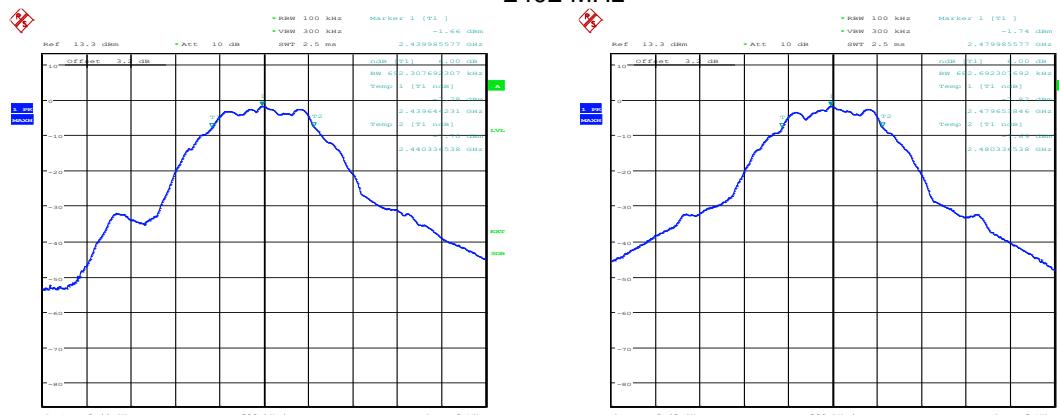
12.6 Test Results

BLE1: FCC 15.247



Date: 22.FEB.2021 17:35:42

2402 MHz



Date: 22.FEB.2021 17:36:16

2440 MHz

Date: 22.FEB.2021 17:36:44

2480 MHz

| FCC 15.247 DTS Bandwidth. Data Rate:1 Mbps | | | | |
|--|-------------|-------------|---------------------|--------|
| Channel Frequency (MHz) | F_L (MHz) | F_H (MHz) | 6dB Bandwidth (kHz) | Result |
| 2402 | 2401.658654 | 2402.336538 | 677.884 | Pass |
| 2440 | 2439.644231 | 2440.336538 | 692.307 | Pass |
| 2480 | 2479.653846 | 2480.336538 | 682.693 | Pass |

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.

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.

13.2 *Test Parameters*

| | |
|--|---------------------------------|
| Test Location: | Element Skelmersdale |
| Test Chamber: | Radio Laboratory |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.9.1 |
| Frequencies Measured: | 2402 MHz, 2440 MHz, 2480 MHz |
| EUT Channel Bandwidths: | 2 MHz |
| Deviations From Standard: | None |
| Measurement BW: | 2 MHz |
| Spectrum Analyzer Video BW: (requirement at least 3x RBW) | 10 MHz |
| Measurement Detector: | Peak |

Environmental Conditions (Normal Environment)

| | |
|--------------------|----------------------------------|
| Temperature: 24 °C | +15 °C to +35 °C (as declared) |
| Humidity: 37 % RH | 20 % RH to 75 % RH (as declared) |

13.3 *Test Limit*

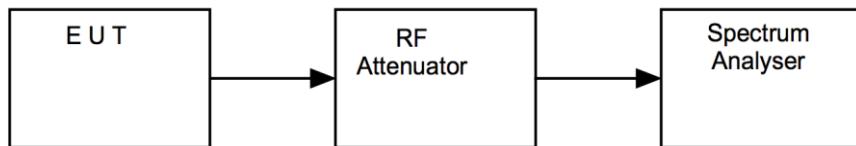
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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

