Report on the Radio Testing

For

SmartSentry Ltd

on

Smart Pod 3

Report no. TRA-053699-47-00A

31 March 2021

Report Number: TRA-053699-47-00A
Issue: A

REPORT ON THE RADIO TESTING OF A
SmartSentry Ltd
Smart Pod 3
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247\ ISED RSS-247

TEST DATE: 1st March - 11th March 2021

Tested by: Steven Hodgkinson

Written by: Steven Hodgkinson
Radio Test Engineer

Digitally signed by Steven Hodgkinson
DN: cn=Steven Hodgkinson, o=Element Materials Technology Ltd, ou, email=steven.hodgkinson@element.com, c=GB
Reason: I am the author of this document
Date: 2021.03.31 15:25:18 +01'00'

Approved by: J Charters
Laboratory Manager

Digitally signed by John Charters
DN: cn=John Charters, o, ou=Element Materials Technology Ltd., email=john.charters@element.com, c=GB
Reason: I am approving this document
Date: 2021.03.31 15:23:21 +01'00'

Date: 31 March 2021

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	31 March 2021	Original

2 Summary

TEST REPORT NUMBER:	TRA-053699-47-00A
WORKS ORDER NUMBER:	TRA-053699-01
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR15.247 RSS-247
EQUIPMENT UNDER TEST (EUT):	Smart Pod 3
FCC IDENTIFIER:	2AYVU-POD1
ISED IDENTIFIER:	26965-POD1
EUT SERIAL NUMBER:	1/2
MANUFACTURER/AGENT:	SmartSentry Ltd
ADDRESS:	1A Grasmere Gardens Machins Industrial Estate Gotham Nottingham NG11 0JD United Kingdom
CLIENT CONTACT:	Mike Gardner ☎ 0115 846 3130 ✉ mike.gardner@smartsentry.co.uk
TEST DATE:	1st March - 11th March 2021
TESTED BY:	Steven Hodgkinson Element

2.1 Test Summary (Section 1 DTS Mode).

Test Method and Description		*Requirement Clause 47CFR15*	*Requirement Clause RSS*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.247 (d)	247, 3.3	☒	*Pass*
AC power line conducted emissions		15.207	Gen, 8.8	☐	*Note 1*
Occupied bandwidth		15.247 (a) (2)	247, 5.2 (a)	☒	*Pass*
Conducted carrier power	Peak	15.247 (b) (3)	247, 5.4 (d)	☒	*Pass*
	Max.			☐	
Out of band emissions		15.247 (d)	247, 5.5	☒	*Pass*
Power spectral density		15.247 (e)	247, 5.2 (b)	☒	*Pass*
Calculation of duty correction		-	15.35 (c)	☐	*Note 2*

Specific Note:

1. The EUT is a battery powered device
2. The EUT was transmitting 100% in test modes provided by the client.
3. The equipment under test operates in the following modes LoRa, and LoRaWan
4. The equipment under test, as declared by the client is a hybrid device.
   KDB 558074 D01 15.247 Meas guidance v05r02, section 10 Hybrid System Equipment Under Section 15.247 was used for guidance, to cover the additional requirements for FHSS operation.
5. Section 1 of this test report covers the DTS requirement, as the equipment uses 500 kHz Bandwidth, section 2 of this test report covers the frequency hopping requirements (125 kHz bandwidth).

2.2 Test Summary (Section 2 FHSS Mode).

Test Method and Description	*Requirement Clause 47CFR15*	*Requirement Clause RSS*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)	15.247(d)	247, 3.3	☒	*Pass*
AC power line conducted emissions	15.207	Gen, 8.8	☐	*Note 1*
Carrier frequency separation	15.247 (a) (1)	247, 5.1 (b)	☒	*Pass*
Number of hopping channels	15.247 (a) (1) (i), (ii) and (iii)	247, 5.1 (c), (d) and (e)	☒	*Pass* *Note 2*
Average time of occupancy	15.247 (a) (1) (i), (ii) and (iii)	247, 5.1 (c), (d) and (e)	☒	*Pass*
Maximum peak conducted output power	15.247 (a) (1), (b)(1) and (b)(2)	247, 5.4 (a), (b) and (c)	☒	*Pass*
20 dB emission bandwidth	15.247 (a) (1) (i) and (ii)	247, 5.1 (a)	☒	*Pass*
Out-of-band emissions	15.247(d)	247, 5.5	☒	*Pass*
Power spectral density	15.247 (e)	247, 5.2 (b)	☒	*Pass*

1. The EUT is a battery powered device
2. The Equipment was tested as a Hybrid System using KDB 558074 D01 15.247 Measurement guidance v05r02 Section 10.

Navitas Pod basic operating mode for FHSS (125 kHz bandwidth).

The equipment enters an acquisition mode and starts frequency hopping across 64 channels, until communication is established with the LoRaWan network.
The LoRaWan network assigns one of the 8 frequency blocks. Each frequency block contains 8 frequency hopping channels.
Once communication is established between the network hub, and the EUT, the EUT starts to frequency hop across 8 channels within one of the 8 frequency blocks.

2.3 HYBRID SYSTEM EQUIPMENT KDB 558074 D01 15.247 v05r02 Section 10

b) Hybrid system device measurement guidelines are as follows.

1) As specified in section 15.247 (f), a hybrid system must comply with power density standard of 8 dBm in any 3 kHz band, when the frequency hopping function is switched off.

2) The transmission must comply with a 0.4 second/channel maximum dwell time when hopping function is turned on.

3) There is no requirement for this type of hybrid system to comply with the 500 kHz minimum Bandwidth normally associated with a DTS device.

4) There is no minimum number of hopping channels associated with this type of hybrid system While there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom per section 15.247(a)(1).

5) The Hopping function must be a true frequency hopping system as described in section 15.247(a)(1). The specific requirements in section 15.247(a)(1) are:

i) a minimum channel separation;
ii) pseudo-random hop sequence;
iii) equal use of each frequency;

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)

3 Contents

1 Revision Record 3
2 Summary 4
2.1 Test Summary (Section 1 DTS Mode). 5
2.2 Test Summary (Section 2 FHSS Mode) 6
2.3 HYBRID SYSTEM EQUIPMENT KDB 558074 D01 15.247 v05r02 Section 10 7
3 Contents 8
4 Introduction 11
5 Test Specifications 12
5.1 Normative References 12
5.2 Deviations from Test Standards 12
6 Glossary of Terms 13
7 Equipment under Test 14
7.1 EUT Identification 14
7.2 System Equipment 14
7.3 EUT Mode of Operation 14
7.4 EUT Radio Parameters 14
7.4.1 General (DTS mode) 14
7.4.1 General (FHSS mode) 14
7.4.2 Antennas 15
7.5 EUT Description 15
8 Modifications 16
9 EUT Test Setup 17
9.1 Block Diagram 17
9.2 General Set-up Photograph 18
9.3 Measurement software 19
10 General Technical Parameters 20
10.1 Normal Conditions 20
10.2 Varying Test Conditions 20
11 Results Section 1 DTS mode of Operation 21
12 Maximum peak conducted output power 21
12.1 Definition 21
12.2 Test Parameters 21
12.3 Test Limit 21
12.4 Test Method 22
12.5 Test Equipment 22
12.6 Test Results 23
13 Power spectral density 24
13.1 Definition 24
13.2 Test Parameters 24
13.3 Test Limit 24
13.4 Test Method 25
13.5 Test Equipment 25
13.6 Test Results 26
14 Occupied Bandwidth 27
14.1 Definition 27
14.2 Test Parameters 27
14.3 Test Limit 27
14.4 Test Method 28
14.5 Test Equipment 28
14.6 Test Results 29
15 Out-of-band and conducted spurious emissions 31
15.1 Definition 31
15.2 Test Parameters 31
15.3 Test Limit 31
15.4 Test Method 32
15.5 Test Equipment 32
15.6 Test Results 33
16 Radiated emissions 37

16.1 Definitions 37
16.2 Test Parameters 37
16.3 Test Limit 37
16.4 Test Method 38
16.5 Test Equipment 38
16.6 Test Results: 500 kHz Operation 39
17 Results Section 2 FHSS mode of Operation 42
18 Maximum peak conducted output power 42
18.1 Definition 42
18.2 Test Parameters 42
18.3 Test Limit 42
18.4 Test Method 43
18.5 Test Equipment 43
18.6 Test Results 44
19 Power spectral density 45
19.1 Definition 45
19.2 Test Parameters 45
19.3 Test Limit 45
19.4 Test Method 46
19.5 Test Equipment 46
19.6 Test Results 47
20 Number of hopping frequencies 48
20.1 Definition 48
20.2 Test Parameters 48
20.3 Test Limit 48
20.4 Test Method 49
20.5 Test Equipment 49
20.6 Test Results 50
21 Average channel occupancy 52
21.1 Definition 52
21.2 Test Parameters 52
21.3 Test Limit 52
21.4 Test Method 53
21.5 Test Equipment 53
21.6 Test Results 53
22 Carrier frequency separation 56
22.1 Definition 56
22.2 Test Parameters 56
22.3 Test Limit 56
22.4 Test Method 57
22.5 Test Equipment 57
22.6 Test Results 57
23 Occupied Bandwidth 59
23.1 Definition 59
23.2 Test Parameters 59
23.3 Test Limit 59
23.4 Test Method 60
23.5 Test Equipment 60
23.6 Test Results 61
24 Out-of-band and conducted spurious emissions 63
24.1 Definition 63
24.2 Test Parameters 63
24.3 Test Limits 63
24.4 Test Method 64
24.5 Test Equipment 64
24.6 Test Results 65
25 Radiated emissions 69
25.1 Definitions 69
25.2 Test Parameters 69
25.3 Test Limit 69

25.4 Test Method 70
25.5 Test Equipment 70
25.6 Test Results LoRaWan 125 kHz channel 71
26 Measurement Uncertainty 74
27 RF Exposure 76
28 RF Exposure 77

4 Introduction

This report TRA-053699-47-00A presents the results of the Radio testing on a SmartSentry Ltd, Smart Pod 3 to specification 47CFR15 Radio Frequency Devices. RSS-247 - Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.

The testing was carried out for SmartSentry Ltd 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:
Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

IC Registration Numbers:

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.
- ISED RSS-247, Issue 2, February 2017 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.
- ISED RSS-Gen, Issue 5, March 2019 – General Requirements for Compliance of Radio Apparatus.
- 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.
- KDB 558074 D01 15.247 Measurement guidance v05r02

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: Smart Pod 3
- Serial Number: 1-2
- Model Number: Smart Pod 3
- Software Revision:1
- Build Level / Revision Number: 1

7.2 System Equipment

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

Test Laptop: Lenovo Thinkpad

7.3 EUT Mode of Operation

The Equipment under test, was programmed via the client provided test software.
The software provided selections of operating frequencies, and the operating bandwidths, 500 kHz for DTS operation, and 125 kHz for FHSS operation.

7.4 EUT Radio Parameters

7.4.1 General (DTS mode)

Frequency of operation:	902 MHz-928 MHz Band
Modulation type(s):	LoRa Chirp Spread Spectrum
Occupied channel bandwidth(s):	500 kHz
Declared output power(s):	14 dBm
Warning against use of alternative antennas in user manual (yes/no):	Not Applicable, internal chip antenna
Nominal Supply Voltage:	3.6 Vdc

7.4.1 General (FHSS mode)

Frequency of operation:	902 MHz-928 MHz Band
Modulation type(s):	LoRa Chirp Spread Spectrum
Occupied channel bandwidth(s):	125 kHz
Declared output power(s):	14 dBm
Warning against use of alternative antennas in user manual (yes/no):	Not Applicable, internal chip antenna
Nominal Supply Voltage:	3.6 Vdc

7.4.2 Antennas

Type:	AVX M620720
Frequency range:	902 MHz-928 MHz
Impedance:	50 Ω
SWR:	2.5:1 Max
Gain:	0.75 dBi
Polarisation:	Linear

7.5 EUT Description

The Navitas Pod measures ambient air temperature and light level, as well as optionally the temperature inside an object using a flying temperature lead. The device operates in the 902MHz to 928MHz ISM frequency band, it utilises LoRaWan.

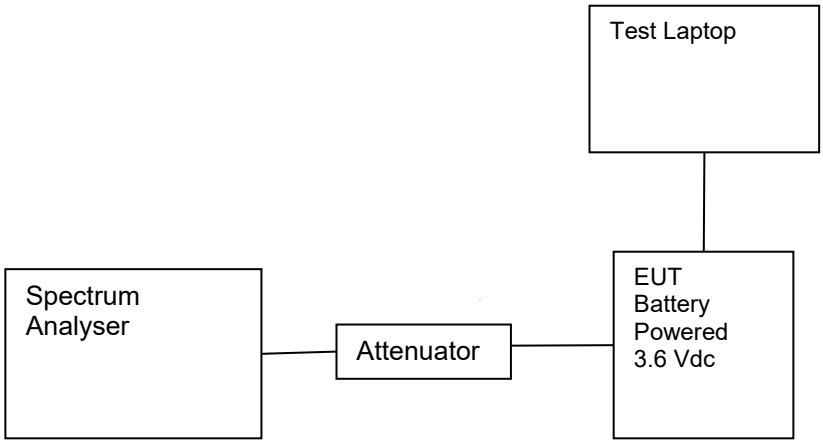
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

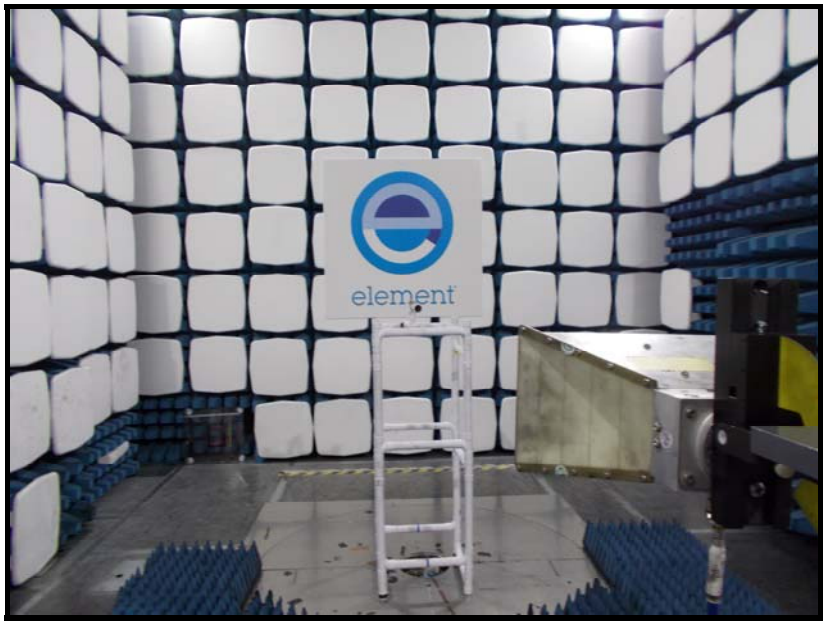
9.1 Block Diagram

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

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 3.6 Vdc from Lithium 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 and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

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

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

11 Results Section 1 DTS mode of Operation

12 Maximum peak conducted output power

12.1 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.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
Frequencies Measured:	903.0 MHz / 915.0 MHz / 927.5 MHz
EUT Channel Bandwidths:	500 kHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

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

12.3 Test Limit

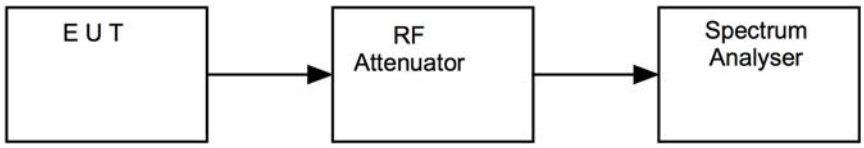
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

12.4 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



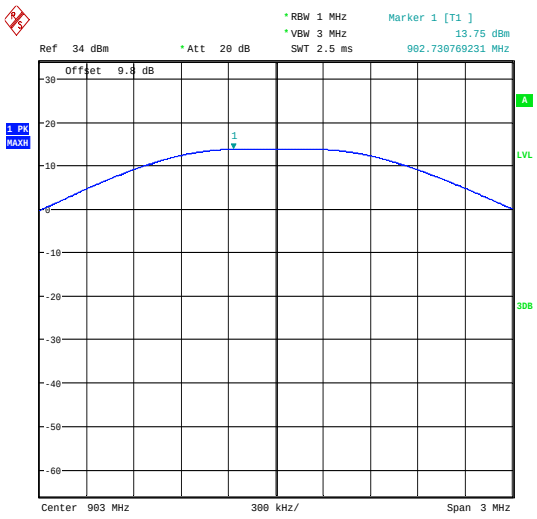
12.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

