Report on the Radio Testing

For

Semtech Neuchatel SARL

on

Corecell version 3

Report no. TRA-051134-47-04B

2020-12-14

RF907 3.0

0026

Report Number: TRA-051134-47-04B
Issue: B

REPORT ON THE RADIO TESTING OF A
Semtech Neuchatel SARL
Corecell Version 3
WITH RESPECT TO SPECIFICATION
ETSI EN 300 220-2 V3.1.1 (2017-02)

TEST DATE: 2020-08-12 to 2020-09-08

Written by: Steven Garwell
Radio Test Engineer

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 13:49:35 Z

Approved by: John Charters
Department Manager - Radio

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 12:05:09 Z

Date: 2020-12-14

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-051134-47-04B
WORKS ORDER NUMBER:	TRA-051134-00
PURPOSE OF TEST:	Testing of radio equipment construction per article 3.2 of the RE-Directive 2014/53/EU
TEST SPECIFICATION:	EN 300 220-2 V3.1.1
EQUIPMENT UNDER TEST (EUT):	Corecell version 3
EUT SERIAL NUMBER:	EU
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 2020-09-08
TESTED BY:	Steven Garwell Element

2.1 Test Summary

Test Method and Description	*Requirement Clause*	*Applicable to this equipment*	*Result / Note*
Operating frequency	4.2.1	☐	*Note 1*
Unwanted emissions in the spurious domain	4.2.2	☒	*PASS*
TX effective radiated power	4.3.1	☒	*PASS*
TX maximum e.r.p. spectral density	4.3.2	☐	*Note 2*
TX duty cycle	4.3.3	☒	*Note 1*
TX occupied bandwidth	4.3.4	☒	*PASS*
TX out of band emissions	4.3.5	☒	*PASS*
TX transient power	4.3.6	☒	*PASS*
TX adjacent channel power	4.3.7	☐	*Note 3*
TX behaviour under low voltage conditions	4.3.8	☐	*Note 7*
TX adaptive power control	4.3.9	☐	*Note 4*
TX FHSS	4.3.10	☐	*Note 5*
TX short term behaviour	4.3.11	☐	*Note 2*
RX sensitivity	4.4.1	☐	*Note 6*
Clear channel assessment threshold	4.5.2	☐	*Note 6*
Polite spectrum access timing parameters	4.5.3	☐	*Note 6*
RX blocking	4.4.2	☒	*PASS*
Adaptive frequency agility	4.5.4	☐	*Note 2*

Notes:

Note 1: Manufacturer declaration (See Appendix A)
Note 2: Not applicable to the operating band.
Note 3: Not applicable operating channel width greater than 25 kHz.
Note 4: Not applicable none adaptive.
Note 5: Not applicable not a frequency hopping device.
Note 6: Not applicable not a polite spectrum device.
Note 7: Not a battery operated device.

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-051134-47-04B presents the results of the Radio testing on a, Semtech Neuchatel SARL Corcell Version 3 to specification EN 300 220-2 V3.1.1 Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 2: Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU for non-specific radio equipment.

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
Skelmersdale
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.

5 Test Specifications

5.1 Normative References

- ETSI EN 300 220-2 V3.1.1 (2017-02) – Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 2: Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU for non-specific radio equipment.

- ETSI EN 300 220-1 V3.1.1 (2017-02) – Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement.

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

6.1 Acronyms, symbols and abbreviations

§	Denotes a section reference from the standard, EN 300 220-1, not this document
§§	Denotes a section reference from the standard, EN 300 220-2, not this document
AC	Alternating Current
AFA	Adaptive Frequency Agility
AM	Amplitude Modulated
BW	Bandwidth
C	Celcius
CW	Continuous Wave
dB	Decibels
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum (or other non-FHSS spread spectrum)
EIRP	Equivalent Isotropically Radiated Power
emf	electromotive force
EN	European Normative document
erp	Effective Radiated Power
EUT	Equipment Under Test
f	Frequency
FHSS	Frequency hopping spread spectrum
Hz	Hertz
IF	Intermediate Frequency
ITU	International Telecommunication Union
LBT	Listen Before Talk
LO	Local Oscillator
m	metre
max	Maximum
min	Minimum
N/A	Not Applicable
No.	Number
NRI	National Radio Interface
OCW	Operating Channel Width (i.e. the channel spacing)
PCB	Printed Circuit Board
PDF	Portable Document Format
PSA	Polite Spectrum Access
RE-D	Radio Equipment Directive
R&TTE	Radio and Telecommunications Terminal Equipment
RE	Radio Equipment
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	Receiver
s	Second
SRD	Short Range Device
Tx	Transmitter
UKAS	United Kingdom Accreditation Service
V	Volt
W	Watt
Ω	Ohm

6.2 Block diagrams

Block diagrams are used in this report to illustrate test set-ups. Each major item of test or support equipment is contained in a block representing a separate physical unit and labelled accordingly. Physical connections, e.g. leads, between units are drawn in solid lines. Other, e.g. over the air, connections are drawn with dashed lines. The arrows indicate the direction of propagation of the signal required in order for the measurement to be taken at the measurement point. They do not signify that propagation in the opposite direction is somehow prevented. Where the environment around specific units is controlled, e.g. use of a shielded chamber, the boundary between the controlled and uncontrolled areas is drawn with a dotted line.

7 Equipment Under Test

7.1 EUT Identification

- Name: Corecell version 3
- Serial Number: EU
- Model Number: Corecell version 3
- Software Revision: Conducted - Version 1.0
  Radiated 30 MHz to 1 GHz - Version 1.0
  Radiated 1 GHz to 6 GHz - Version 1.1
- 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.

- *Raspberry Pi*
- *Host Board*
- *Laptop Computer*

7.3 EUT Mode of Operation

7.3.1 Transmissions

The mode of operation for Transmit tests was as follows:-

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

7.3.2 Reception

The mode of operation for Receive tests was as follows:-

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

7.4 EUT Radio Parameters

7.4.1 General

Bands of operation:	868 MHz to 868.6 MHz	869.4 MHz to 869.65 MHz
Frequencies of operation:	868.100 MHz	869.525 MHz
Modulation type:	LoRa Chirp Spread Spectrum	LoRa Chirp Spread Spectrum
Channel bandwidth:	200 kHz	200 kHz
Declared output power:	14 dBm	27 dBm
Antenna type and gain:	0 dBi	0 dBi
Nominal Supply Voltage:	3.3 Vdc regulated from 5 Vdc (via USB) supplied to host	3.3 Vdc regulated from 5 Vdc (via USB) supplied to host

7.5 EUT Description

The EUT is an 868 MHz radio with a single antenna and category 2 receiver.

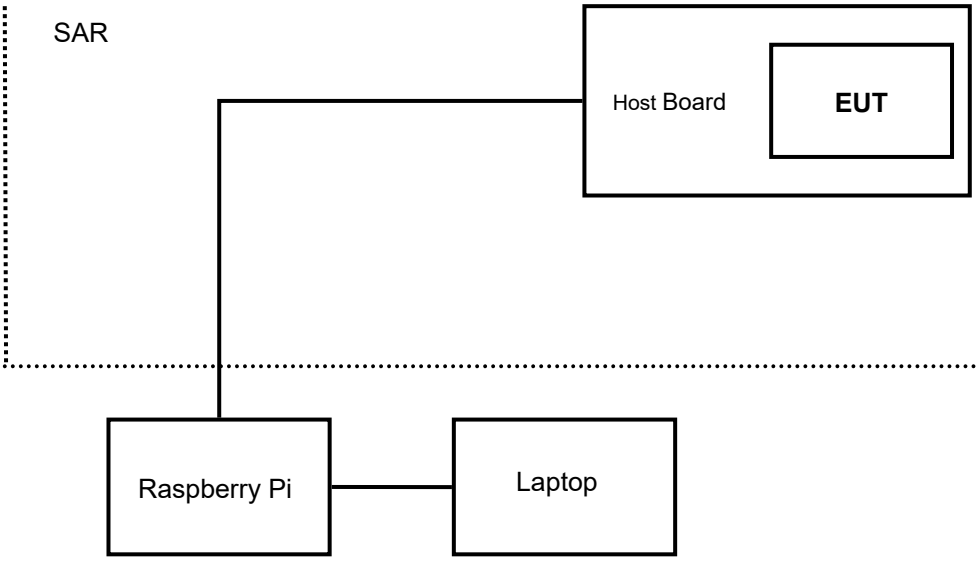
8 Modifications

Software change to version 1.1_the software was amended by the manufacturer.

9 EUT Test Setup

9.1 Block Diagram

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



`

9.2 General Set-up Photograph

The following photograph shows basic radiated 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 to the module was 3.3 Vdc this was regulated by the host board which was powered by 5 Vdc via USB.

10.2 Extreme Test Conditions

Where extreme temperatures are required to be tested the following extremes were used:

Applicable	*Category*	*Range*
☐	Category I (General)	-20 to +55 C
☐	Category II (Portable)	-10 to +55 C
☐	Category III (Equipment for normal indoor use)	+5 to +35 C
☐	Category IV (Automotive)	-40 to +125 C
☒	Declared by provider	-40 C to + 85 C

Where extreme voltages are required to be tested the following extremes were used:

Applicable	*Category*	*Range*
☐	Mains (single nominal voltage)	230 V ac ± 10%
☐	Regulated lead-acid	12 V x1.3 max. 12 V x0.9 min.
☐	Other battery types	3.2 V max. 3 V x0.85 min.
☒	Other (including multi-ranging mains)	2.5 Vdc to 3.6 Vdc (via host board)

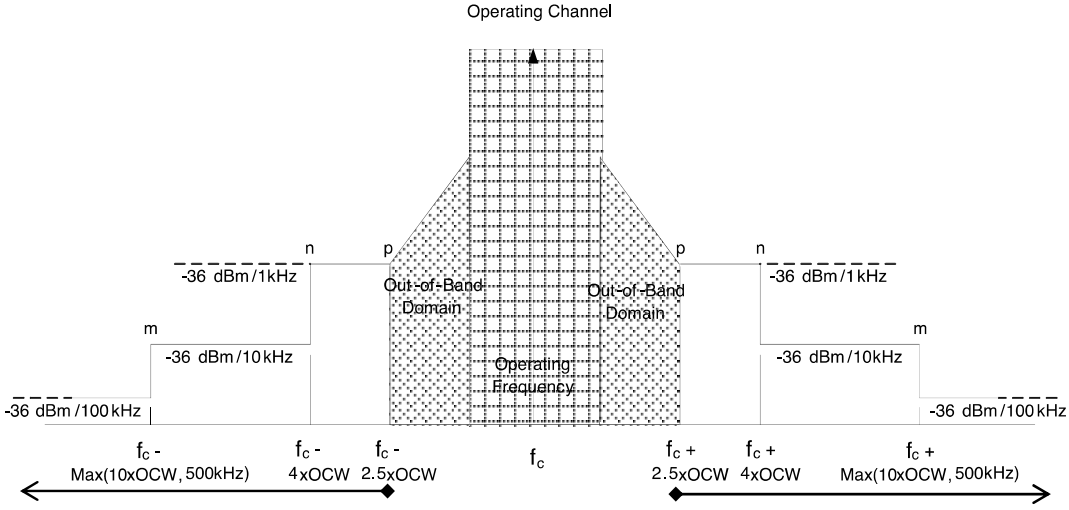
11 Unwanted emissions in the spurious domain

11.1 Definition

11.1.1 Unwanted emissions for a TX mode

Spurious emissions are unwanted emissions in the spurious domain at frequencies other than those of the Operating Channel and it's Out Of Band Domain. The relevant spurious domain is shown in Figure 7.

Figure 7: Spectrum Mask for Unwanted Emissions in the Spurious Domain with reference BW



11.1.2 Unwanted emissions for all other modes

Spurious radiations from the EUT are components, at any frequency, radiated by the equipment and antenna.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Chamber 3
Test Standard and Clause:	ETSI EN 300 220-1 V3.1.1 (2017-02), Clause 5.9
Operating Bands:	h1.5: 868 MHz to 868.6 MHz h1.7: 869.4 MHz to 869.65 MHz
Frequencies Measured:	868.1 MHz, 868.5 MHz and 869.525 MHz
Modulation:	D-M2
Deviations From Standard:	Substitution antennas used are Log Periodic / Bi-conical in lieu of Standard Dipole antennas
Measurement BW:	300 Hz (9 kHz – 150 kHz) 10 kHz (150 kHz – 25 MHz) 100 kHz (25 MHz – 1 GHz); 1 MHz (1GHz-12.75GHz)
Measurement Detector:	Below 1 GHz: RMS (max. held) Above 1 GHz: RMS (max. held)

Environmental Conditions (Normal Environment)

Radiated

Temperature: 24 °C	Standard Requirement: +15 ºC to +35 ºC
Humidity: 69 %RH	Standard Requirement: 20%RH to 75%RH
Supply: 3.3 Vdc	3.3 Vdc (via host board)

Test Limits
The power of any unwanted emission in the spurious domain shall not exceed the values given in Table 19.

