RADIOCOMMUNICATIONS TESTING DEPARTMENT

FCC EMC COMPLIANCE MEASUREMENTS ON THE ERA TECHNOLOGY LTD 250 MHz SURFACE PENETRATING RADAR SYSTEM

D A Legge

ERA Test Report 4252/223

Report approved by: Peter Mallinson

P Mallinson
Manager
Radiocommunications Testing Department

February 2000
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Description of Equipment Under Test:	SPRscan
Type Number:	250 MHz
Serial Number:	USPP2
Test Specification(s):	47 CFR part 15.209
Equipment Received:	31st January 2000
Test Date(s):	31st January 2000 – 4th February 2000

Test Engineer(s):	D A Legge	
Report Written by:	D A Legge	
Checked By Group Leader:	R Orchard	
Checked By Technical Executive:	A McHale	

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EMC COMPLIANCE MEASUREMENTS ON THE ERA TECHNOLOGY LTD 250 MHz SURFACE PENETRATING RADAR SYSTEM

1 INTRODUCTION

The ERA Technology Ltd "SPRscan" 250 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 47 CFR 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

Brand Name:	SPRscan
Model Name or Number:	250 MHz
Unique Type Identification:	US Variant
Serial Number:	USPP2
Country of Manufacture:	United Kingdom
Date of Receipt:	31st January 2000

2.2 Modifications for Testing Incorporated in EUT

None.

2.3 System Components

Description:	SPRscan Head
Model / Name:	136
Description:	Trolley
Model/ Name:	139
Description:	Controller
Model/ Name:	114
Description:	Function Handle
Model/ Name:	119
Description:	25 m Cable
Model/ Name:	Standard Production

2.4 Additional Information Related to Testing

Type of Unit:	Surface Penetrating Radar
Power Supply Requirements:	
DC Supply (Volts/Amp):	External Battery. 12 V / 3.5 A nominal
AC Supply (Volts/Amp):	N/A

2.5 Support Equipment

None

3 TEST SPECIFICATION, METHOD AND PROCEDURES

3.1 Test Specification

Reference:	47 CFR parts 0 to 19
Title:	Code of Federal Regulations: 1998
Purpose of Test:	Intentional Transmitter Certification

3.2 Clauses and Applicability

3.2.1 Emissions

Clause	Comment	Applicability	Note
-	Enclosure	Yes	-

3.3 Methods and Procedures

The methods and procedures used were in accordance with:

47 CFR part 15.209 Code of Federal Regulations : Radiated Emission Limits, General requirements

3.4 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 in the UK.

4 MEASUREMENT EQUIPMENT

The measurement equipment used complied with the requirements of the standards referenced in Section 3.3 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 and configured in accordance with the test plan.

6 MEASUREMENTS, EXAMINATIONS AND DERIVED RESULTS

6.1 Summary of Test Results

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

6.2 Radiated Enclosure Emissions

6.2.1 General Comments

The SPRscan system was tested to the code of Federal Regulations 47 CFR 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

Temperature:	15ºC
Relative Humidity:	66%

6.2.3 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.

6.2.4 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 wooden turntable in the chamber. 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.

6.2.5 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 31.01.2000. The SPRscan system was sited on 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 measuring receiver set to 120 kHz bandwidth. The antenna was connected via two microwave cables joined in series to a pre-amplifier which has a nominal gain of 26 dB and then to the measuring receiver, which was sited behind the antenna. The cables were also ferrite loaded. The results are shown in Table 1 with the QP value being 2 or 3 dB below the peak value. There were no emissions within 6 dB of the test limit.

Table 1

Frequency MHz	Level (dBmV/m) Quasi Peak	Limit dBmV/m
144.90	23.30	43
148.90	23.10	43
151.90	18.40	43
155.98	19.50	43
168.90	20.00	43
198.90	30.90	43
233.90	38.70	46
234.90	37.70	46
249.90	39.50	46
300.00	34.60	46
349.90	38.00	46
399.90	33.80	46
599.90	36.10	46
699.90	30.00	46
800.00	27.95	46
898.90	31.20	46
999.90	33.00	54

For the frequency range 1 to 10 GHz a double ridge horn antenna was used. The antenna was set at 1 m height and connected via the two microwave cables in series to a pre-amplifier, which has a nominal gain of 29 dB over the frequency range of 100 MHz to 18 GHz into the measuring analyser, which was set to 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.

Plots 1 and 2 in Annex 2 show the horizontal and vertical polarisation emissions 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 24.28 dBµV. Adding the antenna correction factor of 26.5 dB and cable loss of 1.6 dB, and subtracting pre-amp gain of 29 dB gives a corrected value of 23.38 dBµV/m with a limit of 54 dBµV/m. Both plots are in peak mode.

Plot 3 shows an average level in the horizontal mode for the same frequency span, whilst plot 4 shows the average in vertical mode. Plots 5, 6, 7, 8 and 9 show the ambient peak levels for the frequency ranges 1 to 10 GHz in the vertical mode on the open area test site.

Additional plots were taken in the frequency range 1559 to 1610 MHz in order to characterise the transmission envelope from the SPRscan. Plot 10 shows the emissions at the centre position for 3 metre test site at 1 metre height, for a vertical polarisation. Plots 11 and 12 are for 0.5 and 1 metre to the right of the centre point, whilst 13 and 14 are 0.5 and 1 metre to the left. Plots 15 and 16 are at the centre point for 1.45 and 1.90 metres high.

Note: Plots 1 – 16 are uncorrected. Annexes 5, 6 and 7 provide the horn, pre-amplifier and cable calibration factors to convert the plots to dBµV/m. In the worst case Plot 13 indicates the levels at this position exceeded those at the central position by 1.46 dB.

6.2.6 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, 3 and 4 show the arrangement of the SPR for testing.

Annex 1

List of Test Equipment

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Annex 1 : Test Equipment List

Equipment	**Plant No.**	**Cal. Due Date**
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
Marconi Pre-amplifier 54432 – 010A	B657B	14/01/2001
ERA Pre Amplifier Type WBA3-4-6G20N	C122C	10/09/2000
N type Cables:		
2.0 m long	B540B	16/10/2000
3.0 m long	B541B	16/10/2000
4.0 m long	B224B	07/10/2000

