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Chamber of Commerce
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FCC and IC Test report for parts 15.109, 15.209, 15.247, RSS-247, RSS-Gen

Product name	: DeskSense
Applicant	: Head Electronics B.V.
FCC ID	: 2AXRUP190201
IC ID	: 26960-DESKSENSE

Test report No. : 200801041 004 Ver 2.0

Laboratory information

Accreditation

Telefication complies with the accreditation criteria for test laboratories as laid down in ISO/IEC 17025:2017. The accreditation covers the quality system of the laboratory as well as the specific activities as described in the authorized annex bearing the accreditation number L021 and is granted on 30 November 1990 by the Dutch Council For Accreditation (RvA: Raad voor Accreditatie).

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Documentation

The test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory. The documentation of the testing performed on the tested devices is archived for 10 years at Telefication Netherlands.

Testing Location

Test Site	Telefication BV
Test Site location	Wilmersdorf 50 7327 AC Apeldoorn The Netherlands Tel. +3188998 3393
Test Site FCC	NL0001

Revision History

Version	Date	Remarks	By
v0.50	14-12-2020	First draft	R.T
V1.0	23-02-2021	Initial release version	PvW
V2.0	18-03-2021	Expanded frequency range to cover full LoRa application Added additional RF measurements to cover delta in module test report	PvW

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Summary of Test results

FCC	ISED	Description	Section in report	Verdict
15.247(d) 15.209 (a) 15.109	RSS-Gen 8.9	Radiated spurious emissions	3.1	Pass
15.205 (a)	RSS Gen 8.10	Spurious emissions in the restricted bands	3.1	Pass
15.247 (a)	RSS-247 5.2(a)	6 dB bandwidth	3.3	Pass
--	RSS-Gen 6.7	99% bandwidth	3.4	Pass
15.247 (b)	RSS-247 5.4 (d)	RF output power	3.2	Pass
15.247 (e)	RSS-247 5.2 (b)	Power spectral density	3.5	Pass
15.247 (d)	RSS-247 5.5	Band edge	3.6	Pass

1 General Description

1.1 Applicant

Client name:	Head Electronics B.V
Address	Ambachtsweg 17 Katwijk NETHERLANDS
Zip code:	2222 AH
Telephone:	+31 (0)6 25237695
E-mail:	t.klijn@head.nl
Contact name:	Tom Klijn

1.2 Manufacturer

Manufacturer name:	Head Electronics B.V.
Address:	Ambachtsweg 17 Katwijk NETHERLANDS
Zip code:	2222 AH
Telephone:	+31 (0)6 25237695
E-mail:	t.klijn@head.nl
Contact name:	Tom Klijn

1.3 Tested Equipment Under Test (EUT)

Product name:	DeskSense
Brand name:	Head Electronics B.V.
FCC ID:	2AXRUP190201
IC ID:	26960-DESKSENSE
Product type:	Wireless battery powered desk occupancy sensor
Model(s):	P190201-1900001
Batch and/or serial No.	--
Software version:	V2.0
Hardware version:	V07
Date of receipt	10-11-2020
Tests started:	23-11-2020
Testing ended:	05-03-2021

1.4 Product specifications of Equipment under test

Tx Frequency:	LoRa: 902-928 MHz
Rx frequency:	LoRa: 902-928 MHz
Antenna type	Meandering PCB antenna
Type of modulation:	CSS
Emission designator	125KG1D 250KG1D 500KG1D

1.5 Environmental conditions

Test date	04-12-2020	26-11-2020	10-11-2020	05-03-2021
Ambient temperature	20.0°C	20.0°C	19.1°C	20.6°C
Humidity	33.3%	48.6%	41.0%	20.7%

1.6 Measurement standards

- ANSI C63.4:2014
- ANSI C63.10:2013

1.7 Applicable standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- FCC Part 15 Subpart C §15.109
- FCC Part 15 Subpart C §15.209
- FCC Part 15 Subpart C §15.247
- RSS-Gen Issue 5
- RSS-247 Issue 2

1.8 Observation and remarks

The manufacturer provided samples with antenna connectors in place of the regular antenna for conducted testing. The equipment under test uses a pre-certified module so only RF power and radiated spurious emissions are measured.

The RF module test report does not cover the 8x 500kHz BW LoRa downlink channels, so this test report covers the RF requirements for those channels only.
Spurious emission measurements cover the entire operating frequency range.

1.9 Conclusions

The sample of the product showed NO NON-COMPLIANCES to the specifications stated in paragraph 1.7 of this report.

The results of the test as stated in this report, are exclusively applicable to the product items as identified in this report. Telefication accepts no responsibility for any properties of product items in this test report, which are not supported by the tests as specified in paragraph 1.7 *"Applicable standards".*

All conducted tests are performed by:

Name : Raoul Tolud, MSc under supervision of P. van Wanrooij, BASc

Review of test methods and report by:

Name : ing. R. van Barneveld

The above conclusions have been verified by the following signatory:

Date : 08-04-2021

Name : ing. R. van Barneveld

Function : Test Engineer

Signature :

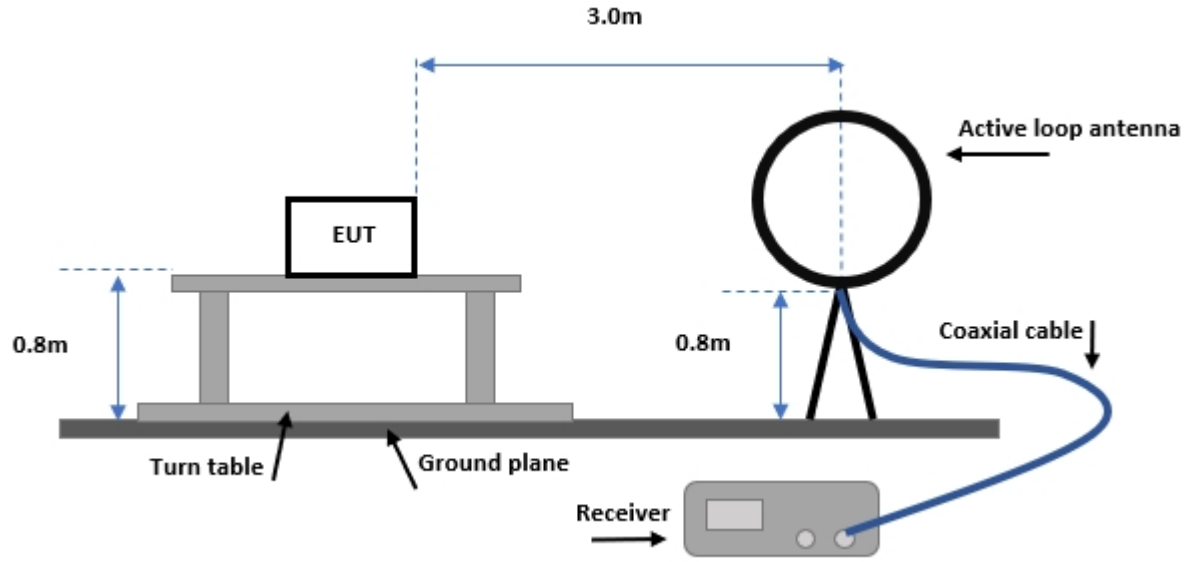
2 Test configuration of the Equipment Under Test

