

# 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 Köhler

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

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

**5.1 Operating environment**

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

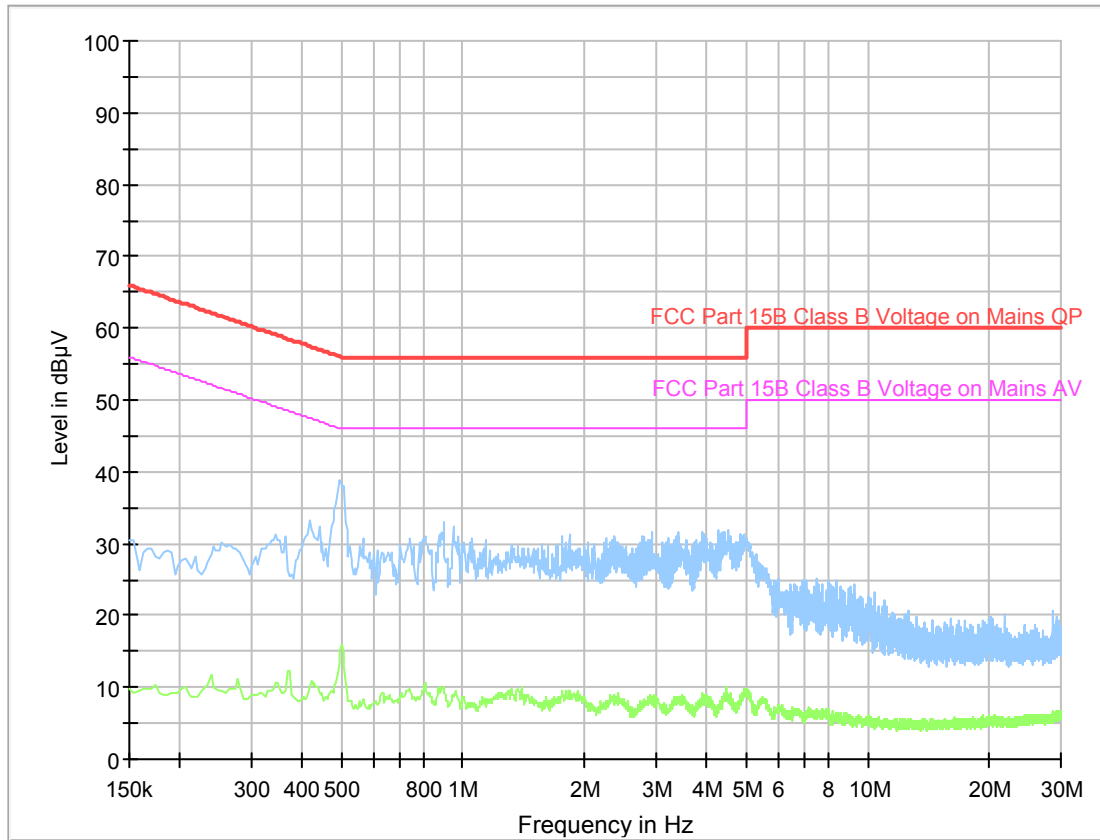
Continuous conducted disturbances with AMN  
in the frequency range 150 kHz to 30 MHz

± 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**

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

**30 MHz to 1000 MHz**

Test receiver set-up:  
 Preview test: Peak, RBW 120 kHz VBW 1 MHz  
 Final test: Quasi-Peak, RBW 120 kHz VBW 1 MHz  
 EUT height above ground plane: 0.8 m  
 Measuring distance: 3 m  
 Measuring angle: 0 – 359°  
 Antenna  
     Height above ground plane: 1 – 4 m  
     Polarisation: Vertical and Horizontal  
     Type: Bilog

**Test set-up:**

**1 GHz – 10 GHz**

Test receiver set-up:  
 Preview test: Peak, RBW 1 MHz VBW 3 MHz  
                   Average, RBW 1 MHz VBW 3 MHz  
 Final test: Peak, RBW 1 MHz VBW 3 MHz  
                   Average RBW 1 MHz VBW 3 MHz  
 EUT height above ground plane: 1.5 m  
 Measuring distance: 3 m  
 Measuring angle: 0 – 359°  
 Antenna  
     Height above ground plane: 1.5 m  
     Polarisation: Vertical and Horizontal  
     Type: Horn  
     Antenna tilt: 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 (dBµV/m)	Field strength at 10 m (dBµV/m)	Detector (dBµV/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

