***********************DRAFT**************************

Synopsis V1.0
Single Event Latchup Testing of the
AD5334 Analog Devices Digital to Analog Converter

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I. Introduction

This study was undertaken to determine the latchup susceptibility AD5334 Analog Devices Digital to Analog Converter. The device was monitored for latchup induced high power supply currents by exposing it to a number of heavy ion beams at the Texas A&M University Cyclotron Single Event Effects Test Facility.

II. Devices Tested

The devices were manufactured by Analog Devices, Inc and all devices were characterized prior to exposure. The four devices were from date code 0011.

III. Test Facility

Facility: Texas A&M University Cyclotron Single Event Effects Test Facility
Flux: 9.9×10^2 to 6.3×10^4 particles/cm^2/s.

Ion	Energy (MeV)	LET (MeVcm^2/mg)
Ar	490	8.8

IV. Test Methods

Temperature: room temperature

Test Hardware:
A wirewrap board contained an oscillator and a counter built out of 74'163s, along with the DUT socket. The counter provided a periodic signal, which flipped the Most Significant Bit (MSB) of each DAC, so that the analog outputs were each changing by _ full scale at a high rate. All four outputs were monitored with a four-channel oscilloscope for DUT activity (four square waves). A loss of functionality was indicated when at least one of the outputs stopped transitioning.

The HP5524A quad power supply under remote control provided V_{dd} = +5.0 Volts, V_{ss} = 0.0 Volts and V_{ref} = +1.235 Volts to the DUT, in addition to V_{aux} = +5.0 Volts to the auxiliary circuitry (oscillator, counters). An ammeter under programmatic control monitored the precise DUT current. A TDS800 series oscilloscope under programmatic control monitored the four DUT outputs.

Software: Customized LABVIEW software provided a user interface to control signals to the DUT. The software also automatically monitor supply currents and generated a file history. The software automatically turned off the DUT power supply when the current exceeded a user-defined value. This predefined current is called the limiting current (I_L).

Test Techniques: Tests were performed to screen for the possibility of SEL and measure sensitivity as a function of particle LET. Test conditions are as described above. These are application specific test conditions and this data is therefore not for general usage.

A fluence of at least $1x10^7$ ions/cm^2 was used at each test condition. The input voltage conditions were evaluated at a number of values of Linear Energy Transfer (LET). Testing was done with normal and angled incident ions to achieve an LET range of 8.8 to 42.7 MeV-cm^2/mg.

If the device current experienced a sudden increased larger than I_L, the power was cycled and the DUT was checked for functionality, we called this an SEL. The DUT functionality information was not saved to a file.

The test sequence was:

1. DUT would be powered, and monitoring (ammeter, scope) started;
2. Irradiation would be commenced;
3. Ammeter and scope would be monitored for indication of SEL (excessive current, loss of activity on any one or more of the DAC outputs);
4. Beam would terminated at end-of-fluence or would be quickly be terminated upon observation of SEL;
5. In the case of SEL, depending on the degree of conservativeness dictated by the stage of testing, either the DUT would be powered down or the DUT activity and DUT current would be monitored for some time.
6. SELs did occur. As the testing progressed, the current level at which the test would be terminated was raised to determine whether fatal SEL would occur.

V. Results

Four Digital to Analog Converters were tested under the above conditions The current trip point was set between 1 mA and 2 Amps (nominal supply current was approximately 600 μAmps). Latchup events did occur that would trigger the shutdown of the device when the trip level was set below a few hundred milliamps. The current trip point was gradually increased until the current from the latch event would saturate. This value was typically in the 300 - 400 milliamp range. During some of the latchup events the current would continue to jump to higher values after sitting in the latched condition for a few minutes. Even when the current would peak over an ampere, the part did survive. That is, under these test conditions, the latchups observed are not considered destructive events. However, higher LETs could possibly produce events that are destructive or the device could be sensitive to "latent damage". These possibilities were not investigated.