Table 19: Spurious domain emission limits

Frequency / ***State***	***47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 790 MHz***	***Other frequencies below 1 000 MHz***	***Frequencies above 1 000 MHz***
Tx mode	-54 dBm	-36 dBm	-30 dBm
RX and all other modes	-57 dBm	-57 dBm	-47 dBm

11.3 Conducted Measurement

11.3.1 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii-a, the RF spectrum of the EUT was observed. Additional filtering (with calibrated path losses taken into account) was added prior to the analyser, where necessary, to prevent overload.
The measurements were performed with EUT set at its maximum power setting and repeated in its standby condition and receive only modes.
Reduced RBW settings were used close to the carrier in accordance with the specification.

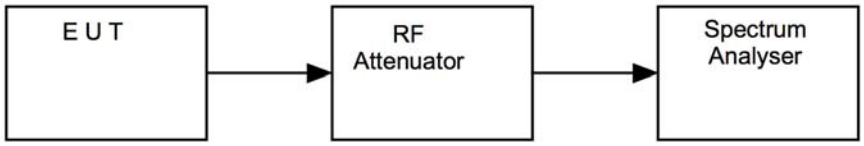
[1] Emissions are detected within 10 dB of the specified limit between 1.5 GHz and 4 GHz

Measurements were made over the range 25 MHz to 6 GHz.

[2] Other cases

Measurements were made over the range 25 MHz to 4 GHz.

Figure vii-a Test Setup

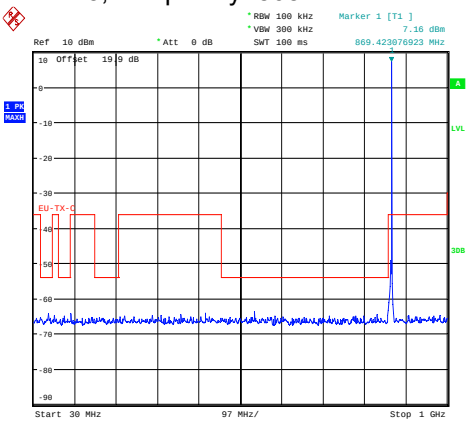


11.3.2 Test Equipment

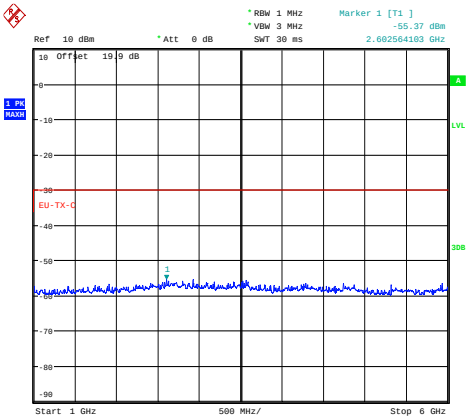
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU46	REF910	2021-11-16
Tuneable Notch Filter 0.5GHz - 1GHz	K&L Microwave Inc	3TNF-500/1000-N	U710	Cal In Use
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use

11.3.3 Test Results

Band: h1.5; Frequency: 868.1 MHz



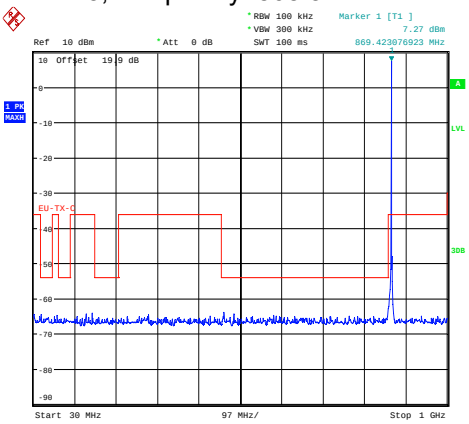
30 MHz to 1 GHz



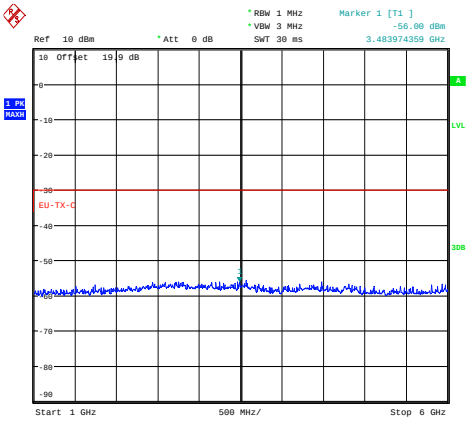
1 GHz to 6 GHz

Frequency: 868.1 MHz; Modulation: LoRa					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

Band: h1.5; Frequency: 868.5 MHz



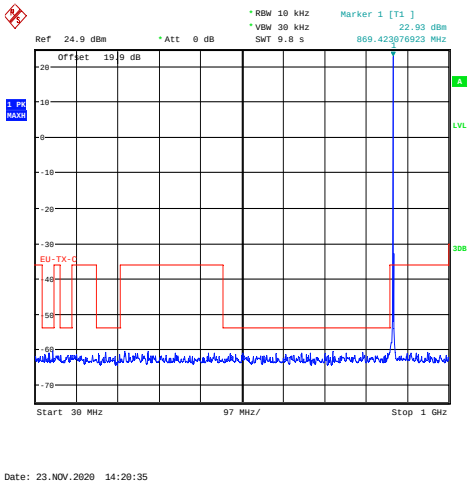
30 MHz to 1 GHz



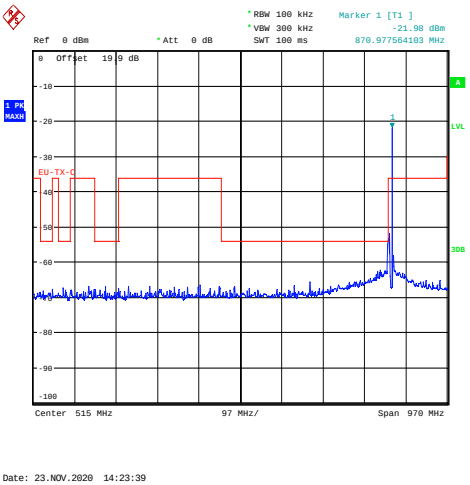
1 GHz to 6 GHz

Frequency: 868.5 MHz; Modulation: LoRa					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

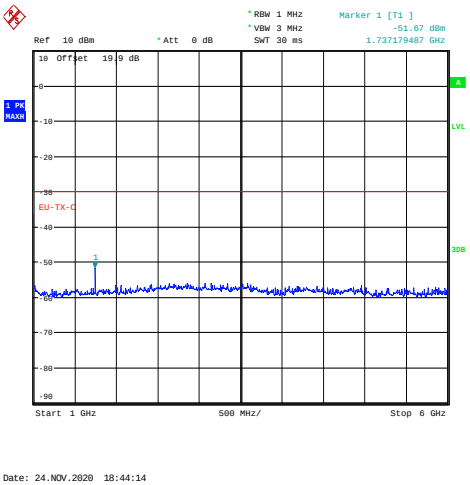
Band: h1.7; Frequency: 869.525 MHz



Note: The above plot was taken without a notch filter and in a reduced bandwidth to meet the system measurement noise floor. This was taken to show that no emissions were present without the use of the filter.



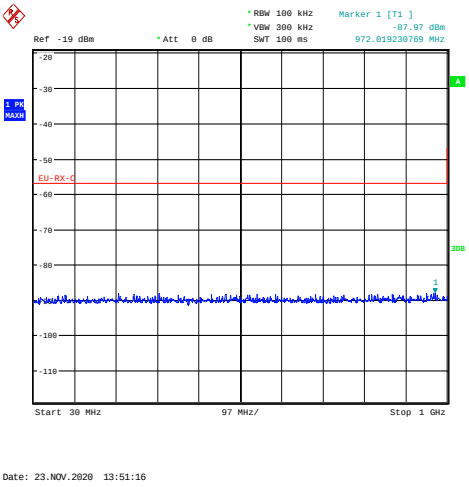
30 MHz to 1 GHz



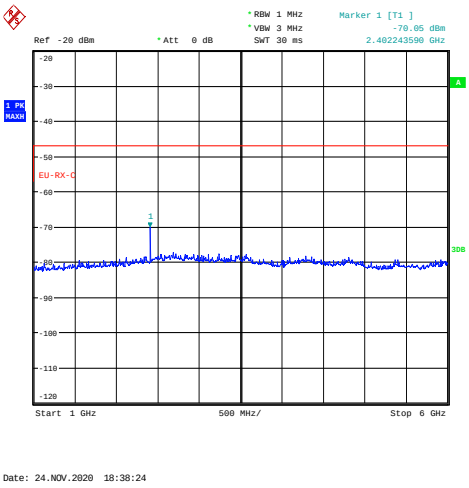
1 GHz to 6 GHz

Frequency: 869.525 MHz; Modulation: LoRa					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

Receive Mode



30 MHz to 1 GHz



1 GHz to 6 GHz

EUT Receive Mode					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

11.4 Radiated Measurement.

11.4.1 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii-b, the RF spectrum of the EUT was observed as the EUT was rotated through 360 degrees.
The measurements were performed with EUT set at its maximum power setting and repeated at its minimum power setting and in the standby condition.
The EUT was substituted with a known generator and antenna and for the same level achieved at the analyser, the effective radiated power was recorded.

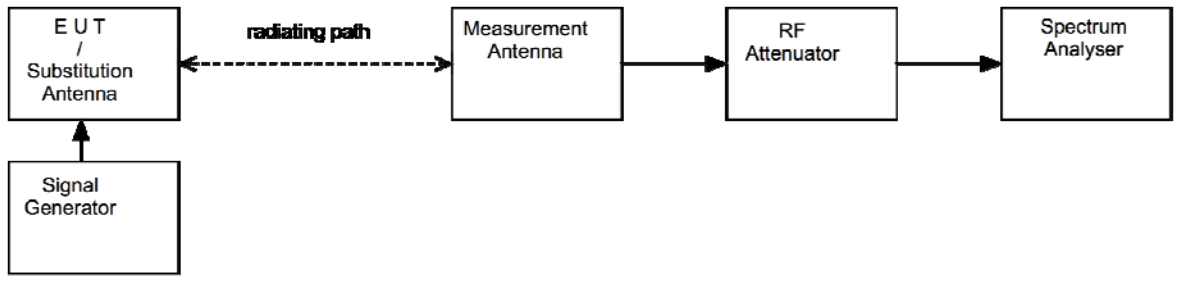
[1] Emissions are detected within 10 dB of the specified limit between 1,5 GHz and 4 GHz

Measurements were made over the range 25 MHz to 6 GHz.

[2] Other cases

Measurements were made over the range 25 MHz to 4 GHz.

