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TEST REPORT

ISL70321SEH, ISL73321SEH

Single Event Effects (SEE) Testing

TR051
Rev.0.00
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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). Single event effects 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 ISL70321SEH quad power supply sequencer designed for space applications. This report also applies to the ISL73321SEH part which is sourced from the same silicon die as the ISL70321SEH part.

Part Description

The ISL70321SEH and ISL73321SEH are radiation hardened and SEE mitigated power supply sequencers designed to drive Point-of-Load (POL) regulators with enable or shutdown pins. The ISL70321SEH and ISL73321SEH are sourced from the same silicon die so a single SEE report covers both parts. Up to four power supplies can be fully sequenced by a single device or multiple devices can be easily cascaded to sequence an unlimited number of power supplies.

This power supply sequencer requires only two feedback resistors per power supply and a single resistor to set a common rising and falling delay. The device features precision input comparators with an input threshold voltage of 600mV ±1.5% for high accuracy when monitoring power supplies.

The ISL70321SEH is offered in an 18 Ld 10mm x 12mm CDFP package or die form and is fully specified across the military temperature range of T_A = -55°C to +125°C. With a minimal external component count, precision voltage monitoring, and SET mitigation, the ISL70321SEH is the ideal choice to control many of today’s highly dense power systems in high reliability applications.

For a more detailed description of the part please refer to the datasheet.

The ISL70321SEH parts reported on here came from lot 5STWB, wafers V2BG8CW and VTBG6MW manufactured on Intersil’s proprietary P6 process, and were packaged in the production 18 Ld CDFP without lids. The parts did not see production burn-in nor over-temperature testing in deference to the lidless state.

Related Literature

- For a full list of related documents, visit our website
  - ISL70321SEH, ISL73321SEH product pages

1. Test Description

1.1 Test Objective

The ISL70321SEH was tested to determine its susceptibility to destructive single event effects (SEL, SEGR, and SEB, collectively referred to as SEB) and to characterize its Single Event Transient (SET) behavior over various operational conditions and ion Linear Energy Transfer (LET) levels.

1.2 Test Facility

Testing was performed at the Texas A&M University (TAMU) Cyclotron Institute heavy ion facility. This facility is coupled to a K500 super-conducting cyclotron, which is capable of generating a wide range of test particles with the various energy, flux, and fluence levels needed for advanced radiation testing. Details on the test facility can be found on the TAMU Cyclotron website. The bulk of the testing was carried out March 9-11, 2017. Some additional testing was done on May 6, 2017.

1.3 Test Set-Up

The SEE testing of the ISL70321SEH used a SEE board with two parts configured as shown in Figures 1 through 3 to allow two parts at a time to be tested.

