

Report on the Radio Testing

For

Sound Devices LLC

on

A20-TX

Report no. TRA-061998-47-05B

26th January 2024

RF916 14.0



0026

Report Number: TRA-061998-47-05B
Issue: B

REPORT ON THE RADIO TESTING OF A
Sound Devices LLC
A20-TX
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 13th October 2023

Tested by: M Else/S Hodgkinson

Written by:

S Hodgkinson
Radio Test Engineer

Approved by:

John Charters
Lab Manager

Date: 26th January 2024

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

RF916 14.0



1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	26th January 2024	Original
B	26 th January 2024	Antenna details changed

2 Summary

TEST REPORT NUMBER:	TRA-061998-47-05B
WORKS ORDER NUMBER:	TRA-061998-00
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	A20-TX
FCC IDENTIFIER:	2AKLX-9808
EUT SERIAL NUMBER:	SP0223137019
MANUFACTURER/AGENT:	Sound Devices LLC
ADDRESS:	E7556 State Road 23 and 33 Reedsburg WI 53959
CLIENT CONTACT:	Lee Stone ✉ lee.stone@audioltd.com
ORDER NUMBER:	73795
TEST DATE:	13th October 2023
TESTED BY:	S Hodgkinson Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Requirement Clause 47CFR15</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Radiated spurious emissions (restricted bands of operation and cabinet radiation)	15.247(d)	☒	Pass
AC power line conducted emissions	15.207	☐	Note 1
Carrier frequency separation	15.247 (a) (1)	☒	Pass
Number of hopping channels	15.247 (a) (1) (i), (ii) and (iii)	☒	Pass
Average time of occupancy	15.247 (a) (1) (i), (ii) and (iii)	☒	Pass
Maximum peak conducted output power	15.247 (a) (1), (b)(1) and (b)(2)	☒	Pass
20 dB emission bandwidth	15.247 (a) (1) (i) and (ii)	☒	Pass
Out-of-band emissions	15.247(d)	☒	Pass
Calculation of duty correction	-	☒	Note 2

Specific Note:

1. The EUT is a battery powered device and can be used with rechargeable batteries, but as per clients declaration, it does not transmit while charging.
2. No Pass/Fail requirement.

General Notes:

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

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

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

General notes

The decision rule for compliance is not inherent within this specification and compliance is based on the customer requesting a simple acceptance rule based on understanding and acceptance of Elements Measurement Uncertainty values.

3 Contents

1	Revision Record	3
2	Summary	4
2.1	Test Summary	5
3	Contents	6
4	Introduction	8
5	Test Specifications	9
5.1	Normative References	9
5.2	Deviations from Test Standards	9
6	Glossary of Terms	10
7	Equipment under Test	11
7.1	EUT Identification	11
7.2	System Equipment	11
7.3	EUT Mode of Operation	11
7.4	EUT Radio Parameters	11
7.4.1	General	11
7.4.2	Antennas	12
7.5	EUT Description	12
8	Modifications	13
9	EUT Test Setup	14
9.1	Block Diagram	14
9.2	General Set-up Photograph	15
9.3	Measurement software	15
10	General Technical Parameters	16
10.1	Normal Conditions	16
10.2	Varying Test Conditions	16
11	Radiated emissions	17
11.1	Definitions	17
11.2	Test Parameters	17
11.3	Test Limit	17
11.4	Test Method	18
11.5	Test Equipment	19
11.6	Test Results	20
12	Carrier frequency separation	25
12.1	Definition	25
12.2	Test Parameters	25
12.3	Test Limit	25
12.4	Test Method	26
12.5	Test Equipment	26
12.6	Test Results	27
13	Number of hopping frequencies	28
13.1	Definition	28
13.2	Test Parameters	28
13.3	Test Limit	28
13.4	Test Method	29
13.5	Test Equipment	29
13.6	Test Results	30
14	Average channel occupancy	31
14.1	Definition	31
14.2	Test Parameters	31
14.3	Test Limit	31
14.4	Test Method	32
14.5	Test Equipment	32
14.6	Test Results	33
15	Maximum peak conducted output power	34
15.1	Definition	34
15.2	Test Parameters	34
15.3	Test Limit	34
15.4	Test Method	35
15.5	Test Equipment	35
15.6	Test Results	36
16	Occupied Bandwidth	37
16.1	Definition	37
16.2	Test Parameters	37
16.3	Test Method	38
16.4	Test Equipment	38

16.5	Test Results.....	39
17	Out-of-band and conducted spurious emissions.....	40
17.1	Definition.....	40
17.2	Test Parameters	40
17.3	Test Limits	40
17.4	Test Method.....	41
17.5	Test Equipment.....	41
17.6	Test Results.....	42
17.7	Test Method.....	43
17.8	Test Equipment.....	43
18	Radio Testing – General Uncertainty Schedule	45

4 Introduction

This report TRA-061998-47-05B presents the results of the Radio testing on a Sound Devices LLC, A20-TX to specification 47CFR15 Radio Frequency Devices. The testing was carried out for Sound Devices LLC by Element, at the address detailed below.

☐	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☒	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK	☐	Element Surrey Hills Unit 15 B Henley Business Park Pirbright Road Normandy Guildford GU3 2DX 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:

The test laboratory is accredited for the above sites under the following US-UK MRA, Designation numbers.

Element Hull	UK2007
Element Skelmersdale	UK2020

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

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

5 Test Specifications

5.1 Normative References

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

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

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

7 Equipment under Test

7.1 EUT Identification

- Name: A20-TX
- Serial Number: SP0223137019
- Model Number: 9808
- Software Revision: 7.50.8629
- Build Level / Revision Number: 02

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.

HP Spectre Laptop

7.3 EUT Mode of Operation

Transmission: The channels were selected using the client supplied test scripts

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2400.8 MHz – 2481.6 MHz
Modulation type(s):	Chirp Spread Spectrum (CSS)
Occupied channel bandwidth(s):	287 kHz
Channel spacing:	400 kHz
Declared output power(s):	5.0 dBm - 7.0 dBm
Nominal Supply Voltage:	4.5 Vdc via batteries

7.4.2 Antennas

Type:	Antenova SMD A5645H
Frequency range:	2.4 GHz – 2.5 GHz
Impedance:	50Ω
SWR:	Max 1.8:1
Gain:	1.8 dBi peak
Polarisation:	Linear

7.5 EUT Description

The EUT is a Professional (Body-Worn) Wireless Microphone Transmitter, which incorporates the following radios BTLE, LoRa, and various frequency bands for the digital Wireless Audio, this report is reporting on the LoRa radio only.

