ISL70062SEH, ISL73062SEH

SEE Test Report

Introduction

The intense proton and heavy ion environment encountered in space applications can cause a variety of Single Event Effects (SEE) in electronic circuitry, including Single Event Upset (SEU), Single Event Transient (SET), Single Event Functional Interrupt (SEFI), Single Event Latch-Up (SEL), Single Event Gate Rupture (SEGR), and Single Event Burnout (SEB). SEE can lead to system-level performance issues including disruption, degradation, and destruction. For predictable and reliable space system operation, individual electronic components should be characterized to determine their SEE response. This report discusses SEE testing results performed on the ISL70062SEH 10A, NMOS protection switch. This report also applies to the ISL73062SEH as the parts only differ in TID radiation assurance testing. The ISL73062SEH only sees 75krad(Si) of low dose rate (0.01rad(Si)/s) assurance testing, while the ISL70062SEH also sees assurance testing to 100krad(Si) at high dose rate (50-300rad(Si)/s).

Product Description

The ISL70062SEH and ISL73062SEH are radiation hardened protection switches featuring a low resistance NMOS switch and fixed slew rate controlled turn-on. These devices are capable of 10A continuous current, simple on/off logic control input, and reverse current protection to stop current from flowing toward the input when the output voltage increases above the input voltage. They also have a selectable internal 100Ω NMOS device to discharge the output when the switch is off. The discharge circuitry is active when DON input is high, and it is inactive when DON is low. The supply voltage V_{CC} can be from 3V to 5.5V and the switched voltage can be from 0V to V_{CC} - 2V. These parts are offered in 14 LD CDFP packages with the pinout displayed in Figure 1.

The parts used for the testing described here were from lot 2CC8B wafer VKC8URW. The parts used for SEE testing did not see temperature testing because they did not have lids installed so as to allow irradiation.

The input to the switch (SWI) are Pins 1-5. The gate drive supply, VCC, is Pin 6. The switch output (SWO) are Pins 10-14. The control signal ON (switch command) is Pin 7, DON (discharge MOSFET control) is Pin 9, and ground (GND) is Pin 8.

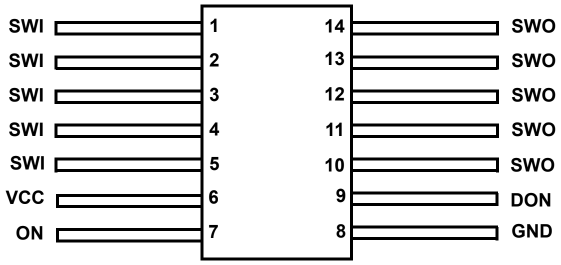

Figure 1. Pinout of the ISL70062SEH

Related Literature

For a full list of related documents, visit our website:

- ISL70062SEH, ISL73062SEH device pages

1. SEE Testing

1.1 Objectives

The ISL70062SEH was tested to determine susceptibility to destructive single event effects (referred in the document as SEB to include SEL) and to characterize SET behavior over different operating conditions.

1.2 Facility

Testing was performed at the Texas A & M University (TAMU) Radiation Effects Facility of the Cyclotron Institute heavy ion facility. This facility is coupled to a K500 super-conducting cyclotron, which is capable of generating a wide range of particle beams with the various energy, flux, and fluence levels needed for advanced radiation testing. Further details on the test facility can be found on their website. The Devices Under Test (DUTs) were located in air outside an Aramica window for the ion beam. Ion Linear Energy Transfer (LET) values are quoted at the DUT surface. Signals were communicated to and from the DUT test fixture through 20 foot cables connecting to the control room. The testing reported here was conducted on March 31 and April 1, 2019.

1.3 Set-up

For SEE testing the general circuit configuration in Figure 2 was used. Kelvin connections were provided to both high current terminals, SWI and SWO, so that accurate voltages could be measured at the unit even under high current tests. VCC, ON, and DON were brought out to be accessible.

