6Rev.	ECO	Description	Author	Approved	Date
A	32-238	Initial Release for comment	RFGoeke		

CRaTER
Electro-Magnetic Compatibility
Test Procedure

Dwg. No. 32-06006.01

Revision A
August 30, 2007

S/N:_____ Date:_____

Table of Contents

Preface

Revision A is being released for comment and use.

1 Introduction

The flight hardware for the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument on the Lunar Reconnaissance Orbiter (LRO) is composed of a single assembly incorporating both radiation detector and all associated power, command, data processing, and telemetry electronics.

1.1 Activity Description

This procedure will provide a demonstration that the instrument meets its requirements for electromagnetic compatibility and susceptibility. The test will be run on only one flight instrument; the remaining flight instruments will be considered qualified by similarity.

Monitoring of instrument performance during the test is accomplished by use of the tools contained within the CRaTER Short Form Functional Performance test (32-06003.02).

1.2 Test Item Description

Six silicon particle detectors (labeled D1, D3, D5 for the "thin" 140um units; D2, D4, D6 for the "thick" 1000um units) are arranged in a stack with intermediate cylinders of Tissue Equivalent Plastic (TEP). When used in coincidence, these detectors form a crude telescope with a 35 degree field-of-view. Charge collected by each detector is separately amplified, filtered, and converted by an A/D converter. The six values of deposited charge for a hextuple of 12-bit values which comprise the primary science data for a single event. The FPGA packs a series of these hextuples into a CCSDS primary science telemetry packet for transmission to the spacecraft data system. Similarly, secondary science information (*e.g.:* rejected event rates) and analog housekeeping values are packed by the FPGA into their own CCSDS telemetry packets. All telemetry is transmitted on a MIL-STD-1553 data bus.

Similarly, all instrument commands are received from the spacecraft *via* the 1553 bus.

Although there are some configuration settings which govern which or how many primary science events are put into telemetry, the instrument itself has only one operating mode (and the telemetry rate is constant in all cases).

The instrument Thermal Protection System will not be installed for this test.

1.3 Support Item Description

1.3.1 Spacecraft Simulator

The spacecraft simulator is composed of a single-board-computer (SBC) married to a MIL-STD-1553 bus controller. The SBC is programmed to interrogate the instrument on a fixed cadence, retrieving up to 25 primary science packets per second, 1 secondary science packet per second, and 1 housekeeping packet per second. (Once integrated with the LRO spacecraft, the housekeeping packets are only retrieved once every 16 seconds, but the packets are available from the instrument at the higher rate, since the instrument runs at a one second cadence.)

1.3.2 28VDC Power Supply

A standard laboratory DC power supply, adjustable over the range of 27 to 35 VDC, 0.5 amperes maximum, is required to power the instrument.

2 Requirements

2.1 Verification Plan

This Procedure supports the Instrument Performance and Environmental Verification Plan (32-01206).

2.2 EMI/EMC Requirements

The EMI/EMC test requirements are contained in the LRO Electrical Systems Specification (431-SPEC-000008 Rev D) and use sections of MIL-STD-461C to impose the following tests on CRaTER

- CE01 Conducted Emissions, 30Hz – 20KHz
- CE03 Conducted Emissions, 20KHz – 50MHz
- RE02 Narrowband Radiated Emissions, 14KHz – 30GHz
- CS01 Conducted Susceptibility, 30Hz - 50KHz
- CS02 Conducted Susceptibility, 50KHz – 400Mz
- CS06 Conducted Susceptibility, power line transients
- RS03 Radiated Susceptibility, 14KHz – 30Ghz

The detailed requirements have been extracted from the referenced document and appended here in Appendix A – Extracts from 431-SPEC-000008

2.3 List of Required Items

- EMC Facility
- Spacecraft Simulator
- 28VDC Adjustable Power Supply
- Flight CRaTER Instrument

2.4 Order of Test

There is no requirement to run the tests in any particular order. A Long Form Functional test (32-06003.01) should be run before the instrument is transported to the EMI/EMC test facility and after it returns there from.

2.5 Documents to be on Hand

- 32-06003.02 Instrument Short Form Functional Test Procedure

3 Configuration

3.1 General Constraints

Electrostatic Discharge (ESD) protection procedures per MIT 99-01003 shall be observed.

Connector mating/demating procedures per MIT 99-03002 shall be observed. Any connections made directly to the unit under test shall be noted in the mate/demate log.

The flight instrument shall be maintained in a clean environment per MIT 32-01203.

The laboratory power supply shall only be operated within the range of 16 to 40 VDC.

A three-digit, calibrated digital voltmeter shall be used for the initial setup of the input power. No other calibrated MIT support equipment is required.