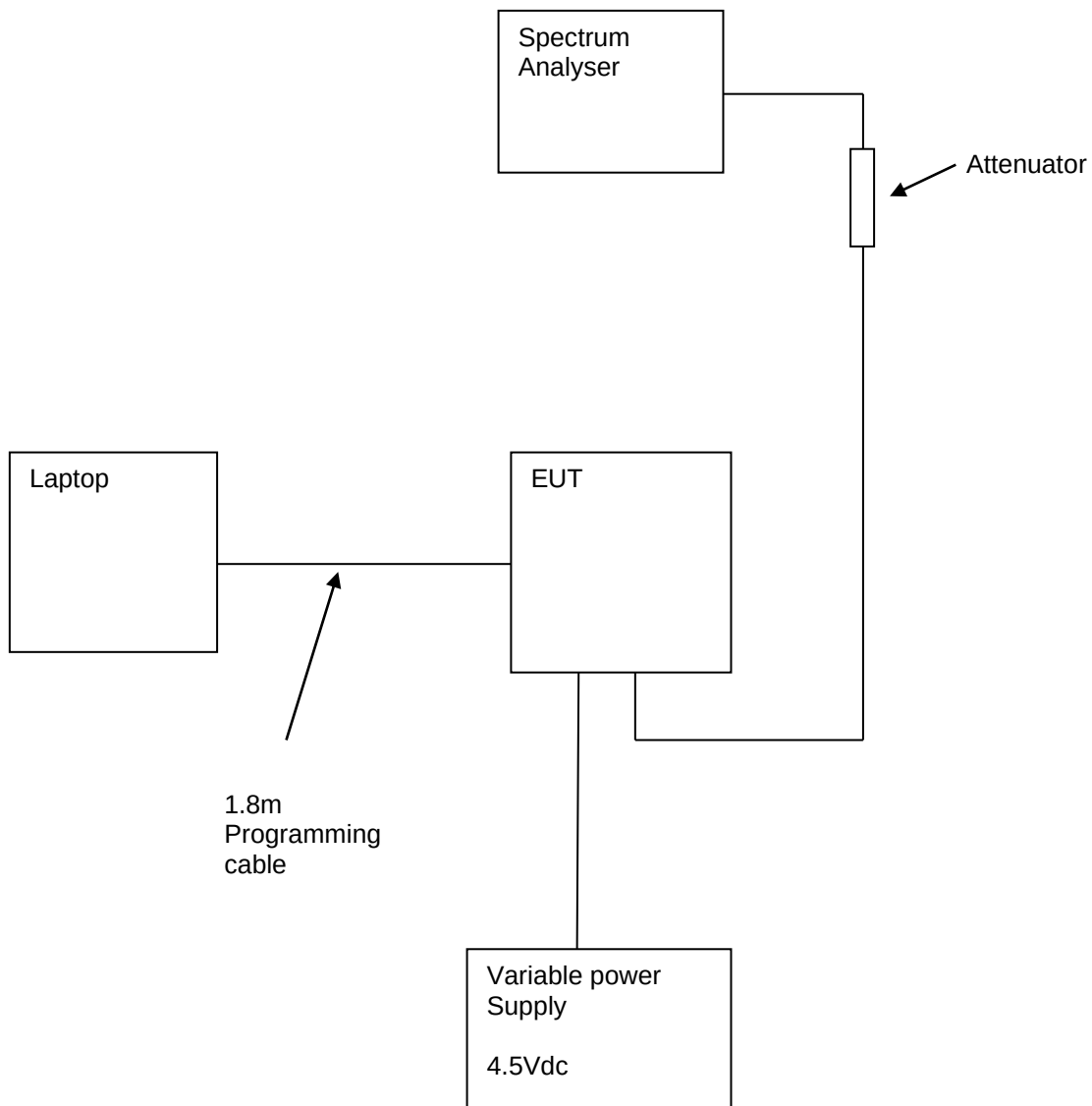
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

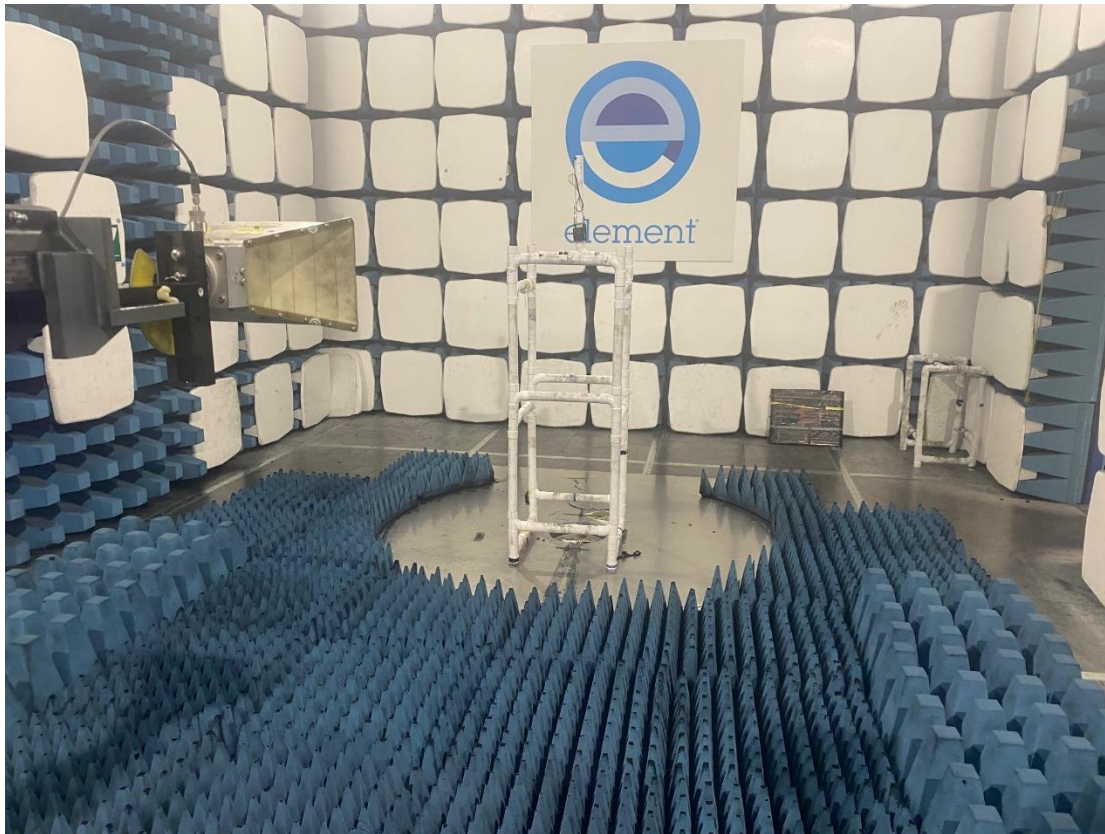
9.1 Block Diagram

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



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9.3 Measurement software

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

Element Emissions R5
Element Transmitter Bench Test
ETS Lindgren EMPower V1.0.4.2

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 4.5 Vdc from batteries.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band.

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	<i>Category</i>	<i>Nominal</i>	<i>Variation</i>
☐	Mains	110 Vac +/-2 %	85 % and 115 %
☒	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

Spurious emissions

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

Restricted bands

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

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber 03
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2400.8 MHz, 2440.8 MHz & 2481.6 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: 22°C	+15 °C to +35 °C (as declared)
Humidity: 50% RH	20 % RH to 75 % RH (as declared)
Supply: 4.5 Vdc	As declared

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	Field Strength (μV/m at 3 m)	Field Strength (dBμV/m at 3 m)
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

On frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function. On frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit.

11.4 Test Method

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

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

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

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

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

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

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

Where,

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

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

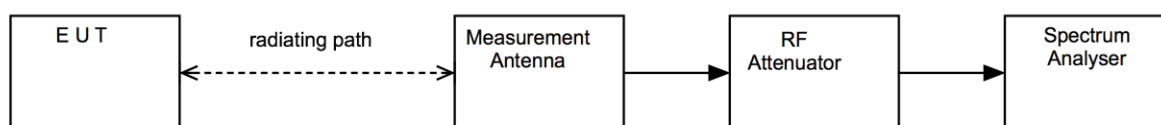
PA is the pre-amplifier gain in dB (where used);

