SEE Test Report V5.0
Heavy ion SEE test of Optek from Analog Devices

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I. Introduction

This study was undertaken to determine the Single Event Latchup (SEL) and Single Event Transient (SET) susceptibility of the Optek Hall Effect Sensor, OMH3075B, for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Lawrence Berkeley Nuclear Laboratory. Utilizing the Berkeley Accelerator Space Effects Facility (BASEF), this test was performed for the potential use in electronic circuitry for the Sample Analysis at Mars (SAM) Instrument as a part of the Mars Science Laboratory (MSL) Project.

II. Devices Tested

The sample size of Device Under Test (DUT) for testing was four. Three devices were exposed to the radiation beam and one control device compared for verification. The test samples code markings are for DUT1-SN0011, DUT2-SN0137, and DUT3-SN0136.

The device contained a monolithic integrated circuit, which incorporates a Hall element, a linear amplifier, a threshold amplifier, and Schmitt trigger on a single Hallogic silicon chip. A bandgap voltage regulator was included on-chip to allow operation with a wide range of supply voltages. The power supply ranged from 4.5 to 24V.

III. Test Facility

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

Flux: 1.47×10^3 to 1.26×10^5 particles/cm^2/s.

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

For non destructive events, all tests will be run to 1×10^6 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•cm^2/mg)	Range (µm)
Xe	58.72	96

IV. Test Conditions and Error Modes

Test Temperature: Room Temperature
Bias conditions Vcc = 5V, Magnetic Coil Inserted/Removed from DUT
See Table 1 for detailed conditions

Table 2: Test conditions

	Switch		Magnet		Icc	Vcc
	On	Off	Inserted	Removed	(mA)	(V)
DUT 1	On		Inserted		6.7	5V
DUT 1	On		Removed		6.7	5V
DUT 1	Off		Inserted		4.2	5V
DUT 1	Off		Removed		4.2	5V
DUT 2	On		Inserted		6.7	5V
DUT 2	On		Removed		6.7	5V
DUT 2	Off		Inserted		4.2	5V
DUT 2	Off		Removed		4.2	5V
DUT 3	On		Inserted		6.7	5V
DUT 3	On		Removed		6.7	5V
DUT 3	Off		Inserted		4.2	5V
DUT 3	Off		Removed		4.2	5V

PARAMETERS OF INTEREST: Power supply currents, output voltage

SEE Conditions: SEL, SEGR, SET

V. Test Methods

The device was tested in four conditions for each of the devices utilizing the sensor switch and the magnet as shown in Table 2. After the sensor switch was powered on, the magnet coil will be inserted then removed from the DUT. Next the sensor switch was turned off and then the magnetic coil procedure was repeated. Each of the three device outputs was displayed on the digital scope, which was set to trigger on voltages that are above or below a predetermined threshold (set to 75 mV). Each device output was tested one after each other and these characterizations were performed for each exposure run. All anomalies were recorded.

The block diagram, as shown in Figure 1, contained a power supply, a DUT board for the test circuitry, a laptop for GPIB control of measurement equipment, and a digital scope to capture any output anomalies.

