

RADIO TEST REPORT

No. 1721221STO-002, Ed. 1

RF Performance

EQUIPMENT UNDER TEST

Equipment: Wireless sensor
Type/Model: Level Sensor for Tork EasyCube™
Manufacturer: Essity Hygiene and Health AB
Tested by request of: Essity Hygiene and Health AB

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 (2016): Subpart C: Intentional radiators. Section 15.247

47 CFR Part 15 (2016): Subpart B: Unintentional radiators

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: 2018-03-27

Tested by: 
Daniel Nilsson

Approved by: 
Matti Virkki

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Revision History

Edition	Date	Description	Changes
1	2018-03-27	First release	

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1 CLIENT INFORMATION

The EUT has been tested by request of

Company Essity Hygiene and Health AB
Mölnåls bro 2
Mölnåls
SE-405 03 Göteborg
SWEDEN

Name of contact Rickard Holmersson

2 EQUIPMENT UNDER TEST (EUT)

2.1 Identification of the EUT

Equipment: Wireless sensor

Type/Model: Level Sensor for Tork EasyCube™

Brand name: Essity

Serial number: See section 2.2

Manufacturer: Essity Hygiene and Health AB

Transmitter frequency range: 2405 MHz

Receiver frequency range: 2405 MHz

Frequency agile or hopping: ☐ Yes ☒ No

Antenna: ☒ Internal antenna ☐ External antenna

Antenna connector: ☒ None, internal antenna ☐ Yes

Antenna gain: +3 dBi

Rating RF output power: 5.6 dBm (measured conducted)

Type of modulation: OQPSK

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 +55°C

Transmitter stand by mode supported: ☒ Yes ☐ No

2.2 Additional information about the EUT

The EUT consists of the following units:

Unit	Type	Serial number	Comment
TCPRBS	Level Sensor for Tork EasyCube™	10-44221	Modified with temporary antenna connector and continuous modulated transmission.
TCTX1	Level Sensor for Tork EasyCube™	10-44223	Modified with temporary antenna connector and intermittent modulated transmission.
TCRX	Level Sensor for Tork EasyCube™	10-44224	Modified with temporary antenna connector and continuous receive mode.
TCN	Level Sensor for Tork EasyCube™	10-44220	Modified with temporary antenna connector.
TRPRBS	Level Sensor for Tork EasyCube™	10-44225	Integral antenna and continuous modulated transmission.
TRRX	Level Sensor for Tork EasyCube™	10-44222	Integral antenna and continuous receive mode.

During the tests the EUT supported following software:

Software	Version	Comment
ToF_SCU_1sec_tx.hex	1.0	Normal operation but with 1s tx interval (based on ToF_SCU version 1.1)
ToF_SCU_constant_rx.hex	1.0	Constant RX mode
ToF_SCU_cw.hex	1.0	Carrier wave
ToF_SCU_prbs.hex	1.0	PRBS data

2.3 Test signals and operation modes

The following operating modes were used during testing:

Continuous transmission of modulated carrier
Normal transmission of modulated carrier
Receive mode

3 TEST SPECIFICATIONS

3.1 Standards

Requirements:

47 CFR Part 15 (2016): Subpart C: Intentional radiators. Section 15.247

47 CFR Part 15 (2016): Subpart B: Unintentional radiators

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 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
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
3M FAC	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 Battery operated equipment.	NA
FCC §15.247 (b)(4) RSS-247 5.4(4), 5.4(5)	Field strength of fundamental and antenna gain The EUT complies with the limits. Antenna gain is less than 6 dBi.	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. The margin to the limit was at least 15.3 dB at 944.273 MHz. See clause 5.4 – 5.5.	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. The margin to the limit was at least 20 dB. See clause 5.6 – 5.7.	PASS
FCC §15.247(a)(2) RSS-GEN 6.6 RSS-247 5.2(1)	Occupied bandwidth The EUT complies with the limits. The margin to the limit is at least 0.8 MHz See clause 8.4.	PASS
FCC §15.247(b) RSS-247 5.4(4)	Conducted output power The EUT complies with the limits. The margin to the limit was at least 27.4 dB at 2405.0 MHz. See clause 7.4.	PASS
FCC §15.247(e) RSS-247 5.2(2)	Peak power spectral density The EUT complies with the limits. The margin to the limit was at least 14.0 dB at 2405.0 MHz. See clause 10.4.	PASS
FCC §15.247(e) RSS-247 5.5	Band edge The EUT complies with the limits. The margin to the limit was at least 20.0 dB at 2400.0 MHz. See clause 6.4.	PASS

5 RADIATED RF EMISSION IN THE FREQUENCY-RANGE 30 MHz TO 26.5 GHz

Date of test:	2018-02-16, 2018-02-20, 2018-02-21, 2018-02-26	Test location:	Stora Hallen
EUT Serial:	TRPRBS	Ambient temp:	21 – 22°C
Tested by:	DNI	Relative humidity:	15 – 23%
Test result:	PASS	Margin:	15.3 dB

5.1 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.

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.

5.2 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:

Measuring distance:

Measuring angle:

Elevation angle:

Antenna

Height above ground plane:

Polarisation:

Type:

1 GHz – 26.5 GHz

Peak

RBW 1 MHz

VBW 3 MHz

Average

RBW 1 MHz

VBW 3 MHz

Peak

RBW 1 MHz

VBW 3 MHz

Average

Peak value + 20 x LOG (Duty cycle)

3 m

0 – 359°

0 – 180°

1.5 m

Vertical and Horizontal

Horn

5.3 Requirements

Within restricted bands and receive mode:

Reference: CFR 47 §15.209, §15.109, 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

