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TEST REPORT

Distribution	Document	Ref. No	Page
Malå Geoscience AB Skolgatan 11 SE-930 70 Malå Sweden	**Test Report**	EMC-Osd-12-0663-01	1(24)
Copy OFLV archive	Date December 7, 2012	Supersedes	
	Prepared OFLBI, Lennart Hamberg *Technical Manager*		

Title

EMC Test of Easy Locator antenna 3G

Summary:

The object of the test is to show compliance with the emission requirements of Federal Communications Commission (FCC) Part 15 Subpart F and Industry Canada (IC) RSS-220 for ground penetrating radars (GPR) using ultra wideband (UWB) technology.

The EUT complied with the requirement of radiated emissions given in FCC Part 15 Subpart F and IC RSS-220, measured in the frequency range 30 MHz – 10 GHz.

The tests have been performed at an Open Area Test Site (OATS). The test site is registred at FCC with the registration number 389317 and at IC with the site number 4660C-1.

Approved:

Björn Olsson
Senior EMC Engineer

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Contents

1 General information

Date of test:	November 6-7, 2012
Location of the test:	Saab AB Storlienvägen 56 SE-831 52 Östersund Sweden
Test performed by:	Lennart Hamberg, Saab AB
Client:	Malå Geoscience AB Skolgatan 11 SE-930 70, Malå Sweden
Client's observer:	Bernth Johansson, Malå Geoscience AB (2012-11-06) Lars Mikaelsson, Malå Geoscience AB (2012-11-07)

2 Test methods and results

2.1 Results

The test results in this report apply only for the tested EUT.

EMISSION REQUIREMENTS ACCORDING TO FCC Part 15 Subpart F and IC RSS-220					
Environmental phenomena	**Test method**	**Requirement**	**Result**	**Comments**	**Test order**
Radiated emission 30 MHz – 960 MHz	ANSI C63.4	FCC 15.209 IC RSS-220, section 3.4	**PASS**		1
Radiated emission 960 MHz – 10 GHz	FCC 02-48 IC RSS-220	FCC 15.509 (d) IC RSS-220, section 6.2.1(d)	**PASS**		2
Radiated emission 1164 MHz – 1240 MHz 1559 MHz – 1610 MHz	FCC 02-48 IC RSS-220	FCC 15.509 (e) IC RSS-220, section 6.2.1(e)	**PASS**		3
UWB definition		FCC 15.503 (a) 15.509(a) IC RSS-220, section 6.2.1(a)	**PASS**	f_M: 223 MHz f_L: 73.7 MHz f_H: 467 MHz f_C: 270 MHz	5
Peak emission at f_M	FCC 02-48 IC RSS-220	FCC 15.509 (f) IC RSS-220, section 6.2.1(g)	**PASS**		4

2.2 Applicable documents

Measurements		
ANSI C63.4	2009-09-15	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz
FCC CFR 47 Part 15	2011-10-01	Radio Frequency Devices
FCC 02-48	2002-04-22	Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems
IC RS-Gen	December 2010	General requirements and Information for the Certification of Radio Apparatus
IC RSS-220	March 2009	Devices Using Ultra-Wideband (UWB) Technology

3 Equipment under test (EUT)

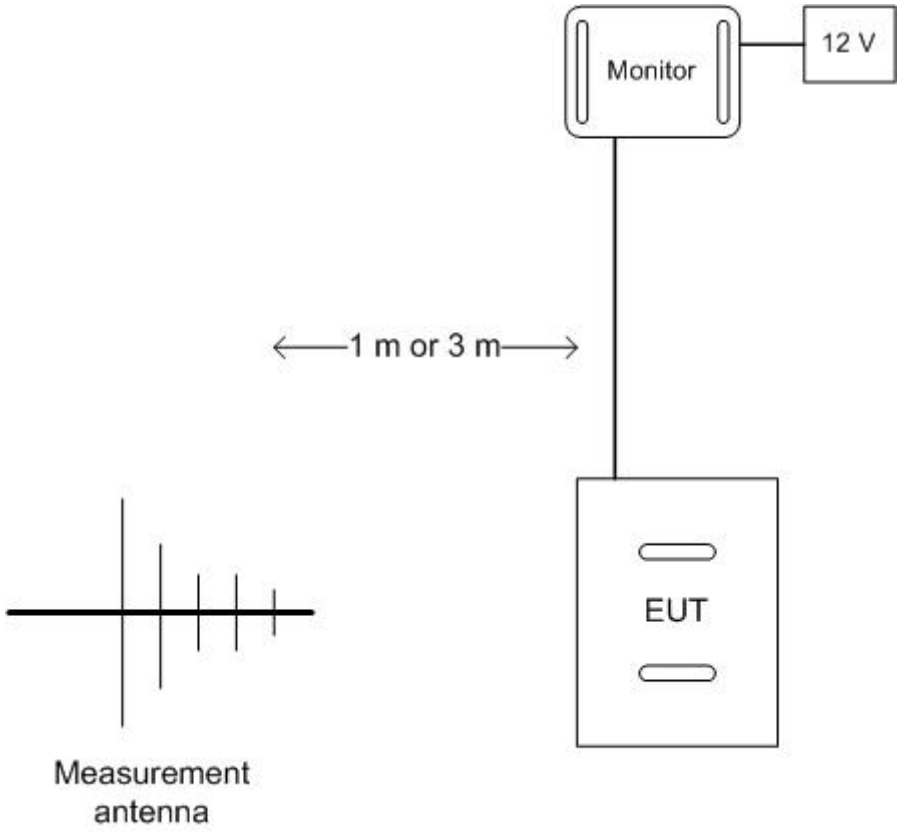
3.1 Identification of equipment under test

Description:	Ground penetrating radar antenna
UWB subclass:	Ground Penetrating Radar (GPR)
Manufacturer:	Malå Geoscience AB
Model name:	Easy Locator antenna 3G
Model No:	21-004800
Serial No:	46295
Build state:	Production sample

3.2 General configuration of EUT

The EUT was connected to a Malå Monitor XV positioned approximately 1 m away from the EUT. The monitor unit was powered by a 12 V battery. See also Picture 1 and 2 for a description of the setup.

