

MIL-STD-462  
NOTICE 3 (EL)  
9 February 1971

MILITARY STANDARD

ELECTROMAGNETIC INTERFERENCE  
CHARACTERISTICS, MEASUREMENT OF

This notice is applicable for all Army procurements and shall be filed in front of MIL-STD-462, dated 31 July 1967 superseding the document in those areas detailed herein. In case of joint Military procurement, procurement specifications shall be determined and coordinated by the procurement office.

THIS DOCUMENT CONTAINS 137 PAGES.

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MIL-STD-462 NOTICE 3(EL)  
9 February 1971

DEPARTMENT OF THE ARMY

WASHINGTON, D.C. 20360

Electromagnetic Interference  
Characteristics Requirements for Equipment, Sub-system and System  
MIL-STD-462 NOTICE 3

1. This standard is mandatory for use by the Department of the Army.

2. Recommended corrections, additions, or deletions should be addressed to Commanding General, US Army Electronics Command, ATTN: AMSEL-PP-EM-2, Fort Monmouth, New Jersey 07703

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9 February 1971ELECTROMAGNETIC INTERFERENCE  
CHARACTERISTICS, MEASUREMENT OF

## 1. SCOPE

1.1 Scope. This standard establishes techniques to be used for the measurement and determination of the electromagnetic interference characteristics (emission and susceptibility) of electrical, electronic, and electromechanical equipments, sub-systems and systems as required by MIL-STD-461A, NOTICE 4.

1.2 Format.

1.2.1 Numbering System. - The test methods contained in this standard are designated by an alpha numeric identification scheme. Each method is identified by a two (sometimes three) letter combination followed by a two digit number. The meaning of the individual letters is:

- R = Radiated
- C = Conducted
- E = Emission
- S = Susceptibility
- T = New or modified test procedure included for trial use, or as required by procuring activity.

(a) Conducted Emission tests are designated by "CE--."

(b) Radiated Emission tests are designated by "RE--."

(c) Conducted Susceptibility tests designated by "CS--."

(d) Radiated Susceptibility tests designated by "RS--."

(e) Radiated and Conducted Emission testing techniques for transient interference measurement and for testing the presence of high ambient conditions are designated "CRE---" tests.

(f) The number following the letters in task sequence from 01 to 99.

1.2.2 Revision of Test Methods. - Revisions of test methods are indicated by a letter following the method number, for example, the original number assigned to the conducted emission 30 Hz to 50 KHz Power Leads Method is CEO1; the first revision of that method is CEO1A, the second revision, CEO1B, etc.

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1.2.3 Test Method Applicability. - Unless otherwise specified, the test methods contained herein are invoked by MIL-STD-461 NOTICE 4.

1.3 Units. The international system of units, specified in MIL-STD-463 is used.

## 2. Referenced Documents

### Specifications

EL-CD-6003-0009A Electromagnetic Interference Measurement Instrumentation Characteristics for

MIL-C-45662 Calibration of Standards

### Standards

MIL-STD-461  
NOTICE 4 Electromagnetic Interference Characteristics, Requirements for Equipment, Sub-system and System

MIL-STD-463 Definitions and Systems of Units, Electromagnetic Interference Technology

MIL-STD-285 Attenuation Measurements for Enclosures, Method of

MIL-STD-633B Mobile Electric Power Engine Generator Set Family

MIL-STD-220A Method of Insertion Loss Measurement

MIL-STD-704A Electric Power, Aircraft Characteristics and Utilization of

### Drawings

ES-DL-198697 Line Impedance Stabilization Network 2MHz to 65MHz

SK.N 1791 Line Impedance Stabilization Network 10KHz to 10MHz

ES-F-201286 Antenna, Biconical 30MHz to 300MHz, less Balun

ES-DL-176439 Bifalar Balun, 30 MHz to 300MHz

62J4040 Antenna, Conical Log Spiral, 200 to 1000 MHz

62J4041 Antenna, Conical Log Spiral, 1 to 10 GHz

DL-ES-A-217563 Antenna, Double Ridged Horn, 200 to 2000 MHz

DL-ES-A-217311  
and Drawings  
thereto Antenna, Double Ridged Horn, 1 to 12.4 GHz



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and Drawings:  
theretoAntennas, Microwave 12 to 40 GHz  
Detail Assembly

Copies of these drawings may be obtained from the contracting officer or from the following activities:

62J4040 and 62J4041  
Hq, USAF Logistics Command  
Engineering Data Center (SGCDC)  
Wright Patterson Air Force Base, Ohio 45433

US Naval Applied Science Laboratory  
Brooklyn, New York, N.Y.

Others: SK.N 1791

Commanding General,  
US Army Electronics Command  
ATTN: AMSEL-TD-TE-C  
Fort Monmouth, New Jersey 07703

#### Other Publications.

The documents referenced below form a part of this standard to the extent specified herein.

Society of Automotive Engineers, Inc. (SAE)

SAE-ARP-936 - Ten Microfarad Capacitor

SAE-J551 - Measurement of Electromagnetic Radiation from  
Motor Vehicles

Interference (20 to 1000 MHz)

(Copies may be obtained from the Society of Automotive Engineers, Inc.,  
2 Pennsylvania Plaza, New York, New York 1001)

3. Definitions. - The terms used herein are defined in MIL-STD-463.

4. Requirements.

4.1 General Requirements. - General requirements pertaining to the application of this standard, and applicable test limits, are specified in MIL-STD-461 NOTICE 4. The test procedures contained in this standard shall be used in complying with MIL-STD-461, NOTICE 4 measurement requirements and in preparing the EMI test plan.

4.2 Specific Requirements for Testing to the Requirements of MIL-STD-461 NOTICE 4. Details pertaining to the performance of the tests contained in this standard are presented in this section.

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4.2.1 Test Conditions. -

4.2.1.1 Ambient Electromagnetic Level. - The ambient electromagnetic field level, during testing, measured with the test sample de-energized, shall be at least 6dB below the allowable specified limit. Conducted ambient levels need not be measured, provided that the primary power is adequately filtered. Precautions for avoiding ambient signals generated by test equipment, as outlined in the various test procedures, shall be observed. At the lower frequencies, where screenroom filtering may be inadequate and where the power line 10UFd capacitor represents a significant impedance, various methods for verifying the source of an excessive emission can be utilized, such as the technique discussed in the notes to Method CEO2, and should be made a subject of the test plan. If a test site does not meet the requirements specified herein, measurements shall be performed using the procedure specified in Method CRE O2. When instrumentation for performing CRE O2 is not available, the contractor may use an equivalent method with the approval of the procuring activity.

4.2.1.2 Ground Plane. - A copper or brass ground plane (solid Plate) shall be used that has a minimum thickness of 0.25mm for copper or 0.63mm, for brass and is 2.25 square meters or larger in area with the smaller side no less than 76cm. When testing is performed in a shielded enclosure, the ground plane shall be bonded to the shielded room such that the dc bonding resistance shall not exceed 2.5 milliohms. In addition, the bonds shall be placed at distances no greater than 90cm apart. For large equipment mounted on a metal test stand, the test stand shall be considered a part of the ground plane for testing purposes and shall be bonded accordingly.

4.2.1.3 Accessory Equipment Precaution. - Care shall be taken to insure that accessory equipments (spectrum monitors, oscilloscopes, earphones and other equipments) used in conjunction with interference meters do not affect measurement integrity.

4.2.1.4 Excess Personnel and Equipment. - The shielded enclosure shall be kept free of unnecessary equipment, cable racks, and desks. Only the equipment essential to the test being performed shall be in the enclosure. Personnel not actively involved in the test shall not be permitted in the enclosure.

4.2.1.5 Power Supply Characteristics. - Power sources which are required for the operation of the equipment, sub-system or system under test, and which are not supplied by the Government, shall have characteristics and tolerances as specified in MIL-STD-704, MIL-STD-633 or in the equipment specification as is applicable.

4.2.1.6 R f Absorber Material. - R f absorber material may be used in shielded enclosures to reduce reflections from the surfaces of the

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enclosure to the measurement antennas. It is encouraged that this material be used immediately behind the test specimen against the enclosure wall in line with the test antennas.

#### 4.2.1.7 Test Site.

4.2.1.7.1 Shielded Enclosures. - Shielded enclosures shall be of sufficient size to adequately accept the item under test without sacrificing test accuracy or requiring deviation from the methods specified herein. Shielding and filtering characteristics shall meet the following minimum requirements:

(a) Shielding effectiveness to electric fields and plane waves, as measured in accordance with MIL-STD-285, shall be at least 80 dB over the frequency range of test.

(b) Power line filtering must be included and shall have an attenuation to frequencies above 10 KHz of at least 80 dB as measured in accordance with MIL-STD-220A.

4.2.1.7.2 Open Areas. - Open field sites may be used when sufficiently large screen rooms are not available or when the nature of the equipment tested precludes their usage. The ambient requirements of paragraph 4.2.1.1 must be observed.

4.2.1.8 Test Site Atmospheric Conditions. - Testing shall be performed under the following atmospheric conditions where possible:

Temperature	<u>20 to 30</u>	°C
Pressure	<u>78</u>	Cm Hg
Relative Humidity	<u>70</u>	% of Saturation

4.2.2 Measuring Equipment. - This section describes the test equipment used in the test methods contained in this standard.

4.2.2.1 Test Antennas. - Table I lists antennas which shall be used for performing radiated emission (RE) and radiated susceptibility (RS) measurements. Where antenna frequency ranges overlap either may be used, receiver sensitivity permitting. EL-CD-6003-0009A states requirements and testing techniques for antennas used in testing to this standard; antenna factors shall be determined in accordance with the testing techniques of that standard.

4.2.2.1.1 Test Antenna Counterpoise (Monopole). - The test antenna counterpoise shall be referenced to the same ground reference used for

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the EMI meter For shielded enclosure measurements, this would require bonding the counterpoise to the reference ground plane. The bond must be achieved by use of a solid metal sheet having the same width as the counterpoise and by welding along the entire edge at the points of contact. If desired the counterpoise may be configured so that one dimension is of adequate length to reach the equipment ground plane. For out-of-door measurements the counterpoise and EMI meter should be referenced to a good earth ground. The antenna matching network must be mounted below the counterpoise.

4.2.2.2 Other Equipment Characteristics. - Requirements for measuring equipment characteristics are contained in EL-CD-6003-0009A along with techniques for measurement of these characteristics. Table II represents a suggested list of equipments for each test. In some cases the list presents more than 1 model capable of performing a given function. Any equipment equivalent to those listed may be used with the approval of the procuring activity.

4.2.3 Use of Measuring Equipment. - All laboratory equipment shall be operated as prescribed by the applicable instruction manuals unless otherwise specified herein. This standard takes precedence in the event of conflict with instruction manuals or other such documents issued by industry or other government agencies.

4.2.3.1 Grounding of Measuring Equipment. - It is important that grounding of EMI instrumentation be accomplished in accordance with the following rules to avoid false data that may be introduced by ground loops.

(a) The antenna shall be remote from the measuring instrument.

(b) The EMI measuring instrument shall be physically grounded with only one connection to the equipment ground plane or to earth ground. The power line ground shall be broken by means of an isolation transformer.

4.2.3.2 Equipment Warm-Up Time. - Prior to commencing data collection, the measuring equipment shall have been switched on for a period of time adequate to allow parameter stabilization. If the operation manual does not specify a specific warm-up time, a period of one-hour shall be observed.

TABLE I. PRESSURE-SENSITIVE ANTENNAS

Antenna Identification, Nomenclature	Frequency Range	Applicability			Antenna Factor Figure #	Military Drawing Number	Physical Description Reference	Manufacturer
		RE	RS	REO3				
Magnetic Field Loop	30Hz to 30 KHz	X			Figure 1	None	Paragraph	Fairchild D. Stoddart (AT-205)
Magnetic Field Loop	30Hz to 30 KHz		X		None	None	Figure RSO1	None
Li <sup>+</sup> Rod Antenna and Matching Network	14KHz to 30 MHz	X		X	Equipment Manual	None	None	Electro-Matrix Singer-Matrix Stoddart
Parallel Strip Line	14KHz to 30 MHz		X		None	None	Figures	None
Biconical Antenna w/ T-1 Balun	20 MHz to 200 MHz	X	X	X	Figure 2	ES-F-201286		EMCO, Honeywell
Long Wire Antenna	14 KHz to 20 MHz		X		None	None		None
Biconical Antenna w/ Bifilar Balun	30 MHz to 300 MHz	X	X	X	Figure 2a	ES-DL-176439	See Drawing	Stoddart
Conical Logrithmic Spiral	200 to 1000 MHz	X	X		Figure 3	62J 4040	See Drawing	EMCO Electro-metrics
Conical Logrithmic Spiral	1 to 10GHz	X	X		Figure 4	62J 4041	See Drawing	Stoddart EMCO Electro-metrics
Linearly Polarized Double Ridge Waveguide Horn	200 to 2000MHz	X	X	X	Figure 6	DL-ES-A 217563	See Drawing	EMCO
" "	1 to 12.4GHz	X	X	X	Figure 5	DL-ES-A 217311	See Drawing	EMCO
Horn Feeding 18 in Diameter Dish	12 to 18 GHz			X		ES-DL-201090	See Drawing	
Horn Feeding 12 in. Diameter Dish	18 to 26 GHz			X				
Horn Feeding 18 in Diameter Dish	25 to 40 GHz			X				

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- NOTE: (1) ANTENNA CONNECTED DIRECTLY TO METER  
HIGH  $\neq$  INPUT  
ADD TO LOOP INDUCED VOLTAGE, EXPRESSED  
AS dB RELATIVE TO 1  $\mu$ V, TO OBTAIN FLUX  
DENSITY IN dB RELATIVE TO 1 PICOTESLA
- (2) ANTENNA MATCHED TO METER 100k  $\Omega$  INPUT  
WHERE A TRANSFORMER IS USED TO INCREASE  
PROBE SENSITIVITY, USE THE FOLLOWING  
EQUATION:  $B(\text{dB}_{\text{pt}}) = \text{METER READING}$   
 $(\mu\text{S}/\sqrt{\text{V}}) - \text{TRANSFORMER VOLTAGE}$   
 $\text{GAIN}(\text{dB}) + \text{CONVERSION FACTOR}$   
 $(\text{dB}) + 6(\text{dB})$

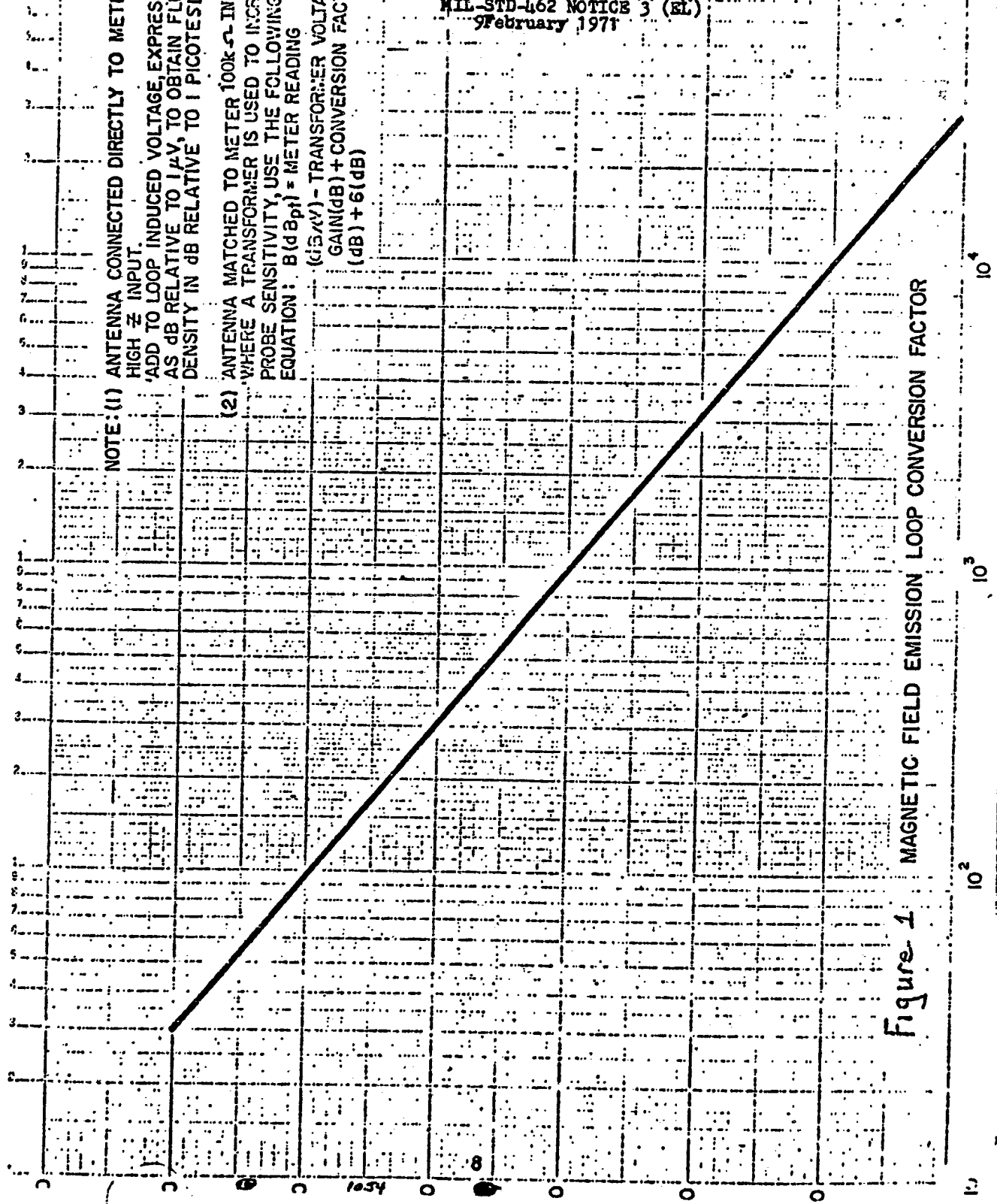


Figure 1  
MAGNETIC FIELD EMISSION LOOP CONVERSION FACTOR

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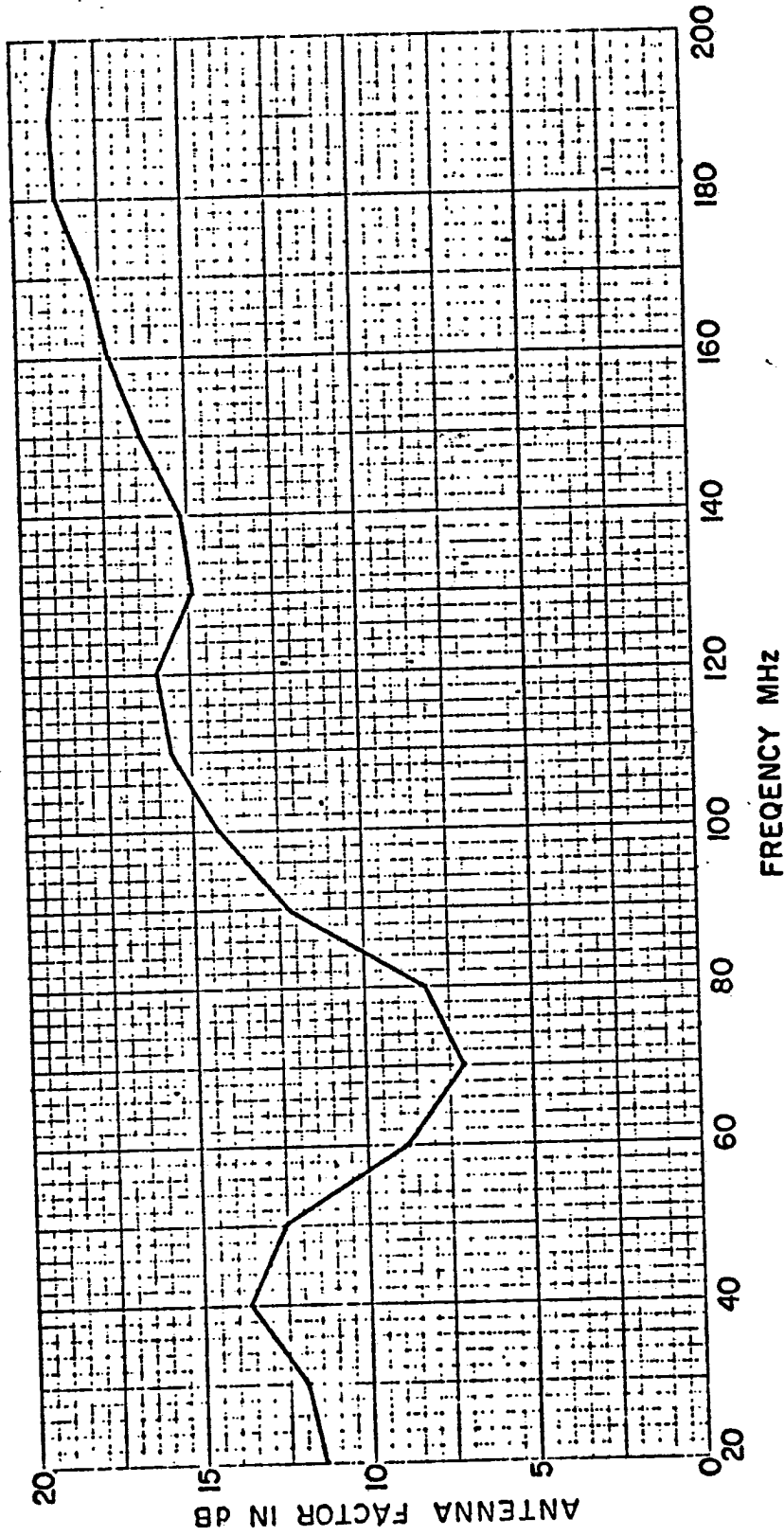


FIG. 2 ANTENNA FACTOR FOR BI CONICAL ANTENNA (TO BE ADDED TO RECEIVER METER READING IN  $\text{dB}\mu\text{V}$  TO CONVERT TO FIELD INTENSITY IN  $\text{dB}\mu\text{V}/\text{METER}$ ).  
DWG. ES - F - 201286

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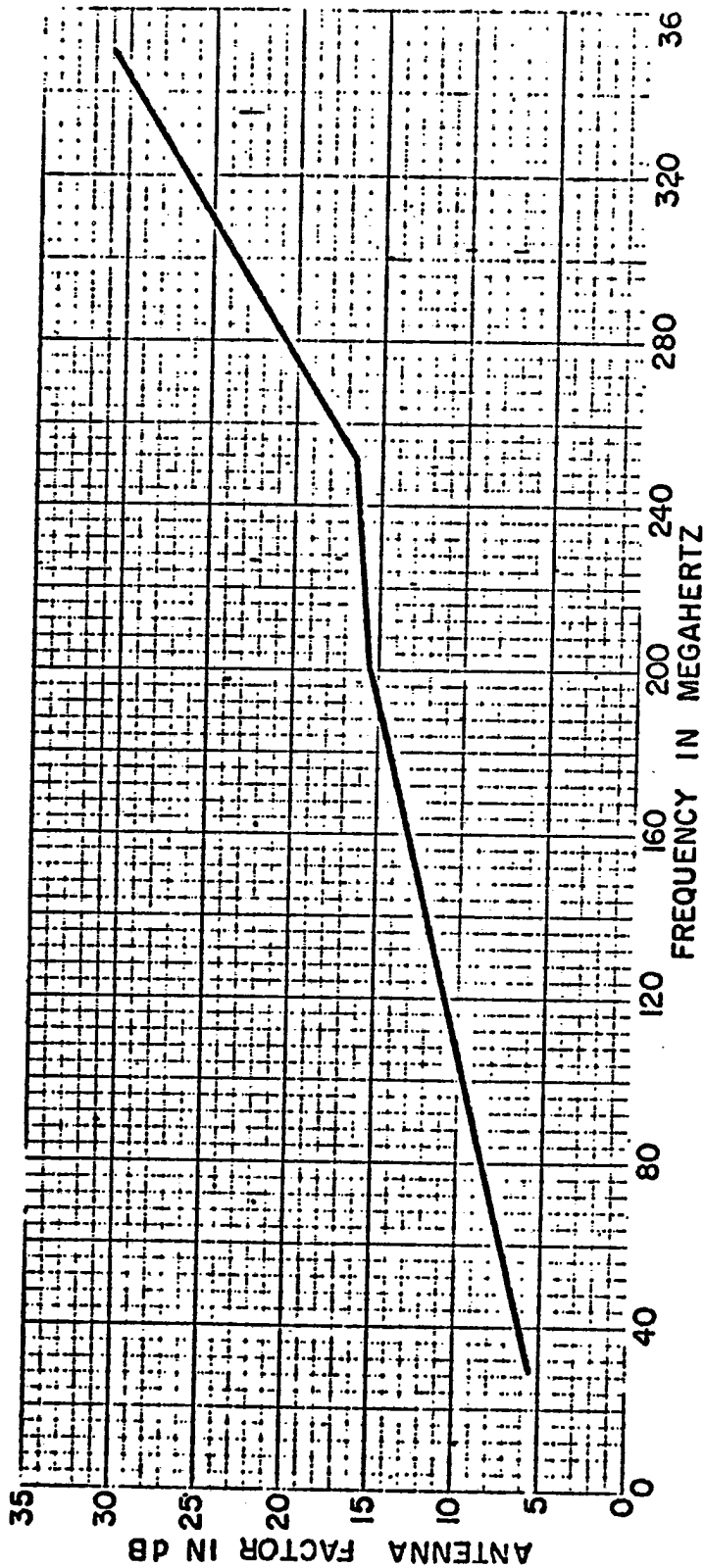


FIG. 2a BICONICAL ANTENNA WITH BIFALAR BALUN PER ES-DL-176439 AND ES-F-201286.



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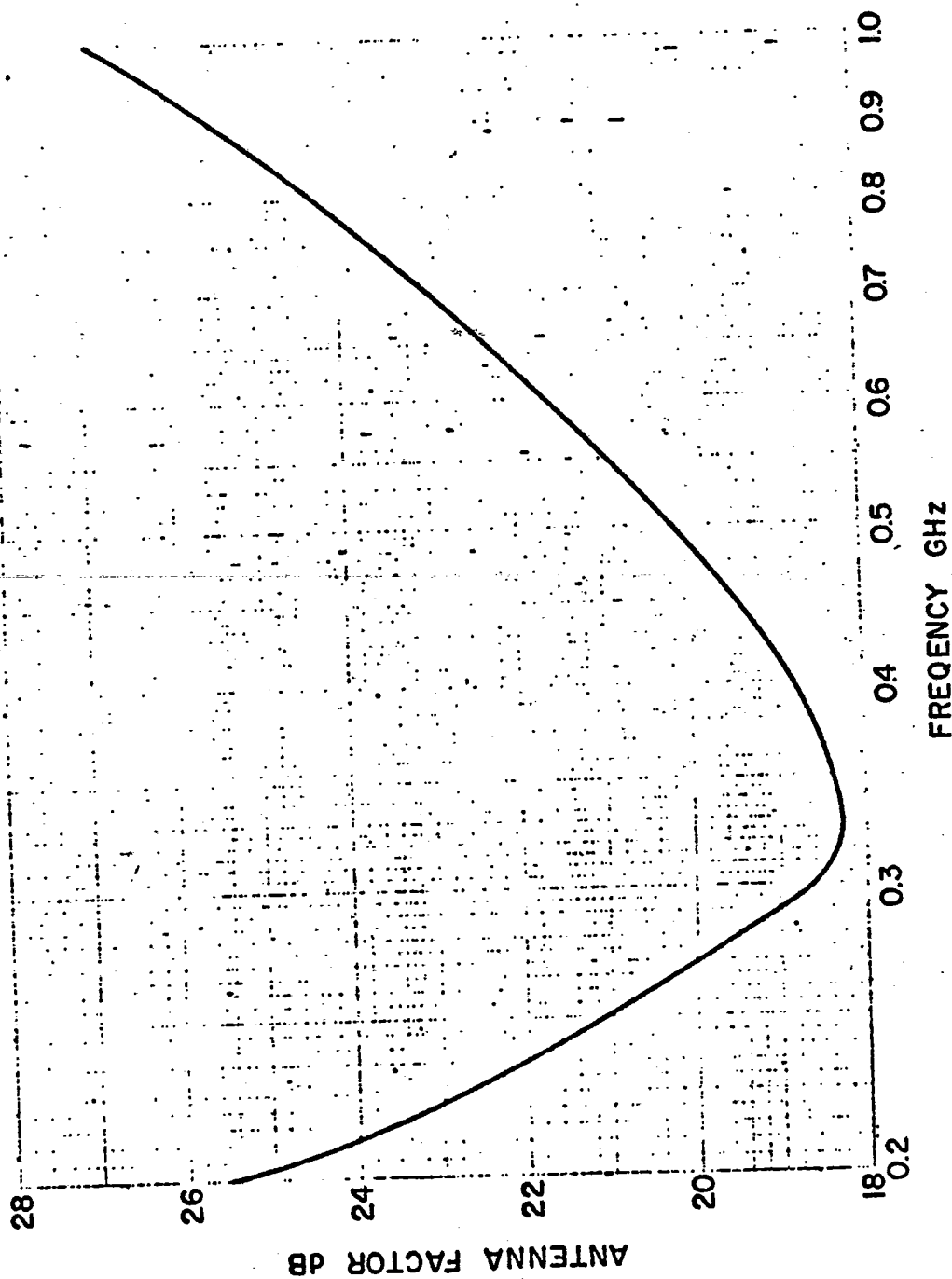


FIG. 3 ANTENNA FACTOR FOR LOG SPIRAL  
(TO BE ADDED TO RECEIVER READING IN  $\text{dB}\mu\text{V}$  TO CONVERT TO FIELD INTENSITY IN  $\text{dB}\mu\text{V}/\text{METER}$ ).

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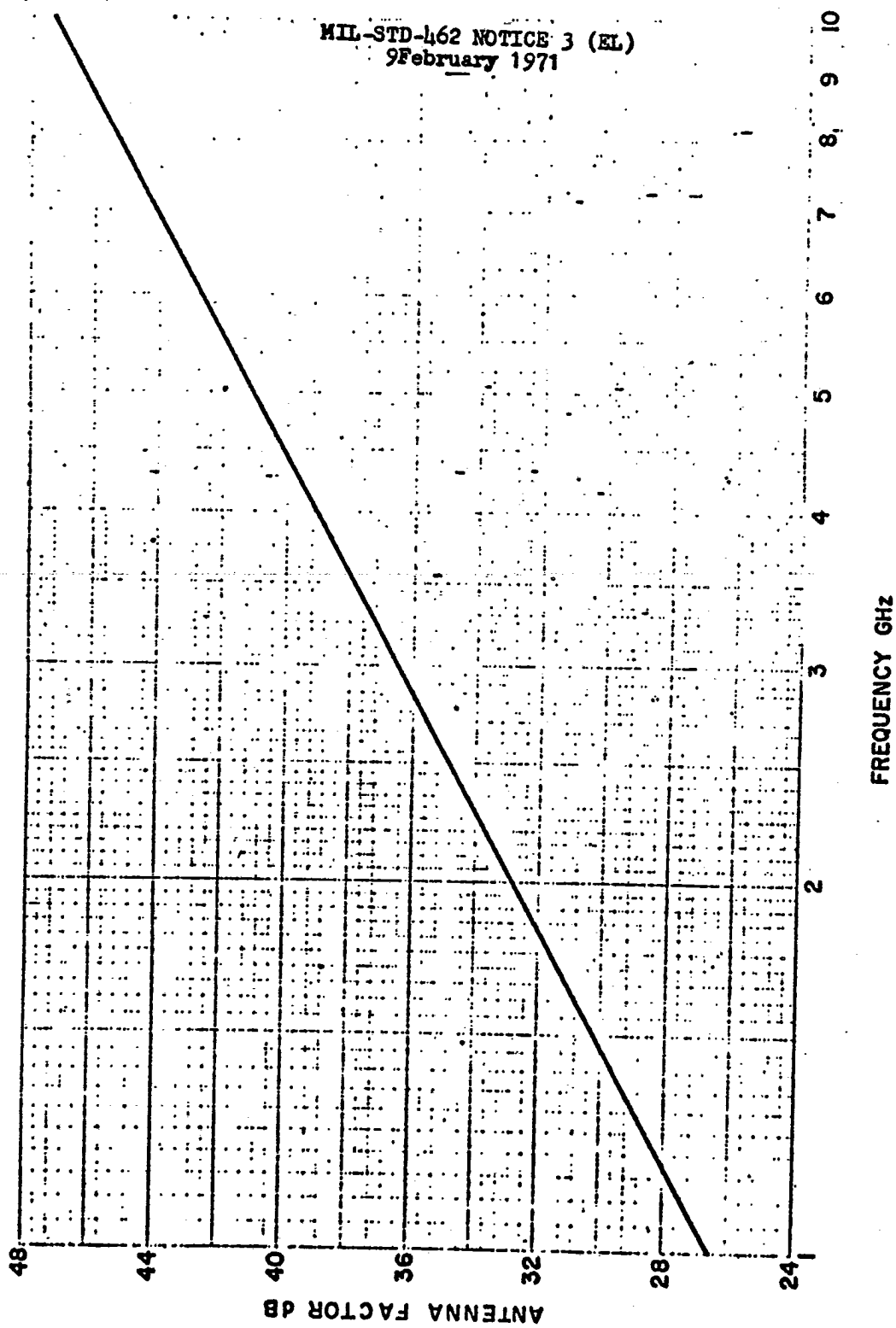


FIG. 4 ANTENNA FACTOR FOR LOG SPIRAL  
(TO BE ADDED TO RECEIVER METER READING IN  $\mu\text{V}$  TO CONVERT TO FIELD INTENSITY IN  $\mu\text{V}/\text{METER}$ ).

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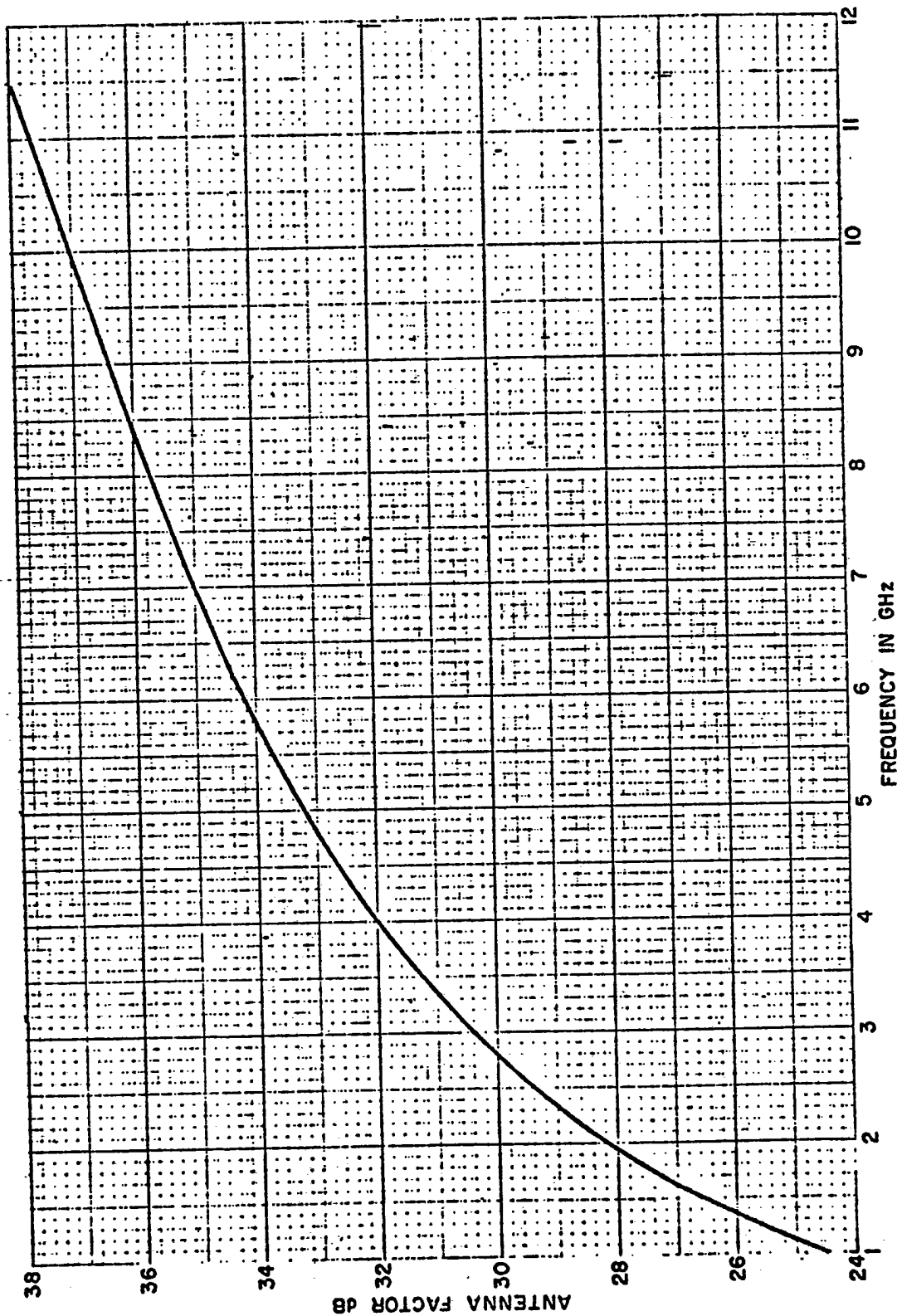


FIG. 5 ANTENNA FACTOR FOR RIDGED HORN ANTENNA (TO BE ADDED TO RECEIVER METER READING IN  $\text{dB}\mu\text{V}$  TO CONVERT TO FIELD INTENSITY IN  $\text{dB}\mu\text{V}/\text{METER}$ ).