Figure vii-b Test Setup

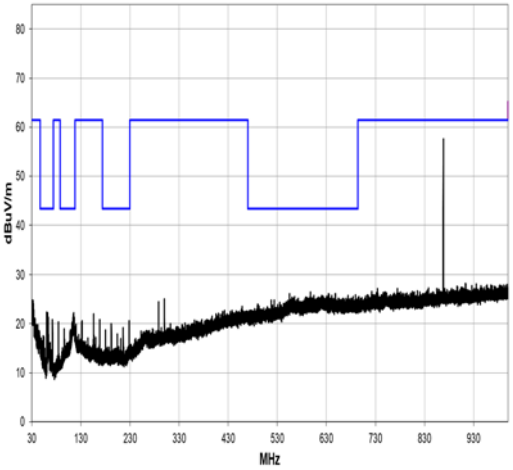


11.4.2 Test Equipment

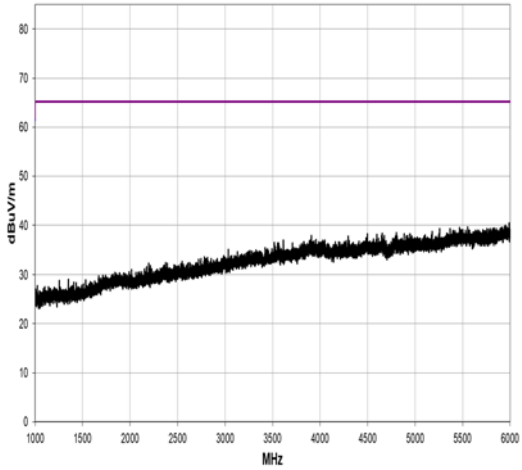
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2021-07-09
Receiver	R&S	ESVS10	L352	2020-09-26
Bilog	Chase	CBL611/A	U573	2021-09-19
Log Periodic Ant	Chase	UPA6108	L203	2022-06-16
Pre Amp	Watkins Johnson	6201-69	U372	2021-02-26
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
Radio Chamber - PP	Rainford EMC	ATS	REF940	2021-12-09

11.4.3 *Test Results*

Band: h1.5; Frequency: 868.1 MHz



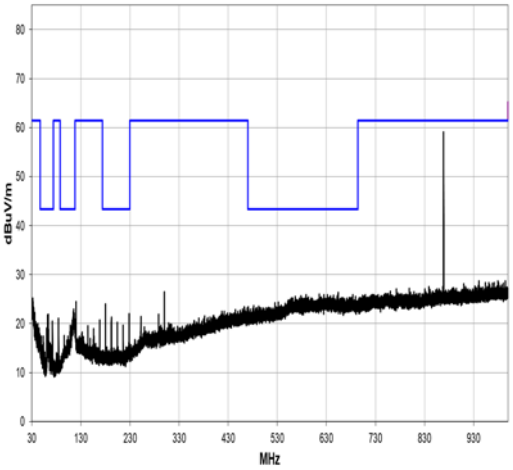
30 MHz to 1 GHz



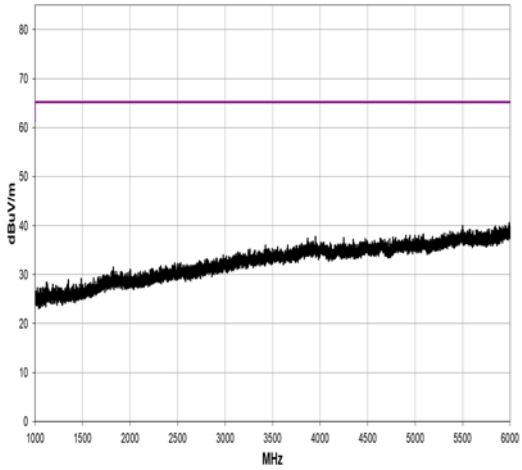
1 GHz to 6 GHz

Frequency: 868.1 MHz; Modulation: LoRa					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

Band: h1.5; Frequency: 868.5 MHz

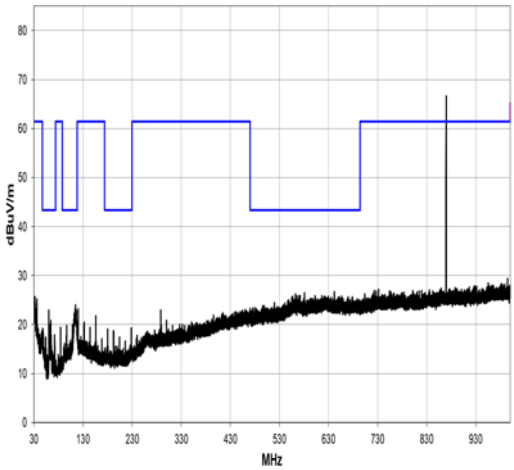


30 MHz to 1 GHz

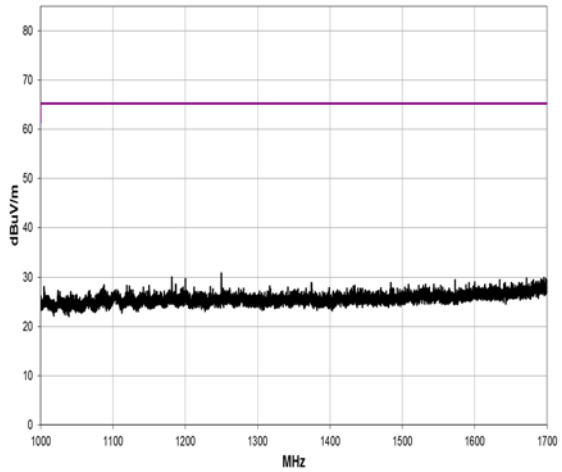


Frequency: 868.5 MHz; Modulation: LoRa					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

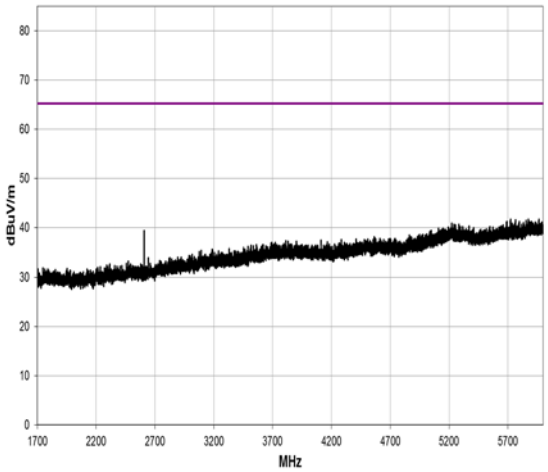
Band: h1.7; Frequency: 869.525 MHz



30 MHz to 1 GHz



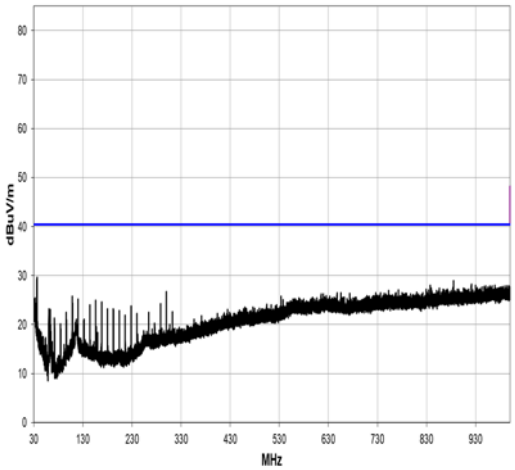
1 GHz to 1.7 GHz



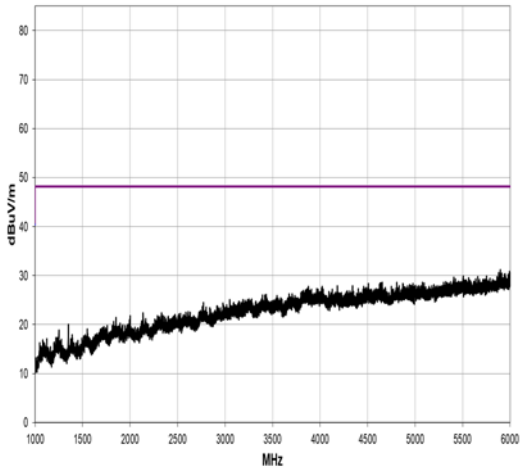
1.7 GHz to 6 GHz

Frequency: 869.525 MHz; Modulation LoRa					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

Receive Mode



30 MHz to 1 GHz



1 GHz to 6 GHz

EUT Receive Mode					
Emission	***Frequency (MHz)***	***Emission level (dBm)***	***Limit (dBm)***	***Margin (dB)***	***Result***
No significant emissions within 10 dB of the limit					PASS

12 Effective radiated power

12.1 Definition

The effective radiated power (e.r.p.) is the power radiated in the direction of the maximum radiated power under specified conditions of measurements for any condition of modulation. For equipment with a permanent or temporary antenna connection it may be taken as the power delivered from that connector taking into account the antenna gain.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ETSI EN 300 220-1 V3.1.1 (2017-02), Clause 5.2
Operating Bands:	h1.5: 868 MHz to 868.6 MHz h1.7 869.4 MHz to 869.65 MHz
Frequencies Measured:	868.1 MHz, 868.5 MHz and 869.525 MHz
Modulation:	Off
Measurement Distance:	3m to front face of EUT / At antenna port
EUT Height:	1.5m
Measurement Antenna Height:	1-4m
Antenna Polarisation:	Vertical and Horizontal
Deviations From Standard:	Substitution antennas used are Log Periodic / Bi-conical in lieu of Standard Dipole antennas
Measurement Antenna Types and Standard Reference Bandwidths:	30MHz – 1000MHz - Bi-log Hybrid antenna, 100kHz BW
Temperature Extreme Environment Test Range:	-40 C to + 85 C
Voltage Extreme Environment Test Range (High / low):	2.5 Vdc to 3.6 Vdc (via host board)

Extreme Environment test Levels

$T_{nominal}$	22 ºC
$T_{minimum}$	-40 ºC
$T_{maximum}$	+85 ºC
$V_{nominal}$	3.3 Vdc
$V_{minimum}$	2.5 Vdc
$V_{maximum}$	3.6 Vdc

Test Limits

The effective radiated power shall not be greater than the value shown in table C1.

Table C.1: Regulatory Parameters

Frequency Bands	*Power/Magnetic Field*	*Spectrum access and mitigation requirements*	*Modulation / maximum occupied bandwidth*	*ECC/ERC Deliverable*	*Notes*
868-868.6 MHz	25 mW e.r.p.	≤ 1% duty cycle or LBT+AFA	Not specified		
869.4-869.65 MHz	500 mW e.r.p.	≤ 10% duty cycle or LBT+AFA	Not specified		

12.3 Conducted measurement

12.3.1 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i-a, the power of the EUT was measured at the antenna port / test fixture and the result calculated by taking into account any cable and attenuator calibration factors and adding the declared antenna gain.

[1] D-M1 test signal available

The measurements were performed with no modulation and with the EUT set at its highest output power.

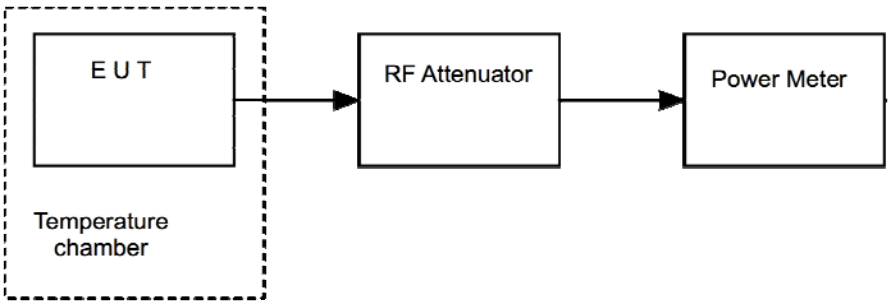
[2] Peak measurements

In the case of non-constant envelope modulation, a peak detector was used.

[3] RMS measurements

Where required (no unmodulated measurement possible), the power was measured using spectrum analyser in the relevant bandwidth with RMS detector and max hold.

Figure i-a Test Setup



12.3.2 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW	*	2021-07-23
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use
Temperature Chamber	ETS-S1000CHS	ETS	U522	Use L426
Temperature Indicator	Digitron	2038T	TRLS377	2021/05/18
Power Supply	ISO-Tech	IPS-303DD	U515	Use REF976
Multimeter	Agilent	34405a	REF976	2020-11-21

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

12.3.3 Test Results

Band: h1.5; Frequency: 868.1 MHz					
Test Environment		***Measured Power (dBm)***	***Antenna Gain (dBi)***	***E.R.P. (W)***	***Result***
$T_{nominal}$	$V_{nominal}$	13.07	0	0.020	PASS
$T_{minimum}$	$V_{minimum}$	12.44	0	0.018	PASS
	$V_{maximum}$	11.73	0	0.015	PASS
$T_{maximum}$	$V_{minimum}$	13.08	0	0.020	PASS
	$V_{maximum}$	13.10	0	0.020	PASS

Band: h1.5; Frequency: 868.5 MHz					
Test Environment		***Measured Power (dBm)***	***Antenna Gain (dBi)***	***E.R.P. (W)***	***Result***
$T_{nominal}$	$V_{nominal}$	13.64	0	0.023	PASS
$T_{minimum}$	$V_{minimum}$	12.54	0	0.018	PASS
	$V_{maximum}$	11.98	0	0.016	PASS
$T_{maximum}$	$V_{minimum}$	12.88	0	0.019	PASS
	$V_{maximum}$	12.75	0	0.019	PASS

Band: h1.7; 869.525 MHz					
Test Environment		***Measured Power (dBm)***	***Antenna Gain (dBi)***	***E.R.P. (W)***	***Result***
$T_{nominal}$	$V_{nominal}$	25.92	0	0.391	PASS
$T_{minimum}$	$V_{minimum}$	22.27	0	0.169	PASS
	$V_{maximum}$	25.72	0	0.373	PASS
$T_{maximum}$	$V_{minimum}$	21.57	0	0.144	PASS
	$V_{maximum}$	23.44	0	0.221	PASS

Occupied bandwidth

12.4 Definition

The occupied bandwidth (OBW) is the frequency range in which 99% of the total mean power of a given emission falls. The maximum occupied bandwidth includes all associated side bands above the appropriate emissions level and the frequency error or drift under extreme conditions.

