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The Netherlands
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	: MET Sensor
Applicant	: SenseNL B.V.
FCC ID	: 2AWXW-MSSL01
IC ID	: 26309-MSSL01

Test report No. : 200200690 001 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	Edisonstraat 12a 6902 PK Zevenaar The Netherlands Tel. +31316583180 Fax. +31316583189
Test Site FCC	NL0001

Revision History

Version	Date	Remarks	By
v0.50	10-09-2020	First draft	PvW
v1.00	11-09-2020	Initial Release	PvW
V2.00	23-02-2021	Corrected FCC ID Added reference to 15.109	PvW

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Summary of Test results

FCC	IC	Description	Section in report	Verdict
15.247(d) 15.209 (a) 15.109(a)	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	3.2	Pass
--	RSS-Gen 6.7	99% bandwidth	3.3	Pass
15.247 (b)	RSS-247 5.4 (d)	RF output power	3.4	Pass
15.247 (f)	RSS-247 5.3 (b)	Power spectral density	3.5	Pass
15.247 (f)	RSS-247 5.3 (a)	Average occupancy time	3.6	Pass
15.247 (a)(1)	RSS-247 5.1 (b)	Channel separation	3.7	Pass
15.247 (a)(1)	RSS-247 5.1 (a)	Hopping function	3.8	Pass

1 General Description

1.1 Applicant

Client name:	SenseNL B.V.
Address:	Ambachtsweg 41F, Pijnacker
Zip code:	2641 KT, the Netherlands
Telephone:	0858 768909
E-mail:	w.kavelaars@sownet.nl
Contact name:	Mr. W. Kavelaars

1.2 Manufacturer

Manufacturer name:	SenseNL B.V.
Address:	Ambachtsweg 41F, Pijnacker
Zip code:	2641 KT, the Netherlands
Telephone:	0858 768909
E-mail:	w.kavelaars@sownet.nl
Contact name:	Mr. W. Kavelaars

1.3 Tested Equipment Under Test (EUT)

Product name:	MET Sensor Slab
Brand name:	SOWNet
FCC ID:	2AWXW-MSSL01
IC ID:	26309-MSSL01
Product type:	Wireless Humidity sensor
Model(s):	CARA MET
Batch and/or serial No.	--
Software version:	--
Hardware version:	--
Date of receipt:	24-08-2020
Tests started:	24-08-2020
Testing ended:	09-09-2020

1.4 Product specifications of Equipment under test

Tx Frequency:	LoRa: 903.9 – 905.3 MHz
Rx frequency:	LoRa: 903.9 – 905.3 MHz
Antenna type	Antenna plane, 0 dBd
Type of modulation:	CSS
Emission designator	125KF1D

1.5 Environmental conditions

Test date	24-08-2020	25-08-2020	26-08-2020	09-09-2020
Ambient temperature	25.3°C	25.1°C	24.6°C	23.0°C
Humidity	47.0%	47.2%	48.3%	60.2%

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 B §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 EUT is considered hybrid system equipment under FCC section 15.247 and complies with the requirements for hybrid spread-spectrum devices under section 15.247.
The equipment is a class B device.

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 : 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 : 23-02-2021

Name : ing P.A. Suringa

Function : Senior Test Engineer

Signature :

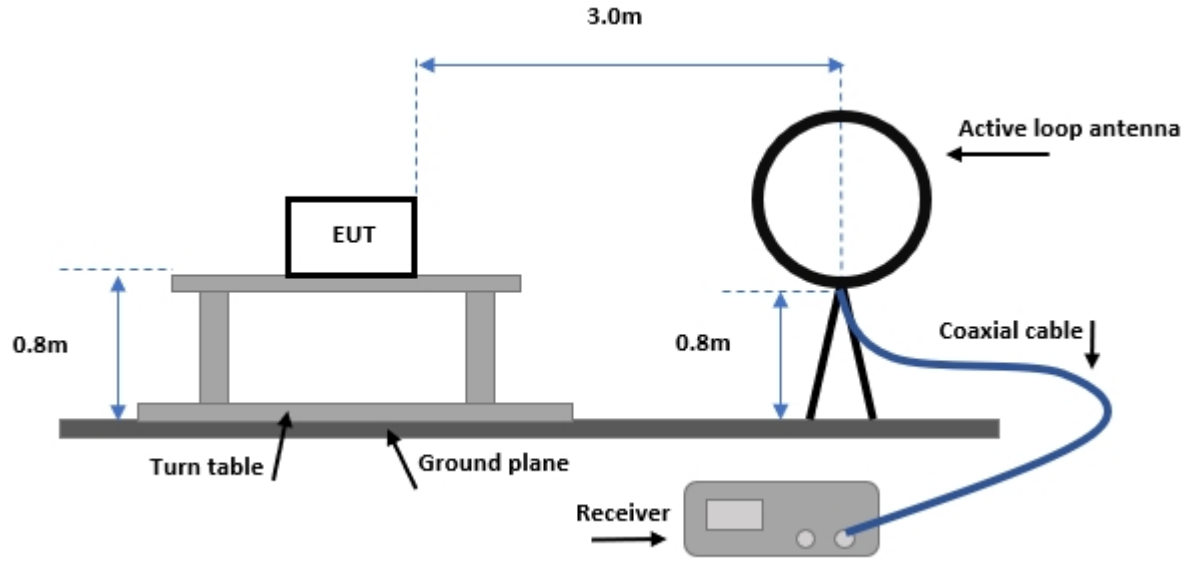
2 Test configuration of the Equipment Under Test

2.1 Test mode

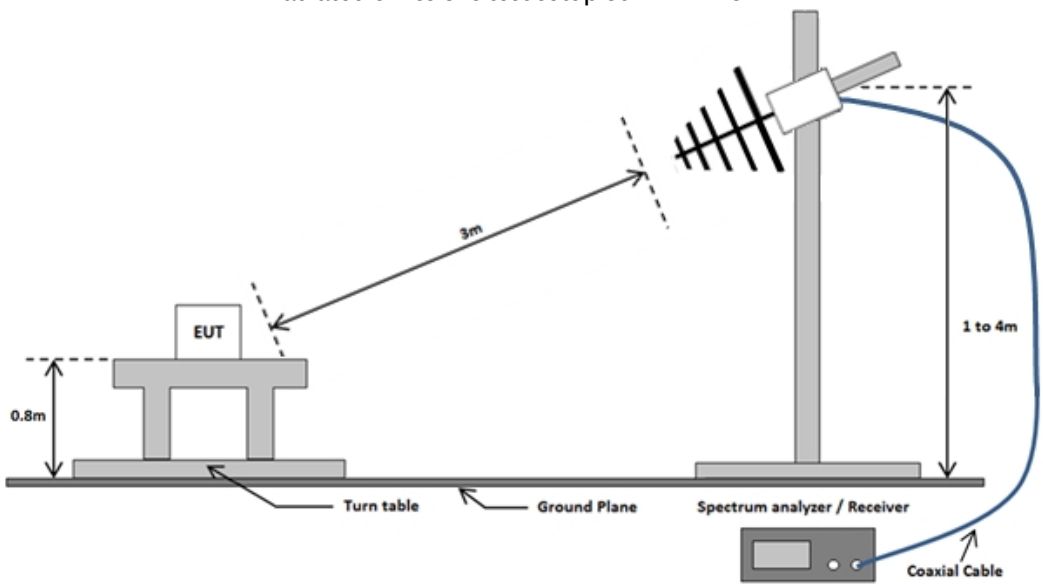
The applicant provided test mode firmware which allowed the transmitter to be set to continuously transmit with a CW or modulated signal. Hopping mode tests were performed by connecting the EUT to a LoRa gateway and communicating regularly.