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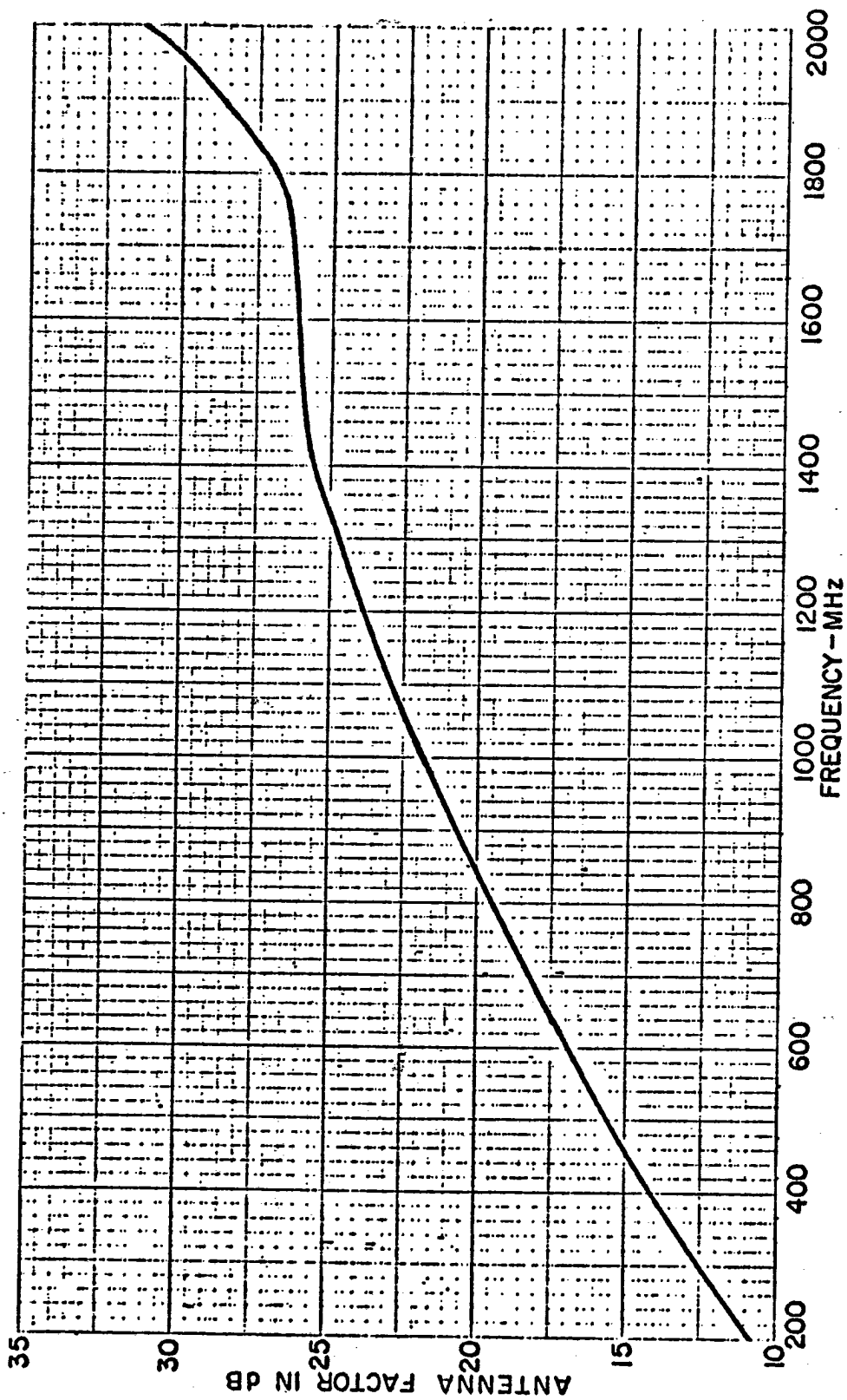


FIG. 6 ANTENNA FACTOR DOUBLE RIDGE WAVEGUIDE HORN



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TABLE II - SUGGESTED TEST EQUIPMENT OR EQUIVALENT

EQUIPMENT	MODEL	FREQUENCY RANGE	TEST METHOD																									
			CE01	CE02	CE03	CE04	CE05	CE06	CS01	CS02	CS03	CS04	CS05	CS06	CS07	CS08	RE01	RE02	RE03	RE04	RE05	RE06	RS01	RS02	RS03	RS04		
AMPLIFIERS																												
McINTOSH	200B	10HZ TO 50KHZ																										
KROHN - HITE	DCA-10R	DC TO 1 MHZ																										
INSTRUMENTS FOR	5000	10KHZ TO 220MHZ																										
INDUSTRY (IFI)																												
MICRODOT	248A	200 TO 575 MHZ																										
	296	500 TO 1000MHZ																										
Servo	2000	1 to 16 GHz																										
POWER OSCILLATORS																												
MICRODOT	1927	2 TO 2500 MHZ																										
AIRCRANE INST LAB	125	200 TO 2000MHZ																										
SPECTRUM DISPLAY UNITS																												
ELECTRO - METRICS	SPD-125																											
ELECTRO - MAGNETICS	"ADAPTER"																											

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TABLE II - SUGGESTED TEST EQUIPMENT OR EQUIVALENT

EQUIPMENT	MODEL	FREQUENCY RANGE	TEST METHOD																									
			CE01	CE02	CE03	CE04	CE05	CE06	CS01	CS02	CS03	CS04	CS05	CS06	CS07	CS08	RE01	RE02	RE03	RE04	RE05	RE06	RS01	RS02	RS03	RS04		
EMI METERS																												
SINGER - METRICS	NF-105A	14 KHZ TO 1GHZ																										
SINGER - METRICS	EMA-910-10	1 TO 22 GHZ																										
FAIRCHILD ELECTRO - METRICS	EMC-10E	20 HZ TO 50 KHZ																										
FAIRCHILD ELECTRO - METRICS	EMC-25R	14 KHZ TO 1 GHZ																										
STODART N:62A	NM62A	1 TO 10GHZ																										
ELECTRO - MECHANICS	6540	.1HZ TO 50 KHZ																										
Automatic Scan System																												
Fairchild Electro-Metrics FSS-250		14 KHZ TO 1 GHZ																										
RFI	130A	20 HZ TO 1GHZ																										
Line Irradiance																												
Stabilization Networks																												
Filttron	FSQ-702S6	2 to 50 KHZ																										
Centor	SM-112-115	2 to 50 MHZ																										
		10 KHZ to 2 MHZ																										
SIGNAL GENERATORS																												
SOLAR	6254 -5	TRANSIENT																										
HONEYWELL	4821	TRANSIENT																										



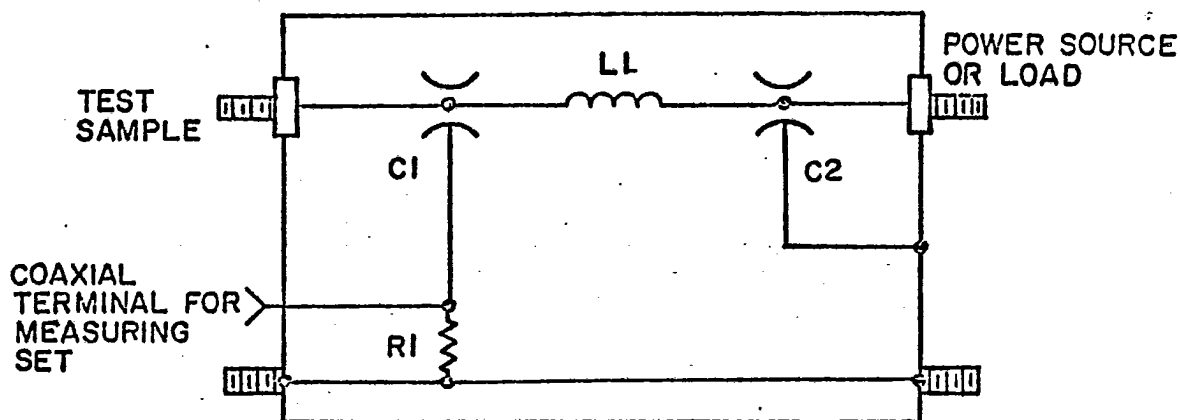


**TABLE II - SUGGESTED TEST EQUIPMENT OR EQUIVALENT**  
**MIL-STD-462 NOTICE 3 (E)**  
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EQUIPMENT	MODEL	FREQUENCY RANGE	TEST METHOD																											
			CE01	CE02	CE03	CE04	CE05	CE06	CS01	CS02	CS03	CS04	CS05	CS06	CS07	CS08	RE01	RE02	RE03	RE04	RE05	RE06	RS01	RS02	RS03	RS04				
DIRECTIONAL COUPLERS																														
NARDA SERIES																														
PIN DIODE MODULATORS																														
HEWLETT PACKARD	8730 SERIES	400 MHZ TO 12.4 GHz																												
BALANCED MIXERS																														
HEWLETT PACKARD	10514	200 KHZ TO 500 MHZ																												
	10534	50 KHZ TO 150 MHZ																												
VTVM																														
HP	410 C	20HZ TO 700MHZ																												
REJECTION NETWORKS																														
ELECTRO - METRICS	TRFII - 15	14 KHZ TO 1 GHz																												
ELECTRO - METRICS	HPK - 10	400HZ																												
ELECTRO - METRICS	NRG - 10	400 HZ																												
ELECTRO - MECHANICS	3011	LF																												
ELECTRO - MECHANICS	3012	MF																												
ELECTRO - MECHANICS	3013	HF																												
AMP - METER																														
WESTON	433																													
TRANSFORMER , STEP DOWN																														
CRITTENDON	F037E																													

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FIGURE 7 Powerline stabilization network schematic diagram, per ES-DL-198697



ENCLOSURE DATA: 14 GAGE (B&S) ALUMINUM SUGGESTED SIZE 9-3/8 IN. BY 4 BY 4 IN.  
FORM DATA: 5-1/4 IN. LENGTH, 3 IN. DIA (OD), .125 IN. WALL DRILL 3/8 IN. HOLE  
7/16 IN. FROM EACH END.

WIRE DATA: AWG 6, 600VOLT, .310 IN. DIA (OD)

COIL DATA: L1 - 5 MICROHENRIES, 13 TURNS SINGLE LAYER, 1/4 IN. WINDING LENGTH.

CAPACITOR DATA: C1 SHALL BE MOUNTED ON 1 IN. INSULATING BLOCK ABOVE GROUND.

CAPACITOR DATA: C1 = .1 UF, 600-VOLT DC, FEEDTHRU

C2 = 1 UF, 600-VOLT DC, FEEDTHRU

RESISTOR DATA: R1 = 5,000-OHM; 5-WATT CARBON

1. THE VALUES GIVEN FOR THE COMPONENT PARTS OF THE NETWORK ARE NOMINAL. REGARDLESS OF THE CONSTRUCTION OR DEVIATION FROM NOMINAL VALUES, THE NETWORK MUST HAVE AN IMPEDANCE WITHIN 20 PERCENT OF THAT GIVEN IN FIGURE 8.
2. CONNECTING LEADS TO CONDENSERS AND RESISTORS SHOULD BE AS NEARLY AS POSSIBLE TO ZERO LENGTH.
3. NETWORKS MAY ALSO BE CONSTRUCTED HAVING A 1-OHM SERIES RESISTOR BETWEEN THE LINE AND CAPACITOR C2. THIS 1-OHM RESISTOR SHALL BE MADE UP FROM TEN 10-OHM, 1-WATT COMPOSITION RESISTORS.
4. THE DATA GIVEN IN THIS FIGURE IS SUITABLE FOR THE CONSTRUCTION OF 50-AMPERE NETWORKS. LARGER CURRENT-CARRYING NETWORKS MAY BE CONSTRUCTED BY INCREASING THE WIRE SIZE GIVEN FOR THE COIL AND THE SIZE OF THE OVERALL ENCLOSURE.
5. THE 50-OHM TRANSMISSION LINE SHOULD BE EXTENDED WITHIN THE ENCLOSURE RIGHT UP TO THE LOCATION WHERE IT CONNECTS WITH CAPACITOR C1.
6. CAUTION: THE NETWORK SHALL BE PROMINENTLY AND PERMANENTLY MARKED "CAUTION-SHOCK HAZARD - CONNECT CASE TO EARTH GROUND BEFORE CONNECTING A-C POWER LINE."
7. NETWORKS PROCURED PRIOR TO THE DATE OF THIS SPECIFICATION, BUT MEETING THE IMPEDANCE REQUIREMENTS OF FIGURE 8, MAY STILL BE USED.
8. EACH NETWORK SHALL BE PERMANENTLY LABELED WITH THE FOLLOWING DATA: CURRENT RATING IN AMPERES AND VOLTAGE RATING IN VOLTS AT DIRECT CURRENT, 60, 400, AND 800 CPS.

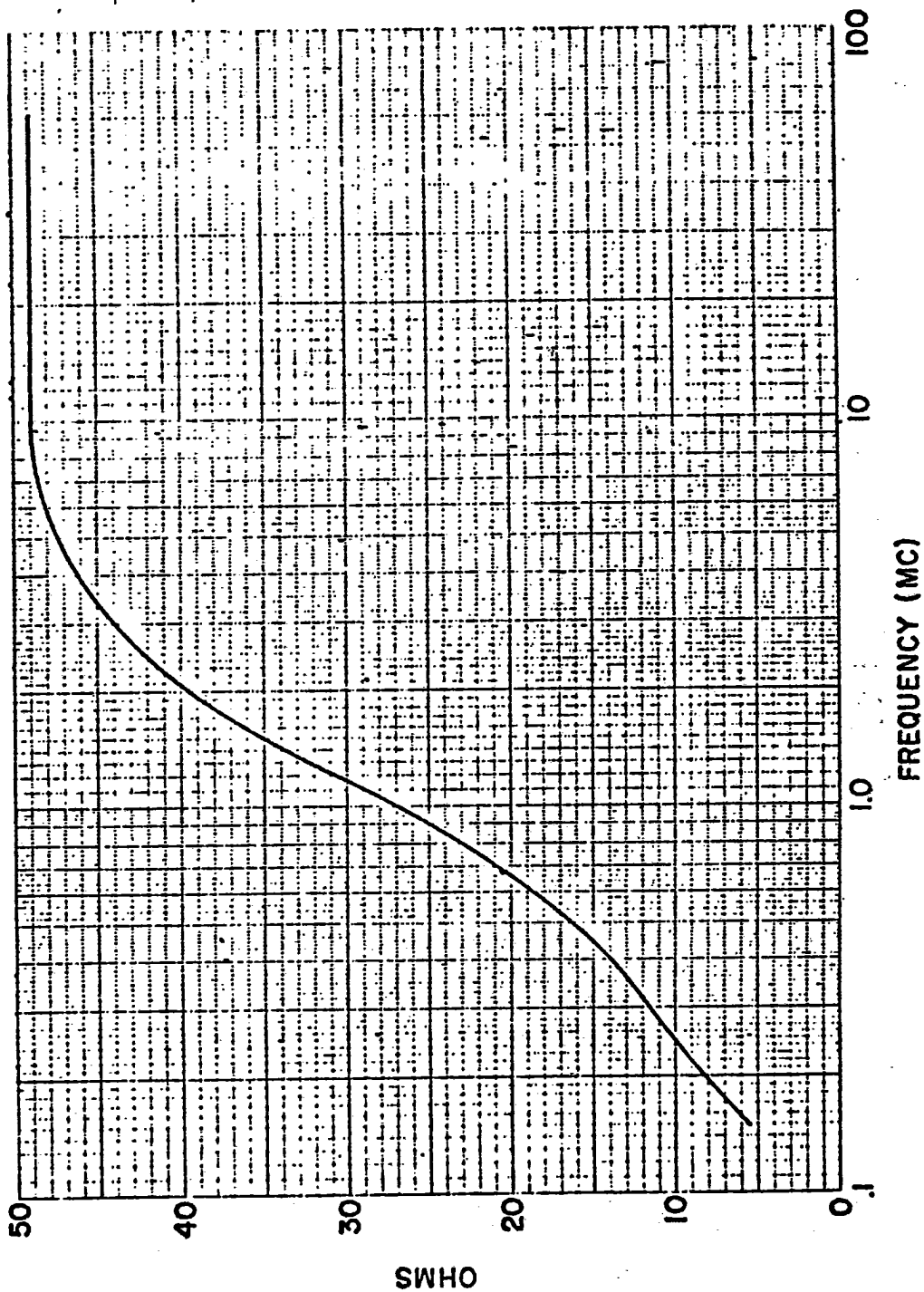
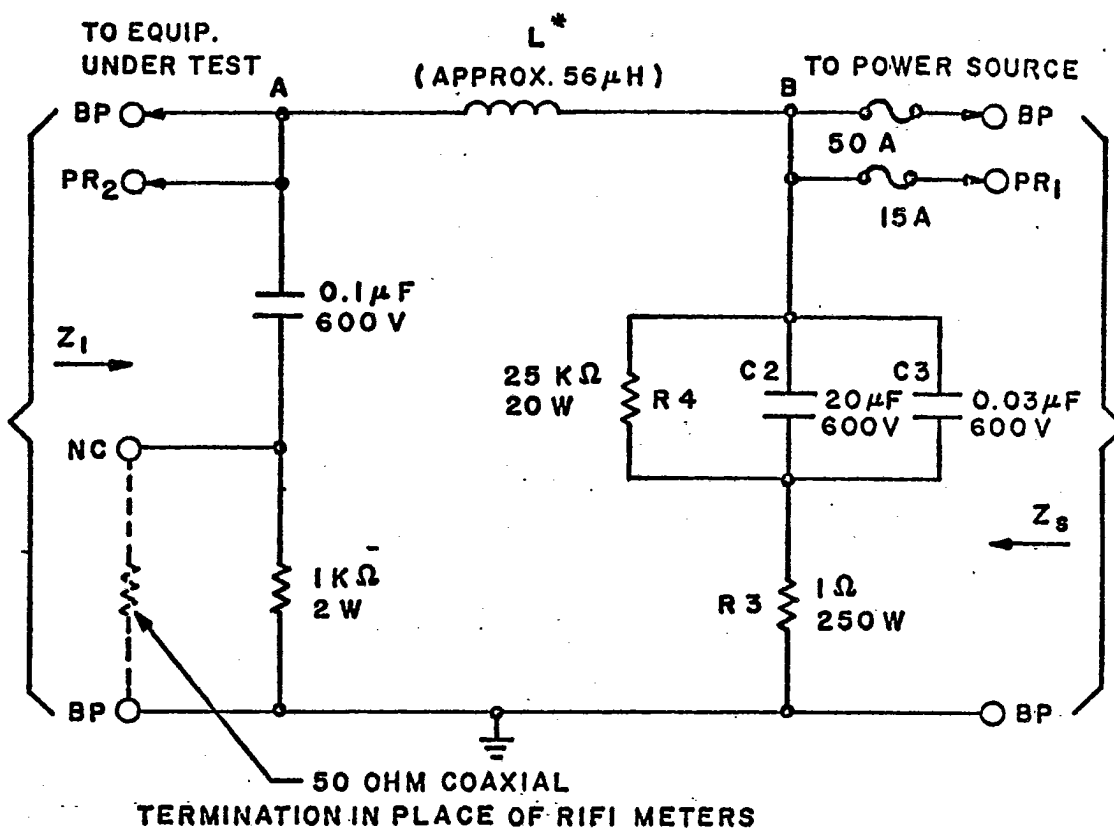


FIG.8 INPUT IMPEDANCE AT TEST SAMPLE TERMINAL OF STABILIZATION NETWORK WITH COAXIAL CONNECTOR TERMINATED IN 50 OHMS, POWER TERMINAL OPEN.



$Z_1$  — IMPEDANCE PRESENTED TO THE EQUIPMENT WHEN CONNECTED FOR MEASUREMENTS.

$Z_s$  — IMPEDANCE OF THE POWER SOURCE USED.

BP — HEAVY DUTY BINDING POSTS (MFR. STANDARD ELECTRIC TIME CO.)

PR<sub>1</sub> — POWER RECEPTACLE, 115 V., 15 AMPS. (3-WIRE POLARIZED TWIST LOCK, MALE BASE)

PR<sub>2</sub> — POWER RECEPTACLE, 115 V., 15 AMPS. (3-WIRE NON-POLARIZED, "U" SHAPED GROUNDING SLOT.)

NC — TYPE "N" CONNECTOR (UG-58/U) PANEL MOUNTING.

$L^*$  — COIL - 26 TURNS OF NO. 6 - 600 VOLTS INSULATED WIRE (STRANDED), WOUND ON  $5\frac{1}{2}$ " DIAMETER COIL FORM.

CASE:  $17\frac{1}{2}$ " L x  $17\frac{1}{2}$ " W x  $8\frac{3}{4}$ " H BRASS (DIVIDED IN TWO SECTIONS BY A BRASS PLATE  $17\frac{1}{2}$ " x  $8\frac{5}{8}$ " x  $\frac{1}{16}$ " THICK.

NOTE: DUAL LINE STABILIZATION NETWORK CONSISTS OF TWO OF THE ABOVE NETWORKS.

FIG. 9 A NETWORK OF THE DUAL LINE IMPEDANCE STABILIZATION NETWORK (LOW FREQUENCY) per SK.N 1791

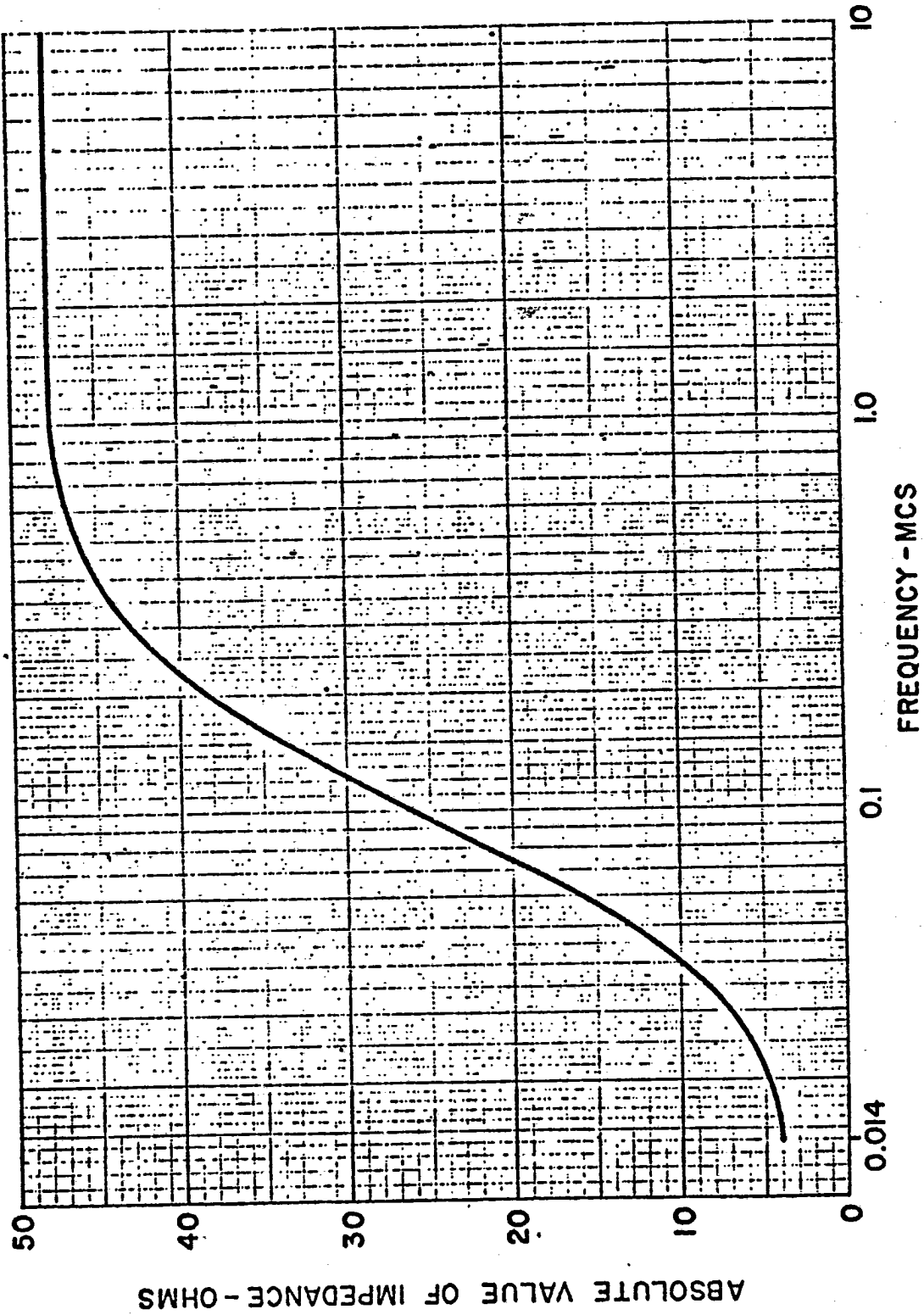


FIG. 10 LOW FREQUENCY LINE IMPEDANCE STABILIZATION NETWORK

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**4.2.3.3 Detector Function.** - A peak detector shall be used for all measurements required by MIL-STD-461 NOTICE 4; however, for narrowband measurements, the average or rms functions may be used, if authorized by the procuring activity. Substitution generator output levels shall be corrected when the detector output and the signal generator output calibration are different functions of sign wave (peak, average, rms).

**4.2.3.4 Monitoring of Measuring Equipment.** - The IF output of the EMI measuring instrument shall be monitored with a device that gives an amplitude versus frequency presentation on a cathode ray tube. This monitor is used to obtain information on the characteristics of the signals being measured. The measuring equipment shall also be monitored with headphones or a speaker.

**4.2.3.5 Identification of Spurious Responses in Measuring Equipment.** - The measurement equipment shall be checked for spurious responses. False data caused by such spurious responses shall be so identified on the X-Y recordings or data sheets.

**4.2.3.6 Calibration of Measuring Equipment.** - Measuring instruments and accessories used in determining compliance with this standard shall be calibrated under an approved program in accordance with MIL-C-45662. The calibration program document required by MIL-C-45662 shall be submitted for government approval as part of the test plan. See EL-CD-6003-0009A for calibration methods for impulse generators.

**4.2.3.7 Accuracy of Measurement.** - All measurements made in accordance with this standard shall have the following accuracies. Proof of such accuracy shall be documented in the test report.

(a) **Frequency Accuracy:**

Where specified limits are exceeded in the spurious response and harmonic and spurious emissions tests (antenna terminal), the frequency of measurement shall be accurate to within  $\pm 0.1\%$ . Since signal generators and EMI meters usually do not offer this accuracy, it will be necessary to employ a frequency counter or other similar standard. All other tests shall be subject to a frequency accuracy of  $\pm 2\%$ .

(b) **Amplitude Accuracy**

Amplitude Accuracies shall be  $\pm 2\text{dB}$ .

**4.2.4 Positioning of Measurement Antennas.** -

**4.2.4.1** Each face of the test sample shall be probed with a loop or other suitable sensor to determine the localized area producing maximum emission or susceptibility. Probing shall be performed at frequencies known or calculated to represent worst case interference; or, if no such information is available, probing shall be performed at no fewer points than 1 frequency for every two octaves over the frequency range of test.

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The face exhibiting worst case characteristics in any octave or band, provided that a band is not less than two octaves, shall face the test antenna for that portion of the frequency scan. Automatic scan techniques may be used to scan all sides.

4.2.4.2 When performing radiated emission and susceptibility tests no point of the antennas shall be less than 1 meter to the walls and 0.5 meters to the ceiling of the shielded enclosure or obstruction.

4.2.4.3 For radiated emission measurements between 30 MHz and 12.4 GHz linearly polarized antennas shall be positioned alternately to measure the vertical and horizontal components of the emission. For radiated susceptibility measurements between 30 MHz and 12.4 GHz, linearly polarized antennas shall be positioned so as to generate alternately vertical and horizontal fields.

4.2.5 Measuring Frequencies. - The entire specified frequency range for each applicable test shall be scanned. Measurements shall be taken at not less than three frequencies per octave representing the maximum indications within the octave. In addition, measurements shall also be made at the test sample's critical frequencies (power frequency and harmonics, local oscillator frequencies, I.f. frequency and others) as specified in the equipment, sub-system or system specification and the government approved test plan.

4.2.6 Identification of Broadband and Narrowband Emissions. - Identification of broadband and narrowband interference may be accomplished by use of the monitoring equipment specified in 4.2.3.4 or by observing effects due to switching of bandwidths or detection functions. Also, a differentiation can be made by measuring the pulse repetition rate of the emission, (Optional). If the pulse repetition rate is less than the rate specified in the following table it should be considered a broadband emission and should be measured with an instrument having a bandwidth equal to or greater than the value of the specified rate; if the repetition rate is greater than specified below, the emission should be considered narrowband and should be measured with an instrument having a bandwidth less than or equal to the value of the specified repetition rate.

Frequency Range	Repetition Rate
20KHz - 150KHz	200Hz
150KHz - 30MHz	5KHz
30MHz - 400MHz	100KHz
400MHz - 1000MHz	300KHz

4.2.6.1 Pulsed CW Requirements. - The pulse repetition criteria expressed in the foregoing shall apply for pulsed CW up to 1000MHz.

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Above 1000 MHz pulsed CW emission shall be compared to narrowband limits; however, bandwidth corrections should be employed to normalize the measurements to 1 MHz bandwidth.

#### 4.2.7 Arrangement and Operation of Test Sample.

4.2.7.1 Control Adjustment. - For all modes of operation, controls on the test sample shall be operated and adjusted as prescribed in the instruction manual or as required by the equipment specification to obtain optimum design performance.

4.2.7.2 Signal Inputs. - Actual or simulated signal inputs required to activate, utilize, or operate all circuits shall be used during emission and susceptibility testing.

4.2.7.3 Arrangement and Operating Conditions. - Interconnecting cable assemblies and supporting structures shall simulate actual installation and usage. Shielded leads shall not be used in the test setup unless they have been specified in government furnished installation drawings or in the government approved electromagnetic compatibility control plan. Cables shall be checked against the installation requirements to verify that no extra shielded wires have been used. Cables and equipments shall be so arranged that there is no shielding interposed between the test sample cables and the measurement antennas. When testing in shielded enclosures, the faces of the test sample shall be located  $10 \pm 2$  centimeters (cm) from the edge of the ground plane. All leads and cables shall be within  $10 \pm 2$  cm from the edge of the ground plane, and shall be approximately 5 cm above the ground plane.

4.2.7.4 Bonding of Test Sample. - Except as indicated for conducted emission tests, only the provisions included in the design of the equipment or as specified in government approved installation drawings shall be used to bond units such as equipment case and mount together, or to the ground plane. When bonding straps are required to complete the test setup, they shall be identical to those specified in the installation drawings. Portable equipments that are intended to be grounded through the third wire of the power cable shall be grounded as indicated in the applicable test procedure, and shall not be grounded by any other means; for radiated emissions testing, this would require the use of an isolation test stand.

4.2.7.4.1 Shock and Vibration Isolators. - Test samples shall be secured to mounting bases having shock or vibration isolators, if such mounting bases are used in the installation. The bonding straps furnished with the mounting base shall be connected to the ground plane. When mounting bases do not have bonding straps, bonding straps shall not be used in the test setup.



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4.2.7.4.2 External Ground Terminal. - When an external terminal is provided for a ground connection on the test sample, this terminal shall be connected to the ground plane.

4.2.7.5 Loads. - The equipment under test shall be loaded with the full mechanical and electrical load, or equivalent for which it is designed. This requirement specifically includes electrical loading of the contacts of mechanisms which are designed to control electrical loads even though such loads are physically separate from the equipment under test. Operation of voltage regulators and other circuits that function intermittently is required during testing. The loads used shall simulate the resistance, inductance, and capacitance of the actual load. Mechanical devices shall also be operated under load. The device under test shall be actuated by the same means as in the installation. Example: If a solenoid is actuated by a silicon-controlled rectifier, do not use a toggle switch to operate the solenoid for the test.

4.2.7.5.1 Source and Loads for C-E Equipment. - All RF outputs of C-E equipment shall be terminated with shielded dummy loads as appropriate for the equipment under test and the test being run to produce maximum normal output. At the frequencies of concern, the VSWR of resistive dummy loads, attenuators, directional couplers, samplers, power dividers, and the internal output impedance of standard signal generators shall be no greater than:

Transmitter Loads 1.5:1  
All other dummy loads and pads 1.3:1  
Standard Signal Generators 1.3:1

4.2.7.6 Operating Frequencies. - Measurements shall be performed with the test sample tuned according to the following rule:

(a) Where the test sample has only one continuously tunable band (without band switching) or a single range of fixed channels, perform tests with the test sample tuned to frequencies or channels not more than 5 percent removed from the lower and upper tunable frequency limits. If these selected frequencies are of ratio greater than 2 to 1, perform tests with test sample tuned to the center frequency of the tunable band or range, also.

(b) For test samples with multiple tuning bands or ranges of fixed channels, perform tests with test sample tuned to frequencies 5 percent removed from the extremes of each band or range. Where this would involve greater than 6 tests, perform tests with test sample tuned to the center frequency at each band or range only.

(c) In addition to the above, narrowband tests shall be conducted with the test sample tuned to frequencies or channels as indicated in the

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government approved control and test plans as being potentially subject to spurious responses and emissions.

## 5 Measurement Procedures. -

5.1 This section contains the measurement procedures to be used in determining compliance with the emission and susceptibility requirements MIL-STD-461 NOTICE 4. The test procedures are for the entire specified frequency range; however, certain equipments sub-systems or systems may not require testing throughout the complete measurement frequency range. These modifications are specified in MIL-STD-461 NOTICE 4

5.2 Table III is an index of measurement procedures by method number, date, and title.

Table III - Index of Measurement Procedures

<u>Method</u>	<u>Date</u>	<u>Title</u>
CEO1	5 Sept 1969	Conducted Emission, 30 Hz to 50 KHz, dc Power Leads
CEO2	5 Sept 1969	Conducted Emission, 10 KHz to 50 KHz, ac Power Leads
CEO3	5 Sept 1969	Conducted Emission, 30 Hz to 50 KHz, Control and Signal Leads
CEO4	5 Sept 1969	Conducted Emission, 50 KHz to 50 MHz, Power Leads
CEO5	5 Sept 1969	Conducted Emission, 50 KHz to 50 MHz, Control and Signal Leads
CEO6	5 Sept 1969	Conducted Emission 10 KHz to 12.4 GHz, Antenna Terminal
CEO7	10 June 1970	Power Source, Tactical Vehicles 1.5 to 65 MHz
CSO1	5 Sept 1969	Conducted Susceptibility, 30 Hz to 50 KHz, dc Power Leads
CSO2	5 Sept 1969	Conducted Susceptibility, 50 KHz to 400 MHz Power Leads
CSO3	5 Sept 1969	Conducted Susceptibility, 30 Hz to 10 GHz, Intermodulation, Two Signal
CSO4	5 Sept 1969	Conducted Susceptibility, 30 Hz to 10 GHz, Rejection of Undesired Signals at Input Terminals (2-Signal Generator - Method)
CSO6	5 Sept 1969	Conducted Susceptibility, Spike, Power Leads

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CS07	31 July 1967	Conducted Susceptibility, Squelch Circuits
CRED1	5 Sept 1969	Transient Measurements of Manual Switching and Low Repetition Noise
CRED2	5 Sept 1969	Emission Measurements in a High Ambient Field
RE01	31 July 1967	Radiated Emission, 30 Hz to 30 KHz, Magnetic Field
RE02	5 Sept 1969	Radiated Emission, 14 KHz to 12.4 GHz, Electric Field
RE03	5 Sept 1969	Radiated Emission, Spurious and Harmonic Emissions 10 KHz to 40 GHz
RE03	5 Sept 1969	Radiated Emission, 20 Hz to 40 KHz, -Magnetic Field
RE04	5 Sept 1969	Radiated Emission, 20 Hz to 50 KHz, Magnetic Field
RE05	31 July 1967	Radiated Emission, 150 KHz to 400 MHz Vehicles and Engine-Driven Equipment
RE06	31 July 1967	Radiated Emission, 14 KHz to 1 GHz, Overhead Power Lines
RS01	31 July 1967	Radiated Susceptibility, 30 Hz to 30 KHz, Magnetic Field
RS02	5 Sept 1969	Radiated Susceptibility, Magnetic Induction Fields
RS03	5 Sept 1969	Radiated Susceptibility, 14KHz to 12.4 GHz Electric Field

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## METHOD CEO1

### CONDUCTED EMISSION, 30 Hz to 50 KHz DC POWER LEADS

1. Applicability - This test method is applicable for measuring conducted emissions in the frequency range of 30 Hz to 50 KHz on dc power input and output leads. It is especially useful where flat frequency response or increased sensitivity is desired.

#### 2. Apparatus -

a. Solar Electronics Co., Audio Isolation Transformer Type 6220-1A or equivalent.

b. Electromagnetic Interference Meter.

c. Ten-Micro-Farad Feed-Through Capacitor.

