REPORT

issued by an FCC listed Laboratory Reg. no. 93866.
The test site complies with RSS-Gen, Issue 2,
file no: IC 3482A-2

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Date	Reference	Page
2013-03-20	FX112896-P90	1 (1)

1002
ISO/IEC 17025

RECCO AB
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Equipment Authorization measurements on 902-904 MHz Transceiver Unit

(7 appendices)

Product name: RECCO Detector
Product number: R99
Serial number: 99A-1306
The test object was equipped with an earphone and a battery charger during the test, see Appendix 1.

Summary

See Appendix 1 for general information and Appendix 7 for photos.
Emission measurements as specified below have been performed.

Standard	Compliant	Appendix	Remarks
FCC 47 CFR Part 90 I/M Operation frequency: 902.85 MHz	**Yes**		Note 1
IC RSS-137 Issue 2, February 2009	**Yes**		
90.205 (l) / RSS-137 6.4 RF output power	Yes	2	
90.209 (b) (5) / RSS-137 6.1.2 Occupied bandwidth (Bandwidth limitations)	Yes	3	
90.209 (k) / RSS-317 6.5.3 Radiated emission/Band edge (Emission masks)	Yes	4	
90.213 (a) / RSS-137 6.3 Frequency Stability	Yes	5	
15.207 / RSS-Gen 7.2.4 AC Conducted emission limits	Yes	6	

Note: Above RSS items are given as cross-reference only. Measurements were performed according to ANSI C63.10-2009 and ANSI/TIA-603-C-2004 procedures referenced by FCC and covered by SP's accreditation.

Note 1: To fulfil the FCC requirements for the output frequency spectrum some improvements were done on the RECCO Detector, see Appendix 1.

SP Technical Research Institute of Sweden
Electronics - EMC

Performed by

Fredrik Isaksson

Examined by

Christer Karlsson

Performance test and requirements

The tests were performed to verify that RECCO Detector meets the electromagnetic compatibility requirements of FCC 47 CFR part 90 I/M.

Test facility

The used anechoic chamber is compliant with the requirements of section 2.948 of the FCC rules and listed, registration number 96866, as a facility accepted for certification under parts 15 and 18. The site complies with RSS Gen, Issue 2 and is accepted by Industry Canada for the performance of radiated measurements, IC-file number 3482A-2.

Test object

Transceiver:	RECCO Detector
Antenna:	Integrated
Antenna gain:	9 dBi
Rated peak output power:	35 dBm ERP
Frequency range:	902.85-902.95 MHz
Frequencies used during test:	902.85 MHz 902.95 MHz (ALT activated)
Modulation:	AM 100% / 1.2 kHz and pulsed with 10 Hz
Declared duty cycle:	20 %
Supply voltage:	7.4 V DC, internal batteries
Battery type:	Li-ion ABATEL 363-1025 7.4 1.6Ah/11.8 Wh
Ear phone	J22
Battery Charger	RECCO 2 cells Li-Ion battery charger Type 2740

Measurement equipment

Measurement equipment	Calibration Due	SP number
Test site Edison	2011-12	504 114
EMI test receiver R&S ESIB 26	2013-07	503 885
LISN Schwarzbeck NNLA 8120	2015-02	504 129
Antenna Schaffner CBL 6143	2013-04	504 079
Horn antenna EMCO 3115	2014-01	501 548
Low Noise Amplifier Miteq	2014-08	504 160
High pass filter Wainwright WHKY	2013-07	504 199
Multimeter Fluke 85 III 625	2012-08	503 418
Temperature and humidity meter Testo 625	2013-06	504 117
Temperature and humidity meter Testo 635-1	2013-06	504 203

Operational test mode

An earphone was connected to the EUT during the test.
During the AC Conducted emission test also the battery charger was connected to the EUT.
Fully charged internal batteries were used during the test, except for the AC Conducted emission where the test was performed with the batteries in a charging mode.
The test was performed in high power mode with continuous transmission and with normal modulation.
The ALT function (+100 kHz) was not activated during the measurements, if not otherwise stated.

For duty cycle and PRF measurements see appendix 2.
The PRF was calculated to PRF = 1/T = 1/100 ms = 10 Hz, thus peak detector was used without any correction for pulse desensitization.

Cabling during emission test:

EUT port	Cable type	Termination / use
Ear phone	2-wire unshielded, 1.2 m (not stretched)	Ear phone
Charger	3-wire, unshielded, 1.7 m length	Connected to 120 VAC/60 Hz. (Only connected during conducted emission measurements)

Uncertainties

Measurement and test instrument uncertainties are described in the quality assurance documentation ”SP QD 10885”. The measurement uncertainties can be found in the table below. The uncertainties are calculated with a coverage factor k=2 (95% level of confidence). The measurement uncertainties can be found in the table below:

Method	**Uncertainty**
Radiated emission, 30 – 1000 MHz	4.8/5.6 dB (V/H-pol)
Radiated emission, 1 – 40 GHz	2.6 dB
Conducted emission	3.5 dB

Compliancy evaluation is based on a shared risk principle with respect to the measurement uncertainty.

Reservation

The test results in this report apply only to the particular test object as declared in the report.

To fulfil the FCC requirements for the output frequency spectrum the following improvements were done on the RECCO Detector:

- Improved decoupling of the varicap and synthesizer feeding voltage by changing C19 in position R17 from 10pF to 1000pF ceramic capacitor.
- Additional decoupling of amplifier U3 from 1nF to 10nF ceramic capacitor.
- New loading capacitor 1000uF/16V at the input of the voltage regulator.

Delivery of test object

The test object was delivered: 2011-06-20 and 2012-05-30

Test participant

K-G Forsen, RECCO AB (present 2012-09-11)

Test engineers

Fredrik Isaksson and Olof Johansson, SP

RF output power, radiated, measurements according to FCC 47 CFR part 90.205(l) / RSS-137 6.4

Date	Temperature	Humidity
2012-01-03	22 °C ± 3 °C	18 % ± 5 %
2012-09-11	23 °C ± 3 °C	60 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI/TIA-603-C-2004.

The radiated maximum peak radiated output power measurements were performed in the semi-anechoic chamber.
The measurements were performed with both horizontal and vertical polarization of the antenna.

A propagation loss in free space was calculated. The used formula was
$\gamma = 20\log\left(\frac{4\pi D}{\lambda}\right)$, γ is the propagation loss and D is the antenna distance.
The fundamental was scanned with peak detector with the antenna height 1-4 m and the turntable was varied between 0-360 degrees for maximum response. The antenna distance during the measurements was 3.0 m.
Final measurement was performed with detector according to the FCC rules and then measured with the substitution method according to the standard.

Test set-up photos during the tests can be found in Appendix 7.

