ESA-QCA00119T-C

esa estec

european space research and technology centre

Components Division
Laboratory Support Group

RADIATION ANALYSIS REPORT

RA 064

Part Type : Integrated Circuit
High Speed CMOS

Type No : M54HC86F1

Manufacturer: SGS

Project : Standardisation

ANALYST	H.MEIJER/QCL		31/05/91
REVIEWED	P.ELLEN/QCL		31/05/91
APPROVED	B.JOHLANDER /QCA		18/7-91

Keplerlaan 1 - Noordwijk - The Netherlands
Mail address: Postbus 299 - 2200 AG Noordwijk - The Netherlands
Tel.: 01719-86555 - Telex: 39098 - Cables: Spaceurop, Noordwijk - Fax.: 01719 -17400

Contents

Summary

1. A large increase in Quiescent Device Current occurred for those devices irradiated with bias applied.

2. A change from positive to negative voltage was measured for P-Channel Threshold voltage for those devices irradiated with bias applied.

3. There were no significant changes for the remaining DC and AC parameters.

1.0 Introduction

This assessment of radiation performance, of the M54HC86 manufactured by SGS, was undertaken to establish whether any changes in radiation susceptibility had occurred due to the transfer of the wafer fabrication to a different manufacturing plant.

2.0 Objective

The objective of the test was to establish that the devices assembled from wafers processed at the new plant had the same radiation performance as previously evaluated for the original wafer fabrication location.
The device type tested was supplied by SGS on a random basis and was not specifically identified by ESTEC as necessarily being 100% representative of the new wafer processing plant.

3.0 Radiation Source and Dosimetry

The 1460 Curie Co-60 facility at ESTEC was used for exposing the samples to ionising radiation (1.25 MeV gamma radiation). The dose rate can be varied by placing the samples at a different distance from the Co-60 pellets. The dose rate chosen for the irradiation in this test is detailed in paragraph 4.0.
The dose was monitored using an Ionex Dosemaster equipped with a 0.6cc ion probe placed at the same distance from the Co-60 source as the samples. The Ionex Dosemaster is calibrated to $\pm$ 0.5%.

4.0 Sample Identification and Allocation

A total of 10 parts were available and were distributed as follows:-

Note:-2 parts were not subjected to irradiation and were kept as control samples.

Sample	Condition	Description
21	A	Static
22	A	Static
23	A	Static
24	A	Static
32	B	Static
H7	B	Static
H8	B	Static
H9	B	Static
73	-	Control
74	-	Control

A. Figure 1

B. All pins grounded

5.0 Biasing Conditions

The biasing conditions applied, during the irradiation of the devices, are shown in figure 1.

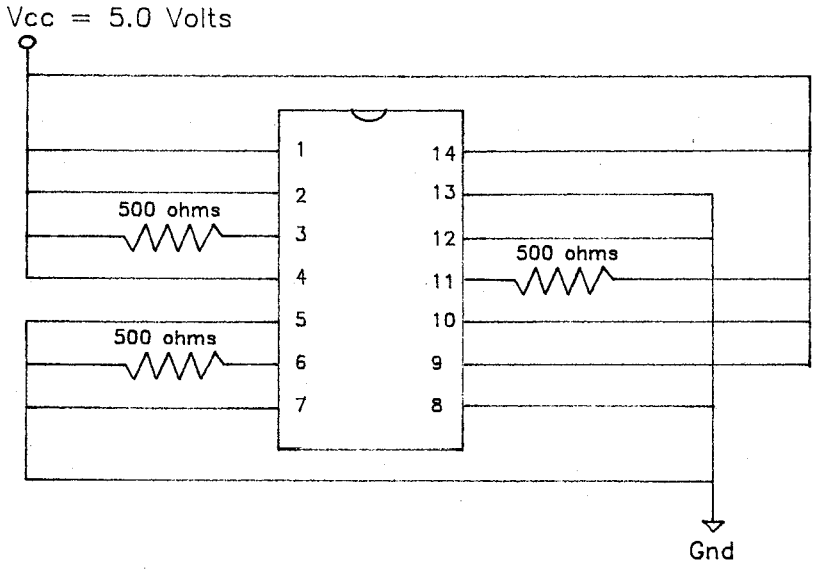

Figure 1 Biasing circuitry

6.0 Irradiation Schedule

The following information details the time and dose rate schedule used in the performance of this radiation testing:-

Start Time	Accumulated Dose (krad)	Dose Rate (rads/min)
08:57	6.0	147.1
10:02	10.0	146.5
10:59	15.0	146.5
13:26	25.0	146.5
15.45	40.0	146.5

Note:- The irradiation was carried out on 20.03.91.

7.0 Test Results

A very large quantity of test data was generated during this analysis, for the purposes of presentation in this report the DC results of one device from each group only is included. The test results for Quiescent Device Current for group A, and P-Channel Threshold Voltage of one device from each group are presented graphically in figures 2-4 as these are the only parameters that vary significantly.

