Report on the Radio Testing

For

Semtech Neuchatel SARL

on

Corecell Version 3

Report no. TRA-051134-47-03B

2020-12-14

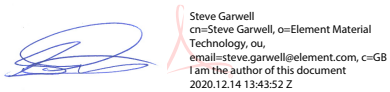
RF915 6.0

0026

Report Number: TRA-051134-47-03B
Issue: B

REPORT ON THE RADIO TESTING OF A
Semtech Neuchatel SARL
Corecell Version 3
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2020-08-12 to 2020-10-02

Written by:	 Steve Garwell cn=Steve Garwell, o=Element Material Technology, ou, email=steve.garwell@element.com, c=GB I am the author of this document 2020.12.14 13:43:52 Z	Steven Garwell Radio Test Engineer
Approved by:	 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: 2020.12.14 12:09:53 Z	John Charters Department Manager-Radio
Date:	2020-12-14	

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[1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2020-12-09	Original
B	2020-12-14	Amended customer address and minor technical updates.

2 Summary

TEST REPORT NUMBER:	TRA-051134-47-03B
WORKS ORDER NUMBER:	TRA-051134-00
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	Corecell Version 3
FCC IDENTIFIER:	Awaiting FCC identifier
EUT SERIAL NUMBER:	US
MANUFACTURER/AGENT:	Semtech Neuchâtel Sàrl
ADDRESS:	Route des Gouttes d'Or 40 Neuchâtel CH-2000 Switzerland
CLIENT CONTACT:	Tim Cooper ☎ +41 32 700 29 41 46 ✉ tcooper@semtech.com
ORDER NUMBER:	6000072680
TEST DATE:	2020-08-12 to 2020-10-02
TESTED BY:	Steven Garwell Element

2.1 Test Summary

Test Method and Description		*47CFR15 Requirement Clause*	*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	☒	*PASS*
Occupied bandwidth		15.247(a)(2)	☒	*PASS*
Conducted carrier power	Peak	15.247(b)(3)	☒	*PASS*
	Max.		☐	
Conducted / radiated RF power out-of-band		15.247(d)	☒	*PASS*
Power spectral density, conducted		15.247(e)	☒	*PASS*
Calculation of duty correction		15.35(c)	☐	*N/A*

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

4 Introduction

This report TRA-051134-47-03B presents the results of the Radio testing on a Semtech Neuchatel SARL, Corcell Version 3 to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Semtech Neuchatel SARL 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 Number(s):

Element Hull	3483A
Element North West	3930B

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

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

5 Test Specifications

5.1 Normative References

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

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	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: Corecell Version 3
- Serial Number: US
- Model Number: Corecell Version 3
- Software Revision: Not Applicable
- Build Level / Revision Number: Prototype

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.

1. Raspberry Pi
2. Host Board
3. Laptop Computer

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for transmitter tests was as follows:

The EUT was programmed via test scripts to transmit on the selected channel.

7.4 EUT Radio Parameters

7.4.1 General

Frequencies of operation:	902 MHz to 928 MHz Band
Modulation type:	LoRa Chirp Spread Spectrum
Occupied channel bandwidth:	700 kHz
Declared output power:	27 dBm
Warning against use of alternative antennas in user manual (yes/no):	Not applicable
Nominal Supply Voltage:	5 Vdc (via USB)

7.4.2 Antennas

Type:	915 MHz Straight Dipole Whip
Frequency range:	900-930 MHz
Impedance:	50 Ω
SWR:	≤ 2.0 typical
Gain:	0 dBi

7.5 EUT Description

The EUT is a 915 MHz radio with a single antenna

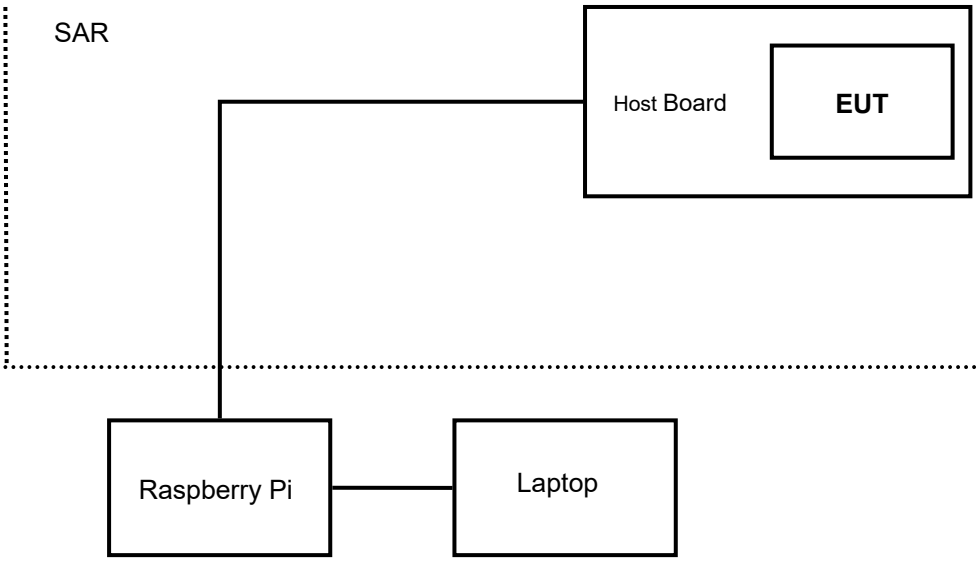
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

