Unisys

DATE: July 15, 1998 PPM-98-020
TO: J. Dafnis/303
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SUBJECT: Radiation Report on **LM117HVH (National Semi.) (LDC 9727)**
PROJECT: GOES (ITT)

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A radiation evaluation was performed on **LM117HVH 3-Terminal Adjustable Regulator (National Semi.)** 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 24 and 168 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 Figures 1 and 2.

**All parts exceeded the specification limit for VLine_3V_to_40V after 40-200kRads. No significant degradation was noted in any other parameter. No significant recovery was noted in any parameter following annealing at 25℃ for 168 hours.**

Initial electrical measurements were made on 10 samples. Eight samples (SN's 59, 60, 62, 63, 66, 68, 71, and 72) were used as radiation samples while SN's 57 and 58 were used as control samples. All parts passed all tests during initial electrical measurements.

After the 20.0 kRad irradiation, SN 72 marginally exceeded the specification limit of 8.44mV for VLine_3V_to_40V with a reading of 9.55mV.

After the 40.0, 60.0 and 80.0 kRad irradiations, all parts exceeded the specification limit for VLine_3V_to_40V with readings in the range of 10.19 to 12.48mV. **All parts passed all other tests.**

After the 100.0 kRad irradiation, all parts exceeded the specification limit for VLine_3V_to_40V with readings in the range of 9.26 to 10.96mV. **All parts passed all other tests.**

After the 150.0 kRad irradiation, most parts exceeded the specification limit for VLine_3V_to_40V with readings in the range of 8.65 to 9.74mV. Most parts showed some degradation in all three Vload parameters with significant variation in the readings. **All parts passed all other tests.**

After the 200.0 kRad irradiation, a malfunction of the test equipment resulted in no reliable data at this level.

After annealing the parts for 24 hours at 25°C, the parts showed significant recovery in VLine_3V_to_40V with all parts passing. There was a slight increase in the degradation of all three Vload parameters.

[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 annealing the parts for 168 hours at 25°C, parts showed no significant change from the values after 24 hours annealing.

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.

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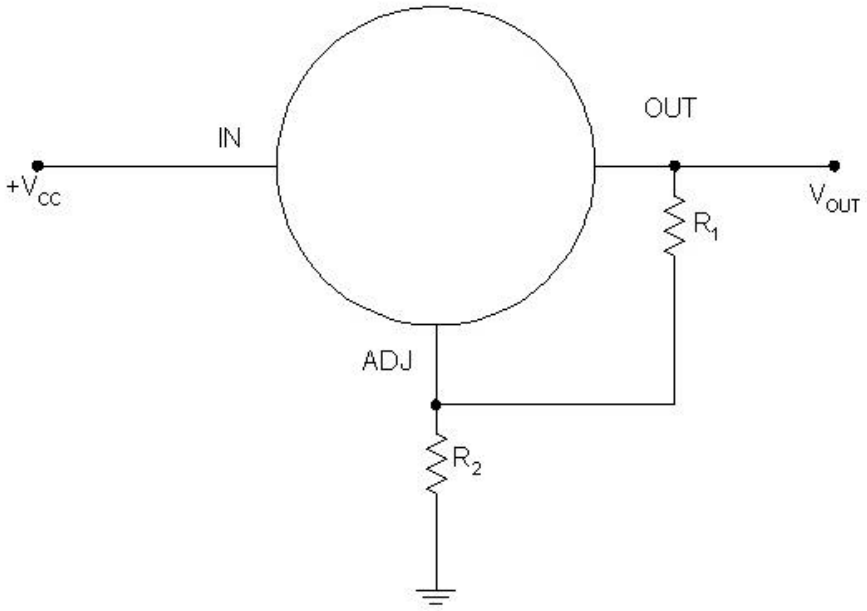
Figure 1. Radiation Bias Circuit for LM117HVH




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

TABLE I. Part Information

| | |
|---|---|
| Generic Part Number: | LM117HVH |
| GOES (ITT) Part Number | LM117HVH |
| Charge Number: | C80709/C80825 |
| Manufacturer: | National Semi. |
| Lot Date Code (LDC): | 9727 |
| Quantity Tested: | 10 |
| Serial Number of Control Samples: | 57, 58 |
| Serial Numbers of Radiation Samples: | 59, 60, 62, 63, 66, 68, 71, and 72 |
| Part Function: | 3-Terminal Adjustable Regulator |
| Part Technology: | Bipolar |
| Package Style: | TO-39 Can |
| Test Equipment: | A540 |
| Test Engineer: | S. Archer-Davies |

