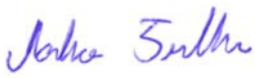
Test report
for
Sigma M

Report Date: November 1, 2006

Signatures:

Reported by: 

Marko Turkkila Testing Engineer

Contents approved: 

Tuomo Hahl Testing Engineer

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1 LABORATORY INFORMATION

Test Laboratory	NATLABS OY EMC Laboratory Koneenkatu 12 / K17 05830 Hyvinkää FINLAND Tel: +358 20 475 2600 Fax: +358 20 475 2719 e-mail: firstname.surname@ette.com
FCC registration number: **IC file number:**	910391 (January 27, 2003) IC 4616A-1 (May 14, 2003)

2 CUSTOMER INFORMATION

Client	Instrumentarium Dental, Palodex Group Oy Nahkelantie 160 04300 Tuusula Finland Tel. +358 400 740 186 Fax +358 2 733 9988
Contact person:	Mika Anttila Instrumentarium Dental, Palodex Group Oy Nahkelantie 160 04300 Tuusula Finland Tel. +358 400 740 186 Fax +358 2 733 9988
Receipt of EUT:	July 14, 2006
Testing date:	July 14 – October 23, 2006
Report date:	October 25, 2006

The tests listed in this report have been done to demonstrate compliance to the FCC rules section §15.247, §15.207 and IC standard RSS-GEN / RSS-210.

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3 SUMMARY OF TEST RESULTS

Transmitter measurements

Section in CFR 47	Section in RSS-210	Test	Result
15.247, a 2	A8.2 (1)	6 dB bandwidth	PASS
15.247, d	A8.2 (2)	Power spectral density	PASS
15.247, b 3	A8.4 (4)	Peak output power	PASS
15.247, c	A8.5	Band-edge compliance of RF emissions	PASS
15.247, c	A8.5	Spurious RF conducted emissions	PASS
15.247, c	A8.5	Spurious radiated emissions	PASS

Receiver measurements

Section in CFR 47	Section in RSS-GEN	Section in ICES-003	Test	Result
§15.107	7.2.2	5.3	Conducted emissions to AC-power lines	PASS
§15.109	7.2.3	5.5	Radiated emissions	PASS

PASS Pass
FAIL Fail
X Measured, but there is no applicable performance criteria
- Not done

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4 EUT INFORMATION

The EUT and accessories used in the tests are listed below. Later in this report only EUT numbers are used as reference.

	Device	Type	S/N	EUT number
EUT	WLAN Intraoral sensor	Sigma M	-	12301 ***
Accessories	USB cable	Mini USB	-	12302
	Laptop computer	Dell PR04S	0J7316-36521 -55K-0548	12303
	Printer	HP Deskjet 890C	SG78I19082	12304
	Serial mouse	Logitech	LZB83902452	12305

Notes:

*** EUT has antenna connector on circuit board inside the casing for conducted measurements.

4.1 EUT description

EUT is a battery powered intraoral x-ray sensor that transmits measurement data to computer via 2.4 GHz WLAN (iEEE 802.11b) link. The measurement data can also be transferred via USB cable. The transmitter is disabled when the charger is connected.

The EUT was not modified during the tests.

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5 EUT TEST SETUPS

For each test the EUT was exercised to find out the worst case of operation modes and device configuration.

Two different test setups were used: one for conducted measurements, another for radiated measurements. One EUT was equipped with an external antenna connector for conductive measurements.

The test setup photographs are in the document referenced in section 16.

6 APPLICABLE STANDARDS

The tests were performed in guidance of CFR 47 Part 15.247, 15.209, 15.107, 15.109 and Part 2, ANSI C63.4 (2003), ICES-003 and RSS-GEN / RSS-210

Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method" for each test case.

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7 6 dB BANDWIDTH

EUT	12301		
Accessories			
Temp, Humidity, Air Pressure	23 ºC	61 RH%	997 hPa
Date of measurement	September 11, 2006		
FCC rule part	15.247, a 2		
RSS-210 section	A8.2 (1)		
Measured by	Matti Virkki		

7.1 Test setup and measurement method

Picture 1: Test setup for conducted RF output power measurement

The 6 dB bandwidth was measured using 100 kHz resolution bandwidth and maximum hold function of the spectrum analyzer. 6 dB bandwidth was defined by measuring the maximum level on the measured channel and by placing display line 6 dB below this value and by reading the bandwidth from the intersection of the measured trace and display line.

7.2 EUT operation mode

EUT operation mode	Max Power, Normal modulation
EUT channel	1, 7 and 11
EUT TX power level	Full Power

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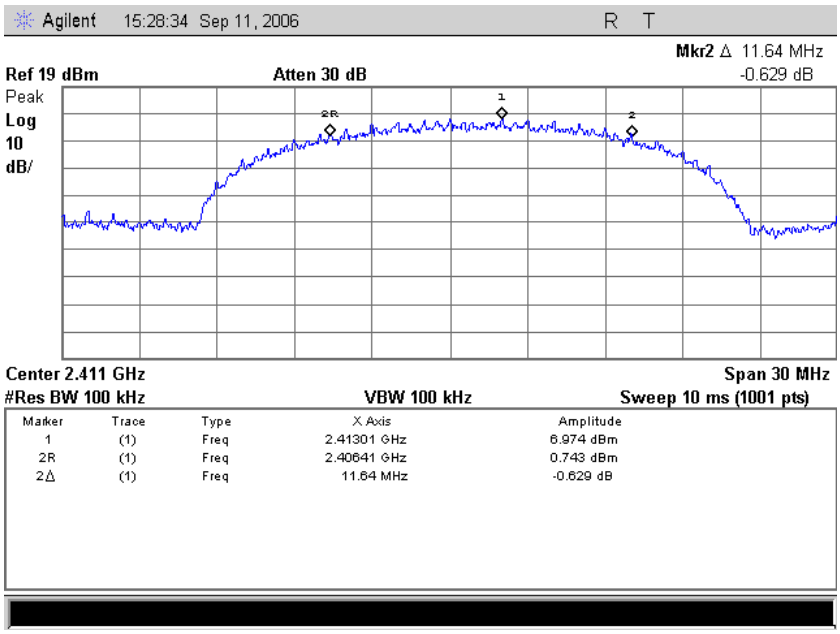
7.3 Results

