Single-Event Latchup Testing of the Texas Instruments ADS7881 12-bit SAR ADC

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1. Purpose

The purpose of this testing is to characterize the Texas Instruments ADS7881 12-bit successive approximation register analog-to-digital converter (SAR ADC) for single-event latchup (SEL) susceptibility. These data will be used for flight lot evaluation purposes.

2. Devices Tested

The ADS7881 is a 12-bit 4 MS/s ADC with a 2.5 V internal reference. The device includes a capacitor-based SAR ADC with inherent sample and hold. The device offers a 12-bit parallel interface with an additional byte mode that provides easy interface with 8-bit processors. The device has a pseudo-differential input stage. The −IN swing of ±200 mV is useful to compensate for ground voltage mismatch between the ADC and sensor and also to cancel common-mode noise. With nap mode enabled, the device operates at lower power when used at lower conversion rates. The device is in a 48-pin TQFP package.

Five (5) parts were provided for SEL testing. We prepared four parts for irradiation and kept the remaining pieces as spares. More information about the devices can be found in Table 1. The parts were prepared for testing by acid etching the plastic package and encapsulant away from the target die. The parts were then soldered to small copper circuit adapter boards for easy handling. These parts are fabricated in a bulk CMOS technology. Since we do not know the number of overlayers used in the fabrication processes, linear energy transfer calculations are determined based on the top-surface incident ion species and kinetic energy.

Table 1: Part Identification Information

Qty	Part Number	LDC	Source	Package
5	Flight: ADS7881IPFBT Generic: ADS7881	1010	Texas Instruments	48-lead TQFP (SOIC)

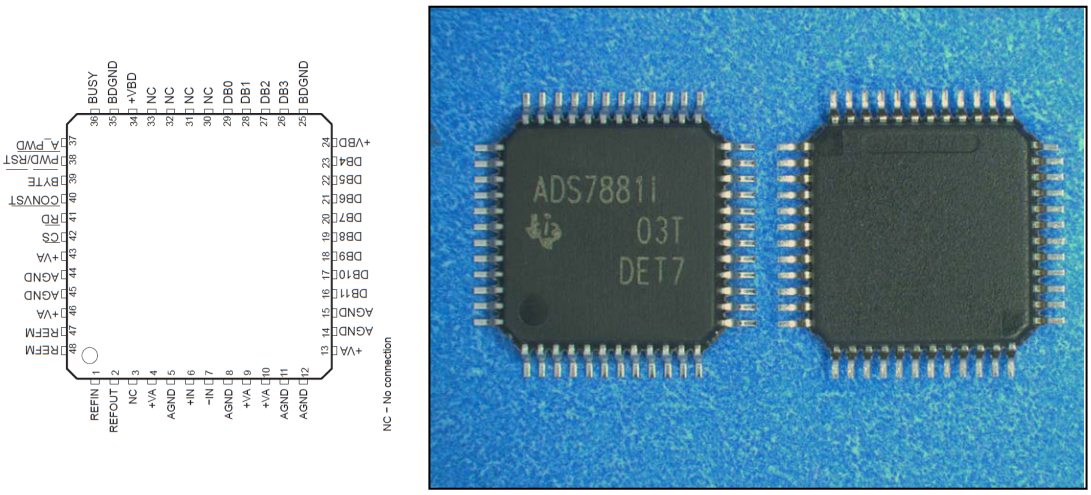
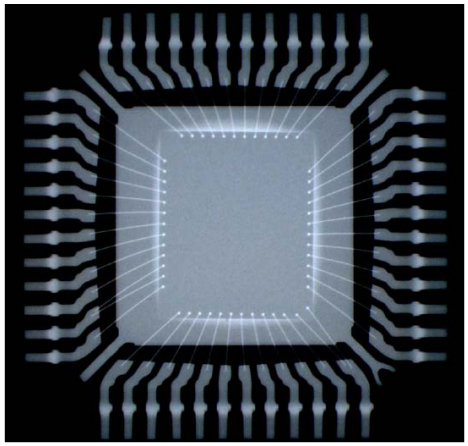
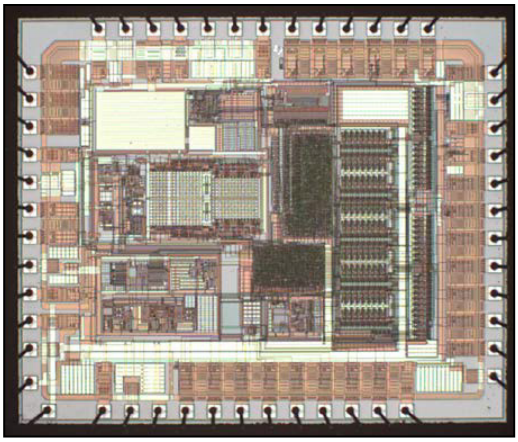


Figure 1: Pin diagram and corresponding package photo of ADS7881 SAR ADC



(a)



(b)

Figure 2: ADS7881 radiographic image and die photograph. Die photo taken after acid etching/decapsulation.