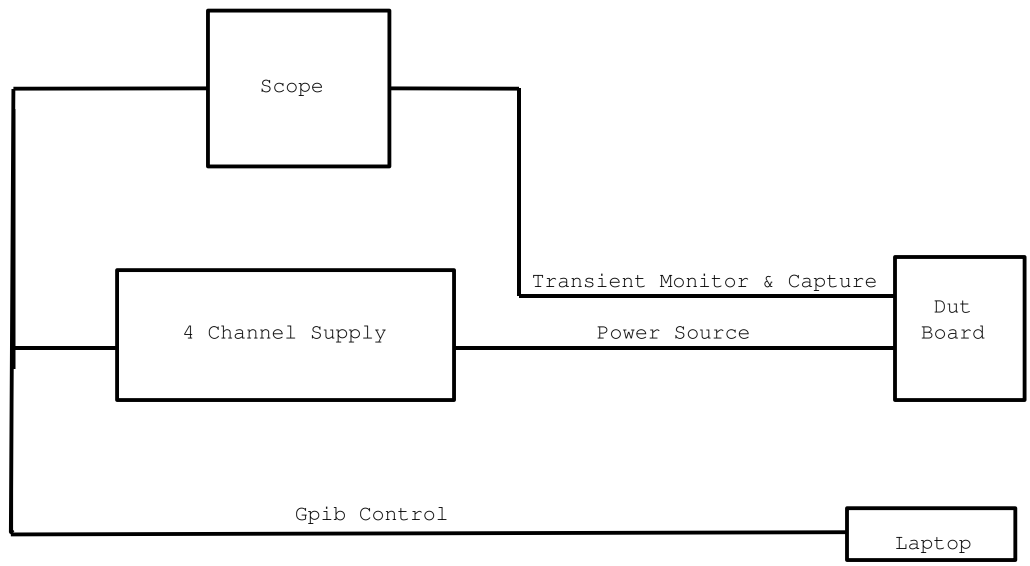

Figure 1. Optek Hall Effect Sensor Overall Block Diagram for the testing

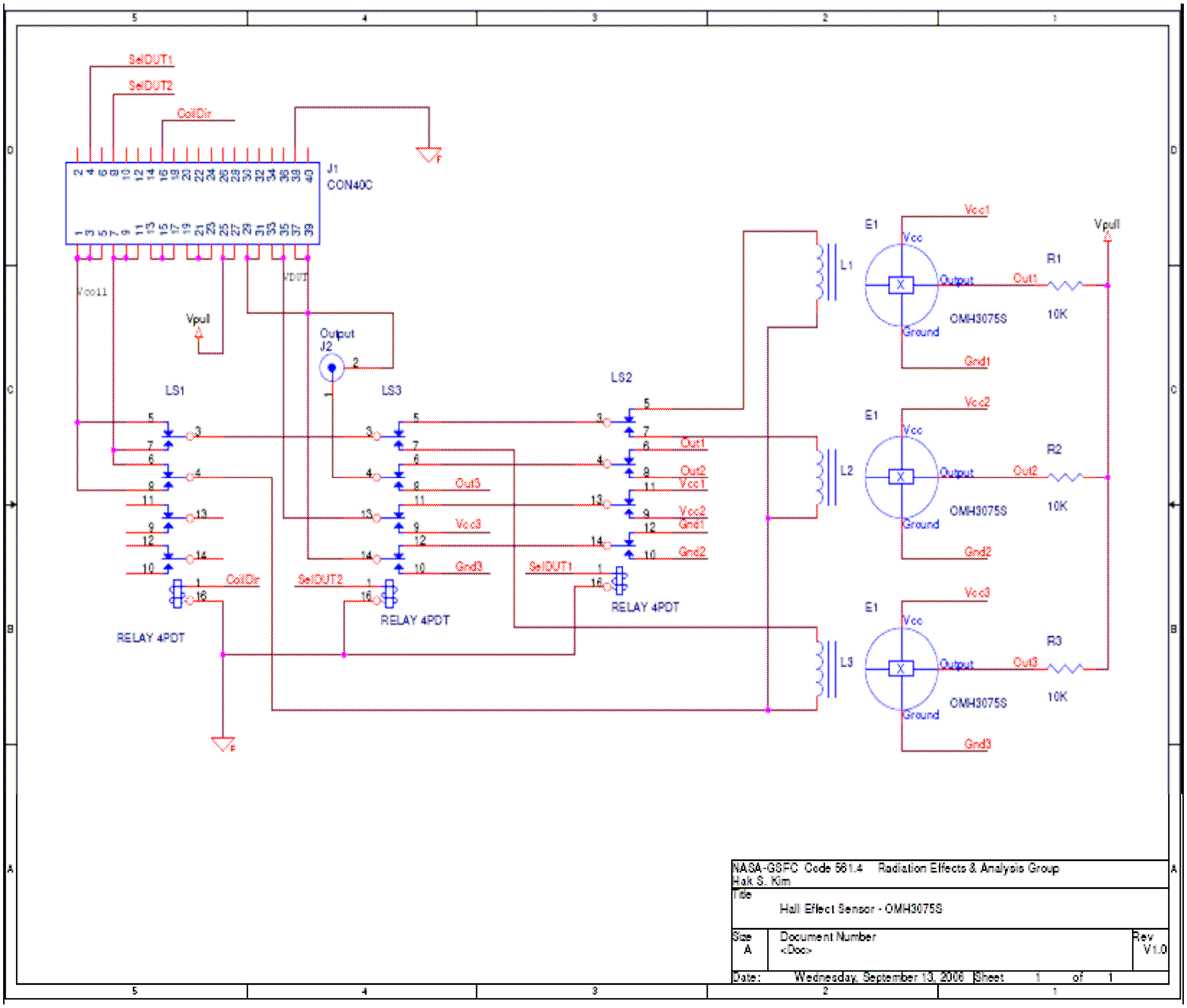

