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ENGINEERING REPORT

CONTRACT NO. NAS 8-1691

ENVIRONMENTAL AND RFI TEST PROCEDURE
200 VOLT D.C. MISSILE POWER SUPPLY
(Interelectronics Corp., Model 28BF3B-AN)

REPORT NO. 00.360 MODEL Saturn

Task Order No. (M-G & C-I) -T -12

Date 15 June 1962

No. of Pages 12

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REVISIONS

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ABSTRACT

This document describes the test procedures for testing of an Interelectronics Inc. Model 28BF3B-AN, miniaturized, solid state, missile power supply. Tests to be performed are Performance Evaluation, Radio Frequency Interference, and Environmental. Environmental tests include Temperature, Altitude, Vibration, Shock, Moisture, Thermal Shock, and Acceleration.

All testing shall be in accordance with Task Order No. (M-G & C-I)-T-12 dated 11 May 1962.

REFERENCE DOCUMENTS

1. Task Order No. (M-G & C-I)-T-12, dated 11 May 1962

2. Guidance and Control Division, Preliminary Environmental Requirements for Saturn Booster (SA-1, SA-2, and SA-3)

3. Military Specification Mil-I-6181D, Interference Control Requirements, Aircraft Equipment

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1.0 SUMMARY

The purpose of this test procedure is to present a detailed plan for the accomplishment of performance evaluation, radio frequency interference, and environmental testing of a minaturized, solid state, missile power supply. Environmental conditions to which the power supply will be subjected are Temperature, Altitude, Vibration, Shock, Moisture, Thermal Shock, and Acceleration.

2.0 TEST SPECIMEN

The test specimen shall consist of one (1) all silicon, miniaturized, solid state, missile power supply, Interelectronics Corporation, Model 28BF3B-AN "Interverter", Serial Number 233771. The test specimen operates with a nominal input voltage of 28 volts d-c and delivers 200 volts d-c at 100 ma. The "Interverter" has a 2 inch square mounting base with a height of 2 inches and weighs 15 ounces.

3.0 TESTING SEQUENCE

The following test sequence shall be observed unless equipment conflicts necessitate minor changes to avoid serious delay in the completion of the test program:

a. Performance Evaluation (ambient)

b. High Temperature

c. Low Temperature

d. Altitude

e. Vibration

f. Shock

g. Moisture

h. Radio Frequency Interference

i. Thermal Shock

j. Acceleration

k. Performance Evaluation (ambient)

4.0 TEST EQUIPMENT

The following equipment, or equivalent, shall be required for the performance of the tests listed herein. All electronic test equipment shall possess a valid certification stamp as proof of performance within the manufacturer's specifications.

Item	Manufacturer	Type
Power Supply	Lambda	L2095M
Shunt	Weston	9992
Millivoltmeter	Weston	622
Oscilloscope	Tektronix	545
Voltmeter	Weston	931
Ammeter	Phaostron	625
Oscilloscope	Hewlett Packard	130A
Differential Voltmeter	John Fluke	803
Vibration Facility	Ling PP 20-20/C with MB C-25H Exciter	
Shock Machine	Barry	20 VI
Temperature Chamber	Bemco	AF-100/500-27
G-Accelerator	Genisco	A 1030

Item	Manufacturer	Type
Altitude Chamber	CVC	SCI-14B
Humidity Chamber	American Instruments	
Accelerometer	Endevco	2211
Amplifier	Endevco	2216
RMS Voltmeter	Ballantine	320
Recorder	Sanborn	150

5.0 PERFORMANCE EVALUATION TEST

A performance evaluation test, as specified in paragraphs 5.1 through 5.4, shall be conducted at laboratory ambient conditions prior and subsequent to environmental testing to provide data for evaluation of environmental exposure. All tests shall be performed with the test specimen mounted on a 4 x 4 x 1¼ inches aluminum heat sink. Portions of the evaluation test shall be repeated, as specified herein, during the environmental tests.

5.1 Input Current and Ripple

The test setup shall be as illustrated in Figure 1, page 11 The input voltage shall be adjusted to 28 volts d-c and the input current and ripple (reflected to the power source) measured for resistive loads of 2500, 2000, and 1667 ohms. The measurements shall then be repeated for input voltages of 25 and 31 volts d-c. All data shall be recorded in the form indicated by Figure 2, page 12.

5.2 Output Voltage, Output Current, Output Ripple

The test setup shall be as illustrated in Figure 1, page 11. The input voltage shall be adjusted to 28 volts d-c and the output voltage, current, and ripple measured with resistive loads of 2500, 2000, and 1667 ohms. The measurements shall be repeated for input voltages of 25 and 31 volts d-c. Output measurements may be performed concurrently with the input measurements of paragraph 5.1. All data shall be recorded in the form indicated by Figure 2 page 12.

5.3 Short Circuit Protection

The test setup shall be as illustrated by Figure 1, page 11. The input voltage shall be adjusted to 28 volts d-c and the input current, output voltage, and output current, recorded for a resistive load of 2000 ohms. The test specimen output shall be shorted and the above measurements repeated. The short circuit shall be replaced after thirty seconds with the 2000 ohm load and the previous measurements repeated. All data shall be in the form indicated by Figure 2, page 12.

5.4 Open Circuit Protection

The test setup shall be as illustrated by Figure 1, page 11. The input voltage shall be adjusted to 28 volts d-c and the input current, output voltage and output current recorded for a resistive load of 2000 ohms. The 2000 ohm load shall be removed and the input current and output voltage measured for a no-load condition. The 2000 ohm

load shall be replaced after 30 seconds of no load operation, and the input current, output voltage, and output current recorded. All data shall be presented in the form indicated by Figure 2 page 12.

6.0 ENVIRONMENTAL TESTS

Abbreviated evaluation tests shall be conducted as specified herein to provide data for evaluation of the effect of environmental conditions upon the test specimen. Because of the evaluation nature of the test program, failure of the test specimen to conform to specifications shall not necessarily cause discontinuation of the testing. All data shall be recorded in the form indicated by Figure 2, page 12.

6.1 High Temperature

The test specimen shall be placed in a test chamber and a reference test performed at laboratory ambient conditions. The reference test shall consist of the tests of paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4 respectively. After completion of the reference test, the test specimen shall be de-energized and a thermocouple installed adjacent to the test specimen. The chamber temperature shall be increased and the test specimen temperature stabilized at 71°C (160°F). The test specimen shall be subjected to the test temperature for two hours after stabilization occurs. While still at the test temperature the test specimen shall be energized and the reference test repeated. After completion of the reference test, the test specimen shall be de-e

and the chamber temperature increased to 100°C (212°F). The test specimen shall be stabilized, and maintained at 100°C for two hours. While still at the test temperature, the test specimen shall be energized and the reference test repeated. After completion of the reference test, the test specimen shall be de-energized and allowed to return to laboratory ambient conditions.

6.2 Low Temperature

Low temperature tests shall be accomplished with the procedure of paragraph 6.1, page 5, except the test temperatures shall be -17°C (2°F) and -54°C (-65°F) respectively.

6.3 Altitude

The test specimen shall be placed in a test chamber and a reference test performed at laboratory ambient conditions. The reference test shall be as specified in paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4. The test specimen shall be de-energized and the test chamber pressure reduced to 10^{-4} millimeters of mercury. While at the simulated altitude, the test specimen shall be energized and the reference test repeated. After all test measurements are complete, the test specimen shall be de-energized and the chamber pressure returned to laboratory ambient conditions.

6.4 Vibration

6.4.1 Definition of Axes

For purpose of the test program, the test specimen axes are defined as follows: the longitudinal axis is defined to be parallel with the longest dimension of the electrical connector; the vertical axis is defined to be perpendicular to the mounting base; the

lateral axis is defined to be perpendicular to the vertical and longitudinal axes.

6.4.2 Vibration Testing

The test specimen shall be rigidly attached to the vibration exciter and a reference test performed at laboratory ambient conditions. The reference test shall be as specified in paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4. The reference test shall be repeated after all vibration testing is completed. During application of the vibration environment, the test specimen shall be operated with an input voltage of 28.0 volts d-c, and a 2000 ohm resistive load. The input voltage, input current, output voltage, output current, and output ripple shall be monitored during application of the vibration environment.

An accelerometer shall be mounted as near the test specimen as feasible for monitoring and control purposes. Vibration system response shall be equalized flat within ± 3 db at a vibration level of ± 2 g's. The test specimen shall then be subjected to the following random motion in each of the three axes defined in paragraph 6.4.1:

Test Time Seconds	Test Level g rms	Bandwidth cps
4	20	20 - 2000
180	10	20 - 2000

6.5 Shock

The test specimen shall be rigidly attached to the shock machine table and a reference test performed at laboratory ambient

conditions. The reference test shall be as specified in paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4. The reference test shall be repeated after all shock tests are completed. During the shock impact, the input voltage, input current, output voltage, output current, and output ripple shall be monitored. The test specimen shall be operating during the shock impact with an input voltage of 28 volts d-c and a resistive load of 2000 ohms.

The test specimen shall be subjected to one (1) shock of 100 g's peak magnitude in each direction of the three major axes defined in paragraph 6.4.1. The shock wave shall approximate a square wave of 6.6 milliseconds duration.

6.6 Moisture

The test specimen shall be placed in a Humidity Chamber and a reference test performed at laboratory ambient conditions. The reference test shall be as specified in paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4. After completion of the reference test, the test specimen shall be de-energized and dummy plugs installed on the electrical connector during the exposure period. The test specimen shall be subjected to ten (10) of the following humidity cycles.

Test Time	Test Temperature	Humidity
0	25°C to 38°C	Uncontrolled
0.4 hours	increasing to 71°C	95%
1.2 hours	stabilized 71°C	95%
3.2 hours	decreasing to (25° to 38°C)	95%

After completion of the test period the test specimen shall be removed from the test chamber and the above reference test repeated within one hour.

6.7 **RFI**

Radio Frequency Interference testing shall be conducted in accordance with Appendix A of this document.

6.8 Thermal Shock

The test specimen shall be energized and the reference tests of paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4, performed at laboratory ambient conditions prior and subsequent to thermal shock exposure. The latter test shall be performed within one hour after completion of the exposure period. The test article shall be de-energized throughout the exposure period and the electrical connector terminated with a dummy plug.

The test specimen shall be placed in a test chamber with an internal temperature of 71°C (160°F). The test specimen shall be subjected to the 71°C temperature for a period of two (2) hours, at the conclusion of which, and within 5 minutes, the test specimen shall be transferred to a test chamber having an internal temperature of -17°C (2°F). The test specimen shall be subjected to the -17°C temperature for a period of two (2) hours. This completes one thermal-shock cycle. The test specimen shall be subjected to a total of three (3) thermal shock cycles.

6.9 Acceleration

The test specimen shall be rigidly attached to the centrifuge basket and a reference test performed at laboratory ambient conditions. The reference test shall be as specified in paragraphs 5.1, 5.2, 5.3 and 5.4, pages 3 and 4. The reference test shall be repeated after all acceleration tests are completed. During the acceleration environment, the test specimen shall be energized with 28 volts d-c and the input voltage, input current, output voltage, and output current monitored for variations.

The test specimen shall be subjected to an acceleration of 50 g's for one (1) minute in each direction of the three axes defined in paragraph 6.4.1, page 6.

