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Appendices **–**

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Date of handing in: 19.03.2014

Tested by:



Pekka Kälviäinen, Test Engineer

Reviewed by:



Timo Hietala, Test Specialist

SORT OF EQUIPMENT:

2.4 GHz Transceiver

MARKETING NAME:

TYPE:

MANUFACTURER:

Quha USB Receiver

Quha Oy

CLIENT:

Quha Oy

ADDRESS:

Pirkkalaistie 1, FI-3700 Nokia, Finland

TELEPHONE:

+358 (0)400 339655

TEST LABORATORY:

Nemko Oy

FCC REG. NO.

359859 October 25, 2013

IC FILE NO.

2040F-1 November 22, 2012

SUMMARY:

In regard to the performed tests the equipment under test fulfils the requirements defined in the test specifications, see page 2 for details

The test results are valid for the tested unit only. Without a written permission of SGS Fimko EMC Oy it is allowed to copy this report as a whole, but not partially.

Summary of performed tests and test results

<i>Section in CFR 47</i>	<i>Section in RSS-GEN or RSS-210, Issue 8</i>		<i>Result</i>
15.249 (a)	A2.9	Field strength of fundamental	PASS
15.249 (d)(e), 15.209	A2.9	Band-edge compliance of RF emissions	PASS
15.249 (d)(e), 15.209	A2.9	Spurious radiated emissions	PASS
15.215	-	20 dB bandwidth	X
-	4.6.1	99% bandwidth	X
15.207	7.2.4	AC power line conducted emissions	PASS

Explanations:

PASS	The EUT passed that particular test.
FAIL	The EUT failed that particular test.
N.A.	The test not applicable, battery operated equipment
X	The measurement was done, but there is no applicable performance criteria.

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1. EUT and Accessory Information

1.1 EUT description

2.4 GHz transceiver, Digital modulated, 16 channels

1.2 EUT and accessories

	<i>unit</i>	<i>type</i>	<i>s/n</i>
<i>EUT (2405MHz)</i>	Transceiver	Quha USB Receiver	838861062
<i>EUT (2440MHz)</i>	Transceiver	Quha USB Receiver	838861061
<i>EUT (2475MHz)</i>	Transceiver	Quha USB Receiver	838861063
<i>AE</i>	Portable Computer	hp ProBook 5320m	CND0380L7Y
<i>AE (2405MHz)</i>	Transceiver	Quha Zono	838861062
<i>AE (2440MHz)</i>	Transceiver	Quha Zono	838861061
<i>AE (2475MHz)</i>	Transceiver	Quha Zono	838861063
<i>AE mouse button</i>	Mouse button	Liberator Mini Lib Switch	-
<i>AE mouse button</i>	Mouse button	Liberator Mini Lib Switch	-

EUTs were connected to the Portable Computer during the tests.

AE transceivers were located outside of the test area during the tests

Mouse buttons were connected to Quha USB Receiver, the cable length was 1.5 m each.

Operating voltages

Transceiver: 5.0V DC (USB)

Portable Computer: 230V 50Hz AC

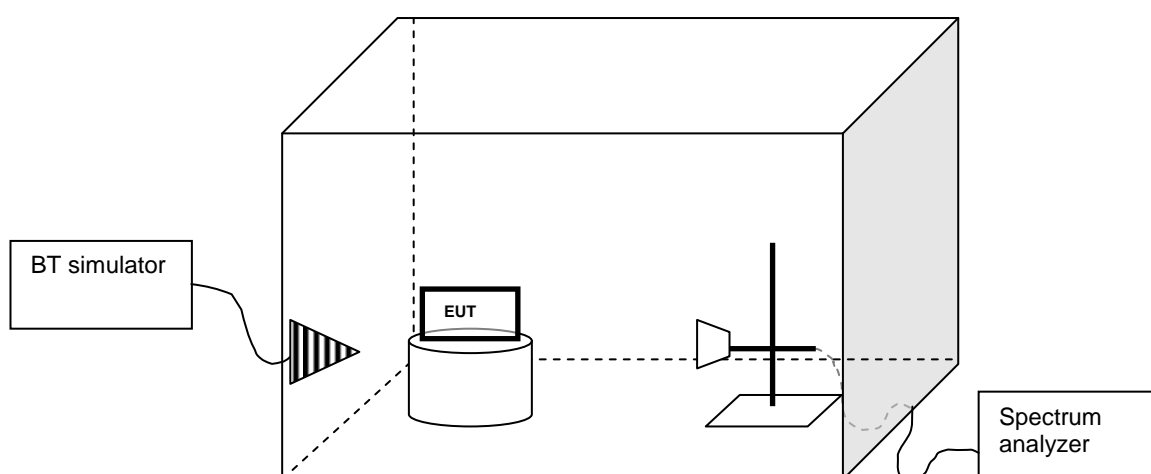
1.3 Additional information related to testing

Tested Technology:	Digital modulated, 16 channels	
Antenna:	Integral	
Type of Unit	Transmitter	
Modulation:	DSSS	
Power Supply Requirement:	Nominal	5.0VDC
Transmit Frequency Range	2400 MHz to 2483.5 MHz	
Transmit Channels Tested:	Channel Frequency (MHz)	
	2405	
	2440	
	2475	

2. Test setups

Setup (Radiated measurements)

The test was performed inside a semi anechoic shielded room. For the duration of the test the EUT was placed on a non-conductive support 0.8 m high standing on the turntable. The tower and turn table were remotely controlled to turn the EUT and change the antenna polarization. The measured signal was routed from the measuring antenna to the spectrum analyzer. A BT simulator was not used.



