

## Introduction

The intense heavy ion environment encountered in space applications can cause transient and destructive effects in analog circuits including Single Event Latch-Up (SEL), Single Event Transients (SET), and Single Event Burnout (SEB). Transient and destructive effects can lead to system-level failures including disruption and permanent damage. For a predictable and reliable system operation, system components have to be formally designed and fabricated for SEE hardness and followed by a detailed SEE testing to validate the design. This report discusses the results of SEE testing of the Renesas ISL70218SRH.

## Related Literature

For a full list of related documents, visit our website:

- [ISL70218SRH](#) product page

## Product Description

The ISL70218SRH is a dual, low-power precision amplifier optimized for single-supply applications. The operational amplifier (op amp) features a common-mode input voltage range extending to 0.5V below the V- rail, a rail-to-rail differential input voltage range, and a rail-to-rail output voltage swing. This makes it ideal for single-supply applications where input operation at ground is important.

The ISL70218SRH is implemented in an advanced bonded wafer SOI process using a deep trench isolation that results in a fully isolated structure. The SOI process technology also results in latch-up free performance, whether electrically or Single Event (SEL) caused.

This amplifier operates over a single supply range of 3V to 36V or a split supply voltage range of +1.8V/-1.2V to ±18V. The combination of precision and small footprint provides the user with outstanding value and flexibility relative to similar competitive parts.

Applications for these amplifiers include precision active filters, low noise front ends, loop filters, and data acquisition and charge amplifiers. The part is packaged in a 10 Ld hermetic ceramic flat pack and operates across the extended temperature range of -55 °C to +125 °C. A summary of key full temperature range specifications follows:

- Input Offset Voltage ..... 290µV, max.
- Offset Voltage Drift ..... 1µV/°C, max.
- Input Offset Current ..... 75nA, max.
- Input Bias Current ..... 800nA, max.
- Supply Current/Amplifier ..... 1.4mA, max.
- Gain Bandwidth Product ..... 4MHz, typ.

## SEE Test Objective

The objectives of SEE testing on the ISL70218SRH were to evaluate its susceptibility to SEL and SEB and characterize its SET behavior over various LET levels.

## SEE Test Facility

Testing was performed at the Texas A&M University (TAMU) Cyclotron Institute heavy ion facility. The facility is coupled to a K500 super-conducting cyclotron that is capable of generating a wide range of test particles with the various energy, flux, and fluence levels needed for advanced radiation testing.

## SEE Test Procedure

The part was tested for single event latch-up and burnout using Au ions (LET = 86.4MeV/mg/cm<sup>2</sup>) and single event transient using Ne, Ar, and Kr ions.

The Device Under Test (DUT) was mounted in the beam line and irradiated with heavy ions of the appropriate species. The parts were assembled in 10 lead dual in-line packages with the metal lid removed for beam exposure. The beam was directed onto the exposed die, and the beam flux, beam fluence, and errors in the device outputs were measured.

The tests were controlled remotely from the control room. All input power was supplied from portable power supplies connected using cable to the DUT. The supply currents were monitored along with the device outputs. All currents were measured with digital ammeters, while all the output waveforms were monitored on a digital oscilloscope for ease of identifying the different types of SEE, which the part displayed. Events were captured by triggering on changes in the output.

## SEE Test Set-Up Diagrams

A schematic of the evaluation board is shown in [Figure 1](#).

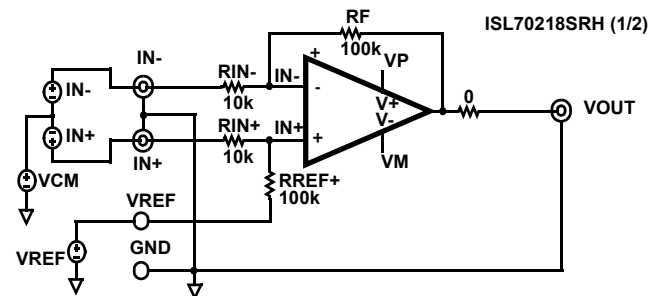


FIGURE 1. SIMPLIFIED SEE SCHEMATIC

Each operational amplifier was set up in a non-inverting operation with  $G = 11V/V$ . The IN- inputs were grounded and the input signal was applied to the IN+ pin.

## Cross-Section Calculation

Cross sections are calculated using [Equation 1](#):

$$CS (LET) = N/F \quad (EQ. 1)$$

where:

- CS is the SET cross section ( $\text{cm}^2$ ) expressed as a function of the heavy ion LET
- LET is the linear energy transfer in  $\text{MeV} \cdot \text{cm}^2/\text{mg}$  corrected according to the incident angle, if any.
- N is the total number of SET events
- F is fluence in particles/ $\text{cm}^2$  corrected according to the incident angle, if any.

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

## Single Event Latch-Up and Burnout Results

The first testing sequence looked at the destructive effects due to burnout or latch-up. A burnout condition is indicated by a permanent change in the device supply current after application of the beam. If the increased current is reset by cycling power, it is termed a latch-up. No burnout or latch-up was observed using Au ions ( $\text{LET} = 86.4 \text{MeV} \cdot \text{cm}^2/\text{mg}$ ) at  $0^\circ$  incidence from the perpendicular. Testing was performed on four parts at  $+125^\circ\text{C}$  (case temperature) and up to the maximum voltage,  $V_S = \pm 18.2\text{V}$ . The first two parts (part ID 1 and 2) commenced testing with  $V_S = \pm 15\text{V}$  and on subsequent tests  $V_S$  voltage was increased to  $\pm 17.5\text{V}$  and then  $\pm 18.2\text{V}$ . All other parts were tested with a  $V_S$  of  $\pm 17.5\text{V}$  and  $\pm 18.2\text{V}$ . All test runs were run to a fluence of  $2 \times 10^6/\text{cm}^2$ . A power supply applied a DC voltage of 200mV to the non-inverting inputs of the amplifiers during the test. Functionality of all outputs was verified after exposure.  $I_{DD}$  and  $I_{EE}$  were recorded pre and post exposure, with 5% resolution. Results are shown in [Table 1](#) for the 36.4V total supply voltage.

## Single Event Transient Testing

### Test Method

Biasing used for SET test runs was  $V_S = \pm 4.5\text{V}$  and  $\pm 18\text{V}$ . Similar to SEL/B testing, a DC voltage of 200mV was applied to the non-inverting inputs of the amplifiers. Signals from the switch board in the control room were connected to two LECROY oscilloscopes: one was set to capture transients due to the output of channel A, and the other was set to capture transients on the output of channel B.

