ISL70444SEH

Single Event Effects Testing of the ISL70444SEH, Quad 40V Radiation Hard Precision Operational Amplifier

Introduction

Commercial integrated circuits do not encounter many of the phenomena that occur past Earth's atmosphere. Among these, we have effects that can cause a variety of transient and destructive effects in analog circuits; these are termed Single Event Latch-up (SEL), Single Event Burnout (SEB), and Single Event Transients (SET). Collectively they are called Single Event Effects (SEE). SEE can lead to system level failures including the disruption in normal operation as well as permanent damage. For a device to be deemed reliable under heavy ion environments, it should be designed from the ground up with SEE hardness in mind. It will then undergoes extensive SEE testing to validate the design. This report discusses the results of SEE testing for the ISL70444SEH. Although this report is written for the ISL70444SEH, it applies equally to the ISL70444ASEH and the ISL73444SEH as they are of the same design and silicon.

Product Description

The ISL70444SEH features four low-power amplifiers optimized to provide maximum dynamic range. This operational amplifier (op amp) features a common-mode input voltage range that goes all the way to the rails and a rail-to-rail output voltage swing.

The ISL70444SEH also offers low power, low offset voltage, and low temperature drift, making it ideal for applications requiring both high DC accuracy and AC performance. This amplifier is designed to operate across a single supply range of 2.7V to 40V or a split supply voltage range of ±1.35V to ±20V. Applications for this amplifier include precision instrumentation, data acquisition, precision power supply controls, and process controls.

The ISL70444SEH is available in a 14 Ld hermetic ceramic flatpack and operates across the extended temperature range of -55°C to +125°C. A summary of the op amp features is as follows:

- Rail-to-Rail on Input/Output (RRIO) operation
- Wide gain·bandwidth product: 19MHz
- Low input offset voltage: 300µV
- Low current consumption (per amp): 1.1mA, Typ.
- Enhanced large signal SR: 60V/µs

Related Literature

For a full list of related documents, visit our website

- ISL70444SEH product page

Contents

1. SEE Testing

1.1 Objective

The objective of the SEE testing was to evaluate the ISL70444SEH's Single Event Transient (SET) behavior and its susceptibility to destructive events induced by single event effects such as Single Event Burnout (SEB).

1.2 Facility

Testing for the ISL70444SEH was conducted at Texas A&M University (TAMU) Cyclotron Institute, Heavy Ion Facility. This facility is coupled with a K500 super-conducting cyclotron, which can generate a wide range of test particles with various energy, flux, and fluence levels required for advanced radiation testing.

1.3 Procedure

The ISL70444SEH was tested for Single Event Burnout (SEB) using Au ions at normal incidence (LET = 86.4MeV•cm^2/mg) with a case temperature of +125°C and Single Event Transient with a gain of 10 using Ne, Ar, Kr, Ag, Pr, and Au, and gain of 1 with Kr and Pr, which provided the range of LET values required for the tests. In both cases the case temperature was +25°C.

The Device Under Test (DUT) was mounted in 14 LD dual in-line packages with the lid removed. It was then placed in the beam line and irradiated with heavy ions of the appropriate species. The beam was directed onto the exposed die and the beam flux, beam fluence, and error in device outputs were monitored. There were eight parts in total. SN1 through SN4 were used for SEB testing and SN5-SN8 were used for SET testing.

The testing of the ISL70444SEH was conducted remotely from the control room at TAMU. Power to the DUT was supplied through bench-top power supplies and connected using heavy gauge stranded wires to minimize loss. The supply currents were monitored along with device outputs. Supply currents were monitored using digital ammeters and device outputs were monitored using an oscilloscope to help identify how the part reacted to various SEE. Events were captured by triggering on deviations in the output.

1.4 Setup Diagrams

Figure 1 and Figure 2 show the evaluation board setup used during testing.

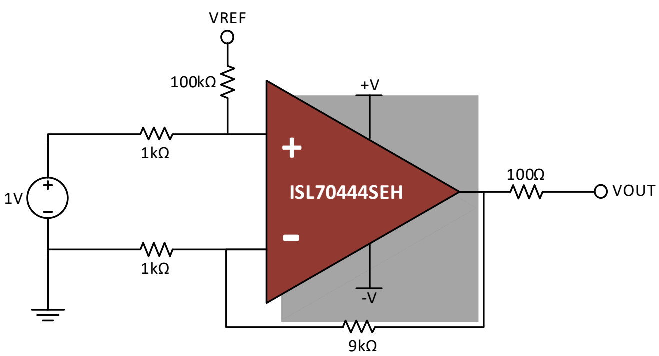

Figure 1. ISL70444SEH Configuration (Gain of 10)

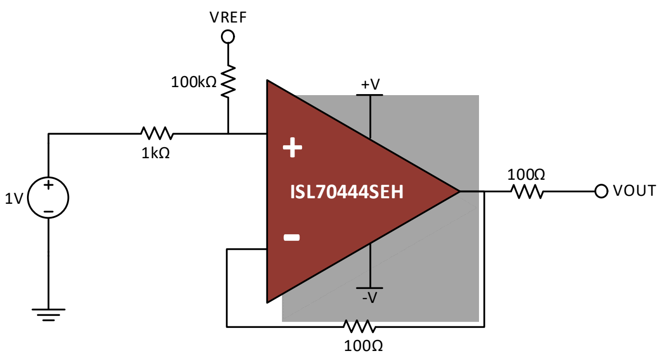

Figure 2. ISL70444SEH Configuration (Gain of 1)

The ISL70444SEH was tested under two conditions, gain of 10 (Figure 1) and gain of 1 (Figure 2). Under each condition, each channel of the quad amplifier was configured identically and VREF was left to float. A 100Ω series resistor was used to shield the amplifier from cable capacitance. See Appendix for a more detailed board schematic and layout of the evaluation board.

2. Results

2.1 Cross Section Calculations

Cross Sections (CS) are calculated as shown by Equation 1:

(EQ. 1) $$CS_{(LET)} = \frac{N}{F}$$

where:

- CS is the SET cross section in cm^2, expressed as a function of the heavy ion LET.
- LET is the linear energy transfer in MeV•cm^2/mg
- N is the total number of SET events
- F is the fluence in particles/cm^2

A value of 1/F is the assumed cross section when no event is observed.

2.2 Single Event Burnout (SEB) Results

The first test in the sequence was to look for destructive events due to SEB. A failure due to burnout was indicated by a permanent change in the part's supply current after the beam was turned off. If the supply current reverted back to its pre-radiation value after a power cycle, the event was deemed as latch-up. The ISL70444SEH did not have any latch-up events; this can be attributed to the SOI construction of the process and therefore, it is latch-up immune.

No burnout was observed for the ISL70444SEH when using Au ions at normal incidence. Testing was performed on four parts at a T_C of +125°C using the schematic shown in Figure 1. The common voltage at which each part passed was ±21V_{SUPPLY}. SN1 and SN4 both passed to ±23V, SN3 passed to ±22V, and SN2 passed to ±21V. Each part was started at ±18V and stepped up incrementally until it failed. All test runs were run in a gain of 10 to a fluence of $2x10^6/cm^2$ with an input of 100mV applied to the non-inverting input of the amplifiers. After each run, the functionality of the op amp was verified by monitoring the outputs of all amplifiers with an oscilloscope. IDD and IEE were recorded pre- and post-exposure and then summed up; a ±5% delta (to allow for measurement repeatability) would indicate a failure. Table 1 shows the SEB results for the ISL70444SEH for a supply voltage of ±21V.

Table 1. SEB Results (Fluence = $2x10^6/cm^2$) with No Destructive or Latch Events; All Parts Passed to V_S = ±21V

SN	TEMP (°C)	Pre-Exposure		Post Exposure		SEB/L
		I- (mA)	I+ (mA)	I- (mA)	I+ (mA)	
1	+125	8.92	8.56	8.94	8.57	PASS
2	+125	10.95	10.53	10.47	10.14	PASS
3	+125	7.41	7.04	7.39	7.02	PASS
4	+125	15.28	14.97	15.57	15.20	PASS

2.3 Single Event Transient (SET) Results

2.3.1 Test Setup (Gain of 1)

Two devices were tested at two different supply voltages, V_S = ±1.35V and V_S = ±15V. The non-inverting inputs for all amplifiers were set to 1V for V_S = ±1.35V and 2V for V_S = ±15V. The outputs were monitored from the control room with four LeCroy oscilloscopes. A summary of the scope settings is as follows:

Trigger Connections

- Scope 1 triggered on Channel A
- Scope 2 triggered on Channel B
- Scope 3 triggered on Channel C
- Scope 4 triggered on Channel D

SET events were recorded whenever the output deviated from a trigger window during beam exposure. The window was ±100mV (±1% of V_{OUT}) for V_S = ±1.35V and ±200mV (±1% of V_{OUT}) for V_S = ±15V. The volts per division on each captured trace was 1V/div for V_S = ±1.35V and 5V/div for V_S = ±15V. During post-processing, transient durations are defined as any voltage transient in excess of ±10mV from V_{OUT}. The time spent ±10mV away from V_{OUT} is then summed up and presented in histograms in Figure 3 and Figure 4. Positive and negative voltage deviations were recorded separately from each other.

2.3.1.1 Cross Section Results

The results shown in Table 2 and Table 3 are the cross sectional results for the twodevices that were tested in unity gain at LET = 28 and 60MeV•cm^2/mg. It appears that in this case the higher supply voltage of ±15V had a lower cross section.

