SINGLE EVENT TRANSIENT TEST REPORT

PRODUCT:	ADL5513/QMLR
DIE TYPE:	ADL5513
DATE CODE:	1132
CASE TEMPERATURE:	25°C
EFFECTIVE LET:	(8.6 - 80.2) MeV-cm^2/mg
AVERAGE FLUX:	(6.75e3 - 1.27e5) ion/cm^2/s
TOTAL EFFECTIVE FLUENCE:	(2.06E5 - 1E7) ion/cm^2
FACILITIES:	Texas A&M University – K500 Cyclotron Superconducting Facility
TESTED:	September 26, 2011

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Single Event Transient Testing of the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller for Analog Devices

Customer: Analog Devices (PO# 45352065)

RAD Job Number: 11-473

Part Types Tested: Analog Devices ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller. The units were irradiated on September 26th, 2011.

Traceability Information: Manufacturing Code: E195635.1 wafer 11 and E195637.1 wafer 12; see a photograph of a sample unit-under-test in Appendix A for traceability information/part markings.

Quantity of Parts for Testing: Four units were exposed to a maximum fluence of 1E7ion/cm^2 at a maximum LET of approximately 80MeV-cm^2/mg. Three of the units were exposed using the worst-case bias for SET event of 2.7V and at ambient room temperature

Pre-Irradiation Burn-In: Burn-in not specified by the customer.

Referenced Test Standard(s): ASTM F1192, EIA/JESD57

Electrical Test Conditions: Output V_{OUT} monitored during exposure for SET events. The supply current was also monitored during exposure.

Test Software / Hardware: See Appendix C, Table C.1 for a list of test equipment and calibration dates.

Bias Conditions: All units-under-test were biased during heavy ion irradiation using a worst-case supply potential and while operating at 5MHz. See Section 4 and Appendix B for the details of the bias conditions.

Ion Energy and LET Ranges: 15MeV/n Ho, Kr and Ar beams with a maximum effective LET of approximately 80MeV-cm^2/mg. The 15MeV/n Ho beam had a minimum range of approximately 100µm in silicon to the Bragg Peak (which is the shortest range particle used).

Heavy Ion Flux and Maximum Fluence Levels: Flux of approximately 1E4ion/cm^2 to 1E5ion/cm^2 (depending on SET rate of the unit-under-test). Maximum 1E7 ions/cm^2 per unit tested, depending on the number of SET events detected.

Facility and Radiation Source: Texas A&M University (TAMU) using the K500 Cyclotron and the 15MeV/n beam.

Irradiation Temperature: Approximately 25°C case temperature (ambient room temperature for the TAMU Radiation Effects Facility exposure room.

The ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller exhibited SET events at various LETs. The units exhibited a relatively low error cross-section/device of approximately 2E-5cm^2. The SETs were manifested primarily as disruptions in the output level lasting less than a couple of microseconds.

1.0. Overview and Background

It is well known that heavy ion exposure can cause soft errors (temporary events) that can spontaneously recover or require an external operation to restore. The errors can occur through various mechanisms including single event upset (SEU), single event functional interrupt (SEFI) and/or single event transient (SET). A SEU event occurs when a feedback storage element (typically a 6-transistor memory cell or D-type flip-flop) switches from one state to the other. That is a logical "1" flips to a logical "0" or vice versa. This new (and incorrect) state persists until the user rewrites the correct data into the storage element. A single event functional interrupt is similar to an SEU event in that a storage element switches state due to a single heavy ion. Where an SEU generally affects only a single bit of data within a word (and is usually correctable using error detection and correction (EDAC) a SEFI will cause the loss of proper functionality of the unit-under-test and will frequently require a power cycle to restore proper operation of the device.

An SET is an error that usually affects combinational logic cells instead of storage latches (as discussed above for SEUs and SEFIs). For SETs the heavy ion will cause a momentary disruption of an input or output of a particular cell within the unit-under-test that propagates through the internal logic paths and becomes manifested as a temporary disruption of the proper operation of the device. The two test standards usually used to govern this testing are ASTM F1192 and EIA/JESD57. This non-destructive single event effects testing is usually performed at the minimum datasheet voltage and at room temperature to a total fluence of 1E6ion/cm2 or until a "statistically significant" number of events are captured.

2.0. Single Event Transient Test Apparatus

The non-destructive single event effects testing described in this final report was performed at Texas A&M University (TAMU) using their K500 Cyclotron. The testing was performed in air using the 15MeV/n beam. This beam was selected since it provides plenty of range for de-encapsulated or delidded die being irradiated from the top surface and offers a wide selection of ions and LETs. When necessary, beam degraders can be inserted into the beam line to achieve the desired LET and a wider LET range for a given ion. The beam characteristics and dosimetry were provided by the Texas A&M heavy ion test facility. TAMU can deliver the beam with a high degree of uniformity over a 1-inch diameter circular cross sectional area using the in-air test system. Uniformity is achieved by magnetic defocusing and by thin foil scattering. The beam uniformity and flux are determined using an array of five plastic scintillators coupled to photo multiplier tubes, located in the diagnostic chamber adjacent to and upstream from the target. Four of the five 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 center. The fifth scintillator is inserted to measure the beam particle counting rate right at the beam axis and is removed to provide an unobstructed beam during testing. The control software determines the beam uniformity (ranging from 0 to 100%), axial gain (%), and beam flux (in particles/cm^2/s) based on the scintillator counting rates. The parameters are displayed on the computer screen in the control room and are updated about once every second.

For the SET testing described in this final report the units-under-test were placed in the exposure room and aligned with the heavy ion beam line. The test stage has full x and y alignment capabilities along with 2-dimensional rotation, allowing for a variety of effective LETs for each ion. Each ion is calibrated just prior to use using five photomultiplier tubes (PMTs), as discussed above. Figure 2.1 shows an illustration of the facility; including the location of radiation effects facility, where heavy ion SEE testing takes place.

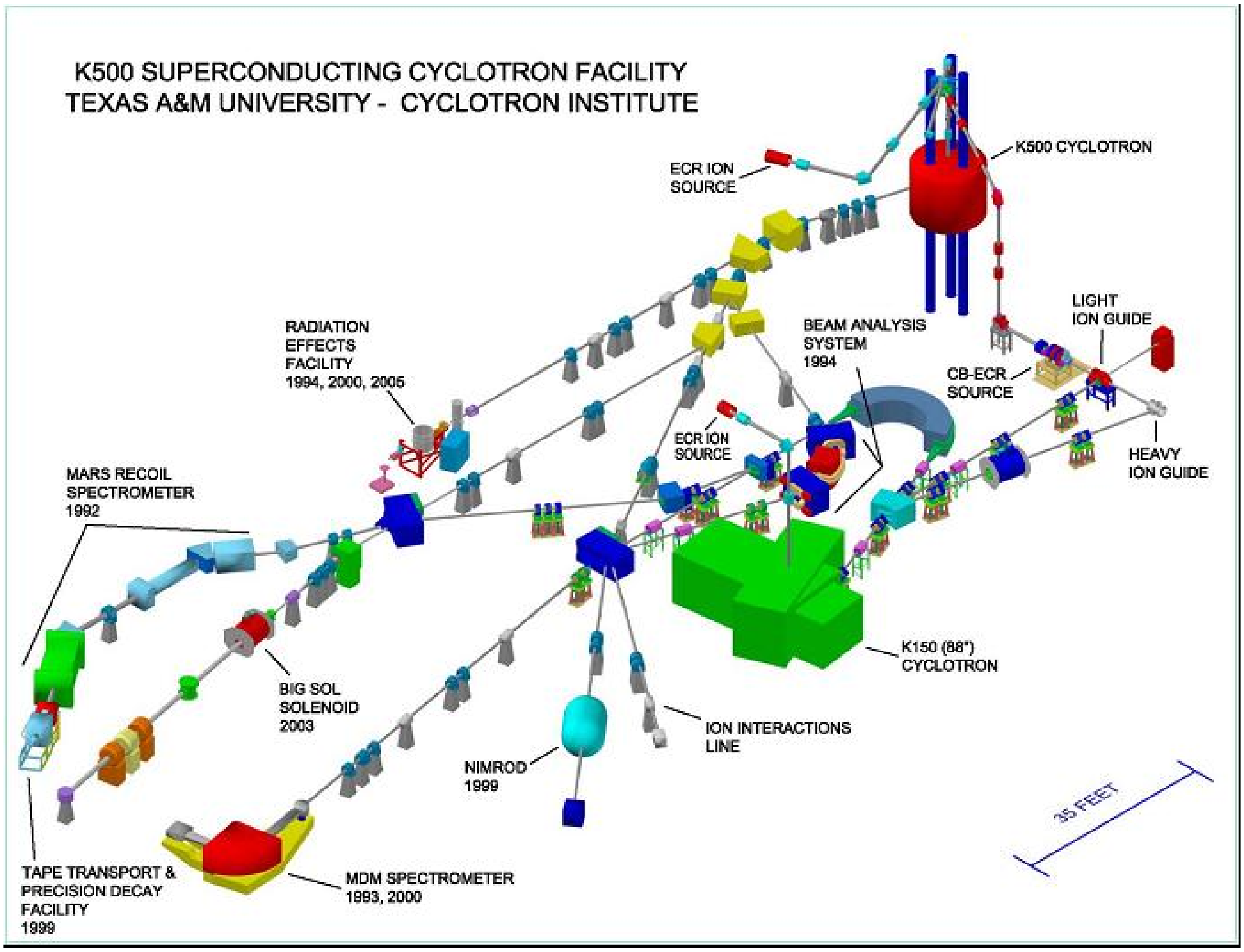


Figure 2.1. Map of K500 Cyclotron Facility at Texas A&M University. The location of the radiation effects, where the SEE testing discussed in this report was performed, is shown on the left-hand side of the diagram.

3.0. Radiation Test Conditions

The ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller described in this final report was irradiated using the 15MeV/n Ho, Kr and Ar using a (worst-case) supply voltage of 2.7V and at a case temperatures of approximately 25°C (±5°C), which was ambient room temperature for the TAMU Radiation Effects Facility exposure room during this test run. Note that minimum datasheet input supply potentials are generally considered to be worst-case for single event transient testing. Figure 3.1 shows the test board used for the SET testing described in this final report. The test board was mounted on the test stage at TAMU and provided 3-axis of motion plus rotation. The board had two units-under-test that allowed for sequential testing of the units without entering the exposure room during testing. See the test circuit schematic in Appendix B for the specific details of the bias conditions. Additional features of the test board include:

1. Log Amps individually powered – power inputs filtered via RLC filters. (See top of site 1 schematic in Appendix B).

2. Outputs brought out for monitoring

3. Log Amp inputs held at steady-state cw rf signal during testing

4. V_{OUT} tied to V_{SET} (20mV/dB) on daughter card

5. T_{ADJ} set at 0.9V

6. Outputs are buffered with Gain = +2 (Ideal output at scope should range from 1.6V to 3.3V). Range is limited by input signal and system noise floor.

The 15MeV/n beam was used to provide sufficient range in silicon while meeting the LET requirements of the program. The other beams available at TAMU are the 25MeV/n beam and the 40MeV/n beam. While both the 25MeV/n and 40MeV/n beam would provide additional range for this type of SEE testing, the additional cost of using these beams is not justified since the 15MeV/n fully penetrates the active layer with a range to the Bragg peak of greater than 50µm.

Figure 3.2 shows the 15MeV/n beam characteristics for holmium, krypton and argon calculated using SRIM. As seen in the figure, the 15MeV/n Ho beam has a surface LET of approximately 67MeV-cm^2/mg, an LET of approximately 82MeV-cm^2/mg at the Bragg peak and a range to the Bragg peak of more than 100µm in silicon. Figure 3.3 shows the characteristics for all the 15MeV/n beams available at TAMU.

Note that the units-under-test were decapsulated prior to testing and all exposures took place from the top surface in air and through an Aramica foil. Based on the technology of the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller we assume a distance to the active layer in silicon of approximately 5 to 10μm providing for irradiation well below the Bragg peak for all of the ions used. See Appendix A for a photo of the die (unit-under-test delidded in preparation for the SEE testing).

During the irradiation, the flux varied somewhat, but was consistently targeted between approximately 1E4ion/cm^2-s to 1E5ion/cm^2-s depending on the ion species and the response of the unit-under-test. The irradiation of the units-under-test continued until either the minimum fluence was reached or a sufficient number of SET events were observed.

