General Surge Response Test Procedure Development

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Abstract

The General Surge Response test procedure is performed for space systems equipment to ensure the equipment remains undamaged when subjected to step changes in input voltages. The Systems Integration & Test Branch (SITB) Electromagnetic Compatibility (EMC) Test Facility is tasked with developing this test procedure in order to provide this test capability to future EMC lab customers. This General Surge Response (GSR) test will be performed along with the other EMC tests outlined when equipment arrives at Langley Research Center for environmental testing.

This is the first time that the EMC test lab has been tasked with completing this test, so developing this test procedure will add to the EMC lab's testing capability. Since this is the first time the EMC lab has been tasked with GSR testing, a full test procedure needs to be written for EMC technicians or test engineers to follow. The first step is to gather information about GSR requirements from applicable military standards. This will provide the standards to which the Equipment Under Test (EUT) must be tested in order to verify its performance when subjected to the GSR profiles. After all standards are understood, time will be spent selecting and procuring appropriate test equipment that will be capable of verifying all requirements. With requirements and equipment gathered, the test procedure will be ready to be written. The goal at the end of this project is to have a step-by-step test procedure developed and ready to be included in any future test procedure for EMC technicians to follow during EMC testing.

Approach

The military standard applicable to this test procedure is MIL-STD-1541A, Electromagnetic Compatibility Requirements for Space Systems. Within MIL-STD-1541A, two General Surge Response requirements are applicable. The first requirement is stated in paragraph 5.3.3.7.1. The second requirement, specific to essential space systems equipment, is outlined in the next paragraph 5.3.3.7.2.

> **5.3.3.7 Electrical Power Surges.** Equipment shall withstand positive and negative input voltage surges which are sustained for at least 10 and 200 milliseconds, respectively.
>
> **5.3.3.7.1 General Surge Response.** Equipment shall remain undamaged when subjected to step changes of the input voltage from 0 to 175 percent and from 120 to 0 percent of the nominal load voltage. With step changes from 0 to 100 percent of the nominal load voltage the instantaneous inrush current shall not exceed 10 times the average steady-state input current.
>
> **5.3.3.7.2 Surge Response of Essential Equipment.** Essential subsystems and components shall satisfy their performance requirements when subjected to input voltage step changes from 100 to 65 percent and from 100 to 130 percent of the nominal load voltage.

Since two separate requirements are potentially applicable, the GSR testing will consist of two test procedures. Paragraph 5.3.3.7.1 will outline GSR1, while paragraph 5.3.3.7.2 will outline GSR2. Paragraph 5.3.3.7 provides a minimum time that the step voltages must be supplied to the equipment. Although there is a requirement for the

minimum time step voltages must be applied, no requirements exist for rise and fall times.

For the purposes of developing a standard test procedure capable of being tailored to any future project, a nominal voltage of 29.5 V with a nominal current draw of 3.3 A was chosen to verify the test procedure is functional. Given this nominal voltage, GSR1 and GSR2 test requirements are as follows.

Table: GSR1 Test Requirements

Voltage	Minimum duration at test voltage
0 – 49	10 msec
33.6 – 0	200 msec

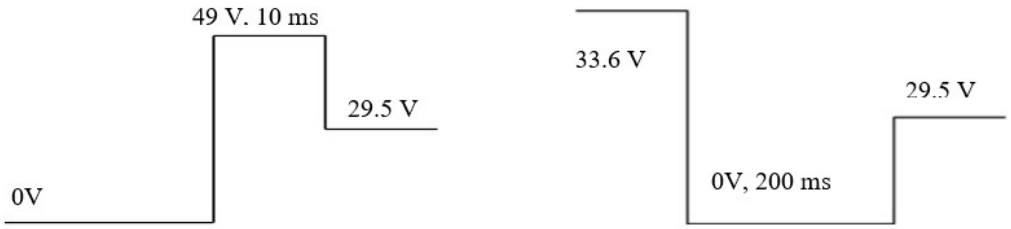


Figure: GSR1 Test Requirements

Table: GSR2 Test Requirements

Voltage	Duration at test Voltage
29.5 – 38.5	10 msec
29.5 – 19.5	200 msec
29.5 - 0	250 µsec

