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DATE: November 14, 1997 PPM-97-051
TO: W. Daney/303
FROM: K. Sahu/300.1
SUBJECT: Radiation Report on: LM317AT
Project: NOAA
Job #: M78293
Project part #: LM317AT

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A radiation evaluation was performed on LM317AT to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through IV and Figure 1.

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 5.0, 10.0, 20.0, 30.0, 50.0, 75.0, and 100.0 kRads.* The dose rate was between 0.125 and 0.625 kRads/hour (0.035 to 0.174 Rads/s). After the 50.0 kRad irradiation, the parts were annealed for 48 hours at 25°C. After the 100.0 kRad exposure, the parts were annealed for 168 hours at 25°C. See Table II for the radiation schedule and effective dose rate calculation. The effective dose rate over all testing was 0.036Rads/sec. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits** listed in Table III.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 198, 199, 200, 201, 202, 203, 204, and 205) were used as radiation samples while SN's 196 and 197 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests to 10.0 kRads. No significant degradation was noted in any parameter. After the 20-100kRad exposures, the parts showed degradation in V_Line1. The readings for V_Line1 after 20 kRads were in the range of 8.1 to 11.4mV and ranged from 17.5 to 20.5mV after the50kRad step. The specification limit is ±7.4mV. The parts also showed marginal degradation in Delta_IADJ_1, V_Out_1, V_Out_2, V_Out3, V_Out_4, and V_Load1. **A detailed summary of the results after each radiation level is provided on the following page**.

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 me at (301) 731-8954.

Detailed Summary:

* The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
** 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 20.0 kRad irradiation, four parts marginally exceeded the specification limit of 1.270 for V_Out_3 with readings in the range of 1.271 to 1.278V. Three parts marginally exceeded the specification limit of 1.270 for V_Out_4 with readings in the range of 1.274 to 1.277V. All parts exceeded the specification limit of 7.4V for V_Line1 with readings in the range of 8.1 to 11.4mV. **All parts passed all other tests.**

After the 30.0 kRad irradiation, all but one part marginally exceeded the specification limit for V_Out_3 with readings in the range of 1.271 to 1.286V. Six parts marginally exceeded the specification limit for V_Out_4 with readings in the range of 1.272 to 1.285V. All parts exceeded the specification limit for V_Line1 with readings in the range of 11.5 to 16.5mV. **All parts passed all other tests.**

After the 50.0 kRad irradiation, SN 205 marginally exceeded the specification limit of 5.00V for Delta_IADJ_1 with a reading of 5.16V. SN's 198 and 203 marginally exceeded the specification limit of 1.270 for V_Out_2 with readings of 1.273 and 1.272V respectively. All parts marginally exceeded the specification limit for V_Out_3 with readings in the range of 1.274 to 1.294V. All parts marginally exceeded the specification limit for V_Out_4 with readings in the range of 1.272 to 1.292V. All parts exceeded the specification limit for V_Line1 with readings in the range of 17.5 to 20.5mV. **All parts passed all other tests.**

After the 75.0 kRad irradiation, five parts marginally exceeded the specification limit for Delta_IADJ_1 with readings in the range of 5.31 to 5.47V. Five parts marginally exceeded the specification limit of 1.270 for V_Out_1 with readings in the range of 1.272 to 1.280V. Six parts marginally exceeded the specification limit for V_Out_2 with readings in the range of 1.277 to 1.285V. All parts marginally exceeded the specification limit for V_Out_3 with readings in the range of 1.286 to 1.312V. All parts marginally exceeded the specification limit for V_Out_4 with readings in the range of 1.285 to 1.309V. All parts exceeded the specification limit for V_Line1 with all readings greater than 20.5mV. **All parts passed all other tests.**

After the 100.0 kRad irradiation, all parts marginally exceeded the specification limit for Delta_IADJ_1 with readings in the range of 5.47 to 6.41V. SN's 201 and 204 fell below the specification limit of 1.225V for V_Out_1 with readings of 1.102 and 1.192V respectively. SN's 201 and 204 fell below the specification limit of 1.225V for V_Out_2 with readings of 1.210 and 1.201V respectively. Six parts marginally exceeded the specification limit for V_Out_3 with readings in the range of 1.273 to 1.301V. Six parts marginally exceeded the specification limit for V_Out_4 with readings in the range of 1.271 to 1.299V. All parts exceeded the specification limit for V_Line1 with all readings greater than 20.5mV. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, the parts showed no significant recovery in any parameter.

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 me at (301) 731-8954.