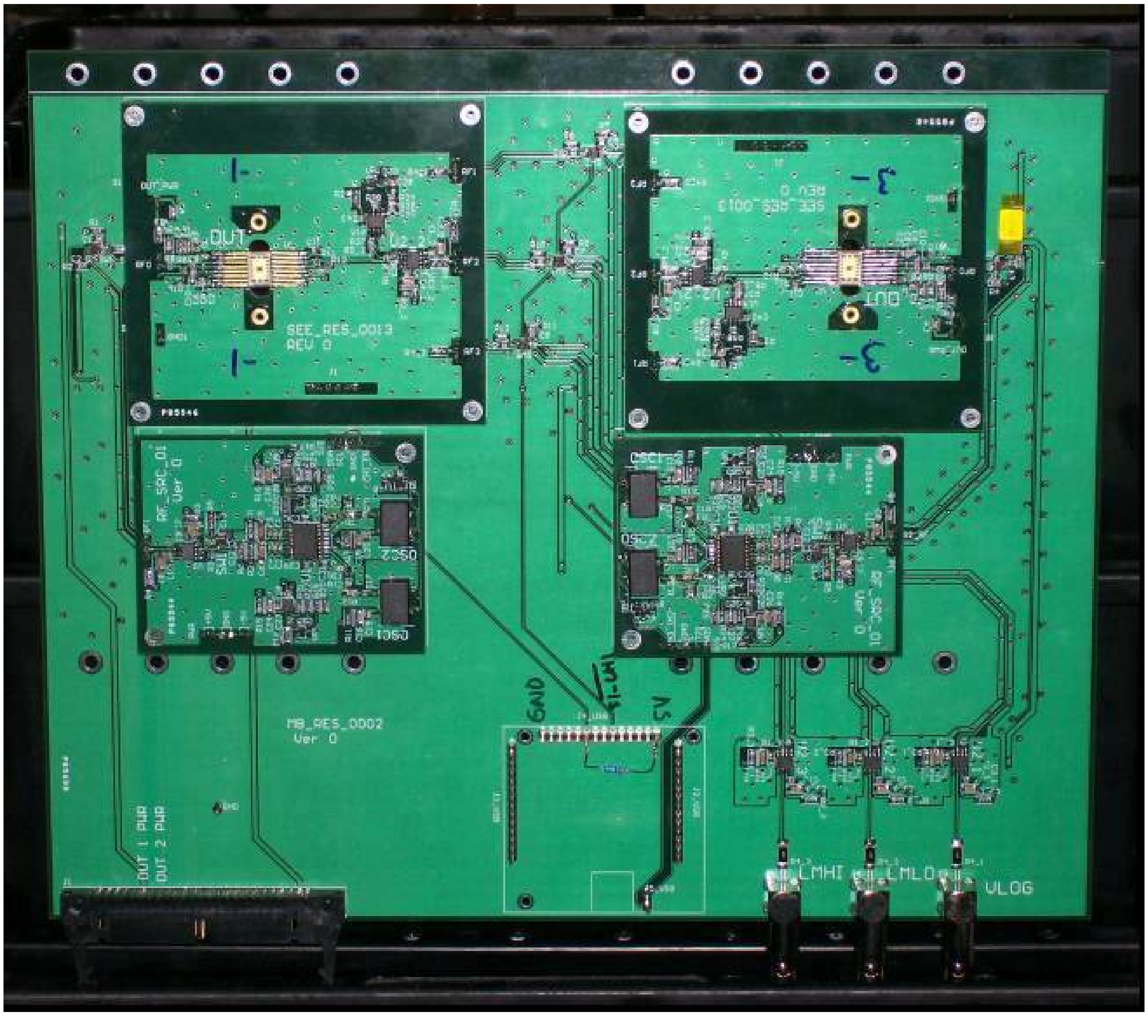


Figure 3.1. Single event test board prepared for mounting on the test stage at TAMU. The board has two units-under-test mounted simultaneously to minimize interruptions during testing. Also seen on the motherboard are two custom RF source daughter cards used to supply clean 5MHz or 10MHz signals to the units-under-test.

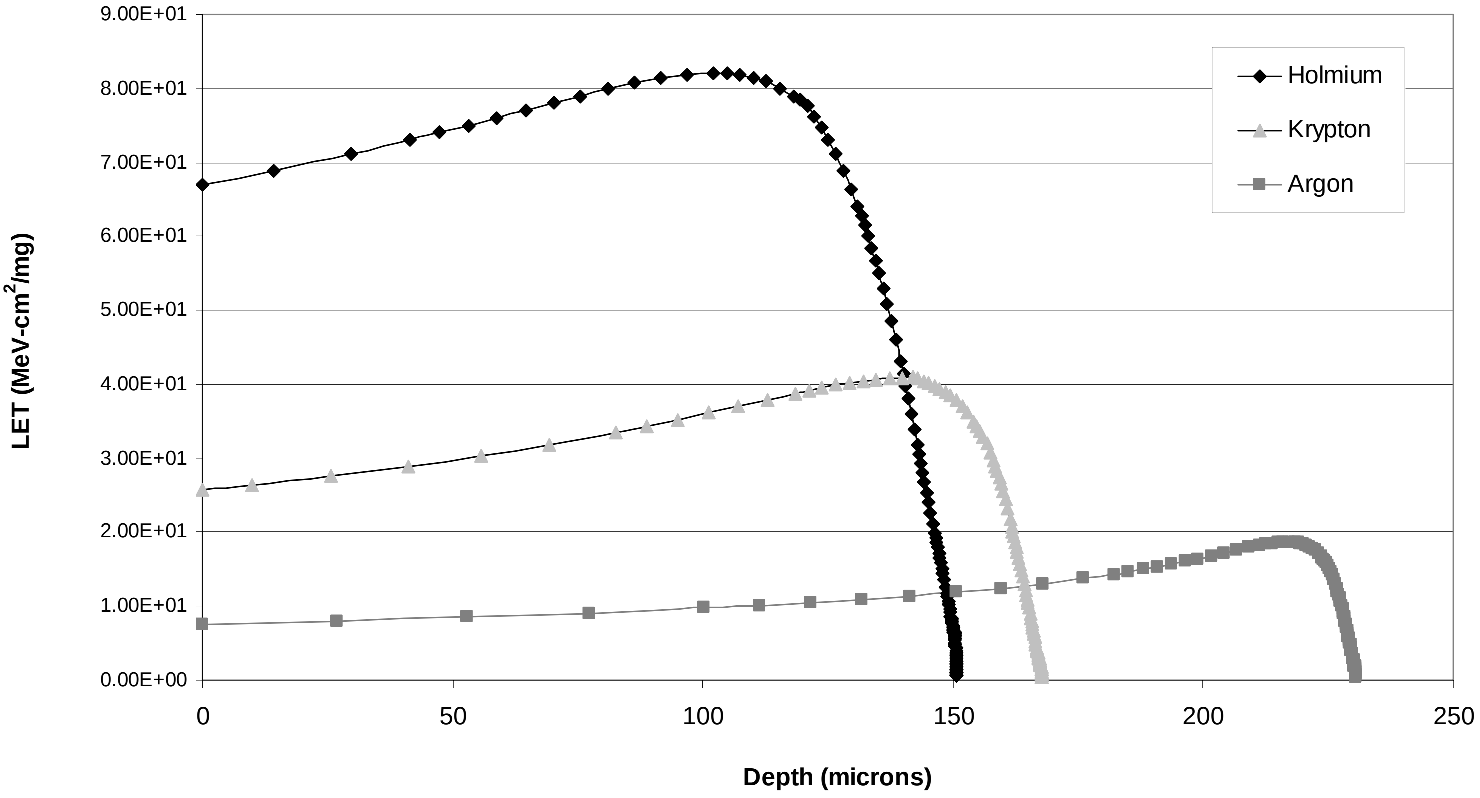
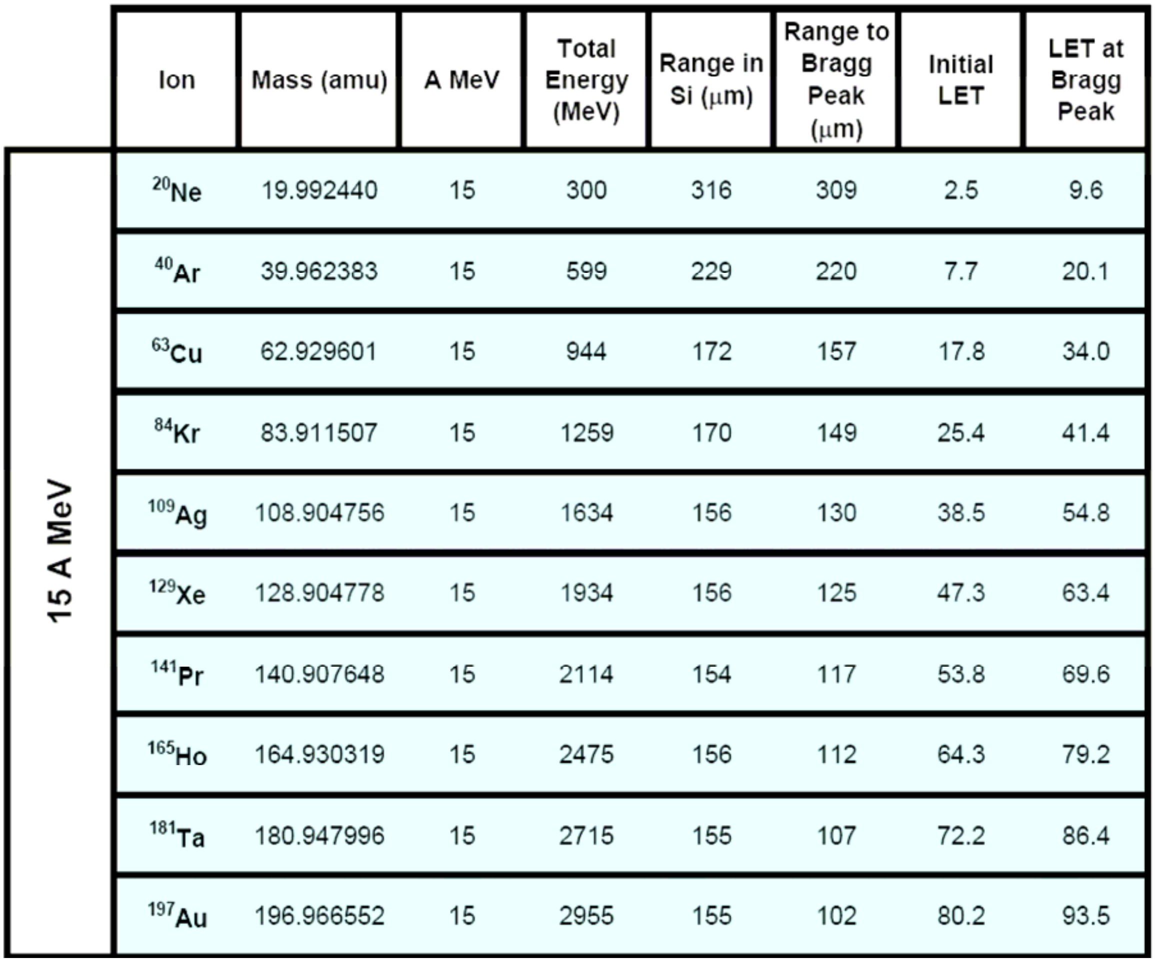


Figure 3.2. Range of the 10MeV/n Ho, Kr and Ar beams into silicon. The range to the Bragg Peak for Ho (the shortest range ion used) is approximately 100µm while the surface LET is approximately 67MeV-cm2/mg.



	Ion	Mass (amu)	A MeV	Total Energy (MeV)	Range in Si (μm)	Range to Bragg Peak (μm)	Initial LET	LET at Bragg Peak
15 A MeV	^{20}Ne	19.992440	15	300	316	309	2.5	9.6
	^{40}Ar	39.962383	15	599	229	220	7.7	20.1
	^{63}Cu	62.929601	15	944	172	157	17.8	34.0
	^{84}Kr	83.911507	15	1259	170	149	25.4	41.4
	^{109}Ag	108.904756	15	1634	156	130	38.5	54.8
	^{129}Xe	128.904778	15	1934	156	125	47.3	63.4
	^{141}Pr	140.907648	15	2114	154	117	53.8	69.6
	^{165}Ho	164.930319	15	2475	156	112	64.3	79.2
	^{181}Ta	180.947996	15	2715	155	107	72.2	86.4
	^{197}Au	196.966552	15	2955	155	102	80.2	93.5

Figure 3.3. Characteristics of all the 15MeV/n beams available at Texas A&M University. For the testing discussed in this report the 15MeV/n beam was used exclusively.

4.0. Tested Parameters

During the heavy ion exposure the V_{OUT} output of the units-under-test was measured for proper operation and the potential existence of transients. The units-under-test were run using a 5MHz clock signal generated using RF source daughter cards mounted on the test motherboard. The output was captured on a digitizing oscilloscope (see Table C.1 for a list of the equipment used during this test) with the oscilloscope set to trigger whenever a significant distortion in the output amplitude. The output was configured for a nominal 1.2V output and the trigger was set approximately 100mV above and below the output level. Note that for each test, the oscilloscope could run "indefinitely" in the acquisition/"ready for trigger" mode without triggering or capturing a waveform without application of the heavy ion beam. Therefore, we have a very high likelihood that after the unit-under-test was exposed to the heavy ion beam and an event occurs that the event was caused by the heavy ion radiation and not spurious noise.

During the SET portion of the heavy ion exposure the device was also monitored for single event latchup events, which would interfere with the operation of the unit-under-test and consequently the capture of SET events. The singe event latchup behavior of this device is reported separately in a report entitled "Single Event Latchup Testing of the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller for Analog Devices". Table 4.1 summarizes the single event transient tests performed for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller. The table records the total effective fluence, the average flux, the run time, the beam energy, the ion and the effective LET. As noted above, the SET testing occurred at a case temperature of approximately 25°C (±5°C).

In general there are no pass/fail criteria for non-destructive SEE testing. The testing is used to calculate the error rate (or event rate) for specific mission applications and it is up to the user to determine whether or not the error rate is acceptable for their particular application. Further, for SETs the characteristic of the transient event can be at least as important as the overall error rate. Therefore, in this report we provide the raw data for error cross-section versus LET and Weibull fitting parameters that can be used to estimate the SET error rate in a given orbit environment using a space radiation effects code such as CREME96, SPENVIS or SpaceRadiation and we also provide a sample oscilloscope captures that are representative of the SET events observed during the testing. Note that the full set of SET events is available in a separate format.

