Heavy ion Single Event Effects test of 4A Adjustable Switching regulator MSK5042 from M. S. Kennedy

Test Report

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1 Introduction

This report gives heavy ion SEE test data on the switching regulator MSK5042 from National Semiconductor. This work has been performed in the frame of the ST5 project.

2 Tested Devices

The tested devices are described in Table 1. A picture of the part is shown in Figure 1.

Type	**MSK5042**
Manufacturer	M. S. Kennedy
Function	4A adjustable switching regulator
Package	44 pin metal package
Package marking	MSK 5042 0204 51651 USA
Previous SEE testing	No data available

Table 1: description of the tested devices.

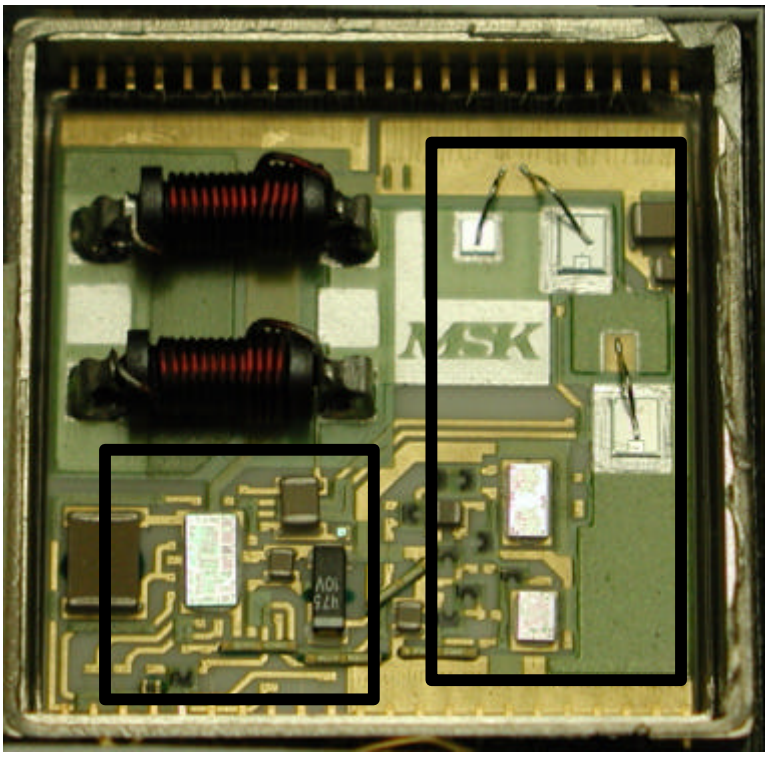

Figure 1: MSK5042

3 Test description

3.1 Irradiation facility

The tests have been performed at the Brookhaven National Laboratories in March 2002. The ion beams used are described in Table 2. The max 797 has been irradiated alone, then the other active parts (linear devices and MOSFET) have been irradiated together. The two different irradiation areas are shown in Figure 1.

Ion	Energy (MeV)	Average flux (#/cm^2-s)	Range (mm)	LET (MeVcm^2/mg)
Cl-35	210	~1E+03	63	11.4
Ti-48	233	~1E+04	49	18.6
Fe-56	231	~5E+03	40	24.7
Br-81	280	~2E+04	36	37.4
Ni-58	266	~2E+04	42	26.6

Table 2: Ions used at BNL.

3.2 Test set-up

Figure 2 shows the bias circuitry. The part has been biased with a 30V input voltage. The output voltage has been adjusted to 2.5V. An oscilloscope monitors the device output. As soon as the device output deviates of 500 mV from the nominal output voltage, an output is counted. Two different load conditions have been investigated: no load and Iload=130 mA (~3% of maximum load). We have not been able to test higher loads. The reason is the use of improper output capacitors.

