IS-1715ARH

Single Event Testing

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Introduction

The intense heavy ion environment encountered in space applications can cause a variety of transient and destructive effects in analog circuits, including Single Event Latchup (SEL), Single Event Transient (SET), and Single Event Burnout (SEB). These effects can lead to system-level failures including disruption and permanent damage. For predictable space system operation, these components have to be specifically designed for SEE hardness, followed by SEE testing to validate the design. This report describes the detailed results of single event phenomena testing of the complementary FET driver (IS-1715ARH) to determine its susceptibility to the effects of heavy ions.

Product Description

The Intersil IS-1715ARH is a high speed, high voltage, complementary power MOSFET driver designed for use in synchronous rectification applications. It has a single TTL compatible input and can run at frequencies up to 1MHz. It is constructed in the Intersil Radiation-hardened Silicon Gate (RSG) process for superior hardness in total dose and SEE environments. This process uses dielectrically isolated substrates and is SEL immune as a result. It is hardened to 300krad(Si) and features greatly enhanced low dose rate (ELDRS) hardness.

Related Literature

- For a full list of related documents, visit our website
  - IS-1715ARH product page

SEE Test Procedure

This testing was done at Texas A&M University on August 15-18, 2000. The Cyclotron facility at Texas A&M University was used to provide the heavy ions. The facility, coupled to a K500 superconducting cyclotron, is capable of providing a wide range of test particles and energies for advanced radiation testing.

The instrumentation used to control and monitor the IS-1715ARH while it was under test consisted of the following:

- DVM
- Regulated power supply
- DC current meter
- 2-Channel storage oscilloscope
- 2 High-speed counters

The DVM was used to monitor the regulated power supply voltage before and after exposure. The DC current meter was used to monitor the current drawn by the device under test. In addition to supplying power to the device, the regulated power supply also supplied the input bias conditions. The oscilloscope was used to continuously monitor the two device outputs during exposure, triggering on a transient, and then storing the output. Transients were then observed by setting the oscilloscope's persistence to infinity so any transient would be captured and stored. The counters were also connected to the two outputs and were used to count transients that were of sufficient magnitude to be recognized as a change in logic state.

Test Devices and Set-Up

Seven fully functional parts, packaged in 24 Ld DIPs with die exposed were tested. The parts were biased with the regulated supply between V_{CC} and GND, with the DC current meter monitoring the current between V_{CC} and GND. 10k resistors were placed from T1 and T2 to GND. Toggle switches controlled the bias condition on ENBL and INPUT. The outputs were PWR and AUX.

The truth table for the IS-1715ARH is shown in Table 1. When ENBL is HIGH, the part is enabled and PWR follows the INPUT signal. When ENBL is LOW, the part is disabled and both outputs are held LOW. In addition, when V_{CC} is less than 8V, the Low Voltage Lockout (LVLO) circuitry ensures that both outputs are held low.

The design goal for the part was to have no LOW to HIGH (LH) glitches on the outputs as this could prove catastrophic to the MOSFET devices being driven. Therefore, four conditions were tested, with the first two being the most important.

1. ENBL HIGH/INPUT HIGH - To check if AUX goes from LOW to HIGH during exposure.
2. ENBL HIGH/INPUT LOW - To check if PWR goes from LOW to HIGH during exposure.
3. ENBL LOW/INPUT LOW - To check if AUX and/or PWR go HIGH during exposure.
4. ENBL LOW/INPUT HIGH - To check if AUX and/or PWR go HIGH during exposure.

TABLE 1. IS-1715ARH TRUTH TABLE

ENBL	INPUT	PWR	AUX
LOW	LOW	LOW	LOW
LOW	HIGH	LOW	LOW
HIGH	LOW	LOW	HIGH
HIGH	HIGH	HIGH	LOW

The toggle switches were used to provide the appropriate levels on ENBL and INPUT. The outputs (PWR and AUX) were connected through scope probe connectors to oscilloscopes and through BNC connectors to pulse counters.

Test Procedure

Several devices were first exposed to Au ions at an incident angle of 60° under dynamic operating conditions and at maximum supply voltage at temperatures of approximately +27°C and +125°C, for determination of latchup or burnout. During and after exposure, the devices were monitored for excessive current with the DVM.

