ISL75051ASEH, ISL73051ASEH

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), Single Event Latch-Up (SEL), 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 ISL75051ASEH 3A, low-dropout linear regulator. This report also applies to the ISL73051ASEH as it only differs in the TID radiation assurance testing.

Product Description

The ISL75051ASEH and ISL73051ASEH are radiation hardened low-voltage, high-current, single-output LDOs specified for up to 3.0A of continuous output current. These devices operate over an input voltage range of 2.2V to 6.0V and are capable of providing an output voltage of 0.8V to 5.0V adjustable, based on resistor divider setting. Dropout voltages as low as 65mV can be realized using these devices. They are both offered in an 18 Ld CDFP package.

The parts used for the testing described here were from lot 1JLUB00000. The parts used for SEE testing did not see temperature testing because they did not have lids to allow irradiation.

Related Literature

- For a full list of related documents, visit our website
  - ISL75051ASEH, ISL73051ASEH product pages

1. Test Description

1.1 SEE Test Objectives

The ISL75051ASEH was tested to establish equivalency with the predecessor part ISL75051SRH as reported in Application Note 1666. This consisted of duplicating tests to determine susceptibility to destructive single event effects (referred to herein as SEB) and to characterize Single Event Transient (SET) behavior over several operating conditions and output capacitor values.

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 40mm 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 October 14 and 15 of 2017.

1.3 SEE Test Set-Up

SEE testing was broken into three types of testing. The first type of testing was for destructive SEE effects (termed SEB/L here). This consisted of putting the device into disabled and enabled operating conditions with various supply voltages and then irradiating the parts. The second and third types of testing were for Single Event Transients (SET) on the output voltage for different output conditions and two values of output capacitance, 220µF and 47µF.

For the SEB/L testing, three parameters were monitored before and after irradiation to look for changes indicative of SEB/L. The first parameter was V_{OUT} which was set to a nominal value of 1.8V. In addition to the feedback divider between VOUT and GND to ADJ, a 100pF capacitance was provided from ADJ to GND. The next two parameters were the supply current with zero load (other than the feedback resistor divider) and the shutdown (EN = 0V) supply current.

The test boards were configured so that two ISL75051ASEH at a time could be irradiated and monitored. The input (VIN, Pins 12-17) capacitors to GND (Pin 1) for each part were 220µF with a 6mΩ ESR (Kemet T530D227M010ATE006) in parallel with a 0.1µF ceramic capacitor. The output (VOUT, Pins 2-7) capacitors to GND were either the same as the input or a 47µF with 35mΩ ESR (Kemet T525D476M016ATE035) with the 0.1µF ceramic. The OCP (Pin 11) resistors to GND were 576Ω. The PG (Pin 18) was pulled up to VIN by 549Ω resistors. The BYP (Pin 9) was connected to GND by a 0.1µF ceramic capacitor. The EN (Pin 10) was pulled to VIN with 10kΩ resistors. The ADJ (Pin 8) was connected to VOUT by a 4.32kΩ resistor in parallel with the series combination of a 2.67kΩ resistor and a 4.7nF capacitor. The feedback network was completed by connecting the ADJ to GND through the parallel combination of a 1nF capacitor and either a 1.74kΩ resistor (for V_{OUT} = 1.8V) or a 442Ω resistor (for V_{OUT} = 5.6V). These lower feedback resistors were selected by relays so the parts could be remotely switched between output voltages. VIN and VOUT were Kelvin connected so that high currents did not interfere with the voltage readings of those nodes. The five control pins (ADJ, EN, OCP, PG, and BYP) were brought out, along with the Kelvin connections of VIN and VOUT, to the 20 foot cabling to make them accessible in the irradiation control room.

1.4 SEB/L Testing of the ISL75051ASEH with Effective LET = 85.6MeV·cm2/mg

Single event burnout and single event latch-up (SEB/L) testing of the ISL75051ASEH was first done using silver with LET of 42.8MeV·cm^2/mg at an incidence angle of 60° for an effective LET of 85.6MeV·cm^2/mg. This replicated the testing done on the original ISL75051SRH. The SEB/L testing done with silver was done at input voltages of 6.7V and 7.1V, with the 220µF output capacitor, and used a current load of 20mA when the part was enabled. The parameters monitored before and after irradiation for indication of SEB/L were the output voltage (nominally 1.8V), the enabled supply current with zero load current, and the disabled supply current. Irradiations were done in both the disabled and enabled states. A summary of the results is presented in Table 1 on page 3.

Table 1. SEB/L testing results data for the ISL75051ASEH irradiated with 60° incidence silver for effective LET of 85.6MeV·cm^2/mg. Each irradiation was to 2x10^{6}ion/cm^2 at a case temperature of +125°C. When enabled, the part was loaded with 20mA.