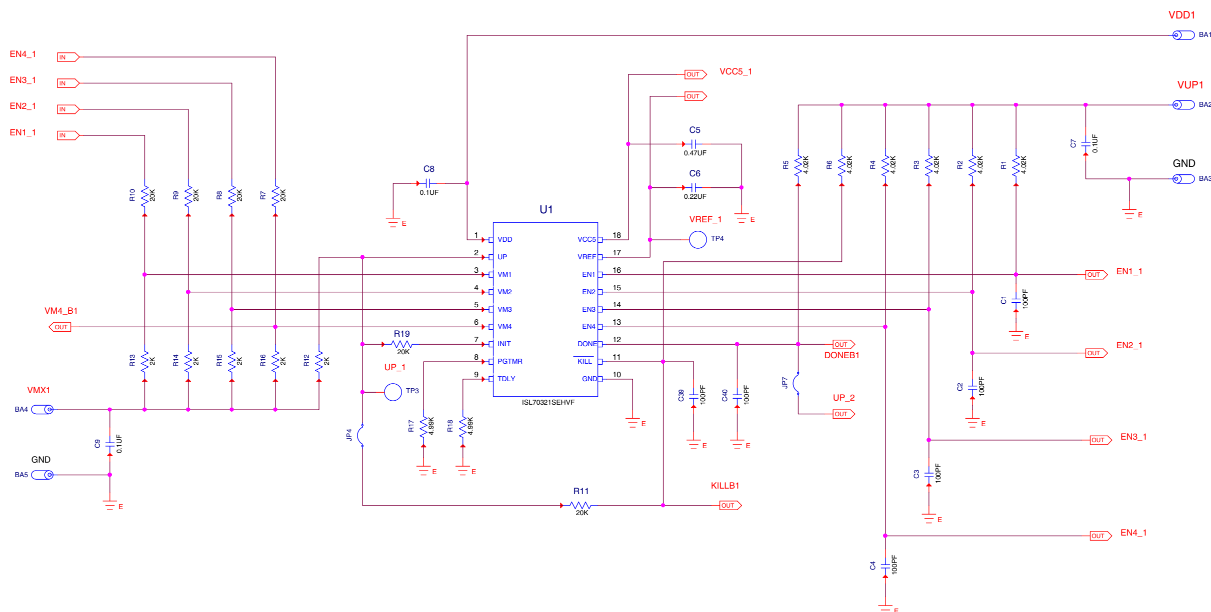

Figure 1. Schematic of SEE Configurations Page 1

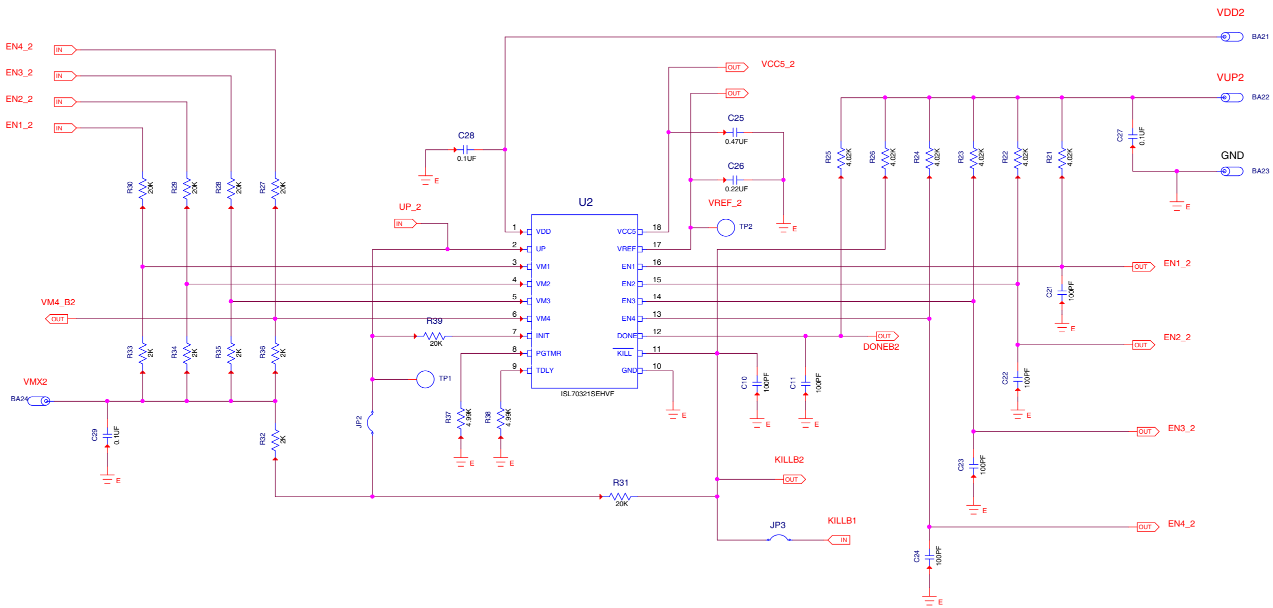

Figure 2. Schematic of SEE Configurations Page 2

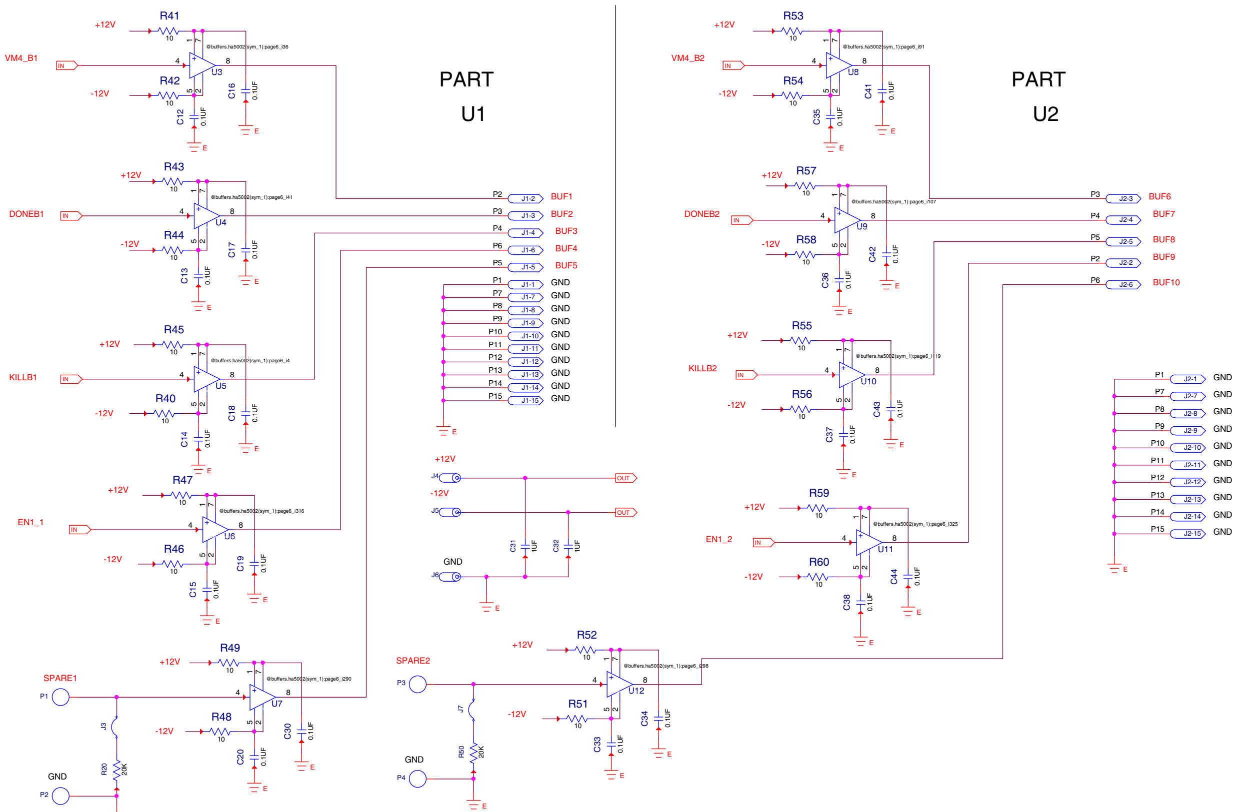

Figure 3. Schematic of SEE Configurations Page 3

The selection of the component values and voltage conditions determines if the configuration is to be used for destructive SEE (SEB) testing or if it is for Single Event Transient (SET) testing. The values used for the two configurations are listed in Table 1.

