Government Systems Group

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DATE: August 24, 1995

PPM-95-130

TO: G. Kramer/311
FROM: K. Sahu/300.1
SUBJECT: Radiation Report on 1020B
Control No. 11951

cc: R. Katz/738.2
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A radiation evaluation was performed on 1020B (Field Programmable Gate Array) 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 Figures 1, 2 and 3.

The total dose testing was performed using a Co^{60} gamma ray source. During the radiation testing, six parts were irradiated under bias (see Figure 1 for bias configuration), and two parts were used as control samples. Three of the irradiated parts (S/N 506, 507 and 508) were burned-in (BI) by the manufacturer before irradiation at 125°C for 168 hours and the other three (S/N 567, 572 and 575) were not burned-in (NBI). This was done in order to determine the effect of burn-in on radiation sensitivity. The wafer number was 9.

The total dose radiation levels were 5, 15, 20, 30, 50 and 75 krads*. The dose rate was between 0.06 and 1.47 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 75 krad irradiation, parts were annealed at 25C for 72 hours. Following this, the parts were annealed for an additional 240 hours at 25 for a cumulative total of 312 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. These tests included six functional tests, three at 1 Mhz, with Vcc = 4.5 V, 5.0 V and 5.5 V, and three at 5 Mhz, with Vcc = 4.5 V, 5.0 V and 5.5 V.

All parts passed initial electrical measurements. All irradiated parts passed all electrical and functional tests up to and including the 5 krad irradiation.

After the 15 krad irradiation, S/N 567 and 572 (NBI) marginally exceeded the maximum specification limit of 20 mA for ICCH3, with readings of 21.8 and 20.3 mA, respectively. All other irradiated parts passed all electrical and functional tests.

After the 20 krad irradiation, S/N 506 and 507 (BI) and 567, 572 and 575 (NBI) exceeded the maximum specification limit of 20 mA for at least two and as many as six of six ICCL and ICCH tests, with readings ranging from 20.7 to 35.3 mA

After the 30 krad irradiation, all irradiated parts except S/N 508 (BI) exceeded the maximum specification limit for all ICCL and ICCH tests except for ICCL1, with readings ranging from 21.2 to 29.1 mA. S/N 508 read 20.2 mA for ICCH3 and passed all other ICCL and ICCH tests. All other irradiated parts passed all electrical and functional 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. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

At the 50 krad level, S/N 506 (BI) failed Functional Tests #1, 4 and 5; S/N 507 (BI) failed Functional Tests # 1, 2, 4 and 5; S/N 567 (NBI) failed Functional Tests # 1 and 4; and S/N 575 (NBI) failed Functional Test # 4. In addition, at this level, all irradiated parts read either 999 or 1000 mV for VOL and 0.00 V for VOH, which is indicative of functional failure.

Also, at the 50 krad level, S/N 507 had a reading of -3.43 mA for -IOS, which is above the maximum specification limit of -10 mA; and S/N 506 and 507 read 999 µs for TPLH and TPHL, which is above the maximum specification limit of 100 ns. All irradiated parts except S/N 508 (BI) and 567 read >256 mA for at least one ICCL or ICCH test, which is at the limit of the range of the test equipment. All irradiated parts exceeded the maximum specification limit for all other ICCL and ICCH tests, with readings ranging from 27.3 to 250 mA.

The dose rate for the 75 krad level was accidentally increased to 1.47 krads/hour, which is approximately 10 times the intended rate. At this level, all irradiated parts failed all functional tests. The same failures in VOH and VOL as at the 50 krad level were observed, and, in addition, all irradiated parts read approximately -1.0 mA for -IOS, which is above the minimum specification limit. All irradiated parts read >256 mA for all ICCH and ICCL tests; and all irradiated parts read 999 µs for TPLH and TPHL.

After annealing for 72 hours at 25°C, S/N 506 (BI) continued to fail all functional tests and S/N 567, 572 and 575 (NBI) passed all functional tests. S/N 507 (BI) passed Functional Test # 3 and failed all others, and S/N 508 (BI) failed Functional Test # 4 and passed all others. S/N 572 recovered to within specification limits for VOH and S/N 506, 572 and 575 recovered to within specification limits for VOL. All irradiated parts continued to exceed specification limits for all ICCL and ICCH tests, and all irradiated parts except S/N 506 and 507 recovered to within specification limits for TPLH and TPHL.

