Parker Chomerics

TEST SERVICES

ELECTROMAGNETIC INTERFERENCE
(EMI) TEST PROCEDURE FOR THE
COSMIC RAY TELESCOPE for the EFFECTS of RADIATION
(CRaTER)

Date: **OCTOBER 8, 2007**
Test Plan Number: **TP4875.07**

IN ACCORDANCE WITH
MIL-STD 461C

Prepared For: **MASSACHUSETTS INSTITUTE OF TECHNOLOGY**
KAVLI INSTITUTE
77 MASS AVENUE
CAMBRIDGE, MASSACHUSETTS 02139
ATTENTION: ROBERT GOEKE

Prepared By: **DENNIS HENNIGAN N.C.E.**
CHOMERICS TEST SERVICES
77 DRAGON COURT
WOBURN, MASSACHUSETTS 01801

Test Technician or Engineer: _____ **Date:**

CTS Approved Signatory: _____ **Date:**

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REVISION RECORD SHEET

Revision	Description	Date	Approval
NA	Created Draft Copy	October 4, 2007	
N/A	Finalized Test Plan	October 8, 2007	

LIST OF DEFINITIONS/ABBREVIATIONS

BW	Bandwidth
cm	Centimeter
dB	Decibel
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ER	Electric Radiation
EUT	Equipment Under Test
GHz	GigaHertz
Hz	Hertz
I-face	Interface
kHz	KiloHertz
m	Meter
MHz	MegaHertz
mm	Millimeter
MR	Magnetic Radiation
PLC	Power Line Conduction
uV	MicroVolt

1.0 INTRODUCTION

1.1 Purpose

This document defines the requirements, methods, and procedures for electromagnetic emission and susceptibility testing of the MIT Cosmic Ray Telescope for the Effects of Radiation (CRaTER).

This document was prepared by Chomerics Test Services at the request of MIT.

The purpose of this plan is to implement the tests necessary to demonstrate compliance defined by MIL-STD-461C, Part 3 Class A2 (Equipment and Subsystems Installed Aboard Spacecraft and Launch Vehicles, Including Associated Ground Equipment) in accordance with the CRaTER Electromagnetic Compatibility Test Procedure Drawing. Number 32-06006.01 Revision A- August 26, 2007.

The test shall be performed at Chomerics Inc. in Woburn, Massachusetts at the request of MIT.

The test personnel used to perform the tests are accredited by the National Association of Radio and Telecommunications Engineers, Inc. (NARTE) as certified electromagnetic compatibility engineers.

1.2 Requirements

The MIT CRaTER, defined herein, shall meet the following radiated and conducted emission/susceptibility requirements of MIL-STD-461C:

1.2.1 Description

TEST NAME	SECTION IN TEST PLAN	32-06006.01 SECTION
CE01/03 Conducted Emissions Power Lines (30Hz to 50MHz)	7.1	3.3.1.1
CS01 Conducted Susceptibility Power Lines (30Hz to 50 kHz)	7.2	3.3.3.1
CS02 Conducted Susceptibility Power Lines (50 kHz to 400MHz)	7.3	3.3.3.1

TEST NAME	SECTION IN TEST PLAN	LRO ESS SECTION
CS06 Conducted Susceptibility Power Lines Transients (31V spike superimposed)	7.4	3.3.3.5
RE02 Radiated Electric Field Emissions (14 kHz to 30GHz)	7.5	3.3.2
RS03 Radiated Electric Field Susceptibility (14 kHz to 30GHz)	7.6	3.3.4

1.2.2 Test Sequence/Order

Following the completion of each test, a representative from MIT and Chomerics must sign to verify the proper test performance.

Radiated Electric Field Emissions (Section 7.6) shall be the first formal EMI test to be performed. Following this test, the remaining Conducted Emissions test defined within Sections 7.1 through 7.3 shall be performed. Subsequent to the radiated and conducted emission testing, the remaining susceptibility tests shall be performed in any sequence.

Test	Section #	Signatures	Date
1	7.5 (RE02)	MIT: _____	_____
		Chomerics: _____	_____
2	7.1 (CE01/03)	MIT: _____	_____
		Chomerics:_____	_____
3	7.2 (CS01)	MIT: _____	_____
		Chomerics:_____	_____
4	7.3 (CS02)	MIT: _____	_____
		Chomerics:_____	_____

Test	Section #	Signatures	Date
5	7.4 (CS06)	MIT: _____	_____
		Chomerics: _____	_____
6	7.5 (RS03)	MIT: _____	_____
		Chomerics: _____	_____

1.3 Equipment Under Test

The CRaTER is comprised of the following:

1. One Cosmic Ray Telescope for the Effects of Radiation
2. Two shielded 1553 Bus harnesses
3. One unshielded DC power line test harness
4. One 1 PPS test cable

1.4 Test Deviations

Any exceptions/deviations to the test plan incorporated during testing must be approved by a MIT representative. All deviations and exceptions shall be documented and described in the final test report.

1.5 Recorded Data

All radiated and conducted emission test data shall be presented graphically. All measurement plots will be saved electronically. Susceptibility tests shall be recorded on tabular data sheets. Photos of each test setup shall be included in the test report.

All data shall be converted, as necessary, so that it can be presented in units consistent with the applied limits.

2.0 APPLICABLE DOCUMENTS

MIT: CRaTER Electro-Magnetic Compatibility Test Procedure. Drawing Number 32-06006.01 Revision A
Dated: August 26, 2007

NASA:
Lunar Reconnaissance Orbiter Project LRO Electrical Systems Specification 431-SPEC-000008
Revision D
Dated 4 June 2007

MIL-STD-461C: Requirements for the Control of Electromagnetic Interference Emission and Susceptibility
Dated: 4 August 1986

MIL-STD-462: Measurements of Electromagnetic Interference characteristics Notice 6
Dated: 31 July 1967

MIL-STD-285: Military Standard Attenuation Measurements Enclosures, Electromagnetic Shielding, For Electronic Tests Purposes Method of
Dated: 25 June 1956

CHO-QA002 Revision J:
Chomerics Quality Assurance Manual
Dated: 27 February 2007

CHO-QA001 Revision O:
Chomerics Calibration Manual
Dated: 7 March 2007

3.0 TEST SITE

3.1 Shielded Enclosure

Figure 1 illustrates the overall floor plan of Chomerics EMI testing facility. The CRaTER test shall be performed with the unit located in Test Chamber A or C, Figure 1.

Test Chamber A: Chomerics' Test Chamber "A", if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 1). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of IEEE-STD-299. This Test Chamber conforms to the requirements of MIL-STD-461E Section 4.3 for all conducted emissions and susceptibility Tests. The chamber is not lined with absorber material and therefore is not used for qualification radiated emissions and susceptibility tests.

The main test chamber is 22 x 10 x 10 feet in size with an adjacent enclosure that is 8 x 8 x 8 feet in size. The adjacent room used for support equipment and the main test chamber are connected together and referenced to the same single point ground.

When needed for tabletop equipment, a wooden table measuring 3 x 9 feet in size is positioned within the test chamber. When used for MIL-STD-461E tests the tabletop surface is covered with a copper sheet and grounded to the test chamber wall so that the resistance is less than 2.5 milliohms.

The power line filters supplying the power to the enclosure provide 100dB of attenuation from 10kHz to 10GHz. The adjacent room, used for support equipment, and the main test chamber have independent AC power obtained from independent AC power line filters.

The available AC power in Test Chamber "A" is 120V 60Hz Single Phase 100Amps; 120V 400Hz Three Phase 50Amps; 208V 60Hz Three Phase 100Amps; 208V 60Hz Single Phase 100Amps; 230V 50Hz Single Phase 50Amps.

Test Chamber B: Chomerics' Test Chamber "B", if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 1). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of IEEE-STD-299. This Test Chamber is only used for preliminary testing to MIL-STD-461E. This chamber is not used for qualification tests to MIL-STD-461E.

The main test chamber is 22 x 10 x 10 feet in size with an adjacent enclosure that is 8 x 8 x 8 feet in size. The adjacent room used for support equipment and the main test chamber are connected together and referenced to the same single point ground.

Test Chamber "B" is lined with Rantec ferrite absorber tiles FT-100. All surfaces of the room are lined with FT-100 material. The floor is lined with removable tiles.

This absorber material allows the test chamber to meet the 0-6dB field uniformity requirements of IEC 1000-4-3.

There are two access panels between the main test chamber and the support room. The access panels are covered with absorber tiles. The absorber tiles can be removed from the access panels.

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. The adjacent rooms, used for support equipment, and the main test chamber have independent AC power obtained from independent AC power line filters.

The available AC power in Test Chamber "B" is 120V 60Hz Single Phase 30Amps; 208V 60Hz Three Phase 30Amps and 230V 50Hz Single Phase 30Amps: A wooden table 3 x 6 feet in size is used for tabletop equipment.

Test Chamber C: Chomerics' Test Chamber "C", if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 1). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. This Test Chamber conforms to the requirements of MIL-STD-461E Section 4.3 for all tests.

Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of IEEE Std 299. The main test chamber is 16 x 20 x 10 feet in size with two adjacent enclosures on either side which are 8 x 8 x 8 and 8 x 12 x 10 feet in size, respectively.

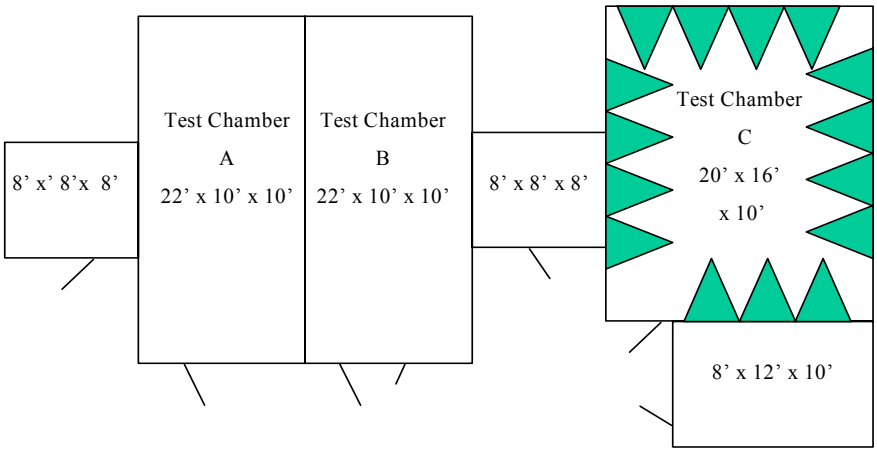
Test Chamber "C" is lined with Emerson-Cuming RF absorber material. This absorber material meets the following absorption specifications: 80MHz 6dB, 300MHz 30dB, 500MHz 35dB, 1GHz 40dB, and 3 to 24 GHz 50dB. Each of the two adjacent rooms used for support equipment and the main test chamber are connected together and referenced to the same single point ground.

When needed for tabletop equipment, a wooden table measuring 3 x 9 feet in size is positioned within the test chamber. When used for MIL-STD-461E tests, the tabletop surface is covered with a copper sheet and grounded to the test chamber wall so that the resistance is less than 2.5 milliohms. When used for radiated electromagnetic field tests, to some standards, the copper tabletop surface is removed.

The available AC power in Test Chamber "C" is 120V 60Hz AC Single Phase 60Amps; 230V 50Hz AC Single Phase 50Amps; 115V 400Hz AC Three Phase 30Amps (through access panel); 208V 60Hz AC Three Phase AC 30Amps (through access panel).

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. Each of the two adjacent rooms used for support equipment and the main test chamber has independent AC power obtained from independent AC power line filters.

FIGURE 1
CHOMERICS EMI/EMC LAB LAYOUT



Key:

= Emerson-Cuming RF absorber material

3.2 Ground Plane

The CRaTER shall be bonded to the ground plane. The EUT's cabling shall be supported 5cm above the ground plane.

Within Test Chamber A and C, the floor of the test chamber contains a copper ground plane.

Chomerics copper ground planes conform to the following requirements: "A copper or brass ground plane (a solid plate) shall be used with a minimum thickness of 0.25mm for copper or 0.63mm for brass and is 2.25 square meters or larger in surface area with the smaller side no less than 76cm."

"The ground plane shall be bonded to the shielded enclosure such that the DC bonding resistance shall not exceed 2.5 milliohms."

3.3 Electromagnetic Ambient Conditions

The electromagnetic ambient levels within the shielded enclosure shall be measured either before the commencement of formal EMI testing or before each of the individual EMI emissions tests. The ambient scans can be performed at a minimum scan rate of 2 minutes per decade. The person conducting the test shall determine the ambient scan rate.

Ambient test measurements required are as follows:

CONDUCTED EMISSIONS

CE01/03 Power Hot Line and Power Bundle.

RADIATED EMISSIONS

RE02 Electric Field 10 kHz to 1GHz Vertical polarity

If ambient signals are detected above 500MHz, then the ambient signal control shall be extended to 18GHz. If signals are detected above 5GHz then the ambient test shall be extended to 30GHz.

The ambient tests listed above shall be performed with the CRaTER powered OFF and with all other test setup equipment powered ON. All necessary test instrumentation and associated CRaTER operating equipment shall be connected and operating normally.

Radiated measurements shall be made with vertical polarization of the antenna at the antenna distance that shall be used during the EMI tests. If ambient signals are detected within 10dB of the limit then the test shall be repeated with the antenna placed in the horizontal polarity.

The resulting ambient data shall be graphs of amplitude versus frequency.

Following the completion of each ambient test, Chomerics and the MIT representative shall sign to verify that the 6dB ambient levels are met.