3. Standards and measurement methods

The test were performed in guidance of the CFR 47, FCC Rules Part 15 Subpart C, ANSI C63.4 (2003), CISPR 22 Ed. 6.0, ANSI C63.10 (2009), IC standards RSS-GEN (Issue 3, December 2010) and RSS-210 (Issue 8, December 2010).

4. Test results

4.1 Field strength of fundamental

The test was performed as a compliance test. The test parameters concerned were as follows:

<i>EUT</i>	EUT
<i>Site name</i>	Perkkaa
<i>FCC rule part</i>	§ 15.249 (a)
<i>Section in RSS-210</i>	A2.9
<i>Date of testing</i>	21.03. and 17.5.2014
<i>Test equipment</i>	566, 525, 350
<i>Test conditions</i>	22 °C, 30 % RH

4.1.1 EUT operation mode

<i>EUT frequency (MHz)</i>	2405, 2440 and 2475
----------------------------	----------------------------

4.1.2 Test method and limit

<i>Frequency range (MHz)</i>	<i>Limit Average (dBµV/m)</i>	<i>Limit Peak (dBµV/m)</i>
2400 – 2483.5	≤ 94	≤ 114

The measurement results were obtained as described below.

$$E [\text{dB}(\mu\text{V/m})] = U_{RX} + A_{CABLE} + AF$$

Where

U_{RX} receiver reading

A_{CABLE} attenuation of the cable

AF antenna factor

Duty Cycle correction factor(dB) -41.41 dB was used. (RFon 0.850ms/100ms)

4.1.3 Test results

frequency (MHz)	E Average (dB μ V/m)	E Peak (dB μ V/m)	Result
2405	45.30	86.71	PASS
2440	46.38	87.79	PASS
2475	46.33	87.74	PASS

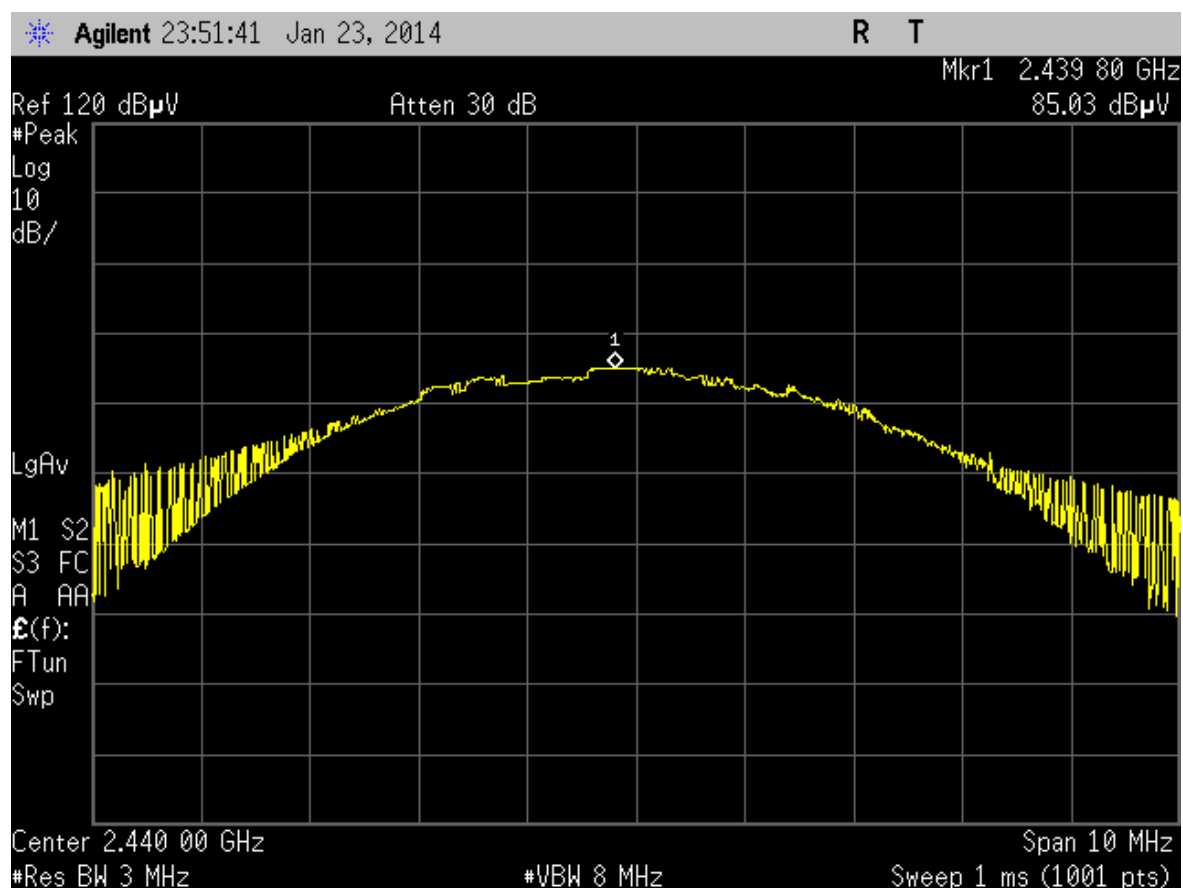


Figure 1. 2440MHz, Field strength of fundamental

4.2 Band-edge compliance of RF emissions

The test was performed as a compliance test. The test parameters concerned were as follows:

<i>EUT</i>	EUT
<i>Site name</i>	Perkkaa
<i>FCC rule part</i>	§ 15.249 (d)(e), § 15.209
<i>Section in RSS-210</i>	A2.9
<i>Date of testing</i>	21.03. and 22.5.2014
<i>Test equipment</i>	566, 525, 350
<i>Test conditions</i>	22 °C, 35 % RH
<i>Test result</i>	PASS

4.2.1 EUT operation mode

<i>EUT frequency (MHz)</i>	2405 and 2475
----------------------------	----------------------

4.2.2 Test method and limit

The measurement is made according to ANSI C63.10 (2009) and IC standard RSS-210.

3m measurement distance

<i>Frequency range (MHz)</i>	<i>Limit Average (dBμV/m)</i>	<i>Limit Peak (dBμV/m)</i>
Below 2400 and above 2483.5	≤ 54	≤ 74

The measurement results were obtained as described below.

$$E [\text{dB}(\mu\text{V/m})] = U_{RX} + A_{CABLE} + AF$$

Where

U_{RX} receiver reading

A_{CABLE} attenuation of the cable

AF antenna factor

Duty Cycle correction factor(dB) -41.41dB was used. (RFon 0.850ms/100ms)

4.2.3 Test results

2405 MHz:

Below 2400 MHz:

<i>Detector (RBW: 1MHz)</i>	<i>E (dBμV/m)</i>	<i>Result</i>
Peak	60.26	PASS
Average	18.85	PASS

2475 MHz:

Above 2483.5 MHz:

<i>Detector (RBW: 1MHz)</i>	<i>E (dBμV/m)</i>	<i>Result</i>
Peak	56.23	PASS
Average	14.82	PASS