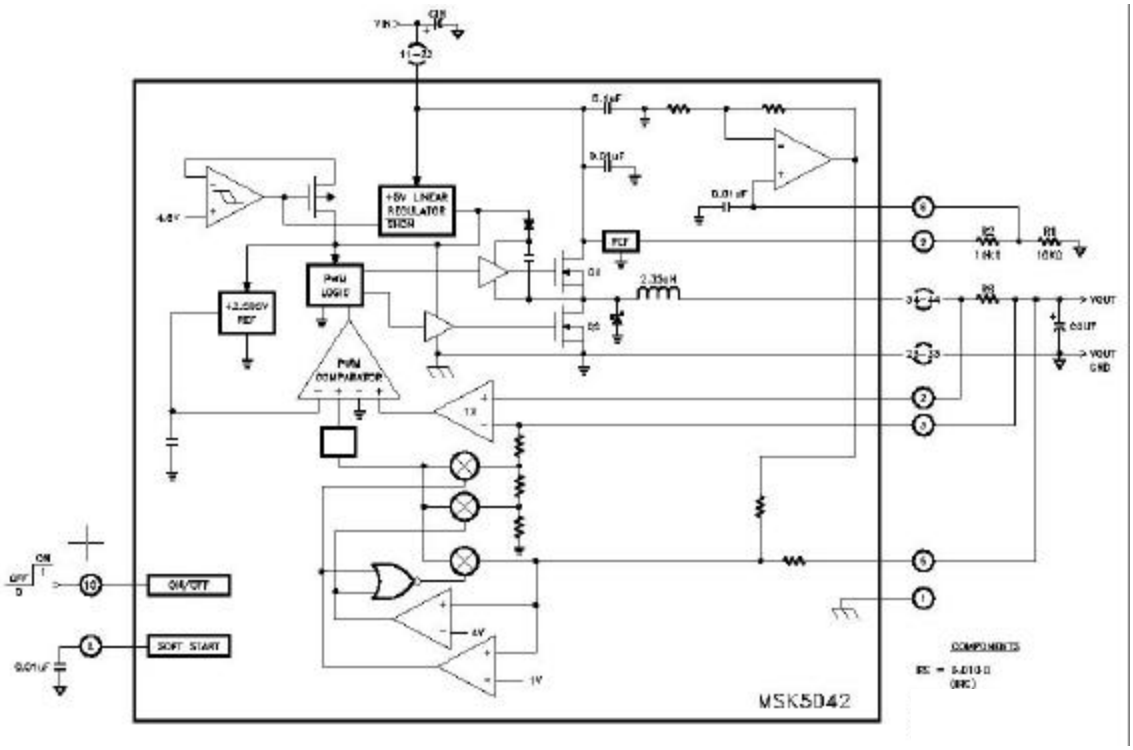

Figure 2: Bias schematics

4 Test results

The test results are presented in Table 3. A low transient sensitivity has been observed. Two failures have been observed, one at the LET of 59 MeVcm2/mg and the other at the LET of 37 MeVcm2/mg, when the linear devices and the power MOSFET were irradiated.

Run #	Part #	Angle	LET	Load (%)	Irradiated area	Fluence	SET	failure	Cross section SET (cm2/dev)	Cross section failure (cm2/dev)
1	1	0	11.44	0.00	max797	2.97E+05	0	0	0.00E+00	0.00E+00
2	1	0	11.44	3.25	max797	3.40E+05	0	0	0.00E+00	0.00E+00
3	1	0	11.44	0.00	linear+MOSFET	7.45E+05	0	0	0.00E+00	0.00E+00
4	1	0	11.44	3.25	linear+MOSFET	7.90E+05	0	0	0.00E+00	0.00E+00
5	1	0	**59.39**	0.00	linear+MOSFET	1.50E+03		**1**	0.00E+00	6.67E-04
6	2	0	11.40	0.00	max797	6.95E+06	0	0	0.00E+00	0.00E+00
7	2	0	11.40	3.25	max797	7.61E+06	0	0	0.00E+00	0.00E+00
8	2	0	11.40	0.00	linear+MOSFET	7.14E+06	0	0	0.00E+00	0.00E+00
9	2	0	11.40	3.25	linear+MOSFET	6.82E+06	0	0	0.00E+00	0.00E+00
10	2	0	18.58	3.25	linear+MOSFET	1.95E+06	2	0	1.03E-06	0.00E+00
11	2	0	18.58	0.00	linear+MOSFET	2.02E+06	3	0	1.49E-06	0.00E+00
12	2	0	18.58	0.00	max797	2.07E+06	0	0	0.00E+00	0.00E+00
13	2	0	18.58	3.25	max797	2.16E+06	0	0	0.00E+00	0.00E+00
14	2	0	24.72	0.00	max797	1.99E+06	5	0	2.52E-06	0.00E+00
15	2	0	24.72	3.25	max797	2.09E+06	0	0	0.00E+00	0.00E+00
16	2	0	24.72	0.00	linear+MOSFET	4.08E+06	0	0	0.00E+00	0.00E+00
17	2	0	24.72	3.25	linear+MOSFET	2.41E+06	0	0	0.00E+00	0.00E+00
18	2	0	26.55	0.00	linear+MOSFET	2.23E+06	0	0	0.00E+00	0.00E+00
19	2	0	26.55	3.25	linear+MOSFET	2.21E+06	0	0	0.00E+00	0.00E+00
20	2	0	26.55	0.00	max797	2.20E+06	0	0	0.00E+00	0.00E+00
21	2	0	26.55	3.25	max797	2.01E+06	0	0	0.00E+00	0.00E+00
22	2	0	37.45	3.25	max797	2.01E+06	0	0	0.00E+00	0.00E+00
23	2	0	37.45	0.00	max797	2.06E+06	0	0	0.00E+00	0.00E+00
24	2	0	**37.45**	0.00	linear+MOSFET	1.41E+05	0	**1**	0.00E+00	7.07E-06
25	3	0	59.39	0.00	max797	4.83E+06	0	0	0.00E+00	0.00E+00
26	3	0	59.39	3.25	max797	2.01E+06	0	0	0.00E+00	0.00E+00
27	3	45	83.74	3.25	max797	2.18E+06	0	0	0.00E+00	0.00E+00
28	3	0	26.55	0.00	max797	2.00E+06	0	0	0.00E+00	0.00E+00
29	3	0	26.55	3.25	max797	1.91E+06	0	0	0.00E+00	0.00E+00
30	3	0	26.55	0.00	linear+MOSFET	4.01E+06	0	0	0.00E+00	0.00E+00
31	3	0	26.55	3.25	linear+MOSFET	2.03E+06	0	0	0.00E+00	0.00E+00