Ambient Test Description	Signatures	Date
CE01/03	MIT: _____	_____
	Chomerics: _____	_____
RE02	MIT: _____	_____
	Chomerics: _____	_____

3.4 Excess Personnel and Equipment

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

4.0 TEST INSTRUMENTATION

4.1 Test Equipment

Section 7 of this document defines each test and the equipment needed to perform each test. Although equipment has been specified, test personnel reserve the right to substitute alternate test equipment, providing the equipment performance is equal to or greater than the performance parameters of the one specified. Any substituted equipment would be due to the maintenance of the calibration cycle and repair time of test equipment, if necessary.

The test equipment required for each test is shown within each segment of Section 7. The date of the equipment's last calibration shall be recorded in the final EMI test report. If the substitution requires a different test configuration than that indicated in this test plan, the new test configuration shall be included in the test report and justified where applicable.

The instruments used for the conducted immunity tests are automatically controlled by the TILE EMC test program while the EUT is monitored by the test engineer for any degradation of performance.

The instruments used for the remaining conducted and radiated immunity tests are manually controlled by the test engineer while the EUT is monitored for any degradation of performance.

The measurement instrument used for the radiated and conducted emissions scans is the Rohde and Schwarz Model ESIB 40 EMI Test Receiver System.

The same test setup and the same test article must be used for all tests. If substitution of the test equipment requires a new test setup and/or a new test article, then the new test setup and/or new test article must be confirmed by the FAA.

4.2 Detection System Parameters

The detection system parameters specified, and used for test, reflect the conditions to which the ESIB 40 receiving system shall be set to meet the room ambient within Section 3.3.

The Rohde and Schwarz ESIB 40 EMI Test Receiver will be used as the detection system for the emissions testing. The Rohde and Schwarz ESIB 40 EMI Test Receiver Detection System is designed for manual or fully automated detection. During formal tests, the Rohde and Schwarz ESIB 40 EMI Test Receiver shall operate fully automated via a remote external Dell personal computer. The software used is Quantum Change TILE EMI measurement software. Measuring and analyzing capabilities extend from 20Hz to 40GHz.

Within the detection system parameters specified, two setting variations in Ranges and Sweep time per range parameters exist which effect the measurement time. The data is stored in the computer memory and then later displayed as a .wmf or .bmp file. The data is displayed with respect to actual limit dimensions (such as dBμV/m) with transducer, attenuation, and cable loss corrections made to the data.

All measuring equipment shall be calibrated in conformance to the requirements of MIL-STD-45662A with all measurements traceable to the National Institute of Standards and Technology. The following tables show the typical test parameters. The actual parameters will be listed in the test report.

The detection system parameters used for the test reflect the conditions to which the ESIB 40 shall be set to ensure that the room ambient condition shall be 6dB below the appropriate limit.

4.3 Conversion and Correction Factors

The graphs of radiated and conducted emissions are automatically scanned using an ESIB 40 receiving system which is remotely controlled via a personal computer. All conversion and correction factors shall be automatically added/subtracted to the detected EMI emissions by the TILE EMI software running on the personal computer. The TILE software is Version 3.4.H.2. (14 Sept 2005).

Chomerics data correction files are updated upon receipt of most recent antenna/probe conversion and/or correction factor calibration data. As a check at the time of test, the antenna/probe conversion and/or correction factors from the most recent calibration shall be compared to those used in the data correction files. If a discrepancy is encountered, the data correction files shall be altered to reflect the most recent calibration factors prior to formal testing. These changes shall be noted in the final test report.

Final test setup files will be verified at the time of the test with signal substitution methods and ambient measurements.

TABLE 1
RF RADIATED EMISSIONS
DETECTION SYSTEM PARAMETERS (Typical)

Test Parameters RE02 Narrow Band				
	Range 1	Range 2	Range 3	Range 4
Start Frequency	14kHz	150kHz	20MHz	200MHz
Stop Frequency	150kHz	20MHz	200MHz	1GHz
RF Bandwidth	1kHz	10kHz	100kHz	100kHz
Video Bandwidth	100Hz	1kHz	10kHz	10kHz
Ranges	60	60	100	200
Sweep Time Per Range	Auto	Auto	Auto	Auto
Number of Sweeps Per Range	1	1	1	1
Detector	Peak	Peak	Peak	Peak
Reference Level	87dBuV	87dBuV	87dBuV	87dBuV
Internal Attenuation	0	0	0	0
Preamplifier On/Off	On	On	On	On
Preselector On/Off	On	On	On	On
Amplifier Used	No	No	No	No

Test Parameters RE02 Narrow Band				
	Range 5	Range 6	Range 7	Range 9
Start Frequency	1GHz	2GHz	4GHz	8GHz
Stop Frequency	2GHz	4GHz	8GHz	12GHz
RF Bandwidth	1MHz	1MHz	1MHz	1MHz
Video Bandwidth	100kHz	100kHz	100kHz	100kHz
Ranges	10	10	15	15
Sweep Time Per Range	Auto	Auto	Auto	Auto
Number of Sweeps Per Range	1	1	1	1
Detector	Peak	Peak	Peak	Peak
Reference Level	87dBuV	87dBuV	87dBuV	87dBuV
Internal Attenuation	0	0	0	0
Preamplifier On/Off	On	On	On	Off
Preselector On/Off	On	On	On	On
Amplifier Used	Yes	Yes	Yes	Yes

Test Parameters RE02				
	Range 9	Range 10	Range 11	
Start Frequency	12GHz	18GHz	26.5GHz	
Stop Frequency	18GHz	26.5GHz	30GHz	
RF Bandwidth	1MHz	1MHz	1MHz	
Video Bandwidth	100kHz	100kHz	100kHz	
Ranges	20	20	20	
Sweep Time Per Range	Auto	Auto	Auto	
Number of Sweeps Per Range	1	1	1	
Detector	Peak	Peak	Peak	
Reference Level	87dBuV	87dBuV	87dBuV	
Internal Attenuation	0	0	0	
Preamplifier On/Off	Off	Off	Off	
Preselector On/Off	On	Off	Off	
Amplifier Used	Yes	Yes	Yes	

Test Parameters RE02 Notch Frequencies				
	Range 1	Range 2	Range 3	
Start Frequency	2085MHz	2365MHz	7125MHz	
Stop Frequency	2097MHz	2395MHz	7155MHz	
RF Bandwidth	1kHz	1kHz	1kHz	
Video Bandwidth	100Hz	100Hz	100Hz	
Ranges	50	50	50	
Sweep Time Per Range	Auto	Auto	Auto	
Number of Sweeps Per Range	1	1	1	
Detector	Peak	Peak	Peak	
Reference Level	47dBuV	47dBuV	47dBuV	
Internal Attenuation	0	0	0	
Preamplifier On/Off	On	On	Off	
Preselector On/Off	Off	Off	Off	
Amplifier Used	Yes	Yes	Yes	

TABLE 2
RF CONDUCTED EMISSIONS
DETECTION SYSTEM PARAMETERS (Typical)

Test Parameters CE01 Power Lines			
	Range 1	Range 2	
Start Frequency	30Hz	1kHz	
Stop Frequency	1000Hz	14kHz	
RF Bandwidth	10Hz	10Hz	
Video Bandwidth	10Hz	10Hz	
Ranges	20	150	
Sweep Time Per Range	Auto	Auto	
Number of Sweeps Per Range	1	1	
Detector	Peak	Peak	
Reference Level	110dBuV	110dBuV	
Internal Attenuation	Auto	Auto	
Preamplifier On/Off	Off	Off	
Preselector On/Off	On	On	
Amplifier Used	No	No	

Test Parameters CE03Power Lines			
	Range 1	Range 2	Range 3
Start Frequency	10kHz	2MHz	30MHz
Stop Frequency	2MHz	30MHz	50MHz
RF Bandwidth	1kHz	10kHz	100kHz
Video Bandwidth	1kHz	10kHz	100kHz
Ranges	100	60	60
Sweep Time Per Range	Auto	Auto	Auto
Number of Sweeps Per Range	1	1	1
Detector	Peak	Peak	Peak
Reference Level	97dBuV	97dBuV	97dBuV
Internal Attenuation	0	0	0
Preamplifier On/Off	On	On	On
Preselector On/Off	On	On	On
Amplifier Used	No	No	No

Test Parameters CE01 Common mode			
	Range 1	Range 2	
Start Frequency	30Hz	1kHz	
Stop Frequency	1000Hz	14kHz	
RF Bandwidth	10Hz	10Hz	
Video Bandwidth	10Hz	10Hz	
Ranges	20	150	
Sweep Time Per Range	Auto	Auto	
Number of Sweeps Per Range	1	1	
Detector	Peak	Peak	
Reference Level	87dBuV	87dBuV	
Internal Attenuation	0dB	10dB	
Preamplifier On/Off	Off	Off	
Preselector On/Off	On	On	
Amplifier Used	No	No	

Test Parameters CE03 Common Mode			
	Range 1	Range 2	Range 3
Start Frequency	10kHz	2MHz	30MHz
Stop Frequency	2MHz	30MHz	50MHz
RF Bandwidth	1kHz	10kHz	100kHz
Video Bandwidth	1kHz	10kHz	100kHz
Ranges	100	60	60
Sweep Time Per Range	Auto	Auto	Auto
Number of Sweeps Per Range	1	1	1
Detector	Peak	Peak	Peak
Reference Level	97dBuV	97dBuV	97dBuV
Internal Attenuation	0	0	0
Preamplifier On/Off	On	On	On
Preselector On/Off	On	On	On
Amplifier Used	No	No	No

In all cases, the minimum scanning speed for each tuning band across the entire frequency range tested meets or exceeds the requirements of MIL-STD 461C.

4.4 RF Conducted and Radiated Emissions Bandwidth Requirements

The measurement receiver bandwidths listed in Tables 1 and 2 shall be used for Radiated and Conducted RF emission testing. The receiver bandwidths of the ESIB40 and TILE operating software does not allow bandwidths of 5Hz, 500Hz, 5 kHz and 50 kHz. The bandwidths used will be 10Hz, 1 kHz, 100 kHz and 100 kHz.

The Rohde and Schwarz ESIB 40 EMI Test Receiver will be used as the analog detection system for the RF conducted and radiated emissions testing.

4.5 Transducers Factors

All transducers used for the testing of the EUT are listed in Table 3 to 7. The actual transducer factors used for each test will be documented in the test report.

TABLE 3
CURRENT PROBE FACTORS
20Hz to 100MHz (Typical)

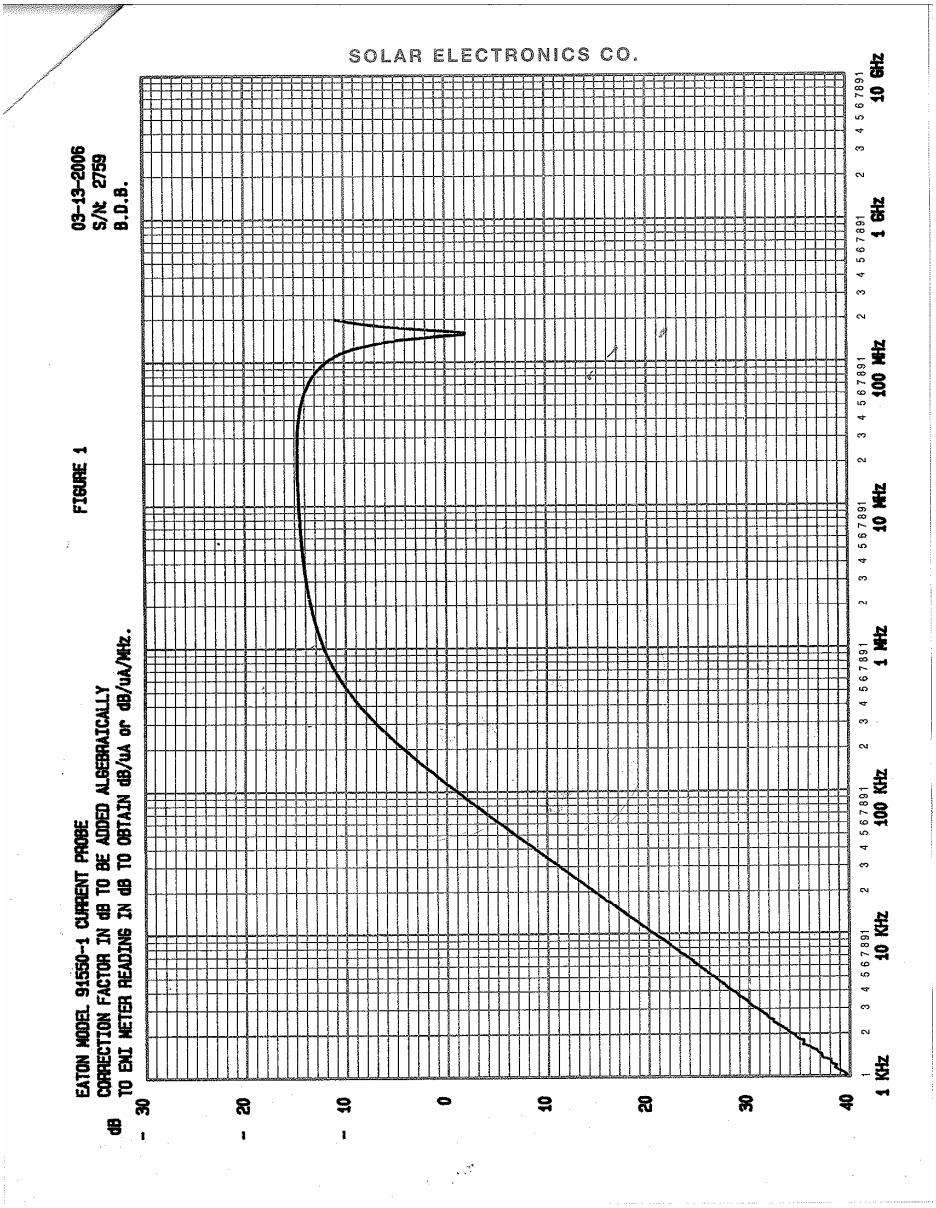


TABLE 4
ACTIVE MONOPOLE ANTENNA FACTORS
10kHz to 50MHz (Typical)

