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The Netherlands
Chamber of Commerce
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FCC Test Report for Parts 15.207, 15.209 and 15.247

Product name	: Masterspot 2 Track
Applicant	: Invisua Lighting B.V.
FCC ID	: 2AK87-MS2-TR-SFO

Test report No. : 161201223 003 V1.0

Laboratory information

Accreditation

Telefication is designated by the FCC as an Accredited Test Firm for compliance testing of equipment subject to Certification under Parts 15 & 18. The Designation number is: NL0001

Documentation

Telefication complies with the accreditation criteria for test laboratories as laid down in ISO/IEC 17025:2005. 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).

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
0.50	14-12-2016	First draft	PvW
1.0	20-04-2017	Final version	PvW

Table of Contents

Summary of Test results

FCC	Description	Section in report	Verdict
15.247(a)	6dB Bandwidth	3.1	Pass
15.247(b)	RF output power	3.2	Pass
15.247(e)	Power spectral density	3.3	Pass
15.247(d)	Conducted Band edge	3.4	Pass
15.209 (a)	Radiated Magnetic Disturbance	3.5	Pass
15.209 (a)	Radiated Spurious emissions	3.6	Pass
15.207 (a)	Conducted spurious on AC mains	3.7	Pass

1 General Description

1.1 Applicant

Client name:	Invisua Lighting B.V.
Address	Nuenenseweg 167-B23, Geldrop, The Netherlands
Zip code:	5667 KP
Telephone:	+31 407370190
E-mail:	Loek.janssen@invisua.com
Contact name:	L. Janssen

1.2 Manufacturer

Manufacturer name:	Invisua Lighting B.V.
Address:	Nuenenseweg 167-B23, Geldrop, The Netherlands
Zip code:	5667 KP
Telephone:	+31 407370190
E-mail:	Loek.janssen@invisua.com
Contact name:	L. Janssen

1.3 Tested Equipment Under Test (EUT)

Product name:	Masterspot 2 Track
Brand name:	Invisua
Product type:	Color Tunable LED spot
FCC ID:	2AK87-MS2-TR-SFO
Model(s):	-
Software version:	-
Hardware version:	BOM version 01
Date of receipt	12-12-2016
Tests started:	12-12-2016
Testing ended:	13-12-2016

1.4 Product specifications of Equipment under test

Tx Frequency range (MHz):	2405.0-2480.0
Rx frequency range (MHz):	2405.0-2480.0
Maximum output power to antenna (dBm):	2.23
Antenna type :	Monopole Antenna
Antenna gain(dBi):	0
Type of modulation:	O-QPSK
Emission designator 802.15.4:	1M68G1D

1.5 Modification of the Equipment Under Test (EUT)

None.

1.6 Observations and remarks

None.

1.7 Environmental conditions

Test date	12-12-2016	13-12-2016
Ambient temperature	22.5°C	22.5°C
Humidity	35.9%	33.4%

1.8 Measurement Standards

- FCC KDB Publication No. 558074 D01DTS Meas. Guidance V03r05
- ANSI C63.10:2013

1.9 Applicable Standards

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

- FCC Part 15, §15.207, §15.209, §15.247

1.10 Conclusions

The sample of the product showed NO NON-COMPLIANCES to the specifications stated in paragraph 1.9 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 1.9 *"Applicable standards".*

All tests are performed by:

Name : ing P. Suringa and 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 : 12-05-2017

Name : ing. K.A. Roes

Function : Coordinator Radio Laboratory

Signature :

2 Test configuration of the Equipment Under Test

2.1 Test mode

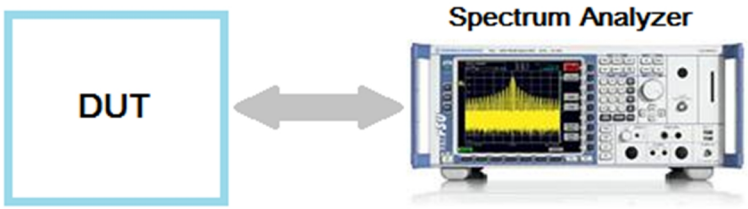
The applicant provided test mode firmware for the EUT, in which it was possible to configure the EUT into different test channels.

2.2 Tested channels and Data rates

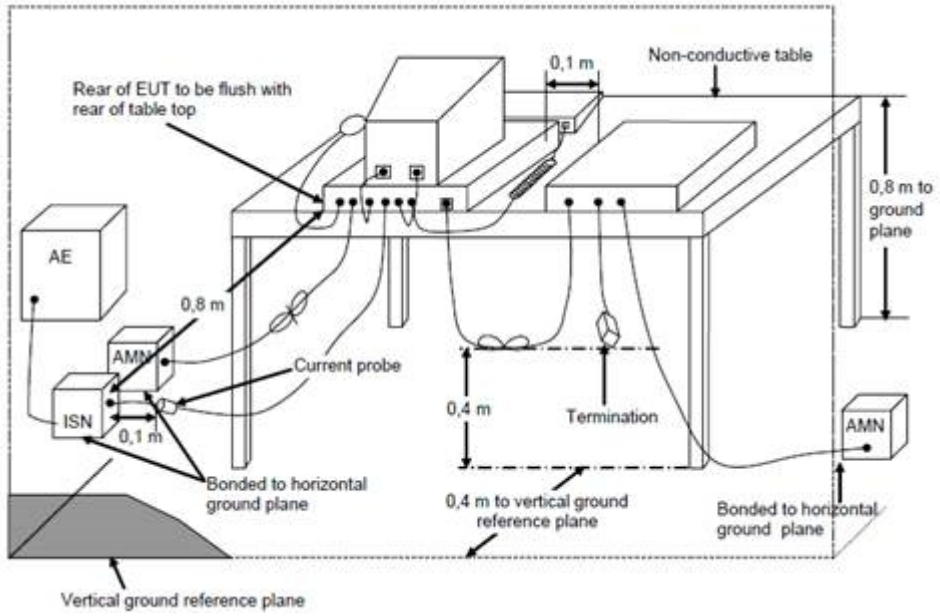
Technology	Channels	Data rate	Frequency (MHz)
802.15.4	11	250 kbps	2404.5
	18	250 kbps	2439.5
	26	250 kbps	2479.5