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyser R&S ESI 26	503 885
EMI measurement computer	-
Software: R&S EMC32, ver. 6.30.20	503 745
Antenna Schaffner Bilog CBL6143	504 079
Multimeter Fluke 85 III	503 418
Temperature and humidity meter Testo 625	504 117

Results

Duty cycle measurements can be found in the diagrams below:

Diagram 1:	Tx on
Diagram 2:	Period time

Field strength of fundamental measurements:
RBW=100 kHz
Rated peak output power: 35 dBm ERP

		Max peak output power Peak detector
		902.85 MHz
	Antenna height	1.46 m
	Azimuth	0 deg
	Polarization	Horizontal
T_{nom} 23°C	V_{nom} 7.4 V DC	34.8 dBm ERP

Note: According 47CFR 15.31(e), for intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

Limits

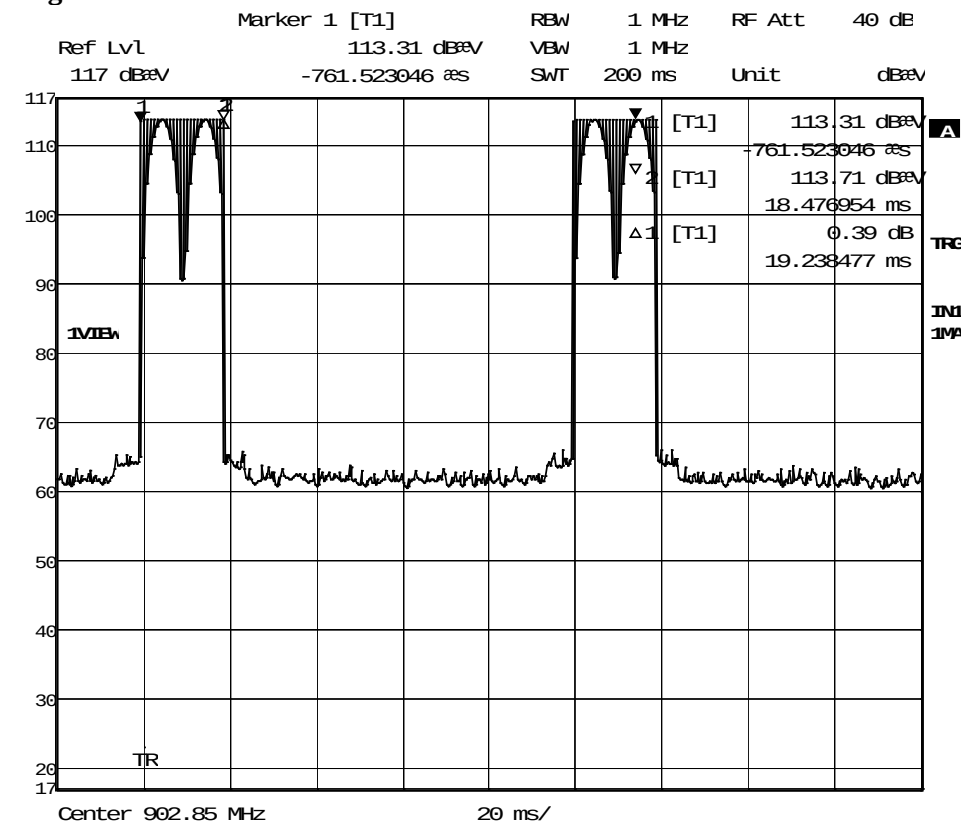
According to 47CFR 90.205(l), 902–928 MHz. LMS systems operating pursuant to subpart M of this part in the 902–927.25 MHz band will be authorized a maximum of 30 watts (44.8 dBm) ERP. ERP must be measured as peak envelope power.

According to IC RSS 137.6.4, the output power shall be within ±1.0 dB of the manufacturer's rated value, and the e.r.p. shall not exceed 30 watts (44.8 dBm) for the band 902-927.25 MHz.

Complies?	Yes

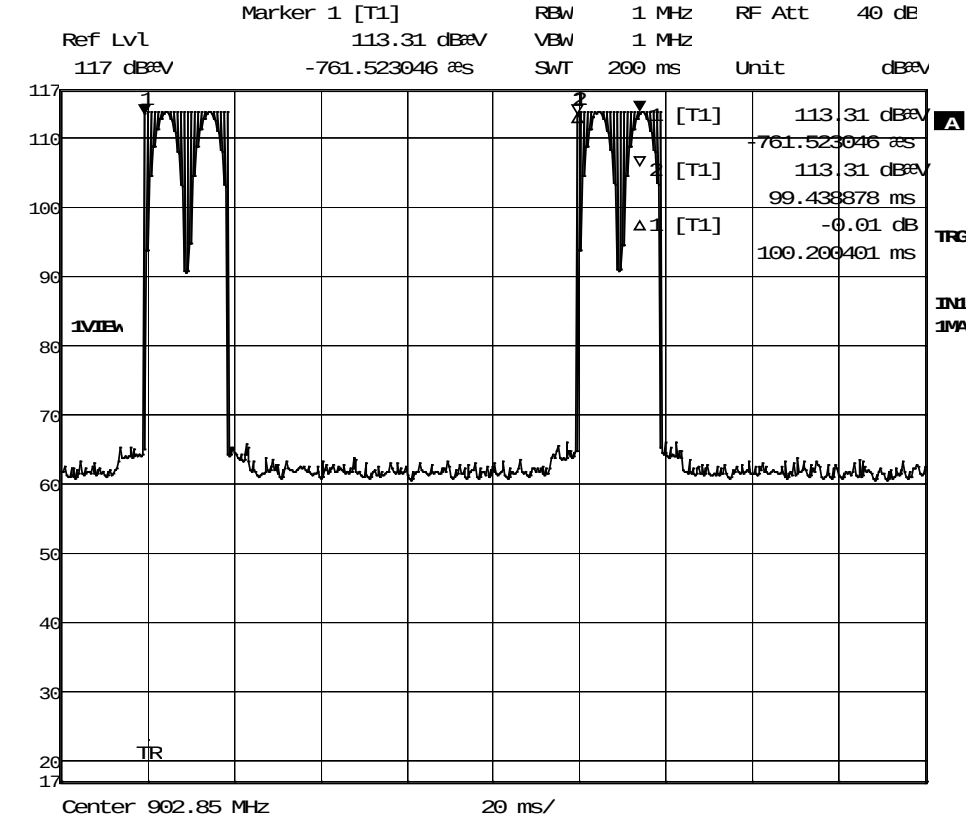
Appendix 2

Diagram 1



Date: 30.JAN.2012 15:23:27

Diagram 2



Date: 30.JAN.2012 15:24:01

Bandwidth limitations (OBW) measurements according to FCC 47 CFR part 90.209 (b)(5) / RSS-137 6.1.2

Date	Temperature	Humidity
2012-09-11	23 °C ± 3 °C	60 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009.

The radiated measurements were performed in the semi-anechoic chamber.
The fundamental was scanned with peak detector with the antenna height 1-4 m and the turntable was varied between 0-360 degrees for maximum response, see Appendix 2. The antenna distance during the measurements was 3.0 m.

Test set-up photos during the tests can be found in Appendix 7.

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyser R&S ESI 26	503 885
EMI measurement computer	-
Software: R&S EMC32, ver. 6.30.10	503 745
Antenna Schaffner Bilog CBL6143	504 079
Temperature and humidity meter Testo 625	504 117

Measurement uncertainty: 2.6 %

Results

The OBW measurements can be found in the diagram below:

Diagram 1	902.85 MHz	OBW = 14.43 kHz (99 %)