After annealing for 312 hours at 25°C, all irradiated parts continued to exceed specification limits for all ICCL and ICCH tests. All irradiated parts recovered to within specification limits for all other electrical and functional tests.

Table IV provides a summary of the mean and standard deviation values for each parameter after different irradiation exposures and annealing steps.

Readings for ICCL1 and ICCH1 are plotted vs. total dose in Figures. 2 and 3, respectively, for both burned-in (BI) and non burned-in (NBI) parts. As can be seen in both figures, there does not seem to be a consistent difference between BI and NBI parts.

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

TABLE I. Part Information

Generic Part Number:	1020B*
Code 400 Part Number:	1020B
Code 400 Control Number:	11951
Charge Number:	EE44502
Manufacturer:	Actel
Lot Date Code:	unknown
Quantity Tested:	6
Serial Number of Control Samples:	509, 555
Serial Numbers of Radiation Samples:	506, 507, 508 (Burned-In) 567, 572, 575 (not Burned-In)
Wafer No.:	9
Part Function:	Field Programmable Gate Array
Part Technology:	CMOS
Package Style:	84-pin CPGA
Test Equipment:	S-50
Test Engineer:	T. Scharer

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

TABLE II. Radiation Schedule for 1020B

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	12/23/94
2) 5 KRAD IRRADIATION (0.12 KRADS/HOUR)	12/27/94
POST-5 KRAD ELECTRICAL MEASUREMENT	12/29/94
3) 15 KRAD IRRADIATION (0.06 KRADS/HOUR)	12/30/94
POST-15 KRAD ELECTRICAL MEASUREMENT	01/03/95
4) 20 KRAD IRRADIATION (0.12 KRADS/HOUR)	01/10/95
POST-20 KRAD ELECTRICAL MEASUREMENT	01/12/95
5) 30 KRAD IRRADIATION (0.11 KRADS/HOUR)	01/13/95
POST-30 KRAD ELECTRICAL MEASUREMENT	01/20/95
6) 50 KRAD IRRADIATION (0.31 KRADS/HOUR*)	01/20/95
POST-50 KRAD ELECTRICAL MEASUREMENT	01/23/95
7) 75 KRAD IRRADIATION (1.47 KRADS/HOUR**)	01/23/95
POST-75 KRAD ELECTRICAL MEASUREMENT	01/24/95
8) 72-HOUR ANNEALING @25C	01/24/95
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/27/95
9) 312-HOUR ANNEALING @25C	01/27/95
POST-312 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/03/95

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

*The dose rate for the 20 krad irradiation was accidentally increased by a factor of approximately 2-3.
***The dose rate for the 75 krad irradiation was accidentally increased by a factor of approximately 10.

Table III. Electrical Characteristics of 1020B

FUNCTIONAL TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ -55C,+25C,+125C
FUNCT 1	4.5V	0.0V	4.5V	FREQ=1.000MHZ	ALL I/O	VOL<1.50V , VOH>1.50V
FUNCT 2	5.0V	0.0V	5.0V	FREQ=1.000MHZ	ALL I/O	VOL<1.50V , VOH>1.50V
FUNCT 3	5.5V	0.0V	5.5V	FREQ=1.000MHZ	ALL I/O	VOL<1.50V , VOH>1.50V
FUNCT 4	4.5V	0.0V	4.5V	FREQ=5.000MHZ	ALL I/O	VOL<1.50V , VOH>1.50V
FUNCT 5	5.0V	0.0V	5.0V	FREQ=5.000MHZ	ALL I/O	VOL<1.50V , VOH>1.50V
FUNCT 6	5.5V	0.0V	5.5V	FREQ=5.000MHZ	ALL I/O	VOL<1.50V , VOH>1.50V

