Total Dose Radiation Test Report
Interpoint SMHF2805
DC-DC Dual Output Converters

Tests at Low Dose Rate

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1.0 General

This test report covers total ionizing dose tests of SMHF2805 DC-DC converters, manufactured by Interpoint. Although these converters are radiation hardened, earlier tests at higher dose rates showed that they failed *catastrophically* at levels of 3.9 to 6.6 krad(Si). The purpose of this report is to provide test results at low dose rates for comparison with previous tests that were done at intermediate and high dose rates.

Two samples (S/N 34 and 35) were tested to failure by monitoring the performance of the converters at various input load conditions. All radiation testing was done with loads of 1.67A on the positive output, and 0.68A on the negative output (83% of the maximum rated load). That condition was used because of specific applications on the Jason program.

Tests were performed August 28 thru September 17, 2001 at JPL's low-dose rate cobalt-60 facility. The dose rate was 0.0066 rad(Si)/s. A special heat sink was used during the tests to raise the operating temperature to about 60 °C, the nominal temperature expected in the Jason application. That is higher than the temperature used for most of the earlier tests at higher dose rate, and could be important when comparisons are made between results at different dose rates.

2.0 Summary of Results

The failure level depended on input voltage conditions. The failure mode was defined as the condition where the output voltage decreased more than 5% below the nominal 5V output voltage. Failure first occurred for input voltages of 28V. The converters continued to operate, but no longer met their operation specifications unless the input voltage was increased to higher levels. Higher total dose failure levels occurred for input voltages of 32V. Table 1, below, summarizes the test results for the two converters for two different input voltage conditions.

Table 1. Summary of Test Results for the Two Converters

Serial Number	Temp. (°C)	Failure Level with Vin=28V [krad(Si)]	Failure Level with Vin=32V [krad(Si)]
34	55	8.72	9.58
35	58	6.29	6.96

3.0 Test Procedure

3.1 Test samples- Devices are DC-DC dual output converters manufactured by Interpoint. These are hybrid devices, and they can be manufactured with different types of internal components which makes it more difficult to ensure that radiation test data actually applies to the specific parts used in an actual space program. The key properties of these specific devices are as follows:

a) They use a TCS4426 MOSFET driver which is suspected to be the internal component that causes the devices to fail at levels well below the 100 krad level guaranteed by the manufacturer; and
b) They use a special hardened optocoupler in order to improve their radiation hardness to proton damage.

The samples were procured from the same lot used by the Genesis and Jason programs and the test conditions used to evaluate them were based on applications in those two spacecraft. The test samples were identified as follows:

Table 2. Part Identification

Generic Part Number:	SMHF2805
Part Stamp:	SMHF2805D/KR
Date Code:	QML9849
Package Description:	10-pin metal casing
Serial Numbers:	34 & 35

3.2 Irradiation facility- Total dose irradiations were performed using the JPL low-dose rate cobalt-60 facility. The dose rate was 0.0066 rad(Si)/s. This facility is compliant with Mi-STD-883, method 1019. Pb-Al shields were used to eliminate low-energy scattered gamma rays, in accordance with the test method.

3.3 Electrical tests- Both devices were attached to a copper coated bias card connected with approximately 24 foot wires and GPIB connection to all instrumentation. The devices' input and output voltages and currents were monitored via a Visual Basic program along with two Agilent 34401A Digital Multimeters throughout irradiation. Input current and output voltage were monitored to determine failures; typically the input current decreased just before the output voltage started to exceed specification limits. Temperature was also monitored via a copper thermocouple wire attached to an HP34970A Data Acquisition Switch and recorded at intermediate times during testing and irradiation.

Detailed electronic tests were performed at specific intervals, temporarily removing the devices from the irradiation test area. A separate Visual Basic program was used to make the detailed measurements, completing them within one hour of each exposure. The detailed tests involved "ramping" the input voltage (with constant load conditions established by an electronic load), measuring the output voltage. This test determined the minimum input voltage required to start the regulator, as well as the output voltage under the specified load conditions. A complementary test was also done, holding the input voltage constant and varying the output load conditions.