Date:
Client: Chomerics, Inc.
Manufacturer: EMCO
Model 3301
Serial 2901

Notes: Switch # 1 - OFF - 10 dB Input Attenuator
Switch # 2 - OFF - 30 dB Input Attenuator
Switch # 3 - OFF - 1.9 kHz Low Frequency Roll Off
Switch # 4 - OFF - 22.0 kHz Low Frequency Roll Off
Gain Switch OFF

Freq (MHz)	ACF (dB)
0.01	3.46
0.02	3.43
0.03	3.41
0.04	3.39
0.05	3.38
0.06	3.38
0.07	3.36
0.08	3.37
0.09	3.4
0.1	3.37
0.125	3.36
0.15	3.35
0.175	3.35
0.2	3.35
0.3	3.35
0.4	3.35
0.5	3.35
0.6	3.37
0.7	3.36
0.8	3.4
0.9	3.41
1	3.44
2	3.59
3	3.73
4	3.84
5	3.95
6	4.06
7	4.17
8	4.27
9	4.39
10	4.54
15	5.3
20	6.23
25	7.35
30	8.58
35	10.06
40	11.66
45	13.46
50	15.5

TABLE 5
BICONICAL ANTENNA FACTORS
20MHz to 300MHz (Typical)

Date Printed:
Customer Name: Chomerics, Inc.
Antenna Manufacturer: EMCO
Antenna Model: 3109
Antenna Serial No.: 2123
Temperature (Deg C): 17
Humidity (%): 52
Measurement Distance in Meters 1
Antenna Polarization = HORZ

NOTES: Calibrated with Liberty Labs.

CAL CERT 2001012308

Freq (MHz)	ACF (dB)	Gain (dBi)	Num GAIN
20.0000	18.4	-22.1	0.01
25.0000	15.5	-17.3	0.02
30.0000	14.2	-14.4	0.04
35.0000	13.3	-12.2	0.06
40.0000	12.5	-10.3	0.09
45.0000	11.7	-8.5	0.14
50.0000	10.9	-6.7	0.21
55.0000	10.0	-5.0	0.32
60.0000	9.0	-3.3	0.47
65.0000	8.5	-2.1	0.62
70.0000	8.8	-1.7	0.68
75.0000	7.6	0.1	1.02
80.0000	7.2	1:0	1.27
85.0000	7.4	1.4	1.37
90.0000	8.0	1.3	1.36
95.0000	8.6	1.2	1.31
100.0000	9.2	1.0	1.26
105.0000	9.9	0.7	1.19
110.0000	10.5	0.5	1.13
115.0000	11.1	0.3	1.07
120.0000	11.7	0.0	1.01
125.0000	12.2	-0.1	0.98
130.0000	12.6	-0.1	0.97
135.0000	12.8	0.0	1.00
140.0000	12.8	0.3	1.06
145.0000	12.9	0.6	1.14
150.0000	12.8	1.0	1.24
155.0000	12.6	1.4	1.38

160.0000	12.4	1.8	1.53
165.0000	12.2	2.4	1.72
170.0000	12.1	2.7	1.85
175.0000	12.2	2.8	1.92
180.0000	12.4	2.9	1.94
185.0000	12.7	2.8	1.91
190.0000	13.2	2.6	1.82
195.0000	13.8	2.2	1.67
200.0000	14.2	2.0	1.59
205.0000	14.6	1.8	1.53
210.0000	14.8	1.8	1.51
215.0000	15.2	1.7	1.48
220.0000	15.3	1.7	1.49
225.0000	15.5	1.7	1.48
230.0000	15.7	1.8	1.50
235.0000	15.7	1.9	1.55
240.0000	15.8	2.0	1.58
245.0000	16.0	2.0	1.59
250.0000	16.1	2.1	1.60
255.0000	16.3	2.0	1.60
260.0000	16.6	1.9	1.57
265.0000	17.1	1.6	1.43
270.0000	16.9	1.9	1.56
275.0000	17.1	1.9	1.54
280.0000	17.5	1.7	1.47
285.0000	17.9	1.4	1.37
290.0000	18.3	1.1	1.29
295.0000	18.9	0.7	1.19
300.0000	19.8	-0.1	0.99

TABLE 6
DOUBLE RIDGE GUIDE ANTENNA FACTORS
200MHz to 1,390MHz (Typical)

Date Printed:
Customer Name: Chomerics, Inc.
Antenna Manufacturer: EMCO
Antenna Model: 3106
Antenna Serial No.: 2212
Temperature (Deg C): 17
Humidity (%): 52
Measurement Distance in Meters 1
Antenna Polarization = HORZ

NOTES: 1 meter measured tip to tip.

CAL CERT 2001012301

Freq (MHz)	ACF (dB)	Gain (dBi)	Num GAIN
200.0000	12.0	4.2	2.64
210.0000	12.3	4.3	2.71
220.0000	12.9	4.1	2.58
230.0000	13.6	3.9	2.43
240.0000	13.5	4.3	2.71
250.0000	13.4	4.7	2.98
260.0000	13.2	5.3	3.36
270.0000	13.2	5.7	3.67
280.0000	13.3	5.8	3.82
290.0000	13.5	5.9	3.92
300.0000	13.8	5.9	3.90
310.0000	14.3	5.7	3.74
320.0000	14.9	5.4	3.50
330.0000	15.0	5.6	3.59
340.0000	15.0	5.8	3.79
350.0000	15.0	6.1	4.10
360.0000	15.0	6.3	4.25
370.0000	15.0	6.6	4.58
380.0000	14.8	7.0	4.97
390.0000	14.9	7.1	5.18
400.0000	14.7	7.5	5.69
410.0000	15.2	7.2	5.31
420.0000	15.3	7.4	5.45
430.0000	15.5	7.4	5.44
440.0000	16.2	6.9	4.88
450.0000	16.5	6.8	4.74
460.0000	16.7	6.8	4.77
470.0000	17.0	6.7	4.65
480.0000	17.4	6.4	4.37
490.0000	17.7	6.3	4.25

500.0000	17.7	6.5	4.47
510.0000	18.0	6.4	4.35
520.0000	17.9	6.6	4.62
530.0000	17.7	7.0	5.02
540.0000	17.6	7.2	5.28
550.0000	17.8	7.2	5.29
560.0000	17.9	7.2	5.29
570.0000	18.3	7.0	5.06
580.0000	18.7	6.8	4.80
590.0000	18.8	6.8	4.80
600.0000	19.2	6.6	4.53
610.0000	19.4	6.5	4.49
620.0000	19.4	6.7	4.64
630.0000	19.7	6.5	4.48
640.0000	19.5	6.8	4.81
650.0000	19.4	7.0	5.03
660.0000	19.5	7.1	5.17
670.0000	19.2	7.5	5.68
680.0000	19.0	7.8	6.03
690.0000	19.3	7.7	5.84
700.0000	19.9	7.2	5.28
710.0000	20.1	7.1	5.16
720.0000	20.0	7.4	5.49
730.0000	20.2	7.3	5.37
740.0000	20.4	7.2	5.21
750.0000	20.4	7.3	5.32
760.0000	19.9	7.9	6.15
770.0000	19.8	8.1	6.53
780.0000	20.0	8.0	6.34
790.0000	20.6	7.6	5.74
800.0000	20.9	7.4	5.49
810.0000	21.2	7.2	5.19
820.0000	21.6	6.8	4.83
830.0000	22.0	6.6	4.59
840.0000	22.1	6.6	4.52
850.0000	22.2	6.6	4.61
860.0000	22.3	6.6	4.58
870.0000	22.2	6.7	4.72
880.0000	22.4	6.7	4.64
890.0000	22.6	6.6	4.58
900.0000	22.9	6.4	4.40
910.0000	23.2	6.2	4.15
920.0000	23.6	5.9	3.85
930.0000	23.8	5.8	3.77
940.0000	23.9	5.7	3.75
950.0000	24.2	5.5	3.57
960.0000	24.5	5.3	3.40
970.0000	24.7	5.3	3.36
980.0000	24.7	5.4	3.44
990.0000	24.6	5.5	3.53
1000.0000	24.6	5.6	3.66

1010.0000	24.2	6.0	4.02
1020.0000	24.4	5.9	3.93
1030.0000	24.4	6.1	4.03
1040.0000	24.1	6.4	4.36
1050.0000	24.1	6.5	4.49
1060.0000	24.0	6.7	4.71
1070.0000	24.4	6.3	4.31
1080.0000	24.8	6.1	4.03
1090.0000	24.9	6.1	4.05
1100.0000	24.9	6.1	4.09
1110.0000	25.0	6.1	4.05
1120.0000	24.6	6.5	4.50
1130.0000	24.2	7.1	5.09
1140.0000	24.1	7.2	5.25
1150.0000	24.3	7.2	5.19
1160.0000	24.4	7.1	5.08
1170.0000	24.4	7.1	5.16
1180.0000	24.3	7.3	5.40
1190.0000	24.5	7.2	5.28
1200.0000	24.7	7.1	5.08
1210.0000	24.8	7.1	5.12
1220.0000	25.0	7.0	4.96
1230.0000	25.0	7.0	4.99
1240.0000	25.1	7.0	4.96
1250.0000	25.1	7.0	5.04
1260.0000	25.5	6.7	4.72
1270.0000	25.7	6.6	4.59
1280.0000	25.4	6.9	4.91
1290.0000	25.3	7.1	5.10
1300.0000	25.5	7.0	5.02
1310.0000	25.7	6.9	4.85
1320.0000	25.7	6.9	4.89
1330.0000	25.9	6.8	4.81
1340.0000	25.9	6.9	4.86
1350.0000	25.8	7.0	4.99
1360.0000	26.0	6.9	4.86
1370.0000	26.0	7.0	4.96
1380.0000	26.2	6.8	4.78
1390.0000	26.1	7.0	5.00

TABLE 7
DOUBLE RIDGE GUIDE ANTENNA FACTORS
1GHz to 18GHz (Typical)

Date of Calibration:
Date Printed On:
Customer Name: Chomerics, Inc.
Antenna Manufacturer: EMCO
Antenna Model: 3115
Antenna Serial No.: 2796
Temperature (Deg C).: 22
Humidity (%).: 31
Measurement Distance in Meters 1
Antenna Polarization = HORZ
NOTES:

FREQ MHz	ACF dB/m	Gain dBi	NUM Gain
1000.0000	22.9	7.3	5.37
1500.0000	24.6	9.1	8.11
2000.0000	27.2	9.0	7.98
2500.0000	28.0	10.1	10.28
3000.0000	30.1	9.7	9.27
3500.0000	31.4	9.7	9.29
4000.0000	32.7	9.5	8.94
4500.0000	32.4	10.9	12.29
5000.0000	33.1	11.1	12.82
5500.0000	34.6	10.4	11.06
6000.0000	34.7	11.0	12.66
6500.0000	34.4	12.0	15.95
7000.0000	36.3	10.8	12.11
7500.0000	37.3	10.4	10.97
8000.0000	36.8	11.4	13.91
8500.0000	37.4	11.4	13.86
9000.0000	37.8	11.5	13.98
9500.0000	37.3	12.5	17.72
10000.0000	38.0	12.2	16.44
10500.0000	38.5	12.1	16.31
11000.0000	38.5	12.5	17.77
11500.0000	39.8	11.6	14.40
12000.0000	40.5	11.2	13.32
12500.0000	39.7	12.5	17.69
13000.0000	40.0	12.5	17.70
13500.0000	41.2	11.6	14.38
14000.0000	41.0	12.1	16.30
14500.0000	40.0	13.5	22.22
15000.0000	39.3	14.5	27.87
15500.0000	37.6	16.4	44.02
16000.0000	37.7	16.6	45.21
16500.0000	40.8	13.7	23.55
17000.0000	41.4	13.4	22.07
17500.0000	44.8	10.2	10.55
18000.0000	45.5	9.8	9.56

TABLE 8
HORN ANTENNA FACTORS
18GHz to 26.5GHz (Typical)

18	33.6
18.5	33.9
19	34
19.5	34.1
20	34.1
20.5	34.3
21	34.5
21.5	34.8
22	34.6
22.5	34.8
23	35
23.5	35.2
24	35.3
24.5	35.4
25	35.5
25.5	35.9
26	35.8
26.5	36.1

TABLE 9
HORN ANTENNA FACTORS
26.5GHz to 40GHz (Typical)

26.5	35.8
27	35.9
27.5	36.1
28	36.1
28.5	35.8
29	36.2
29.5	36.1
30	36.3
30.5	36.4
31	36.6
31.5	36.7
32	36.7
32.5	36.4
33	36.9
33.5	37.1
34	37.8
34.5	37.7
35	37.9
35.5	37.9
36	37.7
36.5	38
37	38.1
37.5	37.7
38	37.3
38.5	37.3
39	38
39.5	38.7
40	39.3

5.0 EQUIPMENT UNDER TEST - SETUP

The Cosmic Ray Telescope for the Effects of Radiation (CRaTER) is the equipment under test (EUT).

