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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

ELECTROMAGNETIC COMPATIBILITY
REQUIREMENTS ON PAYLOAD EQUIPMENT AND SUBSYSTEMS

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1	1 03/20/91	N/A	REPLACE FIGURE 3.3

MSFC-Form 4140

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- **EMISSIONS**
  - **CONDUCTED**
    - **D.C. POWER BUS 28V. NOMINAL**
      - CEO1
        RIPPLE 30Hz TO 20kHz
        130dBμA 30Hz to 2kHz
        FALLING TO 80dBμA AT
        20kHZ
      - CEO3
        R.F. 20kHz TO 50MHz
        80dBμA 30Hz to 20kHz
        FALLING TO 30dBμA AT
        2MHZ FLAT TO 50MHz
      - TTO1
        TRANSIENTS
        (+ OR -) 28V. TO 10us;
        (+ OR -) 4V. TO 100ms;
        (+ OR -) 1V TO INFINITY.
    - **A.C. POWER BUS**
      - TTO1
        TRANSIENTS
        (+ OR -) 60V., 10us
        MAX OR EQUIVALENT
        VOLTSECOND PRODUCT.
    - **ANTENNA CONDUCTED**
      - 14kHz TO 15.5GHz
        80dB BELOW FUNDAMENTAL
        -10dBm AT SECOND AND
        THIRD HARMONIC
  - **RADIATED**
    - **A.C. MAGNETIC FIELD**
      - REO4
        50Hz TO 50kHz
        130dBpT 50 Hz TO 1kHz
        FALLING 40dB/DECADE TO 50kHz
    - **ELECTRIC FIELD**
      - REO2
        N.B. 14kHz TO 10GHz;
        45dBμV/m AT 14kHz
        TO 30dBμV/m AT 25MHz
        TO70dBμV/m At 10GHz
        35dBμV/m 1.77GHz TO 2.3GHz
      - REO2
        B.B. 14kHz TO 10GHz;
        110dBμV.m.MHz AT14kHz
        TO 65dBμV/m/MHz AT 200MHz
        To 100dBμV/m/MHz AT 10GHz
        70dBμV/m/MHz 1.77GHz TO 2.3GHz
- **SUSCEPTIBILITY**
  - **CONDUCTED**
    - **D.C. POWER BUS 28V. NOMINAL**
      - CSO1
        30Hz TO 50kHz
        RIPPLE 1.5V RMS
        ON (+) AND (-) LINES.
        SAWTOOTH
        OSCILLATIONS
        500Hz TO 700Hz WITH
        AMPLITUDE 11V P-P
        ON AFT PL B AND AFT
        PL C BUSSES AND 4V
        P-P ON PRIMARY PL,
        CABIN PL, AUX PL A,
        AND AUX PL B BUSSES.
      - CSO2
        50kHz TO 400MHz
        R.F. 0.1V. RMS
        ON (+) AND (-) LINES.
      - CSO6
        TRANSIENTS
        10us DURATION.
        (+ AND -) 56V.
        MAGNITUDE BETWEEN
        EACH UNGROUNDED
        POWER LEAD AND
        GROUND.
  - **RADIATED**
    - **A.C. MAGNETIC FIELD**
      - 30Hz TO 50kHz
        140dBpT 30Hz
        TO 2kHz, THEN
        FALLING 40dB PER
        DECADE TO 84dB
        AT 50kHz.
    - **ELECTRIC FIELD**
      - RSO3
        14kHz TO 10GHz
        2.0 VOLT PER METER;
        HIGHER AT
        ORBITER TRANSMITTING
        FREQUENCIES.
    - **D.C. MAGNETIC FIELD**
      - 170dBpT NO TEST
        REQUIRED.

5-4001-8-52

ELECTROMAGNETIC COMPATIBILITY REQUIREMENTS ON PAYLOAD EQUIPMENT AND SUBSYSTEMS

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LIST OF ABBREVIATIONS AND ACRONYMS

ac	Alternating Current
AM	Amplitude Modulation
ATC	Automatic Test Equipment Computer
AUX	Auxiliary
BB	Broadband
cm	Centimeter
dB	Decibel
dBm	Decibel Above 1 Milliwatt
dBμA	Decibel Above 1 Microampere
dBpT	Decibel Above 1 Picotesla
dBμV	Decibel Above 1 Microvolt
dc	Direct Current
DIH	Discrete Input, High-Level
DIL	Discrete Input, Low-Level
DoD	Department of Defense
DOH	Discrete Output, High-Level
DOL	Discrete Output, Low-Level
DSN	Deep Space Network
E-Field	Electric Field
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESA	European Space Agency
ESD	Electrostatic Discharge
EVA	Extravehicular Activity
fc	Carrier Frequency
FM	Frequency Modulation
ft	Foot
GHz	Gigahertz
HEMI	Hemispherical
HI	High
Hz	Hertz
ICD	Interface Control Document
JSC	Johnson Space Center
kHz	Kilohertz
kohm	kilohm
Ku-Band	Ku-Band Frequency

ELECTROMAGNETIC COMPATIBILITY
REQUIREMENTS ON PAYLOAD EQUIPMENT AND SUBSYSTEMS

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

LO	Low
m	Meter
MAX	Maximum
MDM	Multiplexer/Demultiplexer
MHz	Megahertz
μA	Microampere
μF	Microfarad
μH	Microhenry
μs	Microsecond
μV	Microvolt
MIL	Military
mA	Milliampere
MIN	Minimum
MSFC	Marshall Space Flight Center
MSL	Material Science Laboratory
NASA	National Aeronautics and Space Administration
NB	Narrowband
nF	nanofarad
NSTS	National Space Transportation System
Ω	ohm
pF	picofarad
PL	Payload
PM	Pulse Modulation
PPS	Pulse per Second
PRI	Primary
PSK	Phase Shift Keyed
PWR	Power
QPSK	Quadrature Phase Shift Keyed
QUAD	Quadrature
RAU	Remote Acquisition Unit
RF	Radio Frequency
RMS	Root-Mean-Square
SCU	Signal Control Unit
SGLS	Space Ground Link System
SL	Spacelab
SLP	Spacelab Payload
SPAH	Spacelab Payload Accommodations Handbook
SPEC	Specification

ELECTROMAGNETIC COMPATIBILITY
REQUIREMENTS ON PAYLOAD EQUIPMENT AND SUBSYSTEMS

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

STD	Standard
STDN	Spaceflight Tracking and Data Network
STS	Space Transportation System
UHF	Ultra High Frequency
Vdc	Volt-Direct Current
V	Volt
v-s	Volt-Second Product

1.0 INTRODUCTION

1.1 Background

Electromagnetic compatibility (EMC) requirements for shuttle, spacelab, and payloads are presented in various levels of documentation for each system. Not all the entries are applicable to individual payload equipment. This document interprets and integrates the various requirements found in system documentation and applies them to the payload subsystems and equipment.

The basic EMC requirement for a system is that all subsystems shall be able to operate compatibly during the mission. To accomplish this, requirements are imposed at two levels: one at the system level, the other at the equipment or subsystem level. Some system level requirements are outlined here, but the primary objective of this document is to define equipment level requirements that shall be adhered to by the equipment developer. The requirements of this specification were derived, primarily, from the Spacelab Payload Accommodation Handbook, SLP-2104; the Orbiter/Spacelab ICD, 2-05301; MIL-STD-461; NSTS-SL-E-0002; the MSL User's Handbook, JA655; and the Space Shuttle Payload Accommodations Handbook, Volume XIV of NSTS 07700. Since this specification is intended to provide, at low cost, reasonable confidence that payload equipment can operate compatibly within the operating environment, only the most important emission and susceptibility requirements have been chosen. Some requirements have been converted into more usable terms, and some have been modified to be more easily verified.

1.2 Scope

This document defines the minimum electromagnetic compatibility (EMC) requirements to be imposed on any payload electrical and/or electronic equipment to be transported by the space shuttle, spacelab, other carriers, or satellite system. This includes experiment equipment and flight support equipment subsystems which are payload elements of the spacelab, other carriers, or partial payloads in the payload bay, middeck experiments, or free-flying satellites.

1.3 Modifications to Requirements

If an equipment developer intends to place on equipment builders additional or more stringent requirements than those stated here, those new requirements to be imposed must first be documented in detail. Two acceptable methods of documenting details of new requirements would be: (1) In the systems level EMC control plan, or (2) as a line item in the preliminary requirements review. Note that an EMC Control Plan is not required at the equipment level.

1.4 EMC Control Plan

The system level EMC Control Plan is a requirement of MIL-E-6051D and is applicable to the system (whole payloads, free-flying satellites, rocket stages, etc.). The equipment level EMI Control Plan normally required by MIL-STD-461 is not applicable to equipment to be delivered to NASA/MSFC.

Commentary - Whether or not a formal EMC Control Plan is required, the EMC engineers must have a systems engineering overview of the design, manufacturing, and test activities. This will ensure that bonding, isolation, shielding, and other requirements of this document are met by the hardware system produced.

1.5 EMC Test Report

The equipment level EMC qualification test report shall include test procedures and results.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent defined herein.

MIL-B-5087B 15 October 1964	Bonding, Electrical, and Lightning Protection, for Aerospace Systems

2.2 Referenced Documents

ICD-2-05301 Rev. G Dec. 19, 1975	Shuttle Vehicle/Spacelab Avionics Interfaces
JA-655 Latest Issue	MSL User's Handbook
NSTS-SL-E-0002B May 11, 1987	Electromagnetic Interference Characteristics Requirements for the Space Shuttle Program
JSC 07700, Vol. XIV Attachment 1, ICD 2-19001 Rev. J May 1, 1988	Shuttle/Orbiter Cargo Standard Interfaces
MIL-STD-461A Notices 1, 2, & 3 1 May 1970	Electromagnetic Interference Characteristics, Requirements for Equipment
SLP-2104, NASA/ESA Latest Issue	Spacelab Payload Accommodations Handbook (SPAH)
MIL-E-6051D 7 September 1967	Electromagnetic Compatibility Requirements Systems

3.0 REQUIREMENTS

3.1 System Compatibility

3.1.1 Functional Compatibility

Payload equipment shall not generate levels of interference which would degrade performance or cause malfunction in the orbiter, spacelab, other carriers, or other payload subsystems. Payload equipment shall not malfunction due to susceptibility to emissions from these sources.

3.1.2 Safety Critical Circuits

Any payload equipment , and its associated cabling which contains safety critical circuits, shall be required to meet the standard 6 dB safety margin (20 dB for pyrotechnic circuits) between the susceptibility of the circuit and the interference present. The designer shall provide definition of actual threshold sensitivity or susceptibility levels for safety critical circuits. This data shall be used in the systems analysis or test planning.

Commentary - A circuit shall be considered a safety critical circuit if the function of that circuit falls into one or more of the following categories:

a. A circuit which provides the power necessary to maintain the safe status of the payload or spacecraft system

b. A circuit which inhibits power to a hazardous function

c. A circuit which provides control of a safety inhibit

d. A circuit which is used to monitor the safety status of payloads or spacecraft functions, devices, inhibits and other safety related parameters

3.2 Design Requirements

3.2.1 Primary Power

Payload equipment using primary dc power shall maintain at least 1 megohm dc isolation shunted by not more than 10 uF between both the high and return lines and structure. Isolation between primary power line and each secondary power lines shall be greater than 1 megohm dc.

Equipment using ac power shall limit capacitance to case so that no more than 5 mA of current at the power frequency will flow through structure.

3.2.2 Secondary Power

Secondary power, inherently isolated from primary power by dc-to-dc converters, dc-to-ac inverters, or isolation transformers, and routed external to the source equipment, shall be grounded to the structure at one point. Normally, this point will be the equipment case containing the secondary power supply. The properly bonded mounting surface of an equipment case is considered to be a single point. In the event that a secondary power source is only used by one subsystem, that subsystem design agency may designate the single-point ground location at the source or at any one load. Care should be taken to isolate signal, command, and control lines such that separate, independently grounded power supply returns will not be inadvertently interconnected. Signal receivers which form the input to a box must have floating inputs which are isolated from structure by 1.0 megohm or greater and be shunted by less than 1 nF except for differential receiver circuits. Differential receiver circuits shall maintain a dc isolation of at least 5.0 kohms and be shunted by less than 1 nF between the circuit input and structure and between the circuit return and structure. Signal drivers shall be referenced to signal ground which is connected to structure at one point. Some exceptions are found in the grounding characteristics of experiments or equipment connected to the Shuttle MDM, Spacelab RAU, and MSL carrier SCU and are described in Table 3-1.

Commentary - The "single-point ground" policy is used for payloads. The objective is to use structure as an equipotential reference plane (ground) and to prevent dc or low frequency ac current flow in the ground reference plane. A single connection (single-point ground) is made to structure from each power subsystem dc return or ac neutral.

Primary power is generated on the orbiter by fuel cells. These 28-volt dc buses have their returns grounded at one point each near the source on the orbiter. The 400 Hz ac from the orbiter inverter is treated the same way with its neutral grounded near the source. The orbiter may return some current through structure, but all other systems must return power through dedicated wires.

3.2.3 Electrical Bonding

All payload equipment utilizing electronic circuitry shall have their cases bonded to structure in accordance with MIL-B-5087B. Electrical bond classes of application shall be as specified below. Where a single bond is used to serve two or more classes of application, the design shall conform to the most stringent requirement.

CLASS	APPLICATION
A	Antenna Installation
C	Current Path Return
H	Shock Hazard
L	Lightning Protection
R	RF Potentials
S	Static Charge

Portable equipment using external power must have a safety wire in the power cable connecting the equipment case to vehicle structure.

Commentary - The use of conductive mounting surfaces is the preferred method of bonding. Use of bonding straps is regarded as a last resort.

3.2.4 Circuit Classification

All payload circuits which interface with the Shuttle, Spacelab, other carriers, or other subsystems shall be assigned a category according to Table 3-2. Class I and II circuits shall not be routed through the same connector with Class III and IV at a cable interface. When both I/II and III/IV are present at the interface, a minimum of two connectors shall be used.

Commentary - This will facilitate separation of long cable bundles to minimize coupling. Separation of these wire classes internal to experiment subsystems is recommended.

3.2.5 Wire Twisting

Circuits that interconnect equipment shall provide for minimum loop coupling and maximum field cancellation by twisting of return with high side. Both signal and power circuits shall be twisted with their respective returns. Multiple circuits using a common return shall be twisted as a group.

3.2.6 Wire Shielding

Wire shields shall cover the twisted pair or twisted group rather than individual wires. No shield shall intentionally carry current except for coax cables used with radio frequencies only (100 kHz and above). Circuit shields should normally be grounded to the equipment case at each end. The preferred method of grounding shields is through a conductive backshell which makes good electrical contact to the equipment case. Overall shields may be used over a cable bundle for additional protection and shall also be grounded to equipment case at each end.

3.2.7 Electrostatic Discharge (ESD)

Electronic equipment shall not be damaged by electrostatic discharge of less than 4000 volts to the case or to any pin on external connectors. Equipment that may be damaged by electrostatic discharge up to 15000 volts must have a label stating so affixed to the case.

Commentary - These voltages represent charges that may be discharged from personnel during equipment installation or from astronauts during on-orbit maintenance. Electrostatic characteristics of a typical human may be simulated by a 100 pF capacitor charged with the voltages stated above and discharged through a 1500 ohm resistor to the case or pin in question.

3.3 Subsystem and Equipment Emission and Susceptibility requirements

Specific requirements are made applicable to payload equipment or subsystems in order to enhance meeting the system level compatibility requirements.

Commentary - These requirements are normally applicable at the equipment level, however they may be made applicable to a set of equipment which operates together (subsystem level).

When the following requirements state that they are applicable to payload equipment, it should be understood that the requirement may be applicable at either the equipment or subsystem level.

3.3.1 Payload Produced Emission

Conducted and radiated emissions produced by payload equipment shall be controlled as follows.

3.3.1.1 Conducted Emissions (CE)

3.3.1.1.1 DC Power Bus Ripple (CE01) (Narrowband)

Payload equipment shall be designed to draw near-constant current from the power source. The narrowband emissions between 30 Hz and 20 kHz produced by the equipment and conducted on the dc power lines shall not exceed the levels shown in Figure 3-1.

3.3.1.1.2 DC Power Bus RF (CE03) (Narrowband)

The narrowband radio frequency emissions between 20 kHz and 50 MHz produced by the equipment and conducted on the dc power lines shall be limited to the levels indicated in Figure 3-2.

3.3.1.1.3 DC Power Bus Transients (TT01)

Payload equipment shall not generate transients on the dc power bus in excess of the limits presented in Figure 3-3 when power is supplied from the source impedance presented in Figure 3-4. These limits shall be applicable during turn on, turn off, and normal operation.

3.3.1.1.4 AC Power Bus Transients (TT01)

Transients in excess of $\pm$ 60 volts, 10 microseconds in duration or equivalent volt-second (v-s) product (= 600 X 10^{-6} v-s) shall not be impressed on the 400 Hz power buses by payload equipment. The impedance network of Figure 3-4, with the input capacitor removed from the circuit, shall be used to simulate line impedance during EMC testing.

