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Document
Test Report

Date
June 21, 2004

Prepared
FBM, Per Larsson
EMC Test Engineer

Ref. No
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Supersedes

Page
1 (23)

Title
EMC Test, Cart 400

Equipment under test (EUT):

Description:	Ground Penetrating Radar System
Manufacturer:	Malå Geoscience AB
Model name:	Cart 400

Summary:

The EUT complied with the requirement of radiated emissions given in FCC Part 15 Subpart F, measured in the frequency range 30 – 10 000 MHz.

Approved:

Petter Gärdin
EMC Test Supervisor

Contents

1 Introduction

The object of the test is to show compliance with the emission requirements of FCC Part 15 Subpart F.

Date of test:	Mars 29 – 31, 2004
Location:	AerotechTelub AB, Östersund
Test performed by:	Per Larsson, AerotechTelub / FBM
Client:	Malå Geoscience Skolgatan 11 SE-930 70 Malå Sweden
Client's observer:	Lars Mikaelsson, Malå Geoscience AB

2 Test methods and results

2.1 Results

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

The results in this table are only valid with the modifications of the EUT specified in section 4.4.

EMISSION REQUIREMENTS ACCORDING TO FCC Part 15 Subpart F					
Environmental phenomena	Test method	Requirement	Result	Comments	Test order
Radiated emission	ANSI C63.4	FCC 15.209	**PASS**		1
UWB definition		FCC 15.503 (a) 15.509(a)	**PASS**	f_L 35 MHz f_C 314 MHz f_H 593 MHz	4
Peak emission at f_M	FCC 02-42	FCC 15.509 (f)	**PASS**		5
Radiated emission	FCC 02-42	FCC 15.509 (d)	**PASS**		2
Radiated emission	FCC 02-42	FCC 15.509 (e)	**PASS**		3

3 Applicable documents

Measurements		
ANSI C63.4	07/17/1992	Radio noise emissions from low-voltage electrical and electronic equipment in the range of 9 kHz to 40 GHz.
FCC Part 15	12/8/2003	Radio Frequency Devices
FCC 02-42	4/22/2002	Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems

4 Equipment under test (EUT)

4.1 Identification of equipment under test

Equipment under test (EUT):

Description:	Ground Penetrating Radar System
Manufacturer:	Malå Geoscience AB
Model name:	Cart 400
Build state:	Production sample
Serial no:	12627

4.2 General configuration of EUT

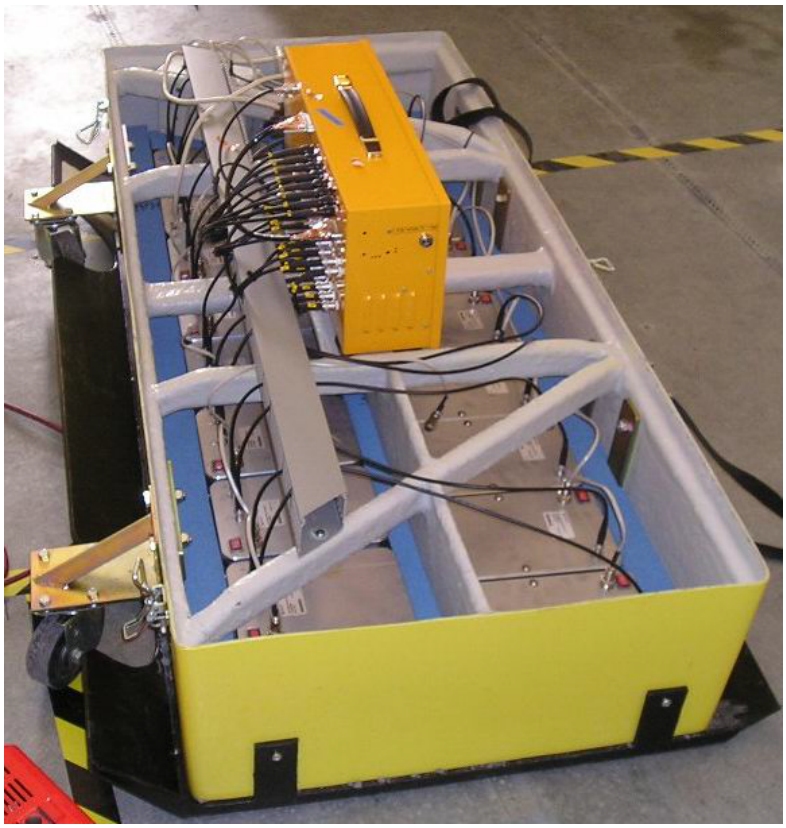
A battery powered the EUT.

