

## **Introduction**

The intense, heavy ion environment encountered in space applications can cause a variety of effects in electronic circuitry, including single event transient (SET), single event latchup (SEL) and single event burnout (SEB). These single event effects (SEE) can lead to system-level performance issues including degradation, disruption 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 IS-1825ASRH Pulse Width Modulator.

## **Product Description**

The IS-1825ASRH is a monolithic, pulse width modulator (PWM) controller fabricated using the Intersil Corporation dielectrically isolated (DI), radiation-hardened silicon gate (RSG) process. This process is optimized for power management functions and features complementary high-voltage MOS and bipolar devices as well as various passive components. The IS-1825ASRH is hardened to a total ionizing dose of 300krads(Si).

Functionally, the IS-1825ASRH is a dual-output, high-speed PWM controller equivalent to commercial 1825A types. It has been specifically designed to provide a high level of SEE hardness by selected use of redundant circuitry, careful device sizing and other proprietary techniques. The device is capable of implementing power supplies in a variety of topologies using either voltage or current-mode control.

## **SEE Test Objectives**

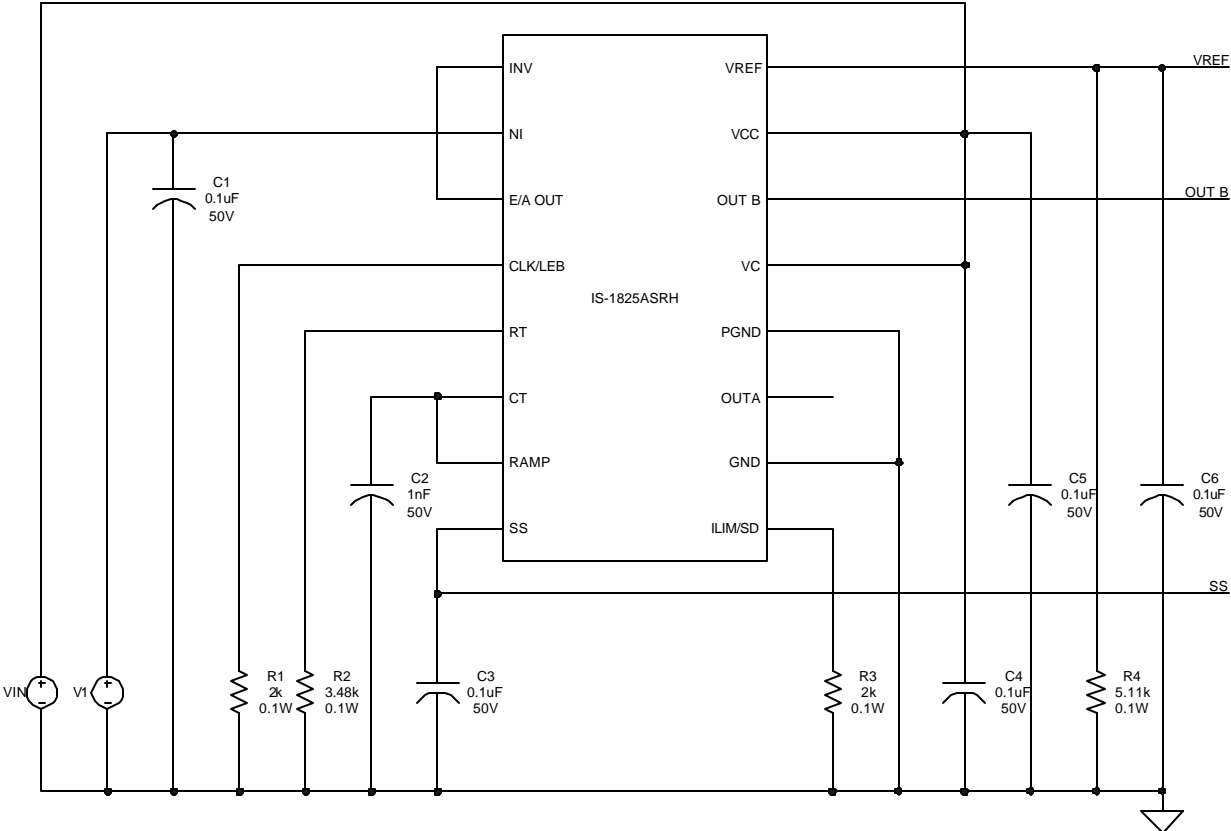
The IS-1825ASRH was tested for SEE to verify its immunity to SEL/SEB and to characterize its SET performance.

