Report on the Radio Testing

For

Chiaro Technology Limited

on

Elvie Pump

Report no. TRA-056398-47-01B

2021-11-22

Report Number: TRA-056398-47-01B
Issue: B

REPORT ON THE RADIO TESTING OF A
Chiaro Technology Limited
Elvie Pump
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2021-11-01 to 2021-11-05

Tested by:		Steven Garwell, Michael Else
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Date:	2021-11-22	

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2021-11-22	Original
B	2021-11-30	General Updates

2 Summary

TEST REPORT NUMBER:	TRA-056398-47-01B
WORKS ORDER NUMBER:	TRA-056398-00
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	Elvie Pump
FCC IDENTIFIER:	2AEHI-EP0121
EUT SERIAL NUMBER:	ST-41
MANUFACTURER/AGENT:	Chiaro Technology Limited
ADDRESS:	2nd Floor 63-66 Hatton Garden London EC1N 8LE United Kingdom
CLIENT CONTACT:	Shiva Golchi ☎ +44 (0)203 745 5201 ✉ shiva.golchi@chiaro.co.uk
ORDER NUMBER:	PO0124733
TEST DATE:	2021-11-01 to 2021-11-05
TESTED BY:	Steven Garwell, Michael Else 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)		15.247 (d)	☒	*Pass*
AC power line conducted emissions		15.207	☐	*Note 1*
Occupied bandwidth		15.247 (a) (2)	☒	*Pass*
Conducted carrier power	Peak	15.247 (b) (3)	☒	*Pass*
	Max.		☐	
Out of band emissions		15.247 (d)	☒	*Pass*
Power spectral density		15.247 (e)	☒	*Pass*
Calculation of duty correction		-	☒	*Pass*

Specific Note:

1. The EUT is a battery powered device / The EUT has got a rechargeable battery, but as per client's declaration, it doesn't transmit while charging.

General Notes:

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

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

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

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4 Introduction

This report TRA-056398-47-01B presents the results of the Radio testing on a Chiaro Technology Limited, Elvie Pump to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Chiaro Technology Limited 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
Skemersdale
West Lancashire
WN8 9PN
UK

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

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

Throughout this report EUT denotes equipment under test.

FCC Site Listing:
The test laboratory is accredited for the above sites under the 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: Elvie Pump
- Serial Number: ST-41
- Model Number: EP01
- Software Revision: bt-cert v8.0.0
- Build Level / Revision Number: V2.01 (main board), V6.1.1 (driver board), V4.1.0 (UI board), V2.01 (IR board)

7.2 System Equipment

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

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

The mode of operation for transmitter test's where as follows:

The EUT was transmitting a modulated carrier on the frequencies as indicated. This was selectable by pressing buttons on the control pad and the correct mode of operation was indicated via a flashing LED.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2402 MHz to 2480 MHz
Modulation type:	GFSK
Occupied channel bandwidth:	2 MHz
Channel spacing:	2 MHz
Declared output power:	≤ 3 dBm
Nominal Supply Voltage:	3.7 Vdc

7.4.2 Antennas

Type:	Integral (Pulse Larsen – W3008)
Gain:	1.1 dBi

7.5 EUT Description

The EUT is an electric breast pump containing a BLE radio.

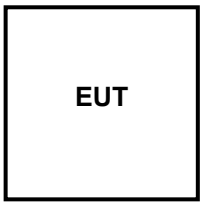
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

The following diagram shows basic EUT interconnections:
The EUT has got a rechargeable battery, but as per client's declaration, it doesn't transmit while charging.



9.2 General Set-up Photograph

The following photograph illustrates 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: Revision 2021.09.09.0
Element Transmitter Bench Test
ETS Lindgren EMPower V1.0.4.

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.7 Vdc from an internal Lithium battery.

11 Radiated emissions

11.1 Definitions

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

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

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber SK01
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
Deviations from Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak; Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 19.4 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47.4 % RH	20 % RH to 75 % RH (as declared)
Supply 3.7 Vdc	3.7 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:

$$FS = PR + CL + AF – PA + DC – CF$$

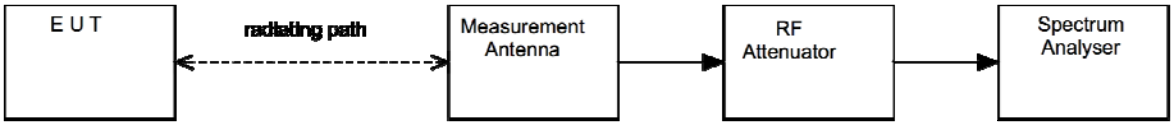
$$Factor = CL + AF – PA$$

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

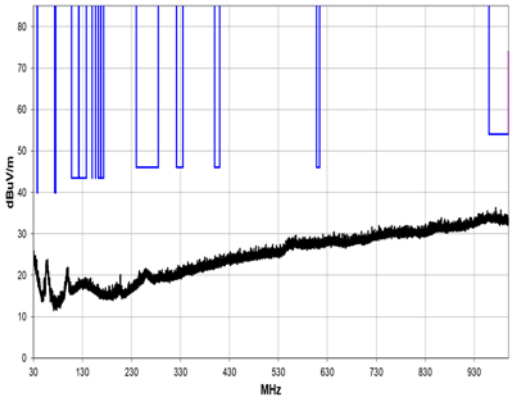


11.5 Test Equipment

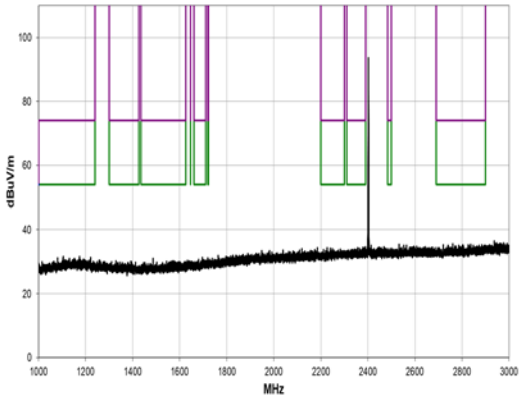
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	ESR 7	U727	2022-03-30
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
1-18GHz Horn	EMCO	3115	L139	2023-07-27
Pre Amp	Agilent	8449B	U457	2022-02-02
Bilog	Chase	CBL611/B	U573	2023-01-28
PreAmp	Watkins Johnson	6201-69	U372	2022-03-01
2.4G Band Stop Filter	BSC	SN 4478	U543	2022-01-30
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09
Horn 18-26GHz (&U330)	Flann	20240-20	L300	2022-04-23
High Pass Filter	Atlantic Microwave	AFH-07000	U558	2022-01-30