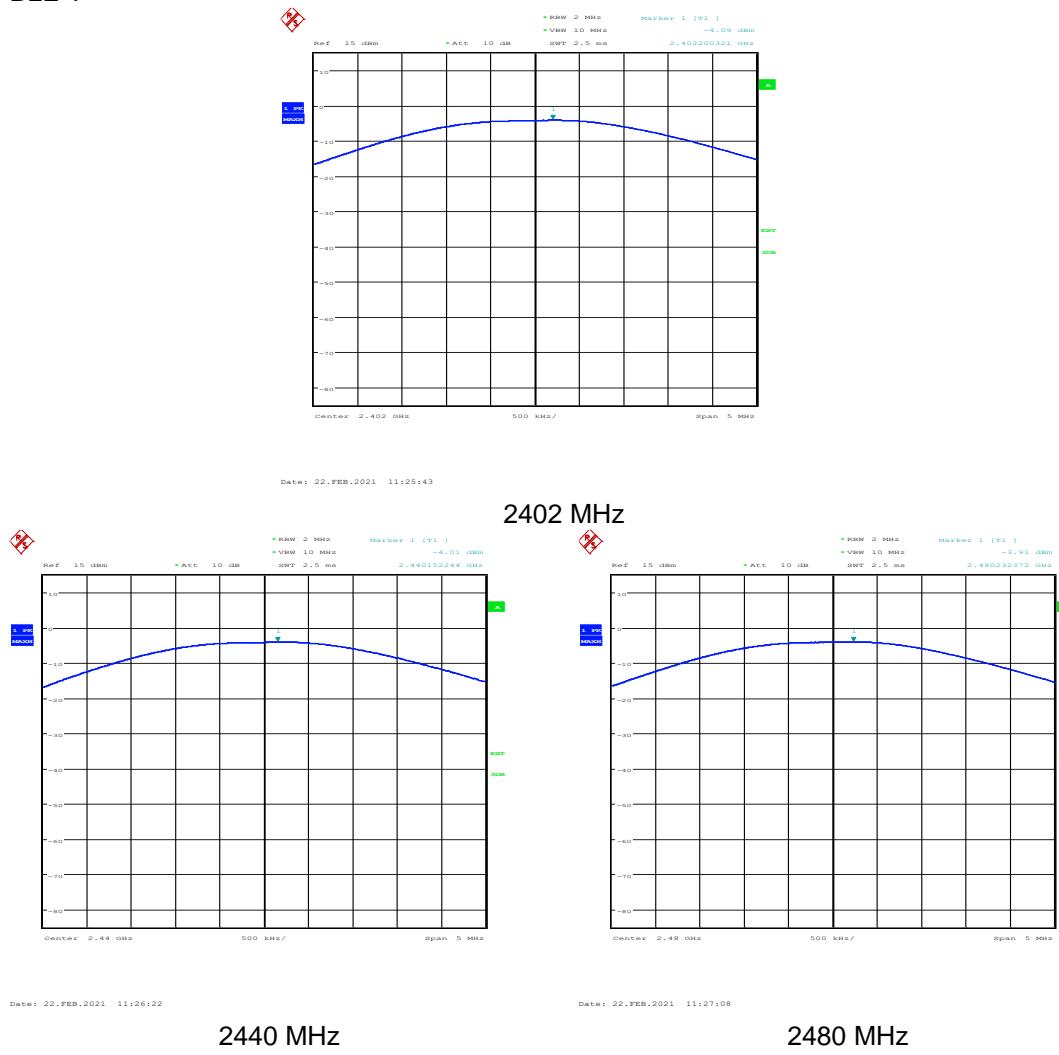


13.5 Test Equipment

| <i>Equipment Type</i> | <i>Manufacturer</i> | <i>Equipment Description</i> | <i>Element No</i> | <i>Due For Calibration</i> |
|-----------------------|-----------------------|------------------------------|-------------------|----------------------------|
| Spectrum Analyser | R&S | FSU46 | REF910 | 2021-11-16 |
| Attenuator | AtlanTechRF Microwave | 3dB SMA | U639 | Cal in use |