3. Test Setup - The test setup shall be as shown in Figure CEO1-1. The resistor R shunts the primary, its value determining the system transfer impedance. The transfer impedance or correction factor shall be determined as shown in Figure CEO1-2 and plotted as shown in Figure CEO1-3. A value of R less than 5 ohms should be chosen so as to give essentially a flat response across the frequency range. The transfer impedance can also be determined by a single calculation as follows.

$$z = 20 \log \frac{R}{2} = \text{db relative to one ohm } (R \ll 50 \text{ ohms})$$

The correction factor is then just the negative of z, (This calculation will be in slight error if the transformer turns ratio is not exactly 2 to 1. In such case  $z = 20 \log \frac{R}{n}$  where n is the turns ratio). In

order to maintain required sensitivity a value of R less than .5 ohms should not be used.

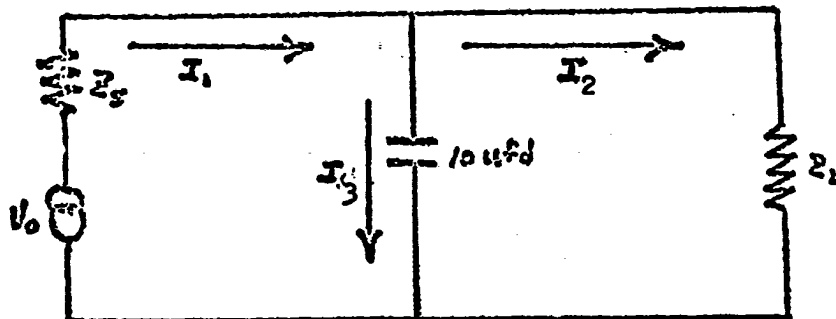
3.1 A measurement instrument bandwidth between 50 and 75 Hz shall be used.

## METHOD CE01

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## NOTES:

1. Technique for Determining Source of Conducted Emission (Ambient or Test Sample Generated)



$$I_1 = I_2 + I_3$$

$I_1$  is always greater than  $I_2$

When taking measurements on both sides of the capacitor, the highest level at any given frequency will always be on the same side with the generator or source of that emission. Thus, if the higher level is measured on the test sample side of the capacitor, the emission is coming from the test sample. If the level is higher on the power source side of the capacitor the emission is ambient.

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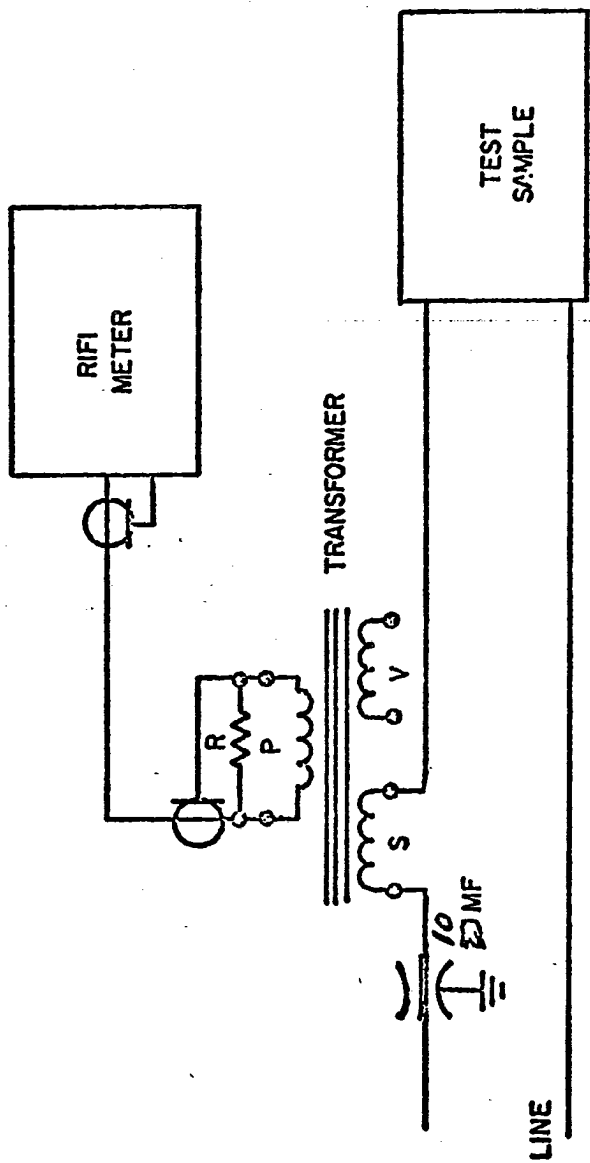


FIG : CE01 - 1 TEST SETUP FOR MEASURING LOW FREQUENCY, LOW AMPLITUDE EMC CURRENT

BASED ON SOLAR ELECTRONICS COMPANY AN 622001

- NOTES: (1) IF INPUT CIRCUIT TO RIFI METER IS REACTIVE, USE A MINIMUM LOSS "T" PAD AT THE INPUT TO THE METER.
- (2) MAINTAIN AF GENERATOR OUTPUT FOR CONSTANT VOLTAGE DROP ACROSS THE 10-OHM RESISTOR.

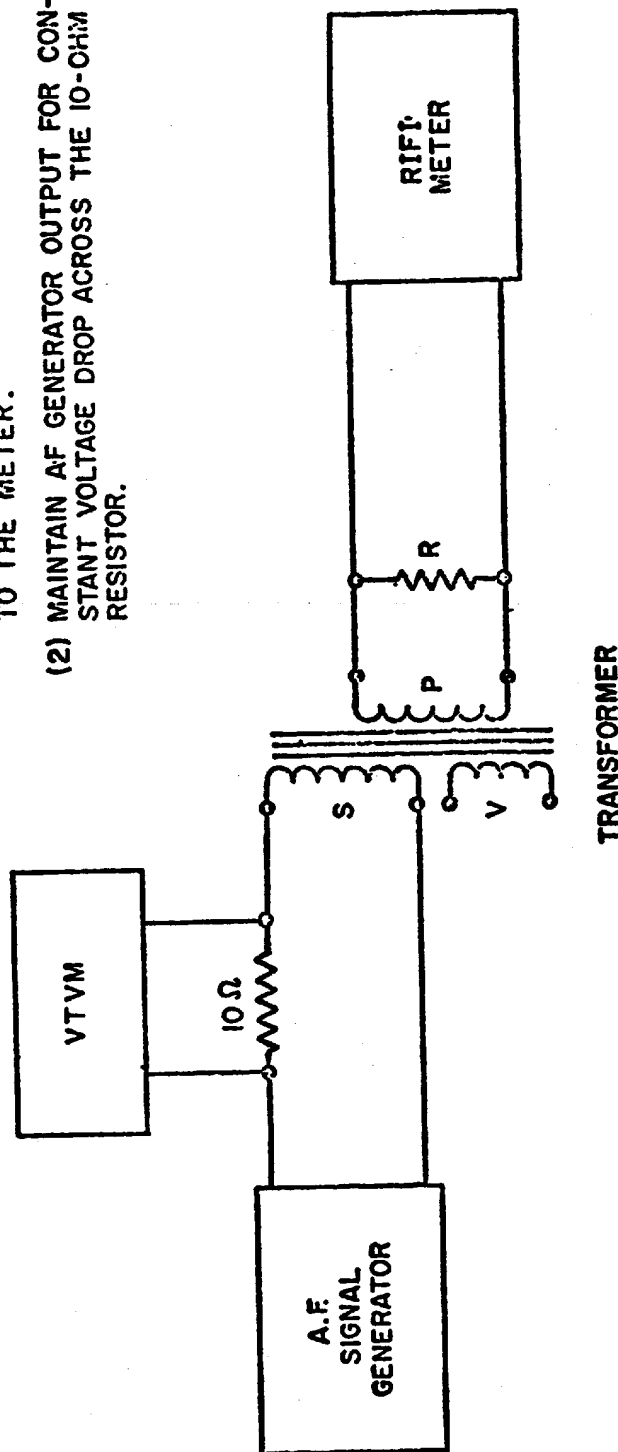


FIG. 1. CE01 -2- TEST SETUP FOR DETERMINING CORRECTION FACTOR.

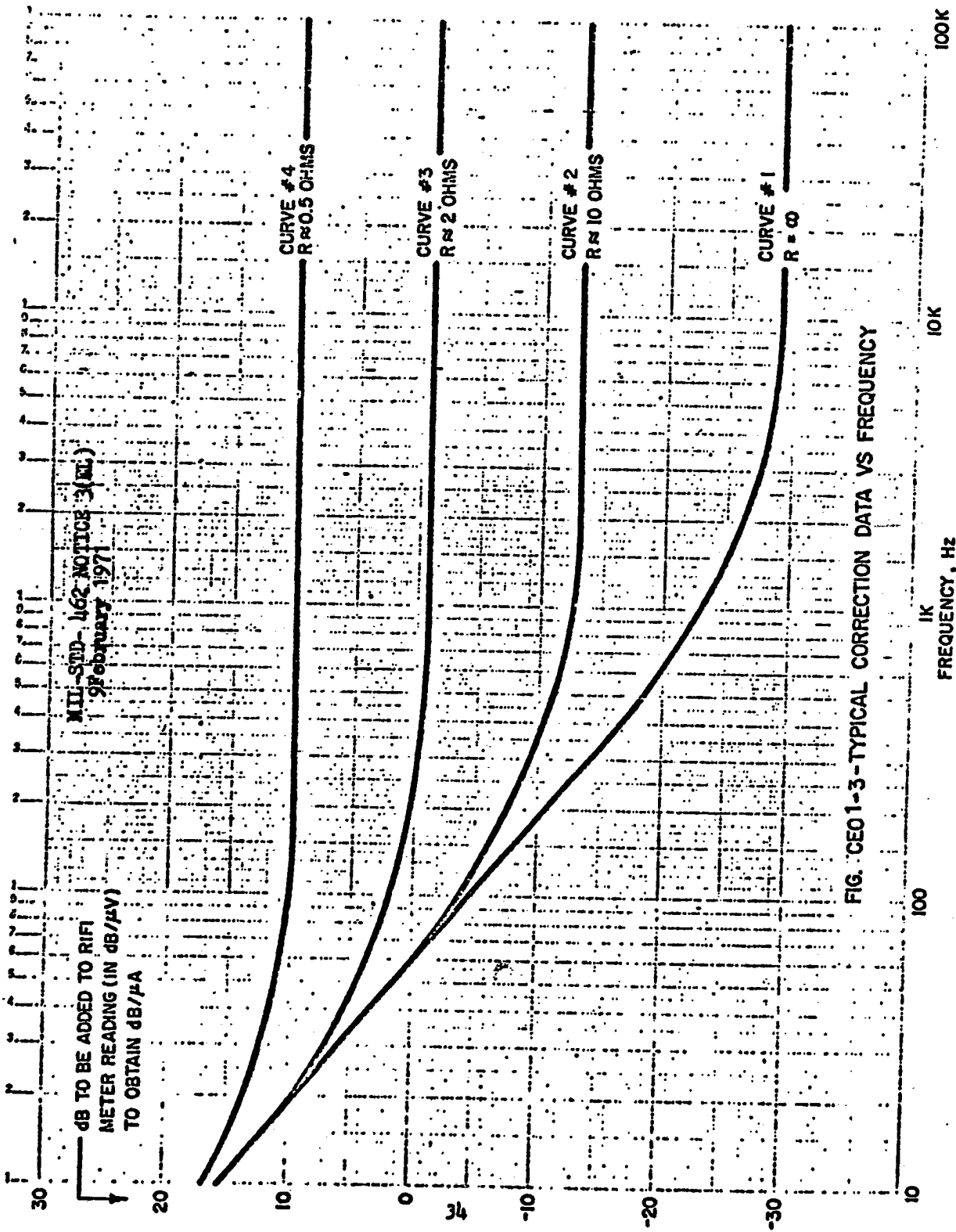


FIG. CE0 1-3-TYPICAL CORRECTION DATA VS FREQUENCY



## METHOD CEO2

## CONDUCTED EMISSION, 10 KHz to 50 KHz, AC POWER LEADS

1. Applicability - This test method is applicable for measuring conducted emissions on ac power input and output leads, including neutrals which are grounded externally to the equipment and whose length exceeds 6 inches.
2. Apparatus -
  - a. Current Probe.
  - b/ Matching Transformer -- If required between current probe and the interference meter to allow the measuring system to meet the sensitivity requirements needed to perform the test.
  - c. Electromagnetic Interference Meter.
  - d. Band - Reject or High Pass Filter - A filter shall be used in the measuring circuit to attenuate all frequencies below 10 KHz.
  - e. Line Impedance stabilization networks. See Figures 9 and 10 for details of LISN covering applicable frequency range.
  - f. Headphones and IF monitor.
  - g. 50 ohm resistive terminations for LISN's
3. Test Procedure - The test setup shall be as shown on Figure CEO2.
  - 3.1 A meter bandwidth between 50 and 75 Hz shall be used.

## Notes:

- a. When matching transformers or band-reject filters are used, their characteristics must be described in the test plan and/or test report.
- b. Conducted emissions shall be measured separately on each power lead.

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FIGURE CMO2

NOTES:

1. The equipment power ground shall be referenced to the ground plane for this test.
2. The minimum separation between cables, leads, and ground plane shall be 5 cm.
3. The length of power lead from the test sample to the stabilization networks shall be at least 2 meters long but not greater than 3 meters long.
4. The length of each power lead between the point of separation and connection to the stabilization network shall be  $30 \pm 2$  cm.
5. The test sample and EMI instrumentation should derive their power requirements from separate phases of the ac power source, if possible. The purpose of this requirement is to provide isolation between the test sample and measurement instrumentation through the shielded enclosure power line filters.
6. The EMI measurement instrument chassis power ground must be broken at the isolation transformer to prevent circulation of r.f. ground currents in the test equipment.
7. Calibration generators and other electronic measurement instrumentation must not contribute adversely to the power line ambient level. Separate power source phases, filters, reversed line impedance stabilization networks, etc. should be used as required to provide r.f. isolation.

**CAUTION:** Be sure all test instrumentation is properly bonded to the ground plane before applying power to prevent a potential shock hazard to personnel.

1. 3 cm STANDOFFS
2. LOW IMPEDANCE BOND TO GROUND PLANE
3. CURRENT PROBE
4. TEST SAMPLE CHASSIS GROUND
5. HIGH SIDE
6. RETURN (neutral line)
7. DC BOND IMPEDANCE BETWEEN THE GROUND PLANE AND ENCLOSURE SHALL NOT EXCEED 2.5 MILLIOHMS.
8. LEE FEEDBACK STABILIZATION NETWORKS SHALL BE TERMINATED IN 50 OHMS RESISTIVE AT TYPE II CONNECTOR

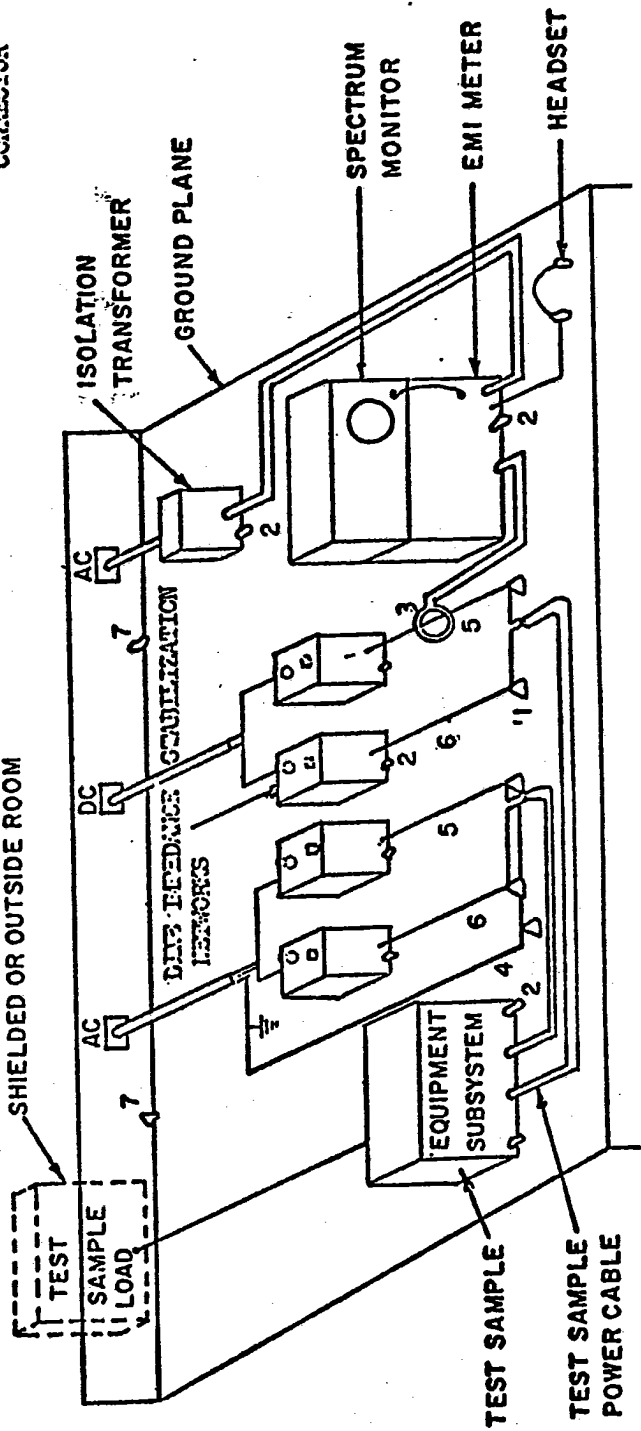


FIG. CE02  
TYPICAL TEST SETUP FOR CONDUCTED EMISSION MEASUREMENTS ON POWER LEADS

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### METHOD CEO3

#### CONDUCTED EMISSIONS, 30 Hz to 50 KHz, SUB\_SYSTEM CONTROL AND SIGNAL LEADS

1. Applicability - This test method is applicable for measuring conducted emissions on control and signal leads which interconnect sub-systems of a system. Interconnecting cables, signal leads and control leads existing at the interface of Contract End Items being supplied under a single contract by a single contractor need not be tested.

2. Apparatus - The test apparatus shall include the following.

a. Current Probe.

b. Matching Transformer - If required between current probe and the interference meter to allow the measuring system to meet the sensitivity requirements needed to perform the test.

c. Electromagnetic Interference Meter with 50 to 75 Hz bandwidth.

3. Test Setup and Procedure - The test setup shall be as shown in Figure CEO3-1

3.1 Measurements shall be taken with the EMI meter bandwidth selection control set to 50 to 75 Hz.

4. Notes:

a. Where individual or groups of leads, contained in a shielded or sheathed bundle, must be tested, an extension or segment, fabricated especially for the purposes of this test, must be added to the cable. This segment would be unshielded and would include no shields. Rules for grouping signal and control leads, within the same lead bundle, for testing are as follows.

(1) In no case shall a group of leads be probed with both the high and return leads in the test group. Twisted pairs will be tested in the same manner at the bundle test extension or segment where the twisting is discontinued.

(2) The size of the group tested should not exceed  $\frac{1}{2}$  inch in diameter. Each group which results from the division should contain a approximately the same number of conductors.

(3) When a group of leads exceeds the limits of this standard, the offending leads shall be identified and measured separately.

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b. When the test sample provides secondary power to another equipment which is not included in the test, the power lines shall be appropriately loaded, excluding LISN's and measurements shall be made using method for signal and control leads.

## FIGURE CEO3-1 NOTES

1. The d.c. bond resistance between the ground plane and the enclosure shall not exceed 2.5 milliohms.
2. The minimum separation between cables, leads and ground plane shall be 5 cm.
3. The test sample and EMI instrumentation should derive their power requirements from separate phases of the ac power source, if possible. The purpose of this requirement is to provide isolation between the test sample and measurement instrumentation through the enclosure power line filters.
4. The EMI measurement instrument chassis power ground must be broken at the isolation transformer to prevent circulation of r.f. ground currents in the test equipment.
5. Calibration generators and other electronic measurement instrumentation must not contribute adversely to the power line ambient level. Separate power source phases, filters, reversed impedance stabilization networks, etc., should be used as required to provide r.f. isolation.

**CAUTION:** Be sure the instrumentation is properly bonded to the ground plane before applying ac power to prevent potential shock hazard to personnel.

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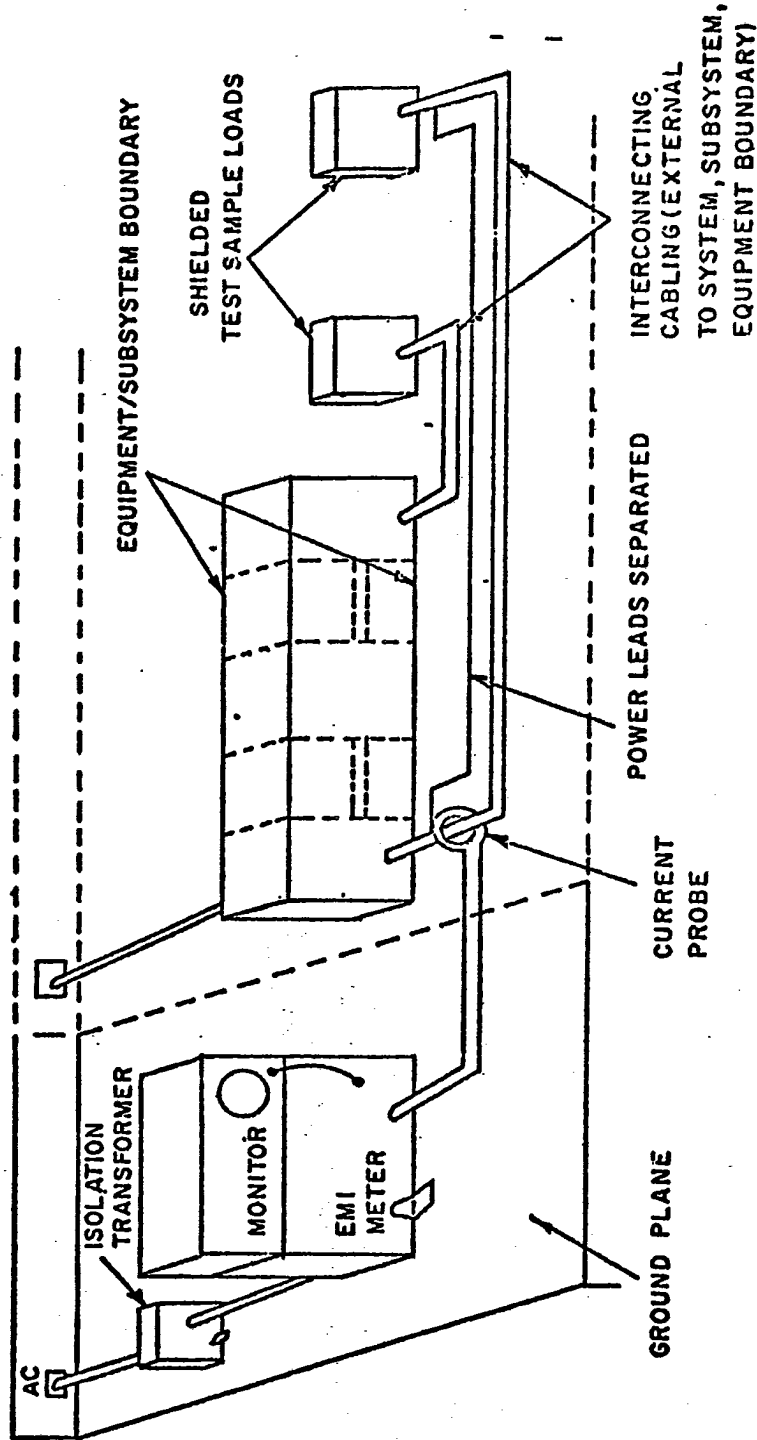


FIG. CE03-1 TYPICAL TEST SETUP FOR MEASURING CONDUCTED EMISSIONS AT EQUIPMENT, SUBSYSTEM, SYSTEM OUTPUT TERMINALS.

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#### METHOD CE04

### (A) CONDUCTED EMISSIONS 50 KHz to 50MHz, POWER LEADS

1. Applicability - This test method is applicable for measuring conducted emissions on equipment/sub-system a.c. and d.c. power leads, including neutrals which are grounded externally to the equipment. This includes equipment-sub-system leads supplying unfiltered primary a.c. and d.c. power to other equipments or sub-systems. To be used in testing to the requirements of Tables I thru VII of MIL-STD-461 NOTICE 4
2. Apparatus: Measurement instrumentation shall include.
  - a. Current Probes.
  - b. Electromagnetic Interference Meter.
  - c. Line Impedance Stabilization Networks- Two such networks, covering separate frequency ranges, are required for each line to be tested (See Table II and Figures , 7, 8, 9 and 10).
  - d. Headset and IF Monitoring Device
  - e. 50 ohm resistive terminations
3. Test Procedure - The test setup shall be as shown in Figure CE02. See Figure CE04-1 for details of LISN setup.

#### NOTES:

1. The current probe shall be positioned along the length of power lead to produce a maximum reading on the EMI meter.
2. Engine Generators - No LISN is required in the output power leads. Measurements shall be made with the output end of the power cable terminated with a normal operating load. A cable length of 50 feet should be used and measurements made near the load end.

### (B) CONDUCTED INTERFERENCE, POWERLINE - .150 to 65 MHz LISN METHOD

1. Applicability - This test method is applicable for measuring conducted emissions in the frequency range of .150 to 65 MHz on A.C. and D.C. power leads for all electronic and electro-mechanical equipment except engine generators and vehicles. To be used in testing to the requirements of Tables A-I thru A-VI of MIL-STD-461 NOTICE 4.

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2. Apparatus - The test apparatus shall include the following:

a. Line impedance stabilization networks (impedance characteristics per Figure 8 and 10.

b. 50 ohm resistive terminations (VSWR not greater than 1.3 at frequencies of concern).

c. Isolation transformer.

3. Test Procedure - The test setup shall be as shown in Figure CED4-2. Conducted emissions, both narrowband and broadband, shall be measured on all A.C. and D.C. power input and output leads, including neutrals which are grounded externally to the equipment. Bonding straps do not have to be measured. The limits of Figures A-3a through A-3d of MIL-STD-461 NOTICE 4 shall apply.



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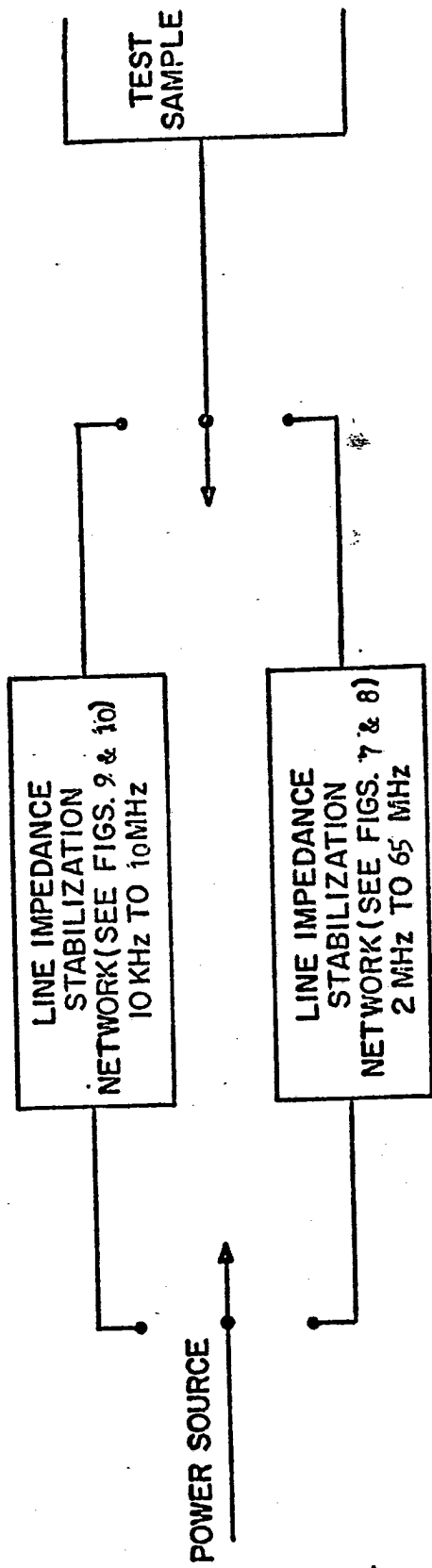


FIG. CE04-1 DETAILED SETUP OF LINE IMPEDANCE STABILIZATION NETWORKS

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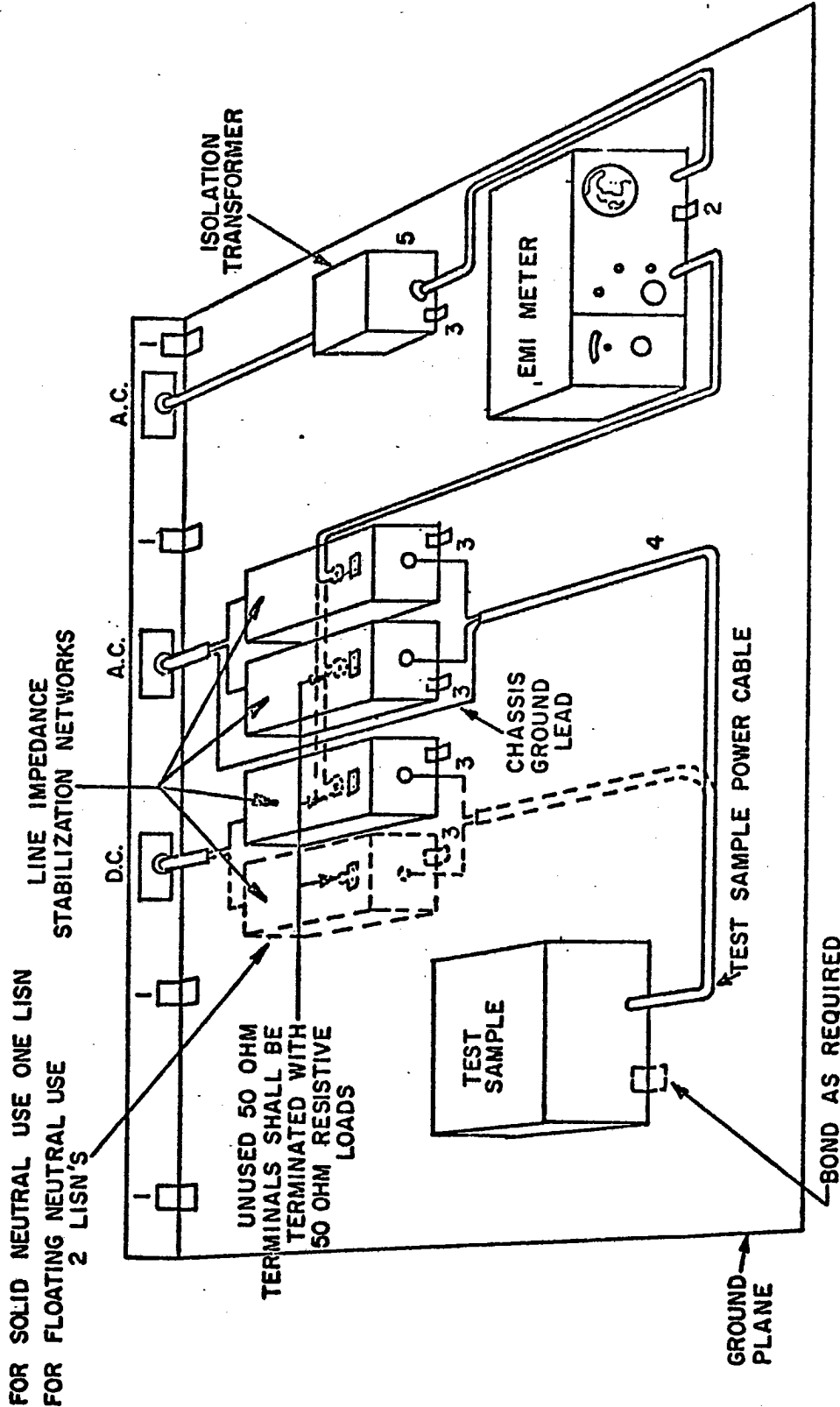


FIG. CE04-2 TYPICAL TEST SETUP FOR MEASUREMENT OF CONDUCTED INTERFERENCE ON POWERLINES, LISN METHOD B

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NOTES - Figure CED4-2

1. The D.C. bond impedance between the ground plane and enclosure shall not exceed 2.5 milliohms.
2. The EMI meter shall be bonded to the ground plane at one point only. The chassis ground lead shall be broken.
3. Line impedance stabilization networks and isolation transformer shall be bonded to the ground plane.
4. The minimum separation between cables, leads and ground plane shall be 5 CM.
5. When possible, the test sample and EMI measuring instrumentation shall derive their power from two separate phases of the A.C. source. The purpose of this is to provide additional isolation between the test sample and measuring instrumentation through the enclosure's power line filters.

**CAUTION:** Be sure all test instrumentation is properly bonded to the ground plane before applying power to prevent a potential shock hazard to personnel.

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## METHOD CEO5

## CONDUCTED EMISSIONS, 50 KHz to 50-MHz SUB-SYSTEM CONTROL AND SIGNAL LEADS

1. Applicability - This method is applicable for measuring conducted emissions on control and signal leads which interconnect sub-systems of a system configuration. Interconnecting cables, signal leads and control leads existing at the interface of Contract End Items being supplied under a single contract by a single contractor need not be tested.

2. Apparatus - The test apparatus shall include the following:

- a. Current probes.
- b. Electromagnetic Interference Meter.
- c. Headset and IF monitoring device.

3. Test Setup and Procedure - The test setup shall be as shown in Figure CEO3-1.

4. Notes:

a. Where individual or groups of leads, contained in a shielded or sheathed bundle, must be tested, an extension or segment, fabricated especially for the purposes of this test, must be added to the cable. This segment would be unsheathed and would include no shields. Rules for grouping signal and control leads, within the same lead bundle, for testing are as follows.

(1) In no case shall a group of leads be probed with both the high and return leads in the test group. Twisted pairs will be tested in the same manner at the bundle test extension or segment where the twisting is discontinued.

(2) The size of the group tested should not exceed  $\frac{1}{2}$  inch in diameter. Each group which results from the division should contain approximately the same number of conductors.

(3) When a group of leads exceeds the limits of this standard, the offending leads shall be identified and measured separately.

b. When the test sample provides secondary power to another equipment which is not included in the test, the power lines shall be appropriately loaded, excluding LISN's and measurements shall be made using the method for signal and control lines.

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c. The current probe shall be positioned along the length of interconnecting cable to produce a maximum reading on the EMI meter.

d. The equipment shall be loaded as specified under the test sample requirements in this standard.

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## METHOD CEO6

CONDUCTED EMISSION, 10 KHz to 12.4GHz

ANTENNA TERMINAL, EQUIPMENT, SUB-SYSTEM, SYSTEM

1. Applicability - This test procedure shall be used to measure the power of emissions appearing at equipment, sub-system and system antenna terminals. The procedures outlined herein for the range from 10 KHz to 12.4GHz are applicable for receivers, transmitters (key-up and key-down) and r.f. amplifiers operating below 1.24 GHz. These procedures do not apply to equipments designed to operate into a fixed nonremovable antenna, for transmitters whose average output power is greater than five kilowatts, or for transmission systems above the frequency where multimode propagation can exist.

2. Frequency Range of Test - Frequency range of the test is as follows:

<u>Equipment (test Sample) Operating Range</u>	<u>Range of Test</u>
VLF (10 to 30 KHz)	0.01 to 10 MHz
LF (30 to 300 KHz)	0.01 to 100 MHz
MF (.3 to 3 MHz)	0.01 to 600 MHz
HF (3 to 30 MHz)	0.01 to 1,000 MHz
VHF (30 to 300 MHz)	0.01 to 3,000 MHz
UHF (300 to 1240 MHz)	0.01 to 12,400 MHz

3. Apparatus - The measuring apparatus shall be as indicated in Figures CEO6-1, CEO6-2, CEO6-3 and CEO6-4 as applicable.

4. Test Setup - The test procedure shall be selected in accordance with the title descriptions of Figures CEO6-1, CEO6-2 and CEO6-3.

4.1 If the equipment is designed for operation into a specified antenna, it shall be tested using the actual antenna as the load.

4.2 For testing receivers and transmitters in the key-up condition, the rejection networks and attenuators should not be used. Measurements should be made by interposing an appropriate matching network between the antenna terminal and the EMI meter.

4.3 When the power available at the antenna terminals is greater than 30 dBW or the operating frequency of the test sample is greater than 1.24 GHz or multimode emissions exist below 12.4 GHz in waveguide transmission lines, measurements shall be made in the radiated field, using Method RED3.

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4.4 Selection of directional couplers for use in this test should be based on the following criteria.

a. Insertion loss between test sample and load shall not exceed 1dB over the frequency range of test.

b. Coupling arm calibration error shall not exceed  $\pm 0.25$  dB over the frequency range of test.

c. The coupling arm isolation shall be consistent with adequate reduction of the transmitter's fundamental power and the test configuration sensitivity required to measure spurious and harmonic levels indicated in the limit curve of MIL-STD 461 NOTICE 4.

5. Procedure to be Used in Conjunction With the Test Setup of Figure CED6-4.

a. Tune the transmitter to a specified test frequency. With the coaxial switch of Figure CED6-4 in position 1, and the fundamental frequency rejection network bypassed, tune the frequency - selective volt meter to the transmitter frequency. Adjust the variable attenuator and the voltmeter controls for a convenient reading on the meter. Record all settings and attenuator settings including power monitor level.

b. Using the transmitter settings of (a) above, insert the fundamental frequency rejection network, and tune it to reject the transmitter fundamental frequency.

c. With minimum system attenuation and maximum instrument sensitivity, tune the frequency selective voltmeter through its full frequency range/s to detect all emissions.

d. Each time a spurious transmitter output is found, adjust the meter sensitivity to give a convenient reading. Set the coaxial switch to position 2 and determine the signal level of the responses by substituting an equivalent signal from the signal generator. Record these values. When determining the level of the responses, the attenuation of the signal coupling device, at the spurious frequency shall be known to within  $\pm 0.25$  db.

e. Repeat the foregoing steps at each specified transmitter test frequency.