5.1 Location and Configuration

The CRaTER and its associated cabling will be placed within the main test chamber. The DC power lines shall be filtered at the screen room wall with 10uF capacitors.

The CRaTER device and cabling shall be set up 5cm above the copper (ground plane) using non conductive standoffs (wood) within the shielded enclosure as shown in Figure 3.

The CRaTER cabling shall similar to the configuration used in the actual installation. The actual flight harness has yet to be built.

If the actual cable harness is not used then the cabling shall be at least 3.3 meters in length.

The CRaTER shall be placed inside a shielded room for all EMI tests. The CRaTER shall be placed on its mounting base and bonded to the copper ground plane as in a normal installation. All power and interface cabling needed to run the CRaTER shall be configured as close as possible to the actual installation during the time of the test setup.

A representative from MIT and the person conducting the test shall lay out the cables as close as possible to Figure 3. The MIT representative and the person conducting the test shall note the setup and lengths of the cables in the final test report.

All cables of the CRaTER shall be placed 5cm above the copper ground plane. The +31VDC power lines shall be placed 10 cm from the front of the ground plane with 5cm spacing between the hot and return line. The 1553 bus and 1 PPS test cable lines shall be placed behind the DC power lines with 5cm spacing between each line.

The DC power, 1 PPS test cable and one 1553 bus line shall be routed to the bulkhead wall. The DC power shall be routed to the DC power supply located outside the test chamber through 10uF capacitors. The 1 PPS test cable shall be routed through the bulkhead wall via a 9 pin RS232 D sub connector. The 1553 bus line shall be connected to a twinax bulkhead coaxial connector. The output of the connector shall be connected to the spacecraft simulator.

The remaining 1553 bus line and 1 PPS test cable shall be placed on the test bench 5cm above the groundplane.

The input voltages to the EUT shall be supplied via the 10μF capacitors in accordance with the MIL-STD-462 setup procedures.

A probing technique shall be used initially to locate the position of maximum radiation from the CRaTER over the frequency range of each antenna. During formal measurements, the antenna shall be located at the position of maximum radiation as determined by the probing technique.

If no well defined position of maximum radiation is found by the probing technique, the antenna shall be placed in a position judged by the test personnel to offer the greatest possibility for detecting radiation (i.e., position the antenna near or facing cable entrances, control panels, air intakes, and exhausts, covers, doors, and openings).

5.2 Bonding and Grounding

The CRaTER shall be bonded to the ground plane as in normal installation. All grounds connections shall be documented in the test report. The DC continuity tests shall be performed on the chassis with a minimum of 50milli Ohms DC resistance required.

5.3 Support Equipment

Support equipment will be required for this test. The CRaTER will be setup and tested as outlined within Figure 3. The support equipment used to monitor the EUT shall be located adjacent to the test chamber. The support equipment shall be monitored and maintained by MIT test personnel.

FIGURE 2
INTERFACE CONTROL DRAWING

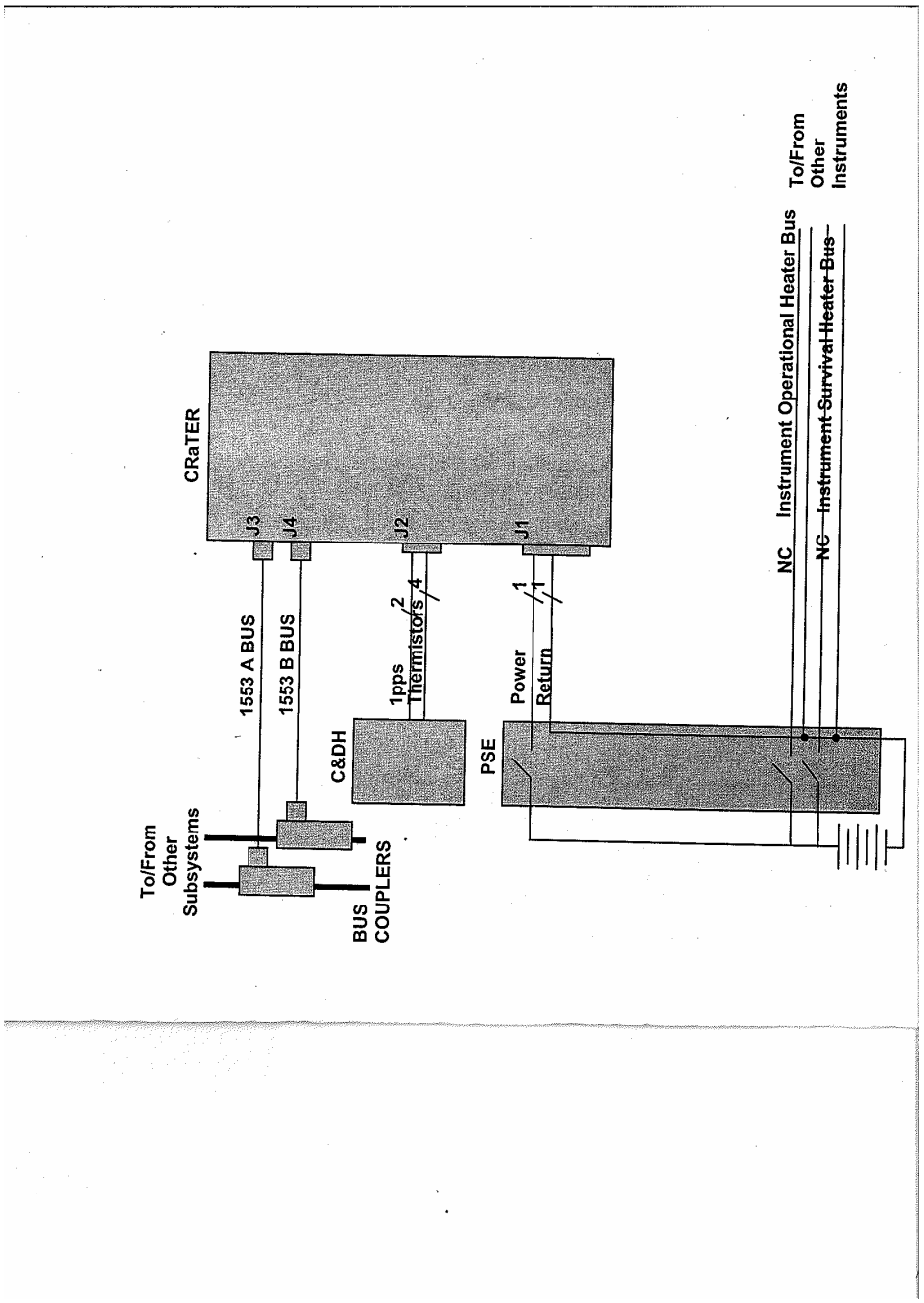
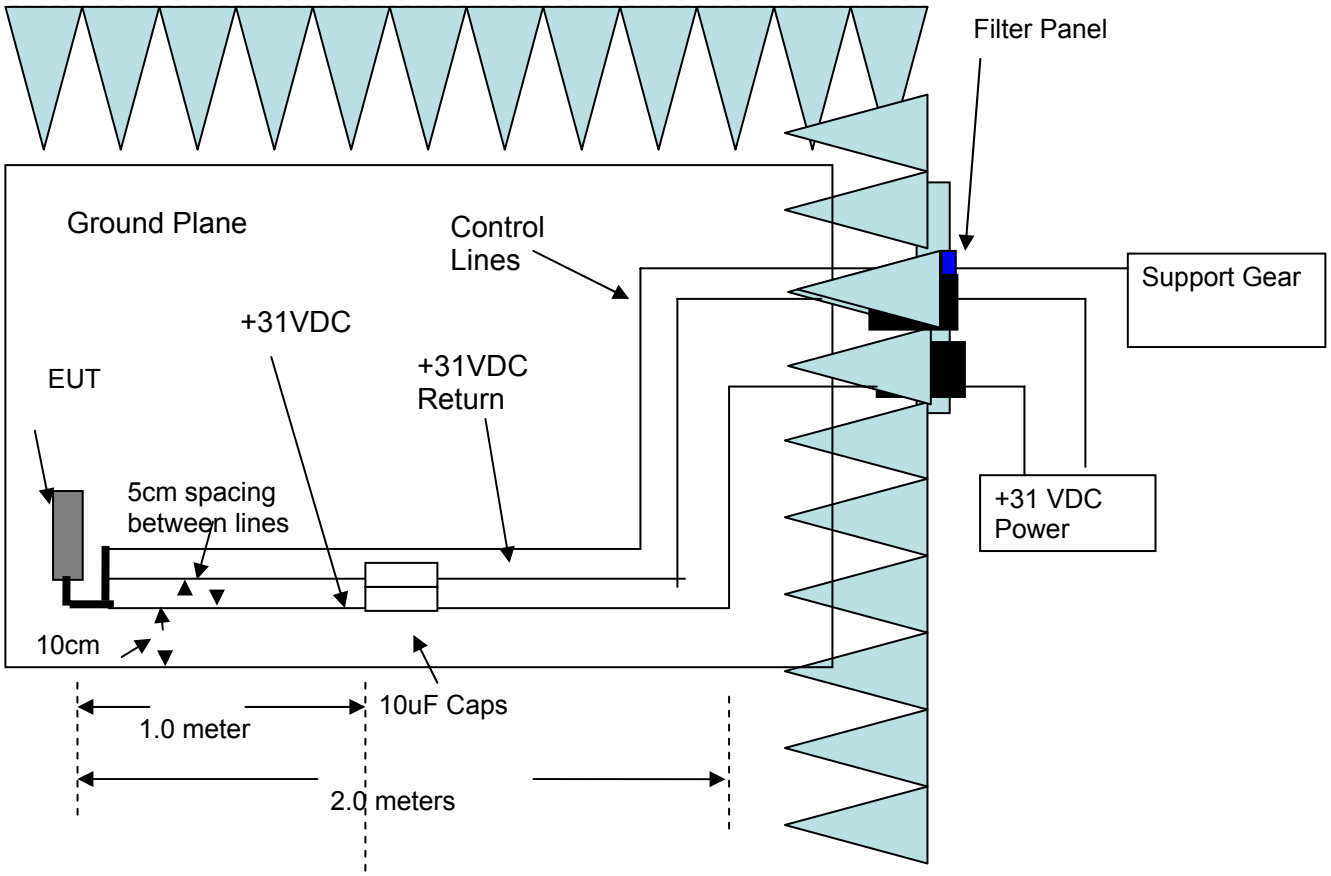


FIGURE 3
GENERAL TEST SETUP



6.0 EQUIPMENT UNDER TEST - OPERATION

6.1 Mode of Operation

The MIT CRaTER has only one mode of operation. This is the power on mode.

The MIT CRaTER shall be tested for emission and susceptibility while in the normal power on mode of operation.

6.2 Performance Checks

An operational check shall be performed on the CRaTER during and after each susceptibility test.

If errors have been introduced, the test shall be re-executed to determine duplicity of results. Precise information concerning the source of the error shall be identified, and susceptibility thresholds shall be recorded.

An operational check shall be performed on the CRaTER during each susceptibility test.

A Short Form Functional test shall be performed to demonstrate basic aliveness. When finished, the instrument will be left running. When necessary to secure instrument power to reconfigure for EMC testing, return to this powered up state before continuing.

A data log (sf_log) can be left running continuously for all emission tests. For each susceptibility test, a log shall be started for each test.

During each susceptibility test, the analog housekeeping shall be monitored for spurious readings. With the internal calibration source on, one can monitor the analog noise present on the data. See Section 5 of the CRaTER EMC Test Procedure Drawing. 32-06006.01

Pre- and Post-test performance checks shall be performed for each test.

A post-test performance check can be utilized as a pre-test for the next test to be performed.

The instrument shall be purged prior to returning the instrument to storage after testing.

6.3 Failure Criteria

Emissions tests:
For emissions tests, the EUT shall not radiate or conduct signals above the applicable limits.

Susceptibility tests:
For susceptibility tests, any failure which causes degradation in performance outside the limits of normal operation will be noted in the test report. The EUT shall be monitored by MIT representatives for any degradation in performance.

7.0 TEST MEASUREMENTS

7.1 Conducted Emissions (Power Leads 30Hz to 50MHz) CE01/CE03

Conducted emission measurements in the frequency range 30Hz to 50MHz shall be made on the input DC power leads of the EUT. They are as follows:

1. +31VDC Hot Line
2. +31VDC Return Line
3. +31VDC Power Bundle

7.1.1 Conducted Emissions Test Method

The CRaTER shall be set up as in MIL-STD-462 and Figure 4 of this test plan. The CRaTER shall be placed inside a shielded room. The CRaTER shall be bonded to the copper ground plane as in a normal installation.

The test method of CE01 and CE03 of MIL-STD-462 shall be employed.

Using the test set-up of Figure 4, connect the current probe on the Hot line. Activate the EUT in its mode of operation as stated in Section 6.1. Tune the receiver through the frequency range of 30Hz to 50MHz.

Repeat the test on the return line. A common mode test shall also be performed by testing the hot and return lines bundled together.

A peak detector shall be used for all tests.

Test Equipment

Description	Asset#	Serial#
Rohde and Schwarz ESIB 40 EMI Test Receiver	803	1088.7490
Quantum Change/EMC Systems, LLC T.I.L.E. Software Version 3.4.K.13	N/A	N/A
Dell Desktop Computer	N/A	N/A
Dell Flat Panel Monitor	N/A	N/A
Solar 6741-1 Current Probe	468	901610

7.1.2 Mode of Operation

The EUT shall be tested in the normal mode of operation as listed in Section 6.1 of this test plan.