12.6 Test Results

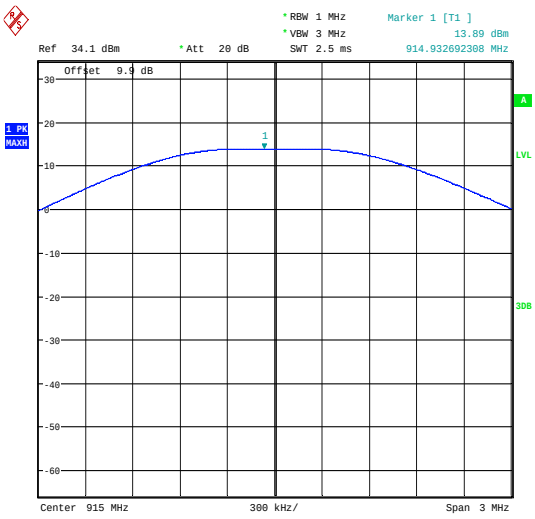
LoRa 500 kHz channel					
Channel Frequency (MHz)	**Max Power (dBm)**	**Antenna Gain (dBi)**	**EIRP (dBm)**	**EIRP (mW)**	**Result**
903.0	13.75	0.75	14.50	0.028	PASS
915.0	13.89	0.75	14.64	0.029	PASS
927.5	13.94	0.75	14.69	0.029	PASS

903.0 MHz



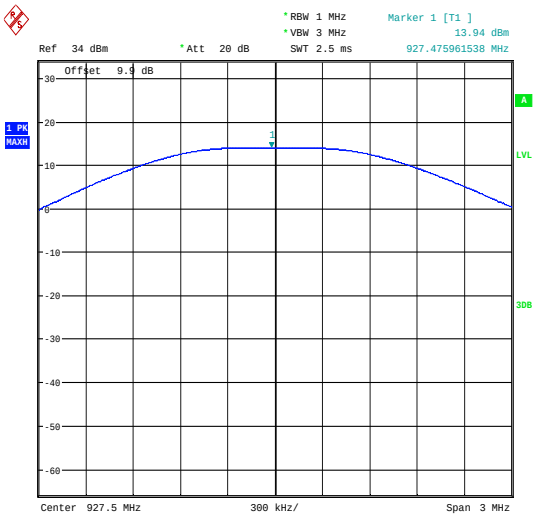
Date: 3.MAR.2021 11:56:06

915.0 MHz



Date: 3.MAR.2021 11:57:18

927.5 MHz



Date: 3.MAR.2021 12:12:10

13 Power spectral density

13.1 Definition

The power per unit bandwidth.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
Frequencies Measured:	903.0 MHz / 915.0 MHz/ 927.5 MHz
EUT Channel Bandwidths:	500 kHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6Vdc	

13.3 Test Limit

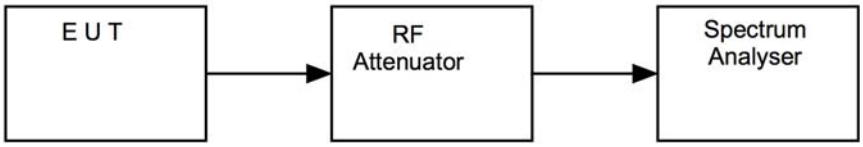
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

13.4 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



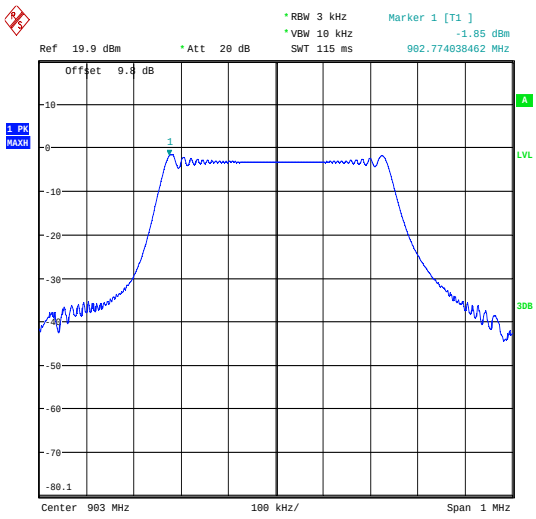
13.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

13.6 Test Results

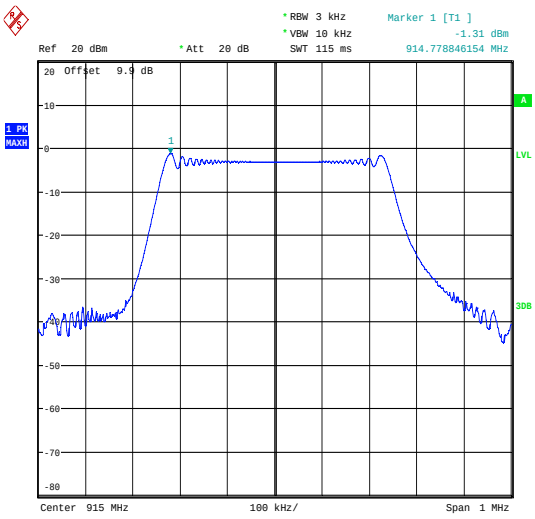
LoRa 500 kHz channel			
Channel Frequency (MHz)	**Max PSD (dBm)**	**Limit (dBm)**	**Result**
903.0	-1.85	8.0	PASS
915.0	-1.31	8.0	PASS
927.5	-1.19	8.0	PASS

903.0 MHz



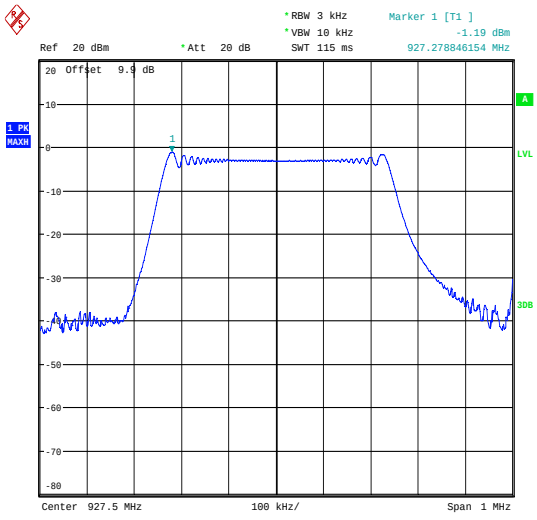
Date: 3.MAR.2021 12:05:46

915.0 MHz



Date: 3.MAR.2021 12:07:30

927.5 MHz



Date: 3.MAR.2021 12:08:34

14 Occupied Bandwidth

14.1 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.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
Frequencies Measured:	903.0 MHz / 915.0 MHz / 927.5 MHz
EUT Channel Bandwidths:	500 kHz
EUT Test Modulations:	LoRa
Deviations From Standard:	None
Measurement BW: (IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	100 kHz 10 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz 50 kHz
Measurement Span: (requirement 2 to 5 times OBW)	2 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

14.3 Test Limit

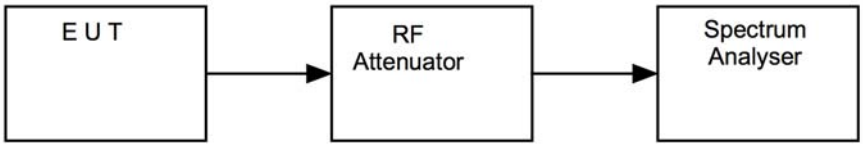
The minimum -6 dB bandwidth shall be at least 500 kHz.

14.4 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



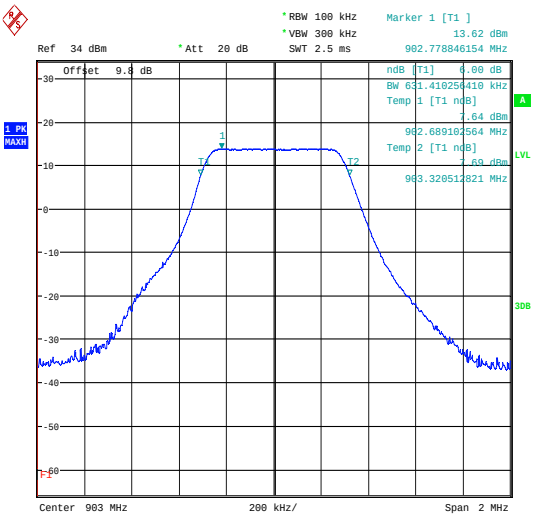
14.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

14.6 Test Results

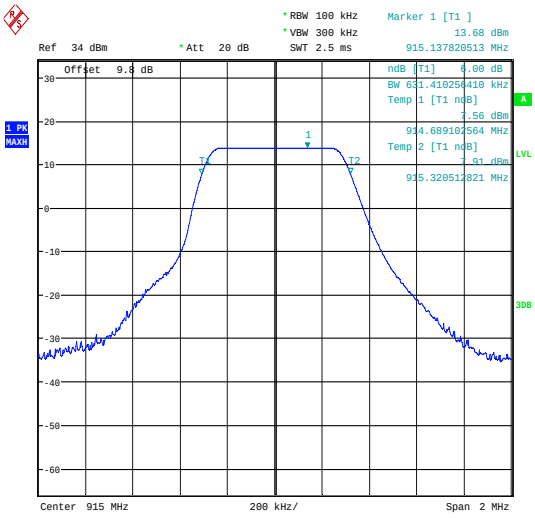
DTS Bandwidth : 500 kHz Operation				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**6dB Bandwidth (kHz)**	**Result**
903.0	902.689102	903.320512	631.41	PASS
915.0	914.689102	915.320512	631.41	PASS
927.5	927.189102	927.823717	634.61	PASS

903.0 MHz



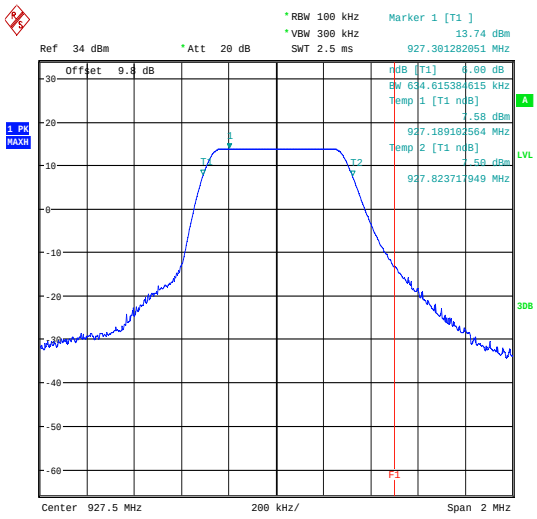
Date: 3.MAR.2021 11:24:05

915.0 MHz



Date: 3.MAR.2021 11:26:08

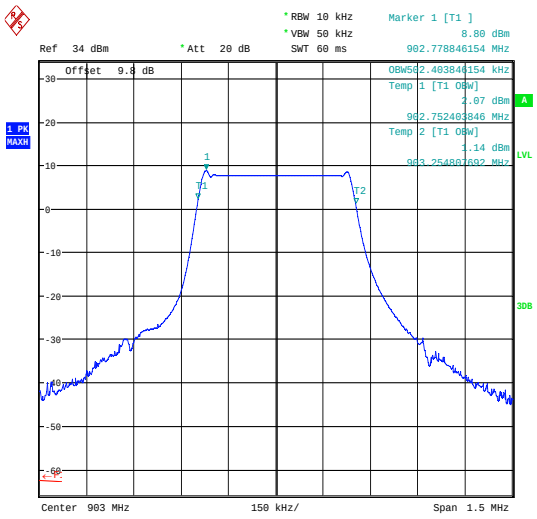
927.5 MHz



Date: 3.MAR.2021 11:28:54

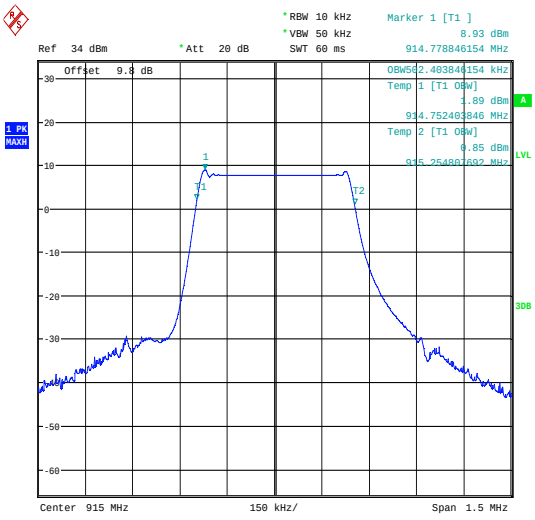
99% Bandwidth : 500 kHz Operation				
Channel Frequency (MHz)	**F_L (MHz)**	**F_H (MHz)**	**99% Bandwidth (kHz)**	**Result**
903.0	902.752403	903.254807	502.4040	PASS
915.0	914.752403	915.254807	502.4040	PASS
927.5	927.254807	927.754807	500.0000	PASS

903.0 MHz



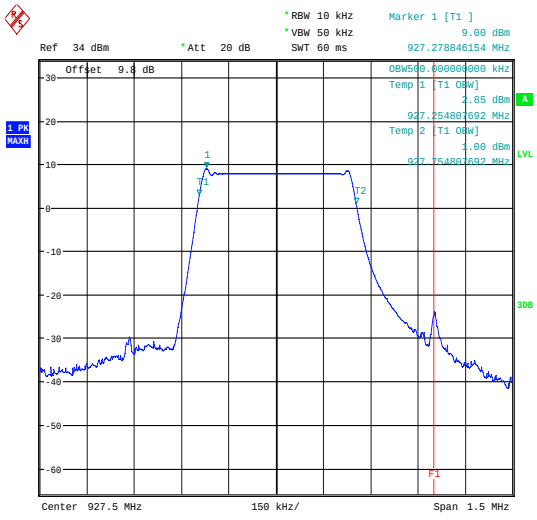
Date: 3.MAR.2021 11:40:05

915.0 MHz



Date: 3.MAR.2021 11:45:39

927.5 MHz



Date: 3.MAR.2021 11:48:05

15 Out-of-band and conducted spurious emissions

15.1 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.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
Frequencies Measured:	903.0 MHz / 915.0 MHz/ 927.5 MHz
EUT Channel Bandwidths:	500 kHz
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 10 GHz

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

15.3 Test Limit

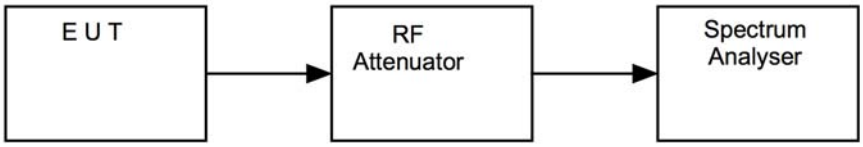
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

15.4 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



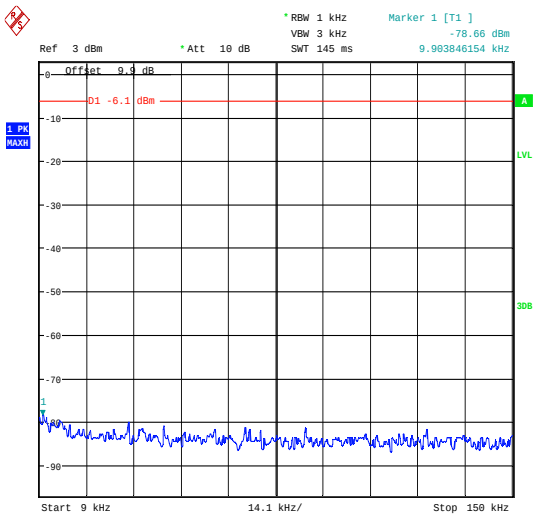
15.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

15.6 Test Results

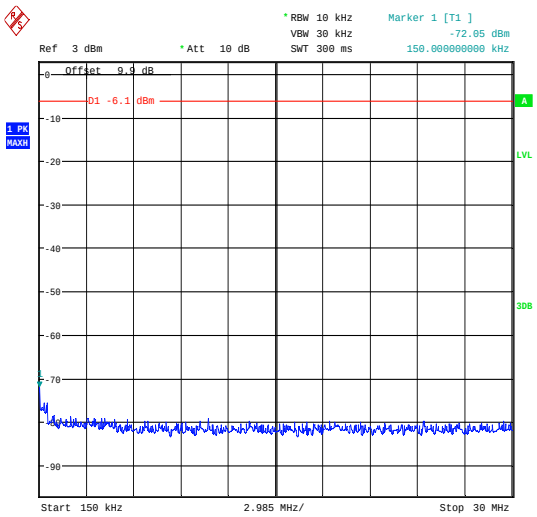
903.0 MHz: 500 kHz Operation						
Channel Frequency (MHz)	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
No Significant emissions within 20 dB of the limit						PASS