Table 1. Component Values and Voltage Conditions to Configure the SEE Board for Either SEB or SET Testing

	SEB Testing	SET Testing
R_1 to R_4, R_{21} to R_{24}	4kΩ 1%	Do not populate
R_7 to R_{10}, R_{27} to R_{30}	20kΩ 1%	0Ω
R_{11} and R_{31}	10kΩ 1%	10kΩ 1%
R_{13} to R_{16}, R_{33} to R_{36}	2kΩ 1%	1kΩ 1%
VUP (V)	15.6 to 19.5	5
V_{DD} (V)	13.2 to 16.5	3.0 and 13.2
VMX (V)	GND	0.61V

For the SEB configuration, the part is set to sequence up to a done state (DONE = high). The biasing is also such that the #KILL signal for a fault (#KILL = low) puts the part into a reset condition from which it immediately recovers and sequences back up to a DONE condition. This ensures that the part remains in a DONE state for the bulk of the SEB irradiation so long as the sequence up time is small compared to the time between faults.

For the SET testing, the biasing allows the part to be configured either into the DONE state (UP = open, VMX = 0.61V) or to be set to wait for an UP signal (UP = GND, VMX = 0.59V) to begin sequencing. The former allows testing for SET that interrupt a DONE state with a fault, whereas the latter looks for SET that would be inappropriate ENx signals.

1.4 Destructive SEE Testing

Destructive SEE (collectively termed SEB here but includes SEL and SEGR) testing of the ISL70321SEH sequencer proceeded with the part in a completed sequence-up state (DONE). The biasing configuration provided for an automatic reset and resequence up should a fault be encountered. This ensured that the part was in the DONE state throughout the bulk of the time it was being tested for SEB. The biasing configuration allowed the open-drain outputs to rise up to a close approximation of V_{DD} so all these terminals could be tested for voltage tolerance to SEB. Before and after irradiation, six parameters were measured to check for changes indicative of damage. The results of the SEB testing are presented in Table 2.

Table 2. Parameter Measurements Looking for Indication of SEE Damage

V_{DD} (V)	DUT		VDONEB (V)	IDD (mA)	IVUP (mA)	VREF (mV)	VCC5 (V)	VM4B (mV)
14.5	DUT1	Pre	14.438	5.053	3.927	598	5.065	1.369
		Delta	0.0%	-0.1%	0.0%	0.0%	-0.2%	0.1%
	DUT2	Pre	14.692	5.063	3.997	598	5.059	1.393
		Delta	0.0%	0.4%	-0.1%	0.0%	-0.1%	0.0%
	DUT3	Pre	14.860	5.097	4.044	598	5.060	1.408
		Delta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	DUT4	Pre	15.028	5.112	4.092	598	5.063	1.423
		Delta	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%

Table 2. Parameter Measurements Looking for Indication of SEE Damage (Continued)

V_{DD} (V)	DUT		VDONEB (V)	IDD (mA)	IVUP (mA)	VREF (mV)	VCC5 (V)	VM4B (mV)
14.7	DUT1	Pre	14.436	5.010	3.927	598	5.059	1.379
		Delta	0.0%	-0.2%	0.0%	0.2%	-0.1%	0.0%
	DUT2	Pre	14.688	5.019	3.997	598	5.060	1.403
		Delta	0.0%	-0.1%	0.0%	0.0%	-0.1%	0.0%
	DUT3	Pre	14.857	5.032	4.044	598	5.060	1.418
		Delta	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%
	DUT4	Pre	15.024	5.047	4.092	598	5.058	1.434
		Delta	0.0%	-0.2%	0.0%	0.2%	-0.1%	0.0%
14.9	DUT1	Pre	14.439	5.096	3.933	599	5.068	1.366
		Delta	0.0%	-0.4%	0.0%	0.0%	-0.1%	0.0%
	DUT2	Pre	14.692	5.093	4.003	599	5.066	1.389
		Delta	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%
	DUT3	Pre	14.859	5.110	4.050	599	5.066	1.405
		Delta	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
	DUT4	Pre	15.027	5.125	4.098	599	5.072	1.420
		Delta	0.0%	-0.1%	0.0%	0.0%	-0.1%	0.0%
15.1	DUT1	Pre	14.444	5.182	3.936	599	5.038	1.372
		Delta	0.0%	-0.4%	0.0%	0.0%	-0.1%	0.0%
	DUT2	Pre	14.697	5.178	4.006	599	5.039	1.396
		Delta	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
	DUT3	Pre	14.865	5.196	4.054	599	5.037	1.411
		Delta	0.0%	0.1%	0.0%	0.0%	-0.1%	0.3%
	DUT4	Pre	15.032	5.220	4.101	599	5.037	1.426
		Delta	0.0%	0.2%	0.0%	0.0%	-0.1%	0.2%

Note: Each V_{DD} voltage indicates an irradiation with Au for an LET = 86MeV•cm^2/mg which was run to a fluence of 1x10^{7}ion/cm^2 with the part at a case temperature of +125°C. The V_{DD} voltages were run sequentially on each Device Under Test (DUT).

The largest magnitude delta recorded in Table 2 is 0.4%, so it is concluded the no significant permanent damage occurred in any of the tests. The ISL70321SEH is SEB, SEL, and SEGR immune with V_{DD} up to 15.1V and case temperature of +125°C to an LET of 86MeV•cm^2/mg.