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Annex 2

Plots of Emissions

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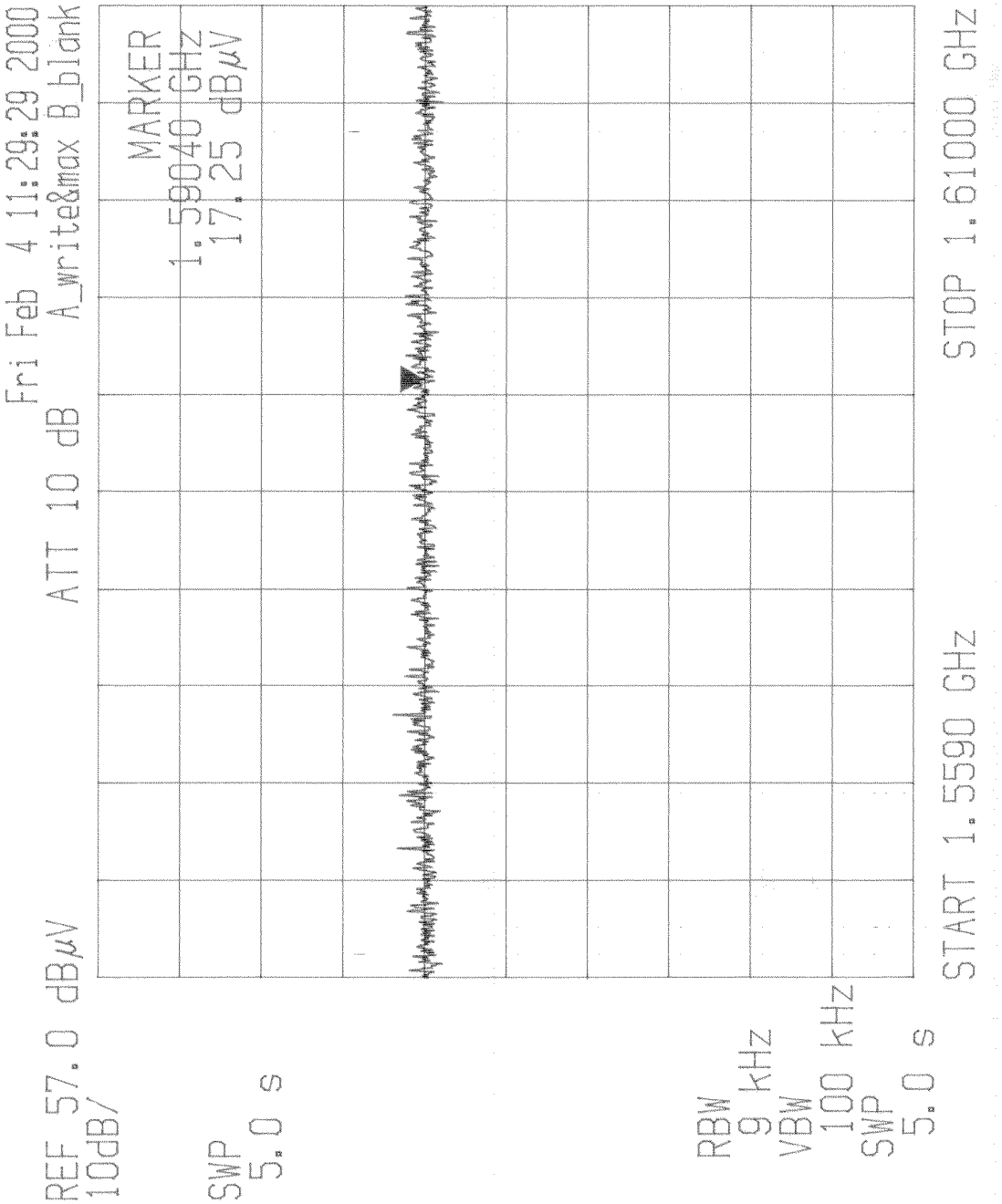
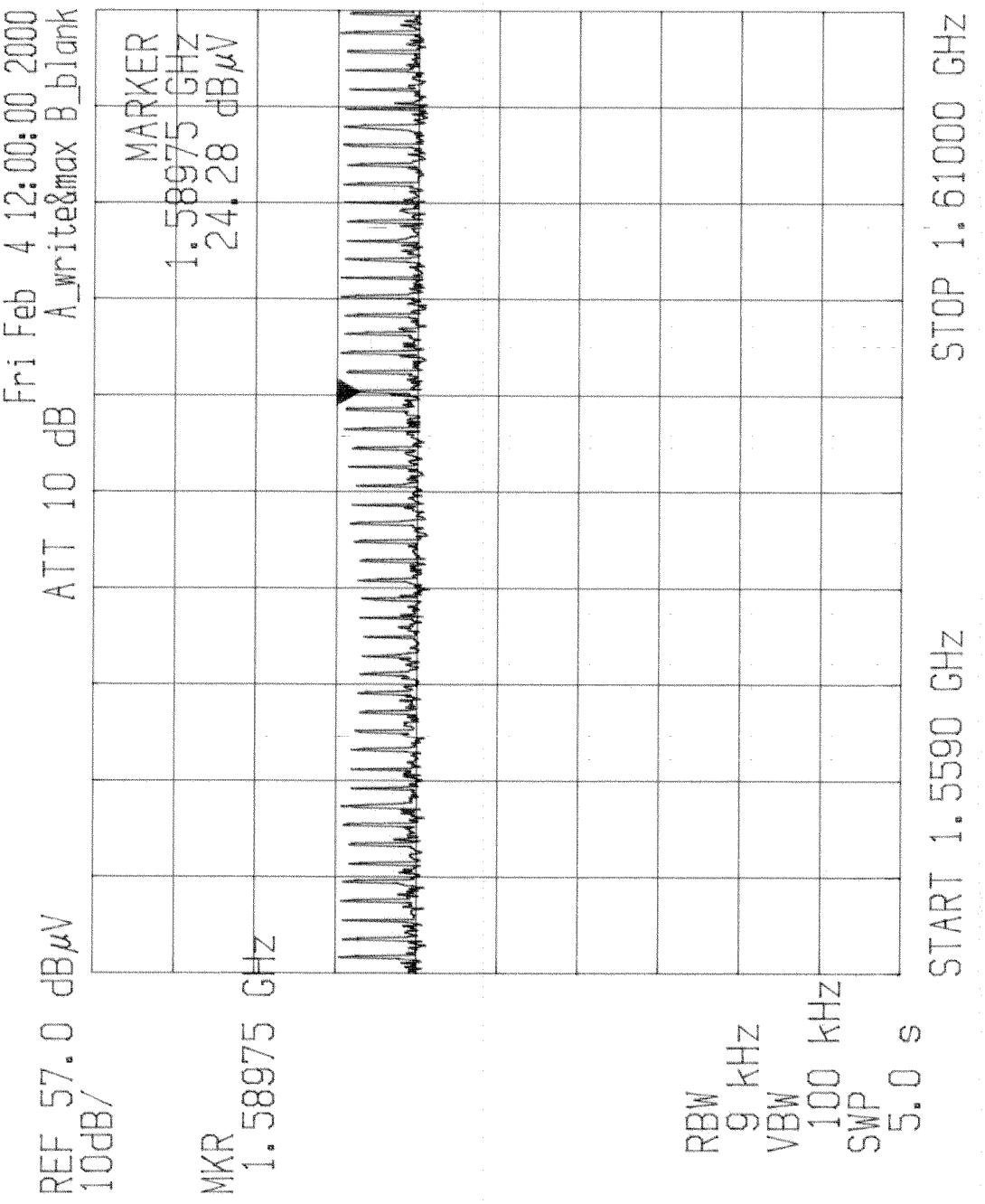
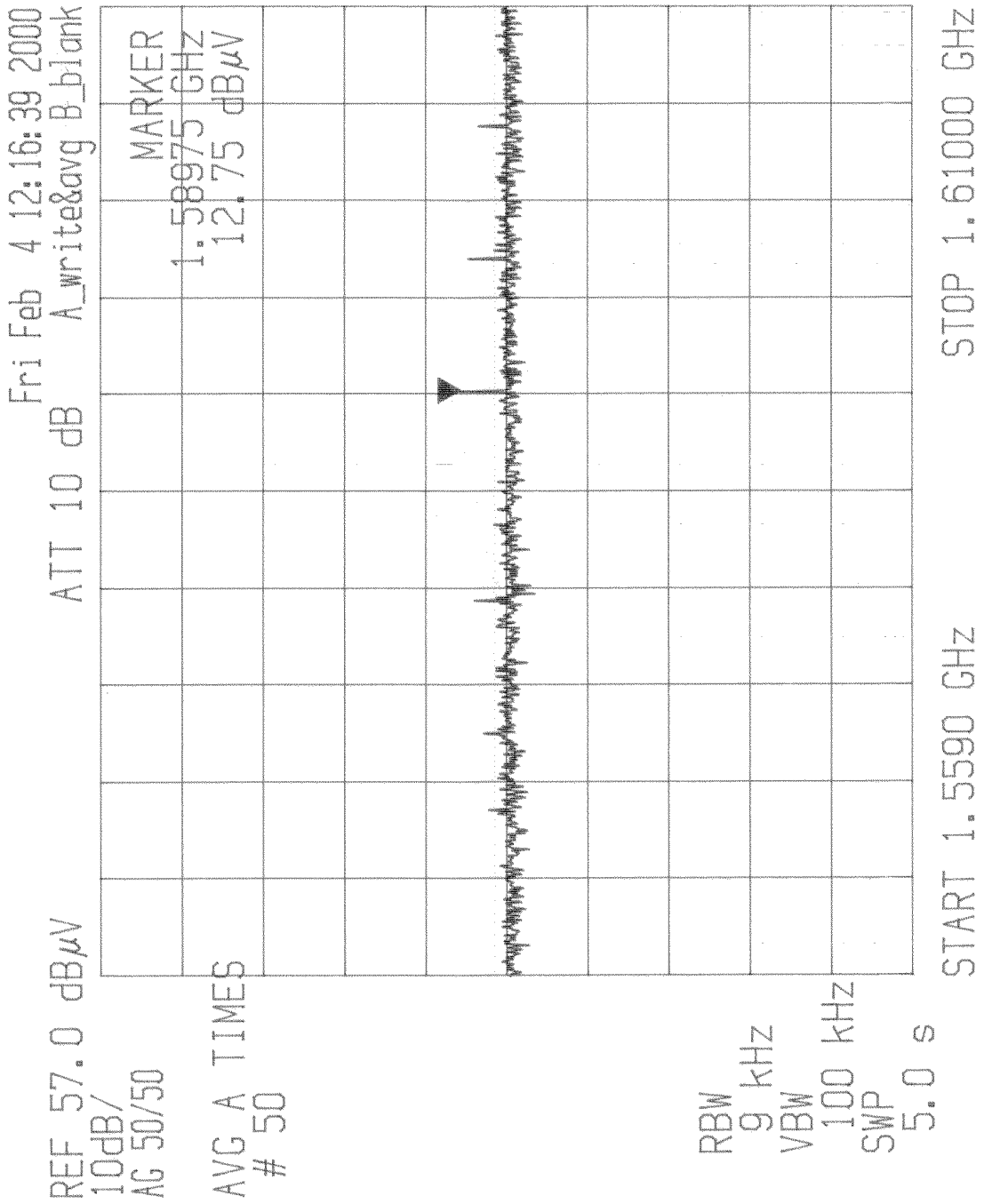


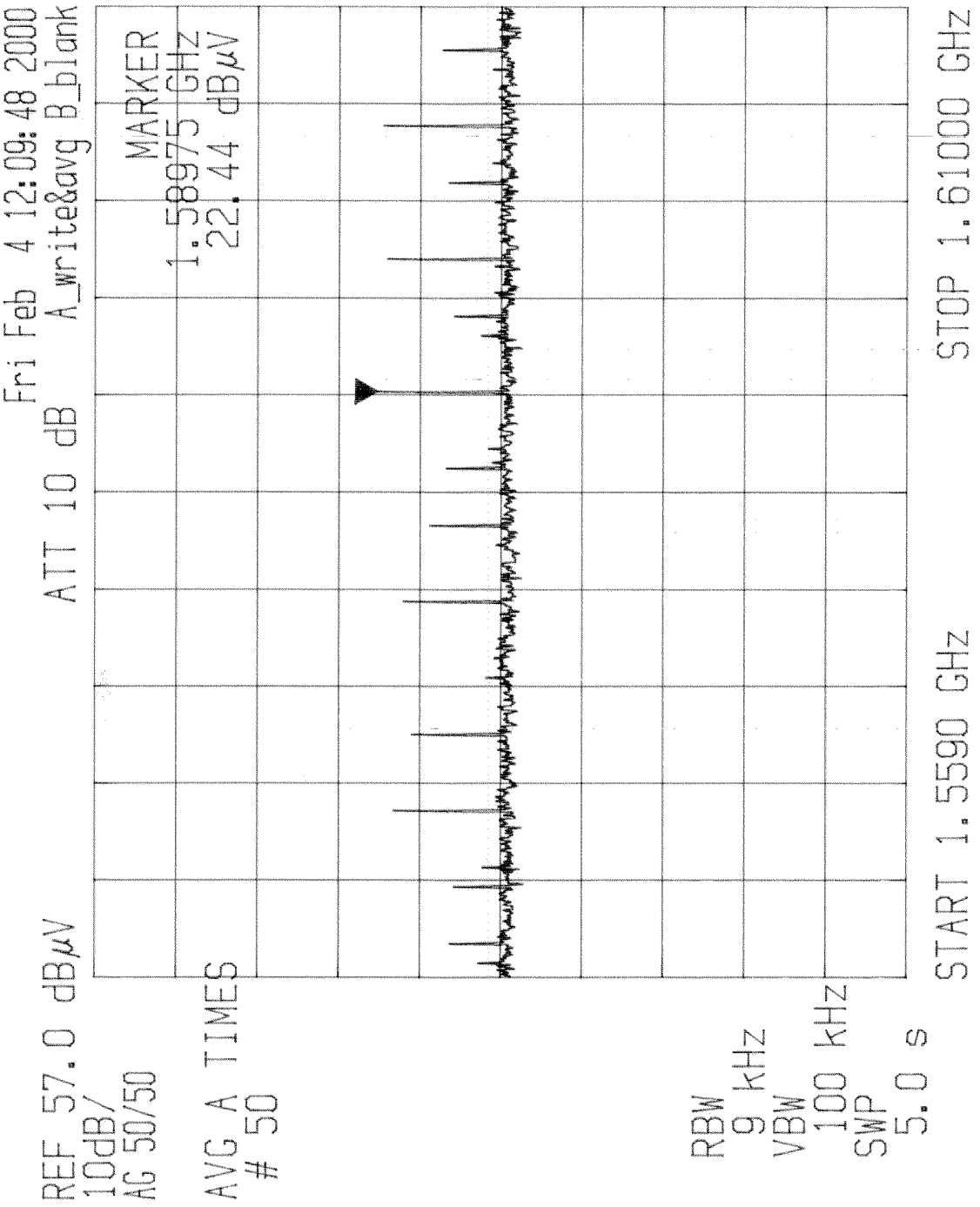
Plot 1 Horizontal polarisation – peak mode