	Irradiation Conditions		V_{OUT}, EN = V_{IN}		I_{IN} at 0A I_{OUT}, EN = V_{IN}		I_{IN} at 0A I_{OUT}, EN = GND	
	V_{IN}	EN (V)	Pre (V)	Delta	Pre (mA)	Delta	Pre (µA)	Delta
DUT1	6.7	0 (Note 1)	1.817	0.06%	13.01	0.08%	11.40	-0.18%
		V_{IN}	1.815	0.06%	12.98	-0.06%	11.50	-0.35%
	7.1	0 (Note 2)	1.824	-0.05%	13.30	-0.15%	12.04	-0.04%
		V_{IN}	1.821	0.27%	13.28	-0.53%	12.04	-0.04%
DUT2	6.7	0 (Note 1)	1.822	0.22%	13.24	0.30%	11.70	0.51%
		V_{IN}	1.823	-0.05%	13.31	0.08%	11.80	0.17%
	7.1	0 (Note 2)	1.828	0.00%	13.61	0.29%	12.53	-0.64%
		V_{IN}	1.826	0.11%	13.65	0.22%	12.45	-0.24%
DUT45	6.7	0 (Note 1)	1.821	0.00%	12.96	0.15%	11.40	0.18%
		V_{IN}	1.821	0.00%	12.98	-0.46%	11.42	-0.09%
	7.1	0 (Note 2)	1.823	0.22%	13.14	0.15%	11.99	0.00%
		V_{IN}	1.827	-0.11%	13.16	0.15%	11.99	-0.50%
DUT46	6.7	0 (Note 1)	1.819	-0.11%	13.20	0.00%	11.80	-0.17%
		V_{IN}	1.817	0.11%	13.20	0.15%	11.78	0.17%
	7.1	0 (Note 2)	1.824	-0.11%	13.57	-0.07%	12.48	-0.06%
		V_{IN}	1.822	-0.05%	13.57	-0.22%	12.47	-0.50%

Notes:
1. Occasional I_{IN} events up to 30mA occurred and resolved if ion beam remained. If the ion beam was stopped during such an event, the elevated I_{IN} continued until the part was power cycled.
2. Occasional I_{IN} events up to 200mA occurred and resolved if ion beam remained. If the ion beam was stopped during such an event, the elevated I_{IN} continued until the part was power cycled.

Although no permanent damage was observed in the irradiation runs represented in Table 1, events occurred (Notes 1 and 2) that appeared to be Single Event Latch-Up (SEL). The supply current exhibited a sudden increase during irradiation for the disabled state. If the ion beam was continued, the currents would switch back to the normal levels. If the ion beam was stopped during a high current event, the high current would remain until a power cycle was performed on the part. After the power cycle, the current returned to the pre-irradiation level, indicating no permanent damage had occurred. These SEL events were not noted in the testing of the original part (ISL75051SRH), but because the SEL events resolved under continued irradiation it is possible that such events were simply not noted in that original testing.

SEB/L testing of the ISL75051ASEH was next done using normal incidence gold for a LET of 86.3MeV·cm^2/mg. The testing repeated the methodology of the testing with silver with the exception of the voltages which were 6.2V and 7.1V. As before, the output capacitor was 220µF and the enabled current load was 20mA.

Table 2. SEB/L testing results data for the ISL75051ASEH irradiated with normal incidence gold for LET of 86.3MeV·cm^2/mg. Each irradiation was to 1x10^{7}ion/cm^2 at a case temperature of +125°C

	Irradiation Conditions		V_{OUT}, EN = V_{IN}		I_{IN} at 0A I_{OUT}, EN = V_{IN}		I_{IN} at 0A I_{OUT}, EN = GND	
	V_{IN}	EN (V)	Pre (V)	Delta	Pre (mA)	Delta	Pre (mA)	Delta
DUT17	6.2	0	1.816	0.2%	13.060	0.0%	11.200	0.0%
		V_{IN}	1.819	0.2%	13.060	0.1%	11.200	-0.6%
	7.1	0	1.830	0.1%	13.600	1.5%	12.750	0.0%
		V_{IN}	1.832	-0.2%	13.800	-2.3%	12.750	0.4%
DUT18	6.2	0	1.819	0.1%	12.380	0.2%	10.500	1.0%
		V_{IN}	1.821	0.8%	12.410	0.7%	10.600	-0.2%
	7.1	0	1.843	-0.5%	13.190	-0.7%	12.210	-2.0%
		V_{IN}	1.833	0.3%	13.100	1.7%	11.970	12.2%
DUT19	6.2	0	1.814	-0.1%	13.200	0.2%	11.100	0.1%
		V_{IN}	1.813	-0.1%	13.200	0.2%	11.110	1.2%
	7.1	0	1.818	1.3%	13.920	593.2%	12.730	559.9%
		V_{IN}						
DUT20	6.2	0	1.815	0.1%	12.500	0.0%	10.540	0.1%
		V_{IN}	1.816	-0.1%	12.500	0.0%	10.550	-0.1%
	7.1	0	1.816	-100.0%	13.150	-37.6%	12.150	492.6%
		V_{IN}						

Note: Shaded entries indicate a test failure, a delta in excess of 3%.

The results of the SEB/L testing with gold as shown in Table 2 indicate that the ISL75051ASEH is immune to both SEB and SEL when operated at V_{IN} = 6.2V and irradiated with ions of LET 86.3MeV·cm^2/mg. It is clear that operation at V_{IN} = 7.1V along with irradiation of 86.3MeV·cm^2/mg can lead to destructive events.

