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ELECTROMAGNETIC ENVIRONMENT MEASUREMENTS OF PRT SYSTEMS AT "TRANSPO®72" VOLUME V TTI SYSTEM

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JANUARY 1974

FINAL REPORT

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16. Abstract

An X-Y plot is made of the radiated Electromagnetic signals and noise between 1KHz and 50KHz at each of the four Personalized Rapid Transit (PRT) sites at Dulles International Airport. The PRT systems were operated individually to establish the signal characteristics of each system. A spectrum analyzer was used to view the frequency spectrum broadband prior to recording and a Polaroid scope camera was used in conjunction with the spectrum analyzer to photograph signals between 50KHz and 50MHz. This frequency range was sufficiently broad to cover all command and control frequencies of the four PRT systems.

The purpose of the measurements program was to establish some base line information on the electromagnetic signal characteristics in the Dulles area in the event there was an interaction between the PRT Command and Control systems and the Federal Aviation Administration Air Traffic Control equipment.

The measurements obtained during this series of tests will be used for a comparison with data obtained with no PRT systems operating and later with all four systems operating simultaneously.

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PREFACE

The work described in this report was performed as part of a test program conducted to evaluate the Safety and Performance characteristics of the four Personalized Rapid Transit Systems (PRT) on display at Transpo® 72. Sponsored by the U.S. Department of Transportation, Transpo® 72 was the first United States International Transportation Exposition and was intended to demonstrate to the general public new technologies in transportation.

The PRT demonstration program was the responsibility of the Urban Mass Transportation Administration (UMTA) and was conducted to provide detailed engineering test data in addition to providing mature candidates for an Urban demonstration.

RADIATED FIELD NOISE MEASUREMENTS

TTI SYSTEM - TRANSPO® '72

1. INTRODUCTION

This technical report presents the data obtained in the performance of tests for radiated field noise at the personal rapid transit (PRT) system of TTI at TRANSPO® '72 - Dulles Airport, Washington, D. C. This report covers one of the four tests defined under Item 2 of Contract No. DOT-TSC-375, and as performed by National Scientific Laboratories.

Item 2 calls for the performance of radiated field noise measurements from each PRT system in the frequency range from 1 KHz to at least 50 MHz, with one PRT system on. The objective of the test was to gather operational data for each of the PRT systems. Such data will enable characterization of the noise increase attributable to system operation, when considered in comparison with the ambient data collected and documented* previously by NSL.

The measurements reported in this document were made during the forenoon of July 24, 1972.

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* Technical Report, Item 1, Ambient Radiated Field Noise Survey, PRT Systems - TRANSPO® '72, March 1972, Contract DOT-TSC-375, Department of Transportation, Transportation Systems Center, 55 Broadway, Cambridge, Massachusetts 02142

2. METHOD OF MEASUREMENT

All measurements were made using test setups and instruments as nearly identical as possible to those used during ambient testing.

2.1 Instruments

The measurements made in the frequency range from 1 KHz to 50 KHz were performed using a Fairchild Model EMC-10 Interference Analyzer. This device is a battery-operated calibrated RFI/EMI meter, which, when operated as a narrowband tunable device, covers the frequency range from 1 KHz to 50 KHz. The receiver incorporates a meter circuit of such design that signal levels are expressed in decibels on a linear scale. In addition, the receiver incorporates circuitry providing buffered, voltage outputs in proportion to meter indication and tuned frequency. A Hewlett Packard Model 3005B X-Y Plotter was driven from the receiver.

Signals were obtained from the electro-magnetic environment by use of either an NSL verticle top loaded whip antenna mounted on a cathode-follower or a Fairchild ALP-10 Magnetic Field Antenna. The latter antenna is directional in the horizontal plane, therefore, measurements were made for North/South and East/West orientations.

The measurements made in the 50 KHz to 60 MHz frequency range were performed using a Hewlett Packard Model 8552/8553A Spectrum Analyzer. The analyzer is an extremely versatile instrument in that it has numerous frequency scan and bandwidth settings throughout the frequency spectrum of a few cycles up to 100 MHz. The analyzer was used in four frequency bands --50 KHz to 100 KHz, 100 KHz to 1.1 MHz, 1 MHz to 21 MHz, and 10 MHz to 60 MHz. Data was recorded photographically with a Hewlett Packard Model 198A oscilloscope camera.

Signals were obtained from the electro-magnetic environment in the 50 KHz to 21 MHz frequency range by using an NSL verticle top loaded whip electric field antenna mounted on a cathode follower. This antenna is non-directional in the horizontal plane. In the 20 MHz to 60 MHz frequency range, an EMCO Model 3104 biconical electric field antenna was utilized. This antenna is directional in the horizontal plane, therefore, measurements were made in the North/South and East/West orientations.

During the tests, the various antennas were attached to the top of a mast mounted on the NSL instrumentation van. An antenna rotator was incorporated in the antenna mast to enable rotation in azimuth. The antenna height was approximately 12 feet above ground.

The various instruments received ac power from a motor generator positioned 150 feet from the van.

2.2 Test Sites

The test sites used during the performance of the measurements were the same locations as denoted in the Item 1 report for the ambient noise tests. The sites are numbered 1 through 11 for the entire PRT area. Sites 2, 3 and 10 are located at the TTI system as shown in the map, Figure 1. A complete set of measurements was obtained at each site - magnetic field, 1 KHz to 50 KHz, and electric field, 1 KHz to 60 MHz.

2.3 Measurement Technique

Data were obtained in the 1 KHz to 50 KHz frequency range by scanning manually the EMC-10 receiver, using a 50 Hz bandwidth setting. Two recordings have been made for the two orientations (North/South, East/West) of the magnetic field antenna, and one recording for electric-field data. The scanning time per recording averaged four to six minutes.

The magnetic field recordings, denoted as MSR type test on the charts, are reproduced in the Appendix as the upper half of Pages A-2, A-3, A-10, A-11, A-18 and A-19. The dB scale refers to the level at the instruments input connector. Some of the charts have two amplitude scales. Located somewhere along the bottom of the chart is an upside down letter "Y" which denotes the point of changeover from the scale on the left side to the scale on the right side. The lower chart on each page is a plot of approximately one level in each major frequency increment of the chart directly above it. Peaks were selected

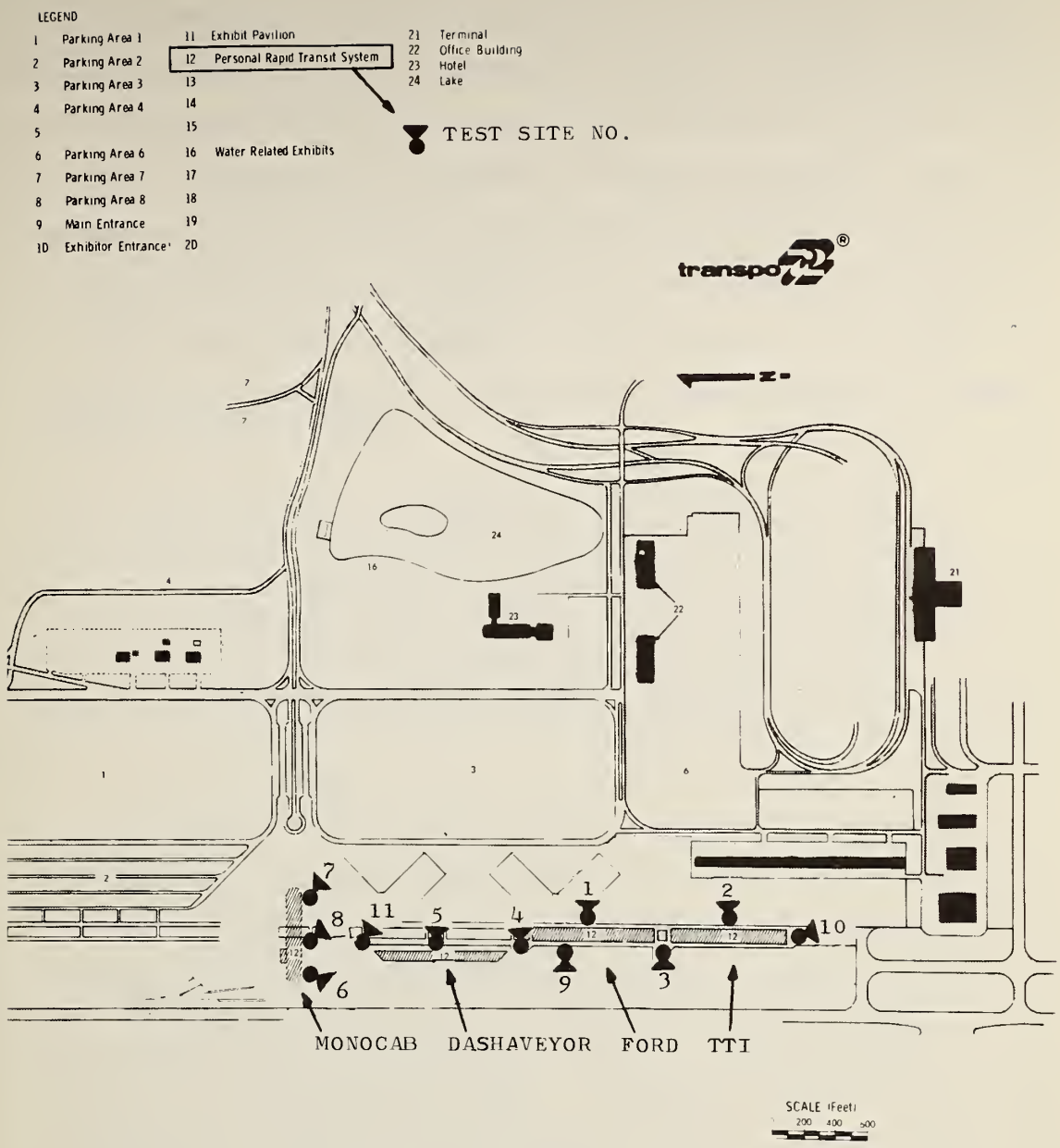


FIGURE 1. PRT TEST SITE LOCATIONS

wherever available. A correction factor for the antenna (antenna amplitude response is non-linear with frequency) has been included in the levels plotted in the lower graphs. In the upper charts, noise peaks recorded in the top major amplitude division are out of the calibrated range of the instrumentation system. Thus, the levels plotted for peaks that enter the upper division are plotted as having an amplitude of the highest level indicated numerically on the chart for that particular frequency.

The electric field chart recordings, denoted as ESR type test on the charts, are reproduced in the Appendix on pages A-4, A-12, and A-20. The antenna employed has a constant correction factor for all frequencies, and it has been included in the scale designations on these charts.

