

Report on the Radio Testing

For

Renishaw Plc

on

RMP400

Report no. TRA-046259-47-00B

1 September 2020

RF916 10.0



Report Number: TRA-046259-47-00B  
Issue: A

REPORT ON THE RADIO TESTING OF A  
Renishaw Plc  
RMP400  
WITH RESPECT TO SPECIFICATION  
FCC 47CFR 15.247

TEST DATE: 27th July 2020 - 31st July 2020

Written by:

D Moncayola  
Radio Test Engineer

Approved by:

J Charters  
Lab Manager

Date: 1 September 2020

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	1 September 2020	Original

## 2 Summary

TEST REPORT NUMBER: TRA-046259-47-00B

WORKS ORDER NUMBER: TRA-046259-00

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(S): 47CFR15.247

EQUIPMENT UNDER TEST (EUT): RMP400

EQUIPMENT VARIANTS: RMP400QE

FCC IDENTIFIER: KQGRMP400QE

EUT SERIAL NUMBER: 22FF67

MANUFACTURER/AGENT: Renishaw Plc

ADDRESS: New Mills  
Wotton Under Edge  
Gloucestershire  
GL12 8JR  
United Kingdom

CLIENT CONTACT: Rich Warren  
☎ 01453 523240  
✉ richard.warren@renishaw.com

TEST DATE: 27th July 2020 - 31st July 2020

TESTED BY: Dan Moncayola  
Element

## 2.1 Test Summary

Test Method and Description		Requirement Clause 47CFR15	Applicable to this equipment	Result / Note
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	<input checked="" type="checkbox"/>	Pass Note 4
AC power line conducted emissions		15.207	<input type="checkbox"/>	Note 1
Carrier frequency separation		15.247(a)(1)	<input checked="" type="checkbox"/>	Pass Note 2
Number of hopping channels		15.247(a)(1) (i), (ii) and (iii)	<input checked="" type="checkbox"/>	Pass Note 2
Average time of occupancy		15.247(a)(1) (i), (ii) and (iii)	<input checked="" type="checkbox"/>	Pass Note 2
Maximum peak conducted output power		15.247 (a)(1), (b)(1) and (b)(2)	<input checked="" type="checkbox"/>	Pass Note 2
Conducted carrier power	Peak	15.247(b)(3)	<input type="checkbox"/>	Pass Note 3
	Max.		<input checked="" type="checkbox"/>	
Power spectral density, conducted		15.247(e)	<input checked="" type="checkbox"/>	Pass Note 3
20dB emission bandwidth		15.247(a)(1) (i) and (ii)	<input checked="" type="checkbox"/>	Pass Note 2
Occupied bandwidth		15.247(a)(2)	<input checked="" type="checkbox"/>	Pass Note 3
Out-of-band emissions		15.247(d)	<input checked="" type="checkbox"/>	Pass Note 4

### Notes:

- 1 Note applicable EUT is battery powered
- 2 Applicable for Mode 1 and Mode 2 – FHSS Operation
- 3 Applicable for Mode 2 – DTS operation
- 4 Applicable for Mode 1 and Mode 2 (both FHSS and DTS Operation) EUT uses same modulation techniques for both FHSS and DTS operation

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-046259-47-00B presents the results of the Radio testing on a Renishaw Plc, RMP400 to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Renishaw Plc 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 Skemersdale West Lancashire WN8 9PN UK
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This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

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

Throughout this report EUT denotes equipment under test.

### FCC Site Listing:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

### IC Registration Number(s):

Element Hull	3483A
Element North West	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

<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: RMP400
- Serial Number: 22FF67
- Model Number: RMP400QE
- Software Revision: Not Applicable
- Build Level / Revision Number: 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.

*Not Applicable – No support/monitoring equipment required.*

### 7.3 EUT Mode of Operation

#### 7.3.1 Transmission

The mode of operation for transmitter tests was as follows.

The EUT contains selections for test menus for Mode 1 or Mode 2 and selection of normal operation.

These test menus allow the unit to be set to top, middle or bottom frequencies or hopping across all frequencies in either Mode 1 or Mode 2.

## 7.4 EUT Radio Parameters

### 7.4.1 General

<b>Frequency of operation:</b>	2403 MHz-2481 MHz
<b>Modulation type(s):</b>	Mode 1: 1 Mbps Binary GFSK Frequency Hopping Mode 2: 2 Mbps Binary GFSK Frequency Hopping Mode 2: 2 Mbps Binary GFSK DSSS
<b>Occupied channel bandwidth(s):</b>	Mode 1: 1 MHz Mode 2: 2 MHz
<b>Channel spacing:</b>	Mode 1: 1 MHz Mode 2: 2 MHz
<b>Declared output power(s):</b>	Mode 1: 0dBm Mode 2: +4dBm
<b>Antenna type:</b>	Slot type
<b>Antenna gain:</b>	-0.81 dBi
<b>Nominal Supply Voltage:</b>	3.0 Vdc

## 7.5 EUT Description

The EUT is a measuring probe, using the 2400 MHz - 2483.5 MHz frequency band, and uses frequency hopping.

Mode 1 uses FHSS operating over 79 channels.

Mode 2 uses DTS and FHSS over 39 channels. DTS mode is used during setup and FHSS mode in probe operation.

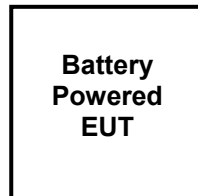
## **8 Modifications**

No modifications were performed during this assessment.

## 9 EUT Test Setup

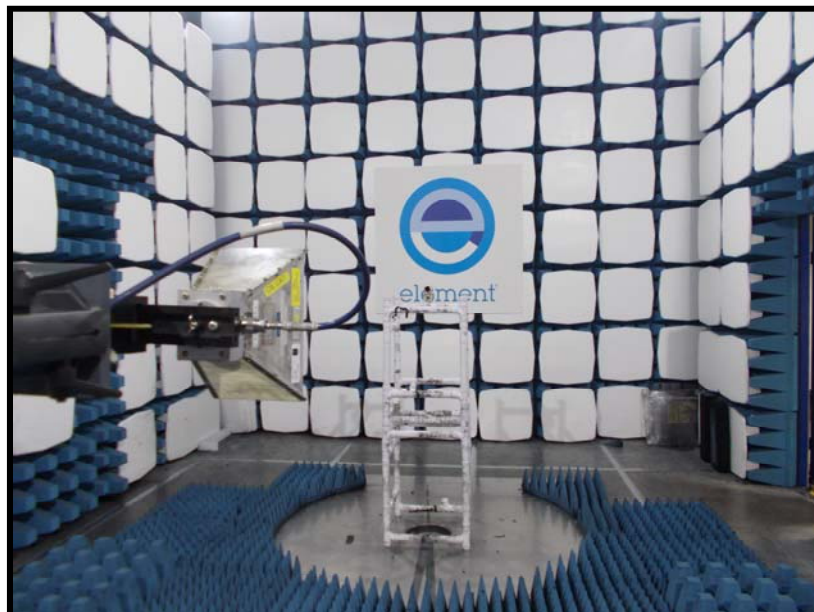
### 9.1 Block Diagram

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



### 9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



### 9.3 Measurement software

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

Element Emissions R5 (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 E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx. 3 Vdc from alkaline batteries

#### 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"/>	Battery	New battery	N/A

## 11 Radiated emissions

### 11.1 Definitions

#### *Spurious emissions*

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

#### *Restricted bands*

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

### 11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Chamber 3
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels Measured:	Low / Mid / High
EUT Channel Bandwidths:	1 MHz / 2 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: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 39 % RH	20 % RH to 75 % RH (as declared)
Supply: 3 V dc	

### 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

<i>Frequency (MHz)</i>	<i>Field Strength (<math>\mu</math>V/m at 3 m)</i>
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 $\mu$ V/m at the regulatory distance, using:

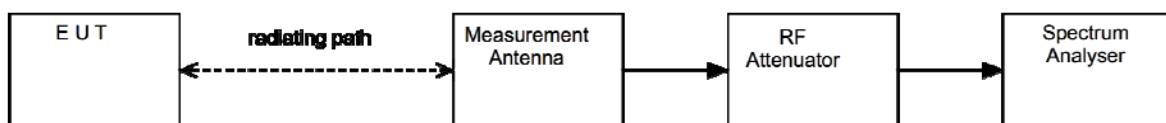
$$FS = PR + CL + AF - PA + DC - CF$$

Where,

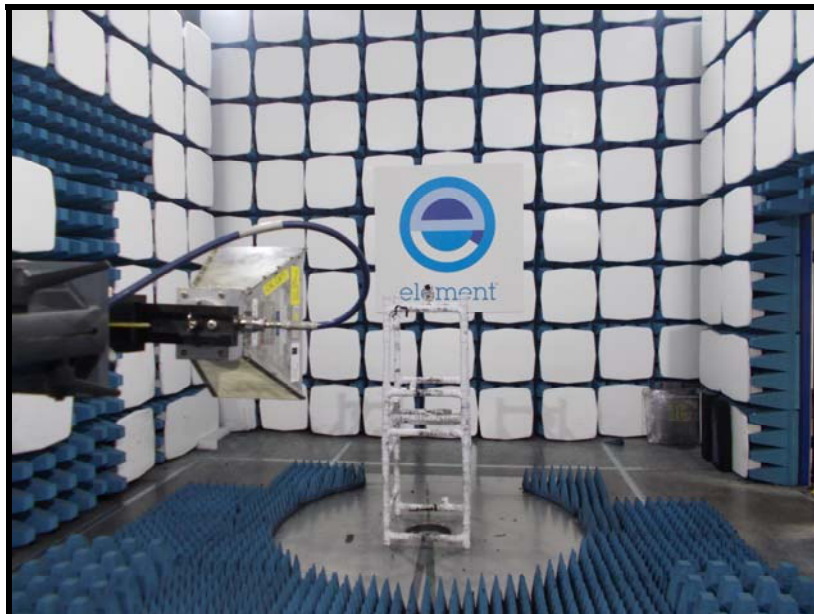
- PR is the power recorded on the receiver / spectrum analyzer in dB $\mu$ V;
- CL is the cable loss in dB;
- AF is the test antenna factor in dB/m;
- PA is the pre-amplifier gain in dB (where used);
- DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
- CF is 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 Photographs

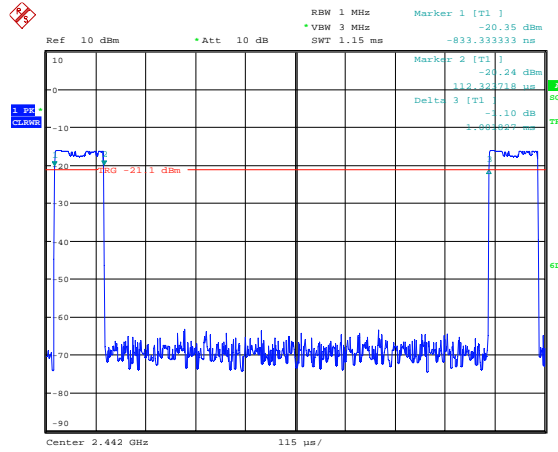


### 11.6 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Bilog	Chase	CBL611/A	U573	2021-09-19
PreAmp	Watkins Johnson	6201-69	U372	2021-02-26
8449B	Agilent	Pre Amp	L572	2020-10-15
1-18GHz Horn	EMCO	3115	L139	2021-07-16

### 11.7 Test Results

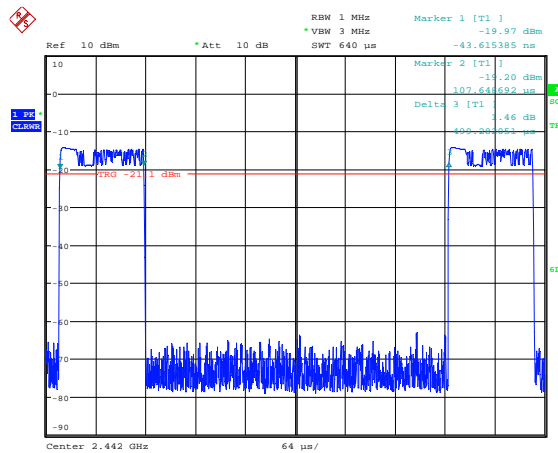
#### Duty cycle correction Mode 1



Date: 30.JUL.2020 10:03:40

Duty Cycle Correction=  $20\log(1/D) = 20\log(T/T_{on}) = 19.2$   
 Where D is the duty cycle=  $T_{on}/T$

