WL-TR-91-4093

PORTABLE RF LEAK DETECTOR EVALUATIONS AND UDRI/MRC HAMS REFINEMENTS

David A. Schafer
Gerald P. Chapman
Aka G. Finci

Mission Research Corporation
1720 Randolph Road, SE.
Albuquerque, NM 87106-4245

7 July 1992

Interim Report for Period April 1990-November 1990

Approved for public release; distribution unlimited.

MATERIALS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6533

NOTICE

This technical report has been reviewed and is approved for publication.

FRANK J. FECHEK
Materials Engineer
Materials Engineering Branch

THEODORE J. REINHART, Chief
Materials Engineering Branch
Systems Support Division

FOR THE COMMANDER

JOSEPH R. KOLEK, JR., Lt Col, USAF
Asst Chief, Systems Support Division
Materials Directorate

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
7 Jul 92

3. REPORT TYPE AND DATES COVERED
Interim; 4/90 to 11/90

4. TITLE AND SUBTITLE
PORTABLE RF LEAK DETECTOR EVALUATIONS AND UDRI/MRC HAMS REFINEMENTS

5. FUNDING NUMBERS
PE 69120
PR 2418
TA 04
WU 41

6. AUTHOR(S)
David A. Schafer, Gerald P. Chapman, Aka G. Finci

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Frank Fechek (513/255-7484)
Mission Research Corporation
1720 Randolph Road, SE.
Albuquerque, NM 87106-4245

8. PERFORMING ORGANIZATION REPORT NUMBER
MRC/ABQ-R-1364
UDR-TR-90-126

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Materials Directorate (WL/MLSE)
Wright Laboratory
Wright-Patterson AFB, OH 45433-6533

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
WL-TR-91-4093

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Two tasks related to the detection and measurement of EMI/RFI leaks in electrically shielded portable tactical shelters have been carried out. The first task consisted of the evaluation of four portable, hand-held, radio frequency (RF) leak detectors ("sniffers"). The evaluation consisted of an assessment of their reliability, ease of operation, battery life, and sensitivity. Their performance was measured on an S250G tactical shelter and compared against MIL-STD-285 test results. The second task consisted of the refinement of a previously developed hardness assurance monitoring system (HAMS). These refinements included further development of the sensor-driven pairs by which EMI leaks are detected and identification of commercial replacement components for custom-built parts in the original prototype unit. This is the first step towards militarization of the design.

14. SUBJECT TERMS

EMI	Electromagnetic Hardening	Radio Frequency
RFI	Electromagnetic Shielding	RF Sniffer
Prototype	Automated Monitoring	MIL-STD-285
Tactical Shelter	RF Leak Detectors	

15. NUMBER OF PAGES
250

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	Same as report

PREFACE

This report covers work performed during the period April 1990 to November 1990 under Air Force contract F33616-85-C-5094. The contract was initiated under Project Number 2418. The work was administered under the direction of the Systems Support Division of the Wright Laboratory/Materials Directorate, Wright-Patterson Air Force Base, Ohio. Mr. Frank Fechek (WL/MLSE) acted as project engineer.

This work was carried out by Mission Research Corporation (MRC) under subcontract to the University of Dayton Research Institute (UDRI). The program at UDRI is under the general supervision of Mr. D. Gerdeman, Project Supervisor, with Mr. D. Robert Askins acting as the Principal Investigator and as the point-of-contact with MRC. At MRC, Mr. David A. Schafer acted as the lead engineer with contributions from Gerald P. Chapman and Aka G. Finci.

CONTENTS

CONTENTS (CONCLUDED)

FIGURES

FIGURES (CONCLUDED)

TABLES

TABLES (CONCLUDED)

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this project is to evaluate four portable radio frequency (RF) leak detectors ("sniffers") and further refine the Hardness Assurance Monitoring System (HAMS) developed by the University of Dayton Research Institute (UDRI) and Mission Research Corporation (MRC). Evaluation of the sniffers entailed comparing sniffer, UDRI/MRC HAMS, and MIL-STD-285 test results, as performed on an S250 shelter. Evaluation of the sniffers also included reliability, ease of operation, battery life, and sensitivity. Further refinements to the HAMS addressed such issues as using commercial components and designing, testing, and improving sensor driver pairs.

1.2 BACKGROUND

MRC under contract with the UDRI developed a prototype HAMS (Ref. 1). This system has the capability to automatically monitor eight individual locations under electromagnetic (EM) stimulation at five discrete frequencies.

Reference 1 recommended further refinement of the system in the areas of sensor improvement, internal microprocessor control, and the militarization of the design. Two of these recommendations are addressed in the following report—sensor improvement and initial militarization by using commercial replacement components for a production-type unit.

1.3 SUMMARY

This report is divided into four sections addressing two tasks. Task 1 is the evaluation of the RF leak detectors, task 2 is the refinement of the UDRI/MRC HAMS. The remainder of this report addresses these tasks based on the considerations presented in the following paragraphs.

Section 2 describes the baseline MIL-STD-285 tests and the sniffer tests; critiques of all tests are included. Data analysis was done by comparing test results and evaluating operational characteristics. The MIL-STD-285 tests described in this section incorporate the revised electromagnetic interference (EMI) provisions test parameter (MIL-STD-907B EMI test procedures) for measuring attenuations at edges and corners. The S250 shelter is almost all edges and corners and required extensive use of the revised EMI test techniques.

Task 2 efforts are documented in section 3. This section presents the survey results and identifies our recommended replacements. Most of the task 2 effort focuses on the evaluation of the previously used "folded inductor" sensor drivers (Ref. 1) and the development/evaluation of other sensor drivers for use with the HAMS.

Section 4 proffers our conclusions and recommendations.

2.0 TASK 1: RF LEAK DETECTOR EVALUATIONS

The RF leak detector evaluations were performed on three types of units. The first type are units that operate in the 400-MHz range, usually termed plane wave by military standards. The two units of this type were the SIMS II owned by MRC and the ASM owned by UDRI. The second type are units that operate at low frequencies (≤10 MHz) using loop antennas. This type was represented by the EUROSHIELD, which performs the low-frequency magnetic measurements. The third type of unit tested was the Eaton Shielding Effectiveness Leak Detection System (SELDS) device. This unit direct-drives an enclosure or surface and locates leaks using a small magnetic dipole at the tip of a sensor probe. No military standards precisely define the use of this device. All of these devices were tested and compared to a standard MIL-STD-285 type test as well as to the UDRI HAMS system. Complete user's manuals for the ASM, EUROSHIELD, and Eaton units are provided in appendix A.

2.1 BASELINE

The S250 shelter was characterized using techniques in accordance with MIL-STD-285. Frequency coverage ranged from 10 kHz to 12 GHz using the low-impedance and plane wave test configurations. The selected frequencies coincide with operating frequencies of the sniffers, the HAMS, and additional frequencies recommended by the military standard. The MIL-STD-285 tests used an HP8566B spectrum analyzer or HP3577A or HP8753C network analyzers as the receivers. Two sources were required to cover the bandwidth of measurements. These sources were a Wavetek 166 for frequencies below 30 MHz and an HP83592B for frequencies up to 12 GHz. Two sets of MRC loop antennas provided frequency coverage from 10 kHz to 10 MHz. A single set of MRC dipole antennas covered the plane wave frequencies of 450, 462, 500, and 1000 MHz. Finally, two Narda K-band microwave horns covered the frequencies of 10 and 12 GHz. An HP8447A low-noise preamp provided additional measurement sensitivity for frequencies of measurements (100 kHz to 400 MHz) when necessary. The dynamic range of measurement for each of the tested frequencies is presented in table 1.

TABLE 1. Measurement dynamic range for the MIL-STD-285 tests.

Frequency	Dynamic Range (dB)	Antennas
10 kHz	100	LF loop/MRC
106 kHz	102	LF loop/MRC
150 kHz	97	LF loop/MRC
1 MHz	≥106	HF loop/MRC
10 MHz	99	HF loop/MRC
400 MHz	120	HF dipole/MRC
450 MHz	110	HF dipole/MRC
462.5 MHz	110	HF dipole/MRC
500 MHz	110	HF dipole/MRC
500 MHz*	68	HF dipole/ASM
1 GHz	101	HF dipole/MRC
10 GHz	86	Horn/Narda
12 GHz	78	Horn/Narda

*Unusual measurement results dictated retesting with the HP8753C network analyzer using the ASM antennas.

Measurements consisted of single-frequency magnitudes as described in the military standard, with the exception of the 106-kHz measurements. These measurements consisted of swept continuous wave (CW) from 100 kHz to 1 MHz. The equipment complement and appropriate test configurations are depicted in figures 1 and 2. Intentional faults

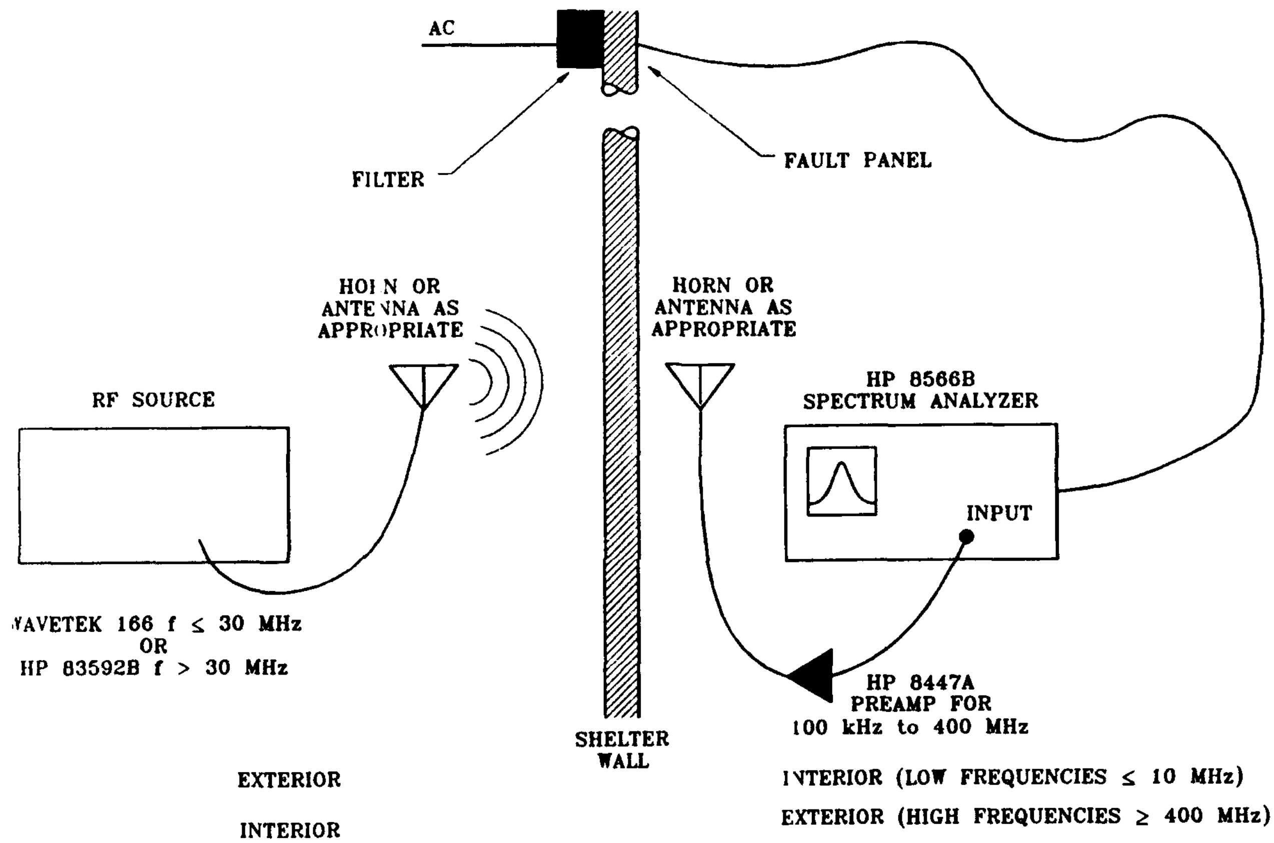


Figure 1. MIL-STD-285 spectrum analyzer configuration.

were fabricated for use in evaluating the sniffers since no well-defined or controlled faults exist on the shelter. The removal of the "kick" panel on the door and its replacement with a faulted steel panel provided the necessary faults for proper sniffer evaluation. The faults were made in a 24 $\frac{1}{2} \times 36 \times \frac{1}{8}$-inch steel panel. Figure 3 shows the panel. Attenuation measurements used nominal antenna separations as identified in the MIL-STD-285 (26-inch loop and 72-inch E dipole), with the exception of the low-frequency

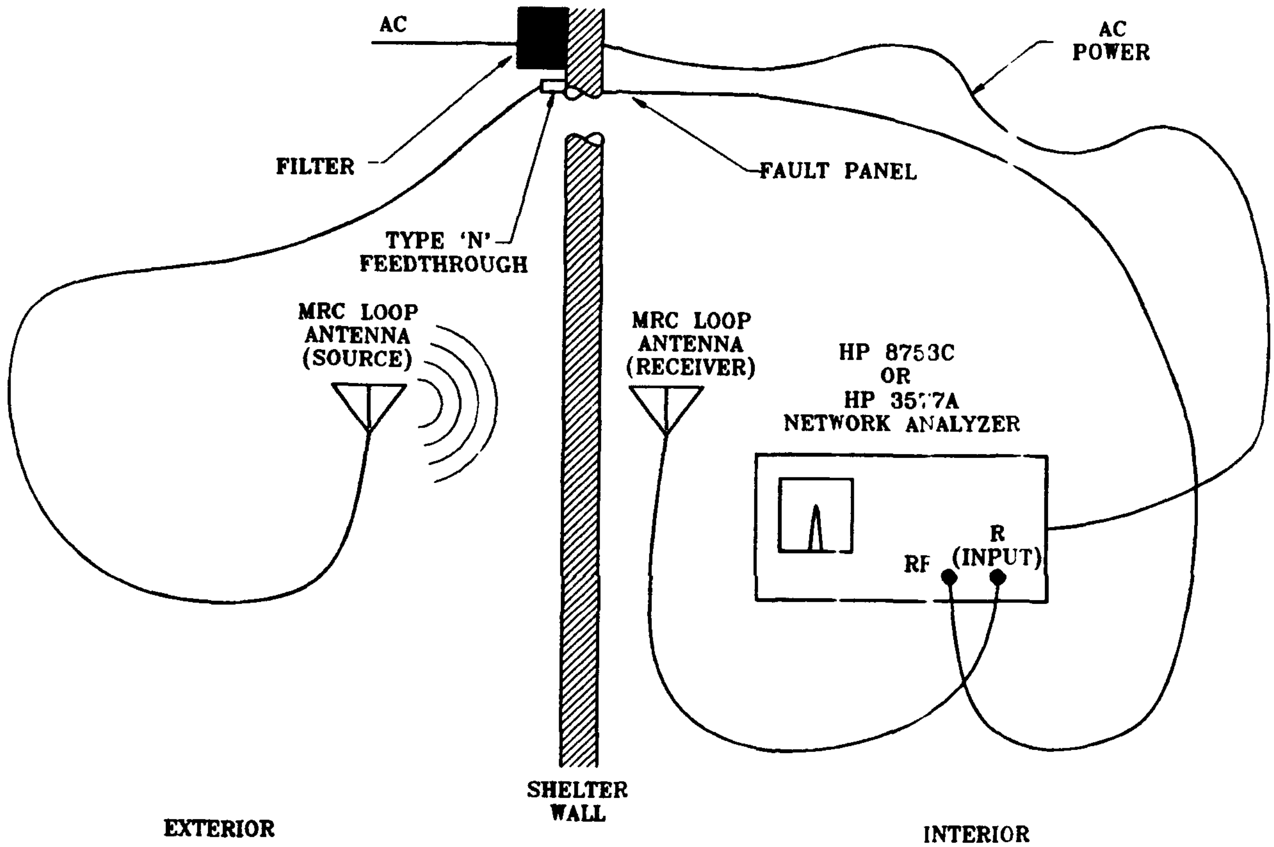


Figure 2. MIL-STD-285 network analyzer configuration.

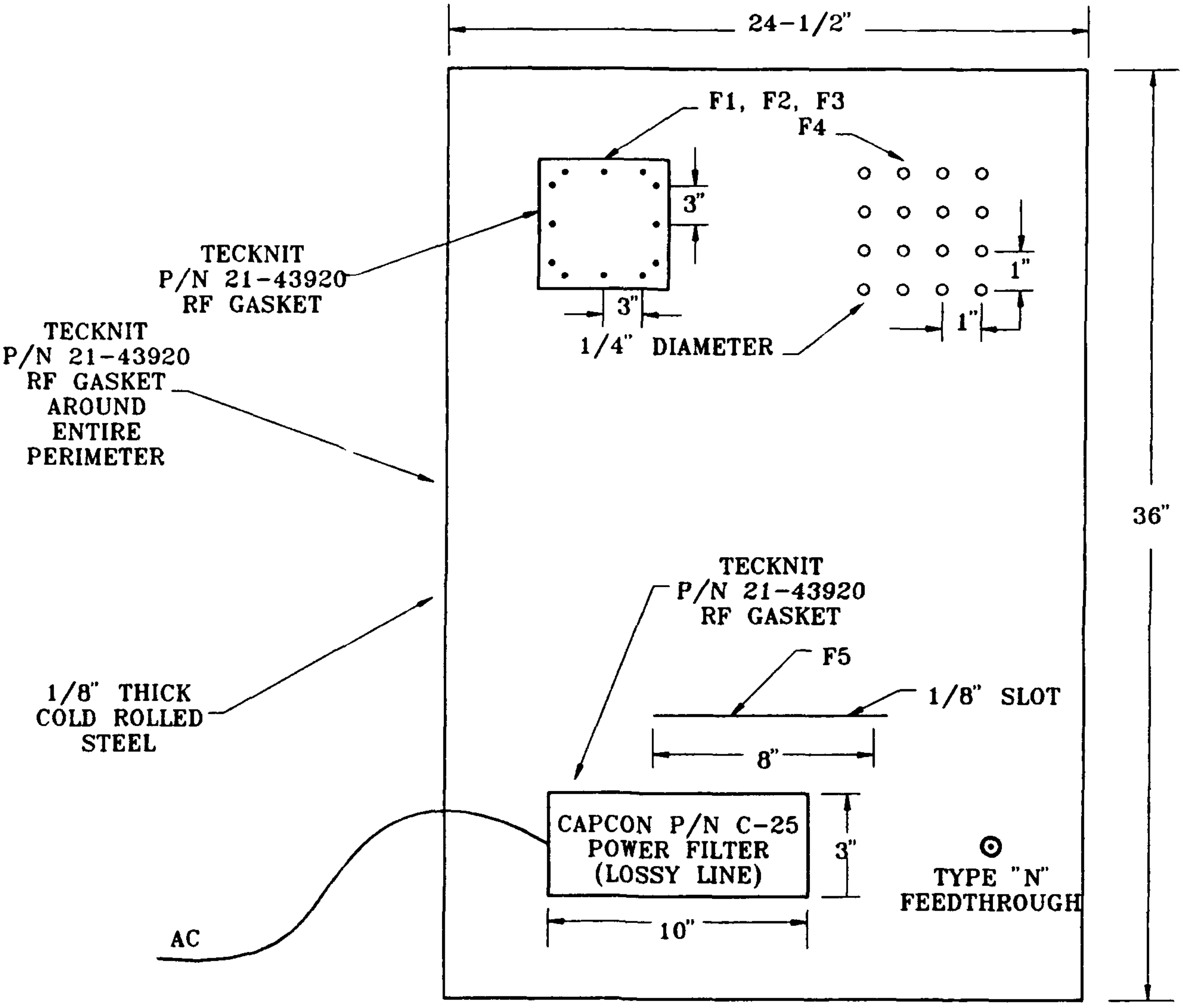
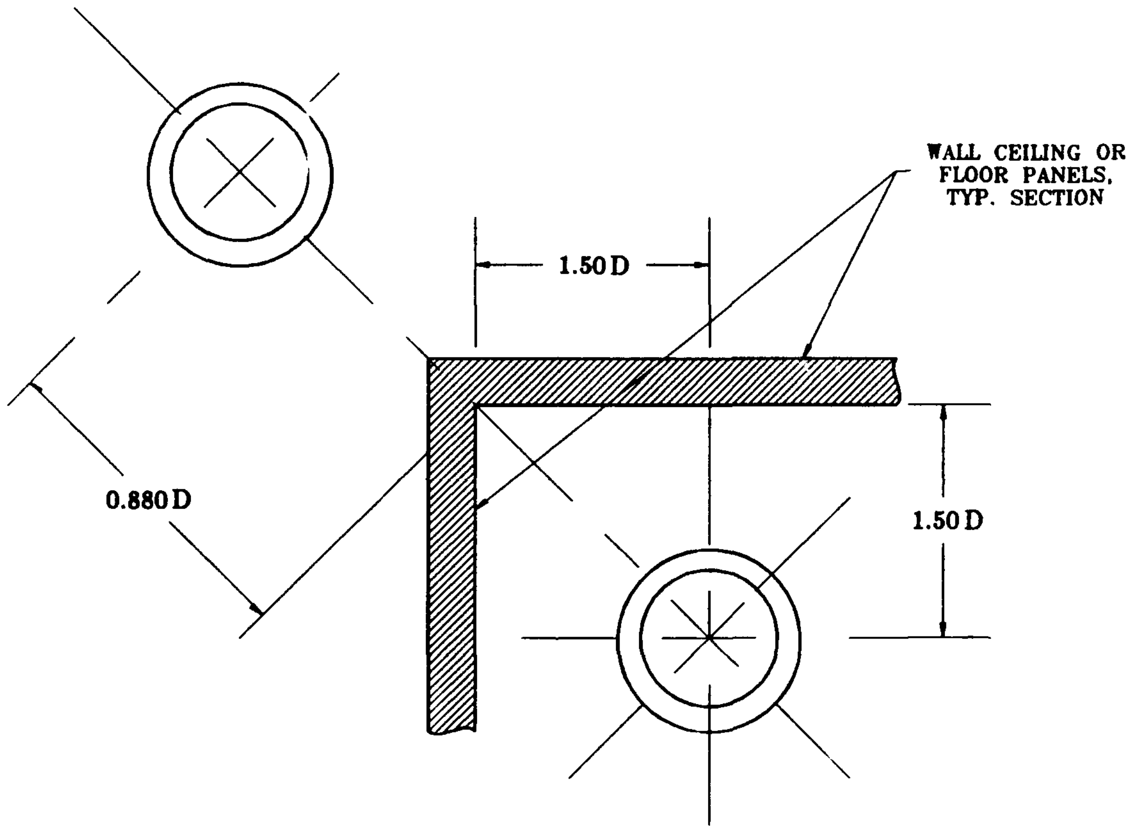


Figure 3. Fault panel detail.

magnetic measurements at corners. These measurements used the recommended antenna placements of revised MIL-STD-907B, as shown in figure 4. Due to the large number of corners on the shelter and since most edge measurements were acquired very close to the corners (within 4 inches of MIL-STD-907B requirements), we confined the MIL-STD-907B corner measurement technique to one location. All of the edges, however, were tested in strict accordance with MIL-STD-907B.



D = diameter of loop antenna
Dimensions shown are measured from the interior shelter surfaces, in loop diameters

Figure 4. Antenna placement for MIL-STD-907B.

2.2 TEST DESCRIPTIONS

The testing and comparisons of the various sniffers and HAMS is intended to identify similarities or differences between the individual units. It is unnecessary to perform complete MIL-STD-285 measurements on the entire shelter for good comparisons to be made. The test data are included in appendix B.

Figures 5 and 6 show the locations of the test points. Faults F2 and F3 are located coincident with F1 and are unique identifiers for different gasket configurations. Faults F2 and F3 are used in the sniff-off portion of the test effort.

The ASM (ASM Products, Inc.) sniffer exhibited variations in attenuations for the ungrounded and grounded cases. For all tests, the shelter was grounded through its power cord to maintain configuration consistency.

2.2.1 MIL-STD-285 Testing

2.2.1.1 Low-Frequency Magnetic Testing. Initial calibrations using 26-inch separations between the transmitting and receiving loops quantified the unattenuated coupling between the loops. Figure 7 shows the two calibration configurations used. Calibration consisted of single frequencies only. Placing the receiving antenna inside the shelter helped reduce the noise floor of the measurement by taking advantage of the shielding provided by the shelter. This technique is particularly useful for measurements in the 100-kHz (fluorescent light noise) to 10-MHz (AM radio noise) range. Measurement of the shelter's attenuation at 26 test points and three faults then proceeded. The difference between the initial calibration and the measured coupling at each test point is the shelter attenuation at that point. At the conclusion of the test, recalibration ensured that no deviation from the initial calibration had occurred. In all cases throughout this test, the initial and final calibrations agreed. Table 2 presents the data acquired during this test.

2.2.1.2 High-Frequency Plane Wave Testing. Initial calibrations using 72-inch separations between the MRC transmitting and receiving dipoles quantified the unattenuated coupling between the antennas. Figure 8 shows the calibration configuration. A single

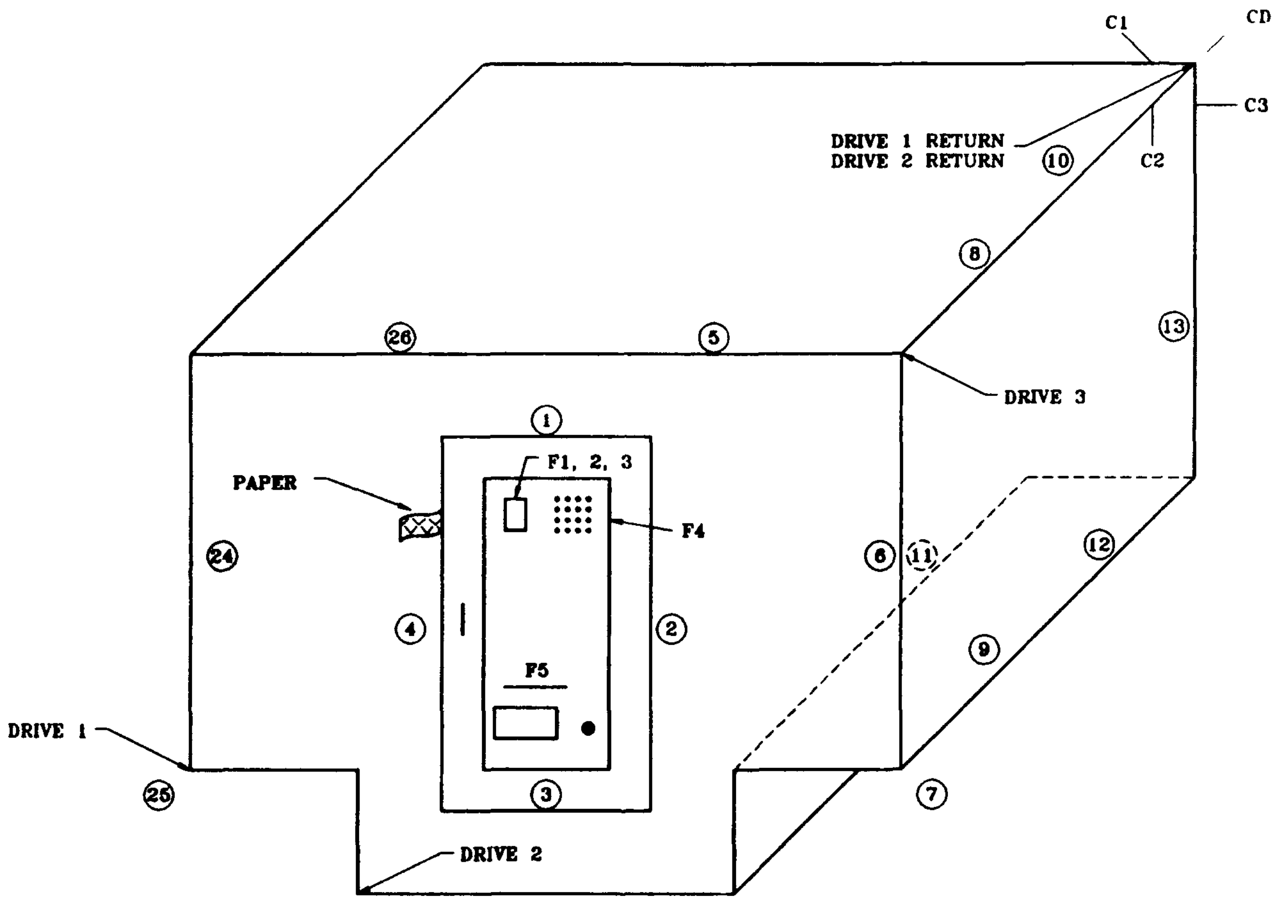


Figure 5. S250 test point location (front view).

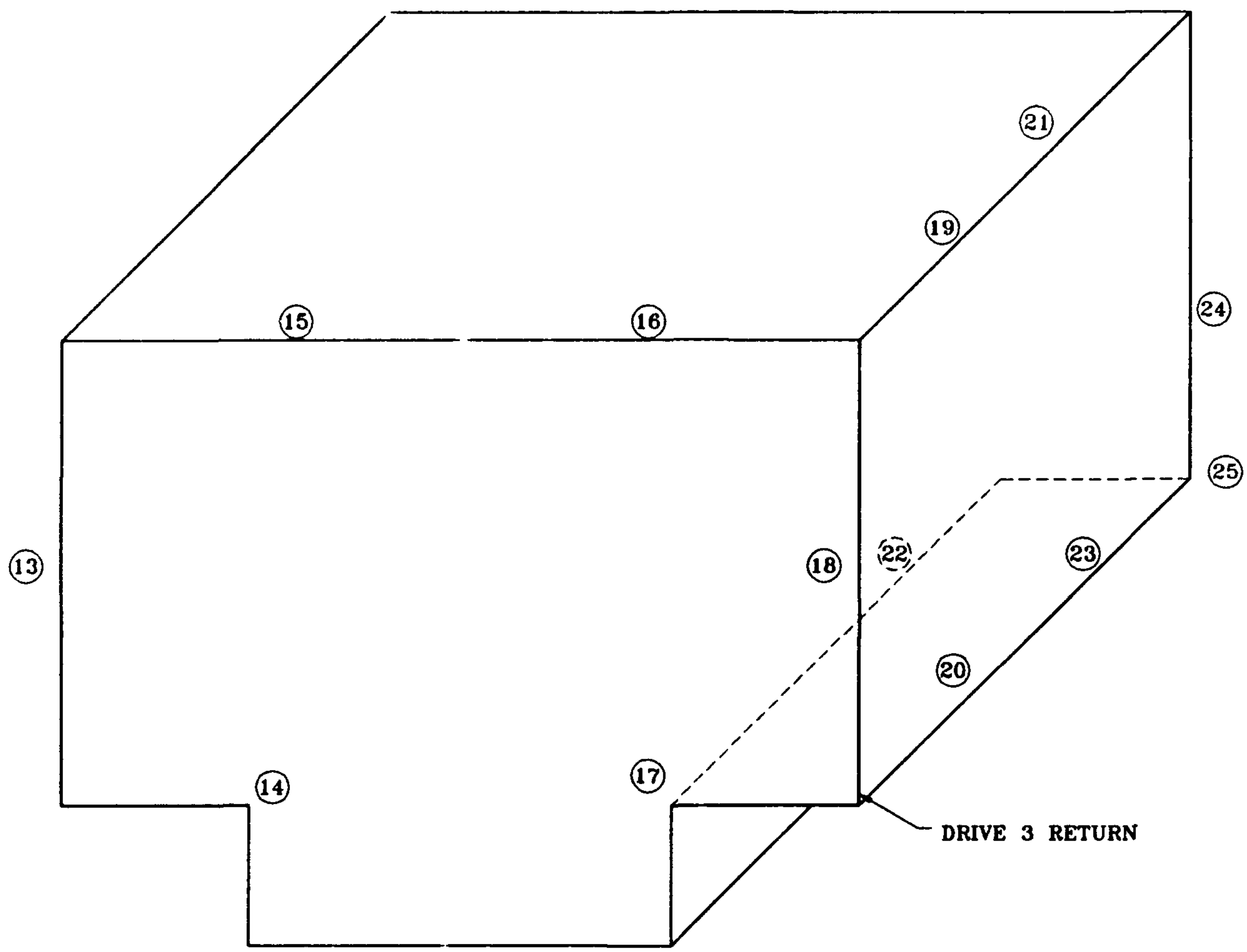


Figure 6. S250 test point location (rear view).

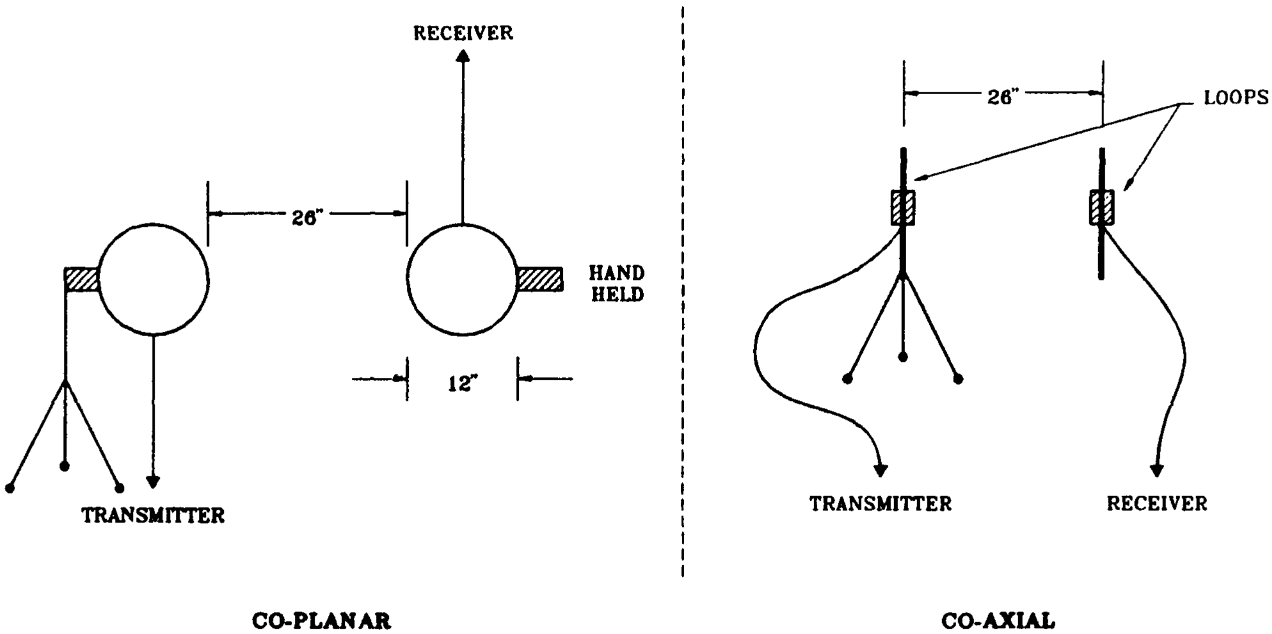


Figure 7. Loop calibration.

TAB .E 2. Low-frequency MIL-STD-285 test results.

Attenuation in dB

Test Point	Frequency: 10 kHz	106 kHz	150 kHz	1 MHz	10 MHz
1-V	35	71	48	63	85
2-V	50	73	63	90	83
3-V	28	67	52	63	68
4-V	47	48	62	64	86
5-V	47	59	62	61	88
6-H	47	48	86	67	83
7-V	58	49	80	63	76
8-V	52	56	83	75	82
9-V	54	52	80	66	81
10-V	56	56	74	78	89
11-V	54	51	85	69	89
12-V	55	53	78	70	99
13-H	56	57	75	106	90
14-V	55	54	73	78	78
15-V	52	59	78	77	87
16-V	53	53	77	88	92
17-V	67	61	73	71	91
18-H	54	58	75	77	89
19-V	52	58	74	79	90
20-V	58	55	77	75	99

V = vertical
H = horizontal
C = coaxial loops
D = measured on diagonal

TABLE 2. Low-frequency MIL-STD-285 test results (concluded).

Attenuation in dB

Test Point	Frequency: 10 kHz	106 kHz	150 kHz	1 MHz	10 MHz
21-V	53	55	77	70	83
22-V	57	56	85	84	87
23-V	54	46	77	58	80
24-H	50	46	75	61	95
25-V	65	38	77	49	80
26-V	43	53	62	64	79
F1-H	31	51	55	54	89
F1-V	31	42	48	51	67
F1-C	41	–	60	–	52
F4-H	31	46	55	54	67
F4-V	33	47	54	54	75
F4-C	37	–	60	59	55
F5-H	29	49	61	53	79
F5-V	31	38	38	39	49
F5-C	38	–	53	–	57
C1-V	56	–	78	63	89
C2-V	54	–	82	69	89
C3-H	56	–	79	54	87
CD-D	68	–	80	62	89

V = vertical
H = horizontal
C = coaxial loops
D = measured on diagonal

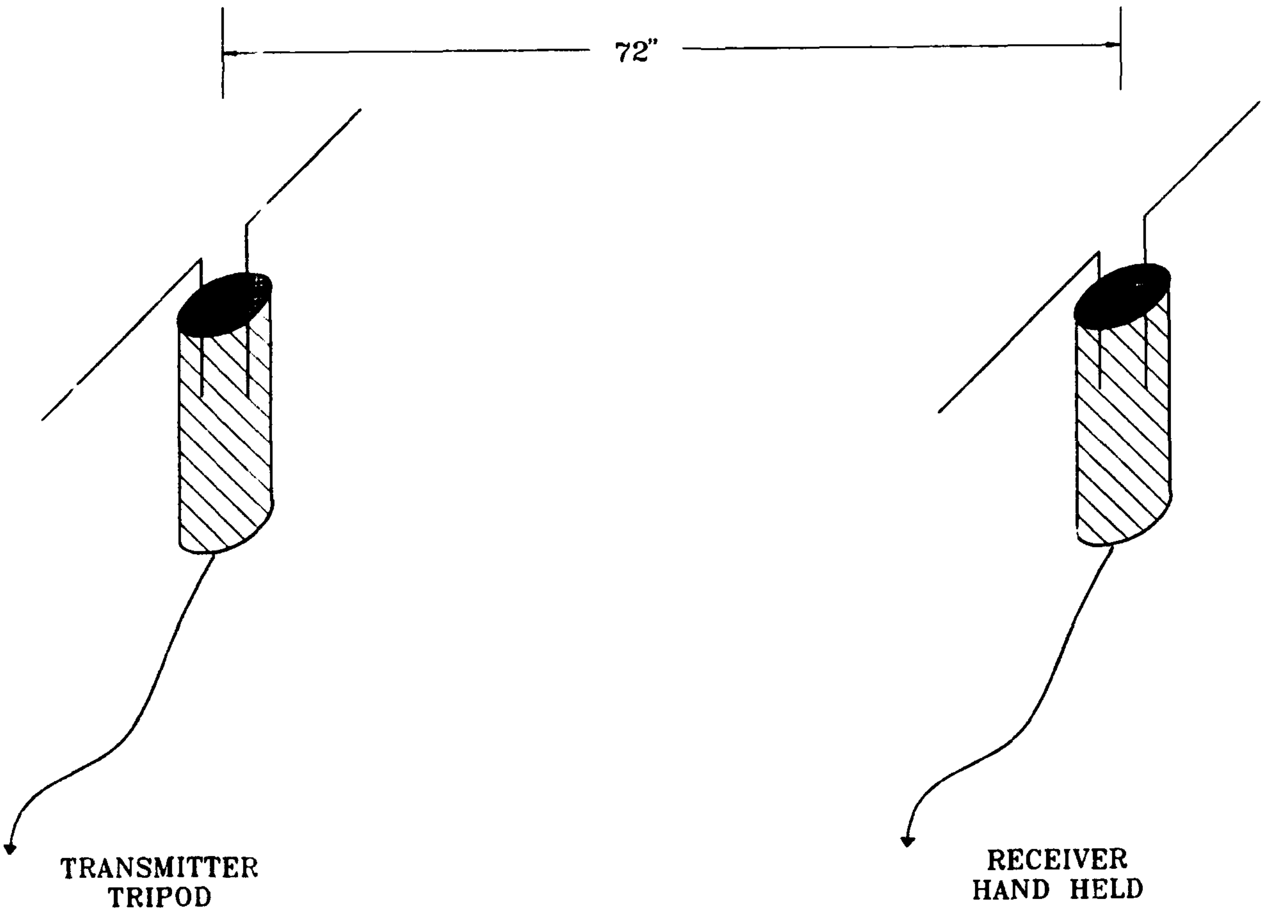


Figure 8. Electric dipole calibration.

frequency at a time was calibrated for each of the measurements sets. Placing the transmitting antenna at a central point within the shelter expedited the measurement process. The dipole orientation (parallel to the wall under measurement) illuminated a single side of the shelter at a time. Vertical and horizontal orientations were used. Measurements were taken on one side at a time. For test points on a vertical edge, measurements were acquired twice, once for illumination directed at each of its associated walls. The receiving antenna and the transmitting antenna were maintained a distance of 36 inches on either side of the wall. Measurement of the shelter's attenuation characteristics at 26 test points and three faults proceeded after the calibrations. At the conclusion of the test, recalibration ensured that no deviation from the initial calibration had occurred. In all cases throughout this test, the initial and final calibrations agreed. The data collected during this test effort are presented in table 3.

2.2.2 UDRI/MRC HAMS MIL-STD-285 Testing

2.2.2.1 Low-Frequency Testing. A low-frequency MIL-STD-285 test with the HAMS used the same loop antennas as the previous low-frequency tests. The test points 2 through 5 and 26 and faults F1, F4, and F5 were measured. Calibration and test conditions were otherwise identical to those of the full MIL-STD-285 test. The HAMS measured attenuations at all of its frequencies of operation. As expected, higher frequencies did not measurably couple through the loops. Table 4 presents the data gathered during this effort. The calibration level for the 100-kHz test was 39 dB with a noise floor of 103 dB, resulting in a measurement range of 66 dB. Similarly, for the 1-MHz measurements, the calibration was 52 dB with a noise of 104 dB, resulting in a measurement range of 52 dB. The HAMS has a demonstrated fluctuation of about ±3 dB. Therefore, most of the measurements made by the HAMS at 1 MHz result from the limits of the measurement and do not describe the shelter attenuation.

2.2.2.2 High-Frequency Testing. A high-frequency MIL-STD-285 test using the HAMS and the ASM dipole antennas measured the attenuation of the shelter's face. ASM dipoles were used since they have better EM characteristics than the MRC units. These antennas would have been used for the standard 285 test as well had they been available at the time of testing. Test points 2 through 7 and 24 through 26 were measured. Calibration and

TABLE 3. High-frequency MIL-STD-285 test results

Attenuation in dB

Test Point	Frequency: 400 MHz	450 MHz	462.5 MHz	500 MHz	1 GHz	10 GHz	12 GHz
1-H	41	33	27	40	36	–	–
1-V	35	29	24	26	28	35	42
2-H	50	33	26	45	47	–	–
2-V	32	29	23	22	25	39	52
3-H	57	35	32	39	34	–	–
3-V	35	31	26	35	23	45	46
4-H	50	36	30	42	31	–	–
4-V	34	37	22	28	24	34	40
5-H	57	35	23	49	32	–	–
5-V	41	34	27	30	31	42	56
6-HF	64	46	30	40	52	–	–
6-HS	57	50	50	37	38	–	–
6-V	45	27	40	43	39	55	70
7-HF	52	44	41	37	40	–	–
7-HS	44	51	54	30	31	–	–
7-V	39	21	31	39	44	54	69
8-H	44	51	47	38	43	–	–
8-V	52	49	45	39	45	62	75
9-H	61	48	58	34	35	–	–
9-V	60	53	45	53	48	69	70
10-H	55	48	46	39	39	–	–
10-V	50	52	39	52	50	65	67
11-H	47	62	63	39	54	–	–
11-V	–	55	51	49	45	70	73
12-H	49	53	57	40	40	–	–
12-V	60	52	46	54	46	69	72
13-HR	56	46	48	60	61	–	–
13-HS	47	51	52	41	46	–	–
13-V	60	51	44	56	44	67	76
14-HR	66	45	56	–	58	–	–
14-HS	58	61	67	55	49	–	–
14-V	64	52	39	48	50	69	70
15-H	60	47	46	49	45	–	–
15-V	65	56	43	45	48	57	75

TABLE 3. High-frequency MIL-STD-125 test results (concluded).

Attenuation in dB

Test Point	Frequency: 400 MHz	450 MHz	462.5 MHz	500 MHz	1 GHz	10 GHz	12 GHz
16-H	56	42	50	52	62	–	–
16-V	55	50	44	47	43	63	72
17-HR	59	51	49	50	57	–	–
17-HS	47	47	32	–	44	–	–
17-V	61	54	31	50	40	70	72
18-HS	49	37	52	51	49	–	–
18-HR	53	44	29	44	56	–	–
18-V	59	51	47	45	38	67	76
19-H	44	32	42	37	39	–	–
19-V	51	49	33	45	44	67	57
20-H	48	43	43	34	41	–	–
20-V	55	50	40	46	40	83	76
21-H	52	41	39	36	43	–	–
21-V	67	53	38	45	42	71	74
22-H	47	25	45	36	43	–	–
22-V	56	34	45	45	40	65	70
23-H	44	27	41	34	34	–	–
23-V	58	36	34	46	46	72	75
24-HF	48	32	30	32	38	–	–
24-HS	39	22	30	32	26	–	–
24-V	53	39	41	49	34	50	65
25-HF	43	33	36	30	48	–	–
25-HS	40	38	37	33	29	–	–
25-V	48	26	29	49	41	56	72
26-H	56	33	37	41	50	–	–
26-V	40	28	28	38	26	46	58
F1-H	53	40	32	40	32	–	–
F1-V	32	27	22	33	28	33	37
F4-H	52	37	40	43	37	–	–
F4-V	34	28	22	27	26	36	42
F5-H	47	36	35	43	52	–	–
F5-V	31	28	20	28	23	28	37

TABLE 4. Low-frequency HAMS MIL-STD-285 test results.

Attenuation in dB

Test Point	Frequency: 100 kHz	1 MHz
2	64	51
3	36	51
4	55	52
5	56	51
26	57	51
F1	43	49
F4	47	51
F5	36	40

test conditions were otherwise identical to those of the full MIL-STD-285 test. The HAMS measured attenuation at all of its frequencies of operation. Low frequencies did not couple well through the dipoles, as expected. Difficulties were encountered with the 30- and 509-MHz oscillators. The 509-MHz oscillator was replaced; however, a 30-MHz replacement was unavailable. The HAMS measurement range precluded accurate measurements during the HAMS MIL-STD-285 high-frequency tests; therefore, the data are unacceptable. The measurement range for the 100-MHz test was 19 ± 3 dB; the range for the 500-MHz test was 28 ± 3 dB. The HAMS 12-GHz sniffer also measured the shelter attenuation. The measurement range for the sniffer is 50 dB. In addition to the data presented in table 5, the 12-GHz sniffer measured 41 ± 3-dB attenuation on faults F1, F4, and F5.

The data gathered by this test is summarized in table 5. The raw data sheets are supplied in appendix B of this report.

2.2.3 UDRI/MRC HAMS Sensor/Fault Testing

After completing the MIL-STD-285 tests and the sensor driver tests identified in task 2 (section 3), the HAMS evaluation began using these sensor driver pairs. Sensor/fault selection was initially based on finding the most sensitive pairs for the faults with the

TABLE 5. UDRI/MRC HAMS high-frequency MIL-STD-285 test summary.

Attenuation in dB

Test Point	Frequency: 100 MHz	500 MHz	12 GHz
2	19	28	≥50
3	18	28	≥50
4	19	29	≥50
5	18	28	≥50
6	19	27	≥50
7	18	27	≥50
24	19	29	≥50
25	18	29	≥50
26	18	28	≥50

poorest coupling; then, the remaining sensor/faults were selected based on their ability to provide adequate signals for measurement. Several data runs were made by the HAMS. The difficulty with comparing the HAMS data with any of the tests performed is that no absolute baseline calibration is made by the system. The HAMS acquires a baseline as an initial measurement of shelter performance and not as a controlled unobstructed environment.

The tabulated data from the HAMS are presented in table 6.

2.2.4 Sniffer Performance Tests

The EUROSHIELD sniffer testing replicated the low-frequency MIL-STD-285 testing already described. The recommended manufacturer test configuration (Ref. 2) is consistent with the standard. Figure 9 shows the Euroshield unit. The Euroshield data are summarized in table 7.

The SIMS II and ASM sniffer measurements followed the plane wave testing techniques described in MIL-STD-285. The manufacturer-recommended test technique for the ASM

TABLE 6. HAMS sensor/fault data results.

Values in dBm

Channel:	0	1	2	3	4
Fault:	F_5	F_4	F_1	F_1	F_5
Sensor:	UC	SL	FI	FA	FC
Door-Open Position					
100 kHz	93	77	81	92	45
1 MHz	103	103	103	103	47
30 MHz	59	68	61	64	6
100 MHz	96	74	83	91	18
500 MHz	96	102	96	104	61
Door-Closed Position					
100 kHz	97	78	101	103	96
1 MHz	103	103	103	103	103
30 MHz	99	67	103	103	103
100 MHz	86	75	103	103	103
500 MHz	103	103	103	103	88

UC = unshielded coax core wire
SL = slotted coax
FI = folded inductor large dimension
FA = folded inductor small dimension
SC = slotted coax

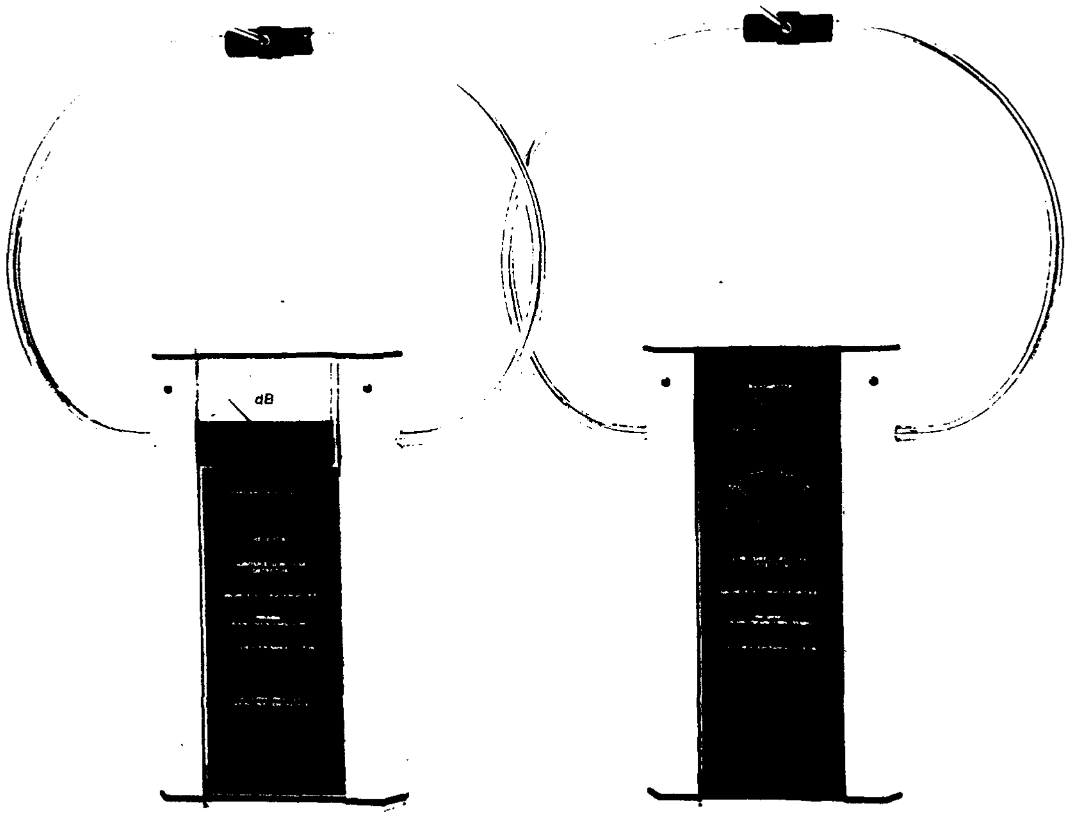


Figure 9. Euroshield RF leak detector 4F-130.

TABLE 7. EUROSHIELD test results.