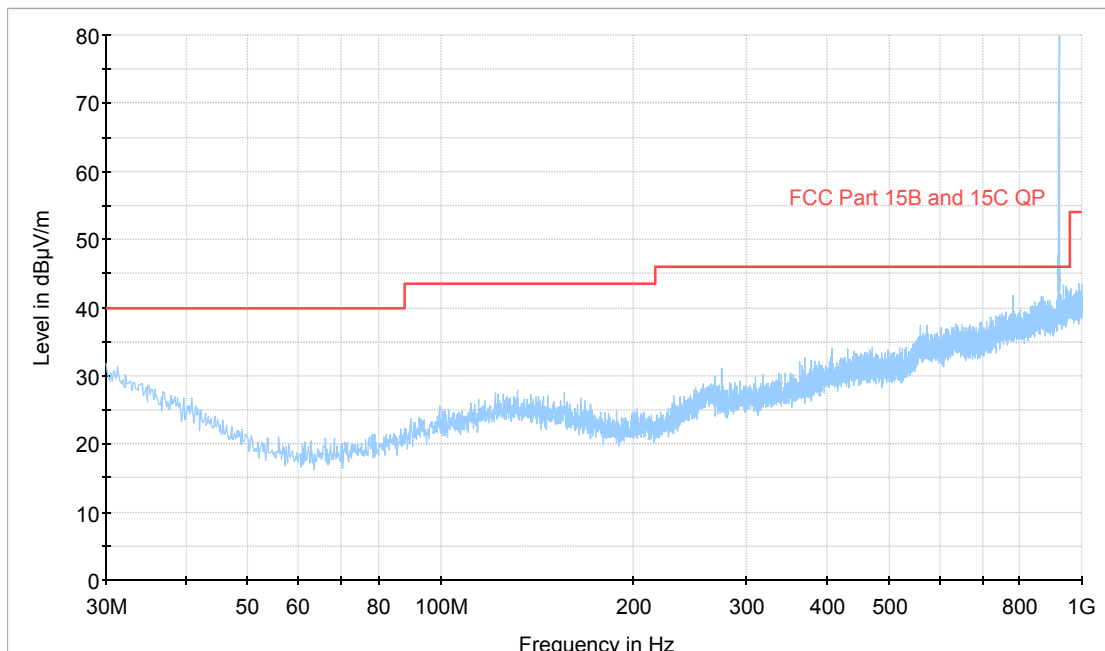
The values for 10 m measuring distance are calculated by subtracting 10.5 dB from the 3 m limit. (i.e. an extrapolation factor of 20 dB/decade according to CFR 47 §15.31(f)(1))

Outside the restricted bands:

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

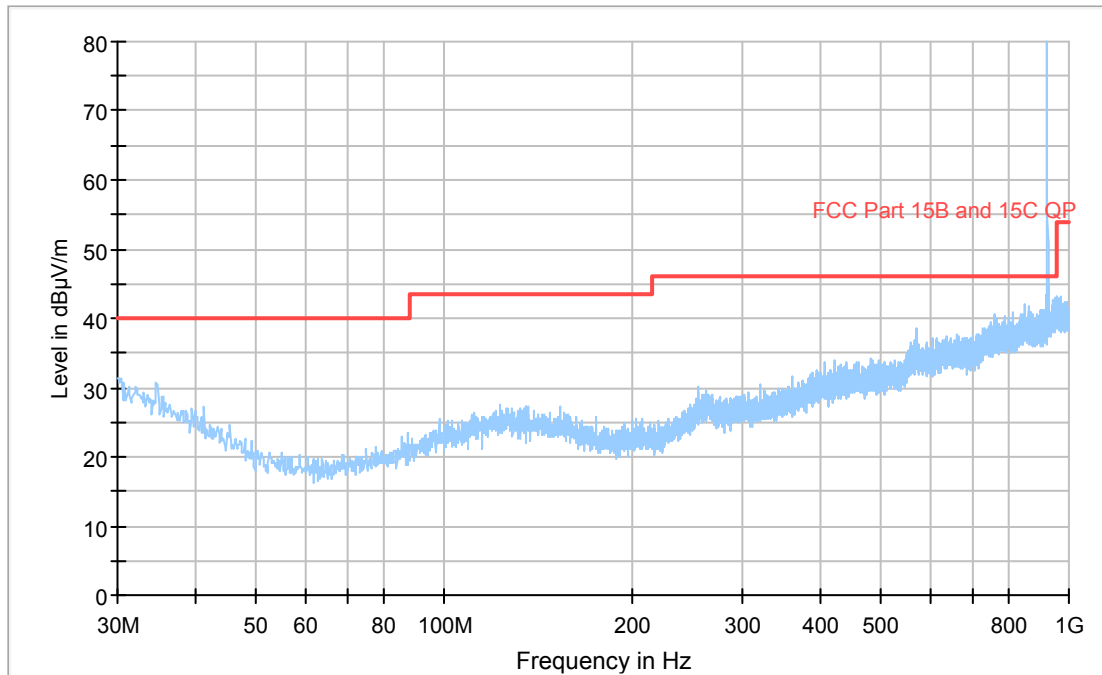
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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