2.1 Test mode

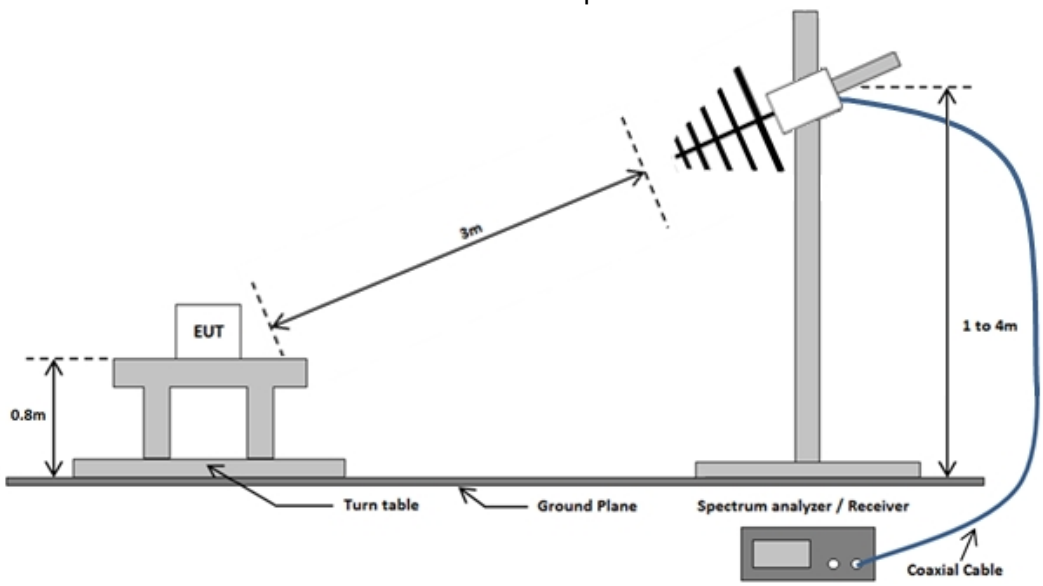
The applicant provided test mode firmware for the LoRa radio, in which it was possible to configure the radio to transmit continuously.

2.2 Test setups

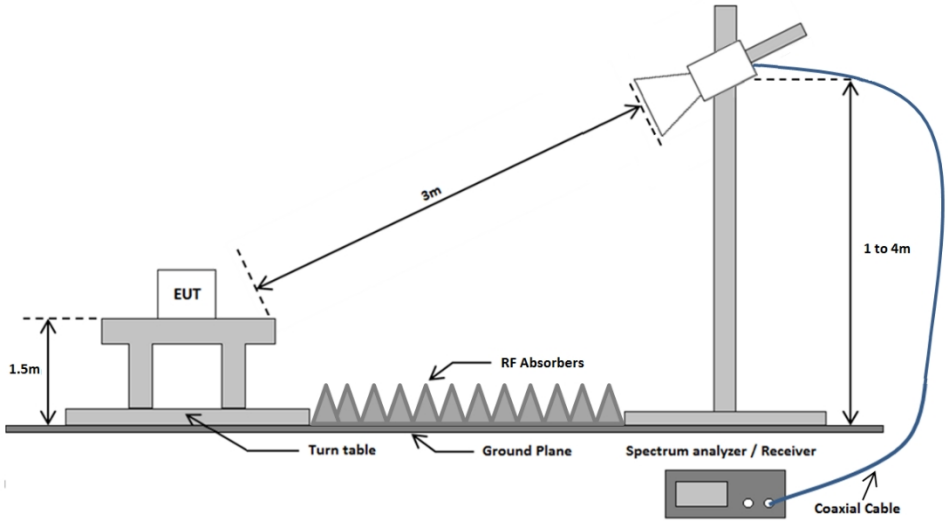
Radiated emissions test setup 9 kHz – 30 MHz



Radiated emissions test setup 30 MHz - 1 GHz



Radiated emissions test setup above 1 GHz



2.3 Equipment used in the test configuration

Description	Manufacturer	Model	ID	Used at Par.
EMI Receiver	Rohde & Schwarz	ESR7	TE01220	3.1
Spectrum analyzer	Rohde & Schwarz	FSP40	TE11125	3.1
3.0 GHz HPF	Wainwright	WHK3.0/18G-10EF	TE01140	3.1
Active loop antenna	EMCO	6502	TE11171	3.1
Biconilog antenna	Chase	CBL6112A	TE00967	3.1
Horn antenna	EMCO	3115	TE00531	3.1
EMI Receiver	Rohde & Schwarz	ESCI	TE11128	3.2
Low noise amplifier 1 - 18 GHz	µComp Nordic	MCNA-40-0010800-25-10P	TE11175	3.2
Spectrum Analyzer	Rohde & Schwarz	FSV40	TE11160	3.2 – 3.6

2.4 Sample calculations

All formulas for data conversions and conversion factors are reported in chapter 4 of this test report.

3 Test results

3.1 Radiated spurious emissions

3.1.1 Limit

Frequency (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance(m)
0.009 – 0.490	2400/F(kHz)	20*{log[2400]-log[F(kHz)]}	300*
0.490 – 1.705	24000/F(kHz)	20*{log[24000]-log[F(kHz)]}	30*
1.705 – 13.11 14.01 – 30.0	30	29.5	30*
30 -88	100	40	3
88 - 216	150	43,5	3
216-960	200	46	3
Above 960	500	54	3

*Note: Limit lines in the plots corrected to 3m measurement distance according to the method described in ANSI C63.10-2013, clause 6.4

3.1.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.1.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.1.4 Test procedure

9 kHz – 30 MHz: According to ANSI C63.4-2014, section 5.4.2 and 8.2.3
30 MHz to 26.5 GHz: According to ANSI C63.4-2014, section 8.3

9 kHz to 30 MHz: IRN 026 – Method 10
30 MHz to 1 GHz: IRN 026 – Method 1
1 GHz to 18 GHz: IRN 026 – Method 2

3.1.5 Measurement Uncertainty

Frequency range	Polarization	Uncertainty
9 kHz – 30 MHz	--	±1.6 dB
30 – 200 MHz	Horizontal	±4.5 dB
	Vertical	±5.4 dB
200 -1000 MHz	Horizontal	±3.6 dB
	Vertical	±4.6 dB
1 – 18 GHz	Horizontal	±5.7 dB
	Vertical	±5.7 dB

3.1.6 Results of radiated spurious emissions measurements

Measured peaks Horizontal 30 – 1000 MHz Low channel

Frequency	Polarization	Height	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference
961,031 MHz	Horizontal	2,5 m	30,5 dBµV/m	54 dBµV/m	-23,5 dB

Measured peaks Vertical 1 – 10 GHz Low channel

Frequency	Polarization	Height	Peak	Average	Peak Limit	Average Limit	Peak Difference	Average Difference
6,327 GHz	Vertical	2,2 m	51,9 dBµV/m	48,3 dBµV/m	74 dBµV/m	54 dBµV/m	-22,1 dB	-5,7 dB

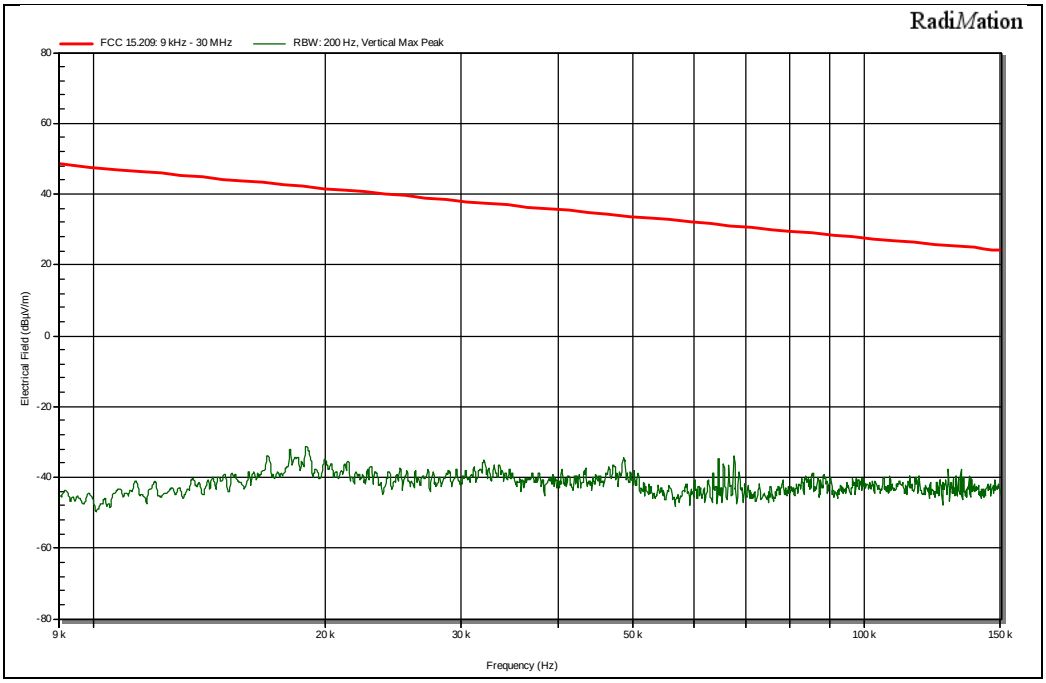
Measured peaks Vertical 1 – 10 GHz high channel