9 kHz-150 kHz



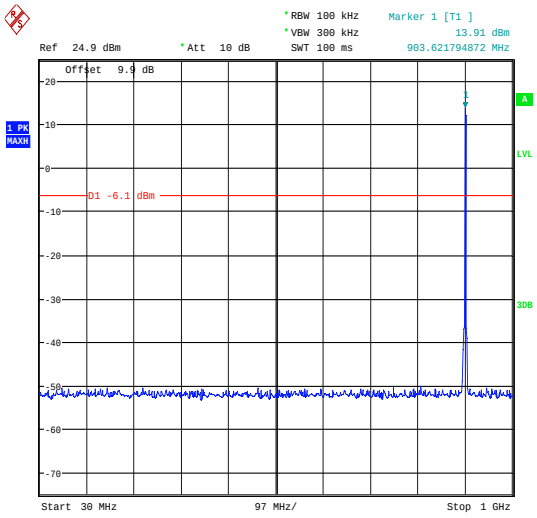
Date: 3.MAR.2021 12:26:11

150 kHz- 30 MHz



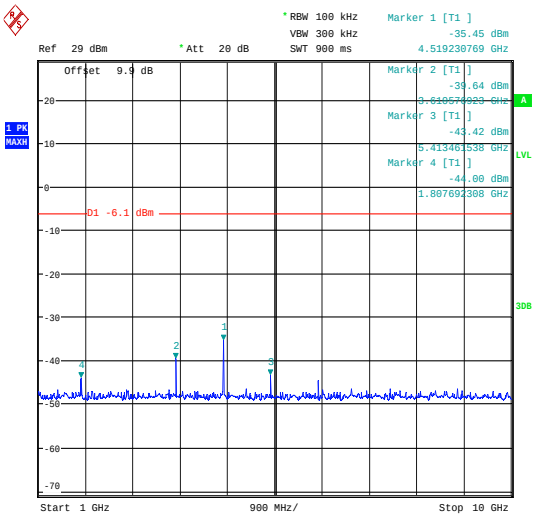
Date: 3.MAR.2021 12:26:49

30 MHz-1 GHz



Date: 3.MAR.2021 12:25:10

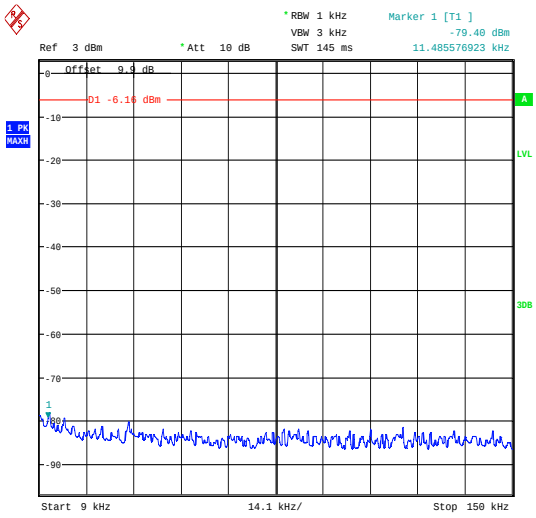
1 GHz-10 GHz



Date: 3.MAR.2021 12:46:48

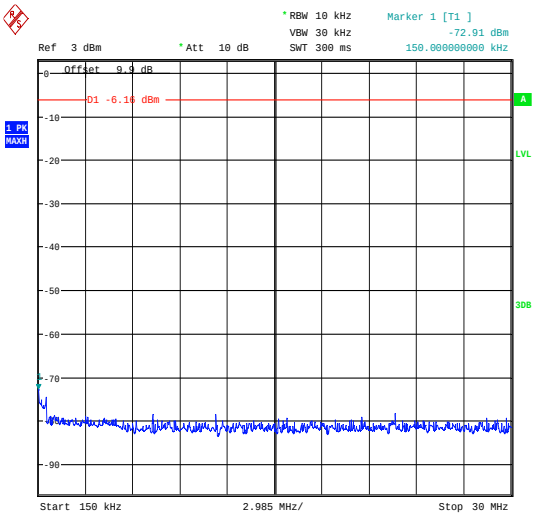
915.0 MHz: 500 kHz Operation						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant emissions within 20 dB of the limit						PASS

9 kHz-150 kHz



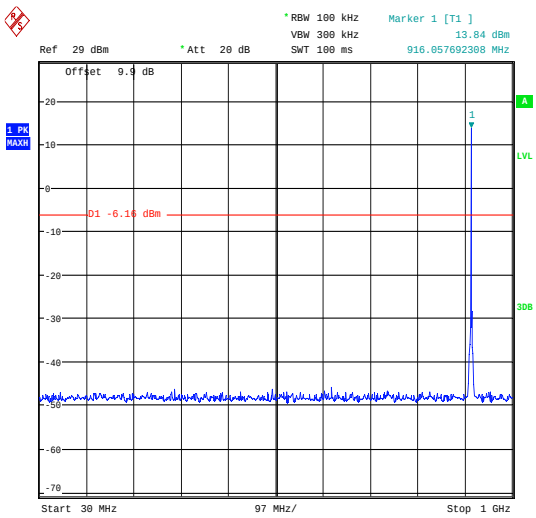
Date: 3.MAR.2021 12:52:48

150 kHz- 30 MHz



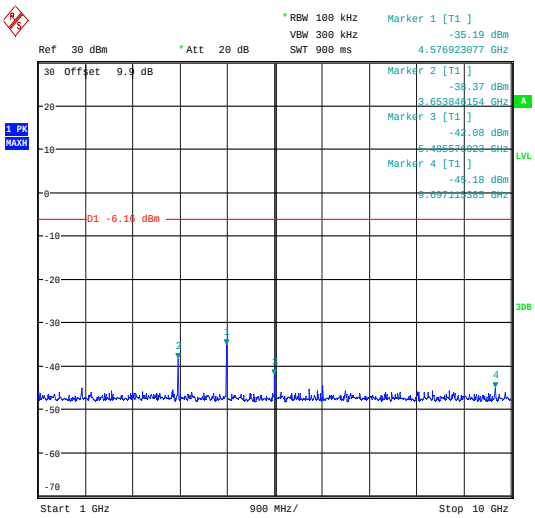
Date: 3.MAR.2021 12:53:29

30 MHz-1 GHz



Date: 3.MAR.2021 12:51:31

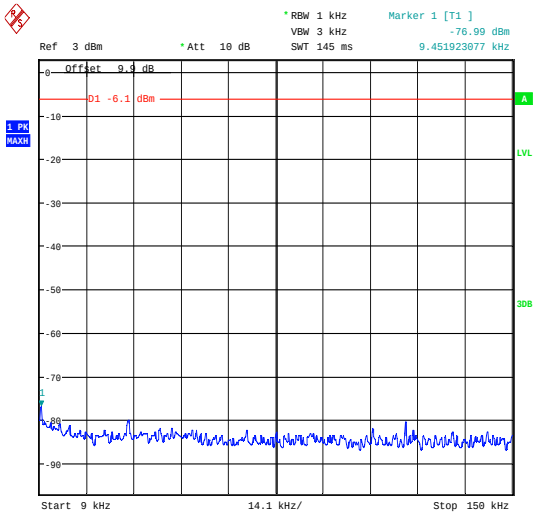
1 GHz-10 GHz



Date: 3.MAR.2021 12:55:28

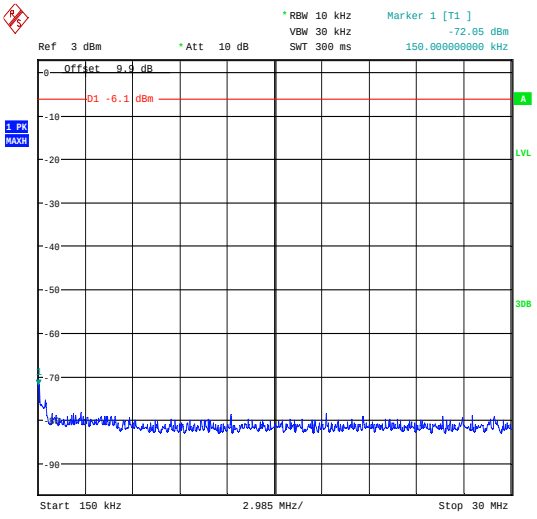
927.5 MHz: 500 kHz Operation						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant emissions within 20 dB of the limit						PASS

9 kHz-150 kHz



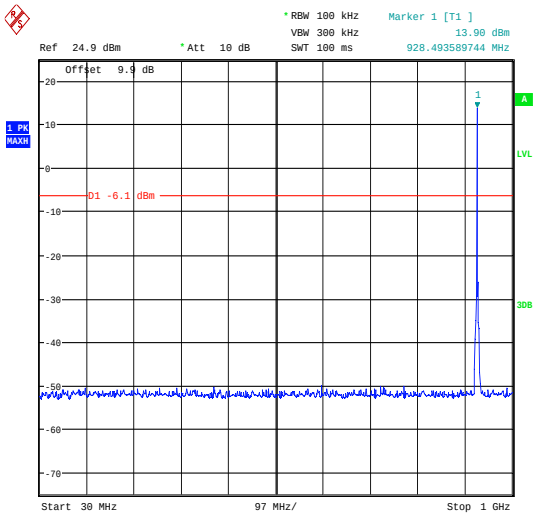
Date: 3.MAR.2021 12:59:35

150 kHz- 30 MHz



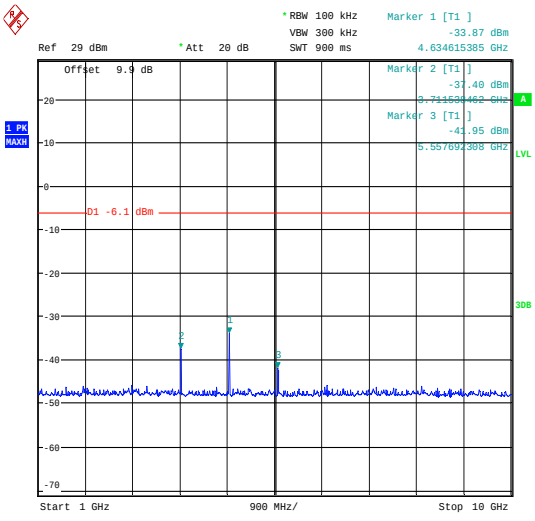
Date: 3.MAR.2021 13:00:16

30 MHz-1 GHz



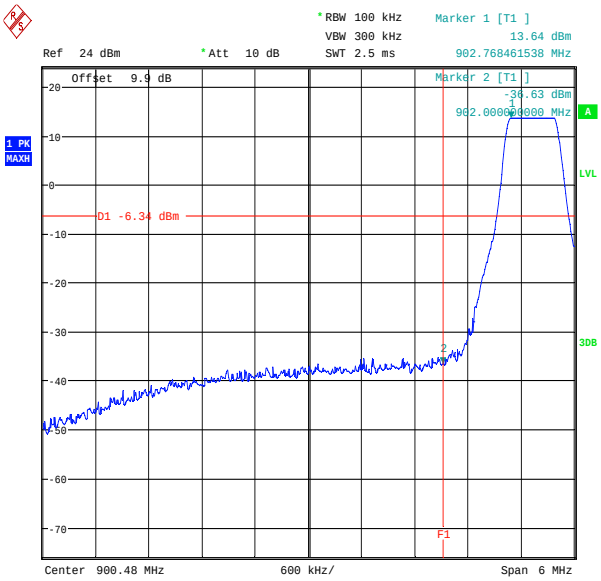
Date: 3.MAR.2021 12:58:13

1 GHz-10 GHz



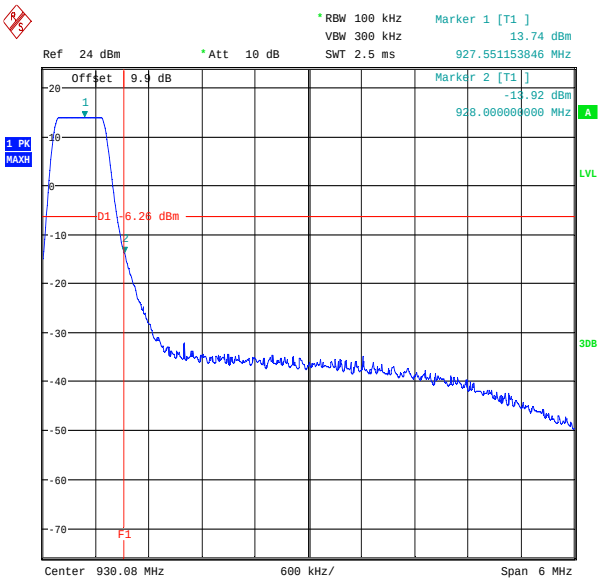
Date: 3.MAR.2021 13:06:49

Lower Conducted Band edge



Date: 3.MAR.2021 14:47:19

Upper Conducted Band edge



Date: 3.MAR.2021 14:49:47

16 Radiated emissions

16.1 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.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	903.0 MHz/915.0 MHz/927.5 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: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 37 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

16.3 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.

16.4 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:

$$FS = PR + CL + AF – PA + DC – CF$$

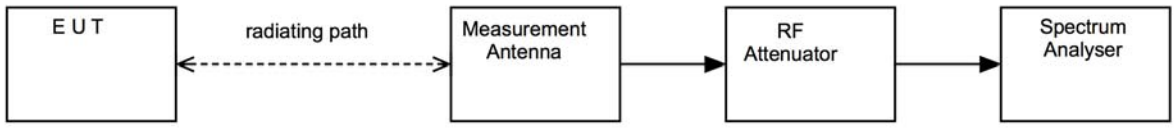
$$Factor = AF+CL-PA$$

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



16.5 Test Equipment

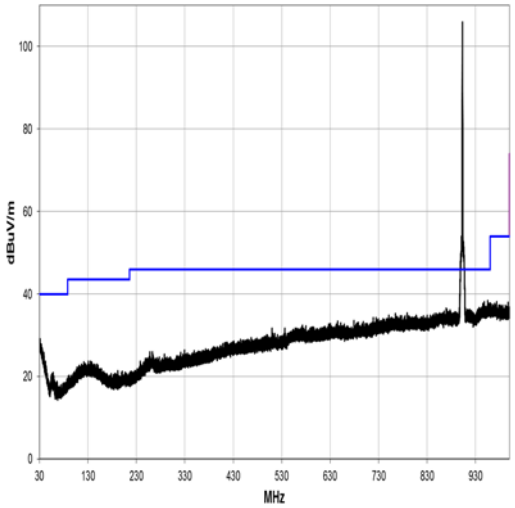
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	U573	2023-01-28
LNA6901	Ametek CTS Europe	Pre amp	UH711	2022-09-01
3115	EMCO	1-18GHz Horn	L139	2021-07-16
8449B	Agilent	Pre Amp	U457	2021-08-26
VHF-1500+	MiniCircuits	High Pass Filter	U519	2022-01-30
AFH-07000	Atlantic Microwave	High Pass Filter	U558	2022-01-30

16.6 Test Results: 500 kHz Operation

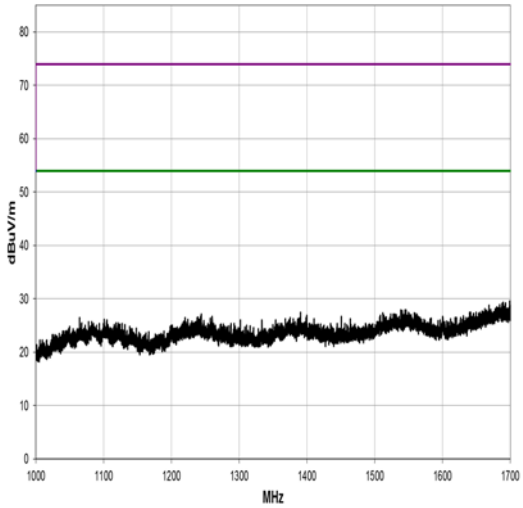
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
5418.123	34.6	7.3	1.12	181.1	3.0	0.0	Vert	AV	0.0	41.9	54.0	-12.1
5417.540	34.3	7.3	1.5	146.0	3.0	0.0	Horz	AV	0.0	41.6	54.0	-12.4
3611.940	37.7	1.8	1.69	73.2	3.0	0.0	Vert	AV	0.0	39.5	54.0	-14.5
4515.035	33.8	3.9	1.5	167.1	3.0	0.0	Horz	AV	0.0	37.7	54.0	-16.3
4515.060	33.3	3.9	1.08	177.9	3.0	0.0	Vert	AV	0.0	37.2	54.0	-16.8
5417.840	48.1	7.3	1.5	146.0	3.0	0.0	Horz	PK	0.0	55.4	74.0	-18.6
5418.140	48.1	7.3	1.12	181.1	3.0	0.0	Vert	PK	0.0	55.4	74.0	-18.6
3611.907	32.2	1.8	1.46	139.2	3.0	0.0	Horz	AV	0.0	34.0	54.0	-20.0
2708.998	34.3	-1.7	1.5	76.0	3.0	0.0	Vert	AV	0.0	32.6	54.0	-21.4
4515.302	47.3	3.9	1.5	167.1	3.0	0.0	Horz	PK	0.0	51.2	74.0	-22.8
4516.068	47.0	3.9	1.08	177.9	3.0	0.0	Vert	PK	0.0	50.9	74.0	-23.1
3612.373	48.3	1.8	1.69	73.2	3.0	0.0	Vert	PK	0.0	50.1	74.0	-23.9
2709.032	31.7	-1.7	1.22	125.9	3.0	0.0	Horz	AV	0.0	30.0	54.0	-24.0
3611.615	44.9	1.8	1.46	139.2	3.0	0.0	Horz	PK	0.0	46.7	74.0	-27.3
2709.357	46.3	-1.7	1.5	76.0	3.0	0.0	Vert	PK	0.0	44.6	74.0	-29.4
2709.240	44.8	-1.7	1.22	125.9	3.0	0.0	Horz	PK	0.0	43.1	74.0	-30.9