2.3 Conducted Test setup

RF tests at antenna connector

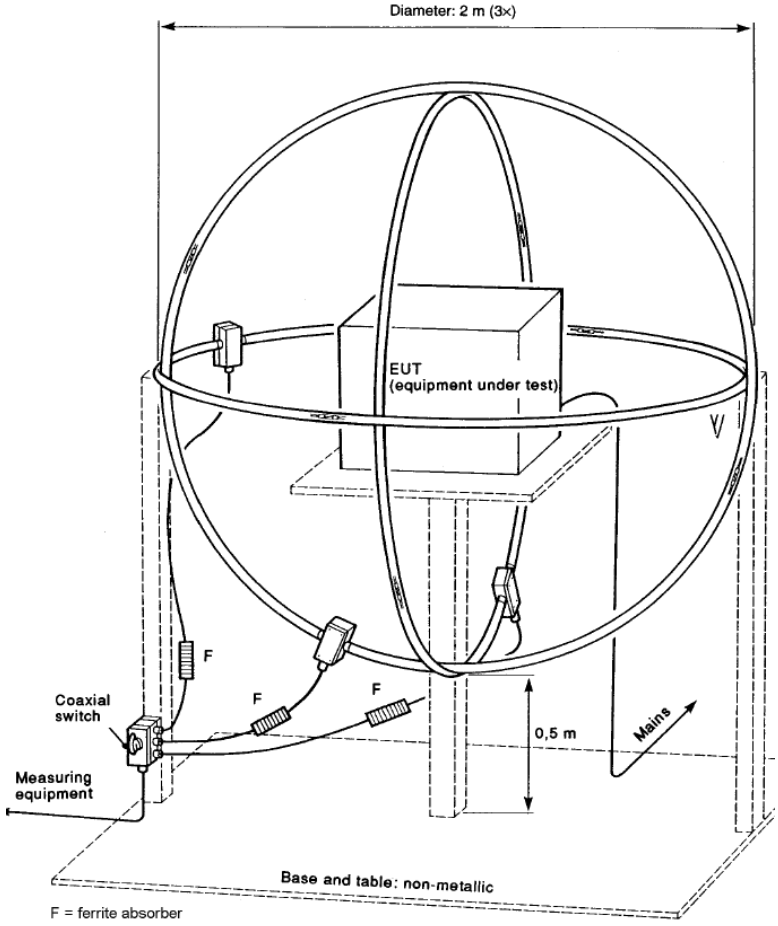


Emissions test at AC mains

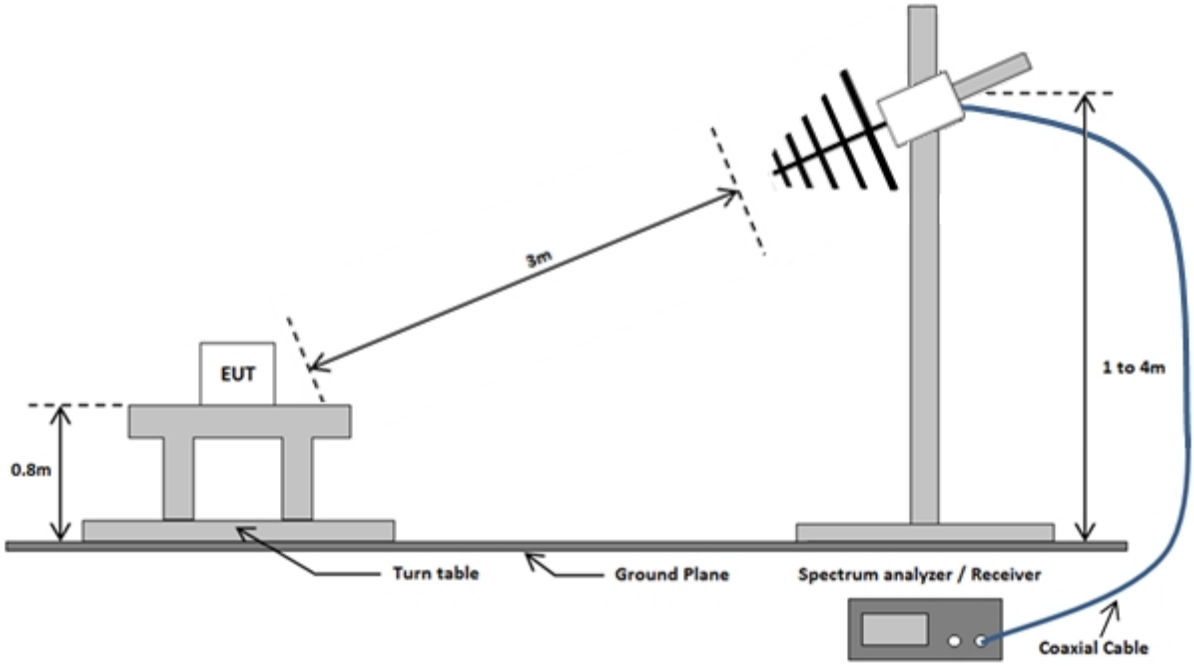


2.4 Radiated Test setup

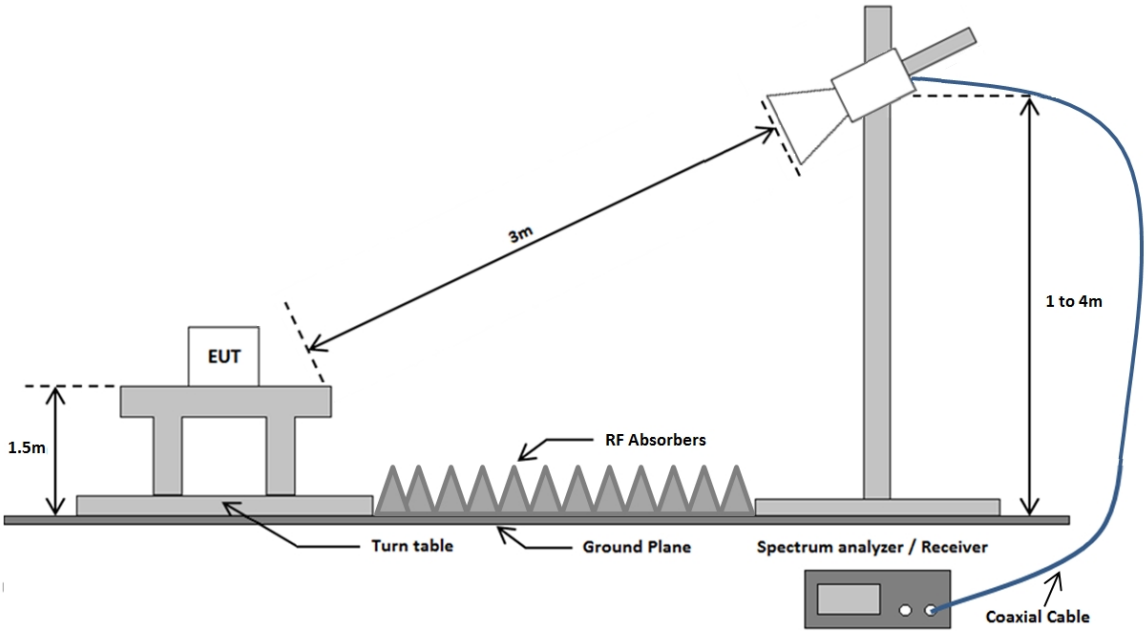
Radiated magnetic disturbance test setup 0.009 – 30 MHz (FCC)



Radiated emissions test setup 30 MHz - 1 GHz (FCC)



Radiated emissions test setup above 1 GHz (FCC)



2.5 Equipment used in the test configuration

Description	Manufacturer	Model	ID	Used at Par.
Signal Generator	Hewlett Packard	83650B	TE00487	3.1 to 3.4
Spectrum Analyzer	Rohde & Schwarz	FSV	TE01269	3.1 to 3.4
Spectrum Analyzer	Rohde & Schwarz	ESR7	TE01220	3.5, 3.6
Spectrum Analyzer	Rhode & Schwarz	ESCI	TE11128	3.7
Biconilog Antenna	Chase	CBL6112A	TE00967	3.6
Horn Antenna	EMCO The Electro – Mechanics Co	3115	TE00531	3.6
Horn Antenna	FM LT.D	-	TE00818	3.6
SAC Chamber	Comtest Engineering BV	-	TE00861	3.6
Artificial Mains Network (AMN)	Rohde & Schwarz	ESH3-Z5	TE00208	3.7
High pass filter	Wainwright instruments	WHK3.0/18G-10EF	TE01140	3.6
Pre-amplifier 1-18GHz	Hewlett Packard	8449B	TE00092	3.6
Pre-amplifier 18-26GHz	Miteq	JS4	TE11131	3.6
Triple loop antenna	Schwarzbeck	HXYZ9170	TE01311	3.5
Measurement software	DARE!!	RadiMation® Ver. 2016.2.8	--	3.6, 3.7
Measurement software	Rebase systems	2.0	--	3.1, 3.2, 3.3, 3.4

2.6 Explanation of the Measurement results for all conducted test items

The path loss between the EUT and the spectrum analyser for the frequency range of 30 MHz to 40 GHz has been measured and stored in the transducer table of the spectrum analyser. This transducer table is used for level offset of the spectrum analyser. With this level offset the spectrum analysers reading will be exactly the RF output.

2.7 Sample calculation

Field Strength Measurement example:

Frequency (GHz)	Polarization	Height(m)	Peak (dBµV/m)
7,236	Horizontal	2	52.5

The following relation applies:
E (dBµV/m) = U(dBµV) + AF (dB/m) – G (dB) + CL (dB)

Where:
E = Electric field strength
U = Measuring receiver voltage
AF = Antenna factor
G = Gain of the pre-amplifier
CL = Cable loss

(52.5 = 48.12 + 36.1 - 37.42 + 5.7)

3 Test results

3.1 6dB bandwidth Measurement

3.1.1 Limit

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

3.1.2 Measurement instruments

The measurement instruments are listed in chapter 2.5 of this report.

3.1.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.1.4 Test procedure

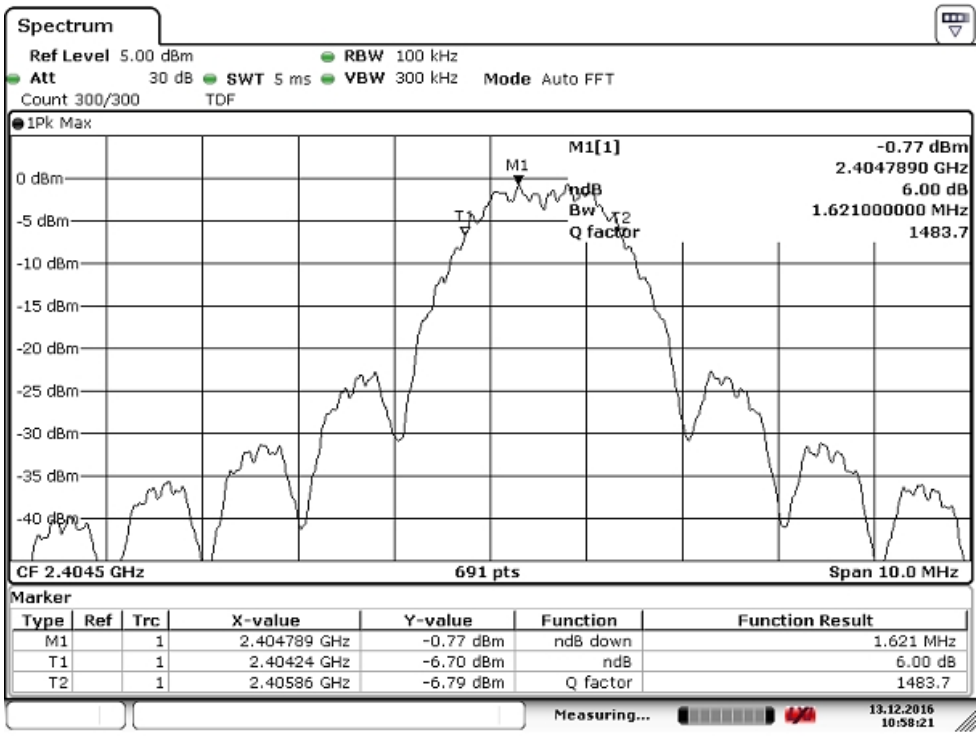
The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v03r05.

3.1.5 Test Results of the 6 dB bandwidth Measurement

Technology Std.	Channel	Frequency (MHz)	6dB bandwidth (kHz)
IEEE 802.15.4	11	2404.5	1621
	18	2439.5	1650
	26	2479.5	1679
Uncertainty	±136 kHz		

3.1.6 Plots of the 6 dB bandwidth Measurement

Channel 11



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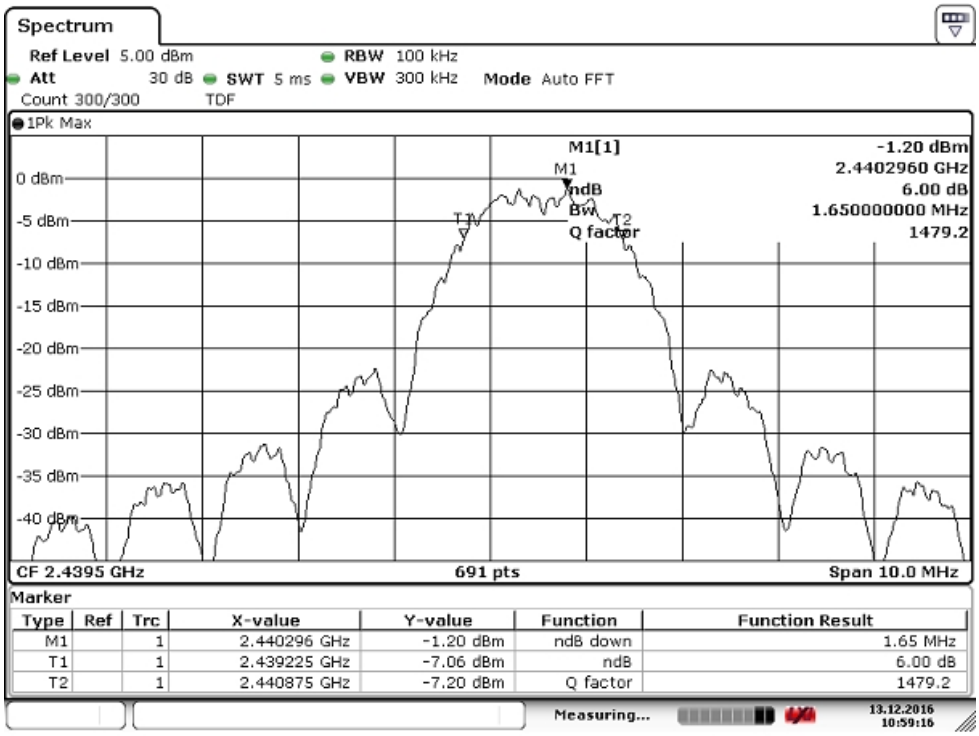
Channel 18