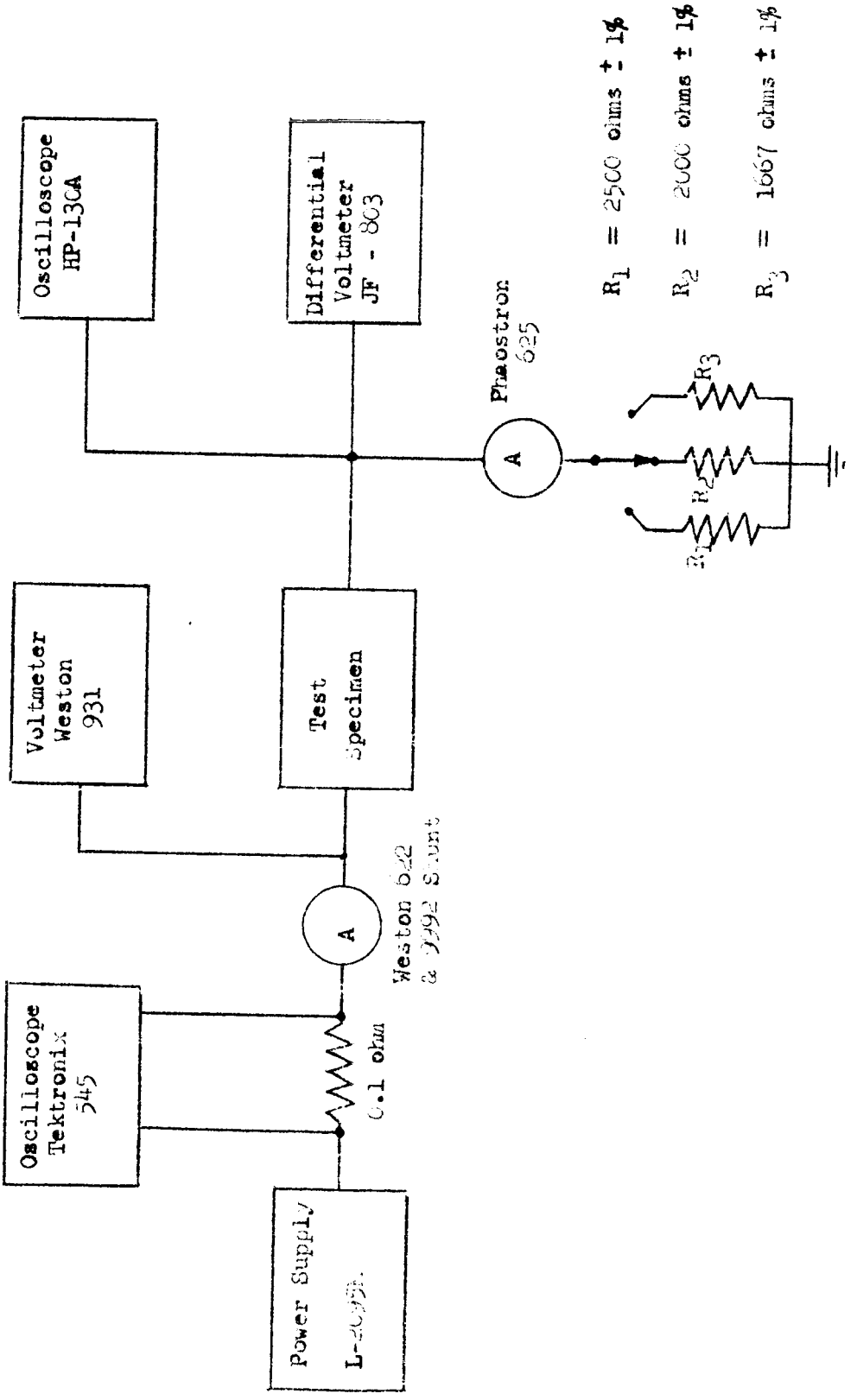

FIGURE 1

BASIC TEST SETUP

FIGURE 2

DATA SHEET

Interelectronics Model 28BF3B-AN Missile Power Supply

S/N 23371 Date:

Input - Output Parameters

INPUT			OUTPUT			
Voltage volts d-c	Current ma d-c	Ripple * mv p-p	Voltage volts d-c	Current ma d-c	Ripple mv p-p	Load ohms
28						2000
28						2500
28						1667
25						2000
25						2500
25						1667
31						2000
31						2500
31						1667

* Measured across 0.1 ohm resistor

Short Circuit and Open Circuit Protection

INPUT		OUTPUT		
Voltage Volts d-c	Current ma d-c	Voltage Volts d-c	Current ma d-c	Load Condition
28				2000 ohms
28				Short circuit**
28				2000 ohms
28				Open Circuit **
28				2000 ohms

** Load condition to be maintained 30 seconds

APPENDIX A

RADIO FREQUENCY INTERFERENCE TEST PROCEDURE

200 VOLT D.C. MISSILE POWER SUPPLY

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1.0 PURPOSE - The purpose of this procedure is to present the test methods to be followed in performing interference and susceptibility tests on the test specimen. These tests will provide engineering data covering possible interference problem areas whose reduction or elimination may be required to assure that the test specimen can be operated in close proximity with other electrical and electronic equipment without generating or being affected by electromagnetic interference.

2.0 INTERFERENCE TESTS TO BE PERFORMED - The RF Interference and susceptibility tests to be performed on the test sample are presented below:

Test No. 1. Measurement of R. F. Conducted Interference generated by the Test Sample (150 KC through 25 MC).

Test No. 2. Measurement of R. F. Radiated Interference generated by the Test Sample (150 KC through 10 GC).

Test No. 3. Susceptibility of the Test Sample to R. F. Radiated Interference (150 KC through 10 GC).

Test No. 4. Susceptibility of the Test Sample to R. F. Conducted Interference (150 KC through 10 GC).

Test No. 5. Susceptibility of the Test Sample to Audio Conducted Interference (50 through 15,000 c.p.s.).

3.0 TEST EQUIPMENT REQUIRED

3.1 INTERFERENCE TEST EQUIPMENT - A list of typical test equipment required in the performance of RFI Tests is provided in Table I, Addendum I.

4.0 GENERAL PROCEDURES FOR INTERFERENCE TESTS

4.1 TEST LOCATION - The RF interference and susceptibility test shall be performed within a cell type copper mesh shielded enclosure having a working area at least 16' x 10' x 8'. The enclosure shall contain a copper ground plate at least 0.01 in. thick with a surface area of 12

square feet or more. The ground plane shall be bonded to the screen room at both ends and at intervals no greater than three feet along three edges of the ground plane.

4.2 SCREEN ROOM FILTERS - All primary power leads entering the screen room from laboratory power sources shall be filtered with low pass RF filters that provide RF attenuation characteristics over a frequency range from 150 KC to 10 GC.

4.3 TEST ARRANGEMENT - Typical test arrangements for interference tests and susceptibility measurements are presented in Figures 1 and 2, Addendum I. Photographs of the actual test setup shall be made at the time interference tests are performed.

4.4 LINE IMPEDANCE STABILIZATION NETWORKS (LISN) - A line impedance stabilization network shall be connected in series with each primary power lead during all interference tests and susceptibility measurements, except when conducted audio susceptibility tests are being made. The metal case of the LISN shall be bonded to the screen room ground plane by copper ground straps. When a respective LISN is not being used to measure conducted RF interference or for injecting an RF signal on to the primary power line during RF conducted susceptibility measurements, the type "N" coaxial connector on the LISN metal case shall be terminated into a 50 ohm shielded load. During conducted audio susceptibility tests, the LISN shall be removed and replaced with the secondary of a stepdown isolation transformer in series with the ungrounded primary power lead being investigated for audio susceptibility.

4.5 INTERCONNECTING LEADS - Interconnecting leads, external leads and cable groups associated with the test sample shall be routed along the front

edge of the screen room ground plane nearest the interference monitoring receiver antenna.

4.5.1 PRIMARY POWER LEADS - Leads supplying primary input power to the test sample shall be 24 ± 1 inch in length, extending from the load side of the LISN to the primary power input connector on the test sample. A physical separation of 2 inches shall be maintained, as close as practical, between each primary power lead and from each power lead to the ground plane.

4.5.2 SHIELDED LEADS - Shielded leads shall not be used during the RF interference tests unless they are specifically required in the system installation. The requirement for shielded leads will be determined by the results of these tests.

4.5.3 LEAD LENGTHS - Leads between the test sample and external loads shall be 5 feet long.

4.6 EQUIPMENT BONDING - Before interference tests are initiated, the test sample and interference measuring instruments shall be bonded to the screen room ground plane as detailed in the following paragraphs.

4.6.1 BONDING OF TEST SAMPLE - The test sample shall be bonded to the screen room ground plane in a manner similar to that required in an actual installation.

4.6.2 BONDING OF INTERFERENCE MONITORING RECEIVERS

4.6.2.1 BONDING OF THE NF-105 NOISE FIELD INTENSITY METER - When RF interference measurements are made, the NF-105 receiver shall be bonded to the screen room ground plane at a single point. During conducted RF interference measurements, the NF-105 receiver shall be bonded to the screen room ground plane through the coaxial cable connected to the LISN. When the RF current probe is used, the NF-105 receiver shall be bonded to the

screen room ground plane using the ground strap normally supplied with the NF-105 receiver. During radiated RF interference measurements in the frequency range from 150 KC to 25 MC, the NF-105 receiver shall be bonded to the screen room ground plane through the 41" vertical rod antenna counterpoise. When radiated interference measurement in the frequency range from 25 MC to 1000 MC is made, the tuned dipole shall be used and the NF-105 shall be bonded to the screen room ground plane using the ground strap normally supplied with the receiver.

4.6.2.2 BONDING OF THE NF-112 NOISE FIELD INTENSITY METER - When radiated interference measurements are being made in the frequency range from 1 through 10 GC, the NF-112 shall be bonded to the screen room ground plane through the NF-112 chassis return line in the power cord.

4.7 TEST SAMPLE OPERATION - The test sample shall be energized and operated under normal conditions, using typical electrical loads.

4.8 FUNCTIONAL TESTS - Functional tests shall be repeated periodically during the interference tests to assure that the test sample continues to provide its normal output.

4.9 TEST SAMPLE CONTROLS - There are no external controls on the test sample that require operation for the purposes of determining RF interference caused by control actuation.

4.10 FREQUENCIES AT WHICH INTERFERENCE MIGHT BE EXPECTED - The test sample contains intentional oscillatory circuits; therefore, narrowband interference is likely to be encountered at the fundamental frequency and harmonics. Broadband interference is expected from the gating diodes contained in the test sample.

4.11 PRIMARY POWER INPUT AND OUTPUT VOLTAGE

The connector used on the test sample is a Cannon type DE-9P, with 9 pins.

Connector pin numbers, circuit functions, primary power voltages and typical loads are as follows: (all leads are unshielded)

PIN NO.	CIRCUIT FUNCTION	OUTPUT OR INPUT	IMPEDANCE OHMS
1	+ 28V DC	Input (Primary Power)	
2	Not Connected	-	
3	Not Connected	-	
4	Not Connected	-	
5	+ 200V DC	-	2000 ohms (to Pin 9)
6	- 28V DC	Input (Primary Power)	
7	Not Connected		
8	NotCConnected	-	
9	-200V DC	-	2000 ohms (to Pin 5)

4.12 ELECTRICAL AND MECHANICAL LOADS

4.12.1 ELECTRICAL LOADS - The output circuit of the test sample shall be terminated into a typical resistive load as given in paragraph 4.11. The load used shall be mounted in a small metal box and unshielded leads 5' in length shall be used between the test sample and the load.

4.12.2 MECHANICAL LOADS - There are no mechanical loads associated with the operation of the test sample.

4.13 INTERFERENCE MONITORING RECEIVER OPERATION PROCEDURES

4.13.1 SELECTION OF TEST FREQUENCIES - During the radio frequency interference test, "Test Frequencies" shall be selected by slowly scanning the frequency range of each frequency band associated with the interference

monitoring receiver and recording those frequencies where maximum interference levels occur. In the event that interference levels are relatively constant and no obvious interference peaks are observed, the test sample interference, the interference monitoring receiver inherent background noise levels and the radiated ambient interference levels shall be recorded at those test frequencies given in Table II, Addendum I. In any event a minimum of three (3) test frequencies shall be selected in each continuous tuning range of the interference monitoring receiver.

4.13.2 ANTENNA ORIENTATION - During radiated RF interference and RF radiated susceptibility tests, the interference monitoring receiver or signal generator antenna shall be set up near the center of the screen room test setup, while searching for interference peaks, then oriented along a line parallel to the screen room ground plane and positioned in accordance with paragraph 4.2.6 of Specification MIL-I-6181D where maximum interference levels are indicated.

4.13.3 NF-105 NOISE AND FIELD INTENSITY METER OPERATION - The Empire Devices Noise and Field Intensity Meter, Model NF-105, shall be used as the interference monitoring receiver during tests in the frequency range from 150 KC to 1000 MC. The frequency range of the NF-105 receiver shall be slowly scanned during the radiated and conducted RF interference tests in search of interference peaks which result from normal operation of the test sample.

4.13.3.1 During radiated RF interference measurements in the frequency range from 150 KC to 25 MC, the (VA-105) 41" vertical rod antenna shall be used for monitoring interference radiating from the test sample. In the frequency range from 25 MC to 1000 MC, the tuned dipole antenna

(DM-105) shall be used to monitor interference radiating from the test sample.

4.13.3.2 The antenna input terminal of the NF-105 receiver shall be connected to a line impedance stabilization network or to the RF current probe when conducted RF interference measurements are being made.

4.13.4 NF-105 RECEIVER CALIBRATION - At each test frequency, the NF-105 receiver shall be calibrated using the impulse generator, within the receiver, as the calibration source. Standard calibration procedures outlined in the NF-105 Noise and Field Intensity Meter instruction manual shall be used. The aural output and visual panel meter shall be monitored continuously throughout the interference test to assist in identifying the type and determining the level of interference observed.