Attenuation in dB

Test Point	Frequency: 10 kHz	156 kHz	1 MHz	10 MHz
1	25	58	55	60
2	45	70	80	87
3	25	78	60	69
4	40	72	75	95
5	35	82	65	80
6	40	60	75	86
7	35	55	90	86
8	50	90	85	98
9	60	82	100	90
10	55	105	95	105
11	55	90	95	102
12	80	104	95	105
13	50	87	95	110
14	65	86	90	107
15	75	100	95	104
16	70	102	90	107
17	75	100	90	100
18	55	92	90	110
19	85	93	90	105
20	55	106	90	101
21	60	84	85	97
22	55	92	85	101
23	55	101	85	94
24	40	63	80	98
25	45	64	85	95
26	35	60	75	94
F1	30	44	50	61
F4	30	46	55	66
F5	25	36	40	46

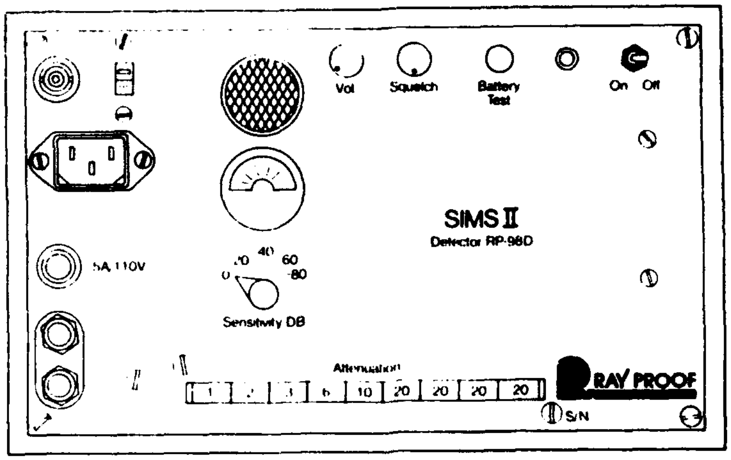
is rather unusual (see Ref. 3). The operation manual for the SIMS II (Ref. 4) was cumbersome but understandable. Figures 10 and 11 depict the SIMS II and ASM units, respectively. SIMS II and ASM data are presented in table 8.

SELDS testing (Ref. 5) is done differently than MIL-STD-285 testing, as it injects rather than radiates current onto the test article (shelter). The test procedures provided by the manufacturer were followed. Figure 12 shows the Eaton SELDS unit used during the test. Three drive locations were necessary to optimize current flow over the test points and faults as shown in figures 5 and 6. SELDS data is summarized in table 9. A brief investigation of the SELDS' ability to measure the performance on a filter, demonstrated that the SELDS has capabilities beyond those advertised. The SELDS direct drove the input side of the power filter on the kick-panel replacement. A 1 μF capacitor connected on the SELDS output decoupled the 60-Hz AC power from the SELDS. Figure 13 shows the details. External measurements near the coupling point were off scale, while internal measurement readings indicated 60 db of signal. The SELDS does not have sufficient attenuation settings to allow for the measurement of magnetic fields near the drive connections. Current-limiting resistors or smaller coupling capacitors could be used in the drive line, but this would only serve to limit the measurement range of the test setup. The modification of the receiver with more attenuation settings would be the best alternative to allow for the accurate measure of the fields near the drive line.

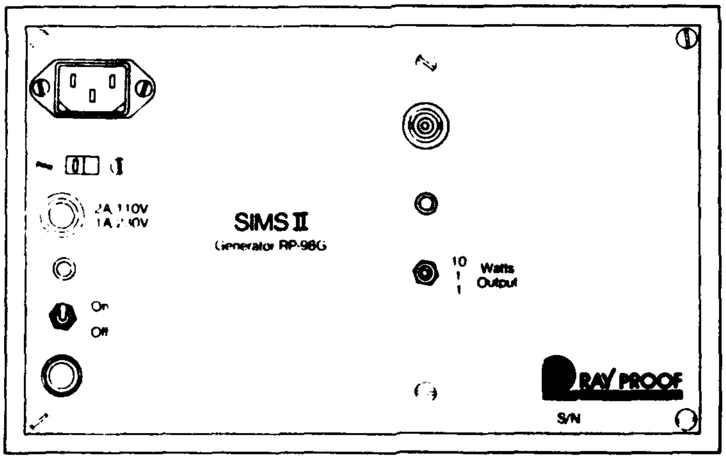
2.3 TESTS CRITIQUE

2.3.1 MIL-STD-285 Test Critique

The MIL-STD-285 test, as performed, adhered to all of the standards requirements. Testing was not done for the low-frequency electric fields, since none of the sniffers operate within this band or mode. No unusual conditions or circumstances were encountered. Low-frequency electric fields are not done as a matter of course since no additional fault detection over the other test frequencies have ever been demonstrated (Ref. 6).



a. Detector.



b. Generator.

Figure 10. SIMS II sniffer.

Figure 11. ASM sniffer.

TABLE 8. SIMS II and ASM test results.

Test Point	SIMS II	ASM PC*	ASM NPC**
1	25	24	22
2	21	24	15
3	25	30	24
4	23	25	19
5	29	31	24
6	40	40	29
7	50	45	34
8	39	39	35
9	41	44	42
10	42	41	42
11	52	48	46
12	48	45	39
13	51	51	40
14	54	43	43
15	46	36	31
16	46	42	31
17	54	41	40
18	42	40	32
19	44	41	33
20	55	43	42
21	48	38	33
22	49	45	40
23	42	42	36
24	45	36	29
25	35	38	27
26	32	34	20
F1	22	22	17
F4	20	23	16
F5	23	20	14

*PC indicates that the shelter was grounded.
**NPC indicates that the shelter was ungrounded.

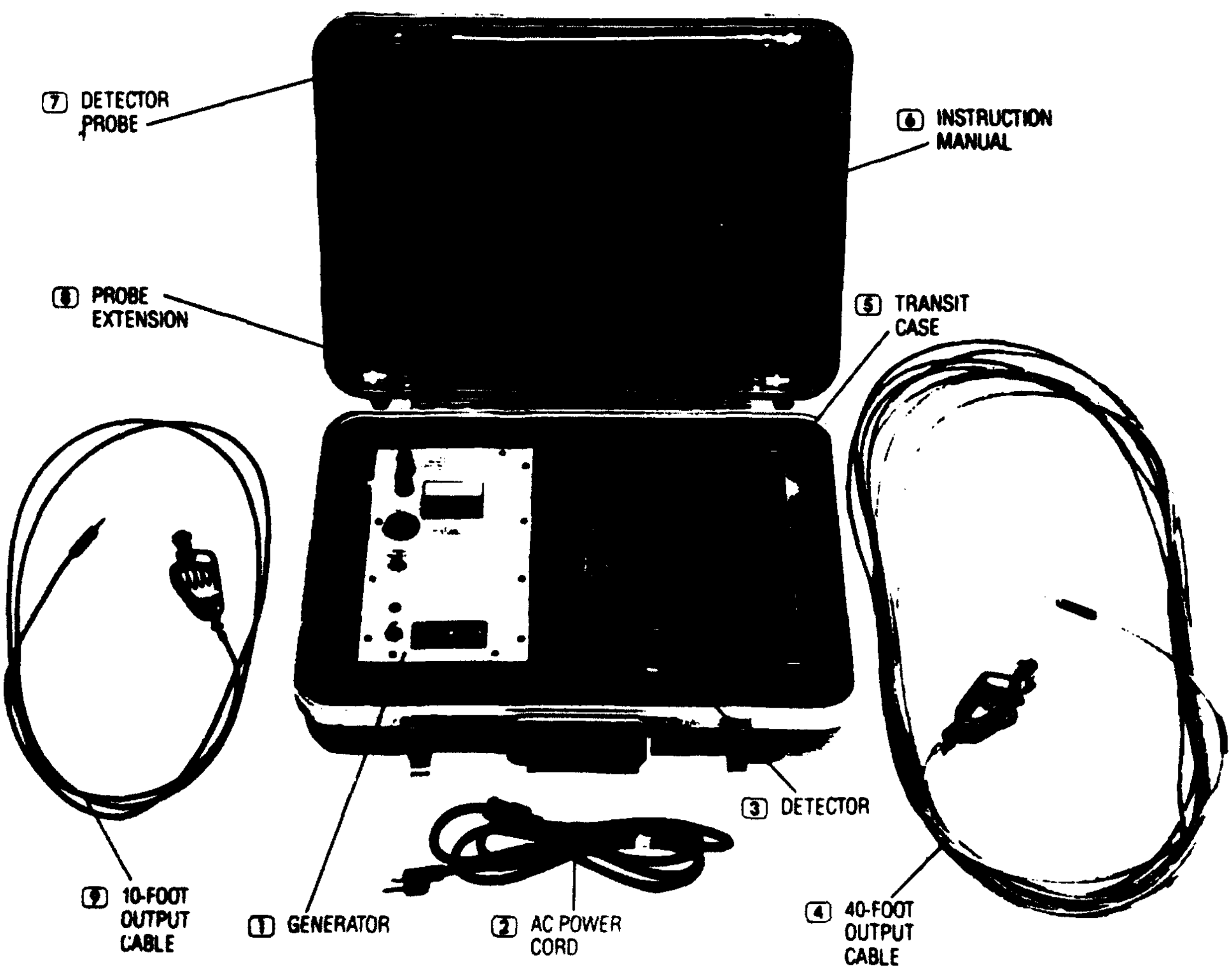


Figure 12. Eaton 3500 shielded enclosure leak detection system.

TABLE 9. SELDS test results.

Attenuation in dB

Test Point	Drive 1	Drive 2	Drive 3
1	34	30	20
2	32	10	12
3	29	15	18
4	24	27	22
5	32	34	22
6	47	46	39
7	42	43	44
8	57	52	47
9	47	49	48
10	52	52	67
11	47	43	42
12	52	55	61
13	37	40	58
14	52	52	50
15	57	57	57
16	64	65	64
17	59	56	53
18	64	63	60
19	66	66	57
20	62	66	54
21	55	54	49
22	44	48	51
23	52	52	52
24	48	48	46
25	44	45	60
26	37	33	34
F1	27	22	20
F4	34	26	22
F5	22	12	4

Drive 1: Test point 25 to upper right rear corner
Drive 2: Bottom left of door to upper right rear corner
Drive 3: Upper right front corner to lower left rear

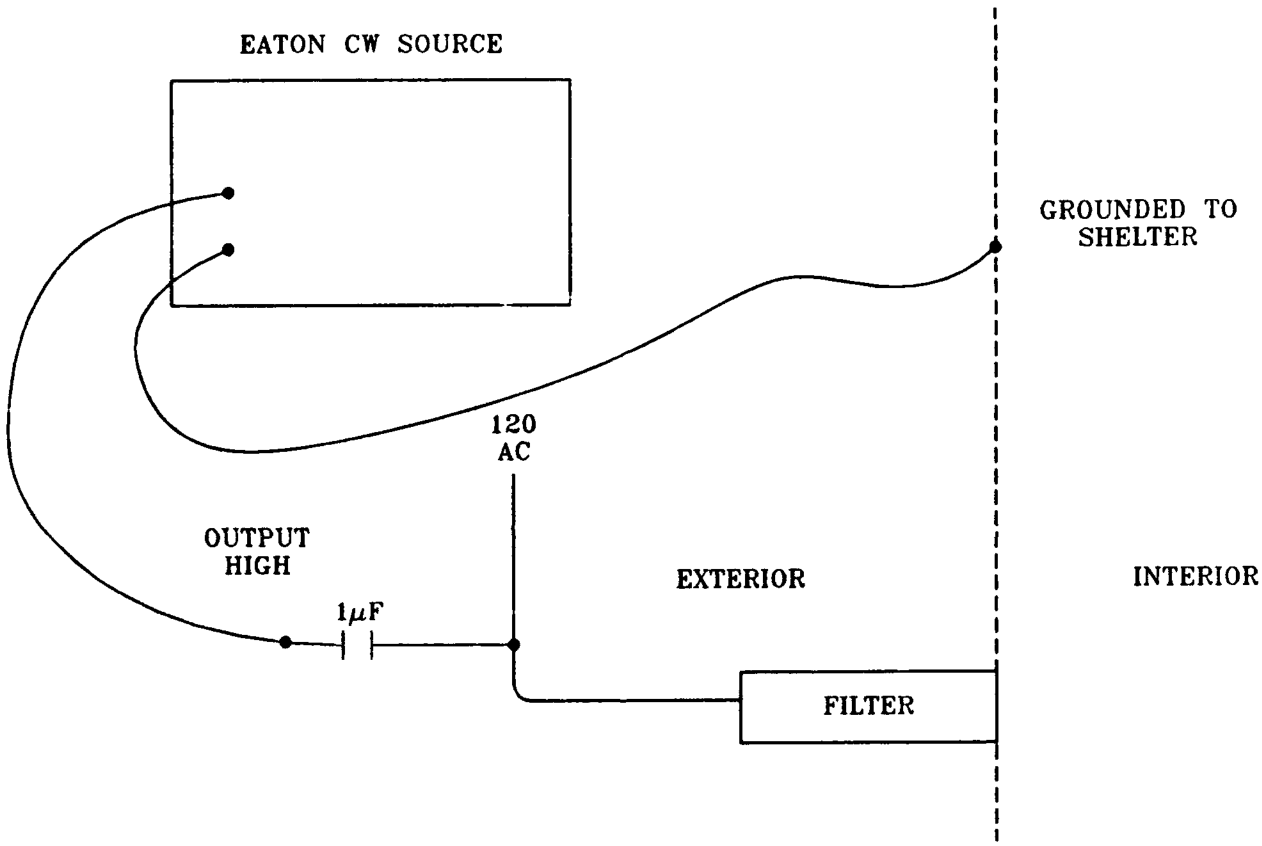


Figure 13. Eaton SELDS direct drive setup.

2.3.2 UDRI MIL-STD-285 Test Critique

This test sequence used the HAMS in an inappropriate and unusual way. The HAMS actually acted as a semiautomated MIL-STD-285 system. Signal-level calibrations were made in accordance with the techniques described in the military standard. Difficulty with the 509-MHz oscillator of the HAMS transmitter required the use of an HP8753C network analyzer as the 509-MHz source. During the MIL-STD-285 test, we allowed the HAMS to run through all of its frequencies rather than modify the controller program. The HAMS operated normally for the test. This test was performed on the front of the shelter only. The majority of the data reflects the measurement range of the UDRI MIL-STD-285 test setup. The data are not an indication of shelter performance, with the exception of the 100-kHz test. The UDRI/MRC 12-GHz sniffer did not have sufficient range to measure the shelter attenuation, with the exception of faults F1, F4, and F5.

2.3.3 UDRI/MRC HAMS Sensor/Fault Testing

The UDRI/MRC HAMS sensor test went smoothly with no anomalous behavior encountered.

2.3.4 Sniffer Performance Test Critique

The sniffer tests went smoothly and much more rapidly than the previous tests. The ASM test results exhibited an unexpected dependence on shelter grounding which is discussed in the following analysis section.

2.4 DATA ANALYSIS

The data gathered in the RF portions of the sniffer evaluations are analyzed statistically. Two fundamental quantities—the standard deviation (σ) and the correlation coefficient (corr)—are used to evaluate the data. Equations (1) and (2) describe these two quantities.

$$\sigma = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(Xi - \bar{X})^2} \quad (1)$$

$$\text{corr} = \frac{\sum_{i=1}^{n}(Xin_1 - \bar{X}n_1)(Xin_2 - \bar{X}n_2)}{\sqrt{\sum_{i=1}^{n}(Xin_1 - \bar{X}n_1)^2 \sum_{i=1}^{n}(Xin_2 - \bar{X}n_2)^2}} \quad (2)$$

where

n is the number of test points

$\bar{X}$ is the average of the total test points at a given frequency

X is a particular test point value

The standard deviation is used to quantify the variation of the data at a specific frequency for an entire test point matrix. While the standard deviation alone provides no information, it does provide an averaged constant over all the test points that can be compared to similar tests at other frequencies. The comparison provides insight to the basic trends of the data and is a quality check on the consistency of the tests. For instance, if two frequencies were to provide the same relative variations in attenuation measurement for all the test points, but have a consistent difference of X dB then the standard deviations for each sniffer would be identical. In this way, relative devices such as the HAMS and the SELDS can have a basis for comparison to the absolute devices (MIL-STD-285, SIMS II, and ASM). The correlation coefficient uses this feature and is well suited for comparing like devices, such as the HAMS to SELDS or the MIL-STD-285 to SIMS II to ASM. A correlation coefficient of 1 indicates a very close match between two tests. A correlation coefficient of 0 indicates no correlation at all.

2.4.1 Baseline MIL-STD-285

2.4.1.1 Uniformity Over Shelter. The baseline MIL-STD-285 tests performed on the shelter using the HP spectrum analyzer displayed good uniformity over the shelter when the standard deviations are compared for each frequency. The low-impedance fields (.01 to 10 MHz) demonstrated reasonable similarities for the standard deviations with the exception of the 1-MHz set. The 1-MHz measurements reside in the AM band and interference is always encountered at this frequency. Table 10 lists the standard deviations and correlation coefficients with their respective frequency for the .01- to 10-MHz measurements. Table 11 shows the MIL-STD-285 standard deviations and sniffer correlation coefficients for the five plane wave frequencies with two polarizations. Table 12 presents similar information for the 10- and 12-GHz frequencies.

TABLE 10. Standard deviations and correlation coefficients for MIL-STD-285 tests 0.01 to 10 MHz (29 samples).

	Frequency (MHz)				
	0.01	0.106	0.15	1	10
Standard Deviation (MIL-STD-285)	11	8.8	12.3	15.3	12.2
Correlation Coefficient (EUROSHIELD)	.74	NA	.63	.74	.76

2.4.1.2 Fault Sensitivity. In all cases for the .4- to 1-GHz frequencies, the best fault detection occurred in the vertical mode. Of these cases, the vertically polarized 462.5-MHz test displayed the greatest fault sensitivity. The 462.5-MHz horizontal mode also displayed the best sensitivity over the other horizontal modes. In the vertical mode, no shelter resonances are near the operating frequencies of the sniffers. The primary shelter resonances occur at 152 MHz for the shelter depth, 184 MHz for the shelter height (vertical), and 155 MHz for the shelter width.

2.4.1.3 Reasonableness of Data. The data results were quite reasonable and consistent throughout the test frequencies. Few inconsistencies were encountered, as demonstrated in the tables of the standard deviations. The correlation coefficients also demonstrated good comparisons for the MIL-STD-285 and sniffer tests.

TABLE 11. Standard deviations and correlation coefficients for MIL-STD-285 tests 0.4 to 1 GHz (29 samples).

	Frequency (GHz)				
	0.4	0.45	.4625	0.5	1
Standard Deviation (MIL-STD-285)					
Horizontal	5.8	9.4	10.4	6.9	8.3
Vertical	11.6	8.5	9.3	9.5	8.9
Correlation Coefficient					
Vertical (ASM)	NA	0.6	NA	NA	NA
Vertical (SIMS II)	NA	NA	0.83	NA	NA

TABLE 12. Standard deviations for MIL-STD-285 tests 10 and12 GHz (29 samples).

	Frequency (GHz)	
	10	12
Standard Deviation (MIL-STD-285, all test points)	14.8	13.5
Correlation Coefficient (UDRI/MRC sniffer)	NA	(1)*

*This correlation coefficient is based only on faults F1, F4, and F5 (3 samples).

Two measurements were taken on each vertical edge. Each measurement was the result of horizontal illumination centered on one of the intersecting walls. In each case, the attenuation indicated was different dependent upon the wall illuminated. The measurement location remained the same for both directions of illumination. For all vertical edge measurements, the measurement location was centered on the bisector of the angle made by the intersecting wall (exterior). These differences are attributed to the shelter resonances in the depth and width orientations. The third harmonics of these fundamental resonances are extremely close to the 450- and 462.5-MHz measurements. The two illumination orientations set up resonances on the shelter in different directions and could cause a leaky seam to radiate in one direction better than the other, not necessarily in the direction of the wall illuminated. The effect also could simply be due to the location or geometry of the leak. The most accurate data, however, should be at 0.4, 0.5, and 1 GHz. Table 13 shows the standard deviations for the edge measurements. As can be seen in the table, the highest variations from vertical to horizontal are at the frequencies of 0.45 and 0.4625 GHz. Another interesting feature at these frequencies (table 3) is that the trend of greater attenuation for the frontal or rear illuminations versus the sides (for 0.4, 0.5, and 1 GHz) is reversed for the frequencies of 0.45 and 0.4625 GHz. This is believed to be due to third harmonic standing waves set up at these frequencies. While both the 0.45 and0 .4625 GHz frequencies (ASM and SIMS II) are consistent with each other, the absolute attenuation indicated is erroneous.

TABLE 13. Vertical edge measurements (MIL-STD-285 data) (4 samples).

	Frequency (GHz)				
	0.4	0.45	.4625	0.5	1
Standard Deviation					
Horizontal	7.4	11.3	9.2	8.8	10.3
Vertical	6.9	11.5	7.8	5.7	4.1

2.4.1.4 Modified MIL-STD-907B Corner Measurement Technique. The technique described in MIL-STD-907B is useful for ensuring consistent, repeatable attenuation measurements at corners and edges. Measurements done on corners in accordance with the military standard and repeated, as shown in figure 5, did not indicate that the technique produces more accurate results; however, it does produce consistent results, and the measurement is easier to implement. Table 14 presents the MIL-STD-285 data for the low-frequency tests done on one corner of the shelter. As can be seen in table 14, the average value and measurement on bisector of corner (CD) are very close for frequencies of 150 kHz and above.

TABLE 14. Corner measurement comparisons.

Attenuation in dB

Test Point	Frequency: 10 kHz	150 kHz	1 MHz	10 MHz
C1	93	91	93	110
C2	91	95	99	110
C3	93	92	84	108
CD	105	93	92	110
AVERAGE	92	93	93	109

2.4.1.5 HAMS MIL-STD-285.

Comparison to Baseline. The HAMS employs a technique of monitoring that is quite different from the MIL-STD-285 method. The HAMS system uses the shelter itself as part of the sensor/driver arrangement. The MIL-STD-285 keeps the sensors and drivers separate from the shelter. The HAMS also places the sensor and driver within $\frac{1}{8}$ inch, while the MIL-STD-285 has separations of up to 72 inches, an increase of as much as 600 times.

While it is true that the HAMS has an operational measurement range in excess of 100 dB when properly configured, the increased distances required by MIL-STD-285 significantly reduce the measurement range of the HAMS. For the HAMS to be used effectively as a MIL-STD-285 device, additional power amplification is required for the transmitter output signals. For these reasons, the HAMS could not be compared with MIL-STD-285, with the exception of the 100-kHz frequency. At this frequency, the HAMS did have sufficient measurement range.

2.4.1.6 Sniffers. The sniffer data compared favorably with the baseline MIL-STD-285 tests, as shown in tables 10 through 12, with one notable exception for the ASM unit. The ASM unit displayed an unusual dependence on shelter grounding. Since the ASM receiver and transmitter are both battery-powered, the initial measurements were made with the shelter ungrounded. The test results were not consistent between the MIL-STD-285 or SIMS II, and the ASM. Investigation showed that both the MIL-STD-285 and the SIMS II test were done with the shelter grounded. Grounding the shelter for the ASM tests resulted in virtually identical data (correlation of .95) between the SIMS II and the ASM. Difference in the grounded and ungrounded ASM data, as shown in table 8 (summary), result from changes in current distributions of the standing waves within the shelter. When the shelter is floating, the current distributions are constrained to one configuration. While grounded, the current distributions change since the shelter has a different resonant frequency. The change in resonant frequency is due to the change in the electrical length of the shelter due to the grounding.

2.4.1.7 Eaton SELDS. The SELDS data is highly dependent on the placement of the drive lines. As expected, faults residing near the drive points indicate a disproportionate degree of shielding over remote test points since the current density is highest near the drive lines. This effect is present independent of shelter size; however, the larger the shelter, the smaller this effect is when compared to the surface of coverage (the larger the shelter, the more uniform the current distribution). For the shelter tested, the variation in current distribution is very evident in the data. The data tabulated in table 9 does have some trends worth mentioning. The average attenuations seen over the shelter for all three drive conditions is remarkably similar, 45, 43, and 42 dB for drive conditions 1, 2, and 3, respectively. This is not unexpected since the overall gains and losses for each condition should average out for uniform test point distributions. Using the SELDS as a direct drive device for filter tests is a useful tool. The selection of coupling capacitors must be based on the filter ratings for maximum current in order to preclude damage to the filter under test.

2.4.2 Traits and Operation Evaluations

2.4.2.1 SIMS II. The SIMS II unit displayed good sensitivity and immunity to the ambient RF environment of our laboratory. The unit was able to detect all of our fabricated faults and measured attenuations comparable to the MIL-STD-285 and ASM tests over the surface of the shelter. The resonant effects of the shelter and SIMS II did not prevent the detection of leaks, but did prevent the measure of absolute attenuations. The dynamic range for the SIMS II was 95 dB, and the maximum attenuation measurable was 95 dB. This is adequate for use on most shelters presently in use. The following paragraphs present our detailed operational evaluations. The bandwidth of the SIMS II was unmeasurable since it required a variable FM source.

Ease of Operation. The operational manual is brief, nine half-size pages. Three pages are figures. The operating instructions are four pages, two describing either the Leak Location Mode or the Automatic Alarm Mode. The Automatic Alarm Mode is probably what this unit was actually meant to do, or at least some compromise was made to accommodate this capability.

Continuous handling, a two-handed operation, of the detector is awkward and not particularly functional since it was noted that the (attenuation) level meter needle on our unit tended to stick at either extreme and usually had to be tapped to dislodge it. Alternatively, the attenuation has to be dramatically changed to cause movement.

Power Application. After power is applied, there is a short 3- to 5-minute delay. Attempts to use the units before this delay seems to produce erratic readings. The generator, RP-98G, has a temperature stability range of −30°C to +50°C. No temperature range is given for the detector, but is assumed to be nearly the same. For this report, the temperature was approximately 22°C.

The calibration procedure is unconventional. As stated in the operating instructions, the generator and detector are to be placed inside the shielded enclosure being tested and the door is to be closed. All tested units other than this Ray Proof unit have instructions that direct calibration be done remotely to the shielded surfaces. This avoids unnecessary reflections and interference. The instructions do not indicate at what power setting the calibration should be accomplished so it is assumed to be the choice of the user and the situation. For testing a well-built/-assembled enclosure, the 10-watt power selection is preferred. This certainly applies to the Leak Location Mode. In the Automatic Alarm Mode, 0.1 watt is recommended to detect the cycling of a door.

It was not possible to get the 120- to 140-dB dynamic range stated in step 6 of the Measurement Mode. The dynamic range also varied with the generator power selection. For example, at 0.1-watt setting, the range was 87 dB; at 1.0-watt setting, the range was 97 dB; and at 10.0-watt setting, the range was 107 dB. Also, from day-to-day, these readings varied from −5 to −12 dB.

Power Requirements. The generator is powered by 115/230 VAC at 50/60 Hz, selective depending on the supply. This is converted to 15 VDC at 3.4-A output. The detector is powered by 13.5 VDC. The detector DC system is powered by either 115/230 VAC at 50/60 Hz or internally by 12 V supplied by two 6-V Gel Cells. The Gel Cells are inactivated when commercial power is applied. When using 110-VAC commercial power, the AC is fused at 0.5 A; when using 230-VAC commercial power, the AC is fused at 0.25 A.

Battery Life. The Gel Cell operating time, as identified in the SIMS II manual, is 15 hours with 8 hours needed for recharging. These values were found to be correct. The quality of the charge on the Gel Cell may be tested using the detector battery test button. On the level meter is a red line which indicates minimum allowable charge. No instructions are given for replacing the Gel Cell.

Charging Time. The charger is built in the detector unit, RP-98D. The detector may be operated while being charged. This is very positive with regard to continued testing, following battery discharge, if a commercial power source is convenient to the test area. The charger output is at 13.5 VDC.

Reliability. This unit, the SIMS II, has been used periodically over a long period. Generally, this use has been for small-volume testing over relatively short periods at temperatures of 10 to 27°C. This unit has also been transported to distant test sites and traveled well in the manufacturer-provided case. Because of the level meter needle and attenuator variances, the accuracy of this test unit is not within 1 dB as stated in the operational manual.

Following the Limited Warranty (last page of the operational manual) is a statement that the service for the SIMS II contains no user-serviceable parts. Past experience with similar testing units has shown that the battery may be replaced by any competent technician; thus, the expense in time and money of returning the unit to the manufacturer (RayProof) is unnecessary. However, for other services, such as calibration, sticking needle, and unreliable attenuators, it may be more advantageous to have the unit checked by the manufacturer.

Maintainability. Maintainability relates to the ease with which equipment functions can be restored once a malfunction occurs.

2.4.2.2 ASM. The ASM unit displayed good sensitivity and immunity to the ambient RF environment of our laboratory. The unit was able to detect all of the fabricated faults and measured attenuations comparable to the MIL-STD-285 and SIMS II tests over the surface of the shelter. The resonant effects of the shelter and ASM did not prevent the detection of leaks, but did prevent the measure of absolute attenuations. The dynamic range for the ASM was 110 dB.

The maximum measurable attenuation using the ASM was 116 dB. This is in excess of the 100 dB requirement of MIL-STD-285. The ASM unit has a receiver bandwidth of 8 MHz.

Ease of Operation. Generally, this test set is superior to most single frequency test sets for the frequency range of 450 MHz. It is easy to operate, dependable, and accurate.

The operation manual is brief. Section 3.3 is confusing. Other sections are adequate but do not provide enough information to fully describe or to completely understand some of the necessary specifications and operation/maintenance procedures.

The transmitter and receiver are quickly available for testing after turn-on. There are no operational or storage temperature limits provided. These limits are assumed to be similar to other test sets. For this evaluation, the temperature was approximately 22°C.

The calibration of the transmitter/receiver is straightforward, but as described in the section 3.3, Operation Procedure (MIL-STD-285-Type Testing), it is confusing. This published procedure instructs the operator to place the transmitter 30 feet from the shielded wall under test, but the reason for this is not stated. In practice, the calibration should be remote to the shield and 30 feet may be appropriate. The procedures further stated that the transmitter should never be moved closer than 7 feet from the shielded wall under test. Again, no explanation is given. Most likely, the distance is based upon the transmitter frequency wavelength, about 1.5 meters.

The calibration should be done in the open, away from the shielded structure, and the transmitter and receiver should be about 7-feet apart. Other instructions given, concerning calibration, state the receiver should be zeroed while the receiver is being moved back and forth from 2 to 24 inches from the shield. This is very confusing!

Once the calibration is completed, the receiver may be placed no closer than 2 inches to the shielded surface while the transmitter is a least 7 feet from the nearest shielded surface to be tested and on the opposing side to the receiver. The receiver may be moved about the opposite shield surface with the disadvantage being the loss of dynamic range as the transmitter and receiver separation is increased.

Power Requirements. Both the transmitter and receiver are battery-powered.

The specific battery specifications are not given, other than an ASM part number. The batteries are lead-acid and rechargeable. Based upon experience with this unit over several years, this appears to be simply a marketing technique. The batteries may be purchased at any battery specialty shop and installed by a technician. The replacement is a bit awkward, but not difficult.

The battery charger may operate at either 120 or 240 VAC, 60 Hz.

Battery Life. During the endurance test, the transmitter was expected to show the first signs of power failure. The first indication the system was not performing 100 percent was an increased attenuation reading for a single test point that was repeatedly used. This occurred after 9 hours and 40 minutes of continuous operation. After 10 hours of operation, the transmitter battery-condition indicator needle began to show a fluctuation below the battery check mark.

The operation manual specifications indicate the transmitter operating time to be 8 hours and the receiver operating time to be 8 to 12 hours. From experience, these numbers are probably correct, but there has never been an occasion to use the receiver separate from the transmitter; therefore, using the receiver beyond 8 hours has not been verified. Obviously, these times may be extended by judicious use of the on/off switch during periods of no testing.

Charging Time. Recharging time for the transmitter and receiver batteries is 2 to 3 hours. This is accomplished using the provided charger which is equipped to charge both units simultaneously

Reliability. This test set is constructed of quality parts and functions as designed; the batteries are the only parts to have failed in our experience with four of these sets over 5 years. In an earlier design of the antennas, it was possible to break the antenna wire inside the vertical member of the antenna by twisting the upper limit of the threaded connector which is used to attach the antenna to either the transmitter or the receiver. In the test set used here, the redesigned antennas did not have this weakness. The two antennas are identical and interchangeable.

Maintainability. Maintainability relates to the ease with which equipment functions can be restored once a malfunction occurs.

The foam-lined, metal carrying case is adequate for all uses and resists damage. The two closures do not require a key. Using tape to secure these closures is recommended when the case is checked with a common carrier or when the case will be repeatedly handled during transportation.

Battery replacement takes reasonable effort and care. Because the batteries are secured with brackets that have very small screws and nuts, some special tools are needed.

The operation manual gives no maintenance information except for battery replacement. Here it is stated that the units are to be returned to ASM Products, Inc., for replacement. With the proper tools and test equipment, it is possible for the user to replace the batteries and any other part for which he has the proper replacement and to accomplish a calibration of the transmitter and receiver.

2.4.2.3 EUROSHIELD. The EUROSHIELD unit displayed good sensitivity and immunity to the ambient RF environment of our laboratory, with the exception of the 150-kHz and 1-MHz test frequencies. For these measurements, it was necessary to use the receiver unit inside the shelter. The unit was able to detect all of our fabricated faults and measured attenuations comparable to the MIL-STD-285 tests over the surface of the shelter. The unit was not affected by shelter grounding configurations. The dynamic range for each of the test frequencies and their corresponding measurement range was identical. Table 15 lists the measured bandwidth and sensitivities for each frequency.

Ease of Operation. The user's guide is well written and contains adequate information concerning the intended use for measuring magnetic attenuation at four frequencies (10 kHz, 150 kHz, 1 MHz, 10 MHz). These measurements are intended to be in accordance with MIL-STD-285 and/or NSA 65-6.

TABLE 15. Bandwidth and sensitivities for each EUROSHIELD frequency.

Frequency	Bandwidth (Hz)	Sensitivity (nA/m)
10 kHz	36	1500
150 kHz	26	204
1 MHz	30	112
10 MHz	25	10.6

Power Application. The units are quickly available for testing after turn-on. The user's guide states the calibration of the receiver is affected by temperatures below freezing and that the unit should be warmed to above freezing prior to calibration.

The operating range is specified as 0°C to +40°C. For this report, the temperature was approximately 22°C.

The calibration procedure is conventional and straightforward. The 30-cm rods supplied with each unit allow for accurate unit separation plus the measured wall thickness. Experience has shown that the magnetic attenuation measurement process is very sensitive to transmitter/receiver separation.

Assuming adequate battery power (see the following section), choose the appropriate frequency with the transmitter selector. Then, press the calibration button of the receiver; this starts an automatic built-in test sequence in the receiver. This sequence selects the transmitted frequency and then shows 0-dB attenuation. If the needle does not settle on the zero point, then a screwdriver adjustment should be made so subsequent readings will be accurate. This adjustment is usually unnecessary. During measurement sequences, the receiver microprocessor searches for the peak intermediate frequency using Fast Fourier Transforms and a 64-sampling algorithm for comparison with the calibration signal.

Care should be taken to prevent inadvertent pressing of the calibration button after calibration is complete. This button is located near the receiver's center of gravity; hence, the person holding the receiver may easily, inadvertently, touch/press this button. This initiates a new calibration sequence and will require recalibration at the correct distance separation of the receiver/transmitter. It would be better if the calibration button were a throw switch or other mechanical device requiring more deliberate user action.

Power Requirements. The transmitter and the receiver each require six 1.5-V D-cell batteries. Depending on the frequency selected, the transmitter RF currents vary from 110 mA at 10 MHz to 1.3 A at 10 kHz. For this exercise, the 10-kHz frequency was selected since higher current will discharge the batteries more quickly. The first symptom of battery failure manifests as increased attenuation readings of the receiver at the same test point locations. Both units have small green bulb indicators for battery status. Both bulbs were "weaker" in brightness at the time of the increased attenuation reading, but the bulbs never flashed as stated in the user's guide. The best indication of power failure is the increase in attenuation above a number recorded at an earlier measured, unaltered, test point. Alternatively, a check on total hours of system use based upon numbers presented in the next paragraph give an estimate of time for failure.

Battery Life. The user's guide specifies battery life as 10 hours. Following a 3-day experiment (with the same batteries) using the units continuously for 6, 10, and 24 hours, it is believed the units may be operated successfully well in excess of the 10 hours specified. The attenuation measurement was nearly constant through the first 26 hours of noncontinuous use. The variance was +1 dB and was probably because of measurement error, not instrument error. The measurements appeared to be accurate within 1 dB at 10 kHz.

Battery failure indications are an increase in attenuation for the same test point as stated above, and the dimming of the green bulb intensity for both units. Both units showed the same degree of dimming (subjective judgment). One would normally expect the transmitter to use a greater amount of power and fail first. This is why the 10-kHz frequency was chosen, as it requires a 1.3-A RF current.

A power-supply compensating circuit for fluctuations in the battery-supply voltage may be a reason the transmitter is able to maintain its constant output as "seen" by the receiver even as the batteries are degrading.

Charging Time. Charging is not applicable to the as-delivered Euroshield 4F-130. The batteries are simply replaced.

Reliability. A long-time test of this equipment being used in many environments by many different users was not possible. With proper care, this system appears to have the characteristics of a well-designed and -constructed instrument using quality parts. The Euroshield 4F-130 should continue to function as required. One difficulty was encountered with this unit. When the receiver is set down vertically with normal care, the batteries momentarily disconnect from the terminals of the unit which causes the unit to recalibrate. This should be fixed. In the meantime, the unit should be set down horizontally.

Maintainability. Maintainability relates to the ease with which equipment functions can be restored once a malfunction occurs.

Paragraph 6.2 of the user's guide does not provide enough detail for the techniques needed for performance verification tests of the transmitter and receiver. These tests are required if the receiver will not calibrate or will not calibrate at one frequency, or if the needle hits at the left end of the display.

The carrying case is adequate for normal laboratory, local, or carry-on (airline) uses, but it is not adequate for checked luggage. The latches are light duty and may open during handling or transporting in common carriers. Taping the latches and packing in a well-padded, second container are recommended.

Battery replacement takes reasonable effort and care. The six batteries are installed in series, giving 9 V.

Since the units are a product of Finland, more time may be needed to receive parts replacement or to get damaged units repaired.

2.4.2.4 Eaton. The Eaton unit displayed good sensitivity. The presence of fluorescent lights will affect the measurement range of the device when the sensing element is near or pointed at an active light fixture. This occurs primarily for measurements near ceilings. The unit detected all of our fabricated faults. Indicated attenuations varied significantly for different drive configurations. The SELDS is a useful tool for finding leaks, but it cannot quantify the amount of leakage. The SELDS could also be used as a relative device for measuring degradations from baseline set-up measurements. The bandwidth of the SELDS was 3.5 kHz and the minimum sensitivity was 450 nA/m using the Wellems 2 magnetic dipole as the measuring antenna.

Ease of Operation. The operator's manual is lengthy, detailed, and well written. In addition to operation, the manual covers performance tests (analogous to calibration for sniffers), maintenance, replaceable parts list, schematic diagrams, functional and physical descriptions, etc. The confidence test makes use of a Test Well on the generator front panel. The detector probe is placed into this well and toggled on while the test push button on the generator is depressed. The Signal Level Meter then should read between 15 and 25 dB. It usually reads 20 dB.

Upon completion of the confidence test, the SELDS is ready for operation. This may be as little as 3 or 4 minutes. The operating environment temperature range is 0°C to +55°C. The temperature might possibly be near 0°C for some testing since the SELDS may be used before building closure and heating of tested volume.

The purpose of a SELDS is to detect, measure (relative), and precisely locate defects that permit RF leakage through a shielded enclosure. Because of its low operating frequency (106 kHz), the SELDS may be used on welded joints that are not fully enclosed in a box, such as a Faraday enclosure. This allows testing to occur while the welding is in progress and is a very efficient process. Depending upon the user's knowledge and skill, a successful SELDS test will find well over 90 percent of all "leaks" before they are found by other, later-time, higher frequency testing. The remaining 10 percent of leaks seldom includes sheet/plate steel seam welding flaws but is related to penetrations such as doors, and these "leaks" are found only after the welding is complete and the Faraday-type enclosure is fully closed.

A headset is recommended when examining large surface areas. The headset allows better concentration by the user and allows for easier detection of any variance/modulation in the 700-Hz audio signal.

Power Requirements. The Eaton 3500 generator requires 115/230 VAC at 50-60 Hz and uses 25 watts. The detector uses six size AA ($1\frac{1}{2}$-V) batteries. Two of these batteries (3 V) provide power for the two lamps on the detector while the remaining four batteries (6 V) provide power for the detector circuitry. The detector circuit powered life time is dependent upon the user's operation of the switch. Using headphones cuts out the built-in speaker and is a more positive technique for hearing the difference in frequency as a test progresses from a no-leakage area to one with leakage. Also, the headphones generally require less power than does the built-in audio speaker.

The two batteries used to power the two bulbs, one for lighting the test area and the second for lighting the level meter, are not essential for operation unless there is no alternative light source.

Battery Life. To investigate the life of the batteries in the detector, the detector switch was tapped on for 30 minutes and released to off for 5 minutes. This procedure was done for 8 hours with no change in receiver performance.

After a 10-hour wait, the procedure was repeated for another 4 hours; now, degradation was seen. A period of 48 hours elapsed before the next test. The procedure was again repeated for $6\frac{1}{2}$ hours when erroneous readings finally began to occur. The meter illumination batteries were not tested for this effort.

Charging Time. Non-applicable.

Reliability. Reliability is simply the ability of an instrument or piece of equipment to function as required, as it is advertised to do. The Eaton 3500 does function as advertised. Using the Eaton 3500 system to detect, measure, and precisely locate defects that permit RF leakage is what it's advertised to do and it does it. Short-term failure of this equipment seldom occurs. Over a long period of heavy use, the detector probe may be damaged by wear against the shielding surface since the probe is usually dragged along that surface during testing. Also, damage may occur to the probe extension after much bending.

Maintainability. Maintainability relates to the ease with which equipment functions can be restored once a malfunction occurs.

2.4.3 Sniff-Off

All of the sniffers were able to detect the fabricated faults in the replacement kick panel. The ability of one sniffer to detect a fault more readily than another is due to two frequency-dependent considerations. The amount of coupling through a fault depends on the resonant frequency of the fault as well as the operating frequency of the sniffer. The fabricated faults are primarily low frequency in nature. Thus, the Euroshield and MIL-STD-285 loop tests measured the lowest amount of shielding, since they are low-frequency tests. The unintentional faults in the joints of the shelter tend to be small cracks or separations in seams. These smaller cracks allow for good coupling at the higher frequencies. At low frequencies, the skin depth effect can dominate the data and make minor cracks in the shield virtually undetectable, especially for nonferrous shields; thus, higher frequency testing is required.

All of the sniffers performed as expected for their frequency of operation. Clearly, none of the sniffers out-performed the others in the ability to determine the shielding effectiveness of the shelter, with the exception of the Eaton SELDS. The Eaton sniffer is not capable of determining the amount of shielding provided by a shelter and can only provide indications of faults. This limitation is not a problem. The UDRI/MRC HAMS system operates in a similar manner in the monitoring mode. Table 16 presents the sniff-off data for the sniffers as measured for intentional faults. For the sniff-off, only one fault existed at a time; the others were sealed over with copper tape to ensure that only the fault in question was being detected. Fault 4 was modified so that only one hole was open. Figure 3 shows the fault and measurement location for this test.

The most interesting feature apparent in this table is the variation in the attenuations for the three measurement locations when the paper is inserted between the door and frame.

TABLE 16. Sniff-off data.

Attenuation in dB

	Fault/Measurement Location							
Sniffer	F1	F2	F3	F4	F6	PAPER1	PAPER2	PAPER3
EUROSHIELD								
10 kHz	35	35	35	24	30	32	22	29
150 kHz	50	49	50	46	46	48	39	54
1 MHz	60	60	60	61	46	68	46	62
10 MHz	74	74	74	79	69	88	54	71
SIMS II	61	62	62	60	–	18	20	28
ASM	60	70	69	68	–	34	12	27

The SIMS II demonstrated the least variations with regard to measurement location. This indicates that the SIMS II will detect a leak more readily but will have difficulty isolating it. The EUROSHIELD at 10 MHz had the largest variation over the measurement locations indicating better leak-isolating capabilities. Another interesting feature of this test is that faults 1, 2, and 3 yielded identical data, indicating that the cover contact was good even without a gasket. By adding one more compression stop (F6), the cover finally leaked. The gasket was barely held in place for this last test point.

3.0 TASK 2: UDRI/MRC HAMS REFINEMENT

3.1 GENERAL DISCUSSION FOR TASK 2

This task has two objectives: (1) the identification of commercial replacement components for the HAMS and (2) further development of efficient sensor driver pairs for use by the HAMS. The replacement of components with commercial equivalents is the first step toward the militarization of the design. Both objectives were met with reasonable success.

3.2 PARTS SURVEY

The component survey consisted exclusively of telephone contact with numerous manufacturers. Table 17 lists the MRC-manufactured components used in the HAMS and their commercial alternatives.

Replacement oscillators, a mixer, and an IF amplifier were all located. The oscillator select cards and oscillator power relay cards were not included in the survey. Both of these cards are easily manufactured and of such specific application that they would not exist commercially. The AGC circuit is also rather specific in application and is better manufactured by the system manufacturer. The Vectron 500-MHz oscillator used in the HAMS system is marginal only due to its output signal voltage. The vectron was purchased originally because of its availability and cost; we recommend a higher voltage output device for use in the production version of the HAMS. All the components identified in table 17 appear to be adequate for the HAMS. Specific recommendations cannot be made without testing and evaluating these components.

3.3 DRIVER RECEIVERS

Six sensor driver pairs were characterized and used in this program effort. Table 18 presents the name, intended usage, and physical dimensions for each of the sensor drivers used. The sensor driver pairs are shown in figures 14 through 16.

TABLE 17. Replacement parts survey for UDRI/MRC HAMS.

Product	Manufacturer & Address	Telephone #	Comments
IF Amplifier	Avantek, Inc. Santa Clara, CA	(408) 943-4343	Available, type UTC5-212 (47-dB gain, 2.7-dB noise, 1-V output)
IF Amplifier	Aydin Vector Division Newtown, PA	(215) 968-4271	Available
RF Mixer	Anzac Division Burlington, MA	(617) 273-3333	Available, from 200 kHz to 200 MHz, or from 500 kHz to 50 MHz (7–13 dBm, mixer output at 9 MHz
RF Mixer	Merrimac Inds. Corp. Caldwell, NJ	(201) 575-1300	Available, from 400 kHz to 500 MHz (100 kHz to 509 MHz available on special order)
RF Mixer	Mini-Circuits Laboratory Brooklyn, NY	(718) 934-4500	Available, from 500 kHz to 500 MHz (7–13 dBm, type SRA-1MH)
RF Mixer	Tele-Tech Corp. Bozeman, MT	(406) 586-0291	Available, from 200 kHz to 500 MHz (7–13 dBm, mixer output at 9 MHz)
Oscillators	Ball Corp. Irvine, CA	(714) 770-5000	Available: 10 MHz only
Oscillators	Communication Tech., Inc. Whippany, NJ	(201) 884-2580	Available: 39 MHz, 100 MHz, 109 MHz, 509 MHz
Oscillators	Comstron Corp. Melville, NY	(516) 694-6700	Available: 100 kHz, 1 MHz, 3 MHz, 9.1 MHz, 10 MHz, 39 MHz, 100 MHz 109 MHz, 509 MHz

TABLE 17. Replacement parts survey for UDRI/MRC HAMS (concluded).

Product	Manufacturer & Address	Telephone #	Comments
Oscillators	Electronic Research Corp. Overland Park, KS	(913) 631-6700	Available: 100 kHz, 1 MHz, 3 MHz, 9.1 MHz, 10 MHz, 39 MHz, 100 MHz 109 MHz
Oscillators	K&L Microwave, Inc. Kansas City, KS	(913) 631-6700	Available: 100 kHz, 1 MHz, 3 MHz, 9.1 MHz, 10 MHz, 39 MHz, 100 MHz
Oscillators	Piezo Crystal Company Carlisle, PA	(717) 249-2151	Available: 1 MHz, 3 MHz, 9.1 MHz, 10 MHz, 39 MHz, 100 MHz, 109 MHz
Oscillators	RFM, Inc. Dallas, TX	(214) 233-2903	Available: 509 MHz only
Oscillators	Vectron Labs., Inc. Norwalk, CT	(203) 853-4433	Available: 100 kHz, 1 MHz, 3 MHz, 9.1 MHz, 10 MHz, 39 MHz, 100 MHz 109 MHz, 509 MHz

TABLE 18. Sensor driver specifications.

Name	Usage	Dimensions	Comments
Folded inductors	Door seals Panel joints	FI type, 18" × 2" FA type, 14" × 1/2"	Used in previous UDRI/MRC efforts
Leaky coax	Waveguide penetrations Panel joints	RG58 coax 18 inches long	1/8-in diam. holes (three inch spacing) short-circuit termination
Unshielded coax core and dielectric	Door seals Panel joints Waveguide	RG58 coax	Similar to the Rockwell International sensor
Slotted coax	Panel joints Waveguide penetrations	1/2-in outer diam. 18 inches long	1/16-in slot width #20 AWG core wire loose*
Series loop	Door seals Waveguide penetrations Panel joints	1/2-in inner diam. 18 inches long	Four loops three turns each 3-in separation wired in series
Parallel loop	Door seals Waveguide penetrations Panel joints	1/2-in inner diam. 18 inches long	Four gapped loops one turn each, 3/8-in wide 3-in separation wired in parallel

*Indicates that the core wire was allowed to reside anywhere within the 3/8-in interior of the coaxial arrangement.

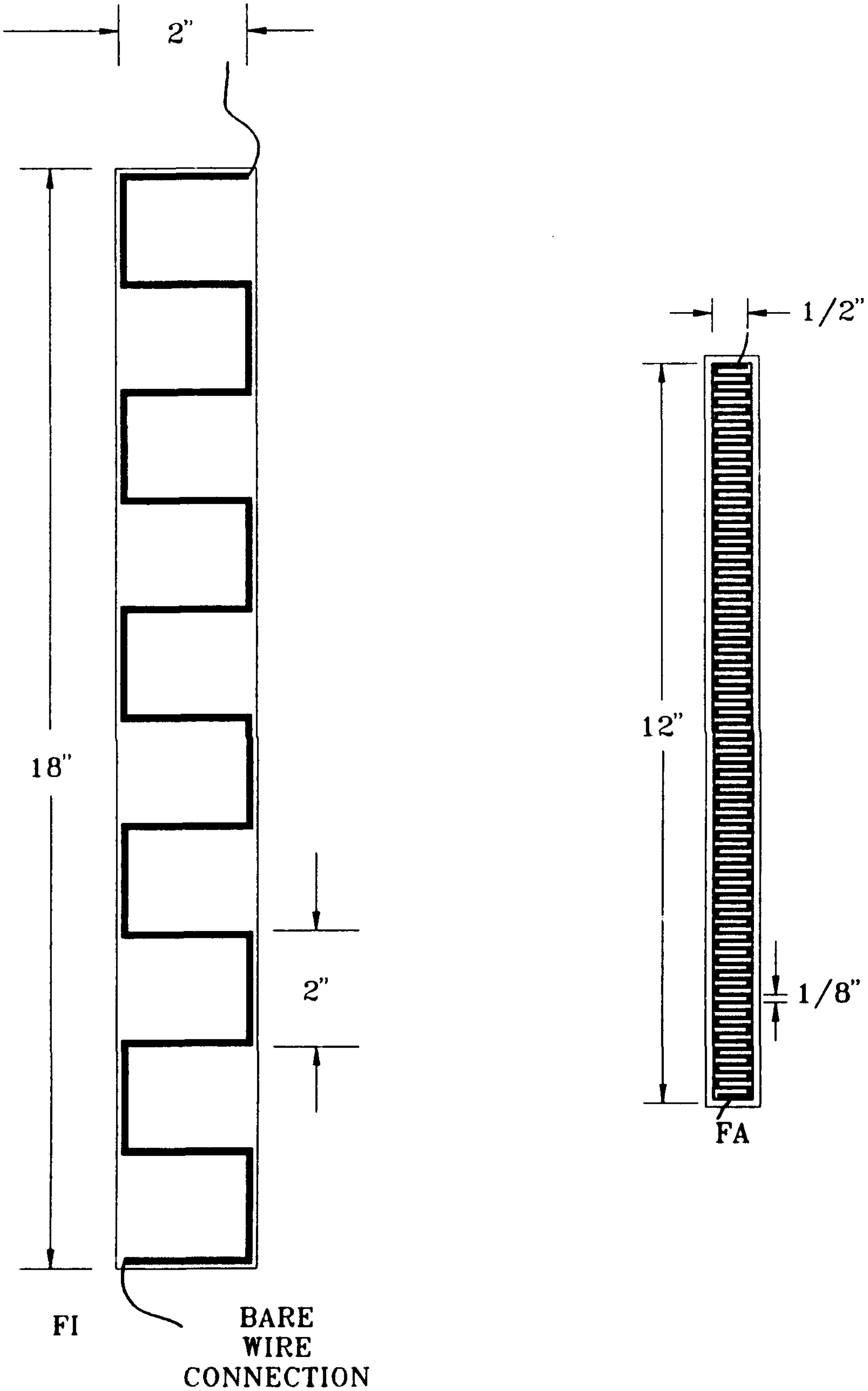


Figure 14. Sensors FI and FA.