For the testing described in this report the following general test procedure was used:

1. Turn on power (DUT power = +2.7V, board power = ±5V)
2. Select Site 1 by setting (1 state) S1_EN
3. Select either input Frequency (5MHz or 10MHz) using S1_CH1_EN
4. Leave device at room temperature
5. Program RF Source with 0x08 in the high byte and 0x00 in the low byte

6. Configure scope to capture transients outside of noise floor on VOUT output
7. Turn ON ion beam, observe/monitor/log device current
8. Record scope data (waveforms, number of triggers, etc.)
9. Change ion flux as dictated (too many triggers/sec, too few)
10. Repeat process with different ion energies

Table 4.1. Summary of the single event transient test runs for the Analog Devices ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller.

Run	DUT	Wafer	VPOS (V)	Temp (°C)	Ion	Effective LET (MeV-cm2/mg)	Effective Range (um)	Effective Fluence (ion/cm2)	Dose (rad)	Average Flux (ions/cm2/s)	Angle	Degrader
10	1	11	2.7	25	Kr	35.0	63.3	9.99E+05	5.60E+02	1.27E+04	0	2,1.3
11	1	11	2.7	25	Kr	35.0	63.3	6.54E+05	3.67E+02	1.18E+04	0	2,1.3
12	1	11	2.7	25	Kr	35.0	63.3	4.69E+05	3.01E+02	9.89E+03	0	2,49
13	1	11	2.7	25	Kr	40.0	33.3	7.09E+05	4.55E+02	1.02E+04	0	2,49
14	1	11	2.7	25	Kr	61.0	16.4	9.99E+05	9.76E+02	9.53E+03	47.45	2,53
15	1	11	2.7	25	Kr	55.0	33.3	2.90E+05	2.56E+02	6.75E+03	47.45	2,36
16	1	11	2.7	25	Kr	55.0	33.3	2.56E+05	2.26E+02	8.94E+03	47.45	2,36
17	2	11	2.7	25	Kr	61.0	16.4	9.47E+05	9.25E+02	9.86E+03	47.45	2,53
18	2	11	2.7	25	Kr	61.0	16.4	5.79E+05	5.41E+02	8.52E+03	44.95	2,53
19	2	11	2.7	25	Kr	45.0	62.4	2.06E+05	1.49E+02	8.37E+03	44.95	1,29
20	2	11	2.7	25	Kr	28.9	120.8	9.13E+05	4.23E+02	1.30E+04	0	0
21	2	11	2.7	25	Kr	37.0	50.5	9.26E+05	5.49E+02	9.26E+03	0	2,35
22	4	12	2.7	25	Kr	37.0	50.5	4.85E+05	2.88E+02	2.29E+04	0	2,35
23	4	12	2.7	25	Kr	32.0	86.8	3.91E+05	2.00E+02	2.21E+04	0	1,33
24	4	12	2.7	25	Kr	32.0	86.8	4.87E+05	2.50E+02	1.82E+04	0	1,33
39	2	11	5.5	125	Kr	55.0	27.7	1.00E+07	8.83E+03	1.05E+05	44.9	2,45
44	4	12	2.7	25	Ar	12.1	126.7	7.57E+05	1.47E+02	1.01E+04	44.9	0,0
45	4	12	2.7	25	Ar	8.6	178.9	1.01E+06	1.38E+02	1.12E+04	0	0,0
46	4	12	5.5	125	Ho	80.2	48	2.04E+06	2.63E+03	1.26E+05	10	1,59
47	4	12	5.5	125	Ho	80.2	48	9.98E+06	1.28E+04	1.27E+05	10	1,59
48	3	11	5.5	125	Ho	80.2	48	9.98E+06	1.28E+04	7.58E+04	10	1,59

5.0. Single Event Transient Test Results

As noted above, we do not use any pass/fail criteria for non-destructive SEE testing. This type of testing is most often used to calculate the error rate (or event rate) for specific mission environments and it is up to the user to determine whether or not the error rate is acceptable for their particular application. Therefore, in this results section we provide the error cross-section versus LET and the corresponding Weibull fitting parameters and a series of oscilloscope captures that are representative of the SET events observed. The ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (of the lot date code identified on the first page of this report) are susceptible to SET events at various LETs. The SETs were manifested primarily as disruptions in the output level lasting less than a couple of microseconds. As noted above and reported in a separate report ("Single Event Latchup Testing of the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller for Analog Devices") these units were not susceptible to SEL events.

Table 5.1 shows a summary of all of the single event transient test runs and results. The table records the total effective fluence, the average flux, the run time, the beam energy, the ion and effective LET, number of SET events and cross-section.

Figure 5.1 shows the single event transient cross-section (for all captured SET events using a supply potential of 2.7V, note that the 5.5V SEL data points are excluded from this plot) versus LET. The device was tested at the Texas A&M University using a wide variety of effective LETs from approximately 9MeV-cm^2/mg to 60MeV-cm^2/mg (using a supply potential of 2.7V and up to 80MeV-cm^2/mg using a supply potential of 5.5V). In the figure, the solid data points represent the results for all tested serial numbers while the solid line represents a Weibull fit to the data. Table 5.2 shows the Weibull fitting parameters used to generate the fit shown in Figure 5.1.

Figures 5.2 through 5.15 show plots of the SET events represented by output V_{OUT} versus time from the trigger event. As noted above the trigger was initiated if the output waveform deviated by greater than or less than the widow trigger (approximately ±100mV). As seen in these figures, the SET events are manifested by a disruption (frequently a short perturbation) in the output potential lasting for less a couple of microseconds.

Table 5.1. Summary of the SET test runs for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller

Run	DUT	Wafer	VPOS (V)	Ion	Effective LET (MeV-cm2/mg)	Effective Fluence (ion/cm2)	Angle	Number of SET Events	Cross Section (ion/cm2)
10	1	11	2.7	Kr	35.0	9.99E+05	0	8	8.01E-06
11	1	11	2.7	Kr	35.0	6.54E+05	0	5	7.64E-06
12	1	11	2.7	Kr	35.0	4.69E+05	0	5	1.07E-05
13	1	11	2.7	Kr	40.0	7.09E+05	0	5	7.05E-06
14	1	11	2.7	Kr	61.0	9.99E+05	47.45	3	3.00E-06
15	1	11	2.7	Kr	55.0	2.90E+05	47.45	5	1.72E-05
16	1	11	2.7	Kr	55.0	2.56E+05	47.45	5	1.95E-05
17	2	11	2.7	Kr	61.0	9.47E+05	47.45	5	5.28E-06
18	2	11	2.7	Kr	61.0	5.79E+05	44.95	5	8.64E-06
19	2	11	2.7	Kr	45.0	2.06E+05	44.95	5	2.42E-05
20	2	11	2.7	Kr	28.9	9.13E+05	0	5	5.48E-06
21	2	11	2.7	Kr	37.0	9.26E+05	0	5	5.40E-06
22	4	12	2.7	Kr	37.0	4.85E+05	0	5	1.03E-05
23	4	12	2.7	Kr	32.0	3.91E+05	0	5	1.28E-05
24	4	12	2.7	Kr	32.0	4.87E+05	0	5	1.03E-05
39	2	11	5.5	Kr	55.0	1.00E+07	44.9	3	2.99E-07
44	4	12	2.7	Ar	12.1	7.57E+05	44.9	3	3.97E-06
45	4	12	2.7	Ar	8.6	1.01E+06	0	1	9.95E-07
46	4	12	5.5	Ho	80.2	2.04E+06	10	1	4.90E-07
47	4	12	5.5	Ho	80.2	9.98E+06	10	1	1.00E-07
48	3	11	5.5	Ho	80.2	9.98E+06	10	1	1.00E-07

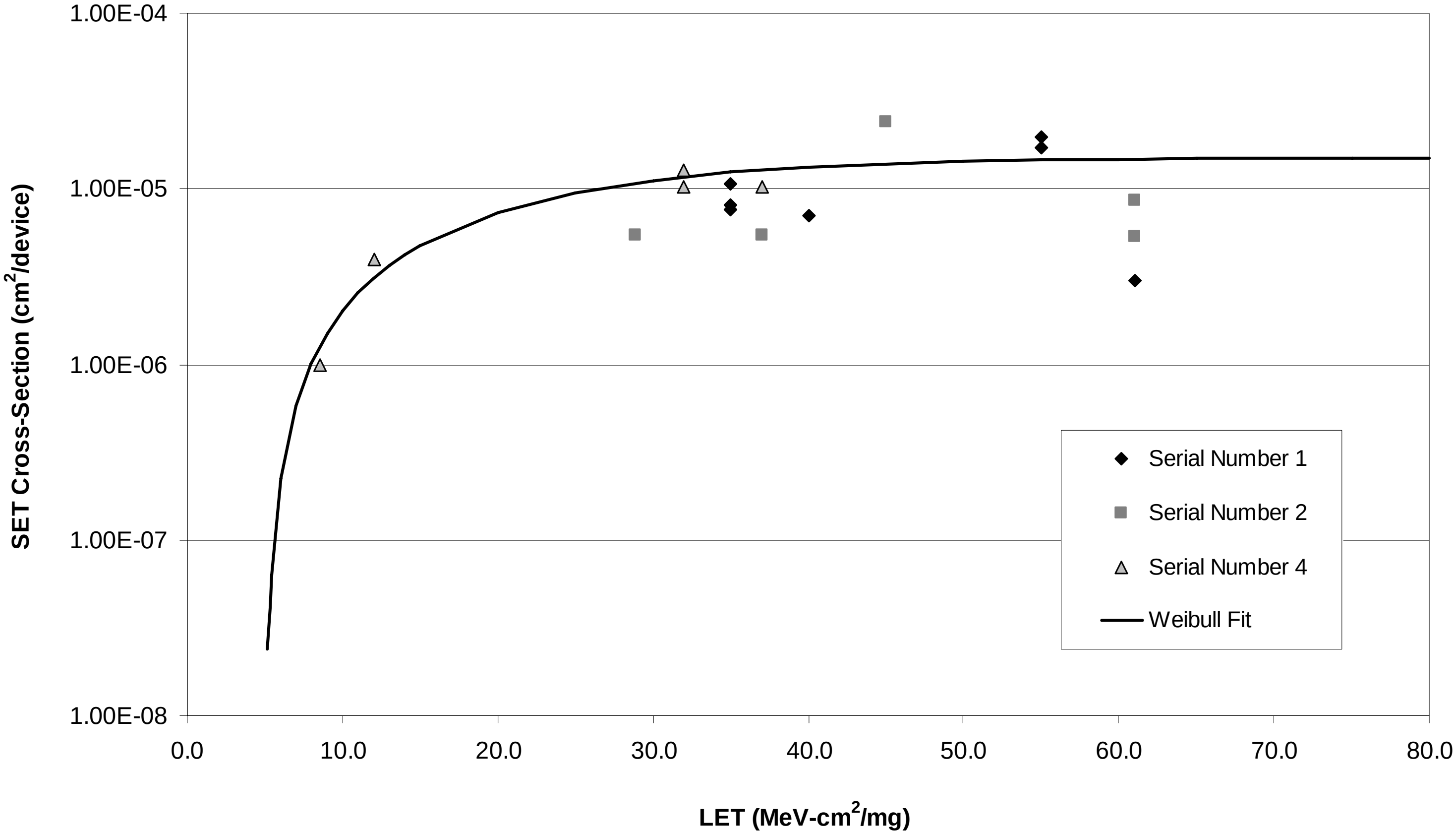


Figure 5.1. SET error cross-section (cm^2/device) versus LET for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller. This device was tested at Texas A&M University (TAMU) using a wide variety of effective LETs from approximately 9MeV-cm^2/mg to 60MeV-cm^2/mg. The data points represent the results for the four different part numbers and the solid line represents a Weibull fit to the data.

Table 5.2. Weibull fitting parameters for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller.

ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller	Shape Parameter	Width Parameter	Saturated Cross Section* (cm^2/device)	Onset LET (MeV-cm^2/mg)
	1.4	20	1.50E-05	5

*Note that the saturated cross-section used for each device type is based on the cross-section at approximately 70MeV-cm^2/mg. However, the unit's may not exhibit full saturation up to the maximum LET tested. This should be taken into account when predicting the error rate for a particular mission environment, since it could lead to a slightly lower error rate prediction.

