SEE Test Report V1.0
Heavy ion SEE test of TPS73601 from TEXAS INSTRUMENTS

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I. Introduction

This study was undertaken to determine the single event destructive and transient susceptibility of the TPS73601MDBVREP low dropout linear adjustable voltage regulator. The device was monitored for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Lawrence Berkeley Laboratory (LBL) Cyclotron Single Event Effects Test Facility. This test was performed in the frame of NEPP project.

II. Devices Tested

The sample size of the testing is three devices. Two devices were exposed and one served as a control sample. The test samples lot date code is unknown. The device technology is BiCMOS. The test samples were packaged in a 5-pin TSSOP SOT23 (DBV) package. The test samples were prepped for test by delidding.

III. Test Facility

Facility: LBL Cyclotron Single Event Effects Test Facility, (10 MeV/u cocktail)
Flux: 1 x 10^3 to 1 x 10^5 particles/cm^2/s.
Fluence: All tests were run to 1 x 10^6 p/cm^2 or until a sufficient (>100) number of transient events occurred.

The ions, corresponding LET values and ranges used for these tests are listed in Table 1.

Table 1: characteristics of ions used for the experiments
(10 MeV/u cocktail)

Ion	Energy (MeV)	LET ($MeVcm^2/mg$)	Range (μm)
^{18}O	184	2.22	227
^{40}Ar	400	9.74	130
^{65}Cu	659	21.33	110
^{86}Kr	886	31.28	110
^{136}Xe	1330	58.72	97

IV. Test Conditions and Error Modes

Test Temperature: Room Temperature
Bias conditions Vin = 3.3V
Vout= 1.5V
Devices were biased as shown in Figure 1. Different test conditions are presented in Table 2. Resistive loads were be used.

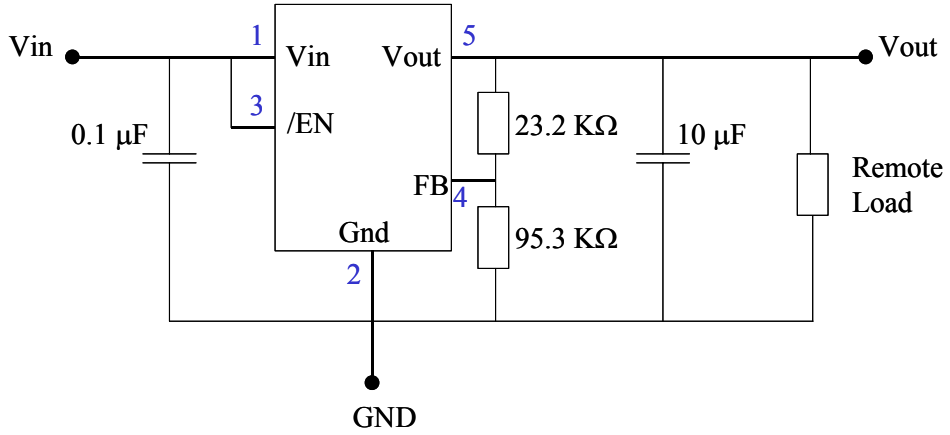

Figure 1: Bias conditions, *10 µF output capacitor ESR is between 50 mΩ and 1.5 Ω

Table 2: Test conditions

Vin (V)	Vout (V)	Iout (mA)
3.3	1.5	10
3.3	1.5	50
3.3	1.5	100
3.3	1.5	250

PARAMETERS OF INTEREST: Power supply currents, output voltage

SEE Conditions: SEL, SEGR, SET

V. Test Methods

Test circuit, as shown in Figure 2, for the adjustable regulator contains a power supply for the input voltage, a resistive load for drawing current, and a digital scope for capturing any output anomalies. Once the, programmable output is present and the load conditions are set, the digital scope is set to trigger on and voltages that are above or below a predetermined threshold (set to 75 mV).

Once the adjustable regulator receives the input voltage, it produces a regulated output. The digital scope triggered for both voltage dropouts and over voltage conditions at the output terminal.

