ISL71610SLHM, ISL71710SLHM

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), and Destructive Single Event Effects (DSEE). 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 ISL71610SLHM and ISL71710SLHM parts.

Contents

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1. Product Description

The two digital isolators discussed here come in 8 Ld NSOIC packages, and the pin assignments are shown in Figure 1. The pins on the left (Pins 1-4) are electrically isolated from the pins on the right (Pins 5-8) for both parts. The signal is magnetically transmitted from the input side (Pins 1-4) to the output side (Pins 5-8) with the isolation provided by a dielectric between the magnetic elements.

The ISL71610SLHM is a passive input digital isolator. The input is a current forced between input pins IN+ and IN-. The output on OUT is a digital output that follows the current applied at the inputs, with current flowing into IN- resulting in a low on OUT. Zero current at the input results in a high on the output.

The ISL71710SLHM is an active input digital isolator. The input is a digital signal applied to the IN pin relative to the GND1 pin. The output on OUT is a digital output that follows the state of the input IN.

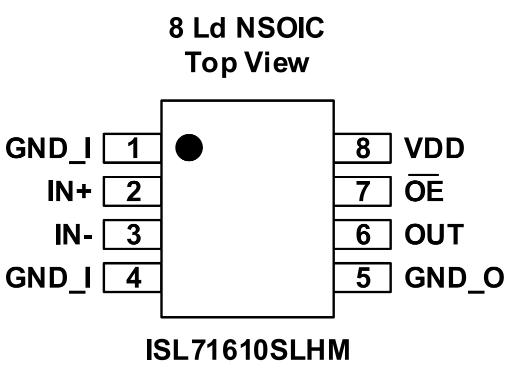

Figure 1. ISL71610SLHM and ISL71710SLHM Pin Assignments

2. Testing Setup and Facility

To accomplish the irradiations the parts had the plastic encapsulation removed from over the circuit die. This had the effect of lowering the free air isolation of the devices to about 750V, but otherwise left the parts functioning normally. The parts were then mounted on a PCB with the terminals brought out to connectors to allow cabling to the control room at the SEE testing facility. Four parts were mounted within the 1 inch beam diameter to allow simultaneous irradiation.

The parts were tested at Texas A&M University's Cyclotron Institute using the K500 cyclotron. The ISL71610SLHM was tested on August 12, 2019, and the ISL71710SLHM was tested on July 2, 2020.

3. Barrier Dielectric Single Event Dielectric Rupture (SEDR)

Both parts were tested for SEDR in the same manner. For SEDR the parts were mounted with Pins 1-4 tied to the test voltage and Pins 5-8 tied to the supply ground. The test voltage was applied across the barrier dielectric. The current flowing through the dielectric was monitored with a current meter. The test voltage was taken from 200V to 500V in 100V increments. At each voltage, the parts were subjected to irradiation with normal incidence gold having a Linear Energy Transfer (LET) of 86MeV·cm^2/mg to a fluence of 1x10^{7}ion/cm^2. The parts were heated to 125°C during the testing.

Both part types reached 500V without significant changes in current that would indicate dielectric rupture had occurred. The pre and post current measurements for the 500V exposure case are presented in Table 1.

Table 1. Pre and Post current measurements for the 500V dielectric bias during irradiations to $1x10^7$ion/cm^2 with normal incidence gold for an LET of 86MeV·cm^2/mg.

Part Type	DUT	Pre (nA)	Post (nA)	Delta
71610	1	3.2	2.9	-9.38%
	2	5.1	5.2	1.96%
	3	10.1	9.8	-2.97%
	4	57.0	54.0	-5.26%
71710	1	2.4	3.0	25.00%
	2	5.4	6.9	27.78%
	3	23.4	30.1	28.61%
	4	15.4	21.7	40.91%

All eight of the parts tested (four ISL71610SLHM and four ISL71710SLMH) survived at 500V dielectric bias with 86MeV·cm^2/mg irradiation by normal incidence gold. Although the 710 devices had larger percentage changes in the current, the small absolute magnitudes of the post irradiation values indicate that no SEDR occurred.