1.5 SET DONE Testing

The first SET testing looked for false faults that would interrupt a DONE state and generate a #KILL low event. These events are actually SEFI in that the system is shut down as a result of the #KILL event. The biasing selected for this test configures the part for an automatic restart to return to the DONE state. This allows a simple count of DONEB (buffered DONE signal) events to determine the susceptibility to SET initiating #KILL events. The faults were triggered on the falling edge of DONEB to a 50% voltage point (2.5V) of the full pull-up value (5V). In a real system the customer would need to either detect the fault and initiate another up sequence to DONE or select a biasing scheme that automatically initiates a restart. Such a biasing scheme is presented in the ISL70321SEHDEMO1Z Demonstration Board User's Guide.

According to plan, the first four parts for the DONE SET were irradiated to 1x10^{7}ion/cm^2 at 5x10^{4}ion/(s•cm^2) for each exposure with Au and then Ho. At each species the V_{DD} was set first to 3V and then to 13.2V, leading to a total of four exposures per part totaling 4x10^{7}ion/cm^2. The results from this sequence of tests are presented in Table 3.

Table 3. SET Counts of DONE Interruptions for Au and Ho

Species and LET ($MeV \cdot cm^2/mg$)	V_{DD} (V)	DUT5 SET Count	DUT6 SET Count	DUT7 SET Count	DUT8 SET Count	Cross Section (cm^2)
Au, 86	3	148	132	72	72	$1.06x10^{-5}$
	13.2	39	34	43	70	$4.63x10^{-6}$
Ho, 69	3	14	1	7	3	$6.25x10^{-7}$
	13.2	0	0	0	0	0

Note: Sequence of irradiations is from top to bottom. Each irradiation was to a fluence of $1x10^7 ion/cm^2$ at a flux of $5x10^4 ion/(s \cdot cm^2)$.

Again, according to plan, a new set of four parts were irradiated with Pr using the same procedure as previously described. The results are in Table 4.

Table 4. SET Counts of DONE Interruptions for Pr

Species and LET ($MeV \cdot cm^2/mg$)	V_{DD} (V)	DUT9 SET Count	DUT10 SET Count	DUT11 SET Count	DUT12 SET Count	Cross Section (cm^2)
Pr, 60	3	51	29	96	35	$5.28x10^{-6}$
	13.2	5	4	10	1	$5.00x10^{-7}$

Note: Sequence of irradiations is from top to bottom. Each irradiation was to a fluence of $1x10^7 ion/cm^2$ at a flux of $5x10^4 ion/(s \cdot cm^2)$.

Both human observation of the SET accumulation rates during testing and the data presented in Tables 3 and 4 indicated a fluence effect on the SET counts. The SET count per unit fluence decreased with accumulated fluence. This may be due to the accumulation of Total Ionizing Dose (TID), but the mechanism was not further explored at the time of testing. This observation led to a change in plans. Four fresh parts were irradiated again with Ho using four irradiations of $2.5x10^6 ion/cm^2$ at $2.5x10^4 ion/(s \cdot cm^2)$ to total the full $1x10^7 ion/cm^2$ at each condition. In addition, the sequence of voltages used was alternated between the pair of parts. The SET count summary for this testing with Ho appears in Table 5 on page 7.

Table 5. SET Counts of DONE Interruptions for Fresh Parts Irradiated with Ho

Species and LET ($MeV•cm^2/mg$)	V_{DD} (V)	DUT31 SET Count	DUT32 SET Count	DUT33 SET Count	DUT34 SET Count	DUT60 SET Count	Mean Cross Section (cm^2)
Ho, 69 Tests were sequential from top to bottom.	3	21	32			27	$1.06x10^{-5}$
		24	28			13	$8.67x10^{-6}$
		17	16			10	$5.73x10^{-6}$
		13	16			11	$5.33x10^{-6}$
	13.2	0	2				$4.00x10^{-7}$
		1	3				$8.00x10^{-7}$
		0	1				$2.00x10^{-7}$
		0	0				0
	13.2			11	9		$4.00x10^{-6}$
				6	6		$2.40x10^{-6}$
				2	5		$1.40x10^{-6}$
				3	3		$1.20x10^{-6}$
	3			13	7		$4.00x10^{-6}$
				7	7		$2.80x10^{-6}$
				7	5		$2.40x10^{-6}$
				7	7		$2.80x10^{-6}$

Note: Sequence of events proceeds from top to bottom. Each irradiation was to a fluence of $2.5x10^6 ion/cm^2$ at a flux of $2.5x10^4 ion/(s•cm^2)$.

The data in Table 5 supports the observation of a fluence suppression on the SET rate. The data also indicates a higher SET rate for the 3V V_{DD} bias than for the 13.2V. This is in accordance with the expectations of the upset susceptibility of the logic as it depends on bias.

During testing to this point, it was noted that the DONE SET interruptions had an unexpected form; they were longer than expected and of variable length. This was contrary to expectation based on the part operation. To address this observation, a fifth part (DUT60 in Table 5) was run with Ho and at V_{DD} = 3V while experiments were performed to isolate the cause of the SET length anomaly. This experimentation was successful and found that the power supply used for VMX was malfunctioning. The malfunction was delaying the reset of #KILL and so prolonging the SET. Replacing this supply resulted in DONE SET interruptions that were in the 4ms-6ms range as expected. Examples of the normal SET forms appear in Figures 4 and 5.