Table 1: 6 dB bandwidth measurement results

EUT Channel	Limit (MHz)	Measured value (MHz)
1	> 0.5	11.64
7		11.64
11		12.00

7.4 Screen shots



Picture 2: 6 dB Bandwidth measurement result, Channel 1

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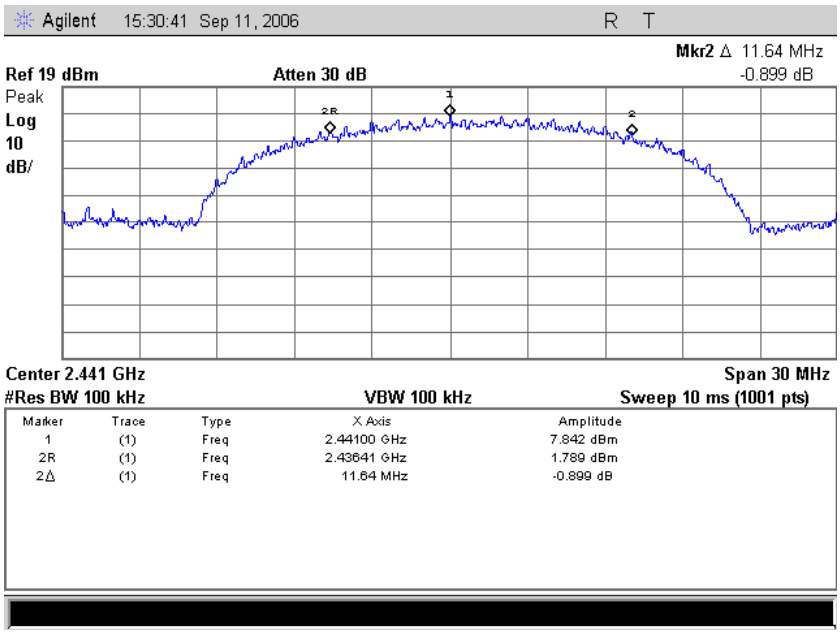
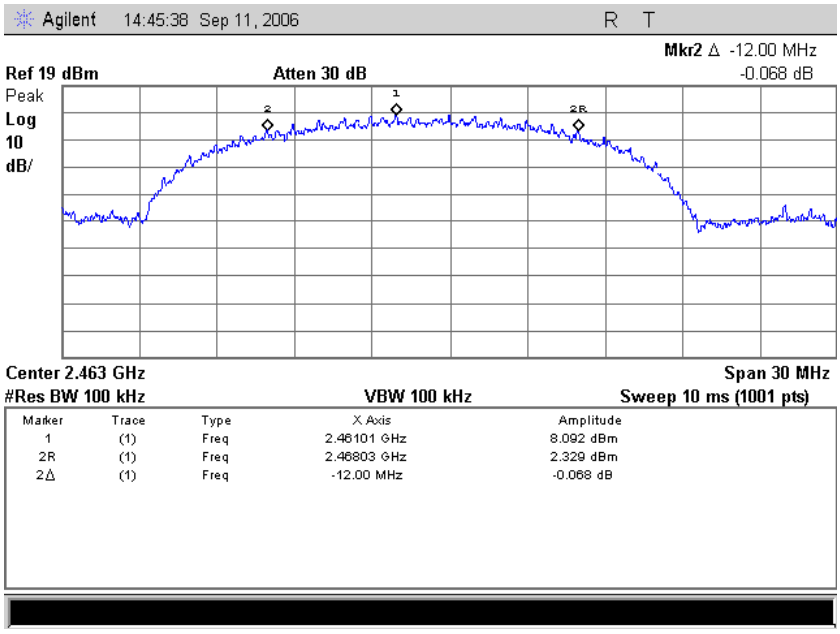


Picture 3: 6 dB Bandwidth measurement result, Channel 7



Picture 4: 6 dB Bandwidth measurement result, Channel 11

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8 PEAK OUTPUT POWER

EUT	12301		
Accessories			
Temp, Humidity, Air Pressure	24 ºC	69 RH%	994 hPa
Date of measurement	August 24, 2006		
FCC rule part	15.247, b 3		
RSS-210 section	A8.4 (4)		
Measured by	Matti Virkki		

8.1 Test setup and measurement method

Picture 5: Test setup for conducted RF output power measurement

In the peak output power measurement the cable attenuations were measured prior to the power measurement and set as parameter for external preamplifier gain in the spectrum analyzer to correct the reading of the peak output power. Spectrum analyzer subtracts the set PG value shown in the screenshots from the measured reading.

The measurement was made using spectrum analyzer band power function.

8.2 EUT operation mode

EUT operation mode	Max Power, Normal modulation
EUT channel	1, 7 and 11
EUT TX power level	Full Power

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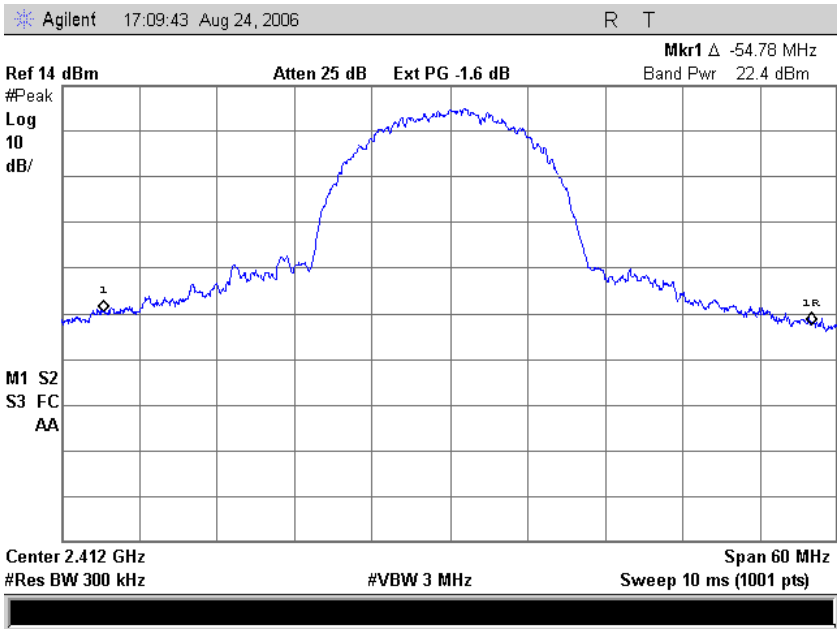
8.3 Results

Table 2: Peak output power measurement results

EUT Channel	Limit (W)	Test result (W)	Limit (dBm)	Test result (dBm)
1	≤ 1	0.28	≤ 30	22.4
7		0.21		23.2
11		0.22		23.5