4. Circuitry Single Event Latch-Up (SEL) and Destructive SEE (DSEE)

With no bias across the barrier dielectric, the circuitry (receiver for both parts and transmitter for the ISL71710SLHM) was then biased for irradiation. Both parts were set to operate dynamically during the SEL/DSEE irradiations. The input of the ISL71610SLHM had a 500kHz signal of ±8mA imposed on it. The ISL71710SLHM had a 1MHz signal of 0-5V imposed on it. The supply current was measured before and after each irradiation to look for signs of damage or latch-up. The supply currents were measured without input stimuli for the ISL71610SLHM but with the input signal for the ISL71710SLMH. In both cases, the static output voltages were also checked. The parts were heated to 125°C during the testing.

The supply voltages were set to 5.8V, 6.2V, 6.5V, and 6.9V during successive irradiations. All eight parts tested survived through the 6.5V test without significant change in supply currents or output voltages. The current results for the 6.5V irradiations are presented in Table 2. The output voltages did not show any measurable changes at the 6.5V level. At 6.9V supplies, both part types had two of four parts exhibit increases in supply current that indicated damage during the irradiation.

Table 2. Supply currents Pre and Post irradiation with $1x10^7$ion/cm^2 normal incidence gold at 86MeV·cm^2/mg at a bias of 6.5V.

Part Type	DUT	I_VDD1 (mA)			I_VDD or I_VDD2 (mA)		
		Pre	Post	Delta	Pre	Post	Delta
71610	5				2.803	2.799	-0.14%
	6				2.363	2.365	0.08%
	7				2.424	2.424	0.00%
	8				4.425	4.425	0.00%
71710	5	3.990	4.010	0.50%	1.990	2.000	0.50%
	6	1.330	1.339	0.68%	4.100	4.121	0.51%
	7	3.133	3.140	0.22%	2.100	2.104	0.19%
	8	7.010	6.370	-9.13%	2.071	2.072	0.05%

The results demonstrate that both parts are immune from SEL and DSEE for normal incidence 86MeV·cm^2/mg gold ions while operating at 6.5V supply and at 125°C.

5. Static Single Event Transient (SET) of the ISL71610SLHM

Testing for static SET was done with normal incidence praseodymium for 60MeV·cm^2/mg. For the ISL71610SLHM, testing was done with input currents of 0 and ±8mA. Testing was done at both 3V and 4.5V supply for a total of six conditions. The parts were at room temperature (approximately 25°C) during the testing. The output (OUT) was monitored with an oscilloscope set to trigger and capture a trace with any OUT transition through 1.5V. The oscilloscope capture window was from -10µs to +40µs relative to the trigger point. Two forms of SET were observed for the ISL71610SLHM.

The first SET type is a noise spike as shown in Figure 2. This trace is for 0mA input and a 3V supply. There is considerable ringing in this capture, which appears to prolong the event. The initial spike is less than 0.1µs as can be seen in Figure 3, which is an expanded view of the SET. The ringing is because of the test fixturing and the cable connecting the oscilloscope to the DUT.