12.5 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ETSI EN 300 220-1 V3.1.1 (2017-02), Clause 5.6
Operating Bands:	h1.5: 868 MHz to 868.6 MHz h1.7: 869.4 MHz to 869.65 MHz
Frequencies Measured:	868.1 MHz, 868.5 MHz and 869.525 MHz
EUT Modulation:	D-M2
Declared OCW:	200 kHz
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-40 ºC to +85 ºC as declared
Voltage Extreme Environment Test Range (High / low):	2.5 Vdc to 3.6 Vdc (via host board)
Measurement Detector:	RMS

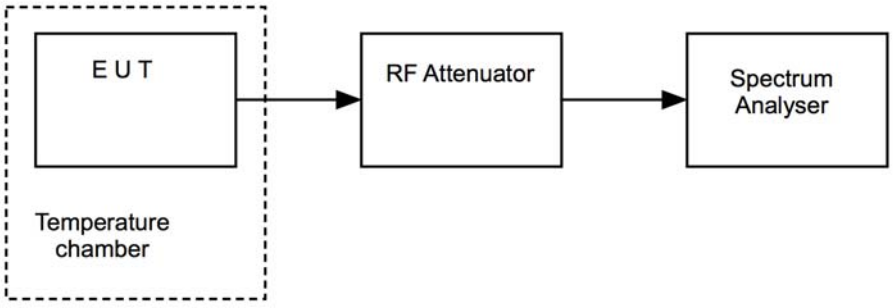
Test Limits

The Operating Channel (OC) shall be declared and shall reside entirely within the Operational Frequency Band.
The Maximum Occupied Bandwidth at 99% shall reside entirely within the Operating Channel defined by F_{low} and F_{high}.

12.6 Test Method

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

Figure iv Test Setup



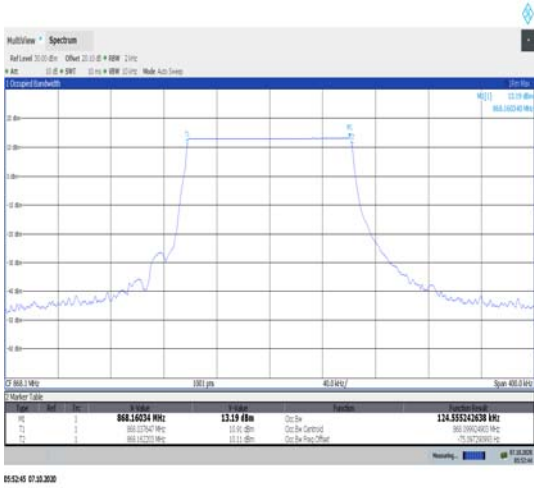
12.6.1 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW	*	2021-07-23
Temperature Chamber	ETS-S1000CHS	ETS	U522	Use L426
Temperature Indicator	Digitron	2038T	TRLS377	2021/05/18
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use
Power Supply	ISO-Tech	IPS-303DD	U515	Use REF976
Multimeter	Agilent	34405a	REF976	2020-11-21

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

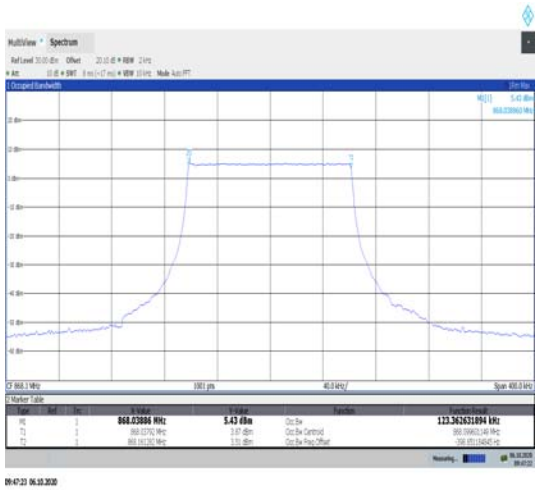
12.7 Test Results

Band: h1.5; Frequency: 868.1 MHz

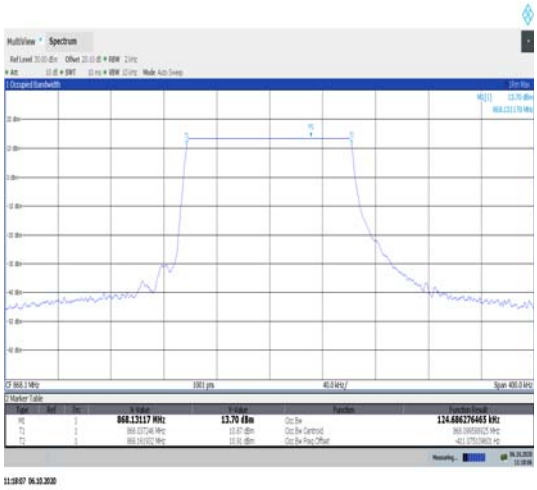


T_{Nom} V_{Nom}

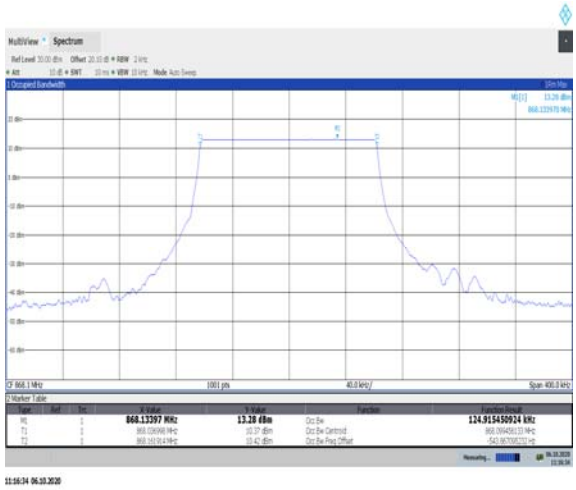
T_{Min} V_{Max}



T_{Min} V_{Min}



T_{Max} V_{Max}

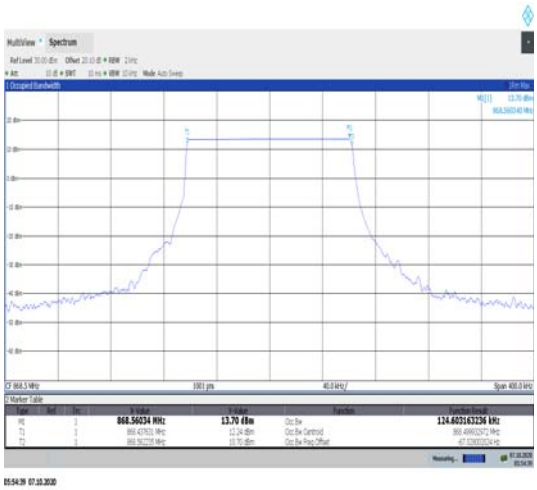


T_{Max} V_{Min}

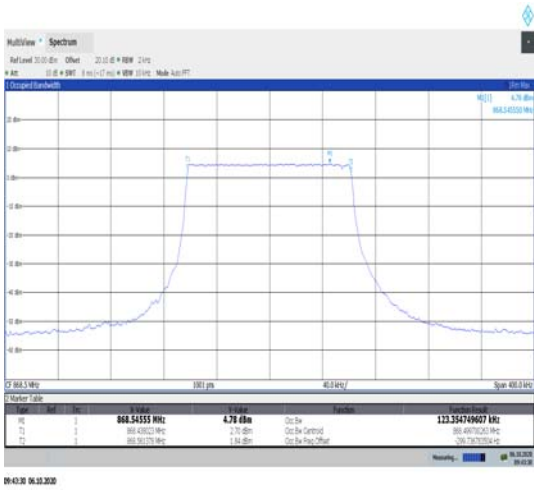
Band: h1.5; Frequency: 868.1 MHz; Modulation: LoRa					
Test Environment		Measured 99% Bandwidth (kHz)	Frequency Error (kHz)	Within Operating Channel	Result
$T_{nominal}$	$V_{nominal}$	124.556	N/A	YES	PASS
$T_{minimum}$	$V_{minimum}$	123.362	N/A	YES	PASS
	$V_{maximum}$	123.355	N/A	YES	PASS
$T_{maximum}$	$V_{minimum}$	124.916	N/A	YES	PASS
	$V_{maximum}$	124.686	N/A	YES	PASS

Maximum Occupied Bandwidth					
Centre Frequency (MHz)	Lowest Fl (MHz)	Highest Fh (MHz)	Maximum Occupied Bandwidth (kHz)	Within Operating Channel	Result
868.1	868.036998	868.162203	125.205000	YES	PASS