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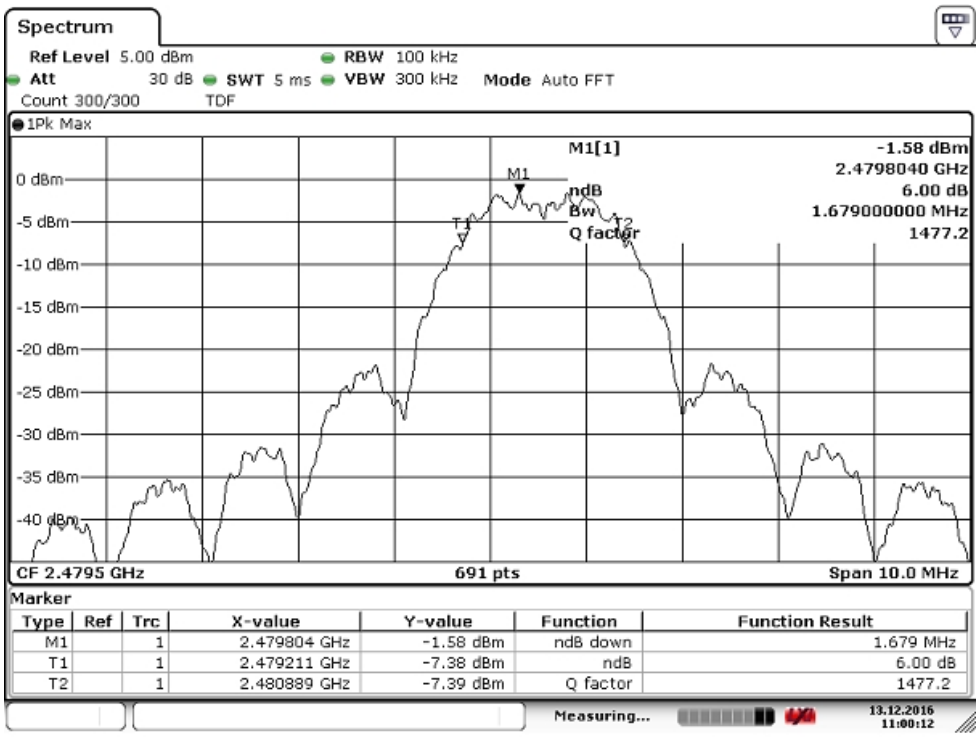
Channel 26



Date: 13.DEC.2016 11:00:12

3.2 Output Power Measurement

3.2.1 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.

3.2.2 Measurement instruments

The measurement instruments are listed in chapter 2.5 of this report.

3.2.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.2.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v03r05.

3.2.5 Test results of Output Power Measurement

Duty cycle

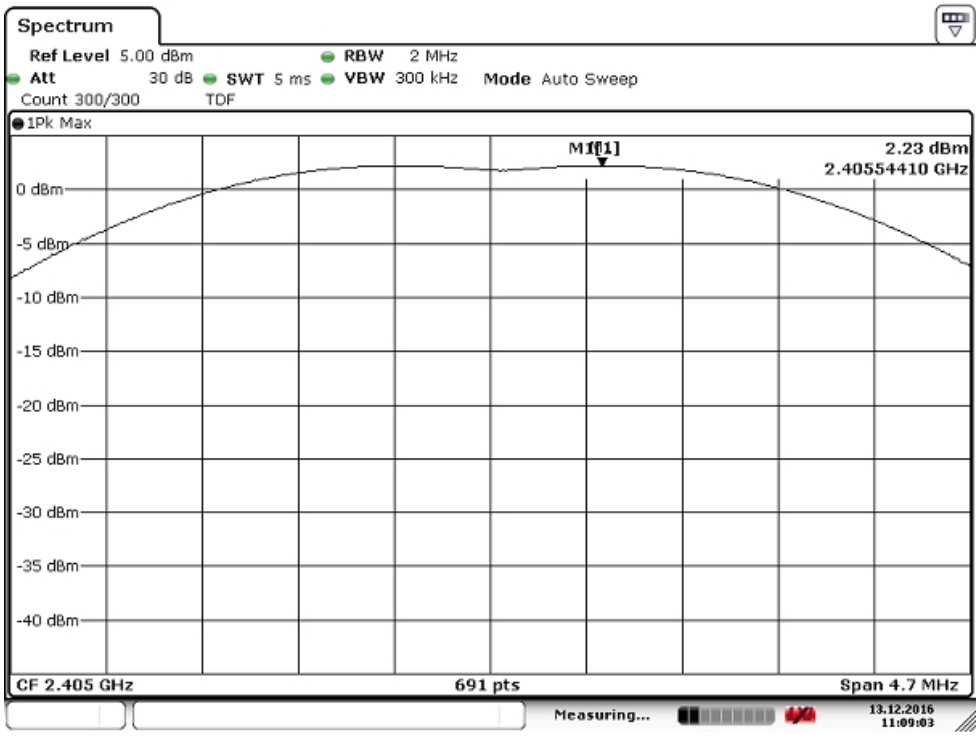
Technology Std.	Channel	Frequency (MHz)	Duty cycle (%)
IEEE 802.15.4	11	2405	100
	18	2440	100
	26	2480	100

Peak method

Technology Std.	Channel	Frequency (MHz)	Peak output power (dBm)
IEEE 802.15.4	11	2405	2.23
	18	2440	1.99
	26	2480	1.90
Uncertainty	±0.63 dB		

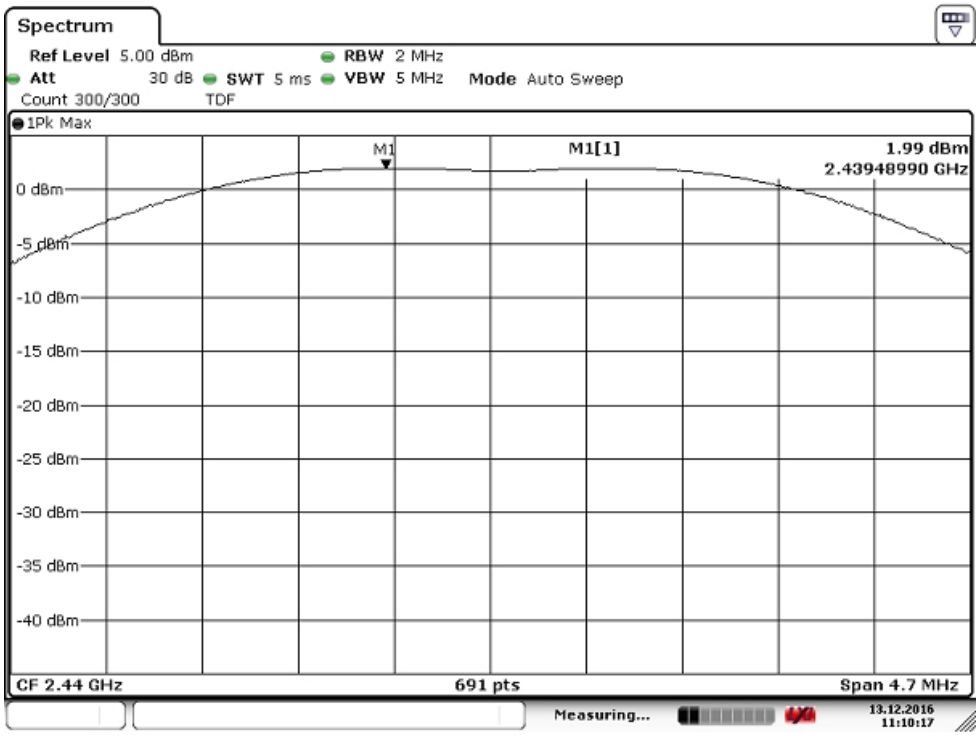
3.2.6 Plots of Output Power Measurement

Channel 11



Date: 13.DEC.2016 11:09:04

Channel 18



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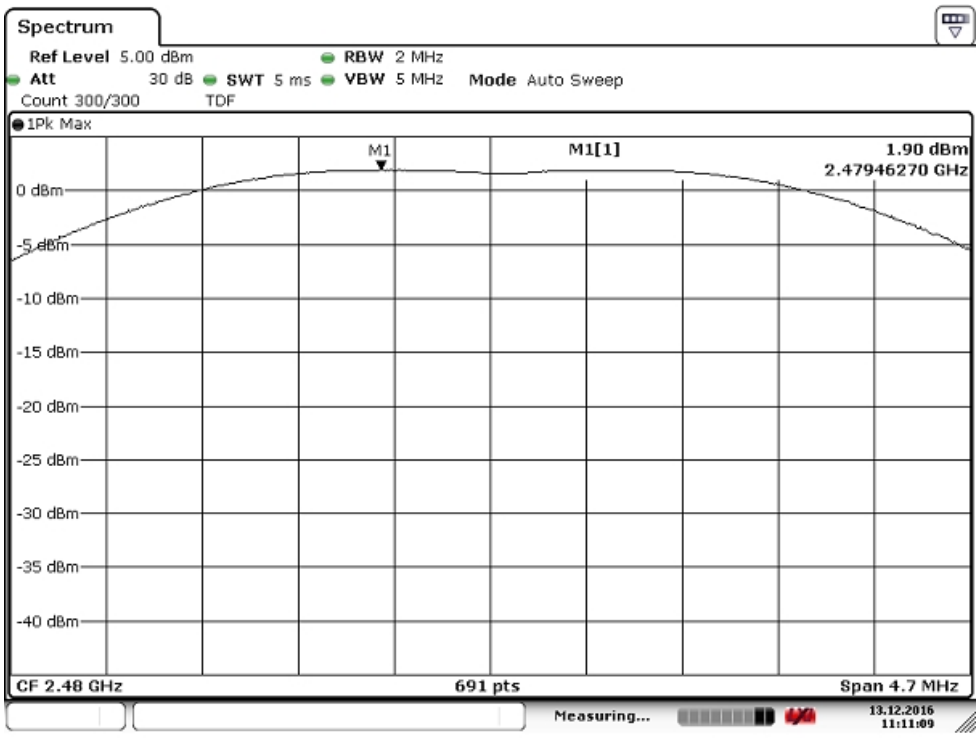
Channel 26


Spectrum
Ref Level 5.00 dBm
RBW 2 MHz
Att 30 dB
SWT 5 ms
VBW 5 MHz
Mode Auto Sweep
Count 300/300
TDF
1Pk Max
M1
M1[1]
1.90 dBm
2.47946270 GHz
0 dBm
-5 dBm
-10 dBm
-15 dBm
-20 dBm
-25 dBm
-30 dBm
-35 dBm
-40 dBm
CF 2.48 GHz
691 pts
Span 4.7 MHz
Measuring...
13.12.2016
11:11:09
Date: 13.DEC.2016 11:11:09

3.3 Power Spectral Density

3.3.1 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.