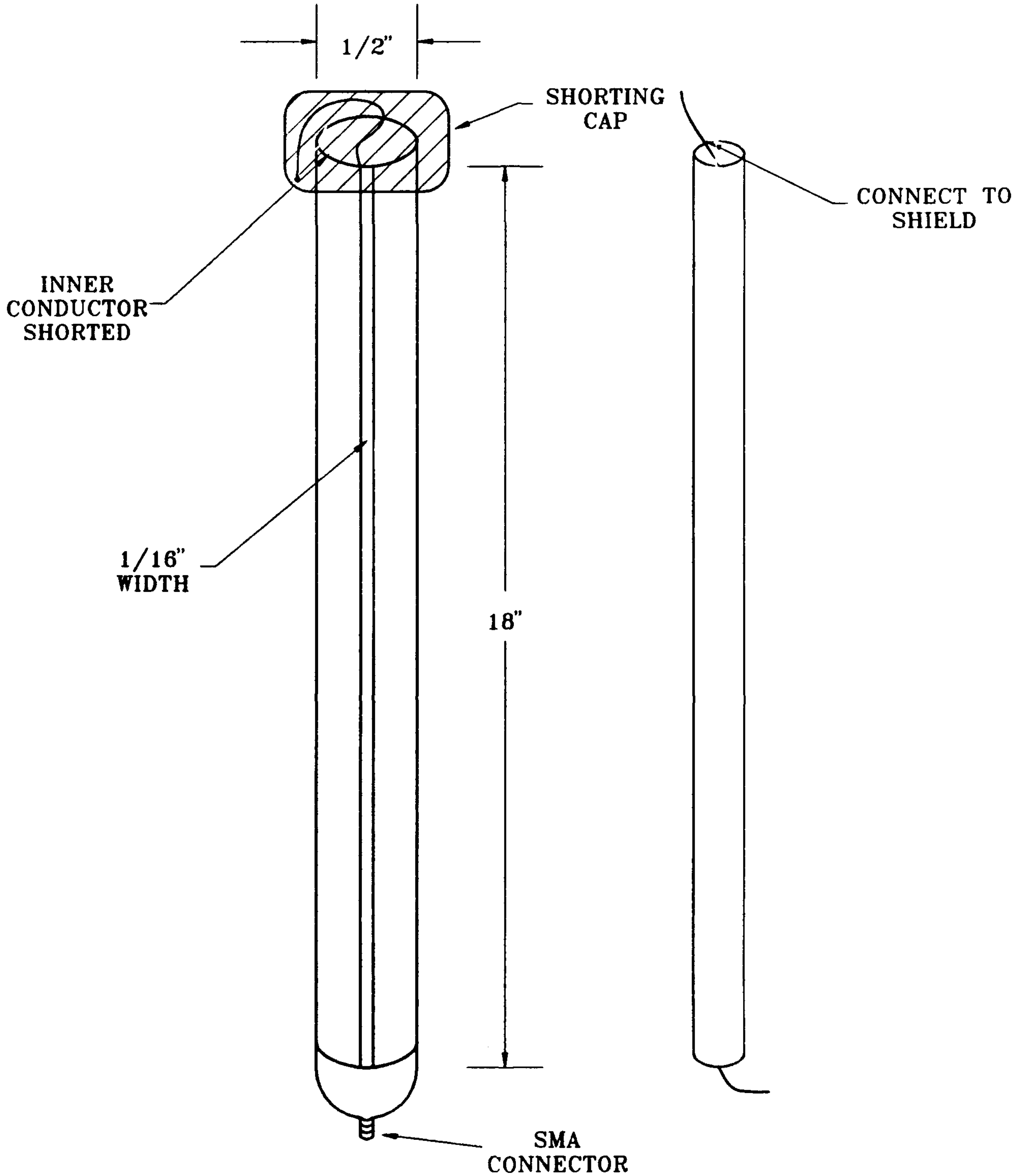


Figure 15. Sensors slot and unshielded coaxial core.

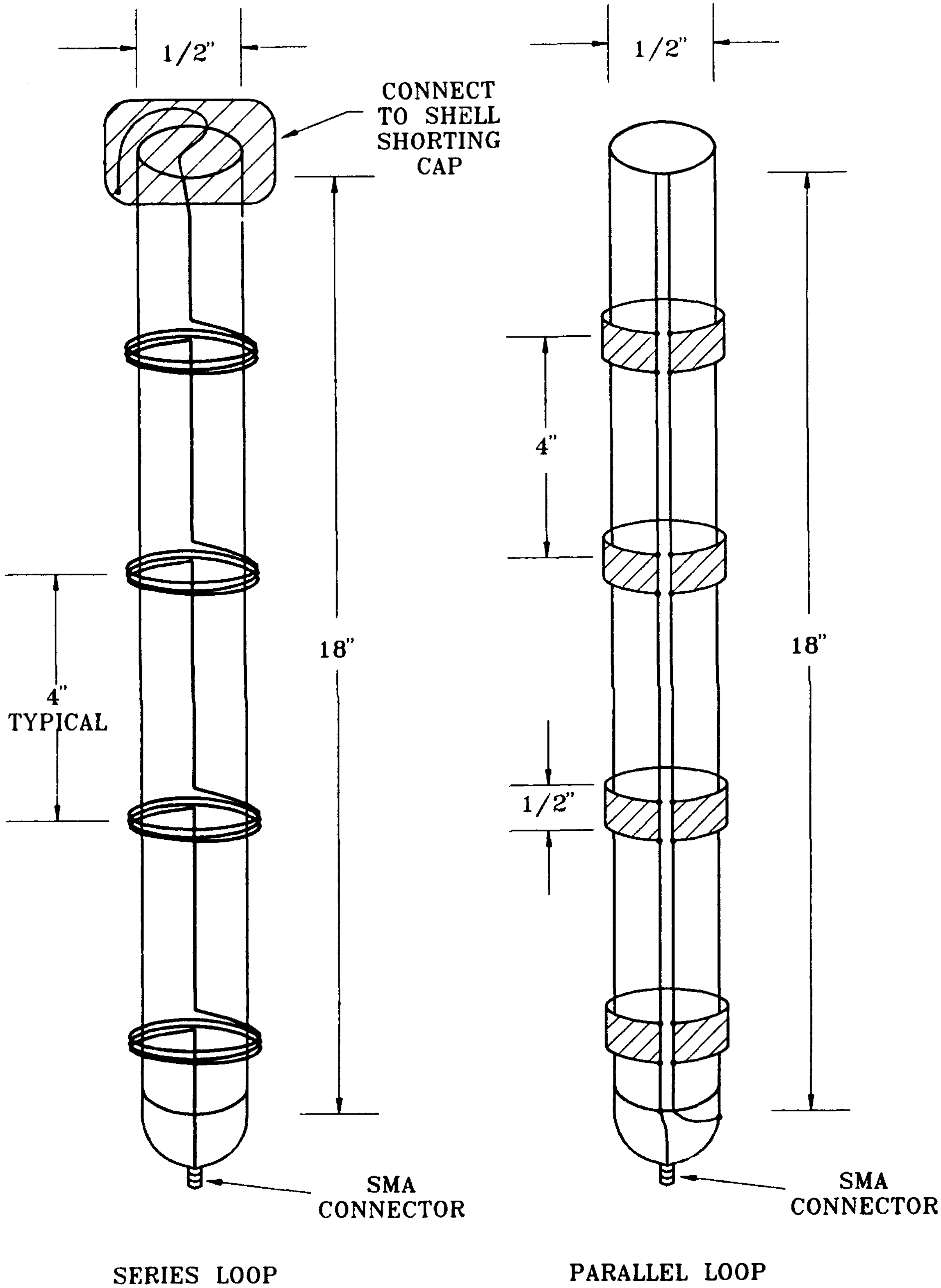


Figure 16. Sensors series loops and parallel loops.

Sensor driver pair characterization used two network analyzers covering the frequency range of 100 kHz to 500 MHz. Measurements consisted of "S" parameters for the pairs when placed side by side over a ground plane. The height of the pairs over the ground plane varied from 0 to $\frac{1}{2}$ inch. The pairs were separated by a distance of 2 inches, and the pairs were terminated in three different configurations: short circuit, 50 Ω, and open circuit. Figure 17 shows the details of a typical sensor driver characterization. The resultant calibration data for the optimum terminations and elevation above the ground plane is presented in figures 18 through 24. As is seen in the figures, the series loops demonstrated the highest degree of coupling for all of the sensors. The high degree of coupling between these sensors is due to two conditions. The series loops have both capacitive and inductive geometries. The loops are inductive, and the wire running between them is capacitive at the higher frequencies. The combination of these two features tends to make the sensors appear more sensitive than the other pairs. In an overall sense this is true, but their ability to detect small area faults is highly dependent upon the nature of the fault as well as the proximity of the proper portion of the sensor (loop or wire).

The two sensors that displayed the most consistent behavior over the greatest bandwidth were the small folded inductor (FA) and the bare coaxial cable core. Both sensors displayed inductive coupling from 10 kHz to 20 MHz. The small folded inductor had better coupling by 20 dB over the bare coax.

The larger folded inductor (FI) exhibited capacitive coupling up to 1 MHz and inductive coupling beyond, up to about 20 MHz. After 20 MHz, the inductive and capacitive effects produced several resonances. The larger folded inductor is useful in measuring capacitive faults up to 1 MHz.

The parallel loops exhibited capacitive properties up to about 700 kHz, but their sensitivity was poor. After 700 kHz, they became inductive and behaved similarly to the series loops, but with less efficiency.

The slot sensor exhibited a rather flat response up to about 1 MHz, and then became inductive. Good sensitivity up to 70 MHz was seen.

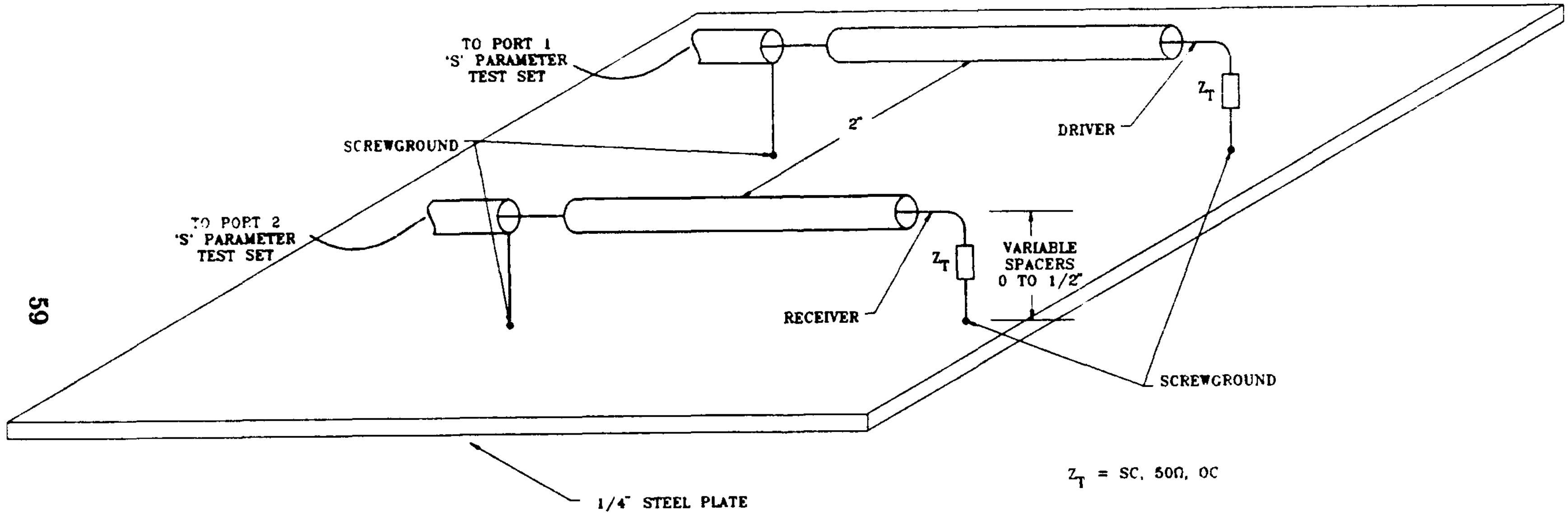
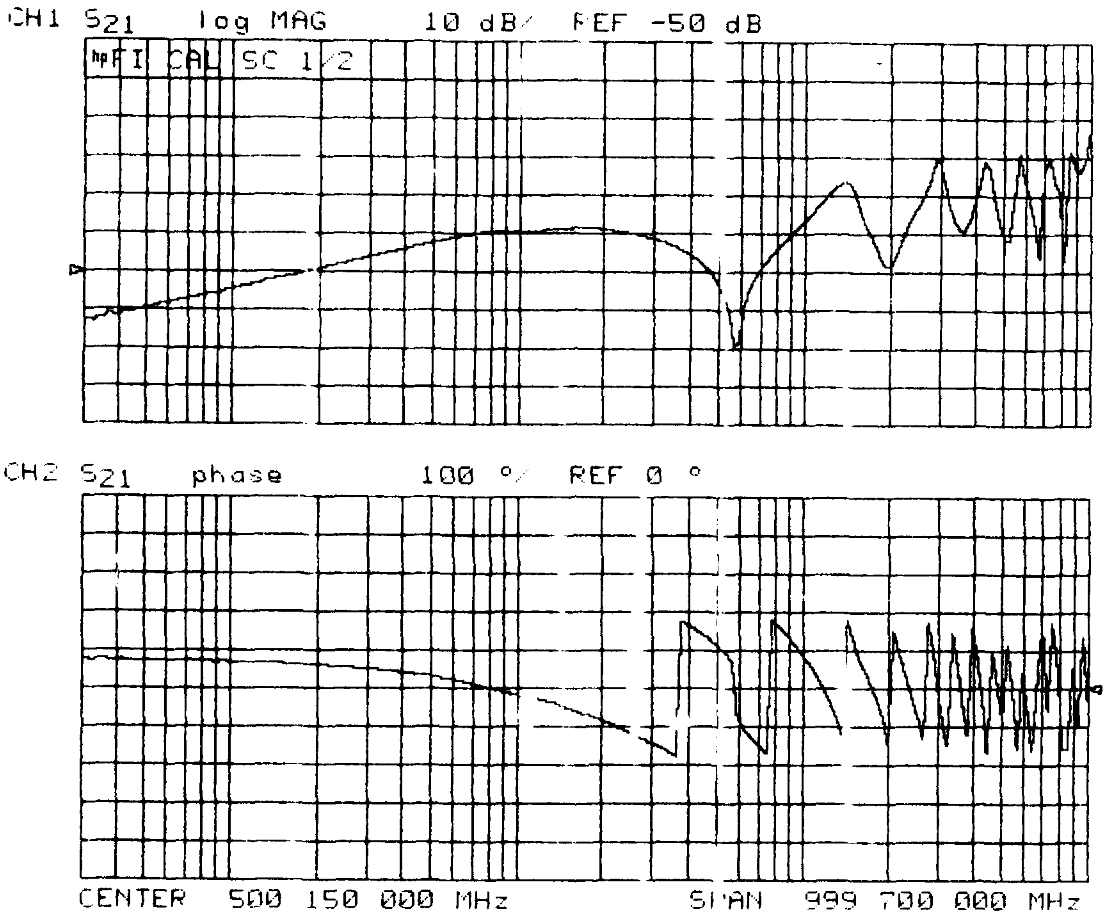
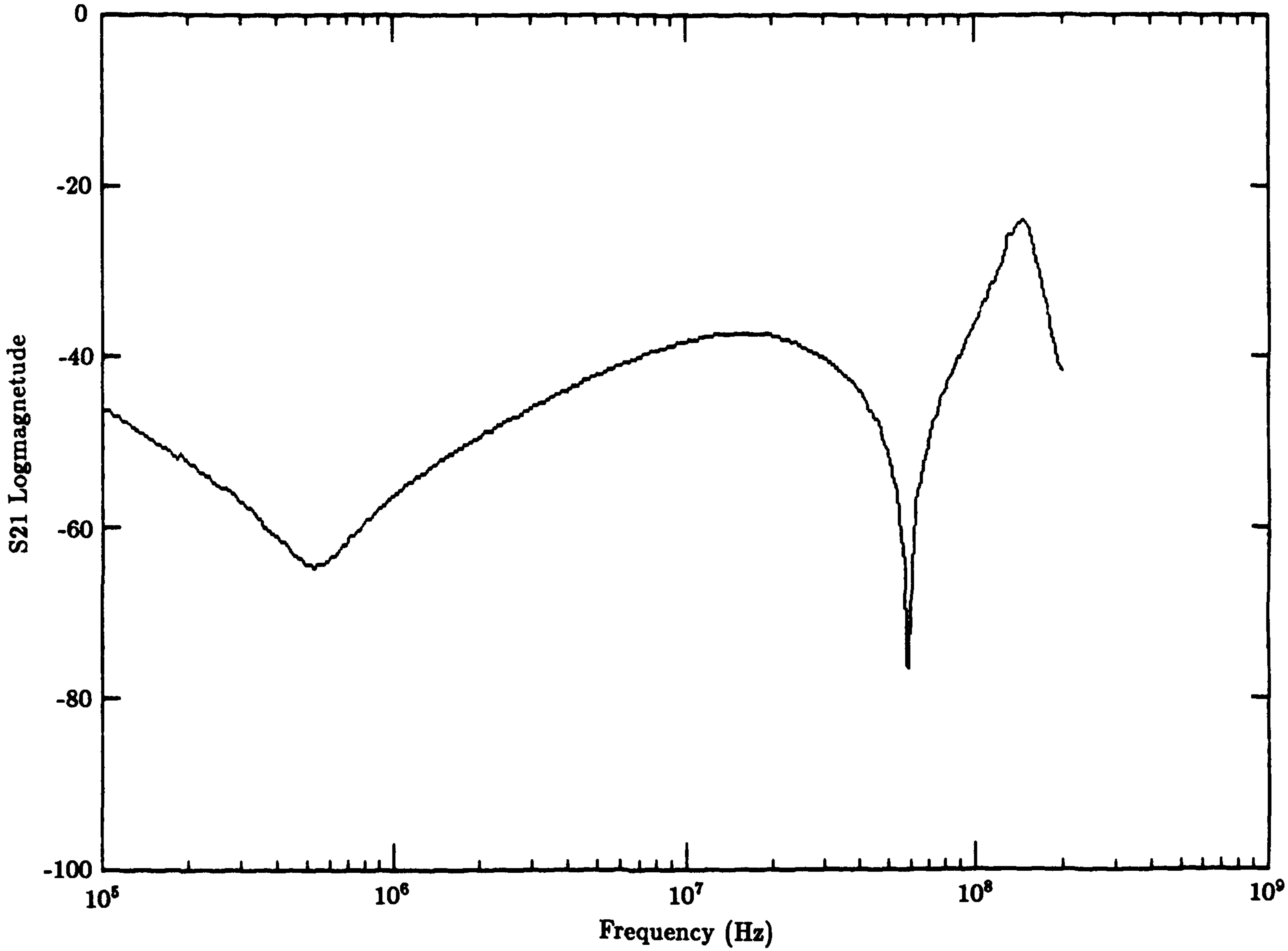


Figure 17. Typical sensor driver calibration.



a. 300 kHz–1 GHz.

Figure 18. Folded inductor (FI) calibration, 1/2-in elevation, short-circuit termination.



b. 100 kHz–200 MHz.

Figure 18. Folded inductor (FI) calibration, 1/2-in elevation, short-circuit termination (concluded).

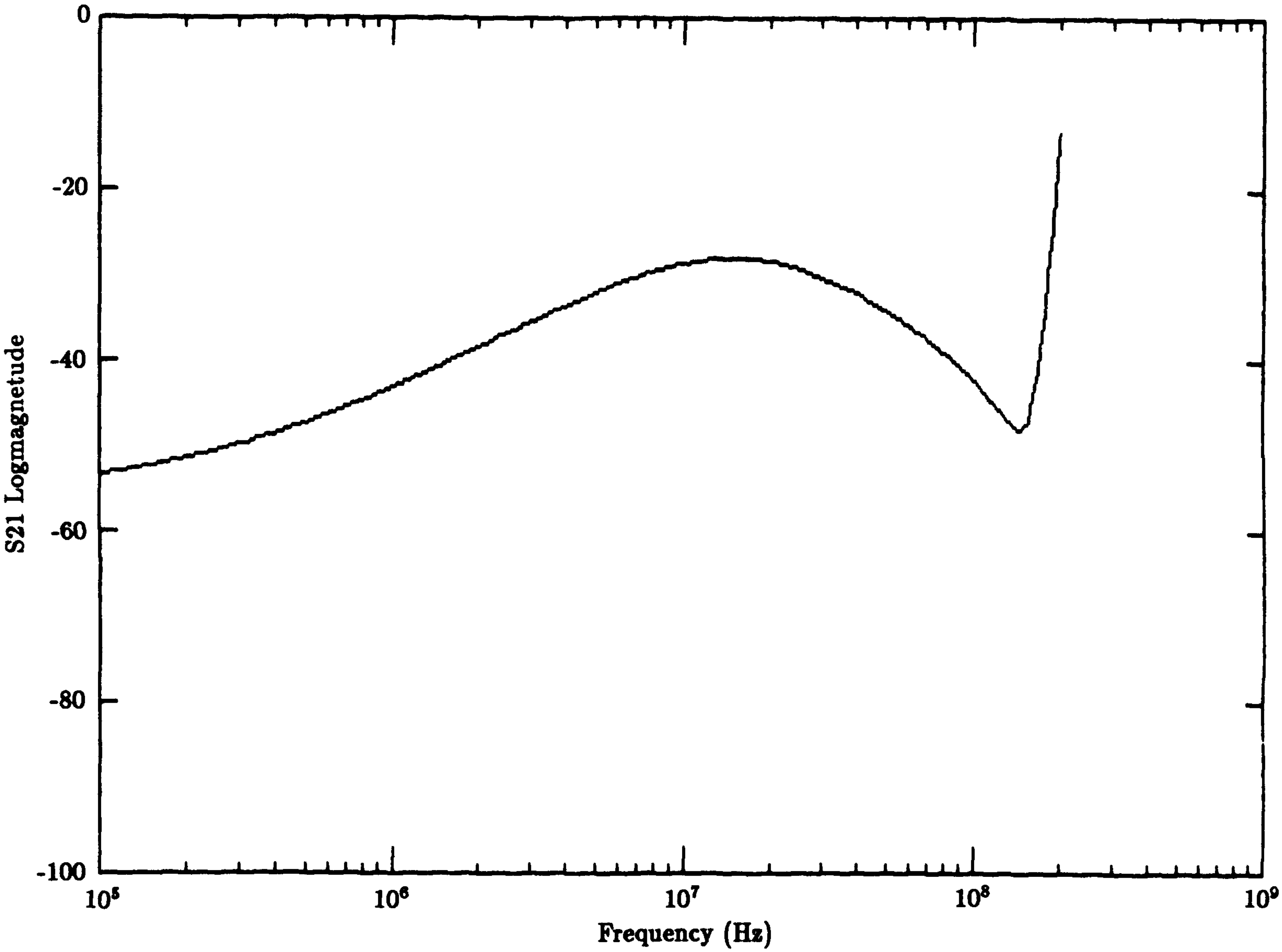


Figure 19. Folded inductor Farrand Industries pattern (FA), 1/2-in elevation, short-circuit termination (100 kHz–200 MHz).

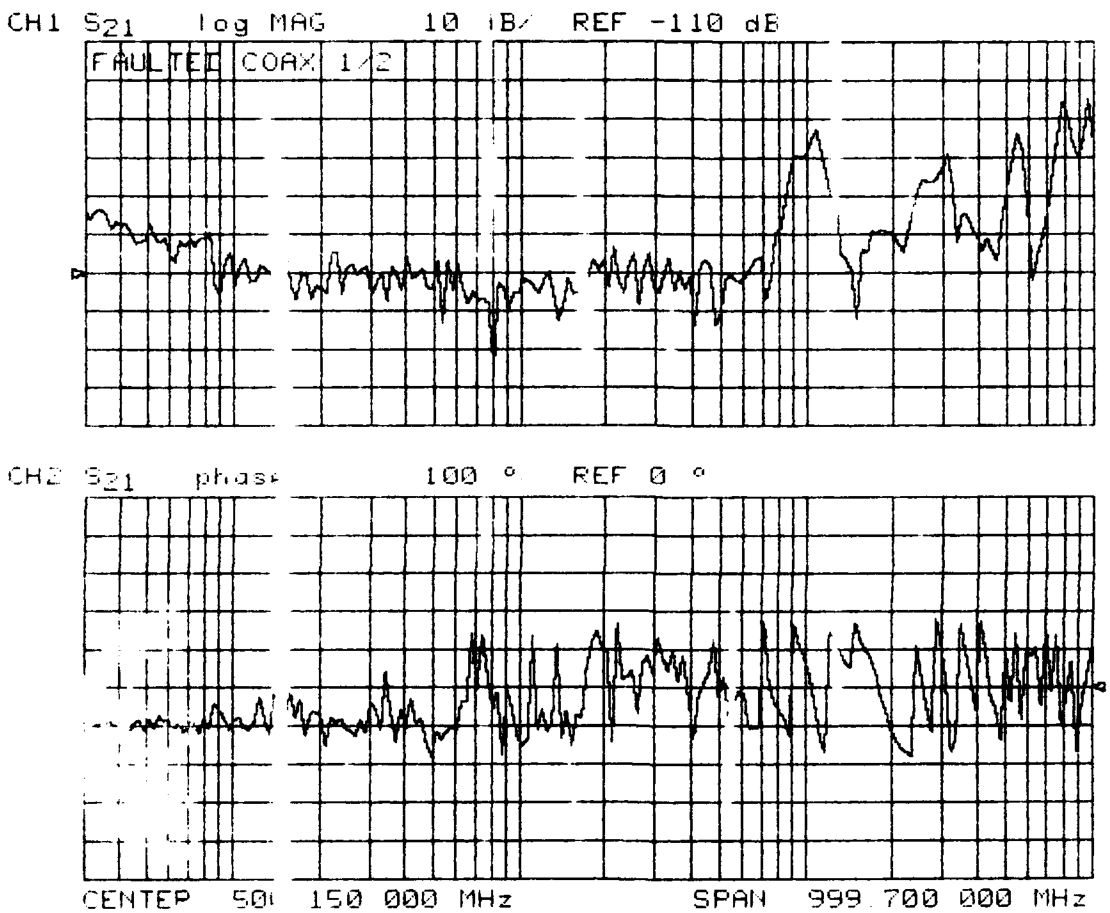


Figure 20. Faulted coaxial calibration, 0-in elevation, 1/2-in separation, short-circuit termination (300 kHz–1 GHz).

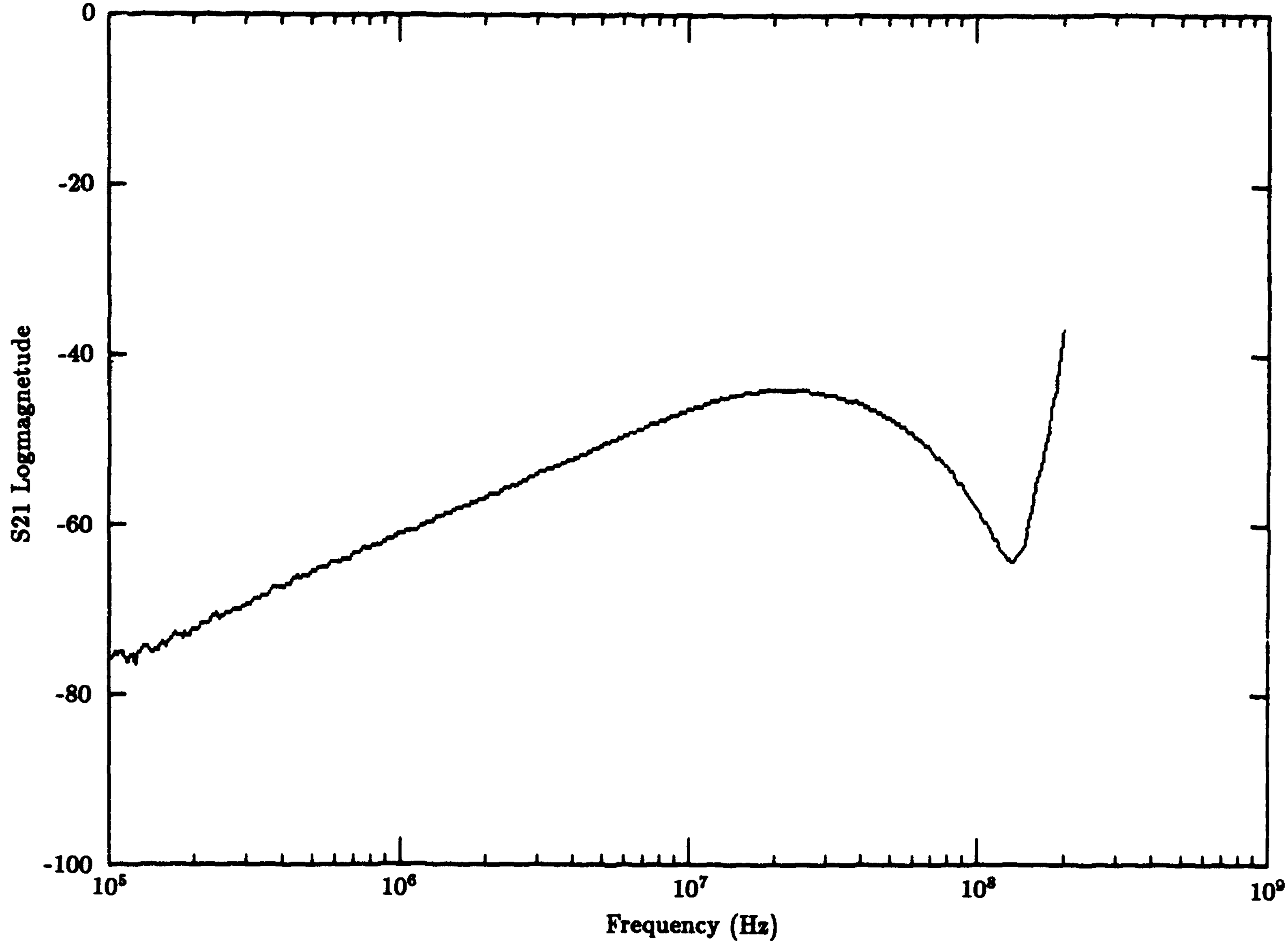
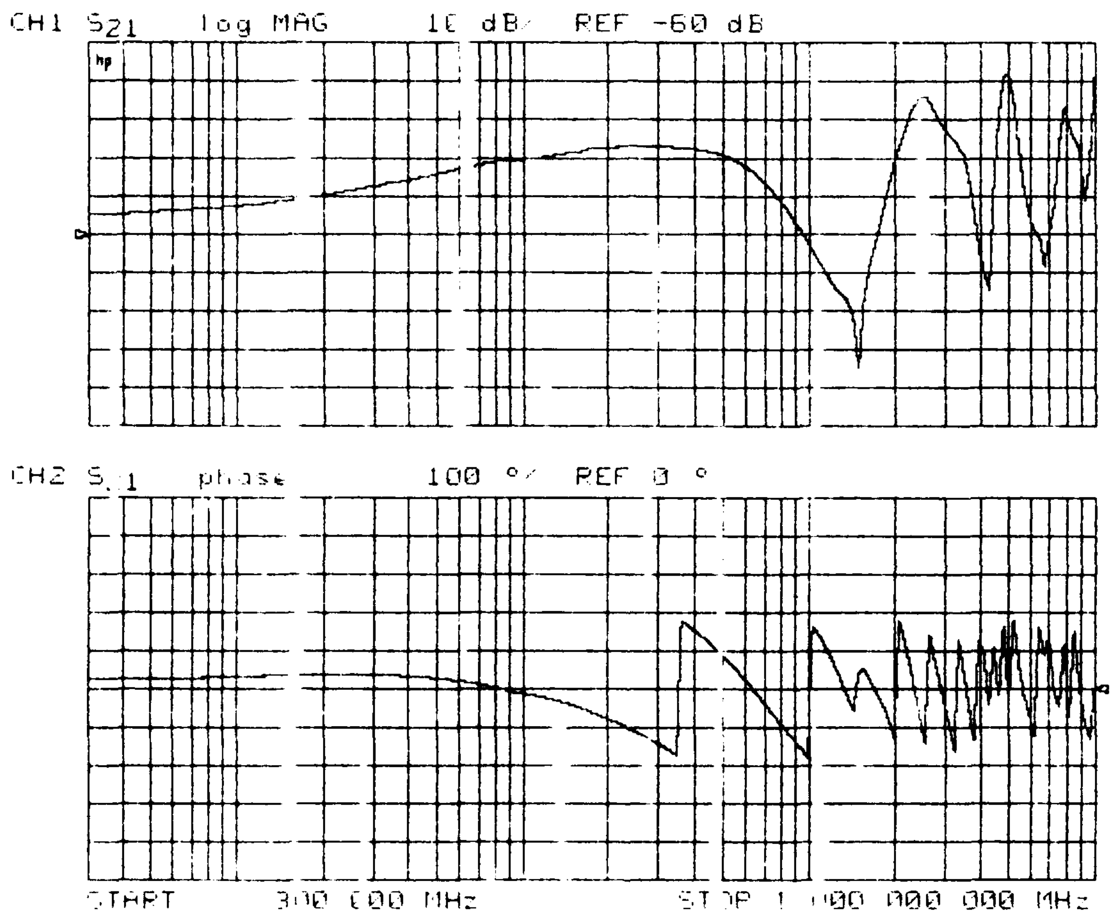
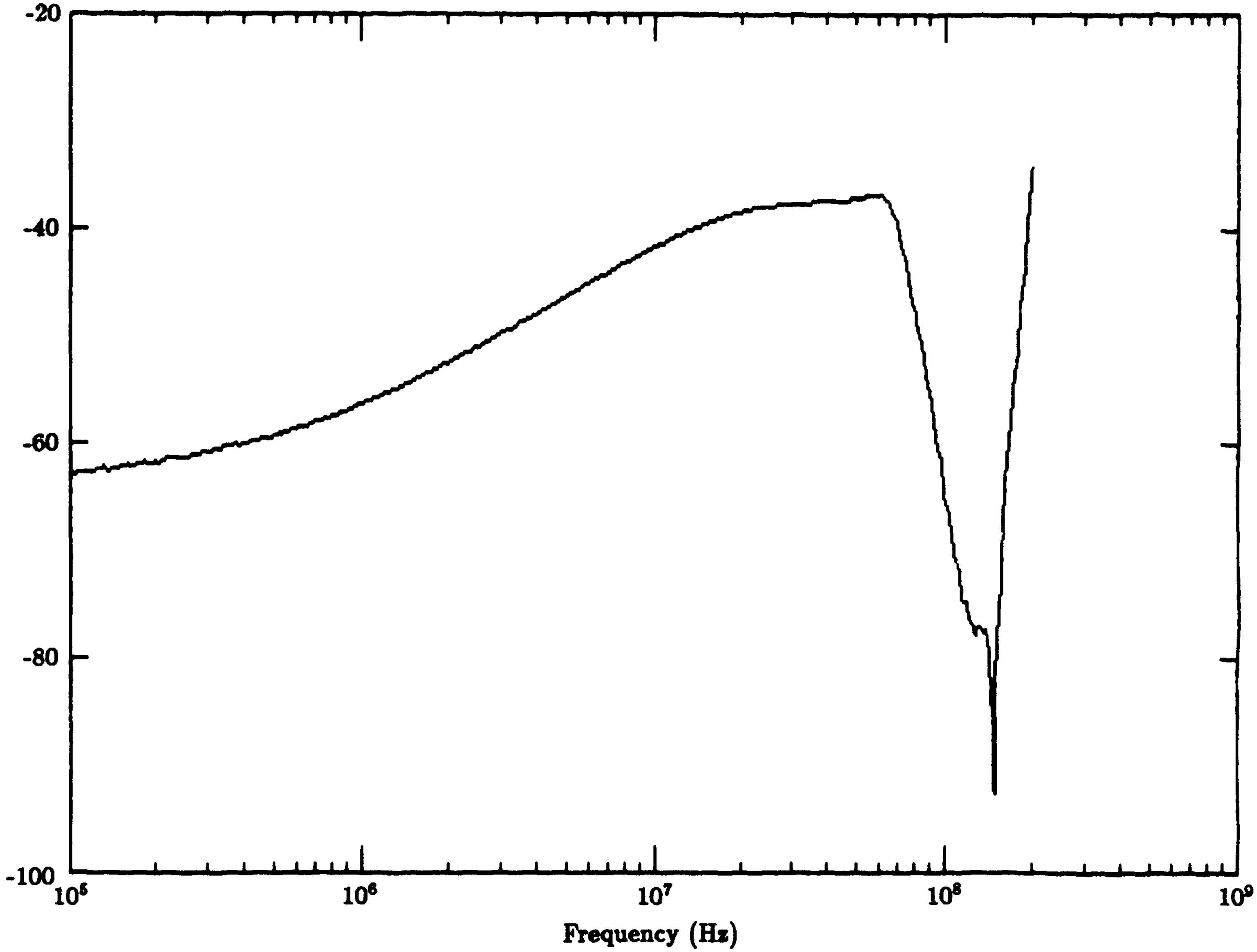


Figure 21. Unshielded coaxial core, short-circuit termination (100 kHz–200 MHz).

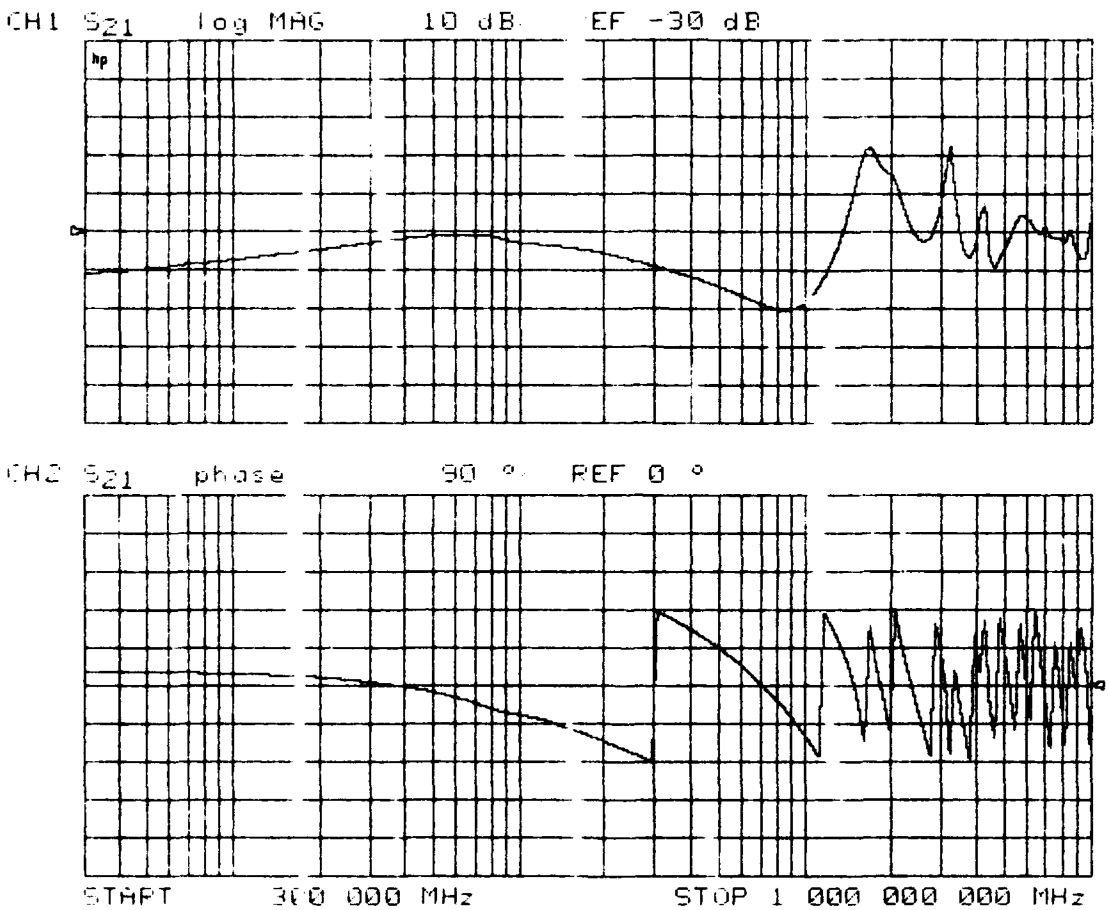


a. 300 kHz–1 GHz.

Figure 22. Slotted coaxial calibration, 0-in elevation, short-circuit termination.

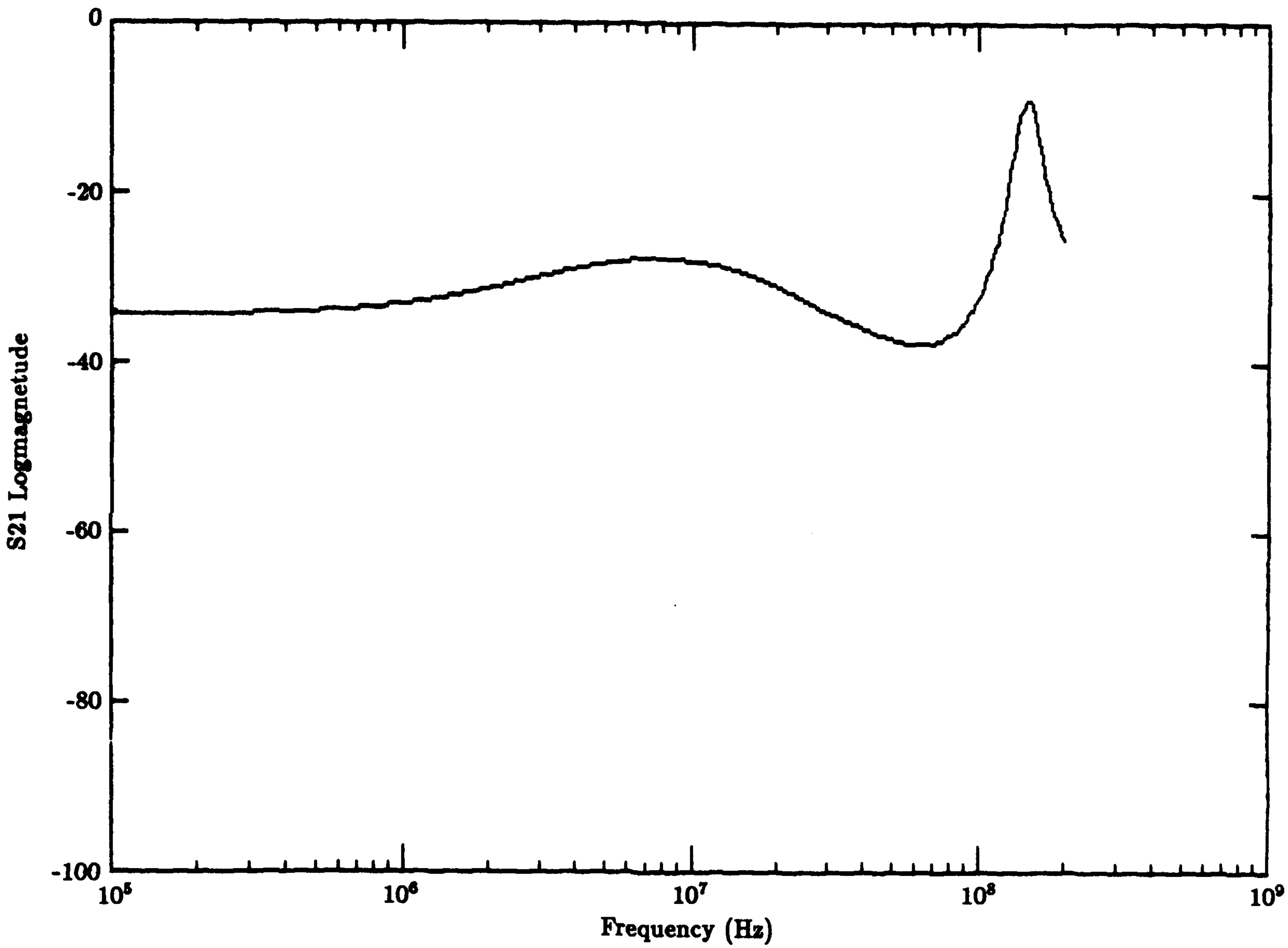


b. 100 kHz–200 MHz.
Figure 22. Slotted coaxial calibration, 0-in elevation, short-circuit termination (concluded).

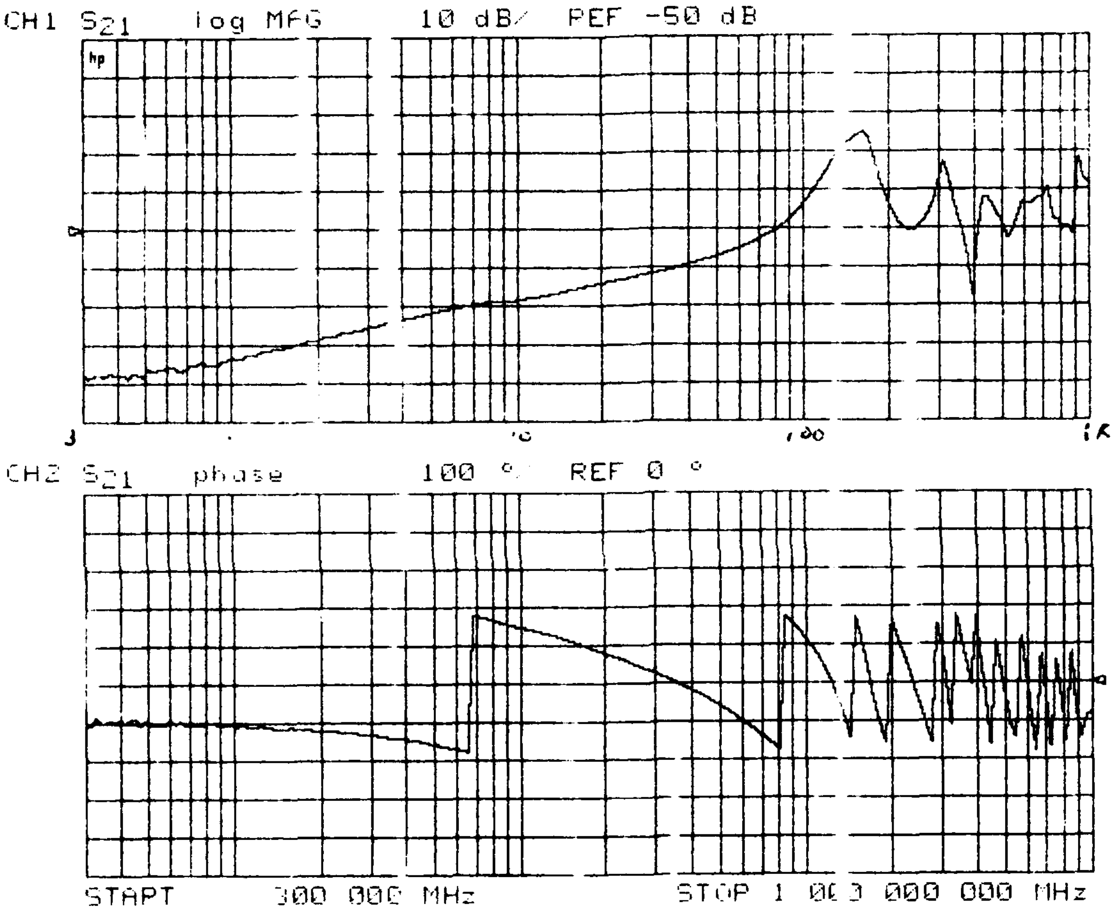


a. 300 kHz–1 GHz.

Figure 23. Series loop calibration, 0-in elevation, short-circuit termination.

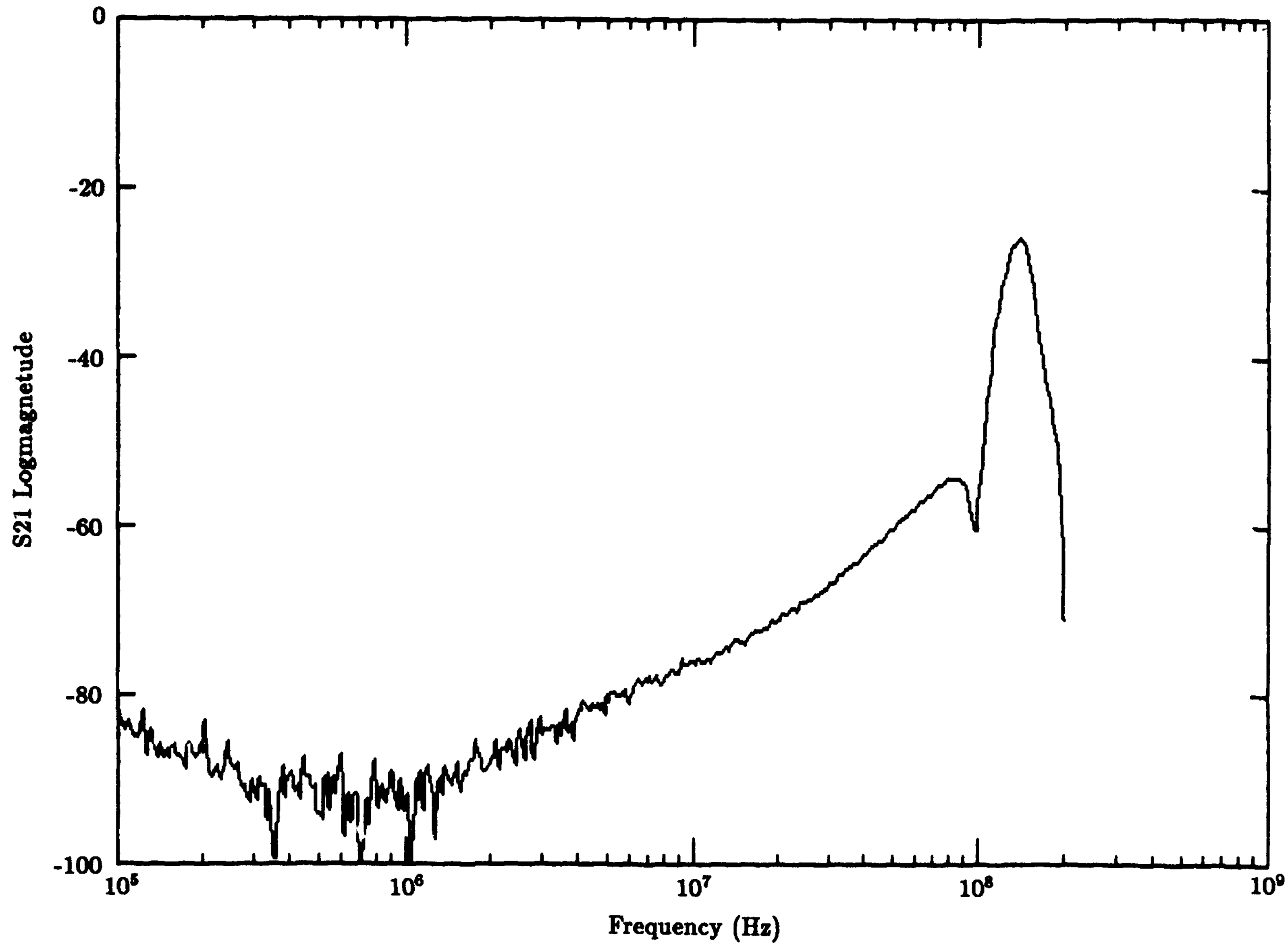


b. 100 kHz–200 MHz.
Figure 23. Series loop calibration, 0-in elevation, short-circuit termination (concluded).



a. 300 kHz–1 GHz.

Figure 24. Parallel loop calibration, 0-in elevation, no termination.



b. 100 kHz–200 MHz.

Figure 24. Parallel loop calibration, 0-in elevation, no termination (concluded).

"S" parameters provide information regarding coupling efficiency between the source and driver as well as the coupling between pairs. Figures 18 through 24 show the optimal "S" parameter behavior of the sensor drivers. The remainder of the data is presented in appendix B.