DC PARAMETRIC TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ -55C,+25C,+125C
VOH1	4.5V	0.00V	4.50V	LOAD=-4.0MA	OUTS	>+3.70V , <+4.50V
VOL1	4.5V	0.00V	4.50V	LOAD=+6.0MA	OUTS	>+0.0V , <+0.40V
IIH	5.5V	0.00V	5.5V	VIN = 5.5V	INS	>-10UA , <+10UA
IIL	5.5V	0.00V	5.5V	VIN = 0.0V	INS	>-10UA , <+10UA
IOSN	5.5V	0.0V	5.5V	VOUT= GND	VCC	>-100MA , <-10MA
ICCL1	4.5V	0.0V	4.5V	VOUT= 0.0V	VCC	>+0.0MA , <+20MA
ICCH1	4.5V	0.0V	4.5V	VOUT= 4.5V	VCC	>+0.0MA , <+20MA
ICCL2	5.0V	0.0V	5.0V	VOUT= 0.0V	VCC	>+0.0MA , <+20MA
ICCH2	5.0V	0.0V	5.0V	VOUT= 5.0V	VCC	>+0.0MA , <+20MA
ICCL3	5.5V	0.0V	5.5V	VOUT= 0.0V	VCC	>+0.0MA , <+20MA
ICCH3	5.5V	0.0V	5.5V	VOUT= 5.5V	VCC	>+0.0MA , <+20MA

AC PARAMETRIC TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ -55C,+25C,+125C
TPLH	4.5V	0.00V	3.00V	VTEST=2.0V	OUTS	>+0.0NS , <+100NS
TPHL	4.5V	0.00V	3.00V	VTEST=2.0V	OUTS	>+0.0NS , <+100NS

Table IV: Total Dose Exposures and Annealing for 1020B /1

Test #	Parameters	Units	Spec. Lim./2 min	Spec. Lim./2 max	Initials -55°C mean	Initials -55°C sd	Initials 25°C mean	Initials 25°C sd	Initials 125°C mean	Initials 125°C sd	TDE (krads) 5 mean	TDE (krads) 5 sd	TDE (krads) 15 mean	TDE (krads) 15 sd	TDE (krads) 20 mean	TDE (krads) 20 sd	TDE (krads) 30 mean	TDE (krads) 30 sd	TDE (krads) 50 mean	TDE (krads) 50 sd	TDE (krads) 75/6 mean	TDE (krads) 75/6 sd	Annealing 72 hrs @25°C mean	Annealing 72 hrs @25°C sd	Annealing 312 hrs @25°C mean	Annealing 312 hrs @25°C sd
1	FUNC1, VCC=4.5V, VIL=0.8V, VIH=4.5V, 1MHz				P		P		P		P		P		P		P		3P3F		F		4P2F		P	
2	FUNC2, VCC=5.0V, VIL=0.8V, VIH=5.0V, 1MHz				P		P		P		P		P		P		P		5P1F		F		4P2F		P	
3	FUNC3, VCC=5.5V, VIL=0.8V, VIH=5.5V, 1MHz				P		P		P		P		P		P		P		P		F		5P1F		P	
4	FUNC4, VCC=4.5V, VIL=0.8V, VIH=4.5V, 5MHz				P		P		P		P		P		P		P		2P4F		F		3P3F		P	
5	FUNC5, VCC=5.0V, VIL=0.8V, VIH=5.0V, 5MHz				P		P		P		P		P		P		P		4P2F		F		4P2F		P	
6	FUNC6, VCC=5.5V, VIL=0.8V, VIH=5.5V, 5MHz				P		P		P		P		P		P		P		P		F		4P2F		P	
7	VOH	V	3.7	4.5	4.29	.01	4.23	.01	4.15	.01	4.22	.01	4.23	.01	4.22	.01	4.22	.01	0	0	0	0	1.41	2.2	4.21	.02
8	VOL	mV	0	400	84.3	1.5	135	5.9	159	3.7	94.2	44	112	4.0	111	2.0	112	2.1	1000	0.5	1000	0.5	417	371	115	3.0
9	IIH	uA	-10	10	0	0	0	0	0.17	.02	0	0	0	0	0	0	0	0	0.05	.07	0.66	.29	0.10	.09	0.05	.03
10	IIL	uA	-10	10	0	0	0	0	-0.03	.02	0	0	0	0	0	0	0	0	-0.02	.04	-0.59	.23	-0.11	.17	-0.01	.01
11	-IOS	mA	-100	-10	-45.2	1.0	-36.0	.81	-28.0	.43	-36.2	.69	-36.2	.83	-36.3	.69	-35.4	.77	-26.8	14	-1.02	.41	-23.3	17	-34.7	0.8
12	ICCL1	mA	0	20	1.93	.14	1.93	.14	3.66	.34	6.61	3.1	9.02	4.5	16.0	9.0	18.2	2.0	231	12	>256		170	104	44.9	27
13	ICCH1	mA	0	20	3.61	.14	3.23	.18	4.64	.18	8.49	3.4	11.4	5.0	23.7	13	21.7	2.6	250	7.9	>256		>256		40.4	10
14	ICCL2	mA	0	20	/4		/4		/4		8.31	3.8	10.9	5.4	14.6	7.4	20.8	2.3	110	113	>256		108	111	36.4	6.3
15	ICCH2	mA	0	20	/4		/4		/4		10.3	4.2	13.5	6.1	17.7	8.4	24.5	3.0	114	110	>256		114	110	40.4	7.7
16	ICCL3	mA	0	20	/4		/4		/4		10.2	4.7	13.1	6.4	17.2	8.6	23.6	2.7	77.7	88	>256		111	112	39.2	6.8
17	ICCH3	mA	0	20	/4		/4		/4		12.2	5.1	15.8	7.2	20.4	9.8	27.2	3.5	78.3	88	>256		114	110	43.0	8.2
18	TPLH /5	ns	0	100	36.8	12	40.2	18	48.4	23	37.8	14	39.4	16	55.0	7.5	39.9	17	4P2F		F		4P2F		45.3	16
19	TPHL /5	ns	0	100	29.8	11	46.3	14	49.7	18	36.5	14	46.5	10	45.8	5.6	45.5	12	4P2F		F		4P2F		51.2	9.8