Picture 1. Configuration of the EUT.



Picture 2. Schematic illustration of the EUT configuration.

3.3 Operation of EUT during tests

The EUT was gathering data like in normal operation.

4 Test site

4.1 Description

The measurements were all performed on a weather protected open area test site (OATS) that was modified with a flat sand bed located in the ground plane. The depth of the sand bed was more than 0.5 m. The EUT was positioned on the sand bed with no ground plane beneath.

At frequencies below 960 MHz the measurement distance from the antenna to the EUT was 3 m. The measurement receiver and related equipment, such as a PC and equipment for remote control, were placed next to the test site approximately 10 m from the antenna.

At frequencies above 960 MHz the measurement distance from the antenna to the EUT was 1 m. The measurement receiver and a preamplifier were placed next to the measurement antenna while other related equipment was placed next to the site.

4.2 Ambient signals

A number of ambient signals were frequently detected in the different frequency ranges where measurements were made, see table below. Additionally, many signals of short-term duration were found. Each measurement signal close to or above the limit was examined if ambient or related to the EUT.

Frequency	Service
87 MHz – 108 MHz	FM Broadcast
390 MHz – 395 MHz	Mobile radio (TETRA)
470 MHz – 790 MHz	Television
876 MHz – 960 MHz	Mobile phones (GSM)
960 MHz – 1164 MHz	Aironautical radio
1.3 GHz	Radar system
1. 7 GHz – 2.2 GHz	Mobile phones (DECT, GSM, W-CDMA)
2.4 GHz – 2.5 GHz	Wireless-LAN

5 Results

5.1 Measurement of radiated emission, 30 MHz – 960 MHz

5.1.1 Requirements according to FCC 15.509 (d), 15.209 and IC RSS-220

Radiated emission from the EUT in the frequency range 30 MHz to 960 MHz shall not exceed the limit as specified below.

Frequency range	Limit
30 – 88 MHz	40 dBµV/m
88 – 216 MHz	43.5 dBµV/m
216 – 960 MHz	46 dBµV/m

5.1.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) with 3 meters measuring distance as described in section 4, see Picture 3.

The EUT was configured and the test was performed in accordance with ANSI C63.4.

The test was initiated with a pre-scan with peak detector in the frequency range 30 MHz to 960 MHz. The emission level was measured in 64 different combinations of 16 EUT angle positions plus vertical and horizontal polarisation and two antenna heights. For each position the EUT was turned manually. The antenna height was changed in two steps from 1 m to 2.5 m.

A measurement software was used to add antenna factors and cable attenuation and to form a composite trace of the peak field strength.

EUT positions and frequencies with the highest emission were selected based on the pre-scan. EUT angle, antenna height and antenna polarisation were thereafter adjusted in order to find the highest emission level. The antenna height was changed between 1 m and 4 m. At these maximized positions quasi peak values were measured.

Picture 3. Measurement setup.

5.1.3 Deviations from ANSI C63.4

The test site was arranged according to FCC 02-48 with a flat sand bed located in the ground plane.

5.1.4 Environmental conditions

Temperature (inside test facility): 16 to 17°C

5.1.5 Results

Results are valid for the described arrangement and operation of the tested EUT.

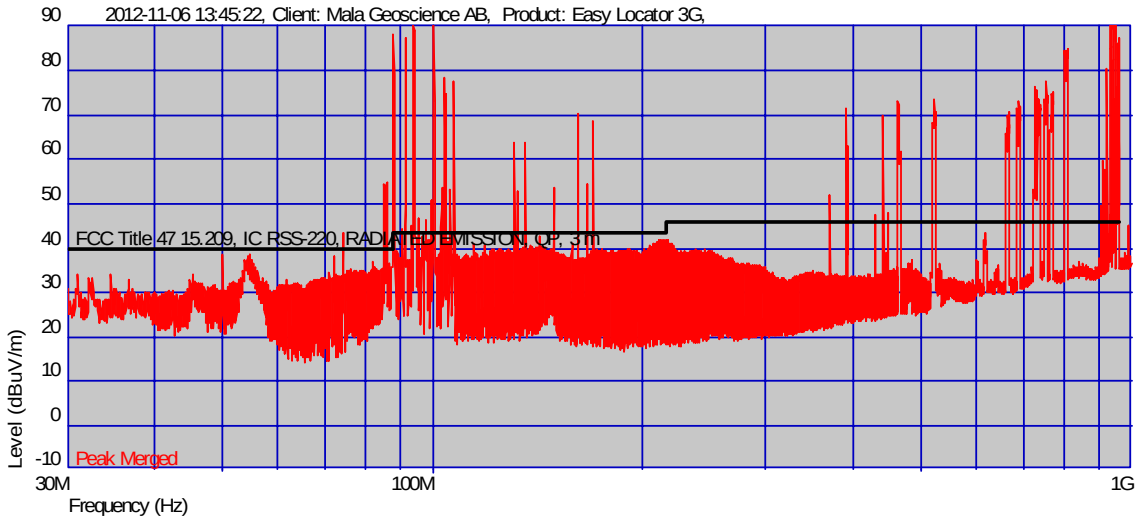
The EUT complied with the requirement of radiated emission specified in FCC 15.209 and IC RSS-220 in the frequency range 30 MHz – 960 MHz. No narrowband signals above the limit line were related to the EUT.