SET events are recorded when movement on output during beam exposure exceeds the set window trigger of  $\pm 80\text{mV}$ . Summary of the scope settings are as follows:

- Scope 1 is set to trigger on Channel 1 to a OUTA window of  $\pm 80\text{mV}$ . Measurements on Scope 1 are:  
CH1 = OUTA 200mV/div, CH2 = OUTA 500mV/div,  
CH3 = OUTB 200mV/div, CH4 = OUT5 500mV/div.
- Scope 2 is set to trigger on Channel 3 to a OUTB window of  $\pm 80\text{mV}$ . Measurements on Scope 2 are:  
CH1 = OUTA 200mV/div, CH2 = OUTA 500mV/div,  
CH3 = OUTB 200mV/div, CH4 = OUT5 500mV/div.

The switch board at the end of the 20-ft cabling was found to require terminations of 10nF to keep the noise on the waveforms to a minimum.

### Cross Section Results

Compared to other Renesas radiation tolerant circuits, the ISL70218SRH was not designed for SET mitigation. The best approach to characterize the single event transient response is to represent the data on an LET threshold plot.

[Figure 2 on page 3](#) shows the cross section of the IC versus the LET level at  $V_S = \pm 4.5\text{V}$  and  $\pm 18\text{V}$ . For an  $\text{LET} < 20 \text{MeV} \cdot \text{cm}^2/\text{mg}$ , the cross section is nearly the same independent of supply voltage. As the linear energy transfer increases, there is noticeable increases in the cross section area with a higher supply voltage. Data from [Figure 2](#) is represented in [Table 2 on page 3](#).

[Figures 3 through 6](#) show the cross section of each channel independently at  $V_S = \pm 4.5\text{V}$  and  $\pm 18\text{V}$  with confidence interval bars for a 90% confidence level.

TABLE 1. ISL70218SRH DETAILS OF SEB/L TESTS FOR  $V_S = \pm 18.2\text{V}$  and  $\text{LET} = 86.4 \text{MeV} \cdot \text{cm}^2/\text{mg}$

TEMP (°C)	LET ( $\text{MeV} \cdot \text{m}^2/\text{mg}$ )	SUPPLY CURRENT PRE- EXPOSURE (mA)	SUPPLY CURRENT POST- EXPOSURE (mA)	LATCH EVENTS	CUMULATIVE FLUENCE (PARTICLES/ $\text{cm}^2$ )	CUMULATIVE CROSS SECTION ( $\text{cm}^2$ )	DEVICE	SEB/L
+125	86	3.8	3.7	0	$2.0 \times 10^6$	$5.0 \times 10^{-7}$	1	PASS
+125	86	3.8	3.8	0	$2.0 \times 10^6$	$5.0 \times 10^{-7}$	2	PASS
+125	86	4.0	3.9	0	$2.0 \times 10^6$	$5.0 \times 10^{-7}$	3	PASS
+125	86	3.8	3.7	0	$2.0 \times 10^6$	$5.0 \times 10^{-7}$	4	PASS
TOTAL EVENTS				0				
OVERALL FLUENCE					$8.0 \times 10^6$			
OVERALL CS						$1.25 \times 10^{-7}$		
TOTAL UNITS							4	

TABLE 2. DETAILS OF THE CROSS SECTION OF THE ISL70218SRH vs LET vs SUPPLY VOLTAGE

SUPPLY VOLTAGE (V)	ION	ANGLE (°)	EFF LET (cm <sup>2</sup> /mg)	FLUENCE PER RUN (PARTICLES/cm <sup>2</sup> )	NUMBER OF RUNS	TOTAL EVENTS	EVENT CS cm <sup>2</sup>
±4.5V	Ne	0	2.7	2.0 x 10 <sup>6</sup>	4	13	1.63 x 10 <sup>-6</sup>
±4.5V	Ar	0	8	2.0 x 10 <sup>6</sup>	3	53	8.83 x 10 <sup>-6</sup>
±4.5V	Ar	60	17	2.0 x 10 <sup>6</sup>	4	391	4.89 x 10 <sup>-5</sup>
±4.5V	Kr	0	28	2.0 x 10 <sup>6</sup>	4	1097	1.37 x 10 <sup>-4</sup>
±4.5V	Kr	60	56	2.0 x 10 <sup>6</sup>	4	1579	1.97 x 10 <sup>-4</sup>
±18V	Ne	0	2.7	2.0 x 10 <sup>6</sup>	4	25	3.13 x 10 <sup>-6</sup>
±18V	Ne	60	5.4	2.0 x 10 <sup>6</sup>	4	148	1.85 x 10 <sup>-6</sup>
±18V	Ar	0	8	2.0 x 10 <sup>6</sup>	4	123	1.54 x 10 <sup>-6</sup>
±18V	Ar	60	17	2.0 x 10 <sup>6</sup>	4	390	4.88 x 10 <sup>-5</sup>
±18V	Kr	0	28	2.0 x 10 <sup>6</sup>	4	1655	2.07 x 10 <sup>-4</sup>
±18V	Kr	60	56	2.0 x 10 <sup>6</sup>	4	3410	4.26 x 10 <sup>-4</sup>

