

ADVISORY ON THE USE OF THIS DOCUMENT

The information contained in this document has been developed solely for the purpose of providing general guidance to employees of the Goddard Space Flight Center (GSFC). This document may be distributed outside GSFC only as a courtesy to other government agencies and contractors. Any distribution of this document, or application or use of the information contained herein, is expressly conditioned upon, and is subject to, the following understandings and limitations:

- (a) The information was developed for general guidance only and is subject to change at any time;
- (b) The information was developed under unique GSFC laboratory conditions which may differ substantially from outside conditions;
- (c) GSFC does not warrant the accuracy of the information when applied or used under other than unique GSFC laboratory conditions;
- (d) The information should not be construed as a representation of product performance by either GSFC or the manufacturer;
- (e) Neither the United States government nor any person acting on behalf of the United States government assumes any liability resulting from the application or use of the information.

Memorandum

PARAMAX
A Unisys Company

DATE: February 23, 1993
TO: B. Fafaul/311
FROM: K. Sahu/300.1 *KS*
SUBJECT: Radiation Report on FAST/MUE
Part No. 54ACTQ14DMQB (54AC14)
Control No. 5998

PPM-93-036

cc: R. Kolecki/740.4
T. Miccolis/300.1
A. Sharma/311
Library/300.1 ✓
L. Cusick/740.4
SMEX, PPM File

A radiation evaluation was performed on 54AC14 (Hex Inverter) 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 levels were 5, 10, 20, 40 and 60 krads*. After 60 krads, parts were annealed at 25°C for 595 hours. The irradiation was then continued to 100 krads (cumulative). The dose rate was between 0.15 and 1.05 krads/hour, depending on the total dose level (see Table II for radiation schedule). Finally the parts were annealed for 168 hours at 100°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. These tests included three functional tests at 1.0 MHz with Vcc = 4.5, 5.0 and 5.5 V.

All ten parts passed initial (pre-rad) electrical tests. All eight irradiated parts passed all electrical tests at each irradiation and annealing level up to and including the 20-krad irradiation. After the 40-krad irradiation, two parts (SN 72 and 74) exceeded the maximum specification limit of 4.0 uA for ICCH; with readings of 9.50 and 6.89 uA, respectively, and six parts (SN 72, 73, 74, 75, 76 and 77) exceeded the maximum specification

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

**These are manufacturers' non-irradiated data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

limit of 4.0 uA for ICCL, with readings ranging from 5.26 to 27.73 uA. After the 60-krad irradiation, four parts (SN 72, 74, 75 and 77) failed ICCH, with readings ranging from 4.08 to 15.56 uA, and the same six parts (SN 72 - 77) failed ICCL, with readings ranging from 7.82 to 41.83 uA.

After annealing for 595 hours at 25°C, all irradiated parts recovered to within specification limits for all test parameters. All eight irradiated parts continued to pass all electrical tests at subsequent irradiation to 100 krads.

After a final annealing at 100°C, no rebound effects were observed.

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.

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

ADVISORY ON THE USE OF THIS DOCUMENT

The information contained in this document has been developed solely for the purpose of providing general guidance to employees of the Goddard Space Flight Center (GSFC). This document may be distributed outside GSFC only as a courtesy to other government agencies and contractors. Any distribution of this document, or application or use of the information contained herein, is expressly conditional upon, and is subject to, the following understandings and limitations:

- (a) The information was developed for general guidance only and is subject to change at any time;
- (b) The information was developed under unique GSFC laboratory conditions which may differ substantially from outside conditions;
- (c) GSFC does not warrant the accuracy of the information when applied or used under other than unique GSFC laboratory conditions;
- (d) The information should not be construed as a representation of product performance by either GSFC or the manufacturer;
- (e) Neither the United States government nor any person acting on behalf of the United States government assumes any liability resulting from the application or use of the information.