2.2 Test setups

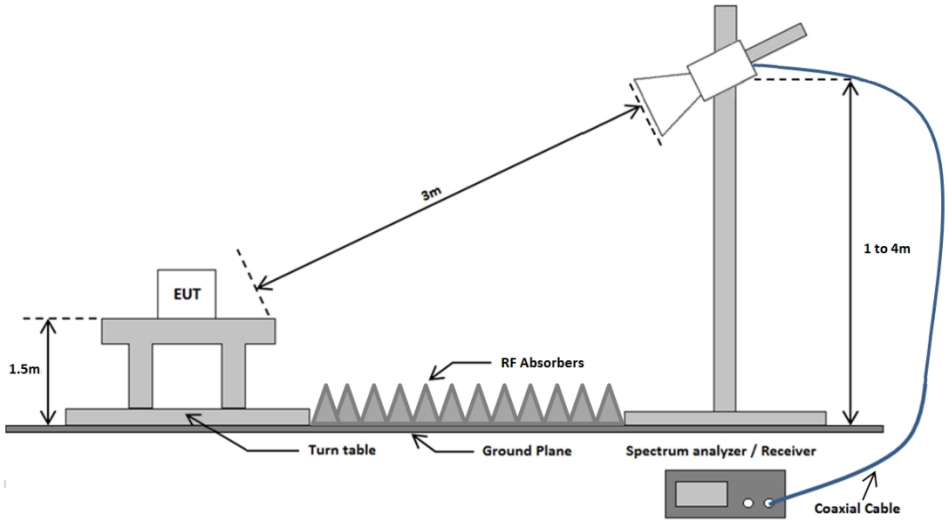
Radiated emissions test setup 9 kHz – 30 MHz



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
Spectrum Analyzer	Rohde & Schwarz	FSV40	TE01269	3.2 – 3.7
1.1 GHz HPF	Wainwright	WHK1.1/15G-10EF	TE01139	3.1
Active loop antenna	EMCO	6502	TE11171	3.1
Biconilog antenna	Chase	CBL6112A	TE00967	3.1
Horn antenna	EMCO	3115	TE00531	3.1

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

According to FCC part 15.209

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 10 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 – 10 GHz	Horizontal	±5.7 dB
	Vertical	±5.7 dB

3.1.6 Test results of the radiated spurious emissions measurement

Measured peaks Vertical 30 – 1000 MHz Low channel

Frequency	Polarization	Height	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference
841,047 MHz	Vertical	2,7 m	31,7 dBµV/m	46 dBµV/m	-14,3 dB
30,785 MHz	Vertical	3,7 m	27,2 dBµV/m	40 dBµV/m	-12,8 dB

Measured peaks Vertical 30 – 1000 MHz Middle channel

Frequency	Polarization	Height	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference
884,315 MHz	Vertical	3,5 m	29,7 dBµV/m	46 dBµV/m	-16,3 dB

Measured peaks Vertical 30 – 1000 MHz High channel

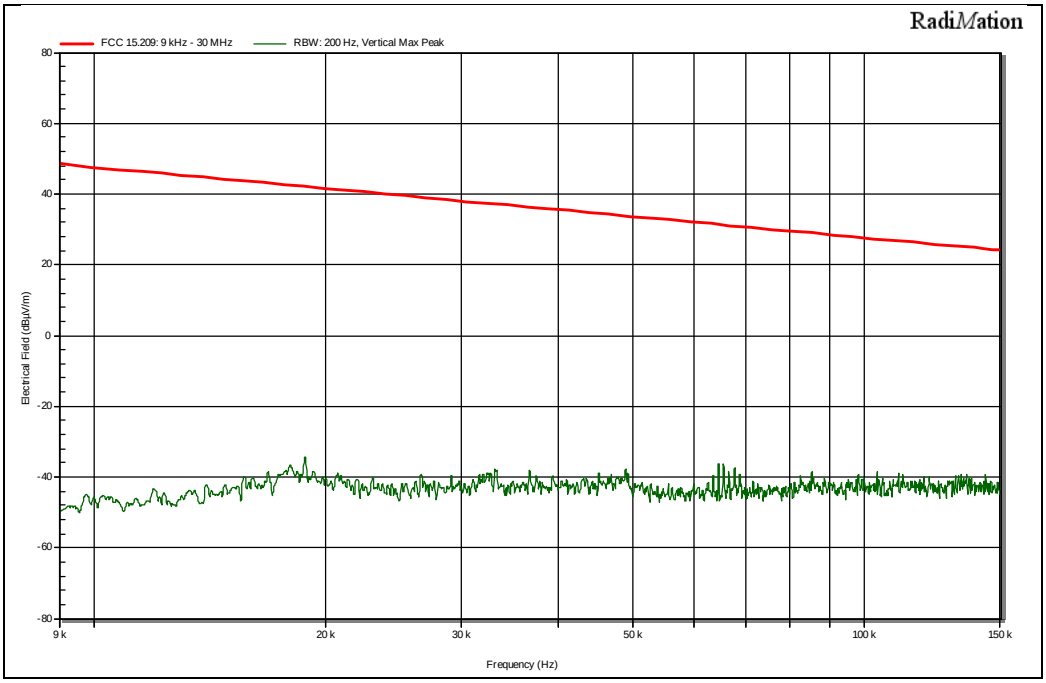
Frequency	Polarization	Height	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference
957,611 MHz	Vertical	3,5 m	29,8 dBµV/m	46 dBµV/m	-16,2 dB