Limits

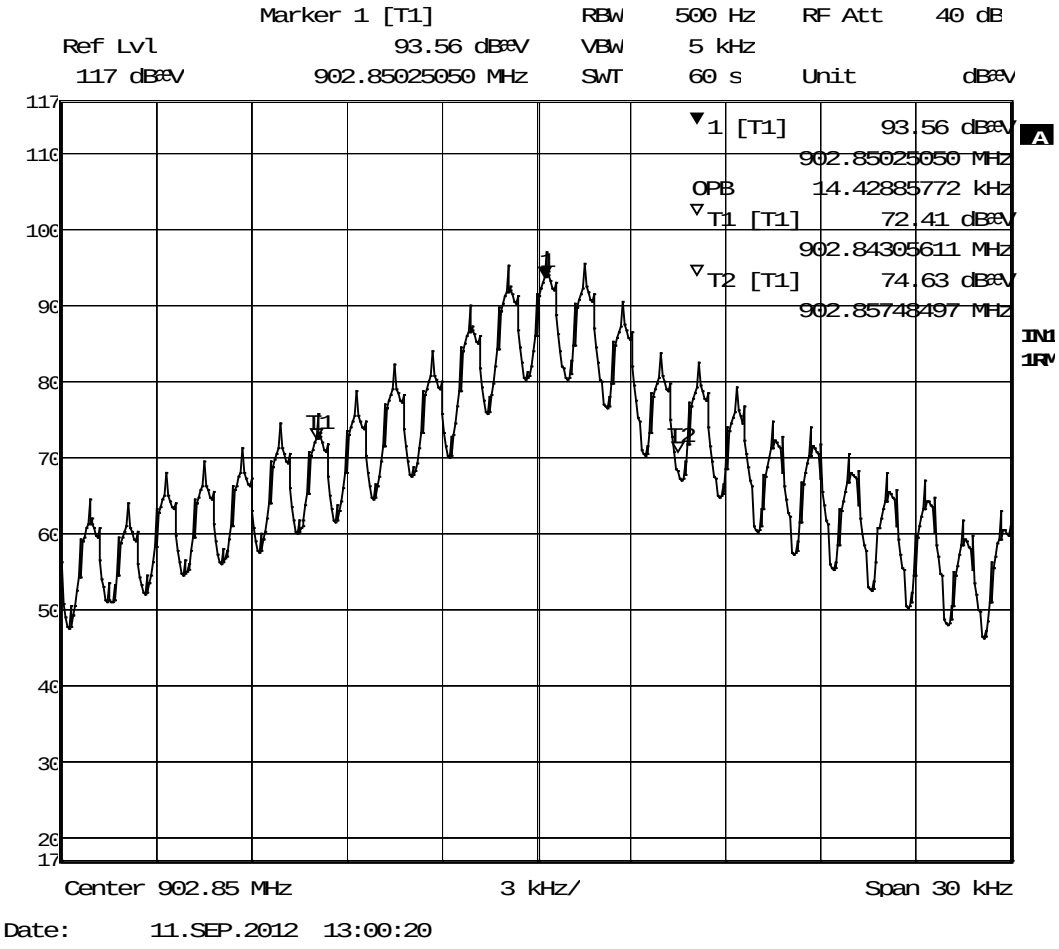
According to 47CFR 90.209(b)(5), the maximum authorized bandwidth shall be 2 MHz for non-multilateration LMS operations in the band 902.00–904.00 MHz.

According to IC RSS 137.6.1.2:
Non-Multilateral LMS Systems

Non-Multilateral LMS Sub-band (MHz)	Maximum Occupied Bandwidth Permitted (MHz)
902-904	2

Complies?	Yes

Diagram 1


Marker 1 [T1]
RBW 500 Hz
RF Att 40 dB
Ref Lvl 93.56 dBµV
VBW 5 kHz
117 dBµV 902.85025050 MHz
SWT 60 s
Unit dBµV
1 [T1] 93.56 dBµV
902.85025050 MHz
OPB 14.42885772 kHz
T1 [T1] 72.41 dBµV
902.84305611 MHz
T2 [T1] 74.63 dBµV
902.85748497 MHz
117
110
100
90
80
70
60
50
40
30
20
17
T1
T2
Center 902.85 MHz
3 kHz/
Span 30 kHz
Date: 11.SEP.2012 13:00:20

Radiated emission/Band edge (Emission masks) measurements according to FCC 47 CFR part 90.210 (k) / RSS 317 6.5.3

Date	Temperature	Humidity
2012-09-11	23 °C ± 3 °C	60 % ± 5 %
2013-03-04	22 °C ± 3 °C	21 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI/TIA-603-C-2004.

At band edge (emission mask) at high band edge, 904 MHz, the measurement was performed with the ALT function activated.

The test of radiated emission was performed in a semi anechoic chamber. The measurements were performed with both horizontal and vertical polarizations of the antenna. The antenna distance was 3.0 m.

A propagation loss in free space was calculated. The used formula was

$\gamma = 20\log\left(\frac{4\pi D}{\lambda}\right)$, γ is the propagation loss and D is the antenna distance.

The measurement procedure was as the following:

1. The pre-measurement was first performed with peak detector. The EUT was measured in eight directions and with the antenna at three heights, 1.0 m, 1.5 m and 2.0 m.
2. Spurious radiation on frequencies closer than 20 dB to the limit in the pre-measurement is scanned 0-360 degrees and the antenna is scanned 1- 4 m for maximum response. The emission is then measured with the peak detector and the peak value is reported. Frequencies closer than 10 dB to the limit when measured with the peak detector were measured with the substitution method according to the standard.

The following RBW were used:
30 MHz-1 GHz: RBW=100 kHz
1-10 GHz: RBW=1 MHz

Test set-up photos during the tests can be found in Appendix 7.

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyser R&S ESI 26	503 885
EMI measurement computer	-
Software: R&S EMC32, ver. 6.30.10	503 745
Antenna Schaffner Bilog CBL6143	504 079
Horn antenna EMCO 3115	501 548
Preamplifier Miteq, 1 18 GHz	504 160
High pass filter Wainwright WHKY	504 199
Temperature and humidity meter Testo 625	504 117

Results

The pre-measurement emission spectra can be found in the diagrams below:

Diagram 1:	30-1000 MHz, vertical and horizontal polarization
Diagram 2	Band edge, horizontal polarization
Diagram 3:	1-10 GHz, vertical and horizontal polarization

The highest detected levels during the final measurement in the frequency range 30 MHz-10 GHz are listed in the tables below.

902.85 MHz

Frequency (MHz)	Peak level (dBm)	Corr (dB)	Limit (dBm)	Height (m)	Azimuth (deg)	Polarization	Substitution performed
370.053106	-45.9	-76.9	-25.0	1.41	208.0	Ver	
816.668337	-35.6	-70.7	-25.0	1.75	0.0	Hor	Yes
830.920842	-37,7	-70.6	-25.0	1.0	0.0	Hor	Yes
893.129259	-48.4	-70.3	-25.0	1.54	0.0	Hor	
913.451904	-48.2	-70.2	-25.0	1.0	0.0	Hor	
1805.981963	-37.3	-110.3	-25.0	1.38	4.0	Ver	
3610.22044	-35.8	-104.8	-25.0	1.05	0.0	Ver	
Band edges							
902.0	-40.4	-70.3	-25.0	1.46	0.0	Hor	Yes
904.0 *)	-44.8	-70.3	-25.0	1.46	0.0	Hor	Yes

*) =Was performed with the ALT-function activated.

Limits

According to 47CFR 90.210(k),
(3) Other transmitters . For all other transmitters authorized under subpart M that operate in the 902–928 MHz band, the peak power of any emission shall be attenuated below the power of the highest emission contained within the licensee's sub-band in accordance with the following schedule:
(i) On any frequency within the authorized bandwidth: Zero dB.
(ii) On any frequency outside the licensee's sub-band edges: 55 + 10 log(P) dB, where (P) is the highest emission (watts) of the transmitter inside the licensee's sub-band
(in our case –25 dBm).
(4) In the 902–928 MHz band, the resolution bandwidth of the instrumentation used to measure the emission power shall be 100 kHz, except that, in regard to paragraph (2) of this section, a minimum spectrum analyser resolution bandwidth of 300 Hz shall be used for measurement center frequencies with 1 MHz of the edge of the authorized subband. The video filter bandwidth shall not be less than the resolution bandwidth.
(5) Emission power shall be measured in peak values.
(6) The LMS sub-band edges for non-multilateration systems for which emissions must be attenuated are 902.00, 904.00, 909.5 and 921.75 MHz.