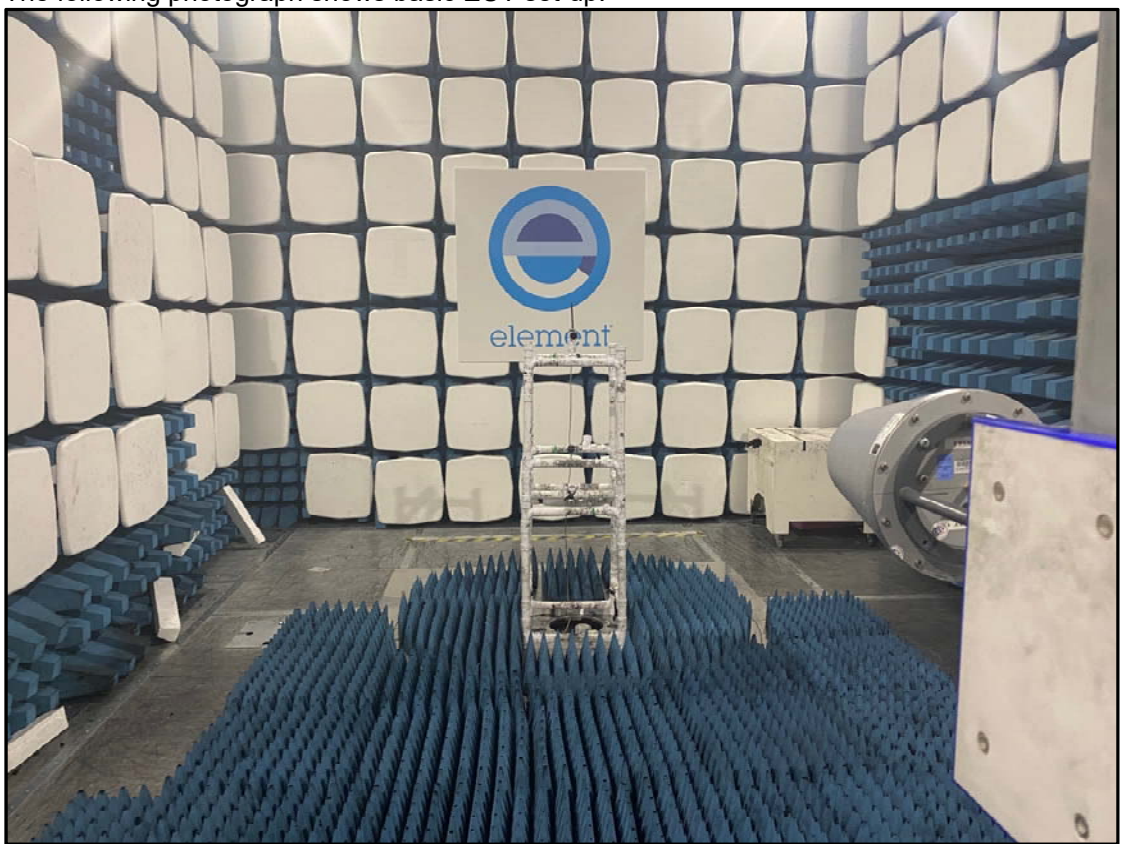
9.1 Block Diagram

The following diagram shows basic EUT interconnections:



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 5 Vdc via USB.

11 Radiated emissions

11.1 Definitions

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

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

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	904.3 MHz, 914.9 MHz, 927.5 MHz
EUT Channel Bandwidth:	700 kHz
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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 54 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc via USB	5 Vdc via USB (as declared)

11.3 Test Limit

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

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

Frequency (MHz)	*Field Strength (µV/m at 3 m)*
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

11.4 Test Method

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

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

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

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

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

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

$$FS = PR + CL + AF – PA + DC – CF$$

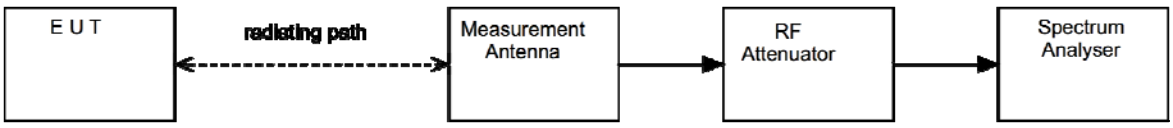
$$Factor = CL + AF – PA$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph

11.6 Test Equipment

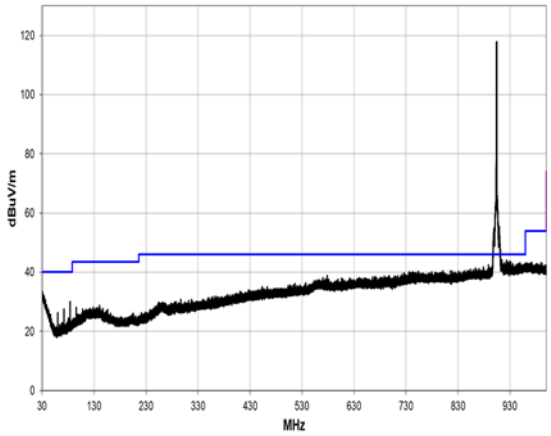
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2020-10-17
Receiver	R&S	ESVS10	L352	2020-09-26
Bilog	Chase	CBL611/A	U573	2021-09-19
Log Periodic Ant	Chase	UPA6108	L203	2022-06-16
Pre Amp	Watkins Johnson	6201-69	U372	2021-02-26
Pre Amp	Agilent	8449	L572	2020-10-15
1-18GHz Horn	EMCO	3115	L139	2021-07-16
1-18GHz Horn	EMCO	3115	U223	2021-11-05
Tunable Notch Filter	K&L	FILTER	U710	Cal in use
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

11.7 Test Results

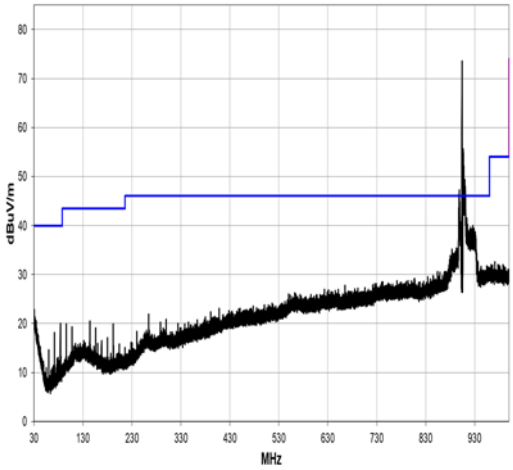
Emissions Common to all modes of operation

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)
72.040	39.1	-15.8	2.0	159.0	3.0	0.0	Vert	QP	0.0	23.3	40.0	-16.7
84.044	35.3	-14.3	2.0	125.9	3.0	0.0	Vert	QP	0.0	21.0	40.0	-19.0
60.047	35.8	-16.6	2.0	264.9	3.0	0.0	Vert	QP	0.0	19.2	40.0	-20.8
30.587	21.9	-4.2	2.7	273.0	3.0	0.0	Vert	QP	0.0	17.7	40.0	-22.3
30.584	21.8	-4.2	3.03	82.0	3.0	0.0	Vert	QP	0.0	17.6	40.0	-22.4
67.752	30.6	-16.2	1.32	74.9	3.0	0.0	Vert	QP	0.0	14.4	40.0	-25.6
96.035	30.1	-12.6	2.8	275.1	3.0	0.0	Vert	QP	0.0	17.5	43.5	-26.0
32.024	18.7	-4.8	1.09	221.0	3.0	0.0	Vert	QP	0.0	13.9	40.0	-26.1
79.754	26.0	-15.0	2.0	216.0	3.0	0.0	Vert	QP	0.0	11.0	40.0	-29.0
54.842	23.4	-16.2	2.0	167.0	3.0	0.0	Vert	QP	0.0	7.2	40.0	-32.8
79.750	21.0	-15.0	1.43	7.9	3.0	0.0	Vert	QP	0.0	6.0	40.0	-34.0

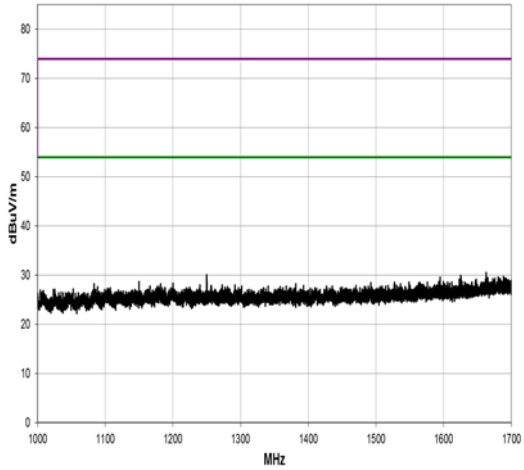
Bottom Channel; Frequency: 904.3 MHz



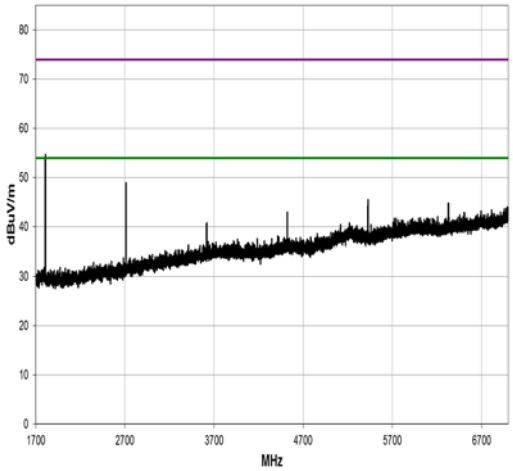
The plot above was taken without the use of a filter to show that no significant emissions were present.