Measured peaks Horizontal 1 – 10 GHz Low channel

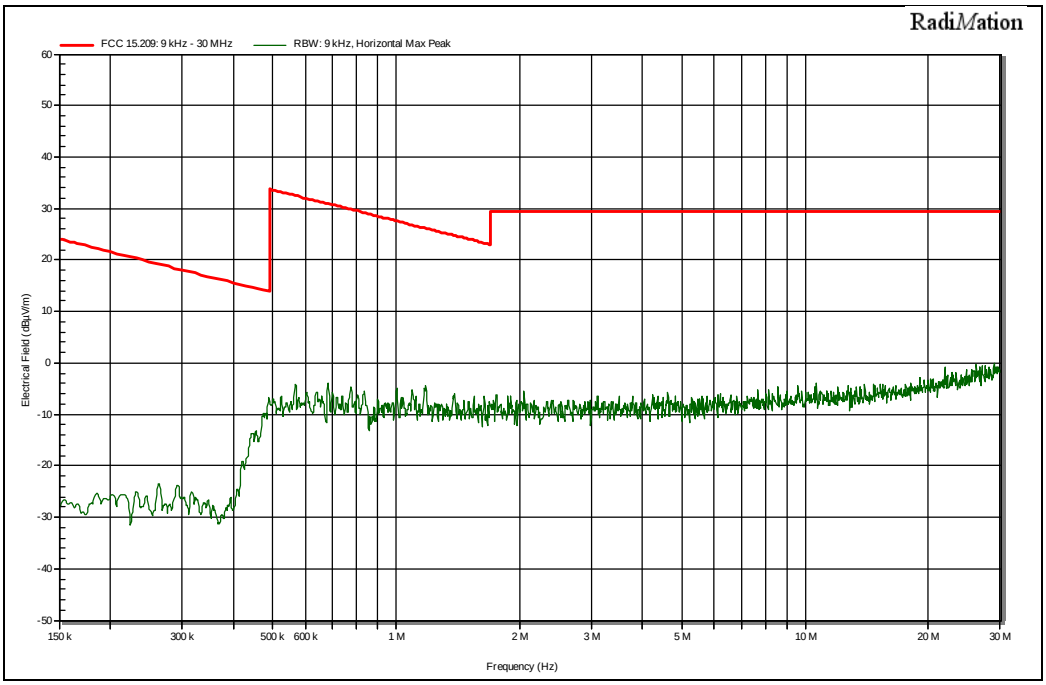
Frequency	Polarization	Height	Peak	Average	Peak Limit	Average Limit	Peak Difference	Average Difference
5,407 GHz	Horizontal	1,5 m	41,8 dBµV/m	31,8 dBµV/m	74 dBµV/m	54 dBµV/m	-32,2 dB	-22,2 dB

3.1.8 Plots of the Radiated Spurious Emissions Measurement

9 kHz to 150 kHz

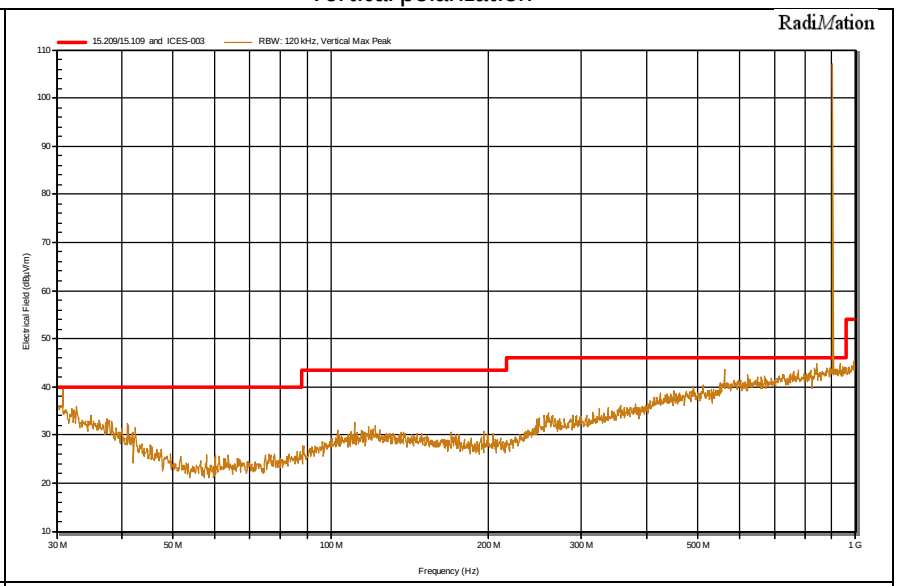
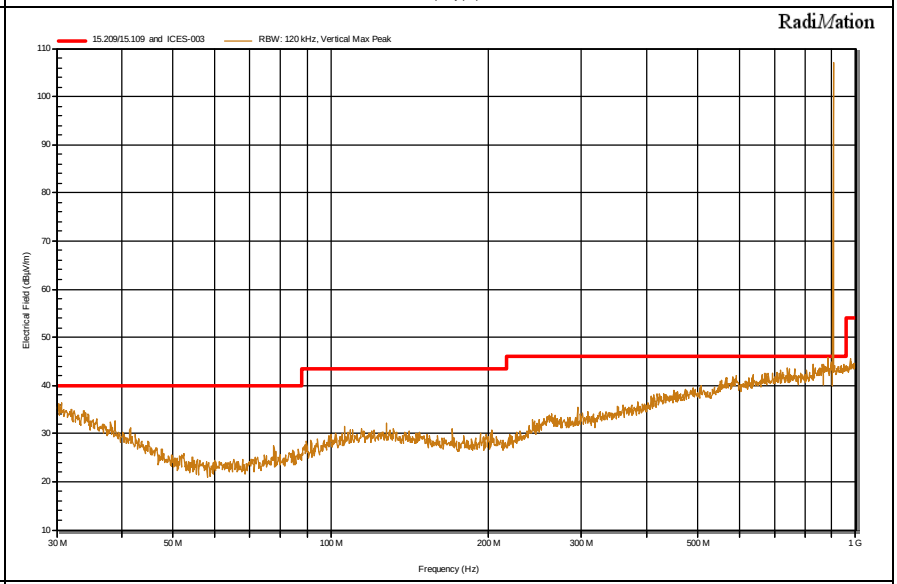
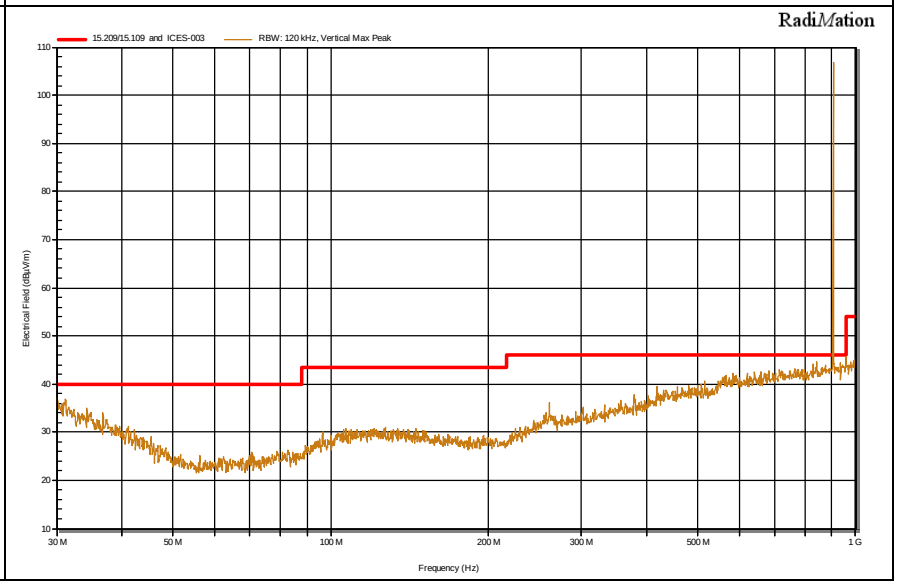