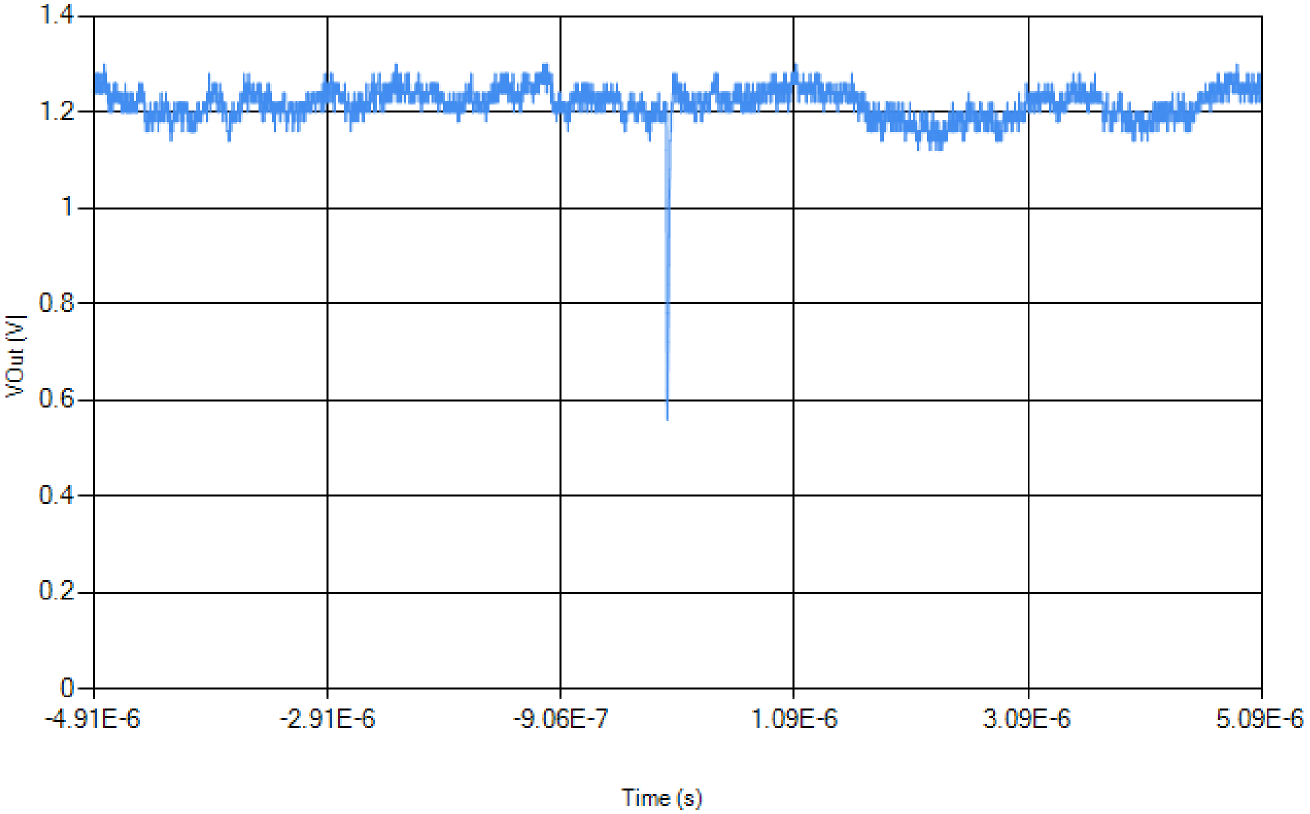


Figure 5.2. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 4 for Run # 11). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

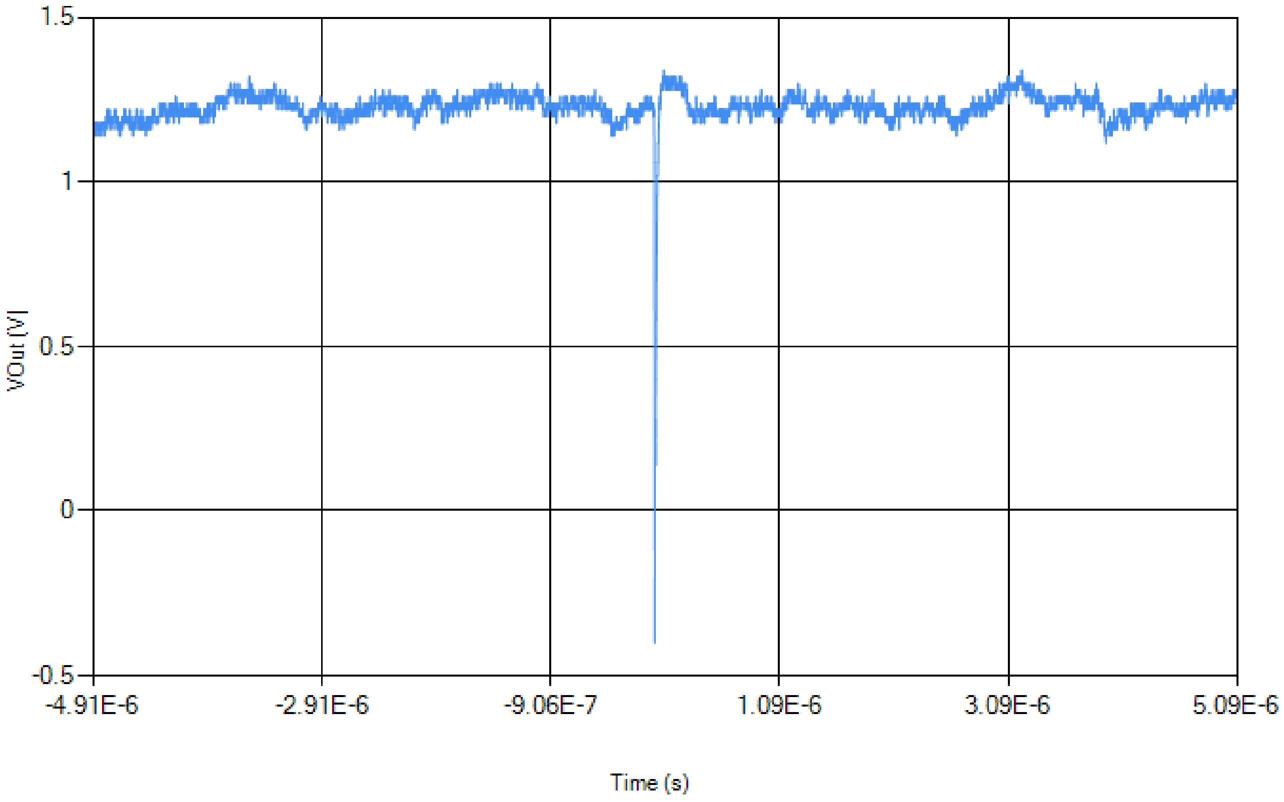


Figure 5.3. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 9 for Run # 12). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

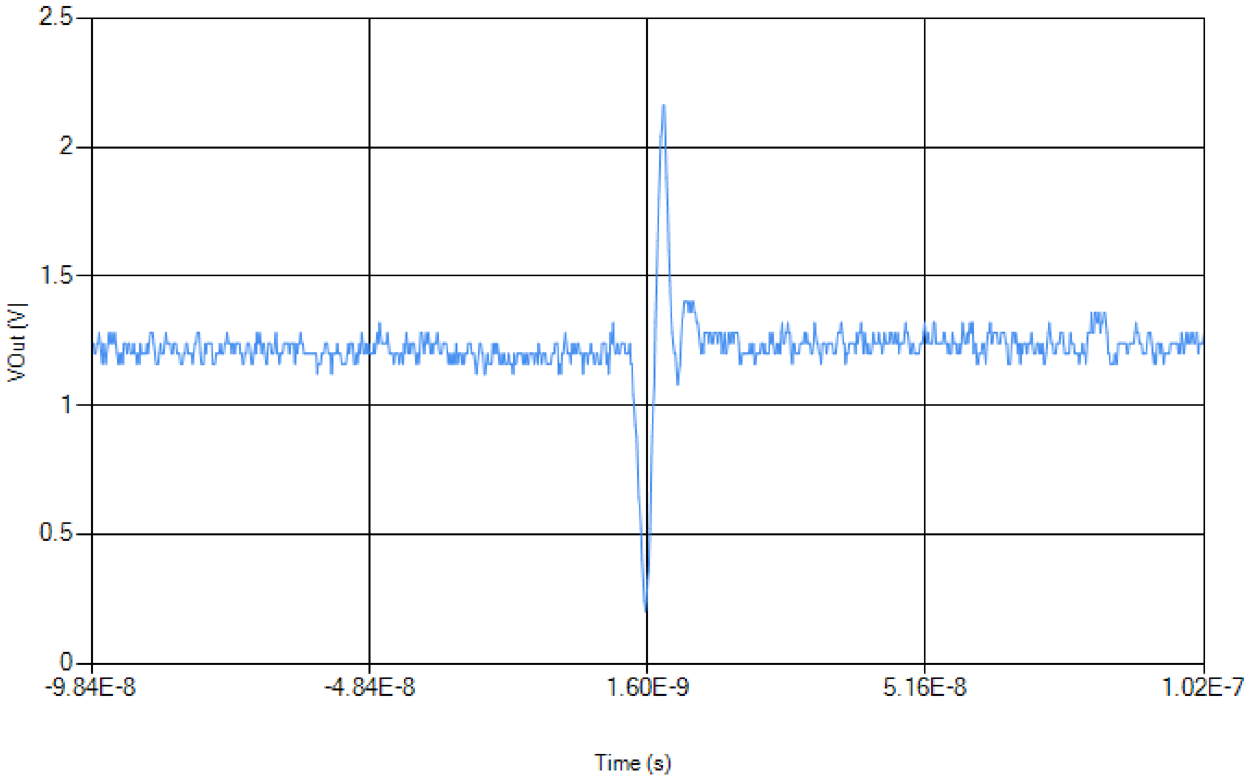


Figure 5.4. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 11 for Run # 13). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

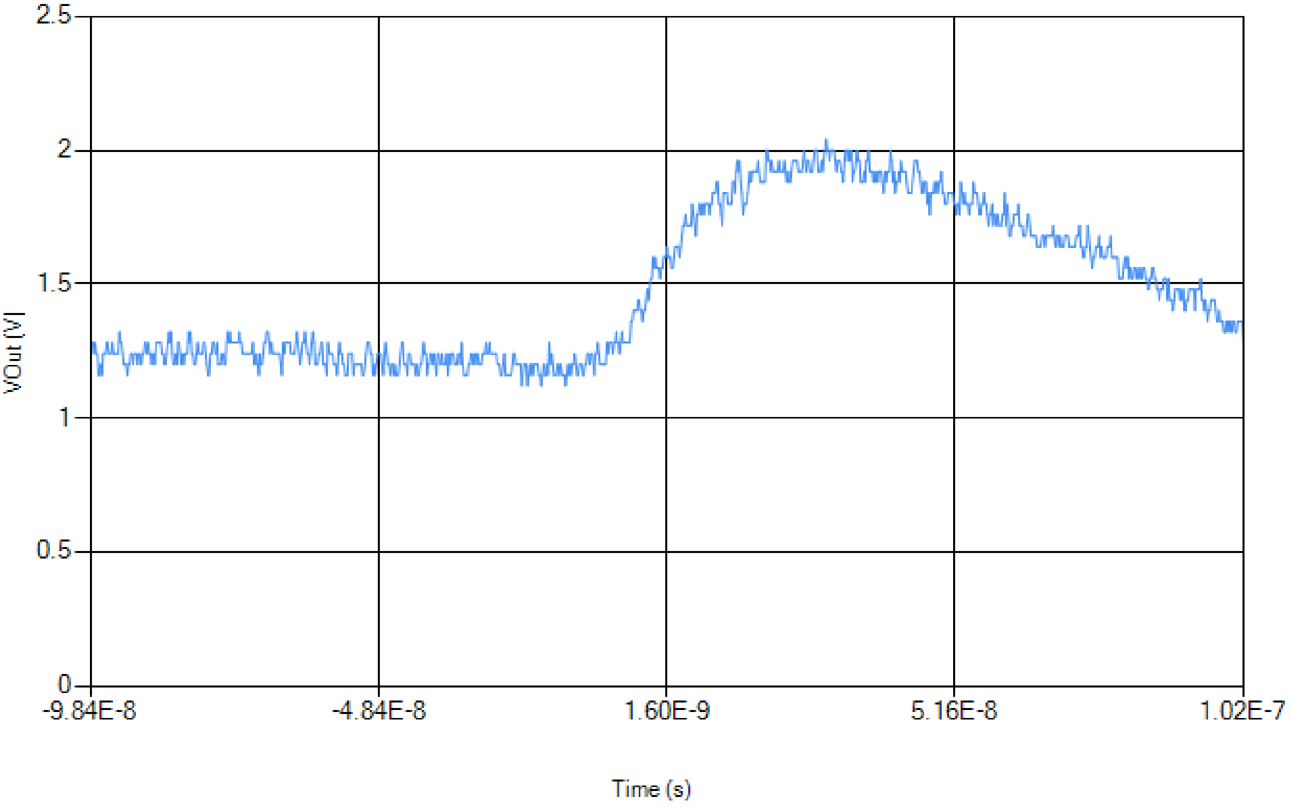


Figure 5.5. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 18 for Run # 14). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

