AHEAD OF WHAT'S POSSIBLE™

SINGLE EVENT EFFECTS TEST REPORT AD9176

October 2023

Radiation Test Report	
Product:	AD9176
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 AD9176 – a Dual 16 bit 12.6 GSPS RF DAC with Wideband Channelizers

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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 Effects (SEU) susceptibility of the AD9176, a Dual 16 bit, 12.6GSPS RF Digital to Analog Converter with Wideband Channelizers. All SEU testing was performed on Channel 1 of the DUT.

Single Event Latch-up (SEL) 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 105 °C and tested at high supply voltages; this puts the part in the most susceptible setting to experience SEL. Two devices were tested, one with an onboard oscillator (Device #1) and the other with an external clocking source (Device #2). Only two devices were tested to determine if the SEL performance was similar to the AD9172.

II. Device Under Test

The AD9176 is a dual, 16-bit, 12.6 GSPS DAC that supports DAC sample rates to 12.6 GSPS. The device feature an 8-lane, 15 Gbps JESD204B data input port, a high performance, on-chip DAC clock multiplier, and digital signal processing capabilities targeted at single-band and multiband direct to radio frequency (RF) wireless applications. 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.

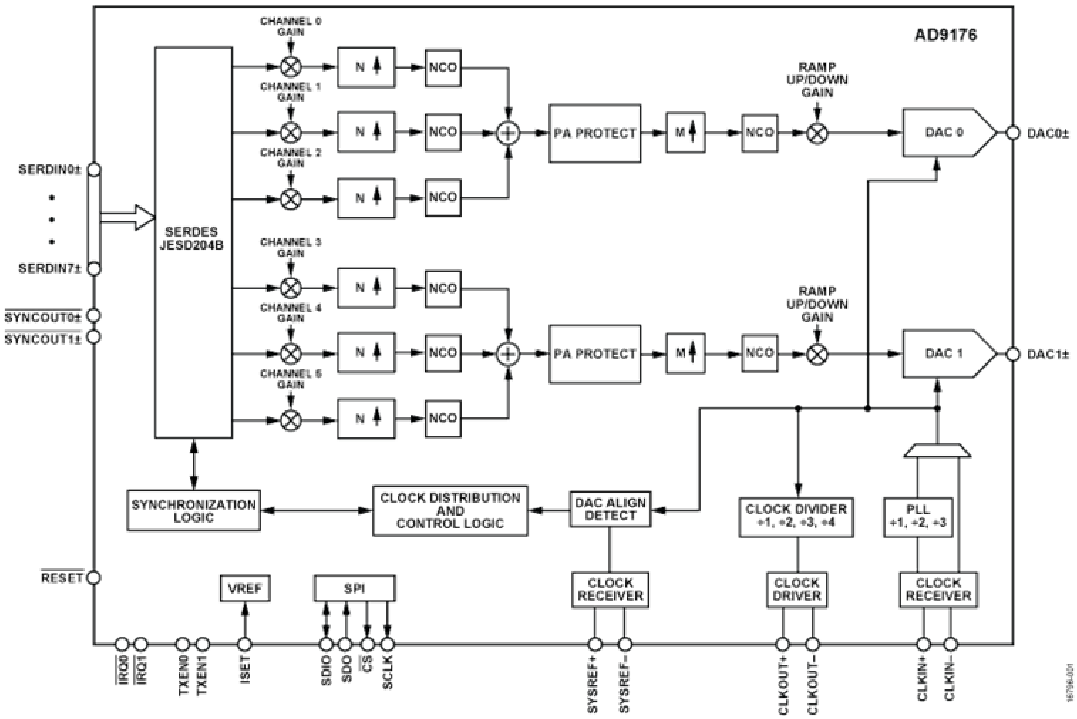

Figure 1. Functional block diagram.

Table 1
Part and test information.

Generic Part Number:	AD9176
Date of Test:	October 22, 2023 – Heavy Ion test
Manufacturer:	Analog Devices
Part Function:	16-bit Dual, 12.6 GSPS RF DAC with Wideband Channelizer
Part Technology:	28 nm CMOS
Package Style:	144-Ball ball BGA_ED
Test Equipment:	Keitheley Power supply, PXA, SMA100A, Laptop

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 open air environment.

Facility: Texas A&M University Cyclotron Facility
Cocktail: 15 MeV/nuc
Flux: 1×10^5 $cm^{-2} \cdot s^{-1}$
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 backside of the die was ground down such that the die was ~100µm thick. The AD9176 was configured using ACE through a micro-USB cable. The DAC output for channel 0 was programmed to 1 GHz and was monitored during testing. The DAC output was monitored using a PXA Spectrum Analyzer. The device was powered using an external 12V power supply to power the evaluation board components required to communicate with the ACE software, and the 1V and 1.8V regulators were also replaced by an external power supply. All of the 1.8V Digital and Analog supplies were tied together, as were the 1.0V Digital and Analog supplies. Figure 2 below shows the test setup.