According to IC RSS 137.6.5.3, Emission Mask – Other Transmitters
Except as provided in sections 6.5.1, 6.5.2 and 6.5.4, the unwanted emission of all other transmitters
operating in the band 902-928 MHz shall comply with the following:
The power of any emission outside the equipment operating sub-band edge shall be attenuated below the maximum permitted output power Pmax by at least 55 + 10 log10 Pmax dB.

Complies?	Yes

Diagram 1

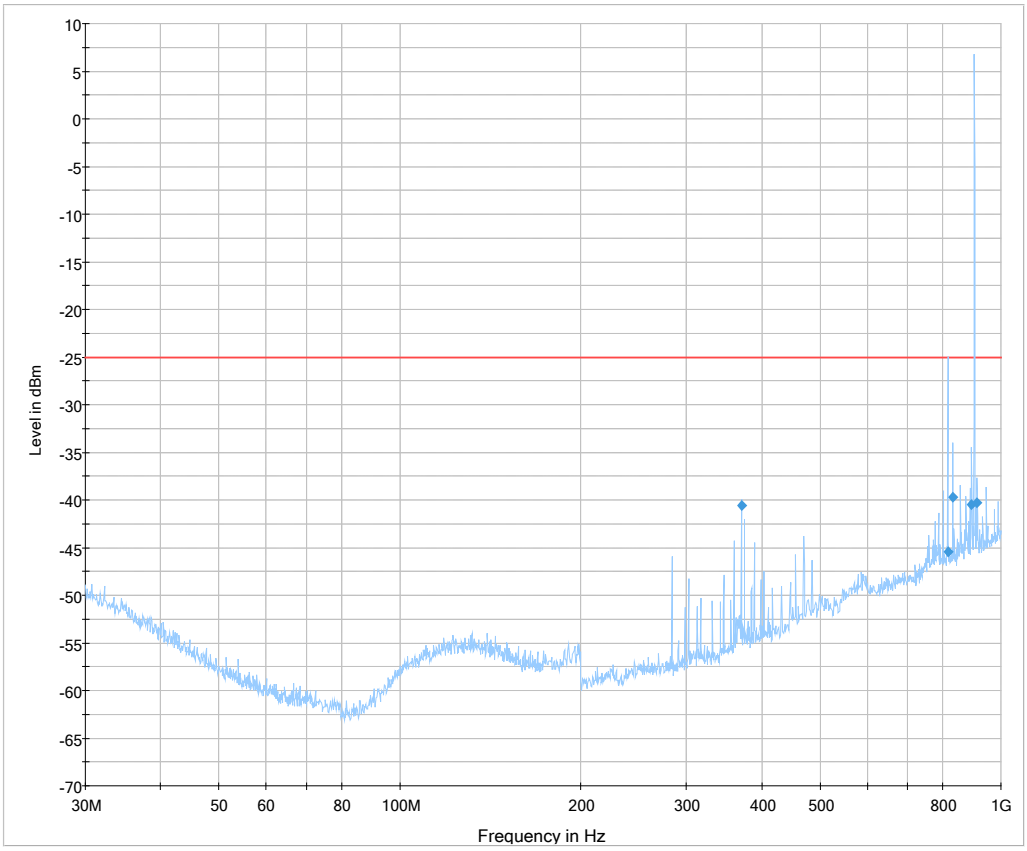
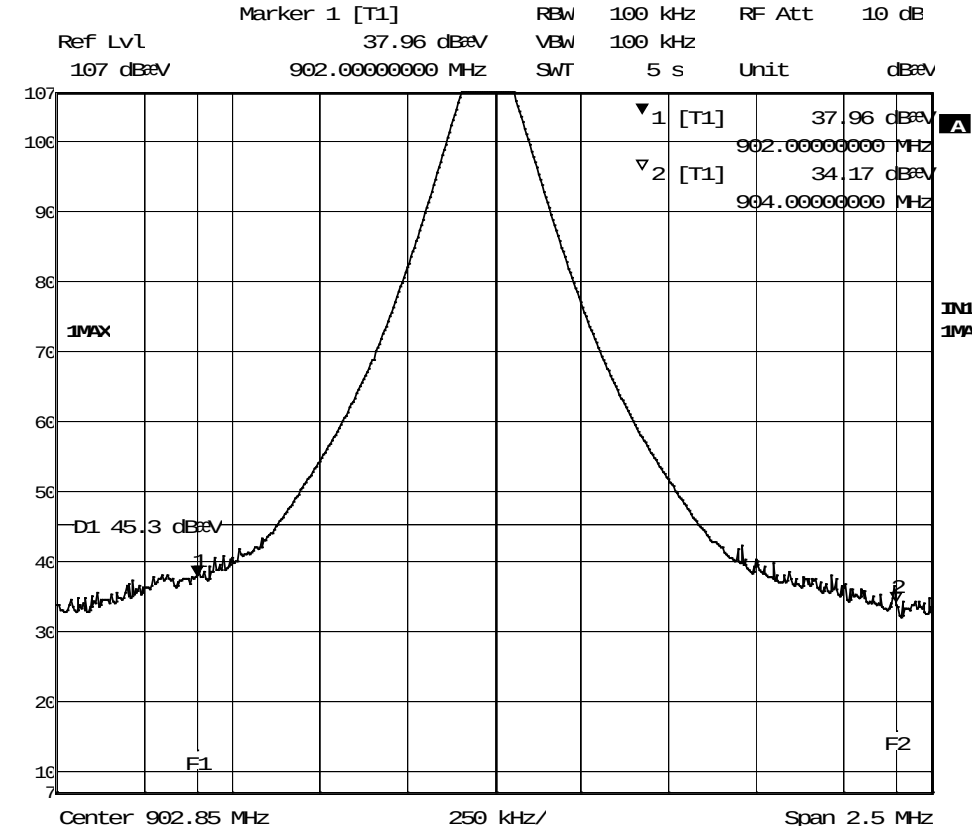
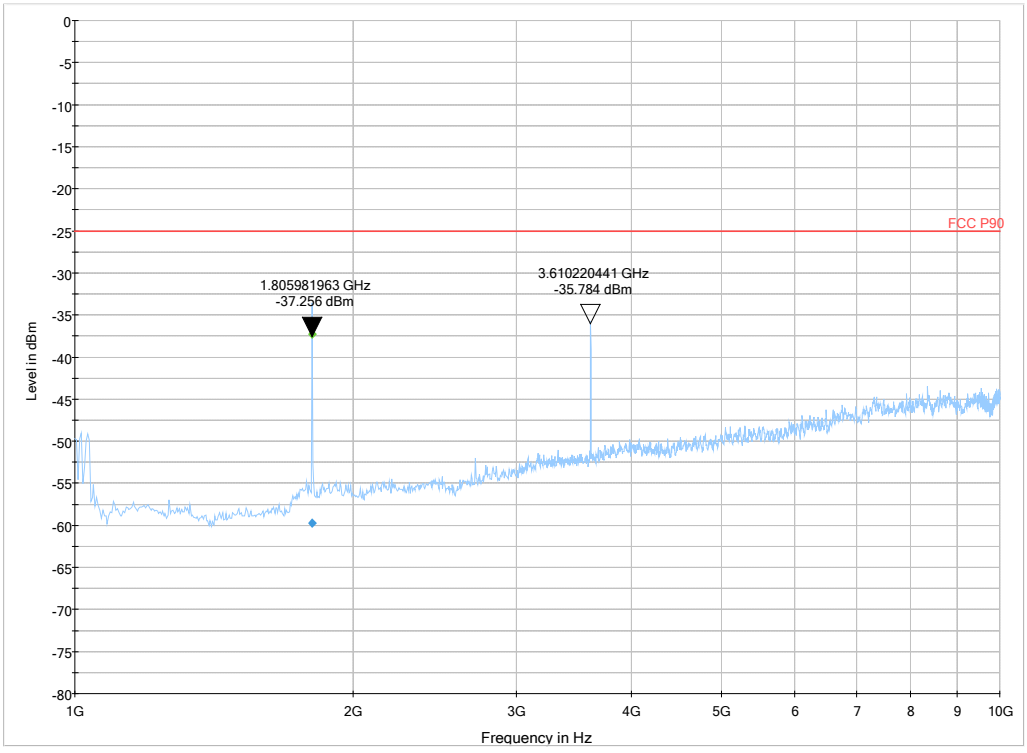