3. Test Facility

Facility: Texas A&M University Radiation Effects Facility. Tune: 15 MeV/amu
Flux: 6×10^{4} to 1×10^{5} ions cm^{-2} s^{-1}
Fluence: All tests run to a fluence of 1×10^{7} cm^{-2} or until a high-current event is observed

Table II: Ion(s) Used for Device Irradiation

Ion	Energy (MeV)	Range in Silicon	Silicon LET (MeV cm^2/mg)
^{40}Ar	516	183	8.5
^{181}Ta	2076	119	77

Note that energy, range, and LET are calculated based on 1 mil aramica window and 30 mm of air prior to the silicon target.

4. Test Conditions and Error Modes

	ADS7881
Test Temperature	60° C
Operating Frequency	Static
Power Supply Voltage	+ 5 Vdc
Parameters of Interest	LET_{th}, temperature, supply voltage
SEE Conditions	Prolonged and self-sustained high-current state*

*Current limit set to 110% of absolute maximum rating.

5. Test Setup

The test circuits for all devices were built to model/approximate the intended application. However, these SEL tests were static with a DC bias on both the analog and digital supplies with the inputs tied low. Decoupling capacitors were used on power lines.

The test setup is fairly simple, requiring only the digital I/O, relays, power supplies, and data logging equipment. The power supplies were located in the TAMU irradiation cave, while the data logging equipment were located in the high-bay. The digital I/O and relays on the test board allowed for rapid switching between parts to make testing more efficient – this includes power, Kapton heaters, and thermistors. The test board actually contained three different part types of which the ADS7881 is only one. A picture of the test board is shown in Figure 3.

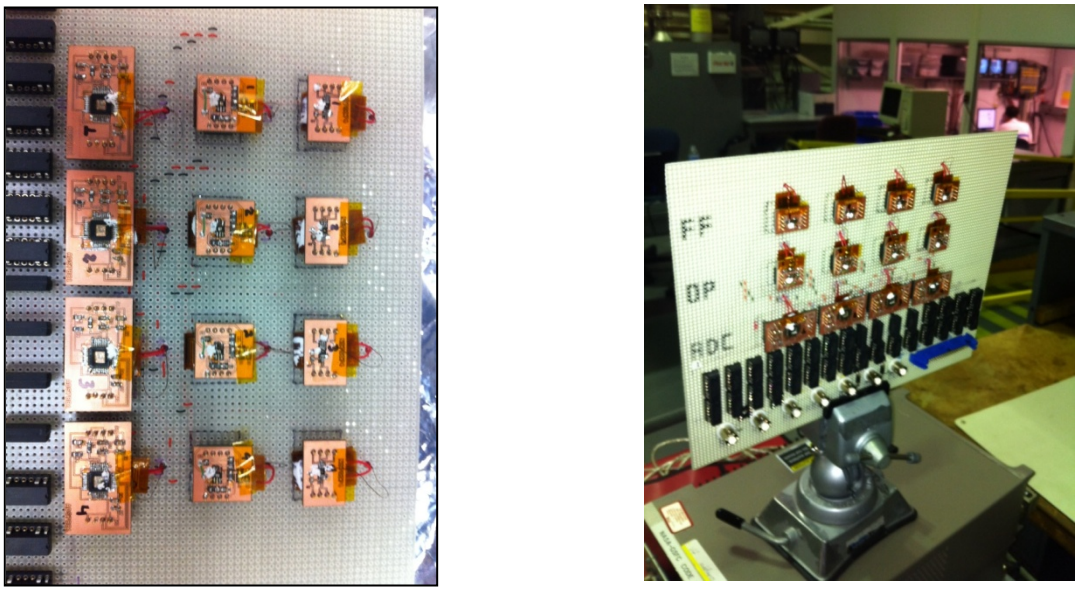


Figure 3: Test board configuration for the SEL test of the ADS7881 SAR ADC. The ADS7881 is located on the left row in the left image and the bottom row in the right image. The other parts on the test board were evaluated during the same run, but are not covered in this report.

6. Test Results

Many exposures were conducted, covering irradiations on four separate devices from the same manufacturing lot date code. None of the devices experienced a **sustained** high-current state that required user-intervention to correct. However, quickly after each irradiation cycle began, a large 0.3-0.5 s current spike was observed. This spike initially looked like a latchup event because it was tripping the current compliance of the power supply. After raising the compliance limit incrementally to approximately 200 mA, we were able to see all the events. Depending on the strike location, the current would either return to background or to approximately 12 mA, which is below the maximum of 22 mA. After the current settled to 12 mA, no more transients appeared. Since the device remained operational throughout the testing, including after exposure, the conclusion is that these events are activating ("turning on") portions of the analog circuitry and are not destructive. Note that these high-current events were observed for both argon and tantalum irradiations, suggesting that the event threshold is low. The data in Figure 4 are representative of all exposures conducted.