Emission levels measured with peak detector and with the quasi peak limit according to FCC 15.209 and IC RSS-220 are shown in the diagrams below. Emission levels measured with quasi-peak detector at maximized positions are shown in the table below.

Frequency (MHz)	Limit (dBµV/m)	Quasi peak Result (dBµV/m)	Margin (dB)	Notes
54.4	40.0	30.2	9.8	Pass
63.7	40.0	30.8	9.2	Pass
99.9	43.5	23.7	19.8	Pass
122	43.5	39.1	4.4	Pass
143	43.5	39.3	4.2	Pass
214	43.5	41.2	2.3	Pass

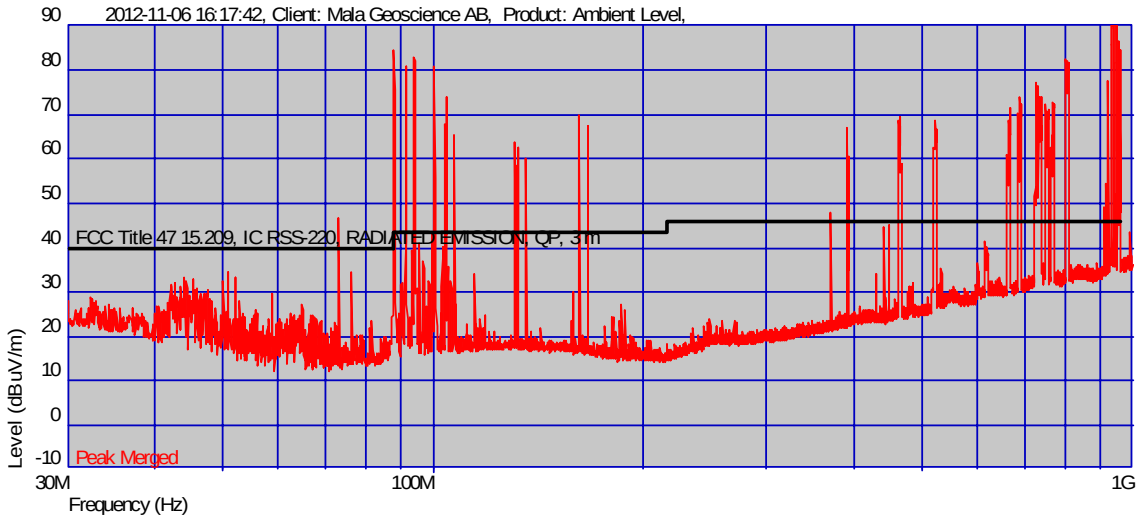
Composite trace of peak emissions. 30 MHz – 960 MHz.

Peak detector, 120 kHz bandwidth.



Ambient emission. 30 MHz – 960 MHz.

Peak detector, 120 kHz bandwidth.



5.1.6 Instrumentation

Manufacturer	Model	Range	S/N	Cal. Interval	Cal. Date
Rohde & Schwarz EMI-receiver	ESU26	20 Hz – 26.5 GHz	100019	24 month	2012-10-04
Chase Bilog antenna	CBL6111A	30 - 1000 MHz	1831	36 month	2012-02-14
EMISYS Antenna tower	140K			Not applicable	
Heinrich Diesel Controller	HD100		100/391	Not applicable	

5.2 Measurement of radiated emission, 960 MHz – 10 GHz

5.2.1 Requirements according to FCC 15.509 (d, e) and IC RSS-220

Radiated emission from the EUT shall not exceed the limit as specified below. Measurements are performed up to 10 GHz, which include the 10th harmonic of the center UWB frequency, see 5.3.3.

Frequency range	Limit	Limit*	Limit**
960 – 1610 MHz	-65.3 dBm EIRP	29.9 dBµV/m	39.4 dBµV/m
1610 – 1990 MHz	-53.3 dBm EIRP	41.9 dBµV/m	51.4 dBµV/m
1990 – 3100 MHz	-51.3 dBm EIRP	43.9 dBµV/m	53.4 dBµV/m
3100 – 10600 MHz	-41.3 dBm EIRP	53.9 dBµV/m	63.4 dBµV/m
> 10600 MHz	-51.3 dBm EIRP	43.9 dBµV/m	53.4 dBµV/m

Frequency range	Limit	Limit*	Limit**
1164 – 1240 MHz	-75.3 dBm EIRP	19.9 dBµV/m	29.4 dBµV/m
1559 – 1610 MHz	-75.3 dBm EIRP	19.9 dBµV/m	29.4 dBµV/m

* Converted to field strength level at 3 meters according to FCC 15.521 (g)
** Converted to field strength level at 1 m according to $E_{1m} = E_{3m} + 9.5$ dBµV/m