3.3.1.1.5 Antenna Conducted Emissions (CE06) (14 kHz - 15.5 GHz)

All spurious emissions and harmonics of payload transmitters, except the second and third harmonics, shall have peak powers 80 dB down from the power at the fundamental frequency. The second and third harmonics shall not exceed -10 dBm. The applicable frequency range is from 14 kHz to 15.5 GHz.

3.3.1.2 Radiated Emissions (RE)

3.3.1.2.1 Electric Field (RE02)

The radiated electric field at 1.0 meter from payload equipment shall not exceed the levels shown in Figures 3-5 and 3-6 from 14 kHz to 10 GHz. However, broadband emissions from equipment in the payload bay shall be limited to 70 dB above 1.0 microvolt per meter per MHz in the frequency range of 1770 MHz to 2300 MHz, and narrowband emissions shall be limited to 35 dB above 1.0 microvolt per meter from 1770 MHz to 2300 MHz. Authorized payload transmitter frequencies are excluded from this requirement.

Commentary - The restrictions from 1770 MHz to 2300 MHz are there to protect orbiter S-Band receiver frequencies.

If payload equipment is located inside an enclosure, such as a spacelab module, these restrictions may be relaxed by the amount of attenuation known to be provided by the enclosure. The spacelab module will provide enough attenuation to allow relaxing the requirement up to the levels shown in Figures 3-5 and 3-6.

If payload receivers are present, their passbands may require protection by incorporating additional emission limits on all payloads at the receiver frequencies.

3.3.1.2.2 AC Magnetic Field (RE04)

The generated ac magnetic fields at a distance of 1 meter from any payload equipment shall not exceed 130 dB above 1 picotesla from 50 Hz to 1 kHz, falling 40 dB per decade to 63 dB above 1 picotesla at 50 kHz. These levels are shown in Figure 3-7.

3.3.2 Payload Susceptibility

Payload equipment shall not malfunction or exhibit degraded performance beyond the tolerance given in the individual equipment specification when subjected to the following electromagnetic environment.

3.3.2.1 Conducted Susceptibility (CS)

3.3.2.1.1 DC Power Bus Ripple (CS01)

Payload equipment shall not be susceptible to 1.5 volts rms injected on its input power lines (positive and return) at frequencies from 30 Hz to 50 kHz. The requirement is also considered met when the ripple source, limited to 50 watts, cannot develop 1.5 volts rms at the test sample power input terminals and the test sample is not susceptible due to the output of the signal source. Payloads must also accommodate sawtooth transient oscillations from 500 Hz to 700 Hz, having a maximum amplitude of 11 volts peak-to-peak for payloads utilizing the Aft PL "B" and Aft PL "C" dc buses and 4 volts peak-to-peak for payloads utilizing the PRI PL Bus, Aux PL "A", Aux PL "B" and the Cabin PL Bus.

Commentary - The sawtooth oscillations are caused by activation of the orbiter hydraulic circulation pumps connected to the respective power buses.

3.3.2.1.2 DC Power Bus RF (CS02)

Payload equipment shall not be susceptible to 0.1 volt rms injected on its input power lines at frequencies from 50 kHz to 400 MHz.

3.3.2.1.3 Power Bus Transients (CS06)

Payload equipment shall not exhibit susceptibility when a test signal of 10 microseconds duration having an amplitude equal to twice the nominal supply voltage (100 volts maximum) is applied on top of the supply voltage. The transient will be applied in both the positive and negative direction between each ungrounded power lead and ground. The applied spike amplitude, rise time, and duration shall follow the typical waveshape shown in Figure 3-8. Pulses of the required amplitude and at a rate of 6 to 10 pulses per second shall be applied for 2.0 minutes or more while monitoring test sample performance for any evidence of degradation or malfunction.

Commentary - Transients of various amplitudes and pulse widths may be expected on the primary power lines. This transient with maximum amplitude and representative pulse width has been chosen for test purposes.

3.3.2.2 Radiated Susceptibility (RS)

3.3.2.2.1 Electric Field (RS03)

Payload equipment shall not be susceptible to an electric field strength of 2.0 volt per meter from 14 kHz to 10 GHz, in addition equipment mounted in the payload bay shall not be susceptible to the field strength levels specified in Figure 3-9 for the frequencies shown in Table 4-1. The levels in Figure 3-9 may be reduced by 20 dB for equipment installed in the spacelab module or any enclosure known to have equal or greater shielding capability. Equipment that protrudes above the payload bay or that is ejected from the payload bay may be subjected to higher KU-band and S-band fields. These will be defined depending on the orientation and whether there are approved operational restrictions on the transmitters for the specific project.

3.3.2.2.2 AC Magnetic Field

Payload equipment shall be designed to withstand ac magnetic fields of 140 dB above 1 picotesla from 30 Hz to 2 kHz falling 40 dB per decade to 84 dB above 1 picotesla at 50 kHz. These levels are shown in Figure 3-10.

3.3.2.2.3 DC Magnetic Field

Payload equipment shall be designed to withstand a dc magnetic field of 170 dB above 1 picotesla.

TABLE 3-1 GROUNDING CHARACTERISTICS OF PAYLOADS INTERFACED WITH THE EXPERIMENT RAU, ORBITER MDM, AND MSL SCU

RAU INPUT/OUTPUT LINE	EXPERIMENT OR EQUIPMENT GROUNDING CHARACTERISTICS
RAU FLEXIBLE INPUT	CONNECTED TO STRUCTURE THROUGH SIGNAL GROUND.
RAU ON/OFF COMMAND OUTPUTS	1 MEGOHM MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.
RAU SERIAL PCM COMMAND OUTPUT	5 kOHMS MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.
RAU SERIAL PCM DATA INPUT	SIGNAL AND RETURN LINE ARE REFERENCED TO EXPERIMENT SIGNAL GROUND.

MDM INPUT/OUTPUT LINE	EXPERIMENT OR EQUIPMENT GROUNDING CHARACTERISTICS
LOW-LEVEL DISCRETE OUTPUT (DOL)	10 kOHMS MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.
HIGH-LEVEL DISCRETE OUTPUT (DOH)	SIGNAL AND RETURN LINES ARE REFERENCED TO PRIMARY DC RETURN LINE.
LOW-LEVEL DISCRETE INPUT (DIL)	10 kOHM MIN. LINE-TO-STRUCTURE SHUNTED WITH 1nF MAX.
HIGH-LEVEL DISCRETE INPUT (DIH)	SIGNAL AND RETURN LINE ARE REFERENCED TO PRIMARY DC RETURN LINE.
DATA	1 MEGOHM MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.
MESSAGE-IN, MESSAGE-OUT WORD ENABLE DISCRETE	10 kOHMS MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.

SCU INPUT/OUTPUT LINE	EXPERIMENT OR EQUIPMENT GROUNDING CHARACTERISTICS
LOW-LEVEL DISCRETE OUTPUT (DOL)	10 kOHM MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.
LOW-LEVEL DISCRETE INPUT (DIL)	10 kOHM MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX.
ANALOG INPUT DIFFERENTIAL (AID)	CONNECTED TO STRUCTURE THROUGH SIGNAL GROUND FOR SINGLE ENDED DRIVER. 1 MEGOHM MIN. LINE-TO-STRUCTURE SHUNTED WITH 1 nF MAX. FOR DIFFERENTIAL DRIVER.
HIGH-LEVEL DISCRETE OUTPUT (DOH)	REFERENCED TO PRIMARY DC POWER RETURN.
HIGH-LEVEL DISCRETE INPUT (DIH)	REFERENCED TO PRIMARY DC POWER RETURN.

Table 3-2 CIRCUIT EMC CLASSIFICATION

THE EMC CATEGORIES USED IN ESTABLISHING THE WIRE BUNDLES FOR EACH CABLE ROUTE SHALL BE AS FOLLOWS:

(1) CLASS I:

- ALL PRIMARY POWER WIRING
- SECONDARY CARRYING AC OR SWITCHED DC CURRENTS IN EXCESS OF 1 AMPERE (PEAK TRANSIENT)

(2) CLASS II:

- SECONDARY WIRING CARRYING AC OR SWITCHED DC CURRENTS RANGING FROM 0.05 TO 1 AMPERE (PEAK TRANSIENT)
- SECONDARY WIRING CARRYING AC OR SWITCHED DC VOLTAGES GREATER THAN 6V PEAK

(3) CLASS III:

- SECONDARY WIRING CARRYING LOW LEVEL VOLTAGE (6V PEAK) AND CURRENT (0.05 AMPERE PEAK TRANSIENT) WITH RISE TIME GREATER OR EQUAL TO 2 us EXCEPT VIDEO AND RF COMMUNICATION LINES
- AUDIO COMMUNICATION LINES

(4) CLASS IV:

- VIDEO AND RF COMMUNICATION LINES
- SECONDARY WIRING CARRYING LOW LEVEL VOLTAGE (6V PEAK) AND CURRENT (0.05 AMPERE PEAK TRANSIENT) WITH RISE TIME LESS THAN 2 us.

WIRE BUNDLES OF DIFFERING EMC CLASSIFICATION SHALL BE PHYSICALLY SEPARATED FROM EACH OTHER. WHERE NO METALLIC SHIELD, OTHER THAN AN INDIVIDUAL BRAIDED SHIELD, EXISTS BETWEEN THEM, EACH CLASSIFICATION SHALL BE SEPARATED FROM ALL OTHER CLASSES BY 5 CENTIMETERS.
EXCEPTIONS FOR SHORT RUNS ARE ALLOWED WHERE ALL CLASSES MAY BE ROUTED TOGETHER FOR PARALLEL RUNS TOTALING LESS THAN 3 FEET IN LENGTH.