All pairs were characterized on each of the replacement kick-panel faults. The S21 parameters taken on each sensor driver pair are included in appendix B: Table 19 shows the difference between the sensor calibrations and the sensor fault responses for the frequencies indicated. As can be seen in the table, reasonable sensitivities resulted—the smaller the number, the better the coupling. It should be noted that sensor placement was based on the best performance for a specific fault; better numbers on a different fault do not indicate superior performance over other sensors.

TABLE 19. S21 parameters at HAMS frequencies.

Sensor/Fault	Frequencies: 300 kHz	1 MHz	30 MHz	100 MHz	500 MHz
Folded FI inductor/F1	19	41	64	65	46
Folded FA inductor/F1	34	52	75	64	–
Unshielded coaxial core/F5	1	1	7	5	–
Slotted coax/F5	UNAVAILABLE AT TIME OF TEST				
Series loop/F4	49	47	50	47	37

The HAMS measured the faults with the door open and closed. There was sufficient coupling between each of the pairs for use with the HAMS system. The tabulated HAMS output is presented in table 6. The absolute minimum level for detection must be greater than 6 dB above the HAMS sensitivity in order for the HAMS to provide alarm signals.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The UDRI/MRC HAMS can be commercialized. Replacement of custom components in the system should reduce the cost and improve the reliability. Construction of prototype devices by MRC is expensive, and MRC has virtually no capabilities in mechanical reliability design.

While the HAMS has a reasonable sensitivity (−110 dBm), it cannot be used as a MIL-STD-285 test set.

Sniffers at all frequencies of operation were able to adequately measure the shielding effectiveness of the shelter. Clearly, the best unit for reliability and ease of operation was the EUROSHIELD unit.

The design and test of various HAMS sensors were successful with the emergence of three new useful sensor configurations (series loop, bare coaxial cable core, and slotted coax). These sensors showed good wideband response characteristics, allowing them to be used as radiators and detectors for a wide variety of fault types.

The UDRI/MRC (12-GHz) sniffer has reasonable sensitivities for an AM device. The 50-dB dynamic range of the unit is less than desirable. A sniffer operating in the 12-GHz range can be developed using alternative methods of detection for improved sensitivity and noise immunity.

4.2 RECOMMENDATIONS

The commercialization of the UDRI/MRC HAMS should proceed.

The sensors/drivers developed as a subeffort of this program should be pursued in greater detail as a commercial product for use with HAMS.

The present UDRI/MRC HAMS requires an IBM-compatible computer with two serial ports and one parallel port. This is not a common or desirable configuration. Further development of the HAMS should include developing a microprocessor-based system controller with hard memory as part of the receiving unit. The requirement of a full-time, IBM-compatible computer for operating this system is unreasonable for field operations or for operations having limited space. Complete microprocessor control can be accommodated within the present receiver volume.

The continued development of a 12-GHz sniffer appears to be of little use since no additional data was acquired at this frequency over the more conventional plane wave frequencies of MIL-STD-285.

REFERENCES

1. Schafer, David A., Paul R. Tryb_s, and Steven P. Cave, "Prototype Development of an Electromagnetic Hardness Assurance Monitoring System (HAMS)," AFWAL-TR-88-4064, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1988.

2. Euroshield User's Guide: "EUROSHIELD RF Leak Detector 4F-130," Euroshield OY, Eura, Finland.

3. Operation Manual: "Model TS-450 Shielded Enclosure Test Set," ASM Products, Inc., Ronkonkoma, New York.

4. Operational Manual for Models RP 98D (Detector) and RP 98G (Generator): "SIMS II Shielding Integrity Monitoring System," Ray Proof Shielding Systems Corporation, Norwalk, Connecticut.

5. "Operator's Manual for Eaton 3500 Shielded Enclosure Leak Detection System," Manual No. 1-500783-388, Eaton Corporation, Los Angeles, California.

6. Military Standard: "High-Altitude Electromagnetic Pulse (HEMP) Protection for Ground-Based C^4I Facilities Performing Critical, Time-Urgent Missions for Common Long-Haul/Tactical Communication Systems," MIL-STD-188-125, Department of Defense, Washington, DC, 26 June 1990.

APPENDIX A

ASM, EUROSHIELD, AND EATON USER'S MANUALS

ASM PRODUCTS, INC.
795-A Marconi Avenue, Ronkonkoma, N.Y. 11779
Phone 516-737-1248 FAX 516-737-1497

OPERATION MANUAL

MODEL TS-450

SHIELDED ENCLOSURE TEST SET

TABLE OF CONTENT

SECTION I

GENERAL DESCRIPTION

1.0 INTRODUCTION

This manual contains a complete description, and the detailed instructions for the operation of the Model TS-450 SHIELDED ENCLOSURE TEST SET (See Figure 1-1) distributed by ASM PRODUCTS, Inc., Ronkonkoma, New York 11779.

2.0 DESCRIPTION

The Model TS-450 SHIELDED ENCLOSURE TEST SET is a completely portable, direct-reading, measuring system for determining, at a frequency of 450MHZ, the amount of plane wave attenuation provided by a shielded enclosure.

The test set is supplied complete with receiver, transmitter, two (2) fixed tuned dipole antennas, battery charger, two (2) charger cables, one 30 foot coax extension cable and a foam cushioned lightweight aluminum transit case.

The following table defines the specifications of the Model TS-450 SHIELDED ENCLOSURE TEST SET:

TABLE I
SPECIFICATIONS

Operating Frequency	450 MHz
Dynamic Range	110 dB
Accuracy	+/- 1 dB
Battery Type	ASM P/N 450B1
Battery Life (Approx.)	Transmit 6 - 8 Hours Receive 8 - 12 Hours
Power Requirements (Charger)	120/240 VAC, 60 Hz, 50 W
Size:	
Receiver (inch)	8 3/4 x 5 3/4 x 5
Transmitter (inch)	6 3/4 x 4 3/4 x 3 1/4
Charger (inch)	7 1/2 x 4 3/8 x 2 1/2
Weight (Including Case)(lbs)	45

SECTION II

OPERATION

3.0 GENERAL

This section provides the functional control description and the operating instructions for the Model TS-450 SHIELDED ENCLOSURE TEST SET.

3.1 PRELIMINARY INSPECTION

This unit was tested and inspected at the factory prior to shipment. Immediately after unpacking the equipment visually inspect it for damage which may have occurred in transit. Should there be any evidence of damage, please contact the factory so that we may assist you in filing the proper claim with the carrier.

3.2 CONTROL PANEL DESCRIPTIONS (See Figures 3-1 through 3-3)

Table 3-1 through 3-3 provide a complete functional description of all front panel controls on each of the major components of the test set system.

3.3 OPERATION PROCEDURE (MIL-STD-285 Type Testing)

(a) Prior to the start of testing the battery strength of both the Receiver and Transmitter must be checked utilizing the Battery Meter on each unit. Should a weak indication be observed (below the green level) the applicable unit(s) should have their battery charged utilizing the Charger Unit included with the Model TS-450 Test Set. In order to charge a unit, simply connect the charger interconnecting cable(s) from the Output Charging Jacks on the Charger Unit to the Charge Jack on the unit(s) to be charged and power the charger unit. The power switch on the unit(s) being charged should be OFF. (See Figure 3-3) Allow 2 to 3 hours for fully charging of the unit(s).

(b) Screw the Dipole Antenna elements onto the Dipole Antenna and screw the complete Antenna onto the antenna connector on both the Receiver and Transmitter units.

(c) Set the power switches on both the Receiver and Transmitter to the ON position.

3.3 OPERATION PROCEDURE (CONT.)

(c) Place the Transmitter outside of the shielded enclosure to be tested, approimately 30 feet from the shielded wall under test.

NOTE: If a closer distance is desired, attach a standard 50 ohm, 10 dB attenuator, feed thru pad between the Transmitter's antenna output connector and its Dipole antenna, in order to lower the output power. However, even when attenuated, the transmitter should never be moved closer than 7 feet from the shielded wall under test.

(d) Still outside of the enclosure to be tested, place the Receiver opposite the Transmitter at a distance no greater than 24 inches but not less than 2 inches. (Ref. Figure 5 of MIL-STD-285) The Dipole antennas of each unit must be parallel to each other.

(e) Turn the **ZERO SET** control on the Receiver fully CCW.

(f) Set the dB **ATTENUATOR** switch on the Receiver to the **ZERO** dB position.

(g) To calibrate the setup, leave the Transmitter in its stationary position and slowly move the Receiver back and forth from 2 inches to 24 inches from the shielded wall to be tested while observing the **dB ATTENUATION METER** and noting the location which gives the lowest reading in dB's. At this location adjust the **ZERO SET** control on the Receiver for an indication of zero dB on the meter. If an indication of greater than zero dB is obtained and the Receiver cannot be zero adjusted, move the Transmitter closer and repeat step (g). If an indication of less than zero dB is obtained and the Receiver cannot be zero adjusted, move the Transmitter further away and repeat step (g). After completing this calibration, do not adjust the ZERO SET control during measurements or the calibration will no longer be valid.

NOTE: If the supplied extension cable is going to be used during the measurements it must be attached when performing the calibration of step (g). It is recommended that the extension cable be tightly coiled and placed next to the Receiver when performing the calibration. Also when performing this calibration procedure all excess personnel should be kept clear of the antennas to prevent measurement errors.

(h) While leaving the Transmitter in the same stationary position, place the Receiver inside of the enclosure to be tested.

(i) Seal the enclosure under test.

(j) Rotate the dB **ATTENUATOR** switch on the Receiver to the 90 dB position.

(k) Using the receiving antenna, either directly attached to the Receiver or connected to the Receiver by means of the extension cable, probe the entire surface of the enclosure to be tested. During probing the antenna can be positioned to within, but no closer, than 2 inches of the shielded surface.

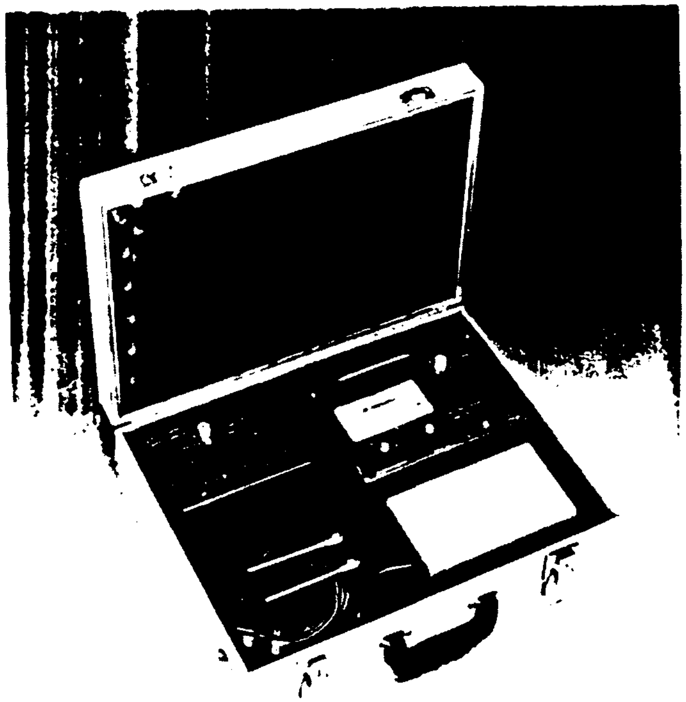
(l) To determine the attenuation, decrease the dB **ATTENUATION** switch on the Receiver until an "On-Scale" indication is observed on the dB **ATTENUATION METER**. Add the dB indication on the meter to that of the dB **ATTENUATION** switch to determine the attenuation measured. If the indication on the dB **ATTENUATION METER** is greater than 20 dB while the dB **ATTENUATION** switch is in the 90 dB position, the attenuation of the surface under test is in excess of 110 dB.

3.4 BATTERY REPLACEMENT

The batteries used in both the Receiver and Transmitter are not field replaceable. Should replacement be required, the unit(s) must be returned to **ASM PRODUCTS, INC.**

FIGURE 1-1

TEST SET COMPONENTS



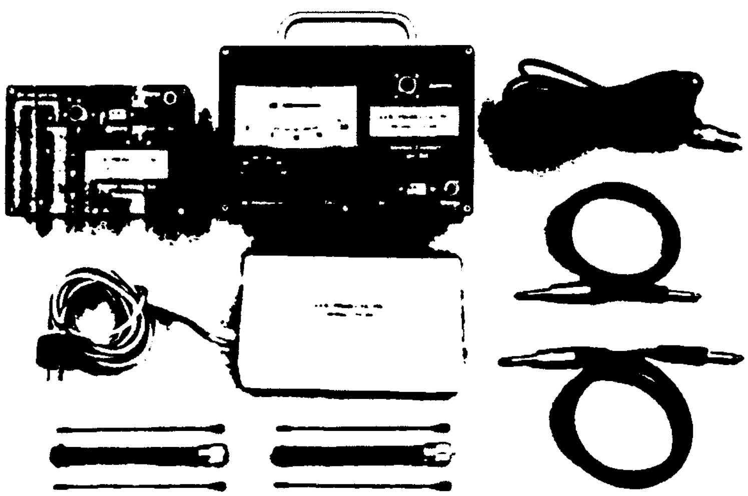


TABLE 3-1

RECEIVER CONTROLS

FIGURE 3-1 INDEX NO.	CONTROL	FUNCTION
1	db ATTENUATION METER	Indicates level of attenuation provided by the shielded material
2	ANTENNA CONNECTOR	Provides for connection of the receiving dipole antenna
3	CHARGE JACK	Provides for connection to the test set charger unit to charge internal batteries
4	BATTERY METER	Indicates charge condition of internal batteries
5	ON/OFF SWITCH	Provides means of turning unit on and off
6	ZERO CONTROL	Adjusts receiver gain for calibration
7	dB ATTENUATION SWITCH	Inserts known levels of attenuation to control the measurement range

FIGURE 3-1

RECEIVER

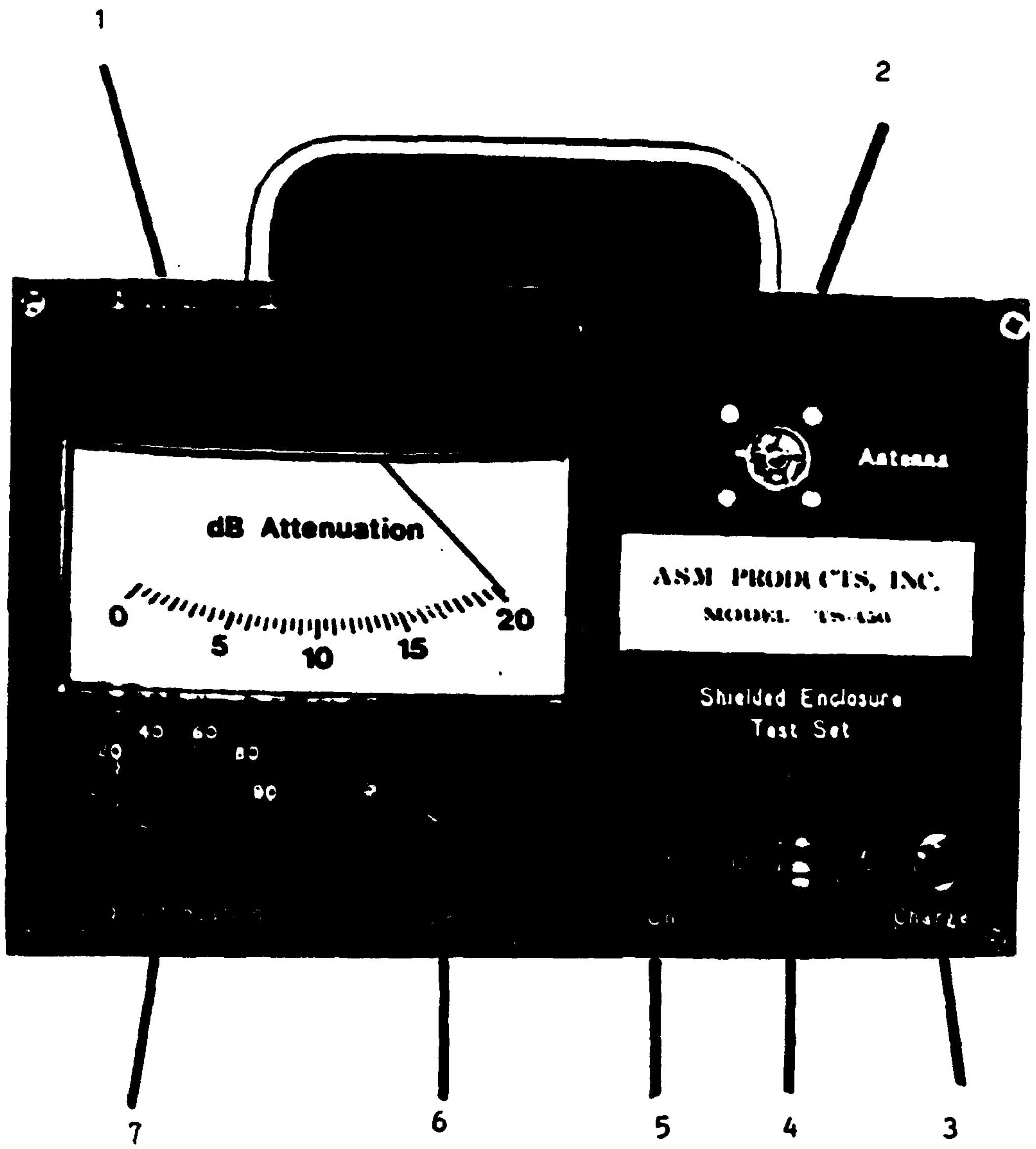


TABLE 3-2

TRANSMITTER CONTROLS

FIGURE 3-2 INDEX NO.	CONTROL	FUNCTION
1	RF TEST PUSHBUTTON	(1) Indicates charge condition of internal batteries (2) Depressed, indicates RF power output status
2	CHARGE JACK	Provides for connection of test set charger to charge internal batteries
3	BATTERY METER	Indicates charge condition of internal batteries
4	ON/OFF SWITCH	Provides means of turning unit on and off
5	ANTENNA CONNECTOR	Provides for connection of transmit antenna

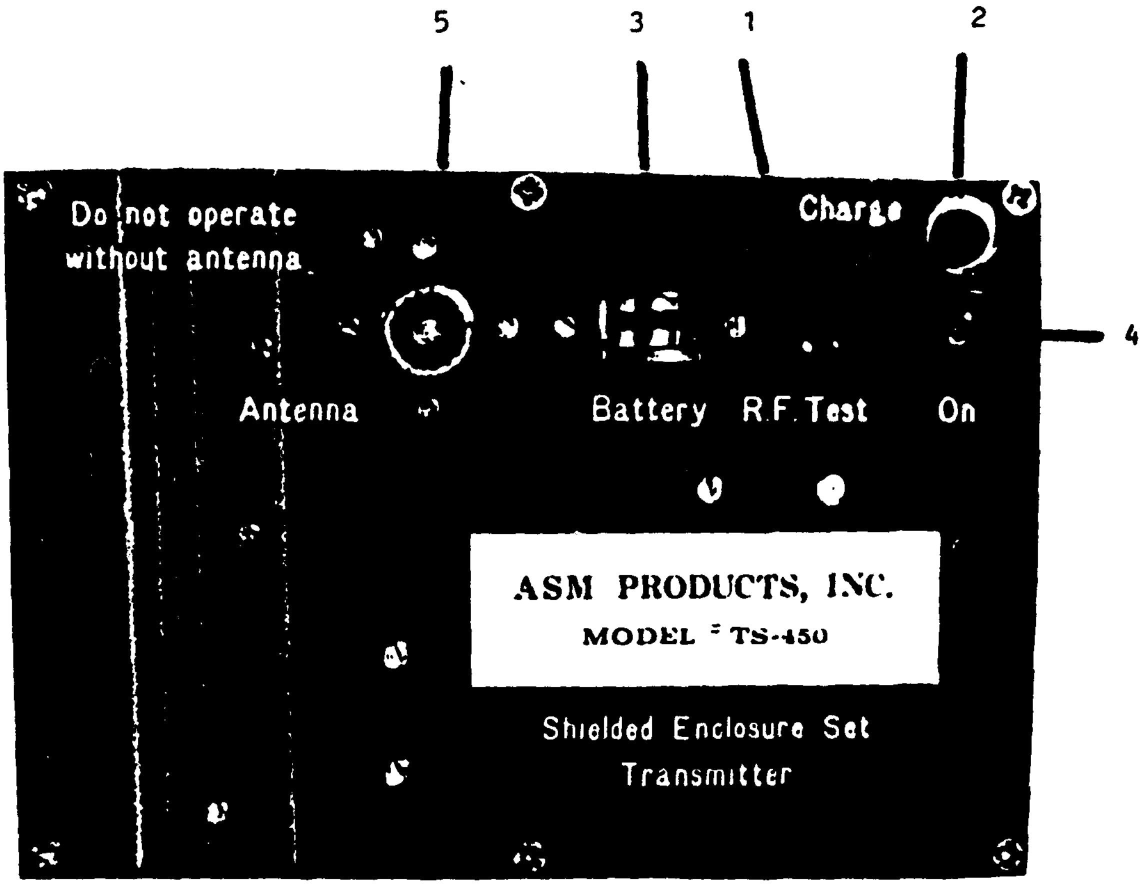
TABLE 3-3

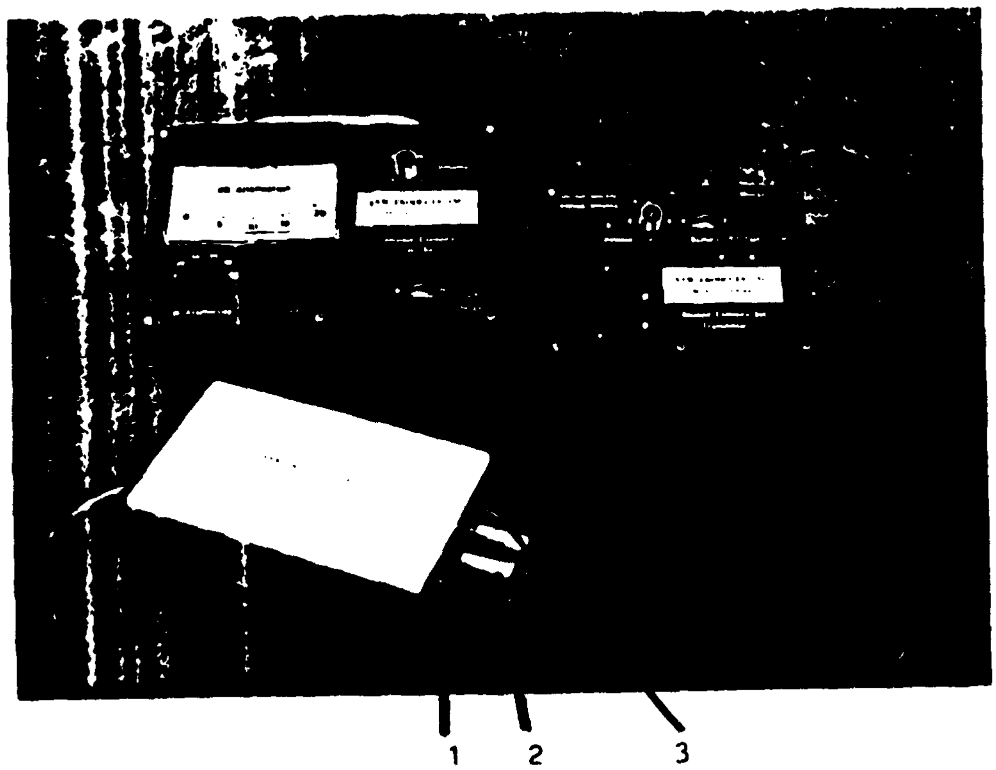
CHARGER CONTROLS

FIGURE 3-3 INDEX NO.	CONTROL	FUNCTION
1	ON/OFF SWITCH	Provides means for turning unit on and off
2	OUTPUT JACKS	Provides for connection to Receiver and Transmitter to charge their internal batteries
3	INDICATOR LAMP	Indicates charger on, battery charging taking place

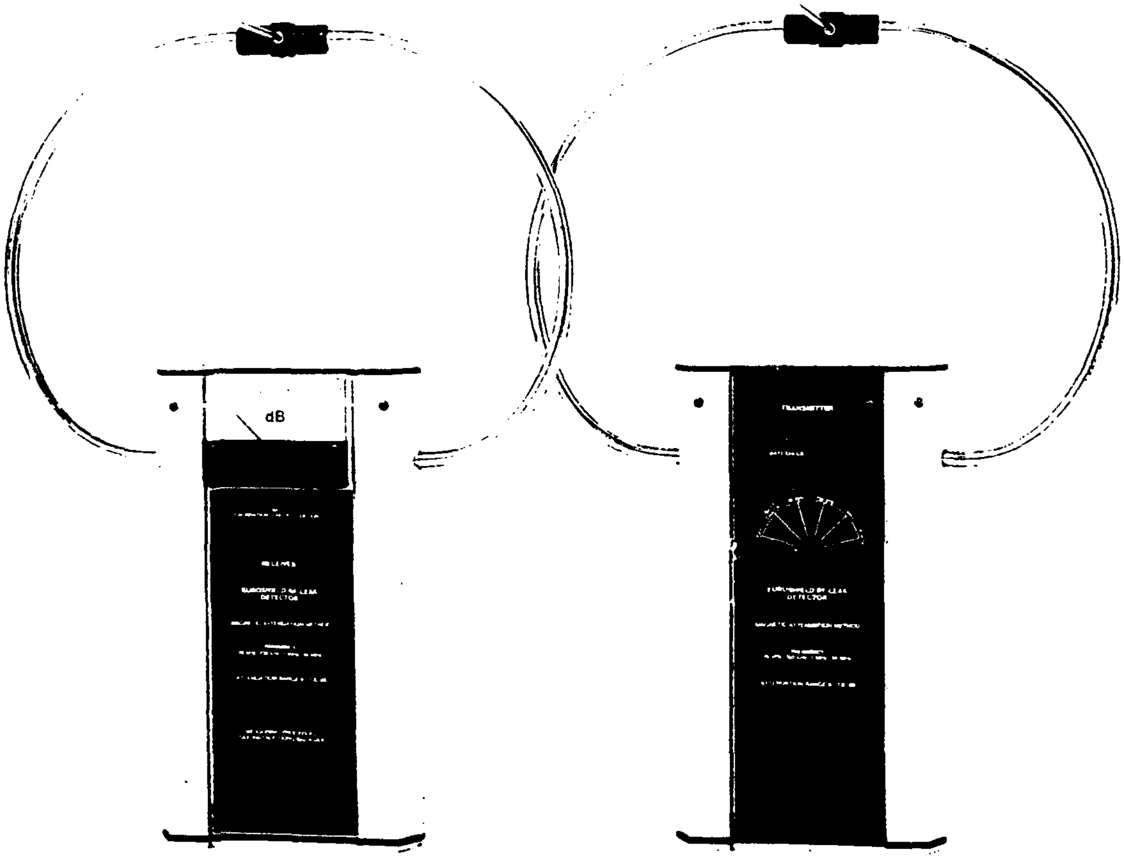
FIGURE 3-2 TRANSMITTER (TOP)

FIGURE 3-3 CHARGER (BOTTOM)





EUROSHIELD RF LEAK DETECTOR 4F-130



USER'S GUIDE

EUROSHIELD OY

SF-27510 Eura, Finland
Tel: International +358 38 506 31,
National (938) 506 31
Telefax +358 38 512 33

EUROSHIELD RF LEAK DETECTOR
MAGNETIC ATTENUATION METHOD

Magnetic attenuation is measured at four frequencies in accordance with MIL-STD-285 or NSA-65-6.

The antenna power supply is automatically kept constant to compensate for fluctuations in battery supply voltage, frequency changes due to adjustments, and changes in the resonance of the antenna circuit caused by the presence of pieces of metal.

Attenuation and frequency calibration

Calibrate the meter in free space as follows: Switch on the receiver and the transmitter and place them as shown in figure 1 or 2 depending on the method of measurement used. A gap corresponding to the thickness of the wall should be left between the measuring tips. Choose the measuring frequency and push the calibration knob on the receiver and calibration will take place automatically.

Measuring magnetic attenuation according to NSA:

Place the receiver and the transmitter as shown in figure 1 at the point to be measured with the receiver inside the enclosure and the transmitter outside. The attenuation value may now be read from the meter.

Measuring magnetic attenuation according to MIL-STD-285:

Place the transmitter and the receiver at the point to be measured as shown in figure 2. Turn the antenna of the transmitter and the receiver until the minimum attenuation reading is obtained. The minimum reading indicates shielding at that point.

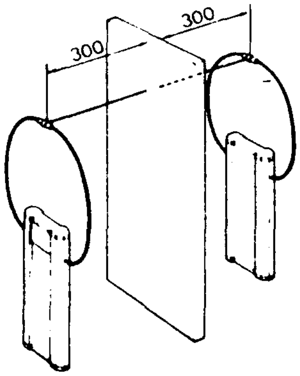


Figure 1

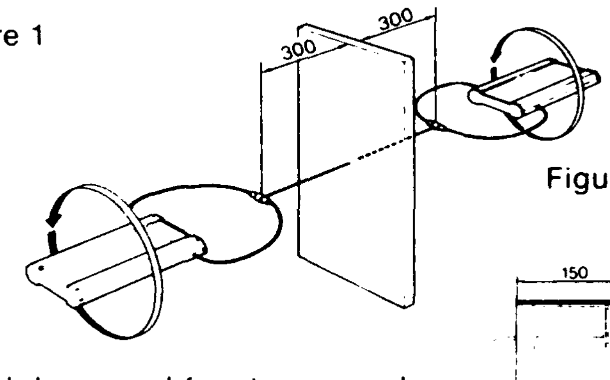
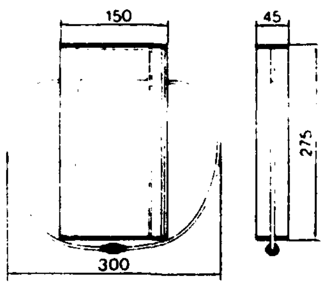


Figure 2



The antenna can be turned downward for storage and transportation.

Weight of receiver 1.8 kg•
Weight of transmitter 1.7 kg.•

•Without batteries.

USER'S GUIDE

CONTENTS

1 GENERAL INFORMATION

1.1 Introduction

During acceptance of a shielded enclosure generally a report is presented with measurement data which is relevant for the particular shielding effectiveness of the enclosure. There are two methods for testing the shielding effectiveness that have long been accepted:

a) MIL-STD-285
b) NSA 65-6

1.2 Purpose and use of Euroshield Leak Detector

The EUROSHIELD RF leak detector was designed to simplify the check-out of the performance for a shielded enclosure. With the possibility of generating four frequencies, the technician is able to check the shielding effectiveness very quickly.

The test system consists of two items, a transmitter and a receiver part. The test frequencies transmitted were chosen in that way that a complete attenuation curve can be generated starting from 10 kHz which is the most important and most degrading magnetig field section, and up to 10 MHz.

1.3 MIL-STD-285

MIL-STD-285 originally was part of a governmental specification (MIL-S-4957A) for screen mesh enclosures. It was prepared in the early 1950's to procure some wire mesh screen rooms for a research project. The testing portion was later published as MIL-STD-285.

The test methods specified by this document became the standard for determining the performance of all RF shielded enclosures. These test methods provide the technician with antenna placements for conducting reference level measurements, a detailed measurement procedure and a description of test equipment to be used.

During last 30 years the test procedures changed somewhat, with a major change of the advancement in test equipment. The attenuation requirements were 70 dB for magnetic fields for 150...200 kHz, 100 dB for 200 kHz...18 MHz in the electric field and 100 dB at 400 MHz.

1.4 NSA 65-6

In 1964, the NSA published NSA 65-6. This document was a general specification issued to standardize the requirements for the agency's RF shielded enclosures. A test procedure for measuring the shielding effectiveness for the enclosures was also included. The procedures are basically the same as those in MIL-STD-285, with some slight variances. The antenna positioning specification for magnetic field measurements were coaxial instead of coplanar.

1.5 Maintenance aspect

During the lifetime of a shielded enclosure it is of good practice to perform any kind of maintenance on the enclosure. Practically spoken the weakest points in the enclosure are the openings and entrance. When people carry in equipment, damage may be caused to seams and the door sealing springs, and the shielding properties may be derated. With the EUROSHIELD RF LEAK DETECTOR it is very easy to do tests both in the laboratory and field purposes.

2 UNPACKING AND SET-UP

2.1 Unpacking and physical inspection

Examine the shipping package before unpacking the equipment. If the carton has been damaged, check with care if the equipment was damaged and retain the shipping carton.

Check that the equipment is complete as listed on the packing list. Examine the contents of the carrying case visually. If any damage is evident, notify the carrier and your local Euroshield Representative, or the factory.

2.2 Battery installation

Install the batteries as in Fig. 2.2.

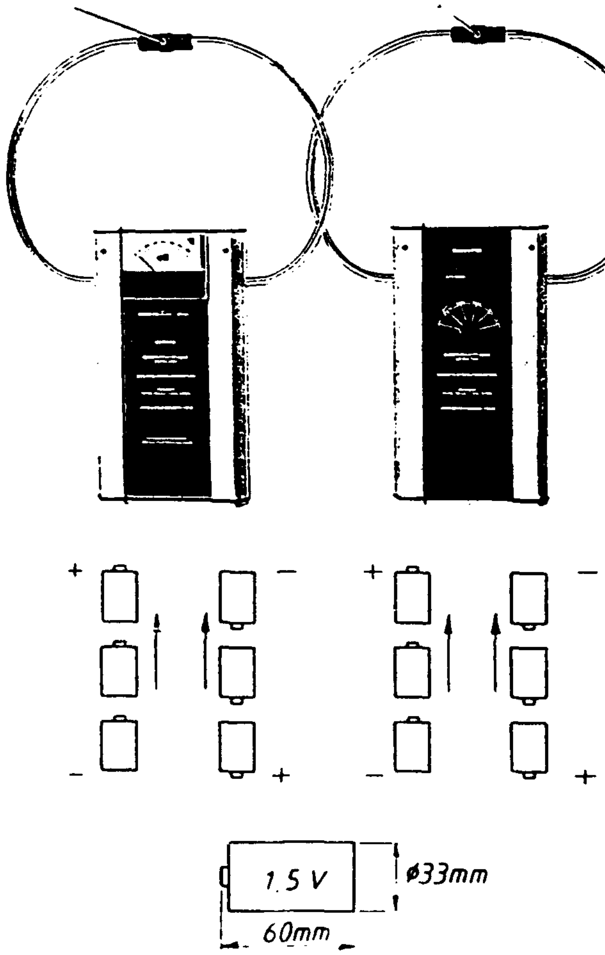


Figure 2.2 Battery installation.

3 TECHNICAL SPECIFICATIONS

3.1 Functional description

The Euroshield Leak Detector set 4F-130 consists of two units; the Transmitter and the Receiver. Both assemblies are completely solid state in design, hand-held and easy-to-use.

The transmitter generates a magnetic field at four operating frequencies: 10 kHz, 156 kHz, 1 MHz and 10 MHz. During calibration the receiver searches for the strongest signal in the frequency spectrum between 40 and 200 Hz (intermediate frequency).

The magnetic field stregth obtained during the measurement of shielding effectiveness is compared to the magnetic field strength during calibration. The display shows the relative magnitudes of the fields in dB units.

3.2 Physical description

The carrying case is a standard travel case with dimensions 455 mm x 185 mm x 385(h) mm. The entire system, including the carrying case weights 8 kg without the batteries.

The transmitter and the receiver are encapsulated with an aluminium case with grey surface paint.

The system includes the following units:

- 1 pc transmitter
- 1 pc receiver
- 2 pcs measuring rods
- 1 pc carrying case
- 1 pc User's guide
- 1 pc screw driver

3.3 Storage and operating environment

Storage temperature: -5°C ... +45°C. Keep the leak detector in a dry place. Make sure that the transmitter and the receiver are in correct position in the carrying case = backs against each other!

The Euroshield Leak Detector 4F-130 can operate over the temperature range from 0°C to +40°C . However,during the measurement the temperature may not vary more than 3 C. Therefore before measurement a warm-up period (2 min) may be needed if the leak detector was taken in from a cold temperature.

3.4 Specifications

EUROSHIELD RF LEAK DETECTOR 4F-130

Frequency range	10.165 kHz 156.085 kHz 1.000165 MHz 9.999835 MHz
Attenuation range	0...130 dB
Attenuation accuracy	+/- 1.5 dB
Display	Analog display
LED indication	Battery check
Antenna	Electrically shielded 12 inch (30 cm) loop
Receiver power supply	6 x 1.5 Volt battery
Receiver weight	1,8 kg
Transmitter power supply	6 x 1.5 Volt battery
Transmitter weight	1.7 kg
Dimensions	275 x 150 x 48 mm (LxWxH)
Accessories	Carrying case, 2 pcs rods of 300 mm
Battery life	10 hrs
Temperature range	0...+40°C
Storage temperature	-5...+45°C

3.5 Safety precautions

Remove the batteries and place them in the carrying case when travelling by aircraft.

Never store the detector for prolonged periods with the batteries installed or battery leakage may cause damage. Do not use the instrument when the battery check is flashing or does not light.

3.6 Warranty

Euroshield Oy warrants each new instrument to be free from defects in material snd workmanship, effective after delivery to the original purchaser as follows:

Electrical and Electronic Measuring Equipment... 1 Year

Repair or replacement (at our option) without charge (FOB factory) will be effected when our examination satisfactorily indicates that defects are due to materials or workmanship. Warranty returns must first be authorized by the factory.

If the instruments or any portion thereof has been abused, misused, damaged by accident or neglicence, or if any serial number or seal has been removed or altered, the warranty is void. Euroshield is not liable for incidental or consequental damages, and the warranty is in lieu of all other warranties.

3.7 Repair and Maintenance

Instruments may be returned only on prior authorization from the Representative or the factory. Validity of warranty will be determined by the factory.

Additional service information is available at our address:

EUROSHIELD OY
SF-27510 Eura
Finland
tel. (+358) 38 50631
fax (+358) 38 51233

4 PRINCIPLE OF OPERATION

4.1 Transmitter

The transmitter antenna consists of 2 loop antennas which are inside the same covering tube (Electric field shield).

RF currents through these loops depend on the frequency in use and will be approximately as follows:

10 MHz......110 mA
1 MHz......450 mA
150 kHz......800 mA
10 kHz......1.3 A

4.2 Receiver

The receiver is planned to measure the relative field strength at four frequencies: 10 MHz, 1 MHz, 150 kHz and 10 kHz.

The receiver starts off with only one crystal oscillator. By digital division, the 5 MHz clock frequency needed for the CPU is achieved as well as the local oscillator frequencies for each frequency to be received.

The receiver antenna consists of three 2-turn loop antennas which are inside the same covering tube and connected in series over separating coils.

During calibration the microprocessor searches for the strongest peak in the intermediate frequency amplifier spectrum, using FFT. The 8-bit A/D transformer takes 64 samples. For the calculation of the shielding level the processor compares only the peak frequency found and memorized during calibration.

5 MEASUREMENT PROCEDURE

For the meter calibration, see chapter 3.

5.1 Measuring in accordance to MIL-STD-285

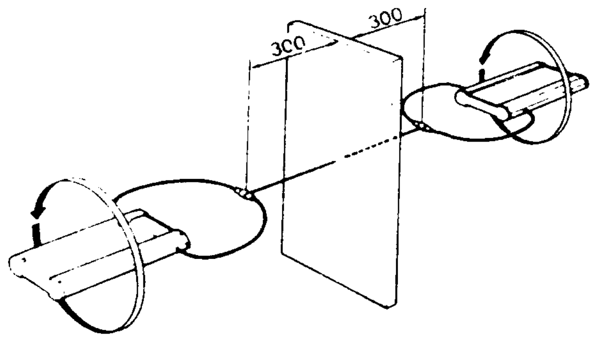


Figure 5.1

Place the transmitter and the receiver at the antenna point to be measured as shown in Fig. 5.1. Turn the antenna of the transmitter and the receiver until a minimum attenuation reading is obtained. The minimum reading indicates shielding at that point.

5.2 Measuring in accordance to NSA 65-6

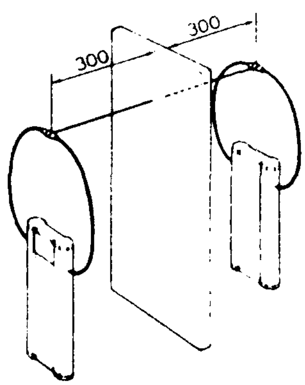


Figure 5.2

Place the transmitter and the receiver at the point to be measured as shown in Fig. 5.2. Hereby is the receiver part of the test system inside the enclosure and the transmitter is outside. The attenuation value may now be read from the meter.

6 CALIBRATION AND PERFORMANCE VERIFICATION

6.1 Calibration procedure

The meter is to be calibrated in free space as follows:

1. Switch on the power in the transmitter and the receiver.

2. Wait about 2 minutes to have the transmitter and the receiver warmed up and to achieve a stable state for calibration. If the unit has been in room temperature long enough, no stand-by period is required.

3. Depending on the measurement method used place the transmitter and the receiver as in Figure 1 (NSA 65-6) or Figure 2 (MIL-STD-285).

4. Use the 30 cm measuring rods supplied with the meter to be sure of the correct distance between the transmitter and the receiver. A gap corresponding to the thickness of the wall should be left between the rods. Note that the minimum calibration distance is 60 cm. A shorter distance may lead to incorrect calibration.

5. Choose the measuring frequency by setting the transmitter frequency selector into the desired position. Push the calibration knob of the receiver, and calibration will take place automatically. Note that the receiver seeks the signal of the transmitter by using a sequence of frequencies 10 MHz - 10 kHz - 1 MHz - 156 kHz. When the correct frequency was found the indicator needle shows the last frequency, and returns to show zero dB attenuation.

6. Note that if the temperature drops below 0°C the calibration of the very sensitive receiver is affected.

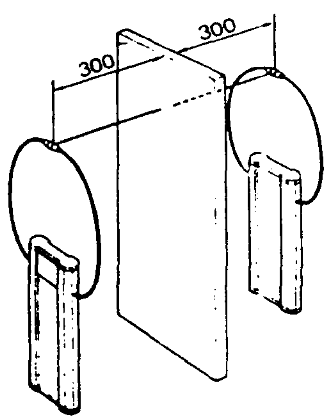


Figure 1

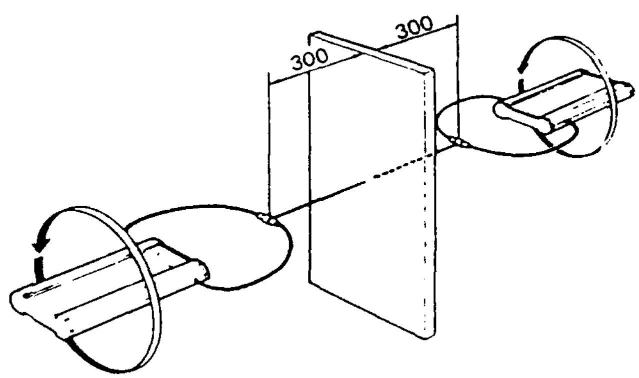


Figure 2

6.2 Performance verification test

To verify the performance you need an oscilloscope and frequency counter. The following procedure is used to check the operation:

TRANSMITTER

1. Measure the voltages of antenna loops using oscilloscope, and set the output stage voltage to 5 V. You should read the following peak-to-peak voltages:

10 kHz	0.8...1.5 Vpp
156 kHz	6...10 Vpp
1 MHz	25...35 Vpp

For 10 MHz, use a separate measuring antenna (2 loops of 100 mm). The voltage should read 8...10 V.

2. Check the frequencies with the counter. Adjust the 1 MHz and 10 MHz frequencies by using trimmer capacitors. The frequnecy shall be correct with 10 Hz accuracy.

3. Measure the current of transmitter antenna. See chapter 4.1.

RECEIVER

1. Start the receiver by setting the power on. The needle shall start seeking the signal using a seguency of frequencies 10 MHz-10 kHz - 1 MHz - 156 kHz.

2. Verify the clock frequency of the CPU by using the frequency counter. The frequency should read exactly 5 MHz. Adjust the correct frequency by using the trimmer capacitor of the CPU circuit. Check that the intermediate frequency is 165 Hz at 1 Mhz and 10 MHz frequencies.

3. Find the maximum reading of the A/D converter input at 10 kHz by using oscilloscope and by tuning the ferrite coil of input stage.

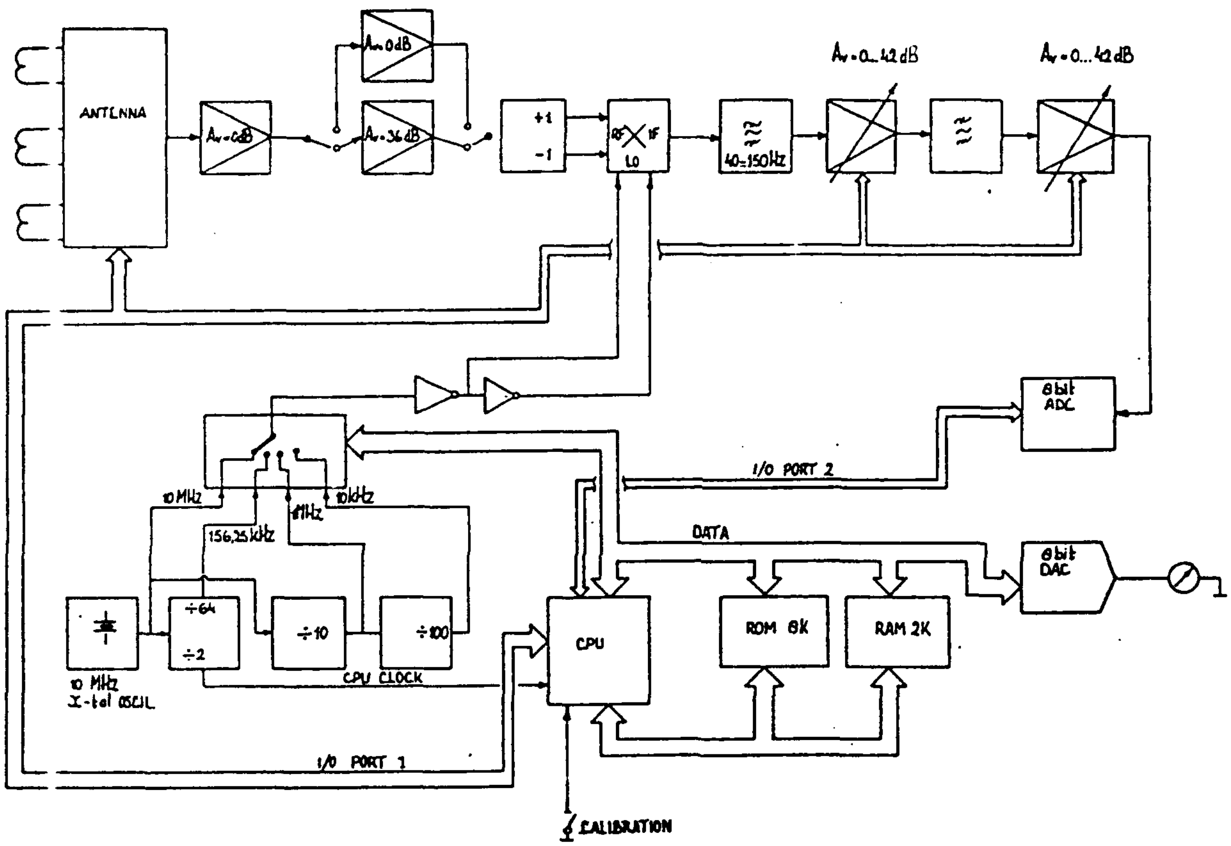
4. Check the operation at different frequencies by calibrating the receiver. Then switch off the transmitter. You should now read the maximum attenuation.

7 MAINTENANCE

7.1 Troubleshooting

Symptom	Reason	Operation
No LED indication on the transmitter or receiver	No batteries/ worn batteries	Insert new batteries
The receiver will not be calibrated	Transmitter fault	Check the power and the frequency of the transmitter
The reciver will not be calibrated at one frequency	Component/ tuning fault in the receiver	Check the performance of the receiver
The needle hits at left end of the display	Negative voltage generation	Check the performance of the receiver
Incorrect reading	Too short or long calibration distance	New calibration at 60 cm distance

8 FUNCTIONAL DIAGRAM



OPERATOR'S MANUAL
FOR
EATON 3500
SHIELDED ENCLOSURE
LEAK DETECTION SYSTEM

Manual No. 1-500783-388

Eaton Corporation
Electronic Instrumentation Division
5340 Alla Road
Los Angeles, California 90066

WARRANTY

Eaton Corporation, Electronic Instrumentation Division, (SELLER) warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

Electrical and Electronic Measuring Instruments ...... 1 Year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and Ratio Tran potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other warranties, express or implied INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY, or fitness for a particular purpose. In no event shall the SELLER be liable for INCIDENTAL OR CONSEQUENTIAL damages. The SELLER neither assumes, nor authorizes any person to assume for it, any other liability in connection with sales of instruments manufactured by SELLER.

With respect to repairs, the foregoing warranty shall apply for a period of ninety days to the repaired portion.

REPAIR AND MAINTENANCE

Instruments should be returned only on prior authorization from the Representative or the factory. You will be advised of detailed shipping instructions at that time. Return the instrument to the factory prepaid. Validity of warranty will be determined by the factory.

Chargeable repairs: If requested, an estimate of charges will be made prior to repairs. Please provide us with the following information in order to expedite the processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble [1]
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Maintenance action previously requested or performed
7. Other comments.

[1] Include data on symptoms measurements taken suspected location of trouble maintenance action taken and any other relevant data

SERVICE

Additional service information can be made available by calling any of these Eaton Sales and Service Centers:

Elmhurst, IL — (312) 279-8220
Los Angeles, CA — (213) 822-3061
Oakton, VA — (703) 620-5820
Sunnyvale, CA — (408) 733-6574

FRANCE • Argenteuil • Telephone: (01) 39-81-74-46 • Telex: 609036
UNITED KINGDOM • Wokingham • Telephone: (0734) 794717 • Telex: 847238
GERMANY • Munich • Telephone: (089) 5233023-24 • Telex: 529420

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

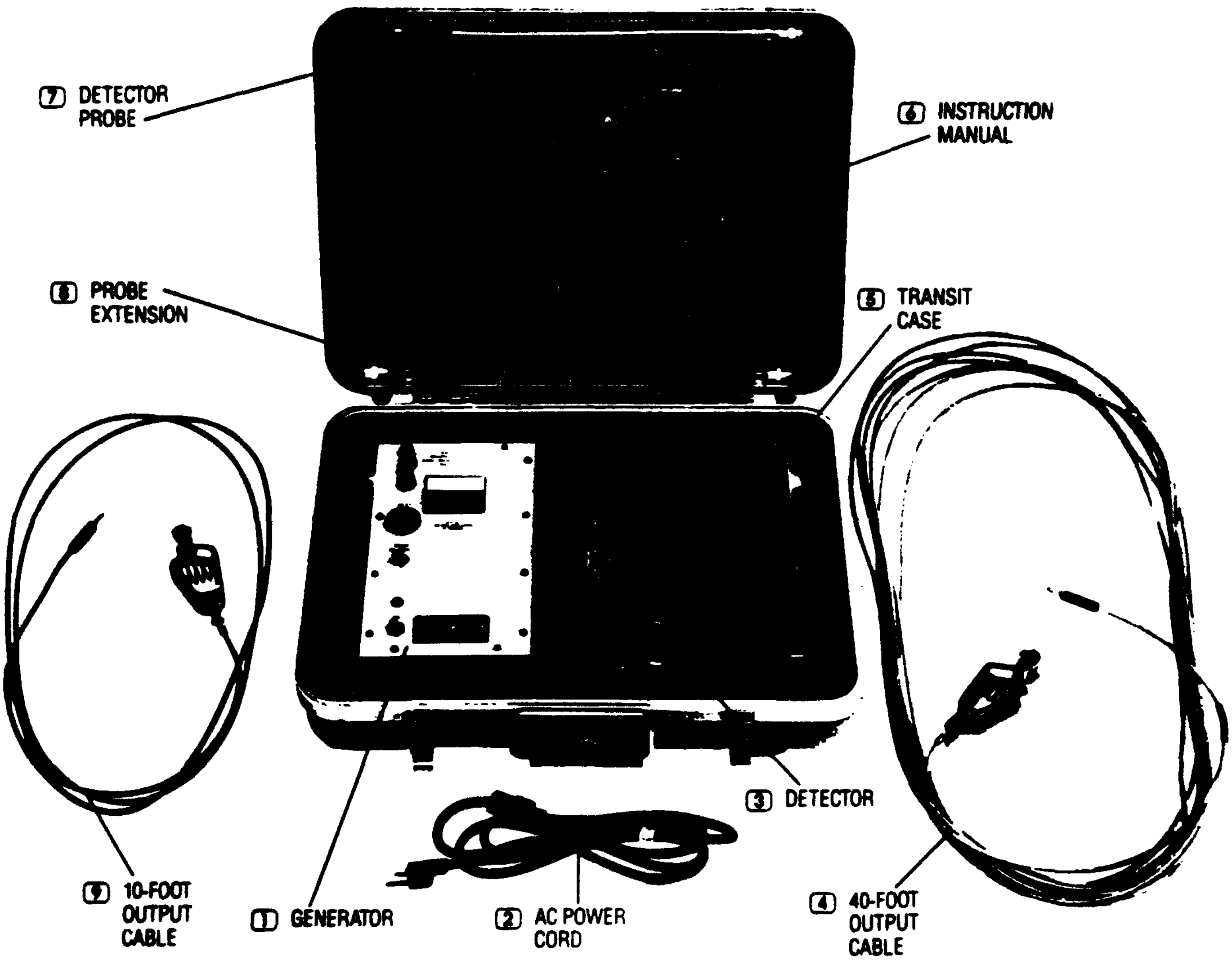


Figure 1-1. EATON 3500 SHIELDED ENCLOSURE LEAK DETECTION SYSTEM

SECTION 1

GENERAL INFORMATION

1-1. SCOPE OF THE MANUAL

This manual contains information necessary for operation and maintenance of the Eaton 3500 Shielded Enclosure Leak Detection System. The manual is divided into eight sections as follows:

Section 1: General Description
Section 2: Unpacking and Installation
Section 3: Operation
Section 4: Principles of Operation
Section 5: Performance Verification Tests
Section 6: Maintenance
Section 7: Replaceable Parts Lists
Section 8: Schematics

1-2. INTRODUCTION

This section of the manual contains a general description of the Eaton 3500 system including purpose and function, equipment requirements, specifications, and safety precautions.