8.4 Screen shots



Picture 6: Peak output power, channel 1

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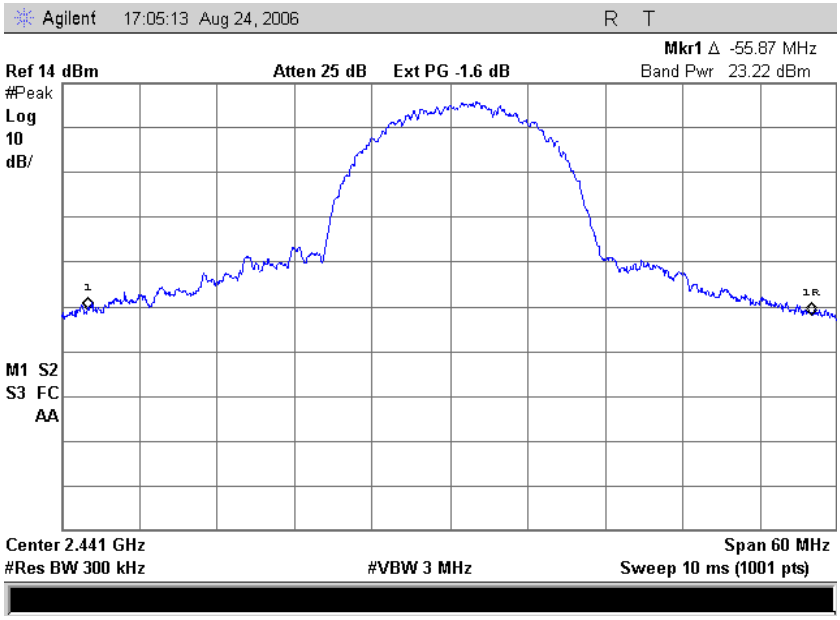
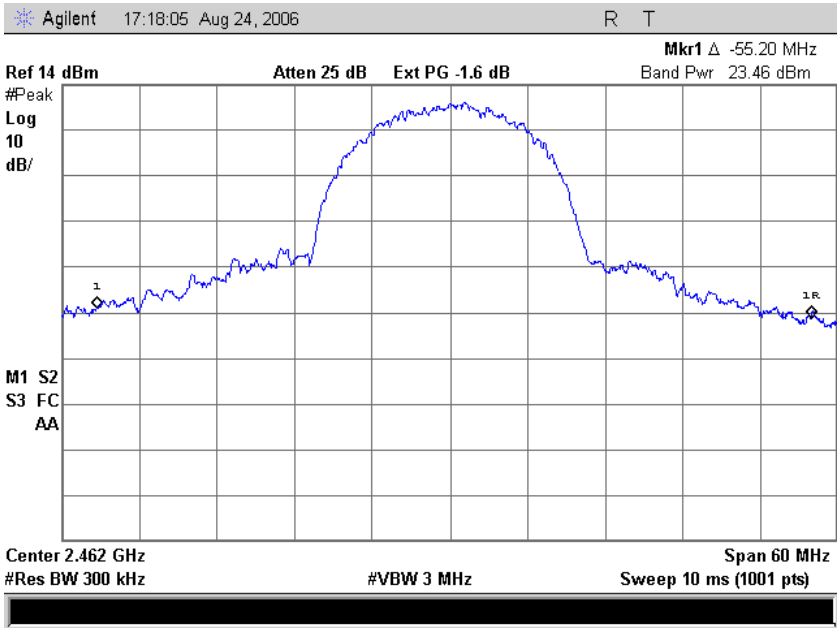


Picture 7: Peak output power, channel 7



Picture 8: Peak output power, channel 11

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9 Power spectral density

EUT	12301		
Accessories			
Temp, Humidity, Air Pressure	24 ºC	69 RH%	994 hPa
Date of measurement	August 24, 2006		
FCC rule part	15.247, d		
RSS-210 section	A8.2 (2)		
Measured by	Matti Virkki		

9.1 Test setup and measurement method

Picture 9: Test setup for conducted RF output power measurement

In the power spectral density measurement the cable attenuations were measured prior to the power measurement and set as parameter for external preamplifier gain in the spectrum analyzer to correct the reading of the peak output power. Spectrum analyzer subtracts the set PG value shown in the screenshots from the measured reading.

The measurement was made by first finding the maximum of emission with wide enough measurement span to cover the whole transmitter spectrum. The maximum was centered to spectrum analyzer display. Zero span and 3 kHz resolution bandwidth were used to measure power spectral density.

9.2 EUT operation mode

EUT operation mode	Max Power, Normal modulation
EUT channel	1, 7 and 11
EUT TX power level	Full Power

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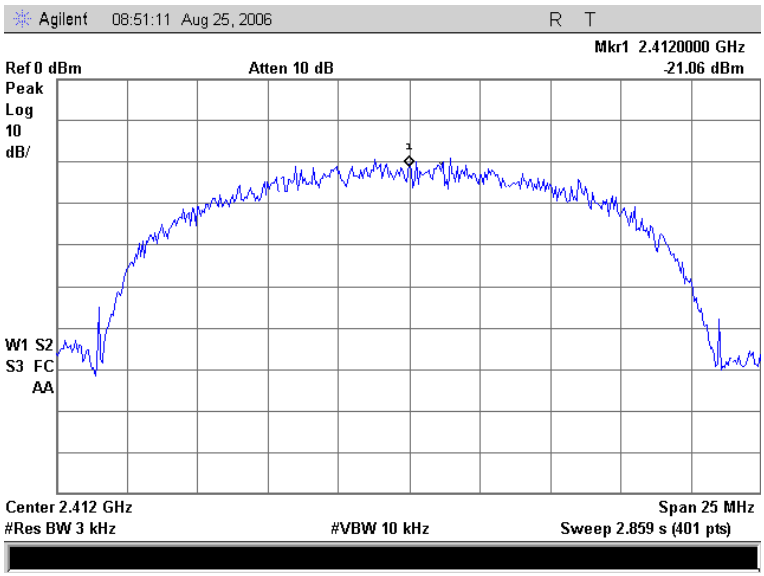
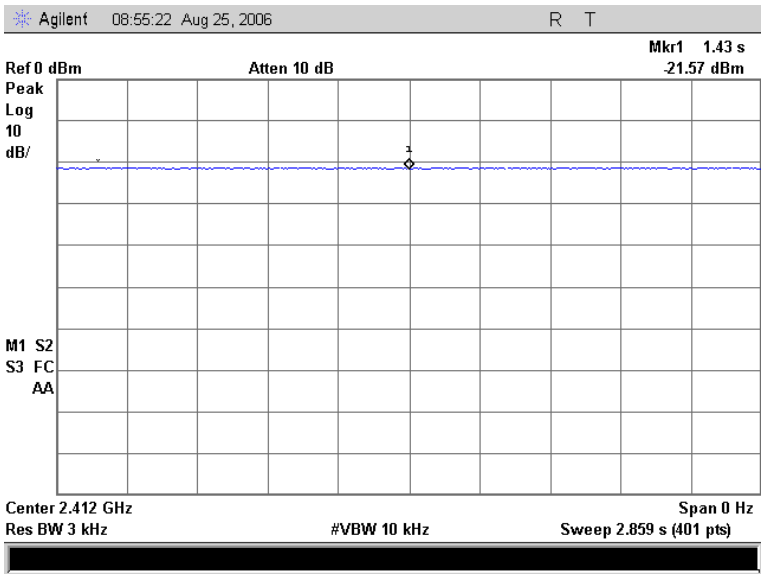
9.3 Results

Table 3: Power spectral density measurement results (Cable attenuation 1.6dB added to results in table below)