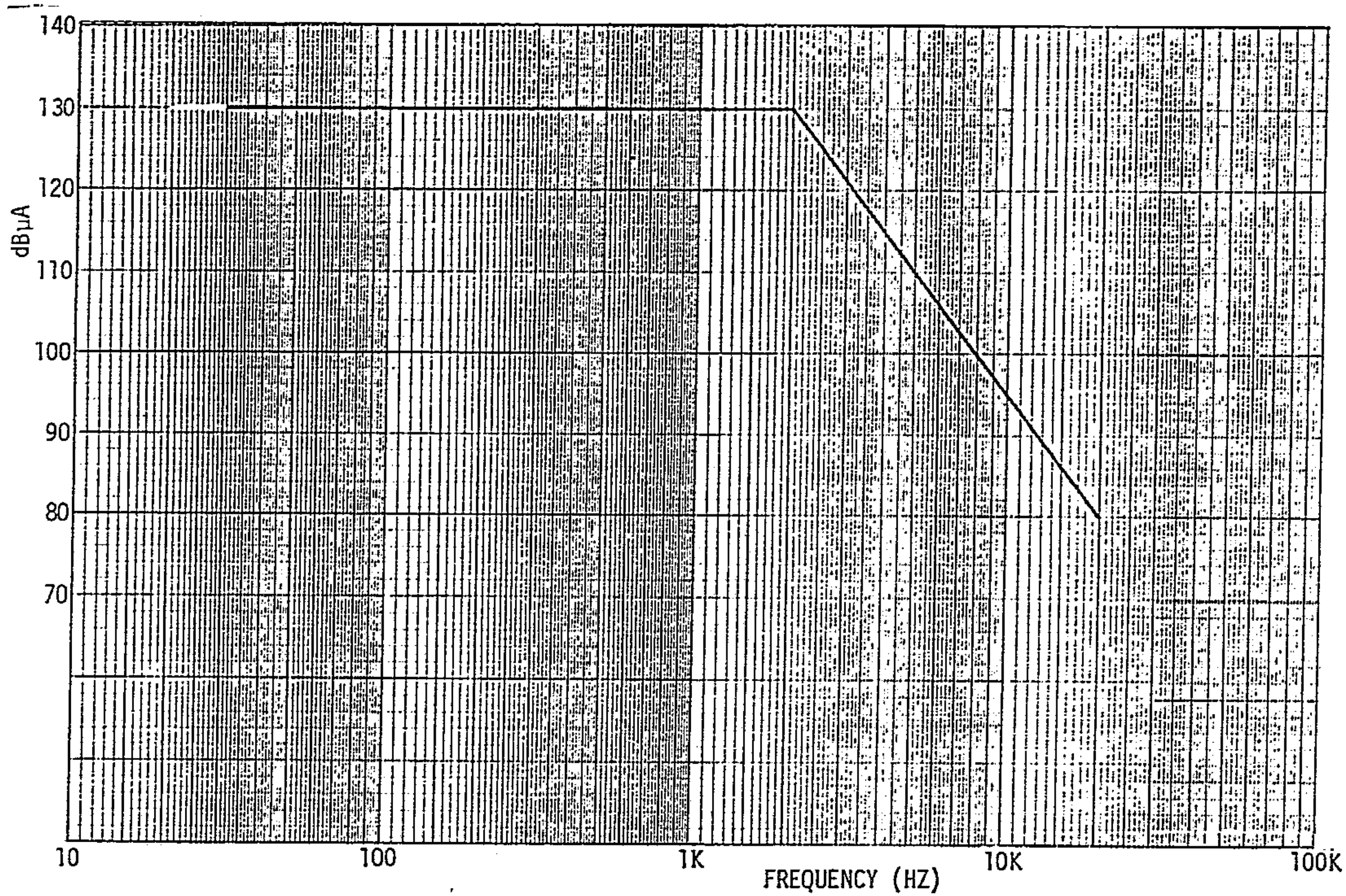


FIGURE 3-1. NARROWBAND CONDUCTED CURRENT RIPPLE, CE01

8 15 90

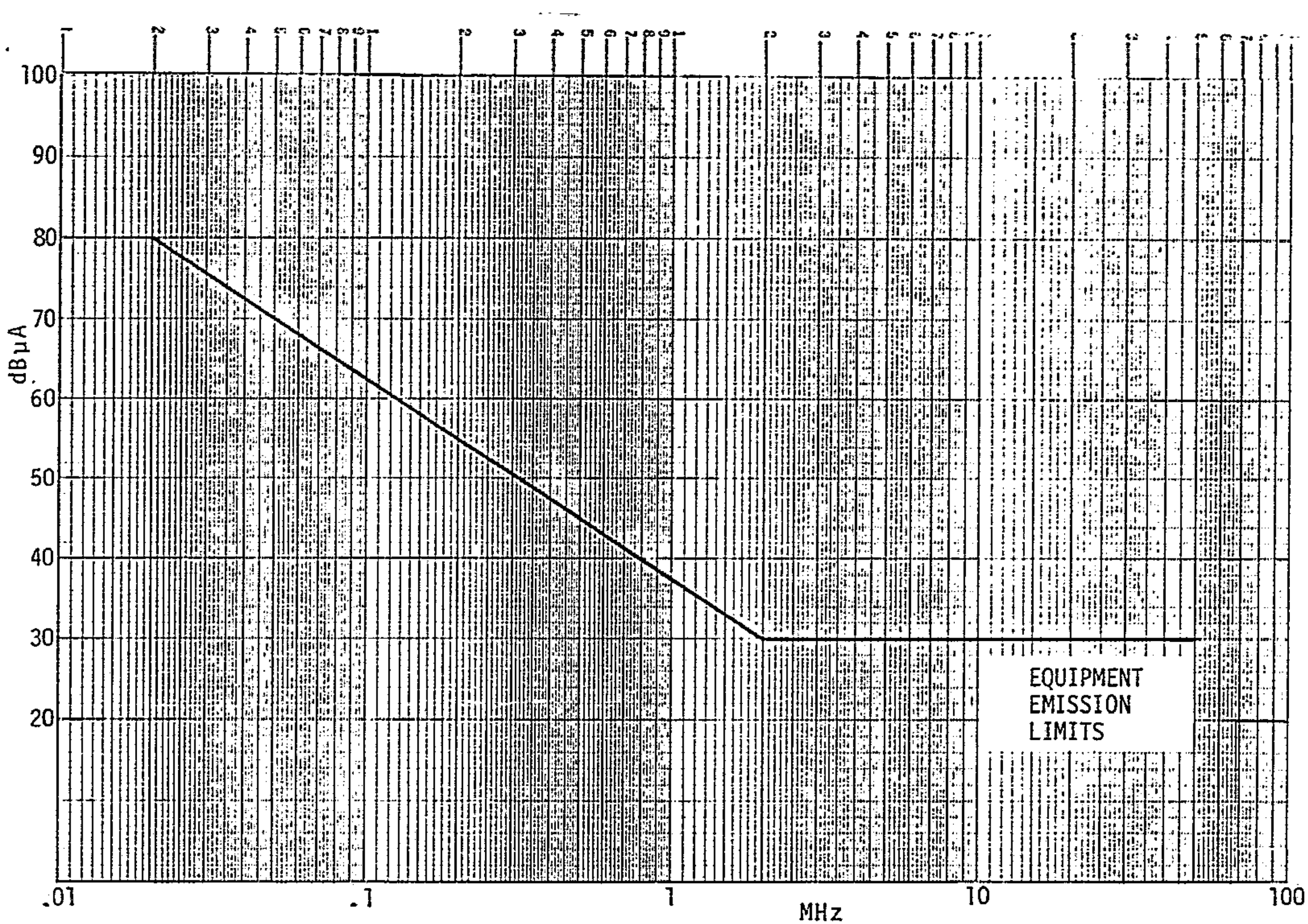


FIGURE 3–2. NARROWBAND CONDUCTED RF EMISSIONS, CE03

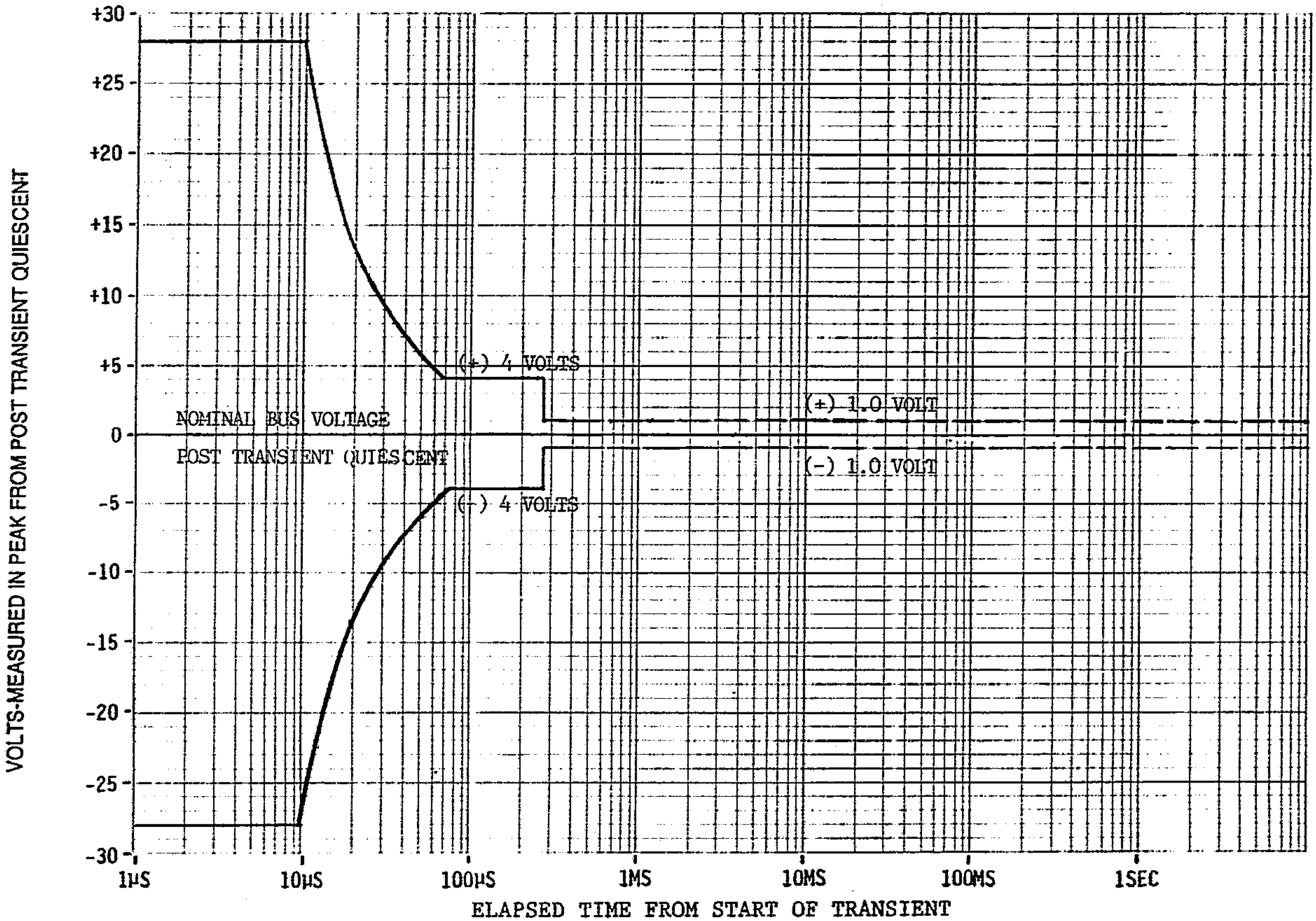


FIGURE 3–3. DC POWER BUS TRANSIENT LIMITS, TT01

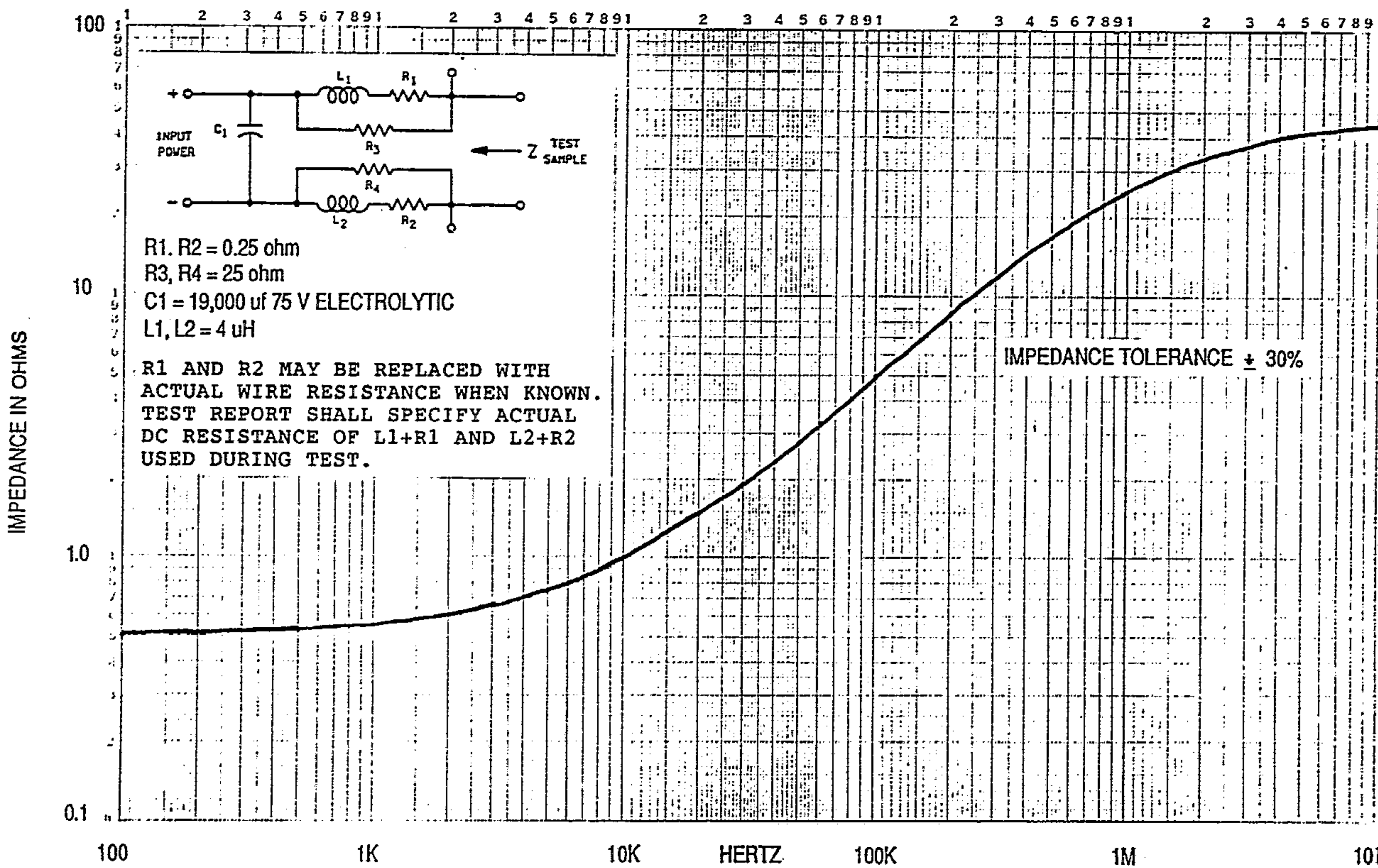


FIGURE 3–4. POWER SOURCE IMPEDANCE NETWORK

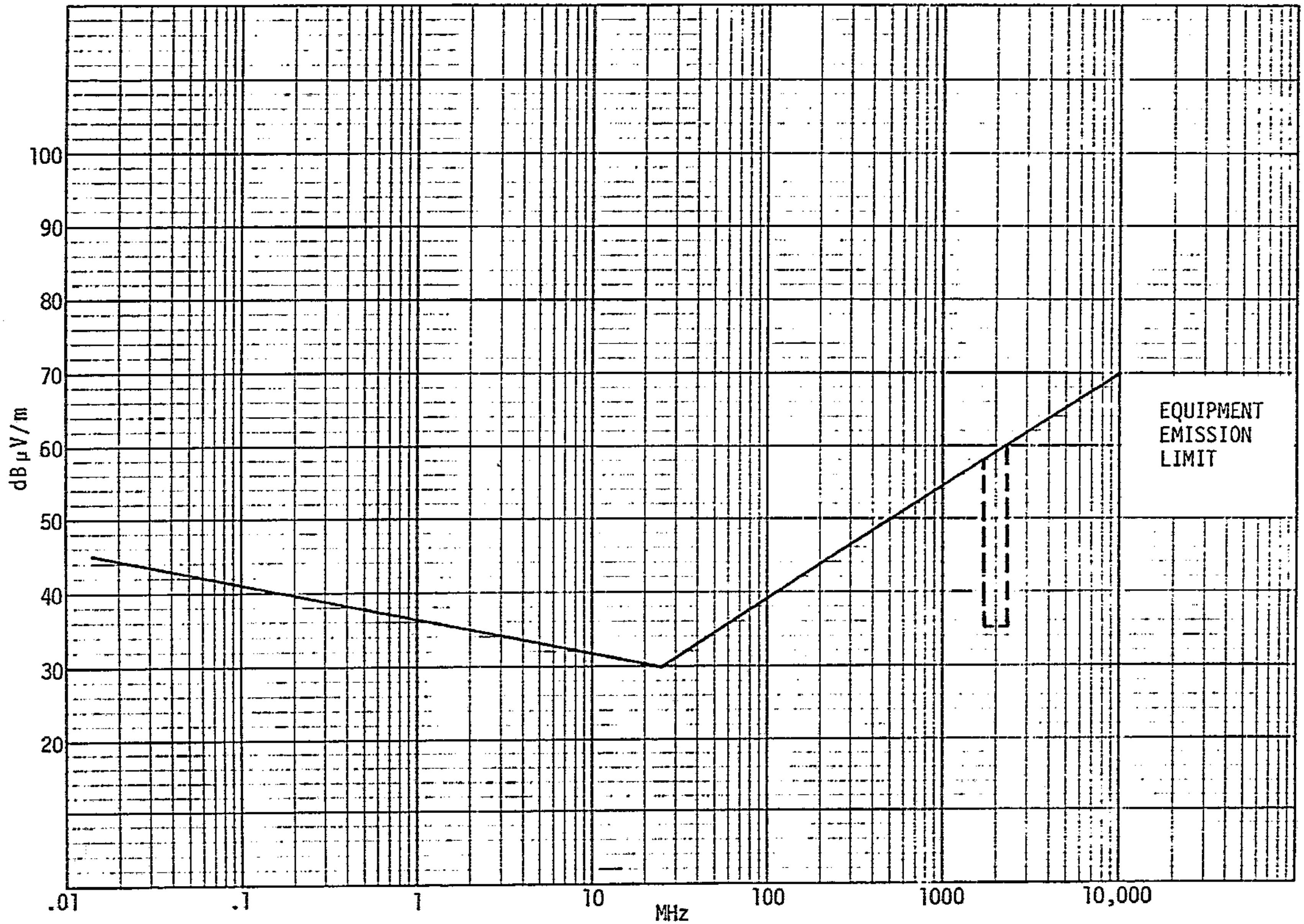


FIGURE 3–5. NARROWBAND RADIATED EMISSIONS, RE02

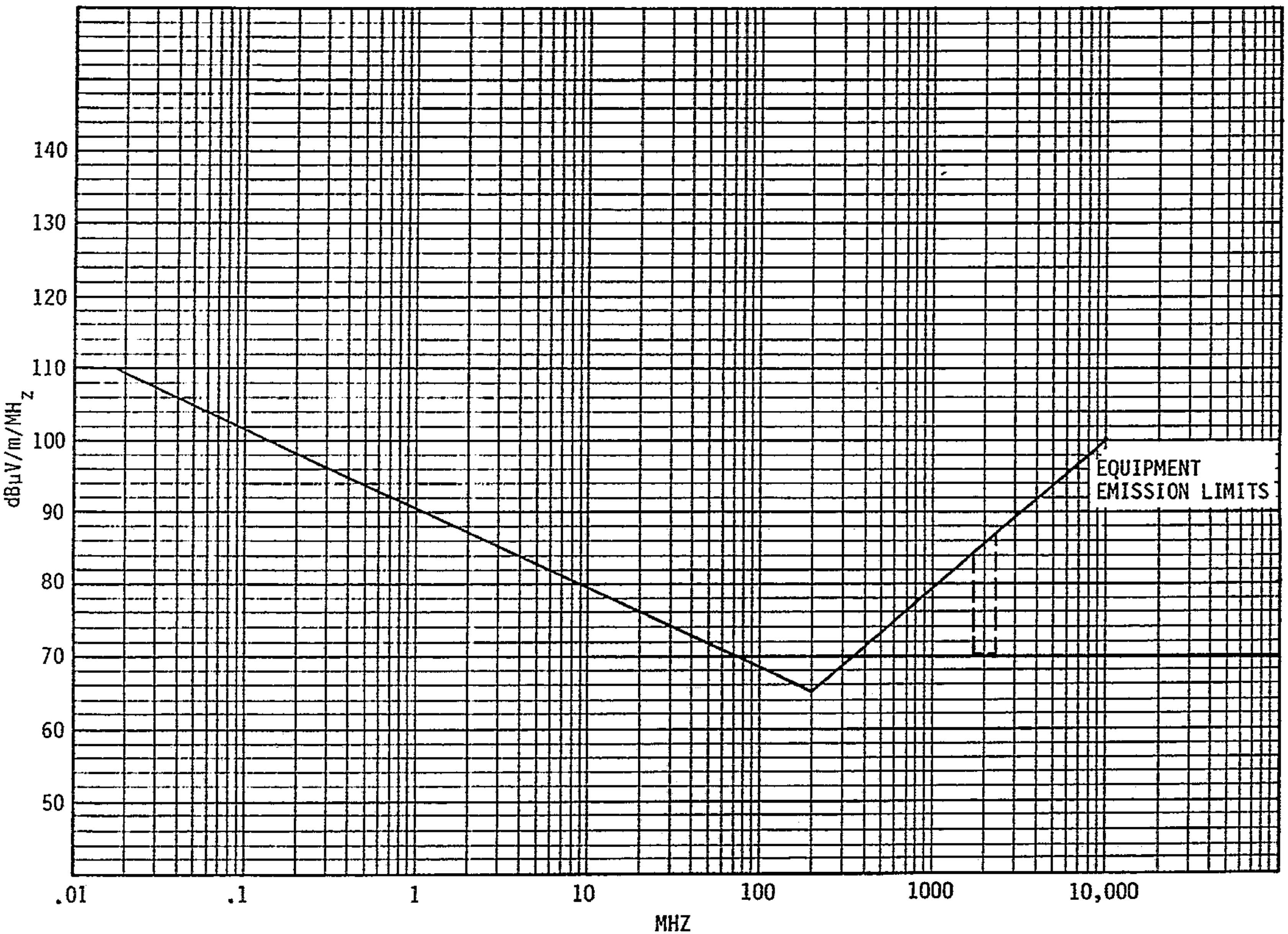


FIGURE 3–6. BROADBAND RADIATED EMISSIONS, RE02

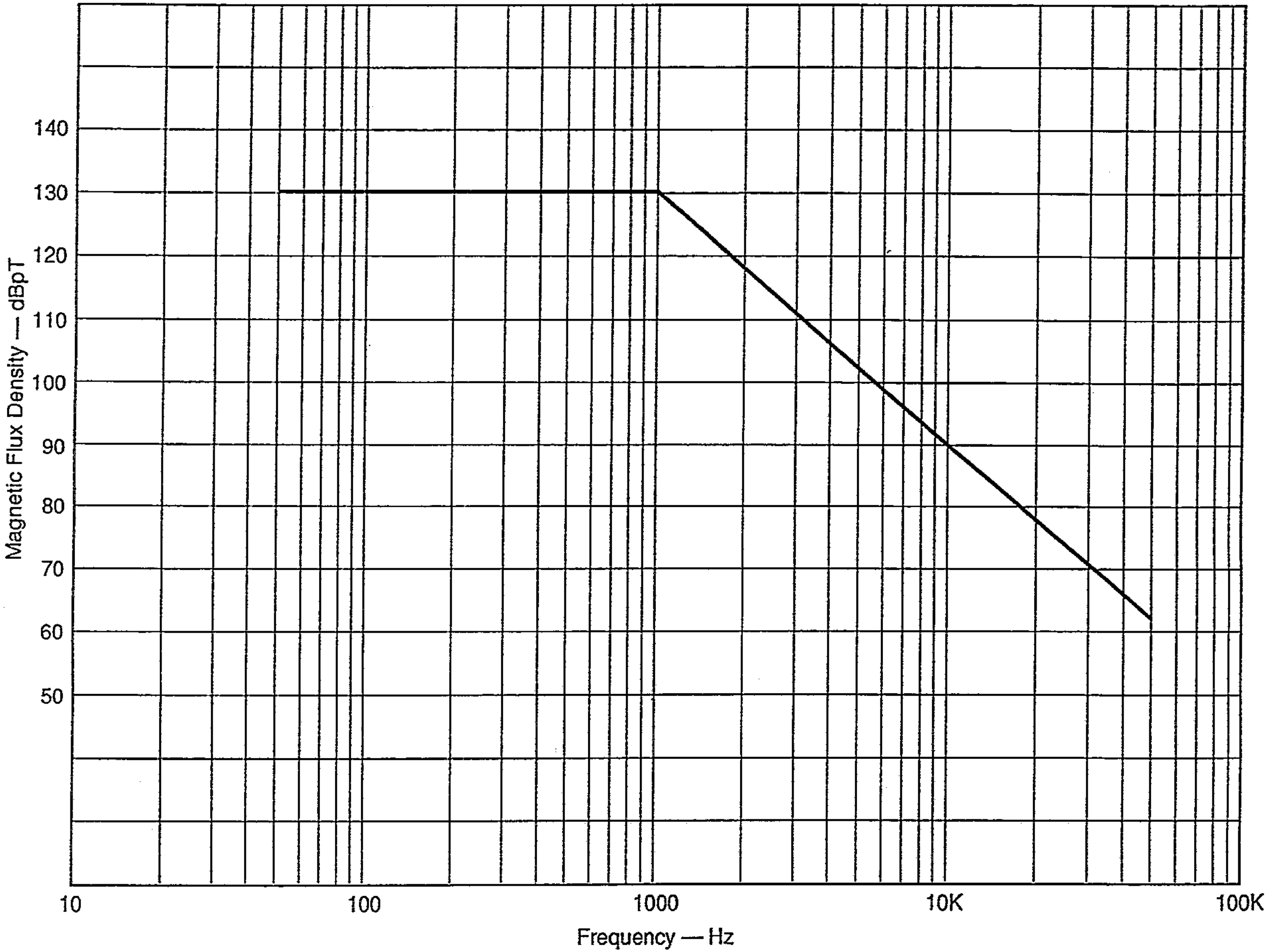
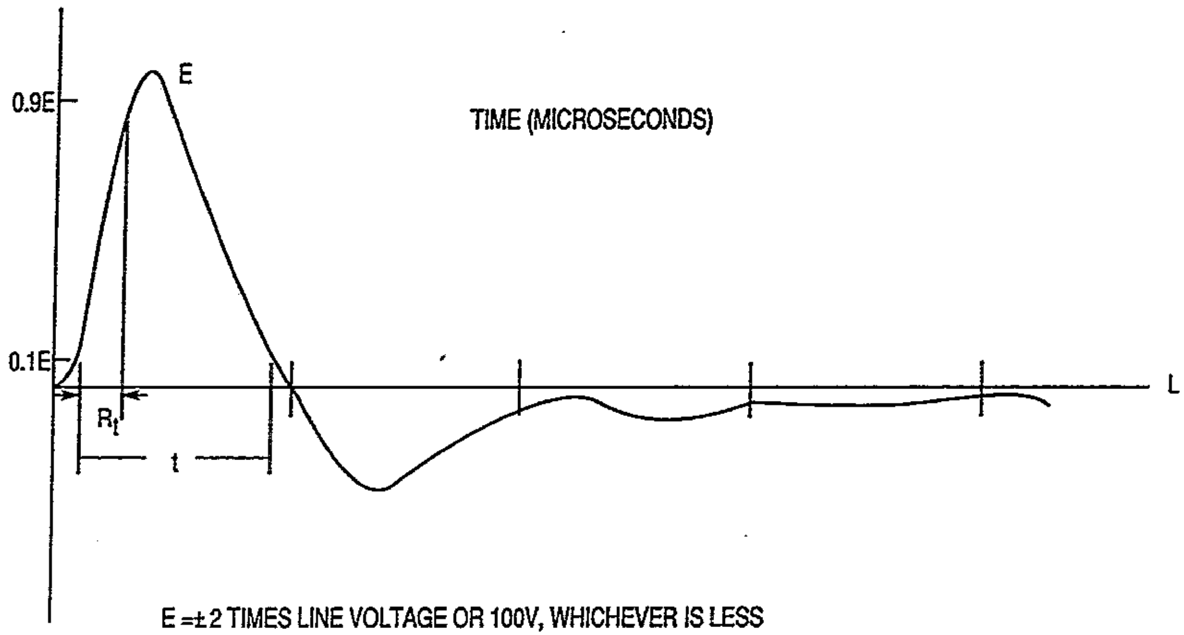


FIGURE 3–7. AC MAGNETIC FIELD EMISSION, RE04

5-6937-0-189



E =± 2 TIMES LINE VOLTAGE OR 100V, WHICHEVER IS LESS

R_t = LESS THAN 1.0 MICROSECOND TRANSIENT RISETIME BETWEEN 0.1E AND 0.9E

t = 10 MICROSECONDS BETWEEN 0.1E ON THE RISING EDGE TO 0.1E ON THE FALLING EDGE

L = NOMINAL LINE VOLTAGE

FIGURE 3-8. AMPLITUDE AND WAVE FORM FOR POWER BUS TRANSIENT SUSCEPTIBILITY, CS06

5-3397-8-52

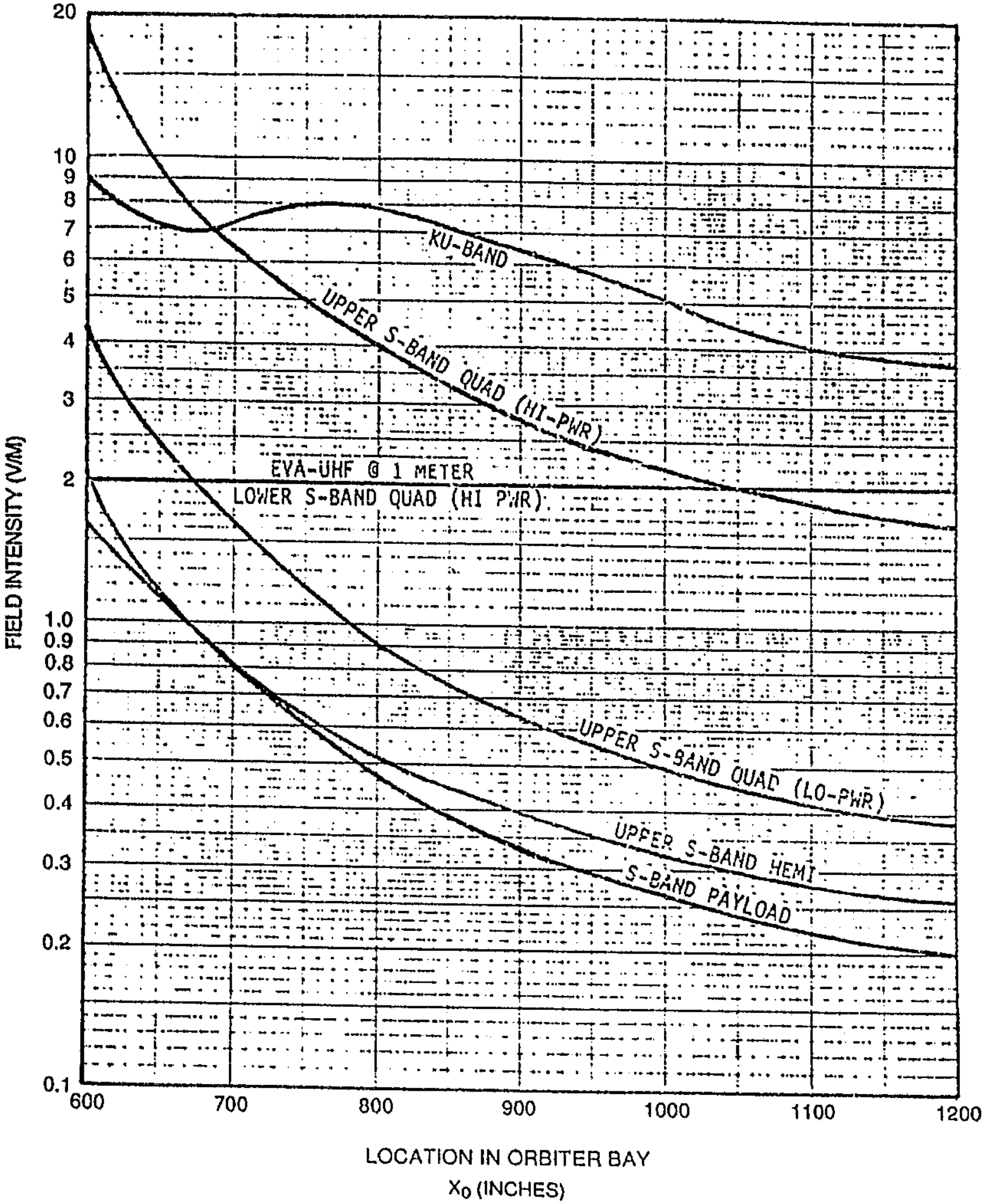


FIGURE 3–9. MAXIMUM FIELD INTENSITIES ON PAYLOAD ENVELOPE

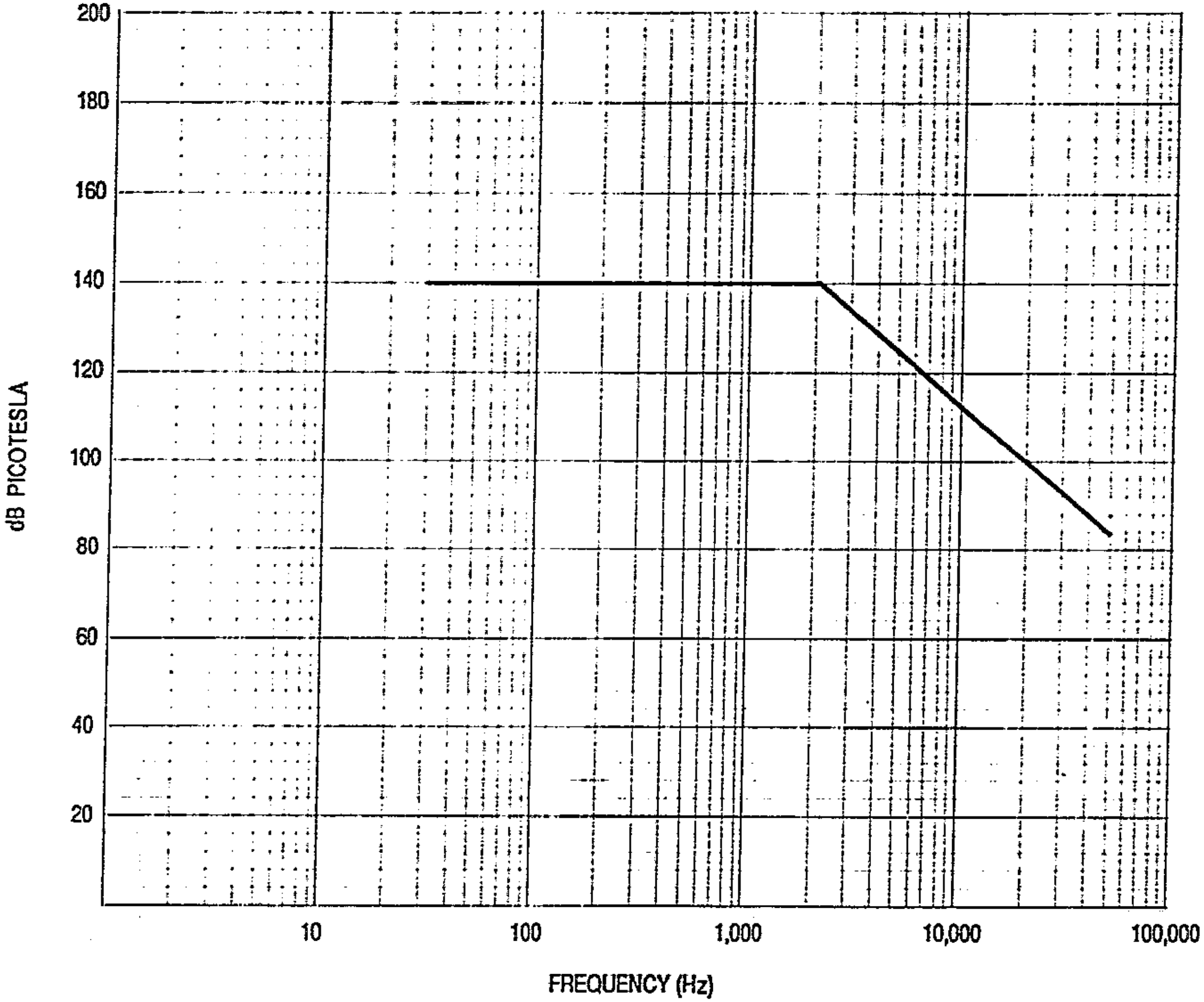


FIGURE 3-10. AC MAGNETIC FIELD SUSCEPTIBILITY

4.0 VERIFICATION

4.1 System Compatibility

Commentary - Since early verification is desirable in order to reduce costs and to allow correction of problems, systems EMC testing should begin at lower levels of integration where feasible. Generally, each higher level of integration should verify functional compatibility of circuits that could be affected by conducted or radiated interference across the new interface, verify 6 dB safety margins on safety critical circuits which have not been verified earlier by test or analysis, and, if feasible, verify that emissions and susceptibility levels are compatible with equipment at the next higher level of integration.

4.1.1 Functional Compatibility

Functional compatibility of payload equipment shall be verified as part of systems level verification that the payload, carrier(s), and orbiter are functionally compatible when operated over a simulated mission timeline.

4.1.2 Safety Critical Circuits

In addition to the functional verification, safety critical circuits which could be affected by electrical interference shall be shown to have at least 6 dB margin between the susceptible level of the circuit and the emission level present on the input lines. The designer shall provide threshold sensitivity data on safety critical circuits for this purpose.