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

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

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

Figure i Test Setup

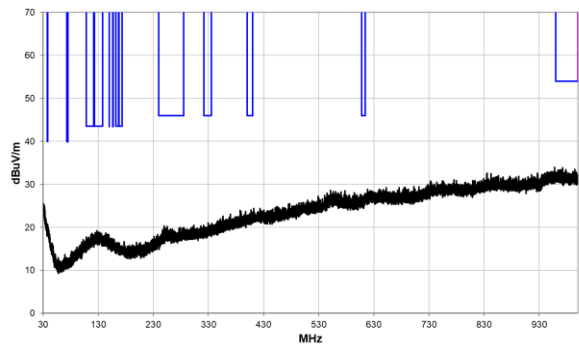


11.5 Test Equipment

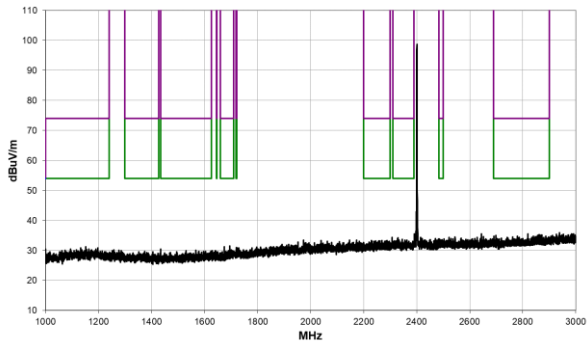
Equipment Description	Manufacturer	Equipment Type	Element No	Last Cal Calibration	Calibration Period	Due For Calibration
Radiated Test Software	Element	Emissions R5	Ref 9000	Cal not required	Cal not required	Cal not required
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-11-06	24	2023-11-06
Spectrum Analyser	R&S	FSU46	REF910	2023-01-10	12	2024-01-10
EMI Receiver	R&S	ESR7	U456	2023-02-06	12	2024-02-06
Bilog	Chase	CBL611/B	U573	2022-10-14	24	2024-10-14
Pre Amp	AMETEK	LNA6901	U711	2022-03-22	12	2023-03-22
Pre Amp	Agilent	8449B	U457	2023-01-24	12	2024-01-24
1-18GHz Horn	EMCO	3115	L139	2022-07-01	24	2024-07-01
2.4G Band Stop Filter	BSC	SN 4478	U543	2023-02-08	12	2024-02-08
High Pass Filter	Atlantic Microwave	AFH-07000	U558	2023-02-13	12	2024-02-13
Horn Antenna	A Info Inc	LB-180400-25-C-KF	REF2246	2022-09-23	24	2024-09-23

11.6 Test Results

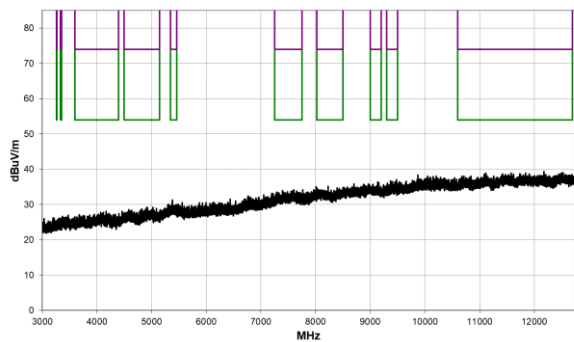
Bottom Channel



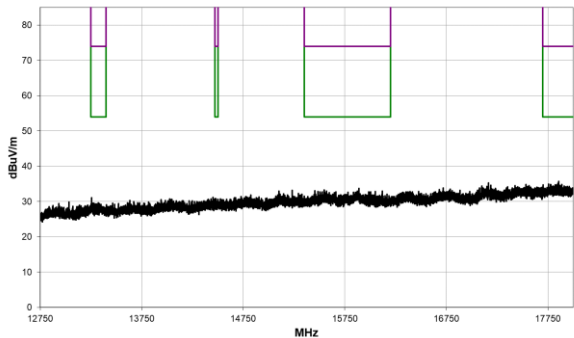
30 MHz to 1 GHz



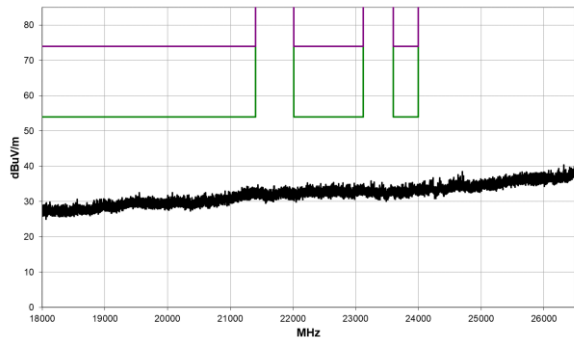
1 GHz to 3 GHz



3 GHz to 12.75 GHz



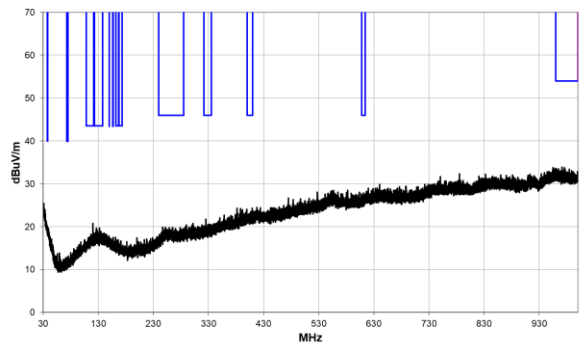
12.75 GHz to 18 GHz



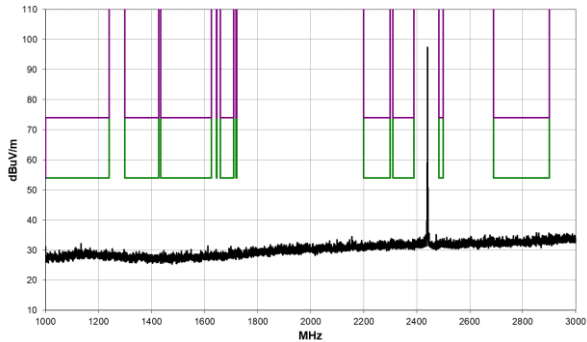
18 GHz to 26.5 GHz

Frequency: 2400.8 MHz; Power Setting: Default;								
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
No significant emissions within 20 dB of the limit.								