10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
Level in dBm
30M
50
60
80
100M
200
300
400
500
800
1G
Frequency in Hz

Diagram 2



Date: 11.SEP.2012 11:18:01

Diagram 3



Frequency stability measurements according to FCC 47 CFR part 90.213 (a) / RSS-137 6.3

Date	Temperature	Humidity
2013-03-06	23 °C ± 3 °C	20 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI/TIA-603-C-2004.

The test was performed with an monopole antenna.
The spectrum analyser had an external 10 MHz reference standard connected.

Measurement equipment	SP number
R&S ESI 40 Spectrum analyser	503 125
Allgon Monopole antenna	-
Agilent E3631A DC power supply	503 997
Fluke 85III True RMS voltmeter	503 418
Weisstechnik 203842/8/001 climate chamber	503 360
Testo 615, Temperature and humidity meter	503 498
Testo 635-1 Temperature and humidity meter	504 203

Results

Nominal Voltage: 7.4 V DC
Batter endpoint (specified by the client): 6.2 VDC
Nominal Tx frequency: 902.85 MHz

Test conditions		Frequency error (kHz)
Supply voltage (V DC)	T (°C)	
7.4 V DC	+20	+0.3
6.2 V DC (battery endpoint)	+20	+0.3
7.4	+30	+0.3
7.4	+40	+0.2
7.4	+50	+0.4
7.4	+10	+0.3
7.4	0	+0.2
7.4	-10	+0.2
7.4	-20	+0.4
7.4	-30	+0.4
Maximum frequency error (kHz)		+0.4
Measurement uncertainty		$< \pm 1 \times 10^{-9}$

Limits

According to 47CFR 90.213, transmitters used in the services governed by this part must have a minimum frequency stability as specified below:

		Mobile stations	
Frequency range (MHz)	Fixed and base stations (ppm)	Over 2 watts output power (ppm)	2 watts or less output power (ppm)
902-928	2.5	**2.5** Note 1	2.5

Note 1: In our case at 902.85 MHz, maximum frequency error is ±2.257 kHz.

According to IC RSS 137.6.3, the carrier frequency shall not depart from the reference frequency in excess of ±2.5 ppm for any type of equipment unless indicated otherwise.

Complies?	Yes

Conducted emission measurements according to FCC 47 CFR part 15.207, class B / RSS-Gen 7.2.4

Date	Temperature	Humidity
2013-03-04	22 °C ± 3 °C	21 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009.

Measurements were performed on the 120 V AC/60 Hz, phase and neutral terminals, at the battery charger, with empty batteries (fully charging activated).

Test set-up photos during the tests can be found in Appendix 7.

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyzer R&S ESI 26	503 885
EMI measurement computer	-
Software: R&S EMC32, ver. 6.30.10	503 745
LISN Schwartzbeck NNLA20	504 129
Temperature and humidity meter Testo 625	504 117

Result

The conducted emission spectra can be found in the diagrams below:

Diagram 1:	Ambient (without the charger), 120 V AC, phase terminal
Diagram 2:	120 V AC, phase terminal
Diagram 3:	120 V AC, neutral terminal

The limit lines indicated as Voltage on Mains in the diagrams are the same limit lines as of FCC part 15.

Limits

According to 47CFR 15.207 and RSS-Gen 7.2.4.

Frequency (MHz)	Quasi-peak value (dBµV)	Average value (dBµV/m)
0.15-0.5	66-56*	56-46*
0.5-5	56	46
5-30	60	50

*=Decreases with the logarithm of the frequency

Complies?	Yes

Appendix 6

Diagram 1

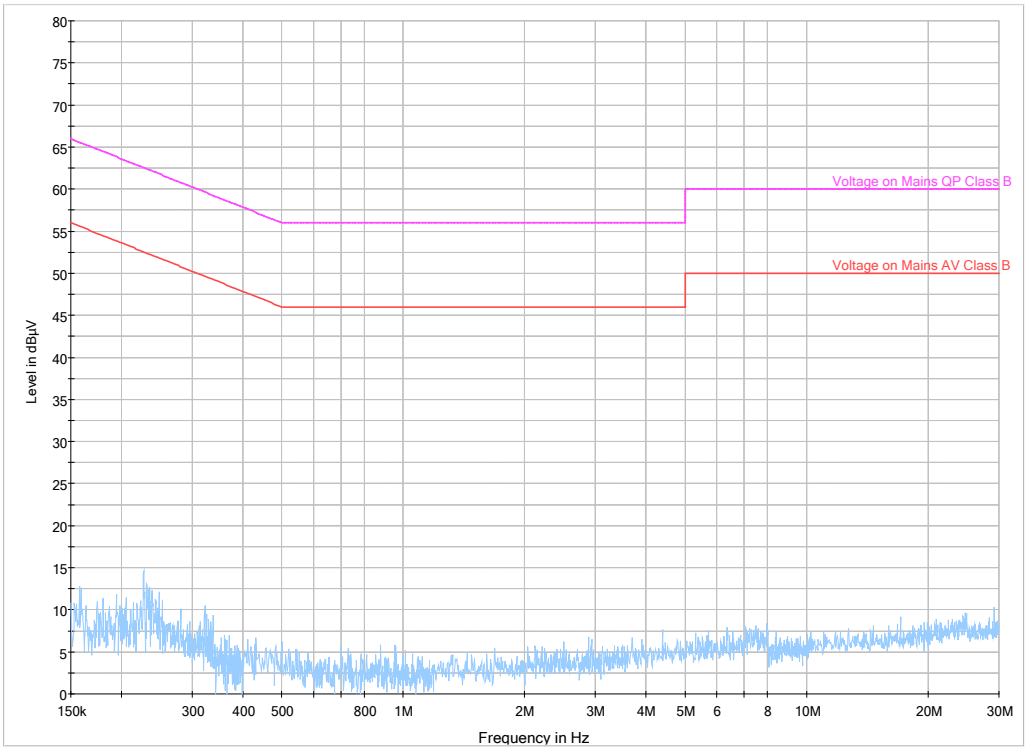
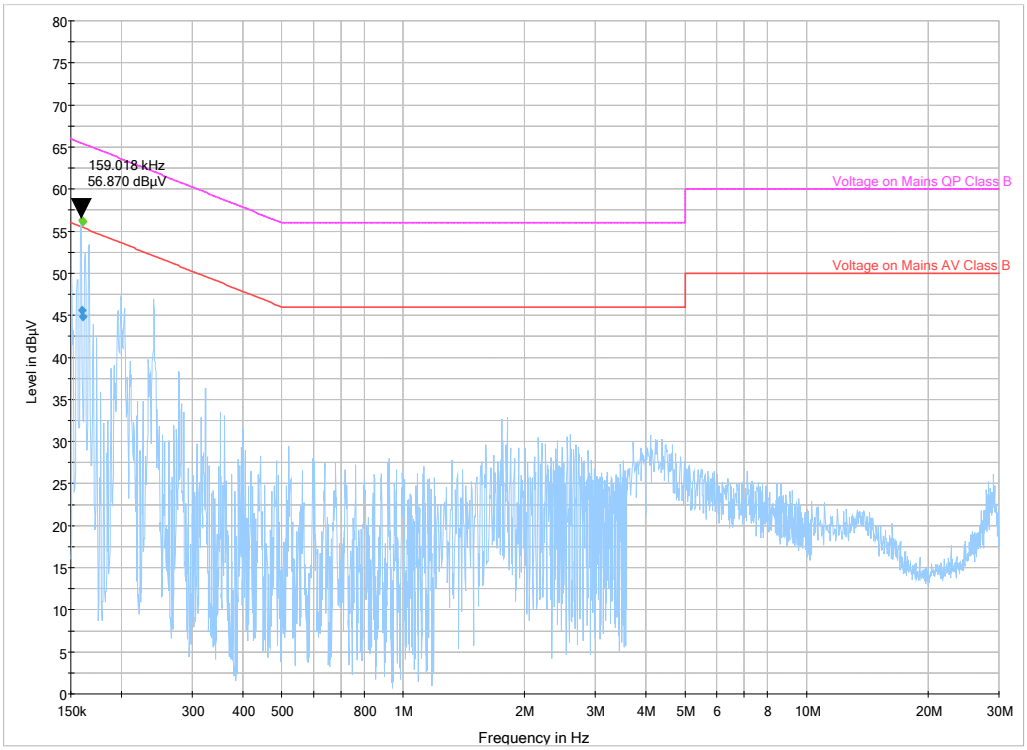