1.5 SET Testing of the ISL75051ASEH with LET = 85.6 MeV·cm^2/mg and 220µF

SET testing was carried out with silver at 60° incidence for an effective LET of 85.6MeV·cm^2/mg. A set of four parts had 220µF output capacitors. The parts were configured so that two parts at a time could be irradiated and monitored. A summary of the SET that exceeded ±15mV deviation (trigger level) on the output for the 220µF output capacitor is presented in Table 3.

Table 3. V_{OUT} ±15mV deviation SET counts for irradiation with silver at 60° incidence for effective LET of 85.6MeV·cm^2/mg to 2x10^{6}ion/cm^2 at +25°C ambient. The output capacitance in this case was 220µF with an ESR of 6mΩ.

V_{IN} (V)	V_{OUT} (V)	I_{OUT} (A)	±15mV V_{OUT} SET Counts			
			DUT40	DUT41	DUT23	DUT24
2.2	1.8	0.1	604	216	386	122
2.2	1.8	3.0	2127	731	2018	885
4.0	1.8	0.1	1408	220	1325	172
4.0	1.8	1.0	1945	837	1782	884
6.0	5.6	0.1	3057	790	1225	735
6.0	5.6	3.0	2553	1012	1599	2131

There appears to be a large difference in event counts according to DUTs. This count difference is in the small magnitude transients near the trigger level. The large magnitude transients were very similar across DUTs, but the results for DUT40 were consistently slightly larger in magnitude. For this reason, DUT40 will be used to provide example SET in the following discussion.

The SET in Figure 1 is the largest positive SET captured for the operating conditions given. The determination of the largest SET was based on the waveform following 4µs from the trigger point (time = 0) so as to exclude this initial spike. The initial positive spike is slightly truncated at about 1.90V by the oscilloscope capture settings, but it appears to be approximately 100mV in magnitude, and it is less than 2µs in duration. During the positive spike, a charge was injected into the output capacitor (220µF) and resulted in the 18mV rise in output voltage as seen at about 5µs. This 18mV was the maximum such charging observed for the operating conditions. This over charge of the capacitor then decayed linearly according to the 100mA load current. The decay of the 18mV took roughly 30µs to the point where LDO regulation returned. Only ten of the SET captured (604) had capacitor voltage rises of greater than 15mV. Only 35 SET events exceeded a 10mV capacitor voltage rise. In fact, 83% of the events had less than +4mV output change beyond 4µs from trigger.

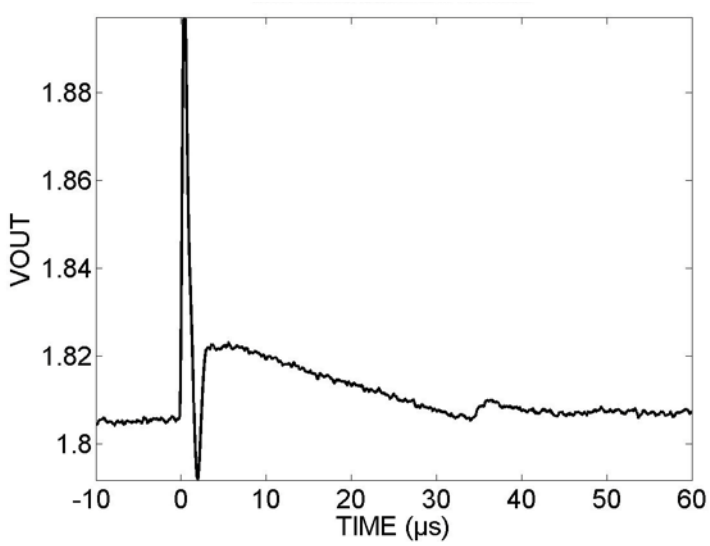

Figure 1. Largest SET (DUT40, trace 560) measured beyond 4µs from trigger with V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 100mA, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm^2/mg).

One question that follows from Figure 1 is whether the capacitor change varies with the difference between the supply voltage and the output voltage. To answer this question the largest DUT40 SET for the case of V_{IN} = 4.0V to V_{OUT} = 1.8V at 100mA is presented in Figure 2 on page 6. Although the initial spike seems somewhat stronger (though still truncated at about 1.90V), the capacitor voltage change is slightly smaller at 17mV. Because this is the same DUT40 and board, it seems that the differential between input voltage and output voltage is not important to the SET charging of the output capacitor.