Considering the cross section data in Figure 1, the AD5334 Analog Devices Digital to Analog Converter is considered to have an LET threshold for latchup of approximately 8 MeV-cm^2/mg. The saturation cross section is approximately 2 to 3 x 10^{-4} cm^2. It should be noted that for LET_{th} of 10 or less, the possibility of sensitivity to proton-induced events exists. This possibility is not addressed by this testing.

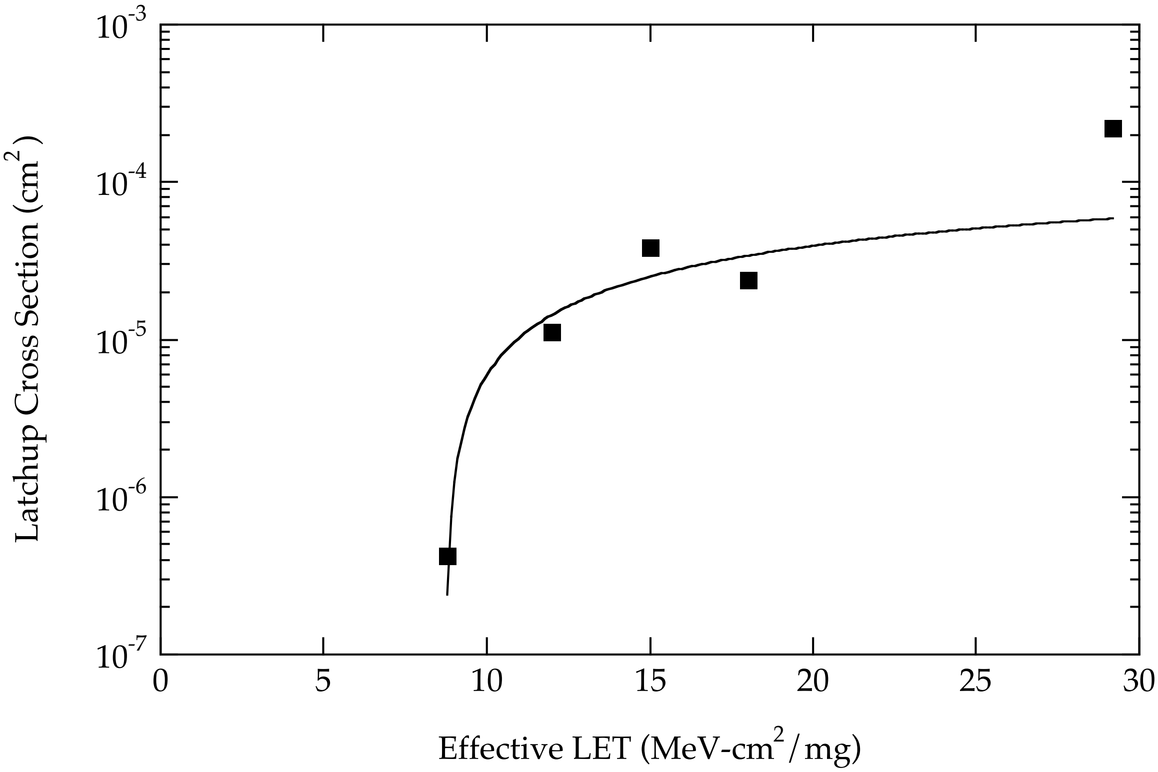

Figure 1. Latchup cross section as a function of the effective LET for the AD5334 Digital to Analog Converter. The curve shows an approximate threshold of 8 MeV-cm^2/mg and a saturation cross section of greater that 10^{-4} cm^2.

VI. Recommendations

In general, devices are categorized based on heavy ion test data into one of the four following categories:

Category 1 – Recommended for usage in all NASA/GSFC spaceflight applications.
Category 2 – Recommended for usage in NASA/GSFC spaceflight applications, but may require mitigation techniques.
Category 3 – Recommended for usage in some NASA/GSFC spaceflight applications, but requires extensive mitigation techniques or hard failure recovery mode.
Category 4 – Not recommended for usage in any NASA/GSFC spaceflight applications.

The AD5334 Analog Devices Digital to Analog Converters are Category 3 devices. If proton test would indicate a high sensitivity to proton-induced latchup, this part could then be considered a Category 4 device.