

RADIO TEST REPORT

No. 1719774STO-003, Ed. 3

RF Performance

EQUIPMENT UNDER TEST

Equipment: VaiNet Wireless Temperature and Humidity Data logger

Type/Model: RFL100

Manufacturer: Vaisala Oyj

Tested by request of: Vaisala Oyj

SUMMARY

Referring to the emission limits, and the operating mode during the tests specified in this report, the equipment complies with the requirements according to the following standards:

47 CFR Part 15: Subpart C: Intentional radiators. Section 15.247

RSS-GEN Issue 4 (2014): General requirements of compliance of radio apparatus (2014)

RSS-247 Issue 2 (2017): Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

For details, see clause 2 – 4.

Date of issue: 2018-05-14

Tested by:


Matti Virkki

Approved by:


Hans Köhlén

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Revision History

Edition	Date	Description	Changes
1	2018-02-28	First release	
2	2018-03-20		Typing error corrections
3	2018-05-14		Conducted emissions from AC mains added

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1 CLIENT INFORMATION

The EUT has been tested by request of

Company Vaisala Oyj
Vanha Nurmijäventie 21
01670 Vantaa
Finland

Name of contact Hilikka Heiskari-Tuohiniemi

2 EQUIPMENT UNDER TEST (EUT)

2.1 Identification of the EUT

Equipment: VaiNet Wireless Temperature and Humidity Data logger
Type/Model: RFL100
Brand name: Vaisala
Serial numbers: M4900267 / M4900268
Manufacturer: Vaisala Oyj

Transmitter frequency range: 921.85 – 924.65 MHz
Receiver frequency range: 921.5 – 925 MHz
Number of channels: 8
Frequency agile or hopping: ☒ Yes, a hybrid device ☐ No
Antenna: ☒ Internal antenna ☐ External antenna
Antenna connector: ☒ None, internal antenna ☐ Yes
Antenna gain: 1 dBi
Rating RF output power: 11.4 dBm (measured conducted)
Type of modulation: LoRa
Temperature range: ☐ Category I (General): -20°C to +55°C
☐ Category II (Portable equipment): -10°C to +55°C
☐ Category III (Equipment for normal indoor use): +5°C to +35°C
☒ Other: <-20°C to +60°C

Transmitter stand by mode supported: ☒ Yes ☐ No

2.2 Test signals and operation modes

1. Continuous signal with LoRa modulation on lowest and highest operating frequency.
2. Normal operation mode for average occupation time measurement.

3 TEST SPECIFICATIONS

3.1 Standards

Requirements:

47 CFR Part 15: Subpart C: Intentional radiators. Section 15.247

RSS-GEN Issue 4 (2014): General requirements of compliance of radio apparatus (2014).

RSS-247 Issue 2 (2017): Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Test methods:

ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

3.2 Additions, deviations and exclusions from standards and accreditation

RSS-247 Issue 2 (2017) is not within Intertek's scope of accreditation.

No other additions, deviations or exclusions have been made from standards and accreditation.

3.3 Test site

Measurements were performed at:

Intertek Semko AB.
Torshamnsgatan 43,
P.O. Box 1103
SE-164 22 Kista

Intertek Semko AB is a FCC listed test site with site registration number 90913
Intertek Semko AB is a FCC accredited conformity assessment body with designation number SE0002
Intertek Semko AB is an Industry Canada listed test facility with IC assigned code 2042G

Measurement chambers

Measurement Chamber	Type of chamber	IC Site filing #
STORA HALLEN	Semi-anechoic 10 m and 3 m	2042G-2
Radio hallen	Fully-anechoic 3 m	2042G-4

4 TEST SUMMARY

The results in this report apply only to sample tested:

Requirement	Description	Result
FCC §15.203 RSS-GEN 8.3	Antenna requirement The EUT has integrated non detachable antenna which can't be remove without breaking the EUT.	PASS
FCC §15.207, 15.107 RSS-GEN 8.8 table 3	Conducted continuous emission in the frequency range 150 kHz to 30 MHz, AC Power input port The EUT complies with the limits.	PASS
FCC §15.247 (d), 15.209(a) RSS-GEN 8.9 RSS-247 5.5	Radiated emission of electromagnetic fields in the frequency range 30 – 1000 MHz The EUT complies with the limits.	PASS
FCC §15.247(d), 15.209(a) RSS-GEN 8.9 RSS-247 5.5	Radiated emission of electromagnetic fields in the frequency range above 1 GHz The EUT complies with the limits.	PASS
RSS-GEN 6.6 RSS-247 5.2(1)	Occupied bandwidth	PASS
FCC §15.247(b) RSS-247 5.4(4)	Conducted output power The EUT complies with the limits.	PASS
FCC §15.247(f) RSS-247 5.2(2)	Power spectral density The EUT complies with the limits.	PASS
FCC §15.247(f) RSS-247 5.2(2)	Transmitter average time of occupation	PASS
	The EUT complies with the limits.	
FCC §15.247(d) RSS-247 5.5	Band edge The EUT complies with the limits.	PASS

5 CONDUCTED CONTINUOUS DISTURBANCES in the frequency-range 0.15 – 30 MHz

5.1 Operating environment

Date of test:	2018-05-09	Test location:	Bur 3
EUT Serial:	M4900268	Ambient temp:	22 °C
Tested by:	Matti Virkki	Relative humidity:	33 %
Test result:	Pass	Margin:	> 20 dB

5.2 Test set-up and test procedure

The test method is in accordance with ANSI C63.4.

The EUT was connected to the power via Artificial Mains Networks AMN and Ethernet port was connected to the PC via impedance stabilizing network ISN.

The EUT was placed on an insulating support 0.8 m above the floor, 0.4 m from the vertical reference ground plane (RGP) and 0.8 m from the AMN/ISN.

Overview sweeps were performed for each lead.

During the tests the EUT was transmitting continuously on highest channel.

5.3 Measurement uncertainty

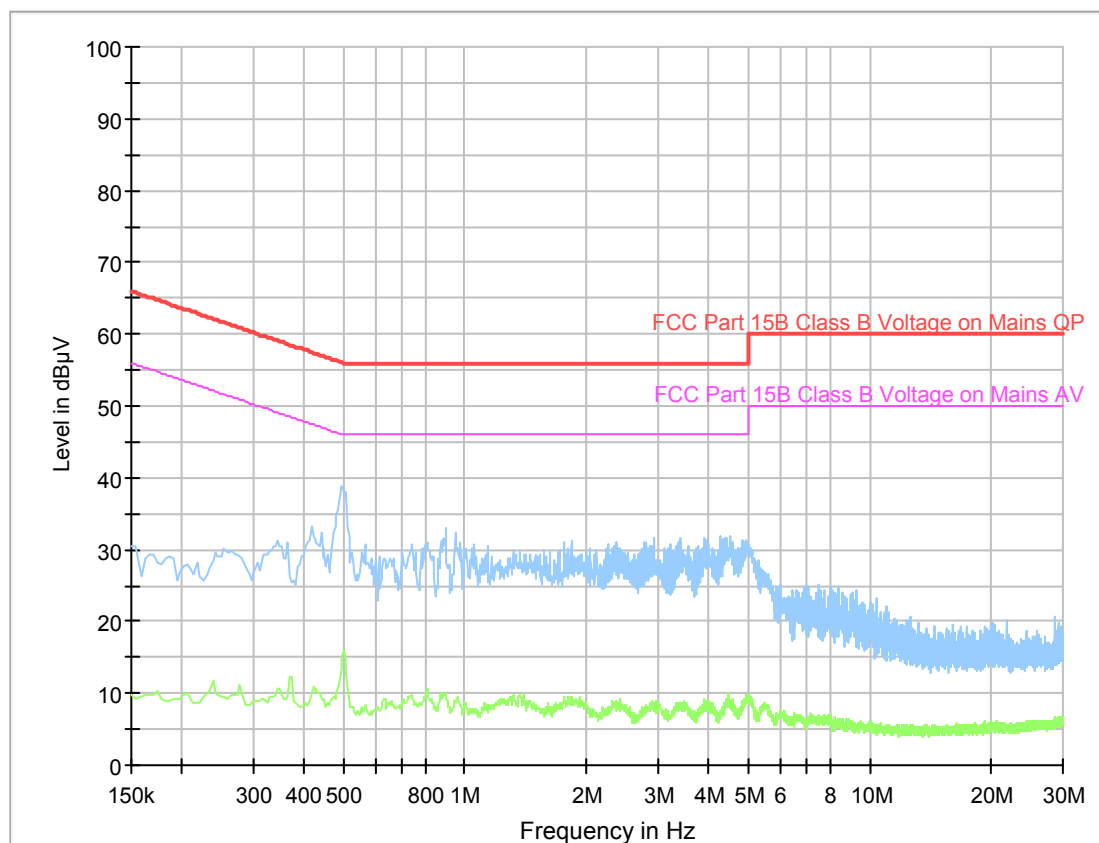
Continuous conducted disturbances with AMN
in the frequency range 150 kHz to 30 MHz