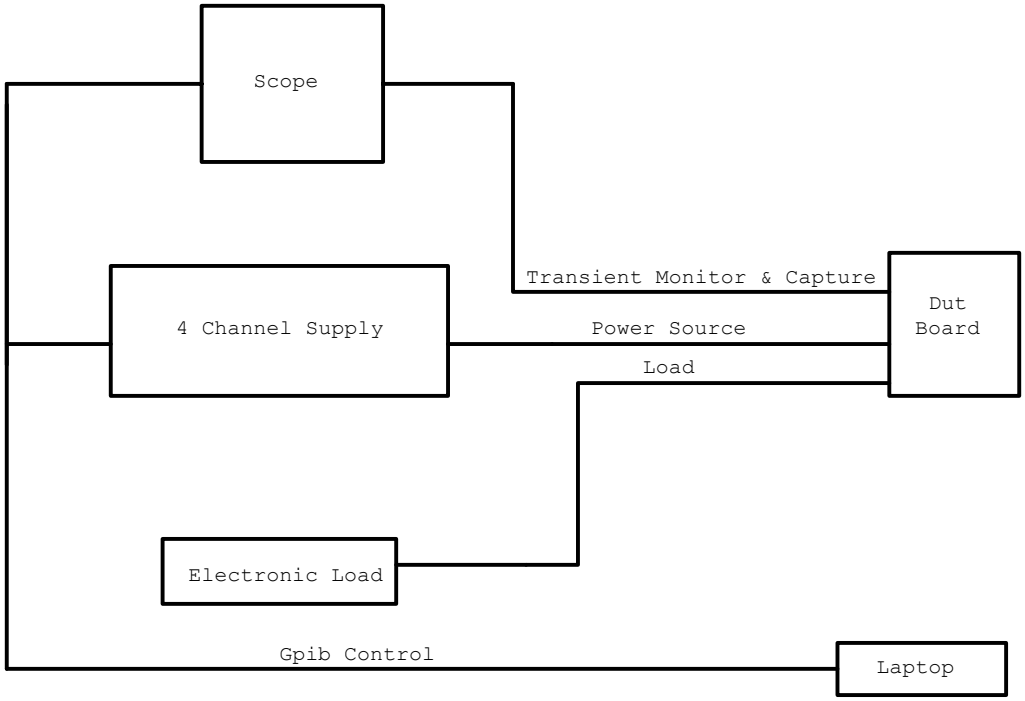

Figure 2. Overall Block Diagram for the testing of the TPS73601.

VI. Test Results

Detailed test results are shown in Table 3. No destructive event was observed up to the maximum tested LET of 59 MeVcm^2/mg. TPS73601 has a high sensitivity to SET. SET sensitivity increase with load current. For low load current (Iout=10 mA), SET sensitivity is negligible. At the highest load current (Iout=250 mA) SET sensitivity is very high with a LETthreshold < 2 MeVcm^2/mg. SET cross sections curves are shown in Figure 3.