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
9030.600	31.4	11.0	2.13	37.1	3.0	0.0	Vert	AV	0.0	42.4	54.0	-11.6
9030.717	30.2	11.0	1.04	319.9	3.0	0.0	Horz	AV	0.0	41.2	54.0	-12.8
9030.367	46.5	11.0	2.13	37.1	3.0	0.0	Vert	PK	0.0	57.5	74.0	-16.5
9032.408	45.2	11.0	1.04	319.9	3.0	0.0	Horz	PK	0.0	56.2	74.0	-17.8

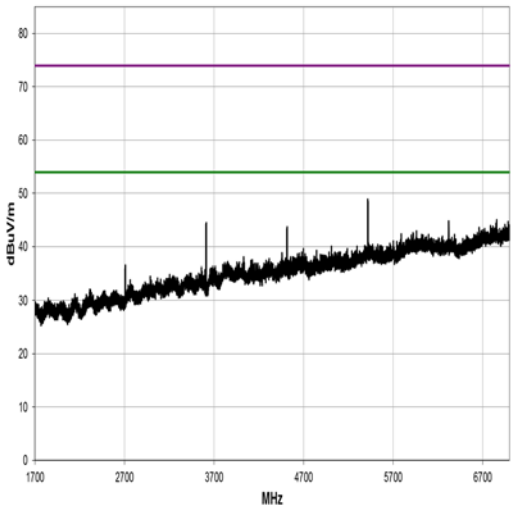
903.0 MHz 30 MHz-1 GHz



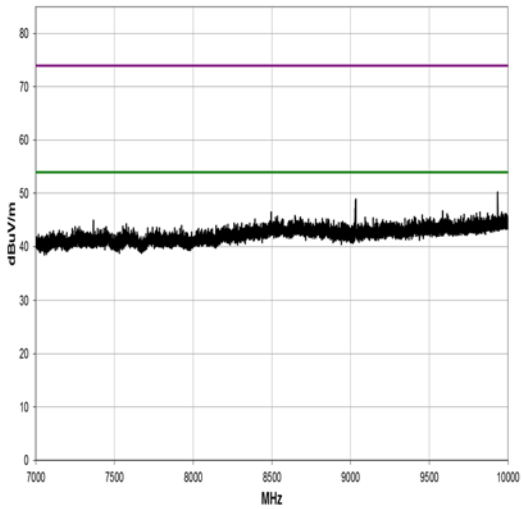
903.0 MHz 1 GHz-1.7 GHz



903.0 MHz 1.7 GHz-7 GHz



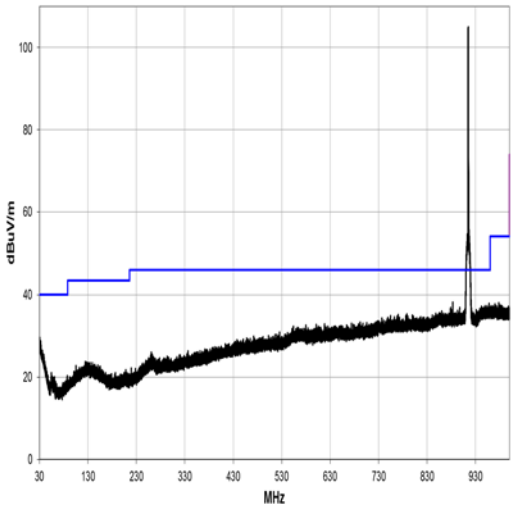
903.0 MHz 7 GHz-10 GHz



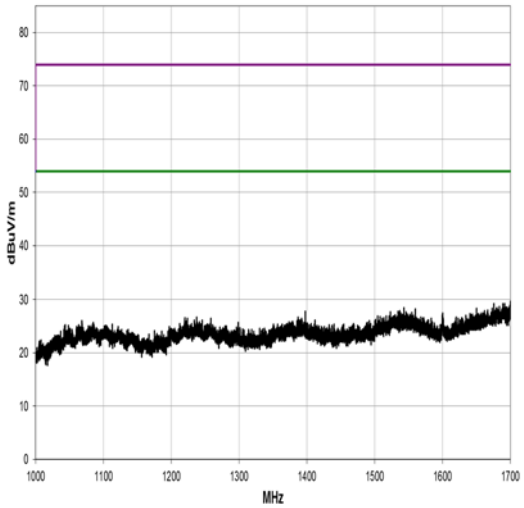
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
3660.015	37.7	2.2	1.5	70.8	3.0	0.0	Vert	AV	0.0	39.9	54.0	-14.1
4575.352	33.8	4.0	1.68	148.2	3.0	0.0	Horz	AV	0.0	37.8	54.0	-16.2
4575.227	33.7	4.0	1.08	184.9	3.0	0.0	Vert	AV	0.0	37.7	54.0	-16.3
3660.240	34.1	2.2	1.26	204.0	3.0	0.0	Horz	AV	0.0	36.3	54.0	-17.7
4573.618	48.3	4.0	1.68	148.2	3.0	0.0	Horz	PK	0.0	52.3	74.0	-21.7
4575.443	48.0	4.0	1.08	184.9	3.0	0.0	Vert	PK	0.0	52.0	74.0	-22.0
3659.207	48.9	2.2	1.5	70.8	3.0	0.0	Vert	PK	0.0	51.1	74.0	-22.9
3660.165	47.1	2.2	1.26	204.0	3.0	0.0	Horz	PK	0.0	49.3	74.0	-24.7

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
9150.875	32.1	11.3	2.44	81.1	3.0	0.0	Vert	AV	0.0	43.4	54.0	-10.6
9150.700	31.2	11.3	1.27	351.9	3.0	0.0	Horz	AV	0.0	42.5	54.0	-11.5
9149.258	47.4	11.2	2.44	81.1	3.0	0.0	Vert	PK	0.0	58.6	74.0	-15.4
9150.333	46.8	11.3	1.27	351.9	3.0	0.0	Horz	PK	0.0	58.1	74.0	-15.9

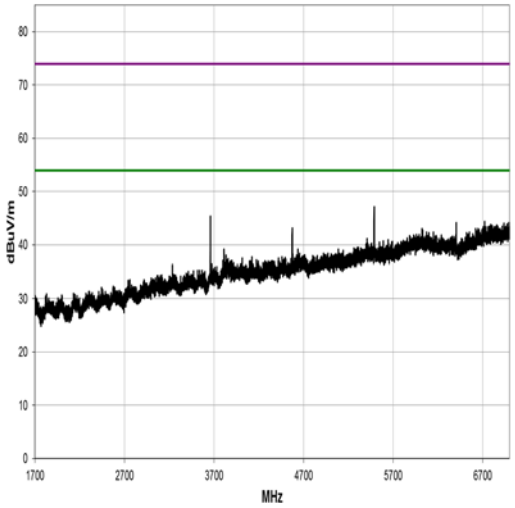
915.0 MHz 30 MHz-1 GHz



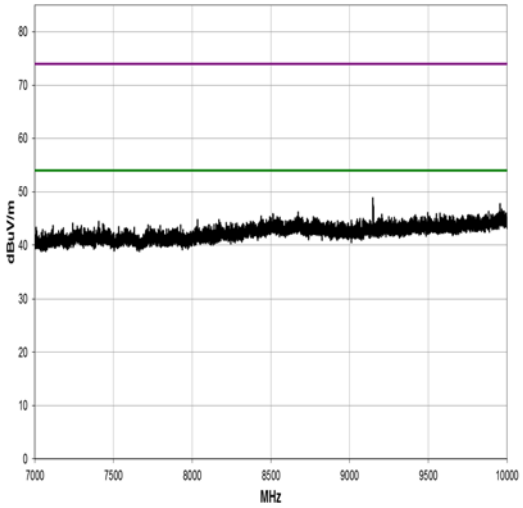
915.0 MHz 1 GHz-1.7 GHz



915.0 MHz 1.7 GHz -7 GHz



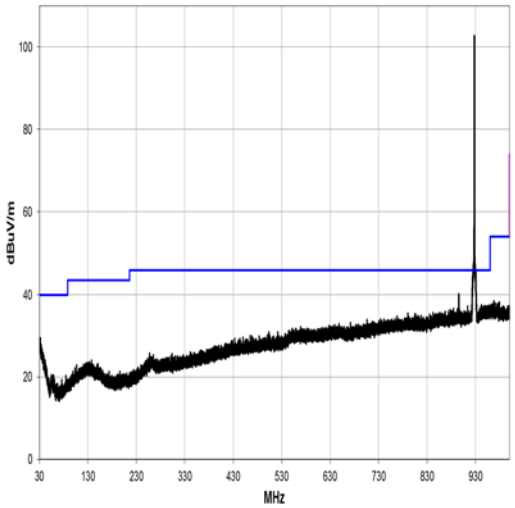
915.0 MHz 7 GHz-10 GHz



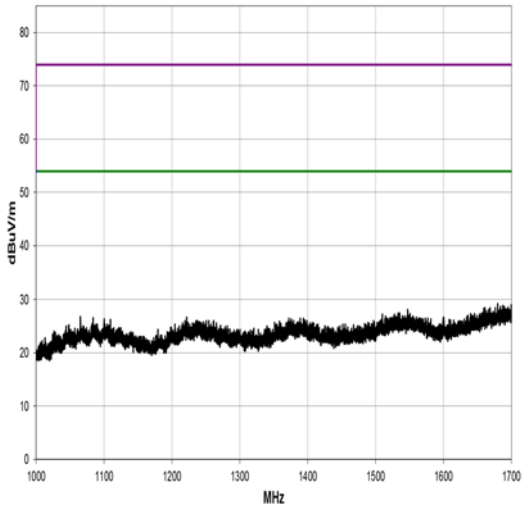
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4636.983	33.7	4.2	1.33	166.1	3.0	0.0	Horz	AV	0.0	37.9	54.0	-16.1
3710.032	35.4	2.5	1.5	89.9	3.0	0.0	Vert	AV	0.0	37.9	54.0	-16.1
4636.992	33.0	4.2	1.23	168.0	3.0	0.0	Vert	AV	0.0	37.2	54.0	-16.8
3710.182	33.1	2.5	1.5	214.2	3.0	0.0	Horz	AV	0.0	35.6	54.0	-18.4
4637.008	47.3	4.2	1.33	166.1	3.0	0.0	Horz	PK	0.0	51.5	74.0	-22.5
4637.108	46.8	4.2	1.23	168.0	3.0	0.0	Vert	PK	0.0	51.0	74.0	-23.0
3708.957	47.4	2.5	1.5	89.9	3.0	0.0	Vert	PK	0.0	49.9	74.0	-24.1
3710.807	46.2	2.5	1.5	214.2	3.0	0.0	Horz	PK	0.0	48.7	74.0	-25.3

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
8348.042	31.8	10.6	1.04	325.0	3.0	0.0	Horz	AV	0.0	42.4	54.0	-11.6
8347.983	31.3	10.6	1.53	5.8	3.0	0.0	Vert	AV	0.0	41.9	54.0	-12.1
8347.258	47.4	10.6	1.04	325.0	3.0	0.0	Horz	PK	0.0	58.0	74.0	-16.0
8347.367	46.6	10.6	1.53	5.8	3.0	0.0	Vert	PK	0.0	57.2	74.0	-16.8

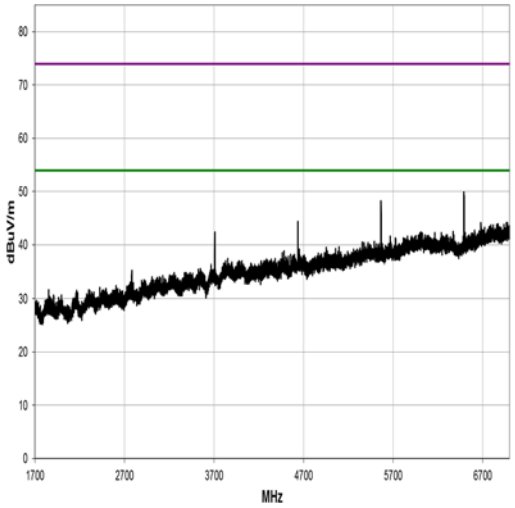
915.0 MHz 30 MHz-1 GHz



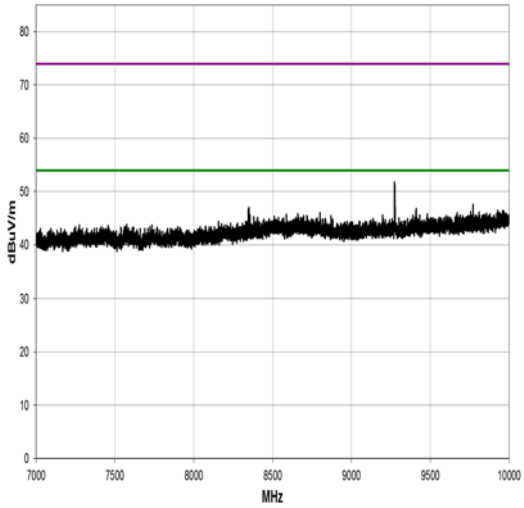
915.0 MHz 1 GHz-1.7 GHz



915.0 MHz 1.7 GHz -7 GHz



915.0 MHz 7 GHz-10 GHz



Note: The data provided in the tables above, are for emissions that fall into the restricted bands only

17 Results Section 2 FHSS mode of Operation

18 Maximum peak conducted output power

18.1 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.

18.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.5
Frequencies Measured:	902.3 MHz/ 914.9 MHz/ 927.5 MHz – hopping disabled.
EUT Channel Bandwidths:	125 kHz
Deviations From Standard:	None
Measurement BW:	200 kHz
Spectrum Analyzer Video BW:	500 kHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Battery Power = new battery.

Environmental Conditions (Normal Environment)

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

18.3 Test Limit

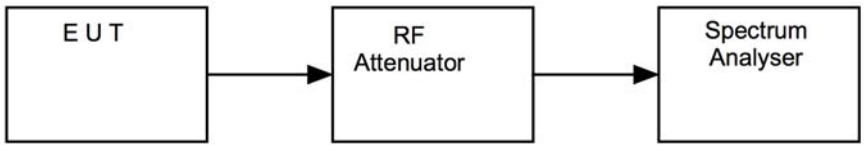
- For frequency hopping systems operating in the band 902 to 928 MHz, the maximum peak conducted output power shall not exceed 1 W, and the e.i.r.p. shall not exceed 4 W, if the hopset uses 50 or more hopping channels;
  the maximum peak conducted output power shall not exceed 0.25 W, and the e.i.r.p.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

18.4 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



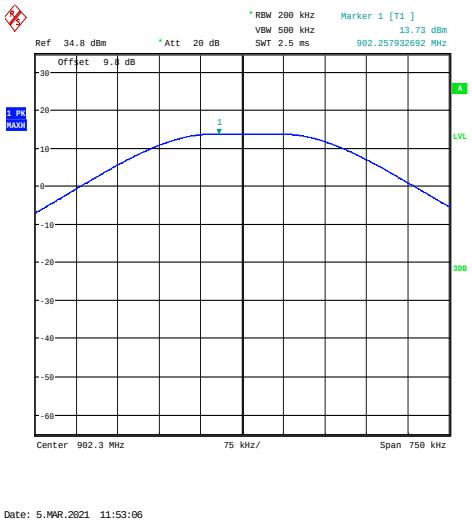
18.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

18.6 Test Results

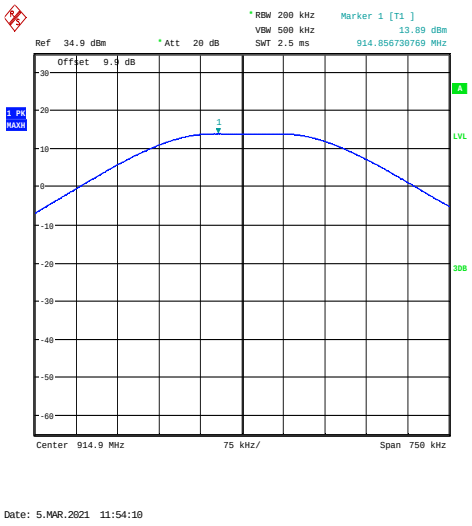
LoRaWan 125 kHz channel					
Channel Frequency (MHz)	***Max Power (dBm)***	***Antenna Gain (dBi)***	***e.i.r.p (dBm)***	***e.i.r.p (mW)***	***Result***
902.3	13.73	0.75	14.48	0.028	PASS
914.9	13.89	0.75	14.64	0.029	PASS
927.5	13.95	0.75	14.70	0.029	PASS

902.3 MHz



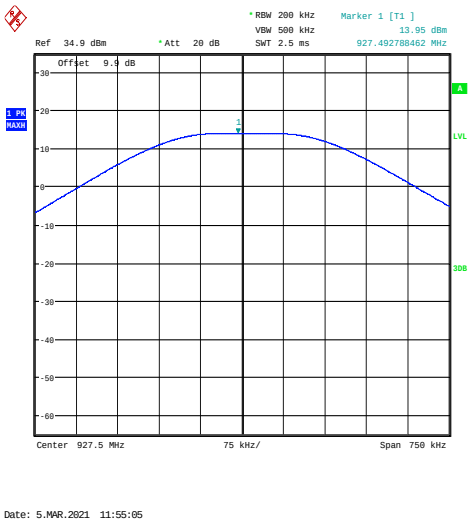
Date: 5.MAR.2021 11:53:06

914.9 MHz



Date: 5.MAR.2021 11:54:10

927.5 MHz



Date: 5.MAR.2021 11:55:05

19 Power spectral density

19.1 Definition

The power per unit bandwidth.