Table 2. SET Cross Section Results of ISL70444SEH in Unity Gain (V_S = ±1.5V); Trigger Window = ±100mV

Supply (V)	Species	LET (MeV•cm^2/mg)	Angle (°)	Channel	Device	Fluence/Run (P/cm^2)	Total Set	Event CS (cm^2)
±1.35V	Kr	28	0	A	6	1.00E+06	502	5.02E-04
±1.35V	Pr	28	0	A	7	1.00E+06	502	5.02E-04
±1.35V	Kr	60	0	A	6	1.00E+06	541	5.41E-04
±1.35V	Pr	60	0	A	7	1.00E+06	678	6.78E-04
±1.35V	Kr	28	0	B	6	1.00E+06	533	5.33E-04
±1.35V	Pr	28	0	B	7	1.00E+06	538	5.38E-04
±1.35V	Kr	60	0	B	6	1.00E+06	680	6.80E-04
±1.35V	Pr	60	0	B	7	1.00E+06	714	7.14E-04
±1.35V	Kr	28	0	C	6	1.00E+06	334	3.34E-04
±1.35V	Pr	28	0	C	7	1.00E+06	294	2.94E-04
±1.35V	Kr	60	0	C	6	1.00E+06	371	3.71E-04
±1.35V	Pr	60	0	C	7	1.00E+06	323	3.23E-04
±1.35V	Kr	28	0	D	6	1.00E+06	478	4.78E-04
±1.35V	Pr	28	0	D	7	1.00E+06	449	4.49E-04
±1.35V	Kr	60	0	D	6	1.00E+06	534	5.34E-04
±1.35V	Pr	60	0	D	7	1.00E+06	500	5.00E-04

Table 3. SET Cross Section Results of ISL70444SEH in Unity Gain (V_S = ±15V); Trigger Window = ±200mV

Supply (V)	Species	LET (MeV•cm^2/mg)	Angle (°)	Channel	Device	Fluence/Run (P/cm^2)	Total Set	Event CS (cm^2)
±15	Kr	28	0	A	6	1.00E+06	355	3.55E-04
±15	Pr	28	0	A	7	1.00E+06	328	3.28E-04
±15	Kr	60	0	A	6	2.00E+06	1027	5.14E-04
±15	Pr	60	0	A	7	1.00E+06	629	6.29E-04
±15	Kr	28	0	B	6	1.00E+06	362	3.62E-04
±15	Pr	28	0	B	7	1.00E+06	316	3.16E-04
±15	Kr	60	0	B	6	1.00E+06	673	6.73E-04
±15	Pr	60	0	B	7	1.00E+06	620	6.20E-04
±15	Kr	28	0	C	6	1.00E+06	248	2.48E-04
±15	Pr	28	0	C	7	1.00E+06	254	2.54E-04
±15	Kr	60	0	C	6	1.00E+06	392	3.92E-04
±15	Pr	60	0	C	7	1.00E+06	340	3.40E-04
±15	Kr	28	0	D	6	1.00E+06	330	3.30E-04
±15	Pr	28	0	D	7	1.00E+06	309	3.09E-04
±15	Kr	60	0	D	6	1.00E+06	531	5.31E-04
±15	Pr	60	0	D	7	1.00E+06	464	4.64E-04

2.3.1.2 SET Characteristics

Figure 3 through Figure 8 are histograms that describe the characteristics of transients caused by SETs. Figure 3 describes the duration of the SETs at V_S = ±1.35V, and Figure 4 describes the duration of the SETs at V_S = ±15V. Figure 5 describes the maximum positive voltage deviation from V_{OUT} during an SET at V_S = ±1.35V, and Figure 6 describes the maximum positive voltage deviation from V_{OUT} during an SET at V_S = ±15V. Figure 7 describes the maximum negative voltage deviation from V_{OUT} during an SET at V_S = ±1.35V, and Figure 8 describes the maximum negative voltage deviation from V_{OUT} during an SET at V_S = ±15V. For V_S = ±1.35V, recovery time from SETs were always within 2µs. For V_S = ±15V, recovery time was much faster (≤400ns).

For the composite pictures in Figure 9 through Figure 12 the first 200 captures at each LET and power supply setting were plotted on top of each other to show an envelope of how the ISL70444SEH reacts during SETs for LET = 28 and 60MeV•cm^2/mg.

2.3.1.3 Histograms

2.3.1.3.1 Transient Duration Histograms

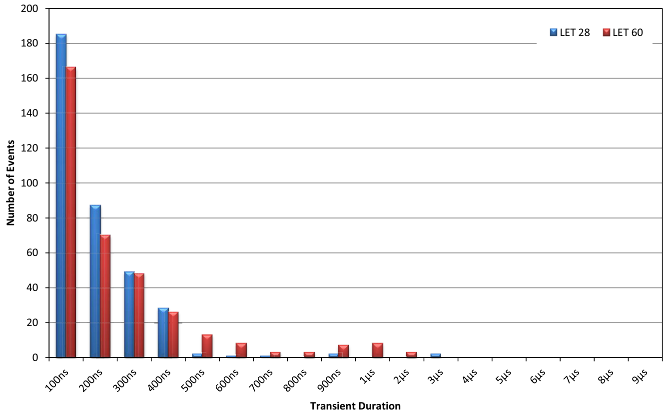

Figure 3. Transient Durations Caused by SETs (V_S = ±1.35V) at LET = 28 and 60MeV•cm²/mg with Fluence of 2x10⁶/cm²; SETs are Defined as a Pulse in Excess of ±10mV from V_{OUT} During Post-Processing

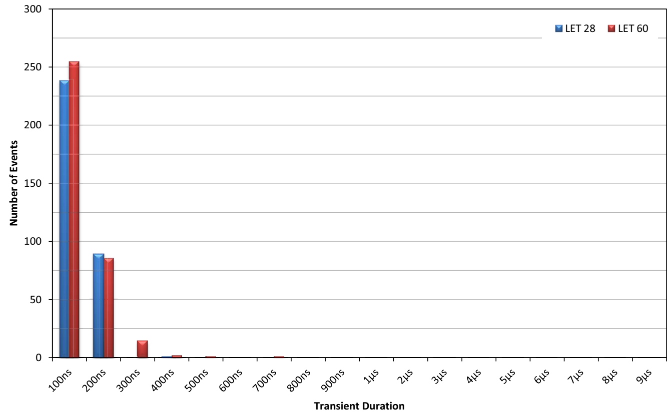

Figure 4. TRANSIENT DURATIONS CAUSED BY SETs (V_S = ±15V) AT LET = 28 AND 60MeV•cm²/mg WITH FLUENCE OF 2x10⁶/cm²; SETs ARE DEFINED AS A PULSE IN EXCESS OF ±10mV FROM V_{OUT} DURING POST-PROCESSING

2.3.1.3.2 Positive Voltage Deviation Histograms

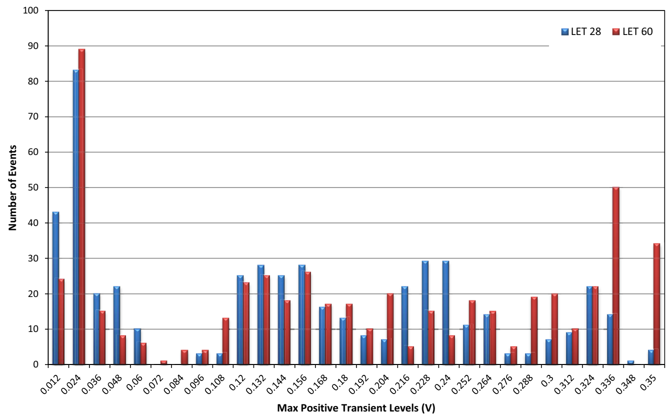

Figure 5. Max Positive Transient Voltage from V_{OUT} = +1V Caused by SETs (V_S = ±1.35V); LET = 28 and 60MeV•cm²/mg with Fluence of 2x10⁶/cm²

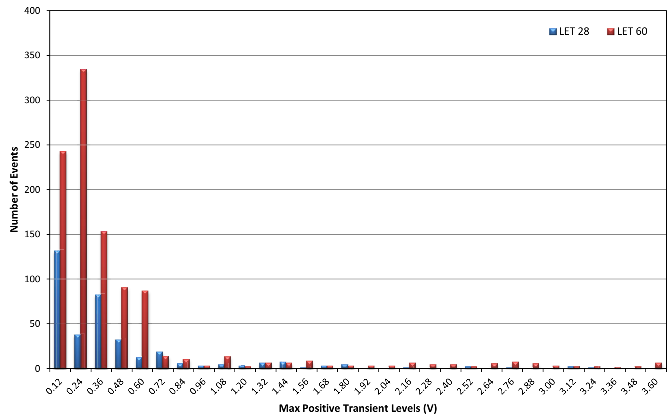

Figure 6. Max Positive Transient Voltage from V_{OUT} = +2V Caused by SETs (V_S = ±15V); LET = 28 and 60MeV•cm²/mg with Fluence of 2x10⁶/cm²

2.3.1.3.3 Negative Voltage Deviation Histograms

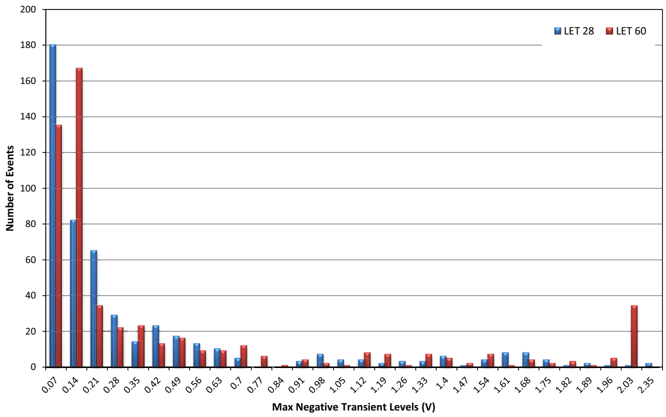

Figure 7. Max Negative Transient Voltage from V_{OUT} = +1V Caused by SETs (V_S = ±1.35V); LET = 28 and 60MeV•cm^2/mg with Fluence of 2x10^6/cm^2

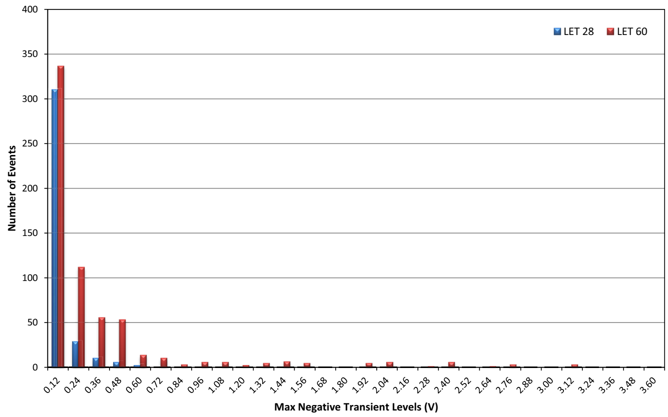

Figure 8. Max Negative Transient Voltage from V_{OUT} = +2V Caused by SETs (V_S = ±15V); LET = 28 and 60MeV•cm^2/mg with Fluence of 2x10^6/cm^2

