PPM 92-279

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Paramax Systems Corporation

4700 Boston Way
Lanham MD 20706

PARAMAX
A Unisys Company

Memorandum

PPM-92-279

DATE: November 9, 1992
TO: B. Fafaul/311
FROM: K. Sahu KS
SUBJECT: Radiation Report on FAST/MUE
Part No. M38510/76302BEA (54AC161)

cc: R. Kolecki/740.4
T. Miccolis
A. Sharma/311
Library/300.1
L. Cusick/740.4

A radiation evaluation was performed on 54AC161 (4-Bit Binary Counter) 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 steps were 5, 10, 20, 40 and 60 krads*. After 60 krads, parts were annealed at +25^{0}C for 168 hours. The irradiation was then continued to 100 krads (cumulative). The dose rate was between 0.24 and 2.0 krads/hour, depending on the total dose level (see Table II for radiation schedule). 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 1.0MHz with VCC = 3.0V, 4.5V, and 5.5V.

All ten parts passed initial (pre-rad) electrical tests. After the 5-krad irradiation, all parts passed all electrical tests except VOH2 and VOH5. Table III shows that VIL and VIH for these two tests are 1.35 and 3.15V, respectively. These failures indicate that VIL of 1.35V is very close to the threshold voltage for these parts, and they are not switching to the correct output state. Therefore, applications of this part should not specify VIL greater than 0.9V, at which the parts passed the VOH tests. Refer to Table III and Appendix 1 for more details. The VOH2 and VOH5 failures continued at higher radiation levels of 20 - 100 krads, but will not be discussed any further in this report.

After the 10-krad irradiation, SN 605 exceeded the maximum specification limits of 2 uA for ICCH and ICCL, with readings of

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*The term rads, as used in this document, means rads(silicon).
**These are manufacturers' non-irradiated data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

47.24 and 107.2 uA, respectively. After the 20-krad irradiation, SN 605 failed ICCH and ICCL with readings of 543 and 791 uA, respectively, SN 607 marginally failed ICCH, with a reading of 2.81 uA and SN608 had a reading of 2.47 uA for ICCH. After the 40-krad irradiation, SN 605 had readings for ICCH and ICCL of 3014 and 2296 uA, respectively and SN 607 had readings of 2.05 and 2.533 uA, respectively. SN 608 had readings of 4.08 uA and 2.48 uA, respectively. After the 60-krad irradiation, six parts (SN 602, 604, 605, 606, 607 and 608) exceeded the maximum specification limits for ICCH and ICCL, with readings ranging from 2.23 uA to 22.7 uA, except for SN 605 which had readings of 6030 and 3850 uA, respectively. After annealing for 168 hours at 25°C, SN 605 had readings of 5510 and 3439 uA for ICCH and ICCL, respectively, and SN 608 read 13.35 uA for ICCH.

After continued irradiation to 100 krads (cumulative), SN 605 continued to exhibit large readings for ICCH (1234 uA) and ICCL (6600 uA). Five other parts continued to fail ICCH and ICCL, with readings ranging from 2.66 uA to 93.80 uA.

After a final annealing at 100°C, no rebound effects were observed. All eight irradiated parts passed all electrical tests, with the exception of SN 605, which continued to fail ICCH and ICCL, with readings of 2895 and 1256 uA, respectively.

All parts passed all functional tests 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.

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:	54AC161
Part Number:	M38510/76302BEA
FAST/MUE Control Number:	6113
Charge Number:	C23971
Manufacturer:	National Semiconductor Corp.
Lot Date Code:	9212
Quantity Tested:	10
Serial Numbers of Radiation Samples:	602, 603, 604, 605, 606, 607, 608, 609
Serial Numbers of Control Samples:	600,601
Part Function:	4-Bit Binary Counter
Part Technology:	CMOS
Package Style:	16-pin DIP
Test Engineer:	C. Nguyen