3.3.2 Measurement instruments

The measurement instruments are listed in chapter 2.5 of this report.

3.3.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.3.4 Test procedure

The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v03r05.

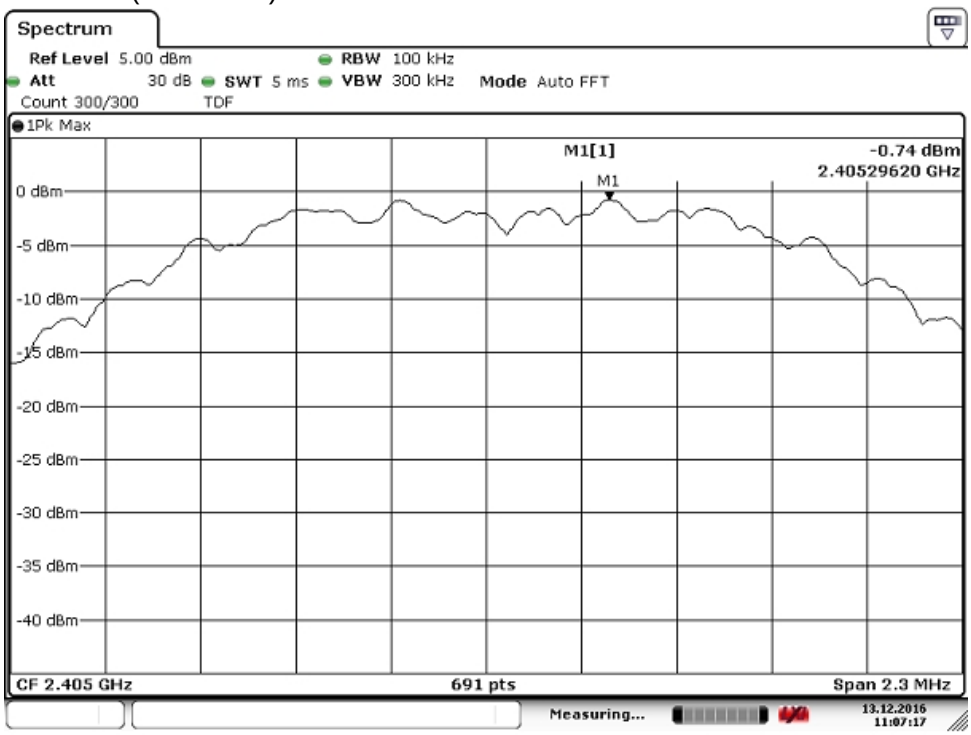
3.3.5 Test results of Power Spectral Density Measurement

Peak Power spectral density

Technology Std.	Channel	Frequency (MHz)	PSD/100 kHz (dBm)
IEEE 802.15.4	11	2405	-0.74
	18	2440	-1.86
	26	2480	-1.58
Uncertainty	±0.63 dB		

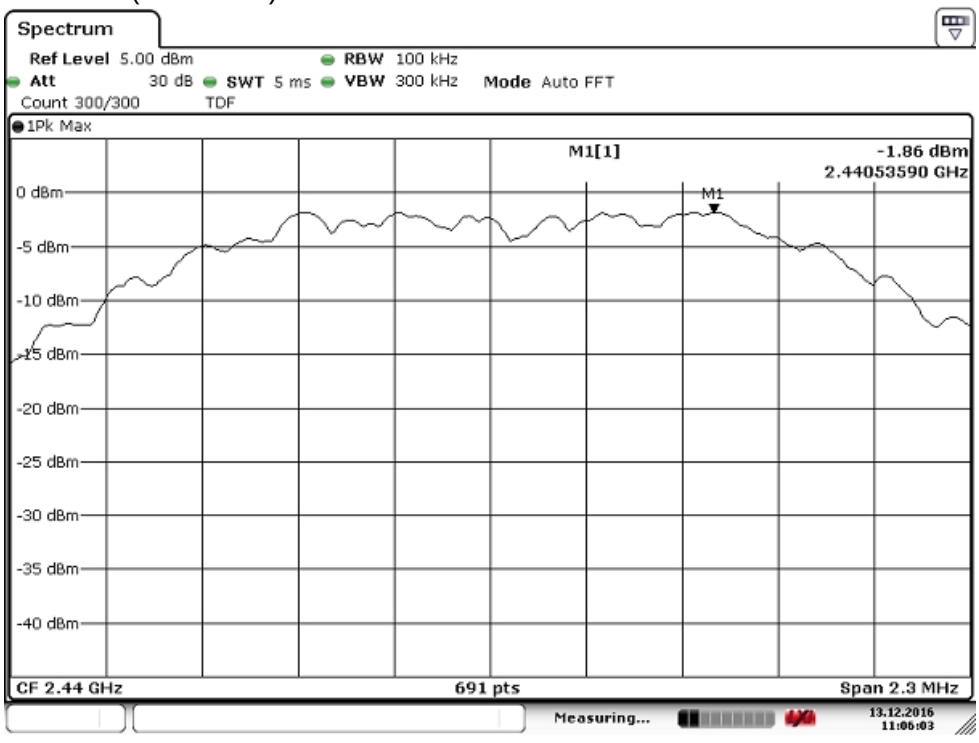
3.3.6 Plots of the Power Spectral Density Measurements

Channel 11 (2405.0 MHz)



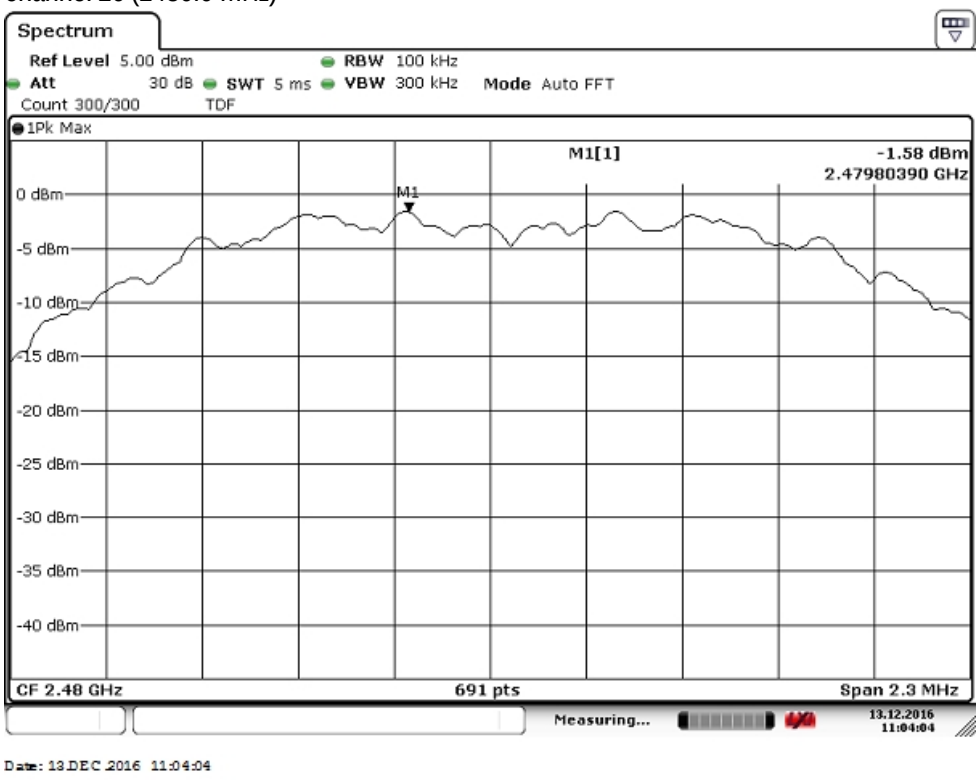
Date: 13.DEC.2016 11:07:17

Channel 18 (2440.5 MHz)



Date: 13.DEC.2016 11:06:03

Channel 26 (2480.0 MHz)



3.4 Conducted Band edge Measurement

3.4.1 Limit

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

3.4.2 Measurement instruments

The measurement instruments are listed in chapter 2.5 of this report.

3.4.3 Test setup

The test setup is as shown in chapter 2.3 of this report.

