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Malå Geoscience AB
Bernth Johansson
Skolgatan 11
93070 Malå, SWEDEN
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Test Report

Date
26 February, 2004

Prepared
FBM, Henrik Olsson
EMC Test Engineer

Ref. No

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Supersedes

Page

1 (22)

Title

EMC Test, 100 MHz Shielded antenna

Equipment under test (EUT):

Description: Ground Penetrating Radar System
Manufacturer: Malå Geoscience
Model name: 100 MHz Shielded antenna

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
Laboratory Technical Manager

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1 Introduction

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

Date of test: 3 – 4 February 2004

Location: AerotechTelub AB, Östersund

Test performed by: Henrik Olsson, AerotechTelub / FBM

Client: Malå Geoscience
Skolgatan 11
SE-93070 Malå
Sweden

Client's observer: Lars Mikaelsson, Malå Geoscience

2 Test methods and results

2.1 Results

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

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		3
UWB definition		FCC 15.503 (a) 15.509(a)	PASS	f _L 61 MHz f _C 165 MHz f _H 268 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		1
Radiated emission	FCC 02-42	FCC 15.509 (e)	PASS		2

3 Applicable documents

Measurements		
ANSI C63.4	1992-07-17	Radio noise emissions from low-voltage electrical and electronic equipment in the range of 9 kHz to 40 GHz.
FCC Part 15	2003-03-13	Radio Frequency Devices
FCC 02-42	2002-04-22	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

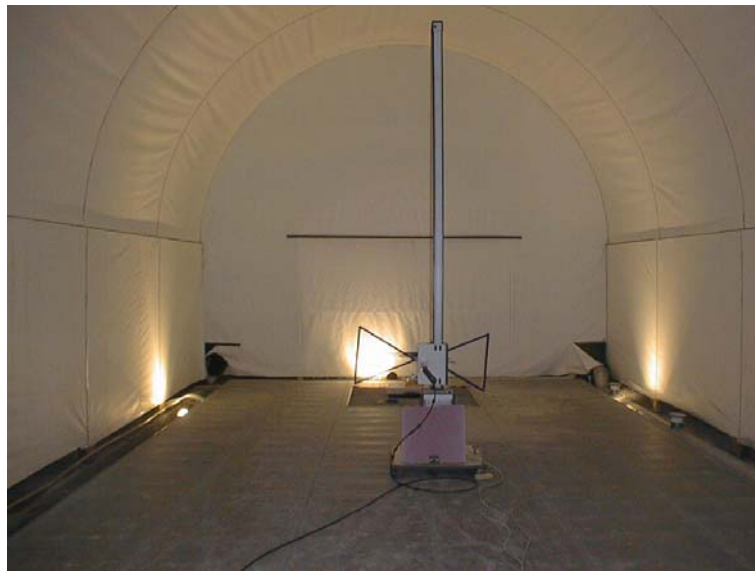
Equipment under test (EUT):

Description:	Ground Penetrating Radar System.
Manufacturer:	Malå Geoscience
Model name:	100 MHz Shielded antenna.
Build state:	Production sample
Serial no:	6741

4.2 Test site

4.2.1 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 1: 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.

4.2.2 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.

4.3 General configuration of EUT

A battery powered the EUT.

The EUT was connected to the control unit with a fibre optical cable.

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



Picture 2: EUT set-up on sand bed

4.4 Operation of EUT during tests

The EUT was gathering data like in normal operation.

5 Emission

5.1 Measurement of radiated emission, ANSI C63.4

5.1.1 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 dB μ V/m
88 – 216 MHz	43.5 dB μ V/m
216 – 960 MHz	46 dB μ V/m

5.1.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) with 3 meters measuring distance described in 4.2.1.

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.

5.1.3 Deviations from the standard

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

5.1.4 Climatic conditions

	Requirement according to standard	Climatic conditions during the test
Temperature	-	5 – 10 °C
Relative humidity	-	Not measured