11.6 Test Results

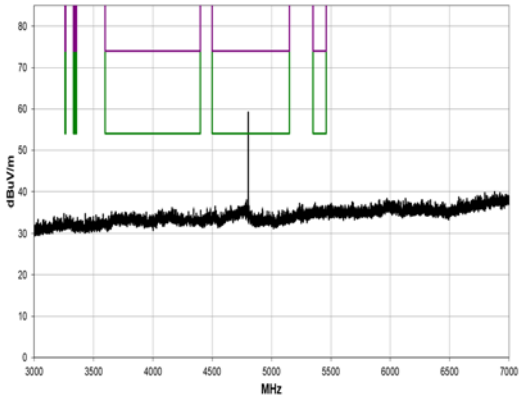
Bottom Channel 2402 MHz



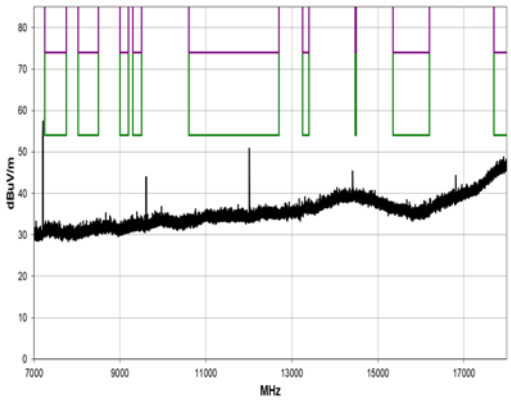
30 MHz to 1 GHz



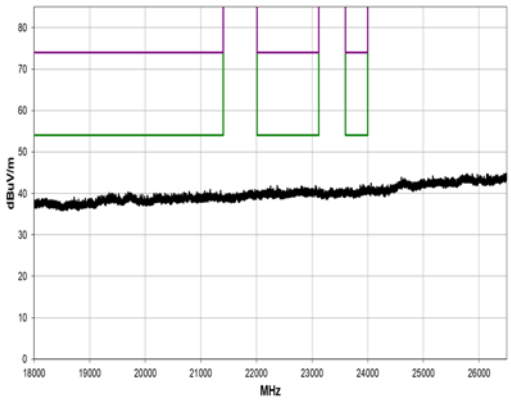
1 GHz to 3 GHz



3 GHz to 7 GHz



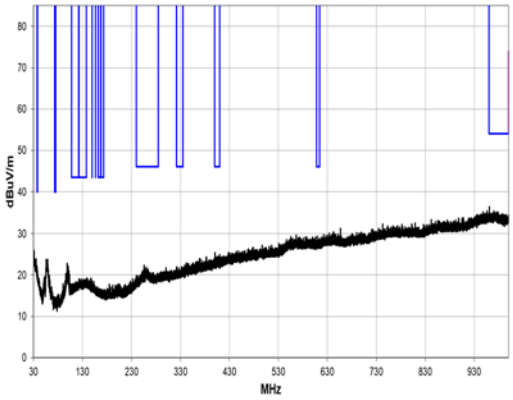
7 GHz to 18 GHz



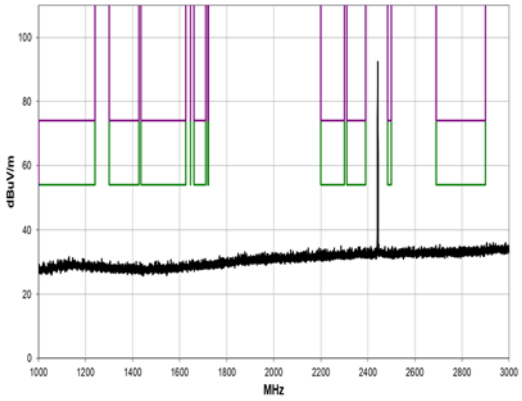
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
4804.117	47.4	2.2	1.1	102.9	3.6	0.0	Horz	AV	0.0	53.2	54.0	-0.8
4804.075	45.4	2.2	1.28	240.9	3.6	0.0	Vert	AV	0.0	51.2	54.0	-2.8
4803.725	62.1	2.2	1.1	102.9		0.0	Horz	PK	0.0	64.3	74.0	-9.7
4803.583	59.5	2.2	1.28	240.9		0.0	Vert	PK	0.0	61.7	74.0	-12.3
12009.580	38.3	11.4	1.61	331.0	3.8	0.0	Vert	AV	-9.5	44.0	54.0	-10.0
12009.580	37.6	11.4	1.59	190.1	3.6	0.0	Horz	AV	-9.5	43.1	54.0	-10.9
12009.050	56.6	11.4	1.61	331.0		0.0	Vert	PK	-9.5	58.5	74.0	-15.5
12009.100	55.5	11.4	1.59	190.1		0.0	Horz	PK	-9.5	57.4	74.0	-16.6