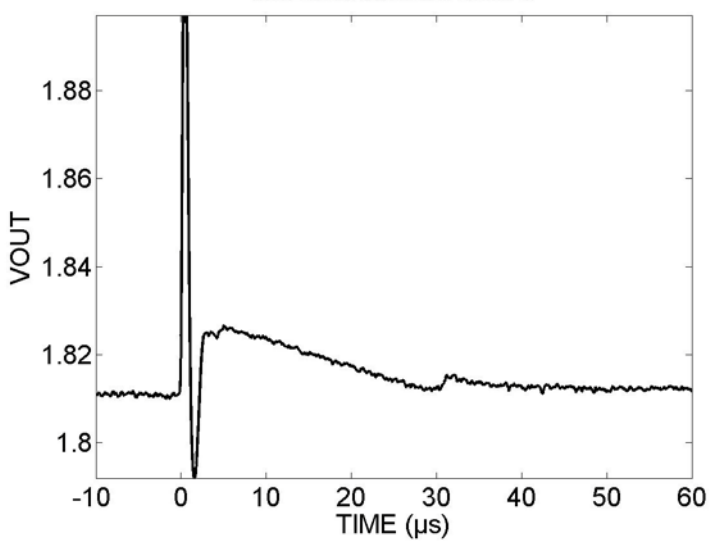

Figure 2. Largest SET (DUT40, trace 845) measured beyond 4µs from trigger with V_{IN} = 4.0V, V_{OUT} = 1.8V, I_{OUT} = 100mA, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm2/mg).

The next question is whether the SET changes with output voltage. This question is explored by Figure 3 which shows the largest positive capacitor charging for the case of V_{IN} = 6.0V and V_{OUT} = 5.6V. The capacitor charging is only about 13mV, somewhat less than the 18mV in the case of Figure 1. It is not clear why the largest positive charging of the output capacitor should be less when operating at V_{IN} = 6.0V and V_{OUT} = 5.6V than with V_{IN} = 2.2V and V_{OUT} = 1.8V, but the results represented in Figures 1 and 3 certainly imply this. Because it is the same DUT40 and test board in both cases, the difference seems to be limited to a result of the operating conditions. At the lower voltages the output capacitor was changed to an 18mV rise, whereas at the higher voltages the rise was only about 13mV. It should be noted that for the conditions of Figures 1 through 3 (I_{OUT} = 100mA) there were no negative going SET excursions of magnitude more than 10mV.

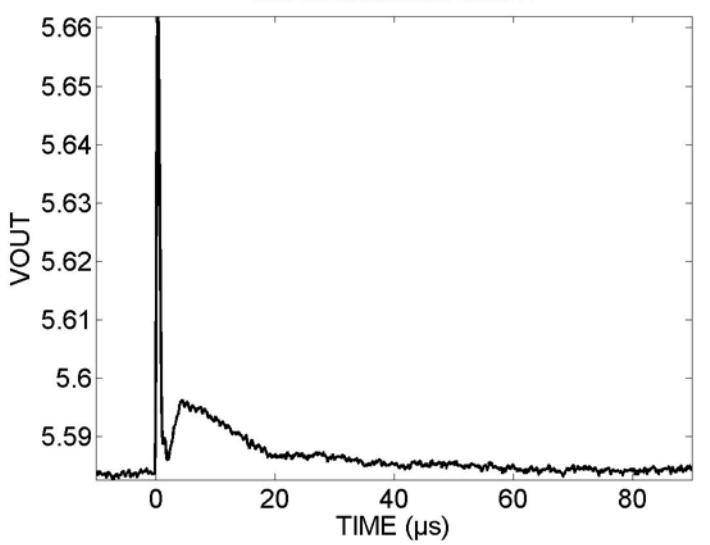

Figure 3. Largest positive SET (DUT40, trace 644) measured beyond 4µs from trigger with V_{IN} = 6.0V, V_{OUT} = 5.6V, I_{OUT} = 100mA, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm^2/mg).

Increasing the load current from 100mA to 3A modified the form of the SETs. Figure 4 shows the largest positive capacitor change for the case of V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 3A, and C_{OUT} = 220µF. In this case, the leading positive spike is only about 30mV and the capacitor change is less than 5mV. Clearly the heavy load suppresses positive SET.

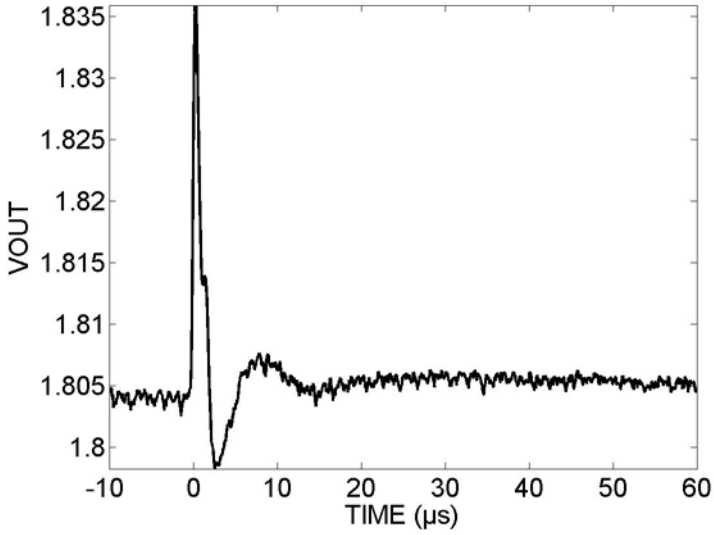

Figure 4. Largest positive SET (DUT40, trace 5) measured beyond 4µs from trigger with V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 3A, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm^2/mg).