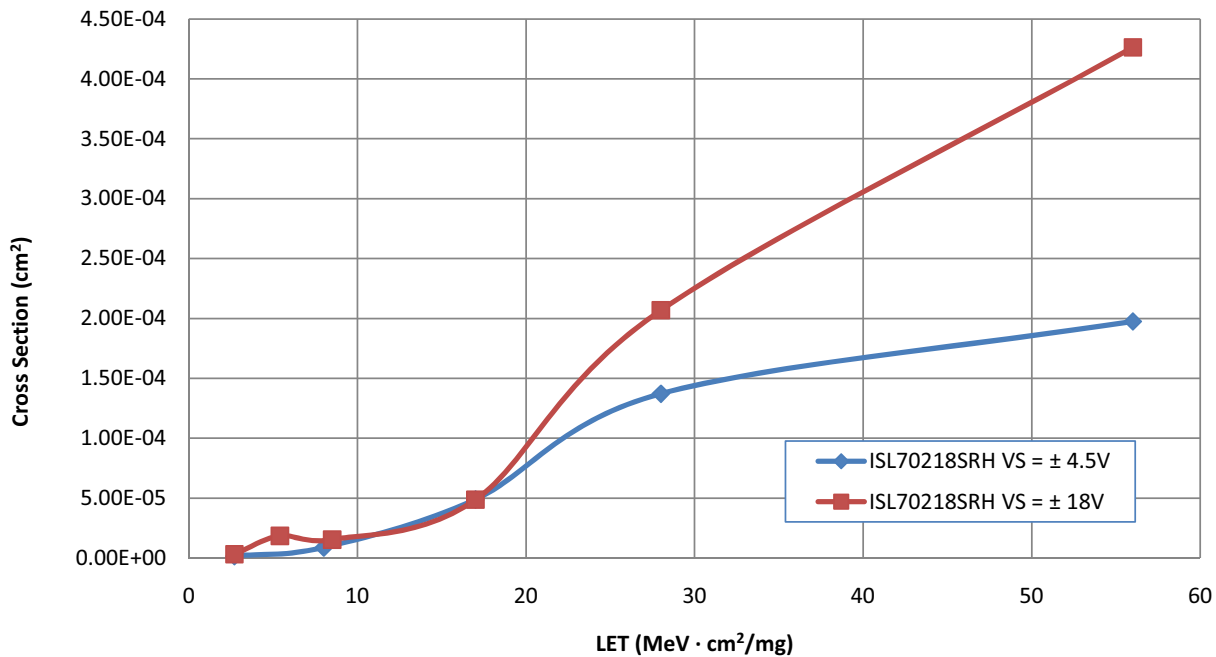


FIGURE 2. CROSS SECTION OF THE ISL70218SRH vs LINEAR ENERGY TRANSFER VS. SUPPLY VOLTAGE

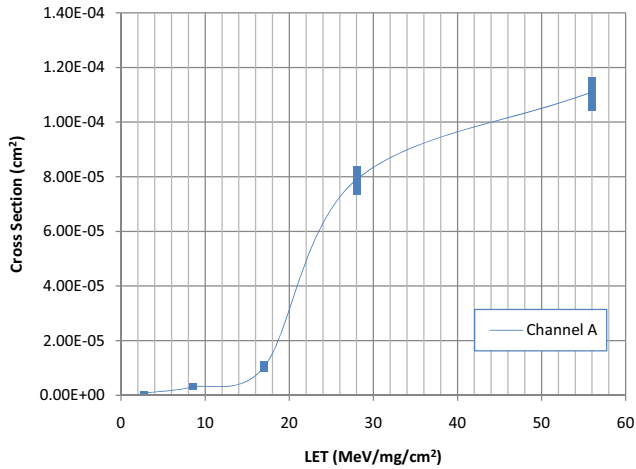


FIGURE 3. CHANNEL A CROSS SECTION VS. LET FOR  $V_S = \pm 4.5V$  WITH 90% CONFIDENCE LEVEL INTERVAL BARS

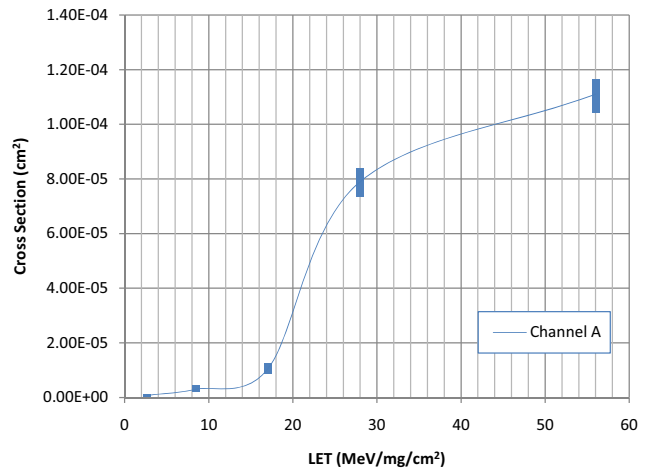


FIGURE 4. CHANNEL B CROSS SECTION VS. LET FOR  $V_S = \pm 4.5V$  WITH 90% CONFIDENCE LEVEL INTERVAL BARS

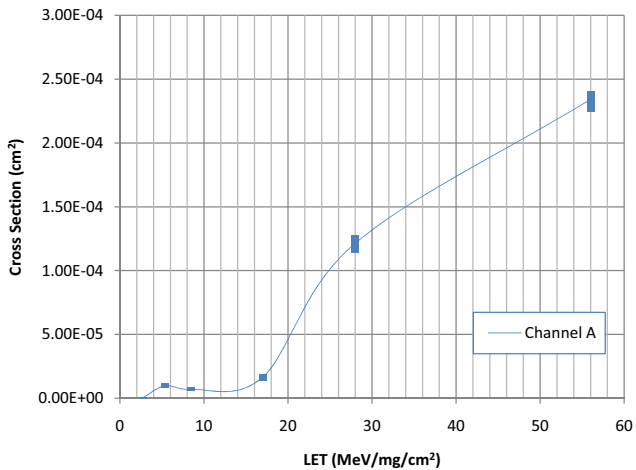


FIGURE 5. CHANNEL A CROSS SECTION VS. LET FOR  $V_S = \pm 18V$  WITH 90% CONFIDENCE LEVEL INTERVAL BARS

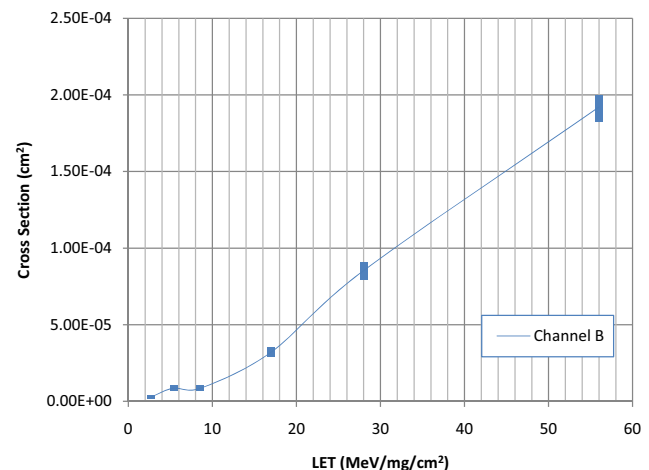
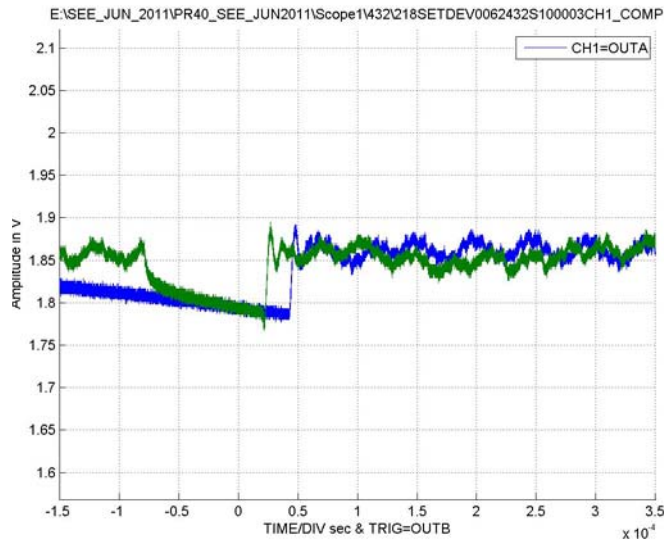


