ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

# SINGLE EVENT LATCH-UP TEST REPORT AD780S

*April 2016*

Generic

| Radiation Test Report | |
|---|---|
| Product: | AD780S |
| Effective LET: | 85 MeV-cm$^2$/mg |
| Fluence: | 1E7 Ions/cm$^2$ |
| Die Type: | 780 |
| Facilities: | TAMU |
| Tested: | June 2014 |

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**SINGLE EVENT EFFECTS**
**TEST REPORT**

| | |
|---|---|
| Test Type: | Heavy ion |
| Test facility: | TAMU, College Station - TX- USA |
| Test Date: | June 2014 |
| Part Type: | AD780 |
| Part Description: | 2.5 V/3.0 V High Precision Reference |
| Part Manufacturer: | Analog Devices |

**Analog Devices PO No 45457246 dated 03/04/2014**

| Hirex reference : | HRX/SEE/0497 | Issue : 01 | Date : | July 23, 2013 |
|---|---|---|---|---|
| **Written by :** | Cédric VIGREUX | Design Engineer | | |
| **Authorized by:** | F.X. Guerre | Study Manager | | |

## RESULTS SUMMARY

### Facility

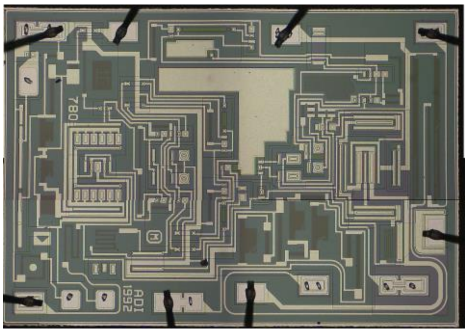
TAMU, College Station, Texas, USA

### Test date

June 2014

### Device description

| | |
|---|---|
| Part type: | AD780 |
| Manufacturer: | Analog Devices |
| Package: | FP-10 |
| Samples used | 4 |
| Top marking: | serial |
| Bottom marking: | E244018 PHIL |
| Date code: | - |
| Die dimensions : | 1.6 mm X. 2.3 mm |



### SEL Results

No SEL neither step current increase has been observed when tested with V+ set to +36V on the 4 samples with LET of 85 MeV/(mg/cm²) and at a temperature of 125°C.

## DOCUMENTATION CHANGE NOTICE

| Issue | Date | Page | Change Item | |
|---|---|---|---|---|
| 01 | 23/07/2014 | All | Original issue | |

Contributors to this work:

Cédric VIGREUX Hirex Engineering

# SEE TEST REPORT

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# 1 Introduction

This report presents the results of SEL Heavy Ions test program carried out on 4 Analog Devices AD780. During June 2014, 4 samples were used for heavy ions testing at TAMU, College Station, Texas, USA. This work was performed for Analog devices under PO n° 45457246 dated 03/04/2014

# 2 Applicable and Reference Documents

## 2.1 Applicable Documents

AD-1. Datasheet http://www.analog.com/static/imported-files/data_sheets/AD780.pdf

## 2.2 Reference Documents

RD-1. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100

# 3 DEVICE INFORMATION

## 3.1 Device description

The AD780 is a 2.5 V/3.0 V High Precision Reference.

| | |
|---|---|
| Part type: | AD780 |
| Manufacturer: | Analog Devices |
| Package: | FP-10 |
| Samples used | 4 |
| Top marking: | serial |
| Bottom marking: | E244018 PHIL |
| Date code: | - |
| Die dimensions: | 1.6 mm X. 2.3 mm |

## 3.2 Sample identification

10 AD780 parts were delivered by Analog Devices. All samples were prepared and delidded to be tested to heavy ions. 4 samples were verified fully functional before the test campaign, and 4 were tested under irradiation.

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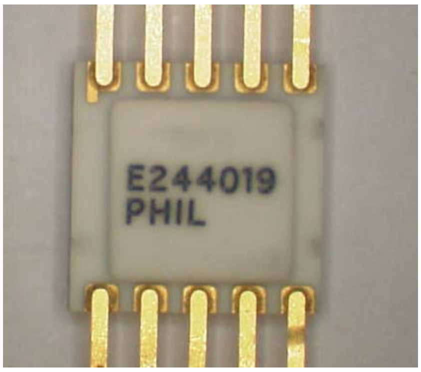