EUT Channel	Limit (dBm)	Test result (dBm)
1	≤ 8	-20.0
7		-22.5
11		-22.1

9.4 Screen shots





Picture 10: Power spectral density, channel 1

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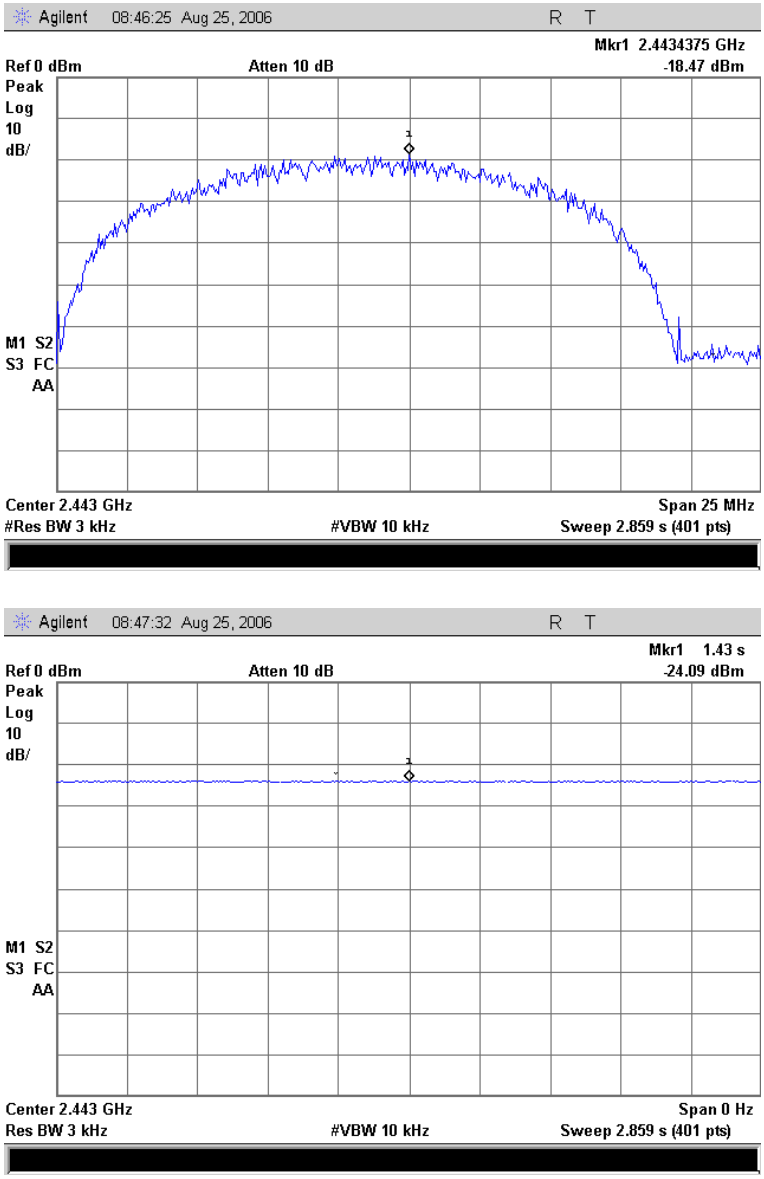

Picture 11: Power spectral density, channel 7

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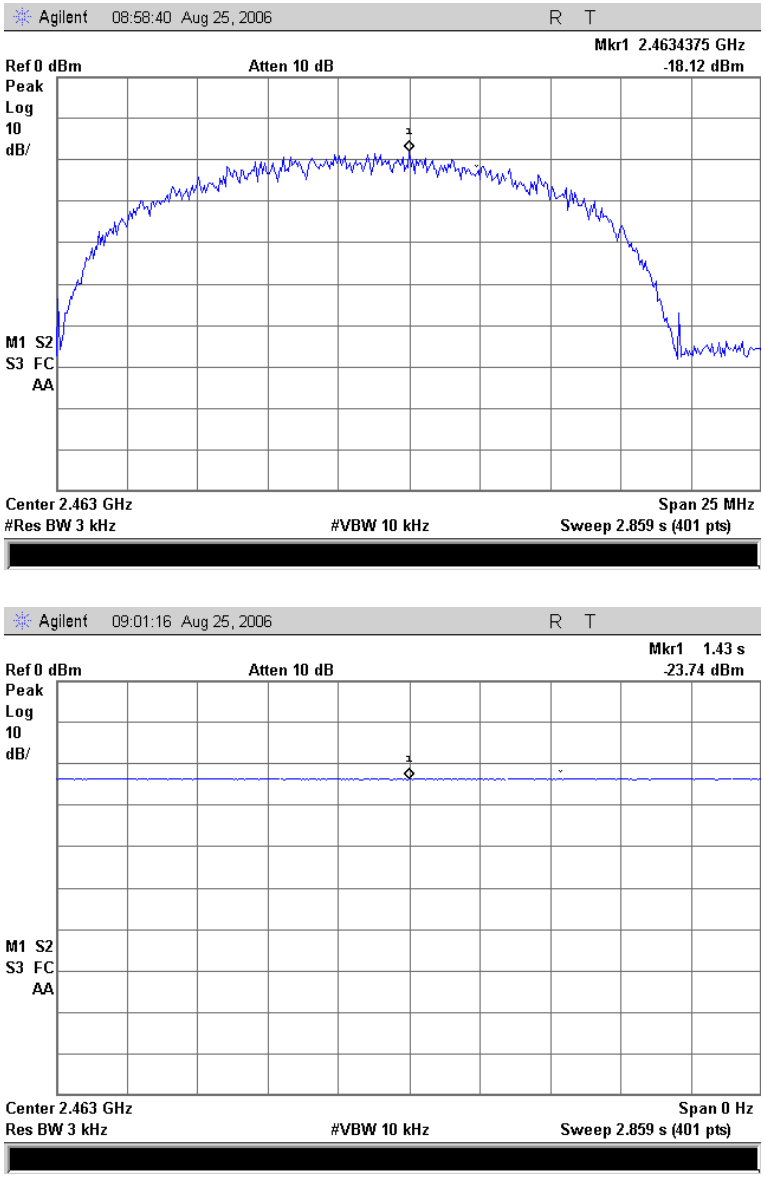

Picture 12: Power spectral density, channel1

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10 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

EUT	12301		
Accessories			
Temp, Humidity, Air Pressure	24 ºC	69 RH%	994 hPa
Date of measurement	August 24, 2006		
FCC rule part	15.247, c		
RSS-210 section	A8.5		
Measured by	Matti Virkki		

10.1 Test setup and measurement method

Picture 13: Test setup for band edge compliance measurement

Band edge compliance of RF-conducted emissions was measured by setting the band edge as center frequency in the spectrum analyzer and measuring the power on the transmission on channels 1 and 11. The measured power and power on the band edge was then compared.

10.2 EUT operation mode

EUT operation mode	Max Power, Normal modulation
EUT channel	1 and 11
EUT TX power level	Full Power

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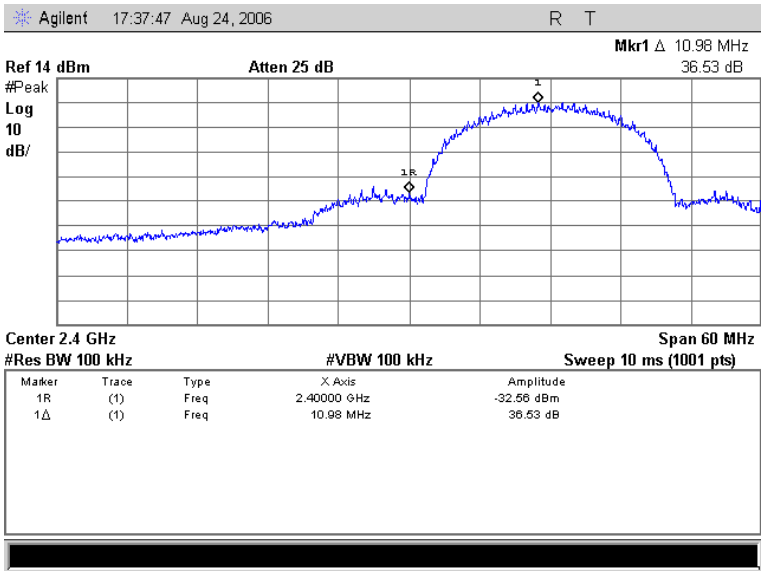
10.3 Results