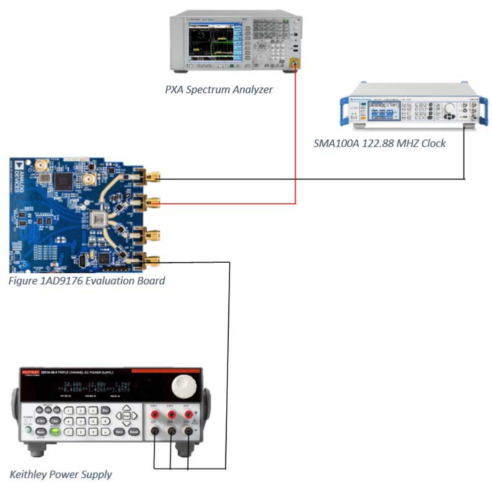

Figure 2. AD9176 test setup.

B. Irradiation procedure

SEL: Configure the device with high supply voltages (1.1V, 2V) and high temperature (105°C). Monitor/record the supply voltages and currents while the ion beam is on. Evaluate at 80 MeVcm^2/mg. If the output dropped, the part was reset through SPI.

C. Test Conditions

Test Temperature: 105 °C
Operating Frequency: 1 GHz
Power Supply(s): 1.1V, 2V
Angles of Incidence: 0° (normal)
Parameters: Supply Currents, Register Values

V. Results

SEL – No latch-up or destructive SEE events were observed on the AD9176 to the effective LET tested of 80 MeV-cm^2/mg. An Effective LET of 80 MeV-cm^2/mg is suggested to increase test margin for SEL on the AD9176. Two devices were tested, device one had an on-board oscillator and device two had an external clock. It is noted that the device with an on-board oscillator (Device #1) experienced a higher level of upsets, but this did not result in a higher latch-up count. The higher quantity of upsets can be seen within Figure A1 and Figure A2, as the device had to be reprogrammed more often when compared to the device with the external clock. The SEL plots are shown in the Appendix. When looking at Figure A2, registers were being upset which caused a small increase in the 2.0V supply bus current. The same applies to figures A1, A3, and A4. These increases are still within expected operating ranges for the part so no SEL is recorded.

Table 3
SEL Test Runs

Device #	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	1.070E+5	9.992E+6	none
2	5	Au	1024	80	1.093E+5	1.002E+7	none

Table 4
Maximum Current per Supply

Supply	Maximum Current (mA)
1.1V	**2980**
2.0V	**180**

Appendix

SEL: The device was re-initialized to clear any SEFIs until a fluence of 1.00E+7 ions/cm^2 is reached. At this time the supply currents on the 2.0V bus and 1.1V bus are reset if needed and monitored to ensure they are still within an appropriate range.

