

DATE: December 21, 1993

PPM-93-104

TO: S. Pszcolka/311.1

FROM: K. Sahu/300.1 *KS*

SUBJECT: Radiation Report on ISTP/SOHO/CELIAS

Part No. CD54HC4051F/3A

Control No. 8959

cc: A. Sharma/311

Library/300.1

A radiation evaluation was performed on CD54HC4051/3A (Analog Multiplexer/Demultiplexer) 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, two 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 2, 5, 10, 15, 20 and 50 krad. The dose rate was between .003 and 1.50 krad/hour, depending on the total dose level (see Table II for radiation schedule). After the 50 krad irradiation, parts were annealed at 25°C for 168 hours, after which the parts were annealed at 100°C for 168 hours. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits listed in Table III. Electrical tests included four functional tests at 1.0 MHz; one at $V_{CC} = 2.0$ V, two at $V_{CC} = 4.5$ V and one at $V_{CC} = 6.0$ V.

All parts passed initial electrical measurements. At the 10 krad irradiation level, both irradiated parts exceeded the maximum specification limit of 8.0 μ A for ICC1, with readings of 9.0 and 12.0 μ A. At the 15 krad level, both parts read zero for these parameters. Both irradiated parts continued to read zero for these parameters at the 20 krad level. At the 50 krad level, both parts exceeded the maximum specification limit of 8 μ A for ICCL1 and ICCH1, with readings of 431 μ A and 391 μ A, and also the maximum specification limit of 16 μ A for ICCL2 and ICCH2, with readings of 399 μ A and 359 μ A. At the 50 krad level, both parts also failed the 2V functional test and exceeded the maximum specification limit of 1.5V for VIH1, with readings of 2.01V and the minimum specification limit of 0.5V for VIL1, with readings of -0.01V. Both parts also exceeded the maximum specification limit of 0.2 μ A for I1ZON1 and I1ZON2 and the maximum specification limit of 0.4 μ A for I2ZON3 and I2ZON4 with maximum readings of 90.1 μ A, 0.376 μ A, 134.3 μ A and 63.8 μ A, respectively. After annealing for 168 hours at 25°C, some recovery was seen in IZZ and ICC, but the readings were still outside the specification limits. At this level, both parts also failed the 2V functional test. After annealing for 168 hours at 100°C, all electrical measurements were within specification limits. However, both parts still continued to fail the 2V functional test.

Both parts passed all other electrical tests, including the functional tests at 4.5V and 6V, throughout all irradiation and annealing steps.

Table IV provides a summary of the functional test results, as well as the mean and standard deviation values for each parameter after different irradiation exposures and annealing steps.

*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.

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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TABLE I. Part Information

Generic Part Number:	54HC4051
ISTP/SOHO/CELIAS Part Number:	CD54HC4051F/3A
ISTP/SOHO/CELIAS Control Number:	8959
Charge Number:	C33706
Manufacturer:	Harris
Lot Date Code:	3A9314
Quantity Tested:	3
Serial Number of Control Sample:	1
Serial Numbers of Radiation Samples:	2, 3
Part Function:	Oscillator
Part Technology:	CMOS
Package Style:	16-pin DIP
Test Equipment:	Sentry S-50
Test Engineer:	T. Scherer

TABLE II, Radiation Schedule for 54HC4051

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	10/15/93
2) 2 KRAD IRRADIATION (0.003 KRADS/HOUR)	10/15/93
POST-2 KRAD ELECTRICAL MEASUREMENT	10/18/93
3) 5 KRAD IRRADIATION (0.15 KRADS/HOUR)	10/18/93
POST-5 KRAD ELECTRICAL MEASUREMENT	10/19/93
4) 10 KRAD IRRADIATION (0.25 KRADS/HOUR)	10/19/93
POST-10 KRAD ELECTRICAL MEASUREMENT	10/20/93
5) 15 KRAD IRRADIATION (0.25 KRADS/HOUR)	10/20/93
POST-15 KRAD ELECTRICAL MEASUREMENT	10/21/93
6) 20 KRAD IRRADIATION (0.073 KRADS/HOUR)	10/15/93
POST-20 KRAD ELECTRICAL MEASUREMENT	10/25/93
7) 50 KRAD IRRADIATION (1.50 KRADS/HOUR)	10/25/93
POST-50 KRAD ELECTRICAL MEASUREMENT	10/20/93
8) 168-HOUR ANNEALING @25°C	10/20/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/02/93
9) 168-HOUR ANNEALING @100°C**	11/02/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/12/93

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

*High temperature annealing is performed to accelerate long term time dependent effects (TDE), namely, the "rebound" effect due to the growth of interface states after the radiation exposure. For more information on the need to perform this test, refer to MIL-STD-883D, Method 1019, Para. 3.10.1.