#### Duty cycle correction Mode 2

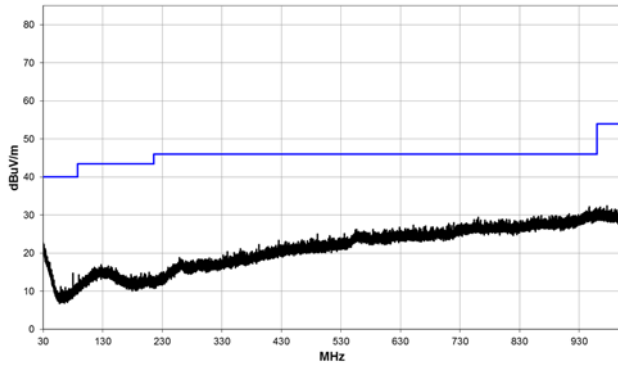


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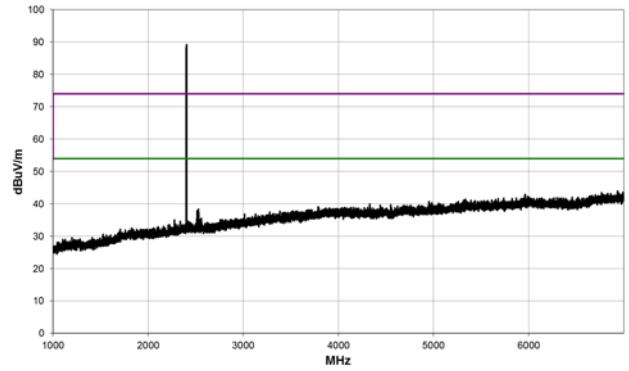
Duty Cycle Correction=  $20\log(1/D) = 20\log(T/T_{on}) = 13.3$   
 Where D is the duty cycle=  $T_{on}/T$

### 11.8 Test Results – RMP400QE

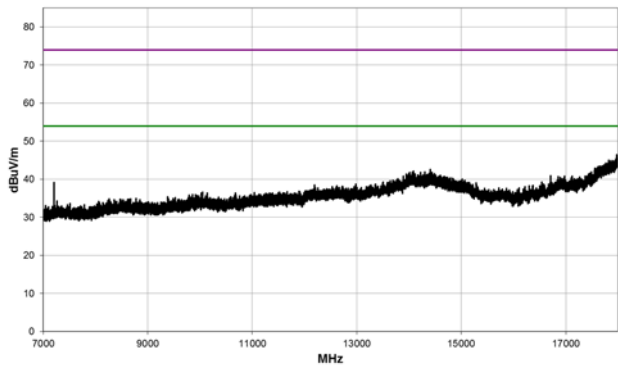
2403 MHz – 1 Mbps



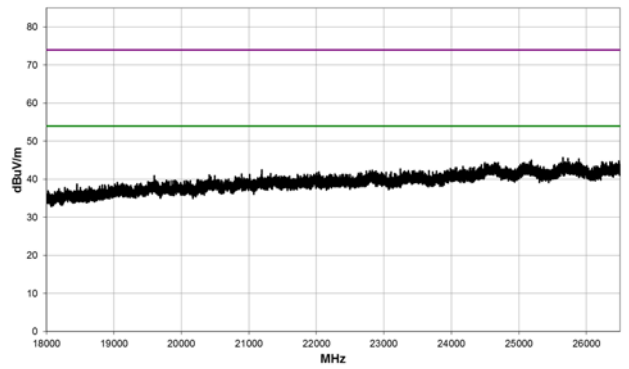
30 MHz to 1 GHz



1 GHz to 7 GHz



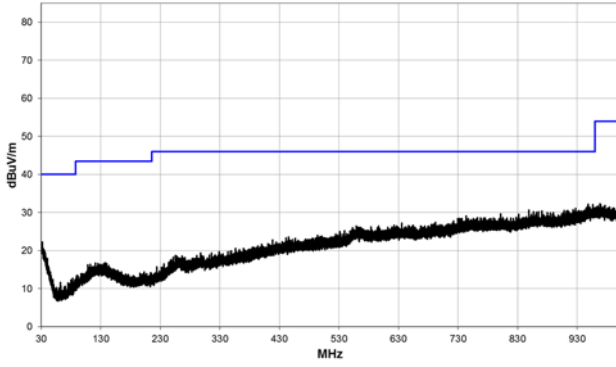
7 GHz to 18 GHz



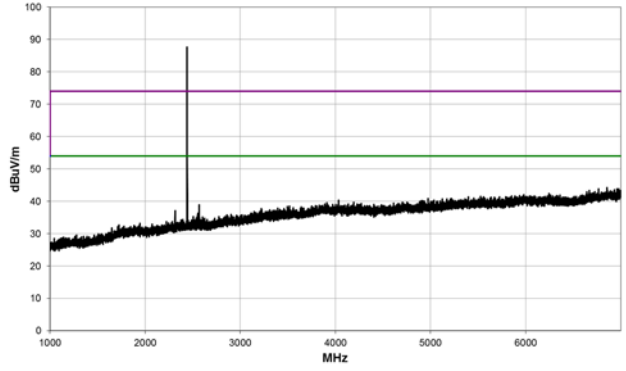
18 GHz to 26.5 GHz

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)	Comments
7208.947	50.8	7.1	1.52	115.0		0.0	Horz	PK	-9.5	48.4	74.0	-25.6	Pass
7209.130	49.6	7.1	1.53	177.0		0.0	Vert	PK	-9.5	47.2	74.0	-26.8	Pass

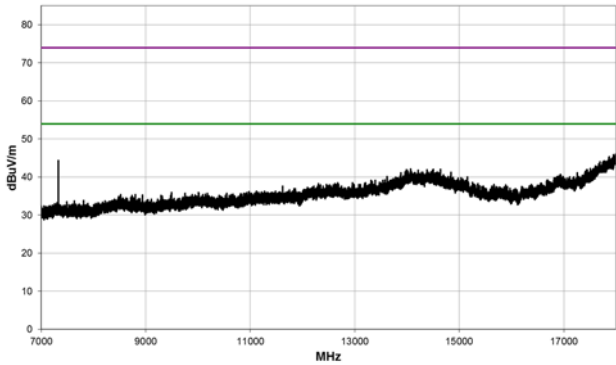
2442 MHz – 1 Mbps



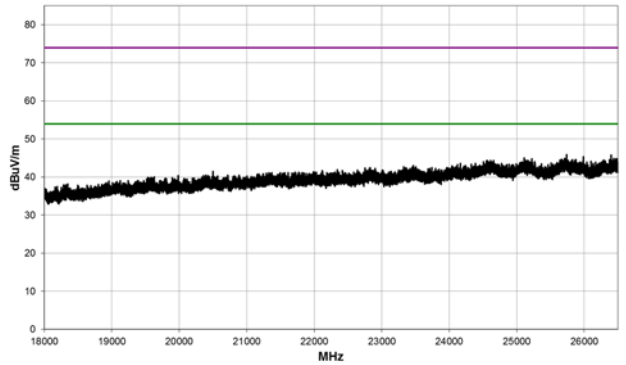
30 MHz to 1 GHz



1 GHz to 7 GHz



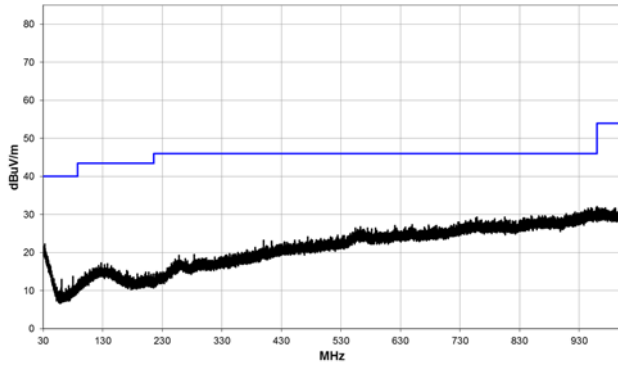
7 GHz to 18 GHz



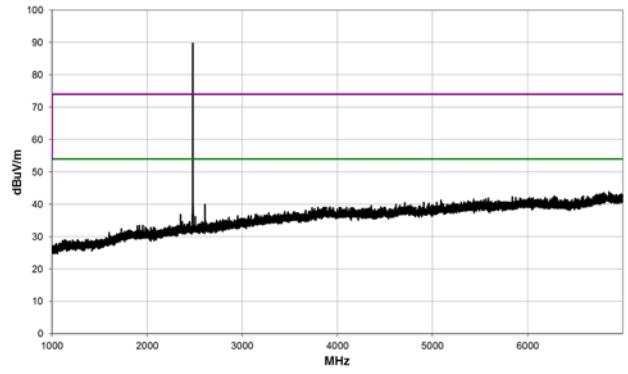
18 GHz to 26.5 GHz

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)	Comments
7326.645	53.1	7.5	1.54	114.9		0.0	Horz	PK	-9.5	51.1	74.0	-22.9	Pass
7325.837	48.6	7.5	1.5	214.0		0.0	Vert	PK	-9.5	46.6	74.0	-27.4	Pass

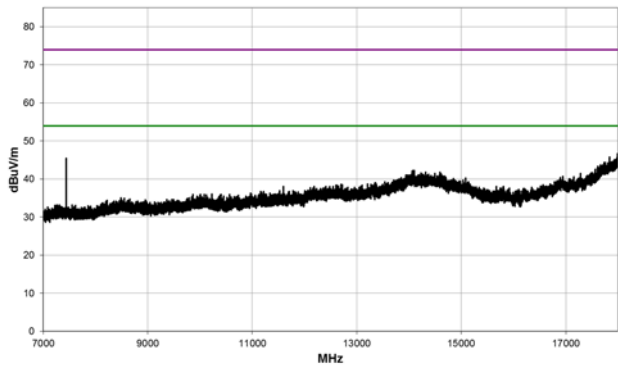
2481 MHz – 1 Mbps



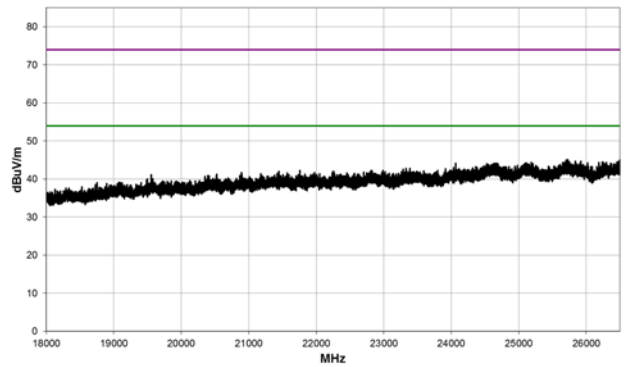
30 MHz to 1 GHz



1 GHz to 7 GHz

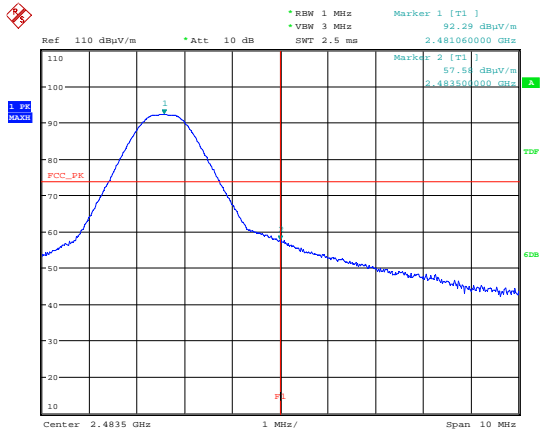


7 GHz to 18 GHz



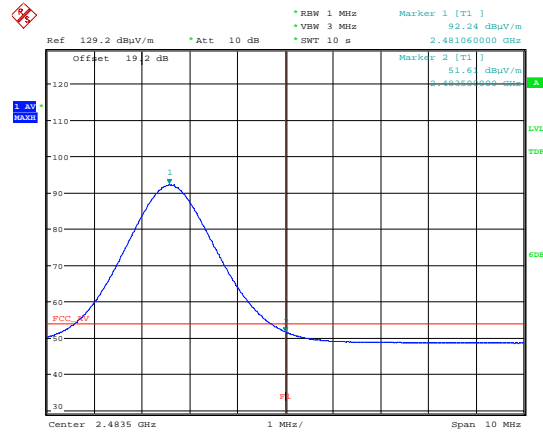
18 GHz to 26.5 GHz

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)	Comments
7443.677	53.4	7.6	1.53	100.0		0.0	Horz	PK	-9.5	51.5	74.0	-22.5	Pass
7443.302	48.4	7.6	1.45	134.9		0.0	Vert	PK	-9.5	46.5	74.0	-27.5	Pass