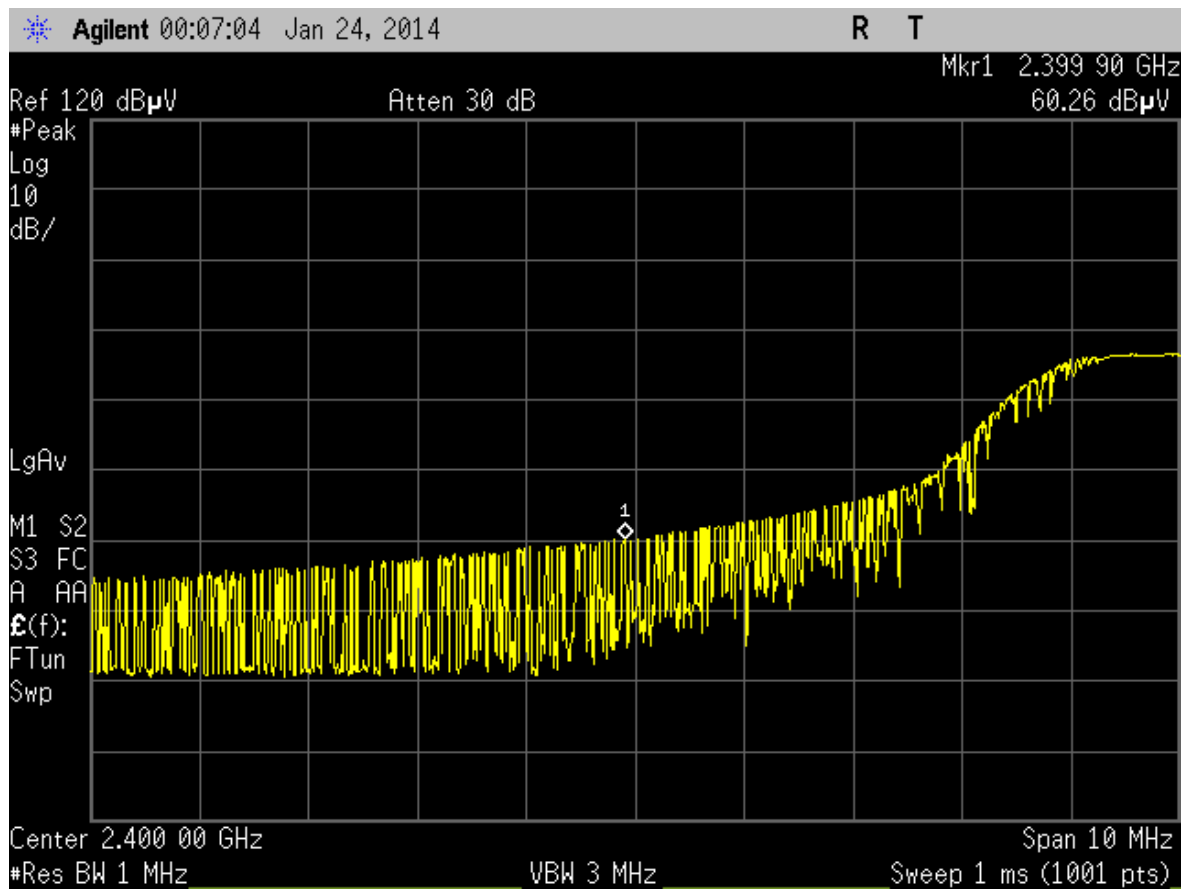


Figure 2. 2405MHz, Band-edge compliance, low end

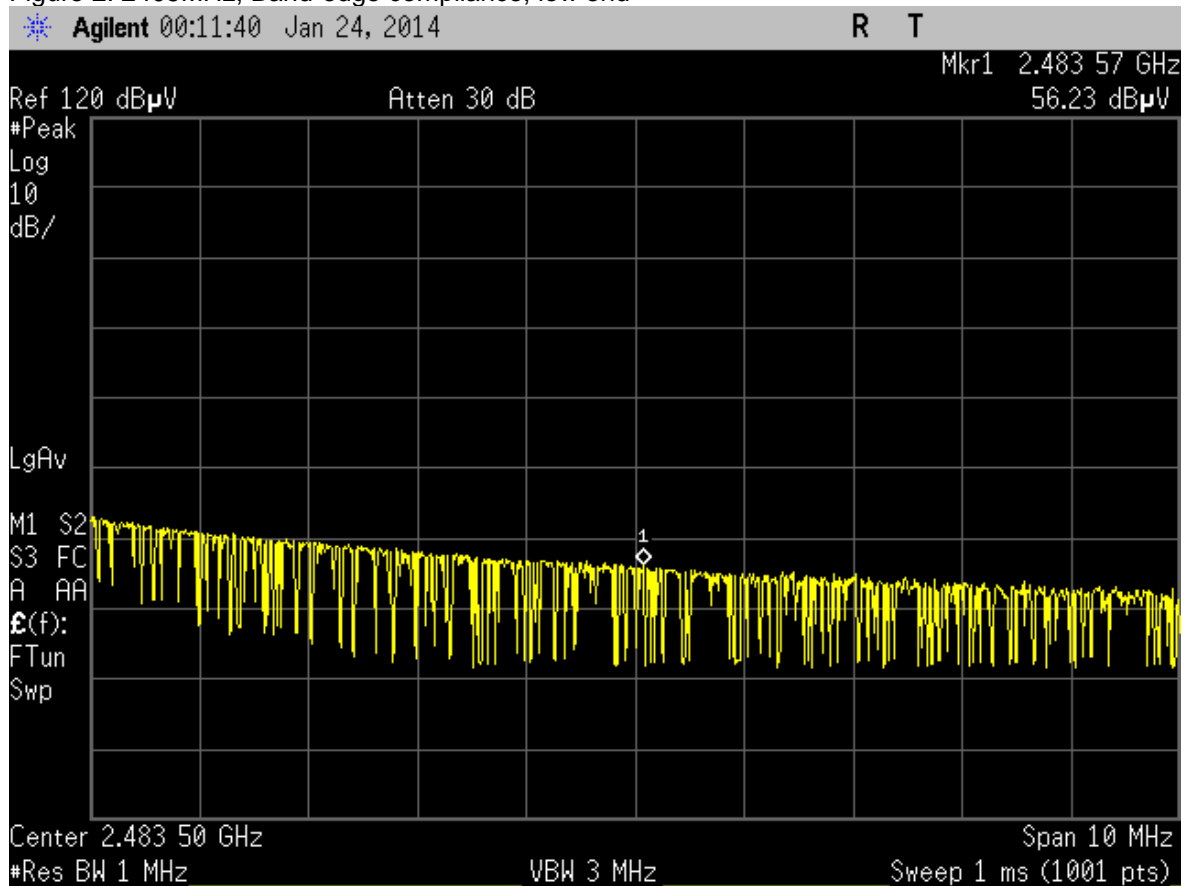


Figure 3. 2475MHz, Band-edge compliance, high end

4.3 Spurious radiated emission

The test was performed as a compliance test. The test parameters concerned were as follows:

<i>EUT</i>	EUT
<i>Site name</i>	Perkkaa
<i>FCC rule part</i>	§ 15.249 (d)(e), § 15.209
<i>Section in RSS-210</i>	A2.9
<i>Date of testing</i>	20.-21.03. and 22.5.2014
<i>Test equipment</i>	566, 709, 564, 559, 525, 319, 544, 350, 88
<i>Test conditions</i>	22 °C, 35 % RH

4.3.1 EUT operation mode

<i>EUT frequency (MHz)</i>	2405, 2440 and 2475
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4.3.2 Test method and limit

The test was performed in a semi-anechoic shielded room. The EUT was placed on a non-conductive 0.8 m high table standing on the turntable. During the test the distance from the EUT to the measuring antenna was 3 m. The excess length of the cables of the EUT was made into bundles 30-40 cm in length. In order to find the maximum levels of the disturbance radiation the angle of the turntable, the height of the measuring antenna and the lay-out of the EUT cables were varied during the tests. The test was performed with the measuring antenna being both in horizontal and vertical polarizations.

Vertical and horizontal polarizations in the frequency range 30 – 1000 MHz was measured by using the peak detector. During the peak detector scan, the turntable was rotated from 0° to 360° with 30° step with the antenna heights 1.0 m and 3.0 m. The highest levels of the radiated interference field strength measured by using the quasi-peak detector were recorded.