13.6 Test Results

BLE 1



| Modulation: GFSK; Data rate: 1Mbps; | | | | | | | |
|-------------------------------------|-------------------------------|-----------------|-----------------------|--------------------|---------------|---------------|--------|
| Channel Frequency (MHz) | Spectrum Analyser Level (dBm) | Cable loss (dB) | Conducted Power (dBm) | Antenna gain (dBi) | E.I.R.P (dBm) | E.I.R.P. (mW) | Result |
| 2402.00 | -4.09 | 3.06 | -1.03 | 2.5 | 1.47 | 1.40281 | Pass |
| 2440.00 | -4.01 | 3.20 | -0.81 | 2.5 | 1.69 | 1.47570 | Pass |
| 2480.00 | -3.91 | 3.06 | -0.85 | 2.5 | 1.65 | 1.46217 | Pass |

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 Skelmersdale |
| Test Chamber: | Radio Laboratory |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.11 |
| Frequencies Measured: | 2402 MHz / 2440 MHz / 2480 MHz |
| EUT Channel Bandwidths: | 1 MHz |
| Deviations From Standard: | None |
| Measurement BW: | 100 kHz |
| Spectrum Analyzer Video BW: (requirement at least 3x RBW) | 300 kHz |
| Measurement Detector: | Peak |
| Measurement Range: | 9 kHz to 25.0 GHz |

Environmental Conditions (Normal Environment)

| | |
|--------------------|----------------------------------|
| Temperature: 24 °C | +15 °C to +35 °C (as declared) |
| Humidity: 37 % RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3 Vdc | 3 Vdc (as declared) |

14.3 Test Limit

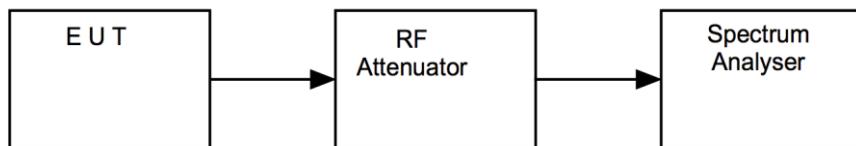
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

