Report on the Radio Testing

For

Extronics Limited

on

iTAG X40

Report no. TRA-063664-47-01B

2024-11-14

Report Number: TRA-063664-47-01B
Issue: B

REPORT ON THE RADIO TESTING OF A
Extronics Limited
iTAG X40
WITH RESPECT TO SPECIFICATION
47CFR 15.247

TEST DATE: 2024-09-02 to 2024-09-18

Tested by:	M Else D Winstanley	M Else, D Winstanley Radio Test Engineer Radio Senior Test Engineer
Written by:	Digitally signed by D Winstanley DN: cn=D Winstanley, o=Element, ou=Radio, email=daniel.winstanley@element.com, c=US Date: 2024.11.14 13:50:38 Z	p.p. S Garwell Radio Test Engineer
Approved by:	Digitally signed by John Charters Date: 2024.11.14 14:05:24 Z	J Charters Lab Manager
Date:	2024-11-14	

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2024-10-02	Original
B	2024-11-14	Updated with certification amendments

2 Summary

TEST REPORT NUMBER:	TRA-063664-47-01B
WORKS ORDER NUMBER:	TRA-053699-01
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR 15.247
EQUIPMENT UNDER TEST (EUT):	iTAG X40
FCC IDENTIFIER:	2AIZE EXTRFID00005
EUT SERIAL NUMBER:	PCB13
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
ORDER NUMBER:	PO0028964
TEST DATE:	2024-09-02 to 2024-09-18
TESTED BY:	M Else, D Winstanley Element

2.1 Test Summary (Section 1 DTS Mode).

Test Method and Description		*Requirement Clause FCC 47 CFR*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	☒	Pass
AC power line conducted emissions		15.207	☐	Note 1
6 dB bandwidth		15.247 (a) (2)	☒	Pass
Occupied bandwidth (99% bandwidth)		N/A	☒	Pass
Conducted output power	Peak	15.247 (b) (3)	☒	Pass
	Maximum		☐	
Undesirable / unwanted emissions		15.247 (d)	☒	Pass
Power spectral density		15.247 (e)	☒	Pass
Pulsed operation correction		15.35 (c)	☐	Note 2

Specific Notes:

1. The EUT is a battery powered device / The EUT has got a rechargeable battery, but as per client's declaration, it doesn't transmit while charging.
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.
5. 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.
6. 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 FCC 47 CFR*	*Applicable to this Equipment*	*Result / Note*
Restricted Bands of Operation	15.205	☒	Pass
AC Power Line Conducted Emissions	15.207	☐	Note 1
Carrier Frequency Separation	15.247 (a) (1)	☒	Pass
Number of Hopping Channels	15.247 (a) (1) (i), (ii) and (iii)	☒	Pass Note 2
Average Time of Occupancy	15.247 (a) (1) (i), (ii) and (iii)	☒	Pass
Maximum Peak Conducted Output Power	15.247 (a) (1), (b)(1) and (b)(2)	☒	Pass
20 dB Emission Bandwidth	15.247 (a) (1) (i) and (ii)	☒	Pass
Undesirable / Unwanted Emissions	15.247(d)	☒	Pass
Pulsed Operation Correction	15.35 (c)	☒	Pass
Occupied Bandwidth (99 % Bandwidth)	N/A	☒	Pass

Specific Notes:

1. The EUT is a battery powered device / The EUT has got a rechargeable battery, but as per client's declaration, it doesn't transmit while charging.
2. The Equipment was tested as a Hybrid System using KDB 558074 D01 15.247 Measurement guidance v05r02 Section 10.

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

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).

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

3 Contents

4 Introduction

This report TRA-063664-47-01B presents the results of the Radio testing on an Extronics Limited, iTAG X40 to specification 47CFR15 Radio Frequency Devices.

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

☒ Element Skelmersdale
Unit 1
Pendle Place
Skelmersdale
West Lancashire
WN8 9PN
UK

☐ Element Surrey Hills
Unit 15 B
Henley Business Park
Pirbright Road
Normandy
Guildford
GU3 2DX
UK

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

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

Throughout this report EUT denotes equipment under test.

FCC Site Listing:
The test laboratory is accredited for the above sites under the US-UK MRA,

Designation number(s):

Element Surrey Hills	UK2027
Element Skelmersdale	UK2020

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

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

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
- 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: iTAG X40
- Serial Number: PCB13
- Model Number: X40
- Software Revision: 2.0.1.1.3
- Build Level / Revision Number: Production

7.2 System Equipment

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

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

The operating mode for transmitter tests was as follows:-

The EUT was set to transmit a modulated signal on the required Frequency.

7.4 EUT Radio Parameters

7.4.1 General (DTS mode)

Frequency of operation:	902 MHz-928 MHz Band
Modulation type:	LoRa Chirp Spread Spectrum
Occupied channel bandwidth:	500 kHz
Declared output power:	14 dBm
Nominal Supply Voltage:	3.7 Vdc Lithium Ion Re-chargeable battery

7.4.1 General (FHSS mode)

Frequency of operation:	902 MHz-928 MHz Band
Modulation type:	LoRa Chirp Spread Spectrum
Occupied channel bandwidth:	125 kHz
Declared output power:	14 dBm
Nominal Supply Voltage:	3.7 Vdc Lithium Ion Re-chargeable battery

7.4.2 Antennas

Manufacturer:	Extronics
Type:	Sheet Metal ILA (Inverted L-Antenna)
Frequency range:	868 MHz (EU) and 915 MHz (US)
Gain:	-2.1 dBi (peak)
Mounting:	Surface mount on PCB with 3 tabs on 3 pads (not through-hole)

7.5 EUT Description

The EUT is a personnel location tag.

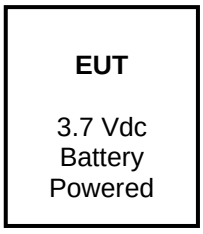
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

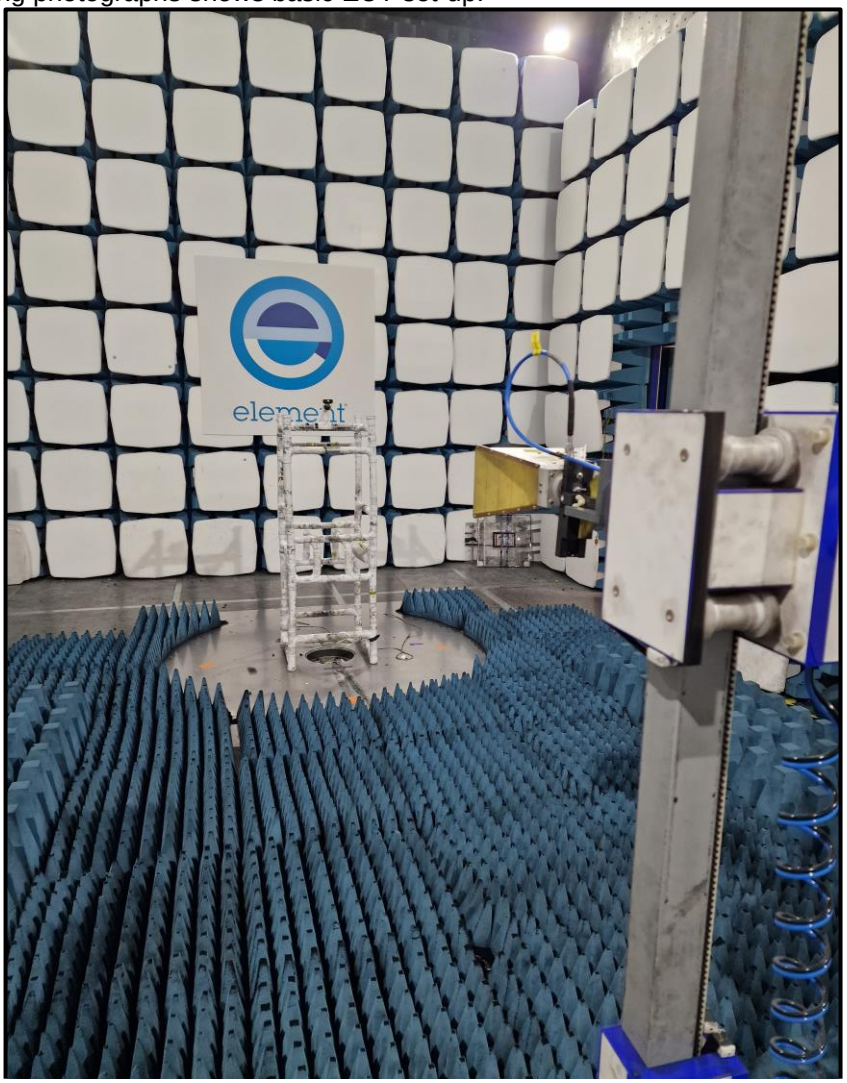
9.1 Block Diagram

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

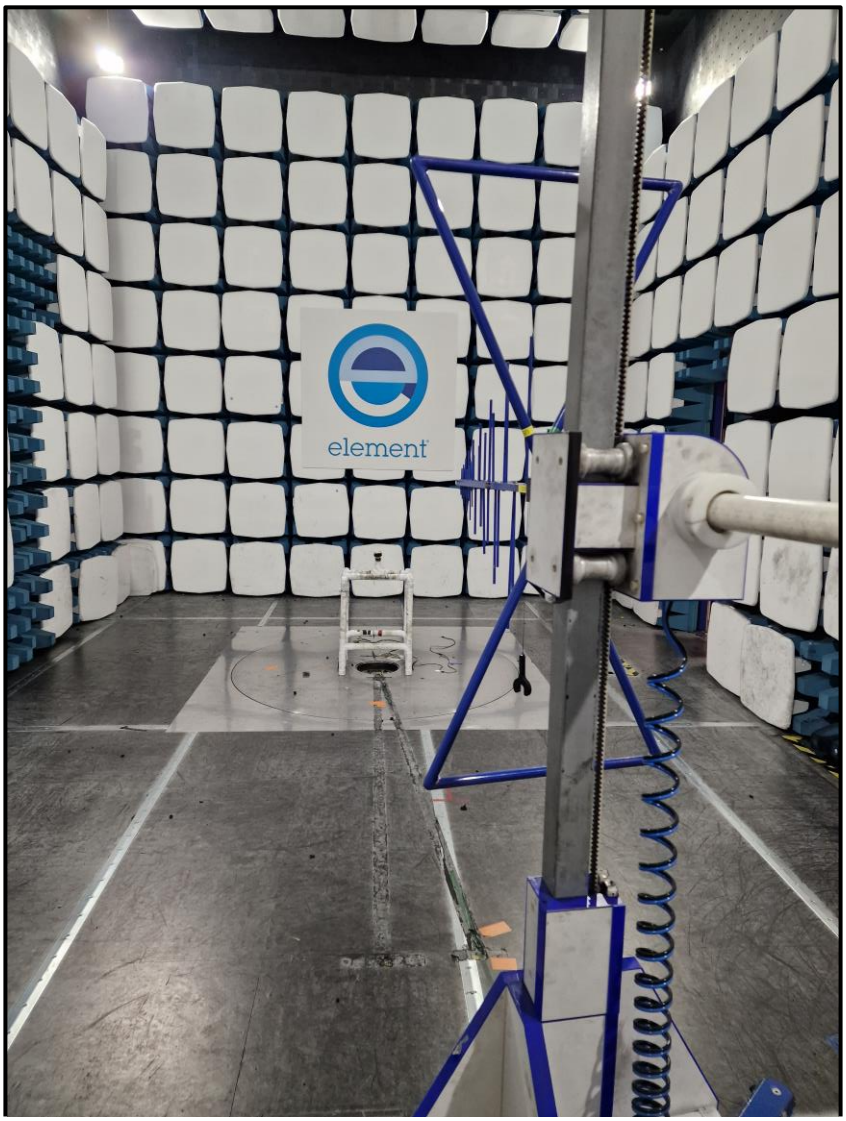


9.2 General Set-up Photograph

The following photographs shows basic EUT set-up:



1 GHz to 26.5 GHz



30 MHz to 1 GHz

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 iTAG X40 was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.7 Vdc from a Lithium Ion Re-chargeable battery

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, 907.8 MHz & 914.2 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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

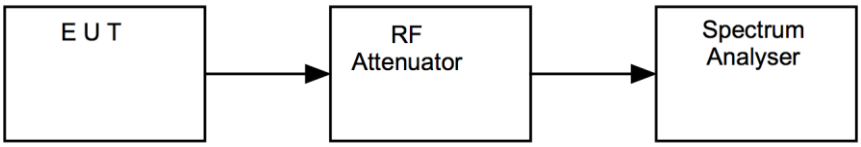
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

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

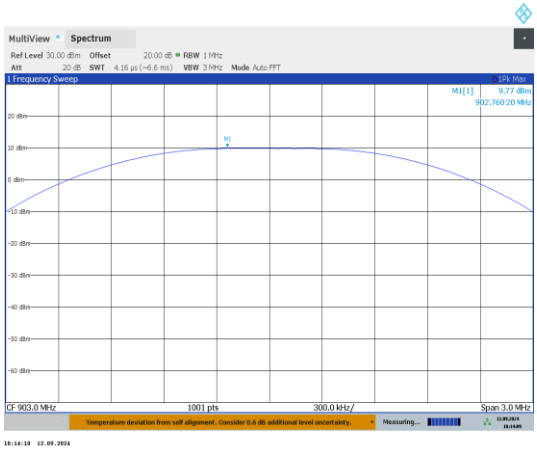


12.5 Test Equipment

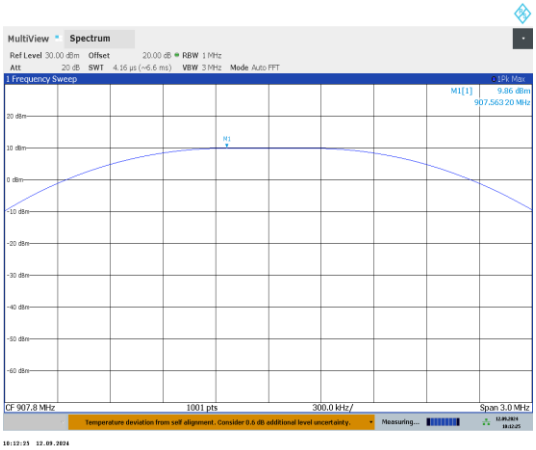
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

12.6 Test Results

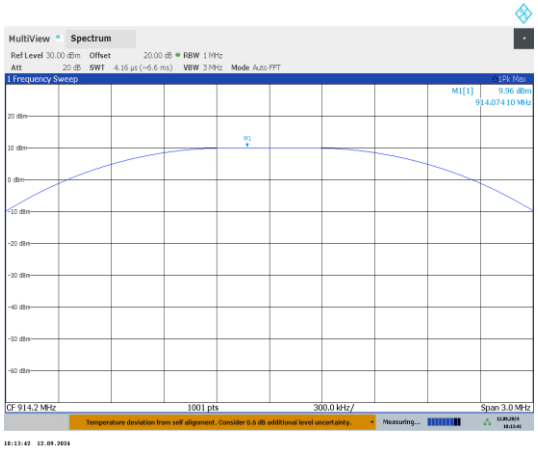
LoRa 500 kHz Channel					
Channel Frequency (MHz)	***Max Power (dBm)***	***Antenna Gain (dBi)***	***EIRP (dBm)***	***EIRP (mW)***	***Result***
903.0	9.77	0.00	9.77	9.484	Pass
907.8	9.86	0.00	9.86	9.683	Pass
914.2	9.96	0.00	9.96	9.908	Pass



903.0 MHz



907.8 MHz



914.2 MHz

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, 907.8 MHz & 914.2 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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

13.3 Test Limit

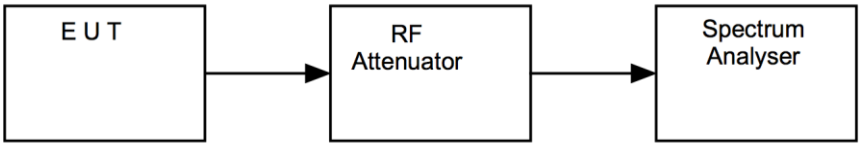
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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

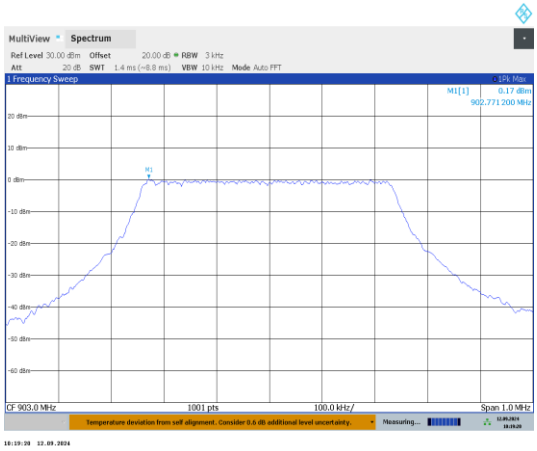


13.5 Test Equipment

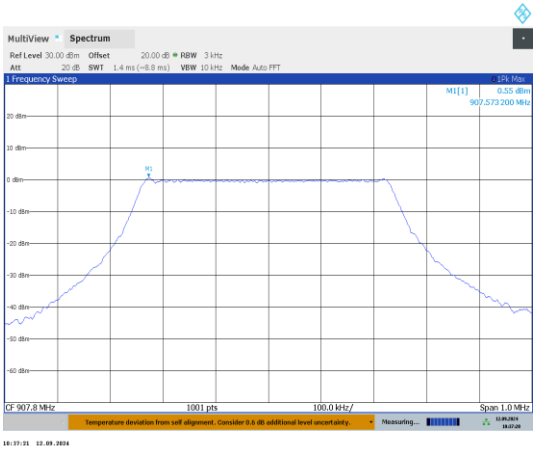
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

13.6 Test Results

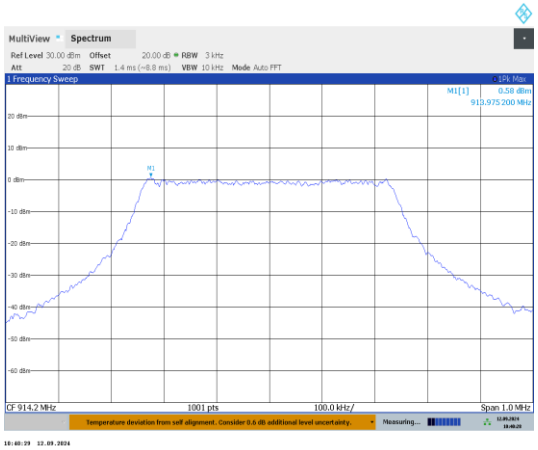
LoRa 500 kHz Channel			
Channel Frequency (MHz)	***Max PSD (dBm / 3 kHz)***	***Limit (dBm / 3 kHz)***	***Result***
903.0	0.17	8.0	Pass
907.8	0.55	8.0	Pass
914.2	0.58	8.0	Pass



903.0 MHz



907.8 MHz



914.2 MHz

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:	FCC: ANSI C63.10-2013, Clause 11.8
Frequencies Measured:	903.0 MHz, 907.8 MHz & 914.2 MHz
EUT Channel Bandwidths:	500 kHz
EUT Test Modulations:	LoRa
Deviations From Standard:	None
Measurement BW: FCC requirement: 100 kHz)	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	2 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

14.3 Test Limit

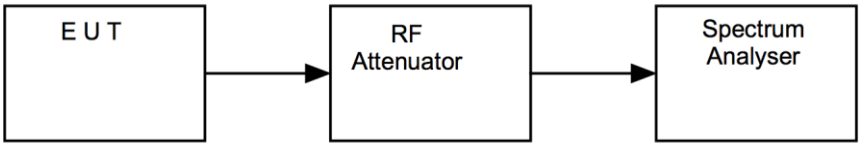
The minimum -6 dB bandwidth shall be at least 500 kHz.