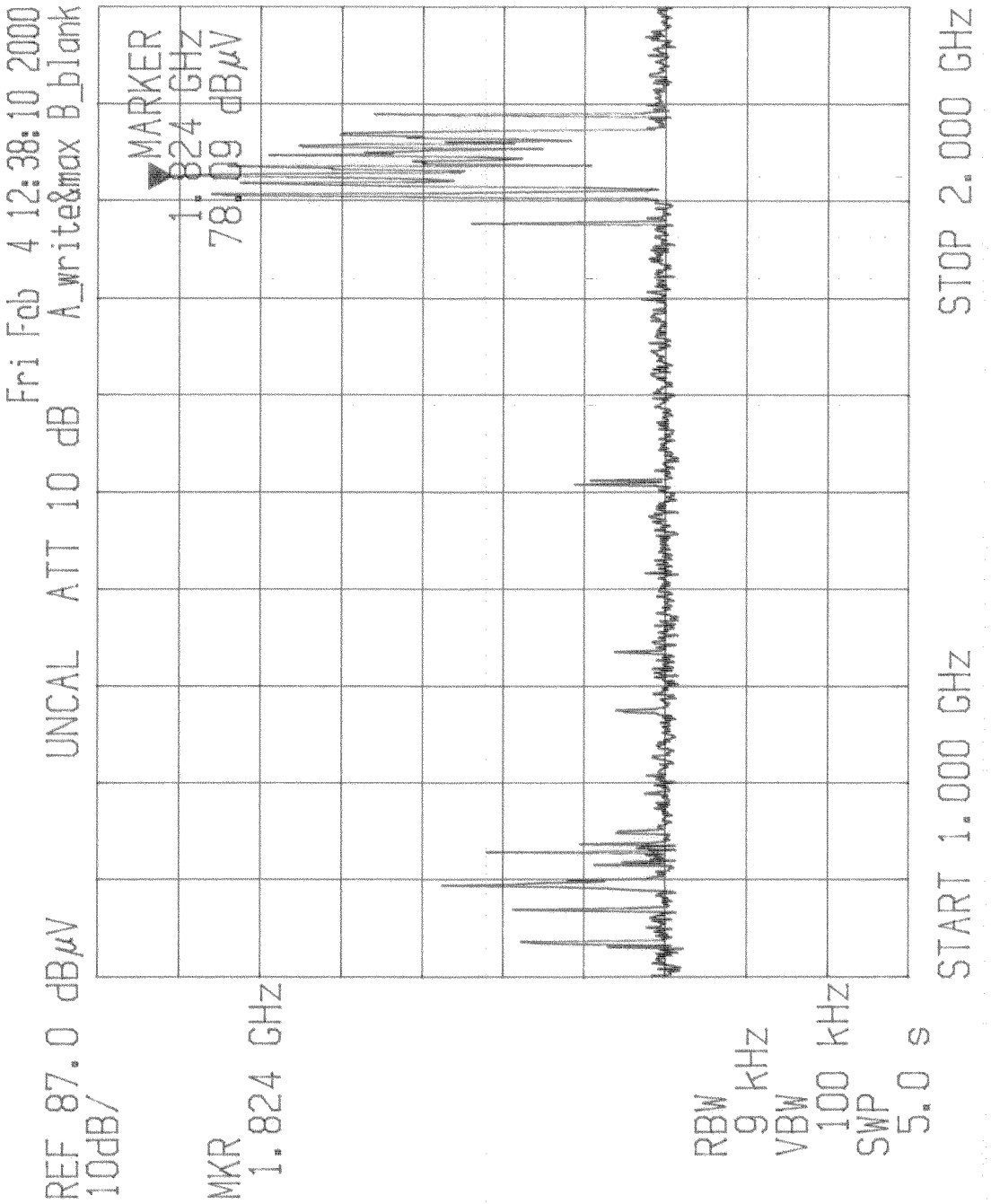
Plot 2 Vertical polarisation - peak mode



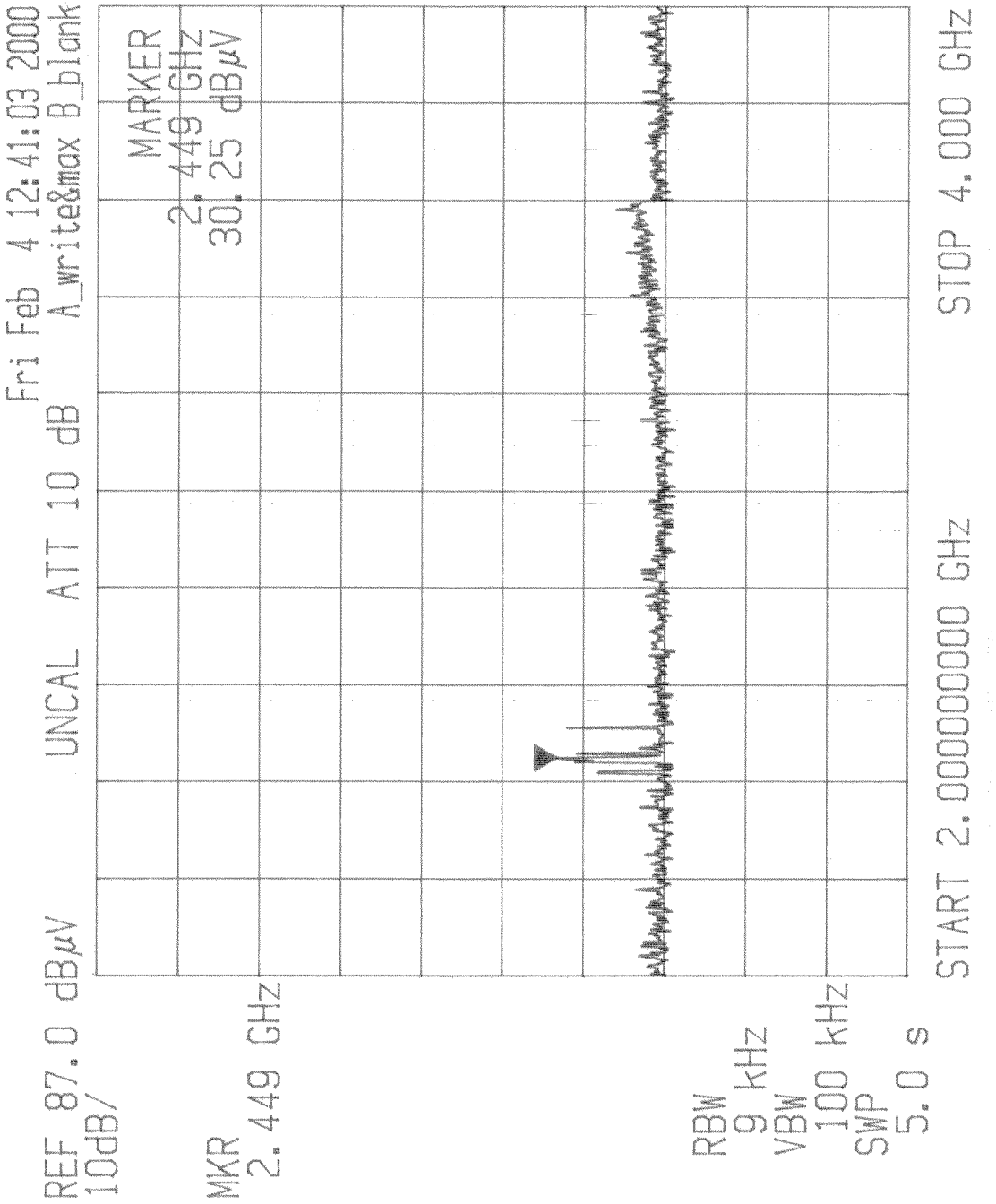
Plot 3 Horizontal polarisation – average mode