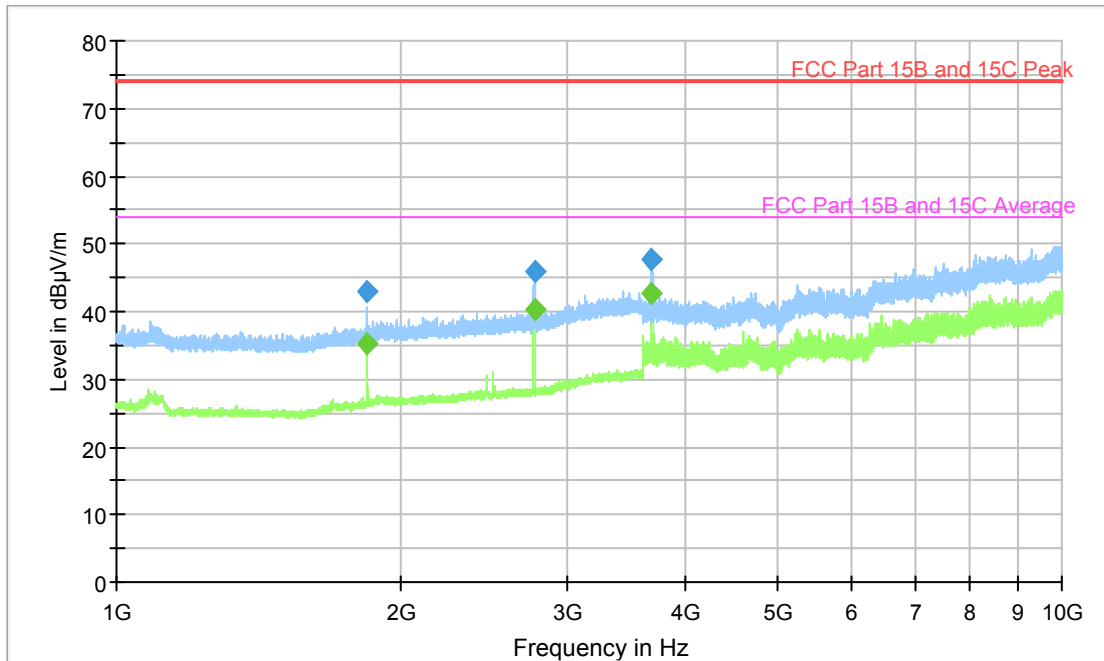
Diagram, Peak overview sweep, 30 – 1000 MHz at 3 m distance. TX high channel

Measurement results, Quasi Peak

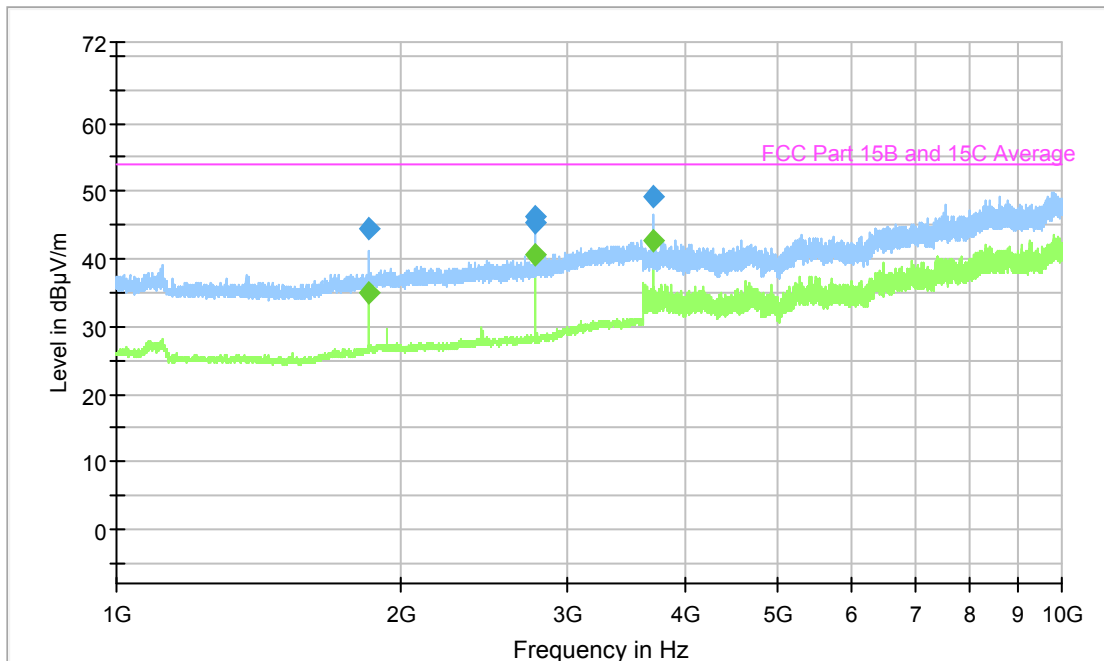
No emissions other than carrier are found above noise floor or closer than 20 dB from limit. Margin to noise floor is at least 6 dB.

$$\text{Result [dB}\mu\text{V/m]} = \text{Analyser reading [dB}\mu\text{V]} + \text{Antenna factor [1/m]} - \text{Amplifier gain [dB]} + \text{Cable loss [dB]}$$