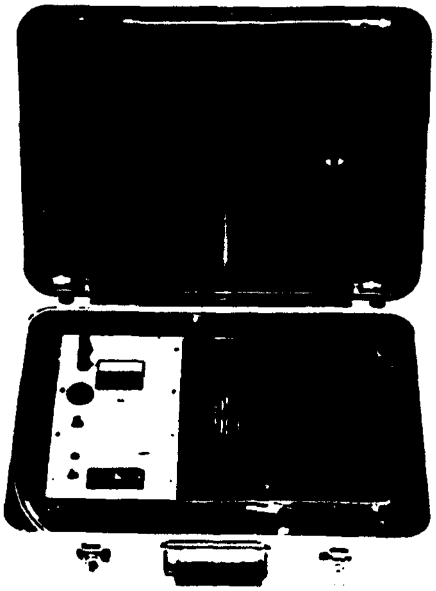


Figure 1-2. SYSTEM COMPONENTS SHOWN IN TRANSIT CASE

1-3. PURPOSE AND USE OF EQUIPMENT

The purpose of the Eaton 3500 system is to detect, measure and precisely locate defects that permit RF leakage through a shielded enclosure.

The Eaton 3500 system provides a highly effective means for detecting and locating defects that allow RF leakage. It is therefore useful for monitoring the integrity of shielded enclosures during the final assembly process. Discontinuities which permit RF leakage at welds, seams, corners, doors and bulkhead feedthroughs, etc. can be detected and remedied to insure that the finished enclosure is properly assembled. However, use of the Eaton 3500 system will not provide absolute proof that an enclosure meets all shielding specifications at all frequencies.

The Eaton 3500 system is also used for periodic monitoring of shielded enclosures. By locating defects that occur with the passage of time due to tarnishing of mating metallic surfaces, loosening of seams, etc., periodic monitoring assures the continued integrity of a shielded enclosure. Using the Eaton 3500 system, a shielding profile for an enclosure can be established after installation. Results of later periodic monitorings can then be compared to the original profile to detect changes in the shielding which permit leakage.

1-4. FUNCTIONAL DESCRIPTION

The Eaton 3500 system consists of two basic assemblies; the Generator and the Detector. These are illustrated in Figures 1-2 and 1-3 respectively. Both assemblies are completely solid state in design.

The generator produces a 106 kHz output signal which is pulse modulated at 700 Hz with a 50 percent duty cycle. During operation this output signal is connected by cables to two opposing corners of the shielded enclosure. The signal causes an RF current of approximately one ampere to flow through the entire outer surface of the enclosure. When the RF current meets a discontinuity in the enclosure surface, such as a "dirty" seam or an opening that would permit RF leakage, a magnetic field is set up perpendicular to the current flow. This magnetic field penetrates the opening and is detected in the interior of the enclosure by the detector.

The generator operates from a 115 volt or 230 volt AC power source.

The detector is a hand-held receiver with an attached loop antenna probe. It is used to probe the interior surfaces of the shielded enclosure and detect the 106 kHz magnetic fields that penetrate to the interior.

A meter on the detector panel is calibrated in dB and provides a visual indication of relative field strength. The meter can be illuminated by an internal light source so it can be easily read in darkened areas. An internal speaker produces an audio tone, the volume of which varies to provide an aural indication of field strength. An audio output jack allows the user to connect headphones for aural monitoring if desired. Operating power for the detector is provided by six size "AA" batteries.

1-5. PHYSICAL DESCRIPTION

A fiberglass transit case holds the generator, the detector, and the cables required for system operation. The transit case is a standard travel case measuring 19.4 inches, by 14.1 inches, by 6.2 inches. The entire system, including the transit case weights less than 25 pounds.

Figure 1-3. DETECTOR

The generator is permanently mounted inside the bottom of the case. The detector, with its detachable probe and probe extension, is stored in a form-fitted foam insert next to the generator. Space is provided around the generator to form a cable-way for storing the system cables.

The generator assembly is enclosed in a metal housing which measures 10¼ inches, by 6 inches, by 3½ inches. All controls, indicators, and connectors are located on the generator front panel, and are accessible while the generator is mounted in the bottom of the transit case. The generator remains in the transit case during operation but can be removed for maintenance.

The detector unit is hand-held, completely self-contained, and is not connected to the rest of the system by any wires or cables. The detector housing measures 6¾ inches, by 3¾ inches, by 2½ inches. The detachable probe is 16 inches in length. A probe extension, also 16 inches in length, is supplied to allow access to areas beyond normal reach of the operator.

A pistol grip allows the detector to be easily held in one hand. All operating controls and indicators, except for the ACTUATING SWITCH, are located on the surface facing the operator for ease of operation. The spring-loaded ACTUATING SWITCH is located just forward of the pistol grip.

1-6. OPERATING ENVIRONMENT

The Eaton 3500 system can be operated over the temperature range from 0 degrees to +55 degrees C°. At the outer edges of the temperature range a slight but measurable meter drift may occur. Because the system makes relative measurements only, this meter drift is not significant.

1-7. STORAGE DATA

The storage temperature range for the Eaton 3500 system extends from 0 to +55C°. The system can be stored within this range for an extended period of time (years) without sustaining damage or degradation.

Six inexpensive and commonly available size "AA" batteries are supplied with the system when it is shipped from the factory. The batteries are not installed before shipment and they should never be installed while the system is in storage, or battery leakage may cause damage. Extended storage periods may exceed the shelf-life of the batteries.

1-8. EQUIPMENT SUPPLIED

The items listed in Table 1-1 are supplied with the Eaton 3500 system. These are illustrated in Figure 1-1.

Table 1-1. Equipment Supplied

ITEM	DESCRIPTION	PART NUMBER
1	Generator	4-006836-001
2	AC Power Cord	1-910166-001
3	Detector	4-006837-001
4	Cable Set: 40-Foot Output Cable	3-006839-001
5	Transit Case	4-006815-001
6	Instruction Manual	1-500783-386
7	Detector Probe	4-006809-001
8	Probe Extension	3-006838-001
9	10-Foot Output Cable (Part of Cable Set)	3-006839-001
0	Battery Set (6 "AA" cells)	1-905005-001

1-9. EQUIPMENT REQUIRED BUT NOT SUPPLIED

All equipment required for system operation is supplied. Some standard test equipment items are required for calibration and troubleshooting, and are listed in Section 1-12, Tools and Test Equipment.

1-10. OPTIONAL ACCESSORIES

No optional equipment accessories are required for use with the Eaton 3500 system. Additional instruction manuals may be ordered by individual part number.

1-11. SPECIFICATIONS

Specifications for the Eaton 3500 system are listed in Table 1-2.

Table 1-2. Eaton 3500 Performance Specification

GENERATOR	
Frequency of Operation	106 kHz ± 2 kHz
Pulse Modulation	Square Wave, 700 Hz ± 100 Hz 50% Duty Cycle
Output Current	1 Ampere Peak
Output Indication	Front Panel Meter
Power Requirements	115/230 VAC 50 - 60 Hz 25 Watts
Physical Dimensions	Height 3½ inches Width 6 inches Length 10½ inches
Weight	15 lbs.
Operating Temperature Range	0 to +55 degrees C°
DETECTOR	
Operating Frequency	106 kHz ± 2 kHz
3 dB Bandwidth	5 kHz ± 1 kHz
Sensitivity	0.5 pico Tesla for discernible signal
Audio Output	2¼ inch speaker, 600 Ohm Headphones
Meter Range	0 - 40 dB (Relative Indication)
Power Requirement	6 size "AA" batteries
Physical Dimensions	Height 9¼ inches Width 2½ inches Depth 6¾ inches
Weight	2.75 lbs. (1.2 kg)
Operating Temperature Range	0 to +55 degrees C°

1-12. TOOLS AND TEST EQUIPMENT REQUIRED

The tools and test equipment listed in Table 1-3 are required for calibration and maintenance of the Eaton 3500.

1-13. CALIBRATION CYCLE

The Eaton 35(0 system should be calibrated at intervals of one year. Calibration procedures are included in Section 6, Maintenance.

Table 1-3. Tools and Test Equipment Required

DESCRIPTION	MINIMUM OR CRITICAL PARAMETERS	RECOMMENDED MODEL
Signal Generator	1-6 kHz, -120 dBm	Hewlett Packard Model 606A
Oscilloscope	5 mV/div vertical sensitivity, 1 MHz bandwidth minimum, calibrated time base	Tektronix 5440/5A48
Frequency Counter	106 kHz	Hewlett Packard Model 5314A
Wirewound Resistor	1 ohm, 1%, 3 watts	Dale type RS-2
Digital Voltmeter		Fluke Model 8010A

1-14. SAFETY PRECAUTIONS

WARNING

This symbol designates precautionary actions which must be followed to avoid the possibility of injury.

1. The generator AC power cable plug shall be inserted into a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective ground conductor.

2. Any interruption of the protective ground conductor inside or outside the generator, or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited.

3. Any adjustment, maintenance, and repair of the generator while AC voltage is applied should be carried out only by a skilled person who is aware of the hazard involved.

CAUTION

This symbol designates precautionary actions which must be followed to avoid damage to the generator or detector.

1. Verify that the line voltage selector card in the generator is in the correct position before connecting the AC power.

2. Verify that the socket for the AC power cord is provided with a protective earth contact.

3. Any interruption of the protective grounding conductor inside or outside the generator is likely to cause damage to the instrument.

4. Make sure that only fuses with required rating and of the specified type are used for replacement.

5. Never store the detector for prolonged periods with the batteries installed or battery leakage may cause damage.

SECTION 2

UNPACKING AND INSTALLATION

2-1. INTRODUCTION

This section contains instructions for unpacking and preparation for use of the Eaton 3500 Shielded Enclosure Leak Detection System.

See that the equipment is complete as listed on the packing slip. Open the system transit case and visually examine the contents for any evidence of physical damage. If any damage is evident, or if the contents are not complete per Table 1-1, immediately notify the carrier and your local Eaton sales office.

2-2 UNPACKING AND PHYSICAL INSPECTION

Examine the shipping carton for damage before unpacking the equipment. If the carton has been damaged, have the carrier's agent present when the equipment is removed from the carton. Retain the shipping carton and padding material for the carrier's inspection if damage to the equipment is evident after it has been unpacked.

CAUTION

Exercise care when removing the instrument from its shipping container to ensure that no damage is incurred at this time.

2-3. AC POWER REQUIREMENTS

Prior to shipping, the generator unit is configured to operate on 115 VAC, 60 Hz line power. The unit is easily reconfigured for operation using 230 VAC. Refer to Figure 2-1 and perform the following steps to verify, or to change, the line voltage configuration.

WARNING

Observe all safety precautions listed in Paragraph 1-14. In particular, determine that the line voltage selector card is set to the correct position for the AC voltage which is to be used.

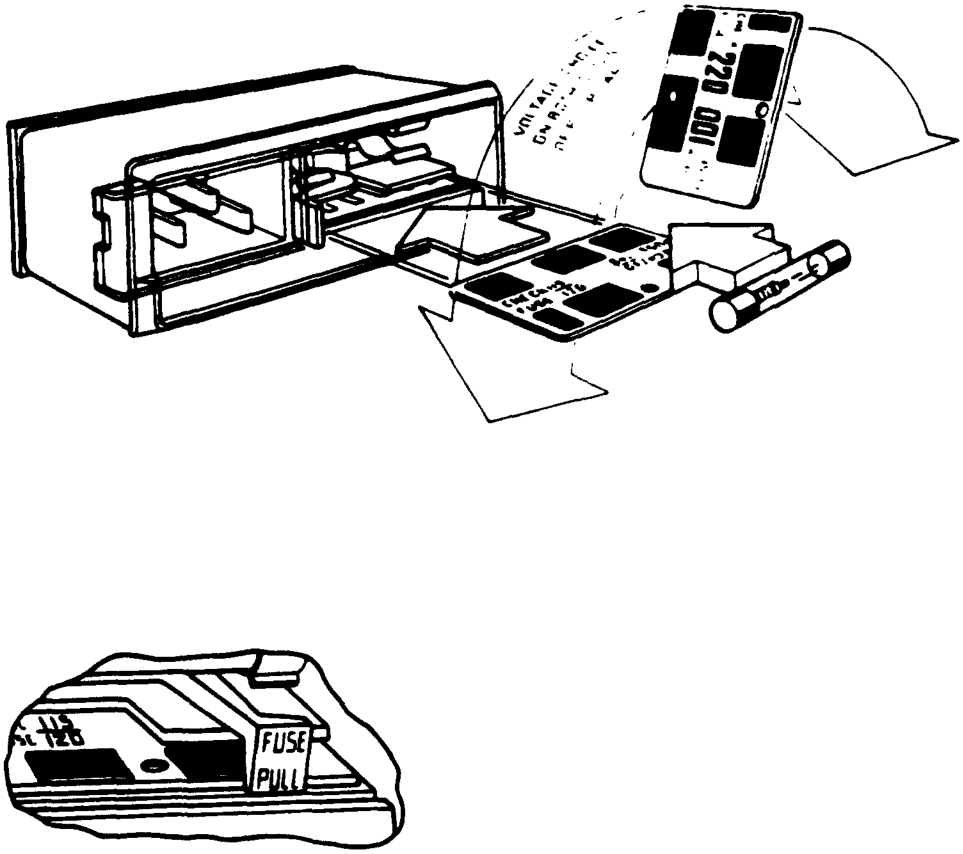


Figure 2-1. AC VOLTAGE SELECTION CARD

1. On the generator, locate the receptacle for the line power cord. Unplug the cord from the receptacle.

2. Slide the transparent fuse cover to the left, and pull the FUSE PULL lever to remove the fuse.

3. Read the voltage printed on the voltage selector card. This number is visible after the fuse is removed. Four different voltages are printed on the card: 100, 120, 220, and 240. When 100 or 120 is visible, the actual operating voltage is 115 volts. When 220 or 240 is visible, the actual operating voltage is 230 volts.

4. The unit is normally configured for 115 volt operation. If it is to be operated using this voltage, verify that either 100 or 120 is visible. Verify that the fuse rating is .5 Amps, slow-blow, and reinsert the fuse.

5. If the unit is to be operated using 230 VAC, remove the voltage selector card. A small hole is provided in the card to accommodate a hook for easy removal.

6. Position the card so that either 220 or 240 will be visible after the card is reinserted.

7. Reinsert the card and verify that either 220 or 240 is visible.

8. Replace the fuse. The same fuse, .5 Amps, slow-blow, is used for operation at 115 or 230 VAC.

9. Slide the fuse cover back into place.

10. Plug the power cord into the receptacle.

WARNING

The power cord is a 3-wire assembly to ensure that the instrument chassis is connected to the main ground. Under no conditions is this ground lead to be interrupted, or a 2-wire extension cord to be used.

CAUTION

The detector should never be stored for a lengthy period with the batteries installed or battery leakage may cause damage. It is also recommended that the battery terminals be cleaned after long periods of use to ensure the optimum performance of the detector.

2-4. BATTERY INSTALLATION

Six 1.5 volt, size "AA" batteries must be installed in the detector before the system can be operated.

1. Loosen the four cover screws from the detector enclosure. These are located, two on each side, near the bottom edges.
2. Remove the cover.
3. Locate the battery holder and install the batteries. All six batteries should be installed with their terminals facing the same direction. Examine the contacts of the battery holder to determine which ones are positive and install the batteries accordingly. The top two batteries provide power for the lamps and the bottom four batteries provide power for the detector circuitry. The lamp batteries will have a shorter lifetime and will need to be replaced after 4 to 8 hours of use.
4. Replace the cover and tighten the screws.

2-5. OPERATIONAL INSPECTION

After verifying that the generator unit is configured for the correct line voltage, the generator and the detector may be subjected to the Performance Verification Tests in Section 5 of this manual. Successful completion of these tests demonstrates that the system is operating properly. As an alternative, the Confidence Test in Section 3 may be performed. Although the Confidence Test does not prove that all system parameters are within specified limits, it does serve as a brief preoperational test and shows that the system is operating.

2-6. INSTALLATION

Because the Eaton 3500 system is a portable system, there is, strictly speaking, no fixed installation. All information pertaining to operation and use of the system is included in Section 3, Operation.

SECTION 3

OPERATION

3-1. INTRODUCTION

This section contains information and procedures necessary for operation of the Eaton 3500 Shielded Enclosure Leak Detection System. The system consists of two units, an RF Generator, and a Detector unit.

3-2. CONTROLS AND INDICATORS—GENERATOR

All generator controls, indicators, and connectors are located on the front panel and are accessible while the generator is in the transit case. Their locations are shown in Figure 3-1; their functions are listed in Table 3-1.

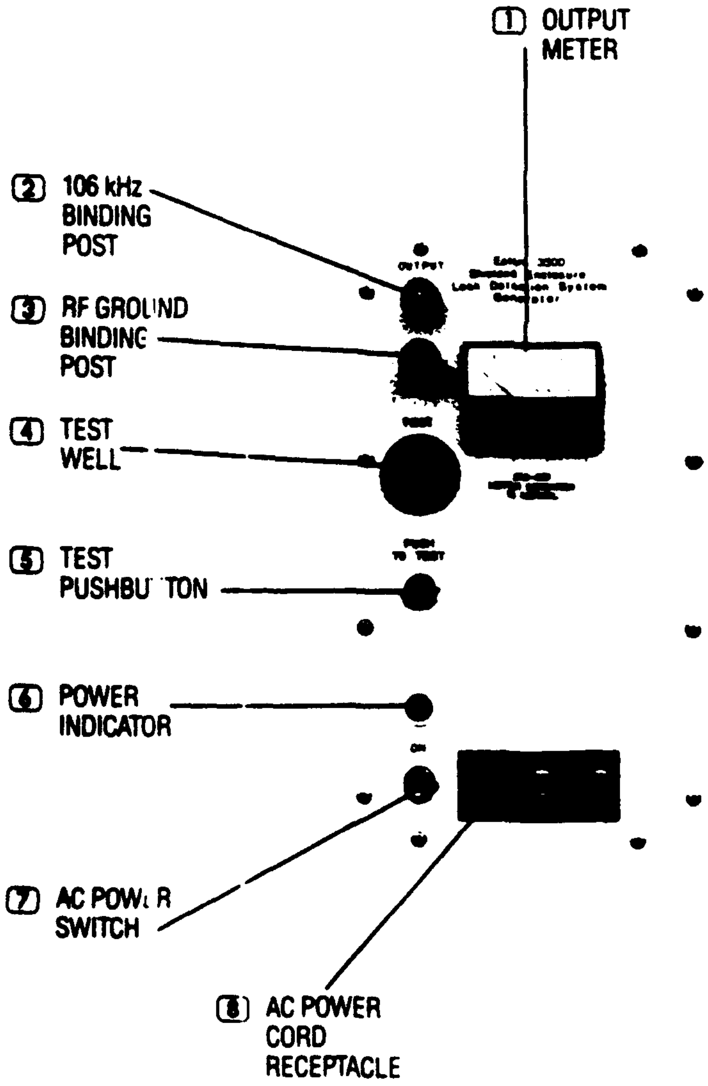


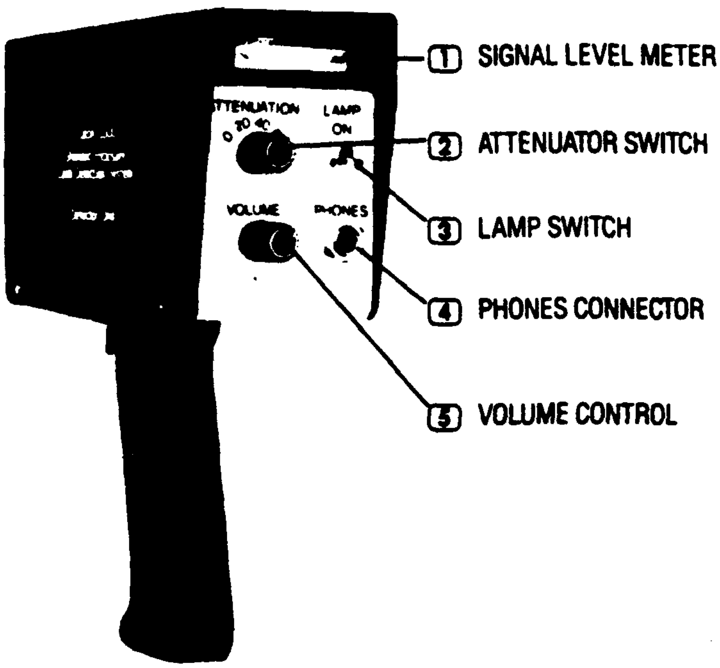
Figure 3-1. GENERATOR CONTROLS AND INDICATORS

Table 3-1. Generator Controls and Indicators

ITEM	DESIGNATION	FUNCTION
1.	OUTPUT METER	The OUTPUT METER monitors the RF current output level from the generator when the RF output cables are connected to the shielded enclosure. The meter is scaled from 0 to 500 DC microamperes. The nominal, normal RF output current of 1 Amp will give a meter reading between 300 and 400. When more than one 40-foot length of output cable is used, a slightly greater load impedance may cause the meter indication to drop slightly below 300.
2.	106 kHz OUTPUT POST	This binding post is the connection point for the 40-foot generator output cable. It is a standard binding post and will accept a banana plug.
3.	RF GROUND BINDING POST	This binding post is the connection point for the 10-foot generator output cable (the return cable). It is a standard binding post and will accept a banana plug.
4.	TEST WELL	The TEST WELL provides a means of checking the operation of the system. The detector probe is inserted into the well, the Test Pushbutton is pressed, and the signal level noted on the detector meter.
5.	TEST PUSHBUTTON	The TEST PUSHBUTTON is pressed to cause a low level, audio modulated, 106 kHz test output signal to be coupled to the TEST WELL.
6.	POWER INDICATOR	The POWER INDICATOR illuminates when AC power is applied to the generator.
7.	AC POWER SWITCH	The AC POWER SWITCH applies the 115 or 230 VAC power to the generator when set to the ON position.
8.	AC POWER CORD RECEPTACLE	This is the connector for the AC power cord. It also holds the 115/230 VAC voltage selection card and the .5 Amp AC fuse.

3-3. CONTROLS AND INDICATORS – DETECTOR

Most of the detector controls and indicators are located on the front panel, facing the operator during use. The ACTUATING SWITCH is located on the bottom of the assembly, just forward of the pistol grip. The PROBE CONNECTOR and LAMP are located on the rear of the detector, facing away from the operator. Control and indicator locations are shown in Figure 3-2; their functions are listed in Table 3-2.



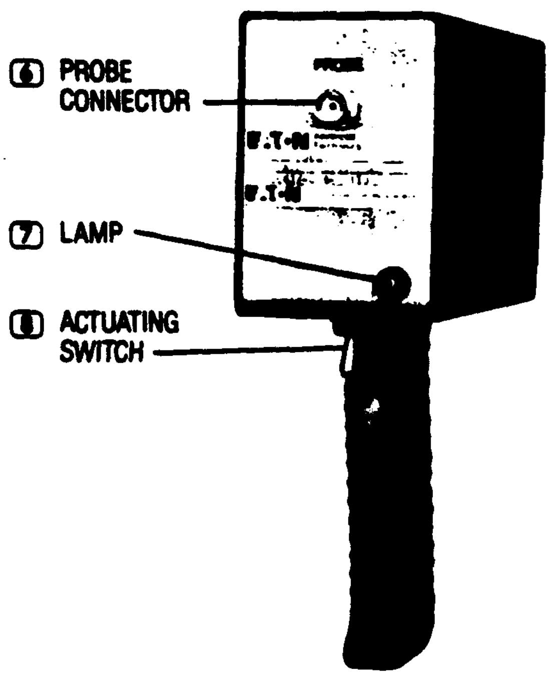


Figure 3-2. DETECTOR CONTROLS AND INDICATORS

Table 3-2. Detector Controls and Indicators

ITEM	DESIGNATION	FUNCTION
1.	SIGNAL LEVEL METER	The SIGNAL LEVEL METER provides a relative indication of the level of the signal leaking through to the interior of the shielded enclosure. It is located on the front of the detector, facing the operator. The meter is scaled from 0 to 40 dB.
2.	ATTENUATOR SWITCH	This is a four position rotary switch used to keep the SIGNAL LEVEL METER needle on the meter scale. The four switch positions are 0 dB, 20 dB, 40 dB, and 60 dB. The switch is located on the front of the detector.
3.	LAMP SWITCH	When the LAMP SWITCH is set to ON it enables two lamps. However, these do not light until the ACTUATING SWITCH is closed. One lamp illuminates the meter scale. The other illuminates the area that is being probed.
4.	PHONES CONNECTOR	This standard audio jack allows connection of headphones, in which case the internal speaker is automatically silenced. The jack is located on the front of the detector.
5.	VOLUME CONTROL	The VOLUME CONTROL adjusts the volume of the audio signal from the internal speaker, or the headset. The control is located on the front of the detector.
6.	PROBE CONNECTOR	The loop antenna probe is connected to this TNC-type connector during operation. It is located on the rear of the detector, facing away from the operator.
7.	LAMP	The LAMP illuminates the area which is being probed. It is located on the rear of the detector.
8.	ACTUATING SWITCH	The ACTUATING SWITCH applies 6 volts DC from the batteries to the detector circuitry. It is located on the bottom of the detector just forward of the pistol grip. This switch is depressed to operate the detector.

3-4. PRELIMINARY SET-UP

The shielded enclosure should be prepared for leak detection by removing or disconnecting all cables and conductors which penetrate from the exterior to the interior. If these are not removed they may conduct signals to the interior. All open holes or bulkhead feedthroughs should be covered with an appropriate shielding.

After installing the batteries in the detector and verifying that the generator is configured for the correct AC line voltage, perform the following steps to set up for operation:

1. Place the system transit case near the shielded enclosure to be tested.

2. Open the transit case and remove the AC power cable and the two generator output cables.

3. Connect the AC power cord to the connector on the generator front panel. Connect the other end to the power source.

4. Connect the 10-foot generator output cable to the GROUND BINDING POST on the generator front panel.

5. Connect the clip end of the 10-foot cable to a point on the shielded enclosure exterior wall close to a corner. Ensure that a good electrical connection is obtained at this point. See Figure 3-3.

6. Connect the 40-foot generator output cable to the 106 kHz OUTPUT BINDING POST on the generator front panel.

7. Connect the clip end of the 40-foot cable to a point on the shielded enclosure exterior wall, diagonally opposite the point where the 10-foot cable is connected. Ensure that a good electrical connection is obtained at this point. More than one 40-foot length can be used if necessary.

NOTE

In cases where the 40-foot cable is not long enough, additional 40-foot output cables may be constructed using the instructions in Paragraph 3-7.

8. Remove the detector and probe from the transit case. Connect the probe to the probe connector.

The system is now ready for operation. However, it is good practice to perform the Confidence Test described in Paragraph 3-5 before using the system.

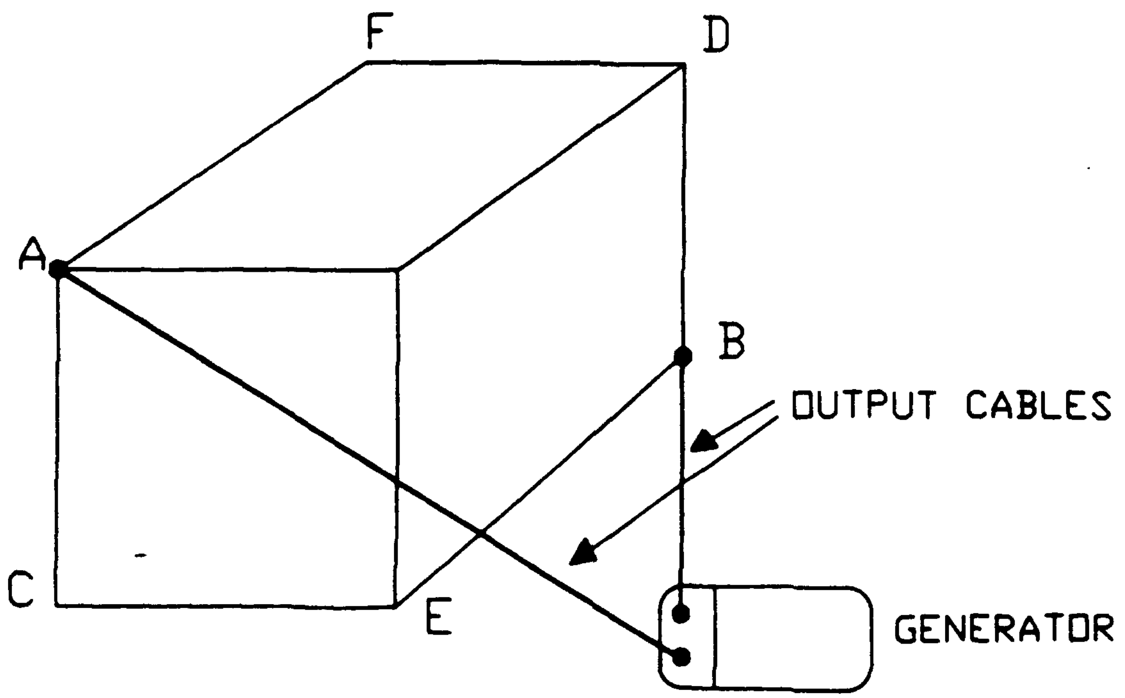


Figure 3-3. TYPICAL CONNECTION TO SHIELDED ENCLOSURE

3-5. CONFIDENCE TEST

After the system is set up and connected to the shielded enclosure, perform the following steps to verify its correct operation:

1. Set the generator AC POWER SWITCH to the ON position and verify that the front panel POWER INDICATOR is lit.

2. Verify that the generator OUTPUT METER indicates an output between 300 and 400 DC microamperes. If the meter reading is not within this range, recheck the clip connections to the shielded enclosure.

NOTE

If more than one 40-foot length of output cable is being used, the meter may indicate an output slightly below 300 microamperes due to the increased load impedance. This lowered current output level will cause a slight lessening of system sensitivity. However, since the detector makes relative measurements only, no significant change in system performance will result.

3. Set the detector LAMP SWITCH to ON. Toggle the ACTUATING SWITCH and verify that the LAMP and the meter scale illuminate.

4. On the detector, set the ATTENUATOR SWITCH to 60 dB and set the VOLUME CONTROL to mid-range.

5. Insert the probe all the way into the TEST WELL on the generator front panel.

6. Depress the TEST PUSHBUTTON and verify that the detector SIGNAL LEVEL METER reads between 15 and 25 dB. (The TEST PUSHBUTTON disables power to the generator final amplifier and applies a reference field to the TEST WELL.)

7. Verify that the audio tone is heard from the detector speaker.

In the event of a problem during the confidence test, or during operation of the system, remove the batteries from the detector and clean the terminals. After completing the confidence test the system is ready for operation.

3-6. SYSTEM OPERATION

After performing the Confidence Test, take the detector into the enclosure and tightly secure the enclosure door. Set the ATTENUATOR SWITCH to 0 dB and begin probing the interior surfaces. The main points of interest during leak detection are seams at corners and edges and also the areas around doors or hatches. If the LAMP SWITCH is set to the ON position, the lamp on the rear panel of the detector will light when the ACTUATING SWITCH is toggled.

When a signal is detected, adjust the ATTENUATOR SWITCH to a position which keeps the needle on the scale of the SIGNAL LEVEL METER.

The coupling of the probe is most sensitive when the probe is held perpendicular to the orientation of the 106 kHz magnetic field set up by the generator current. When probing flat surfaces such as the walls or ceilings, hold the probe perpendicular to the surface. When probing seams at corners, hold the probe at a 45 degree angle to the joining surfaces.

If the angle of the probe relative to the magnetic field is changed, an increase or decrease in detected signal level will be seen. Experimentation with this phenomenon will show the difference between a change in detected signal level caused by a leak, and one caused by a change of probe position.

The recommended method of probing seams is to drag the probe along the seam while the ATTENUATOR SWITCH is set to a position which keeps the meter needle in the low to middle range of the scale. Leaks and small discontinuities will cause a sharp increase, and then decrease, in the meter indication. This will be accompanied by a corresponding increase and decrease in the audio tone from the headset or internal speaker.

When a leak is detected, use a piece of white chalk to circle its location and mark the signal level of the leakage. The signal level is equal to the sum of the meter indication and the setting of the ATTENUATOR SWITCH. For example, if the ATTENUATOR SWITCH is set to the 40 dB position, and the maximum meter indication of the leak is 35 dB, the sum is 75 dB and this level should be marked by the leak.

Mark a reference reading from an adjacent panel with known good shielding so a comparison can be made. It is again stressed here that all leakage measurements made by the 3500 system are relative measurements only.

NOTE

> If any problems are experienced during operation of the system, remove the batteries in the detector and clean the terminals. Refer to Paragraph 2-4.

Because the pattern of RF current density is dependent on the geometry of the shielded enclosure and the points at which the cables are attached, when the detector probe approaches the corners of the enclosure to which the generator output cables are connected, the signal indication from the detector will gradually increase. This is due to the dispersion pattern of the 106 kHz RF current. The current density is greatest at the points where the cables are connected and is least at the midpoints in between.

The RF current density will also tend to be greater at any edges and corners of the enclosure. Accordingly, the signal indication from the detector will be greater in these areas, even when no leak exists. Experience will show the difference between detector readings caused by leaks and those caused by enclosure geometry.

For a slot-shaped discontinuity, the level of detected leakage signal will vary significantly according to the direction of the RF current flow relative to the slot. See Figure 3-4. If the current flow is parallel to the slot as in example A of Figure 3-4, a small leakage signal will be detected. If the current flow is perpendicular to the slot as in example B, a much larger leakage signal will be seen. For this reason it is

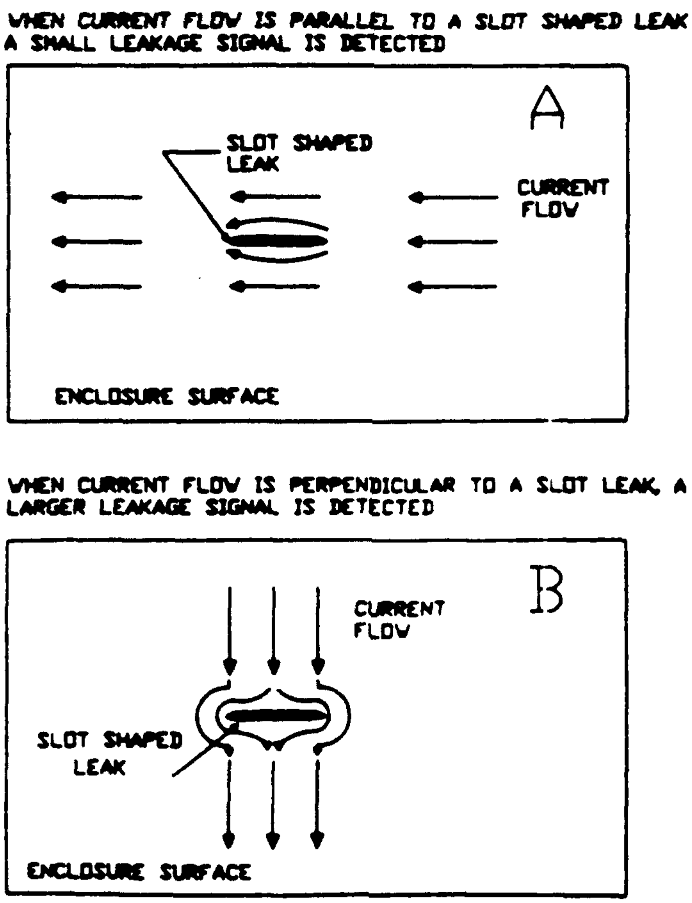


Figure 3-4. RF CURRENT FLOW AROUND SLOT-SHAPED LEAK

recommended that the enclosure be probed several times. The first time, attach the generator cables to diagonally opposing corners A and B as shown in Figure 3-3. Then attach the cables to corners C and D. Finally, attach the cables to corners E and F. If for some reason the generator output cables cannot be attached to the corners, they should be attached as close to the corners as possible.

Where an apparent slight leak is detected at the edges of a door or hatch, the generator output cables may be repositioned on either side of the suspect area. This will increase the current flow through the area and thereby increase the strength of the magnetic field caused by a leak. See Figure 3-5.

After leaks have been repaired, repeat the probing procedure to verify the effectiveness of the repair.

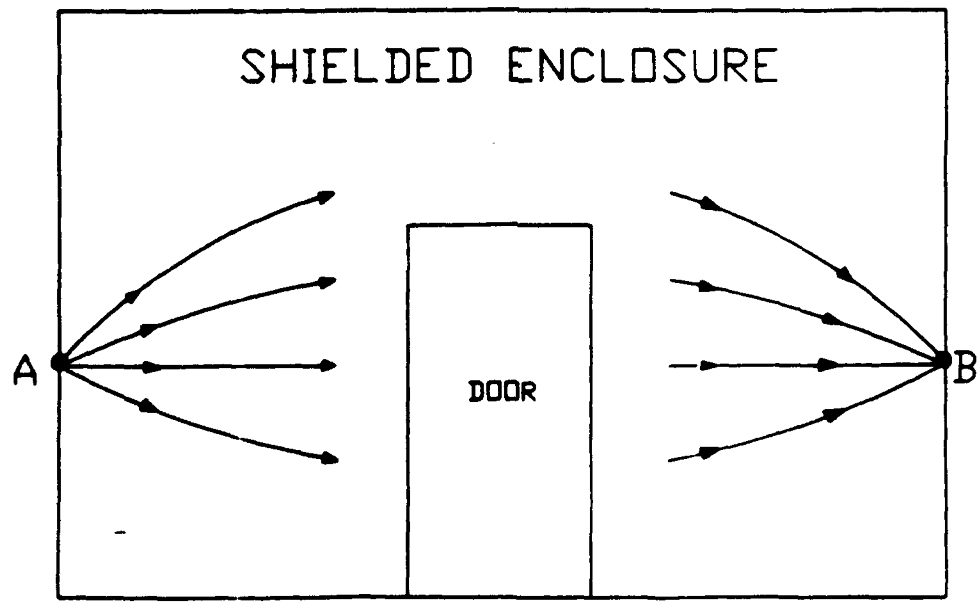
3-7. FABRICATION OF CABLES

Where very large shielded enclosures are being examined with the Eaton 3500 system, the 40-foot length of generator output cable may be too short to reach from the generator to an opposite upper corner. In such cases additional 40-foot lengths may be fabricated and connected in series to provide the required length

Fabricate each additional output cable from a 40-foot length of flexible #12 insulated wire. An 0.15 microfarad capacitor must be connected in series with each added 40-foot cable. The capacitor must be capable of carrying the output load current (1 ampere RMS during the ON portion of each 700 Hz audio pulse).

The added capacitor for each added cable length is necessary to keep the combined reactance of the output circuit reasonably comparable to that of the single 40-foot length. Addition of one 40-foot cable roughly doubles the inductive reactance in the circuit. Addition of the 0.15 microfarad capacitor doubles the capacitive reactance so that the net reactance of the 80-foot cable length approximately equals that of the 40-foot circuit.

As many as two 40-foot cables can be added to the generator output circuit.



ATTACH CABLES TO POINTS A AND B TO INCREASE CURRENT DENSITY ACROSS THE DOOR.

Figure 3-5. CONNECTION TO INCREASE CURRENT DENSITY

SECTION 4

PRINCIPLES OF OPERATION

4-1. INTRODUCTION

This section contains information on the theory and principles of operation for the Eaton 3500 Shielded Enclosure Leak Detection System. This section is divided into three main parts; functional description at the system level, functional description based on block diagrams, and functional description at the circuit level.

4-2. SYSTEM OPERATION

The Eaton 3500 system is composed of two assemblies; the generator and the detector. The generator produces a 106 kHz signal which is pulse modulated at 700 Hz. This signal is carried by two output cables which are connected to two opposing corners of the shielded enclosure. The signal induces an RF current to flow throughout the entire outer surface of the enclosure. The signal frequency, 106 kHz, is low enough to ensure that a relatively uniform RF current flow occurs in all six sides of the enclosure without the formation of standing waves. However, the field is somewhat stronger in the corners where the output cables are connected.

Minute defects in the enclosure's outer surface, such as small openings or separations between panels, create electrical discontinuities in the surface. When the RF current encounters such a discontinuity, a 106 kHz magnetic field is set up perpendicular to the current flow. The magnetic field penetrates the surface at the discontinuity, and can be detected in the enclosure interior by the de ector.

The 106 kHz magnetic field induces a signal voltage in the tuned detector probe. This signal is amplified and demodulated to produce both an indication of relative level on an output meter, and a 700 Hz aural tone at the internal speaker or external headset. A four position step attenuator in the detector is used by the operator to keep the meter reading on scale. As the operator probes the interior surfaces of the enclosure, relative changes in strength of the magnetic field leaking into the interior are indicated by the meter, and also by a change in volume of the 700 Hz audio tone.

4-3. GENERATOR DESCRIPTION BASED ON DETAILED BLOCK DIAGRAM

Figure 8-1 is the detailed block diagram for the generator.

The Astable Multivibrator produces a 700 Hz, ± 100 Hz square wave having a duty cycle of 50 percent. This is the gating signal which is applied to the Modulated Oscillator.

The Modulated Oscillator produces a 106 kHz RF signal when it is gated ON by the positive half-cycle of the 700 Hz square wave. The oscillator RF frequency can be varied by adjusting an internal inductor. The output signal amplitude can be varied by adjusting an internal trimmer. The 106 kHz, pulse modulated output signal goes to the constant current amplifier.

The function of the Constant Current Amplifier is to maintain a constant generator output current of one ampere (1 ampere RMS during the ON part of the cycle, or 1.4 amperes peak) at 106 kHz, regardless of variations in the load (the shielded enclosure and the output cables). The circuit output goes to output connectors J1 and J2, to which the generator output cables are attached during operation.

The Output Meter samples the output from the Constant Current Amplifier to allow monitoring of the generator output current level. The meter face is scaled from 0 to 500 microamperes. However, it should be noted that a meter reading of 300 to 400 indicates the desired nominal output of one ampere.

The DC power supply for the generator is composed of a simple transformer, rectifier, and filter. The power supply output is a nominal +48 volts at approximately .4 ampere. The AC input voltage to the supply can be selected as 115 or 230 VAC by means of a voltage selection card.

4-4. DETECTOR DESCRIPTION BASED ON DETAILED BLOCK DIAGRAM

Figure 8-2 is the detailed block diagram for the detector.

The detector probe is a loop antenna, inductively resonant at 106 kHz. When a 106 kHz magnetic field penetrates to the interior of the shielded enclosure through discontinuities in the outer surface, a small voltage is induced in the probe. The induced voltage is then applied to the RF attenuator.

The RF attenuator reduces the voltage of the signal from the detector probe before it is applied to the amplifiers. A four position switch allows the user to select 0, 20, 40, or 60 dB of attenuation to keep the SIGNAL LEVEL METER needle on the meter scale. The attenuator output signal is applied to the Input RF Amplifier.

The Input RF Amplifier is the first amplifier stage and provides approximately 34 dB of gain. The amplifier output signal is applied to the Tuned RF Amplifier.

The Tuned RF Amplifier is the second amplifier stage and provides approximately 68 dB of gain. This amplifier is tuned to 106 kHz and has a bandwidth of approximately 5 kHz. The amplified output signal is applied to the detector.

The detector operates as a combination demodulator and signal level detector. The demodulator recovers the 700 Hz audio component of the 106 kHz input signal. This audio component is applied to the Audio Amplifier. The signal level detector applies an output signal, proportional to the average input signal level, to the SIGNAL LEVEL METER.

The Audio Amplifier is a push-pull amplifier which provides 20 dB of power gain for the audio signal. The amplified output signal is applied to the internal speaker, or to a headset, used for aural monitoring of the detected signal level.-

The SIGNAL LEVEL METER provides a visual means for monitoring changes in the detected signal level. The meter is scaled from 0 to 40 dB and provides a relative measurement of the level of the magnetic fields penetrating the interior of the shielded enclosure.

4-5. CIRCUIT DESCRIPTION – GENERATOR

Figure 8-3 is the generator schematic.

DC Power Supply

DC power for the generator is supplied by a simple transformer, rectifier, and filter. The output is nominally +48 volts at 400 milliamperes. A circuit card in the input module can be positioned to select an AC input of 115 or 230 volts.

Astable Multivibrator

Transistors Q1, Q2, and the associated circuitry form the Astable (free-running) Multivibrator which functions as the modulating signal source. Its operating frequency is nominally 700 Hz, determined by the R-C components R2, C2, R4, and C3 The square wave output is applied to the base bias circuit of transistor Q3, the Modulated Oscillator.

Modulated Oscillator

During the positive half-cycle of the modulating waveform, the oscillator, Q3, is gated on. It operates at a frequency of 106 kHz, as determined by the resonant circuit formed by C6, C7, and variable inductor L1. Trimmer potentiometer R10, adjusts the oscillator output level to the Constant Current Amplifier. A portion of the oscillator output is coupled to a test well used for checking the operation of the detector unit. Zener diode CR5 stabilizes the DC supply voltage for the oscillator and the multivibrator at approximately +15 volts.

Constant Current Amplifier

Transistors Q4, Q5, Q6, Q7, and the associated circuitry form a constant current amplifier which provides the final output of the generator. Series feedback developed across R23 and R24 provide gain stability for the amplifier. The output current is sampled across R25 and the level is indicated on panel meter M1.

Output Level Meter

Output level meter M1 is used by the operator to monitor the generator output current. This meter will indicate an output of 300 to 400 microamperes when the generator RF output current is 1 ampere RMS.

4-6. CIRCUIT DESCRIPTION – DETECTOR

Figure 8-4 is the schematic diagram of the detector.

Probe and RF Attenuator

Loop probe L1 senses the electromagnetic field signal. The inductance of the loop is resonated at 106 kHz by capacitor C1. The induced signal is applied through attenuator switch S1 and the attenuator network which provides up to 60 dB of attenuator in 20 dB steps.

Input RF Amplifier and Tuned RF Amplifier

The input amplifier consists of transistor Q1 and the associated circuitry in an R-C coupled configuration. It is followed by two tuned RF stages, transistors Q2 and Q3. Variable inductors L2 and L3 permit adjustment of the operating frequency to 106 kHz. The bias to the three stages is stabilized by a resistor-diode network consisting of CR1, R16, CR2, and CR3. Each of the three stages has 34 dB of gain.

Detector and Signal Level Meter

Transistor Q4 operates as a combination audio demodulator and signal level detector. Audio is recovered from the emitter circuit of Q4 and coupled to the volume control, R21. The Q4 collector current, which is proportional to the average signal level, is fed through the signal level meter M1 back to the emitter circuit of Q2. This current feedback causes the gain of Q2 to be reduced as the signal level increases, allowing 40 dB of range on the meter scale. Trimmer potentiometer R12 is adjusted to obtain proper meter scale tracking as a function of signal level.

Audio Amplifier

The audio signal from R21 is buffered by emitter follower Q5. It is then applied to the output current amplifier made up of transistors Q6 and Q7 and their associated circuitry. Diodes CR4 and CR5 help stabilize the bias of the output stage, and resistors R30 and R31 provide series feedback to lower the signal distortion. The 700 Hz audio signal is output to speaker SP1 or to headphone jack JY2.

DC Power

Power for the detector unit is provided by six size "AA" penlight batteries. Four of the batteries supply the 6 volts to operate the circuitry. The other two cells provide the 3 volts used for operation of meter lamp DS2 and probe lamp DS1.

SECTION 5

PERFORMANCE VERIFICATION TESTS

5-1. INTRODUCTION

This section includes procedures for verifying the correct performance of the Eaton 3500 Shielded Enclosure Leak Detection System.

5-2. TEST EQUIPMENT REQUIRED

Table 5-1 lists the test equipment required for the Performance Verification Tests.

Table 5-1. Test Equipment Required

DESCRIPTION	MINIMUM OR CRITICAL PARAMETERS	RECOMMENDED MODEL
Oscilloscope	5 mV/div vertical sensitivity, 1 MHz bandwidth minimum, calibrated time base	Tektronix 5440/5A48
Signal Generator	106 kHz, -120 dBm	Hewlett Packard 606A

5-3. PERFORMANCE VERIFICATION—GENERATOR

The following procedure is used to verify the RF output level, the audio modulating frequency, and the RF frequency of the generator:

1. Connect a 1 ohm, 3-watt resistor across the generator output terminals as shown in Figure 5-1.
2. Apply AC power to the generator and allow 5 minutes warm-up time.

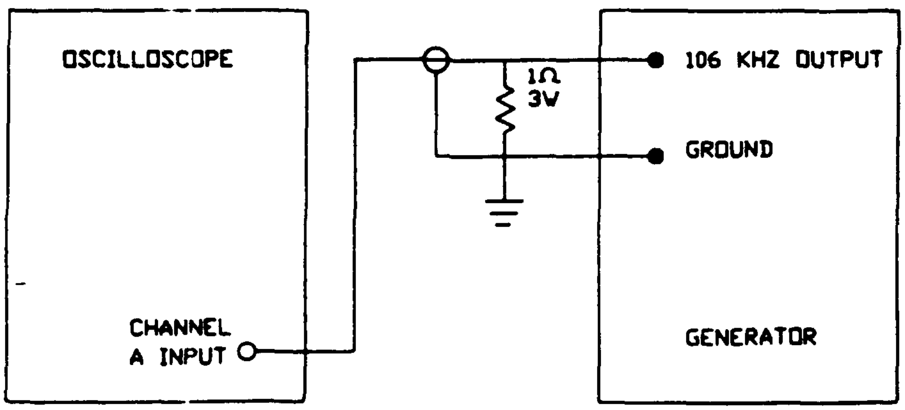


Figure 5-1. GENERATOR PERFORMANCE VERIFICATION TEST SETUP

3. Connect the oscilloscope probe across the 1-ohm resistor.

4. Set the oscilloscope vertical sensitivity to 0.5 volts per division. Set the time base for 0.5 milliseconds per horizontal division. Adjust the synchronization controls to obtain a stable display.

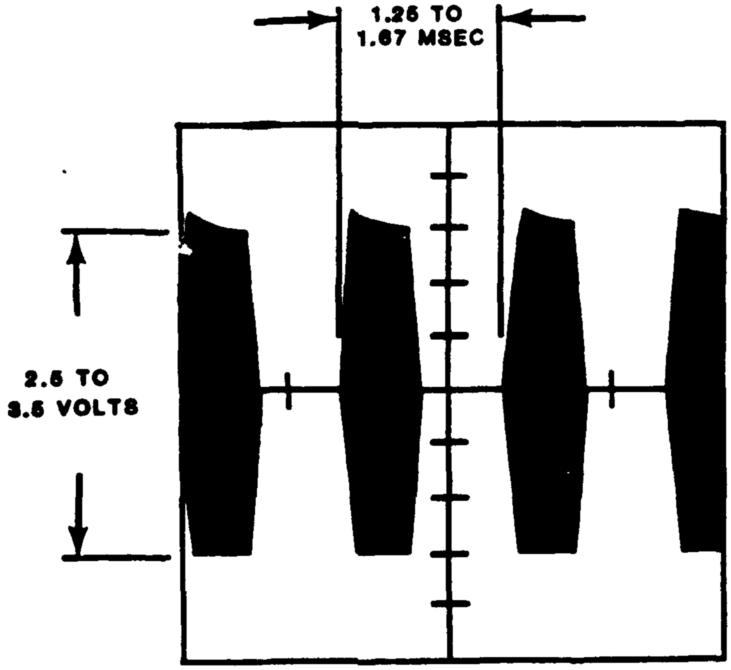


Figure 5-2. TYPICAL GENERATOR OUTPUT-OSCILLOSCOPE DISPLAY

5. The pattern displayed on the oscilloscope should be similar to the one in Figure 5-2. Verify that the peak-to-peak amplitude is approximately 3 volts, ± .5 volts (5 to 7 divisions), indicating an output current of approximately 1 ampere across 1 ohm.