Electric field data for the 50 KHz to 60 MHz frequency range were obtained as photographic recordings of spectrum analyzer amplitude/frequency CRT displays. Two recordings have been made for each frequency band - 50 KHz to 100 KHz, 100 KHz to 1.1 MHz and 1 MHz to 21 MHz. A non-directional antenna was used for the above frequencies. Four recordings were obtained for the 10 MHz to 60 MHz frequency band for which a directional antenna was employed, therefore, two recordings were made for North/South orientation and two recordings for East/West orientation. The antenna employed for the first three frequency bands has a constant correction factor for all frequencies, and this is

included in the amplitude designations for the recorded data. The antenna employed for the high frequency band has a nearly constant correction factor above 20 MHz and this factor has been included in the amplitude designations for the recorded data. Thus, the calibration levels given by the side of the photograph do not apply to frequencies from 10-20 MHz. The photographic recordings are reproduced in the Appendix on pages A-5 to A-9, A-13 to A-17 and A-21 to A-25.

3. INTERPRETATION OF DATA

The radiated field measurement data for the various tests are contained in Appendix A. During the tests, no noise peaks could be identified with specific vehicle movements, etc. Thus, the data is presented without comment, and can be used for comparative purposes with the ambient noise data of report Item 1.

4. TIME LOG

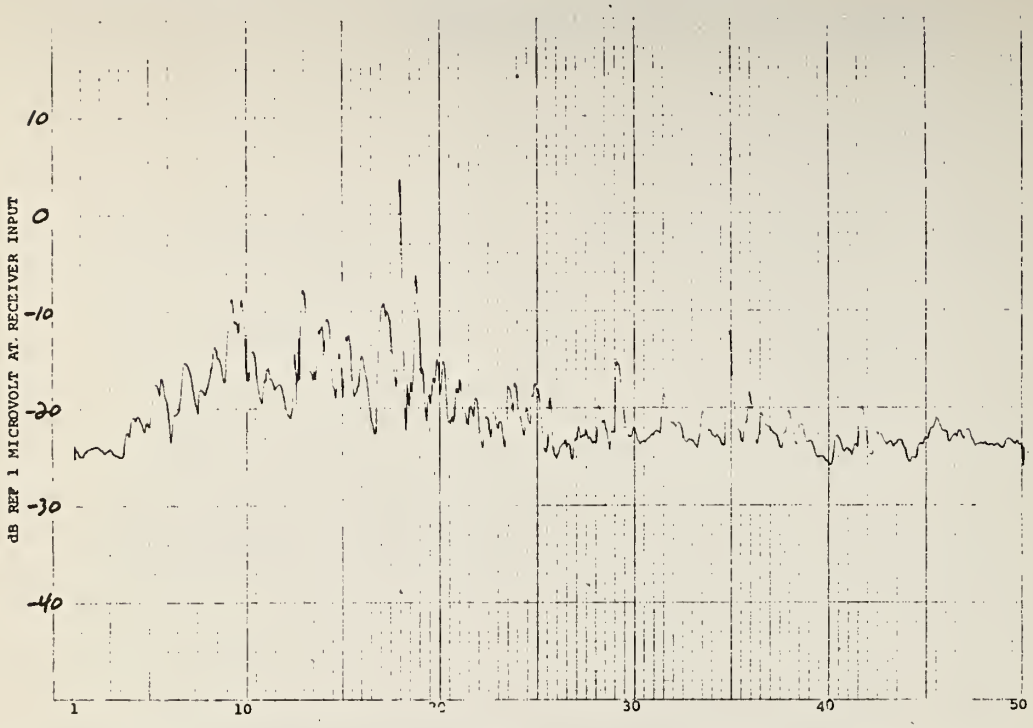
A time log of events was not written by TTI for this test period. However, NSL test personnel observed two vehicles in continuous operation during the test period of 0800 to 1250.

APPENDIX A

RADIATED FIELD MEASUREMENTS DATA

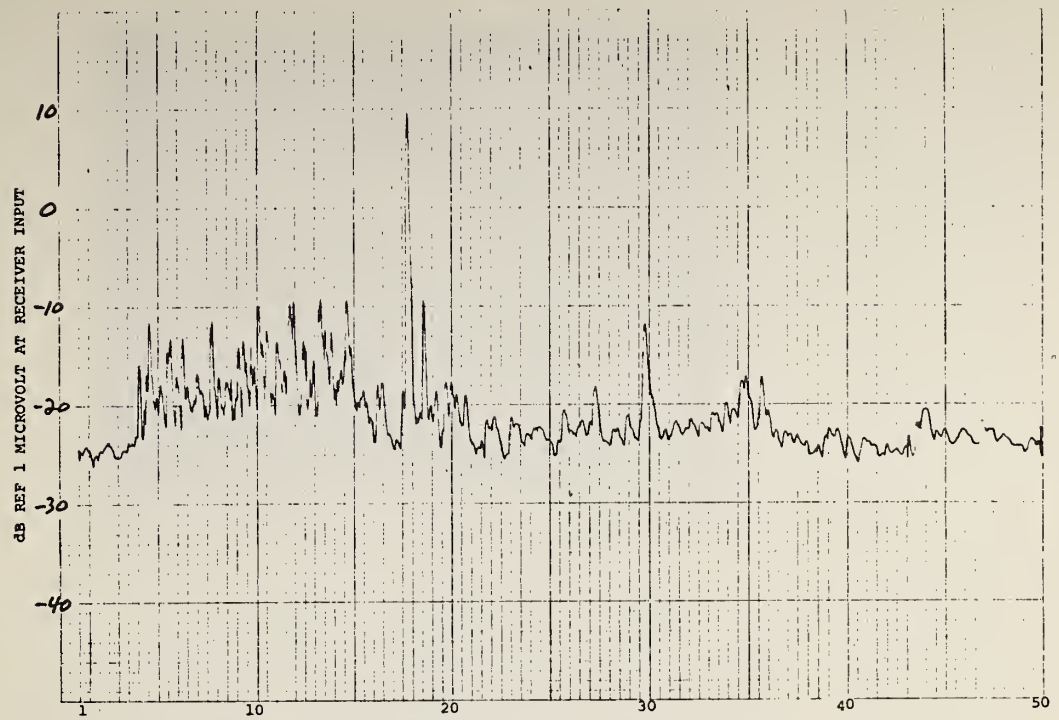
This appendix contains the data obtained during the various tests performed. The data is not presented in numerical sequence as the tests were performed, but rather by site location number from south to north--Site No. 10, 2 and 3. Further, the data are arranged in the following manner - first, magnetic field charts, then electric field charts and photographs in order of frequency progression. Data is contained herein for Test No's. 123 to 129, 130 to 138, 140 to 147.

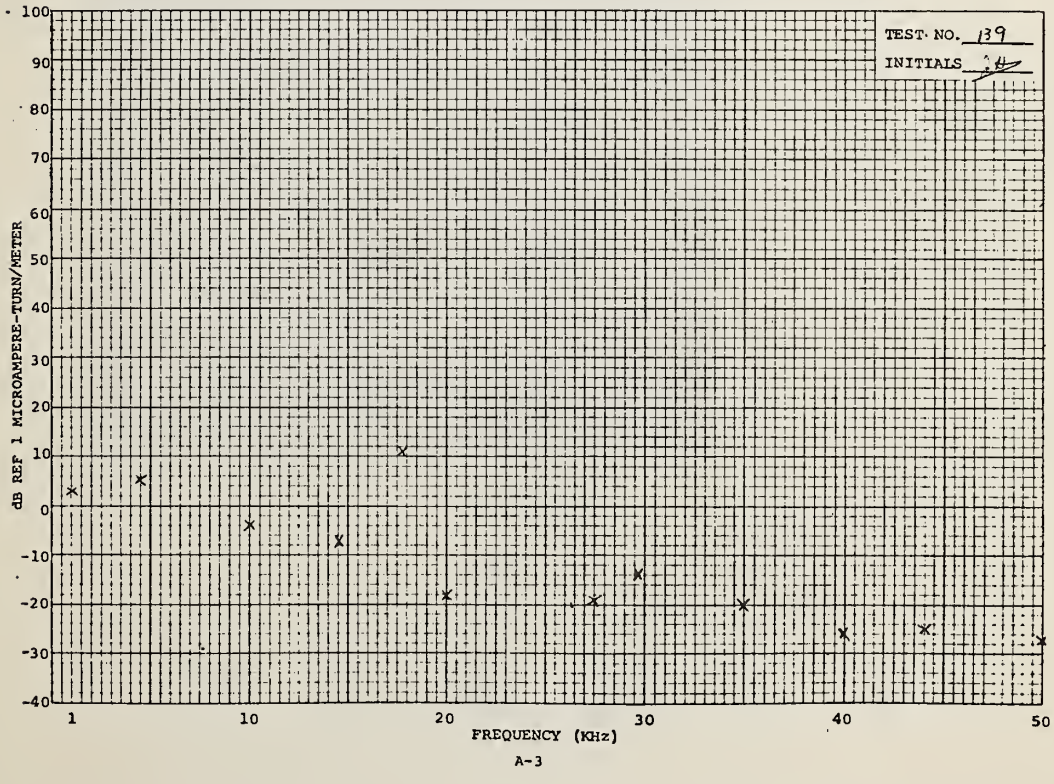
TEST NO. 138 TEST TYPE MSR E-N BANDWIDTH 50 Hz 1135
TEST SPECIMEN 2.0 10 TEST EQUIP. EMC-10 DATE 7-24-72