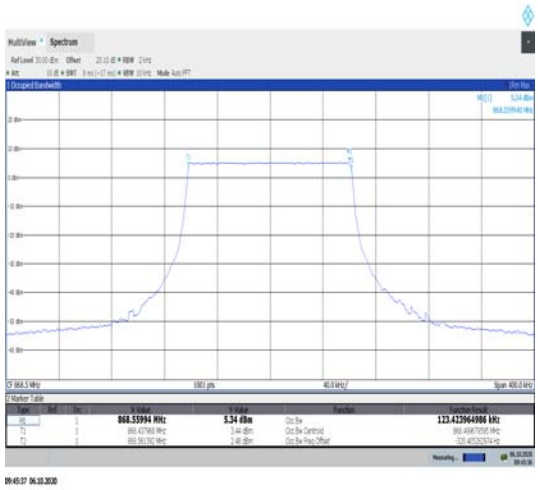
Band: h1.5; Frequency: 868.5 MHz



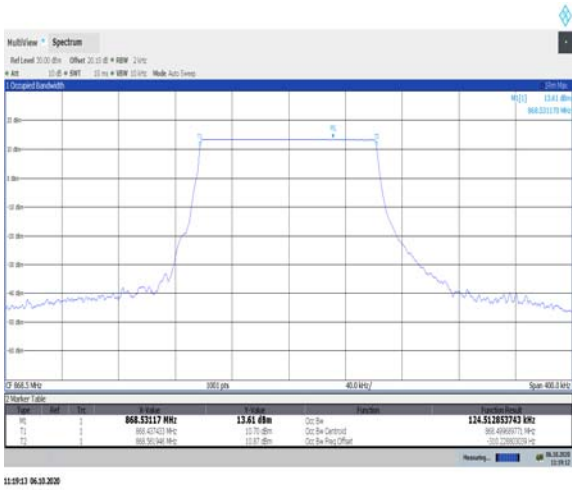
T_{Nom} V_{Nom}



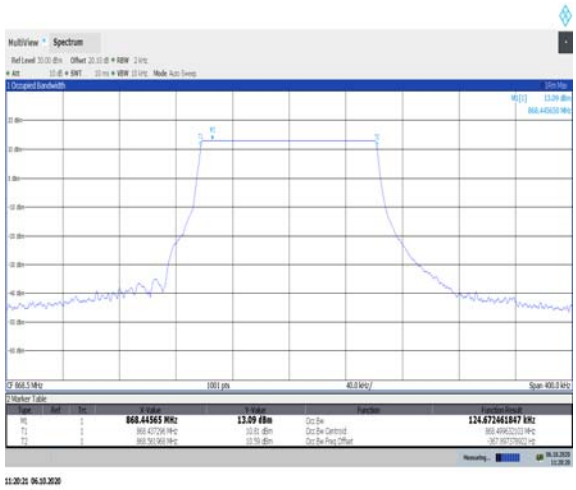
T_{Min} V_{Max}



T_{Min} V_{Min}



T_{Max} V_{Max}

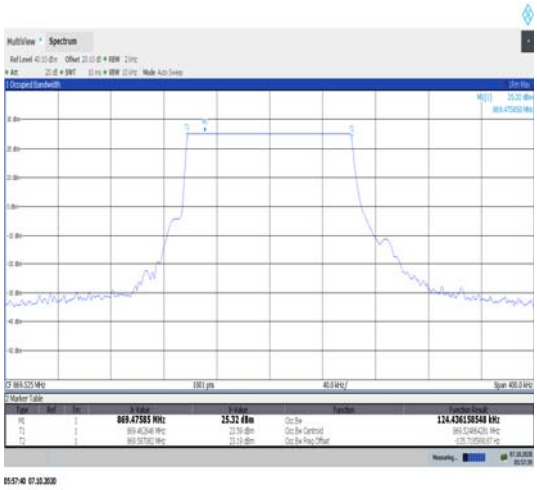


T_{Max} V_{Min}

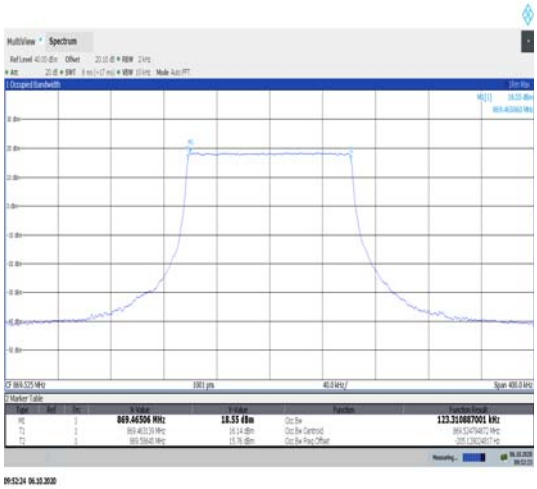
Band: h1.5; Frequency: 868.5 MHz; Modulation: LoRa					
Test Environment		Measured 99% Bandwidth (kHz)	Frequency Error (kHz)	Within Operating Channel	Result
$T_{nominal}$	$V_{nominal}$	124.604	N/A	YES	PASS
$T_{minimum}$	$V_{minimum}$	123.424	N/A	YES	PASS
	$V_{maximum}$	123.355	N/A	YES	PASS
$T_{maximum}$	$V_{minimum}$	124.672	N/A	YES	PASS
	$V_{maximum}$	124.513	N/A	YES	PASS

Maximum Occupied Bandwidth					
Centre Frequency (MHz)	Lowest Fl (MHz)	Highest Fh (MHz)	Maximum Occupied Bandwidth (kHz)	Within Operating Channel	Result
868.5	868.437296	868.562235	124.939000	YES	PASS

Band: h1.7; Frequency: 869.525 MHz

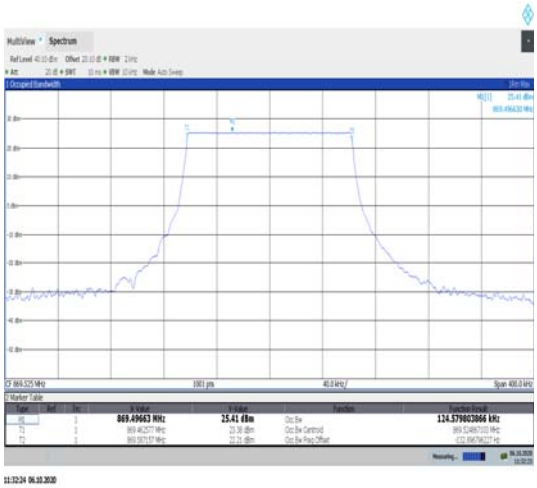


T_{Nom} V_{Nom}

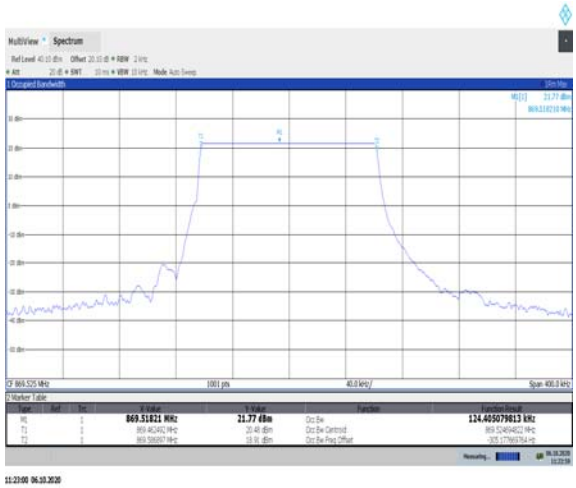


T_{Min} V_{Max}

T_{Min} V_{Min}



T_{Max} V_{Max}



T_{Max} V_{Min}

Band: h1.7; Frequency: 869.525 MHz; Modulation: LoRa					
Test Environment		Measured 99% Bandwidth (kHz)	Frequency Error (kHz)	Within Operating Channel	Result
$T_{nominal}$	$V_{nominal}$	124.436000	N/A	YES	PASS
$T_{minimum}$	$V_{minimum}$	123.417000	N/A	YES	PASS
	$V_{maximum}$	123.311000	N/A	YES	PASS
$T_{maximum}$	$V_{minimum}$	124.405000	N/A	YES	PASS
	$V_{maximum}$	124.580000	N/A	YES	PASS

Maximum Occupied Bandwidth					
Centre Frequency (MHz)	Lowest Fl (MHz)	Highest Fh (MHz)	Maximum Occupied Bandwidth (kHz)	Within Operating Channel	Result
869.525	869.462492	869.587157	124.665000	YES	PASS

13 TX out of band emissions

13.1 Definition

Two OOB domains are defined, one for Operating Channel (see § Figure 5) and one for Operational Frequency band (see § Figure 6).
The spectrum masks for these two OOB domains may overlap.
Unwanted emissions in the Out Of Band domain are those falling in the frequency range immediately below the lower, and above the upper, frequency of the Operating Channel. The OOB domain includes both frequencies outside the Operating Channel within the Operational Frequency Band and frequencies outside the Operational Frequency Band.
The relevant Out Of Band domain is shown in § Figure 5 and applies within the Operational Frequency Band.

Specific limits apply at frequencies immediately above and below the Operational Frequency Band as shown in § Figure 6.

NOTE: f_{low_OFB} is the lower edge of the Operational Frequency Band
F_{high_OFB} is the upper edge of the Operational Frequency Band

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ETSI EN 300 220-1 V3.1.1 (2017-02), Clause 5.8
Operating Bands:	h1.5: 868 MHz to 868.6 MHz h1.7: 869.4 MHz to 869.65 MHz
Frequencies Measured:	868.1 MHz, 868.5 MHz and 869.525 MHz
EUT Modulation:	D-M2
Declared OCW:	200 kHz
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	-40 ºC to +85 ºC as declared
Voltage Extreme Environment Test Range (High / low):	2.5 Vdc to 3.6 Vdc (via host board)
Measurement Detector:	RMS

Environmental Conditions (Normal Environment)

Temperature: 24 °C	Standard Requirement: +15 ºC to +35 ºC
Humidity: 48 %RH	Standard Requirement: 20%RH to 75%RH
Supply: 3.3 Vdc	3.3 Vdc (via host board)

Test Limits
The EUT emissions level in OOB domains for the Operating Channel and the Operational Frequency Band shall be less or equal to Table 15 spectrum mask.

Table 15: Emission limits in the Out Of Band domains

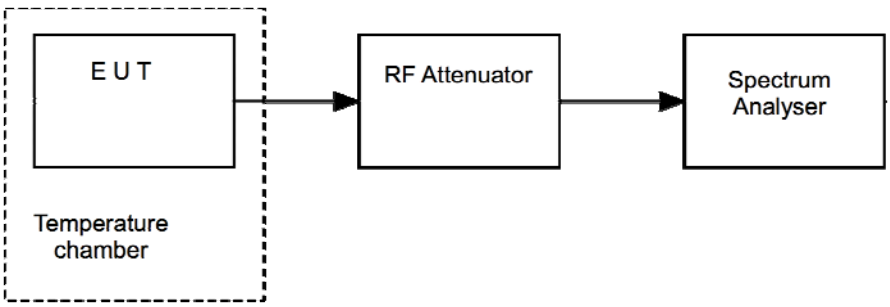
Domain	*Frequency Range*	*RBW_{REF}*	*Max power limit*
OOB limits applicable to Operational Frequency Band (See § Figure 6)	$f \le f_{low\_OFB} - 400$ kHz	10 kHz	-36 dBm
	$f_{low\_OFB} - 400$ kHz $\le f \le f_{low\_OFB} - 200$ kHz	1 kHz	-36 dBm
	$f_{low\_OFB} - 200$ kHz $\le f < f_{low\_OFB}$	1 kHz	See § Figure 6
	$F = f_{low\_OFB}$	1 kHz	0 dBm
	$F = f_{high\_OFB}$	1 kHz	0 dBm
	$f_{high\_OFB} < f \le f_{high\_OFB} + 200$ kHz	1 kHz	See § Figure 6
	$f_{high\_OFB} + 200$ kHz $\le f \le f_{high\_OFB} + 400$ kHz	1 kHz	-36 dBm
	$f_{high\_OFB} + 400$ kHz $\le f$	10 kHz	-36 dBm
OOB limits applicable to Operating Channel (See § Figure 5)	$f = f_c - 2.5 \times OCW$	1 kHz	-36 dBm
	$f_c - 2.5 \times OCW \le f \le f_c - 0.5 \times OCW$	1 kHz	See § Figure 5
	$f = f_c - 0.5 \times OCW$	1 kHz	0 dBm
	$f = f_c + 0.5 \times OCW$	1 kHz	0 dBm
	$f + 0.5 \times OCW \le f \le f_c + 2.5 \times OCW$	1 kHz	See § Figure 5
	$f = f_c + 2.5 \times OCW$	1 kHz	-36 dBm

NOTE: f is the measurement frequency;
f_c is the Operating Frequency;
f_{low_OFB} is the lower edge of the Operational Frequency Band;
f_{high_OFB} is the upper edge of the Operational Frequency Band;
OCW is the operating channel bandwidth.

13.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the RF spectrum from the EUT was measured on a spectrum analyser, after calibrating for path losses.

Figure vi Test Setup

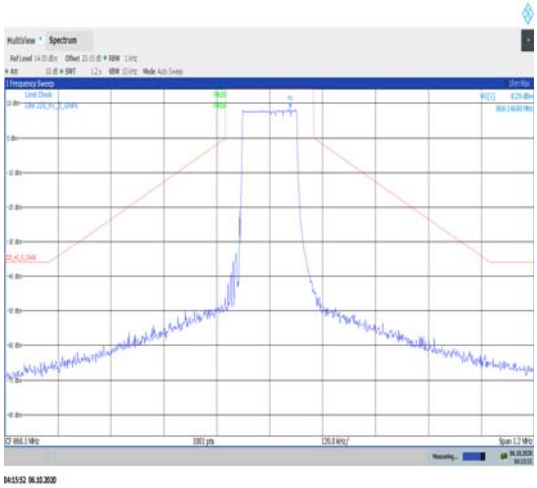


13.4 Test Equipment

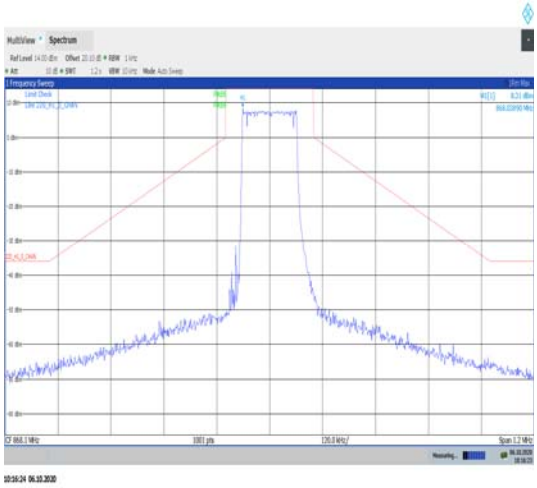
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW	*	2021-07-23
Attenuator	AtlanTechRF Microwave	20 dB SMA	U632	Cal in use
Temperature Chamber	ETS-S1000CHS	ETS	U522	Use L426
Temperature Indicator	Digitron	2038T	TRLS377	2021/05/18
Power Supply	ISO-Tech	IPS-303DD	U515	Use REF976
Multimeter	Agilent	34405a	REF976	2019-01-17