FIGURE 6. CHANNEL B CROSS SECTION VS. LET FOR  $V_S = \pm 18V$  WITH 90% CONFIDENCE LEVEL INTERVAL BARS

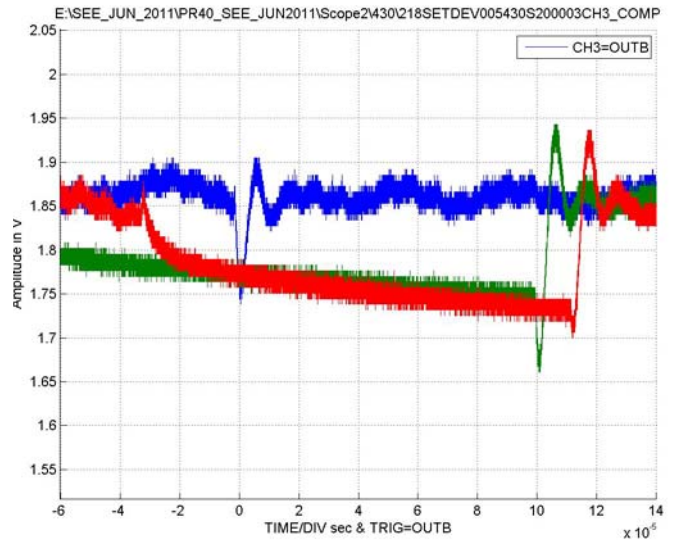
### Transient Response

The ISL70218SRH features rail-to-rail output, so it was expected SETs would cause the output to rail out. Surprisingly, the majority of the transients were less than 10% of output voltage. Duration of the transients range in the 10's of  $\mu s$  to 100's of  $\mu s$ . Figures 7 through 28 represent output waveforms of the amplifiers under test at various bias conditions and LET values. The plots are composites of the first 25 transients captured on the scope. This information is useful in quantifying the excursion of the output as a result of SEE induced transients. The worst voltage transient seen is a 300mV excursion, and the longest SET duration is 1.6ms (see Figure 19 on page 8).

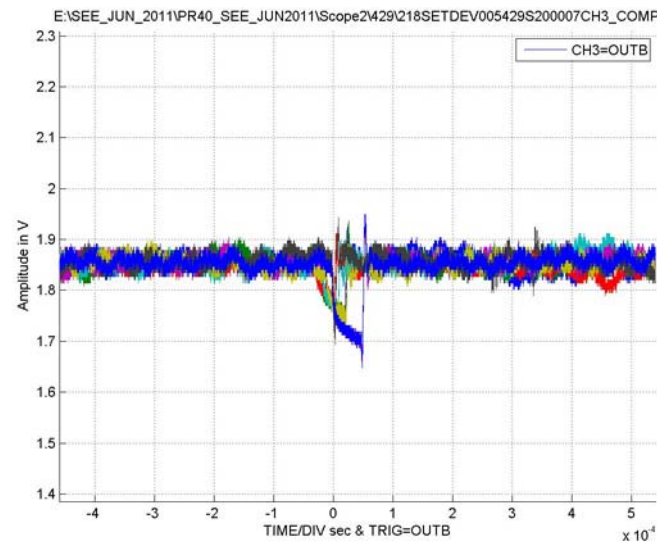
# Typical SET Captures



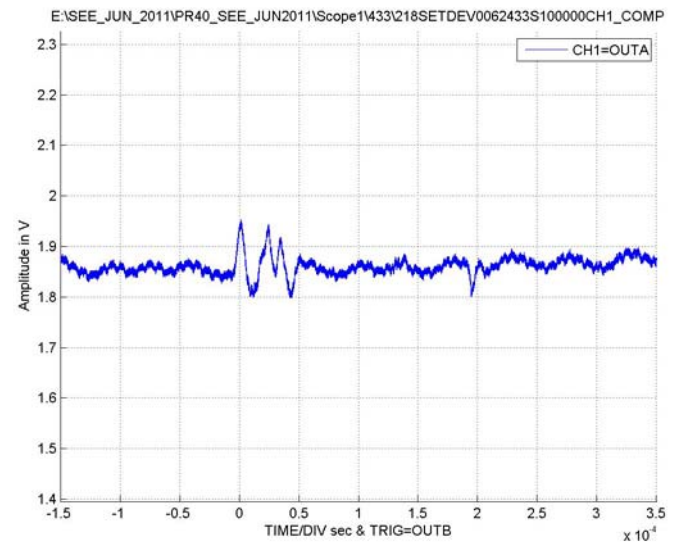
**FIGURE 7. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL A, LET =  $2.7MeV/mg/cm^2$ , RUN 432**