The EUT was placed directly on the dry sand with no ground plane under it.

4.3 Operation of EUT during tests

The EUT was gathering data like in normal operation.

4.4 Modification of EUT



Picture 1. EUT

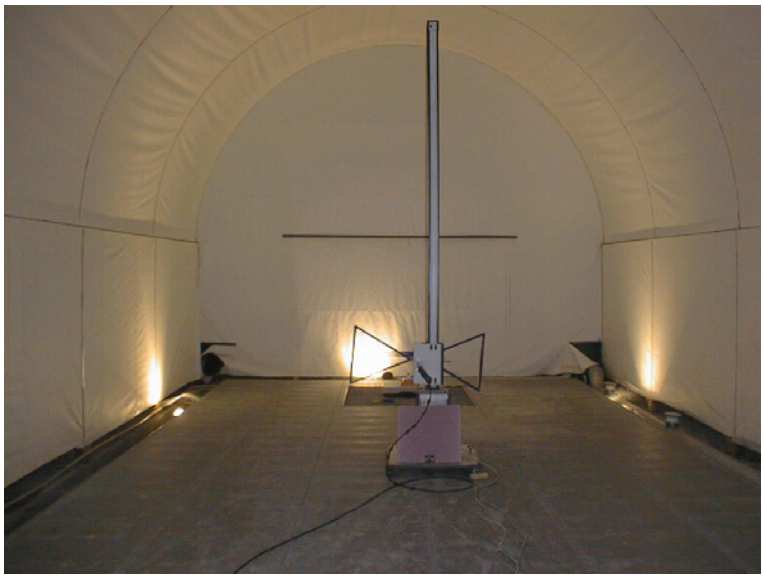
The EUT was modified as below before the tests.

- The shielding of the Cart control unit was improved. The electrical contact between the casing and the cover was improved.
- The ground of the digital control and data signals BNC-connectors were connected to the casing.
- Improved shielding of control cable.

5 Test site

5.1 Description

The measurements were all performed on a weather protected open area test site that was modified with a flat sand bed located in the ground plane. The sand bed is about 50 cm deep.



Picture 2: Test Site

The measurement distance antenna – EUT was 1 and 3 m. The measurement system and related equipment were placed next to the test site.

5.2 Ambient signals

A number of ambient signals were detected in the different frequency ranges measurement was made; some of those are listed below.

Mobile telephones:	460 – 470 MHz, 935 – 960 MHz, 1.8 GHz
FM broadcasts:	87 – 108 MHz
Television:	60 – 70 MHz, 650 – 800 MHz
Radar system:	1.3 GHz

In addition 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.

6 Emission

6.1 Measurement of radiated emission, ANSI C63.4

6.1.1 Requirements according to FCC 15.509 (d) and 15.209

Radiated emission from the EUT in the frequency range 30 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

6.1.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) with 3 meters measuring distance described in section 5.

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

The test was initiated with a pre-scan in the frequency range 30 - 960 MHz, where the emission level was measured in 16 different combinations of 8 EUT angle positions and vertical/horizontal polarisation. For each position the EUT was turned manually.

Measurement software added antenna factors and cable attenuation and a composite trace of the peak field strength measurement were drawn.

Subsequently, frequencies with the highest emission were selected. EUT position, antenna height and polarisation were adjusted in order to find the position with the highest emission level. Quasi peak values were measured in the maximised positions.

The diagrams are shown with the quasi peak limit according to FCC 15.209.

6.1.3 Deviations from the standard

The ground plane was arranged according to FCC 02-42.

6.1.4 Climatic conditions

	Requirement according to standard	**Climatic conditions during the test**
Temperature	-	2 – 10 °C
Relative humidity	-	Not measured

6.1.5 Results

Given measured values are valid for the described arrangement and operation of the EUT.