150 kHz to 30 MHz



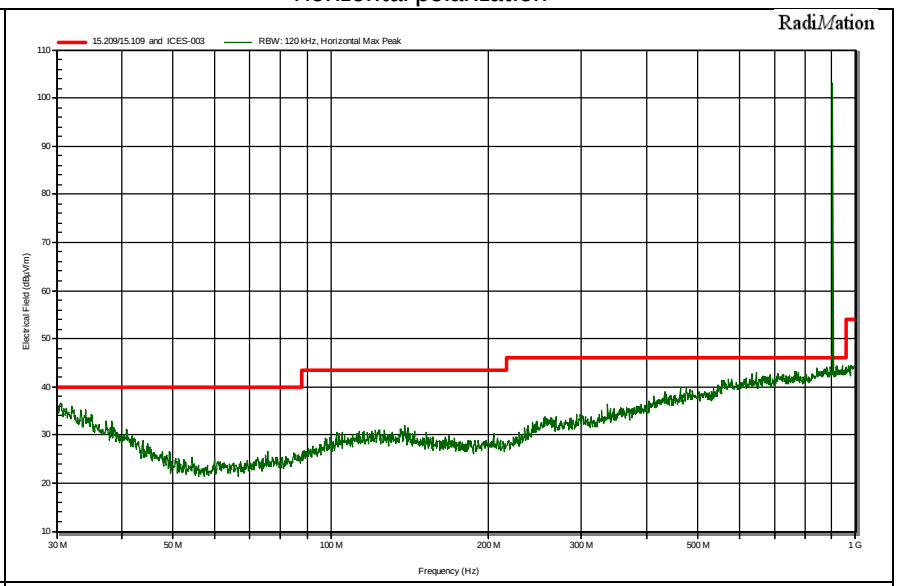
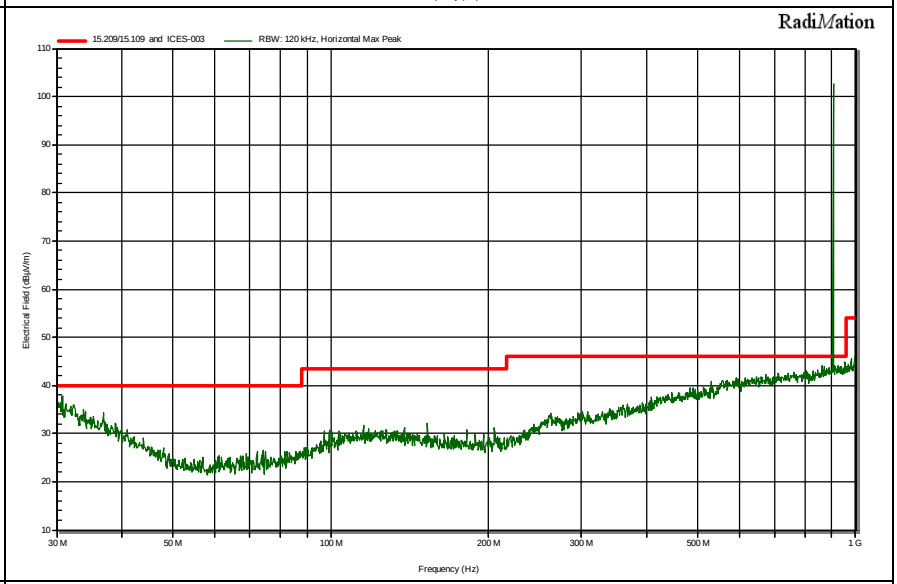
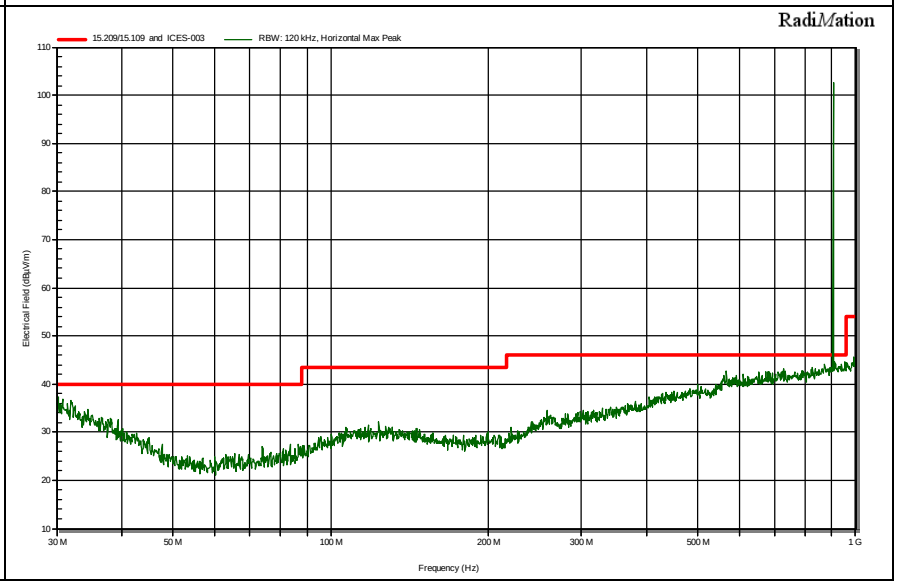
30 MHz to 1 GHz