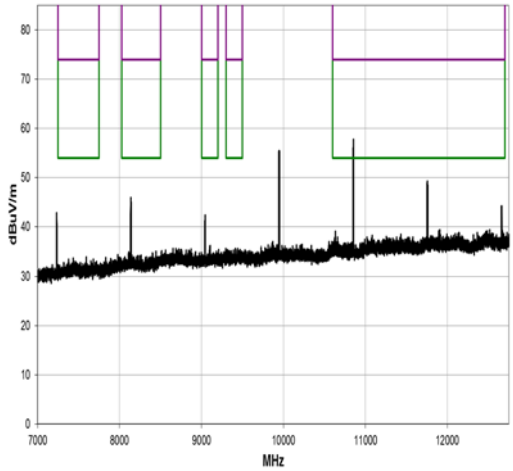
30 MHz to 1 GHz



1 GHz to 1.7 GHz



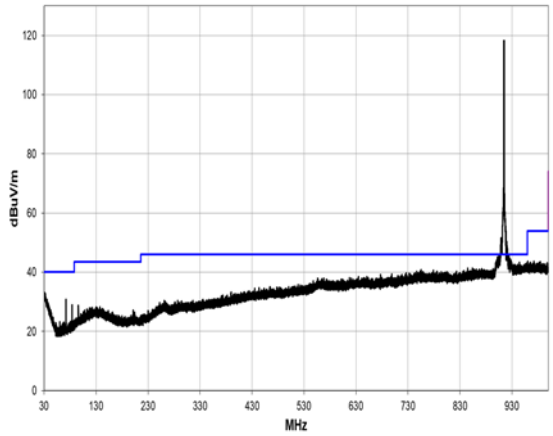
1.7 GHz to 7 GHz



7 GHz to 12 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)
2712.858	49.2	-2.6	1.94	155.1	3.0	0.0	Horz	AV	0.0	46.6	54.0	-7.4
2713.042	48.8	-2.6	1.45	360.1	3.0	0.0	Vert	AV	0.0	46.2	54.0	-7.8
5425.600	33.9	5.8	1.5	276.0	3.0	0.0	Vert	AV	0.0	39.7	54.0	-14.3
6330.483	31.3	7.7	1.5	25.9	3.0	0.0	Vert	AV	0.0	39.0	54.0	-15.0
6329.775	30.5	7.7	1.5	31.0	3.0	0.0	Horz	AV	0.0	38.2	54.0	-15.8
3616.842	36.1	1.1	1.69	222.9	3.0	0.0	Vert	AV	0.0	37.2	54.0	-16.8
3617.692	35.8	1.1	1.94	156.9	3.0	0.0	Horz	AV	0.0	36.9	54.0	-17.1
5424.608	30.2	5.7	1.5	67.0	3.0	0.0	Horz	AV	0.0	35.9	54.0	-18.1
5426.208	48.1	5.8	1.5	276.0	3.0	0.0	Vert	PK	0.0	53.9	74.0	-20.1
6329.200	46.0	7.7	1.5	25.9	3.0	0.0	Vert	PK	0.0	53.7	74.0	-20.3
10853.350	45.5	11.2	1.73	293.0	1.0	0.0	Vert	AV	-9.5	47.2	54.0	-6.8
10852.130	59.2	11.2	1.73	293.0	1.0	0.0	Vert	PK	-9.5	60.9	74.0	-13.1
10853.580	38.8	11.2	1.6	290.0	1.0	0.0	Horz	AV	-9.5	40.5	54.0	-13.5
11758.380	35.9	12.2	1.6	297.9	1.0	0.0	Vert	AV	-9.5	38.6	54.0	-15.4
12657.540	34.9	13.0	1.77	281.9	1.0	0.0	Vert	AV	-9.5	38.4	54.0	-15.6
8140.408	38.3	8.7	1.85	262.9	1.0	0.0	Vert	AV	-9.5	37.5	54.0	-16.5
8140.283	35.9	8.7	1.97	301.0	1.0	0.0	Horz	AV	-9.5	35.1	54.0	-18.9
12657.530	31.3	13.0	1.0	14.1	1.0	0.0	Horz	AV	-9.5	34.8	54.0	-19.2
11759.250	31.8	12.2	1.17	250.0	1.0	0.0	Horz	AV	-9.5	34.5	54.0	-19.5
10853.060	52.7	11.2	1.6	290.0	1.0	0.0	Horz	PK	-9.5	54.4	74.0	-19.6
12660.480	49.9	13.0	1.77	281.9	1.0	0.0	Vert	PK	-9.5	53.4	74.0	-20.6
11757.070	50.6	12.2	1.6	297.9	1.0	0.0	Vert	PK	-9.5	53.3	74.0	-20.7

Middle Channel; Frequency: 914.9 MHz



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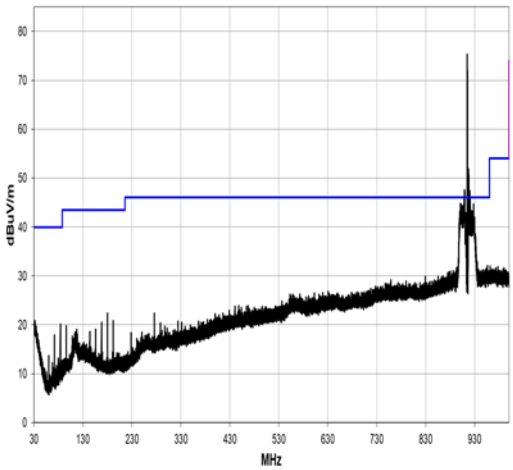
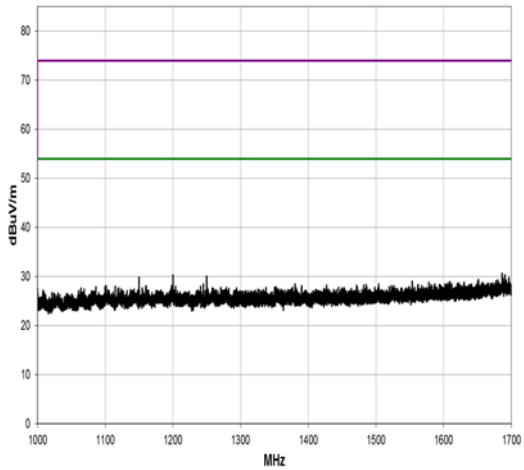
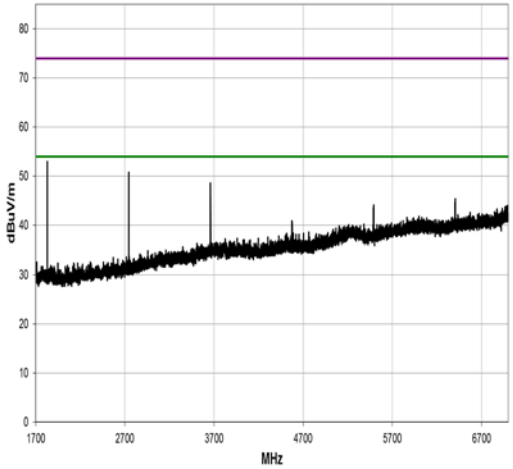