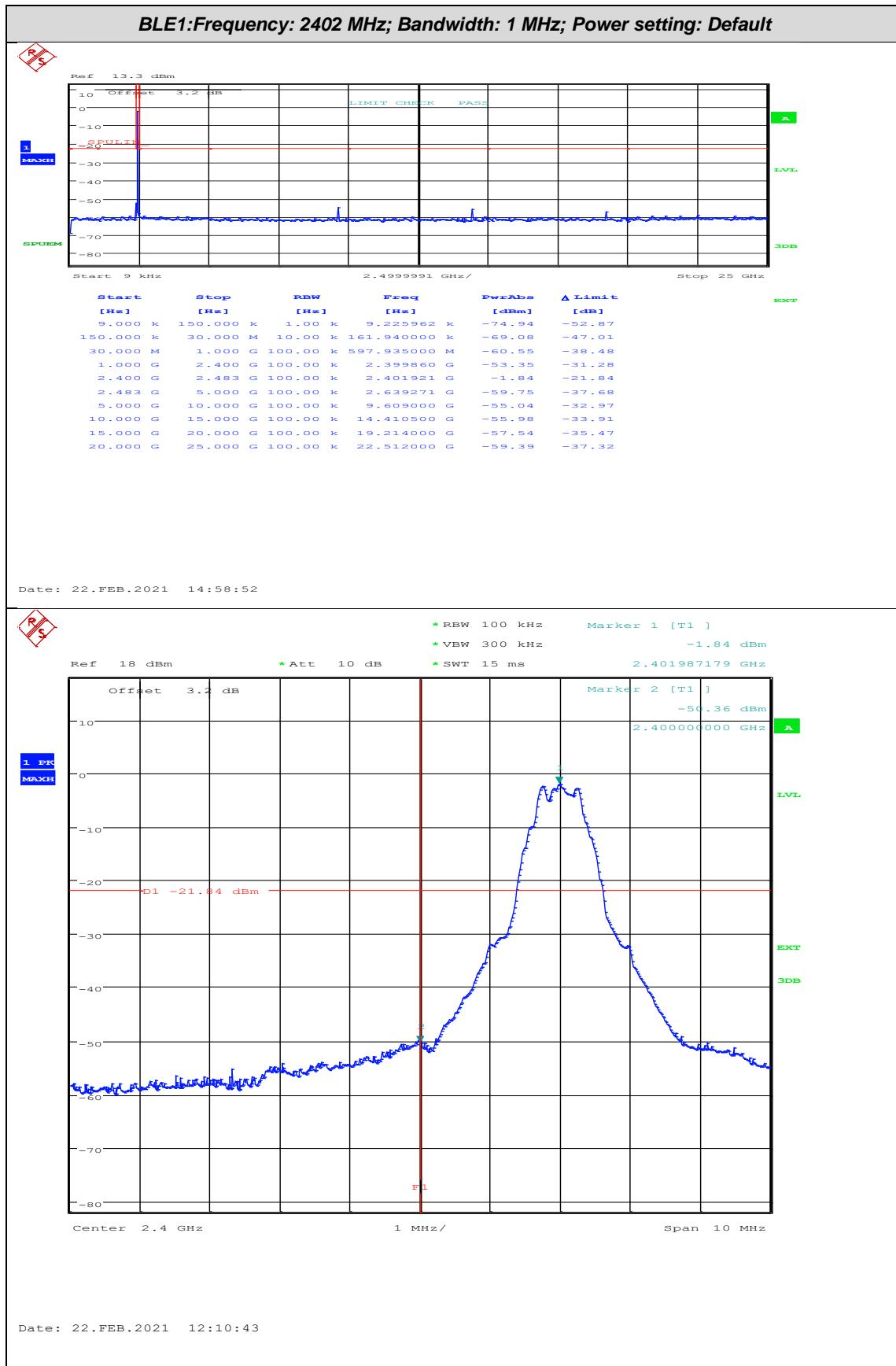
Figure v Test Setup

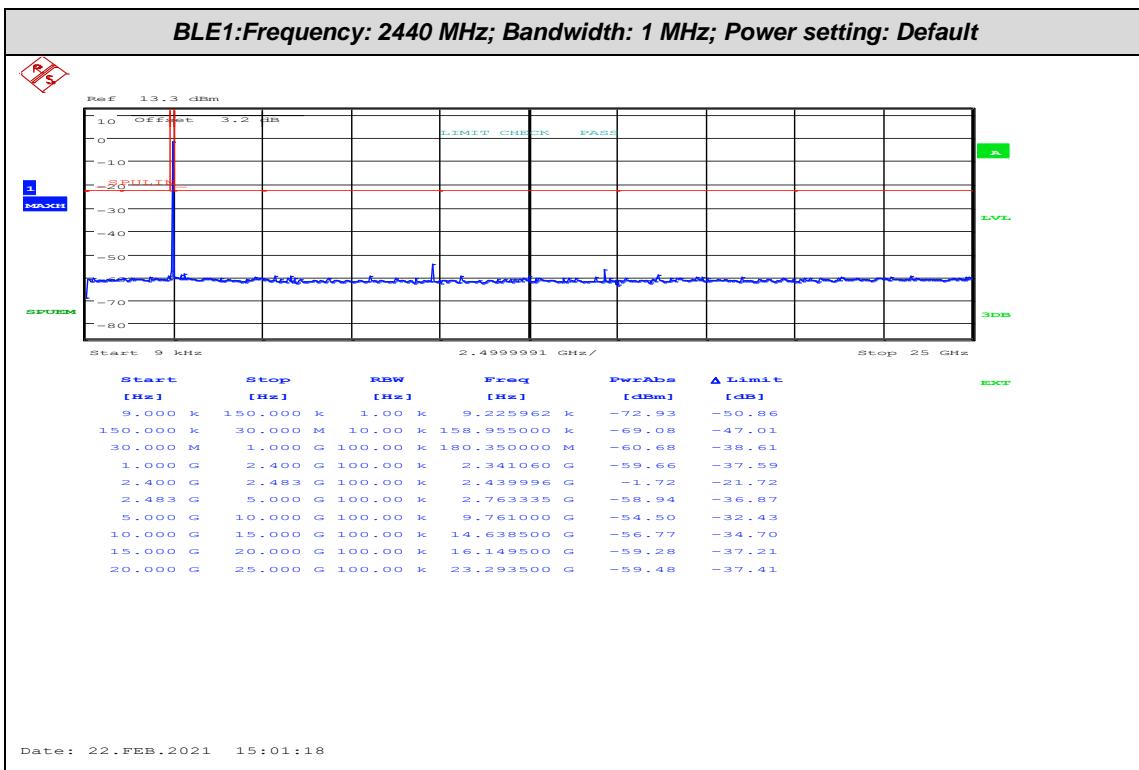


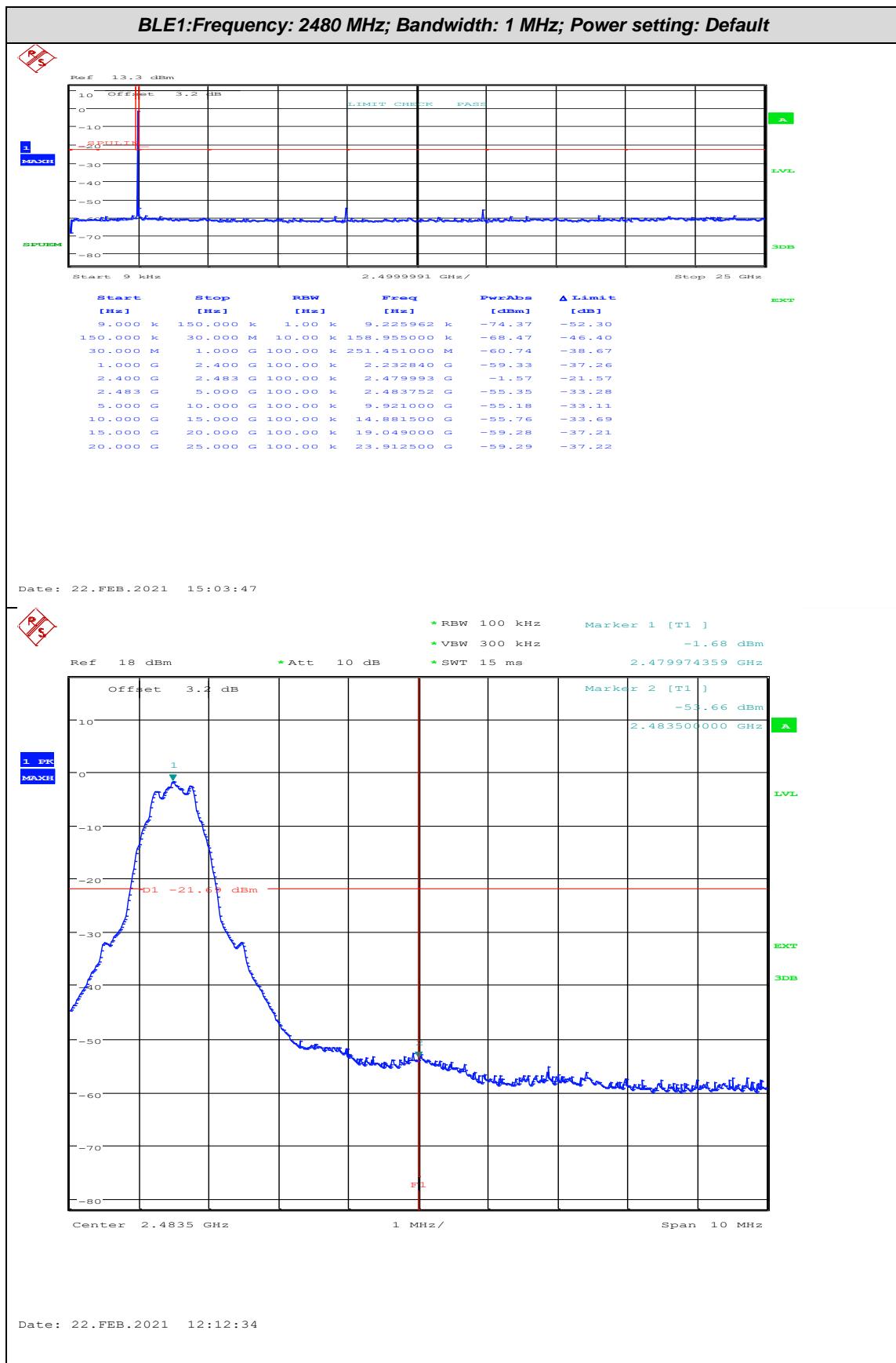
14.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|-------------------|-----------------------|-----------------------|------------|---------------------|
| Spectrum Analyser | R&S | FSU46 | REF910 | 2021-11-16 |
| Attenuator | AtlanTechRF Microwave | 3dB SMA | U639 | Cal in use |