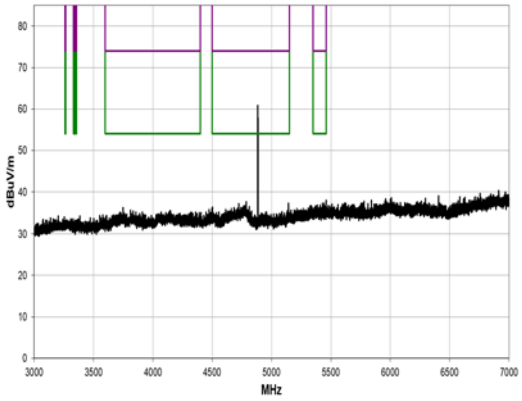
Middle Channel 2442 MHz



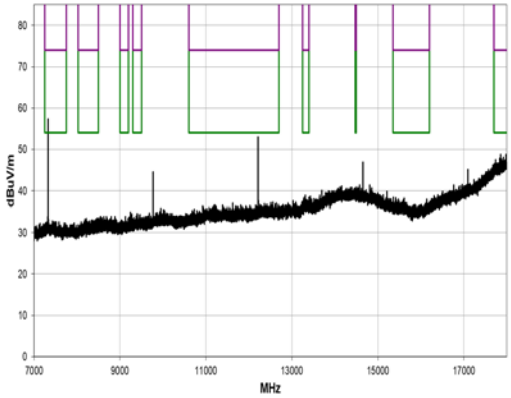
30 MHz to 1 GHz



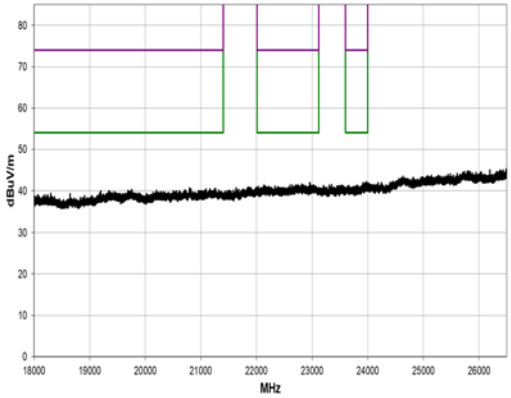
1 GHz to 3 GHz



3 GHz to 7 GHz



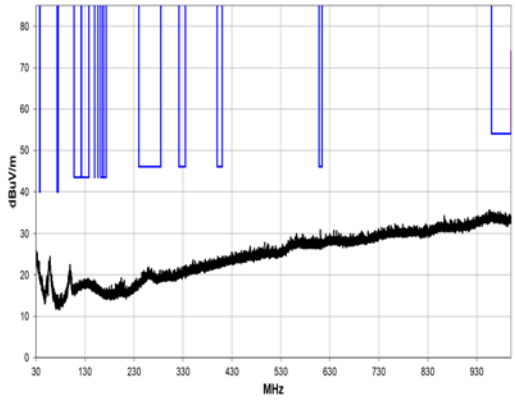
7 GHz to 18 GHz



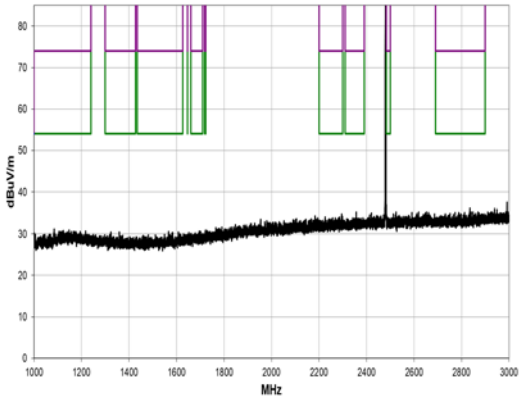
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
7326.175	45.9	7.6	1.43	347.0	3.6	0.0	Vert	AV	-9.5	47.6	54.0	-6.4
12209.600	39.3	11.6	1.68	145.1	3.6	0.0	Horz	AV	-9.5	45.0	54.0	-9.0
7326.192	42.0	7.6	1.67	339.0	3.6	0.0	Horz	AV	-9.5	43.7	54.0	-10.3
7325.442	63.0	7.6	1.43	347.0		0.0	Vert	PK	-9.5	61.1	74.0	-12.9
12209.350	37.9	11.6	1.64	197.0	3.6	0.0	Vert	AV	-9.5	43.6	54.0	-10.4
12209.540	57.6	11.6	1.68	145.1		0.0	Horz	PK	-9.5	59.7	74.0	-14.3
12209.230	55.6	11.6	1.64	197.0		0.0	Vert	PK	-9.5	57.7	74.0	-16.3
7325.500	58.2	7.6	1.67	339.0		0.0	Horz	PK	-9.5	56.3	74.0	-17.7

