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Interoffice Memorandum

To
 W. Beyah
 Department
 Code 716
 From
 K. Sahu KS
 Department
 7809
 Subject
 Radiation Report on ISTEP/NC
 Part No. LF441AMH

Date PPM-91-656
 Location October 31, 1991
 Telephone GSFC
 Location 731-8954
 Lanham
 G. Krishnan
 D. Krus
 R. Woodward
 F. Grena
 J. Scudder
 K. Ogilvie

A radiation evaluation was performed on LF441AMH 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 cobalt-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 steps were 10, 25, 50, and 100 krads (The term rad as used here means rad (Si).) After 100 krads, parts were annealed at 25°C for 24 and 168 hours (cumulative). After this annealing, the parts were irradiated to a total accumulated dose of 200 and 300 krads. Finally, the parts were annealed for 168 hours at 100°C. The dose rate was between 0.5 - 5 krads/hour, depending on the total dose level (see Table II for radiation schedule). After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits listed in Table III.

All parts passed all tests on irradiation up to 10 krads. After 25 krads exposure, parts marginally exceeded the specification limits on Ib+, Ib-, and Ibias. After 50 krads exposure, parts showed increasing degradation in Ib+, Ib-, and Ibias. However, parts were within the specification limits for all other parameters. However, after 100 krads exposure, parts also exceeded the specification limits for Icc, Vos, and Ios. Parts also showed significant degradation in Aol, but all parts met the minimum specification limit for this parameter. On annealing the parts for 24 and 168 hours at 25°C, after 100 krads exposure, parts showed some recovery for Ios and Ib-. On continued irradiation to 200 and 300 krads (cumulative), parts showed increased degradation in Icc, Vos, Ios, Ib-, and Ibias. Also, parts exceeded the maximum specification limit for VosRs. On annealing for 168 hours at 100°C, parts showed significant recovery for a number of parameters including Icc, Vos, and Ios.

Table IV provides the mean and standard deviation values for each parameter after different radiation exposures and annealing treatments.

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

TABLE I. Part Information

| | |
|---|---------------------------------|
| Generic Part Number: | LF441AMH |
| GPEP/PPL Part Numbers: | LF441AMH |
| GPEP/PPL Control Number: | 2095 |
| Charge Number: | C90214 |
| Manufacturer: | NATL SEMICONDUCTOR CORP |
| Lot Date Code: | M9124 |
| Quantity Tested: | 10 |
| Serial Numbers of Radiation Samples: | 503,504,505,506,507,508,509,510 |
| Serial Numbers of Control Samples: | 501,502 |
| Part Function: | Operational Amplifier |
| Part Technology: | Bipolar, JFET inputs |
| Package Style: | 8 PIN CAN |
| Test Engineer: | Tim Mondy |

TABLE II. Radiation Schedule for LF441AMH

| EVENTS | DATE |
|--|----------------------|
| 1) Initial Electrical Measurements | 08/22/91 |
| 2) 10 krad irradiation @ 520 rads/hr Post 10 krad Electrical Measurements | 09/10/91 09/11/91 |
| 3) 25 krad irradiation @ 790 rads/hr Post 25 krad Electrical Measurements | 09/11/91 09/12/91 |
| 4) 50 krad irradiation @ 1320 rads/hr Post 50 krad Electrical Measurements | 09/13/91 09/13/91 |
| 5) 100 krad irradiation @ 740 rads/hr Post 100 krad Electrical Measurements | 09/13/91 09/16/91 |
| 6) 24 hour annealing @ $T_A = 25^\circ\text{C}$ Post 24 hr Electrical Measurements | 09/16/91 09/17/91 |
| 7) 168 hour annealing @ $T_A = 25^\circ\text{C}$ Post 168 hr Electrical Measurements | 09/23/91 09/23/91 |
| 8) 200 krad irradiation @ 5000 rads/hr Post 200 krad Electrical Measurements | 09/23/91 09/24/91 |
| 9) 300 krad irradiation @ 5000 rads/hr Post 300 krad Electrical Measurements | 09/24/91 09/25/91 |
| 10) 168 hour annealing @ $T_A = +100^\circ\text{C}$ Post 168 hour Electrical Measurements | 09/25/91 10/02/91 |

Notes:

- All parts were radiated under bias at the cobalt-60 gamma ray facility at GSFC.
- All electrical measurements were performed off-site at 25°C .
- Annealing performed under bias.

