ANALOG DEVICES

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SINGLE EVENT EFFECTS TEST REPORT AD9361

October 2023

Radiation Test Report	
Product:	AD9361
Effective LET:	80 MeV-cm^2/mg
Fluence:	1E7 Ions/cm^2
Facilities:	TAMU
Tested:	October 2023

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SEE Test Report for the AD9361 – an RF Agile Transceiver

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Test Dates:
October 22, 2023

I. Introduction

The purpose of this test is to determine the heavy ion-induced Single-Event Latch-Up (SEL) susceptibility of the AD9361, an RF Agile Transceiver.

Single Event Latch-up was verified on October 22, 2023, with no latch-up events observed to the highest LET tested of ~80MeV-cm^2/mg. The device was heated to a temperature of 90 °C and tested at high supply voltages (this was the warmest the part would get with the setup utilized).

II. Device Under Test

The AD9361, an RF Agile Transceiver, has 2 transceivers with integrated 12-bit DACs and ADCs. It has a TX band from 47 MHz to 6.0 GHz and an RX band from 70 MHz to 6.0 GHz. The AD9361 supports TDD and FDD operation with a tunable bandwidth between 200 kHz to 56 MHz. Figure 1 shows a functional block diagram of the device. Table 1 shows the basic part and test details. Detailed device parameters and functional descriptions can be found in the datasheet.

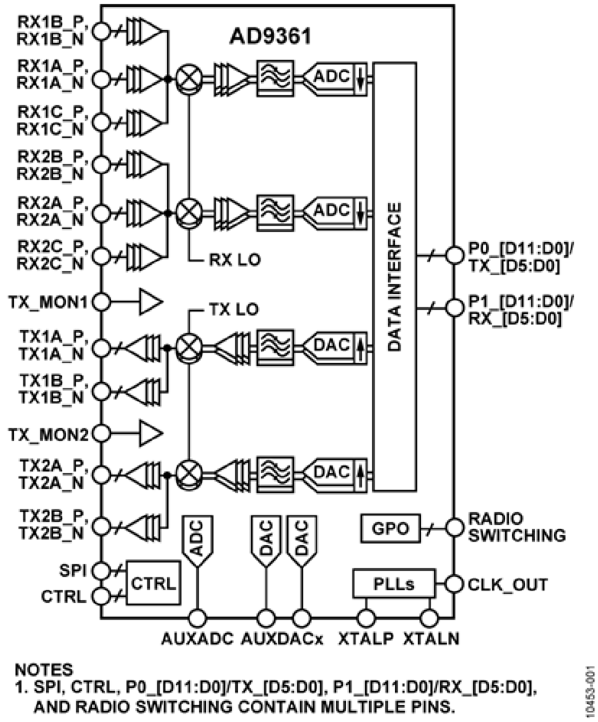

Figure 1. Functional block diagram.

Table 1
Part and test information.

Generic Part Number:	AD9361
Date of Test:	October 22, 2023 – Heavy Ion test
Manufacturer:	Analog Devices
Part Function:	RF Agile Transceiver
Part Technology:	65 nm CMOS
Package Style:	144-Ball CSPBGA
Test Equipment:	Keitheley Power supply, Xilinx ZC706

III. Test Facilities

The heavy-ion beam testing was carried out at the Texas A&M University Cyclotron Facility. The facility utilizes the K500 cyclotron with a superconducting magnet which generates the magnetic field used to accelerate the ions. The test setup was in an air environment.

Facility:	Texas A&M University Cyclotron Facility
Cocktail:	15 MeV/nuc
Flux:	1.5×10^5 $cm^{-2} \cdot s^{-1}$
Fluence:	up to 1×10^7 cm^{-2} (per run)
Ions:	Shown in Table 2

Table 2.
Heavy-ion specie, linear energy transfer (LET) value in air, range to Brag Peak, and Total Energy.

Ion	Initial LET in air ($MeV \cdot cm^2/mg$)	Range to Brag Peak (µm)	Total Energy (MeV)
Au	94.4	108	2954

IV. Test Method

A. Test Setup

The devices under test (DUT) were de-lidded (heavy ion only) and the package was chemically decapsulated to expose the bare die. The AD9361 was configured using the Xilinx ZC706 board. The DAC output for channel 1 was programmed to output a -1 to -2 dB signal at 2 GHz. The DAC output was monitored using the Xilinx ZC706 onboard VNA, outputting an FFT of the DAC for channel 1. Figure 2 below shows the test setup.