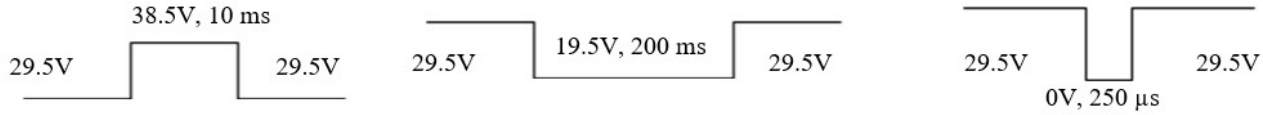


Figure: GSR2 Test Requirements

GSR1 and GSR2 test procedures will also be required to contain test equipment self-check procedures in order to verify the accuracy of the test setup and the performance of the test equipment prior to subjecting the EUT to step voltages. The self-check procedures will include a constant voltage mode system check to verify the power supply front panel display is calibrated to its output. There will also be a sequencing voltage mode system check to verify the test sequences are properly programmed into the power supply.

Equipment

The ideal lab equipment to complete this procedure would be some DC power supply capable of being programmed to deliver multiple voltage levels within precise amounts of time. This should be used in conjunction with a digital voltmeter and an oscilloscope to verify the correct voltage levels are delivered to the EUT for the minimum required time duration. A 9-Ohm test load will also be required for the Constant Voltage Mode and Sequencing Voltage mode system checks. This is to resemble the EUT's expected load as closely as is practical while verifying the test setup and equipment.

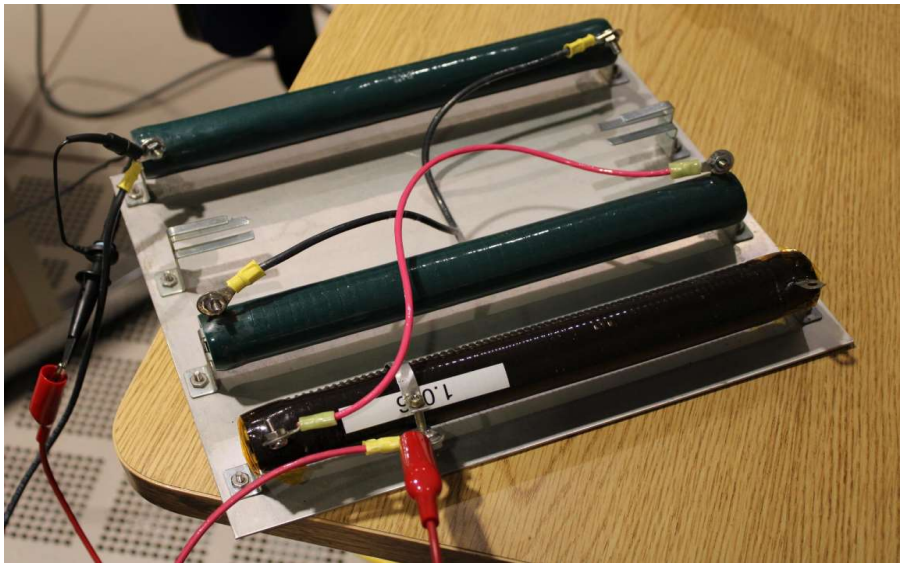
The Sorensen SGI800X13C-1CAB DC Programmable Power Supply was chosen due to its ability to have multiple test sequences programed at a time. The power supply is programmed through the front panel display to facilitate the multiple step voltages that the EUT is required to be subjected to.

A digital voltmeter will be used during the constant voltage mode system checks to verify the front panel display of the power supply is accurately displaying the output voltage.