However, the 3A current leads to negative voltage SETs that were not seen at 100mA. The largest negative SET for the case of V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 3A, and C_{OUT} = 220µF is presented in Figure 5. In this case, the SET was initiated by a roughly 70mV sudden drop in output voltage that lasted about 3µs. A recovery sequence of events then took about 20µs until regulation was restored. The full span of the SET was about -70mV to +20mV.

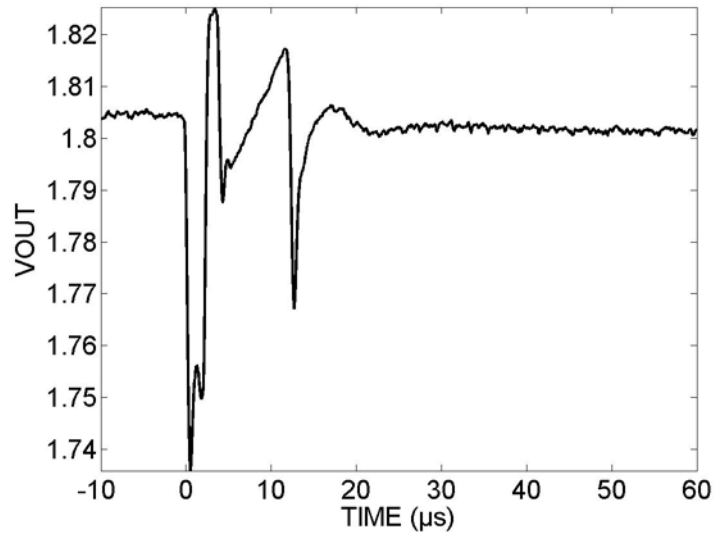

Figure 5. Largest negative SET (DUT40, trace 95) measured beyond 4µs from trigger with V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 3A, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm^2/mg).

The SET observed at V_{IN} = 4.0V, V_{OUT} = 1.8V, I_{OUT} = 3A were minor variations of that seen in Figure 5. They started with a negative portion ranging to about -30mV for 5µs and had recoveries with positive overshoots to about +20mV and then returning to regulation in about 20µs.

There was one form that seemed new, however. An example of this form is shown in Figure 6. It begins again with a negative pulse, then seems to recover by 20µs, but then has a subsequent negative excursion at about 40µs. The voltage deviations are small at about -10mV and +20mV. Numerous examples of this form, with some variation on the timing of the second negative excursion indicate that the form was not due to a double ion event.

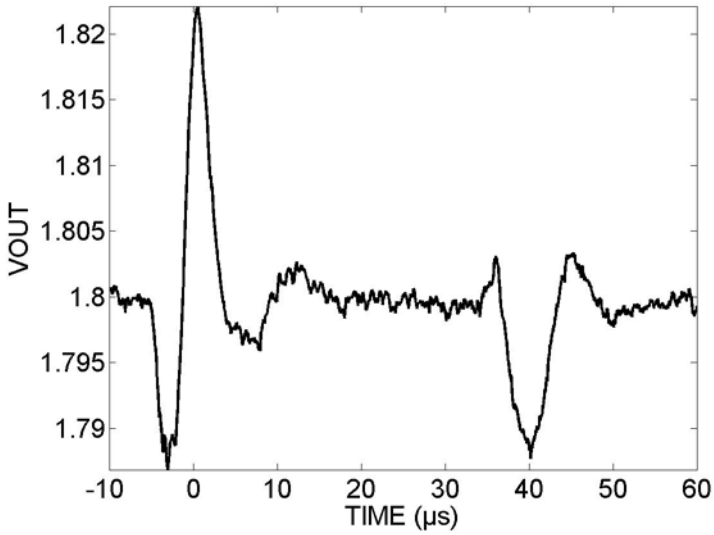

Figure 6. Example SET (DUT40, trace 101) measured beyond 4µs from trigger with V_{IN} = 4.0V, V_{OUT} = 1.8V, I_{OUT} = 3A, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm^2/mg).

When the voltages were pushed from V_{IN} = 2.2V and V_{OUT} = 1.8V as in Figure 5 to V_{IN} = 6.0V and V_{OUT} = 5.6V the form of the SET assumed that depicted in Figure 7. This seems to be a cross between Figures 5 and 6. The recovery sequence from a negative event now is more complicated and takes about 70µs to resolve and even then seems to have a -10mV shift (-0.18%). Even so, the entire event spanned only-70mV to +15mV. At the 5.6V output level this is only -1.25% and +0.27%.