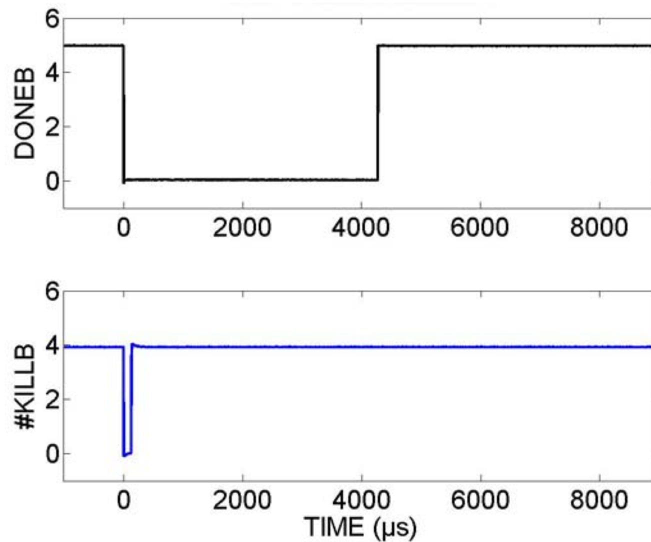

Figure 4. Short recovery (4ms) DONE SET. DONEB and #KILLB both go low in response to an SET, #KILLB recovers quickly but DONEB is delayed by the four channels of delay time totaling about 4ms.

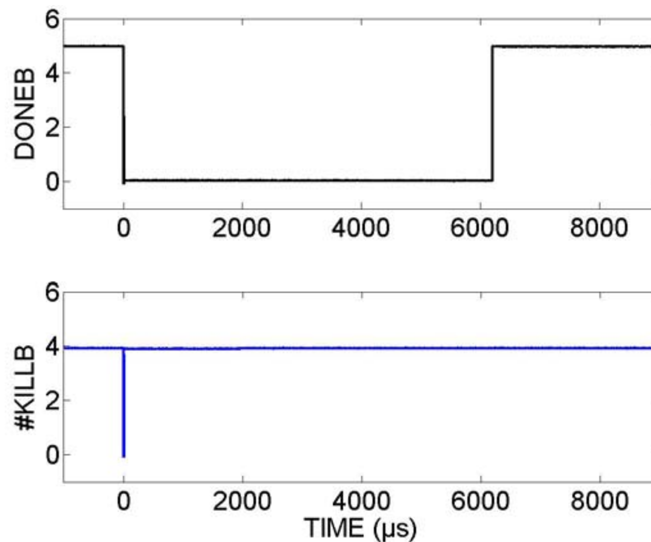

Figure 5. Long recovery (6ms) DONE SET. DONEB and #KILLB both go low in response to an SET. #KILLB recovers quickly but DONEB is delayed by the four channels of delay time and the 2ms of reference voltage delay totaling about 6ms.

At this point, testing moved on to the lower LET of 43MeV•cm^2/mg using Ag. To eliminate the fluence dependence on the bias voltage, fresh parts were used for each bias. The results of the Ag testing are presented in Table 6.

Table 6. SET Counts of DONE Interruptions for Fresh Parts Irradiated with Ag

Species and LET (MeV•cm^2/mg)	V_{DD} (V)	SET Count DUT37	SET Count DUT38	SET Count DUT39	SET Count DUT40	Mean Cross Section (cm^2)
Ag, 43 Tests were sequential from top to bottom.	3	12	10	9	17	$4.80x10^{-6}$
		11	12	14	4	$4.10x10^{-6}$
		10	5	7	5	$2.70x10^{-6}$
		9	4	6	6	$2.50x10^{-6}$
		DUT41	DUT42	DUT43	DUT44	
	13.2	0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0

Note: The sequence of events proceeds from top to bottom. Each irradiation was to a fluence of $2.5x10^6$ion/cm^2 at a flux of $2.5x10^4$ion/(s•cm^2).

The irradiations with Ag did produce SET at 3V bias but did not produce an SET at the 13.2V bias. An accumulated fluence influence on the SET rate was again apparent with an almost 50% reduction after $7.5x10^6$ion/cm^2 fluence.

Irradiations moved to Kr for an LET of 28MeV•cm^2/mg. Since the testing at Ag and 13.2V yielded a null result, only the 3V case was tested at Kr.

Table 7. SET Counts of DONE Interruptions for Fresh Parts Irradiated with Kr

Species and LET (MeV•cm^2/mg)	V_{DD} (V)	DUT47 SET Count	DUT48 SET Count	DUT49 SET Count	DUT50 SET Count	Mean Cross Section (cm^2)
Kr, 28	3	4	6	4	1	$1.50x10^{-6}$
		5	4	2	3	$1.40x10^{-6}$
		2	4	4	0	$1.00x10^{-6}$
		2	2	1	0	$5.00x10^{-7}$

Note: The sequence of events proceeds from top to bottom. Each irradiation was to a fluence of $2.5x10^6$ion/cm^2 at a flux of $2.5x10^4$ion/(s•cm^2).

Testing moved on to Cu for an LET of 20MeV•cm^2/mg. Again the testing only was done for a V_{DD} bias of 3V and the $1x10^7$ion/cm^2 irradiations were done as a single irradiations at $5x10^4$ion/(s•cm^2) because the event counts with Kr were so low. The result was that with four fresh parts (DUT51, DUT52, DUT53, and DUT54) no DONE SETs were captured.