Table III. Electrical Characteristics of 54HC4051

DC PARAMETRIC TESTS PERFORMED								
PARAMETER	VCC	VEE	VISL	VISH	CONDITIONS	LIMITS -55C TO +125C		
VIH1	2.0V	0.0V	0.0V	2.0V	VDSH>1.5V VDSL<0.5V	>+0.0V	<+1.5V	
VIH2	4.5V	0.0V	0.0V	4.5V	VDSH>4.0V VDSL<0.5V	>+0.0V	<+3.15V	
VIH3	6.0V	0.0V	0.0V	6.0V	VDSH>5.5V VDSL<0.5V	>+0.0V	<+4.2V	
VIL1	2.0V	0.0V	0.0V	2.0V	VDSH>1.5V VDSL<0.5V	>+0.5V	<+2.0V	
VIL2	4.5V	0.0V	0.0V	4.5V	VDSH>4.0V VDSL<0.5V	>+1.35	<+4.5V	
VIL3	6.0V	0.0V	0.0V	6.0V	VDSH>5.5V VDSL<0.5V	>+1.8	<+6.0V	
PARAMETER	VCC	VEE	CONDITIONS		PINS	LIMITS AT 25C		
RON1	4.5V	0.0V	VIS = 4.5V		ALL CHANNEL	>0.0 OHMS	<200 OHMS	
RON2	4.5V	0.0V	VIS = 0.0V		ALL CHANNEL	>0.0 OHMS	<200 OHMS	
RON3	6.0V	0.0V	VIS = 6.0V		ALL CHANNEL	>0.0 OHMS	<180 OHMS	
RON4	6.0V	0.0V	VIS = 0.0V		ALL CHANNEL	>0.0 OHMS	<180 OHMS	
RON5	4.5V	-4.5V	VIS = 4.5V		ALL CHANNEL	>0.0 OHMS	<160 OHMS	
RON7	4.5V	0.0V	VIS = 0 TO 4.5V		ALL CHANNEL	>0.0 OHMS	<220 OHMS	
RON8	6.0V	0.0V	VIS = 0 TO 6.0V		ALL CHANNEL	>0.0 OHMS	<200 OHMS	
RON9 *	4.5V	-4.5V	VIS = -4.0 TO 4.5V		ALL CHANNEL	>0.0 OHMS	<170 OHMS	
PARAMETER	VCC	VEE	CONDITIONS		PINS	LIMITS AT -55C TO 125C		
RON1	4.5V	0.0V	VIS = 4.5V		ALL CHANNEL	>0.0 OHMS	<280 OHMS	
RON2	4.5V	0.0V	VIS = 0.0V		ALL CHANNEL	>0.0 OHMS	<280 OHMS	
RON3	6.0V	0.0V	VIS = 6.0V		ALL CHANNEL	>0.0 OHMS	<250 OHMS	
RON4	6.0V	0.0V	VIS = 0.0V		ALL CHANNEL	>0.0 OHMS	<250 OHMS	
RON5	4.5V	-4.5V	VIS = 4.5V		ALL CHANNEL	>0.0 OHMS	<220 OHMS	
RON7	4.5V	0.0V	VIS = 0 TO 4.5V		ALL CHANNEL	>0.0 OHMS	<310 OHMS	
RON8	6.0V	0.0V	VIS = 0 TO 6.0V		ALL CHANNEL	>0.0 OHMS	<280 OHMS	
RON9 *	4.5V	-4.5V	VIS = -4.0 TO 4.5V		ALL CHANNEL	>0.0 OHMS	<235 OHMS	
PARAMETER	VCC	VEE	VIS1	VIS2	CONDITIONS	LIMITS AT 25C		
IIZON1	6.0V	0.0V	6.0V	0.0V	OUTPUT OPEN	>-0.2UA	<+0.2UA	
IIZON2	6.0V	0.0V	0.0V	6.0V	OUTPUT OPEN	>-0.2UA	<+0.2UA	
IIZON3 *	5.0V	-5.0V	5.0V	-4.0V	OUTPUT OPEN	>-0.4UA	<+0.4UA	