14.6 Test Results







15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

| | |
|--|--------------------------------|
| Test Location: | Element Skelmersdale |
| Test Chamber: | Radio Laboratory |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.10 |
| Frequencies Measured: | 2402 MHz, 2440 MHz, 2480 MHz |
| EUT Channel Bandwidths: | 1 MHz |
| Deviations From Standard: | None |
| Measurement BW: | 30 kHz |
| Spectrum Analyzer Video BW: (requirement at least 3x RBW) | 100 kHz |
| Measurement Span: (requirement 1.5 times Channel BW) | 1.1 MHz |
| Measurement Detector: | Peak |

Environmental Conditions (Normal Environment)

| | |
|--------------------|----------------------------------|
| Temperature: 24 °C | +15 °C to +35 °C (as declared) |
| Humidity: 37 % RH | 20 % RH to 75 % RH (as declared) |
| Supply: 3 Vdc | 3 Vdc (as declared) |

15.3 Test Limit

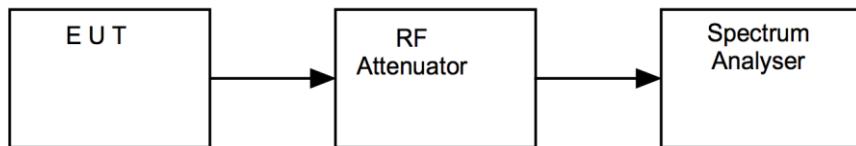
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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

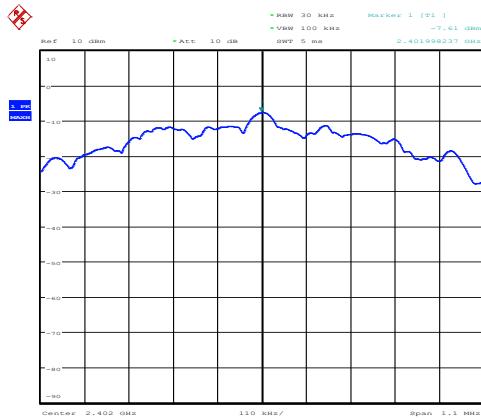


15.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|-------------------|-----------------------|-----------------------|------------|---------------------|
| Spectrum Analyser | R&S | FSU46 | REF910 | 2021-11-16 |
| Attenuator | AtlanTechRF Microwave | 3dB SMA | U639 | Cal in use |