Notes:

1/ The mean and standard deviation values were calculated over the six parts irradiated in this testing. The control samples remained constant throughout the 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/ In the functional Tests, "P" means that all parts passed this test at this irradiation or annealing level, "F" means that all parts failed this test at this irradiation or annealing level and "nPmF" means that n parts passed at this level and m parts failed at this level.

4/ No data were available for this parameter at this irradiation level.

5/ Some parts experienced functional failure at the 50 krad level and beyond, therefore, data are shown as "P/F", as in note 3.

6/ All parts at this irradiation level read at the limit of the test equipment range of 256 mA for all Icc tests, therefore no valid mean could be calculated.

Radiation-sensitive parameters: ICCL, ICCH, TPLH, TPHL, VOH, VOL, IOS, FUNC.

Wafer #: 9

S/N#s: BI: 506, 507, 508

NBI: 567, 572, 575

Control: 509, 555

Figure 1. Radiation Bias Circuit for A1020B

Signal	LocationBurn In Board	NOTES:
PRA	A11	GND
PRB	B10	GND
MODE	E11	GND
SDI	B11	VCC
DCLK	C10	VCC
CLK	F9	GND
INX1	L6	VCC
INX2	G11	VCC
IN1A	J11	GND
IN2A	H10	GND
IN_AND3	L4	VCC
IN_AND4	K9	GND
IN_OR3	F11	VCC
IN_OR4	D11	GND
IN_NAND4	L5	VCC
IN_NOR4	G3	GND
DA	H2	VCC
RESET	K3	GND
ENCNTR	C6	VCC
CNTRLD	B4	GND
RESETCENTR	A7	GND
CLOCK	F9	GND
OUTX1	A10	VCC/2
OUTX2	K11	VCC/2
OUTA	K10	VCC/2
O_AND3	J5	VCC/2
O_AND4	G9	VCC/2
O_OR3	L11	VCC/2
O_OR4	D10	VCC/2
O_NAND4	K6	VCC/2
O_NOR4	G1	VCC/2
QA0	L1	VCC/2
QA1	K1	VCC/2
QA2	L2	VCC/2
YO11	A3	VCC/2
YO10	A4	VCC/2
YO9	B3	VCC/2
YO8	A2	VCC/2
YO7	C7	VCC/2
YO6	A6	VCC/2
YO5	A5	VCC/2
YO4	C5	VCC/2
YO3	B6	VCC/2
YO2	A9	VCC/2
YO1	A8	VCC/2
YO0	B8	VCC/2

1. VCC = 5.0 V, +/- 0.5 V
2. VCC/2 = 2.5 V +/- 0.25 V
3. All outputs through 2.2 kohm +/- 10% 1/4 W resistors to VCC/2
4. Inputs connected to VCC through 2.2 kohm resistor
5. Inputs connected to GND do not require resistors