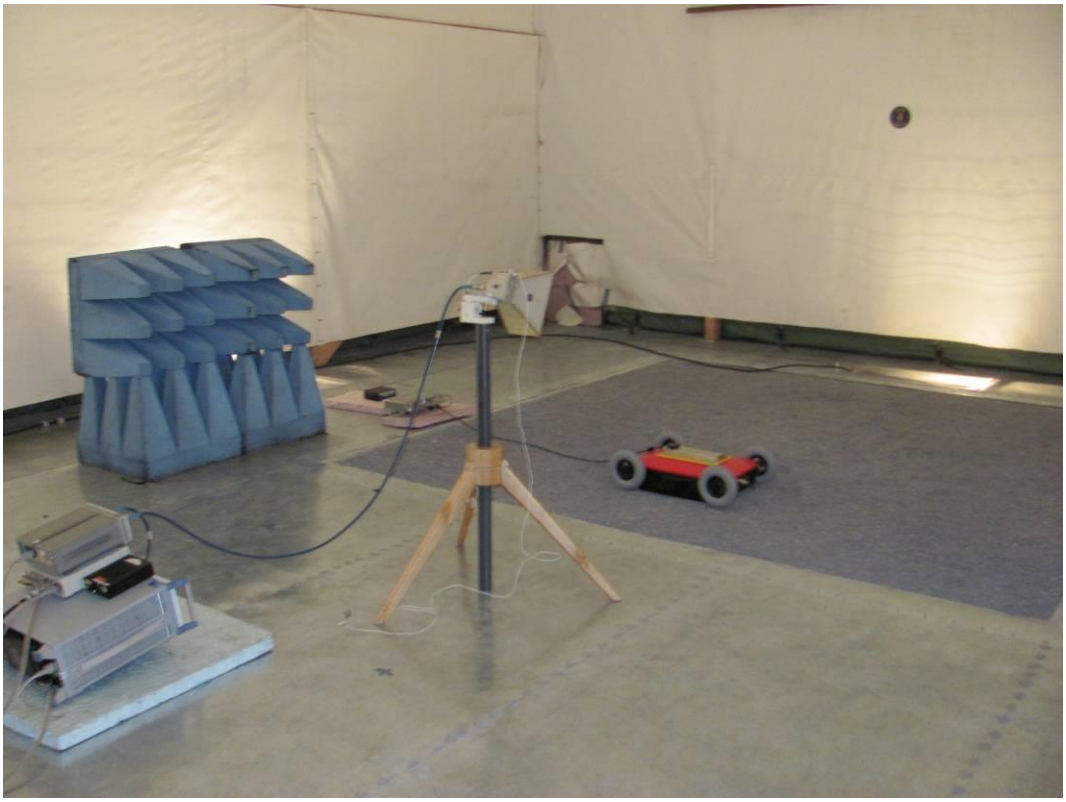
5.2.2 Procedures

Radiated emission was measured on an Open Area Test Site (OATS) with 1 m measuring distance between the EUT and the measurement antenna, see Picture 4. The antenna height was fixed at 1 m and the antenna was slightly tilted and pointed towards the EUT.

The emission was measured with an RMS detector in the frequency range 960 MHz to 10 GHz. The number of sweep points for the whole frequency range was 18081 and the total sweep time was 18 s. Thus the dwell time was 1 ms.

The following resolution bandwidths, video bandwidths and sweep times were used during the measurements.

Frequency range	RBW	VBW	Sweep points	Total sweep time
960 MHz – 10 GHz	1 MHz	5 MHz	18081	18 s
1164 – 1240 MHz	1 kHz	5 MHz	152 000	152 s
1559 – 1610 MHz	1 kHz	5 MHz	102 000	102 s



Picture 4. Measurement setup.

Measurements were performed with the EUT rotated in 16 different positions on the sand bed and with two antenna polarizations resulting in a total of 32 sweeps.

Measurement software was used to add antenna factors and cable attenuation and the resulting maximum field strength level were plotted.

After the sweeps field strength levels above the limit were checked manually due to the high number of ambient signals.

5.2.3 Results

Results are valid for the described arrangement and operation of the tested EUT.

The EUT complied with the requirement of radiated emission specified in FCC 15.509 (d) and (e) and and IC RSS-220 (6.2.1) in the frequency range 960 MHz – 10 GHz. Emissions above the limit were not related to the EUT.

Measured emission levels are shown in the diagrams below. Results are also tabulated including the six highest peaks, where peaks were found, originating from the EUT.

960 MHz – 10 GHz. RMS detector, 1 MHz bandwidth.

Frequency (MHz)	Limit * (dBµV/m)	RMS level (dBµV/m)	Margin (dB)	Notes
1.00	39.4	27.3	12.1	Ambient
2.00	43.9	30.6	13.3	Ambient
4.00	53.9	37.1	16.8	Ambient

* Converted to field strength limit at 1 m according to $E_{1m} = E_{3m} + 9.5$ dBµV/m

1164 MHz – 1240 MHz. RMS detector, 1 kHz bandwidth.

Frequency (MHz)	Limit * (dBµV/m)	RMS level (dBµV/m)	Margin (dB)	Notes
1.20	29.4	20.0	9.4	Ambient

* Converted to field strength limit at 1 m according to $E_{1m} = E_{3m} + 9.5$ dBµV/m

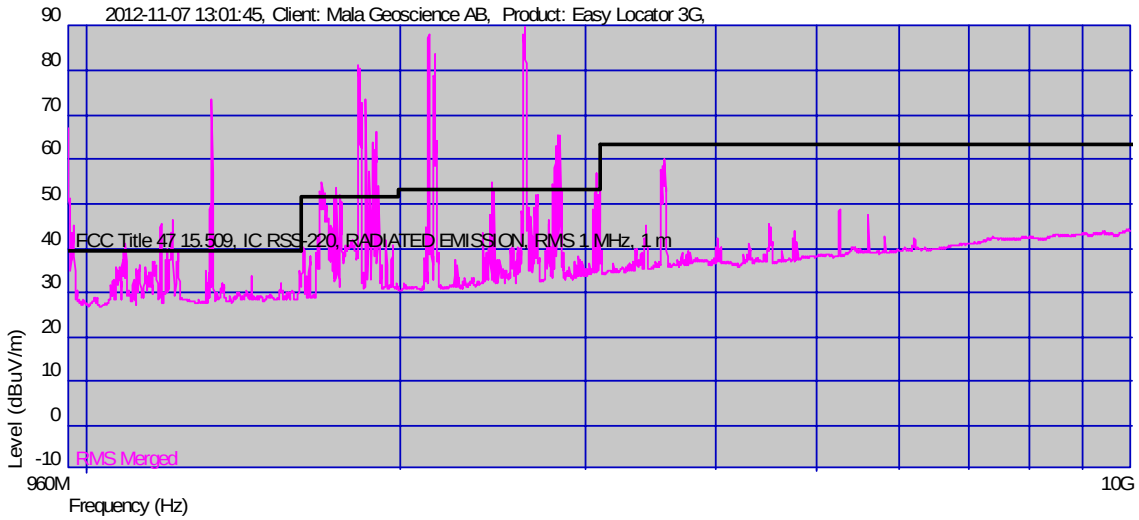
1559 MHz – 1610 MHz. RMS detector, 1 kHz bandwidth.