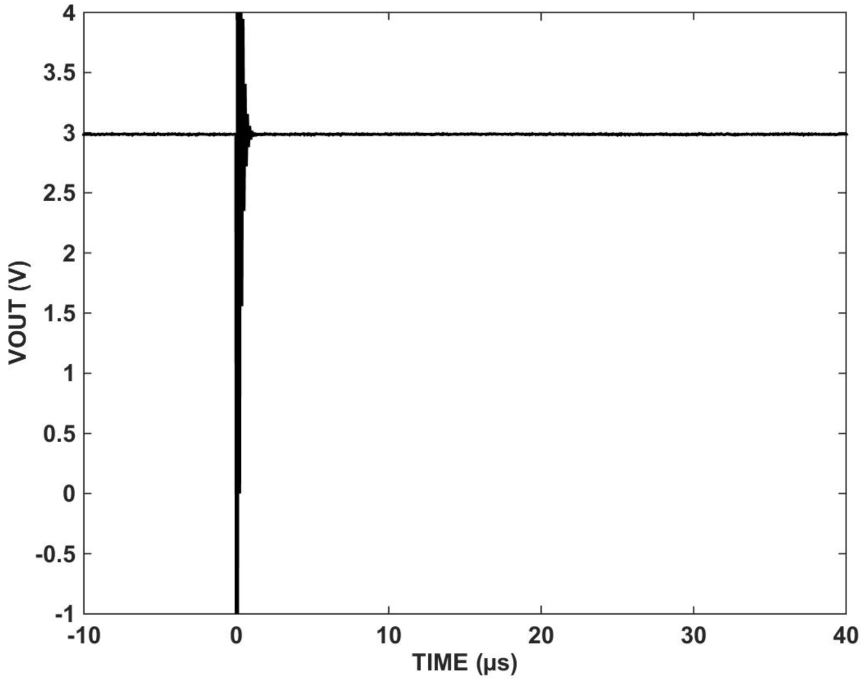

Figure 2. Example of a Spike SET for ISL71610SLHM with 0mA Input and 3V Supply

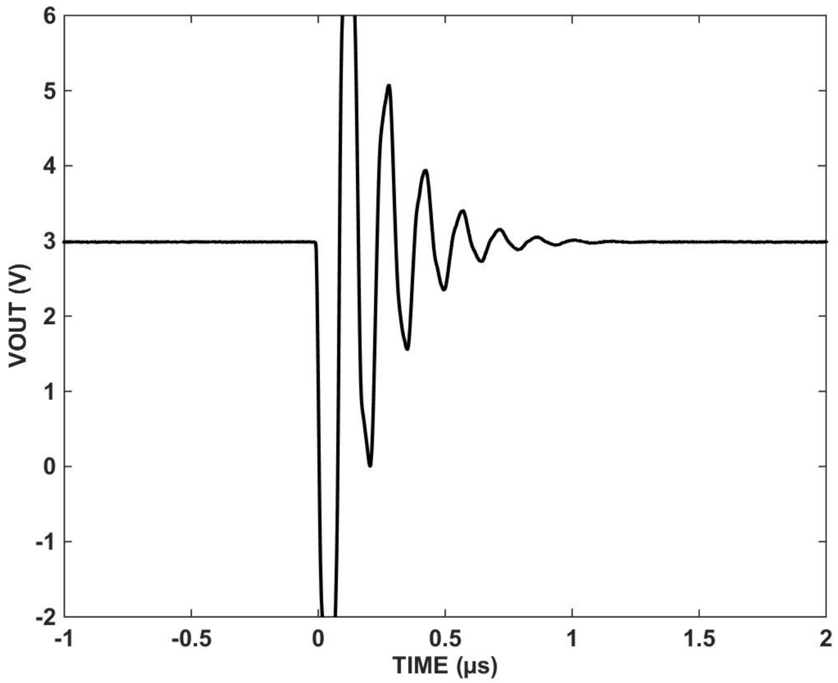

Figure 3. Expanded View of the Spike Event of Figure 2 on the ISL71610SLHM

The second type of SET observed for the ISL71610SLHM was a prolonged state change as shown in Figure 4. The part conditions for Figure 4 were 0mA input current (IN+ = IN-) and 3V supply. In this case, the SET duration is about 19µs. Another part (DUT9) had 13 SETs of this state type that all exceeded the 40µs extent of the window.

The state change SETs were only observed for the case of 0mA input current and 3V supply. No state change SETs were observed when the input was 8mA of either sign or when the supply was 4.5V. In any case, the cross-section for the state change SET was at most 130µm^2 at the 60MeV·cm^2/mg tested.

