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DATE: October 10, 1997 PPM-97-042
TO: P. Huber/400
FROM: K. Sahu/300.1
SUBJECT: Radiation Report on: LM117HV
Project: GOES Sounder/Imager
Job #: M78297
Project part #: LM117HV

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A radiation evaluation was performed on LM117HV 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, seven parts were irradiated under bias (see Figure 1 for bias configuration) and one part was used as a control sample. The total dose radiation levels were 10.0, 20.0, 30.0, 50.0, 75.0, 100.0, 150.0, and 200.0 kRads.* The dose rate was between 0.250 and 1.250 kRads/hour (0.069 to 0.347 Rads/s). After the 30.0 kRad irradiation, the parts were annealed for 48 hours at 25°C. After the 50.0 kRad irradiation, the parts were annealed for 96 hours at 25°C. After the 100.0 kRad irradiation, the ATE suffered a failure. Thus, the post 100 kRad measurements include a 264 hour annealing at 25°C. After the 200.0 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 0.049Rads/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 8 samples. Seven samples (SN's 251, 252, 253, 254, 255, 257, and 258) were used as radiation samples while SN 250 was used as a control sample. 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 20.0 kRad irradiation, SN's 251, 254 and 257 exceeded the specification limit of 11.4mV for V_Line1 with readings of 12.1, 11.5 and 11.5mV respectively. **All parts passed all other tests.**

After the 30.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 11.5 to 14.8mV. **All parts passed all other tests.**

After the annealing the parts for 72 hours at 25°C, parts showed some recovery with one part passing V_Line1 and all others with readings in the range of 12.5 to 13.4V. **All parts passed all other tests.**

After the 40.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 13.0 to 16.3mV. **All parts passed all other tests.**

After the 50.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 14.2 to 16.9mV. **All parts passed all other tests.**

* 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 annealing the parts for 96 hours at 25°C, parts showed no recovery with all parts exceeding the specification limit for V_Line1 with readings in the range of 14.3 to 17.2mV. **All parts passed all other tests.**

After the 75.0 kRad irradiation, all parts exceeded the specification limit for V_Line1 with readings in the range of 16.8 to 19.0mV. **All parts passed all other tests.**

After the 100.0 kRad irradiation and 264 hour annealing at 25°C, all parts showed some recovery, but continued to exceed the specification limit for V_Line1 with readings in the range of 12.8 to 14.2V. **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 17.0 to 19.3mV. **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 17.3 to 19.6mV. **All parts passed all other tests.**

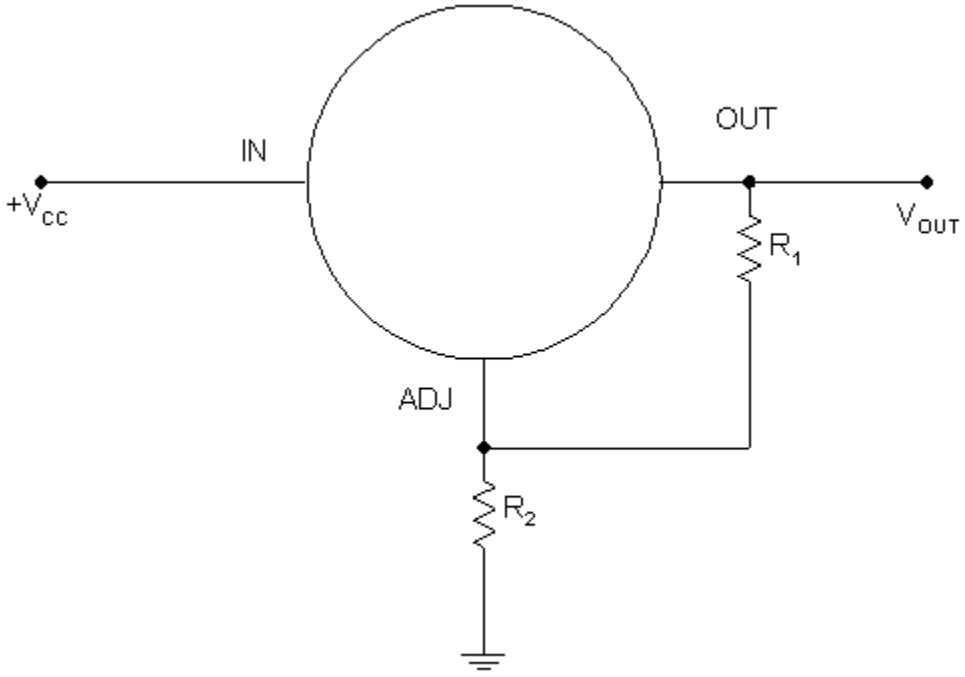
After the annealing the parts for 168 hours at 25°C, parts showed some recovery in V_Line1 with all parts readings in the range of 11.4 to 13.3mV.