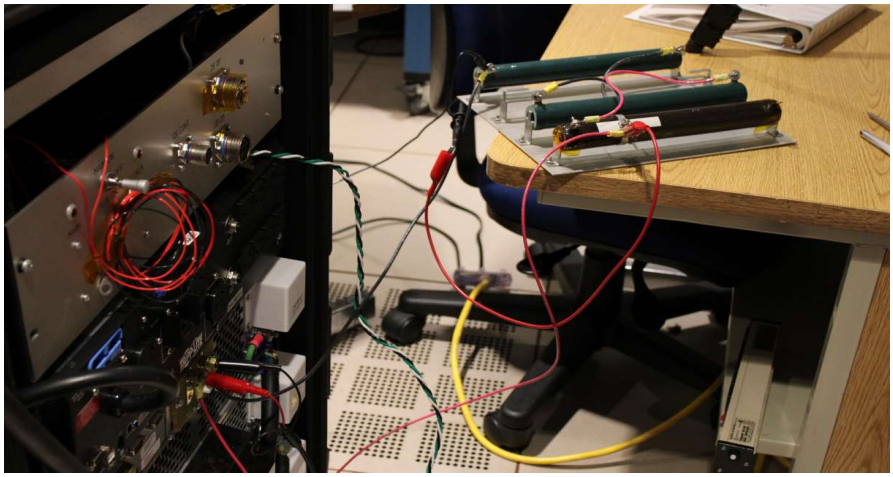
An oscilloscope will be used during the Sequencing Voltage Mode system checks as well as for GSR1 and GSR2 Test Procedures. The output of the power supply will be probed by the oscilloscope such that the step voltages are visible. This will allow the technician to verify the correct voltage levels are delivered to the load.

Sorensen SGI DC Power Supply, Oscilloscope, and Digital Voltmeter

Two 4-Ohm resistors in series with a 1-Ohm resistor will be used for the test load of 9 Ohms. This load condition simulates a nominal 3.3 A operating current.



9-Ohm Test Load

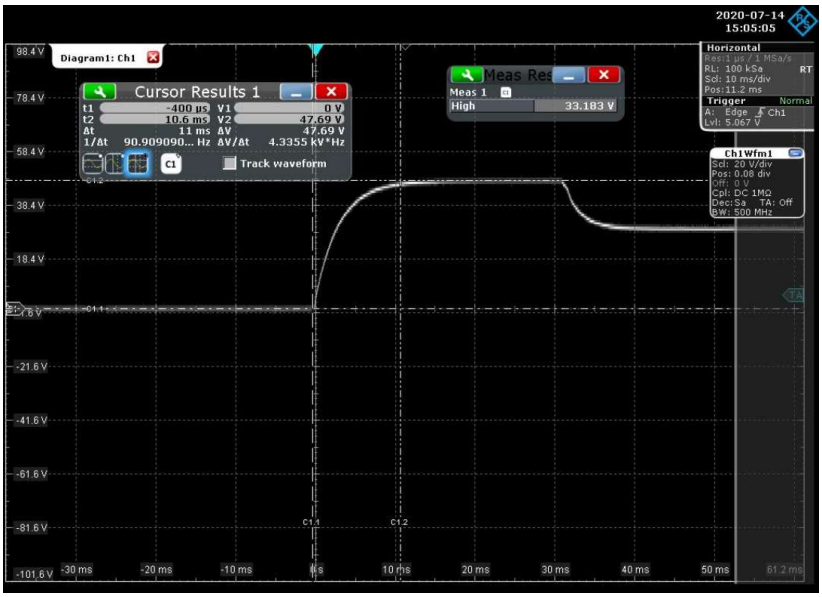


Test Load Connected to Power Supply DC Output

Test Development

With research complete and test equipment selected, the GSR Test Procedure is ready to be written for EMC technicians to follow during testing. The test does not simply involve subjecting the EUT to multiple step voltages. Careful consideration must be taken to ensure the test procedure is adequate to verify the proper operation of the EUT given requirements established in the above standards. System checks must also be prepared in order to prevent inadvertent damage to test equipment or the EUT.

