SEE Test Report V1.0
Heavy ion SEE test of AD549 from Analog Devices

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I. Introduction

This study was undertaken to determine the single event destructive and transient susceptibility of the AD549, Ultralow Input-Bias Current Operational Amplifier, for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Lawrence Berkeley National Laboratory. This test was performed for the potential use in electronic circuitry for the Sample Analysis at Mars (SAM) project.

II. Devices Tested

The sample size of Device Under Test (DUT) for testing was three. Each device was exposed to the radiation beam and the results were compared for verification. The test samples code markings are AD549LH-0535.

The device used Topgate JFET technology, a process development exclusive to Analog Devices, Inc. This technology allows fabrication of extremely low input current JFETs compatible with a standard junction isolated bipolar process. The device is packaged in an 8-pin lead metal can package. The device was prepped for test by delidding.

III. Test Facility

Facility: Lawrence Berkeley Nuclear Laboratory 88 inch Cyclotron, 15 MeV/u beams

Flux: 1.10×10^5 to 1.39×10^5 particles/cm^2/s.

Fluence: For destructive events, all tests were ran to 1×10^7 p/cm^2 or until destructive events occurred

For non destructive events, all tests were ran to 1×10^7 p/cm^2 or until a sufficient (>100) number of transient events occurred.

Table 1: Ion an LET and range values at target for 0 degree incidence

Ion	LET ($MeV \cdot cm^2/mg$)	Range (μm)
Xe	58.72	96

IV. Test Conditions and Error Modes

Test Temperature: Room Temperature
Bias conditions Vin = 100Khz, 200Khz
See Table 2 for detailed conditions

Table 2: Initial Test conditions

	Vsupply (V)	Isupply (uA)	Vin (V)	Freq (hz)
DUT 1	+5/-5	828/769	5V	100K
DUT 2	+5/-5	820/768	5V	100K
DUT 3	+5/-5	823/769	5V	100K
DUT 1	+5/-5	588/578	5V	0
DUT 2	+5/-5	572/580	5V	0
DUT 3	+5/-5	580/610	5V	0
DUT 1	+15/-15	842/774	5V	100K
DUT 2	+15/-15	832/767	5V	100K
DUT 3	+15/-15	840/770	5V	100K
DUT 1	+15/-15	600/590	5V	0
DUT 2	+15/-15	584/592	5V	0
DUT 3	+15/-15	580/620	5V	0

PARAMETERS OF INTEREST: Power supply currents, output voltage

SEE Conditions: SEL, SEGR, SET

V. Test Methods

The block diagram, as shown in Figure 2, for the Operational Amplifier contains a two power supplies, each for +/- input voltages, a DUT board for the test circuitry and devices, a laptop for GPIB control of measurement equipment, and a digital scope to capture any output anomalies, and a After a frequency input (100Khz or 200Khz) was applied, each of the three device outputs displayed on the digital scope, which was set to trigger on voltages that are above or below a predetermined threshold (set to 75 mV).