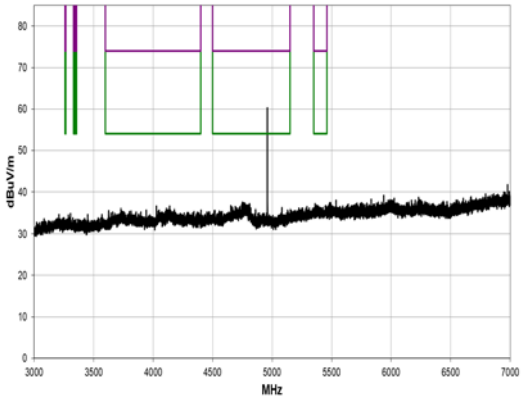
Top Channel 2480 MHz



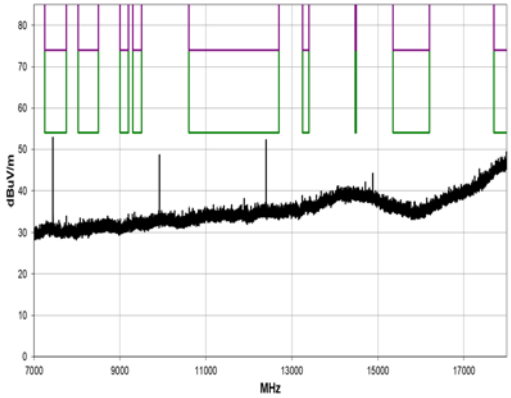
30 MHz to 1 GHz



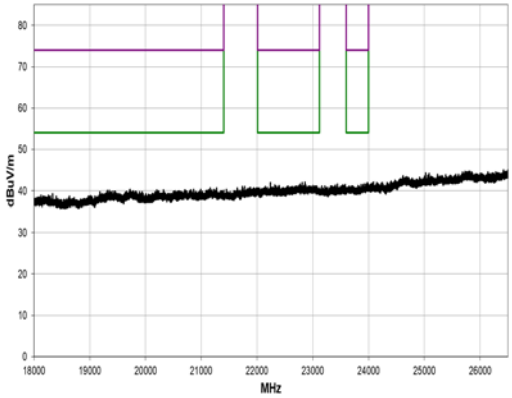
1 GHz to 3 GHz



3 GHz to 7 GHz



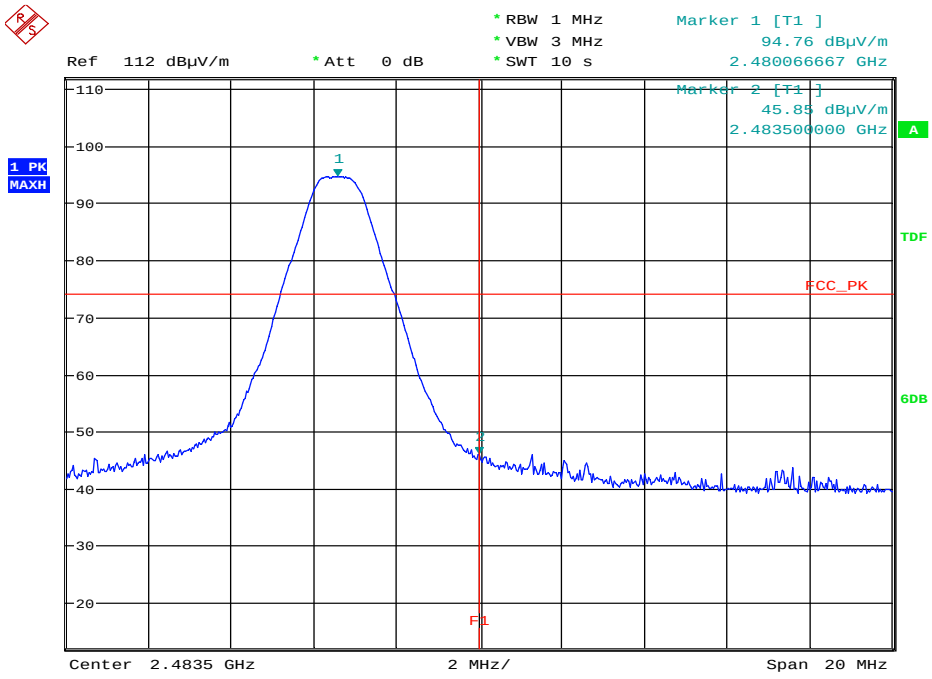
7 GHz to 18 GHz



18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	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)
7440.175	44.4	7.6	1.48	347.9	3.6	0.0	Vert	AV	-9.5	46.1	54.0	-7.9
12399.620	38.0	12.0	1.59	223.1	3.6	0.0	Horz	AV	-9.5	44.1	54.0	-9.9
7440.175	40.3	7.6	1.58	43.0	3.6	0.0	Horz	AV	-9.5	42.0	54.0	-12.0
12399.350	37.4	12.0	1.6	140.0	3.6	0.0	Vert	AV	-9.5	43.5	54.0	-10.5
7439.475	61.4	7.6	1.48	347.9		0.0	Vert	PK	-9.5	59.5	74.0	-14.5
12399.070	55.8	12.0	1.59	223.1		0.0	Horz	PK	-9.5	58.3	74.0	-15.7
12401.580	55.0	12.0	1.6	140.0		0.0	Vert	PK	-9.5	57.5	74.0	-16.5
7439.708	56.4	7.6	1.58	43.0		0.0	Horz	PK	-9.5	54.5	74.0	-19.5

Radiated Band Edge – Peak



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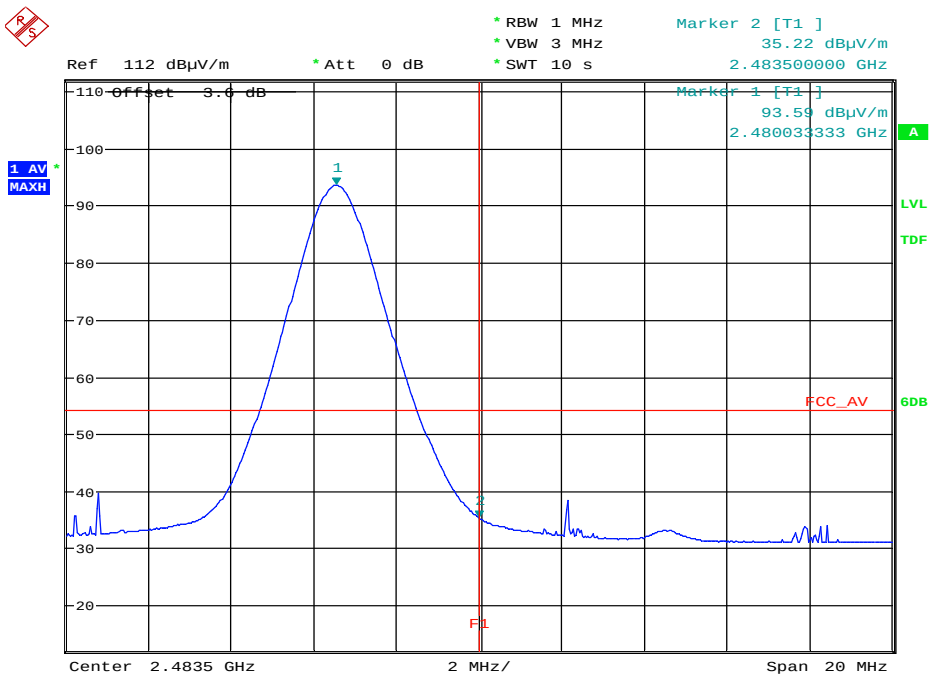
Radiated Band Edge – Average



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12 Occupied Bandwidth

12.1 Definition

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

The 99% emission bandwidth is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
EUT Test Modulations:	GFSK
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

12.3 Test Limit

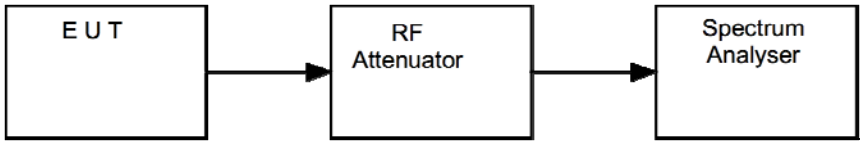
The minimum -6 dB bandwidth shall be at least 500 kHz.

12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

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

Figure iii Test Setup

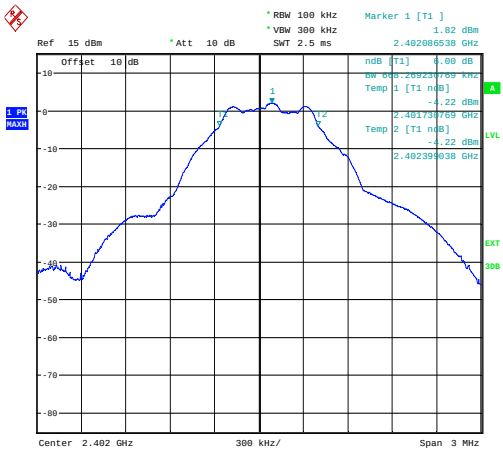


12.5 Test Equipment

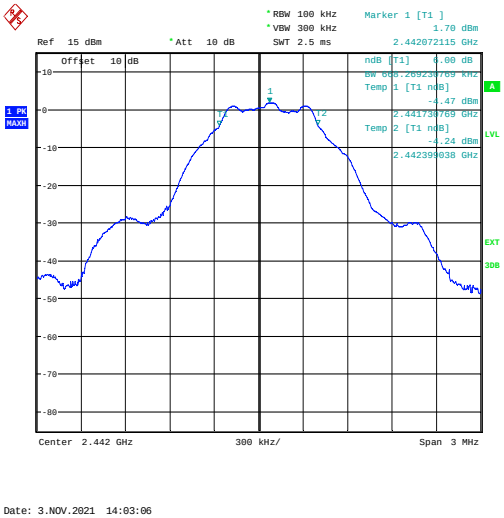
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