4.2 Equipment and Subsystem Test Methods

These are bench tests which are to be performed at the payload subsystem or equipment levels to verify that the requirements of Section 3.3 are met. The test procedures provided in this section do not identify specific test equipment. Standard EMI test equipment may be used to perform the tests specified in this document as long as the minimum requirements specified herein are met. However, the EMI test report should contain a list of all equipment used for performing tests. Measuring instruments shall be properly calibrated and the measuring facility, including measuring instruments and shielded room must be capable of measuring at least 6dB below the applicable limits for each test. A measurement to determine the ambient level shall be performed for each emission test with the equipment under test de-energized.

4.2.1 Conducted Emissions

4.2.1.1 DC Power Bus Ripple Emissions (CE01)

4.2.1.1.1 Purpose

The purpose of this test is to determine and measure conducted emissions in the frequency range of 30 Hz to 20 kHz on test sample input power leads, including high lines and returns which are not grounded internally to the test sample.

4.2.1.1.2 Test Configuration

The test configuration shall be as shown in Figure 4-1.

4.2.1.1.3 Test Procedure

Each of the input power leads shall be tested for conducted emissions in the frequency range of 30 Hz to 20 kHz. All observed continuous or repetitive emissions shall be treated as narrowband, and all measurements shall be made in the average or field intensity mode and shall be compared to the limits given in Figure 3-1. Bandwidth shall be as shown in paragraph 4.2.2.1.3, RE02.

4.2.1.2 DC Power Bus RF Emissions (CE03)

4.2.1.2.1 Purpose

The purpose of this test is to determine and measure conducted emissions in the frequency range of 20 kHz to 50 MHz on the test sample input power leads, including high lines and returns which are not grounded internally in the test sample.

4.2.1.2.2 Test Configuration

The test configuration shall be as indicated in Figure 4-1.

4.2.1.2.3 Test Procedure

Each of the input power leads shall be tested for conducted emissions in the frequency range of 20 kHz to 50 MHz. All observed continuous or repetitive emissions shall be treated as narrowband, and all measurements shall be made in the average or field intensity mode and shall be compared to the limits given in figure 3-2. Bandwidth shall be as shown in paragraph 4.2.2.1.3, RE02.