Table III. Electrical Characteristics of LF441AMH

TA = 25 deg. C, Rs = 10 kohms

| Test | Condition | Limits | | Units |
|--------|--------------------------------------|--------|-----|-------|
| | | Min | Max | |
| Icc | Vcc+ = +20V, Vcc- = -20V Vo = 0 V | 0 | 200 | uA |
| -Icc | Vcc+ = +20V, Vcc- = -20V Vo = 0 V | -200 | 0 | uA |
| Vos@50 | Vcc+ = +20V, Vcc- = -20V | -500 | 500 | uV |
| VosRs | Vcc+ = +20V, Vcc- = -20V | -500 | 500 | uA |
| Ios | Vcc+ = +15V, Vcc- = -15V | -25 | 25 | pA |
| Ib+ | Vcc+ = +15V, Vcc- = -15V | -50 | 50 | pA |
| Ib- | Vcc+ = +15V, Vcc- = -15V | -50 | 50 | pA |
| CMRR | Vcm+ = +14V, Vcm- = -14V | 80 | | dB |
| +PSRR | Vcc+ = (+20,+6), Vcc- = -20V | 80 | | dB |
| -PSRR | Vcc+ = +20V, Vcc- = (-20,-6) | 50 | | V/mV |
| Vo | RL = 10 kohm | 12 | | V |
| -Vo | RL = 10 kohm | | -12 | V |

TABLE IV: Summary of Electrical Measurements after
Total Dose Exposures and Annealing for LF441AMH 1/2/

| Parameters | min | max | Initials | | Total Dose Exposure (krads) | | | | | | | | Annealing | | | | |
|------------|-------|------|----------|-------|-----------------------------|-------|------|-------|------|-------|------|------|---------------------|------|----------------------|-------|------|
| | | | | | 10 | | 25 | | 50 | | 100 | | 24 hrs 25 deg. C | | 168 hrs 25 deg. C | | |
| | | | | | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | |
| Icc | uA | 0 | 200 | 167 | 7.0 | 169 | 6 | 174 | .042 | 187 | 8.0 | 208 | 7.9 | 206 | 9.1 | 203 | 7.8 |
| -Icc | uA | -200 | 0 | -174 | 7.2 | -175 | 6 | -182 | 8 | -193 | 7.5 | -215 | 8 | -213 | 8.1 | -210 | 8.3 |
| Vos@50 | uV | -500 | 500 | -76 | 149 | -50 | 170 | -89 | 172 | -84.3 | 161 | -154 | 182 | -157 | 182 | -160 | 174 |
| Ios | pA | -25 | 25 | 0.1 | .31 | 1.5 | .4 | 5.5 | 1.5 | 44.2 | 27 | 1200 | 103 | 800 | 330 | 743 | 102 |
| Ib+ | pA | -50 | 50 | 5.0 | .40 | 21 | 1.1 | 55 | 4 | 333 | 31 | * | * | * | * | * | * |
| Ib- | pA | -50 | 50 | 5.1 | .50 | 19.4 | 1.2 | 59 | 4 | 289 | 19 | 1170 | 100 | 901 | 330 | 743 | 102 |
| Ibias | pA | -50 | 50 | 5.1 | .48 | 20 | 1.2 | 62 | 4 | 311 | 22 | 584 | 52 | 472 | 55 | 372 | 51 |
| VosRs | uV | -500 | 500 | -77 | 149 | -49.6 | 170 | -70 | 168 | -84 | 161 | -152 | 195 | -165 | 183 | -153 | 185 |
| Aol | KV/V | 50 | | 360 | 35 | 306 | 22 | 243 | 17 | 174 | 7.7 | 121 | 5.4 | 124 | 4.5 | 127 | 4.5 |
| CMRR | 2/ dB | 80 | | >140 | -- | 130 | 8 | 132 | 10 | 127 | 7.9 | 119 | 3.5 | 122 | 8.9 | 123 | 4.6 |
| +PSRR | 2/ dB | 80 | | >140 | -- | 125 | 11 | 132 | 11 | 134 | 12 | 128 | 8.9 | 130 | 9.3 | 133 | 10 |
| -PSRR | 2/ dB | 80 | | >140 | -- | 125 | 9 | 123 | 7 | 123 | 7.5 | 132 | 12.9 | 127 | 10 | 125 | 6.8 |
| GBWP | kHz | 800 | | 1.7 | .05 | 1.73 | 0.5 | 1.8 | .05 | 1.7 | .06 | 1.8 | .04 | 1.8 | 0.07 | 1.82 | 0.07 |
| Vc | V | 12 | | 13.6 | .03 | 13.6 | 0 | 13.6 | .04 | 13.6 | .02 | 13.5 | .03 | 13 | 0.03 | 13.5 | 0.03 |
| -Vc | V | | -12 | -12.8 | 0 | -12.8 | 0.1 | -12.8 | .02 | -13 | .02 | -13 | .02 | -13 | 0.02 | -12.7 | 0.02 |

