

RADIOCOMMUNICATIONS TESTING DEPARTMENT

**FCC EMC COMPLIANCE MEASUREMENTS ON  
THE ERA TECHNOLOGY LTD 500 MHz  
SURFACE PENETRATING RADAR SYSTEM**

D A Legge

ERA Test Report 4252/209

|                                                                          |
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Report approved by:

P. Mallinson  
P Mallinson  
Manager  
Radiocommunications Testing Department

September 1999  
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Description of Equipment Under Test: SPRscan

Type Number: P-0500 Antenna (US Variant)

Serial Number: USPP1

Test Specification(s): 47 C.F.R part 15.209

Equipment Received: 19 August 1999

Test Date(s): 19 – 20 August 1999

|                                        |           |                                                                                      |
|----------------------------------------|-----------|--------------------------------------------------------------------------------------|
| <b>Test Engineer(s):</b>               | D A Legge |  |
| <b>Report Written by:</b>              | D A Legge |  |
| <b>Checked By Group Leader:</b>        | R Orchard |  |
| <b>Checked By Technical Executive:</b> | A McHale  |  |

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**EMC COMPLIANCE MEASUREMENTS ON THE ERA TECHNOLOGY LTD  
500 MHz SURFACE PENETRATING RADAR SYSTEM**

## **1 INTRODUCTION**

The ERA Technology Ltd “SPRscan” 500 MHz Surface Penetrating Radar (SPR) system has been tested by the Radiocommunications Testing Department of ERA Technology Ltd on behalf of the Communications and RF Sensors department of ERA Technology Ltd. The sample was tested for compliance with CFR 47 part 15.209. This report contains the results of these tests and is submitted to ERA Technology Ltd as the final result of testing.

## **2 EQUIPMENT UNDER TEST (EUT)**

### **2.1 Identification of EUT**

|                                    |                |
|------------------------------------|----------------|
| <b>Brand Name:</b>                 | SPRscan        |
| <b>Model Name or Number:</b>       | P-0500         |
| <b>Unique Type Identification:</b> | US Variant     |
| <b>Serial Number:</b>              | USPP1          |
| <b>Country of Manufacture:</b>     | United Kingdom |
| <b>Date of Receipt:</b>            | 19 August 1999 |

### **2.2 Modifications for Testing Incorporated in EUT**

None.

### **2.3 System Components**

|                      |                                    |
|----------------------|------------------------------------|
| <b>Description:</b>  | SPRscan                            |
| <b>Model / Name:</b> | P-0500                             |
| <b>Description:</b>  | Trolley                            |
| <b>Model/ Name:</b>  | TSE-2+ RGO-500 rough ground option |
| <b>Description:</b>  | Controller                         |
| <b>Model/ Name:</b>  | 3D                                 |
| <b>Description:</b>  | 25 m Cable                         |
| <b>Model/ Name:</b>  | Standard Production                |

## 2.4 Additional Information Related to Testing

|                                        |                                              |
|----------------------------------------|----------------------------------------------|
| <b>Equipment Category:</b>             | Domestic/ Light Industrial                   |
| <b>Type of Unit:</b>                   | Surface Penetrating Radar                    |
| <b>Power Supply Requirements:</b>      |                                              |
| <b>DC Supply (Volts/Amp):</b>          | External Battery. 12V / 3.5A nominal         |
| <b>AC Supply (Volts/Amp):</b>          | N/A                                          |
| <b>Intended Operating Environment:</b> | Residential, Commercial and Light Industrial |

## 2.5 Support Equipment

# 3 TEST SPECIFICATION, METHOD AND PROCEDURES

## 3.1 Test Specification

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Reference:</b>       | CFR 47 parts 0 to 19                  |
| <b>Title:</b>           | Code of Federal Regulations: 1998     |
| <b>Purpose of Test:</b> | Intentional Transmitter Certification |

## 3.2 Clauses and Applicability

### 3.2.1 Emissions

| Clause | Comment                   | Applicability | Note       |
|--------|---------------------------|---------------|------------|
| -      | Enclosure                 | Yes           | See note 1 |
| -      | AC Mains Power Input Port | No            | See note 2 |

**Note(s):** 1. CFR 47 part 15:209.  
2. External Battery.

## 3.3 Port Identification

| Port | Description | Type | Applicable |
|------|-------------|------|------------|
| 1    | Enclosure   | -    | Yes        |

### 3.4 Methods and Procedures

The methods and procedures used were as detailed in:

CFR 47 PART 15:209      Code of Federal Regulations : Radiated Emission Limits, General requirements

### 3.5 Location of Tests

All measurements described in this report were performed in the Radiocommunications Testing Department, and the Open Area Test Site at ERA Technology Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA.

## 4 MEASUREMENT EQUIPMENT

The measurement equipment used complied with the requirements of the standards referenced in Section 3.4 Methods and Procedures. The equipment is regularly calibrated to maintain traceability to National Standards. Annex 1 contains a list of the test equipment used.

## 5 PERFORMANCE CRITERIA

### 5.1 Defined Performance

The EUT is to be operated in its normal operating state. No malfunctions should occur during testing.

| Measurement Type             | Specification       | Clause Number | Operating Mode |
|------------------------------|---------------------|---------------|----------------|
| Radiated Enclosure Emissions | CFR 47- Part 15.209 | -             | Transmitting   |

## 6 MEASUREMENTS, EXAMINATIONS AND DERIVED RESULTS

### 6.1 Summary of Test Results

| Measurement Type             | Specification      | Clause Number | Compliance Status |
|------------------------------|--------------------|---------------|-------------------|
| Radiated Enclosure Emissions | CFR 47-Part 15.209 | -             | Complied          |

## 6.2 Radiated Enclosure Emissions

### 6.2.1 General Comments

The SPRscan system was to be tested to the code of Federal Regulations CFR 47 part 15.209 in order to meet compliance requirements for the USA. Before being tested on the open area test site (OATS) it was subject to a prescan in a fully lined anechoic chamber.

### 6.2.2 Environmental Conditions

|                           |      |
|---------------------------|------|
| <b>Temperature:</b>       | 24°C |
| <b>Relative Humidity:</b> | 38%  |

### 6.2.3 Test Summary

|                        |                    |
|------------------------|--------------------|
| <b>Port:</b>           | Enclosure          |
| <b>Basic Standard:</b> | CFR 47 part 15.209 |
| <b>Test Limits:</b>    | CFR 47 part 15.209 |

### 6.2.4 Results - Radiated Enclosure Emissions

The test plan called for a measurement bandwidth of 120 kHz for the frequency range 30 to 1000 MHz and 1 MHz bandwidth for the frequency range 1 to 10 GHz. Using these bandwidths for the initial test runs there were no measurable emissions above system noise level, even with pre-amplifiers in use. It was necessary to reduce the bandwidth to 9 kHz, in order to measure the SPRscan emissions. This procedure was used for both the pre-scans and the open area test site measurements.

### 6.2.5 Anechoic Chamber

Prior to the SPRscan system being tested on the open area test site, it was subject to a pre scan in a fully lined anechoic chamber to determine frequency components of any emissions. The SPR was positioned on a soil box. The soil base being approximately 4 inches deep and 1 inch larger than the outer shell of the SPR. For the frequency range 30 to 1000 MHz a log spiral antenna was used as the measurement antenna and for 1 to 10 GHz a double ridge horn was used.

As called for by the test plan the initial test runs were carried out with the measurement analyser in 120 kHz bandwidth. This showed nothing above the ambient system noise. The bandwidth was then

reduced to 9 kHz and the measurements were repeated, this showed the 1 MHz comb generator emissions. These measurements were all taken in peak mode.

#### **6.2.6 Open Area Test Site**

The SPRscan system was set up on an open area test site in accordance with SPRscan FCC Certification Test Plan dated 18.08.1999. The SPRscan system was sited on the grass with the measurement antenna positioned on the metal ground plane using a 3 m test distance. The controller and battery were placed on a 0.8 m high wooden table, with the antenna placed on the grass under the table with the transmitter (the side face furthest from the radar head connector panel) facing the measurement antenna. A function handle was fitted and placed on the table, with a trolley connected and placed at the rear of the antenna in its normal operating position. A 25 m cable connected the radar head to the controller, with the excess coiled and placed on the table.

For the frequency range 30 to 1000 MHz a bi-log polarised antenna was used with the analyser set to 120 kHz bandwidth. The results are shown in Table 1 with the QP value being 1 or 2 dB below the peak value. There were no emissions within 6 dB of the test limit.