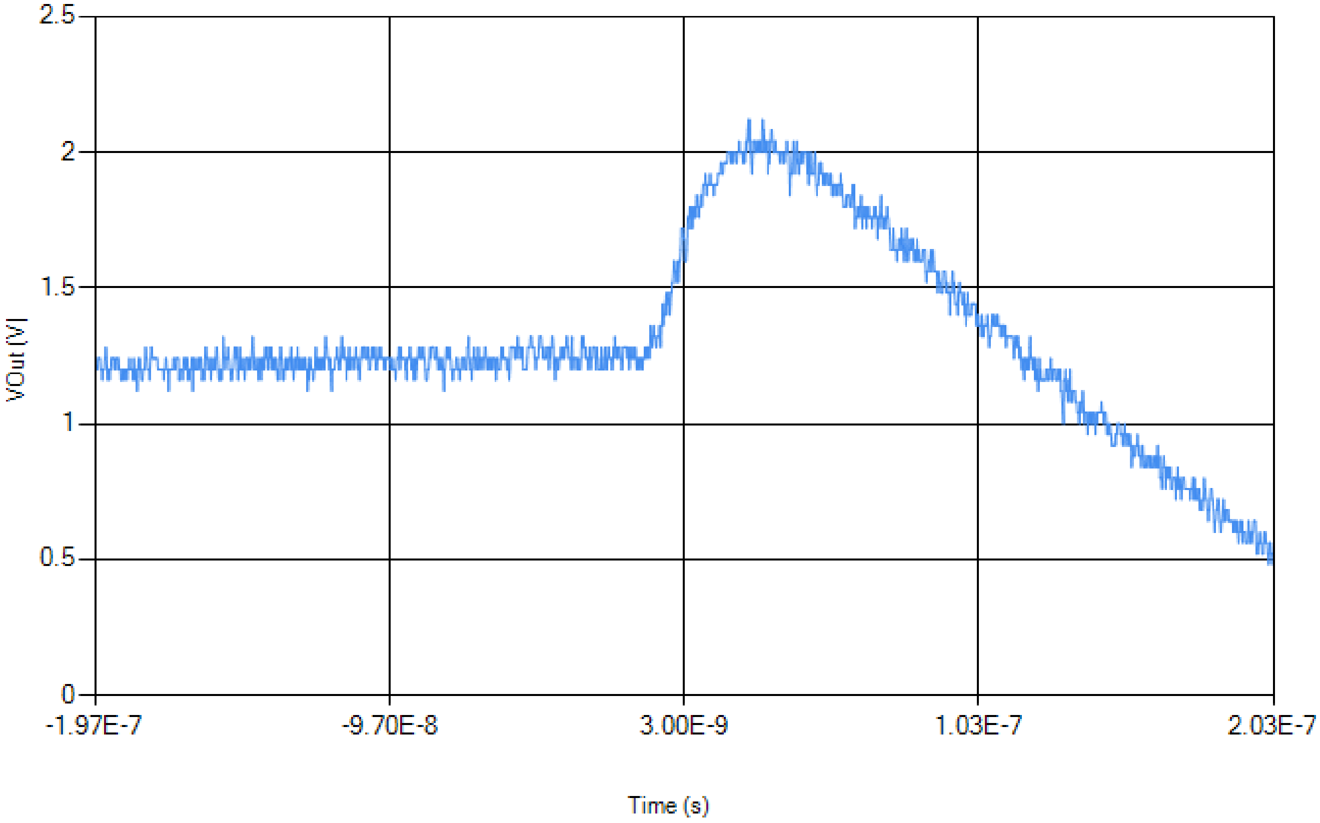


Figure 5.6. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 21 for Run # 15). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

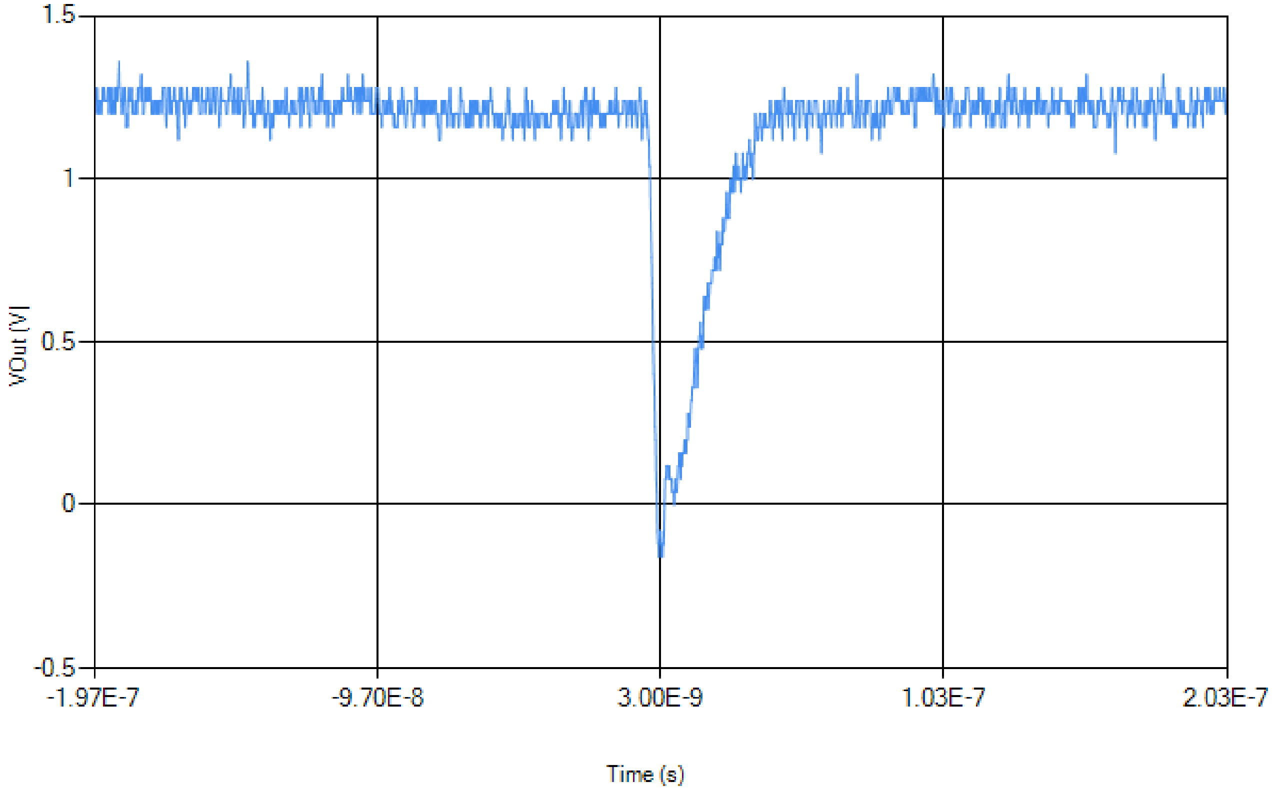


Figure 5.7. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 22 for Run # 15). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

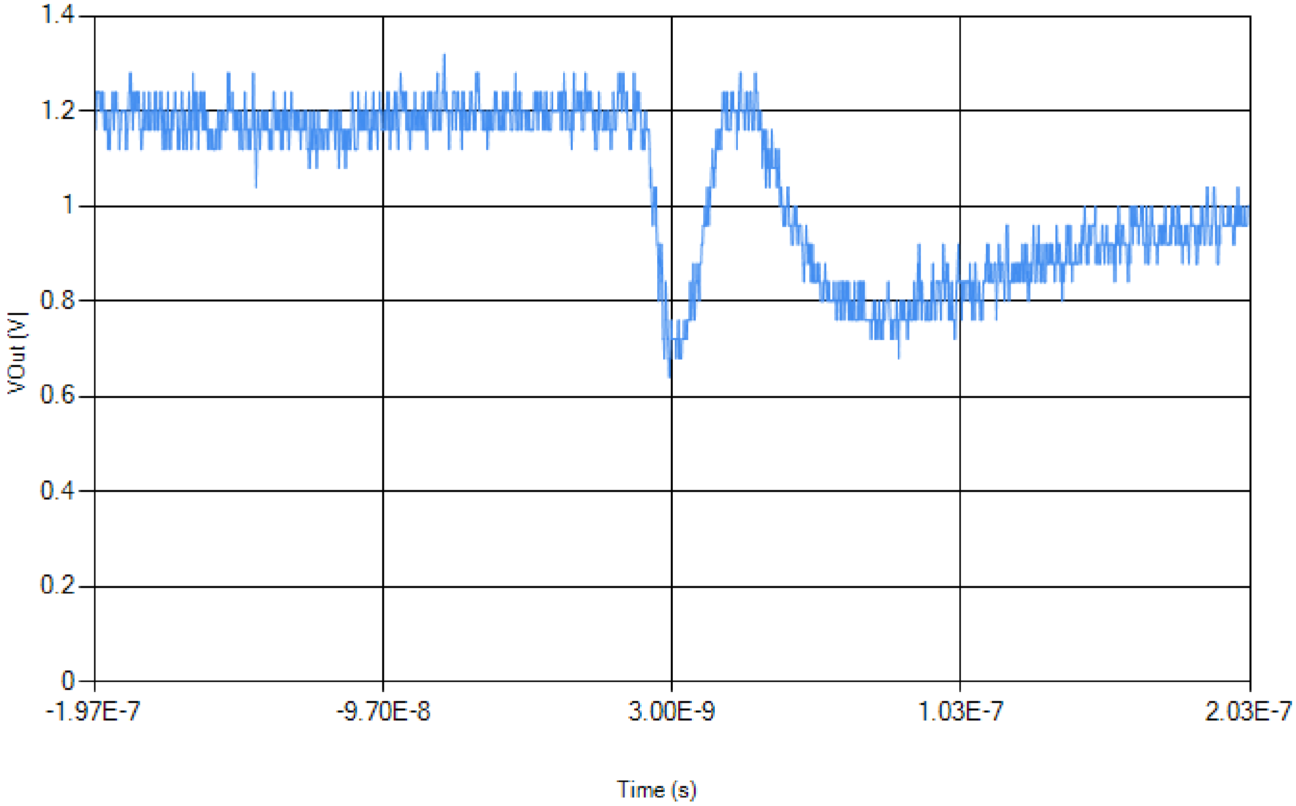


Figure 5.8. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 25 for Run # 15). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

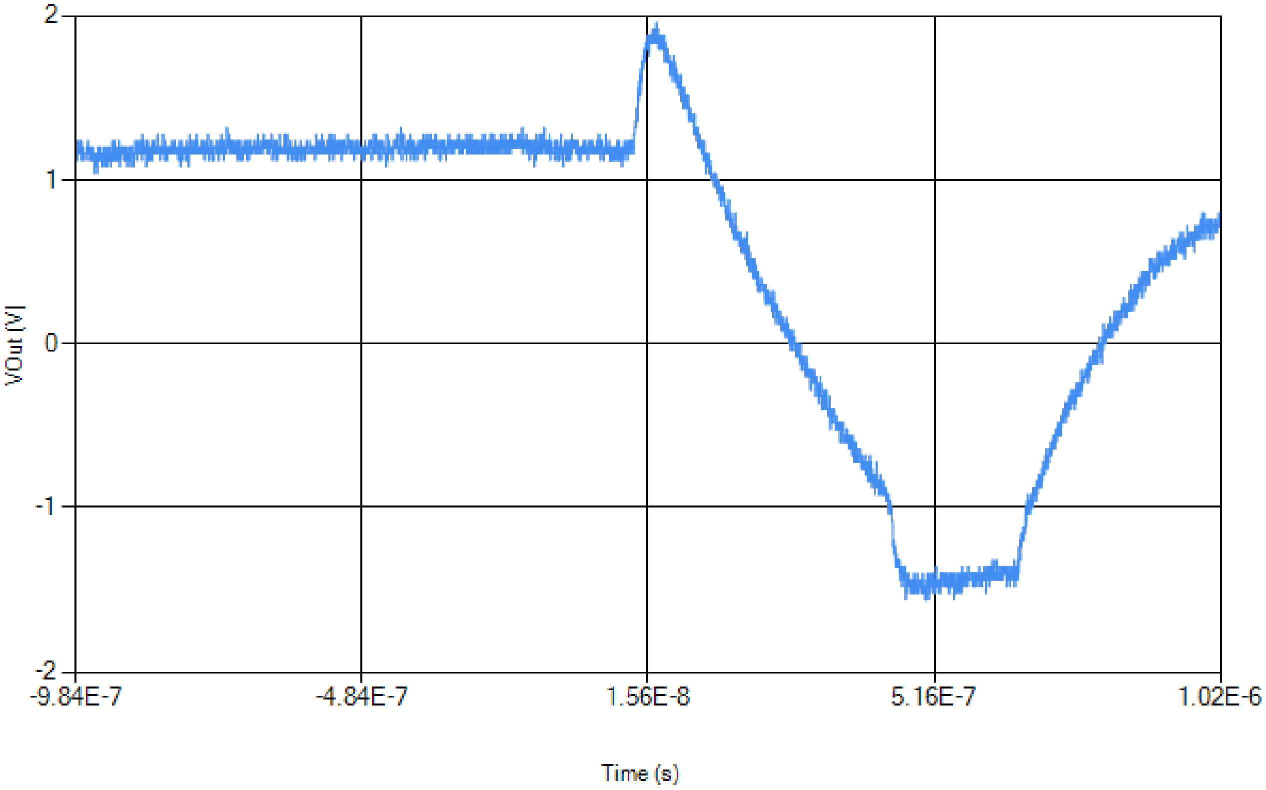


Figure 5.9. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 28 for Run # 16). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

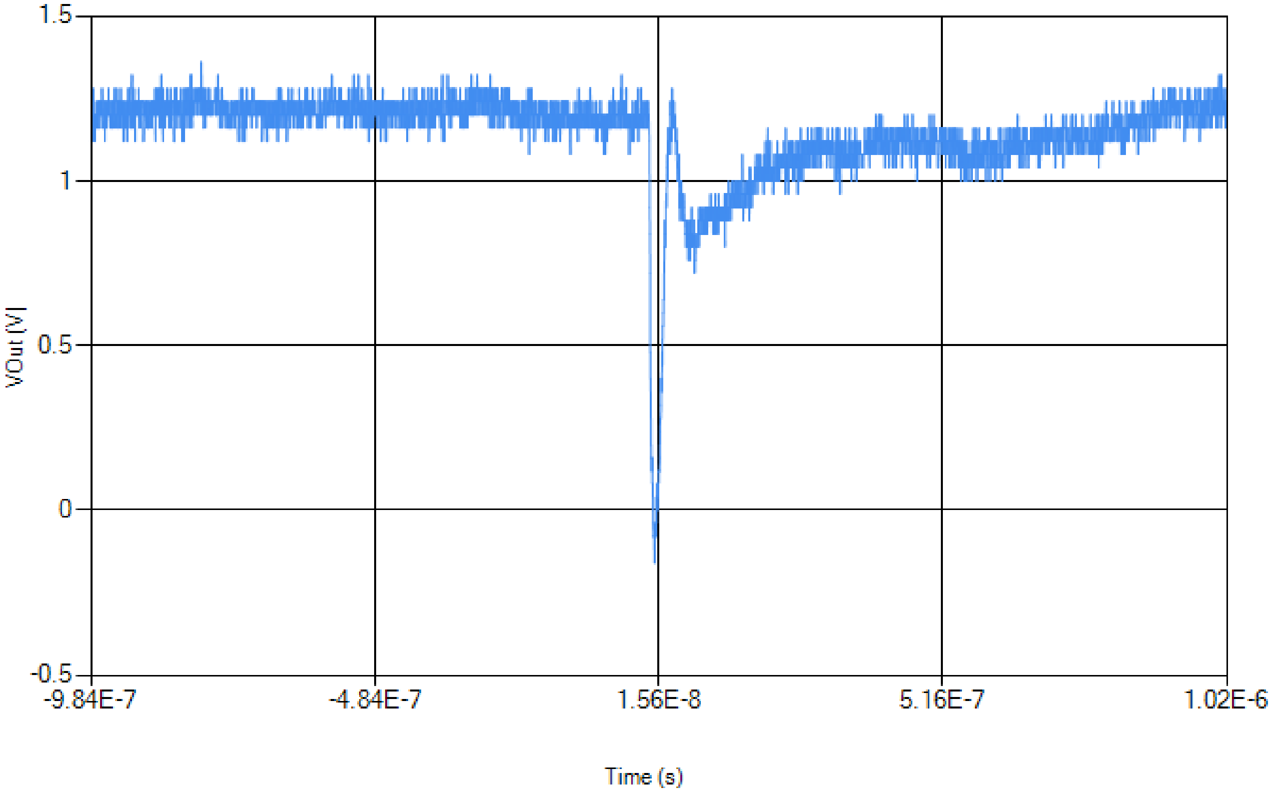


Figure 5.10. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 30 for Run # 16). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