2.3.1.4 SET Composite Plots (Unity Gain)

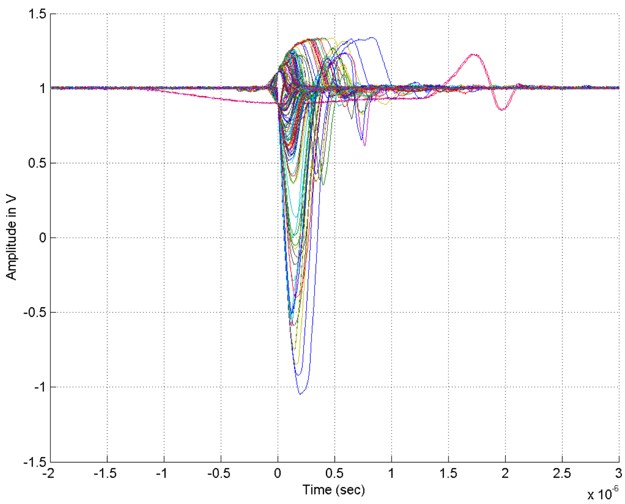

Figure 9. LET = 28MeV•cm^2/mg (V_S = ±1.35V)

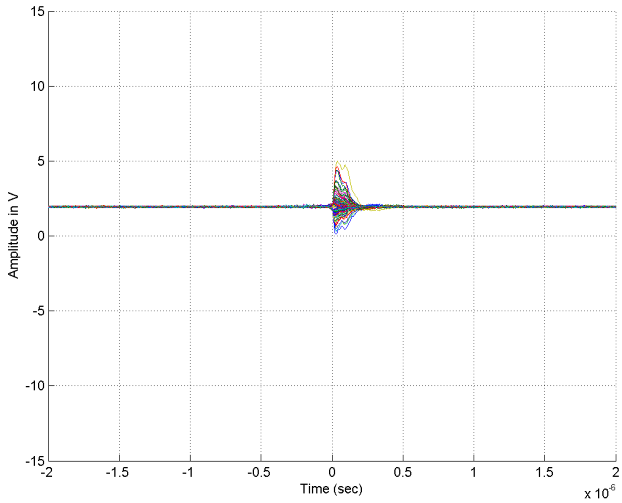

Figure 10. LET = 28MeV•cm^2/mg (V_S = ±15V)

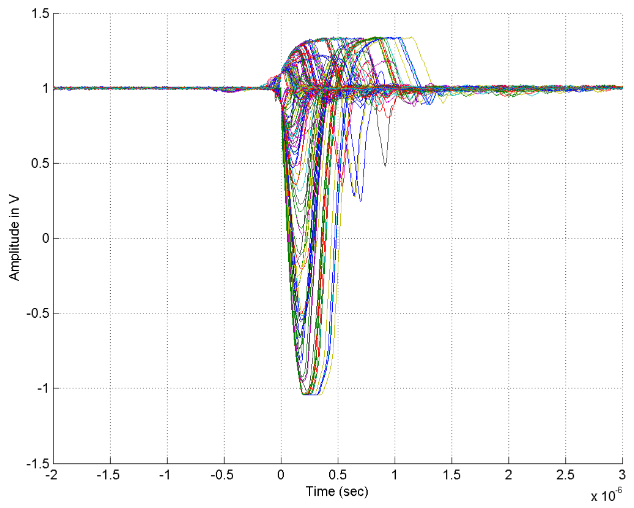

Figure 11. LET = 60MeV•cm²/mg (V_S = ±1.35V)

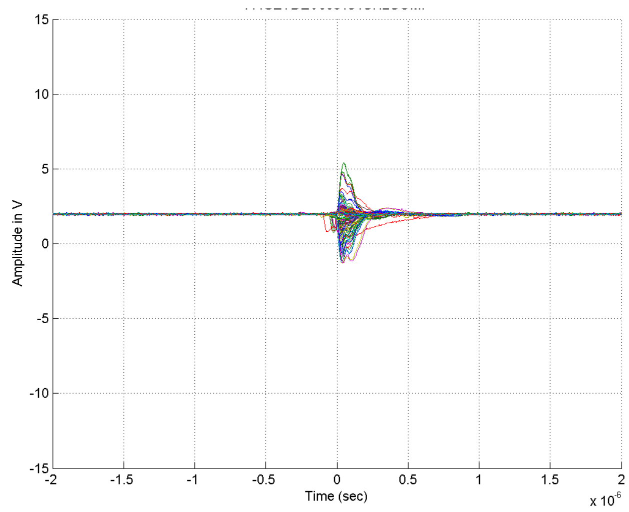

Figure 12. LET = 60MeV•cm²/mg (V_S = ±15V)

2.3.2 Test Setup (Gain of 10)

There is a definite advantage for high speed op amps in applications that use gains greater than 1, as they still provide ample bandwidth comparatively while in a gained configuration. Because most applications tend to use high speed op amps with gains higher than 1, a worst case analysis was studied at several more SETs with ACL = 10. For this worst case analysis, SETs were defined as a ±1V deviation at V_S = ±15V and ±200mV for V_S = ±1.35V to showcase the ultra fast recovery time of the ISL70444SEH under drastic changes (≤5µs in all cases). During post-processing, transient durations are defined as any voltage transient that crosses ±10mV from V_{OUT}. The time spent ±10mV away from V_{OUT} is summed up and presented in histograms in Figure 24 and Figure 27 for their respective test conditions. Positive and negative voltage deviations were recorded separately from each other illustrated in Figure 22, Figure 23, Figure 25, and Figure 26.

The non-inverting inputs for all amplifiers were set to 1V. The outputs were monitored from the control room with four LeCroy oscilloscopes. A summary of the scope settings is as follows:

Trigger Connections

- Scope 1 triggered on Channel A
- Scope 2 triggered on Channel B
- Scope 3 triggered on Channel C
- Scope 4 triggered on Channel D

Channel Connection on All Scopes (V_S = ±1.35V)

- CH1 through CH4 = 1V/div (OUTA through OUTD)

Channel Connection on All Scopes (V_S = ±15V)

- CH1 through CH4 = 5V/div (OUTA through OUTD)

2.3.2.1 Cross Section Results

Unlike other Intersil radiation tolerant circuits, the ISL70444SEH was not designed with SET mitigation. The best approach to characterize the SET response is to represent the data on a LET threshold plot (shown in Figure 13).

As it can be seen, V_S = ±15V has a lower SET cross section across all tested LET levels compared to V_S = ±1.35V. The data represented in Figure 13 is shown in table form in Table 4.

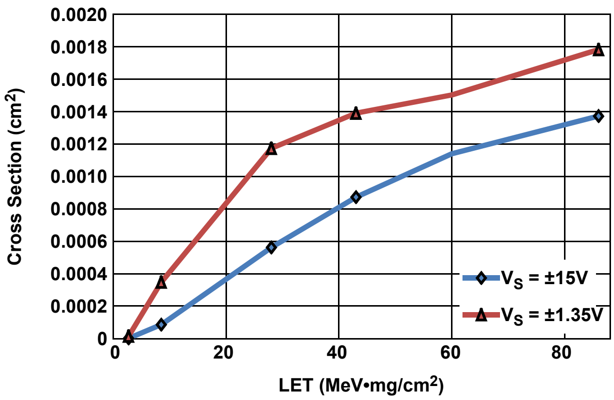

Figure 13. SET Cross Section vs Let vs Supply Voltage

Table 4. Details of LET Threshold Plot; Trigger Windows Defined in Test Setup (Gain of 10)

Supply (V)	Species	LET (MeV•cm^2/mg)	Angle (°)	Runs	Fluence/Run (P/cm^2)	Total Set	Event CS (cm^2)
±1.35V	Ne	2.7	0	4	2.00E+06	126	1.58E-05
	Ar	8.5				2789	3.49E-04
	Kr	28				9385	1.17E-03
	Ag	43				11121	1.39E-03
	Pr	60				12015	1.50E-03
	Au	86				14257	1.78E-03
±15.0V	Ne	2.7	0	4	2.00E+06	19	2.38E-06
	Ar	8.5				693	8.66E-05
	Kr	28				4501	5.63E-04
	Ag	43				6981	8.73E-04
	Pr	60				9119	1.14E-03
	Au	86				10974	1.37E-03

Figure 14 through Figure 17 provide the cross section vs LET on a channel-by-channel basis for V_S = ±1.35V. Figure 18 through Figure 21 provide the cross section vs LET channel-by-channel for V_S = ±15V. At each given LET, the cross section for each of the four devices tested are provided along with the summed average cross section of all devices shown in red for V_S = ±1.35V and blue for V_S = ±15V. The tabular data for Figure 14 through Figure 21 is provided for convenience in Table 5 through Table 12.

2.3.2.2 SET Characteristics

Due to SETs vs LET at V_S = ±15V: Figure 22 describes the positive transient voltage spikes, Figure 23 describes the negative transient voltage spikes, and Figure 24 describes the transient durations. Figure 25, Figure 26, and Figure 27 are identical except with supplies at V_S = ±1.35V.

For the composite pictures in Figure 28 through Figure 39 the first 200 captures at each LET and power supply setting were plotted on top of each other to show an envelope of how the ISL70444SEH reacts during SETs for LET = 2.7, 8.5, 28, 43, 60, and 86MeV•cm²/mg.