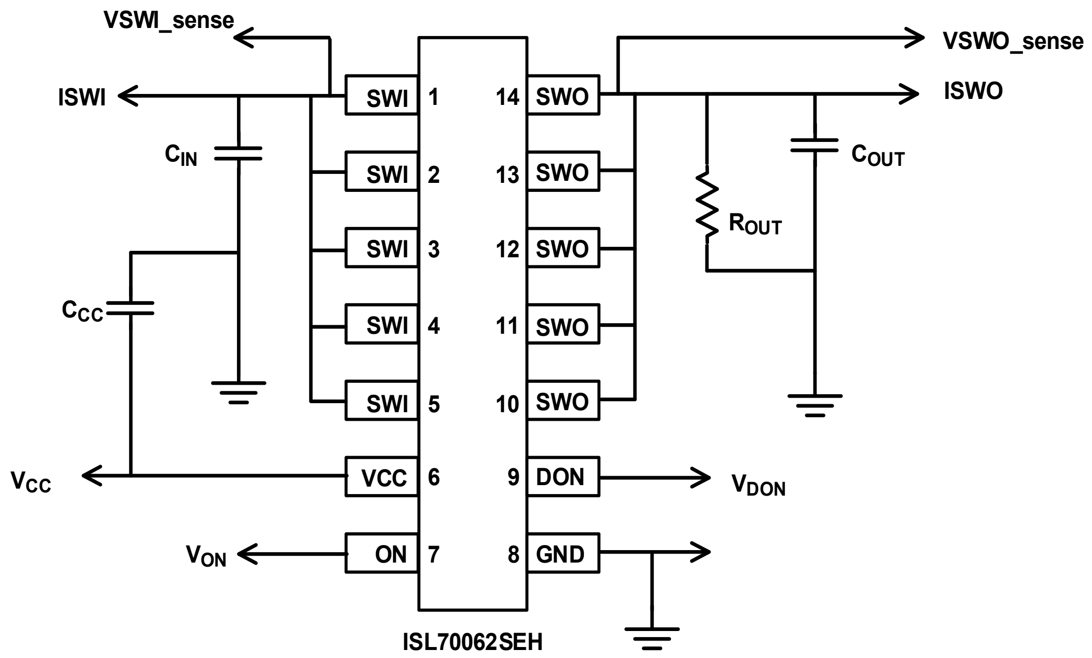

Figure 2. SEE Testing Configuration

For destructive SEE testing (termed SEB but to include SEL) three bias configurations were tested. All three configurations were without R_{OUT} or C_{OUT} components. This allowed currents of the DUT to be measured without contributions from external components. In the first configuration, the SWI, ON, and DON pins were provided with the V_{CC} test voltage so that the switch was on but unloaded (open SWO). In the second configuration, the output (SWO) was remotely loaded with a 1kΩ resistor and the switch control (ON) was provided with a 100Hz square wave between 0V and 5V. For the third configuration, the input (SWI) and the ON pin had a test voltage applied. The output (SWO) had a 12A electronic current sink applied to it. This last case necessitated the Kelvin connection to SWI so that the voltage at the DUT could be monitored under high current conditions. In all cases the V_{CC} voltage was at the test value and the VSWI voltage was set to 2V below V_{CC}. All the destructive SEE testing was done with a case temperature of 125°C ± 10°C. This testing required heating except for the high current condition which self-heated to above 125°C.

For the SET testing the external components R_{OUT} and C_{OUT} were populated with 1kΩ and 1µF. Four configurations were tested for SET. The first two conditions were with ON and DON pins biased at 0.4V (maximal logic low condition) and V_{CC} at both 3.0V and 5.5V with VSWI set to 2V lower. Because the switch was biased off, the SET would indicate a momentary switch to the on condition. The other two SET configurations had ON and DON at 1.2V and an additional 1Ω load on VSWO. In this condition, SET on VSWO indicated cases where the switch tended toward an off condition.