19.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
Frequencies Measured:	902.3 MHz / 914.9 MHz/ 927.5 MHz
EUT Channel Bandwidths:	125 kHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW) Measurement Span: (requirement 1.5 times Channel BW)	10 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 35 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6Vdc	

19.3 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.

Note: Section 10 of KDB 558074 D01 v05r02 Hybrid system equipment under section 15.247.

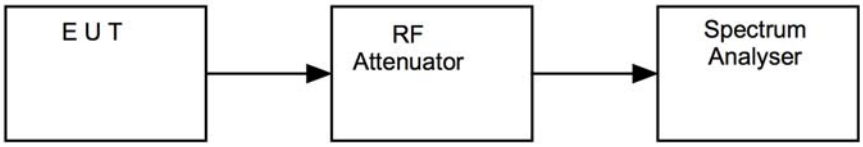
As specified in section 15.247(f), a hybrid system must comply with the power density standard of 8 dBm in any 3 kHz band when the frequency hopping function is turned off.

19.4 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



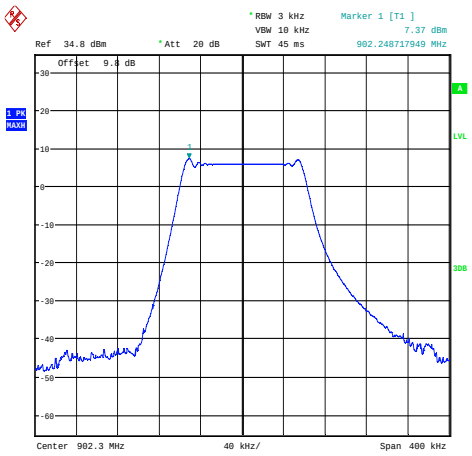
19.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

19.6 Test Results

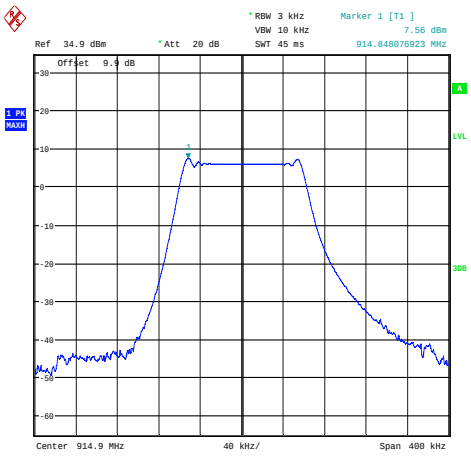
LoRaWan 125 kHz channel			
Channel Frequency (MHz)	***Max PSD (dBm)***	***Limit (dBm)***	***Result***
902.3	7.37	8.0	PASS
914.9	7.56	8.0	PASS
927.5	7.38	8.0	PASS

902.3 MHz



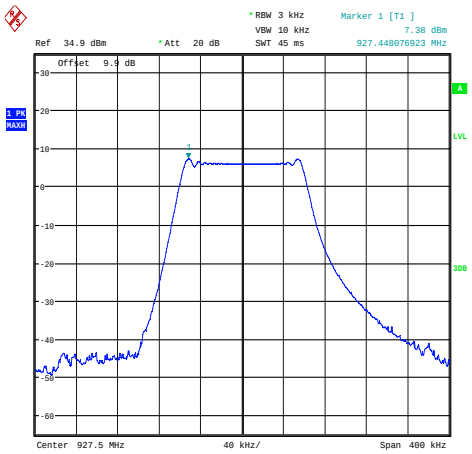
Date: 5.MAR.2021 12:00:08

914.9 MHz



Date: 5.MAR.2021 12:01:15

927.5 MHz



Date: 5.MAR.2021 12:02:10

20 Number of hopping frequencies

20.1 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.

20.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.3
Frequencies Measured:	902.0 MHz – 928 MHz
EUT 20dB Bandwidth:	144 kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	20 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

20.3 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.

Note: The equipment under test does not meet the above frequency hopping requirements KDB 558074 D01 15.247 Measurement Guidance v05r02 was used for guidance

Section 10 of KDB 558074 D01 Hybrid system equipment under section 15.247

The transmission must comply with a 0.4 second/channel maximum dwell time, when the hopping function is turned on.

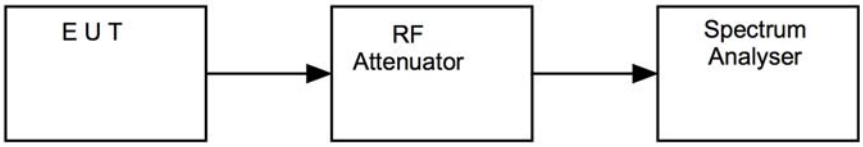
There are no minimum number of hopping channels associated with this type of hybrid system While no there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom as per Section 15.247 (a)(1).

20.4 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



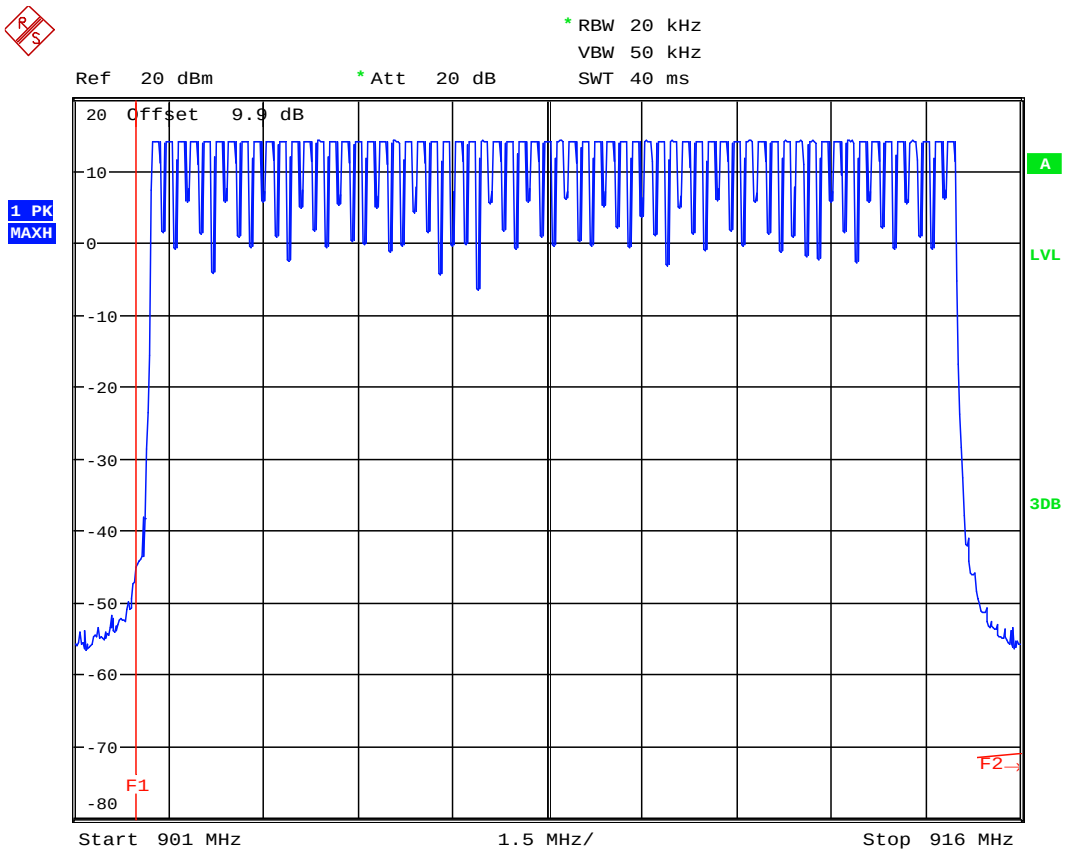
20.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

20.6 Test Results

LoRaWan 125 kHz channel

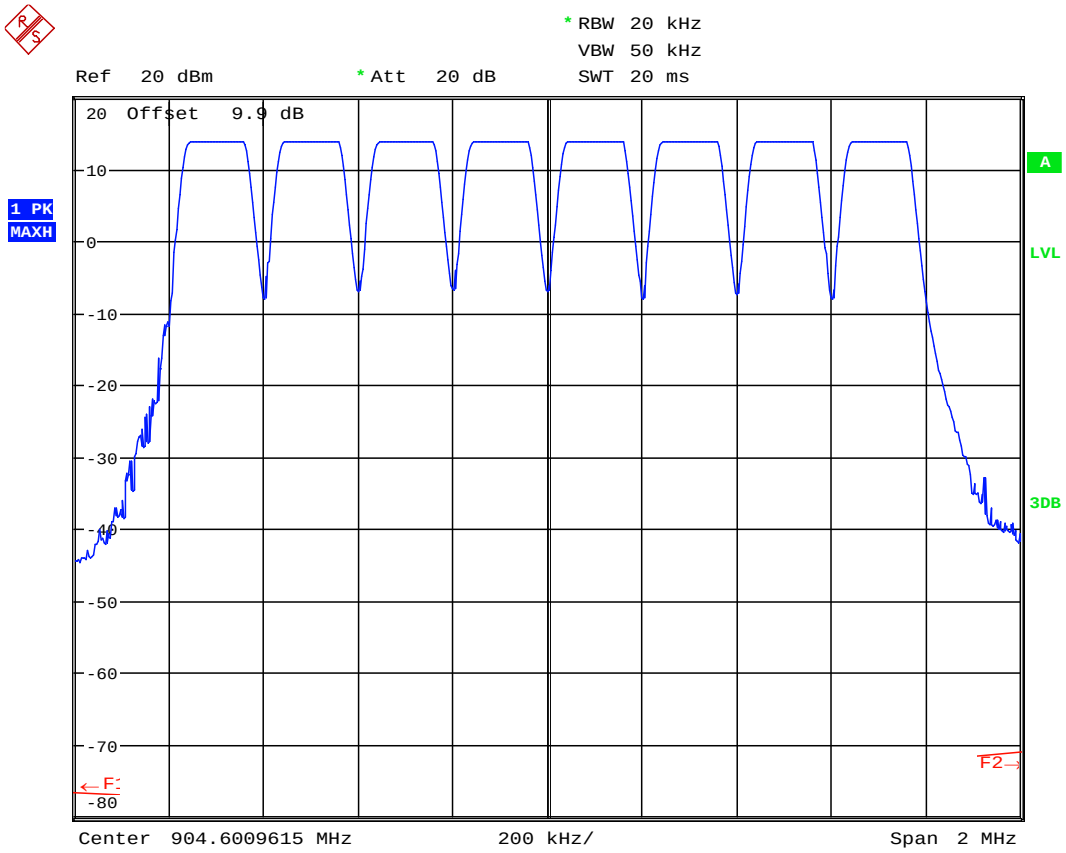
Number of hopping channels observed during acquisition mode.
64 Hopping channels observed



Date: 9.MAR.2021 10:12:10

LoRaWan 125 kHz channel

Number of hopping channels observed after the network assigned a frequency block.
8 hopping channels observed.



Date: 9.MAR.2021 10:55:45

21 Average channel occupancy

21.1 Definition

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

21.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.4
Frequencies Measured:	Mid
EUT 20dB bandwidth:	144 kHz
EUT Number of hopping channels:	64 or 8
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	100 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

21.3 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.

  Note: The equipment under test does not meet the above frequency hopping requirements KDB 558074 D01 15.247 Measurement Guidance v05r02 was used for guidance

  Section 10 of KDB 558074 D01 Hybrid system equipment under section 15.247

  The transmission must comply with a 0.4 second/channel maximum dwell time, when the hopping function is turned on.

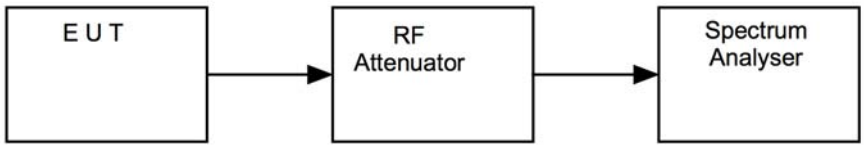
  There are no minimum number of hopping channels associated with this type of hybrid system While no there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom as per Section 15.247 (a)(1).

21.4 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



21.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

21.6 Test Results

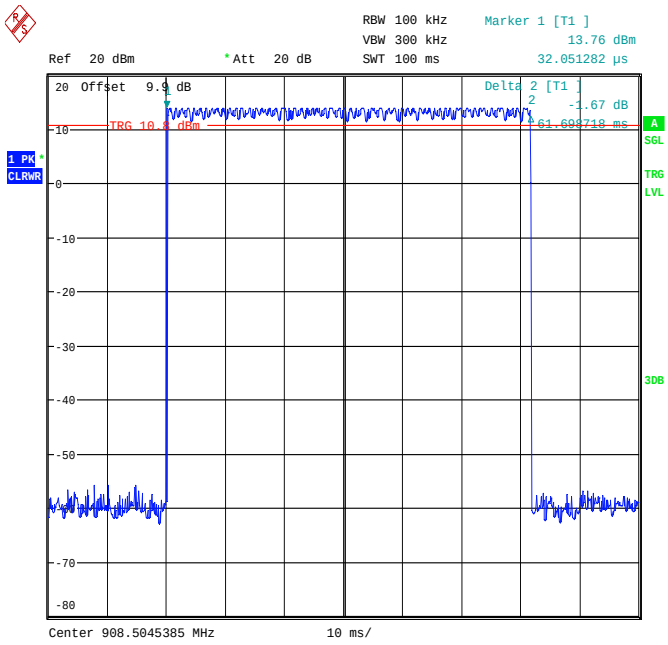
Acquisition mode 64 hopping channels LoRaWan 125 kHz channel

$T_{occ\ (ms)}$	MP (s)	MPTX	AOT (s)	Limit (s)	Result
61.698718	20	1	0.061698718	0.4	PASS

Timings observed after the network assigned a frequency block LoRaWan 125 kHz channel

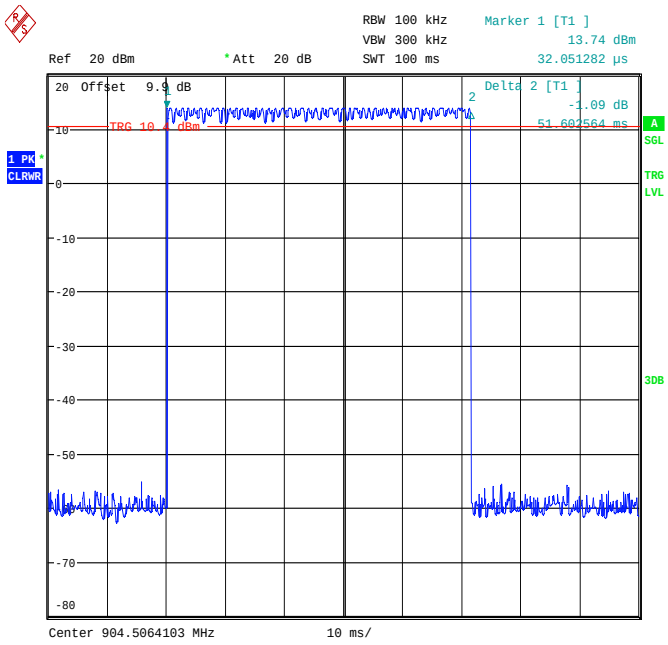
$T_{occ\ (ms)}$	MP (s)	MPTX	AOT (s)	Limit (s)	Result
51.602564	20	1	0.051602564	0.4	PASS