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

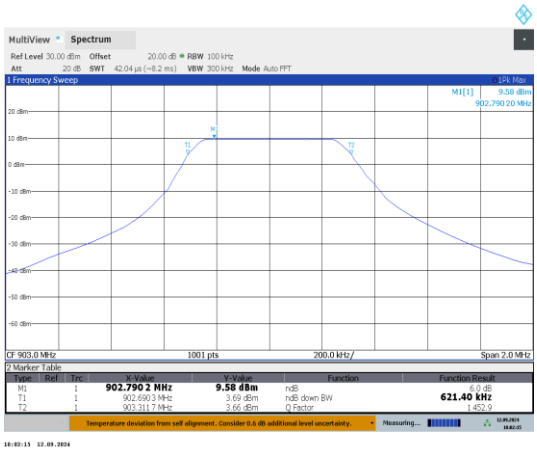


14.5 Test Equipment

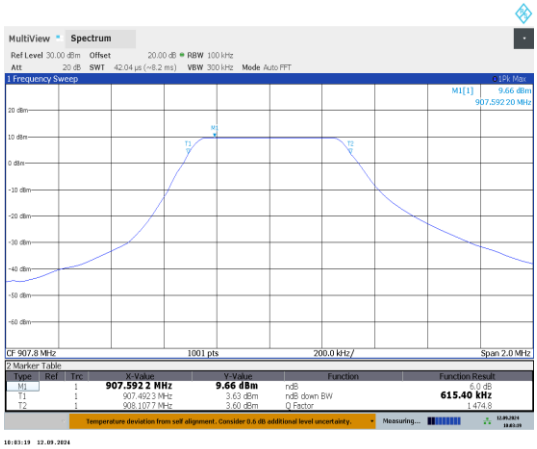
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

14.6 Test Results

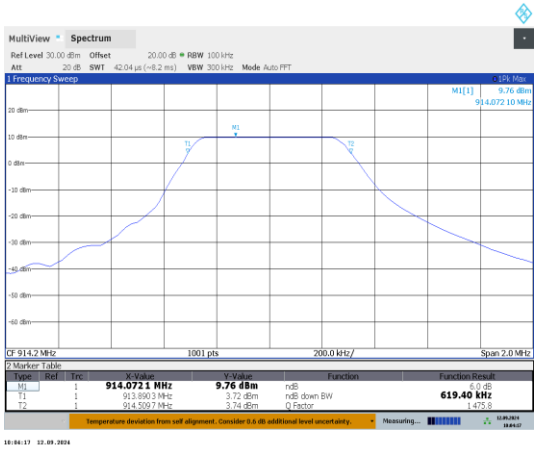
15.247; 6 dB; DTS Bandwidth; 500 kHz Operation				
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***6dB Bandwidth (kHz)***	***Result***
903.0	902.6903	903.3117	621.4	Pass
907.8	907.4923	908.1077	615.4	Pass
914.2	903.8903	904.5097	619.4	Pass



903.0 MHz



907.8 MHz



914.2 MHz

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, 907.8 MHz & 914.2 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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

15.3 Test Limit

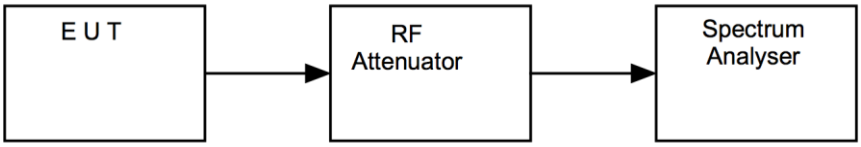
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

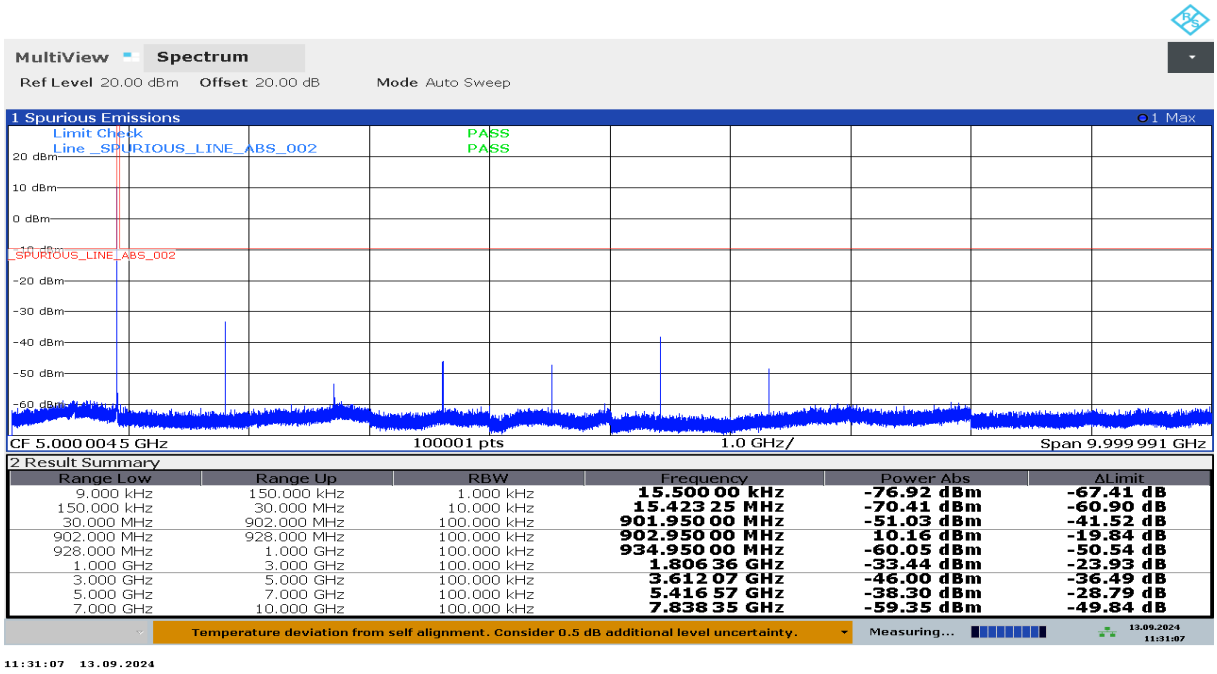
Figure v Test Setup



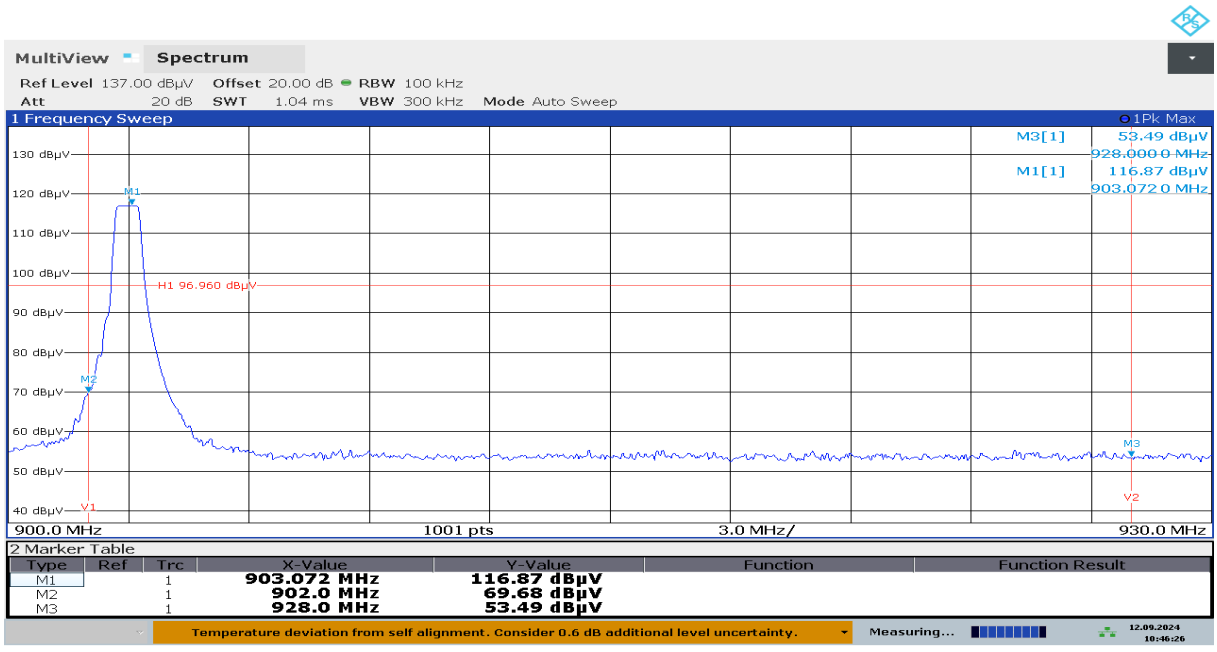
15.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

15.6 Test Results

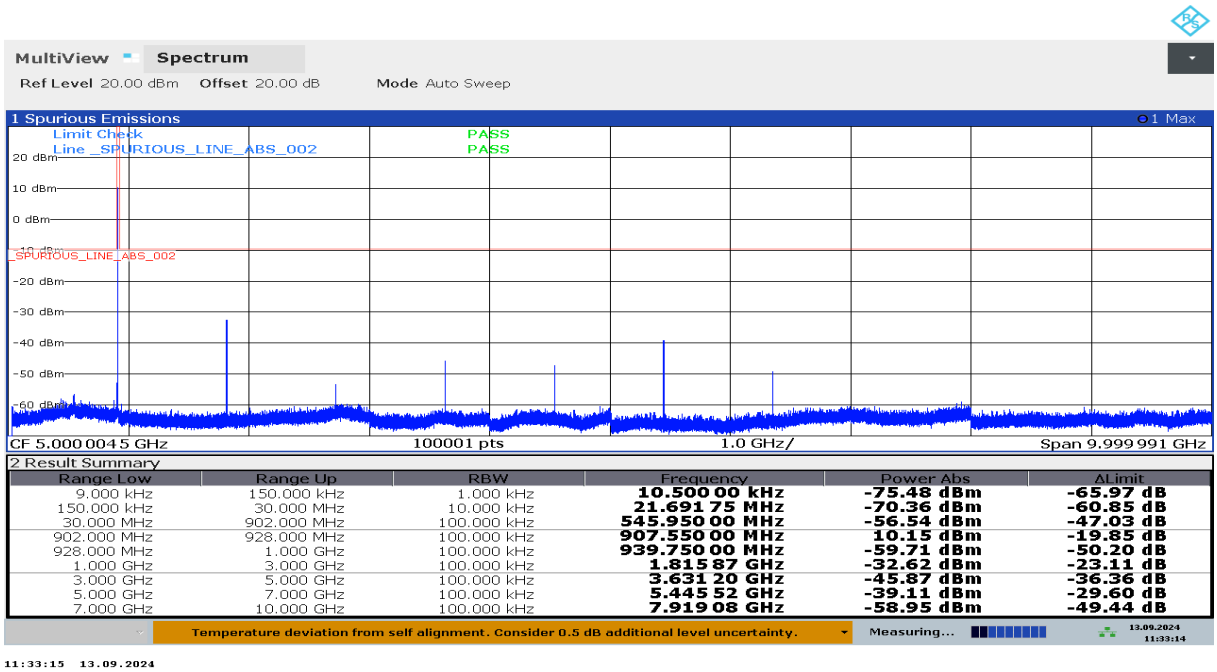


9 kHz to 10 GHz - 903.5 MHz



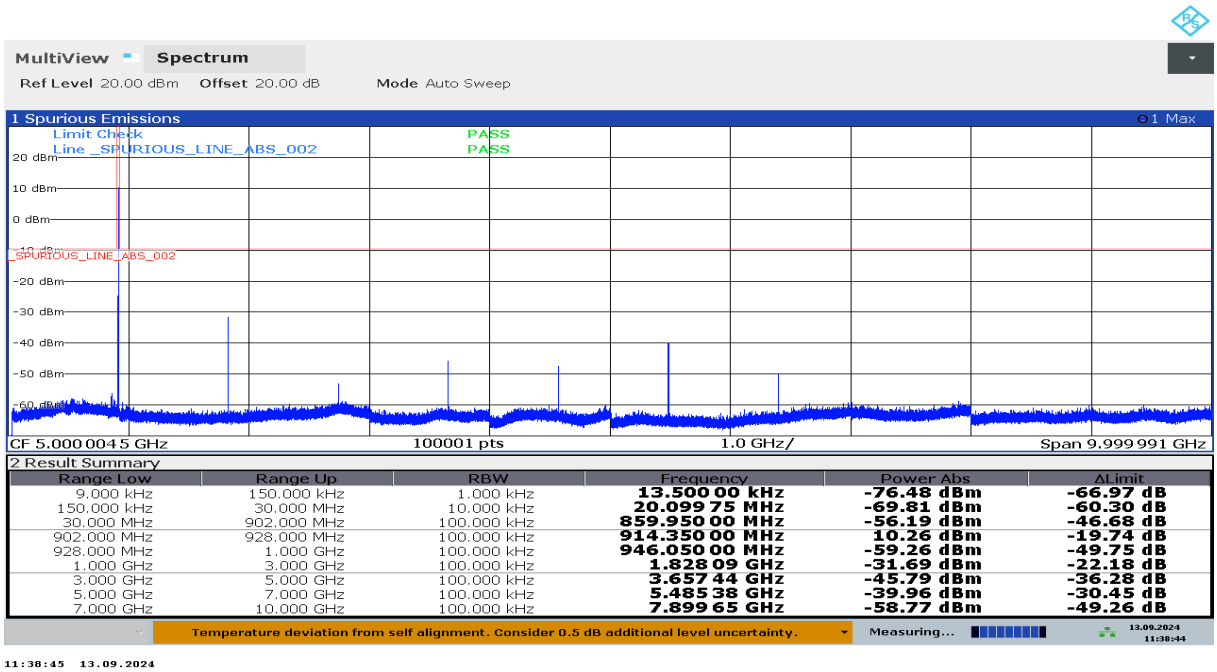
Lower Conducted Band Edge

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

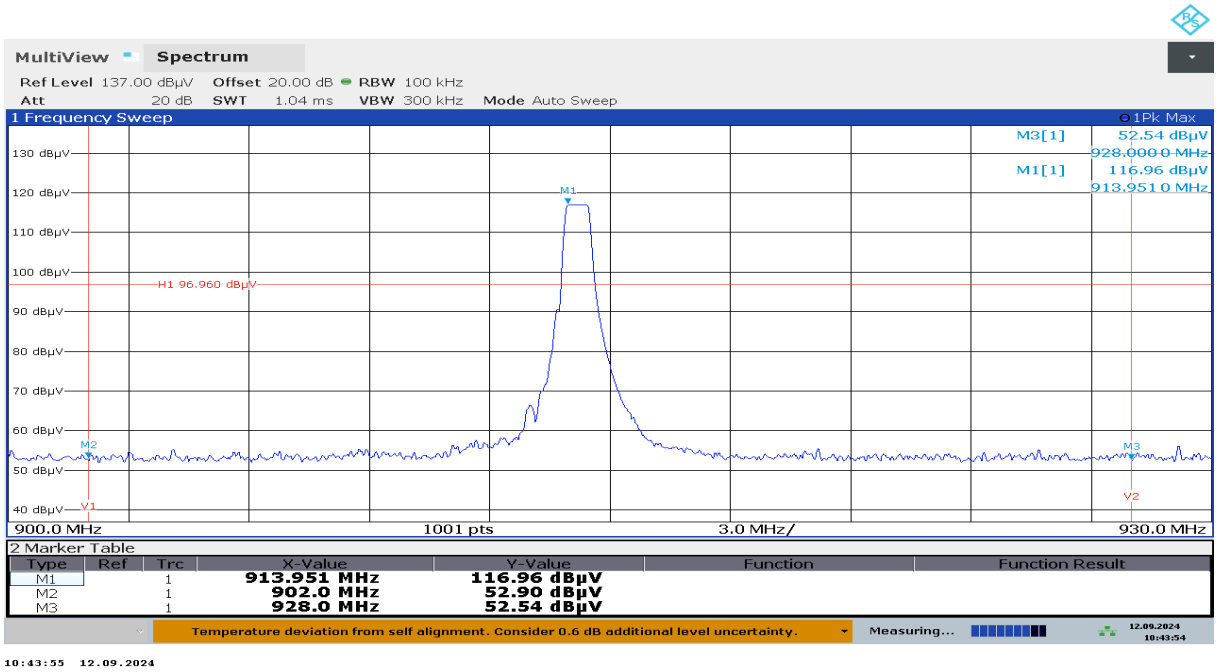


9 kHz to 10 GHz – 907.8 MHz

907.8 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 to 10 GHz – 914.2 MHz