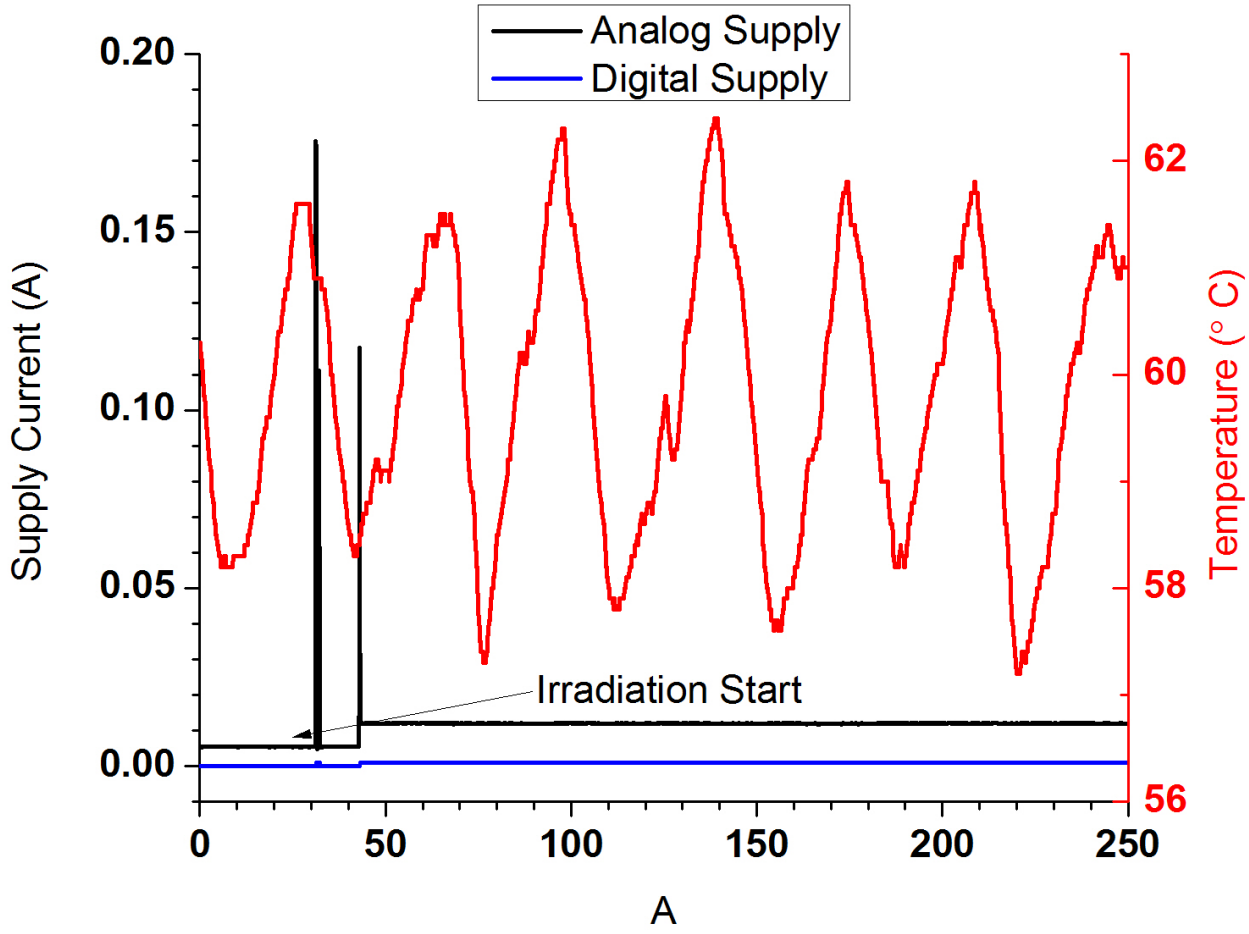


Figure 4: Example of a 240 s 15 MeV/amu Ta irradiation of the ADS7881 SAR ADC. Two high current events were observed in this run, though neither was sustained and device remained operational. Note that the current spikes came from the analog side, not the digital.

7. Recommendation

This manufacturing lot of parts is recommended with reservations for use in NASA/GSFC spaceflight applications. Current-limiting mitigation should be explored as a preventive measure should the elevated current lead to degraded device performance. This recommendation does not extend beyond the conditions tested and only applies to single-event latchup. No single-event upset or transient behavior is included.

8. URL for Device Data Sheet

- ADS7881: http://focus.ti.com/lit/ds/symlink/ads7881.pdf