Input Clamp Voltage

Device Number 21 (Irradiated with bias)

VIKN LIMIT 400 mV <--> 900 mV ABSOLUTE LEVELS
CURRENT 100 μA

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
A1	-634 mV	-637 mV	-634 mV	-633 mV	-638 mV	-637 mV	-633 mV
A2	-634 mV	-636 mV	-634 mV	-633 mV	-637 mV	-635 mV	-633 mV
A3	-634 mV	-636 mV	-634 mV	-634 mV	-637 mV	-636 mV	-632 mV
A4	-635 mV	-636 mV	-636 mV	-635 mV	-639 mV	-638 mV	-634 mV
B1	-635 mV	-636 mV	-635 mV	-633 mV	-638 mV	-636 mV	-634 mV
B2	-635 mV	-636 mV	-636 mV	-634 mV	-639 mV	-638 mV	-633 mV
B3	-633 mV	-635 mV	-634 mV	-633 mV	-637 mV	-635 mV	-632 mV
B4	-634 mV	-637 mV	-635 mV	-634 mV	-638 mV	-637 mV	-634 mV

VIKP LIMIT 400 mV <--> 900 mV ABSOLUTE LEVELS
CURRENT 100 μA

A1	666 mV	668 mV	667 mV	663 mV	668 mV	666 mV	657 mV
A2	663 mV	668 mV	667 mV	665 mV	668 mV	665 mV	657 mV
A3	672 mV	666 mV	672 mV	665 mV	666 mV	662 mV	658 mV
A4	666 mV	663 mV	667 mV	663 mV	667 mV	656 mV	658 mV
B1	666 mV	666 mV	672 mV	667 mV	667 mV	665 mV	658 mV
B2	668 mV	674 mV	665 mV	662 mV	672 mV	659 mV	654 mV
B3	668 mV	672 mV	668 mV	666 mV	663 mV	663 mV	659 mV
B4	663 mV	667 mV	666 mV	663 mV	663 mV	662 mV	655 mV

Input Clamp Voltage

Device Number 32 (Irradiated with all pins grounded)

VIKN LIMIT 400 mV <--> 900 mV ABSOLUTE LEVELS
CURRENT 100 μA

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
A1	-637 mV	-637 mV	-638 mV	-637 mV	-638 mV	-638 mV
A2	-637 mV	-637 mV	-639 mV	-637 mV	-638 mV	-639 mV
A3	-637 mV	-636 mV	-639 mV	-637 mV	-638 mV	-638 mV
A4	-637 mV	-638 mV	-640 mV	-638 mV	-638 mV	-639 mV
B1	-638 mV	-637 mV	-640 mV	-639 mV	-638 mV	-638 mV
B2	-637 mV	-637 mV	-641 mV	-638 mV	-639 mV	-638 mV
B3	-637 mV	-636 mV	-638 mV	-636 mV	-637 mV	-638 mV
B4	-638 mV	-637 mV	-640 mV	-638 mV	-638 mV	-639 mV

VIKP LIMIT 400 mV <--> 900 mV ABSOLUTE LEVELS
CURRENT 100μA

A1	674 mV	672 mV	674 mV	667 mV	663 mV	662 mV
A2	668 mV	663 mV	667 mV	668 mV	668 mV	659 mV
A3	670 mV	667 mV	674 mV	668 mV	662 mV	665 mV
A4	666 mV	668 mV	668 mV	668 mV	663 mV	659 mV
B1	668 mV	672 mV	668 mV	667 mV	668 mV	665 mV
B2	670 mV	667 mV	666 mV	666 mV	662 mV	663 mV
B3	668 mV	666 mV	670 mV	668 mV	666 mV	666 mV
B4	668 mV	666 mV	666 mV	668 mV	663 mV	663 mV

Input Clamp Voltage

Device Number 73 (Control-not irradiated)

VIKN LIMIT 400 mV <--> 900 mV ABSOLUTE LEVELS
CURRENT 100 μA

Pin Identity	6Krad	10Krad	15Krad	25Krad	40Krad	
A1	-636 mV	-641 mV	-636 mV	-637 mV	-633 mV	-637 mV
A2	-635 mV	-641 mV	-636 mV	-636 mV	-633 mV	-636 mV
A3	-637 mV	-641 mV	-636 mV	-636 mV	-633 mV	-636 mV
A4	-636 mV	-641 mV	-636 mV	-637 mV	-632 mV	-637 mV
B1	-637 mV	-641 mV	-635 mV	-636 mV	-633 mV	-637 mV
B2	-637 mV	-641 mV	-636 mV	-636 mV	-633 mV	-637 mV
B3	-636 mV	-640 mV	-635 mV	-636 mV	-632 mV	-637 mV
B4	-636 mV	-641 mV	-636 mV	-637 mV	-632 mV	-637 mV