3.2 Nomenclature

The Electrical Ground Support Equipment (EGSE) consists of a 28 VDC power supply, a Ballard Technologies single board computer with 1553 interface and 1 Hz clock (the spacecraft simulator), a computer workstation, and associated cabling.

3.3 Test Configuration

The flight instrument without its thermal blanket is configured for test in a standard EMI test facility. Connector savers are not used.

3.4 Hazardous Commands

It is not permissible to turn on the detector bias supply in partial vacuum environments where the pressure is between 525 torr (10K feet altitude nominal) and 10^{-3} torr.

3.5 Instrument Purge

The instrument should be purged prior to returning the instrument to storage after testing; see the Instrument GN2 Purge Procedure (32-06003.06).

4 Procedures -- Initialization

Space is provided for the recording of information of particular significance in the conduct of this test. Where a value simply needs to be verified, as opposed to recorded, a simple check mark √ will suffice. In addition the Test Conductor may redline the procedure to more accurately document the actual flow of events, both routine and anomalous.

The pages of this section will be attached to the Test Report that is filed for the instrument on which this activity is conducted. The telemetry data stream generated by the spacecraft simulator is also an integral part of the Test Report; that data is archived on crater.bu.edu. Similarly, the plots generated by the EMC facility for emissions testing should be attached.

4.1 Identification of Equipment and Personnel

Flight Instrument, 32-10000 S/N _____

Spacecraft Simulator, 32-80201 S/N _____

Principal Test Conductor _____

Other Test Conductors _____

_____

_____

QA Representative: _____

Other Individuals: _____

_____

_____

Facility Description _____

_____

_____

4.2 Pre-Test Long Form Functional Test

Perform a Long Form Functional Test (32-06003.01) prior to transporting the instrument to the test facility.

Date	Pass/Fail?	Time	Initial

4.3 Install Instrument on EMC Test Bench

4.3.1 28VDC Power

The 28VDC GSE power supply will be located outside the EMC test room. 28VDC return will be connected to facility ground.

4.3.2 Spacecraft Simulator

The Spacecraft Simulator will be located outside the EMC test room. The power for this unit is derived from standard 3-wire 110VAC, with the third wire connected to facility ground. The outer shield of the 1553 cables is also connected (through the simulator) to this facility ground.

4.3.3 Instrument Under Test

The instrument is set directly upon the conductive table. The electrical contact from the instrument chassis to the table will be measured to be <2.5 milliohms. (The use of a ground strap to the instrument external grounding point may be necessary.) The table to facility ground impedance shall be less than 10 milliohms.

Date	Time	Initial

4.4 Check out the EGSE

Run a Short Form Functional to demonstrate basic aliveness. When finished leave the instrument running in the state defined by para. *4.7 Check Detector Noise Levels* . When necessary to secure instrument power to reconfigure the EMC test equipment, return to this powered up state before continuing.

The data log (`sf_log`) can be left running continuously for all emissions testing. It would be convenient for diagnostic purposes to restart the log for each of the susceptibility tests. Use of the `CComment` command is encouraged.

Pass/Fail	Instr. State	Date	Time	Initial
	On?			

5 Procedures – EMC Testing

All of the following are run per MIL-STD-462/461C to the limits given in Appendix A.

During susceptibility testing the analog housekeeping should be monitored for spurious readings. Primary science, however, is the critical data stream, and may be monitored in one of two (contradictory) ways. With the internal calibration source off, the "singles" rates may be monitored. Cosmic rays will generate a few counts/second spread out over the six detector chains, but discrete noise pulses at a rate >10Hz would be easily recognized in Secondary Science data. With the internal calibration source on (Cal Low, Amplitude 128, Rate 2KHz), one can monitor (using **`sf_noise`**) the analog noise present on the data at levels an order of magnitude more sensitive than anything that would show up as a discrete pulse. Unless otherwise noted, the latter approach will be used.

5.1 CE01 Conducted Emissions, 30Hz – 20KHz

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.2 CE03 Conducted Emissions, 20KHz – 50MHz

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.3 RE02 Narrowband Radiated Emissions, 14KHz – 30GHz

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.4 CS01 Conducted Susceptibility, 30Hz - 50KHz

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.5 CS02 Conducted Susceptibility, 50KHz – 400Mz

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.6 CS06 Conducted Susceptibility, power line transients

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.7 RS03 Radiated Susceptibility, 14KHz – 30Ghz

Notes: _____

_____

_____

_____

_____

Pass/Fail	Data Log File name	Date	Time	Initial

5.8 Power off Instrument

Power off the instrument following para. *4.8 Clean Up and Shut Down* of the Short Form Functional.

Date	Time	Initial

5.9 Post-Test Long Form Functional Test

Perform a Long Form Functional Test (32-06003.01) after transporting the instrument back from the test facility.