Peak Number	Frequency	Peak	Peak Limit	Average	Average Limit	Status	Polarization
1	6,493 GHz	52,9 dBµV/m	74 dBµV/m	49,3 dBµV/m	54 dBµV/m	Pass	Vertical

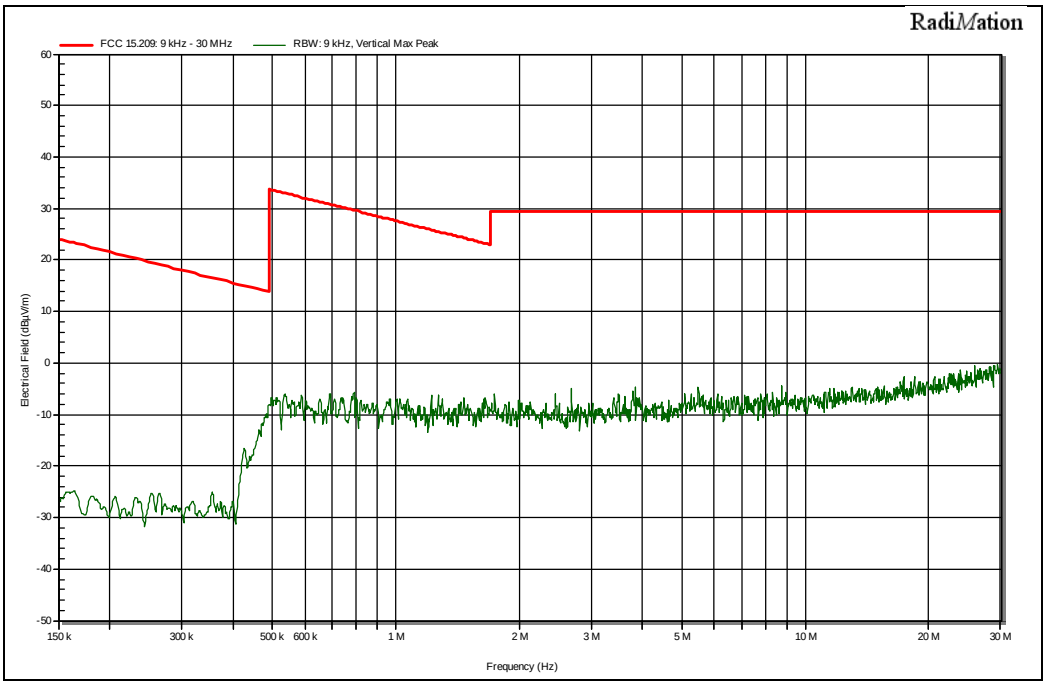
3.1.7 Plots of the Radiated Spurious Emissions Measurement