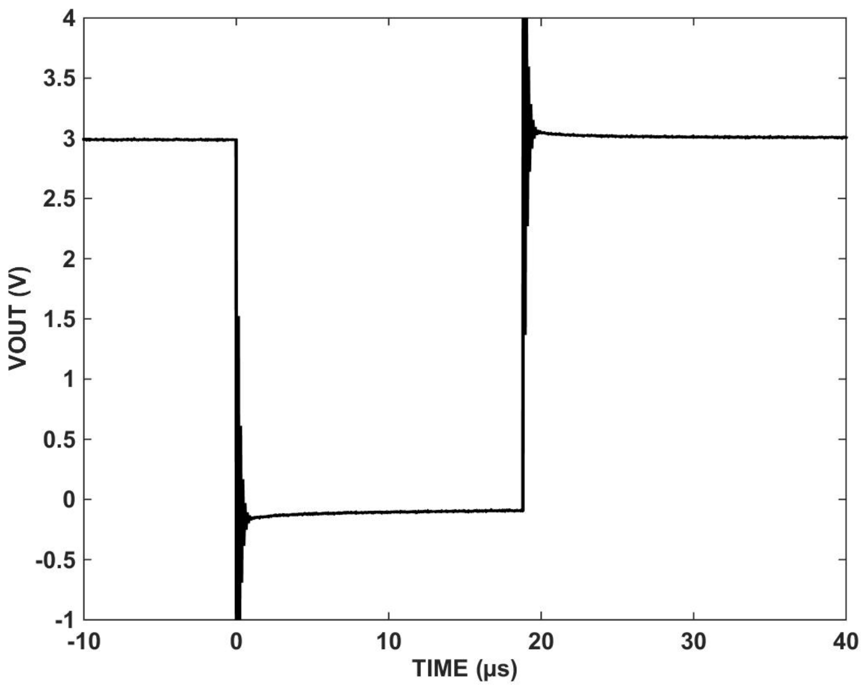

Figure 4. Observed State Change SET for the ISL71610SLHM with 0mA Input and 3V Supply

A summary of the static SET counts for the ISL71610SLHM appears in Table 3.

Table 3. SET count for static testing of the ISL71610SLHM with each irradiation of 1x10^{7}ion/cm^2 normal incidence praseodymium at 60MeV·cm^2/mg.

VDD (V)	I_IN- (mA)	SET Count Triggered at crossing 1.5V on OUT							
		DUT9		DUT10		DUT11		DUT12	
		Spike	State	Spike	State	Spike	State	Spike	State
3.0	0	0	13	15	1	15	0	13	0
3.0	8	11	0	11	0	15	0	9	0
3.0	-8	3	0	1	0	0	0	4	0
4.5	-8	0	0	0	0	0	0	0	0
4.5	8	15	0	11	0	7	0	7	0
4.5	0	11	0	13	0	12	0	10	0

6. Static Single Event Transient (SET) of the ISL71710SLHM

The static SET testing for the ISL71710SLHM was done with normal incidence praseodymium for 60MeV·cm^2/mg to 1x10^{7}ion/cm^2 per irradiation. The conditions tested were input and output supplies at 3V and 5.5V and the inputs at the input thresholds of 0.8V and 2.4V for a total of four conditions. The part temperature was room temp (approximately 25ºC). The capturing oscilloscope was triggering at any OUT transition through 1.5V with a capture window of -2µs to +8µs.

Examples of the SET captured appear in Figure 5 and Figure 6. In both cases, the actual event appears to be less than 20ns in duration with some ringing after the event. The SET magnitudes only marginally cross the trigger threshold at 1.5V.

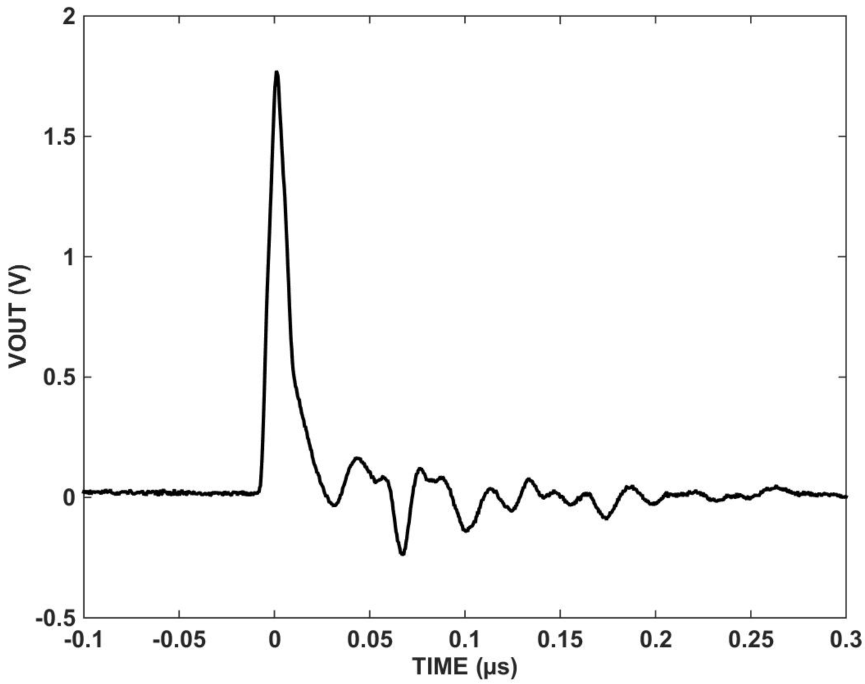

Figure 5. Expanded SET for ISL71710SLHM with IN = 0.8V and VDD1 = VDD2 = 3V with normal incidence praseodymium for 60MeV·cm^2/mg