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**

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

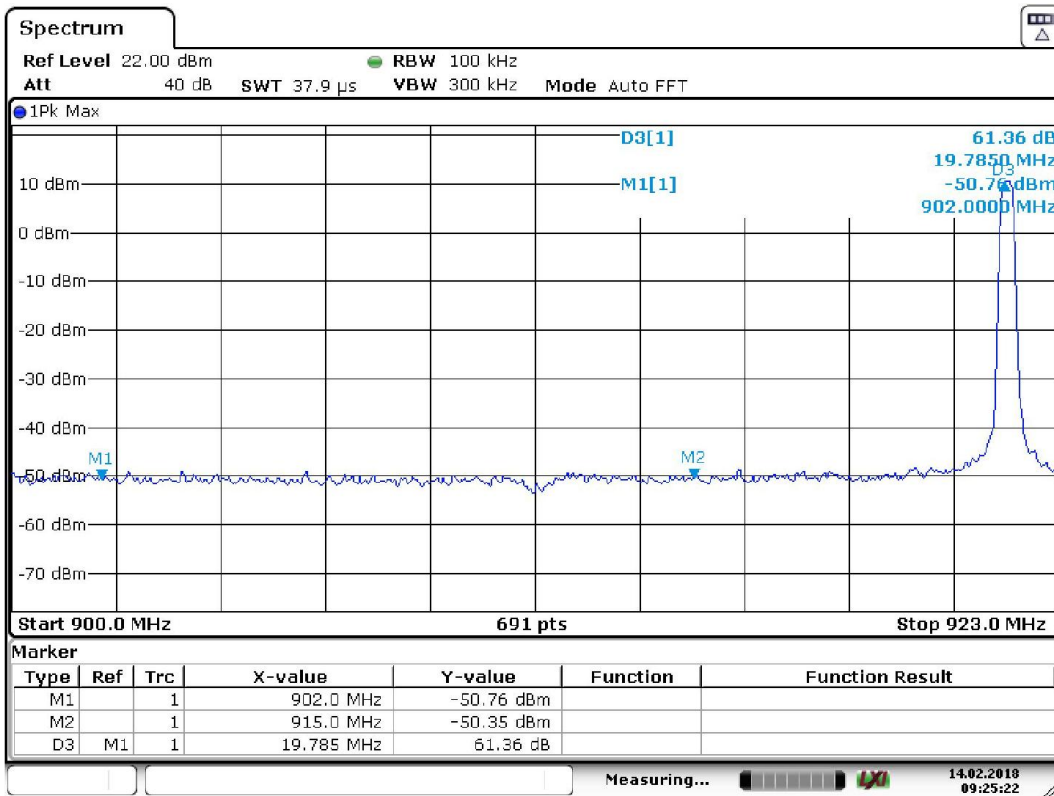
**7.3 Requirement**

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.