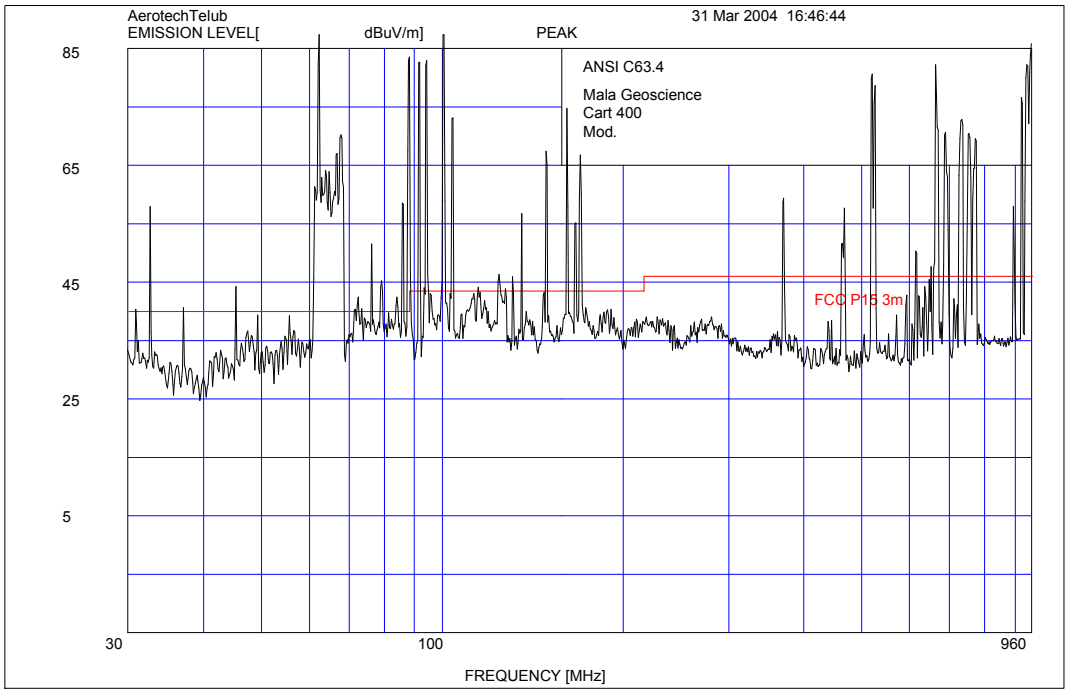
After modifications according to section 4.4 the EUT complied with the requirement of radiated emission specified in FCC 15.209 in the frequency range 30 – 960 MHz.

No narrowband signals above the limit line were related to the EUT.

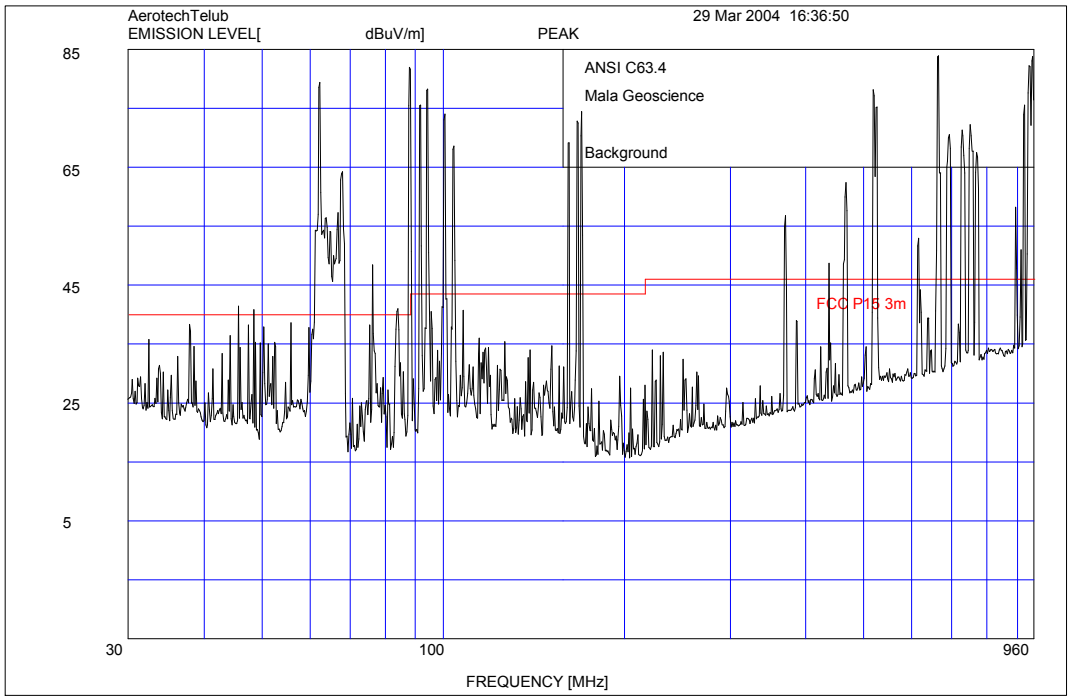
Emission measured with quasi-peak detector