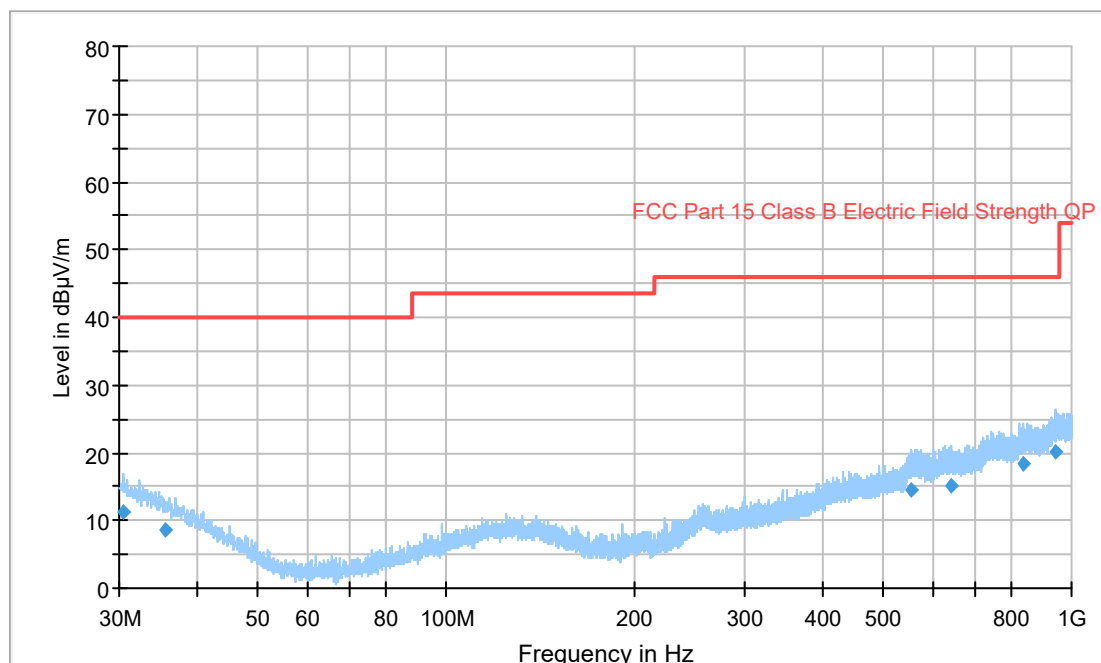
The values for 10 m measuring distance are calculated by subtracting 10.5 dB from the 3 m limit. (i.e. an extrapolation factor of 20 dB/decade according to CFR 47 §15.31(f)(1))

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.

5.4 Test results 30 MHz – 1000 MHz, TX



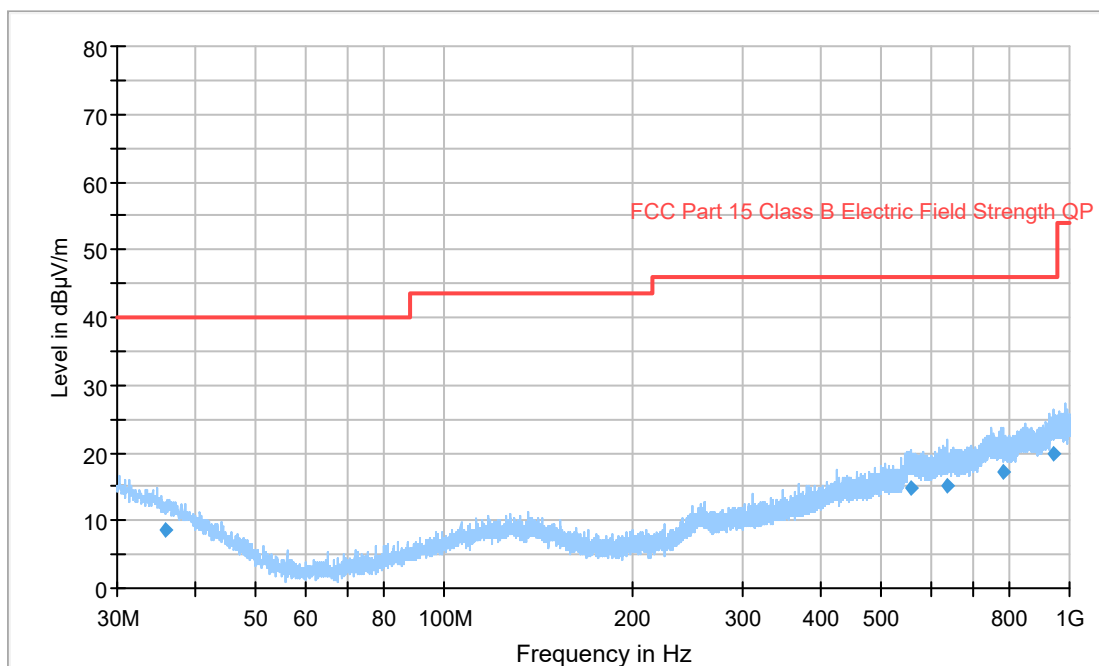
Diagram, Peak overview sweep, 30 – 1000 MHz at 3 m distance. TX.

Measurement results, Quasi Peak

No emissions are found above noise floor. Margin to noise floor is at least 15.3 dB.