Table 1

| Frequency MHz | Level (dB $\mu$ V/m)<br>Quasi Peak | Limit<br>dB $\mu$ V/m |
|---------------|------------------------------------|-----------------------|
| 80.96         | 27.0                               | 40                    |
| 82.90         | 28.5                               | 40                    |
| 83.90         | 29.0                               | 40                    |
| 112.02        | 27.4                               | 43                    |
| 152.00        | 27.0                               | 43                    |
| 180.80        | 37.2                               | 43                    |
| 186.90        | 23.1                               | 43                    |
| 187.90        | 25.1                               | 43                    |
| 201.30        | 28.6                               | 43                    |
| 204.77        | 31.6                               | 43                    |
| 208.00        | 33.6                               | 43                    |
| 270.90        | 23.5                               | 46                    |
| 279.90        | 32.7                               | 46                    |
| 288.90        | 34.2                               | 46                    |
| 296.97        | 33.2                               | 46                    |
| 322.00        | 35.0                               | 46                    |
| 330.90        | 34.0                               | 46                    |
| 339.90        | 34.6                               | 46                    |
| 400.99        | 35.6                               | 46                    |
| 421.00        | 35.0                               | 46                    |
| 452.00        | 35.5                               | 46                    |
| 469.95        | 36.0                               | 46                    |
| 501.00        | 36.5                               | 46                    |
| 516.96        | 36.5                               | 46                    |
| 981.90        | 35.0                               | 46                    |

For the frequency range 1 to 10 GHz a double ridge horn was used, set at 1 m height, for both polarisations, with the measurement analyser set at 1 MHz bandwidth. No emissions were found other than ambient transmissions. It was decided to concentrate on the GPS frequency band of 1559 to 1610 MHz with a bandwidth of 9 kHz. A microwave pre amplifier which has a nominal flat 29 dB gain, from 100 MHz to 18 GHz was used for all measurements above 1 GHz.

Plots 1 and 2 in Annex 2 show the horizontal and vertical polarisations for the frequency range 1.559 GHz to 1.610 GHz with the transmitter running. Plot 1 shows the horizontal polarisation while plot 2 shows the vertical polarisation. As can be seen the emissions are vertically polarised, with a level of 22.25 dB $\mu$ V. Adding the antenna correction factor of 26.5 dB and cable loss of 2 dB, and subtracting pre-amp gain of 29 dB gives a corrected value of 22 dB $\mu$ V/m with a limit of 54 dB $\mu$ V/m. Both plots are in peak mode.

Plot 3 shows an average level in the vertical mode for the same frequency span, whilst plot 4 shows the average in horizontal mode. Plots 5 and 6 show the ambient peak levels for vertical and horizontal modes, whilst Plot 7 shows the ambient average horizontal, covering the frequency range 1.559 to 1.610 GHz.

Plots 8 to 12 show the ambient radiated emissions on the OATS from 1 to 10 GHz peak in the vertical mode.

Note: Plots 1 – 12 are uncorrected. Annexes 5, 6 and 7 provide the horn, pre-amplifier and cable calibration factors to convert the plots to dB $\mu$ V/m.

### **6.2.7 Setup for Testing the SPR Scan**

Annex 3 shows the set ups for the testing on the open area test site.

Photograph 1 shows the general arrangement for testing, whilst 2 and 3 show the arrangement of the SPR for testing.

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**Annex 1**

**List of Test Equipment**

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**Annex 1 : Test Equipment List**

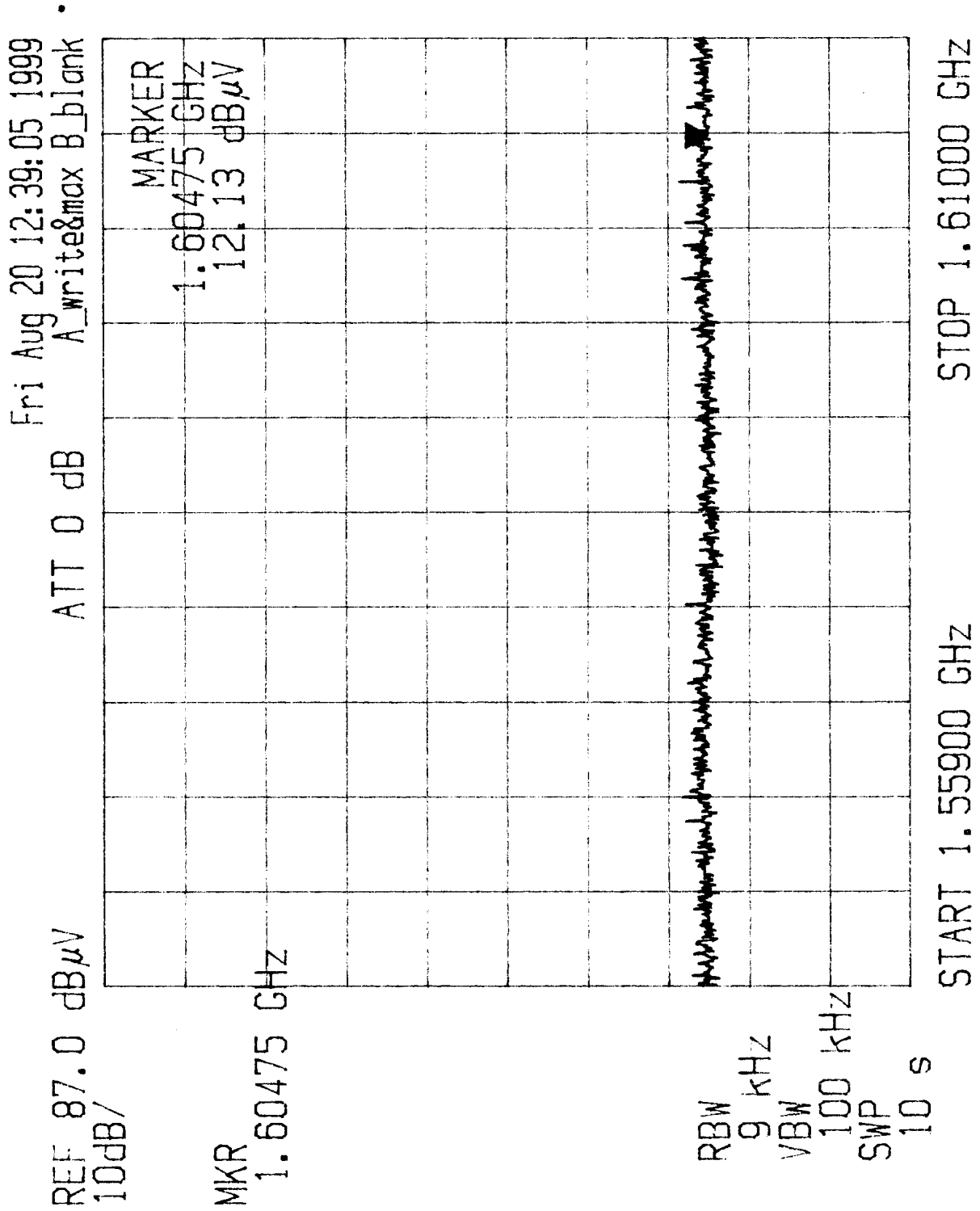
| <b>Equipment</b>                    | <b>Plant No.</b>        | <b>Cal. Due Date</b>       |
|-------------------------------------|-------------------------|----------------------------|
| Advantest Spectrum Analyser R3271   | B160B                   | 07/07/2000                 |
| Chase CBL6111A Bilog Antenna        | B898B                   | 31/08/2001                 |
| Double Ridge Horn Antenna 3115      | B895B                   | 16/02/2000                 |
| Measuring Receiver UHR 4000         | A753A                   | 04/06/2000                 |
| Open Area Test Site                 | A754A                   | 03/08/2000                 |
| Anechoic Chamber                    | B507B                   | 04/09/2000                 |
| Environmental Sensor                | C101C                   | 16/06/2000                 |
| Log Spiral Antenna                  | AZ515                   | 17/12/2000                 |
| ERA Pre Amplifier Type WBA3-4-6G20N | C122C                   | 10/09/2000                 |
| <b>N type Cables:</b>               |                         |                            |
| 0.5 m long                          | B643B                   | 23/10/99                   |
| 4.0 m long                          | B885B                   | 02/11/99                   |
| 5.0 m long                          | B370B                   | 05/10/99                   |
| 17.0 m long                         | B959B                   | 15/10/99                   |
| <b>Software:</b>                    |                         |                            |
| RSUS                                | <b>Version</b><br>2.104 | <b>Serial Number</b><br>53 |