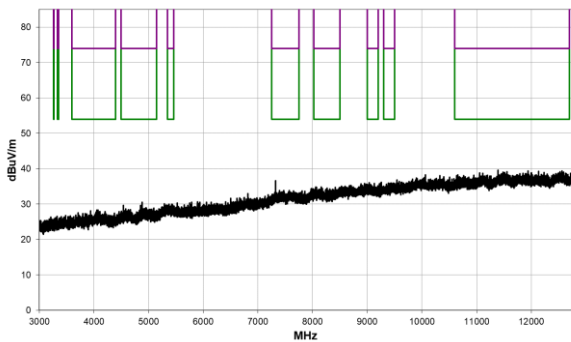
Middle Channel



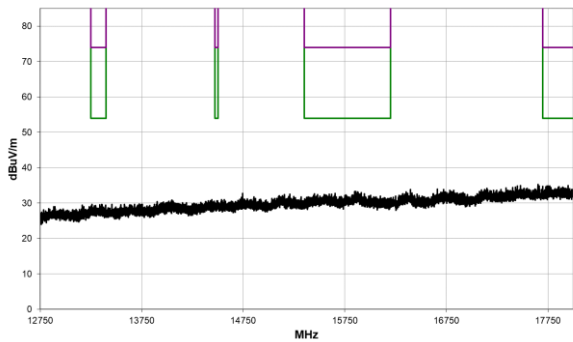
30 MHz to 1 GHz



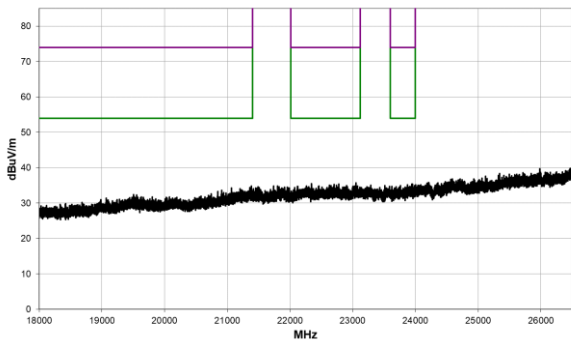
1 GHz to 3 GHz



3 GHz to 12.75 GHz



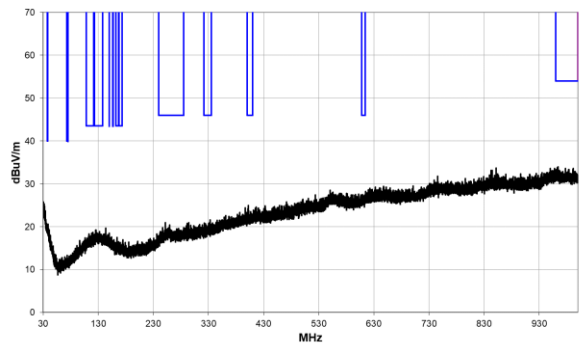
12.75 GHz to 18 GHz



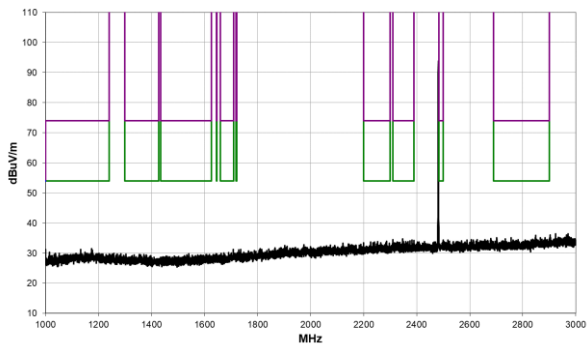
18 GHz to 26.5 GHz

Frequency: 2440.8 MHz; Power Setting: Default;												
F req (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
7320.475	29.5	9.9	1.5	286.0	3.0	0.0	Horz	AV	0.0	39.4	54.0	-14.6
7322.342	29.4	9.9	1.5	267.0	3.0	0.0	Vert	AV	0.0	39.3	54.0	-14.7
7321.233	44.8	9.9	1.5	267.0	3.0	0.0	Vert	PK	0.0	54.7	74.0	-19.3
7324.383	44.6	9.9	1.5	286.0	3.0	0.0	Horz	PK	0.0	54.5	74.0	-19.5

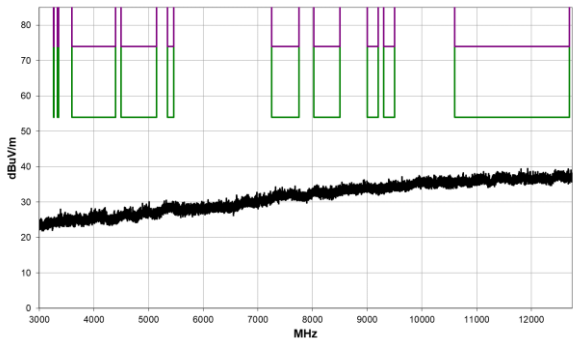
Top Channel



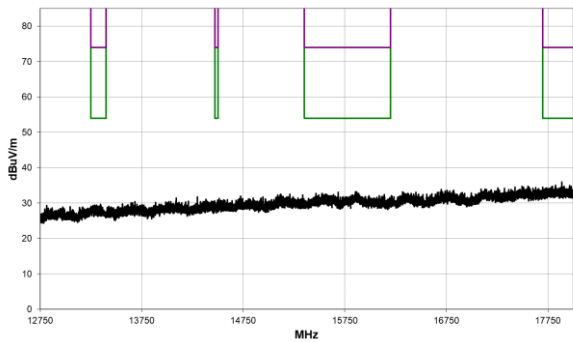
30 MHz to 1 GHz



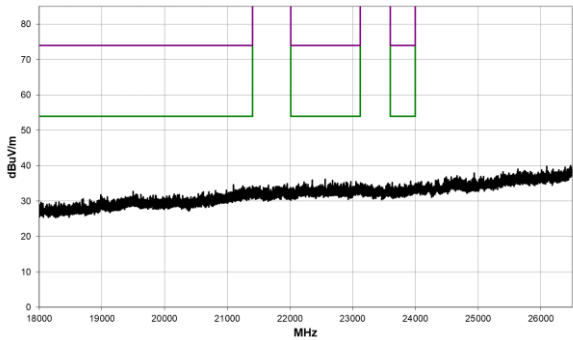
1 GHz to 3 GHz



3 GHz to 12.75 GHz



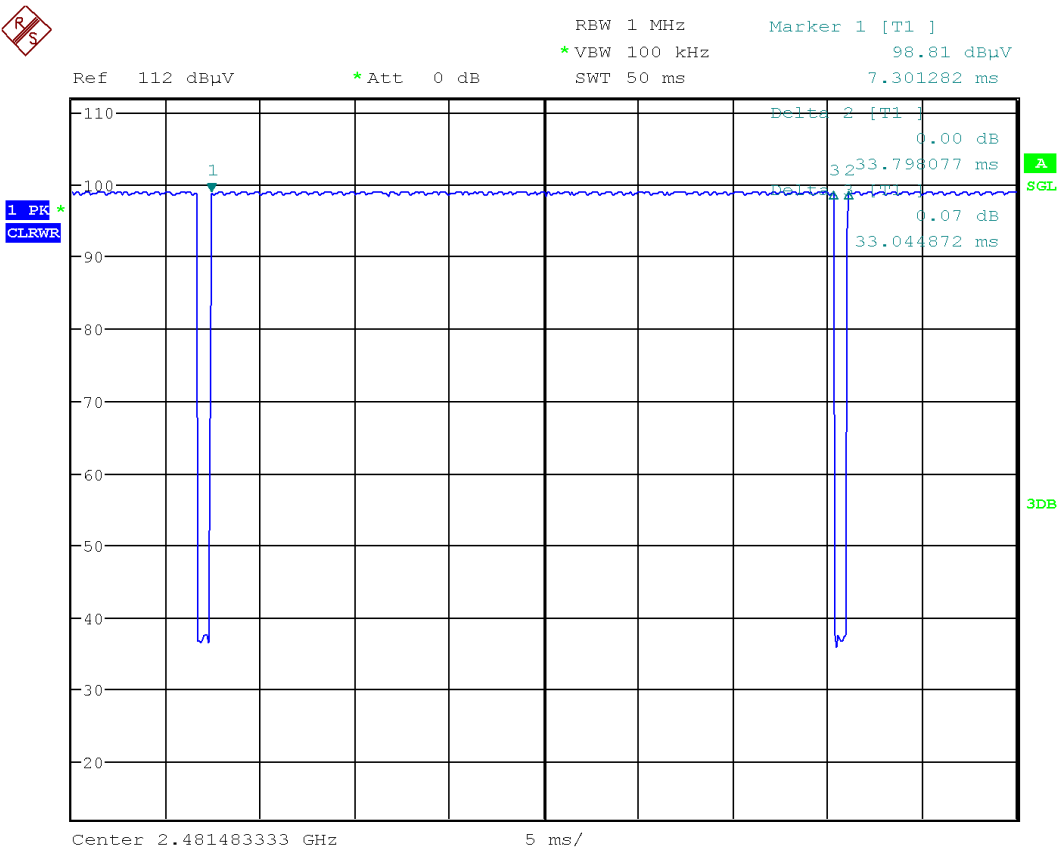
12.75 GHz to 18 GHz



18 GHz to 26.5 GHz

Frequency: 2481.6 MHz; Power Setting: Default;								
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
No significant emissions within 20 dB of the limit.								

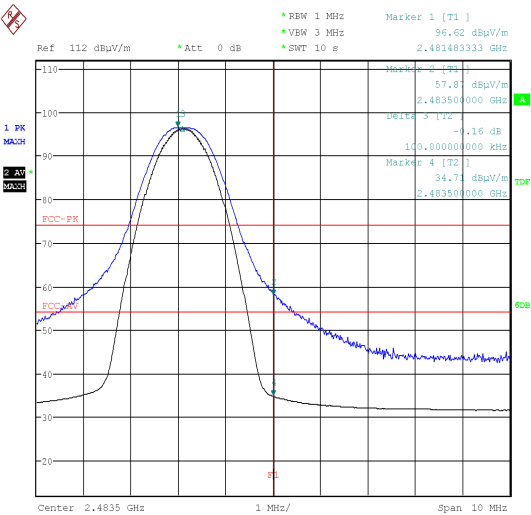
Duty Cycle Correction Factor



Date: 5.JUL.2023 12:56:18

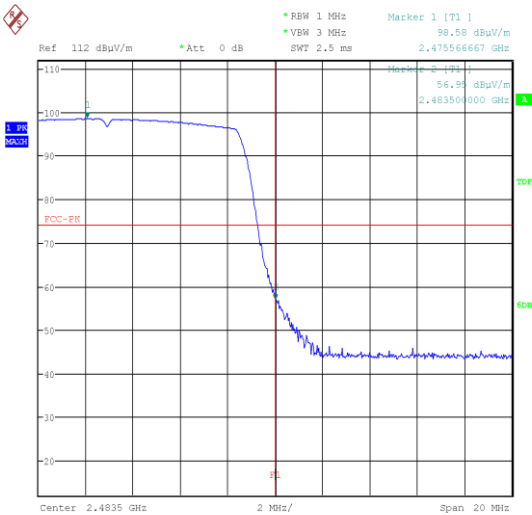
Duty cycle = 98%

Radiated Band Edge Peak / Average



Date: 5.JUL.2023 13:12:12

Radiated Band Edge Peak Hopping



Date: 5.JUL.2023 15:15:17

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:	All; 2400.8 MHz to 2481.6 MHz
EUT 20dB Bandwidth:	280 kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations from Standard:	None
Measurement BW:	10 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)
Supply: 4.5 Vdc	As declared