TEST NO. 139 TEST TYPE MSR N-S BANDWIDTH 50Hz
TEST SPECIMEN ~~26~~ 10 TEST EQUIP. EMC-10 DATE 7-24-72

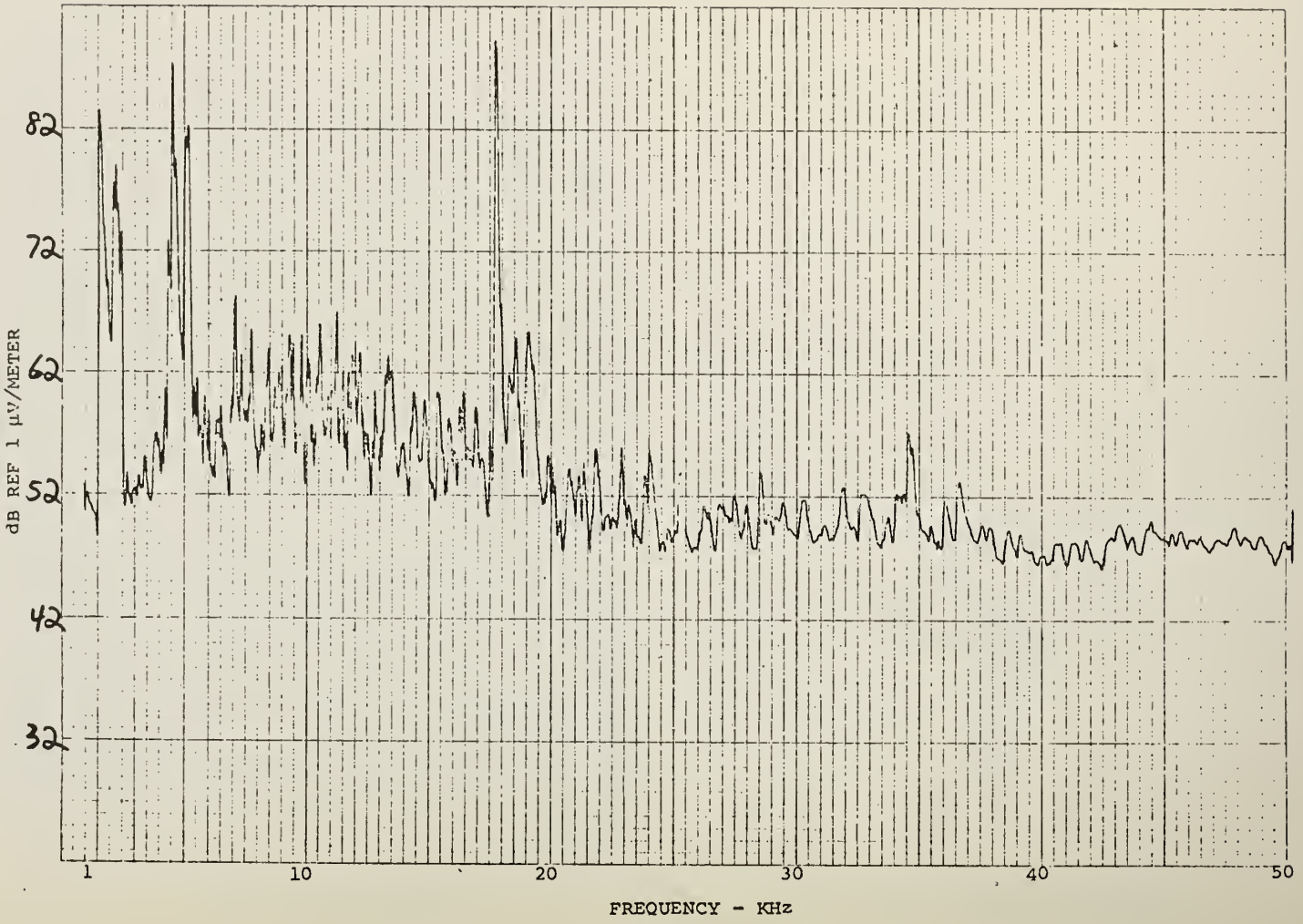
1145



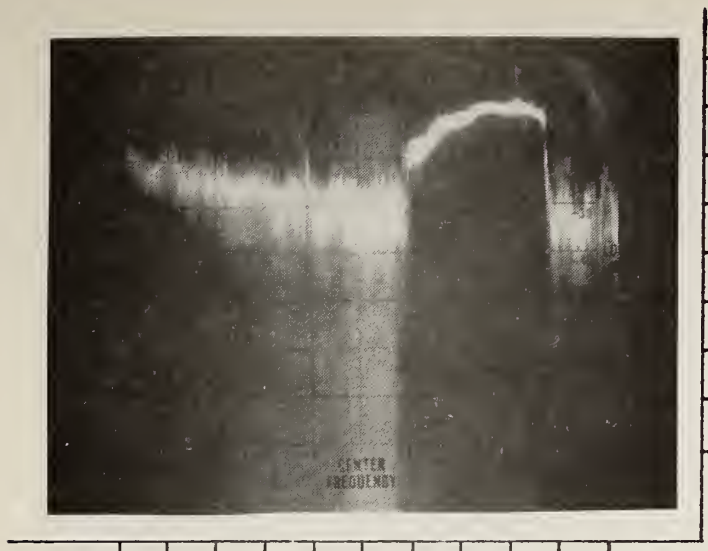


TEST NO. 136 TEST TYPE ESR BANDWIDTH 50Hz 1100

TEST SPECIMEN Sta 10 TEST EQUIP. ENC-10 DATE 7-24-72



LOCATION: SITE 10 TYPE TEST ESR DATE 7-24-72

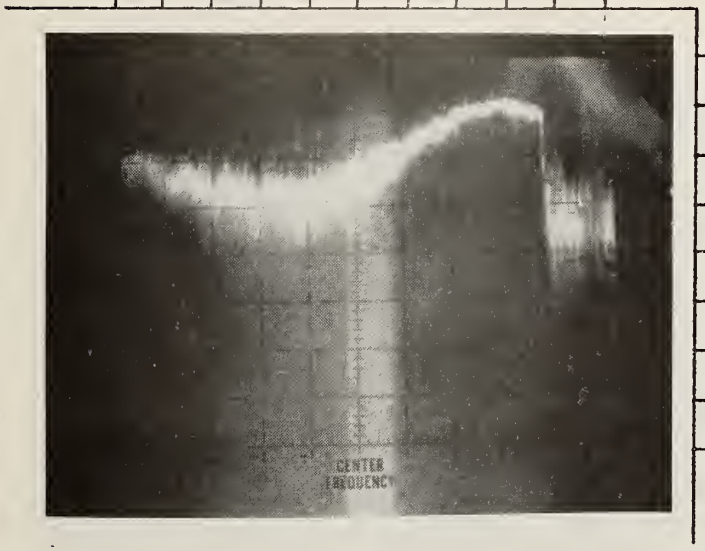


TEST 134
TIME 1030

FREQ. SCAN: 5 KHz/D

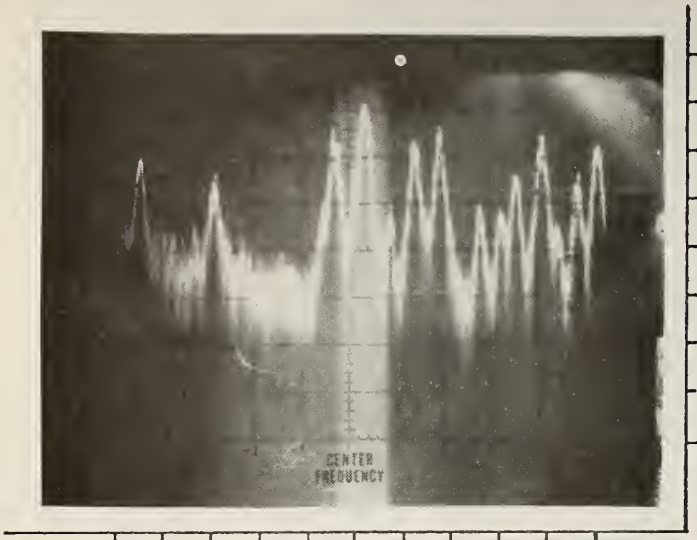
Bandwidth: 10 KHz

50 FREQ. 75 KHz 100



TEST 134
TIME 1031

LOCATION: SITE 10 TYPE TEST ESR DATE 7-24-72



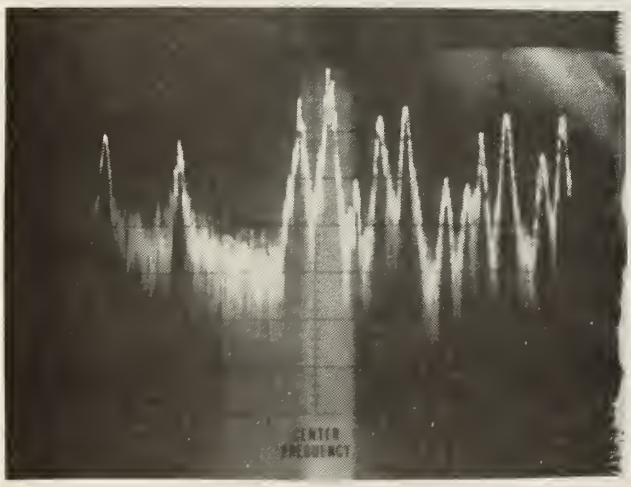
dB REF 1 μV/METER/MHz

101
81
61
41
21

TEST 133
TIME 1023

0.1 FREQ. 0.6 MHz 1.1

FREQ. SCAN: 0.1 MHz/Div
Bandwidth: 10 KHz

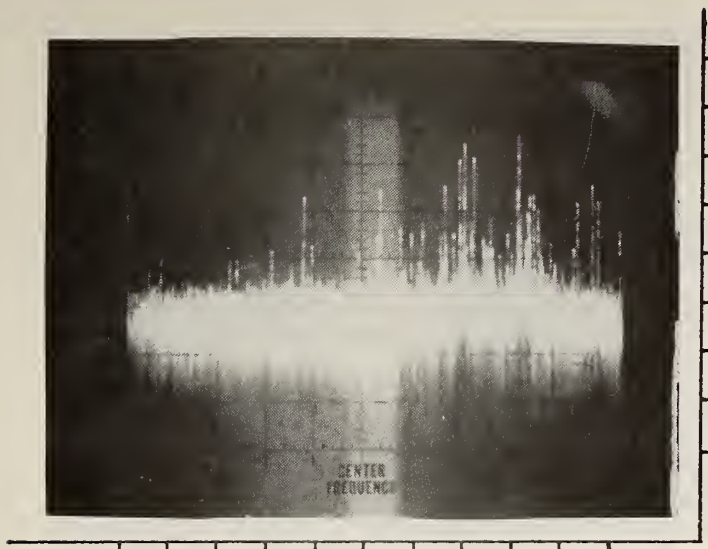


dB REF 1 μV/METER/MHz

101
81
61
41
21

TEST 133
TIME 1024

LOCATION: SITE 10 TYPE TEST ESR DATE 7-24-92



dB REF 1 µV/METER/MHz
101
81
61
41
21

TEST 132
TIME 1014

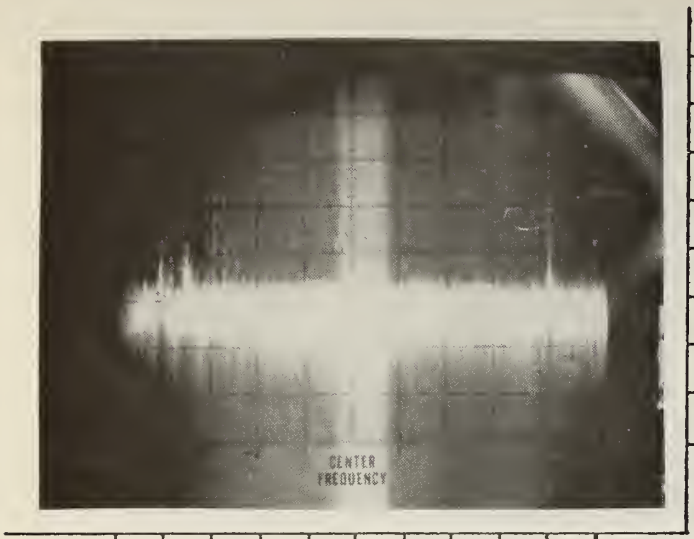
1 FREQ. 11 MHz 21

FREQ. SCAN: 2MHz/Div.
Bandwidth: 10 KHz

dB REF 1 µV/METER/MHz
101
81
61
41
21

TEST 132
TIME 1014.5

LOCATION: SITE 10 TYPE TEST ESR E/W DATE 7-24-72



dB REF 1 μV/METER/MHz

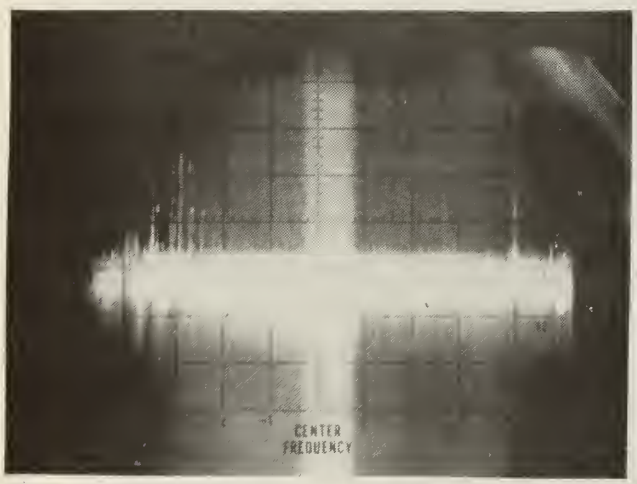
94
74
54
34
14

TEST 131
TIME 1010

10 FREQ. 35 MHz 60

FREQ. SCAN: 5MHz/Div.

