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DATE: January 05, 1998 PPM-97-058
TO: S. Hull/562
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: Radiation Report on: MIC4429 (Micrel) (LDC 9309)
Project: MAP SUBSYS
Job #: C80594
Project part #: MIC4429AJB

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A radiation evaluation was performed on **MIC4429AJB High-Speed, High-Current, Single MOSFET Driver (Micrel)** 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, five 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, 50.0, 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 100.0 kRad exposure, the parts were annealed for 216 hours at 25°C. See Table II for the radiation schedule and effective dose rate calculation. The effective dose rate over all testing was 0.068 Rads/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 6 samples. Five samples (SN's 181, 182, 183, 184, and 185) were used as radiation samples while SN 180 was used as a control sample. All parts passed all tests during initial electrical measurements.

VOL/VOH Tests
For Vs = 10V, all parts passed all functional tests up to 15 kRads. All parts passed all VOH tests for hard 0V and Vil = 0.2V and 0.4V up to 50kRads. At 100 kRads, some parts did fail VOH tests, even for Vil = 0V.
For Vs = 15V, all parts passed all VOH tests up to 10 kRads. At 15 and 20 kRads, the parts failed VOH tests at Vil = 0.8V but passed for Vil = 0, 0.2, 0.4, and 0.6V. All parts passed all VOH tests at Vil = 0V and 0.2V through 100 kRads with most parts failing at Vil = 0.4V.
For the VOH = 4.5V functional tests, one part failed the Vil = 0.8V test at 5 kRads, most parts failed all VOH tests including Vil = 0V at 10 kRads, and all parts failed all tests for VOH at 15 kRads.
All parts passed all VOL tests at all voltages through 100 kRads. See Table V for further details.

Parametric Tests
After the 20.0 kRad irradiation, three parts exceeded the specification limit of 2.80Ω for ROUT_1 with readings greater than 51.2Ω. **All parts passed all other tests.**

After the 30.0 kRad irradiation, one part passed, four parts failed ROUT_1, all failing parts read >51.2Ω. **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 50.0 kRad irradiation, all parts exceeded the specification limit for ROUT_1 with readings of >51.2Ω. **All parts passed all other tests.**

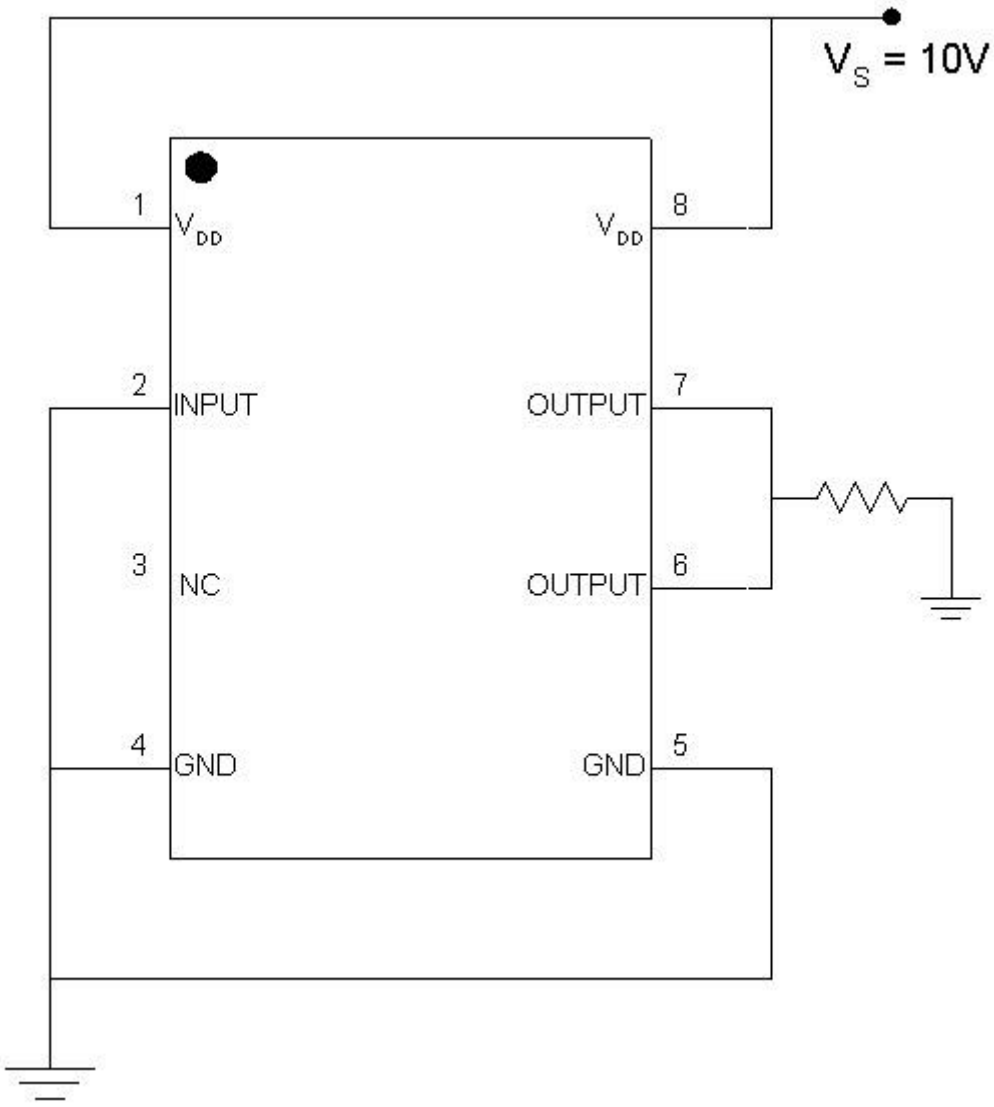
After the 100.0 kRad irradiation, three parts exceeded the specification limit of 0.150mA for Icc_0V_10V with readings of 1.376, 0.915, and 1.316mA. All parts exceeded the specification limit for ROUT_1 with readings of >51.2Ω. **All parts passed all other tests.**