9 kHz to 150 kHz

Parallel

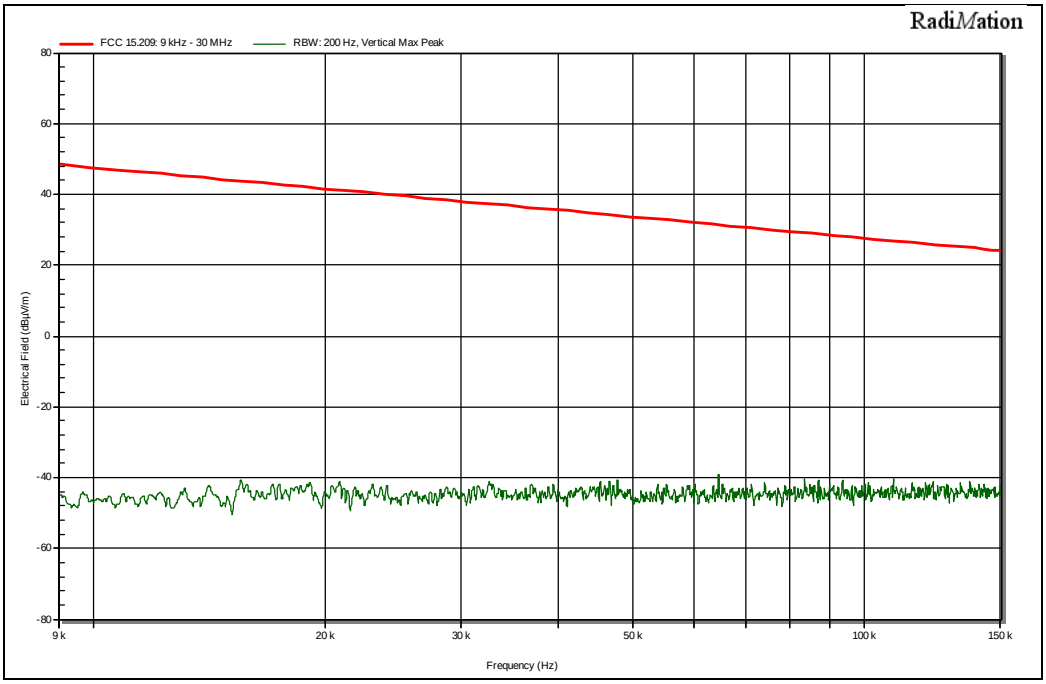


150 kHz to 30 MHz

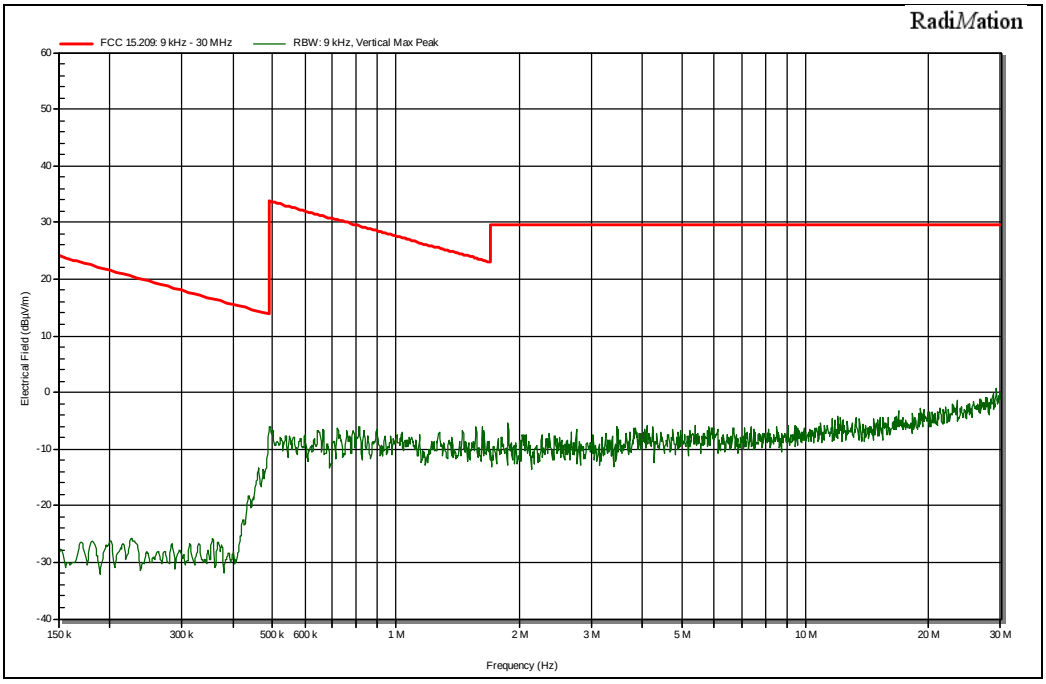


9 kHz to 150 kHz

Parallel

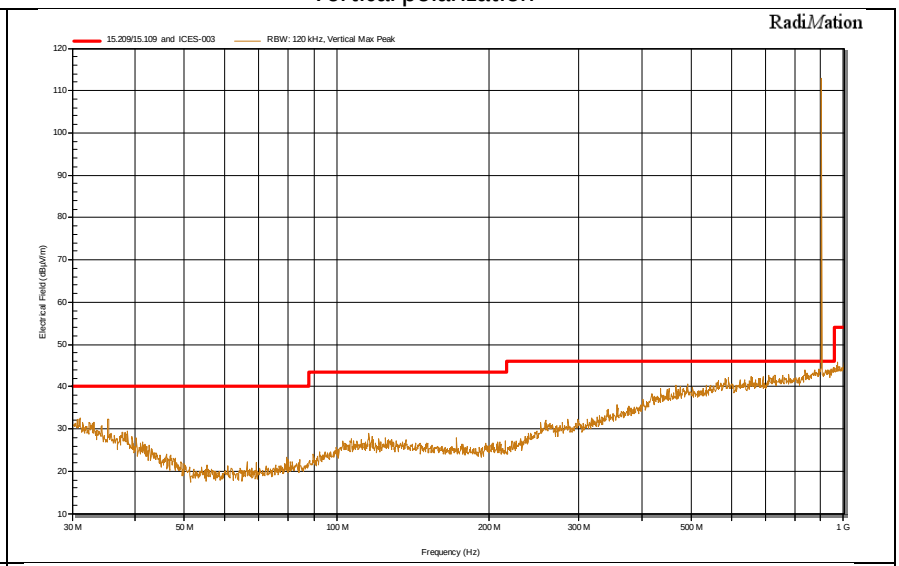
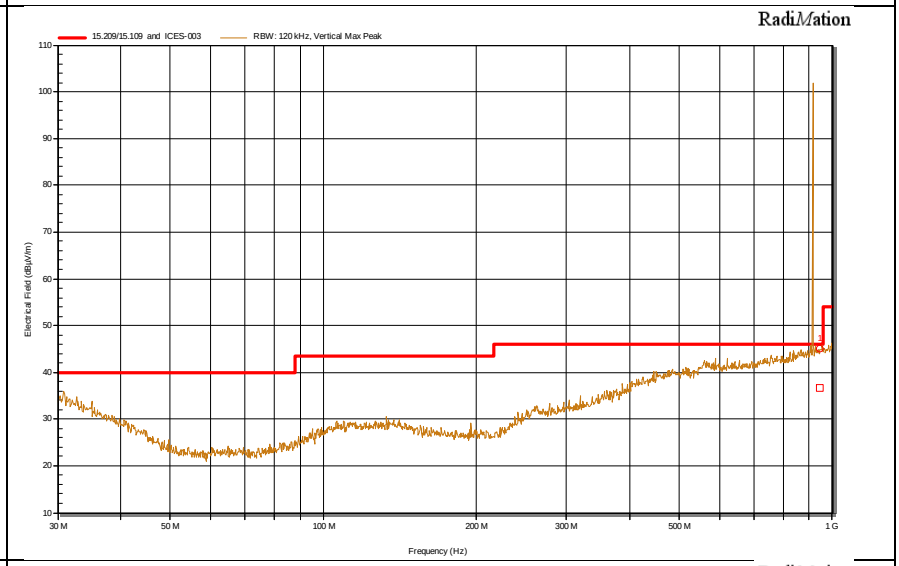
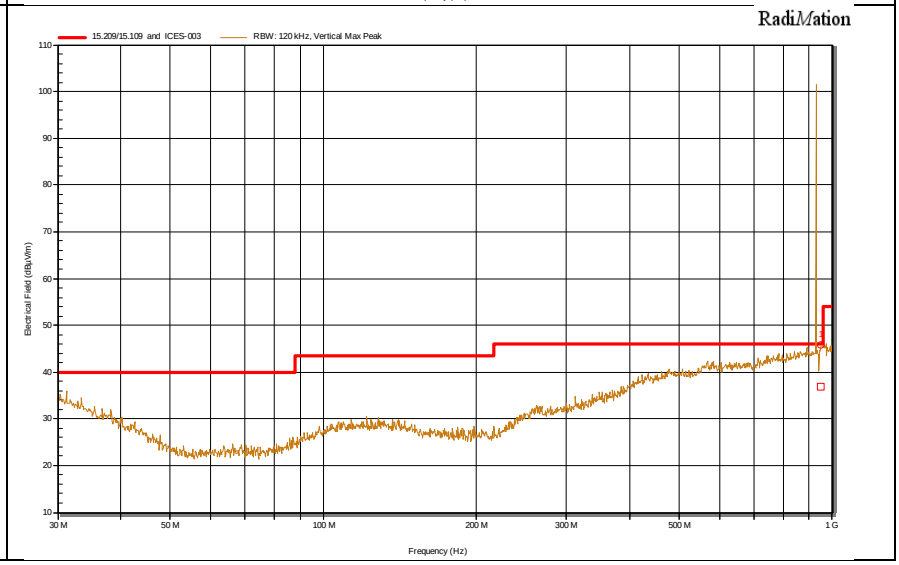


150 kHz to 30 MHz



30 MHz to 1 GHz

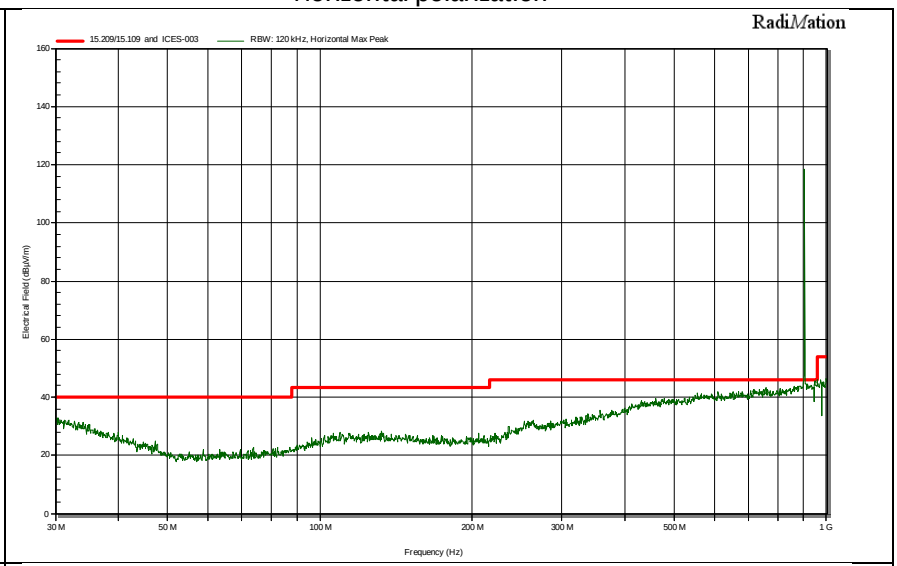
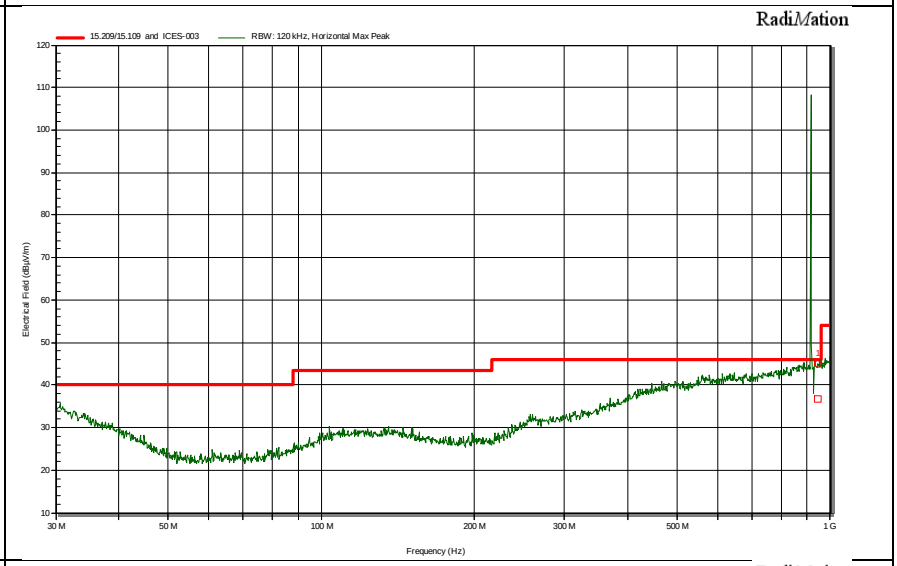
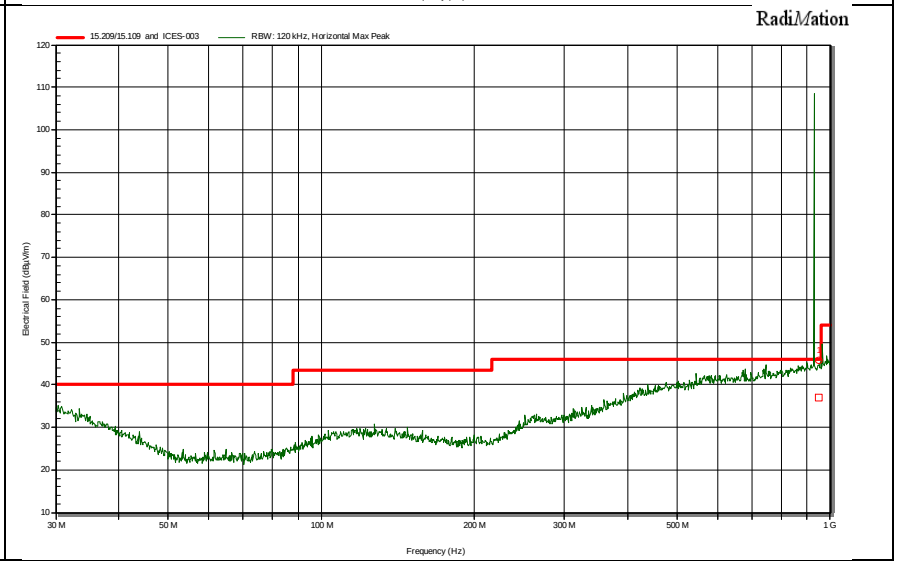
Vertical polarization