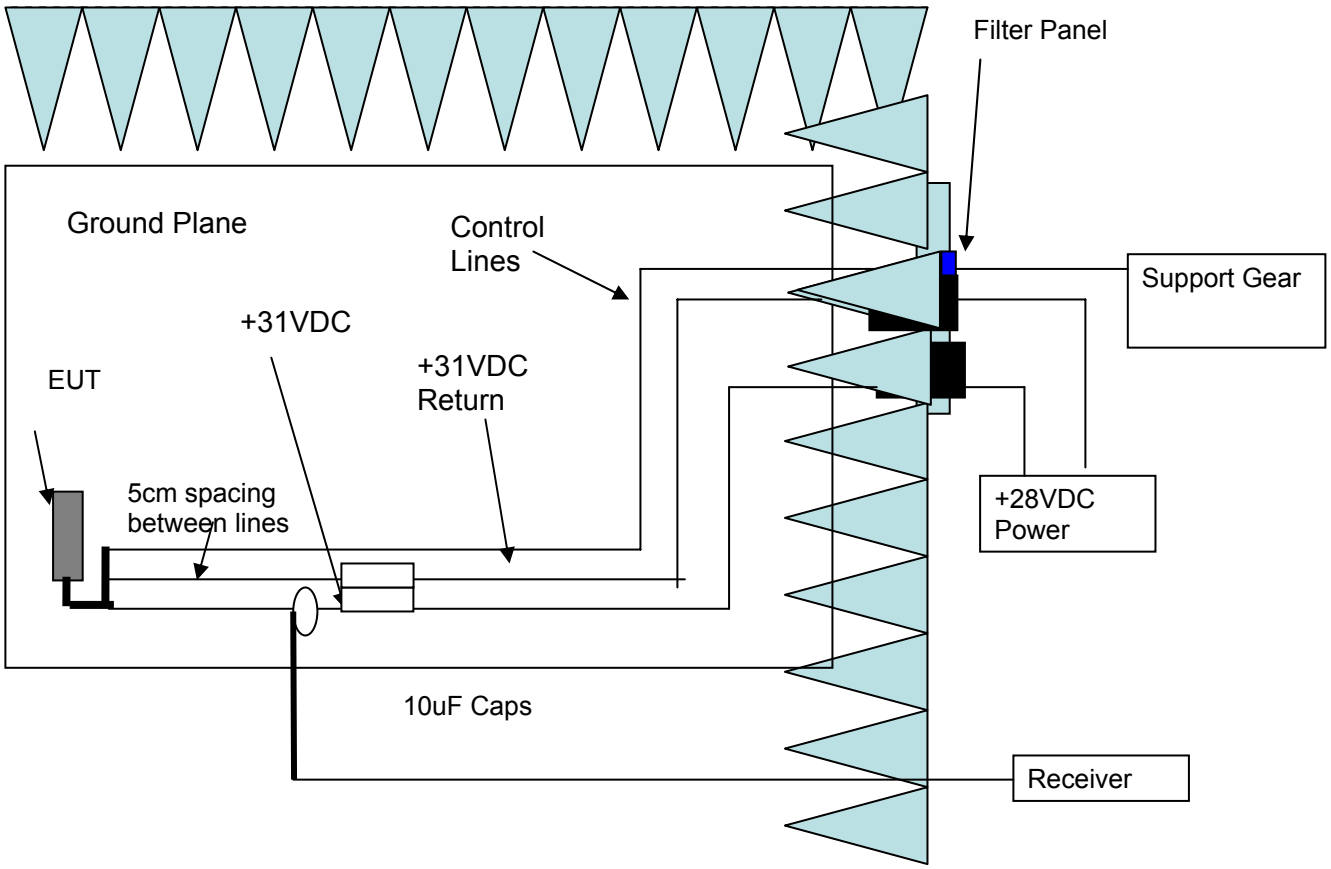
7.1.3 Pass/Fail Criteria

Electromagnetic emissions in the frequency range of 30Hz to 50MHz shall not appear on the leads over the applicable limit as shown on Graph 1.

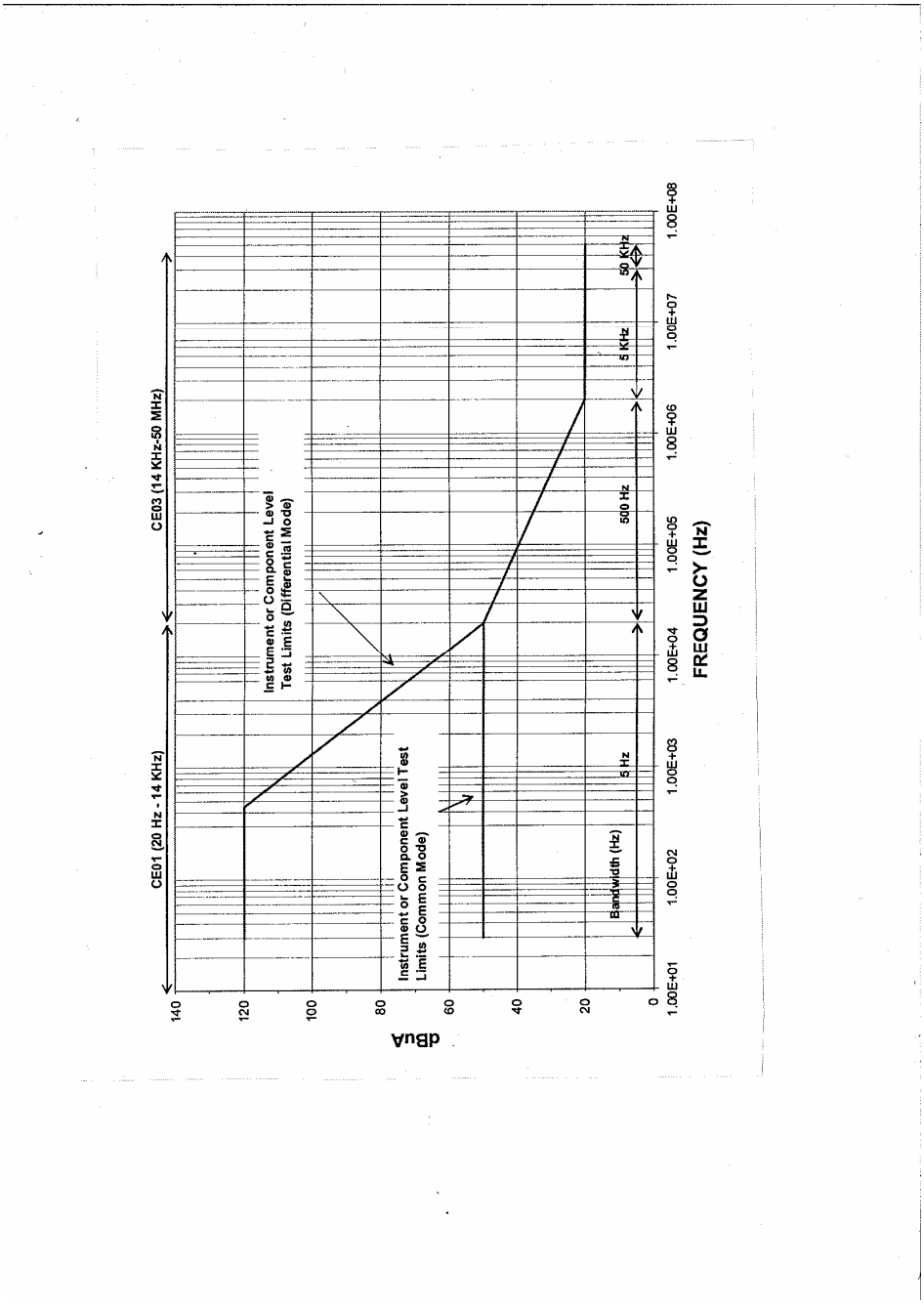
7.1.4 Data Presentation

Data presentation shall be as follows:
Continuously and automatically plot amplitude versus frequency profiles.
Display the applicable limit on each plot.

FIGURE 4
CE01/CE03 TEST SETUP



GRAPH 1
CE01/CE03 LIMIT



7.2 Conducted Sine Wave Susceptibility (Power Line Audio Frequency) CS01

Conducted sine wave susceptibility tests (CS01) shall be performed in the frequency range of 30Hz to 50 kHz on the DC power leads of the CRaTER. They are as follows:

1. +31VDC Hot Line
2. +31VDC Return Line

7.2.1 Conducted Susceptibility Test Method

The CRaTER shall be set up as in MIL-STD-462 and Figure 5 of this test plan. The CRaTER shall be placed inside a shielded room. The CRaTER shall be bonded to the copper ground plane as in a normal installation.

The test method of CS01 of MIL-STD-462 shall be employed.

A 10uF capacitor shall be placed across the 31VDC input lines.

The CRaTER shall be subjected to the electromagnetic energies injected on the DC power input leads from 30Hz to 50 kHz, as shown on Graph 2.

Using the test set-up of Figure 5, connect the series coupling transformer as close as possible, from the point where the power leads exit the EUT. Activate the EUT in its mode of operation as stated in Section 6.1. Tune the oscillator through the frequency range of 30Hz to 50 kHz with the desired voltage while monitoring the EUT for any failure. The sweep time shall be a minimum of 3 minutes per Octave.

Should performance degradation occur, reduce the injected signal level until normal operation is restored. Record the frequency, threshold level, and nature of performance degradation.

Test Equipment

Description	Asset#	Serial#
HP 3326A Signal Generator	37	2519A007503
Solar Transformer 7033-1	283	N/A
Solar Audio Amplifier 8500-1	55	915620
RF Power Labs 220-1K60 KW Driver	418	153497
HP 83640B Signal Generator	38	3001A00119
Solar 9226.05 Precision Resistor	192	N/A
Tektronix 7B10 Time Base	154	B060353
Tektronix 7A26 Dual Trace Amp	152	B130224
Tektronix 7844 Scope	59	B142861

7.2.2 Mode of Operation

The CRaTER shall be tested in the mode of operation listed in Section 6.1 "Mode of Operation" within this test plan.

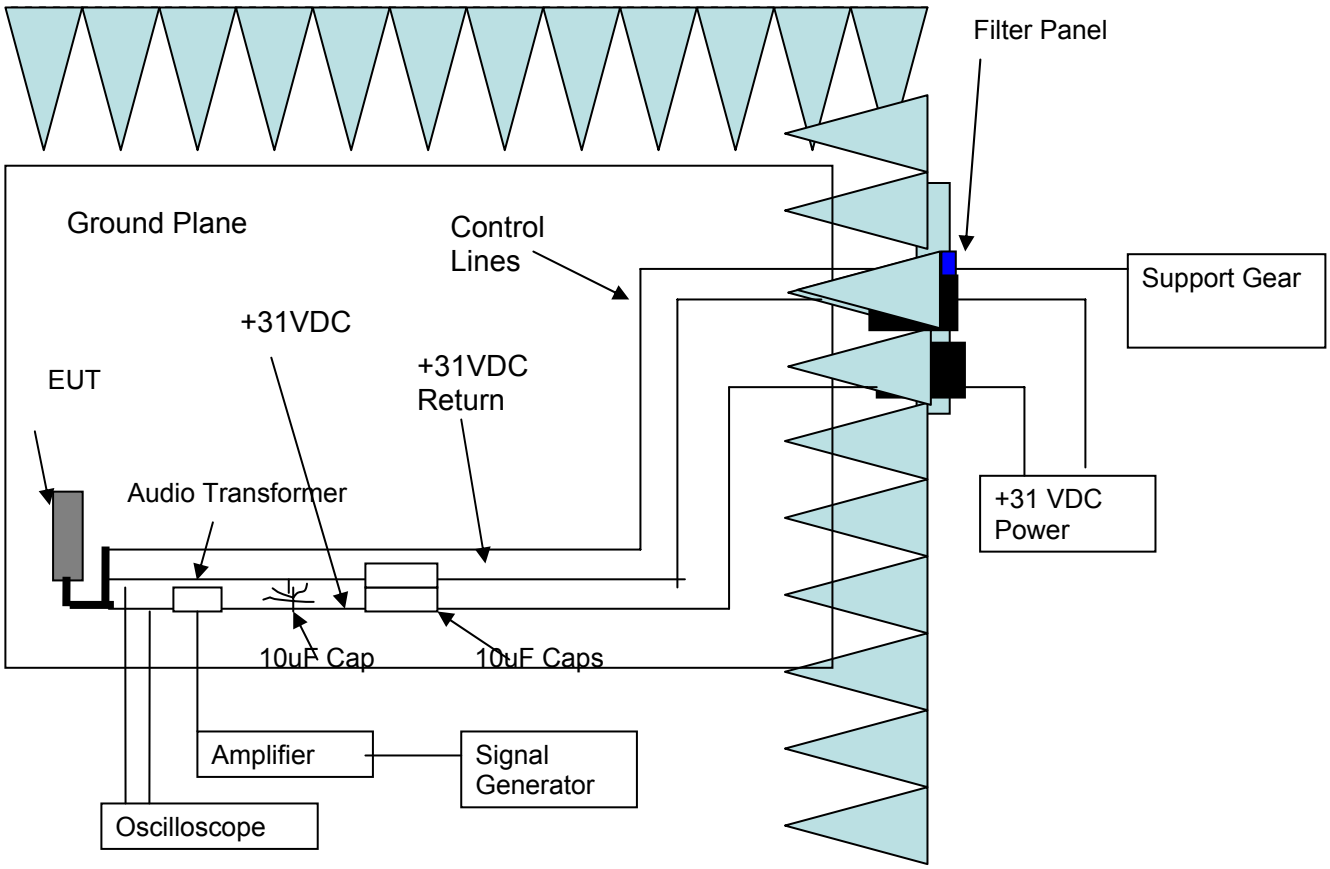
7.2.3 Pass/Fail Criteria

The CRaTER shall not exhibit any malfunction, degradation of performance or deviation from the mode of operation, which exceed the limits listed in Section 6.3 "Failure Criteria" within this test plan. The MIT representative shall determine at the time of the test if the CRaTER passes or fails to meet the performance criteria.