VIKP LIMIT 400 mV <--> 900 mV ABSOLUTE LEVELS
CURRENT 100

A1	668 mV	677 mV	676 mV	668 mV	668 mV	676 mV
A2	668 mV	668 mV	670 mV	668 mV	668 mV	668 mV
A3	668 mV	670 mV	674 mV	668 mV	666 mV	667 mV
A4	668 mV	670 mV	667 mV	672 mV	666 mV	674 mV
B1	670 mV	670 mV	676 mV	670 mV	667 mV	676 mV
B2	674 mV	670 mV	670 mV	674 mV	667 mV	668 mV
B3	668 mV	672 mV	674 mV	667 mV	667 mV	670 mV
B4	674 mV	670 mV	668 mV	674 mV	667 mV	667 mV

Input Leakage Current

V_{cc} : 6.0V
I_{ILL} : Pin under test-low, all other inputs grounded
I_{ILH} : Pin under test-low, all other inputs at V_{cc}
I_{IHL} : Pin under test-high, all other inputs grounded
I_{IHH} : Pin under test-high, all other inputs at V_{cc}

Device Number 21 (Irradiated with bias)

I_{ILL}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
A1	150 pA	200 pA	400 pA	200 pA	-400 pA	150 pA	0.00 A
A2	-400 pA	-200 pA	0.00 A	0.00 A	350 pA	250 pA	-1.25nA
A3	100 pA	250 pA	-150 pA	-300 pA	0.00 A	50.0pA	0.00 A
A4	150 pA	0.00 A	50.0pA	0.00 A	0.00 A	0.00 A	400 pA
B1	-100 pA	-950 pA	-300 pA	0.00 A	0.00 A	0.00 A	0.00 A
B2	100 pA	250 pA	50.0pA	50.0pA	400 pA	600 pA	350 pA
B3	0.00 A	-850 pA	0.00 A	-350 pA	-100 pA	-450 pA	-1.20nA
B4	0.00 A	200 pA	-100 pA	50.0pA	0.00 A	0.00 A	0.00 A

I_{ILH}

A1	350 pA	0.00 A	-850 pA	100 pA	200 pA	-400 pA	0.00 A
A2	350 pA	0.00 A	50.0pA	-600 pA	-500 pA	0.00 A	350 pA
A3	0.00 A	-100 pA	0.00 A	200 pA	50.0pA	-100 pA	50.0pA
A4	0.00 A	-400 pA	-400 pA	-300 pA	-150 pA	0.00 A	0.00 A
B1	350 pA	0.00 A	0.00 A	200 pA	-500 pA	50.0pA	300 pA
B2	0.00 A	-300 pA	-600 pA	0.00 A	450 pA	-450 pA	0.00 A
B3	0.00 A	-50.0pA	-200 pA	-200 pA	400 pA	0.00 A	250 pA
B4	0.00 A	0.00 A	700 pA	400 pA	0.00 A	-400 pA	-50.0pA

Input Leakage Current

Device Number 32 (Irradiated with all pins grounded)

I_{ILL}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
A1	500 pA	0.00 A	200 pA	200 pA	250 pA	0.00 A
A2	0.00 A	150 pA	0.00 A	0.00 A	0.00 A	50.0pA
A3	0.00 A	-300 pA	50.0pA	50.0pA	250 pA	550 pA
A4	500 pA	200 pA	100 pA	100 pA	0.00 A	200 pA
B1	0.00 A	600 pA	0.00 A	0.00 A	50.0pA	-200 pA
B2	0.00 A	0.00 A	500 pA	500 pA	0.00 A	600 pA
B3	-550 pA	0.00 A	-800 pA	-800 pA	0.00 A	200 pA
B4	400 pA	0.00 A	250 pA	250 pA	150 pA	-400 pA

I_{ILH}

A1	100 pA	350 pA	-750 pA	-750 pA	-200 pA	50.0pA
A2	-50.0pA	-750 pA	150 pA	150 pA	-300 pA	350 pA
A3	0.00 A	350 pA	50.0pA	50.0pA	50.0pA	100 pA
A4	400 pA	0.00 A	0.00 A	0.00 A	200 pA	250 pA
B1	600 pA	250 pA	100 pA	100 pA	50.0pA	0.00 A
B2	-250 pA	150 pA	-400 pA	-400 pA	200 pA	-200 pA
B3	50.0pA	-600 pA	0.00 A	0.00 A	-100 pA	0.00 A
B4	-250 pA	-50.0pA	-700 pA	-700 pA	150 pA	150 pA

Input Leakage Current

Device Number 73 (Control-not irradiated)

I_{ILL}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
A1	150 pA	500 pA	100 pA	0.00 A	250 pA	100 pA
A2	0.00 A	0.00 A	350 pA	200 pA	-800 pA	0.00 A
A3	-600 pA	-100 pA	-600 pA	300 pA	0.00 A	300 pA
A4	200 pA	50.0pA	0.00 A	-850 pA	0.00 A	0.00 A
B1	100 pA	0.00 A	-200 pA	450 pA	-300 pA	50.0pA
B2	-100 pA	0.00 A	300 pA	0.00 A	250 pA	0.00 A
B3	0.00 A	-550 pA	0.00 A	0.00 A	0.00 A	0.00 A
B4	-400 pA	50.0pA	0.00 A	250 pA	350 pA	400 pA