TABLE I. Part Information

Generic Part Number:	54AC14
Part Number:	54ACT14DMQB
FAST/MUE Control Number:	5998
Charge Number:	C23991
Manufacturer:	National Semiconductor Corp.
Lot Date Code:	9231A
Quantity Tested:	10
Serial Numbers of Radiation Samples:	72, 73, 74, 75, 76, 77, 78, 79
Serial Numbers of Control Samples:	70, 71
Part Function:	Hex Inverter Schmitt Trigger
Part Technology:	CMOS
Package Style:	14-pin DIP
Test Equipment:	S-50
Test Engineer:	K. Kim

TABLE II. Radiation Schedule for 54AC14

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	01/05/93
2) 5 KRAD IRRADIATION (0.25 KRADS/HOUR) POST-5 KRAD ELECTRICAL MEASUREMENT	01/06/93 01/07/93
3) 10 KRAD IRRADIATION (0.26 KRADS/HOUR) POST-10 KRAD ELECTRICAL MEASUREMENT	01/07/93 01/08/93
4) 20 KRAD IRRADIATION (0.15 KRADS/HOUR) POST-20 KRAD ELECTRICAL MEASUREMENT	01/08/93 01/11/93
5) 40 KRAD IRRADIATION (1.05 KRADS/HOUR) POST-40 KRAD ELECTRICAL MEASUREMENT	01/11/93 01/12/93
6) 60 KRAD IRRADIATION (1.00 KRADS/HOUR) POST-60 KRAD ELECTRICAL MEASUREMENT	01/12/93 01/13/93
7) 595 HOUR* ANNEALING @25°C POST-595 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/13/93 02/05/93
8) 100 KRAD IRRADIATION (0.57 KRADS/HOUR) POST-100 KRAD ELECTRICAL MEASUREMENT	02/05/93 02/08/93
9) 168 HOUR ANNEALING @100°C* POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/08/93 02/16/93

ALL ELECTRICAL MEASUREMENTS WERE PERFORMED AT 25°C.

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

*Due to malfunction of the ATE, the parts were in annealing for 595 hours, instead of the usual 168 hours.

**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 54AC14

FUNCTIONAL TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C, -55C, +125C
FUNCT 1	4.5V	0.0V	4.5V	FREQ=1.000MHZ	ALL I/O	VOL<1.5V / VOH>1.5V
FUNCT 2	3.0V	0.0V	3.0V	FREQ=1.000MHZ	ALL I/O	VOL<2.5V / VOH>2.5V
FUNCT 3	5.5V	0.0V	5.5V	FREQ=1.000MHZ	ALL I/O	VOL<2.75V / VOH>2.75V
I _{OH} = -1.00mA I _{REF} = 2.5V I _{OL} = +1.00mA LOAD USED <=						
DC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
VOH1	4.5V	0.8V	2.0V	LOAD=-50uA	OUTS	>+4.4V / <+4.5V
VOH2	5.5V	0.8V	2.0V	LOAD=-50uA	OUTS	>+5.4V / <+5.5V
VOH3	4.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+3.7V / <+4.5V
VOH4	5.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+4.7V / <+5.5V
VOH5	5.5V	0.0V	5.5V	LOAD=-50uA	OUTS	>+3.85V / <+5.5V
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
VOH3	4.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+3.86V / <+4.5V
VOH4	5.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+4.86V / <+5.5V
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
VOL1	4.5V	0.8V	2.0V	LOAD=+50uA	OUTS	>+0.0V / <+0.1V
VOL2	5.5V	0.8V	2.0V	LOAD=+50uA	OUTS	>+0.0V / <+0.1V
VOL3	4.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.5V
VOL4	5.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.3V
VOL5	5.5V	0.0V	5.5V	LOAD=+50uA	OUTS	>+0.0V / <+1.65V
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
VOL3	4.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.36V
VOL4	5.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.36V
DC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
I _{IH}	5.5V	0.0V	5.5V	V _{IN} = 3.5V	INS	>-1.0uA / <+1.0uA
I _{IL}	5.5V	0.0V	5.5V	V _{IN} = 0.0V	INS	>-1.0uA / <+1.0uA
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
I _{IH}	5.5V	0.0V	5.5V	V _{IN} = 3.5V	INS	>-0.1uA / <+0.1uA
I _{IL}	5.5V	0.0V	5.5V	V _{IN} = 0.0V	INS	>-0.1uA / <+0.1uA
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
I _{CC1}	5.5V	0.0V	5.5V	V _{IN} = 3.5V	VCC	>+0.0uA / <+80uA
I _{CC2}	5.5V	0.0V	5.5V	V _{IN} = 0.0V	VCC	>+0.0uA / <+80uA
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
I _{CC1}	5.5V	0.0V	5.5V	V _{IN} = 3.5V	VCC	>+0.0uA / <+4.0uA
I _{CC2}	5.5V	0.0V	5.5V	V _{IN} = 0.0V	VCC	>+0.0uA / <+4.0uA
AC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
TPLH	5.0V	0.0V	3.0V	LOW-HIGH	OUTS	>+0.0NS / <+11.5NS
TPRL	5.0V	0.0V	3.0V	HIGH-LOW	OUTS	>+0.0NS / <+12.5NS
COMMENTS/EXCEPTIONS						
(1) VIL & VIH were tested during VOL & VOH tests as Go/NoGo.						
(2) V _{OL} (max/min), V _{IL} (+/-), I _{CC1} , V _{OLP} , V _{OLV} , V _{OMP} , V _{OMV} , V _{IHD} , V _{ILO} , t _{USL} , t _{OSL} , C _{in} and C _{pd} tests are NOT PERFORMED.						
(3) I _{OL} and I _{OH} are tested Go/NO-GO during VOL5 and VOH5 tests.						
MARKING REQUIREMENTS				TEMPERATURE TESTING CAPABILITY		
DEVICE CONFIGURATION : 14-PIN DIP				25 DEG. C. X		
LEAD ORDER # 17 : PIN 7 JUMPED TO GND.				-55 DEG. C. X		
				125 DEG. C. X		

TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annealing for 54AC14 1/

Parameters	Spec. Lim./2	min	max	Total Dose Exposure (TDE) (krads)												Anneal		TDE		Anneal	
				Initial		5		10		20		40		60		595 hrs @25°C		100 krads		168 hrs @100°C	
				mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
FUNC1, 1 MHz, 4.5 V				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC2, 1 MHz, 5.5 V				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC3, 1 MHz, 4.5 V				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
VOH1 /3	V	4.4	4.5	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0
VOH3	V	5.4	5.5	4.14	.01	4.15	.02	4.14	.04	4.14	.02	4.14	.02	4.14	.02	4.14	.02	4.13	.01	4.13	.02
VOH5	V	3.86	5.5	4.84	.03	4.85	.03	4.84	.07	4.84	.03	4.83	.04	4.83	.03	4.84	.03	4.83	.02	4.83	.03
VOL1	mV	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VOL5	mV	0	1.65	0	.02	0.36	.02	0.36	.04	0.37	.03	0.36	.03	0.35	.03	0.34	.02	0.33	.01	0.35	.02
I IH	uA	-1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I IL	uA	-1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICCH	uA	0	4.0	0	0	0	0	0.16	.09	0.45	3.0	5.48	4.6	0.13	.04	0.58	.31	0	0	0	0
ICCL	uA	0	4.0	0	0	0.15	.09	1.45	.09	8.85	8.3	13.4	13	0.13	.07	1.00	.71	0.04	.04	0.04	.04
TPLE	ns	0	11.5	8.70	.15	8.67	.14	8.68	.14	8.69	.16	8.65	.18	8.61	.16	7.98	.17	8.05	.16	8.09	.25
TPHL	ns	0	12.5	6.23	.14	6.18	.15	6.18	.16	6.15	.15	5.21	.18	6.10	.16	5.76	.12	5.62	.16	5.70	.19

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/These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

3/ No significant variation was observed in VOH2-4 or VOL2-4 during irradiation and annealing. Additional data are available on request.

Radiation sensitive parameters were ICCH and ICCL.