12.6 Test Results

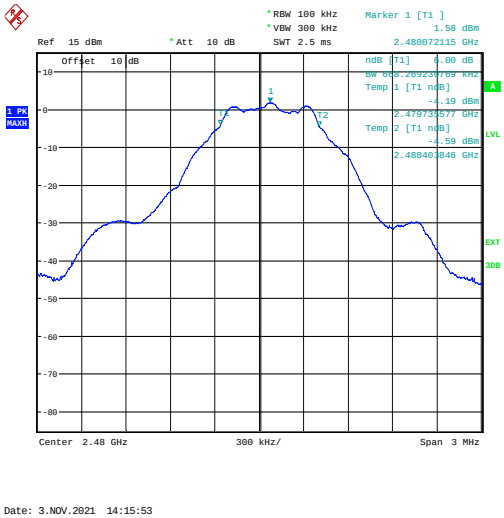
Bandwidth Type: 6 dB; Modulation: GFSK; Data rate: 1 Mbps; Power setting: 3 dBm				
Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**Bandwidth (kHz)**	**Result**
2402	2401.730769	2402.399038	668.269	Pass
2442	2441.730769	2442.399038	668.269	Pass
2480	2479.735577	2480.403846	668.269	Pass



2402 MHz



2442 MHz



2480 MHz

13 Maximum peak conducted output power

13.1 Definition

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

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

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

13.3 Test Limit

FCC:

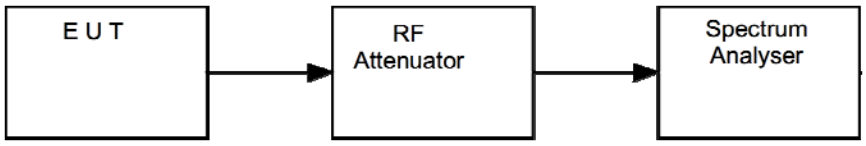
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

13.4 Test Method

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

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

Figure iv Test Setup

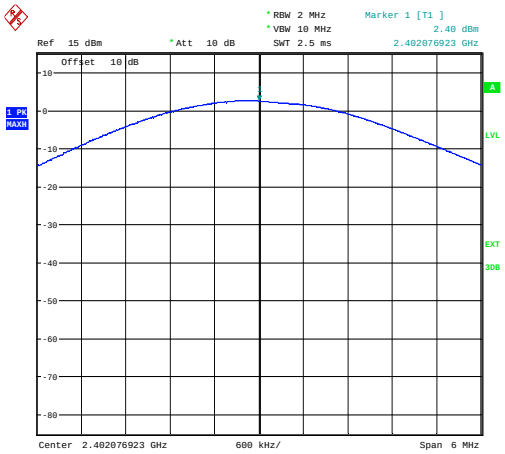


13.5 Test Equipment

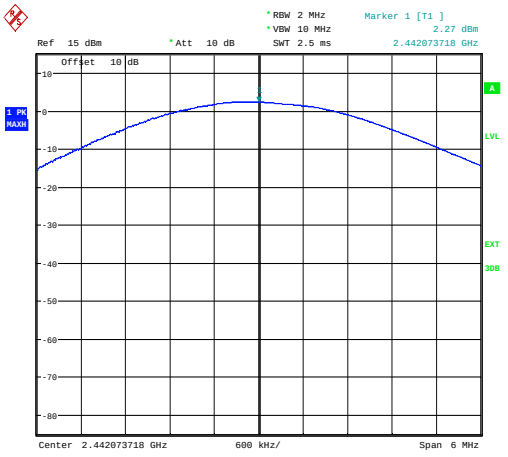
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

13.6 Test Results

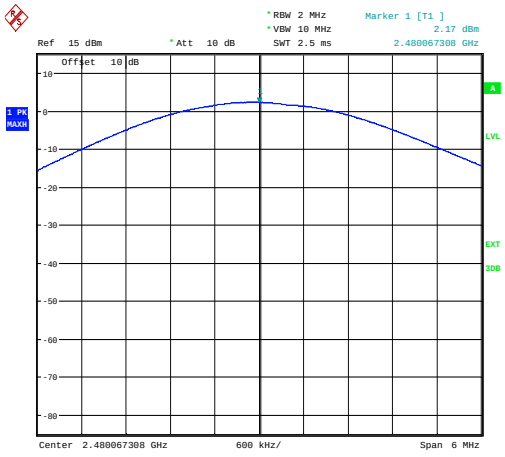
Modulation: GFSK; Data rate: 1 Mbps; Power setting: 3 dBm					
Channel Frequency (MHz)	***Maximum peak conducted output power (dBm)***	***Antenna gain (dBi)***	***E.I.R.P. (dBm)***	***E.I.R.P (W)***	***Result***
2402.00	2.40	1.1	3.50	0.0022	Pass
2442.00	2.27	1.1	3.37	0.0022	Pass
2480.00	2.17	1.1	3.27	0.0021	Pass



2402 MHz



2442 MHz



2480 MHz

14 Out-of-band and conducted spurious emissions

14.1 Definition

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

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

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

14.3 Test Limit

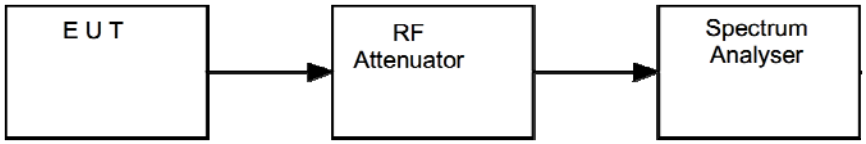
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