5.1.5 Results

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

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

QP measurement 30-960 MHz

Measurement antenna: Chase Bilog CBL6111A s/n 1831

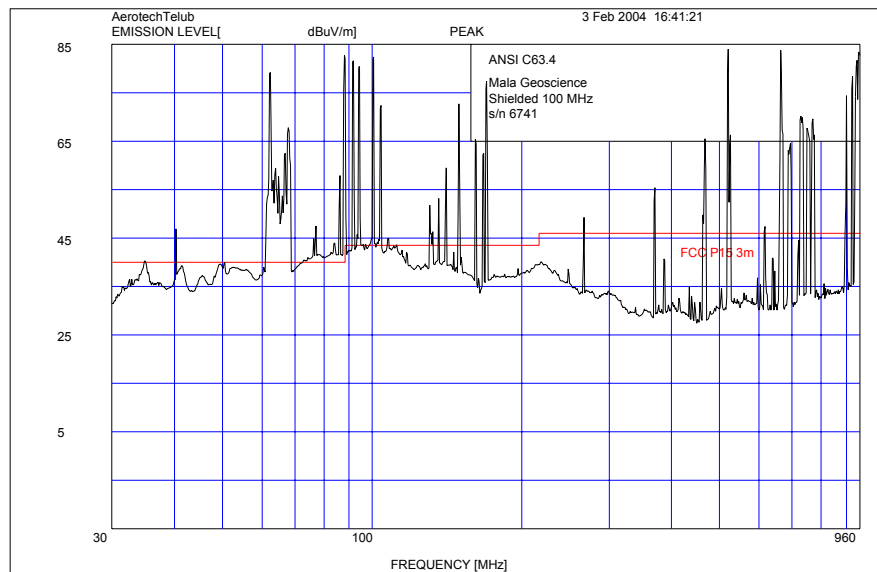
EUT: Shielded 100 MHz

s/n : 6741

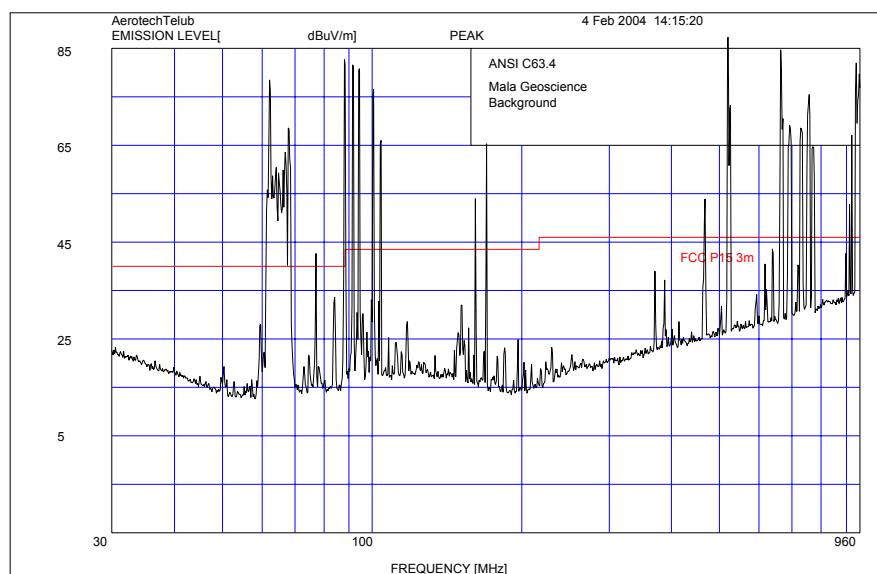
Measurement setup: RBW 120 kHz, VBW 1 MHz, QP detector

<u>Frequency</u>	<u>Raw value</u>	<u>Cable loss</u>	<u>Antenna factor</u>	<u>Limit</u>	<u>Result</u>	<u>Margin</u>	<u>Notes</u>
MHz	dB μ V	dB	dB	dB μ V/m	dB μ V/m	dB	
35	18,72	0,78	15,5	40	35	5	PASS
41	22,89	0,81	12,9	40	36,6	3,4	PASS
42	23,29	0,81	12,9	40	37	3	PASS
50	29,29	0,91	7,8	40	38	2	PASS
53	29,79	0,91	7,8	40	38,5	1,5	PASS
76	31,2	1,2	6,2	40	38,6	1,4	PASS
97	31,9	1,4	9,2	43,5	42,5	1	PASS

Emission measured with peak detector



Background emission measured with peak detector



5.1.6 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

5.2 Measurement of radiated emission

5.2.1 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 dB μ V/m
1610 – 1990 MHz	-53.3 dBm EIRP	41.9 dB μ V/m
1990 – 3100 MHz	-51.3 dBm EIRP	43.9 dB μ V/m
3100 – 10600 MHz	-41.3 dBm EIRP	53.9 dB μ V/m
> 10600 MHz	-51.3 dBm EIRP	43.9 dB μ V/m

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

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

5.2.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) as described in 4.2.1 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 measurement

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 manually measured and then calculated to the correct field strength shown in the spreadsheets under 5.2.3. Results.