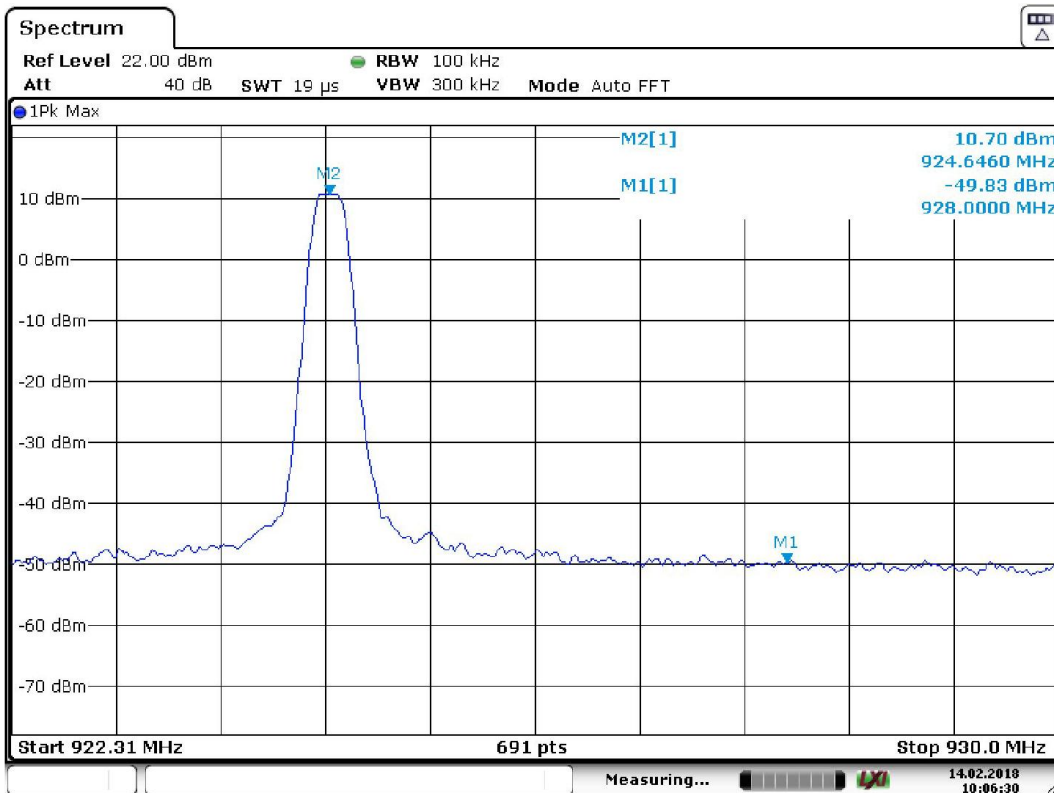
**7.4 Test results**

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**

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

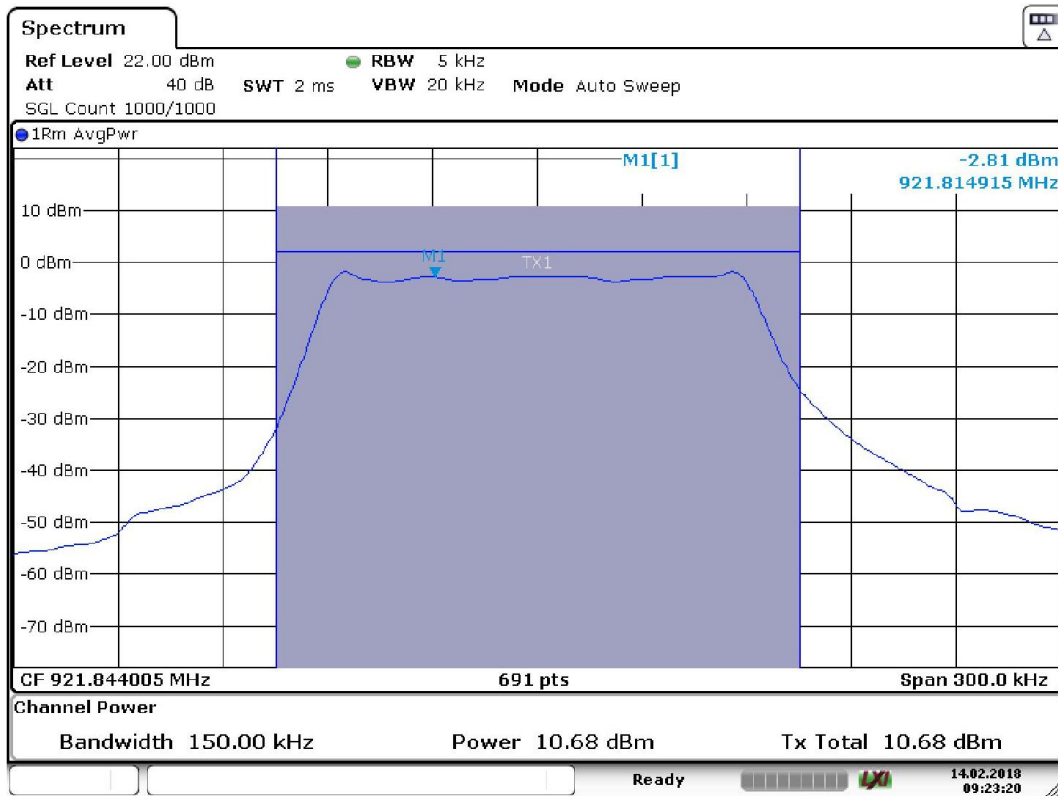
For DTSs employing digital modulation techniques operating in the bands 902 – 928 MHz, 2400 – 2483.5 MHz and 5725 – 5850 MHz, the maximum peak conducted output power shall not exceed 1W.

**8.4 Test results**

**Test result**

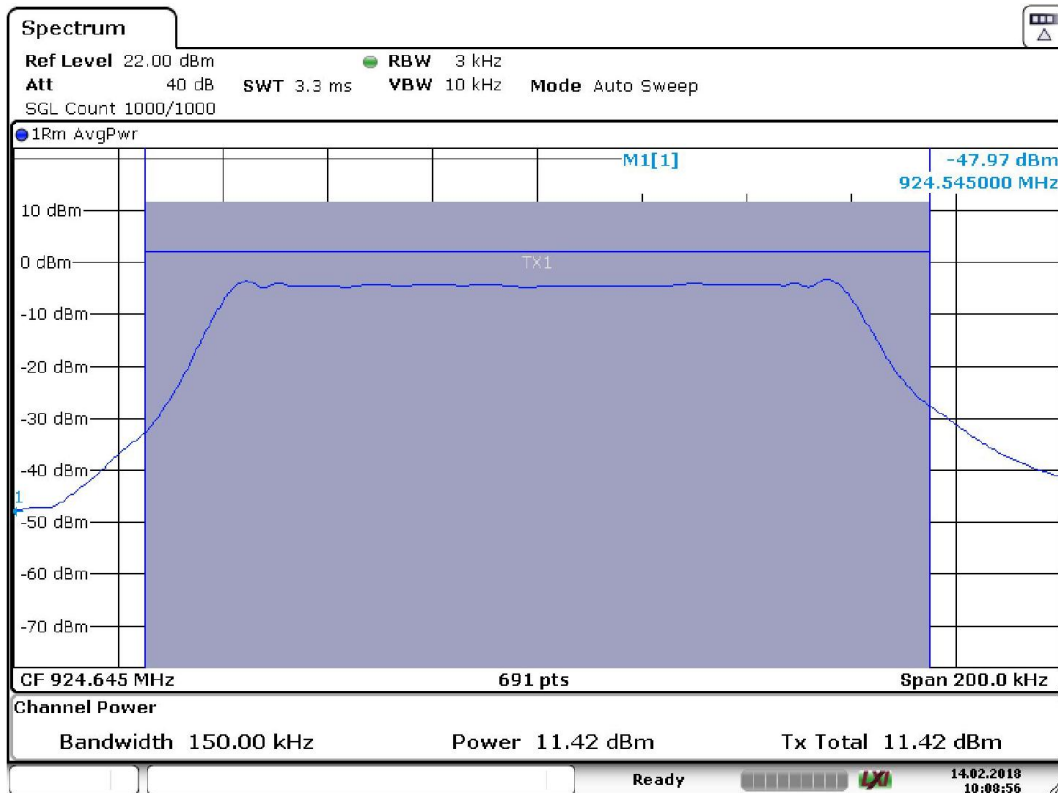
Channel [MHz]	Output power [dBm]	Limit [dBm]	Margin [dB]
921.85	10.7	30	19.3
924.65	11.4	30	18.6