4.13.4.1 At each test frequency the interference observed shall be identified and recorded as broadband (BB) or narrowband (NB or CW). If broadband interference is encountered, the NF-105 receiver shall be calibrated with the function switch in the PEAK position using the inpulse generator and the signal substitution method of measurement. The interference level shall be measured with the function switch in the PEAK position.

4.13.4.2 If narrowband interference is encountered, the NF-105 receiver shall be calibrated with the function switch in the PEAK position using the impulse generator and the two terminal voltmeter method of measurement. The level of narrowband interference shall be measured with the function switch in the CARRIER position. At each test frequency the 41" vertical rod antenna frequency band select switch shall be positioned to the frequency band in which measurements are being made. For test frequencies from 25 MC to 35 MC the dipole antenna shall be tuned to 35 MC.

For frequencies above 35 MC, the dipole antenna shall be tuned to the specific test frequency from 35 MC to 1000 MC.

4.13.5 NF-112 MICROWAVE INTERFERENCE RECEIVER - The Empire Devices Noise and Field Intensity Meter, Model NF-112, shall be used for RF interference measurements in the frequency range of 1 GC to 10 GC. Each tuning range of the NF-112 shall be slowly scanned while searching for interference peaks. Standard operating procedures outlined in the instruction manual for the receiver shall be followed.

4.13.5.1 NF-112 CALIBRATION - The NF-112 Microwave Interference Receiver shall be calibrated at each test frequency using the internal impulse generator. The direct calibrating method shall be used in measuring the interference levels encountered. To calibrate the NF-112, place the READ-CALIBRATE switch to the CALIBRATE position, set the FUNCTION SWITCH to PULSE PEAK and set the SIGNAL INPUT ATTENUATOR to the db level required for the frequency by the calibration chart in the instruction manual. Place the BANDWIDTH switch in the WIDE position, set the IMPULSE GENERATOR LEVEL switch to maximum of 53 DB, turn the IMPULSE GENERATOR switch to the ON position and set the IF GAIN for meter reading to the value indicated for the desired frequency in the calibration chart. Turn the IMPULSE GENERATOR switch to OFF and turn the READ-CALIBRATE switch to READ. The NF-112 is ready to make broadband measurements with the bandwidth switch in the WIDE position and the function switch in the PULSE PEAK position. Narrowband measurements can easily be made by placing the bandwidth switch in the NARROW position and the function switch in the CW PEAK or CW AVERAGE depending on whether the signal is modulated or unmodulated.

5.0 DETAILED PROCEDURES FOR INTERFERENCE TESTING

5.1 GENERAL TEST INFORMATION - Particular information concerning the test sample and screen room test arrangement shall be recorded on data sheets similar to those in Addendum 1, as soon as the test setup is completed.

5.2 AMBIENT INTERFERENCE MEASUREMENTS - The ambient interference levels within the shielded enclosure shall be determined under the following conditions.

5.2.1 TEST SAMPLE AND EQUIPMENT OPERATION DURING AMBIENT TESTS

While radiated ambient interference levels are being made, the test sample and all other equipment inside the shielded enclosure test area, with the exception of the interference monitoring receiver, shall be turned OFF.

5.2.2 INTERFERENCE MONITORING RECEIVER OPERATION DURING AMBIENT TESTS

The interference monitoring receiver, Noise and Field Intensity Meter (NFIM), shall be energized and the receiver frequency ranges from 150 KC to 10 GC shall be slowly scanned for any evidence of ambient interference peaks. The radiated ambient interference levels shall be measured with the antenna of the interference monitoring receiver located near the center of the screen room in their approximate test positions with respect to the screen room ground plane. Radiated ambient interference and the interference monitoring receiver background level shall be recorded on data sheets similar to those contained in Addendum 1. In the event that no interference peaks are found, the radiated ambient and receiver background levels shall be recorded at a minimum of three test frequencies, selected from Table II, Addendum 1,

in each continuous tuning range of the interference monitoring receiver being used.

5.2.3 INTERFERENCE MONITORING RECEIVER RF LEAKAGE TESTS - For the purposes of this test, RF leakage is defined as interference resulting from a coupling medium other than through the receiving antenna.

The interference monitoring receiver and the test sample shall be energized. The signal input of the interference monitoring receiver shall be terminated at the antenna end of the coaxial cable with a 50 ohm coaxial RF load. The frequency range of the interference monitoring receiver shall be scanned to determine if RF leakage is present.

Usually, when interference monitoring receivers have been approved by military agencies for use in interference control specification testing, RF leakage will not be encountered unless the test sample and/or test arrangement produces a high density RF Field. If no RF leakage is found during these tests, the meter readings on the interference monitoring receiver will be synonymous with the receiver's internal background noise levels. Since the receiver background levels were recorded in the ambient tests above, and to conserve test time, meter readings observed during the RF leakage tests shall not be recorded. On the other hand, if objectionable RF leakage (above specification requirements) is found during normal operation of the test sample, the test arrangement shall be reconsidered and corrective action initiated to minimize RF leakage before interference tests proceed.

The corrective action which shall be applied is as follows. With the interference monitoring receiver's antenna remaining in its normal position inside the shielded enclosure, the interference monitoring

receiver shall be moved outside the shielded enclosure to minimize RF leakage of the receiver.

If at the time RF conducted and RF radiated measurements are made, the ambient plus the test sample interference levels does not exceed the limits as specified by the applicable specification, the test sample shall be considered to have met specification requirements.

5.3 **INTERNAL NOISE LEVEL OF INTERFERENCE MONITORING RECEIVER**

The internal noise level of the interference monitoring receiver shall be measured and recorded at each test frequency with the function switch on the appropriate positions required by the characteristics (Broadband or Narrowband) of the interference encountered.

5.4 **TEST NO. 1 - CONDUCTED RF INTERFERENCE TEST (150 KC - 25 MC)**

5.4.1 The purpose of this test is to determine the RF interference levels conducted from the test sample by primary power leads and any other leads which may be capable of conducting interference to other equipments. The following step by step procedure shall be followed as closely as possible.

5.4.2 Position the test sample on the ground plane of the shielded enclosure test area in a manner similar to that shown in Figure 1, Addendum I. Once established, this test arrangement is to be maintained during each of the remaining tests.

5.4.3 Bond the test sample to the ground plane.

5.4.4 Select the positive 28V DC Primary Power input lead as the initial lead to be investigated for conducted RF interference.

5.4.5 Directly connect the signal input terminal of the NF-105 to the type "N" coaxial connector located on the LISN in series with the respec-

tive primary power lead being investigated for conducted RF interference with the 30 foot length of RG-55/U double shielded 50 ohm coaxial cable supplied with the receiver.

Terminate the unused type "N" coaxial connectors on the LISN used on the negative 28V DC with a shielded 50 ohm load.

5.4.6 Apply the required primary input power voltages to the NF-105 and to the test sample (5 minute warm-up recommended.)

5.4.7 Determine that the test sample is operating correctly under normal load conditions before proceeding with conducted RF interference measurements.

5.4.8 Slowly tune through the frequency range of the NF-105 receiver and perform RF conducted interference measurements as required over the frequency range from 150 KC to 25 MC. Record the interference levels at those frequencies where maximum interference peaks are observed. A minimum of three test frequencies shall be selected in each continuous tuning range of the interference monitoring receiver (refer to paragraph 4.13.1.) Calibrate the NF-105 receiver at each test frequency with the function switch in the Peak position. When interference levels are measured place the detector switch in the Peak position for broadband (BB) and in the CARRIER position for narrowband (NB) interference signals.

5.4.9 Record the observed interference levels on Data Sheet 4, Addendum 1.

5.4.10 Specification limits for RF conducted interference levels using LISN's are presented in graphical form in Figures 3 and 4, Addendum 1.

5.4.11 Repeat the above conducted RF interference measurements on the negative 28V DC power lead.

5.4.12 Using the clamp-on RF current probe, measure the RF conducted interference levels existing on the output leads of the test sample. Note, the current probe is clamped around the two leads simultaneously.

5.4.13 At each test frequency position the RF current probe along the cable group to the point where maximum interference levels are indicated.

5.4.14 Record the RF current probe position and the measured interferenc levels on Data Sheet 4, Addendum I.

5.4.15 Specification limits for RF conducted interference using the current probe are presented in graphical form in Figures 5 and 6, Addendum 1.

5.5 **TEST NO. 2 - RADIATED RF INTERFERENCE TEST (150 KC - 10 GC)**

5.5.1 The purpose of this test is to determine the RF interference levels radiating from the test sample and its interconnecting leads in the frequency range from 150 KC to 10 GC.

5.5.2 For this test, the test sample is to remain in the same position on the screen room ground plane as specified in TEST No.1, paragraph 5.4.2.

5.5.3 Terminate the unused Type "N" coaxial connector on each LISN into a shielded 50 ohm load.

5.5.4 Apply power to the NF-105 and allow sufficient time to complete normal warm-up of the receiver (3 to 5 minutes).

5.5.5 Apply power to the test sample (5 minute warm-up recommended).

5.5.6 Determine that the test sample is operating correctly under normal load conditions before proceeding with the test.

5.5.7 Connect the signal input of the NF-105 receiver to the 41" vertical rod antenna with the 30 foot length of RG-55/U coaxial cable. Position the rod antenna 8" away and the base of the vertical rod 0" (counterpoise 10") below the front edge of the ground plane. Orient the antenna along a line parallel with the screen room ground plane to that

position where maximum interference levels are indicated. Refer to paragraph 4.13.2.

5.5.8 Slowly scan the frequency range from 150 KC to 25 MC, selecting test frequencies in accordance with paragraph 4.13.1.

5.5.9 At those frequencies selected for measurement, make broadband or narrowband measurements as indicated by the type of interference encountered. Broadband measurements are to be made in all cases where narrowband interference is not encountered. The vertical rod antenna frequency band select switch position shall be consistent with and correspond to the test frequency.

5.5.10 Record the measured interference levels on Data Sheet 4, Addendum I.

5.5.11 When measurements using the vertical rod antenna are completed from 150 KC to 25 MC, set up the tuned dipole antenna and repeat the above measurements over a frequency range from 25 to 1000 MC. At frequencies from 25 to 35 MC, measure the interference levels with the dipole antenna adjusted to 35 MC. At all other frequencies up to 1000 MC, tune the dipole antenna to the respective test frequency. Orientate the antenna in accordance with paragraph 4.13.2, herein.

5.5.12 Specification limits for RF radiated interference levels from 150 KC to 1 GC are presented in graphical form in Figures 7, 8, 9 and 10, Addendum I.

5.5.13 The same techniques outlined above are to be followed during RF radiated interference measurements between 1 GC and 10 GC using the NF-112 microwave receiver and its associated antenna.

5.5.14 Record the measured interference levels on Data Sheet 4, Addendum I.

5.5.15 Specification limits for radiated RF interference levels from 1 to 10 GC are presented in graphical form in Figures 11 and 12, Appendix I.

5.6 **TEST NO. 3 - RADIATED RF SUSCEPTIBILITY TEST (150 KC to 10 GC)**

5.6.1 The purpose of this test is to determine the susceptibility characteristics of the test sample and its interconnecting leads to an RF signal radiating from a test antenna in close proximity with the test sample over the frequency range from 150 KC to 10 GC.

5.6.2 Replace the NF-105 receiver used in Test No. 2 with a Hewlett-Packard Model 606A (50 KC - 65 MC) signal generator.

5.6.3 The susceptibility test antennas and the specification requirements for RF signal levels to be applied to the test antenna are presented in Table III, Addendum I.

5.6.4 The RF signal generator, 41" vertical rod antenna and matching networks shall be set up as required by specification MIL-I-6181D for radiated susceptibility measurements with the test antenna positioned one foot from the test sample.

5.6.5 For this test, the test sample is to remain in the same position on the screen room ground plane as specified in Test No. 1, paragraph 5.4.2.

5.6.6 Connect an oscilloscope (Tektronix Model 535 or equivalent) and a Triplett model 630 APL VOM across the 2000 ohm load resistor.

5.6.7 Set the VOM switch to the 300 volt position.

5.6.8 Energize the RF signal generator and the test sample.

5.6.9 Determine that the test sample is operating correctly under normal load conditions.

5.6.10 Inject an RF signal into the radiating test antenna. The RF signal level shall be at least 200,000 microvolts (modulated 30% by a 1000 cps signal) across 50 ohms at the test antenna terminals.

5.6.11 While slowly scanning the signal generator's frequency range from 150 KC to 25 MC, use the 41" vertical rod as the test antenna, and observe

the test sample's monitored outputs for any change or other departure from their normal output characteristics due to the radiating RF signal.

5.6.12 In the event that susceptible frequencies are found, record the change in the normal output with 100,000 microvolts applied to the base of the antenna.