4.2.1.3 DC Power Bus Transient Emissions (TT01)

4.2.1.3.1 Purpose

The purpose of this test is to measure the amplitudes of transients appearing between the dc power leads when the test sample is switched through all operational modes including "ON" and "OFF."

4.2.1.3.2 Test Configuration

A block diagram of the test configuration is shown in Figure 4-2. Figure 4-3 shows the Impedance and Power switching Network schematic.

4.2.1.3.3 Test Procedure

Connect the test equipment and equipment under test as shown in Figures 4-2 and 4-3 (prior to applying primary power).

a. Set the power switch to the "OFF" position and apply required voltage to "control" terminals of Impedance and Power Switching Network.

b. Apply nominal voltage to the "input voltage" terminals of the Impedance and Power Switching Network (see Figure 4-2).

c. Exercise test sample "ON" and "OFF" with Impedance and Power Switching Network Control Voltage Power Switch as required to synchronize transient monitoring equipment.

d. Record the magnitude of the transient generated if the transient peak amplitude exceeds 2-volt positive or negative when the test sample is switched "ON" or "OFF."

e. Switch the test sample through all operational modes that could be switched either during checkout or flight.

f. Record the transient magnitude as in step d. above.

4.2.1.4 AC Power Bus Transient Emissions (TT01)

4.2.1.4.1 Purpose

The purpose of this test is to measure the amplitudes of transients appearing on each phase of the AC power leads when the test sample is switched through all operational modes including "ON" and "OFF."

4.2.1.4.2 Test Configuration

A block diagram of the test configuration is shown in Figure 4-2. Figure 4-3 shows the Impedance and Power Switching Network Schematic.

4.2.1.4.3 Test Procedure

Connect the test equipment and equipment under test as shown in Figure 4-2 and 4-3 (prior to applying primary power). CAUTION: Remove the capacitor from across the input Impedance Network of Figure 4-3. Small feedthrough capacitors may be used to decouple interference if necessary.

a. Set the power switch to the "OFF" position and apply required voltage to "control" terminals of Impedance and Power Switching Network.

b. Apply phase "A" of primary power to the "input voltage" terminals of the Switching Network (see Figure 4-3).

c. Exercise test sample "ON" and "OFF" with Impedance and Power Switching Network Control Voltage Power Switch as required to synchronize transient monitoring equipment.

d. Record the magnitude of the transient generated if the peak amplitude exceeds 5-volts positive or negative when the test sample is switched "ON" or "OFF."

e. Switch the test sample through all operational modes that could be switched either during checkout or flight. Record the transient magnitude as in step d. above.

f. Repeat steps a. through e. for phase "B" and "C" if applicable. **NOTE:** For test articles using three-phase power, the two phases not being tested through the Impedance and Power Switching Network may be connected directly to the test article.

4.2.1.5 Antenna Conducted Emissions (CE06)

4.2.1.5.1 Purpose

The purpose of this test is to determine and measure conducted emissions in the frequency range of 14 kHz to 15.5 GHz appearing at the antenna terminal of transmitters, RF amplifiers, and other devices designed to be connected to antennas. This test shall be used for all operating frequencies below 15.5 GHz and for any power level (not to exceed 2,000 watts peak power) unless the antenna is an integral non-removable part of the system under test.

4.2.1.5.2 Test Configuration

The test configuration shall be as indicated in Figures 4-4 and 4-5. The test configuration depicted in Figure 4-4 shall be used for testing of RF amplifiers and transmitters with average power output less than 20 watts. Figure 4-5 shall be used for testing of RF amplifiers and transmitters with average power output greater than 20 watts but less than 2,000 watts peak.

4.2.1.5.3 Test Procedure

Measurement of conducted emissions at the test sample terminals shall be accomplished over the frequency range of 14 kHz to 3,000 MHz for test sample RF ports with operating frequencies below 300 MHz. The test range shall be 14 kHz to 15.5 GHz for RF ports with operating frequencies above 300 MHz.

a. Test samples with the capability of transmitting and receiving, i.e., transponders, shall be tested in both modes over the frequency range. RF amplifiers and active and passive transmitting/receiving components (RF filters, pin diode modulators, etc.) shall be operated at their specified input level.

b. Spurious emissions from test samples requiring an external RF input will be identified as not emanating from the test equipment used to generate the external RF input.

c. Test samples shall be modulated as specified in the section of the test sample's detailed equipment specification during testing.

4.2.2 Radiated Emissions

4.2.2.1 Electric Field Emissions (RE02)

4.2.2.1.1 Purpose

The purpose of this test is to determine test sample radiated emissions levels in the frequency range of 14 kHz to 10 GHz.

4.2.2.1.2 Test Configuration

Figure 4-6 shows the test configuration for the frequency range from 0.014 to 30 MHz. The antennas for testing above 30 MHz shall be located 1.0 meter from the test sample measured from the antenna centerline as shown in Figure 4-6 and the 60 centimeter wide ground strap shall be deleted. The 30-200 MHz biconical antenna shall be oriented 45° from horizontal.

Interface cabling shall be the same type as that to be used in actual installation. All support equipment normally required for operation and all other equipment operating in concert with the equipment under test shall be attached and operating. Where it is not practical to have the actual support or other equipment operating, the test loads may be simulated provided the simulation equipment is accurately described in the test plan or test report.

4.2.2.1.3 Test Procedure

Test samples with multiple operating modes shall be tested in the mode determined to be generating the highest amplitude radiated emissions; i.e., highest bit rate, maximum use of signal cables, etc.

All emissions from 14 kHz to 10 GHz shall be measured using the average or field intensity detector and shall be compared to the limits of Figure 3-5, narrowband.

All emissions from 14 kHz to 10 GHz shall be measured using the peak detector and shall be compared to the limits of Figure 3-6, broadband.

The measuring instrument bandwidth shall be less than one third the lowest tuned frequency in the range for narrowband and less than one half the lowest tuned frequency for broadband. Suggested narrowband ranges for each tuned frequency range are listed below. Broadband measurements should be made using bandwidths approximately ten times the narrowband bandwidth.

Recommended Narrowband Bandwidths

Tuned Frequency(Hz)	Bandwidth Range(Hz)
10 - 300	1 - 30
300 - 3K	5 - 50
3K - 30K	10 - 500
30K - 1M	300 - 5K
1M - 30M	1K - 50K
30M - 1G	1K - 100K
1G - 10G	100K - 50M
1.77G - 2.3G	1M - 10M

NOTE: If the bandwidths listed above are not available on the instrument used for measuring narrowband and broadband emissions, the bandwidth nearest to those identified shall be used and noted on the test data sheet.

4.2.2.2 AC Magnetic Field Emission (RE04)

4.2.2.2.1 Purpose

The purpose of this test is to determine and measure radiated magnetic field emissions in the frequency range of 50 Hz to 50 kHz emitted from the test sample.

4.2.2.2.2 Test Configuration

The test configuration shall be as shown in Figure 4-7.

Caution: Coaxial cable from the sensor to the measuring instrument should be grounded at one point only, usually at the measuring instrument. Multiple grounds may cause ground loops allowing the shield to pick up stray magnetic fields that could exceed the fields being measured or the emission limits.

4.2.2.2.3 Test Procedure

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

a. Position the sensor at the 1.0 meter distance and opposite the center of the test sample.

b. Scan the full range (50 Hz to 50 kHz) of the EMI test receiver for the frequency giving the maximum indication.

c. At this frequency, move the sensor horizontally to determine the location of the maximum emission level. This location shall be the sensor location for the recording data.

Peak emissions shall be measured; at least one for each of the following frequency ranges:

Measurement	Frequency Range	Bandwidths
1	50 Hz to 200 Hz	Per para
2	200 Hz to 2 kHz	4.2.2.1.3
3	2 kHz to 50 kHz	For RE02

4.2.3 Conducted Susceptibility

4.2.3.1 DC Power Bus Ripple Susceptibility (CS01)

4.2.3.1.1 Purpose

The purpose of this test is to determine if the test sample is susceptible to signals present on its input power leads in the frequency range of 30 Hz to 50 kHz.

4.2.3.1.2 Test Configuration

The test configuration shall be as shown in Figure 4-8.

4.2.3.1.3 Test Procedure

The test signal of 50 watts or less shall be applied to each of the primary power leads of the test sample to determine the test sample audio conducted susceptibility.

a. 50-Watt Limit - Switch the 0.5-ohm resistor across the secondary of the isolation transformer. The audio oscillator and power amplifier level controls shall be increased to produce 5 volts rms (14.1 volts peak-to-peak), 30 Hz sine wave on the oscilloscope. The level control setting, representing the 50-watt maximum test signal level, shall be noted and not exceeded during test. The level control setting shall also be determined at 1.5 kHz, 10 kHz, and 50 kHz to assure that the test signal does not exceed 50 watts over the test frequency range. Reduce the audio oscillator frequency to 30 Hz. Reduce the level control settings on the audio oscillator and power amplifier to their minimum levels.

b. Switch the secondary of the isolation transformer to one of the primary power leads and readjust primary power voltage to the nominal test sample value if required.

c. Increase the audio oscillator and power amplifier level controls until the oscilloscope indicates the required test signal voltage (4.2 volts peak-to-peak for 28 volt system). The level control settings shall not exceed those noted in step a. above.

d. If the test signal voltage of step c. cannot be achieved at a test frequency with the maximum level setting noted in step a. and the test sample displays no susceptibility, the test sample complies with the requirement at that frequency.

e. Slowly tune the audio oscillator from 30 Hz to 50 kHz. When the test sample displays susceptibility, determine the threshold level.

f. The susceptibility frequencies and susceptibility threshold levels (volts rms, determined by dividing the voltage measured on the oscilloscope by 2.8) of the test sample shall be recorded.

g. Repeat steps b. through f. for each test sample primary power lead not grounded internally to the test sample.

4.2.3.2 DC Power Bus RF Susceptibility (CS02)

4.2.3.2.1 Purpose

The purpose of this test is to determine if the test sample is susceptible to signals injected on its input power leads in the frequency range of 50 kHz to 400 MHz.

4.2.3.2.2 Test Configuration

The test configuration shall be as indicated in Figure 4-9.

4.2.3.2.3 Test Procedure

The performance characteristics of the test sample shall be monitored while applying a signal of 0.1-volt amplitude over the frequency range of 50 kHz to 400 MHz to input power leads. Each input power lead not grounded internally to the test sample shall be tested. Signal sources will have 50-ohm output impedance. The signal sources will be modulated 70 percent with a 1,000-Hz sine wave if the capability exists. Otherwise, 100 Hz square wave modulation will be used.

The lead being tested shall have a 20-microhenry inductor between the voltage injection point and the 10-microfarad feedthrough capacitor. Primary power voltage shall be readjusted after insertion of 20-microhenry inductor if required for nominal operating voltage.

Prior to applying the test signal to the test sample, the signal will be applied to the 50-ohm resistor. The signal source control setting necessary to apply 7.0 volts to the 50-ohm resistor will be noted and recorded. The control settings, which represent the maximum allowable signal source output of 1 watt, shall not be exceeded during testing on any power lead.

The signal source will be reduced to the threshold of susceptibility when susceptibility occurs. The signal source output level will be recorded at the susceptibility threshold.

4.2.3.3 DC Power Bus Transient Susceptibility (CS06)

4.2.3.3.1 Purpose

The purpose of this test is to determine if the test sample is susceptible to transient interference on input power leads. This test shall be performed on all input power leads not grounded internally to the test sample.

4.2.3.3.2 Test Configuration

Connect the test sample and test instrumentation as shown in Figure 4-10 for test on dc power leads.

4.2.3.3.3 Test Procedure

a. Apply power to test sample.

b. The applied spike amplitude, rise time, and duration, as measured across the input terminals of the test sample, shall follow the typical wave shape shown in Figure 3-7.

c. Susceptibility will be evidenced by any degradation of performance. When susceptibility occurs, reduce the transient generator level until all evidence of degradation disappears. Record the transient level and pulse position relative to test sample signals if applicable.

4.2.3.4 AC Power Bus Transient Susceptibility (CS06)

4.2.3.4.1 Purpose

The purpose of this test is to determine if the test sample is susceptible to transient interference on input power leads. This test shall be performed on each phase of the ac power if more than one phase is used.

4.2.3.4.2 Test Configuration

Connect the test sample and test instrumentation as shown in Figure 4-10 with the following exceptions:

a. Remove the 20-microhenry inductor.

b. The transient generator SERIES output shall be used.

4.2.3.4.3 Test Procedure

a. Apply power to test sample.

b. The applied spike amplitude, rise time, and duration, as measured across the input terminals of the test sample, shall follow the typical wave shape shown in Figure 3-7.

c. Pulses shall be synchronized to the power line frequency and positioned on each 90-degree phase position (0, 90, 180, 270) for 2 minutes. The pulse shall then be varied continuously from 0 to 360 degrees on the input power wave form for 5 minutes utilizing the transient generator synchronization control. A rate of approximately 360 degrees per minute shall be utilized. To perform this test, the transient generator shall be connected to the same ac power source as the test sample.

d. Susceptibility will be evidenced by any degradation of performance. When susceptibility occurs, reduce the transient generator level until all evidence of degradation disappears. Record the transient level, pulse position relative to test sample signals if applicable, and phase position on ac power leads.

e. Repeat steps a. through d. for each phase used.

4.2.4 Radiated Susceptibility

4.2.4.1 Electric Field Susceptibility (RS03)

4.2.4.1.1 Purpose

The purpose of this test is to determine if the test sample is susceptible to electric fields in the frequency range of 14 kHz to 10 GHz and 13 to 15 GHz.

4.2.4.1.2 Test Configuration

The test configurations are shown in Figures 4-11 and 4-12.

4.2.4.1.3 Test Procedure

4.2.4.1.3.1 14 kHz to 220 MHz

a. Connect the test equipment as shown in Figure 4-11 and energize test equipment.

b. Illuminate the test sample with a field intensity of at least 2.0 volts per meter over the frequency range of 14 kHz to 220 MHz while monitoring test sample performance for any evidence of degradation or malfunction.

c. When degradation of performance or malfunction occurs, reduce the test signal level until the malfunction or degradation completely disappears. If the new test level is below 2.0 volt per meter, an out-of-specification condition has occurred. Record the frequency and field intensity level.

4.2.4.1.3.2 <u>220 MHz to 10 GHz and 13 to 15 GHz</u>

a. Connect the test equipment as shown in Figure 4-12. FM Modulate the signal generator with a 32 Kilobit square wave signal.

b. Illuminate the test sample with a field intensity of at least 2.0 volts per meter over the frequency range 220 MHz to 10 GHz. In addition, illuminate the test sample, if it is to fly in the payload bay, with a field intensity level shown in Figure 3-9 over the frequency range of 250-360 MHz, 2.0-2.3 GHz, and 13.0-15.0 GHz while monitoring the test sample performance for any evidence of degradation or malfunction. Use similar procedures at higher levels as defined by the particular project for equipment which protrudes above the payload bay or is ejected from the bay.

c. When degradation of performance occurs, reduce the test level until the malfunction or degradation completely disappears. If the new test level is below levels indicated in Note 1, an out-of-specification condition occurred. Record the frequency and field intensity level. The field intensity level in volts/meter at susceptibility is found as follows:

$$E = \sqrt{\frac{P_1}{P2}} \quad \frac{\text{VOLT}}{\text{METER}}$$

Where:

- o P_1 is the power indication at threshold of susceptibility.
- o P_2 is the power indication for 1.0 volt/meter.

NOTE: The level for all frequencies from 14 kHz to 10 GHz (except 250-300 MHz, 2.0-3.0 GHz, and 13 to 15 GHz) is 2.0 volt/meter.

The level for those frequencies in the range of 250-300 MHz, 2.0-3.0 GHz, and 13-15 GHz depends on the location of test sample with respect to the orbiter installed transmitter-produced electric field.

4.2.4.2 AC Magnetic Field

No test is required for susceptibility to ac magnetic fields.

4.2.4.3 DC Magnetic Fields

No test is required for susceptibility to dc magnetic fields.