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

5.5 Test results 30 MHz – 1000 MHz, RX



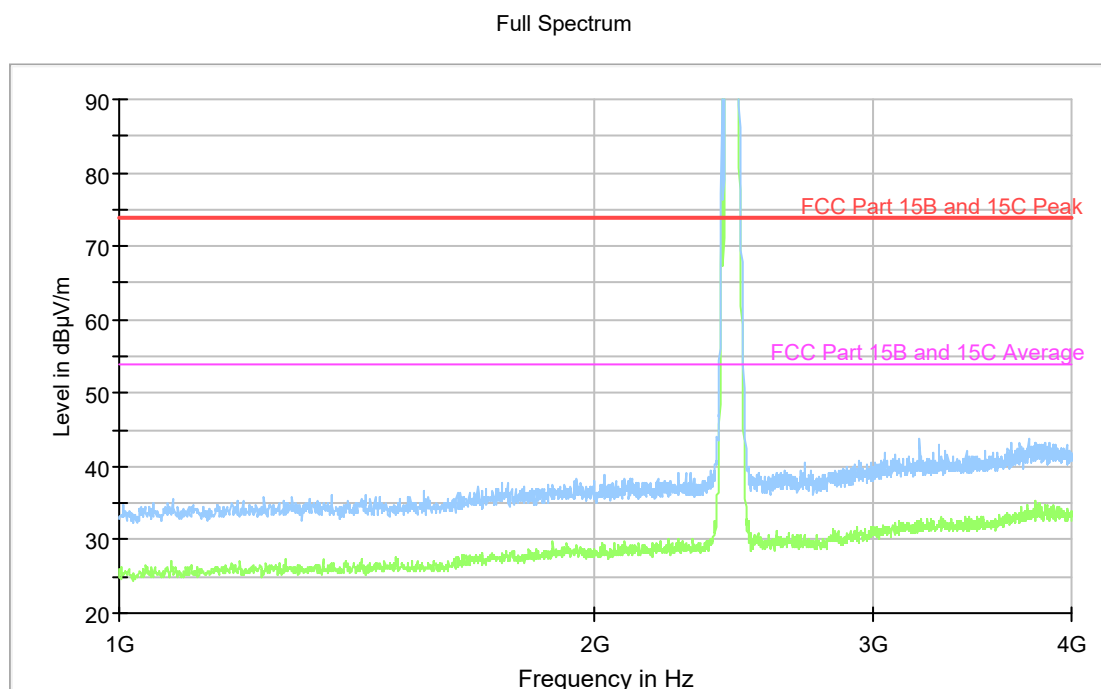
Diagram, Peak overview sweep, 30 – 1000 MHz at 3 m distance. RX.

Measurement results, Quasi Peak

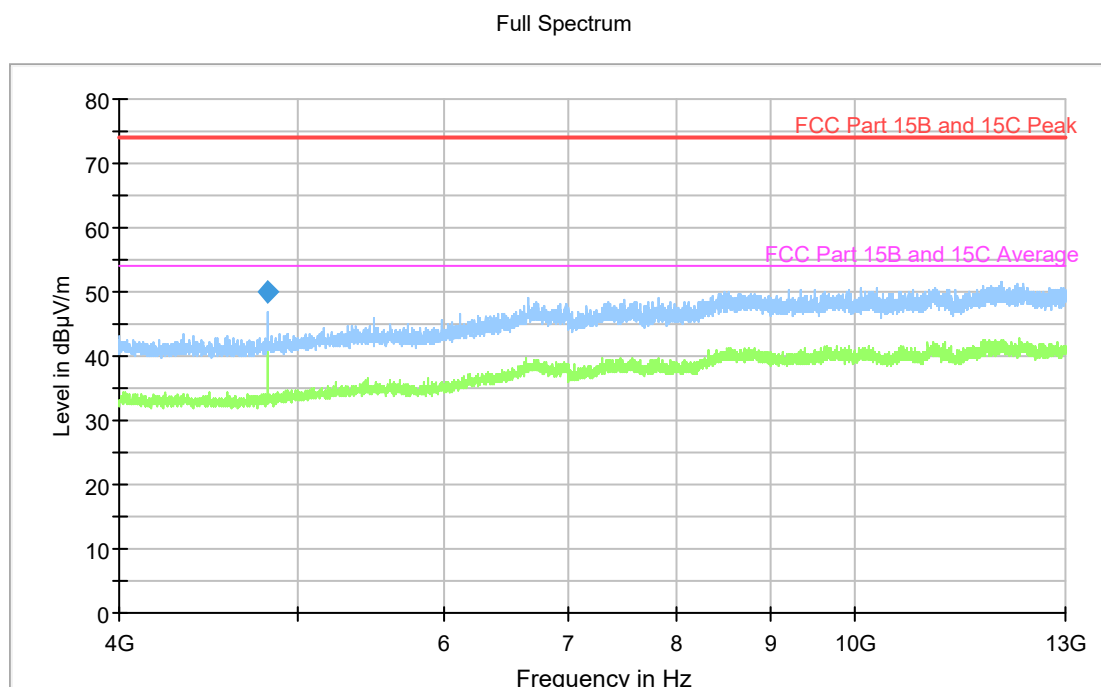
No emissions are found above noise floor. Margin to noise floor is at least 15 dB.

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

5.6 Test results 1 GHz – 26.5 GHz, TX

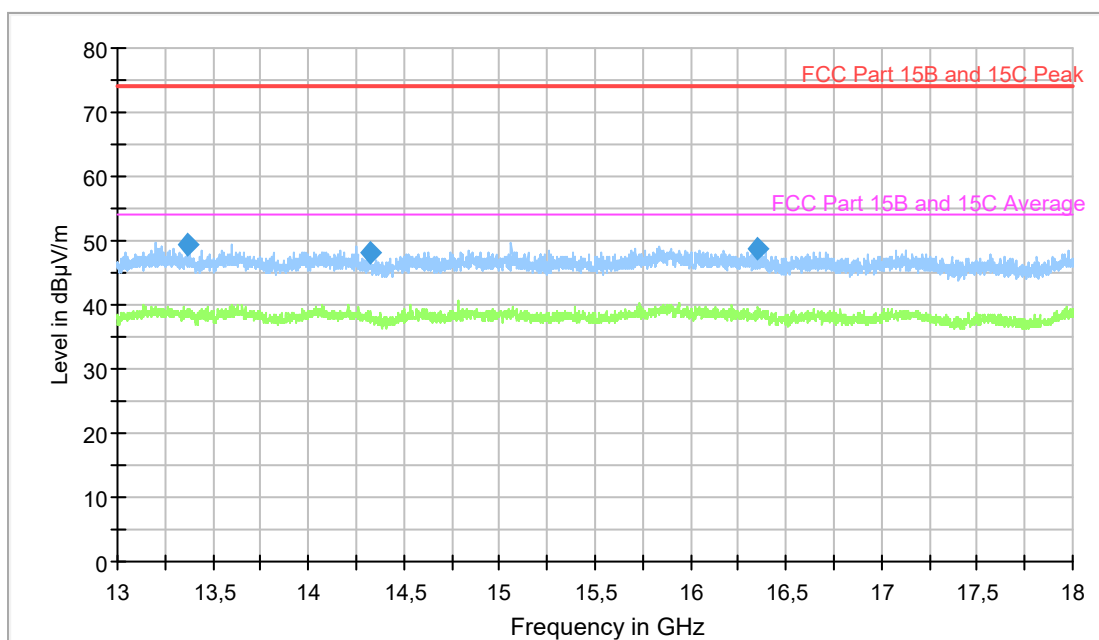


Diagram, Peak overview sweep, 1– 4 GHz at 3 m distance. TX. Carrier is attenuated by band rejection filter K&L 6N45-2450/T 100-0/0.