After annealing the parts for 216 hours at 25°C, parts showed significant recovery. **All parts passed all other tests.**

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.

Figure 1. Radiation Bias Circuit for MIC4429



Notes:
1. Resistor is 10kΩ ±5% ¼W.
2. V_S = 10.0±0.5V, V_{IN} = 0V.

TABLE I. Part Information

Generic Part Number:	MIC4429
MAP SUBSYS. Part Number	MIC4429AJB
Charge Number:	C80594
Manufacturer:	Micrel
Lot Date Code (LDC):	9309
Quantity Tested:	6
Serial Number of Control Samples:	180
Serial Numbers of Radiation Samples:	181, 182, 183, 184, and 185
Part Function:	High-Speed, High-Current, Dingle MOSFET Driver
Part Technology:	Bipolar
Package Style:	8 Pin DIP
Test Equipment:	A540
Test Engineer:	D. Davis

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

TABLE II. Radiation Schedule for MIC4429

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	12/06/97
2) 5.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	12/08/97
POST-5.0 KRAD ELECTRICAL MEASUREMENT	12/09/97
3) 10.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	12/09/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT	12/10/97
4) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	12/10/97
POST-15.0 KRAD ELECTRICAL MEASUREMENT	12/12/97
5) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	12/15/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT	12/17/97
6) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	12/17/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT	12/19/97
7) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)	12/19/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT	12/22/97
8) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	12/22/97
POST-100.0 KRAD ELECTRICAL MEASUREMENT	12/24/97
9) 216 HOUR ANNEALING @25°C	12/24/97
POST-216 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/02/98

Effective Dose Rate = 100,000 RADS/17 DAYS=245.1 RADS/HOUR=0.068 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

