Unisys

DATE: September 24, 1998 PPM-98-027
TO: S Hull/562
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SUBJECT: Radiation Report on **54AC74 (National Semiconductor) (LDC 9610)**
PROJECT: MIDEX/MAP Transponder

cc: M. Delmont/303, A. Reyes/790.2, R. Reed/562, A. Sharma/562, OFA Library/300.1

A radiation evaluation was performed on **54AC74 (M38510/75302BCA) Dual D-Type Positive Edge Triggered Flip-Flop (National Semiconductor)** to determine the total dose tolerance of these parts. 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 one part was used as a control sample. The total dose radiation levels were 5.0, 10.0, 20.0, 50.0, and 100.0 kRads.[1] The dose rate was 0.595kRads/hour (0.16 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 100.0kRad irradiation, the parts were annealed under bias at 25°C and tested after and 168 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] listed in Table III.

An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step. For detailed information, refer to Tables I through IV and Figure 1.

All parts passed all tests up to 5kRads. After 10kRads, all parts showed significant degradation from specification limits for ICCH and ICCL. However, after annealing the parts for 120 hours at 25℃, all parts showed significant recovery in ICCH and ICCL and passed all tests. On continued irradiation from 20 to 100kRads, the parts again showed significant degradation in both ICCH and ICCL. However, on annealing for 168 hours at 25℃, all parts showed significant recovery in ICCH and ICCL. No significant degradation was observed in any other parameter. Figure 2 shows the variations in ICCH and ICCL after each radiation or annealing step.

Initial electrical measurements were made on 6 samples. Five samples (SN's 71, 72, 73, 74, and 75) were used as radiation samples while SN 70 was used as a control sample. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 5.0 kRads.

After the 10.0 kRad irradiation, all parts exceeded the specification limit of 1.0µA for ICCH and ICCL with readings in the range of 7.3 to 9.7µA for ICCH and 1.2 to 1.7µA for ICCL. **All parts passed all other tests.**

After annealing the parts for 120 hours at 25°C, the parts showed significant recovery in ICCH and ICCL with all parts passing all tests.

After the 20.0 to 100kRad irradiations, all parts exceeded the specification limit of 1.0µA for ICCH and ICCL with readings in the range of 26.2 to 61.5µA for ICCH and 4.5 to 11.6µA for ICCL. **All parts passed all other tests.**

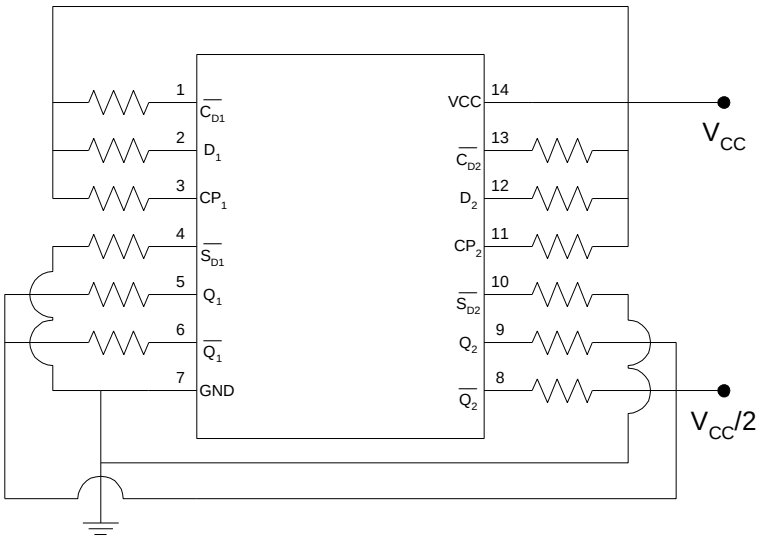
[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After annealing the parts for 168 hours at 25°C, the parts showed significant recovery in ICCH and ICCL. All parts marginally exceeded the specification limit for ICCH with readings in the range of 2.3 to 2.6µA and all parts passed ICCL.

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 us at (301) 731-8954.

Figure 1. Radiation Bias Circuit for 54AC74



Notes:
1. V_{CC} = 5.50V ±0.5V.
2. $V_{CC}/2$ = 2.75V ±0.5V.
3. R = 2kΩ ±5%, ½W.

TABLE I. Part Information

Generic Part Number:	54AC74
MIDEX/MAP Transponder	M38510/75302BCA
Charge Number:	C80979
Manufacturer:	National Semiconductor
Lot Date Code (LDC):	9610
Quantity Tested:	6
Serial Number of Control Samples:	70
Serial Numbers of Radiation Samples:	71, 72, 73, 74, and 75
Part Function:	Dual D-Type Positive Edge Triggered Flip-Flop
Part Technology:	Bipolar
Package Style:	14 Pin Dip
Test Equipment:	A540
Test Engineer:	A. Duvalsaint

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

TABLE II. Radiation Schedule for 54AC74

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/31/98
2) 5.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	08/31/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	09/01/98
3) 10.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	09/01/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	09/02/98
4) 120 HOUR ANNEALING @25°C	09/02/98
POST-120 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/08/98
5) 20.0 KRAD IRRADIATION (0.588 KRADS/HOUR)	09/08/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	09/10/98
6) 50.0 KRAD IRRADIATION (1.176 KRADS/HOUR)	09/10/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	09/14/98
7) 100.0 KRAD IRRADIATION (0.562 KRADS/HOUR)	09/14/98
POST-100.0 KRAD ELECTRICAL MEASUREMENT	09/16/98
8) 168 HOUR ANNEALING @25°C	09/16/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/23/98

Effective Dose Rate = 50,000 RADS/8 DAYS=595.2 RADS/HOUR=0.16 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the weekend and the extended step.

