

## ISL75054SLH

Single Event Effects (SEE) Testing of the ISL75054SLH Ultra Low Noise LDO

### Introduction

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), Single Event Gate Rupture (SEGR), and Single Event Burnout (SEB). SEE can lead to system-level performance issues including disruption, degradation, and destruction. For predictable and reliable space system operation, individual electronic components should be characterized to determine their SEE response. This report discusses the results of the SEE testing performed on the ISL75054SLH product. The ISL75054SLH is offered with radiation assurance screening to 75krad(Si) at 10mrads(Si)/s.

### SEE Summary

SEE testing was performed with normal incidence gold for an LET of  $86.3\text{MeV}\cdot\text{cm}^2/\text{mg}$  at the surface of the device. The LET in the active silicon layer ranged from  $88.7\text{MeV}\cdot\text{cm}^2/\text{mg}$  to  $90.9\text{MeV}\cdot\text{cm}^2/\text{mg}$ . The range to Bragg peak was  $51\mu\text{m}$ .

Additional testing was performed with normal incidence silver for an LET of  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$  at the surface of the device. The LET in the active silicon layer ranged from  $48.1\text{MeV}\cdot\text{cm}^2/\text{mg}$  to  $50.5\text{MeV}\cdot\text{cm}^2/\text{mg}$ . The range to Bragg peak was  $67.6\mu\text{m}$ .

The ISL75054SLH proved to be free of Destructive Single Event Effects (DSEE) under the following maximal parameter set at a die temperature of  $125^\circ\text{C}$ :  $V_{\text{IN}} = 27\text{V}$ ,  $V_{\text{PG}} = 27\text{V}$ , and  $I_{\text{OUT}} = 1.1\text{A}$  at  $86.3\text{MeV}\cdot\text{cm}^2/\text{mg}$  and  $V_{\text{IN}} = 32\text{V}$ ,  $V_{\text{PG}} = 32\text{V}$ , and  $I_{\text{OUT}} = 1.1\text{A}$  at  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$ .

The LDO did not exhibit any  $V_{\text{OUT}}$  SET events during which  $V_{\text{OUT}}$  deviated beyond  $\pm 2\%$  of its operating value.

A device was considered to have exhibited a PG SET when PG pulled low but the device did not enter fast-start and there was no hold time on PG. The device exhibited PG SETs with an average cross-section of  $927.5\mu\text{m}^2$  at  $86.3\text{MeV}\cdot\text{cm}^2/\text{mg}$ . PG, which operates at 5V, was less than 4.5V for at most  $8.4\mu\text{s}$  during an event. The device did not exhibit PG SETs at  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$ .

A SEFI was defined as an event in which PG pulled low and there was a loss of regulation in  $V_{\text{OUT}}$ . The ISL75054SLH did not exhibit SEFIs.

The results of this report apply to both the ISL75054SLHMF (ceramic) and the ISL75054SLHMOVZ (plastic) as the parts were unpackaged for testing such that the bare silicon was exposed to the heavy ion beam.

### Product Description

The ISL75054SLH is a radiation-hardened low dropout linear regulator with ultra-low noise, and high PSRR intended for ADC, RF, and other noise sensitive applications. The device has an operating supply voltage range of 2.7V to 30V and an output voltage range of 0.5V to  $V_{\text{IN}} - V_{\text{DO}}$ . The device supplies up to 1.0A of current at a typical 379mV dropout voltage. Built-in protection includes foldback, internal and externally programmable current limit, and over temperature protection. The ISL75054SLH features excellent noise performance and PSRR for radiation-hardened LDOs, with ultra-low RMS noise of  $4\mu\text{VRMS}$  from 10Hz to 100kHz and ultrahigh PSRR of 101.5dB at 120Hz.

The ISL75054SLHMF is offered in a 10 Ld CDFP, and the ISL75054SLHMOVZ is offered in a 16 LD HTSSOP. Both versions operate across the full-range military temperature of  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ .

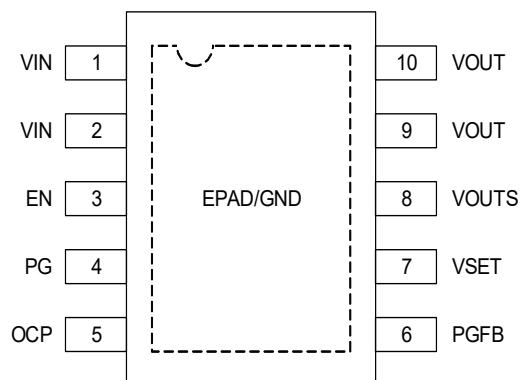


Figure 1. ISL75054SLHMF Pin Assignments

Table 1. ISL75054SLHMF Pin Descriptions

| Pin Number | Pin Name | Description                                                                                                                                                                                                                                                                                                                                                                 |
|------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 2       | VIN      | Input supply pins. $V_{IN}$ range is from 2.7V to 30V. This pin requires sufficient input capacitance from $V_{IN}$ to GND, 30 $\mu$ F is recommended and should be placed close to the device pins.                                                                                                                                                                        |
| 3          | EN       | Enable pin. When set above 1.14V nominally, the device is enabled.                                                                                                                                                                                                                                                                                                          |
| 4          | PG       | Power-Good output. This output is open-drain logic, connect a pull-up resistor to a logic supply or $V_{IN}$ . For SEE mitigation, connect a 150pF capacitor from PG to GND.<br>PG stays low and fast start-up functionality is disabled by connecting PGFB to $V_{IN}$ .                                                                                                   |
| 5          | OCP      | Overcurrent protection. OCP allows the current limit to be programmed with an external resistor, $R_{OCP}$ , between a typical range of 0.2A to 1.4A. Connect OCP directly to GND to set the maximum current limit. <i>Note:</i> The OCP pin sources a 530:1 ratio of the current out of $V_{OUT}$ .                                                                        |
| 6          | PGFB     | Power-good feedback. To enable fast start-up functionality and power-good detection, connect an external resistor divider from $V_{OUT}$ so that 665mV is provided to PGFB at the nominal output voltage.<br>For SEE mitigation, connect a 470pF capacitor from $V_{OUT}$ to PGFB.<br>Connect PGFB to $V_{IN}$ to disable fast start-up and PG functions when not required. |
| 7          | VSET     | Voltage set. $V_{SET}$ sources a precision 100 $\mu$ A current that flows through the external $R_{SET}$ resistor to GND. $V_{SET}$ sets the soft-start output voltage ramp rate through an external capacitor, $C_{SET}$ , to GND. $C_{SET}$ also provides filtering to internal device noise. Renesas recommends selecting $C_{SET}$ between 0.47 $\mu$ F and 10 $\mu$ F. |
| 8          | VOUTS    | Output voltage sense. $V_{OUTS}$ is the non-inverting input to the error amplifier. Connect $V_{OUTS}$ directly to the output capacitor.                                                                                                                                                                                                                                    |
| 9, 10      | VOUT     | Output voltage pins. A capacitance is required from $V_{OUT}$ to GND, 30 $\mu$ F is recommended. $V_{OUT}$ is set through a resistor from the $V_{SET}$ pin to GND and can range from 0.5V to $V_{IN} - V_{DO}$ .                                                                                                                                                           |
| -          | EPAD     | Ground. The EPAD is the electrical connection to GND and is additionally used as a heatsink.                                                                                                                                                                                                                                                                                |

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# 1. SEE Testing

## 1.1 Objective

The testing was planned to find the limit of the input voltage set by the onset of DSEE at a LET of  $86.3\text{MeV}\cdot\text{cm}^2/\text{mg}$  (normal incidence gold) and  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$  (normal incidence silver). Additional testing was planned to identify and quantify SETs and SEFIs occurring in the output voltage or on the PG pin of the ISL75054SLH. The SET studies included irradiation with normal incidence gold ( $86.3\text{MeV}\cdot\text{cm}^2/\text{mg}$ ). Testing was also performed at an LET of  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$  (normal incidence silver) to determine the PG SET onset LET.

## 1.2 Facility

SEE testing was done at the Texas A&M University (TAMU) Radiation Effects Facility of the Cyclotron Institute in College Station, Texas. This facility is coupled with a K500 superconducting cyclotron that can supply a wide range of ion species and flux. The SEE testing in this report was performed on October 17, 2024.

# 2. Results

## 2.1 DSEE Results

DSEE testing was performed to determine the maximum input supply voltage ( $V_{\text{IN}}$ ) free from DSEEs at a die temperature of  $125^{\circ}\text{C}$ . The test board was laid out such that two parts could be irradiated simultaneously. During each run, the devices were exposed to heavy ions to a fluence of  $1\text{E}7\text{ions}/\text{cm}^2$ . Testing was conducted in two sections, one with EN high and one with EN grounded.

For DSEE testing with EN high,  $I_{\text{OUT}}$  was set to 1.1A.  $V_{\text{IN}}$  was initially set to 26V and  $V_{\text{OUT}}$  was initially set to 25V. The values of  $V_{\text{IN}}$  and  $V_{\text{OUT}}$  were simultaneously increased by 1V following each run until a DSEE was observed or  $V_{\text{IN}}$  reached 32V and  $V_{\text{OUT}}$  reached 31V. [Figure 2](#) shows the test schematic used for DSEE testing. To increase  $V_{\text{IN}}$  and  $V_{\text{OUT}}$  without making a board modification between runs  $V_{\text{OUT}}$  was set using an external power supply connected to  $V_{\text{SET}}$ . Due to this, PG and fast-start functionalities were disabled, however their circuit blocks were still on and had the opportunities to exhibit DSEE. A device was considered to have exhibited a DSEE if the output voltage at no load deviated by  $\pm 1\%$ , the current on  $V_{\text{IN}}$  or PG at no load deviated by  $\pm 5\%$ , or there was a loss of functionality.