I_{ILH}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
A1	0.00 A	0.00 A	0.00 A	50.0pA	-550 pA	50.0pA
A2	-200 pA	100 pA	0.00 A	-550 pA	200 pA	50.0pA
A3	100 pA	0.00 A	0.00 A	-200 pA	0.00 A	100 pA
A4	0.00 A	200 pA	0.00 A	600 pA	100 pA	500 pA
B1	400 pA	250 pA	0.00 A	-400 pA	50.0pA	0.00 A
B2	0.00 A	0.00 A	-150 pA	0.00 A	-50.0pA	150 pA
B3	-400 pA	-200 pA	0.00 A	0.00 A	250 pA	0.00 A
B4	50.0pA	-100 pA	150 pA	0.00 A	0.00 A	-50.0pA

Input Leakage Current

Device Number 21 (Irradiated with bias)

I_{IHL}

Pin Number	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
A1	750 pA	750 pA	750 pA	1.55nA	1.15nA	1.60nA	800 pA
A2	1.40nA	1.60nA	1.00nA	1.15nA	1.40nA	800 pA	1.35nA
A3	600 pA	750 pA	1.00nA	50.0pA	750 pA	1.20nA	50.0pA
A4	350 pA	1.15nA	500 pA	350 pA	750 pA	1.60nA	1.60nA
B1	800 pA	400 pA	800 pA	600 pA	900 pA	800 pA	1.20nA
B2	900 pA	800 pA	1.15nA	1.10nA	400 pA	350 pA	1.60nA
B3	800 pA	50.0pA	1.20nA	500 pA	1.00nA	200 pA	500 pA
B4	800 pA	750 pA	1.20nA	800 pA	0.00 A	750 pA	1.20nA

I_{IHH}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
A1	1.55nA	900 pA	800 pA	1.60nA	750 pA	1.00nA	1.80nA
A2	350 pA	200 pA	250 pA	150 pA	800 pA	600 pA	250 pA
A3	700 pA	1.35nA	350 pA	800 pA	750 pA	750 pA	750 pA
A4	0.00 A	0.00 A	350 pA	-400 pA	750 pA	-50.0pA	1.00nA
B1	700 pA	550 pA	750 pA	300 pA	800 pA	950 pA	800 pA
B2	500 pA	-200 pA	150 pA	150 pA	1.00nA	0.00 A	50.0pA
B3	400 pA	650 pA	750 pA	800 pA	50.0pA	750 pA	350 pA
B4	-150 pA	50.0pA	50.0pA	0.00 A	800 pA	300 pA	150 pA

Input Leakage Current

Device Number 32 (Irradiated with all pins grounded)

I_{IHL}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
A1	800 pA	1.75nA	350 pA	350 pA	1.60nA	1.60nA
A2	1.20nA	800 pA	750 pA	750 pA	350 pA	750 pA
A3	800 pA	1.00nA	800 pA	800 pA	1.05nA	900 pA
A4	1.25nA	1.20nA	650 pA	650 pA	1.20nA	800 pA
B1	0.00 A	1.15nA	350 pA	350 pA	1.15nA	1.15nA
B2	350 pA	250 pA	950 pA	950 pA	950 pA	550 pA
B3	350 pA	1.05nA	650 pA	650 pA	500 pA	750 pA
B4	350 pA	350 pA	900 pA	900 pA	1.15nA	-100 pA

I_{IHH}

A1	1.60nA	650 pA	750 pA	750 pA	750 pA	1.00nA
A2	150 pA	1.05nA	150 pA	150 pA	650 pA	250 pA
A3	950 pA	350 pA	1.20nA	1.20nA	700 pA	800 pA
A4	350 pA	1.20nA	50.0pA	50.0pA	1.10nA	650 pA
B1	550 pA	350 pA	800 pA	800 pA	400 pA	800 pA
B2	350 pA	350 pA	0.00 A	0.00 A	400 pA	1.40nA
B3	100 pA	750 pA	150 pA	150 pA	800 pA	1.05nA
B4	200 pA	750 pA	0.00 A	0.00 A	450 pA	800 pA

Input Leakage Current

Device Number 73 (Control-not irradiated)

I_{IHL}

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
A1	950 pA	800 pA	2.30nA	1.60nA	1.40nA	1.60nA
A2	800 pA	900 pA	550 pA	800 pA	1.55nA	650 pA
A3	1.10nA	1.00nA	1.45nA	150 pA	550 pA	1.60nA
A4	100 pA	750 pA	800 pA	350 pA	900 pA	800 pA
B1	900 pA	150 pA	1.40nA	800 pA	1.00nA	750 pA
B2	250 pA	1.00nA	350 pA	350 pA	800 pA	1.30nA
B3	550 pA	1.00nA	600 pA	450 pA	50.0pA	750 pA
B4	500 pA	750 pA	100 pA	250 pA	1.50nA	800 pA