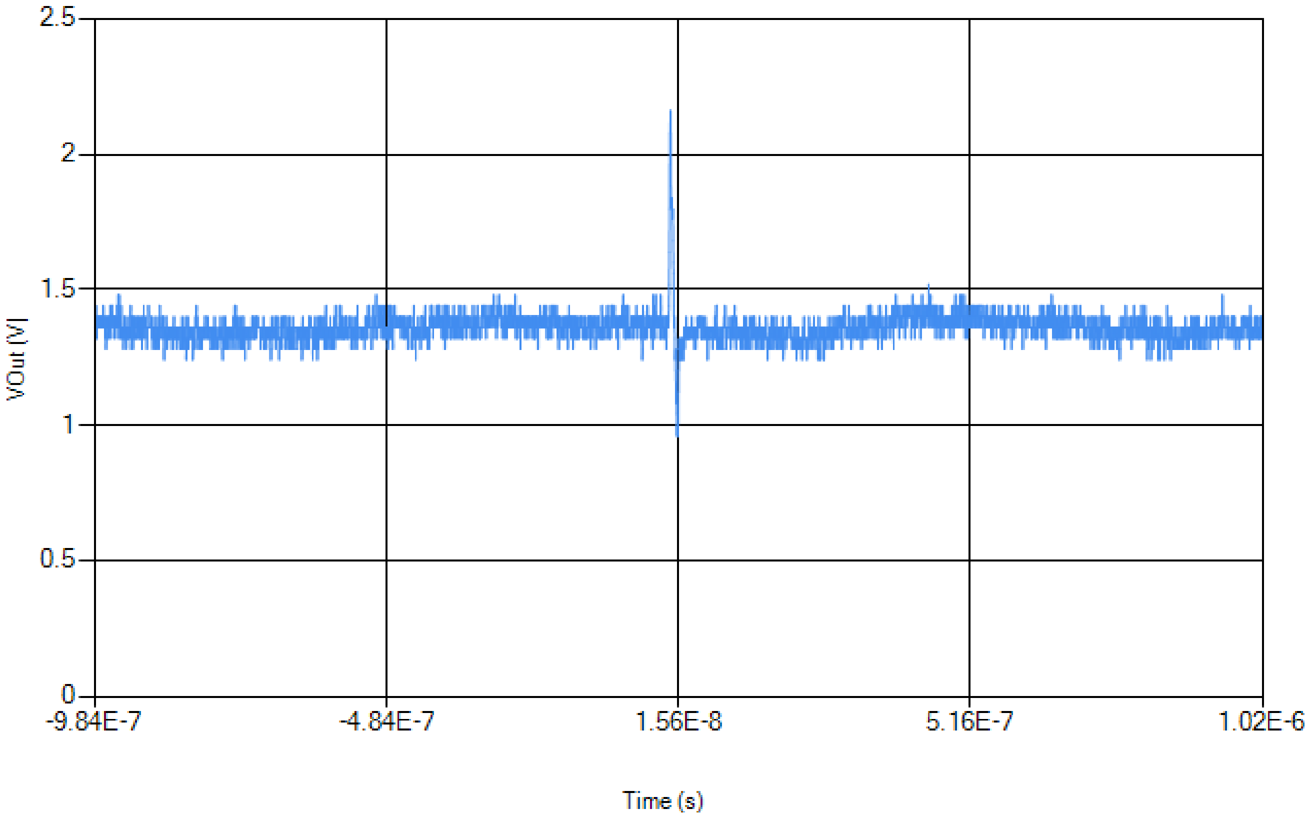


Figure 5.11. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 34 for Run # 17). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

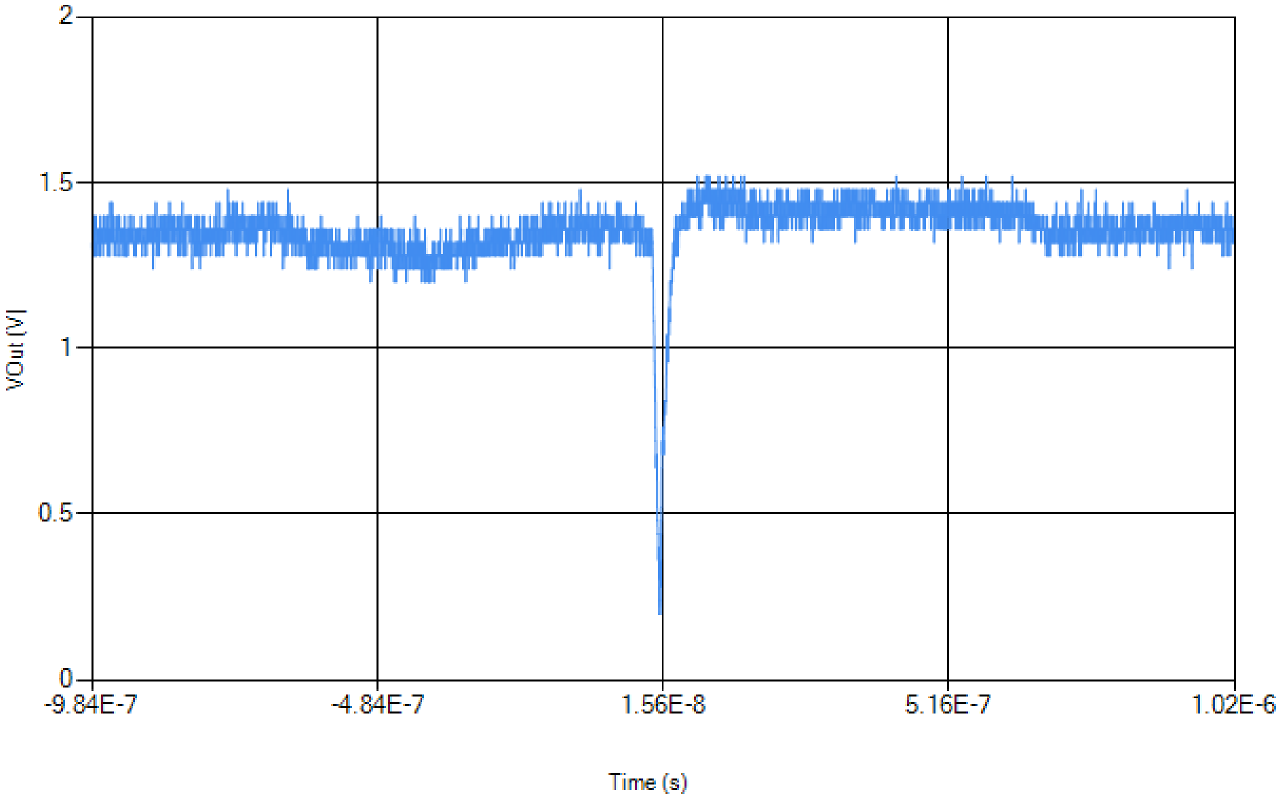


Figure 5.12. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 36 for Run # 18). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

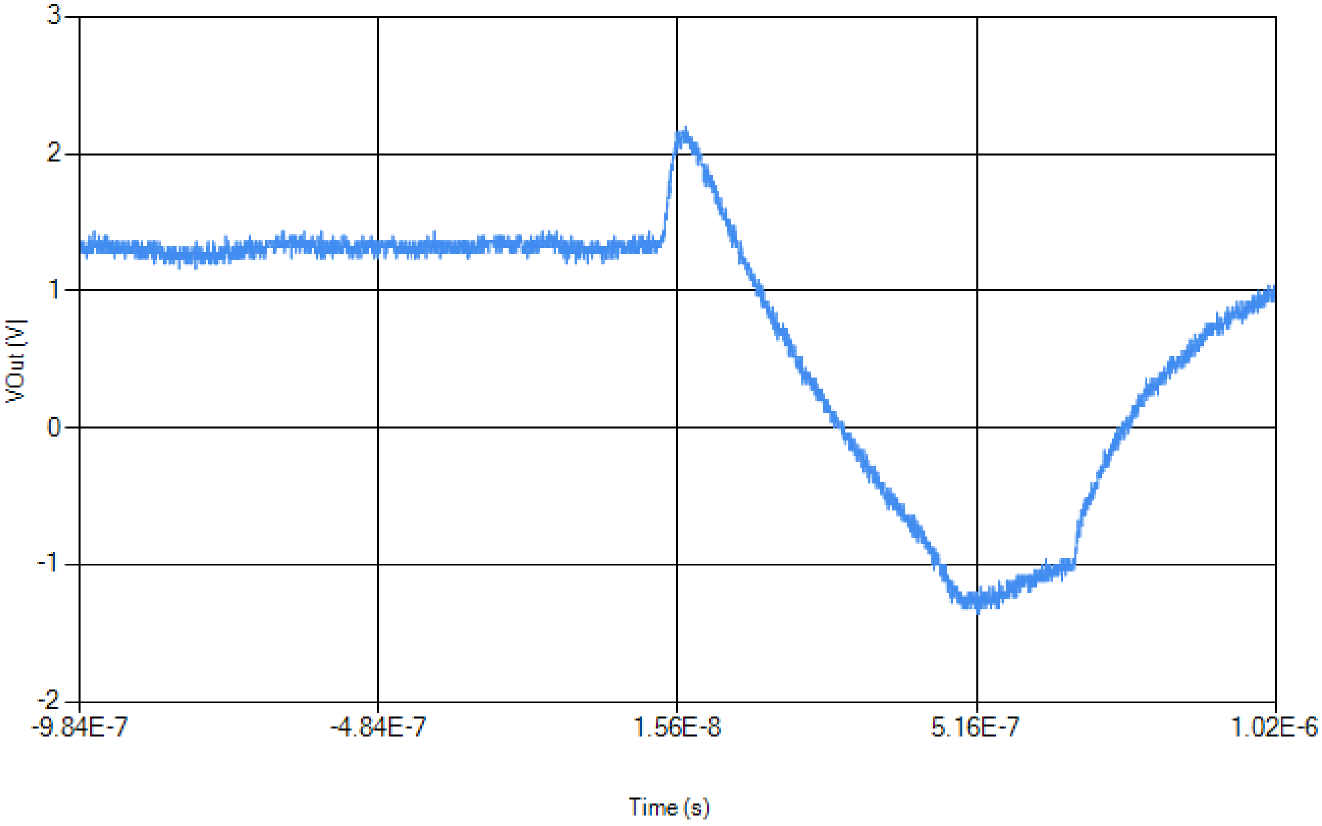


Figure 5.13. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 39 for Run # 18). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