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

Table III. Electrical Characteristics of MIC4429 /1

Test #	Parameter	Units	Test Conditions /2	Spec. min	Lim. max
1,3,5	Icc_0V	mA	V_{DD} = 4.5, 10, & 15V, V_{IN} = 0V	0	0.15
2,4,6	Icc_3V	mA	V_{DD} = 4.5, 10, & 15V, V_{IN} = 3V	0	1.5
13,19,25,31,37	4.5V_VOL@vih_4.5V	V	V_{DD} = 4.5V, V_{IH} = 4.5V		0.025
14,20,26,32,38	4.5V_VOH@vil_*.*V	V	V_{DD} = 4.5V, V_{IL} = 0.0 to 0.8V in 0.2V steps	4.475	
15,21,27,33,39	10V_VOL@vih_10V	V	V_{DD} = 10V, V_{IH} = 10V		0.025
16,22,28,34,40	10V_VOH@vil_*.*V	V	V_{DD} = 10V, V_{IL} = 0.0 to 0.8V in 0.2V steps	9.975	
17,23,29,35,41	15V_VOL@vih_15V	V	V_{DD} = 15V, V_{IH} = 15V		0.025
18,24,30,36,42	15V_VOH@vil_*.*V	V	V_{DD} = 15V, V_{IL} = 0.0 to 0.8V in 0.2V steps	14.975	
43	ROUT_1	W	I_{OUT} = 10mA, V_{DD} = 18V		2.8
44	HARD_ROUT_1	W	I_{OUT} = 10mA, V_{DD} = 18V		2.8
45	ROUT_0	W	I_{OUT} = 10mA, V_{DD} = 18V		2.5
46	HARD_ROUT_0	W	I_{OUT} = 10mA, V_{DD} = 18V		2.5
47	IIL_4.5V	mA	V_{DD} = 4.5V	-10.0	10.0
48	IIH_4.5V	mA	V_{DD} = 4.5V	-10.0	10.0
49	IIL_10V	mA	V_{DD} = 10V	-10.0	10.0
50	IIH_10V	mA	V_{DD} = 10V	-10.0	10.0
51	IIL_15V	mA	V_{DD} = 15V	-10.0	10.0
52	IIH_15V	mA	V_{DD} = 15V	-10.0	10.0

Notes:

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/ For all tests, $\pm V_S = \pm 15V$, $T_A = 25°C$ unless otherwise specified.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for MIC4429 /1

					Initial		Total Dose Exposure (kRads) 5.0		10.0		15.0		20.0		30.0		50.0		100.0		Annealing 216 hours @25°C	
Test			Spec. Lim. /2																			
#	Parameters /3	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	Icc_0V_4.5V	mA	0	0.15	0.049	0.009	0.025	0.015	0.005	0.005	0.005	0.005	0.004	0.005	0.004	0.005	0.130	0.075	0.011	0.006	0.007	0.009
2	Icc_3V_4.5V	mA	0	1.5	0.247	0.036	0.117	0.084	0.012	0.002	0.010	0.001	0.024	0.012	0.048	0.028	0.111	0.053	0.016	0.027	0.007	0.012
3	Icc_0V_10V	mA	0	0.15	0.057	0.014	0.041	0.012	0.029	0.013	0.025	0.013	0.019	0.005	0.021	0.013	0.019	0.014	0.733	0.597	0.359	0.448
4	Icc_3V_10V	mA	0	1.5	0.343	0.041	0.186	0.055	0.111	0.026	0.085	0.009	0.091	0.012	0.108	0.024	0.171	0.058	0.061	0.027	0.051	0.012
5	Icc_0V_15V	mA	0	0.15	0.094	0.027	0.065	0.020	0.059	0.022	0.057	0.021	0.053	0.020	0.051	0.020	0.048	0.022	0.054	0.022	0.044	0.021
6	Icc_3V_15V	mA	0	1.5	0.435	0.046	0.277	0.022	0.233	0.024	0.210	0.016	0.212	0.023	0.225	0.022	0.283	0.059	0.168	0.032	0.154	0.017
43	ROUT_1 /4	W		2.8	1.3	0	1.4	0	1.4	0	1.4	0	2P/3F		1P/4F		>51.2		>51.2		>51.2	
44	HARD_ROUT_1	W		2.8	1.3	0	1.4	0	1.4	0	1.4	0	1.5	0.04	1.5	0.08	1.6	0.08	1.6	0.08	1.6	0.04
45	ROUT_0	W		2.5	1.7	0.04	1.7	0.04	1.7	0.05	1.7	0.04	1.7	0.05	1.7	0.05	1.7	0.05	1.7	0.05	1.7	0.05
46	HARD_ROUT_0	W		2.5	1.7	0.04	1.7	0.04	1.7	0.05	1.7	0.04	1.7	0.05	1.7	0.05	1.7	0.05	1.7	0.05	1.7	0.05
47	IIL_4.5V	mA	-10.0	10.0	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001
48	IIH_4.5V	mA	-10.0	10.0	0.03	0	0.03	0.001	0.03	0.002	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.003
49	IIL_10V	mA	-10.0	10.0	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001	-0.02	0.001
50	IIH_10V	mA	-10.0	10.0	0.07	0.001	0.07	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001
51	IIL_15V	mA	-10.0	10.0	-0.06	0.011	-0.04	0.004	-0.05	0.003	-0.05	0.003	-0.06	0.001	-0.06	0.010	-0.06	0.010	-0.08	0.015	-0.08	0.010
52	IIH_15V	mA	-10.0	10.0	0.06	0.001	0.07	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001	0.06	0.001

