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Title

**EMC Test, 500 MHz Shielded antenna**

Document

**Test Report**

Date

December 18, 2002

Prepared

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*EMC Test Engineer*

Ref. No

E014-TR 020223

Supersedes

Page

1 (18)

**Equipment under test (EUT):**

Description: Ground Penetrating Radar System

Manufacturer: Malå Geoscience

Model name: 500 MHz 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 – 5000 MHz.

**Approved:**

Per Larsson

*Ass. 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: December 10-11, 2002

Location: AerotechTelub AB, Östersund

Test performed by: Petter Gärdin, AerotechTelub / FBM

Client: Malå Geoscience  
Skolgatan 11  
SE-93070 Malå  
Sweden

Client's observers: Lars Lundmark, Malå Geoscience

## 2 Test methods and results

### 2.1 Results

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

<b>EMISSION REQUIREMENTS ACCORDING TO FCC Part 15 Subpart F</b>					
Environmental phenomena	Test method	Requirement	Result	Comments	Test order
Radiated emission	ANSI C63.4	FCC 15.209	<b>PASS</b>		3
UWB definition		FCC 15.503 (a) 15.509(a)	<b>PASS</b>	$f_L$ 195 $f_C$ 340 $f_H$ 486	1
Peak emission at $f_M$	FCC 02-42	FCC 15.509 (f)	<b>PASS</b>		2
Radiated emission	FCC 02-42	FCC 15.509 (d)	<b>PASS</b>		4
Radiated emission	FCC 02-42	FCC 15.509 (e)	<b>PASS</b>		5

### 3 Applicable documents

<b>Measurements</b>		
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	2002-07-22	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: 500 MHz Shielded antenna.

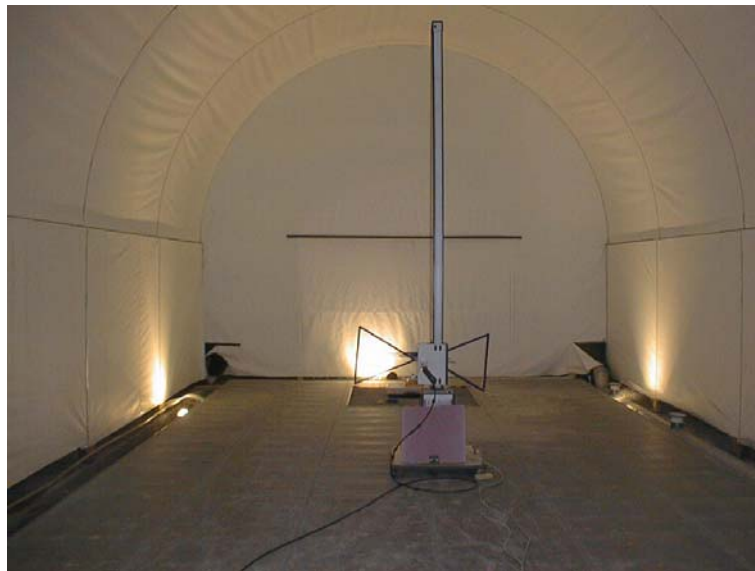
Build state: Production sample

Serial no: 6386

### 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, 937 – 945 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 with the control unit with a fiber optical cable.

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



*Picture 2: EUT setup 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 method and result* are only valid with the following modifications on the EUT:

- The antenna was loaded with an extra SMD resistor  $36 \Omega$  between the feeding terminals to the antenna flares and a SMD capacitor  $5.6 \text{ pF}$  at the output to the balun.



## 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 $\mu$ V/m
88 – 216 MHz	43.5 dB $\mu$ V/m
216 – 960 MHz	46 dB $\mu$ 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.