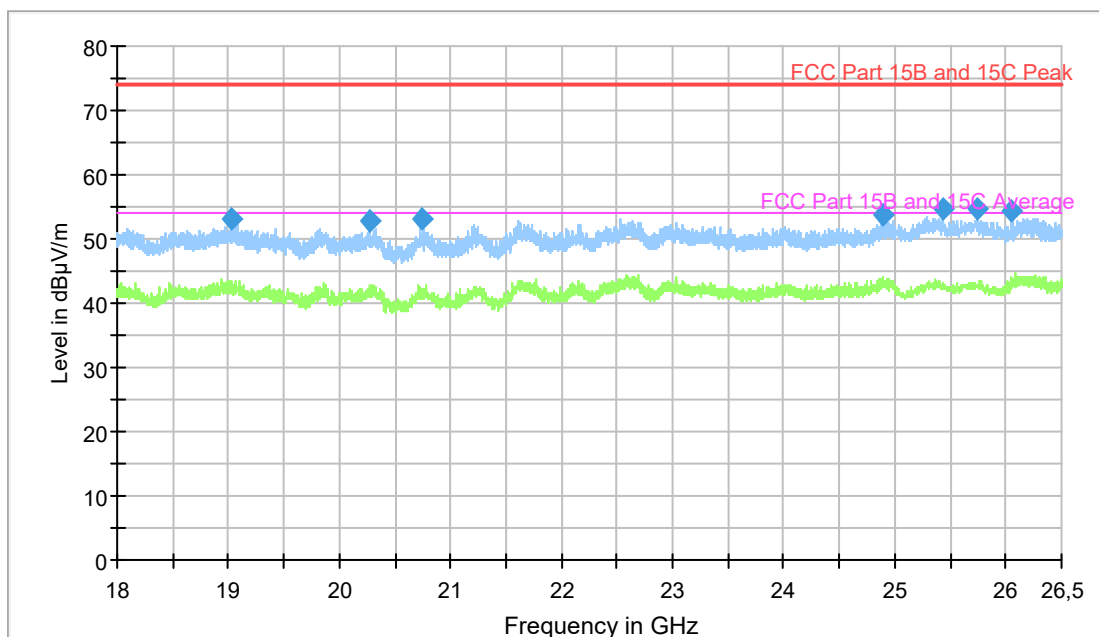
Diagram, Peak overview sweep, 4– 13 GHz at 3 m distance. TX. Emissions below 4000 MHz are attenuated by high-pass filter K&L 4410-X4500/18000-0.

Full Spectrum



Diagram, Peak overview sweep, 13 – 18 GHz at 3 m distance. TX.

Full Spectrum



Diagram, Peak overview sweep, 18 – 26.5 GHz at 3 m distance. TX.

Measurement results, Peak, TX

Frequency [MHz]	Level [dBμV/m]	Limit [dBμV/m]	Polarization H/V	Margin [dB]
4809.1	49.9	74.0	V	24.1

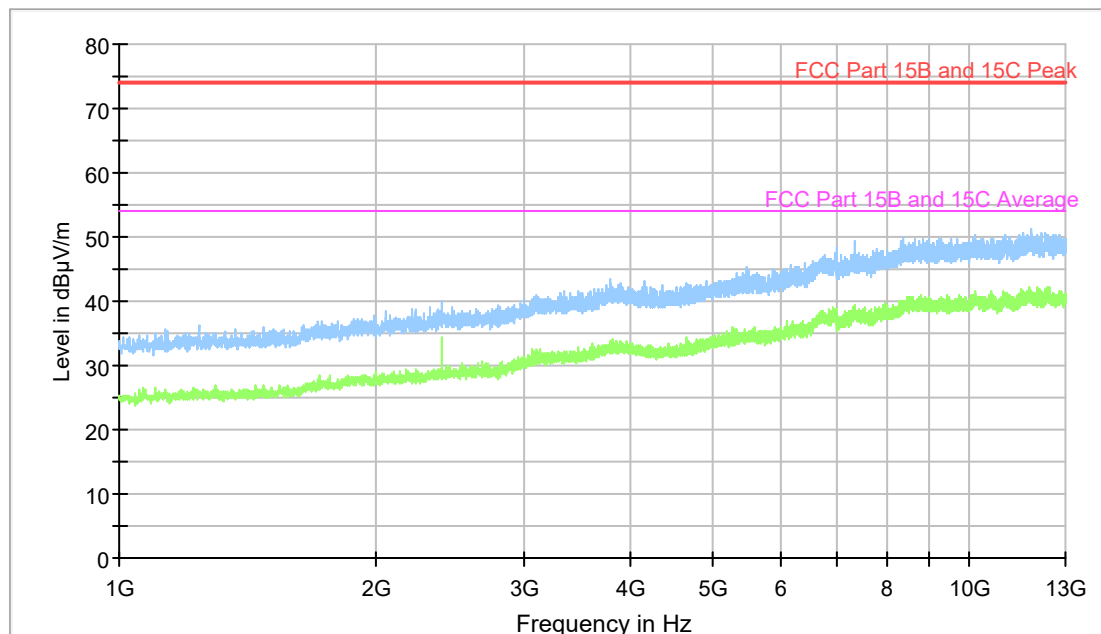
Measurement results, Average, TX

Frequency [MHz]	Level [dBμV/m]	Limit [dBμV/m]	Polarization H/V	Margin [dB]
4809.1	29.9	54.0	V	24.1

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

5.7 Test results 1 GHz – 13 GHz, RX

Full Spectrum



Diagram, Peak overview sweep, 1– 13 GHz at 3 m distance. RX.