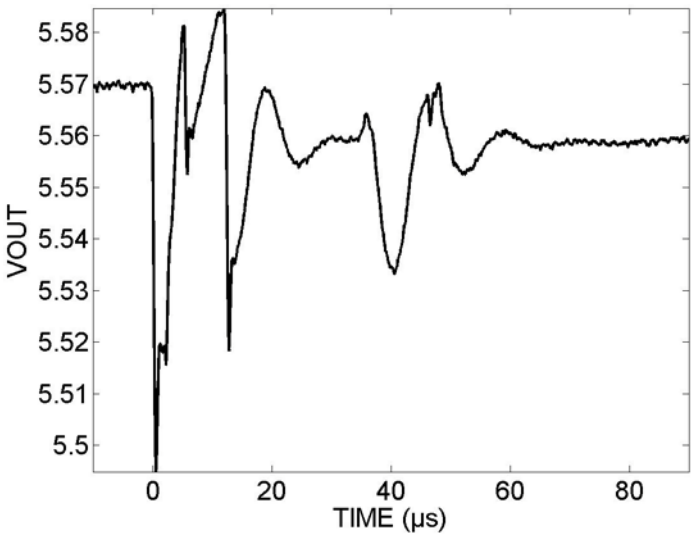

Figure 7. Largest negative SET (DUT40, trace 961) measured beyond 4µs from trigger with V_{IN} = 6.0V, V_{OUT} = 5.6V, I_{OUT} = 3A, and C_{OUT} = 220µF irradiated with silver at 60° incidence (effective LET of 85.6MeV·cm^2/mg).

Examination of Figures 1 through 7 indicate that with the 220µF output capacitor with 6mΩ of ESR the single event transients on the output are within +100mV to -70mV, depending on the output current. The low currents enable the positive events and the high current pushes the events toward the negative deviations. The output voltage did not seem to have a significant influence on the SET deviations.

1.6 SET Testing of the ISL75051ASEH with LET = 85.6 MeV·cm^2/mg and 47µF

Another set of four parts with C_{OUT} = 47µF were irradiated as outlined in Table 4. These were intended to provide an approximate estimate of the impact of the output capacitance. There is still considerable disparity in SET counts. This comes from the small magnitude SET near the triggering level. SET examples will be taken for DUT21 so long as they are representative of the other DUT results.

Table 4. V_{OUT} ±15mV deviation SET counts for irradiation with silver at 60° incidence for effective LET of 85.6MeV·cm^2/mg to 2x10^6 ion/cm^2 at +25°C ambient. The output capacitance in this case was 47µF with an ESR of 35mΩ.

V_{IN} (V)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} ±15mV SET Counts			
			DUT21	DUT22	DUT25	DUT26
2.2	1.8	0.1	1320	669	1309	416
2.2	1.8	3.0	2036	1866	2044	1796
4.0	1.8	0.1	1401	1055	1349	622
4.0	1.8	1.0	2442	2270	2660	1483
6.0	5.6	0.1	1414	2114	1407	1163
6.0	5.6	3.0	2092	1870	2324	1961

Figure 8 on page 9 provides a direct comparison to Figure 1 on page 5 to assess the impact of changing the output capacitance. The positive spike in Figure 8 is again truncated at 1.90V but appears to be about the same 100mV as for the 220µF case. This seems to indicate that the spike is not capacitor dependent and relates to parasitic inductance.

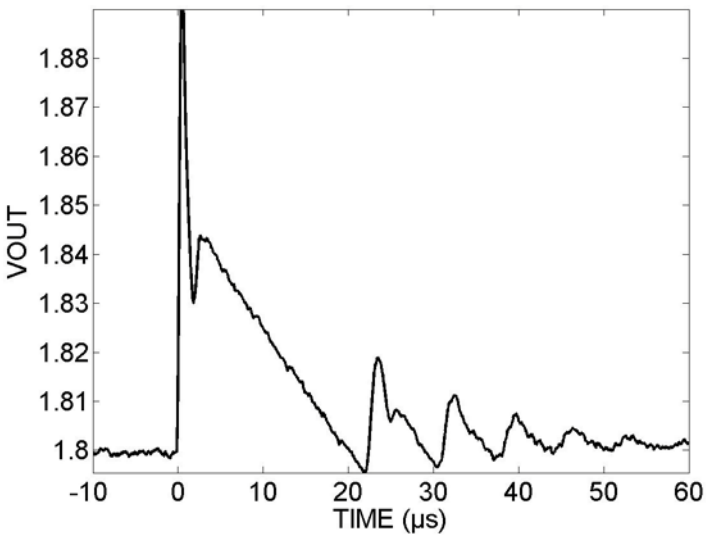

Figure 8. Largest positive SET (DUT21, trace 875) measured beyond 4µs from trigger with V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 100mA, and C_{OUT} = 47µF irradiated with silver at 60° incidence (85.6MeV·cm^2/mg).

The capacitor voltage in Figure 8 exhibits a +42mV change for the 47µF output capacitor. This is slightly more than twice the largest rise of 18mV seen with the 220µF capacitor, but it is much less than the 4.6 ratio of the capacitance values would imply for the same injected charge. In fact, 97% of the SET provided less than 18mV rise in capacitor value. This is somewhat surprising because it implies that the charge injected into the output capacitor is not a constant of the SET but is dependent on the capacitor value. The decay of the voltage with the load current of 100mA reveals a decaying oscillation in the recovery. This indicates the 47µF capacitance is at the low end of appropriate output capacitance.

The largest SET for the case of V_{IN} = 4.0V provided a capacitor voltage change of +43mV and exhibited virtually identical recovery oscillations. Again, the voltage headroom (V_{IN} - V_{OUT}) does not significantly change the SET deviations.