TABLE 4-1. TRANSMITTER CHARACTERISTICS

TRANSMITTER	ANTENNA	CARRIER FREQ. (fc)	MODULATION
S-BAND FM	S-BAND HEMI	2250.0 MHz	FM
S-BAND PM (NETWORK TRANSPONDER)	S-BAND QUAD	2217.5 OR 2287.5 MHz	PSK, PM
PAYLOAD INTERROGATOR			
STDN (NASA)	S-BAND PAYLOAD	2025.8334 TO 2117.9166 MHz	PM
DSN (NASA)	S-BAND PAYLOAD	2110.2431 TO 2119.7924 MHz	PM
SGLS (DoD)	S-BAND PAYLOAD	1763.721 TO 1839.795 MHz	PM
KU-BAND	KU-BAND		
	RETURN LINK	15.0034 GHz	QPSK, FM
	RADAR RANGING	13.779163 GHz 13.831258 GHz 13.883353 GHz 13.935448 GHz 13.987543 GHz	PULSED CARRIER PULSE RATE: 3,000 TO 7,000 PPS PULSE WIDTH: 66.4 μs MAX. 122.0 Ns MIN.
EVA/ATC FROM CREW FROM ORBITER	UHF	243.0, 259.7 MHz 296.8 MHz	AM 90% (VOICE AND DATA)

5-3399-8-52

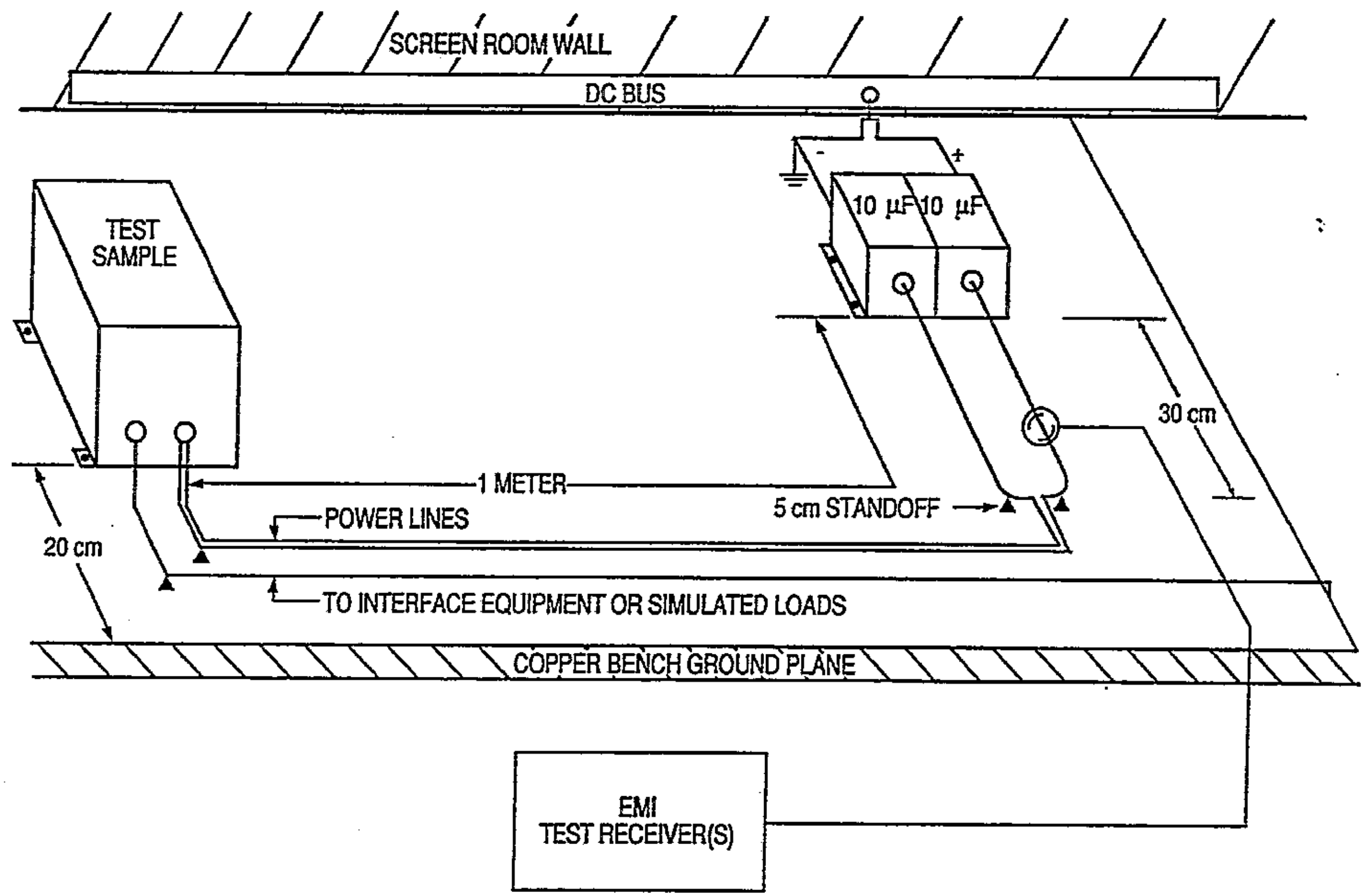


FIGURE 4-1. TEST CONFIGURATION FOR DC POWER BUS RIPPLE AND DC POWER BUS RF EMISSIONS, CE01, CE03

5-3396-8-52

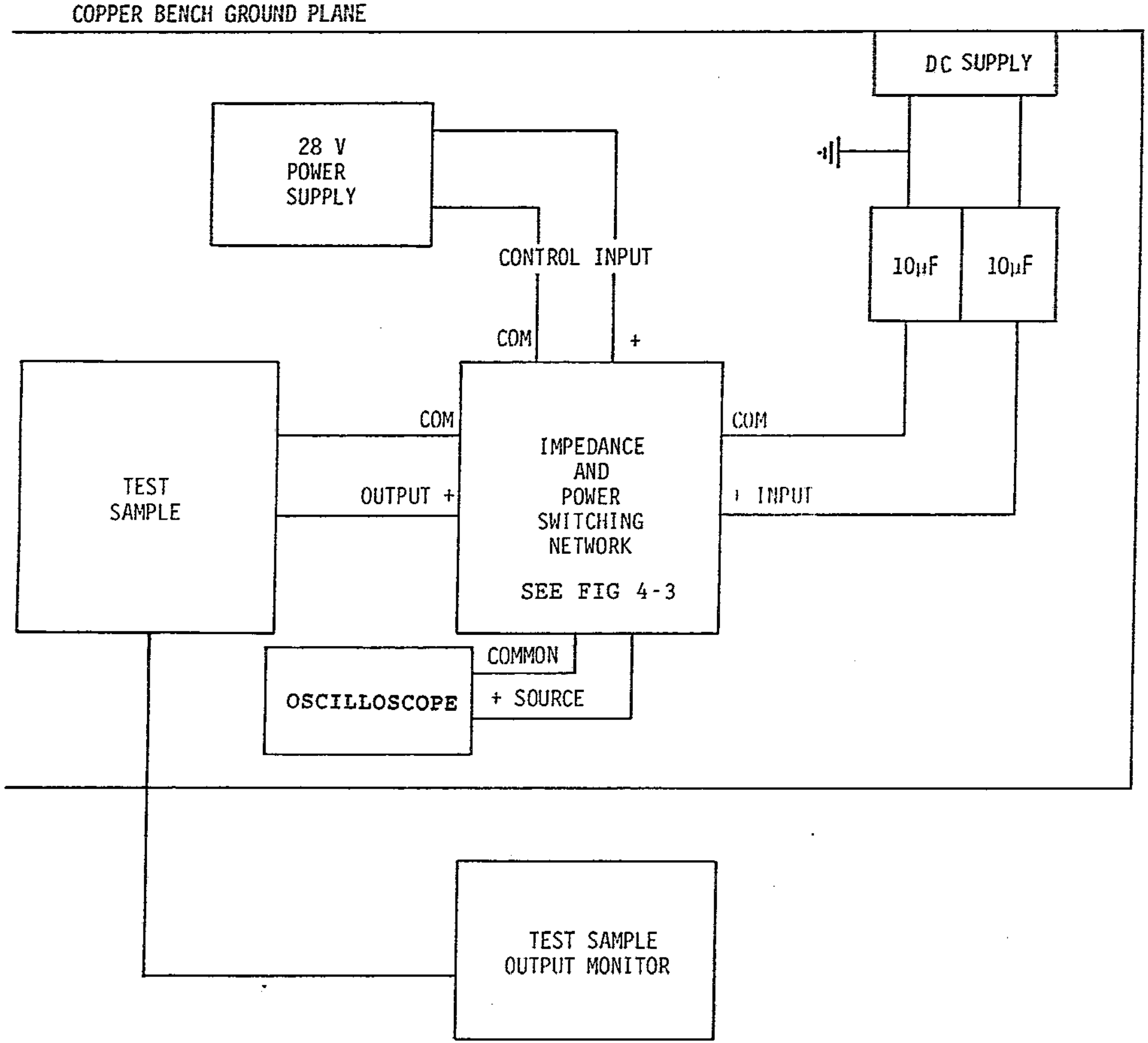
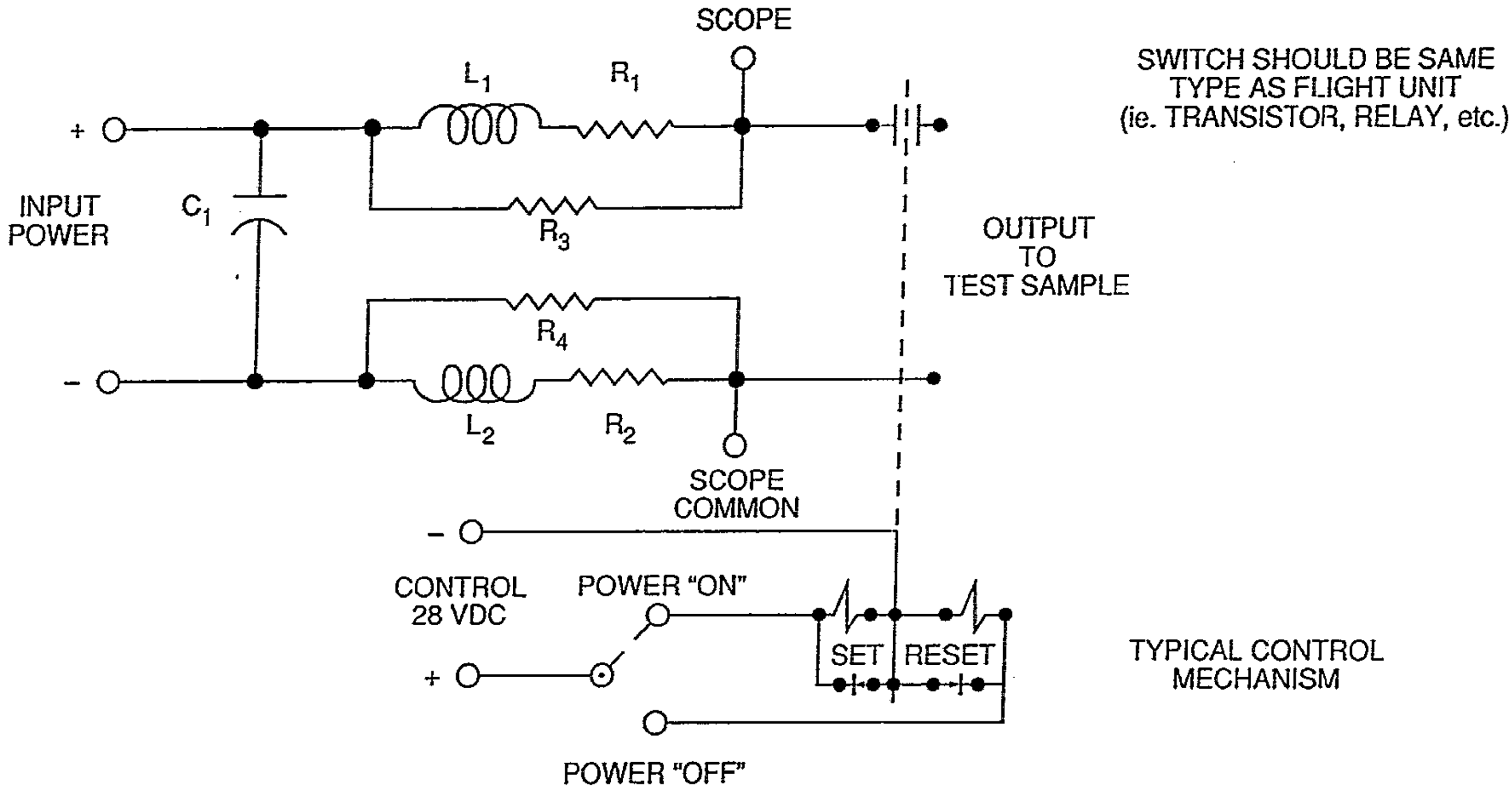


FIGURE 4-2. TEST CONFIGURATION POWER BUS TRANSIENT EMISSION, TT01

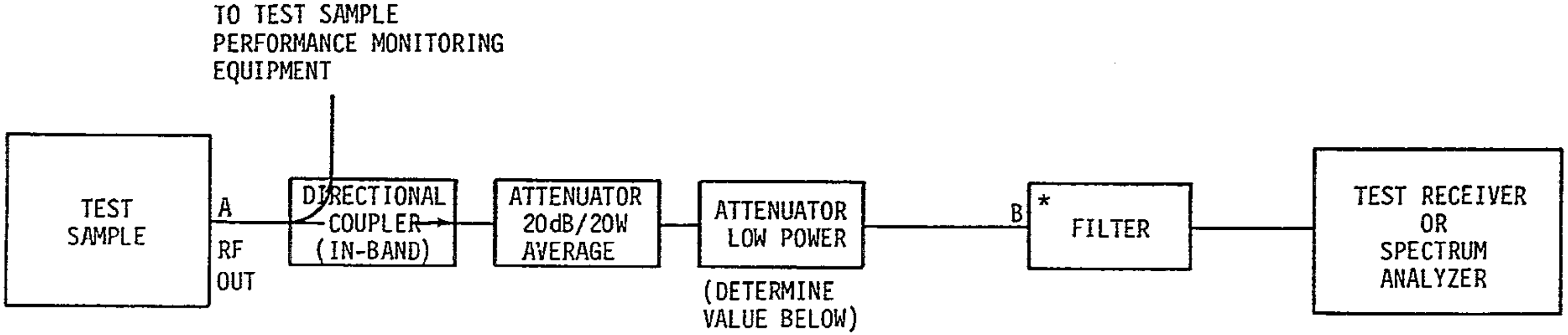


R1, R2 = 0.25 ohm
R3, R4 = 25 ohm
C1 = 19,000 uf 75 V ELECTROLYTIC
L1, L2 = 4 uH

NOTE: R1 AND R2 MAY BE REPLACED WITH ACTUAL WIRE RESISTANCE WHEN KNOWN. TEST REPORT SHALL SPECIFY ACTUAL DC RESISTANCE OF L1+R1 AND L2+R2 USED DURING TEST.

FIGURE 4–3. IMPEDANCE AND POWER SWITCHING NETWORK SCHEMATIC, FOR TT01

5-8139-0-208



$A_t = S_L - R_S - K$

WHERE:

A_t = TOTAL INSERTION LOSS FROM A TO B (SELECT PRIOR TO TEST)

S_L = MAXIMUM SPURIOUS LEVEL SPECIFIED

R_S = TEST RECEIVER MINIMUM SENSITIVITY. WHEN TEST RECEIVER SENSITIVITY VARIES WITH FREQUENCY, USE THE POOREST SENSITIVITY LEVEL OR CHANGE ATTENUATOR WHEN SENSITIVITY CHANGES.

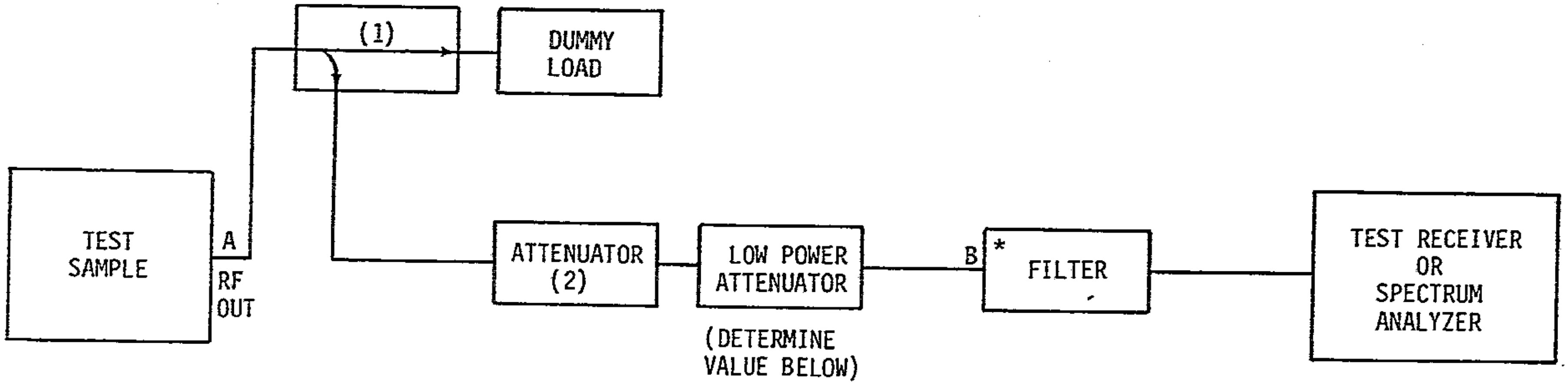
K = 10dB - TO PROVIDE A SIGNAL MARGIN BETWEEN SPECIFICATION LIMIT AND RECEIVER NOISE LEVEL.