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

Table III. Electrical Characteristics of 54AC74 /1

Test #	Parameter	Units	Test Conditions /2	Spec. min	Lim. max
100	Funct. 3.0V		V_{CC}=3.0V, V_{IH}=2.5V, V_{IL}=0.45V, Load=50mA, 1MHz, V_{OL}<1.5V, V_{OH}>1.5V		
150	Funct. 4.5V		V_{CC}=4.5V, V_{IH}=3.7V, V_{IL}=0.60V, Load=50mA, 1MHz, V_{OL}<1.5V, V_{OH}>1.5V		
200-207	Iih_H	nA	V_{CC}=5.5V, V_{IH}=V_{CC}, V_{IL}=0V, V_{IN}=V_{CC}, other ins=V_{CC}	-100	100
250-257	Iih_L	nA	V_{CC}=5.5V, V_{IH}=V_{CC}, V_{IL}=0V, V_{IN}=V_{CC}, other ins=0V	-100	100
300-307	Iil_H	nA	V_{CC}=5.5V, V_{IH}=V_{CC}, V_{IL}=0V, V_{IN}=V_{CC}, other ins=V_{CC}	-100	100
350-357	Iil_L	nA	V_{CC}=5.5V, V_{IH}=V_{CC}, V_{IL}=0V, V_{IN}=V_{CC}, other ins=0V	-100	100
400-403	Voh1	V	V_{CC}=3.0V, V_{IH}=2.10, V_{IL}=0.90V, I_{OH}=-50mA	2.90	
410-413	Voh2	V	V_{CC}=4.5V, V_{IH}=3.15, V_{IL}=1.35V, I_{OH}=-50mA	4.40	
420-423	Voh3	V	V_{CC}=5.5V, V_{IH}=3.85, V_{IL}=1.65V, I_{OH}=-50mA	5.40	
430-433	Voh4	V	V_{CC}=3.0V, V_{IH}=2.10, V_{IL}=0.90V, I_{OH}=-4mA	2.40	
440-443	Voh5	V	V_{CC}=4.5V, V_{IH}=3.15, V_{IL}=1.35V, I_{OH}=-24mA	3.70	
450-453	Voh6	V	V_{CC}=5.5V, V_{IH}=3.85, V_{IL}=1.65V, I_{OH}=-24mA	4.70	
460-463	Voh7	V	V_{CC}=5.5V, V_{IH}=3.85, V_{IL}=1.65V, I_{OH}=-50mA	3.85	
200-503	Vol1	mV	V_{CC}=3.0V, V_{IH}=2.10, V_{IL}=0.90V, I_{OH}=-50mA		100
510-513	Vol2	mV	V_{CC}=4.5V, V_{IH}=3.15, V_{IL}=1.35V, I_{OH}=-50mA		100
520-523	Vol3	mV	V_{CC}=5.5V, V_{IH}=3.85, V_{IL}=1.65V, I_{OH}=-50mA		100
530-533	Vol4	mV	V_{CC}=3.0V, V_{IH}=2.10, V_{IL}=0.90V, I_{OH}=-4mA		400
540-543	Vol5	mV	V_{CC}=4.5V, V_{IH}=3.15, V_{IL}=1.35V, I_{OH}=-24mA		400
550-553	Vol6	mV	V_{CC}=5.5V, V_{IH}=3.85, V_{IL}=1.65V, I_{OH}=-24mA		400
560-563	Vol7	V	V_{CC}=5.5V, V_{IH}=3.85, V_{IL}=1.65V, I_{OH}=-50mA		1.65
600-607	Vic_+	V	V_{CC}=GND, for input under test: I_{IN}=1mA	0.40	1.50
650-657	Vic_-	V	V_{CC}=OPEN, for input under test: I_{IN}=-1mA	-1.50	-0.40
700	ICCH	mA	V_{CC}=5.50V, all inputs=V_{CC}		1.00
750	ICCL	mA	V_{CC}=5.50V, all inputs=GND=0V		1.00
900-903	TPD3V_SDCD_to_OUTS	ns		1.0	12.0
920-923	TPD3V_CP_to_OUTS	ns		1.0	10.0
940-943	TPD4.5V_SDCD_to OUT	ns		1.0	13.5
960-963	TPD4.5V_CP_to_OUTS	ns		1.0	10.0

Notes:

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/ $V_{IN} - V_{OUT}$ = 5V, I_{OUT} = 10mA unless otherwise noted.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for 54AC74 /1

					Total Dose Exposure (kRads Si)						Annealing		Total Dose Exposure (kRads Si)						Annealing	
					Initial		5.0		10.0		120 hours @25°C		20.0		50.0		100.0		168 hours @25°C	
Test #	Parameters	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
100	Funct. 3.0V /3				P		P		P		P		P		P		P		P	
150	Funct 4.5V /3				P		P		P		P		P		P		P		P	
200-207	Iih_H	nA	-100	100	-9	1	-6	2	-9	2	-11	4	-11	4	-10	2	-13	2	-12	1
250-257	Iih_L	nA	-100	100	-11	2	-10	3	-9	3	-12	1	-12	4	-12	2	-9	2	-13	2
300-307	Iil_H	nA	-100	100	4	3	4	3	2	4	4	4	4	3	4	4	2	2	2	3
350-357	Iil_L	nA	-100	100	6	4	6	3	6	2	7	3	6	3	5	3	8	2	6	4
400-403	Voh1	V	2.90		3.00	0	3.00	0	3.00	0	3.00	0	3.00	0	3.00	0	3.00	0	3.00	0
410-413	Voh2	V	4.40		4.50	0	4.50	0	4.50	0	4.50	0	4.50	0	4.50	0	4.50	0	4.50	0
420-423	Voh3	V	5.40		5.49	0	5.49	0	5.48	0	5.48	0	5.49	0	5.49	0	5.49	0	5.49	0
430-433	Voh4	V	2.40		2.93	0	2.93	0	2.93	0	2.93	0	2.93	0	2.93	0	2.93	0	2.93	0
440-443	Voh5	V	3.70		4.20	0	4.20	0	4.19	0	4.19	0	4.20	0	4.20	0	4.18	0	4.18	0
450-453	Voh6	V	4.70		5.23	0.01	5.23	0.01	5.23	0.01	5.23	0	5.23	0.01	5.23	0.01	5.22	0.01	5.22	0.01
460-463	Voh7	V	3.85		4.93	0.01	4.93	0.01	4.92	0.01	4.92	0.01	4.92	0.01	4.92	0.01	4.91	0.01	4.91	0.01
500-503	Vol1	mV		100	3	2	4	1	4	1	3	1	4	1	3	2	4	2	3	2
510-513	Vol2	mV		100	7	2	8	1	9	2	7	2	8	2	7	2	7	2	6	3
520-523	Vol3	mV		100	10	2	12	1	12	2	11	2	11	2	11	2	12	2	11	2
530-533	Vol4	mV		400	44	2	45	3	44	2	44	1	45	1	43	2	43	2	44	3
540-543	Vol5	mV		400	190	3	188	2	188	3	189	7	187	2	188	7	188	3	189	4
550-553	Vol6	mV		400	170	2	170	3	170	2	170	6	167	5	168	3	170	4	171	4
560-563	Vol7	mV		1650	352	6	350	4	348	6	352	13	347	5	349	13	351	7	352	6
600-607	Vic_-	V	-1.50	-0.40	-0.74	0	-0.74	0	-0.74	0	-0.74	0	-0.74	0	-0.74	0	-0.74	0	-0.74	0
650-657	Vic_+	V	0.40	1.50	0.78	0	0.78	0	0.78	0	0.78	0	0.78	0	0.78	0	0.78	0	0.78	0
700	ICCH	mA		1.0	0.005	0	0.4	0.05	7.9	1.0	0.5	0.04	29.5	4.2	48.8	7.6	28.3	2.6	2.5	0.1
750	ICCL	mA		1.0	0.005	0	0.07	0.01	1.3	0.2	0.08	0	5.1	0.8	9.1	1.5	6.0	0.5	0.9	0.04
900-903	TPD3V_SDCD_to_OUTS	ns	1.0	12.0	5.4	0.2	5.4	0.2	5.4	0.2	5.4	0.2	5.4	0.2	5.4	0.2	5.6	0.2	5.4	0.2
920-923	TPD3V_CP_to_OUTS	ns	1.0	10.0	5.4	0.2	5.4	0.2	5.4	0.2	5.4	0.2	5.4	0.2	5.4	0.2	5.5	0.4	5.4	0.2
940-943	TPD4.5V_SDCD_to OUT	ns	1.0	13.5	4.5	0	4.5	0	4.5	0	4.5	0	4.5	0	4.5	0	4.5	0	4.5	0
960-963	TPD4.5V_CP_to_OUTS	ns	1.0	10.0	4.3	0.3	4.1	0.2	4.2	0.3	4.1	0.2	4.1	0.2	4.2	0.3	4.1	0.2	4.1	0.2

Notes:

1/ The mean and standard deviation values were calculated over the eight 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/ For these tests, P implies that all devices passed this functional test.

Radiation sensitive parameters: ICCH, ICCL.

Figure 2: ICCH & ICCL vs Total Ionizing Dose [kRads (Si)]