Unisys

DATE: September 24, 1998 PPM-98-026
TO: J. Dafnis/303
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SUBJECT: Radiation Report on **LM117H (National Semiconductor) (LDC 9727)**
PROJECT: GOES (ITT)

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A radiation evaluation was performed on **LM117H Voltage Regulator (National Semiconductor)** to determine the total dose tolerance of these parts. The total dose testing was performed using a Co^{60} gamma ray source. During the radiation testing, eight parts were irradiated under bias (see Figure 1 for bias configuration) and two parts were used as control samples. The total dose radiation levels were 20.0, 40.0, 60.0, 80.0, 100.0, 150.0, and 200.0 kRads.[1] The dose rate was 1.200 kRads/hour (0.33 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 200.0 kRad irradiation, the parts were annealed under bias at 25°C and tested after 96 and 240 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] listed in Table III.

An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step. For detailed information, refer to Tables I through IV and Figure 1.

All parts passed all tests up to 20kRads. After the 40 to 80kRad irradiations, the parts showed some degradation from the specification limit in the V_Line1 parameter (See Figure 2). After annealing the parts for 72 hours at 25°C, there was some recovery in V_Line1. After the 100 to 200kRad irradiations, the parts continued to exceed the specification limit for V_Line1. After annealing the parts for 96 hours at 25°C, the parts showed significant recovery in V_Line1 with all parts measuring within the specification limits. After annealing the parts for 240 hours at 25°C, the parts showed additional recovery with readings similar to those at 20kRads. No significant degradation was observed in any other parameter.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 328, 367, 380, 394, 401, 406, 412, and 426) were used as radiation samples while SN's 322 and 327 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 20.0 kRads.

After the 40.0 kRad irradiation, all parts exceeded the specification limit of 12.5mV for V_Line1 with readings in the range of 14.1 to 17.0mV. **All parts passed all other tests.**

After the 60.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 17.0 to 19.0mV. **All parts passed all other tests.**

After the 80.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 18.8 to 19.8mV. **All parts passed all other tests.**

After annealing the parts for 72 hours at 25°C, the parts showed some recovery in V_Line1 with readings in the range of 14.0 to 14.1mV.

[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After the 100.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 17.3 to 18.4mV. **All parts passed all other tests.**

After the 150.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 15.9 to 17.0mV. **All parts passed all other tests.**

After the 200.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 15.6 to 16.9mV. **All parts passed all other tests.**

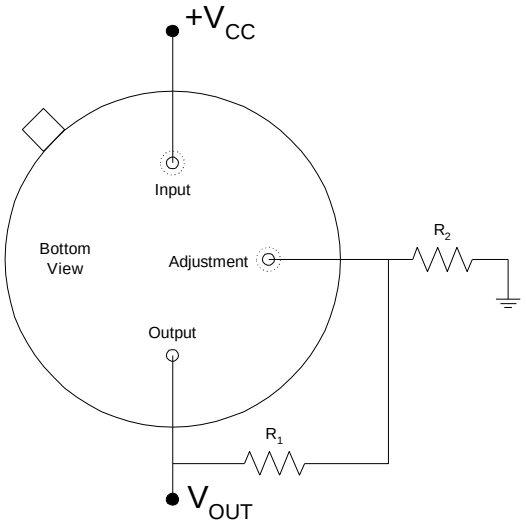
After annealing the parts for 96 hours at 25°C, the parts showed significant recovery with all parts passing all tests and readings for V_Line1 in the range of 10.4 to 11.2mV.

After annealing the parts for 240 hours at 25°C, all parts passed all tests with readings similar to those after 20kRads.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call us at (301) 731-8954.

Figure 1. Radiation Bias Circuit for LM117H



Notes:
1. V_{CC} = 30.0V ±0.5V.
2. Check $V_{OUT} \approx$ 15.0V.
3. R_1 = 270Ω ±5%, ½W.
4. R_2 = 2.7kΩ ±5%, ½W.

TABLE I. Part Information

Generic Part Number:	LM117H
GOES (ITT) Part Number	LM117H
Charge Number:	C80709/C80825
Manufacturer:	National Semiconductor
Lot Date Code (LDC):	9727
Quantity Tested:	10
Serial Number of Control Samples:	322, 327
Serial Numbers of Radiation Samples:	328, 367, 380, 394, 401, 406, 412, and 426
Part Function:	Voltage Regulator
Part Technology:	Bipolar
Package Style:	TO-39 Can
Test Equipment:	A540
Test Engineer:	S. Norris

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for LM117H

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/24/98
2) 20.0 KRAD IRRADIATION (1.200 KRADS/HOUR)	08/24/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	08/25/98
3) 40.0 KRAD IRRADIATION (1.200 KRADS/HOUR)	08/25/98
POST-40.0 KRAD ELECTRICAL MEASUREMENT	08/26/98
4) 60.0 KRAD IRRADIATION (1.200 KRADS/HOUR)	08/26/98
POST-60.0 KRAD ELECTRICAL MEASUREMENT	08/27/98
5) 80.0 KRAD IRRADIATION (1.200 KRADS/HOUR)	08/27/98
POST-80.0 KRAD ELECTRICAL MEASUREMENT	08/28/98
6) 72 HOUR ANNEALING @25°C *	08/28/98
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/31/98
7) 100.0 KRAD IRRADIATION (1.200 KRADS/HOUR)	08/31/98
POST-100.0 KRAD ELECTRICAL MEASUREMENT	08/01/98
8) 150.0 KRAD IRRADIATION (1.200 KRADS/HOUR)	09/01/98
POST-150.0 KRAD ELECTRICAL MEASUREMENT	09/03/98
9) 200.0 KRAD IRRADIATION (0.450 KRADS/HOUR)	09/03/98
POST-200.0 KRAD ELECTRICAL MEASUREMENT	09/04/98
10) 96 HOUR ANNEALING @25°C	09/04/98
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/08/98
11) 240 HOUR ANNEALING @25°C	09/04/98
POST-240 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/14/98

Effective Dose Rate = 200,000 RADS/11 DAYS=757.5 RADS/HOUR=0.21 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the weekend and the extended step.