Vertical and horizontal polarizations in the frequency range 1000 – 25000 MHz was measured by using the peak detector. During the peak detector scan, the turntable was rotated from 0° to 360° with 15° step with the antenna heights 1.0 m, 1.5m, 2.0m, 2.5m and 3.0 m. The highest levels of the radiated interference field strength measured by using the average and peak detectors were recorded.

Minimum Standard: Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209, whichever is the lesser attenuation.

Emissions falling in the restricted bands of 15.205 shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions.

3m measuring distance, FCC Part 15.209

<i>Frequency band MHz</i>	<i>limit, Quasi peak detector dB(μV/m)</i>
30 - 88	40
88 - 216	43.5
216 - 960	46
960 - 1000	54

<i>Frequency band MHz</i>	<i>limit, average detector dB(μV/m)</i>	<i>limit, peak detector dB(μV/m)</i>
1000 - 25000	54	74

The EUT was tested on three orthogonal axes.

The device was tested from 30 MHz to the tenth harmonic of the highest fundamental frequency per 15.33.

The device was tested on three channels per 15.31(l).

The CFR 47 Part 15. Subpart B. Class B limit of 500 μV/m has been calculated to correspond 54 dB(μV/m) as follows: $[dB(\mu V/m)] = 20 \log[\mu V/m]$.

The measurement results were obtained as described below.

$$E [dB(\mu V/m)] = U_{RX} + A_{CABLE} + AF - G_{PREAMP}$$

Where

U_{RX} receiver reading

A_{CABLE} attenuation of the cable

AF antenna factor

G_{PREAMP} gain of the preamplifier

Duty Cycle correction factor(dB) -41.41 dB was used. (RFon 0.850ms/100ms)

4.3.3 Test results

below 1GHz: RBW 120kHz

above 1GHz: peak, RBW 1MHz, VBW 3MHz

2405MHz, above 1GHz

<i>Frequency MHz</i>	<i>Peak dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
4810	52.9	74	21.1	PASS
7215	58.0	74	16.0	PASS

<i>Frequency MHz</i>	<i>Average dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
4810	11.5	54	42.5	PASS
7215	16.6	54	37.4	PASS

2440MHz, below 1GHz and above 1GHz

<i>Frequency MHz</i>	<i>Quasi Peak dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
30.01	26.6	40.0	13.4	PASS
204.76	22.0	43.5	21.5	PASS
216.92	23.3	46.0	22.7	PASS
375.00	42.0	46.0	4.0	PASS

<i>Frequency MHz</i>	<i>Peak dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
4880	55.5	74	18.5	PASS
7320	53.6	74	20.4	PASS

<i>Frequency MHz</i>	<i>Average dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
4880	14.1	54	39.9	PASS
7320	12.2	54	41.8	PASS

2480MHz, above 1GHz

<i>Frequency MHz</i>	<i>Peak dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
4960	52.3	74	21.7	PASS
7425	56.9	74	17.1	PASS

<i>Frequency MHz</i>	<i>Average dB(μV/m)</i>	<i>Limit dB(μV/m)</i>	<i>Margin dB</i>	<i>Result</i>
4960	10.9	54	43.1	PASS
7425	15.5	54	38.5	PASS

Results more than 20 dB below the limit are not listed.

4.4 20 dB and 99% bandwidths

The test was performed as a compliance test. The test parameters concerned were as follows:

<i>EUT</i>	EUT
<i>Site name</i>	Perkkaa
<i>FCC rule part</i>	§ 15.215
<i>IC rule part</i>	RSS-GEN: 4.6.1
<i>Date of testing</i>	21.03. and 22.5.2014
<i>Test equipment</i>	566, 525, 350
<i>Test conditions</i>	22 °C, 35 % RH

4.4.1 EUT operation mode

<i>EUT frequency (MHz)</i>	2405, 2440 and 2475
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4.4.2 Test method and limit

The measurement is made according to Public notice ANSI C63.10 (2009) and IC standards RSS-210 / RSS-GEN.

<i>Limit (MHz)</i>
N/A

4.4.3 Test results

<i>EUT frequency (MHz)</i>	<i>20 dB bandwidth (MHz)</i>	<i>99% bandwidth (MHz)</i>
2405	1.650	1.689
2440	1.337	1.413
2480	1.441	1.467