± 3.3 dB

Measurement uncertainty is calculated in accordance with CISPR 16-4-2: 2011.

The measurement uncertainty is given with a confidence of 95 %.

5.4 Test results, AC Power input port, Class B



Diagram, Peak and Average overview sweep

Measurement results, Quasi-peak, Class B

Not measured. No emissions within 20 dB from limit were found

Measurement results, Average, Class B

Not measured. No emissions within 20 dB from limit were found

Result [dBμV] = Analyser reading [dBμV] + cable loss [dB] + LISN insertion loss [dB]

6 RADIATED RF EMISSION IN THE FREQUENCY-RANGE 30 MHz TO 10 GHz

Date of test:	2018-01-23 / 2018-01-25	Test location:	Stora Hallen / Radio hallen
EUT Serial:	M4900268	Ambient temp:	21 / 22 °C
Tested by:	Matti Virkki	Relative humidity:	18 / 21 %
Test result:	Pass	Margin:	11.2 dB

6.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013.
The EUT was set up in order to emit maximum disturbances.

30 – 1000 MHz: The EUT was placed on an insulating support 0.8 m above the turntable which is part of the reference ground plane.

1 – 10 GHz: The EUT was placed 1.5 m above the floor on a positioner which allows EUT to rotate freely around its X and Y axis

Overview sweeps were performed with the measurement receiver in max-hold mode and the peak detector activated in the frequency-range 30 – 1000 MHz. Above 1 GHz additionally the average detector was activated.

6.2 Test conditions

Test set-up:

Test receiver set-up:

Preview test:

Final test:

EUT height above ground plane:

Measuring distance:

Measuring angle:

Antenna

Height above ground plane:

Polarisation:

Type:

30 MHz to 1000 MHz

Peak,

RBW 120 kHz

VBW 1 MHz

Quasi-Peak,

RBW 120 kHz

VBW 1 MHz

0.8 m

3 m

0 – 359°

1 – 4 m

Vertical and Horizontal

Bilog

Test set-up:

Test receiver set-up:

Preview test:

Final test:

EUT height above ground plane:

Measuring distance:

Measuring angle:

Antenna

Height above ground plane:

Polarisation:

Type:

Antenna tilt:

1 GHz – 10 GHz

Peak,

RBW 1 MHz

VBW 3 MHz

Average,

RBW 1 MHz

VBW 3 MHz

Peak,

RBW 1 MHz

VBW 3 MHz

Average

RBW 1 MHz

VBW 3 MHz

1.5 m

3 m

0 – 359°

1.5 m

Vertical and Horizontal

Horn

The EUT is rotated around its axis as described in ANSI C63.10 (2013) clause 6.6.5

6.3 Requirements

Within restricted bands

Reference: CFR 47 §15.209, RSS-Gen section 8.9

Field strength of emissions must comply with limits shown in table below

Frequency range [MHz]	Field strength at 3 m (dB μ V/m)	Field strength at 10 m (dB μ V/m)	Detector (dB μ V/m)
30 – 88	40.0	29.5	Quasi Peak
88 – 216	43.5	33.0	Quasi Peak
216 – 960	46.0	35.5	Quasi Peak
960 – 1000	54.0	43.5	Quasi Peak
Above 1000	54.0 / 74.0	43.5 / 63.5	Average / Peak

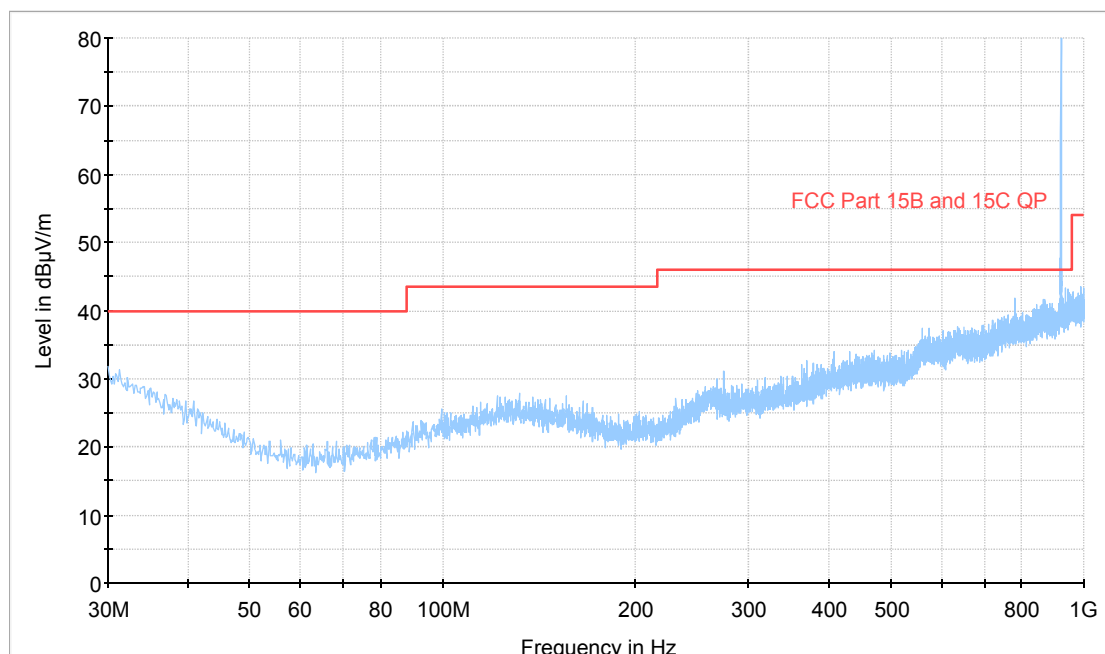
The values for 10 m measuring distance are calculated by subtracting 10.5 dB from the 3 m limit. (i.e. an extrapolation factor of 20 dB/decade according to CFR 47 §15.31(f)(1))

Outside the restricted bands:

Reference: CFR 47 §15.247(d), RSS-247 5.5,

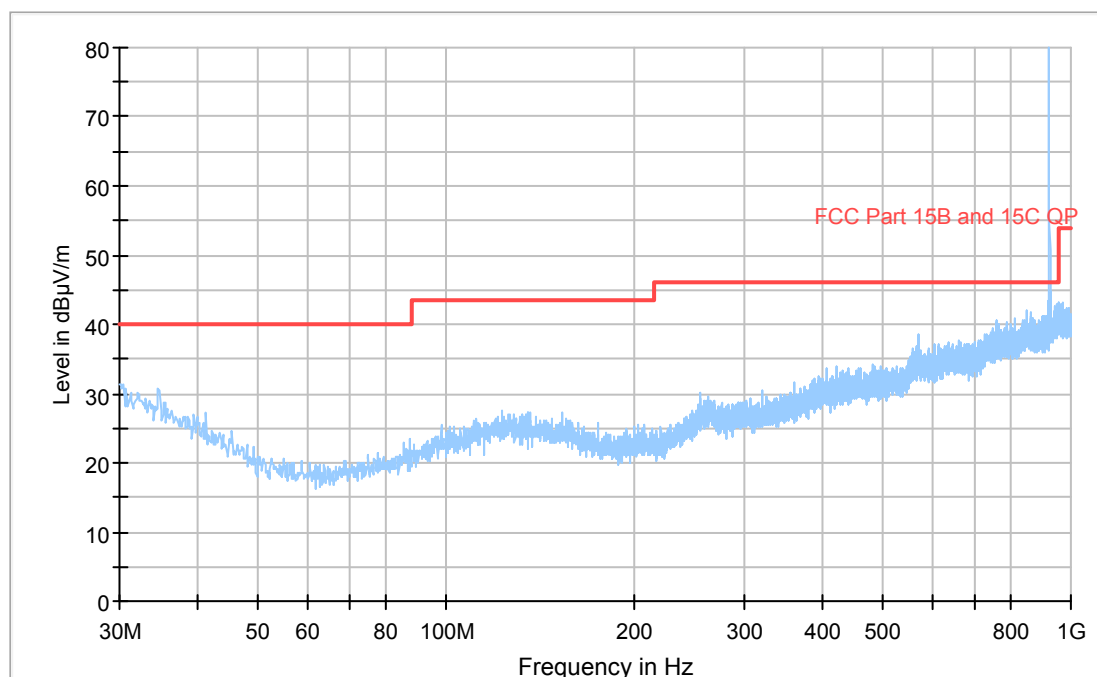
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits.

6.4 Test results 30 MHz – 1000 MHz, TX



Diagram, Peak overview sweep, 30 – 1000 MHz at 3 m distance. TX low channel

Full Spectrum



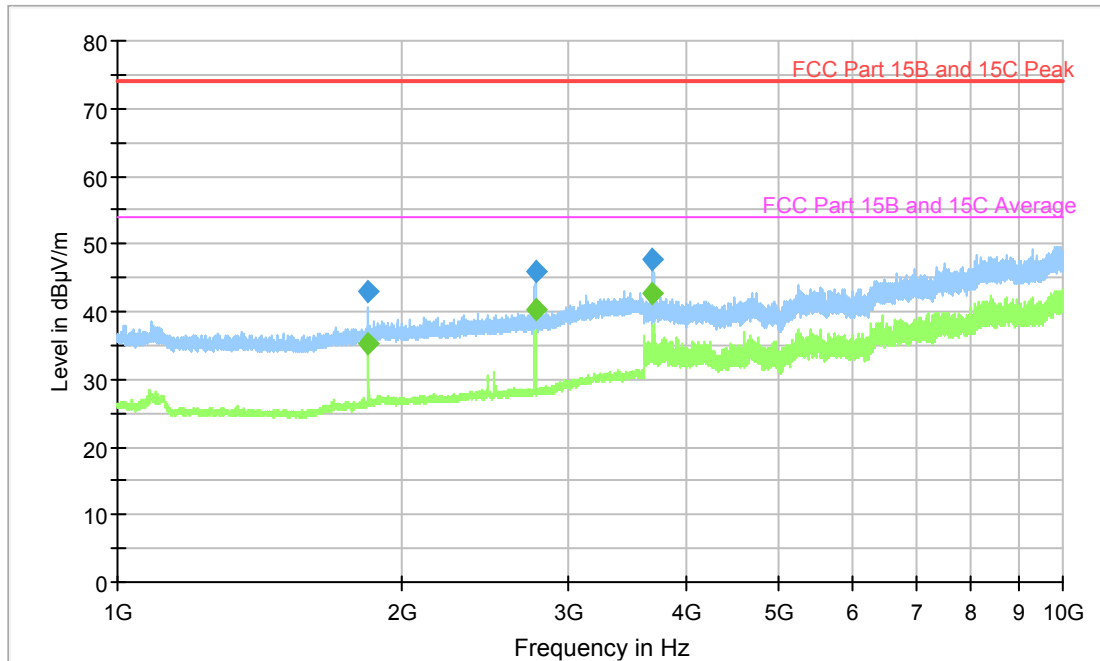
Diagram, Peak overview sweep, 30 – 1000 MHz at 3 m distance. TX high channel

Measurement results, Quasi Peak

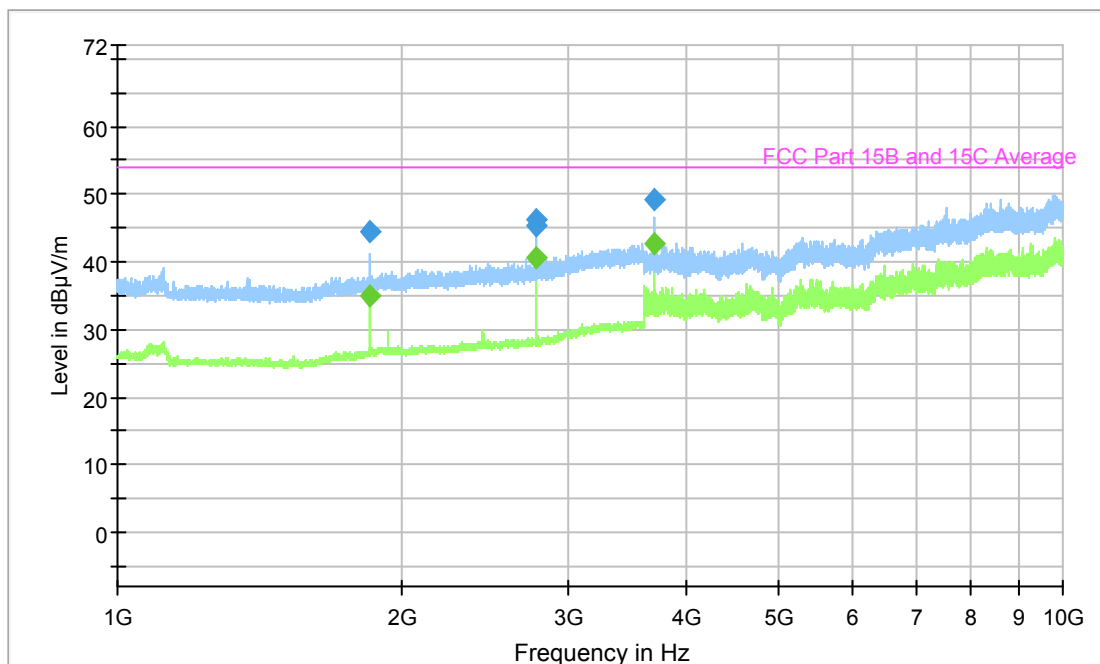
No emissions other than carrier are found above noise floor or closer than 20 dB from limit. Margin to noise floor is at least 6 dB.