2.3.2.3 Cross Section Results: ±1.35V (Channel-by-Channel)

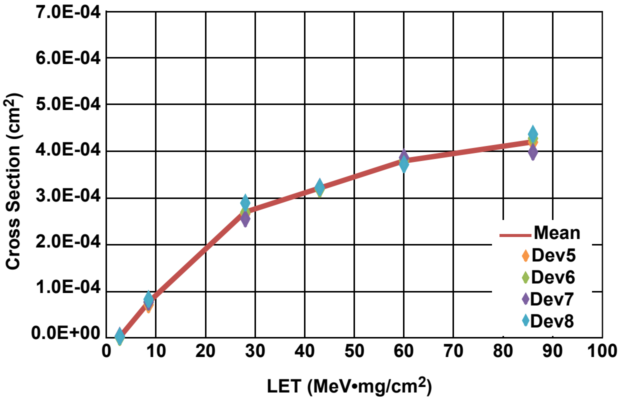

Figure 14. Channel A SET Cross Section vs LET (V_S = ±1.35V) ACL = 10

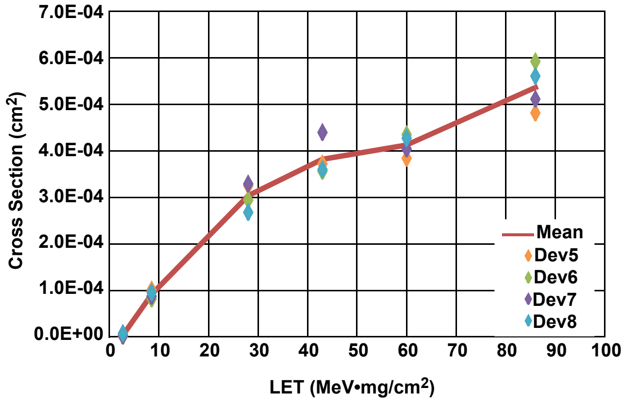

Figure 15. Channel B SET Cross Section vs LET (V_S = ±1.35V) ACL = 10

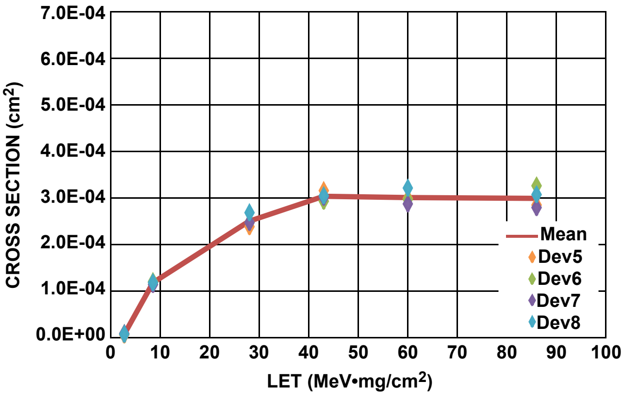

Figure 16. Channel C SET Cross Section vs LET (V_S = ±1.35V) ACL = 10

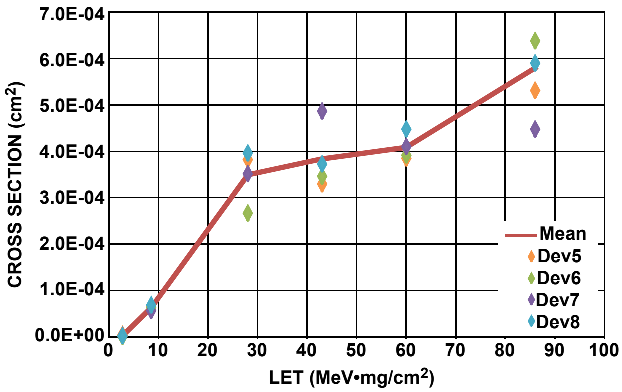

Figure 17. Channel D SET Cross Section vs LET (V_S = ±1.35V) ACL = 10

2.3.2.4 Cross Section Results: ±15V (Channel-by-Channel)

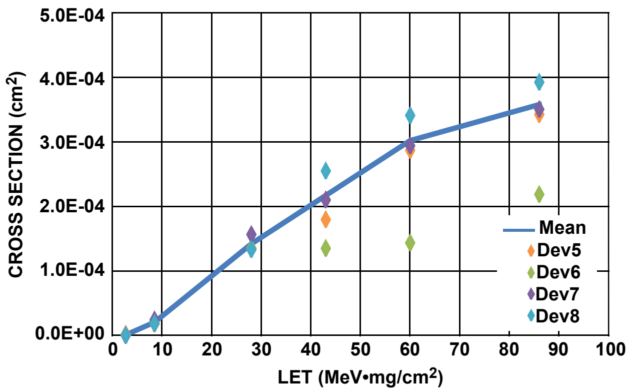

Figure 18. Channel A SET Cross Section vs LET (V_S = ±15V) ACL = 10

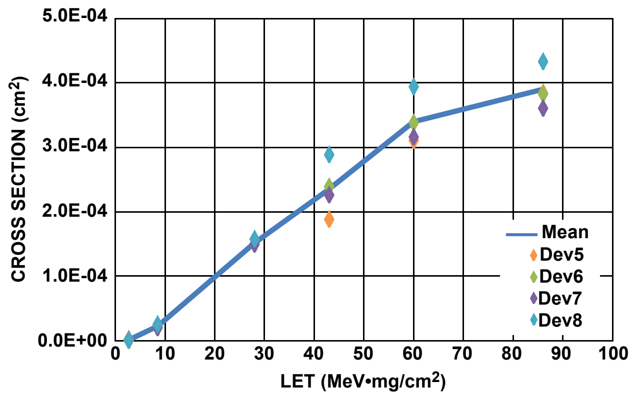

Figure 19. Channel B SET Cross Section vs LET (V_S = ±15V) ACL = 10

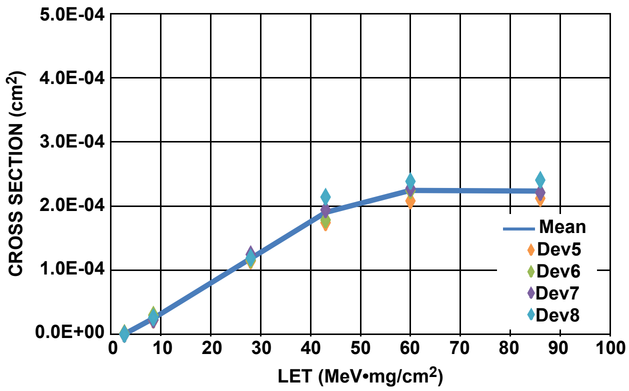

Figure 20. Channel C SET Cross Section vs LET (V_S = ±15V) ACL = 10

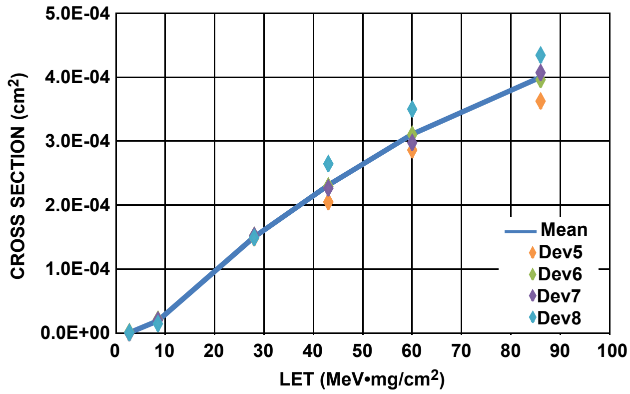

Figure 21. Channel D SET Cross Section vs LET (V_S = ±15V) ACL = 10

2.3.2.5 Tabular Cross Section Results: ±1.35V, ACL = 10 (Channel-by-Channel)

Table 5. Data of Channel Cross Section of ISL70444SEH for V_S = ±1.35V (Device 5)

Supply (V)	Species	LET (MeV•cm2/mg)	Channel	Device	Fluence/Run (P/cm²)	Events	Event CS (cm²)
±1.35	Ne	2.7	A	5	2.00E+06	3	1.50E-06
	Ar	8.5				141	7.05E-05
	Kr	28				531	2.66E-04
	Ag	43				639	3.20E-04
	Pr	60				759	3.80E-04
	Au	86				839	4.20E-04
±1.35	Ne	2.7	B	5	2.00E+06	8	4.00E-06
	Ar	8.5				202	1.01E-04
	Kr	28				650	3.25E-04
	Ag	43				744	3.72E-04
	Pr	60				768	3.84E-04
	Au	86				963	4.82E-04

Table 5. Data of Channel Cross Section of ISL70444SEH for V_S = ±1.35V (Device 5) (Cont.)

Supply (V)	Species	LET (MeV•cm2/mg)	Channel	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±1.35	Ne	2.7	C	5	2.00E+06	12	6.00E-06
	Ar	8.5				238	1.19E-04
	Kr	28				477	2.39E-04
	Ag	43				632	3.16E-04
	Pr	60				599	3.00E-04
	Au	86				570	2.85E-04
±1.35	Ne	2.7	D	5	2.00E+06	9	4.50E-06
	Ar	8.5				128	6.40E-05
	Kr	28				764	3.82E-04
	Ag	43				659	3.30E-04
	Pr	60				770	3.85E-04
	Au	86				1062	5.31E-04

Table 6. Data of Channel Cross Section of ISL70444SEH for V_S = ±1.35V (Device 6)

Supply (V)	Species	LET (MeV•cm2/mg)	Channel	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±1.35	Ne	2.7	A	6	2.00E+06	1	5.00E-07
	Ar	8.5				151	7.55E-05
	Kr	28				538	2.69E-04
	Ag	43				637	3.19E-04
	Pr	60				761	3.81E-04
	Au	86				855	4.28E-04
±1.35	Ne	2.7	B	6	2.00E+06	3	1.50E-06
	Ar	8.5				163	8.15E-05
	Kr	28				588	2.94E-04
	Ag	43				712	3.56E-04
	Pr	60				870	4.35E-04
	Au	86				1184	5.92E-04
±1.35	Ne	2.7	C	6	2.00E+06	17	8.50E-06
	Ar	8.5				241	1.21E-04
	Kr	28				496	2.48E-04
	Ag	43				587	2.94E-04
	Pr	60				594	2.97E-04
	Au	86				653	3.27E-04
±1.35	Ne	2.7	D	6	2.00E+06	1	5.00E-07
	Ar	8.5				126	6.30E-05
	Kr	28				533	2.67E-04
	Ag	43				692	3.46E-04
	Pr	60				783	3.92E-04
	Au	86				1276	6.38E-04

Table 7. Data of Channel Cross Section of ISL70444SEH for V_S = ±1.35V (Device 7)

Supply (V)	Species	LET (MeV•cm2/mg)	Channel	Device	Fluence/run (P/cm^2)	Events	Event CS (cm^2)
±1.35	Ne	2.7	A	7	2.00E+06	6	3.00E-06
	Ar	8.5				153	7.65E-05
	Kr	28				510	2.55E-04
	Ag	43				645	3.23E-04
	Pr	60				773	3.87E-04
	Au	86				796	3.98E-04
±1.35	Ne	2.7	B	7	2.00E+06	5	2.50E-06
	Ar	8.5				175	8.75E-05
	Kr	28				658	3.29E-04
	Ag	43				879	4.40E-04
	Pr	60				808	4.04E-04
	Au	86				1022	5.11E-04
±1.35	Ne	2.7	C	7	2.00E+06	18	9.00E-06
	Ar	8.5				229	1.15E-04
	Kr	28				495	2.48E-04
	Ag	43				603	3.02E-04
	Pr	60				575	2.88E-04
	Au	86				559	2.80E-04
±1.35	Ne	2.7	D	7	2.00E+06	5	2.50E-06
	Ar	8.5				113	5.65E-05
	Kr	28				703	3.52E-04
	Ag	43				973	4.87E-04
	Pr	60				820	4.10E-04
	Au	86				1122	5.61E-04

Table 8. Data of Channel Cross Section of ISL70444SEH for V_S = ±1.35V (Device 8)

Supply (V)	Species	LET (MeV•cm2/mg)	Ch	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±1.35	Ne	2.7	A	8	2.00E+06	4	2.00E-06
	Ar	8.5				164	8.20E-05
	Kr	28				578	2.89E-04
	Ag	43				644	3.22E-04
	Pr	60				743	3.72E-04
	Au	86				873	4.37E-04
±1.35	Ne	2.7	B	8	2.00E+06	15	7.50E-06
	Ar	8.5				191	9.55E-05
	Kr	28				535	2.68E-04
	Ag	43				720	3.60E-04
	Pr	60				854	4.27E-04
	Au	86				1121	5.61E-04

Table 8. Data of Channel Cross Section of ISL70444SEH for V_S = ±1.35V (Device 8) (Cont.)