Date	Pass/Fail?	Time	Initial

Appendix A – Extracts from 431-SPEC-000008

The document from which these requirements are extracted is the LRO Electrical Systems Specification, Rev. D (431-SPEC-000008). The pages are only available in PDF format. The requirement ESS-94 is supplemented with guidance from GSFC-STD-7000.

As of 29 August 2007 the RE02 limit shown in Figure 3-8 has been raised from 8 dbμV/m to 23 dbμV/m.

3.2.6.3 Solar Array (SA) Panels

ESS-60 Solar array (SA) panels and substrates shall be electrically grounded to the SC structure.

ESS-61 Ground straps shall be implemented per Section 3.2.4.

3.2.6.4 Antennas and Antenna Booms

ESS-62 The HGA assembly shall employ a grounding scheme to assure HGA metal surfaces and waveguides are grounded directly or indirectly to the SC structure through less than 100 milliohms DC resistance.

The HGA boom gimbal rotating joints and deployment hinges should not be considered adequate in providing a good ground path. Therefore, separate ground connections will be provided in slip-rings on a rotating joint or a dedicated ground strap.

ESS-63 The omnidirectional antenna metal surface and cable shields shall be grounded directly or indirectly to the SC structure through less than 5 milliohms DC resistance.

3.3 EMI/EMC REQUIREMENTS

ESS-64 Emissions and susceptibility testing shall be performed per this document, which has tailored the General Environmental Standards for GSFC Flight Programs and Projects (GEVS) (GSFC-STD-7000) test levels for the LRO mission.

The EMI/Electromagnetic Compatibility (EMC) tests required below are meant to cover the LRO mission environments including Orbiter RF self compatibility, launch site, launch pad, launch/ascent, lunar transfer, and lunar orbit.

ESS-65 Table 3-3 indicates the tests that shall be performed on each component and at the Orbiter level.

Table 3-3. EMI/EMC Applicability and References

	Components (1) (2)	RF Comp (3)	Orbiter	ESS Section	GSFC-STD-7000 Section(4)	461C Section (4)
CE01	X	X		3.3.1.1	2.5.2.1	2
CE03	X	X		3.3.1.1	2.5.2.1	3
CE06		X		3.3.1.2	2.5.2.1	4
RE02	X	X	X	3.3.2	2.5.2.2	17
CS01	X	X		3.3.3.1	2.5.3.1a	6
CS02	X	X		3.3.3.2	2.5.3.1a	7
CS03		X		3.3.3.3	2.5.3.1b	8
CS04		X		3.3.3.4	2.5.3.1c	9
CS05		X		3.3.3.5	2.5.3.1d	10
CS06	X	X		3.3.3.6	2.5.3.1e	11
RS03	X	X	X	3.3.4	2.5.3.2	21
Self Compatibility			X	3.3.5		

Notes: (1) X= Applicable
(2) Subsystems may be tested as individual components or assemblies where applicable. Subsystems include instruments (see section 1.2).
(3) RF Components includes all RF receiving components and instruments
(4) GSFC-STD-7000 and MIL-STD-461C sections provided for reference. See applicable ICD section for LRO specific requirements.
Test levels of emissions and susceptibility defined in applicable figures may differ from GSFC-STD-7000 and MIL-STD-461C, this document takes precedence.

The EMI/EMC tests shall be performed with primary power at the LRO nominal +31VDC, unless otherwise stated.

ESS-66 The EMI/EMC test methods shall be per the requirements of MIL-STD-462 (Notice 6) unless noted in this document. EMI/EMC requirements will be imposed on individual components.

ESS-67 Deleted.

When fully integrated into the SC, this will ensure that these components will not interfere with each other. In addition, the radiated emission and susceptibility requirements are imposed on a fully integrated SC. This will ensure that the SC will not adversely affect the launch vehicle, will not be affected by the external emissions (particularly at the launch site), and will not interfere with any sensitive instruments making science measurements.

ESS-68 All tests shall be performed in ambient with either the component or system in its most sensitive mode for susceptibility testing and in its most noisy mode as appropriate for the EMI emission test.

3.3.1 Conducted Emissions

3.3.1.1 CE01/CE03

ESS-69 Conducted emissions (CE) from components shall not exceed the values shown in Figure 3-6 when subjected to CE01 (30 Hz - 20 kHz) and CE03 (20 kHz - 50 MHz) narrowband testing.

ESS-70 CE01/CE03 shall be performed on all primary power and return lines to each component.

ESS-71 CE01/CE03 shall be performed in differential and common mode.

Conducted emissions testing will be performed only at the subsystem or component levels.

