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DATE: March 16, 1994

PPM-94-005

TO: A. Sharma/311.2

FROM: K. Sahu/300.1 KS

SUBJECT: Radiation Report on GPEP/PPL
Part No. A1020B
Control No. 8989

cc: G. Kramer/311.0
Library/300.1
R. Katz/743.0
A. Karygiannis
J. Lander

A radiation evaluation was performed on A1020B (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-IV and Figures 1-3.

The total dose testing was performed using a Cobalt-60 gamma ray source. During the radiation testing, four 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 2.5, 5, 7.5, 10, 15, 20, 30 and 50 krads*. After the 50 krad irradiation, parts were annealed at 25°C for 24, 192 and 264 hours (cumulative)**. Following these annealing steps, the parts were irradiated to 75 krads (cumulative). After this irradiation step, the parts were annealed at 25°C for 168 hours. The parts were then irradiated to 100 krads (cumulative) and then annealed at 25°C for 168 hours. Following this annealing step, the parts were irradiated to 107, 125, 150 and 200 krads. Finally, the parts were annealed at 25°C for 168 hours and at 100°C for 168 hours.
The dose rate was between 0.13 and 0.50 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. The electrical tests included 6 functional tests, three at 1 MHz, with Vcc = 4.5, 5.0 and 5.5 V, and three at 5 MHz, with Vcc = 4.5, 5.0 and 5.5 V.

All parts passed initial electrical measurements. All irradiated parts passed all functional tests throughout all irradiation steps up to and including the 75 krad level. At the 100 krad level, S/N's 3, 4 and 6 failed functional tests #'s 1 and 4, both of which are at V_{CC} = 4.5 V, and S/N 5 failed functional tests #'s 1, 4 and 5, which is at V_{CC} = 5.0 V. After annealing for 168 hours at 25°C, all four irradiated parts passed all functional tests and continued to pass all functional tests throughout all remaining irradiation steps up to 200 krads.

All irradiated parts passed all parametric (DC and AC) tests up to and including the 30 krad level. At the 50 krad level, all four irradiated parts exceeded the maximum specification limit of 25 mA for ICCH and ICCL. ICCH and ICCL failures continued to be observed throughout almost all of the subsequent irradiation and annealing steps. For details of the ICCH and ICCL failures, see Figures 2 and 3. In most cases, the parts showed significant decrease in ICCH and ICCL on annealing at 25°C.

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*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.
**Times for consecutive annealing steps are cumulative; however, non-consecutive annealing times after different irradiation steps are not added together.

After annealing for 168 hours at 100°C after the 200 krad irradiation, no rebound effects were observed. Table IV provides the 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:	A1020B
GPEP/PPL Part Number:	A1020B/PG84B*
ISTP/SOHO/CELIAS Control Number:	8989
Charge Number:	C45256
Manufacturer:	Actel
Lot Date Code:	9315
Quantity Tested:	6
Serial Number of Control Samples:	1, 2
Serial Numbers of Radiation Samples:	3, 4, 5, 6
Part Function:	Gate Array
Part Technology:	CMOS
Package Style:	84-pin CPGA
Test Equipment:	S-50
Test Engineer:	A. Karygiannis