Diagram 2



Final measurement: CISPR-Average detector

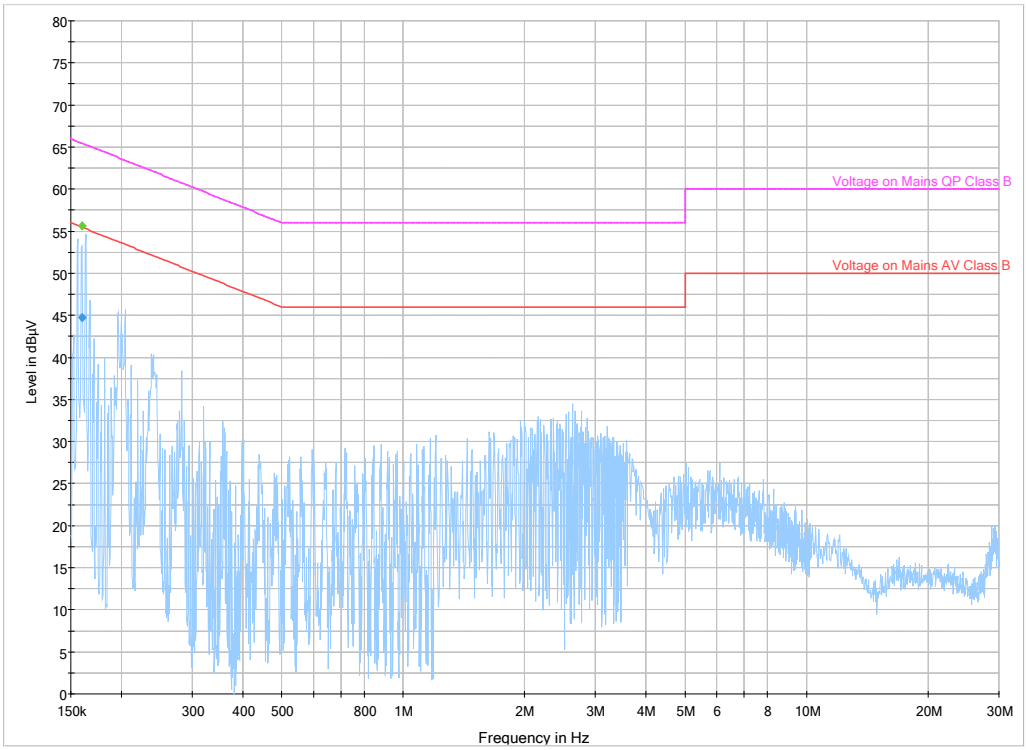
Frequency (MHz)	CAverage (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.160000	45.6	5000.0	9.000	GN	L1	0.2	9.9	55.5	
0.160681	44.8	5000.0	9.000	GN	L1	0.2	10.6	55.4	

Final measurement: QP detector

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.160000	56.3	5000.0	9.000	GN	L1	0.2	9.2	65.5	
0.160681	56.1	5000.0	9.000	GN	L1	0.2	9.3	65.4	

Appendix 6

Diagram 3



Final measurement: CISPR-Average detector

Frequency (MHz)	CAverage (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.160000	44.7	5000.0	9.000	GN	L1	0.2	10.8	55.5	

Final measurement: QP detector

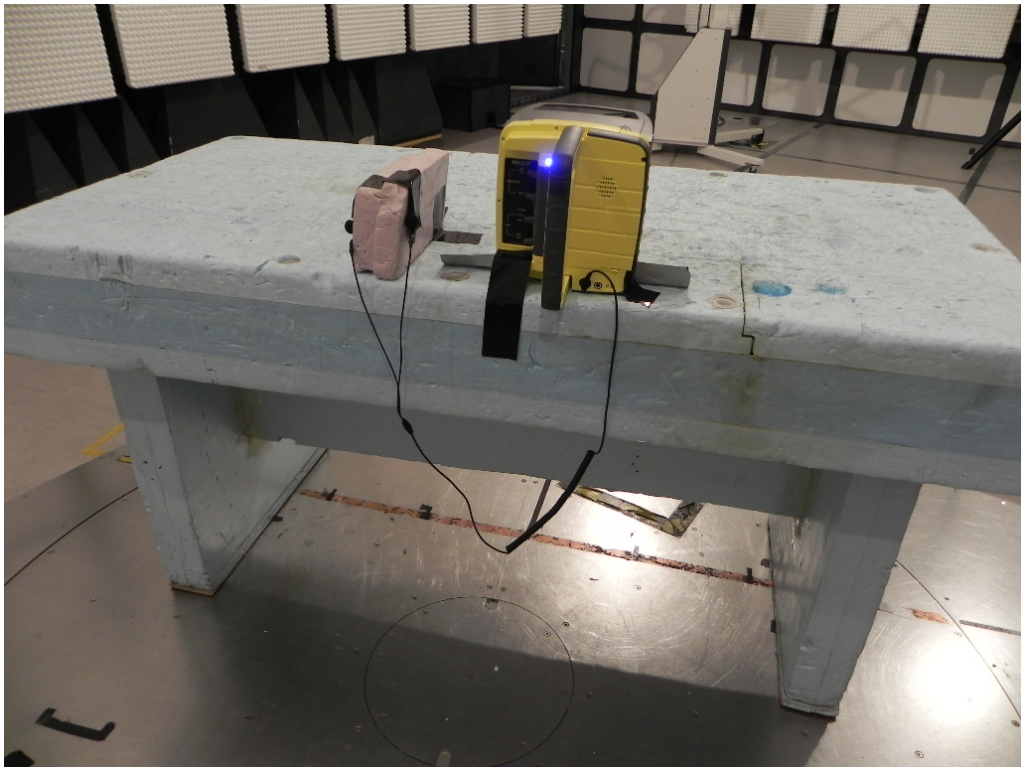
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)	Comment
0.160000	55.6	5000.0	9.000	GN	L1	0.2	9.9	65.5	