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

5.2.3 Results

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

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

RMS measurement 960 - 10000 MHz

Measurement antenna: EMCO 3115 s/n 2796

EUT: Shielded 100 MHz

s/n : 6741

Measurement setup: RBW 1 MHz, VBW 3 MHz, RMS detector

<u>Frequency</u>	<u>Raw value</u>	<u>Cable/amp</u>	<u>Antenna factor</u>	<u>Distance factor</u>	<u>Limit</u>	<u>Result</u>	<u>Margin</u>	<u>Notes</u>
MHz	dBμV	dB	dB	dB	dBμV/m	dBμV/m	dB	
960	43,6	-34,70	24,27	9,5	29,9	23,67	6,23	PASS
970	39,5	-35,30	24,26	9,5	29,9	18,96	10,94	PASS
985	38,6	-35,30	24,27	9,5	29,9	18,07	11,83	PASS
1000	38	-35,10	24,00	9,5	29,9	17,40	12,50	PASS
1084	38	-35,10	24,00	9,5	29,9	17,40	12,50	PASS
1090	38,2	-35,10	24,00	9,5	29,9	17,60	12,30	PASS
1113	38,6	-35,10	24,00	9,5	29,9	18,00	11,90	PASS
1177	37,6	-35,10	24,00	9,5	29,9	17,00	12,90	PASS
1200	37,3	-35,10	24,00	9,5	29,9	16,70	13,20	PASS
1236	37,7	-35,10	24,00	9,5	29,9	17,10	12,80	PASS
2000	35,5	-31,00	27,80	9,5	43,9	22,80	21,10	PASS