Given the chosen Sorensen DC Power Supply, test sequence programming needs to be developed. This model of power supply allows users to save up to 50 test sequences at a time, with up to 20 steps per sequence. Each step voltage requirement outlined above will be programmed into its own sequence. To do this, each test sequence will utilize the Voltage/Current (V/I) Mode step function along with other operations. The V/I Mode allows the user to program a voltage level, current limit, overvoltage protection level, and time duration before moving to the next step. For example, the first test sequence will program the power supply to begin at 0 volts, step to 49 volts for the required duration of time, then return to the nominal voltage level of 29.5 volts. As mentioned earlier, there is an established minimum time duration for each sustained step voltage, but, no required rise or fall times. So, for each step in each test sequence, rise and fall times were calculated and factored into the time duration of each step. This allowed enough time for the voltage to rise and fall and hold at different levels for the required duration.



Test Sequence Step Voltage Captured on Oscilloscope

The System checks developed for this procedure includes a Constant Voltage Mode and Sequencing Voltage mode System Check. The Constant Voltage Mode check is performed to verify the front panel display of the power supply is calibrated correctly to its DC output. This eliminates the risk of supplying an incorrect voltage level to the EUT. The Sequencing Voltage Mode check is performed to verify the test sequences that are programmed into the power supply will deliver the correct step voltages. This also mitigates the risk of damaging the equipment.

Test Procedure

Constant Voltage Mode System Check

The Constant Voltage Mode System Check will be completed before use of the Sorensen SGI DC Power Supply in order to ensure proper calibration of DC output voltages needed to complete GSR test procedures. This check will consist of programming the power supply output voltage to zero, then connecting the 9-Ohm test load and the digital voltmeter to the DC output of the power supply. The digital voltmeter and the front panel display of the power supply will be observed while the output voltage is increased from 0 volts to 60 volts. If the front panel display and the voltmeter readings track within their respected accuracies, the front panel display of the power supply will be shown to be calibrated to its DC output.

Sorensen SGI DC Power Supply Front Panel Display

Sequencing Voltage Mode System Check

The Sequencing Voltage Mode System Check will be completed before performing GSR test procedures in order to verify the test sequences programmed into the power supply are suitable for use in the GSR test procedures. To set up this system check, the voltage of the power supply will be programmed to zero, then the oscilloscope and 9-Ohm test load will be connected to the DC output of the power supply. During the check, all test sequences that will be used for GSR1 and GSR2 test procedures will be programmed into the power supply and ran with the test load and oscilloscope connected. A test sequence consists of one step voltage requirement outlined above. The oscilloscope will be set up to trigger at the start of each test sequence so that the step voltage signature is displayed on the screen. For each sequence performed, the signature on the oscilloscope will be analyzed to ensure the sequence was programmed to accurately supply the test load voltage for the required time duration. Since the test load is designed to simulate the EUT, these voltage signatures will be similar enough to what the EUT will be subjected to that they can be verified to be appropriate for the tests.

GSR1 and GSR2 Test Procedure

The Sequencing Mode Voltage Check is meant to simulate the GSR1 and GSR2 test procedures in order to verify the test equipment is programmed and set up properly to ensure accurate results. So, all sequences that were verified during that system check will be used in the GSR1 and GSR2 tests.

To set up the test procedure, the power supply output voltage is programmed to 0 volts, then connected to the power inputs of the EUT being tested. The oscilloscope will also probe the DC output to verify correct step voltages are applied to the EUT. The oscilloscope will be set to trigger at the beginning of a test sequence. Once a test sequence is performed, the voltage signature on the oscilloscope will be analyzed to verify the correct voltage was supplied. After the voltage is verified to be correct, the EUT is inspected to ensure it remained undamaged during the step changes in input voltage. The EUT will pass the test when it is able to be subjected to all step voltages and remain undamaged.

Conclusion

Through thorough research into the military standards and working with the selected test equipment, the GSR test procedure has been refined into step-by-step procedures that are capable of being used to ensure reliability of spaceflight equipment when subjected to step changes of input voltages. The completion of this test procedure establishes that the EMC Test Facility can perform these tests for any future projects that require General Surge Response verification. This also proves that the EMC test facility has the resources to develop other types of electrical verification testing procedures that it has not normally facilitated. The EMC test lab is continuing to increase its testing capabilities with this new GSR test procedure along with any newly developed electrical verifications.

References

MIL-STD-1541A. Electromagnetic Compatibility Requirements For Space Systems. United States Air Force. 30 Dec 1987.