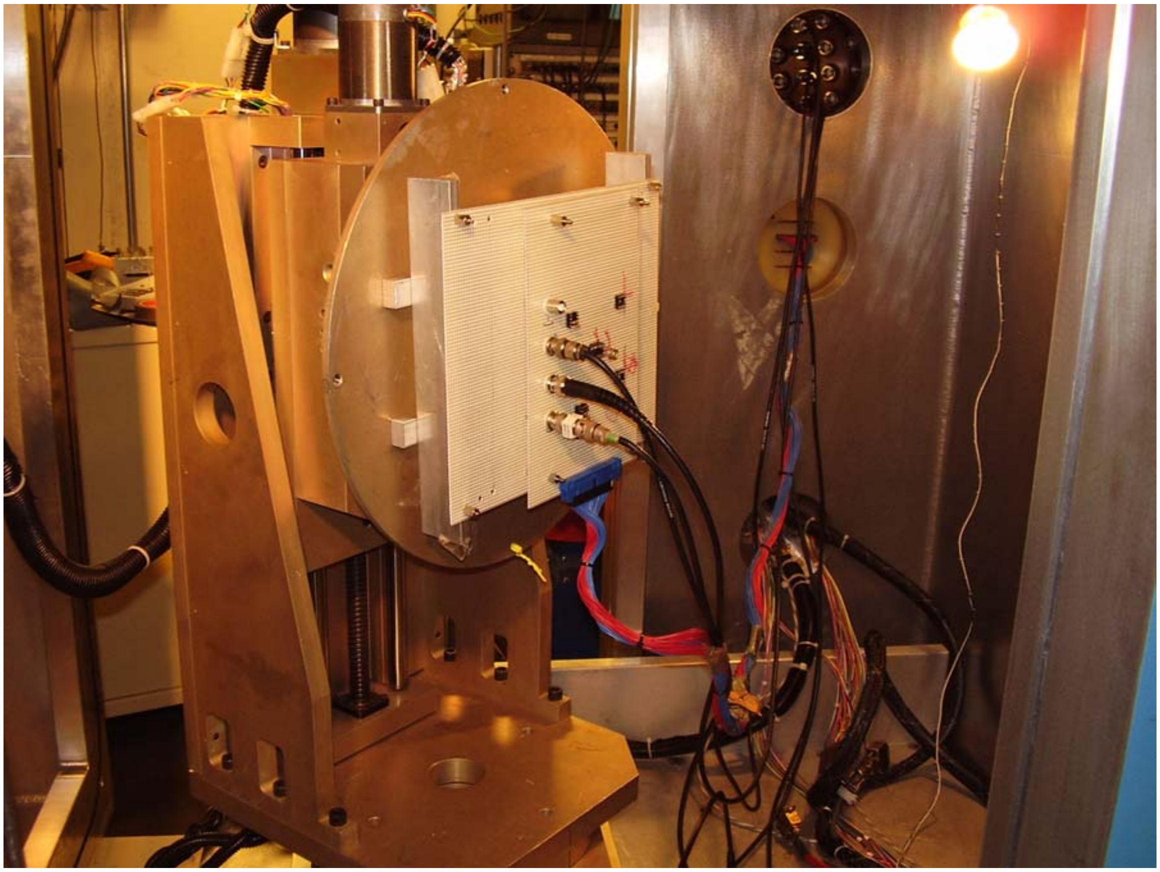

Figure 1. AD549 Test Board inside vacuum chamber in Lawrence Berkeley National Laboratory.