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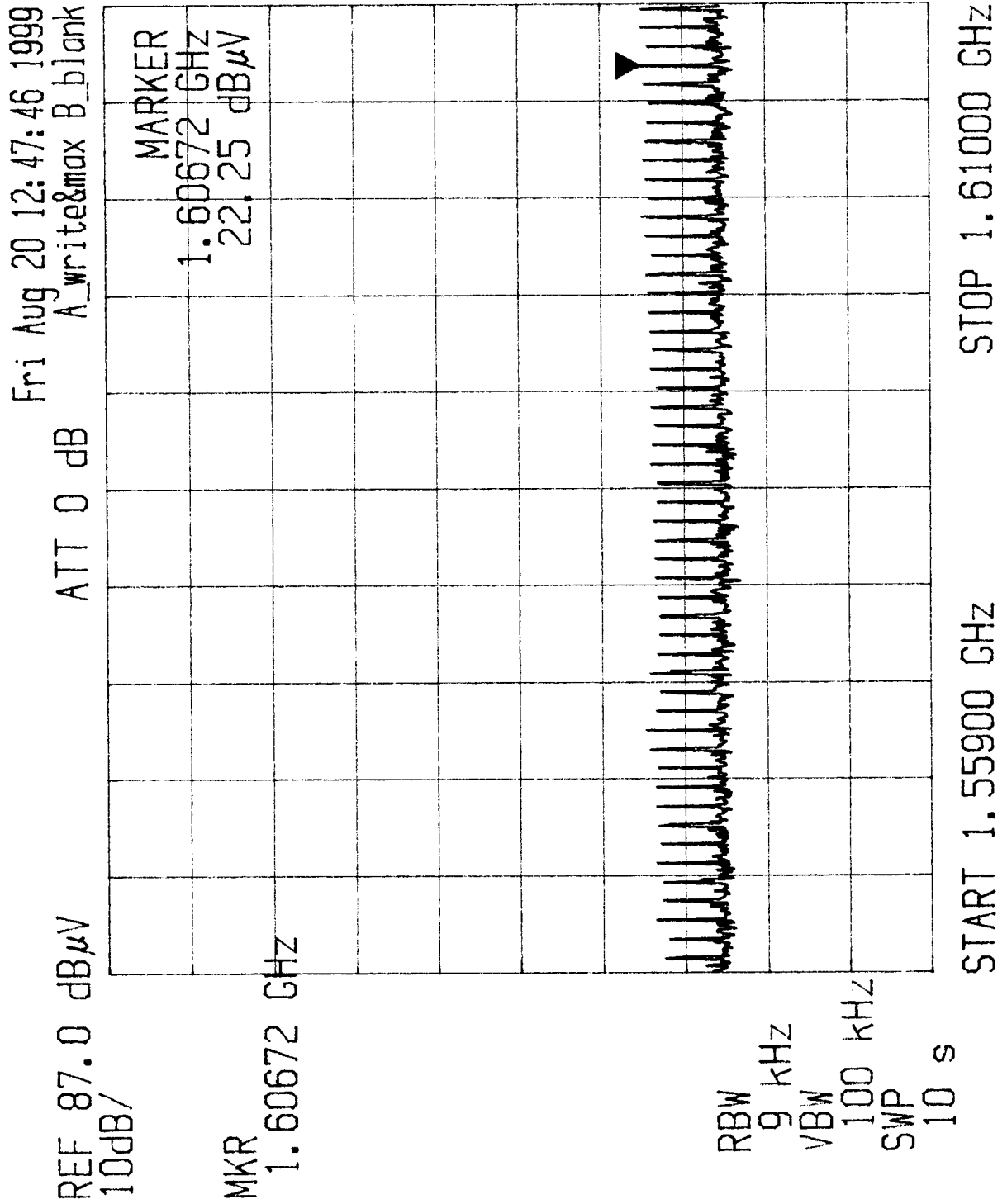
## **Annex 2**

### **Plots of Emissions**

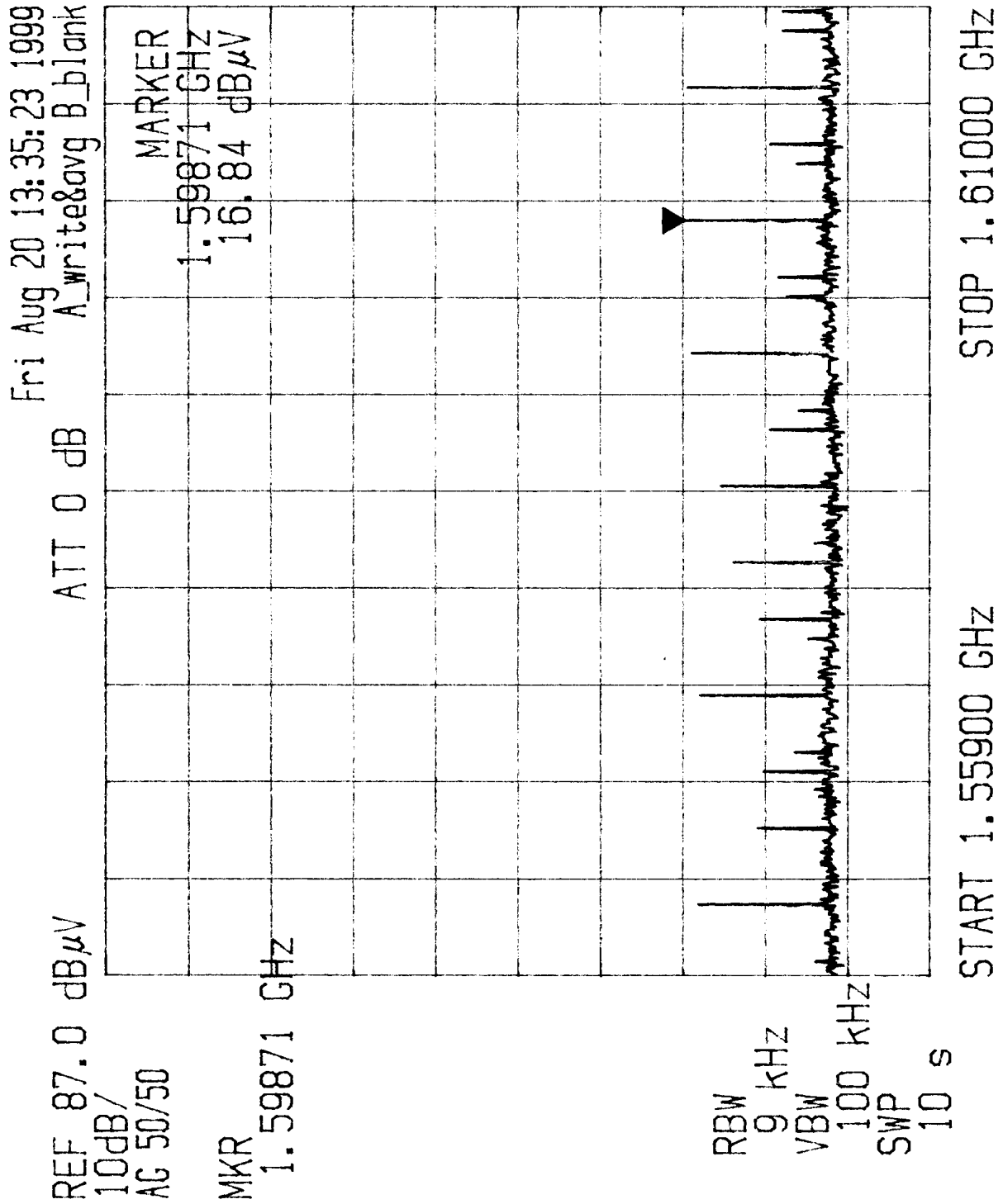
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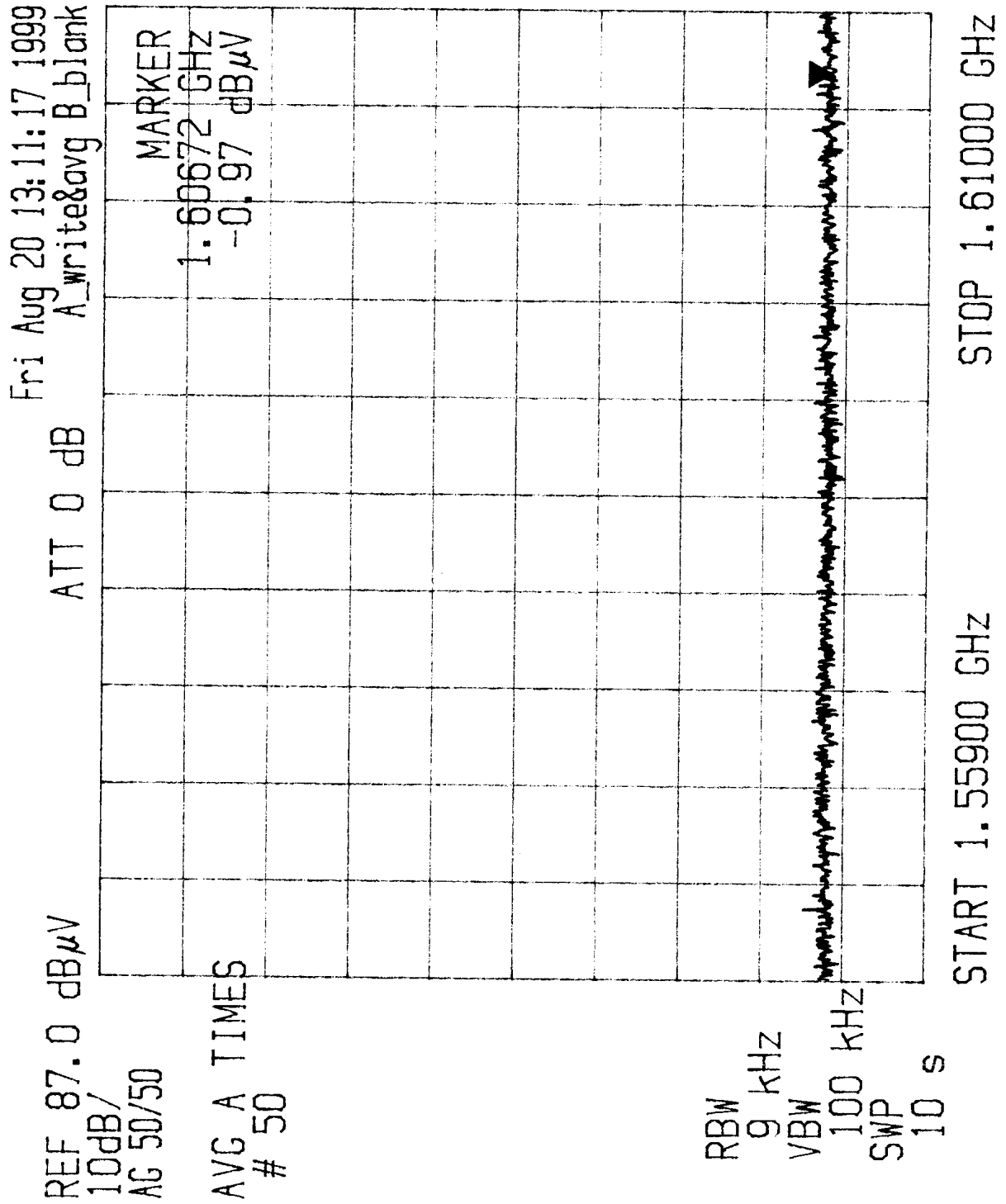
Plot 1