* LOW PASS WITH CUTOFF APPROXIMATELY 0.8 f_o WHEN MEASURING BELOW f_o.

* HIGH PASS WITH CUTOFF APPROXIMATELY 1.2 f_o WHEN MEASURING ABOVE f_o.

* TUNABLE BANDPASS OR STEP ATTENUATOR WHEN OUT-OF-SPECIFICATION CONDITION OBSERVED BETWEEN LOW AND HIGH PASS FILTER CUTOFF FREQUENCIES.

FIGURE 4–4. TEST CONFIGURATION FOR TRANSMITTERS, 20 WATTS OR LESS, CE06



$A_t = S_L - R_S - K$

WHERE:

A_t = TOTAL INSERTION LOSS FROM A TO B (SELECTED PRIOR TO TEST)

S_L = MAXIMUM SPURIOUS LEVEL SPECIFIED

R_S = TEST RECEIVER MINIMUM SENSITIVITY WHEN TEST RECEIVER SENSITIVITY VARIES WITH FREQUENCY, USE THE POOREST SENSITIVITY LEVEL.

K = 10dB - TO PROVIDE A SIGNAL MARGIN BETWEEN SPECIFICATION LIMIT AND RECEIVER NOISE LEVEL.

* LOW PASS WITH CUTOFF APPROXIMATELY 0.8 f_o WHEN MEASURING BELOW f_o.

* HIGH PASS WITH CUTOFF APPROXIMATELY 1.2 f_o WHEN MEASURING ABOVE f_o.

* TUNABLE BANDPASS OR STEP ATTENUATOR WHEN OUT OF SPECIFICATION CONDITION OBSERVED BETWEEN LOW AND HIGH PASS FILTER CUTOFF FREQUENCIES.

NOTE:

(1) DIRECTIONAL COUPLERS OR SIGNAL SAMPLER - A LOW FREQUENCY LIMITATION OF APPROXIMATELY .15 MH_z EXISTS WITH DIRECTIONAL COUPLERS.

(2) 20 WATT AVERAGE WITH ATTENUATION NECESSARY TO REDUCE FUNDAMENTAL TO BELOW 1 WATT.