## **SEE Test Procedure**

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

Diagram 1 shows the IS-1825ASRH SEE test fixture schematic. R2 and C2 were selected to program the oscillator frequency to 400kHz and V1 was adjusted to produce a 20% duty-cycle at the A and B outputs. An oscilloscope was connected to OUT B via channel 1, VREF via channel 2 and SS via channel 3 in order to monitor the output driver voltage,

reference voltage and soft-start voltage respectively. In all Figures, the top trace is OUT B (channel 1), the middle trace is VREF (channel 2) and the bottom trace is SS (channel 3).



**Diagram 1: IS-1825ASRH SEE Test Fixture Schematic**

Table 1 shows the characteristics of the various beams used for SEE testing.

Beam Type	Incident Angle (°)	LET (MeV/mg/cm <sup>2</sup> )	Fluence (p/cm <sup>2</sup> )	Flux (p/cm <sup>2</sup> /s)
Gold	0	87.4	1x10 <sup>7</sup>	Various
Krypton	0	36	1x10 <sup>7</sup>	Various
Argon	0	15	1x10 <sup>7</sup>	Various

**Table 1: Beam Type and Characteristics**

Table 2 indicates test number, beam type and test conditions for each of the SEE tests.

Test Number	Beam Type	Test Conditions
1	Gold	Vcc=20V; fosc=400kHz; Duty-cycle=20%
2	Gold	Vcc=12V; fosc=400kHz; Duty-cycle=20%
3	Krypton	Vcc=12V; fosc=400kHz; Duty-cycle=20%

**Table 2: SEE Tests**

**SEL/SEB Testing**

The goal of SEL/SEB testing was to apply the highest energy particles to the PWM controller under worst-case bias conditions to maximize the chance of latchup or burnout. Consequently, gold ions with a Linear Energy Transfer (LET) of 87.4MeV/mg/cm<sup>2</sup> and a fluence of 1x10<sup>7</sup> p/cm<sup>2</sup> were used. Supply current increased slightly from 38.15mA to 38.64mA. The reference voltage was unchanged at 5.15V. No evidence of latchup or burnout was observed. Figure 1 corresponds to test #1 and shows the results of the SEL/SEB testing.

**SET Testing**

The goal of SET testing was to characterize the performance of the PWM controller when subjected to the beams shown in Table 1. The driver output was monitored for double pulses or pulse stretching, which could saturate a power transformer, possibly resulting in catastrophic failure of the power MOSFETs in a DC-DC converter. The reference voltage was monitored for excursions beyond the nominal, which would proportionately affect the output voltage of a DC-DC converter. Finally, the soft-start pin was monitored to determine if the fault latch had triggered, which can shutdown a DC-DC converter for extended periods of time.

**Gold Ion SET Testing**

The PWM controller exhibited a variety of transient behaviors during gold ion SET testing. First, the output driver showed evidence of double pulsing and pulse stretching. Additionally, a number of output drive pulses appeared to have terminated prematurely due to do triggering of the fault latch. Second, the soft-start voltage produced multiple discharges, some to within about 140mV of ground, indicating that the fault latch was triggered a number of times. Somewhat surprisingly, the reference voltage emerged relatively intact, except for a small amount of switching noise that was noted to be synchronous with the turn-on/turn-off of the output A and B drivers. Figure 2 corresponds to test #2 and shows the results of gold ion SET testing. Since transients were recorded using gold ions, testing was continued using lower energy krypton ions with an LET of 36 MeV/mg/cm<sup>2</sup>.

### Krypton Ion SET Testing

The performance of the PWM controller was much improved using lower energy krypton ions. The output driver showed no evidence of double pulsing or pulse stretching. A small narrowing of the pulse-width was noted in one instance and a slight phase shift was noted in another. Neither of these minor changes should have any significant system level impact. In contrast to gold ion SET testing, where multiple soft-start discharges were noted, during krypton ion SET testing the soft-start voltage was solid and showed no evidence of discharge. This provides assurance that the fault latch was not triggered. As expected, the reference voltage remained intact, displaying smaller amounts of switching noise, which again was noted to be synchronous with the PWM switching intervals.