Considering individually each $1x10^7$ion/cm^2 irradiation at each species and at 3V produces the data set presented in Table 8 on page 10. The threshold for SET events at V_{DD} = 3V is found at LET = 20MeV•cm^2/mg, since testing there yielded zero events and a cross section of less than $2.5x10^{-8}cm^2$. The data for gold was augmented by another run of four virgin units tested on May 4, 2017. These units showed a significantly higher cross section than the original four units tested. This may be due in part to the reduction of the flux from $5x10^4$ion/(cm^2s) used in the first set of irradiations to $2.5x10^4$ion/(cm^2-s) for the second set.

Table 8. DONE SET Counts and Resulting Average Cross Sections for 3V V_{DD} Bias and a Total of $1x10^7$ion/cm^2 at Each Irradiation

Species and LET (MeV•cm²/mg)	1st DUT SET Count	2nd DUT SET Count	3rd DUT SET Count	4th DUT SET Count	Mean Cross Section (cm²)
Au, 86	148	132	72	72	$1.06x10^{-5}$
	199	145	170	190	$1.76x10^{-5}$
Ho, 69	75	92	61		$7.60x10^{-6}$
Pr, 60	51	29	96	35	$5.28x10^{-6}$
Ag, 43	42	31	36	32	$3.53x10^{-6}$
Kr, 28	13	16	11	4	$1.10x10^{-6}$
Cu, 20	0	0	0	0	0

Note: Each entry represents new DUTs irradiated for the first time with V_{DD} = 3V.

An attempt to do a least squares fit of Weibull parameters to the maximum SET count data at each LET, led to unrealistic values for the saturation count (16,800) and the distribution width (1443 MeV•cm²/mg) so that approach was abandoned. Instead, Weibull fit parameters were selected to give a reasonable fit encompassing all the SET data. The fit and parameters are shown in Figure 6.

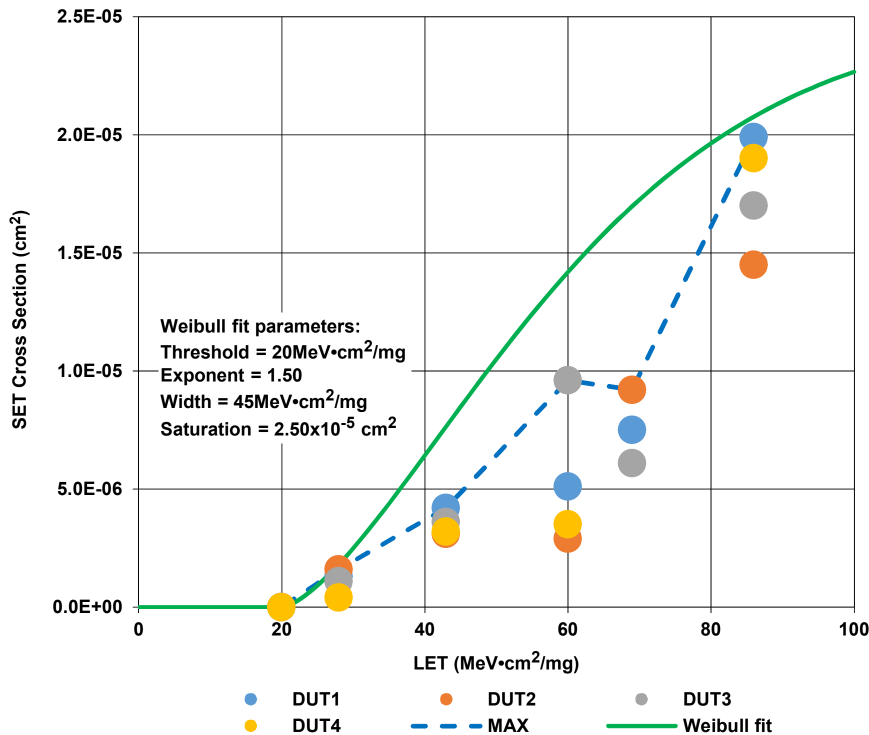

Figure 6. Weibull Parameter Fit of SET Data Based on the Maximum Cross Sections at Each LET.

The Weibull parameters in Figure 6 were used to run Vanderbilt University's on-line CRÈME simulations for LEO (low earth orbit, 1200km, 45° inclination, stormy magnetosphere, solar min for worst case conditions, 100 mil shielding) and for GEO (geosynchronous earth orbit, 45° inclination, solar min, 100 mil shielding) with the results as in Table 9.

Table 9. Results of CRÈME Simulations Based on the Weibull Parameters Presented in Figure 6

CRÈME for Weibull fit from SET maximums		
	(SEFI/Device/Day)	(Device/Year/SEFI)
LEO	3.89×10^{-7}	7042
GEO	5.25×10^{-6}	521

All the previous testing included a 100pF capacitor on the DONE output to provide filtering of the DONE output SET caused by a direct hit on the pull-down MOSFET. An attempt to test the necessity of this capacitor was accomplished by running two parts without capacitors on DONE at Au irradiation. The SET results of those runs are summarized in Table 10. The resulting SET were of two varieties. The first type was the same milliseconds long SEFI as seen with the capacitor, and the remainder were spike SET due to the absence of the capacitor. An example of the spikes SET is shown in Figure 7. The ringing is the result of parasitic loading of the DONE/DONEB lines and is not actually part of the SET.