5.6.13 Reduce the level of the signal applied to the antenna until a level is reached where the change in the test sample monitored output is just discernible.

5.6.14 At all susceptible points found, record the data as required by the previous steps (Ref. para. 5.6.12 and 5.6.13).

5.6.15 Refer to Table III, Appendix I, and replace the vertical rod antenna with a dipole antenna, tuned to 35 MC, and positioned one foot from the equipment under test.

5.6.16 Repeat the above procedure over the frequency range from 25 to 35 MC with the dipole antenna tuned to 35 MC, recording the change in the normal output with 100,000 microvolts applied to the antenna and the lowest applied signal where a change in the output is just discernible on Data Sheet 5.

5.6.17 Continue the above procedure using the appropriate signal generators, and dipole antenna over the frequency range from 35 to 1000 MC. Adjust the dipole antenna to the proper length at all frequencies. Record all signal levels and susceptible frequencies on Data Sheet 5, Addendum I.

5.6.18 Continue the above test over the frequency range of 1 to 10 GC using the NF-112 directive microwave antenna positioned three feet from

the equipment under test. The microwave signal generator in this frequency range shall be modulated with a 1000 cycle square wave (duty cycle 0.5).

5.6.19 Radiated RF Susceptibility Limits - Specification MIL-I-6181D requires that the test sample withstand, without degraded performance, an RF signal level of 100,000 microvolts applied to a radiating test antenna positioned in close proximity with the test sample.

5.7 **TEST NO. 4 - CONDUCTED RF SUSCEPTIBILITY TEST (150 KC to 10 GC)**

5.7.1 The purpose of this test is to determine the susceptibility of the test sample to an RF signal applied to each ungrounded primary power input lead.

5.7.2 Replace the NF-105 receiver used in Test No. 1 with a Hewlett-Packard Model 606A (50 KC - 65 MC) signal generator.

5.7.3 For this test, the test sample is to remain in the same position on the screen room ground plane as specified in Test No. 1, paragraph 5.4.2.

5.7.4 The same test sample output is to be monitored in the same manner as in Test No. 3 (ref. paragraph 5.6.6.)

5.7.5 Connect the RF signal generator output through a 5' length of RG-9/U coaxial cable to the type "N" coaxial connector on the LISN in series with the positive 28V DC primary power line.

5.7.6 Energize the test sample and determine that the test sample is operating correctly under normal load conditions.

5.7.7 Set the RF output of the signal generator to 200,000 microvolts (modulated 30% by a 1,000 cps signal) and apply this signal through the LISN to the positive 28V DC primary power line.

5.7.8 The RF signal level of 200,000 microvolts shall be held relatively constant through the range of each RF signal generator used.

5.7.9 While slowly tuning through the signal generators frequency range from 150 KC to 65 MC, observe the test sample monitored outputs for any change or departure from their normal output characteristics due to the applied RF signal.

5.7.10 In the event that susceptible frequencies are found, record the frequency, the change in the normal output with 100,000 microvolts applied to the LISN and the lowest applied signal where a change in the output is just discernible on Data Sheet 5.

5.7.11 Repeat the above conducted RF susceptibility measurements while an RF signal is injected on the negative 28V DC lead, recording the susceptible frequencies, the change in the output with 100,000 microvolts applied to the LISN and the lowest applied signal where a change in the output is just discernible on Data Sheet 5.

5.7.12 Conducted RF susceptibility limits - Specification MIL-I-6181D requires that the test sample withstand, without degraded performance, an RF signal level of 100,000 microvolts applied to each ungrounded primary power input lead.

5.8 <u>TEST NO. 5 CONDUCTED AUDIO FREQUENCY SUSCEPTIBILITY TESTS (50CPS to 15KCS)</u>

The purpose of this test is to determine the susceptibility of the test sample to a 3 volt RMS sine wave audio signal imposed on each ungrounded primary power lead over a frequency range from 50 CPS to 15 KCS.

5.8.2 Select the positive 28V DC lead as the primary power lead on which

the audio signal is to be imposed.

5.8.3 For this test, the test sample shall remain in the same position on the screen room ground plane as in previous tests except that the audio signal shall be imposed on the test sample primary power lead using a test set-up similar to that shown in Figure 2, Addendum 1.

5.8.4 The line impedance stabilization network (LISN) in series with the primary power line being investigated shall be disconnected and electrically replaced with the secondary of an audio stepdown isolation transformer. Connect an audio oscillator to the input of the 60 watt audio power amplifier and connect the output of the power amplifier to the primary of the isolation transformer.

5.8.5 Energize the audio oscillator and power amplifier. Adjust the gain settings on the audio oscillator and amplifier for a 3 volt RMS audio signal, open circuit voltage, on the secondary of the isolation transformer.

5.8.6 Energize the test sample and output monitoring equipment.

5.8.7 The same test sample output is to be monitored in the same manner as in Test No. 3 (ref. Para. 5.6.6).

5.8.8 Determine that the test sample is operating correctly under normal load conditions.

5.8.9 With a 3 volt RMS audio signal applied to the positive 28V DC primary power lead, slowly tune through the range of the audio oscillator from 50 CPS to 15 KCS and observe the test sample monitored output for any change or departure from the normal output characteristic due to the applied audio signal.

5.8.10 In the event that susceptible frequencies are found, record the

frequency, the change in the normal output with 100,000 microvolts applied to the LISN and the lowest applied signal where a change in the output is just discernible on Data Sheet 5.

5.8.11 Repeat the above procedure on the negative 28V DC power line.

5.8.12 Conducted audio frequency susceptibility limits - Specification MIL-I-6181D requires that the test sample withstand, without degraded performance, an audio signal level of 3 volts RMS applied to each ungrounded primary power lead.

ADDENDUM I

Contains pertinent information for performing interference and susceptibility tests and recording test results.

TEST INSTRUMENT DATA

TEST INSTRUMENT	SERIAL NO.	DESCRIPTION	FREQ. RANGE	CALIB. DATE
Empire Devices NFIM Model NF-105		Basic Unit		
T-A/NF-105		Tuning Unit	.150-30MC	
T-1/NF-105		Tuning Unit	20-200MC	
T-2/NF-105		Tuning Unit	200-400MC	
T-3/NF-105		Tuning Unit	400-1000MC	
Empire Devices NF-112		Basic Unit		
T-1/NF-112		Tuning Unit	.9-2.1GC	
T-2/NF-112		Tuning Unit	2.0-4.0GC	
T-3/NF-112		Tuning Unit	3.9-7.2GC	
T-4/NF-112		Tuning Unit	7.0-10.2GC	
Hewlett Packard 606A		Sig. Gen.	50KC-65MC	
" " 608C		Sig. Gen.	10MC-480MC	
" " 612A		Sig. Gen.	480MC-1.2GC	
" " 200CD		Audio Osc.	5CPS-600KC	
" " 400D		VTVM	10CPS-4MC	
" " 212A		Pulse Gen.	5000PPS	
" " 614A		Sig. Gen.	.8-2.12GC	
Polarad MSG-2		Sig. Gen.	2.15-4.6GC	
" " -34		Sig. Gen.	4.2-11GC	
Tektronix 545A		Basic Unit	Scope	
" Vert-Amp		Ca-Head	DC-24MC	
Polarad CA-B		Broadband Antenna	1-10GC	
Empire Devices CP-105		RF Current Probe	.15-30MC	

TABLE II

TEST FREQUENCIES

.15 mc	240.0 mc
.20 mc	300.0 mc
.25 mc	350.0 mc
.30 mc	400.0 mc
.40 mc	450.0 mc
.50 mc	500.0 mc
.60 mc	600.0 mc
.80 mc	700.0 mc
1.0 mc	800.0 mc
1.2 mc	900.0 mc
1.6 mc	1000.0 mc
1.8 mc	1.2 gc
2.0 mc	1.4 gc
2.4 mc	1.6 gc
2.6 mc	1.8 gc
3.0 mc	2.0 gc
4.0 mc	2.4 gc
5.0 mc	2.8 gc
6.0 mc	3.0 gc
8.0 mc	3.4 gc
10.0 mc	3.8 gc
12.0 mc	4.0 gc
14.0 mc	4.4 gc
16.0 mc	4.8 gc
18.0 mc	5.0 gc
20.0 mc	5.5 gc
25.0 mc	6.0 gc
30.0 mc	6.5 gc
40.0 mc	7.0 gc
50.0 mc	7.5 gc
60.0 mc	8.0 gc
80.0 mc	8.5 gc
100.0 mc	9.0 gc
120.0 mc	9.5 gc
150.0 mc	10.0 gc
200.0 mc	

TABLE III

RF RADIATED SUSCEPTIBILITY
ANTENNAS AND SIGNAL LEVELS

Frequency MC	Radiating Test Antenna	Radiated Signal Level Microvolts
.15 to 25	41" Vertical Rod	100,000
25 to 35	NF-105 Dipole Tuned to 35 MC	100,000
35 to 1000	NF-105 Tuned Dipole	100,000
1 to 10 K	Empire Devices Directive Antenna	100,000

RF INTERFERENCE TEST INFORMATION
(SHEET 1)

1. Equipment Nomenclature:

2. Equipment Serial No:

3. List of RFI Tests to be performed: (Give Freq. Range of each test)

	Test Applicable	Frequency Range
RF Radiated Interference		
RF Conducted Interference		
RF Radiated Susceptibility		
RF Conducted Susceptibility		
Audio Frequency Susceptibility		
Antenna Conducted (Receive Condition)		
Antenna Conducted (Transmit Condition)		
Intermodulation		
Front End Rejection		

Other:

4. Electrical and/or Mechanical Loads Required: (List connector and pin nos. for electrical loads)

Connector No.	Pin No.	Load

RF INTERFERENCE TEST INFORMATION
(SHEET 2)

5. Equipment output or functions monitored during susceptibility tests:

6. Conducted interference and conducted susceptibility: (List connector and pin nos. on which conducted measurements are to be made)

Pin No.	Connector No.

7. Identify the type of interference that is anticipated such as transients, Local Oscillator signals, broadband impulse noise, etc:

8. Test Sample Control Operation and positions to be actuated and/or maintained during RFI Test:

RF INTERFERENCE TEST INFORMATION
(SHEET 3)

9. List photographs of Test Set-Up:

10. Block Diagram of RFI Test Set-Up: (Refer to Test Procedures when applicable)

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REPORT DATE:

TEST NO. Saturn

TEMCO AEROSYSTEMS

RF INTERFERENCE TEST DATA SHEET

TEMCO FM 326-4

DATA SHEET 4

TEST SAMPLE: _____ TEST DATE _____

_____ TEST PROCEDURE: _____ TEST SPEC: _____

TYPE OF RFI TEST: _____ DATA RECORDED BY: _____

_____ TEST WITNESSED BY: _____

TEST FREQ. MC S	AMBIENT & METER BG LEVEL DB 1UV MCBW		MEASURED * RFI LEVEL		CORRECT: FACTORS DB	FINAL RFI * LEVEL		MIL SPEC * LIMITS		REMARKS (Describe interference observed)
			BB	CW		BB	CW	BB	CW	
			DB MCBW	DB 1UV		DB MCBW	DB 1UV	DB MCBW	DB	
	METER	AMB								

COMMENTS: * DB above 1 microvolt MC Bandwidth (DB MCBW) or DB above 1 Microvolt
(BB) Broadband — (CW) Narrowband