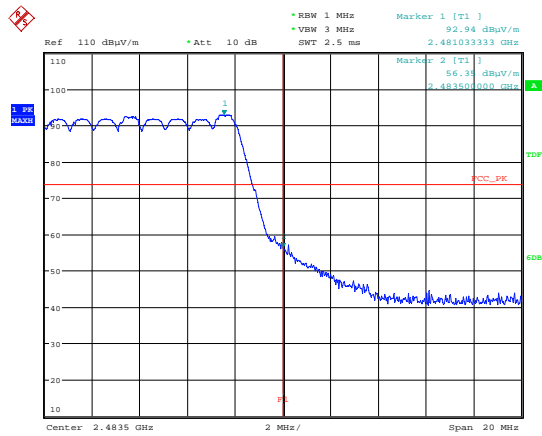
Date: 30.JUL.2020 10:33:56

2481 MHz Upper Band Edge Plot – Peak



Date: 30.JUL.2020 10:33:25

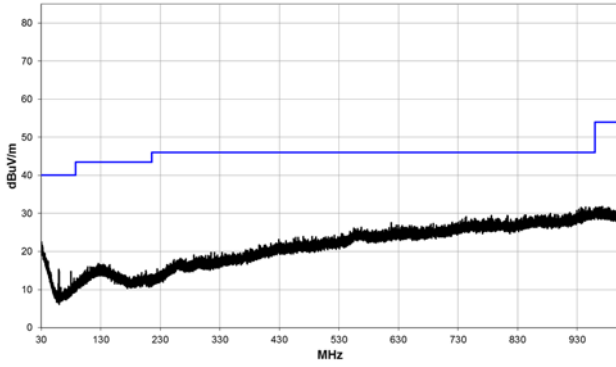
2481 MHz Upper Band Edge Plot – Average



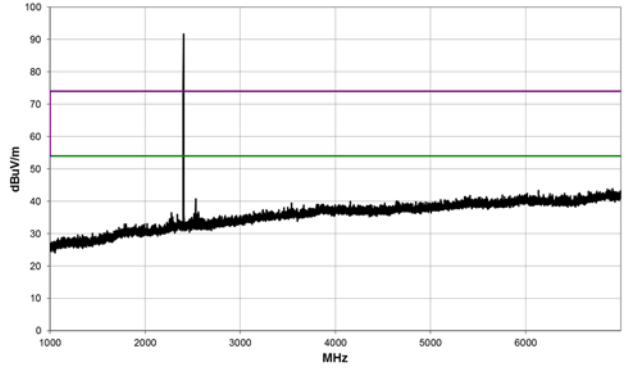
Date: 30.JUL.2020 17:52:19

2481 MHz Upper Band Edge Plot – All Hopping

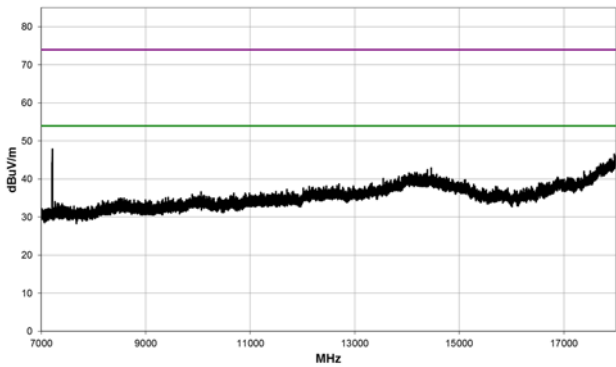
2404 MHz – 2 Mbps



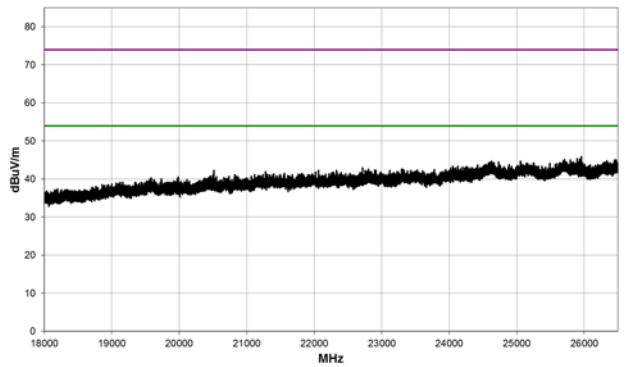
30 MHz to 1 GHz



1 GHz to 7 GHz



7 GHz to 18 GHz

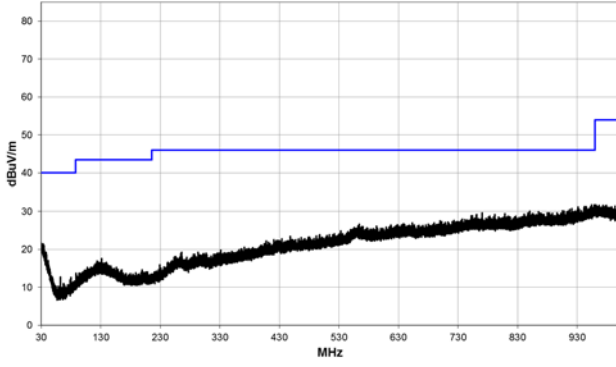


18 GHz to 26.5 GHz

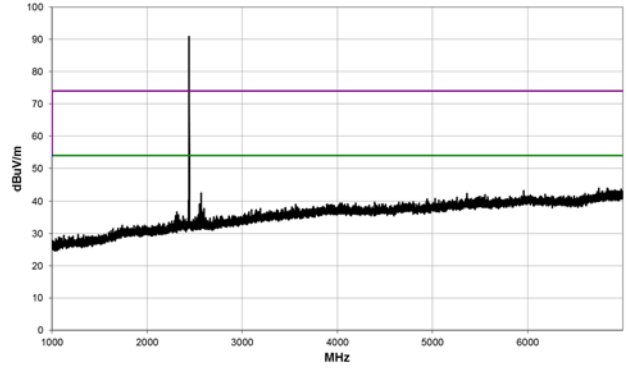
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
2532.383	56.5	-3.4	1.1	189.1		0.0	Horz	PK	0.0	53.1	74.0	-20.9	Pass
2276.312	53.8	-4.2	1.68	59.1		0.0	Horz	PK	0.0	49.6	74.0	-24.4	Pass
2532.350	52.3	-3.4	1.36	187.0		0.0	Vert	PK	0.0	48.9	74.0	-25.1	Pass
2276.412	52.4	-4.2	1.55	183.0		0.0	Vert	PK	0.0	48.2	74.0	-25.8	Pass
7213.11	38.60	7.10	1.50	97.00	13.30	0.00	Horz	AV	-9.50	49.50	54.00	-4.50	Pass
7212.23	56.40	7.10	1.50	97.00		0.00	Horz	PK	-9.50	54.00	74.00	-20.00	Pass
7211.08	52.90	7.10	1.54	183.00		0.00	Vert	PK	-9.50	50.50	74.00	-23.50	Pass



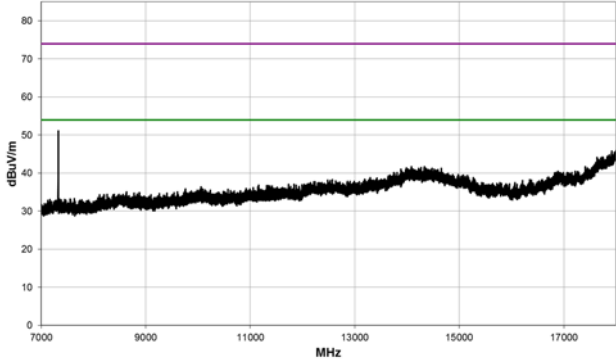
2442 MHz – 2 Mbps



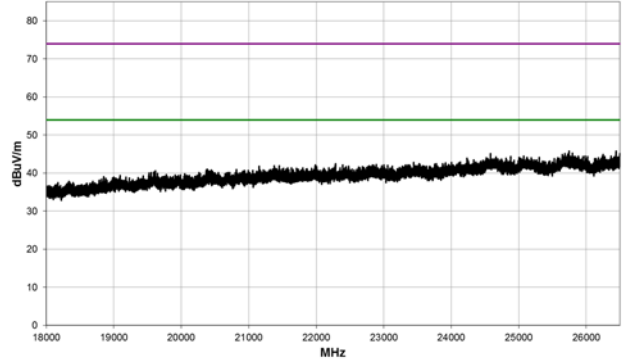
30 MHz to 1 GHz



1 GHz to 7 GHz



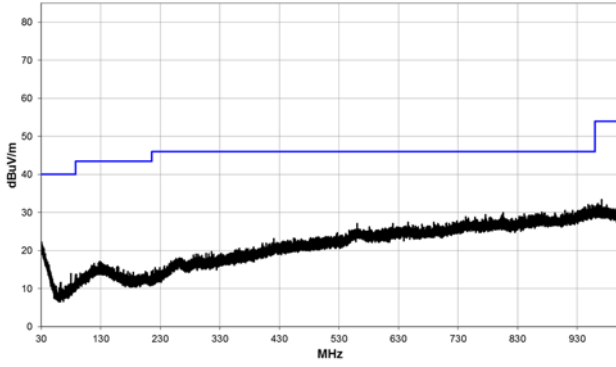
7 GHz to 18 GHz



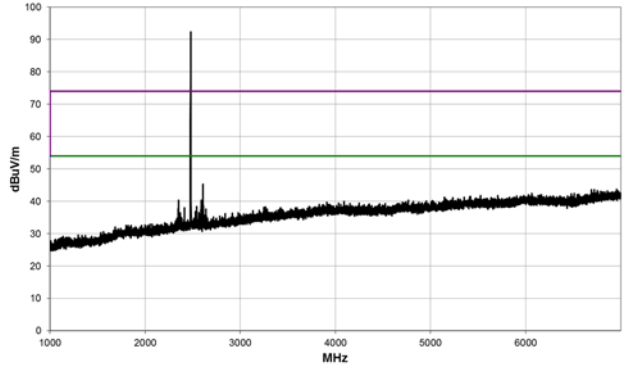
18 GHz to 26.5 GHz

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)	Comments
2570.157	36.4	-3.4	1.11	184.9	13.3	0.0	Horz	AV	0.0	46.3	54.0	-7.7	Pass
2569.715	57.6	-3.4	1.11	184.9		0.0	Horz	PK	0.0	54.2	74.0	-19.8	Pass
2569.723	51.3	-3.4	1.5	177.0		0.0	Vert	PK	0.0	47.9	74.0	-26.1	Pass
2330.295	50.1	-3.9	1.89	69.0		0.0	Horz	PK	0.0	46.2	74.0	-27.8	Pass
2330.103	48.6	-3.9	1.39	181.0		0.0	Vert	PK	0.0	44.7	74.0	-29.3	Pass
7327.13	41.40	7.50	1.51	94.00	13.30	0.00	Horz	AV	-9.50	52.70	54.00	-1.30	Pass
7327.20	59.50	7.50	1.51	94.00		0.00	Horz	PK	-9.50	57.50	74.00	-16.50	Pass
7327.03	53.50	7.50	1.51	132.90		0.00	Vert	PK	-9.50	51.50	74.00	-22.50	Pass