12.3 Test Limit

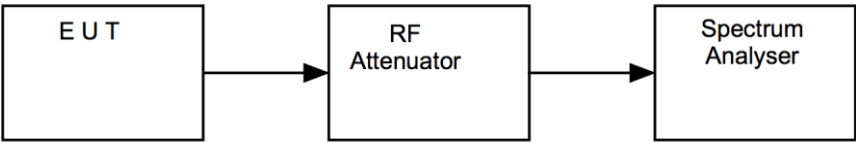
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400 to 2483.5 MHz may have hopping channel carrier frequencies 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

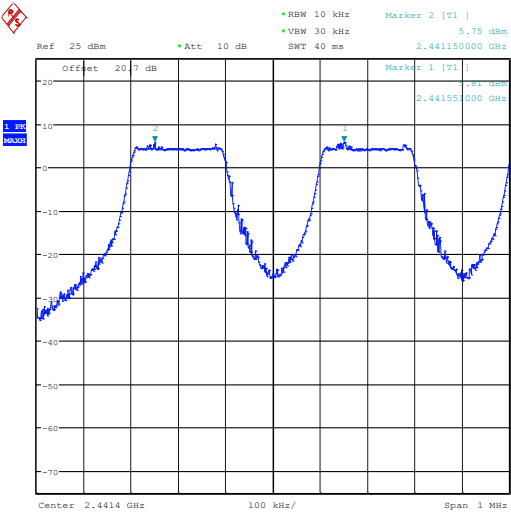


12.5 Test Equipment

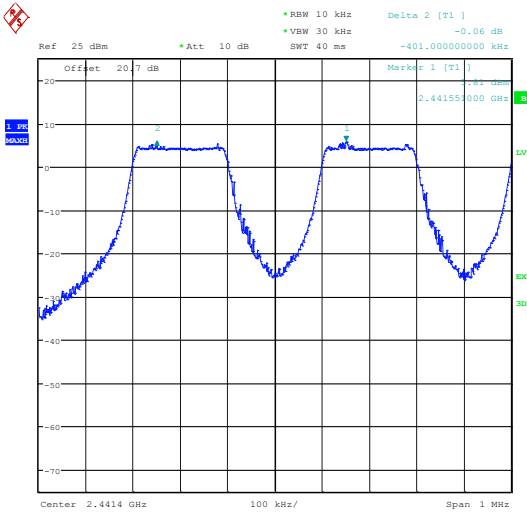
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2024-01-10
20dB SMA	AtlanTech	Attenuator	U631	Cal in use
IPS 303A	ISO-Tech	Power Supply	U748	Use REF976
34405a	Agilent	Multimeter	REF976	2024-01-24

12.6 Test Results

Power setting: Default				
Data Rate	F1 _c (MHz)	F2 _c (MHz)	Channel Separation, F1 _c – F2 _c (kHz)	Result
1.09 kbit/s	2441.55100	2441.150000	401.0	PASS



Date: 13.OCT.2023 12:40:14



Date: 13.OCT.2023 12:40:00

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:	All; 2400.8 MHz to 2481.6 MHz
EUT 20dB Bandwidth:	280 kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations from Standard:	None
Measurement BW:	10 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)
Supply: 4.5Vdc	As declared

13.3 Test Limit

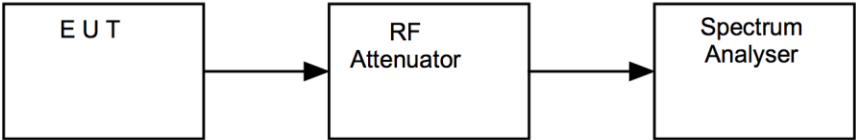
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels; If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels;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



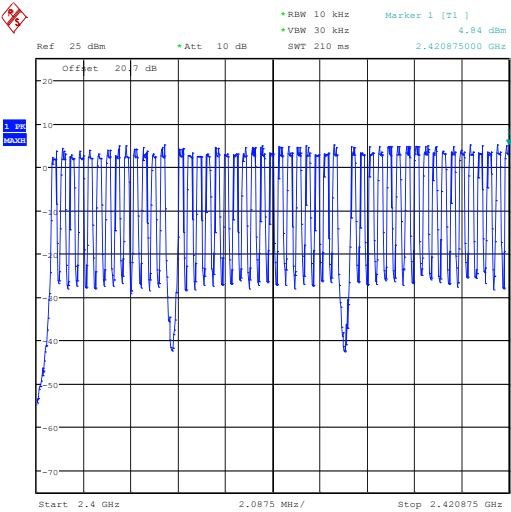
13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2024-01-10
20dB SMA	AtlanTech	Attenuator	U631	Cal in use
IPS 303A	ISO-Tech	Power Supply	U748	Use REF976
34405a	Agilent	Multimeter	REF976	2024-01-24

13.6 Test Results

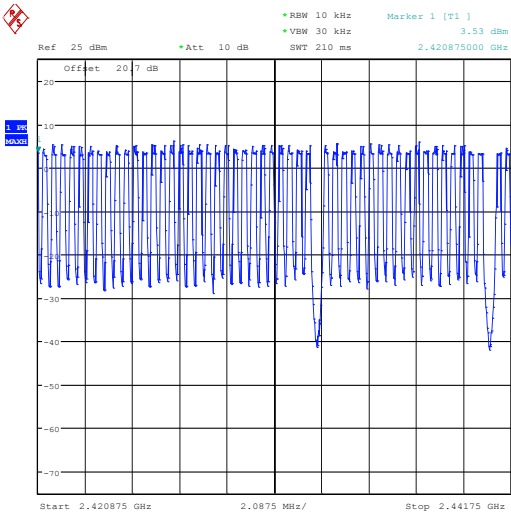
Power setting: Default				
Data Rate	Lowest channel, <i>F_{CL}</i> (MHz)	Highest channel, <i>F_{CH}</i> (MHz)	Number of channels observed	Result
1.09kbit/s	2400.8	2481.6	197	PASS