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**

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

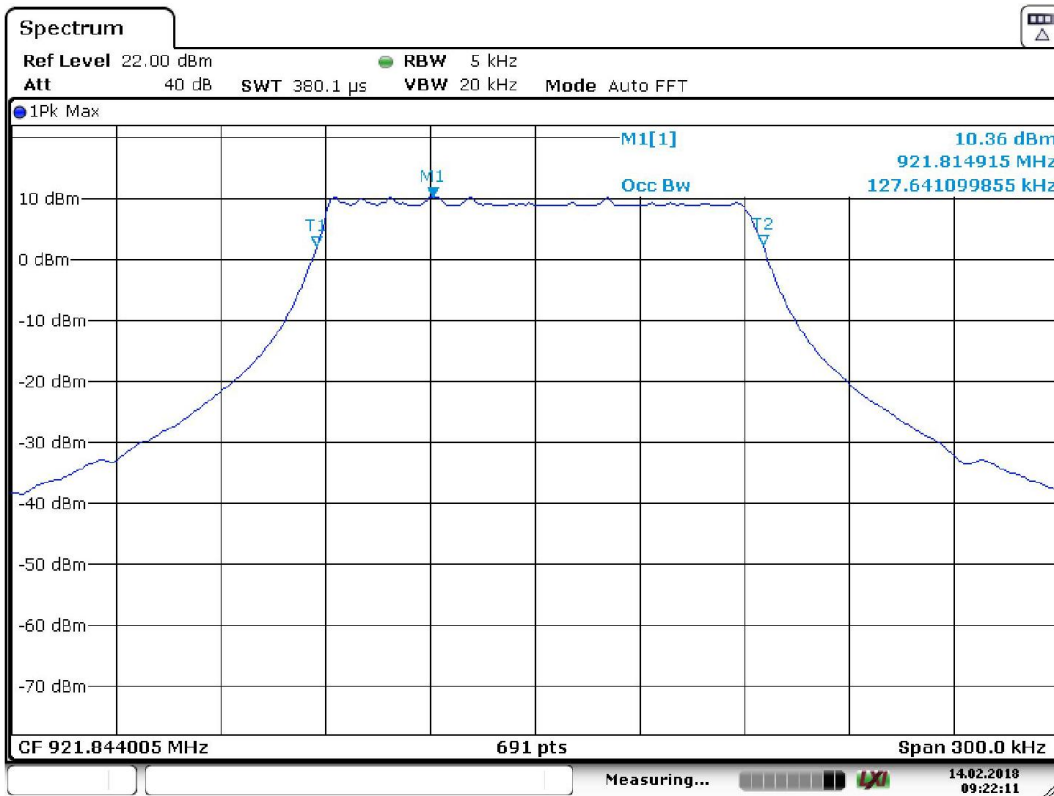
**9.2 Test conditions**

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

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

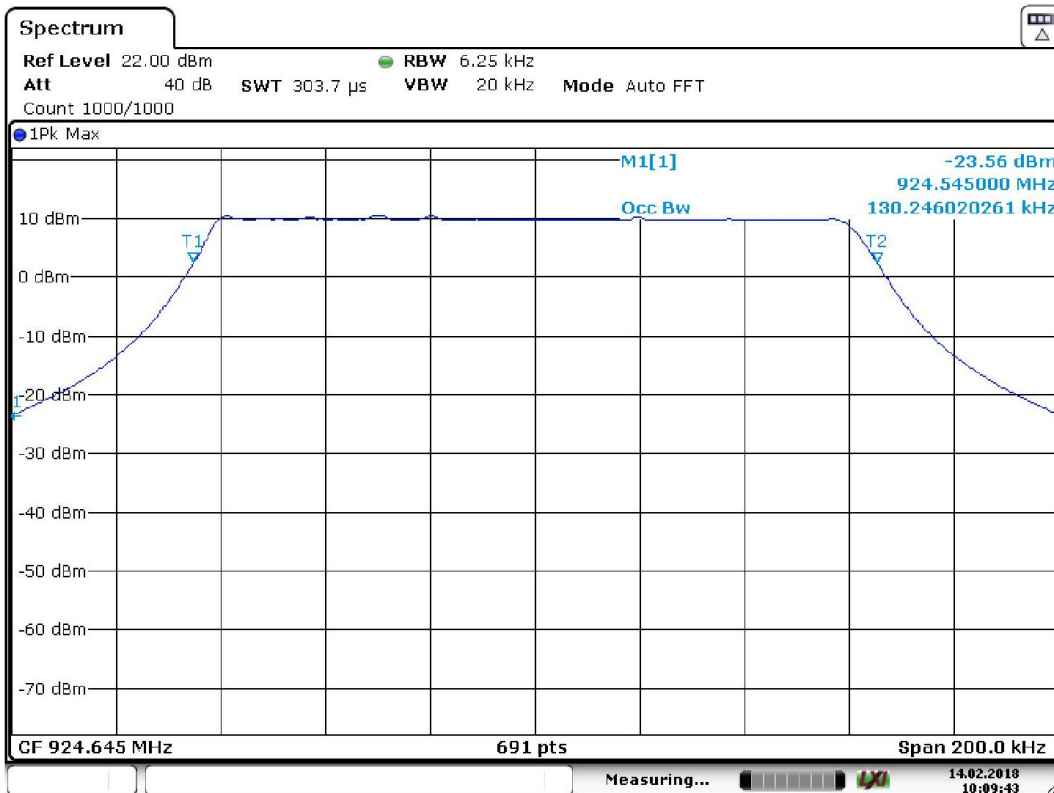
**9.3 Test results**

<b>Channel [MHz]</b>	<b>99 % BW [kHz]</b>
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**