3.4.4 Test procedure

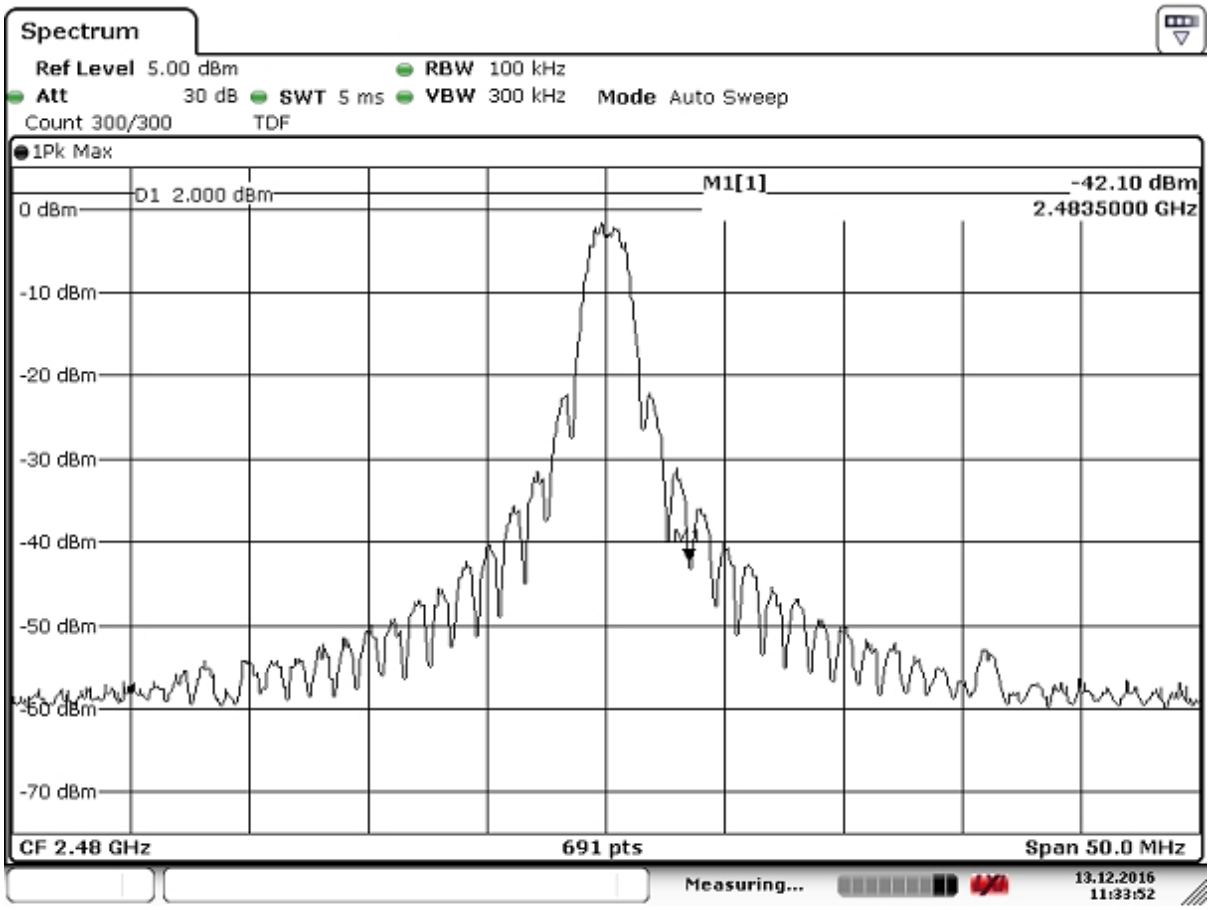
According to KDB Publication 558074 V03r05, sections 11.3 and 12.1

3.4.5 Test results of conducted Band Edge Measurements

Band edge

Technology Std.	Channels	Frequency (MHz)	Band edge (dB)	Limit (dB)
IEEE 802.15.4	26	2480	-42.1	-20
Uncertainty	±0.63 dB			

3.4.6 Plot of the Band edge Measurement



3.5 Radiated Magnetic Disturbance 9 kHz to 30 MHz

3.5.1 Limit

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (µV/m)	Measurement distance(m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 - 30	30	30

3.5.2 Measurement instruments

The measurement instruments are listed in chapter 2.5 of this report.

3.5.3 Test setup

The test setup is as shown in chapter 2.4 of this report.

3.5.4 Test procedure

The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz.
Radiated emission limits in these three bands are based on measurements employing an average detector.

3.5.5 Notes

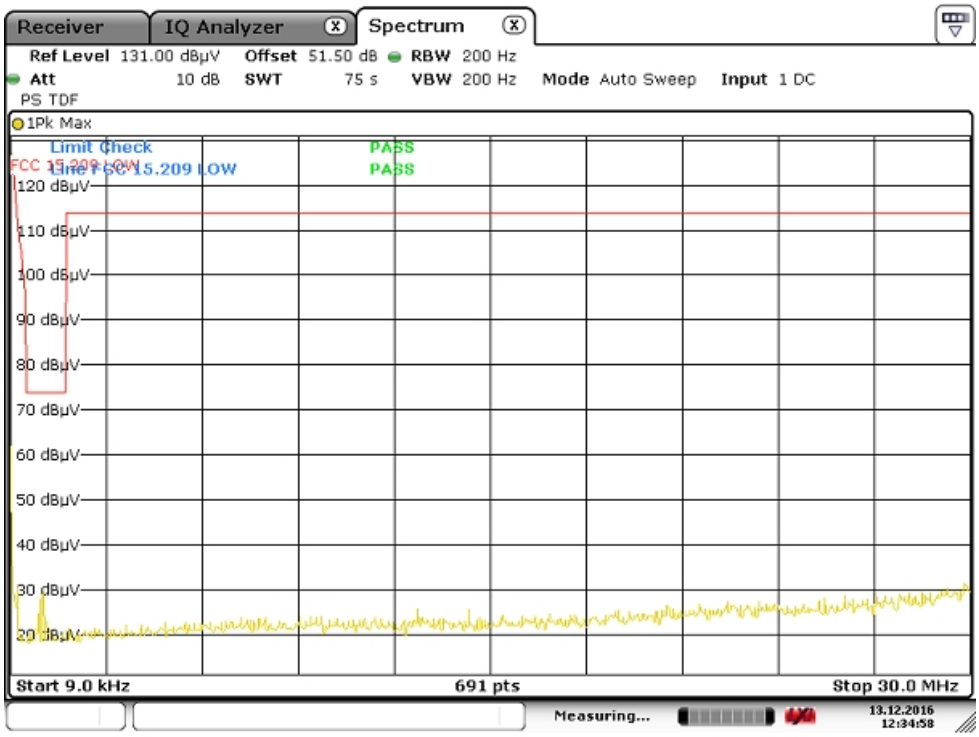
The measurement was performed with the Masterspot emitting the highest possible light level, with the radio in normal (real life) operation. In this mode the EUT emits the highest magnetic field in the 0.009-30MHz range.

3.5.6 Measurement uncertainty

+/- 3.0 dB

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=1.96, providing a level of confidence of 95%.

3.5.8 Plot of the Radiated Magnetic Disturbance 9kHz to 30MHz



3.6 Radiated Spurious Emissions 30MHz to 26GHz Measurement

3.6.1 Limit

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (µV/m)	Measurement distance(m)
30 -88	100	3
88 - 216	150	3
216-960	200	3
Above 960	500	3

3.6.2 Measurement instruments

The measurement instruments are listed in chapter 2.5 of this report.

3.6.3 Test setup

The test setup is as shown in chapter 2.4 of this report.

3.6.4 Test procedure

The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands above 1000 MHz.
Radiated emission limits in these three bands are based on measurements employing an average detector.

Other details are according to KDB Publication 558074 V02r05, sections 11.3 and 12.1

3.6.5 Notes

- In the frequency range of 1 – 18 GHz the green trace is measured using a peak detector and the red trace is measured using an average detector. The top limit line represent the peak limit and the bottom limit represents the average limit
- It is not possible to set the Masterspot at the maximum light level while staying in test mode, going to test mode automatically lowers the light level to 50% of the maximum.

3.6.6 Plots of the Radiated Spurious Emissions Measurement

Masterspot set at the maximum possible light level with the radio in normal (real life) operation.

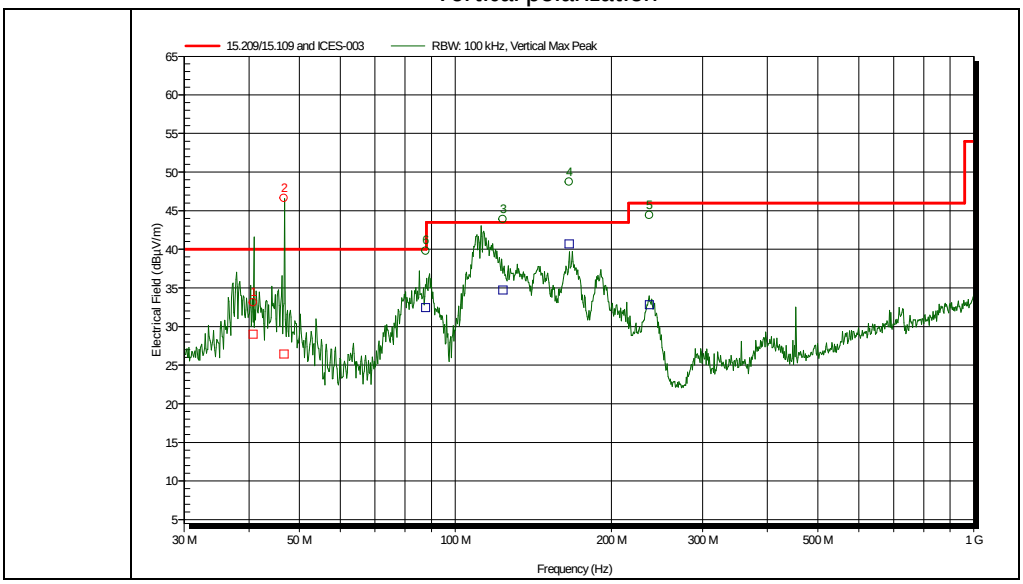
Measured peaks Horizontal 30 – 1000 MHz

Frequency	Polarization	Height	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference
87,705 MHz	Horizontal	2 m	32,4 dBµV/m	40 dBµV/m	-7,6 dB
165,8 MHz	Horizontal	2,5 m	40,7 dBµV/m	43,5 dBµV/m	-2,8 dB
123,55 MHz	Horizontal	3,5 m	34,7 dBµV/m	43,5 dBµV/m	-8,8 dB
236,7 MHz	Horizontal	1 m	32,8 dBµV/m	46 dBµV/m	-13,2 dB

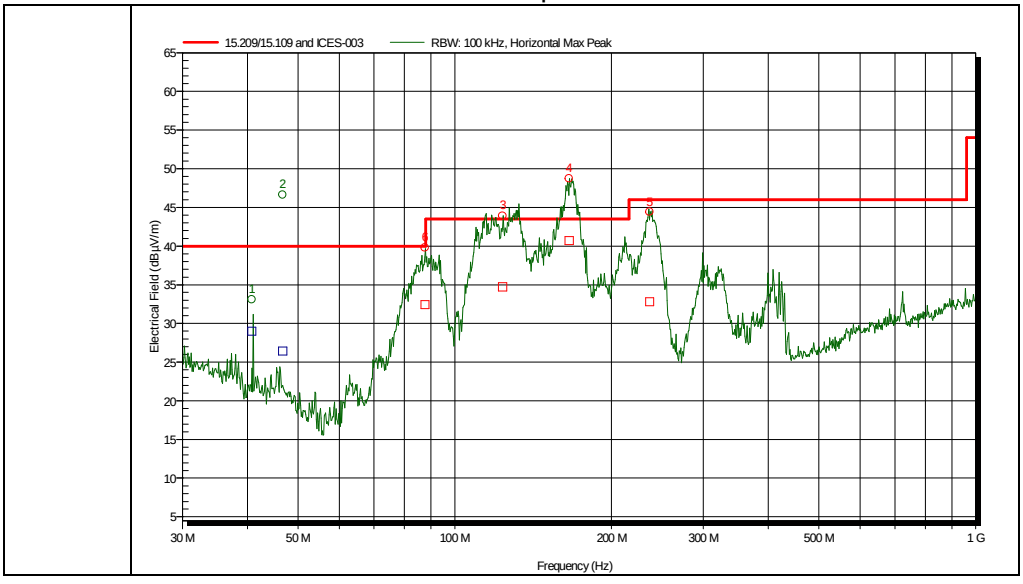
Measured peaks Vertical 30 – 1000 MHz

Frequency	Polarization	Height	Quasi-Peak	Quasi-Peak Limit	Quasi-Peak Difference
46,75 MHz	Vertical	3 m	26,4 dBµV/m	40 dBµV/m	-13,6 dB
40,765 MHz	Vertical	2 m	29 dBµV/m	40 dBµV/m	-11,0 dB