Upper Conducted Band Edge

914.2 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

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, 907.8 MHz & 914.2 MHz
Deviations from Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak; Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 ºC to +35 ºC (as declared)
Humidity: 64 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

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:

$$FS = PR + CL + AF – PA + DC – CF$$

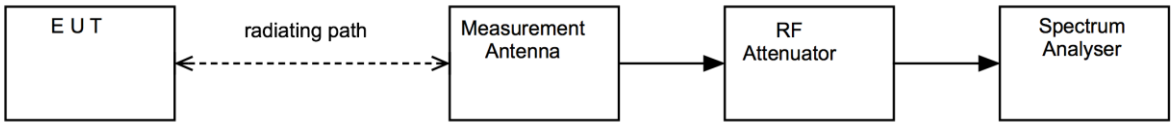
$$Factor = AF+CL-PA$$

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

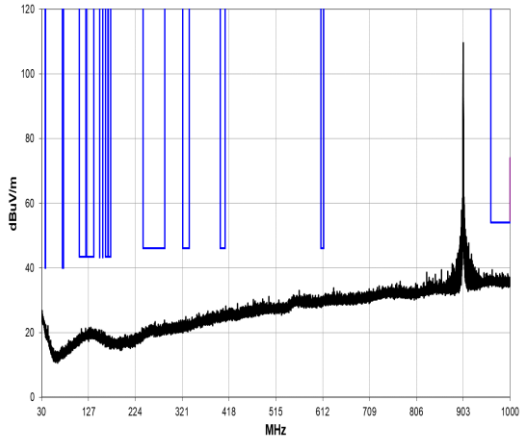


16.5 Test Equipment

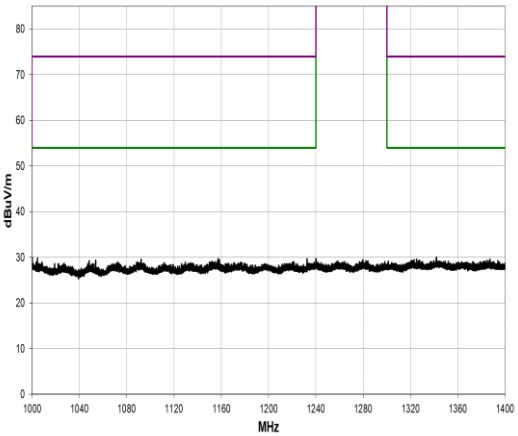
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Emissions R5	Element	Radiated Test Software	REF9000	Cal Not Required
ATS	Rainford EMC	Chamber 1	U387	2026-01-24
ATS	Rainford EMC	Radio Chamber - PP	REF940	2026-01-29
FSU50	R&S	Spectrum Analyser	U544	2024-11-28
ESR7	R&S	EMI Receiver	U456	2025-03-08
8449B	Agilent	Pre Amp	L572	2024-10-30
6201-69	Watkins Johnson	PreAmp	U372	2025-03-15
LNA6901	AMETEK	Pre Amp	U711	2025-04-11
HL 050	R&S	Log Periodic Antenna	U385	2026-01-05
LPF 1000+	MiniCircuits	1 GHz Low Pass Filter	U717	2025-02-15
VHF-1500+	MiniCircuits	High Pass Filter	U519	2025-02-15
AFH-07000	Atlantic Microwave	High Pass Filter	U558	2025-02-15
CBL611/B	Chase	Bilog	U573	2024-10-14
3115	EMCO	1-18GHz Horn	U223	2026-01-17
PAM-840A	Com-Power	Pre-Amp (18 - 40 GHz)	REF2390	2024-10-02
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2024-09-23
AFH-05000 Rev A	Atlantic Microwave	HI Pass Fillter 5-16 GHz	U663	2025-02-15

16.6 Test Results: 500 kHz Operation

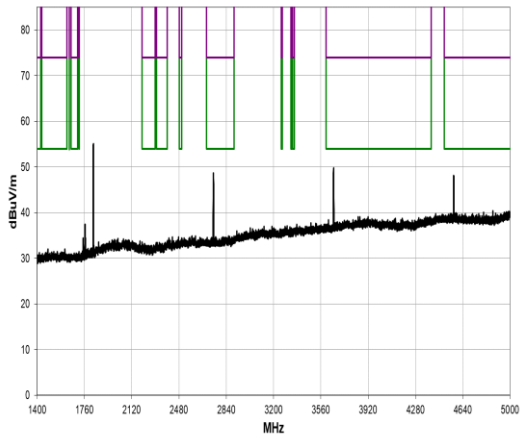
Frequency: 903 MHz; Channel: 0; Power Setting: 14dBm



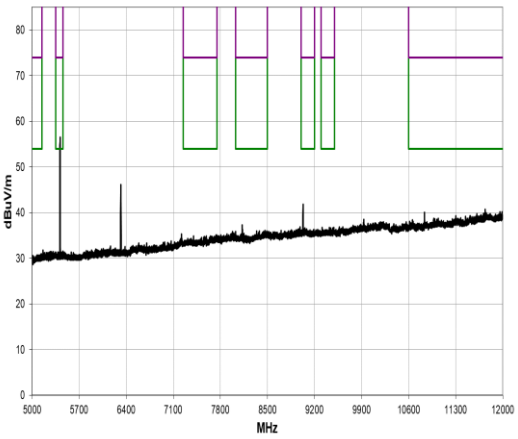
30 MHz to 1GHz



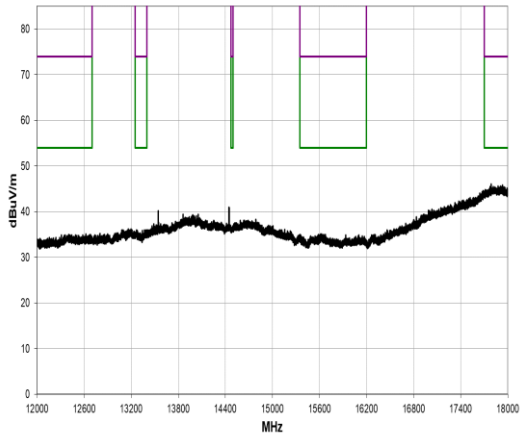
1 GHz to 1.4 GHz



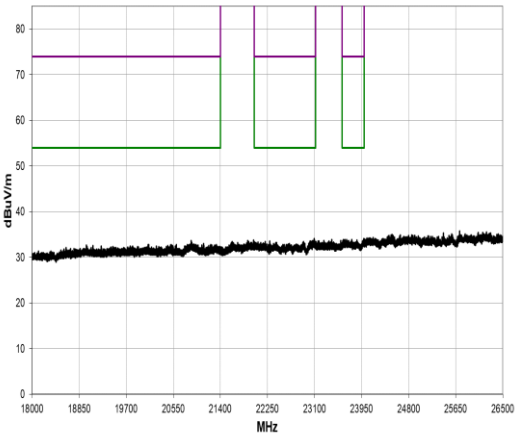
1.4 GHz to 5 GHz



5 GHz to 12 GHz



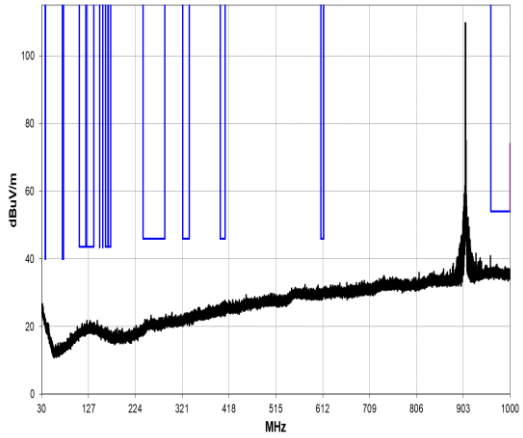
12 GHz to 18 GHz



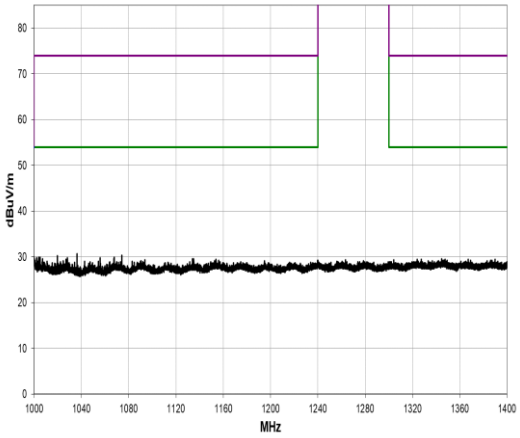
18 GHz to 26.5 GHz

Frequency: 903 MHz; Channel: 0; Power Setting: 14dBm								
Freq	**Amplitude**	**Factor**	**External Attenuation**	**Detector**	**Distance Adjustment**	**Adjusted**	**Spec. Limit**	**Compared to Spec.**
(MHz)	**(dBuV)**	**(dB/m)**	**(dB)**		**(dB)**	**(dBuV/m)**	**(dBuV/m)**	**(dB)**
5417.083	50.4	4.5	0.0	AV	-9.5	45.4	54.0	-8.6
5417.833	48.1	4.5	0.0	AV	-9.5	43.1	54.0	-10.9
3656.683	41.9	0.9	0.0	AV	0.0	42.8	54.0	-11.2
3657.025	41.8	0.9	0.0	AV	0.0	42.7	54.0	-11.3
4571.183	37.4	3.0	0.0	AV	0.0	40.4	54.0	-13.6
2742.083	42.7	-2.6	0.0	AV	0.0	40.1	54.0	-13.9
5418.333	64.2	4.5	0.0	PK	-9.5	59.2	74.0	-14.8
2743.292	41.2	-2.6	0.0	AV	0.0	38.6	54.0	-15.4
4571.792	35.1	3.0	0.0	AV	0.0	38.1	54.0	-15.9
5417.875	61.7	4.5	0.0	PK	-9.5	56.7	74.0	-17.3
3656.642	53.2	0.9	0.0	PK	0.0	54.1	74.0	-19.9
3656.725	52.9	0.9	0.0	PK	0.0	53.8	74.0	-20.2
4572.033	50.8	3.0	0.0	PK	0.0	53.8	74.0	-20.2
4570.950	49.2	3.0	0.0	PK	0.0	52.2	74.0	-21.8
2742.042	53.6	-2.6	0.0	PK	0.0	51.0	74.0	-23.0
2742.000	53.2	-2.6	0.0	PK	0.0	50.6	74.0	-23.4

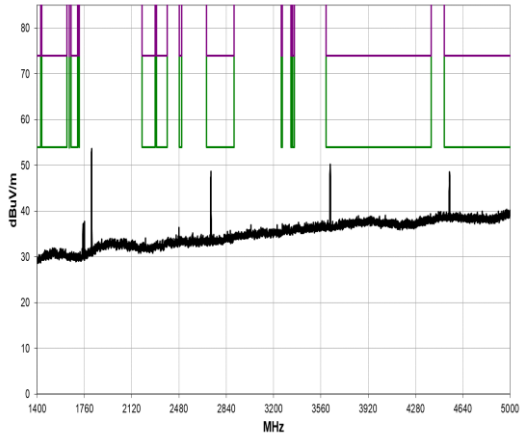
Frequency: 907.8 MHz; Channel: 3; Power Setting: 14dBm



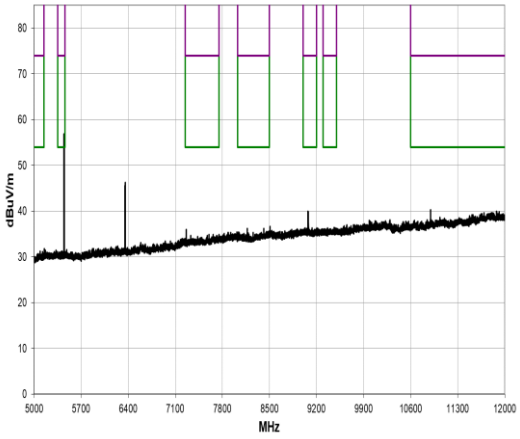
30 MHz to 1GHz



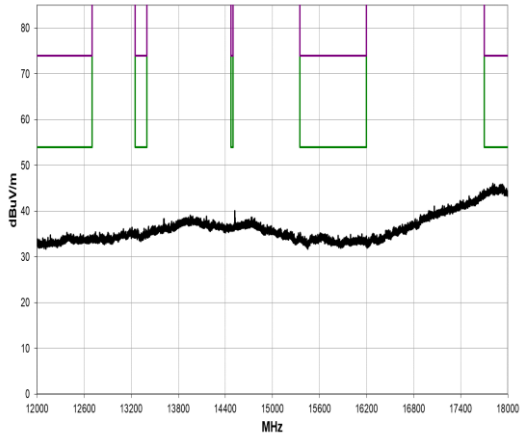
1 GHz to 1.4 GHz



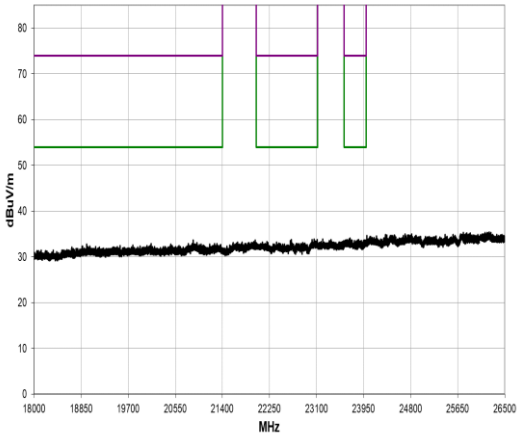
1.4 GHz to 5 GHz



5 GHz to 12 GHz



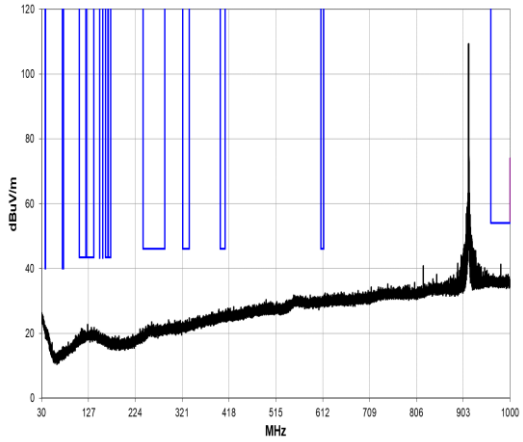
12 GHz to 18 GHz



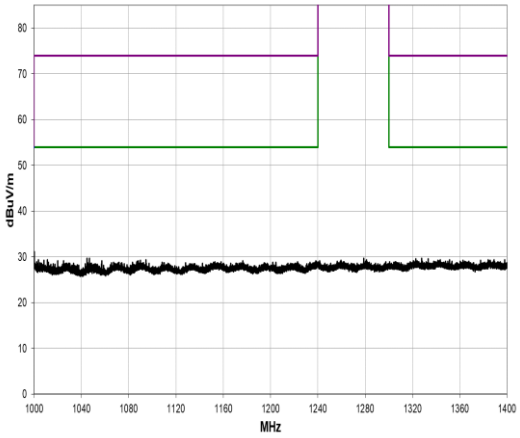
18 GHz to 26.5 GHz

Frequency: 907.8 MHz; Channel: 3; Power Setting: 14dBm								
Freq	**Amplitude**	**Factor**	**External Attenuation**	**Detector**	**Distance Adjustment**	**Adjusted**	**Spec. Limit**	**Compared to Spec.**
(MHz)	**(dBuV)**	**(dB/m)**	**(dB)**		**(dB)**	**(dBuV/m)**	**(dBuV/m)**	**(dB)**
5446.708	51.4	4.6	0.0	AV	-9.5	46.5	54.0	-7.5
5446.667	49.8	4.6	0.0	AV	-9.5	44.9	54.0	-9.1
3631.583	41.4	0.8	0.0	AV	0.0	42.2	54.0	-11.8
3630.625	40.8	0.7	0.0	AV	0.0	41.5	54.0	-12.5
4539.458	37.3	3.0	0.0	AV	0.0	40.3	54.0	-13.7
2724.083	42.6	-2.6	0.0	AV	0.0	40.0	54.0	-14.0
2723.958	42.4	-2.6	0.0	AV	0.0	39.8	54.0	-14.2
5446.625	64.5	4.6	0.0	PK	-9.5	59.6	74.0	-14.4
4539.458	36.0	3.0	0.0	AV	0.0	39.0	54.0	-15.0
5446.500	62.4	4.6	0.0	PK	-9.5	57.5	74.0	-16.5
4538.250	50.6	3.0	0.0	PK	0.0	53.6	74.0	-20.4
3630.333	52.6	0.7	0.0	PK	0.0	53.3	74.0	-20.7
3630.958	52.4	0.7	0.0	PK	0.0	53.1	74.0	-20.9
4539.583	49.6	3.0	0.0	PK	0.0	52.6	74.0	-21.4
2723.417	55.1	-2.6	0.0	PK	0.0	52.5	74.0	-21.5
2713.000	54.9	-2.6	0.0	PK	0.0	52.3	74.0	-21.7