I_{IHH}

A1	1.50nA	1.20nA	1.25nA	900 pA	500 pA	400 pA
A2	600 pA	100 pA	1.20nA	350 pA	150 pA	1.00nA
A3	1.05nA	1.20nA	1.20nA	1.05nA	550 pA	400 pA
A4	350 pA	150 pA	800 pA	300 pA	800 pA	550 pA
B1	150 pA	350 pA	600 pA	550 pA	650 pA	-100 pA
B2	950 pA	400 pA	1.15nA	650 pA	250 pA	150 pA
B3	150 pA	800 pA	0.00 A	800 pA	550 pA	0.00 A
B4	1.30nA	400 pA	1.00nA	250 pA	550 pA	150 pA

Quiescent Device Current

V_{cc}: 6.0V

Device Number	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
			QUIESCENT CURRENT - ALL INPUTS HIGH		LIMIT : 1.00µA		
21	12.80nA	1.840µA	9.950µA	42.00µA	111.5µA	296.0µA	54.00µA
22	6.850nA	3.675µA	19.25µA	71.50µA	191.5µA	402.0µA	63.50µA
23	4.750nA	2.555µA	17.60µA	63.50µA	184.0µA	400.0µA	96.00µA
24	6.300nA	2.680µA	14.55µA	72.00µA	151.5µA	324.5µA	63.50µA
			QUIESCENT CURRENT - ALL INPUTS LOW		LIMIT : 1.00µA		
21	6.400nA	44.75nA	955.0nA	17.20µA	88.00µA	195.5µA	35.20µA
22	12.75nA	122.5nA	3.515µA	38.55µA	127.0µA	272.0µA	51.10µA
23	-3.20nA	111.5nA	2.555µA	33.40µA	107.5µA	283.5µA	61.60µA
24	6.400nA	83.50nA	2.230µA	28.20µA	95.50µA	248.0µA	56.00µA
			QUIESCENT CURRENT - ALL INPUTS HIGH		LIMIT : 1.00µA		
32	6.350nA	3.950nA	3.10nA	0.000 A	6.40nA	6.350nA	
H7	2.350nA	4.750nA	3.150nA	-9.650nA	9.60nA	6.400nA	
H8	6.750nA	6.400nA	6.400nA	7.200nA	6.400nA	-9.800nA	
H9	6.350nA	-6.400nA	-6.900nA	-8.650nA	6.300nA	5.550nA	
			QUIESCENT CURRENT - ALL INPUTS LOW		LIMIT : 1.00µA		
32	12.70nA	-4.250nA	-6.40nA	6.400nA	-9.65nA	3.150nA	
H7	7.20nA	7.150nA	6.350nA	9.300nA	-6.00nA	12.70nA	
H8	-12.50nA	-9.600nA	6.550nA	5.200nA	-3.20nA	3.150nA	
H9	10.00nA	6.350nA	9.200nA	6.350nA	6.35nA	2.350nA	

Quiescent Device Current

V_{CC} : 6.0V

Control Devices QUIESCENT CURRENT - ALL INPUTS HIGH LIMIT : 1.00μA

Device Number	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
73	8.00nA	9.500nA	6.400nA	4.750nA	7.950nA	9.550nA
74	6.40nA	12.80nA	-11.45nA	-6.450nA	-3.200nA	12.00nA

QUIESCENT CURRENT - ALL INPUTS LOW LIMIT : 1.00μA

73	-8.050nA	6.40nA	-3.20nA	6.350nA	0.000 A	-12.05nA
74	50.0pA	-12.85nA	6.400nA	150.0pA	11.80nA	-6.450nA

Output Voltages

V_{CC} : 2.0V
I_{OL} : 20μA
I_{OH} : -20μA

Device Number 21 (Irradiated with bias)

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
V_{OL}							
Y1	3.75 mV	3.40 mV	3.40 mV	3.40 mV	3.15 mV	3.20 mV	3.15 mV
Y2	3.50 mV	3.35 mV	3.00 mV	3.15 mV	3.25 mV	3.15 mV	3.05 mV
Y3	3.60 mV	3.45 mV	3.15 mV	3.40 mV	3.15 mV	3.55 mV	3.15 mV
Y4	3.15 mV	3.45 mV	3.30 mV	3.15 mV	3.00 mV	3.20 mV	3.10 mV
V_{OH}							
Y1	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	1.99 V	2.00 V
Y2	2.01 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V
Y3	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V
Y4	2.00 V	2.00 V	2.00 V	2.00 V	1.99 V	1.99 V	1.99 V

Output Voltages

V_{CC} : 2.0V
I_{OL} : 20μA
I_{OH} : -20μA

Device Number 32 (Irradiated with all pins grounded)

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
V_{OL}							
Y1	3.40 mV	3.25 mV	3.50 mV	3.25 mV	3.15 mV	2.75 mV	
Y2	3.35 mV	3.25 mV	3.15 mV	3.00 mV	3.10 mV	2.95 mV	
Y3	3.35 mV	3.35 mV	3.30 mV	3.20 mV	3.30 mV	3.05 mV	
Y4	3.50 mV	3.30 mV	3.05 mV	3.00 mV	2.95 mV	3.20 mV	
V_{OH}							
Y1	2.00 V	2.00 V	1.99 V	2.00 V	2.00 V	2.00 V	
Y2	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	
Y3	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	
Y4	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	