Frequency (MHz)	Raw value (dBµV)	Cable loss (dB)	Antenna factor	Limit (dBµV/m)	Result (dBµV/m)	Margin (dB)	Notes
31.06	10.1	0.61	18	40	28.7	11.3	PASS
31.71	9.9	0.61	18	40	28.5	11.5	PASS
32.71	10.6	0.62	18	40	29.2	10.8	PASS
33.63	10.8	0.62	18	40	29.4	10.6	PASS
34.58	7.6	0.63	18	40	26.2	13.8	PASS
36.55	14.2	0.64	15.5	40	30.3	9.7	PASS
41.25	14.7	0.66	12.9	40	28.3	11.7	PASS
43.00	18.6	0.67	12.9	40	32.2	7.8	PASS
43.75	18.5	0.67	12.9	40	32.1	7.9	PASS
44.83	18.0	0.68	12.9	40	31.6	8.4	PASS
45.77	22.3	0.68	10.4	40	33.4	6.6	PASS
46.73	24.0	0.69	10.4	40	35.1	4.9	PASS
47.55	25.5	0.69	10.4	40	36.6	3.4	PASS
49.91	24.9	0.70	10.4	40	36.0	4.0	PASS
54.23	15.5	0.75	7.8	40	24.0	16.0	PASS
55.18	22.3	0.76	6.4	40	29.5	10.5	PASS
56.92	24.9	0.78	6.4	40	32.1	7.9	PASS
72.54	26.5	0.93	5.4	40	32.8	7.2	PASS
84.18	29.6	1.06	6.9	40	37.6	2.4	PASS
112.98	27.6	1.31	10.9	43.5	39.8	3.7	PASS
140.52	20.1	1.49	11.2	43.5	32.8	10.7	PASS
186.01	27.7	1.74	8.15	43.5	37.6	5.9	PASS
218.88	21.6	1.89	8.6	46	32.1	13.9	PASS
278.91	21.5	2.13	12.5	46	36.1	9.9	PASS
359.12	14.0	2.45	14.65	46	31.1	14.9	PASS

Emission measured with peak detector



Background emission measured with peak detector



6.1.6 Instrumentation

Hewlett Packard RF Preselector	85685A	20 Hz - 2 GHz	2724A00609
Hewlett Packard Spectrum analyser	8566B	100 Hz - 22 GHz	2404A08864 / 2504A01320
Hewlett Packard Quasi-Peak Adapter	85650A		3303A01810
Chase Bilog antenna	CBL6111A	30 - 1000 MHz	1831

6.2 Measurement of radiated emission

6.2.1 Requirements according to FCC 15.509 (d) and (e)

Radiated emission from the EUT shall not exceed the limit as specified below.

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

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

* Converted to field strength level at 3 meters according to FCC 15.521 (g)

6.2.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) as described in section 5 with 1 meters measuring distance. The measurement level was re-calculated to a 3 m measurement distance (with 9.5 dB).

According to the provisions of FCC 15.509 (d) and (e) the emissions shall be measured with a RMS detector.

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

Frequency range	RBw	VBw
960 – 10 000 MHz	1 MHz	3 MHz
1164 – 1240 MHz	1 kHz	1 kHz
1559 – 1610 MHz	1 kHz	1 kHz

The measurements were made with the EUT in 8 different positions on the sand bed and the antenna position was changed as well as its polarization.

A sweep of the frequency range was made at each position. Measurement software added antenna factors and cable attenuation and the resulting maximum field strength level were plotted.

After the sweeps the maximum radiated field strength were controlled manually due to the high number of ambient signals.

The maximum emission was then manually measured with a RMS detector and then calculated to the correct field strength shown in the spreadsheets under section 6.2.3. *Results*.

6.2.3 Results

Given measured values are valid for the described arrangement and operation of the EUT.

After modifications according to section 4.4 the EUT complied with the requirement of radiated emission specified in FCC 15.509 (d) and (e) in the frequency range 960 – 10 000 MHz.

Maximum emissions measured with a RMS detector

Frequency (MHz)	Raw value (dBµV)	Cable loss (dB)	Antenna factor	Distance factor	Limit (dBµV/m)	Result (dBµV/m)	Margin (dB)	Notes
970	45.76	-34.75	24.26	9.5	29.9	25.8	4.1	PASS
1083	46.04	-34.16	24.00	9.5	29.9	26.4	3.5	PASS
1191	43.67	-33.64	24.00	9.5	29.9	24.5	5.4	PASS
1290	43.56	-33.20	24.70	9.5	29.9	25.6	4.3	PASS
1416	43.04	-32.69	24.70	9.5	29.9	25.5	4.4	PASS
1620	37.74	-31.96	25.40	9.5	41.9	21.7	20.2	PASS
1720	35.25	-31.63	25.40	9.5	41.9	19.5	22.4	PASS
1800	35.73	-31.38	26.60	9.5	41.9	21.5	20.4	PASS
1956	35.20	-30.92	26.60	9.5	41.9	21.4	20.5	PASS

