ISL70040SEH, ISL73040SEH

Single Event Effects (SEE) Testing

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Overview

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 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 the results of SEE testing performed on the ISL70040SEH and ISL73040SEH low-side GaN FET drivers.

Product Description

The ISL70040SEH and ISL73040SEH are radiation hardened low-side drivers designed to drive enhancement mode Gallium Nitride (GaN) FETs in isolated topologies and boost type configurations. The ISL70040SEH and ISL73040SEH offer both inverting and non-inverting inputs to satisfy requirements for inverting and non-inverting gate drive with a single device. The part operates from a supply of 4.5V to 13.2V. The part is manufactured in Intersil's proprietary P6 junction isolated BiMOS process.

The parts used for the testing described here were from manufacturing wafer lot 5VD7B and wafer AYI4GDW. They were mounted without lids in the 8 Ld flatpack production package with code JSE. They did not receive any of the production burn-ins or over-temperature testing, since they did not have lids, so as to allow SEE irradiation.

Related Literature

- For a full list of related documents, visit our website
  - ISL70040SEH, ISL73040SEH product pages

1. Test Description

1.1 SEE Test Objectives

The ISL70040SEH was tested to determine its susceptibility to destructive single event effects (referred to herein as SEB) and to characterize its Single Event Transient (SET) behavior over different operating conditions. This testing also serves to characterize the ISL73040SEH part.

1.2 SEE Test 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 at the website (http://cyclotron.tamu.edu/). The Devices Under Test (DUTs) were located in air at 30mm to 50mm from the Aramica window for the ion beam. Ion 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 May 2, 2017.

1.3 SEE Test Set-Up

SEE testing was carried out with the samples in an active configuration. The schematic of the ISL70040SEH SEE test fixture is shown in Figure 1. Four units were mounted on every test board so that four units could be simultaneously irradiated and tested.

With the objective for testing the ISL70040SEH for damaging SEE (collectively termed SEB), the part was placed in an operating condition with the input signal, IN, being driven by a 500kHz square wave switching between GND and 10V. The INB terminal was tied to GND, and the output was loaded with C_{OUT} = 10nF. The parameters monitored before and after irradiation to check for SEB were operating I_{DD} at the 500kHz input to IN, static I_{DD} at IN = 1.00V, static I_{DD} at IN = 2.0V, I_{IN} at IN = 0V, I_{IN} at IN = 13.2V, V_{OUT} at IN = 1.00V, and V_{OUT} at IN = 2.0V. V_{DD} was varied above the maximum operating voltage to test the limits of damage-free operation at levels of 14.7V, 15.1V, 15.6V, and 16.5V.

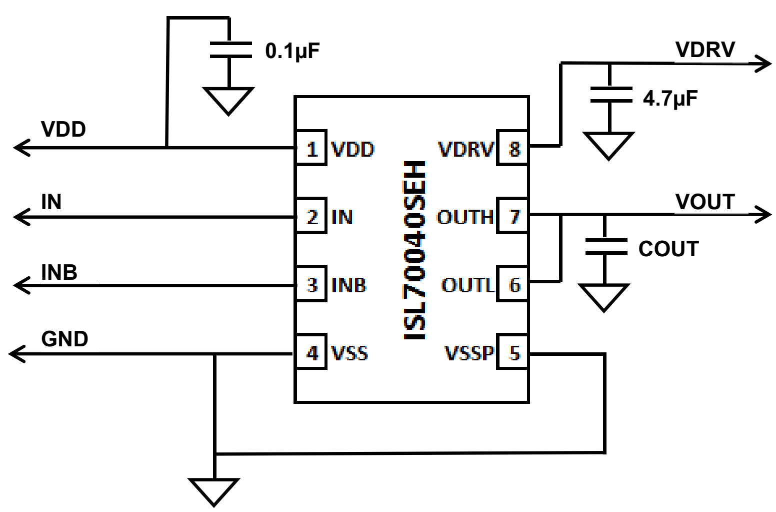

Figure 1. Schematic of the ISL70040SEH SEE testing circuit. Connectors indicated go to 20 foot cables connecting to the control room. C_{OUT} and V_{DD} varied depending on the test.