Supply (V)	Species	LET (MeV•cm2/mg)	Ch	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±1.35	Ne	2.7	C	8	2.00E+06	15	7.50E-06
	Ar	8.5				237	1.19E-04
	Kr	28				537	2.69E-04
	Ag	43				610	3.05E-04
	Pr	60				643	3.22E-04
	Au	86				615	3.08E-04
±1.35	Ne	2.7	D	8	2.00E+06	4	2.00E-06
	Ar	8.5				137	6.85E-05
	Kr	28				792	3.96E-04
	Ag	43				745	3.73E-04
	Pr	60				895	4.48E-04
	Au	86				1180	5.90E-04

2.3.2.6 Tabular Cross Section Results: ±15V, ACL = 10 (Channel-by-Channel)

Table 9. Data of Channel Cross Section of ISL70444SEH for V_S = ±15V (Device 5)

Supply (V)	Species	LET ($MeV•cm^2/mg$)	Channel	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±15	Ne	2.7	A	5	2.00E+06	4	2.00E-06
	Ar	8.5				36	1.80E-05
	Kr	28				270	1.35E-04
	Ag	43				359	1.80E-04
	Pr	60				574	2.87E-04
	Au	86				685	3.43E-04
±15	Ne	2.7	B	5	2.00E+06	4	2.00E-06
	Ar	8.5				40	2.00E-05
	Kr	28				300	1.50E-04
	Ag	43				376	1.88E-04
	Pr	60				621	3.11E-04
	Au	86				769	3.85E-04
±15	Ne	2.7	C	5	2.00E+06	0	0.00E+00
	Ar	8.5				44	2.20E-05
	Kr	28				229	1.15E-04
	Ag	43				348	1.74E-04
	Pr	60				416	2.08E-04
	Au	86				424	2.12E-04
±15	Ne	2.7	D	5	2.00E+06	0	0.00E+00
	Ar	8.5				41	2.05E-05
	Kr	28				297	1.49E-04
	Ag	43				410	2.05E-04
	Pr	60				572	2.86E-04
	Au	86				725	3.63E-04

Table 10. DATA OF CHANNEL CROSS SECTION OF ISL70444SEH FOR V_S = ±15V (DEVICE 6)

Supply (V)	Species	LET (MeV•cm^2/mg)	Channel	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±15	Ne	2.7	A	6	2.00E+06	0	0.00E+00
	Ar	8.5				43	2.15E-05
	Kr	28				287	1.44E-04
	Ag	43				437	2.19E-04
	Pr	60				575	2.88E-04
	Au	86				693	3.47E-04
±15	Ne	2.7	B	6	2.00E+06	0	0.00E+00
	Ar	8.5				46	2.30E-05
	Kr	28				300	1.50E-04
	Ag	43				478	2.39E-04
	Pr	60				676	3.38E-04
	Au	86				765	3.83E-04
±15	Ne	2.7	C	6	2.00E+06	3	1.50E-06
	Ar	8.5				60	3.00E-05
	Kr	28				232	1.16E-04
	Ag	43				357	1.79E-04
	Pr	60				448	2.24E-04
	Au	86				442	2.21E-04
±15	Ne	2.7	D	6	2.00E+06	3	1.50E-06
	Ar	8.5				42	2.10E-05
	Kr	28				304	1.52E-04
	Ag	43				459	2.30E-04
	Pr	60				620	3.10E-04
	Au	86				792	3.96E-04

Table 11. Data of Channel Cross Section of ISL70444SEH for V_S = ±15V (Device 7)

Supply (V)	Species	LET (MeV•cm^2/mg)	Ch	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±15	Ne	2.7	A	7	2.00E+06	0	0.00E+00
	Ar	8.5				48	2.40E-05
	Kr	28				313	1.57E-04
	Ag	43				420	2.10E-04
	Pr	60				588	2.94E-04
	Au	86				701	3.51E-04
±15	Ne	2.7	B	7	2.00E+06	2	1.00E-06
	Ar	8.5				40	2.00E-05
	Kr	28				299	1.50E-04
	Ag	43				452	2.26E-04
	Pr	60				632	3.16E-04
	Au	86				721	3.61E-04

Table 11. Data of Channel Cross Section of ISL70444SEH for V_S = ±15V (Device 7) (Cont.)

Supply (V)	Species	LET (MeV•cm^2/mg)	Ch	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±15	Ne	2.7	C	7	2.00E+06	0	0.00E+00
	Ar	8.5				45	2.25E-05
	Kr	28				249	1.25E-04
	Ag	43				388	1.94E-04
	Pr	60				455	2.28E-04
	Au	86				442	2.21E-04
±15	Ne	2.7	D	7	2.00E+06	0	0.00E+00
	Ar	8.5				40	2.00E-05
	Kr	28				304	1.52E-04
	Ag	43				453	2.27E-04
	Pr	60				595	2.98E-04
	Au	86				814	4.07E-04

Table 12. Data of Channel Cross Section of ISL70444SEH for V_S = ±15V (Device 8)

Supply (V)	Species	LET (MeV•cm^2/mg)	Ch	Device	Fluence/Run (P/cm^2)	Events	Event CS (cm^2)
±15	Ne	2.7	A	8	2.00E+06	1	5.00E-07
	Ar	8.5				37	1.85E-05
	Kr	28				266	1.33E-04
	Ag	43				510	2.55E-04
	Pr	60				682	3.41E-04
	Au	86				785	3.93E-04
±15	Ne	2.7	B	8	2.00E+06	1	5.00E-07
	Ar	8.5				50	2.50E-05
	Kr	28				315	1.58E-04
	Ag	43				577	2.89E-04
	Pr	60				788	3.94E-04
	Au	86				866	4.33E-04
±15	Ne	2.7	C	8	2.00E+06	0	0.00E+00
	Ar	8.5				52	2.60E-05
	Kr	28				238	1.19E-04
	Ag	43				428	2.14E-04
	Pr	60				477	2.39E-04
	Au	86				481	2.41E-04
±15	Ne	2.7	D	8	2.00E+06	1	5.00E-07
	Ar	8.5				29	1.45E-05
	Kr	28				298	1.49E-04
	Ag	43				529	2.65E-04
	Pr	60				700	3.50E-04
	Au	86				869	4.35E-04

2.3.2.7 Histograms

2.3.2.7.1 Voltage Deviation Histograms: ±15V

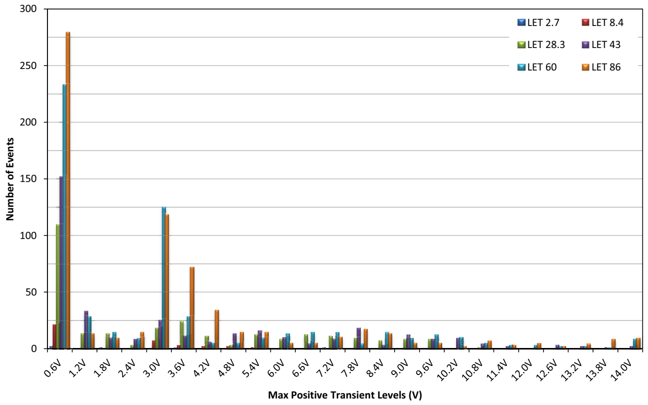

Figure 22. Max Positive Voltage Transients from V_{OUT} = +1V Caused by SETs (V_S = ±15V, ACL = 10), Fluence was Run at $2x10^6/cm^2$

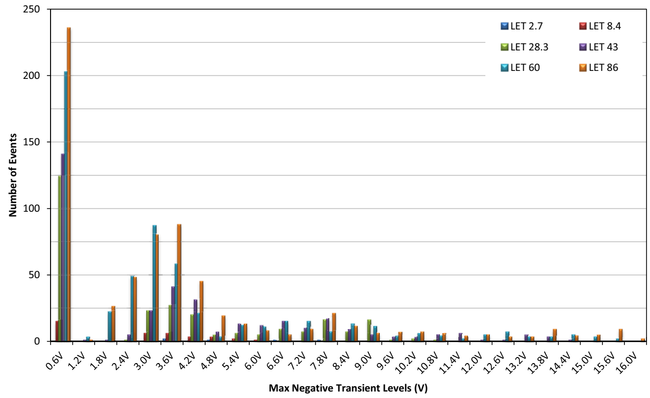

Figure 23. Max Negative Voltage Transients from V_{OUT} = +1V Caused by SETs (V_S = ±15V, ACL = 10), Fluence was Run at $2x10^6/cm^2$

2.3.2.7.2 Transient Deviation Histogram: ±15V

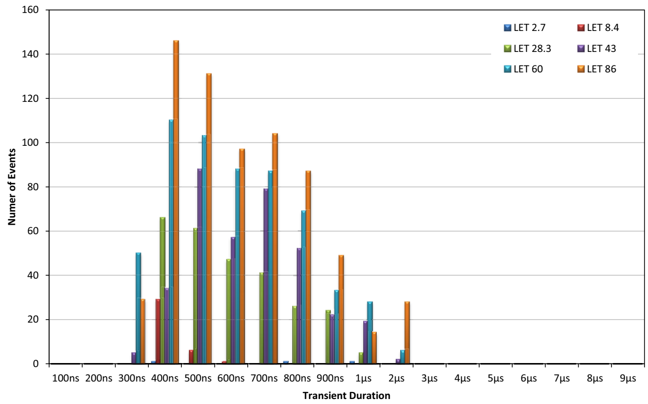

Figure 24. Max Transient Duration Caused by SETs (V_S = ±15V, ACL = 10), Fluence was Run at $2x10^6/cm^2$