A measurement software added antenna factors and cable attenuation and a composite trace of the peak field strength measurements was 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

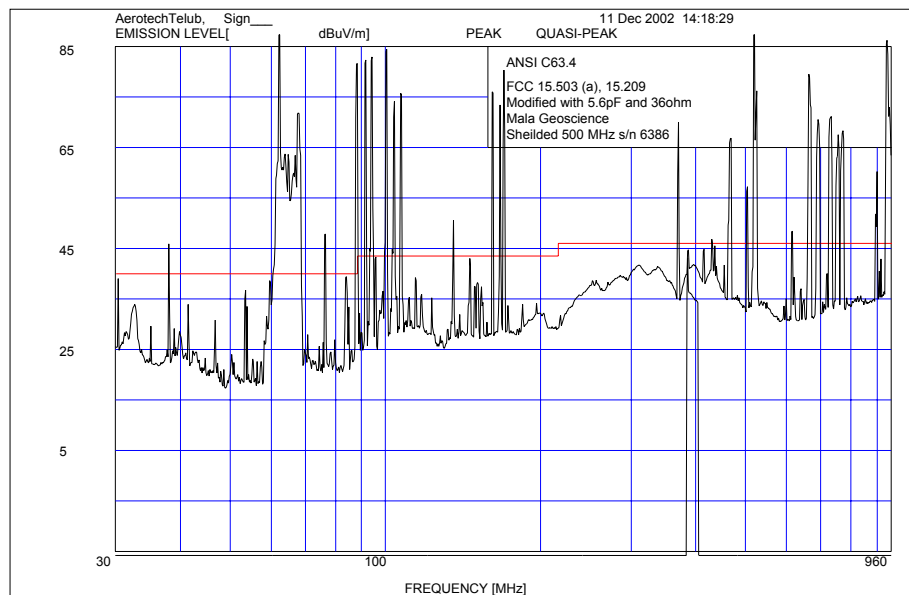
### 5.1.5 Results

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 signals above the limit line were related to the EUT.

Quasi-peak measurements were not made in the entire frequency range. In order to preserve time measurements were taken in certain ranges only. The characteristics of the signal were the same in the entire range.

Emission measured with peak detector. Quasi peak measurement at 400 MHz



## 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 $\mu$ V/m
1610 – 1990 MHz	-53.3 dBm EIRP	41.9 dB $\mu$ V/m
1990 – 10000 MHz	-51.3 dBm EIRP	43.9 dB $\mu$ V/m

Frequency range	Limit	Limit*
1164 – 1240 MHz	-75.3 dBm EIRP	19.9 dB $\mu$ V/m
1559 – 1610 MHz	-75.3 dBm EIRP	19.9 dB $\mu$ 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.

According to the provisions of FCC 15.509 (d) and (e) the emissions should be compared with an average limit measured with a RMS detector.

These measurements were made with a peak detector and remeasured with an rms detector if necessary.

The following resolution bandwidths and video bandwidths were used during the final measurement

Frequency range	RBw	VBw
960 – 5000 MHz	1 MHz	3 MHz
1164 – 1240 MHz	1 kHz	1 kHz
1559 – 1610 MHz	1 kHz	1 kHz

Because the measurements were made at 1 meters distance a correction factor (9.5 dB) have been applied to the limits.

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. A measurement software added antenna factors and cable attenuation and the resulting max field strength level was plotted.