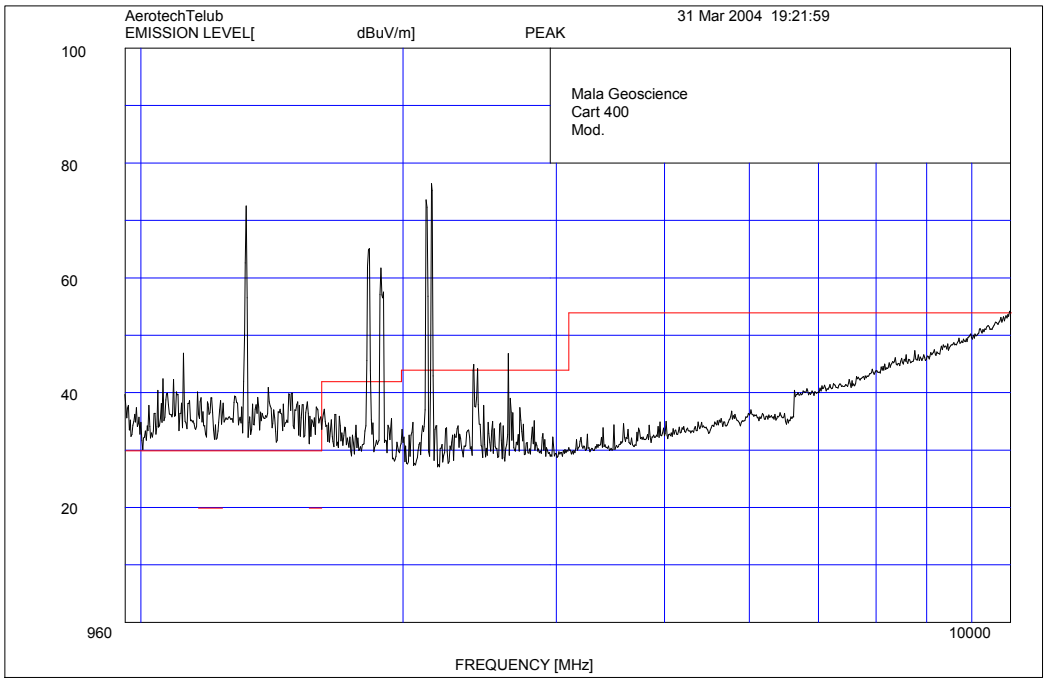
In the spreadsheets “cable/amp” denotes the total correction for cable loss and preamplifier gain. Negative value means amplification.

Maximum emission in GPS band 1164 – 1240 MHz and 1559-1610 MHz, measured with RMS detector

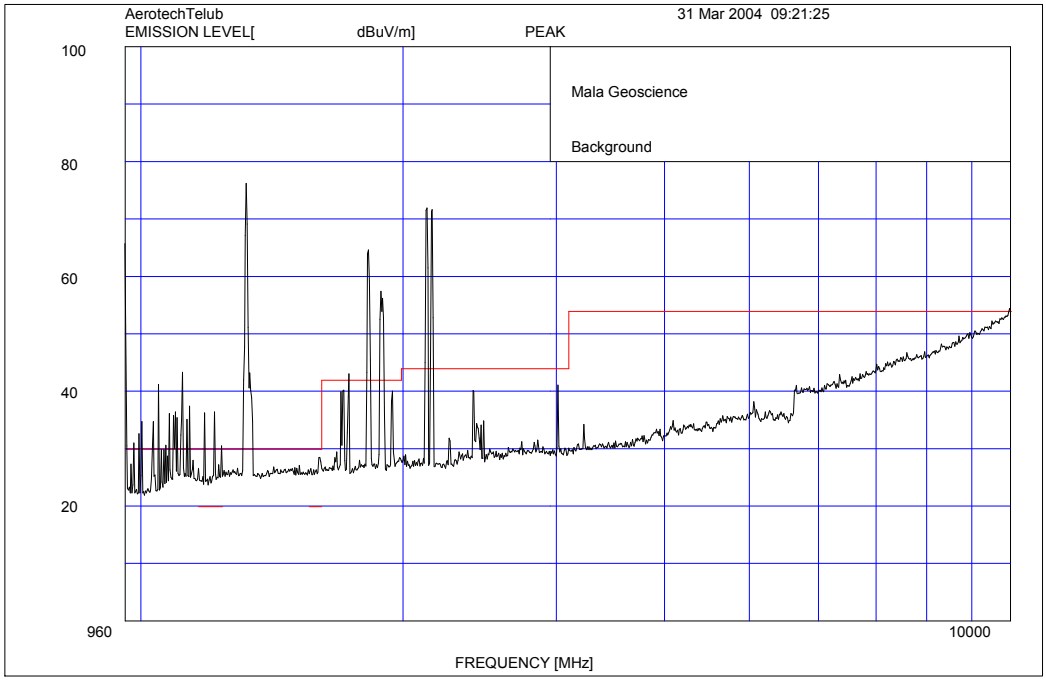
Frequency (MHz)	Raw value (dBµV)	Cable loss (dB)	Antenna factor	Distance factor	Limit (dBµV/m)	Result (dBµV/m)	Margin (dB)	Notes
1164	14.42	-33.77	24	9.5	19.9	-4.8	24.7	PASS
1184	16.75	-33.67	24	9.5	19.9	-2.4	22.3	PASS
1200	16.49	-33.60	24	9.5	19.9	-2.6	22.5	PASS
1240	13.45	-33.42	24	9.5	19.9	-5.5	25.4	PASS
1559	13.50	-32.17	25.4	9.5	19.9	-2.8	22.7	PASS
1580	11.83	-32.09	25.4	9.5	19.9	-4.4	24.3	PASS
1590	9.63	-32.06	25.4	9.5	19.9	-6.5	26.4	PASS
1610	7.24	-31.99	25.4	9.5	19.9	-8.8	28.7	PASS