Ton during acquisition mode



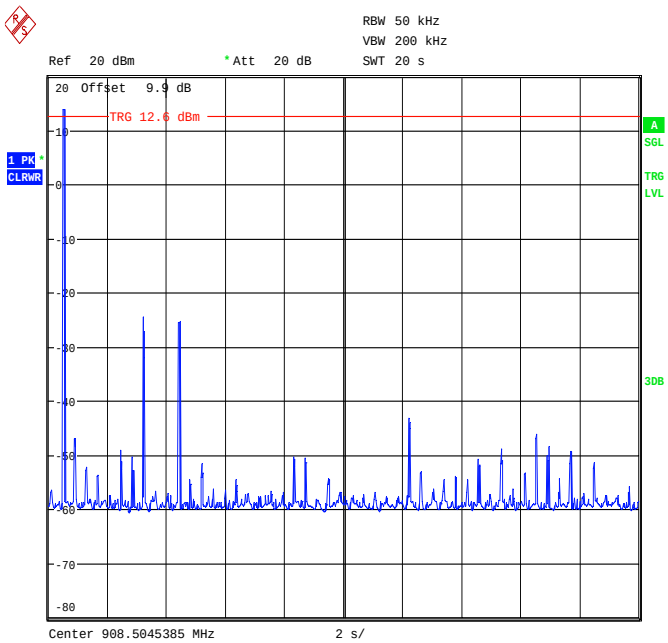
Date: 9.MAR.2021 11:39:50

Ton after network assigned frequency block



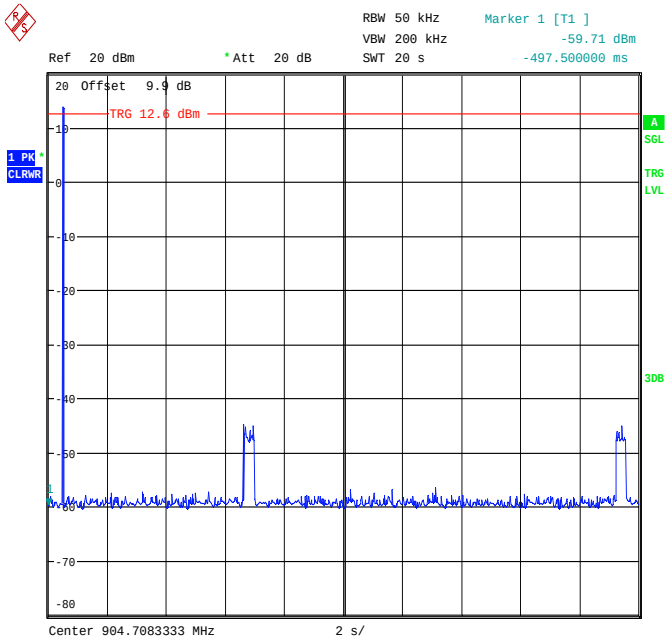
Date: 9.MAR.2021 13:25:51

Number of transmissions during 20 second observation period
64 hopping channels



Date: 9.MAR.2021 11:47:33

Number of transmissions during 20 second observation period
8 hopping channels



Date: 9.MAR.2021 12:06:55

22 Carrier frequency separation

22.1 Definition

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

22.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.2
Frequencies Measured:	902 MHz-928 MHz
EUT 20dB Bandwidth:	144 kHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	20 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

22.3 Test Limit

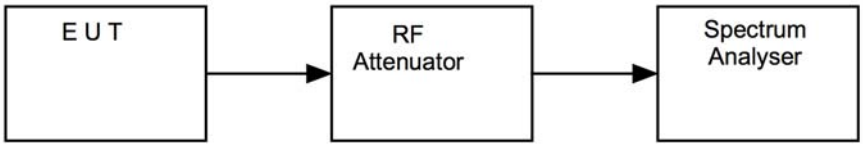
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400 to 2483.5 MHz may have hopping channel carrier frequencies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

22.4 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



22.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

22.6 Test Results

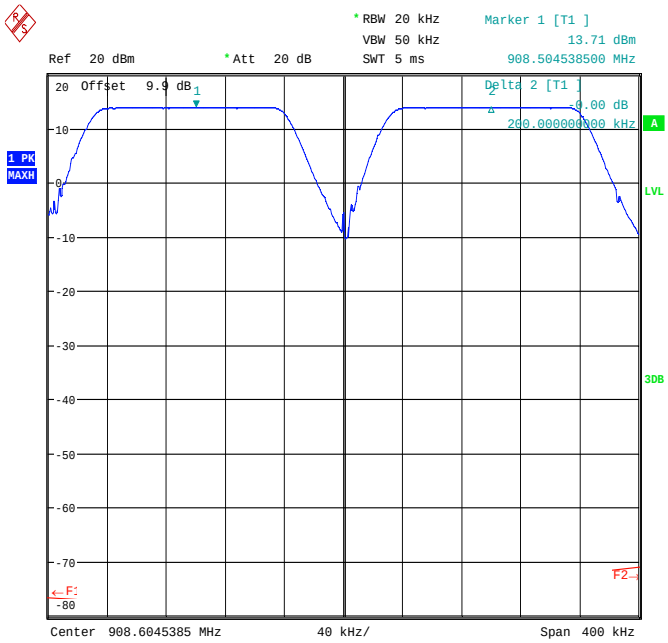
Channel separation observed
64 Hopping channels LoRaWan 125 kHz channel

Measured Channel Spacing (kHz)	Limit	Result
200	(25kHz or 2/3 Measured 20 dB Bandwidth kHz)	Pass

Channel separation observed
8 Hopping channels LoRaWan 125 kHz channel

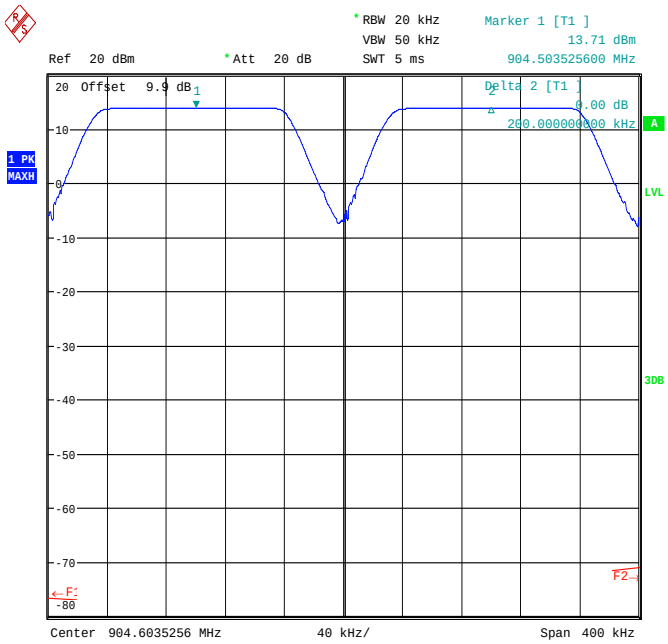
Measured Channel Spacing (kHz)	Limit	Result
200	(25kHz or 2/3 Measured 20 dB Bandwidth kHz)	Pass

Channel separation 64 hopping channels LoRaWan 125 kHz channel



Date: 9.MAR.2021 11:28:48

Channel separation 8 hopping channels LoRaWan 125 kHz channel



Date: 9.MAR.2021 11:05:59

23 Occupied Bandwidth

23.1 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.

23.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.9
Frequencies Measured:	902.3 MHz/ 914.9 MHz / 927.5 MHz
EUT Channel Bandwidths:	125 kHz
Deviations From Standard:	None
Measurement BW: (requirement: 1 % to 5 % OBW)	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 2 to 5 times OBW)	300 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6Vdc	

23.3 Test Limit

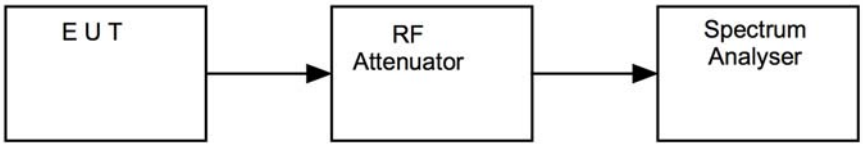
- For frequency hopping systems in the band 902 to 928 MHz: The maximum allowed -20 dB bandwidth of the hopping channel is 500 kHz.
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The maximum -20 dB bandwidth of the hopping channel shall be 1 MHz

23.4 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



23.5 Test Equipment

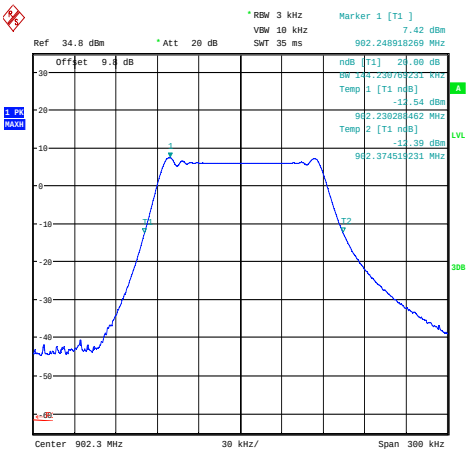
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

23.6 Test Results

LoRaWan 125 kHz channel

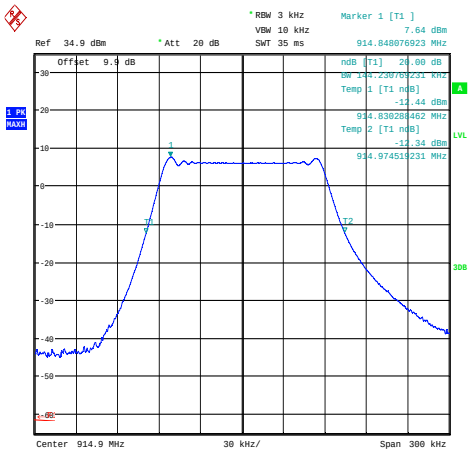
Frequency (MHz)	Fl MHz	FH MHz	20 dB BW kHz
902.3	902.230288	902.374519	144.231
914.9	914.830288	914.974519	144.231
927.5	927.430769	927.575000	144.231

902.3 MHz



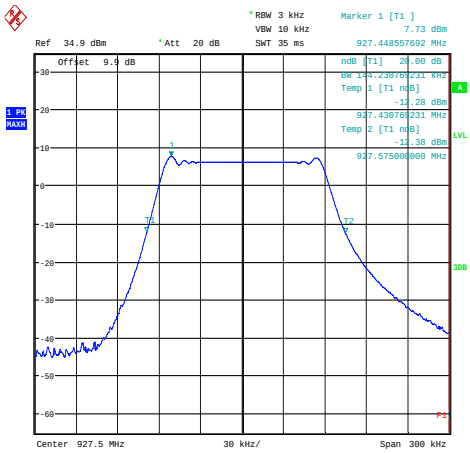
Date: 5.MAR.2021 11:16:52

914.9 MHz



Date: 5.MAR.2021 11:37:37

927.5 MHz

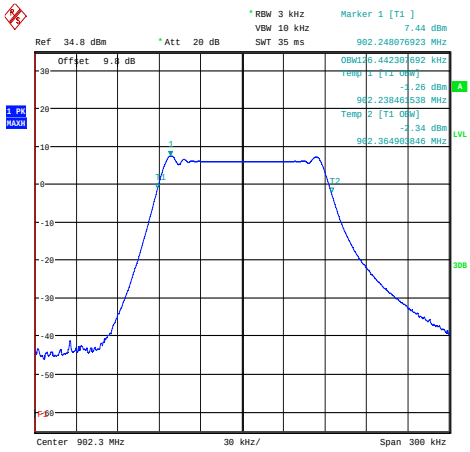


Date: 5.MAR.2021 11:40:44

LoRaWan 125 kHz channel

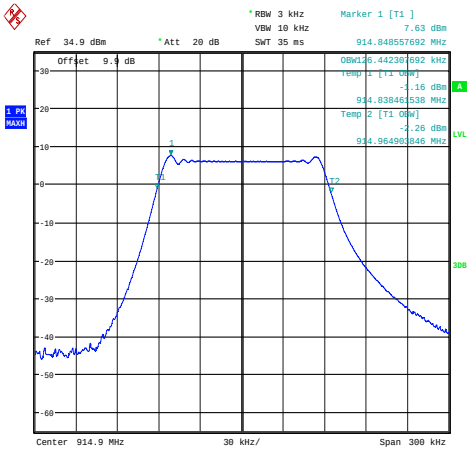
Frequency (MHz)	Fl MHz	FH MHz	99% BW kHz
902.3	902.238461	902.364903	126.442
914.9	914.838461	914.964903	126.442
927.5	927.438942	927.564903	125.961

902.3 MHz



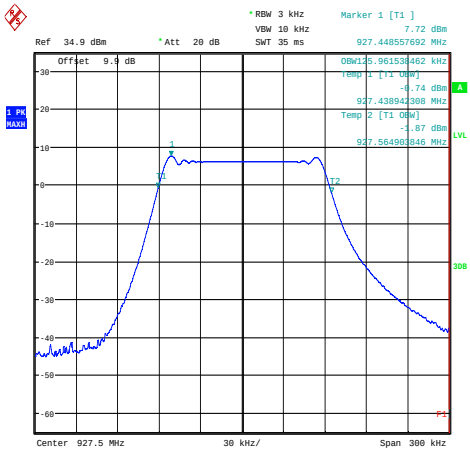
Date: 5.MAR.2021 11:45:42

914.9 MHz



Date: 5.MAR.2021 11:47:16

927.5 MHz



Date: 5.MAR.2021 11:48:39

24 Out-of-band and conducted spurious emissions

24.1 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.

24.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 7.8.8
Frequencies Measured:	902.3 MHz / 914.9 MHz / 927.5 MHz
EUT Channel Bandwidths:	125 kHz
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 10 GHz

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 34% RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

24.3 Test Limits

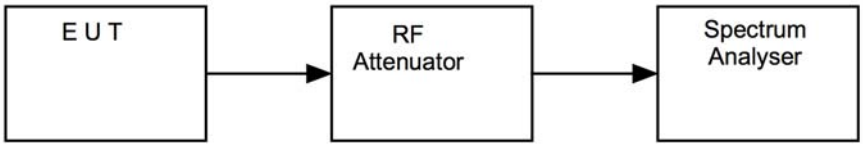
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

24.4 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



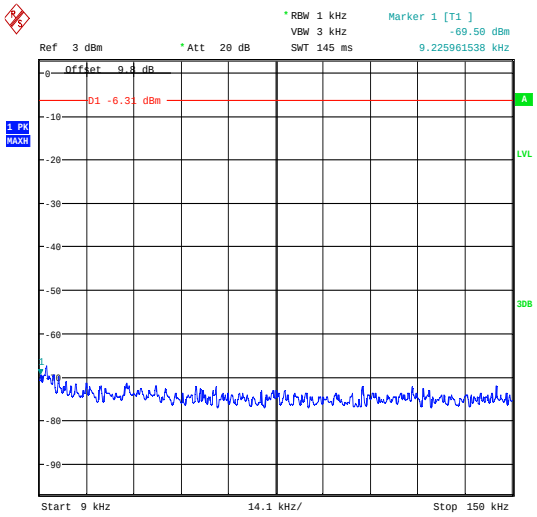
24.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2021-11-18
Attenuator	AtlanTechRF Microwave	10dB SMA	U634	Cal in use
SMBV100A	R&S	Signal Generator	U674	2021-05-12

24.6 Test Results

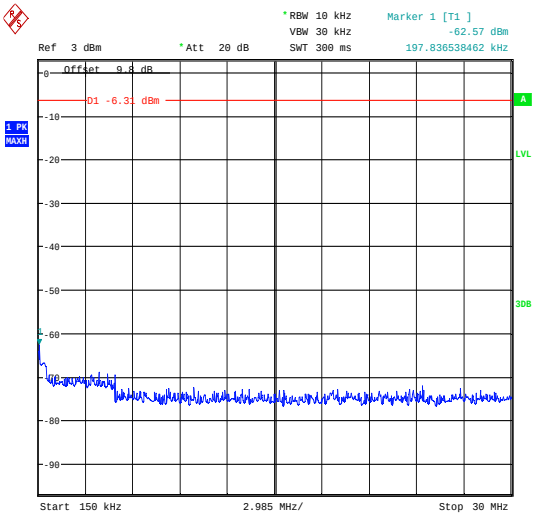
902.3 MHz LoRaWan 125 kHz channel						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant emission within 20dBm of the limit						PASS