Low ch	
Mid ch	
High ch	

Note: the peak at 900 MHz is the transmission frequency and is not subject to the spurious limit

30 MHz to 1 GHz

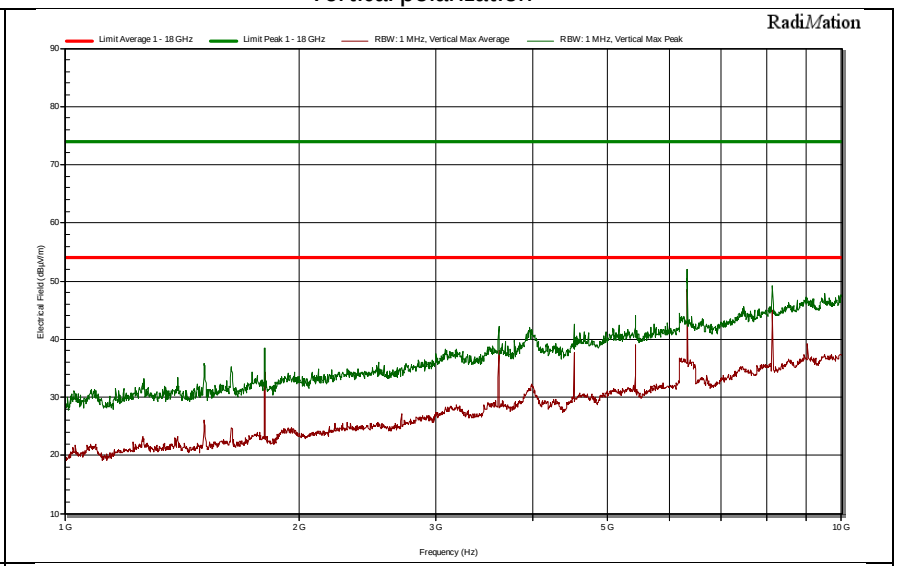
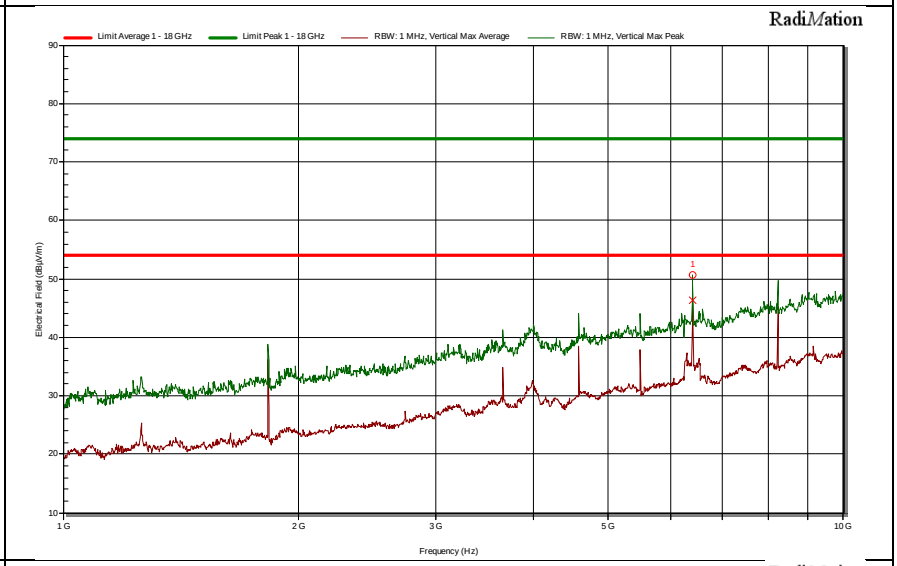
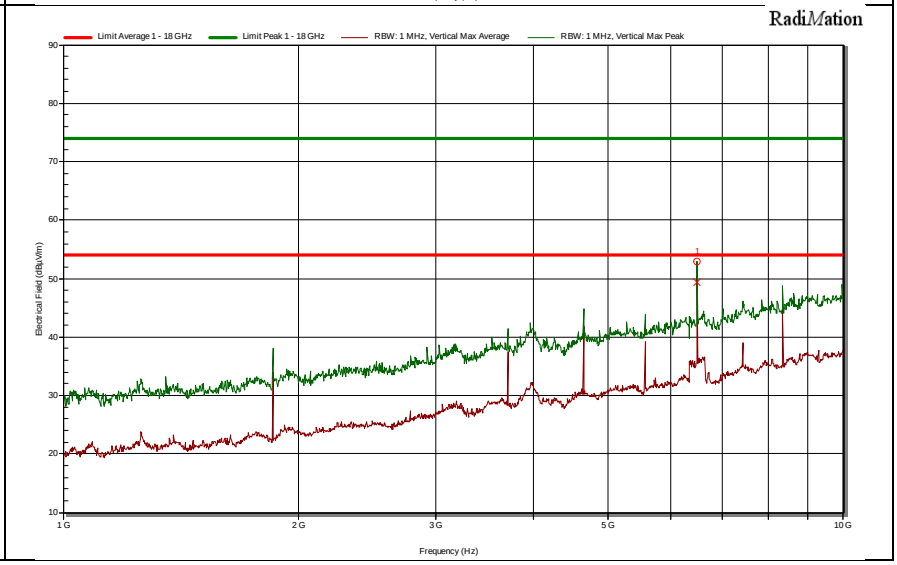
Horizontal polarization

Low ch	
Mid ch	
High ch	

Note: the peak at 900 MHz is the transmission frequency and is not subject to the spurious limit