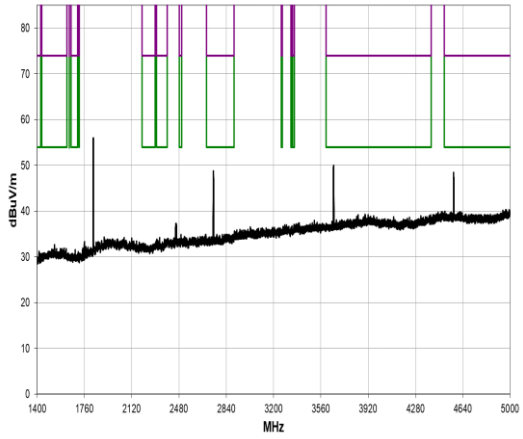
Frequency: 914.9 MHz; Channel: 7; Power Setting: 14dBm



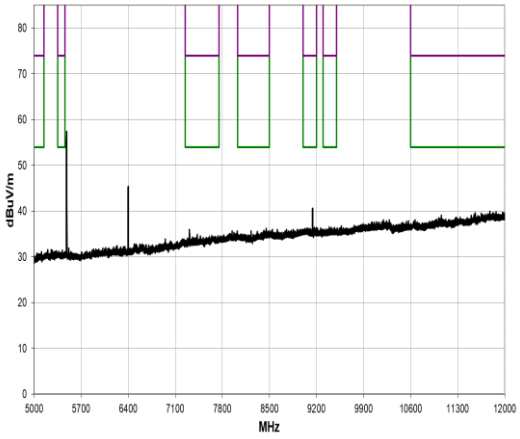
30 MHz to 1GHz



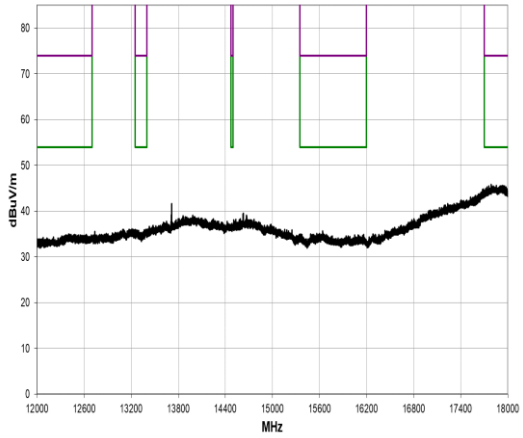
1 GHz to 1.4 GHz



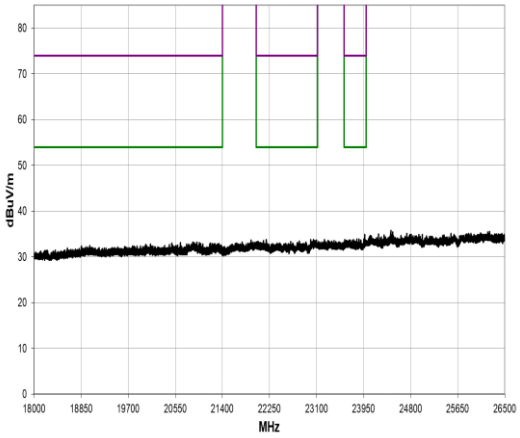
1.4 GHz to 5 GHz



5 GHz to 12 GHz



12 GHz to 18 GHz



18 GHz to 26.5 GHz

Frequency: 914.9 MHz; Channel: 7; Power Setting: 14dBm								
Freq	**Amplitude**	**Factor**	**External Attenuation**	**Detector**	**Distance Adjustment**	**Adjusted**	**Spec. Limit**	**Compared to Spec.**
(MHz)	**(dBuV)**	**(dB/m)**	**(dB)**		**(dB)**	**(dBuV/m)**	**(dBuV/m)**	**(dB)**
3656.958	41.7	0.9	0.0	AV	0.0	42.6	54.0	-11.4
2742.208	44.7	-2.6	0.0	AV	0.0	42.1	54.0	-11.9
2742.500	43.6	-2.6	0.0	AV	0.0	41.0	54.0	-13.0
4572.042	36.1	3.0	0.0	AV	0.0	39.1	54.0	-14.9
4571.250	35.6	3.0	0.0	AV	0.0	38.6	54.0	-15.4
3655.833	37.3	0.9	0.0	AV	0.0	38.2	54.0	-15.8
3656.458	52.7	0.9	0.0	PK	0.0	53.6	74.0	-20.4
4572.000	50.4	3.0	0.0	PK	0.0	53.4	74.0	-20.6
2750.292	55.4	-2.6	0.0	PK	0.0	52.8	74.0	-21.2
3655.958	51.6	0.9	0.0	PK	0.0	52.5	74.0	-21.5
4570.292	49.5	3.0	0.0	PK	0.0	52.5	74.0	-21.5
2743.167	54.2	-2.6	0.0	PK	0.0	51.6	74.0	-22.4

20 Results Section 2 FHSS mode of Operation

21 Maximum peak conducted output power

21.1 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.

21.2 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, 908.5 MHz & 914.9 MHz – hopping disabled.
EUT Channel Bandwidths:	125 kHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW:	3 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)

21.3 Test Limit

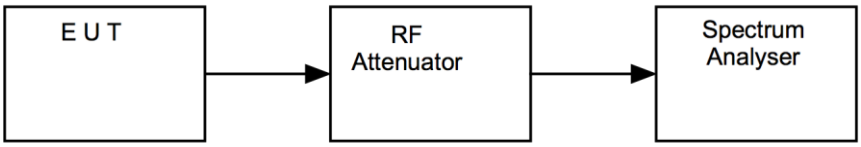
- For frequency hopping systems operating in the band 902 to 928 MHz, the maximum peak conducted output power shall not exceed 1 W, and the e.i.r.p. shall not exceed 4 W, if the hopset uses 50 or more hopping channels;
  the maximum peak conducted output power shall not exceed 0.25 W, and the e.i.r.p.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

21.4 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

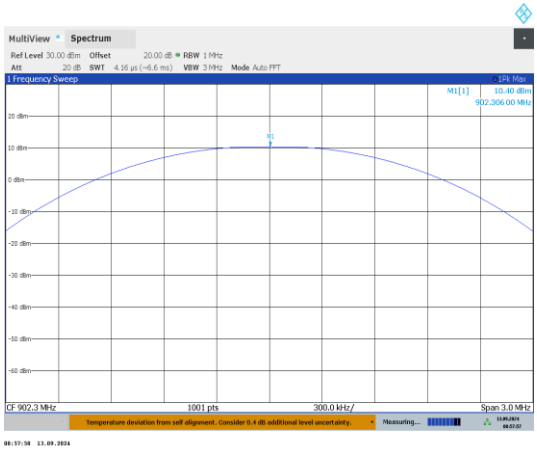


21.5 Test Equipment

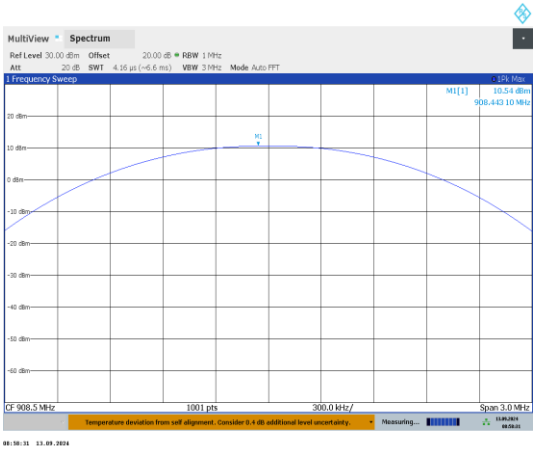
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

21.6 Test Results

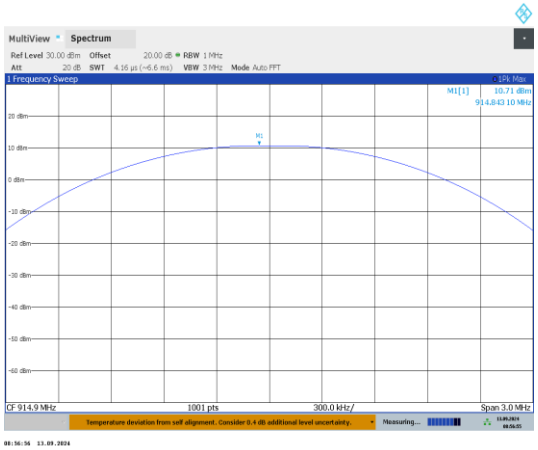
LoRaWan 125 kHz channel					
Channel Frequency (MHz)	***Max Power (dBm)***	***Antenna Gain (dBi)***	***e.i.r.p (dBm)***	***e.i.r.p (mW)***	***Result***
902.3	10.40	0.00	10.40	10.96	Pass
908.5	10.54	0.00	10.54	11.32	Pass
914.9	10.71	0.00	10.71	11.78	Pass



902.3 MHz



908.5 MHz



914.9 MHz

22 Number of hopping frequencies

22.1 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.

22.2 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 – 928.0 MHz
EUT Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	30 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

22.3 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.

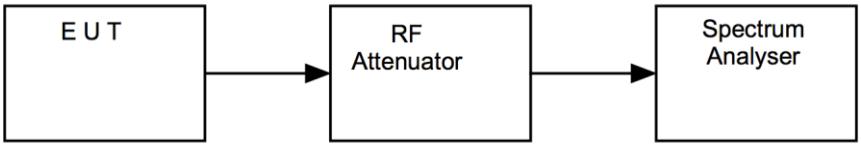
There are no minimum number of hopping channels associated with this type of hybrid system While no there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom as per Section 15.247 (a)(1).

22.4 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



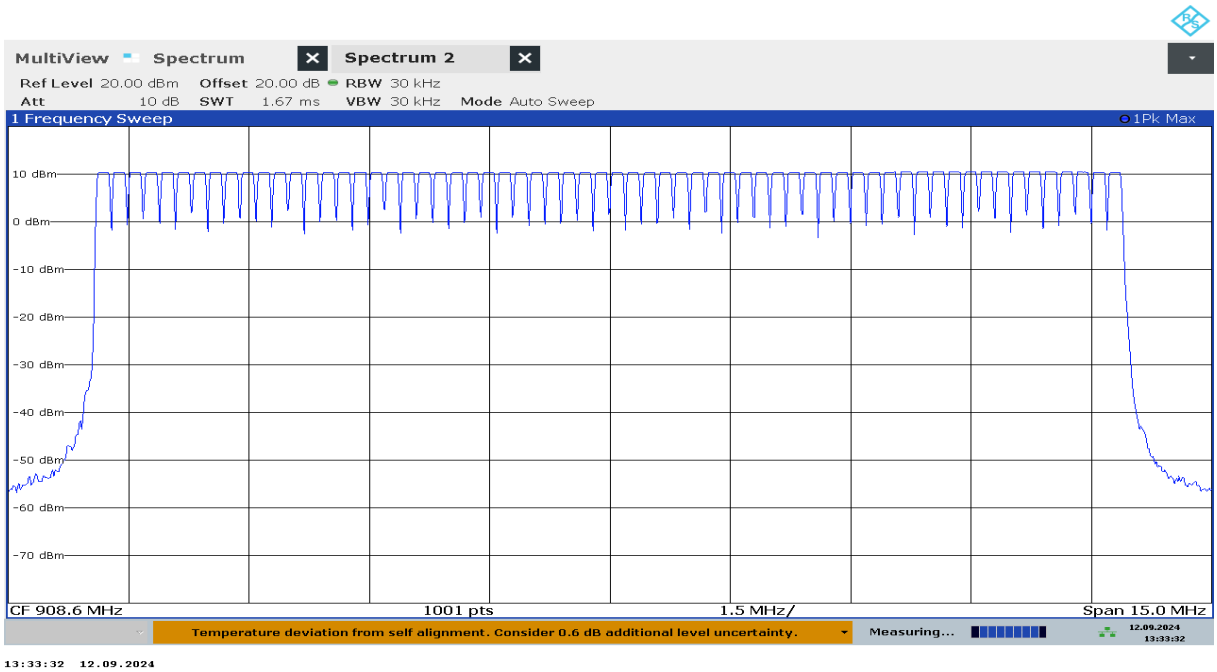
22.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

22.6 Test Results

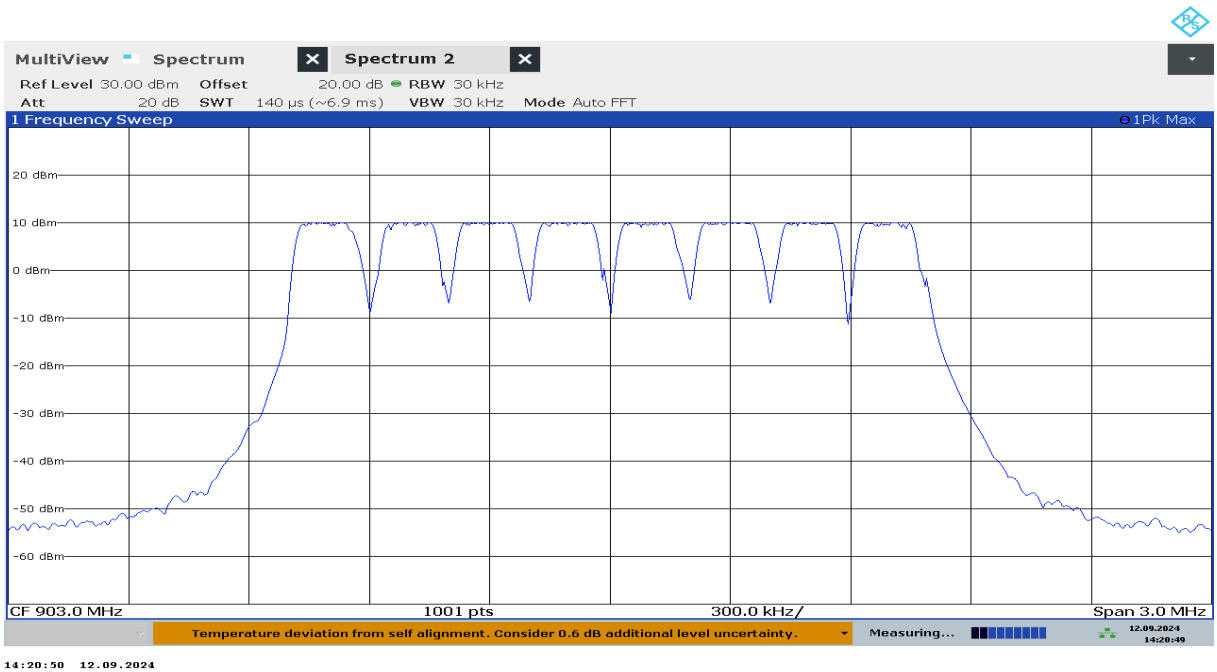
LoRaWan 125 kHz channel

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



LoRaWan 125 kHz channel

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



23 Average channel occupancy

23.1 Definition

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

23.2 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 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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

23.3 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.

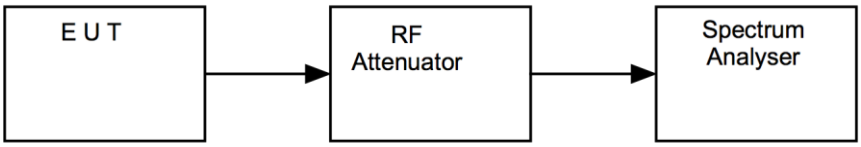
  There are no minimum number of hopping channels associated with this type of hybrid system While no there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom as per Section 15.247 (a)(1).