**FIGURE 8. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL B, LET =  $2.7MeV/mg/cm^2$ , RUN 430**

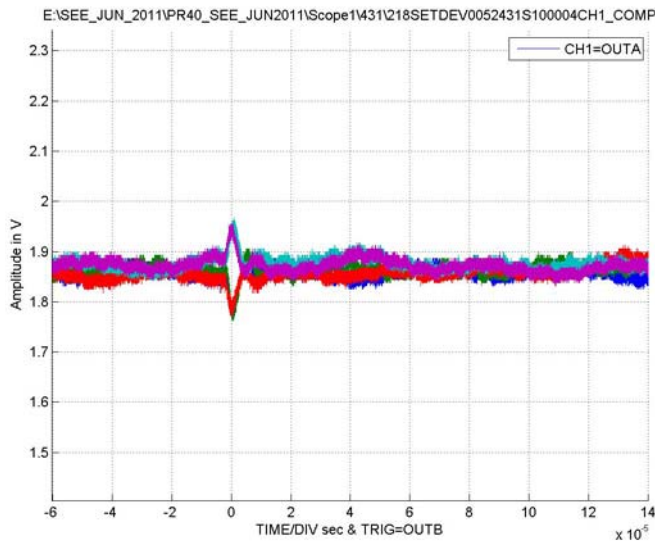


**FIGURE 9. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL B, LET =  $2.7MeV/mg/cm^2$ , RUN 429**

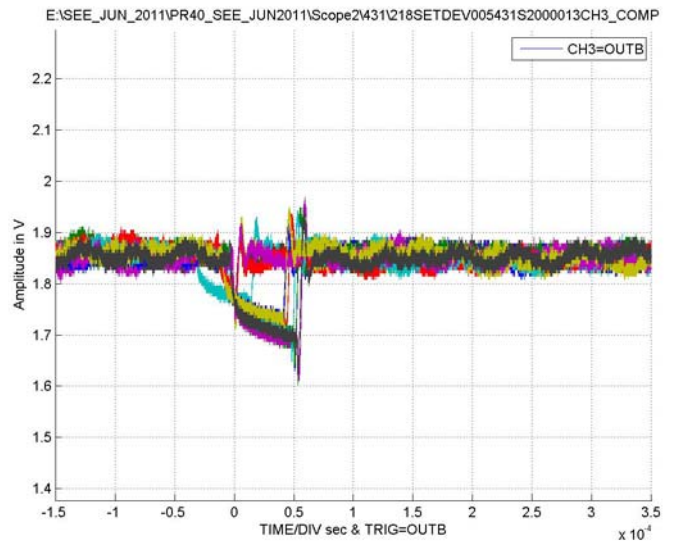


**FIGURE 10. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL A, LET =  $2.7MeV/mg/cm^2$ , RUN 433**

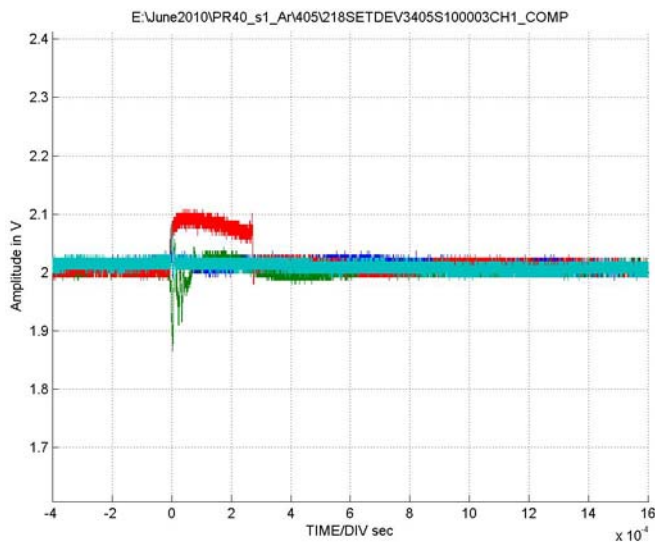
**Typical SET Captures (Continued)**



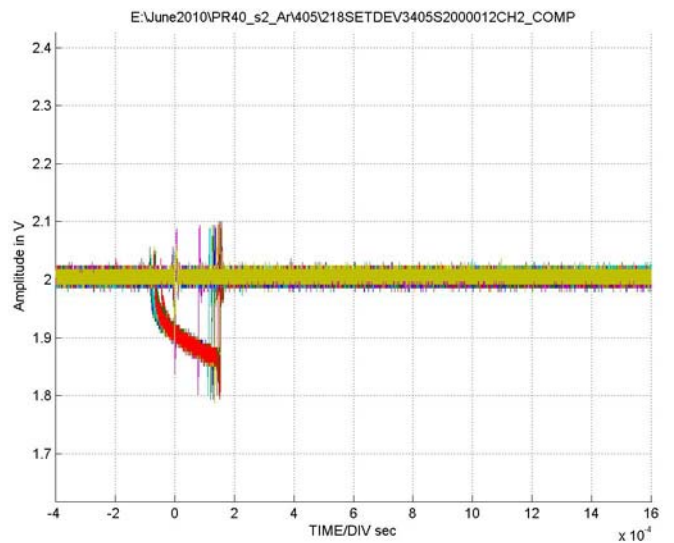
**FIGURE 11. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL A, LET = 5.6MeV/mg/cm<sup>2</sup>, RUN 431**



**FIGURE 12. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL B, LET = 5.6MeV/mg/cm<sup>2</sup>, RUN 432**



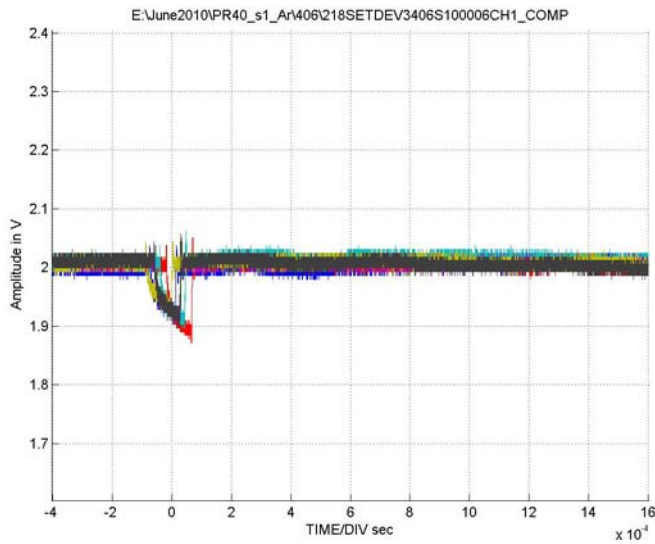
**FIGURE 13. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL A, LET = 8.5MeV/mg/cm<sup>2</sup>, RUN 405**