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00.360
REPORT DATE

TEST NUMBER
Saturn

TEMCO AEROSYSTEMS
RF INTERFERENCE TEST DATA SHEET
SUSCEPTIBILITY TESTS

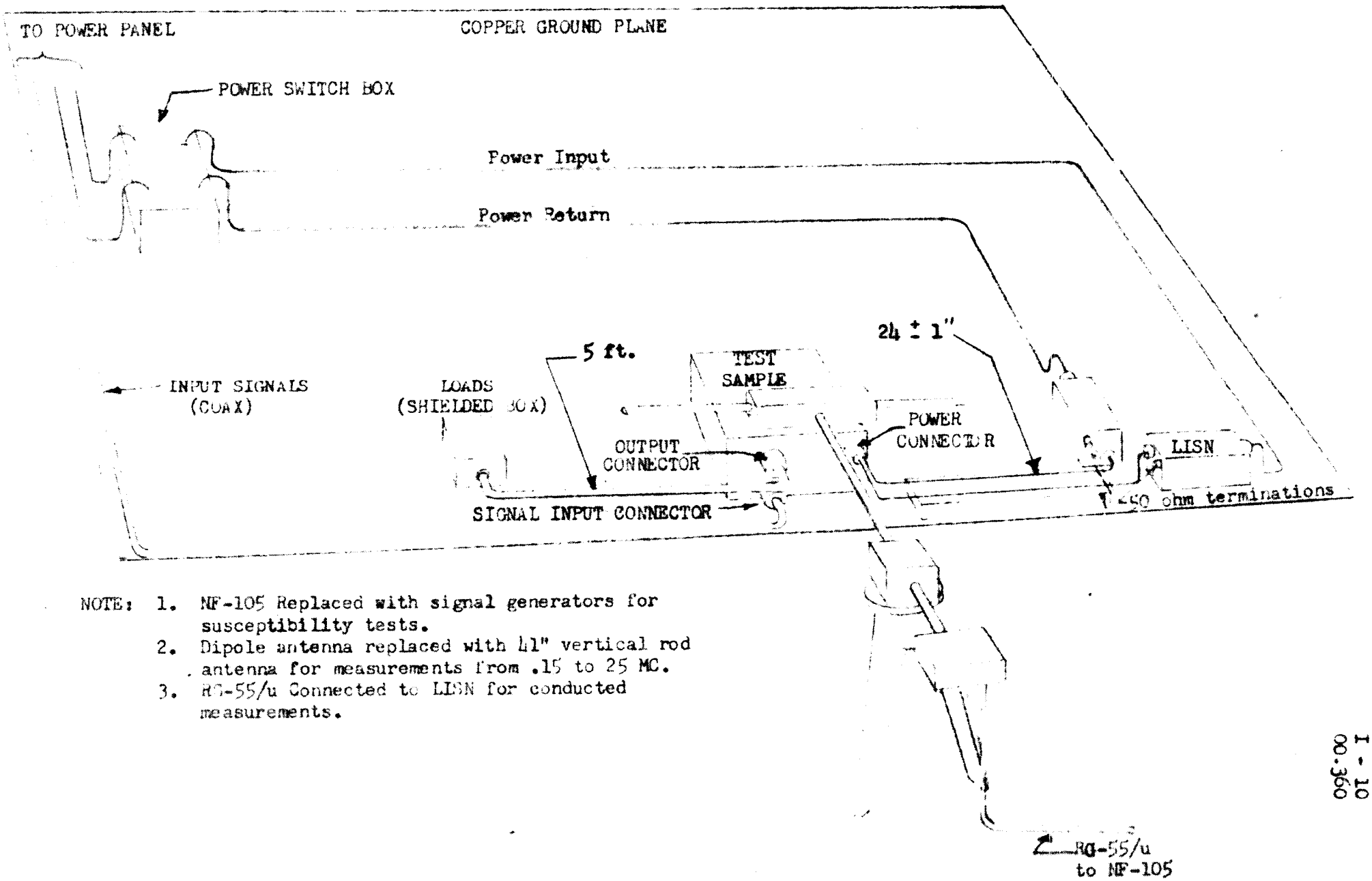
TEMCO FM 936-X

DATA SHEET 5

TEST SAMPLE	TEST DATE
TEST PROCEDURE	TEST SPEC.
TYPE OF SUSCEPTIBILITY TEST	SPEC. LIMIT
WITNESSED BY	DATE RECORDED BY

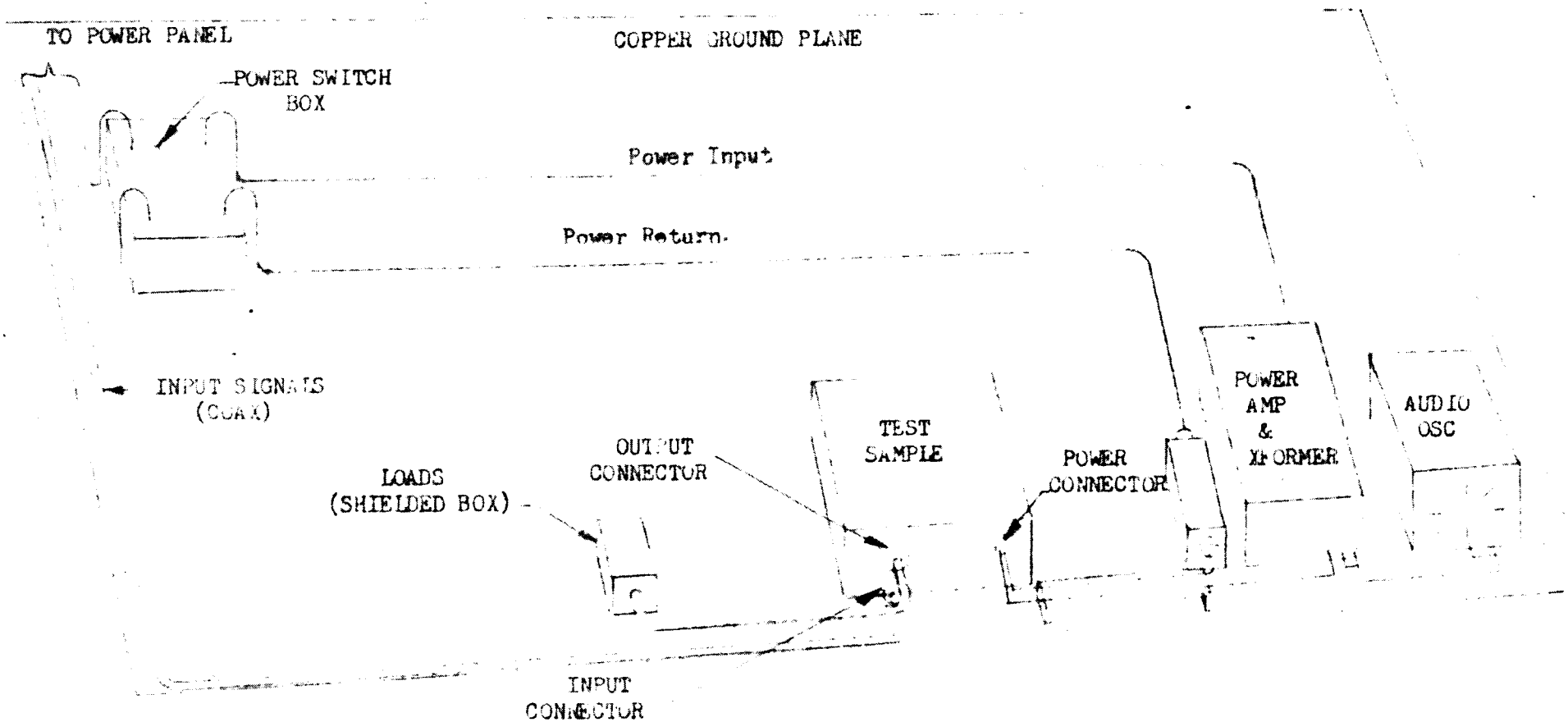
TEST LEVEL MC/S	TEST LEVEL*	CIRCUITS MONITORED	MALFUNCTION		REMARKS
			YES	NO	

* MINIMUM DISCERNABLE SIGNAL LEVEL WHERE RESPONSE CHANGE WAS OBSERVED IN NOTES



NOTE: 1. NF-105 Replaced with signal generators for susceptibility tests.
2. Dipole antenna replaced with 41" vertical rod antenna for measurements from .15 to 25 MC.
3. RG-55/u Connected to LISN for conducted measurements.

FIGURE NO. 1 TYPICAL TEST SET-UP FOR RF INTERFERENCE



NOTES:
1. Audio amplifier shall be 30-50 watts and shall have a low impedance output of 5 ohms or less.
2. Transformer shall carry all currents without saturation.
3. Series capacitor on AC voltmeter shall have a reactance not greater than 1/10 meter impedance.
4. The Voltmeter shall read an open-circuit voltage (test sample disconnected) of 3 volts RMS.