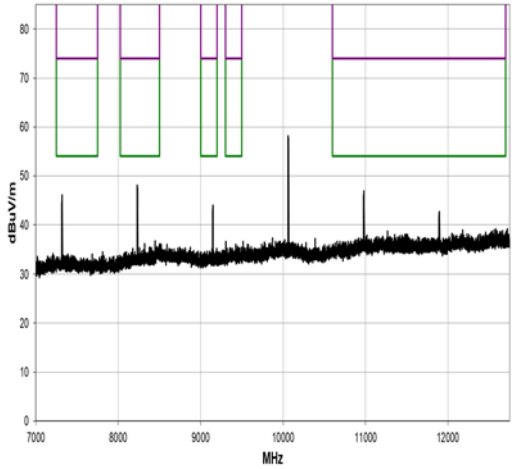
30 MHz to 1 GHz



1 GHz to 1.7 GHz



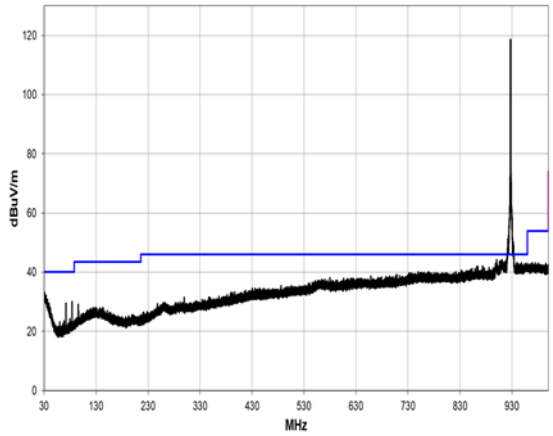
1.7 GHz to 7 GHz



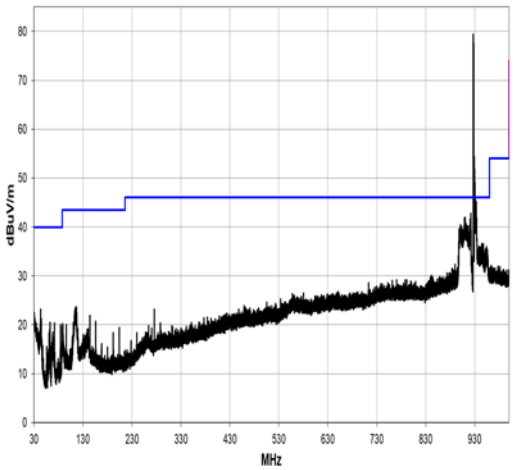
7 GHz to 12 GHz

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)
7319.533	41.2	7.8	1.83	63.1	1.0	0.0	Vert	AV	-9.5	39.5	54.0	-14.5
10980.780	37.2	11.4	1.89	230.9	1.0	0.0	Vert	AV	-9.5	39.1	54.0	-14.9
8234.058	38.1	8.9	1.39	68.0	1.0	0.0	Vert	AV	-9.5	37.5	54.0	-16.5
10981.090	34.8	11.4	2.01	340.0	1.0	0.0	Horz	AV	-9.5	36.7	54.0	-17.3
11892.590	34.2	12.0	1.95	224.9	1.0	0.0	Vert	AV	-9.5	36.7	54.0	-17.3
9147.450	36.8	9.3	1.9	262.9	1.0	0.0	Vert	AV	-9.5	36.6	54.0	-17.4
11892.820	32.6	12.0	1.94	199.0	1.0	0.0	Horz	AV	-9.5	35.1	54.0	-18.9
8234.433	35.2	8.9	1.96	65.0	1.0	0.0	Horz	AV	-9.5	34.6	54.0	-19.4
9150.167	34.2	9.3	1.74	327.9	1.0	0.0	Horz	AV	-9.5	34.0	54.0	-20.0
10978.620	51.8	11.4	1.89	230.9	1.0	0.0	Vert	PK	-9.5	53.7	74.0	-20.3
11890.960	50.2	12.0	1.95	224.9	1.0	0.0	Vert	PK	-9.5	52.7	74.0	-21.3
7317.850	34.2	7.8	1.43	12.9	1.0	0.0	Horz	AV	-9.5	32.5	54.0	-21.5
7318.350	54.0	7.8	1.83	63.1	1.0	0.0	Vert	PK	-9.5	52.3	74.0	-21.7
10978.610	50.1	11.4	2.01	340.0	1.0	0.0	Horz	PK	-9.5	52.0	74.0	-22.0
9148.642	51.5	9.3	1.9	262.9	1.0	0.0	Vert	PK	-9.5	51.3	74.0	-22.7
11891.330	48.4	12.0	1.94	199.0	1.0	0.0	Horz	PK	-9.5	50.9	74.0	-23.1
8233.767	51.0	8.9	1.39	68.0	1.0	0.0	Vert	PK	-9.5	50.4	74.0	-23.6
8234.342	50.0	8.9	1.96	65.0	1.0	0.0	Horz	PK	-9.5	49.4	74.0	-24.6
9147.317	49.5	9.3	1.74	327.9	1.0	0.0	Horz	PK	-9.5	49.3	74.0	-24.7
7317.967	49.0	7.8	1.43	12.9	1.0	0.0	Horz	PK	-9.5	47.3	74.0	-26.7

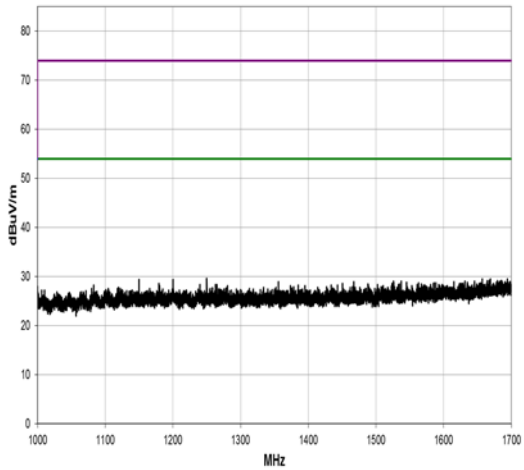
Top Channel; Frequency: 927.5 MHz



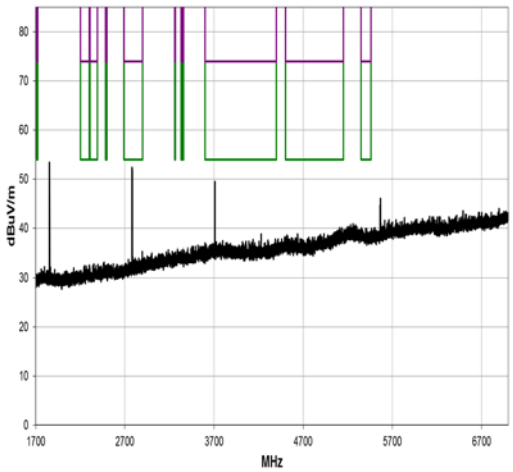
The plot above was taken without the use of a filter to show that no significant emissions were present.