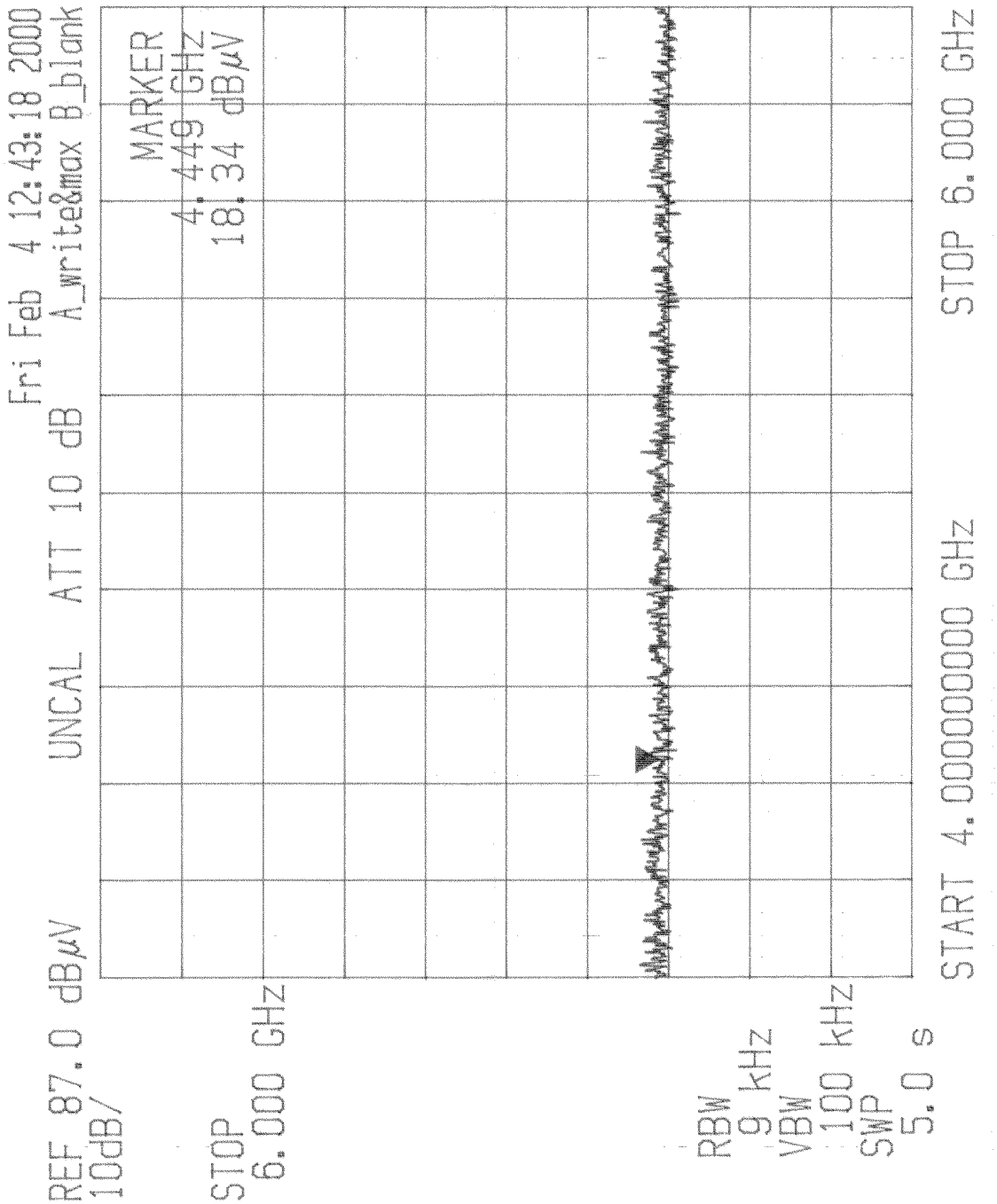
Plot 4 Vertical polarisation – average mode