DSEE testing was also performed with EN grounded to apply the maximum stress to the pass transistor as blocking mode is the worst-case condition for testing MOSFETs. For this testing,  $V_{\text{OUT}}$  was tied to ground and there was no load. The voltage on  $V_{\text{IN}}$  was increased by 1V following each run until a DSEE was observed or  $V_{\text{IN}}$  reached 32V. A device was considered to have exhibited a DSEE if the current on  $V_{\text{IN}}$  deviated by  $\pm 10\%$ .

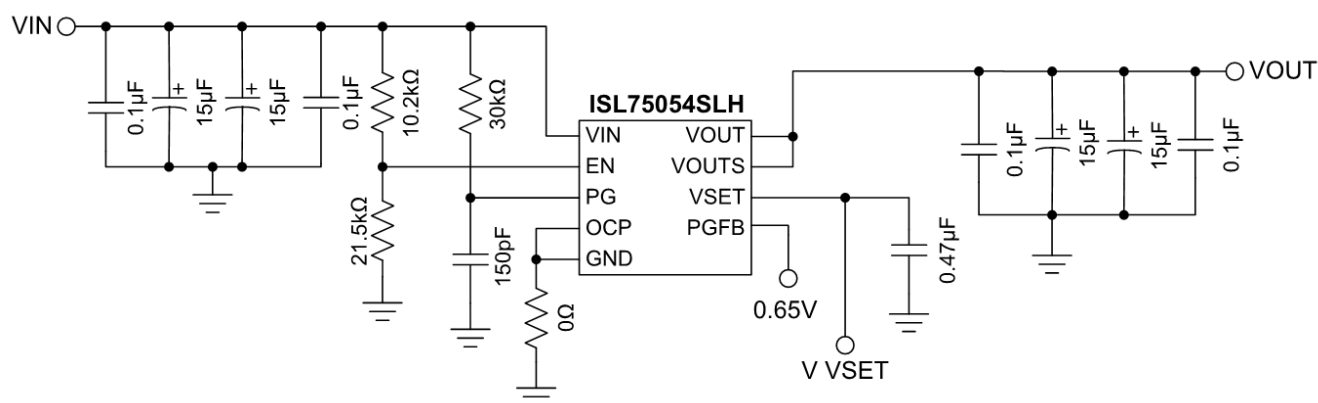


Figure 2. ISL75054SLH DSEE Test Schematic

### 2.1.1 LET = 86.3MeV·cm<sup>2</sup>/mg

Table 2 shows the results of DSEE testing with EN high at 86.3MeV·cm<sup>2</sup>/mg. Two of the four devices exhibited DSEEs when operated with  $V_{IN} = 28V$ . Those devices no longer regulated while under a load. DSEE testing indicates that the device should be operated with the following maximum parameter set to be robust against DSEE:  $V_{IN} = 27V$ ,  $V_{PG} = 27V$ , and  $I_{OUT} = 1.1A$  at 125°C.

Table 2. ISL75054SLH DSEE with EN High Test Results at 86.3MeV·cm<sup>2</sup>/mg

| $V_{IN} / V_{PG}$ (V) | $V_{OUT}$ (V) | $I_{OUT}$ (A) | DUT # | Result | Notes                        | $V_{OUT} (\pm 1\%)$ |          |              | $I_{VIN} \text{ at } I_{OUT} = 0A (\pm 5\%)$ |           |              | $I_{PG} (\pm 5\%)$ |           |              |
|-----------------------|---------------|---------------|-------|--------|------------------------------|---------------------|----------|--------------|----------------------------------------------|-----------|--------------|--------------------|-----------|--------------|
|                       |               |               |       |        |                              | Pre (V)             | Post (V) | $\Delta$ (%) | Pre (mA)                                     | Post (mA) | $\Delta$ (%) | Pre (mA)           | Post (mA) | $\Delta$ (%) |
| 26                    | 25            | 1.1           | 1     | Pass   | -                            | 24.98               | 24.99    | 0.02         | 2.16                                         | 2.16      | 0.00         | 0.133              | 0.133     | 0.00         |
|                       |               |               | 2     | Pass   | -                            | 24.98               | 24.98    | 0.02         | 2.17                                         | 2.17      | 0.00         | 0.136              | 0.136     | 0.00         |
|                       |               |               | 3     | Pass   | -                            | 24.98               | 24.98    | 0.00         | 2.14                                         | 2.14      | 0.00         | 0.137              | 0.137     | 0.00         |
|                       |               |               | 4     | Pass   | -                            | 24.98               | 24.98    | 0.02         | 2.16                                         | 2.15      | -0.46        | 0.137              | 0.137     | 0.00         |
| 27                    | 26            | 1.1           | 1     | Pass   | -                            | 25.99               | 25.98    | 0.00         | 2.34                                         | 2.32      | -0.85        | 0.165              | 0.165     | 0.00         |
|                       |               |               | 2     | Pass   | -                            | 25.98               | 25.98    | 0.00         | 2.21                                         | 2.19      | -0.90        | 0.168              | 0.169     | 0.60         |
|                       |               |               | 3     | Pass   | -                            | 25.98               | 25.98    | 0.00         | 2.16                                         | 2.16      | 0.00         | 0.169              | 0.170     | 0.59         |
|                       |               |               | 4     | Pass   | -                            | 25.98               | 25.98    | 0.00         | 2.19                                         | 2.19      | 0.00         | 0.169              | 0.169     | 0.00         |
| 28                    | 27            | 1.1           | 1     | Fail   | Does not regulate under load | 26.98               | 26.98    | 0.00         | 2.84                                         | 2.95      | 3.91         | 0.198              | 0.197     | -0.5         |
|                       |               |               | 2     | Fail   | Does not regulate under load | 26.98               | 26.98    | 0.00         | 2.24                                         | 2.20      | -1.79        | 0.201              | 0.201     | 0.00         |
|                       |               |               | 3     | Pass   | -                            | 26.98               | 26.98    | 0.00         | 2.18                                         | 2.19      | 0.46         | 0.202              | 0.202     | 0.00         |
|                       |               |               | 4     | Pass   | -                            | 26.98               | 26.98    | 0.00         | 2.21                                         | 2.22      | 0.45         | 0.202              | 0.202     | 0.00         |