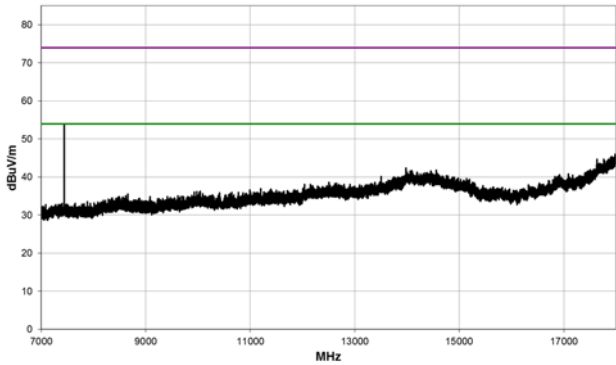
2480 MHz – 2 Mbps



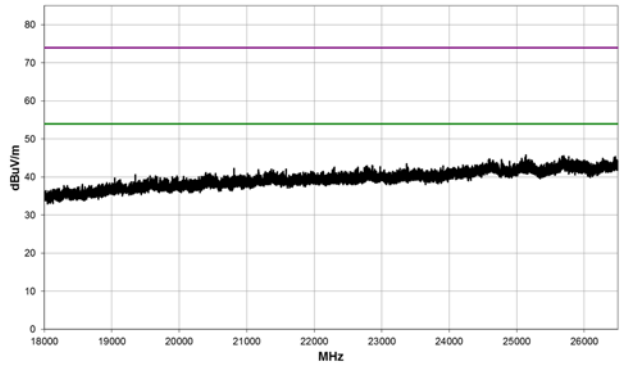
30 MHz to 1 GHz



1 GHz to 7 GHz

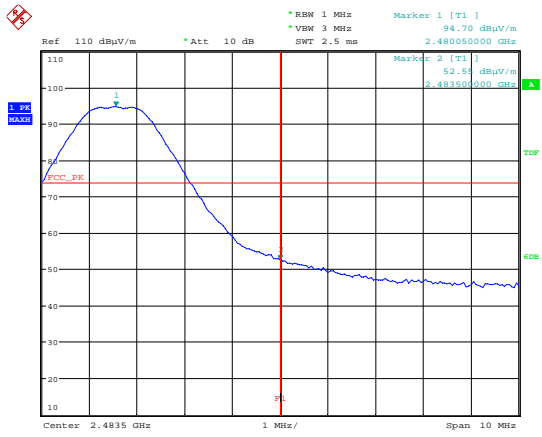


7 GHz to 18 GHz



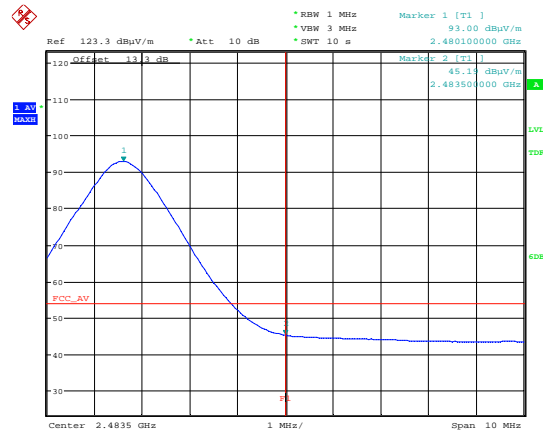
18 GHz to 26.5 GHz

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)	Comments
2608.098	37.1	-3.3	1.42	183.0	13.3	0.0	Horz	AV	0.0	47.1	54.0	-6.9	Pass
2607.548	58.3	-3.3	1.42	183.0		0.0	Horz	PK	0.0	55.0	74.0	-19.0	Pass
2351.812	54.7	-3.8	1.56	180.0		0.0	Horz	PK	0.0	50.9	74.0	-23.1	Pass
2352.353	53.2	-3.8	1.5	173.0		0.0	Vert	PK	0.0	49.4	74.0	-24.6	Pass
2608.340	52.0	-3.3	1.7	182.1		0.0	Vert	PK	0.0	48.7	74.0	-25.3	Pass
7441.10	41.00	7.60	1.52	95.00	13.30	0.00	Horz	AV	-9.50	52.40	54.00	-1.60	Pass
7441.20	59.30	7.60	1.52	95.00		0.00	Horz	PK	-9.50	57.40	74.00	-16.60	Pass
7440.23	52.90	7.60	1.53	133.00		0.00	Vert	PK	-9.50	51.00	74.00	-23.00	Pass



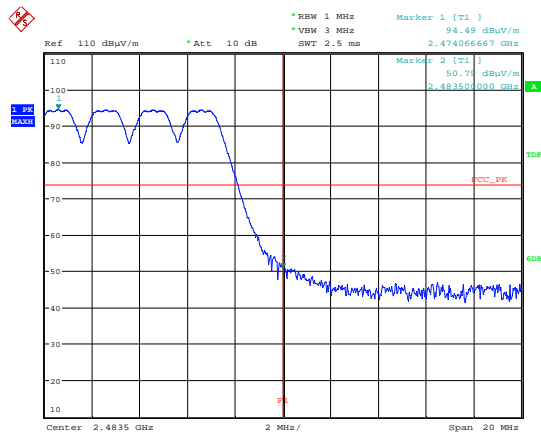
Date: 30.JUL.2020 11:16:46

2481 MHz Upper Band Edge Plot – Peak



Date: 30.JUL.2020 11:18:03

2481 MHz Upper Band Edge Plot – Average



Date: 30.JUL.2020 17:59:08

2481 MHz Upper Band Edge Plot – All Hopping

## 12 Carrier frequency separation

### 12.1 Definition

The carrier frequency separation is the frequency separation between two adjacent hopping frequencies.

### 12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.2
EUT Channels / Frequencies Measured:	Mode 1: 2403 to 2481 MHz Mode 2: 2404 to 2480
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	100 kHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 29 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

### 12.3 Test Limit

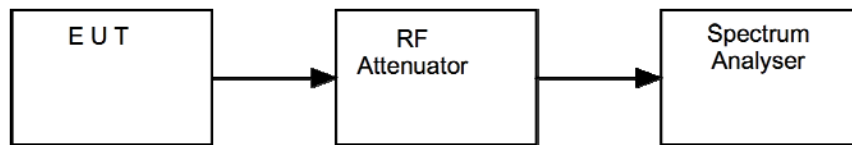
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400 to 2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the -20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

## 12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the emissions of 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 nominal bandwidth.

Figure iii Test Setup



## 12.5 Test Equipment

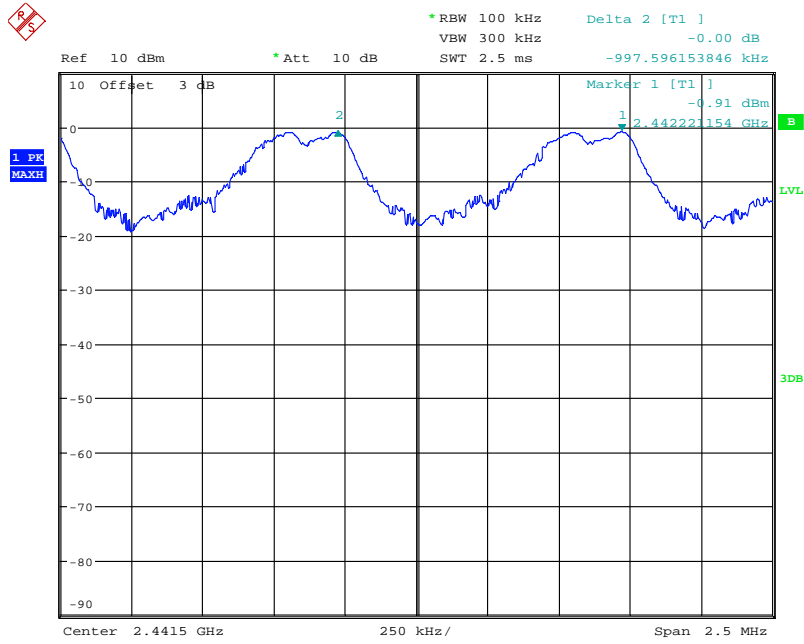
<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

## 12.6 Test Results

<i>Mode 1: 1MBps</i>		
<i>Data Rate</i>	<i>Channel Separation, <math>F2_c - F1_c</math> (kHz)</i>	<i>Result</i>
1 MBps	997.59612	PASS

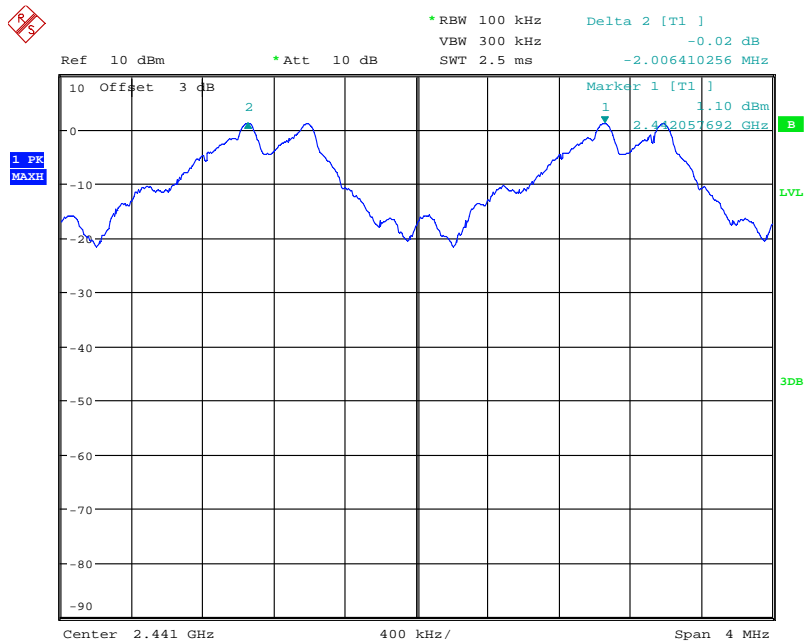
<i>Mode 2: 2MBps</i>		
<i>Data Rate</i>	<i>Channel Separation, <math>F2_c - F1_c</math> (MHz)</i>	<i>Result</i>
2 MBps	2.00641	PASS

Mode 1:



Date: 31.JUL.2020 04:08:53

Mode 2:



Date: 31.JUL.2020 04:56:20

## 13 Number of hopping frequencies

### 13.1 Definition

The total number of hopping frequencies (the centre frequencies defined within the hopping sequence of a FHSS equipment) which are randomly sequenced in order to spread the transmission.

### 13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.3
EUT Channels / Frequencies Measured:	All; 2403 – 2481 MHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 29 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 V dc	

### 13.3 Test Limit

- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels; If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels;
- Frequency hopping systems operating in the band 2400 to 2483.5 MHz shall use at least 15 hopping channels;
- Frequency hopping systems operating in the band 5725 to 5850 MHz shall use at least 75 hopping channels.

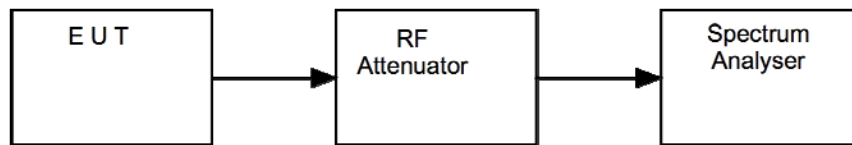
### 13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the emissions of 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 nominal bandwidth.

**Figure iv Test Setup**

<



### 13.5 Test Equipment

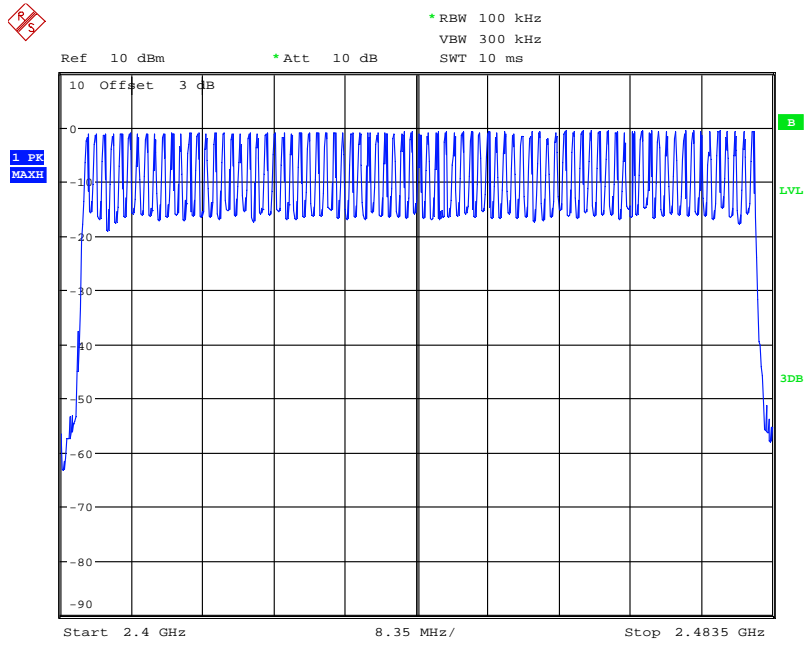
<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

### 13.6 Test Results

<i>Data Rate</i>	<i>Lowest channel, F<sub>CL</sub> (MHz)</i>	<i>Highest channel, F<sub>CH</sub> (MHz)</i>	<i>Number of channels observed</i>	<i>Result</i>
1 Mbps	2403.0 MHz	2481.0 MHz	79	PASS
2 Mbps	2404.0 MHz	2480.0 MHz	39	PASS

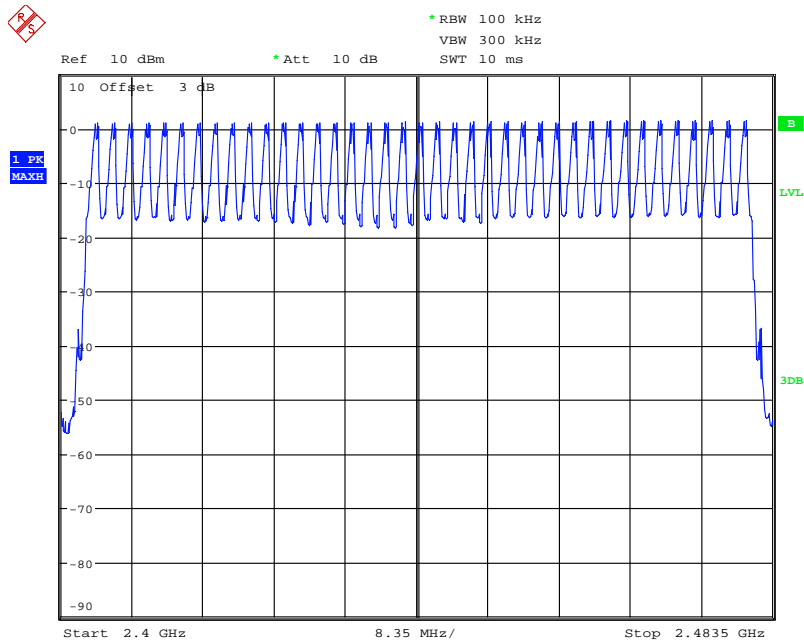


Mode 1:



Date: 31.JUL.2020 04:14:07

Mode 2:



Date: 31.JUL.2020 04:51:01

## 14 Average channel occupancy

### 14.1 Definition

The channel occupancy is the total of the transmitter 'on' times, during an observation period, on a particular hopping frequency.