Table 3: detailed test results

RUN #	SN #	Iout (mA)	ION	TILT (°)	Eff LET (MeVcm^2/mg)	Flux (#/cm^2-s)	Fluence (#/cm^2)	SET #	X SET (cm^2/dev)
64	1	10	Xe	0	58.72	4.00E+03	1.14E+06	0	0.00E+00
65	1	250	Xe	0	58.72	2.00E+04	1.41E+05	14	9.93E-05
66	1	250	Xe	0	58.72	2.00E+04	6.46E+04	1	1.55E-05
67	1	250	Xe	0	58.72	2.00E+03	3.00E+04	3	1.00E-04
68	1	100	Xe	0	58.72	2.00E+03	3.05E+05	10	3.28E-05
69	1	100	Xe	0	58.72	1.00E+03	4.96E+05	23	4.64E-05
70	1	50	Xe	0	58.72	2.00E+03	3.50E+05	14	4.00E-05
73	1	50	Kr	0	31.28	3.00E+03	6.99E+05	102	1.46E-04
74	1	50	Kr	0	31.28	3.00E+03	6.89E+05	99	1.44E-04
75	1	10	Kr	0	31.28	2.00E+04	1.22E+06	1	8.20E-07
76	1	100	Kr	0	31.28	3.00E+03	5.24E+05	95	1.81E-04
77	1	250	Kr	0	31.28	2.00E+03	3.81E+04	45	1.18E-03
78	1	250	Kr	0	31.28	4.00E+02	2.71E+03	3	1.11E-03
79	1	250	Kr	0	31.28	4.00E+02	1.65E+04	14	8.48E-04
80	1	250	Kr	0	31.28	1.00E+04	1.80E+06	157	8.72E-05
81	1	250	Cu	0	21.33	2.00E+03	1.14E+05	28	2.46E-04
82	1	250	Cu	0	21.33	1.00E+04	5.93E+05	115	1.94E-04
83	1	100	Cu	0	21.33	1.00E+04	3.35E+05	9	2.69E-05
84	1	100	Cu	0	21.33	1.00E+04	1.01E+06	36	3.56E-05
85	1	50	Cu	0	21.33	1.00E+04	1.24E+06	36	2.90E-05
86	1	10	Cu	0	21.33	1.50E+04	1.03E+06	1	9.71E-07
87	1	250	Ar	0	9.74	2.00E+03	6.46E+05	102	1.58E-04
88	1	100	Ar	0	9.74	2.00E+04	1.12E+06	12	1.07E-05
89	1	50	Ar	0	9.74	2.00E+04	1.10E+06	13	1.18E-05
90	1	10	Ar	0	9.74	2.00E+04	1.00E+06	0	0.00E+00
91	1	50	O	0	2.2	2.00E+04	1.19E+06	0	0.00E+00
92	1	100	O	0	2.2	2.00E+04	1.84E+06	0	0.00E+00
93	1	250	O	0	2.2	3.00E+04	5.31E+06	100	1.88E-05
94	1	250	Kr	0	31.28	1.00E+03	8.54E+04	54	6.32E-04
95	2	100	Kr	0	31.28	1.00E+04	8.31E+05	121	1.46E-04
96	2	100	Kr	0	31.28	1.00E+04	6.05E+05	106	1.75E-04
97	2	250	Kr	0	31.28	1.00E+04	1.84E+05	138	7.50E-04
98	2	250	Kr	0	31.28	1.00E+03	7.08E+04	61	8.62E-04
99	2	10	Kr	0	31.28	1.00E+04	1.08E+06	1	9.26E-07
100	2	50	Kr	0	31.28	1.00E+04	1.65E+06	105	6.36E-05
119	2	50	Xe	0	58.72	1.00E+04	1.62E+06	21	1.30E-05
120	2	100	Xe	0	58.72	1.00E+04	1.13E+06	55	4.87E-05
121	2	250	Xe	0	58.72	1.00E+03	4.55E+05	101	2.22E-04
122	2	250	Cu	0	21.33	3.00E+03	4.35E+05	101	2.32E-04
124	2	50	Cu	0	21.33	3.00E+04	2.35E+06	18	7.66E-06
140	2	50	Ar	0	9.74	2.00E+04	1.61E+06	4	2.48E-06
141	2	100	Ar	0	9.74	2.00E+04	3.42E+06	39	1.14E-05
142	2	250	Ar	0	9.74	2.00E+04	1.00E+06	107	1.07E-04
143	2	250	Ne	0	3.45	3.00E+04	1.67E+06	107	6.41E-05
144	2	100	Ne	0	3.45	3.00E+04	1.92E+06	0	0.00E+00
145	2	50	Ne	0	3.45	3.00E+04	1.51E+06	0	0.00E+00
146	2	250	O	0	2.22	6.00E+03	1.02E+06	36	3.53E-05
147	2	250	O	0	2.22	6.00E+03	3.00E+06	27	9.00E-06