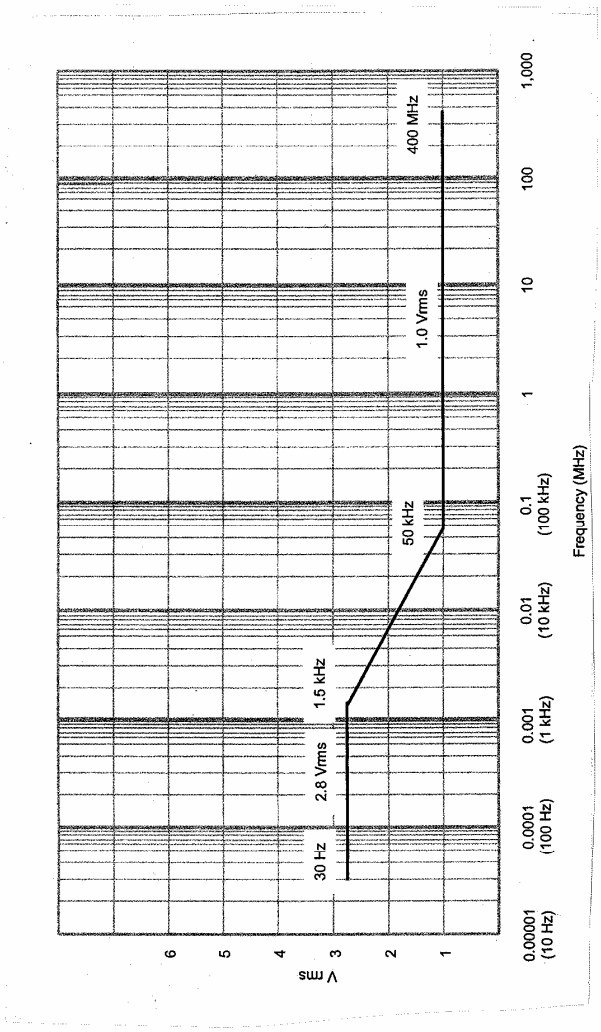
7.2.4 Data Presentation

Data presentation shall be as follows:
Provide tables showing scanned frequency and test levels.
Provide any susceptibility thresholds that were determined, along with their associated frequencies.

FIGURE 5
CS01 TEST SETUP



GRAPH 2
CS01/CS02 LIMIT



7.3 Conducted Sine Wave Susceptibility (Radio Frequency) CS02

Conducted sine wave susceptibility tests (CS02) shall be performed in the frequency range of 50 kHz to 400MHz on the DC power leads of the CRaTER. They are as follows:

1. +31VDC Hot Line
2. +31VDC Return Line

7.3.1 Conducted Susceptibility Test Method

The CRaTER shall be set up as in MIL-STD-462 and Figure 6 of this test plan. The CRaTER shall be placed inside a shielded room. The CRaTER shall be bonded to the copper ground plane as in a normal installation.

The test method of CS02 of MIL-STD-462 shall be employed.

The CRaTER shall be subjected to the electromagnetic energies injected on the DC power input power leads from 50 kHz to 400MHz.

A 20mH inductor shall be placed in series with the +31VDC hot line.

The CRaTER shall be subjected to the electromagnetic energies injected on the DC power input leads from 50 kHz to 400MHz, as shown on Graph 2.

Using the test set-up of Figure 6, connect the coupling capacitor within 5cm from the point the +31VDC hot lead exit the CRaTER. Activate the EUT in its mode of operation as stated in Section 6.1. Tune the oscillator through the frequency range of 50 kHz to 400MHz with the desired voltage while monitoring the EUT for any failure. Repeat the test for the +31VDC return line. The sweep time shall be 3 minutes per octave.

Should performance degradation occur, reduce the injected signal level until normal operation is restored. Record the frequency, threshold level, and nature of performance degradation.

Test Equipment

Description	Asset#	Serial#
HP 3326A Signal Generator	37	2519A007503
Solar Audio Amplifier 8500-1	55	915620
RF Power Labs 220-1K60 KW Driver	418	153497
Chomerics .7 uF capacitor	N/A	N/A
HP 83640B Signal Generator	38	3001A00119
Tektronix 7B10 Time Base	154	B060353
Tektronix 7A26 Dual Trace Amp	152	B130224
Tektronix 7844 Scope	59	B142861

7.3.2 Mode of Operation

The CRaTER shall be tested in the mode of operation listed in Section 6.1 "Mode of Operation" within this test plan.

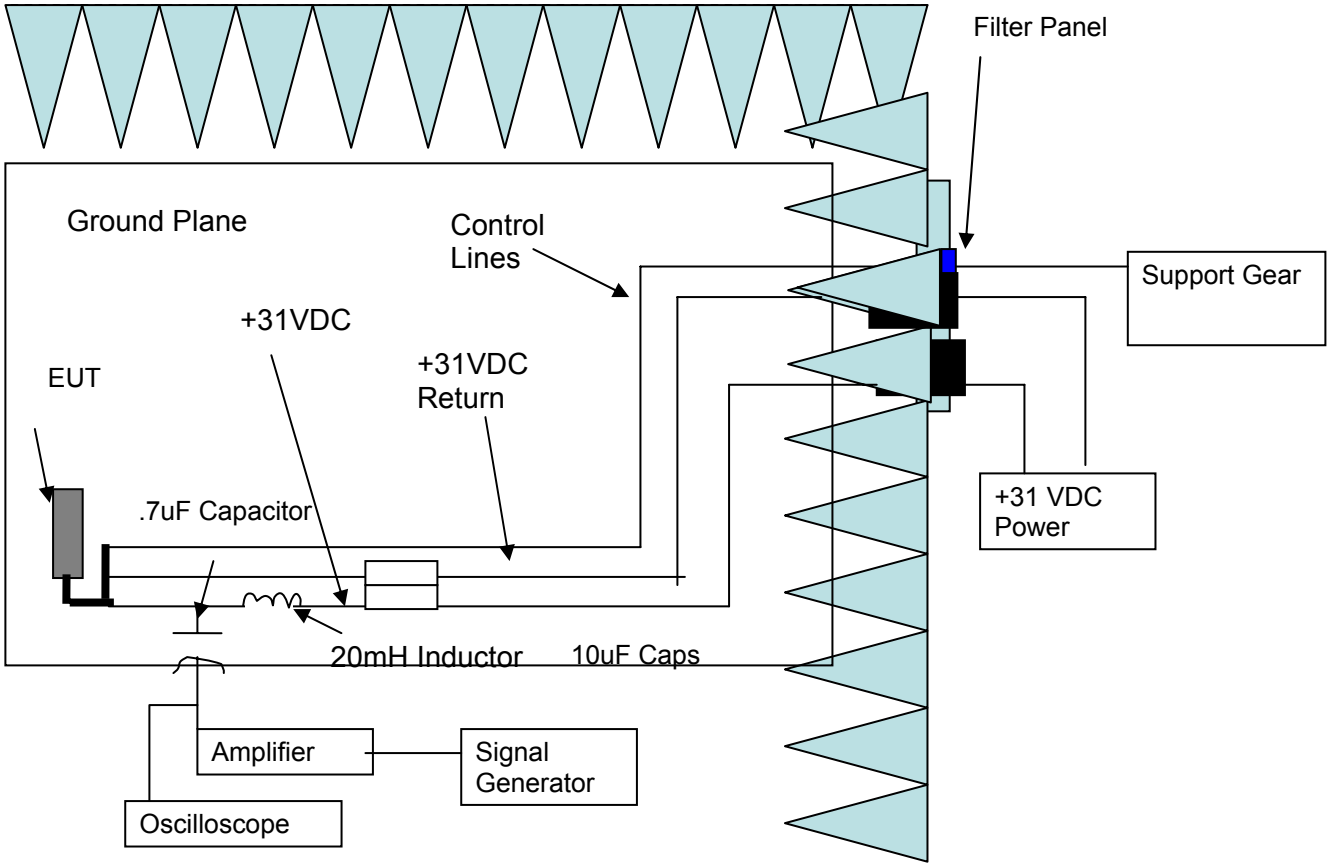
7.3.3 Pass/Fail Criteria

The CRaTER shall not exhibit any malfunction, degradation of performance or deviation from the mode of operation, which exceed the limits listed in Section 6.3 "Failure Criteria" within this test plan. The MIT representative shall determine at the time of the test if the CRaTER passes or fails to meet the performance criteria.

7.3.4 Data Presentation

Data presentation shall be as follows:
Provide tables showing scanned frequency and test levels.
Provide any susceptibility thresholds that were determined, along with their associated frequencies.

FIGURE 6
CS02 TEST SETUP



7.4 Conducted Susceptibility (Power Line Transients) CS06

Conducted transient susceptibility tests (CS06) shall be performed on the DC power leads of the CRaTER. They are as follows:

1. +31VDC Hot Line
2. +31VDC Return Line

7.4.1 Conducted Transient Susceptibility Test Method

The CRaTER shall be set up as in MIL-STD-462 and Figure 7 of this test plan. The CRaTER shall be placed inside a shielded room. The CRaTER shall be bonded to the copper ground plane as in a normal installation.

The test method of CS06 of MIL-STD-462 shall be employed.

The CRaTER shall be subjected to the electromagnetic energies injected on the DC power input leads.

Test Voltage	+25V
Spike Duration	10uS
Pulse per Second	10
Duration Minutes	5

Test Voltage	-31V
Spike Duration	10uS
Pulse per Second	10
Duration Minutes	5

Using the test set-up of Figure 7, connect the coupling transient generator's parallel output as close as possible, from the point the DC power leads exit the CRaTER. Activate the EUT in its mode of operation as stated in Section 6.1. Increase the voltage output to the desired level while monitoring the EUT for any failure.

The pulse shall be limited to an absolute voltage limit of +56VDC and a minimum of 0VDC. See Graph 3.

Should performance degradation occur, reduce the injected signal level until normal operation is restored. Record the frequency, threshold level, and nature of performance degradation.

Test Equipment

Description	Asset#	Serial#
Solar 8282-1 Transient Generator	169	8399-53
Solar 7144-5 5 ohm Resistor	299	N/A
HP 83640B Signal Generator	38	3001A00119
Tektronix 7B10 Time Base	154	B060353
Tektronix 7A26 Dual Trace Amp	152	B130224
Tektronix 7844 Scope	59	B142861

7.4.2 Mode of Operation

The CRaTER shall be tested in the mode of operation listed in Section 6.1 "Mode of Operation" within this test plan.

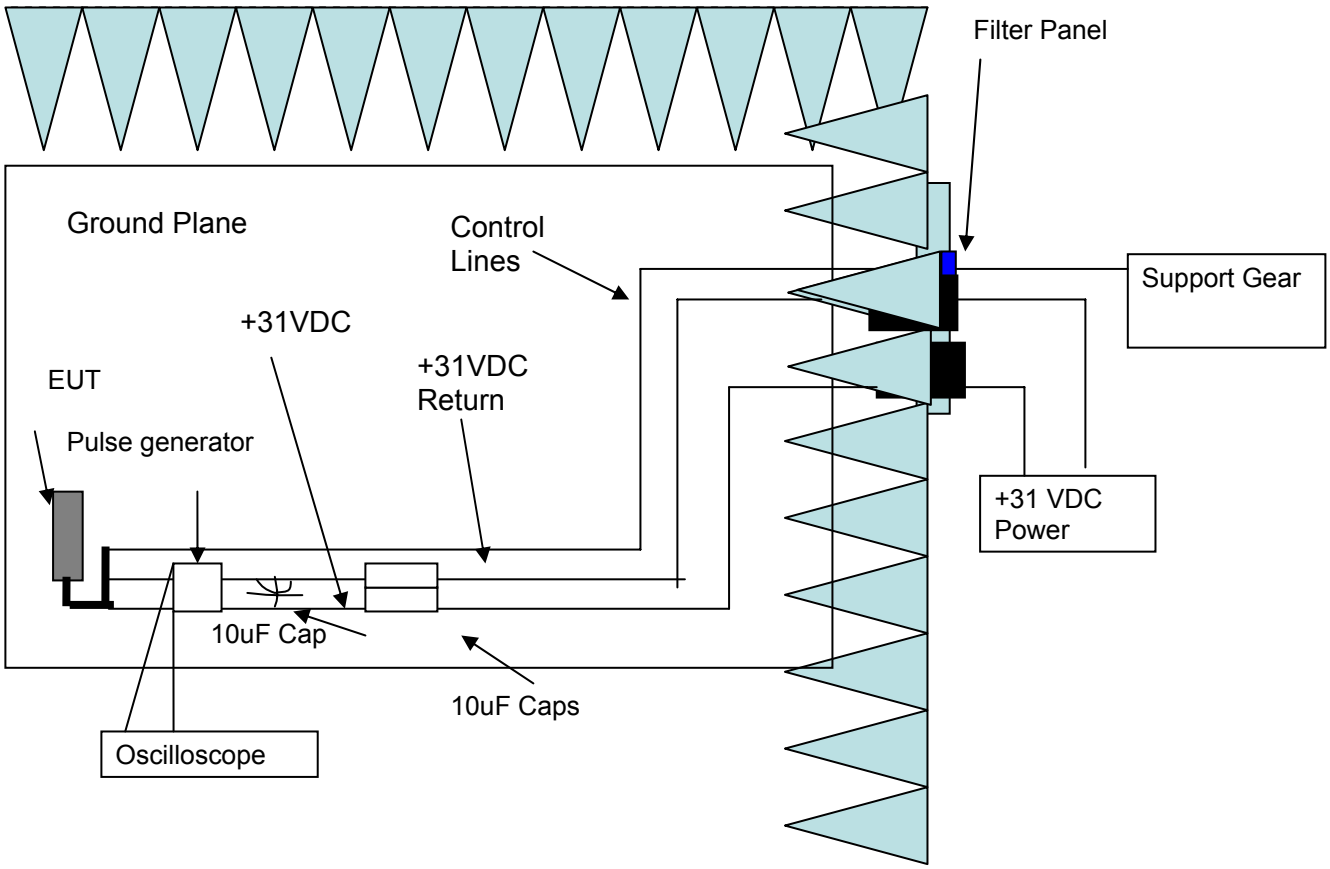
7.4.3 Pass/Fail Criteria

The CRaTER shall not exhibit any malfunction, degradation of performance or deviation from the mode of operation, which exceed the limits listed in Section 6.3 "Failure Criteria" within this test plan. The MIT representative shall determine at the time of the test if the CRaTER passes or fails to meet the performance criteria.