14.4 Test Method

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

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

Figure v Test Setup

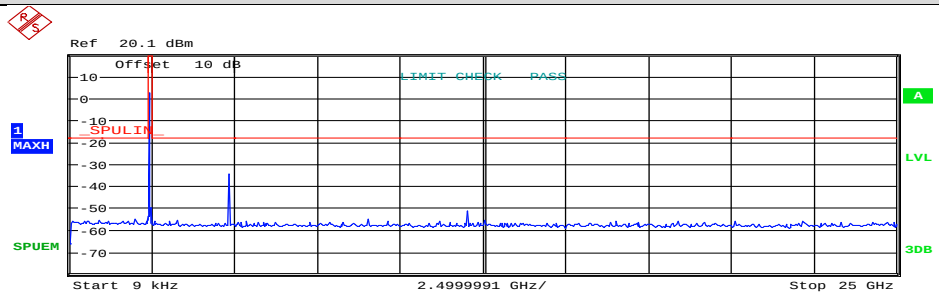


14.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

14.6 Test Results

BLE1: Frequency: 2402 MHz; Bandwidth: 1 MHz; Power setting: 3 dBm



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	124.918269 k	-76.48	-58.81
150.000 k	30.000 M	10.00 k	839.535000 k	-66.41	-48.74
30.000 M	1.000 G	100.00 k	867.595000 M	-55.94	-38.27
1.000 G	2.400 G	100.00 k	2.399720 G	-53.86	-36.19
2.400 G	2.483 G	2.00 M	2.401946 G	2.28	-17.72
2.483 G	5.000 G	100.00 k	4.803713 G	-34.59	-16.92
5.000 G	10.000 G	100.00 k	8.999500 G	-55.03	-37.36
10.000 G	15.000 G	100.00 k	12.011500 G	-51.47	-33.80
15.000 G	20.000 G	100.00 k	18.386500 G	-55.96	-38.29
20.000 G	25.000 G	100.00 k	22.171000 G	-56.01	-38.34

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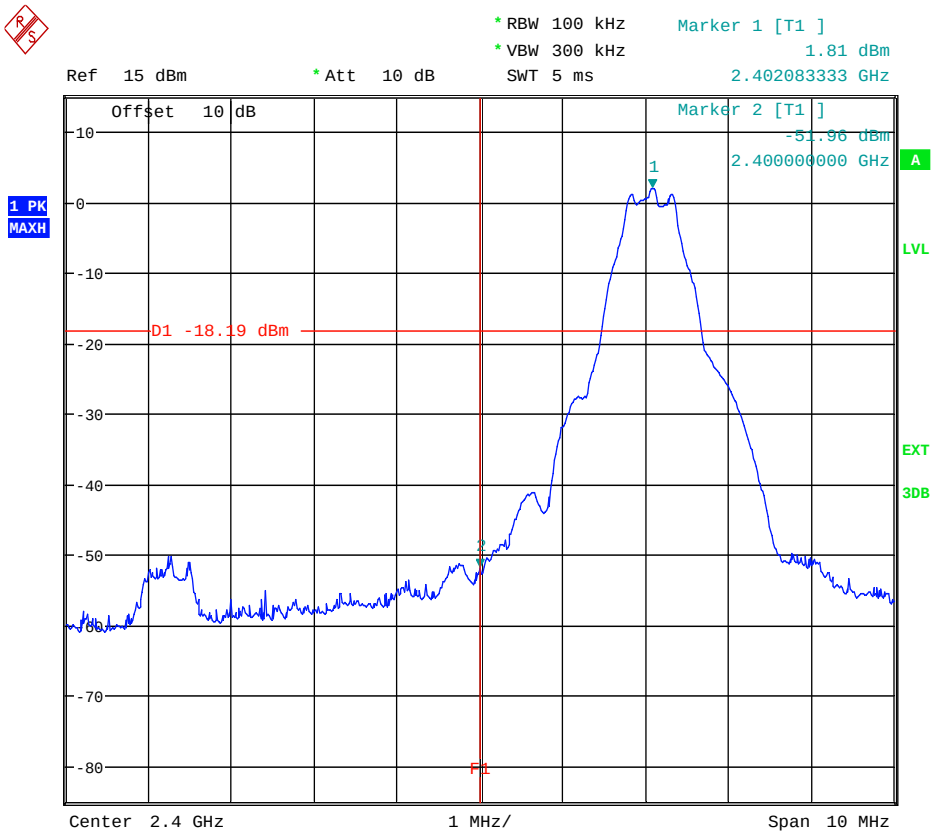

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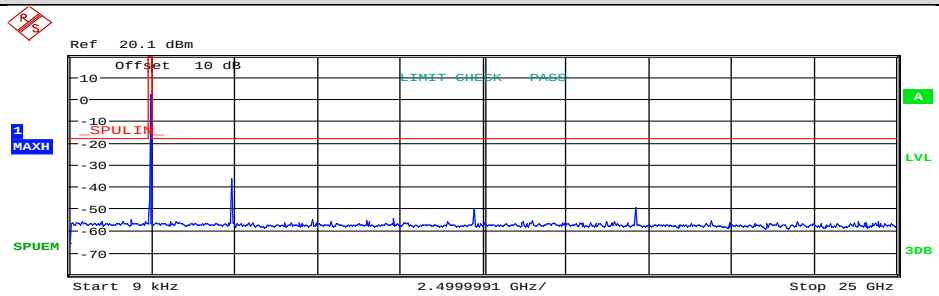
BLE1: Frequency: 2442 MHz; Bandwidth: 1 MHz; Power setting: 3 dBm



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	59.389423 k	-76.11	-58.44
150.000 k	30.000 M	10.00 k	9.663195 M	-65.85	-48.18
30.000 M	1.000 G	100.00 k	367.754000 M	-56.08	-38.41
1.000 G	2.400 G	100.00 k	1.833280 G	-55.20	-37.53
2.400 G	2.483 G	2.00 M	2.441909 G	2.19	-17.81
2.483 G	5.000 G	100.00 k	4.883738 G	-36.51	-18.84
5.000 G	10.000 G	100.00 k	9.769500 G	-54.96	-37.29
10.000 G	15.000 G	100.00 k	12.209000 G	-50.10	-32.43
15.000 G	20.000 G	100.00 k	17.096000 G	-49.59	-31.92
20.000 G	25.000 G	100.00 k	22.002500 G	-55.98	-38.31

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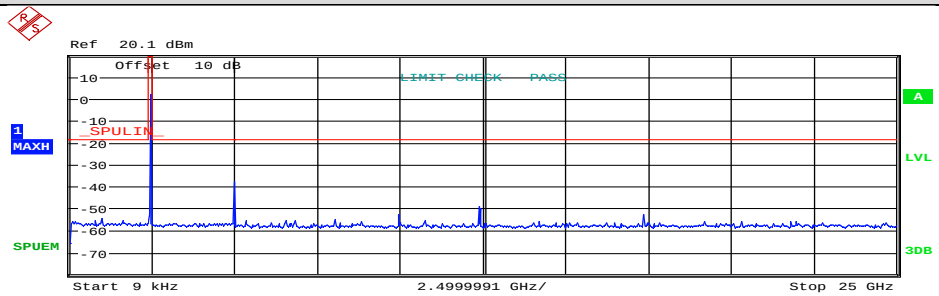
BLE1: Frequency: 2480 MHz; Bandwidth: 1 MHz; Power setting: 3 dBm