The event pictured in Figure 9 for I_{OUT} = 3A shows the same propensity for recovery oscillation as seen in Figure 8 but this time starting with a sudden negative spike. The negative spike in this case exceeds the oscilloscope capture range and saturates at just below 1.68mV. Extrapolation predicts a spike of approximately -100mV. The entire event lasts about 40µs with deviations of roughly -100V and +50mV.

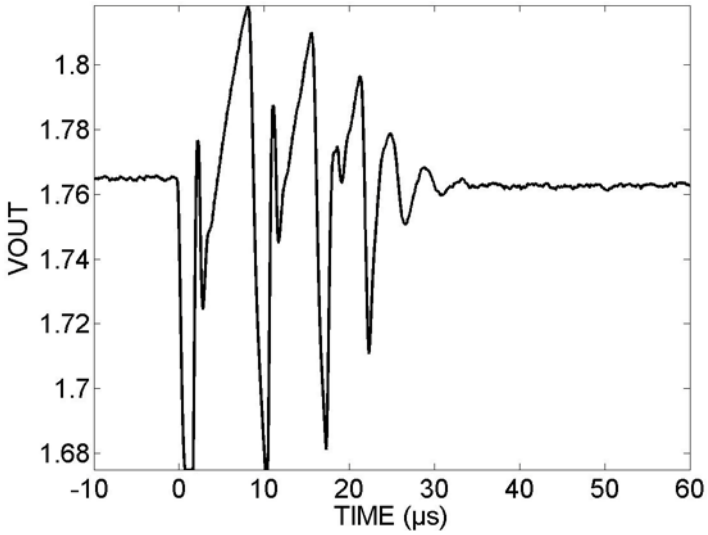

Figure 9. Largest negative SET (DUT21, trace 10) measured beyond 4µs from trigger with V_{IN} = 2.2V, V_{OUT} = 1.8V, I_{OUT} = 3A, and C_{OUT} = 47µF irradiated with silver at 60° incidence (85.6MeV·cm^2/mg).

Shifting the voltage to V_{IN} = 6.0V and V_{OUT} = 5.6V did little to change the positive SET at I_{OUT} = 100mA as can be seen by comparing Figure 10 to Figure 8. The capacitor change is slightly higher at the higher voltages at 50mV versus the 42mV at the lower voltages. Another difference is that the recovery oscillation appears suppressed at the higher voltages. In general however the SET look quite comparable at the two voltage settings.

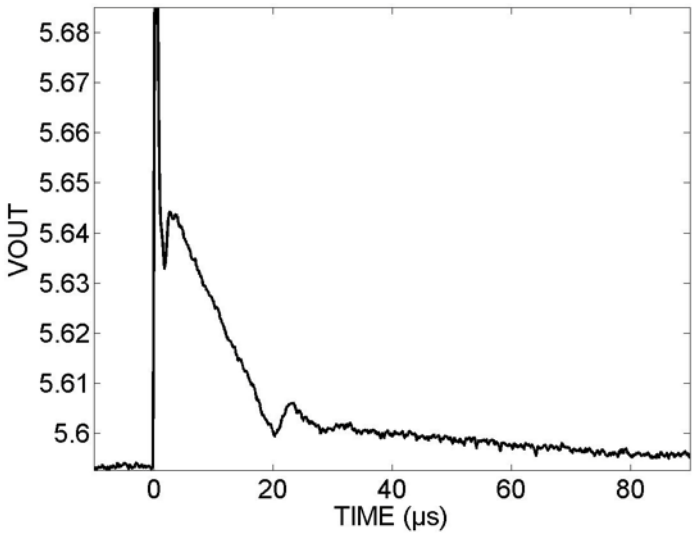

Figure 10. Largest positive SET (DUT21, trace 616) measured beyond 4µs from trigger with V_{IN} = 6.0V, V_{OUT} = 5.6V, I_{OUT} = 100mA, and C_{OUT} = 47µF irradiated with silver at 60° incidence (85.6MeV·cm^2/mg).

The high current behavior appears to undergo more change at high voltages than the low current case did as can be seen by comparing Figure 11 to Figure 9. Again the higher voltage case of Figure 11 is without the oscillatory behavior seen at the low voltage case of Figure 9. The high voltage case does show the delayed negative excursion noted in Figure 7 for the 220µF case. However, the SET excursions are within ±30mV with the exception of the negative spike at the onset of the event.