Table 3 displays the results of DSEE testing with EN grounded for the ISL75054SLH. All four devices exhibited DSEEs when operated with  $V_{IN} = 28V$ . The devices had large increases in supply current. DSEE testing indicates that the device should be operated with the following maximum parameter set to be robust against DSEE:  $V_{IN} = 27V$  with  $EN = 0V$  at  $125^{\circ}C$ .

**Table 3. ISL75054SLH DSEE with EN=0V Test Results at  $86.3MeV \cdot cm^2/mg$**

| $V_{IN}$ (V) | $V_{OUT}$ (V) | DUT # | Result | $I_{VIN}$ ( $\pm 10\%$ ) |                  |              |
|--------------|---------------|-------|--------|--------------------------|------------------|--------------|
|              |               |       |        | Pre ( $\mu A$ )          | Post ( $\mu A$ ) | $\Delta$ (%) |
| 25           | Tied to GND   | 5     | Pass   | 163                      | 165              | 1.23         |
|              |               | 6     | Pass   | 171                      | 173              | 1.17         |
|              |               | 7     | Pass   | 243                      | 247              | 1.65         |
|              |               | 8     | Pass   | 401                      | 398              | -0.75        |
| 27           | Tied to GND   | 5     | Pass   | 169                      | 165              | -2.34        |
|              |               | 6     | Pass   | 176                      | 166              | -5.68        |
|              |               | 7     | Pass   | 246                      | 249              | 1.22         |
|              |               | 8     | Pass   | 403                      | 403              | 0.00         |
| 28           | Tied to GND   | 5     | Fail   | 168                      | 15,000           | 8,828.57     |
|              |               | 6     | Fail   | 171                      | 53,000           | 30,894.15    |
|              |               | 7     | Fail   | 252                      | 28,000           | 11,011.11    |
|              |               | 8     | Fail   | 406                      | 13,800           | 3,299.01     |

DSEE testing indicates that the ISL75054SLH should be operated with a maximum of  $V_{IN} = 27V$ ,  $V_{PG} = 27V$ , and  $I_{OUT} = 1.1A$  at  $125^{\circ}C$  regardless of whether EN is high or low at  $86.3MeV \cdot cm^2/mg$ .

## 2.1.2 LET = $45.8MeV \cdot cm^2/mg$

Table 4 displays the results of DSEE testing with EN high at  $45.8MeV \cdot cm^2/mg$ . All four devices passed when operated with  $V_{IN} = 32V$ . DSEE testing indicates that the device should be operated with the following maximum parameter set to be robust against DSEE:  $V_{IN} = 32V$ ,  $V_{PG} = 32V$ , and  $I_{OUT} = 1.1A$  at  $125^{\circ}C$ .