2400 MHz – 2420.875 MHz
49 Channels



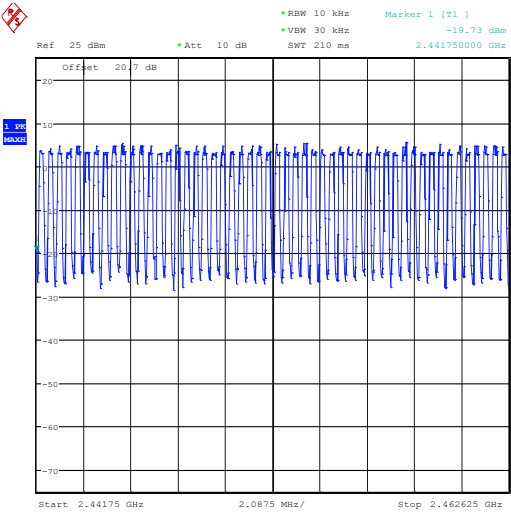
Date: 12.OCT.2023 16:27:57

2420.875 MHz-2441.75 MHz
50 Channels



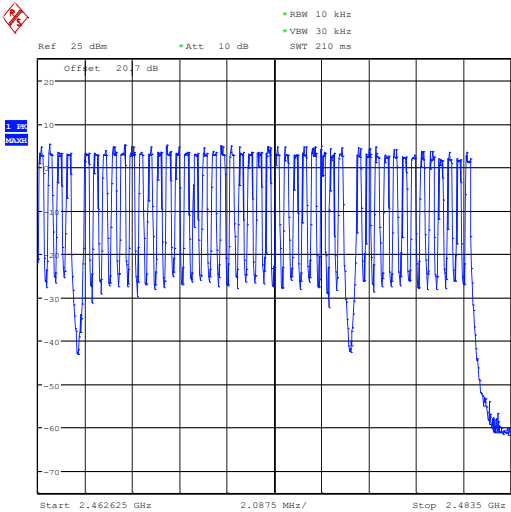
Date: 12.OCT.2023 16:42:45

2441.75 MHz-2462.625 MHz
52 Channels



Date: 12.OCT.2023 16:56:32

2462.625 MHz-2483.5 MHz
46 Channels



Date: 12.OCT.2023 17:05:57

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:	2441.199577 MHz
EUT 20dB bandwidth:	280kHz
EUT Number of hopping channels:	197
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: 53 % RH	20 % RH to 75 % RH (as declared)
Supply: 4.5 Vdc	As declared

14.3 Test Limit

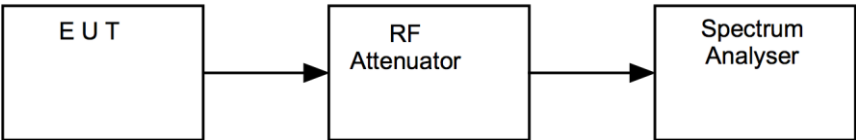
- For frequency hopping systems in the band 902 to 928 MHz: if the -20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20 second period;
If the -20 dB bandwidth of the hopping channel is 250 kHz or greater, 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



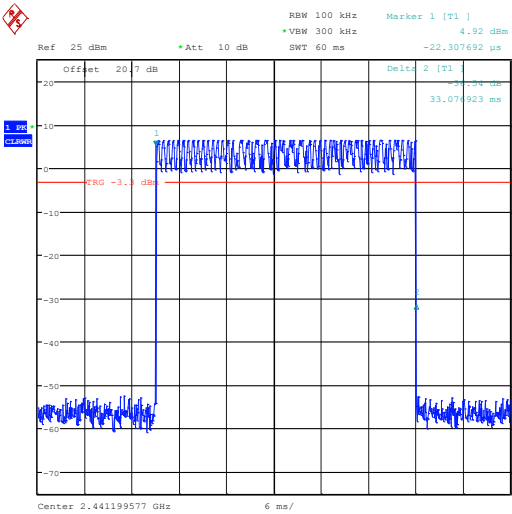
14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2024-01-10
20dB SMA	AtlanTech	Attenuator	U631	Cal in use
IPS 303A	ISO-Tech	Power Supply	U748	Use REF976
34405a	Agilent	Multimeter	REF976	2024-01-24

14.6 Test Results

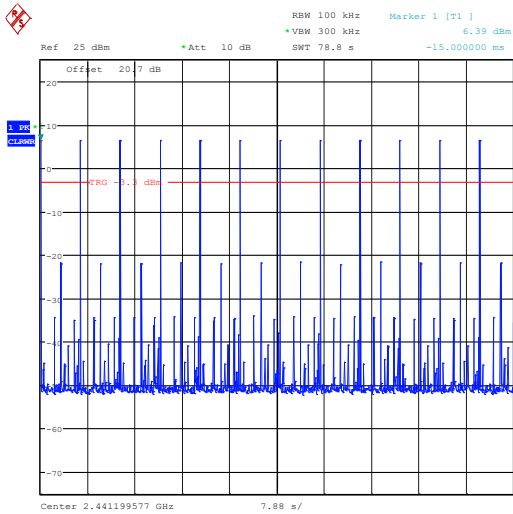
Power setting: Default					
Data Rate	Individual occupancy time (ms)	Observation period (s)	Number of hops observed	Average time of occupancy (s)	Result
1.09kbit/s	33.076	78.8	12.0	0.396912	PASS

Tx On



Date: 13.OCT.2023 13:40:12

Hops observed



Date: 13.OCT.2023 13:45:37

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.

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:	2400.8 MHz/ 2440.8 MHz / 2481.6 MHz – hopping disabled.
EUT Channel Bandwidths:	400 kHz
Deviations from Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW:	3 MHz
Measurement Detector:	Peak
Voltage: 4.5 Vdc	Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

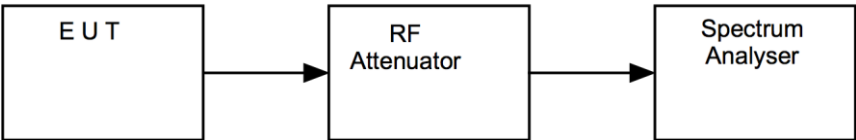
- For frequency hopping systems operating in the band 902 to 928 MHz, the maximum peak conducted output power shall not exceed 1 W, and the e.i.r.p. shall not exceed 4 W, if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W, and the e.i.r.p. 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.

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



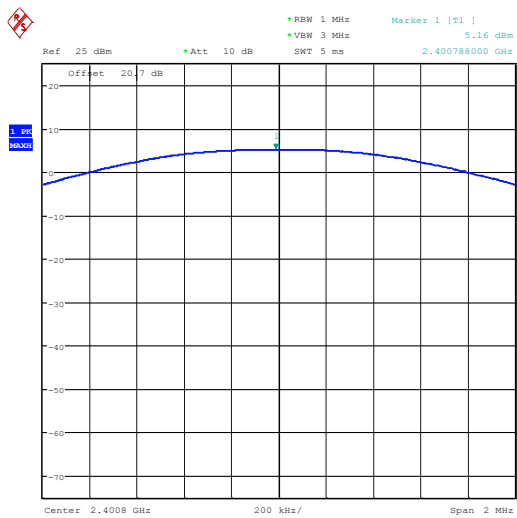
15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2024-01-10
20dB SMA	AtlanTech	Attenuator	U631	Cal in use
IPS 303A	ISO-Tech	Power Supply	U748	Use REF976
34405a	Agilent	Multimeter	REF976	2024-01-24

15.6 Test Results

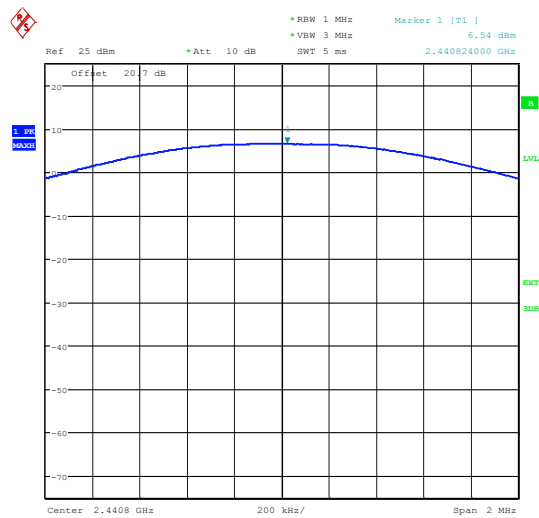
Power setting: Default				
Channel Frequency (MHz)	Analyzer Level (dBm)	Maximum peak conducted output power (W)	Output power Limit (W)	Result
2400.8	5.16	0.0033	1.0	PASS
2440.8	6.54	0.0045	1.0	PASS
2481.6	4.74	0.0030	1.0	PASS