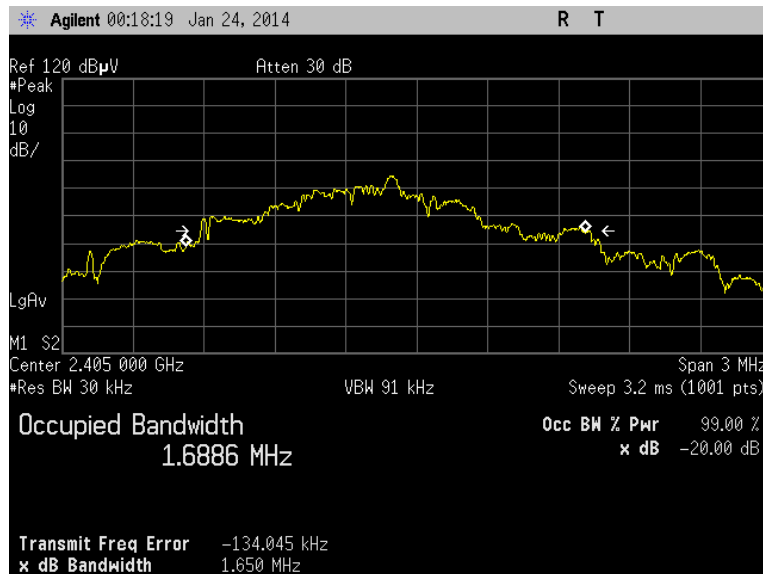


Figure 4. 2405MHz, 20 dB bandwidth

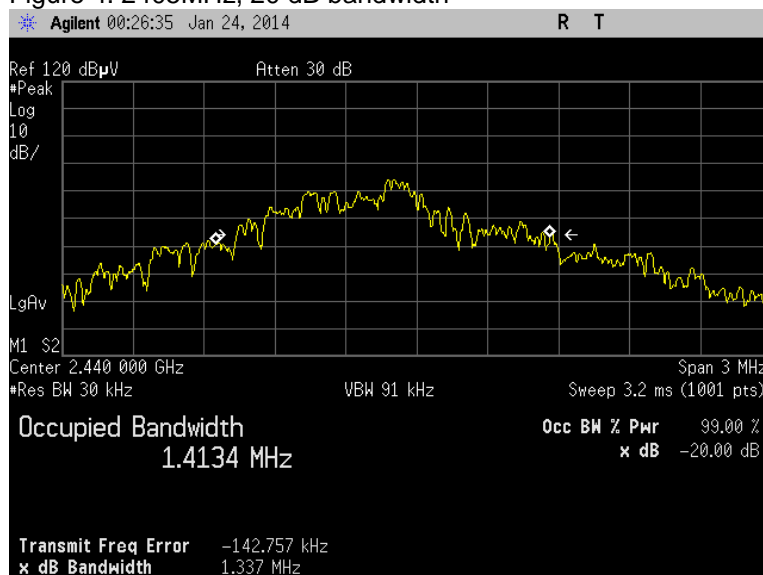


Figure 5. 2440MHz, 20 dB bandwidth



Figure 6. 2475MHz, 20 dB bandwidth

4.5 Duty cycle correction factor, Transmit time in 100 ms

Spectrum analyzer with zero span was used to investigate spectrum.

15.35(c) Unless otherwise specified, e.g. § 15.255(b), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

4.5.1 Test data

Pulses/100ms=10

Length of one pulse = 0.085ms

*DutyCycleCorrectionFactor=20*log(Tocc/100)=20*log(10*0.085/100)=-41.41dB*

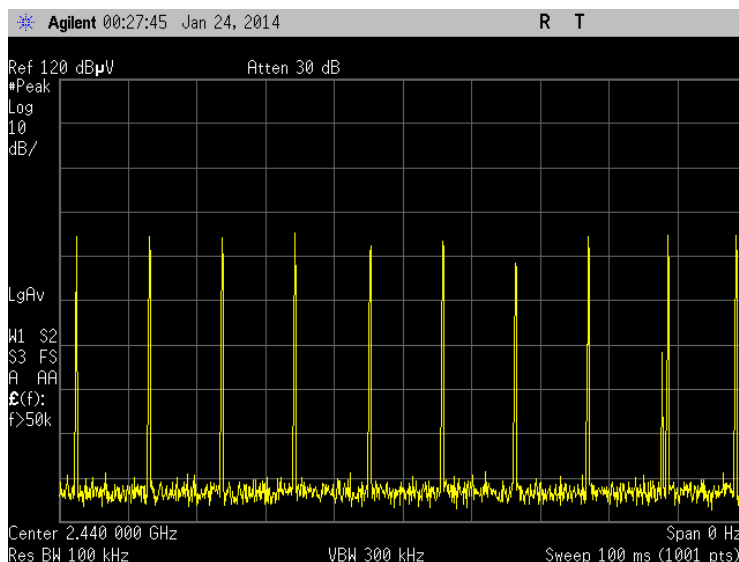


Figure 9. Duration of one transmission, 2440MHz

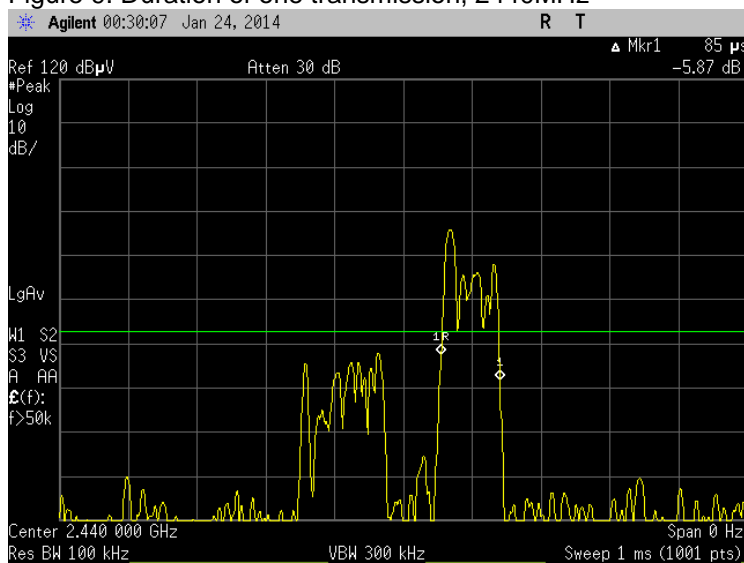


Figure 10. Duration of 100 ms, 2440MHz

4.6 Conducted disturbance at mains ports emission test

The test was performed as a compliance test. The test parameters concerned were as follows:

Parameter	Specification
Frequency range	0.150 – 30 MHz
Site name	Nemko Oy / Perkkää
FCC rule part	§ 15.207
IC	RSS Gen 7.2.4
Date of testing	22.5.2015
Test equipment	745, 338, 348
Test uncertainty U95	±3.5dB
Test conditions	24 °C, 30 % RH

4.6.1 EUT operation mode

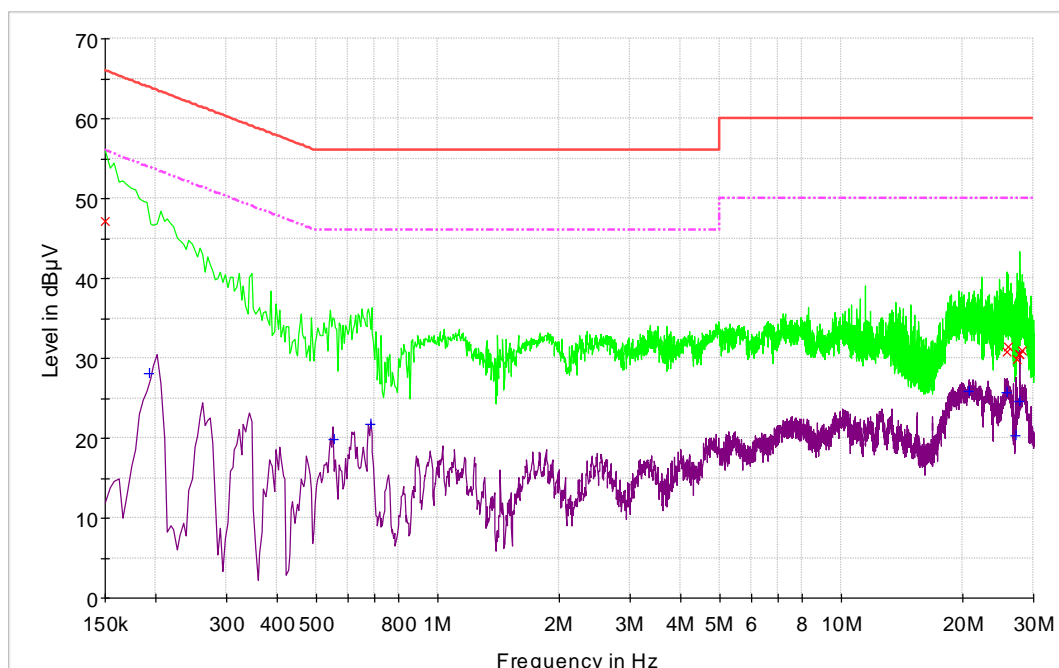
<i>EUT frequency (MHz)</i>	2440
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The test was performed inside a shielded room where the floor and one of the walls of the test site comprised the reference ground plane (RGP). For the duration of the test the EUT was placed on a non-conductive table 0.8 m high 0.4 m apart from the vertical RGP. The excess lengths of the cables of the EUT were made into bundles 30-40 cm in length. The power input cable of the EUT was connected to an artificial mains network. The test was performed separately on each phase and also on the neutral wire.

The disturbances were first examined by performing a spectrum scan by using a peak detector. The general procedure in the conducted disturbance emission test is that no further measurements are necessary if the disturbance levels measured by using the peak detector are below the limit value defined for the measurement performed by using an average detector. If not, then at the test frequencies concerned the measurement is performed also by using a quasi-peak detector. If the disturbance levels measured by using the quasi-peak detector are below the limit value defined for the measurement performed by using an average detector, then measurements by using the average detector are not necessary.

4.6.2 Test results

Line N



The graphs of the disturbances measured by using a peak and average detectors in the frequency range of 0.150 - 30 MHz.