**Table 4. ISL75054SLH DSEE with EN High Test Results at  $86.3MeV \cdot cm^2/mg$**

| $V_{IN} / V_{PG}$ (V) | $V_{OUT}$ (V) | $I_{OUT}$ (A) | DUT # | Result | $V_{OUT}$ ( $\pm 1\%$ ) |          |              | $I_{VIN}$ at $I_{OUT} = 0A$ ( $\pm 5\%$ ) |           |              | $I_{PG}$ ( $\pm 5\%$ ) |           |              |
|-----------------------|---------------|---------------|-------|--------|-------------------------|----------|--------------|-------------------------------------------|-----------|--------------|------------------------|-----------|--------------|
|                       |               |               |       |        | Pre (V)                 | Post (V) | $\Delta$ (%) | Pre (mA)                                  | Post (mA) | $\Delta$ (%) | Pre (mA)               | Post (mA) | $\Delta$ (%) |
| 28                    | 27            | 1.1           | 17    | Pass   | 26.98                   | 26.98    | 0.00         | 3.50                                      | 3.40      | -2.86        | 0.203                  | 0.203     | 0.00         |
|                       |               |               | 18    | Pass   | 26.99                   | 26.98    | 0.00         | 3.20                                      | 3.20      | 0.00         | 0.202                  | 0.202     | 0.00         |
| 29                    | 28            | 1.1           | 17    | Pass   | 27.98                   | 27.99    | 0.01         | 3.71                                      | 3.69      | -0.54        | 0.235                  | 0.235     | 0.00         |
|                       |               |               | 18    | Pass   | 27.98                   | 27.99    | 0.01         | 3.63                                      | 3.59      | -1.10        | 0.235                  | 0.235     | 0.00         |
| 30                    | 29            | 1.1           | 17    | Pass   | 28.99                   | 28.99    | 0.00         | 3.72                                      | 3.73      | 0.27         | 0.267                  | 0.267     | 0.00         |
|                       |               |               | 18    | Pass   | 28.98                   | 28.98    | 0.00         | 3.65                                      | 3.65      | 0.00         | 0.267                  | 0.267     | 0.00         |
| 31                    | 30            | 1.1           | 17    | Pass   | 29.98                   | 29.98    | 0.00         | 3.79                                      | 3.80      | 0.26         | 0.299                  | 0.300     | 0.33         |
|                       |               |               | 18    | Pass   | 29.98                   | 29.98    | 0.00         | 3.72                                      | 3.76      | 1.08         | 0.299                  | 0.301     | 0.67         |
|                       |               |               | 19    | Pass   | 29.98                   | 29.98    | 0.00         | 3.65                                      | 3.65      | 0.00         | 0.298                  | 0.209     | 0.00         |
|                       |               |               | 20    | Pass   | 29.98                   | 29.98    | 0.00         | 3.71                                      | 3.71      | 0.00         | 0.300                  | 0.300     | 0.00         |
| 32                    | 31            | 1.1           | 17    | Pass   | 30.98                   | 30.98    | 0.00         | 3.82                                      | 3.83      | 0.26         | 0.323                  | 0.323     | 0.00         |
|                       |               |               | 18    | Pass   | 30.98                   | 30.93    | -0.17        | 3.78                                      | 3.81      | 0.79         | 0.324                  | 0.324     | 0.00         |
|                       |               |               | 19    | Pass   | 30.98                   | 30.98    | 0.00         | 3.69                                      | 3.72      | 0.81         | 0.343                  | 0.343     | 0.00         |
|                       |               |               | 20    | Pass   | 30.98                   | 30.98    | 0.00         | 3.75                                      | 3.77      | 0.53         | 0.324                  | 0.324     | 0.00         |

Table 5 displays the results of DSEE testing with EN grounded at  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$ . All four devices passed with  $V_{\text{IN}} = 32\text{V}$ . DSEE testing indicates that the device should be operated with the following maximum parameter set to be robust against DSEE:  $V_{\text{IN}} = 32\text{V}$  with  $\text{EN} = 0\text{V}$  at  $125^\circ\text{C}$ .

Table 5. ISL75054SLH DSEE with  $\text{EN}=0\text{V}$  Test Results at  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$

| $V_{\text{IN}}$ (V) | $V_{\text{OUT}}$ (V) | DUT # | Result | $I_{\text{VIN}} (\pm 10\%)$ |                        |              |
|---------------------|----------------------|-------|--------|-----------------------------|------------------------|--------------|
|                     |                      |       |        | Pre ( $\mu\text{A}$ )       | Post ( $\mu\text{A}$ ) | $\Delta$ (%) |
| 31                  | Tied to GND          | 21    | Pass   | 904                         | 911                    | 0.77         |
|                     |                      | 22    | Pass   | 955                         | 957                    | 0.21         |
|                     |                      | 23    | Pass   | 645                         | 642                    | -0.47        |
|                     |                      | 24    | Pass   | 349                         | 351                    | 0.93         |
| 32                  | Tied to GND          | 21    | Pass   | 914                         | 914                    | 0.00         |
|                     |                      | 22    | Pass   | 958                         | 958                    | 0.00         |
|                     |                      | 23    | Pass   | 646                         | 652                    | 0.93         |
|                     |                      | 24    | Pass   | 353                         | 355                    | 0.57         |

DSEE testing indicates that the ISL75054SLH should be operated with a maximum of  $V_{\text{IN}} = 32\text{V}$ ,  $V_{\text{PG}} = 32\text{V}$ , and  $I_{\text{OUT}} = 1.1\text{A}$  at  $125^\circ\text{C}$  regardless of whether EN is high or low at  $45.8\text{MeV}\cdot\text{cm}^2/\text{mg}$ .