IIZON4 *	5.0V	-5.0V	-4.0V	5.0V	OUTPUT OPEN	>-0.4UA	<+0.4UA	
PARAMETER	VCC	VEE	VIS	VOS	CONDITIONS	LIMITS AT 25C		
IIZOFF1	6.0V	0.0V	6.0V	0.0V	CHANNEL CLOSED	>-0.2UA	<+0.2UA	
IIZOFF2	6.0V	0.0V	0.0V	6.0V	CHANNEL CLOSED	>-0.2UA	<+0.2UA	
IIZOFF3 *	5.0V	-5.0V	5.0V	-4.0V	CHANNEL CLOSED	>-0.4UA	<+0.4UA	
IIZOFF4 *	5.0V	-5.0V	-4.0V	5.0V	CHANNEL CLOSED	>-0.4UA	<+0.4UA	
PARAMETER	VCC	VEE	VIS1	VIS2	CONDITIONS	LIMITS AT -55C,+125C		
IIZON1	6.0V	0.0V	6.0V	0.0V	OUTPUT OPEN	>-2.0UA	<+2.0UA	
IIZON2	6.0V	0.0V	0.0V	6.0V	OUTPUT OPEN	>-2.0UA	<+2.0UA	
IIZON3 *	5.0V	-5.0V	5.0V	-4.0V	OUTPUT OPEN	>-4.0UA	<+4.0UA	
IIZON4 *	5.0V	-5.0V	-4.0V	5.0V	OUTPUT OPEN	>-4.0UA	<+4.0UA	
PARAMETER	VCC	VEE	VIS	VDS	CONDITIONS	LIMITS AT -55C,+125C		
IIZOFF1	6.0V	0.0V	6.0V	0.0V	CHANNEL CLOSED	>-2.0UA	<+2.0UA	
IIZOFF2	6.0V	0.0V	0.0V	6.0V	CHANNEL CLOSED	>-2.0UA	<+2.0UA	
IIZOFF3 *	5.0V	-5.0V	5.0V	-4.0V	CHANNEL CLOSED	>-4.0UA	<+4.0UA	
IIZOFF4 *	5.0V	-5.0V	-4.0V	5.0V	CHANNEL CLOSED	>-4.0UA	<+4.0UA	
PARAMETER	VCC	VEE	VIL	VIH	CONDITIONS	PINS	LIMITS AT 25C	
IIH	6.0V	0.0V	0.0V	6.0V	VIN = 5.0V	D-INS	>-0.1UA	<+0.1UA
IIL	6.0V	0.0V	0.0V	6.0V	VIN = 0.0V	D-INS	>-0.1UA	<+0.1UA
PARAMETER	VCC	VEE	VIL	VIH	CONDITIONS	PINS	LIMITS -55C TO 125C	
IIH	6.0V	0.0V	0.0V	6.0V	VIN = 6.0V	D-INS	>-1.0UA	<+1.0UA
IIL	6.0V	0.0V	0.0V	6.0V	VIN = 0.0V	D-INS	>-1.0UA	<+1.0UA
PARAMETER	VCC	VEE	VIL	VIH	CONDITIONS	PINS	LIMITS AT 25C	
ICCH1	6.0V	0.0V	0.0V	6.0V	ALL INS HIGH	VCC	>+0.0A	<+8.0UA
ICCL1	5.0V	0.0V	0.0V	6.0V	ALL INS LOW	VCC	>+0.0A	<+8.0UA
ICCH2	5.0V	-5.0V	0.0V	5.0V	ALL INS HIGH	VCC	>+0.0A	<+16.0UA
ICCL2	5.0V	-5.0V	0.0V	5.0V	ALL INS LOW	VCC	>+0.0A	<+16.0UA
PARAMETER	VCC	VEE	VIL	VIH	CONDITIONS	PINS	LIMITS -55C TO 125C	
ICCH1	6.0V	0.0V	0.0V	6.0V	ALL INS HIGH	VCC	>+0.0A	<+160UA
ICCL1	6.0V	0.0V	0.0V	6.0V	ALL INS LOW	VCC	>+0.0A	<+160UA
ICCH2	5.0V	-5.0V	0.0V	5.0V	ALL INS HIGH	VCC	>+0.0A	<+320UA
ICCL2	5.0V	-5.0V	0.0V	5.0V	ALL INS LOW	VCC	>+0.0A	<+320UA