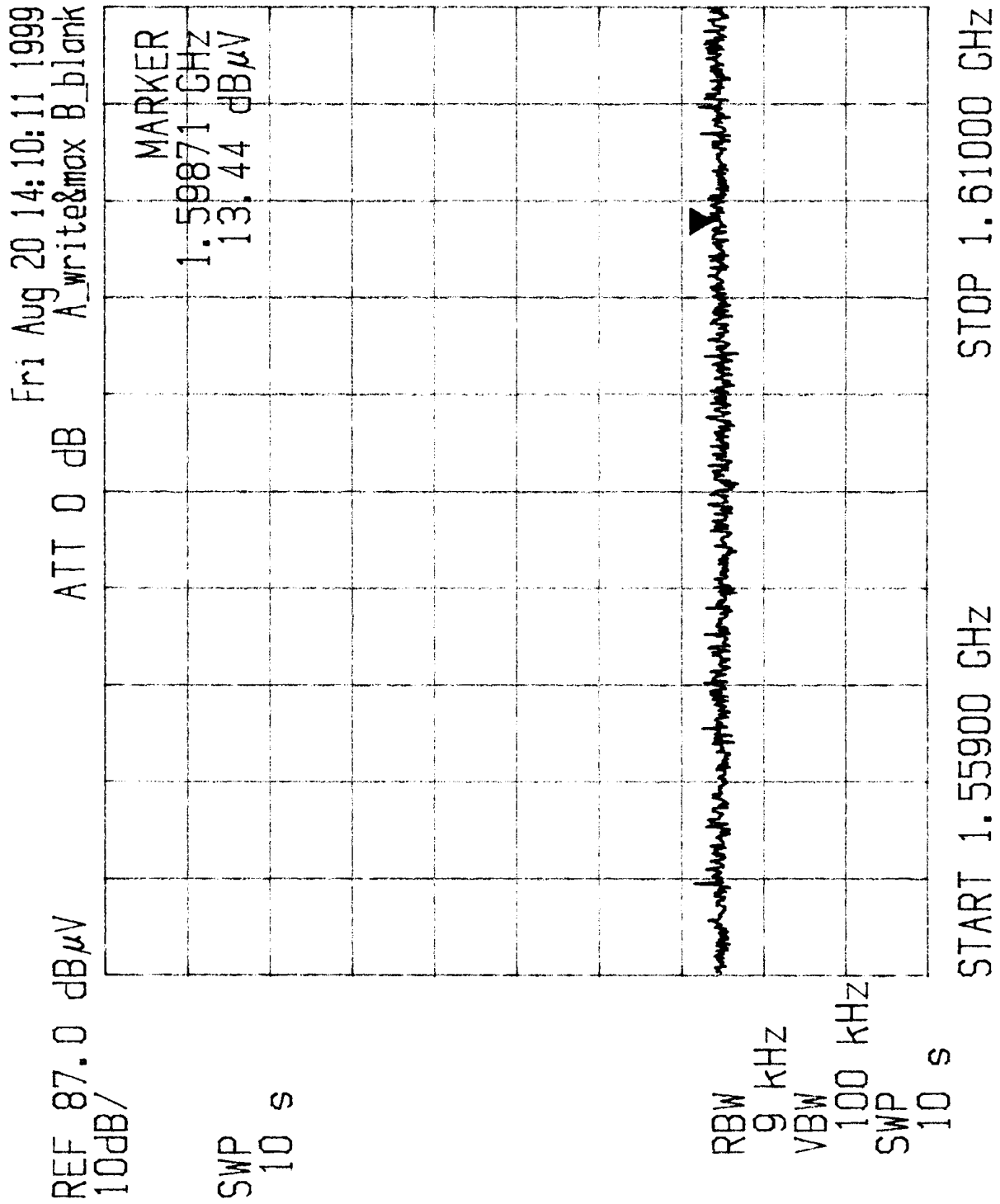
Plot 2

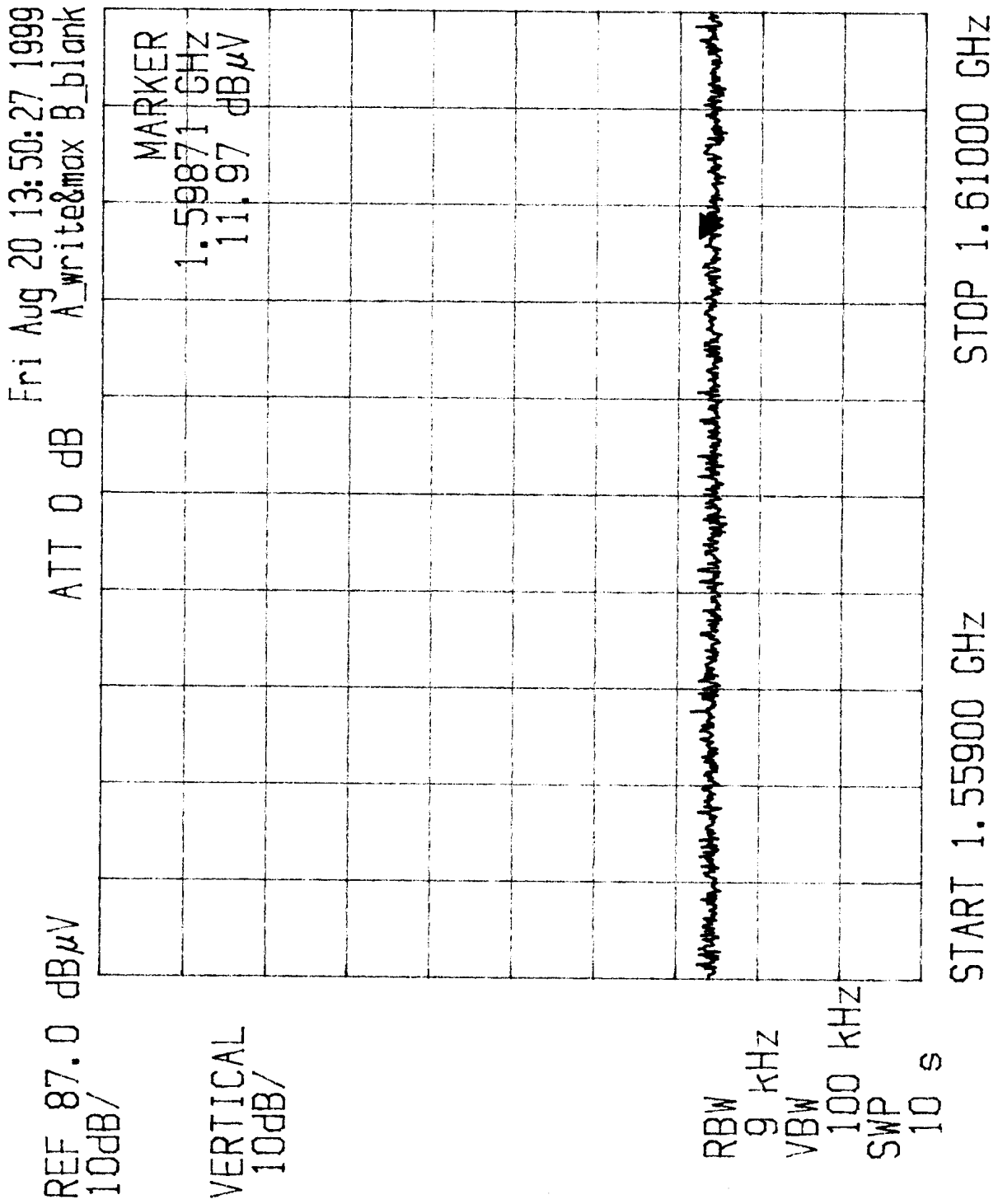


Plot 3

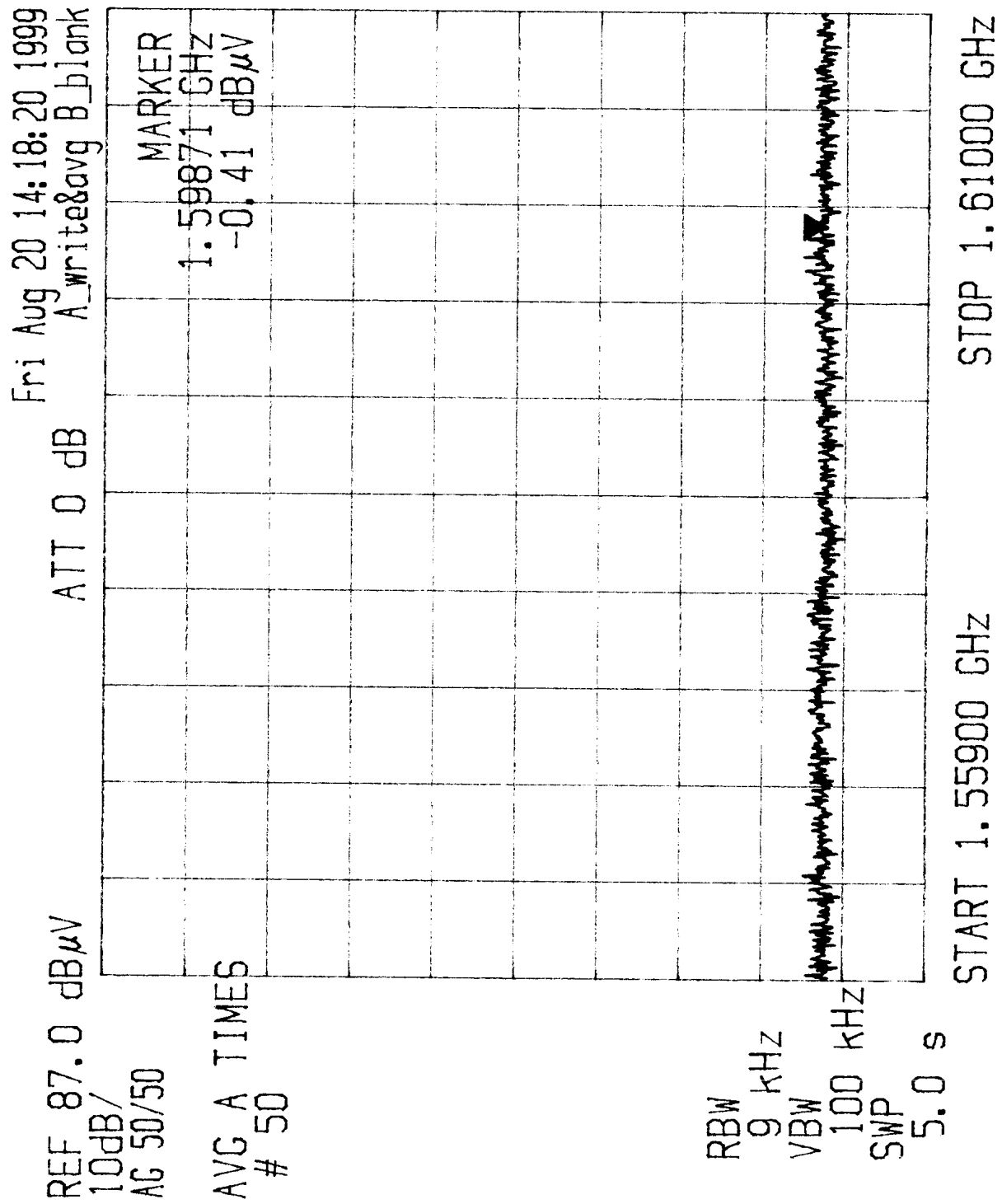


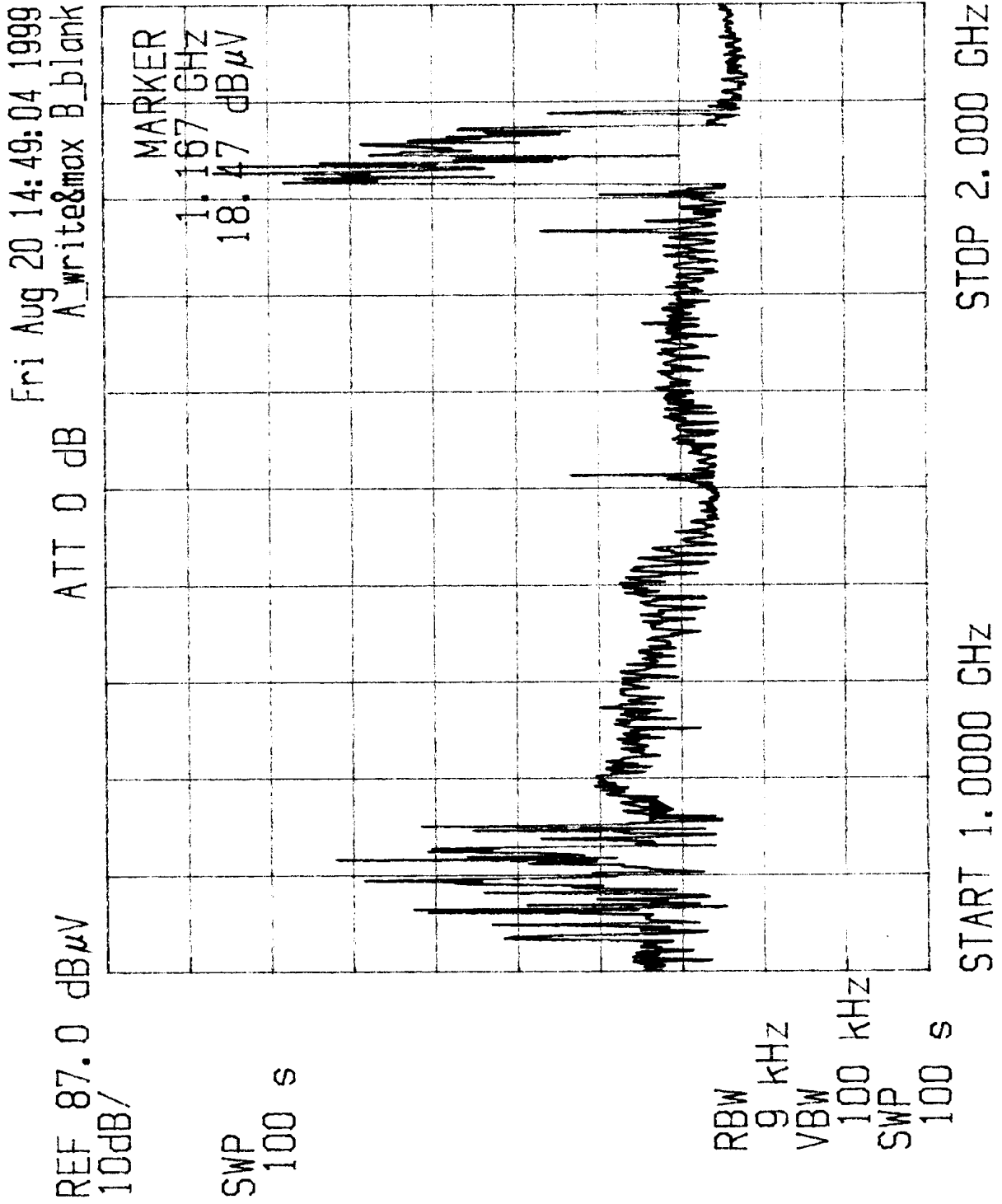
Plot 4



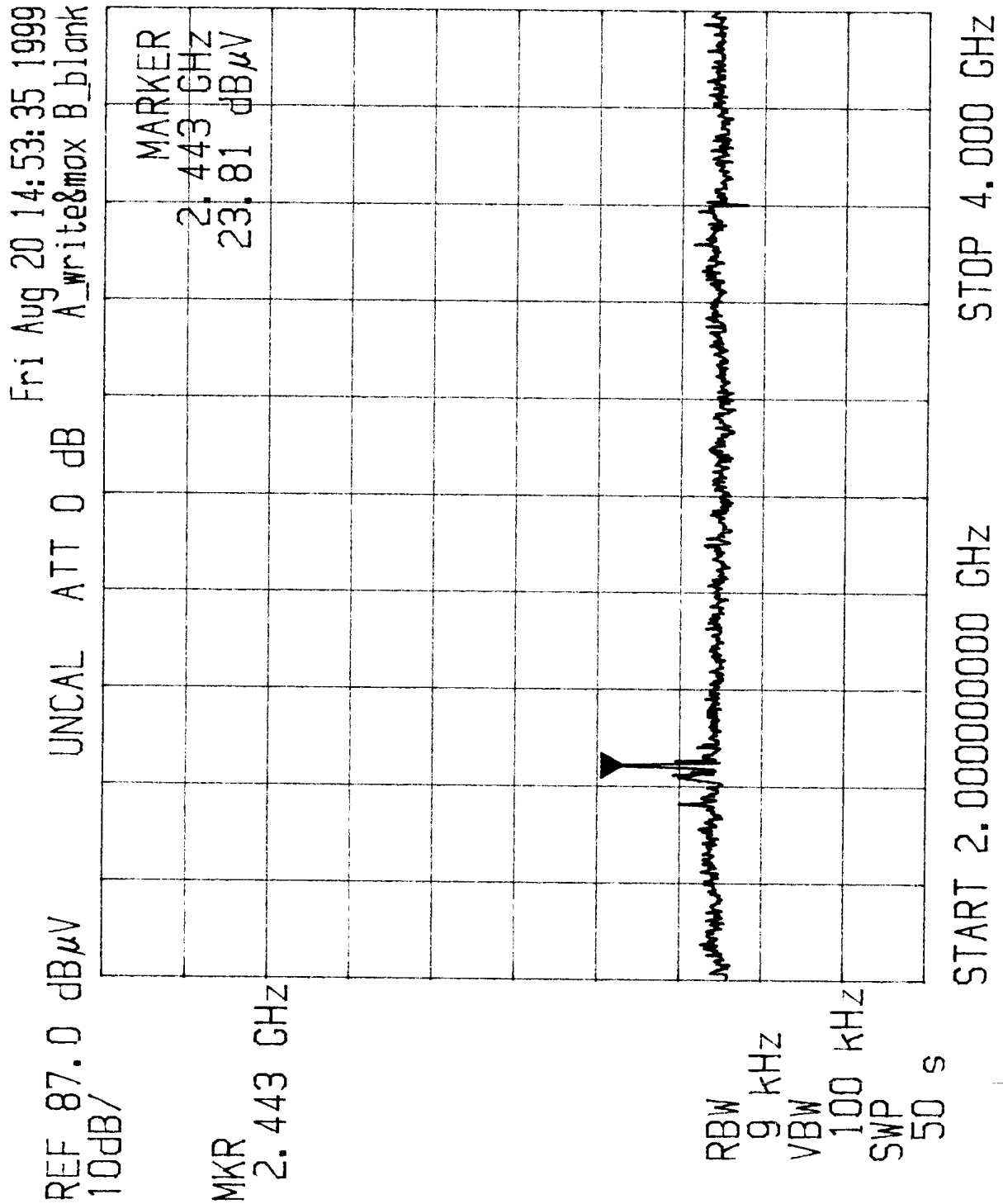


Plot 6

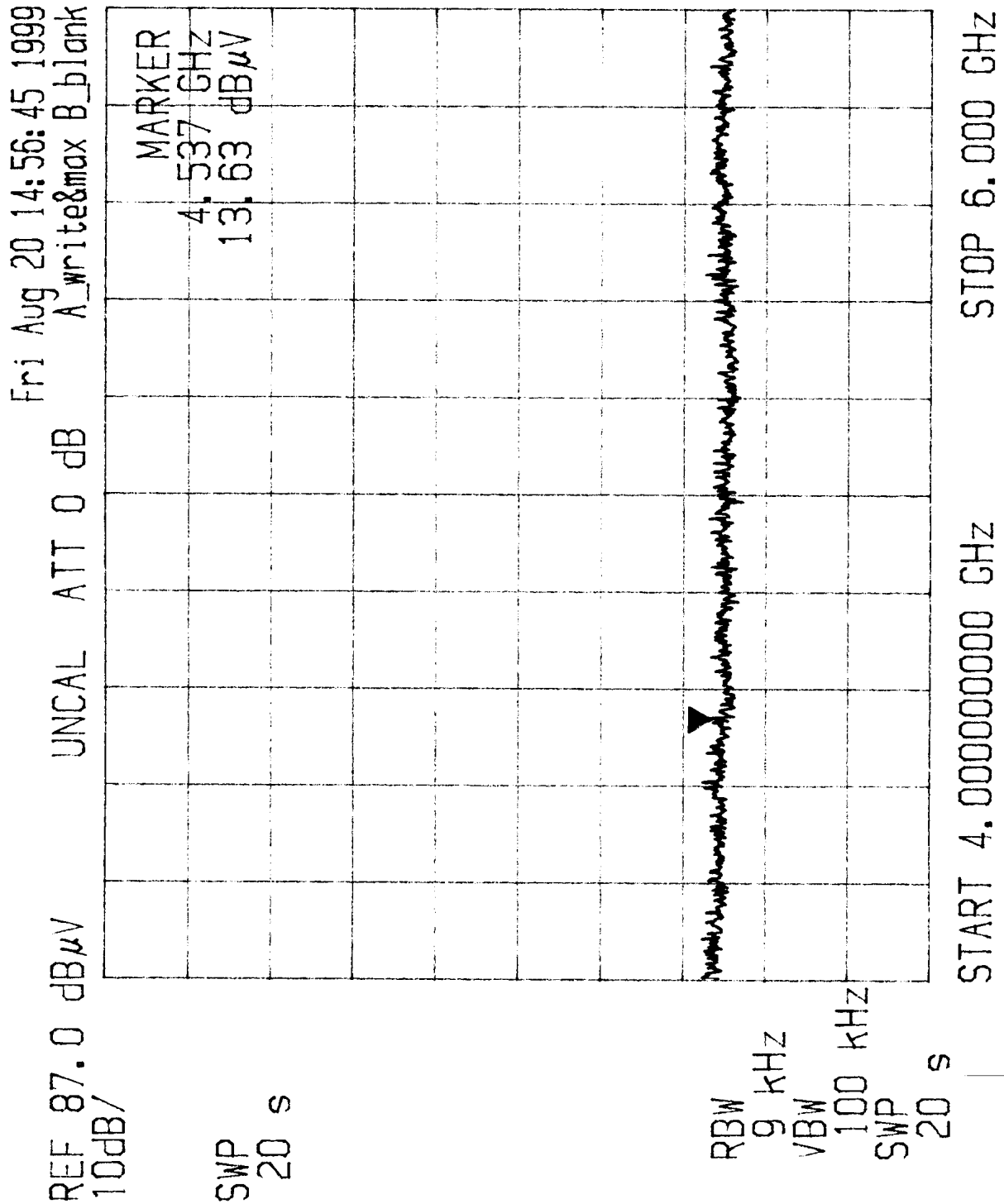




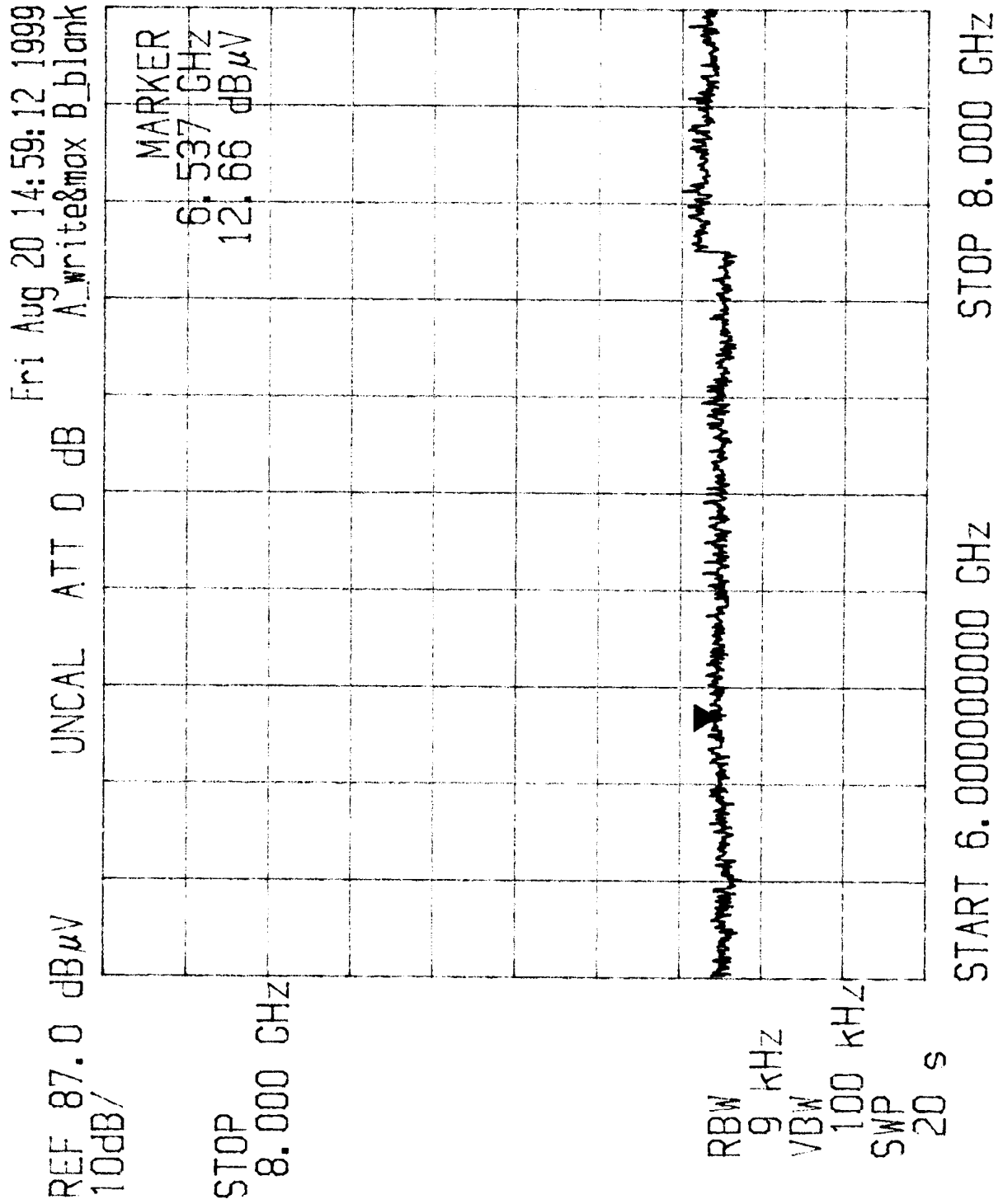
Plot 8



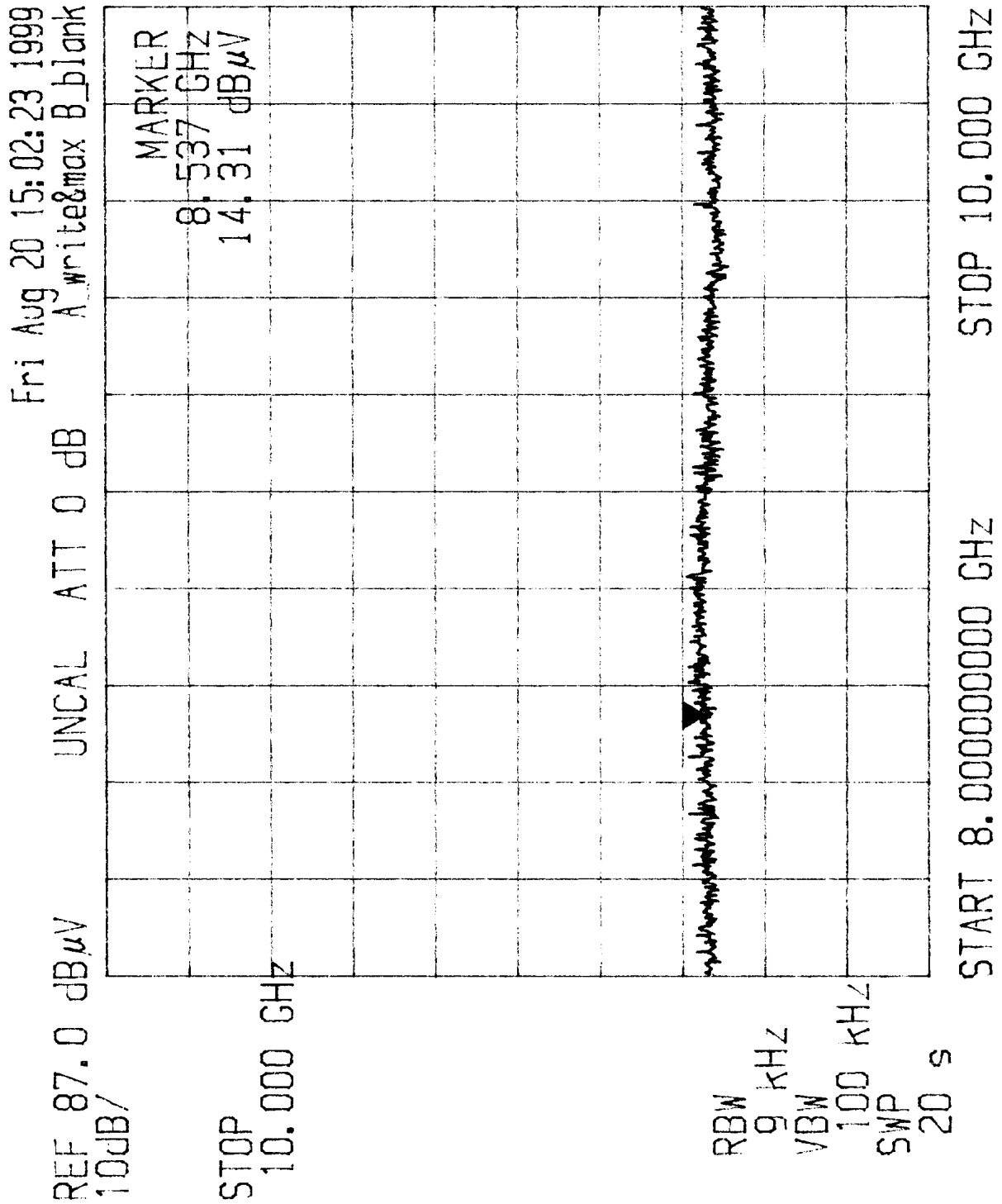
Plot 9



Plot 10



Plot 11



Plot 12

**Annex 3**

**Photographs of EUT**

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**Photograph Number** : 4252/209/01  
**Model Number** : P-0500  
**External View** : General arrangement for testing



**Photograph Number** : 4252/209/02  
**Model Number** : P-0500  
**External View** : Arrangement of the SPR for testing



**Photograph Number** : 4252/209/03

**Model Number** : P-0500

**External View** : Arrangement of the SPR for testing

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**Annex 4**

**Test Plan**

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## **SPRscan FCC Certification Test Plan**

Date: 18.8.1999

Author: N G I Hunt

### **Introduction**

This document specifies the tests that need to be done to provide formal proof that SPRscan meets the requirements of FCC specification 47 C.F.R part 15.209.