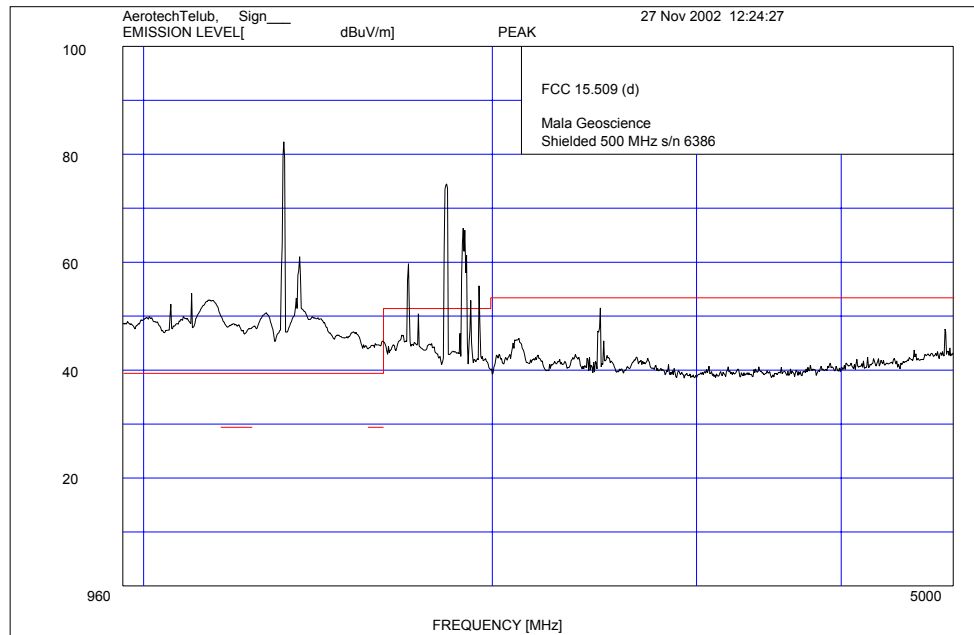
After the sweeps the max radiated field strength were controlled manually due to the high number of ambients.

The peaks in the max peak field strength were manually measured with a spectrum analyzer using a rms detector.

### **5.2.3 Results**

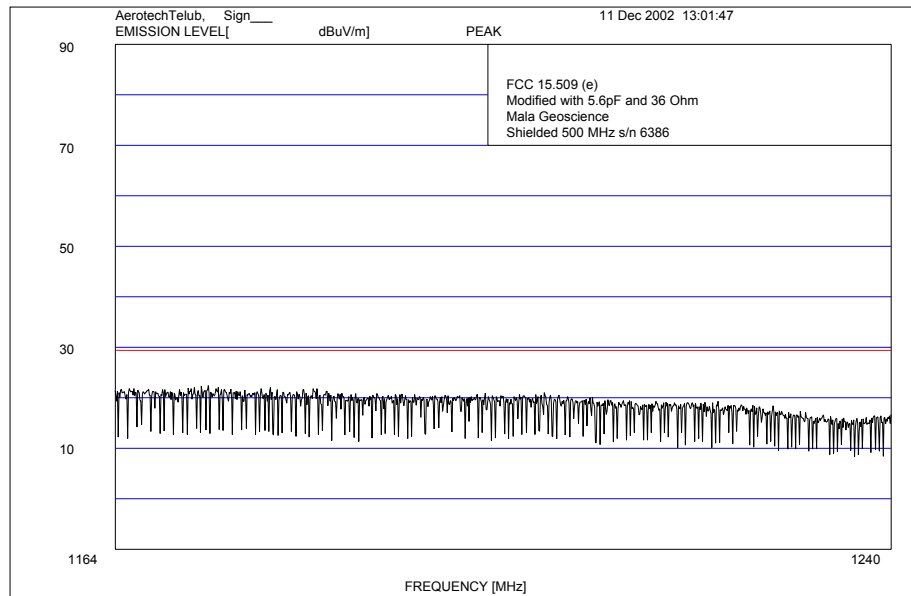
Given measured values are valid for the described arrangement and operation of the EUT.

The EUT complied with the requirement of radiated emission specified in FCC 15.509 (d) and (e) in the frequency range 960 – 5000 MHz.