Vertical polarization

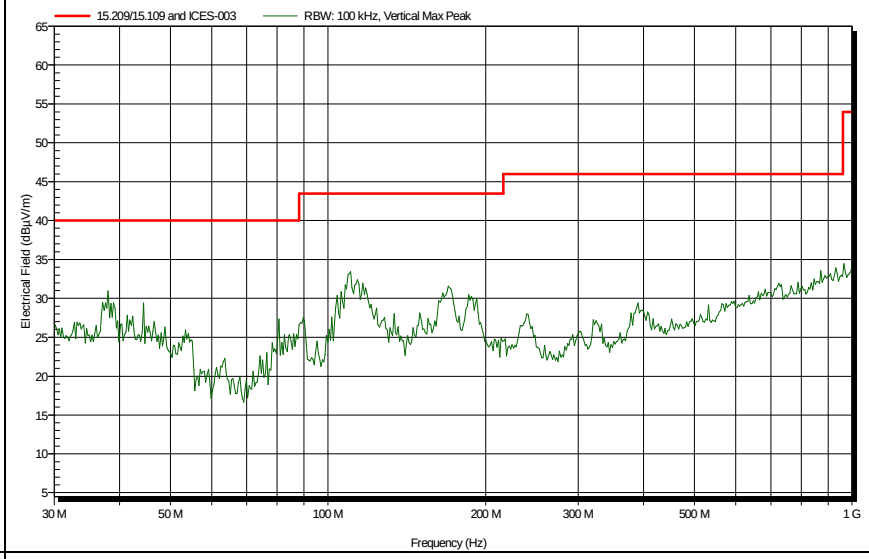
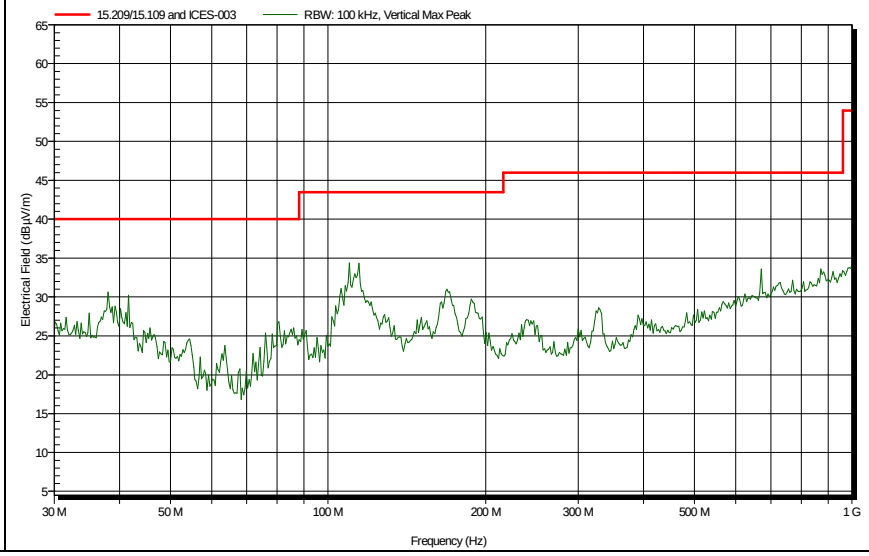


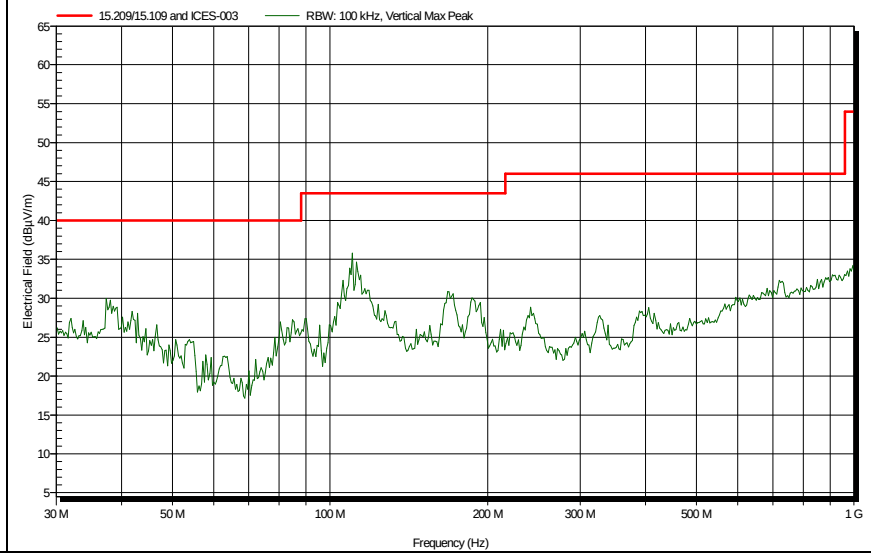
Horizontal polarization



30 MHz to 1 GHz

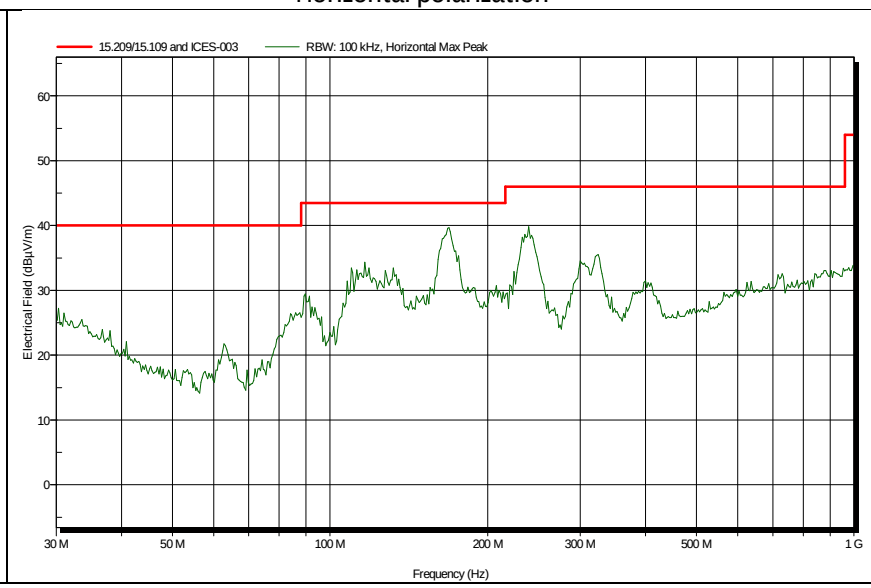
Vertical polarization

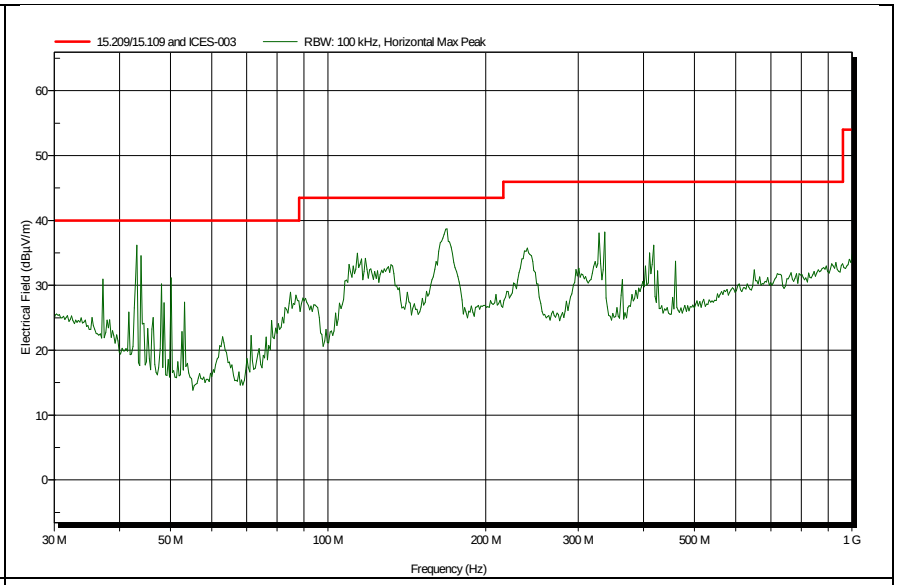
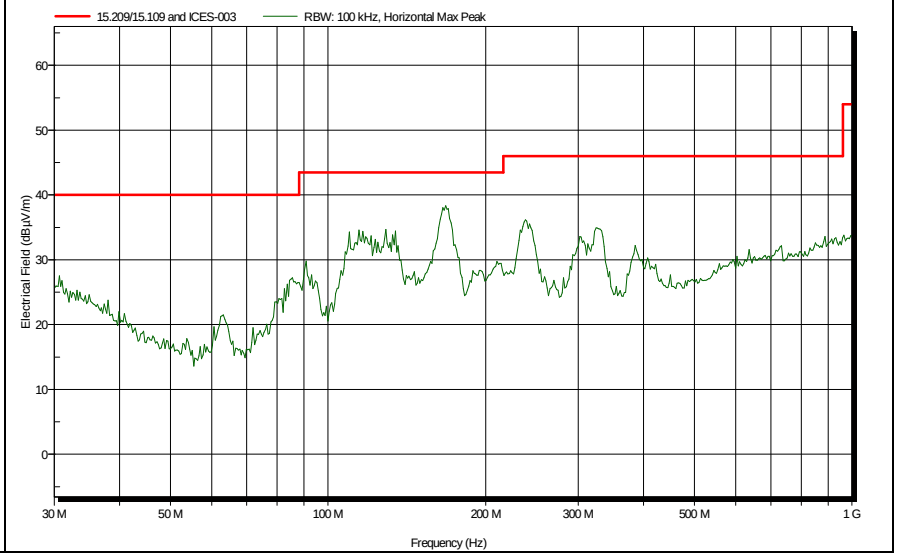
Low ch	
Mid ch	