Device Number 73 (Control-not irradiated)

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
V_{OL}							
Y1	3.85 mV	3.65 mV	3.60 mV	3.80 mV	3.70 mV	3.80 mV	
Y2	3.45 mV	3.70 mV	3.80 mV	3.50 mV	3.55 mV	3.50 mV	
Y3	3.75 mV	3.80 mV	3.50 mV	3.70 mV	3.75 mV	3.65 mV	
Y4	3.45 mV	3.50 mV	3.70 mV	3.35 mV	3.50 mV	3.45 mV	
V_{OH}							
Y1	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	
Y2	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	
Y3	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	
Y4	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	2.00 V	

THRESHOLD VOLTAGE N-CHANNEL: -450 mV <--> -1.45 V

Device Number	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
21	-1.17 V	-1.17 V	-1.16 V	-1.15 V	-1.20 V	-1.30 V	-1.15 V
32	-1.17 V	-1.17 V	-1.16 V	-1.15 V	-1.13 V	-1.15 V	
73	-1.21 V	-1.20 V	-1.18 V	-1.19 V	-1.19 V	-1.17 V	

THRESHOLD VOLTAGE P-CHANNEL: 450 mV <--> 1.35 V 468 mV

Device Number	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
21	468 mV	523 mV	**-440 mV**	**-680 mV**	**-725 mV**	**-755 mV**	**-690 mV**
32	470 mV	530 mV	563 mV	601 mV	665 mV	750 mV	
73	483 mV	485 mV	481 mV	482 mV	479 mV	483 mV	

Output Voltage

Device Number 21

V_{CC} : 4.5 V
I_{OL1} : 20 μA
I_{OH1} : -20 μA
I_{OL2} : 4.0mA
I_{OH2} : -4.0mA

	Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
V_{OL1}	Y1	2.35mV	2.25mV	2.20mV	2.50mV	2.30mV	2.70mV	2.35mV
	Y2	2.35mV	2.20mV	2.25mV	2.35mV	2.20mV	2.65mV	2.40mV
	Y3	2.20mV	2.25mV	2.15mV	2.40mV	2.25mV	2.60mV	2.35mV
	Y4	2.20mV	2.15mV	2.20mV	2.35mV	2.25mV	2.35mV	2.25mV
V_{OH1}	Y1	4.50 V	4.50 V	4.50 V	4.49 V	4.49 V	4.49 V	4.49 V
	Y2	4.49 V	4.49 V	4.50 V	4.49 V	4.49 V	4.49 V	4.50 V
	Y3	4.50 V	4.50 V	4.50 V	4.50 V	4.50 V	4.49 V	4.50 V
	Y4	4.50 V	4.49 V	4.50 V	4.49 V	4.49 V	4.49 V	4.49 V
V_{OL2}	Y1	122 mV	125 mV	120 mV	122 mV	115 mV	118 mV	117 mV
	Y2	119 mV	122 mV	118 mV	118 mV	113 mV	116 mV	116 mV
	Y3	120 mV	122 mV	118 mV	118 mV	113 mV	116 mV	114 mV
	Y4	118 mV	121 mV	115 mV	116 mV	112 mV	114 mV	113 mV
V_{OH2}	Y1	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.37 V	4.38 V
	Y2	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.37 V	4.37 V
	Y3	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V
	Y4	4.38 V	4.38 V	4.38 V	4.38 V	4.37 V	4.36 V	4.36 V

Output Voltage

Device Number 32

V_{CC} : 4.5 V
I_{OL1} : 20 μA
I_{OH1} : -20 μA
I_{OL2} : 4.0mA
I_{OH2} : -4.0mA

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
V_{OL1}						
Y1	2.50mV	2.50mV	2.25mV	2.15mV	2.15mV	2.15mV
Y2	2.45mV	2.45mV	2.20mV	2.20mV	2.20mV	2.10mV
Y3	2.45mV	2.50mV	2.25mV	2.15mV	2.25mV	2.15mV
Y4	2.40mV	2.40mV	2.15mV	2.20mV	2.10mV	2.10mV
V_{OH1}						
Y1	4.50 V	4.50 V	4.49 V	4.49 V	4.49 V	4.50 V
Y2	4.50 V	4.50 V	4.50 V	4.49 V	4.50 V	4.50 V
Y3	4.50 V	4.50 V	4.50 V	4.50 V	4.50 V	4.50 V
Y4	4.50 V	4.50 V	4.49 V	4.50 V	4.50 V	4.49 V
V_{OL2}						
Y1	118 mV	122 mV	119 mV	116 mV	115 mV	112 mV
Y2	116 mV	119 mV	116 mV	115 mV	112 mV	110 mV
Y3	117 mV	119 mV	117 mV	114 mV	113 mV	109 mV
Y4	115 mV	116 mV	115 mV	112 mV	111 mV	107 mV
V_{OH2}						
Y1	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V
Y2	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V
Y3	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V
Y4	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V