ESS-72 Each component shall meet the transient current pulse limits, both single event (excluding turn-on) and recurring, as specified in Section 3.1.3. Applicable test parameters and limits are as follows for narrowband conducted emissions:

a.Interface lines to be measured are differential mode current lines: primary power inputs, primary power returns.
b.Interface lines to be measured are common mode current lines: primary power inputs with return including heater circuits.
c.Differential mode narrowband test limits are 120 decibel microamps (dBuA) (1.0 A rms) from 30 Hz to 450Hz, then decreasing to 50 dBuA (0.316 mA rms) at 20 KHz, then decreasing to 20 dBuA (10uA rms) at 2 MHz, and then continuing at that level to 50 MHz, as shown in Figure 3-6.
d.Common mode narrowband test limits are 50 dBuA (0.316 mA rms) from 30 Hz to 20 KHz, then decreasing to 20 dBuA (10uA rms) at 2 MHz, and then continuing at that level to 50 MHz, as shown in Figure 3-6.

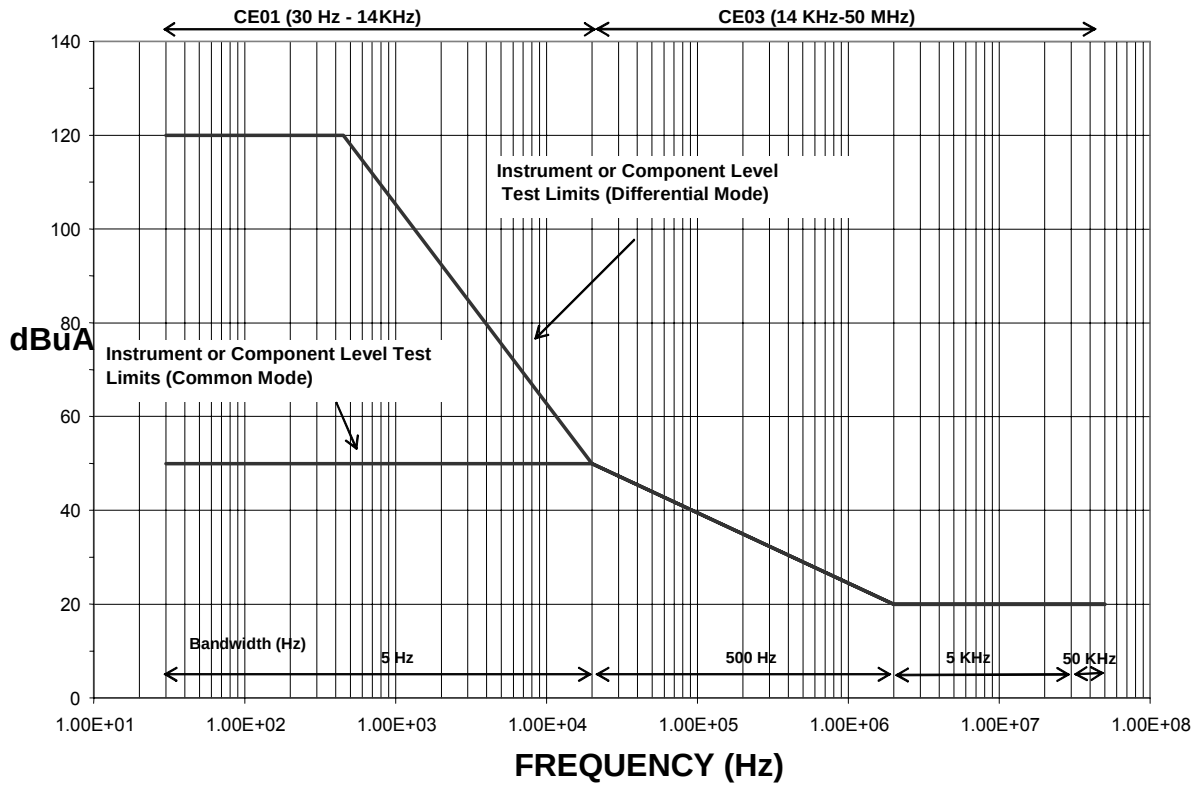


Figure 3-6. Narrowband Conducted Emissions CE01/CE03 Limits

3.3.1.2 CE06

ESS-73 All RF receivers and transmitters shall perform the additional CE06 EMI test to the limits contained in MIL-STD-461C.

3.3.2 Radiated Emissions (RE02)

ESS-74 Radiated emissions (RE) from subsystem or components shall not exceed the values shown in Figure 3-7 or Figure 3-8 when subjected to RE02 narrowband testing.

ESS-75 Radiated electric field emissions from any components that are ON from launch to vehicle separation shall not exceed the limits shown in Figure 3-7 (lower line).

ESS-76 Radiated electric field emissions from any components that are OFF from launch to vehicle separation shall not exceed the limits shown in Figure 3-8.

ESS-77 The aggregate RE from the Orbiter shall not exceed the limits shown in Figure 3-7 (upper line).