Notes:

1/ The mean and standard deviation values were calculated over the five 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/ See Table V for tests 13 to 42.

4/ "P" ("F") implies all parts passed (failed) this test at this level. nPmF implies that "n" parts passed and "m" parts failed this test at this level.

Radiation sensitive parameters: ROUT_1, Icc_0V_10V.

TABLE V: Summary of Electrical Measurements after Total Dose Exposures and Annealing for MIC4429 /1
VOL/VOH Tests

					Total Dose Exposure (kRads)																Annealing	
					Initial		5.0		10.0		15.0		20.0		30.0		50.0		100.0		216 hours @25°C	
Test #	Parameters /3	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
13	4.5V_VOL@vih_4.5V	V		0.025	P		P		P		P		P		P		P		P		P	
14	4.5V_VOH@vil_0.0V	V	4.475		P		P		2P/3F		F		1P/4F		F		F		F		F	
20	4.5V_VOH@vil_0.2V	V	4.475		P		P		2P/3F		F		1P/4F		F		F		F		F	
26	4.5V_VOH@vil_0.4V	V	4.475		P		P		1P/4F		F		1P/4F		F		F		F		F	
32	4.5V_VOH@vil_0.6V	V	4.475		P		P		1P/4F		F		1P/4F		F		F		F		F	
38	4.5V_VOH@vil_0.8V	V	4.475		P		4P/1F		1P/4F		F		F		F		F		F		F	
15	10V_VOL@vih_10V	V		0.025	P		P		P		P		P		P		P		P		P	
16	10V_VOH@vil_0.0V	V	9.975		P		P		P		P		P		P		P		2P/3F		3P/2F	
22	10V_VOH@vil_0.2V	V	9.975		P		P		P		P		P		P		P		2P/3F		3P/2F	
28	10V_VOH@vil_0.4V	V	9.975		P		P		P		P		P		P		P		2P/3F		2P/3F	
34	10V_VOH@vil_0.6V	V	9.975		P		P		P		P		P		P		2P/3F		F		F	
40	10V_VOH@vil_0.8V	V	9.975		P		P		P		P		1P/4F		1P/4F		F		F		F	
17	15V_VOL@vih_15V	V		0.025	P		P		P		P		P		P		P		P		P	
18	15V_VOH@vil_0.0V	V	14.975		P		P		P		P		P		P		P		P		P	
24	15V_VOH@vil_0.2V	V	14.975		P		P		P		P		P		P		P		P		P	
30	15V_VOH@vil_0.4V	V	14.975		P		P		P		P		P		P		P		2P/3F		F	
36	15V_VOH@vil_0.6V	V	14.975		P		P		P		P		P		1P/4F		F		F		F	
42	15V_VOH@vil_0.8V	V	14.975		P		P		P		F		F		F		F		F		F	

Notes:

1/ The mean and standard deviation values were calculated over the five 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/ "P" ("F") implies all parts passed (failed) this test at this level. nPmF implies that "n" parts passed and "m" parts failed this test at this level.

Radiation sensitive parameters: 4.5V_VOH@vil_*.*V, 10V_VOH@vil_*.*V, 15V_VOH@vil_0.4/0.6/0.8V.