The time intervals used for irradiation and testing are shown in Table 3. The irradiation required nearly three weeks to complete, and the time intervals required for the detailed tests (when the parts were temporarily removed from the cell) were very short compared to the total irradiation time.

3.4 Bias conditions- Loads of 1.67A on the positive output and 0.68A on the negative output were applied to both parts during irradiation. This was done using fixed resistive loads of 3Ω on the positive 5V outputs and 7.3Ω on the negative 5V outputs. Parts were first biased with an input voltage of 28V until a >200mA decrease in input current or 5% decrease in output voltage was observed. Thereafter, a 32V input voltage (with the same loads) was applied to both converters, using the same specifications for failure, stopping the test after each part failed with the higher input voltage conditions.

3.5 Procedure- Pre-test data was taken on the two parts prior to irradiation and repeated at selected intervals during the irradiation sequence . Parts were positioned at 78cm from the source to obtain a constant dose rate of 0.0066 rad(Si)/s [0.4 rad(Si)/min]. A copper-constantan thermocouple was taped to the side of each converter, monitoring the temperature during irradiation as well as during the detailed measurements.

Table 3. Time Intervals for Irradiation and Measurement

DATE	OFF	ON	HOURS	MINUTES	TOTAL HRS.	TOTAL MIN.	TOTAL DOSE [rad(Si)]
28-Aug		9:30 PM					
29-Aug	2:00 PM	4:30 PM	16	30	16	30	392
4-Sep	10:30 AM	12:15 PM	138	0	154	30	3671
8-Sep	11:10 AM	11:15 AM	95	0	249	30	5928
9-Sep	**2:30 AM**	*** #35 FAIL 28V**	**15**	**15**	**264**	**45**	**6290**
9-Sep	10:15 AM	12:15PM	7	45	271	90	6475
9-Sep	7:00 PM	10:00 PM	6	45	277	135	6635
10-Sep	**11:40 AM**	*** #35 FAIL 32V**	**13**	**40**	**290**	**175**	**6960**
10-Sep	3:00 PM	5:00 PM	3	20	293	195	7039
13-Sep	**4:00 PM**	*** #34 FAIL 28V**	**71**	**0**	**364**	**195**	**8726**
14-Sep	10:40 AM	2:30 PM	18	40	382	235	9169
15-Sep	**8:00 AM**	*** #34 FAIL 32V**	**17**	**30**	**399**	**265**	**9585**
17-Sep	2:45 PM	* TEST STOPPED	54	45	453	310	10,886

4.0 Discussion

These tests at low dose rate were part of a series of tests under different conditions (including some parts irradiated with protons) that were done to determine (a) whether we were in agreement with data from other laboratories that showed very low failure levels for these supposedly hardened devices, and (b) if annealing would cause the failure level to be higher under the low dose-rate conditions in space. The dose rate used for these tests was less than two orders of magnitude higher than the average dose rate expected on the Jason spacecraft.

Even though the dose rate used for these tests was quite low, the failure level of these two converters was only slightly higher than the failure levels of similar parts that were irradiated at intermediate dose rates (see other reports in this series of tests for details). This indicates that very little annealing takes place during the irradiation, and that little improvement could be expected from annealing at the low dose rate conditions in space. However, only two devices were tested and the failure level of the first part was 35% higher than that of the second part. Part-to-part variability limits our ability to compare test results under different conditions. Similar part-to-part variations were observed in some of the other tests that were done on converters from this same lot. Temperature may also be a factor. Tests done at higher dose rates with better heat sinks that reduce the case temperature to about 35 °C have generally shown failure levels that are 20-30% lower than tests done with more limited temperature control.

Based on these tests, as well as earlier tests at different dose rates, the converters cannot be recommended for use at total dose levels above 5 krad(Si).