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

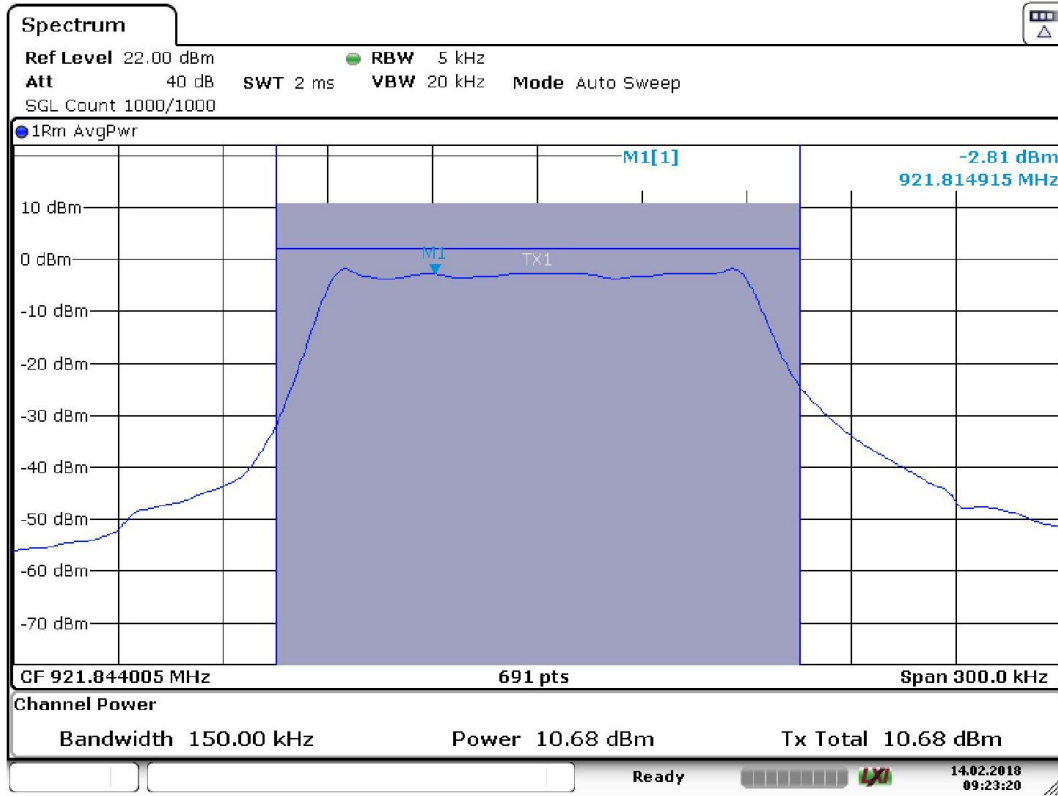
**10.3 Requirements**

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

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

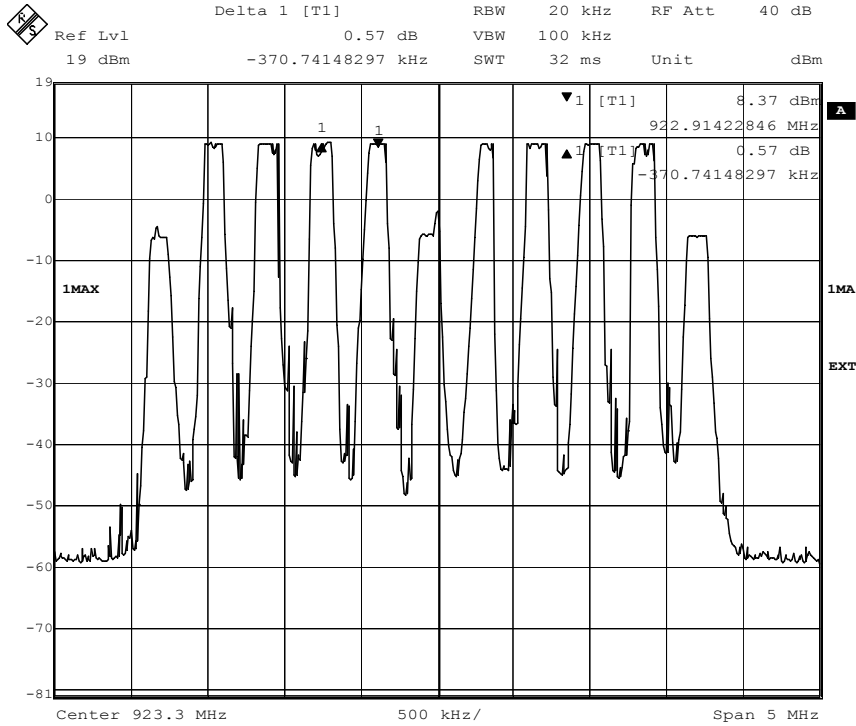
CFR 47 15.247 (f) The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed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