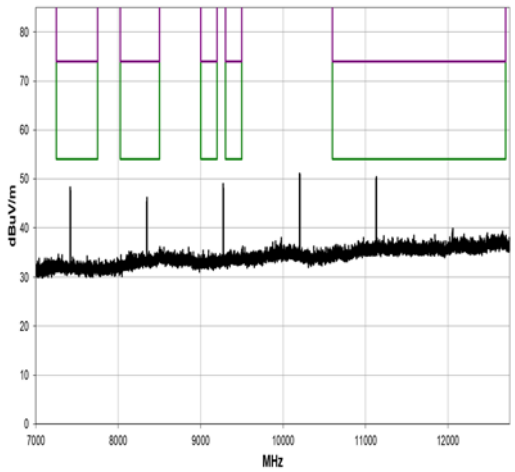
30 MHz to 1 GHz



1 GHz to 1.7 GHz



1.7 1GHz to 7 GHz



7 GHz to 12 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)
11132.470	39.8	11.7	1.94	278.0	1.0	0.0	Vert	AV	-9.5	42.0	54.0	-12.0
7419.650	43.4	7.9	1.89	311.0	1.0	0.0	Vert	AV	-9.5	41.8	54.0	-12.2
8347.317	38.8	9.2	1.79	231.0	1.0	0.0	Vert	AV	-9.5	38.5	54.0	-15.5
11131.900	35.9	11.7	1.97	329.0	1.0	0.0	Horz	AV	-9.5	38.1	54.0	-15.9
7421.375	39.2	7.9	1.94	114.1	1.0	0.0	Horz	AV	-9.5	37.6	54.0	-16.4
11131.970	54.2	11.7	1.94	278.0	1.0	0.0	Vert	PK	-9.5	56.4	74.0	-17.6
8345.800	34.2	9.2	1.45	217.1	1.0	0.0	Horz	AV	-9.5	33.9	54.0	-20.1
7418.025	55.4	7.9	1.89	311.0	1.0	0.0	Vert	PK	-9.5	53.8	74.0	-20.2
11131.820	50.7	11.7	1.97	329.0	1.0	0.0	Horz	PK	-9.5	52.9	74.0	-21.1
8347.483	52.4	9.2	1.79	231.0	1.0	0.0	Vert	PK	-9.5	52.1	74.0	-21.9
7421.192	52.4	7.9	1.94	114.1	1.0	0.0	Horz	PK	-9.5	50.8	74.0	-23.2
8345.617	48.8	9.2	1.45	217.1	1.0	0.0	Horz	PK	-9.5	48.5	74.0	-25.5

12 AC power-line conducted emissions

12.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Transient Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels Measured:	Mid
EUT Channel Bandwidth:	700 kHz
EUT Modulation:	LoRa Chirp Spread Spectrum
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 21°C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc via USB	5 Vdc via USB (as declared)

12.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 3.

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	***Conducted limit (dBµV)***	
	Quasi-Peak	***Average****
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.
**A linear average detector is required.

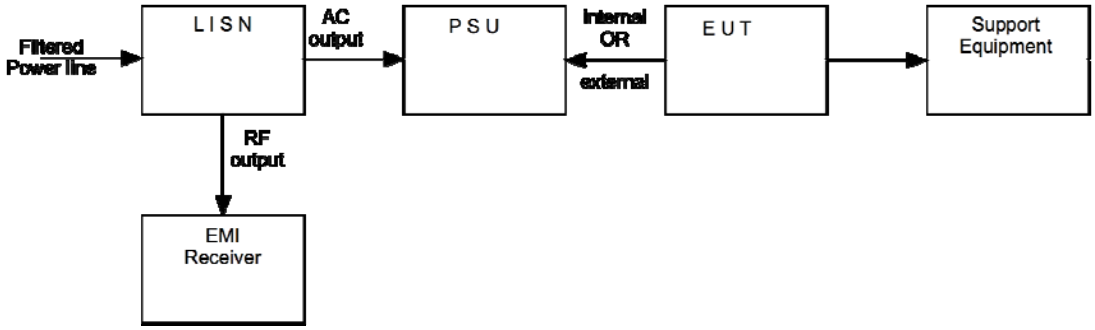
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup

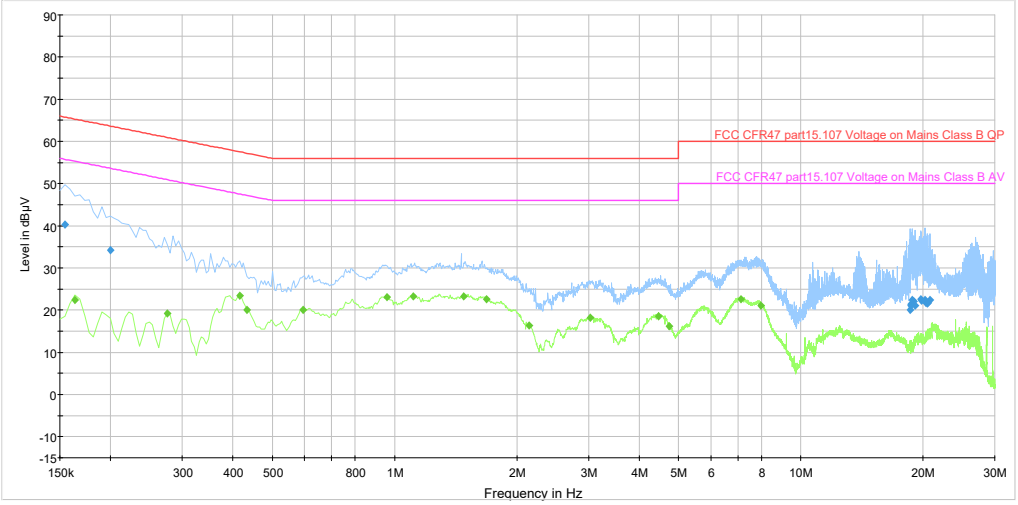


12.5 Test Set-up Photograph

12.6 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
EMI Receiver	R&S	ESR7	U456	2020-11-25
ENV216	R&S	Lisn	U396	2021-09-07

12.7 Test Results



Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.154500	40.3	2000.0	9.000	On	N	19.4	25.5	65.8
0.199500	34.2	2000.0	9.000	On	L1	19.4	29.5	63.6
18.541500	20.1	2000.0	9.000	On	L1	19.7	39.9	60.0
18.645000	21.0	2000.0	9.000	On	L1	19.7	39.0	60.0
18.663000	21.5	2000.0	9.000	On	N	19.8	38.5	60.0
18.802500	22.5	2000.0	9.000	On	N	19.8	37.5	60.0
18.973500	22.1	2000.0	9.000	On	N	19.8	37.9	60.0
19.081500	21.1	2000.0	9.000	On	L1	19.7	38.9	60.0
19.711500	22.6	2000.0	9.000	On	N	19.8	37.4	60.0
19.833000	22.2	2000.0	9.000	On	N	19.8	37.8	60.0
20.224500	22.5	2000.0	9.000	On	N	19.9	37.5	60.0
20.328000	21.7	2000.0	9.000	On	N	19.9	38.3	60.0
20.422500	21.6	2000.0	9.000	On	N	19.9	38.4	60.0
20.548500	21.7	2000.0	9.000	On	N	19.9	38.3	60.0
20.778000	22.3	2000.0	9.000	On	N	19.9	37.7	60.0