Output Voltage

Device Number 73

V_{CC} : 4.5 V
I_{OL1} : 20 μA
I_{OH1} : -20 μA
I_{OL2} : 4.0mA
I_{OH2} : -4.0mA

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
V_{OL1}						
Y1	2.40mV	2.00mV	2.20mV	2.10mV	2.35mV	2.20mV
Y2	2.40mV	2.15mV	2.20mV	2.05mV	2.25mV	2.20mV
Y3	2.35mV	2.10mV	2.25mV	2.20mV	2.30mV	2.25mV
Y4	2.30mV	2.00mV	2.25mV	2.00mV	2.30mV	2.20mV
V_{OH1}						
Y1	4.49 V	4.50 V	4.50 V	4.49 V	4.49 V	4.49 V
Y2	4.49 V	4.50 V	4.49 V	4.50 V	4.50 V	4.50 V
Y3	4.49 V	4.50 V	4.50 V	4.50 V	4.50 V	4.50 V
Y4	4.49 V	4.50 V	4.50 V	4.50 V	4.50 V	4.49 V
V_{OL2}						
Y1	128 mV	132.mV	132 mV	132 mV	131 mV	132 mV
Y2	126 mV	154.mV	128 mV	127 mV	127 mV	126 mV
Y3	125 mV	133.mV	128 mV	128 mV	124 mV	127 mV
Y4	123 mV	126.mV	124 mV	124 mV	124 mV	124 mV
V_{OH2}						
Y1	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V
Y2	4.38 V	4.35 V	4.38 V	4.38 V	4.37 V	4.38 V
Y3	4.38 V	4.37 V	4.38 V	4.38 V	4.38 V	4.38 V
Y4	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V	4.38 V

Output Voltage

Device Number 21

V_{CC} : 6.0 V
I_{OL1} : 20 μA
I_{OH1} : -20 μA
I_{OL2} : 5.2mA
I_{OH2} : -5.2mA

Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad	40Krad Annealed
V_{OL1}							
Y1	2.50mV	2.10mV	2.15mV	2.25mV	2.30mV	2.40mV	2.10mV
Y2	2.30mV	2.10mV	2.15mV	2.10mV	2.15mV	2.35mV	2.00mV
Y3	2.50mV	2.15mV	2.20mV	2.15mV	2.10mV	2.40mV	2.15mV
Y4	2.45mV	2.15mV	2.10mV	2.05mV	2.10mV	2.45mV	1.95mV
V_{OH1}							
Y1	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
Y2	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
Y3	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
Y4	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
V_{OL2}							
Y1	122 mV	125 mV	119 mV	122 mV	116 mV	120 mV	120 mV
Y2	118 mV	122 mV	115 mV	119 mV	114 mV	118 mV	118 mV
Y3	118 mV	121 mV	117 mV	118 mV	114 mV	118 mV	117 mV
Y4	116 mV	120 mV	113 mV	117 mV	112 mV	115 mV	115 mV
V_{OH2}							
Y1	5.87 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
Y2	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
Y3	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
Y4	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V

Output Voltage

Device Number 32

V_{CC} : 6.0 V
I_{OL1} : 20 μA
I_{OH1} : -20 μA
I_{OL2} : 5.2mA
I_{OH2} : -5.2mA

	Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
V_{OL1}	Y1	1.80mV	2.25mV	1.85mV	2.00mV	2.00mV	2.25mV
	Y2	1.75mV	2.20mV	1.85mV	2.00mV	2.00mV	2.20mV
	Y3	1.95mV	2.20mV	1.95mV	1.95mV	1.95mV	2.35mV
	Y4	1.80mV	2.20mV	1.80mV	1.95mV	2.00mV	2.25mV
V_{OH1}	Y1	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
	Y2	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
	Y3	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
	Y4	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
V_{OL2}	Y1	117 mV	122 mV	120 mV	116 mV	117 mV	113 mV
	Y2	115 mV	119 mV	116 mV	114 mV	113 mV	110 mV
	Y3	116 mV	119 mV	116 mV	112 mV	114 mV	110 mV
	Y4	113 mV	116 mV	115 mV	111 mV	113 mV	109 mV
V_{OH2}	Y1	5.87 V	5.87 V	5.87 V	5.87 V	5.87 V	5.87 V
	Y2	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
	Y3	5.87 V	5.87 V	5.87 V	5.87 V	5.87 V	5.87 V
	Y4	5.87 V	5.86 V	5.87 V	5.86 V	5.86 V	5.86 V