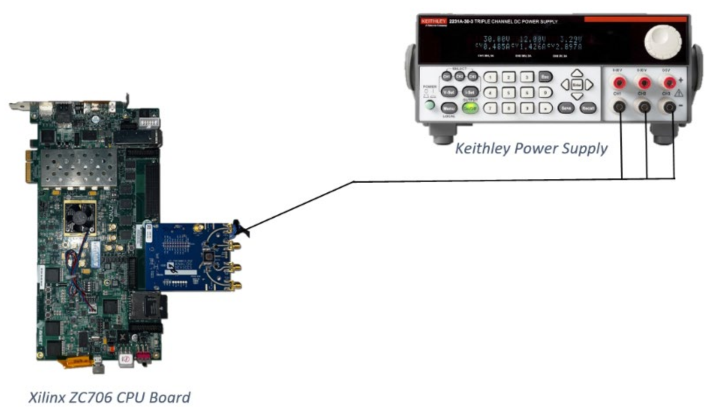

Figure 2. AD9361 test setup.

B. Irradiation procedure

SEL: Configure the device with high supply (1.4V, 3.6V) voltages and high temperature (90 °C). Monitor/record the supply voltages and currents while the ion beam is on. Evaluate at 80 MeVcm^2/mg. If the device is upset, and the device was unconfigurable from the Xilinx ZC706, the beam was paused, the device was restarted and once the device was reprogrammed, the beam was reapplied and testing continued. If the device did not see a current spike outside of normal operation ranges, no SEL was detected.

C. Test Conditions

Test Temperature: 90 C
Operating Frequency: 2.008 GHz
Power Supply(s): 1.4V, 3.6V
Angles of Incidence: 0º (normal)
Parameters: Supply Currents

V. Results

SEL – No latch-up or destructive SEE events were observed on the AD9361 at the effective LET tested of 80 MeV-cm^2/mg. Two devices were tested. The devices were heated to 90 °C during testing to put them in the most susceptible state for SEL. There are small current spikes in all the supply current graphs that indicate registers being hit and different device modes being activated, however; none of these current spikes take the current outside of the operating range for the given channel, thus can be ignored when looking for SEL. The large current drops within figure A1 and A4 can be attributed to the device being reset, to reset this device power is cycled to the Xilinx ZC706 board. 80 MeV-cm^2/mg is the standard level for which ADI attempts to test, any level above this adds margin into the testing data. The SEL plots are shown in the Appendix.

Table 3
SEL Test Runs

Board #	Run	Ion	Energy	Effective LET	Ave. Flux	Fluence	SEL
#	#		*MeV*	*MeV·cm^2/mg*	*#/cm^2/sec*	*#/cm^2/sec*	
1	4	Au	1024	80	8.41E+04	1.011E+7	none
2	5	Au	1024	80	6.99E+04	9.97E+06	none

Table 4
Max Current Per Channel

Channel	Max Current (mA)
1.4V + VDD Interface	1050
VDDA_GPO	10

Appendix

SEL: The device was re-initialized to clear any SEFIs until a fluence of 1.00E+7 was reached, then the device was reprogrammed if needed and supply currents were checked to ensure they are still within an appropriate range.