23.4 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



23.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2025-01-30
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

23.6 Test Results

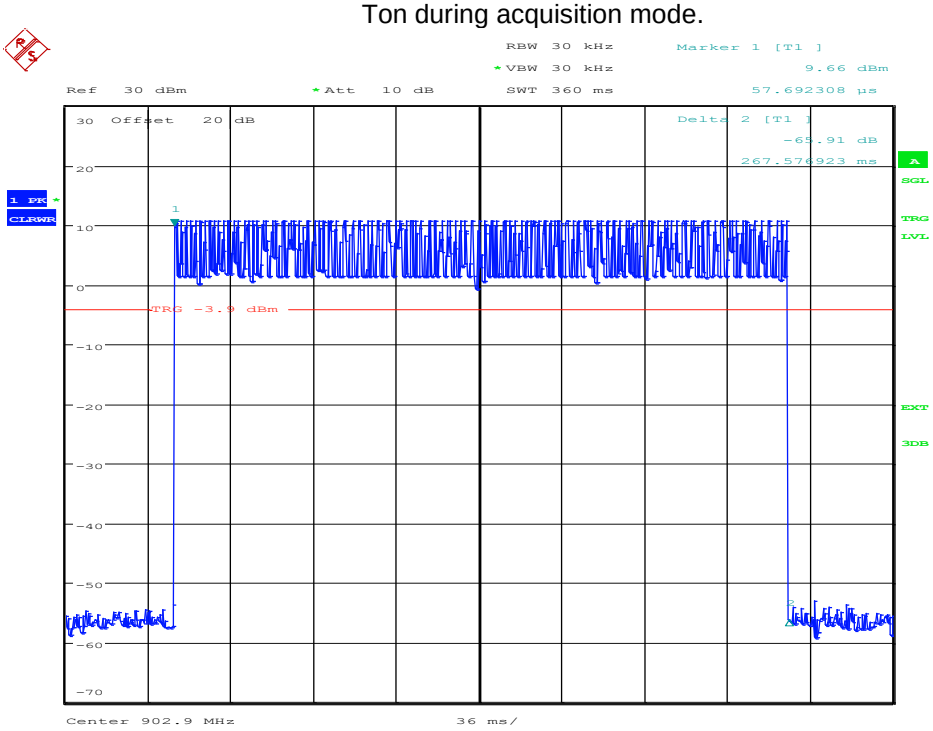
Acquisition mode 64 hopping channels LoRaWan 125 kHz channel

$T_{occ\ (ms)}$	*MP (s)*	*MPTX*	*AOT (s)*	*Limit (s)*	*Result*
267.576923	20	1	0.267576923	0.4	Pass

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

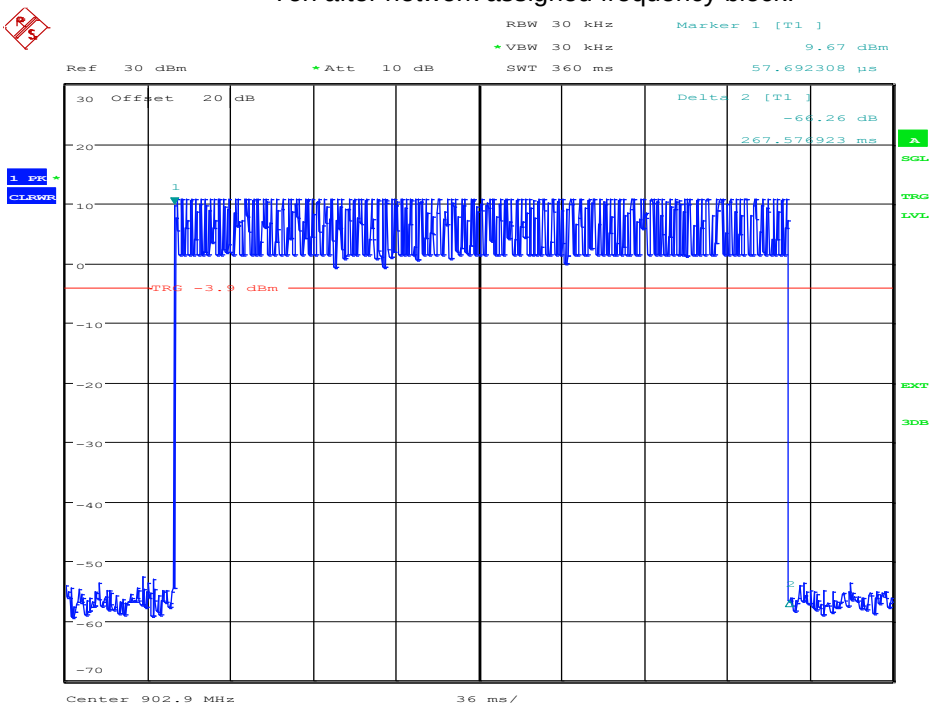
$T_{occ\ (ms)}$	*MP (s)*	*MPTX*	*AOT (s)*	*Limit (s)*	*Result*
267.576923	3.2	1	0.267576923	0.4	Pass

Ton during acquisition mode.



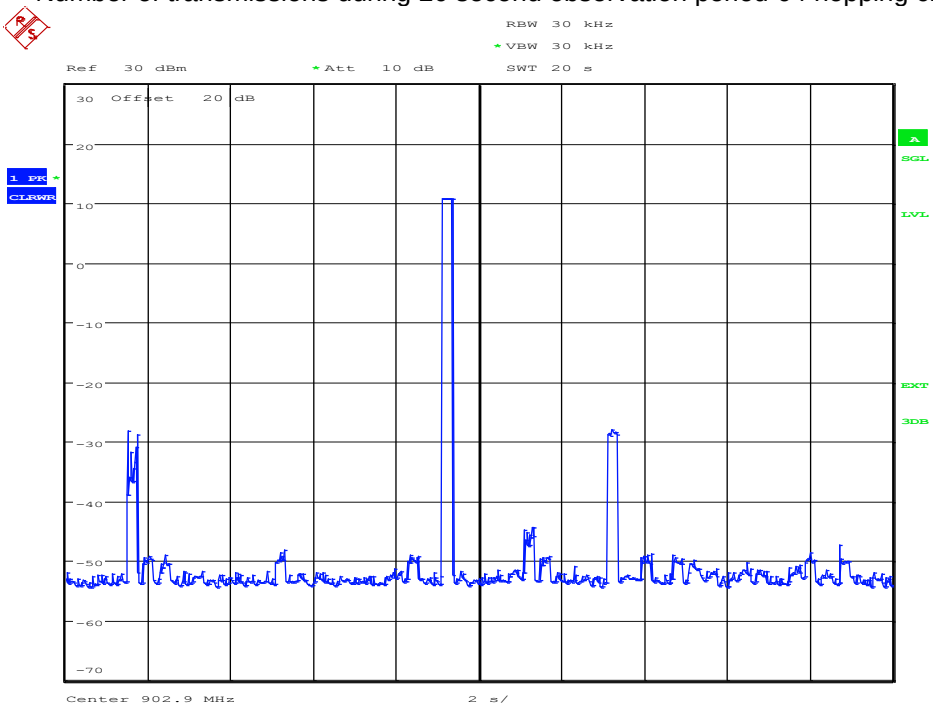
Date: 25.SEP.2024 10:29:06

Ton after network assigned frequency block.



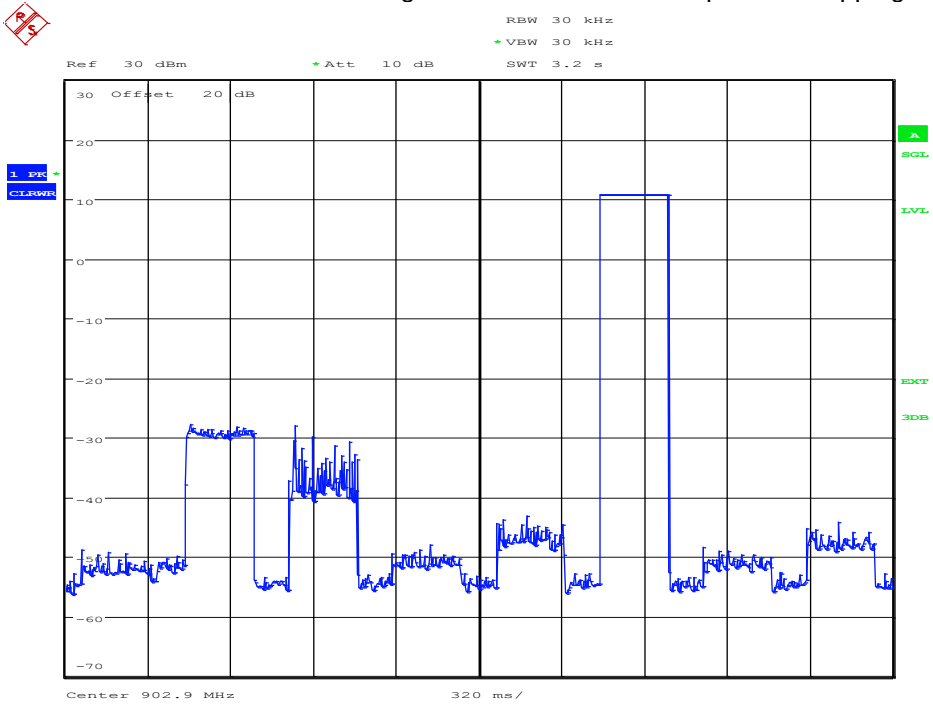
Date: 25.SEP.2024 10:28:26

Number of transmissions during 20 second observation period 64 hopping channels.



Date: 25.SEP.2024 10:30:48

Number of transmissions during 3.2 second observation period 8 hopping channels.



Date: 25.SEP.2024 10:34:34

24 Carrier frequency separation

24.1 Definition

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

24.2 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 Test Modulations:	Internal pattern generation – hopping enabled
Deviations From Standard:	None
Measurement BW:	30 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

24.3 Test Limit

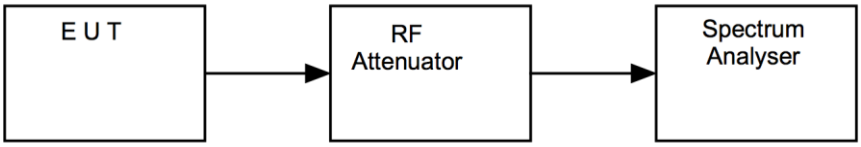
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400 to 2483.5 MHz may have hopping channel carrier frequencies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

24.4 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



24.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

24.6 Test Results

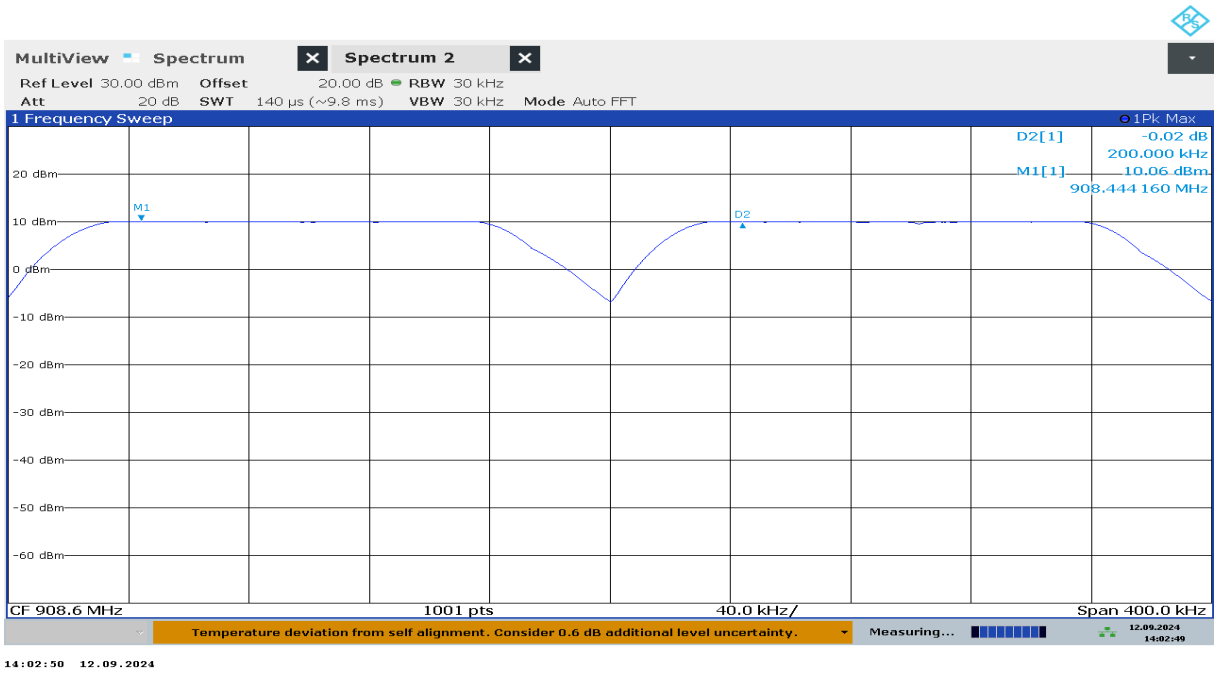
Channel separation observed
64 Hopping channels LoRaWan 125 kHz channel

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

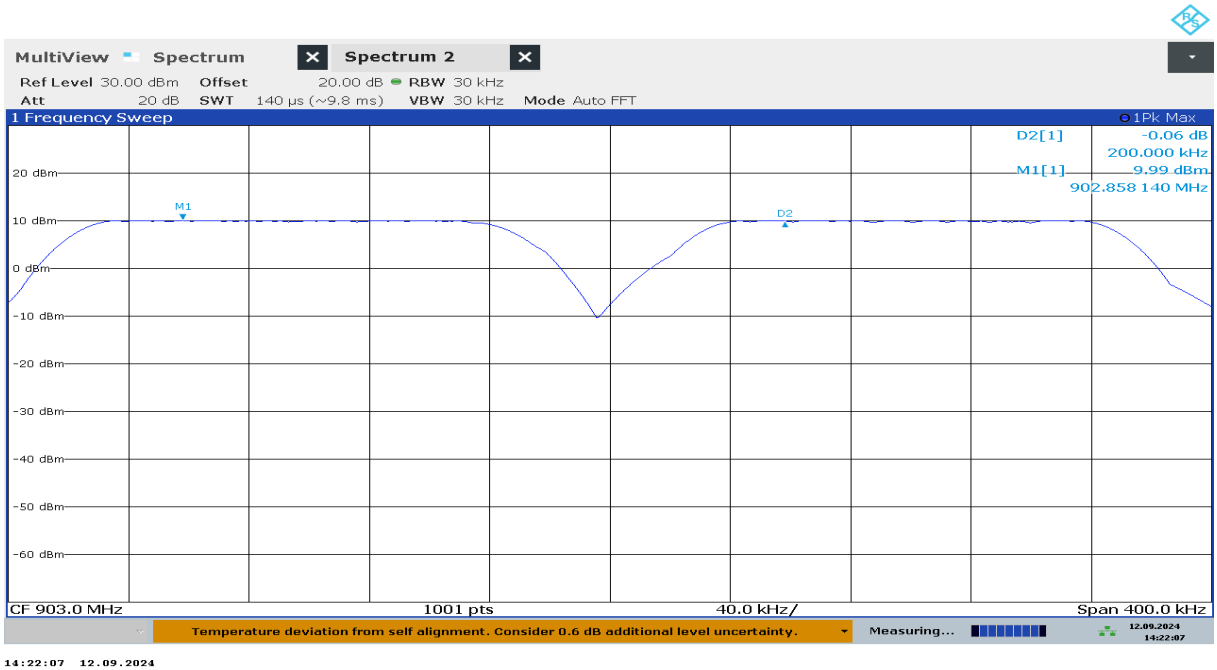
Channel separation observed
8 Hopping channels LoRaWan 125 kHz channel

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.



Channel separation 8 hopping channels LoRaWan 125 kHz channel.



25 Occupied Bandwidth

25.1 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.