## 2.2 SET Results

### 2.2.1 LET = $86.3\text{MeV}\cdot\text{cm}^2/\text{mg}$

Figure 3 shows the test schematic used for SET testing.  $V_{\text{OUT}}$  was set using the  $R_{\text{SET}}$  resistor, and PG and fast-start were enabled. The voltage on PG was pulled up to 5V and PGFB was set using a voltage divider. A 30k $\Omega$  pull-up resistor and 150pF capacitor to ground were applied to PG and a 470pF capacitor was connected from  $V_{\text{OUT}}$  to PGFB for SEE mitigation. The test board was laid out such that two parts could be irradiated simultaneously.

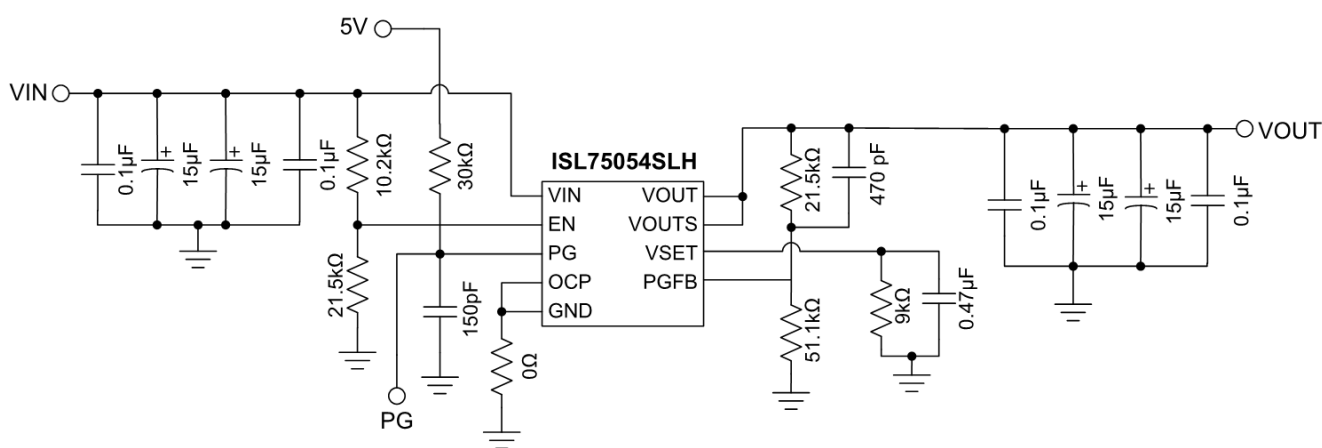


Figure 3. ISL75054SLH SET Test Schematic

For SET testing, devices were tested under three different test conditions as given in Table 6 at an ambient temperature of  $25^\circ\text{C}$ . During each run, the devices were exposed to heavy ions to a fluence of  $1\text{E}7\text{ions}/\text{cm}^2$ . Devices were monitored for  $V_{\text{OUT}}$  SETs, PG SETs, and SEFIs. A device exhibited a  $V_{\text{OUT}}$  SET when  $V_{\text{OUT}}$  deviated beyond  $\pm 2\%$  of its operating value. A device exhibited a PG SET when PG pulled low but the device did not enter fast-start and there was no hold time on PG. The device exhibited a SEFI when PG pulled low and there

was a loss of  $V_{OUT}$  regulation. The device then would spontaneously recover with a normal fast-start.  $V_{OUT}$  SETs were captured with a trigger set to capture events in which  $V_{OUT}$  deviated beyond  $\pm 2\%$  of its operating value. PG SETs and SEFIs were captured with a trigger set to capture events in which PG dropped by 0.5V.

**Table 6. ISL75054SLH SET Test Conditions**

| Test Condition | Number of Devices Tested | $V_{IN}$ (V) | $V_{OUT}$ (V) | $I_{OUT}$ (mA) |
|----------------|--------------------------|--------------|---------------|----------------|
| #1             | 4                        | 2.7          | 0.9           | 1000           |
| #2             | 4                        | 5            | 0.9           | 440            |
| #3             | 4                        | 27           | 0.9           | 69             |

The results of SET testing for the ISL75054SLH are displayed in [Table 7](#).

**Table 7. ISL75054SLH SET Test Results at 86.3MeV·cm<sup>2</sup>/mg**

| Test Condition | $V_{IN}$ (V) | DUT # | Fluence (ions/cm <sup>2</sup> ) | # of $V_{OUT}$ SETs | # of PG SETs | # of SEFIs |
|----------------|--------------|-------|---------------------------------|---------------------|--------------|------------|
| #1             | 2.7          | 9     | 1.0E7                           | 0                   | 0            | 0          |
|                |              | 10    | 1.0E7                           | 0                   | 0            | 0          |
|                |              | 11    | 1.0E7                           | 0                   | 0            | 0          |
|                |              | 12    | 1.0E7                           | 0                   | 0            | 0          |
| #2             | 5            | 9     | 1.0E7                           | 0                   | 93           | 0          |
|                |              | 10    | 1.0E7                           | 0                   | 92           | 0          |
|                |              | 11    | 1.0E7                           | 0                   | 105          | 0          |
|                |              | 12    | 1.0E7                           | 0                   | 81           | 0          |
| #3             | 27           | 9     | 1.0E7                           | 0                   | 0            | 0          |
|                |              | 10    | 1.0E7                           | 0                   | 0            | 0          |
|                |              | 11    | 1.0E7                           | 0                   | 0            | 0          |
|                |              | 12    | 1.0E7                           | 0                   | 1            | 0          |

The results are summarized in [Table 8](#).