### **Method**

The tests shall be carried out in accordance with ANSI C63.4 1992 as qualified by section 15 of the FCC specifications and as varied by the FCC labs to be relevant for the SPRscan system. The system must be tested on an FCC approved test site. In ERA's case this is the covered OATS. The FCC has confirmed that they will accept results above 1 GHz from the site. The measurement frequency range is 30 MHz to 10 GHz.

The measurement system noise floor (excluding ambients) should be at least 6 dB, ideally 10 dB, below the FCC 15.209 3 m test distance limits. These are: 30 – 88 MHz :- 40 dBuV/m, 88 – 216 MHz :- 43 dBuV/m, 216-960 MHz :- 46 dBuV/m, above 960 MHz :- 54 dBuV/m.

The SPRscan 500 MHz system is designed to operate into a lossy medium with the spurious antenna radiation to be measured being the residual from the front side of the antenna and the spurious emissions from the equipment itself. The FCC therefore want the system tested just off the OATS ground plane on grass with the measurement antenna on the ground plane at the test distance (3 m). The emissions peak should be sought by adjusting the height of the measurement antenna.

The controller and battery should be on a 0.8m wooden table. The antenna should be on the grass under the table with the transmitter (the side face furthest from the radar head connector panel) facing the measurement antenna. A function handle should be fitted and placed on the