6. Notes.

6.1 An impedance match between the test sample and the measuring equipment shall be maintained.

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6.2 It is easy to damage equipment during this test or to generate spurious responses in the interference measuring set. To minimize these problems, it is recommended that the fundamental frequency be attenuated to approximately - 30dBW at the input to the rejection network.

6.3 Identification of spurious responses can be simplified by monitoring the measurement instruments IF with a spectrum analyzer or pan adapter.

6.4 The test sample shall always operate into a matched resistive load for all antenna terminal tests except when the test setup of CED6-3 is used, where the actual equipment antenna is used as a load.

6.5 The insertion loss of fundamental frequency rejection networks shall be known, at the frequencies of the spurious output being measured, to +1dB.

6.6 Dummy loads shall be of adequate power handling capacity to terminate the transmitters.

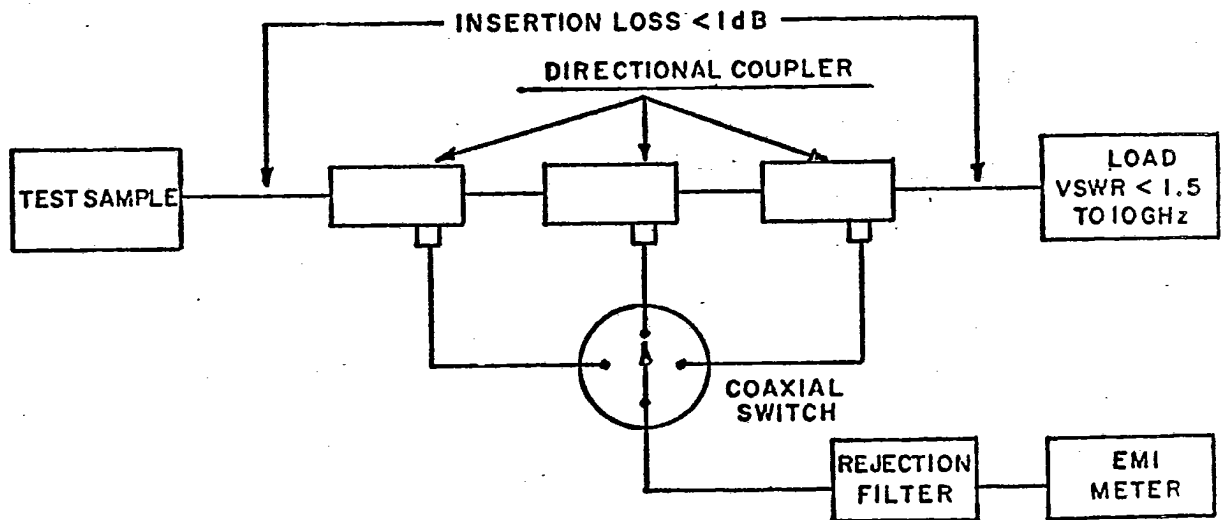


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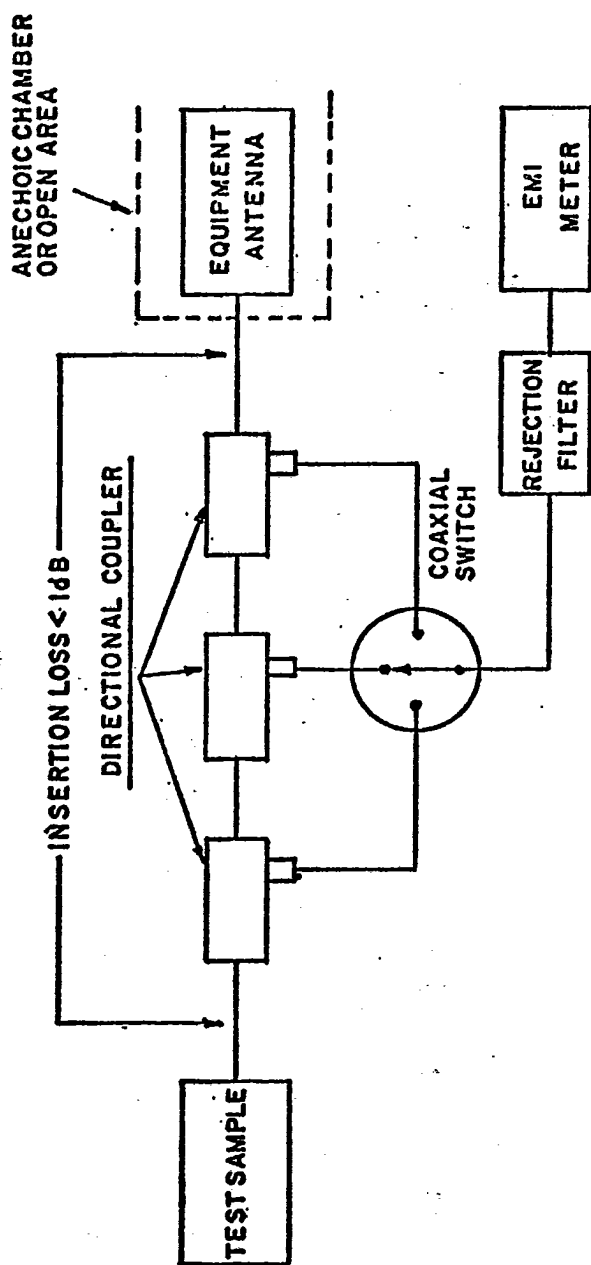
AVERAGE POWER AT INPUT TO EMI METER AT  $f_0$  SHOULD NOT BE GREATER THAN 40dB ABOVE METER SENSITIVITY LEVEL.

FIG. CE06-1 TEST SETUP FOR CONDUCTED EMISSIONS, ANTENNA TERMINAL WHERE  $f_0$  IS IN RANGE OF 10 KHz TO 100 MHz AND AVERAGE POWER DOES NOT EXCEED 30 dBW.



AVERAGE POWER AT INPUT TO EMI METER AT  $f_0$  SHOULD NOT BE GREATER THAN 40dB ABOVE METER. Sensitivity Level

FIG. CE06-2 TEST SETUP FOR CONDUCTED EMISSIONS, ANTENNA TERMINAL WHERE  $f_0$  IS IN RANGE 100 MHz TO 1.24 GHz AND AVERAGE POWER DOES NOT EXCEED 30 dBW.



AVERAGE POWER AT INPUT TO EMI METER AT  $f_0$  SHOULD NOT BE GREATER THAN 40dB ABOVE METER SENSITIVITY LEVEL.

FIG. CE06-3 TEST SETUP FOR CONDUCTED EMISSIONS ANTENNA TERMINAL WHERE  $f_0$  IS IN RANGE 100 MHz TO 1.24 GHz AND THE EQUIPMENT IS DESIGNED TO OPERATE WITH A SPECIFIED ANTENNA.

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EQUIPMENT, SUBSYSTEM OR SYSTEM

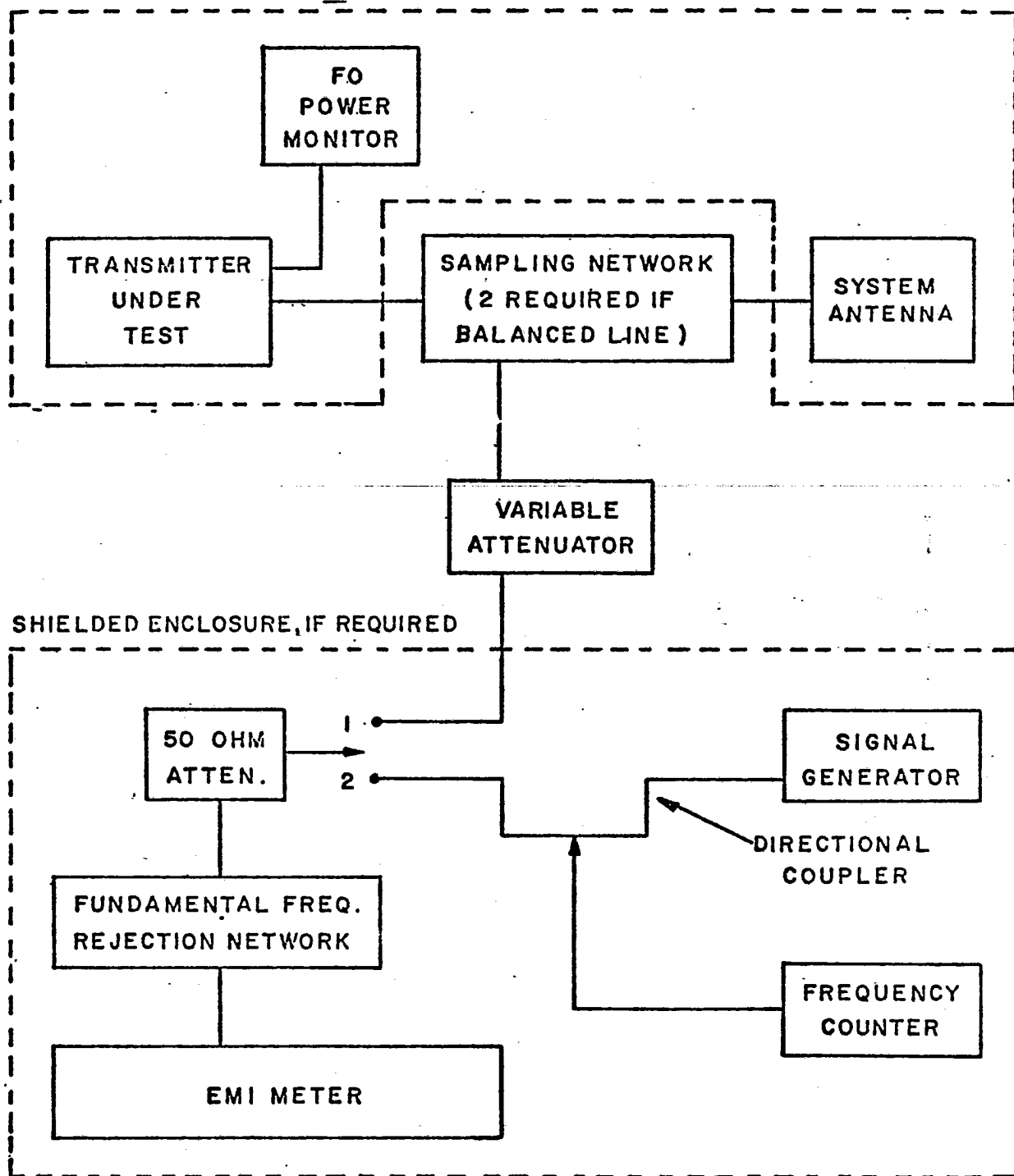


FIG. CE06-4 TEST SETUP FOR CONDUCTED EMISSIONS, ANTENNA TERMINAL TO BE USED AS APPLICABLE.

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### METHOD CEO7

CONDUCTED EMISSION, TACTICAL VEHICLE POWER SOURCE LEADS - 1.5 to 65 MHz

#### COUPLING BLOCK METHOD

1. Applicability - This method is applicable for measuring interference voltage on electric power output terminals of vehicular electric terminal boxes, and other power generations, and conversion equipment where the nominal line voltage does not exceed 440 volts r.m.s. ac or 500 volts dc. The interference voltage to be measured is from each line to ground for grounded systems and from each line to neutral for ungrounded systems.
2. Apparatus - The measuring equipment required is as follows.
  - a. Interference measuring set having 50-ohm resistive input impedance over the frequency range required for the test, and the capability of measuring broadband interference.
  - b. One each Coupler, Radio Frequency Interference, CU-891/URM-85.
  - c. One each Coupler, Radio Frequency Interference, CU-896/URM-85.
3. Test Procedure - The test setup shall be as indicated in Figure CEO7-1. Measurements shall be made at normal operating load or simulated normal operating conditions, and, if applicable, at no load. The equipment shall be loaded electrically or mechanically, or both, as applicable. Vehicular power sources shall be tested with the 50 ohm coupling block connected across the storage battery terminals, with all charging circuitry, including output voltage regulators, in operation throughout the test.
4. Caution - Care shall be exercised that:
  - a. The "ground" binding post terminal of the coupler is connected to the ground or neutral line of the power line or terminal box under test.
  - b. The nominal voltage of the line under test does not exceed the rating quoted above under "Applicability".
  - c. The leads from the coupler binding post terminals to the line or terminal box are as short as possible, and insulated as necessary for safety. The higher the test frequency, the shorter is the permissible lead length.

## 5. Notes -

5.1 Couplers CU-891/URM-85 and CU-896/URM-85, when used with a 50-ohm measuring set, load the line to be measured with a 50-ohm rf impedance.

5.2 The CU-891 has a usable frequency range of 0.150 to 30 MHz, and the CU-896, 20 to 1000 MHz.

5.3 Couplers CU-892/URM-85 and CU-897/URM-85 are also available providing approximately 500-ohms rf load on the source. The former covers 0.150 to 30 MHz, and the latter 20 to 1000 MHz. They are used in the same manner and with the same precautions as the 50-ohm couplers. An approximation can be made as to the magnitude of the rf impedance of the source being measured, by comparison of the readings made with a 500-ohm coupler against those made with the 50-ohm coupler of the same rated frequency range. This may be an aid in designing or choosing line filters for the particular application. The 500-ohm couplers have a 20-dB loss, which must be added to the instrument reading for a proper comparison against the reading taken with the 50-ohm coupler.

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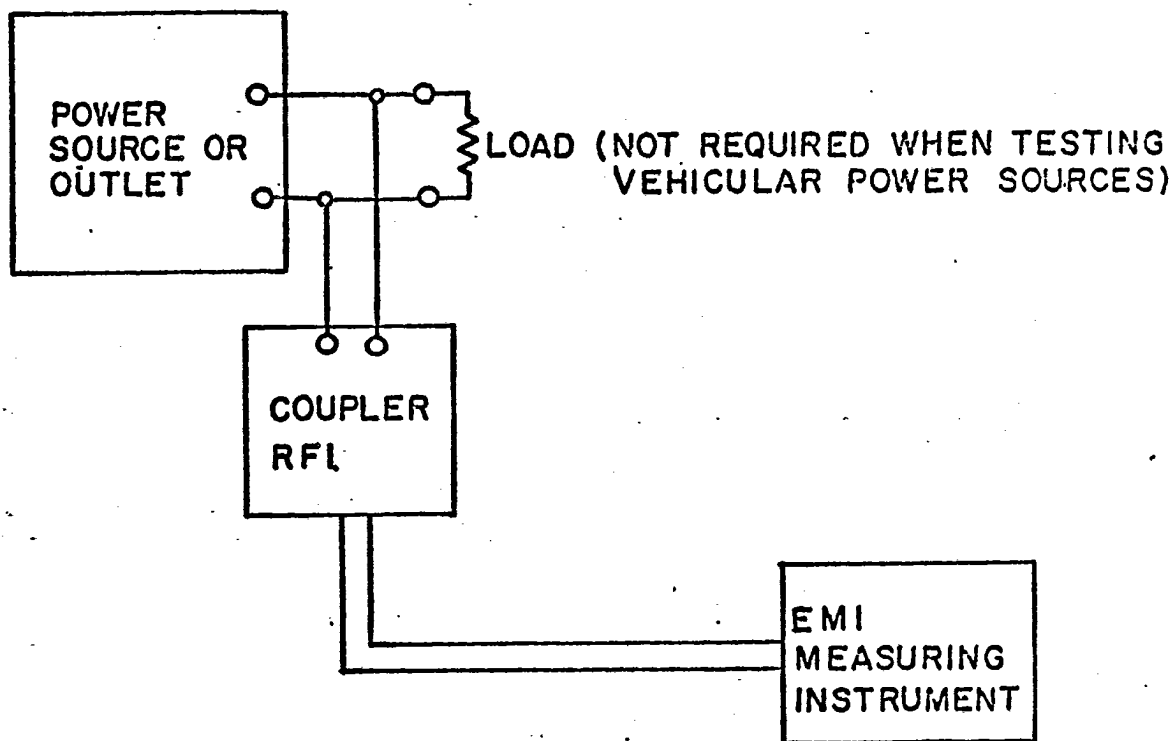


FIG. CE07-1 CONDUCTED EMISSION, VOLTAGE MEASUREMENT  
COUPLING BLOCK METHOD

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METHOD CRED1 (Supplemental to CEO2, CEO4, REO1, REO2)

TRANSIENT MEASUREMENTS OF MANUAL SWITCHING AND LOW REPETITION RATE  
NOISE-CONDUCTED OR RADIATED

1. Applicability - This method shall be used in conjunction with Methods CEO2, CEO4, REO1, and REO2 to measure transient interference with repetition rates less than 10 pulses per second (p.p.s.) as specified hereinafter. Apparatus and Setup - See Applicable Method. Where a "true peak" detector is available and accurate at low repetition rates, this procedure need not be used.

2. Procedure

a. Measure radiated transients at one frequency every octave over the frequency range required for the equipment under test. Measure conducted transients at one frequency every octave from .020 to 50 MHz (in the case of transient interference caused by manual switching operations, the frequencies at which measurements are taken may be selected prior to testing).

b. Use the substitution method with the slide back detector function. Monitor the detector output with an oscilloscope. Using an impulse generator, preset the slideback cutoff point at a level which is equivalent to the required specification limit.

c. Operate the test sample so that the transient occurs. If the transient is not detected above the slideback cutoff, record the level on a pre-printed graph as being below the required limit.

d. If the transient is above the slideback cutoff, use the impulse generator to increase the slideback cutoff setting by 10 dB.

e. Repeat this procedure until the transient is no longer detected above the slideback cutoff.

f. The amplitude of the transient is now known within two levels that are 10 dB apart. At each measurement frequency, draw and identify a short horizontal dash on the preprinted graph at these two levels to indicate that the transient amplitude is between the levels.

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### METHOD CRE01 (OPTIONAL)

Transient Measurement of Manual Switching and Low Repetition Rate Noise Conducted or Radiated.

1. Applicability - This method may be used, in lieu of the preceding CRE01 method, to measure transient interference with repetition rates less than 10 pulse per second (p.p.s)

#### 2. Apparatus and Test Setup

a. H.P. Spectrum Analyzer Model 8552A with 8553L RF section (141S display section with variable persistence or equal).

b. As specified in applicable test methods (CE02, CE04 or RE02).

#### 3. Procedure - Adjust the analyzer controls as follows:

a. Set bandwidth to 100 Hz for CE02 testing. For CE04 and RE02, use 1 KHz bandwidth.

b. Set scan time per division so that the product with the measured interference repetition rate is at least 10 using seconds as the time unit.

c. Set scan width per division to allow reasonably accurate frequency determination of emissions.

d. Determine broadband levels by dividing the calibrated equivalent narrowband level in microvolts by the employed bandwidth expressed in MHz.

e. Adjust the scope persistence to allow retention of the display for a time adequate to photograph or record data.



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METHOD CRED2

EMISSION MEASUREMENTS IN HIGH AMBIENT FIELDS (150KHz - 30 MHz)

1. Applicability - The technique specified hereafter can be used for measuring electromagnetic emissions when high ambient signals prevent the performance of the measurements by the normal methods given in this standard. This technique shall be used only when authorized by the procuring activity.

2. Apparatus - Because of the special techniques specified, the use of the following specific apparatus is required:

a. Raster Generator - Honeywell RG-3 or equivalent.

b. Dual Beam Oscilloscope with P7 phosphor screen - Tektronix type 555 or equivalent.

c. Primary Pickup Device.

d (1) Antenna Unit - Honeywell ARP 3005 or equivalent.

(2) Current Probe - As applicable.

d. EMI Meter

e. Synch Pickup Probe -LO-205 (part of NF 205) or equivalent.

f. Amplifier (1KHz-150MHz) - Hewlett Packard 461A or equivalent.

g. Signal Generators.

(1) Hewlett Packard Model 606B or equivalent.

(2) General Radio GR-805D or equivalent.

(3) Hewlett Packard Model 651B or equivalent.

3. Test Setup and Procedure - The basic test setup is shown of Figure CRED2. The choice of pickup devices shall depend on the ambient noise level and the type and level of the emission being detected and measured. The final test configuration shall conform to the measuring requirements of this standard.

3.1 Setting of Operating Controls

3.1.1 EMI Meter - The input attenuator, r.f. gain control and audio level control shall be set so that there will not be any overloading

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or signal clipping.

**3.1.2 Raster Generator** - The raster generator accepts detected video from the EMI meter. After amplification in a video amplifier stage, the video is processed by a paraphase amplifier where either normal or inverted signal amplification may be selected. A final video amplifier restores the signal to the proper level for cathode follower output to the Z output jack and the audio stage. Along with the video signal processing, a variable sweep generator produces a sawtooth waveform which can be made to recur at a predetermined rate obtained either externally or internally as chosen by the operator.

**3.1.3 Sampling Pickup System** - The controls shall be set as follows:

a. Probe - Place the probe at desired point on the test sample to pick up sufficient synch signal.

b. Amplifier H.P; Model 461A - Set the gain control for a normal presentation on the oscilloscope. There shall be no clipping or distortion of the synch signal.

**3.1.4 Dual Beam Oscilloscope** - The controls shall be set as follows:

a. Trigger - Set for external synch.

b. Vertical Sensitivity Controls - Set for normal presentation on A and B channels. There shall be no clipping or distortion of signals.

c. Other Controls - Set to compensate for signal amplitude, shape, and frequency.

**3.2 Measurement Procedures** - Measurement procedures shall be as follows:

a. Scan the full frequency range of the lowest tuning band of the EMI Meter for the frequency of maximum emission.

b. Adjust the operating controls of the EMI Meter, raster generator, dual beam oscilloscope, and signal sampling amplifier to produce the desired display on the dual beam oscilloscope.

c. Adjust the trace on the dual beam oscilloscope so that the vertical sweeps are positioned symmetrically about the zero voltage reference axis.

d. Reduce the channel A intensity on the oscilloscope to the Fadeout point.

e. Set the channel B intensity on the oscilloscope to a point where

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the brightness of the presentation does not obscure the raster presentation on channel A.

4 f. Readjust the gain and attenuation controls of the EMI Meter, raster generator, sampling amplifier, and oscilloscope controls to obtain channel A and B waveforms which do not overload the video amplifiers.

g. Adjust the sweep rate controls on the raster generator and oscilloscope for the desired frame rate.

h. Correlated, repetitive interference pulses should appear as vertical columns of dots or solid vertical lines depending upon the sensitivity setting of the oscilloscope vertical amplifier. This is a means of separating the source interference signal from any high ambient random noise. The interference source signal is thus identified when this correlation is found between the monitor signal and the raster presentation.

i. Adjust the channel A intensity control so that the correlated source interference signal is just visible.

j. Turn off test sample.

k. Place S1 and S2 in the measure position.

l. Tune the signal generator to same frequency as the EMI Meter.

m. Place signal generator modulation control at 400 Hz 30 percent modulation.

n. Without resetting operating controls of EMI Meter, raster generator and oscilloscope, set the rf output of the signal generator so that the writing on the oscilloscope equals the intensity as in step d.

o. The induced voltage of the emission at the antenna shall equal the output voltage of the signal generator minus antenna injection network loss.

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## METHOD CS01

## CONDUCTED SUSCEPTIBILITY, 30 Hz to 50 KHz, DC POWER LEADS

1. Applicability - This test method is applicable for determining susceptibility of equipment, sub-systems and systems to electrical energy appearing on d.c. power leads.
2. Apparatus - Test apparatus shall be as follows.
  - a. Audio Oscillator.
  - b. Audio Power Amplifier (50 watts or greater with output impedance equal to or less than 2.0 ohms or capable of delivering 50 watts into a 0.5 ohm resistive load connected across the isolation transformer secondary).
  - c. Oscilloscope, VTVM
  - d. A 100-microfarad capacitor may be required as a shunt to dc power source impedance if difficulty is encountered in obtaining the required test voltage.
  - e. Transformer (see suggested list of test equipments - Table II).
3. Test Setup and Procedure - The test setup is shown in Figure CS01-1. The procedure is as specified in 3.1 to 3.4.
  - 3.1 The test sample shall be connected as in Figure CS01-1 with appropriate monitoring devices as indicated for various types of test sample outputs.
  - 3.2 The oscillator shall be tuned through the required frequency range with the output adjusted to the specified level. Monitor the equipment for (a) malfunction, (b) degradation of performance or (c) deviation of parameters beyond tolerances indicated in the equipment specification.
  - 3.3 When a test sample susceptibility is noted, decrease the output level to determine the susceptibility threshold level. Record this value.
  - 3.4 The required nominal supply voltage applied to the test sample shall be measured and maintained within specified tolerances during the test.

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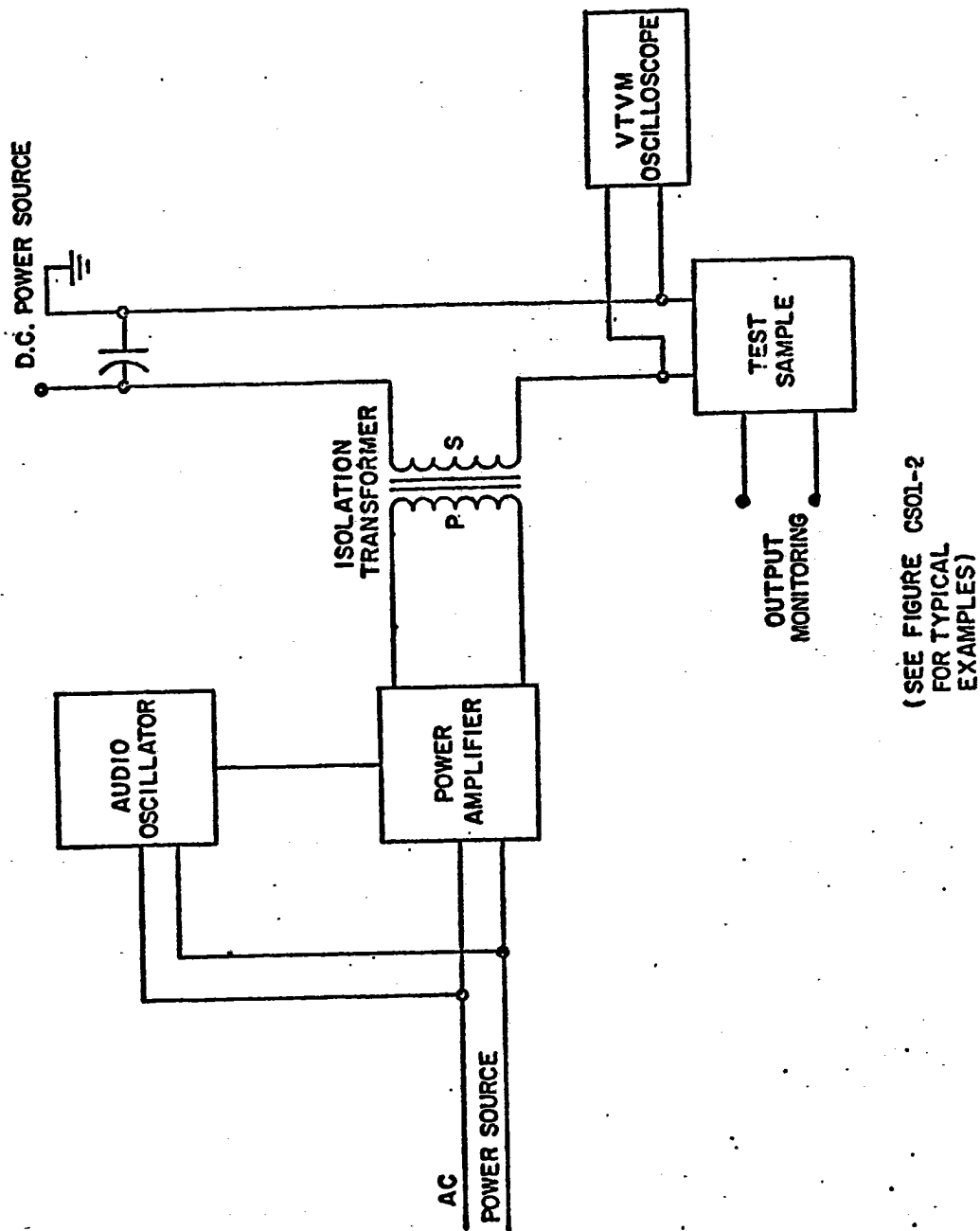
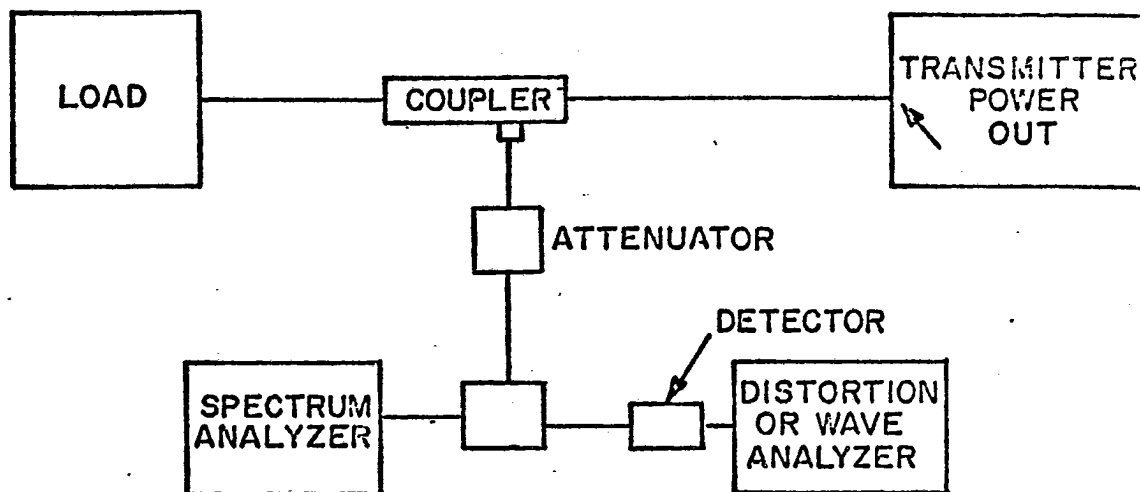


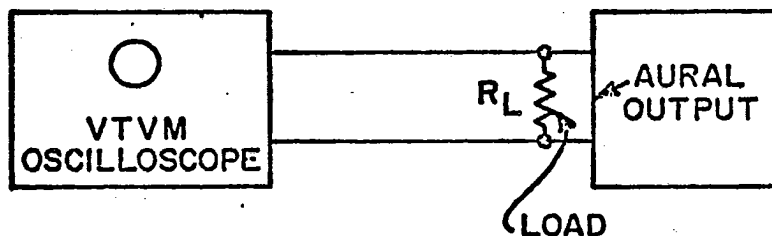
FIG. CS01-1 CONDUCTED SUSCEPTIBILITY, 30Hz TO 50kHz TYPICAL TEST SETUP

MIL-STD-462 NOTICE 3 (E<sub>1</sub>)  
9 February 1971A. TRANSMITTER POWER OUTPUT

MONITOR FOR CHANGE IN OUTPUT SPECTRUM

B. AURAL OUTPUTS

MONITOR FOR CHANGE FROM REFERENCE OUTPUT LEVEL



REFERENCE LEVEL TO BE SPECIFIED AS: 1) NOISE LEVEL 3) 10dB QUIETING

2) 10dB  $\frac{S+N}{N}$  4) OTHERC. VIDIO OUTPUTS

MONITOR FOR CHANGE IN REFERENCE LEVEL OR DEVIATION FROM SPECIFIED PARAMETERS

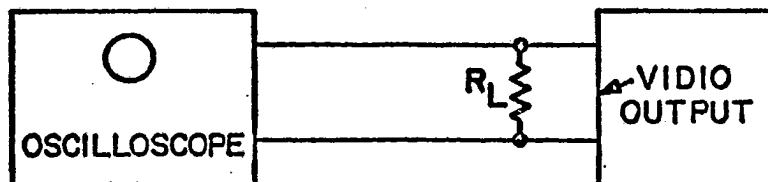


FIG. CSOI - 2 TYPICAL METHODS FOR MONITORING EQUIPMENT FOR SUSCEPTIBILITY

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## METHOD CSO2

### A. Conducted Susceptibility 50 KHz to 400 MHz, AC & DC Power Leads

1. Applicability - This test method is applicable for determining susceptibility of equipments, sub-systems and systems to electrical energy appearing on ac and dc power leads. To be used in testing to the requirements of Tables I thru VII of MIL-STD-461 NOTICE 4.

2. Apparatus - The apparatus shall consist of the following:

a. Signal Source - A 50 ohm output impedance source capable of generating the required susceptibility current.

b. Line Impedance Stabilization Networks (LISN) as specified in Table II with 50 ohm r.f. resistive terminations.

c. Current Probe for monitoring susceptibility current.

d. Tunable VTVM. High Z input meter for monitoring voltage developed across test sample terminals. For AC lines, a probe device with incorporated power frequency blocking capacitor will be required.

e. EMI Meter.

f. Monitoring Device. An appropriate monitoring device as indicated in Figure CSO1-2 is required.

3. Test Setup and Procedure.

a. Use the general setup as shown in Figure CSO2-1.

b. Apply the susceptibility signal to the type N terminal of the LISN and adjust the level until the readings on the voltage and current monitoring devices indicate a power equal to the applicable limit of Figure 19 of MIL-STD-461 NOTICE 4

c. Slowly tune the generator through the required frequency range while maintaining the required signal level (or greater) and monitoring for signs of susceptibility.

d. If the test sample is susceptible to the applicable limit level, decrease the signal output to determine the threshold level. Record all pertinent data.

4. Susceptibility Signal Modulation Rules - Test signals shall be modulated according to the following rules.

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4.1 Test Samples with Audio Channels/Receivers -

- a. AM Receivers: Modulate 50% with 1000 Hz tone.
- b. FM Receivers: When monitoring signal to noise ratio modulate with 1000 Hz signal using 10 KHz deviation. When monitoring receiver quieting, use no modulation.
- c. SSB Receivers; Use no modulation.
- d. Other Equipments: Same as for AM receivers.

4.2 Test Samples with Video Channels Other Than Receivers - Modulate 90 to 100% with pulse of duration  $\frac{2}{BW}$  and repetition rate equal to  $\frac{BW}{1000}$  where

BW is the video bandwidth.

4.3 Digital Equipment.- Use pulse modulation with pulse duration and repetition rate equal to that used in the equipment under test.

4.4 Non-tuned Equipments - Amplitude modulate 50% with 1000 Hz tone.



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B. Conducted Susceptibility, Powerline - .150 to 65 MHz, LISN Method

1. Applicability - This test method is applicable for all communication electronic (C-E) equipment. To be used in testing to the requirements of Tables A-I thru A-VI of MIL-STD-461 Notice 4.

2. Apparatus - The test apparatus shall include the following:

a. Line impedance stabilization networks (impedance characteristics as per Figure 8 and 10,) as applicable.

b. 50 ohm rf resistive terminations (VSWR not greater than 1.3 at frequencies of concern).

c. Signal source (nominal source impedance of 50 ohms).

d. Impulse generator (frequency range of .150 to 1000 MHz - output of 100 dBuV/MHz).

e. 50 ohm 6 dB symmetrical pad.

3. Test Setup and Procedures - The test setup for power line conducted rf susceptibility shall be as shown on Figure CEO4-2 except that the signal source is substituted for the EMI measuring set at the coaxial connector of the appropriate LISN. When subjected to the following tests, no malfunction or degradation of CE equipment shall occur.

3.1 Narrowband Susceptibility - The 50 ohm loaded output voltage of the CW generator shall be 0.1 volt. The frequency range of .150 to 65 MHz shall be scanned. Particular attention shall be given to the specific frequencies indicated by the test plan as being likely to exhibit susceptibility.

3.2 Broadband Susceptibility - The impulse generator shall be terminated by a 50 ohm 6 dB resistive pad at the coaxial sampling terminal of the LISN. The output of the impulse generator with its specified termination shall be 90 dBuV/MHz.

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NOTES:

- (1) ——— FOR TWO WIRE POWER SYSTEMS, TEST HOT LEAD ONLY.  
 (2) ——— SPECIAL CAUTION SHOULD BE EXERCISED TO ASSURE THAT  
 PROPER POWER LEAD IS GROUNDED, WHEN REQUIRED.