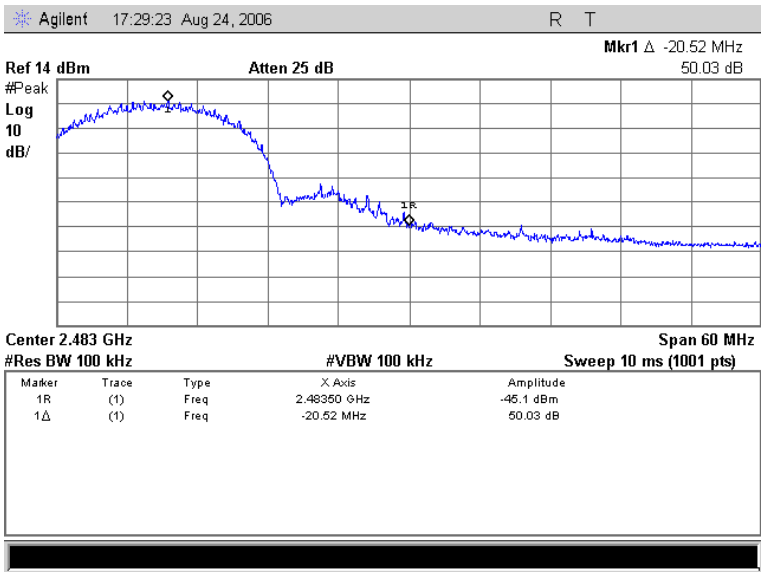
Table 4: Signal attenuation at band-edge

EUT Channel	Limit (dBc)	Test result (dBc)
1	≤ -20	36.5
11		50.0

10.4 Screen shots



Picture 14: Band edge compliance, channel 1



Picture 15: Band edge compliance, channel 11

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11 SPURIOUS RF CONDUCTED EMISSIONS

EUT	12301		
Accessories			
Temp, Humidity, Air Pressure	22 ºC	50 RH%	996 hPa
Date of measurement	October 20, 2006		
FCC rule part	15.247, c		
RSS-210 section	A8.5		
Measured by	Jani Kiiski		

11.1 Test setup and measurement method

Picture 16: Test setup for spurious conducted emission measurement

Spectrum analyzer and automated software were used to record conducted spurious emissions on frequency range 30 MHz – 25 GHz. Frequency range was scanned using 100 kHz resolution bandwidth and 50 kHz steps.
Spurious emissions levels relative to the carrier level were read from the measured results.

11.2 EUT operation mode

EUT operation mode	Max Power, Constant carrier
EUT channel	1, 7 and 11
EUT TX power level	Full Power

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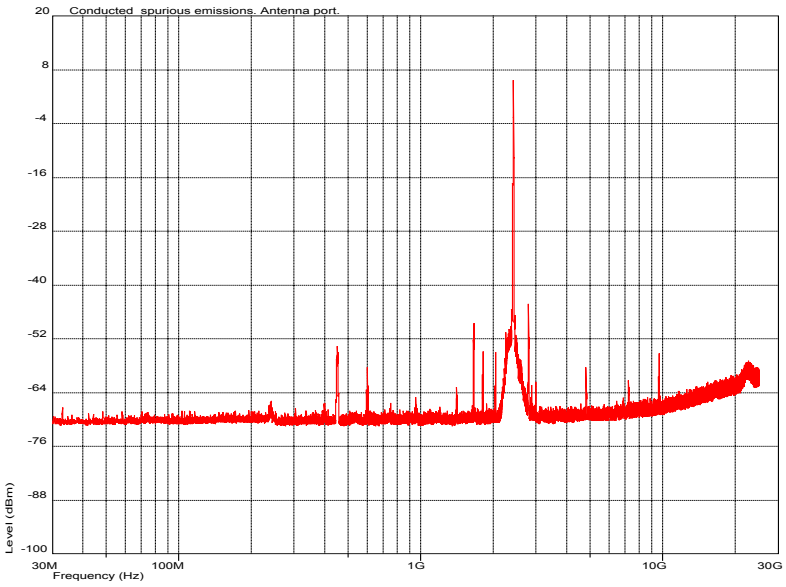
11.3 Limit

EUT Channel	Limit (dBc)
1	≤ -20
7	
11	

11.4 Results

All spurious emissions measured were least 40 dB below the carrier level.



Picture 17: Conducted spurious emissions on antenna port, Channel 1

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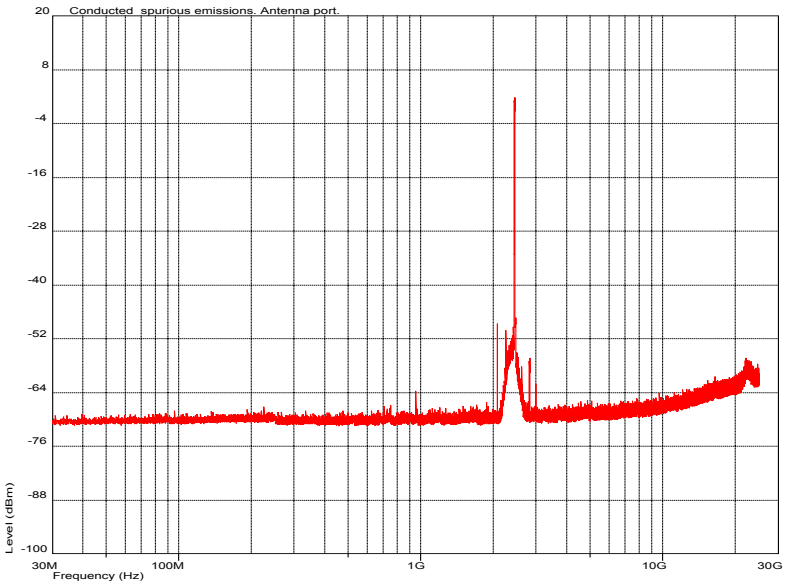
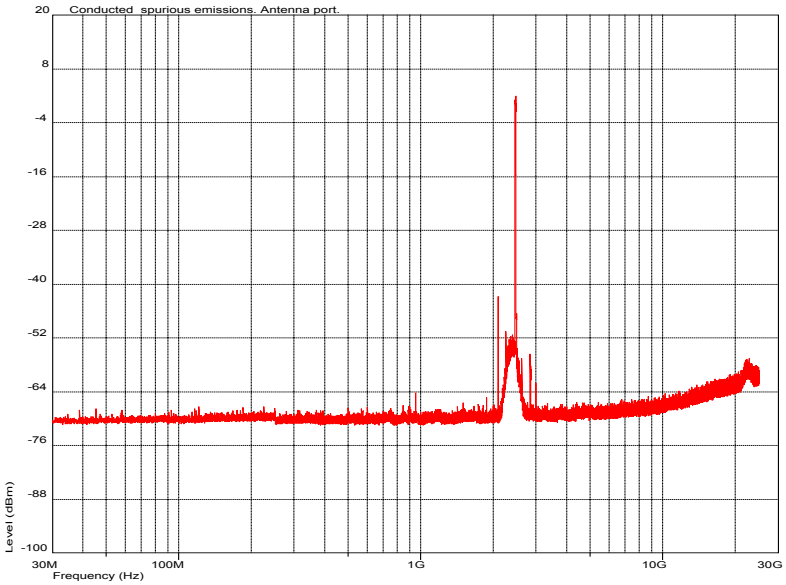