VCC: K2, B5, F1, G2, K7, E9, E10 (NO RESISTOR)
GND: B7, E2, E3, K5, F10, G10, E11

Figure 2. Comparison of Burned-In (BI) vs. Non Burned-In (NBI) Parts
1020B ICCL Wafer 9

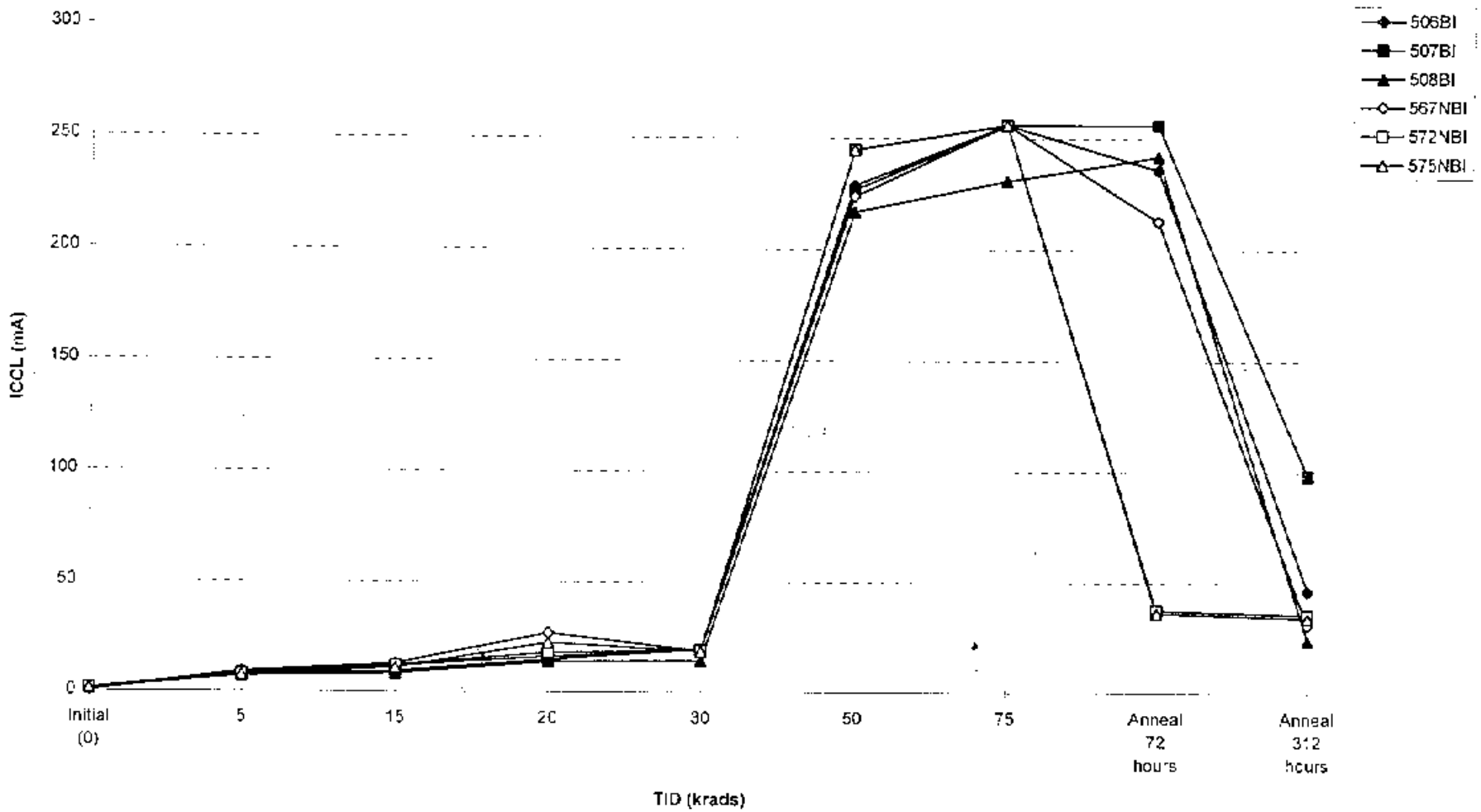

Figure 3. Comparison of Burned-In (BI) vs. Non Burned-In (NBI) Parts
1020B ICCH Wafer 9