Table III (Cont.) Electrical Characteristics of 54HC4051

FUNCTIONAL TESTS PERFORMED								
PARAMETER	VCC	VEE	VIL	VIH	VISL	VISH	PINS	LIMITS AT -55C TO 125C
FUNCT 1	2.0V	0.0V	0.0V	2.0V	0.0V	2.0V	ALL	VOSL<1.5V ; VOSH>1.5V
FUNCT 2	4.5V	-4.5V	0.0V	4.5V	0.0V	4.5V	ALL	VOSL<4.0V ; VOSH>4.0V
FUNCT 3*	4.5V	-4.5V	0.0V	4.5V	-4.0V	0.0V	ALL	VOSL<-3.5V ; VOSH>-3.5V
FUNCT 4	6.0V	0.0V	0.0V	6.0V	0.0V	6.0V	ALL	VOSL<5.0V ; VOSH>5.0V
FREQ=1.000MHz (IOH = -1mA (VREF = 0.5*(VCC+VEE) (IOL = +1mA STD Load <=								
AC PARAMETRIC TESTS PERFORMED								
PARAMETER	VCC	VEE	VIL	VIH	VISL	VISH	CONDITIONS	PINS LIMITS AT 25C
TPLH1	4.5V	0.00V	0.0V	4.5V	0.0V	4.5V	FREQ=1.0MHz	I/O 12NS MAX
TPHL1	4.5V	0.00V	0.0V	4.5V	0.0V	4.5V	FREQ=1.0MHz	I/O 12NS MAX
PARAMETER	VCC	VEE	VIL	VIH	VISL <th>VISH</th> <th>CONDITIONS</th> <th>PINS LIMITS AT 25C</th>	VISH	CONDITIONS	PINS LIMITS AT 25C
TPLH2 *	4.5V	-4.5V	0.0V	4.5V	-4.0V	4.5V	FREQ=1.0MHz	I/O 8NS MAX
TPHL2 *	4.5V	-4.5V	0.0V	4.5V	-4.0V	4.5V	FREQ=1.0MHz	I/O 8NS MAX
COMMENTS/EXCEPTIONS								
(1) This Program detects improper Device insertion.								
(2) AC PARAMETRIC TEST PERFORMED AT VCC = 4.5V, VEE = 0.0V AND AT VCC = 4.5V, VEE = -4.5V ONLY.								
(3) DELTA ON_RESISTANCE IS CALCULATED FOR INFORMATION ONLY.								
* (4) DUE TO THE ATE LIMITATION LOWEST VOLTAGE DRIVED (ON VIS OR VOS) IS -4.0V INSTEAD OF VEE AS SPECIFIED IN THE SPECIFICATION (S-311-725).								
(5) ON-RESISTANCE TEST AT VCC=4.5V, VEE = -4.5V AND VIS = -4.5V TEST IS NOT PERFORMED								
(6) 40 OHMS ARE ADDED TO ALL ON-RESISTANCE TEST LIMITS TO COMPENSATE FOR MEASUREMENT ERROR, CONTACT RESISTANCE, ECT..								
(7) TPLZ, TPZH, TPHZ, AND TPZL ARE NOT TESTED								