Result [dBµV/m] = Analyser reading [dBµV] + Antenna factor [1/m] - Amplifier gain [dB] + Cable loss [dB]

6.5 Test results 1 GHz – 10 GHz, TX



Diagram, Peak overview sweep, 1– 10 GHz at 3 m distance. TX low channel



Diagram, Peak overview sweep, 1– 10 GHz at 3 m distance. TX high channel

Measurement results, Peak, TX low channel

Frequency [MHz]	Level [dBμV/m]	Limit [dBμV/m]	EUT Orientation [deg]	Polarization H/V	Margin [dB]
1843.9	42.9	74.0	49.0	V	31.1
2765.4	45.9	74.0	79.0	H	28.1
3686.8	47.6	74.0	70.0	V	26.4

Measurement results, Average, TX low channel

Frequency [MHz]	Level [dBμV/m]	Limit [dBμV/m]	EUT Orientation [deg]	Polarization H/V	Margin [dB]
1843.6	35.1	54.0	60.0	H	18.9
2765.5	40.3	54.0	120.0	H	13.7
3687.1	42.8	54.0	150.0	V	11.2

Measurement results, Peak, TX high channel

Frequency [MHz]	Level [dBμV/m]	Limit [dBμV/m]	EUT orientation	Polarization H/V	Margin [dB]
1849.2	44.4	74.0	58.0	H	29.6
2773.5	45.3	74.0	62.0	H	28.7
2774.0	46.1	74.0	62.0	H	27.9
3698.7	49.3	74.0	126.0	V	24.7

Measurement results, Average, TX high channel

Frequency [MHz]	Level [dBμV/m]	Limit [dBμV/m]	EUT Orientation [deg]	Polarization H/V	Margin [dB]
1849.0	34.9	54.0	90.0	H	19.1
2773.9	40.6	54.0	60.0	H	13.4
3698.8	42.8	54.0	150.0	V	11.2

Result [dBμV/m] = Analyser reading [dBμV] + Antenna factor [1/m] - Amplifier gain [dB] + Cable loss [dB]

7 CONDUCTED BAND EDGE MEASUREMENT

Date of test:	2018-02-14	Test location:	Wireless Center
EUT Serial:	M4900267	Ambient temp:	21 °C
Tested by:	Matti Vlrkki	Relative humidity:	16 %
Test result:	Pass	Margin:	19.8 dB

7.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013 section 6.10.4.

The EUT was connected to spectrum analyser via rf-cable and attenuator.

The EUT was set up in order to emit maximum disturbances.

7.2 Test conditions

Detector: Peak,
RBW: 100 kHz
VBW: 300 kHz

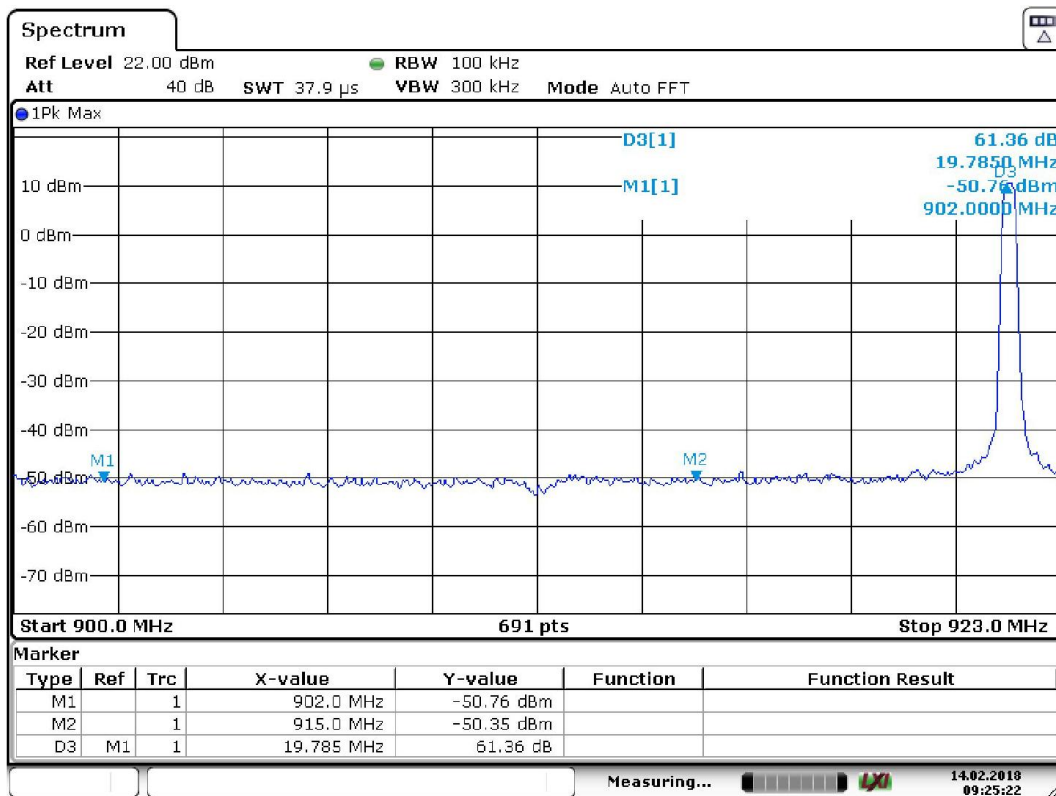
7.3 Requirement

Reference: CFR 47 §15.247(d), RSS-247 5.5,

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

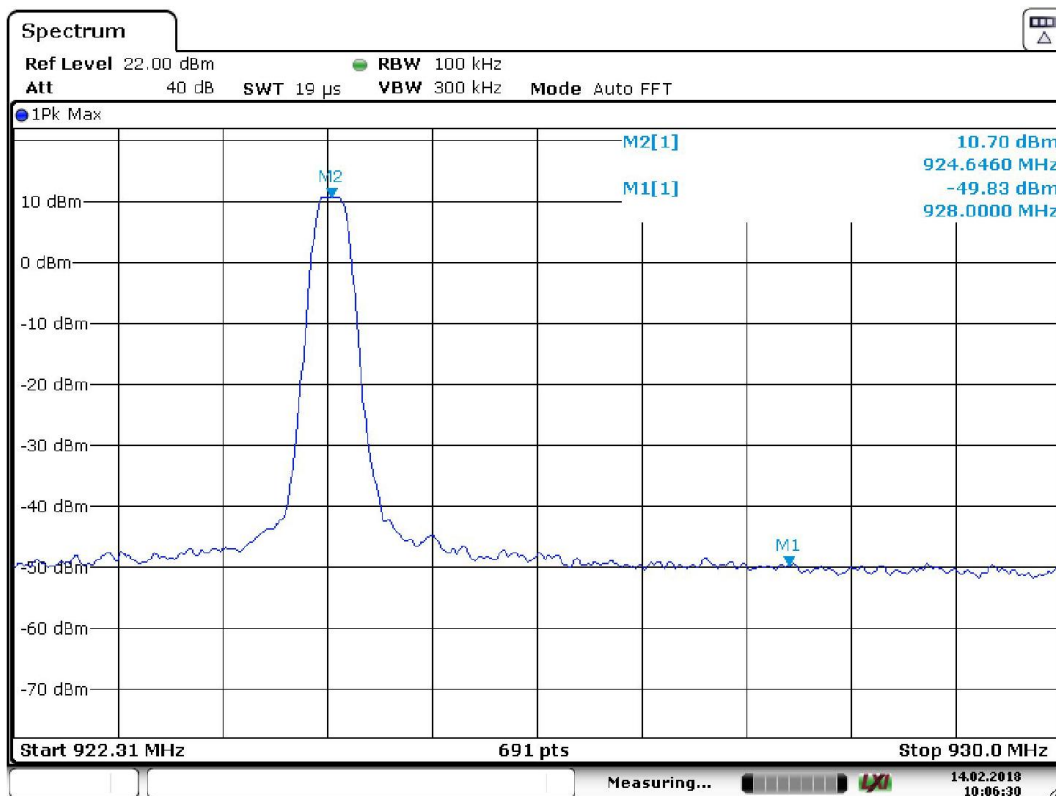
7.4 Test results

Band edge	Delta [dBc]	Limit [dBc]	Margin [dB]
Lower	50.8	30.0	20.8
Upper	49.8	30.0	19.8