Bandwidth: 10 KHz



dB REF 1 μV/METER/MHz

94
74
54
34
14

TEST 131
TIME 1011

LOCATION: SITE 10 TYPE TEST ESR N/S DATE 7-24-72

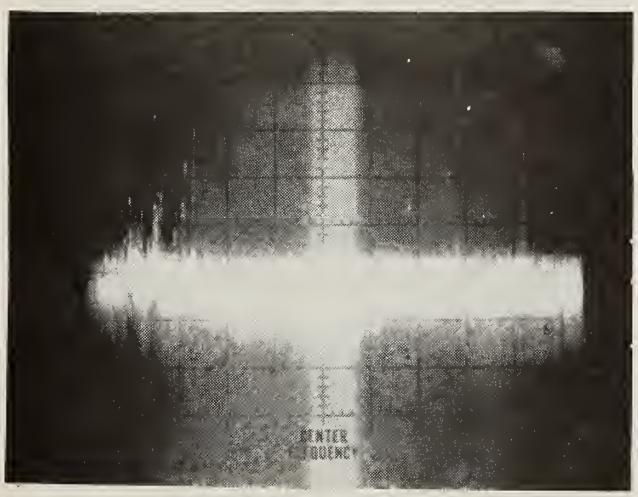
dB REF 1 μV/METER/MHz

94
74
54
34
14

TEST 130
TIME 1005

10 FREQ. 35 MHz 60

FREQ. SCAN: 5MHz/Div.
Bandwidth: 10 KHz



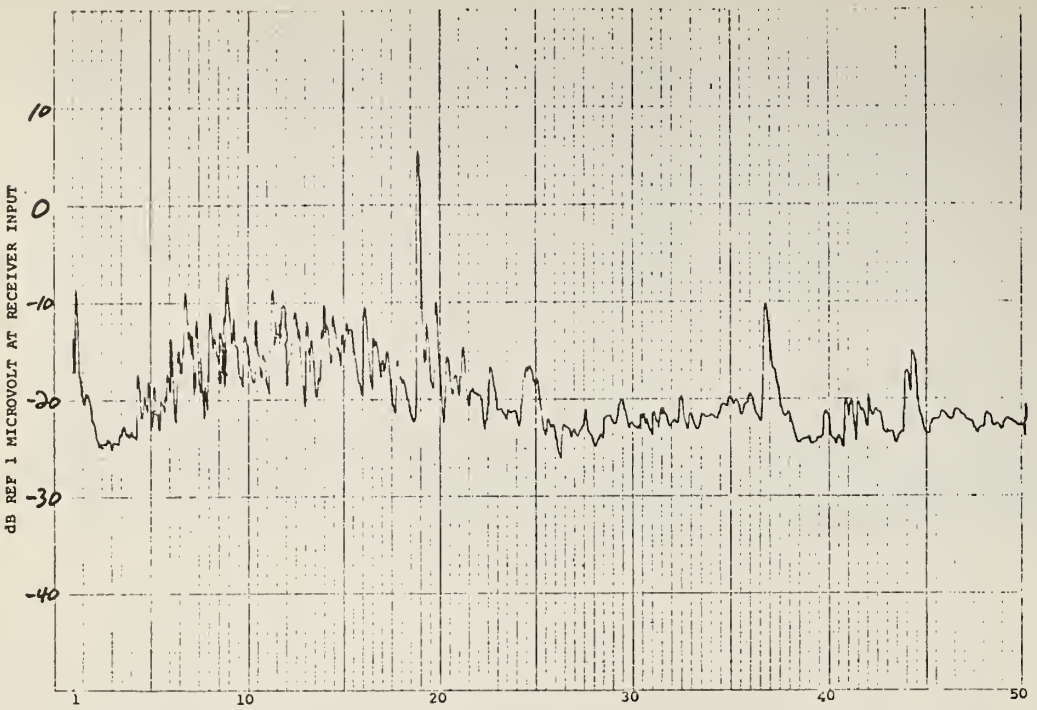
dB REF 1 μV/METER/MHz

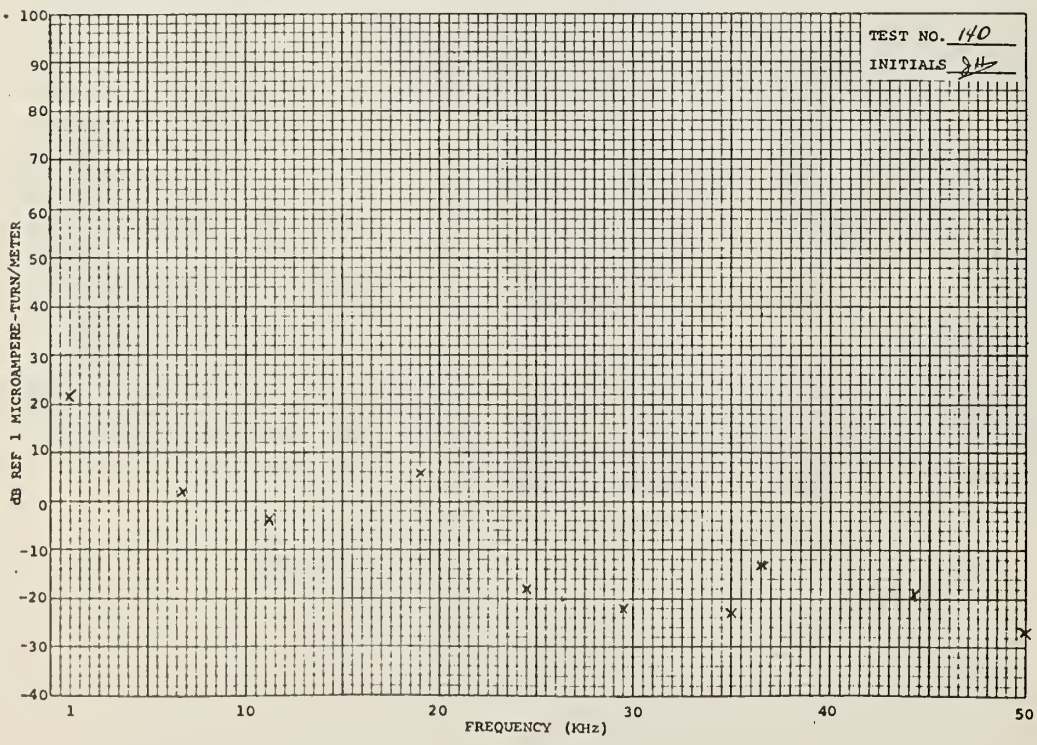
94
74
54
34
14

TEST 130
TIME 1006

TEST NO. 140 TEST TYPE MSR E-W BANDWIDTH 50 Hz
TEST SPECIMEN 302 TEST EQUIP. EMC-10 DATE 7-24-72

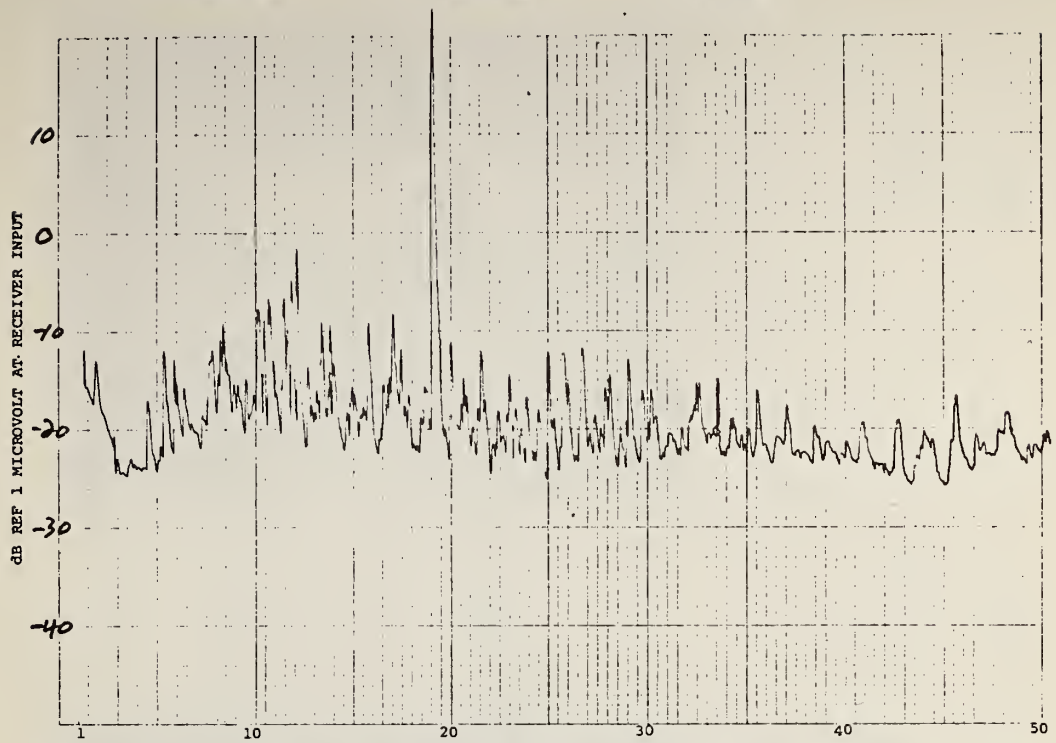
1200





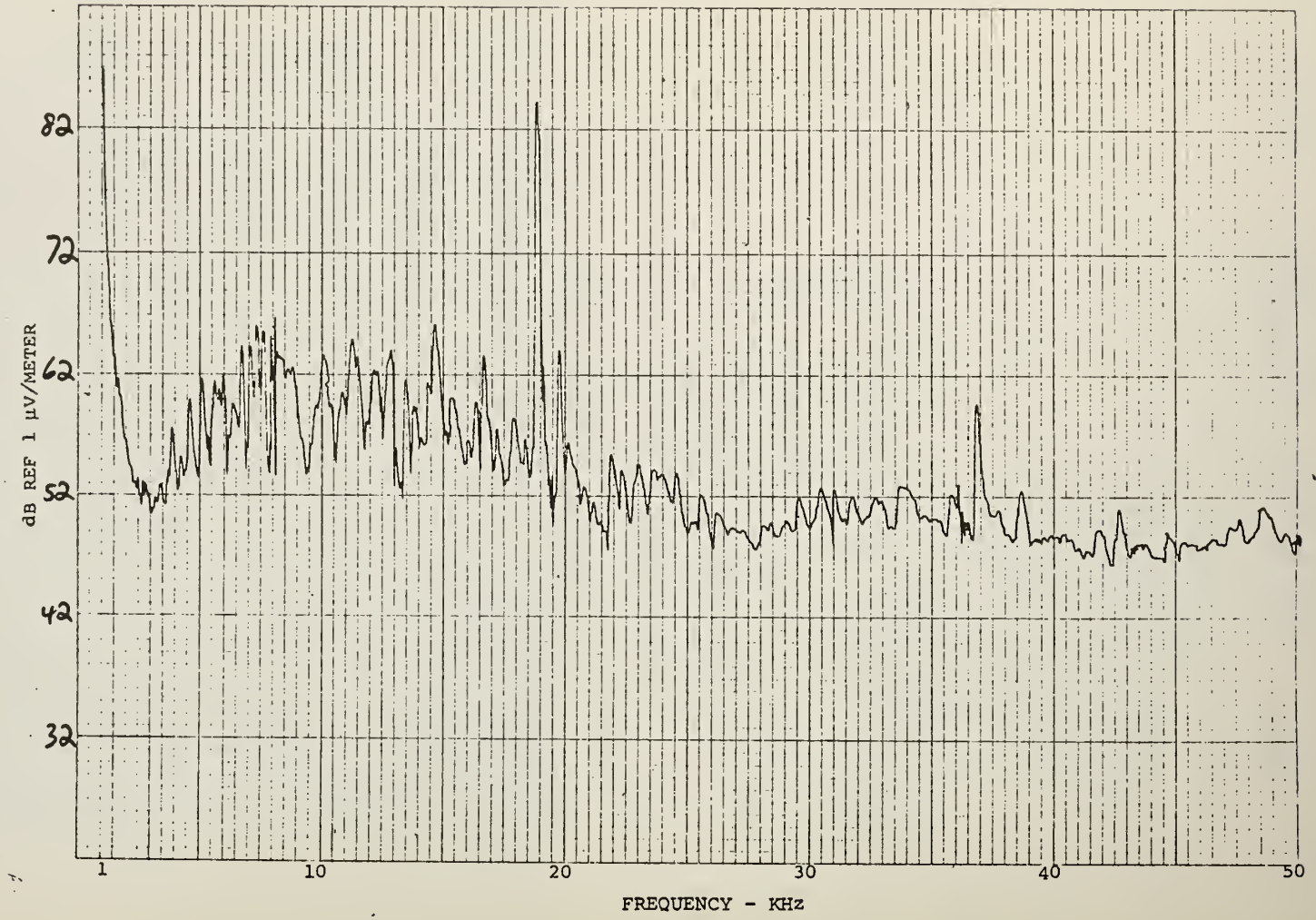
TEST NO. 141
TEST SPECIMEN 8 & 2