In the spreadsheets “cable/amp” denotes the total correction for cable loss and preamplifier gain. Negative value means amplification.

Composite trace of peak emissions



Composite trace of background peak emissions



6.2.4 Instrumentation

Hewlett Packard Spectrum analyser	8566B	100 Hz - 22 GHz	2404A08864 / 2504A01320
Hewlett Packard Pre-amplifier	8449B	1 GHz - 26.5 GHz	3008A00103
Rohde & Schwartz Spectrum analyser	FSP40	9 kHz - 40 GHz	100011
Emco Double Ridge Waveguide	3115	0.96 GHz - 18 GHz	2800

6.3 Measurement of UWB bandwidth and peak emissions

6.3.1 Requirements according to FCC 15

6.3.1.1 Definition according to FCC 15.503 (a)

The UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission. as based on the complete transmission system including antenna.

6.3.1.2 Requirements according to FCC 15.509 (a)

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

6.3.1.3 Requirements according to FCC 15.509 (f)

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. That 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 Section 15.521.

6.3.2 Procedures

The equipment was placed on the test site described under section 5 and the radiated emission was measured at 3 meters or 1 meter.

The measurements were made with the EUT in 8 different positions on the sand bed and the antenna position was changed as well as its polarization resulting in 16 different sweeps of the frequency range.

A 1 MHz resolution bandwidth was used during the measurement.

Measurement software added antenna factors and cable attenuation and a composite trace of the peak field strength were drawn.

At the peak of emission (f_M), the emission was measured with a resolution bandwidth of 1 MHz.

6.3.3 Results

Given measured values are valid for the described arrangement and operation of the EUT.

The EUT complies with the requirement in FCC 15.509 (a) and (f).

According to 15.509 (a)

Data regarding UWB transmissions was gathered and calculated from the diagrams below:

Frequency of highest emission f_M: 113 MHz

Upper boundary f_H: 593 MHz

Lower boundary f_L: 35 MHz

Centre frequency f_C: 314 MHz

Fractional bandwidth: 1.78

According to 15.509 (f)

