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Test Report

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Prepared
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EMC Test Engineer

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Supersedes

Page

1 (24)

Title

EMC Test, 1 GHz Shielded antenna - modified

Equipment under test (EUT):

Description: Ground Penetrating Radar System
Manufacturer: Malå Geoscience
Model name: 1 GHz Shielded antenna

Summary:

With modifications described in 4.5 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:	24 – 27 March 2003 15 – 26 August 2003
Location:	AerotechTelub AB, Östersund
Test performed by:	Henrik Olsson, AerotechTelub / FBM
Client:	Malå Geoscience Skolgatan 11 SE-93070 Malå Sweden
Client's observers:	Kenneth Jakobsson, Malå Geoscience Bernth Johansson, 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 227 MHz f _C 977 MHz f _H 1728 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

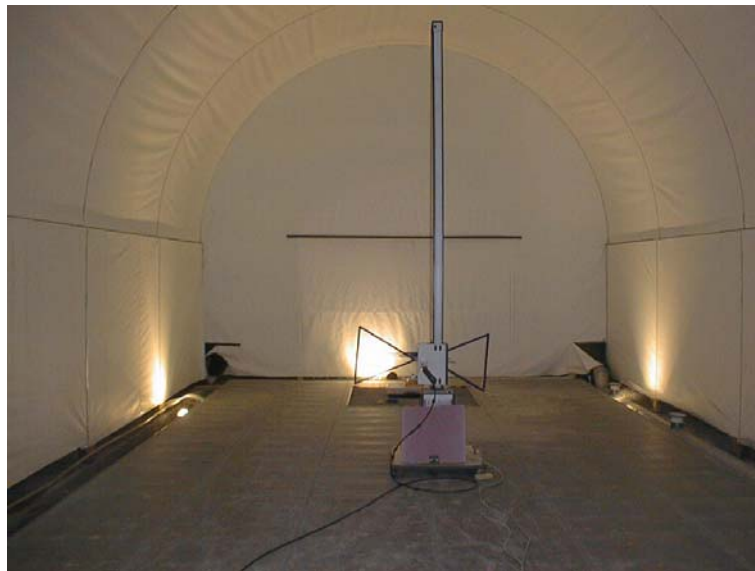
Equipment under test (EUT):

Description:	Ground Penetrating Radar System.
Manufacturer:	Malå Geoscience
Model name:	1 GHz Shielded antenna.
Build state:	Production sample
Serial no:	4771

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.

4.5 Modifications

The results under section 2 *Test methods and results* are only valid with the following modifications on the EUT:

- $R1 = 22 \, \Omega$
- $RA1 = 82 \, \Omega$

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 1827

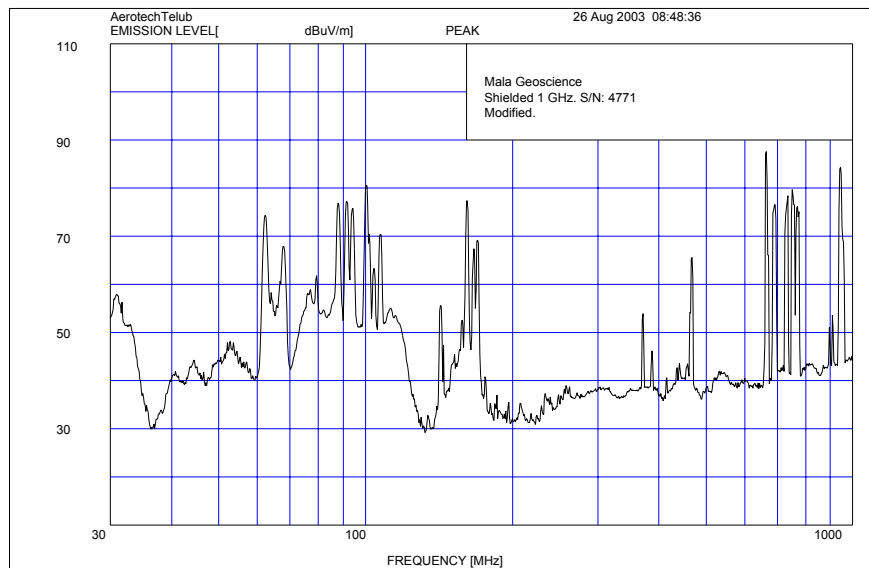
EUT: Shielded 1 GHz, modified

s/n : 4771

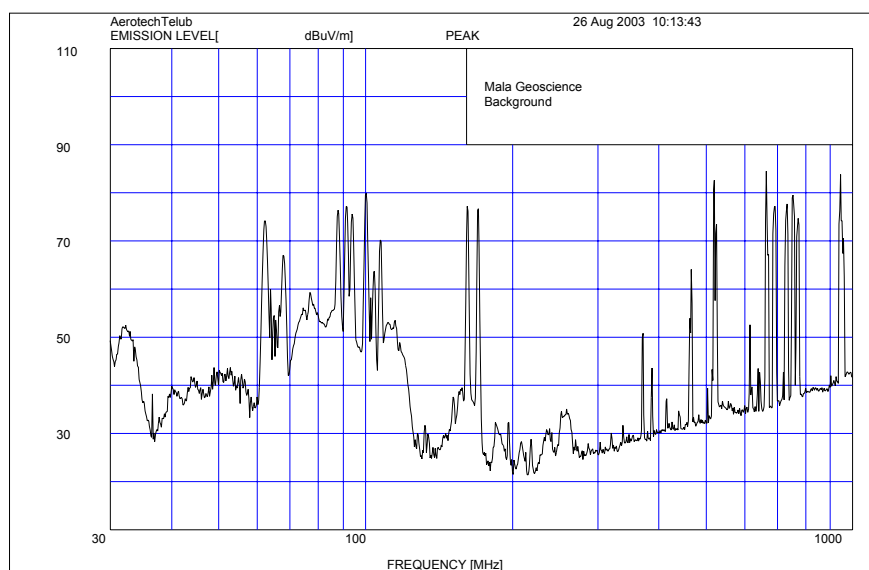
Measurement setup: RBW 120 kHz, VBW 1 MHz, QP detector

<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	dBμV	dB	dB	dBμV/m	dBμV/m	dB	
30	14,1	0,7	18	40	32,8	7,2	PASS
32	13,8	0,7	18	40	32,5	7,5	PASS
34	16,1	0,7	18	40	34,8	5,2	PASS
50	16,8	0,91	7,8	40	25,51	14,49	PASS
75	15,5	1,2	6,2	40	22,9	17,1	PASS
87	17	1,3	7,7	40	26	14	PASS
97	18,8	1,4	9,2	43,5	29,4	14,1	PASS
120	17,4	1,6	11,3	43,5	30,3	13,2	PASS
145	18,9	1,7	10,9	43,5	31,5	12	PASS
216	17,8	2	8,6	43,5	28,4	15,1	PASS
300	17,7	2,6	13,1	46	33,4	12,6	PASS
400	15,9	3,1	16,1	46	35,1	10,9	PASS
500	16,6	3,4	17,9	46	37,9	8,1	PASS
600	8,8	3,8	19,8	46	32,4	13,6	PASS
700	8,3	4,2	21,2	46	33,7	12,3	PASS
800	10	4,5	22,6	46	37,1	8,9	PASS
960	9,7	5	25	46	39,7	6,3	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		2430A00465
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.

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 1 GHz, modified

s/n : 4771

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

<u>Frequency</u>	<u>Raw value</u>	<u>Cable loss</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	49,2	-35,30	24,27	9,5	29,9	28,67	1,23	PASS
970	49,5	-35,30	24,26	9,5	29,9	28,96	0,94	PASS
985	49,8	-35,30	24,27	9,5	29,9	29,27	0,63	PASS
1000	47,8	-35,10	24,00	9,5	29,9	27,20	2,70	PASS
1084	49,3	-35,10	24,00	9,5	29,9	28,70	1,20	PASS
1090	47,3	-35,10	24,00	9,5	29,9	26,70	3,20	PASS
1100	47,5	-35,10	24,00	9,5	29,9	26,90	3,00	PASS
1177	42,2	-35,10	24,00	9,5	29,9	21,60	8,30	PASS
1194	46,3	-35,10	24,00	9,5	29,9	25,70	4,20	PASS
1258	47,4	-34,30	24,70	9,5	29,9	28,30	1,60	PASS
1500	40	-33,60	25,40	9,5	29,9	22,30	7,60	PASS
1610	42,6	-33,60	25,40	9,5	29,9	24,90	5,00	PASS
1700	37,2	-33,60	25,40	9,5	41,9	19,50	22,40	PASS
1990	36,1	-32,70	26,60	9,5	41,9	20,50	21,40	PASS
2000	34,6	-32,20	27,80	9,5	43,9	20,70	23,20	PASS
2338	35,7	-31,40	28,40	9,5	43,9	23,20	20,70	PASS
3000	36,7	-29,60	30,60	9,5	43,9	28,20	15,70	PASS