Next, while maintaining the appropriate static input conditions from Table 1, additional devices were exposed to gold ions at an incident angle of 60° and temperatures of approximately +27°C and +125°C and minimum supply voltage (and one at maximum voltage), to determine single event upset and/or transients. During and after exposure, the devices were monitored for excessive current with the DVM and for upset with the oscilloscope.

Results

No latchup or burnout was observed on three parts tested dynamically at +27°C and one part at +125°C at maximum voltage (V_{CC} = 20V) using Au ions (LET Init = 90.9MeV/mg/cm^2) at 60° incidence from perpendicular (an effective LET of 181.8 as compared to testing with normal incidence). All exposures were run to a fluence of 1x10^{7}particles/cm^2. Parts were toggled at 1kHz, 50% duty cycle. Supply current was measured pre-radiation and post-radiation and the results are shown in Table 2. As can be seen, there was little or no difference in the pre- and post-radiation supply currents. The total accumulated dose for these parts was about 1.4x10^{4}rad(Si). An oscilloscope trace of Unit 2, showing high to low glitches, but no low to high glitches, is shown in Figure 1.

TABLE 2. IS-1715ARH DYNAMIC SEE LATCHUP/BURNOUT TEST RESULTS

	SUPPLY CURRENT		CONDITIONS AND COMMENTS
UNIT	PRE (mA)	POST (mA)	V_{CC} = 20V, TEMPERATURE = +27°C AND +125°C ION = GOLD, 90MeV/mg/cm^2 FLUENCE = 1x10^7; Flux = 0.8x10^5 ANGLE = 60°; LET_{EFF} = 181.8 TOTAL ACCUMULATED DOSE = 1.4x10^4 Rad(Si)
1	3.54	3.54	No Latchup or Burnout
2	3.56	3.56	No Latchup or Burnout (see Figure 1)
3	3.53	3.53	No Latchup or Burnout
4	3.18	3.13	No Latchup or Burnout

Three parts were then tested for single event transients per Table 1, with some units being tested under several conditions. These results are shown in Table 3. The conditions with ENBL low were only recorded for Unit 5 at 10V and +27°C because the part was totally insensitive to radiation under those conditions. The conditions for the INPUT STATES and corresponding OUTPUT STATES are shown, along with the pre- and post-radiation currents. The columns for PWR SET and AUX SET are to indicate if any transients were seen on the PWR or AUX outputs. For all practical purposes, none were recorded. The only anomaly of that type that was seen was on Unit 5 at +27°C, 20V. That scope trace is shown in Figure 2. The top trace is INPUT, the middle trace is PWR and the bottom trace is AUX.

Based on the results from Tables 2 and 3 at +27°C, a conservative transient cross section and minimum LET can be estimated. Using a very conservative estimate of 100 transients (more than were seen) at a fluence of 1 x 10^{6}particles/cm^2, the saturated cross section would be 1 x 10^{-4}cm^2. Because no counted transients were recorded using Au ions, the minimum LET number can be established at 90MeV/mg/cm^2, which again is very conservative but basically SEE immune.