The SET behavior of the ISL70040SEH was tested in both static and dynamic input cases. For these, the C_{OUT} was removed to speed the V_{OUT} response, and only the cable capacitance of about 700pF loaded the output. Again, the INB input was tied to GND. In the static testing, IN was alternately set to 1.00V (V_{IL}) and 2.0V (V_{IH}) to provide the minimum noise margin on the input. The output, V_{OUT}, was monitored by an oscilloscope and triggered a capture whenever V_{OUT} deviated by ±0.5V. VDRV was also captured in an SET event. The captures encompassed time of -2µs to +18µs from the trigger point. During the dynamic testing, IN was again provided a 500kHz signal with a GND to 5V swing. In this case, V_{OUT} was monitored, and captures were triggered on ±20ns deviation from the nominal 1µs pulse width. Again, VDRV was also captured for any SET, and the capture time was -2µs to +18µs from the trigger time.

1.4 Destructive SEE Testing of the ISL70040SEH with LET = 86MeV•cm^2/mg

Destructive SEE (SEB) testing of the ISL70040SEH proceeded with varying V_{DD} (14.7V, 15.1V, 15.6V, and 16.5V) and checking the operating parameters (dynamic I_{DD} at 500kHz into 10nF, static I_{DD} at IN = 1.00V, I_{DD} at IN = 2.0V, I_{IN} at IN = 0V, I_{IN} at IN = 13.2V, V_{OUT} at IN = 1.00V, V_{OUT} at IN = 2.0V) before and after irradiation to identify any damaging effects. Irradiation was done with 2.954 GeV gold (Au) at normal incidence for LET at the die surface (after an aramica window and an 30mm air gap) of 86MeV•cm^2/mg to a fluence of 1x10^{7}ion/cm^2 at a flux of 5x10^{4}ion/(cm^{2}s) and at a case temperature of +125°C ±10°C.

Although testing was also done at V_{DD} of 14.7V, 15.1V, and 15.1V, only the results at V_{DD} = 16.5V are presented here in Table 1. The results at the other voltages were similarly unchanging and, so add no new information.

Table 1. ISL70040SEH SEB monitor measurements for V_{DD} = 16.5V and LET = 86MeV•cm^2/mg to a fluence of 1x10^7 ion/cm^2 with T_{CASE} = +125ºC ±10ºC.

V_{DD} = 16.5V		I_{DD} 500kHz (mA)	I_{IN} at IN = 0V (nA)	I_{IN} at IN = 13.2V (µA)	I_{DD} at IN = 1.00V (mA)	V_{OUT} at IN = 1.00V (µV)	I_{DD} at IN = 2.0V (mA)	V_{OUT} at IN = 2.0V (V)
DUT1	Pre	24.21	3.99	73.1	1.73	152	9.90	4.54
	Post	23.96	4.20	73.1	1.73	143	9.95	4.54
	Delta	-1.0%	5.3%	0.0%	0.0%	-5.9%	0.5%	0.0%
DUT2	Pre	22.97	2.24	71.8	1.75	157	9.85	4.59
	Post	22.79	2.50	71.7	1.75	148	9.90	4.59
	Delta	-0.8%	11.6%	-0.1%	0.0%	-5.7%	0.5%	0.0%
DUT3	Pre	23.89	6.38	73.1	1.75	153	10.00	4.54
	Post	23.94	6.11	72.9	1.75	146	10.05	4.54
	Delta	0.2%	-4.2%	-0.2%	0.0%	-4.6%	0.5%	0.0%
DUT4	Pre	22.41	74	72.4	1.73	176	9.75	4.57
	Post	22.35	79	72.5	1.73	169	9.79	4.57
	Delta	-0.3%	6.8%	0.1%	0.0%	-4.0%	0.4%	0.0%

The data presented in Table 1 supports the conclusion that the ISL70040SEH is immune to damaging SEE for operation at V_{DD} = 16.5V and case temperature of +125°C when irradiated with ions of LET 86MeV•cm^2/mg at normal incidence. All of the monitored parameters exhibited variations within the reasonable accuracy of the measurements.