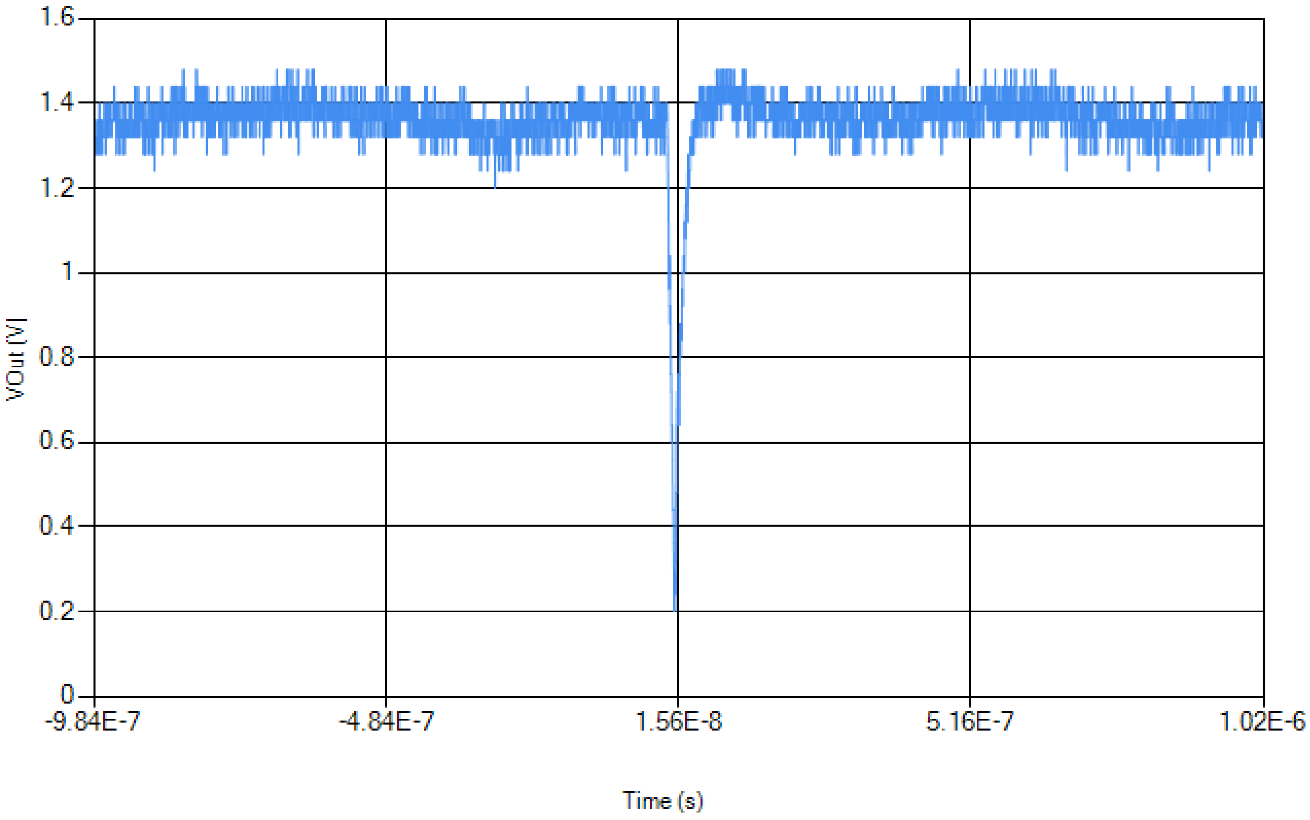


Figure 5.14. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 45 for Run # 19). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

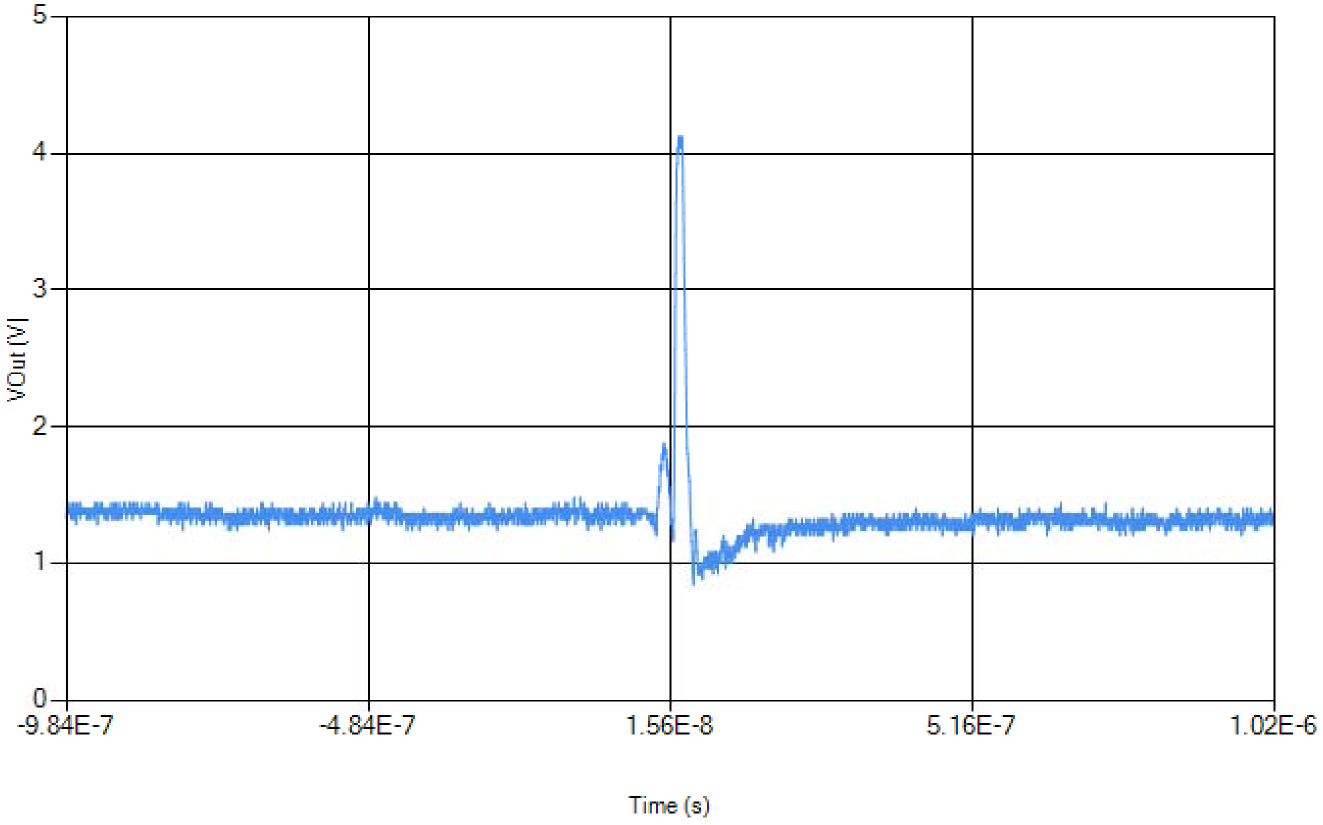


Figure 5.15. Representative single event transient for the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (Event 55 for Run # 21). The data is presented as output potential versus time/fluence. See Table 4.1 for the details of the test conditions.

6.0. Summary/Conclusions

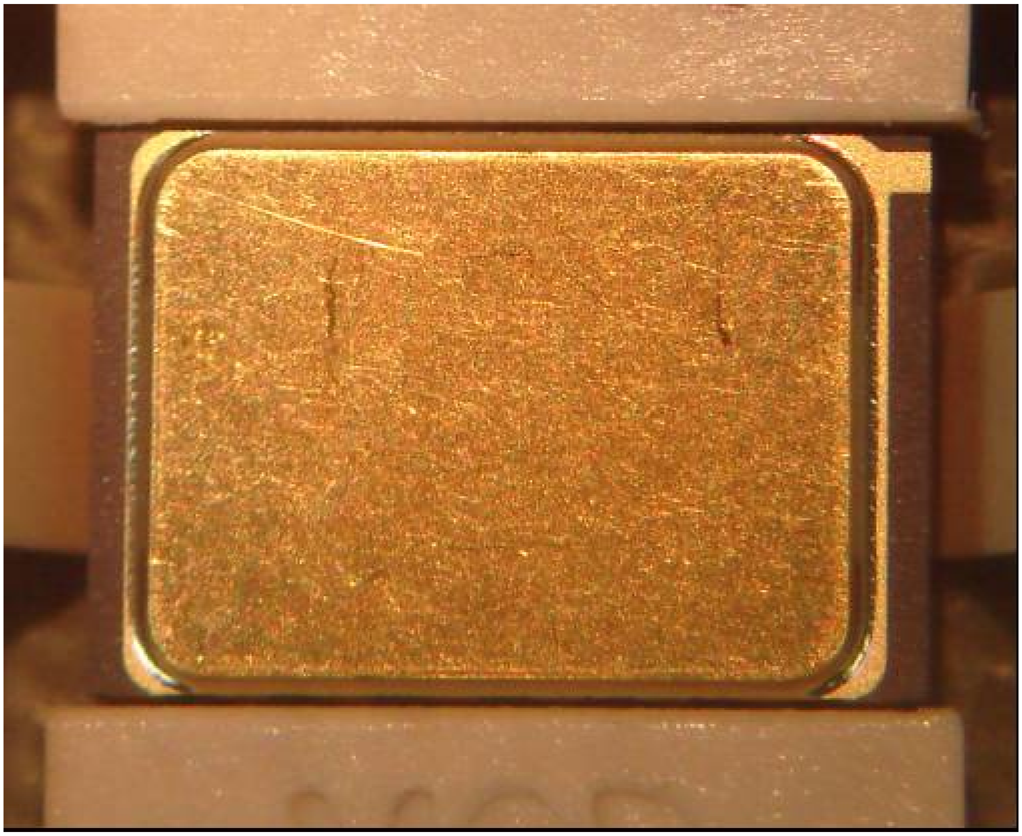
The non-destructive single event effects testing described in this final report was performed at Texas A&M University (TAMU) using their K500 Cyclotron. The testing was performed in air using the 15MeV/n beam. This beam was selected since it provides plenty of range for de-encapsulated or delidded die being irradiated from the top surface and offers a wide selection of ions and LETs. When necessary, beam degraders can be inserted into the beam line to achieve the desired LET and a wider LET range for a give ion. The beam characteristics and dosimetry were provided by the Texas A&M University heavy ion test facility. TAMU can deliver the beam with a high degree of uniformity over a 1-inch diameter circular cross sectional area using the in-air test system. Uniformity is achieved by magnetic defocusing and by thin foil scattering. The beam uniformity and flux are determined using an array of five plastic scintillators coupled to photo multiplier tubes, located in the diagnostic chamber adjacent to and upstream from the target.

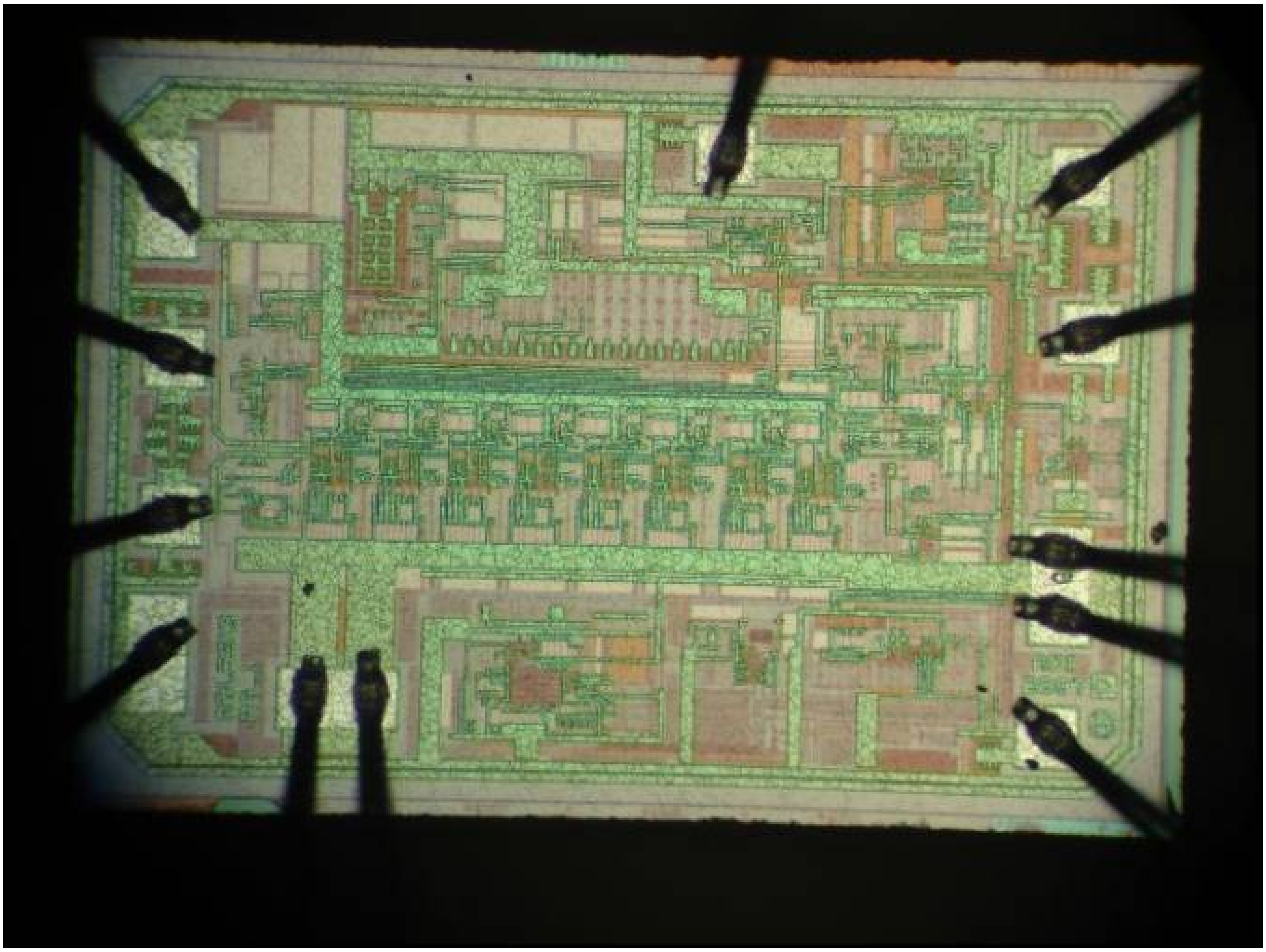
The ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller described in this final report was irradiated using the 15MeV/n Ho, Kr and Ar using a (worst-case) supply voltage of 2.7V and at a case temperatures of approximately 25°C (±5°C), which was ambient room temperature for the TAMU Radiation Effects Facility exposure room during this test run. Note that minimum datasheet input supply potentials are generally considered to be worst-case for single event transient testing.