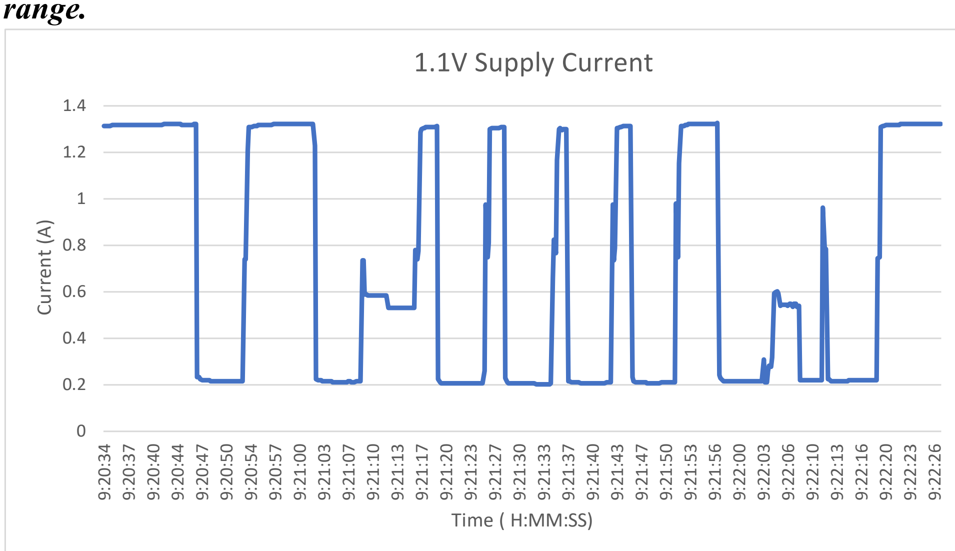

Figure A1: SEL run 4 +1.1V bus supply currents

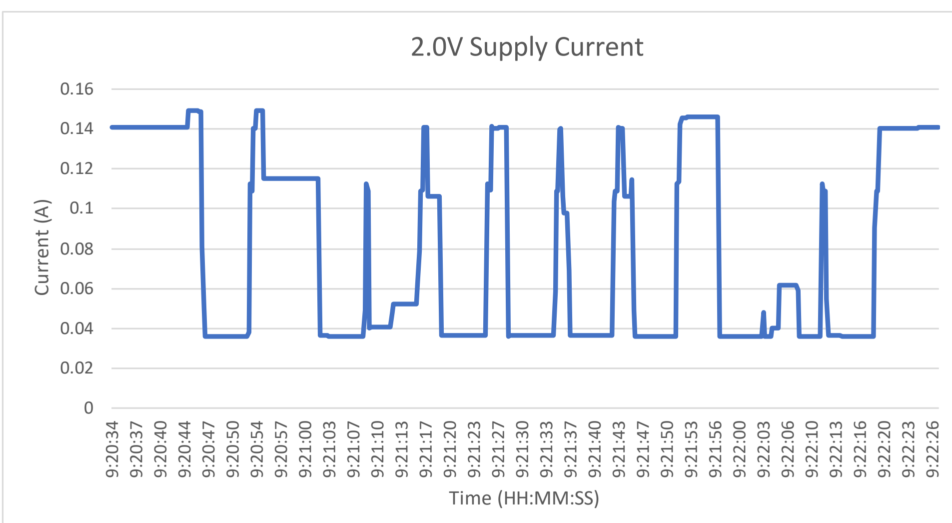

Figure A2: SEL run 4 +2.0V bus supply currents

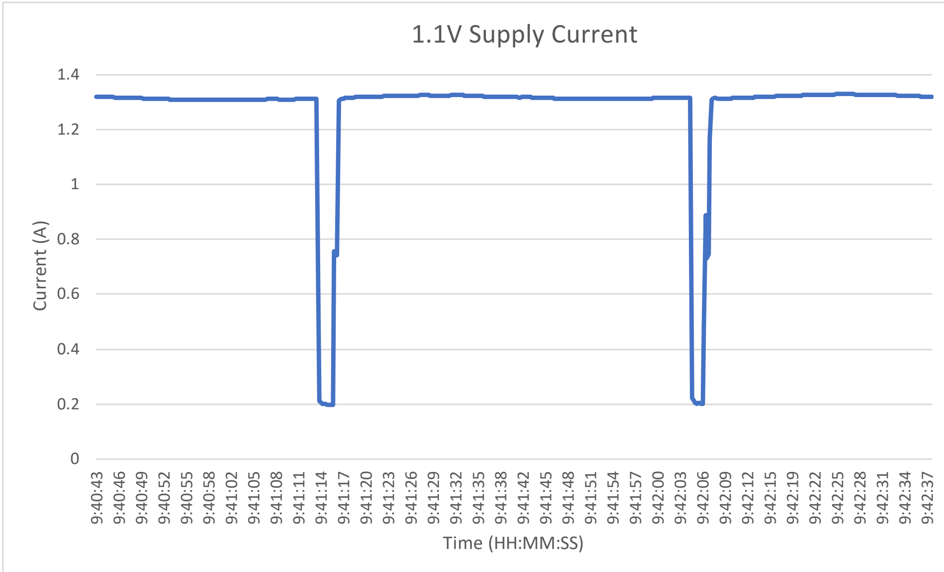

Figure A3: SEL run 5 +1.1V bus supply currents (external Oscillator)

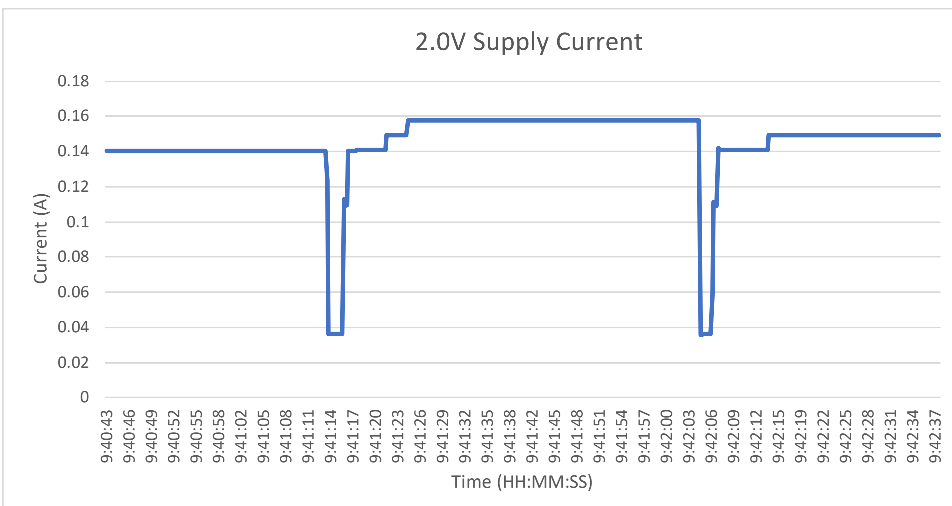

Figure A4: SEL run 5 +2.0V bus Supply Current (external Oscillator)