### 14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.4
Frequencies Measured:	2440 MHz
EUT Number of hopping channels:	Mode 1: 79 Mode 2: 39
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	100 kHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 30 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

### 14.3 Test Limit

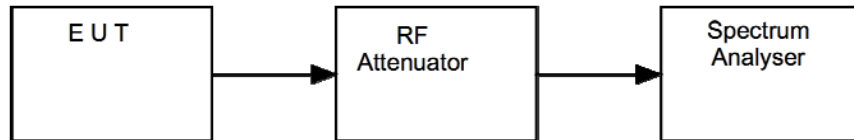
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20 second period;  
If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10 second period;
- Frequency hopping systems operating in the band 2400 to 2483.5 MHz: The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed;
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

#### 14.4 Test Method

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

The measurements were performed with EUT set at its maximum duty. A number of hops were observed to confirm consistency of the dwell time / observe the worst case. All modulation schemes, data rates and power settings were used to observe the worst-case configuration.

**Figure v Test Setup**

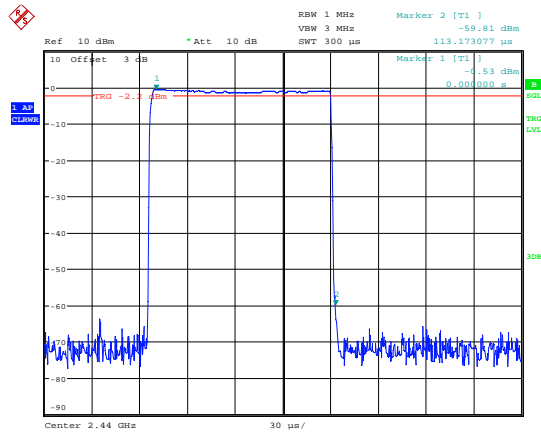


#### 14.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

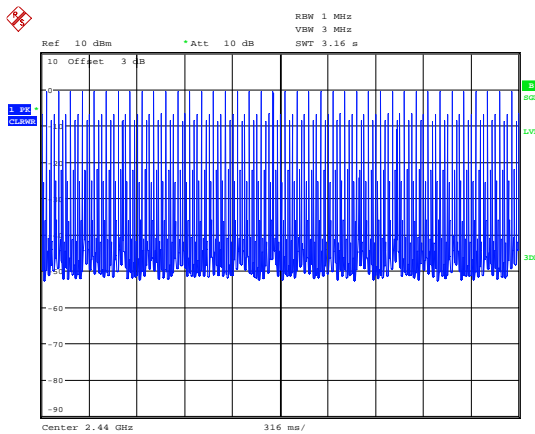
### 14.6 Test Results

Mode 1: 1MBps					
Data Rate	Individual occupancy time (ms)	Observation period (s)	Number of hops observed	Average time of occupancy (s)	Result
1MBps	0.113173	31.6	400	0.0452692	PASS

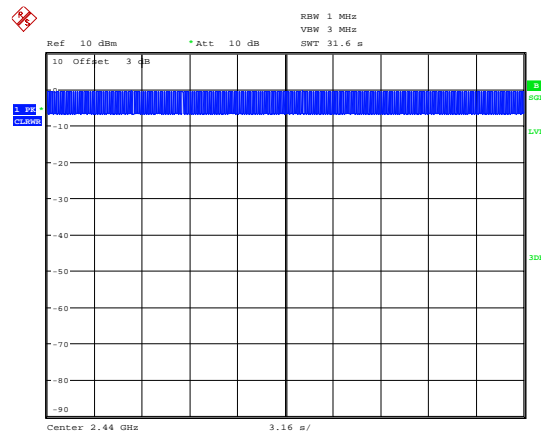


Date: 31.JUL.2020 04:17:02

TX On



Date: 31.JUL.2020 04:21:37

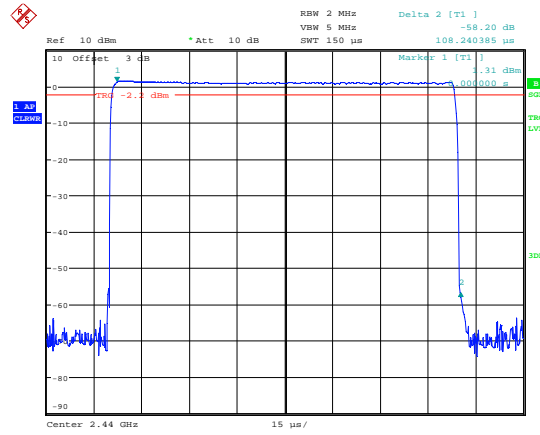


Date: 31.JUL.2020 04:19:29

Number of Transmissions in measurement period

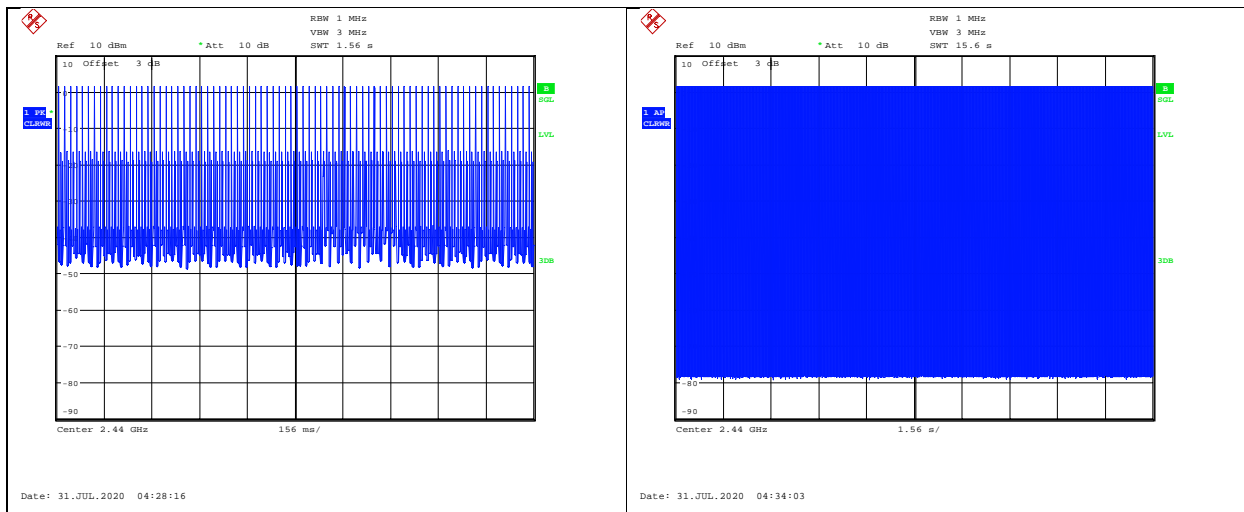
Number of transmissions in a 3.16 second period = 40  
 Number of transmissions in a 31.6 second period = 40 \* 10 = 400

Mode 2: 2MBps					
Data Rate	Individual occupancy time (ms)	Observation period (s)	Number of hops observed	Average time of occupancy (s)	Result
2MBps	0.10824	15.6	800	0.086592	PASS



Date: 31.JUL.2020 04:36:27

TX On



Number of Transmissions in measurement period

Number of transmissions in a 1.56 second period = 80  
 Number of transmissions in a 15.6 second period = 80 \* 10 = 800

## 15 Maximum peak conducted output power

### 15.1 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.

### 15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.5
Frequencies Measured:	Mode 1: 2403 MHz / 2442 MHz/ 2481 MHz – hopping disabled. Mode 2: 2404 MHz / 2442 MHz/ 2480 MHz – hopping disabled / DTS
EUT Channel Bandwidths:	Mode 1: 1 MHz Mode 2: 2 MHz
Deviations From Standard:	None
Measurement BW:	Mode 1: 1 MHz Mode 2: 2 MHz
Spectrum Analyzer Video BW:	Mode 1: 3 MHz Mode 2: 5 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Battery Power = new battery.

### Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 29 % RH	20 % RH to 75 % RH (as declared)

### 15.3 Test Limit

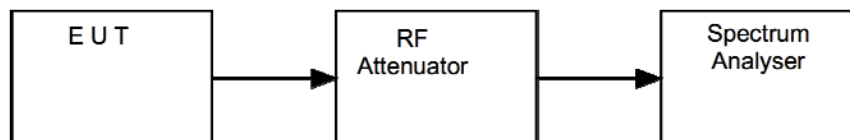
- For frequency hopping systems operating in the band 902 to 928 MHz, the maximum peak conducted output power shall not exceed 1 W, and the e.i.r.p. shall not exceed 4 W, if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W, and the e.i.r.p. shall not exceed 1 W, if the hopset uses less than 50 hopping channels.
- For frequency hopping systems operating in the band 2400 to 2483.5 MHz and employing at least 75 hopping channels, the maximum peak conducted output power shall not exceed 1 W; for all other frequency hopping systems in the band, the maximum peak conducted output power shall not exceed 0.125 W. The e.i.r.p. shall not exceed 4 W.
- For frequency hopping systems operating in the band 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W.
- Point-to-point systems in the bands 2400-2483.5 MHz and 5725 to 5850 MHz are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers.
- 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.

### 15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, 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 vi Test Setup**

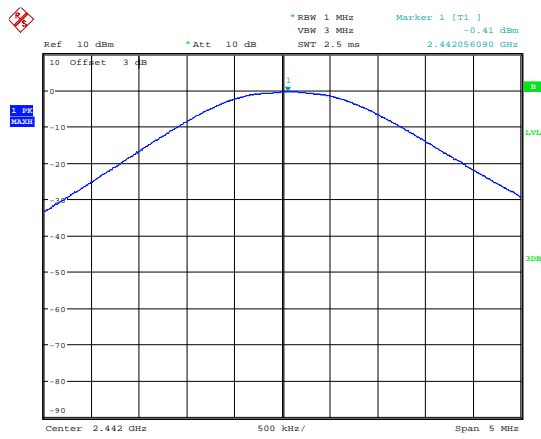
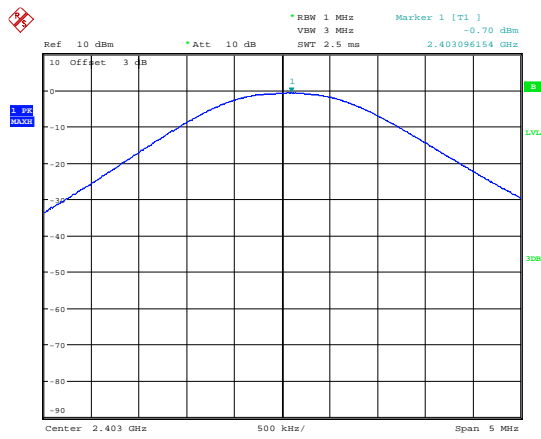


### 15.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

### 15.6 Test Results

Mode 1: 1 Mbps					
Channel Frequency (MHz)	Maximum Peak Conducted Output power (dBm)	Maximum peak conducted output power (W)	Antenna gain (dBi)	E.I.R.P. (W)	Result
2403	-0.70	0.0009	-0.81	0.0007	PASS
2442	-0.41	0.0009	-0.81	0.0008	PASS
2481	-0.12	0.0010	-0.81	0.0008	PASS