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.163500	22.4	2000.0	9.000	On	N	19.4	32.9	55.3
0.276000	19.3	2000.0	9.000	On	N	19.4	31.7	50.9
0.415500	23.4	2000.0	9.000	On	N	19.4	24.1	47.5
0.433500	20.1	2000.0	9.000	On	L1	19.5	27.1	47.2
0.595500	20.1	2000.0	9.000	On	L1	19.5	25.9	46.0
0.955500	23.1	2000.0	9.000	On	L1	19.5	22.9	46.0
1.113000	23.2	2000.0	9.000	On	L1	19.5	22.8	46.0
1.482000	23.2	2000.0	9.000	On	N	19.5	22.8	46.0
1.684500	22.6	2000.0	9.000	On	N	19.5	23.4	46.0
2.143500	16.3	2000.0	9.000	On	N	19.5	29.7	46.0
3.030000	18.2	2000.0	9.000	On	N	19.5	27.8	46.0
4.461000	18.5	2000.0	9.000	On	N	19.6	27.5	46.0
4.744500	16.1	2000.0	9.000	On	N	19.6	29.9	46.0
7.125000	22.6	2000.0	9.000	On	N	19.6	27.4	50.0
7.980000	21.1	2000.0	9.000	On	L1	19.6	28.9	50.0

13 Occupied Bandwidth

13.1 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.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Frequencies Measured:	904.3 MHz, 914.9 MHz, 927.5 MHz
EUT Channel Bandwidths:	700 kHz
EUT Test Modulations:	LoRa Chirp Spread Spectrum
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	1.5 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc via USB	5 Vdc via USB (as declared)

13.3 Test Limit

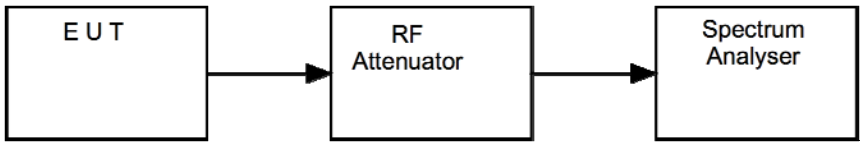
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 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.

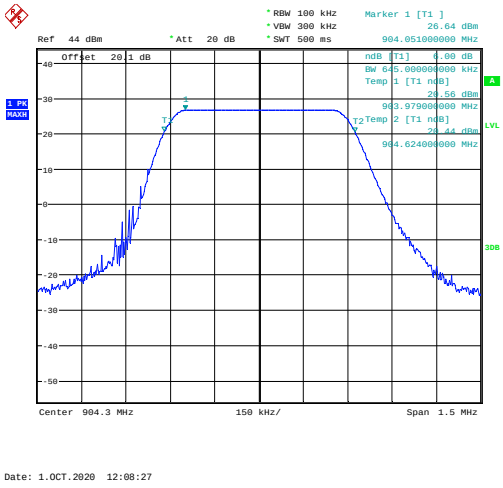
Figure iii Test Setup



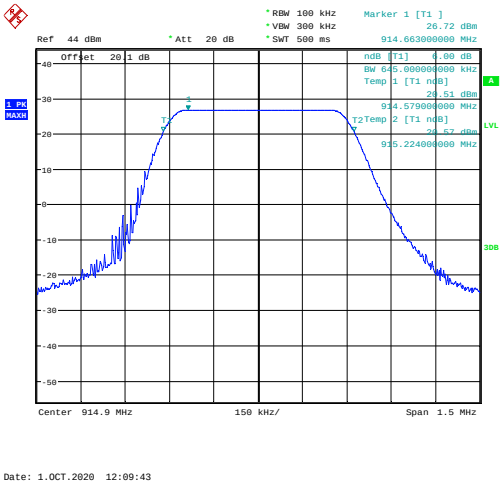
13.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use

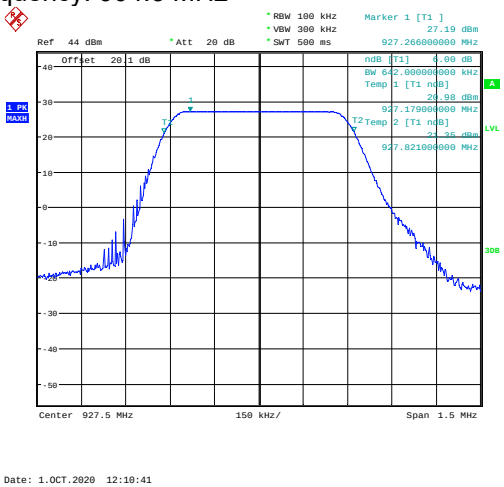
13.6 Test Results



Bottom Channel; Frequency: 904.3 MHz



Middle Channel; Frequency: 914.9 MHz



Top Channel; Frequency: 927.5 MHz

FCC 15.247. Modulation: LoRa; Power setting: High				
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***6dB Bandwidth (kHz)***	***Result***
904.3	903.979	904.624	645.000	PASS
914.9	914.579	915.224	645.000	PASS
927.5	927.179	927.821	642.000	PASS

14 Maximum peak conducted output power

14.1 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.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
Frequencies Measured:	904.3 MHz, 914.9 MHz, 927.5 MHz
EUT Channel Bandwidths:	700 kHz
Deviations From Standard:	None
Measurement BW:	10 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	100 kHz
Measurement Detector:	RMS Average

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

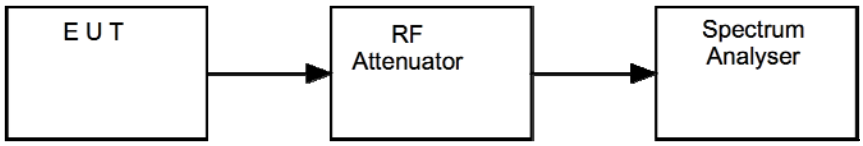
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

14.4 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.

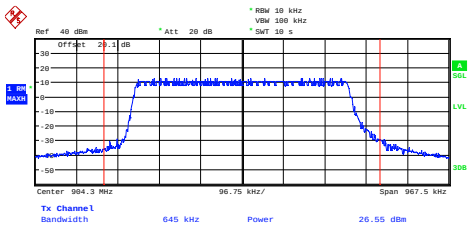
Figure iv Test Setup



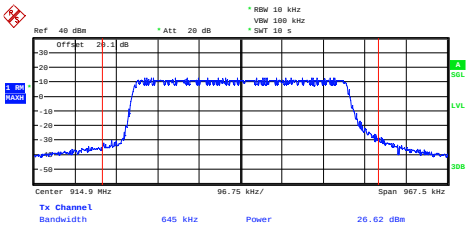
14.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use

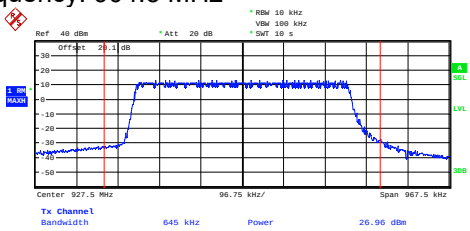
14.6 Test Results



Bottom Channel; Frequency: 904.3 MHz



Middle Channel; Frequency: 914.9 MHz



Top Channel; Frequency: 927.5 MHz

Modulation: LoRA; Power setting: High				
Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Power (W)***	***Verdict***
904.30	26.55	0.0	0.451	PASS
914.90	26.62	0.0	0.459	PASS
927.50	26.96	0.0	0.497	PASS

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
EUT Frequencies Measured:	904.3 MHz, 914.9 MHz, 927.5 MHz
EUT Channel Bandwidths:	700 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:	30 MHz to 12 GHz

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc via USB	5 Vdc via USB (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) is not required.