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.

V_Line1 was the only parameter that showed any degradation with radiation. Figure 2 shows the trend of V_Line1 after each radiation 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.

Figure 1. Radiation Bias Circuit for LM117HV



Notes:
1. R_1 = 150Ω ±5% ½W
2. R_2 = 2.7kΩ ±5% ½W
3. V_{CC} = 50.0 ±0.5V
4. Check V_{OUT} ~ 24.0V

TABLE I. Part Information

Generic Part Number:	LM117HV
GOES Sounder/Imager Part Number	LM117HV
Charge Number:	M78297
Manufacturer:	National Semiconductor
Lot Date Code (LDC):	9054
Quantity Tested:	10
Serial Number of Control Samples:	250
Serial Numbers of Radiation Samples:	251, 252, 253, 254, 255, 257, and 258
Part Function:	Voltage Regulator
Part Technology:	Bipolar
Package Style:	TO-39
Test Equipment:	A540
Test Engineer:	D. Davis

- No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

TABLE II. Radiation Schedule for LM117HV

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	09/12/97
2) 10.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	09/12/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT	09/15/97
3) 20.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	09/15/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT	09/18/97
4) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	09/19/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT	09/22/97
5) 72 HOUR ANNEALING @25°C	09/22/97
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/25/97
6) 40.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	09/25/97
POST-40.0 KRAD ELECTRICAL MEASUREMENT	09/27/97
7) 50.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	09/27/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT	09/30/97
8) 96 HOUR ANNEALING @25°C	09/30/97
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/04/97
9) 75.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	10/04/97
POST-75.0 KRAD ELECTRICAL MEASUREMENT	10/07/97
10) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR) + 264 HOUR ANNEALING @25°C	10/07/97
POST-100.0 KRAD + 264 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/22/97
11) 150.0 KRAD IRRADIATION (1.250 KRADS/HOUR)	10/22/97
POST-150.0 KRAD ELECTRICAL MEASUREMENT	10/24/97
12) 200.0 KRAD IRRADIATION (1.250 KRADS/HOUR)	10/27/97
POST-200.0 KRAD ELECTRICAL MEASUREMENT	10/29/97
13) 168 HOUR ANNEALING @25°C	10/29/97
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/06/97

Effective Dose Rate = 200,000 RADS/47 DAYS=177.3 RADS/HOUR=0.049 RADS/SEC

The interim annealing following the 30.0 and 50.0 kRad steps were added due to degradation in the parts. The addition of an interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow the parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

The annealing after the 100 kRad step was the result of test equipment repair.

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

Table III. Electrical Characteristics of LM117HV /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_60V	mA	I_L = 5mA, V_{DIF} = 60V	-100	100
5	Delta_IADJ_1	mA	3V £ (V_{IN} - V_{OUT}) £ 60V, 10mA £ I_{OUT} £ I_{MAX}	-5.0	5.0
6	V_Out_1	V	3V £ (V_{IN} - V_{OUT}) £ 60V, 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 60V	-7.4	11.4
10	V_Load1	mV	I_{IN} = 200mA	-12.5	12.5
11	V_Load2	mV	I_{IN} = 200mA	-12.5	12.5

Note:

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

2/ V_{IN} - V_{OUT} = 5V, I_{OUT} = 0.1A unless otherwise noted.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LM117HV /1