Table III. Electrical Characteristics of 54AC14

FUNCTIONAL TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C, -55C, +125C
FUNCT 1	4.5V	0.0V	4.5V	FREQ=1.000MHZ	ALL I/O	VOL<1.5V / VOH>1.5V
FUNCT 2	5.0V	0.0V	5.0V	FREQ=1.000MHZ	ALL I/O	VOL<2.5V / VOH>2.5V
FUNCT 3	5.5V	0.0V	5.5V	FREQ=1.000MHZ	ALL I/O	VOL<2.75V / VOH>2.75V
				ICCH = -1.00mA		
				LOAD RES = 2.5V		
				ICL = +1.00mA		
DC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
VOH1	4.5V	0.8V	2.0V	LOAD=-50uA	OUTS	>+4.4V / <+4.5V
VOH2	5.5V	0.8V	2.0V	LOAD=-50uA	OUTS	>+5.4V / <+5.5V
VOH3	4.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+3.7V / <+4.5V
VOH4	5.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+4.7V / <+5.5V
VOH5	5.5V	0.0V	5.5V	LOAD=-50uA	OUTS	>+3.85V / <+5.5V
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
VOH3	4.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+3.86V / <+4.5V
VOH4	5.5V	0.8V	2.0V	LOAD=-24mA	OUTS	>+4.86V / <+5.5V
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
VOL1	4.5V	0.8V	2.0V	LOAD=+50uA	OUTS	>+0.0V / <+0.1V
VOL2	5.5V	0.8V	2.0V	LOAD=+50uA	OUTS	>+0.0V / <+0.1V
VOL3	4.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.3V
VOL4	5.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.5V
VOL5	5.5V	0.0V	5.5V	LOAD=+50uA	OUTS	>+0.0V / <+1.65V
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
VOL3	4.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.36V
VOL4	5.5V	0.8V	2.0V	LOAD=+24mA	OUTS	>+0.0V / <+0.36V
DC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
I _{IH}	5.5V	0.0V	5.5V	V _{IN} = 5.5V	INS	>-1.0uA / <+1.0uA
I _{IL}	5.5V	0.0V	5.5V	V _{IN} = 0.0V	INS	>-1.0uA / <+1.0uA
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
I _{IH}	5.5V	0.0V	5.5V	V _{IN} = 5.5V	INS	>-0.1uA / <+0.1uA
I _{IL}	5.5V	0.0V	5.5V	V _{IN} = 0.0V	INS	>-0.1uA / <+0.1uA
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
ICCH	5.5V	0.0V	5.5V	V _{IN} = 5.5V	VCC	>+0.0uA / <+80uA
ICCL	5.5V	0.0V	5.5V	V _{IN} = 0.0V	VCC	>+0.0uA / <+80uA
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at +25C only
ICCH	5.5V	0.0V	5.5V	V _{IN} = 5.5V	VCC	>+0.0uA / <+4.0uA
ICCL	5.5V	0.0V	5.5V	V _{IN} = 0.0V	VCC	>+0.0uA / <+4.0uA
AC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS at -55C to +125C
TP _{LH}	5.0V	0.0V	5.0V	LOW-HIGH	OUTS	>+0.0NS / <+11.5NS
TP _{HL}	5.0V	0.0V	5.0V	HIGH-LOW	OUTS	>+0.0NS / <+12.5NS
COMMENTS/EXCEPTIONS						
(1) VIL & VIH were tested during VOL & VOH tests as Go/NoGo.						
(2) Vn(max/min), Vt(+/-), Iccy, VOLP, VOLV, VOHP, VOHV, VIHO, VILD, t _{USHL} , t _{OSLH} , C _{in} and C _{pd} tests are NOT PERFORMED.						
(3) I _{OLH} and I _{OH} are tested Go/NO-GO during VOL5 and VOH5 tests.						
HARDWARE REQUIREMENTS				TEMPERATURE TESTING CAPABILITY		
DEVICE CONFIGURATION : 14-PIN DIP				25 DEG. C. X		
LOAD BOARD : 17 : PINS 7 JUMPED TO GND.				-55 DEG. C. X		
				125 DEG. C. X		

TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annealing for 54AC14 1/

Parameters	Spec. Lim./2 min max	Total Dose Exposure (TDE) (krads)										Anneal		TDE		Anneal			
		Initial		5		10		20		40		60		595 hrs @25°C		100 krads		168 hrs @100°C	
		mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
FUNC1, 1 MHz, 4.5 V		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC2, 1 MHz, 5.5 V		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC3, 1 MHz, 4.5 V		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
VOH1 /3	V 4.4 4.5	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0	4.49	0
VOH3	V 5.4 5.5	4.14	.01	4.15	.02	4.14	.04	4.14	.02	4.14	.02	4.14	.02	4.14	.02	4.13	.01	4.13	.02
VOH5	V 3.85 5.5	4.84	.03	4.85	.03	4.84	.07	4.84	.03	4.83	.04	4.83	.03	4.84	.03	4.83	.02	4.83	.03
VOL1	mV 0 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VOL5	mV 0 1.65	0	.02	0.35	.02	0.36	.04	0.37	.03	0.36	.03	0.35	.03	0.34	.02	0.33	.01	0.35	.02
I IH	uA -1.0 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I IL	uA -1.0 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICCH	uA 0 4.0	0	0	0	0	0	0	0.16	.09	3.45	3.0	5.48	4.6	0.13	.04	0.58	.31	0	0
ICCL	uA 0 4.0	0	0	0	0	0.15	.09	1.45	.09	8.85	8.3	13.4	13	0.13	.07	1.00	.71	0.04	.04
TP LH	ns 0 11.5	8.70	.15	8.67	.14	8.68	.14	8.69	.16	8.86	.18	8.81	.16	7.98	.17	8.05	.16	8.09	.25
TP HL	ns 0 12.5	5.23	.14	6.18	.15	6.18	.16	6.15	.15	6.21	.18	6.10	.16	5.76	.12	5.62	.16	5.70	.19

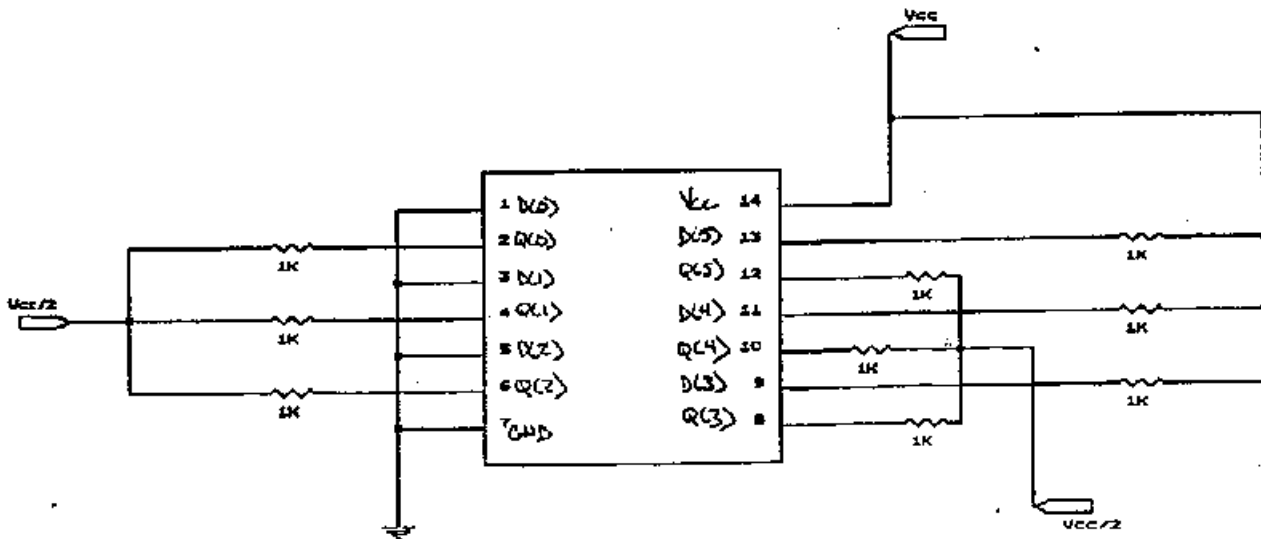
1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.

2/ These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

3/ No significant variation was observed in VOH2-4 or VOL2-4 during irradiation and annealing. Additional data are available on request.

Radiation sensitive parameters were ICCH and ICCL.

Figure 1. Radiation Bias Circuit for 54AC14



Vcc = 5.0 volts +/- .5 volts
 Vcc/2 = 2.5 volts +/- .25 volts
 ALL RESISTORS ARE 1/4 WATT