Vertical polarization

Low ch	
Mid ch	
High ch	

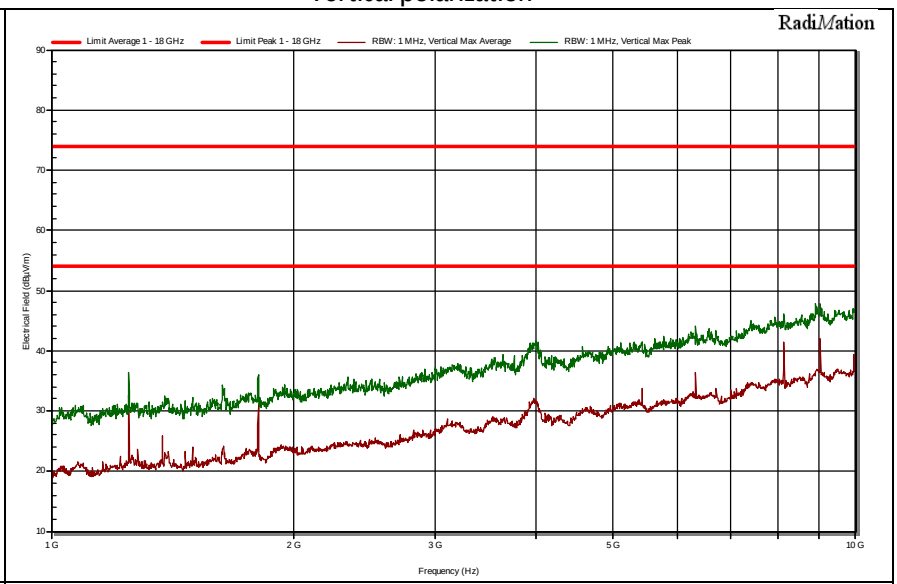
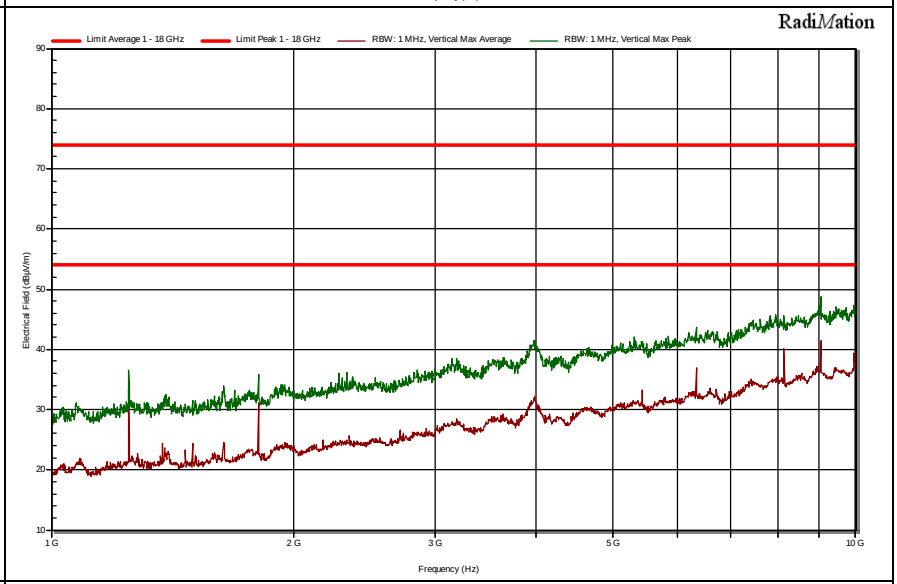
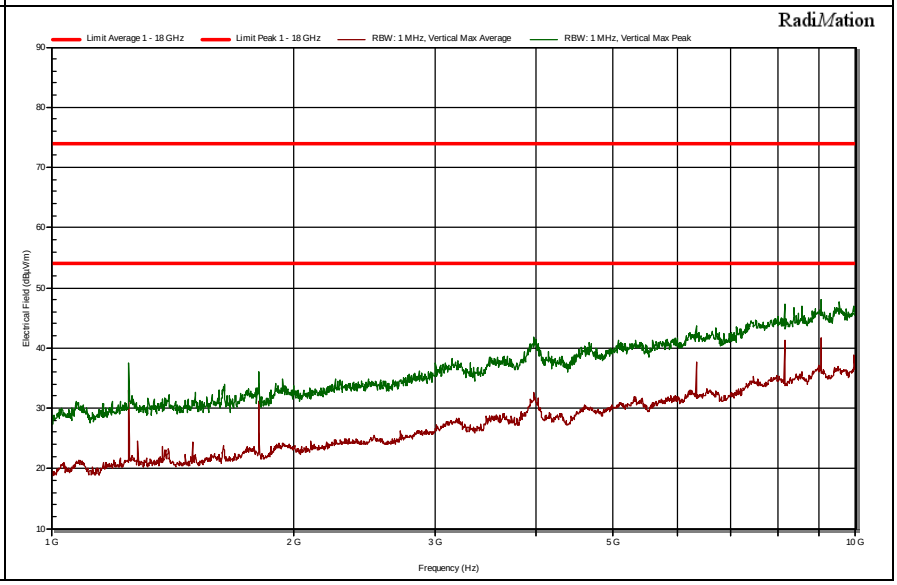
30 MHz to 1 GHz

Horizontal polarization

Low ch	
Mid ch	
High ch	

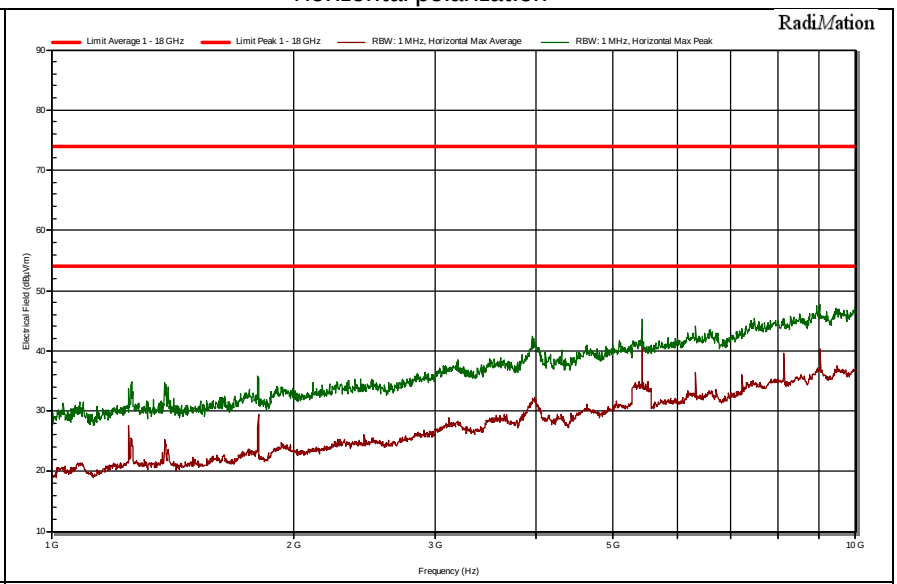
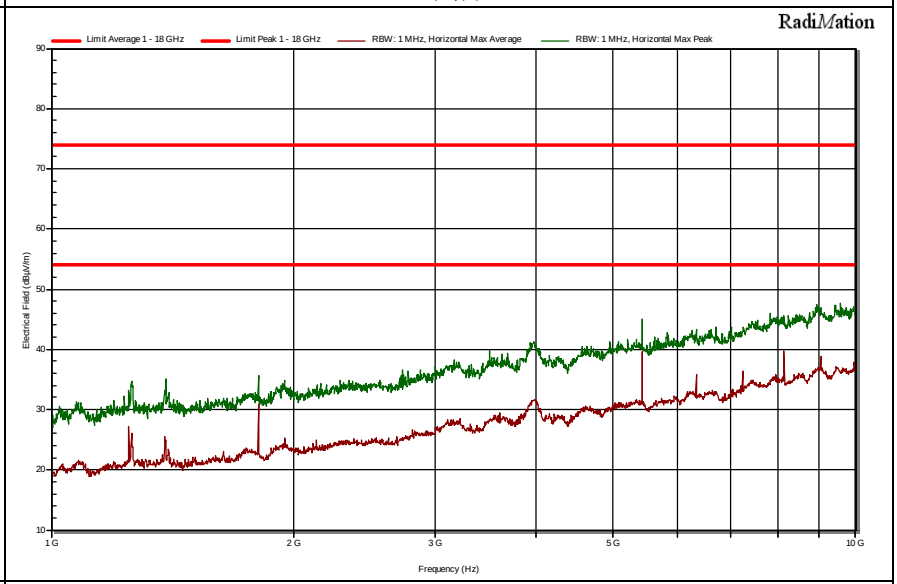
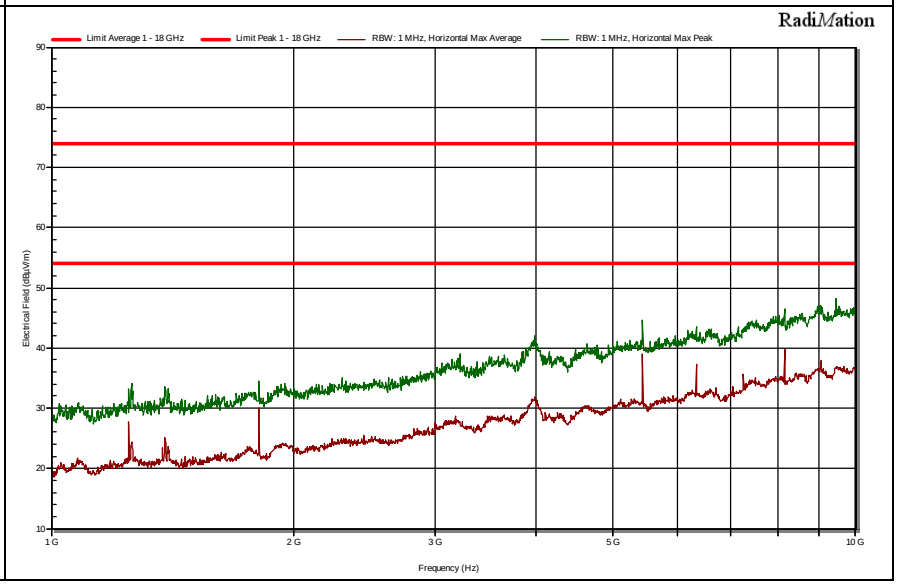
1 GHz to 10 GHz