6. Verify that the time period for one full modulation cycle is between 1.25 and 1.67 milliseconds (2.5 to 3.3 divisions), indicating a modulating frequency of 700 Hz ± 100 Hz.

7. Set the oscilloscope time base to 5 microseconds per division and adjust the synchronization controls to obtain a stable display of the RF output. Some jitter may be present due to the square wave modulation.

8. Verify that the time period for 5 cycles of the RF wave is between 46 and 48 microseconds (9.2 to 9.6 divisions), indicating an RF frequency of 106 kHz ± 2 kHz.

This concludes the procedure.

5-4. PERFORMANCE VERIFICATION – DETECTOR

The following procedure is used to verify the correct performance of the detector:

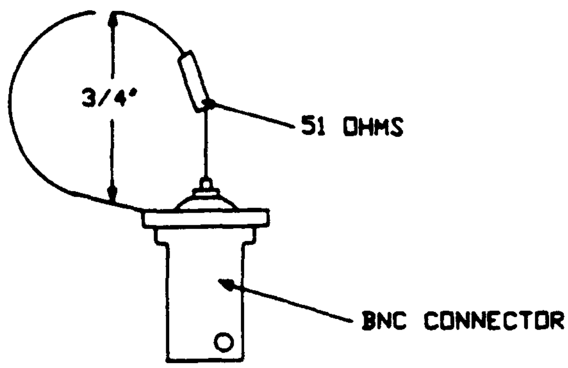


Figure 5-3. SIGNAL INJECTION LOOP

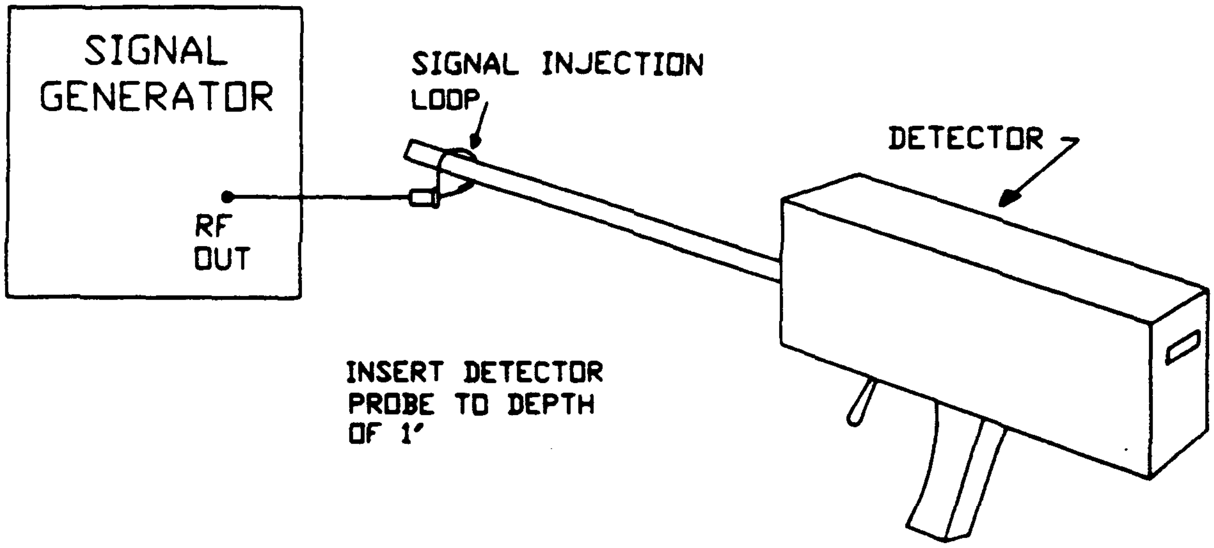


Figure 5-4. DETECTOR PERFORMANCE VERIFICATION TEST SETUP

1. Construct a signal injection loop as shown in Figure 5-3. The loop is made from a 51-ohm resistor soldered across the inner and outer conductors of a standard BNC-type connector. The resistor leads should be left long enough so that the finished loop has a diameter of approximately 3/4 of an inch.

2. Connect the test equipment as shown in Figure 5-4.

3. Apply a -30 dBm, 106 kHz test signal to the loop. The test signal should be modulated at 1 kHz with 80% modulation.

4. Couple the test signal to the detector probe by inserting the probe into the loop to a depth of 1 inch.

5. Set the ATTENUATOR SWITCH on the detector to the 60 dB position.

6. Energize the detector by holding the ACTUATING SWITCH and verify that the SIGNAL LEVEL METER indicates a reading between 15 and 25 dB.

7. Vary the signal generator RF frequency to obtain the maximum reading on the SIGNAL LEVEL METER. Verify that the maximum reading is obtained at a frequency of 106 kHz ± 2 kHz. Record the frequency.

8. Rotate the detector VOLUME CONTROL clockwise and verify that an audio modulation tone is heard from the speaker.

9. Note the level of the maximum reading obtained in Step 7. Increase the output level from the signal generator by 3 dB.

10. Remove the 1 kHz amplitude modulation from the signal generator. Then, adjust the output level from the signal generator to obtain an indication of 20 dB on the SIGNAL LEVEL METER. This is a reference level. Then increase the output level from the signal generator by 3 dB.

11. To check the detector bandwidth, increase the RF frequency of the signal generator until the SIGNAL LEVEL METER indication decreases by 3 dB, to the 20 dB reference level. Record the frequency at which this occurs.

12. To find the low frequency 3 dB band edge, decrease the RF frequency of the signal generator until the SIGNAL LEVEL METER indication peaks and then decreases again by 3 dB, to the 20 dB reference level. Record this frequency.

13. Verify that the difference between the RF frequencies recorded in Steps 11 and 12 is approximately 5 kHz ± 1 kHz. This is the 3 dB bandwidth of the detector unit.

This concludes the procedure.

SECTION 6

MAINTENANCE

6-1. INTRODUCTION

This section contains procedures for maintenance of the Eaton 3500 Shielded Enclosure Leak Detection System. The first part of this section covers calibration of the generator and detector units. The second part includes information for troubleshooting.

6-2. TEST EQUIPMENT REQUIRED

The test equipment listed in Table 6-1 is required for calibration and troubleshooting of the generator and detector units.

6-3. CALIBRATION – GENERATOR

The following procedure is used to calibrate the RF frequency and RF current output of the generator:

Table 6-1. Test Equipment Required for Calibration

DESCRIPTION	MINIMUM OR CRITICAL PARAMETERS	RECOMMENDED MODEL
Signal Generator	106 kHz, -120 dBm	Hewlett Packard Model 606A
Oscilloscope	5 mV/div vertical sensitivity, 1 MHz bandwidth minimum, calibrated time base	Tektronix 5440/5A48
Frequency Counter	106 kHz	Hewlett Packard Model 5314A
Wirewound Resistor	1 ohm, 1%, 3 watt	Dale type RS-2
Digital Voltmeter		Fluke Model 8010A

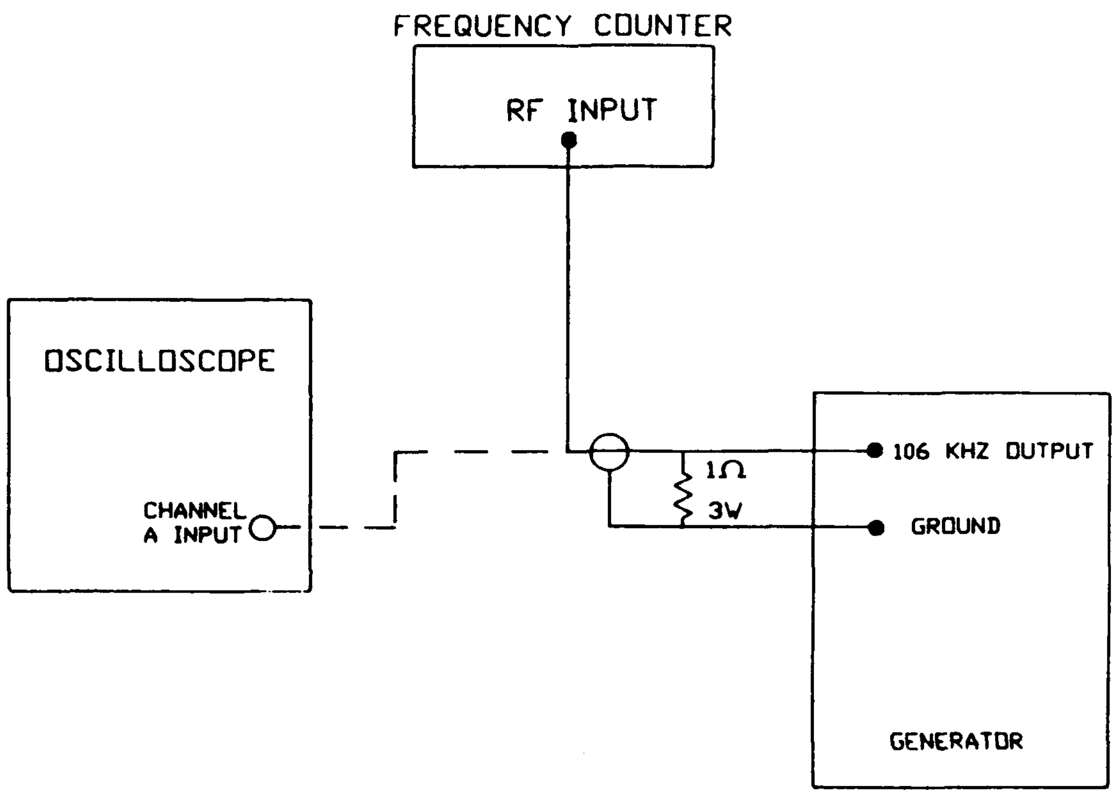


Figure 6-1. GENERATOR CALIBRATION SET-UP

1. Remove the six screws in the bottom of the transit case. Then remove the 12 cover screws which secure the Generator cover to its metal enclosure. The Generator can now be removed from its enclosure.
2. Connect a 1-ohm, 3-watt resistor across the generator output terminals as shown in Figure 6-1.
3. Apply AC power to the generator and allow 5 minutes warm-up time.

WARNING

High voltage is exposed at various components inside the generator. Care must be exercised to avoid possible injury.

4. Connect a test lead to short Test Point 1 to Ground. This will disable the modulation signal and provide a continuous wave 106 kHz RF output. Refer to Figure 6-2 for the location of components on the generator PC board.
5. Connect the frequency counter leads across the 1-ohm resistor.
6. Observe the frequency as indicated on the frequency counter. It should read approximately 106 kHz.

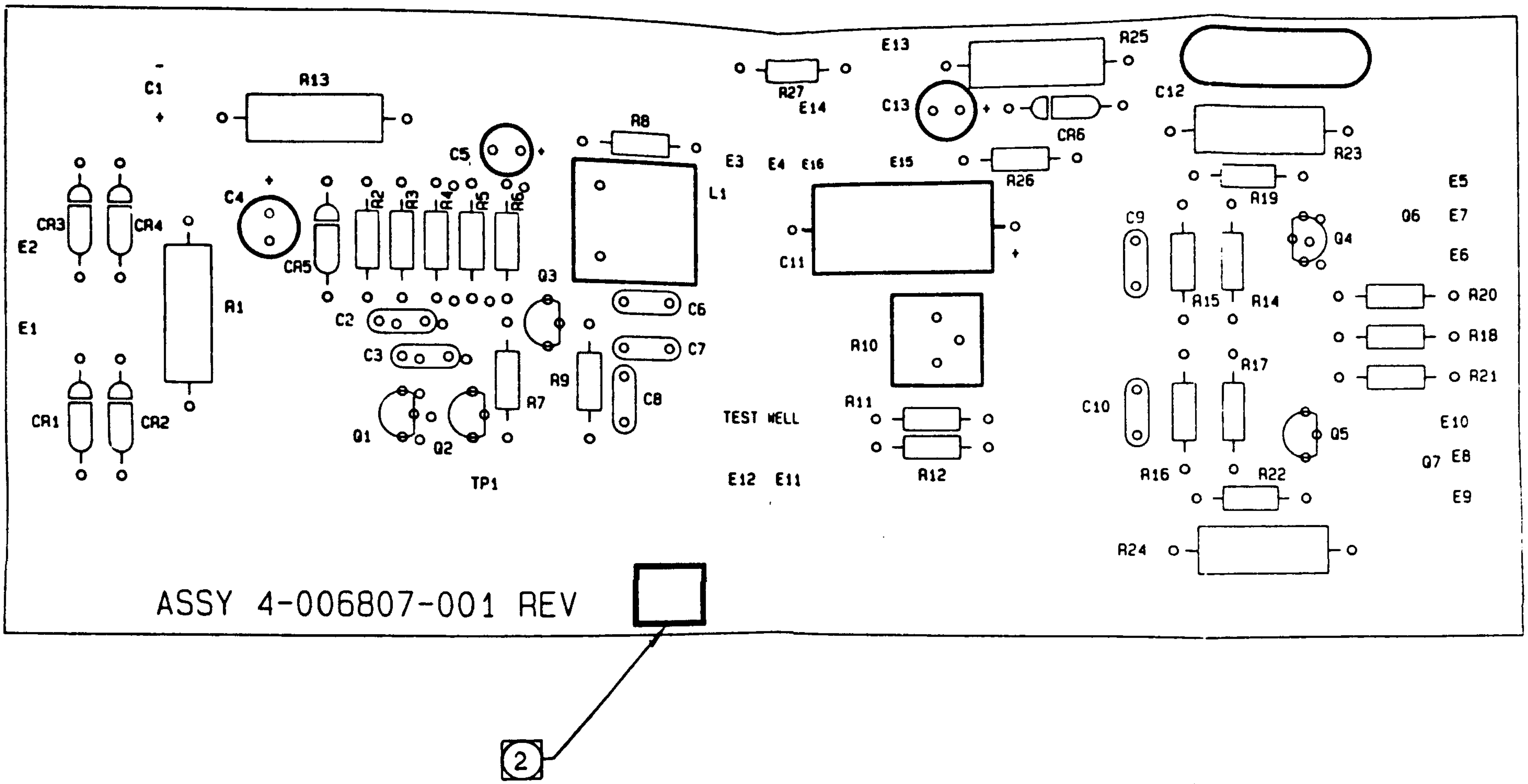


Figure 6-2. Generator Component Locations.

7. Adjust coil L1, the 106 kHz Frequency Adjust, to obtain an indication of 106 kHz, ± 0.1 kHz on the frequency counter.

8. Disconnect the frequency counter leads from the 1-ohm resistor and remove the shorting lead from between Test Point 1 and Ground.

9. Connect the oscilloscope probe across the 1-ohm resistor.

10. Adjust the oscilloscope vertical sensitivity to .5 volts per division. Adjust the time base and synchronization controls to obtain a relatively stable display. Some jitter may be present.

11. Adjust resistor R10, the RF current adjust to obtain a peak-to-peak value of 3 volts on the scope display. This is equivalent to a current of approximately 1 ampere RMS across the 1-ohm resistor.

12. Disconnect the test equipment and replace the generator in its transit case.

'his concludes the procedure.

6-4. CALIBRATION – DETECTOR

The following calibration procedure is used to adjust the RF tuning and trim the SIGNAL LEVEL METER in the detector:

1. Construct a signal injection loop as shown in Figure 5-3. The loop is made from a 51-ohm resistor soldered across the inner and outer conductors of a standard BNC-type connector. The resistor leads should be left long enough so that the finished loop has a diameter of approximately 3/4 of an inch.

2. Connect the test equipment as shown in Figure 5-4.

3. Apply a -30 dBm, 106 kHz test signal to the loop. The test signal should be modulated at 1 kHz with 80% modulation.

4. Couple the test signal to the detector probe by inserting the probe into the loop to a depth of 1 inch.

5. Set the ATTENUATOR SWITCH on the detector to the 60 dB position.

6. Energize the detector by holding the ACTUATING SWITCH and verify that the SIGNAL LEVEL METER indicates a reading between 15 and 25 dB.

7. Set the signal generator frequency to exactly 106 kHz.

8. Adjust inductors L2 and L3 to obtain a maximum reading on the SIGNAL LEVEL METER. Refer to Figure 6-3 for the location of components on the detector PC board.

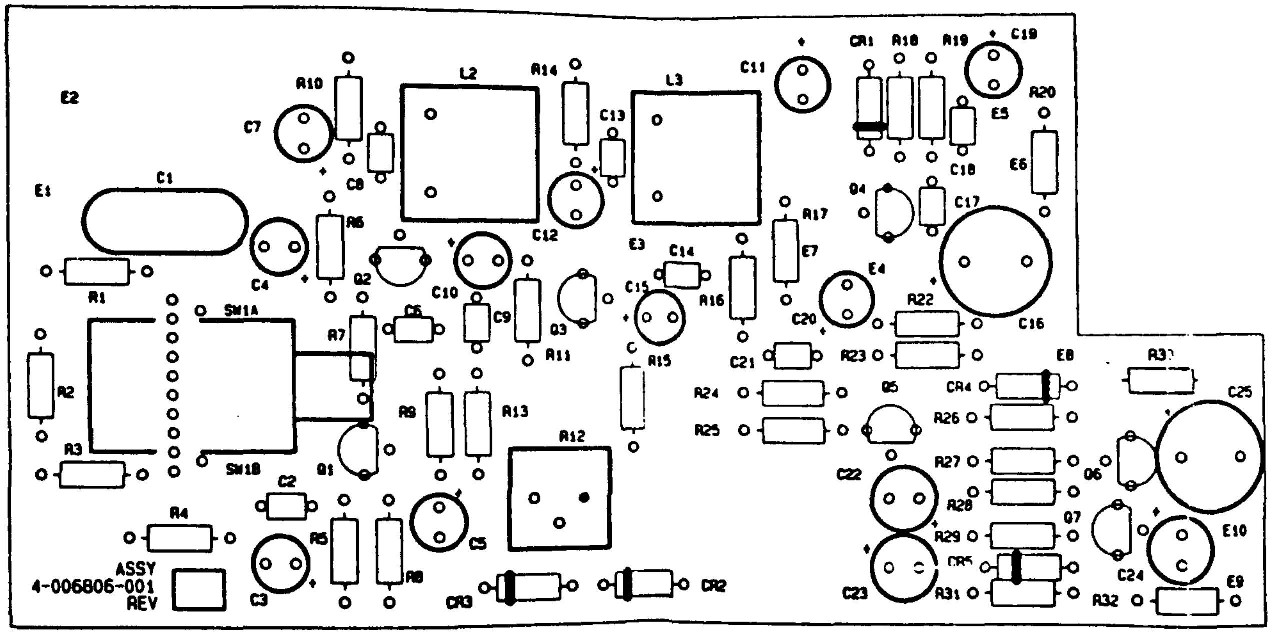


Figure 6-3. Detector Component Locations.

9. Adjust the signal generator level to obtain a reading of 20 dB on the detector SIGNAL LEVEL METER.

10. Increase the signal generator output level by 20 dB. Adjust resistor R12 to get a reading of 40 dB on the SIGNAL LEVEL METER.

11. Repeat Steps 9 and 10 as necessary until a 20 dB change at the signal generator causes a 20 dB change on the SIGNAL LEVEL METER.

12. Verify that a signal generator output level of -10 dBm, ± 5dBm, gives a reading of 40 dB on the detector meter.

13. Rotate the VOLUME CONTROL and verify that the 1 kHz audio tone is heard from the speaker.

Use the following steps to verify that the 3 dB bandwidth of the detector is approximately 5 kHz:

14. Remove the 1 kHz amplitude modulation from the signal generator. Then increase the RF frequency of the signal generator until the SIGNAL LEVEL METER indication decreases by 3 dB. Record the frequency of this high 3 dB band edge.

15. Decrease the RF frequency of the signal generator until the SIGNAL LEVEL METER indication peaks and then decreases again by 3 dB. Record the frequency of this low 3 dB band edge.

16. Verify that the difference between the RF frequencies recorded in Steps 14 and 15 is approximately 5 kHz. This is the 3 dB bandwidth of the detector unit.

This concludes the procedure.

6-5. SYSTEM TROUBLESHOOTING

Troubleshooting of the Eaton 3500 system is assisted by the use of the schematic diagrams in Figures 8-3 and 8-4, and the circuit descriptions in Section 4 of this manual. Refer to Table 6-1 for failure symptoms and their probable causes. Then use the information contained in the schematic diagrams and the circuit descriptions to locate and replace the failing component. After repair of the failing unit, use the Calibration Procedure described in Paragraphs 6-3 and 6-4, whichever applies, to calibrate the unit.

Test equipment required for troubleshooting is the same as that listed in Table 6-1.

Only qualified service personnel experienced in troubleshooting and maintenance of electronic instrumentation should attempt to repair a system failure.

WARNING

High voltage is exposed at various points inside the generator. Care must be exercised to avoid possible injury.

Table 6-2. Failure Symptoms and Remedies

GENERATOR:	
FAILURE SYMPTOM	REMEDY
POWER ON indicator does not light.	Verify that the unit is plugged into an energized AC source. Remove and check the fuse located in the AC POWER RECEPTACLE. Verify that the AC voltage selection card is positioned to select the correct AC voltage.
OUTPUT METER gives no indication of RF current output.	To obtain a meter indication of RF current output, the 106 kHz OUTPUT POST and the GROUND BINDING POST must be connected. They must be connected either through a load such as the output cables and a shielded enclosure, or they may be connected through a resistor, or they may be shorted together. Verify that the two posts are connected and check to see that the electrical connection is good. Perform the Confidence Test described in Paragraph 3-5. If the system passes the Confidence Test but there is still no meter indication, the failure is probably in the Constant Current Amplifier. Refer to Figure 8-3. If the system fails the Confidence Test, check the power supply output by verifying the presence of the +48 volts DC potential at the top of resistor R1. See Figure 8-3. If the +48 volt potential is present, connect an oscilloscope probe across Test Point 1 and Ground, and verify the presence of the 700 Hz sawtooth modulating wave. If the modulating wave is present, check for 106 kHz output from transistor Q3, the 106 kHz oscillator.

Table 6-2. Failure Symptoms and Remedies (Continued)

DETECTOR:	
Lamps do not light, but SIGNAL LEVEL METER operates normally.	Verify the presence of the +3 volt potential at the lamp sockets. Replace the batteries or the lamps if necessary.
No 700 Hz tone is heard from the speaker, but SIGNAL LEVEL METER operates normally.	Check the speaker wiring and the headset jack. Check transistors Q6 and Q7 in the audio amplifier output section. See Figure 8-4.
Meter gives no indication of detected signal.	Verify the presence of the +6 volt potential from the batteries. Replace the batteries if necessary. Follow Steps 1 through 7 described in Paragraph 6-4 to input a 106 kHz test signal to the detector, except set the ATTENUATOR SWITCH to 0 dB. Check the collectors of transistors Q1, Q2 and Q3 for the 106 kHz output signal.

SECTION 7

REPLACEABLE PARTS LIST

7-1. INTRODUCTION

This section contains the replaceable parts list for the Eaton 3500 Shielded Enclosure Leak Detection System. The parts list contains the reference designator, Eaton Part number, description, manufacturer's code, and manufacturer's part number.

7-2. LIST OF MAJOR COMPONENTS

Table 1-1 of Section 1 provides a list of major components of the Eaton 3500 system. The table gives the description and Eaton part number for each component.

7-3. REPLACEABLE PARTS LIST

Table 7-1 provides a list of replaceable parts for the generator. Table 7-2 provides a list of replaceable parts for the detector. To order any part for the generator, preface the part designator with A1A1. For example, the full designator for resistor R1 in the generator is A1A1R1.

To order any part for the detector, preface the designator with A1A2. For example, when ordering capacitor C1, the complete designator is A1A2C1.

7-4. SPARES

The following items should be kept on hand to provide a minimum stock of replacement parts:

DESIGNATOR	DESCRIPTION	EATON PART NUMBER
A1A1F1	FUSE, SLO BLO, 3 AG 0.5 amps, 250V	924000-014
A1A2DS1	LAMP, INCANDESCENT, 3V	925036-001
A1A2BT1	BATTERY, ALKALINE Type "AA"	905005-001

Table 7-1. Replaceable Parts List for Generator

Note: Preface all generator parts with the designator A1A1 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg Code	Mfr. Part Number
C1	900102-043	CAPACITOR, ELECTROLYTIC 2500 μF, 75 VDC	56289	36D252F075AC2A
C2	900122-045	CAPACITOR, CERAMIC .047 μF, 10%, 50 VDC	IND STD	CK05BX473K
C3	900122-045	CAPACITOR, CERAMIC .047 μF, 10%, 50 VDC	IND STD	CK05BX473K
C4	900115-007	CAPACITOR, TANTALUM 10 μF, 20%, 20 VDC	56289	196D106X0020JA1
C5	900115-003	CAPACITOR, TANTALUM 1 μF, 20%, 50 VDC	56289	196D105X0050HA1
C6	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C7	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C8	900122-049	CAPACITOR, CERAMIC .1 μF, 10%, 50 VDC	IND STD	CK05BX104K
C9	900122-049	CAPACITOR, CERAMIC .1 μF, 10%, 50 VDC	IND STD	CK05BX104K
C10	900122-049	CAPACITOR, CERAMIC .1 μF, 10%, 50 VDC	IND STD	CK05BX104K
C11	900085-158	CAPACITOR, ELECTROLYTIC 10 μF, 100 VDC	56289	500D106F100DC
C12	900001-115	CAPACITOR, PLASTIC .15 μF, 10%, 250 VDC	80031	C280AE/A150KSR
CR1	913001-002	DIODE, RECTIFIER IN4002	04713	IN4002
CR2	913001-002	DIODE, RECTIFIER IN4002	04713	IN4002

Table 7-1. Replaceable Parts List for Generator (Continued)

Note: Preface all generator parts with the designator A1A1 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
CR3	913001-002	DIODE, RECTIFIER 1N4002	04713	1N4002
CR4	913001-002	DIODE, RECTIFIER IN4002	04713	1N4002
CR5	913020-017	DIODE, ZENER 15V, 1 W	04713	IN4744
CR6	913007-002	DIODE, SIGNAL Vr=75V, I_f=10 ma	IND STD	IN4148
DS1	925035-001	LAMP, NEON, 115 VAC	LEE CRAFT	32-2311
F1	924000-014	FUSE, SLO BLO, 3AG 0.5 A, 250V	75915	313.500
J1	941001-001	BINDING POST, RED	58474	DF31RC
J2	941001-002	BINDING POST, BLACK	58474	DF31BC
L1	906066-006	INDUCTOR, VARIABLE 470 μHy	76493	9057
M1	937014-001	METER PANEL 500 μA	32171	1SDVA-500
Q1	958000-001	TRANSISTOR, NPN 2N3904	04713	2N3904
Q2	958000-001	TRANSISTOR, NPN 2N3904	04713	2N3904
Q3	958000-001	TRANSISTOR, NPN 2N3904	04713	2N3904
Q4	958000-002	TRANSISTOR, NPN 2N3906	04713	2N3906
Q5	958000-001	TRANSISTOR, NPN 2N3904	04713	2N3904

Table 7-1. Replaceable Parts List for Generator (Continued)

Note: Preface all generator parts with the designator A1A1 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
Q6	958115-001	TRANSISTOR, NPN MJE2955	04713	MJE2955
Q7	958116-001	TRANSISTOR, NPN MJE3055	04713	MJE3055
R1	945002-186	RESISTOR, COMPOSITION 10K, 5%, 1 W	01121	GB1035
R2	945000-198	RESISTOR, COMPOSITION 33K, 5%, 1/4 W	01121	CB3335
R3	945000-178	RESISTOR, COMPOSITION 4.7K, 5%, 1/4 W	01121	CB4725
R4	945000-198	RESISTOR, COMPOSITION 33K, 5%, 1/4 W	01121	CB3335
R5	945000-178	RESISTOR, COMPOSITION 4.7K, 5%, 1/4 W	01121	CB4725
R6	945000-178	RESISTOR, COMPOSITION 4.7K, 5%, 1/4 W	01121	CB4725
R7	945000-178	RESISTOR, COMPOSITION 4.7K, 5%, 1/4 W	01121	CB4725
R8	945000-138	RESISTOR, COMPOSITION 100 OHMS, 5%, 1/4 W	01121	CB1015
R9	945000-162	RESISTOR, COMPOSITION 1K, 5%, 1/4 W	01121	CB1025
R10	945162-007	RESISTOR, VARIABLE, CERMET 1K, 20%, 1/2 W	01121	E2A102
R11	945000-138	RESISTOR, COMPOSITION 100 OHMS, 5%, 1/4 W	01121	CB1015
R12	945000-150	RESISTOR, COMPOSITION 330 OHMS, 5%, 1/4 W	01121	CB3315
R13	945002-170	RESISTOR, COMPOSITION 2.2K, 5%, 1 W	01121	CB2225

Table 7-1. Replaceable Parts List for Generator (Continued)

Note: Preface all generator parts with the designator A1A1 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
R14	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB2225
R15	945000-198	RESISTOR, COMPOSITION 33K, 5%, 1/4 W	01121	CB3335
R16	945000-198	RESISTOR, COMPOSITION 33K, 5%, 1/4 W	01121	CB3335
R17	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB2225
R18	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB2225
R19	945000-146	RESISTOR, COMPOSITION 220 OHMS, 5%, 1/4 W	01121	CB2215
R20	945000-146	RESISTOR, COMPOSITION 220 OHMS, 5%, 1/4 W	01121	CB2215
R21	945000-146	RESISTOR, COMPOSITION 220 OHMS, 5%, 1/4 W	01121	CB2215
R22	945000-146	RESISTOR, COMPOSITION 220 OHMS, 5%, 1/4 W	01121	CB2215
R23	945079-005	RESISTOR, WIREWOUND 2 OHMS, 1%, 3 W	91637	RS-2B
R24	945079-005	RESISTOR, WIREWOUND 2 OHMS, 1%, 3 W	91637	RS-2B
R25	945079-001	RESISTOR, WIREWOUND 1 OHM, 1%, 3 W	91637	RS-2A
R26	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB2225
R27	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	EB2225

Table 7-2. Replaceable Parts List for Detector

Note: Preface all detector parts with the designator A1A2 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg Code	Mfr. Part Number
S1	951089-001	SWITCH, TOGGLE	95691	83054
S2	951085-001	SWITCH, PUSHBUTTON	27193	8411K8
T1	954025-001	TRANSFORMER, POWER 35V, 1.5 A	81095	F-354X
BT1	905005-001	BATTERY ALKALINE TYPE "AA"	EVEREADY	E91
BT2	905005-001	BATTERY ALKALINE	EVEREADY	E91
BT3	905005-001	BATTERY ALKALINE	EVEREADY	E91
BT4	905005-001	BATTERY ALKALINE	EVEREADY	E91
BT5	905005-001	BATTERY ALKALINE	EVEREADY	E91
BT6	905005-001	BATTERY ALKALINE	EVEREADY	E91
C1	900004-028	CAPACITOR, MICA 4700 pF, 5%, 500 VDC	84171	DM19FD472J
C2	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK02BX103K
C3	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C4	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C5	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C6	900122-037	CAPACITOR, CERAMIC 0.1 μF, 10%, 100 VDC	IND STD	CK05BX103K
C7	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1

Table 7-2. Replaceable Parts List for Detector (Continued)

Note: Preface all detector parts with the designator A1A2 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
C8	900122-033	CAPACITOR, CERAMIC .0047 μF, 10%, 100 VDC	IND STD	CK05BX472K
C9	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C10	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C11	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C12	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C13	900122-003	CAPACITOR, CERAMIC .0047 μF, 10%, 100 VDC	IND STD	CK05BX472K
C14	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C15	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C16	900115-012	CAPACITOR, TANTALUM 100 μF, 20%, 20 VDC	56289	196D107X0020TE4
C17	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C18	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C19	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C20	900115-003	CAPACITOR, TANTALUM 1.0 μF, 20%, 50 VDC	56289	196D105X0050HA1
C21	900122-037	CAPACITOR, CERAMIC .01 μF, 10%, 100 VDC	IND STD	CK05BX103K
C22	900115-006	CAPACITOR, TANTALUM 22 μF, 20%, 15 VDC	56289	196D226X0015KA1

Table 7-2. Replaceable Parts List for Detector (Continued)

Note: Preface all detector parts with the designator A1A2 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg Code	Mfr. Part Number
C23	900115-006	CAPACITOR, TANTALUM 22 µF, 20%, 15 VDC	56289	196D226X0050KA1
C24	900115-006	CAPACITOR, TANTALUM 22 µF, 20% 15 VDC	56289	196D226X0050KA1
C25	900115-012	CAPACITOR, TANTALUM 100 µF, 20%, 20 VDC	56289	195D107X0020TE4
CR1	913007-002	DIODE, SIGNAL, 1N4148	IND STD	1N4148
CR2	913007-002	DIODE, SIGNAL, 1N4148	IND STD	1N4148
CR3	913007-002	DIODE, SIGNAL, 1N4148	IND STD	1N4148
CR4	913007-002	DIODE, SIGNAL, 1N4148	IND STD	1N4148
CR5	913007-002	DIODE, SIGNAL, 1N4148	IND STD	1N4148
DS1	925036-001	LAMP, INCANDESCENT, 3V	IND STD	#222
J1	910471-001	CONNECTOR, COAX, TNC	11636	KA-79-27
J2	910077-001	CONNECTOR, PHONE JACK	92389	L112A
L1	3-006816-001	INDUCTOR ASSY, PROBE 475 µH, NOMINAL	88869	3-006-816-001
L2	906066-006	INDUCTOR, VARIABLE 470 µH, NOMINAL	76493	9057
L3	906066-006	INDUCTOR, VARIABLE 470 µH, NOMINAL	76493	9057
M1	404781-001	METER, SIGNAL LEVEL 500 µA	88869	
Q1	958000-001	TRANSISTOR, NPN	04713	2N3904
Q2	958000-001	TRANSISTOR, NPN	04713	2N3904
Q3	958000-001	TRANSISTOR, NPN	04713	2N3904

Table 7-2. Replaceable Parts List for Detector (Continued)

Note: Preface all detector parts with the designator A1A2 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
Q4	958000-002	TRANSISTOR, PNP	04713	2N3906
Q5	958000-001	TRANSISTOR, NPN	04713	2N3904
Q6	958000-002	TRANSISTOR, PNP	04713	2N3906
Q7	958000-001	TRANSISTOR, NPN	04713	2N3904
R1	945000-173	RESISTOR, COMPOSITION 3K, 5%, 1/4 W	01121	CB 3025
R2	945000-150	RESISTOR, COMPOSITION 330 OHMS, 5%, 1/4 W	01121	CB 3315
R3	945000-125	RESISTOR, COMPOSITION 30 OHMS, 5%, 1/4 W	01121	CB 3005
R4	945000-102	RESISTOR, COMPOSITION 3.3 OHMS, 5%, 1/4 W	01121	CB 3R35
R5	945000-186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R6	945000-154	RESISTOR, COMPOSITION 470 OHMS, 5%, 1/4 W	01121	CB 4715
R7	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB 2225
R8	945000-154	RESISTOR, COMPOSITION 470 OHMS, 5%, 1/4 W	01121	CB 4715
R9	945000-186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R10	945000-154	RESISTOR, COMPOSITION 470 OHMS, 5%, 1/4 W	01121	CB 4715
R11	945000-154	RESISTOR, COMPOSITION 470 OHMS, 5%, 1/4 W	01121	CB 4715
R12	945162-007	RESISTOR, VARIABLE, DERMET 1K, 20%, 1/2 W	01121	E2A102

Table 7-2. Replaceable Parts List for Detector (Continued)

Note: Preface all detector parts with the designator A1A2 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
R13	945000-186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R14	945000-154	RESISTOR, COMPOSITION 470 OHMS, 5%, 1/4 W	01121	CB 4715
R15	945000-146	RESISTOR, COMPOSITION 220 OHMS, 5%, 1/4 W	01121	CB 2215
R16	945000-198	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R17	945000-198	RESISTOR, COMPOSITION 33K, 5%, 1/4 W	01121	CB 3335
R18	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB 2225
R19	94500-154	RESISTOR, COMPOSITION 470 OHMS, 5%, 1/4 W	01121	CB 4715
R20	945000-114	RESISTOR, COMPOSITION 10 OHMS, 5%, 1/4 W	01121	CB 1005
R21	945176-003	RESISTOR, VARIABLE, CERMET 10K, 10%, 1 W	01121	70UIG040R103V
R22	945000-178	RESISTOR, COMPOSITION 4.7K, 5%, 1/4 W	01121	CB 4725
R23	945000-186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R24	945000-186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R25	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB 2225
R26	945000-162	RESISTOR, COMPOSITION 1K, 5%, 1/4 W	01121	CB 1025
R27	945000-186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035

Table 7-2. Replaceable Parts List for Detector (Continued)

Note: Preface all detector parts with the designator A1A2 to obtain the complete designator.

Reference Designator	Eaton Part Number	Description	Mfg. Code	Mfr. Part Number
R28	945000 186	RESISTOR, COMPOSITION 10K, 5%, 1/4 W	01121	CB 1035
R29	945000 162	RESISTOR, COMPOSITION 1K, 5%, 1/4 W	01121	CB 1025
R30	945000-114	RESISTOR, COMPOSITION 10 OHMS, 5%, 1/4 W	01121	CB 1005
R31	945000-114	RESISTOR, COMPOSITION 10 OHMS, 5%, 1/4 W	01121	CB 1005
R32	945000-170	RESISTOR, COMPOSITION 2.2K, 5%, 1/4 W	01121	CB 2225
S1	951986-001	SWITCH, ROTARY 2 POLE, 4 POSITION	81073	71AF36-01-2-4-N
S2	951084-001	SWITCH, TOGGLE, DPST MOMENTARY		
S3	951036-001	SWITCH, TOGGLE, SPDT	09353	7101 S YZQ
SP1	936000-002	SPEAKER, PM, 100 OHMS	QUAM	22A 05Z100

SECTION 8

SCHEMATICS

8-1. INTRODUCTION

This section contains block diagrams and schematics for the generator and detector assemblies. Component location diagrams are located on the apron of each schematic.

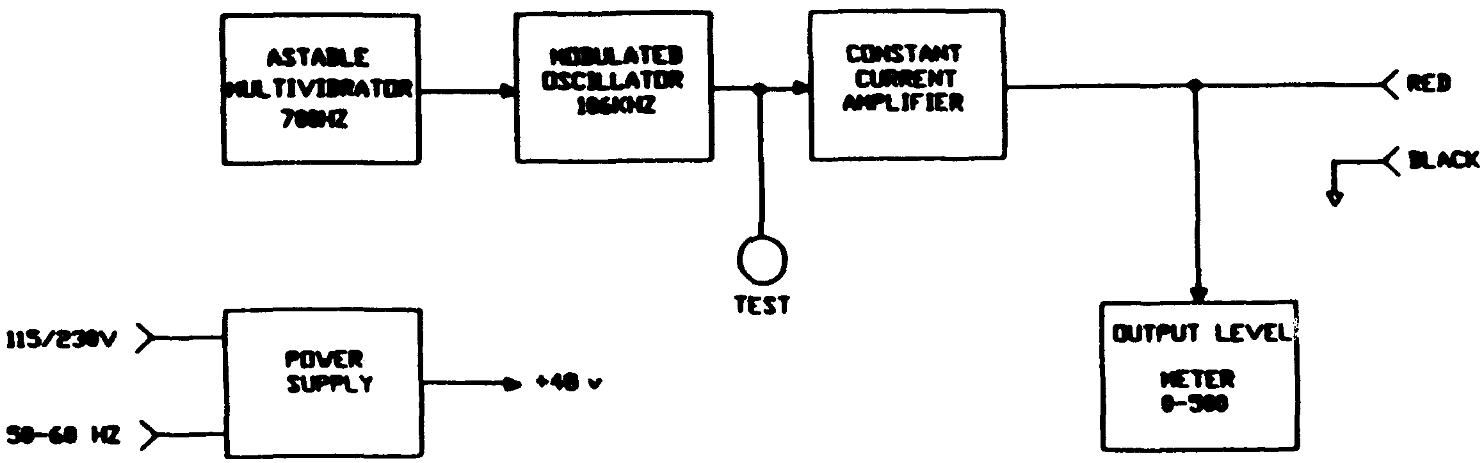


Figure 8-1. GENERATOR UNIT BLOCK DIAGRAM

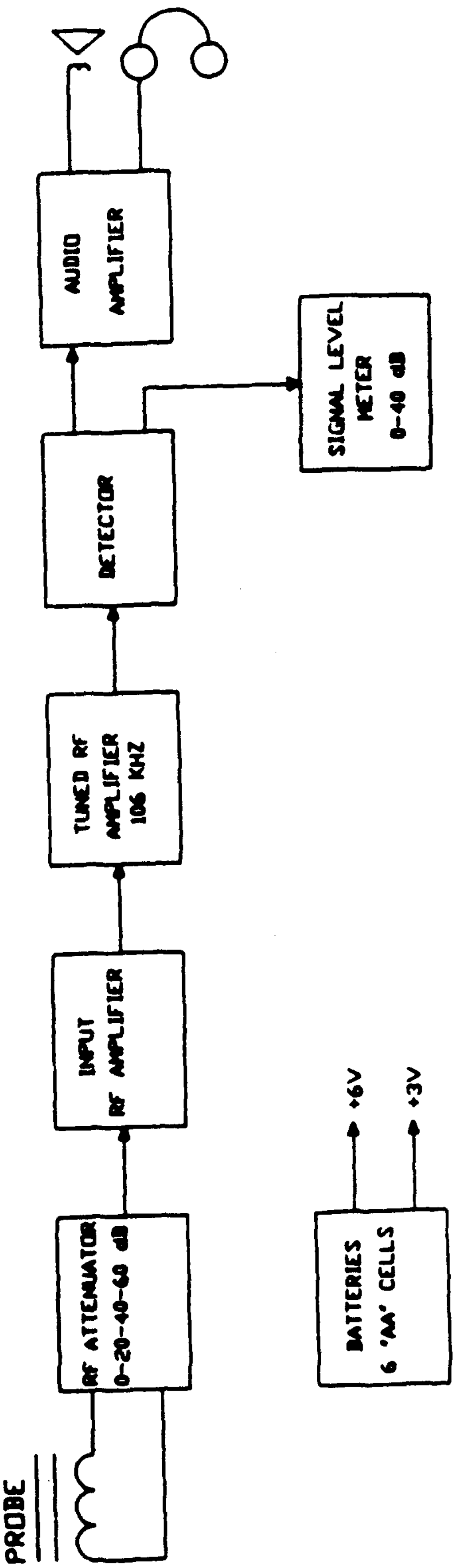


Figure 8-2. DETECTOR UNIT BLOCK DIAGRAM

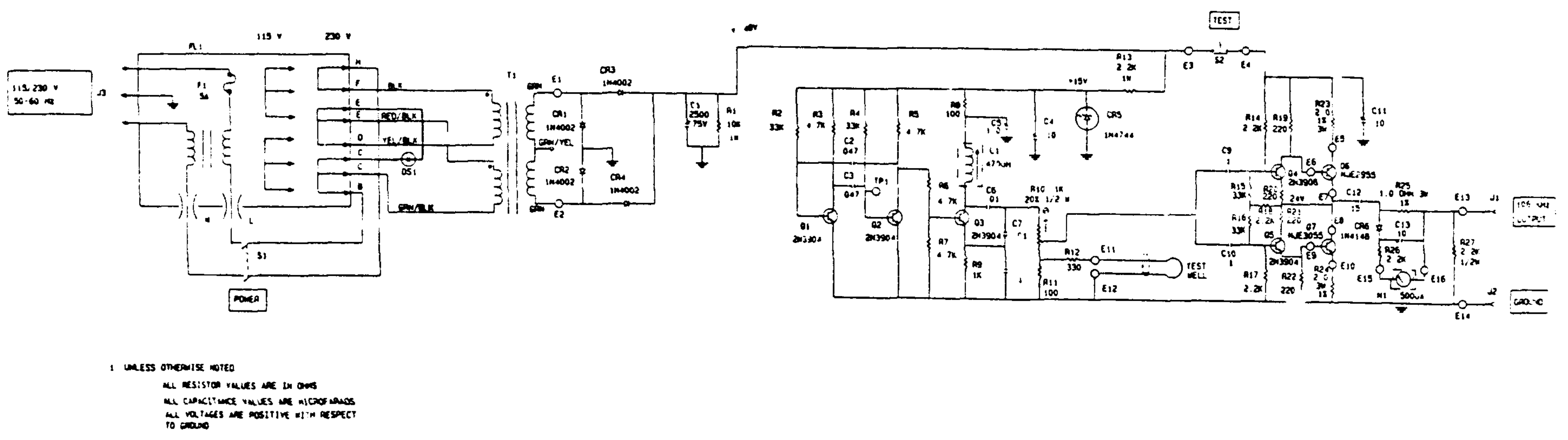


Figure 8-3. Generator Schematic Diagram.

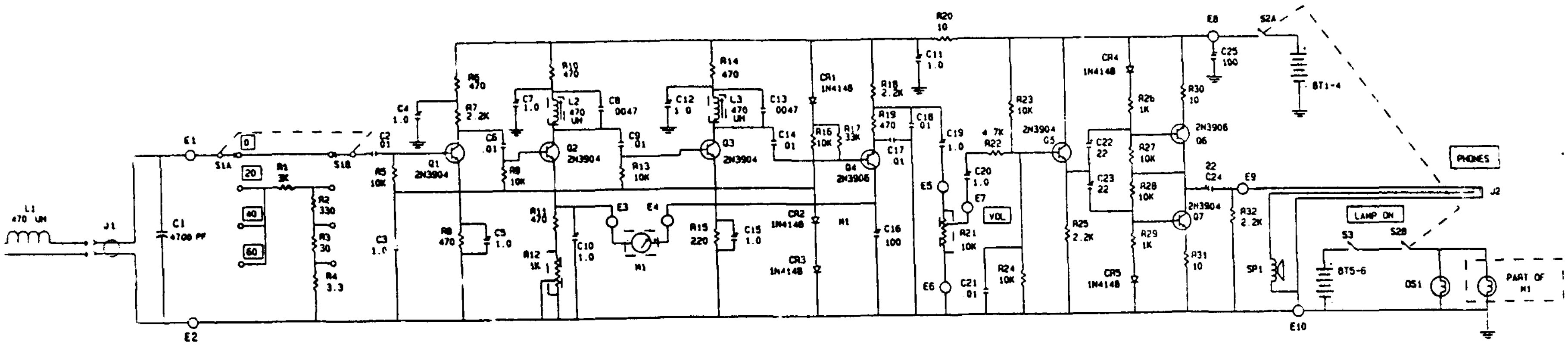


Figure 8-4. Detector Schematic Diagram.

8-6/8-7

APPENDIX B

MIL-STD-285 TEST DATA

SYSTEM	REFERENCE			DATE 10/24/90	
3577A	NOISE		dBm	FREQUENCY	
	CALIBRATION	Normalized	dBm	106 K	Hz
	SEPARATION	24	inches	Wellems 2	RCl
				Wellems 2	XM

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V		32
2	V		48
3	V		21
4	V		48
5	V		59
6	H		48
7	V		49
8	V		56
9	V		52
10	V		56
11	V		51
12	V		53
13	H		57
14	V		54
15	V		59
16	V		53
17	V		61
18	H		58
19	V		57
20	V		55
21	V		55
22	V		56
23	V		46
24	H		46

COMMENTS: ____________________

SYSTEM	REFERENCE			DATE 10/24/90	
3577A	NOISE		dBm	FREQUENCY	
	CALIBRATION	Normalized	dBm	106 K	Hz
	SEPARATION	24	inches	Wellems 2	RCI
			Ant2	Wellems 2	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	V		38
26	V		53
F1	V		42
F4	V		47
F5	V		38
F1	H		51
F4	H		46
F5	H		49

COMMENTS: ______________________

SYSTEM	REFERENCE			DATE 7/11/90	
HP 8566B S/A	NOISE	-137	dBm	FREQUENCY	
Wavetek 166 F/G	CALIBRATION	-37	dBm	10 K	Hz
	SEPARATION	25	inches	Wellems 1	RCl
			Ant2	Wellems 1	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	VCP	72	
2	VCP	87	
3	VCP	65	
4	VCP	84	
5	VCP .38 outer	84	
6	HCP .38 outer	84	
7	VCP .38 outer diagcorner	95	
8	VCP .38 outer	89	
9	VCP .38 outer	91	
10	VCP .38 outer	93	
11	VCP .38 inner	91	
12	VCP .38 outer	92	
13	HCP .38 outer	93	
14	VCP .38 outer	92	
15	VCP .38 outer	89	
16	VCP .38 outer	90	
17	VCP .38 outer	104	
18	HCP .38 outer	91	
19	VCP .38 outer	89	
20	VCP .38 outer	95	
21	VCP .38 outer	90	
22	VCP .38 inner	94	
23	VCP .38 outer	91	
24	HCP .38 outer	87	

COMMENTS: VCP = Vertical Coplaner; HCP = Horizontal Coplaner Wellem 1 = L Floops .38 outer = out position measurement .38 x 12" Distant from bisectecte angle .38 inner (same but inside) source on inside of shelter.

SYSTEM	REFERENCE			DATE 7/11/90	
HP 85663 S/A	NOISE	-137	dBm	FREQUENCY	
WAVETEK 166 F/G	CALIBRATION	-37	dBm	10 K	Hz
	SEPARATION	25	inches	Wellems 1	RCl
			Ant2	Wellems 1	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	VCP .38 outer	102	
26	VCP .38 outer	80	
F1	HCP VCP CA	68 68 65	
F4	HCP VCP CA	68 70 61	
F5	HCP VCP CA	66 68 62	
C1	Rear Upper	93	
C2	Side Upper	91	
C3	Edge	93	
C	3K Average	105	

COMMENTS: C 1, 2, 3 are measured in accordance with ASTM Techniques. CA = CoAxial (inplane of test surface) additional cal data is included with each CA testpoint.

SYSTEM	REFERENCE			DATE 7/18/90	
HP 8566B 3/A	NOISE	-120	dBm	FREQUENCY	
HP 8447A Amp	CALIBRATION	-13 cp -8 ca	dBm	150 K	Hz
Wavetek 166	SEPARATION	25	inches	Wellems 2	RCl
			Ant2	Schafer 1	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	HCP VCP	72 61	59 48
2	HCP VCP	74 76	61 63
3	VCP	65	52
4	HCP VCP	73 75	60 62
5	VCP .38 outer	75	62
6	HCP .38 outer	99	86
7	VCP .38 outer	93	80
8	VCP .38 outer	96	83
9	VCP .38 outer	93	80
10	VCP .38 outer	87	74
11	VCP .38 inner	98	85
12	VCP .38 outer	91	78
13	HCP .38 outer	88	75
14	VCP .38 outer	86	73
15	VCP .38 outer	91	78
16	VCP .38 outer	90	77
17	VCP .38 outer	86	73
18	VCP .38 outer	88	75
19	VCP .38 outer	87	74
20	VCP .38 outer	90	77
21	VCP .38 outer	90	77
22	VCP .38 inner	98	85
23	VCP .38 outer	90	77
24	HCP .38 outer	88	75

COMMENTS: Brass strip loop with additional #10 wire loops (Schafer 1).