TEST TYPE MSR N-S
TEST EQUIP. EMC-10
BANDWIDTH 50 Hz
DATE 7-24-72

1205

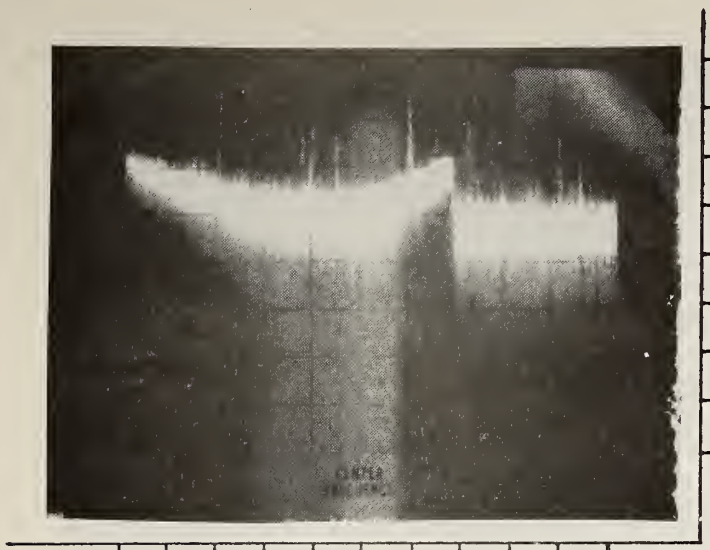


TEST NO. 142 TEST TYPE ESR BANDWIDTH 50 Hz
TEST SPECIMEN Lib 2 TEST EQUIP. EMC-10 DATE 7-24-72

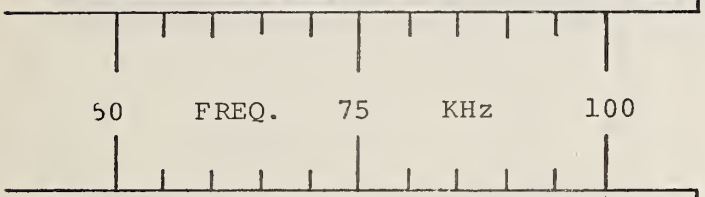
1210



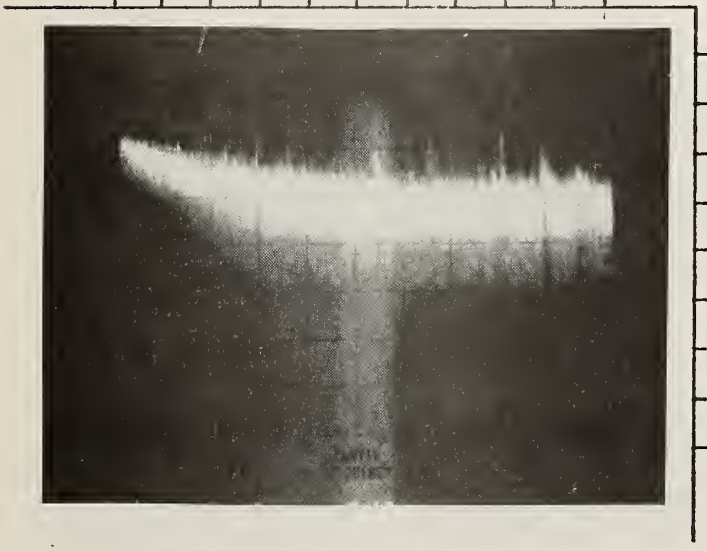
LOCATION: SITE 2 TYPE TEST ESR DATE 7-24-72



TEST 143
TIME 1225

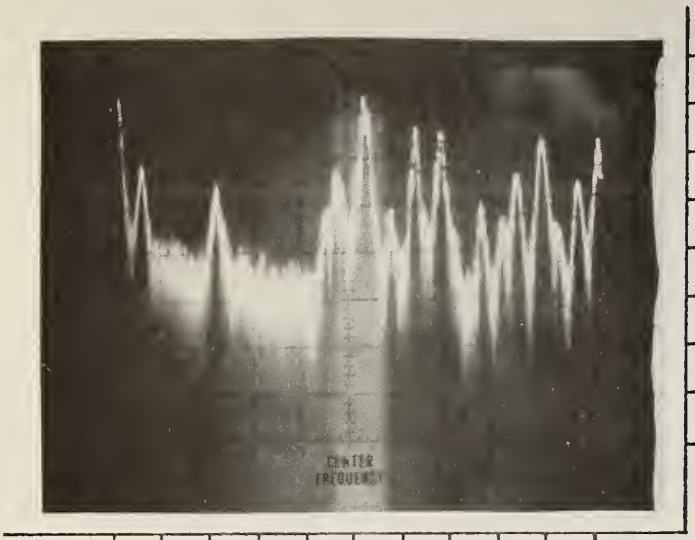


FREQ. SCAN: 5 KHz/Div
Bandwidth: 10 KHz



TEST 143
TIME 1226

LOCATION: SITE 2 TYPE TEST ESR DATE 7-24-72



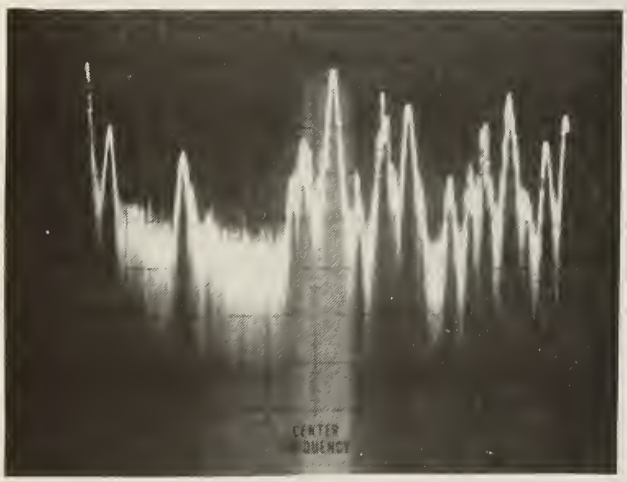
101
81
61
41
21
dB REF 1 μV/METER/MHz

TEST 144
TIME 1230

0.1 FREQ. 0.6 MHz 1.1

FREQ. SCAN: 0.1 MHz/Div.