Vertical polarization

Low ch	
Mid ch	
High ch	

1 GHz to 10 GHz

Horizontal polarization

Low ch	
Mid ch	
High ch	

3.2 6dB bandwidth Measurement

3.2.1 Limit

No Limit. According to KDB 558074 D01 15.247 Measurement Guidance v05r02, clause 10; b); 4):
"There is no requirement for this type of hybrid system to comply with the 500 kHz minimum bandwidth normally associated with a DTS service."

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

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

3.2.5 Test Results of the 6 dB bandwidth Measurement

Technology Std.	Channel	Frequency (MHz)	Data rate	6dB bandwidth (kHz)
LoRa	1	903.9	5470	119.7
	5	904.7	5470	120.0
	8	905.3	5470	126.2
Uncertainty	± 36.2 kHz			

3.3 99% Occupied Bandwidth

3.3.1 Limit

According to RSS-Gen 6.7

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

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

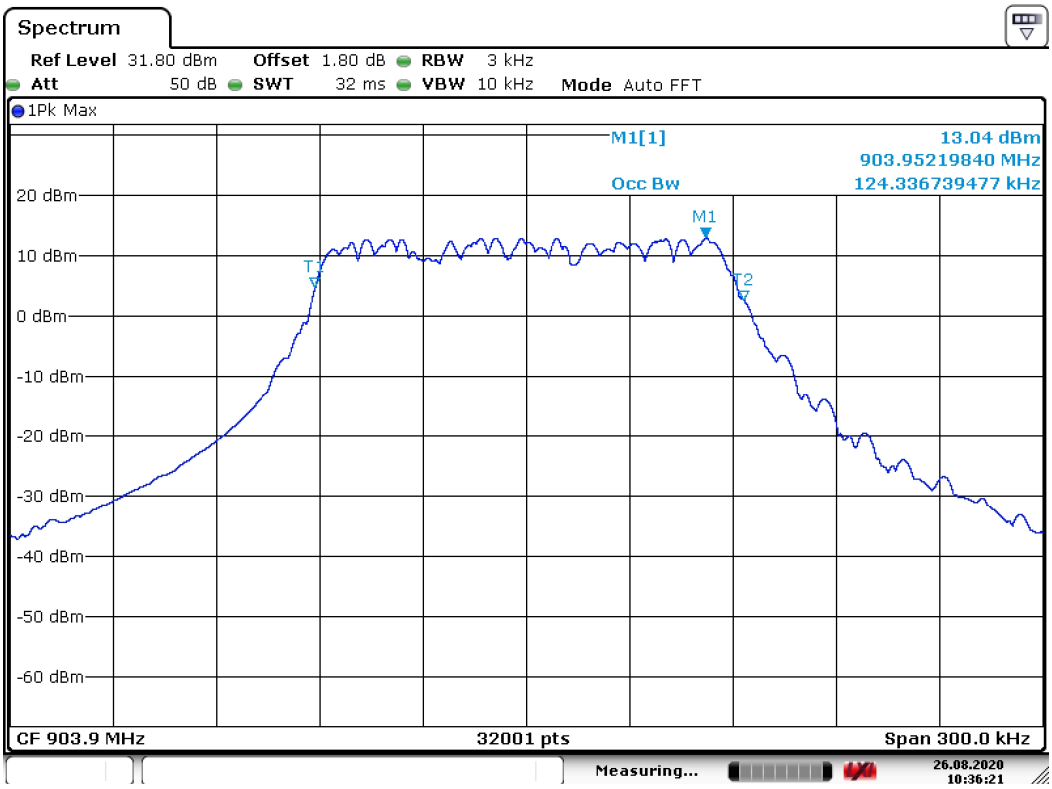
1. Set the centre frequency to the nominal EUT channel centre frequency
2. Set span = 1.5 times to 0.5 times the Occupied Bandwidth
3. Set VBW ≥ 3x RBW
4. Video averaging is not permitted. Where practical, detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until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