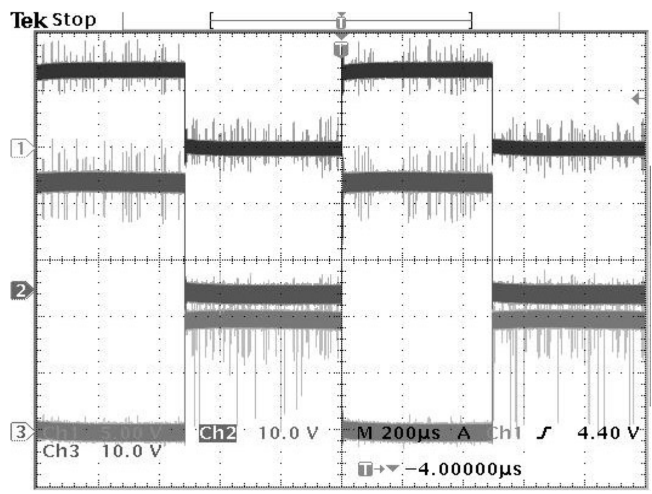

FIGURE 1. IS-1715ARH SCOPE TRACES DURING DYNAMIC EXPOSURE AT 20V, Au AT LET = 90

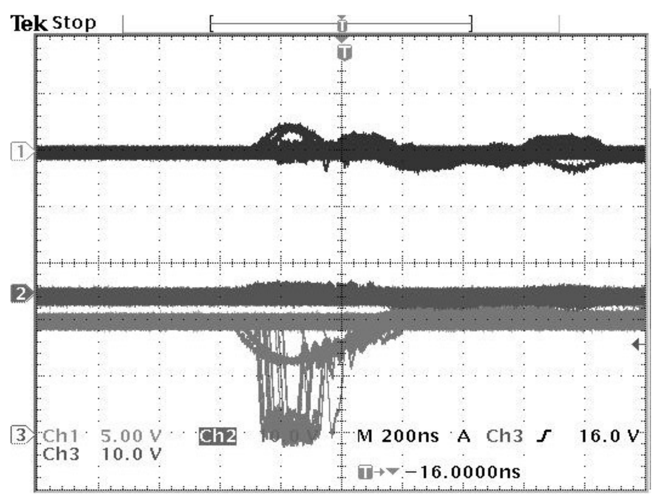

FIGURE 2. IS-1715ARH SCOPE TRACES DURING STATIC EXPOSURE AT 20V, Au AT LET = 90

Conclusion

As expected, SEE testing of the IS-1715ARH did not produce any latchup or destructive effects even at a high LET of $90MeV/mg/cm^2$. Additionally, no potentially destructive (at the system level) LOW to HIGH (LH) transients were encountered, validating the SEE hardness of this part.

TABLE 3. IS-1715ARH DYNAMIC SEE LATCHUP/BURNOUT TEST RESULTS

	INPUT STATES		OUTPUT STATES				CURRENT		CONDITIONS AND COMMENTS
UNIT	ENBL	INPUT	PWR	PWR SET?	AUX	AUX SET?	PRE (mA)	POST (mA)	V_{CC} = 10V AND 20V; TEMPERATURE = +27°C AND +125°C ION = GOLD, $90MeV/mg/cm^2$ FLUENCE = $1x10^6$; FLUX = $1x10^4$ ANGLE = 60°; LET_{EFF} = 181.8
5	LOW	LOW	LOW	NO	LOW	NO	0.46	0.46	Temperature = +27°C, V_{CC} = 10V - This is the only device these two conditions were tested on - No glitches. No glitches of sufficient magnitude to be counted were observed.
	LOW	HIGH	LOW	NO	LOW	NO	0.47	0.47	
	HIGH	LOW	LOW	NO	HIGH	NO	2.98	2.98	
	HIGH	HIGH	HIGH	NO	LOW	NO	3.69	3.69	
5	HIGH	LOW	LOW	NO	HIGH	YES	3.18	3.19	Temperature = +27°C, V_{CC} = 20V - Same device tested at 20V saw some high to low glitches - saved on scope.
	HIGH	HIGH	HIGH	NO	LOW	NO	3.93	3.92	
5	HIGH	LOW	LOW	NO	HIGH	NO	2.99	2.99	Temperature = +27°C, V_{CC} = 10V - No glitches but a slight logic dip on output
	HIGH	HIGH	HIGH	NO	LOW	NO	3.70	3.69	
6	HIGH	LOW	LOW	NO	HIGH	NO	2.99	2.99	Temperature = +27°C, V_{CC} = 10V - No glitches
	HIGH	HIGH	HIGH	NO	LOW	NO	3.69	3.69	
7	HIGH	LOW	LOW	NO	HIGH	NO	2.97	2.96	Temperature = +27°C, V_{CC} = 10V - No glitches
	HIGH	HIGH	HIGH	NO	LOW	NO	3.68	3.68	
7	HIGH	LOW	LOW	NO	HIGH	NO	2.74	2.73	Temperature = +125°C, V_{CC} = 10V - No glitches
	HIGH	HIGH	HIGH	NO	LOW	NO	3.45	3.44	

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