Frequency (MHz)	Limit * (dBµV/m)	RMS level (dBµV/m)	Margin (dB)	Notes
1.60	29.4	16.8	12.6	Ambient

* Converted to field strength limit at 1 m according to $E_{1m} = E_{3m} + 9.5$ dBµV/m

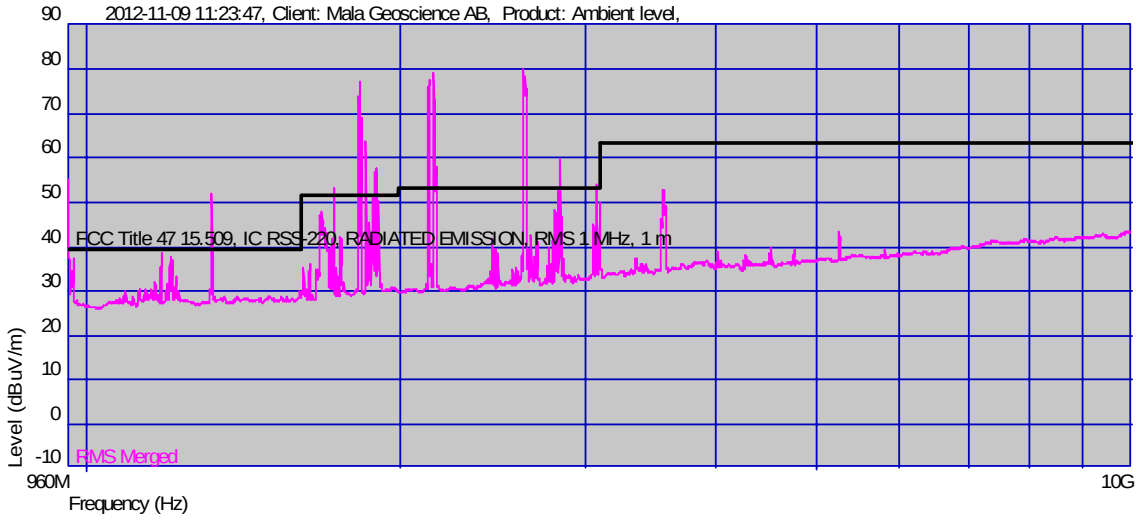
Composite trace of peak emissions. 960 MHz – 10 GHz.

RMS detector, 1 MHz bandwidth.



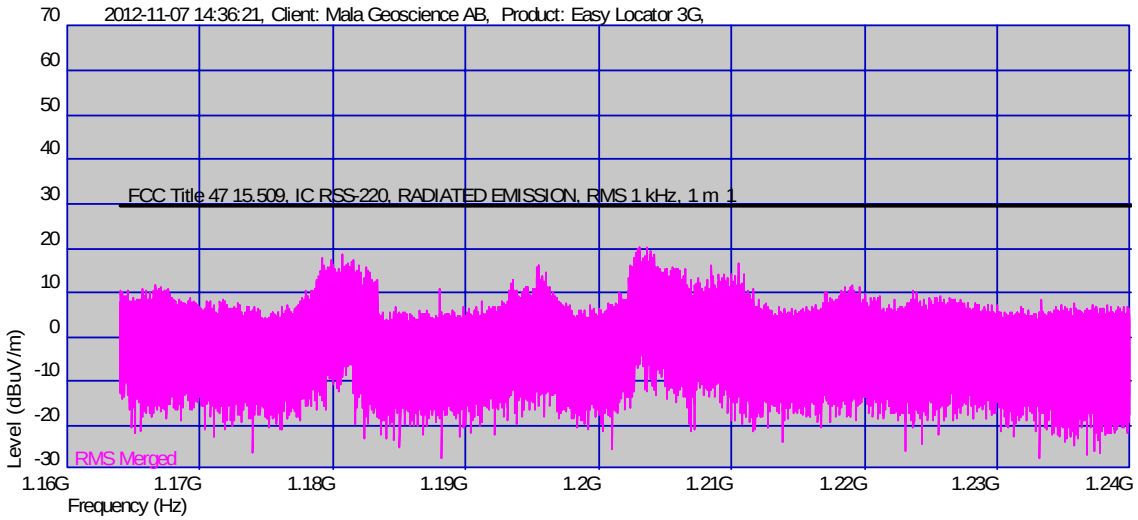
Ambient emissions. 960 MHz – 10 GHz.

RMS detector, 1 MHz bandwidth.



