Draft Synopsis V1.0

Single Event Transient and Destructive Single Event Effects Re-Testing of the MDI3051RED12ZF Modular Devices, Inc. DC / DC Converters (with radiation hardened MOSFET)

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Test Date: October 15, 2001 Report Date: November 6, 2001

I. Introduction

This study was undertaken to determine the single event destructive and transient susceptibility of the MDI3051RED12ZF Modular Devices, Inc. DC / DC Converters that was modified to include a more radiation tolerant power MOSFET. The device was monitored for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Texas A&M University Cyclotron Single Event Effects Test Facility.

II. Devices Tested

The sample size of the testing was limited to one device. The device was manufactured by Modular Devices, Inc. and was characterized prior to exposure. The device tested had a serial number of 2019, and a Lot Date Code of 0132.

III. Test Facility

Facility: Texas A&M University Cyclotron Single Event Effects Test Facility, 15 MeV / amu tune.

Flux: 3.4 x 10^4 to 5.4 x 10^4 particles / cm^2 / s.

Ion	LET (MeVcm^2/mg)
Kr	28.4
Energy Degraded Kr	37
Energy Degraded Xe	60

IV. Test Methods

The test hardware for this testing was a digitizing oscilloscope, programmable power supplies and an electronic load. The programmable power supplies were used as an input to the DC / DC converter, allowing remote control of the input voltage. The output from the device was swept across the high impedance input of the digital scope and into an electronic load that maintained the device loading constant via a constant current mode on the output of the device. Any transients that would appear on the output pins of the devices would be triggered, captured and saved to a file by the Labview-controlled digital scope. The definition of a destructive event is an event that causes the output of the device to change to a value outside the specifications and that power cycling the device does not lead to a recovery of functionality.

Due to the high power nature of this device, special attention needed to be placed on the temperature control of the device. The device was mounted to a copper plate via a thremasil pad (electrically non-conductive, thermally highly conductive). On the reverse of the copper plate was welded copper coil tubing. The temperature of the device was monitored using a thermister in thermal contact with the casing of the device. Since the device sits in air in the TAMU facility, no forced cooling through the tubing was required. During the entire testing, the temperature remained between 20 and 25 °C.

V. Results

The DC/DC converters were tested under bias conditions of 120 and 126 volts at a loading of approximately 9.37 (25%), 18.72 (50%) and 28.1 (75%) watts. The DC/DC converter was de-lidded and the active device area divided into three circular regions. Region number 1 is the power MOSFET, Region #2 contained the linear devices at the device output and Region #3 is a linear device near the MOSFET.

For all of the conditions and all regions, no single event transients were observed at the output voltage port. However, the device did experience a destructive event when the MOSFET was exposed under the 120 volt, 50% loading condition and an LET of 60. That event resulted in the output dropping to zero volts and a loss of functionality that was not recovered after a power cycle. Prior to that failure, the device successfully ran through approximately 10^7 cm^{-2} ions at the other test conditions including:

- 75% loading at 120 volts at an LET of 28.4
- 75% loading at 126 volts at an LET of 28.4
- 50% loading at 120 volts at an LET of 37
- 25% loading at 120 volts at an LET of 60

The cross section for this one failure was approximately 2.5×10^{-6} cm^2. However, due to the sample size being only one device there could be substantial variation in this number.

VI. Recommendations

In general, devices are categorized based on heavy ion test data into one of the four following categories:

Category 1 – Recommended for usage in all NASA / GSFC spaceflight applications.
Category 2 – Recommended for usage in NASA / GSFC spaceflight applications, but may require mitigation techniques.
Category 3 – Recommended for usage in some NASA / GSFC spaceflight applications, but requires extensive mitigation techniques or hard failure recovery mode.
Category 4 – Not recommended for usage in any NASA / GSFC spaceflight applications.

The MDI3051RED12ZF Modular Devices, Inc. DC / DC Converters are Category 3 devices. Before these devices should be considered for spaceflight applications, more testing is required, including testing on a much larger sample size and testing under multiple load conditions at all LETs.