During the heavy ion exposure the V_{OUT} output of the units-under-test was measured for proper operation and the potential existence of transients. The units-under-test were run using a 5MHz clock signal generated using RF source daughter cards mounted on the test motherboard. The output was captured on a digitizing oscilloscope with the oscilloscope set to trigger whenever a significant distortion in the output amplitude. The output was configured for a nominal 1.2V output and the trigger was set approximately 100mV above and below the output level. Note that for each test, the oscilloscope could run “indefinitely” in the acquisition/”ready for trigger” mode without triggering or capturing a waveform without application of the heavy ion beam. Therefore, we have a very high likelihood that after the unit-under-test was exposed to the heavy ion beam and an event occurs that the event was caused by the heavy ion radiation and not spurious noise.

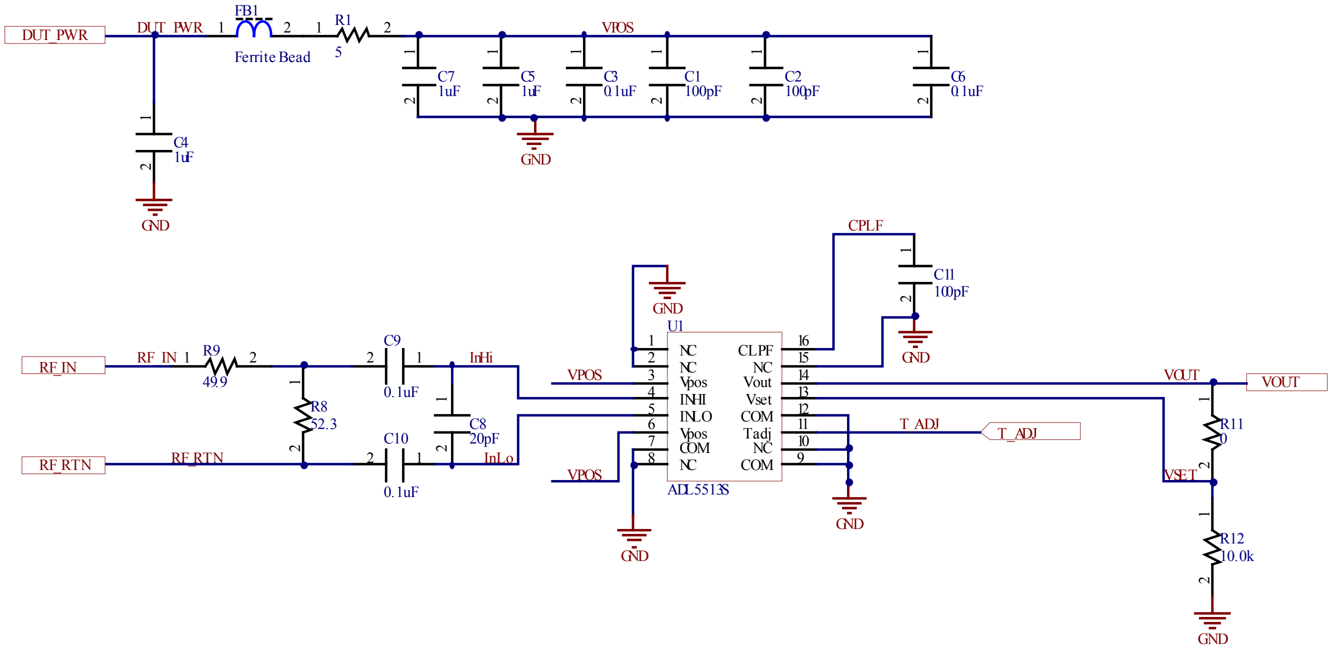
We do not use any pass/fail criteria for non-destructive SEE testing. This type of testing is most often used to calculate the error rate (or event rate) for specific mission environments and it is up to the user to determine whether or not the error rate is acceptable for their particular application. Therefore, in this report we provide the error cross-section versus LET and the corresponding Weibull fitting parameters and a series of oscilloscope captures that are representative of the SET events observed. The ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller (of the lot date code identified on the first page of this report) are susceptible to SET events at various LETs. The SETs were manifested primarily as disruptions in the output level lasting less than a couple of microseconds.

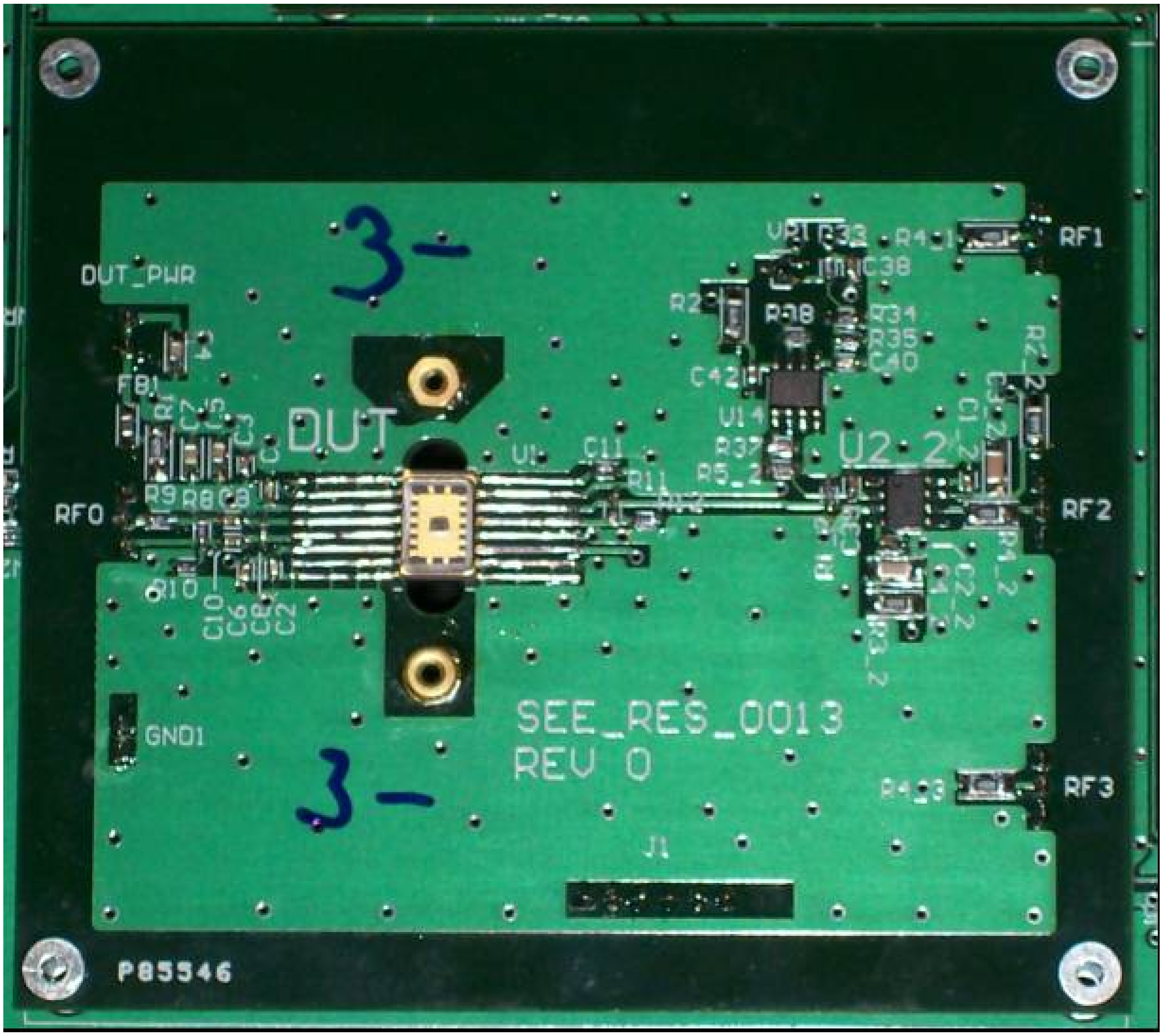
Appendix A: Photograph of a Sample Unit-Under-Test (front side, unmarked and shipping tube) for Device Traceability and a Decapsulated Unit Ready for SET Testing



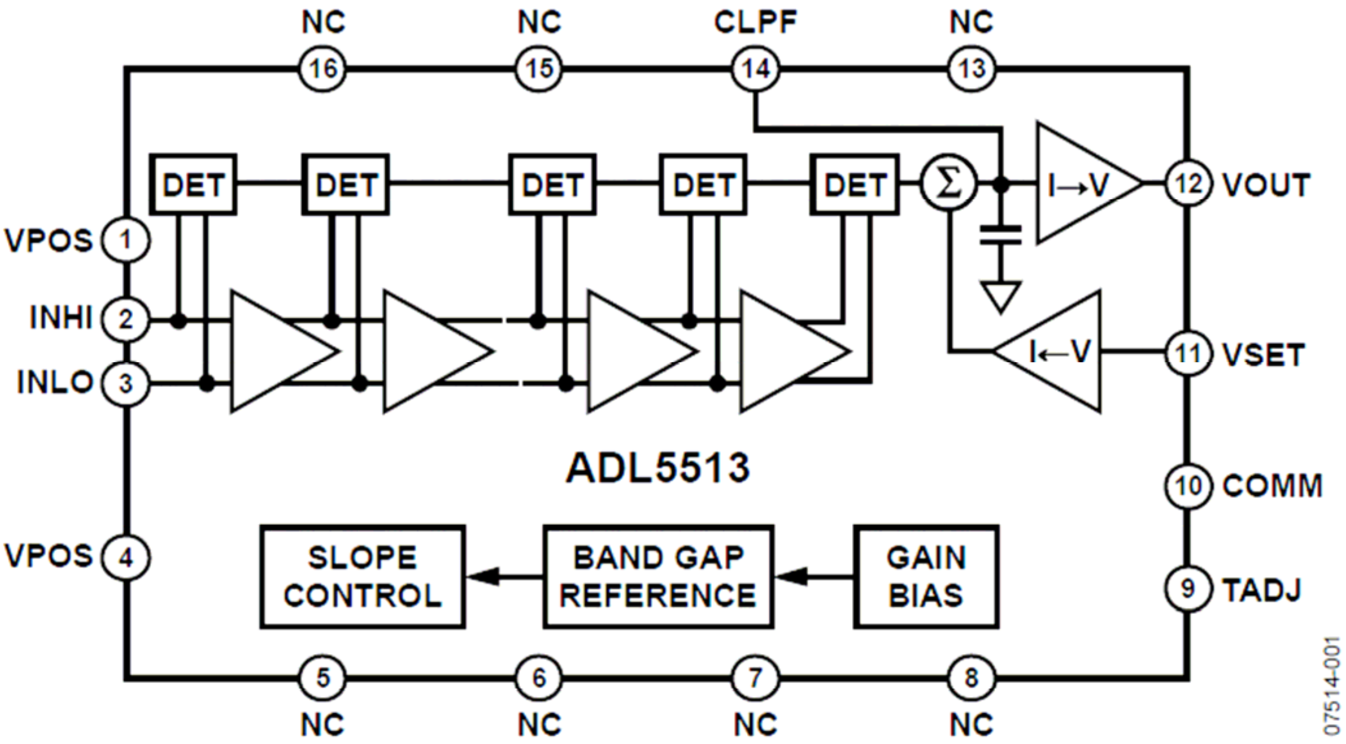


Appendix B: Schematic of Test Board (Single Test Site) and Photograph of Daughter card Used During Heavy Ion Exposure and Functional Block Diagram of the Unit-Under-Test




3-
DUT_PWR
DUT
RF0
FB1
R9
R8
C8
R10
C10
C6
C5
C2
U1
C11
R11
VR1
C33
R41
RF1
C38
R2
R38
R34
R35
C40
C42
U14
R37
R5_2
U2_2
RF2
SEE_RES_0013
REV 0
GND1
3-
R4_3
RF3
J1
P85546

FUNCTIONAL BLOCK DIAGRAM



Appendix C: Electrical Test Parameters and Equipment List

The single event transient testing described in this final report was performed at Texas A&M University (TAMU) using the K500 Cyclotron. The testing was performed in air using the 15MeV/n beam. This beam was selected since it provides plenty of range for de-encapsulated or delidded die being irradiated from the top surface and offers a wide selection of ions and LETs. The beam characteristics and dosimetry were provided by the Texas A&M University heavy ion test facility. TAMU can deliver the beam with a high degree of uniformity over a 1-inch diameter circular cross sectional area using the in-air test system. Uniformity is achieved by magnetic defocusing and by thin foil scattering. The beam uniformity and flux are determined using an array of five plastic scintillators coupled to photo multiplier tubes, located in the diagnostic chamber adjacent to and upstream from the target.

The devices were irradiated to a minimum fluence of 1E7ion/cm2, if no events were detected. The flux varied during the testing, but was consistently targeted to approximately 1E5ion/cm^2-s, depending on the ion species and the response of the unit-under-test. Table C.1 shows the test equipment used for this testing.

Table C.1. Test equipment and calibration dates for testing the ADL5513 1 MHz to 4 GHz, 80dB Logarithmic Detector/Controller

HP 34401A Multimeter	3146A65284	5/15/011	5/15/12	I_{CC} measurement
Agilent E3642A DC Power Supply	MY40004345	N/A	N/A	Test power supply-Positive Supply
Agilent E3631A DC Power Supply	K920920312	N/A	N/A	Test power supply-Negative Supply
Fluke Model 77 Multimeter	38301747	2/19/11	2/19/12	Vcc measurement at the DUT
Omega HH12 Handheld Thermometer	233126	2/19/11	2/19/12	Temperature Calibration
Tektronics TDS5104B Oscilloscope	B011044	10/22/10	10/22/11	Output Waveform Measurements