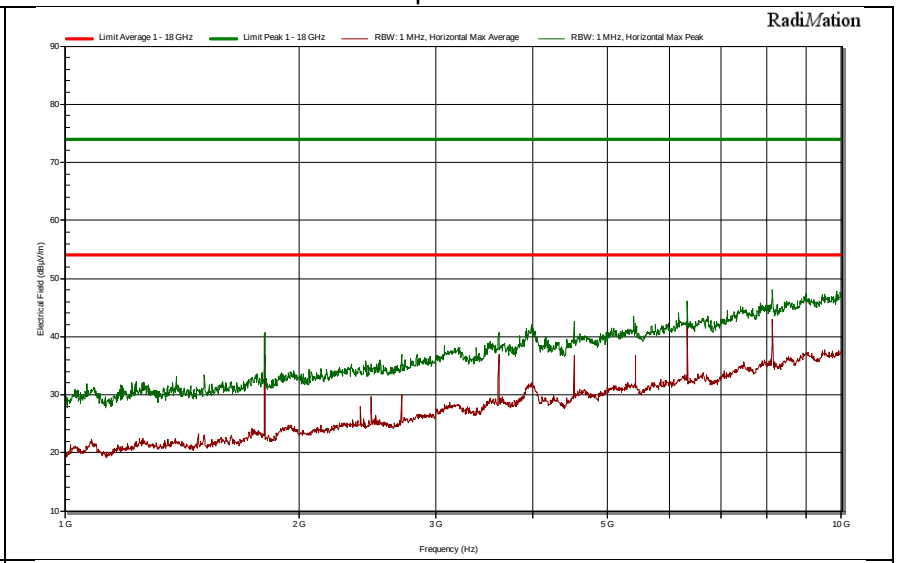
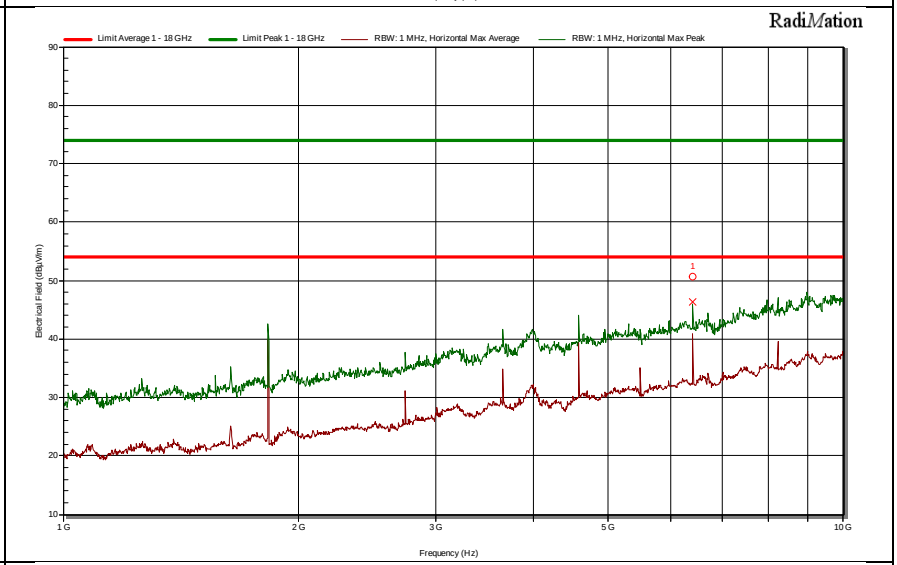
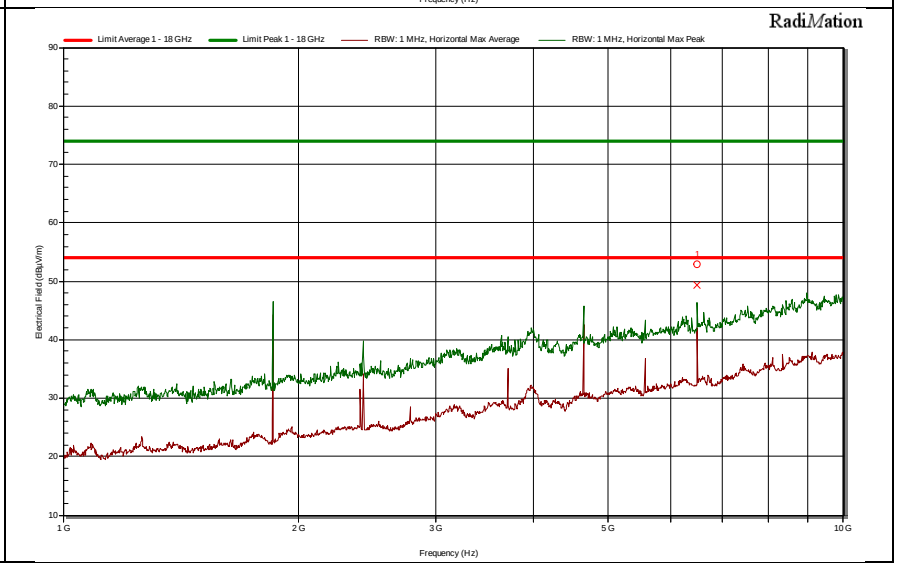
1 GHz to 10 GHz

Vertical polarization

Low ch	
Mid ch	
High ch	

1 GHz to 10 GHz

Horizontal polarization

Low ch	
Mid ch	
High ch	

3.2 Output Power Measurement

3.2.1 Limit

For systems using digital modulation in the 902-928 MHz frequency range, the limit for the peak output power is 30 dBm. If transmitting antenna of directional gain greater than 6 dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point to point operation, the limit has to be reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

3.2.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.2.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.2.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05.
IRN 014 - RF power (W) - Method 1 – AVGSA (DTS) according to ANSI C63.10.

3.2.5 Test results of Output Power Measurement

Peak method

Technology Std.	Channel	Frequency (MHz)	Data rate	Peak output power (dBm)
LoRa	Low	923.3	5047bits/s	12.40
	High	927.5	5047bits/s	12.29
Uncertainty	±0.71 dB			

3.3 6dB bandwidth Measurement

3.3.1 Limit

The minimum 6 dB Bandwidth shall be at least 500 kHz.

3.3.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.3.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.3.4 Test procedure

Tests according to ANSI C63.10
IRN 017 - Occupied bandwidth (Hz) Method 4 – DTS Bandwidth.

3.3.5 Test Results of the 6 dB bandwidth Measurement

Technology Std.	Channel	Frequency (MHz)	Data rate	6dB bandwidth (kHz)
LoRa	Low	923.3	5047bits/s	780.35
	High	927.5	5047bits/s	785.10
Uncertainty	± 36.2 kHz			

3.4 99% Occupied Bandwidth

3.4.1 Limit

According to RSS-Gen 6.7

3.4.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.4.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.4.4 Test procedure

IRN 017 - Occupied bandwidth (Hz) Method 1 – XX % power bandwidth.

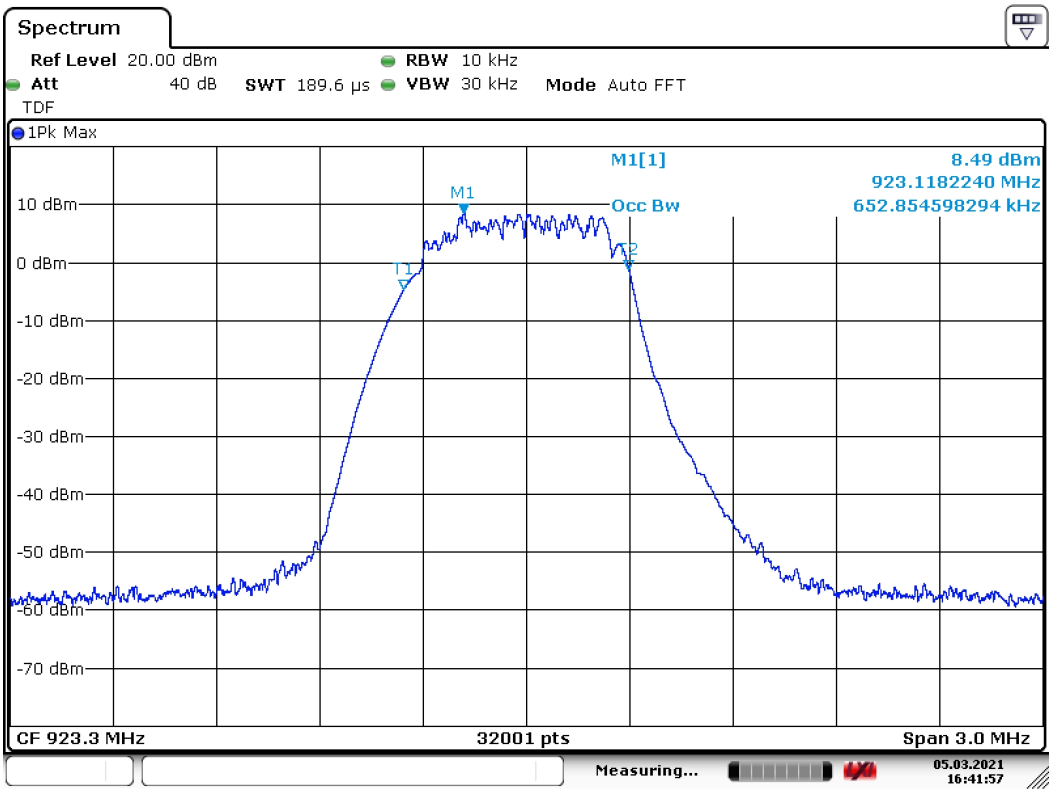
1. Set the centre frequency to the nominal EUT channel centre frequency
2. Set span = 1.5 times to 0.5 times the Occupied Bandwidth
3. Set VBW ≥ 3x RBW
4. Video averaging is not permitted. Where practical, detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