2.3.2.7.3 Voltage Deviation Histograms: ±1.35V

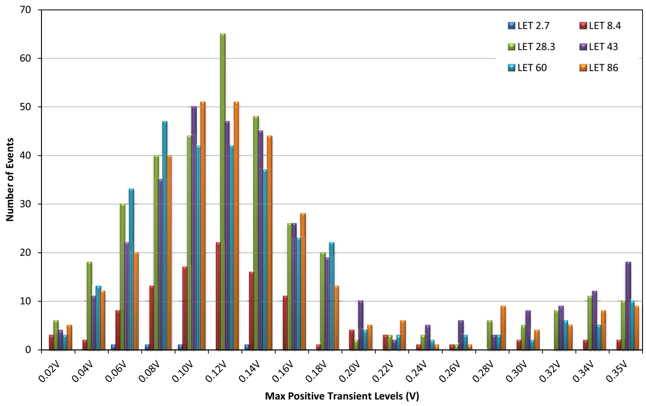

Figure 25. Max Positive Voltage Transients from V_{OUT} = +1V Caused by SETS (V_S = ±1.35V, ACL = 10), Fluence was Run at $2x10^6/cm^2$

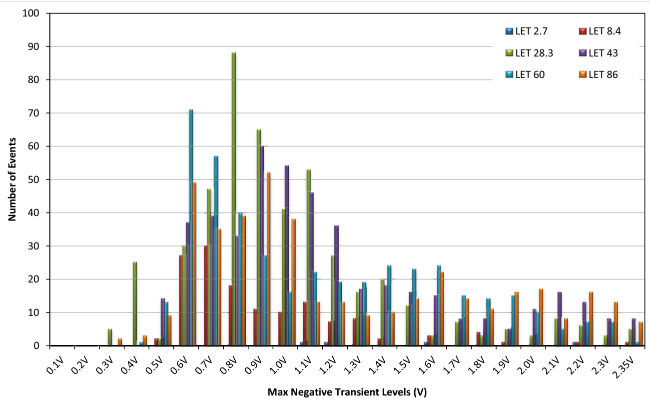

Figure 26. Max Negative Voltage Transients from V_{OUT} = +1V Caused by SETS (V_S = ±15V, ACL = 10), Fluence was Run at $2x10^6/cm^2$

2.3.2.7.4 Transient Deviation Histogram: ±1.35V

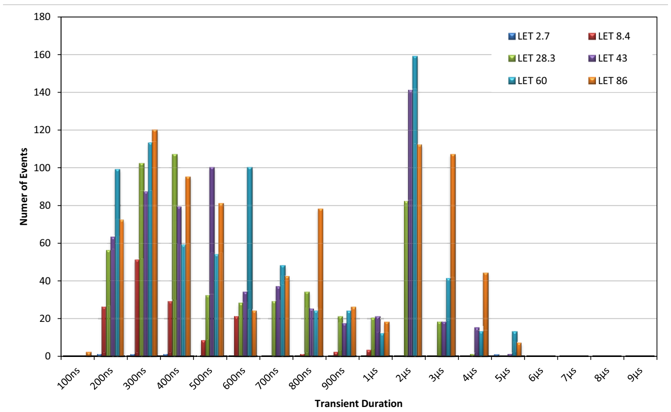

Figure 27. Max Transient Duration Caused by SETS (V_S = ±1.35V, ACL = 10), Fluence was Run at $2x10^6/cm^2$

2.3.2.7.5 SET Composite Plots (Gain = 10)

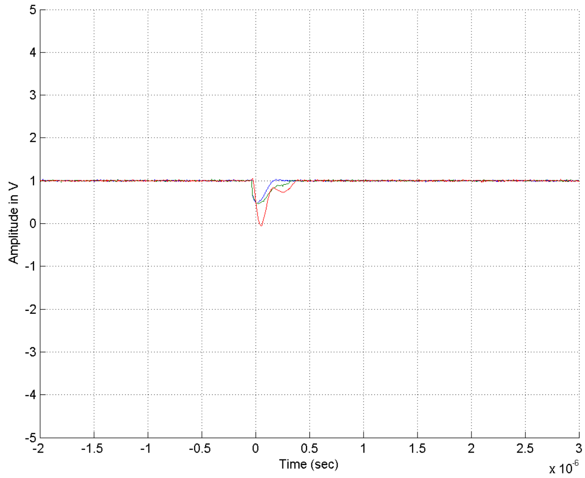

Figure 28. LET = 2.7MeV • cm^2/mg (V_S = ±1.35V); Fluence was Run at $2x10^6/cm^2$

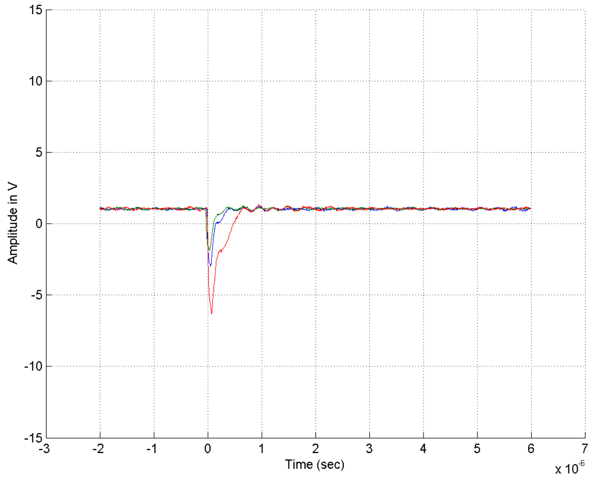

Figure 29. LET = 2.7MeV • cm^2/mg (V_S = ±15V); Fluence was Run at $2x10^6/cm^2$

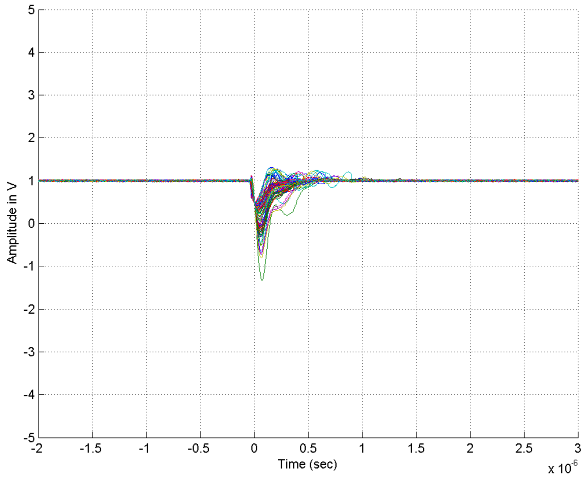

Figure 30. LET = 8.4MeV • cm^2/mg (V_S = ±1.35V); Fluence was Run at $2x10^6/cm^2$

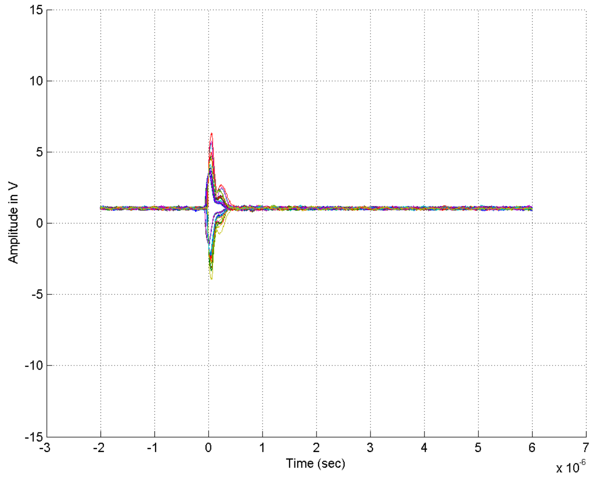

Figure 31. LET = 8.4MeV • cm^2/mg (V_S = ±15V); Fluence was Run at $2x10^6/cm^2$

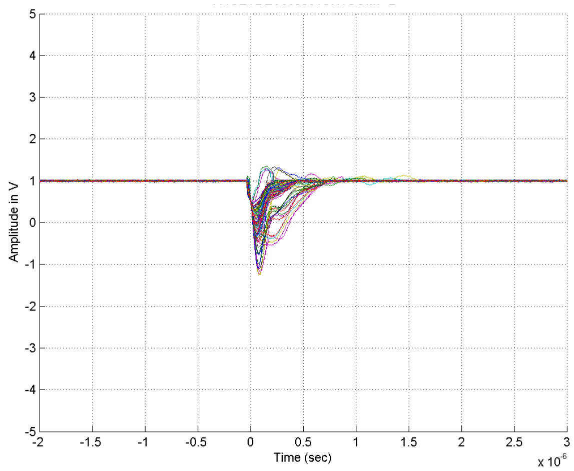

Figure 32. LET = 28.3MeV • cm^2/mg (V_S = ±1.35V); Fluence was Run at $2x10^6/cm^2$

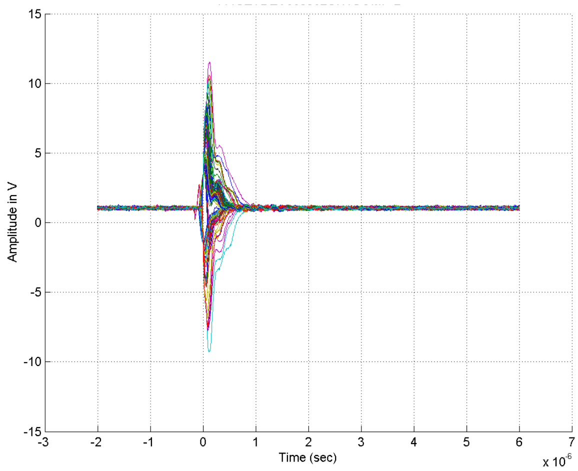

Figure 33. LET = 28.3MeV • cm^2/mg (V_S = ±15V); Fluence was Run at $2x10^6/cm^2$