SYSTEM	REFERENCE			DATE 7/18/90	
HP 3566B S/A	NOISE	-120	dBm	FREQUENCY	
HP 8447A Amp	CALIBRATION	-13 cp -8 ca	dBm	150 K	Hz
Wavetek 166	SEPARATION	25	inches	Wellems 2	RCUR
			Ant2	Schafer 1	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	VCP outer	90	77
26	VCP outer	75	62
F1	HCP VCP CA	68 61 68	55 48 60
F4	HCP VCP CA	68 67 68	55 54 60
F5	HCP VCP CA	74 51 61	61 38 53
C1	Rear Upper	91	
C2	Side Upper	95	
C3	Edge	92	
C	Bisetors - 3	93	

COMMENTS:

SYSTEM	REFERENCE			DATE 7/13/90	
HP 8566B S/A	NOISE	-130-5	dBm	FREQUENCY	
Wavetek 166 F/G	CALIBRATION	-30	dBm	1M	Hz
	SEPARATION	25	inches	Wellems 2	RCl
			Ant2	Wellems 2	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	VCP HCP	93 123	
2	VCP HCP	120 102	
3	VCP	93	
4	VCP HCP	117 108	
5	VCP .38 outer	114	
6	HCP .38 outer	122	
7	VCP .38 outer	113	
8	VCP .38 outer	125	
9	VCP .38 outer	115	
10	VCP .38 outer	133	
11	VCP .38 inner	133	
12	VCP .38 outer	134	
13	HCP .38 outer	133	
14	VCP .38 outer	133	
15	VCP .38 outer	133	
16	VCP .38 outer	133	
17	VCP .38 outer	133	
18	HCP .38 inner	133	
19	VCP .38 outer	133	
20	VCP .38 outer	133	
21	VCP .38 outer	124	
22	VCP .38 inner	133	
23	VCP .38 outer	118	
24	HCP .38 outer	122	

COMMENTS: Wellems 2 = HF Loops; Bad cable data Redone using HP 3577A.

SYSTEM	REFERENCE			DATE 7/13/90	
HI'8566B S/A	NOISE	-130-5	dBm	FREQUENCY	
Wa' etek 166 F/G	CALIBRATION	-30	dBm	1M	Hz
	SEPARATION	25	inches	Wellems 2	RCUR
			Ant2	Wellems 2	XMTR
			Ant2		

T :ST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	VCP	115	
26	VCP	115	
C1	RU	93	
C2	SU	99	
C3	E	84	
C	Corner Bisector	92	
F1	VCP HCP CA	8ℓ 95 78	
F4	VCP HCP CA	9(96 80	
F5	VCP HCP CA	75 109 89	

COMMENTS: CA Calibration level was -21 dBm.

SYSTEM	REFERENCE			DATE 10/24/90	
3577A	NOISE		dBm	FREQL ENCY	
	CALIBRATION	Normalized	dBm	1M	Hz
	SEPARATION	24	inches	Wellems 2	RCl
			Ant2	Wellems 2	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V		43
2	V		59
3	V		33
4	V		64
5	V		61
6	H		67
7	V		63
8	V		75
9	V		66
10	V		76
11	V		69
12	V		70
13	H		106
14	V		78
15	V		77
16	V		88
17	V		71
18	H		77
19	V		79
20	V		75
21	V		70
22	V		84
23	V		58
24	H		61

COMMENTS:

SYSTEM	REFERENCE			DATE 10/24/90	
3577A	NOISE		dBm	FREQUENCY	
	CALIBRATION	Normalized	dBm	1M	Hz
	SEPARATION	24	inches	Wellems 2	RCl
			Ant2	Wellems 2	XM
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	V		49
26	V		64
F1	V		51
F4	V		54
F5	V		39
F1	H		54
F4	H		54
F5	H		53

COMMENTS:

SYSTEM	REFERENCE			DATE 7/19/90	
HP 8566B S/A	NOISE	-120	dBm	FREQUENCY	
HP 8447A Amp	CALIBRATION	-21 cp -23 ca	dBm	10M	Hz
Wavetek 166 S/O	SEPARATION	25	inches	Schafer 2	RCUR
			Ant2	Schafer 2	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	VCP outer	106	
2	VCP outer	104	
3	VCP outer	89	
4	VCP outer	107	
5	VCP outer	109	
6	HCP outer	104	
7	VCP outer	97	
8	VCP outer	103	
9	VCP outer	102	
10	VCP outer	110	
11	VCP inner	110	
12	VCP outer	120	
13	HCP outer	111	
14	VCP outer	99	
15	VCP outer	108	
16	VCP outer	113	
17	VCP outer	112	
18	HCP outer	110	
19	VCP outer	111	
20	VCP outer	120	
21	VCP outer	104	
22	VCP inner	108	
23	VCP outer	101	
24	HCP outer	116	

COMMENTS: Schafer 2 - multiturn #10 - unshielded.

SYSTEM	REFERENCE			DATE 7/19/90	
HP 8566B S/A	NOISE	-120	dBm	FREQUENCY	
HP 8447A Amp	CALIBRATION	-21 CP -23 CA	dBm	10 M	Hz
Wavetek 166 S/O	SEPARATION	25	inches	Schafer 2	RCUR
			Ant2	Schafer 1	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	VCP outer	101	
26	VCP outer	100	
F1	HCP VCP CA	100 88 75	
F4	HCP VCP CA	88 96 78	
F5	HCP VCP CA	100 70 80	
C1	Rear Top	110	
C2	Side Top	110	
C3	Edge	108	
C	Multi angle	110	

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-10	dBm	400 M	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H V	54 45	
2	H V	60 42	
3	H V	67 45	
4	H V	60 44	
5	H V	67 51	
6	H H V	74F 67S 55	
7	H H V	62F 54S 49	
8	H V	54 62	
9	H V	71 70	
10	H V	65 60	
11	H (antenna 6" above ground)	57	
12	H V	59 70	
13	H H V	57S 66R 70	
14	H H V	68S 76R 74	
15	H V	70 75	
16	H V	66 65	
17	H H V	69R 57S 71	
18	H H V	63R 59S 67	
19	H V	54 61	
20	H V	58 65	
21	H V	62 77	
22	H V (antenna 6" above ground)	57 66	
23	H V	54 68	
24	H H V	58F 49S 63	

COMMENTS: Wellems 3 = Short dipoles; Source is centered inside of shelter; H = Horizontal; V = Vertical; F = Front side illuminated; S = Side; R = Rear.

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-10	dBm	400 M	Hz
HP 83572B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	H H V	53F 50S 58	
26	H V	66 50	
F1	H V	53 42	
F4	H V	62 44	
F5	H V	57 41	

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350A	CALIBRATION	-20	dBm	450 M	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H V	53 49	33 29
2	H V	53 49	33 29
3	H V	55 51	35 31
4	H V	56 57	36 37
5	H V	55 54	35 34
6	H H V	66F 70S 47	46 50 27
7	H H V	64F 71S 41	44 51 21
8	H V	71 69	51 49
9	H V	68 73	48 53
10	H V	68 72	48 52
11	H V	82 75	62 55
12	H V	73 72	53 52
13	H H V	71S 66R 71	51 46 51
14	H H V	81S 65R 72	61 45 52
15	H V	67 76	47 56
16	H V	62 70	42 50
17	H H V	71R 67S 74	51 47 54
18	H H V	64R 57S 71	44 37 51
19	H V	52 69	32 49
20	H V	63 70	43 50
21	H V	61 73	41 53
22	H V	55 64	35 44
23	H V	57 66	37 46
24	H H V	52F 42S 59	32 22 39

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B	NOISE	-130	dBm	FREQUENCY	
HP 8350A	CALIBRATION	-20	dBm	450 M	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
25	H H V	53F 58S 46	33 38 26
26	H V	63 48	43 28
F1	H V	60 47	40 27
F4	H V	57 48	37 28
F5	H V	56 48	36 28

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-20	dBm	462.5 M	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H V	47 44	27 24
2	H V	46 43	26 23
3	H V	52 46	32 26
4	H V	50 42	30 22
5	H V	43 47	23 27
6	H H V	50F 70S 60	30 50 40
7	H H V	61F 74S 51	41 54 31
8	H V	67 65	47 45
9	H V	78 65	58 45
10	H V	66 59	46 39
11	H V	83 71	63 51
12	H V	77 66	57 46
13	H H V	68R 72S 64	48 52 44
14	H H V	76R 87S 57	56 67 39
15	H V	66 63	46 43
16	H V	70 64	50 44
17	H H V	52S 69R 51	32 49 31
18	H H V	49S 72R 67	29 52 47
19	H V	62 53	42 33
20	H V	63 60	43 40
21	H V	59 58	39 38
22	H V	65 65	45 45
23	H V	61 54	41 34
24	H H V	50S 50F 61	30 30 41

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-20H (-20V)	dBm	462.5	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	H H V	57S 56R 49	37 36 29
26	H V	57 48	37 28
F1	H V	52 42	32 22
F4	H V	60 42	40 22
F5	H V	55 40	35 20

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-20	dBm	500 OM	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H V	58 47	
2	H V	51 43	
3	H V	67 50	
4	H V	50 46	
5	H V	48 49	
6	H H V	53F 50S 58	
7	H H V	59F 53S 61	
8	H V	53 65	
9	H V	62 67	
10	H V	62 64	
11	H V	62 64	
12	H V	62 63	
13	H H V	62S 75R 69	
14	H H V	63S 82R 61	
15	H V	70 58	
16	H V	73 54	
17	H H V	73R 79S 61	
18	H H V	71R 88S 57	
19	H V	76 53	
20	H V	77 62	
21	H V	75 59	
22	H V	74 67	
23	H V	77 69	
24	H H V	53R 76S 48	

COMMENTS:

SYSTEM	REFERENCE			DATE 7/16/90	
HP 8566B S/A	NOISE	-130	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-20H (-20V)	dBm	500 M	Hz
HP 83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	H H V	52F 79S 57	
26	H V	55 48	
F1	H V	64 45	
F4	H V	65 43	
F5	H V	80 45	

COMMENTS:

SYSTEM	REFERENCE			DATE 7/19/90	
HP 8566B S/A	NOISE	-124	dBm	FREQUENCY	
HP 8447A * Amp	CALIBRATION	-23	dBm	1 G	Hz
HP 8350B/83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H V	59 51	
2	H V	70 48	
3	H V	57 46	
4	H V	54 47	
5	H V	55 54	
6	H H V	75F 61S 62	
7	H H V	63F 54S 67	
8	H V	66 68	
9	H V	58 71	
10	H V	62 73	
11	H V	77 68	
12	H V	63 69	
13	H H V	69S 84R 67	
14	H H V	72S 81R 73	
15	H V	68 71	
16	H V	85 66	
17	H H V	80R 67S 63	
18	H H V	79R 72S 61	
19	H V	62 67	
20	H V	64 63	
21	H V	66 65	
22	H V	66 63	
23	H V	57 69	
24	H H V	61R 49S 57	

COMMENTS: * The 8447A provide > 6 dB gain at this frequency.

SYSTEM	REFERENCE			DATE 7/19/90	
HP 8566B S/A	NOISE	-128	dBm	FREQUENCY	
HP 8447A Amp.	CALIBRATION	-23	dBm	1 G	Hz
HP 8350B/83592B S/O	SEPARATION	72	inches	Wellems 3	RCUR
			Ant2	Wellems 3	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	H H V	71F 52S 64	
26	H V	73 49	
F1	H V	55 51	
F4	H V	60 49	
F5	H V	75 46	

COMMENTS:

SYSTEM	REFERENCE			DATE 7/20/90	
HP 8566B S/A	NOISE	-11[illegible]	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-2[illegible]	dBm	10 G	Hz
HP 83592B S/O	SEPARATION	72	inches	HORN	RCUR
			Ant2	HORN	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V	64	
2	V	68	
3	V	74	
4	V	63	
5	V	71	
6	V	84	
7	V	83	
8	V	91	
9	V	98	
10	V	94	
11	V	99	
12	V	98	
13	V	96	
14	V	98	
15	V	86	
16	V	92	
17	V	99	
18	V	96	
19	V	96	
20	V	112	
21	V	100	
22	V	94	
23	V	101	
24	V	79	

COMMENTS: HORN centrally located in shelter 36" from walls. Beam directed to each edge containing test point. 36" maintained for each edge. All measurements vertical E field.

SYSTEM	REFERENCE			DATE 7/20/90	
HP 8566B S/A	NOISE	-115	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-29	dBm	10 G	Hz
HP 83592B S/O	SEPARATION	72	inches	HORN	RCUR
			Ant2	HORN	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	V	85	
26	V	75	
F1	V	62	
F4	V	65	
F5	V	57	

COMMENTS: ____________________

SYSTEM	REFERENCE			DATE 9/23/90	
HP 8566B S/A	NOISE	-105	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-27	dBm	12 G	Hz
HP 83592B S/O	SEPARATION	72	inches	HORN	RCUR
			Ant2	HORN	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V	69	
2	V	79	
3	V	72	
4	V	62	
5	V	82	
6	V	97	
7	V	96	
8	V	102	
9	V	97	
10	V	94	
11	V	100	
12	V	99	
13	V	103	
14	V	97	
15	V	102	
16	V	99	
17	V	99	
18	V	103	
19	V	102	
20	V	103	
21	V	101	
22	V	97	
23	V	102	
24	V	92	

COMMENTS: ______

SYSTEM	REFERENCE			DATE 9/23/90	
HP 8566B S/A	NOISE	-105	dBm	FREQUENCY	
HP 8350B	CALIBRATION	-27	dBm	12 G	Hz
HP 83592B S/O	SEPARATION	72	inches	HORN	RCUR
			Ant2	HORN	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
25	V	98	
26	V	75	
F1	V	64	
F4	V	69	
F5	V	64	

COMMENTS: ______________________

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	95	dBm	FREQUENCY	
	CALIBRATION		dBm	10	KHz
	SEPARATION	20	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V		25
2	V		45
3			25
4			40
5			35
6			40
7			35
8			50
9			60
10			55
11			55
12			80
13			50
14			65
15			75
16			70
17			75
18			55
19			85
20			55
21			60
22			55
23			55
24			40

COMMENTS:

SYSTEM REFERENCE

NOISE dBm

CALIBRATION dBm

SEPARATION inches

Ant2

Ant2

DATE ---

FREQUENCY

10 K Hz

RCUR

XMTR

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25			45
26			35
F1			30
F4			30
F5			25

COMMENTS:

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	-105	dBm	FREQUENCY	
	CALIBRATION		dBm	150 K	Hz
	SEPARATION	265	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1			58
2			70
3			78
4			72
5			82
6			60
7			55
8			90
9			82
10			105
11			90
12			104
13			87
14			86
15			100
16			102
17			100
18			92
19			93
20			106
21			84
22			92
23			101
24			63

COMMENTS: Need ±5 dB ~ 95-100dB.

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	-105	dBm	FREQUENCY	
	CALIBRATION		dBm	150 K	Hz
	SEPARATION	26	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25			64
26			60
F1			44
F4			46
F5			36

COMMENTS:

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	-115	dBm	FREQUENCY	
	CALIBRATION		dBm	1 M	Hz
	SEPARATION	26	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
1			55
2			80
3			60
4			75
5			65
6			75
7			75
8			90
9			85
10			100
11			95
12			95
13			95
14			95
15			90
16			95
17			90
18			90
19			90
20			90
21			85
22			85
23			85
24			80

COMMENTS: Needle jumps alot.

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	-115	dBm	FREQUENCY	
	CALIBRATION		dBm	1 M	Hz
	SEPARATION	26	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	ATTENUATION Result dB
25			85
26			75
F1			50
F4			55
F5			40

COMMENTS:

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	-112	dBm	FREQUENCY	
	CALIBRATION		dBm	10 M	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1			60
2			87
3			69
4			95
5			80
6			86
7			86
8			98
9			90
10			105
11			102
12			105
13			110
14			107
15			104
16			107
17			100
18			110
19			105
20			101
21			97
22			101
23			94
24			98

COMMENTS:

SYSTEM	REFERENCE			DATE 9/12/90	
Euroshield	NOISE	-112	dBm	FREQUENCY	
	CALIBRATION		dBm	10 M	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25			95
26			94
F1			61
F4			66
F5			46

COMMENTS: ______

SYSTEM	REFERENCE			DATE 7/26/90	
RP-SIMS-II	NOISE		dBm	FREQUENCY	
	CALIBRATION	-95	dBm	462.6 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V	70	25
2	V	74	21
3	V	70	25
4	V	72	23
5	V	66	29
6	V	55	40
7	V	45	50
8	V	56	39
9	V	54	41
10	V	53	42
11	V	43	52
12	V	47	48
13	V	44	51
14	V	41	54
15	V	49	46
16	V	49	46
17	V	41	54
18	V	53	42
19	V	51	44
20	V	40	55
21	V	47	48
22	V	46	49
23	V	53	42
24	V	50	45
25	V	60	35
26	V	63	32

COMMENTS: TX @ 1 W output. TX in shelter RX outside.

SYSTEM	REFERENCE				
RP-SIMS-II	NOISE		dBm	DATE 7/26/90	
	CALIBRATION	-95	dBm	FREQUENCY 462.6 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
F1	V	73	22
F2	V	later	later
F3	V	later	later
F4	V	75	20
F5	V	+72	23

COMMENTS: TX @ 1 W output, TX inside shelter, RX outside.

SYSTEM	REFERENCE			DATE 10/22/90	
	NOISE		dBm	FREQUENCY	
	CALIBRATION	-36	dBm	450 M	Hz
	SEPARATION	72	inches	ASM	RCUR
			Ant2	ASM	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V	-62	26
2	V	-58	22
3	V	-71	35
4	V	-64	28
5	V	-66	30
6	V	-79	43
7	V	-75	39
8	V	-85	49
9	V	-89	53
10	V	-88	52
11	V	-85	49
12	V	-90	54
13	V	-92	56
14	V	-84	48
15	V	-81	45
16	V	-83	47
17	V	-86	50
18	V	-81	45
19	V	-81	45
20	V	-82	46
21	V	-81	45
22	V	-81	45
23	V	-82	46
24	V	-85	49

COMMENTS: Ground through power cord.

SYSTEM	REFERENCE			DATE 10/22/90	
	NOISE		dBm	FREQUENCY	
	CALIBRATION	-36	dBm	450 M	Hz
	SEPARATION	72	inches	ASM	RCUR
			Ant2	ASM	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	V	-85	49
26	V	-74	38
F1	V	-69	33
F4	V	-63	27
F5	V	-64	28

COMMENTS:

SYSTEM	REFERENCE			DATE 10/22/90	
ASM TS 450	NOISE	103	dBm	FREQUENCY	
	CALIBRATION	-35	dBm	450	Hz
	SEPARATION	72	inches	ASM	RCUR
			Ant2	ASM	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H	75	40
2	H	80	45
3	H	74	39
4	H	77	42
5	H	84	49
6	H	75	40
7	H	72F 65S	37 30
8	H	73	38
9	H	69	34
10	H	74	39
11	H	74	39
12	H	75	40
13	H	95R 76S	60 41
14	H	90	55
15	H	84	49
16	H	87	52
17	H	85	50
18	H	86R 79S	51 44
19	H	72	37
20	H	69	34
21	H	71	36
22	H	71	36
23	H	69	34
24	H	67F 66S	32 31

COMMENTS:

SYSTEM	REFERENCE			DATE 10/22/90	
ASM TS 450	NOISE	103	dBm	FREQUENCY	
	CALIBRATION	-35	dBm	450 M	Hz
	SEPARATION	72	inches	ASM	RCUR
			Ant2	ASM	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
25	H	65F 68S	30 33
26	H	76	41
F1	H	76	40
F4	H	75	37
F5	H	79	43

COMMENTS:

ASM TS 450 GROUNDING VARIATIONS TEST DATA

SYSTEM	REFERENCE			DATE 7/26/90	
ASM TS 450	NOISE		dBm	FREQUENCY	
	CALIBRATION	1	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H	42	41
2	H	41	40
3	H	41	40
4	H	43	42
5	H	42	41
6	H	39	38
7	H	44	43
8*	H	39	38
9*	H	33	32
10*	H	41	40
11*	H	43	42
12*	H	42	41
13	H	49	48
14	H	52	51
15	H	53	52
16	H	52	51
17	H	56	55
18	H	47	46
19*	H	32	31
20*	H	37	36
21*	H	36	35
22*	H	33	32
23*	H	34	33
24	H	44	43
25	H	45	44
26	H	4	40

COMMENTS: Placed a 6 dB (2 x 50 λ 2W) alternates pad on TX output. TX placed in shelter. RX outside. (*) TX antenna parallel to side walls.

SYSTEM	REFERENCE			DATE ---	
ASM	NOISE		dBm	FREQUENCY	
TS 450	CALIBRATION	1	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
F1	H	45	44
F2	H	later	later
F3	H	35	34
F4	H	44	43
F5	H	39	38

COMMENTS: 6 dB att. pad on TX output. TX in shelter RX outside.

SYSTEM	REFERENCE			DATE 7/26/90	
ASM	NOISE		dBm	FREQUENCY	
TS 450	CALIBRATION	0	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
1	V		22 (25)
2	V		15 (24)
3	V		24 (28)
4	V		19 (25)
5	V		24 (31)
6	V		29 (38)
7	V		34 (51)
8	V		35 (44)
9	V		42 (46)
10	V		42 (43)
11	V		46 (56)
12	V		39 (51)
13	V		40 (47)
14	V		43 (49)
15	V		31 (44)
16	V		31 (40)
17	V		40 (43)
18	V		32 (40)
19	V		33 (45)
20	V		42 (51)
21	V		33 (41)
22	V		40 (47)
23	V		36 (41)
24	V		29 (40)
25	V		27 (40)
26	V		20 (34)

COMMENTS: Placed a 6 dB att. pad on TX out. TX in shelter. RX outside. (*) Measurements in parenthesis (..) are taken with power cord connected (grounded shelter).

SYSTEM	REFERENCE			DATE 7/26/90	
ASM	NOISE		dBm	FREQUENCY	
TS 450	CALIBRATION	0	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
F1	V		17 (24)
F2	V		later
F3	V		later
F4	V		16 (24)
F5	V		14 (23)

COMMENTS: 0dB att. pad on TX output. TX in shelter. RX outside.

SYSTEM	REFERENCE			DATE 7/27/90	
ASM	NOISE		dBm	FREQUENCY	
TS 450	CALIBRATION	0	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	H		48
2	H		45
3	H		49
4	H		42
5	H		47
6	H		55
7	H		52
8*	H		44
9*	H		48
10*	H		48
11*	H		53
12*	H		50
13	H		68
14	H		70
15	H		53
16	H		65
17	H		64
18	H		57
19*	H		47
20*	H		47
21*	H		43
22*	H		45
23*	H		55
24	H		54
25	H		54
26	H		46

COMMENTS: 6 dB attenuator on TX antenna output. TX inside, RX outside, power cord connected; (*) TX antenna parallel to side walls.

S 'STEM	REFERENCE			DATE 7/2790
ASM	NOISE		dBm	FREQUENCY
TS 450	CALIBRATION	0	dBm	450 M Hz
	SEPARATION	72	inches	RCUR
			Ant2	XMTR
			Ant2	

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
F1	H		45
F2	H		later
F3	H		later
F4	H		41
F5	H		45

COMMENTS: 6dB altemater on TX antenna output. TX inside. RX outside. power cord connector.

SYSTEM	REFERENCE			DATE 7/27/90	
ASM	NOISE		dBm	FREQUENCY	
TS 450	CALIBRATION	0	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1	V		24
2	V		24
3	V		30
4	V		25
5	V		31
6	V		40
7	V		45
8	V		39
9	V		44
10	V		41
11	V		48
12	V		45
13	V		51
14	V		43
15	V		36
16	V		42
17	V		41
18	V		40
19	V		41
20	V		43
21	V		38
22	V		45
23	V		42
24	V		36
25	V		38
26	V		34

COMMENTS: 6 dB attenuator on TX antenna output. TX inside. RX outside. power cord connected.

S 'STEM	REFERENCE			DATE 7/27/90	
ASM	NOISE		dBm	FREQUENCY	
'S 450	CALIBRATION	0	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
F1	V		22
F2	V		later
F3	V		later
F4	V		23
F5	V		20

COMMENTS: 6dB attenuator on TX antenna output. TX inside. RX outside. power cord connected.

SYSTEM	REFERENCE			DATE 8/2/90	
Eaton 3500	NOISE		dBm	FREQUENCY	
	CALIBRATION	82	dBm	160 K	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
1		48	34
2		50	32
3		53	29
4		58	24
5		50	32
6		35	47
7		40	42
8		25	57
9		35	47
10		30	52
11		35	47
12		30	52
13		45	37
14		30	52
15		25	57
16		18	64
17		23	59
18		18	64
19		16	66
20		20	62
21		27	55
22		38	44
23		30	52
24		34	48
25		38	44
26		45	37

COMMENTS: Drive Points: Signal: corner b/w TPS: 10, 13, 15.
Grid: corner @ TP:25.

SYSTEM	REFERENCE			DATE 7/27/90	
ASM	NOISE		dBm	FREQUENCY	
T^ 450	CALIBRATION	0	dBm	450 M	Hz
	SEPARATION	72	inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION	
		Reading dBm	Result dB
F1	V		22
F2	V		later
F3	V		later
F4	V		23
F5	V		20

COMMENTS: 6dB attenuator on TX antenna output. TX inside, RX outside, power cord connected.

SYSTEM	REFERENCE			DATE 8/2/90	
Eaton 3500	NOISE		dBm	FREQUENCY	
	CALIBRATION	80	dBm	106 K	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1		50	30
2		70	10
3		65	15
4		53	27
5		46	34
6		34	46
7		37	43
8		28	52
9		31	49
10		28	52
11		37	43
12		25	55
13		40	40
14		28	52
15		23	57
16		15	65
17		24	56
18		17	63
19		14	66
20		14	66
21		26	54
22		32	48
23		28	52
24		32	48
25		35	45
26		47	33

COMMENTS: Drive Points: Signal: corner b/w TPS: 10, 13, 15. Grid: below TP:25 (botton left corner of door.

SYSTEM	REFERENCE			DATE 8/2/90	
E: ton 3500	NOISE		dBm	FREQUENCY	
	CALIBRATION	80	dBm	106 K	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

' EST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
F1		58	22
F2		later	later
F3		later	later
F4		54	26
F5		68	12

COMMENTS: Drive Points: Signal: Corner b/w TPS:10, 13, 15
Grid: below TP:25 (bottom left corner of door).

SYSTEM	REFERENCE			DATE 8/2/90	
Eaton 3500	NOISE		dBm	FREQUENCY	
	CALIBRATION	82	dBm	106 K	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
1		62	20
2		70	12
3		64	18
4		60	22
5		60	22
6		43	39
7		38	44
8		35	47
9		34	48
10		15	67
11		40	42
12		21	61
13		24	58
14		32	50
15		25	57
16		18	64
17		29	53
18		22	60
19		25	57
20		28	54
21		33	49
22		31	51
23		30	52
24		36	46
25		22	60
26		48	34

COMMENTS: Drive Points: Signal: corner b/w TPS: 17 & 20. Grid: corner b/w TP:5 & 8

SYSTEM	REFERENCE			DATE 8/2/90	
Eaton 3500	NOISE		dBm	FREQUENCY	
	CALIBRATION	82	dBm	106 K	Hz
	SEPARATION		inches		RCUR
			Ant2		XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
F1		62	20
F2		later	later
F3		later	later
F4		60	22
F5		78	4

COMMENTS: Drive Points: Signal: corner b/w TPS: 17 & 20.
Grid: corner b/w TP:5 & 8

SYSTEM	REFERENCE			DATE 10/24/90	
Selds	NOISE		dBm	FREQUENCY	
	CALIBRATION	20	dBm		Hz
	SEPARATION		inches		RCUR
			Ant2	-1 µf	XMTR
			Ant2		

TEST POINT	ORIENTATION	ATTENUATION Reading dBm	Result dB
Filter Area External		Off scale	11
Filter Area Internal		60 dB	60 dB

COMMENTS: Direct Drive on power phase input to Filter. Return on shelter TP 25.

HAMS MIL-STD-285 TEST DATA

BASELINE DATA

MRC/UD SHIELD ROOM MONITOR SYSTEM 13:42:00 09-10-1990

CHANNEL / FREQ	0	1
0	39	103
1	52	104
2	97	103
3	65	85
4	100	76

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 13:43:52 09-10-1990

CHANNEL / FREQ	0	1
0	0	2
1	0	0
2	0	0
3	0	0
4	-1	-2

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 13:50:57 09-10-1990

CHANNEL / FREQ	0	1
0	0	2
1	0	0
2	0	-1
3	0	0
4	-1	1

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 13:58:03 09-10-1990

CHANNEL FREQ	0	1
0	0	2
1	0	-1
2	0	0
3	0	1
4	-1	-2

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:05:09 09-10-1990

CHANNEL FREQ	0	1
0	0	0
1	0	-1
2	0	0
3	0	1
4	0	2

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:12:14 09-10-1990

CHANNEL FREQ	0	1
0	0	0
1	0	0
2	0	-1
3	-1	-1
4	0	5

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:19:26 09-10-1990

CHANNEL FREQ	0 TP5	1 TP6
0	36	1
1	40	0
2	7	0
3	39	18
4	3	28

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:26:37 09-10-1990

CHANNEL FREQ	0 TP4	1 TP25
0	55	0
1	52	0
2	7	0
3	38	18
4	4	28

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:33:48 09-10-1990

FREQ \ CHANNEL	0	1
	TP2	TP4
0	64	2
1	51	-1
2	6	1
3	39	19
4	5	29

CURRENT VARIATION FROM BASELINE

MRC/LD SHIELD ROOM MONITOR SYSTEM 14:40:59 09-10-1990

FREQ \ CHANNEL	0	1
	—	TP2
0	65	1
1	51	-1
2	7	1
3	39	19
4	3	28

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:48:10 09-10-1990

FREQ \ CHANNEL	0	1
	F4	TP3
0	47	1
1	51	-1
2	6	0
3	39	18
4	4	27

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 14:55:21 09-10-1990

CHANNEL FREQ	0 FI	1 TP25
0	13	0
1	19	-1
2	7	1
3	39	18
4	4	29

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 15:02:32 09-10-1990

CHANNEL FREQ	0 –	1 TP24
0	54	0
1	12	0
2	6	1
3	39	19
4	4	29

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 15:09:43 09-10-1990

CHANNEL	0	1
FREQ	TP5	TP6
0	56	2
1 TP5	51	-1 TP6
2	7	1
3	38	19
4	4	27

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 15:16:54 09-10-1990

CHANNEL	0	1
FREQ	TP26	TP7
0	57	0
1 TP26	51	-1 TP7
2	5	0
3	38	18
4	5	27

CURRENT VARIATION FROM BASELINE

MRC/UD SHIELD ROOM MONITOR SYSTEM 15:24:05 09-10-1990

CHANNEL	0	1
FREQ	TP3	–
0	36	0
1	51	-1
2	6	0
3	39	18
4	4	28

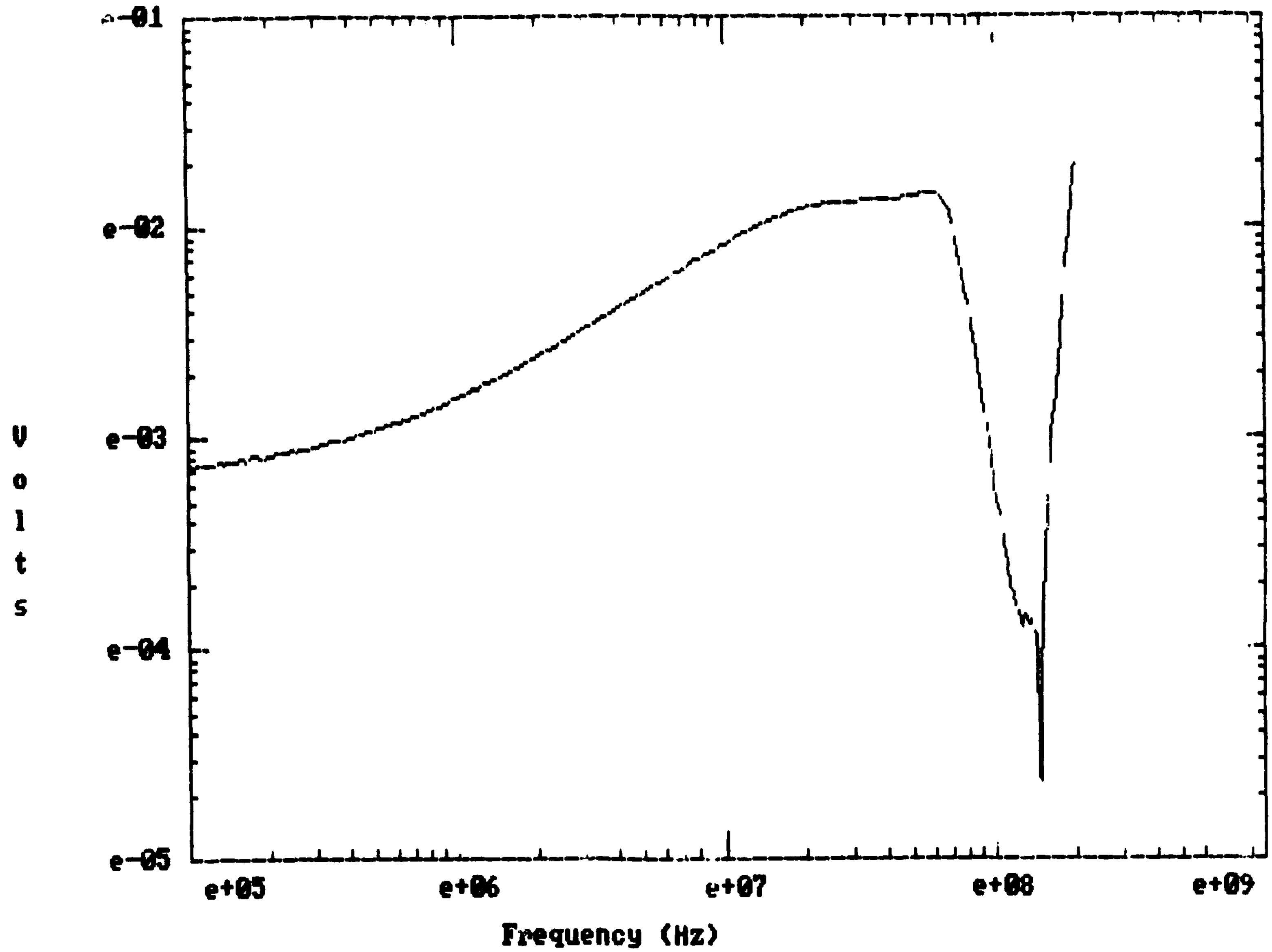


Figure B-1. S21 slotted coax calibration, 2-in separation, 0-[illegible] elev[illegible], short-circuit termination.

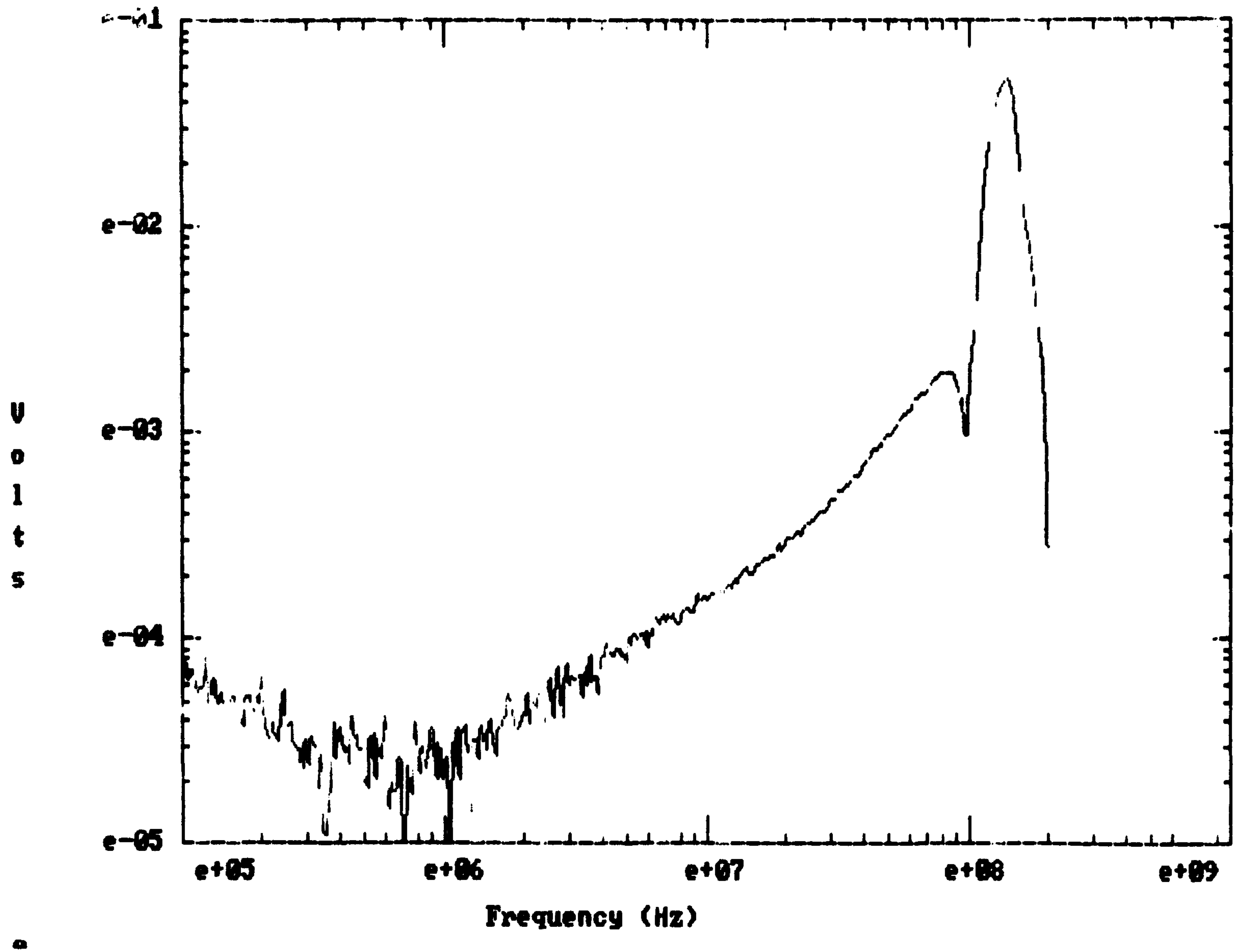


Figure B–2. S21 parallel loop calibration, 2-in separation, 0-in elevation.

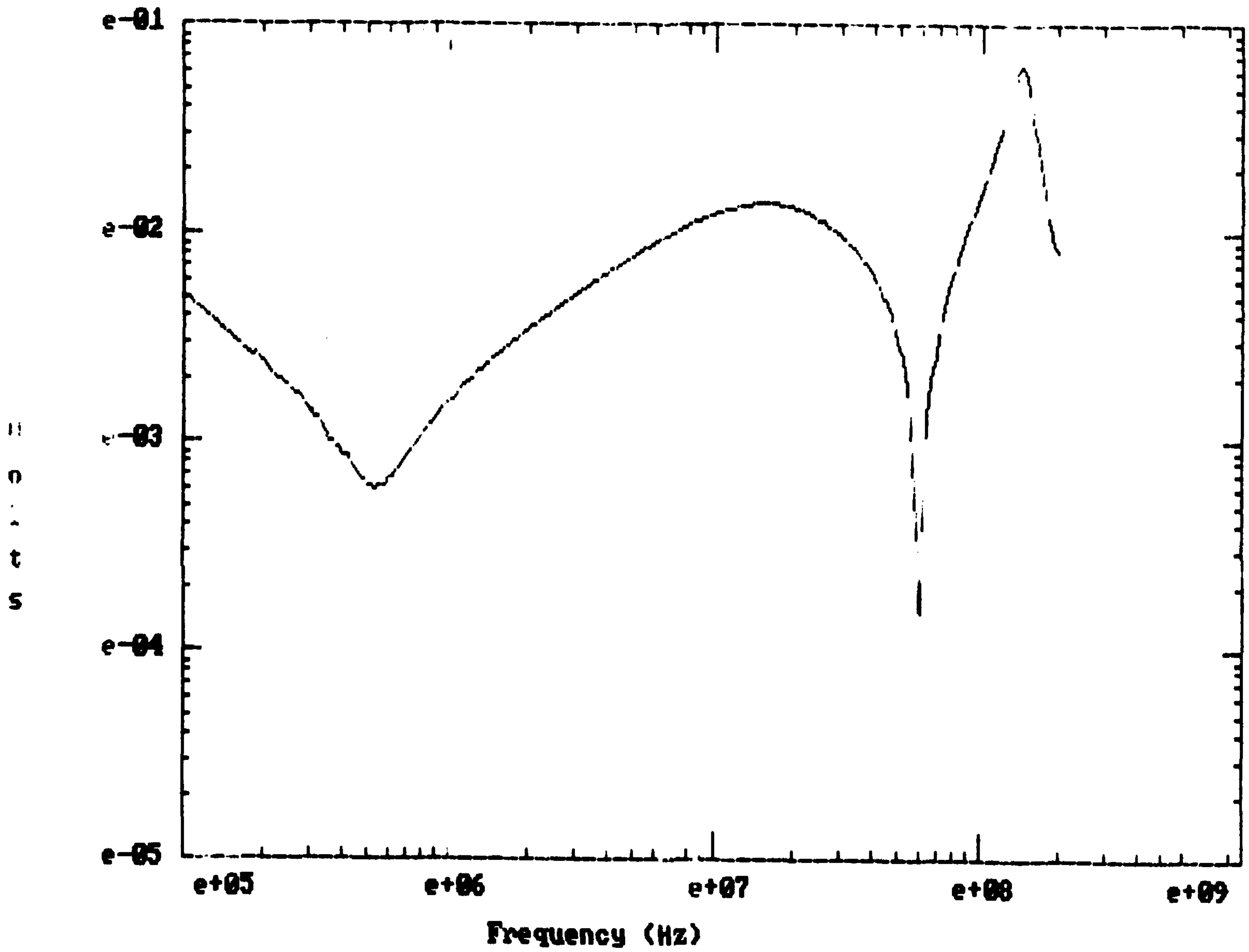


Figure B–3. S21 folded inductor calibration, 2-in separation, 1/2-in elevation, short-circuit termination.

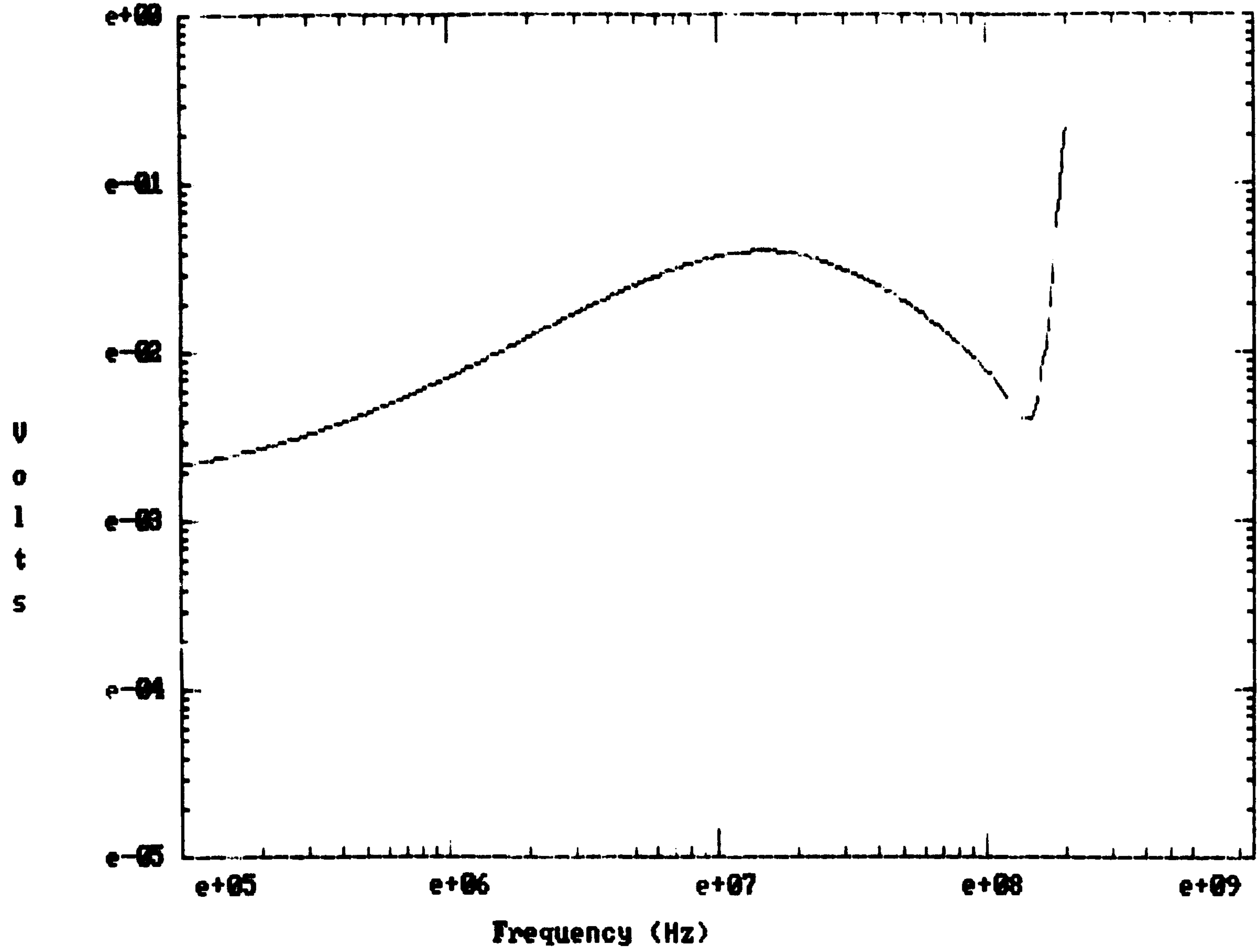


Figure B–4. S21 (FA) calibration, 2-in separation, ½-in elevation, short-circuit termination.

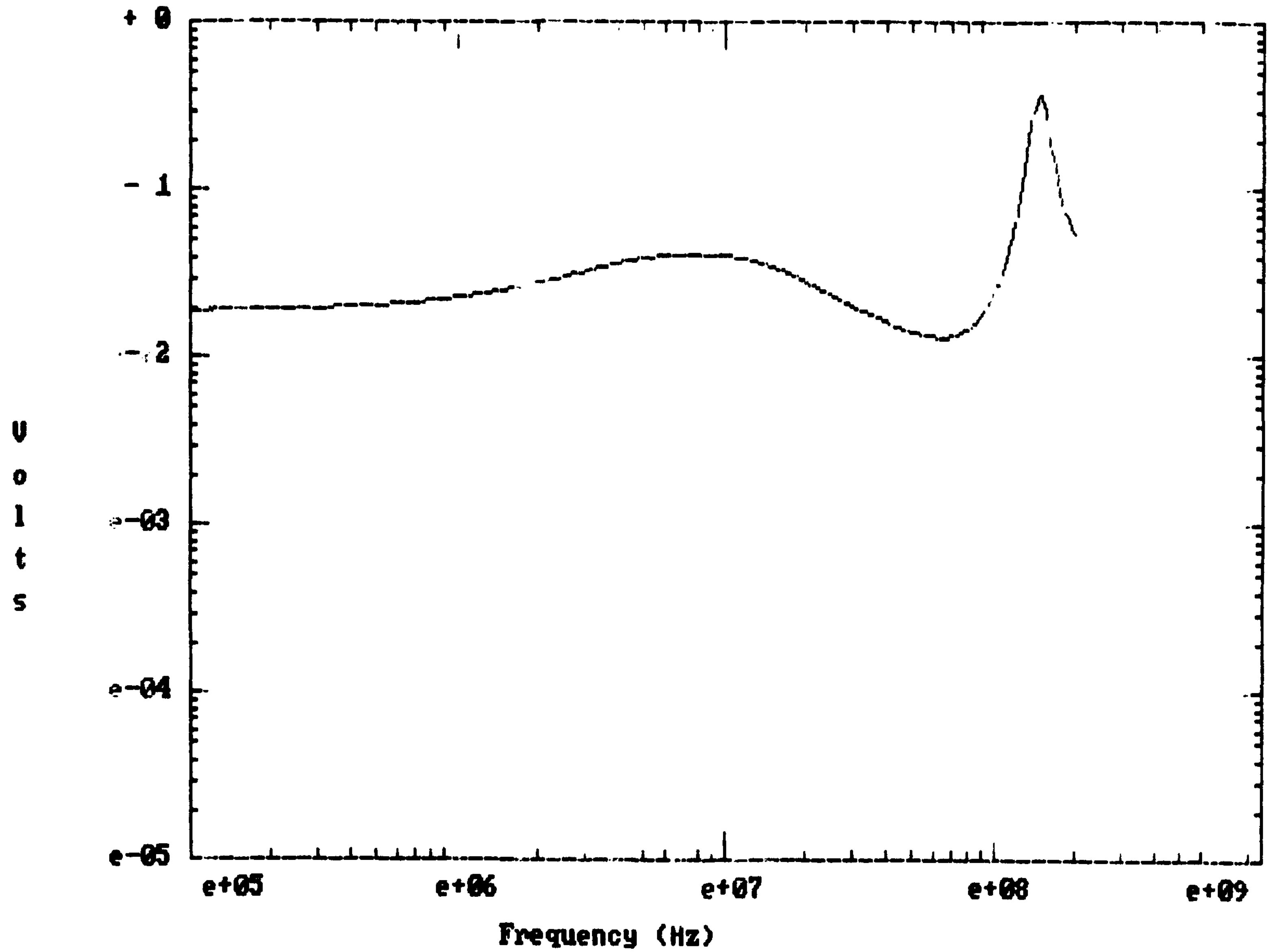


Figure B–5. S21 series loop calibration, 2-in separation, 0-in elevation, short-circuit termination.

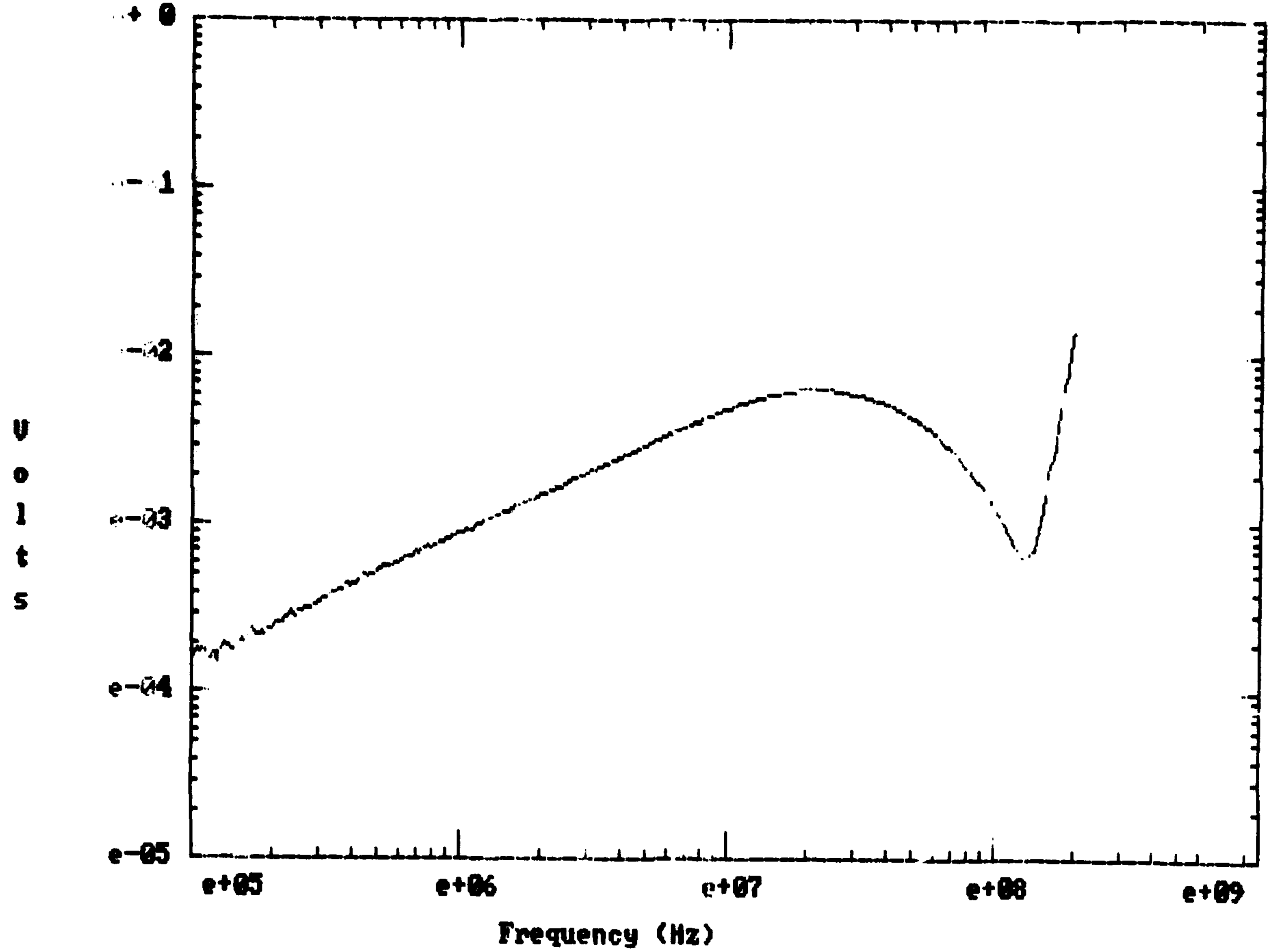


Figure B–6. S21 bare core (coax) calibration, 2-in separation, 0-in elevation, short-circuit termination.