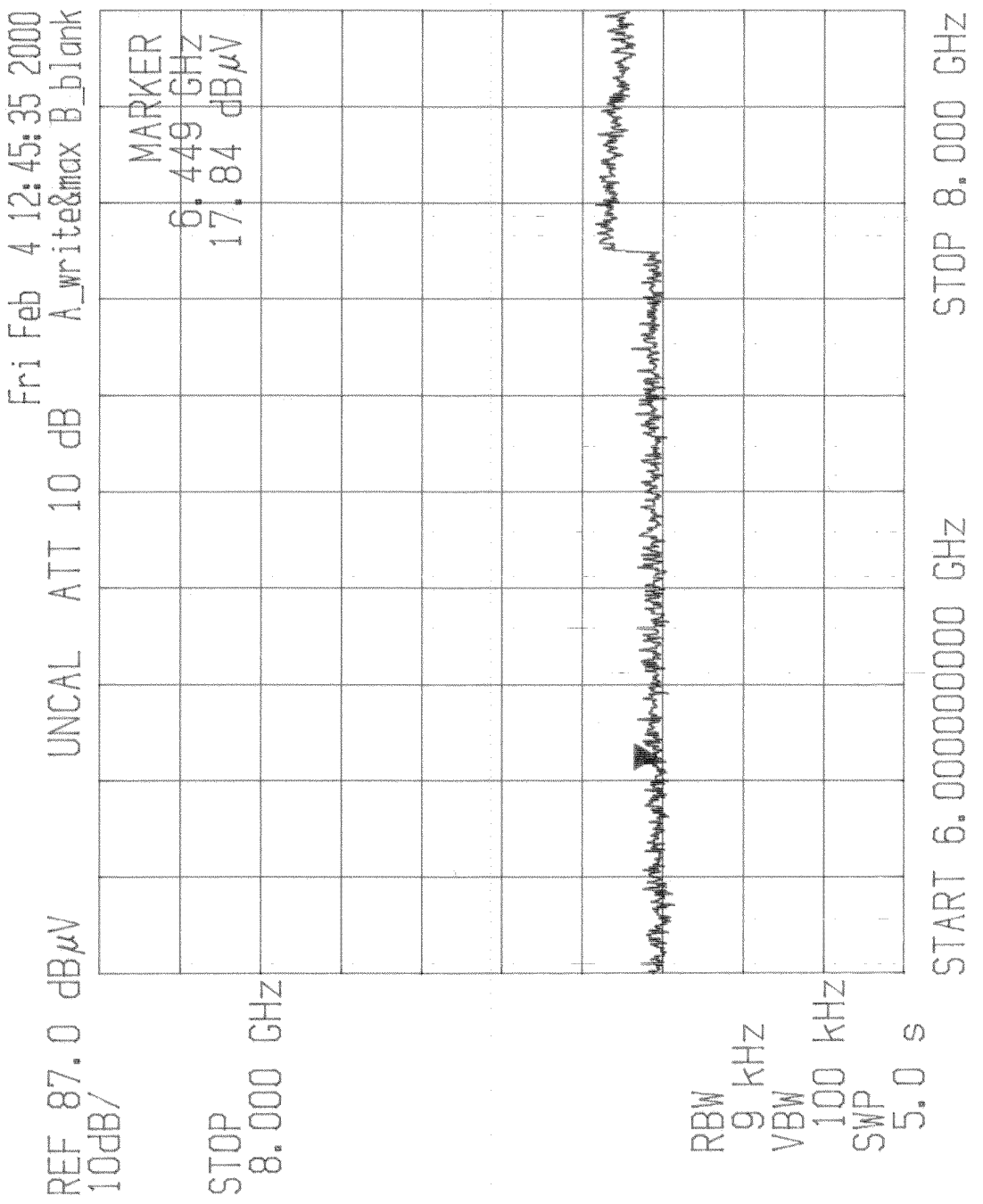
Plot 5 Ambient levels



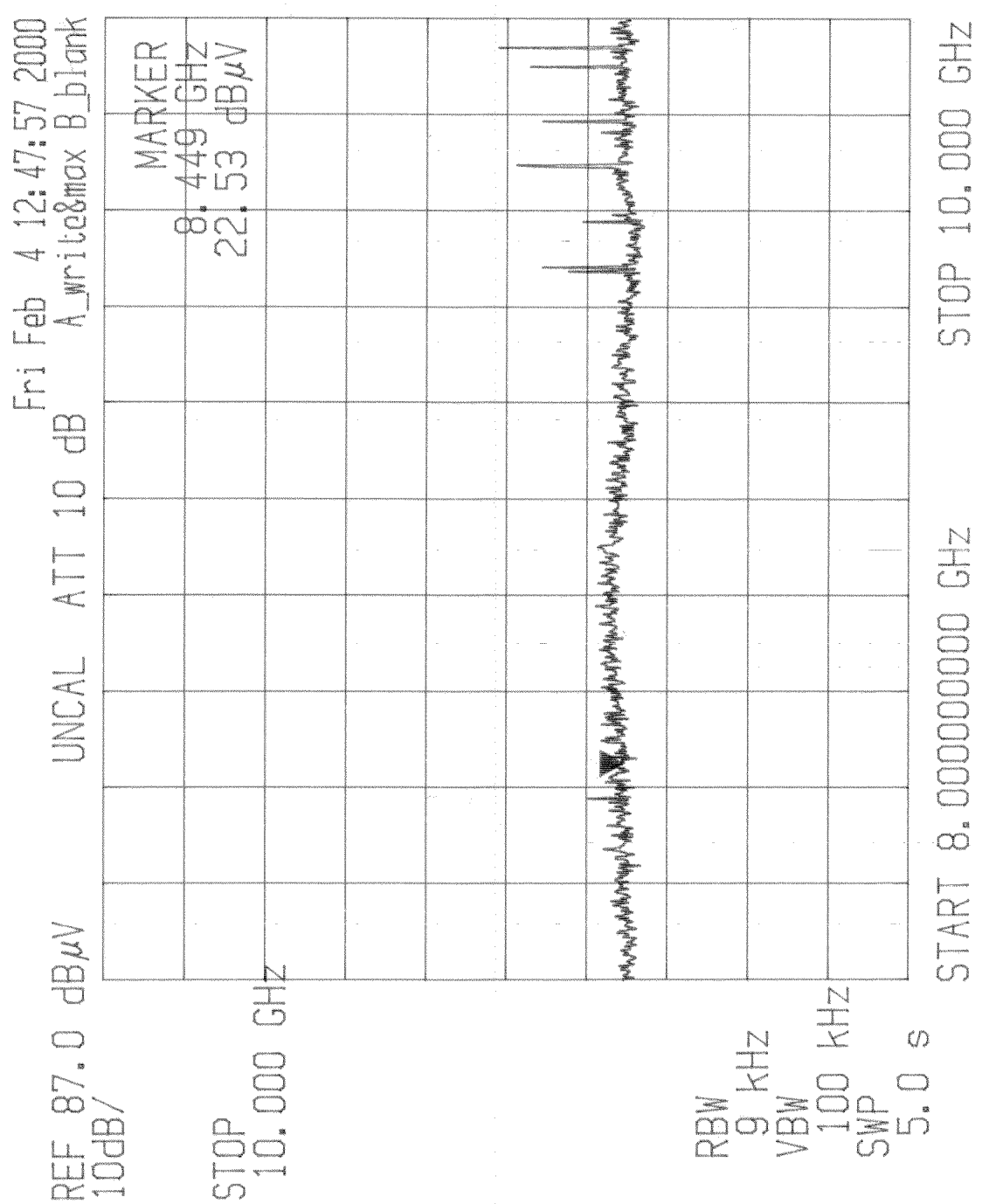
Plot 6 Ambient levels



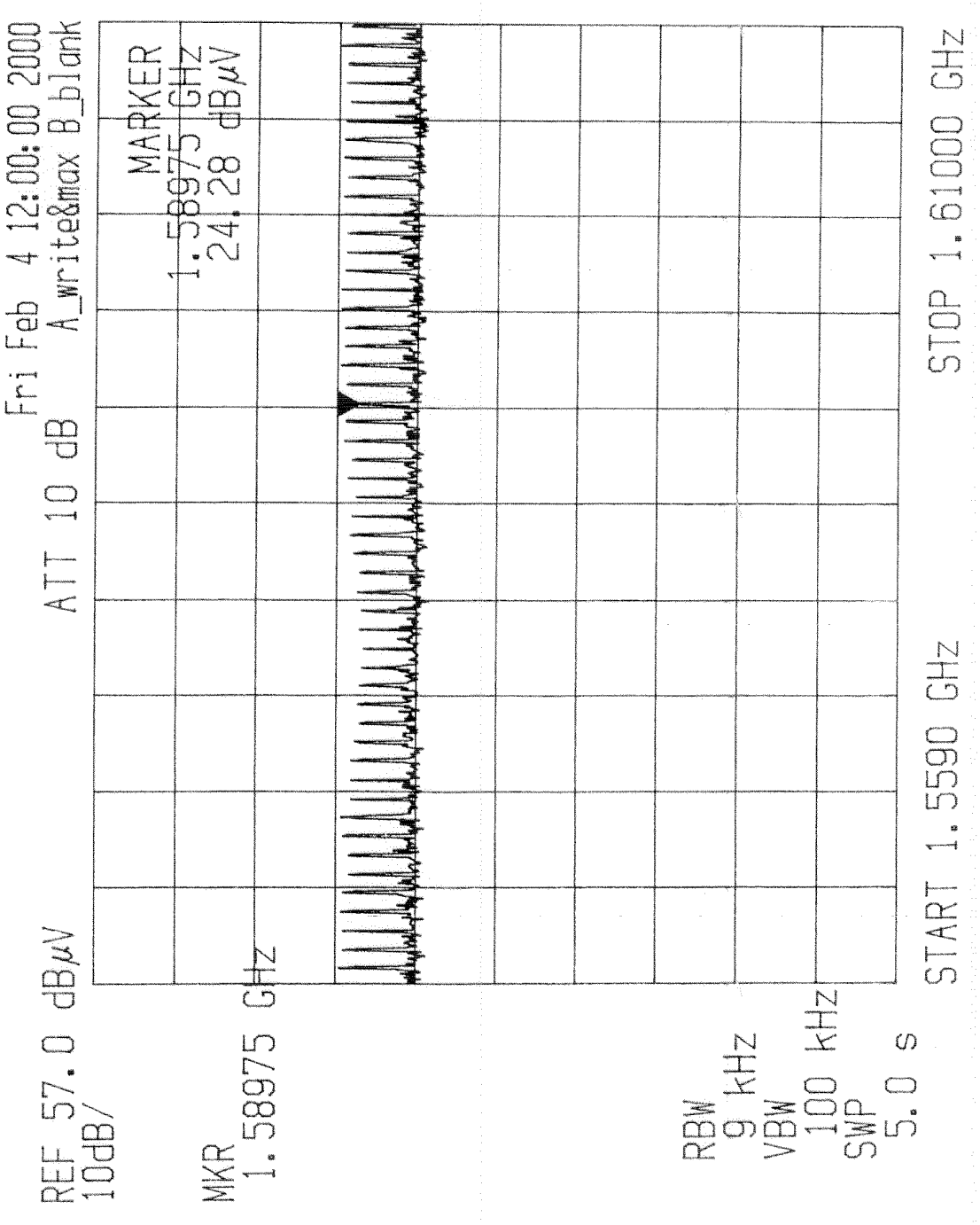
Plot 7 Ambient levels



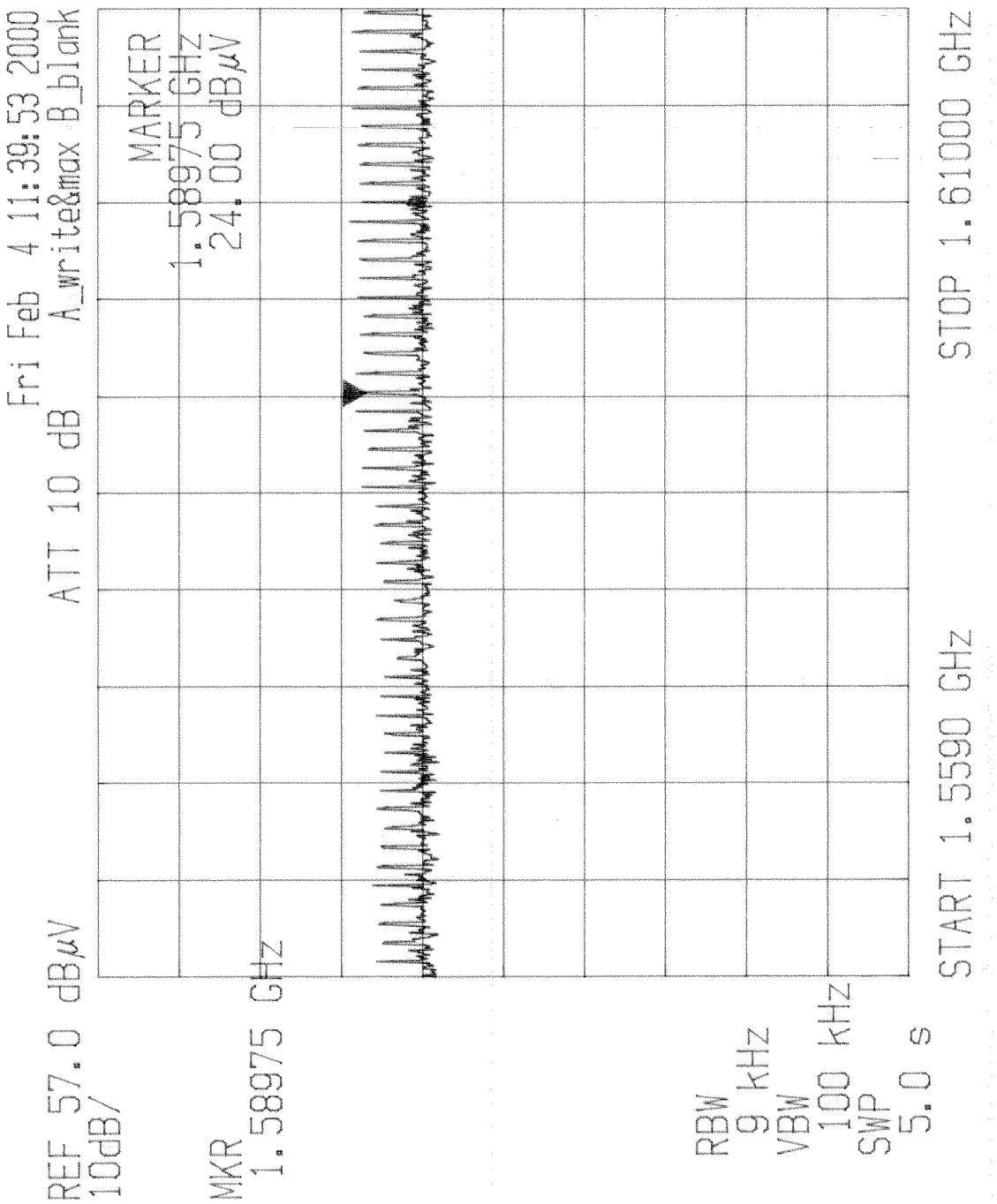
Plot 8 Ambient levels