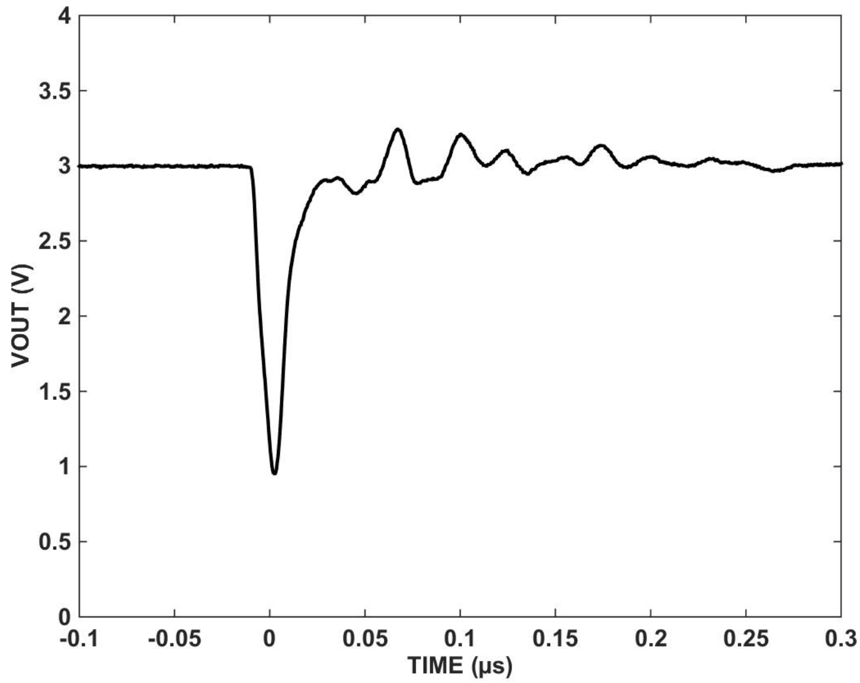

Figure 6. Expanded SET for ISL71710SLHM with IN = 2.4V and VDD1 = VDD2 = 3V with normal incidence praseodymium for 60MeV·cm2/mg.

All the static SET captured for the ISL71710SLHM appeared to be of the spike type with no state change events observed. The events captured were short duration spikes toward the opposite state, but never really attained the opposite state magnitude. These SET events were rare representing cross-sections of less than 50µm^2 as can be seen in Table 4.

Table 4. SET count for static testing of the ISL71710SLHM with each irradiation of 1x10^{7}ion/cm^2 normal incidence praseodymium at 60MeV·cm^2/mg.

VDD (V)	V_IN (V)	SET Count Triggered at crossing 1.5V on OUT			
		DUT9	DUT10	DUT11	DUT12
3.0	0.8	5	5	1	1
3.0	2.4	0	3	0	1
5.5	2.4	0	0	0	0
5.5	0.8	0	0	0	0

7. Dynamic Single Event Transient (SET)

Both the ISL71610SLHM and ISL71710SLHM were tested for SET while operating with dynamic inputs. The ISL71610SLHM was driven with a 500kHz input of either 0mA to 8mA or ±8mA while at either 3V or 4.5V supply. The ISL71710SLHM was provided a 1MHz signal between threshold levels (0.8V and 2.4V) at supplies of either 3V or 5.5V. Oscilloscopes were set to trigger and capture on an OUT signal deviating by ±10ns from the nominal signal timing registered at 1.5V.

The SET captured in the dynamic mode of operation appeared as the spike events from a static operation. It appeared that the dynamic events were identical to the static spike events, just superimposed on the dynamic waveform. Figure 7 presents an example for the ISL71710SLHM.

