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DATE: October 02, 1997 PPM-97-040
TO: Scott Hull/311
FROM: K. Sahu/300.1
SUBJECT: Radiation Report on: 2N6849
Project: HST-486 ST M&R FOLLOW ON
Job #: M78236
Project part #: JANTXV2N6849

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A radiation evaluation was performed on JANTXV2N6849 PFET 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, 15.0, 20.0 30.0, and 50.0 kRads.* The dose rate was between 0.125 and 0.500 kRads/hour (0.035 to 0.139 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 10.0 and 15.0 kRad irradiation, the parts were annealed for 48 hours at 25°C. After the 50.0 kRad exposure, the parts were annealed for 168 hours at 25°C. 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 543, 609, 615, 616, 619, 623, 626, and 630) were used as radiation samples while SN's 540 and 541 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests to 5.0 kRads. No significant degradation was noted in any parameter.

After the 10.0 kRad irradiation, all parts marginally exceeded the specification limit of 4V for VGSth with readings in the range of 4.08 to 4.24V. **All parts passed all other tests.**

After the annealing the parts for 48 hours at 25°C, the parts showed no significant change in VGSth. **All parts passed all other tests.**

After the 15.0 kRad irradiation, all parts exceeded the specification limit for VGSth with readings in the range of 4.54 to 4.70V. **All parts passed all other tests.**

After the annealing the parts for 48 hours at 25°C, the parts showed a slight increase in VGSth with readings in the range of 4.52 to 4.74V. **All parts passed all other tests.**

After the 20.0 kRad irradiation, all parts exceeded the specification limit for VGSth with readings in the range of 4.98 to 5.16V. SN 543 marginally exceeded the specification limit of 300mΩ for RDS on (Test #6) with a reading of 306.6mΩ. SN's 543, 609, 616 and 630 marginally exceeded the specification limit of 320mΩ for RDS on (Test #7) with readings in the range of 322 to 355mΩ. **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 30.0 kRad irradiation, all parts exceeded the specification limit for VGSth with readings in the range of 6.08 to 6.26V. All parts except SN 615 marginally exceeded the specification limit for RDS on (Test #6) with readings in the range of 307 to 393mΩ. All parts exceeded the specification limit for RDS on (Test #7) with readings in the range of 366 to 777mΩ **All parts passed all other tests.**

After the 50.0 kRad irradiation, all parts exceeded the specification limit for VGSth with readings in the range of 7.62 to 8.00V. All parts exceeded the specification limit for RDS on (Test #6) with readings in the range of 2,988 to 3,812mΩ. **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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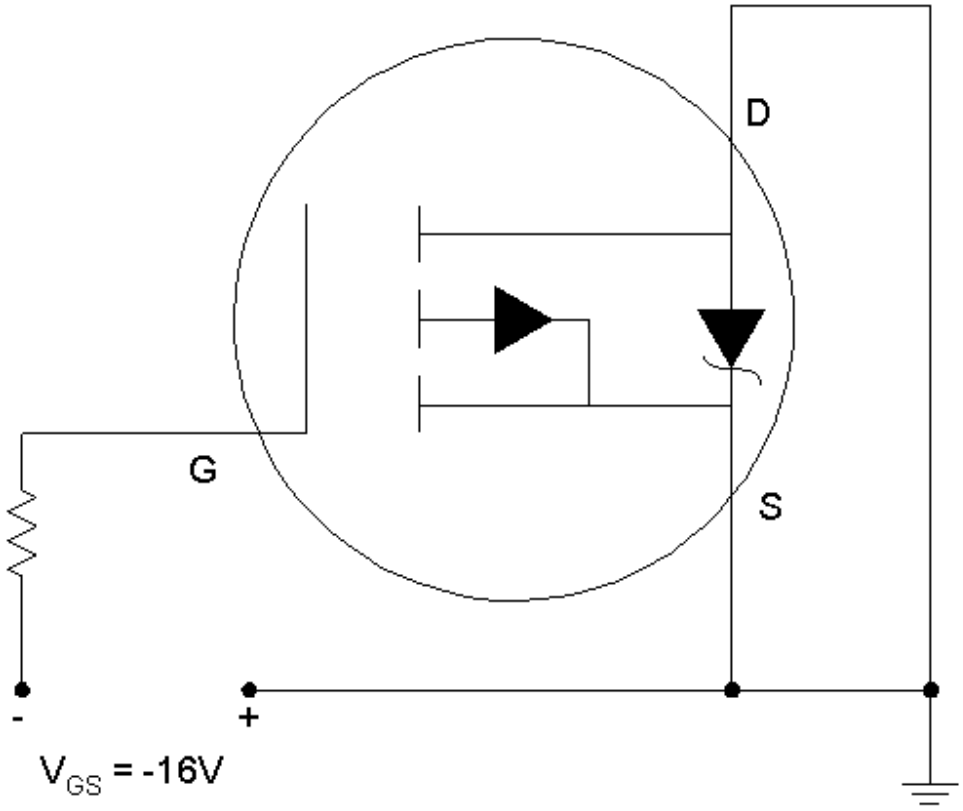
Figure 1. Radiation Bias Circuit for 2N6849



Resistor is 10kΩ ±5%, ¼W.