The Orbiter receiver has a center frequency at 2091.3967 MHz and the notches in Figure 3-7 and Figure 3-8 will protect the receiver with at least 6 MHz on both sides of the center frequency.

The Mini-RF Technology Demonstration receiver has a center frequency at 2380 MHz (S-Band) and 7140 MHz (X-Band), and the notches in Figure 3-7 and 3-8 will protect the receiver with at least 15 MHz on both sides of the center frequency.

The Atlas V maximum allowable payload RE levels are provided for reference only in Table 3-4. Since the Atlas allowable RE levels are higher than GSFC GEVS levels, the LRO Orbiter and subsystems shall be required to meet the GEVS levels per Figure 3-7 and 3-8.

Table 3-4. Atlas V Spacecraft RE Limits

Frequency Range	dB uV/m
14 kHz - 410 MHz	114
410 - 430 MHz	37
430 MHz - 1 GHz	114
1 - 5.660 GHz	154
5.660 - 5.720 GHz	73
5.720 - 18 GHz	154

3.3.3 Conducted Susceptibility

ESS-78 Undesirable response, malfunction, or degradation of performance shall not be produced in any components during CS testing with the tests specified below. Performance deviation of Instruments is acceptable as long as the component under test survives the component CS test. CS testing will not be performed at the Orbiter level.

3.3.3.1 CS01/CS02

ESS-79 The CS01 and CS02 (injection of energy into power lines) shall be performed on all components that contain the DC/DC converters or power regulation devices.

ESS-80 The CS01 test limits for the components level tests shall be 2.8 V rms at the frequency range of 30 Hz to 1.5 kHz, and ramping in a straight line down to 1.0 volt at 50 kHz.

ESS-81 The CS02 limit for the component level test shall be 1.0 V rms at the frequency range of 50 KHz to 400 MHz.

These limits, which are defined by MIL-STD-461C, are shown in Figure 3-9 below.

ESS-82: The CS01 and CS02 (injection of energy into power lines) performance shall be verified at the nominal +31V only.

3.3.3.2 CS03

ESS-83 The CS03 (Two Signal Intermodulation) test shall be performed on all RF receiving components.

ESS-84 The CS03 (Two Signal Intermodulation) test performed on all RF receiving equipment shall not cause the RF equipment to exhibit any intermodulation products from two input signals, beyond those permitted in the RF component specification.

ESS-85 The CS03 test for RF receiving components shall be conducted per MIL-STD-462 to the limits specified in GSFC-STD-7000.

3.3.3.3 CS04

ESS-86 The CS04 (Rejection of Undesired Signals) test shall be performed on all RF receiving components.

The CS04 (Rejection of Undesired signals) test for RF receiving components consists of a 0.0 decibel milliwatt (dBm) (decibels referenced to 1 milliwatt) signal applied directly to the receiver input terminals and notched around the receiver input bandwidth at 80.0 decibels (dB) above its threshold.

ESS-87 The input notch center shall be at the receiver-tuned frequency and in the center of the notch.

ESS-88 The CS04 test for RF receiving components shall be conducted per MIL-STD-461C to the limits specified in GSFC-STD-7000.

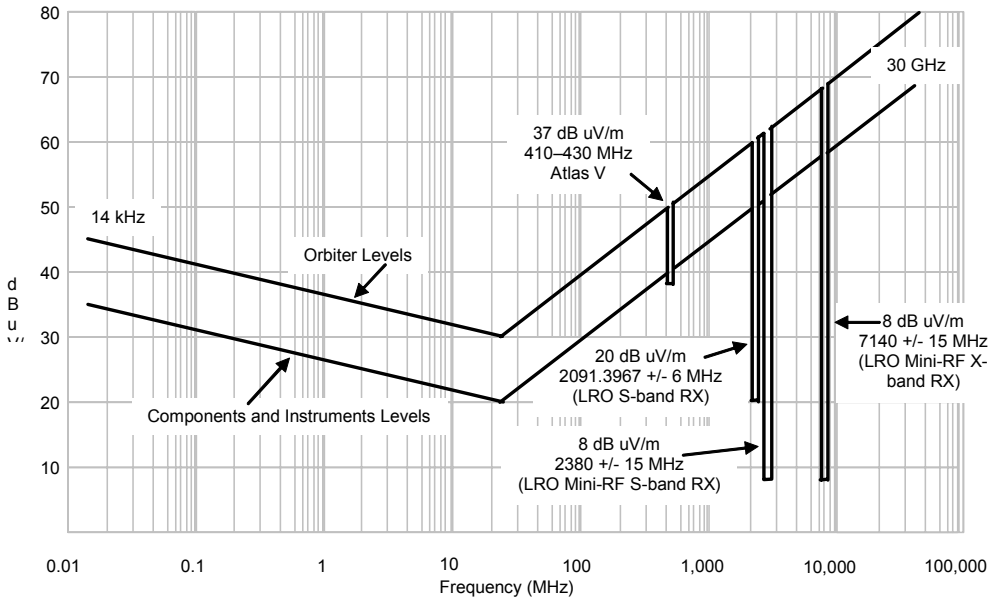


Figure 3-7. RE02 Limits for the Orbiter and Components that are ON from launch to vehicle separation (vertical axis is dBmicrovolts/meter)