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

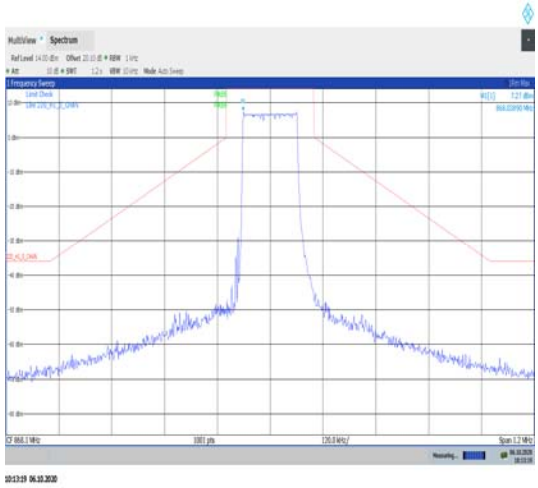
Band: h1.5; Frequency: 868.1 MHz out of band operating channel masks



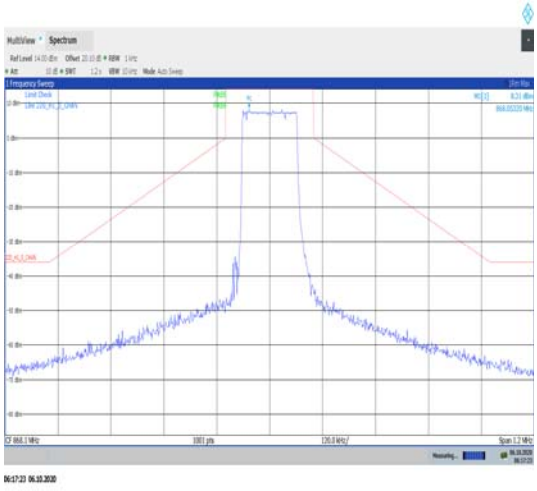
T_{Nom} V_{Nom}



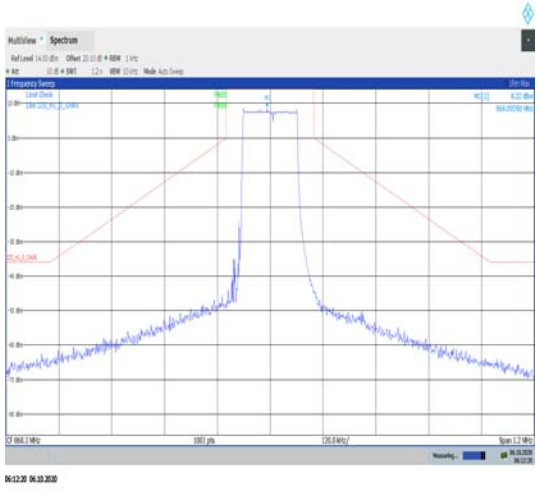
T_{Min} V_{Min}



T_{Min} V_{Max}

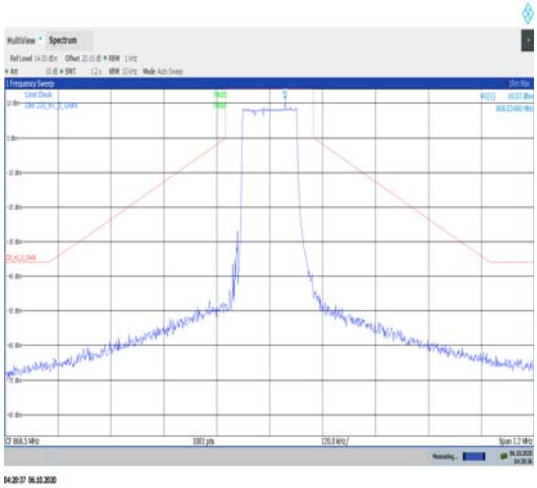


T_{Max} V_{Min}

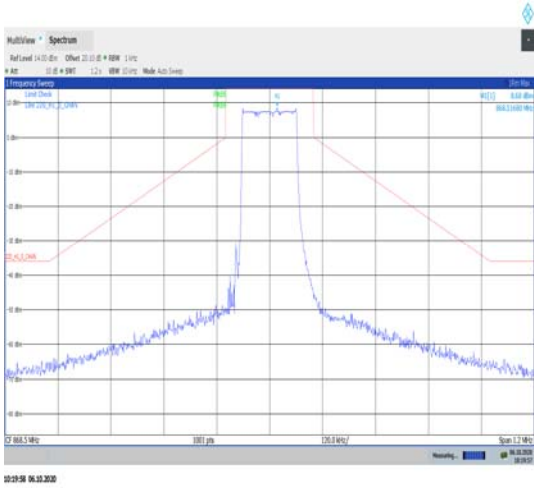


T_{Max} V_{Max}

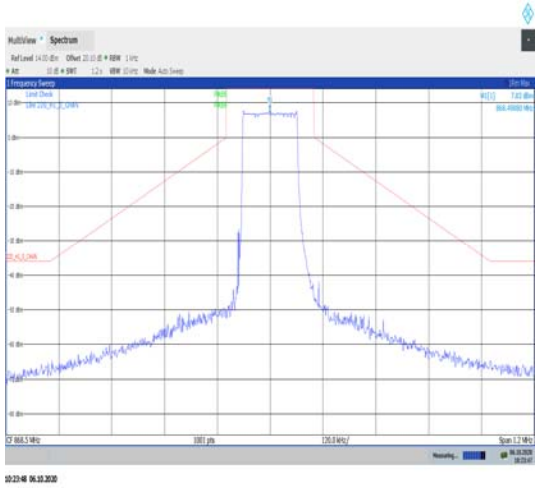
Band: h1.5; Frequency: 868.5 MHz out of band operating channel masks



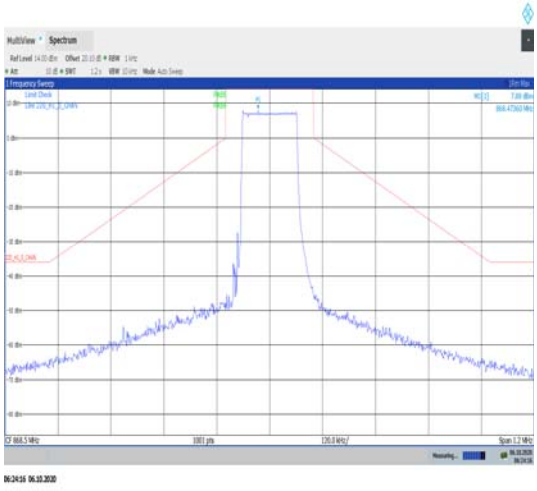
T_{Nom} V_{Nom}



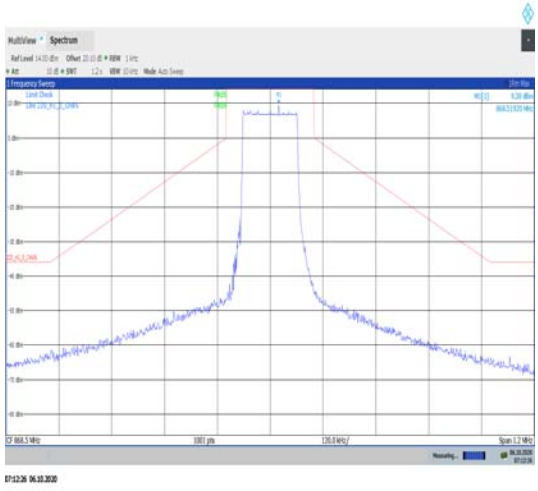
T_{Min} V_{Min}



T_{Min} V_{Max}

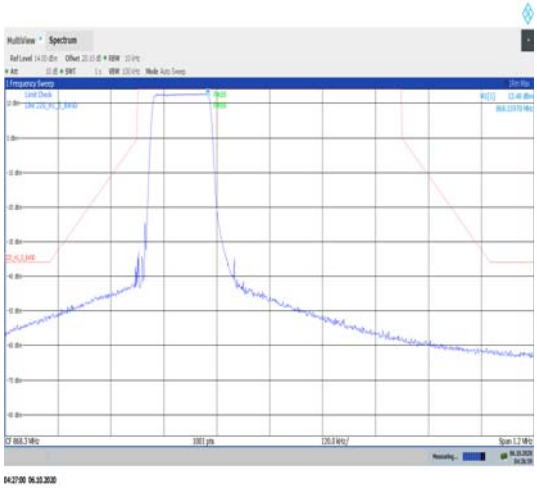


T_{Max} V_{Min}

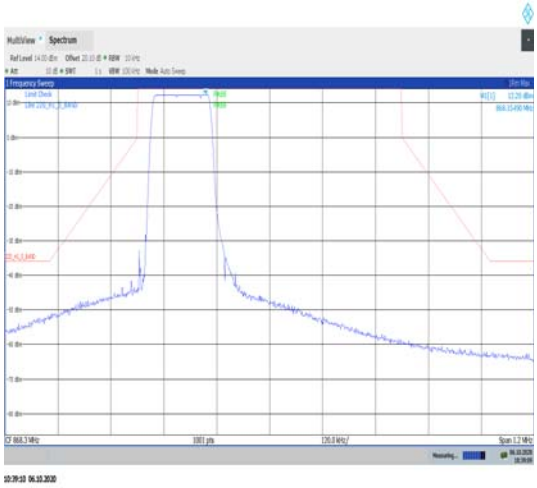


T_{Max} V_{Max}

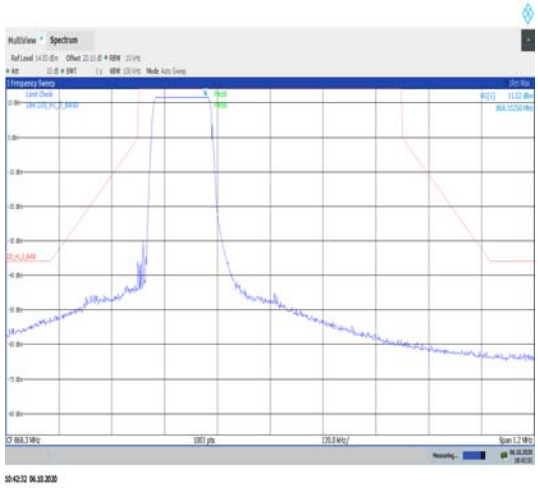
Band: h1.5; Frequency: 868.1 MHz out of band operating frequency masks