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

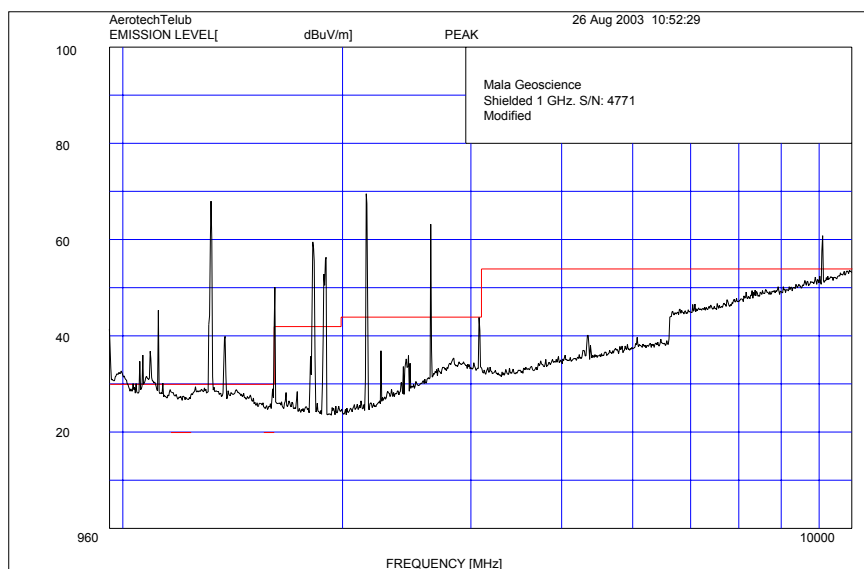
EUT: Shielded 1 GHz, modified

s/n : 4771

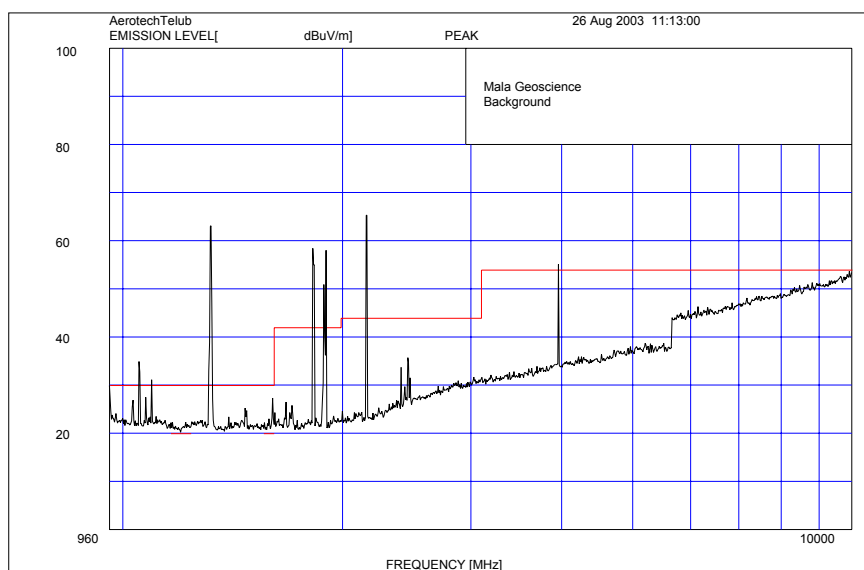
Measurement setup: RBW 1 kHz, VBW 1 kHz, RMS detector