2400.8 MHz



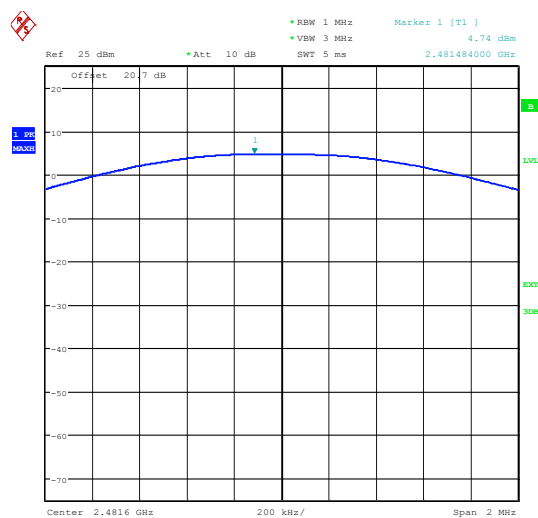
Date: 13.OCT.2023 12:52:51

2440.8 MHz



Date: 13.OCT.2023 12:56:50

2481.6 MHz



Date: 13.OCT.2023 12:55:13

16 Occupied Bandwidth

16.1 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.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
EUT Channels:	2400.8 MHz / 2440.8 MHz / 2481.6 MHz – hopping stopped.
EUT Channel Bandwidths:	400 kHz
EUT Test Modulations:	Chirp Spread Spectrum
Deviations from Standard:	None
Measurement BW:	10 kHz
(requirement: 1 % to 5 % OBW)	
Spectrum Analyzer Video BW:	30 kHz
(requirement at least 3x RBW)	
Measurement Span:	800 kHz
(requirement 2 to 5 times OBW)	
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

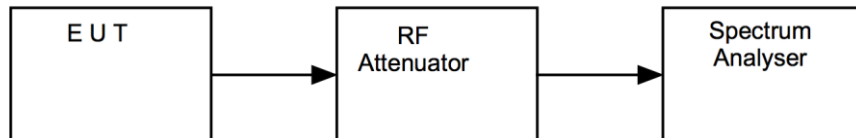
Temperature: 21 °C	+15 °C to +35 °C (as declared)
Humidity: 53 % RH	20 % RH to 75 % RH (as declared)
Supply: 4.5 Vdc	As declared

16.3 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



16.4 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2024-01-10
20dB SMA	AtlanTech	Attenuator	U631	Cal in use
IPS 303A	ISO-Tech	Power Supply	U748	Use REF976
34405a	Agilent	Multimeter	REF976	2024-01-24

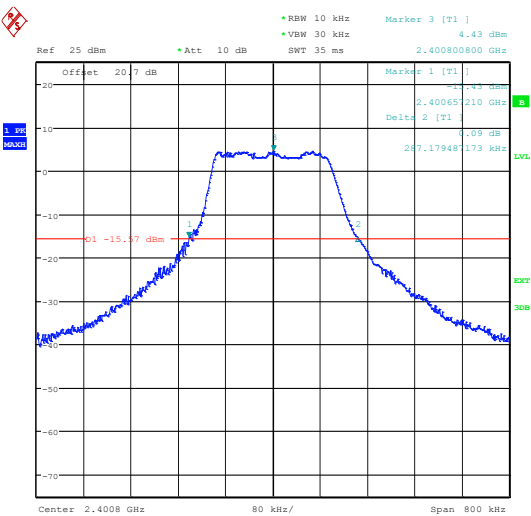
Test Limits

No occupied bandwidth test limit is defined for the 2400 MHz - 2483.5 MHz frequency band, the occupied bandwidth will be dependent on the channel spacing and the number of hopping channels employed, as long as the measured 20 dBc occupied bandwidth falls within the 2400.0 MHz and 2483.5 MHz frequency band.

16.5 Test Results

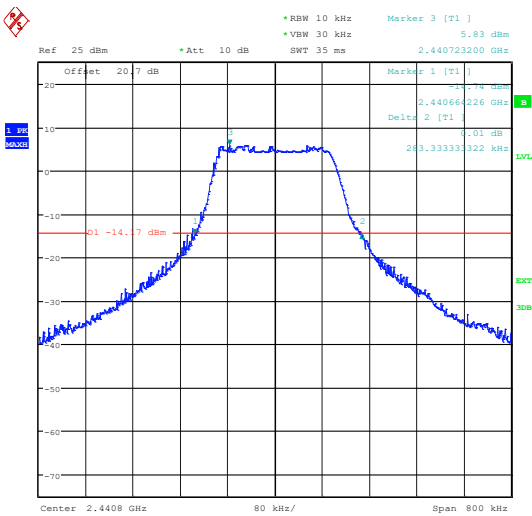
Power setting: default: Data Rate: 1.09 kbit/s				
Channel Frequency (MHz)	F _L (MHz)	F _H (MHz)	20dB Bandwidth (kHz)	Result
2400.8	2400.657210	2400.944389	287.179	PASS
2440.8	2440.664226	2440.947559	283.333	PASS
2481.6	2481.461662	2481.743713	282.051	PASS

2400.8 MHz



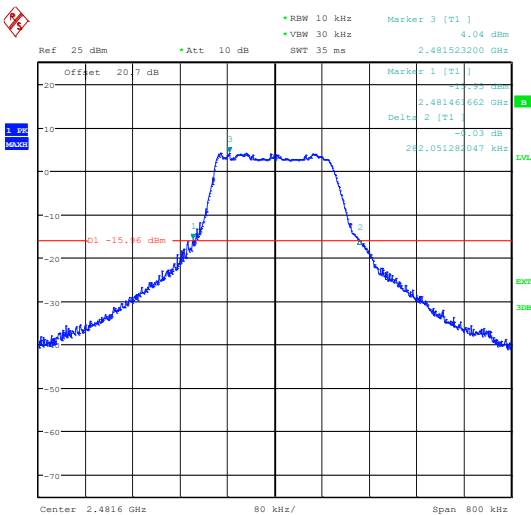
Date: 12.OCT.2023 15:39:55

2440.8 MHz



Date: 12.OCT.2023 15:51:02

2481.6 MHz



Date: 12.OCT.2023 15:55:45

fl = 2400.657210 MHz
fh = 2481.743713 MHz

17 Out-of-band and conducted spurious emissions

17.1 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.

17.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Chamber 03
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
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

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 50% RH	20 % RH to 75 % RH (as declared)
Supply: 4.5 Vdc	

17.3 Test Limits

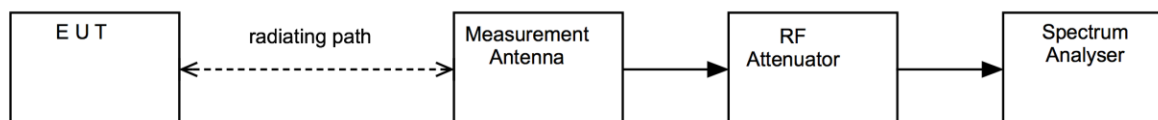
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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) is not required.

17.4 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



17.5 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Last Cal Calibration</i>	<i>Calibration Period</i>	<i>Due For Calibration</i>
Radiated Test Software	Element	Emissions R5	Ref 9000	Cal not required		
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-11-06	24	2023-11-06
Spectrum Analyser	R&S	FSU46	REF910	2023-01-10	12	2024-01-10
EMI Receiver	R&S	ESR7	U456	2023-02-06	12	2024-02-06
Bilog	Chase	CBL611/B	U573	2022-10-14	24	2024-10-14
Pre Amp	AMETEK	LNA6901	U711	2023-04-12	12	2024-04-12
Pre Amp	Agilent	8449B	U457	2023-01-24	12	2024-01-24
1-18GHz Horn	EMCO	3115	L139	2022-07-01	24	2024-07-01
2.4G Band Stop Filter	BSC	SN 4478	U543	2023-02-08	12	2024-02-08
High Pass Filter	Atlantic Microwave	AFH-07000	U558	2023-02-13	12	2024-02-13
Horn Antenna	A Info Inc	LB-180400-25-C-KF	REF2246	2022-09-23	24	2024-09-23

17.6 Test Results

Frequency: 2400.8 MHz; Power Setting: Default; Data Rate: 1.09 kbit/s								
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
No significant emissions within 20 dB of the limit.								