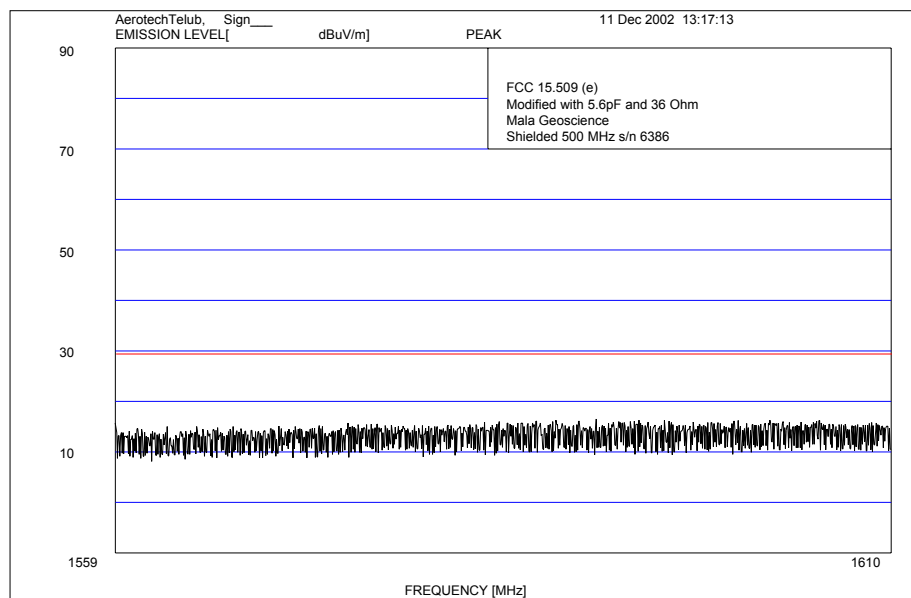
Composite trace of peak emissions

Peak emissions remeasured with a RMS detector

Frequency	dB $\mu$ V	Antenna factor	Preamp and cable	dB $\mu$ V/m	Limit	Margin
0,96	<b>37,80</b>	23,90	33,80	27,90	39,44	-11,54
1,00	<b>44,80</b>	24,00	33,70	35,10	39,44	-4,34
1,10	<b>47,80</b>	24,50	33,00	39,30	39,44	-0,14
1,26	<b>40,40</b>	24,80	32,50	32,70	39,44	-6,74
1,37	<b>45,40</b>	25,00	32,00	38,40	39,44	-1,04
1,49	<b>39,60</b>	25,40	31,50	33,50	39,44	-5,94
1,60	<b>34,50</b>	25,80	30,50	29,80	39,44	-9,64

Maximum emission in GPS band 1164 – 1240 MHz measured with peak detector



Maximum emission in GPS band 1559-1610 MHz measured with peak detector



## 5.2.4 Measurement uncertainty

For the test site used no calculations exists.

## 5.2.5 Instrumentation

Hewlett Packard Spectrum analyzer	8566B	100 Hz - 22 GHz	2404A08864 / 2504A01320
Hewlett Packard Pre-amplifier	8449B	1 GHz - 26.5 GHz	3008A00103
Rohde & Schwartz Spectrum analyzer	FSU8 1129900308-2	20 Hz - 8 GHz	100158
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 960 MHz.

#### 5.3.1.3 Requirements according to FCC 15.509 (f)

There is a limit on the peak level of emission contained within a 50 MHz bandwidth centered on  $f_M$ . That limit is 0 dBm EIRP. According to the provisions in 15.521 the limit is converted to field strength level in 3 MHz bandwidth.

### 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.

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.

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

At the peak of emission ( $f_M$ ), the emission was manually measured with a resolution bandwidth of 3 MHz and the field strength calculated with added antenna factors and cable attenuation.



### 5.3.3 Results

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

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

According to 15.509 (a)

From the diagrams below the following data was gathered and calculated.