Figure 2. Optek Hall Effect Sensor Schematic for the testing

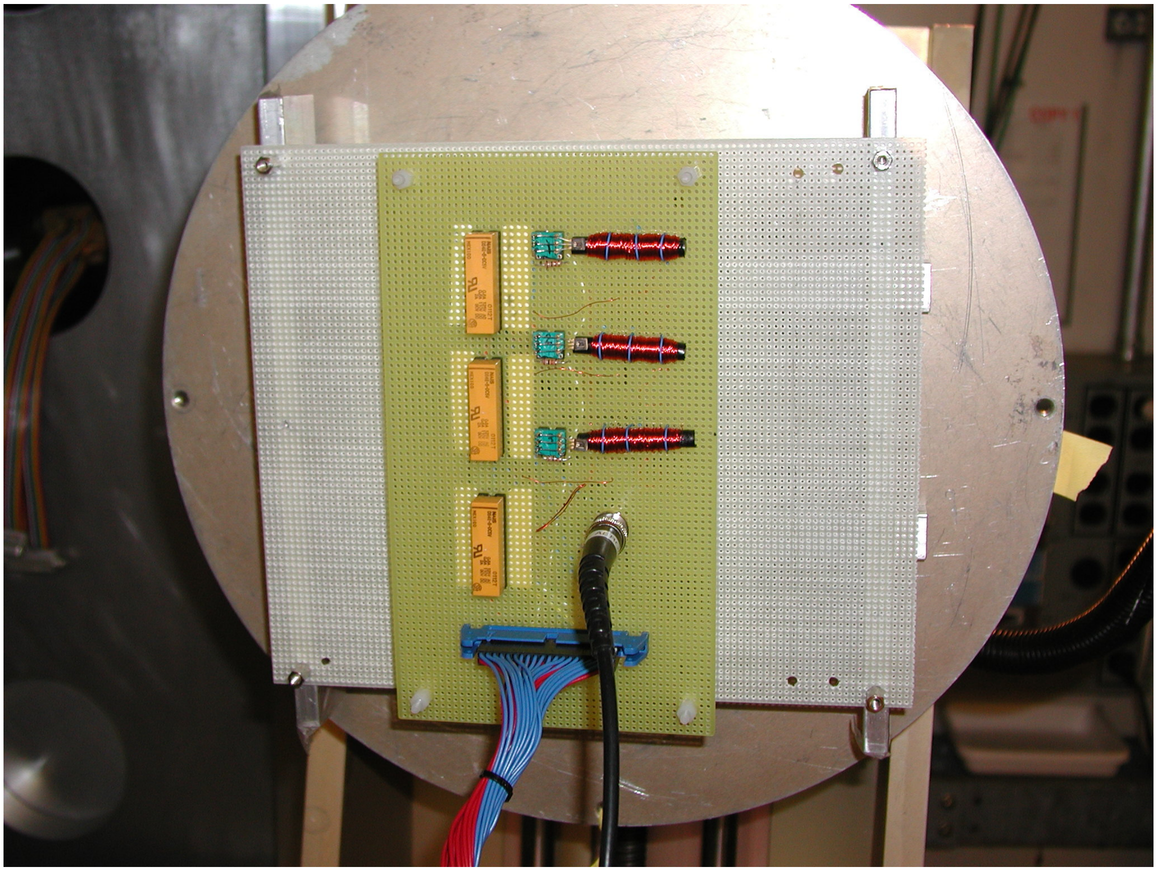

Figure 3. Test Board mounted inside chamber at Lawrence Berkeley National Laboratory ready for beam.