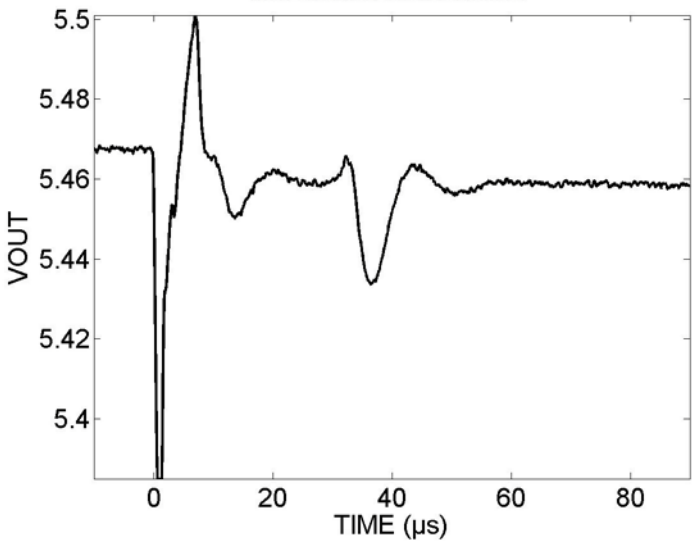

Figure 11. Largest negative SET (DUT21, trace 997) measured beyond 4µs from trigger with V_{IN} = 6.0V, V_{OUT} = 5.6V, I_{OUT} = 3A, and C_{OUT} = 47µF irradiated with silver at 60° incidence (85.6MeV·cm^2/mg).

1.7 SEU Testing of the ISL75051ASEH Test and Trim Mode with LET = 86.3MeV·cm^2/mg

The ISL75051ASEH corrected a Test and Trim Mode (TTM) issue with the original part. The issue was that the original part could power-up into TTM. The TTM state is stored by a memory element that was not robustly reset at power-up. When the memory is in the set condition, it invokes TTM. When the part is in TTM, the enable (EN) pin state is ignored. This allows the output to be active even when the enable pin is held in the low (disabled) condition.

The TTM issue created a concern over the SEU behavior of the memory element controlling TTM and led to a test to look for such an SEU. To test the SEU behavior of TTM, the output (V_{OUT}) was monitored for transitions during irradiation while the EN pin was held low. Only if the part transitioned into TTM would V_{OUT} rise. If in TTM, another SEU would take it out of TTM. So by counting V_{OUT} events, the number of TTM SEU could be monitored.

Four ISL75051ASEH parts were irradiated at both 2.2V and 4.5V V_{IN} with the EN held low. Each irradiation was with normal incidence gold for an LET of 86.3MeV·cm^2/mg to a fluence of 1x10^{7}ion/cm^2. The V_{OUT} was monitored for transitions through 0.5V (the V_{OUT} was set for 1.8V) and the events counted. No events were found indicating that there were no TTM SEU for the ISL75051ASEH.

2. Discussion and Conclusions

The ISL75051ASEH survived without SEL or SEB under irradiation with normal incidence gold for an LET of 86.3MeV·cm^2/mg to 1x10^{7}ion/cm^2 while operating with a supply voltage of 6.2V at +125°C. At a supply of 7.1V and the same irradiation conditions, three of four parts exhibited damage (see Table 2). Four parts survived without permanent damage at +125°C with a supply of 6.7V and 7.1V when irradiated with 60° incidence silver for an effective LET of 85.6MeV·cm^2/mg. However, high supply current events occurred at both voltages. These events spontaneously recovered if the parts were left under ion beam. However, these high current events continued if the ion beam was stopped. The parts then recovered to pre-radiation conditions with a power cycle. This is a clear indication of non-destructive latch-up in the parts. Consequently, operation to only a supply of 6.2V is SEB and SEL immune at an LET of 86.3MeV·cm^2/mg and normal incidence.

The SEL events were not noted in the testing of the progenitor part the ISL75051SRH (AN1666). The parts do not differ in such a way that a difference in this behavior would be expected or explained. Given the self-recovery aspect noted, it is possible that events were there before, but were simply not noted. In any case, the SEL were observed with the ISL75051ASEH for V_{IN} = 6.7V and irradiation with 60° incidence silver for an effective LET of 85.6MeV·cm^2/mg.

The SET excursions were within ±50mV for most cases except for initial spikes that could exceed ±100mV for about 2-3µs. The initial spikes seemed related to board and cabling parasitics as they varied with DUT location and test board. The examples presented in the figures in Sections 1.5 and 1.6 had the largest spikes observed. At the low output capacitor value of 47µF, recovery oscillation was noted at both 100mA and 3A output current for the case of V_{IN} = 2.2V with V_{OUT} = 1.8V. These oscillations died out after about five cycles. At V_{IN} = 6.0V and V_{OUT} = 5.6V, these oscillations were absent even with the 47µF capacitor. In the case of 3A with 47uF and V_{IN} = 2.2V (Figure 9), the first oscillation exceeded -60mV. No oscillations were recorded for any conditions with the 220µF output capacitor. The SET magnitudes seemed weaker than an expected inversely proportion function of output capacitor. Changing the output capacitor by a factor of 4.6 (47µF to 220µF) only reduced the SET capacitor charging at 100mA by a factor of 0.43 (42mV to 18mV).

The ISL75051ASEH was also tested for Test and Trim Mode (TTM) SEU with normal incidence gold for LET of 86.3MeV·cm^2/mg. Four parts yielded no TTM SEU when tested at VIN of 2.2V and 4.5V with a fluence of 1x10^{7}ion/cm^2. This indicates an immunity to TTM SEU.

3. Revision History

Rev.	Date	Description
0.00	Feb 12, 2018	Initial release

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