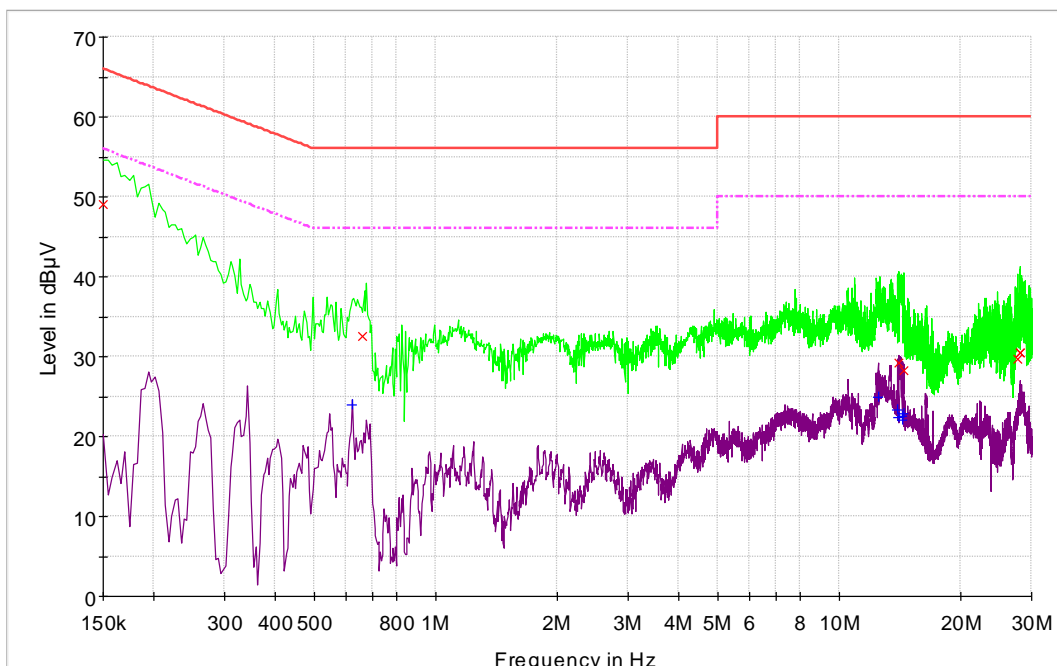
Measurement results (QP):

Frequency MHz	Level dBμV	Limit dBμV	Margin dB	Line	Conclusion Pass/Fail
0.15	47.1	66.0	18.9	N	Pass
25.69	30.7	60.0	29.3	N	Pass
25.99	31.5	60.0	28.5	N	Pass
27.34	29.8	60.0	30.2	N	Pass
27.70	30.5	60.0	29.5	N	Pass
27.79	30.5	60.0	29.5	N	Pass
28.18	30.9	60.0	29.1	N	Pass

Measurement results (Average):

Frequency MHz	Level dBμV	Limit dBμV	Margin dB	Line	Conclusion Pass/Fail
0.19	28.1	53.9	25.8	N	Pass
0.55	19.8	46.0	26.2	N	Pass
0.68	21.7	46.0	24.3	N	Pass
20.72	25.8	50.0	24.2	N	Pass
25.68	25.6	50.0	24.4	N	Pass
27.03	20.3	50.0	29.7	N	Pass
27.70	24.6	50.0	25.4	N	Pass

Line L



The graphs of the disturbances measured by using a peak and average detectors in the frequency range of 0.150 - 30 MHz.

Measurement results (QP):

Frequency MHz	Level dBμV	Limit dBμV	Margin dB	Line	Conclusion Pass/Fail
0.15	49.1	46.0	16.9	L	Pass
0.65	32.6	50.0	23.4	L	Pass
14.10	29.2	50.0	30.8	L	Pass
14.47	28.2	50.0	31.8	L	Pass
27.70	29.7	50.0	30.3	L	Pass
28.04	30.5	50.0	29.5	L	Pass
28.10	30.4	50.0	29.6	L	Pass

Measurement results (Average):

Frequency MHz	Level dBμV	Limit dBμV	Margin dB	Line	Conclusion Pass/Fail
0.62	24.0	50.0	28.0	L	Pass
12.48	24.8	50.0	27.1	L	Pass
13.96	23.3	50.0	28.0	L	Pass
14.07	22.4	50.0	27.1	L	Pass
14.34	22.5	50.0	28.0	L	Pass
14.39	22.0	50.0	27.1	L	Pass
14.44	22.9	50.0	28.0	L	Pass

5. List of test equipment

Each active test equipment is calibrated once a year, antennas every 18 months and other passive equipment every 24 months.

Nr.	Equipment	Type	Manufacturer	Serial number	Cal date	Cal due
338	Test receiver	ESS	Rohde & Schwarz	847151/009	24.11.2013	11.2014
566	Spectrum analyzer	E4448A	Agilent	US42510236	17.4.2013	4.2014
709	EMI test receiver	ESU8	Rohde & Schwarz	100297	24.07.2013	7.2014
694	EMI Test Receiver	ESPC	Rohde & Schwarz	842888/023	4.3.2014	3.2015
567	RF generator	E8257C	Agilent	MY43320736	11.3.2013	3.2015
544	RF-amplifier	ZFL-2000VH2	Mini-Circuits	QA0749010	29.1.2014	1.2015
564	RF amplifier	CA018-4010	CIAO Wireless	132	3.2.2014	2.2015
745	2-Line V-Network	ENV216	Rohde & Schwarz	101466	11.6.2013	6.2014
319	Antenna	CBL6112	Chase	2018	26.11.2013	5.2015
525	Double-Ridged Horn	3115	Emco	6691	10.10.2012	4.2014
542	Double-Ridged Horn	3115	Emco	00023905	10.10.2012	4.2014
559	Highpass Filter	WHKX3.0/18G-10SS	Wainwright Instruments	1	3.2.2014	2.2016
88	Waveguide horn	638	Narda	8003	-	-
350	Semianechoic shielded room	RFD-F-100	Euroshield Oy	1327	26.10.2012	10.2014
348	Shielded room	RFSD-100	Euroshield Oy	1320	-	-

6. Photographs

Please see Appendix to Test report: 275987B.