2. Results

2.1 ISL70062SEH Destructive SEE Testing with LET = 86MeV·cm²/mg

Destructive SEE testing was done with V_{CC} supply voltages of 6.2V, 6.5V, and 6.7V. The switch voltage (VSWI) was set to be V_{CC} – 2V. The first two configurations of the destructive SEE testing were done on two parts at a time to minimize beam time. The parts were mounted so that both were inside the ion beam diameter. The parts were biased and monitored separately during the testing. Only the high current condition, 12A, was tested one part at a time to mitigate the thermal conditions. For the high current testing the package thermal pad on the bottom was soldered to the board copper to provide better heat sinking.

Destructive SEE testing of the ISL70062SEH proceeded with monitoring six currents before and after irradiation. A description of the six current measurements is presented in Table 1. These monitored all three destructive SEE test configurations:

- Off switch
- 100Hz toggled switch into 1kΩ
- On switch with 12A load current.

Measurements of each current were made prior to irradiation and again after each irradiation. The currents did not move more than -6%, and this was for the IDON where that change was about the resolution of the measurement. So, it was concluded that there was no indication of permanent damage through all forty-eight irradiations done (four parts, three configurations, three voltages).

Table 1. The Six Current Measurements Made on Either Side of Each Irradiation to Monitor for Any Damaging SEE.

Measurement	VCC	VON	VDON	VSWI	VSWO
IVCC	5V	5V	5V	3V	Open
ISWI	5V	5V	5V	3V	Open
ISWI	5V	Open	Open	3V	0V
ISWO	5V	Open	Open	3V	3V
ISWO	5V	Open	5V	3V	3V
IDON	5V	Open	5V	3V	3V

In addition to the monitoring of the six currents described, the V_{CC} supply current during irradiation was continuously monitored and logged. The current monitor logs for V_{CC} were reviewed after the testing. The results for a bias of 6.2V and 6.5V and the switch off were comparable and exhibited isolated, small current events. For the condition of the switch off at V_{CC} = 6.5V, the nominal current on V_{CC} was about 24µA, as shown in Figure 3 on page 4. In the $4x10^7$ion/cm² distributed over four devices there were two events that led to instantaneously higher currents of about 45µA. These events represent a nominal cross section of 5µm². At 6.7V for the off condition, the nature of the events changed as shown in Figure 4 on page 5. In this case, three events produced current events of over 1mA, while four events of less than 50µA were also recorded. The highest events were over 10mA. It is important to note that these events did not persist, and the currents immediately returned to the nominal values. The high currents are indicative of a high gain process associated with the SEE such as could potentially lead to SEL, but the immediate return to nominal currents indicates that the process did not achieve a latching state, which probably indicates conditions that are on the threshold of SEL. The nominal cross section for events at 6.7V was only 20µm² for LET of 86MeV·cm²/mg.