L091906_AD549

AD549 OP-AMP SEE Test Circuit

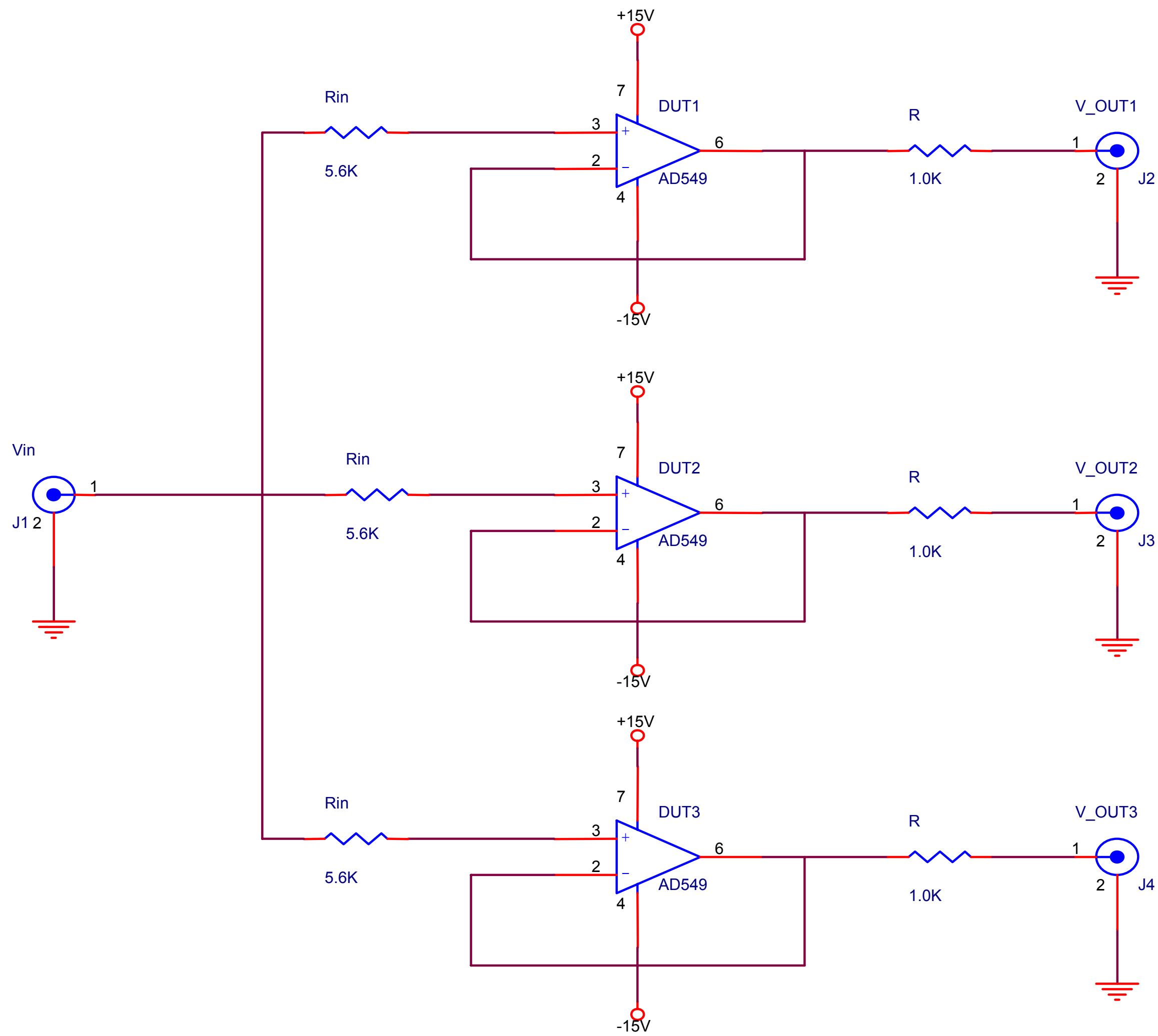

Figure 2. Test Circuit for the testing of the AD549

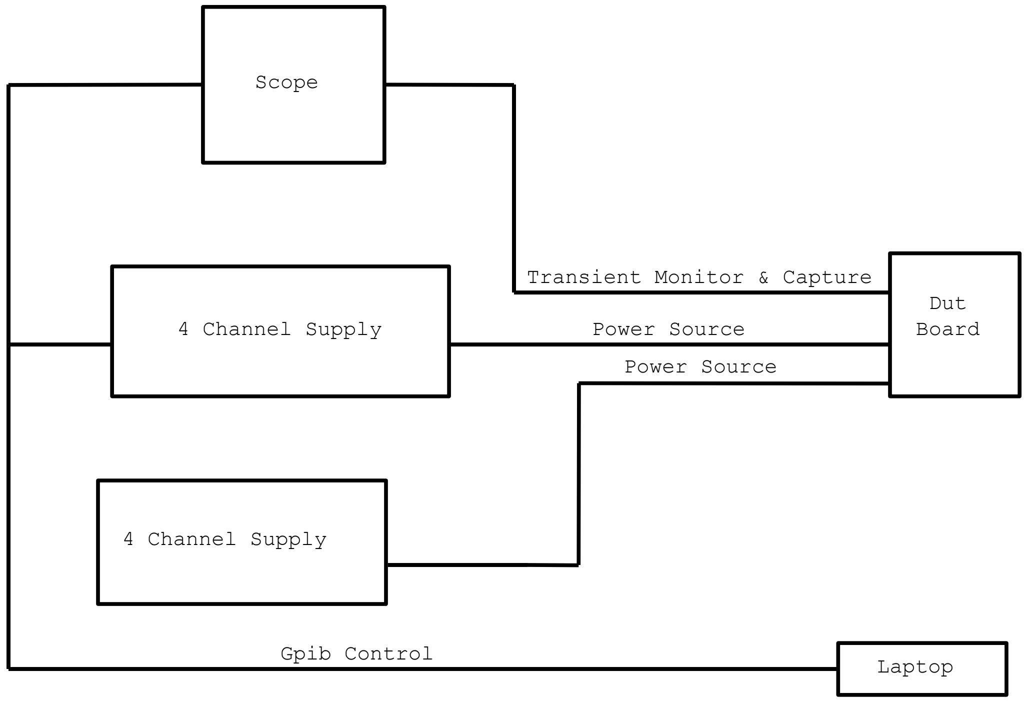

Figure 3. Overall Block Diagram for the testing of the AD549

VI. Test Results

Detailed test results are shown in Table 3 below. The devices were exposed from a fluence of 2..10 x 10^6 to 1.00 x 10^7 particles/cm2 of the Xenon ion beam. Observations for destructive events were for energies up to the maximum LET of 83 MeVcm2/mg. The AD549 was sensitive to transients and did experience errors that can be handled through mitigation. Chart 1 below shows a Weibull Fit Curve of the data collected. Run numbers 2,4,5, and 33 were cancelled runs.

Table 3: Test Data

RUN #	DUT #	Vcc	Vin	Freq (Khz)	Icc (mA)	Errors	Energy (MeV)	Effective LET (MeV-cm2/mg)	SEL	Cross Section (cm2/device)
1	1	15	5	100	1.2	12	1360	58.7	0	5.74E-06
3	1	15	5	100	1.2	31	1360	58.7	0	3.10E-06
6	1	15	5	200	1.2	18	1360	58.7	0	1.53E-06
7	1	15	5	200	1.2	16	1360	58.7	0	2.04E-06
8	1	15	5	100	1.2	22	1360	58.7	0	2.20E-06
9	1	15	5	100	1.2	35	1360	67.8	0	3.50E-06
10	1	15	5	100	1.2	26	1360	67.8	0	2.60E-06
11	1	15	5	200	1.2	20	1360	67.8	0	2.00E-06
12	1	15	5	200	1.2	9	1360	67.8	0	9.00E-07
13	1	15	5	100	1.2	24	1360	83.0	0	2.40E-06