table. A trolley should be connected and placed at the rear of the antenna in its usual position. A 25 m cable should be used to connect the radar head to the controller. The excess should be coiled and placed on the table.

### **Report**

A formal test report is required. This must provide details of the tests carried out, the equipment used, the equipment tested, pictures of the equipment under test and the results. Both paper and electronic media are

required. This report is to be presented to the FCC in electronic format as a MS Word document or Acrobat PDF to permit electronic filing of the certification application.

### **Equipment to be Tested**

The equipment to be tested shall be a current production SPRscan 500 MHz system with the prototype US variant of the 500 MHz antenna with reduced output. The system is to be powered from batteries.

### **Required Tests**

Emissions from 30 MHz to 1 GHz. Peak scan and CISPR quasi-peak on a selection of maximum spurs. 120 kHz resolution bandwidth. 3 m test distance. NOTE: the main peak scan to search for maximum levels may be carried out in a calibrated anechoic chamber. A soil box must be used rather than AN79 RAM to sit the antenna on. However, a peak scan on the OATS is also essential as the grass will have different attenuation characteristics to a soil box. It is recognised that significant ambients will be present.

Background scan for both OATS and anechoic chamber, if used, from 30 MHz to 1 GHz with peak detector. 120 kHz resolution bandwidth.

Emissions from 1 GHz to 10 GHz. Peak scan and average scan. Peak to average ratio to be measured and stated. 1 MHz resolution bandwidth. 3 m test distance. NOTE: the main peak scan to search for maximum levels may be carried out in a calibrated anechoic chamber. A soil box must be used rather than AN79 RAM to sit the antenna on. However, a peak scan on the OATS is also essential as the grass will have different attenuation characteristics to a soil box. It is recognised that significant ambients will be present.

Background scan for both OATS and anechoic chamber, if used, from 1 GHz to 10 GHz with peak detector. 1 MHz resolution bandwidth.

Emissions from 1559 to 1610 MHz (GPS band). Peak scan. Must be carried out on OATS with antenna on grass as described above. 10 kHz resolution bandwidth to minimise noise floor. 3 m test distance. The maximum level of the comb spectrum needs to be measured. Noise floor needs to be 10 dB below measurement. Background noise floor scan to be provided. In addition to the level measurement an approximate estimate of the elevation of the emissions in this band is required. This information is needed to address concerns expressed by the GPS community.