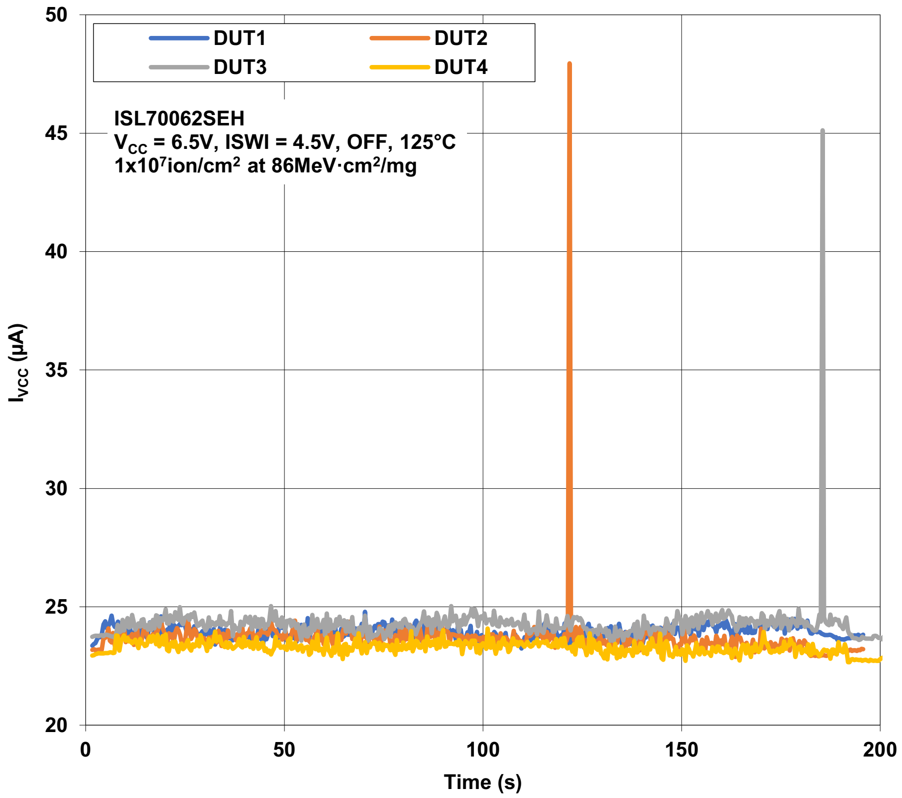

Figure 3. VCC Current Logs for V_{CC} = 6.5V and VSWI = 4.5V with the Switch Off

The currents registered for the case of a 100Hz toggled switch into a 1kΩ load were significantly higher than for the off-switch state at approximately 160µA. There where no current transient events on the four parts tested to $1x10^7$ion/cm^2 at V_{CC} = 6.7V. This is important as no events pushing the current to 1mA or above were captured. In fact, there were no current deviations of even 20µA as noted at 6.5V for the off state.

The on condition of the switch with 12A flowing provides another view of the SEL topic. The currents registered about 24µA and did not exhibit any current spikes. It should be noted that there were a couple of different testing conditions for this 12A case as compared to the other two configurations. First, internal heating of the part took it up to 125°C without any external heaters as were used for the other two destructive SEE test conditions. A second difference was the use of shields in the irradiations to prevent double events in redundant circuits from leading to an abrupt interruption in the current and a resulting transient voltage due to parasitic inductance that could damage the part. The shields were two on the left edge of the parts and two on the right edge so that over the four parts the entire circuit received irradiation.