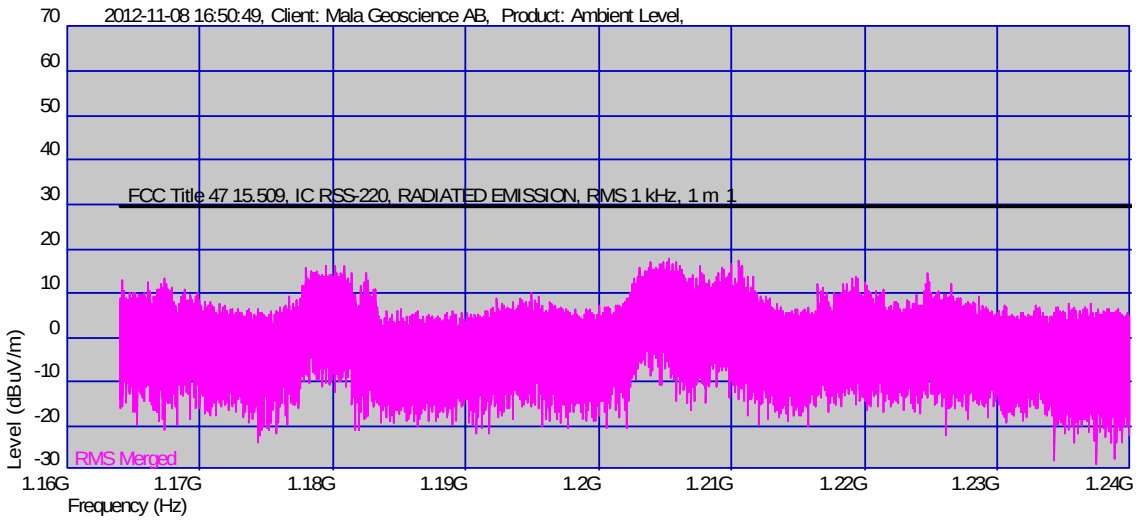
Composite trace of peak emissions. 1164 MHz – 1240 MHz.

RMS detector, 1 kHz bandwidth.



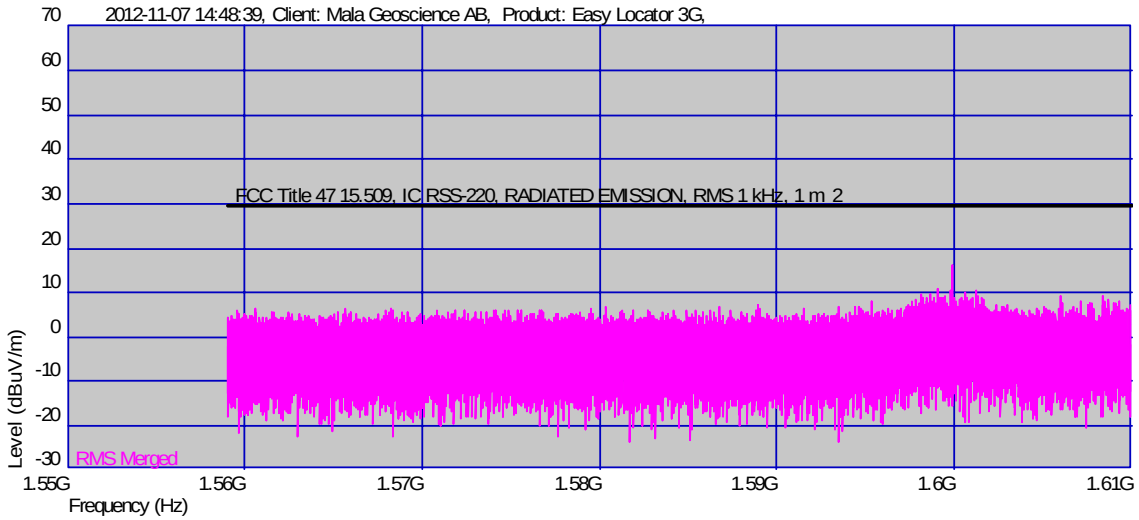
Ambient emissions. 1164 MHz – 1240 MHz.

RMS detector, 1 kHz bandwidth.



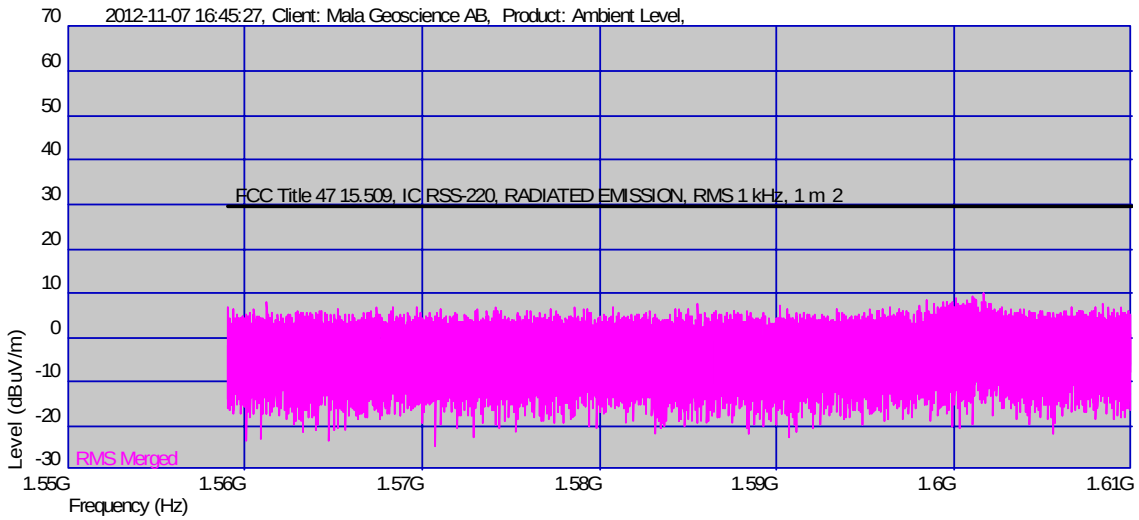
Composite trace of peak emissions. 1559 MHz – 1610 MHz.

RMS detector, 1 kHz bandwidth.



Ambient emissions. 1559 MHz – 1610 MHz.

RMS detector, 1 kHz bandwidth.