### 11.4 Test results

Number of hopping channels = 8

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

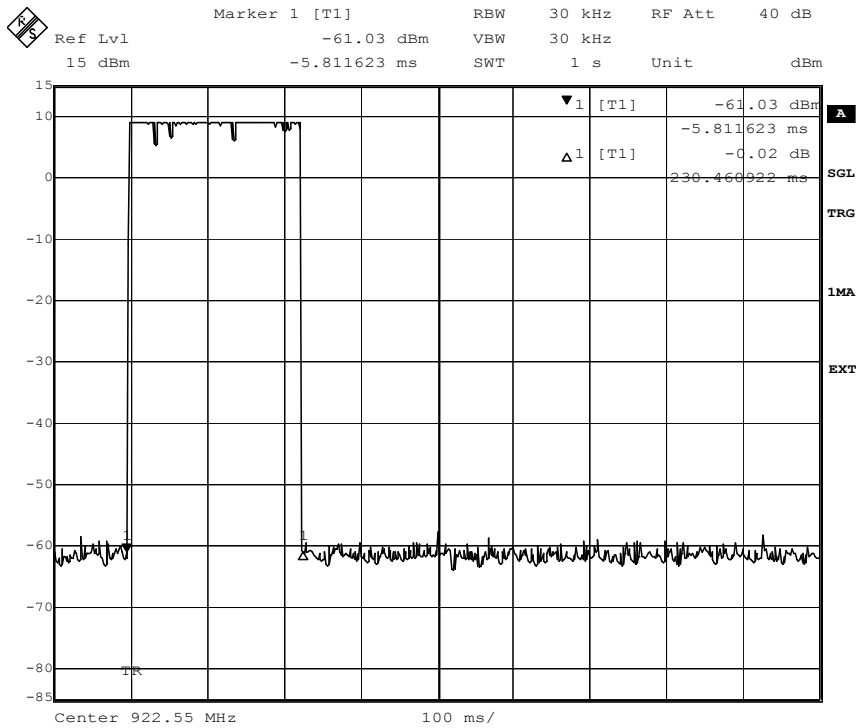
One burst is 230 ms long and occurred once during the measurement period once.  
 The EUT fulfils the requirement.



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

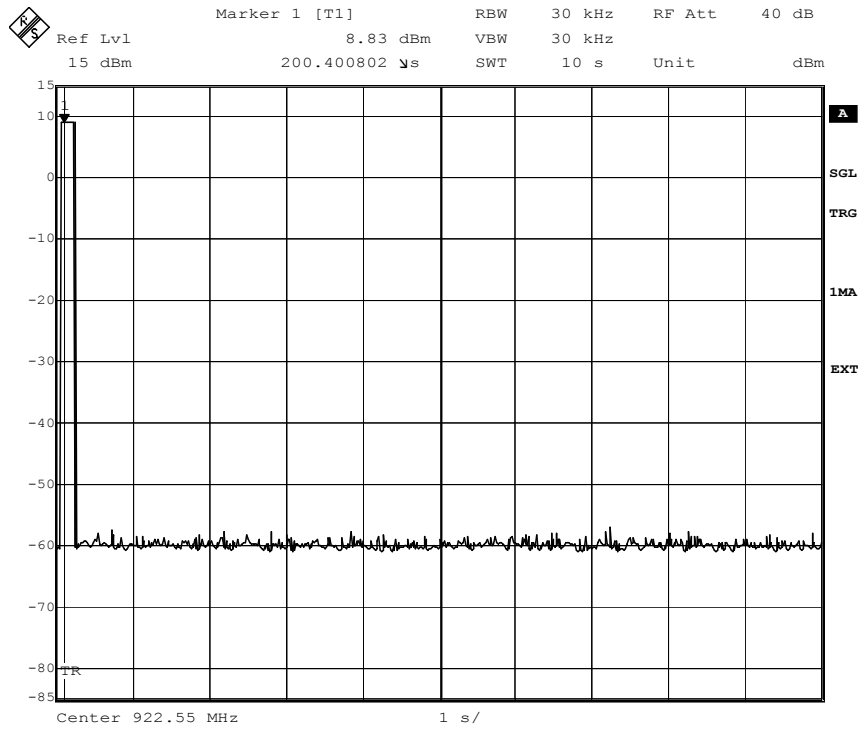
**Screen shot number of hopping frequencies.**

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  $\pm 3.7$  dB

Measurement uncertainty for radiated disturbance

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