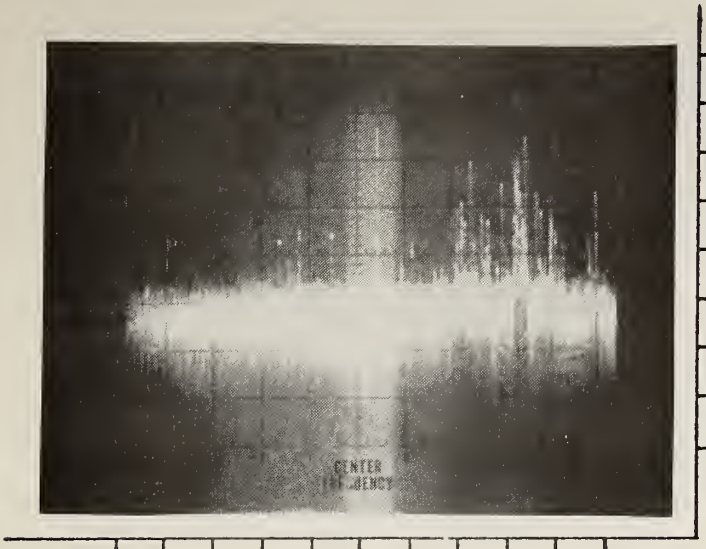
Bandwidth: 10 KHz



101
81
61
41
21
dB REF 1 μV/METER/MHz

TEST 144
TIME 1231

LOCATION: SITE 2 TYPE TEST ESR DATE 7-24-72

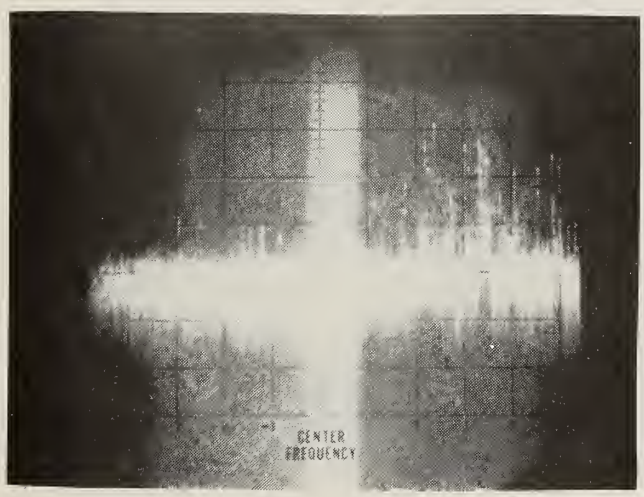


101
81
61
41
21
dB REF 1 μV/METER/MHz

TEST 145
TIME 1234

1 FREQ. 11 MHz 21

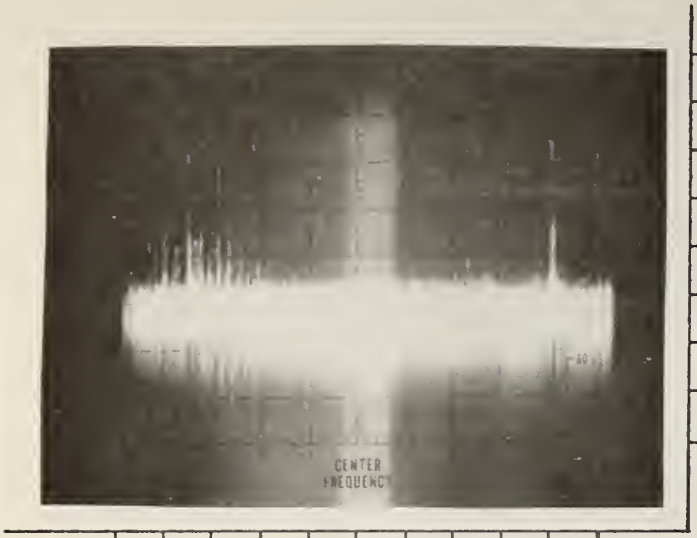
FREQ. SCAN: 2MHz/Div.
Bandwidth: 10 KHz



101
81
61
41
21
dB REF 1 μV/METER/MHz

TEST 145
TIME 1235

LOCATION: SITE 2 TYPE TEST ESR E/W DATE 7-24-72

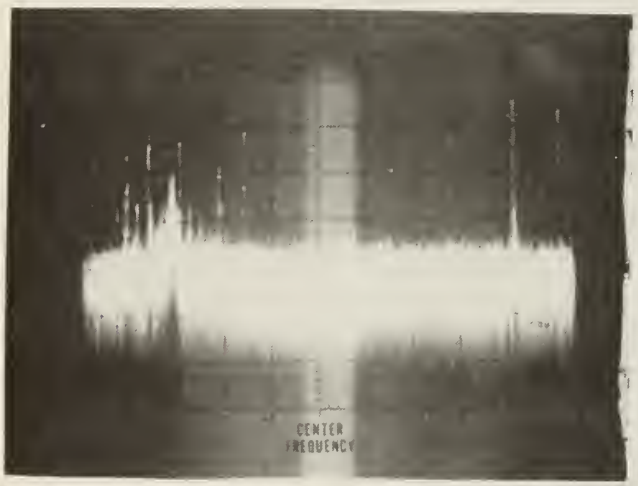


93
73
53
33
13
dB REF 1 µV/METER/MHz

TEST 146
TIME 1240

10 FREQ. 35 MHz 60

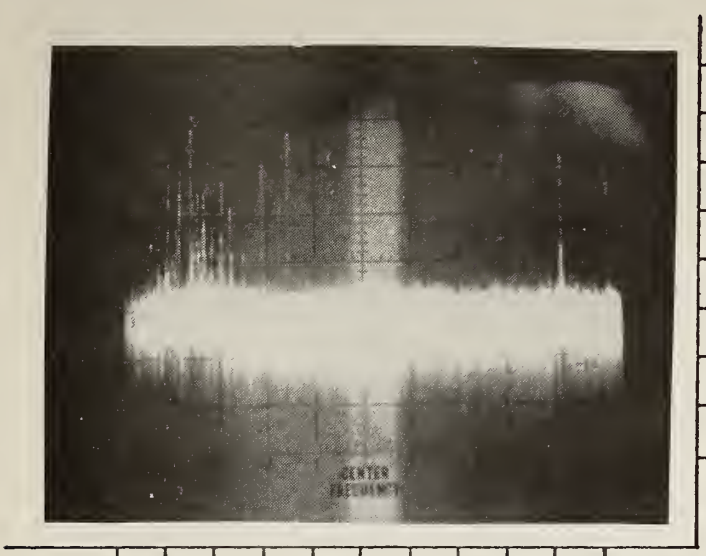
FREQ. SCAN: 5MHz/Div.
Bandwidth: 10 KHz



93
73
53
33
13
dB REF 1 µV/METER/MHz

TEST 146
TIME 1240.5

LOCATION: SITE 2 TYPE TEST ESR N/S DATE 7-24-72

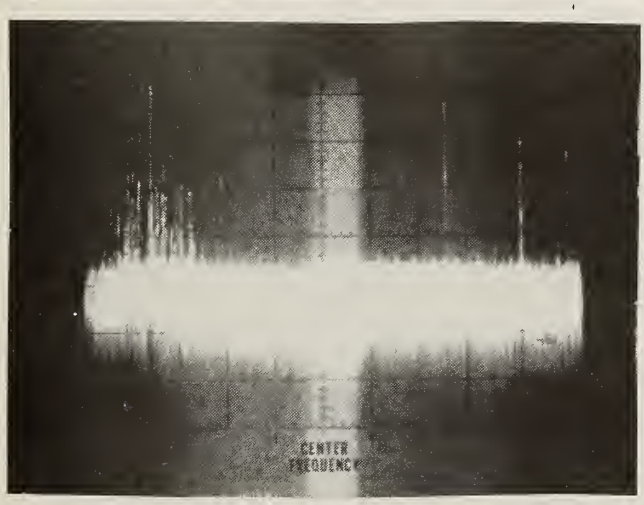


93
73
53
33
13
dB REF 1 µV/METER/MHz

TEST 147
TIME 1245

10 FREQ. 35 MHz 60

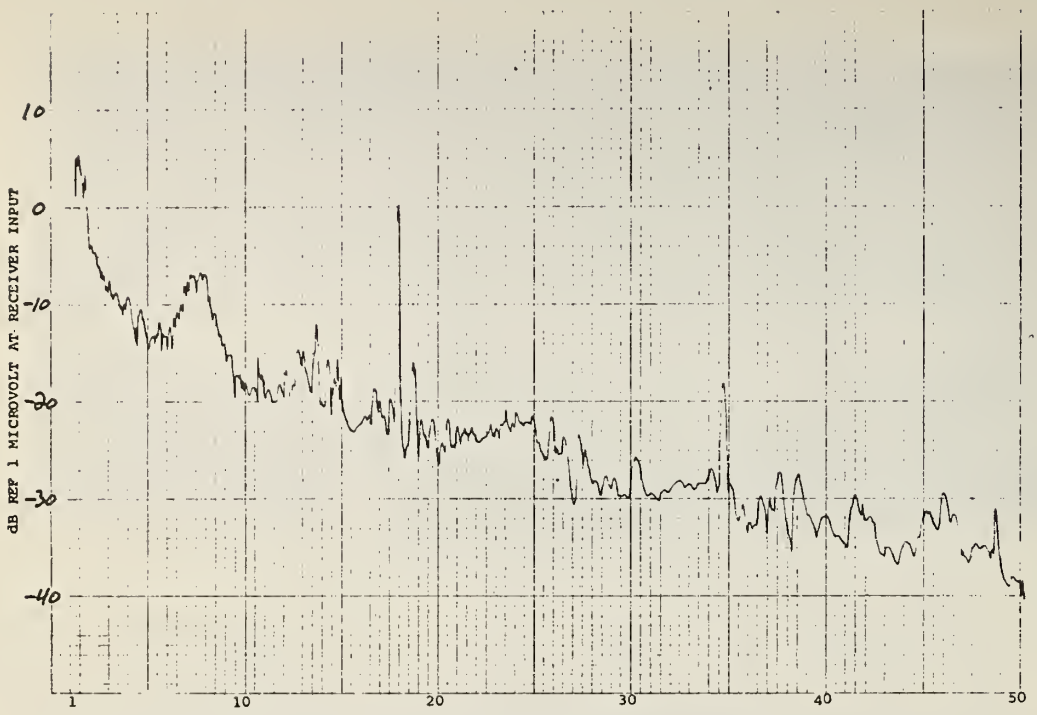