25.2 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, 908.5 MHz & 914.9 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)	500 kHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

25.3 Test Limit

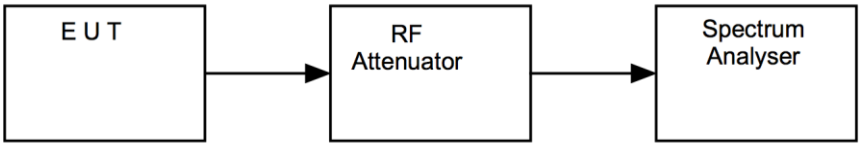
- For frequency hopping systems in the band 902 to 928 MHz: The maximum allowed -20 dB bandwidth of the hopping channel is 500 kHz.
- Frequency hopping systems operating in the band 5725 to 5850 MHz: The maximum -20 dB bandwidth of the hopping channel shall be 1 MHz

25.4 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



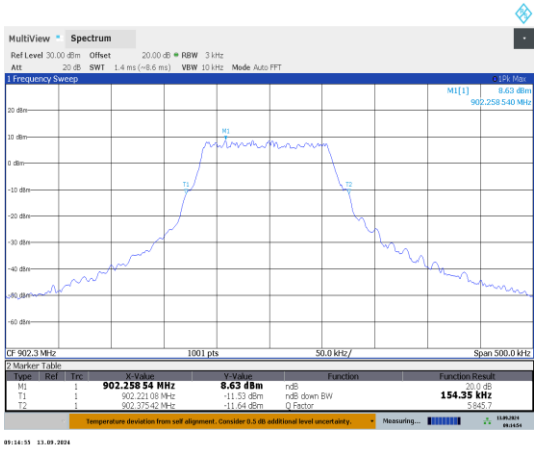
25.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

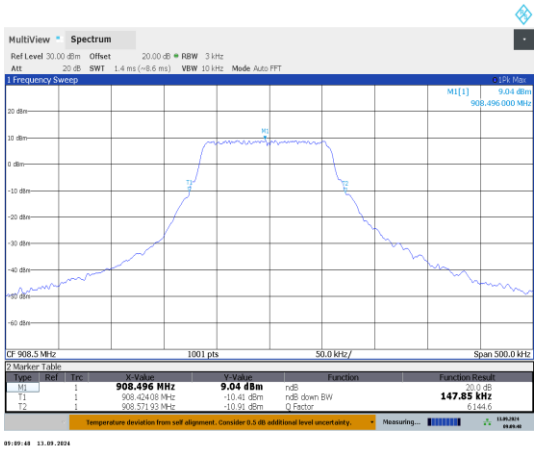
25.6 Test Results

LoRaWan 125 kHz channel

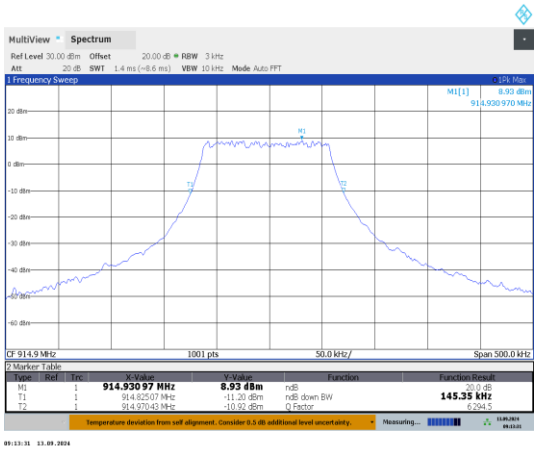
15.247; 20 dB; Bandwidth; 125 kHz Operation				
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***20 dB Bandwidth (kHz)***	***Result***
902.3	902.22108	902.37542	154.34	Pass
908.5	908.42408	908.57193	147.85	Pass
914.9	914.82507	914.97043	145.36	Pass



902.3 MHz



908.5 MHz



914.9 MHz

26 Out-of-band and conducted spurious emissions

26.1 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.

26.2 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, 908.5 MHz & 914.9 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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 52% RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

26.3 Test Limits

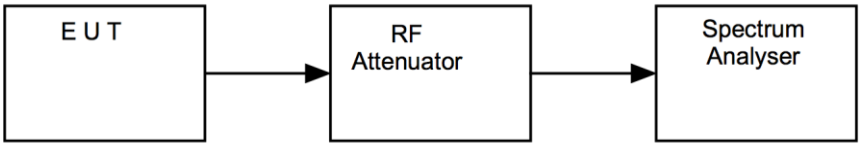
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either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

26.4 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.

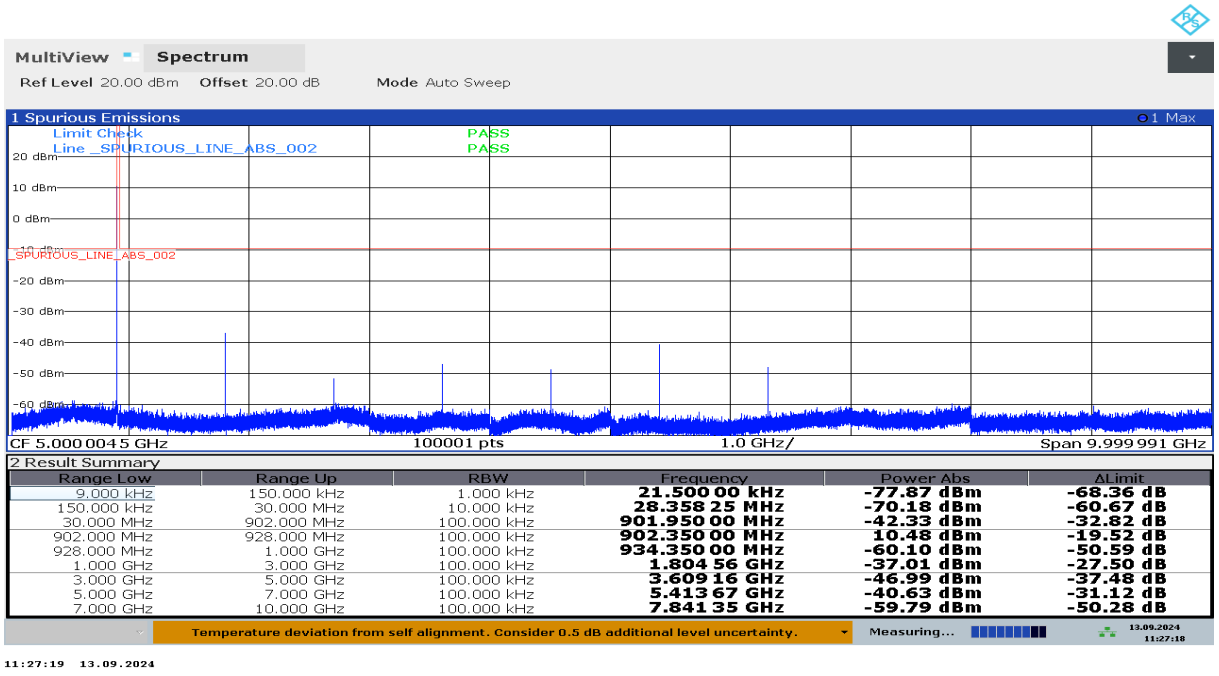
Figure viii Test Setup



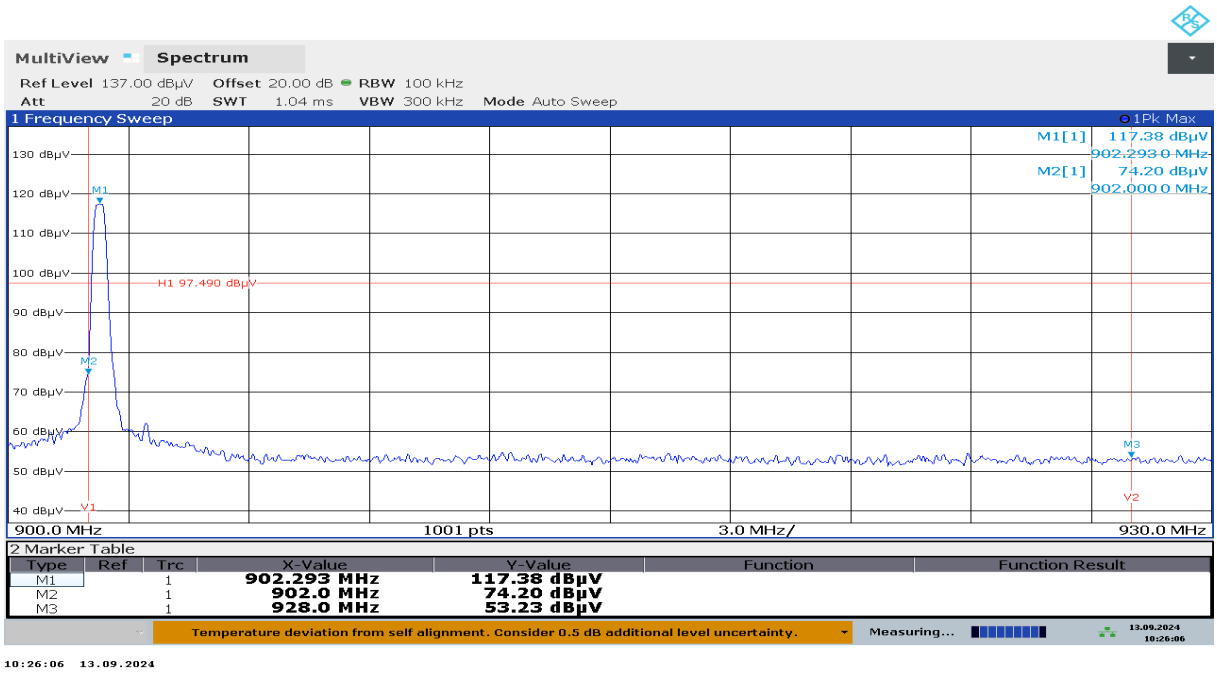
26.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW 43	U728	2025-06-12
Attenuator	AtlanTecRF Microwave	20dB SMA Attenuator	U790	Cal in use

26.6 Test Results

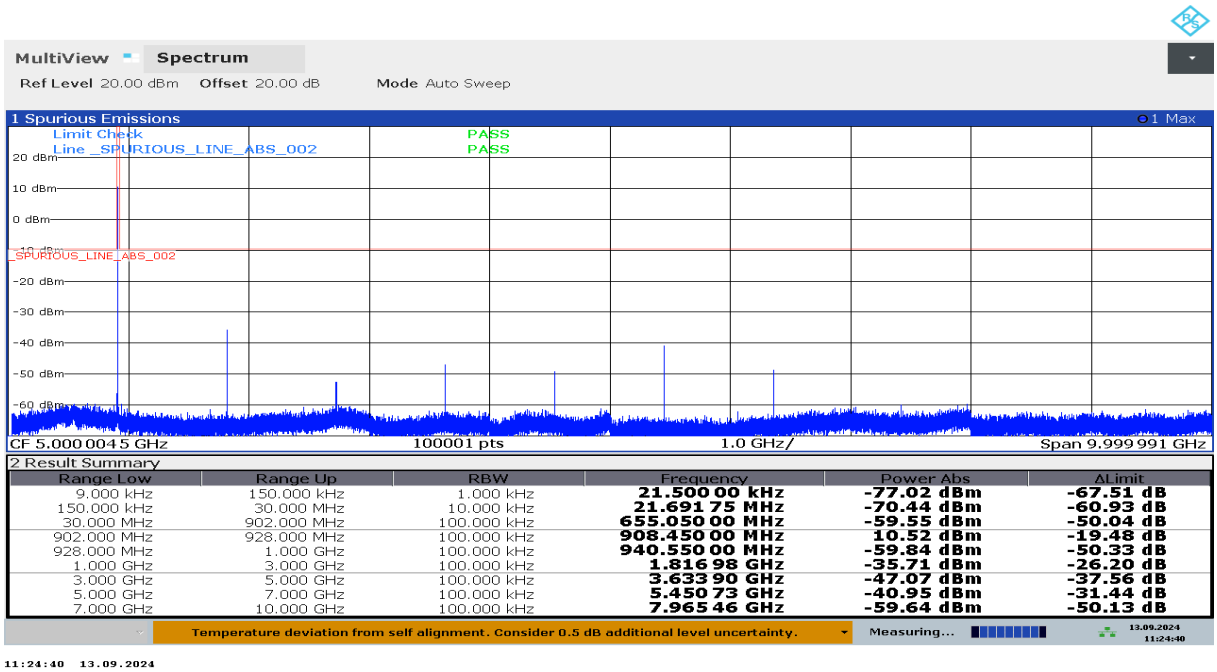


9 kHz to 10 GHz - 902.3 MHz



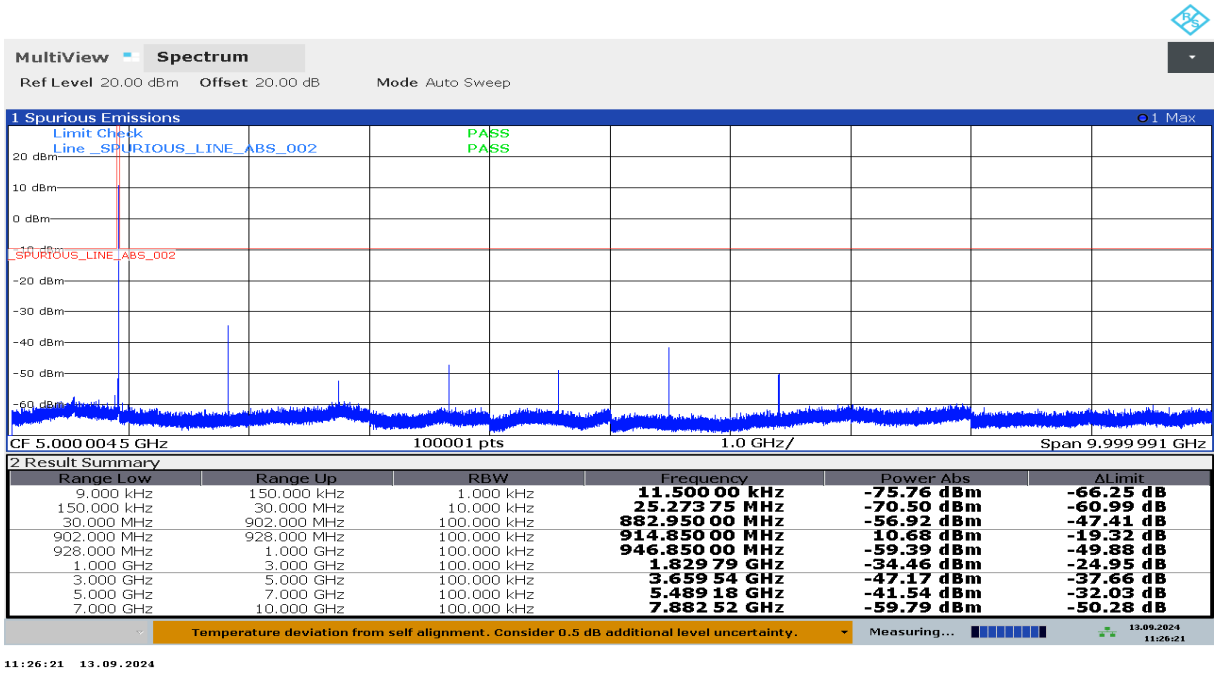
Lower Conducted Band Edge

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 20 dBm of the limit						Pass



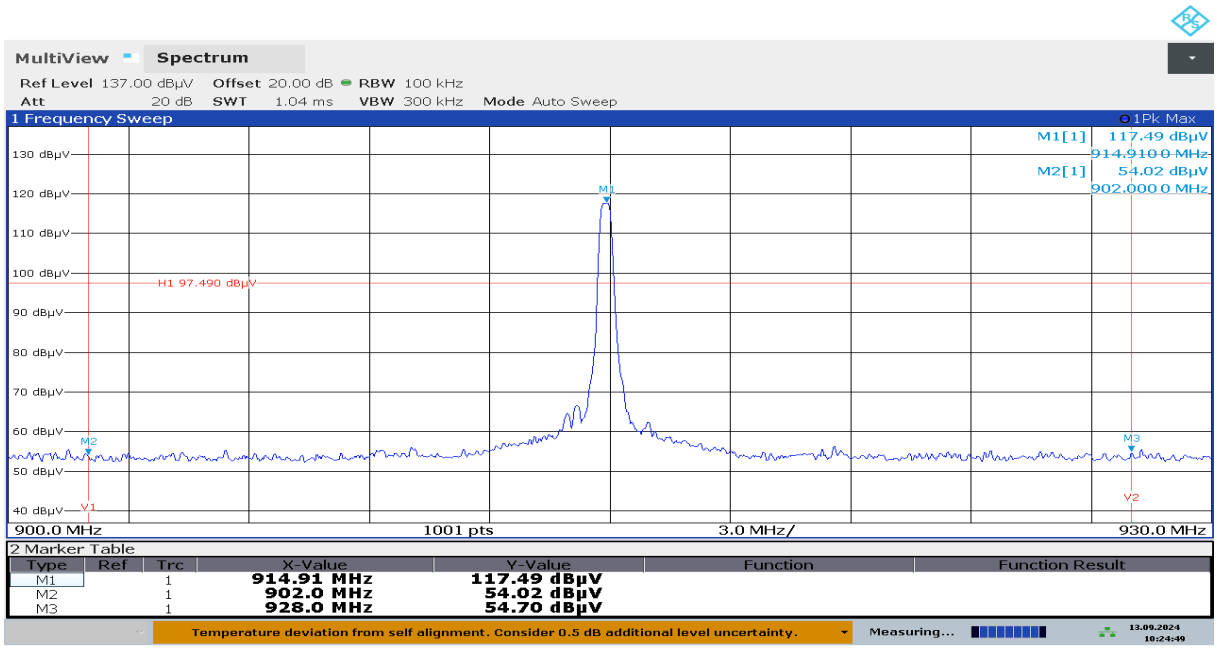
9 kHz to 10 GHz – 908.3 MHz

908.3 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 20 dBm of the limit						Pass