Date: 14.FEB.2018 09:25:22

Screenshot: Lower band edge sweep,



Date: 14.FEB.2018 10:06:31

Screenshot: Upper band edge sweep, single channel

8 CONDUCTED OUTPUT POWER

Date of test:	2018-02-14	Test location:	Wireless Center
EUT Serial:	M4900267	Ambient temp:	21 °C
Tested by:	Matti Vlrkki	Relative humidity:	16 %
Test result:	Pass	Margin:	18.6 dB

8.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013 section 11.9.2.2.2

The EUT was connected to spectrum analyser via rf-cable and attenuator.

8.2 Test conditions

Detector: RMS,
Trace: average
RBW: 1 – 5 % of OBW
VBW: 3 x RBW
Span: >2 x OBW

The EUT was set up in order to emit maximum disturbances.

8.3 Requirements

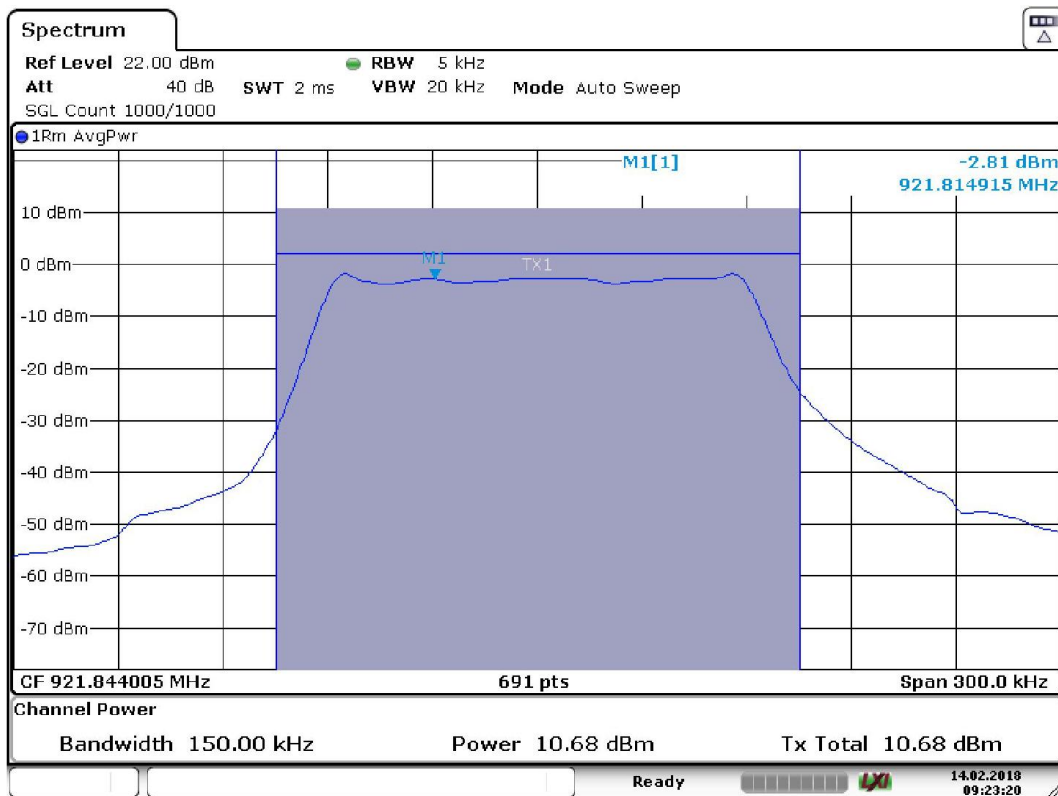
Reference: CFR 47§15.247(b)(3), RSS-247 5.4

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

8.4 Test results

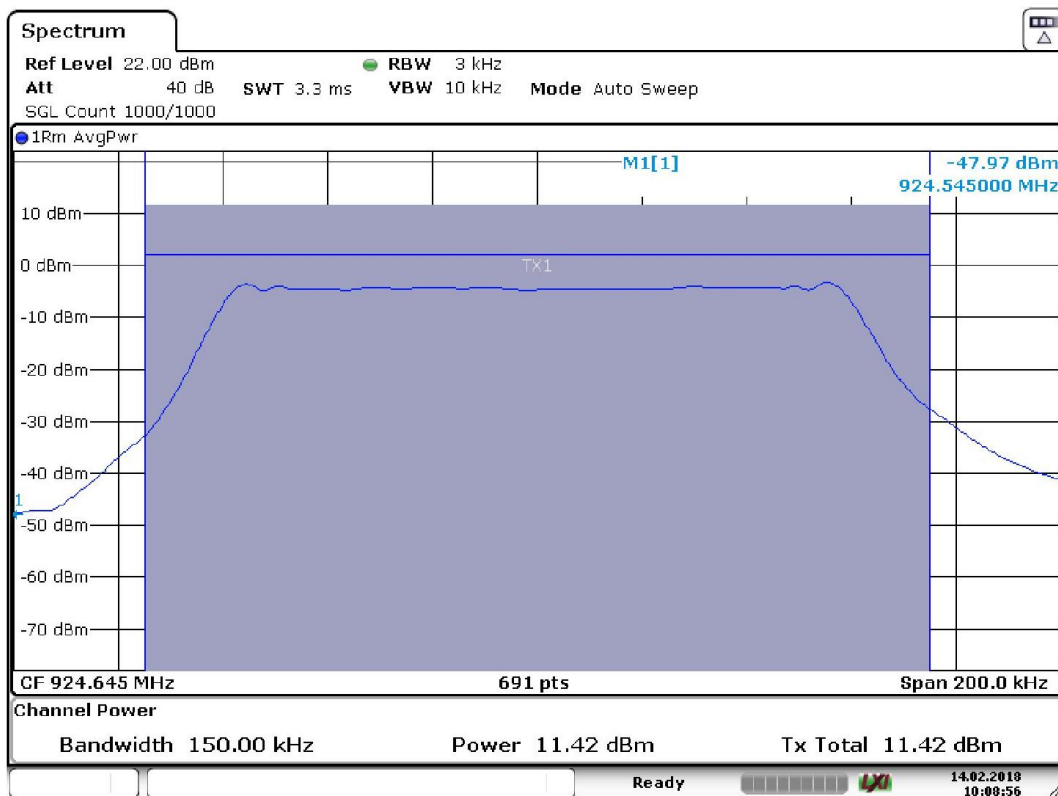
Test result

Channel [MHz]	Output power [dBm]	Limit [dBm]	Margin [dB]
921.85	10.7	30	19.3
924.65	11.4	30	18.6



Date: 14.FEB.2018 09:23:20

Screenshot: Output power, low channel



Date: 14.FEB.2018 10:08:57

Screenshot: Output power, high channel

9 99 % BANDWIDTH

Date of test:	2018-02-14	Test location:	Wireless Center
EUT Serial:	M4900267	Ambient temp:	21 °C
Tested by:	Matti Vlrkki	Relative humidity:	16 %
Test result:	NA	Margin:	NA

9.1 Test set-up and test procedure.

The test method is in accordance with RSS-GEN section 6.6.