### Conclusions

The Intersil IS-1825ASRH PWM controller was tested for SEE under various bias conditions using a variety of heavy ions. As expected, the PWM controller was shown to be SEL/SEB immune when exposed to gold ions at an LET of 87.4MeV/mg/cm<sup>2</sup> under worst-case bias conditions. SET testing using gold ions produced multiple discharges of the soft-start voltage that could cause disruptions at the system level. Disturbances recorded at the driver output included double pulsing and pulse stretching that could result in permanent system damage. When lower energy krypton ions were used, the only disturbances noted were some pulse-widths that were slightly narrowed or shifted in time, neither of which would cause system level problems.

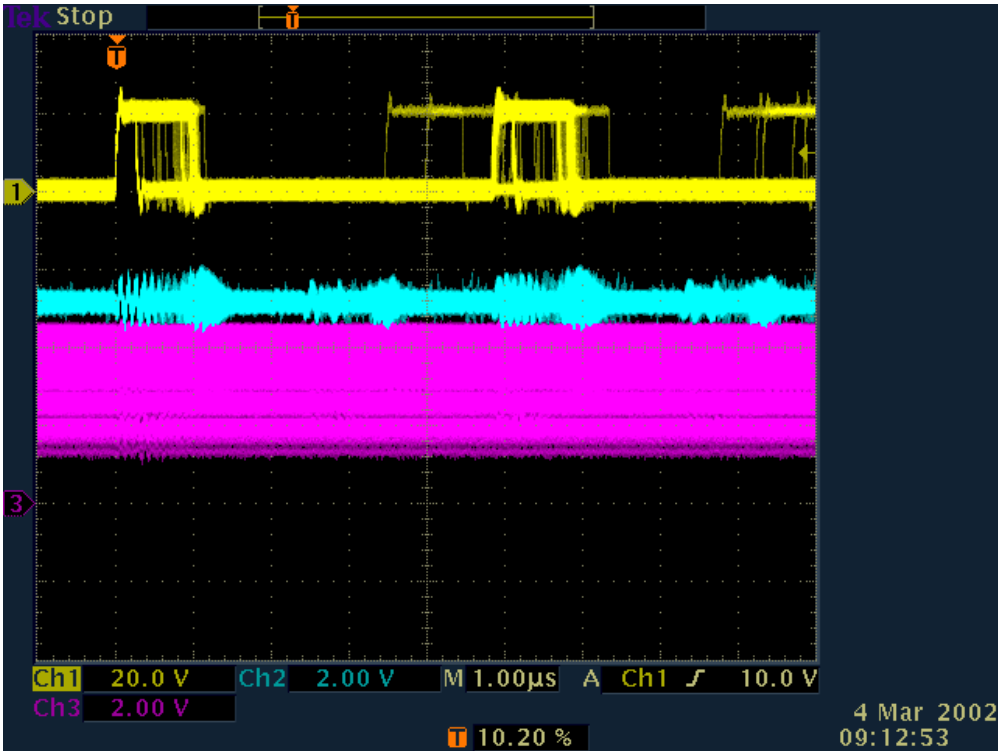


Figure 1: Test #1 Results (Vcc=20V; fosc=400kHz; Duty-cycle=20%)