Table 3: test results

The analysis after irradiation shows that the failure occurred on the power MOSFET. A picture of the burnout of part SN1 power MOSFET is shown in Figure 2 and 3. The reason of this failure could be a heavy ion induced burnout on the IRLC034N power MOSFET, or a transient on the voltage reference or the operational amplifier that causes an overcurrent on the MOSFET.

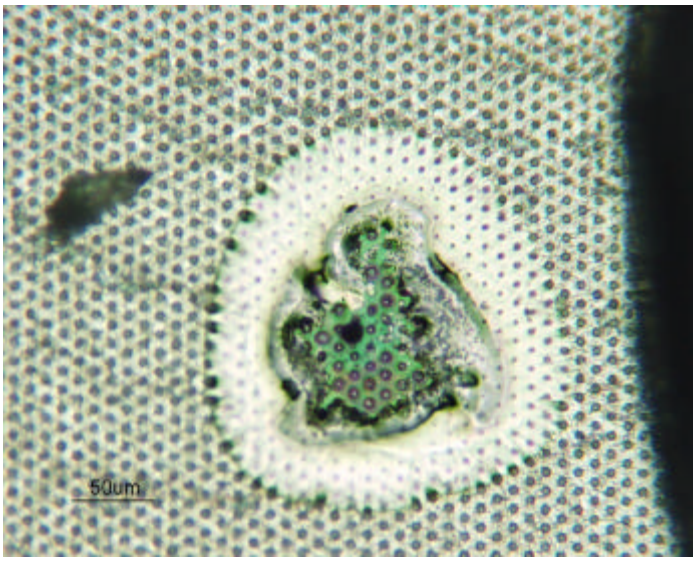

Figure 1: burnout on Q1

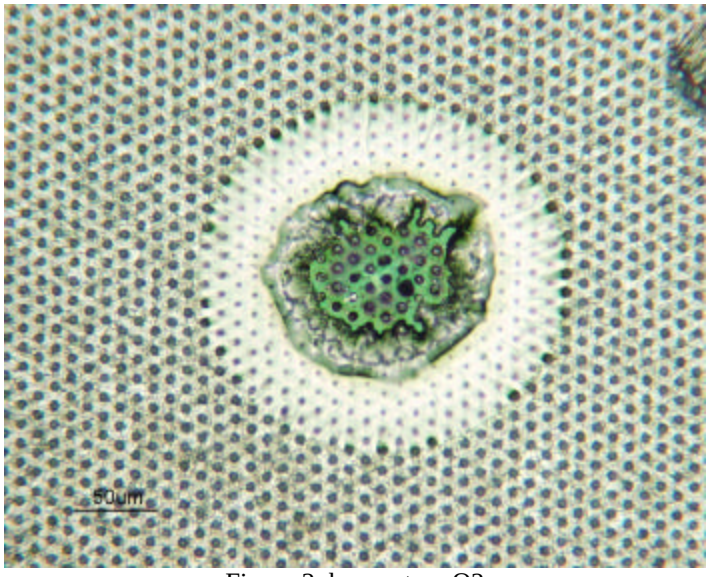

Figure 2: burnout on Q2

5 Conclusions

The test results show that the MS5042 has a low sensitivity to transients. Two functional failures have been observed, due to burnout on the power MOSFET. These failures occurred at high LET (>37 MeVcm2/mg), but the sensitivity could be significantly higher for high load conditions. The most probable cause is the heavy ion induced burnout on power MOSFET. The use of higher voltage MOSFET (ie. 100V devices) will give a lower sensitivity. A design analysis is also recommended to study the impact of transients on the voltage reference and the operational amplifier.