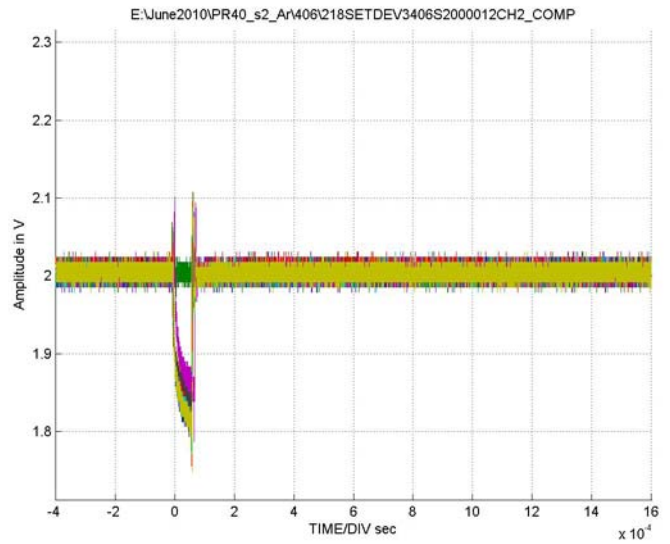
**FIGURE 14. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL B, LET = 8.5MeV/mg/cm<sup>2</sup>, RUN 405**



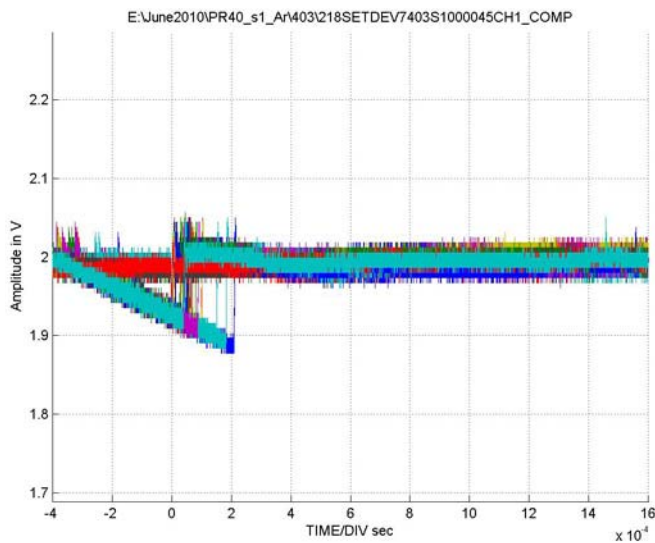
**Typical SET Captures (Continued)**



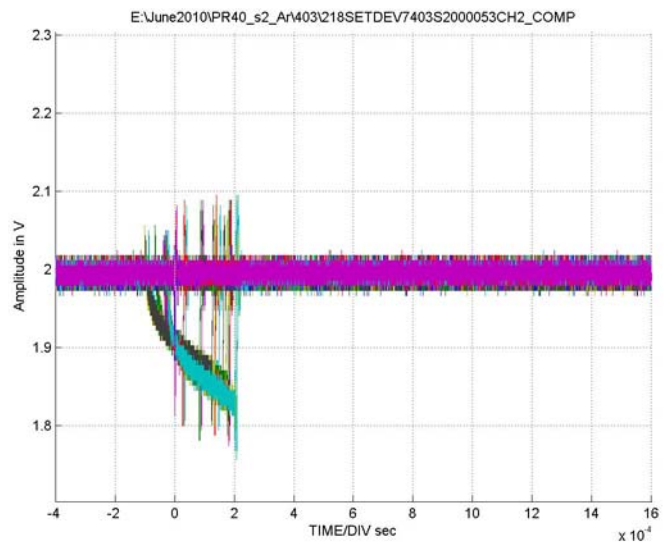
**FIGURE 15. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL A, LET = 8.5MeV/mg/cm<sup>2</sup>, RUN 406**