Table 10. SET Counts by Category (SEFI and Spike) for the 3V and Au Irradiations

Species and LET (MeV•cm^2/mg)	SET Type	DUT5 SET Count	DUT6 SET Count	DUT7 SET Count	DUT8 SET Count	DUT21 SET Count	DUT22 SET Count	Cross Section (cm^2)
		100pF DONE capacitor				No DONE cap		
Au, 86	SEFI	148	132	72	72	124	67	1.03×10^{-5}
	Spike	0	0	0	0	0	257	4.28×10^{-6}

The difference between DUT21 and DUT22 appears to be that the spike SETs were flirting with the oscilloscope trigger setting of 2.5V. For DUT21 the SET did not trigger an oscilloscope capture, but for DUT22 they were just large enough to produce triggers. It appears that the 100pF capacitor is effective at eliminating the spike SET on DONE, but even without the capacitor the events are very fast and not full magnitude.

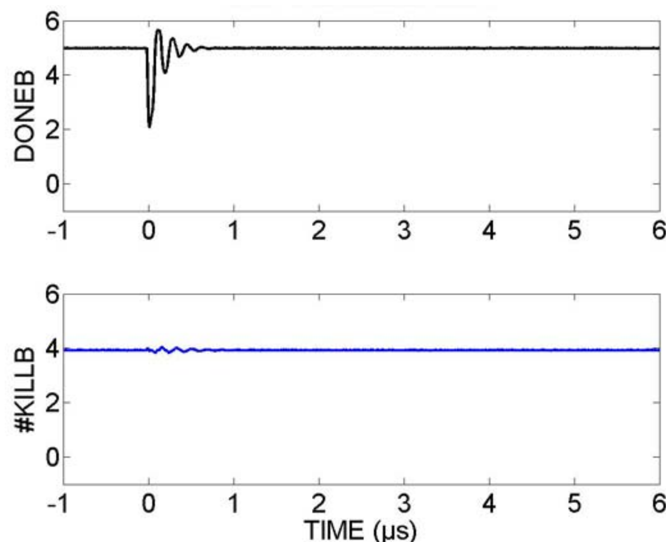

Figure 7. Short Spike DONE SET Found with no DONE Capacitor

Finally an estimate of the ratio of the SET rate at 3V and at 13.2V can be made from the swapped bias pairs tested at Ho as presented in Table 5 on page 7. The result of taking the ratio of the 2.5×10^6ion/cm^2 average counts is 39%. That is, the SEFI rate at 13.2V is estimated to be only about 39% of the rate at 3V. The 13.2V should be equivalent to any V_{DD} above 5.5V since this is where the LDO creating VCC5 becomes fully active.

1.6 SET Ready Testing

A second round of SET testing focused on the case of false enable signals when the part is in waiting to sequence up. For this, the part was biased on the edge of a condition that would start the part sequencing up and all comparators were biased just below threshold. EN1 was monitored through a buffer to see if an EN1B signal ever experienced a false high state. The biasing scheme allowed the EN1 to pull up to only about 590mV, so the capture trigger was set to 250mV. The small magnitude of the SET are a function of the biasing selected for testing. In real usage these SET would be of the magnitude of the pull-up bias on the outputs.

Table 11. SET on EN1B when Waiting to Cycle Up

Species and LET ($MeV \cdot cm^2/mg$)	V_{DD} (V)	DUT5 SET Count (Note 2)	DUT6 SET Count (Note 2)	DUT7 SET Count	DUT8 SET Count	Cross Section (cm^2)
Au, 86	3	51* 2	81* 2	0 3	0 4	$3.30x10^{-6}$ $2.75x10^{-7}$
	13.2	0	0	0	0	0
Ho, 69	3	0	0	0	0	0
	13.2	0	0	0	0	0

Notes:
1. Sequence of irradiations is from top to bottom. Each irradiation was to a fluence of $1x10^7 ion/cm^2$ at a flux of $5x10^4 ion/(s \cdot cm^2)$.
2. Spike SETs are listed first and labeled with an asterisk; the millisecond SETs are listed second.

The first two parts tested exhibited very short spikes (<1µs) at Au and 3V. The other events were of durations of just over a millisecond and are consistent with the TDLY time. An example of the millisecond event appears in Figure 8. It is deduced that EN1 is being tripped into a sequence down state and waits for a TDLY time to allow it to sequence back down to a low again. The other ENx would also be susceptible to a similar false enable high SET. The cross section for any ENx event would be four times that for ENB1. No events were captured at Ho, so testing at lower LET was not pursued.

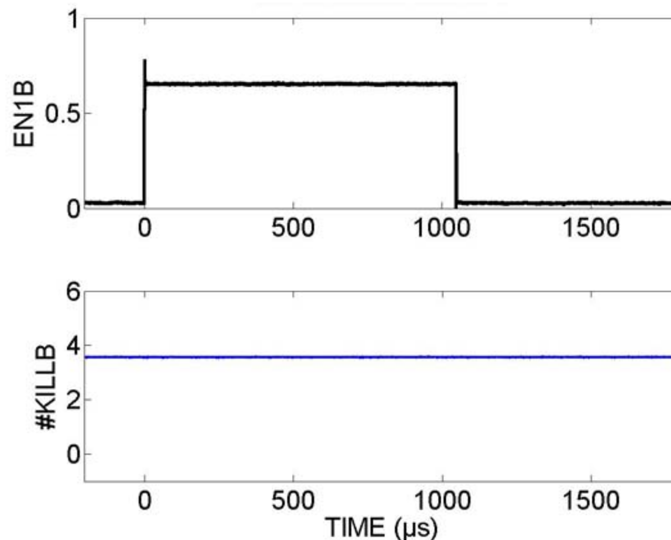

Figure 8. SET of EN1B when part is awaiting an Up command. EN1B goes high (pulls up to supply) and waits for a TDLY time before it returns to a low state. #KILLB does not register a #KILL event during this SET.