High ch	

30 MHz to 1 GHz

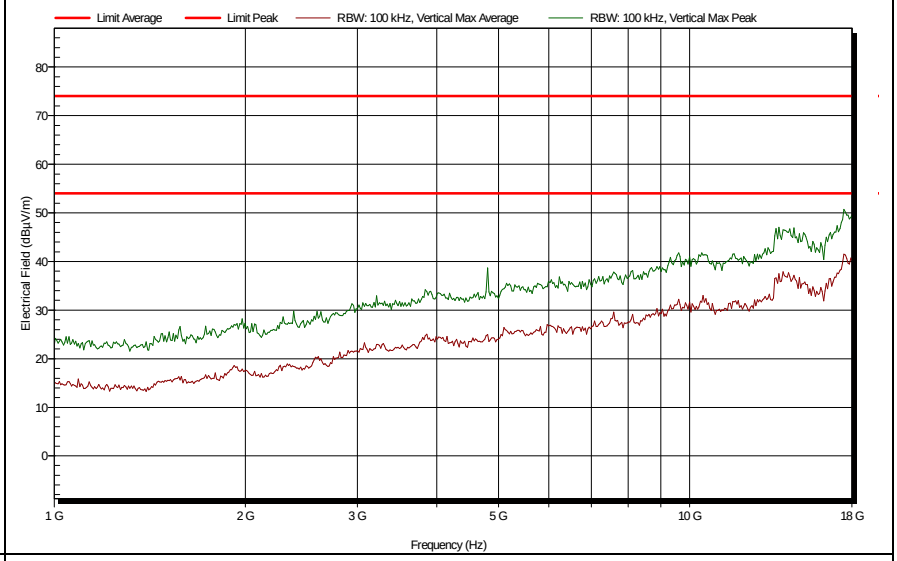
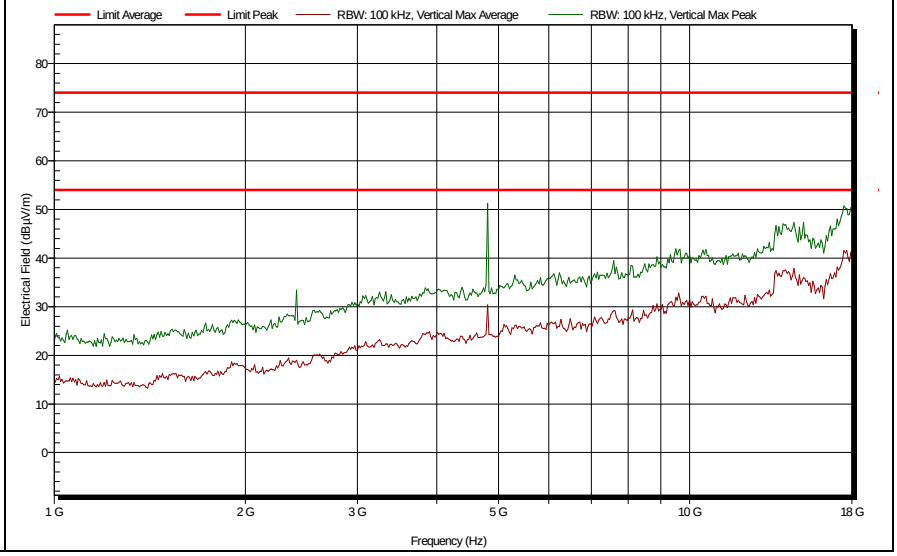
Horizontal polarization

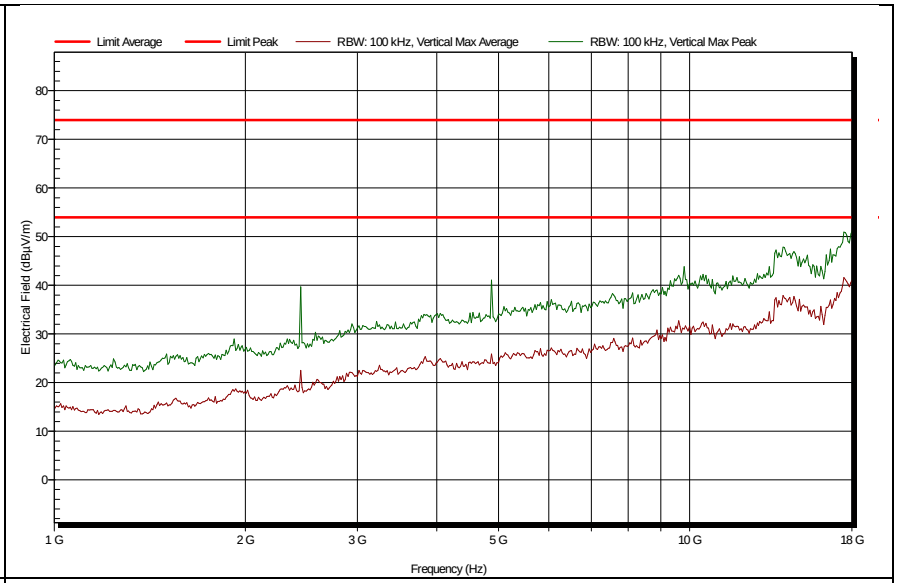
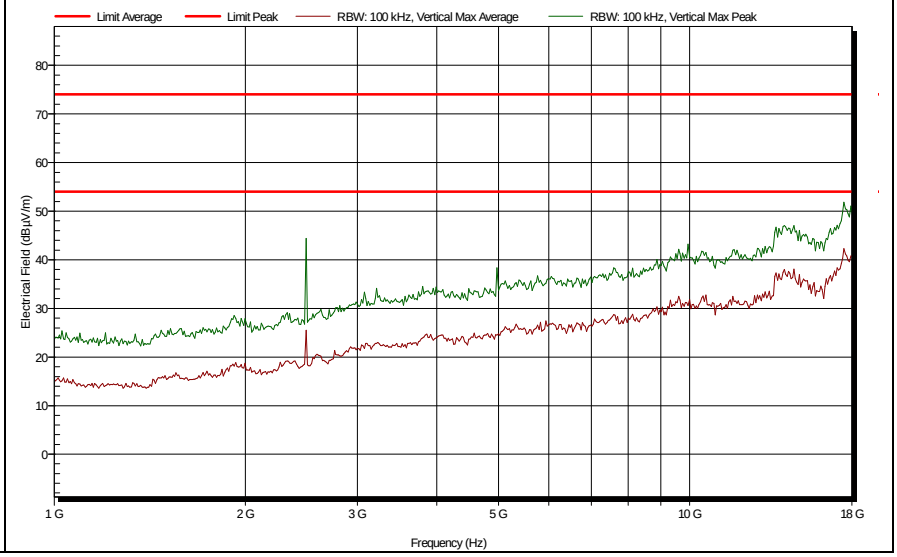
Low ch	

Mid ch	
High ch	

1 GHz to 18 GHz

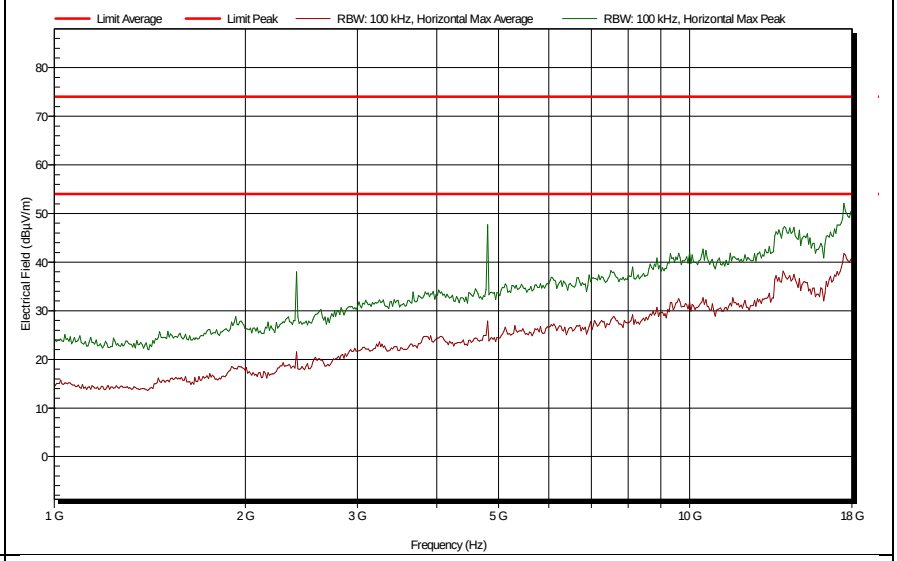
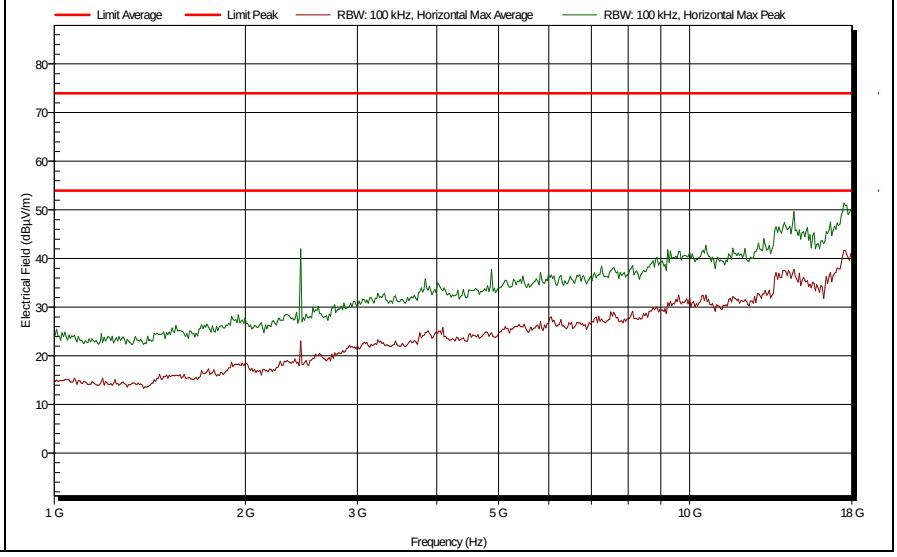
Vertical polarization