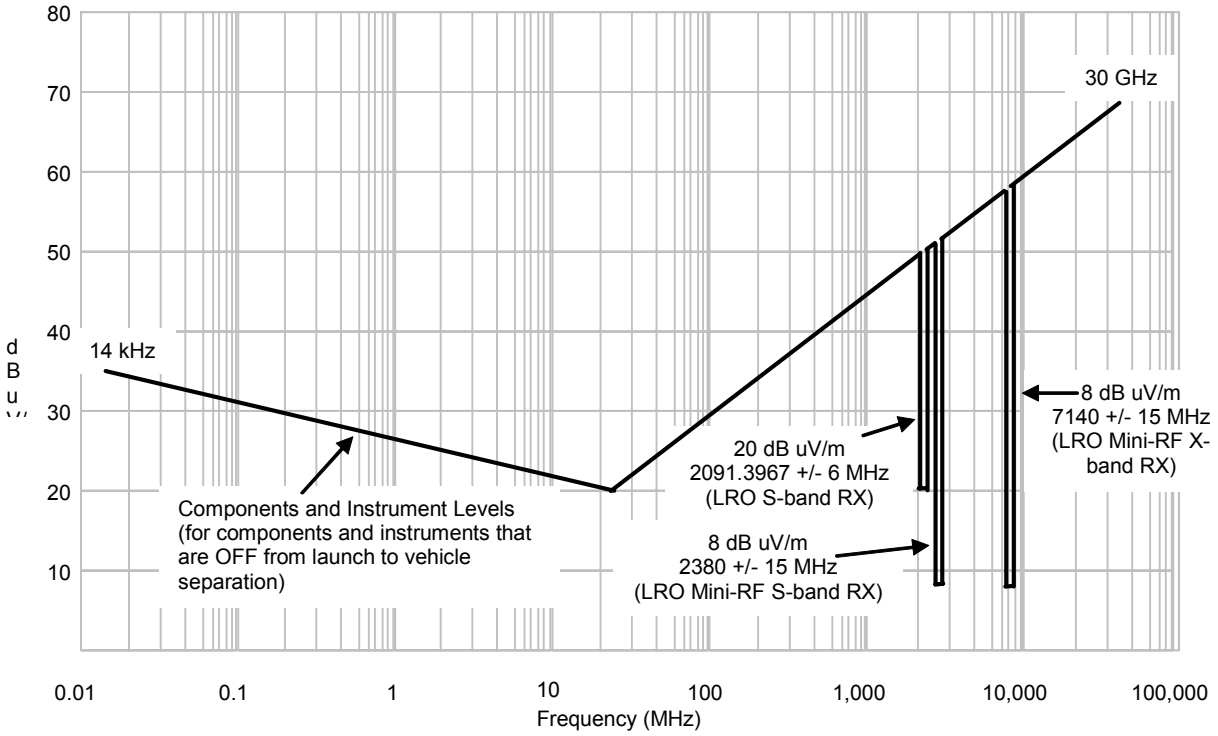


Figure 3-8. RE02 Limits for Components that are OFF from launch to vehicle separation (vertical axis is dBmicrovolts/meter)