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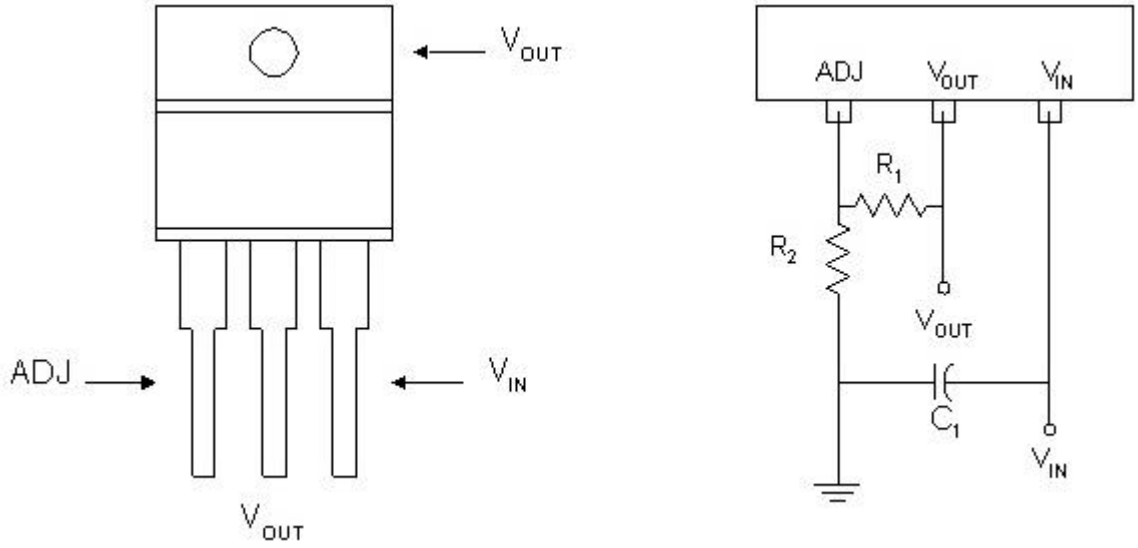
Figure 1. Radiation Bias Circuit for LM317AT



Notes:
1. V_{IN} = 35.0V ±0.5V DC.
2. V_{OUT} = 26.8V ±0.5V DC.
3. Resistor 1 is 240Ω ± 5%, ½ W.
4. Resistor 2 is 5.0kΩ ± 5%, ½ W.
5. Capacitor 1 is 0.1µf.

TABLE I. Part Information

Generic Part Number:	LM317AT
NOAA Part Number	LM317AT
Charge Number:	M78293
Manufacturer:	National Semiconductor
Lot Date Code (LDC):	M73BL
Quantity Tested:	10
Serial Number of Control Samples:	196, 197
Serial Numbers of Radiation Samples:	198, 199, 200, 201, 202, 203, 204, and 205
Part Function:	3 Terminal Adjustable Regulator
Part Technology:	Bipolar
Package Style:	TO-220
Test Equipment:	A540
Test Engineer:	D. Davis

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

TABLE II. Radiation Schedule for LM317AT

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	09/26/97
2) 5.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	10/03/97
POST-5.0 KRAD ELECTRICAL MEASUREMENT	10/06/97
2) 10.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	10/06/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT	10/08/97
3) 20.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	10/08/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT	10/10/97
4) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	10/22/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT	10/24/97
5) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)	10/27/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT	10/29/97
6) 75.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	10/29/97
POST-75.0 KRAD ELECTRICAL MEASUREMENT	10/31/97
7) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	10/31/97
POST-100.0 KRAD ELECTRICAL MEASUREMENT	11/03/97
8) 168 HOUR ANNEALING @25°C	11/03/97
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/10/97

Effective Dose Rate = 100,000 RADS/32 DAYS=130.2 RADS/HOUR=0.036 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

The time gap between the 20 and 30 kRad steps was due to a repair of the ATE.

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

Table III. Electrical Characteristics of LM317AT /1

Test #	Parameter	Units	Test Conditions /2	Spec. min	Lim. max
1	IQ_3V	mA	$(V_{IN} - V_{OUT}) = 3V$	0.0	3.0
2	IQ_13V	mA	$(V_{IN} - V_{OUT}) = 13V$	0.0	3.0
3	IQ_40V	mA	$(V_{IN} - V_{OUT}) = 40V$	0.0	5.0
4	IADJ_3V	mA		-100	100
5	IADJ_40V	mA		-100	100
6	Delta_IADJ_1	mA	$3V \leq (V_{IN} - V_{OUT}) \leq 40V$ $10mA \leq I_{OUT} \leq I_{MAX}$	-5.0	5.0
7	V_Out_1	V	$3V \leq (V_{IN} - V_{OUT}) \leq 40V$ $10mA \leq I_{OUT} \leq I_{MAX}$ $P \leq P_{MAX}$	1.225	1.270
8	V_Out_2	V		1.225	1.270
9	V_Out_3	V		1.225	1.270
10	V_Out_4	V		1.225	1.270
11	V_Line1	mV	$3V \leq (V_{IN} - V_{OUT}) \leq 40V$	-7.4	7.4
12	V_Load1	mV	$10mA \leq I_{OUT} \leq I_{MAX}$	-12.5	12.5
13	V_Load2	mV	$10mA \leq I_{OUT} \leq I_{MAX}$	-12.5	12.5