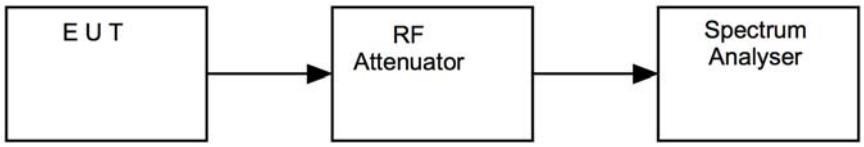
Conducted output power measured using root-mean-square method, 30 dB attenuation requirement applied.

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

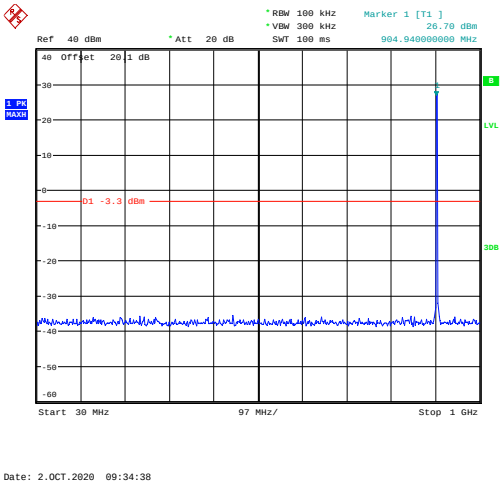


15.5 Test Equipment

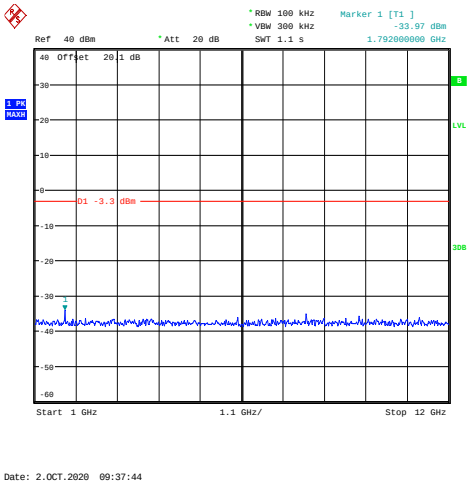
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Spectrum Analyser	R&S	FSW	*	2021-07-23
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use

- *Rental Unit, serial number 101805_calibration due 23rd July 2021

15.6 Test Results

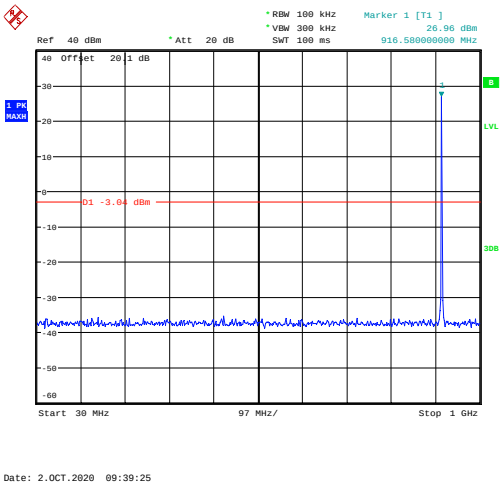


30 MHz to 1 GHz

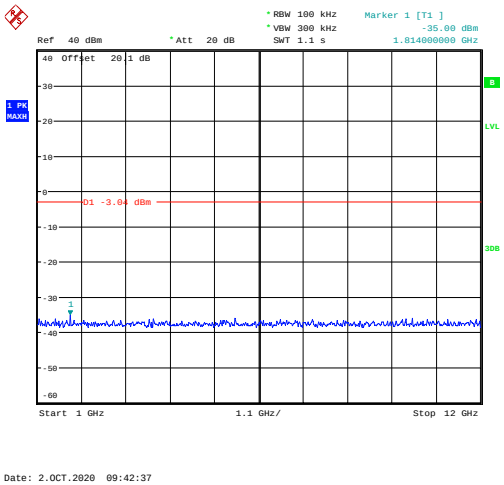


1 GHz to 12 GHz

Frequency: 904.3 MHz; Modulation: LoRa; Power setting: High						
Channel Frequency (MHz)	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
No significant emissions within 20 dB to the limit						PASS

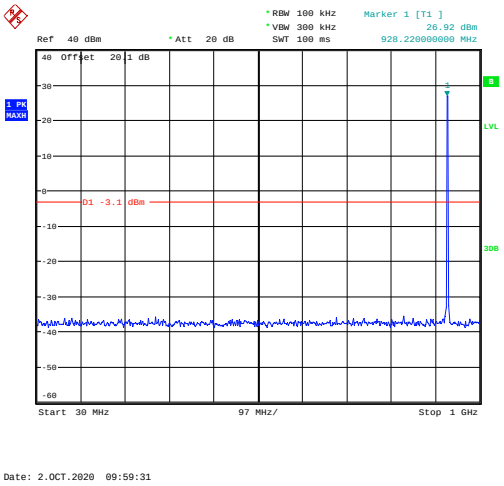


30 MHz to 1 GHz

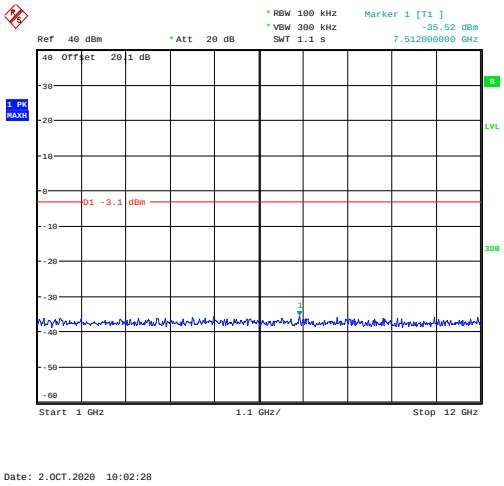


1 GHz to 12 GHz

Frequency: 914.9 MHz; Modulation: LoRa; Power setting: High						
Channel Frequency (MHz)	**Emission Frequency (MHz)**	**Analyzer Level (dBm)**	**Emission Level (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
No significant emissions within 20 dB to the limit						PASS