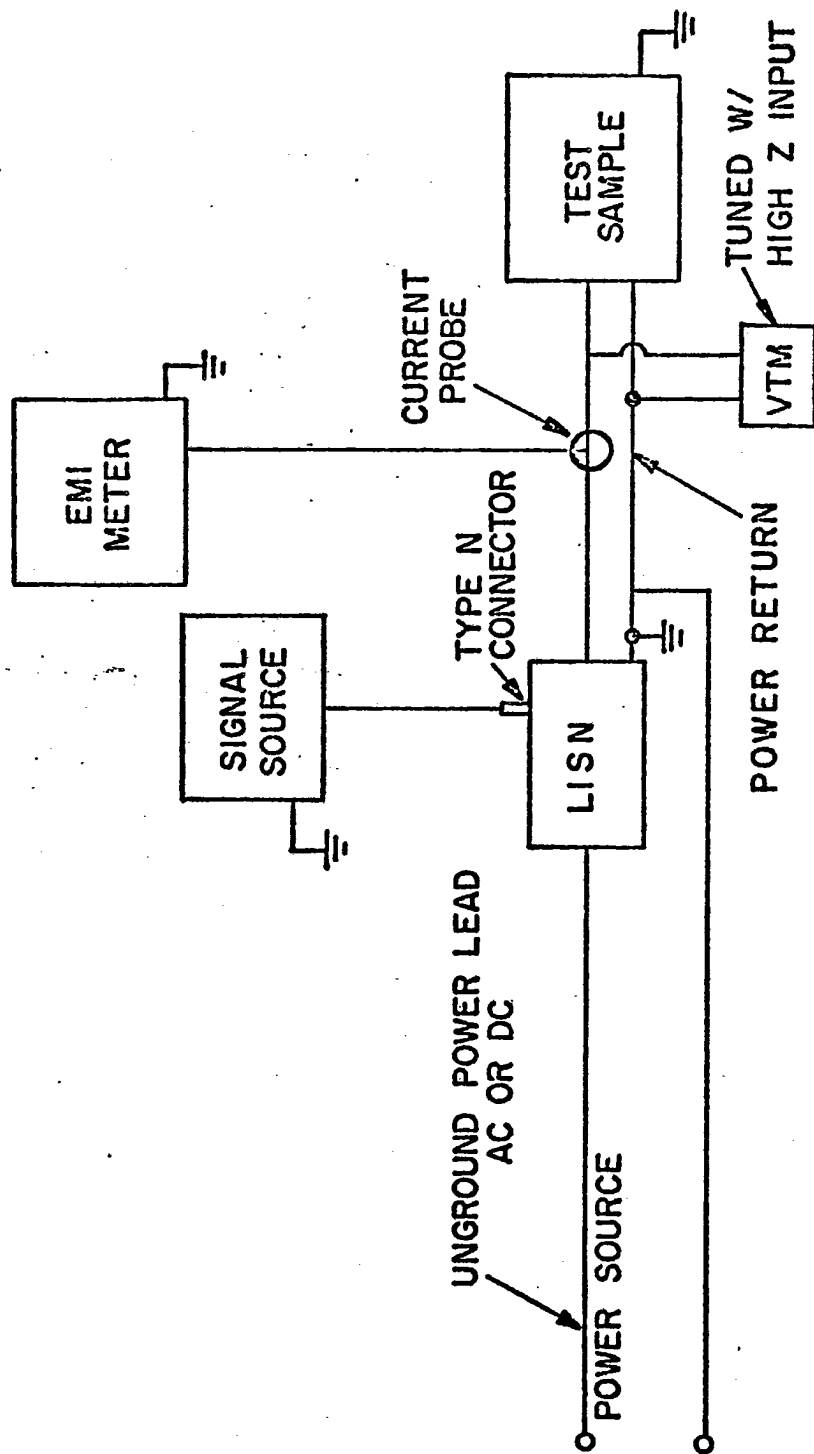


FIG. CS02-1 CONDUCTED SUSCEPTIBILITY 50 KHZ TO 400MHZ

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METHOD CSO3

CONDUCTED SUSCEPTIBILITY, INTERMODULATION

1. Applicability - This method is applicable to receivers operating in the frequency range below 10 GHz. It is intended for use in the measurement of susceptibility characteristics of receivers resulting from the mixing of two undesired signals in the non-linear elements in the front end of the receiver.
2. Apparatus - Test apparatus consists of the following:
  - a. Signal generators capable of delivering the required outputs and frequencies necessary for this test.
  - b. A three-port network or junction providing at least 20 db isolation between signal generators and maintaining the proper impedance match at all its signal ports. Since this test does not involve frequency scanning, directional couplers could conveniently be employed in conjunction with attenuators to provide the required isolation. Care must be exercised to assure that these networks are not a source of intermodulation products.
  - c. Low-pass filters which will attenuate signal generator harmonics to a level at least 80db below the fundamentals.
  - d. Frequency measurement equipment capable of measuring frequency to an accuracy of .01%.
  - e. Outputs monitor (to monitor performance of test sample, see Figure CSO1-2)
3. Symbols - Symbols are defined as follows:
  - a.  $f_0$  = test sample tuned frequency.
  - b.  $f_a$  = frequency of the interfering source signal nearest to  $f_0$ .
  - c.  $f_b$  = frequency of other interfering source signal.
  - d.  $\Delta f = f_a - f_0$
  - e. IF = Receiver intermediate frequency.
  - f.  $m, n$  = Integers giving multiples of  $f_a$  and  $f_b$  respectively.
4. Test Setup and Procedures.

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4.1 General - The measurements to be performed under this test shall be confined to the second order, positive and negative  $\Delta f$  ( $f_a$  above and below  $f_o$ ), third order positive and negative  $\Delta f$  and the fifth order negative products (order  $=r+m+n$ ). Third order difference mix is potentially the most serious type of intermodulation since both signals may be within the v.f. pass band of the input circuits. An example of the relationships for this type of mix is given by:  $f_o = 2f_a - f_b$ .

4.1.1 Special care must be taken in conducting this test to insure that intermodulation does not occur within the signal generators themselves. Also, appropriate filters shall be employed to remove unwanted generator outputs which may interfere with measurements.

4.2 Measurement Setup - The measurement setup shall be as shown on Figure CS03-1 or CS04-1. For non-pulse systems, signal generator No. 2 shall be unmodulated and signal generator No. 1 shall be modulated 30 percent with 1000 Hz for AM receivers, or unmodulated for FM and SSB receivers. For pulsed systems, one of the input signals shall be unmodulated and the other shall be a pulsed signal having a pulse width and repetition rate equal to the nominal pulse characteristics of the system under test.

4.3 Measurement Procedure - The procedure for receiver intermodulation measurements shall be as follows:

a. Set the receiver controls to the same positions as specified in the detailed equipment specification for the measurement of sensitivity. Tune signal generator No. 1 to the receiver tuned frequency,  $f_o$ . Adjust the signal generator output level for a standard receiver response (see Note 6.1). Compute the receiver sensitivity level by subtracting the attenuation (in dB) of the coupling network, and filter from the signal generator output (in dbm). Record this level.

b. Commence to measure the intermodulation responses. With signal generator No. 1 turned on and modulated as previously, set output level to 66 dB above the level obtained in step a. Slowly tune generator above  $f_o$  until there is no longer a response at the receiver output. Measure this frequency to the accuracy indicated above and record as  $f_a$ . The difference between  $f_o$  and  $f_a$  is  $\Delta f$ . Leave generator No. 1 at  $f_a$ .

c. Tune signal generator No. 2 to  $f_b = f_a + f_o$ . The frequency should be measured to the required accuracy and the signal level set to the same level as indicated for signal generator No. 1. Note resulting change in monitored output level of test sample, if any. Tune generator No. 2 as required to peak. Monitor output level. The receiver should have no response due to either  $f_a$  or  $f_b$  alone; if such a response is present, it is not due to intermodulation and should be neglected for this test.

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d. When an intermodulation response is present, reduce the levels of both generators until the standard reference output is obtained. Record the level and frequencies associated with each response. The difference between the resulting signal generator levels and the level obtained in step a. is the intermodulation rejection.

e. Repeat steps b, c and d only using a negative  $\Delta f$  ( $f_a$  below  $f_o$ ) and tuning signal generator #2 to  $f_b = f_o - f_a$ .

f. Repeat steps b, c and d to observe third-order intermodulation products for various positive and negative  $\Delta f$ . For each  $f_a$  determined as indicated in preceding steps determine an  $f_b$  which will have a third order product at  $f_o$ :  $f_b = f_o + 2 \Delta f$ ;  $\Delta f = f_a - f_o$ . For example set signal generator to  $f_b = f_o + 2 (f_a - f_o) = 2 f_a - f_o$ , or to  $f_b = \frac{f_o - f_a}{2}$ .

g. In a like manner test for fifth order intermodulation products in accordance with the equation  $f_b = f_o + 4 \Delta f$  where  $\Delta f = f_a - f_o$ . However, if no second or third order product were observed, a search for fifth order products need not be undertaken.

## 5. NOTES:

5.1 The standard reference output level used in this test shall be as specified in the section of the test sample's detailed equipment specification pertaining to receiver sensitivity measurements. When the equipment specification does not define this parameter the following output reference levels shall be used.

a. AM Receivers -  $\frac{s+n}{n} = 10 \text{ dB}$

b. SSB Receivers -  $\frac{s+n}{n} = 10 \text{ dB}$

c. FM Receivers

(1) Unmodulated - 10dB quieting

(2. Modulated -  $\frac{s+n}{n} = 10\text{dB}$

d. Pulsed Receivers - As above.

5.2 Because some generators may drift in frequency, it may be necessary to retune each generator to be sure the maximum response is being measured.

5.3 To verify that each product is a receiver intermodulation product and not a signal generator spurious emission, signal generator intermodulation product, or a receiver spurious response, the following procedure shall be followed:

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a. Alternately turn off each signal generator (or greatly attenuate its output). If the receiver response remains when one generator is off, it is not an intermodulation product. If the response disappears, it may be either signal generator intermodulation or receiver intermodulation.

b. For non-pulse receivers, after determining the levels for a standard response, increase the signal generator output levels simultaneously by 3dB. Record the receiver output level indication. Increase the attenuation on the step attenuator by 3dB. Receiver intermodulation products will vary non-linearly with the amount of inserted attenuation, while signal generator intermodulation products should vary by the amount of attenuation. Thus, if the receiver output level drops only 3dB when 3dB of attenuation is added, the response is not due to receiver intermodulation. Note that with the signal generator levels increased by 3dB, a standard receiver response should exist for true receiver intermodulation products. For pulse type receivers, the same validation procedure shall be used but it may be necessary to use a larger attenuator and correspondingly larger signal changes in order to observe the proper changes.

5.4 For Receivers with Waveguide Inputs - The required frequency range shall be from 0.8 fco to 10 GHz (fco is the waveguide cutoff frequency).

## REVIEW ACTIVITIES

ARMY - EL, MI, AV

## USER ACTIVITIES

ARMY - AT, ME, WC, EL, CE, MD

## PREPARING ACTIVITY

Electronics Command (EL)  
(Project EMCS A030)

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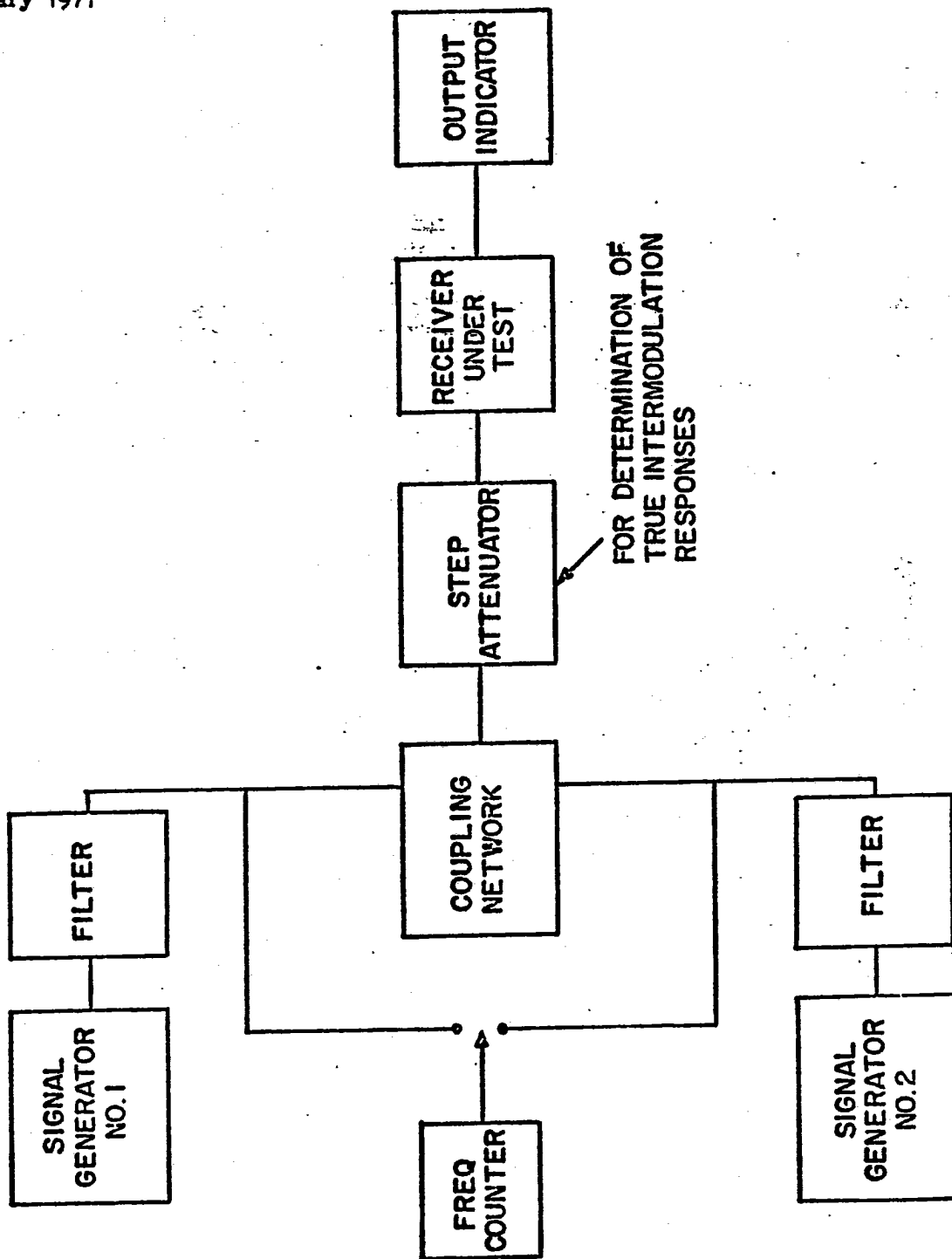


FIG. CS03-1 RECEIVER TWO-SIGNAL TEST SET-UP

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## METHOD CS04

CONDUCTED SUSCEPTIBILITY, 30 Hz to 10 GHz, REJECTION OF UNDESIRE SIGNALS  
AT INPUT TERMINALS (C W DESENSITIZATION)

1. Applicability - This test is used for determining spurious response of receivers operating in the frequency range from 30 Hz to 10 GHz. The frequency of this test is as indicated in 5.3.
2. Apparatus - Test apparatus consists of the following:
  - a. Signal generators capable of delivering the required signals over the required frequency range.
  - b. Low pass filters which will attenuate signal generator harmonics to a level at least 80 dB below the fundamental.
  - c. Frequency measurement equipment capable of measuring frequency to an accuracy of .01 percent.
  - d. Output monitor (to monitor performance of test sample, see Figure CS01-2).
  - e. A three port network providing at least 20 dB isolation between signal generators. The network must maintain the proper impedance match at all its ports. The network should be checked to assure that it does not generate intermodulation products.
3. Symbols.
  - a.  $f_0$  = Test sample tuned frequency.
  - b.  $f_{sp}$  = Frequency at which spurious response occurs.
  - c. IF = Test sample intermediate frequency.
  - d.  $f_{lo}$  = Test sample local oscillator frequency.
4. Test Setup and Procedures.
  - a. Setup the apparatus as shown in Figure CS03-1 or CS04-1, disable receiver AVC and AFC.
  - b. With signal generator #2 turned off, tune generator #1 to  $f_0$  and modulate output in accordance with note 5.1 below. Set level to produce standard reference output as defined in the detailed equipment specification or as indicated in note 5.2. Record level and frequency of generator.



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c. Repeat step (b), with signal generator #1 off and signal generator #2 turned on and tuned to fo with desired modulation. Record level and frequency of generator.

d. For the remainder of the test, turn both signal generators on with required modulation on signal generator 1 and signal generator 2 unmodulated.

e. Set signal generator 1 at the level obtained in step (b) with proper modulation, and signal generator 2 at the specified level above that required to obtain the standard reference output in step (c).

f. Scan the applicable frequency range (see 5.3) with signal generator 2. When a spurious response is obtained, reduce the output of signal generator 2 until the standard reference output is obtained. Calculate the difference in dB between this level and that obtained in step (c). This is the spurious response rejection.

## 5. Notes.

5.1 The modulation used in this test shall be as specified in the section of the test sample's detailed equipment specification pertaining to receiver sensitivity measurements. When the equipment specification does not define this criteria, the following modulation shall be used.

a. AM Receivers - The signal generator shall be 30 percent modulated by 1000 Hz sine wave.

b. SSB Receivers - The signal generators shall be unmodulated.

c. FM Receivers - The signal generators shall be modulated at 1000 Hz with 10 KHz deviation.

d. Pulsed Receivers - The modulation pulse shall be adjusted so that 80 percent of its spectral energy lies within the 3 dB bandwidth of the receiver.

5.2 The standard reference output level used in this test shall be as specified in the section of the test sample's detailed equipment specification pertaining to receiver sensitivity measurements. When the equipment specification does not define this criteria, the following output reference levels shall be used.

a. AM Receivers -  $\frac{s+n}{n} + 10$  dB

b. SSB Receivers -  $\frac{s+n}{n} = 10$  dB

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- c. FM Receivers - Modulated -  $\frac{s+n}{n} + 10$  dB
- d. Pulse Receivers - As above.

5.3 The applicable frequency range for this test is as follows:

5.3.1 Signal generator 2 shall be scanned over the entire frequency range determined from the listing shown herein. The frequency range w. as shown in Figure 19 of MIL-STD-461 NOTICE 4 is exempt from this test. The lower frequency limit shall be the lowest value obtained from Column A and the upper frequency limit shall be the highest value found in Column B (this upper limit shall not exceed 10GHz).

Column A

Column B

IF/5  
.05 fo

$5F_{Lo} + IF$   
 $20 fo$

When testing multiple conversion receivers, the IF of Column A shall be the lowest intermediate frequency while the IF and FLo in Column B shall be the highest frequencies associated with the receiver.

5.3.2 For receivers with waveguide inputs, the required frequency range shall be from 0.8 fco to the higher level obtained from Column B (see 5.3.1) but shall not exceed 10 GHz (fco is the waveguide cutoff frequency).

5.4 All signal generators emit a substantial amount of harmonics and other spurious energy. Care shall be taken not to mistake an emission of the generator falling on fo for a spurious response of the equipment. It is possible to have spurious response indications at fo/2, fo/3, fo/4, etc., which are not due to generator harmonics. Appropriate low pass or band stop filters may be used to eliminate this problem.

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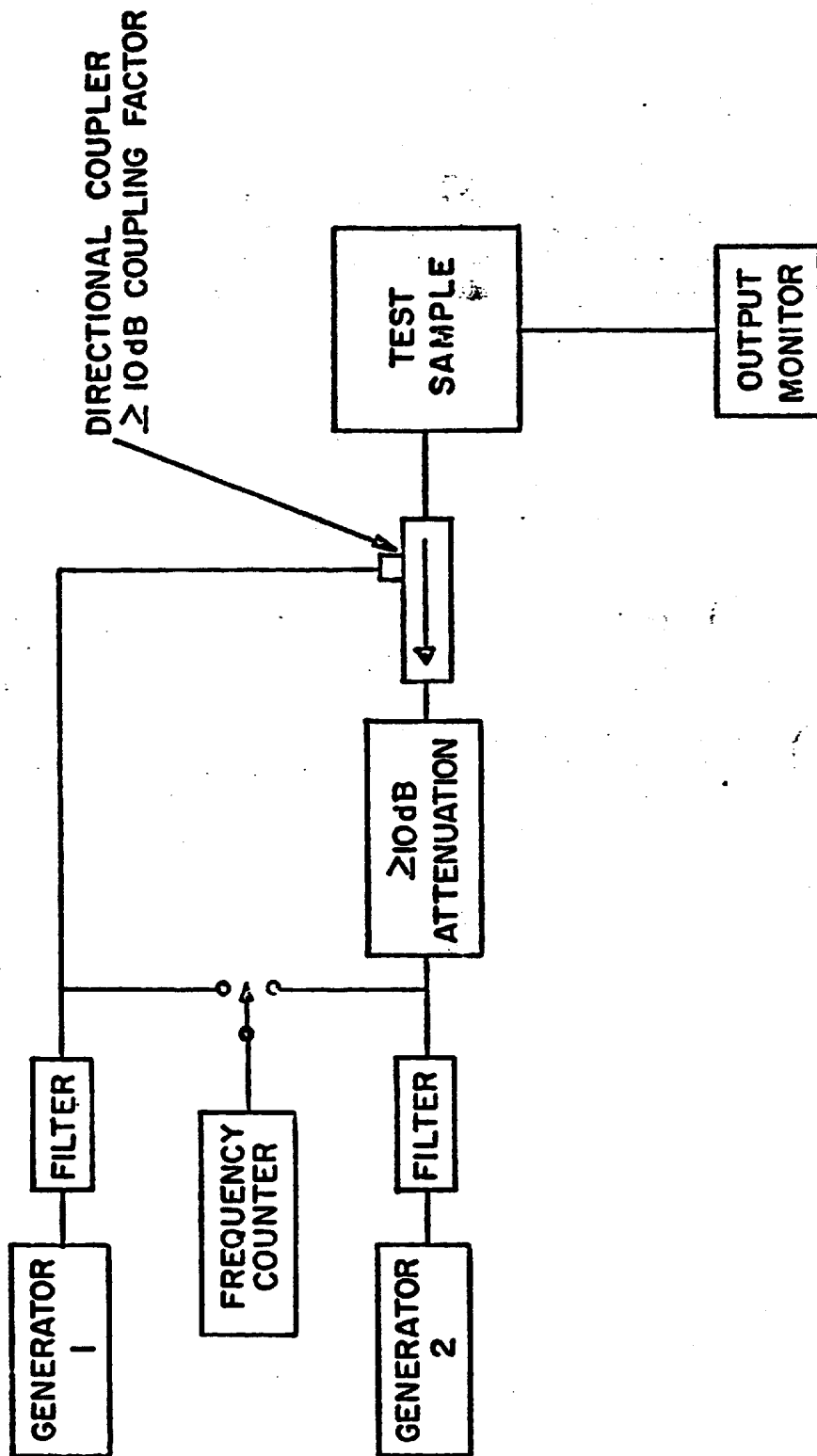


FIG. CS04-1 CONDUCTED SUSCEPTABILITY, INTERMODULATION TEST SET-UP

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## METHOD CS06

## CONDUCTED SUSCEPTIBILITY, SPIKE, POWER LEADS

1. Purpose - The purpose of this test is to determine equipment susceptibility to spike interference on power lines.
2. Applicability - This test shall be performed on all ungrounded a.c. and d.c. input power leads.
3. Apparatus - The test shall consist of the following:
  - a. Spike Generator with characteristics as follows:
    - (1) Pulse Width of 10 usec.
    - (2) Pulse Repetition Rate of 3 to 10 p.p.s.
    - (3) Voltage Output as required by MIL-STD-461 NOTICE 4.
    - (4) Output Control.
    - (5) Phase Positioning from 0 to 360 degrees.
    - (6) Adequate Transformer current capacity (commensurate with line being tested).
    - (7) External Synch capability.
    - (8) External Trigger capability.
    - (9) Source Impedance of 0.5 ohms or less.
  - b. Capacitor - The 10 microfarad feedthrough capacitor as specified for Method CE01.
  - c. Oscilloscope - Any oscilloscope with 10 MHz bandwidth and adequate sweep rates is acceptable.
4. Test Procedure - Test procedures shall be as follows:
  - a. Connect test sample and test instrumentation as shown in Figure CS06-1 or Figure CS06-2.
  - b. Series, shunt, or both test methods may be used.
  - c. The applied spike amplitude, rise time, and duration, as measured by the oscilloscope across the input terminals of the test

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sample, shall follow the typical wave shape specified in the applicable limits.

d. Synchronization and triggering shall be used to position the spike to specific test sample signal conditions which will produce maximum susceptibility.

e. Alternately - positive and negative, single and repetitive (6 to 10 p.p.s) spikes shall be applied to the test sample's ungrounded input lines for a period not less than 10 minutes in duration. Spikes shall be synchronized to the power line frequency and positioned on each 90 degree phase position for a period not less than 5 minutes. On equipment employing gated circuitry, the spike shall be triggered to occur within the time frame of the gate.

f. If susceptibility occurs, determine and record its threshold level, repetition rate, phase position on the a.c. waveform and time occurrence on circuit gates.

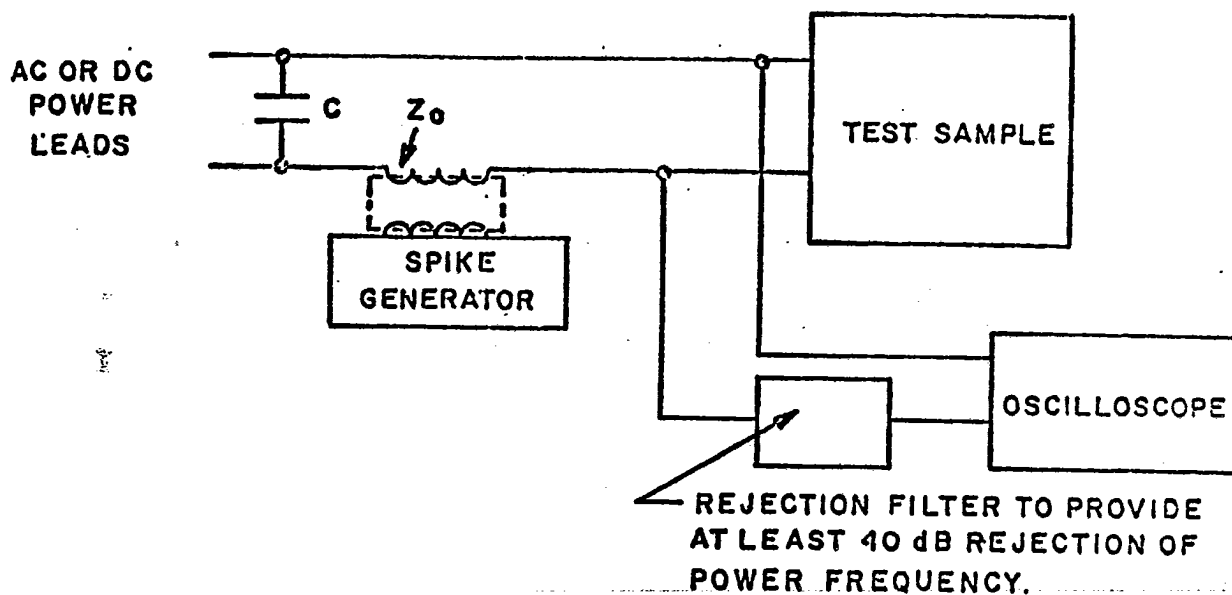
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FIG. CS06-1 CONDUCTED SUSCEPTIBILITY, SPIKE, POWER LEADS, INJECTION IN SERIES.

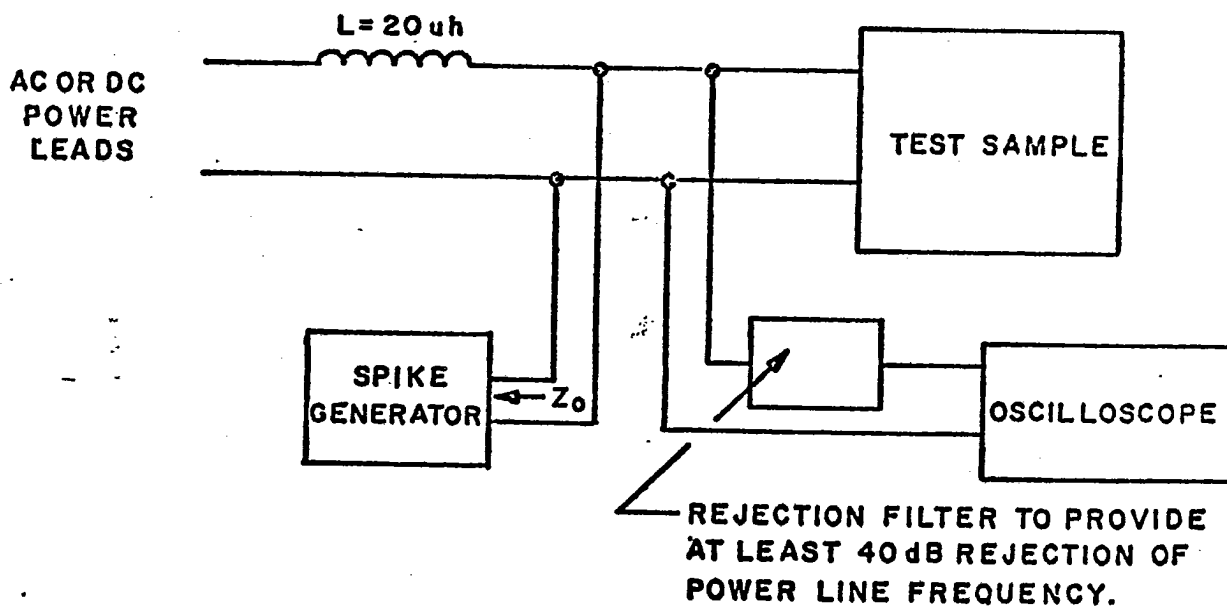
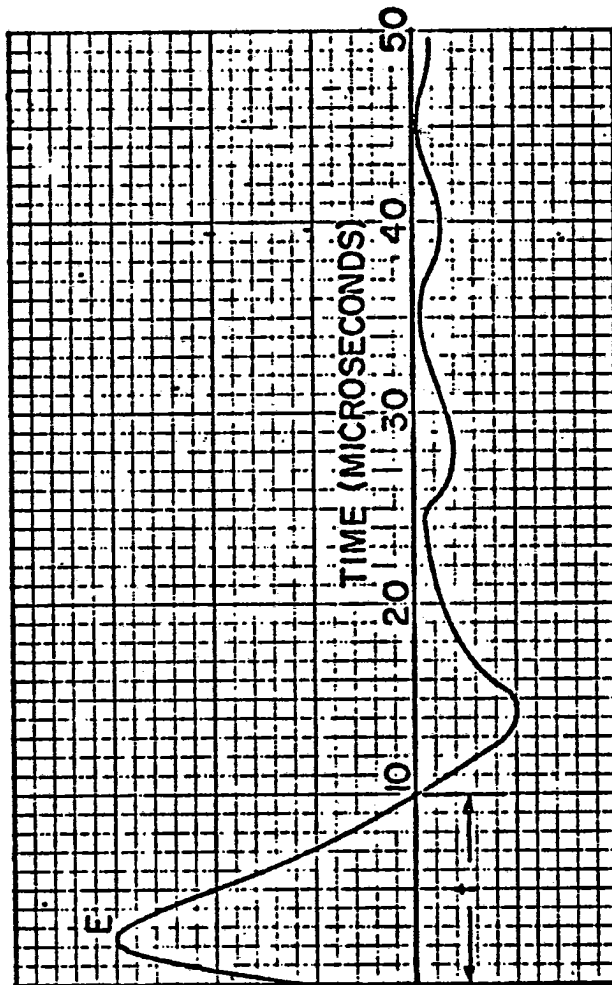


FIG. CS06-2 CONDUCTED SUSCEPTIBILITY, SPIKE, POWER LEADS, INJECTION IN PARALLEL.

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**E = 2 TIMES LINE VOLTAGE OR 100 VOLTS, WHICHEVER IS LESS.  
t = 10 MICROSECONDS.**

**SPIKE CHARACTERISTIC**

**FIG. CS06-3**

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## METHOD CS07

## CONDUCTED SUSCEPTIBILITY, SQUELCH CIRCUITS

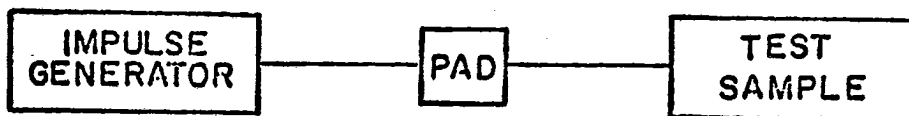
1. Purpose - The purpose of this test is to determine whether the circuit characteristics are adequate so as to prevent the circuit from opening upon application of impulse signals at the equipment input terminals.
2. Applicability - This method is applicable to electronic equipment using squelch circuits.
3. Apparatus - The test apparatus shall consist of the following:
  - a. Signal generator.
  - b. Impulse generator.
  - c. Matching network.
4. Test Setup and Procedure - The test setup and procedure shall be as specified hereinafter.
  - 4.1 Test 1
    - 4.1.1 The test setup shall be as shown in Figure CS07-1 .
    - 4.1.2 The squelch circuit shall be adjusted so that it opens at the test sample's r.f. input voltage specified by the individual equipment specification.
    - 4.1.3 If necessary, a matching network may be used between the impulse generator and test sample. The impulse generator shall be terminated in 50 ohms.
    - 4.1.4 The squelch circuit shall not open when the output of the impulse generator, set at the value specified in the applicable limits is applied to the input terminal of the test sample.
  - 4.2 Test 2
    - 4.2.1 The test setup shall be as shown in Figure CS07-1,
    - 4.2.2 The squelch circuit shall be adjusted so that it opens at the test sample's r.f. input voltage specified by the individual equipment specification or the contract or order.
    - 4.2.3 Networks shall be used as required to isolate the generators from each other and to match them to the test sample.



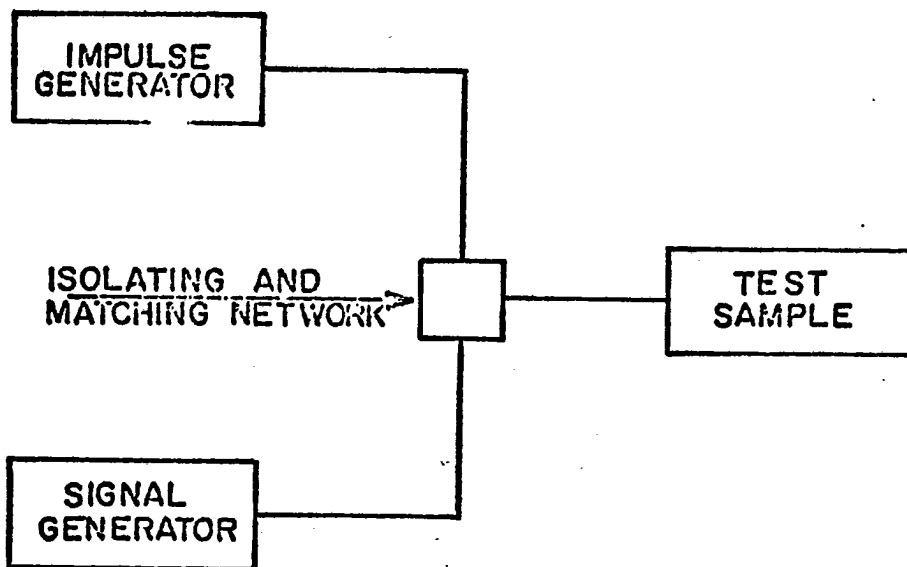
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4.2.4 The squelch circuit shall not open when two signals are applied at the test sample input. One shall be an unmodulated r.f. signal at  $f_0$  (test sample's center frequency) whose amplitude is  $2/3$  the r.f. voltage used in the second step (see 4.2.2) to adjust the squelch threshold. The second signal is an impulse signal whose amplitude is the same as the limit specified in MIL-STD-461 NOTICE 4.

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A. TEST 1



B. TEST 2

FIG. CS07-1 - CONDUCTED SUSCEPTIBILITY, SQUELCH CIRCUITS

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METHOD RED1

RADIATED EMISSION, 30 Hz TO 30 KHz, MAGNETIC FIELD

1. Application - This method is applicable for the measurement of radiated magnetic fields from units, cables (including control, pulse, IF, video, antenna transmission lines and power cables), and inter-connecting wiring over the frequency range of 30 Hz to 30 KHz. This applies to the transmitter fundamental, and spurious and oscillator radiation, but does not include radiation emanating from antennas.
2. Apparatus - The test apparatus shall consist of the following:
  - a. Loop Sensor - A loop having the following specifications shall be used:
    - (1) Diameter = 13.3 cm
    - (2) No. of turns = 36
    - (3) Wire: 7-41 litz
    - (4) Loop shall be electrostatically shielded. The conversion factor is shown in Figure 1.
  - b. EMI Meter - The EMI meter and loop combination shall be capable of measuring magnetic flux densities at least 6dB below the applicable limit for this test. In addition, the meter shall be tunable with a bandwidth no greater than 10 Hz at the 3 dB points.
3. Test Procedure - The test procedures shall be as follows:
  - a. Position the loop sensor approximately 7 cm from one face of the test sample, with the plane of the loop parallel to the face of the test sample. The loop shall be located at a point which may be considered a leakage point (seam, joint, connector, or cable), as approved in the test plan.
  - b. Scan the EMI meter from 30 Hz to 30 KHz to locate the frequencies of maximum radiation, considering the test sample's critical frequencies (for example, those which intentionally exist in the equipment due to its design, such as power frequencies and its harmonics, local oscillator frequency, and so forth), if known, and record these frequencies.
  - c. Tune the EMI meter to one of the frequencies located in b. above and position the loop sensor 7 cm from the surface of the test sample, with the plane of the loop parallel to the surface. For cables, the planes of the loop and the cable shall coincide, and the distance between the center of the loop and the cable shall be 7 cm.

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- d. Monitor the output of the EMI meter while moving the loop sensor over the entire face of the test sample. The point of maximum radiation shall be noted.
- e. At the point of maximum radiation, orient the plane of the loop sensor to give a maximum reading on the EMI meter and record this reading.
- f. Repeat steps c. thru e. for, at least two frequencies of maximum radiation/octave below 200 Hz and three frequencies of maximum radiation/octave above 200 Hz.
- g. Repeat Steps a. thru f. for each face of the test sample.
- h. See Figure 1 for loop factor required to convert EMI meter reading to flux density units.