3.3.5 Test results of the 99% occupied bandwidth measurement

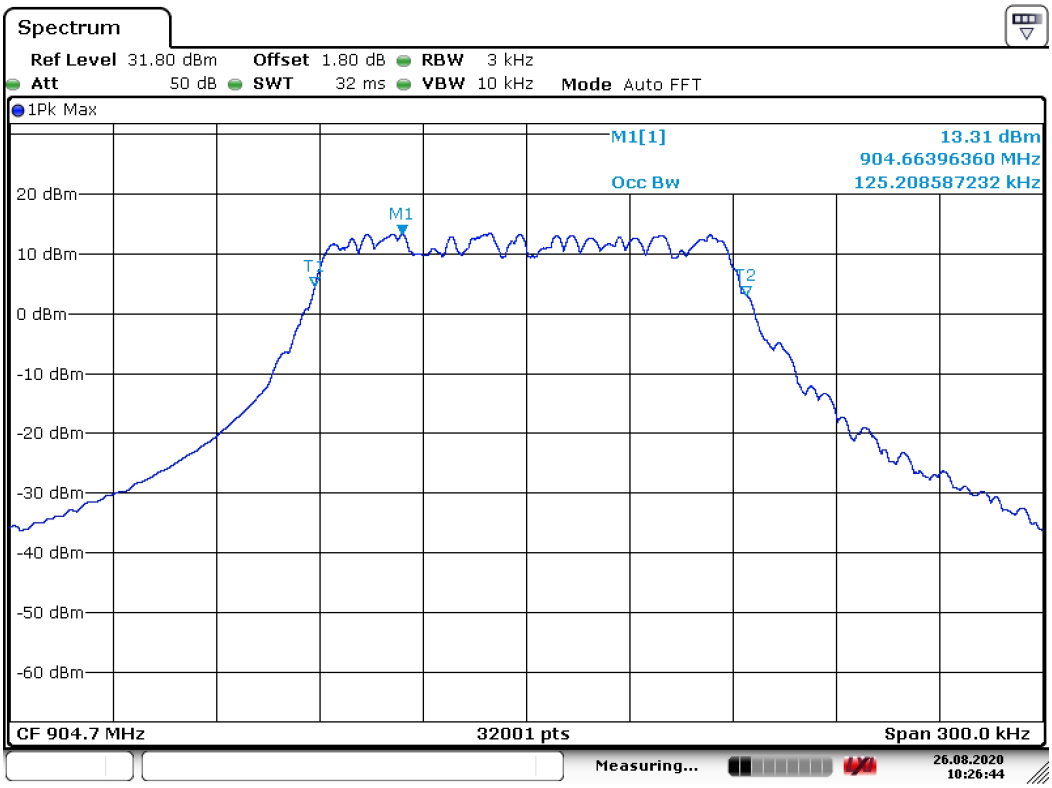
Technology Std.	Channel	Frequency (MHz)	Data rate	99% bandwidth (kHz)
LoRa	1	903.9	5470	124.3
	5	904.7	5470	125.2
	8	905.3	5470	126.2
Uncertainty	± 12 kHz			

3.3.6 Plots of the 99% occupied bandwidth measurement

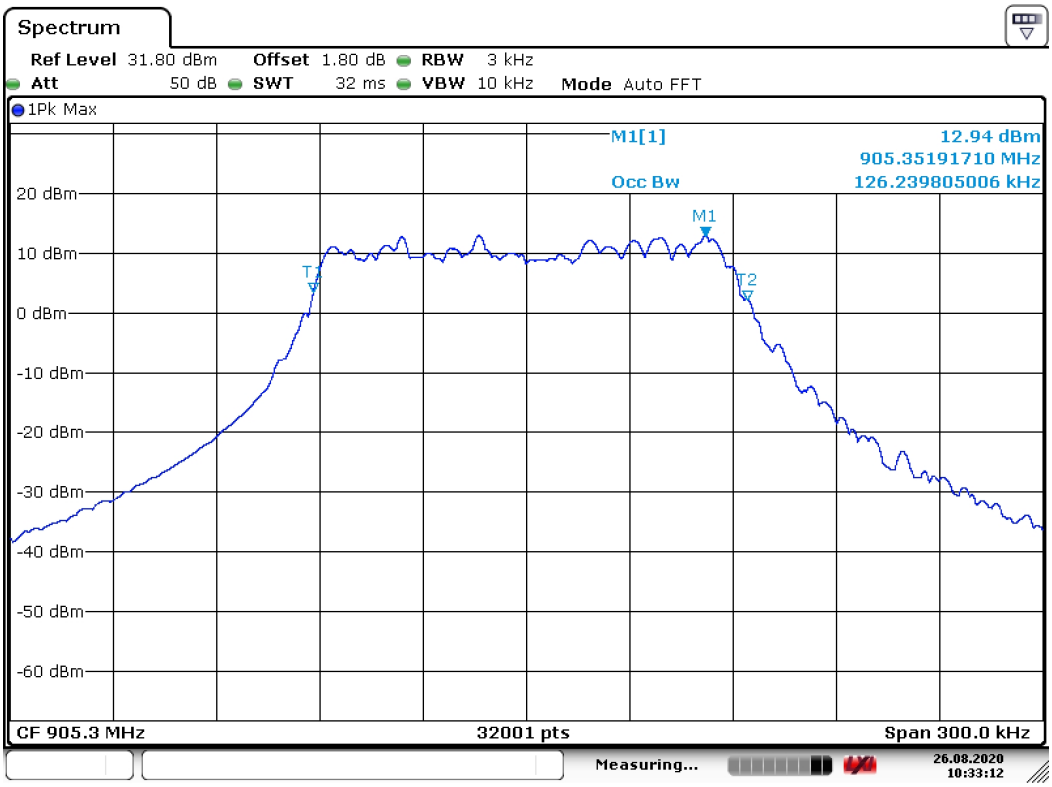
Channel 1



Channel 5



Channel 8



3.4 Output Power Measurement

3.4.1 Limit

For systems using digital modulation in the 2400-2483.5 MHz, 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.

3.4.2 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

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.

3.4.5 Test results of Output Power Measurement

Method AVGPWR2

Technology Std.	Channel	Frequency (MHz)	Data rate (bps)	Peak output power (dBm)
LoRa	1	903.9	5470	10.2
	5	904.7	5470	10.0
	8	905.3	5470	9.0
Uncertainty	±0.71 dB			

Note: The used power setting is “3” (10 dBm)

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 7

3.5.5 Test results of Power Spectral Density Measurement

Method AVGPSD-2

Technology Std.	Channel	Frequency (MHz)	Data rate (bps)	PSD (dBm/3 kHz)
LoRa	1	903.9	5470	-31.5
	5	904.7	5470	-31.2
	8	905.3	5470	-31.2
Uncertainty	±2 dB			

Note: The used power setting is “3” (10 dBm)

3.6 Average time of occupancy

3.6.1 Limit

The average time of occupancy on any frequency shall not exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