5.2.4 Instrumentation

Manufacturer	Model	Range	S/N	Cal. Interval	Cal. Date
Rohde & Schwarz EMI-receiver	ESU26	20 Hz – 26.5 GHz	100019	24 month	2012-10-04
Hewlett Packard Pre-amplifier	8449B	1 GHz – 26.5 GHz	3008A00103	12 month	2011-11-10
Emco Double Ridge Waveguide	3115	0.96 GHz - 18 GHz	2800	36 month	2011-11-29

5.3 Measurement of UWB bandwidth and peak emissions

5.3.1 Requirements and definitions according to FCC and IC

5.3.1.1 Definitions according to FCC 15.503 (d) and IC RSS-220

UWB bandwidth: The frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated f_H and the lower boundary is designated f_L. The frequency at which the highest radiated emission occurs is designated f_M.

Center frequency (f_C): Equals $(f_H + f_L)/2$.

Fractional bandwidth: Equals $2(f_H - f_L) / (f_H + f_L)$.

Ultra-wideband (UWB) transmitter/device: An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

5.3.1.2 Requirements according to FCC 15.509 (a) and IC RSS-220 (6.2.1)

The UWB bandwidth of an imaging system operating under the provisions of this section must be below 10.6 GHz.

5.3.1.3 Requirements according to FCC 15.509 (f) and IC RSS-220 (6.2.1)

For UWB devices where the frequency at which the highest radiated emission occurs, f_M is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on f_M. The limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth and a correspondingly different peak emission limit, following the procedures described in FCC 15.521 and in the Annex of IC RS-220.

5.3.2 Procedures

The equipment was placed on the test site and the radiated emission was measured at 3 m for frequencies below 960 MHz and at 1 m for frequencies above 960 MHz, see sections 5.1.2 and 5.2.2.

To determine the UWB bandwidth separate measurements were made with the EUT tilted and pointing towards the antenna. To compare measurements below and above 960 MHz a conversion factor of 9.5 dB was used for the different measurement distances (1 m and 3 m).

To determine the highest emission at f_M for frequencies above 960 MHz an additional peak detector was used during the measurements described in Section 5.2. Measurements were performed at 1 m distance and with a measurement bandwidth of 1 MHz. The limit (0 dBm EIRP at 3 m and 50 MHz measurement bandwidth) was recalculated according to:

$$E\ (dB\mu V/m) = 0 + 95.2 + 20\log(1MHz/50MHz) + 9.5 = 70.7.$$

Measurement software added antenna factors and cable attenuation.

5.3.3 Results

Results are valid for the described arrangement and operation of the tested EUT.

The EUT fulfilled the definition of an UWB transmitter according to FCC 15.503 (d) and IC RSS-220. The EUT complied with the requirement in FCC 15.509 (a, f) and IC RSS-220 (6.2.1).

UWB definition

Measurement data is presented in diagrams below. From the diagrams data regarding the UWB bandwidth was gathered and calculated.

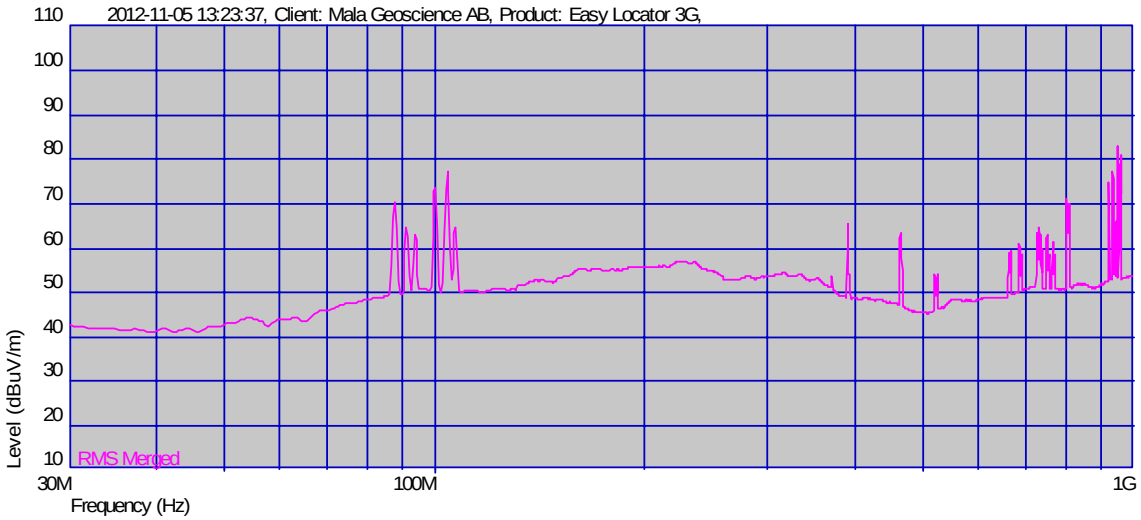
Frequency of highest emission f_M	223 MHz
Lower boundary f_L	73.7 MHz
Upper boundary f_H	467 MHz
Centre frequency f_C	270 MHz
Fractional bandwidth	1.45

Emission at f_M

The frequency of highest emission (f_M) was 223 MHz, which is below 960 MHz. Thus, there is no requirement for the emission at f_M measured with peak detector over 50 MHz bandwidth.