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

TABLE II. Radiation Schedule for LM117HVH

| EVENT | DATE |
|---|---|
| 1) INITIAL ELECTRICAL MEASUREMENTS | 06/08/98 |
| 2) 20.0 KRAD IRRADIATION (1.200 KRADS/HOUR) | 06/15/98 |
| POST-20.0 KRAD ELECTRICAL MEASUREMENT | 06/16/98 |
| 3) 40.0 KRAD IRRADIATION (1.200 KRADS/HOUR) | 06/16/98 |
| POST-40.0 KRAD ELECTRICAL MEASUREMENT | 06/17/98 |
| 4) 60.0 KRAD IRRADIATION (1.200 KRADS/HOUR) | 06/17/98 |
| POST-60.0 KRAD ELECTRICAL MEASUREMENT | 06/18/98 |
| 5) 80.0 KRAD IRRADIATION (1.200 KRADS/HOUR) | 06/18/98 |
| POST-80.0 KRAD ELECTRICAL MEASUREMENT | 06/19/98 |
| 6) 100.0 KRAD IRRADIATION (1.200 KRADS/HOUR) | 06/22/98 |
| POST-100.0 KRAD ELECTRICAL MEASUREMENT | 06/23/98 |
| 7) 150.0 KRAD IRRADIATION (1.200 KRADS/HOUR) | 06/23/98 |
| POST-150.0 KRAD ELECTRICAL MEASUREMENT | 06/25/98 |
| 8) 200.0 KRAD IRRADIATION (0.450 KRADS/HOUR) * | 06/25/98 |
| POST-200.0 KRAD ELECTRICAL MEASUREMENT | 06/29/98 |
| 9) 24 HOUR ANNEALING @25°C | 06/29/98 |
| POST-24 HOUR ANNEAL ELECTRICAL MEASUREMENT | 06/30/98 |
| 10) 168 HOUR ANNEALING @25°C | 06/30/98 |
| POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT | 07/06/98 |

Effective Dose Rate = 200,000 RADS/14 DAYS=595.2 RADS/HOUR=0.16 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.

* This step was extended due to the weekend.

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

Table III. Electrical Characteristics of LM117HVH /1

| Test # | Parameter /2 | Units | Test Conditions | Spec. min | Lim. max |
|---|---|---|---|---|---|
| 1 | IQ_3V | mA | $V_{IN}$ -$V_{OUT}$ = 3V | -5.0 | 5.0 |
| 2 | IQ_40V | mA | $V_{IN}$ -$V_{OUT}$ = 40V | -5.0 | 5.0 |
| 3 | IQ_60V | mA | $V_{IN}$ -$V_{OUT}$ = 60V | -8.2 | 8.2 |
| 4 | IADJ_3V | mA | $V_{IN}$ -$V_{OUT}$ = 3V | -100 | 100 |
| 5 | IADJ_40V | mA | $V_{IN}$ -$V_{OUT}$ = 40V | -100 | 100 |
| 6 | Delta_IADJ_1 | mA | 10mA £ $I_L$ £ $I_{MAX}$, 3V £ ($V_{IN}$ -$V_{OUT}$) £ 60V | -5.0 | 5.0 |
| 7 | Vout_at_Vdiff_3V | V | $V_{DIFF}$ = 3V | 1.200 | 1.300 |
| 8 | Vout_at_Vdiff_40V | V | $V_{DIFF}$ = 40V | 1.200 | 1.300 |
| 9 | Vout_at_Vin_60V | V | $V_{DIFF}$ = 60V | 1.200 | 1.300 |
| 10 | VLine_3V_to_40V | mV | 3V £ ($V_{IN}$ -$V_{OUT}$) £ 40V, $I_L$ = 10mA | -8.64 | 8.644 |
| 11 | VLine_40V_to_58.8V | mV | 40V £ ($V_{IN}$ -$V_{OUT}$) £ 58.8V, $I_L$ = 10mA | -25 | 25 |
| 12 | VLd_3V_10_to_200mA | mV | $V_{IN}$ -$V_{OUT}$ = 3V, 10mA £ $I_L$ £ 200mA | -15 | 15 |
| 13 | VLd_40V_10_to_100mA | mV | $V_{IN}$ -$V_{OUT}$ = 40V, 10mA £ $I_L$ £ 100mA | -15 | 15 |
| 14 | VLd_40V_10_to_150mA | mV | $V_{IN}$ -$V_{OUT}$ = 40V, 10mA £ $I_L$ £ 150mA | -15 | 15 |

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/ For all tests, $V_{IN}$ -$V_{OUT}$ = 5V, $I_{OUT}$ = 0.1A, except where otherwise noted.

## TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LM117HVH /1

| | | | | | Total Dose Exposure (kRads Si) | | | | | | | | | | | | | | | | Annealing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Initial | | 20.0 | | 40.0 | | 60.0 | | 80.0 | | 100.0 | | 150.0 | | 200.0 | | 24 hours @25°C | | 168 hours @25°C | |
| Test # | Parameters | Units | Spec. Lim. /2 min | Spec. Lim. /2 max | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd |
| 1 | IQ_3V | mA | -5.0 | 5.0 | 0.4 | 0 | 0.4 | 0 | 0.4 | 0 | 0.4 | 0 | 0.3 | 0 | 0.3 | 0 | 0.3 | 0.1 | 3/ | | 0.3 | 0 | 0.3 | 0 |
| 2 | IQ_40V | mA | -5.0 | 5.0 | 4.8 | 0.2 | 4.4 | 0.2 | 4.1 | 0.2 | 4.2 | 0.2 | 4.2 | 0.1 | 4.3 | 0.1 | 4.4 | 0.1 | 3/ | | 4.6 | 0.1 | 4.7 | 0.1 |
| 3 | IQ_60V | mA | -8.2 | 8.2 | 6.7 | 0.2 | 5.7 | 0.3 | 5.6 | 0.1 | 5.7 | 0.1 | 5.7 | 0.1 | 5.7 | 0.1 | 5.9 | 0.1 | 3/ | | 6.0 | 0.1 | 6.1 | 0.2 |
| 4 | IADJ_3V | ?A | -100 | 100 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | 3/ | | -1 | 0 | -1 | 0 |
| 5 | IADJ_40V | ?A | -100 | 100 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | -1 | 0 | 3/ | | -1 | 0 | -1 | 0 |
| 6 | Delta_IADJ_1 | ?A | -5.0 | 5.0 | -0.2 | 0 | -0.2 | 0 | -0.2 | 0 | -0.2 | 0.1 | -0.2 | 0.1 | -0.3 | 0.1 | -0.3 | 0.1 | 3/ | | -0.3 | 0.1 | -0.3 | 0.1 |
| 7 | Vout_at_Vdiff_3V | V | 1.200 | 1.300 | 1.245 | 0.004 | 1.234 | 0.005 | 1.223 | 0.006 | 1.221 | 0.003 | 1.219 | 0.004 | 1.221 | 0.003 | 1.219 | 0.004 | 3/ | | 1.228 | 0.004 | 1.220 | 0.015 |
| 8 | Vout_at_Vdiff_40V | V | 1.200 | 1.300 | 1.252 | 0.004 | 1.245 | 0.005 | 1.237 | 0.005 | 1.235 | 0.004 | 1.233 | 0.004 | 1.235 | 0.005 | 1.232 | 0.004 | 3/ | | 1.237 | 0.004 | 1.230 | 0.015 |
| 9 | Vout_at_Vin_60V | V | 1.200 | 1.300 | 1.257 | 0.004 | 1.251 | 0.005 | 1.243 | 0.005 | 1.241 | 0.004 | 1.238 | 0.003 | 1.241 | 0.003 | 1.237 | 0.004 | 3/ | | 1.243 | 0.004 | 1.231 | 0.018 |
| 10 | VLine_3V_to_40V | mV | -8.64 | 8.64 | 2.92 | 0.04 | 7.67 | 0.80 | 10.90 | 0.82 | 11.48 | 0.52 | 11.54 | 0.47 | 9.87 | 0.45 | 5.58 | 4.61 | 3/ | | 5.62 | 2.24 | 4.15 | 2.56 |
| 11 | VLine_40V_to_58.8V | mV | -25 | 25 | 4 | 0.1 | 5 | 0.1 | 6 | 0.1 | 6 | 0.1 | 4 | 2.4 | 4 | 2.2 | 3 | 2.7 | 3/ | | 4 | 1.6 | 3 | 2.2 |
| 12 | VLd_3V_10_to_200mA | mV | -15 | 15 | -7 | 0.7 | -7 | 0.8 | -8 | 0.7 | -10 | 2.6 | -10 | 2.9 | -10 | 2.7 | -27 | 62 | 3/ | | -182 | 418 | -309 | 511 |
| 13 | VLd_40V_10_to_100mA | mV | -15 | 15 | 4 | 0.5 | 3 | 0.6 | 3 | 0.6 | 3 | 0.9 | 3 | 1.7 | 3 | 1.3 | 18 | 33 | 3/ | | 2 | 25 | 1 | 50 |
| 14 | VLd_40V_10_to_150mA | mV | -15 | 15 | -4 | 0.5 | -5 | 0.5 | -5 | 0.5 | -6 | 2.2 | -6 | 2.5 | -6 | 2.3 | 9 | 38 | 3/ | | -11 | 34 | -60 | 134 |

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.

3/ Due to test equipment malfunction, no reliable data was able to be taken just after the 200kRad exposure.

**Radiation sensitive parameter: Vline_3V_to_40V.**

# Figure 2: VLine 3V to 40V vs. TID