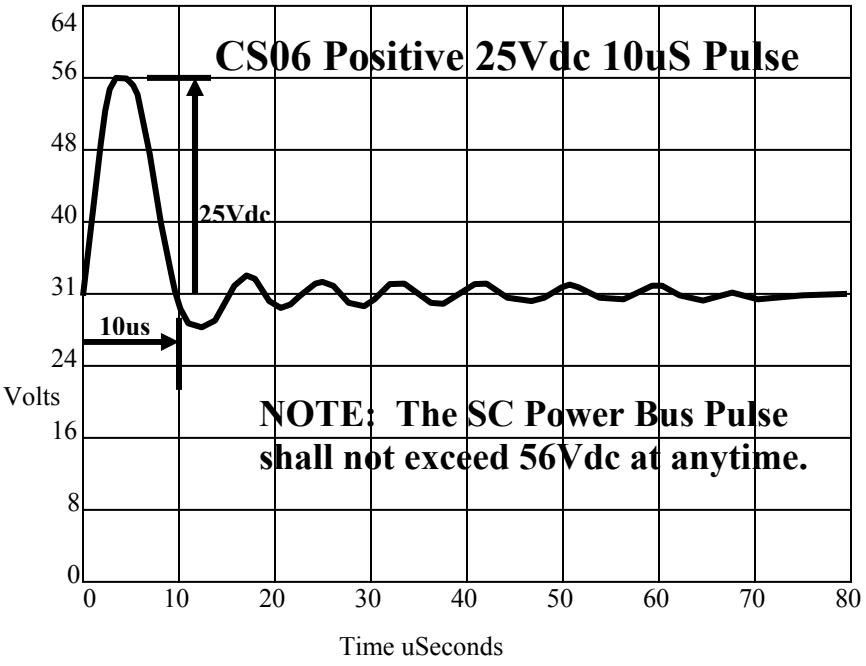
7.4.4 Data Presentation

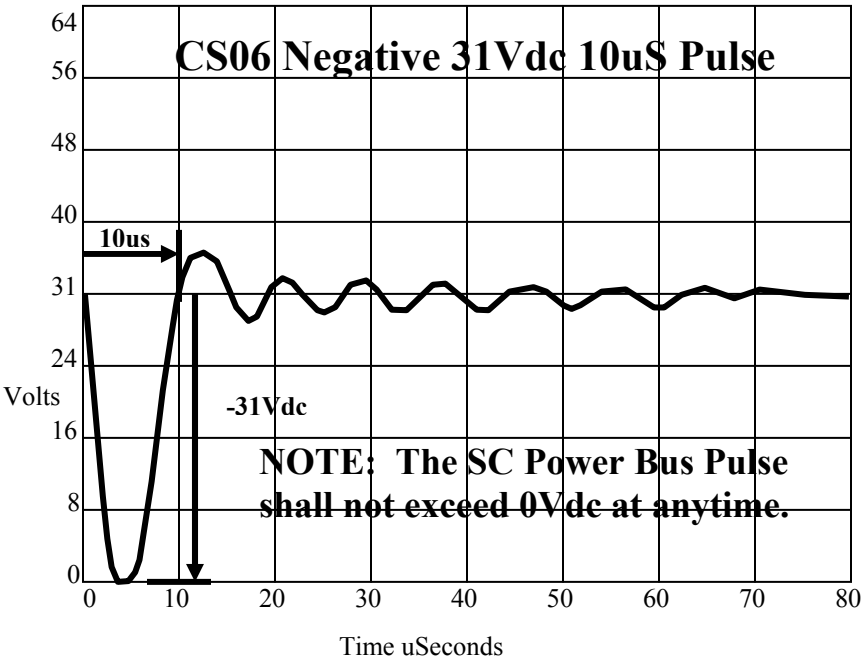
Data presentation shall be as follows:
Provide graphical or tabular data showing the amplitude at which the test was conducted.
Provide any susceptibility thresholds that were determined for the power line.

FIGURE 7
CS06 TEST SETUP



GRAPH 3
CS06 LIMIT





7.5 Radiated Electric Field Emissions RE02

Radiated electric field emissions (RE02) in the frequency 14 kHz to 30GHz shall be measured using the test procedures of MIL-STD-462.

7.5.1 Radiated Electric Field Emissions Test Method

The CRaTER shall be set up as in MIL-STD-462 and Figure 8 of this test plan. The CRaTER shall be placed inside a shielded room. The CRaTER shall be bonded to the copper ground plane as in a normal installation.

The test method of RE02 of MIL-STD-462 shall be employed.

The CRaTER shall be set up and configured as required by MIL-STD-462 and Figure 8 of this test plan.

A probing technique shall be used initially to locate the position of maximum radiation from the CRaTER over the frequency range of each antenna. For each frequency range, record the surface and levels which yield worst case emissions on all surfaces that show peak emissions within 3dB of the limit. During formal measurements, the antenna shall be located at the position of maximum radiation as determined by the probing technique. If no well defined position of maximum radiation is found by the probing technique, the antenna shall be placed in a position judged by the test personnel to offer the greatest possibility for detecting radiation (i.e., position the antenna near or facing cable entrances, control panels, air intakes, and exhausts, covers, doors, and openings).
A peak detector shall be used for all tests. A narrowband scan shall be performed.

The CRaTER shall be tested to the Component and Instrument levels shown in Graph 4.

When performing the radiated emission measurements, no point of the measuring antenna shall be less than 1 meter to the walls of the shielded enclosure or any obstruction. Exceptions to this rule are as follows:

1. The end of a rod antenna shall not be closer than 30cm to the shielded enclosure ceiling.

2. The ends of the Biconical antenna shall not be closer than 30cm to ceiling and floor of the shielded enclosure when measuring vertical polarization.

3. All antennas used shall be placed on the same level as the EUT.

For radiated emission measurements between 20MHz and 30GHz, the Biconical and horn antennas shall be positioned alternately to measure the vertical and horizontal components of the emission.

Test Equipment

Description	Asset#	Serial#
Rohde and Schwarz ESIB 40 EMI Test Receiver	803	1088.7490
Quantum Change/EMC Systems, LLC T.I.L.E. Software Version 3.4.K.13	N/A	N/A
Dell Desktop Computer	N/A	N/A
Dell Flat Panel Monitor	N/A	N/A
EMCO 3301 Monopole Antenna	426	1148
EMCO 3109 Biconical Antenna	82	2054
EMCO 3106 Ridge Guide Antenna	120	2212
EMCO 3115 Ridge Guide Antenna	376	2175

7.5.2 Mode of Operation

The CRaTER shall be tested in the mode of operation listed in Section 6.1 "Mode of Operation" within this test plan.

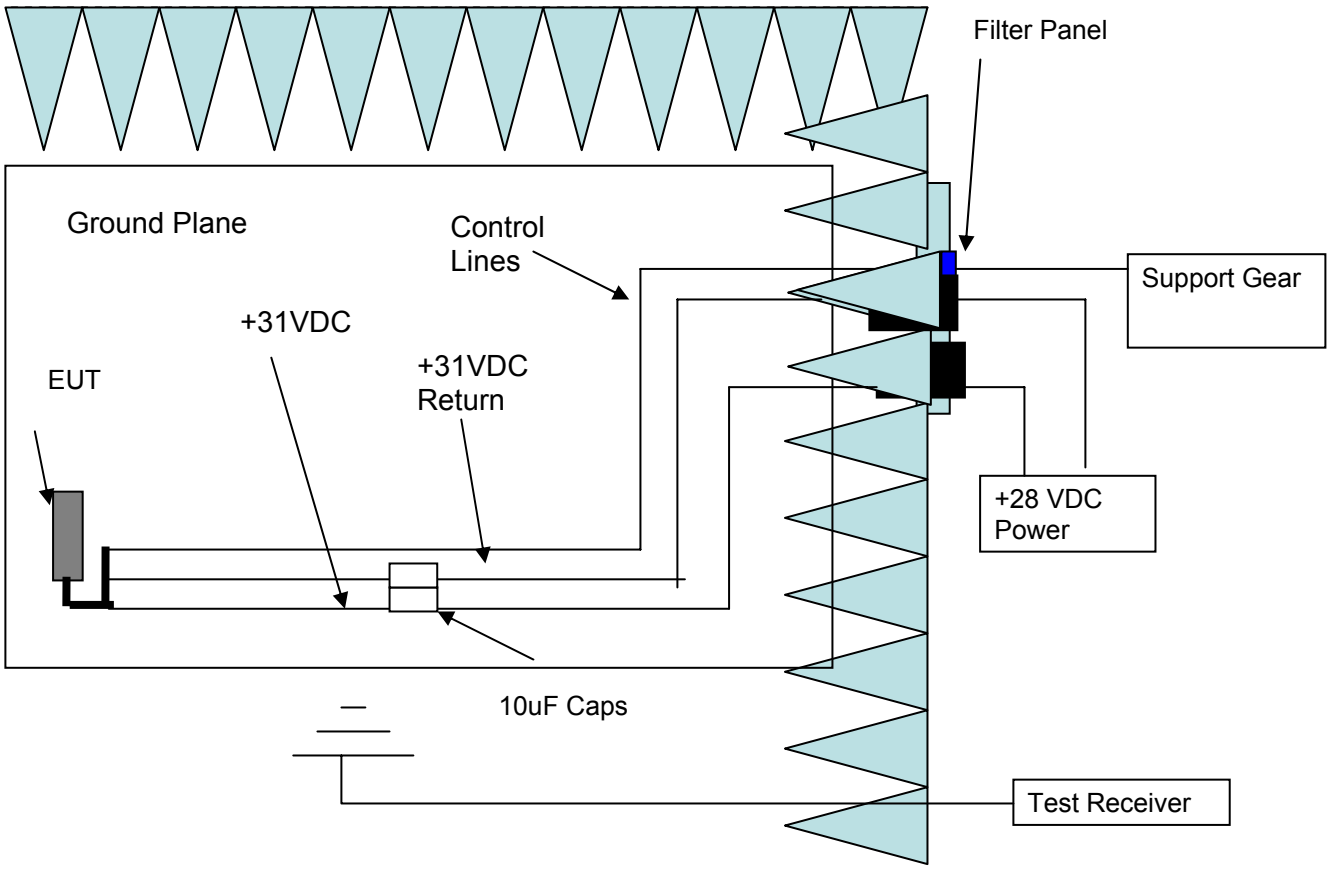
7.5.3 Pass/Fail Criteria

Electric field emissions in the frequency range of 14 kHz to 30GHz not radiated in excess of the levels shown on Graph 4 (Upper Limit).