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

TABLE II. Radiation Schedule for A1020B

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	11/03/93
2) 2.5 KRAD IRRADIATION (0.13 KRADS/HOUR)	11/03/93
POST-2.5 KRAD ELECTRICAL MEASUREMENT	11/04/93
3) 5 KRAD IRRADIATION (0.13 KRADS/HOUR)	11/04/93
POST-5 KRAD ELECTRICAL MEASUREMENT	11/12/93
4) 7.5 KRAD IRRADIATION (0.13 KRADS/HOUR)	11/12/93
POST-7.5 KRAD ELECTRICAL MEASUREMENT	11/15/93
5) 10 KRAD IRRADIATION (0.13 KRADS/HOUR)	11/15/93
POST-10 KRAD ELECTRICAL MEASUREMENT	11/16/93
6) 15 KRAD IRRADIATION (0.30 KRADS/HOUR)	11/16/93
POST-15 KRAD ELECTRICAL MEASUREMENT	11/17/93
7) 20 KRAD IRRADIATION (0.26 KRADS/HOUR)	11/17/93
POST-20 KRAD ELECTRICAL MEASUREMENT	11/18/93
8) 30 KRAD IRRADIATION (0.50 KRADS/HOUR)	11/18/93
POST-30 KRAD ELECTRICAL MEASUREMENT	11/19/93
9) 50 KRAD IRRADIATION (0.30 KRADS/HOUR)	11/19/93
POST-50 KRAD ELECTRICAL MEASUREMENT	11/22/93
10) 24-HOUR ANNEALING @25°C	11/22/93
POST-24 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/23/94
11) 192-HOUR ANNEALING @25°C	11/23/93
POST-192 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/30/94
12) 264-HOUR ANNEALING @25°C	11/30/93
POST-264 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/03/94
13) 75 KRAD IRRADIATION (0.37 KRADS/HOUR)	12/03/93
POST-75 KRAD ELECTRICAL MEASUREMENT	12/06/93
14) 168-HOUR ANNEALING @25°C	12/06/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/12/94
15) 100 KRAD IRRADIATION (0.15 KRADS/HOUR)	12/13/93
POST-100 KRAD ELECTRICAL MEASUREMENT	12/20/93
16) 168-HOUR ANNEALING @25°C	12/20/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/28/94

TABLE II. Radiation Schedule for A1020B (cont.)

17) 107 KRAD IRRADIATION (0.15 KRADS/HOUR)	12/28/93
POST-107 KRAD ELECTRICAL MEASUREMENT	01/03/94
18) 125 KRAD IRRADIATION (0.26 KRADS/HOUR)	01/03/94
POST-125 KRAD ELECTRICAL MEASUREMENT	01/06/94
19) 150 KRAD IRRADIATION (0.35 KRADS/HOUR)	01/07/94
POST-150 KRAD ELECTRICAL MEASUREMENT	01/10/94
20) 200 KRAD IRRADIATION (0.15 KRADS/HOUR)	01/11/94
POST-200 KRAD ELECTRICAL MEASUREMENT	02/09/94
21) 168-HOUR ANNEALING @25°C	02/09/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/17/94
22) 168-HOUR ANNEALING @100°C**	02/18/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	03/11/94

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 A10208

FUNCTIONAL TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT 3 TEMPS
FUNCT 1	4.5V	0.0V	4.5V	FREQ=1.000MHz	ALL I/O	VOL<2.25V , VOH>2.25V
FUNCT 2	5.0V	0.0V	5.0V	FREQ=1.000MHz	ALL I/O	VOL<2.50V , VOH>2.50V
FUNCT 3	5.5V	0.0V	5.5V	FREQ=1.000MHz	ALL I/O	VOL<2.75V , VOH>2.75V
FUNCT 4	4.5V	0.0V	4.5V	FREQ=5.000MHz	ALL I/O	VOL<2.25V , VOH>2.25V
FUNCT 5	5.0V	0.0V	5.0V	FREQ=5.000MHz	ALL I/O	VOL<2.50V , VOH>2.50V
FUNCT 6	5.5V	0.0V	5.5V	FREQ=5.000MHz	ALL I/O	VOL<2.75V , VOH>2.75V
DC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT 3 TEMPS
VOH	4.5V	0.00V	4.50V	LOAD= -3.2mA	OUTS	>+3.70V , <+4.50V
VOL	4.5V	0.00V	4.50V	LOAD= +4.0mA	OUTS	>+0.00V , <+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
-IOS	5.5V	0.00V	5.5V	VOUT= 0.0V	INS	>-100mA , <-10mA
ICCH	5.5V	0.0V	5.5V	VOUT= 5.5V	VCC	>+0.0mA , <+25mA
ICCL	5.5V	0.0V	5.5V	VOUT= 0.0V	VCC	>+0.0mA , <+25mA
AC PARAMETRIC TESTS PERFORMED						
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C ONLY
TPLH	5.0V	0.00V	5.00V	VTEST= 2.0V	OUTS	>+0.0NS , <+100NS
TPHL	5.0V	0.00V	5.00V	VTEST= 2.0V	OUTS	>+0.0NS , <+100NS
TTLH	5.0V	0.00V	5.00V	VTEST= 2.0V	OUTS	>+0.0NS , <+250NS
TTHL	5.0V	0.00V	5.00V	VTEST= 2.0V	OUTS	>+0.0NS , <+250NS

The Vih and Vil parameters were recorded on a shmoo plot with a power supply range of 4.5V to 5.5V. Several iterations of the functional tests are executed while gradually increasing Vil until a functional failure is flagged, and decreasing Vih until a functional failure occurs. Vil tracks VCC while the Vil test is being performed, while Vil is 0.0V when the Vih test is being performed. The shmoo plots of Vil and Vih show the input conditions under which the device will operate properly over the power supply operating range.