Photo 1 – Device top view

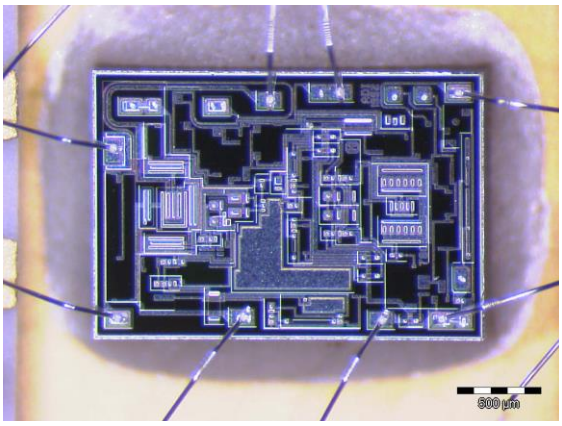

Photo 2 – Device delidded

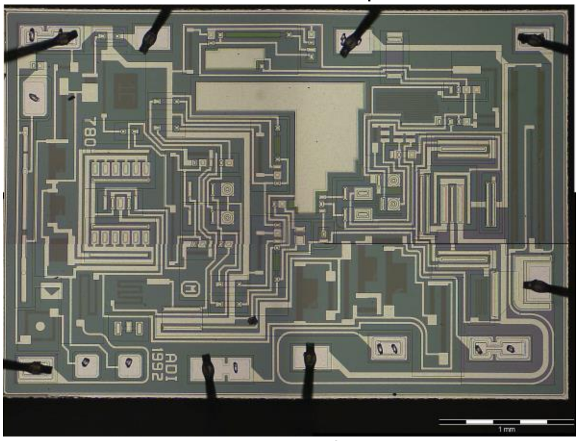

Photo 3 – die, full view

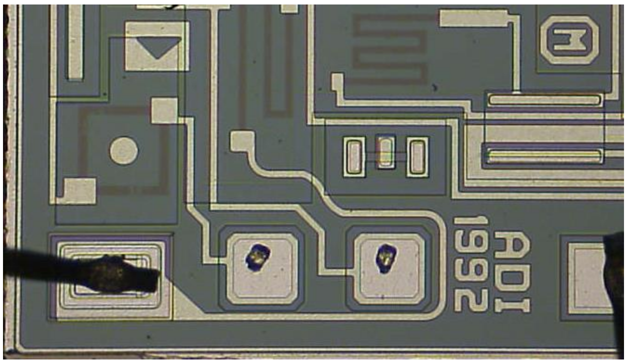


Photo 4 – Die marking

**Figure 1: AD780 device identification**

## 3.3 Sample preparation and evaluation of dead layer thickness

Samples were prepared by mechanical delidding.
Die micro-section results are given in appendix. Overall dead layer thickness on top of active zone is below 10 microns of equivalent silicon.

# 4 TAMU Facility

Test at the cyclotron accelerator was performed at Texas A & M in College Station - TX- USA.
This facility includes a special beam line dedicated to irradiation studies of semiconductor components and devices. Testing may be conducted in either 30" diameter vacuum chamber or with in-air positioning system . Both provide precise positioning in x, y, and z as well as rotations up to 60 degrees. Positioning and dosimetry are carried out by custom-made SEUSS software.

**In Air Station**

The in-air station is located at the end of dedicated beam-line. The station consists of a rotating platform and a removable target mounting fixture. The target positioning assembly allows the motion of the target in four directions: X, Y, Z and Theta. X and Y are the horizontal and the vertical axis in the target plane, respectively. The Z-axis is in the direction of the beam-line, with theta being the clockwise and counter-clockwise rotation about the y-axis. Target position verification is provided by the means of a CCD camera aligned with the beam path and a narrow laser beam that crosses the beam path at the center of the target chamber. The size of the exposed area is controlled by the aperture defined by a pair of remotely adjustable horizontal and vertical slits.

**Vacuum Station**

Vacuum station has an inside diameter of 30inch and a height 30inch.Pumping time to an operating pressure in the low 10 -4 Torr range is approximately ten minutes and the chamber vents to gaseous nitrogen in two and half minutes. Target positioning system allows X, Y, Z and Theta moving. Like for in air station, the position is checked with the means of a CCD camera.

**Ion Beam**

Various ion beams are available for the Radiation Effects Facility. These beams provide for a wide scope of LET with high energies for deep part penetration. Time for beam species changes will vary, but with species that have the same energy per nucleon change times is about one half hour.
Beams can be delivered with a high degree of uniformity over a 1.8" x 1.8" cross sectional area for measurements inside the vacuum chamber and 1" diameter circular cross sectional area for the in-air station. Uniformity is achieved by means of magnetic defocusing.
A degrader foil system makes it possible to set the desired beam LET value at a particular depth inside the target without changing the beam or rotating the target. The beam energy is reduced by means of a degrader system with foils having a suitable thickness and orientation with respect to the incident beam. Each foil can be inserted, withdrawn, and rotated remotely through use of computer controls.
The intensity of any beam is easily regulated over a broad range spanning several orders of magnitude in a matter of seconds. This can be done by the operator on duty at the users request.
The target exposure system is fully automated. Exposure can be set for a certain time, total accumulated fluence, or can be manually stopped at any time.