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## METHOD REQ2

### RADIATED EMISSIONS, ELECTRIC FIELD

1. Applicability - This method is applicable for the measurement of radiated emissions from all units, cables (including control, pulse, IF, antenna transmission lines, and power cables), and interconnecting wiring of equipments, sub-systems, and systems. This method applies to spurious radiation, oscillator radiation, and broadband emissions, but is not intended to be used for measurement of radiation emanation from antennas.

#### 2. Frequency Range of Test.

- a. Narrowband Emissions - 14 KHz to 12.4 GHz
- b. Broadband Emissions - 14 KHz to 1000 Mhz

#### 3. Apparatus.

- a. Test antennas (see paragraph 4.2.2.1)
- b. EMI Meter (see Table II)

#### 4. Test Setup and Procedures.

4.1 Test Setup - The basic test setups shall be as shown in Figures REQ2-1 and REQ2-2. Test sample Antenna terminals if any shall be connected to shielded dummy loads.

4.1.1 Nonportable Equipments - Equipment which is permanently connected either physically or electrically to a vehicle, system or installation shall be tested in accordance with the setup shown in Figure REQ2-1.

4.1.2 Portable Equipment - Portable equipment including manpack operable equipments and test equipment shall be tested in accordance with the setup shown in Figure REQ2-2.

4.1.3 Equipment falling into both of the categories indicated in 4.1.1 and 4.1.2 shall be tested both ways.

#### 4.2 Procedure.

a. Probe the test sample as indicated in Section 4 of this standard to locate the points of maximum radiation from the test sample.

b. Select and position the test antennas as indicated in Section 4 of this standard at a test distance indicated in Table VIII of MIL-STD-461 NOTICE 4. In the frequency range of .030 to 12.4 GHz, position linearly polarized antennas so as to make both vertical and horizontal

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measurements. Bond counterpoise of 41" rod antenna in accordance with paragraph 4.2.2.1.1 of General Requirements.

c. For each antenna, scan the applicable frequency range of this test with the EMI meter and take measurements as required.

5. Notes:

5.1 Errors due to reflections within the shielded enclosure can be reduced by use of absorptive materials lining the walls or by portable panels of such materials placed around the test setup.

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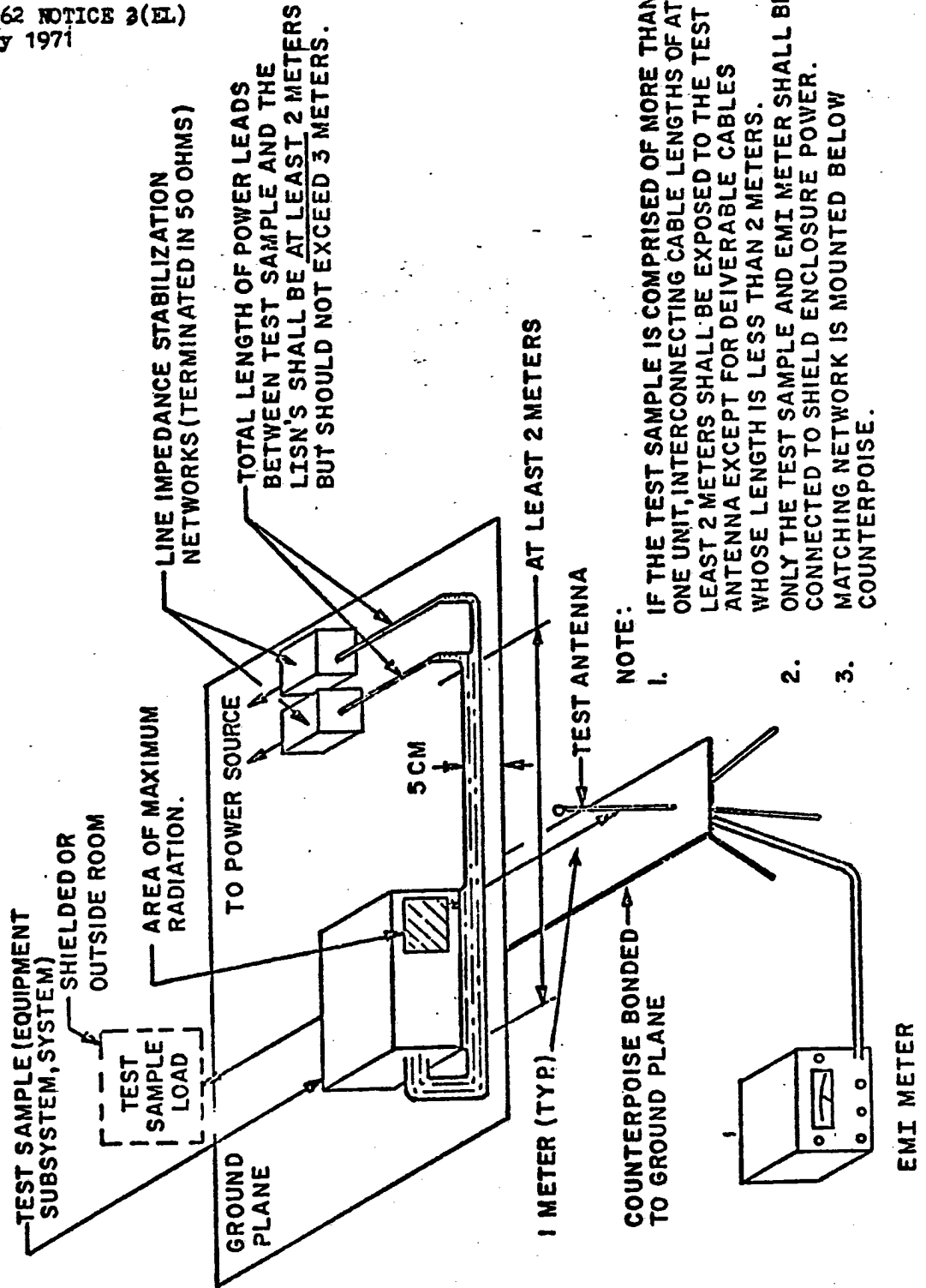
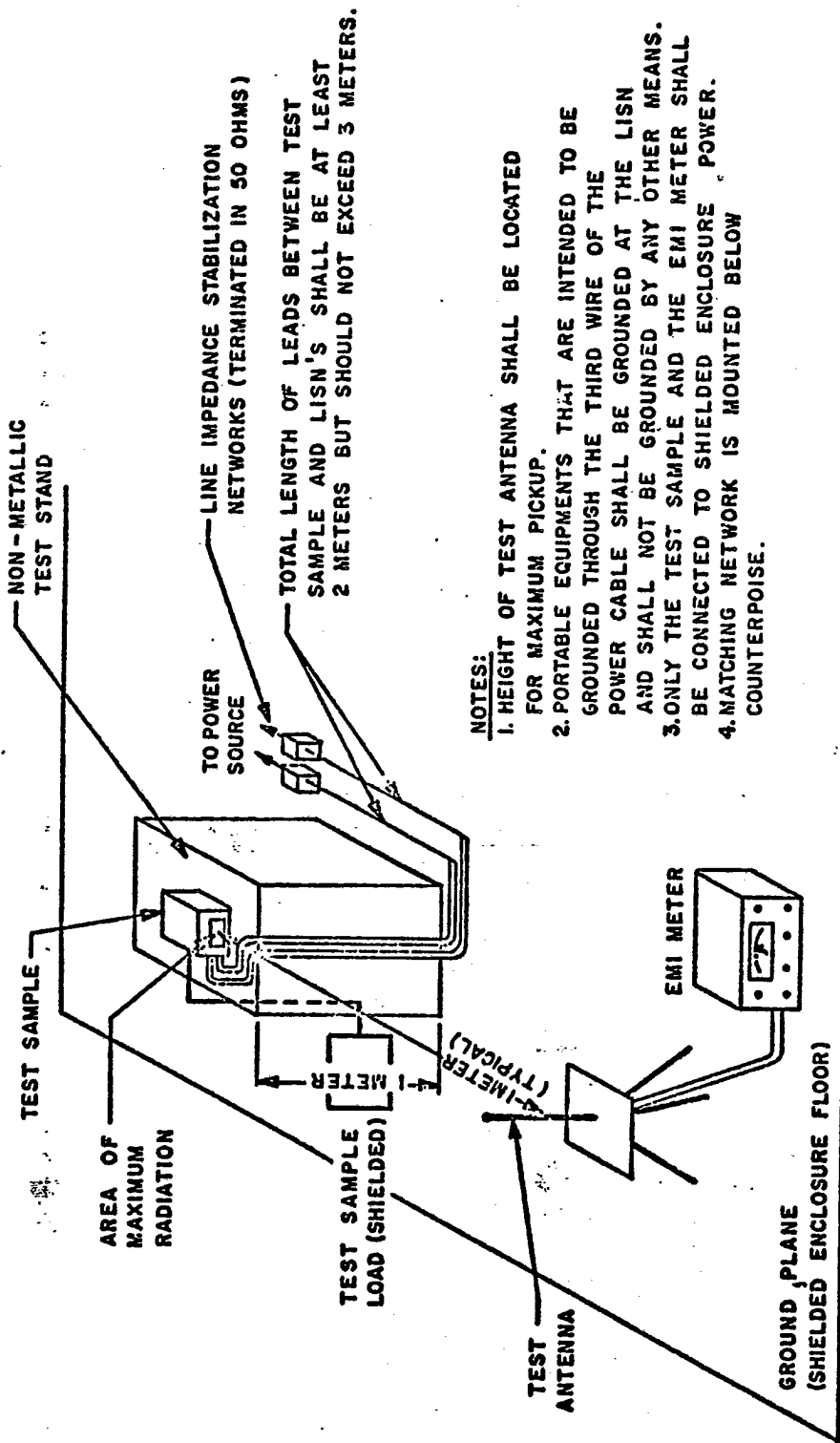


FIG. RE02-1 TYPICAL TEST SETUP FOR RADIATED MEASUREMENTS



NOTES:

1. HEIGHT OF TEST ANTENNA SHALL BE LOCATED FOR MAXIMUM PICKUP.
2. PORTABLE EQUIPMENTS THAT ARE INTENDED TO BE GROUNDED THROUGH THE THIRD WIRE OF THE POWER CABLE SHALL BE GROUNDED AT THE LISN AND SHALL NOT BE GROUNDED BY ANY OTHER MEANS.
3. ONLY THE TEST SAMPLE AND THE EMI METER SHALL BE CONNECTED TO SHIELDED ENCLOSURE POWER.
4. MATCHING NETWORK IS MOUNTED BELOW COUNTERPOISE.

FIG. RE02-2 TYPICAL TEST SETUP FOR RADIATED MEASUREMENTS ON PORTABLE EQUIPMENT



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METHOD RED3

1. Applicability - This method is applicable when the direct coupled techniques of Method RED6 cannot be applied. This procedure, however, shall be used when any one of the following conditions exist.
- a. The transmitter power output is greater than 5 kilowatt average.
  - b. The fundamental frequency is above 1.24 GHz.
  - c. The test sample's antenna is an integral part of transmitter and cannot be replaced by a suitable dummy load. This method shall also be used for equipments with waveguide transmission lines and operating frequencies below 1.24 GHz to measure emissions in the frequency range of 2fo to 12.4 GHz.

2. Frequency Range of Test - Frequency ranges of the test shall be as follows:

<u>Equipment Operating Frequency</u>	<u>Frequency Range of Test</u>
10 to 30 KHz	.01 to 10 MHz
30 to 300 KHz	.01 to 100 MHz
0.3 to 3 MHz	.01 to 600 MHz
3 to 30 MHz	.01 to 1000 MHz
30 to 300 MHz	.01 to 3000 MHz
300 to 1,240 MHz	.01 to 12,400 MHz
1,240 MHz and above	The lowest frequency of test shall be:
	a. coaxial transmission lines: 200 MHz
	b. Waveguide transmission lines: 0.8 fco
<u>Equipment Operating Frequency GHz</u>	<u>The upper frequency limit</u>
1.24 to 5.0	10 GHz to 5 fo whichever is greater
5 to 12.4	5 fo or 40 GHz whichever is less

3. Apparatus - Instrumentation required for testing in the frequency range of 0.01 to 1,000 MHz are as follows: (also refer to Table II)

a. EMI Meter.

b. Attenuators or amplifiers as may be required to insure suitable signal levels at EMI meter input terminals.

c. Antennas (see Table I)

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Instrumentation required for testing in the frequency range above 1000 MHz are as follows: (Also see Table II)

- a. Spectrum analyzer.
- b. Traveling wave tube amplifier.
- c. Preselectors - yig filters.
- d. Frequency counter.
- e. Signal generators.
- f. Antennas (See Table I)

4. Symbols - Symbols are defined as follows:

- a.  $P_r$  = Power delivered to spectrum analyzer's input terminals.
- b.  $P_t$  = Power delivered to the transmitter's antenna at the transmitter's fundamental frequency.
- c.  $G_t$  = Gain of the transmitting antenna over an isotropic radiator. This value is expressed in dB.
- d.  $\lambda$  = Wavelength of the transmitted signal in meters.
- e.  $D$  = Maximum dimension of the receiving antenna in meters.
- f.  $d$  = Maximum dimension of the transmitting antenna in meters.
- g.  $G_r$  = The gain of the receiving antenna over an isotropic radiator + gain of the TWT - cable losses - attenuation or insertion loss of yig filters, and other adjustments as the test setup makes necessary.
- h.  $R$  = Separation between antennas in meters.
- i.  $P_{sp}$  = Power of spurious emission signal delivered to transmitting antenna.
- j.  $T$  = Pulse width in seconds.
- k.  $F_s$  = Desired frequency.
- l.  $N$  = Harmonic number shown on spectrum analyzer.
- m.  $F_{10}$  = Local oscillator frequency of spectrum analyzer.

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- n.  $F_{if}$  = Intermediate frequency of the spectrum analyzer.
- o.  $E_1$  = Measured field strength in volts/meter.

5. Test Setup and Procedures (General) - Two separate test procedures are given in the following paragraphs. The procedure of paragraph 5.1 applies to the testing of equipment with operating frequencies above 1.0 GHz or at frequencies where adequate antenna gain information is available or can be determined. The procedures of paragraph 5.2 applies to the testing of equipments at lower operating frequencies and in situations where the procedures of 5.1 are not feasible.

5.1 Test Setup and Procedure - (1.0 GHz and above)

5.1.1 The test setup shall be as indicated in Figure REO3-1, REO3-2 or REO3-3, whichever is applicable, using the following procedure to establish the distances and actual equipments to be used.

a. Equipment Selection. Select the receiving antenna, TWT's or attenuators which will yield sufficient measurement system sensitivity to allow detection of the transmitter spurious emissions. The following equations should be solved and equipment so selected to assure a  $P_r$  of approximately 0 dBm when  $P_t$  is the value derived from the transmitter's design data.

$$(1) P_r = P_t + G_t + G_r + 40 \log \frac{\lambda}{D+d} - 20 \log 4\pi$$

Use this equation when  $d \geq 0.4D$ .

$$(2) P_r = P_t + G_t + G_r + 40 \log \frac{\lambda}{D} - 20 \log 8\pi$$

Use this equation when  $d < 0.4D$

b. Test Distance. In order to assure far field measurement conditions, the test antenna should be placed at a distance from the transmitting antenna as determined from the following equations.

$$(1) \text{ When } d < 0.4 D$$

$$R = \frac{2D^2}{\lambda}$$

$$(2) \text{ When } d \geq 0.4.D$$

$$R = \frac{(D+d)^2}{\lambda}$$

Further antenna positioning procedures are in the following steps.

c. To complete the test setup analysis, verify by calculation that the received power at the highest frequency of the test,

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assuming a spurious signal ( $P_{sp}$ ) level which is 80 dB below the fundamental transmitted power, is at least 10 dB above the minimum sensitivity of the spectrum analyzer used. The mathematical expression is as follows:

$$P_r = \frac{P_{sp} G_t G_r \lambda^2}{(4\pi R)^2}$$

If the received power is below the sensitivity of the spectrum analyzer, increase the gain of the receiving loop by either removing attenuation or by adding amplification.

**5.1.2 Test Procedure** - Measure and record the value of the power delivered to the transmitting antenna using the following procedure:

a. Adjust the spectrum analyzer to receive the transmitted fundamental signal. Adjust the spectrum analyzer display and resolution bandwidth so that the incoming signal is properly displayed. For pulsed transmitters the display bandwidths should be at least  $10/T$  and the resolution bandwidth should be  $1/10T$ .

b. For orientation of the transmitting and test antennas the following sequence shall be used.

(1) Where azimuth and elevation of the system antenna can be varied, this shall be done to produce the maximum signal at the test antenna. The azimuth angle and elevation angle between the antenna boresight axis of the system and test antenna shall be recorded after the signal is maximized.

(2) The test antenna shall be adjusted in elevation at each measurement frequency to obtain a maximum of received energy. The adjustment should be made over a distance calculated to include two nulls in the elevation interference pattern resulting from ground reflections, where they exist.

(3) All position information shall be recorded together with the test results.

c. Further adjust the spectrum analyzer controls to obtain maximum resolution of the transmitted signal on the CRT display. Once this is accomplished, do not readjust the controls until the measurement is completed.

d. Disconnect the spectrum analyzer from the measurement antenna and connect it to a substitution generator.

e. Adjust the output of the substitution generator to produce the same spectral envelope on the spectrum analyzer as was indicated with the transmitted signal. The signal generator shall be modulated in a manner similar to the modulation used in the transmitter.

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f. Measure and record the power at  $f_0$  delivered to the spectrum analyzer input from the calibrated signal generator.

g. Verify the measurement technique and calibration at  $f_0$  by substituting into the following equation:

$$P_t = \frac{(4\pi R)^2 P_r}{G_t G_r \lambda^2}$$

The above value of  $P_t$  should be within  $\pm 2$  dB of the value measured by the power monitor connected to the transmitter output. If a greater error exists, check the test setup for errors in distance measurement, substitution, drift, correction factors, ground reflections, improper alignment and so forth.

h. Repeat steps a. and f. for the remaining frequency range of test.

**5.2 Test Setup and Procedure** - for equipments with operating frequencies below 1.24 GHz where the procedure of 5.1 cannot be employed. The data obtained using this procedure will be in terms of field intensity at a given distance from the transmitting antenna. The field intensity measured at harmonic and spurious frequencies is compared to the value at the fundamental frequency. The limit is in dB relative to the level measured at the fundamental frequency, and is derived from the RED3 limit of Figure 7 of MIL-STD-461 NOTICE 4 by comparing the absolute power limit placed on harmonics and spurious emissions to the known power rating of the transmitting source.

**5.2.1** The test setup shall be as indicated in Figure REO3-3. The separation between the transmitting antenna and test antenna shall be at least at a distance of  $D^2/\lambda$  or  $3\lambda$ , whichever is larger, unless otherwise specified. (D is taken here to mean the maximum dimension of the largest antenna). Where the received signal at the fundamental frequency is less than the applicable limit above the sensitivity of the EMI meter, place a preamplifier, capable of increasing the measurement sensitivity, between the test antenna and the receiver (In Figure REO3-3 this should be placed between the switch and the EMI meter)

**5.2.2 Test Procedure.**

a. Tune the transmitter to a standard test frequency with the fundamental rejection network bypassed and the switch set to position one (1). Tune the frequency selective voltmeter to the same frequency. Position the antennas to produce maximum received signal at each frequency (fundamental, spurious, harmonic); use the technique outlined in 5.1 above. Set the switch to position 2 and determine the received signal level. This level must be at least as great as the applicable

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limit above the meter sensitivity. Record all settings.

b. Insert the fundamental frequency rejection network, and tune it to reject the transmitter fundamental frequency. With minimum system attenuation and maximum instrument sensitivity, tune the frequency selective voltmeter continuously through the required frequency range to detect all emissions. Each time a spurious transmitter output is found, adjust the meter to give a convenient reading. Determine the signal level and record all values. When determining the level of the responses, the attenuation of the signal sampling network at the spurious frequency shall be known.

c. Repeat the foregoing steps at each transmitter test frequency.

d. Apply effective height and other correction factors (cables losses, attenuations) as required to determine field intensity levels at the antenna.

## 6. NOTES

a. When performing these tests, it may be necessary to enclose the measurement equipment in a shielded enclosure. This necessity arises from the fact that the spectrum analyzer may be susceptible to radiated fields. It is recommended that the spectrum analyzer be disconnected from the measurement antenna and the display checked to verify that a back door response is not being measured.

b. When using the TWT's and yig filters, these parts should be located as near the antenna as possible. This is done so that maximum signal may be applied to the TWT input.

c. It is necessary to monitor continually the transmitter's output power during test. If the power at  $f_0$  changes by more than +2dB, the test shall be terminated until such time that the original output is obtained. Duty cycle considerations shall be adhered to, and should be established as defined in the equipment's test plan.

d. To measure the frequency of the incoming signal, note the signal identifier and harmonic number of the spectrum analyzer. Since the frequency of the desired signal is derived from

$$F_s = N F_{10} + F_{if}$$

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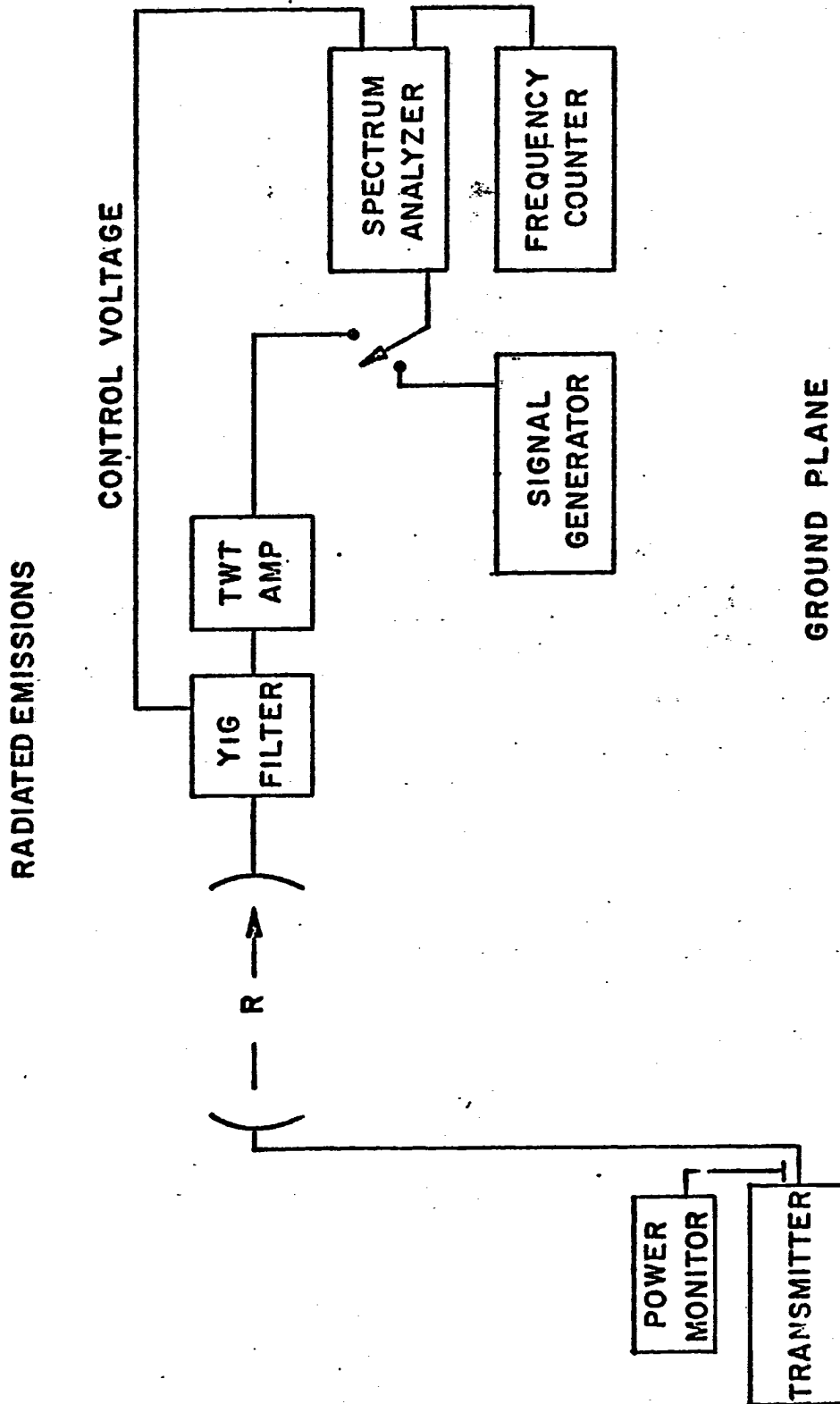


FIG. RE03-1 TYPICAL TEST SETUP - SPURIOUS AND HARMONIC EMISSIONS  
(1 TO 12.4 GHz)

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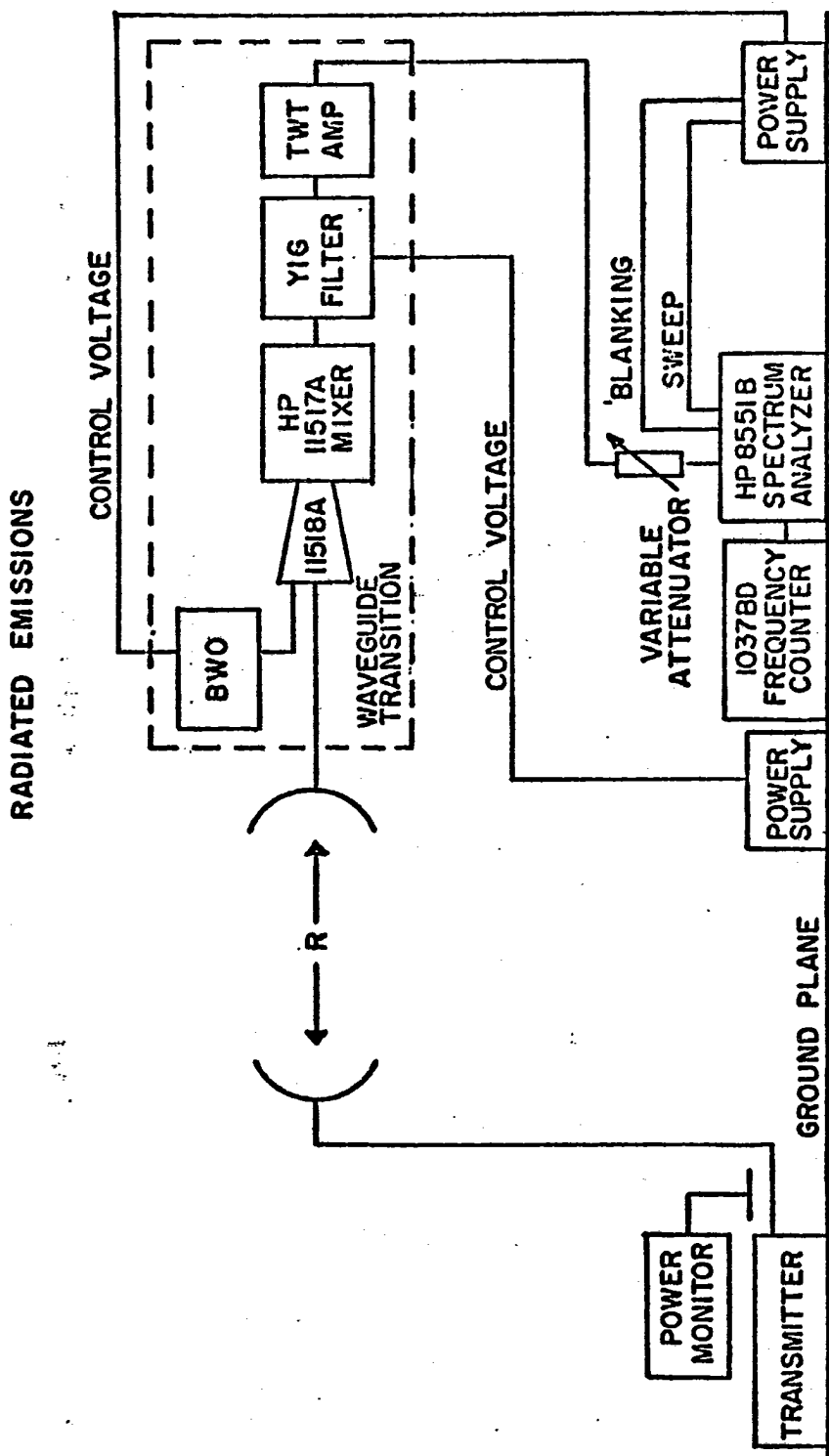


FIG. RE03-2 TYPICAL SETUP - SPURIOUS AND HARMONIC EMISSION (12.4 TO 40GHz)



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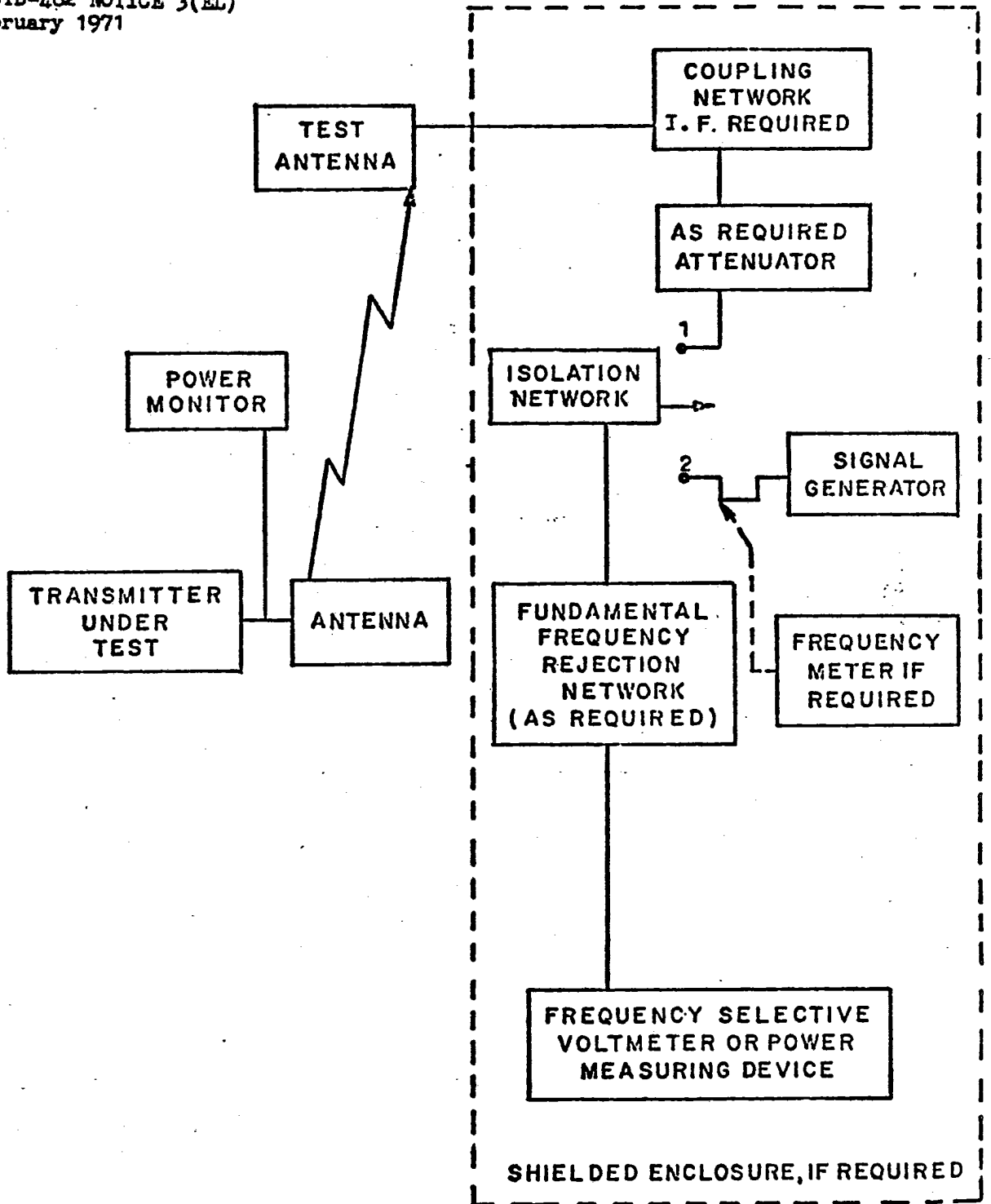


FIG. RE03-3 TYPICAL SETUP - SPURIOUS AND HARMONIC EMISSION (FREQUENCY RANGE AS APPLICABLE)

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## METHOD RE04

## RADIATED EMISSION, 20 Hz to 50 KHz; MAGNETIC FIELD

1. Application - Any equipment to which this test method is applicable will be measured for radiated magnetic fields from all units, cables, (including control pulse, video, antenna transmission line and power cables) and interconnecting wiring, over the frequency range of 20 Hz to 50 KHz. This method applies to transmitter spurious emanations, but does not include desired radiation emanating from antennas. Equipments, that are not capable of producing magnetic fields, either intentional or unintentional, need not be subject to this test.

2. Apparatus - The following test apparatus shall be used as shown in Figure RE04-1 or RE04-2.

a. Magnetic Field Sensor - The loop sensor described in paragraph 2 of Method RE01 or Magnetic field intensity meter and probe (Electro-Mechanics 6640 or equivalent).

b. EMI Meter - Any narrow band EMI meter with adequate sensitivity and characteristics. The meter shall have a bandwidth selection which is no greater than 50 Hz at the 3 dB points.

3. Test Procedure - The basic test setup is shown in Figures RE04-1 or RE04-2

3.1 The point of maximum radiation at a distance of 1 meter from the test sample to the face of the sensor shall be located as follows:

3.1.1 For test samples generating only broadband emission (that is not intended to generate or receive signals).

a. Position the sensor at the 1 meter distance indicated above and opposite the center of the test sample.

b. Scan the full range of the EMI meter and locate the frequency giving the maximum meter indication.

c. At the frequency determined in b. move the sensor horizontally to determine and locate the maximum emission level. This location shall be the sensor position.

3.1.2 For test samples intended to generate or receive signals -

a. Position the sensor as in 4.1.1 a.

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b. Set the test sample to one of its critical operating frequencies.

c. Repeat 3.1.1, b. and c.

3.2 At the point of maximum emission, scan the EMI meter over the frequency range of 20 Hz to 50 KHz and record data as required.