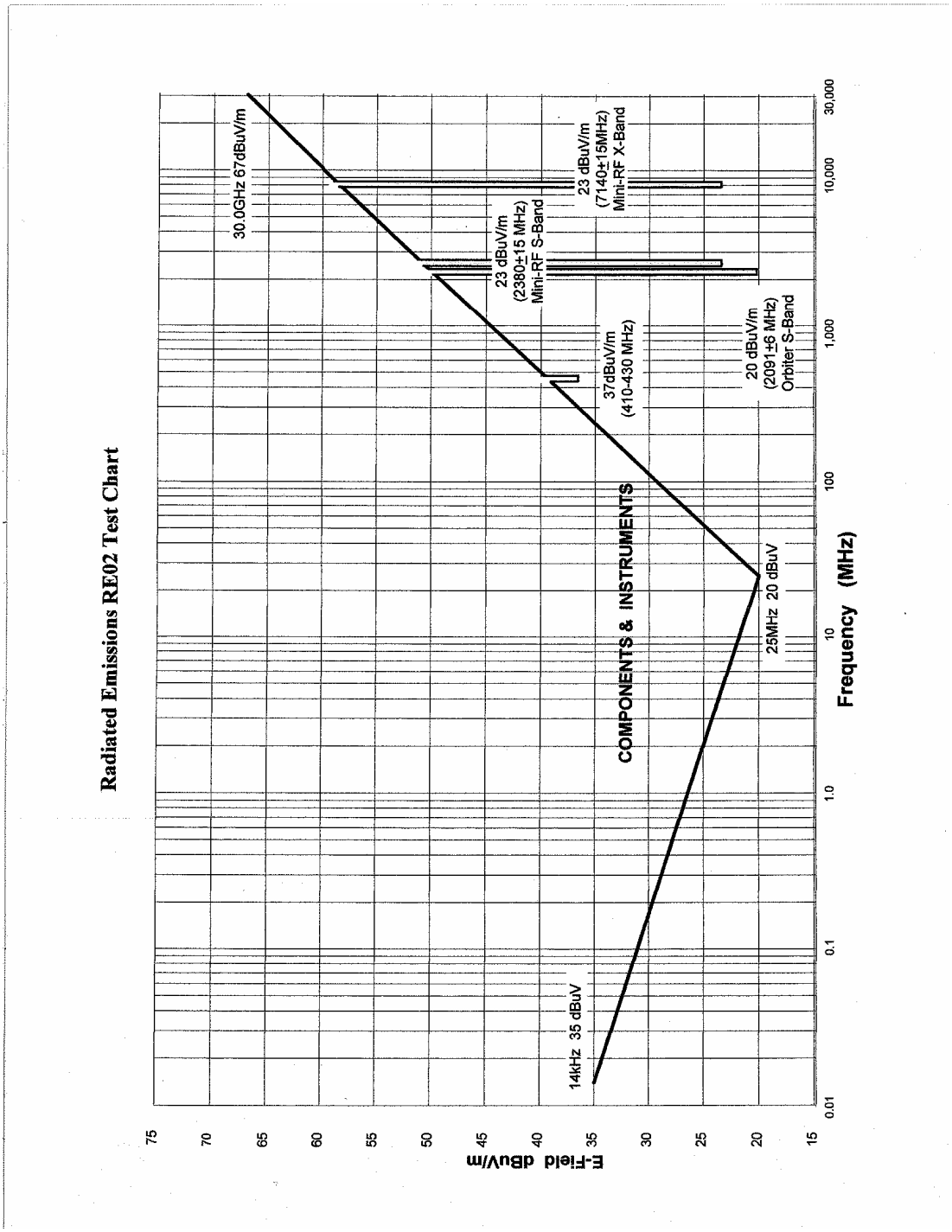
7.5.4 Data Presentation

Data presentation shall be as follows:
Continuously and automatically plot amplitude versus frequency profiles.
Vertical and horizontal data for a particular frequency range shall be presented on separate plots or shall be clearly distinguishable in black or white format for a common plot.
Display the applicable limit on each plot.

FIGURE 8
RE02 TEST SETUP



GRAPH 4
RE02 LIMIT



7.6 Radiated Electric Field Susceptibility RS03

Electric field susceptibility tests shall be performed over the frequency range of 14 kHz to 30GHz. The radiated fields shall be directed at the CRaTER.

7.6.1 Radiated Electric Field Susceptibility Test Method

The CRaTER shall be set up as in MIL-STD-462 and Figure 9 of this test plan. The CRaTER shall be placed inside a shielded room. The CRaTER shall be bonded to the copper ground plane as in a normal installation.

The test method of RS03 of MIL-STD-462 shall be employed. The CRaTER shall be subjected to the radiated electric fields as stated in Tables 10 and 11.

Using the test set-up of Figure 9, the radiating antenna shall be placed in front of the CRaTER at a distance of 1 meter unless otherwise specified by the test setups. Activate the EUT in its mode of operation as stated in Section 6.1. Tune the oscillator through the frequency range of 14 kHz to 30GHz with the desired voltage while monitoring the EUT for any failure. The sweep time shall be 3 minutes per octave.

There are two test levels. Table 10 is for LRO operational test limits. Table 11 is for the Launch Site/Vehicle test levels. Due to redundant test frequencies and levels, the CRaTER shall be tested to the combined levels listed in Table 12. This is worst case test levels.

The test shall be performed using 1 kHz 50%AM modulation below 1GHz. Above 1GHz the modulation used will be 1 kHz 50% pulsed modulation.

Should performance degradation occur, reduce the injected signal level until normal operation is restored. Record the frequency, threshold level, and nature of performance degradation.

14KHZ TO 200MHZ: A manual scan will be performed at a rate of 3 minutes per Octave in this frequency range. A parallel plate billboard style antenna will be used to generate a linearly polarized homogeneous electric field 1-meter from the EUT. The field level will be monitored with an electric field intensity meter with fiber optic coupler. The test is to be performed in both vertical and horizontal polarities.

200MHZ TO 1000MHZ: A manual scan will be performed at a rate of 3 minutes per Octave in this frequency range. A Double Ridge Guide antenna will be used to generate a linearly polarized electric field 1-meter from the EUT. The level will be monitored with an electric field intensity meter with fiber optic coupler. The test is to be performed in both vertical and horizontal polarities.

1000MHz to 30GHz: A manual scan will be performed at a rate of 3 minutes per Octave in this frequency range. A series of horn antennas will be used to generate a linearly polarized electric field 1-meter from the EUT. The level is to be determined by monitoring the field with a calibrated field strength meter. The test is to be performed in both vertical and horizontal polarities.

For test setup boundaries above 200MHz, the antenna will be placed so that the entire width of the EUT and 35cm of cabling are within the 3dB beamwidth of the radiating antenna. If this is not possible, multiple antenna positions are to be used.

The guidelines of MIL-STD-462 will be used for antenna positions.

If a failure occurs, reduce the interference signal level until normal CRaTER performance resumes. Record the frequency and the threshold level.

Test Equipment

Description	Asset#	Serial#
Agilent E4440A Spectrum Analyzer	704	US4142136
HP 3326A Signal Generator	37	2519A007503
HP 83640A Signal Generator	38	3009A00188
HP 83620B Signal Generator	624	3844A00963
RF Power Labs 220-1K60L 1kW Amplifier	35	042594-1
Amplifier Research 2500L 2.5kW Amplifier	NA	25358
RF Power Labs 20 Watt Power Amplifier	563	N/A
AR 100W1000M7 1-1000MHz Amplifier	768	311120
AR 1000W1000C 1kW Amplifier	818	0323326
AR 250T1G3 1-2.5GHz Amplifier	784	313235
AR 300T2G8 2.5-7.5GHz Amplifier	785	313230
AR 250T8G18 7.5-18GHz Amplifier	786	313234
Hughes 8101H11F000 18-26.5GHz Amplifier	230	039
Hughes 8010H12F000 26.5-40GHz Amplifier	231	051
AR FM2000 Isotropic Field Monitor	39	13009
AR FP2000 Isotropic Field Probe	40	12914
AR 888 Leveling Preamplifier	491	15606
IFI EFG-3B Billboard Antenna	122	453B
EMCO 3106 Double Ridge Guide Antenna	117	2213
EMCO 3115 Double Ridge Guide Antenna	376	2175
ETS 3117 Ridge Guide Antenna	376	58877
Eaton 94627-1 26.5-40GHz Antenna	333	136
Eaton 94626-1 18-26.5GHz Antenna	334	145

7.6.2 Mode of Operation

The CRaTER shall be tested in the mode of operation listed in Section 6.1 "Mode of Operation" within this test plan.

7.6.3 Pass/Fail Criteria

The CRaTER shall not exhibit any malfunction, degradation of performance or deviation from the mode of operation, which exceed the limits listed in Section 6.3 "Failure Criteria" within this test plan. The MIT representative shall determine at the time of the test if the CRaTER passes or fails to meet the performance criteria.

7.6.4 Data Presentation

Data presentation shall be as follows:
Provide tables showing scanned frequency and test levels.
Provide any susceptibility thresholds that were determined, along with their associated frequencies.

FIGURE 9
RS03 TEST SETUP

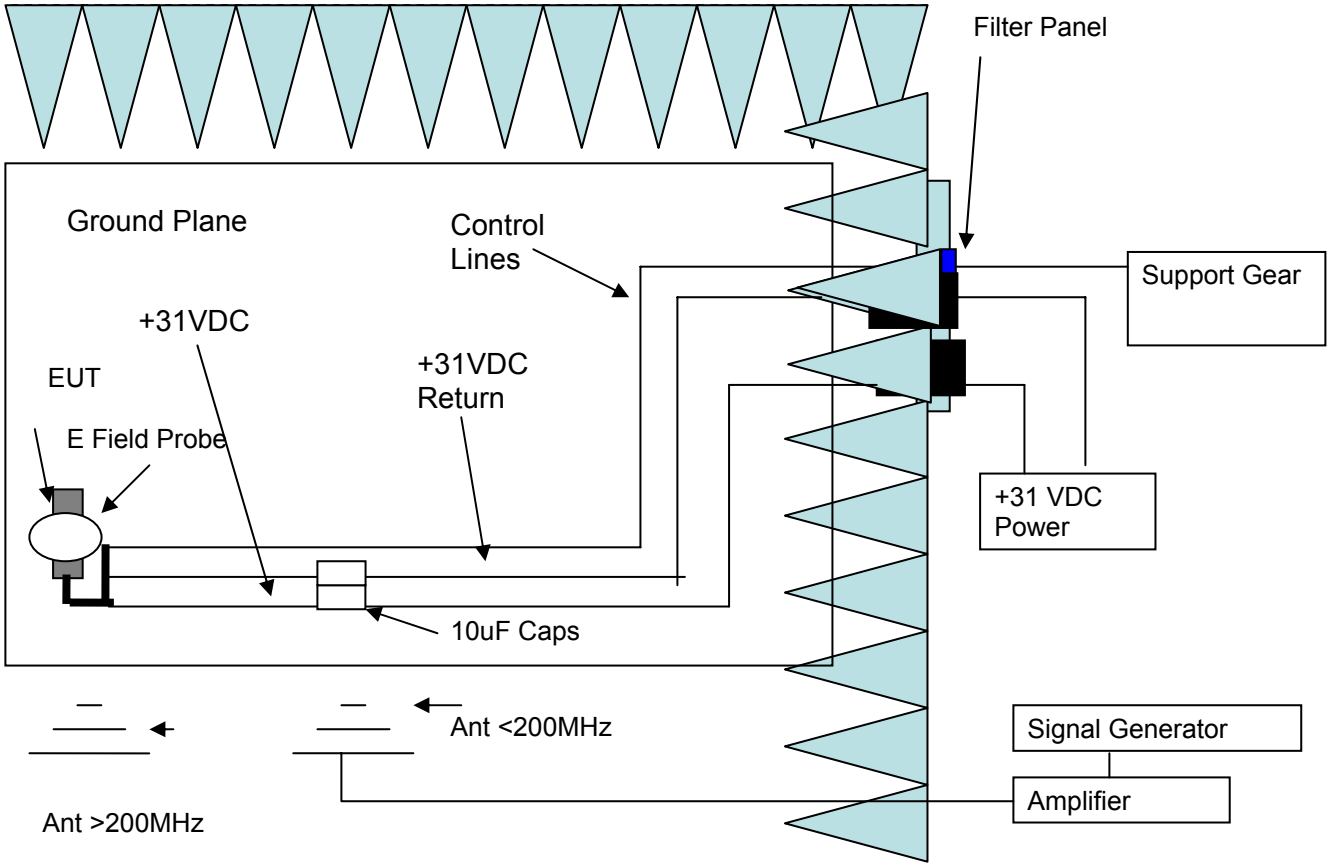


TABLE 10
LRO OPERATIONAL RS TEST LEVELS

Frequency Range	Test Level (V/m)	Test Level (dBuV/m)	Requirement Source
14 KHz - 2 GHz	2	126	GSFC-STD-7000
2 GHz - 12 GHz	5	134	GSFC-STD-7000
12 GHz - 28 GHz	10	140	GSFC-STD-7000
2.271 GHz +/- 5 MHz	12	142	LRO S-Band Transmitter
25.5 GHz - 28.0 GHz	28	149	LRO Ka-Band Indirect Radiation
2.380 GHz +/- 15 MHz	5	134	LRO Mini-RF S-band Indirect Radiation
7.14 GHz +/- 15 MHz	5	134	LRO Mini-RF X-band Indirect Radiation

TABLE 11
LAUNCH SITE/VEHICLE RS TEST LEVELS

Payload Processing and Launch Pad Environment			
Frequency Range	**V/m**	**dBuV/m**	**Source**
14 kHz - 2.700 GHz	20	146	
2.700 - 2.900 GHz	25	148	GPN-20 & WSR-88D
2.900 - 5.400 GHz	20	146	
5.400 - 5.900 GHz	40	152	C-Band Tracking Radars
5.900 - 30 GHz	20	146	
Atlas V Radiated Emissions			
Frequency Range	**V/m**	**dBuV/m**	**Source**
14 kHz - 2.206 GHz	20	146	
2.206 - 2.216 GHz	20	146	Atlas V Second Stage S-band T/M
2.216 - 5.759 GHz	20	146	
5.759 - 5.771 GHz	58	155	Atlas V Second Stage C-band beacon (peak transmit)
5.771 - 30 GHz	20	146	

TABLE 12
CRaTER RS TEST LIMITS

Test Levels	
Frequency Range	**V/m**
14 kHz - 2.700 GHz	20
2.700 - 2.900 GHz	25
2.900 - 5.400 GHz	20
5.400 - 5.759 GHz	40
5.759 - 5.771 GHz	58
5.771 – 5.900 GHz	40
5.900 – 25.5 GHz	20
25.5 – 28 GHz	28
28 - 30 GHz	20