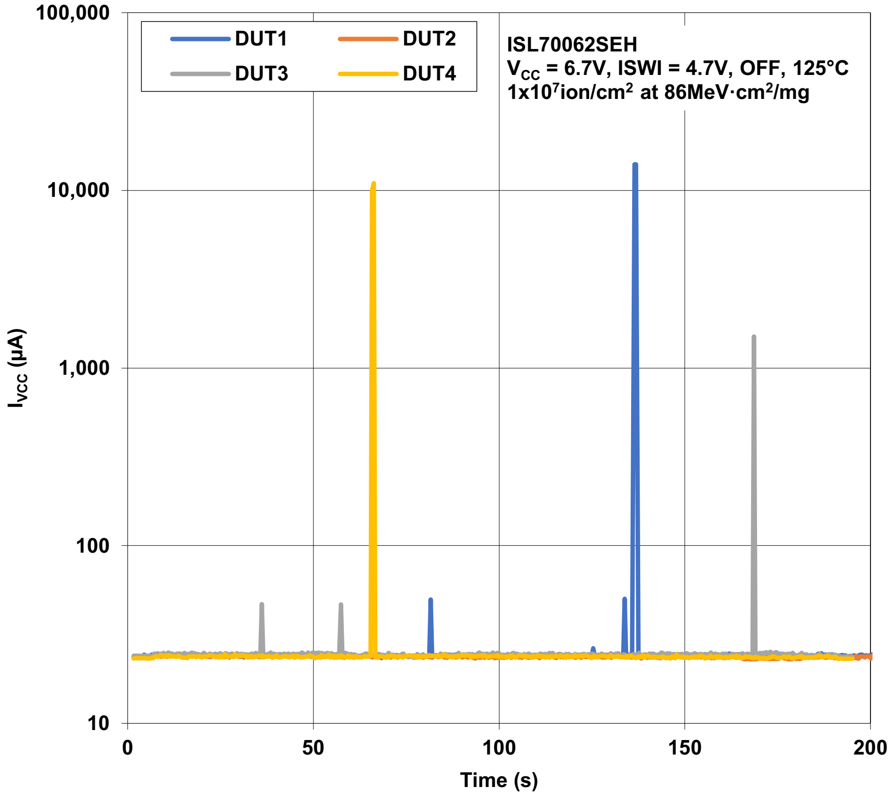

Figure 4. VCC Current Logs for V_{CC} = 6.7V and VSWI = 4.7V with the Switch Off

From the testing it was concluded that the ISL70062SEH did not suffer any SEL or any damaging effects (SEB) from irradiation with normal incidence gold (86MeV·cm^2/mg) while operating at supply voltages up to 6.7V and at case temperature of 125°C.

2.2 ISL70062SEH Single Event Transient (SET) Testing

Single event transient testing of the ISL70062SEH was done under four bias conditions. Testing was done with the supply voltage V_{CC} at both 3.0V and 5.5V to span the operating range. The switch input voltage (VSWI) was set to 1V and 3.0V, respectively. At each voltage, the part was tested in the off condition with both ON and DON biased at 0.4V, the maximum voltage for a logic low on those inputs. The parts were also tested in the on condition with both ON and DON at 1.2V, the minimum voltage for a logic high on those inputs. The output VSWO was loaded with 1kΩ when the switch was off and with 1Ω when the switch was on. In both cases the VSWO had a 1µF capacitor. The 1Ω set the current to 1A and 3A at the two voltage conditions for the switch in the conducting state.

The parts tested for SET included both parts shielded on the left edge (four parts shielded on VSWI side) of the die and parts shielded on the right edge (four parts shielded on VSWO side) of the die. These shields covered redundant channels of the ON, UVLO, and RCP circuitry and eliminated the chance of double ion events defeating those redundant circuits. The two non-overlapping shields ensured that all the circuit was exposed to ion flux when results from both shields are considered together.

During the SET testing, the VSWO of the part was monitored with an oscilloscope set to both trigger and store a trace on a ±10mV deviation on VSWO. Another oscilloscope was set to trigger and store events when VSWO fell through 0.5V. The two oscilloscopes allowed real-time counting of complete shutdown events (triggering at 0.5V), and the calculation of small events by the difference in the counts collected.

No SET to the ±10mV criteria on VSWO were captured. This means that when the switch was off there were no events that led to more than 10mV of output with a 1kΩ load resistor (<10µA). For the on state with a 1Ω load, the less than 10mV deviation means that no current change of more than 10mA occurred.

3. Discussion and Conclusions

The ISL70062SEH proved to be immune to SEL and destructive SEE when tested with a supply voltage at V_{CC} = 6.7V and VSWI = 4.7V, at a case temperature of 125°C, and irradiated with normal incidence gold for an LET of 86MeV·cm^2/mg to a fluence of 1x10^{7}ion/cm^2. A total of twelve parts were tested, four each under three different biasing circumstances. The first configuration looked specifically for signs of SEL in the operating V_{CC} current of an off switch. The second configuration looked at a 100Hz switching case with a lightly loaded output (1kΩ). The third configuration was a high current case with the output supplying 12A. None of the testing resulted in any sign of SEL or damage in the six monitored currents (see Table 1 on page 3).

SET testing did not yield any events with irradiation by normal incidence gold (86MeV·cm^2/mg). SET were counted for any deviation in VSWO by ±10mV. Conditions tested were both the switch off with a 1kΩ load and with the switch on and a 1Ω load at both V_{CC} = 3V, VSWI = 1V and V_{CC} = 5.5V, VSWI = 3V. Four parts were tested to each condition to a fluence of 1x10^{7}ion/cm^2 for each irradiation.

4. Revision History

Rev.	Date	Description
1.00	Aug.12.19	Initial release

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