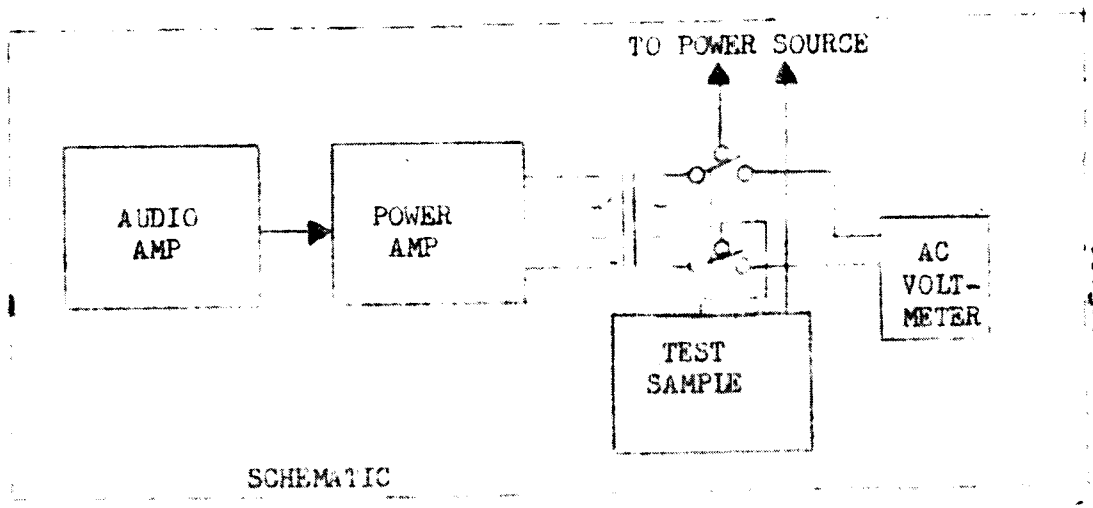
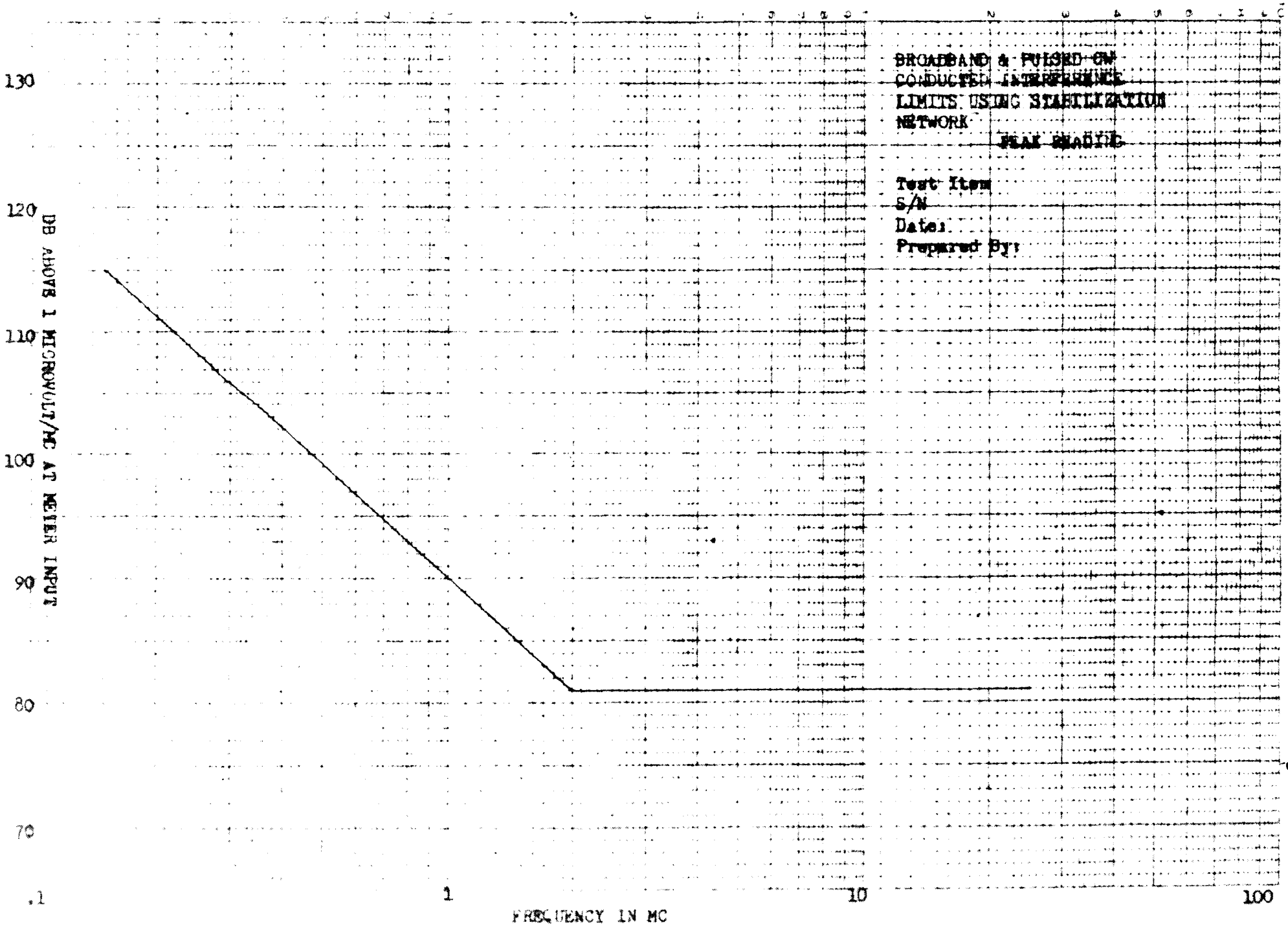
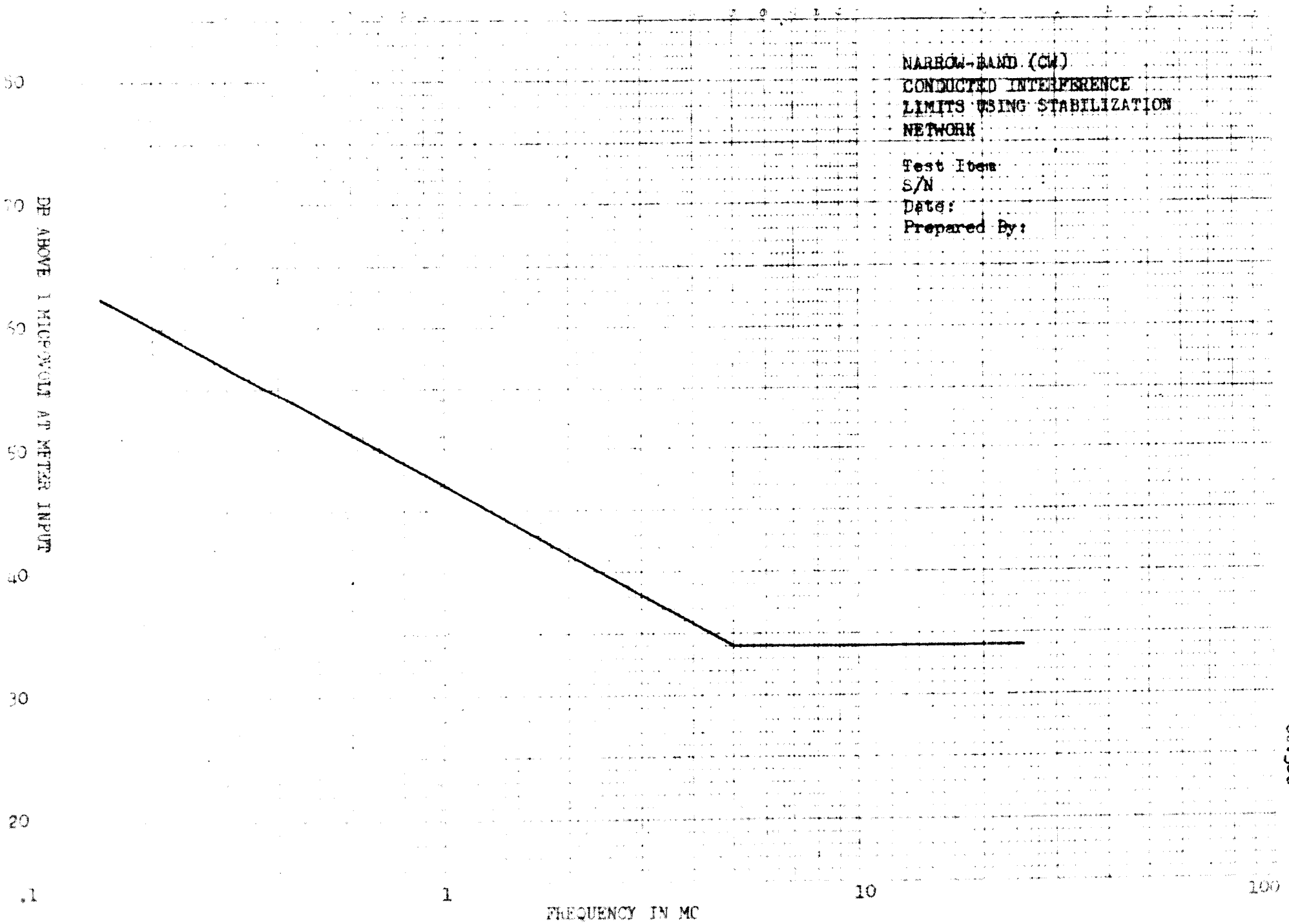
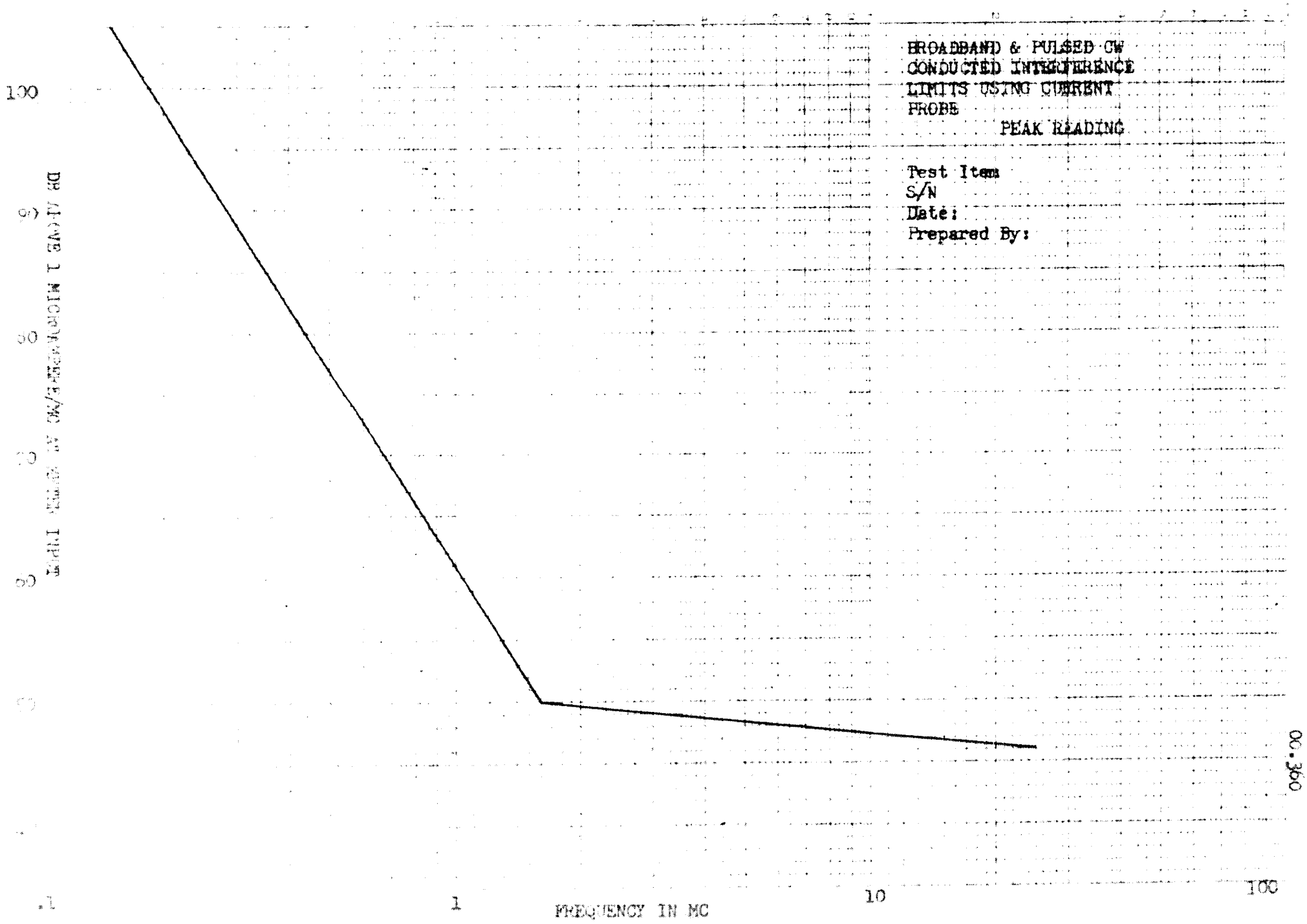
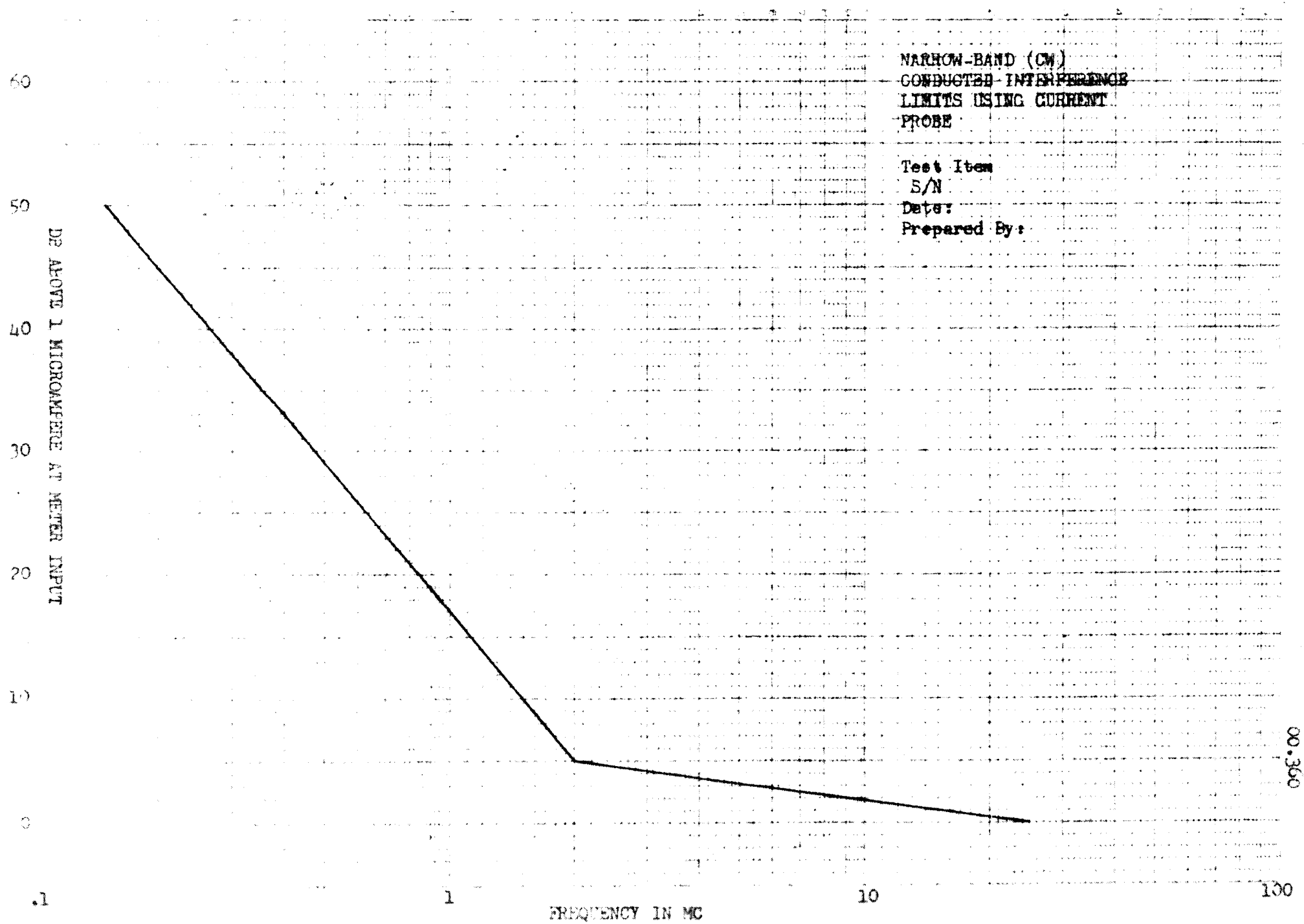