3.4.5 Test results of the 99% occupied bandwidth measurement

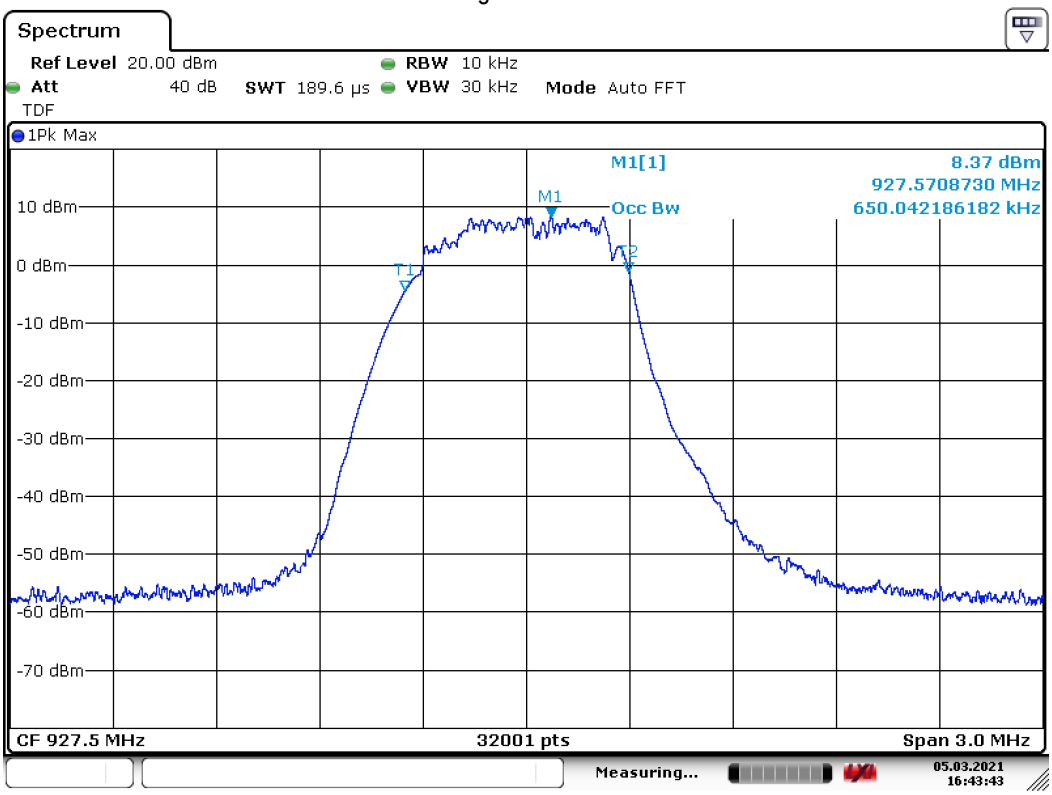
Technology Std.	Channel	Frequency (MHz)	Data rate	99% bandwidth (kHz)
LoRa	Low	923.3	5047bits/s	650
	High	927.5	5047bits/s	653
Uncertainty	± 12 kHz			

3.4.6 Plots of the 99% occupied bandwidth measurement

Low channel



High channel



3.5 Power Spectral Density

3.5.1 Limit

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band at any time interval of continuous transmission.

3.5.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.5.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.5.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05.
IRN 030 - Spectral power density (W per n.Hz) - Method 5 – Peak method PKPSD (PSD in 3 kHz band)

3.5.5 Test results of Power Spectral Density Measurement

Peak Power spectral density

Technology Std.	Channel	Frequency (MHz)	Data rate	PSD (dBm/3 kHz)
LoRa	Low	923.3	5047bits/s	0.32
	High	927.5	5047bits/s	0.43
Uncertainty	±2 dB			

3.6 Band edge Measurement

3.6.1 Limit

Band edge:
At the edge of the authorized band the RF power shall be at least 20 dB down.

3.6.2 Measurement instruments

The measurement instruments are listed in chapter 2.3 of this report.

3.6.3 Test setup

The test setup is as shown in chapter 2.2 of this report.

3.6.4 Test procedure

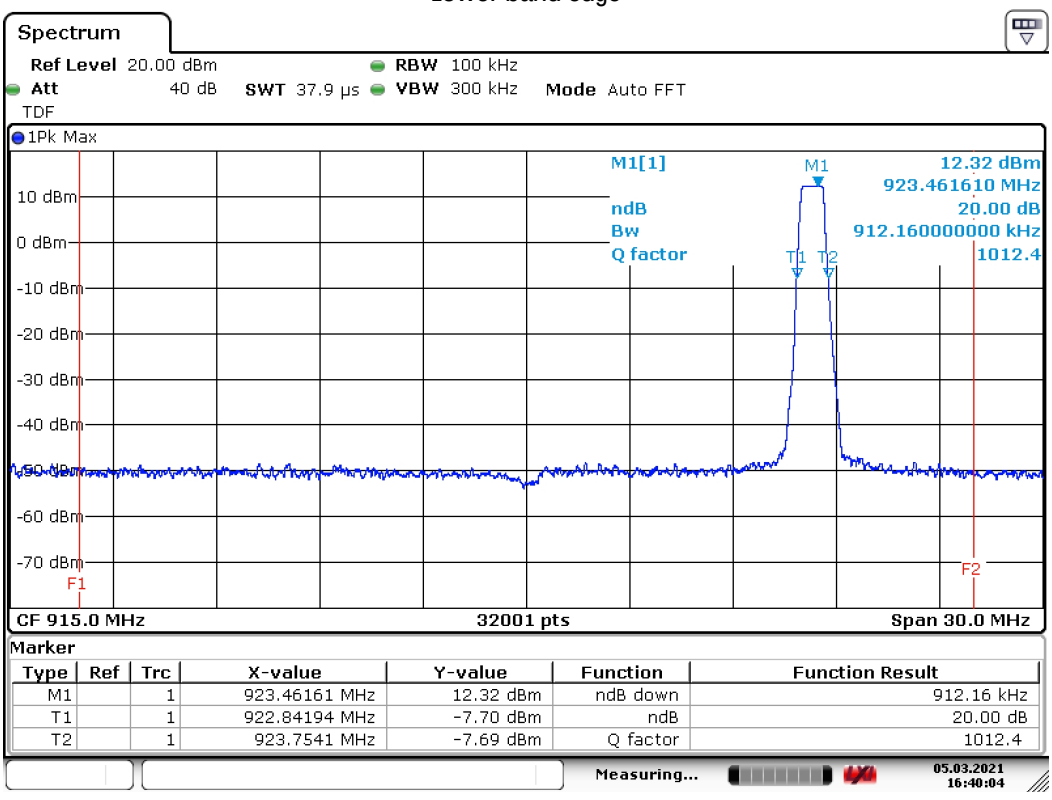
The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05, sections 11.3 and 12.1. IRN 026 - Radiated electrical disturbance (V per m) Method 6 – Radiated electrical disturbance at the Authorized band edge.

3.6.5 Measurement Uncertainty

± 5.7 dB.