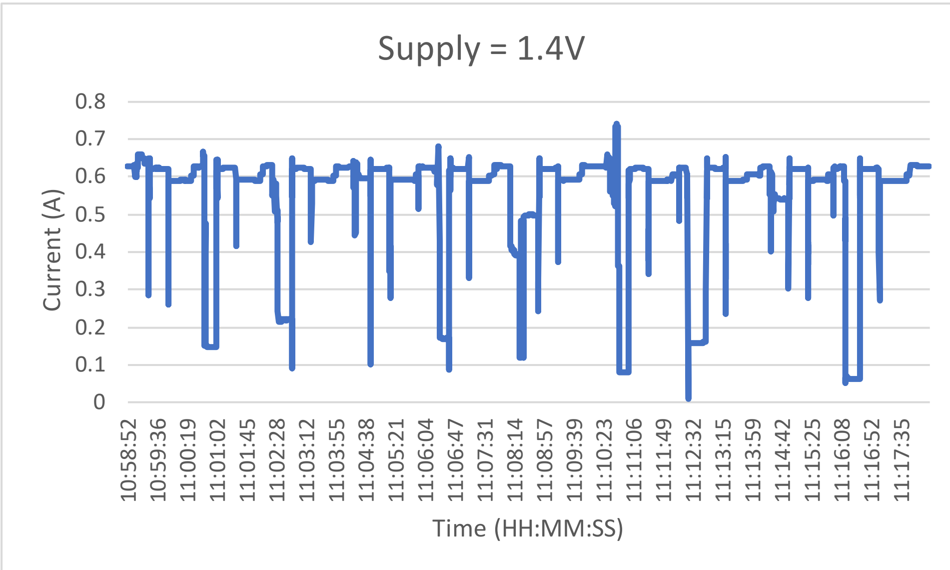

Figure A1: SEL run 4 1.4V Supply Currents

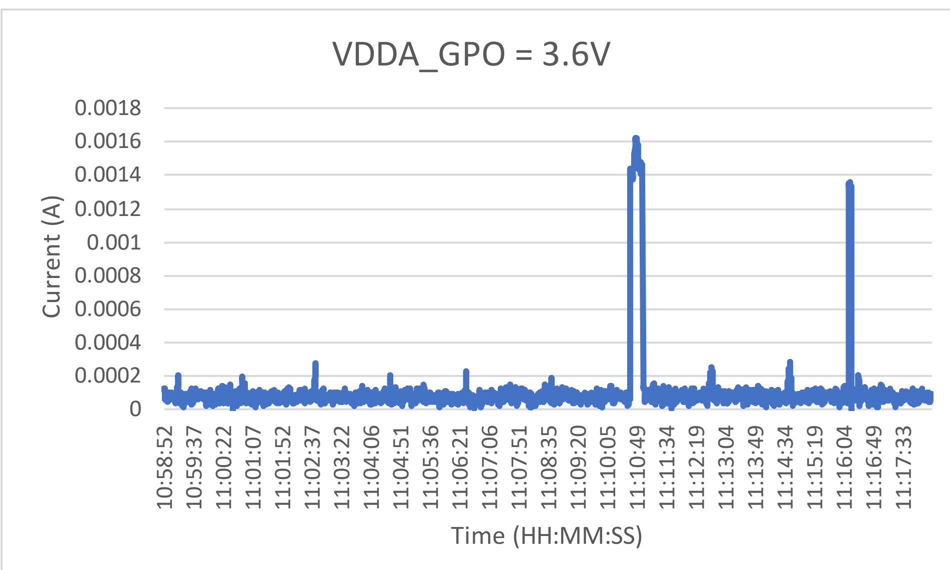

Figure A2: SEL run 4 VDDA GPO Supply Currents

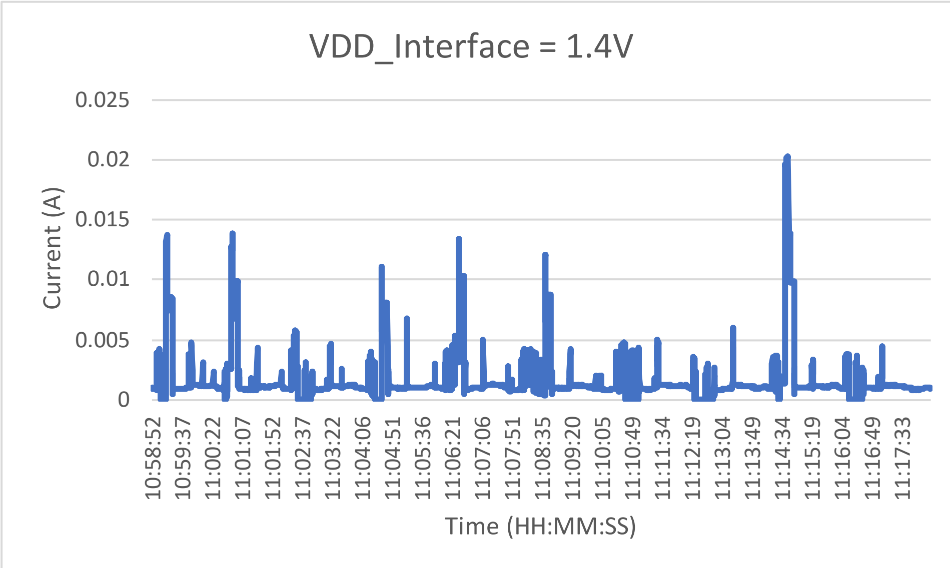

Figure A3: SEL run 4 VDD Interface Supply Currents