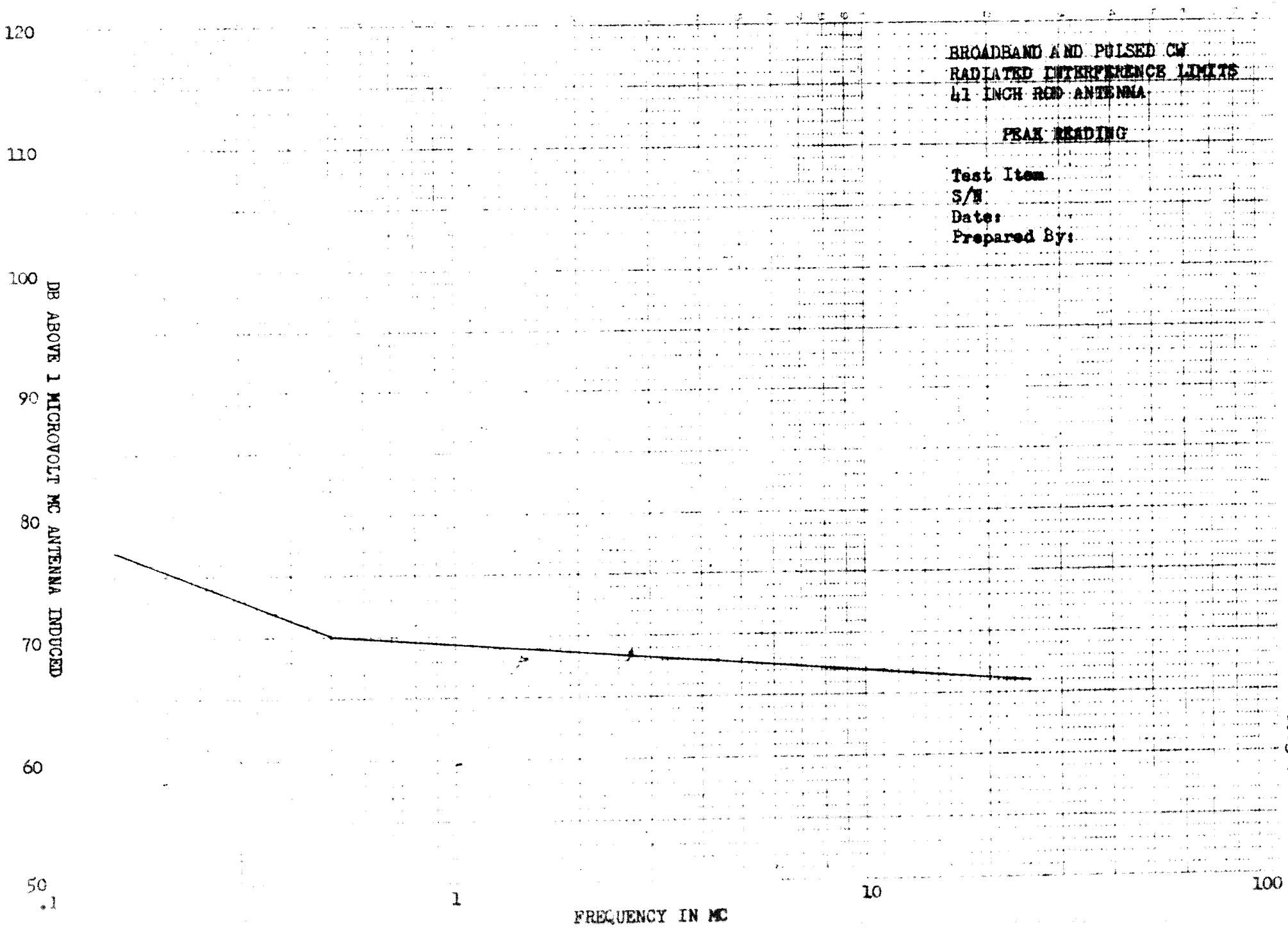
FIGURE NO. 2 TYPICAL TEST SET-UP FOR CONDUCTED AUDIO INTERFERENCE (50-15000 CPS)

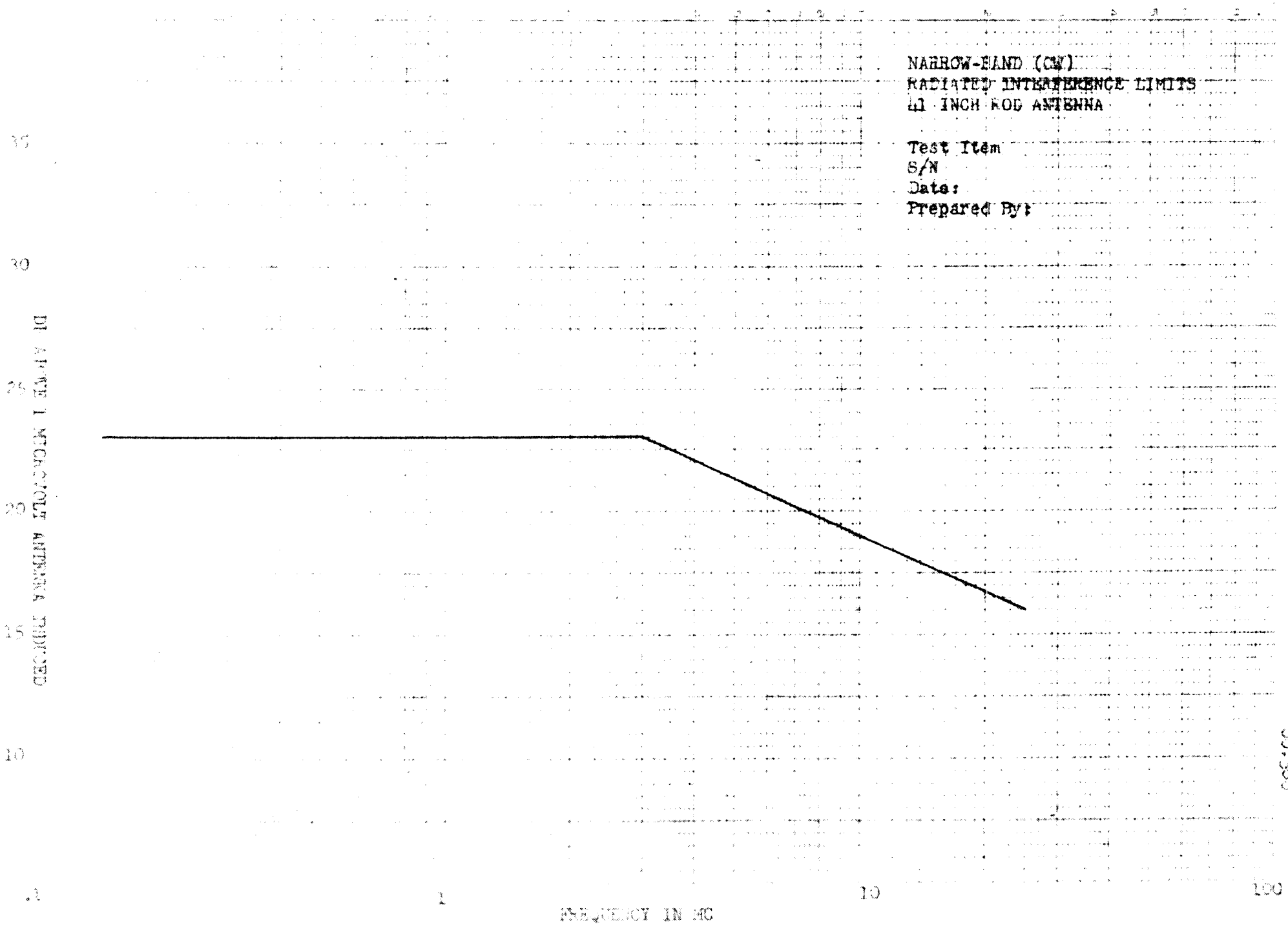

BROADBAND & PULSED CW
CONDUCTED INTERFERENCE
LIMITS USING STABILIZATION
NETWORK
PEAK READING
Test Item
S/N
Date:
Prepared By:
130
120
110
100
90
80
70
DB ABOVE 1 MICROVOLT/MC AT METER INPUT
.1
1
10
100
FREQUENCY IN MC

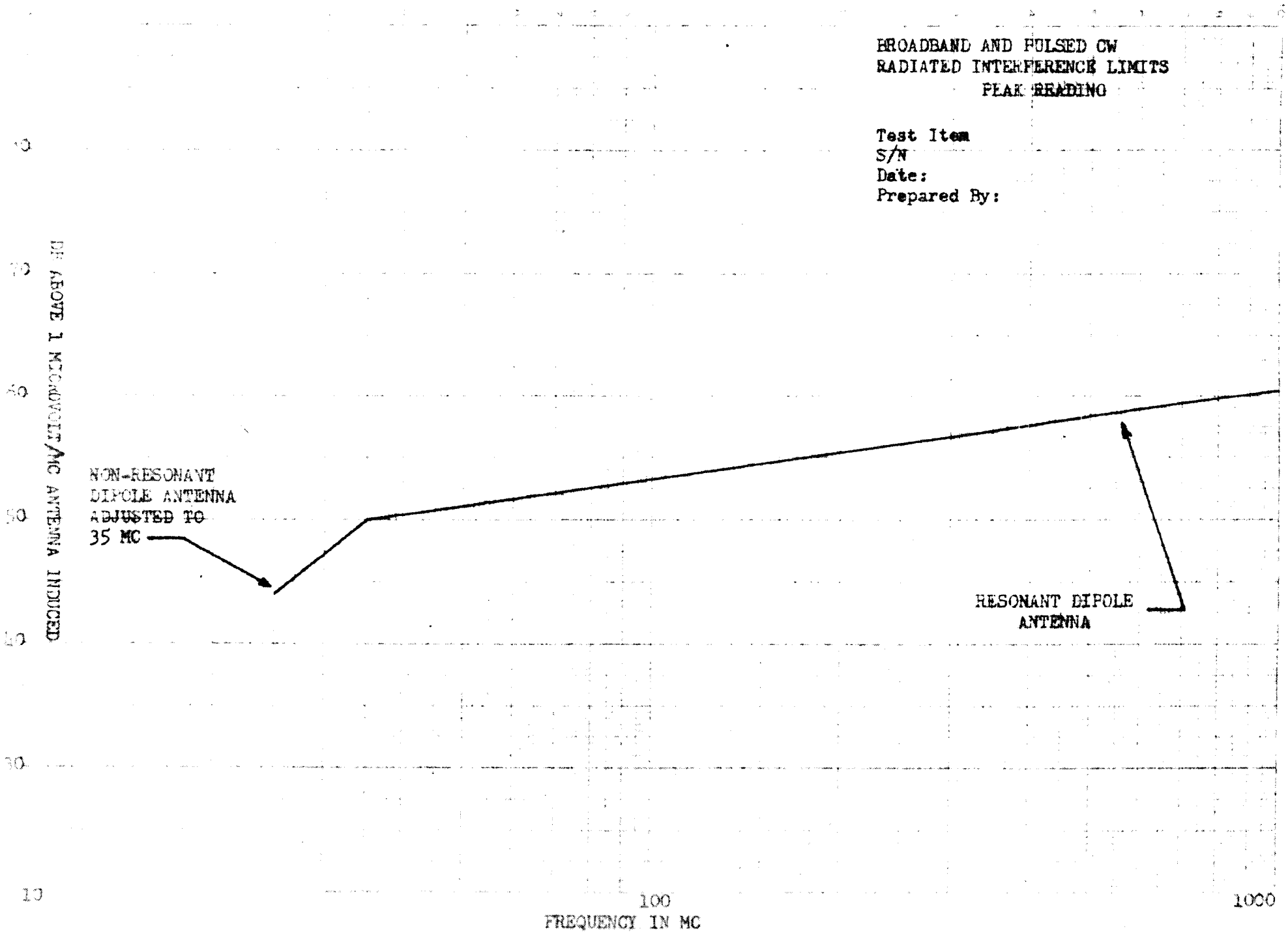

NARROW-BAND (CW)
CONDUCTED INTERFERENCE
LIMITS USING STABILIZATION
NETWORK
Test Item
S/N
Date:
Prepared By:
DB ABOVE 1 MICROVOLT AT METER INPUT
80
70
60
50
40
30
20
.1
1
10
100
FREQUENCY IN MC