Picture 18: Conducted spurious emissions on antenna port, Channel 7



Picture 19: Conducted spurious emissions on antenna port, Channel 11

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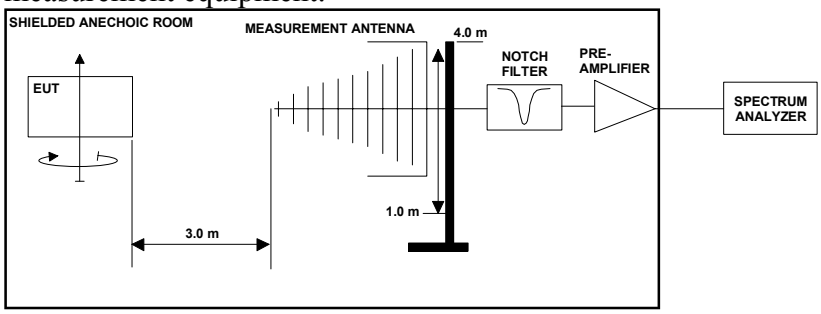
12 RADIATED SPURIOUS EMISSIONS

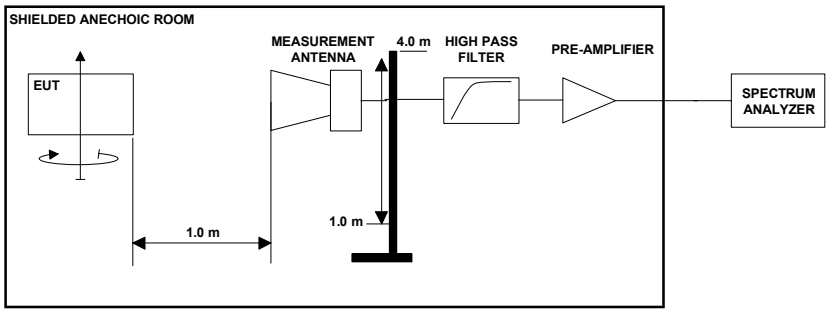
EUT	12301		
Accessories			
Temp, Humidity, Air Pressure	24 ºC	76 RH%	994 hPa
Date of measurement	August 21-29, 2006		
FCC rule part	15.247, c		
RSS-210 section	A8.5		
Measured by	Matti Virkki		

12.1 Test setup

The test was done using an automated test system, where a computer controlled the measurement equipment.



Picture 20: Test setup for radiated spurious emissions measurement 30 MHz - 3 GHz frequencies



Picture 21: Test setup for radiated spurious emissions measurement 3 GHz – 25 GHz frequencies

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12.2 Test method

1. The emissions were searched and maximized by moving the turntable, changing the measuring antenna polarization and height and manipulating the EUT.
2. Levels of suspicious signals and levels of EUT transmitter harmonics were recorded.
3. The recorded levels were corrected in the automated test system with the measurement antenna factor, cable attenuations and filter attenuation.
4. The corrected values, giving the EUT radiated spurious emission levels as dBµV/m at 3 m distance, are reported.

12.3 EUT operation mode

EUT operation mode	Max Power, Constant carrier
EUT channel	1, 7 and 11
EUT TX power level	Full Power

12.4 Limit

Table 5: Radiated spurious emission limits at measurement distance 3m

Frequency band (MHz)	3m Limit (µV/m)	3m Limit (dBµV/m)	Detector
30 – 88	100	40	QP
88 -216	150	43.5	QP
216 - 960	200	46	QP
960 - 1000	500	54.0	QP
1000 - 25000	500	54.0	AVG
1000 - 25000	5000	74.0	PEAK

As default, all emissions were compared against the general limits. If any emission exceeded that limit, it was further checked, if it was outside the restricted band thus complying with the -20dBc requirement.

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12.5 Results

Measurement system noise level was least 15 dB below the spurious emission limit. Only levels of suspicious signals and transmitter harmonic frequencies, which were above the measurement system noise, are reported.

Table 6: Emission levels PEAK (QP) detector, channel 1

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	Turn table angle
175.98	46.2	-11.7	34.5	-9.0	Pos 1	Hor	1.9	26
769.98	33.6	2.0	35.6	-10.4	Pos 1	Hor	1.1	104
813.96	35.8	2.8	38.6	-7.4	Pos 1	Hor	1	93
2038	33.5	14.9	48.4	-25.6	Pos 1	Hor	1.3	192
4824	63.5	-15.6	47.9	-26.1	Pos 1	Ver	1	153
6862	50.6	-6.8	43.7	-30.3	Pos 1	Ver	1.3	235
7236	54.5	-3.7	50.8	-23.2	Pos 1	Ver	1.35	238

Table 7: Emission levels PEAK (QP) detector, channel 7

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	Turn table angle
175.98	47.2	-11.7	35.5	-8.0	Pos 1	Hor	1.3	208
264	35.2	-8.8	26.5	-19.6	Pos 1	Hor	1	300
396	41.7	-4.8	36.9	-9.1	Pos 1	Hor	1	188
2063	32.0	15.1	47.1	-26.9	Pos 1	Hor	2.6	109
4884	61.3	-15.4	45.9	-28.1	Pos 1	Ver	1.1	150
7324.5	52.1	-3.4	48.8	-25.2	Pos 1	Ver	1.4	84

Table 8: Emission levels PEAK (QP) detector, channel 11

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	Turn table angle
175.98	40.2	-11.7	28.6	-14.9	Pos 1	Hor	1.9	230
263.94	48.3	-8.8	39.5	-6.5	Pos 1	Hor	1.2	315
276	48.8	-8.5	40.4	-5.7	Pos 1	Hor	1.1	319
2110	31.5	15.4	46.9	-27.1	Pos 1	Ver	2.1	281
4924	63.0	-15.3	47.7	-26.3	Pos 1	Ver	1	321
7386	49.2	-3.1	46.1	-27.9	Pos 1	Ver	1.7	241

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Table 9: Emission levels AVERAGE detector, channel 1

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	Turn table angle
2038	22.9	14.9	37.9	-16.2	Pos 1	Hor	1.3	192
4824	54.2	-15.6	38.6	-15.4	Pos 1	Ver	1	153
6862	39.3	-6.8	32.5	-21.5	Pos 1	Ver	1.3	235
7236	43.0	-3.7	39.4	-14.7	Pos 1	Ver	1.35	238

Table 10: Emission levels AVERAGE detector, channel 7

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	Turn table angle
2063	18.1	15.1	33.2	-20.8	Pos 1	Hor	2.6	109
4884	51.8	-15.4	36.3	-17.7	Pos 1	Ver	1.1	150
7324.5	42.0	-3.4	38.6	-15.4	Pos 1	Ver	1.4	84

Table 11: Emission levels AVERAGE detector, channel 11

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	Turn table angle
2110	17.9	15.4	33.3	-20.7	Pos 1	Ver	2.1	281
4924	53.6	-15.3	38.3	-15.7	Pos 1	Ver	1	321
7386	36.4	-3.1	33.3	-20.7	Pos 1	Ver	1.7	241

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13 CONDUCTED EMISSIONS TO AC-MAINS

EUT	12301		
Accessories	12302, 12303,12304, 12305		
Temp, Humidity, Air Pressure	22 ºC	49 RH%	997 hPa
Date of measurement	October 23, 2006		
FCC rule part	§15.107		
RSS-GEN section	7.2.2		
ICES-003 section	5.3		
Measured by	Matti Virkki		

13.1 Test setup

Charger was connected to line impedance stabilization network and conducted emissions to AC-mains were measured using measurement receiver.

13.2 EUT operation mode

EUT was connected to Laptop pc USB connector.