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for CD54HC4051 /1

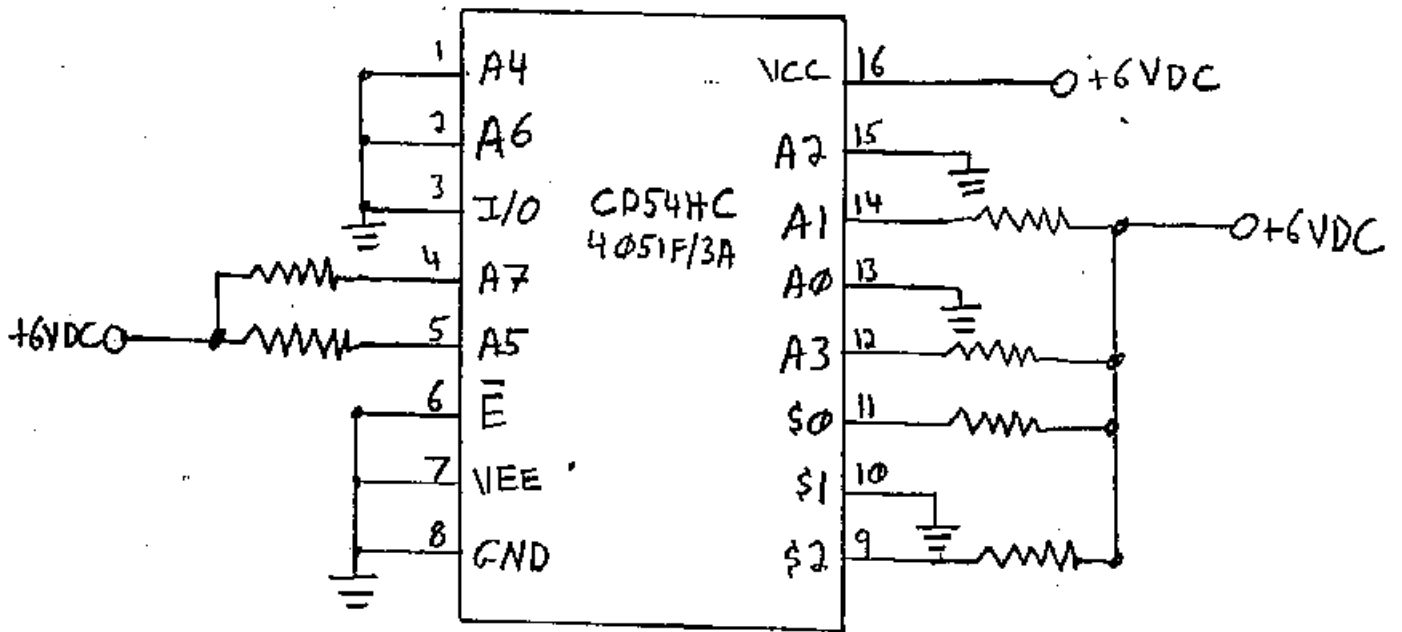
Parameters/2	min	max	Total Dose Exposure (krads)														Annealing			
			Initials		2		5		10		15		20		50		168 hrs @25°C		168 hrs @100°C	
			mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
FUNC1, 2.0V, 1 MHz	-	-	PASS		PASS		PASS		PASS		PASS		PASS		FAIL		FAIL		FAIL	
FUNC2, 4.5V, 1 MHz	-	-	PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC3, 4.5V, 1 MHz	-	-	PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC4, 6.0V, 1 MHz	-	-	PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
VIH1	V	0	1.50	0.49	0	0.49	0	0.49	0	0.49	0	0.49	0	2.01	0	2.01	0	2.01	0	
VIH2	V	0	3.15	1.34	0	1.34	0	1.34	0	1.34	0	1.34	0	1.34	0	1.34	0	1.34	0	
VIH3	V	0	4.2	1.79	0	1.79	0	1.79	0	1.79	0	1.79	0	1.79	0	1.79	0	1.79	0	
VIL1	V	0.5	2	1.35	.28	1.34	.29	1.34	0.3	1.33	.32	1.31	.34	1.30	.36	0.01	0	0.0	0	
VIL2	V	1.35	4.5	2.89	.46	2.89	.47	2.88	.48	2.87	0.5	2.86	.52	2.85	.54	2.8	.63	2.8	.61	
VIL3	V	1.80	6	3.86	0.6	3.86	0.6	3.85	.62	3.84	.64	3.83	.66	3.82	.68	3.78	.75	3.78	.74	
RON1	Ohms	0	200	103	4.6	103	4.6	100	0	101	2.4	103	4.3	103	4.3	103	5.6	110	0	
RDEL1	mOhms	0	100	5	5	5	5	0	0	5	5	5	5	10	0	10	0	0	0	
RON2	Ohms	0	200	145	5	146	4.8	143	4.6	143	4.6	144	5	144	4.8	143	4.3	146	5	
RDEL2	mOhms	C	100	0	0	5	5	10	0	5	5	10	0	10	0	5	5	5	5	
RON3	Ohms	C	180	90	0	90	0	90	0	90	0	91.3	3.3	88.8	3.3	93.8	4.8	97	5.8	
RDEL3	mOhms	0	100	0	0	0	0	0	0	0	0	0	0	10	0	5	5	5	5	
RON4	Ohms	0	180	135	5	135	5	133	4.6	131	3.3	134	4.8	133	4.3	132	3.9	136	5	
RDEL4	mOhms	0	100	0	0	0	0	10	0	5	5	10	0	10	0	5	5	5	5	
RON5	Ohms	0	140	85	5	85.6	5	81.3	3.3	83.1	4.6	83.1	4.6	82.1	4.6	76.1	6	86.3	4.8	
RDEL5	mOhms	0	100	0	0	5	5	5	5	5	5	5	5	10	0	10	0	5	5	
RON7	Ohms	0	220	145	5	146	5	144	4.8	141	3.3	145	5	145	5	142	3.9	146	4.8	
RDEL7	mOhms	0	100	0	0	0	0	10	0	5	5	10	0	10	0	5	5	5	5	
RON8	Ohms	0	200	135	5	135	5	133	4.6	131	3.3	132	3.9	132	3.9	132	3.9	136	5	
RDEL8	mOhms	0	100	0	0	0	0	10	0	5	5	10	0	10	0	5	5	5	5	
RON9	Ohms	0	170	125	5	125	5	121	3.3	121	3.3	122	3.9	122	3.9	121	3.3	126	4.8	
RDEL9	mOhms	0	100	0	0	0	0	5	5	5	5	5	5	10	0	10	0	5	5	
IIZON1	nA	-200	200	0	0	0	0	0	0	2.21	7.3	0	0	0	C	17209	30568	265	101	
IIZON2	nA	-200	200	0	0	0	0	0	0	4.2	12	1.1	3.1	0.8	2.2	2644	70922	4187	160	
IIZON3	nA	-400	400	6.07	23	6	23	6	23	9.19	24	5.89	23	5.21	23	24780	44353	213	835	
IIZON4	nA	-400	400	6	0	0	0	0	0	1.94	6.1	0	0	0	0	2221	21685	632	958	