**Soil Box**

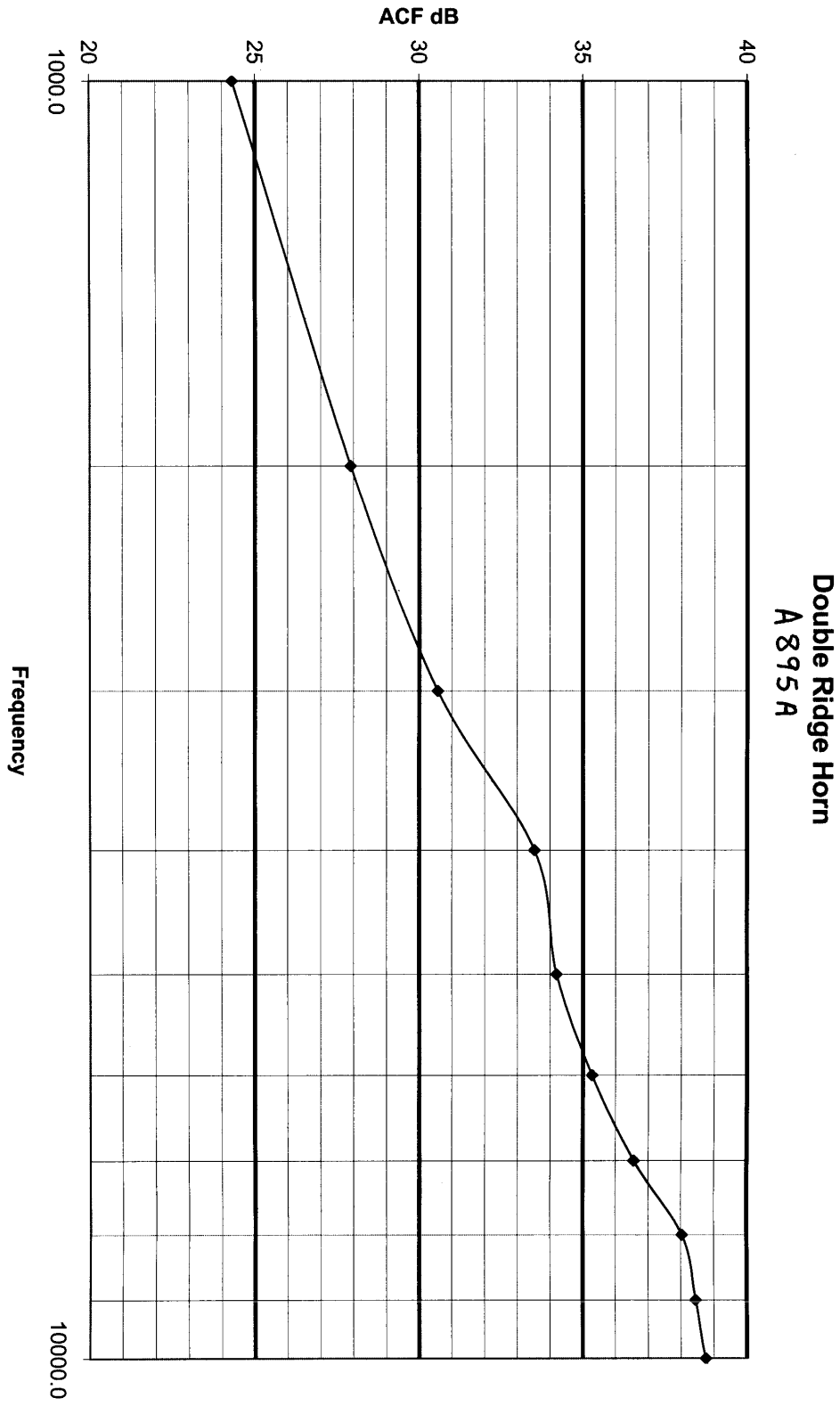
If a soil box is used then this should be at least 100 mm bigger on all sides than the antenna under test. It must be at least 200 mm deep. The bottom and sides should be screened with metal foil to prevent leakage from the sides of the soil box affecting the measurement. The soil should be a moderately damp loam/clay mix.

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**Annex 5**

**Chart showing Antenna Double Ridge Horn Calibration**

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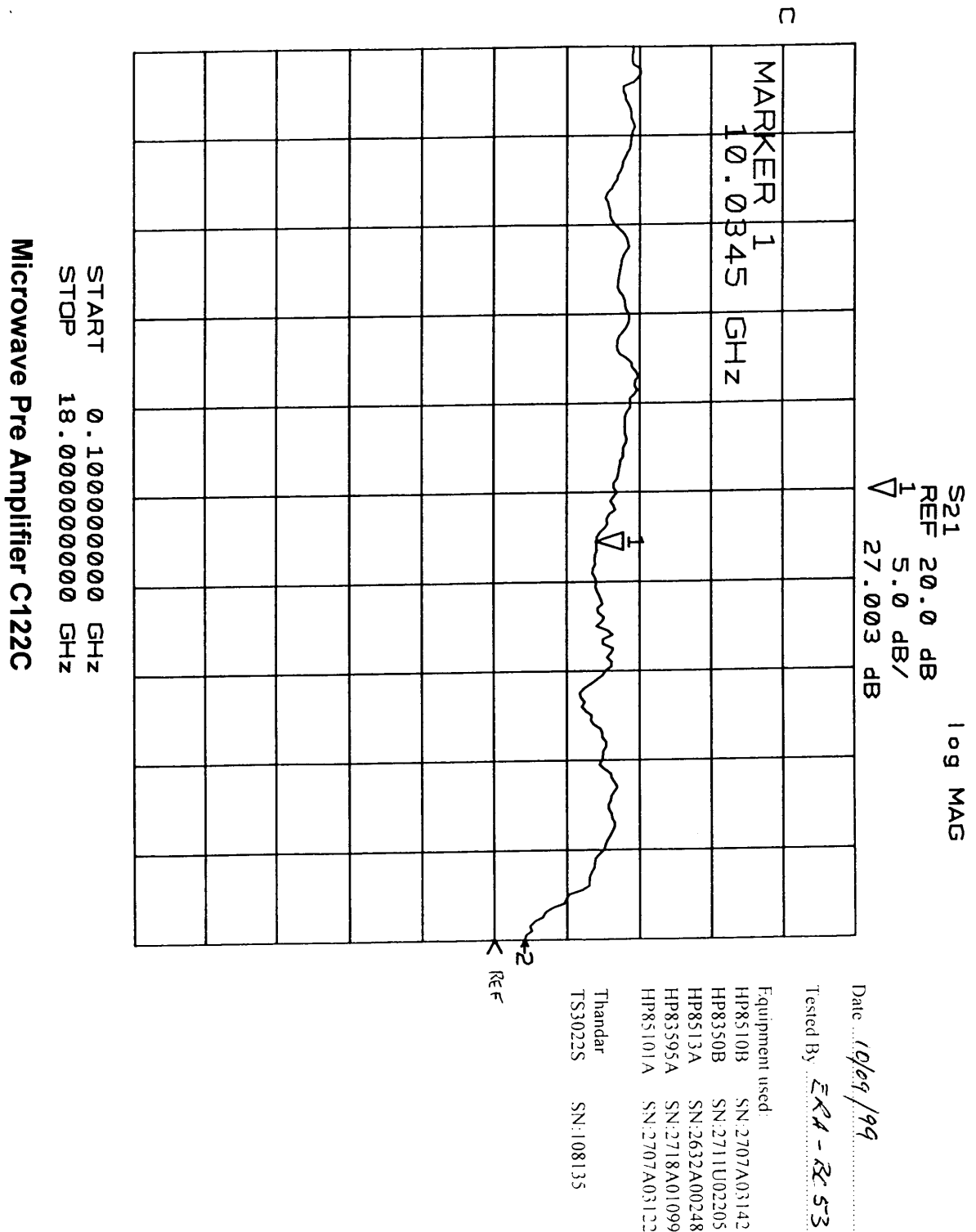


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**Annex 6**

**Chart showing Pre Amplifier Calibration**

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**Annex 7**

**Table showing Cable B370B Correction Factors**

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ERA Technology Ltd

Cleeve Road, Leatherhead, Surrey KT22 7SA England

Telephone: Leatherhead (0372) 374151 Telex:264045

|                                   |          |                  |
|-----------------------------------|----------|------------------|
| TECHNICAL PROCEDURE No: TP34/M002 | Issue: 1 | Sheet: 36 of: 41 |
|                                   |          | Date: 20-07-99   |

Calibration Certificate

Unit: 5.0m N to N

Plant No. B369B, B370B

Serial No.

Calibration Date: 5.10.98

Calibration Due: 5.10.99

Calibrated By: R. Athanachay

Cal. Book No. 40

Cal. File No. 7E

Data File No. 202

Graphic Data Required

by Test House: Yes/No

1. MECHANICAL CONDITION: SATISFACTORY: ☒ FAULTY: ☐  
 FAULT DETAILS:

2. Insertion Loss:

| Plant No.         | B369B         |                | B370B         |                |               |                |
|-------------------|---------------|----------------|---------------|----------------|---------------|----------------|
| Frequency Setting | Nominal Value | Measured Value | Nominal Value | Measured Value | Nominal Value | Measured Value |
| GHz               |               |                |               |                |               |                |
| 0.50              | 1.00          | 0.98           | 1.00          | 0.97           |               |                |
| 2.25              | 2.00          | 2.30           | 2.00          | 2.20           |               |                |
| 4.00              | 2.80          | 3.10           | 2.80          | 3.00           |               |                |
| 5.75              | 3.20          | 3.90           | 3.40          | 3.75           |               |                |
| 7.50              | 3.70          | 4.25           | 3.80          | 4.20           |               |                |
| 9.25              | 4.2           | 4.85           | 4.30          | 4.85           |               |                |
| 11.00             | 4.50          | 5.20           | 4.60          | 5.20           |               |                |
| 12.75             | 5.00          | 5.50           | 5.00          | 5.50           |               |                |
| 14.50             | 5.40          | 5.75           | 5.40          | 5.75           |               |                |
| 16.25             | 5.60          | 6.25           | 5.80          | 6.25           |               |                |
| 18.00             | 6.00          | 6.50           | 6.00          | 6.50           |               |                |

3. Limits:  $\pm 1$ dB of nominal value

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