The setup time shmoo plot shows how much time before the rising edge of the clock that the data must be present in order for it to be latched properly. This test is also performed GO/NOGO by performing several iterations of the functional tests and plotting the passing and failing setup times.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for A1020B/1

Parameters		Spec. Lim./2 min	Spec. Lim./2 max	Initials -55°C mean	Initials -55°C sd	Initials 25°C		Initials 125°C		Total Dose Exposure (TDE) (krads) 2.5 mean	2.5 sd	5 mean	5 sd	7.5 mean	7.5 sd	10 mean	10 sd	15 mean	15 sd	20 mean	20 sd	30 mean	30 sd
VOH	V	3.7	4.5	4.27	.01	4.33	0	4.24	.01	4.28	.01	4.29	0	4.28	0	4.28	0	4.28	0	4.28	0	4.28	0
VOL	mV	0	400	80.4	3.2	57.8	1.5	96.5	2.2	71.6	1.7	71.1	1.6	71.4	1.5	70.5	1.5	70.4	1.4	70.9	2.7	70.9	1.9
IIH	µA	-10	10	0.01	0	0	0	0.07	.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	.02
IIL	µA	-10	10	0	0	0	0	-0.02	.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-IOS	mA	-100	-10	-33.6	1.1	-43.6	.87	-29.3	.62	-36.5	0.6	-36.4	.57	-36.1	.64	-36.3	.66	-36.2	.63	-36.1	.64	-35.9	.64
ICCL	mA	0	25	2.72	.23	2.08	.14	4.13	.24	2.44	.12	2.99	0.5	8.33	2.9	14.2	5.2	13	4.2	13.1	4.6	17	5.7
ICCH	mA	0	25	3.99	.12	3.71	.12	5.48	.31	3.71	.12	4.47	0.4	9.45	2.6	14.9	4.6	13.9	3.7	14.2	4.2	18.7	5.3
TPLH	ns	0	100	41.1	15	31.8	14	46.4	16	52.5	2.1	42.1	14	48.9	12	46.1	13	50.6	11	54.1	4	54.9	2.2
TPHL	ns	0	100	44.9	12	32.4	13	50.2	12	52.2	1.7	46.5	11	49.1	10	49.7	7.9	52.6	5.9	54	3.2	54.5	1.6
TTLH	ns	0	250	5.73	7	1.28	.14	5.03	.16	2.14	.44	1.28	1.3	1.38	1.3	1.27	1.3	1.33	1.4	4.47	7.8	4.49	7.9
TTHL	ns	0	250	9.02	9.9	2.17	0.3	4.28	.21	2.70	.19	14.1	14	1.44	1.4	1.42	1.5	4.64	8.1	11.1	11	11.1	11
FUNC1, 1MHz, 4.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC2, 1MHz, 5.0V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC3, 1MHz, 5.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC4, 5MHz, 4.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC5, 5MHz, 5.0V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC6, 5MHz, 5.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	

1/The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table. Initial readings were taken at three temperatures, -55°C, +25°C and +100°C. Subsequent readings were taken only at +25°C.

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" in this column means that the part passed all tests in this series. "FAIL" means that the part failed all tests in the series. "nPmF" means that the part passed n tests and failed m tests in the series. Data for individual tests in each series are available on request.