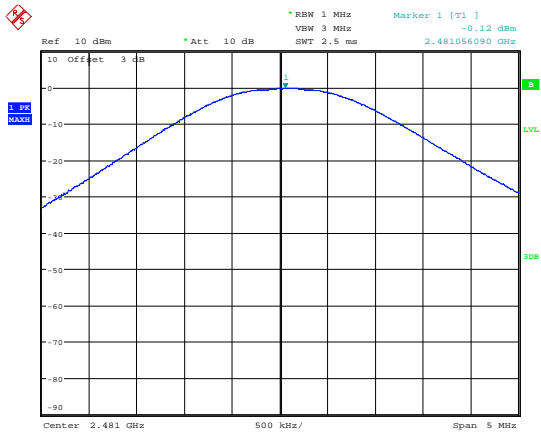


Date: 31.JUL.2020 03:42:19

Date: 31.JUL.2020 03:43:02

2403

2442

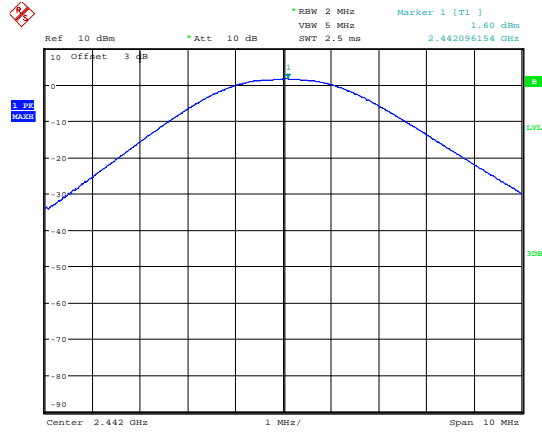
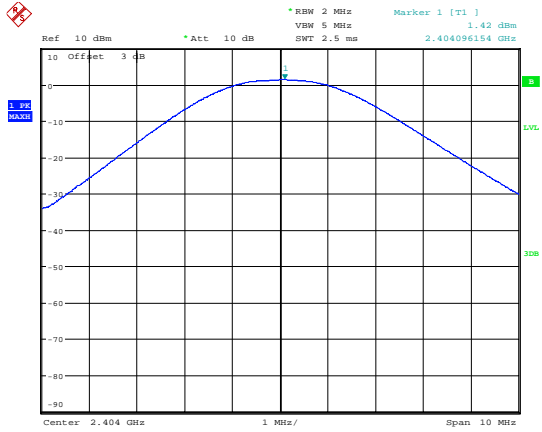


Date: 31.JUL.2020 03:43:30

2481



Mode 2 (DTS and FHSS): 2 Mbps					
Channel Frequency (MHz)	Maximum Peak Conducted Output power (dBm)	Maximum peak conducted output power (W)	Antenna gain (dBi)	E.I.R.P. (W)	Result
2404	1.42	0.0014	-0.81	0.0012	PASS
2442	1.60	0.0014	-0.81	0.0012	PASS
2480	1.90	0.0015	-0.81	0.0013	PASS

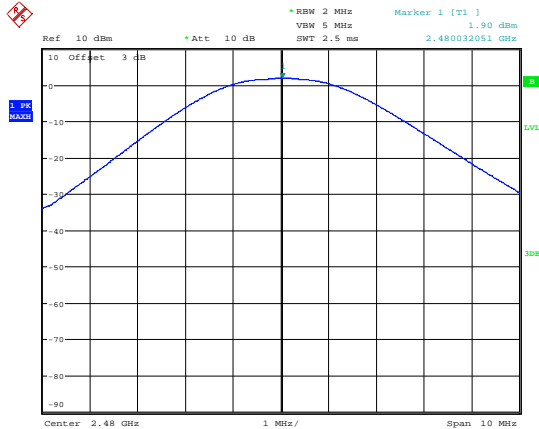


Date: 31.JUL.2020 05:00:10

Date: 31.JUL.2020 05:01:17

2404

2442



Date: 31.JUL.2020 05:02:27

2480

## 16 Power spectral density

### 16.1 Definition

The power per unit bandwidth.

### 16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	2404 MHz / 2442 MHz / 2480 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1.3 MHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)

### 16.3 Test Limit

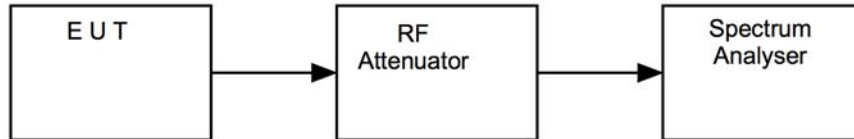
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

### 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**

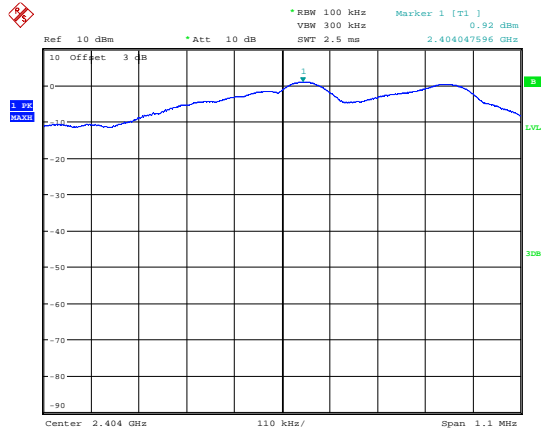


### 16.5 Test Equipment

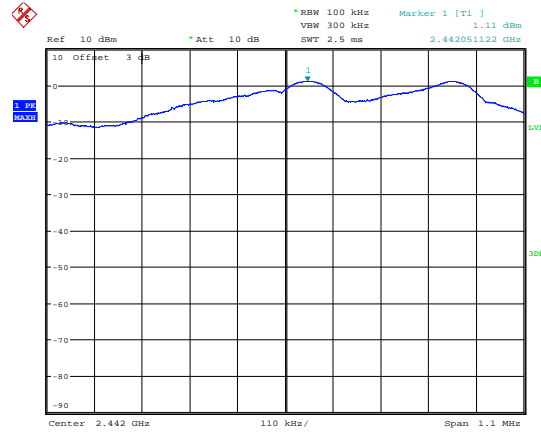
<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

### 16.6 Test Results

Mode 2: 2 Mbps				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
2404	-2.08	3.00	0.92	PASS
2442	-1.89	3.00	1.11	PASS
2480	-1.62	3.00	1.38	PASS



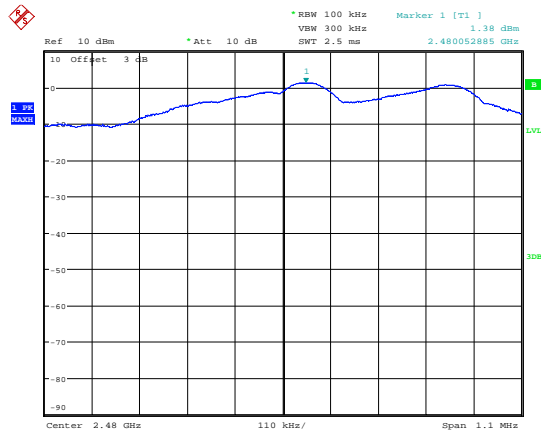
Date: 31.JUL.2020 05:24:38



Date: 31.JUL.2020 05:11:48

Bottom

Middle



Date: 31.JUL.2020 05:12:22

Top

## 17 Occupied Bandwidth

### 17.1 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.

### 17.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
Frequencies Measured:	Mode 1: 2403 MHz 2442 MHz / 2481 MHz – hopping stopped. Mode 2: 2404 MHz 2442 MHz / 2480 MHz – hopping stopped / DTS
EUT Channel Bandwidths:	Mode 1: 1 MHz Mode 2: 2 MHz
EUT Test Modulations:	Mode 1: 1MBps Binary GFSK Mode 2: 1MBps Binary GFSK
Deviations From Standard:	None
Measurement BW:	30 kHz / 100 kHz
Spectrum Analyzer Video BW:	100 kHz / 1 MHz
Measurement Span: (requirement 2 to 5 times OBW)	3 MHz / 5 MHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 29 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

### 17.3 Test Limit

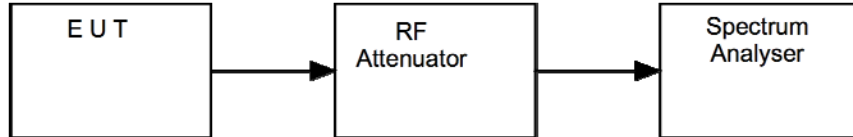
- For frequency hopping systems in the band 902 to 928 MHz: The maximum allowed -20 dB bandwidth of the hopping channel is 500 kHz.
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The maximum -20 dB bandwidth of the hopping channel shall be 1 MHz
- For DTS the minimum -6 dB bandwidth shall be at least 500 kHz.

### 17.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, 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 vii Test Setup**

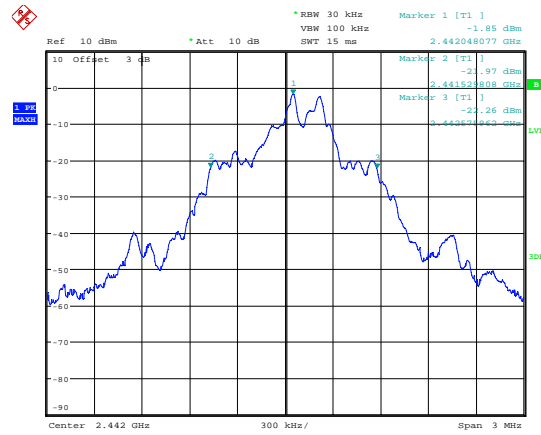
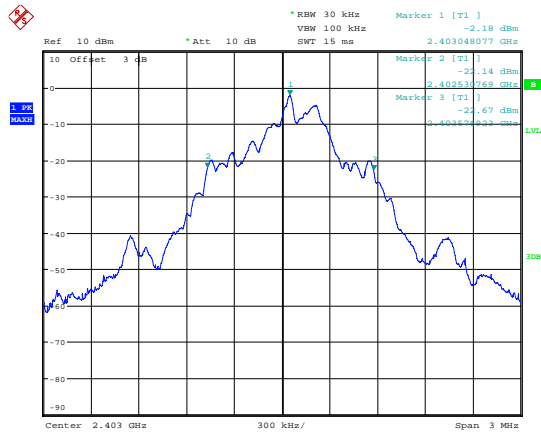


### 17.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

### 17.6 Test Results

Mode 1: 1 Mbps 20 dB Bandwidth				
Channel Frequency (MHz)	$F_L$ (MHz)	$F_H$ (MHz)	20dB Bandwidth (kHz)	Result
2403.0	2402.530769	2403.576923	1046.2	PASS
2442.0	2441.529808	2442.575962	1046.2	PASS
2481.0	2480.525962	2481.575962	1050.0	PASS

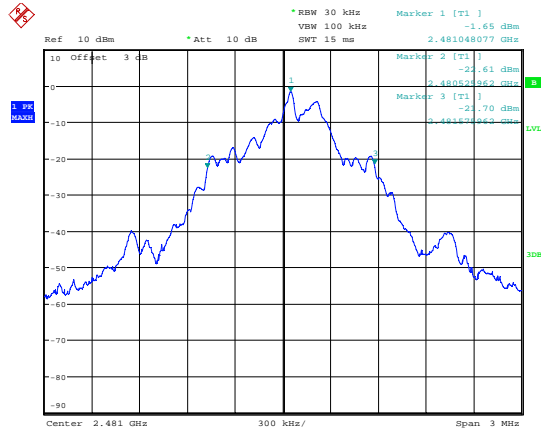


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2403

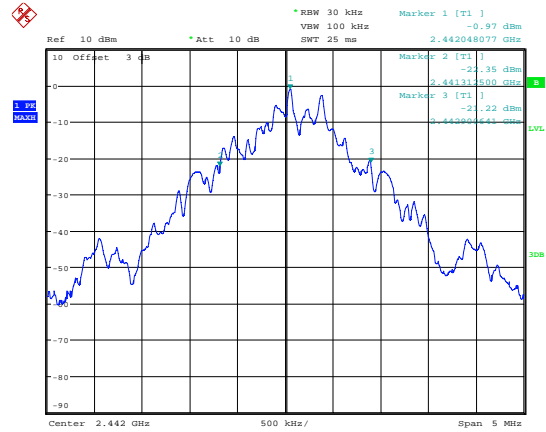
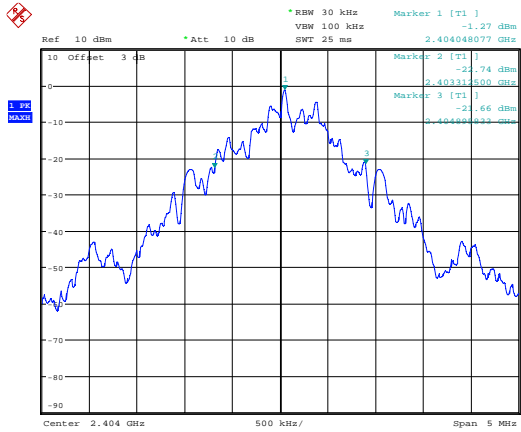
2442



