



# Single Event Effects Testing of a Commercial-Off-The-Shelf Analog-to-Digital Converter in a Camera Application



National Aeronautics and Space Administration

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**Abstract:** Single event effect data is presented on the Analog Devices AD7984. The recent heavy-ion test results showcase application-specific results for the commercial part in its intended application.

## Introduction

Radiation-induced upsets are a concern for microcircuit designs in the space environment. Charged particles that deposit energy within the sensitive node of a device may cause the output to fluctuate from expected values. Destructive single events such as single event latch up (SEL) are of particular concern with commercial off-the-shelf (COTS) devices. Many data converters that have been tested have shown varied response to heavy ion upsets [1-4].

The Analog Devices AD7984 is an 18-bit, successive approximation, analog-to-digital converter (ADC) that operates from a single power supply. It contains a low-power, high-speed, 18-bit sampling ADC and a versatile serial interface port [5].

## Device Preparation

Device preparation for the facility requires that the commercial plastic encapsulant be removed such that the range of particles is sufficient through the semiconductor to penetrate through to the sensitive volumes within the device. Chemical etching was of particular concern because the parts were on a flight like board populated with other actives and the traces on the PWB could not be damaged if we were to retain functionality. The challenges associated with these parts is the small package, and the parts that surround. A silicone mask was set overnight before acid etching to protect the board and support circuitry. To remove the encapsulant we used H<sub>2</sub>SO<sub>4</sub> at an elevated temperature and an acetone wash. The approach was done and repeated on multiple parts seen on the board shown in figure 2 and Figure 3.



Figure 1: Focal Plane Electronics Assembly

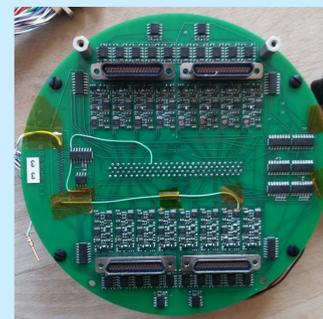


Figure 2: Focal Plane Electronics Subsystem board that houses the AD7984

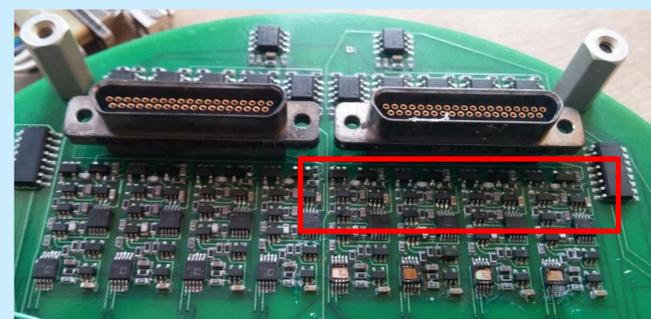


Figure 3: Boxed in red are the devices under test with the encapsulant removed to expose the die for heavy ion testing

## Test Facility

SEE testing was performed at Texas A&M University Cyclotron Facility, Table 1 shows the Ion, angle, and effective LET that was used to experimentally determine the device response to heavy ions. Testing was performed in air at room temperature.

Angle	Ion and Linear Energy Transfer (MeV*cm <sup>2</sup> /mg)		
	Ar	Kr	Xe
0°	8.6	28.8	53.1
30°	9.9	33.2	61.3
45°	12.2	40.8	75
60°	17.2	57.6	106.2

Table 1. Ions used for heavy ion testing of the AD7984

## Test Results and Discussion

The parts were tested for a given LET to a predetermined fluence of ions. During beam exposure the current levels and an image output were monitored from the control room. After each ion beam exposure post processing of the image file was done to determine the count of single events. For this test, a single event upset was defined as a data frame containing more than 10 pixels at least 10 standard deviations beyond the noise floor, data was then scaled to 100 frames and the results are plotted in Figure 2. The Weibull fit to the data has an onset of 23.4 MeV.cm<sup>2</sup>/mg, the last ion LET where no upset was recorded, and an estimated saturation of 3x10<sup>-4</sup> cm<sup>2</sup>/device.

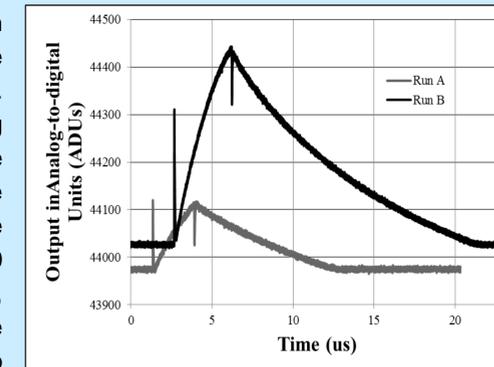


Figure 5: Board response to single event heavy ion strike for two different runs.

## Application

As space-bound instruments demand sensors with increased density and higher resolution, higher speed and lower power are needed to pass data frames efficiently from the instrument to on-board computers. Many radiation-hardened data converters are not able to meet the combination of affordability and performance of commercial alternatives. The radiation response of COTS devices is not easily compared to previous results on other parts, even in the same device family; this investigation was conducted to capture any destructive events or major functionality interruptions for an intended camera circuit shown in Figure 4. The AD7984 is being used in the focal plane electronics of the TESS spacecraft. 4 CCD cameras will cycle through exposures, where this housekeeping ADC digitizes the cameras output.