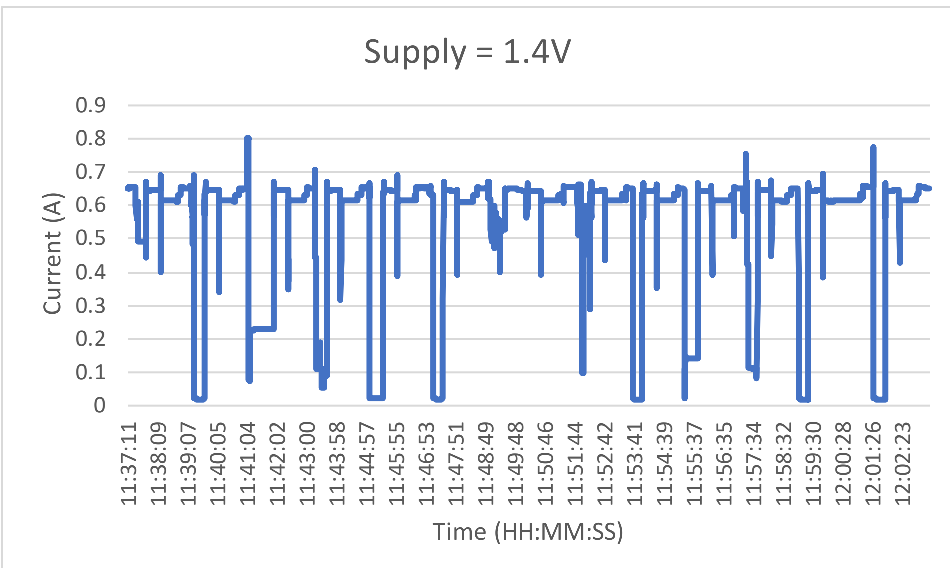

Figure A4: SEL run 5 1.4 V Supply Currents

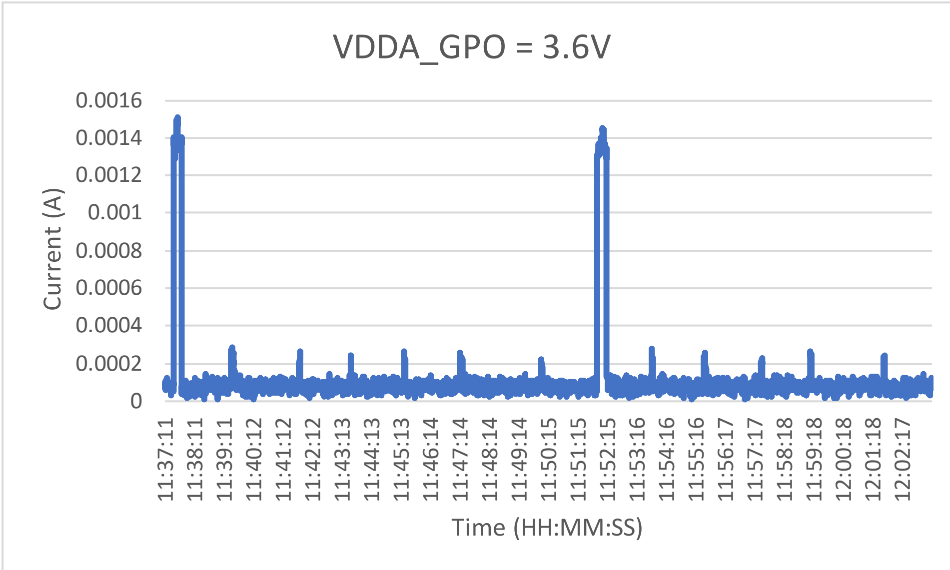

Figure A5: SEL run 5 VDDA GPO Supply Currents

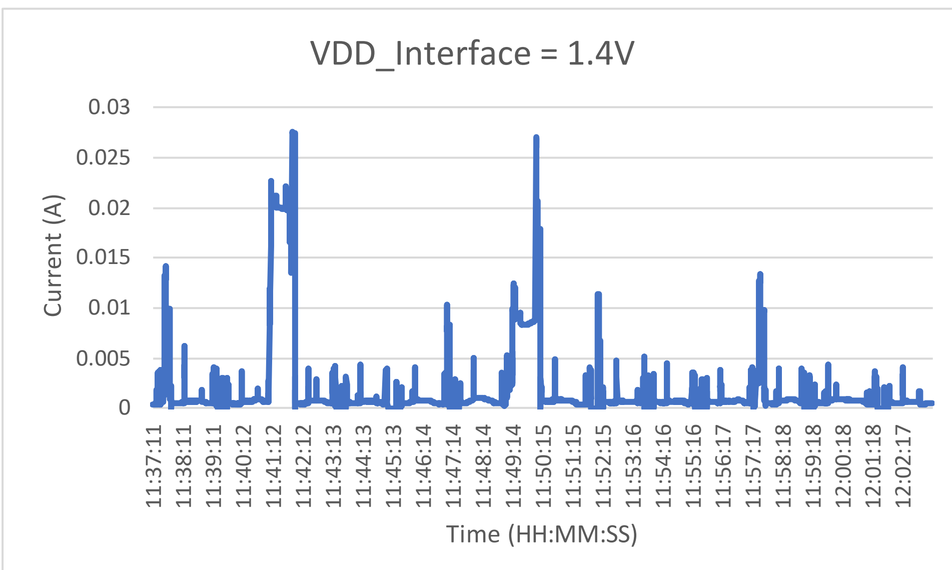

Figure A6: SEL run 5 VDD Interface Supply Currents