SENSOR/TANK NETWORK ANALYZER HP8753 TEST DATA

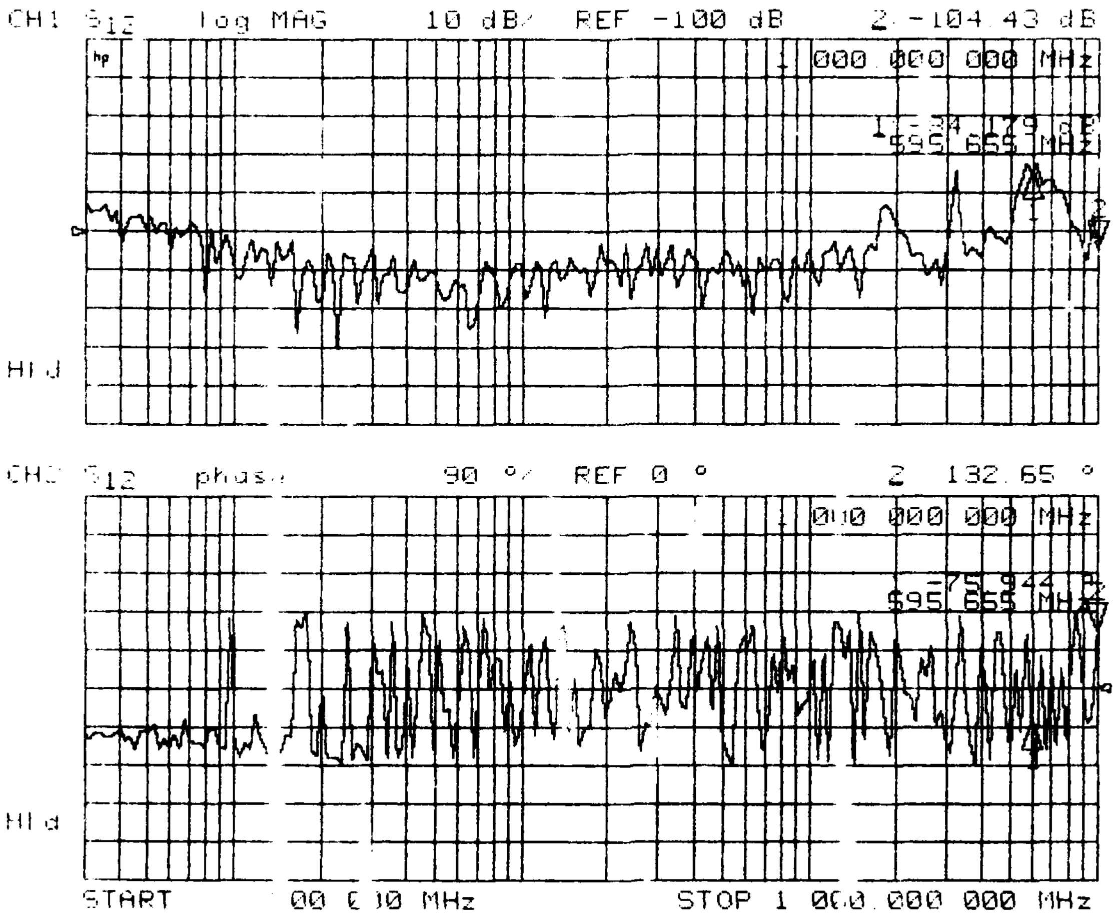


Figure B–7 S12 series loop fault F1, short-circuit termination.

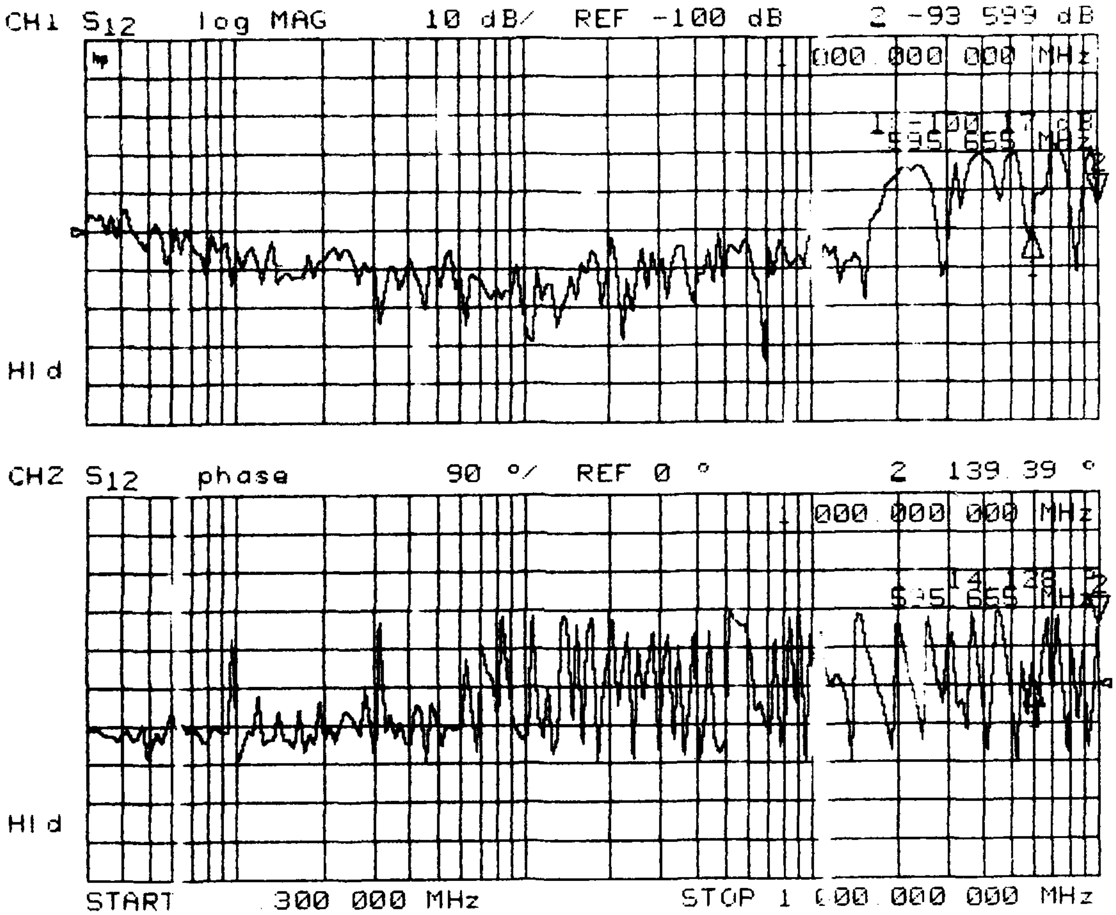


Figure B–8. S12 parallel loop fault F1, 50-Ω termination.

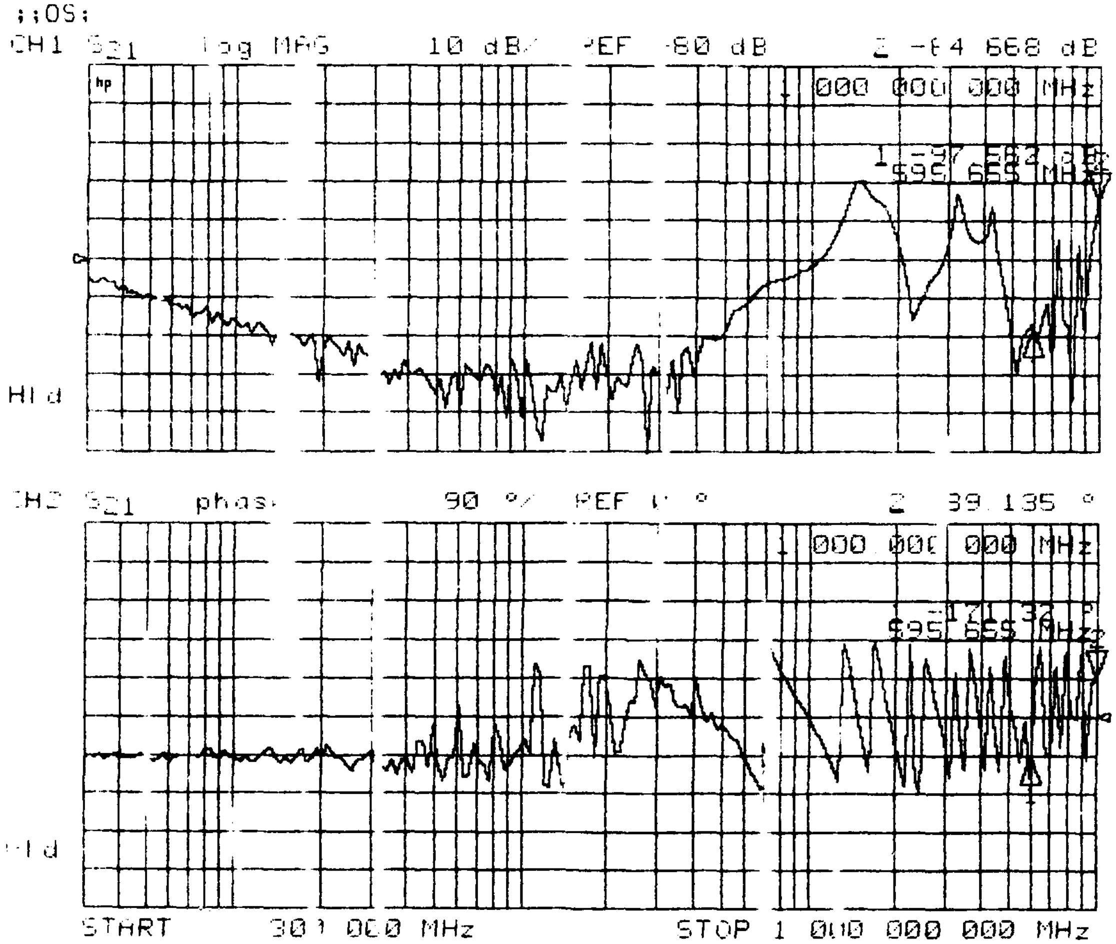


Figure B–9. S21 parallel loop fault F4.

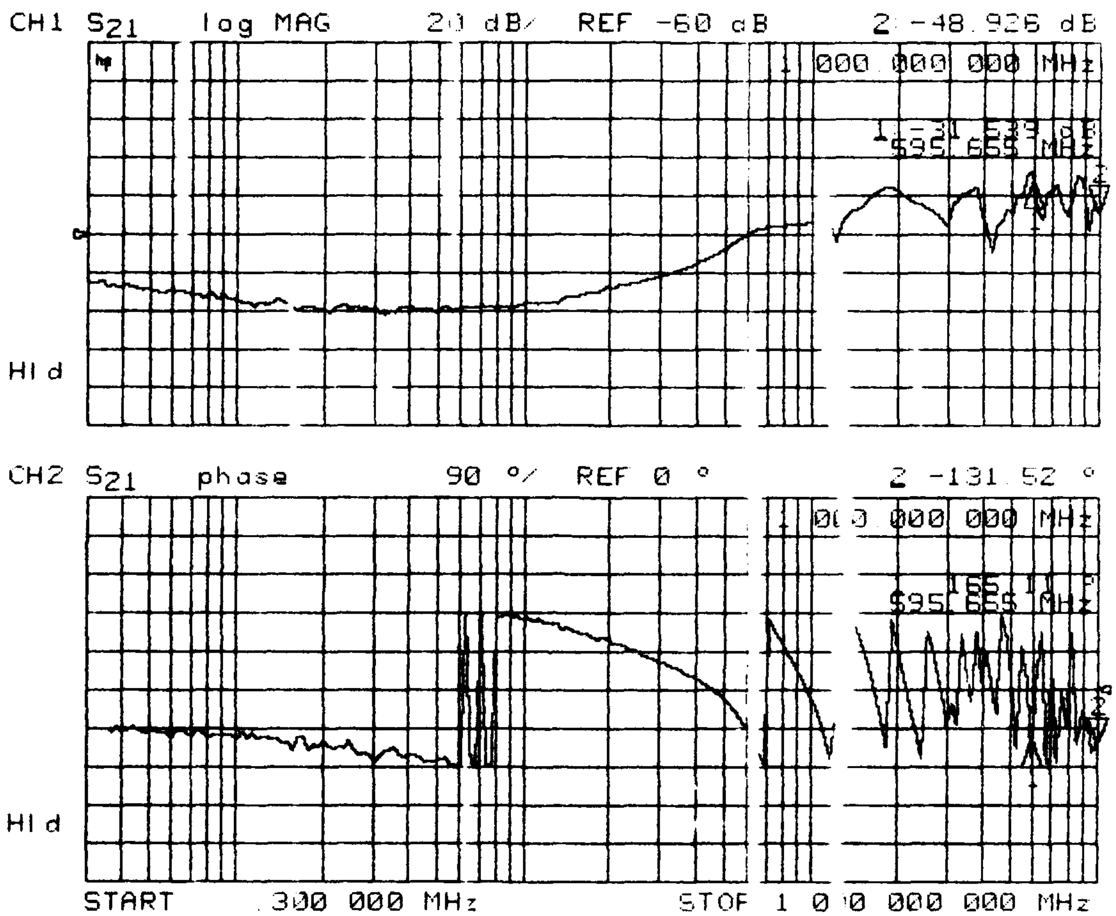


Figure B-10. S21 parallel loop fault F5.

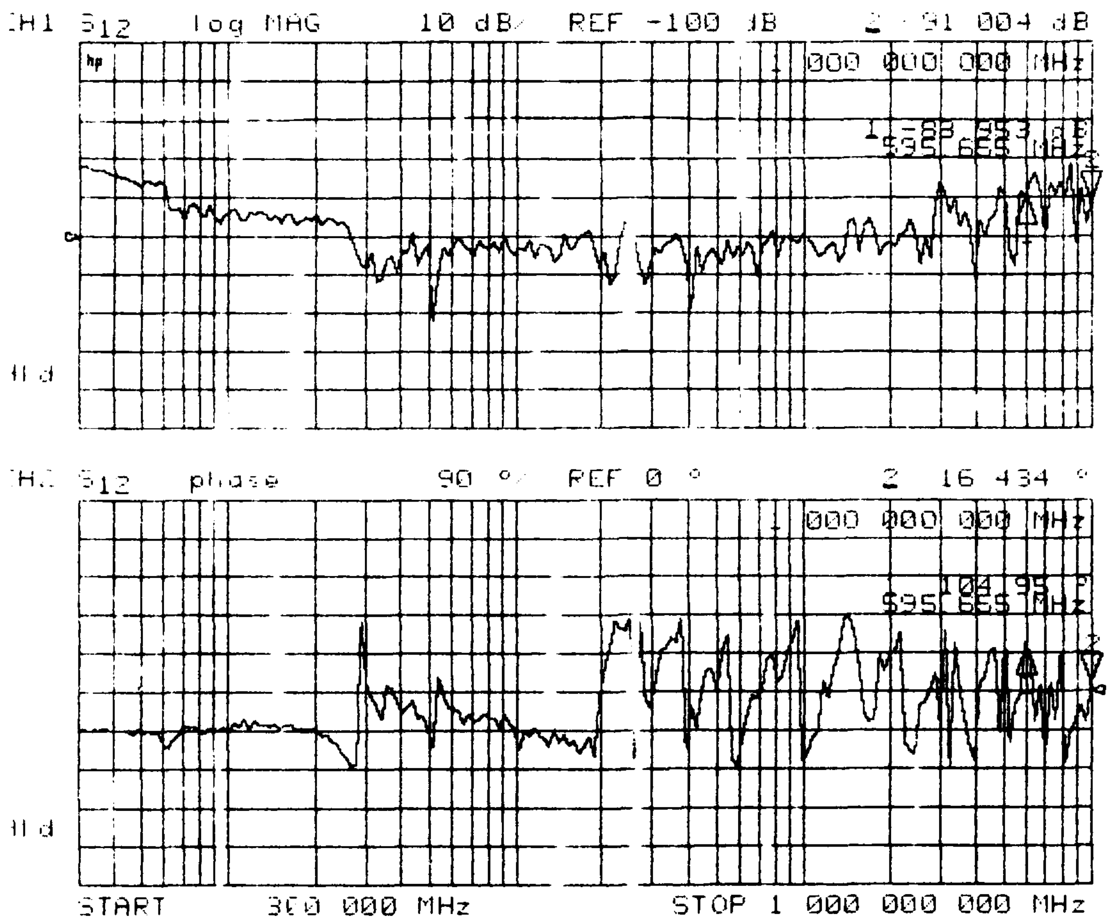


Figure B-11. **S12 folded inductor fault F1, short-circuit termination, $^1/_2$-in elevation.**

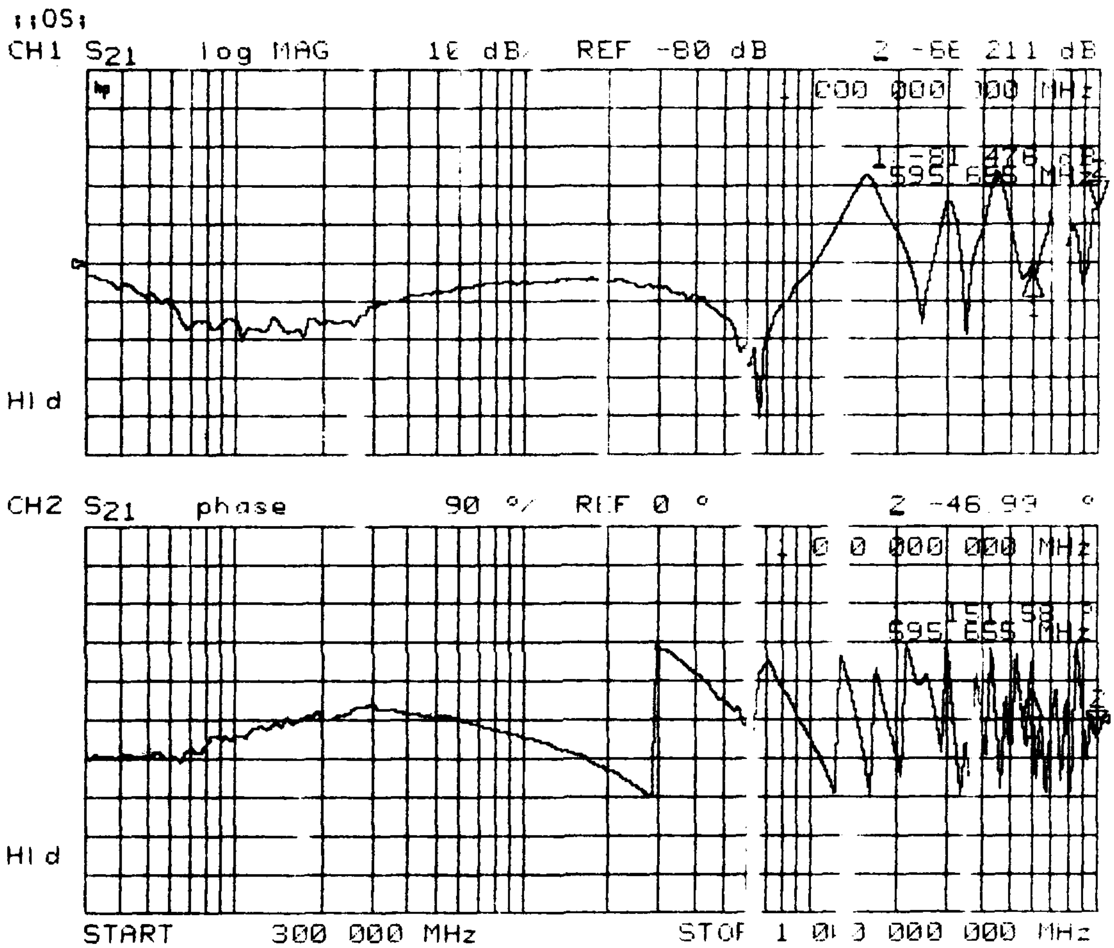


Figure B–12. S21 folded inductor fault F4, short-circuit termination, ½-in elevation.

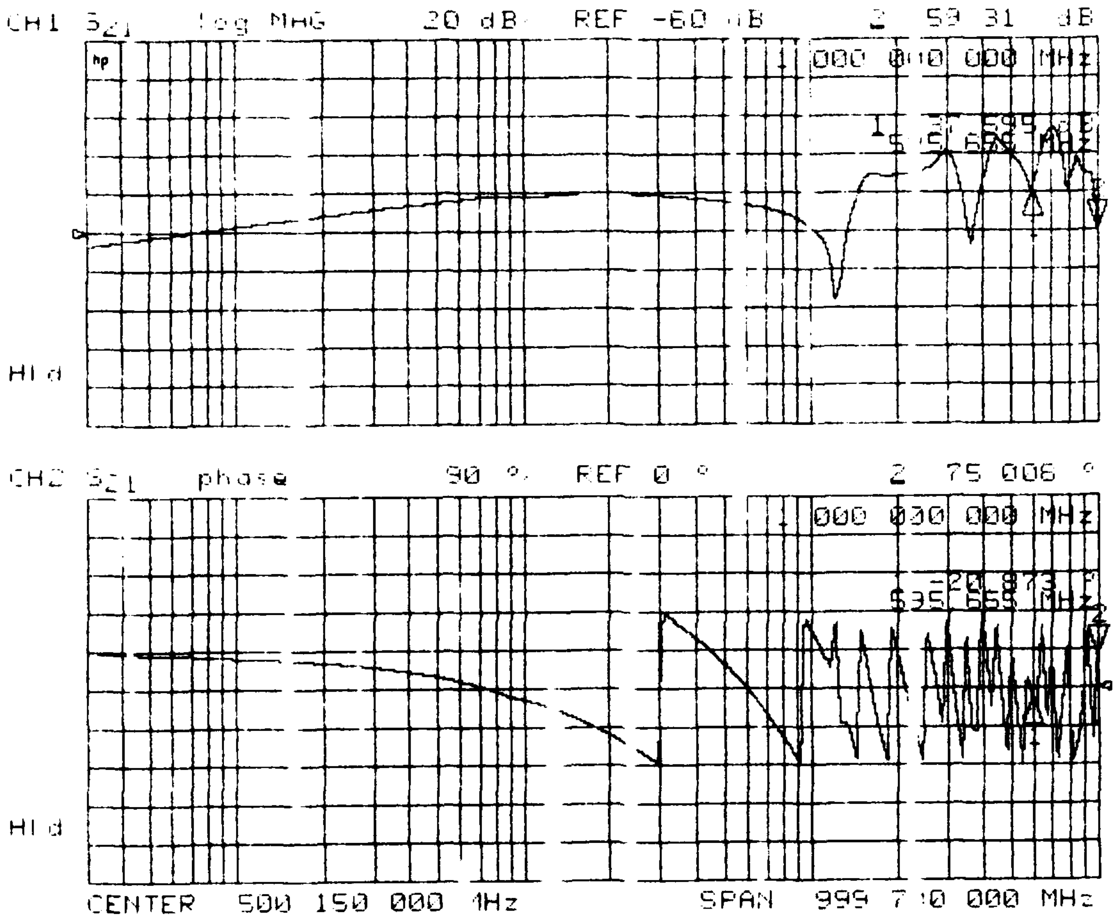


Figure B–13. S21 folded inductor fault F5, short-circuit termination, ½-in elevation.

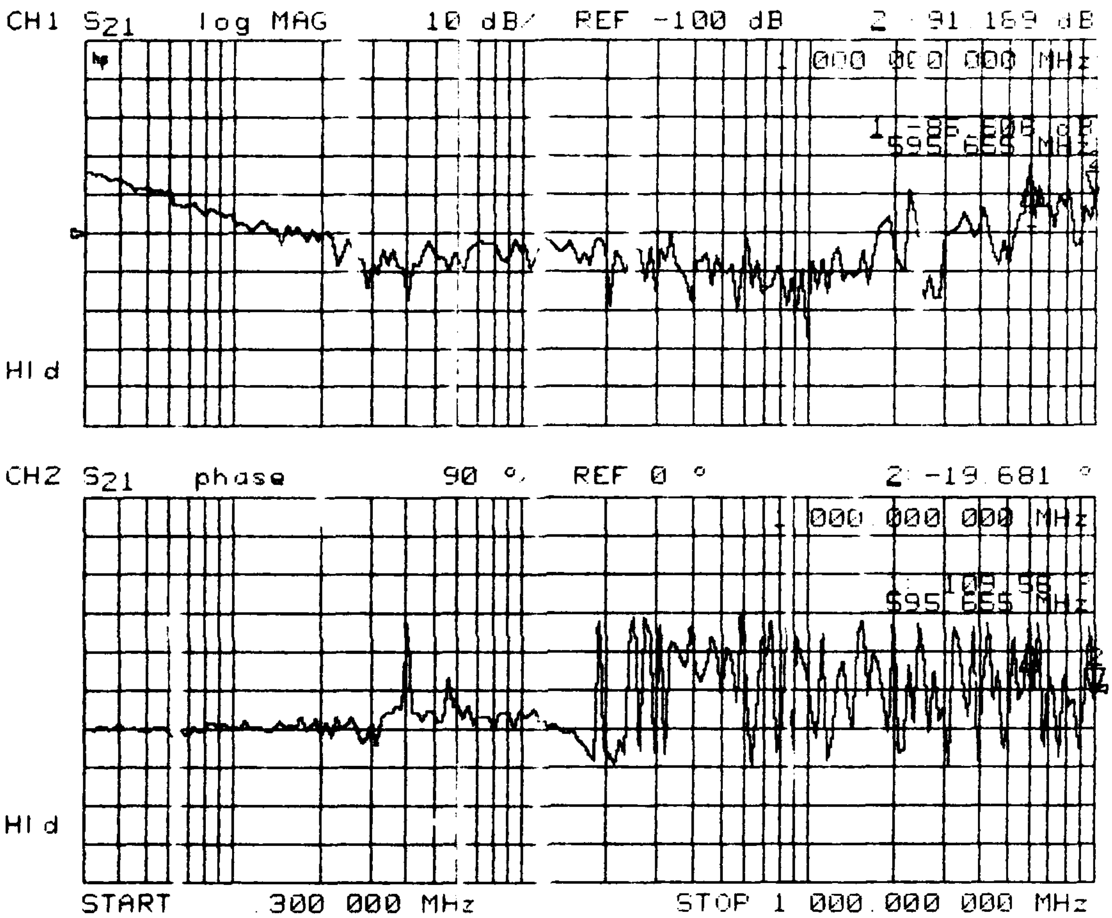


Figure B–14. S21 folded inductor fault F1, short-circuit termination, ½-in elevation.

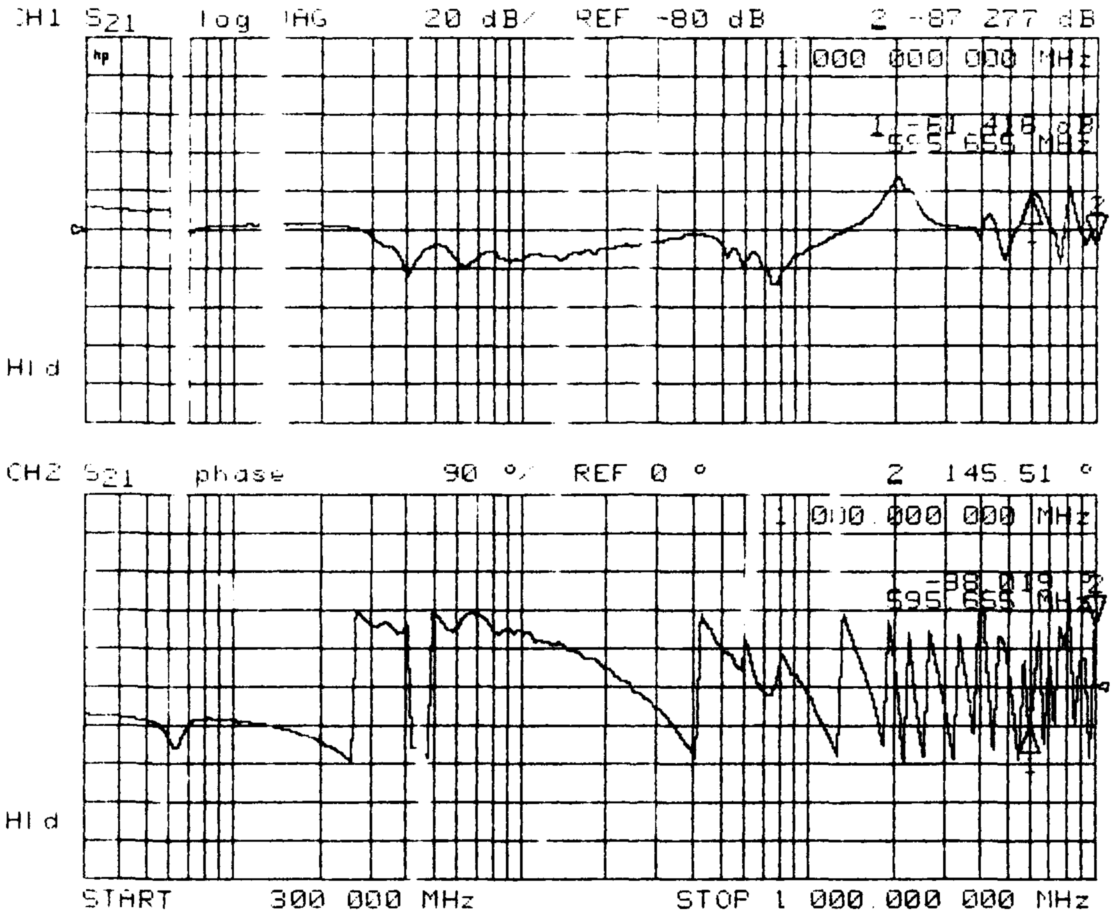


Figure B–15. S21 folded inductor fault F4, short-circuit termination, ½-in elevation.

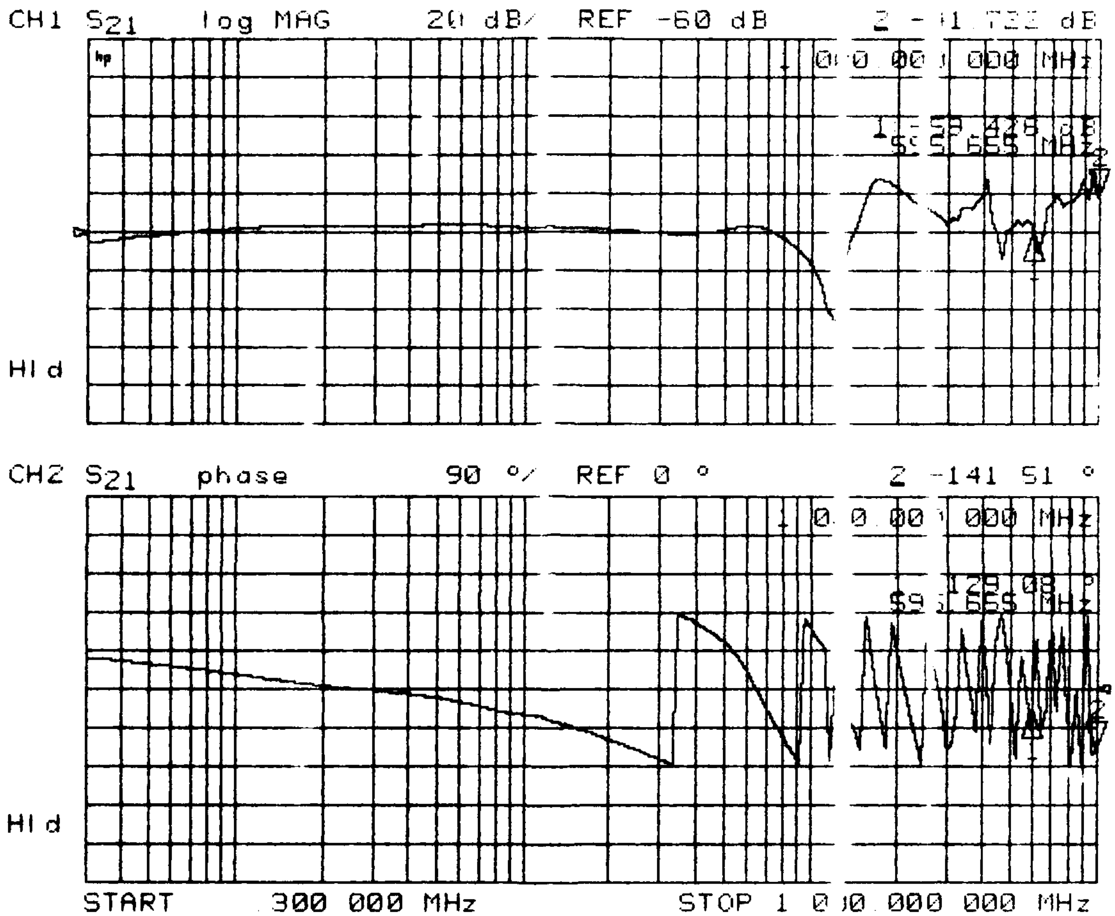


Figure B–16. S21 series loop fault F5, short-circuit termination.

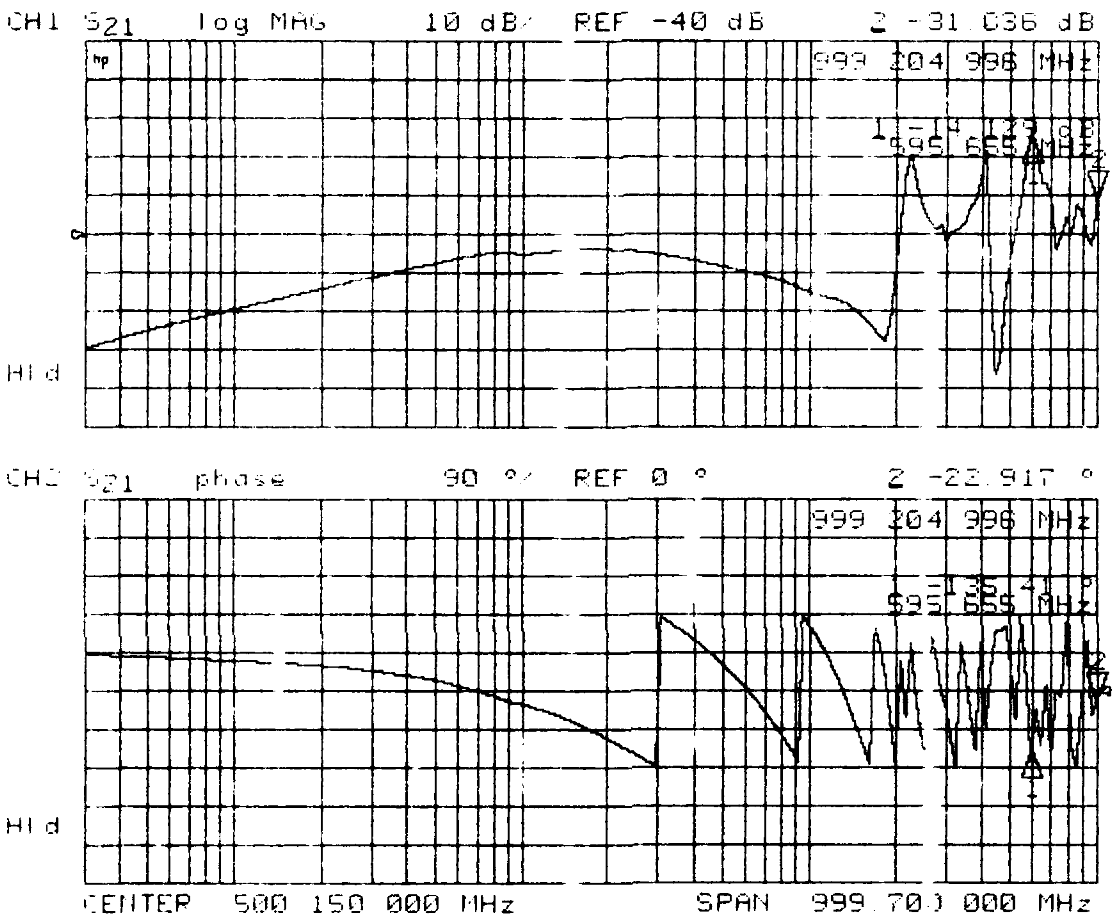


Figure B-17. S21 folded inductor fault F5, short-circuit termination, ½-in elevation.

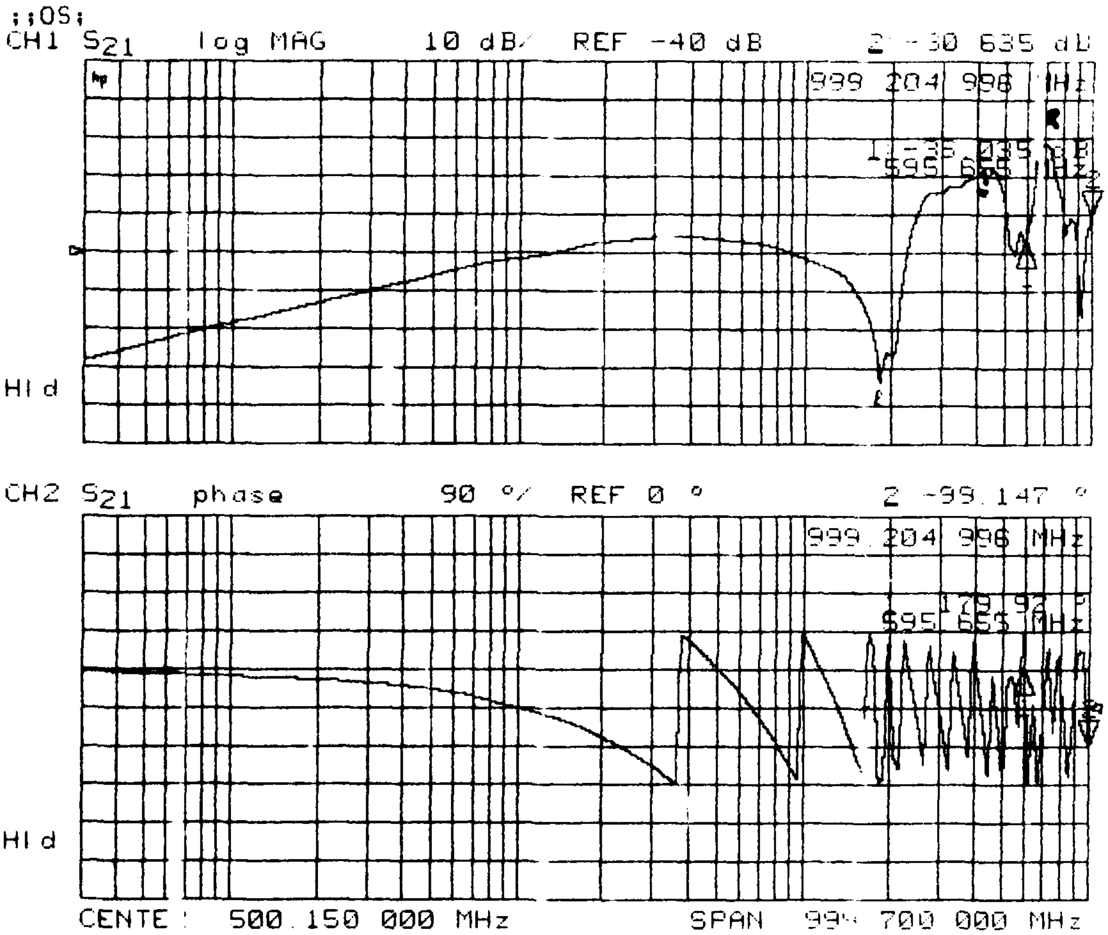


Figure B–18. S21 bare coax fault F5, short-circuit termination.

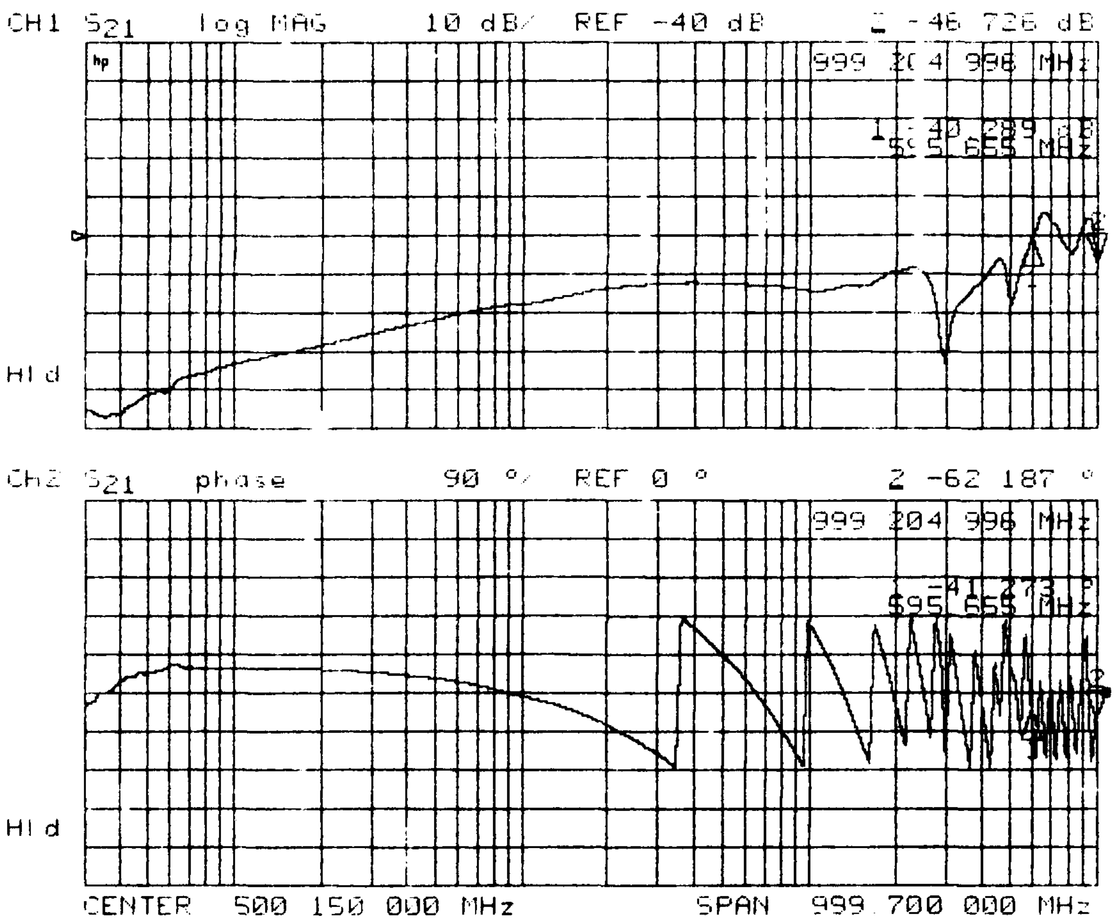


Figure B–19. S21 bare coax fault F4, short-circuit termination.

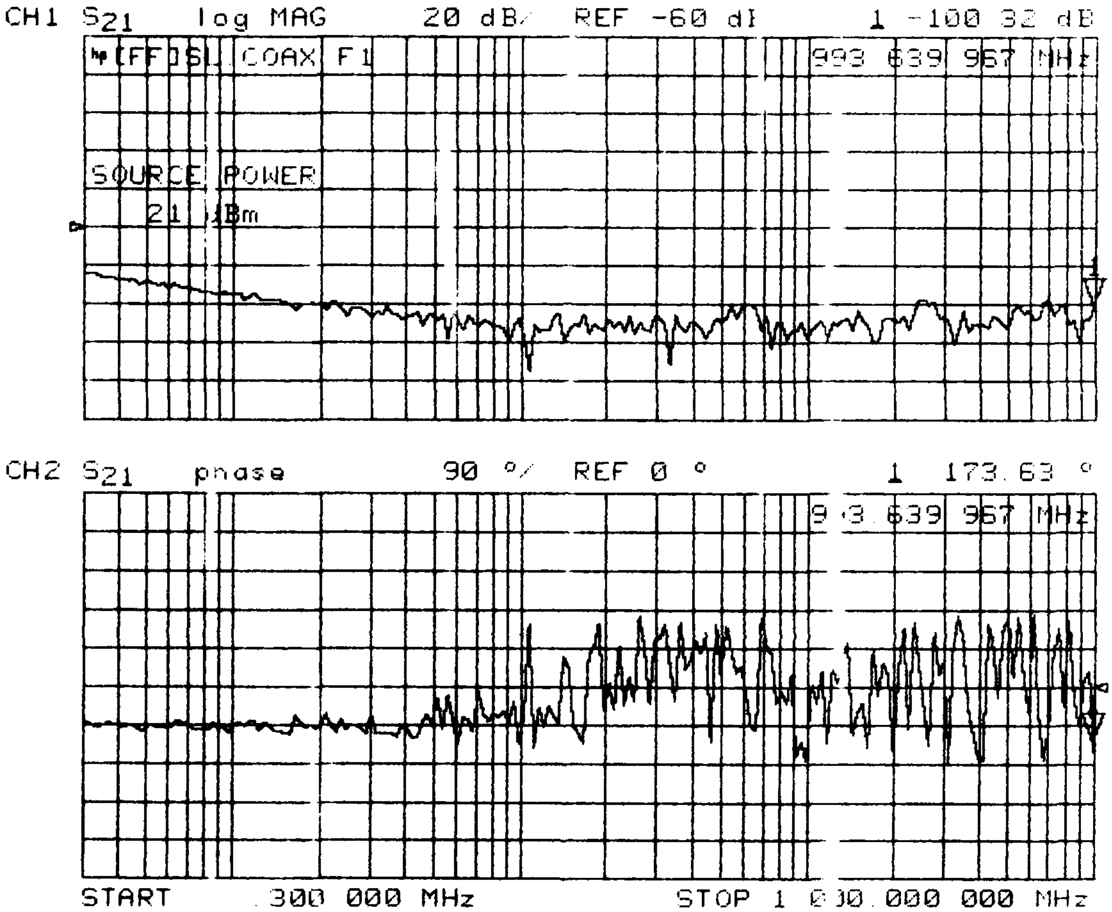


Figure B-20. S21 bare coax fault F1, short-circuit termination.

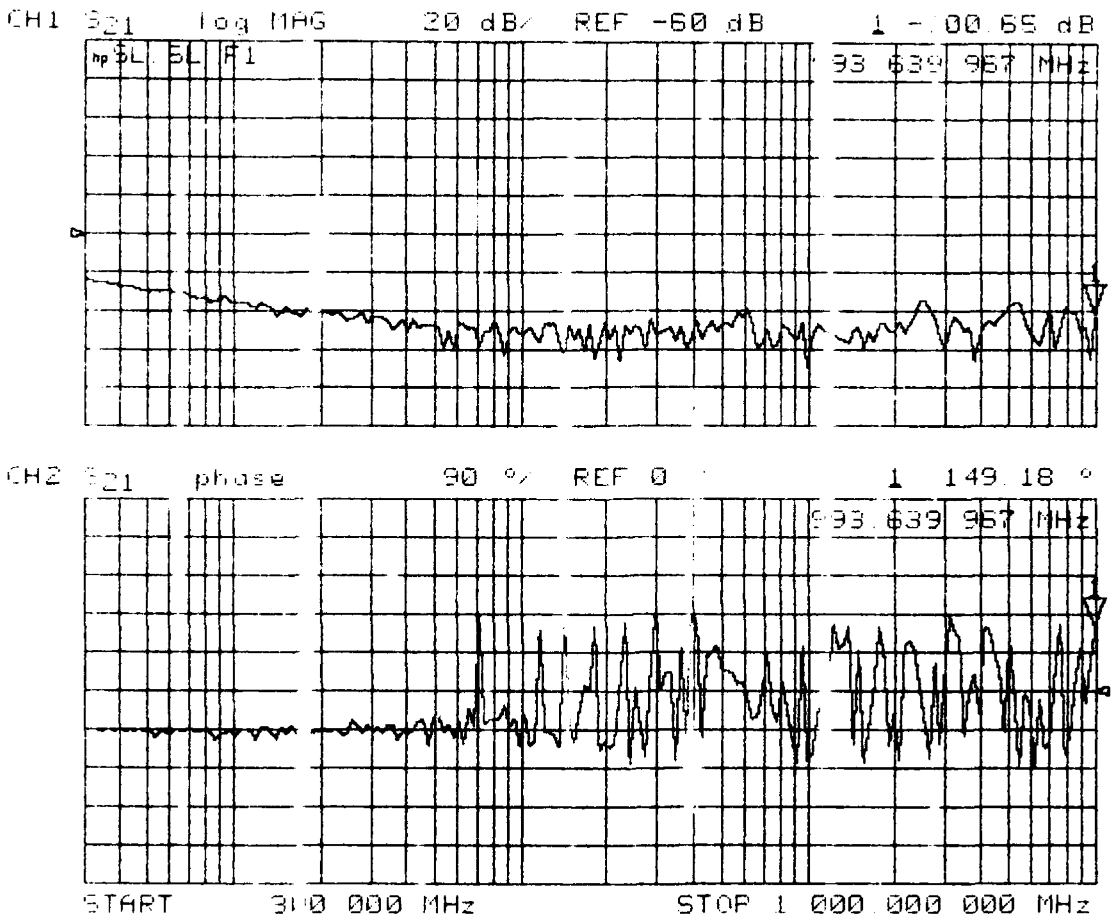


Figure B–21. S21 series loop fault F1, short-circuit termination.

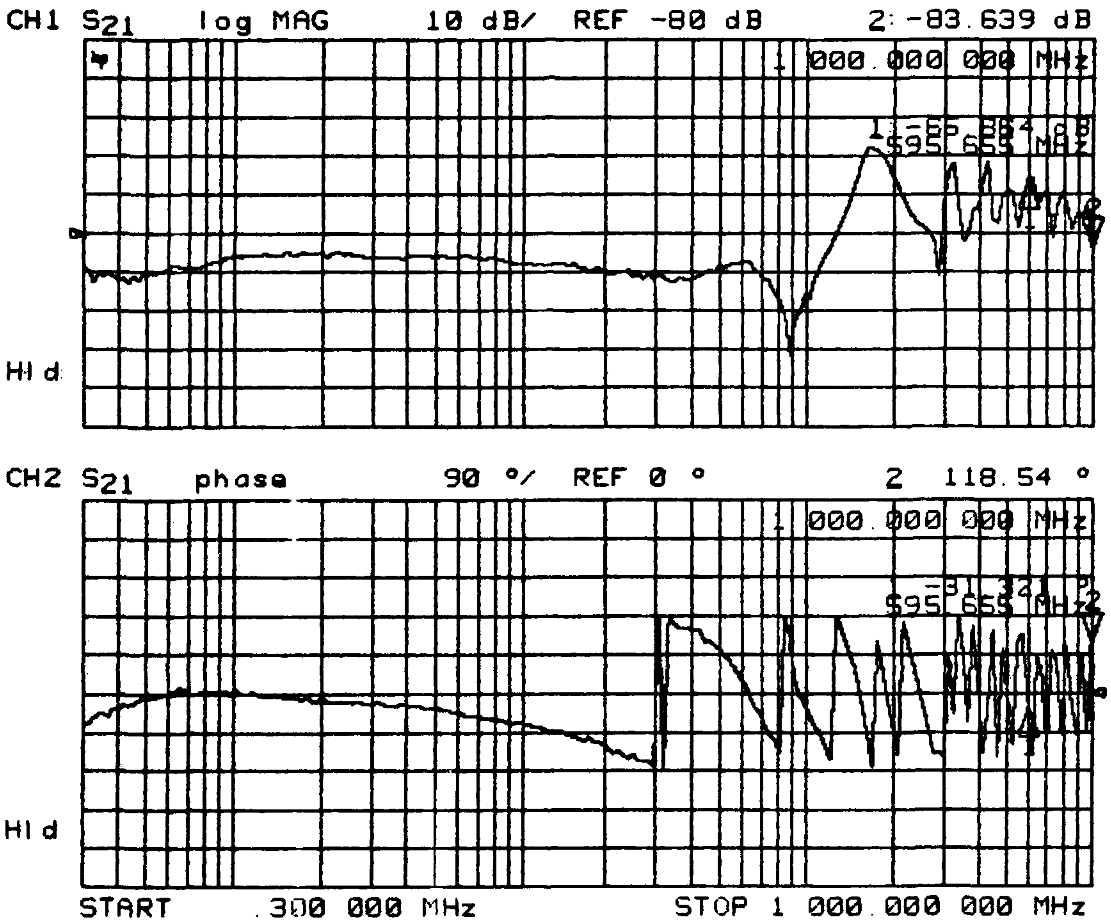


Figure B-22. S21 series loop fault F4, short-circuit termination, 1/2-in elevation.

U.S. GOVERNMENT PRINTING OFFICE 750-113