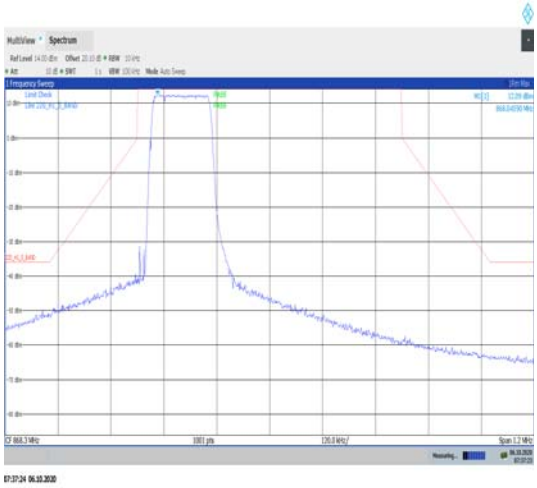
T_{Nom} V_{Nom}



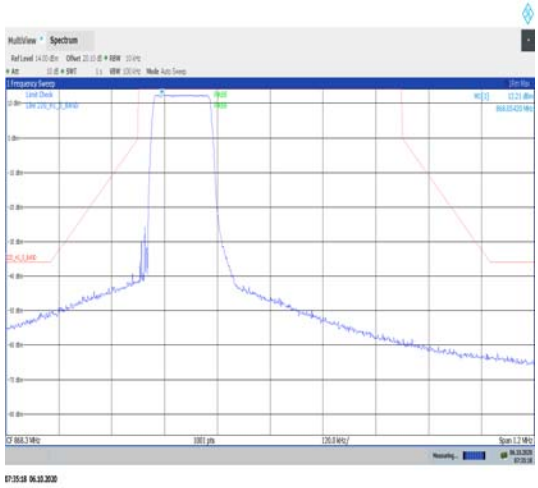
T_{Min} V_{Min}



T_{Min} V_{Max}

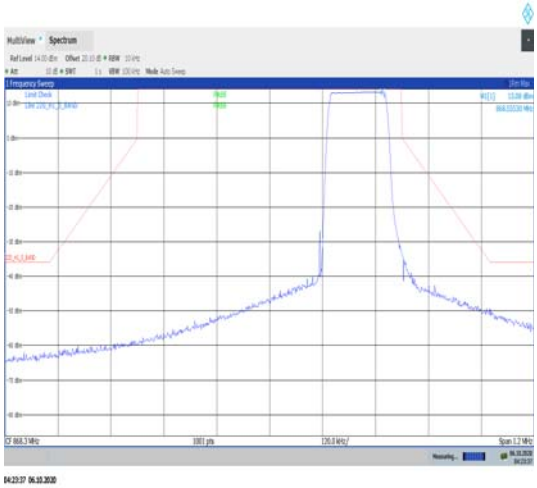


T_{Max} V_{Min}

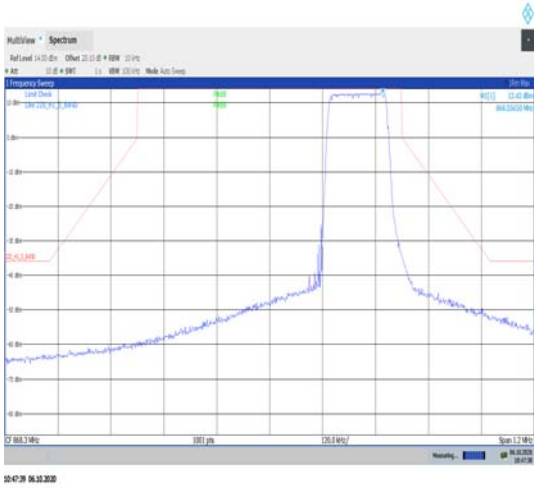


T_{Max} V_{Max}

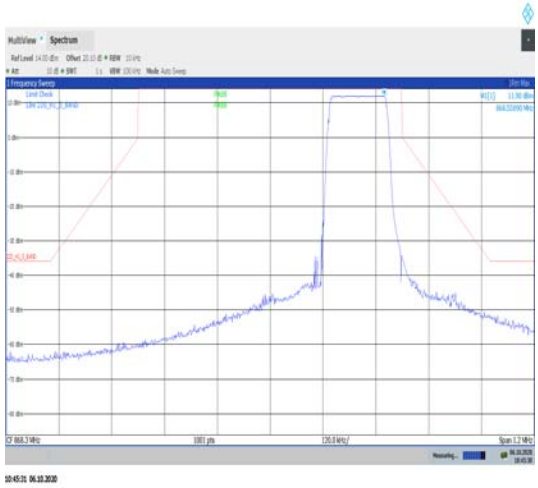
Band: h1.5; Frequency: 868.5 MHz out of band operating frequency masks



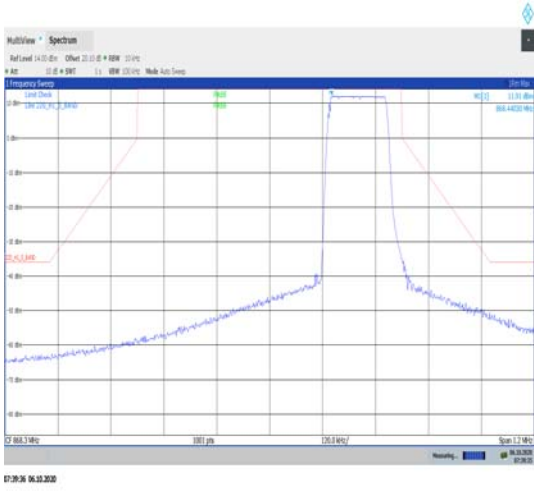
T_{Nom} V_{Nom}



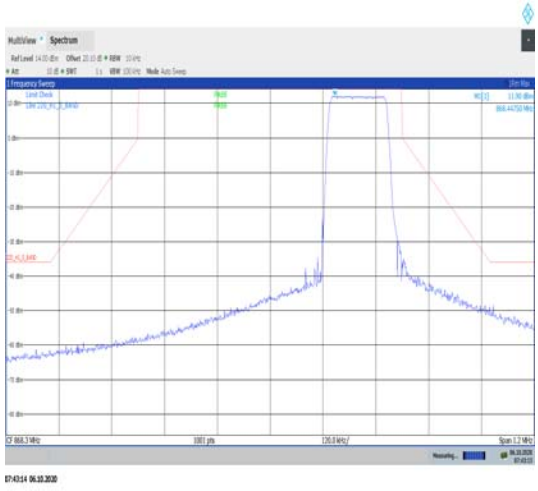
T_{Min} V_{Min}



T_{Min} V_{Max}

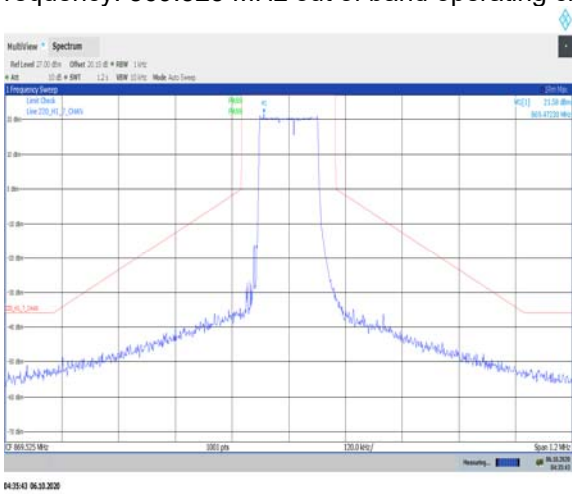


T_{Max} V_{Min}

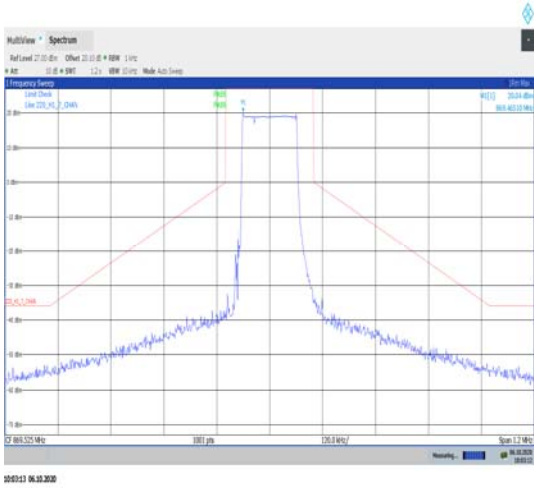


T_{Max} V_{Max}

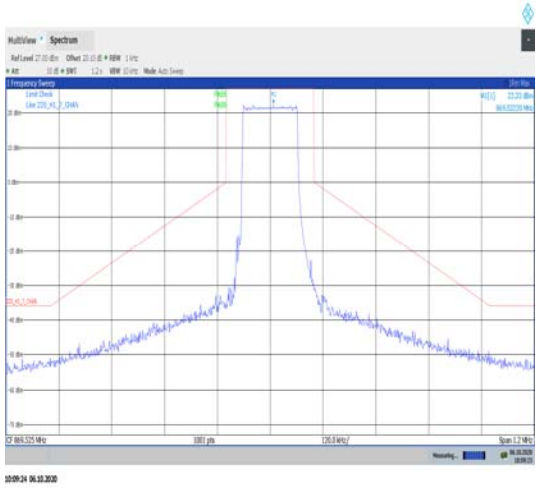
Band: h1.7; Frequency: 869.525 MHz out of band operating channel masks



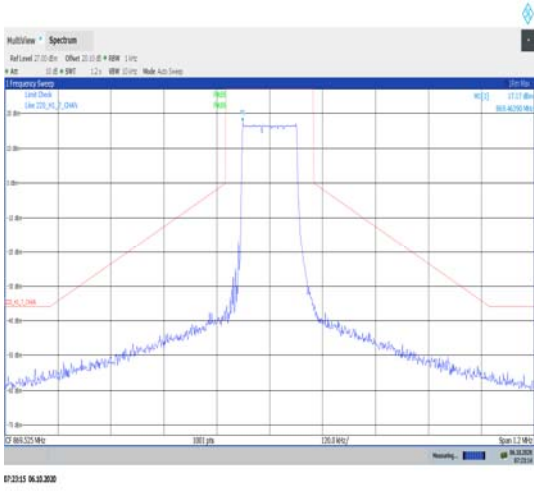
T_{Nom} V_{Nom}



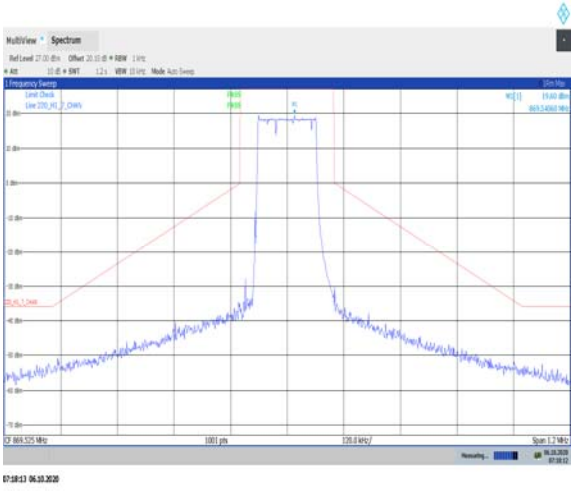
T_{Min} V_{Min}



T_{Min} V_{Max}

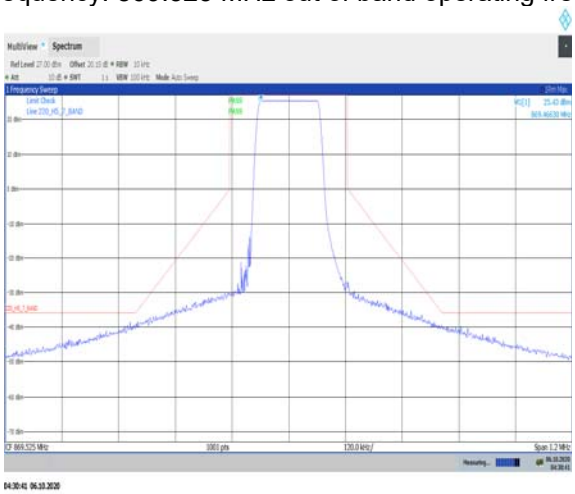


T_{Max} V_{Min}

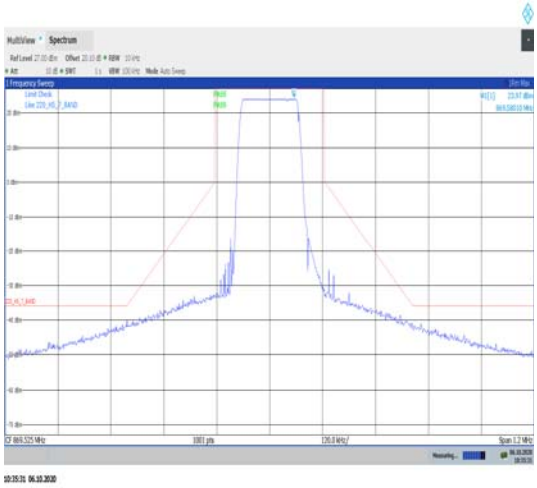


T_{Max} V_{Max}

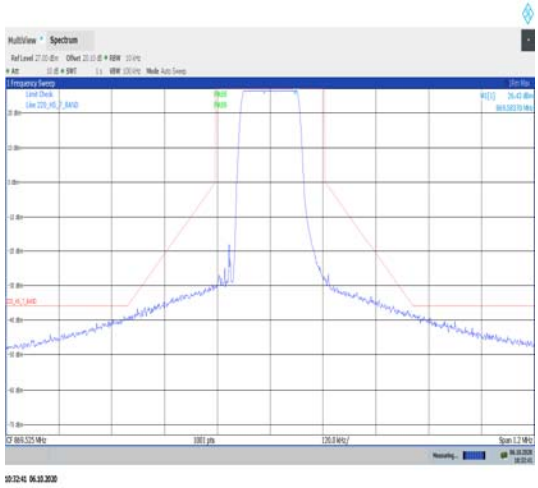
Band: h1.7; Frequency: 869.525 MHz out of band operating frequency masks



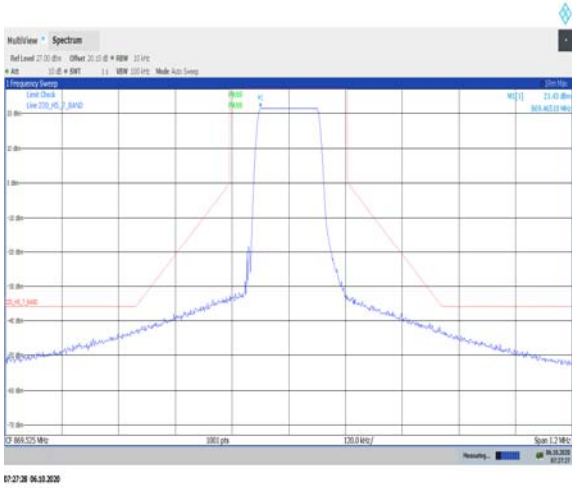
T_{Nom} V_{Nom}



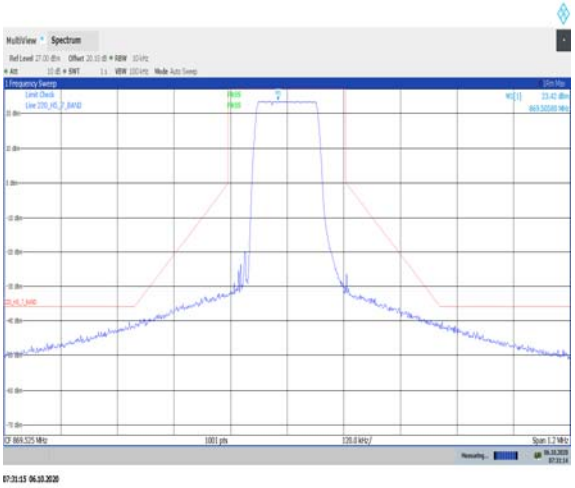
T_{Min} V_{Min}



T_{Min} V_{Max}



T_{Max} V_{Min}



T_{Max} V_{Max}

14 Transient power

14.1 Definition

Transient power is the power falling into adjacent spectrum due to switching the transmitter on and off during normal operation (e.g. cyclic keying during data transmission).