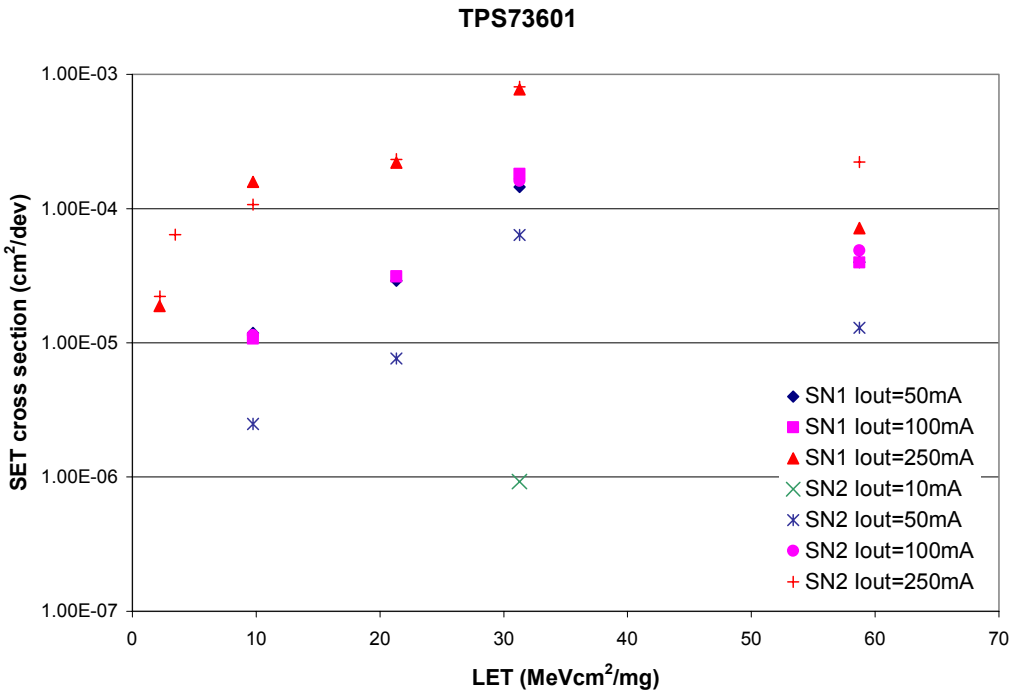

Figure 3: SET cross section curves

Up to a load current of 100 mA, SETs are small amplitude positive going transients. Typical SET waveforms are shown in Figure 4.

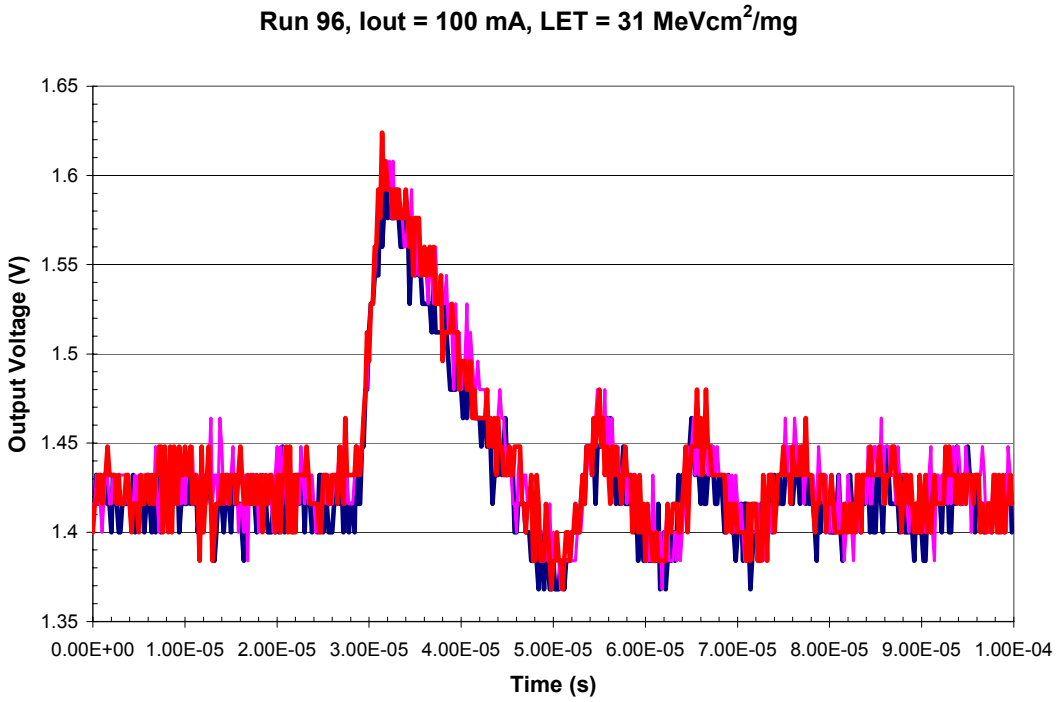

Figure 4: Typical SET waveforms up to a load current of 100 mA

Figure 5 shows SET amplitude versus FWHM plot for all SETs collected during an irradiation run at LET = 58 MeVcm^2/mg for an output current of 100 mA. Maximum transient amplitude is 220 mV and maximum transient FWHM is about 10 μs.