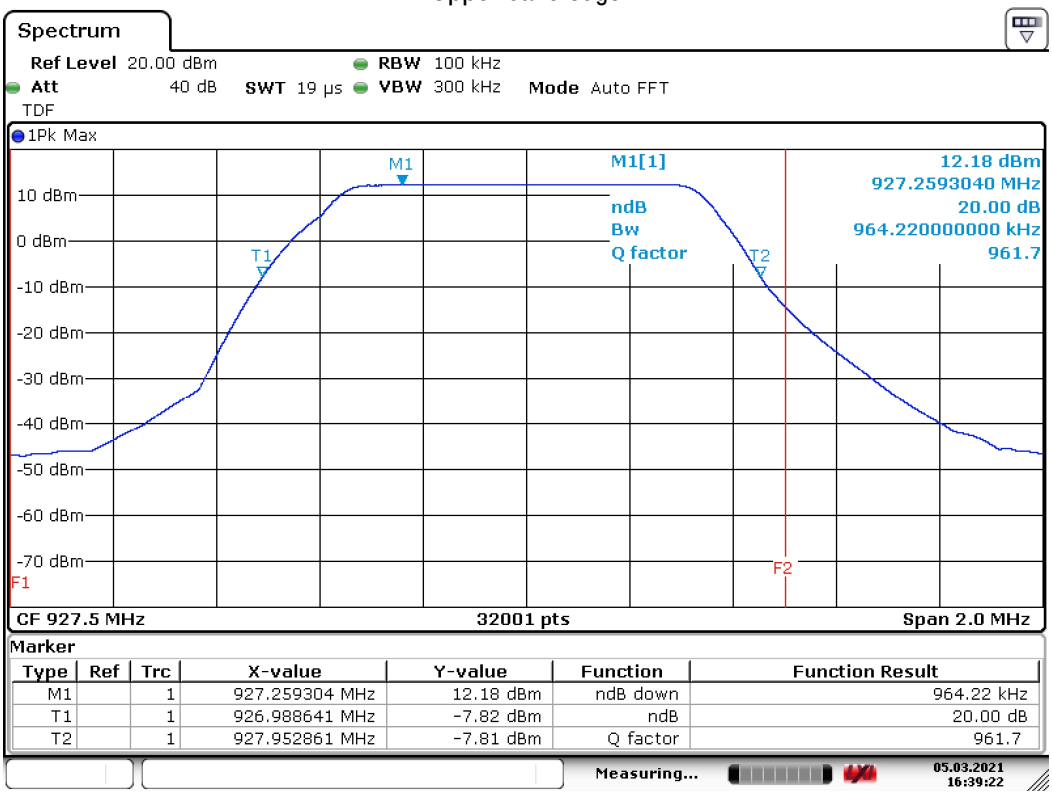
3.6.6 Plots of the Band edge Measurements

Lower band edge



Note: both band edges are shown as the lowest downlink channel is not close to any band edge.

Upper band edge



4 Sample calculations

All formulas for data conversions and conversion factors are reported in this chapter.

Conducted emission Measurement:

U_{lisn} (dBµV) = U (dBµV) + Corr. (dB)

Where:
U = Measuring receiver voltage
LISN insertion loss = Voltage division factor of LISN
Corr. = sum of single correction factors of used LISN, cables and pulse limiter.
Linear interpolation will be used for frequencies in between the values in the table.

Frequency (Mhz)	Voltage division LISN (db)	Insertion Loss Pulse limiter (dB)	Cable loss (dB)	Corr. (dB)
	TE 00208 SN: 892785/004 Rohde & Schwarz ESH3-Z5	TE 00756 SN: 5SM03153 Rohde & Schwarz ESH3-Z2	TE 11134	
0,15	0,09	9,87	0,02	9,98
0,2	0,1	9,87	0,03	10
0,3	0,1	9,87	0,03	10
0,5	0,1	9,87	0,08	10,05
0,7	0,12	9,87	0,25	10,24
0,8	0,12	9,87	0,25	10,24
1	0,13	9,87	0,11	10,11
2	0,16	9,87	0,15	10,18
3	0,19	9,87	0,21	10,27
5	0,26	9,88	0,21	10,35
7	0,36	9,89	0,25	10,5
8	0,39	9,89	0,25	10,53
10	0,46	9,91	0,29	10,66
15	0,77	9,93	0,34	11,04
20	0,95	9,96	0,37	11,28
25	1,12	9,99	0,43	11,54
30	1,1	10,04	0,45	11,59

Field Strength Measurement:

E (dBµV/m) = U(dBµV) + AF (dB/m) + Corr. (dB)

Where:
E = Electric field strength
U = Measuring receiver voltage
AF = Antenna factor
CL = Cable loss

Corr. = sum of single correction factors of used cable and amplifier (if applicable).
Linear interpolation will be used for frequencies in between the values in the table.
Tables shows an extract of the values.

Frequency (Mhz)	AF (dB/m) TE 00967 Chase CBL6112A SN: 2308	Cable loss (dB) Id: SAR cable	Corr. (dB)
30	18,6	0,68	19,28
100	10,7	1,15	11,85
150	10,6	1,41	12,01
200	9,3	1,63	10,93
250	12,6	1,93	14,53
300	13,3	2,12	15,42
350	14,6	2,2	16,8
400	15,5	2,29	17,79
450	16,9	2,53	19,43
500	17,5	2,67	20,17
550	18,4	2,9	21,3
600	18,8	3,02	21,82
650	19,2	3,09	22,29
700	19	3,22	22,22
750	19,8	3,56	23,36
800	19,7	3,69	23,39
900	20,4	3,81	24,21
950	20,8	3,91	24,71
1000	21,2	4,3	25,5

Frequency (Mhz)	AF (dB/m) TE 00531 Emco 3115 SN: 9412-4377	Gain (dB) TE 11132 Miteq JS4-18004000-30-8P-A1	Cable loss (dB) TE 01315	Corr. (dB)
1000	23,6	40,4	2,0	66
1500	25,1	40,5	2,4	68
2000	27,1	40,5	2,7	70,3
2500	28,6	40,7	3,2	72,5
3000	30,5	40,7	3,2	74,4
3500	31,2	40,7	3,4	75,3
4000	32,7	40,9	4,9	78,5
4500	32,4	40,9	4,4	77,7
5000	33,2	40,7	4,6	78,5
5500	34,0	40,5	4,5	79
6000	34,6	40,0	5,2	79,8
6500	34,3	39,4	5,9	79,6
7000	35,2	38,6	5,7	79,5
7500	36,4	39,2	5,9	81,5
8000	37,0	38,9	6,3	82,2
8500	37,5	38,4	6,4	82,3
9000	38,1	37,4	6,5	82
9500	37,8	37,0	7,1	81,9
10000	38,2	36,5	7,3	82
10500	38,1	36,7	7,6	82,4
11000	38,3	36,9	8,3	83,5
11500	38,5	37,6	8,1	84,2
12000	39,1	38,3	8,4	85,8
12500	38,7	38,5	8,3	85,5
13000	39,2	38,9	9,2	87,3
13500	40,5	40,2	8,3	89
14000	41,1	40,0	8,2	89,3
14500	41,4	40,1	8,2	89,7
15000	40,2	41,4	8,3	89,9
15500	37,9	41,4	8,6	87,9
16000	37,5	42,8	9,2	89,5
16500	38,6	42,3	8,8	89,7
17000	41,1	43,1	9,4	93,6
17500	42,7	43,2	9,4	95,3
18000	44,0	44,2	9,8	98

Frequency (Mhz)	AF (dB/m) TE 00531 Emco 3115 SN: 9412-4377	Gain (dB) TE 11132 Miteq JS4-18004000-30-8P-A1	Cable loss (dB) TE 01315	Corr. (dB)
18000	31,3	26,2	9,8	67,3
19000	31,5	26,1	9,6	67,2
20000	31,7	25,9	11	68,6
21000	31,9	24,3	10,7	66,9
22000	32,1	18,3	10,5	60,9
23000	32,2	18,9	10,8	61,9
24000	32,3	23,6	11,4	67,3
25000	32,4	24,5	11,6	68,5
26000	32,5	25,3	11,7	69,5