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ETSI EN 300 220-1 V3.1.1 (2017-02), Clause 5.10
Operating Bands:	h1.5: 868 MHz to 868.6 MHz h1.7: 869.4 MHz to 869.65 MHz
Frequencies Measured:	868.1 MHz, 868.5 MHz and 869.525 MHz
Modulation:	On / Switching
Deviations From Standard:	None
Measurement bandwidth:	3 / 100 / 300 kHz
Measurement detector:	RMS
OCW:	200 kHz

Environmental Conditions (Normal Environment)

Temperature: 24 °C	Standard Requirement: +15 ºC to +35 ºC
Humidity: 48 %RH	Standard Requirement: 20%RH to 75%RH
Supply: 3.3 Vdc	3.3 Vdc (via host board)

Test Limits

The transient power shall not exceed the values given in Table 23.

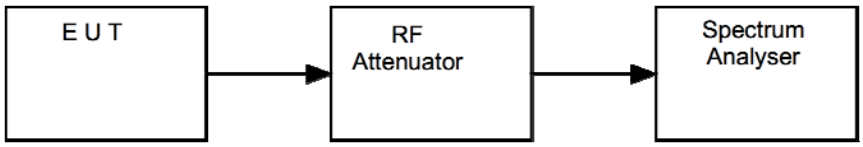
Table 23: Transmitter Transient Power Limits

Absolute offset from centre frequency	*RBW_{REF}*	*Peak power limit applicable at all measurement points*
≤ 400 kHz	1 kHz	0 dBm
> 400 kHz	1 kHz	-27 dBm

14.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure viii the transmitter transient characteristic was measured.

Figure viii Test Setup



14.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
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

14.5 Test Results

Band: h1.5; Frequency: 868.1 MHz; Modulation: LoRa						
Measurement frequency (MHz)	***Frequency offset (kHz)***	***RBW (kHz)***	***RBW_{REF} (kHz)***	***Measured level in RBW (dBm)***	***Power in RBWREF (dBm)***	***Result***
866.8000	-1300.00	300	1	-42.7	-67.5	PASS
867.6000	-500.00	100	1	-47.8	-67.8	PASS
867.9000	-200.00	10	1	-43.8	-53.8	PASS
867.9970	-103.00	1	1	-42.8	-42.8	PASS
868.2030	103.00	1	1	-42.0	-42.0	PASS
868.3000	200.00	10	1	-43.7	-53.7	PASS
868.6000	500.00	100	1	-47.7	-67.7	PASS
869.4000	1300.00	300	1	-40.3	-65.1	PASS

Band: h1.5; Frequency: 868.1 MHz; Modulation: LoRa						
Measurement frequency (MHz)	***Frequency offset (kHz)***	***RBW (kHz)***	***RBW_{REF} (kHz)***	***Measured level in RBW (dBm)***	***Power in RBWREF (dBm)***	***Result***
867.2000	-1300.00	300	1	-41.9	-66.6	PASS
868.0000	-500.00	100	1	-48.7	-68.7	PASS
868.3000	-200.00	10	1	-43.9	-53.9	PASS
868.3970	-103.00	1	1	-42.3	-42.3	PASS
868.6030	103.00	1	1	-42.2	-42.2	PASS
868.7000	200.00	10	1	-44.1	-54.1	PASS
869.0000	500.00	100	1	-47.7	-67.7	PASS
869.8000	1300.00	300	1	-39.7	-64.4	PASS

Band: h1.7; Frequency: 869.525 MHz; Modulation: LoRa						
Measurement frequency (MHz)	**Frequency offset (kHz)**	**RBW (kHz)**	**RBW_{REF} (kHz)**	***Measured level in RBW (dBm)***	***Power in RBWREF (dBm)***	***Result***
868.2250	-1300.00	300	1	-29.8	-54.6	PASS
869.0250	-500.00	100	1	-35.8	-55.8	PASS
869.3250	-200.00	10	1	-32.0	-42.0	PASS
869.4220	-103.00	1	1	-30.3	-30.3	PASS
869.6280	103.00	1	1	-29.5	-29.5	PASS
869.7250	200.00	10	1	-31.3	-41.3	PASS
870.0250	500.00	100	1	-36.0	-56.0	PASS
870.8250	1300.00	300	1	-27.9	-52.7	PASS

15 Blocking

15.1 Definition

Blocking is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequencies other than those of the spurious responses or the adjacent channels or bands.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ETSI EN 300 220-1 V3.1.1 (2017-02), Clause 5.18
Receiver Category:	2
Receiver Bandwidth:	200 kHz
Frequencies Measured:	868.1 MHz and 868.5 MHz
Modulation:	D-M2
Error Correction:	Off
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 23 °C	Standard Requirement: +15 ºC to +35 ºC
Humidity: 52 %RH	Standard Requirement: 20%RH to 75%RH
Supply: 3.3 Vdc	3.3 Vdc (via host board)

Test Limits

The blocking levels at the specified frequency offsets shall be equal to or greater than the limits Table 42, except at frequencies where spurious responses are found.

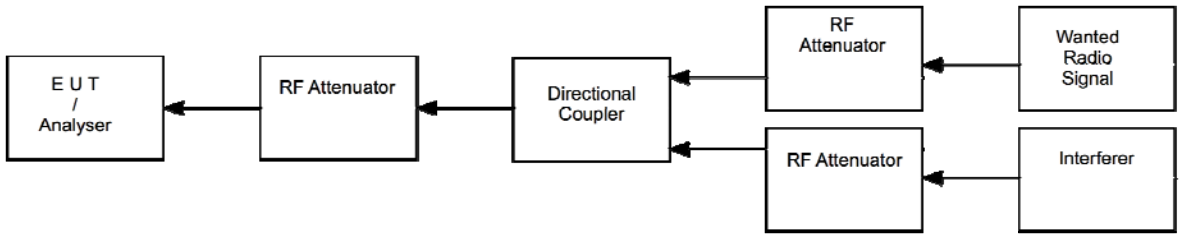
Table 42: Blocking level parameters for RX category 2

Requirement	***Limits***
	Receiver category 2
Blocking at ±2 MHz from OC edge fhigh and flow	≥ -69 dBm
Blocking at ±10 MHz from OC edge fhigh and flow	≥ -44 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -44 dBm

15.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure xvi, the wanted signal (Gen A) was set to 3dB above the specified receiver threshold. The blocking signal (Gen B) was then introduced at increasing levels until the performance criteria was exceeded and measured by replacing the EUT with a spectrum analyser.

Figure xvi Test Setup



15.4 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSW	*	2021-07-23
Signal Generator	R&S	SMB100A	U677	2021-01-10
Attenuator	AtlanTechRF Microwave	10 dB SMA	U633	Cal in use
Variable Attenuator	HP	8496B	RFG470	Cal In use

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

15.5 Test Results

Receive Mode; 868.1 MHz						
Carrier frequency offset (MHz)	Gen A	Gen B		Limit (dBm)	Margin (dB)	Result
	Carrier RSL (dBm)	Interfering frequency (MHz)	Maximum Interfering level (dBm)			
5% of Fc	-94.00	911.50500	-9.49	-44	≥ -44	PASS
10	-94.00	878.20000	-9.48	-44	≥ -44	PASS
2	-94.00	870.20000	-15.57	-69	≥ -69	PASS
-2	-94.00	866.20000	-14.60	-69	≥ -69	PASS
-10	-94.00	858.20000	-9.82	-44	≥ -44	PASS
-5% of Fc	-94.00	824.69500	-9.49	-44	≥ -44	PASS

Receive Mode; 868.5 MHz						
Carrier frequency offset (MHz)	Gen A	Gen B		Limit (dBm)	Margin (dB)	Result
	Carrier RSL (dBm)	Interfering frequency (MHz)	Maximum Interfering level (dBm)			
5% of Fc	-94.00	911.92500	-9.60	-44	≥ -44	PASS
10	-94.00	878.60000	-9.53	-44	≥ -44	PASS
2	-94.00	870.60000	-16.70	-69	≥ -69	PASS
-2	-94.00	866.60000	-17.75	-69	≥ -69	PASS
-10	-94.00	858.60000	-9.85	-44	≥ -44	PASS
-5% of Fc	-94.00	825.07500	-9.58	-44	≥ -44	PASS

Note: Band h1.7; Frequency: 869.525 MHz is for downlink purposes only and does not have a receive function.

16 Measurement Uncertainty

Required Measurement Uncertainties

The following maximum measurement uncertainty requirements are defined in the standard:

Parameter	Uncertainty
Radio frequency	±1 x 10^{-7}
RF power, conducted	±1,5 dB
Adjacent channel power	±3 dB
Conducted spurious emission of transmitter, valid up to 6 GHz	±3 dB
Conducted emission of receivers	±3 dB
Radiated emission of transmitter, valid up to 6 GHz	±6 dB
Radiated emission of receiver, valid up to 6 GHz	±6 dB
RF level uncertainty for a given BER	±1,5 dB
Temperature	±1 °C
Humidity	±10 %

Calculated Measurement Uncertainties

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

[1] Frequency error

Uncertainty in test result (Power Meter) = **0.113ppm**
Uncertainty in test result (Spectrum Analyser) = **0.265ppm**

[2] Average power, conducted

Uncertainty in test result (Power Meter) = **1.08dB**
Uncertainty in test result (Spectrum Analyser) = **2.48dB**
Uncertainty in test result (radiated) = **4.71dB**

[3] Effective Radiated Power

Uncertainty in test result = **4.71dB**

[4] Transient power

Uncertainty in test result = **1.000dB**

[5] Adjacent Channel Power

Uncertainty in test result = **1.86dB**

[6] Modulation bandwidth

Uncertainty in test result = **2.59% (frequency)**
Uncertainty in test result = **1.32dB (amplitude)**

[7] Unwanted emissions in the spurious domain

Uncertainty in test result – Up to 8.1GHz = **3.31dB**
Uncertainty in test result (radiated) = **4.75dB**

[8] Receiver sensitivity

Uncertainty in test result = **3.23dB**

[9] LBT threshold

Uncertainty in test result (level) = **3.23dB**
Uncertainty in test result (time) = **7.98%**

[10] Adjacent channel selectivity

Uncertainty in test result = **1.24dB**

[11] Receiver blocking, conducted

Uncertainty in test result = **1.24dB**

[12] Spurious response rejection

Uncertainty in test result = **1.24dB**

[13] Receiver spurious radiation

Uncertainty in test result – Up to 8.1GHz = **3.31dB**
Uncertainty in test result (radiated) = **4.75dB**

17 Appendix A

1% Duty Cycle Enforcement:

There are two system elements used to ensure compliance with 1% duty cycle restriction of the EN3300 220. The Corecell Gateway transceiver is connected to a remote Network Server. The remote network server may control multiple Corecell Gateways.

Each Corecell Gateway can only receive instructions to transmit from the remote Network Server: which server stores a record of the downlink transmissions both sent, and any to be sent, by that Gateway.

Message transmissions are scheduled by the Network Server and sent to the Corecelll via a secure network connection with both the message (so duration) and precise time at which they are to be transmitted. The combination of precise scheduling by the network server and synchronisation between the Network Severer and Corecell Gateway ensures that a 1% duty cycle enforced in in each sub-band of operation.