**FIGURE 16. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL B, LET = 8.5MeV/mg/cm<sup>2</sup>, RUN 406**

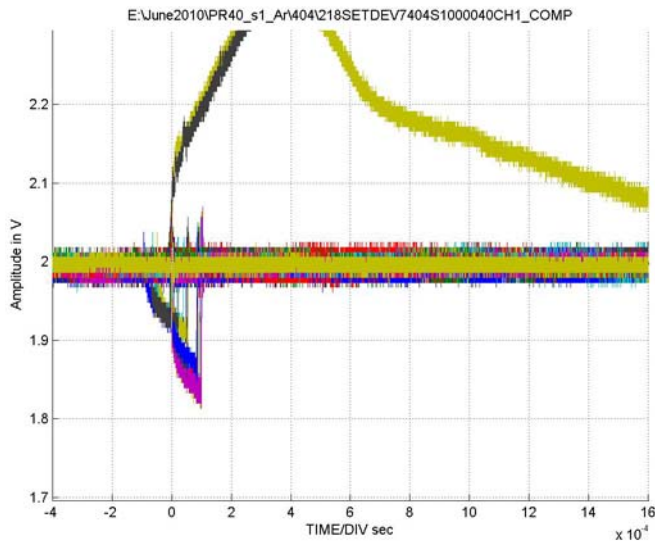


**FIGURE 17. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL A, LET = 17MeV/mg/cm<sup>2</sup>, RUN 403**

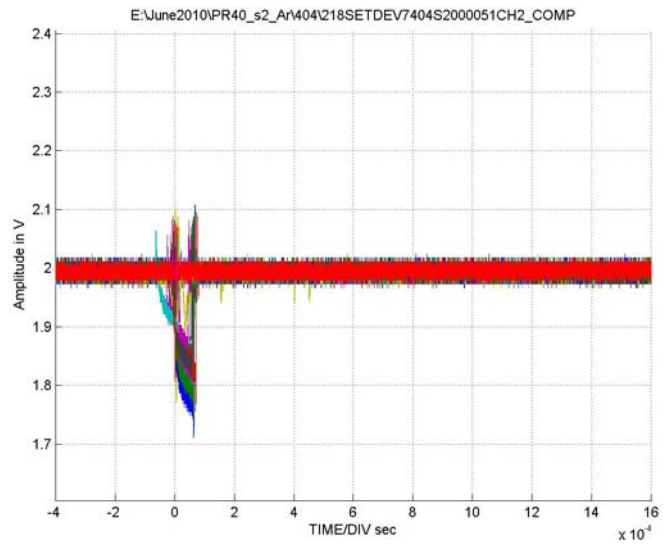


**FIGURE 18. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL B, LET = 17MeV/mg/cm<sup>2</sup>, RUN 403**

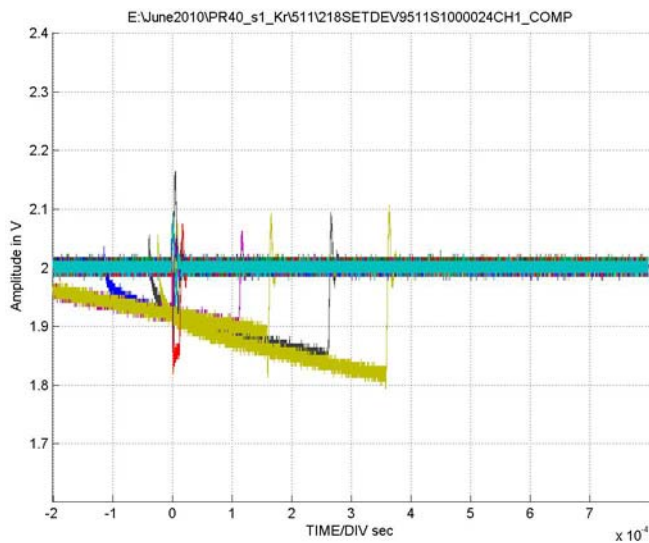
**Typical SET Captures (Continued)**



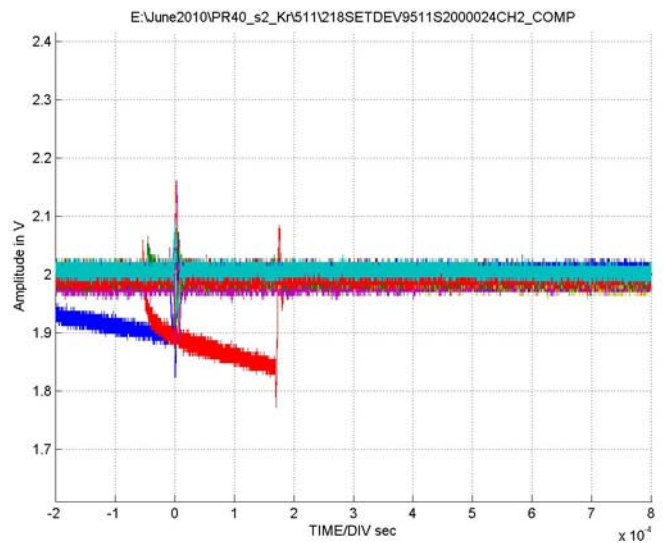
**FIGURE 19. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL A, LET = 17MeV/mg/cm<sup>2</sup>, RUN 404**



**FIGURE 20. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL B, LET = 17MeV/mg/cm<sup>2</sup>, RUN 404**



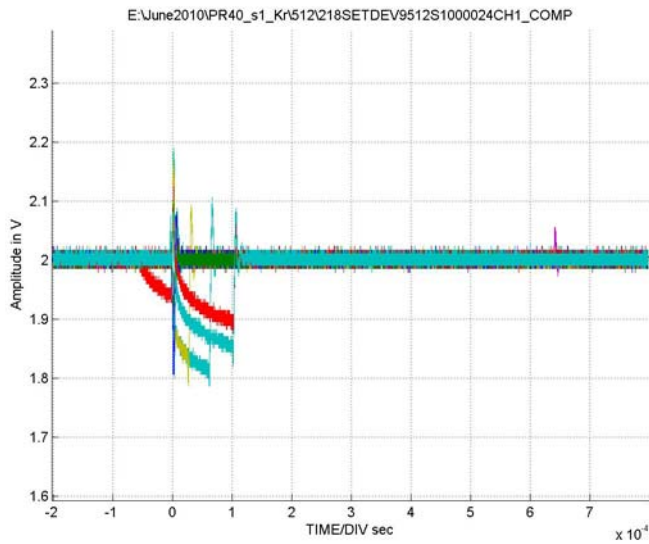
**FIGURE 21. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL A, LET = 28MeV/mg/cm<sup>2</sup>, RUN 511**



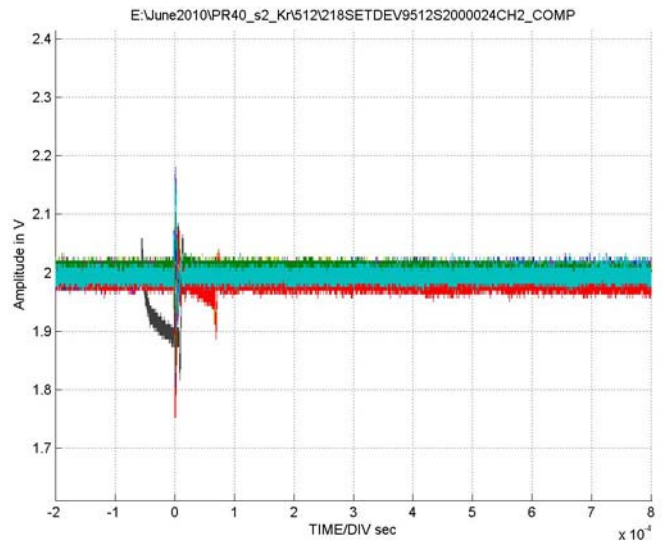
**FIGURE 22. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL B, LET = 28MeV/mg/cm<sup>2</sup>, RUN 511**



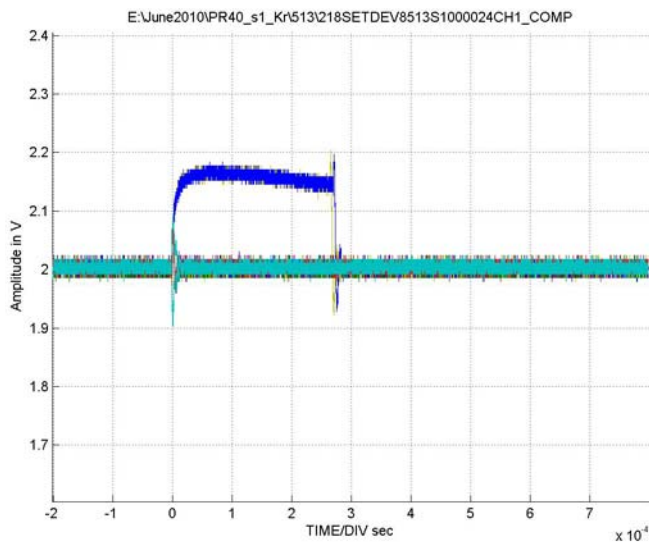
**Typical SET Captures (Continued)**



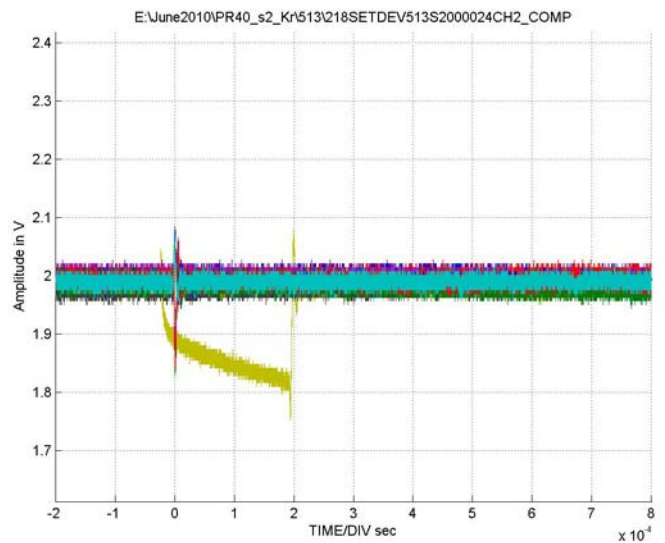
**FIGURE 23. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL A, LET = 28MeV/mg/cm<sup>2</sup>, RUN 512**