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	16.230769 k	-77.12	-59.10
150.000 k	30.000 M	10.00 k	2.161890 M	-66.03	-48.01
30.000 M	1.000 G	100.00 k	953.828000 M	-54.81	-36.62
1.000 G	2.400 G	100.00 k	1.602700 G	-55.92	-37.90
2.400 G	2.483 G	2.00 M	2.480001 G	1.98	-18.02
2.483 G	5.000 G	100.00 k	4.960743 G	-37.74	-19.72
5.000 G	10.000 G	100.00 k	9.921500 G	-52.77	-34.75
10.000 G	15.000 G	100.00 k	12.399000 G	-49.33	-31.31
15.000 G	20.000 G	100.00 k	17.359000 G	-53.05	-35.03
20.000 G	25.000 G	100.00 k	21.970000 G	-56.16	-38.14

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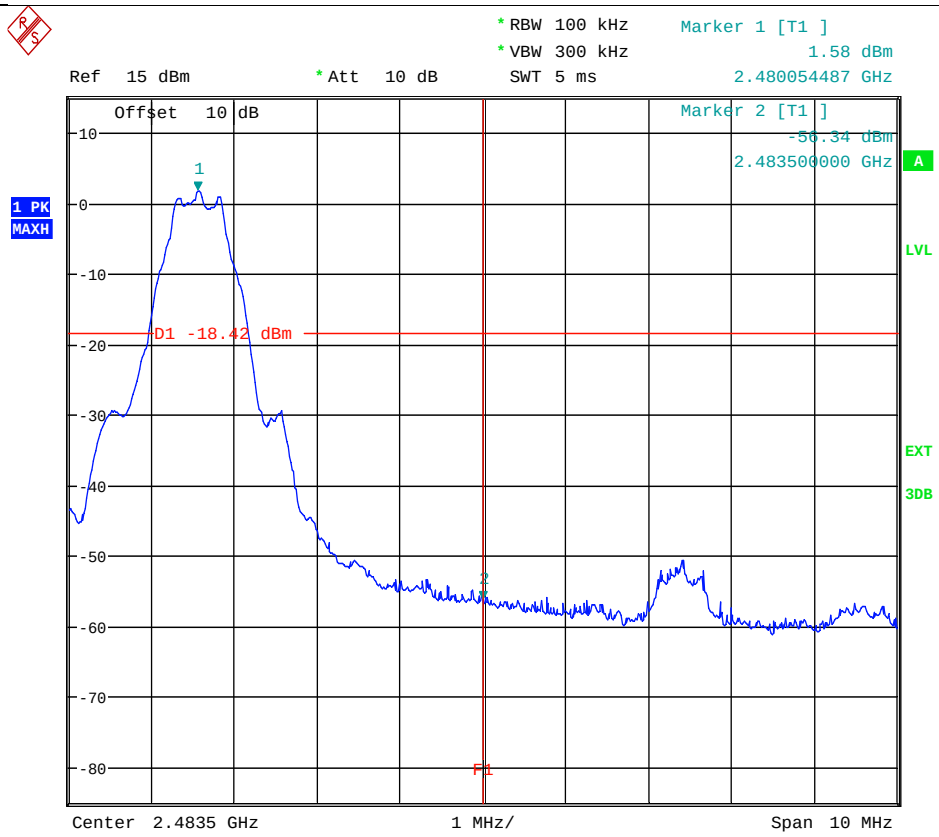

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15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	30 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	100 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1.1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 V dc	3.7 Vdc (as declared)

15.3 Test Limit

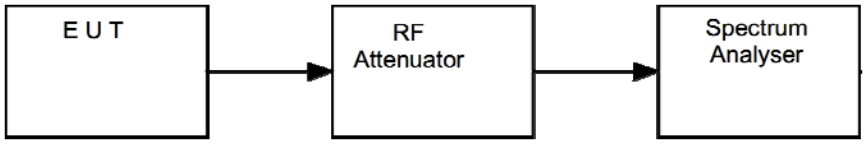
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 Test Method

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

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

Figure vi Test Setup

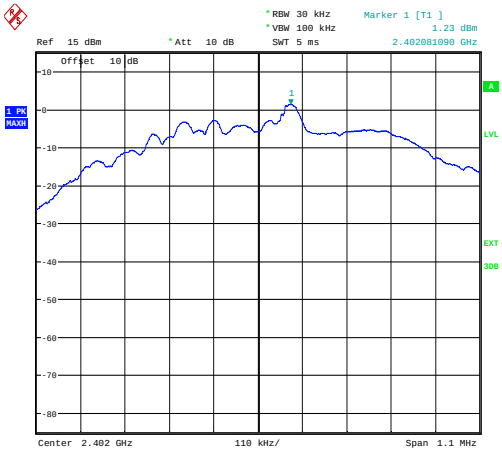


15.5 Test Equipment

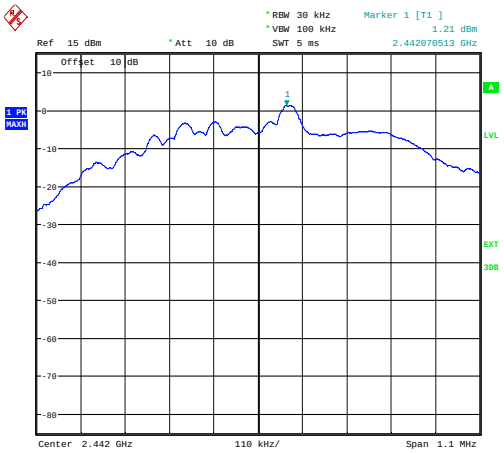
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

15.6 Test Results

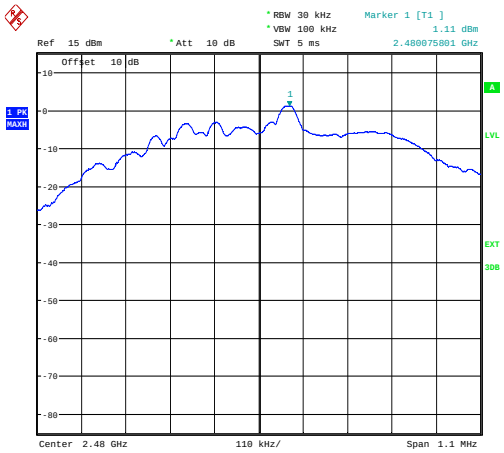
Modulation: GFSK; Data rate: 1 Mbps; Power setting: 3 dBm				
Channel Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Power (dBm)***	***Result***
2402	1.23	0.0	1.23	Pass
2442	1.21	0.0	1.21	Pass
2480	1.11	0.0	1.11	Pass



2402 MHz



2442 MHz



2480 MHz

16 Duty Cycle

16.1 Definition

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

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	SK03 Radio Chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.6
EUT Frequencies Measured:	2442 MHz
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 19 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)

16.3 Test Limit

N/A.