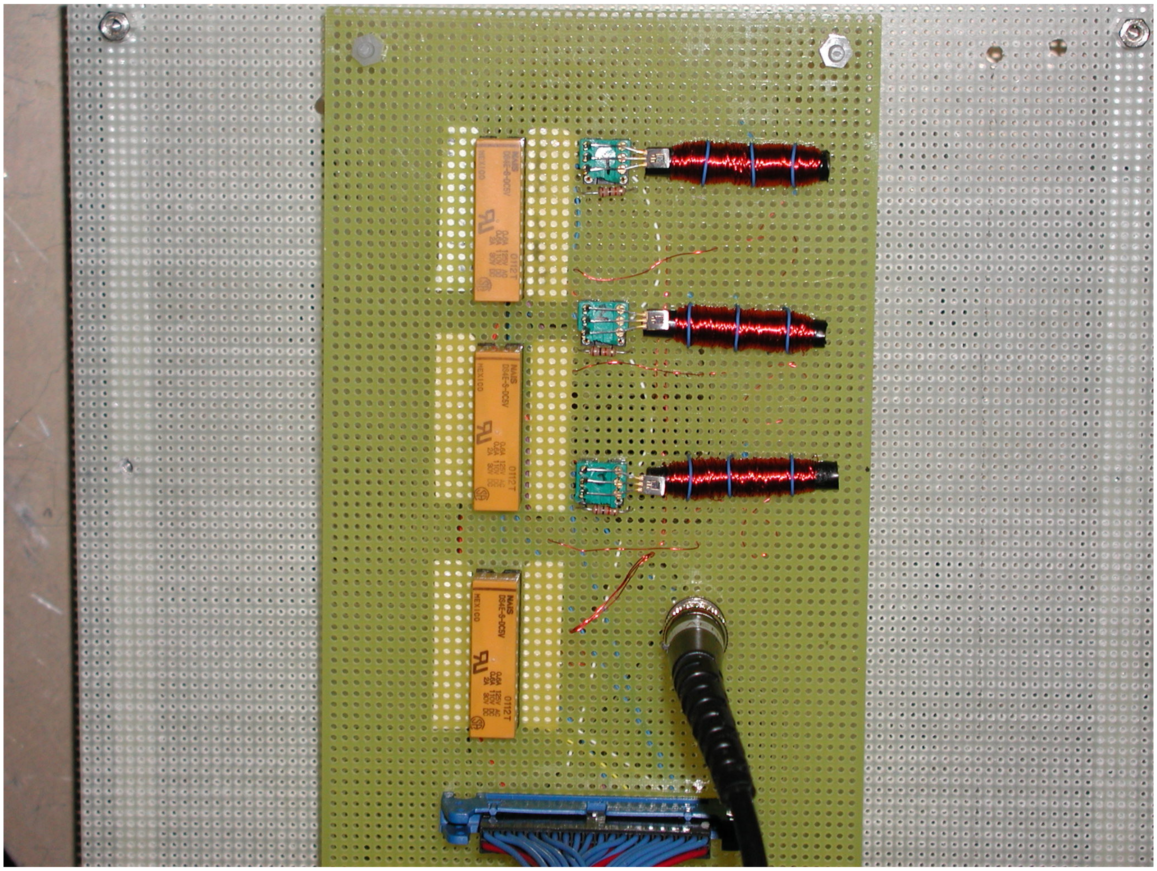

Figure 4. Optek Hall Effect Sensors adjoined by magnetic coils on right.

VI. Test Results

Detailed test results are shown in Table 3 below. The devices were exposed from a fluence of 1.34 x 10^4 to 2.00 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 OMH3075 was sensitive to SETs and did experience errors that can be mitigated. These errors were more frequent at Vcc at 24V than at 5V. With the magnet removed the results were the same whether the switch was on or off, so only one value was taken for this condition with the switch on and the magnet removed. A similar error count was found for the switch off and the magnet inserted. The least amount of errors occurred when the switch was on and the magnet inserted. Charts 1 and 2 below show the worse case transient event for Full Width Half Max (FWHM) and Chart 3 shows a Weibull Fit Curve of the data collected.