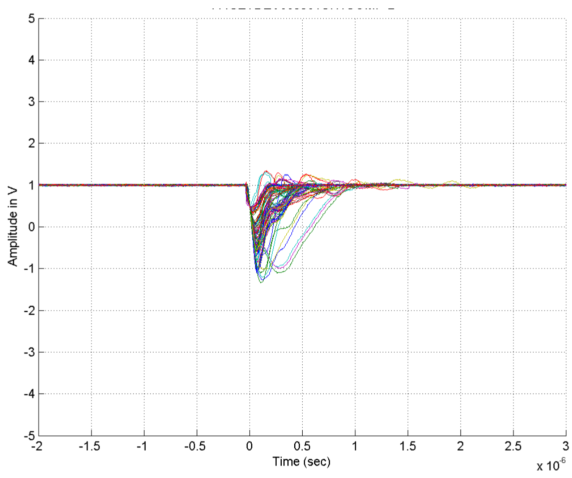

Figure 34. LET = 43MeV•cm²/mg (V_S = ±1.35V); Fluence was Run at 2x10⁶/cm²

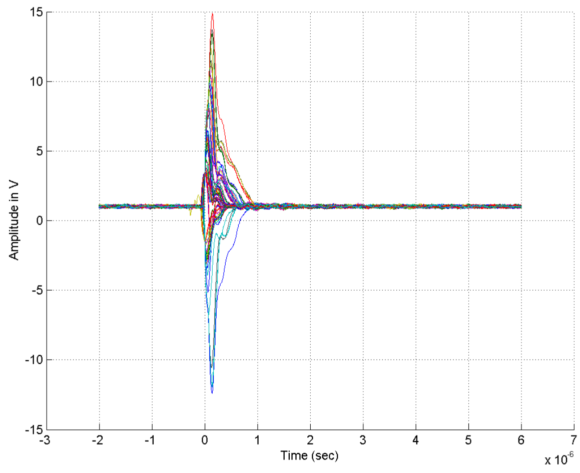

Figure 35. LET = 43MeV•cm²/mg (V_S = ±15V); Fluence was Run at 2x10⁶/cm²

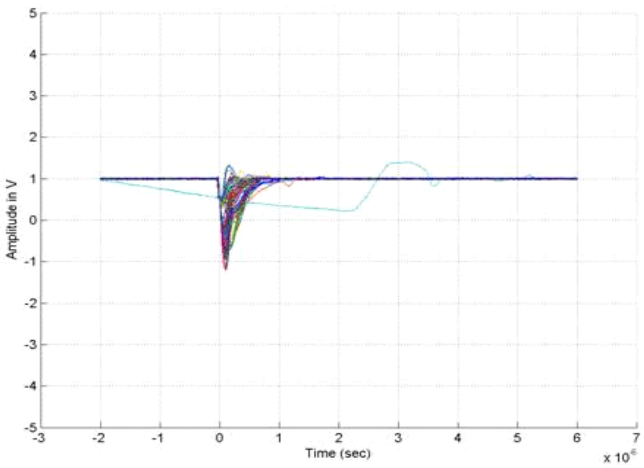

Figure 36. LET = 60MeV•cm²/mg (V_S = ±1.35V); Fluence was Run at 2x10⁶/cm²

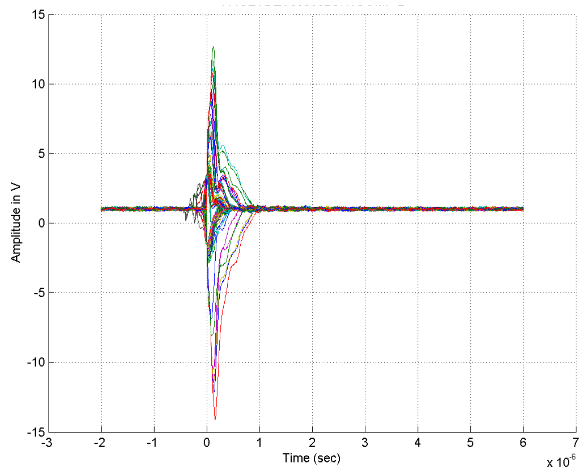

Figure 37. LET = 60MeV•cm²/mg (V_S = ±15V); Fluence was Run at 2x10⁶/cm²

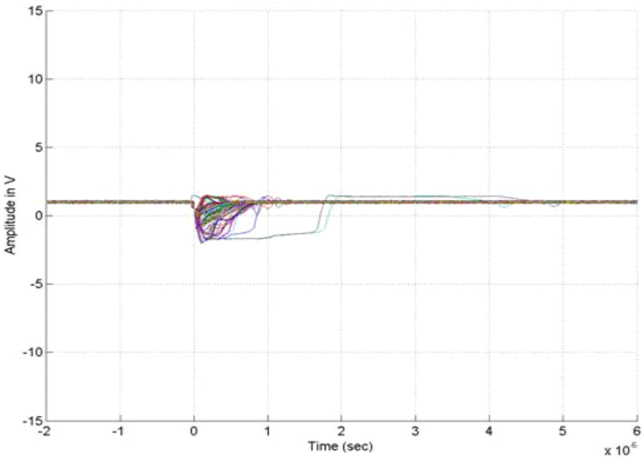

Figure 38. LET = 86MeV•cm²/mg (V_S = ±1.35V); Fluence was Run at 2x10⁶/cm²

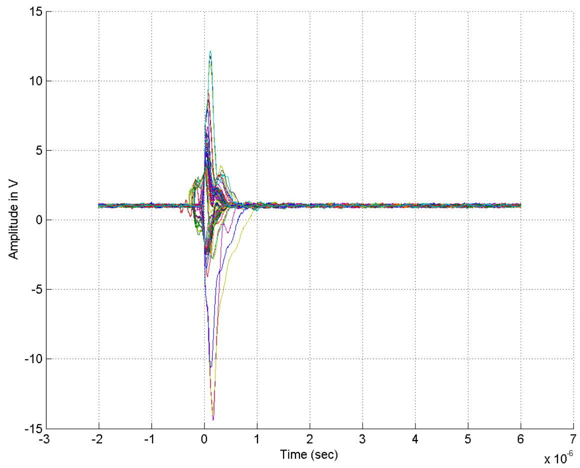

Figure 39. LET = 86MeV•cm²/mg (V_S = ±15V); Fluence was Run at 2x10⁶/cm²

A. Appendix

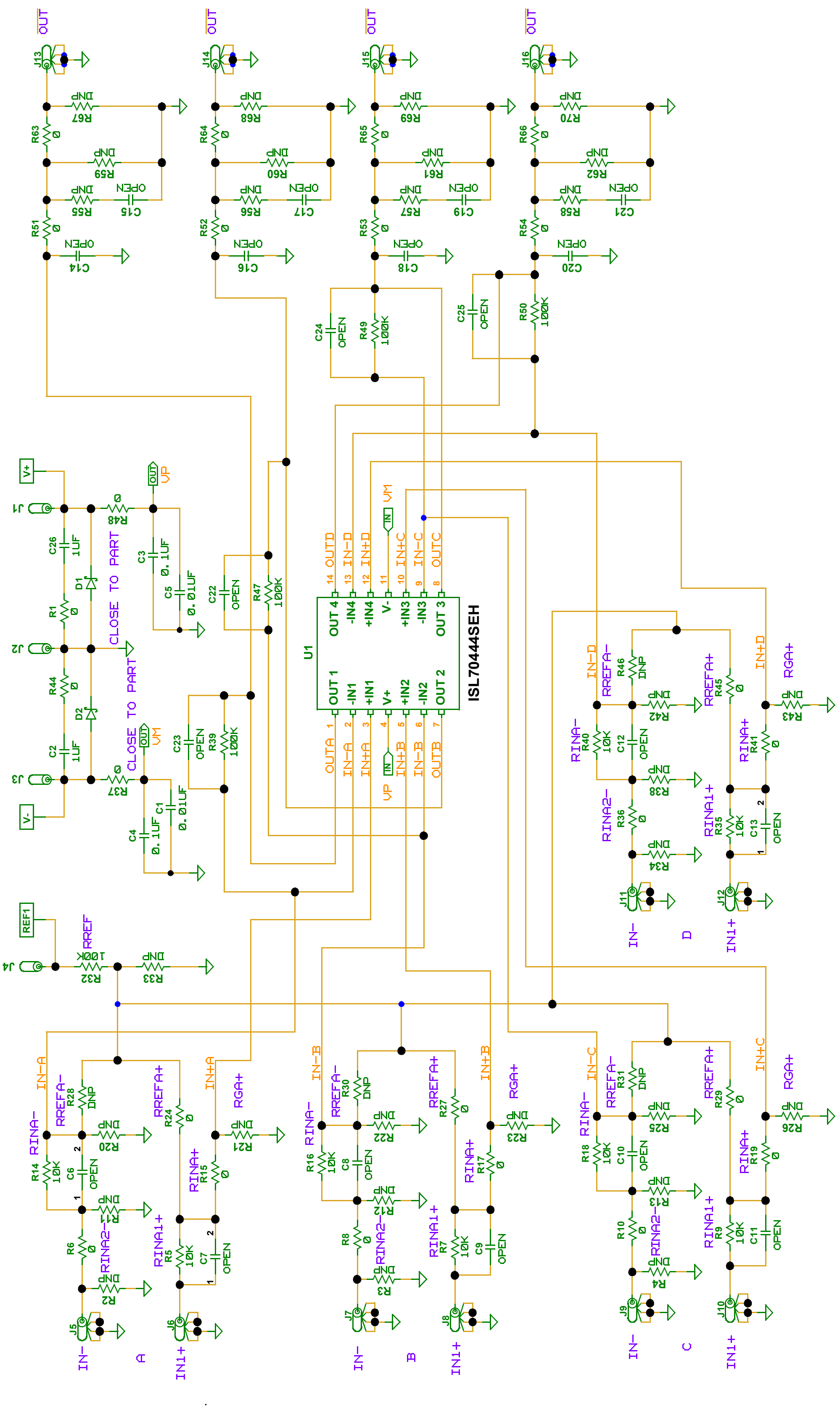

Figure 40. Schematic

A.1 ISL70444SEHEVAL1Z Layout