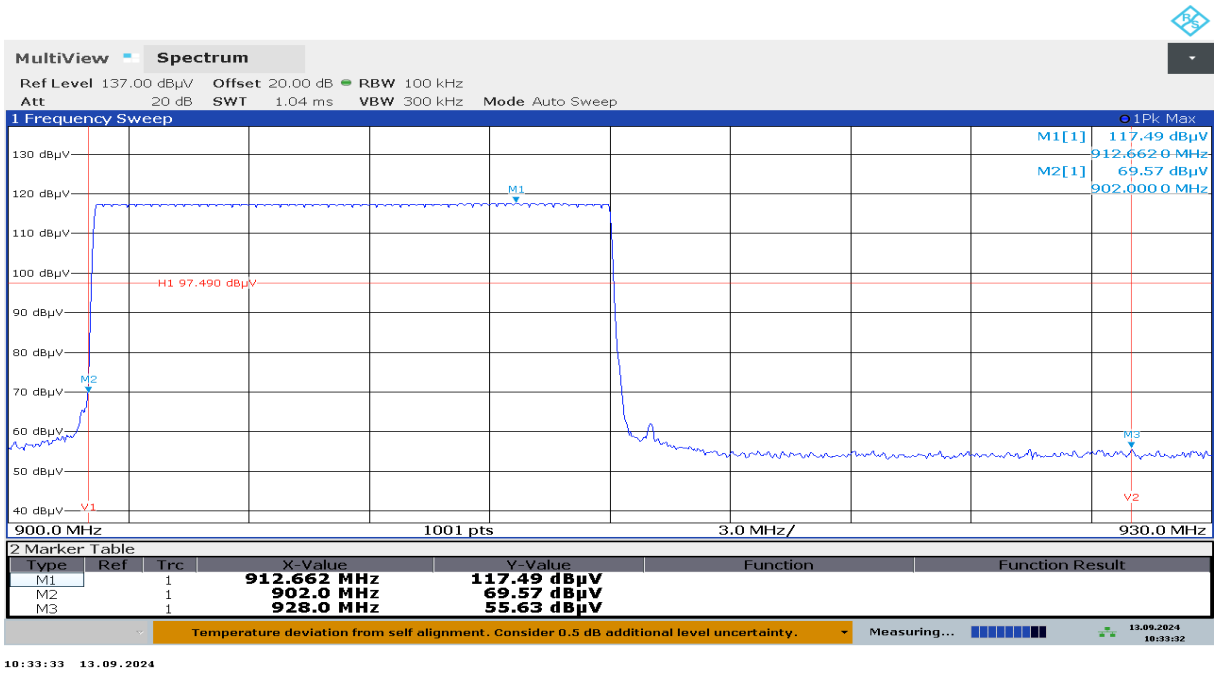


9 kHz to 10 GHz – 914.9 MHz

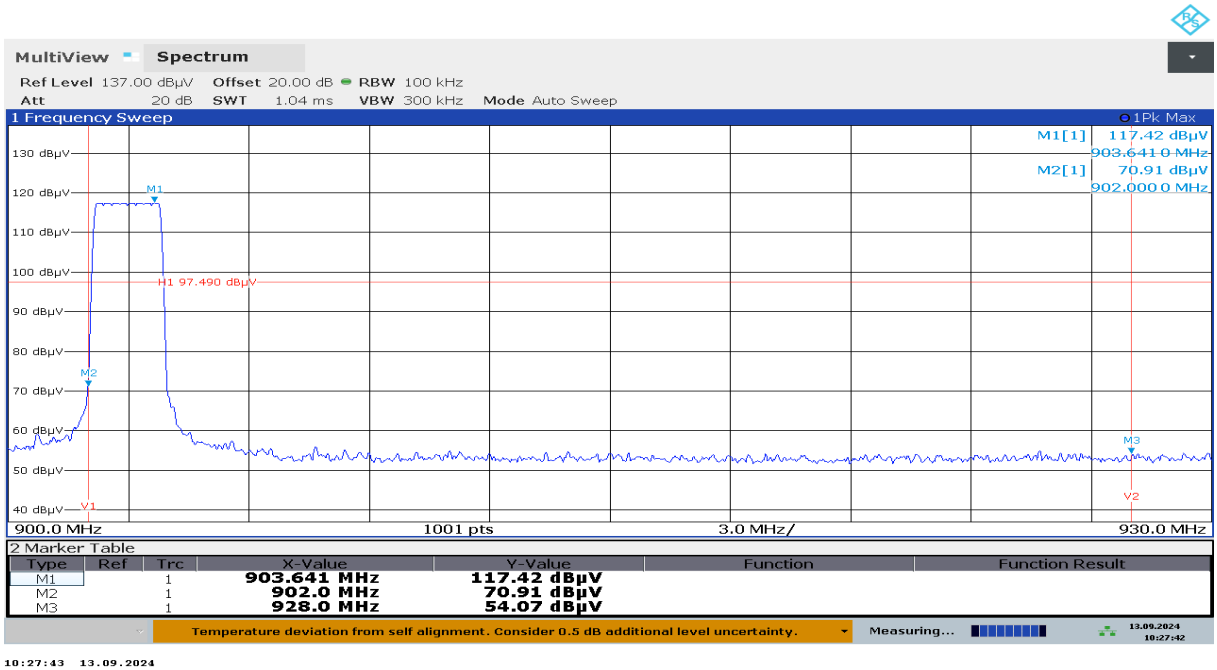
914.9 MHz LoRaWan 125 kHz channel						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emission within 20 dBm of the limit						Pass



Upper Conducted Band Edge



Conducted Band Edge – 64 Hopping Channels



Conducted Band Edge – 8 Hopping Channels

27 Radiated emissions

27.1 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.

27.2 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, 908.5 MHz & 914.9 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: 64 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	3.7 Vdc (as declared)

27.3 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.

27.4 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:

$$FS = PR + CL + AF – PA + DC – CF$$

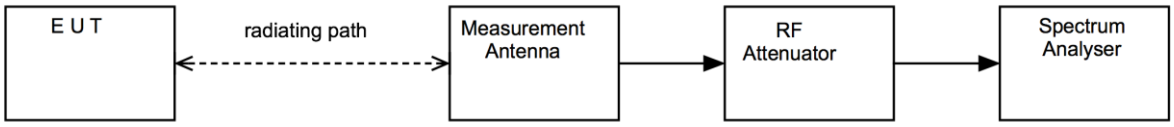
$$Factor = AF+CL-PA$$

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

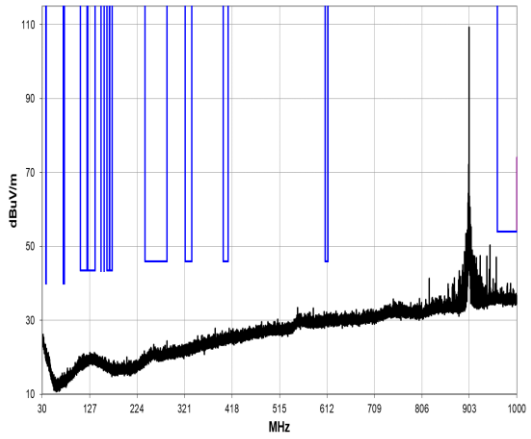


27.5 Test Equipment

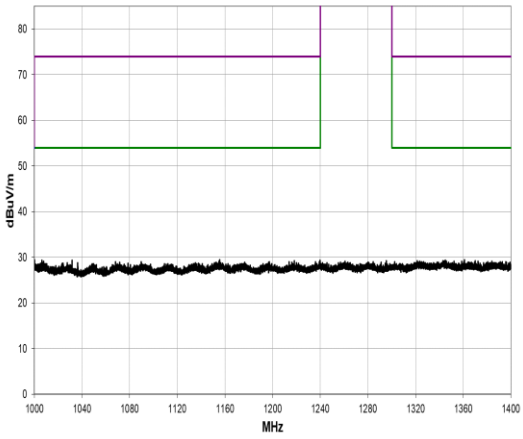
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Emissions R5	Element	Radiated Test Software	REF9000	Cal Not Required
ATS	Rainford EMC	Chamber 1	U387	2026-01-24
ATS	Rainford EMC	Radio Chamber - PP	REF940	2026-01-29
FSU50	R&S	Spectrum Analyser	U544	2024-11-28
ESR7	R&S	EMI Receiver	U456	2025-03-08
8449B	Agilent	Pre Amp	L572	2024-10-30
6201-69	Watkins Johnson	PreAmp	U372	2025-03-15
LNA6901	AMETEK	Pre Amp	U711	2025-04-11
HL 050	R&S	Log Periodic Antenna	U385	2026-01-05
LPF 1000+	MiniCircuits	1 GHz Low Pass Filter	U717	2025-02-15
VHF-1500+	MiniCircuits	High Pass Filter	U519	2025-02-15
AFH-07000	Atlantic Microwave	High Pass Filter	U558	2025-02-15
CBL611/B	Chase	Bilog	U573	2024-10-14
3115	EMCO	1-18GHz Horn	U223	2026-01-17
PAM-840A	Com-Power	Pre-Amp (18 - 40 GHz)	REF2390	2024-10-02
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2024-09-23
AFH-05000 Rev A	Atlantic Microwave	HI Pass Fillter 5-16 GHz	U663	2025-02-15

27.6 Test Results LoRaWan 125 kHz channel

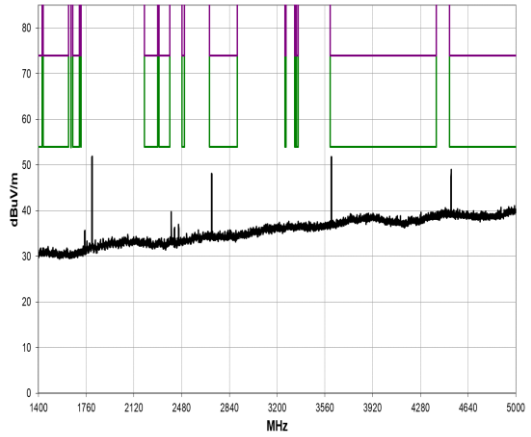
Frequency: 902.3 MHz; Channel: 0; Power Setting: 14dBm



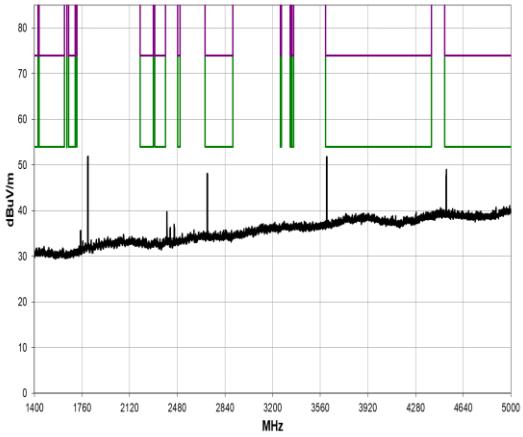
30 MHz to 1GHz



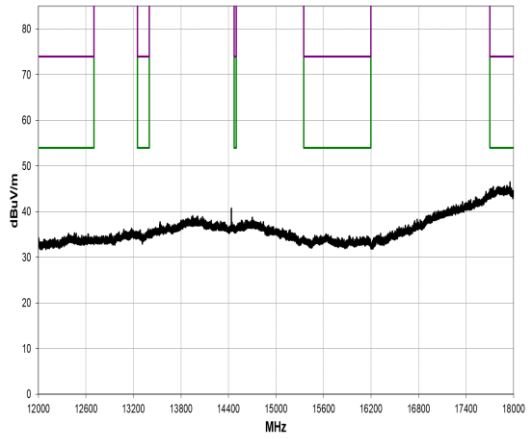
1 GHz to 1.4 GHz



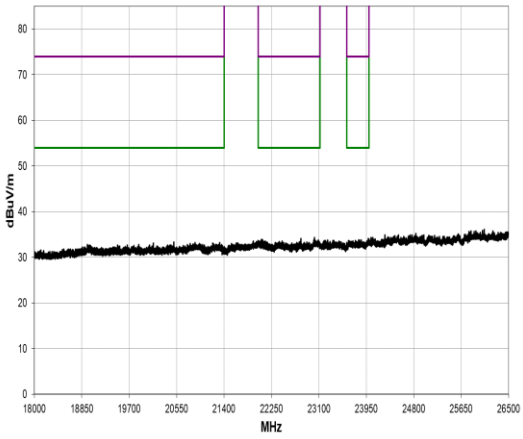
1.4 GHz to 5 GHz



5 GHz to 12 GHz



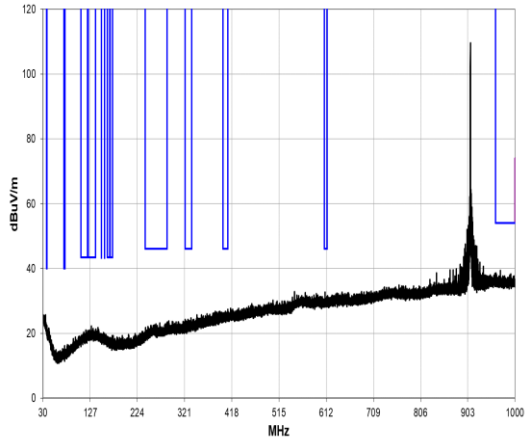
12 GHz to 18 GHz



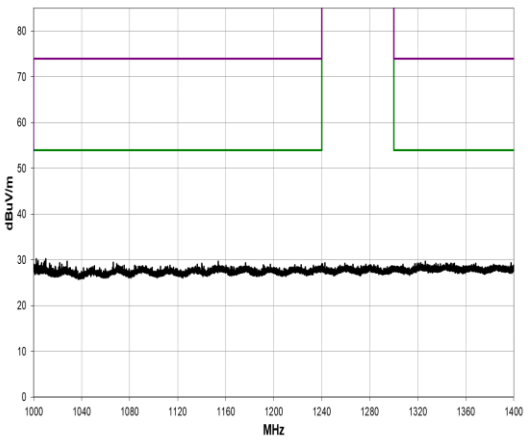
18 GHz to 26.5 GHz

Frequency: 902.3 MHz; Channel: 0; Power Setting: 14dBm								
Freq	**Amplitude**	**Factor**	**External Attenuation**	**Detector**	**Distance Adjustment**	**Adjusted**	**Spec. Limit**	**Compared to Spec.**
(MHz)	**(dBuV)**	**(dB/m)**	**(dB)**		**(dB)**	**(dBuV/m)**	**(dBuV/m)**	**(dB)**
5413.808	58.4	3.1	0.0	AV	-9.5	52.0	54.0	-2.0
3609.192	50.2	0.6	0.0	AV	0.0	50.8	54.0	-3.2
5413.892	56.9	3.1	0.0	AV	-9.5	50.5	54.0	-3.5
3609.333	48.6	0.6	0.0	AV	0.0	49.2	54.0	-4.8
4511.383	43.8	2.9	0.0	AV	0.0	46.7	54.0	-7.3
2706.842	48.8	-2.6	0.0	AV	0.0	46.2	54.0	-7.8
4511.383	42.1	2.9	0.0	AV	0.0	45.0	54.0	-9.0
2707.025	45.7	-2.6	0.0	AV	0.0	43.1	54.0	-10.9
5413.683	63.0	3.1	0.0	PK	-9.5	56.6	74.0	-17.4
9023.292	38.5	7.5	0.0	AV	-9.5	36.5	54.0	-17.5
5413.675	62.5	3.1	0.0	PK	-9.5	56.1	74.0	-17.9
3609.167	54.5	0.6	0.0	PK	0.0	55.1	74.0	-18.9
10827.080	34.3	9.6	0.0	AV	-9.5	34.4	54.0	-19.6
3609.117	53.7	0.6	0.0	PK	0.0	54.3	74.0	-19.7
4511.692	51.1	2.9	0.0	PK	0.0	54.0	74.0	-20.0
4511.300	50.1	2.9	0.0	PK	0.0	53.0	74.0	-21.0
2706.983	53.7	-2.6	0.0	PK	0.0	51.1	74.0	-22.9
2706.817	51.7	-2.6	0.0	PK	0.0	49.1	74.0	-24.9
10828.130	47.9	9.6	0.0	PK	-9.5	48.0	74.0	-26.0
9023.283	49.9	7.5	0.0	PK	-9.5	47.9	74.0	-26.1

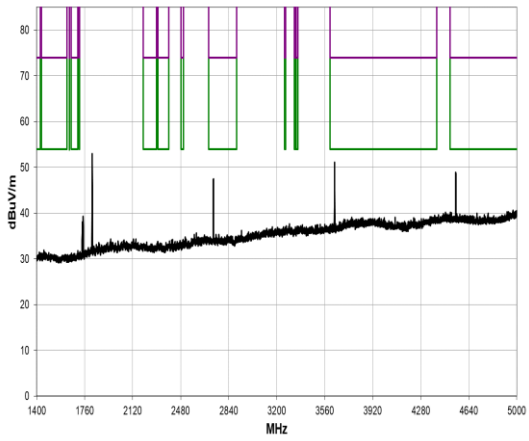
Frequency: 908.5 MHz; Channel: 31; Power Setting: 14dBm