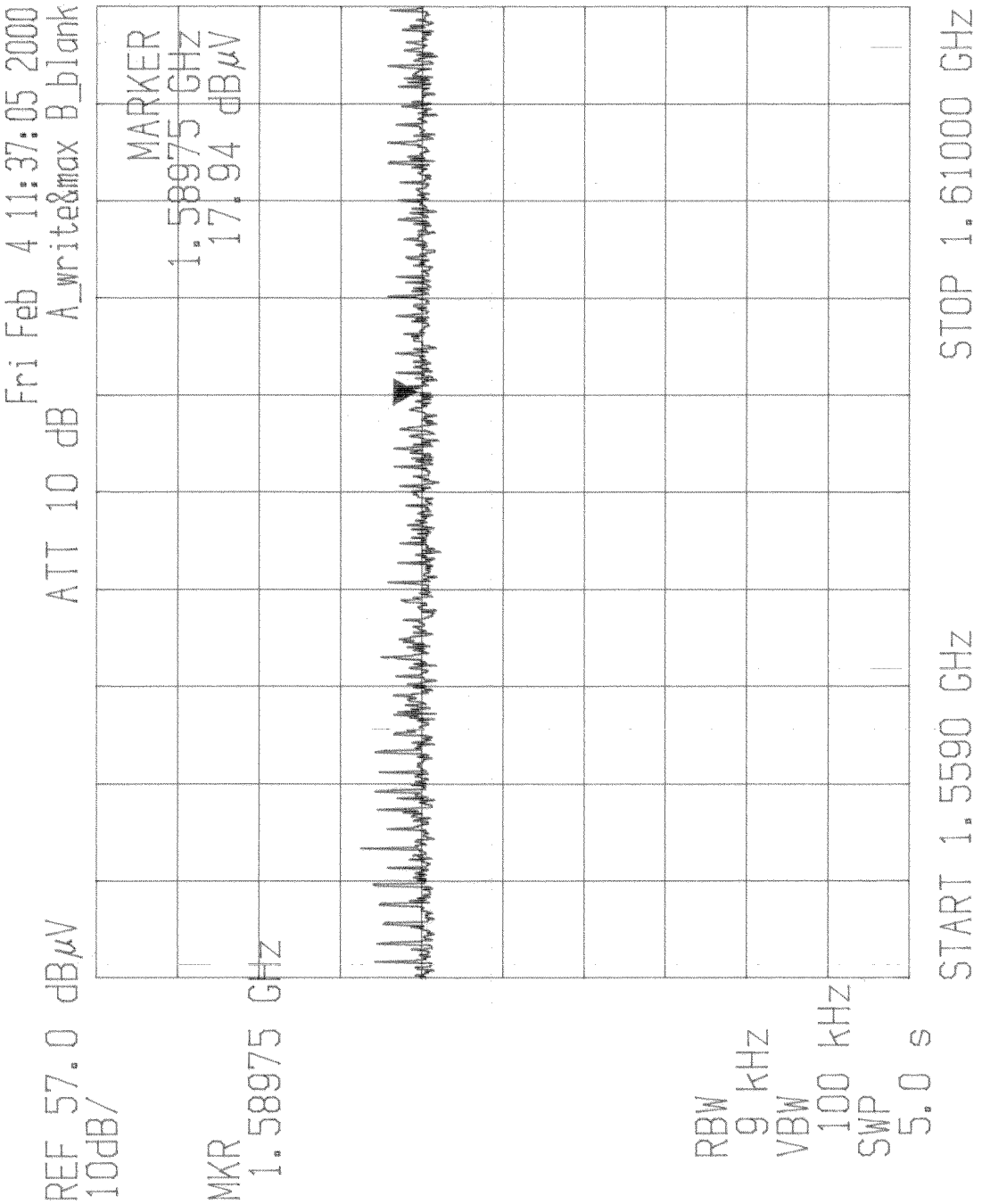
Plot 9 Ambient levels



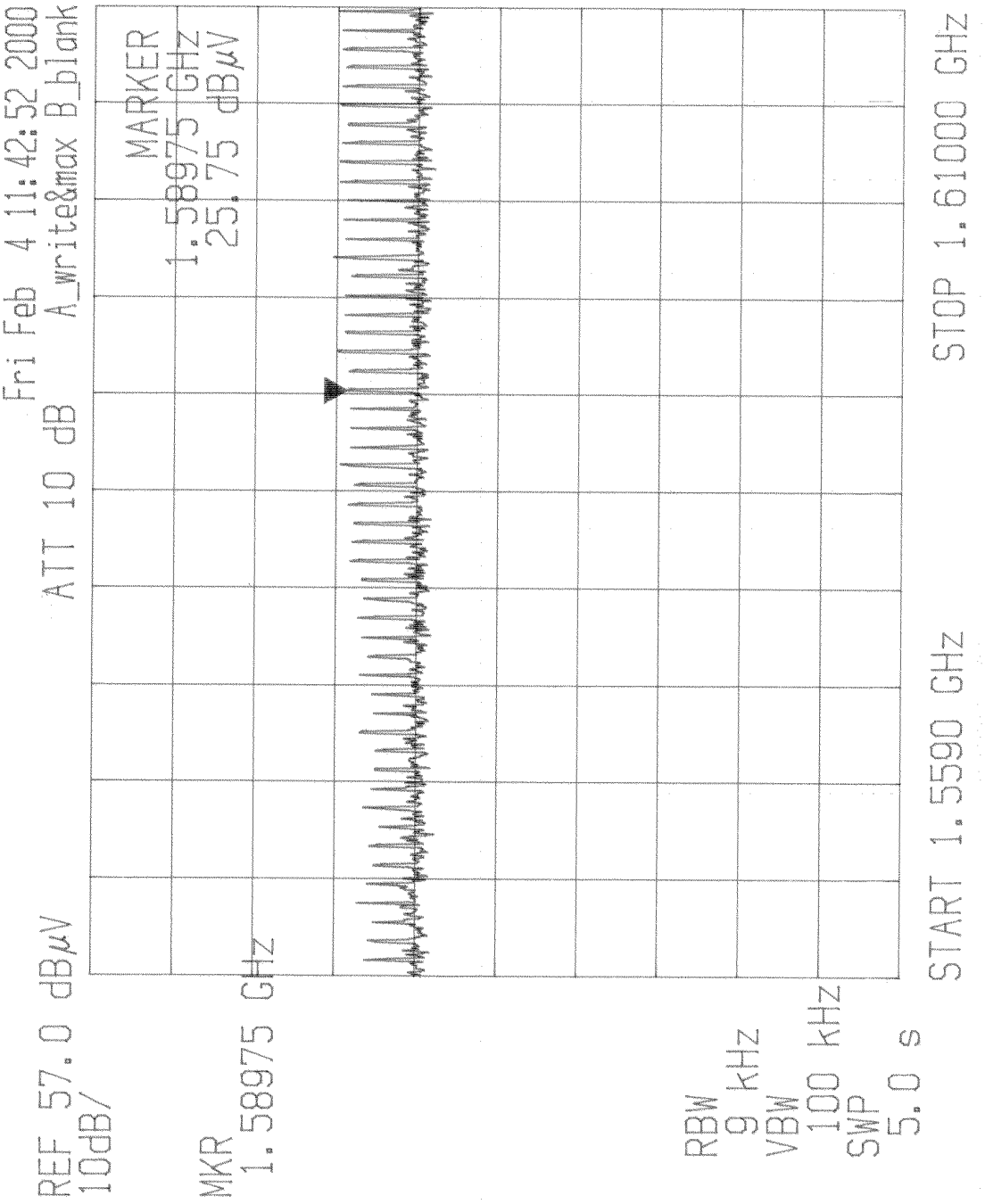
Plot 10 Vertical polarisation – central position – 1.0 m high



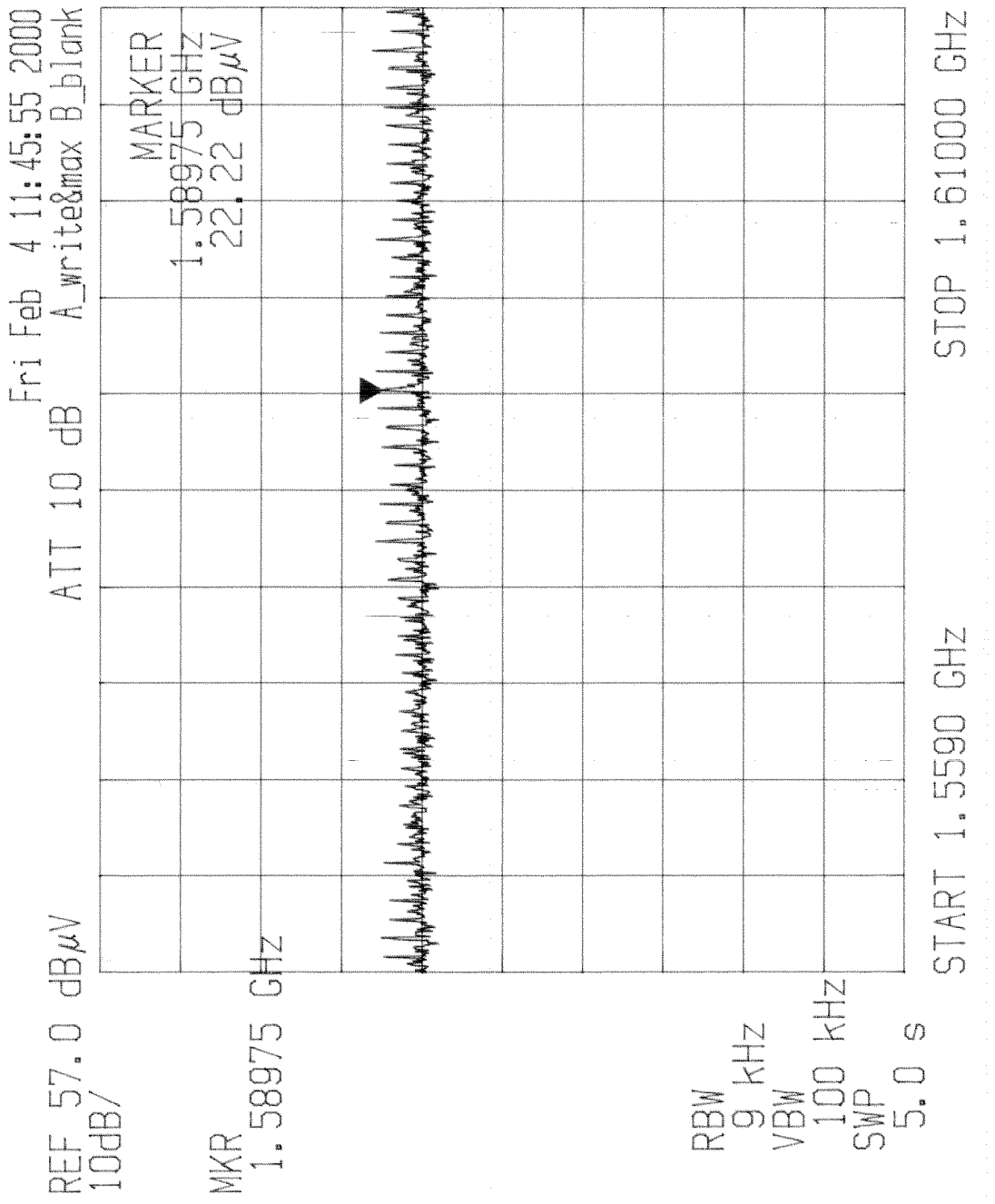
Plot 11 Vertical polarisation – 0.5 m right