No emissions are found above noise floor. Margin to noise floor is at least 20 dB.

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

6 CONDUCTED BAND EDGE MEASUREMENT

Date of test:	2018-02-26	Test location:	Wireless Center
EUT Serial:	TCPRBS	Ambient temp:	22 °C
Tested by:	DNI	Relative humidity:	15 %
Test result:	PASS	Margin:	24.2 dB

6.1 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.

6.2 Test conditions

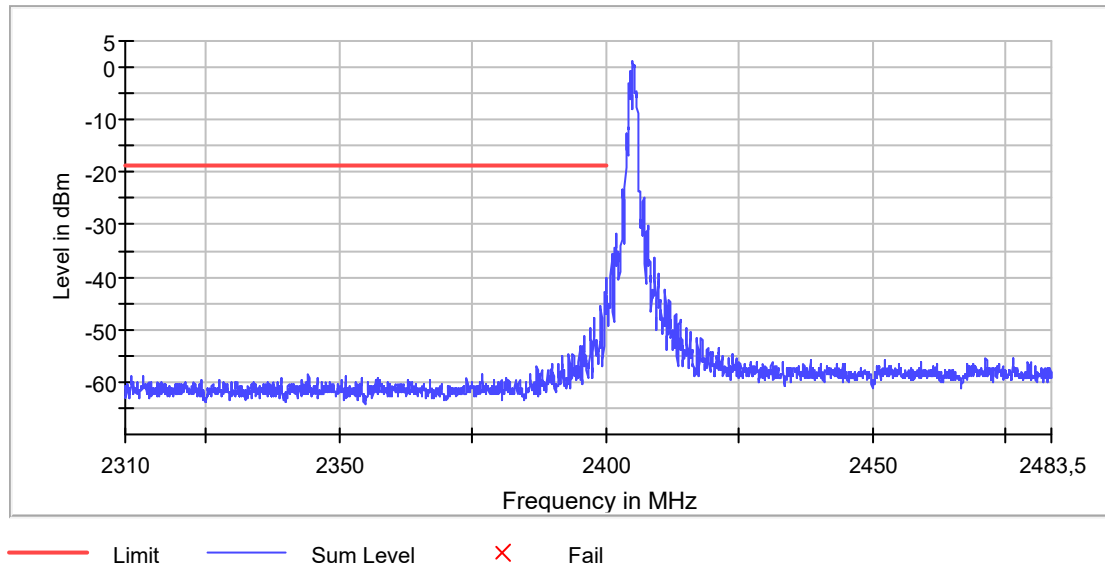
Detector: Peak,
RBW: 100 kHz
VBW: 300 kHz

6.3 Requirement

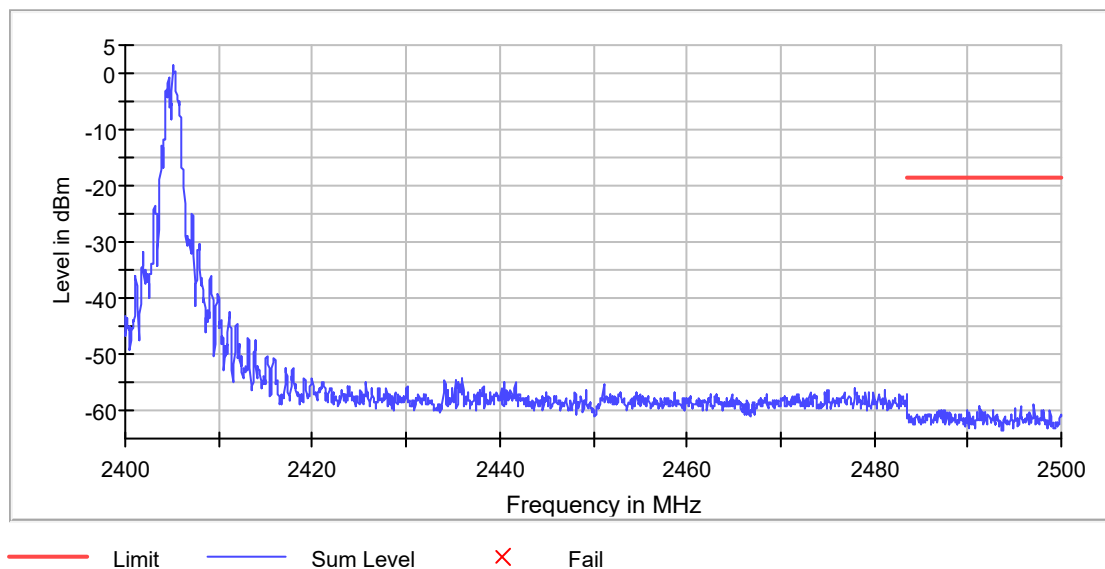
Reference: CFR 47 §15.247(d), RSS-247 5.5,

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.

6.4 Test results



Screenshot: Lower band edge sweep



Screenshot: Upperband edge sweep

Test results

Band edge	Delta [dBc]	Limit [dBc]	Margin [dB]
Lower	44.2	20.0	24.2
Upper	60.1	20.0	40.1

7 PEAK CONDUCTED OUTPUT POWER

Date of test:	2018-02-22	Test location:	Wireless Center
EUT Serial:	TRPRBS	Ambient temp:	21 °C
Tested by:	DNI	Relative humidity:	15 %
Test result:	PASS	Margin:	27.4 dB

7.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013 section 11.9.1.1.