**Beam Quality control**

The beam uniformity and flux are determined using an array of five detectors. Each detector is made up with a plastic scintillator coupled to photo-multiplier tubes. Four of the detectors are fixed in position and set up to measure beam particle counting rates continuously at four characteristic points 1.64 inches (4.71 mm) away from the beam axis. The fifth scintillator can be optionally put in to measure the beam particle counting rate right at the beam axis. The sensitive area of each detector is defined by a 0.1 cm^2 aperture, while the intrinsic efficiency is 100% for all practical purposes. The beam uniformity parameter (ranging from 0 to 100%), the axial gain (%), and the beam flux (in particles/cm^2/s) are determined by the control software based on the detector counting rates. The results are displayed and updated once every second.

**Dosimetry**

The current TAMU Cyclotron dosimetry system and procedures were used.

**Beam configuration used**

15MeV/a cocktail have been for this test.

| Ion | Selected beam | Al degrader thickness (mil) | Number of layers (layer file name) | Beam energy (MeV) | Nominal LET (MeVcm2/mg) | Nominal range (um) |
|---|---|---|---|---|---|---|
| Xe | 15.0 MeV/u Xe | 2,096 | 3 (30 mm air) | 737 | 60 | 59.6 |
| Au | 15 MeV/u Xe | 0 | 3 (30 mm air) | 2247 | 85.4 | 118.1 |

**Figure 2 - ion beam setting**

# 5 Test Set-up

Test system Figure 3 shows the principle of the Heavy Ion test system.

The test system is based on a Virtex5 FPGA (Xilinx). It runs at 50 MHz. The test board has 168 I/Os which can be configured using several I/O standards.

The test board includes the voltage/current monitoring and the latch-up management of the DUT power supplies up to 24 independent channels.
The communication between the test chamber and the controlling computer is effectively done by a 100 Mbit/s Ethernet link which safely enables high speed data transfer.

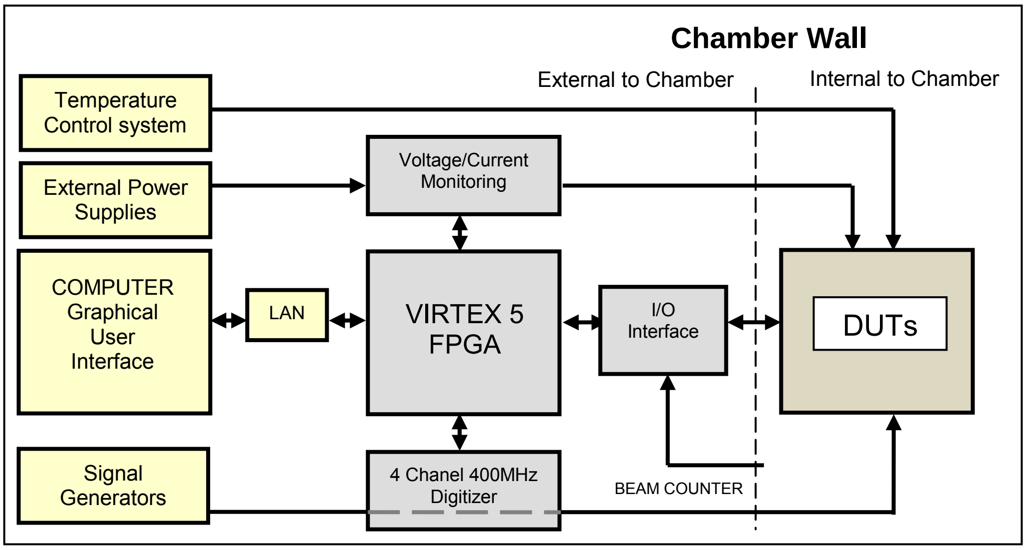


**Figure 3 - Heavy ion test set-up**

## 5.1 AD780 test principle and conditions

In order to test the AD780, two daughter boards were designed. Two DUTs were mounted on each board and bias conditions are given in
Figure 4 and Table 1. Table 2 gives the tester supply channel number used in the tester report.

DUT heating is performed with a thermal resistor and aluminum plate in contact with devices backsides. The temperature is regulated thank to a thermocouple sensor put on top of the device.