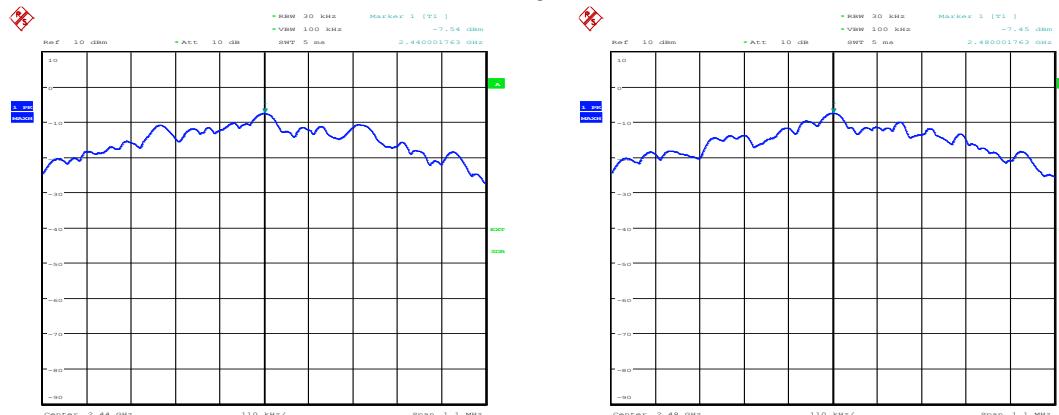
15.6 Test Results

BLE1



Date: 22.FEB.2021 11:39:49

2402 MHz



2440 MHz

2480 MHz

| Modulation: GFSK; Data rate: 1Mbps; Power setting: Default | | | | |
|--|----------------------|-----------------|-----------|--------|
| Channel Frequency (MHz) | Analyzer Level (dBm) | Cable loss (dB) | PSD (dBm) | Result |
| 2402 | -7.61 | 3.06 | -4.55 | Pass |
| 2440 | -7.54 | 3.20 | -4.34 | Pass |
| 2480 | -7.45 | 3.06 | -4.39 | Pass |

16 Duty Cycle

16.1 *Definition*

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

16.2 *Test Parameters*

| | |
|---|-------------------------------|
| Test Location: | Element Skelmersdale |
| Test Standard and Clause: | ANSI C63.10-2013, Clause 11.6 |
| Deviations From Standard: | None |
| Temperature Extreme Environment Test Range: | N/A |
| Voltage Extreme Environment Test Range: | N/A |

Environmental Conditions (Normal Environment)

| | |
|--------------------|----------------------------------|
| Temperature: 24 °C | +15 °C to +35 °C (as declared) |
| Humidity: 37 % RH | 20 % RH to 75 % RH (as declared) |

16.3 *Test Limit*

N/A.

16.4 Test Method

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

The measurements were performed with EUT set at its maximum duty. All modulation schemes, bandwidths, data rates and power settings were measured