The EUT was connected to spectrum analyser via rf-cable and attenuator. Spectrum analyser with occupied bandwidth measurement function is used to determine the occupied bandwidth.

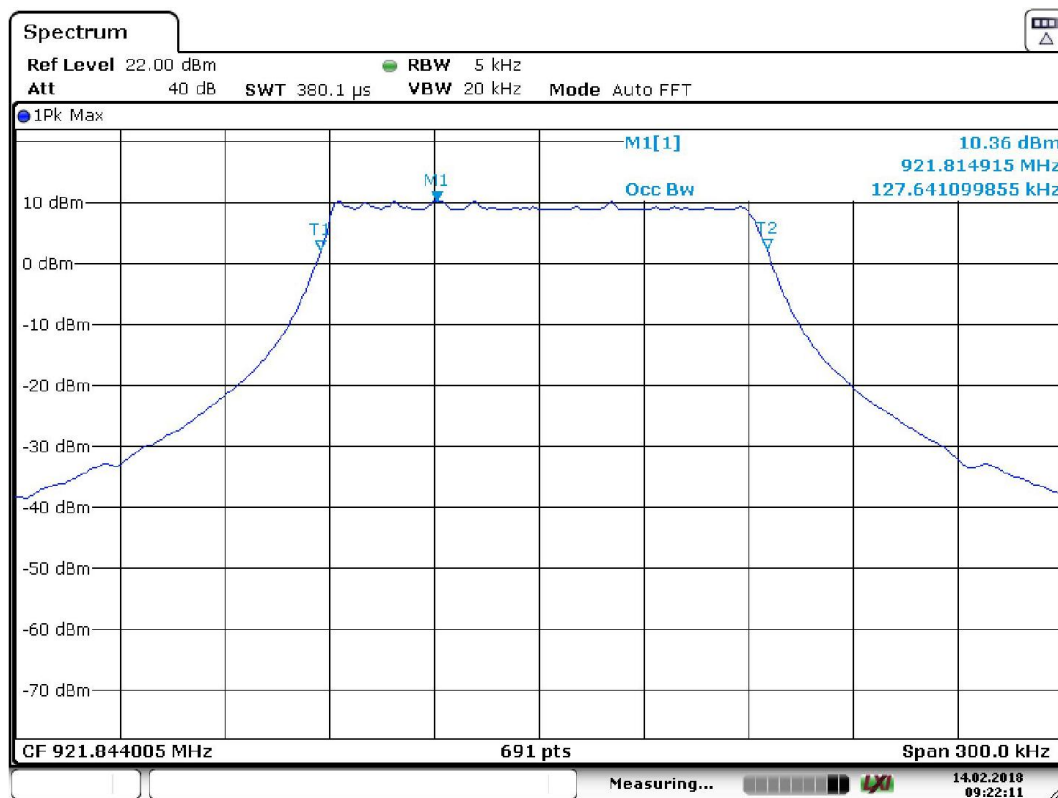
9.2 Test conditions

Detector: Peak,
RBW: 1 – 5 % of OBW
VBW: 3 x RBW

The EUT was set up in order to emit maximum disturbances.

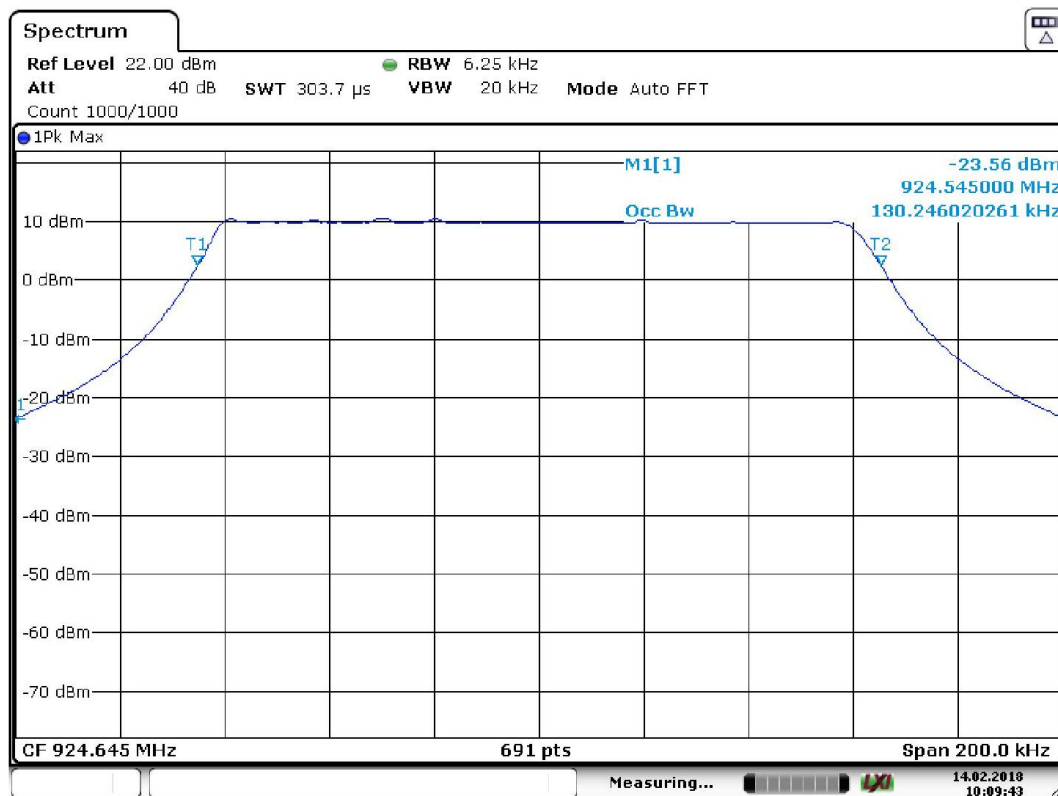
9.3 Test results

Channel [MHz]	99 % BW [kHz]
921.85	127.8
924.65	130.2



Date: 14.FEB.2018 09:22:11

Screenshot: 99 % bandwidth Measurement, low channel



Date: 14.FEB.2018 10:09:43

Screenshot: 99 % bandwidth Measurement, high channel

10 POWER SPECTRAL DENSITY

Date of test:	2018-02-14	Test location:	Wireless Center
EUT number:	M4900267	Ambient temp:	21 °C
Tested by:	Matti Vlrkki	Relative humidity:	16 %
Test result:	Pass	Margin:	10.8 dB

10.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013 section 11.10.3.

The EUT was connected to spectrum analyser via rf-cable and attenuator.

10.2 Test conditions

Detector: rms
 Trace: average
 RBW: 3 kHz
 VBW: >3 x RBW
 Span: 1.5 x OBW

The EUT was set up in order to emit maximum disturbances.