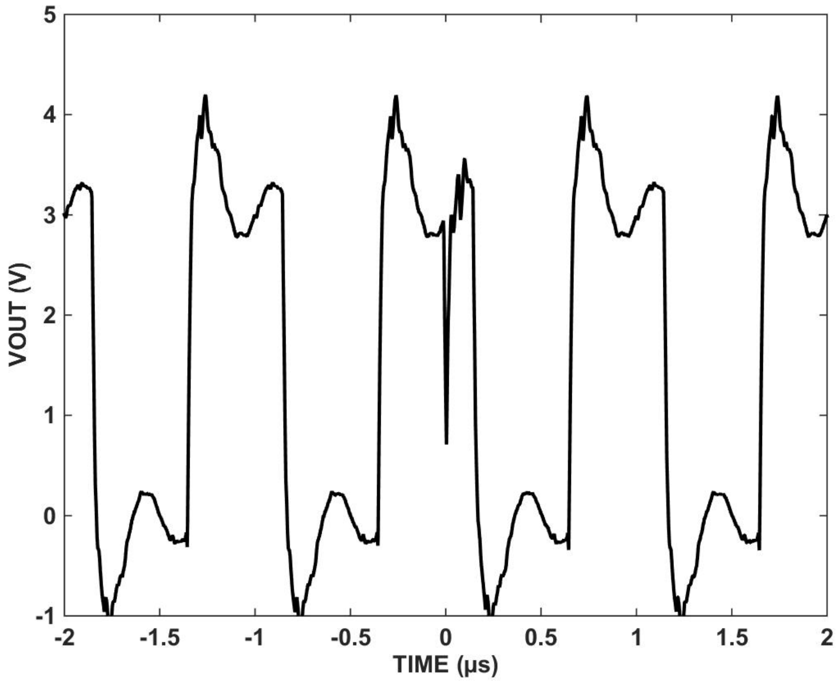

Figure 7. Example of a dynamic SET capture for the ISL71710SLHM operating at 1MHz at 3V and irradiated with praseodymium (60MeV·cm2/mg).

The dynamic events were quite rare and only amounted to cross-sections of 90µm^2 (ISL71610SLHM) and 60µm^2 (ISL71710SLHM). The statistics for these dynamic events appear in Table 5 and Table 6

Table 5. Dynamic (500kHz) SET count for ISL71610SLHM with normal incidence praseodymium for 60MeV·cm^2/mg to 1x10^{7}ion/cm^2.

VDD (V)	I_IN- 500kHz	SET Count Triggered at ±10ns on OUT Pulse			
		DUT13	DUT14	DUT15	DUT16
3.0	±8mA	0	5	4	6
3.0	0 to 8mA	0	1	5	9
4.5	0 to 8mA	N/A	2	0	3
4.5	±8mA	8	3	5	3

Table 6. Dynamic (1MHz) SET count for ISL71710SLHM with normal incidence praseodymium for 60MeV·cm^2/mg to 1x10^{7}ion/cm^2.

VDD (V)	IN 1MHz	SET Count Triggered at ±10ns on OUT Pulse			
		DUT13	DUT14	DUT15	DUT16
3.0	0.8V to 2.4V	1	0	6	2
5.5	0.8V to 2.4V	0	0	1	0

8. Discussion and Conclusions

For both the ISL71610SLHM and the ISL71710SLHM, the barrier dielectric proved to be free of SEDR for biases up to 500V and a temperature of 125°C with normal incidence irradiation of gold at 86MeV·cm^2/mg to 1x10^{7}ion/cm^2.

The circuitry of both part types proved to be free of SEL and DSEE for dynamic operation with supply voltages up to 6.5V at a temperature of 125°C and with irradiation by normal incidence gold having 86MeV·cm^2/mg and fluence of 1x10^{7}ion/cm^2. Signs of DSEE did appear at a supply bias of 6.9V.

Static SETs for the ISL71610SLHM manifested as two types. The spike type of SET (Figure 2) was observed with a cross-section of 160μm^2 or less for irradiation with normal incidence praseodymium at 60MeV·cm^2/mg. These spikes appeared to have a duration of less than 100ns. The other type of SET observed was a state change event where the output changed state and remained there for longer than 40μs (Figure 4). These state change events only appeared when the input current was zero and the supply was 3.0V. They recorded a maximum cross-section of 130μm^2.

Static SETs for the ISL71710SLHM were of shorter durations (Figure 5 and Figure 6) and were exclusive of the spike type. No state change events were observed for the ISL71710SLHM. The cross-section for these events was 50μm^2 for supplies at 3V and less than 2.5μm^2 for supplies at 5.5V.

For both part types, dynamic SETs were of the spike type superimposed on the dynamic waveform. The exhibited cross-sections were less than 90μm^2 for normal incidence praseodymium at 60MeV·cm^2/mg.

9. Revision History

Rev.	Date	Description
1.0	Feb 17, 2021	Initial release

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