<u>Frequency</u>	<u>Raw value</u>	<u>Cable loss</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	22,6	-35,1	24	9,5	19,9	2	17,9	PASS
1180	22,5	-35,1	24	9,5	19,9	1,9	18	PASS
1190	21,5	-35,1	24	9,5	19,9	0,9	19	PASS
1200	21,6	-35,1	24	9,5	19,9	1	18,9	PASS
1210	20,4	-35,1	24	9,5	19,9	-0,2	20,1	PASS
1240	22,2	-35,1	24	9,5	19,9	1,6	18,3	PASS
1559	16,7	-33,6	25,4	9,5	19,9	-1	20,9	PASS
1570	15,1	-33,6	25,4	9,5	19,9	-2,6	22,5	PASS
1580	16,4	-33,6	25,4	9,5	19,9	-1,3	21,2	PASS
1590	15,7	-33,6	25,4	9,5	19,9	-2	21,9	PASS
1600	16,1	-33,6	25,4	9,5	19,9	-1,6	21,5	PASS
1610	15,9	-33,6	25,4	9,5	19,9	-1,8	21,7	PASS

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 32 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 30-960 MHz below the following data was gathered and calculated.

Frequency of highest emission f_M : 1000 MHz

Upper boundary f_H : 1728 MHz

Lower boundary f_L : 227 MHz

Centre frequency f_C : 977 MHz

Fractional bandwidth: 1,54

According to 15.509 (f)

Emission at f_M : Radiated emission 45 dB μ V/m at a 1 MHz RBw.