14	1	15	5	100	1.2	25	1360	83.0	0	2.50E-06
15	1	15	5	200	1.2	19	1360	83.0	0	1.90E-06
16	1	15	5	200	1.2	19	1360	83.0	0	1.90E-06
17	2	15	5	100	1.2	27	1360	58.7	0	2.70E-06
18	2	15	5	100	1.2	18	1360	58.7	0	1.80E-06
19	2	15	5	200	1.2	14	1360	58.7	0	1.40E-06
20	2	15	5	200	1.2	11	1360	58.7	0	1.10E-06
21	2	15	5	100	1.2	22	1360	67.8	0	2.20E-06
22	2	15	5	100	1.2	27	1360	67.8	0	2.70E-06
23	2	15	5	200	1.2	11	1360	67.8	0	1.10E-06
24	2	15	5	200	1.2	12	1360	67.8	0	1.20E-06
25	2	15	5	100	1.2	26	1360	83.0	0	2.60E-06
26	2	15	5	100	1.2	16	1360	83.0	0	1.60E-06
27	2	15	5	200	1.2	21	1360	83.0	0	2.10E-06
28	2	15	5	200	1.2	11	1360	83.0	0	1.10E-06
29	3	15	5	100	1.2	26	1360	58.7	0	2.60E-06
30	3	15	5	100	1.2	19	1360	58.7	0	1.90E-06
31	3	15	5	200	1.2	18	1360	58.7	0	1.80E-06
32	3	15	5	200	1.2	13	1360	58.7	0	1.30E-06
34	3	15	5	100	1.2	27	1360	67.8	0	2.70E-06
35	3	15	5	100	1.2	18	1360	67.8	0	1.80E-06
36	3	15	5	200	1.2	13	1360	67.8	0	1.30E-06
37	3	15	5	200	1.2	14	1360	83.0	0	1.40E-06
38	3	15	5	100	1.2	22	1360	83.0	0	2.20E-06
39	3	15	5	100	1.2	28	1360	83.0	0	2.80E-06
40	3	15	5	200	1.2	15	1360	83.0	0	1.50E-06
41	3	15	5	200	1.2	12	1360	83.0	0	1.20E-06
42	3	15	5	500	1.2	8	1360	83.0	0	8.00E-07
43	3	15	5	500	1.2	12	1360	83.0	0	1.20E-06

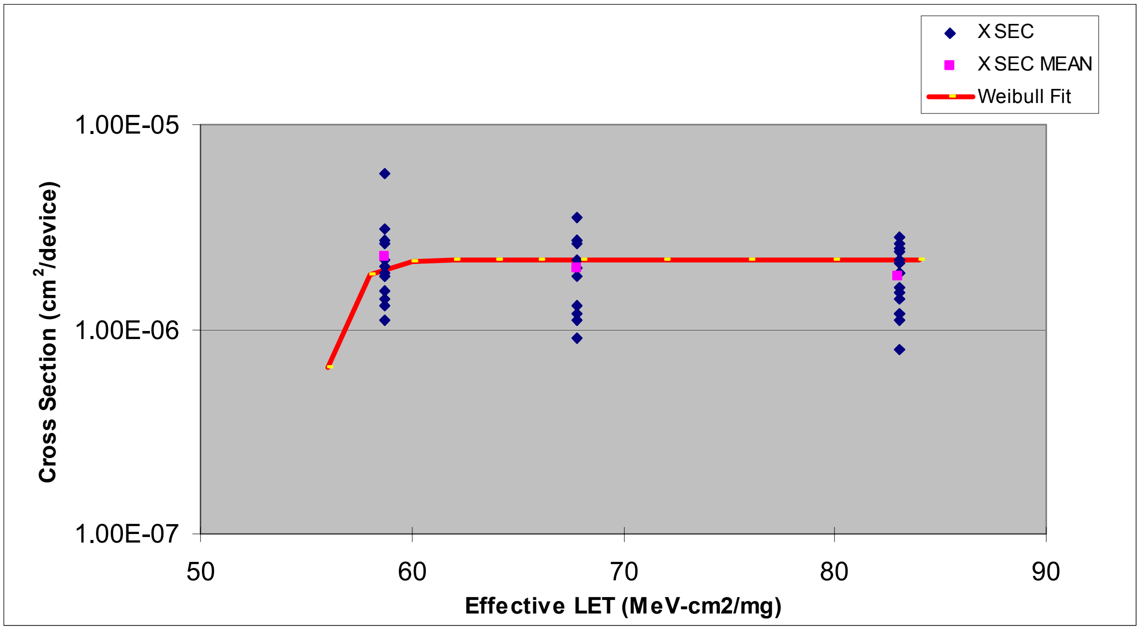

Chart 1. Weibull fit curve for SEL testing of the AD549.

Appendix 1:
http://www.analog.com/
http://www.analog.com/en/prod/0,,759_786_AD549,00.html