**FIGURE 24. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL B, LET = 28MeV/mg/cm<sup>2</sup>, RUN 512**



**FIGURE 25. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL A, LET = 56MeV/mg/cm<sup>2</sup>, RUN 513**



**FIGURE 26. TYPICAL CAPTURE AT  $V_S = \pm 4.5V$ , CHANNEL B, LET = 56MeV/mg/cm<sup>2</sup>, RUN 513**

## Typical SET Captures (Continued)

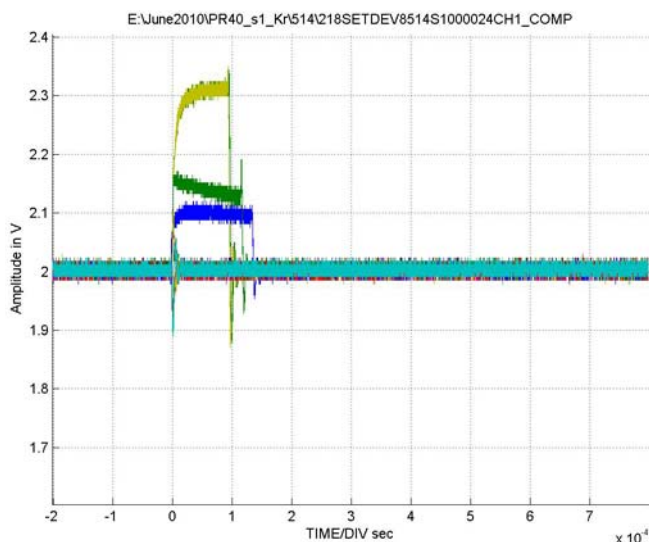


FIGURE 27. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL A, LET = 56MeV/mg/cm<sup>2</sup>, RUN 514

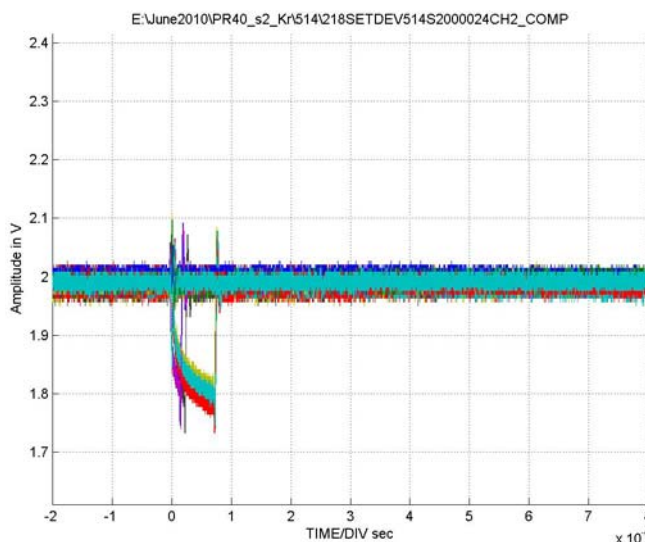


FIGURE 28. TYPICAL CAPTURE AT  $V_S = \pm 18V$ , CHANNEL B, LET = 56MeV/mg/cm<sup>2</sup>, RUN 514

## Summary

### Single Event Burnout/Latch-up

No Single Event Burnout (SEB) was observed for the device up to an LET value of 86MeV • cm<sup>2</sup>/mg (+125 °C) and voltage supply of  $V_S = \pm 18.2V$ . No single event latch-up (SEL) were observed for the device up to an LET value of 86MeV • cm<sup>2</sup>/mg (+125 °C). voltage supply of  $V_S = \pm 18.2V$ .

### Single Event Transient

Based on the results presented, the ISL70218SRH op amp offers advantages over the competitor’s part with respect to maximum SET output voltage excursion. No transient pulses > 0.5V were observed at LET levels up to 56MeV • cm<sup>2</sup>/mg. Both the voltage level and duration of transients were proportional to LET. The maximum transients at an LET of 56MeV • cm<sup>2</sup>/mg were observed to be ~300mV with a typical duration of > 200µs (see [Figure 27](#)). The longest transient duration observed was at an LET of 17MeV • cm<sup>2</sup>/mg with an out of scale transient > 300mV, and the length of the transient was > 1.6ms.

## Revision History

DATE	REVISION	CHANGE
Aug 10, 2018	1.00	Updated typos in the Summary section on page 10. Added Revision History section. Updated the disclaimer.

## Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.  
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.  
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.  
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.  
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.  
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



### SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

**California Eastern Laboratories, Inc.**  
4590 Patrick Henry Drive, Santa Clara, California 95054-1817, U.S.A.  
Tel: +1-408-919-2500, Fax: +1-408-988-0279

**Renesas Electronics Canada Limited**  
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3  
Tel: +1-905-237-2004

**Renesas Electronics Europe Limited**  
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K  
Tel: +44-1628-651-700

**Renesas Electronics Europe GmbH**  
Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

**Renesas Electronics (China) Co., Ltd.**  
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

**Renesas Electronics (Shanghai) Co., Ltd.**  
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

**Renesas Electronics Hong Kong Limited**  
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852 2886-9022

**Renesas Electronics Taiwan Co., Ltd.**  
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

**Renesas Electronics Singapore Pte. Ltd.**  
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

**Renesas Electronics Malaysia Sdn.Bhd.**  
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

**Renesas Electronics India Pvt. Ltd.**  
No.77C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India  
Tel: +91-80-67208700, Fax: +91-80-67208777

**Renesas Electronics Korea Co., Ltd.**  
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5338