[1] Single antenna output devices

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

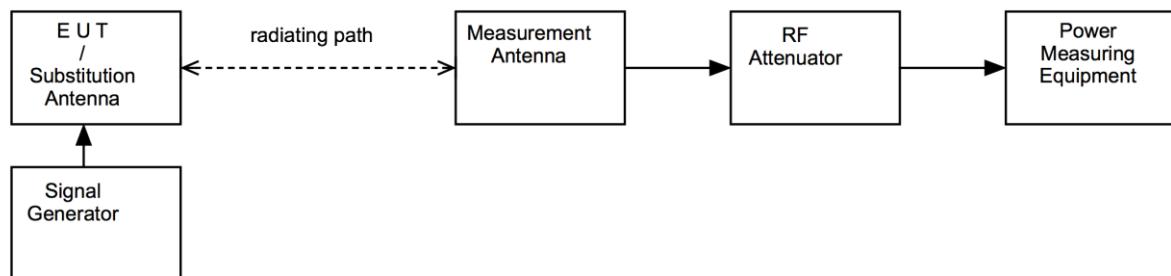
[2] Multiple antenna output devices

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

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

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

Figure vii Test Setup

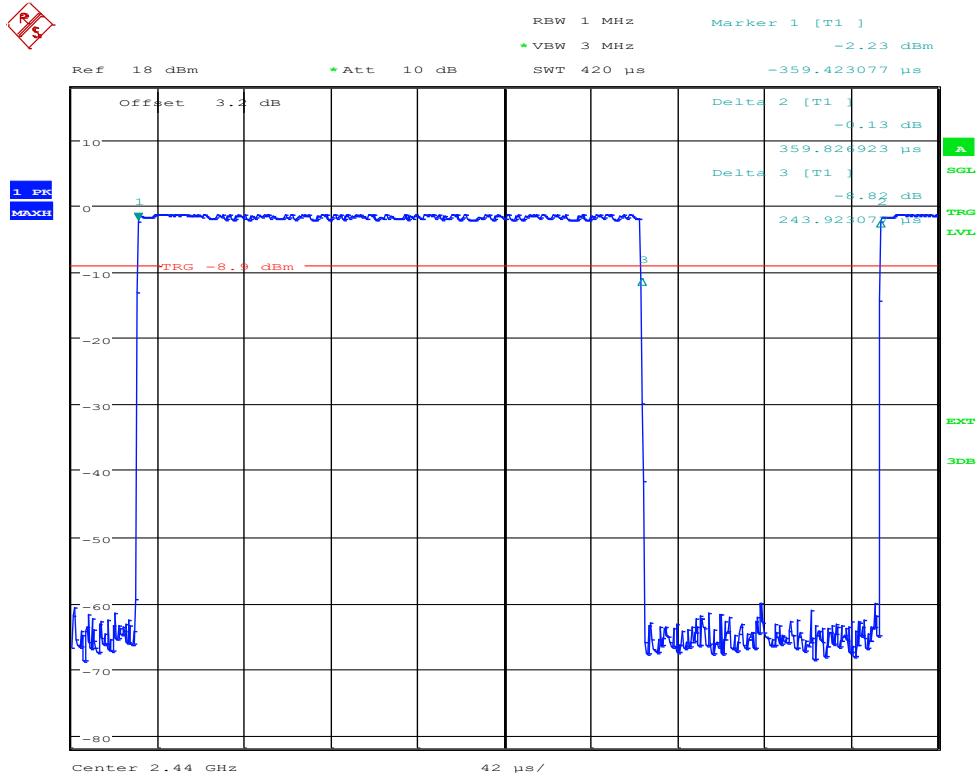


16.5 Test Equipment

| Equipment Type | Manufacturer | Equipment Description | Element No | Due For Calibration |
|-------------------|-----------------------|-----------------------|------------|---------------------|
| Spectrum Analyser | R&S | FSU46 | REF910 | 2021-11-16 |
| Attenuator | AtlanTechRF Microwave | 3dB SMA | U639 | Cal in use |

16.6 Test Results

| BLE1 | | | | |
|----------------------|----------------------|----------------|-------------------|------------------------|
| Test Environment | | TxOn time (us) | Frame Period (us) | Calculated Factor (dB) |
| V_{nominal} | T_{nominal} | 243.923077 | 359.826923 | 3.4 |



Date: 22.FEB.2021 13:42:29

17 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

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

[5] Conducted RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**
Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

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

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**
Uncertainty in test result (Pershore OATS) = **4.26 dB**

18 RF Exposure

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR Exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

The SAR Test Exclusion Threshold for frequencies in the range 100 MHz to 6 GHz, and for test separation distance of \leq 50 mm, is determined as follows.

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

Where,

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

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

f_{GHz} = Transmit frequency in GHz

Results:

| Frequency (MHz) | Maximum Conducted Output Power (mW) | SAR Exclusion Threshold at a distance of 5 mm (mW) | SAR Evaluation |
|-----------------|-------------------------------------|--|----------------|
| 2402 | 0.788 | 9.7 | Not Required |
| 2440 | 0.829 | 9.6 | Not Required |
| 2480 | 0.822 | 9.5 | Not Required |

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