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

7.2 Test conditions

Detector: Peak,
RBW: >OBW
VBW: 3 x RBW
Span: >3 x OBW

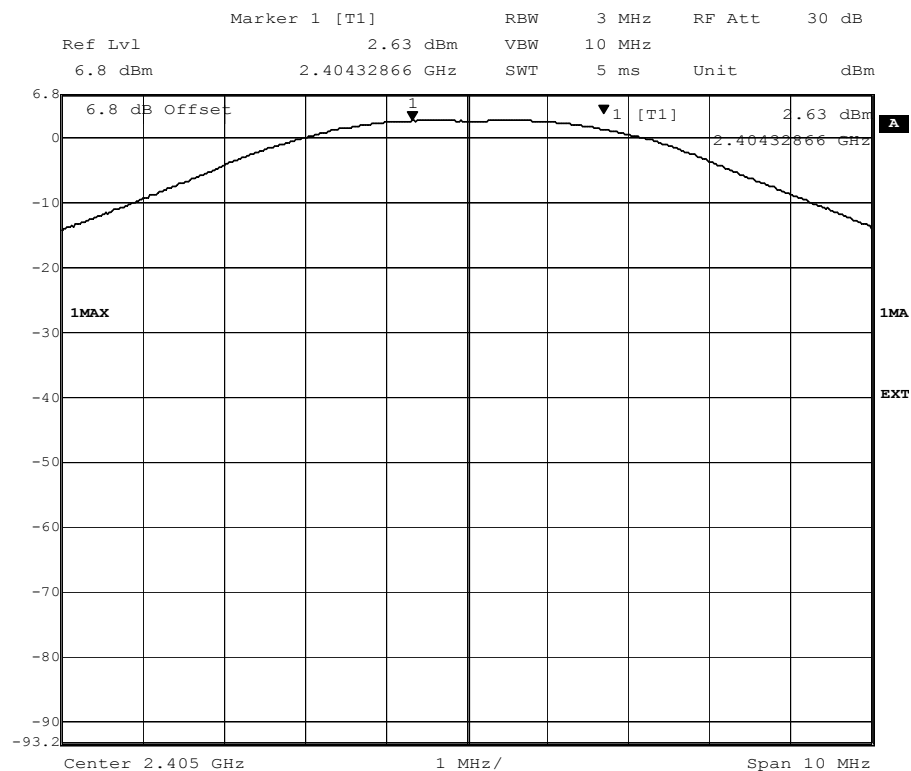
The EUT was set up in order to emit maximum disturbances.

7.3 Requirements

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

For DTSs employing digital modulation techniques operating in the bands 902 – 128 MHz, 2400 – 2483.5 MHz and 5725 – 5850 MHz, the maximum peak conducted output power shall not exceed 1W.

7.4 Test results



Date: 21.FEB.2018 13:55:50

Screenshot: Output power

Test result

Channel [MHz]	Output power [dBm]	Output power [mW]
2405	2.6	1.83

8 OCCUPIED 6 DB BANDWIDTH

Date of test:	2018-02-22	Test location:	Wireless Center
EUT Serial:	TRPRBS	Ambient temp:	21 °C
Tested by:	DNI	Relative humidity:	15 %
Test result:	PASS	Margin:	0.8 MHz

8.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013 section 11.8.1.

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

8.2 Test conditions

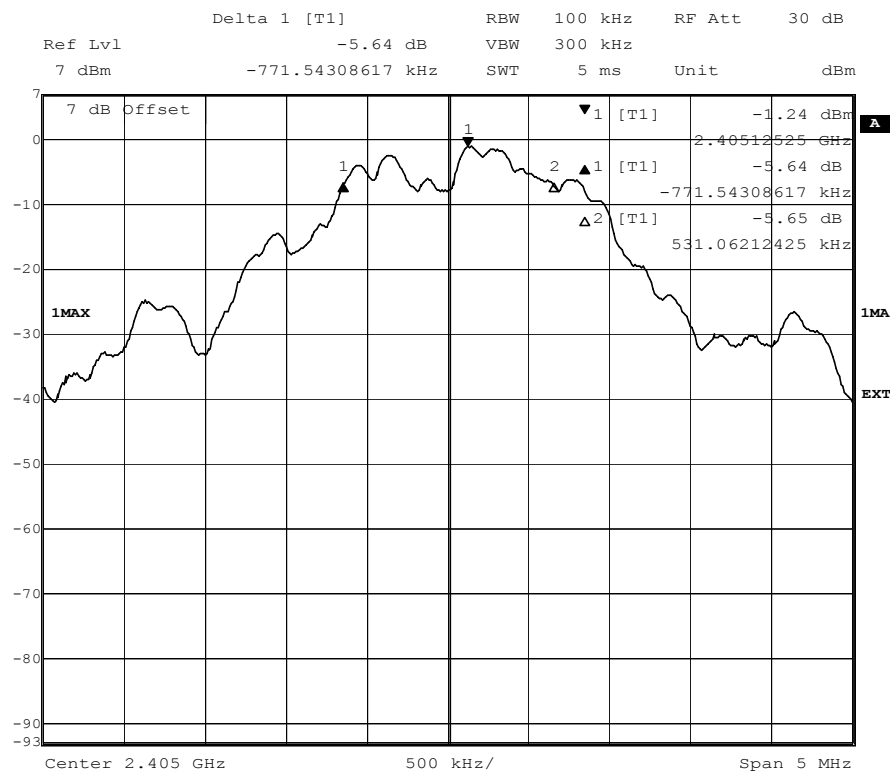
Detector: Peak,
RBW: 100 kHz
VBW: 3 x RBW
Span: >1,5 x OBW

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

8.3 Requirements

Reference: CFR 47§15.247(a)(2), RSS-247 5.2(1)
The minimum 6 dB bandwidth shall be 500 kHz.