TABLE II. Radiation Schedule for 54AC161

EVENTS	DATE
1) Initial Electrical Measurements	10/07/92
2) 5 KRAD IRRADIATION (0.25 krads/hour)	10/08/92
POST-5 KRAD ELECTRICAL MEASUREMENT	10/09/92
3) 10 KRAD IRRADIATION (0.24 krads/hour)	10/10/92
POST-10 KRAD ELECTRICAL MEASUREMENT	10/14/92
4) 20 KRAD IRRADIATION (0.59 krads/hour)	10/15/92
POST-20 KRAD ELECTRICAL MEASUREMENT	10/16/92
5) 40 KRAD IRRADIATION (0.30 KRADS/HOUR)	10/16/92
POST-40 KRAD ELECTRICAL MEASUREMENT	10/19/92
6) 60 KRAD IRRADIATION (1.05 KRADS/HOUR)	10/19/92
POST-60 KRAD ELECTRICAL MEASUREMENT	10/20/92
7) 168 HOUR ANNEALING @25°C	10/20/92
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/27/92
8) 100 KRAD IRRADIATION (2.0 KRADS/HOUR)	10/28/92
POST-100 KRAD ELECTRICAL MEASUREMENT	10/29/92
9) 168 HOUR ANNEALING @100°C*	10/29/92
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/05/92

ALL ELECTRICAL MEASUREMENTS WERE PERFORMED AT 25°C.

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 54AC161

DEVICE	PART TYPE : SYNCHRONOUS 4-BIT BINARY COUNTER PART NO. : M38510/76302BEA (54AC161)	PCN : SI10573A
TEST PROGRAM LOCATION		TEST SPECIFICATIONS
DISK LABEL : LIB_25 DIRECTORY : DQAT:[PROGRAMS.573]		MIL-M-38510/76302 19 NOVEMBER 1990

FUNCTIONAL TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C
FUNCT 1	3.0V	0.45V	2.5V	FREQ=1.000MHz	ALL I/O	VOL<1.50V , VOH>1.50V
FUNCT 2	4.5V	0.60V	3.7V	FREQ=1.000MHz	ALL I/O	VOL<2.25V , VOH>2.25V
FUNCT 3	5.5V	0.00V	5.5V	FREQ=1.000MHz	ALL I/O	VOL<2.75V , VOH>2.75V

DC PARAMETRIC TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C
VOH1	3.0V	0.90V	2.10V	LOAD=-50UA	OUTS	>+2.9V , <+3.0V
VOH2	4.5V	1.35V	3.15V	LOAD=-50UA	OUTS	>+4.4V , <+4.5V
VOH3	5.5V	0.00V	3.85V	LOAD=-50UA	OUTS	>+5.4V , <+5.5V
VOH4	3.0V	0.90V	2.10V	LOAD=-04MA	OUTS	>+2.4V , <+3.0V
VOH5	4.5V	1.35V	3.15V	LOAD=-24MA	OUTS	>+3.7V , <+4.5V
VOH6	5.5V	0.00V	3.85V	LOAD=-24MA	OUTS	>+4.7V , <+5.5V
VOH7	5.5V	0.00V	3.85V	LOAD=-50MA	OUTS	>+3.85V , <+5.5V
VOL1	3.0V	0.90V	2.10V	LOAD=+50UA	OUTS	>+0.0V , <+0.1V
VOL2	4.5V	1.35V	3.15V	LOAD=+50UA	OUTS	>+0.0V , <+0.1V
VOL3	5.5V	0.00V	3.85V	LOAD=+50UA	OUTS	>+0.0V , <+0.1V
VOL4	3.0V	0.90V	2.10V	LOAD=+12MA	OUTS	>+0.0V , <+0.5V
VOL5	4.5V	1.35V	3.15V	LOAD=+24MA	OUTS	>+0.0V , <+0.5V
VOL6	5.5V	0.00V	3.85V	LOAD=+24MA	OUTS	>+0.0V , <+0.5V
VOL7	5.5V	0.00V	3.85V	LOAD=+50MA	OUTS	>+0.0V , <+1.65V
IIL	5.5V	0.00V	5.50V	VIN = 0.0V	INS	>-1.0UA , <+0.0UA
IIH	5.5V	0.00V	5.50V	VIN = 5.5V	INS	>+0.0UA , <+1.0UA
VIC-	5.5V	0.00V	5.50V	IIN = -1MA	INS	>-1.5V , <-0.4V
ICCH	5.5V	0.00V	5.50V	VIN = 5.5V	VCC	>+0.0UA , <+2.0UA
ICCL	5.5V	0.00V	5.50V	VIN = 0.0V	VCC	>+0.0UA , <+2.0UA