FREQ. SCAN: 5MHz/Div.
Bandwidth: 10 KHz

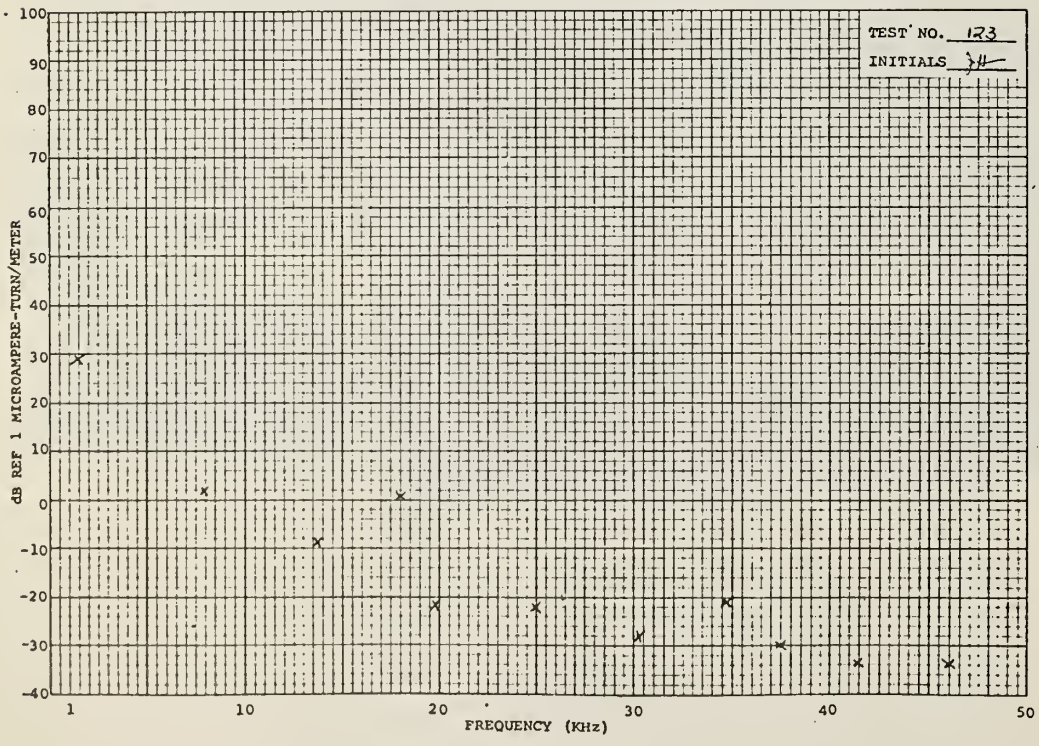


93
73
53
33
13
dB REF 1 µV/METER/MHz

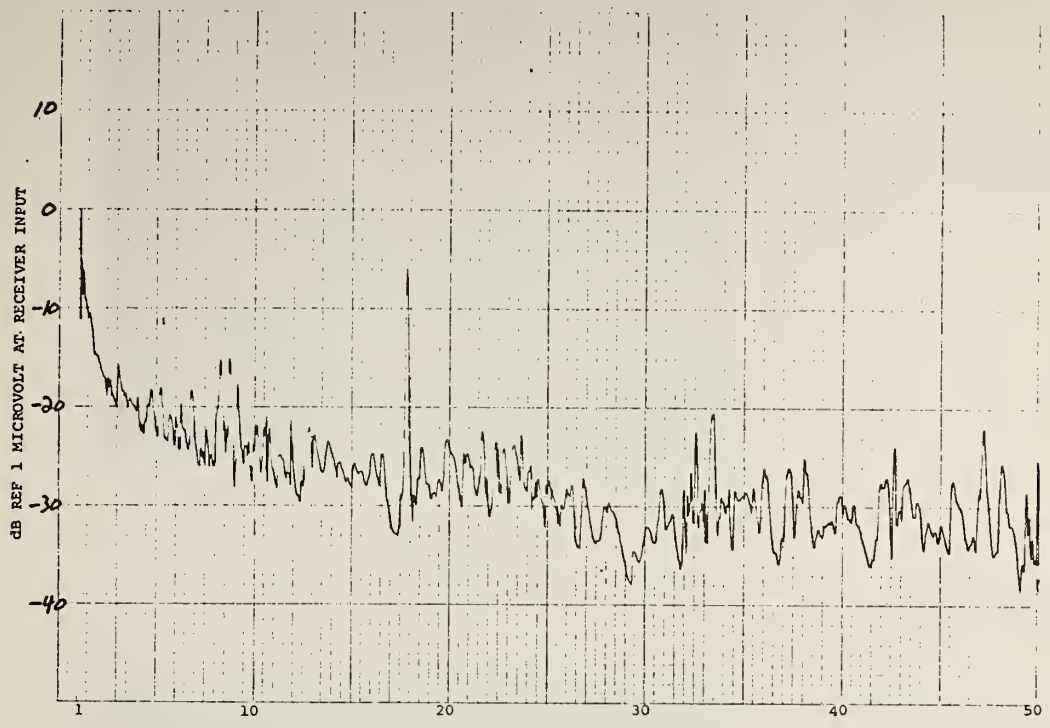
TEST 147
TIME 1246

TEST NO. 123 TEST TYPE MSR E-W BANDWIDTH 50Hz 0807
TEST SPECIMEN 263 TEST EQUIP. EMC-10 DATE 7-24-72



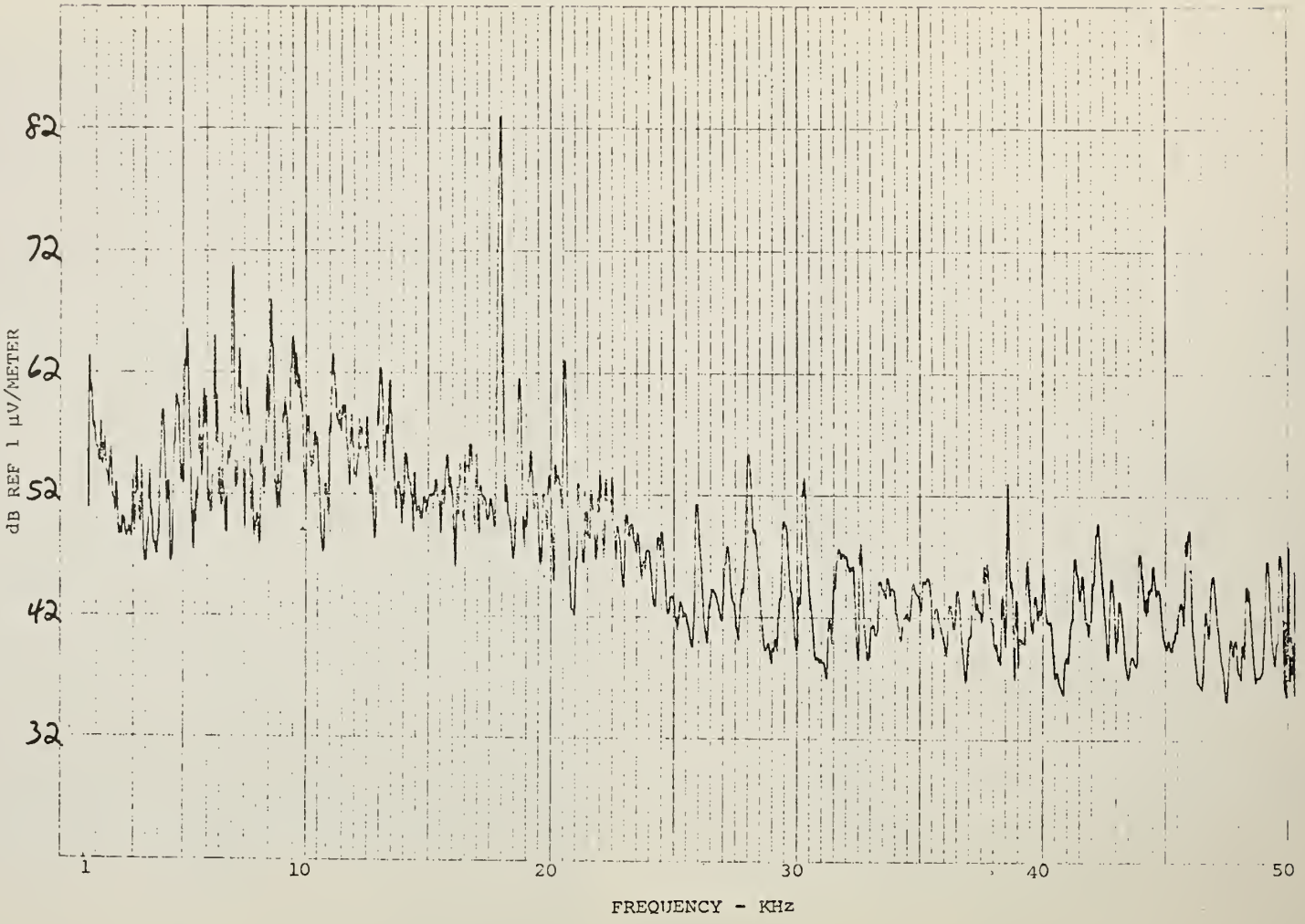


TEST NO. 122 TEST TYPE MSR N-S BANDWIDTH 50Hz 0800
TEST SPECIMEN Sol 3 TEST EQUIP. EMC-10 DATE 7-24-72

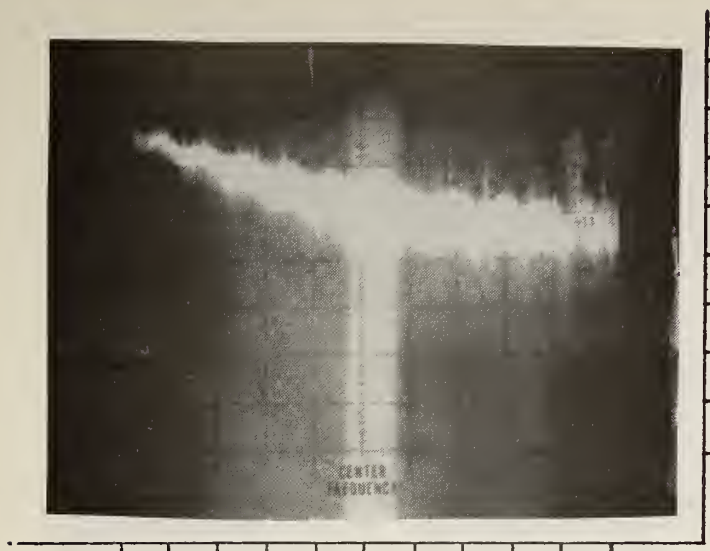


TEST NO. 124
TEST SPECIMEN Lib 3
TEST TYPE ESR
TEST EQUIP. EMC-10
BANDWIDTH 50 Hz
DATE 7-24-72

0818

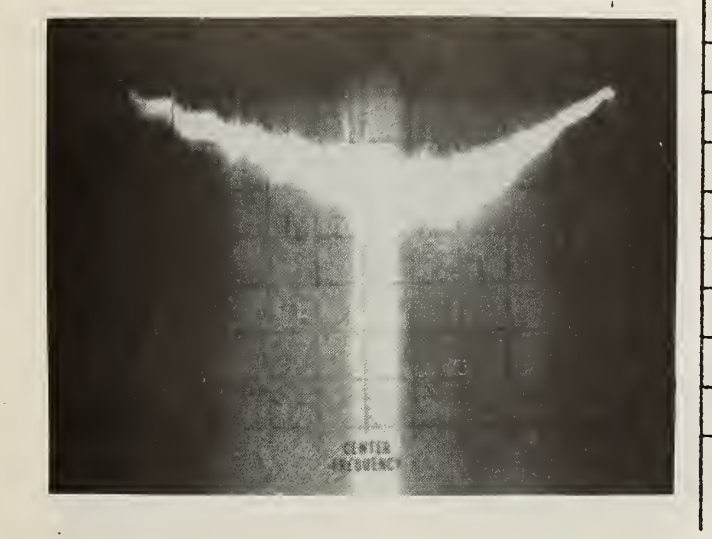


LOCATION: SITE 3 TYPE TEST ESR DATE 7-24-72



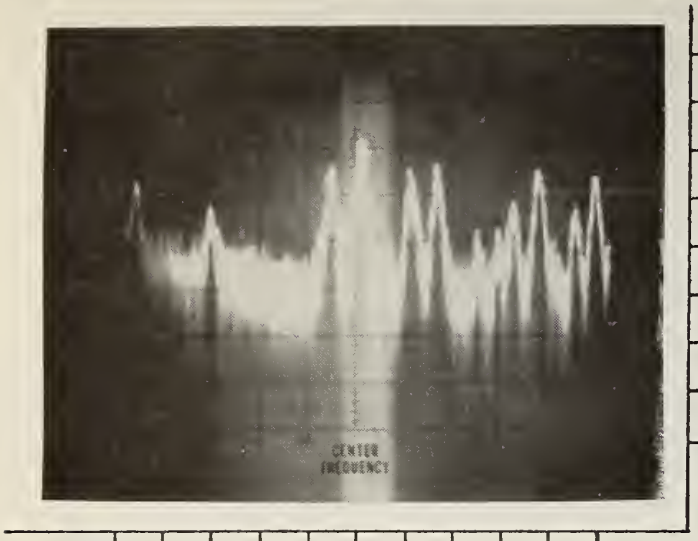
TEST 125
TIME 0900

FREQ. SCAN: 5 KHz/Div.
Bandwidth: 10 KHz



TEST 125
TIME 0902

LOCATION: SITE 3 TYPE TEST ESR DATE 7-24-72



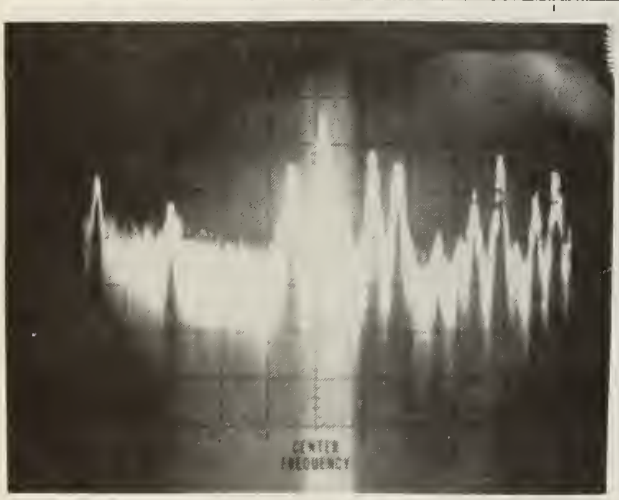
dB REF 1 μV/METER/MHz

91
71
51
31
11

TEST 126
TIME 0909