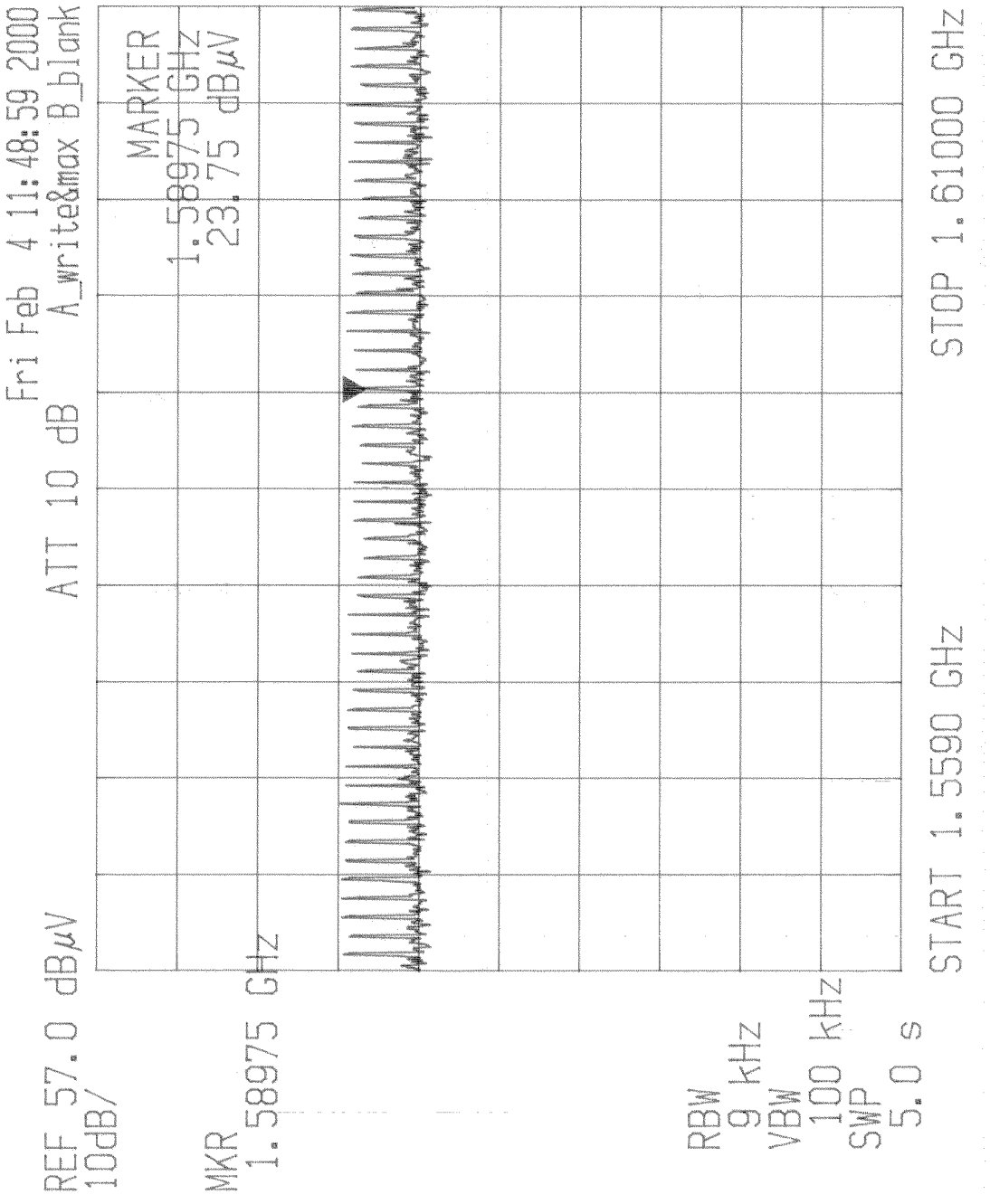
Plot 12 Vertical polarisation – 1.0 m right



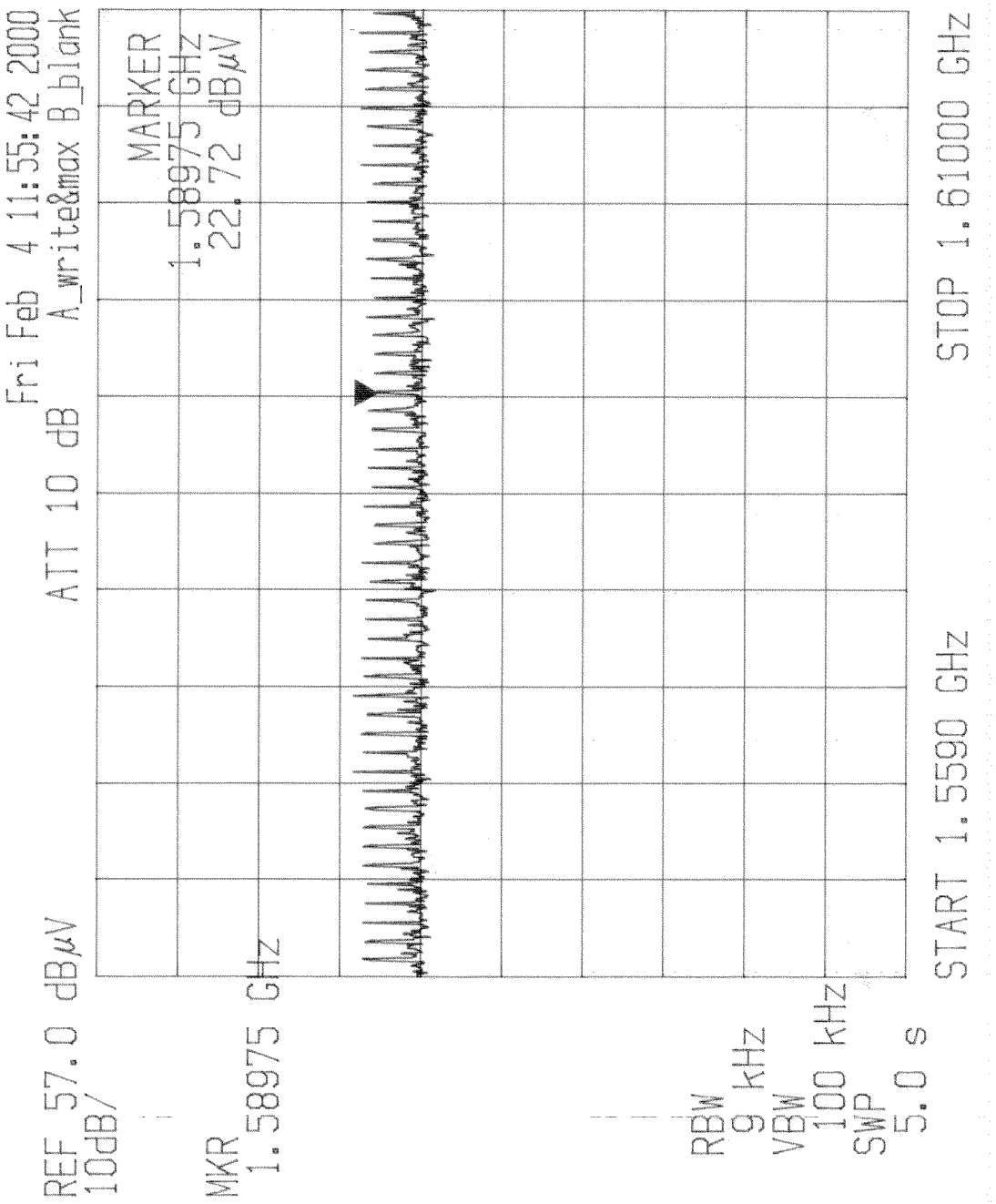
Plot 13 Vertical polarisation – 0.5 m left



Plot 14 Vertical polarisation – 1.0 m left



Plot 15 Vertical polarisation – central position – 1.45 m high



Plot 16 Vertical polarisation – central position – 1.90 m high

Annex 3

Photographs of EUT

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Photograph Number : 4252/223/01
Model Number : SPRscan 250 MHz
External View : General arrangement for testing

Photograph Number : 4252/223/02
Model Number : SPRscan 250MHz
External View : Arrangement of the SPR for testing

Photograph Number : 4252/223/03
Model Number : SPRscan 250MHz
External View : Arrangement of the SPR for testing

Photograph Number : 4252/223/04
Model Number : SPRscan 250MHz
External View : Arrangement of the SPR for testing

Annex 4

Test Plan

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SPRscan FCC Certification Test Plan

Date: 31.01.2000 Author: N G I Hunt

Introduction

This document specifies the tests that need to be done to provide formal proof that SPRscan 250 MHz antenna meets the requirements of FCC specification 47 CFR 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 dBµV/m, 88 – 216 MHz :- 43 dBµV/m, 216-960 MHz :- 46 dBµV/m, above 960 MHz :- 54 dBµV/m.

The SPRscan 250 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 250 MHz system with the prototype US variant of the 250 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. However, a peak scan on the OATS is also essential as the grass will have different attenuation characteristics. 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 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. 3m 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.