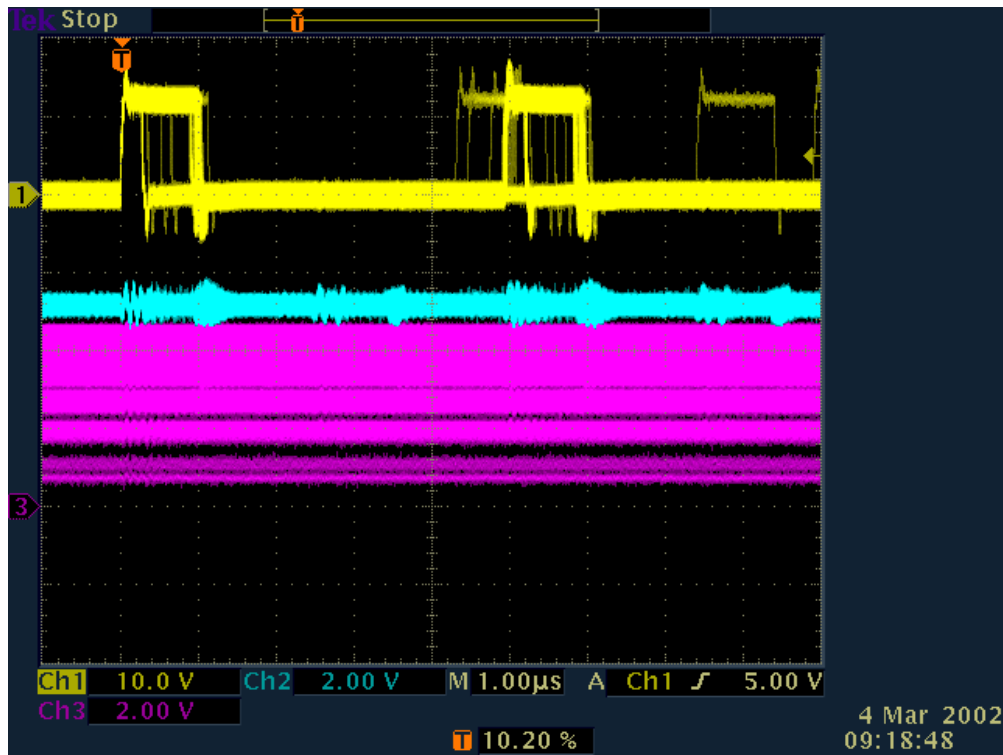


Figure 2: Test #2 Results ( $V_{cc}=12V$ ;  $f_{osc}=400kHz$ ; Duty-cycle=20%)

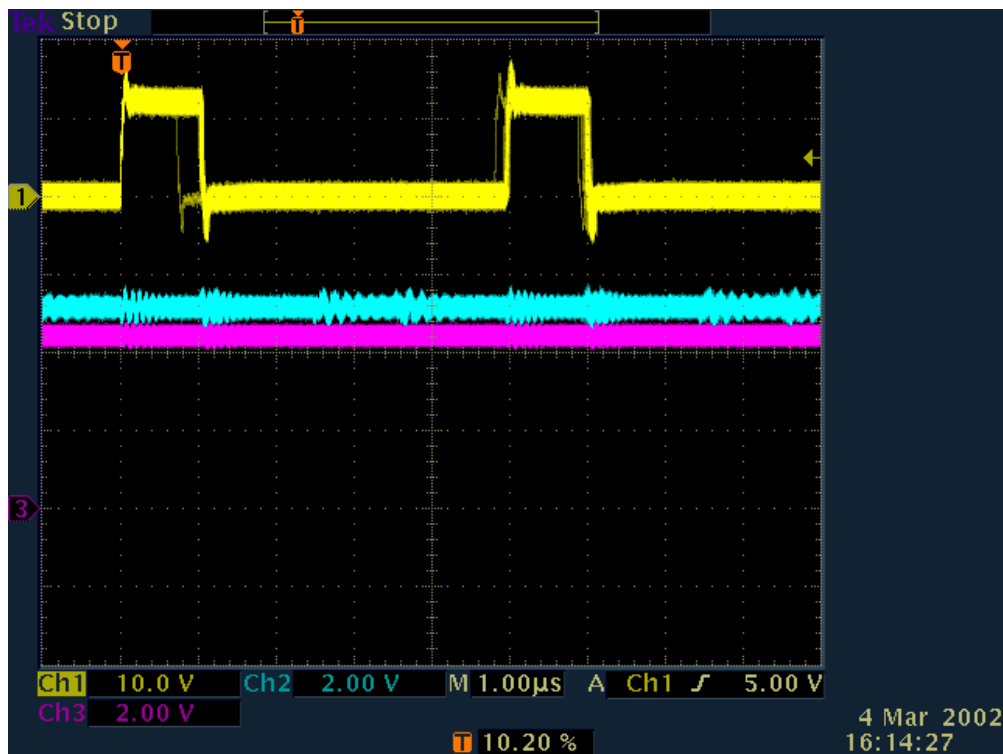


Figure 3: Test #3 Results ( $V_{cc}=12V$ ;  $f_{osc}=400kHz$ ; Duty-cycle=20%)