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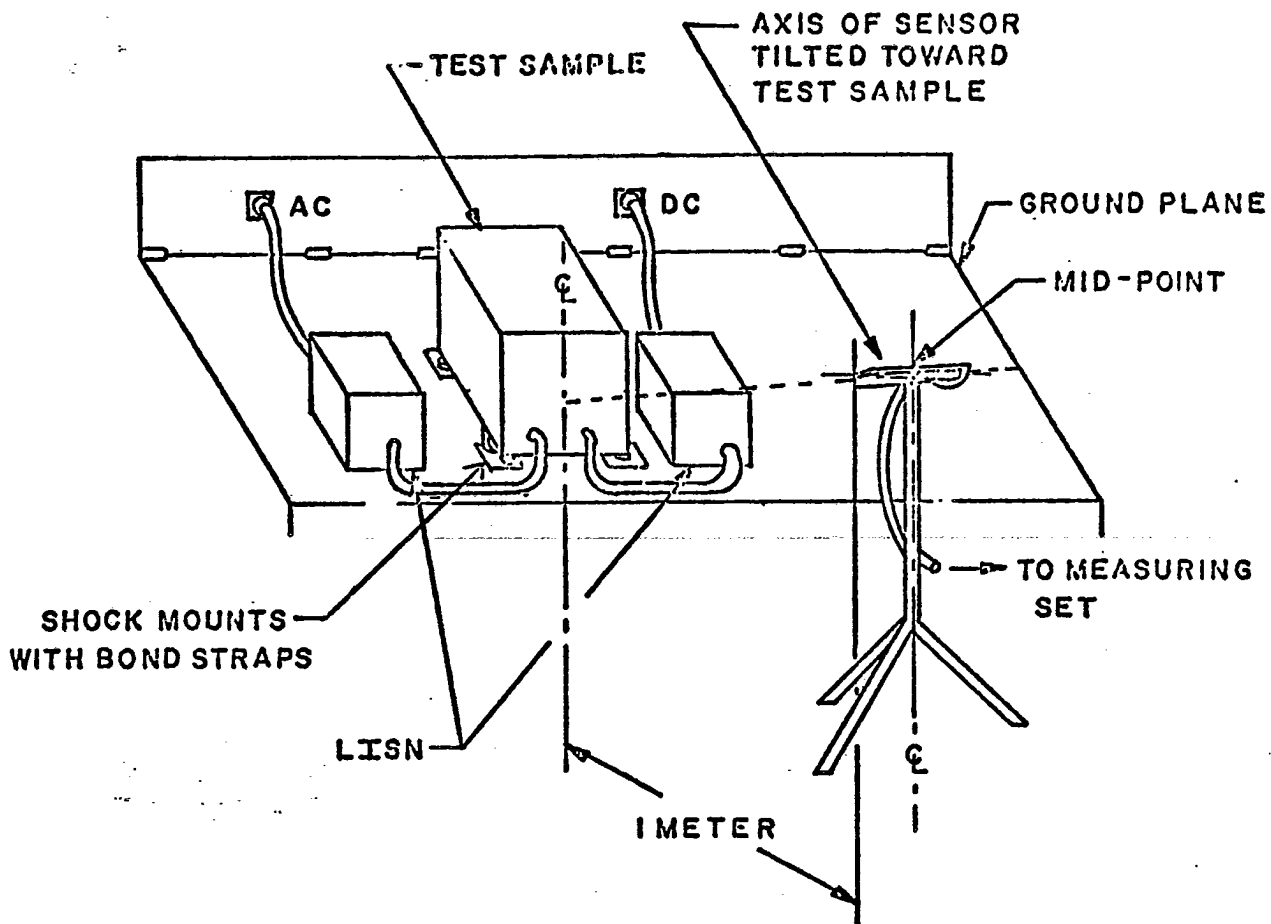


FIG. RE04-1 TYPICAL TEST SETUP FOR RADIATION MEASUREMENTS (MAGNETIC FIELD SENSOR)

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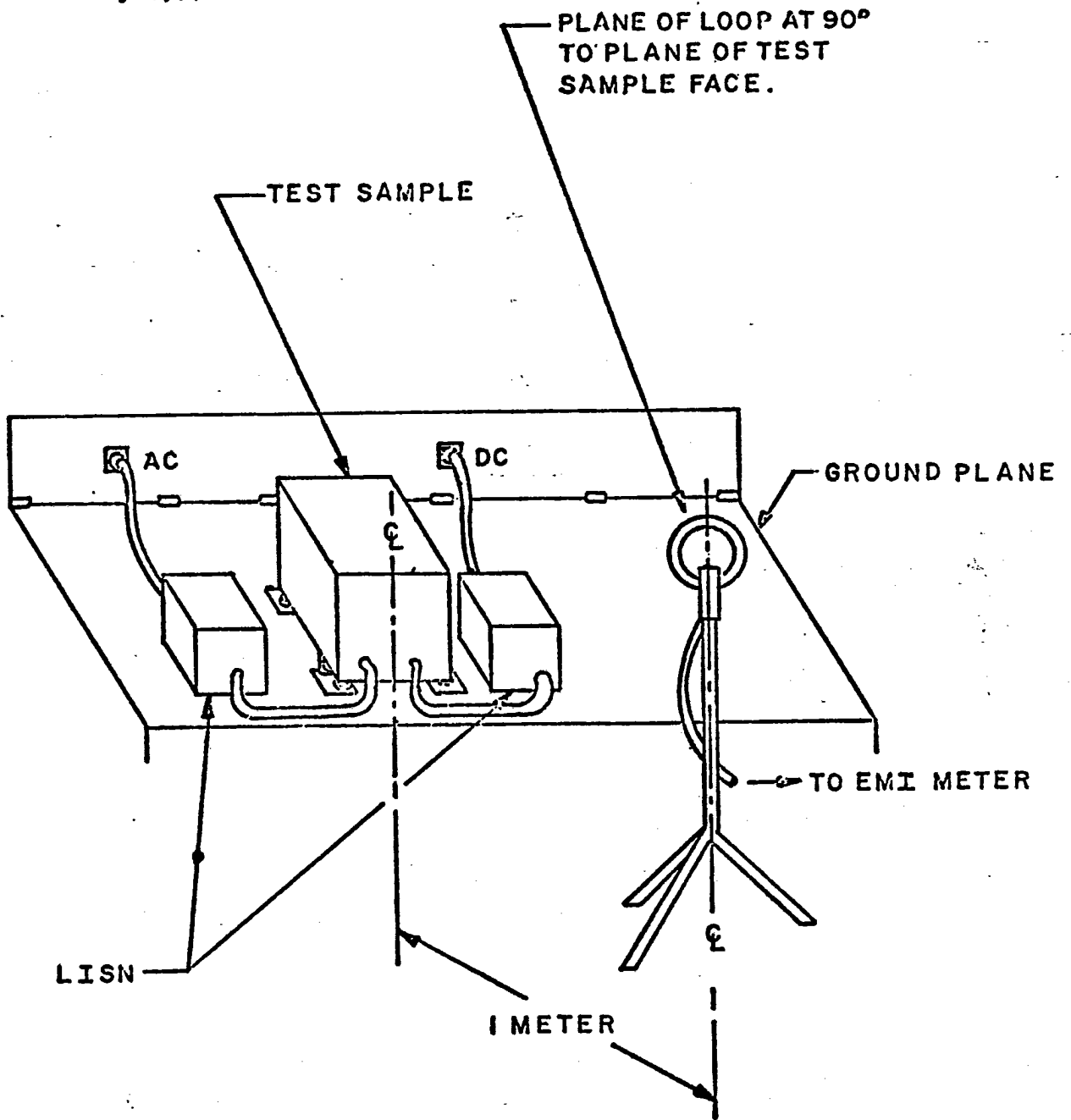


FIG. RE04 - 2 TYPICAL TEST SETUP FOR RADIATION MEASUREMENTS (LOOP SENSOR)

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## METHOD RED5

### RADIATED EMISSION, BROADBAND, 150 KHz to 1000MHz

1. Purpose - The purpose of this method is to establish test setups and procedures for measuring broadband radiated emissions of vehicles and engine-driven equipment, including the electrical equipment, subassemblies, parts and accessories installed thereon.

2. Applicability - This test method is applicable to the measurement of radiated broadband interference emitted by the following equipment:

Tactical vehicles

Special-Purpose vehicles and engine-driven equipment

3. Apparatus - Interference measuring equipment, and antennas, shall be as specified in Tables I and II for radiated measurements in the required frequency range.

#### 4. Test Setup.

4.1 The vehicle or equipment to be tested shall be set up in a fixed position on the earth (see general test conditions) and operated in a manner to cause maximum radiation within normal operating procedures. The tests shall be performed with all electrical equipment in operation, and electrical load conditions adjusted so that the charging system, including output voltage regulators, is in operation throughout the test.

4.2 The measuring antennas, within the limits stated below, shall be located and oriented vertically for maximum pickup at as many positions around the test sample as are necessary to obtain an effective test of the maximum radiation. The horizontal distance from the reference point of the antenna to the outer perimeter of the test sample shall be two meters or as specified in Table VIII of MIL-STD-461 NOTICE 4. The elevation of the antenna reference point above ground shall be from one to two meters, as necessary for maximum pickup, except as follows:

a. To measure radiation from top openings over engine compartments of tanks and other vehicles having such openings, the antenna shall be placed as follows, while maintaining a clearance of two meters between the vehicle and the reference point of the antenna.

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(1) The 41-inch rod shall be tilted over the engine compartment from the end of the vehicle, keeping the antenna horizontal in the vertical longitudinal center plane of the vehicle.

(2) The biconical antenna shall be placed with its axis horizontal over the center of the opening, and in the vertical longitudinal center plane of the vehicle.

(3) The conical spiral antenna shall be placed with the point down, axis vertical, over the center of the opening.

5. Procedure - The test procedure shall be as follows:

a. Scan and record the emissions level as a function of frequency, for the full required frequency range, in each position of the measurement antenna.

b. The frequency range from 25 to 200 MHz shall be scanned with the biconical antenna alternately vertical and horizontal, at the positions chosen for the vertical tests, except for measurements over top openings.

6. Notes.

6.1 Unless otherwise specified in the equipment specification, starting motors and switches associated with starting, short-duration starting aids, and engine-protective warning devices do not require tests. However, low-air warning devices for air-brake vehicles are required to meet the emission limits while indicating low air pressure.

6.2 When applying this standard to unusual equipment such as mobile railroad equipment and watercraft the measuring antenna in these cases shall be placed where the communication receiving antenna would be placed for actual use.

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## METHOD RE06

## RADIATED EMISSION, 14 KHz to 1 GHz, OVERHEAD

## POWER LINES

1. Purpose and Applicability - The purpose of this procedure is to measure radiated emissions from overhead power lines operating at voltages from 0 to 1000 KV. The measurements shall be made in the frequency range from 14 KHz to 1 GHz.

2. Apparatus - Test apparatus shall consist of the following:

- a. EMI Meter (in PEAK position).
- b. Antennas.

3. Test Setup and Procedure

3.1 Make - The test setup shall be as shown in Figure RE06-1

3.2 Measurement Locations - Measurements will usually be required near a critical area. In order to determine if the power line is the source of interference, measurements will be necessary at two or more locations along the line length. For voltages from 0 to 70 KV, measurements are made opposite tower or pole on one side only. For voltages from 70 to 1000KV, measurements shall be made on both sides of the tower as shown in Figure RE06-1.

3.3 Nonpower Line Interference - If it is suspected that the emission measured is other than from the power line, readings at several frequencies should be taken at several distances greater than 50 feet, perpendicular to this power line. Typical measurements of interference from power lines show a  $1/d^3$ ,  $1/d^2$ , or  $1/d$  relationship with distance from the line, depending on the frequency.

4. Notes.

4.1 Antenna Isolation - Proximity effects from nearby objects shall be avoided when making measurements. Measurement of radiated broadband impulse-type interference will be influenced by conducting objects, including personnel, in close proximity to the antenna.

4.2 Monitoring - Meters, either indicating or graphic, should be installed near the measurement location to monitor the line interference while measurements are being made. Readings should be repeated if the monitor shows greater than 6 dB changes. It may be necessary to determine that the entire length of line is within the same weather environment before proceeding with further measurements; otherwise the effects of both fair and foul weather data will be included in the line measurement.



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4.3 Operating Condition.

4.3.1 The transmission line shall be operated near normal operating voltage, during the entire time of test. The actual voltage or variations thereof can be determined from indicating meters usually available at a sub-station.

4.3.1 Weather Conditions - Measurements shall be made at a time when humidity and temperature conditions do not cause condensation of moisture on the overhead lines. This specification is intended for both dry and wet (rain or snow) weather conditions; however, the entire length of the line shall be under the same conditions. It is permissible to avoid measurements during short term dry spells, when insects, dirt, dust and vegetation gather on the conductor or other line parts and may cause high interference levels.

4.4 Measurements with the biconical antenna shall be made in both the vertical and horizontal positions.

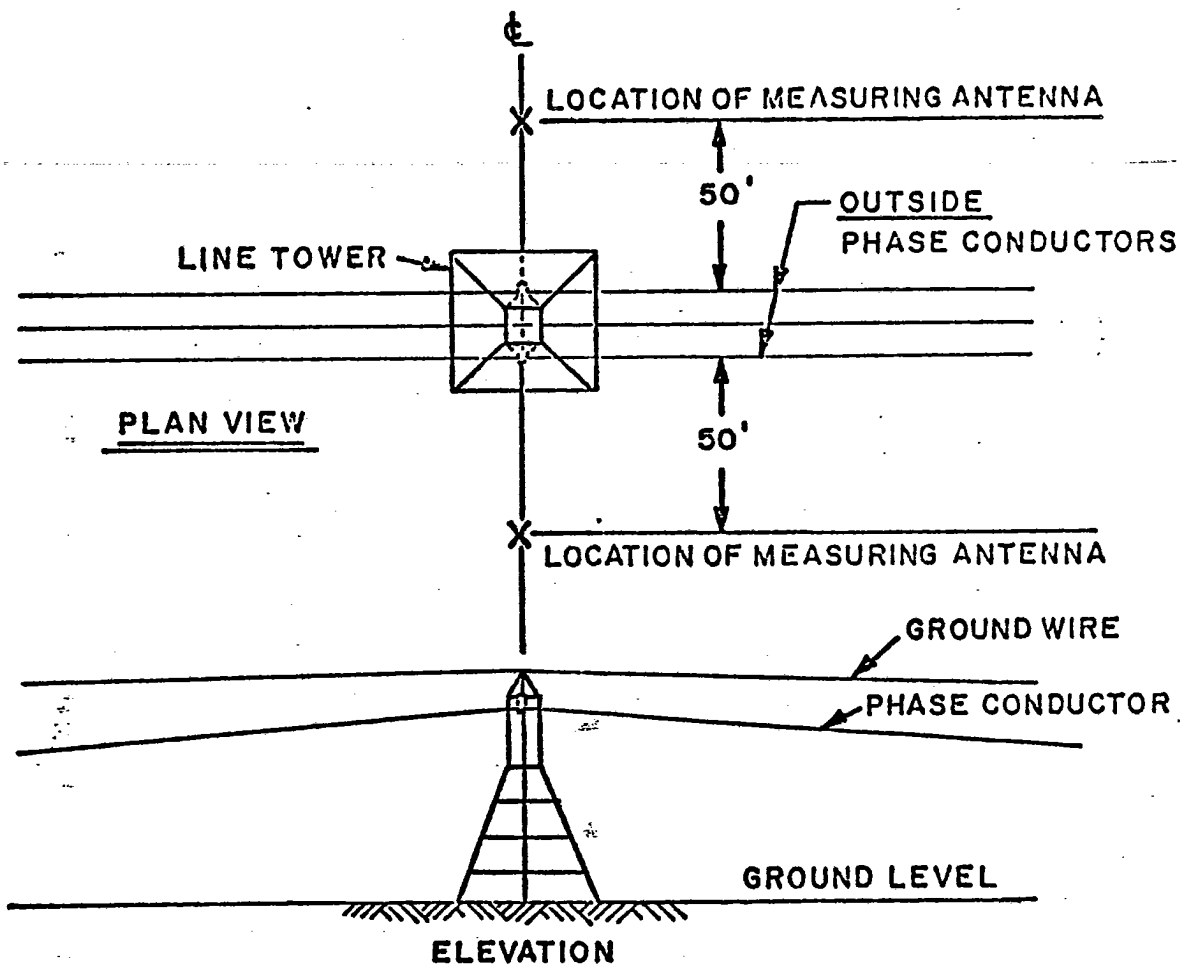
4.5 Measuring antenna shall be positioned on a tripod 1 meter above ground.

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## X ANTENNA LOCATIONS

MEASURE ON BOTH SIDES OF TOWER  
AT VOLTAGES FROM 70-1000 KV

MEASURE ON ONE SIDE OF TOWER  
OR POLE AT VOLTAGES FROM 0-70KV



**FIG. RE06-1 ANTENNA LOCATIONS INTERFERENCE MEASUREMENTS FOR POWER LINES FROM 0-1000 KV.**

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METHOD RS01

RADIATED SUSCEPTIBILITY, 30 Hz to 30 KHz, MAGNETIC FIELD

1. Applicability - This method is applicable, in the frequency range of 30 Hz to 30 KHz, for the determination of equipment susceptibility to magnetic fields.
2. Apparatus - Test apparatus shall consist of the following:
  - a. Radiating Loop - The radiating loop shall be as shown in Figure RS01. The loop is capable of producing a magnetic flux density of  $5 \times 10^{-5}$  Tesla/Ampere at a point approximately 5 cm from the face of the loop. It shall be supported on a wooden form or similar non-conducting material.
  - b. Signal Source - The loop shall be supplied with sufficient current capable of producing magnetic flux densities 20 to 30 dB greater than the applicable limit at the test frequency.
  - c. EMI Meter or Narrowband VTVM - EMI Meter or Narrowband VTVM shall be capable of reading levels 6dB below the specified limit in the 30Hz to 30KHz frequency range. The meter shall have a 10 Hz or narrower bandwidth at the 3dB points.
3. Test Setup and Procedures - Test setup and procedures are as follows:
  - a. Position the field radiating loop 5 cm from the surface of the test sample. The plane of the loop shall be parallel to the plane of the test sample's surface. (See Figure RS01-1)
  - b. Supply the loop with sufficient current to produce magnetic flux densities approximately 20 to 30 db greater than the applicable limit at the test frequencies. (See Figure RS01-2)
  - c. Move the loop over the test sample surface and signal input and output cables and connectors to determine the point at which the applied field produces maximum susceptibility.
  - d. With the loop at the point of maximum susceptibility, adjust the loop current until the performance of the test sample is not affected by the applied field.
    - (1) For test samples with an aural output, adjust the loop current until the test sample gives a reading 20 dB greater than its internal noise. If a 20 dB value cannot be obtained, a 6 dB interference signal to noise ratio will be used.
    - (2) For test samples with outputs other than aural, the degree

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of degradation shall be defined in the test plan.

(3) For test samples with aural and nonaural outputs, the test shall be performed to meet both steps d.(1) and (2).

e. Record the magnitude of the magnetic field density produced by the source and the maximum value of magnetic flux density required by step d. above.

f. Repeat steps a. through e. at the test frequencies approved in the test plan.

#### 4. Notes.

4.1 The magnitude of the magnetic Flux density as determined in 3d. above must be converted to a value representing the equivalent interfering magnetic flux density for a 6 dB signal-to-noise ratio in a system bandwidth of 1 Hz. To make this conversion, the calculations specified hereinafter are necessary.

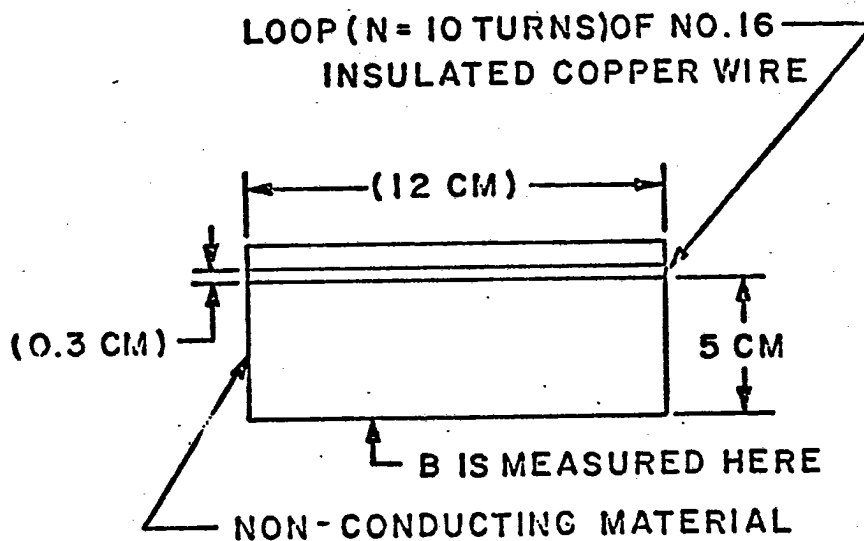
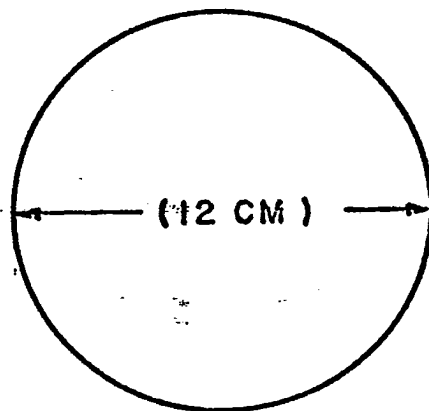
##### 4.1.1

a. If a 20 dB interference signal-to-noise ratio was used the magnetic flux density recorded in step 4e. shall be reduced 14 dB.

b. Reduce by  $\sqrt{\Delta f v}$ , where  $\Delta f v$  is the 3 dB bandwidth

c. Increase by  $\sqrt{\frac{1}{\Delta f v}}$  when the bandwidth of the test sample is less than 1 Hz. This final value shall be recorded and compared with the test limit.

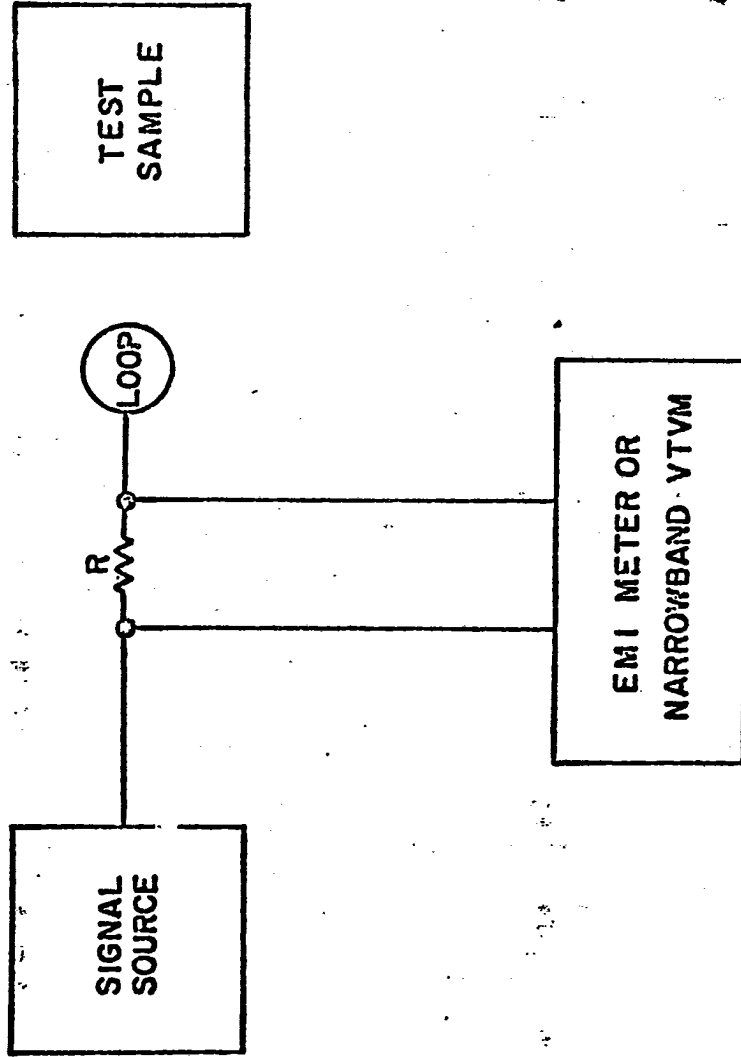
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NOTE 1:  $B = 5 \times 10^{-5} \frac{\text{TESLA}}{\text{AMP}}$  AT 5 CM FROM WIRE TURNS.

NOTE 2: LOOP SELF RESONANT FREQUENCY SHALL BE GREATER THAN 100 kHz.

FIG. RSOI LOOP USED FOR RADIATING MAGNETIC FIELDS



R = RESISTOR OF 1 OHM (A 1 VOLT OUTPUT TO THE VOLTMETER YIELDS A 1 AMP INPUT TO THE LOOP).

FIG. R501-1 - RADIATED SUSCEPTIBILITY, 30 Hz - 30kHz, MAGNETIC FIELD

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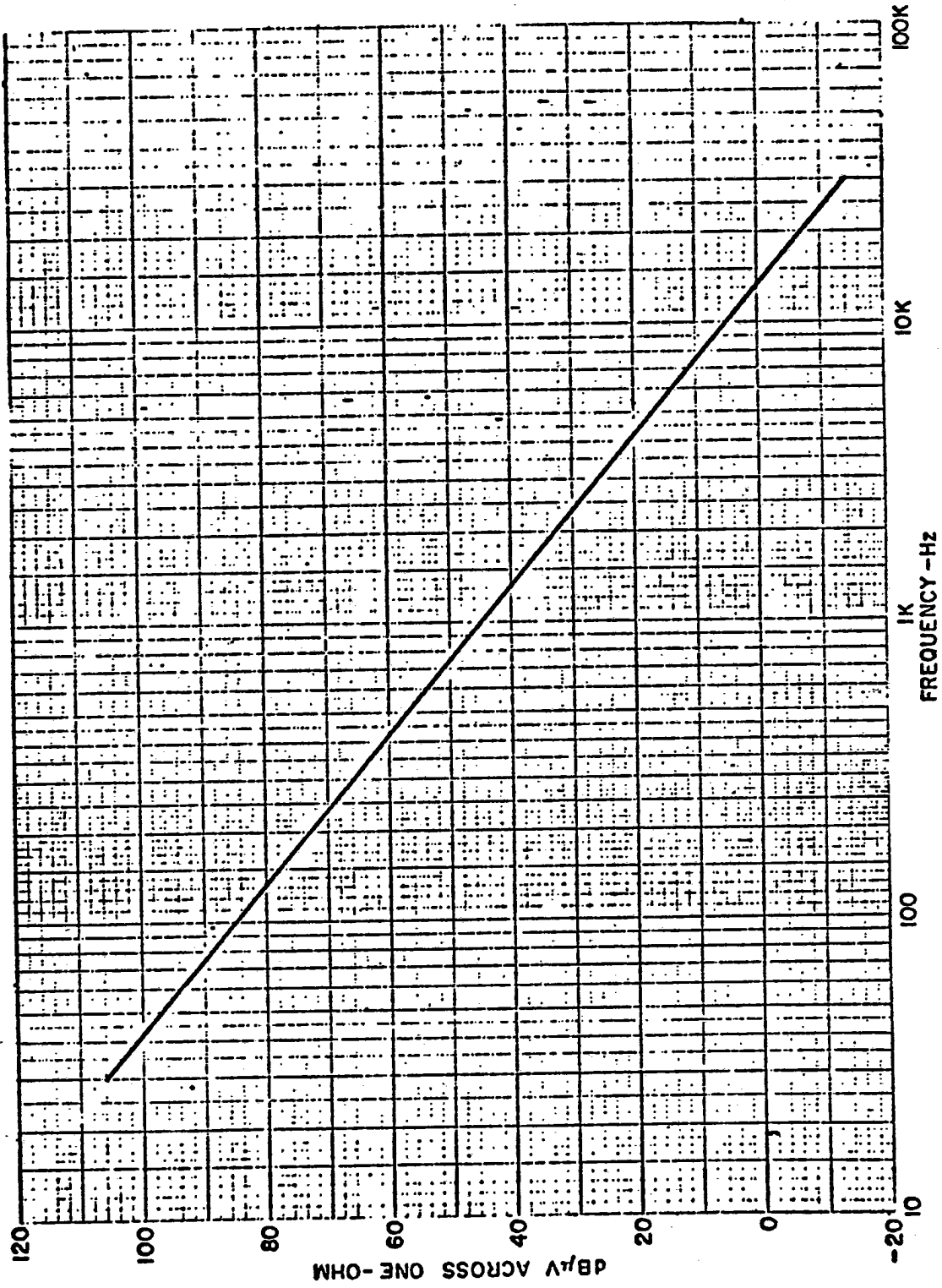


FIG. RS01-2 RS01 LIMIT IN TERMS OF VOLTAGE DEVELOPED ACROSS 1 OHM RESISTOR OF FIG. RS01-1.

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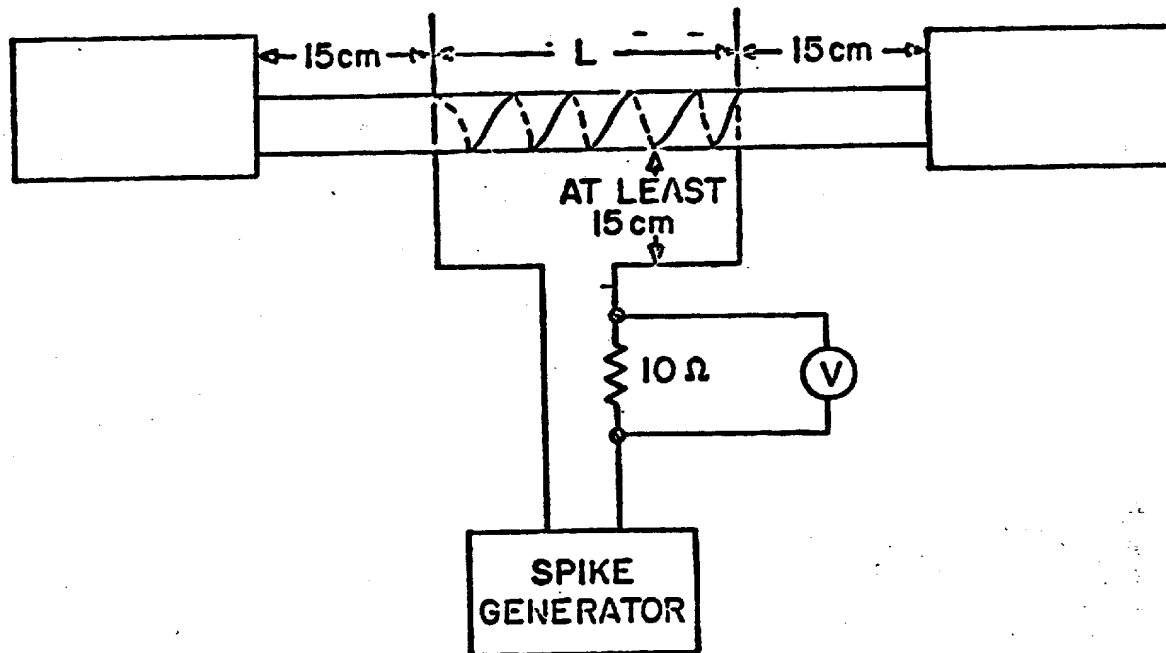
## METHOD RS02

## RADIATED SUSCEPTIBILITY, MAGNETIC INDUCTION FIELD, SPIKE

1. Applicability - This procedure is applicable for determination of susceptibility of equipments to short duration induction fields.
2. Apparatus - The test apparatus shall consist of the following:
  - a. Spike Generator - Spike generators shall be as specified in Method CS06 of this standard.
  - b. Oscilloscope.
3. Test Setup and Procedures.
  - 3.1 Cable Susceptibility Test - The cable susceptibility test shall be performed as specified hereinafter.
    - 3.1.1 Tape an insulated wire to each wire bundle in the test setup, spiralling at two turns per meter (equally spaced) and running the entire length of the bundle to within 15 cm of each end connector (See Figure RS0.2-1). Connect 10 ohm resistor in series as indicated. Monitor for susceptibility.
4. Notes.
  - 4.1 A.C power input and output leads are exempt from the cable test.
  - 4.2 It is not the intention of the cable test to test individual wires but to test groups or bundles or wires.
  - 4.3 Keep current carrying wires 15 cm away from cable connectors.
  - 4.4 All cables should be at least 5 cm above the ground.
  - 4.5 In order to minimize test time, test as many wire bundles at the same time as practicable.



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- NOTE: 1)  $L$  SHALL BE THE LENGTH OF THE CABLE  
IN THE ACTUAL INSTALLATION OR 1.5 METERS,  
WHICHEVER IS LESS.
- 2) SPIRAL WIRE AT 2 TURNS PER METER

FIG. RS02-1 RADIATED SUSCEPTIBILITY, MAGNETIC  
INDUCTION FIELD CABLE TEST

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## METHOD R503

## RADIATED SUSCEPTIBILITY, 14 KHz to 12.4 GHz, ELECTRIC FIELD

1. Applicability - These methods are applicable for determination of equipment, sub-system and system susceptibility in the presence of an electric field.
2. Apparatus - The test apparatus shall consist of the following:
  - a. Signal source.
  - b. EMI meter
  - c. Antennas (See Table I)
  - d. Output Monitor - to monitor performance of test sample.
3. Test Setup and Procedures.
  - 3.1 The test setup shall be as required by the general testing requirements of this standard for placement of antennas.
  - 3.2 Test signals shall be selected in accordance with the rules of paragraph 4 below.
  - 3.3 Fields shall be generated, as required, with the antenna specified in Table I. Care shall be taken so that the test equipment is not affected by the test signals.
  - 3.4 The specified field strength shall be established prior to the actual testing by placing a field measuring antenna at the same distance and in the same relative location as where the test sample will be placed and adjusting the signal level applied to the transmitting antenna until the required field intensity is indicated. The voltage or power at the input terminals of the transmitting antenna, required to establish the specified field shall be monitored and recorded. When performing this calibration in a shielded enclosure, the measurement antenna shall be placed in either the exact location that the test sample will occupy or shall be in a position which simulates exactly the geometry of the test sample location, as regards distances to reflective surfaces. (This calibration may be used for all subsequent testing provided that the data was taken in a reflective free area or the exact same shielded enclosure test sample location is used).
  - 3.5 When a large test sample is to be immersed in a field, the transmitting antenna shall be placed at a distance sufficient to allow the entire test sample to fall within the 3 dB beamwidth of the transmitted field. If this is not feasible because of difficulty in generating the

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required field at the greater distance or because of the nature of the antenna radiation characteristics, the sample may be tested in segments, each segment being equal in dimension to the 6 dB beamwidth of the antenna radiation characteristic. For a whip transmitting antenna the horizontal segments shall have length no greater than given by the following equation:

$$L = 2 \sqrt{Rd - \left(\frac{d}{2}\right)^2}$$

Where R is the test distance and d is the test sample width measured along a line forming a right angle with the face of the test sample which is directed toward the transmitting antenna.

3.6 Determine those frequencies at which the test sample is susceptible. At these frequencies, determine the threshold of susceptibility. Record all pertinent data.

4. Susceptibility Signal Modulation Rules - Test signals shall be modulated according to the following rules.

4.1 Test Samples with Audio Channels/Receivers.

- a. AM Receivers: Modulate 50% with 1000 Hz tone.
- b. FM Receivers: When monitoring signal to noise ratio modulate with 1000 Hz signal using 10 KHz deviation. When monitoring receiver quieting, use no modulation.
- c. SSB Receivers: Use no modulation.
- d. Other Equipments: Same as for AM receivers.

4.2 Test Samples with Video Channels Other Than Receivers. Modulate 90 to 100% with pulse of duration  $\frac{2}{BW}$  and repetition rate equal to  $\frac{1000}{BW}$  where BW is the video bandwidth.

4.3 Digital Equipment - Use pulse modulation with pulse duration and repetition rate/s equal to that used in the equipment.

4.4 Non-tuned Equipments - Amplitude modulate 50% with 1000 Hz tone.

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## 5. METHOD FOR LONGWIRE ANTENNA

5.1 Applicability - This method is applicable for establishing high values of field intensity in the .014 to 30 MHz range.

5.2 Apparatus - Test apparatus shall consist of the following:

- a. 2 VTVM.
- b. RF signal generator capable of 1 volt output into a 100 ohm load.
- c. A d.c. resistance bridge.
- d. Assortment of resistors from 100 to 1000 ohms ("non-inductive") of adequate power dissipating capability.
- e. Wire - #12 copper

5.3 Test Setup and Procedure for Line Termination.5.3.1 Test Setup.

5.3.1.1 The test setup is as indicated in Figure RSO3-1. The horizontal line is located at the longitudinal center of the shielded enclosure at a distance from the ceiling equal to between  $\frac{1}{4}$  to  $\frac{1}{3}$  the height of the room. The line is drawn taut on insulators. A "non-inductive" resistance equal to the characteristic impedance of the line is located at the far end from the signal generator. A concentric feeder line (copper tubing with #16 wire supported in center) extends from the input end of the line down to the terminals of a signal generator. The signal generator output is connected to the concentric line input; the signal generator ground and the concentric line tubing (lower end) is connected to the shield.

5.3.2 Line Terminations.

5.3.2.1 Concentric Line - Disconnect long line from top of concentric feeder line. Connect the vacuum tube voltmeters as shown in Figure RSO3-2 but omit the temporary termination R. until a desirable test frequency has been found. Adjust the generator frequency so that it resonates line as at  $\frac{1}{4}$  wave system. This point will be indicated by a dip in the output calibrating meter on the signal generator or by maximum voltage at top of tubing for constant input. This voltage may be read with the VTVM connected as shown in the sketch. This frequency at which the concentric tube is electrically  $\frac{1}{4}$  wave length long is the one at which the greatest step-up at the end of the line will occur and, therefore, will give the most sensitive indication of correct termination. A frequency near this resonant frequency may be used if the line absorbs too much energy from

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the generator. Connect  $R_1$  temporarily at top end of concentric line between center wire and pipe. The final value of this resistor is to be determined by "cut and try methods"; its approximate value may be obtained from the formula for finding characteristic impedance of a concentric line:

$$Z_0 = R_1 = 138 \log_{10} \frac{d_2}{d_1}$$

$d_2$  = inside diameter of pipe  
 $d_1$  = outside diameter of central conductor

For a specific case of 1" tube and #14 wire the value is approximately 150 ohms. Across this resistor- $R_1$  connect a VTVM. At the input end of the tubing near the generator connect the other VTVM (see Figure RSO3-2); with the generator set at zero output, adjust the voltmeters for zero reading. With input to concentric tubing raised to one or two volts, the meters will read the same if the selected  $R_1$  is correct termination for the system. If the voltage at the top end of tubing is higher than the voltage at the lower end, the termination is too high a value (and conversely). By successive trials, a value of resistance can be found which will terminate the line properly. Several resistors in parallel or series combinations may be used to get the required value if a single resistor of correct value cannot be found. Successive lower frequencies should then be tried and should result in identical readings on the two meters if everything is in order. This termination can now be disconnected and measured on a dc resistance bridge, the value being recorded as  $R_1$ .

5.3.2.2 Termination of Horizontal Line - With the termination of the concentric line removed, connect the end of the horizontal line to the center wire of the tubing (see Figure RSO3-3). With the voltmeters in positions / and C and temporary termination  $R_2$  (approximated with following equations) removed, the frequency at which the system is  $\frac{1}{4}$  wave long is found as in section 3.2.1. This frequency is to be used in the following accurate determination of  $R_2$ .

The following equations can be employed to determine an approximate value for  $R_2$

Case 1 Wire is much closer to ceiling than to floor:

$$Z_0 = 138 \log_{10} \frac{4D}{d}$$

Where  $D$  = distance from wire to ceiling  
 $d$  = diameter of wire ( $80.81 \times 10^{-3}$  inches for #12 wire)

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Case 2 Distance of wire to ceiling is greater than 1/3 room height.

$$Z_0 = \left[ 138 \log \frac{h}{d} \right] + 5$$

Where h = height of screen room  
d = diameter of wire

For finding the exact value of  $R_2$ , the voltmeters are connected in positions B and C (see Figure RS03-3); proceed as in section 3.2.1 to find the correct termination. Once the voltmeters read the same or within 0.1 volt of one another for several frequencies, the termination may be removed, measured on a bridge and replaced permanently as part of the system. Record termination value as  $R_2 = Z_L$ , the characteristic impedance of the line, to be used later in calculation of final concentric line feeder termination and attenuation constant.