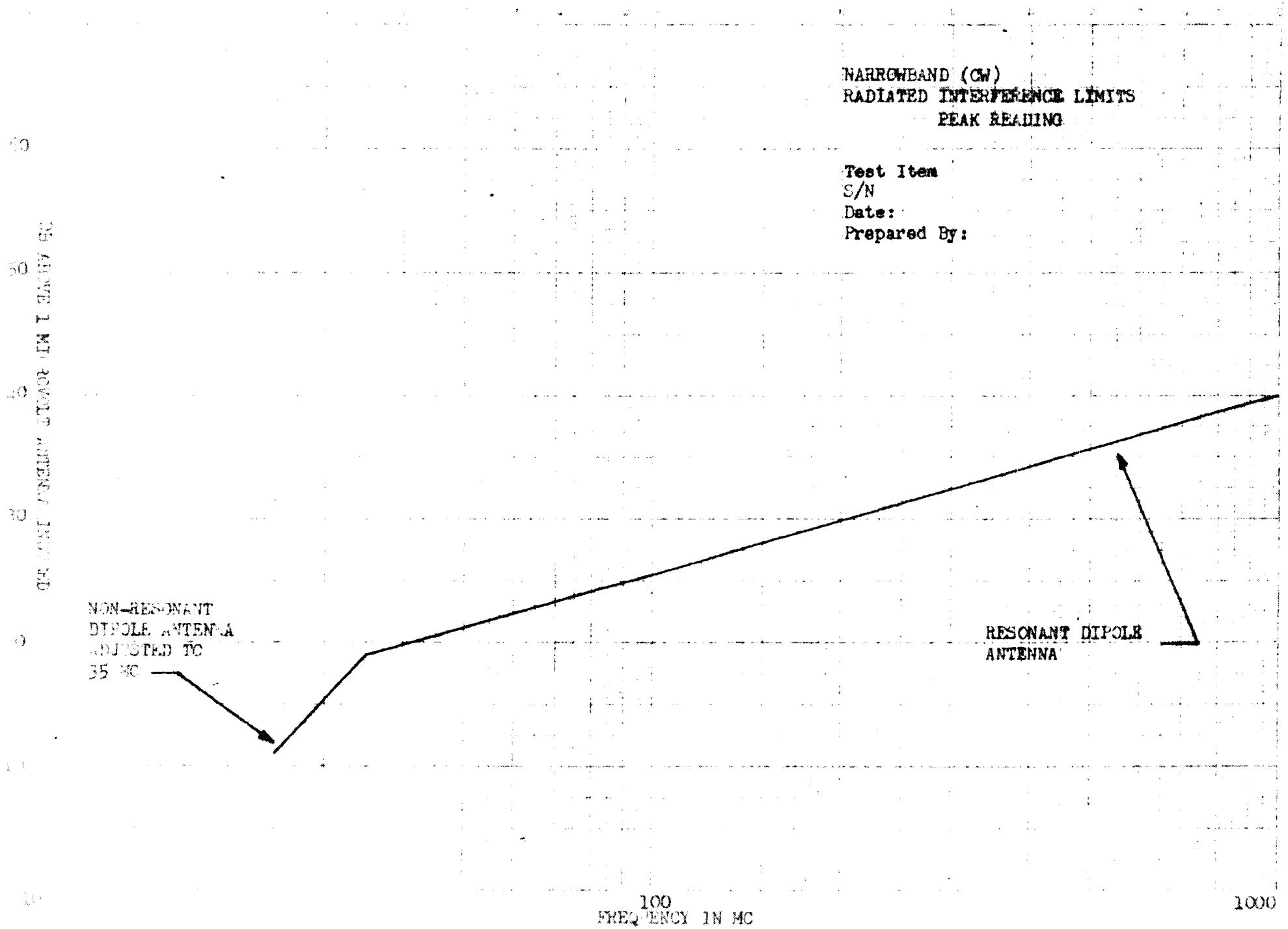

BROADBAND & PULSED CW
CONDUCTED INTERFERENCE
LIMITS USING CURRENT
PROBE
PEAK READING
Test Item
S/N
Date:
Prepared By:
100
90
80
70
60
50
.1
1
10
100
FREQUENCY IN MC
DB ABOVE 1 MICROAMPERE/MC AT MEASURING INPUT


NARROW-BAND (CM)
CONDUCTED INTERFERENCE
LIMITS USING CURRENT
PROBE
Test Item
S/N
Date:
Prepared By:
60
50
40
30
20
10
0
DB ABOVE 1 MICROAMPERE AT METER INPUT
.1
1
10
100
FREQUENCY IN MC


BROADBAND AND PULSED CW
RADIATED INTERFERENCE LIMITS
41 INCH ROD ANTENNA
PEAK READING
Test Item
S/N
Date:
Prepared By:
120
110
100
90
80
70
60
50
DB ABOVE 1 MICROVOLT MC ANTENNA INDUCED
.1
1
10
100
FREQUENCY IN MC

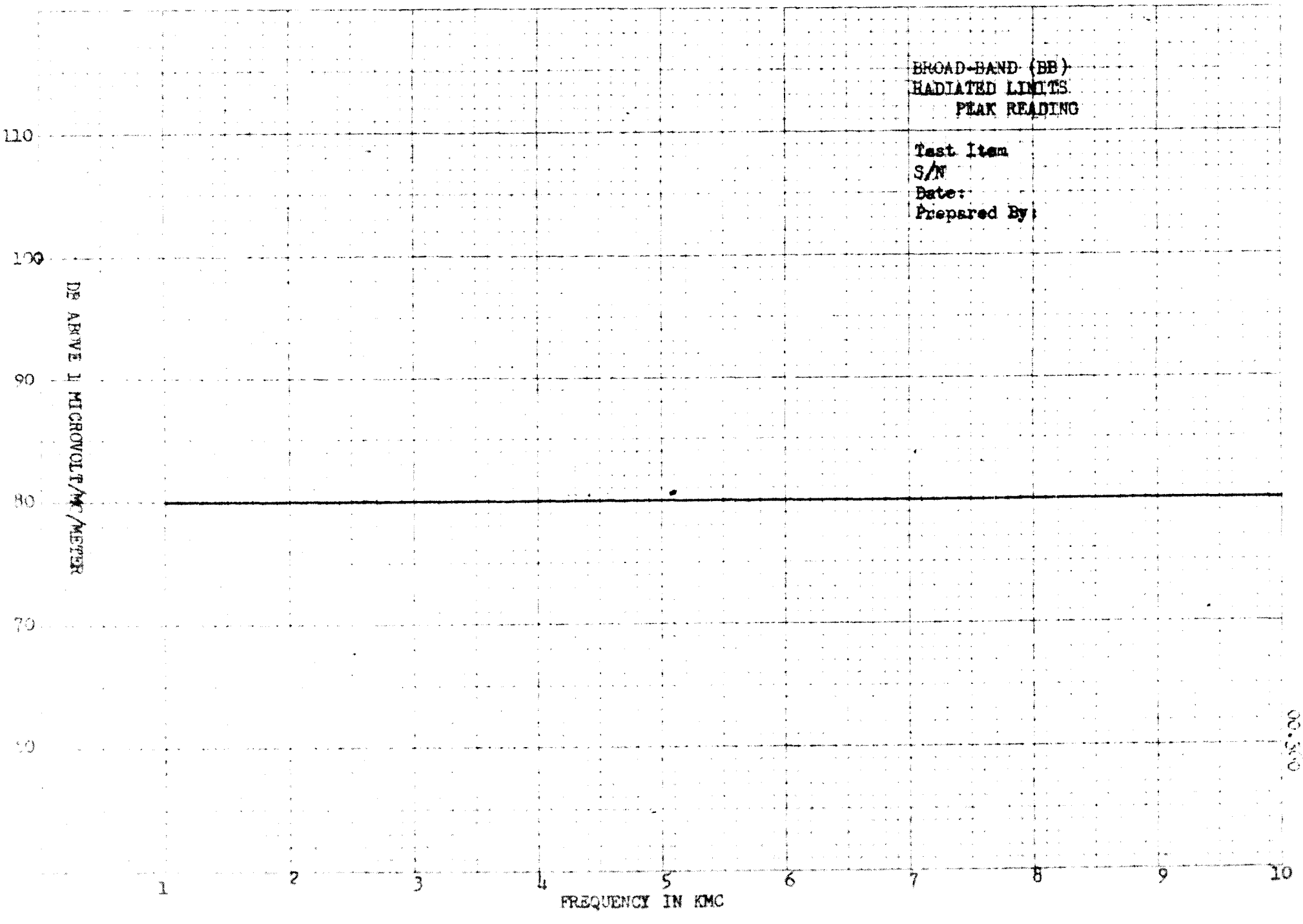

NARROW-BAND (CW)
RADIATED INTERFERENCE LIMITS
41 INCH ROD ANTENNA
Test Item
S/N
Date:
Prepared By:
35
30
25
20
15
10
.1
1
10
100
FREQUENCY IN MC
DB ABOVE 1 MICROVOLT ANTENNA INDUCED

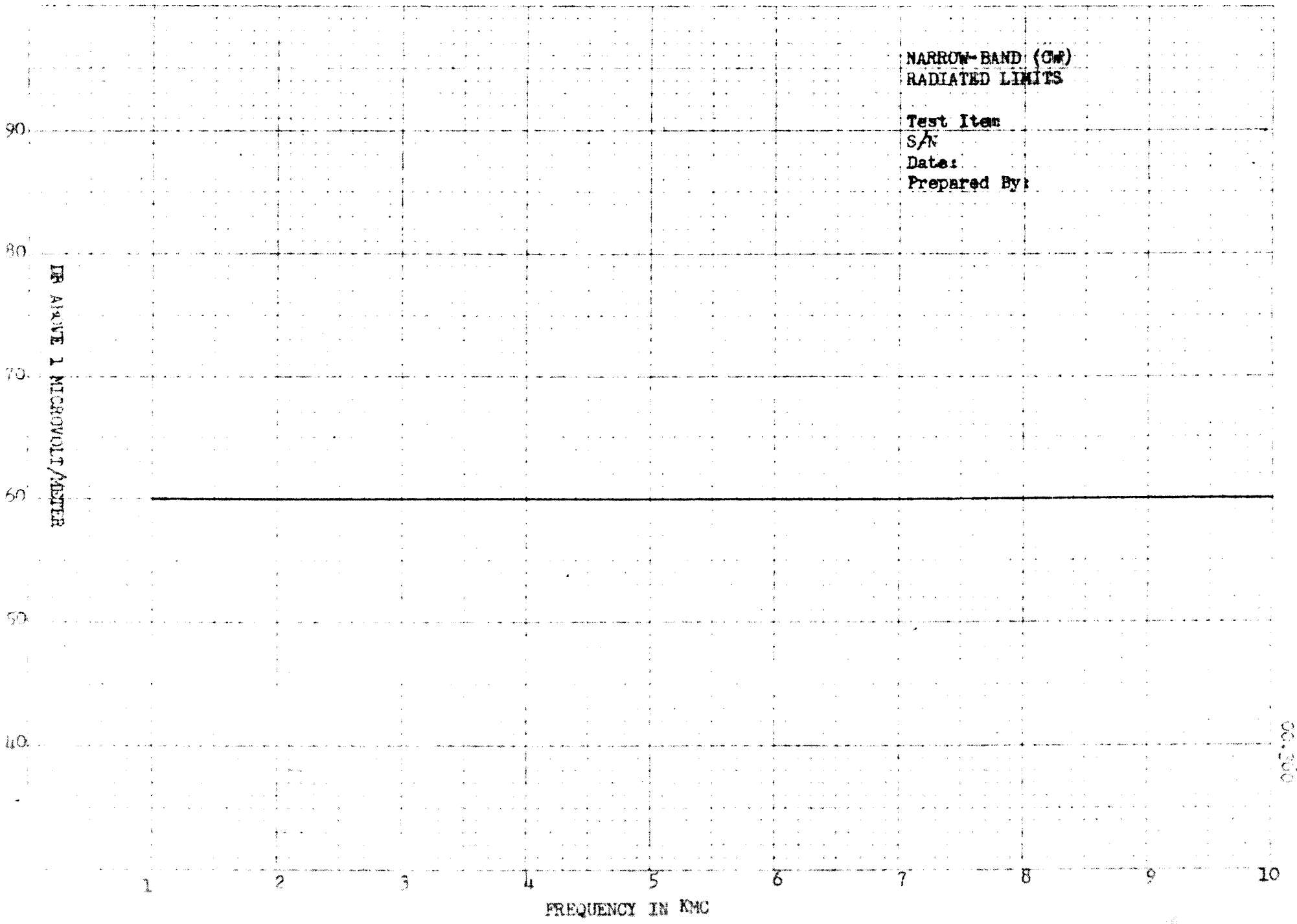

BROADBAND AND PULSED CW
RADIATED INTERFERENCE LIMITS
PEAK READING
Test Item
S/N
Date:
Prepared By:
NON-RESONANT
DIPOLE ANTENNA
ADJUSTED TO
35 MC
RESONANT DIPOLE
ANTENNA
DB ABOVE 1 MICROVOLT/MC ANTENNA INDUCED
10
100
1000
FREQUENCY IN MC


NARROWBAND (CW)
RADIATED INTERFERENCE LIMITS
PEAK READING
Test Item
S/N
Date:
Prepared By:
NON-RESONANT
DIPOLE ANTENNA
ADJUSTED TO
35 MC
RESONANT DIPOLE
ANTENNA
100
FREQUENCY IN MC
1000

NO. 340R 10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.



NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.