1.5 SET Testing of the ISL70040SEH Low-Side GaN FET Driver with LET = 86MeV•cm^2/mg

The SET testing of the ISL70040SEH was first directed to look for the occurrence of V_{OUT} deviations from a static output level. The test was to look for V_{OUT} deviating by ±0.5V for both IN = 1.00V and IN = 2.00V. Tests were run for both V_{DD} = 4.5V and V_{DD} = 13.2V. No static SET were captured for any of the four DUTs tested in all four of the static conditions. With four parts each irradiated to 1x10^{7}ion/cm^2 at an LET of 86MeV•cm^2/mg and +25°C, this put an upper bound on the cross section for a static SET at 2.5x10^{-8}cm^2.

The next SET testing was looking for ±20ns perturbations on a 500kHz signal at the output. Again, both supply voltages, 4.5V and 13.2V, were tested. At testing with 86MeV•cm^2/mg gold ions, a small number of dynamic SET were found. Subsequently the dynamic testing was repeated with 60MeV•cm^2/mg praseodymium ions. The results for this dynamic testing are presented in Table 2. The largest SET seen with gold irradiation was 57ns while the largest SET with praseodymium was 56ns indicating that there was essentially no difference between to two ions in either cross section nor in SET magnitude. All the dynamic SET captured for driving the IN input were narrowed positive pulse events at the output.

Table 2. ISL70040SEH ±20ns perturbation counts on a 500kHz square wave and cross sections for normal incidence ions at 86 and 60MeV•cm^2/mg at +25°C.

	±20ns SET Counts for 500kHz				Average Cross Section (cm^2)
	DUT1	DUT2	DUT3	DUT4	
86MeV•cm^2/mg					
V_{DD} = 4.5V	15	10	14	8	1.18x10^{-6}
V_{DD} = 13.2V	14	17	14	8	1.33x10^{-6}
60MeV•cm^2/mg					
V_{DD} = 4.5V	7	12	11	5	8.75x10^{-7}
V_{DD} = 13.2V	17	12	11	15	1.38x10^{-6}

2. Discussion and Conclusions

The ISL70040SEH and ISL73040SEH were found to be immune to damaging SEE when run at V_{DD} = 16.5V and a case temperature of +125°C ±10°C with a 500kHz signal being driven into a 10nF load capacitance and irradiated with normal gold ions for a surface LET of 86MeV•cm^2/mg. Four parts irradiated to $1x10^7$ion/cm^2 each showed no fundamental changes in the seven monitor parameters as presented in Table 1 on page 3.

The ISL70040SEH and ISL73040SEH demonstrated no static output upsets larger than ±0.5V at either V_{DD} = 4.5V or V_{DD} = 13.2V and the input at either IN = 1.00V (V_{IL}) or IN = 2.00V (V_{IH}). The irradiations to $1x10^7$ion/cm^2 were done with normal gold for a surface LET of 86MeV•cm^2/mg at a case temperature of approximately +25°C.

For dynamic SET defined as a ±20ns perturbation in pulse width for a 500kHz signal, a very small cross section (≤$1.7x10^{-6}cm^2$ as reported in Table 2 on page 4) was found for the ISL70040SEH. This was determined for $1x10^7$ion/cm^2 on each of four parts irradiated with normal incidence gold for LET of 86MeV•cm^2/mg. As with the static SET testing V_{DD} was set to both V_{DD} = 4.5V and V_{DD} = 13.2V with little difference. The dynamic SET testing was also done with normal incidence praseodymium for an LET of 60MeV•cm^2/mg with essentially no difference in cross section (≤$1.7x10^{-6}cm^2$) or in SET magnitude (≤57ns).

3. Revision History

Rev.	Date	Description
0.00	Aug 30, 2017	Initial release

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Refer to "http://www.renesas.com/" for the latest and detailed information.

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