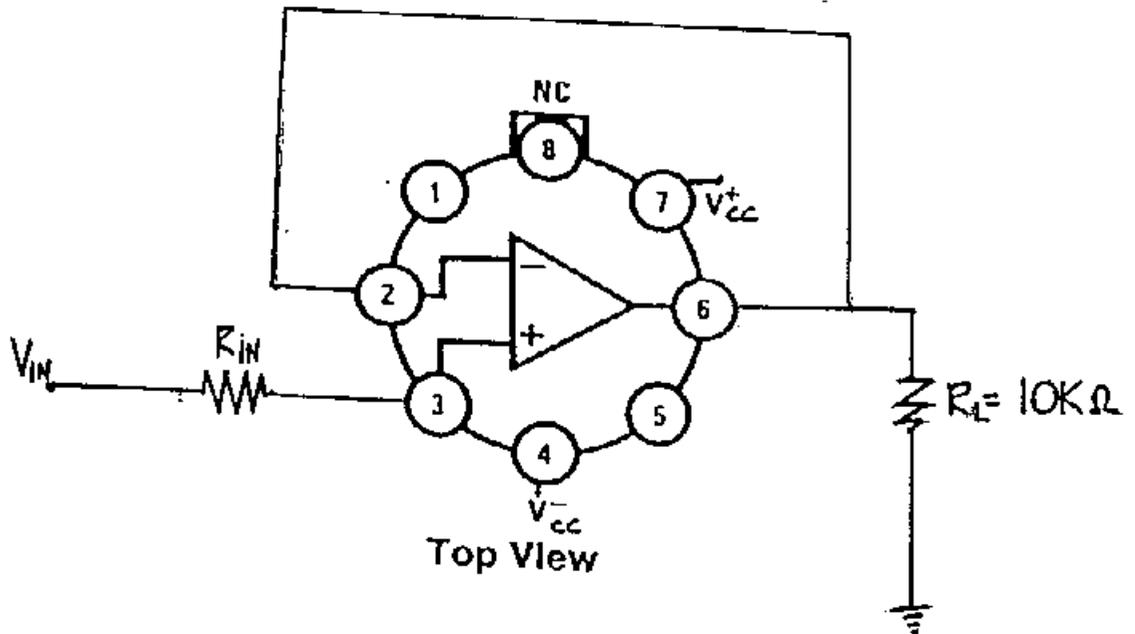
Notes:

- 1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
- 2/ CMRR, +PSRR, and -PSRR readings at initial measurements were greater than 140 dB, the maximum that the test equipment could measure.
- * Ib+ measurements at 100 krads and above were not reliable, and are therefore not included in this table.

TABLE IV (cont'd): Summary Electrical Measurements
after Total Dose Exposures and Annealing for LF441AMH

| Parameters | | min | | max | | Initials | | | | Total Dose Exposure | | Annealing | |
|--------------------|------|------|-----|-------|-----|----------|-----|------|------|---------------------|-----|-----------------------|----|
| | | | | | | mean | sd | 200 | | 300 | | 168 hrs 100 deg. C | |
| | | | | | | | | mean | sd | mean | sd | mean | sd |
| I _{cc} | uA | 0 | 200 | 167 | 7.0 | 235 | 7.8 | 249 | 9.0 | 190 | 11 | | |
| -I _{cc} | uA | -200 | 0 | -174 | 7.2 | -243 | 7.7 | -256 | 9.5 | -197 | 10 | | |
| V _{os@50} | uV | -500 | 500 | -76 | 149 | -344 | 216 | -575 | 212 | -269 | 155 | | |
| I _{os} | pA | -25 | 25 | -0.1 | .31 | 3300 | 600 | 6000 | 1100 | 64 | 4.3 | | |
| I _{b+} | pA | -50 | 50 | 5.0 | .40 | * | * | * | * | * | * | | |
| I _{b-} | pA | -50 | 50 | 5.1 | .50 | 3300 | 600 | 6000 | 1100 | 64 | 4.3 | | |
| I _{bias} | pA | -50 | 50 | 5.1 | .48 | 1.7 | 0.3 | 3 | 0.6 | 32 | 2.1 | | |
| V _{osRs} | uV | -500 | 500 | -77 | 149 | -373 | 223 | -519 | 255 | -270 | 155 | | |
| A _{o1} | KV/V | 50 | | 360 | 35 | 101 | 15 | 119 | 43 | 164 | 8 | | |
| CMRR | dB | 80 | | >140 | -- | 118 | 11 | 112 | 6.5 | 128 | 7.4 | | |
| +PSRR | dB | 80 | | >140 | -- | 129 | 8.5 | 130 | 8.6 | 132 | 9.9 | | |
| -PSRR | dB | 80 | | >140 | -- | 114 | 8.2 | 107 | 12 | 121 | 3.9 | | |
| GBWP | kHz | 800 | | 1.7 | .05 | 1.8 | .04 | 1.8 | 0.07 | 1.6 | .04 | | |
| V _o | V | 12 | | 13.6 | .03 | 13 | .04 | 13.3 | 0.03 | 13.5 | .02 | | |
| -V _o | V | | -12 | -12.8 | 0 | -13 | .03 | -13 | 0.02 | -13 | .02 | | |

Figure 1. Radiation Bias Circuit for LF441AMH



$$\begin{aligned}
 V_{IN} &= 7.5V \pm 0.5V_{DC} \\
 +V_{CC} &= 15.0V \pm 0.5V_{DC} \\
 -V_{CC} &= -15.0V \pm 0.5V_{DC} \\
 R_L &= 10K\Omega, \frac{1}{4}W, 10\% \\
 R_{IN} &= 2K\Omega, \frac{1}{4}W, 10\%
 \end{aligned}$$

$$\begin{aligned}
 +I_{CC} &\approx 1.0mA \\
 -I_{CC} &\approx 200\mu A
 \end{aligned}$$