Test #	Parameters	Units	Spec. Lim. /2 min	Spec. Lim. /2 max	Initial mean	Initial sd	Total Dose Exposure (kRads) 10.0 mean	10.0 sd	20.0 mean	20.0 sd	30.0 mean	30.0 sd	Annealing 72 hours @25°C mean	Annealing 72 hours @25°C sd	Total Dose Exposure (kRads) 40.0 mean	40.0 sd	50.0 mean	50.0 sd	Annealing 96 hours @25°C mean	Annealing 96 hours @25°C sd	Total Dose Exposure (kRads) 75.0 mean	75.0 sd	100.0 + 264 hr Annealing /4 mean	100.0 + 264 hr Annealing /4 sd	150.0 mean	150.0 sd	200.0 mean	200.0 sd	Annealing 168 hours @25°C mean	Annealing 168 hours @25°C sd
1	IQ_3V	mA	-3.0	3.0	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.002	0.22	0.004	0.22	0.004
2	IQ_13V	mA	-3.0	3.0	2.30	0.11	1.88	0.09	1.65	0.09	1.48	0.09	1.58	0.08	1.40	0.09	1.36	0.08	1.34	0.08	1.25	0.008	1.63	0.11	1.32	0.10	1.36	0.10	1.69	0.12
3	IADJ_3V	mA	-100	100	-0.6	0	-0.7	0.1	-0.8	0	-0.8	0	-0.6	0	-0.6	0	-0.8	0	-0.6	0	-0.8	0	-1.4	0	-1.6	0	-1.4	0	-1.1	0
4	IADJ_60V	mA	-100	100	-0.8	0	-0.9	0.1	-0.9	0	-1.1	0	-0.6	0	-0.6	0	-0.8	0	-0.6	0	-0.9	0	-1.5	0.07	-1.6	0	-1.4	0	-1.1	0
5	Delta_IADJ_1	mA	-5.0	5.0	0.16	0	0.18	0.05	0.16	0	0.31	0	0.0	0	0.0	0	0.0	0	0.0	0	0.2	0	0.1	0.1	0.0	0	0.0	0	0.0	0
6	V_Out_1	V	1.200	1.300	1.260	0.004	1.256	0.003	1.251	0.003	1.246	0.002	1.253	0.003	1.244	0.003	1.244	0.002	1.238	0.003	1.232	0.003	1.245	0.003	1.229	0.002	1.227	0.003	1.244	0.003
7	V_Out_2	V	1.200	1.300	1.261	0.004	1.257	0.003	1.252	0.003	1.248	0.003	1.253	0.003	1.244	0.003	1.244	0.002	1.240	0.003	1.233	0.003	1.247	0.003	1.232	0.002	1.229	0.003	1.246	0.003
8	V_Out_3	V	1.200	1.300	1.272	0.004	1.269	0.003	1.267	0.003	1.263	0.003	1.265	0.003	1.264	0.003	1.262	0.003	1.259	0.003	1.252	0.003	1.262	0.003	1.250	0.003	1.248	0.003	1.261	0.003
9	V_Line1	mV	-7.4	11.4	6.7	0.2	9.0	0.3	11.2	0.7	13.2	1.2	12.6	0.7	15.1	1.0	16.0	0.8	16.2	0.8	18.1	0.8	13.6	0.4	18.2	0.7	18.0	1.0	12.6	0.6
10	V_Load1	mV	-12.5	12.5	-6.0	0.5	-6.0	0.4	-5.6	0.4	-5.9	0.4	-6.1	0.4	-6.1	0.3	-6.2	0.4	-6.5	0.4	-6.5	0.5	-7.2	0.4	-7.0	0.3	-6.5	0.4	-6.7	0.3
11	V_Load2	mV	-12.5	12.5	2.1	0.4	2.0	0.3	2.3	0.4	1.9	0.4	1.8	0.4	1.8	0.4	1.7	0.4	1.6	0.4	1.5	0.4	1.9	0.4	1.9	0.4	1.6	0.4	1.7	0.4

Notes:

1/ The mean and standard deviation values were calculated over the seven 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/ "P" ("F") indicates that all parts passed (failed) this test at this irradiation level or annelaing step. "nPmF" means that n parts passed and m parts failed this test at this irradiation level or annealing step. The failing parts had degraded so much that no measurements could be made for these parameters.

4/ This was due to a failure of the test equipment.

Radiation sensitive parameter: V_Line1.

Figure 2: V_Line1(mean) vs Total Ionizing Dose