* The annealing step was included due to the weekend.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.

Table III. Electrical Characteristics of LM117H /1

Test #	Parameter	Units	Test Conditions /2	Spec. min	Lim. max
1	IQ_3V	mA	V_{DIF} = 3V	-3.0	3.0
2	IQ_13V	mA	V_{DIF} = 13V	-3.0	3.0
3	IADJ_3V	mA	I_L = 5mA, V_{DIF} = 3V	-100	100
4	IADJ_40V	mA	I_L = 5mA, V_{DIF} = 40V	-100	100
5	Delta_IADJ_1	mA	3V £ (V_{IN} - V_{OUT}) £ 40V, 10mA £ I_{OUT} £ I_{MAX}	-5.0	5.0
6	V_Out_1	V	3V £ (V_{IN} - V_{OUT}) £ 40V, 10mA £ I_{OUT} £ I_{MAX}, P £ P_{MAX}	1.200	1.300
7	V_Out_2	V		1.200	1.300
8	V_Out_3	V		1.200	1.300
9	V_Line1	mV	V_{DIF} = 3V to 40V	-7.4	12.5
10	V_Load1	mV	I_{IN} = 200mA	-12.5	12.5
11	V_Load2	mV	I_{IN} = 200mA	-12.5	12.5

Notes:

1/ These are the manufacturer's non-irradiated data sheet specification limits. The manufacturer provided no post-irradiation limits at the time the tests were performed.

2/ $V_{IN} - V_{OUT}$ = 5V, I_{OUT} = 10mA unless otherwise noted.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LM117H /1

							Total Dose Exposure (kRads Si)								Annealing		Total Dose Exposure (kRads Si)						Annealing			
					Initial		20.0		40.0		60.0		80.0		72 hours @25°C		100.0		150.0		200.0		96 hours @25°C		168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	IQ_3V	mA	-3.0	3.0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0
2	IQ_13V	mA	-3.0	3.0	2.4	0.1	1.8	0.3	1.4	0.2	1.2	0.1	1.1	0	1.3	0	1.2	0.1	1.3	0.1	1.3	0.1	1.6	0.1	1.6	0.1
3	IADJ_3V	mA	-100	100	-53	0.8	-52	0.7	-51	0.8	-50	0.6	-50	0.6	-51	0.7	-50	0.7	-49	0.7	-49	0.7	-50	0.8	-51	0.8
4	IADJ_40V	mA	-100	100	-57	0.8	-56	0.7	-55	0.8	-54	0.7	-54	0.6	-55	0.7	-54	0.6	-53	0.7	-53	0.7	-54	0.7	-54	0.6
5	Delta_IADJ_1	mA	-5.0	5.0	3.0	0.2	3.5	0.2	3.8	0.1	4.0	0.1	4.1	0.1	3.8	0.1	4.0	0.1	3.9	0.1	4.0	0.1	3.5	0.2	3.4	0.1
6	V_Out_1	V	1.200	1.300	1.248	0.003	1.244	0.07	1.231	0.008	1.217	0.005	1.210	0.003	1.224	0.002	1.211	0.003	1.210	0.004	1.206	0.004	1.225	0.004	1.229	0.003
7	V_Out_2	V	1.200	1.300	1.249	0.003	1.246	0.007	1.234	0.008	1.221	0.004	1.214	0.002	1.226	0.002	1.215	0.003	1.213	0.004	1.209	0.004	1.227	0.004	1.232	0.005
8	V_Out_3	V	1.200	1.300	1.255	0.003	1.257	0.007	1.248	0.007	1.238	0.004	1.231	0.002	1.240	0.002	1.231	0.003	1.228	0.004	1.224	0.004	1.238	0.003	1.241	0.003
9	V_Line1	mV	-7.4	12.5	5.0	0.1	10.5	0.9	15.4	1.0	18.1	0.7	19.1	0.3	14.2	0.2	17.6	0.3	16.5	0.4	16.5	0.5	10.9	0.3	10.0	0.2
10	V_Load1	mV	-12.5	12.5	-7.7	0.9	-5.7	0.2	-6.1	0.2	-6.0	0.2	-6.1	0.3	-5.8	0.2	-6.0	0.3	-6.0	0.3	-6.0	0.2	-5.7	0.2	-5.6	0.2
11	V_Load2	mV	-12.5	12.5	1.5	0.3	0.9	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.5	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.9	0.2	1.0	0.2

Notes:

1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.

2/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

Radiation sensitive parameters: V_Line1.

Figure 2: VLine_1 vs Total Ionizing Dose [kRads (Si)]