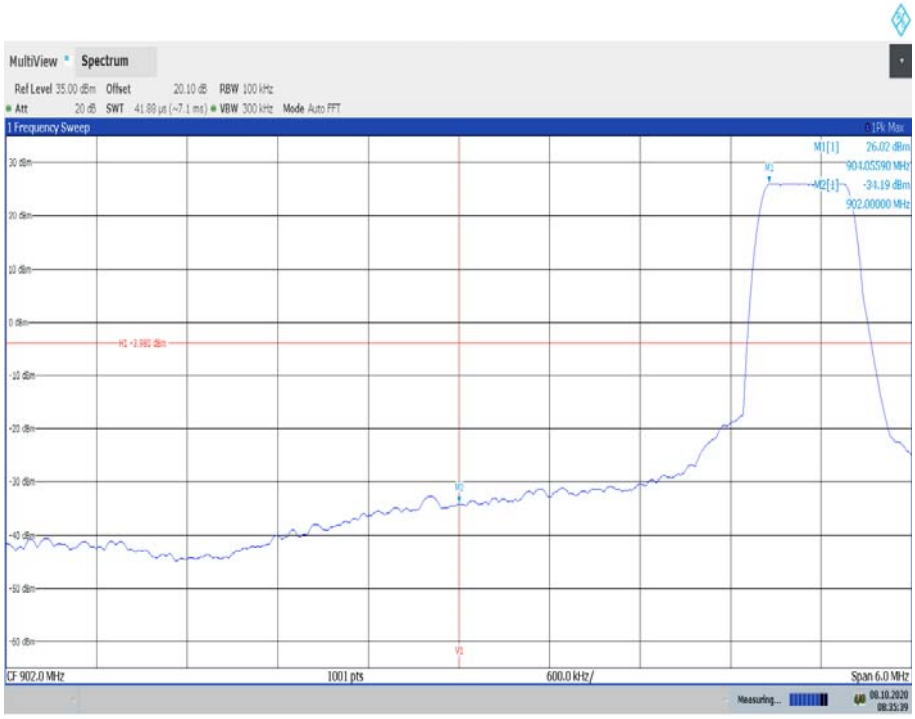


30 MHz to 1 GHz



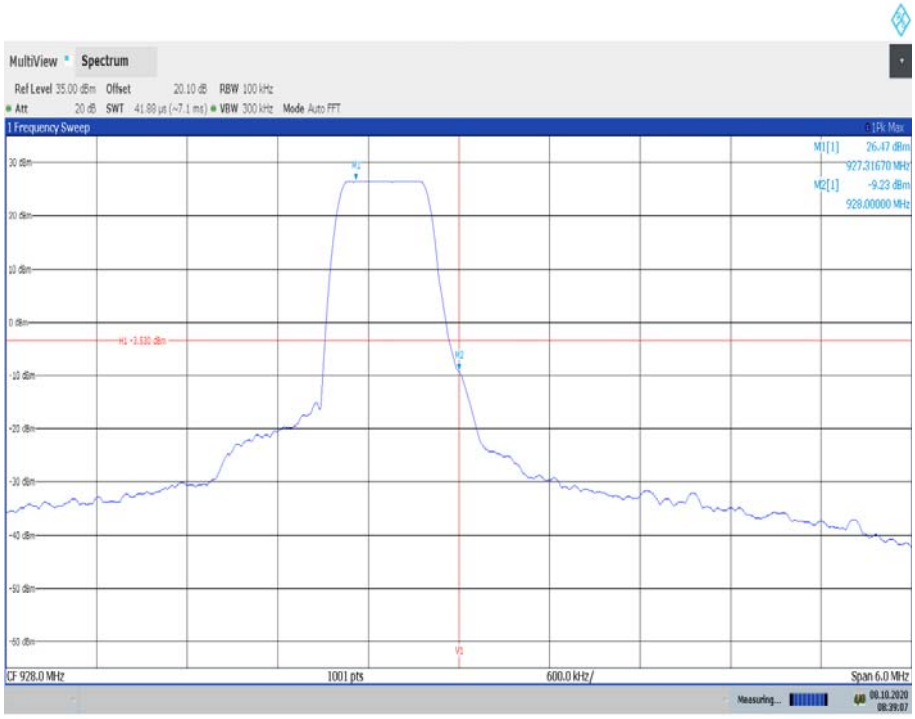
1 GHz to 12 GHz

Frequency: 927.5 MHz; Modulation: LoRa; Power setting: High						
Channel Frequency (MHz)	***Emission Frequency (MHz)***	***Analyzer Level (dBm)***	***Emission Level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 20 dB to the limit						PASS



08:35:40 08.10.2020

Lower Conducted Band Edge



08:39:08 08.10.2020

Upper Conducted Band Edge

16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	904.3 MHz, 914.9 MHz, 927.5 MHz
EUT Channel Bandwidths:	700 kHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	30 kHz
Measurement Span: (requirement 1.5 times Channel BW)	967.5 kHz
Measurement Detector:	RMS (Average)

Environmental Conditions (Normal Environment)

Temperature: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)
Supply: 5 Vdc via USB	5 Vdc via USB (as declared)

16.3 Test Limit

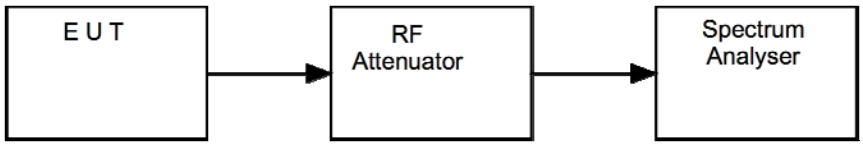
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

16.4 Test Method

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

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

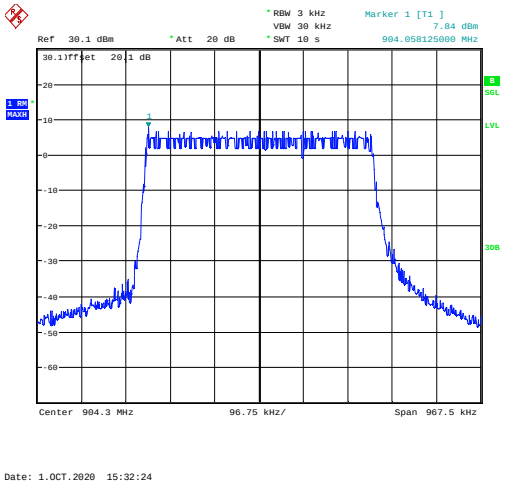
Figure vi Test Setup



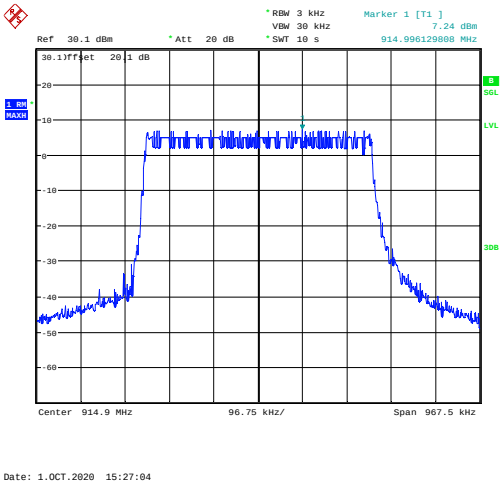
16.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use

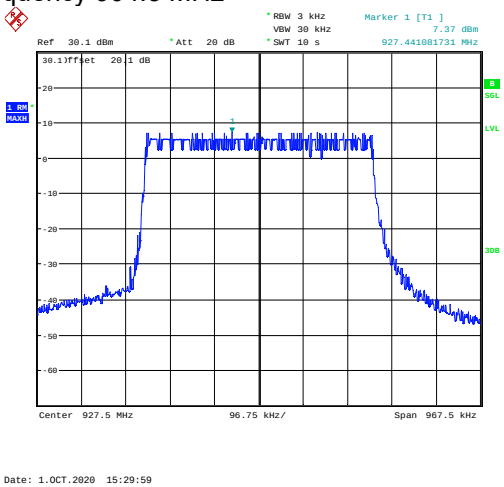
16.6 Test Results



Bottom Channel; Frequency 904.3 MHz



Middle Channel; Frequency: 914.9 MHz



Top Channel; Frequency: 927.5 MHz

Modulation: LoRa; Power setting: High				
Channel Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Power (dBm)***	***Result***
904.3	7.84	0.0	7.84	PASS
914.9	7.24	0.0	7.24	PASS
927.5	7.37	0.0	7.37	PASS

17 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **0.93 dB**

[5] Conducted RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**
Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

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

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**
Uncertainty in test result (Pershore OATS) = **4.26 dB**