TABLE IV (cont.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for A1020B/1

Parameters		Spec. Lim./2 min	Spec. Lim./2 max	TDE 50 krads mean	TDE 50 krads sd	Annealing 24 hrs @25°C mean	Annealing 24 hrs @25°C sd	Annealing 192 hrs @25°C mean	Annealing 192 hrs @25°C sd	Annealing 264 hrs @25°C mean	Annealing 264 hrs @25°C sd	TDE 75 krads mean	TDE 75 krads sd	Annealing 168 hrs @25°C mean	Annealing 168 hrs @25°C sd	TDE 100 krads mean	TDE 100 krads sd	Annealing 168 hrs @25°C mean	Annealing 168 hrs @25°C sd	TDE 107 krads mean	TDE 107 krads sd	TDE 125 krads mean	TDE 125 krads sd
VOH	V	3.7	4.5	4.27	.01	4.28	.01	4.28	0	4.28	0	4.27	.01	4.29	.01	2.3	2.1	4.25	.01	4.16	.61	4.27	.01
VOL	mV	0	400	73.4	2.3	73.2	2.3	71.1	1.9	71	1.8	73	2.3	71.9	2.1	80.9	235	71.2	3.1	71.7	3.9	69.9	1.7
IIH	µA	-10	10	0.06	.07	0.04	.04	0.02	.02	0.02	.02	0.08	.04	0.06	.02	0.26	.11	0.15	.06	0.19	.09	0.32	.13
IIL	µA	-10	10	0	.01	0	.01	0	0	-0.01	0	-0.01	.01	-0.01	.01	-0.03	.03	-0.02	.02	-0.03	.02	-0.03	.04
-IOS	mA	-100	-10	-34.9	.73	-35.3	.74	-35.5	.67	-35.5	.66	-34.7	.73	-34.9	.62	48.7	5.8	34.1	.61	39.1	1.5	16.1	.88
ICCL	mA	0	25	46.5	16	49.8	17	27.6	9.9	24.4	8.9	46.8	12	35.4	8	35.4	8	28.7	1.6	33.7	2.7	11.2	.74
ICCH	mA	0	25	48.5	13	52.1	15	30.7	8.9	27.8	8.2	51.5	11	35.4	9.2	48.7	5.8	34.1	.61	39.1	1.5	16.1	.88
TPLH	ns	0	100	46.1	12	46	13	46.2	13	48.3	11	44.7	14	41.4	14	61.6	16	41.5	15	43.6	15	42.4	15
TPHL	ns	0	100	49.3	8	51.3	5.2	49.8	8	52.5	4.7	48.5	9.5	39.2	16	62.4	14	45.7	11	47.7	11	46.7	12
TTLH	ns	0	250	1.51	1.6	1.46	1.5	1.42	1.4	1.43	1.4	1.50	1.5	16.2	13	0.77	1.4	1.61	1.6	1.59	1.6	1.72	1.7
TTHL	ns	0	250	5	7.8	1.42	1.5	7.82	10	7.84	10	1.42	1.4	2.76	42	3.26	6.5	1.43	1.5	1.43	1.4	1.36	1.4
FUNC1, 1MHz, 4.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		FAIL		PASS		PASS		PASS	
FUNC2, 1MHz, 5.0V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC3, 1MHz, 5.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	
FUNC4, 5MHz, 4.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		FAIL		PASS		PASS		PASS	
FUNC5, 5MHz, 5.0V/3				PASS		PASS		PASS		PASS		PASS		PASS		3P1F		PASS		PASS		PASS	
FUNC6, 5MHz, 5.5V/3				PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS		PASS	

1/The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table. Initial readings were taken at three temperatures, -55°C, +25°C and +100°C. Subsequent readings were taken only at +25°C.

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3/"PASS" in this column means that the part passed all tests in this series. "FAIL" means that the part failed all tests in the series. "nPmF" means that the part passed n tests and failed m tests in the series. Data for individual tests in each series are available on request.