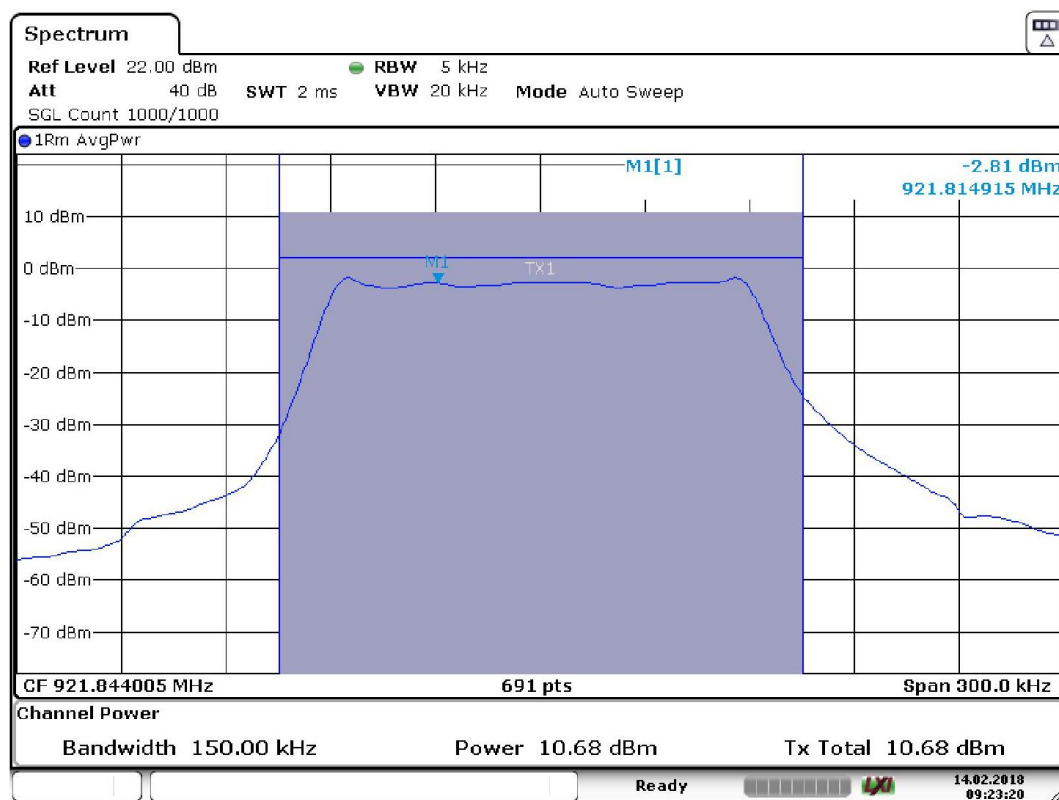
10.3 Requirements

Reference: CFR 47§15.247(3), RSS-247 5.2(2)

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

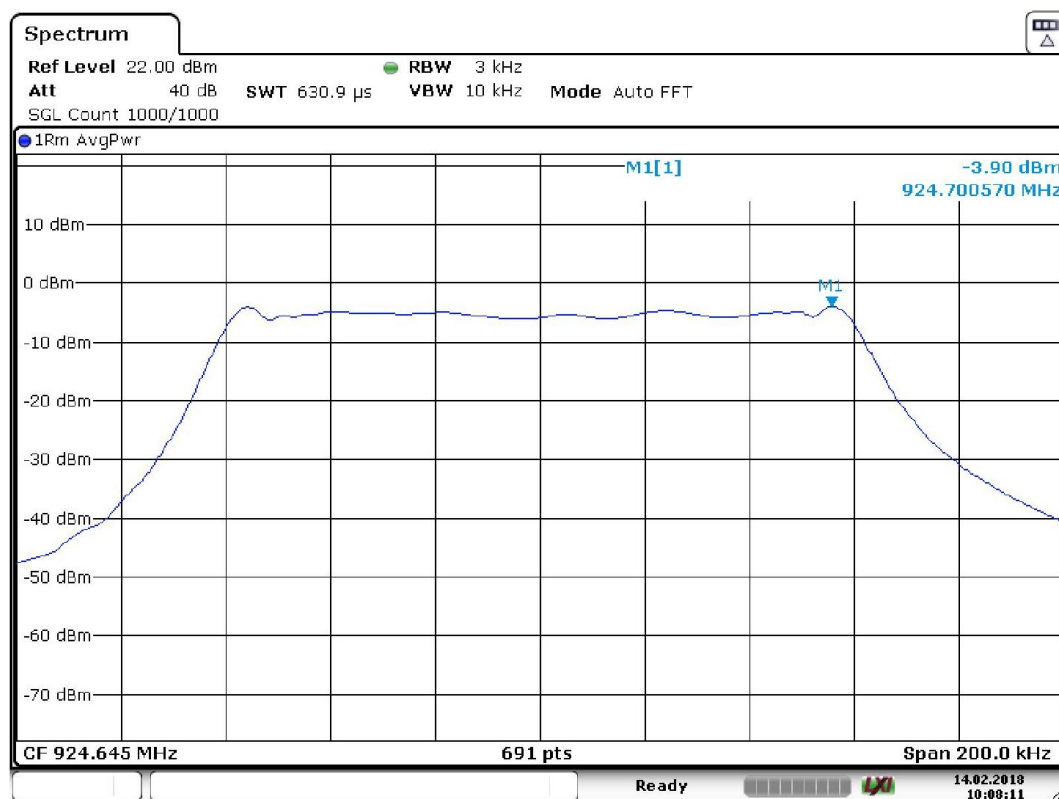
10.4 Test results

Channel [MHz]	PSD [dBm/3kHz]	Limit [dBm/3kHz]	Margin [dB]
921.85	-2.8	8	10.8
924.65	-3.9	8	11.9



Date: 14.FEB.2018 09:23:20

Screenshot: power spectral density, low channel



Date: 14.FEB.2018 10:08:11

Screenshot: power spectral density, high channel

11 TRANSMITTER AVERAGE TIME OF OCCUPANCY

Date of test:	2018-02-23	Test location:	Wireless Center
EUT Serial:	M4900267	Ambient temp:	21°C
Tested by:	Matti Vlrkki	Relative humidity:	16 %
Test result:	Pass	Margin:	2.9 s

11.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10.section 7.5

The EUT was connected to spectrum analyser via rf-cable and attenuator.

11.2 Test conditions

Detector: Peak
 RBW 30 kHz
 VBW 30 kHz
 Span 0 Hz
 Sweep time 1000 ms

11.3 Requirement

CFR 47 15.247 (f) The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

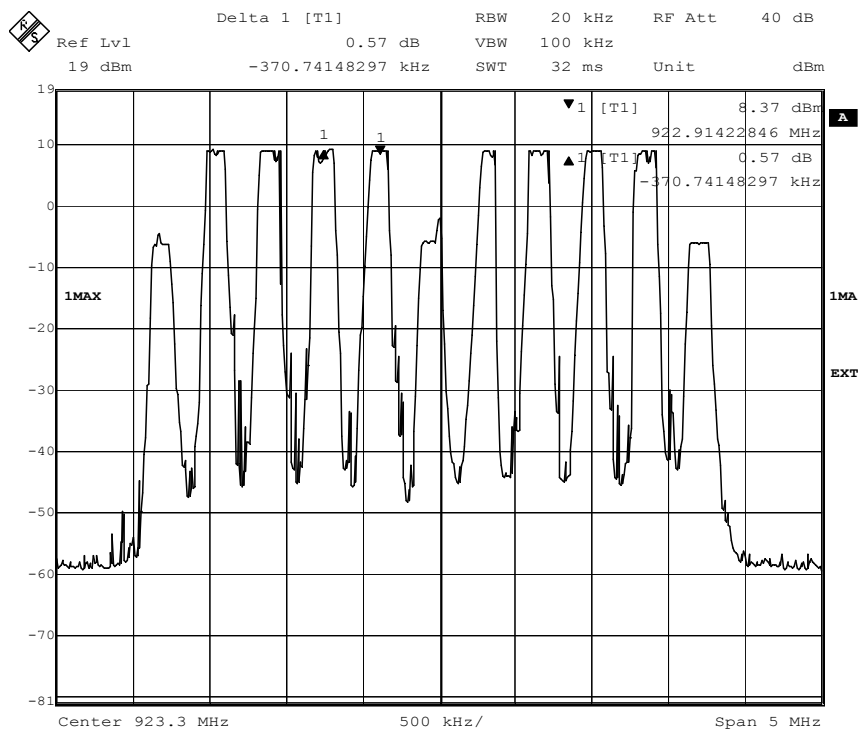
11.4 Test results

Number of hopping channels = 8

$T_{on} \text{ Limit} = 8 * 0.4s = 3.2 \text{ s}$

One burst is 230 ms long and occurred once during the measurement period once.