8.4 Test results



Date: 21.FEB.2018 13:48:55

Screenshot: Occupied 6 dB bandwidth Measurement

Test result

Channel [MHz]	6 dB BW [MHz]
2405	1.3

9 99 % BANDWIDTH

Date of test:	2018-02-22	Test location:	Wireless Center
EUT Serial:	TRPRBS	Ambient temp:	21 °C
Tested by:	DNI	Relative humidity:	15 %
Test result:	NA	Margin:	-

9.1 Test set-up and test procedure.

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

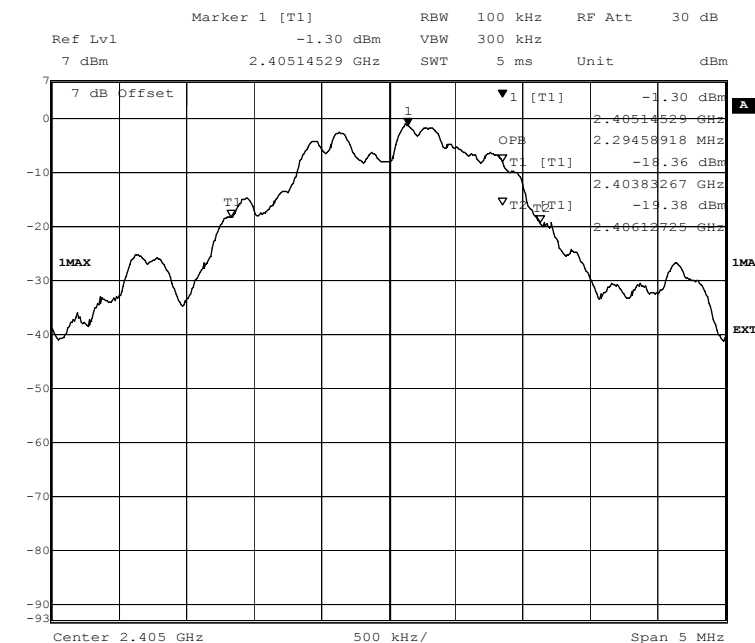
The EUT was connected to spectrum analyser via rf-cable and attenuator. Spectrum analyser with occupied bandwidth measurement function is used to determine the occupied bandwidth.

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



Date: 21.FEB.2018 13:46:23

Screenshot: 99 % bandwidth Measurement

Test result

Channel [MHz]	99 % BW [MHz]
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2405	2.3
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10 PEAK POWER SPECTRAL DENSITY

Date of test:	2018-02-22	Test location:	Wireless Center
EUT Serial:	TRPRBS	Ambient temp:	21 °C
Tested by:	DNI	Relative humidity:	15 %
Test result:	PASS	Margin:	14.0 dB

10.1 Test set-up and test procedure.

The test method is in accordance with ANSI C63.10-2013 section 11.10.2.

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

10.2 Test conditions

Detector: Peak,
RBW: 3 kHz
VBW: >3 x RBW
Span: 1.5 x 6 dB bandwidth

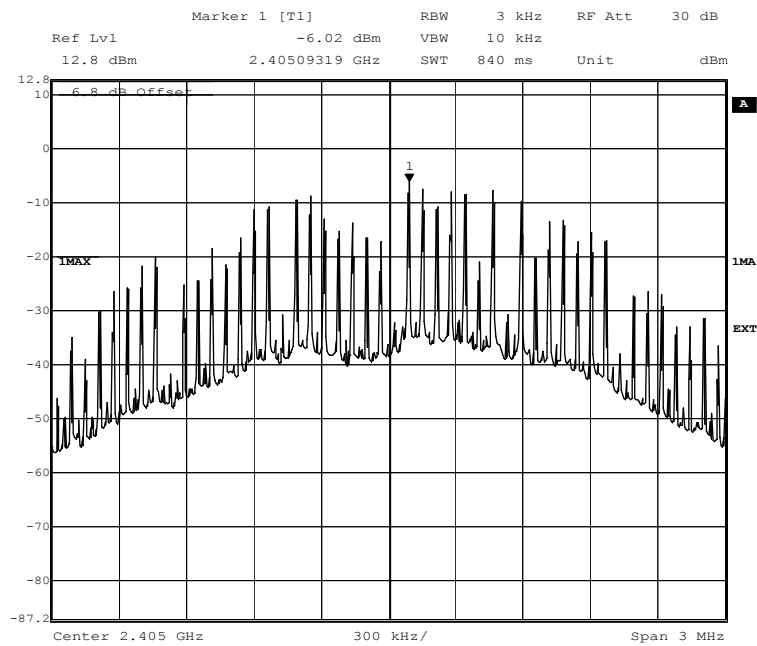
The EUT was set up in order to emit maximum disturbances.

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



Date: 21.FEB.2018 15:26:53

Screenshot: Peak power spectral density

Test result

Channel [MHz]	PSD [dBm/3kHz]
2405	-6.0

11 TRANSMITTER DUTY CYCLE FOR PULSED TRANSMISSIONS

Date of test:	2018-02-22	Test location:	Wireless Center
EUT Serial:	TRPRBS	Ambient temp:	21 °C
Tested by:	DNI	Relative humidity:	15 %
Test result:	NA	Margin:	-