TABLE I. Part Information

Generic Part Number:	2N6849
HST-486, ST M&R FOLLOW ON Part Number	JANTXV2N6849
Charge Number:	M78236
Manufacturer:	Harris
Lot Date Code (LDC):	9646
Quantity Tested:	10
Serial Number of Control Samples:	540, 541
Serial Numbers of Radiation Samples:	543, 609, 615, 616, 619, 623, 626, and 630
Part Function:	P-Channel MOSFET
Part Technology:	MOSFET
Package Style:	TO-39
Test Equipment:	CISTRONICS
Test Engineer:	D. Davis

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

TABLE II. Radiation Schedule for 2N6849

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/08/97
2) 5.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/15/97
POST-5.0 KRAD ELECTRICAL MEASUREMENT	08/18/97
3) 10.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/18/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT	08/20/97
4) 48 HOUR ANNEALING @25°C	08/20/97
POST-48 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/22/97
5) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/22/97
POST-15.0 KRAD ELECTRICAL MEASUREMENT	08/25/97
6) 48 HOUR ANNEALING @25°C	08/25/97
POST-48 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/27/97
7) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/27/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT	08/29/97
8) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	08/29/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT	09/03/97
9) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)	09/03/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT	09/05/97
10) 168 HOUR ANNEALING @25°C	09/05/97
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/12/97

Effective Dose Rate = 50,000 RADS/36 DAYS=57.9 RADS/HOUR=0.016 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 interim annealing steps following the 10.0 and 15.0 kRad runs 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.

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

Table III. Electrical Characteristics of 2N6849 /1

Test #	Parameter	Units	Test Conditions	Spec. min	Lim. max
1	VBDSS	V	V_{GS} = 0V, I_D = 1.0mA	100	
2	VGSth	V	V_{DS} ³ V_{GS}, I_D = 0.25mA	2	4
3	IGSS	nA	V_{DS} = 0V, V_{GS} = +20V		100
4	IGSSr	nA	V_{DS} = 0V, V_{GS} = -20V		100
5	IDSS	mA	V_{DS} = 0V, V_{GS} = 80% rated V_{DS}		25
6	RDS on	mW	V_{GS} = 10V, pulsed /2, I_D = 4.1A		300
7	RDS on	mW	V_{GS} = 10V, pulsed /2, I_D = 6.5A		320
8	VSD	V	V_{GS} = 0V, I_S = I_{D1}, pulsed /2		1.5

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/ Conditions for pulse measurement shall be specified in section 4 of MIL-STD-750.

TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annealing for 2N6849 /1

							Total Dose Exposure (kRads)				Annealing		TDE (kRads)		Annealing		Total Dose Exposure (kRads)						Annealing	
Test			Spec. Lim. /2		Initial		5.0		10.0		48 hours @25°C /3		15.0		48 hours @25°C /3		20.0		30.0		50.0		168 hours @25°C	
#	Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	VBDSS /4	V	100		P		P		P		P		P		P		P		P		P		P	
2	VGSth	V	2	4	3.0	0.04	3.5	0.17	4.1	0.07	4.2	0.06	4.2	0.06	4.6	0.06	5.1	0.08	6.1	0.09	7.8	0.12	7.8	0.11
3	IGSS	nA		100	1.2	0.10	1.76	0.09	1.2	0.14	1.2	0.10	0.98	0.12	0.99	0.08	1.2	0.10	1.0	0	0.78	0.12	0.92	0.09
4	IGSSr	nA		100	0.96	0.07	0.88	0.23	1.03	0.21	1.0	0.09	0.99	0.09	0.96	0.09	0.94	0.11	0.94	0.05	0.95	0.14	0.89	0.15
5	IDSS	mA		25	0.002	0.007	0.004	0.001	0.006	0.001	0.006	0.001	0.009	0.001	0.009	0.001	0.013	0.001	0.012	0.001	0.019	0.001	0.025	0.002
6	RDS on	mW		300	233.4	12.9	226.0	13.5	234.1	14.3	234.7	14.6	250	16.2	250	16.7	271	20.3	341	38.9	3543	274	3520	282
7	RDS on	mW		320	239.4	15.2	242.0	16.0	253.2	17.6	253.6	17.5	274	20.9	271	16.0	307	29.1	604	172.1	67.3	7.4	63.4	6.7
8	VSD	V		4.3	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01	1.1	0.01

Notes:

1/ The mean and standard deviation values were calculated over the seven parts irradiated in this testing. The control samples remained constant throughout the 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/ The interim annealing step was added due to significant degradation in the parts at this level. The addition of this interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

4/ "P" indicates that all parts passed this test at this level.

Radiation sensitive parameters: VGSth, RDS on.