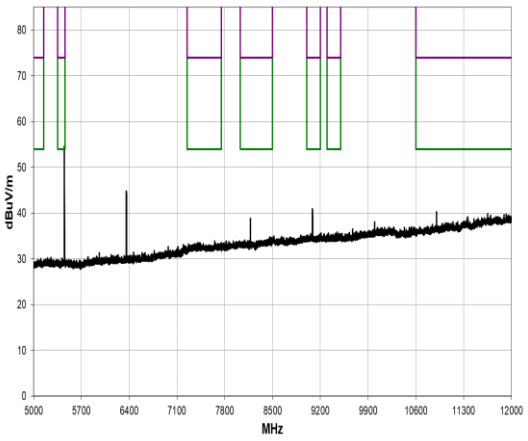
30 MHz to 1GHz



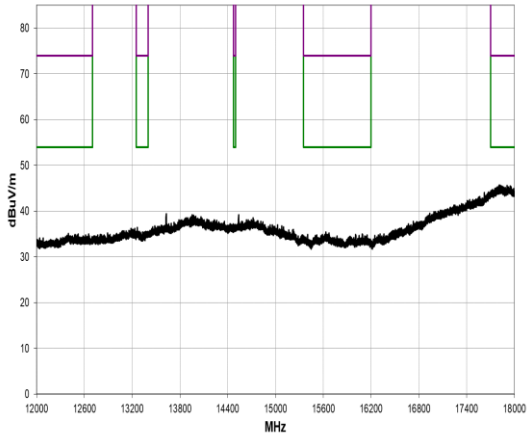
1 GHz to 1.4 GHz



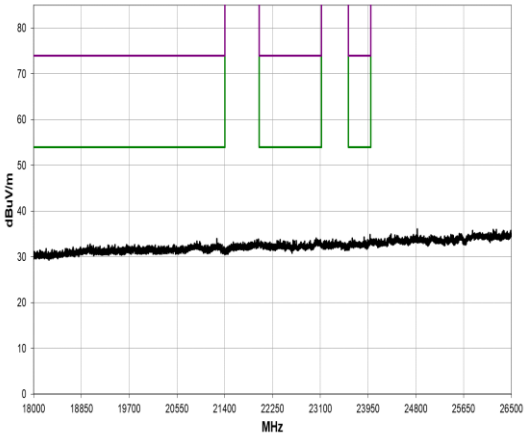
1.4 GHz to 5 GHz



5 GHz to 12 GHz



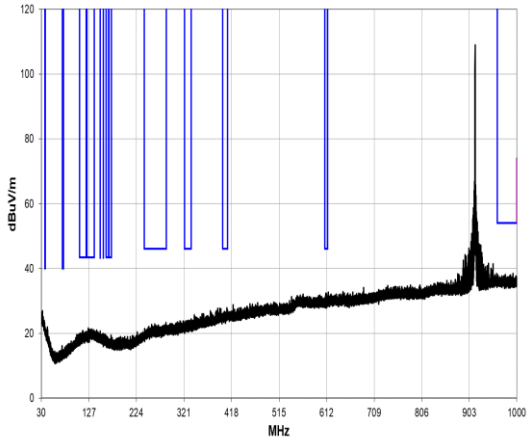
12 GHz to 18 GHz



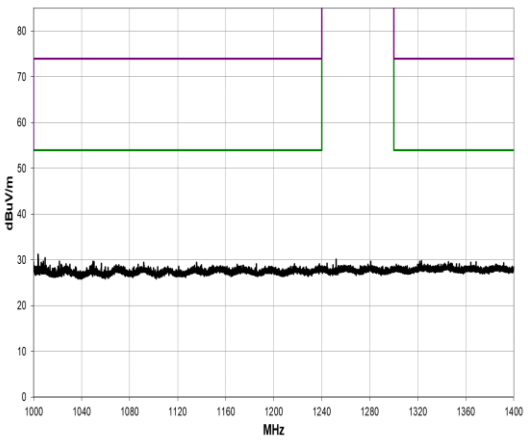
18 GHz to 26.5 GHz

Frequency: 908.5 MHz; Channel: 31; Power Setting: 14dBm								
Freq	**Amplitude**	**Factor**	**External Attenuation**	**Detector**	**Distance Adjustment**	**Adjusted**	**Spec. Limit**	**Compared to Spec.**
(MHz)	**(dBuV)**	**(dB/m)**	**(dB)**		**(dB)**	**(dBuV/m)**	**(dBuV/m)**	**(dB)**
5451.050	59.3	3.2	0.0	AV	-9.5	53.0	54.0	-1.0
3633.975	49.7	0.8	0.0	AV	0.0	50.5	54.0	-3.5
3634.125	48.8	0.8	0.0	AV	0.0	49.6	54.0	-4.4
5451.158	54.7	3.2	0.0	AV	-9.5	48.4	54.0	-5.6
4542.425	44.3	3.0	0.0	AV	0.0	47.3	54.0	-6.7
2725.467	49.8	-2.6	0.0	AV	0.0	47.2	54.0	-6.8
4542.442	41.4	3.0	0.0	AV	0.0	44.4	54.0	-9.6
2725.425	46.3	-2.6	0.0	AV	0.0	43.7	54.0	-10.3
5451.250	64.0	3.2	0.0	PK	-9.5	57.7	74.0	-16.3
9084.942	39.5	7.6	0.0	AV	-9.5	37.6	54.0	-16.4
9084.675	36.8	7.6	0.0	AV	-9.5	34.9	54.0	-19.1
10902.020	34.5	9.9	0.0	AV	-9.5	34.9	54.0	-19.1
3634.200	53.9	0.8	0.0	PK	0.0	54.7	74.0	-19.3
5451.092	60.4	3.2	0.0	PK	-9.5	54.1	74.0	-19.9
4542.875	51.0	3.0	0.0	PK	0.0	54.0	74.0	-20.0
4542.242	50.0	3.0	0.0	PK	0.0	53.0	74.0	-21.0
2725.558	54.2	-2.6	0.0	PK	0.0	51.6	74.0	-22.4
2725.550	52.0	-2.6	0.0	PK	0.0	49.4	74.0	-24.6
10902.560	48.0	9.9	0.0	PK	-9.5	48.4	74.0	-25.6
9085.058	49.8	7.6	0.0	PK	-9.5	47.9	74.0	-26.1
9084.725	49.1	7.6	0.0	PK	-9.5	47.2	74.0	-26.8

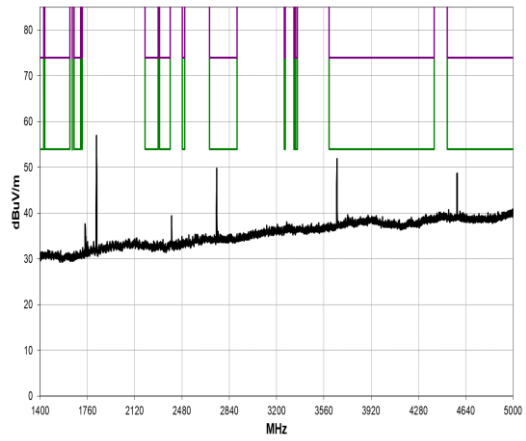
Frequency: 914.9 MHz; Channel: 63; Power Setting: 14dBm



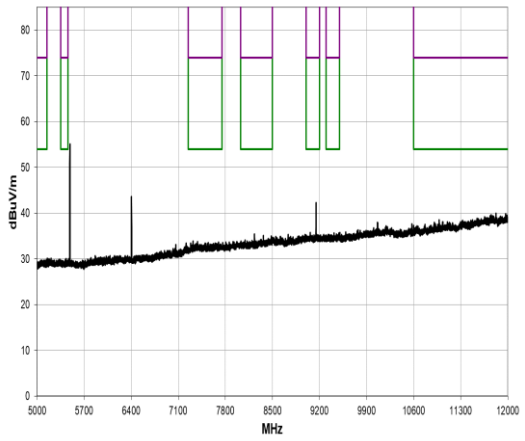
30 MHz to 1GHz



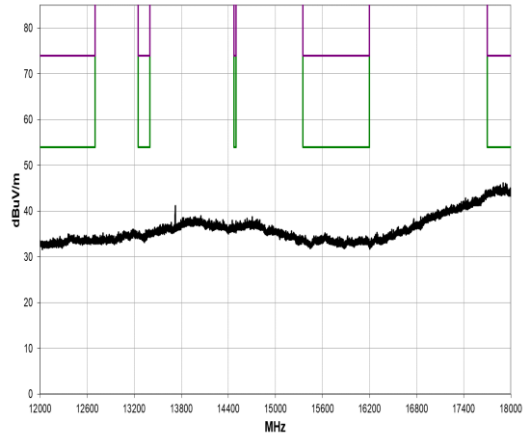
1 GHz to 1.4 GHz



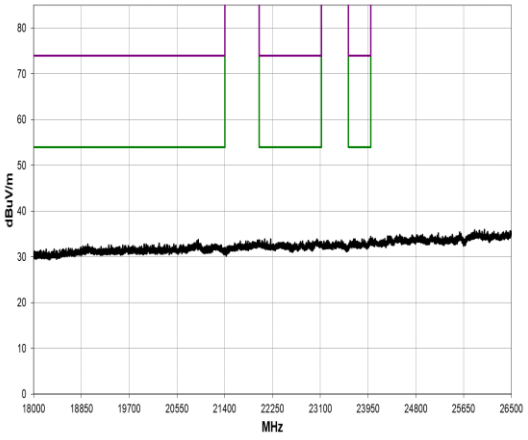
1.4 GHz to 5 GHz



5 GHz to 12 GHz



12 GHz to 18 GHz



18 GHz to 26.5 GHz

Frequency: 914.9 MHz; Channel: 63; Power Setting: 14dBm								
Freq	**Amplitude**	**Factor**	**External Attenuation**	**Detector**	**Distance Adjustment**	**Adjusted**	**Spec. Limit**	**Compared to Spec.**
(MHz)	**(dBuV)**	**(dB/m)**	**(dB)**		**(dB)**	**(dBuV/m)**	**(dBuV/m)**	**(dB)**
3659.750	49.0	0.9	0.0	AV	0.0	49.9	54.0	-4.1
2744.833	50.8	-2.6	0.0	AV	0.0	48.2	54.0	-5.8
3659.533	47.0	0.9	0.0	AV	0.0	47.9	54.0	-6.1
4574.400	44.4	3.0	0.0	AV	0.0	47.4	54.0	-6.6
4574.408	41.0	3.0	0.0	AV	0.0	44.0	54.0	-10.0
2744.492	46.3	-2.6	0.0	AV	0.0	43.7	54.0	-10.3
9149.300	39.3	7.5	0.0	AV	-9.5	37.3	54.0	-16.7
9148.833	37.0	7.5	0.0	AV	-9.5	35.0	54.0	-19.0
3659.633	54.0	0.9	0.0	PK	0.0	54.9	74.0	-19.1
4574.650	51.3	3.0	0.0	PK	0.0	54.3	74.0	-19.7
3659.358	52.4	0.9	0.0	PK	0.0	53.3	74.0	-20.7
4574.658	49.6	3.0	0.0	PK	0.0	52.6	74.0	-21.4
2744.842	55.1	-2.6	0.0	PK	0.0	52.5	74.0	-21.5
2744.667	52.7	-2.6	0.0	PK	0.0	50.1	74.0	-23.9
9149.400	50.2	7.5	0.0	PK	-9.5	48.2	74.0	-25.8
9149.508	48.7	7.5	0.0	PK	-9.5	46.7	74.0	-27.3

28 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.

Test / Measurement	*Budget Number*	*MU*
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connecter) Sampling Power Meter to 8 GHz	MU4001	0.9 dB
Carrier Power and PSD - Spectrum Analysers	MU4004	1.7 dB
Adjacent Channel Power	MU4002	1.9 dB
Transmitter conducted spurious emissions (Including emissions due to intermodulation)	MU4041	0.9 dB
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	2.4 dB
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	2.5 dB
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	2.4 dB
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	3.7 dB
Effective Radiated Power	MU4021	4.7 dB
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	5.3 dB
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	5.1 dB
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	2.7 dB
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	2.7 dB
In-band (3450-3650 MHz) TRP using CATR_ASH_B2	MU4051	4.1 dB
Cellular Radiated Spurious Emissions in a SAC 30 MHz to 180 MHz	MU4052	6.3 dB
Cellular Radiated Spurious Emissions in a SAC 180 MHz to 18 GHz	MU4052	3.6 dB
Cellular Radiated Spurious Emissions in a FAR 30 MHz to 180 MHz	MU4052	5.4 dB
Cellular Radiated Spurious Emissions in a FAR 180 MHz to 18 GHz	MU4052	3.0 dB
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz (Including emissions due to intermodulation)	MU4037	4.7 dB
Radiated Spurious Emissions 1-18 GHz (Including emissions due to intermodulation)	MU4032	4.5 dB
E Field Emissions 18 GHz to 26 GHz	MU4024	3.2 dB
E Field Emissions 26 GHz to 40 GHz	MU4025	3.3 dB
E Field Emissions 40 GHz to 50 GHz	MU4026	3.5 dB
E Field Emissions 50 GHz to 75 GHz	MU4027	3.6 dB
E Field Emissions 75 GHz to 110 GHz	MU4028	3.6 dB
Radiated Magnetic Field Emissions	MU4031	2.3 dB

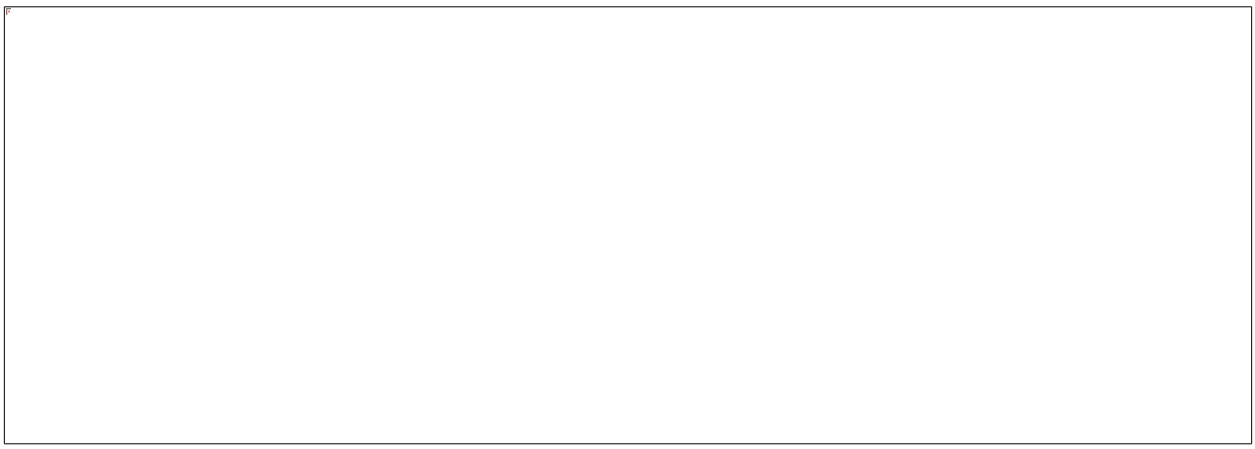
Test / Measurement	*Budget Number*	*MU*
Frequency Measurements		
Frequency Deviation	MU4022	3.7 kHz
Frequency error using CMTA test set	MU4023	113.441 Hz
Frequency error using GPS locked frequency source	MU4045	0.0413 ppm
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	3.87%
Transmitter Mask Amplitude	MU4039	1.3 dB
Transmitter Mask Frequency	MU4040	2.59%
Time Domain Measurements		
Transmission Time	MU4038	4.40%
Dynamic Frequency Selection (DFS) Parameters)		
DFS Analyser - Measurement Time	MU4006	678.984 µs
DFS Generator - Frequency Error	MU4007	91.650 Hz
DFS Threshold Conducted	MU4008	1.3 dB
DFS Threshold Radiated	MU4009	3.2 dB
Receiver Parameters		
EN 300 328 Receiver Blocking	MU4010	1.1 dB
EN 301 893 Receiver Blocking	MU4011	1.1 dB
EN 303 340 Adjacent Channel Selectivity	MU4012	1.1 dB
EN 303 340 Overloading	MU4013	1.1 dB
EN 303 340 Receiver Blocking	MU4014	1.1 dB
EN 303 340 Receiver Sensitivity	MU4015	0.9 dB
EN 303 372-1 Image Rejection	MU4016	1.4 dB
EN 303 372-1 Receiver Blocking	MU4017	1.1 dB
EN 303 372-2 Adjacent Channel Selectivity	MU4018	1.1 dB
EN 303 372-2 Dynamic Range	MU4019	0.9 dB
Receiver Blocking Talk Mode Conducted	MU4033	1.2 dB
Receiver Blocking Talk Mode- radiated	MU4034	3.4 dB
Rx Blocking, listen mode, blocking level	MU4035	3.2 dB
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	3.4 dB
Adjacent Sub Band Selectivity	MU4003	4.2 dB

Test / Measurement	*Budget Number*	*MU*
Rohde & Schwarz TS8997		
Carrier frequency	MU4050	5.2 ppm
RF Output Power	MU4050	1.0 dB
Peak Power	MU4050	0.8 dB
Power Spectral Density	MU4050	1.0 dB
Occupied Channel Bandwidth	MU4050	2.08 %
Transmitter unwanted emissions in-band	MU4050	0.9 dB
Transmitter unwanted emissions in the spurious domain 30 MHz to 1 GHz	MU4050	0.6 dB
Transmitter unwanted emissions in the spurious domain 1 GHz to 12.75 GHz	MU4050	1.8 dB
Receiver Spurious emission 30 MHz to 1 GHz	MU4050	0.6 dB
Receiver Spurious emission 1 GHz to 12.75 GHz	MU4050	1.8 dB
Duty Cycle	MU4050	0.02 %
Tx Sequence	MU4050	0.02 %
Tx Gap	MU4050	0.02 %
Medium Utilisation	MU4050	0.1 %
Accumulated Transmit Time	MU4050	0.01 %
Minimum Frequency Occupation Time	MU4050	0.01 %
Hopping Frequency Separation	MU4050	0.6 %
Receiver blocking (for bit streams)	MU4050	3.0 dB
Channel Access Mechanism / Adaptivity / DFS / Contention Based Protocol	MU4050	1.8 dB

29 Appendix A

29.1 Additional Antenna Information

The image below presents the Antenna Measurement Results.



30 General SAR test reduction & exclusion guidance

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

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

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

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

Where,

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

Channel Frequency (MHz)	***Maximum Conducted Power (mW)***	***SAR Exclusion Threshold at 5 mm (mW)***	***SAR Evaluation***
902.3	11.0	15.8	Not Required
908.5	11.3	15.7	Not Required
914.9	11.8	15.7	Not Required

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