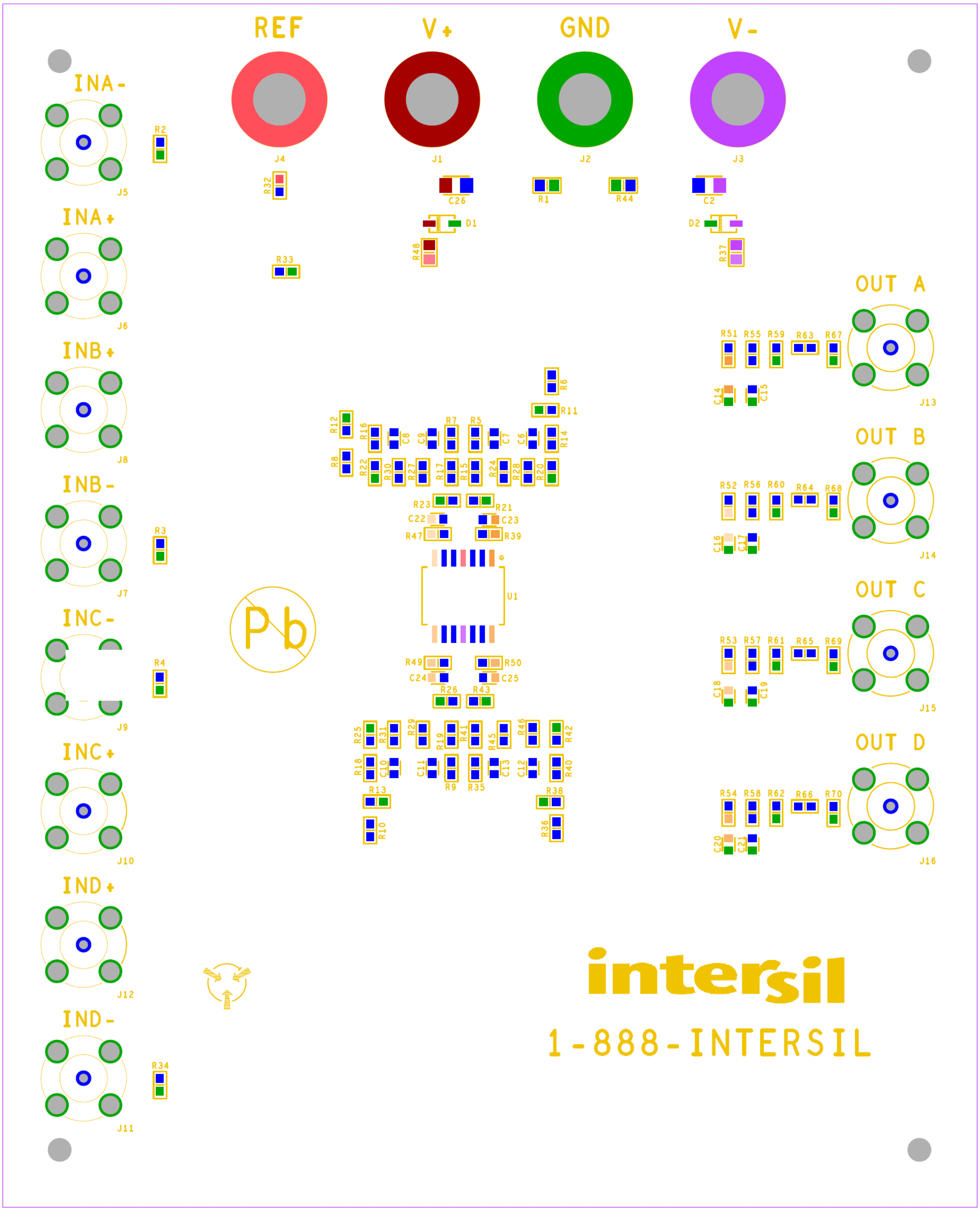

Figure 41. Top View

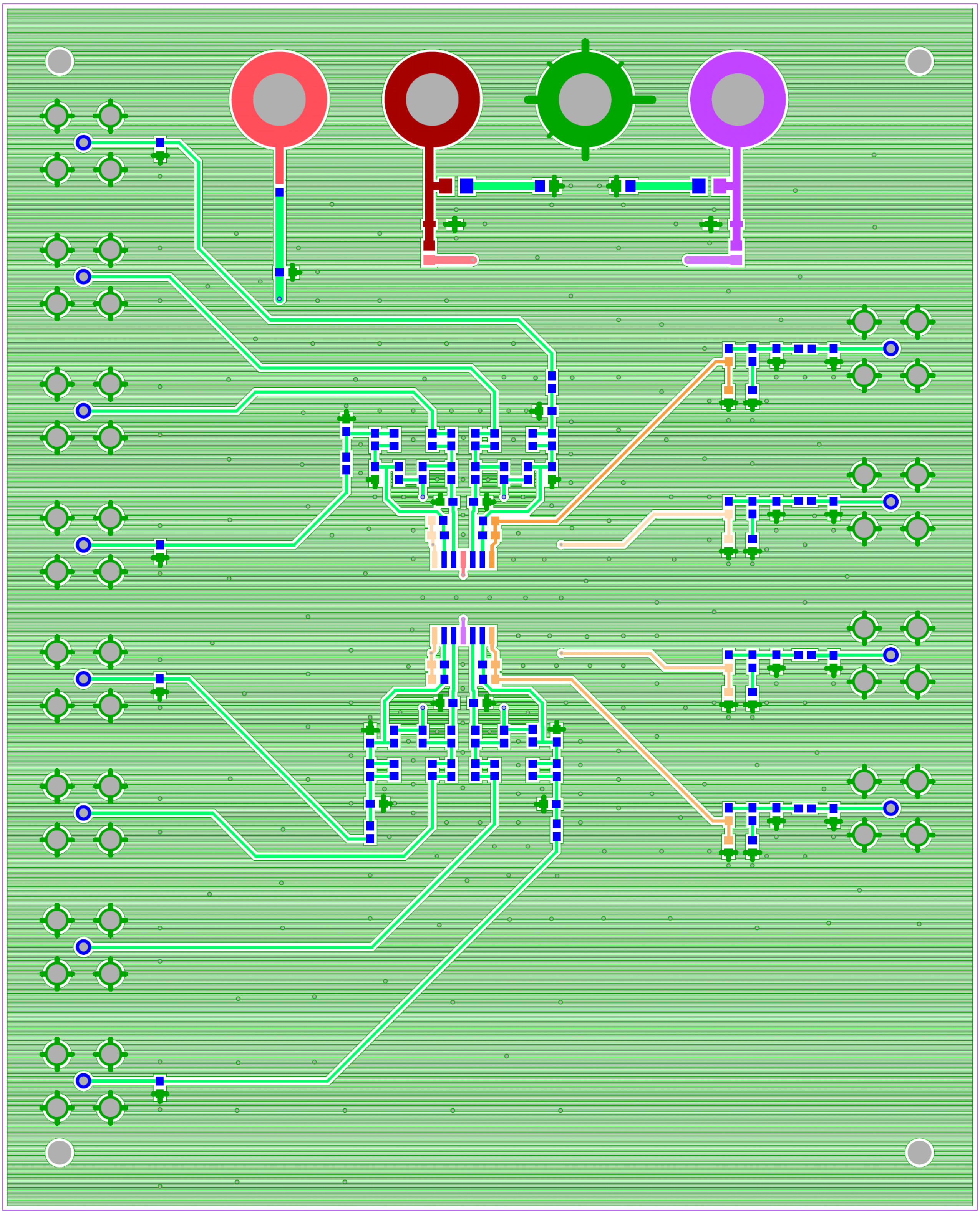

Figure 42. Top Layer

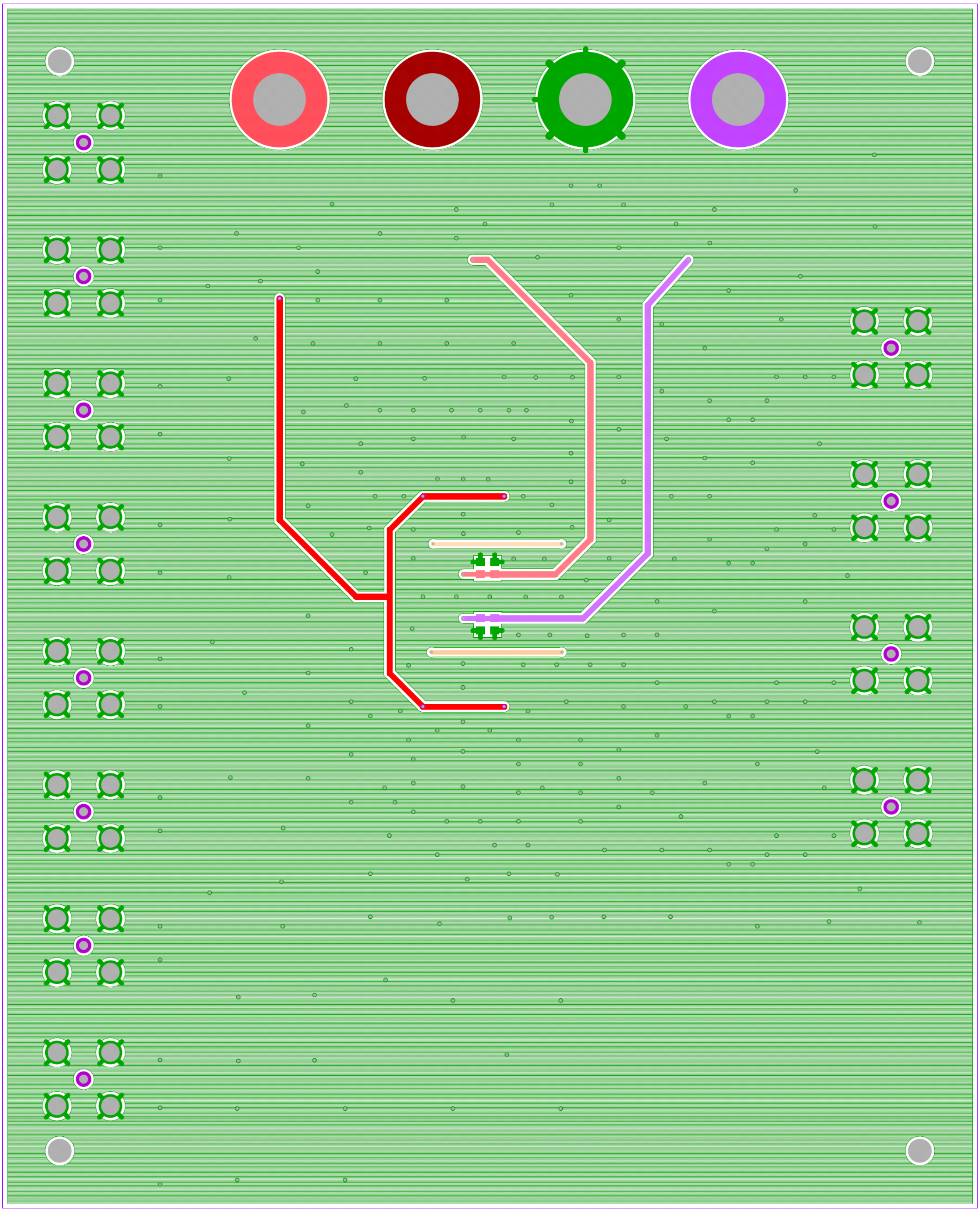

Figure 43. Bottom Layer

3. Revision History

Revision	Date	Description
2.01	Apr 7, 2026	▪ Applied the latest template. ▪ Fixed the legend on Figure 13 and the title on Figure 15.
2.00	Nov, 1, 2018	▪ Added sentence to Introduction to note devices of the same design and silicon: ISL70444ASEH and ISL73444SEH. ▪ Updated sales disclaimer.
1.00	Jun 22, 2017	▪ Applied new header/footer. ▪ Added Revision History at this rev. ▪ Updated supply voltage in Table 2 from ±1.5V to ±1.35V for all rows.
0.00	Jun 28, 2013	Initial release.

IMPORTANT NOTICE AND DISCLAIMER

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.