9 kHz-150 kHz



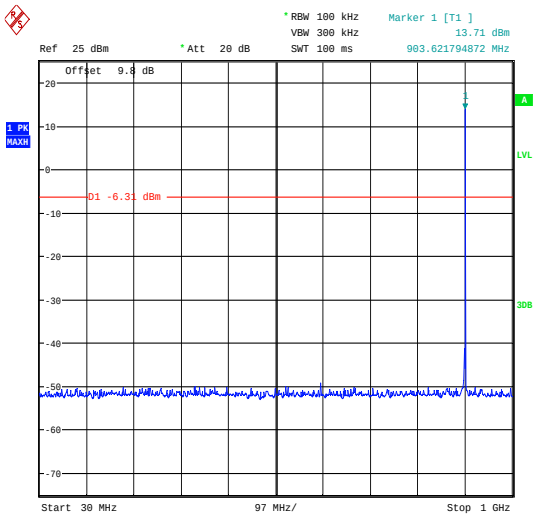
Date: 5.MAR.2021 13:28:01

150 kHz- 30 MHz



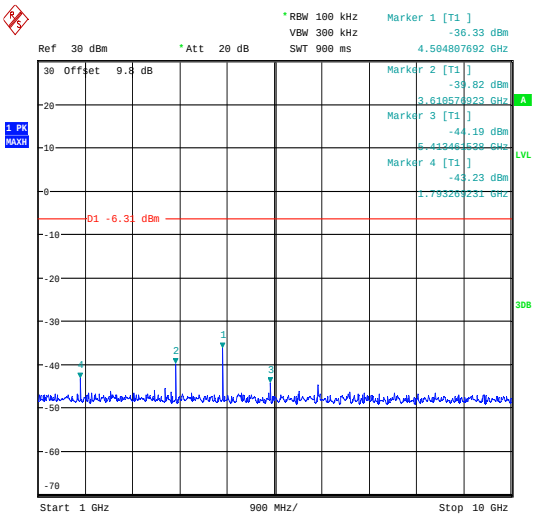
Date: 5.MAR.2021 13:28:31

30 MHz- 1GHz



Date: 5.MAR.2021 13:25:24

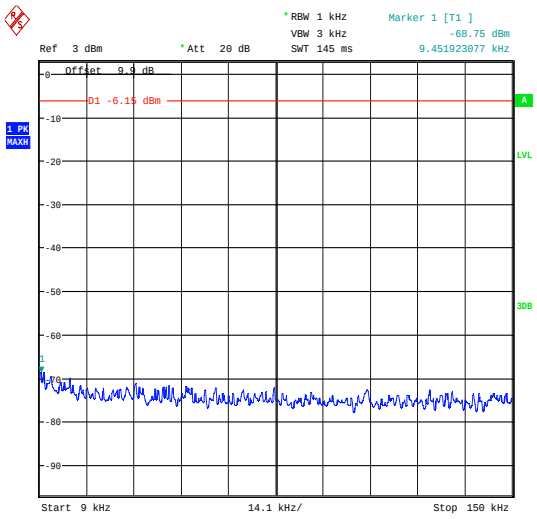
1 GHz- 10 GHz



Date: 5.MAR.2021 13:27:04

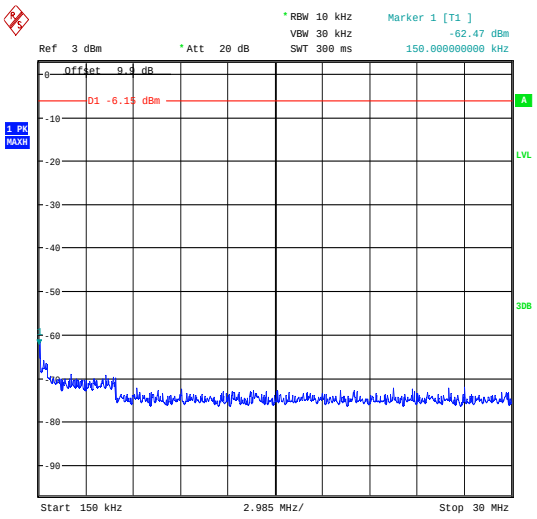
914.9 MHz LoRaWan 125 kHz channel						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant emission within 20dBm of the limit						PASS

9 kHz-150 kHz



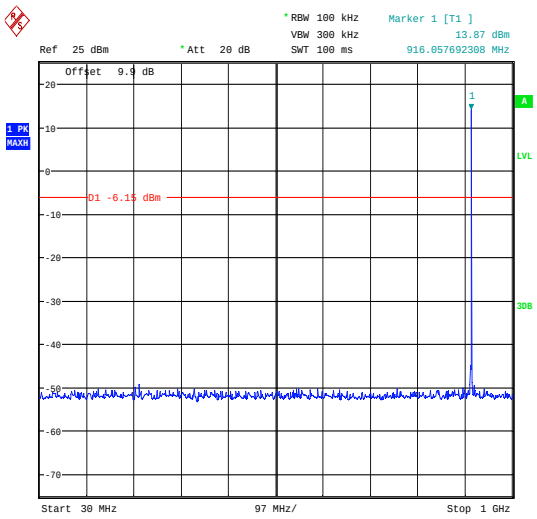
Date: 5.MAR.2021 13:31:48

150 kHz- 30 MHz



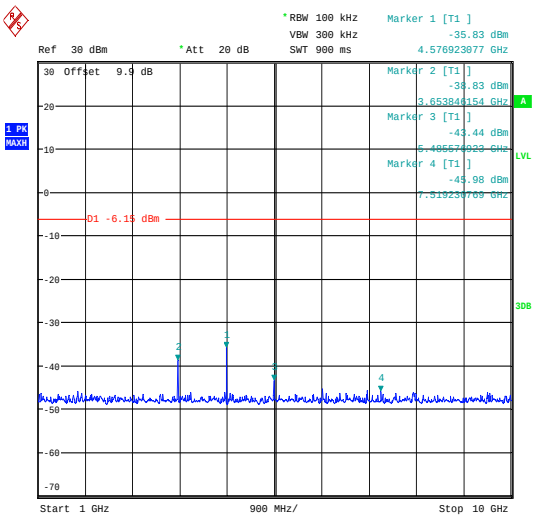
Date: 5.MAR.2021 13:32:14

30 MHz- 1GHz



Date: 5.MAR.2021 13:30:36

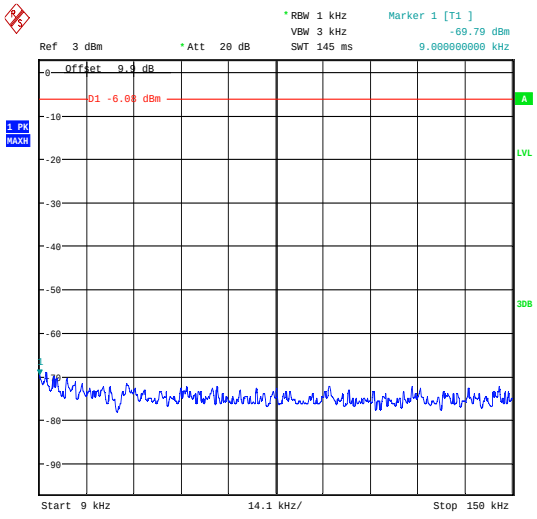
1 GHz- 10 GHz



Date: 5.MAR.2021 13:31:15

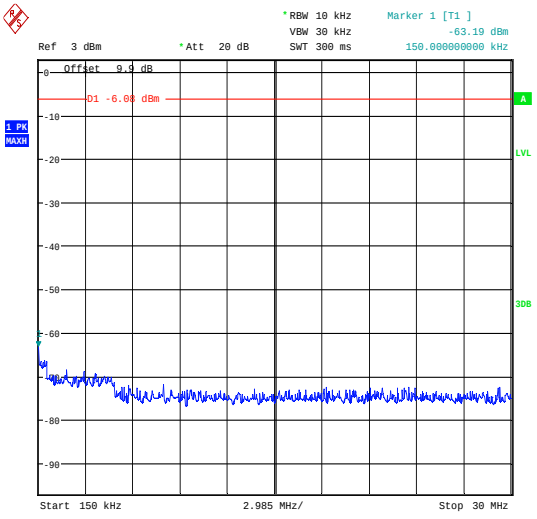
927.5MHz LoRaWan 125 kHz channel						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No Significant emission within 20dBm of the limit						PASS

9 kHz-150 kHz



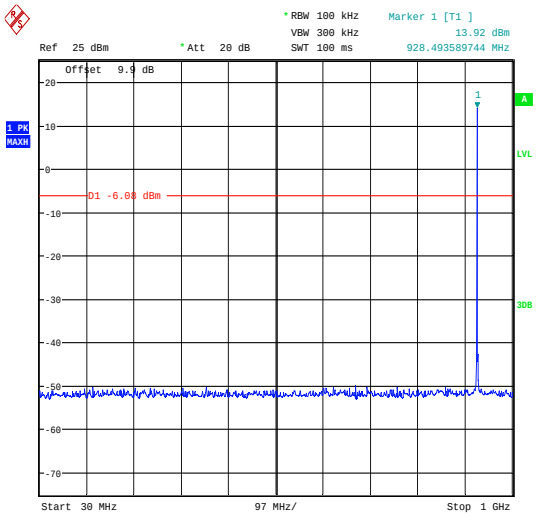
Date: 5.MAR.2021 13:35:24

150 kHz- 30 MHz



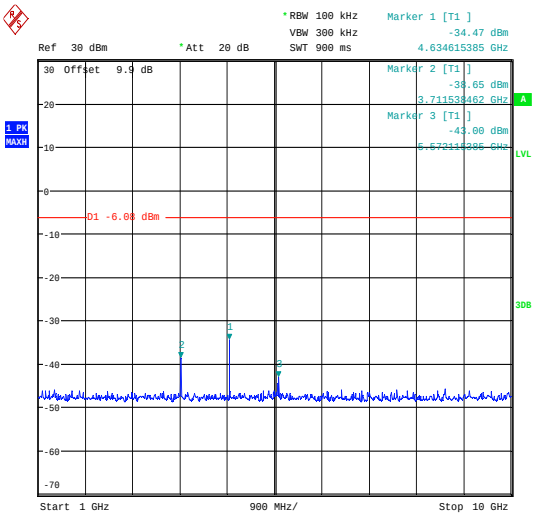
Date: 5.MAR.2021 13:35:53

30 MHz- 1GHz



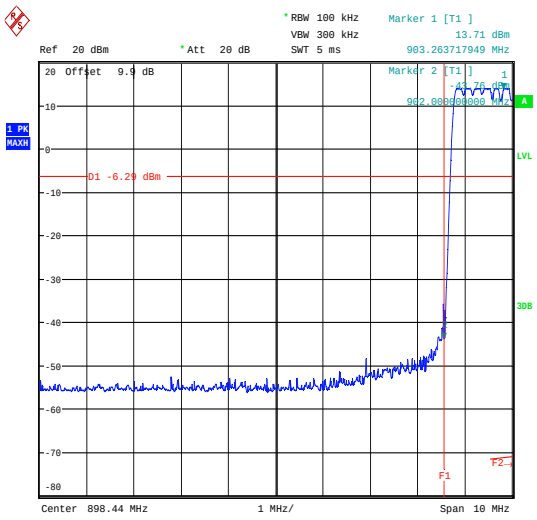
Date: 5.MAR.2021 13:34:06

1 GHz- 10 GHz



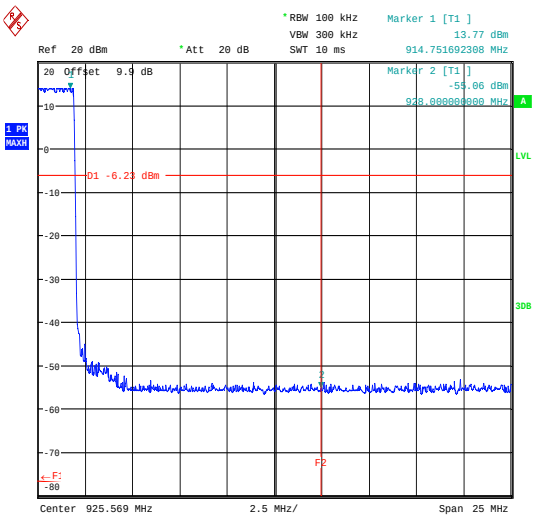
Date: 5.MAR.2021 13:34:53

Lower Bandedge LoRaWan 125 kHz channel



Date: 9.MAR.2021 15:39:54

Upper Bandedge LoRaWan 125 kHz channel



Date: 9.MAR.2021 15:55:03

25 Radiated emissions

25.1 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.

25.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Chamber 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	902.3 MHz/ 914.9 MHz/ 927.5 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: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.6 Vdc	

25.3 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.

25.4 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:

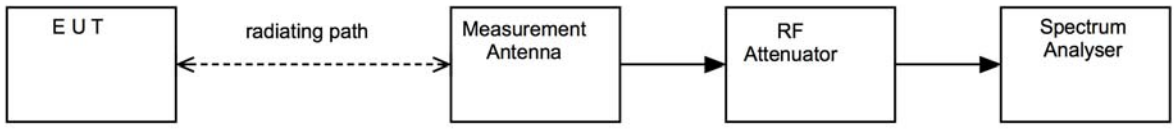
$$\text{Factor} = AF + CL - PA$$

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



25.5 Test Equipment

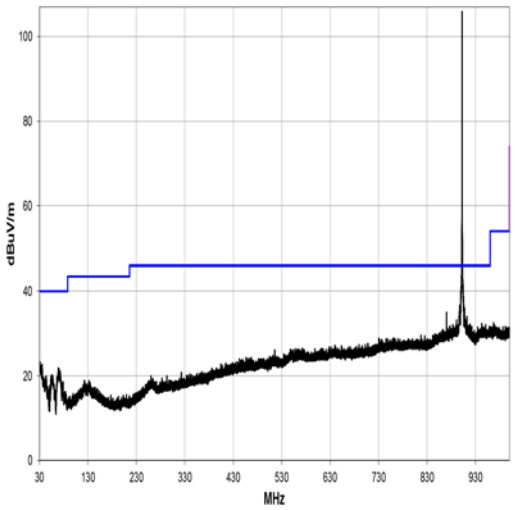
Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
CBL611/A	Chase	Bilog	U573	2023-01-28
LNA6901	Ametek CTS Europe	Pre amp	UH711	2022-09-01
3115	EMCO	1-18GHz Horn	L139	2021-07-16
8449B	Agilent	Pre Amp	U457	2021-08-26
VHF-1500+	MiniCircuits	High Pass Filter	U519	2022-01-30
AFH-07000	Atlantic Microwave	High Pass Filter	U558	2022-01-30

25.6 Test Results LoRaWan 125 kHz channel

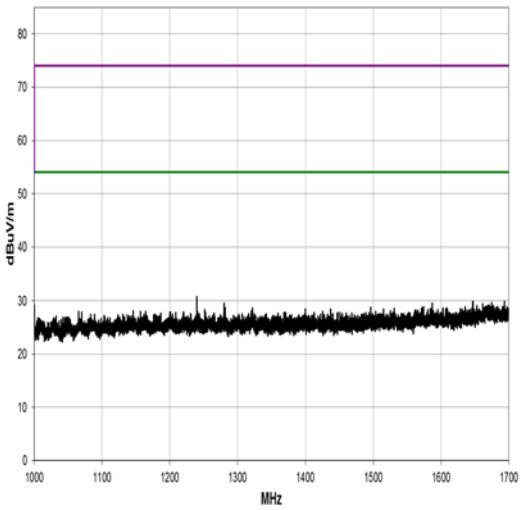
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
5413.817	42.7	6.2	1.5	211.8	3.0	0.0	Horz	AV	0.0	48.9	54.0	-5.1
5413.808	41.9	6.2	1.01	171.2	3.0	0.0	Vert	AV	0.0	48.1	54.0	-5.9
3609.202	45.6	1.0	1.78	71.9	3.0	0.0	Vert	AV	0.0	46.6	54.0	-7.4
4511.500	39.2	3.0	1.5	214.1	3.0	0.0	Horz	AV	0.0	42.2	54.0	-11.8
3609.177	39.3	1.0	1.51	120.2	3.0	0.0	Horz	AV	0.0	40.3	54.0	-13.7
4511.508	35.7	3.0	1.5	137.8	3.0	0.0	Vert	AV	0.0	38.7	54.0	-15.3
2706.920	39.8	-2.7	1.5	75.9	3.0	0.0	Vert	AV	0.0	37.1	54.0	-16.9
5413.758	50.4	6.2	1.01	171.2	3.0	0.0	Vert	PK	0.0	56.6	74.0	-17.4
5413.467	50.3	6.2	1.5	211.8	3.0	0.0	Horz	PK	0.0	56.5	74.0	-17.5
2706.928	35.8	-2.7	1.68	221.0	3.0	0.0	Horz	AV	0.0	33.1	54.0	-20.9
3608.868	51.6	1.0	1.78	71.9	3.0	0.0	Vert	PK	0.0	52.6	74.0	-21.4
2706.875	35.2	-2.7	2.18	153.9	3.0	0.0	Horz	AV	0.0	32.5	54.0	-21.5
4511.183	48.5	3.0	1.5	214.1	3.0	0.0	Horz	PK	0.0	51.5	74.0	-22.5
4511.217	47.5	3.0	1.5	137.8	3.0	0.0	Vert	PK	0.0	50.5	74.0	-23.5
3609.260	48.7	1.0	1.51	120.2	3.0	0.0	Horz	PK	0.0	49.7	74.0	-24.3
2707.045	48.5	-2.7	1.5	75.9	3.0	0.0	Vert	PK	0.0	45.8	74.0	-28.2
2706.767	48.1	-2.7	2.18	153.9	3.0	0.0	Horz	PK	0.0	45.4	74.0	-28.6
2706.437	48.0	-2.7	1.68	221.0	3.0	0.0	Horz	PK	0.0	45.3	74.0	-28.7