SEL event is detected when the supply current is over a configurable threshold (in the present case set to 100 mA) and processed (the power supplies are cut off during a configurable wait time, in the present case set to 1s).

The tester monitors independently the 2 DUTs supplies at the same time. If an SEL is detected on 1 supply channel, the tester system records current/voltage on all channels.

| Supply name | voltage |
|---|---|
| DUT_V+ | **36V** |

**Table 1 - Voltage bias conditions applied to the 2 DUTs**

| Supply name | Tester supply channel # |
|---|---|
| DUT1_V+ | **9** |
| DUT2_V+ | **10** |

**Table 2 - Tester supply channel affectation**

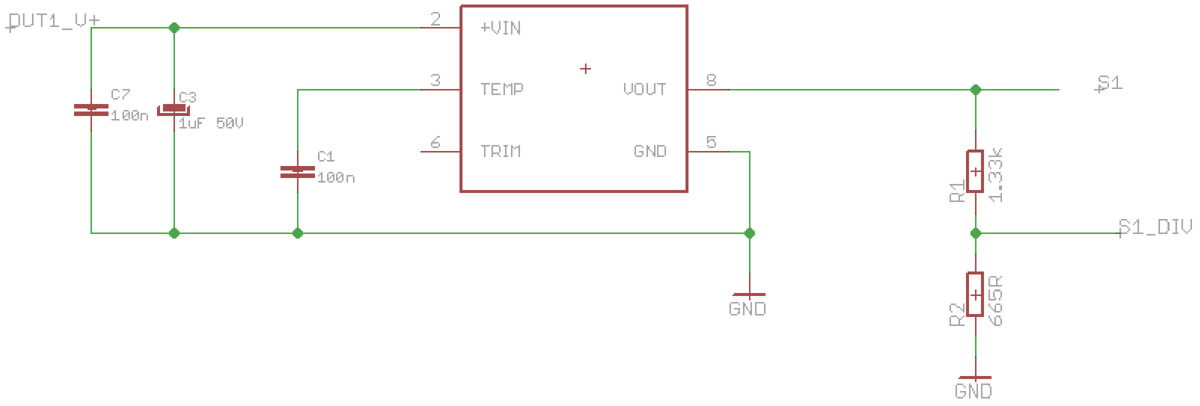


**Figure 4 – AD780 Bias condition**

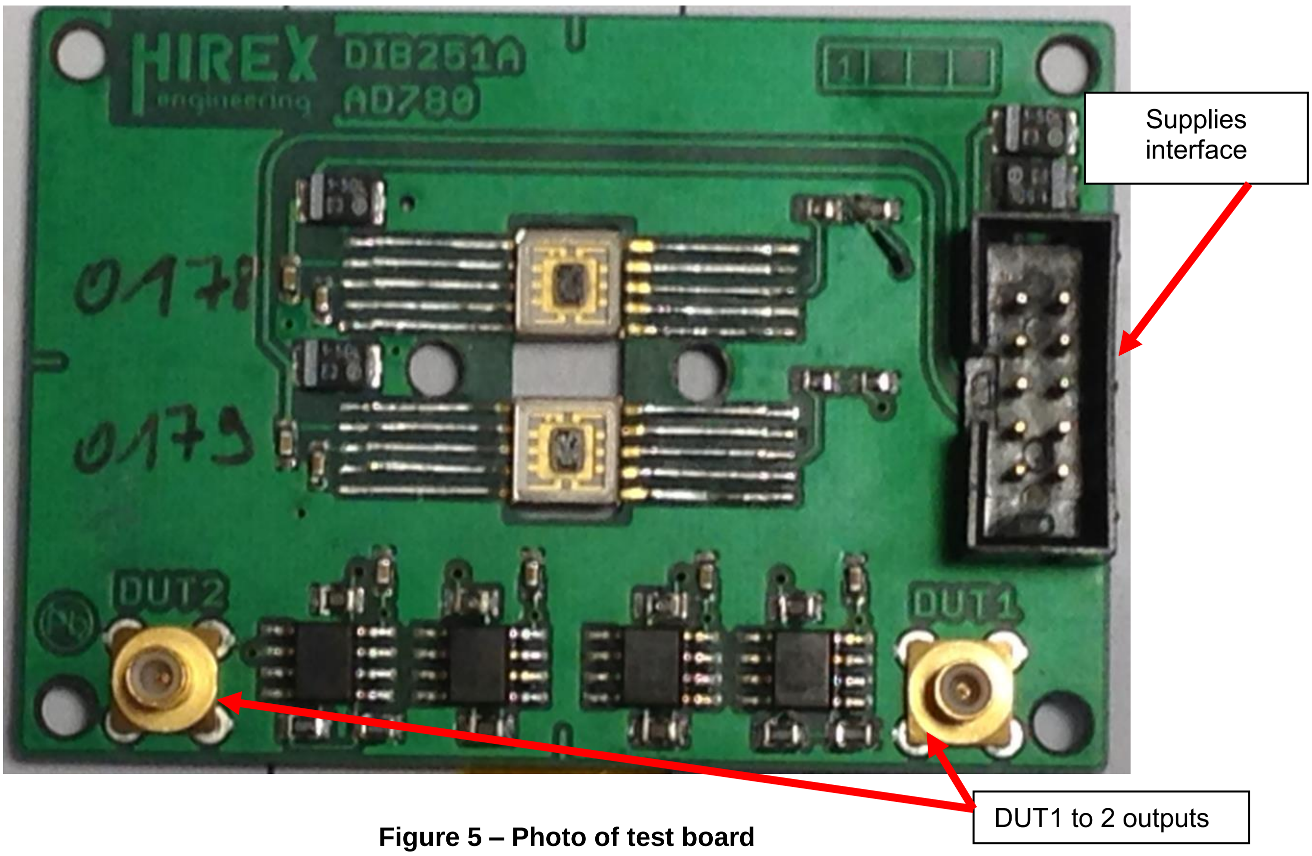


**Figure 5 – Photo of test board**

## SEE test results

Runs performed are listed in Table 3.

Upon test completion, all 4 samples were found fully functional

### 5.2 SEL Results

No SEL neither step current increase has been observed when tested with V+ set to +36V on the 4 samples with LET of 85 MeV/(mg/cm²) and at a temperature of 125°C.

| Run# | DUT# | Power supply V | Temperature °C | Ion | LET MeV/(mg/cm²) | Fluence Ions/cm² | Duration s | SEL |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 to 2 | 36 | 85 | Xe | 60 | 1,00E+07 | 498 | 0 |
| 2 | 1 to 2 | 36 | 125 | Xe | 60 | 1,00E+07 | 507 | 0 |
| 3 | 3 to 4 | 36 | 125 | Xe | 60 | 1,00E+07 | 475 | 0 |
| 4 | 1 to 2 | 36 | 85 | Au | 85.4 | 1,00E+07 | 440 | 0 |
| 5 | 1 to 2 | 36 | 125 | Au | 85.4 | 1,00E+07 | 452 | 0 |
| 6 | 3 to 4 | 36 | 125 | Au | 85.4 | 1,00E+07 | 431 | 0 |
| 7 | 3 to 4 | 36 | 125 | Au | 85.4 | 1,00E+07 | 386 | 0 |

**Table 3 - Run table for the AD780, TAMU June 2014**

# 6 Glossary

Most of the definitions here below are from JEDEC standard JESD89A

DUT: Device under test.