In the spreadsheet above, "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

RMS measurement 1164-1240, 1559-1610 MHz

Measurement antenna: EMCO 3115 s/n 2796

EUT: Shielded 100 MHz

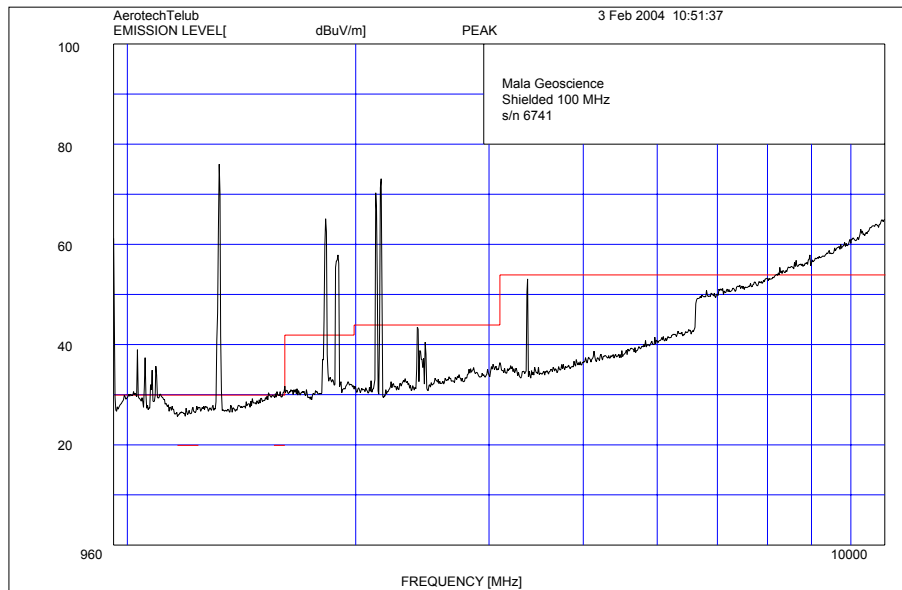
s/n : 6741

Measurement setup: RBW 1 kHz, VBW 1 kHz, RMS detector

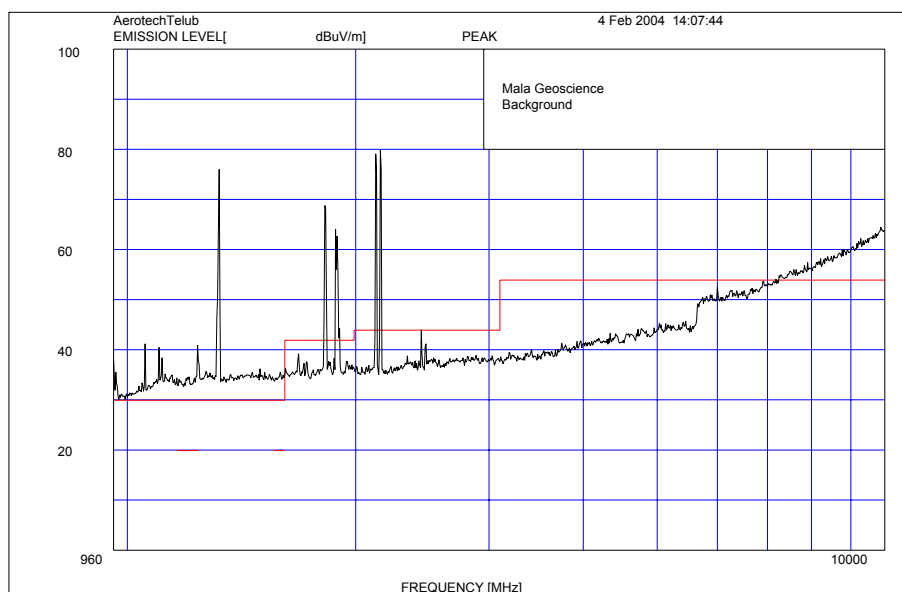
<u>Frequency</u>	<u>Raw value</u>	<u>Cable/amp</u>	<u>Antenna factor</u>	<u>Distance factor</u>	<u>Limit</u>	<u>Result</u>	<u>Margin</u>	<u>Notes</u>
MHz	dBμV	dB	dB	dB	dBμV/m	dBμV/m	dB	
1164	9,3	-35,1	24	9,5	19,9	-11,3	31,2	PASS
1180	7	-35,1	24	9,5	19,9	-13,6	33,5	PASS
1190	8	-35,1	24	9,5	19,9	-12,6	32,5	PASS
1200	8	-35,1	24	9,5	19,9	-12,6	32,5	PASS
1210	8,5	-35,1	24	9,5	19,9	-12,1	32	PASS
1240	8,5	-35,1	24	9,5	19,9	-12,1	32	PASS
1559	6,5	-33,6	25,4	9,5	19,9	-11,2	31,1	PASS
1570	7	-33,6	25,4	9,5	19,9	-10,7	30,6	PASS
1580	8,9	-33,6	25,4	9,5	19,9	-8,8	28,7	PASS
1590	6,5	-33,6	25,4	9,5	19,9	-11,2	31,1	PASS
1600	6,5	-33,6	25,4	9,5	19,9	-11,2	31,1	PASS
1610	8,5	-33,6	25,4	9,5	19,9	-9,2	29,1	PASS

In the spreadsheet above, “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



5.2.4 Measurement uncertainty

For the test site used no calculations exists.

5.2.5 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

5.3 Measurement of UWB bandwidth and peak emissions

5.3.1 Requirements according to FCC 15

5.3.1.1 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.

5.3.1.2 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.

5.3.1.3 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.

5.3.2 Procedures

The equipment was placed on the test site described under paragraph 4.2.1 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.

5.3.3 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)

From the diagram 30-1000 MHz below the following data was gathered and calculated:

Frequency of highest emission f_M : 100 MHz

Upper boundary f_H : 268 MHz

Lower boundary f_L : 61 MHz

Centre frequency f_C : 165 MHz

Fractional bandwidth: 1,26

According to 15.509 (f)

Emission at f_M : Radiated emission 60 dB μ V/m at a 1 MHz RBw.