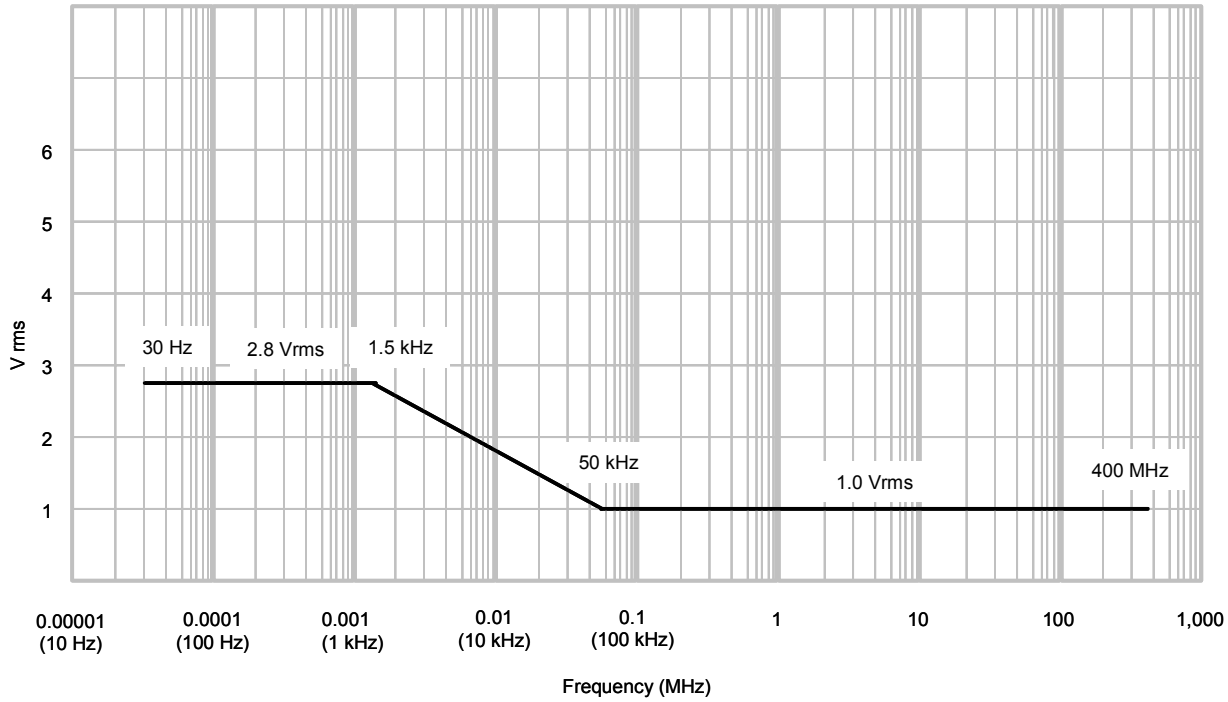


Figure 3-9. CS01/CS02 Limits

3.3.3.4 CS05

ESS-89 The CS05 (Cross Modulation) test shall be performed on all RF receiving components.

ESS-90 The CS05 (cross-modulation) test performed on all RF receiving equipment shall not cause the RF equipment to exhibit any cross-modulation from two input signals.

ESS-91 The CS05 test for RF receiving components shall be conducted per MIL-STD-461C to the limits specified in GSFC-STD-7000.

3.3.3.5 CS06

ESS-92 The CS06 (Powerline Transient) shall be performed on all components that contain the DC/DC converters or power regulation devices.

The CS06 (Powerline Transient) test consists of both a positive transient test and a negative transient test, having amplitude as shown in Figure 3-10 superimposed on the +31V power bus as shown in Figure 3-10.

ESS-93 The CS06 positive transient pulse shall be limited to +56V peak absolute value and a 10 μs width at the +31V steady-state bus crossing point as shown in Figure 3-10.

The CS06 negative transient pulse shall be limited to 0V value and a 10 μs width at the the +31V steady-state bus crossing point as shown in Figure 3-10.

ESS-94 The CS06 test shall be conducted per MIL-STD-462 to the limits specified in GSFC-STD-7000. Apply for 5 minutes at 60 pps.

3.3.4 Radiated Susceptibility (RS03)

ESS-95 Undesirable response, malfunction, or degradation of performance shall not be produced during component, or Orbiter Radiated Susceptibility (RS) testing with the E-field levels shown in Table 3-5.

The LRO Expendable Launch Vehicle (ELV) will be serviced at the Astrotech facility and launched from the Cape Canaveral Air Station (CCAS) and can be exposed to the maximum transmitter limits shown in Table 3-6. These limits include those expected at payload processing at the Astrotech facility, transport to the Vertical Integration Facility and the pad environment.

ESS-96 The Orbiter components and instrument shall survive the RS test levels of the "Payload Processing and Launch Pad Environments" as given in Table 3-6.

ESS-239 All subsystems and instruments shall be tested with power ON to the levels and for the frequencies given in Table 3-6 as “Payload Processing and Launch Pad Environments”

ESS-240 Instruments shall operate in the most typical mission operational state during the "Payload Processing and Launch Pad Environments" test, unless the Instrument