**Table 8. ISL75054SLH SET Test Summary at 86.3MeV·cm<sup>2</sup>/mg**

| Test Condition | # of DUTs | Total Fluence (ions/cm <sup>2</sup> ) | # of $V_{OUT}$ SETs | $V_{OUT}$ SET $\sigma$ ( $\mu\text{m}^2$ ) | # of PG SETs | PG SET $\sigma$ ( $\mu\text{m}^2$ ) | # of SEFIs | SEFI $\sigma$ ( $\mu\text{m}^2$ ) |
|----------------|-----------|---------------------------------------|---------------------|--------------------------------------------|--------------|-------------------------------------|------------|-----------------------------------|
| #1             | 4         | 4.0E7                                 | 0                   | 2.5                                        | 0            | 2.5                                 | 0          | 2.5                               |
| #2             | 4         | 4.0E7                                 | 0                   | 2.5                                        | 371          | 927.5                               | 0          | 2.5                               |
| #3             | 4         | 4.0E7                                 | 0                   | 2.5                                        | 1            | 2.5                                 | 0          | 2.5                               |

No  $V_{OUT}$  SETs or SEFIs were observed during testing.



Figure 4 shows an example of a typical PG SET capture. During all the PG SETs, PG pulled to GND and then recovered according to the RC time constant.  $V_{OUT}$  was unaffected by the event.

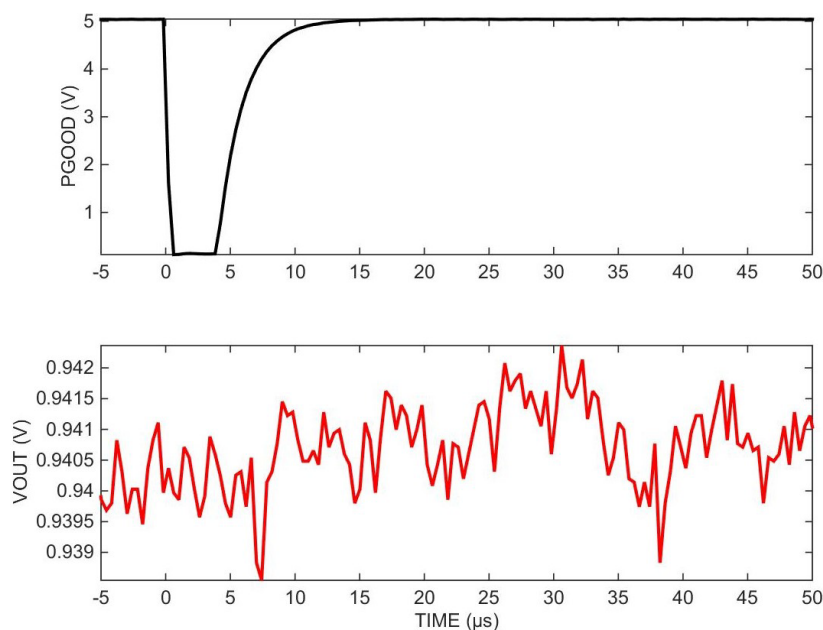


Figure 4. ISL75054SLH Typical PG SET Capture in TC #2

The PG SET recovery times, which were defined as the duration PG is less than 4.5V, for each event in TC #2 are displayed in Figure 5. The longest recovery time in TC #2 was 8.4μs.