13.3 Limits

	FCC / IC	
Frequency of emission [MHz]	**Limit [dBµV] Quasi peak**	**Limit [dBµV] Average**
0,15 – 0,50	66 – 56*	56 – 46*
0,50 – 5	56	46
5 – 30	60	50

* The limit decreases linearly with the logarithm of the frequency

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13.4 Results

The measured interference values using peak and average detectors are shown in the pictures 3 and 4 below.
All signals closer than 6 dB to the limit have been measured using quasi peak and average detectors and reported in the table 12 and 13.

Table 12: Quasi peak detector measurement results, AC live

Frequency [MHz]	Measured value [dBµV]	Limit [dBµV]	Margin to limit [dB]
0.170	16.8	65.0	48.2

Table 13: Average detector measurement results, AC live

Frequency [MHz]	Measured value [dBµV]	Limit [dBµV]	Margin to limit [dB]
0.170	9.4	55.0	45.6

Table 14: Quasi peak detector measurement results, AC neutral

Frequency [MHz]	Measured value [dBµV]	Limit [dBµV]	Margin to limit [dB]
-			

Table 15: Average detector measurement results, AC neutral

Frequency [MHz]	Measured value [dBµV]	Limit [dBµV]	Margin to limit [dB]
-			

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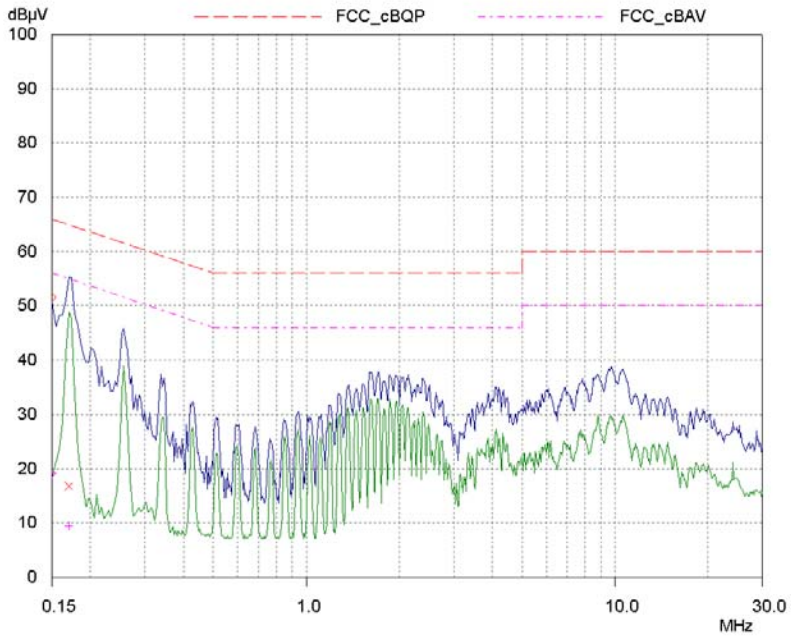
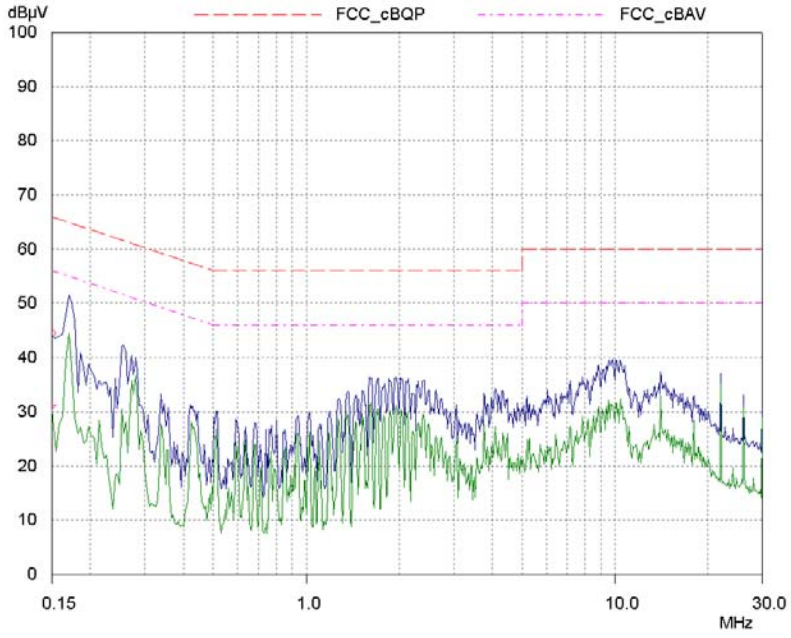
13.5 Screen shots



Picture 22: AC-mains conducted emission measurement results, AC live



Picture 23: AC-mains conducted emission measurement results, AC neutral

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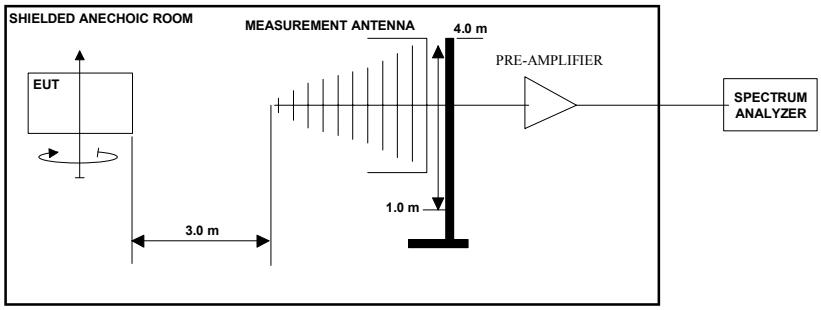
14 RECEIVER RADIATED EMISSION

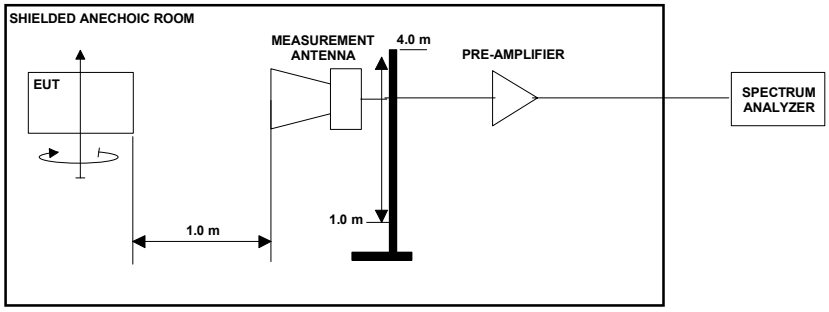
EUT	12301		
Accessories	12302, 12303, 12304, 12305		
Temp, Humidity, Air Pressure	24 ºC	76 RH%	994 hPa
Date of measurement	August 29, 2006		
FCC rule part	§15.109		
RSS-GEN section	7.2.3		
ICES-003 section	5.5		
Measured by	Matti Virkki		

14.1 Test setup

The test was done using an automated test system, where a computer controlled the measurement equipments.