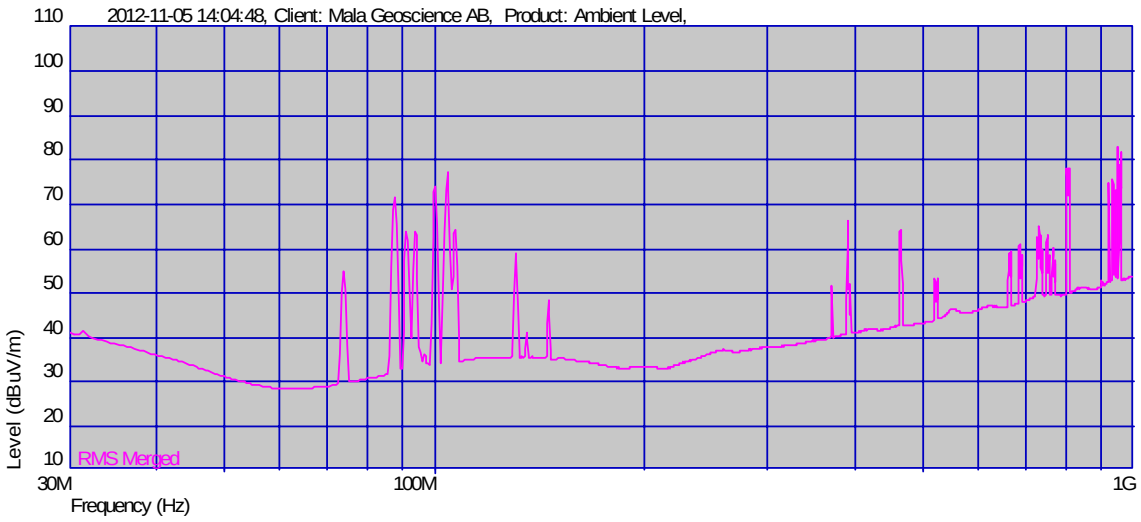
Measurements of UWB bandwidth. 30 MHz – 960 MHz. EUT tilted.

RMS detector, 1 MHz bandwidth.



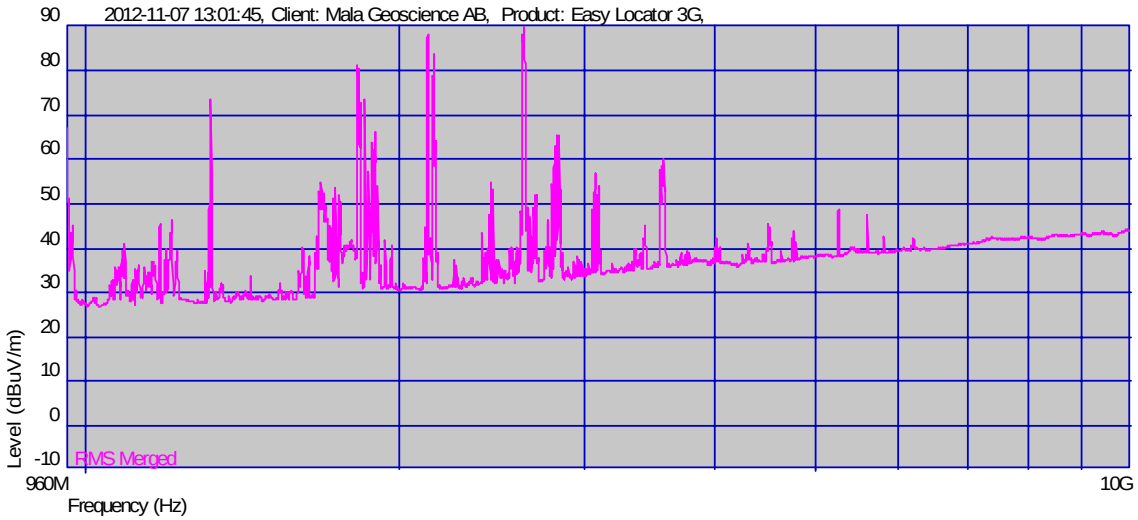
Ambient emissions. 30 MHz – 960 MHz.

RMS detector, 1 MHz bandwidth.



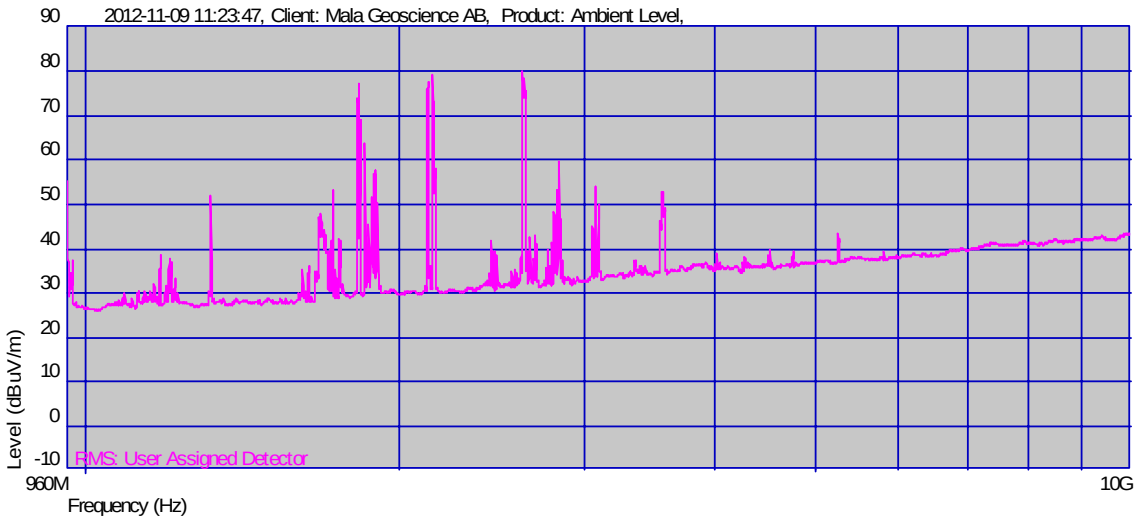
Measurements of UWB bandwidth. 960 MHz – 10 GHz. EUT tilted.

RMS detector, 1 MHz bandwidth.



Ambient emissions. 960 MHz – 10 GHz.

RMS detector, 1 MHz bandwidth.



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