Table 3: Test conditions

RUN #	DUT #	Vmag	Vcc	Switch	Magnet	Icc (mA)	Errors	Energy	eff LET	SEL	X SEC
1	1	3	5	on	inserted	5.7	104	1360	58.7	0	9.72E-05
2	1	3	5	on	inserted	5.7	40	1360	58.7	0	1.19E-04
3	1	3	5	on	removed	5.7	137	1360	58.7	0	3.66E-04
4	1	3	5	on	removed	5.7	94	1360	58.7	0	3.21E-04
5	1	3	5	off	removed	3.8	110	1360	58.7	0	2.81E-04
6	1	3	5	off	inserted	3.8	103	1360	58.7	0	3.65E-04
7	1	3	5	on	inserted	5.7	38	1360	67.8	0	1.16E-04
8	1	3	5	on	removed	5.7	111	1360	67.8	0	6.10E-04
9	1	3	5	off	inserted	3.8	109	1360	67.8	0	4.84E-04
10	1	3	5	off	inserted	3.8	104	1360	83.0	0	4.60E-04
11	1	3	5	on	inserted	5.7	27	1360	83.0	0	7.63E-05
12	1	3	5	on	removed	5.7	105	1360	83.0	0	6.21E-04
13	2	4	5	off	inserted	3.8	105	1360	58.7	0	3.62E-04
14	2	4	5	on	inserted	5.7	28	1360	58.7	0	9.21E-05
15	2	4	5	on	removed	5.7	108	1360	58.7	0	6.43E-04
16	2	4	5	off	inserted	3.8	99	1360	67.8	0	3.79E-04
17	2	4	5	on	inserted	5.7	24	1360	67.8	0	8.99E-05
18	2	4	5	on	removed	5.7	99	1360	67.8	0	7.50E-04
19	2	4	5	off	inserted	3.8	103	1360	83.0	0	5.99E-04
20	2	4	5	on	inserted	5.7	21	1360	83.0	0	5.77E-05
21	2	4	5	on	removed	5.7	102	1360	83.0	0	5.67E-04
22	3	3	5	off	inserted	3.8	100	1360	58.7	0	3.41E-04
23	3	3	5	on	inserted	5.7	75	1360	58.7	0	7.50E-05
24	3	3	5	on	removed	5.7	132	1360	58.7	0	5.52E-04
25	3	3	5	off	inserted	3.8	112	1360	67.8	0	3.94E-04
26	3	3	5	on	inserted	5.7	83	1360	67.8	0	8.30E-05
27	3	3	5	on	removed	5.7	106	1360	67.8	0	5.99E-04
28	3	3	5	off	inserted	3.8	103	1360	83.0	0	4.60E-04
29	3	3	5	on	inserted	5.7	94	1360	83.0	0	9.40E-05
30	3	3	5	on	removed	5.7	101	1360	83.0	0	6.60E-04
31	1	5	5	off	inserted	3.8	40	1360	58.7	0	4.74E-04
32	1	2.5	5	off	inserted	3.8	50	1360	58.7	0	3.29E-04
33	1	2.5	5	off	inserted	3.8	54	1360	58.7	0	3.62E-04
34	1	5	5	off	inserted	3.8	51	1360	58.7	0	3.13E-04
35	1	3	24	off	inserted	3.8	72	1360	58.7	0	3.91E+01
36	3	3	24	off	inserted	3.8	567	1360	58.7	0	3.61E-04
37	3	3	24	off	inserted	3.8	1760	1360	58.7	0	1.76E-04
38	3	3	24	on	inserted	5.7	352	1360	58.7	0	3.52E-05
39	3	3	24	on	removed	5.7	2142	1360	58.7	0	2.14E-04
40	3	3	24	off	inserted	3.8	2282	1360	83.0	0	2.28E-04
41	3	3	24	on	inserted	5.7	397	1360	83.0	0	3.97E-05
42	3	3	24	on	removed	5.7	2648	1360	83.0	0	2.65E-04
43	3	3	24	on	inserted	5.7	286	1360	83.0	0	2.86E-05
44	3	3	24	off	inserted	3.8	2096	1360	83.0	0	2.10E-04
43	2	4	24	on	inserted	5.7	376	1360	83.0	0	3.76E-05
44	2	4	24	off	inserted	3.8	2097	1360	83.0	0	2.10E-04
45	1	3	24	on	inserted	5.7	376	1360	83.0	0	3.76E-05

46	1	3	24	off	inserted	3.8	2277	1360	83.0	0	2.28E-04
47	1	3	24	off	inserted	3.8	343	1360	83.0	0	3.43E-05
48	1	3	24	off	inserted	3.8	2084	1360	83.0	0	2.08E-04
49	3	2.5	5	off	inserted	3.8	60	1360	83.0	0	4.48E-04
50	3	5	5	off	inserted	3.8	49	1360	83.0	0	3.25E-04
51	3	2	5	off	inserted	3.8	56	1360	83.0	0	3.48E-04
52	3	1.85	5	off	inserted	3.8	52	1360	83.0	0	3.23E-04