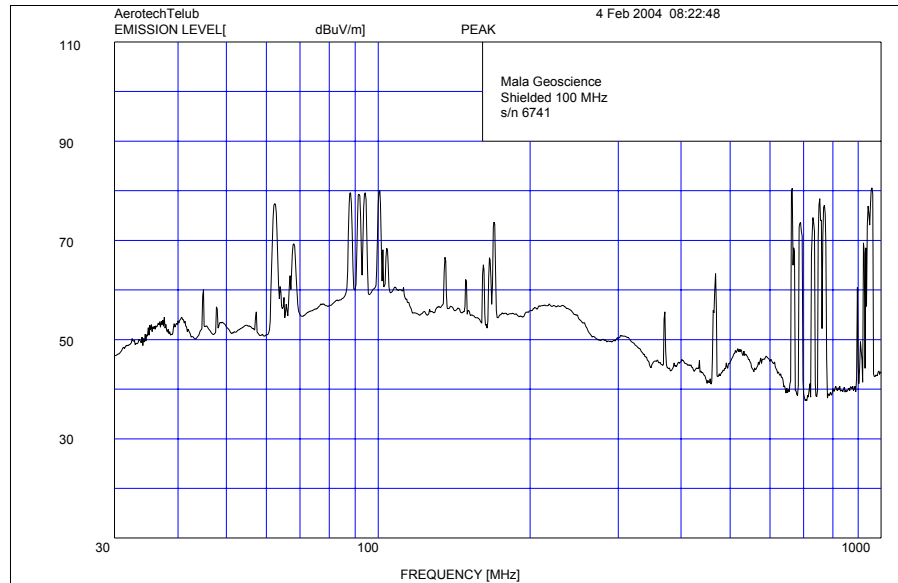
Limit 0 dBm EIRP at 50 MHz RBw

Limit -34 dBm EIRP at 1 MHz RBw

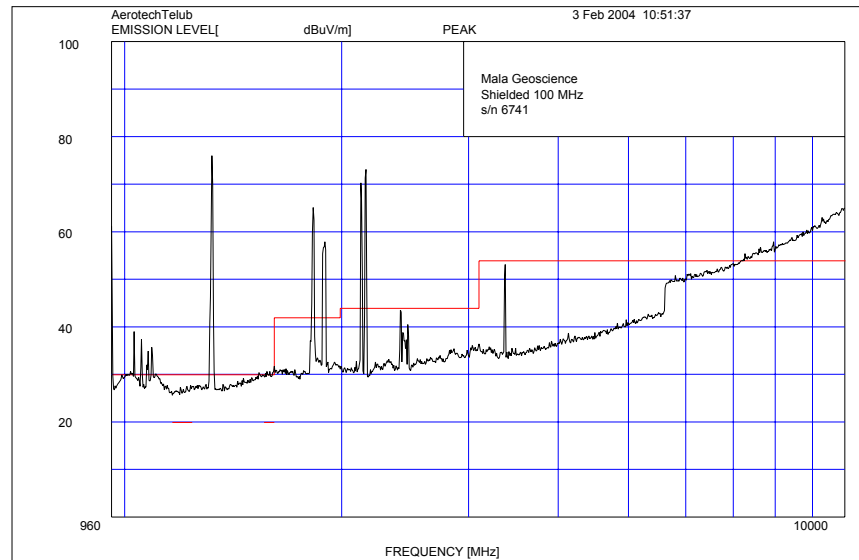
Limit -34 dBm EIRP = 61,2 dB μ V/m

Margin to limit 61,2 – 60 = 1,2 dB

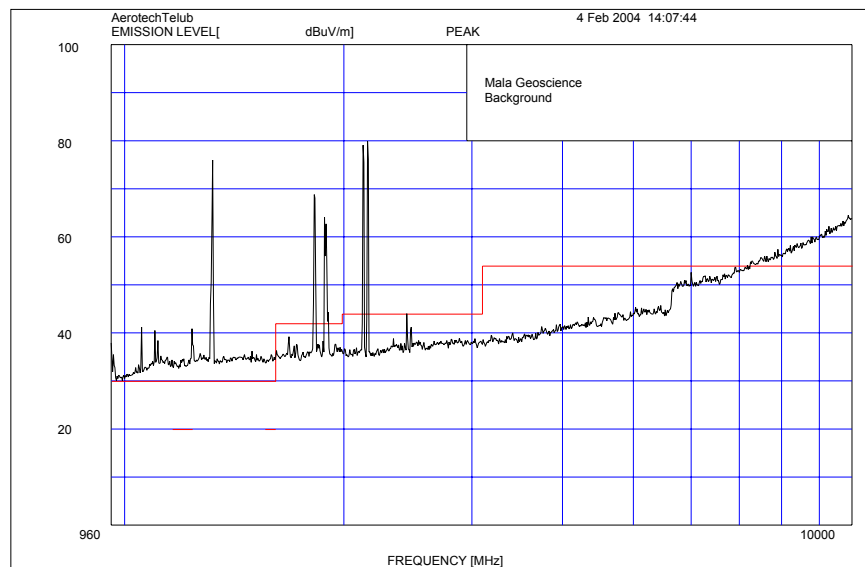
Composite trace of peak emission



Composite trace of maximum emission



Composite trace of background emission



5.3.4 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
Chase Bilog antenna	CBL6111A	30 - 1000 MHz	1164