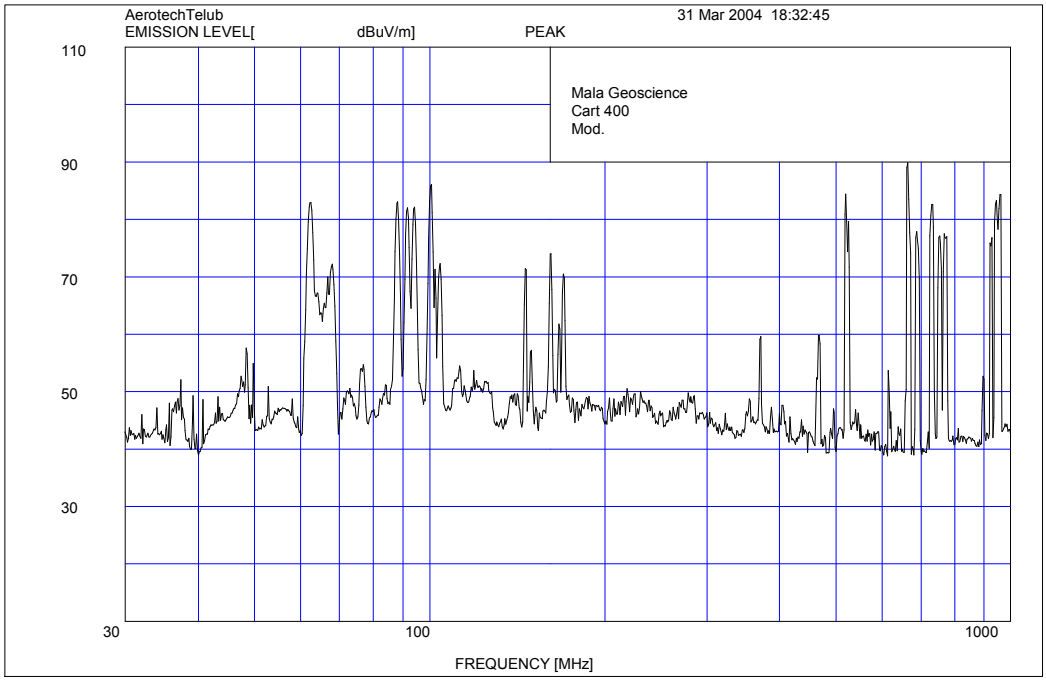
Valid as a limit only when f_M is above 960 MHz.

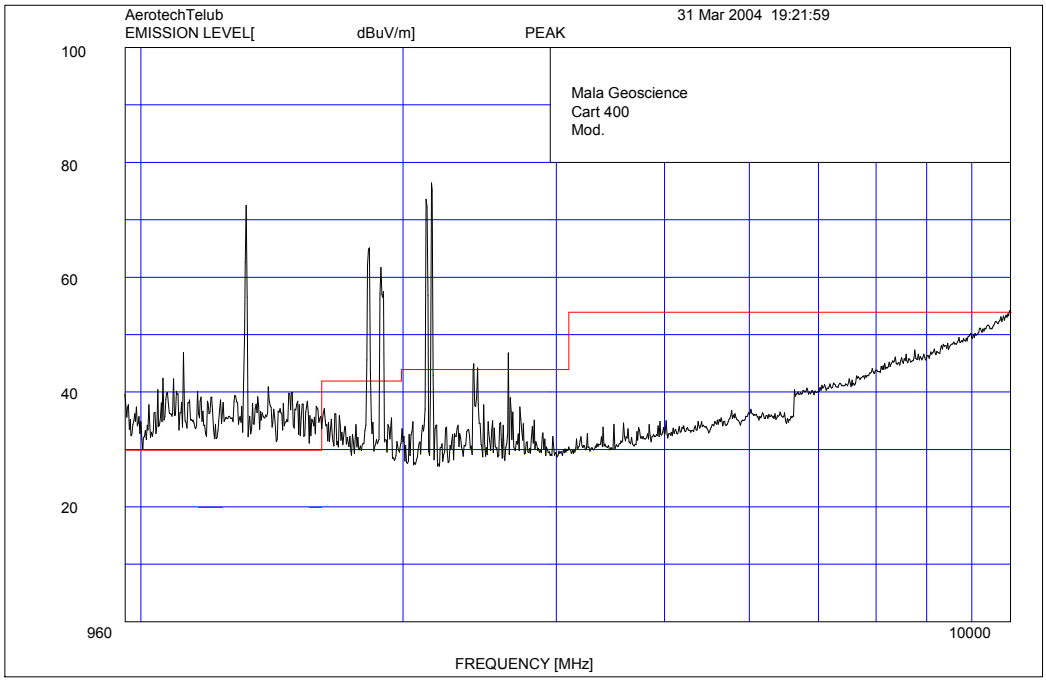
Emission at f_M: Radiated emission 54 dBµV/m at a 1 MHz RBw.

Limit 0 dBm EIRP at 50 MHz RBw
Limit -34 dBm EIRP at 1 MHz RBw
Limit -34 dBm EIRP = 61.2 dBµV/m