Annex 5

Chart showing Antenna Double Ridge Horn Calibration

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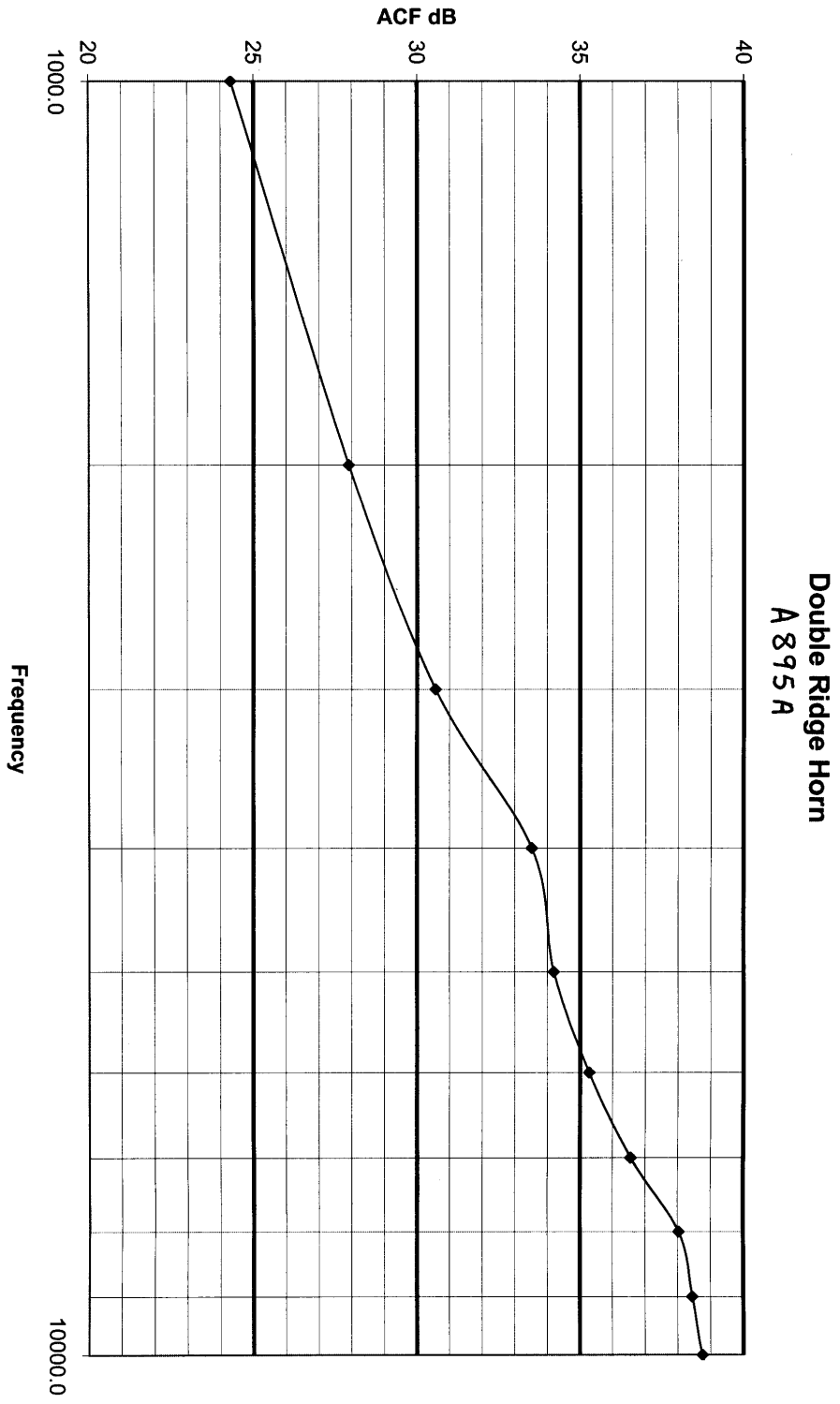
ACF dB
20
25
30
35
40
1000.0
10000.0
Frequency
Double Ridge Horn
A 895 A

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Annex 6

Chart showing Pre Amplifier Calibration

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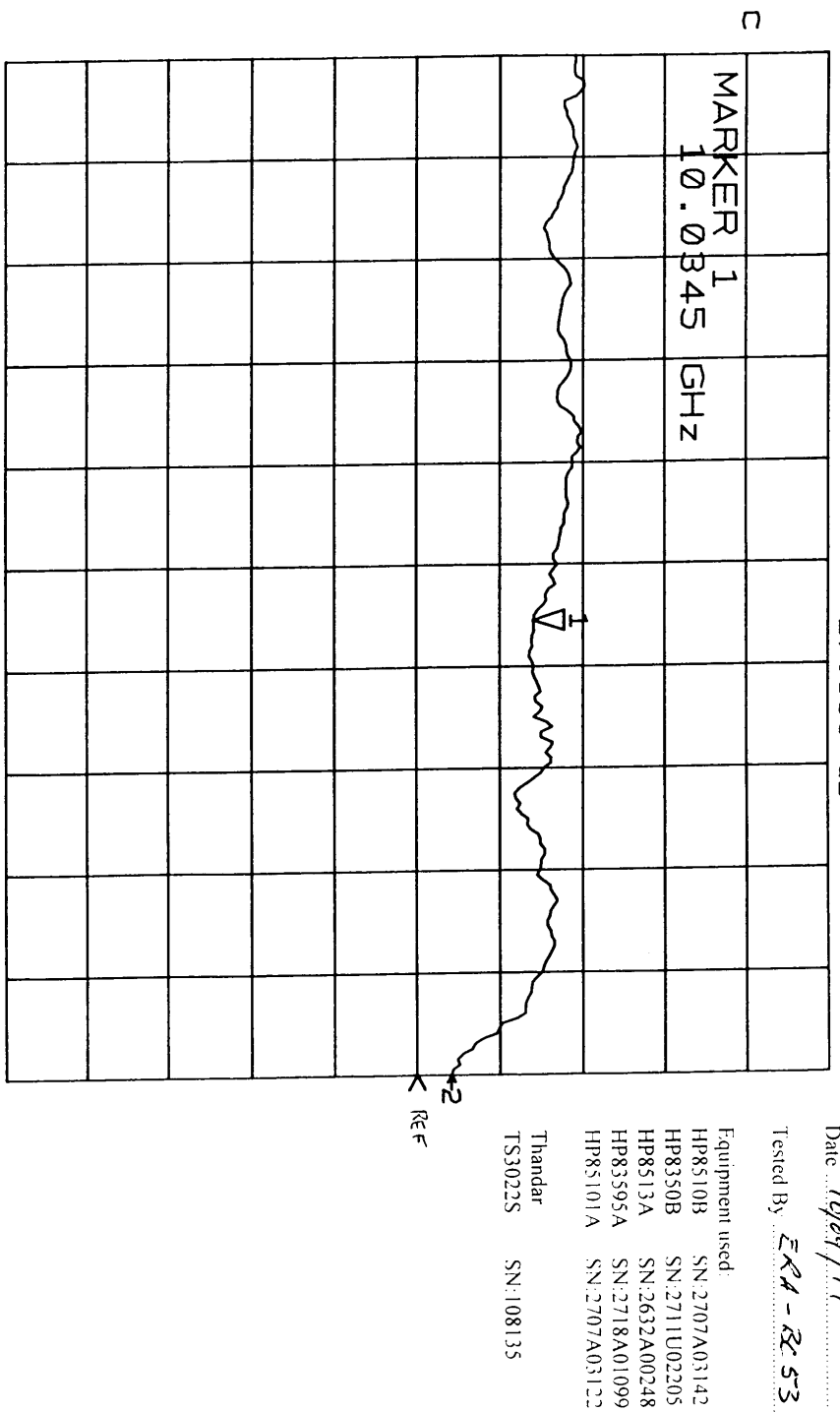

Date ..19/09/99.....

Tested By ..ERA - RC 53.....

Equipment used

HP8510B	SN:2707A03142
HP8350B	SN:2711U02205
HP8513A	SN:2632A00248
HP83595A	SN:2718A01099
HP85101A	SN:2707A03122
Thandar	
TS3022S	SN:108135

Microwave Pre Amplifier C122C

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Annex 7

Table showing Cables B540B and B541B Correction Factors

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CERTIFICATE OF CALIBRATION

Issued by:
IFR Ltd
Measurement Standards Laboratory
Longacres House
Norton Green Road
Stevenage Herts
United Kingdom SG1 2BA
Tel: +44(0)1438 742200
Laboratory Direct Fax: +44(0)1438 772040

NAMAS
CALIBRATION
No. 0006

Certificate Number
21155

Date of issue
16th October 1999

Page 1 of 3 pages

S Littleworth
Approved Signatory

Tested for:	ERA Technology Limited Main Store Cleeve Road Leatherhead Surrey KT22 7SA.
Order No:	S701234
Reference No:	289804/01/001/200
Date received:	12th October 1999
Calibration date:	16th October 1999
Apparatus tested:	Cable Assembly. Identity Number B540B

The ambient temperature was 20°C ±1.0°C and the relative humidity was 50% ±10% RH.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

Continued.....

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IFR Limited

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Page 2 of 3 Pages

The cable assembly was tested in a 50Ω coaxial system in which the source and load VSWR did not exceed 1.05:1. The insertion loss of the Cable Assembly was determined at the frequencies requested by the customer. The results are shown in table 1.

Table 1

Test Frequency GHz	Measured Insertion Loss dB
1	0.53
2	0.77
3	1.00
4	1.25
5	1.26
6	1.35
7	1.53
8	1.72
9	1.78
10	1.92
11	2.02
12	2.29
13	2.33
14	2.38
15	2.36
16	2.35
17	2.59
18	2.65

The limits of uncertainty for the measurements in Table 1 do not exceed the following:

to 1 GHz	±0.04 dB
1GHz to 10GHz	±0.12 dB
10GHz to 18 GHz	±0.13 dB

continued.....

CERTIFICATE OF CALIBRATION

Issued by:
IFR Ltd
Measurement Standards Laboratory
Longacres House
Norton Green Road
Stevenage Herts
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Tel: +44(0)1438 742200
Laboratory Direct Fax: +44(0)1438 772040

NAMAS
CALIBRATION
No. 0006

Certificate Number
21156

Date of issue
18th October 1999

Page 1 of 3 pages

S Littleworth
Approved Signatory

Tested for:	ERA Technology Limited Main Store Cleeve Road Leatherhead Surrey KT22 7SA.
Order No:	S701234
Reference No:	289812/01/001/200
Date received:	12th October 1999
Calibration date:	16th October 1999
Apparatus tested:	Cable Assembly. Identity Number B541B

The ambient temperature was 20°C ±1.0°C and the relative humidity was 50% ±10% RH.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

Continued.....

B5413

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IFR Limited

Certificate Number 21156

Page 2 of 3 Pages

The cable assembly was tested in a 50Ω coaxial system in which the source and load VSWR did not exceed 1.05:1. The insertion loss of the Cable Assembly was determined at the frequencies requested by the customer. The results are shown in table 1.

Table 1

Test Frequency GHz	Measured Insertion Loss dB
1	0.79
2	1.10
3	1.41
4	1.67
5	1.79
6	20.8
7	2.27
8	2.57
9	2.57
10	2.79
11	2.94
12	3.05
13	3.13
14	3.23
15	3.43
16	3.37
17	3.98
18	3.68

The limits of uncertainty for the measurements in Table 1 do not exceed the following:

to 1 GHz	±0.04 dB
1GHz to 10GHz	±0.12 dB
10GHz to 18 GHz	±0.13 dB

continued.....