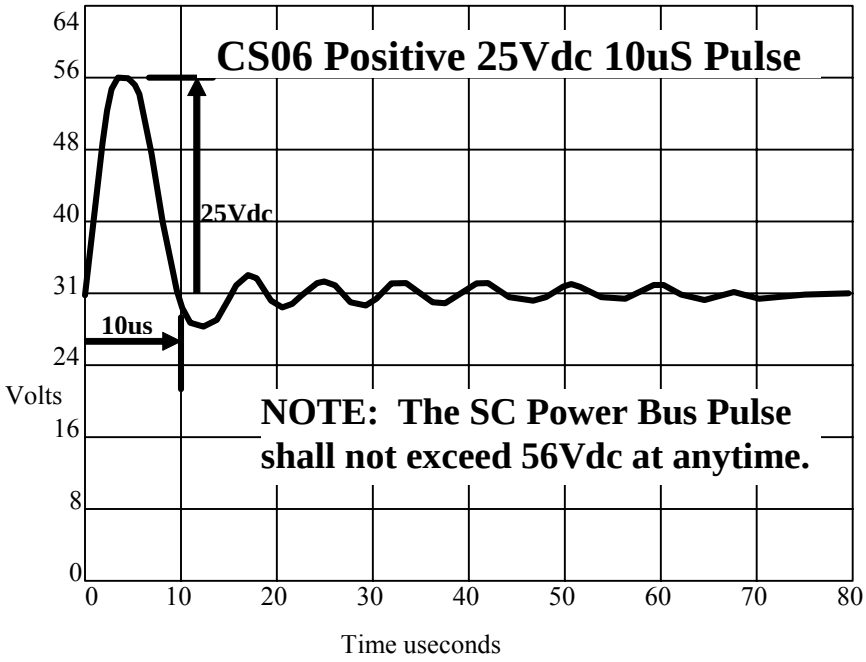
System Engineer determines that the test will damage the instrument, in that case, the instrument shall then be placed in a mode where no damage will occur.

ESS-241 Instruments and subsystems that are powered ON from launch to launch vehicle separation shall be powered ON during the RS test at the ELV S-band and C-band transmitter frequencies shown in Table 3-6.

ESS-242 Instrument and subsystems that are powered OFF from launch to launch vehicle separation shall be tested to survive, but may be powered OFF during the RS test at the ELV S-band and C-band transmitter frequencies shown in Table 3-6.

Table 3-5. LRO Operational RS Test Limits

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



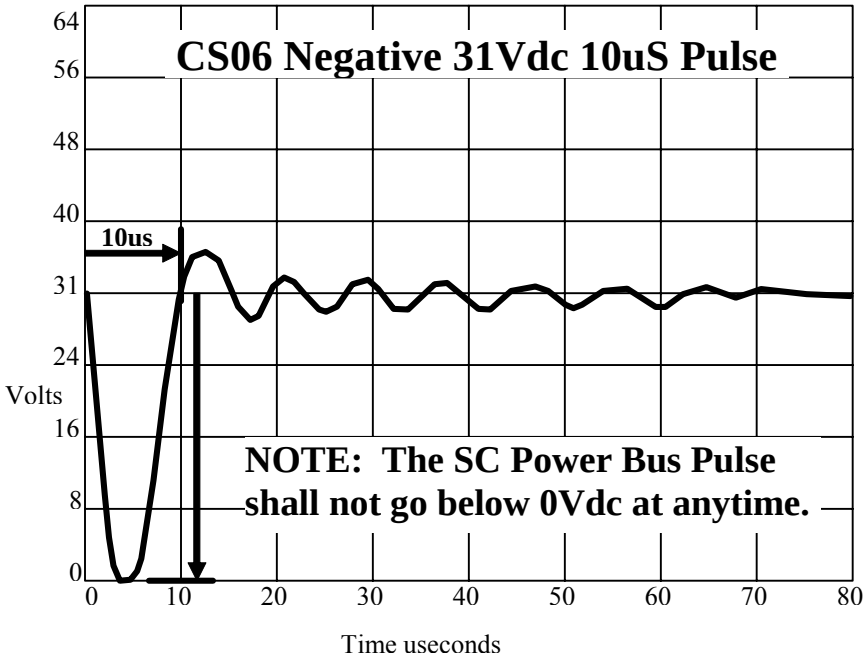


Figure 3-10. CS06 Conducted Susceptibility Test Pulse

Table 3-6. 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	

3.3.5 Orbiter RF Self-Compatibility

ESS-97 The Orbiter RF self-compatibility test shall be included in the Orbiter-level EMI/EMC test.

ESS-98 During Orbiter Self-Compatibility, the Orbiter shall be configured to a nominal science mode to simulate the in-orbit operation. Ka-band and S-band transmitters will free-radiate from their antennae during this test.

3.4 DATA AND SIGNAL INTERFACES

ESS-99 The presence or absence of any combination of the input signals applied in any sequence shall not cause damage to a component, reduce its life expectancy, or cause any malfunction, whether the component is powered or not.

3.4.1 Inter-Component Communications

ESS-100 All signals between boxes shall be controlled to limit signal bandwidth so that no signal should be given more bandwidth than needed to communicate the necessary functions under all expected on-orbit environmental conditions.

ESS-101 Subsystems connected to the C&DH subsystems via the 1553 data bus shall communicate commands and housekeeping telemetry per Section 3.4.1.1.