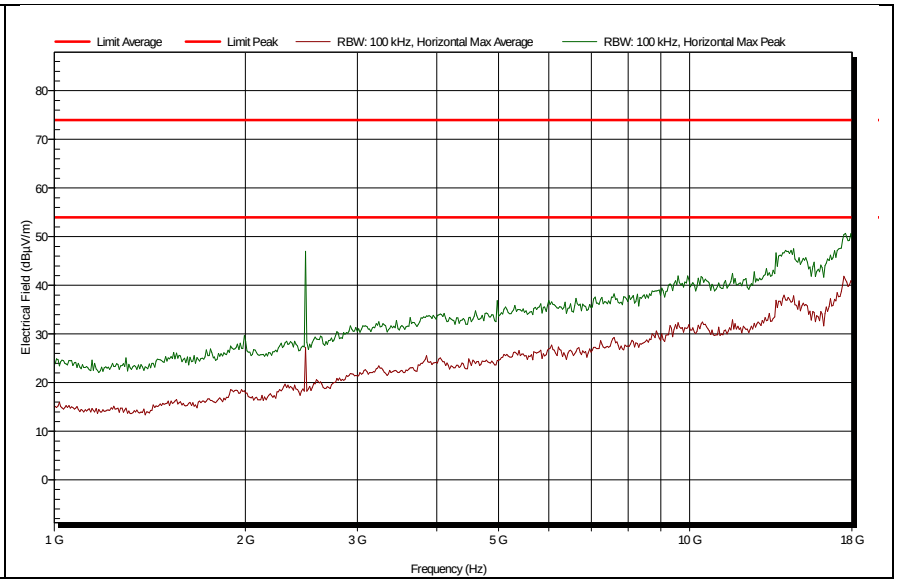
Low ch (antenna heights from 3 to 4m)	
Low ch (antenna heights from 1 to 2.5m)	

Mid ch	
High ch	

1 GHz to 18 GHz

Horizontal polarization

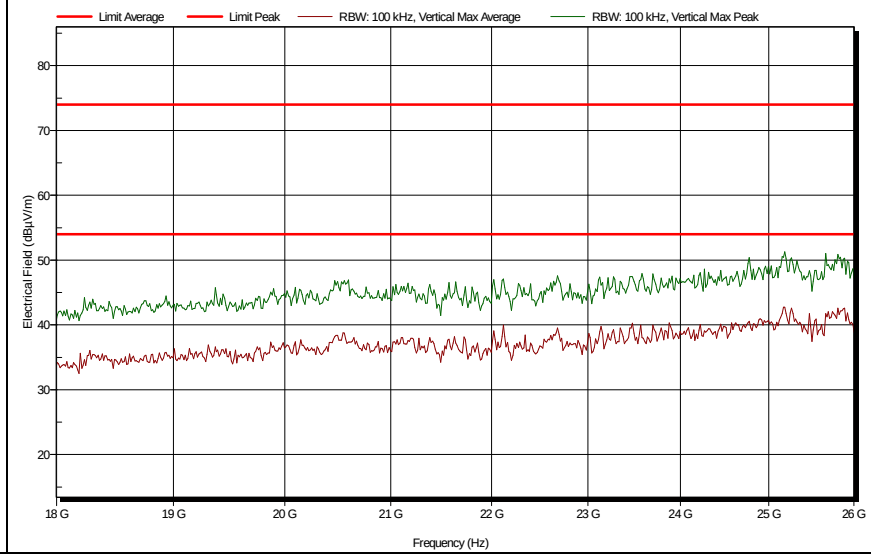
Low ch	
Mid ch	

High ch	

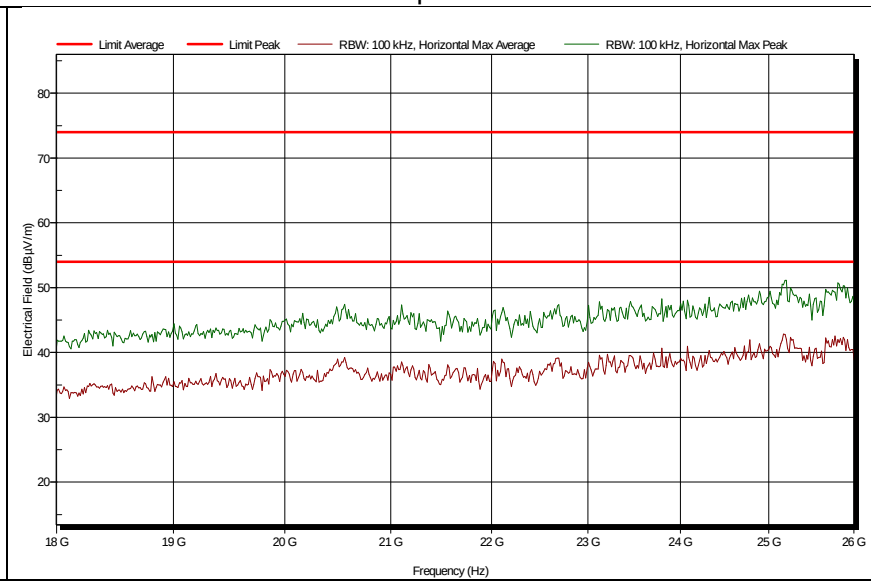
Limit Average
Limit Peak
RBW: 100 kHz, Horizontal Max Average
RBW: 100 kHz, Horizontal Max Peak
Electrical Field (dBµV/m)
80
70
60
50
40
30
20
10
0
1 G
2 G
3 G
5 G
10 G
18 G
Frequency (Hz)

18 GHz to 26 GHz
From the 1 to 18 GHz results the low channel was selected to be representative for the emissions in the 18 to 26 GHz band for all channels.
No emissions above measurement system noise floors are measured. (See below)

Vertical polarization

Low ch	

Horizontal polarization

Low ch	

3.6.7 Measurement Uncertainty

Measurement uncertainty Radiated emissions below 1 GHz

Horizontal polarization	
30 – 200 MHz	4.5 dB
200 – 1000 MHz	3.6 dB
Vertical polarization	
30 – 200 MHz	5.4 dB
200 – 1000 MHz	4.6 dB

Measurement uncertainty Radiated emissions between 1-18 GHz

1000- 18000 MHZ	+ 5.7/- 5.7dB

Measurement uncertainty radiated emissions between 18-26 GHz

18000-26000 MHZ	+ 3.9/- 3.9dB

3.7 Conducted spurious measurement at AC mains

3.7.1 Limit

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

3.7.2 Measurement equipment

The measurement instruments are listed in chapter 2.5 of this report.

3.7.3 Test set up

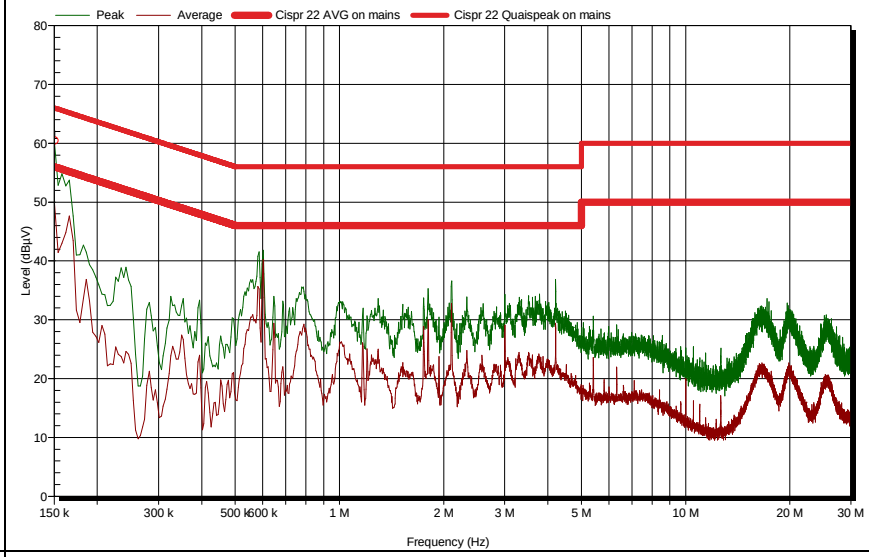
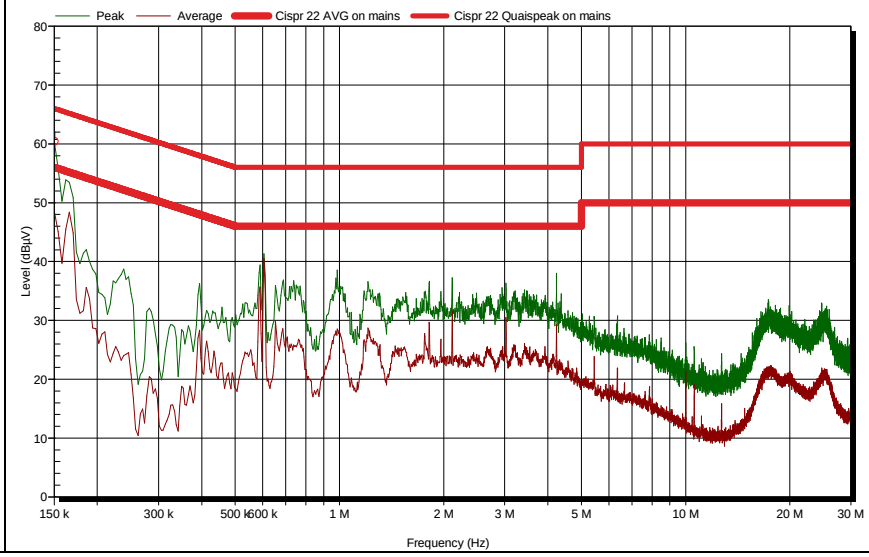
The test setup is as shown in chapter 2.3 of this report.

3.7.4 Test procedure

According to ANSI C63.4: 2014, section 13.3.

3.7.5 Plots of the AC conducted spurious measurement

150 kHz to 30 MHz

Neutral	
Phase	

3.7.6 Measurement uncertainty

+/- 3.6 dB

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approx. 95%, but excluding the effect of measurement system repeatability.