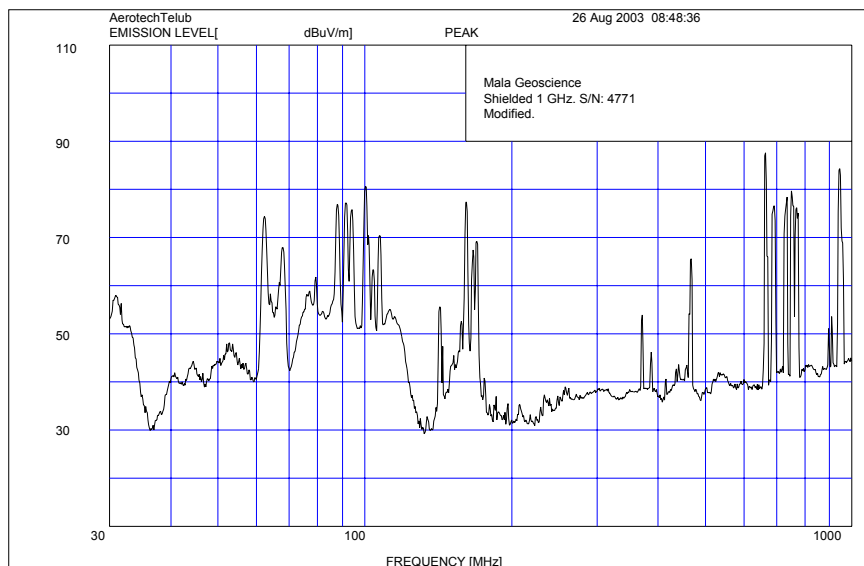
Limit 0 dBm EIRP at 50 MHz RBw

Limit -34 dBm EIRP at 1 MHz RBw

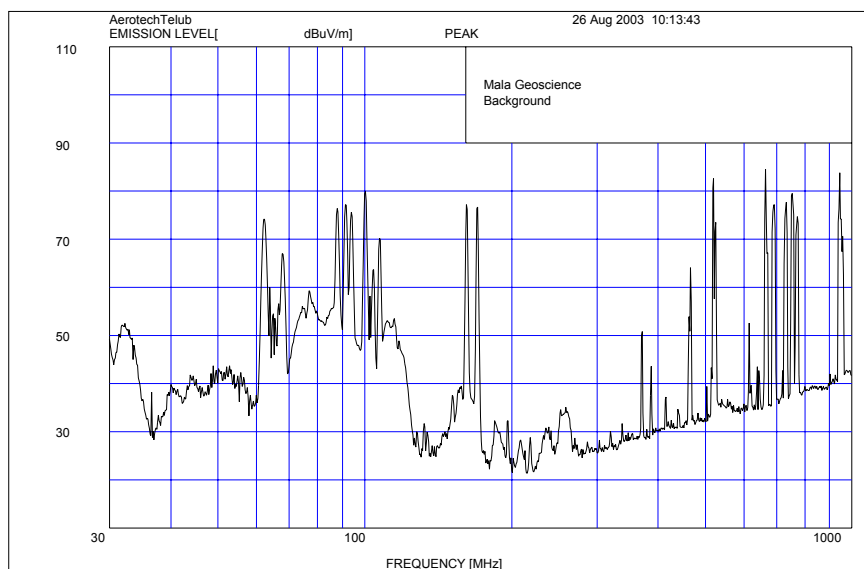
Limit -34 dBm EIRP = 61,2 dB μ V/m

Margin to limit 61,2 – 45 = 16,2 dB

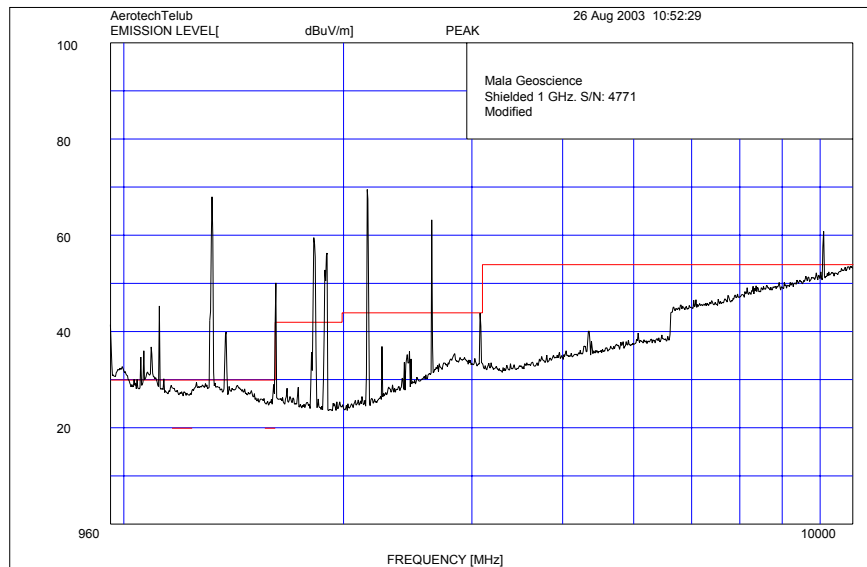
Composite trace of peak emission



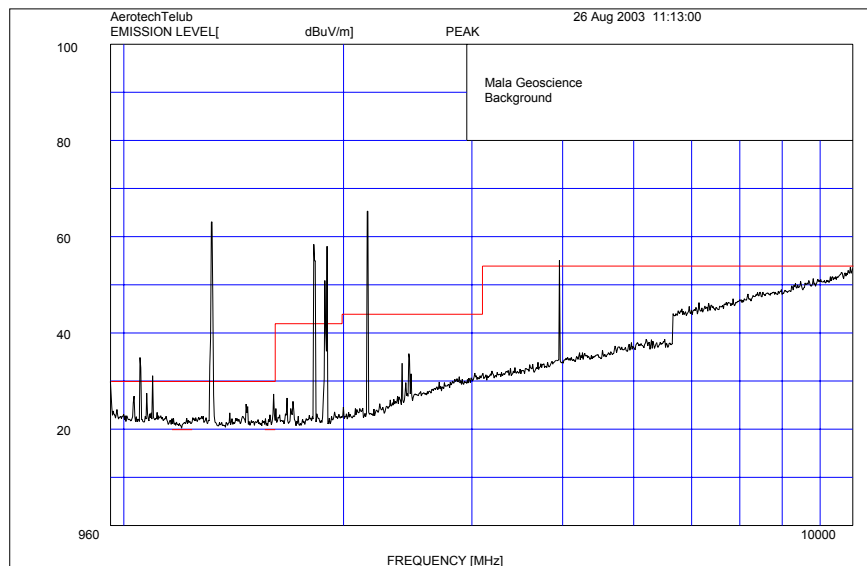
Composite trace of background emission



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