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
9022.867	35.6	9.5	1.62	32.2	3.0	0.0	Vert	AV	0.0	45.1	54.0	-8.9
9022.867	33.9	9.5	1.5	359.8	3.0	0.0	Horz	AV	0.0	43.4	54.0	-10.6
9023.408	47.9	9.5	1.62	32.2	3.0	0.0	Vert	PK	0.0	57.4	74.0	-16.6
9022.200	47.5	9.5	1.5	359.8	3.0	0.0	Horz	PK	0.0	57.0	74.0	-17.0

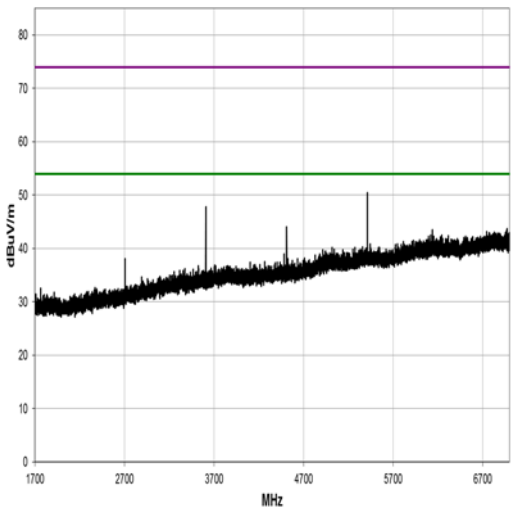
902.3 MHz 30 MHz-1 GHz



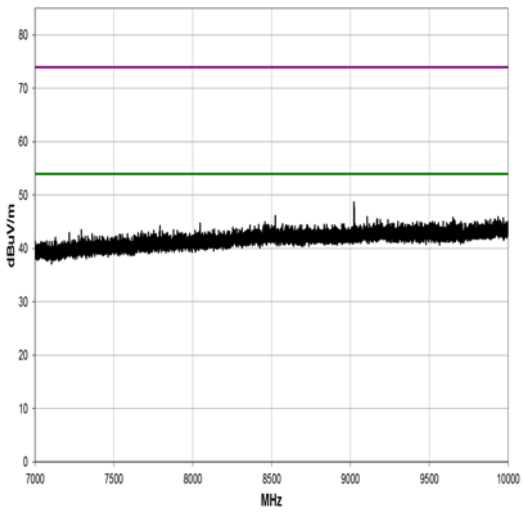
902.3 MHz 1 GHz-1.7 GHz



902.3 MHz 1.7 GHz -7 GHz



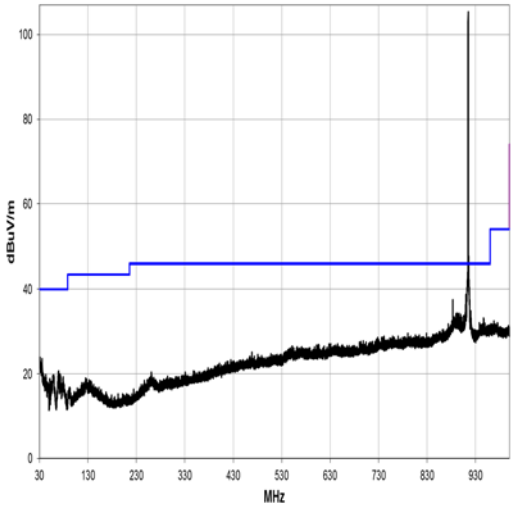
902.3 MHz 7 GHz-10 GHz



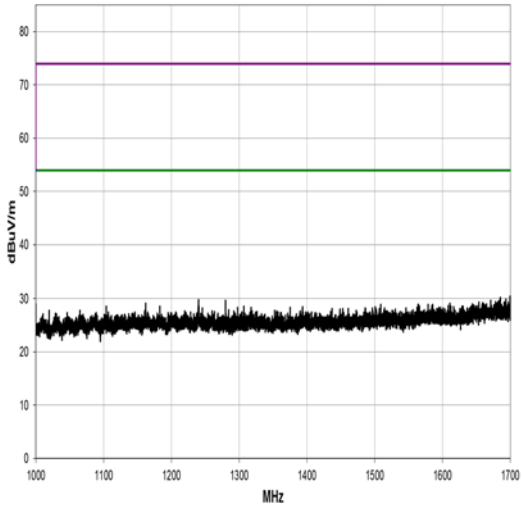
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
3659.592	42.4	1.3	1.46	76.0	3.0	0.0	Vert	AV	0.0	43.7	54.0	-10.3
4574.517	37.6	3.0	1.5	217.2	3.0	0.0	Horz	AV	0.0	40.6	54.0	-13.4
3659.592	49.9	1.3	1.46	76.0	3.0	0.0	Vert	PK	0.0	51.2	74.0	-22.8
4574.150	48.0	3.0	1.5	217.2	3.0	0.0	Horz	PK	0.0	51.0	74.0	-23.0

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
9149.017	38.7	9.7	1.37	31.9	3.0	0.0	Vert	AV	0.0	48.4	54.0	-5.6
9149.008	37.3	9.7	1.42	358.2	3.0	0.0	Horz	AV	0.0	47.0	54.0	-7.0
9149.275	49.5	9.7	1.37	31.9	3.0	0.0	Vert	PK	0.0	59.2	74.0	-14.8
9148.925	49.0	9.7	1.42	358.2	3.0	0.0	Horz	PK	0.0	58.7	74.0	-15.3

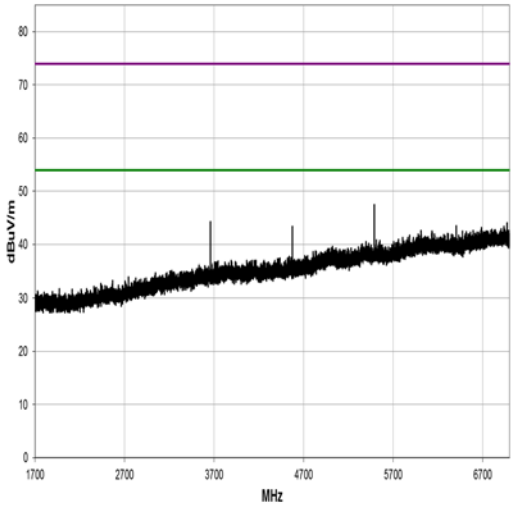
914.9 MHz 30 MHz-1 GHz



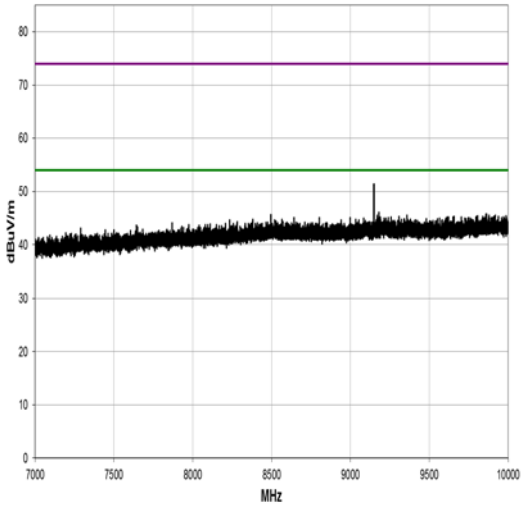
914.9 MHz 1 GHz-1.7 GHz



914.9 MHz 1.7 GHz -7 GHz



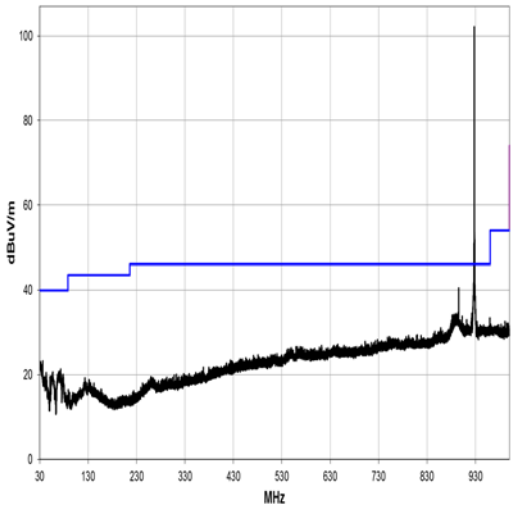
914.9 MHz 7 GHz-10 GHz



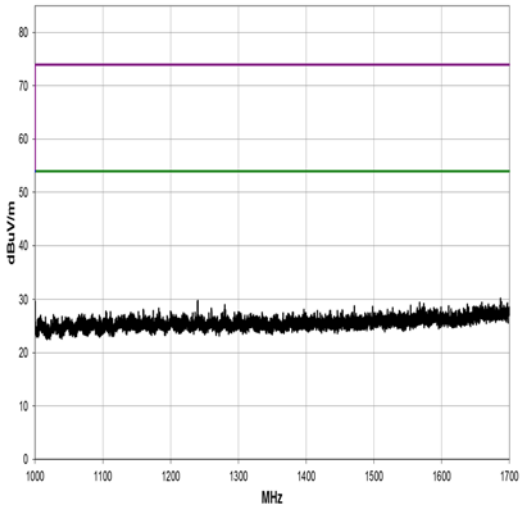
Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Test Distance (meters)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
3709.992	41.2	1.6	1.63	87.9	3.0	0.0	Vert	AV	0.0	42.8	54.0	-11.2
4637.500	38.0	3.2	1.5	156.2	3.0	0.0	Horz	AV	0.0	41.2	54.0	-12.8
4637.408	48.2	3.2	1.5	156.2	3.0	0.0	Horz	PK	0.0	51.4	74.0	-22.6
3710.617	48.8	1.6	1.63	87.9	3.0	0.0	Vert	PK	0.0	50.4	74.0	-23.6

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
8347.550	35.5	9.3	1.46	352.2	3.0	0.0	Horz	AV	0.0	44.8	54.0	-9.2
8347.483	33.8	9.3	1.13	17.2	3.0	0.0	Vert	AV	0.0	43.1	54.0	-10.9
8347.408	47.8	9.3	1.46	352.2	3.0	0.0	Horz	PK	0.0	57.1	74.0	-16.9
8347.475	47.1	9.3	1.13	17.2	3.0	0.0	Vert	PK	0.0	56.4	74.0	-17.6

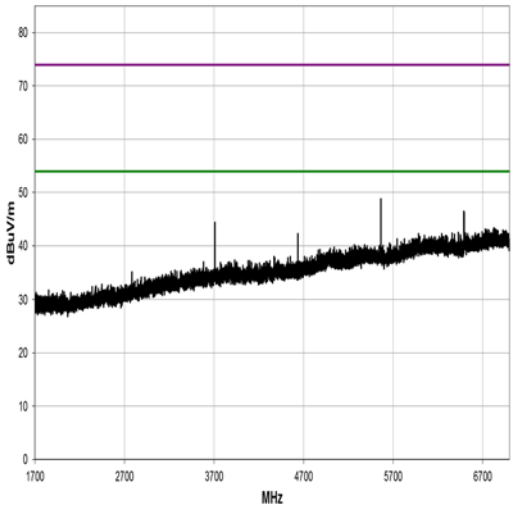
927.5 MHz 30 MHz-1 GHz



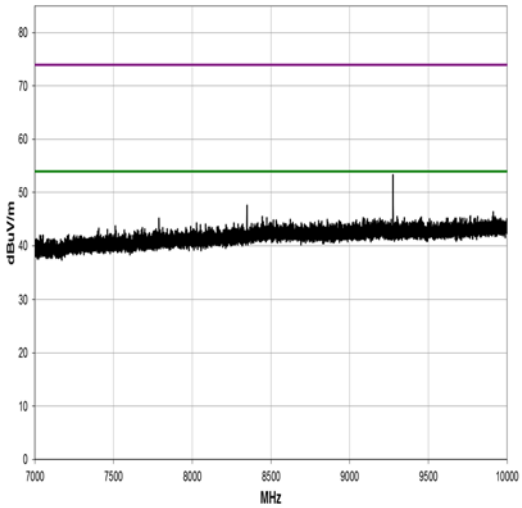
927.5 MHz 1 GHz-1.7 GHz



927.5 MHz 1.7 GHz -7 GHz



927.5 MHz 7 GHz-10 GHz



Note: The data provided in the tables above, are for emissions that fall into the restricted bands only.

26 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

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

Reference No.	Parameter	Description	Value	Unit
1	Adjacent Channel Power	Uncertainty in test result	***1.86***	dB
2	Carrier Power	Uncertainty in test result (Power Meter) Uncertainty in test result (Spectrum Analyser)	**0.070** ***3.11***	dB
3	Effective Radiated Power	Uncertainty in test result	***4.71***	dB
4	Radiated Spurious Emissions	Uncertainty in test result 30 MHz to 1 GHz 1 GHz to 18 GHz	***4.75*** ***4.46***	dB
5	Maximum Frequency Error	Uncertainty in test result (CMTA)	**113.441**	Hz
6	Radiated Emissions, Field Strength OATS 9 kHz – 110 GHz Electric Field	Uncertainty in test result (9 kHz – 30 MHz) Uncertainty in test result (30 MHz – 1 GHz) Uncertainty in test result (1 GHz – 18 GHz) Uncertainty in test result (18 GHz – 26 GHz) Uncertainty in test result (26 GHz – 40 GHz) Uncertainty in test result (40 GHz – 50 GHz) Uncertainty in test result (50 GHz – 75 GHz) Uncertainty in test result (75 GHz – 110 GHz)	**2.3** ***4.75*** ***4.46*** **3.2** **3.3** **3.5** **3.6** **3.6**	dB
7	Frequency Deviation	Uncertainty in test result	**3.7**	%
8	Magnetic Field Emissions	Uncertainty in test result	**2.3**	dB
9	Conducted Spurious	Uncertainty in test result Up to 26 GHz	**0.921**	dB

Reference No.	Parameter	Description	Value	Unit
10	Channel Bandwidth	Uncertainty in test result	***15.71***	%
11	Spectrum Mask Measurements	Uncertainty in test result (frequency) Uncertainty in test result (amplitude)	***2.59*** ***1.32***	% dB
12	Adjacent Sub Band Selectivity	Uncertainty in test result	***1.24***	dB
13	Receiver Blocking – Listen Mode, Radiated	Uncertainty in test result	***3.23***	dB
14	Receiver Blocking – Talk Mode, Radiated	Uncertainty in test result	***3.36***	dB
15	Receiver Blocking – Talk Mode, Conducted	Uncertainty in test result	***1.24***	dB
16	Receiver Threshold	Uncertainty in test result	***3.42***	dB
17	Transmission Time Measurement	Uncertainty in test result	***4.40***	%

27 RF Exposure

MPE Calculation

Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20 cm separation specified under FCC rules may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than the power density limit, as required under FCC rules.

Equation from IEEE C95.1

$$S = \frac{EIRP}{4\pi R^2} \quad \text{re - arranged} \quad R = \sqrt{\frac{EIRP}{S\ 4\pi}}$$

Where:

S = power density
R = distance to the centre of radiation of the antenna
EIRP = EUT Maximum power

Result

Channel Frequency (MHz)	EIRP (mW)	Power Density Limit (mW/cm^2)	R (cm)	RF Exposure Evaluation
903.0	28	0.602	1.92	Not Required
915.0	29	0.610	1.95	Not Required
927.5	30	0.618	1.97	Not Required

28 RF Exposure

RF EXPOSURE TECHNICAL BRIEF

RSS-102 issue 5
2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2}\ f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

Channel Frequency (MHz)	EIRP (W)	Exemption Limit (W)	RF Exposure Evaluation
903.0	0.028	1.37	Not Required
915.0	0.029	1.38	Not Required
927.5	0.030	1.40	Not Required