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

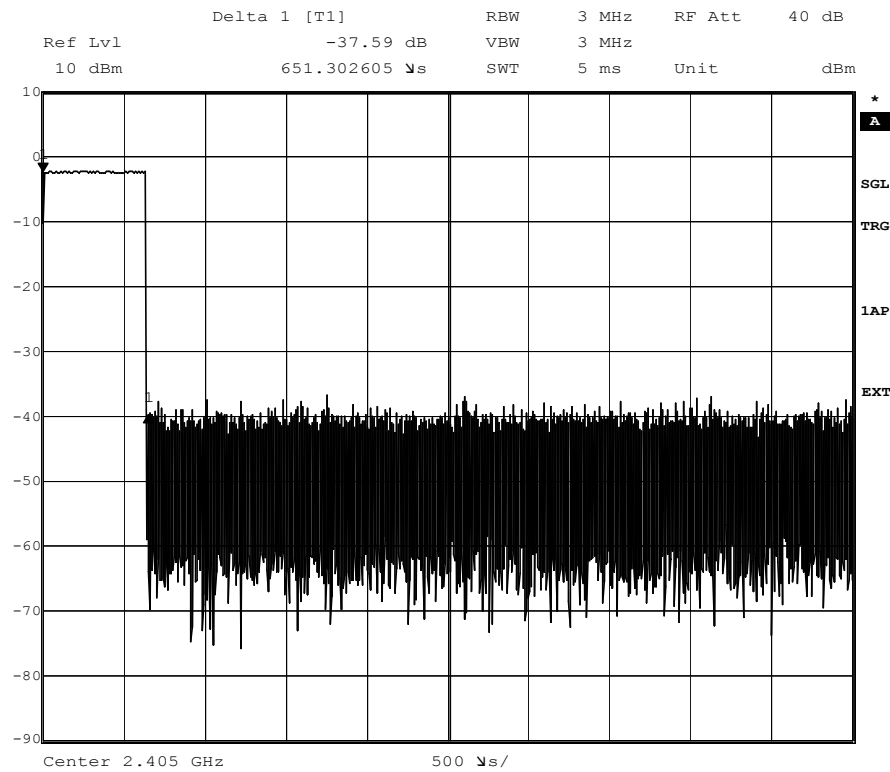
Detector: Peak
 RBW 3 MHz
 VBW 3 x RBW
 Span 0 Hz
 Sweep time 100 ms

11.3 Requirement

CFR 47 15.35(c) and RSS-GEN section 6.10

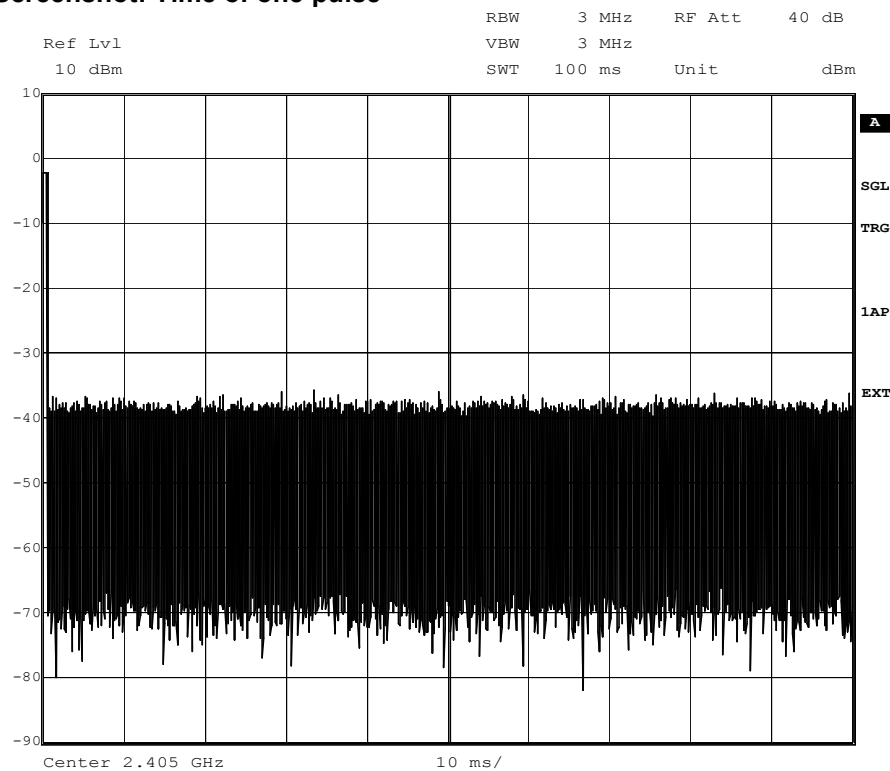
11.4 Test results

$T_{on} = 651 \mu s$
 Duty cycle is calculated $T_{on} / 100 ms = 0.007$
 Peak to average correction factor = $20 \text{ LOG (Duty cycle)} = 20$



Date: 21.FEB.2018 13:37:30

Screenshot: Time of one pulse



Date: 21.FEB.2018 13:38:36

Screen shot: 100 ms measurement

12 TEST EQUIPMENT

Stora Hallen

Equipment type	Manufacturer	Model	Inv. No.	Last Cal. date	Cal. interval
Receiver	Rohde & Schwarz	ESU 8	12866	2017-07	1 year
BiLog antenna	Chase	CBL6110A	971	2017-09	3 years
Preamplifier	SEMKO	--	7993	2017-06	1 year

Wireless Center and 3m FAC

Equipment type	Manufacturer	Model	Inv. No.	Last Cal. date	Cal. interval
Signal analyzer	Rohde & Schwarz	FSIQ 40	12793	2017-07	1 year
Horn antenna	EMCO	3115	4628	2015-11	3 years
Preamplifier	Sangus	00101400-23-10P -6-S ; AFS44-12002400-32-10P -44	12335	2017-07	1 year
Horn antenna	EMCO	3160-08	30099	2016-10	3 years
Horn antenna	EMCO	3160-09	30101	2016-10	3 years
Signal analyzer:	Rohde & Schwarz	FSV	32594	2017-07	1 year
Signal generator:	Rohde & Schwarz	SMB100A	32592	2017-07	1 year
1 GHz high pass filter	MICROWAVE CIRCUITS	H1G013G1	13142	2017-08	1 year
2,4 GHz band reject filter:	K&L MICROWAVE INC	6N45-2450/T100-0/0	12389	2017-03	1 year
4 GHz high pass filter	K&L MICROWAVE INC	4410-X4500/18000-0/0	5133	2017-08	1 year
10 dB Attenuator:	Huber+Suhner	5910_N-50-010	32696	2017-05	1 year
6 dB Attenuator	Midwest Microwave	ATT-0298-06-HEX-02	30105	2016-07	2 years

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 1721221STO-002 Annex 1.

Test set up photos are in separate document 1721221STO-002 Annex 2.