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2481

Mode 2: 2Mbps 20 dB Bandwidth				
Channel Frequency (MHz)	$F_L$ (MHz)	$F_H$ (MHz)	20dB Bandwidth (kHz)	Result
2404.0	2403.312500	2404.895833	1583.3	PASS
2442.0	2441.312500	2442.900641	1588.1	PASS
2480.0	2479.320513	2480.895833	1575.3	PASS

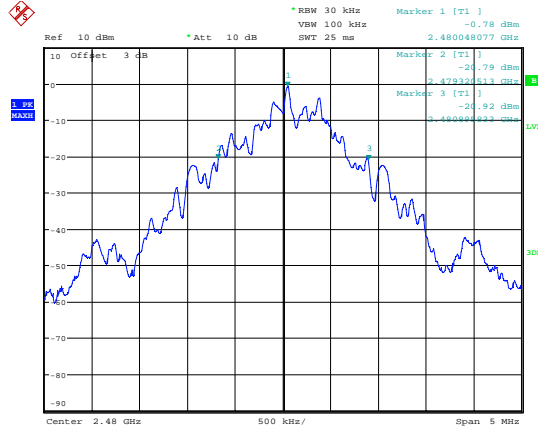


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2404

2442

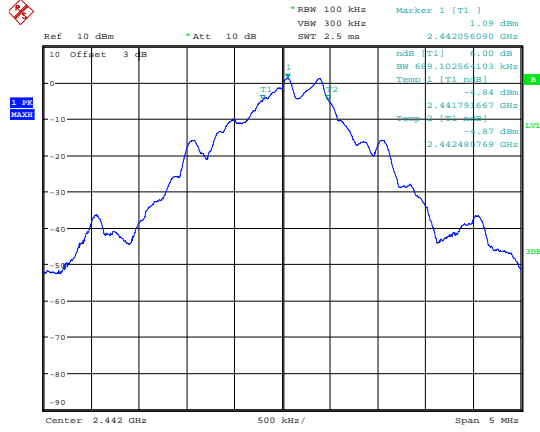
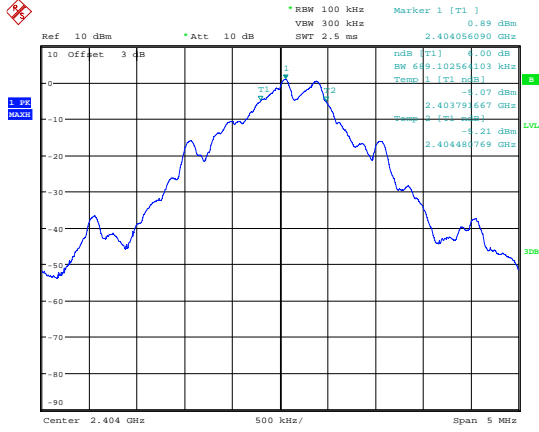


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2480



Mode 2: 2 Mbps 6 dB DTS bandwidth				
Channel Frequency (MHz)	$F_L$ (MHz)	$F_H$ (MHz)	6dB Bandwidth (kHz)	Result
2404.0	2403.791667	2404.480769	689.1	PASS
2442.0	2441.791667	2442.480769	689.1	PASS
2480.0	2479.791667	2480.488782	697.1	PASS

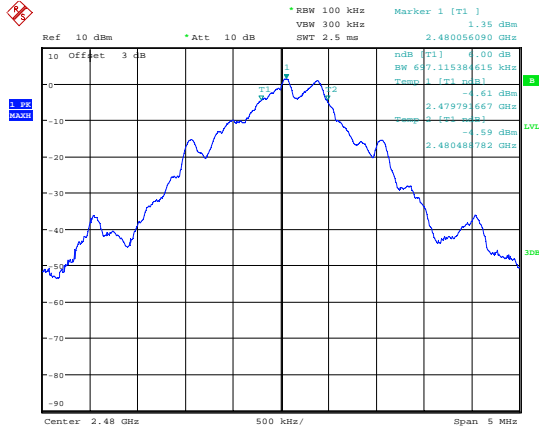


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Date: 31.JUL.2020 05:10:07

2404

2442



Date: 31.JUL.2020 05:04:42

2480

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

### 18.1 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.

### 18.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.8 ANSI C63.10-2013, Clause 11.11
Frequencies Measured:	Mode 1: 2403 MHz/2442 MHz/2481 MHz Mode 2: 2404 MHz/2442 MHz/2480 MHz
EUT Channel Bandwidths:	Mode 1: 1 MHz Mode 2: 2 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:	30 MHz to 25 GHz

### Environmental Conditions (Normal Environment)

Temperature: 23°C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	

### 18.3 Test Limits

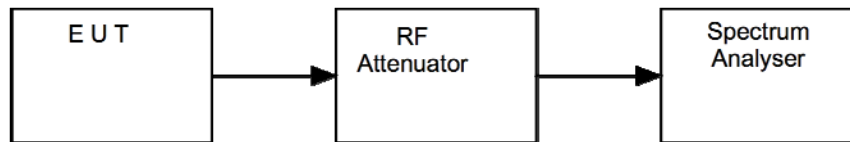
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

### 18.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure viii, 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 viii Test Setup**

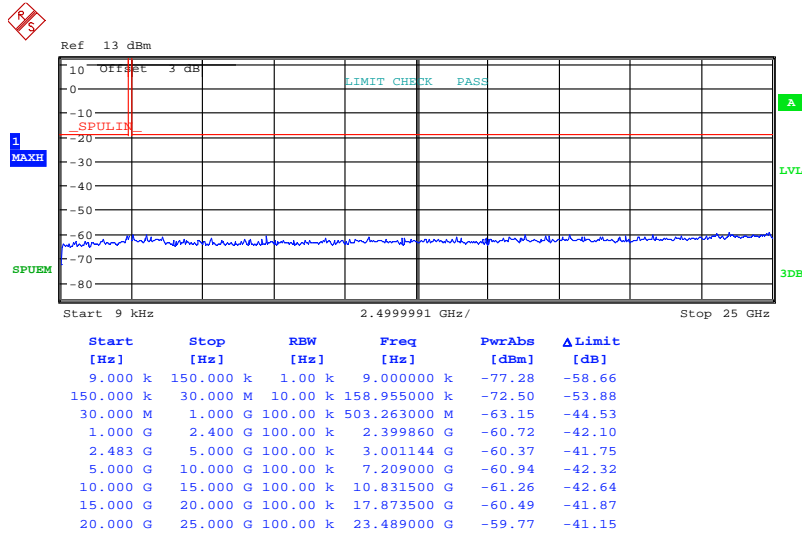


### 18.5 Test Equipment

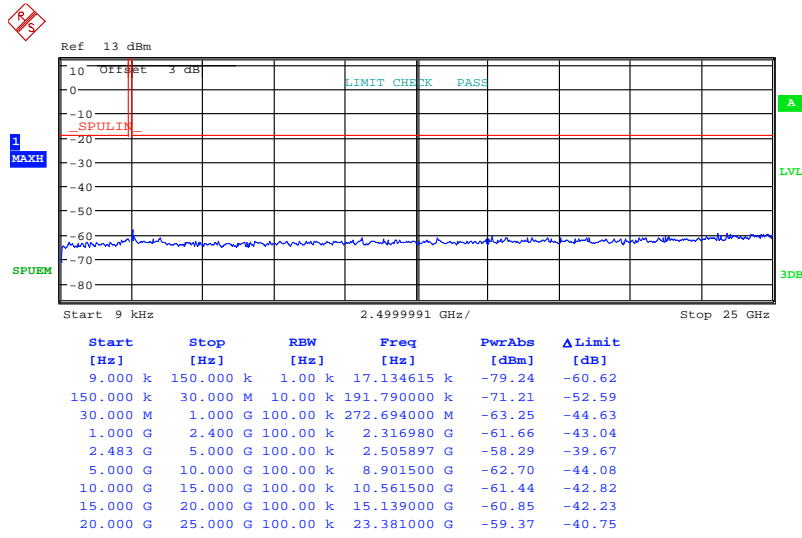
<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09

### 18.6 Test Results

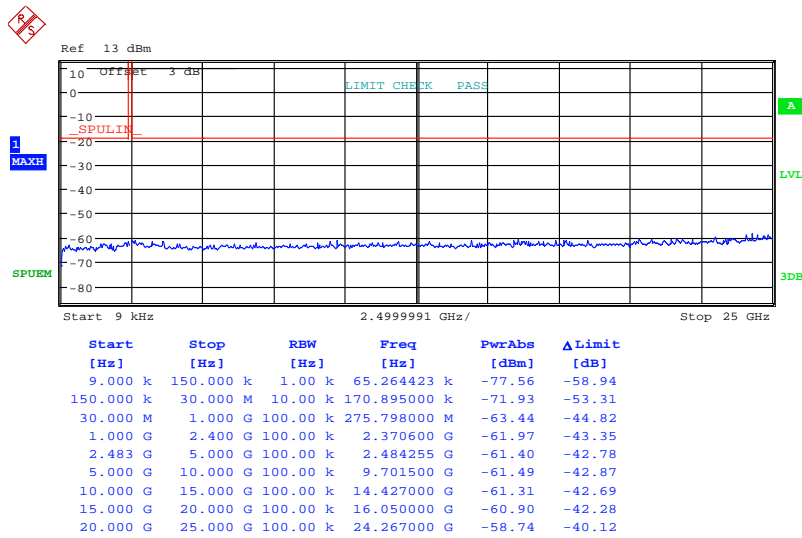
#### Mode 1: 1MBps GFSK



Bottom

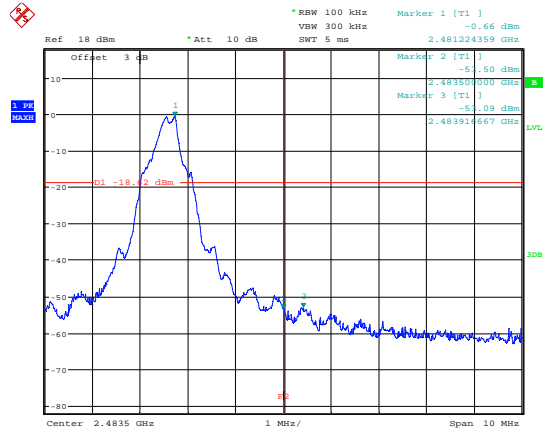
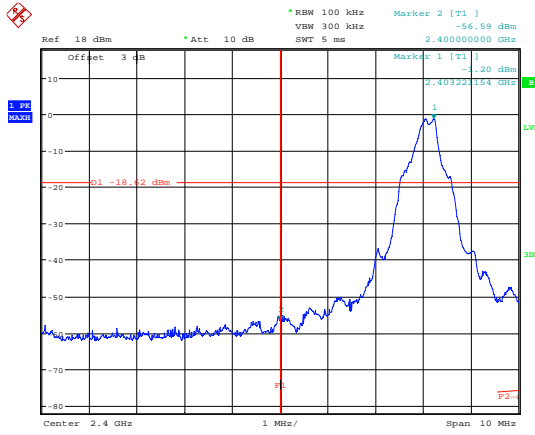


Middle



Top

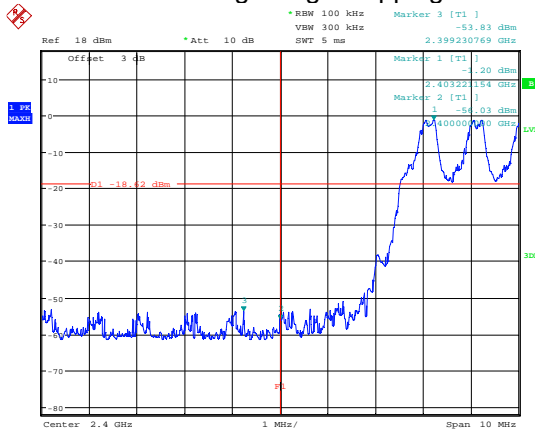
Band edge Mode 1:



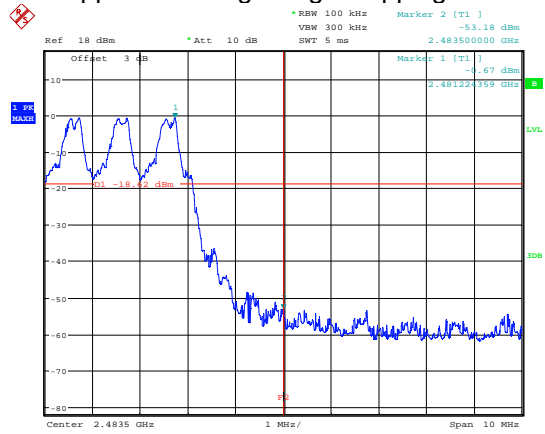
Date: 31.JUL.2020 07:53:14

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Lower band edge single hopping channel



Upper band edge single hopping channel



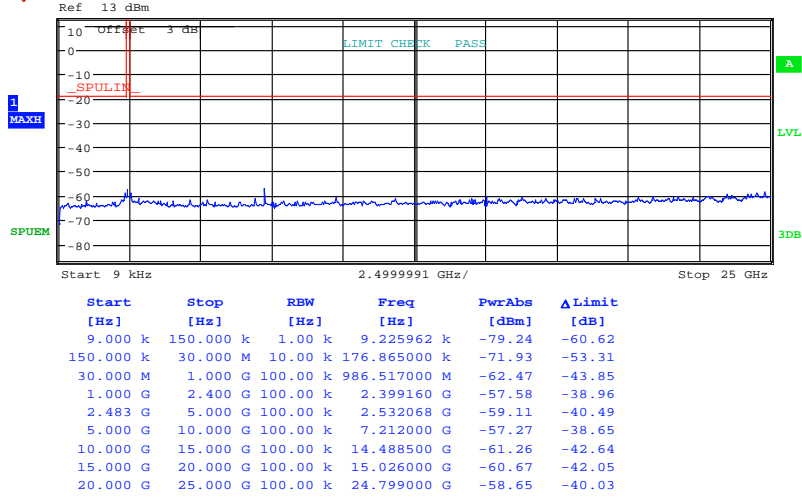
Date: 31.JUL.2020 07:42:04

Date: 31.JUL.2020 07:48:13

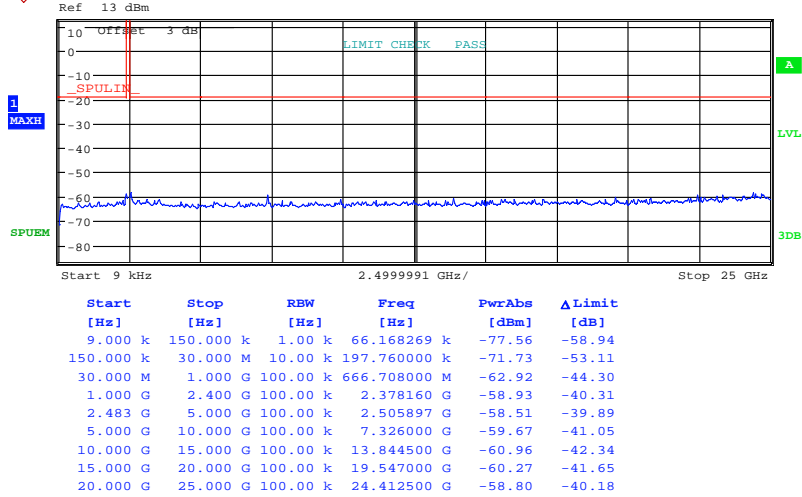
Lower band edge hopping channel

Upper band edge hopping channel

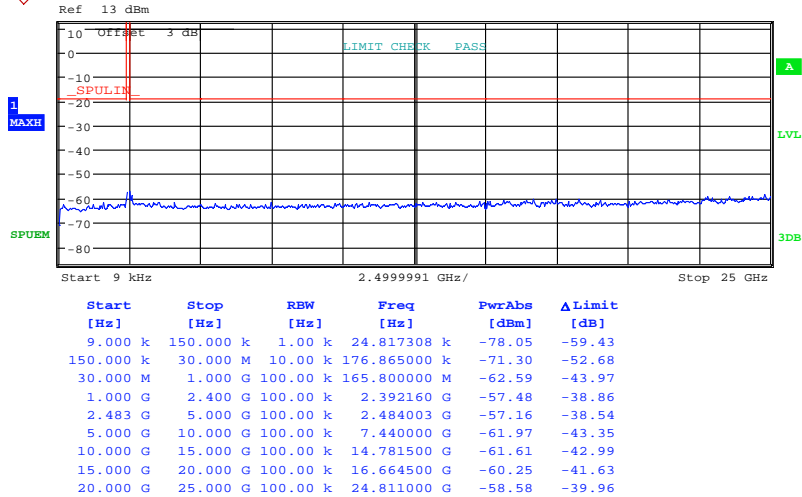
Mode 2: 2Mbps GFSK



Bottom

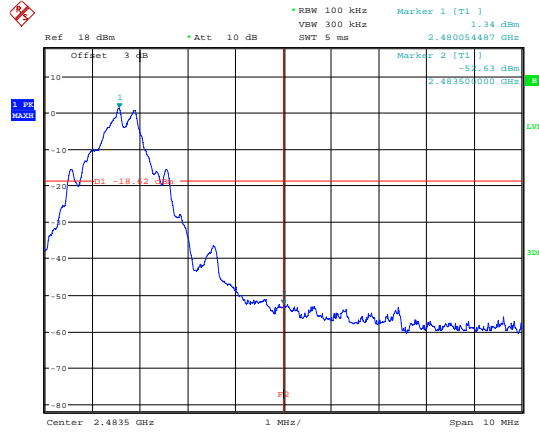
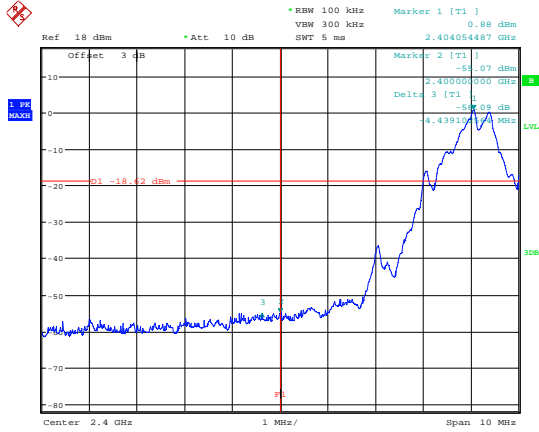


Middle

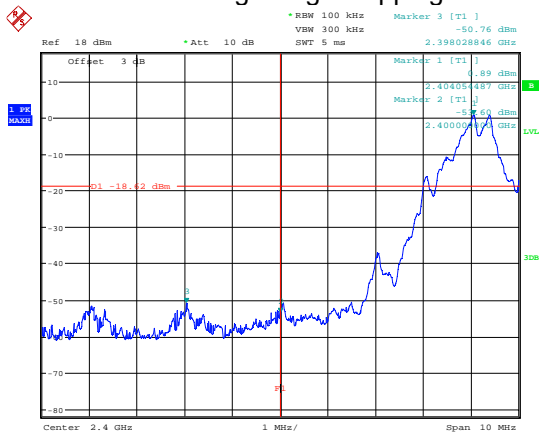


Top

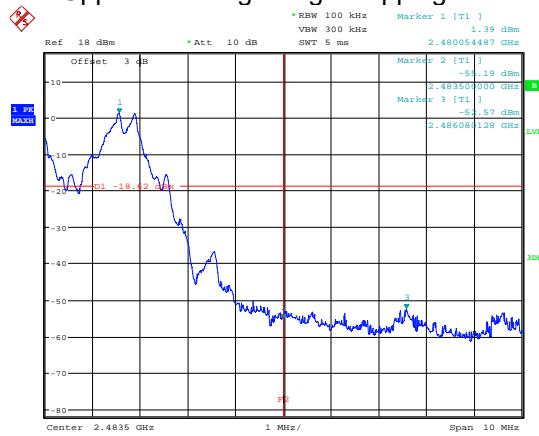
Band edge Mode 2:



Lower band edge single hopping channel



Upper band edge single hopping channel



Lower band edge hopping channel

Upper band edge hopping channel

## 19 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) = **4.6 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

#### [2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

#### [3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

#### [4] Conducted carrier power

Uncertainty in test result (Power Meter) = **1.08 dB**

#### [5] Conducted / radiated 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**

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

Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

#### [6] Frequency separation

Uncertainty in test result (Spectrum Analyser) = **3.6 kHz**

#### [7] Accumulated channel occupancy time

Uncertainty in test result = **7.98 %**

#### [8] 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**

#### [9] Power spectral density

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

#### [10] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**

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



## 20 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.

In the frequency range below 100 MHz to 6 GHz and test separation distance of 50mm, the SAR Test Exclusion Threshold for operation in the 2400 – 2483.5 MHz band will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

#### Step 1

$$NT = [(MP/TSD^A) * \sqrt{f_{GHz}}]$$

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)  
 MP = Max Power of channel (mW) (inc tune up)  
 TSD<sup>A</sup> = Min Test separation Distance or 50mm (whichever is lower) = 50

We can transpose this formula to allow us to find the maximum power of a channel allowed and compare this to the measured maximum power.

$$= [(NT * TSD^A) / \sqrt{f_{GHz}}]$$

For Distances Greater than 50 mm Step 2 applies

#### Step 2

$$(TSD^B - 50mm) * 10\}$$

Where:

TSD<sup>B</sup> = Min Test separation Distance (mm) = 50

**Operating Frequency 2.403 GHz**

$$\begin{aligned} \text{SARET} &= [(3.0 \times 50) / \sqrt{2.402}] + \{ (50 - 50) * 10 \} \\ \text{SARET} &= [150 / 1.55] + (0 * 10) \\ \text{SARET} &= 96.77\text{mW} \end{aligned}$$

**Operating Frequency 2.442 GHz**

$$\begin{aligned} \text{SARET} &= [(3.0 \times 50) / \sqrt{2.442}] + \{ (50 - 50) * 10 \} \\ \text{SARET} &= [150 / 1.56] + (0 * 10) \\ \text{SARET} &= 96.15\text{mW} \end{aligned}$$

**Operating Frequency 2.481 GHz**

$$\begin{aligned} \text{SARET} &= [(3.0 \times 50) / \sqrt{2.481}] + \{ (50 - 50) * 10 \} \\ \text{SARET} &= [150 / 1.57] + (0 * 10) \\ \text{SARET} &= 95.54\text{mW} \end{aligned}$$

<b>Mode 1</b>				
Evaluation Frequency	2403	2442	2481	MHz
SAR Exclusion Threshold	96.77	96.15	95.54	Watts
Conducted Power	-0.7	-0.41	-0.12	dBm
Antenna Gain	-0.81	-0.81	-0.81	dBi
EIRP	0.71	0.76	0.81	mW
<b>SAR Evaluation</b>	<b>Exempt</b>			

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

**Operating Frequency 2.404 GHz**

$$\begin{aligned} \text{SARET} &= [(3.0 \times 50) / \sqrt{2.404}] + \{ (50 - 50) * 10 \} \\ \text{SARET} &= [150 / 1.55] + (0 * 10) \\ \text{SARET} &= 96.77\text{mW} \end{aligned}$$

**Operating Frequency 2.440 GHz**

$$\begin{aligned} \text{SARET} &= [(3.0 \times 50) / \sqrt{2.44}] + \{ (50 - 50) * 10 \} \\ \text{SARET} &= [150 / 1.56] + (0 * 10) \\ \text{SARET} &= 96.15\text{mW} \end{aligned}$$

**Operating Frequency 2.480 GHz**

$$\begin{aligned} \text{SARET} &= [(3.0 \times 50) / \sqrt{2.48}] + \{ (50 - 50) * 10 \} \\ \text{SARET} &= [150 / 1.57] + (0 * 10) \\ \text{SARET} &= 95.54\text{mW} \end{aligned}$$

<b>Mode 2</b>				
Evaluation Frequency	2404	2440	2480	MHz
SAR Exclusion Threshold	96.77	96.15	95.54	Watts
Conducted Power	1.42	1.60	1.90	dBm
Antenna Gain	-0.81	-0.81	-0.81	dBi
EIRP	1.2	1.2	1.3	mW
<b>SAR Evaluation</b>	<b>Exempt</b>			

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