0.1 FREQ. 0.6 MHz 1.1

FREQ. SCAN: 0.1 MHz/Div.
Bandwidth: 10 KHz

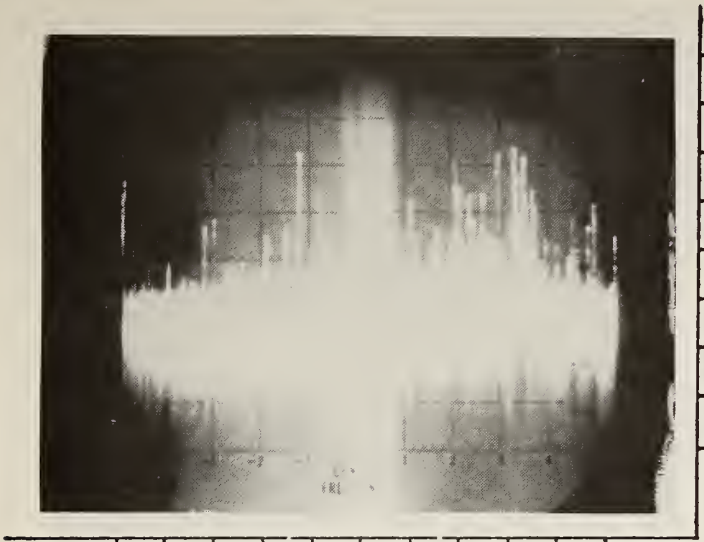


dB REF 1 μV/METER/MHz

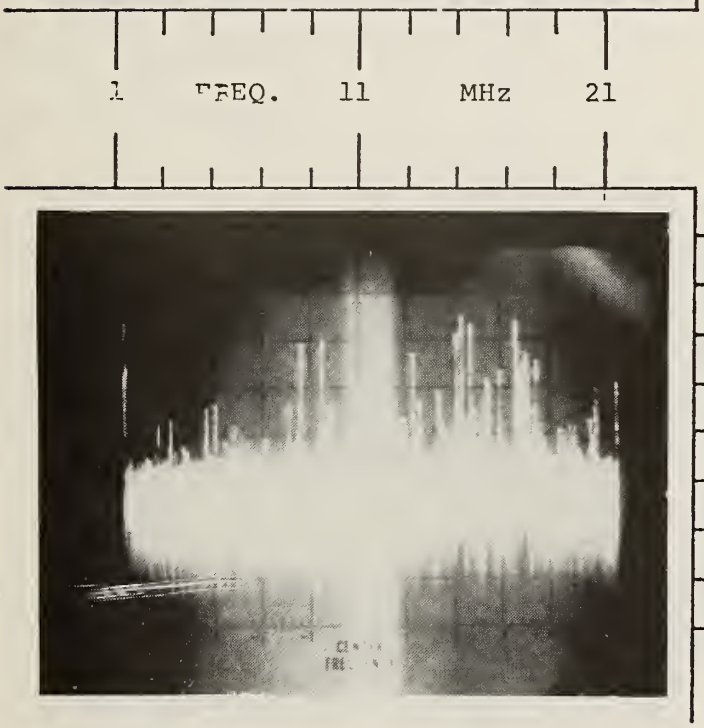
91
71
51
31
11

TEST 126
TIME 0911

LOCATION: SITE 3 TYPE TEST ESR DATE 7-24-72



TEST 127
TIME 0920

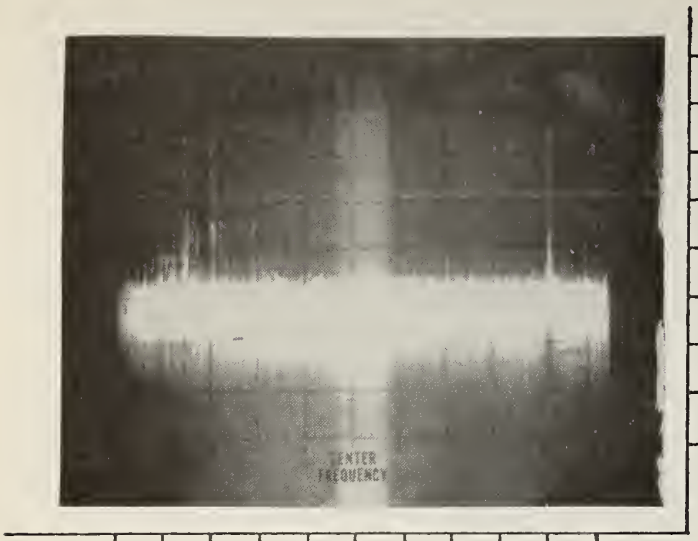


FREQ. SCAN: 2MHz/Div.

Bandwidth: 10 KHz

TEST 127
TIME 0921

LOCATION: SITE 3 TYPE TEST ESR E/N DATE 7-24-72

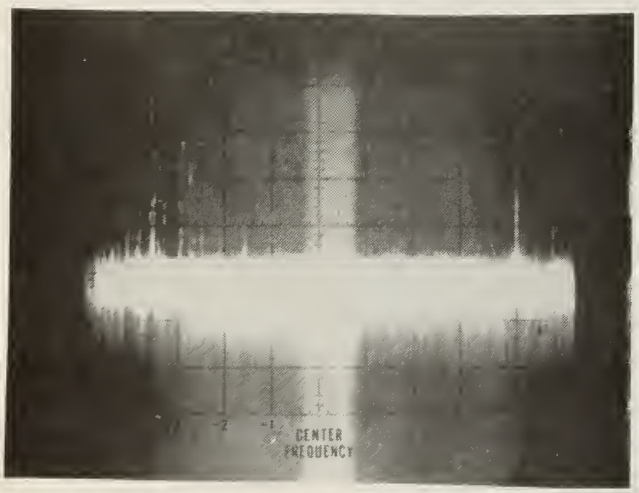


dB REF 1 μV/METER/MHz
94
74
54
34
14

TEST 128
TIME 0937

10 FREQ. 35 MHz 60

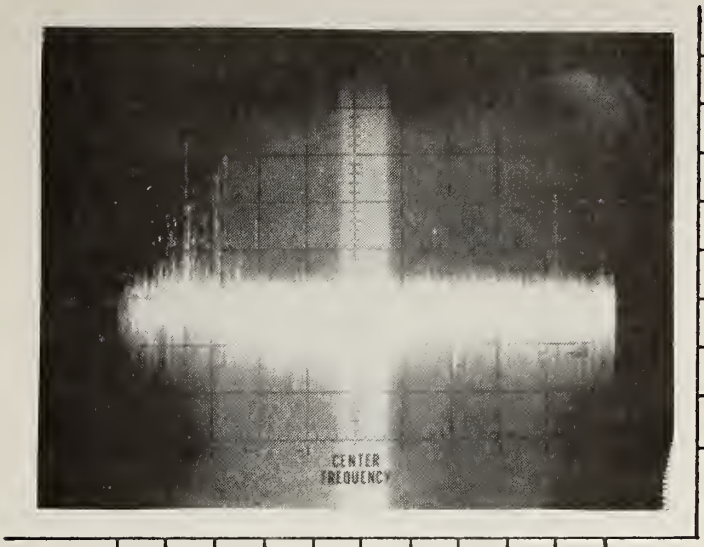
FREQ. SCAN: 5MHz/Div.
Bandwidth: 10 KHz



dB REF 1 μV/METER/MHz
94
74
54
34
14

TEST 128
TIME 0939

LOCATION: SITE 3 TYPE TEST ESR N/S DATE 7-24-72

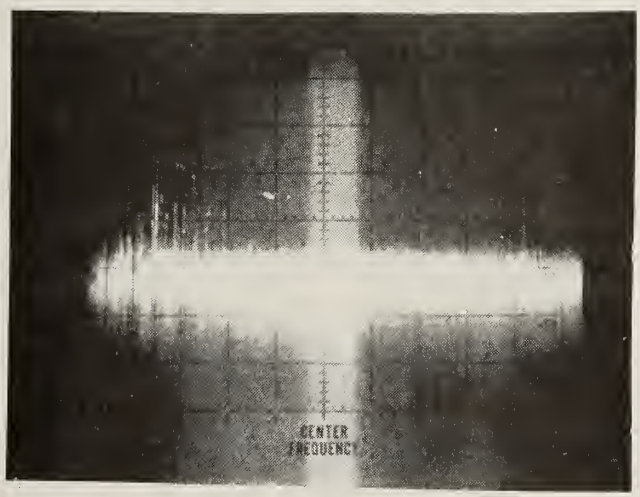


dB REF 1 μV/METER/MHz
94
74
54
34
14

TEST 129
TIME 0945

10 FREQ. 35 MHz 60

FREQ. SCAN: 5MHz/Div.
Bandwidth: 10 KHz



dB REF 1 μV/METER/MHz
94
74
54
34
14

TEST 129
TIME 0946