Sensor On with Magnet Present

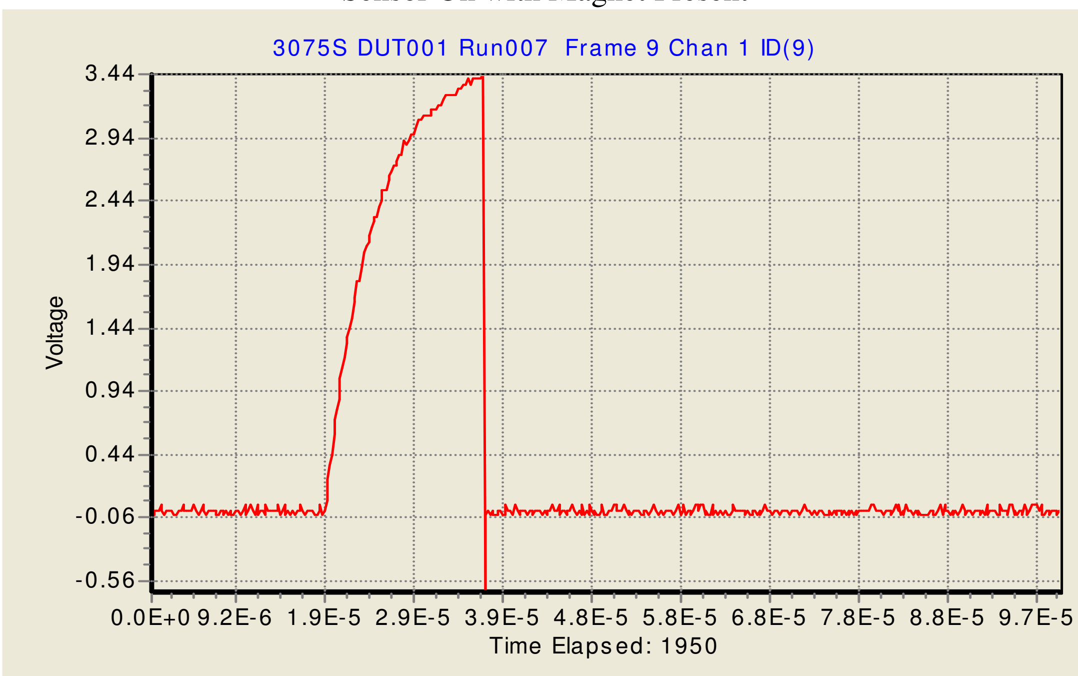

Chart 1. FWHM Transient of 14us at 1.72V

Sensor Off with Magnet Present

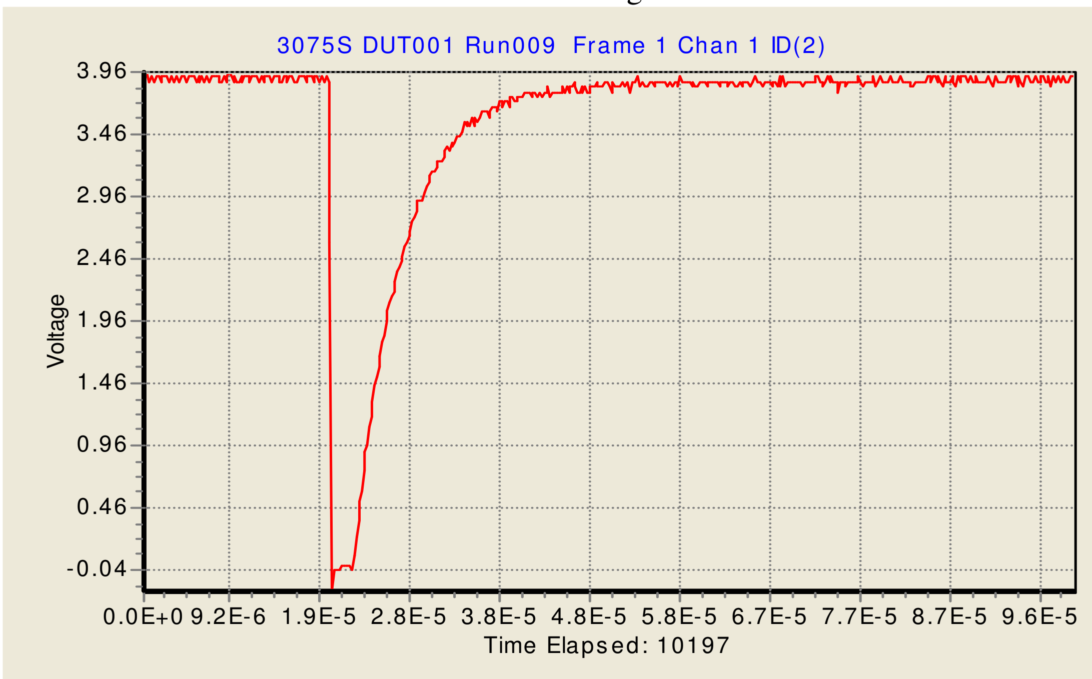

Chart 2. FWHM Transient of 6us at 1.98V

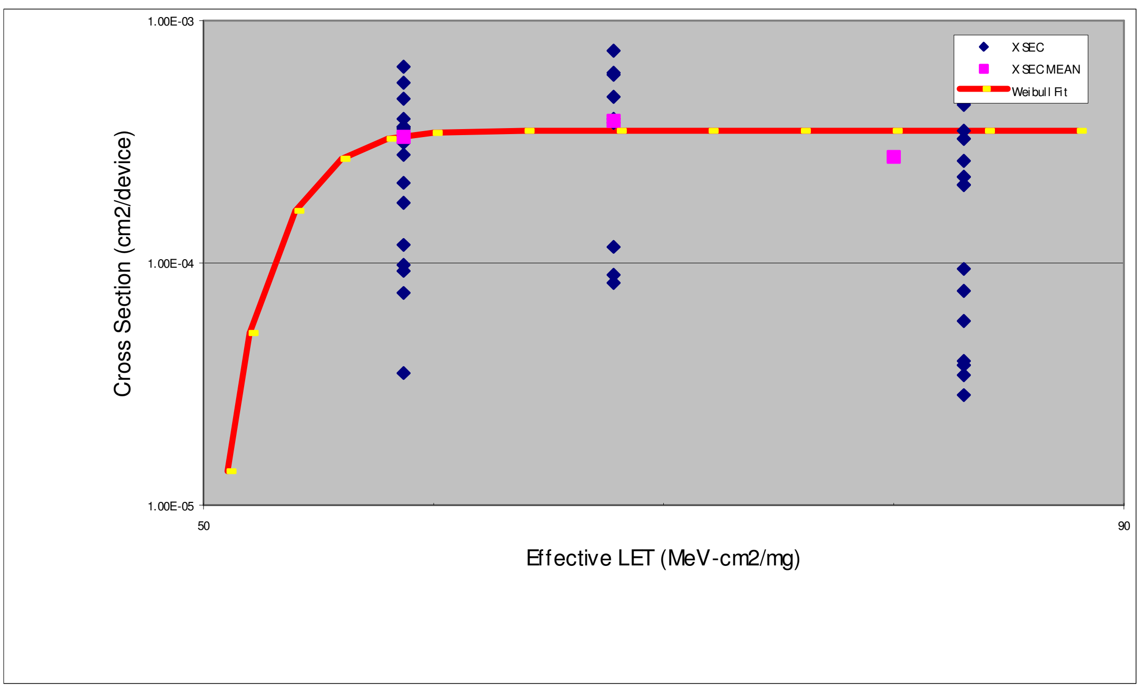

Chart 3. Weibull fit curve for SEL testing of the OMH3075.

VII. COMMENTS AND RECOMMENDATIONS

- Three Optek Hall Effect Sensor OMH3075 devices did not experience SEL up to an LET of 83 MeV/ (mg/cm^2).
- The devices were exposed from a fluence of 9.74×10^3 to 1.00×10^7 particles/cm^2 of the Xenon ion beam per run.
- Transients were observed for all runs that can be handled through mitigation with magnet present.
- Magnetic presence is needed to return device to current condition after a transient event has occurred.
- On and inserted mode: (Magnet Present)
  - Full Width Half Max Transient of 14us
  - Magnetic pulls sensor back to on condition after transient event
- Off and inserted mode: (Magnet Present)
  - FWHM Transient of 6us
  - Magnetic pulls sensor back to off condition after transient event
- On/Off and removed mode: (Magnet Removed)
  - Transient of at least 80us captured
  - Sensor remains in opposite condition after transient event

Recommendation: This device is recommended for usage in NASA/GSFC spaceflight applications, but may require mitigation techniques.

Appendix 1:
http://www.optekinc.com/
http://www.optekinc.com/pdf/OMH090-3075.pdf