TABLE IV (cont.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for A1020B/1

Parameters		Spec. Lim./2 min	max	TDE 150 krads mean	sd	TDE 200 krads mean	sd	Annealing 168 hrs @25°C mean	sd	Annealing 168 hrs @100°C mean	sd
VOH	V	3.7	4.5	4.27	.01	4.23	.02	4.23	.02	4.27	.01
VOL	mV	0	400	70.1	1.2	71.7	4.6	72.1	4.5	80.6	3.9
IIH	µA	-10	10	0.62	0.3	1.36	.41	1.4	.43	0.07	.02
IIL	µA	-10	10	-0.06	.07	-0.19	.18	-0.2	.18	-.01	.01
-IOS	mA	-100	-10	-32.9	6.2	-32.8	.81	-31.9	4.9	-31.1	5.9
ICCL	mA	0	25	8	.99	27.6	5	25.1	5	3.07	0.2
ICCH	mA	0	25	11.4	1.2	31.4	4	28.9	4.4	4.27	.12
TPLH	ns	0	100	42.5	15	40.3	15	40.4	15	45.6	13
TPHL	ns	0	100	46.8	12	44.5	12	44.6	12	48.8	13
TTLH	ns	0	250	1.81	1.8	2.1	1.7	1.93	1.9	2.66	2.6
TTHL	ns	0	250	1.36	1.4	8.63	11	8.63	11	1.62	1.7
FUNC1, 1MHz, 4.5V/3				PASS		PASS		PASS		PASS	
FUNC2, 1MHz, 5.0V/3				PASS		PASS		PASS		PASS	
FUNC3, 1MHz, 5.5V/3				PASS		PASS		PASS		PASS	
FUNC4, 5MHz, 4.5V/3				PASS		PASS		PASS		PASS	
FUNC5, 5MHz, 5.0V/3				PASS		PASS		PASS		PASS	
FUNC6, 5MHz, 5.5V/3				PASS		PASS		PASS		PASS	

1/The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table. Initial readings were taken at three temperatures, -55°C, +25°C and +100°C. Subsequent readings were taken only at +25°C.

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3/"PASS" in this column means that the part passed all tests in this series. "FAIL" means that the part failed all tests in the series. "nPmF" means that the part passed n tests and failed m tests in the series. Data for individual tests in each series are available on request.

Figure 1. Radiation Bias Circuit for A1020B

Signal	Location	Burn-In Board
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
Y07	C7	VCC/2
Y06	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

NOTES:

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. A1020B ICCH Change with Radiation and Annealing

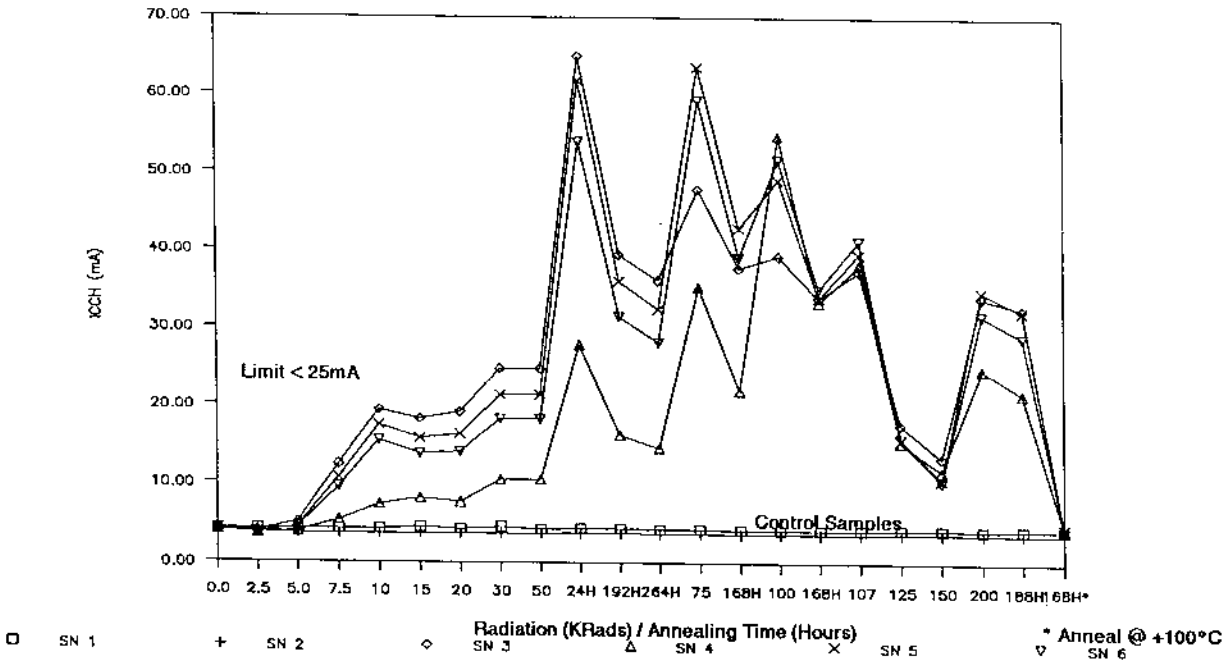

FIGURE 3. A1020B ICCL Change with Radiation and Annealing