Note:

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/ $V_{IN} - V_{OUT} = 5V$ and $I_{OUT} = 10mA$ unless otherwise specified.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LM317AT /1

Test #	Parameters	Units	Spec. Lim. /2 min	Spec. Lim. /2 max	Initial mean	Initial sd	Total Dose Exposure (kRads) 5.0 mean	5.0 sd	10.0 mean	10.0 sd	20.0 mean	20.0 sd	30.0 mean	30.0 sd	50.0 mean	50.0 sd	75.0 mean	75.0 sd	100.0 mean	100.0 sd	Annealing 168 hours @25°C mean	Annealing 168 hours @25°C sd
1	IQ_3V	mA	0.0	3.0	0.32	0.01	0.32	0.01	0.32	0.01	0.32	0.01	0.31	0.01	0.30	0.01	0.28	0.01	0.27	0.01	0.27	0.01
2	IQ_13V	mA	0.0	3.0	2.46	0.05	2.17	0.11	2.19	0.11	1.71	0.07	1.38	0.09	1.06	0.11	0.93	0.15	0.68	0.10	0.58	0.05
3	IQ_40V	mA	0.0	5.0	4.53	0.07	4.21	0.10	4.25	0.10	3.91	0.06	3.60	0.10	3.26	0.14	3.14	0.16	2.77	0.22	2.51	0.14
4	IADJ_3V	mA	-100	100	-49	0.6	-50	0.5	-50	0.6	-51	0.5	-50	0.06	-49	0.7	-50	0.9	-47	1.8	-45	1.3
5	IADJ_40V	mA	-100	100	-53	0.7	-53	0.9	-53	0.9	-53	0.5	-54	0.5	-54	0.8	-55	0.9	-53	1.6	-51	1.0
6	Delta_IADJ_1	mA	-5.0	5.0	3.30	0.05	3.34	0.08	3.54	0.11	2.85	0.07	4.07	0.19	4.62	0.27	5.11	0.30	5.81	0.29	5.59	0.27
7	V_Out_1	V	1.225	1.270	1.249	0.005	1.252	0.004	1.260	0.004	1.259	0.004	1.262	0.005	1.262	0.008	1.269	0.010	1.237	0.024	1.200	0.018
8	V_Out_2	V	1.225	1.270	1.249	0.005	1.254	0.005	1.261	0.004	1.261	0.004	1.264	0.005	1.264	0.008	1.274	0.009	1.244	0.023	1.207	0.017
9	V_Out_3	V	1.225	1.270	1.252	0.005	1.257	0.004	1.267	0.004	1.271	0.005	1.277	0.006	1.284	0.007	1.300	0.009	1.277	0.022	1.237	0.015
10	V_Out_4	V	1.225	1.270	1.252	0.005	1.257	0.004	1.267	0.004	1.270	0.005	1.276	0.006	1.282	0.007	1.298	0.008	1.275	0.021	1.235	0.015
11	V_Line1 /3	mV	-7.4	7.4	1.99	0.04	3.81	0.35	5.71	0.69	10.2	1.4	14.5	2.0	19.6	1.2	>20.5		>20.5		>20.5	
12	V_Load1	mV	-12.5	12.5	-1.63	0.11	-2.14	0.22	-2.23	0.16	-4.01	0.83	-7.34	1.84	-8.13	2.30	-8.66	1.59	-7.97	1.10	-9.95	2.01
13	V_Load2	mV	-12.5	12.5	-0.70	0.05	-0.85	0.08	-0.99	0.08	-1.14	0.14	-1.78	0.28	-2.48	0.30	-2.94	0.48	-2.92	0.49	-2.88	0.45

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 ath the time the tests were performed.

3/ After 75 kRads, the value of V_Line1 exceeded the capability of the ATE to measure it without changing the specifications stated by the manufacturer and in the MIL SPEC.

Radiation sensitive parameters: Delta_IADJ_1, V_Out_1, V_Out_2, V_Out_3, V_Out_4, V_Line1, V_Load1.

Figure 2: V_Line1 (mean) vs Total Ionizing Dose