Fluence (of particle radiation incident on a surface): The total amount of particle radiant energy incident on a surface in a given period of time, divided by the area of the surface.
In this document, Fluence is expressed in ions per cm2.

Flux: The time rate of flow of particle radiant energy incident on a surface, divided by the area of that surface.
In this document, Flux is expressed in ions per cm2*s.

Single-Event Effect (SEE): Any measurable or observable change in state or performance of a microelectronic device, component, subsystem, or system (digital or analog) resulting from a single energetic particle strike.
Single-event effects include single-event upset (SEU), multiple-bit upset (MBU), multiple-cell upset (MCU), single-event functional interrupt (SEFI), single-event latch-up (SEL.

Single-Event Transient (SET): A soft error caused by the transient signal induced by a single energetic particle strike.

Single-Event Latch-up (SEL): An abnormal high-current state in a device caused by the passage of a single energetic particle through sensitive regions of the device structure and resulting in the loss of device functionality.
SEL may cause permanent damage to the device. If the device is not permanently damaged, power cycling of the device (off and back on) is necessary to restore normal operation.
An example of SEL in a CMOS device is when the passage of a single particle induces the creation of parasitic bipolar (p-n-p-n) shorting of power to ground.
Single-Event Latch-up (SEL) cross-section: the number of events per unit fluence. For chip SEL cross-section, the dimensions are cm2 per chip.

Error cross-section: the number of errors per unit fluence. For device error cross-section, the dimensions are cm2 per device. For bit error cross-section, the dimensions are cm2 per bit.

Tilt angle: tilt angle, rotation axis of the DUT board is perpendicular to the beam axis; roll angle, board rotation axis is parallel to the beam axis