AC PARAMETRIC TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	LIMITS AT +25C ONLY
LH_CP_QN	3.0V	0.0V	3.0V	CP TO QN	> 1NS < 12NS
LH_CP_TC	3.0V	0.0V	3.0V	CP TO TC	> 1NS < 14NS
HL_CP_QN	3.0V	0.0V	3.0V	CP TO QN	> 1NS < 12NS
HL_CP_TC	3.0V	0.0V	3.0V	CP TO TC	> 1NS < 14NS
LH_ET_TC	3.0V	0.0V	3.0V	CET TO TC	> 1NS < 11.5NS
HL_ET_TC	3.0V	0.0V	3.0V	CET TO TC	> 1NS < 11.5NS
HL_MR_QN	3.0V	0.0V	3.0V	MR TO QN	> 1NS < 11.5NS
HL_MR_TC	3.0V	0.0V	3.0V	MR TO TC	> 1NS < 15NS
LH_CP_QN	4.5V	0.0V	4.5V	CP TO QN	> 1NS < 8.5NS
LH_CP_TC	4.5V	0.0V	4.5V	CP TO TC	> 1NS < 10.5NS
HL_CP_QN	4.5V	0.0V	4.5V	CP TO QN	> 1NS < 8.5NS
HL_CP_TC	4.5V	0.0V	4.5V	CP TO TC	> 1NS < 10.5NS
LH_ET_TC	4.5V	0.0V	4.5V	CET TO TC	> 1NS < 8.5NS
HL_ET_TC	4.5V	0.0V	4.5V	CET TO TC	> 1NS < 8.5NS
HL_MR_QN	4.5V	0.0V	4.5V	MR TO QN	> 1NS < 8.5NS
HL_MR_TC	4.5V	0.0V	4.5V	MR TO TC	> 1NS < 11.5NS

TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annealing for 54AC161 1/

Parameters	Spec. Lim./2 min	Spec. Lim./2 max	Total Dose Exposure (TDE) (krads) Initial mean	Initial sd	5 mean	5 sd	10 mean	10 sd	20 mean	20 sd	40 mean	40 sd	60 mean	60 sd	Anneal 168 hrs @25°C mean	Anneal 168 hrs @25°C sd	TDE 100 krads mean	TDE 100 krads sd	Anneal 168 hrs @100°C mean	Anneal 168 hrs @100°C sd
FUNC1, 1 MHz, 3.0 V			PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC2, 1 MHz, 4.5 V			PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC3, 1 MHz, 5.5 V			PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
VOH1 V	2.9	3.0	2.99	.01	2.99	.01	2.99	.01	2.99	.01	2.99	.01	2.99	.01	2.99	.01	2.99	.02	2.99	0
VOH3 V	5.4	5.5	5.49	.01	5.49	0	5.49	.01	5.49	.01	5.49	.01	5.49	.01	5.49	.01	5.49	.01	5.49	.01
VOH5/3 V	3.7	4.5	PASS		4P4F		5P3F		3P5F		FAIL		FAIL		FAIL		FAIL		7P1F	
VOH7 V	3.85	5.5	4.90	.05	4.91	.03	4.90	.04	4.90	.04	4.91	.03	4.91	.03	4.88	.05	4.89	.04	4.87	.05
VOL1/4 mV	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.55	1.5	0	0
VOL7 mV	0	1650	530	74	421	33	480	54	480	54	443	34	409	24	396	18	423	46	470	69
IIL nA	-100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IIH nA	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIC- mV	-1500	-400	-705	2.6	-718	2.1	-709	3.5	-709	3.5	-716	2.9	-722	4.5	-726	2.8	-724	13	-717	6.1
ICCH uA	0	2.0	0	0	0.05	.01	6.36	15	6.36	15	378	996	758	1992	691	1821	1566	4072	362	957
ICCL uA	0	2.0	0	0	0.13	0.3	13.5	35	13.5	35	288	759	484	1272	430	1137	836	2178	157	415
LH_CP_QN ns	1.0	12.0	6.67	1.0	6.66	1.0	6.67	1.0	6.67	1.0	6.65	1.0	6.63	1.1	7.08	1.1	7.08	1.2	6.96	1.0
LH_CP_TC ns	1.0	14.0	9.36	1.0	9.39	1.0	9.45	1.0	9.45	1.0	9.42	1.0	9.42	1.0	9.34	1.0	9.36	1.1	9.63	1.1
HL_CP_QN ns	1.0	12.0	6.78	0.9	6.76	0.8	6.83	0.9	6.83	0.9	6.69	0.9	6.64	0.9	6.99	1.0	6.91	1.0	7.33	1.0
HL_CP_TC ns	1.0	14.0	9.80	0.7	9.81	0.7	9.86	0.7	9.86	0.7	9.70	0.6	9.61	0.6	0.0	0.6	9.89	0.7	0.5	0.8
LH_ET_TC ns	1.0	11.5	6.18	0.5	6.20	0.5	6.21	0.5	6.21	0.5	6.20	0.5	6.20	0.5	6.12	0.6	6.08	0.5	6.35	0.6
HL_ET_TC ns	1.0	11.5	7.40	0.3	7.42	0.4	7.43	0.3	7.43	0.3	7.42	0.3	7.40	0.3	7.86	0.3	7.85	0.3	7.50	0.5
HL_NR_QN ns	1.0	11.5	8.51	0.6	8.48	0.6	8.45	0.6	8.45	0.6	8.45	0.6	8.47	0.6	8.85	0.6	8.74	0.5	8.47	0.7
HL_MR_TC ns	1.0	15.0	10.5	0.8	10.4	0.8	10.4	0.8	10.4	0.8	10.4	0.8	10.4	0.8	10.8	0.8	10.6	0.8	10.6	0.9

Notes:

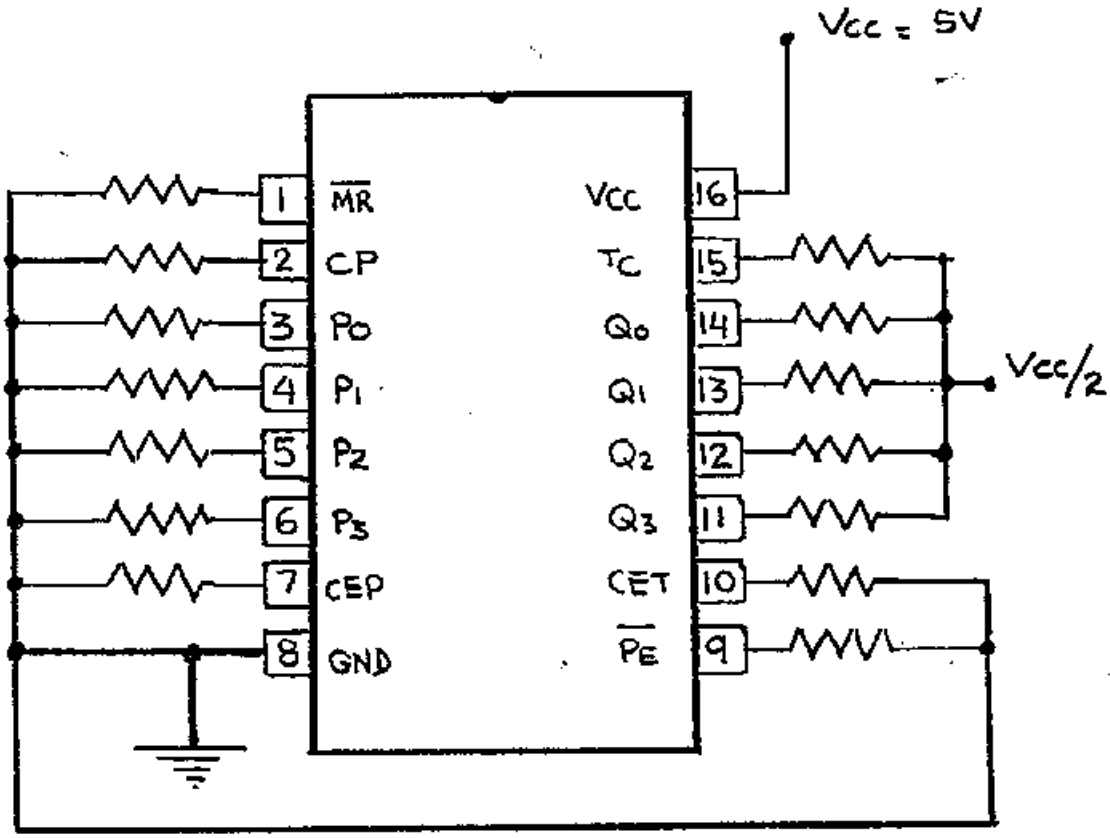
1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.

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/"PASS" indicates that all parts passed the test and "FAIL" indicates that all parts failed the test at a given level. "nPmF" indicates that n parts passed and m parts failed the test. The VOH5 test is shown here as "PASS" or "FAIL", because the value of VIL (1.35V) for both VOH2 and VOH5 were sufficiently close to the threshold voltage for the part that, although it passed initially, it failed these tests after very little (5 krads) radiation dose. All parts passed all other VOH tests; therefore, application of this part in a radiation environment with these values of VIH and VIL should be avoided.

4/No significant variation was observed in VOL1 - VOL7 during irradiation and annealing. Additional data on VOL2 - VOL6 are available on request.

Figure 1. Radiation Bias Circuit for 54AC161



- ALL R = 2KΩ , 5% , ¼ W
- Vcc = 5V ± 5%

Initially, the test conditions for VOH and VOL were used per MIL-M-38510/763 (see Table V). However, the parts failed VOH3, VOH6 and VOH7 in the pre-radiation test. VIL was therefore changed from 1.65V to 0.0V for these tests. The parts were retested under the new VIL conditions and all parts passed all tests. This indicated that the parts were sensitive to the VIL voltage threshold level. VIL was not changed, however, for VOH2 and VOH5, because parts passed these tests before irradiation. Beginning at 5 krads, however, parts also failed these tests.

C. Nguyen
Test Engineer
731-8957

Note: VIL for the VOL tests was also changed, but parts did not fail VOL in the pre-radiation test.

Table V. Comparison of MIL-M-38510/763 and PPM-92-279 Test Specifications

Test	Conditions	MIL-M-38510/763	PPM-92-279
VOH1	VIL= VIH=	0.90V 2.10V	0.90V 2.10V
VOH2	VIL= VIH=	1.35V 3.15V	1.35V 3.15V
VOH3	VIL= VIH=	1.65V 3.85V	0.00V 3.85V
VOH4	VIL= VIH=	0.90V 2.10V	0.90V 2.10V
VOH5	VIL= VIH=	1.35V 3.15V	1.35V 3.15V
VOH6	VIL= VIH=	1.65V 3.85V	0.00V 3.85V
VOH7	VIL= VIH=	1.65V 3.85V	0.00V 3.85V