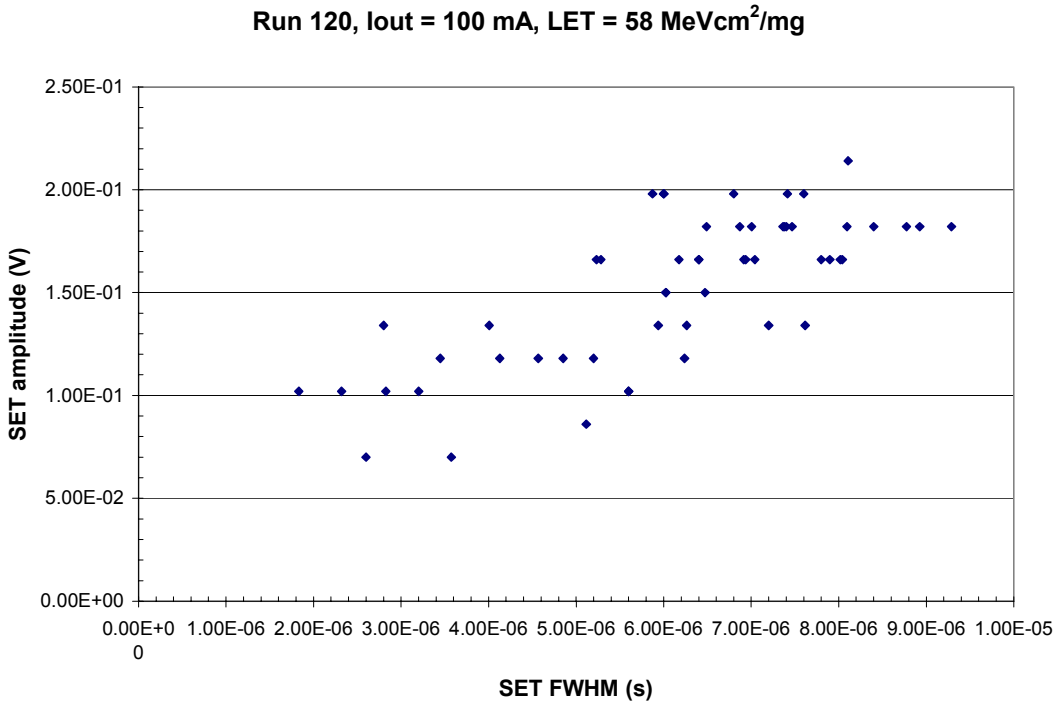

Figure 5: SET amplitude versus FWHM plot for all SETs collected during irradiation run 120

For the largest out current condition of 250 mA, all SET are negative going transient of large amplitude, down to 0V, and long duration. Figure 6 shows typical SET observed during irradiation with 250 mA output current. Maximum measured SET duration is about 100 ms. It is possible that SETs for high current loads trigger the device current limit protection.

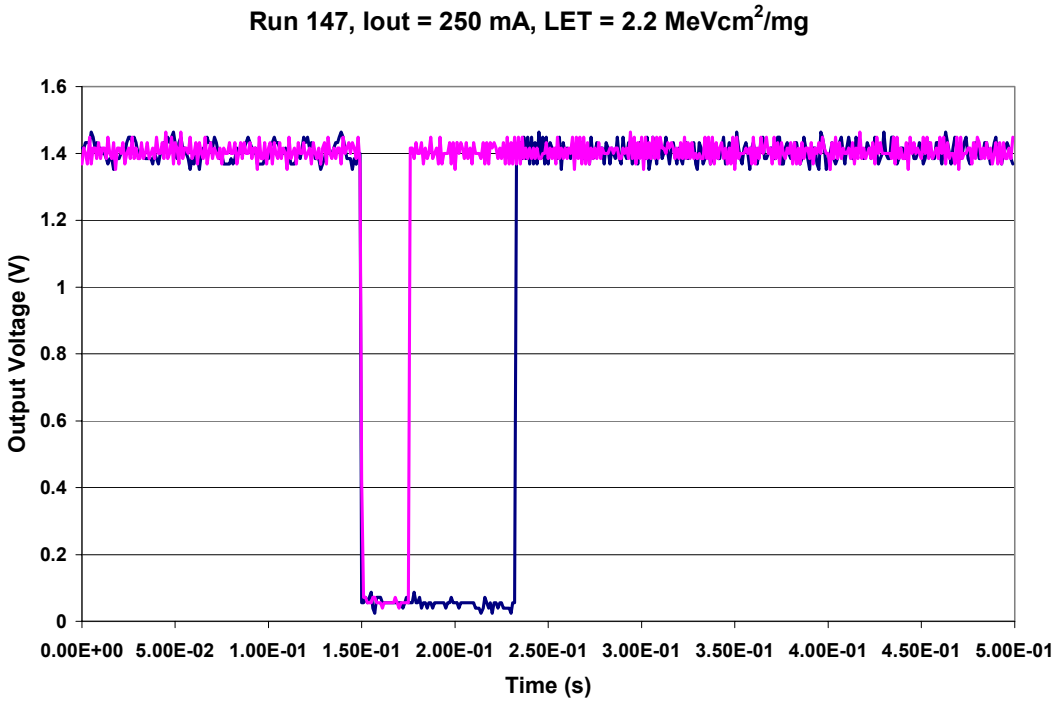

Figure 6: Typical SET waveform with 250 mA output current