3.6.2 Measurement instruments

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

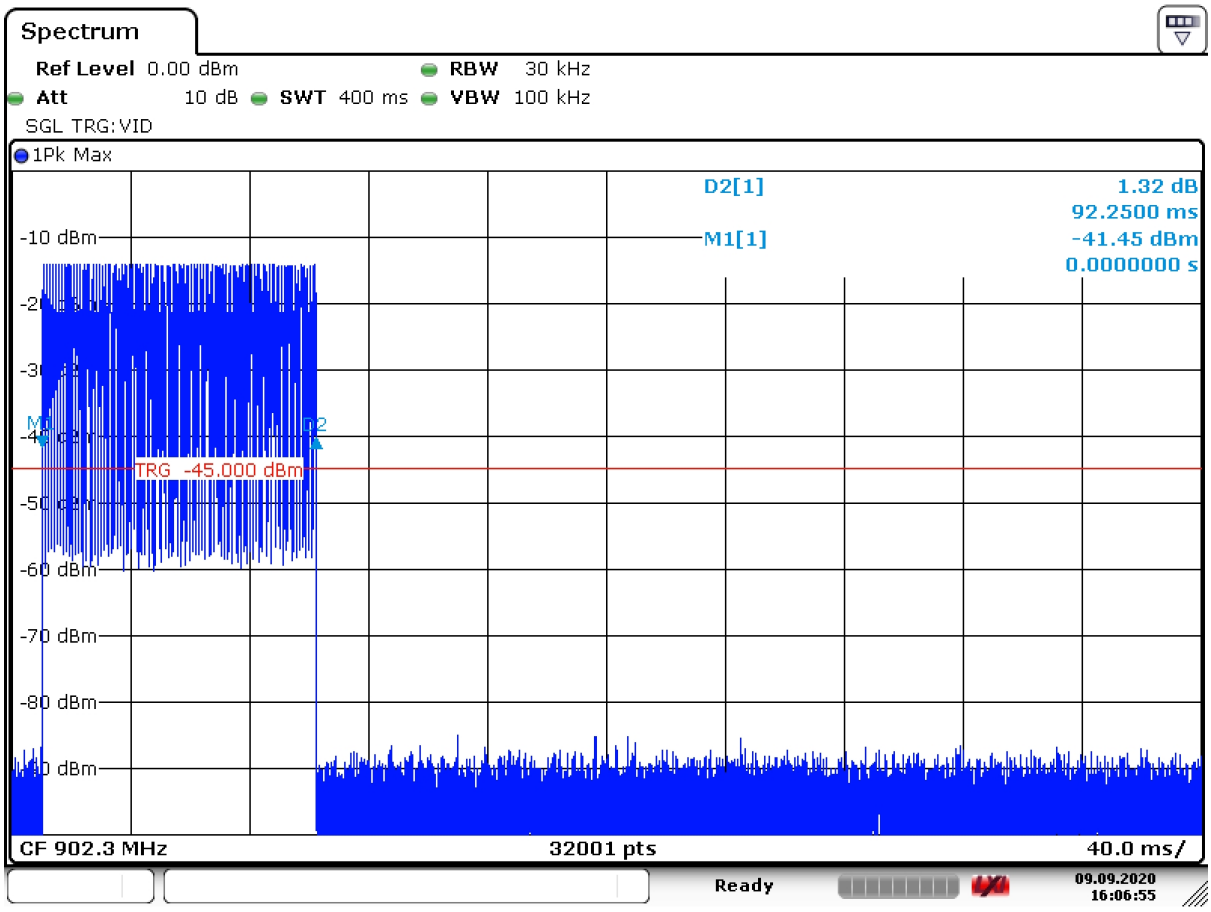
3.6.3 Test setup

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

3.6.4 Test procedure

According to clause 7.8.4 of ANSI C63.10
IRN 013 – Method 2

3.6.5 Plot of the average time of occupancy measurement.



The recorded occupancy time of the sensor is 92.3 msec.
Note: The manufacturer has declared the maximum occupancy time of the sensor can be 154 ms

Measurement uncertainty: ± 5.7%

3.7 Hopping function of a hybrid system: channel separation

3.7.1 Limit

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

3.7.2 Measurement instruments

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

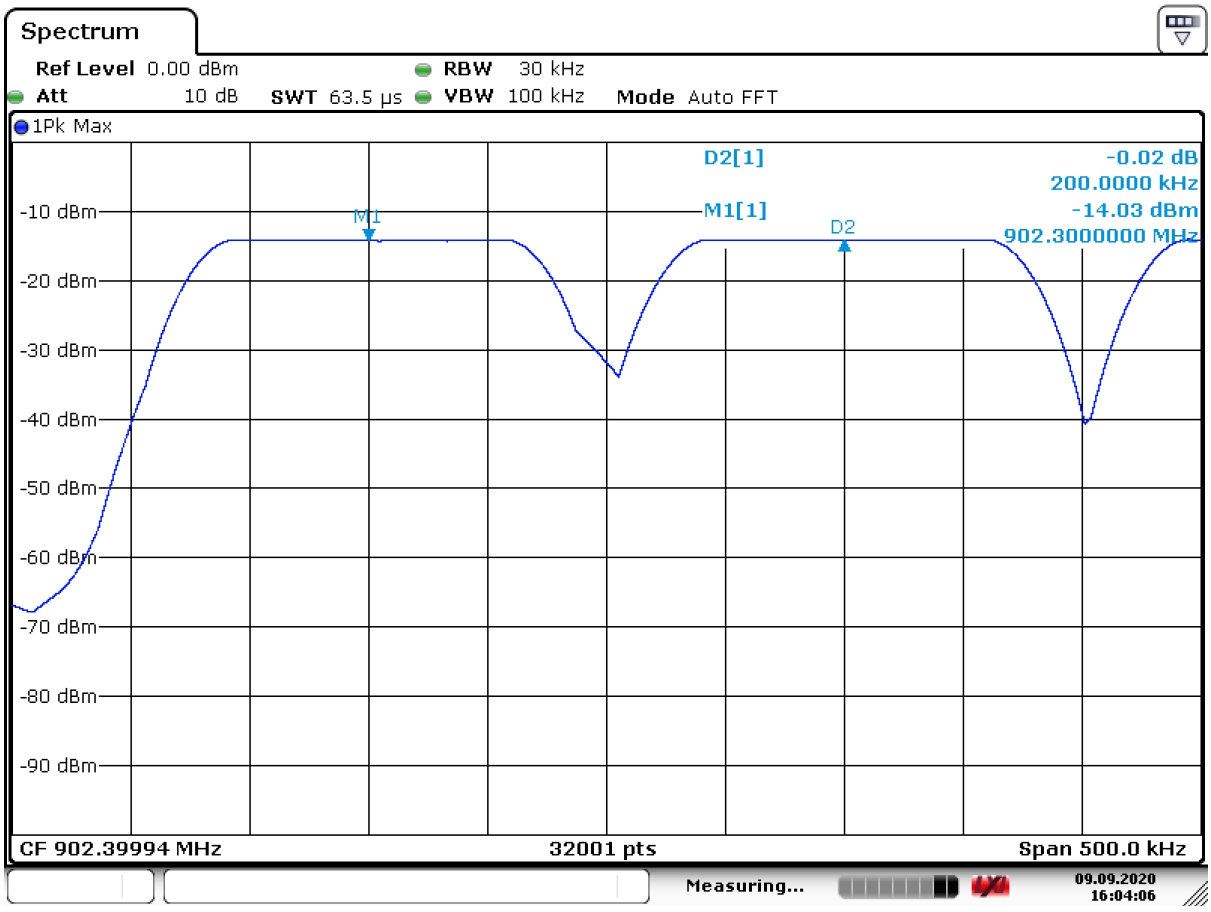
3.7.3 Test setup

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

3.7.4 Test procedure

According to clause 7.8.2 of ANSI C63.10
IRN 005 – Method 2

3.7.5 Plot of the channel separation measurement



The measured channel separation is: 200 kHz
Measurement uncertainty: ± 8 kHz

3.8 Hopping function requirements

3.8.1 Limit

The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

3.8.2 Result of the hopping function requirements check

The transmitter follows the LoRa Alliance protocol which complies with the pseudo-random hop sequence, equal use of each frequency, and receiver matching bandwidth and synchronization requirements.

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 Measurements:

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