16.4 Test Method

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

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

[1] Single antenna output devices

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

[2] Multiple antenna output devices

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

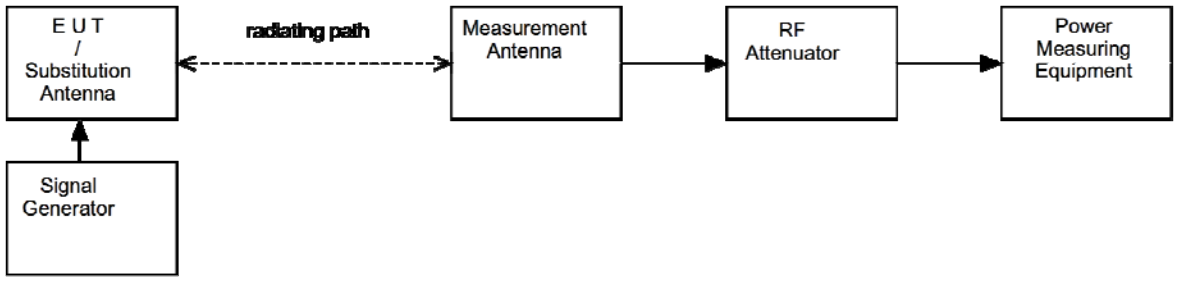
The duty cycle correction factor, DC, shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as:

1) If power averaging (rms) mode was used in step f), then the applicable correction factor is [10 log (1 / *D*)], where *D* is the duty cycle.

2) If linear voltage averaging mode was used in step f), then the applicable correction factor is [20 log (1 / *D*)], where *D* is the duty cycle.

3) If a specific emission is demonstrated to be continuous (*D* ≥ 98%) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Figure vii Test Setup

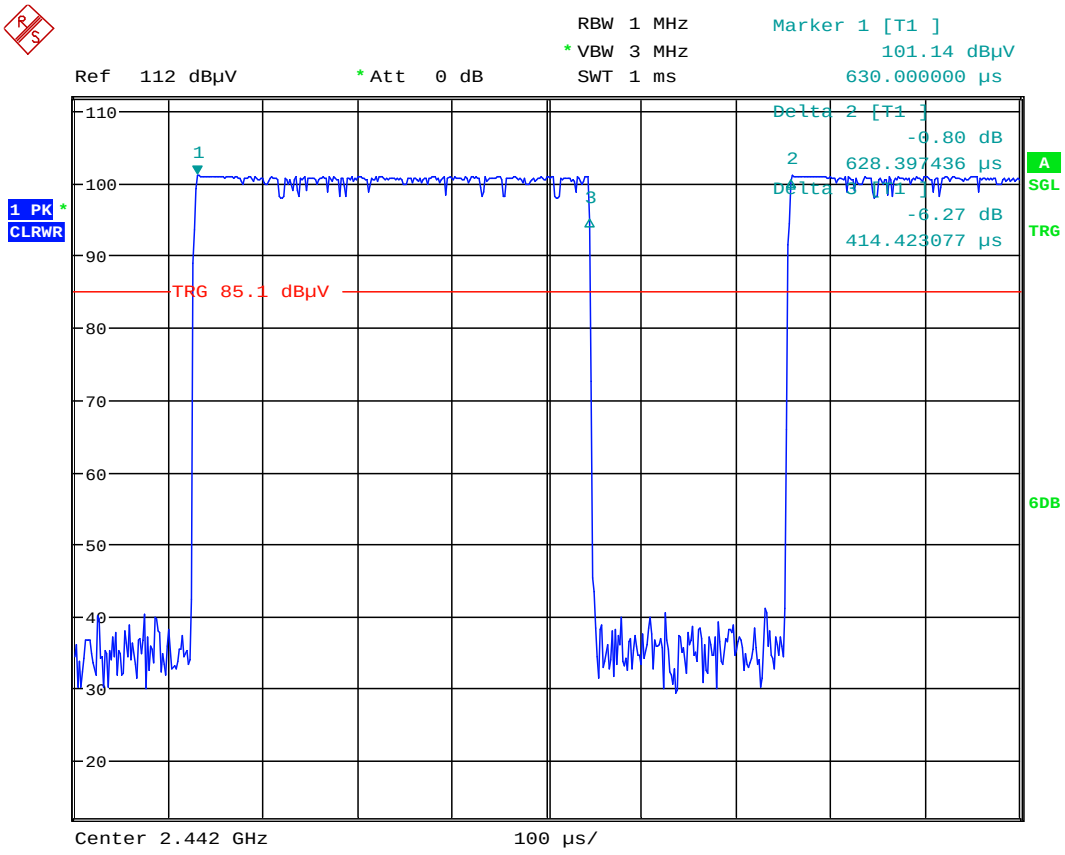


16.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2021-11-18
1-18GHz Horn	EMCO	3115	L139	2023-07-27
Pre Amp	Agilent	8449B	U457	2022-02-02
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

16.6 Test Results

Frequency: 2442 MHz; Modulation: GFSK; Data rate: 1 Mbps				
Test Environment		Total TxOn time (µs)	Frame Period (us)	Calculated Factor (dB)
$V_{nominal}$	$T_{nominal}$	414.423077	628.397436	3.6



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17 Measurement Uncertainty

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 connecter) 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**

18 General SAR test reduction & exclusion guidance

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

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

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

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

Where,

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)
TSD_A = Minimum Test separation distance or 50 mm (whichever is lower)
f_{GHz} = Transmit frequency in GHz

Channel Frequency (MHz)	***Maximum Conducted Power (mW)***	***SAR Exclusion Threshold at 5 mm (mW)***	***SAR Evaluation***
2402	1.7	9.7	Not Required
2440	1.7	9.6	Not Required
2480	1.6	9.5	Not Required

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