Frequency: 2440.8 MHz; Power Setting: Default; Data Rate: 1.09 kbit/s								
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
No significant emissions within 20 dB of the limit.								

Frequency: 2481.6 MHz; Power Setting: Default; Data Rate: 1.09 kbit/s								
Detector	Freq. (MHz)	Meas'd Emission (dBµV)	Factor (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
No significant emissions within 20 dB of the limit.								

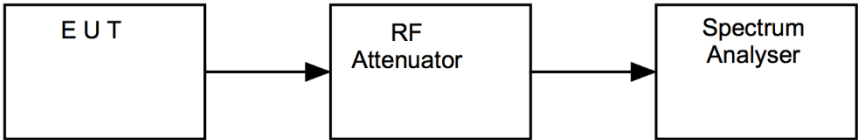
Note: See section 11 for plots

17.7 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

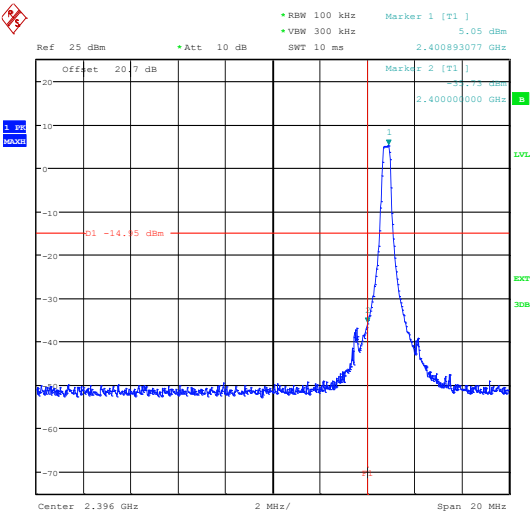


17.8 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2024-01-10
20dB SMA	AtlanTech	Attenuator	U631	Cal in use
IPS 303A	ISO-Tech	Power Supply	U748	Use REF976
34405a	Agilent	Multimeter	REF976	2024-01-24

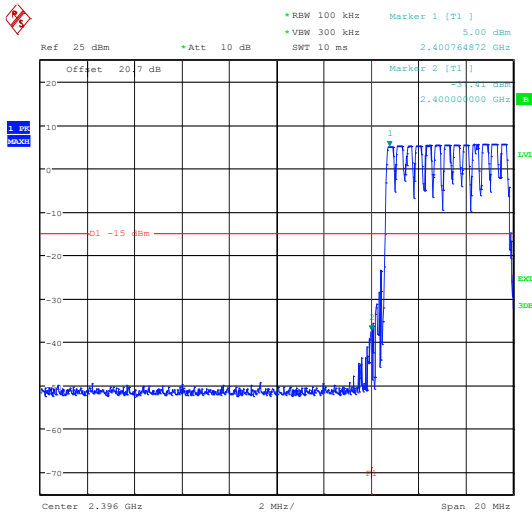
Conducted band edge

Lower band edge single channel



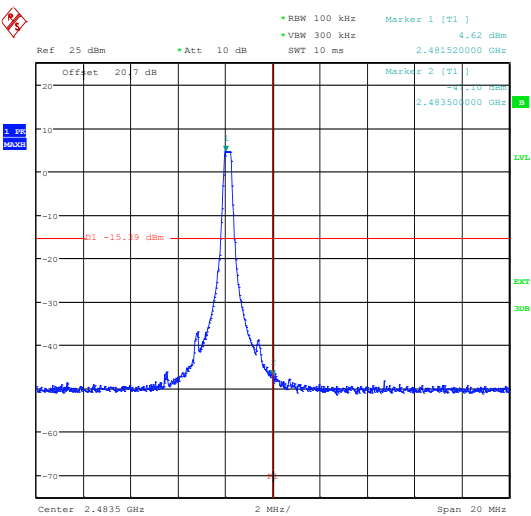
Date: 13.OCT.2023 14:31:38

Lower band edge Hopping all channels



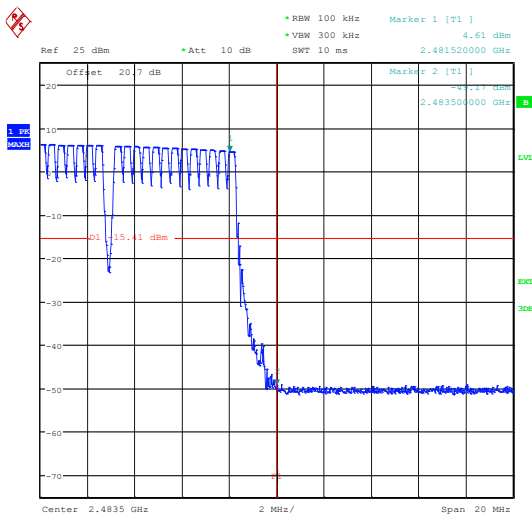
Date: 13.OCT.2023 14:28:17

Upper band edge single channel



Date: 13.OCT.2023 15:08:07

Upper band edge Hopping all channels



Date: 13.OCT.2023 15:32:54

18 Radio Testing – General Uncertainty Schedule

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

Test/Measurement	Budget Number	MU
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connector) Dare RPR3006W Power Head	MU4001	0.9 dB
Carrier Power and PSD - Spectrum Analysers	MU4004	0.9 dB
Adjacent Channel Power	MU4002	1.9 dB
Transmitter conducted spurious emissions	MU4041	0.9 dB
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	2.4 dB
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	2.5 dB
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	2.4 dB
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	3.7 dB
Effective Radiated Power	MU4021	4.7 dB
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	5.3 dB
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	5.1 dB
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	2.7 dB
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	2.7 dB
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz	MU4037	4.7 dB
Radiated Spurious Emissions 1-18 GHz	MU4032	4.5 dB
E Field Emissions 18GHz to 26 GHz	MU4024	3.2 dB
E Field Emissions 26GHz to 40 GHz	MU4025	3.3 dB
E Field Emissions 40GHz to 50 GHz	MU4026	3.5 dB
E Field Emissions 50GHz to 75 GHz	MU4027	3.6 dB
E Field Emissions 75GHz to 110 GHz	MU4028	3.6 dB
Radiated Magnetic Field Emissions	MU4031	2.3 dB
Frequency Measurements		
Frequency Deviation	MU4022	0.316 kHz
Frequency error using CMTA test set	MU4023	113.441 Hz
Frequency error using GPS locked frequency source	MU4045	0.0413 ppm
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	3.87 %
Transmitter Mask Amplitude	MU4039	1.3 dB
Transmitter Mask Frequency	MU4040	2.59 %
Time Domain Measurements		
Transmission Time	MU4038	4.40 %
Dynamic Frequency Selection (DFS) Parameters)		
DFS Analyser - Measurement Time	MU4006	679 µs
DFS Generator - Frequency Error	MU4007	92 Hz
DFS Threshold Conducted	MU4008	1.3 dB
DFS Threshold Radiated	MU4009	3.2 dB

Test/Measurement	Budget Number	MU
Receiver Parameters		
EN300328 Receiver Blocking	MU4010	1.1 dB
EN301893 Receiver Blocking	MU4011	1.1 dB
EN303340 Adjacent Channel Selectivity	MU4012	1.1 dB
EN303340 Overloading	MU4013	1.1 dB
EN303340 Receiver Blocking	MU4014	1.1 dB
EN303340 Receiver Sensitivity	MU4015	0.9 dB
EN303372-1 Image Rejection	MU4016	1.4 dB
EN303372-1 Receiver Blocking	MU4017	1.1 dB
EN303372-2 Adjacent Channel Selectivity	MU4018	1.1 dB
EN303372-2 Dynamic Range	MU4019	0.9 dB
Receiver Blocking Talk Mode Conducted	MU4033	1.2 dB
Receiver Blocking Talk Mode- radiated	MU4034	3.4 dB
Rx Blocking, listen mode, blocking level	MU4035	3.2 dB
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	3.4 dB
Adjacent Sub Band Selectivity	MU4003	4.2 dB