Frequency of highest emission  $f_M$ : 330 MHz

Upper boundary  $f_H$ : 486 MHz

Lower boundary  $f_L$ : 195 MHz

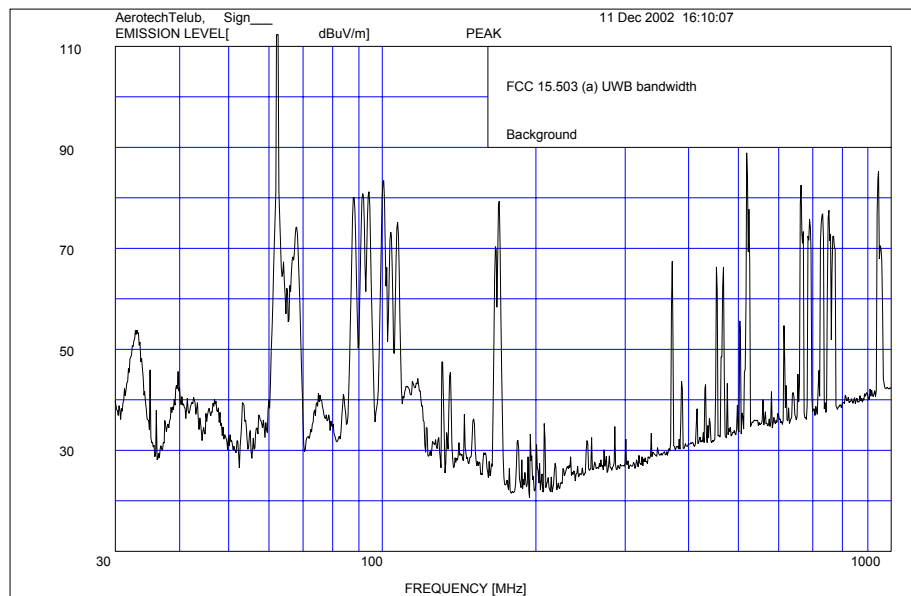
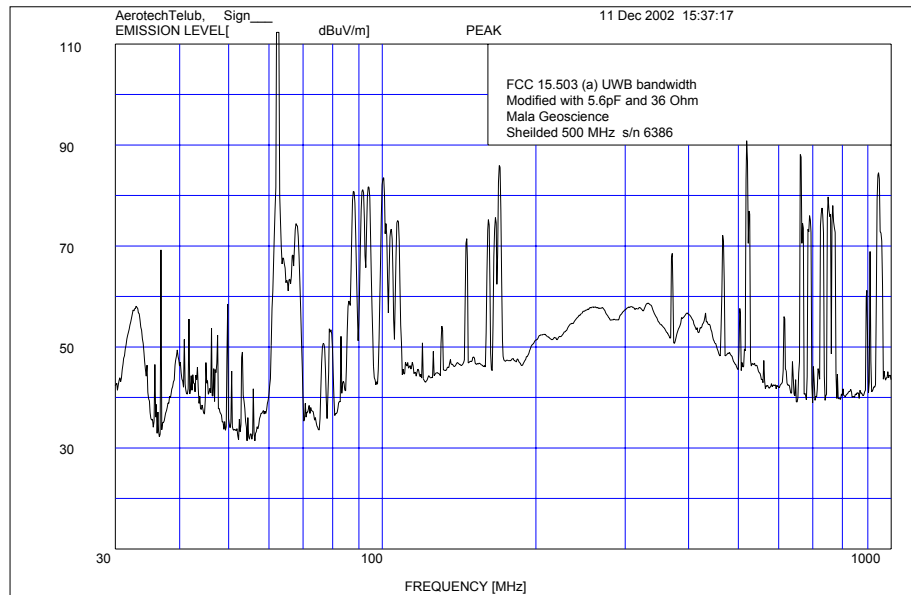
Center frequency  $f_C$ : 340 MHz

Fractional bandwidth: 0.85

According to 15.509 (f)

Emission at  $f_M$ : Radiated emission 63.5 dB $\mu$ V/m  
Limit 70.8 dB $\mu$ V/m  
Margin 7.3 dB

Frequency	dB $\mu$ V	Antenna factor	cable	dB $\mu$ V/m	Limit	Margin
330,00	<b>47,10</b>	14,00	-2,40	63,50	70,80	-7,30



### 5.3.4 Instrumentation

Hewlett Packard Spectrum analyzer	8566B	100 Hz - 22 GHz	2404A08864 / 2504A01320
Chase Bilog antenna	CBL6111A	30 - 1000 MHz	1164