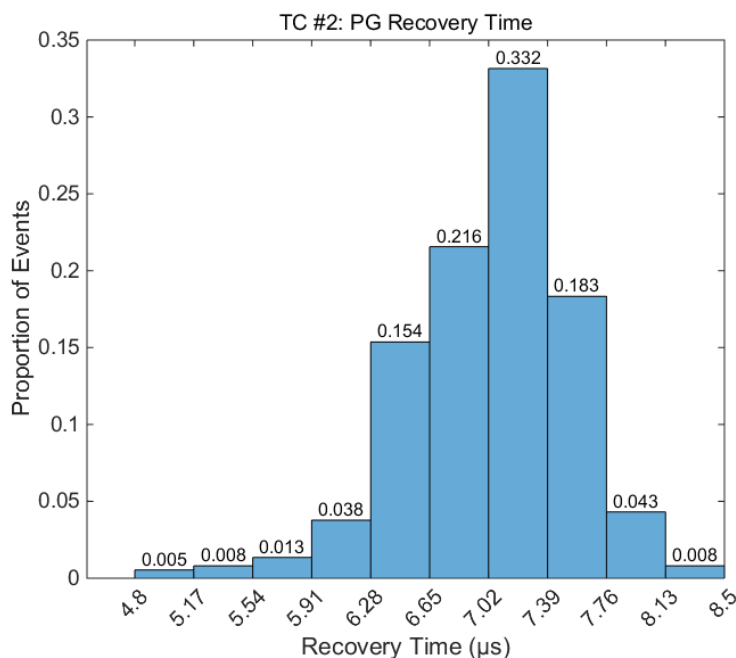


Figure 5. ISL75054SLH TC #2 PG SET Recovery Time

There was only one PG SET in TC #3. That event had a recovery time of 5.2μs.

### 2.2.2 LET = 45.8MeV·cm<sup>2</sup>/mg

Additional SET testing was performed under the same three test conditions at an ambient temperature of 25°C and an LET of 45.8MeV·cm<sup>2</sup>/mg to determine the PG SET onset LET. The results for the LET = 45.8MeV·cm<sup>2</sup>/mg testing are displayed in [Table 9](#).

**Table 9. ISL75054SLH SET Test Results at 45.8MeV·cm<sup>2</sup>/mg**

| Test Condition | V <sub>IN</sub> (V) | DUT # | Fluence (ions/cm <sup>2</sup> ) | # of VOUT SETs | # of PG SETs | # of SEFIs |
|----------------|---------------------|-------|---------------------------------|----------------|--------------|------------|
| #1             | 2.7                 | 13    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 14    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 15    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 16    | 1.0E7                           | 0              | 0            | 0          |
| #2             | 5                   | 13    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 14    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 15    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 16    | 1.0E7                           | 0              | 0            | 0          |
| #3             | 27                  | 13    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 14    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 15    | 1.0E7                           | 0              | 0            | 0          |
|                |                     | 16    | 1.0E7                           | 0              | 0            | 0          |

The results are summarized in [Table 10](#).

**Table 10. ISL75054SLH SET Test Summary at 45.8MeV·cm<sup>2</sup>/mg**

| Test Condition | # of DUTs | Total Fluence (ions/cm <sup>2</sup> ) | # of VOUT SETs | VOUT SET $\sigma$ ( $\mu$ m <sup>2</sup> ) | # of PG SETs | PG SET $\sigma$ ( $\mu$ m <sup>2</sup> ) | # of SEFIs | SEFI $\sigma$ ( $\mu$ m <sup>2</sup> ) |
|----------------|-----------|---------------------------------------|----------------|--------------------------------------------|--------------|------------------------------------------|------------|----------------------------------------|
| #1             | 4         | 4.0E7                                 | 0              | 2.5                                        | 0            | 2.5                                      | 0          | 2.5                                    |
| #2             | 4         | 4.0E7                                 | 0              | 2.5                                        | 0            | 2.5                                      | 0          | 2.5                                    |
| #3             | 4         | 4.0E7                                 | 0              | 2.5                                        | 0            | 2.5                                      | 0          | 2.5                                    |

Testing indicates that the onset LET for PG SETs is at least 45.8MeV·cm<sup>2</sup>/mg. Overall, given the short duration of the events and the high onset LET, these PG SETs pose little risk to a system.

## 3. Discussion and Conclusion

SEE testing was performed with normal incidence gold for an LET of 86.3MeV·cm<sup>2</sup>/mg and normal incidence silver for an of 45.8MeV·cm<sup>2</sup>/mg.

Testing indicated that the maximal parameter set to be robust against DSEE is: V<sub>IN</sub> = 27V, V<sub>PG</sub> = 27V and I<sub>OUT</sub> = 1.1A at 86.3MeV·cm<sup>2</sup>/mg and V<sub>IN</sub> = 32V, V<sub>PG</sub> = 32V and I<sub>OUT</sub> = 1.1A at 45.8MeV·cm<sup>2</sup>/mg.

No V<sub>OUT</sub> SETs or SEFIs were observed during testing.

PG SETs were observed when testing at 86.3MeV·cm<sup>2</sup>/mg. The average cross-section for PG SETs was 927.5 $\mu$ m<sup>2</sup>, and the longest duration event was 8.4 $\mu$ s. It was determined that onset LET for PG SETs was at least 45.8MeV·cm<sup>2</sup>/mg. A worst-case error rate calculation using CREME96 for GEO during solar minimum and using 100mils of aluminum shielding can be performed using a step-function with a saturation value of 927.5 $\mu$ m<sup>2</sup> and a onset LET of 45.8MeV·cm<sup>2</sup>/mg. This gives an error rate of one PG SET every 2,488 years. Given the short duration of the events and the rarity of the events occurring, PG SETs pose little risk to a system.

## 4. Revision History

| Revision | Date         | Description      |
|----------|--------------|------------------|
| 1.00     | Jul 23, 2025 | Initial release. |

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