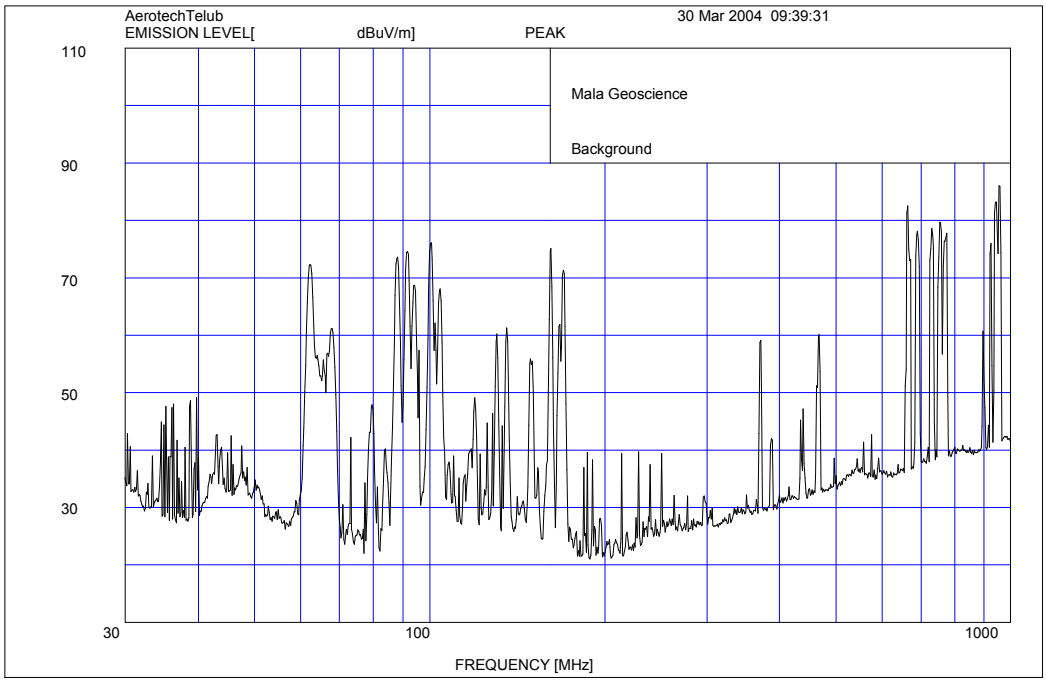
Margin to limit 61.2 – 54 = 7.2 dB

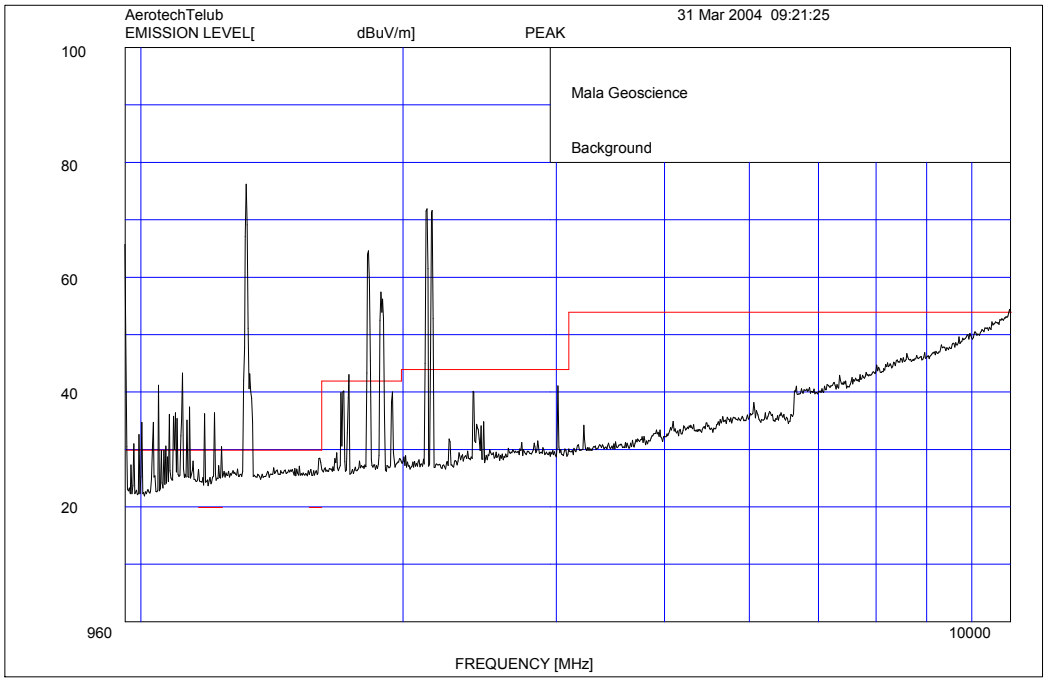
Composite trace of peak emission





Composite trace of background emission





6.3.4 Instrumentation

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Hewlett Packard Pre-amplifier	8449B	1 GHz - 26.5 GHz	3008A00103
Rohde & Schwartz Spectrum analyser	FSIQ26	9 kHz - 26 GHz	100012
Emco Double Ridge Waveguide	3115	0.96 GHz - 18 GHz	2800
Chase Bilog antenna	CBL6111A	30 - 1000 MHz	1831