1.7 SET DONE for Two Cascaded Units

For this testing two ISL70321SEH units were wired in cascaded mode by connecting the DONE output of the first unit to the UP input of the second unit (JP7). Then the parts were irradiated separately and the SET recorded with the DONEB1 (buffered primary unit DONE), #KILLB (buffered system #KILL), DONEB2 (buffered secondary unit DONE), and EN1B1 (buffered primary unit EN1) signals. The results are summarized in Table 12.

Table 12. Summary of the SET Counts for the Irradiation of Cascaded Pairs of ISL70321SEH

Unit Irradiated	SET Counts for $1x10^7$ion/cm^2 gold at 86MeV•cm^2/mg		
	DONEB1 Trigger ↓2V	DONEB2 Trigger ↓4V	EN1B1 Trigger ↓ 0.25V
Primary (1) DUT5	185	184	190
Secondary (2) DUT6	179	181	179
Primary (1) DUT7	208	208	209
Secondary (2) DUT8	214	213	213

Note: Irradiations were $1x10^7$ion/cm^2 each with 86MeV•cm^2/mg normal incidence gold ions.

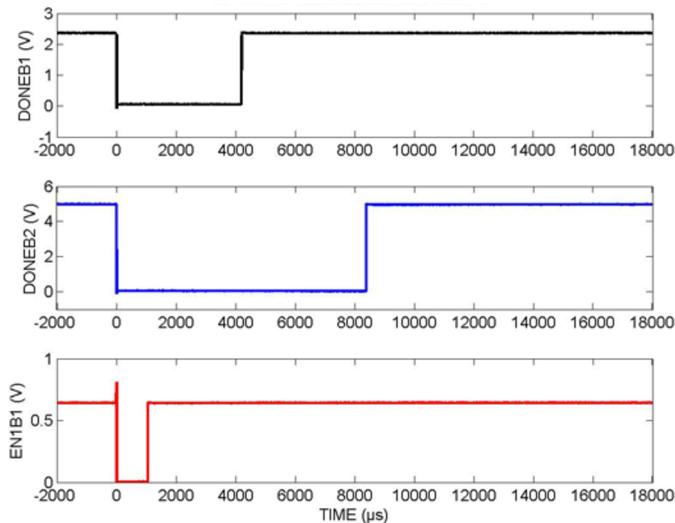

Figure 9. Typical SET for cascaded pair of ISL70321SEH showing full shutdown of both parts and subsequent restart of the cascaded configuration.

Of the 190 SET recorded for DUT5 irradiation on the EN1B1 triggered oscilloscope, five were small EN1B1 transients that barely achieved the 0.25V trigger level and did not reach 0V, nor persisted. For the case of DUT7 irradiation and EN1B1 triggering, three events were also small EN1B1 transients. For these few EN1B1 events, there were no DONEB1 or DONEB2 responses. These events are likely direct SEE at the pull-down device for that output. All the other transients were complete DONEB1 and DONEB2 shutdown and restart events. An example of these events is shown in Figure 9. The initiating #KILLB signal is not shown since the DONE signals are the responses to that event.

2. Conclusions

The testing for damaging SEE (SEL, SEGR, and SEB) proved that the ISL70321SEH is immune from damaging effects when operated at V_{DD} ≤ 15.1V at a case temperature of +125°C ±10°C and subjected to normal incidence Au ions at LET = 86MeV•cm^2/mg.

The ISL70321SEH when in the DONE state, is susceptible to SEFI for LET at or above 28MeV•cm^2/mg for normal incidence Kr when operating at +25°C and biased with V_{DD} between 3V and 13.2V. At 20MeV•cm^2/mg normal incidence Cu no SEFI were recorded in 4x10^{7}ion/cm^2 of testing. The SEFI are initiated by a fault issuing a #KILL signal and taking the part to a waiting state. The duration of the SEFI is determined by how the system responds. A reset (all six input comparators simultaneously below threshold) followed by a high UP input is required to restart the part. This may be handled by the system control or the part can be configured to accomplish a self-restart as used during SET testing and described in the ISL70321SEHDEMO1Z Demonstration Board User’s Guide. In either case, the restart will be gated by all the comparators falling below threshold. Calculations with CRÈME indicate that the SEFI are very rare events, less than once every 500 years, in either LEO or GEO applications (Table 9 on page 11).

In cascaded operation, a system SEFI can be initiated by any of the cascaded units so the susceptible cross section grows with the number of the cascaded devices. However, all SEFI were complete system shutdowns starting with a #KILL signal. There were no partial system shutdowns where one unit shutdown leaving the others still sequenced up.

When the ISL70321SEH is in the ready state (sequenced down) waiting for a high on the UP input signal there is a small chance of a high going SET on any of the output signals (EN1-4, DONE) that wait in a low condition. Such events were only recorded for LET = 86MeV•cm^2/mg with normal incidence Au and a V_{DD} bias of 3V. The SET took two forms; a spike less than 1µs in duration, and rare events (resulting in a very small cross-section of 2.75x10^{7}cm^2) persisting for one TDLY period, as in Figure 8 on page 12. The events were measured on EN1, but any ENx open-drain output would be susceptible. These SET disappeared at LET = 69MeV•cm^2/mg for normal incidence Ho.

3. Revision History

Rev.	Date	Description
0.00	Aug 23, 2017	Initial release

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