Appendix 7

Photos

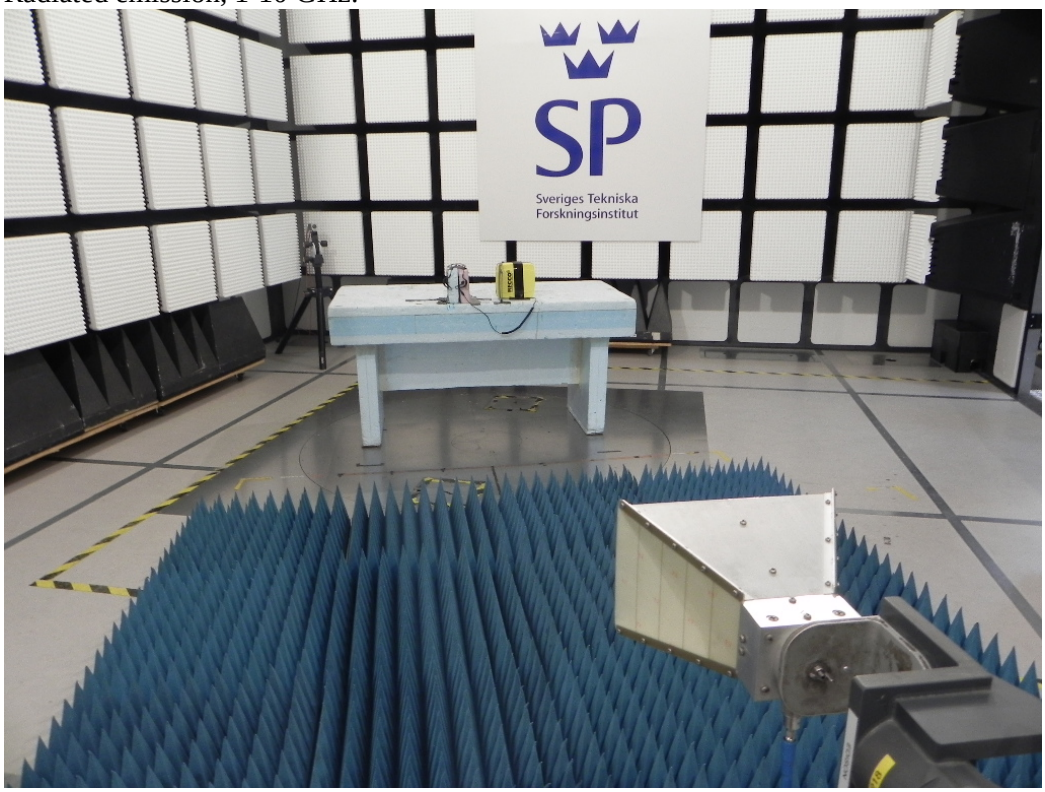
The test set-up during all the radiated tests can be seen in the pictures below.

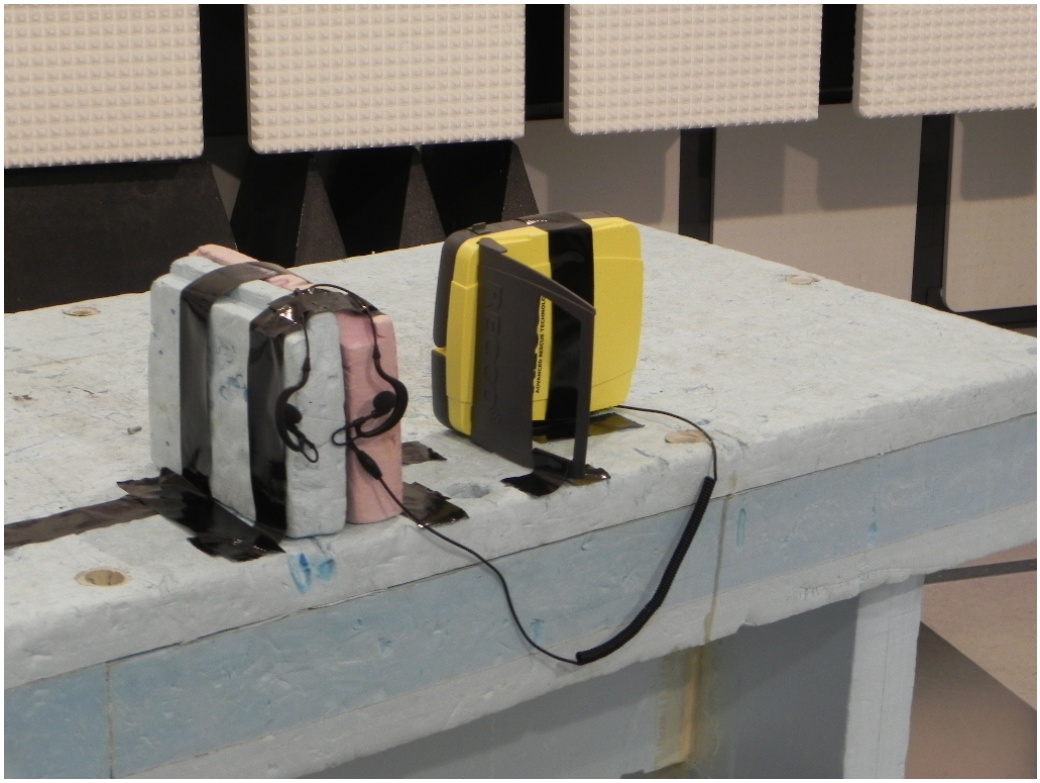
Radiated emission, 30-1000 MHz:



Appendix 7

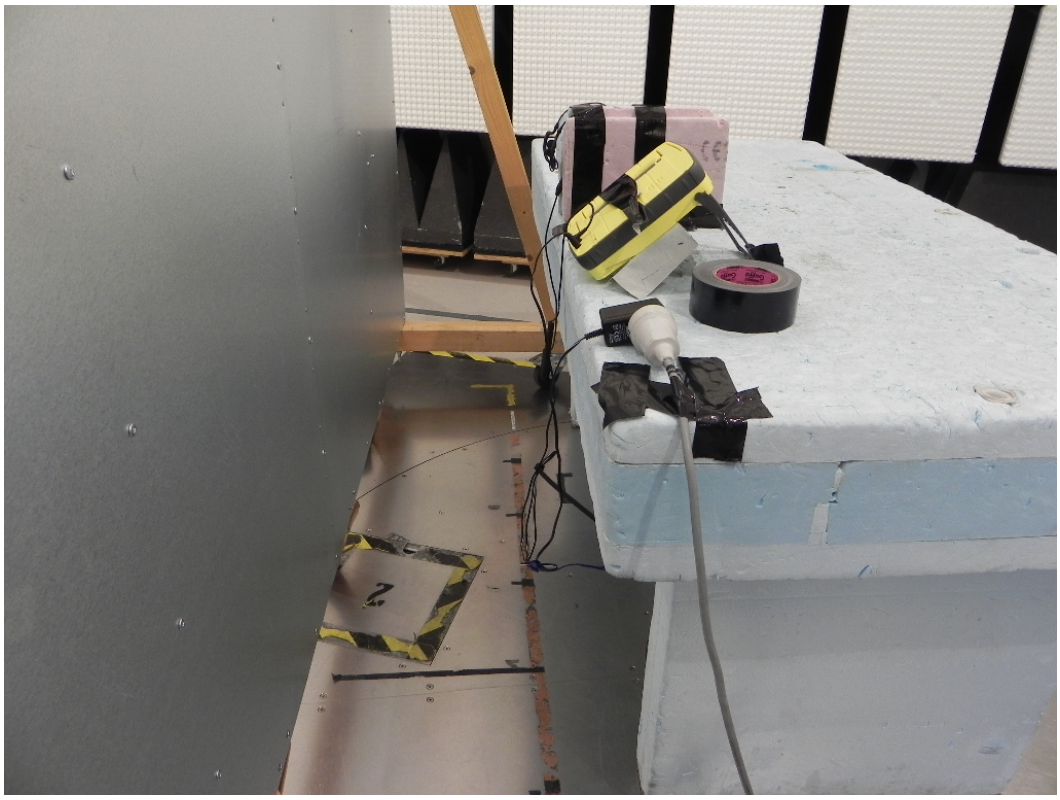
Radiated emission, 1-10 GHz:





Appendix 7

Conducted AC emission:



Appendix 7

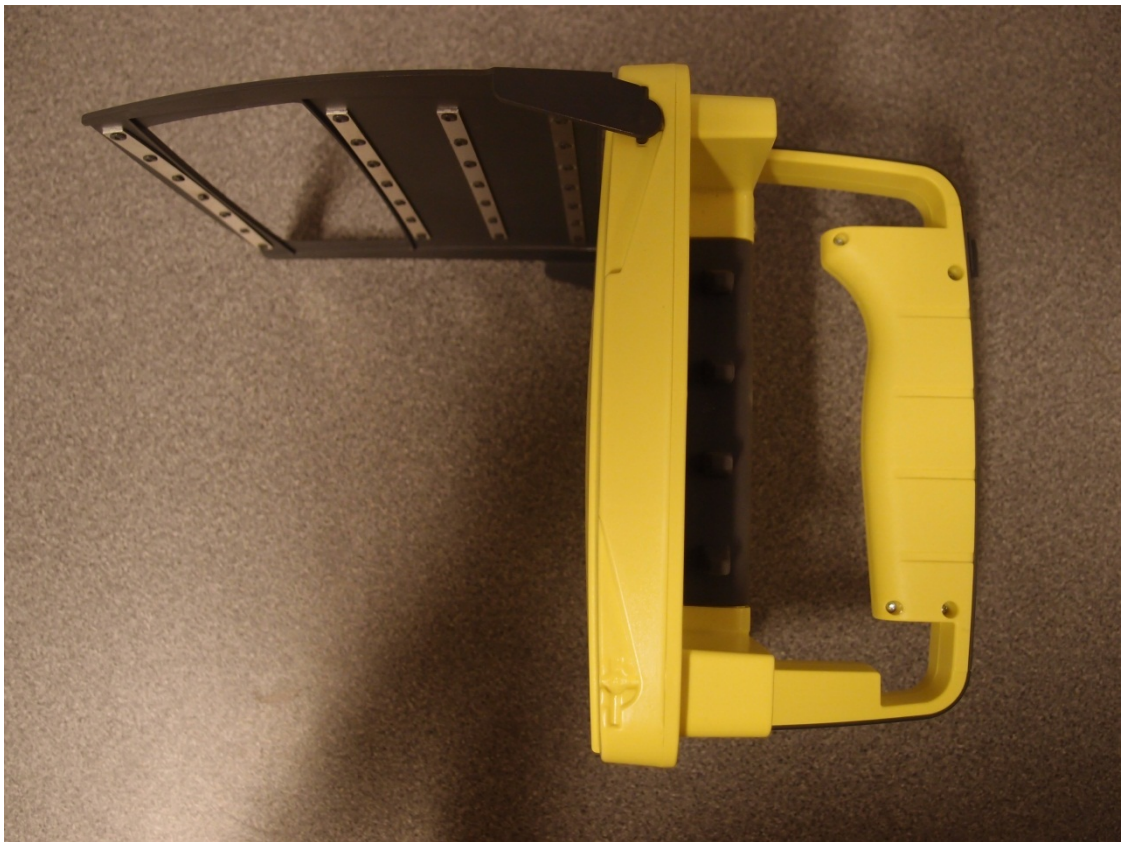
EUT

Front

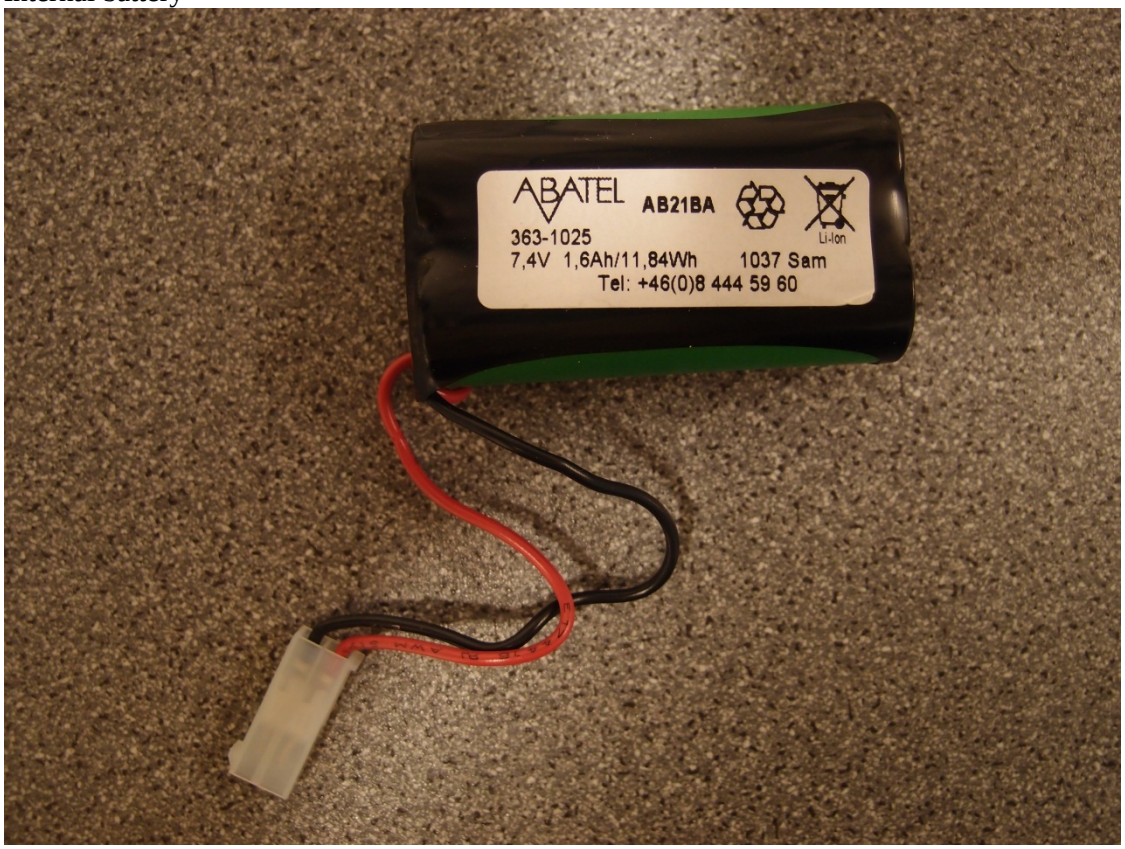
Rear

Appendix 7

Side



Internal battery



Appendix 7

Charger