**5.3.2.3 Matching the Horizontal Line to the Concentric Tube Feeder -**  
The termination found in section 3.2.2 is the correct value for the single wire horizontal line alone and will be the impedance one would "see" looking in the end opposite to that termination. However, this resistance is not the correct value for proper termination of the top of the concentric line. Since the termination of the concentric line at this point is of concern, a resistor may be put in as a termination, which, in parallel with the impedance presented by the horizontal line, will give the value of resistance determined in section 3.2.1 as the correct termination of the concentric line. The formula for finding this resistance is the usual one for finding values of parallel resistance combinations.

$$R_3 = \frac{R_1 \times R_2}{R_2 - R_1}$$

Where  $R_1$  = Termination for concentric line from section 3.2.1

$R_2$  = Termination for horizontal line from section 3.2.2

$R_3$  = Termination which must be put across the top end of concentric line as indicated in Figure RS03-4.

After both terminations have been placed in system (see Figure RS03-4), a final check should be made to see if the voltages at the bottom end of concentric line and far end of horizontal line remain substantially the same over a frequency range from 14 KHz to 15 MHz.

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5.4 Determination of attenuation constant (K) relating voltage at point A of Figure RSO3-5 to field strength (uv/m) around transmission line at a known distance.

$$E_{uv/m} = 2.36 \times 10^3 \frac{E_L}{Z_L} \left( \frac{1}{d} + \frac{1}{2d_1-d} - \frac{1}{2d_2+d} \right)$$

$$\text{and } \frac{1}{K_d} = \frac{2.36 \times 10^3}{Z_L} \left( \frac{1}{d} + \frac{1}{2d_1-d} - \frac{1}{2d_2+d} \right)$$

$$\text{or } \frac{1}{K_d} = \frac{E_{uv/m}}{E_L}$$

- where:
1.  $E_{uv/m}$  = field strength at known distance (microvolts per meter)
  2.  $E_L$  = uv into line at point A (Figure RSO3-5) from a signal generator.
  3.  $Z_L$  = Characteristic impedance of line.
  4.  $d, d_1, d_2$  (inches) are distances as indicated in Figure RSO3-5.
  5.  $K_d$  = Attenuation constant (factor).

$K_d$  is a constant and, for a standard test distance  $d$ , in a given room can always be used to determine field strength in microvolts per meter in terms of the generator input in microvolts.

For example: If this constant ratio is found to be 5, then to obtain a field strength at the test sample of 1 volt/meter the signal generator input will be set at 5 volts. Calculations should be checked by actual measurement of the field.

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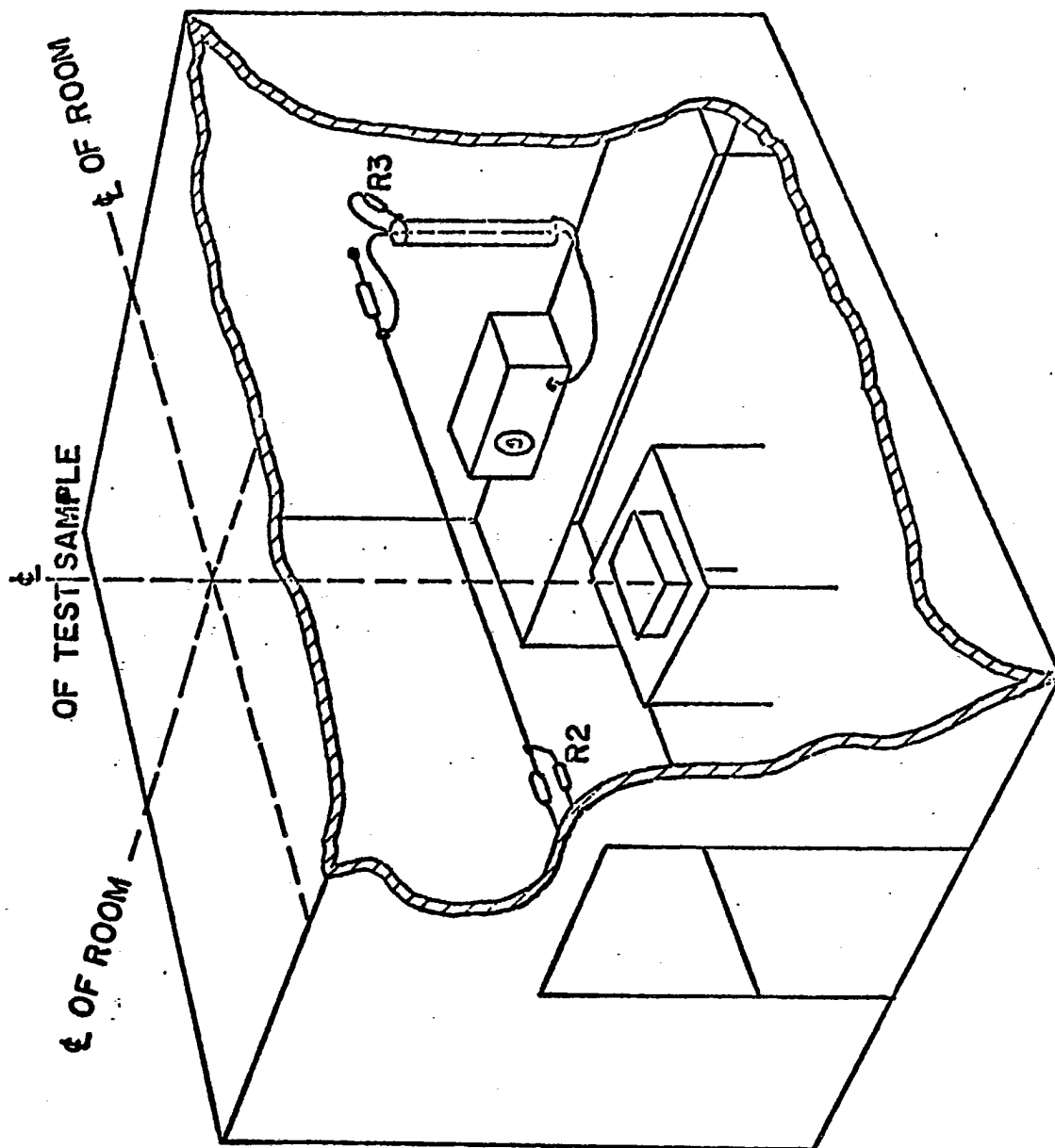
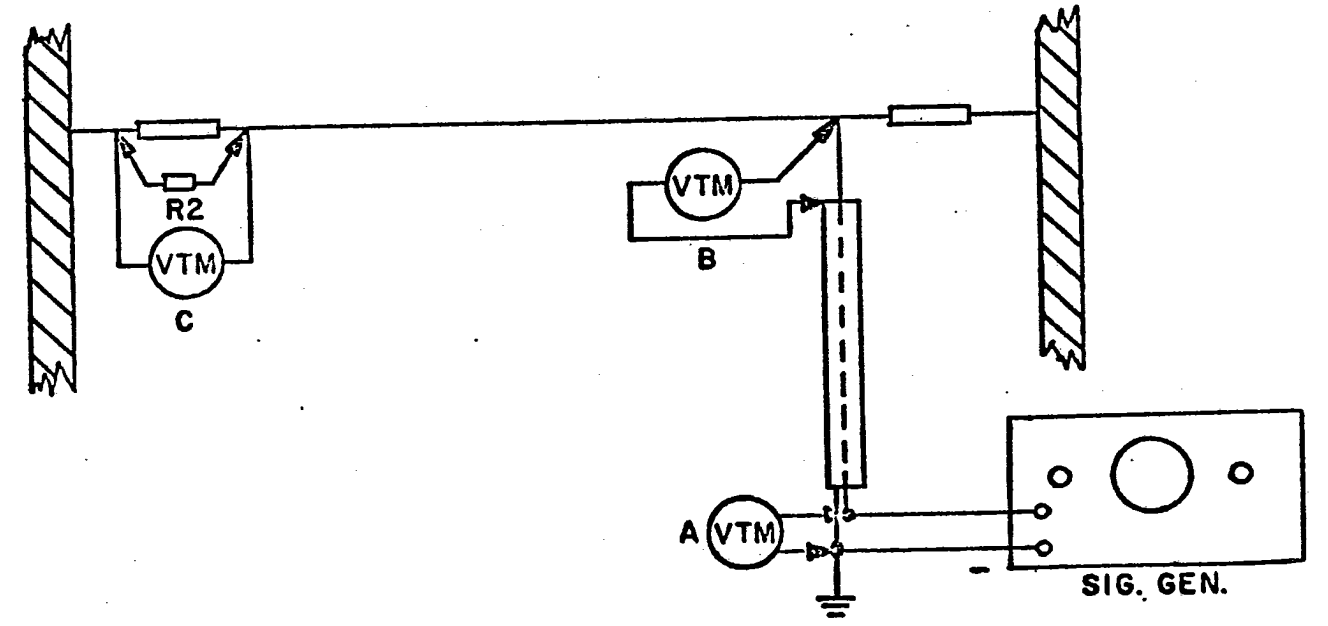
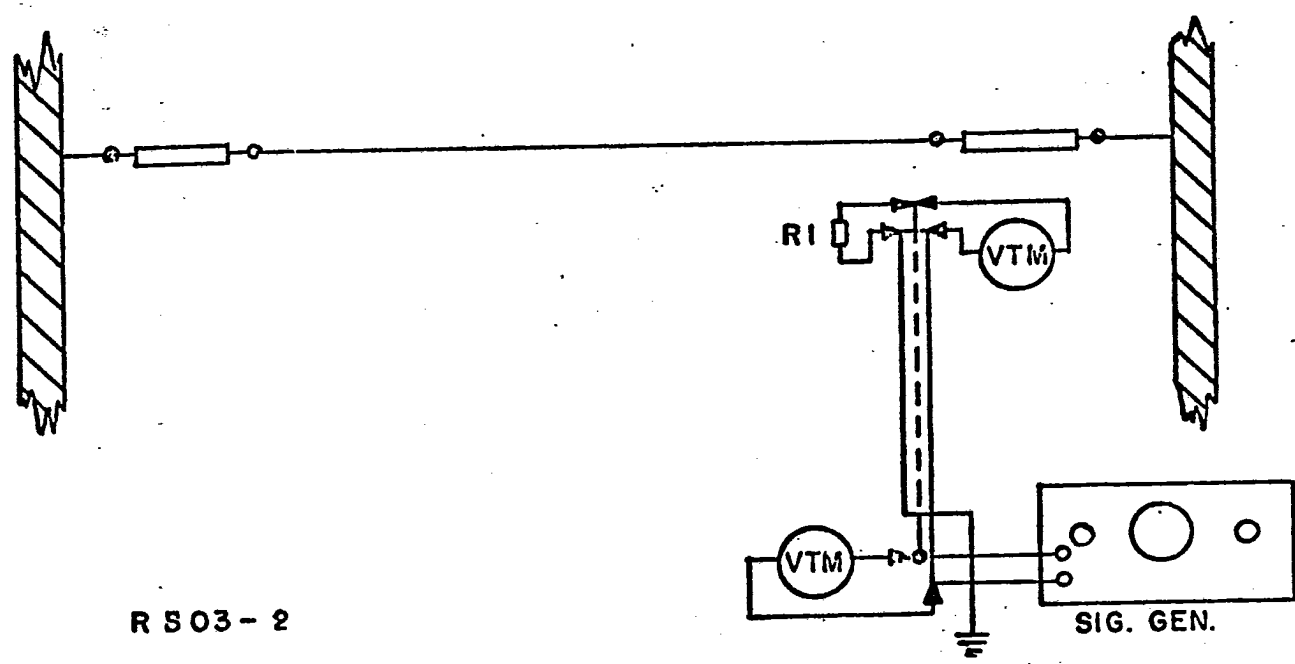


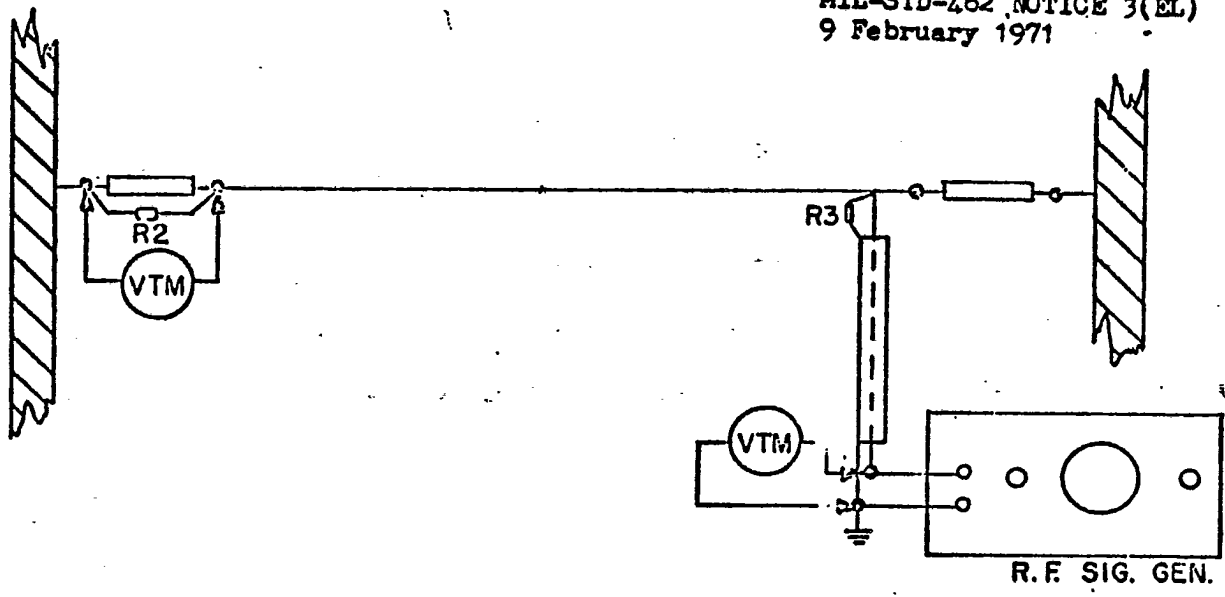
FIG. RS03-1 TYPICAL SCREEN ROOM SET-UP LONG WIRE ANTENNA



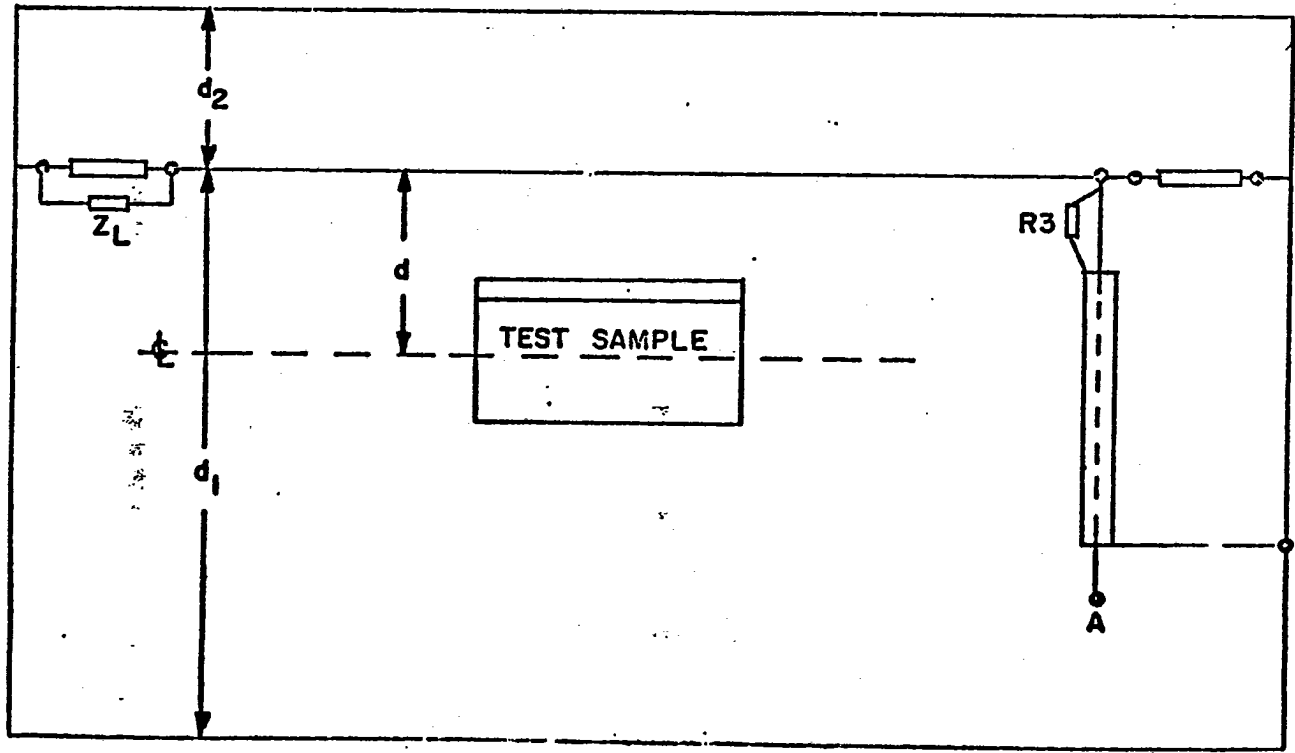
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RS03-4



RS03-5

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6. Method for Parallel Strip Line.

6.1 Application - This method is applicable to all equipments which are of size compatible to the dimensions of this test device and to test limitations herein described. It may be used from 14 KHz to 30 MHz when high intensity fields are required. It is also useful when broadband or spike radiated susceptibility tests are required.

6.2 Apparatus - The test apparatus shall consist of the following:

- a. Parallel Plate Line (see Figures RSO3-6 and RSO3-7).
- b. Signal Source capable of delivering the required signals.
- c. EMI meter or VTVM.
- d. Matching networks (see Figure RSO3-8 (optional)).
- e. 30 MHz Low Pass Filter (optional).

6.3 Test Procedure - The test shall be performed as specified hereinafter.

6.3.1 Set up the equipment as shown in Figure RSO3-8 with special emphasis on placing the test sample as much to the center of the line as possible. Interconnecting and power leads shall be kept 4 to 6 centimeters above the ground plane and laid out parallel to the line for a length not less than 1 meter. Select test signals in accordance with applicable requirements of MIL-STD-461 NOTICE 4 or as specified in the test plan.

6.3.2 By means of the calibration chart of electric field intensity as a function of the EMI meter reading, corrected by the matching pad insertion loss, adjust the output of the signal generator so that the fields between the plates correspond to the applicable limits.

6.3.3 The equipment shall be tested at two orientations in its upright position, one where the front face of the equipment is directed out toward the side of the line and another where the face is directed along the length of the line. Other orientations shall be tested. Sides which have openings for power leads, shafts, ventilation, etc., shall be faced upward toward the top line plate. In no case shall the test sample be closer than 10 cm. to the upper plate.

6.3.4 The chassis of the test sample shall be grounded through the power cord only. An insulating material shall be placed between the test sample and the lower plate of the line.

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6.3.5 Determine the frequencies and the minimum field strength at which the test sample is susceptible. Record all pertinent data.

6.4 Notes.

6.4.1 Especially important to obtaining a uniform field is the loading of the line with a noninductive resistor. This applies equally to the matching network used with the EMI meter. All resistors should be chosen with + 1 percent of tolerance.

6.4.2 Care should be taken to assure that the resistive load used will be able to handle the power which is to be applied.

6.4.3 The EMI meter should be placed outside of the screen room if high intensity fields are being generated. Cables leading to the EMI meter should be kept as short as possible.

6.4.4 A VTVM may be used in place of the EMI meter and matching network if desired.

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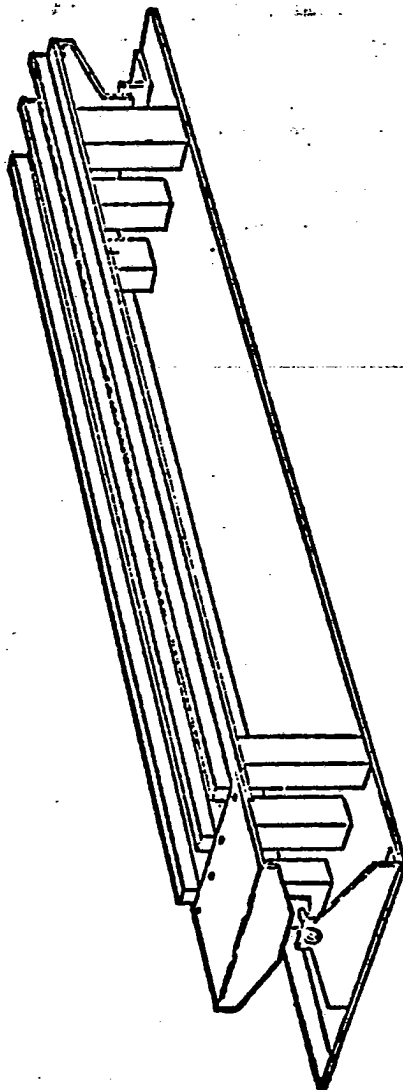


FIG. RS03-6 PARALLEL STRIP LINE FOR RADIATED SUSCEPTIBILITY TESTS

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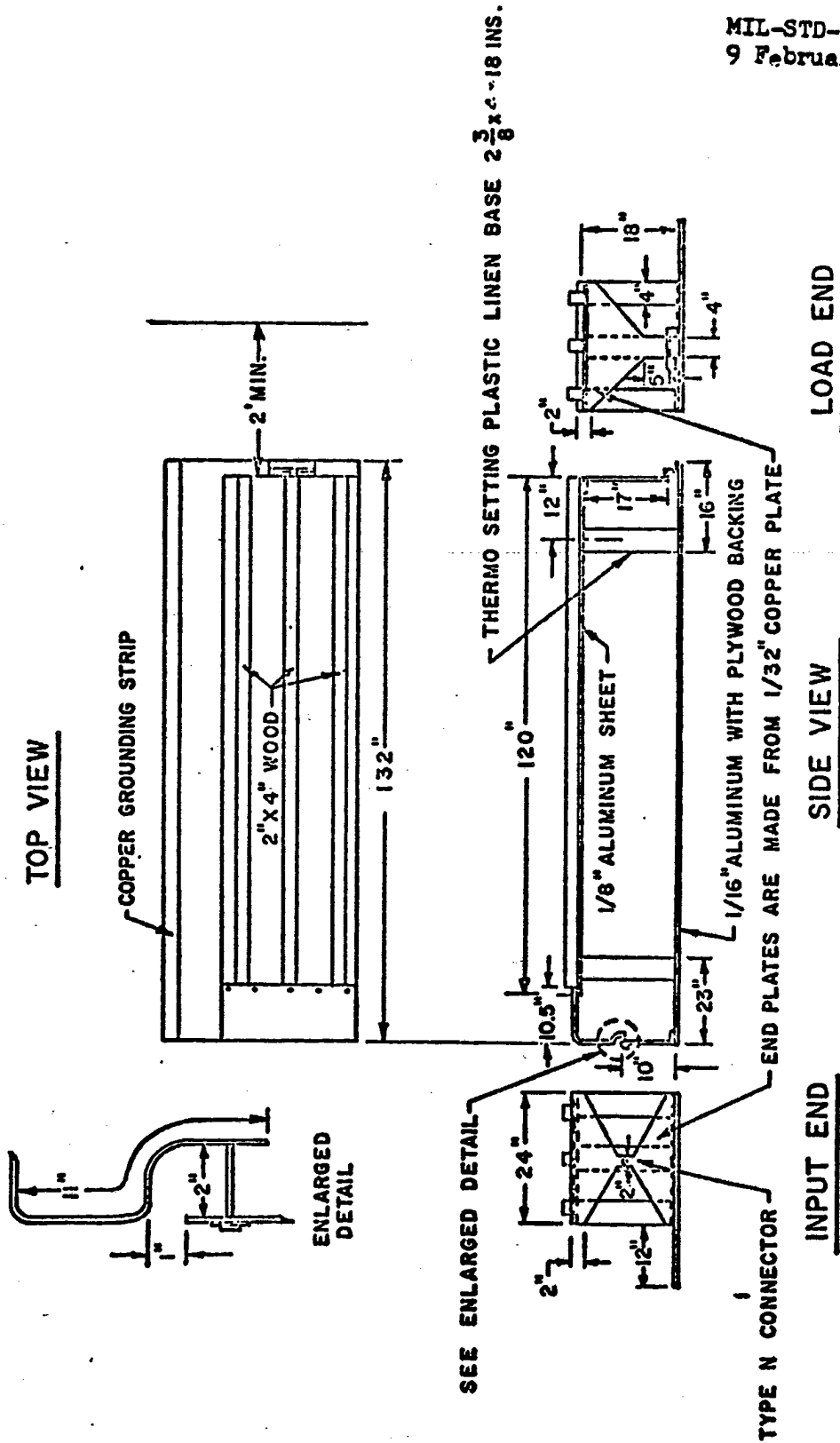


FIG. RS03-7 PARALLEL STRIP LINE FOR RADIATED SUSCEPTIBILITY TESTS  
(TOP AND SIDE VIEW)

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PAD INSERTION LOSS CALCULATION

EXAMPLE:

$$V_0 = \frac{83}{52.2 + 83} V_{in}$$

$$10 \log \frac{P_{in}}{P_{out}} = 10 \log \frac{\left(\frac{V_{in}}{50}\right)^2}{\left(\frac{83}{135} V_{in}\right)^2}$$

$$= 10 \log \left(\frac{V_{in}}{83}\right)^2 \left(\frac{83}{135} V_{in}\right)$$

$$= 20 \log \frac{135}{83} + 10 \log \frac{83}{50}$$

$$= 20 \log 1.625 + 10 \log 1.66$$

$$= 20 \times 0.21 + 10 \times 0.22$$

$$= 4.20 + 2.2 = 6.4 \text{ db}$$

LOAD AND RESISTOR VALUES PRESENTED HERE ARE TYPICAL. THE PROPER VALUE WILL HAVE TO BE DETERMINED ON AN INDIVIDUAL BASIS. ATTEMPTS AT DETERMINING THE CHARACTERISTIC IMPEDANCE OF THE LINE BASED ON CLASSICAL PARALLEL STRIP TRANSMISSION THEORY ARE NOT SUCCESSFUL BECAUSE OF THE INHERENT ASSUMPTION THAT THE WIDTH OF THE STRIPS IS MUCH GREATER THAN STRIP SEPARATION.

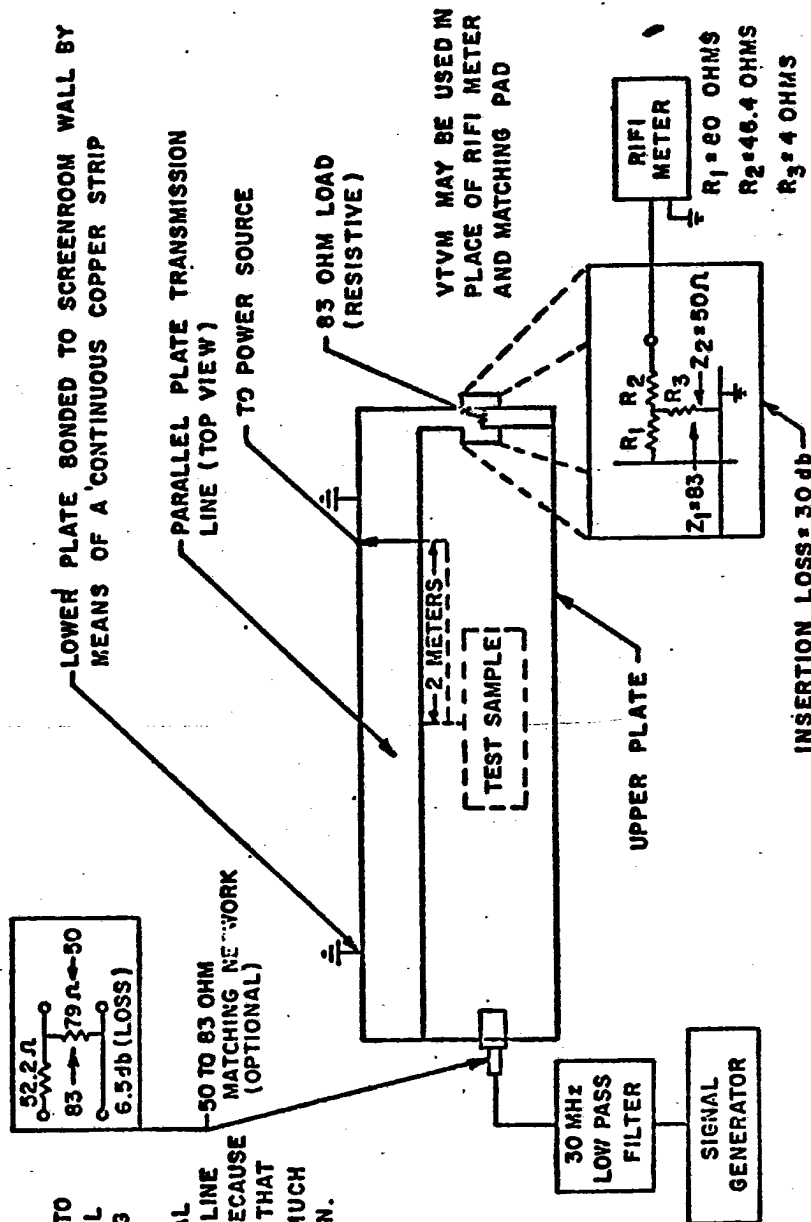
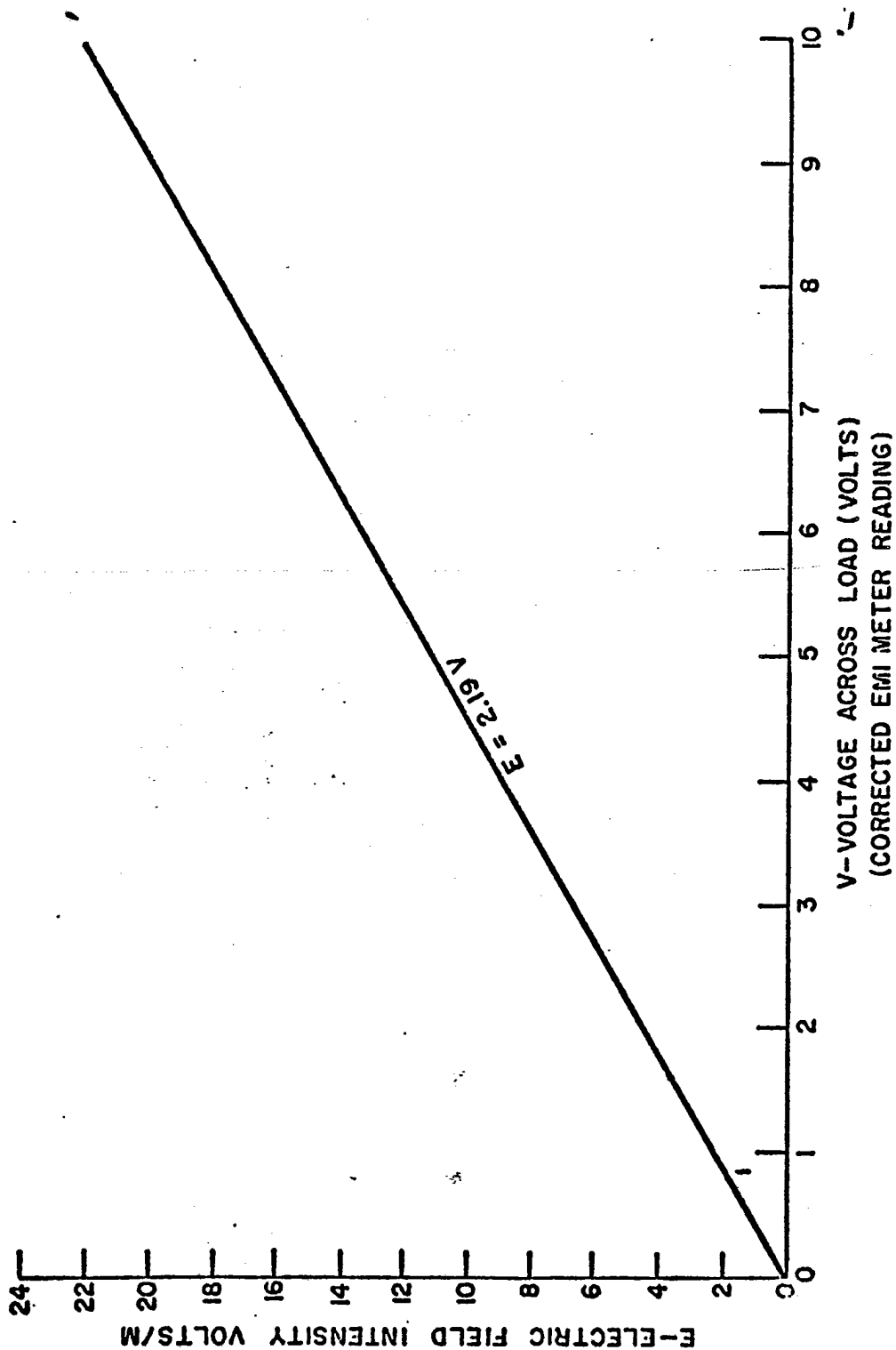


FIG. RS03 - 8 SETUP FOR SUSCEPTIBILITY TESTS USING PARALLEL PLATE LINE

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TYPICAL  
FIG. RS03-9 LINE CALIBRATION CHART



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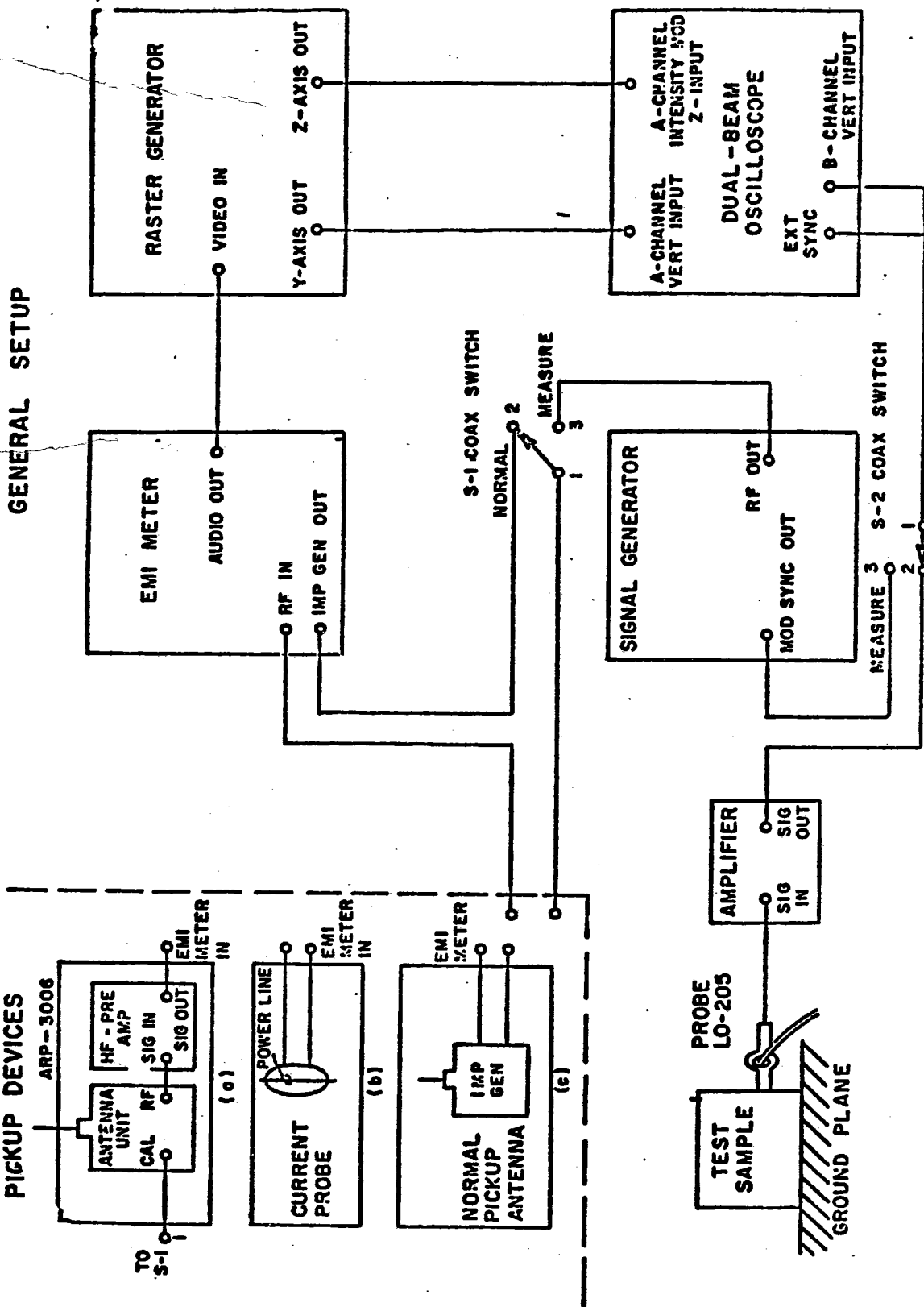


FIG. CREO-2 TEST SETUP FOR EMISSION MEASUREMENTS IN THE PRESENCE OF HIGH AMBIENT FIELDS