Picture 24: Test setup for radiated spurious emissions measurement 30 MHz - 1 GHz frequencies



Picture 25: Test setup for radiated spurious emissions measurement 1 GHz – 12.75 GHz frequencies

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14.2 Test method

1. The emissions were searched and maximized by moving the turntable, changing the measuring antenna polarization and height and manipulating the EUT.
2. Levels of suspicious signals and levels of EUT transmitter harmonics were recorded.
3. The recorded levels were corrected in the automated test system with the measurement antenna factor, cable attenuations and filter attenuation.
4. The corrected values, giving the EUT radiated spurious emission levels as dBµV/m at 3 m distance, are reported.

14.3 EUT operation mode

EUT was connected to Laptop pc USB connector.

EUT operation mode	Receiver mode
EUT frequency	Na
EUT TX power level	Na

14.4 Limit

Table 16: Radiated spurious emission limits at measurement distance 3m

Frequency band (MHz)	3m Limit (µV/m)	3m Limit (dBµV/m)	Detector
30 – 88	100	40	QP
88 -216	150	43.5	QP
216 - 960	200	46	QP
960 - 1000	500	54.0	QP
1000 - 12400	500	54.0	AVG
1000 - 12400	5000	74.0	PEAK

As default, all emissions were compared against the general limits. If any emission exceeded that limit, it was further checked, if it was outside the restricted band thus complying with the -20dBc requirement.

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14.5 Results

The measured interference values using Quasi peak and average detectors are shown in the pictures below.

All signals closer than 6 dB to the limit below 1 GHz have been measured using quasi peak or average detector and reported in the table 17, 18 and 19.

Table 17: Radiated emissions using Quasi peak detector

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	TT angle
132.72	34.7	-9.9	24.8	-18.7	Pos 1	Ver	1.4	226
397.68	28.6	-5.0	23.7	-22.4	Pos 1	Hor	1	168
398.52	37.6	-5.0	32.6	-13.4	Pos 1	Ver	1.1	158
516.06	34.6	-2.5	32.1	-13.9	Pos 1	Ver	2.1	29
518.76	34.9	-2.5	32.4	-13.6	Pos 1	Ver	2.2	30

Table 18: Radiated emissions using Peak detector

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	TT angle
1035.5	60.5	-24.1	36.4	-37.6	Pos 1	Hor	1	49
1060.5	66.7	-24.2	42.4	-31.6	Pos 1	Ver	1	349
1329.5	67.7	-24.6	43.1	-30.9	Pos 1	Ver	1	343
6592	49.4	-9.1	40.4	-33.7	Pos 1	Hor	1.3	28

Table 19: Radiated emissions using Average detector

Freq MHz	Measured Value dBuV	Correction Factor dB	Result dBuV/m	Marginal dBuV/m	EUT Position	Ant Pol.	Ant height	TT angle
1035.5	38.4	-24.1	14.3	-39.7	Pos 1	Hor	1	49
1060.5	46.2	-24.2	22.0	-32.1	Pos 1	Ver	1	349
1329.5	48.1	-24.6	23.5	-30.5	Pos 1	Ver	1	343
6592	43.1	-9.1	34.0	-20.0	Pos 1	Hor	1.3	28

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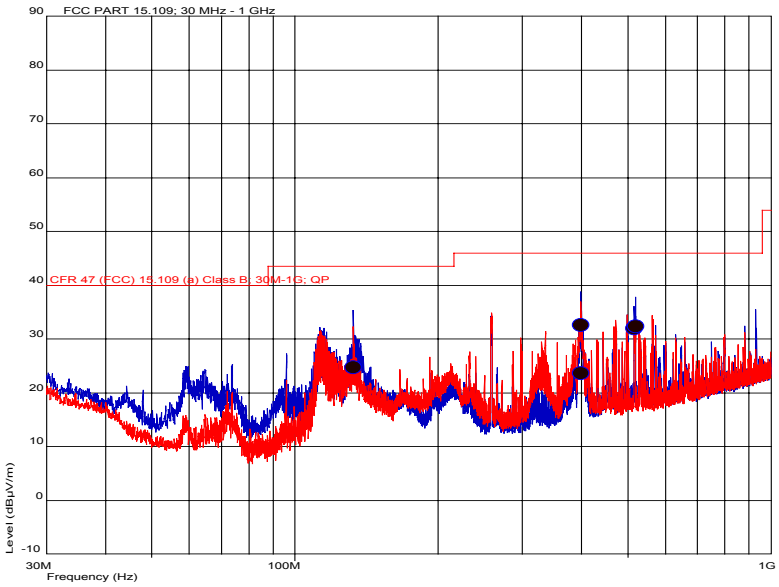
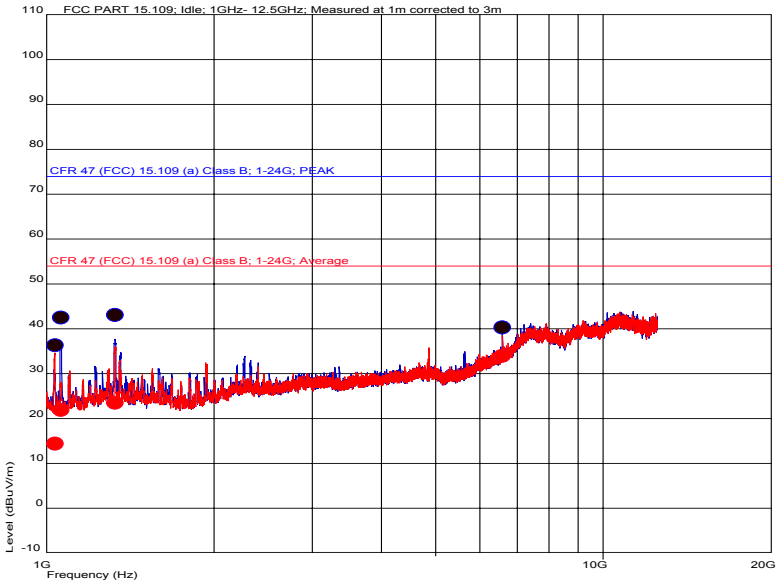


Picture 26: Radiated emission results, 30 – 1000 MHz,
Red= horizontal polarization, blue = vertical polarization



Picture 27: Radiated emission results, 1 – 12.75 GHz,
Red= horizontal polarization, blue = vertical polarization

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15 TEST EQUIPMENT

All testing and measurement equipment has been calibrated once a year, except the antennas that are calibrated every two years.

15.1 Conducted measurements

Equipment	Manufacturer	Model
Spectrum Analyzer	Agilent	E7405A
Measurement receiver	Rohde & Schwarz	ESCS 30
Attenuator 3 dB	Narda	779-3
Power splitter	Mini Circuits	ZFSC-2-4
Power splitter	Narda	4426-2
Transient limiter / 10 dB attenuator	Chase	CFL 9206
Line Impedance Stabilization Network (LISN)	Rohde & Schwarz	ESH 3-Z5

15.2 Radiated measurements

Equipment	Manufacturer	Model
Spectrum Analyzer	Agilent	E7405A
Antenna	Chase	CBL 6141
Antenna	Schwarzbeck	BBHA 9120D
Antenna	Schwarzbeck	BBHA 9170
High pass filter	Wainwright Instruments	WHK3.0/18GST
Pre-amplifier	JCA	118-400
Pre-amplifier	Miteq	AMF-6F-18002650-25-10P
Turn table / antenna mast controller	EMCO	2090
Antenna mast	EMCO	2075-2

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16 TEST SETUP PHOTOGRAPHS

Test setup photograph can be found in a separate document

T06-123A-EMC_PHOTOS.doc

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