FIGURE 4–5. TEST CONFIGURATION FOR TRANSMITTERS, ABOVE 20 WATTS, CE06

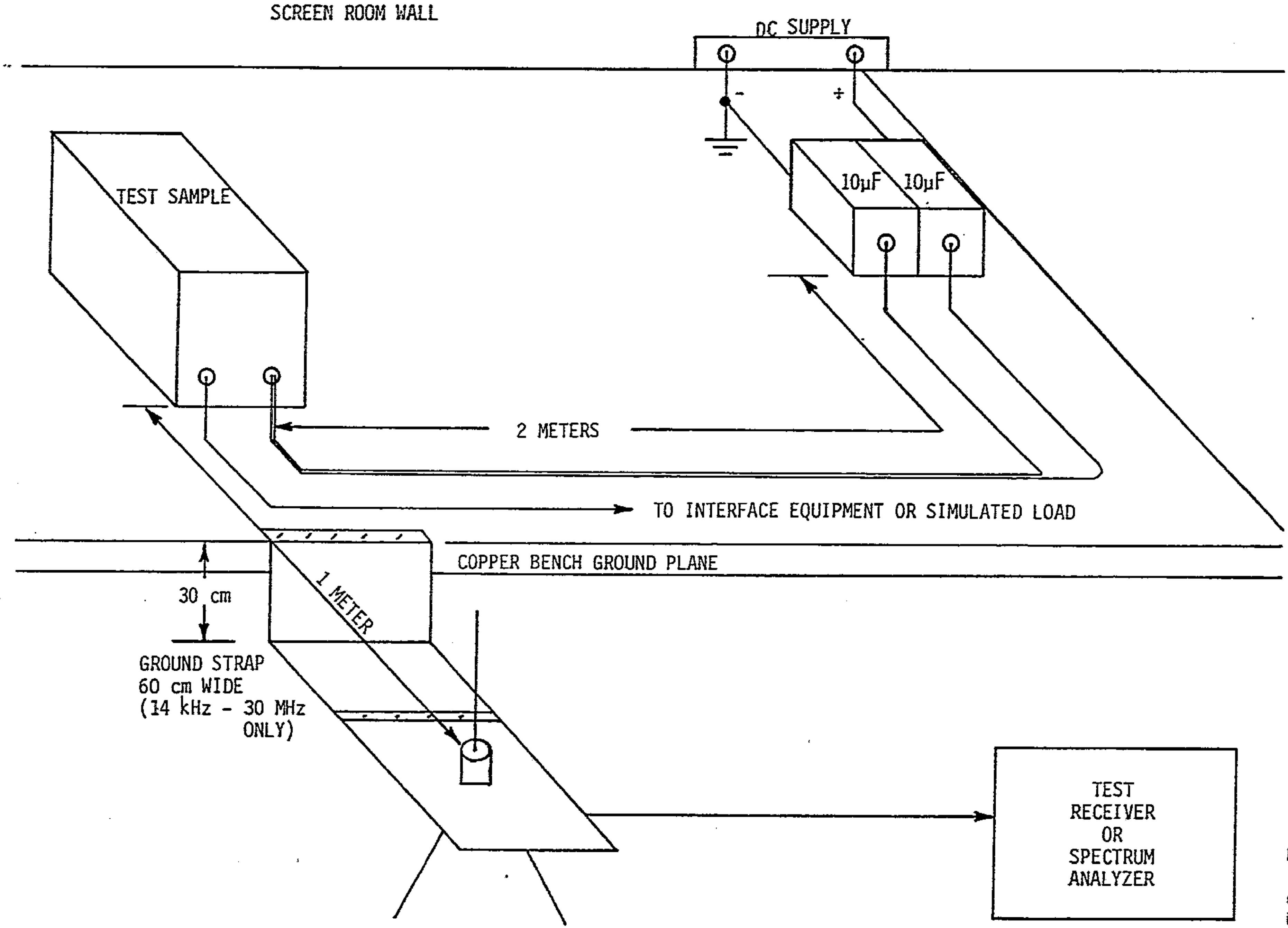


FIGURE 4–6. TEST CONFIGURATION FOR RADIATED EMISSIONS, ELECTRIC FIELD, RE02

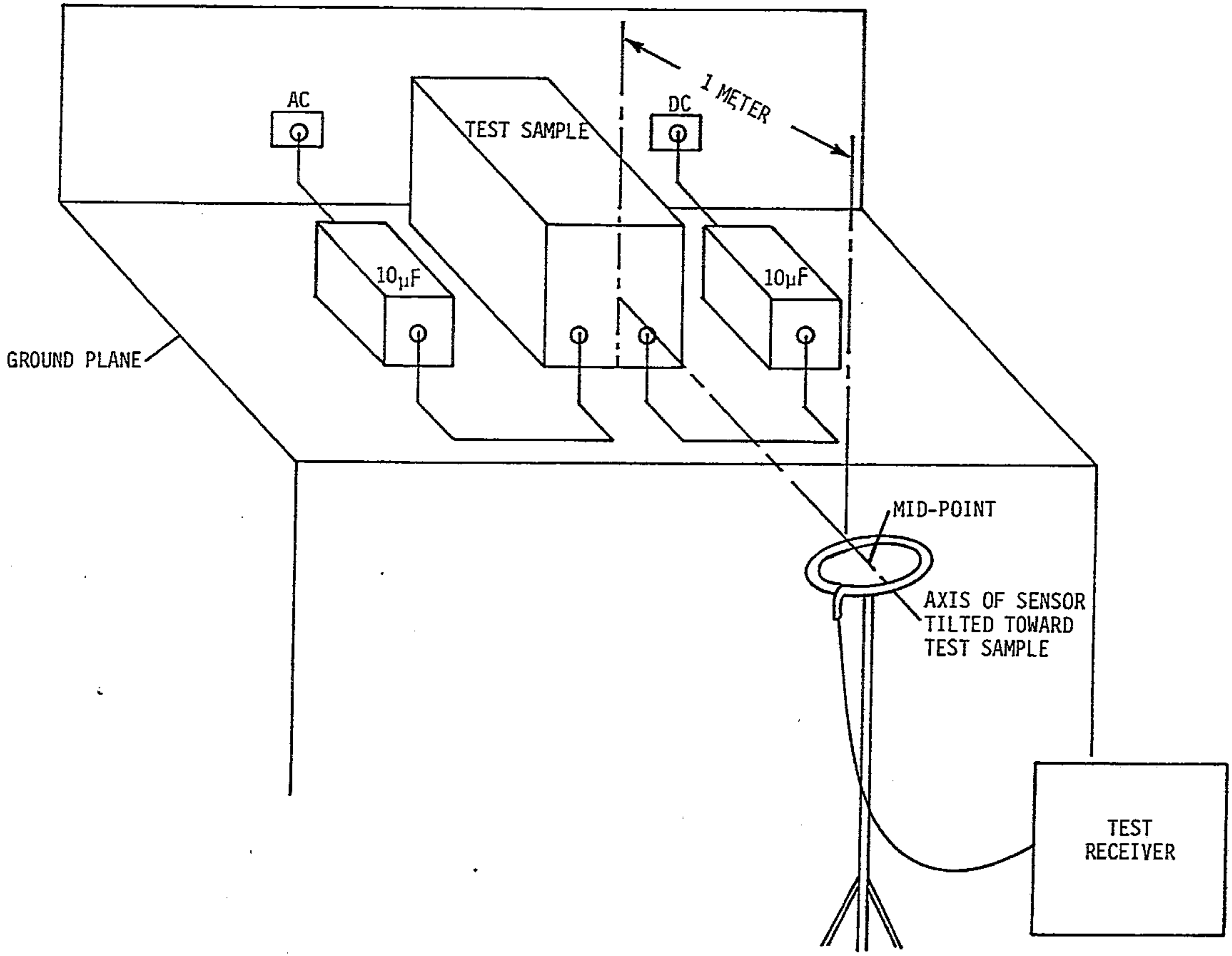


FIGURE 4–7. TEST CONFIGURATION AC MAGNETIC FIELD EMISSIONS, RE04

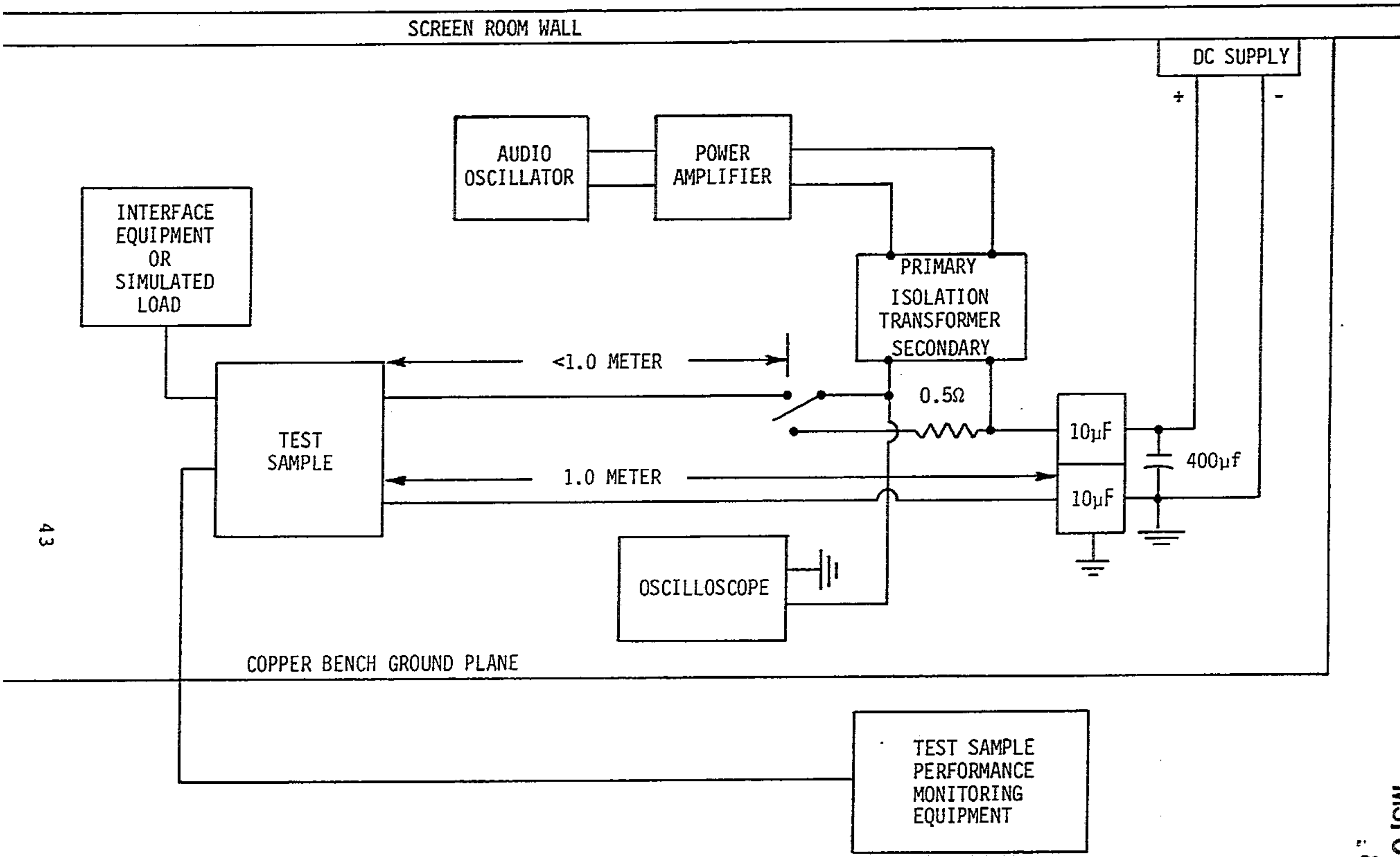


FIGURE 4–8. TEST CONFIGURATION FOR DC POWER BUS RIPPLE SUSCEPTIBILITY, CS01

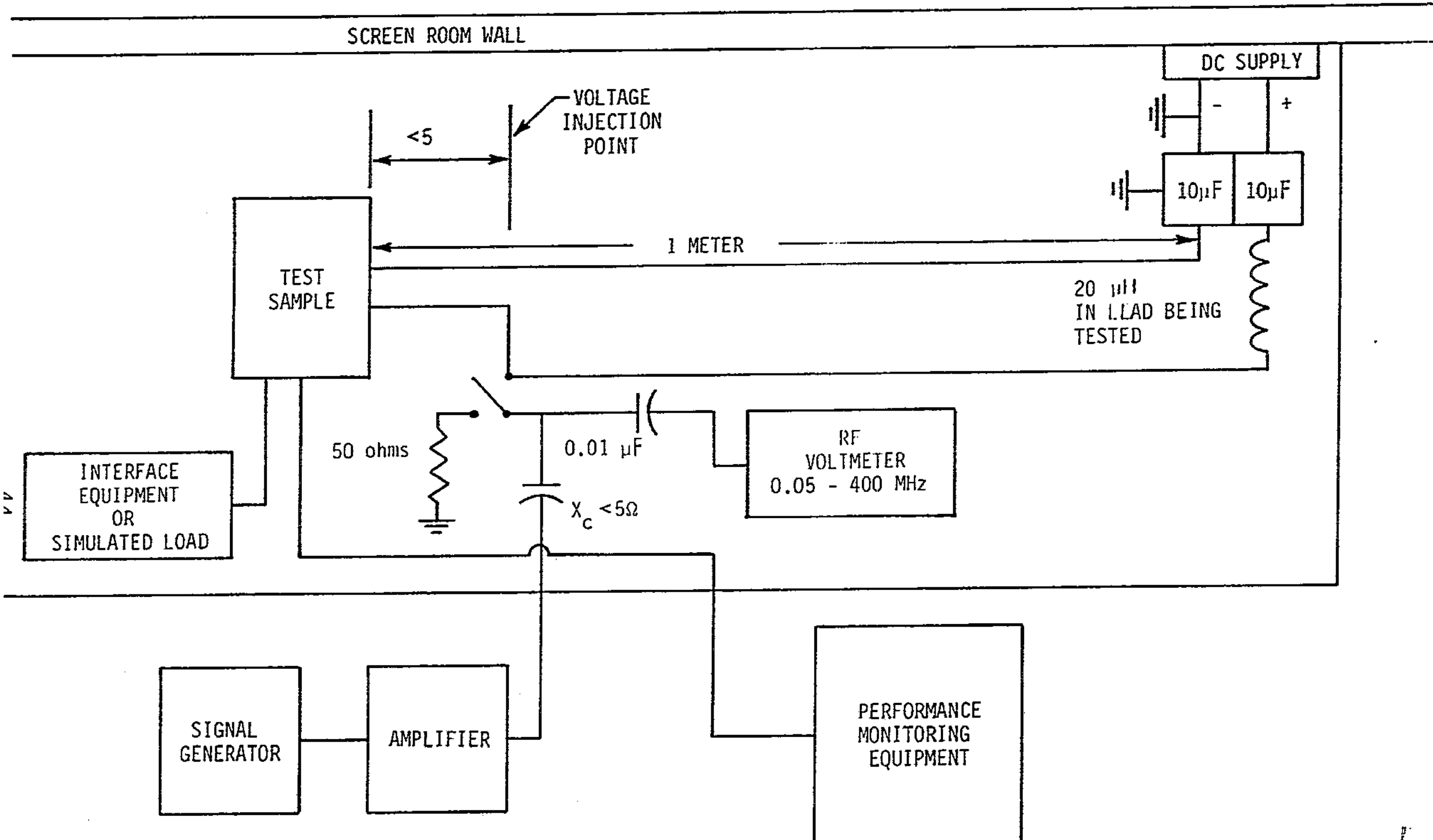


FIGURE 4–9. TEST CONFIGURATION FOR DC POWER BUS RF SUSCEPTIBILITY, CS02

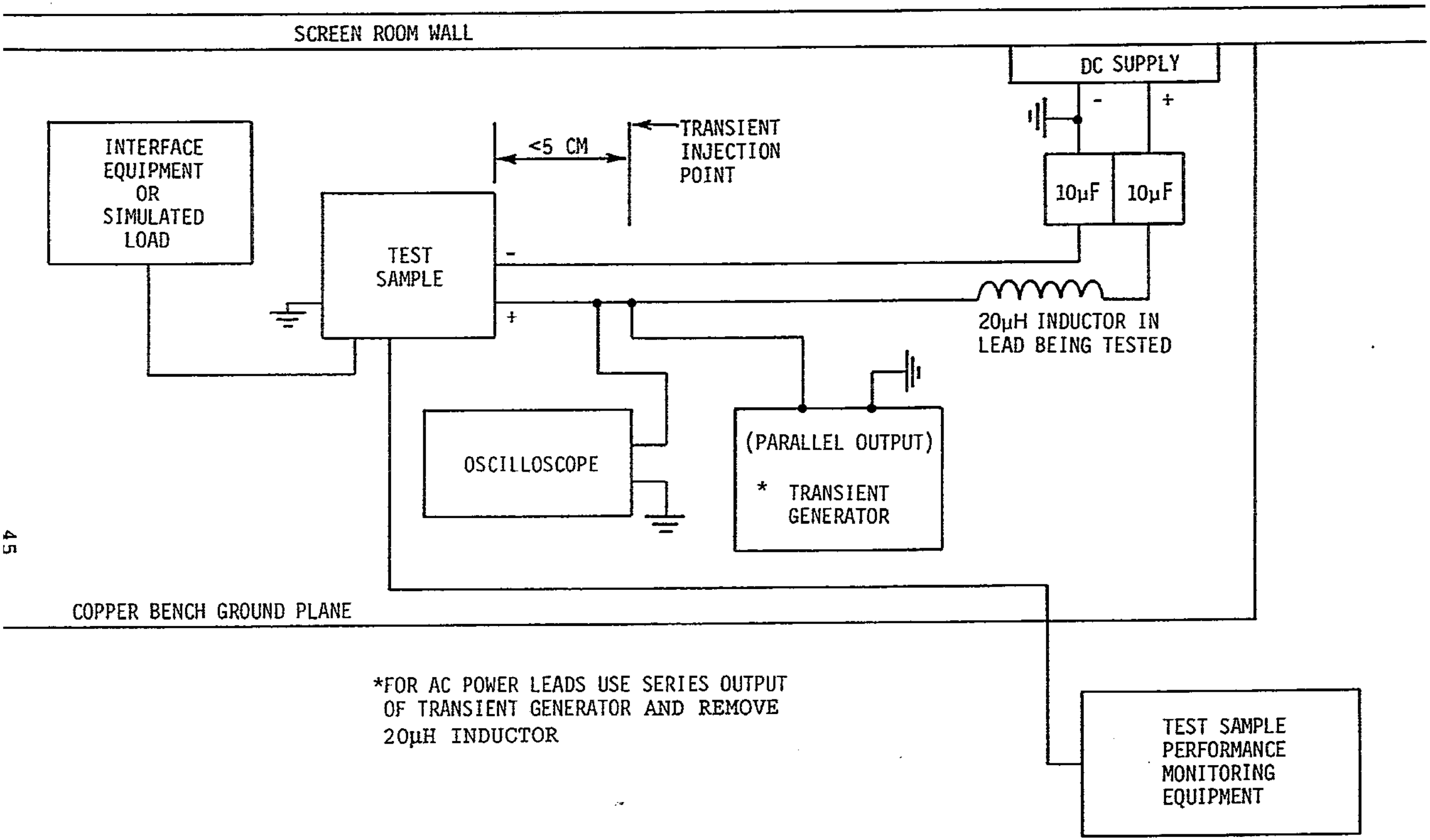


FIGURE 4–10. TEST CONFIGURATION FOR POWER BUS TRANSIENT SUSCEPTIBILITY, CS06

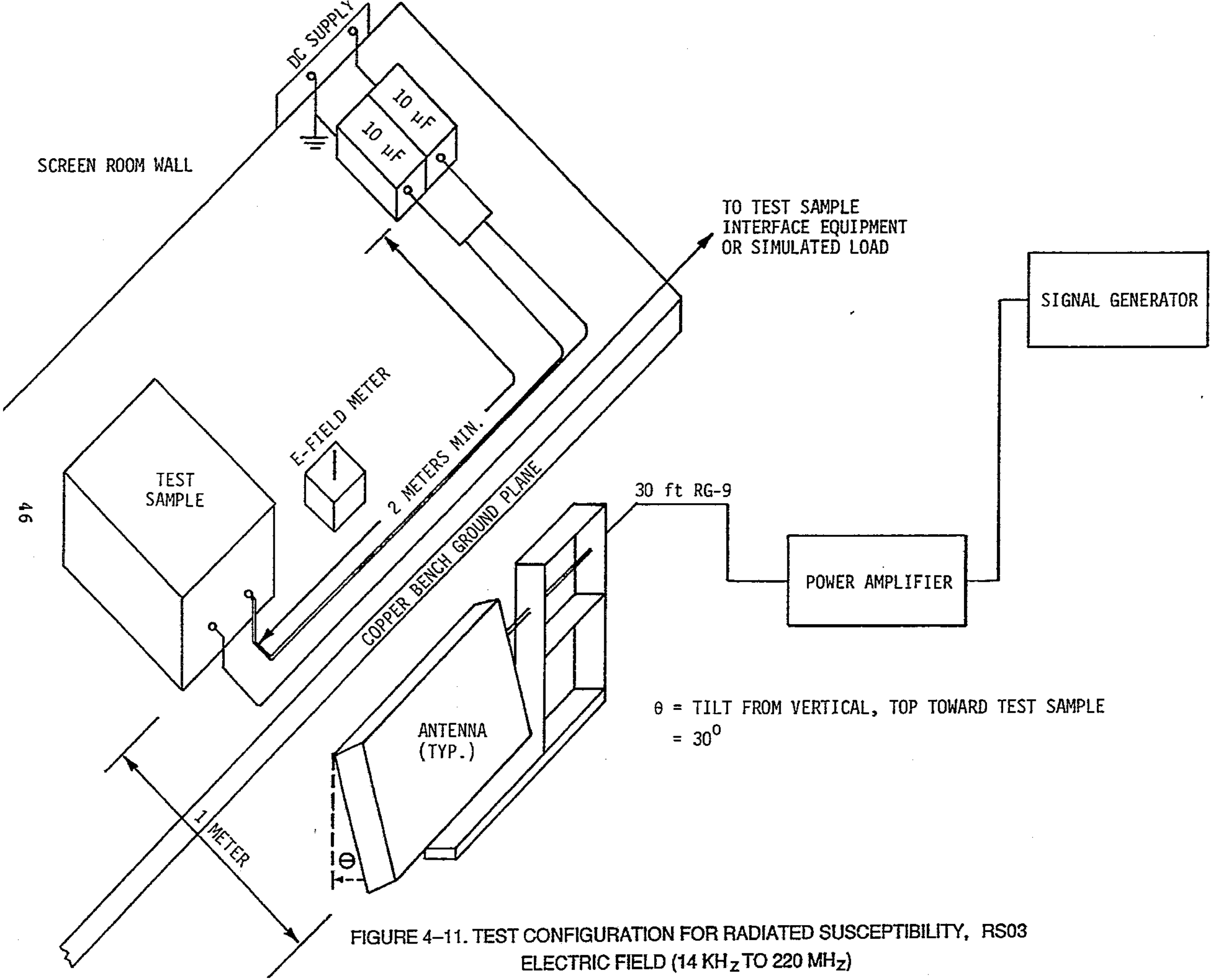


FIGURE 4–11. TEST CONFIGURATION FOR RADIATED SUSCEPTIBILITY, RS03
ELECTRIC FIELD (14 KH_Z TO 220 MH_Z)

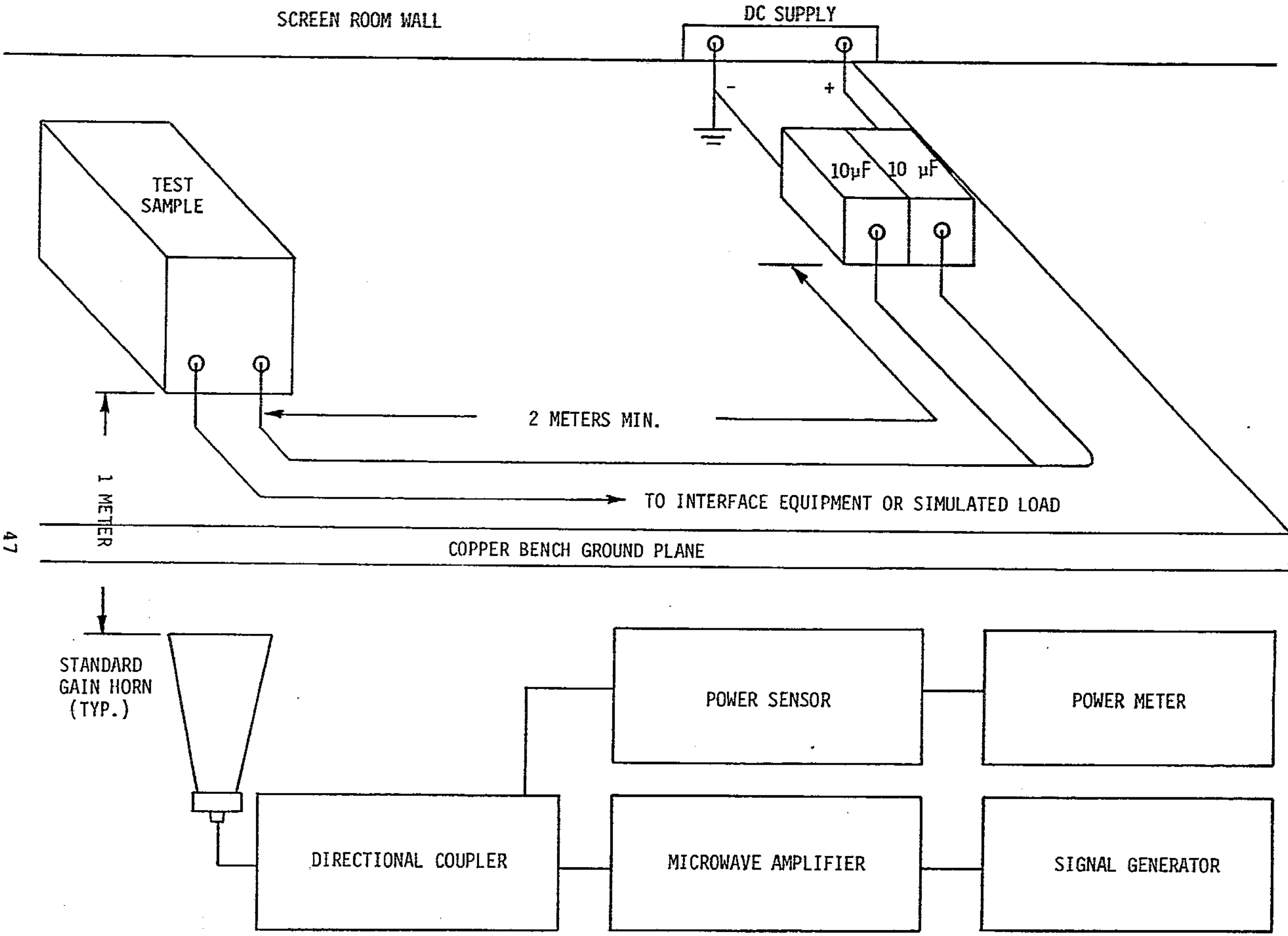


FIGURE 4–12. TEST CONFIGURATION FOR RADIATED SUSCEPTIBILITY, ELECTRIC FIELD (220 MH_z –15 GH_z) RS03

PACKAGE NO. 10443R

DOCUMENTATION RELEASE LIST
GEORGE C. MARSHALL SPACE FLIGHT CENTER

MSFC CODE IDENT 14981/339B2
ISSUE DATE FEB 22 2007

C H	DOCUMENT NUMBER	DRL DSH	DRL REV	TITLE	CCBD NO.	PCN	PC	EFFECTIVITY
*	MSFC-SPEC-521	202	-	ELECTROMAGNETIC COMPAT. REQUIREMENTS ON SPACELAB PAYLOAD EQUIPMENT	000-00-0000	0000000	ZA	NONE

	CHG NO.	CHG REV	CHG NOTICE	RESPONSIBLE ENGINEER	RESPONSIBLE ORGANIZATION	ACTION DATE	DESCRIPTION
		B	SCN000	DAWN SMITH	EL56	03/02/94	REVISION 'B' RELEASED 10/10/90.
	1	B	SCN001	DAWN SMITH	EL56	03/02/94	EMC REQUIREMENTS RELEASED 03/25/91.
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NOMENCLATURE: MSFC-STD- GOING TO NONE EFFECTIVITY

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E003-0000	0000000	000-00-0000 SB3-00-0000	02/22/07

DWG SIZE	DRAWING NUMBER	DWG REV	EPL/DRL/DDS NUMBER	DWG REV	EPL DSH	EPL REV	EO DASH NUMBER	EO REV	PART NUMBER
			MSFC-HDBK-1453		202	-			
			MSFC-HDBK-1674		202	-			
			MSFC-HDBK-2221		203	-			
			MSFC-HDBK-505		202	-			
			MSFC-HDBK-670		202	-			
			MSFC-MNL-1951		209	-			
			MSFC-PROC-1301		202	-			
			MSFC-PROC-1721		202	-			
			MSFC-PROC-1831		202	-			
			MSFC-PROC-1832		202	-			
			MSFC-PROC-404		202	-			
			MSFC-PROC-547		202	-			
			MSFC-QPL-1918		204	-			
			MSFC-RQMT-1282		202	-			
			MSFC-SPEC-1198		202	-			
			MSFC-SPEC-1238		202	-			
			MSFC-SPEC-1443		202	-			
			MSFC-SPEC-164		202	-			
			MSFC-SPEC-1870		202	-			
			MSFC-SPEC-1918		203	-			
			MSFC-SPEC-1919		206	-			
			MSFC-SPEC-2083		202	-			
			MSFC-SPEC-2223		202	-			
			MSFC-SPEC-2489		206	-			
			MSFC-SPEC-2490		205	-			
			MSFC-SPEC-2491		203	-			
			MSFC-SPEC-2492		203	-			
			MSFC-SPEC-2497		211	-			
			MSFC-SPEC-250		202	-			
			MSFC-SPEC-445		202	-			
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			MSFC-SPEC-521		202	-			
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			MSFC-SPEC-560		202	-			
			MSFC-SPEC-626		202	-			
			MSFC-SPEC-684		202	-			
			MSFC-SPEC-708		202	-			
			MSFC-SPEC-766		202	-			
			MSFC-STD-1249		202	-			
			MSFC-STD-1800		202	-			
			MSFC-STD-246		202	-			
			MSFC-STD-2594		203	-			

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DWG SIZE	DRAWING NUMBER	DWG REV	EPL/DRL/DDS NUMBER	DWG REV	EPL DSH	EPL REV	EO DASH NUMBER	EO REV	PART NUMBER
			MSFC-STD-2903		202	-			
			MSFC-STD-2904		202	-			
			MSFC-STD-2905		202	-			
			MSFC-STD-2906		202	-			
			MSFC-STD-2907		202	-			
			MSFC-STD-366		202	-			
			MSFC-STD-383		202	-			
			MSFC-STD-486		202	-			
			MSFC-STD-506		203	-			
			MSFC-STD-531		202	-			
			MSFC-STD-557		202	-			
			MSFC-STD-561		203	-			
			MSFC-STD-781		202	-			

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PREPARED BY:
EUGENA GOGGANS
12/19/06

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