TABLE IV (Cont.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for CD54HC4051 /1

Parameters	min	max	Total Dose Exposure (krads)														Annealing				
			Initials		2		5		10		15		20		50		168 hrs @25°C		168 hrs @100°C		
			mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	
IIZOFF1	nA	-200	200	0	0	0	0	0	0	2.63	8	1.19	3.2	9.31	1.6	76604	20347	181	110	11.9	4.3
IIZOFF2	nA	-200	200	0	0	0	0	0	0	0	0	0	2.59	3.1	446	11446	437	154	1.56	2.7	
IIZOFF3	nA	-400	400	0	0	0	0	0	0	3.37	10	0	0	0	0	10559	28256	549	234	0	0
IIZOFF4	nA	-400	400	0	0	0	0	0	0	2	6.4	0	0	0	0	53911	14380	781	135	0	0
IIL	nA	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IIL	nA	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICCL1	µA	0	8	0	0	0	0	0	0	8	1	0	0	0	0	411	20	52.5	5.5	0	0
ICCH1	µA	0	8	0	0	0	0	0	0	10.5	1.5	0	0	0	0	384	12	45.5	3.5	0	0
ICCL2	µA	0	16	0	0	0	0	0	0	4.5	0.5	0	0	0	0	379	20	47	5	0	0
ICCH2	µA	0	16	0	0	0	0	0	0	5.5	0.5	0	0	0	0	349	12	39	4	0	0
TPLH1	ns	C	12	5.04	.21	5.03	.19	5.04	.19	4.98	.19	5.02	.2	5.0	.19	5.06	.2	5.31	.21	7.8	.28
TPLH1	ns	C	12	4.11	.16	4.15	.16	4.02	.16	4.19	.16	4.09	.15	4.1	.16	4.14	.17	4.17	.19	6.96	.15
TPLH2	ns	C	8	7.86	.21	7.81	.19	7.92	.17	7.77	.18	7.82	.18	7.8	.17	7.92	.18	8.11	.19	10.7	.22
TPLH2	ns	C	8	7.07	.16	7.11	.15	6.84	.14	7.14	.17	7.1	.16	7.04	.16	7.16	.16	7.15	.17	10	.17

- 1/ The mean and standard deviation values were calculated over the two parts irradiated in this testing. The control sample remained constant throughout the testing and is not included in this table.
- 2/ In the functional tests, "PASS" means that all samples passed this functional test at this radiation or annealing level, "FAIL" means that all samples failed this test at this radiation or annealing level, and "nP/mF" means that n samples passed at this level and m samples failed at this level.

Figure 1. Radiation Bias Circuit for 54HC4051



1) $V^{CC} = +6.0 \text{ VDC} \pm 600 \text{ mV}$

2) All $R = 6.2 \text{ k}\Omega \pm 10\%$, 1/4 W (minimum).