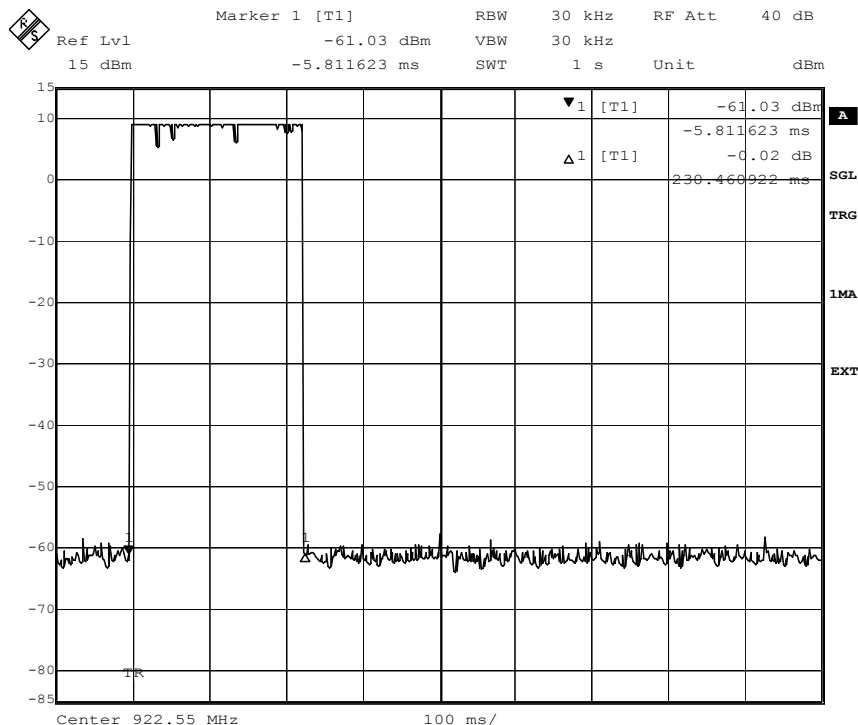
The EUT fulfils the requirement.



Date: 23.FEB.2018 10:30:48

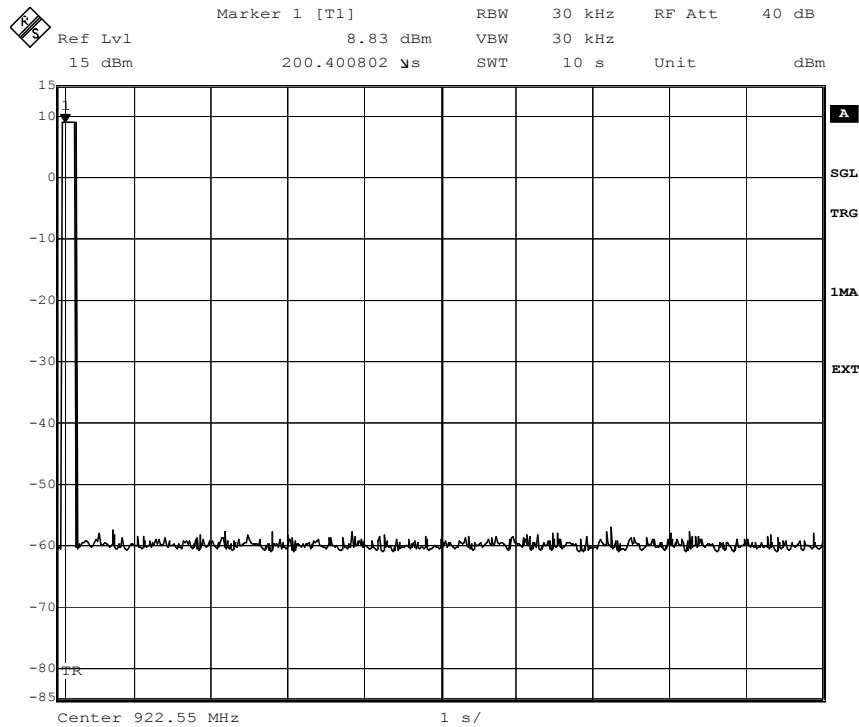
Screen shot number of hopping frequencies.

3 attenuated frequencies are from companion device the EUT was communicating with.



Date: 23.FEB.2018 12:04:25

Screen shot: transmission burst length



Date: 23.FEB.2018 12:01:54

Screen shot: Number of transmission

12 TEST EQUIPMENT

Stora Hallen

Equipment type	Manufacturer	Model	Inv. No.	Last Cal. date	Cal. interval
Measurement software	Rohde & Schwarz	EMC32 -	--	--	--
Receiver	Rohde & Schwarz	ESU 8	12866	7/2017	1 year
BiLog antenna	Chase	CBL6110A	971	9/2017	3 years
Preamplifier	Semko	AM-1331	7993	6/2017	1 year
Horn antenna	Rohde & Schwarz	HF907	31245	12/2016	3 years
Preamplifier	Rohde & Schwarz	BLMA0118	31246	4/2017	1 year

Wireless Center and 3m FAC

Equipment type	Manufacturer	Model	Inv. No.	Last Cal. date	Cal. interval
Measurement software	Rohde & Schwarz	EMC32 -	--	--	--
Receiver	Rohde & Schwarz	Version ESU 40	12793	7/2017	1 year
Measurement cable	Huber + Suhner	Sucoflex 104 PE	39070	7/2017	1 year
Measurement cable	Huber + Suhner	Sucoflex 104 PE	39079	7/2017	1 year
Measurement cable	Huber + Suhner	Sucoflex 104	5191	7/2017	1 year
Horn antenna	EMCO	3115	4936	7/2017	3 years
Pre amplifier	Sangus	00101400-23-10P -6-S ; AFS44-12002400-32-10P -44	12335	7/2017	1 year
High pass filter	Microwave circuits	H1G013G1	13142	8/2017	1 year
Signal analyser:	Rohde & Schwarz	FSV 30	32594	7/2017	1 year
Signal analyser	Rohde & Schwarz	FSIQ 40	12793	7/2017	1 year

13 MEASUREMENT UNCERTAINTY

Continuous conducted disturbances with AMN in the frequency range 9 kHz to 30 MHz ± 3.7 dB

Measurement uncertainty for radiated disturbance

Uncertainty for the frequency range 30 to 1000 MHz at 3 m	± 5.1 dB
Uncertainty for the frequency range 30 to 1000 MHz at 10 m	± 5.0 dB
Uncertainty for the frequency range 1.0 to 18 GHz at 3 m	± 4.7 dB
Uncertainty for the frequency range 18 to 26 GHz at 3 m	± 4.8 dB
Uncertainty for the frequency range 26 to 40 GHz at 3 m	± 5.7 dB

Measurement uncertainty is calculated in accordance with CISPR 16-4-2:2011.

The measurement uncertainty is given with a confidence of 95 %.

14 TEST SET UP AND EUT PHOTOS

EUT photos are in separate document 1719774STO-002 Annex 1.

Test set up photos are in separate document 1719774STO-002 Annex 2.