Output Voltage

Device Number 73

V_{CC} : 6.0 V
I_{OL1} : 20 μA
I_{OH1} : -20 μA
I_{OL2} : 5.2mA
I_{OH2} : -5.2mA

	Pin Identity	0Krad	6Krad	10Krad	15Krad	25Krad	40Krad
V_{OL1}	Y1	2.20mV	2.25mV	2.15mV	2.20mV	2.40mV	2.15mV
	Y2	2.25mV	2.30mV	2.10mV	2.20mV	2.40mV	2.15mV
	Y3	2.25mV	2.25mV	2.00mV	2.30mV	2.35mV	2.25mV
	Y4	2.10mV	2.20mV	1.95mV	2.20mV	2.35mV	2.15mV
V_{OH1}	Y1	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
	Y2	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
	Y3	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
	Y4	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V	5.99 V
V_{OL2}	Y1	128 mV	132 mV	131 mV	131 mV	128 mV	132 mV
	Y2	124 mV	130 mV	126 mV	124 mV	124 mV	124 mV
	Y3	124 mV	132 mV	127 mV	127 mV	125 mV	126 mV
	Y4	120 mV	125 mV	123 mV	121 mV	122 mV	120 mV
V_{OH2}	Y1	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
	Y2	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
	Y3	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V
	Y4	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V	5.86 V

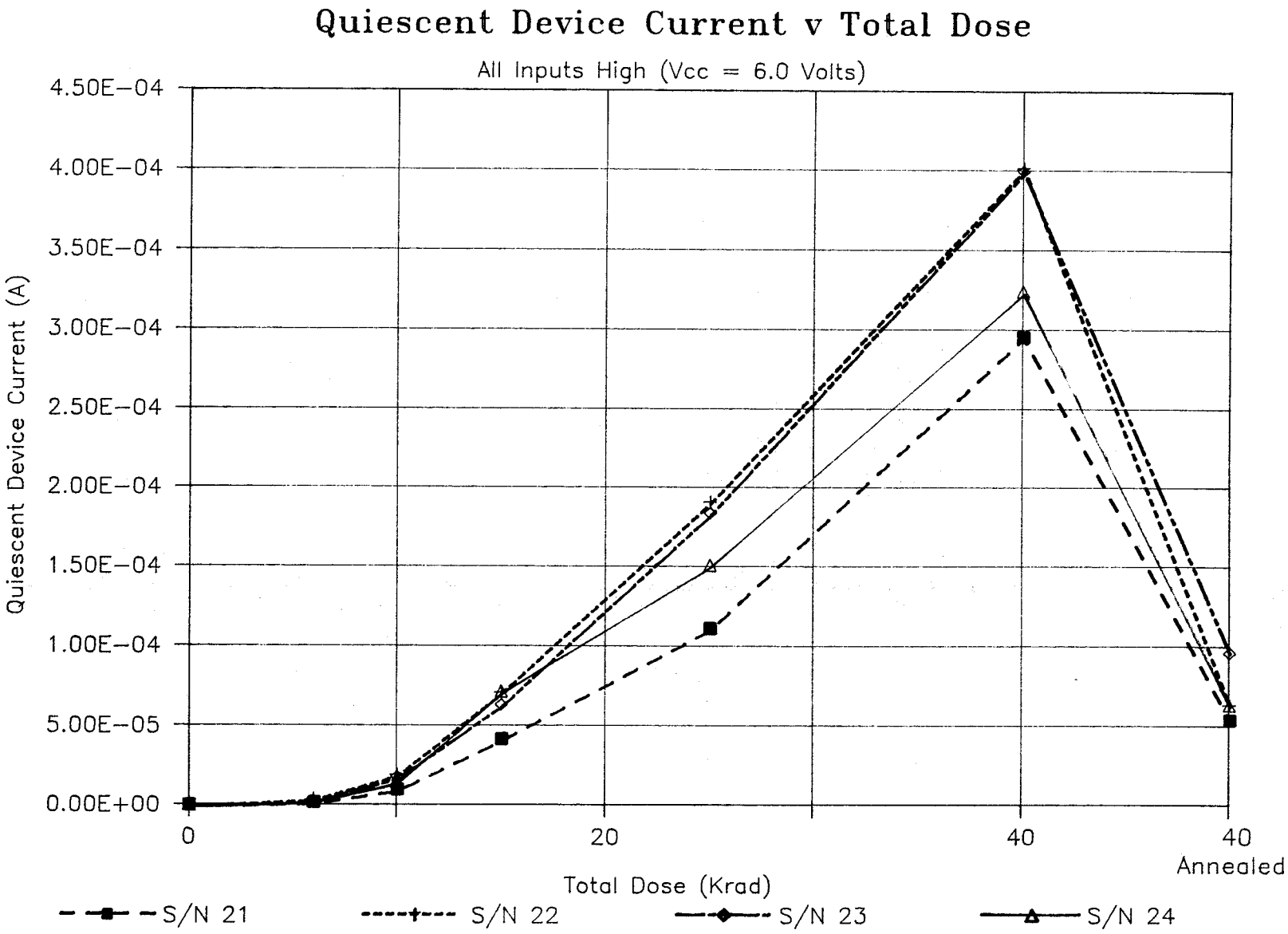
Quiescent Device Current v Total Dose
All Inputs High (Vcc = 6.0 Volts)
Quiescent Device Current (A)
4.50E-04
4.00E-04
3.50E-04
3.00E-04
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
0
20
40
40
Annealed
Total Dose (Krad)
S/N 21
S/N 22
S/N 23
S/N 24

Figure 2

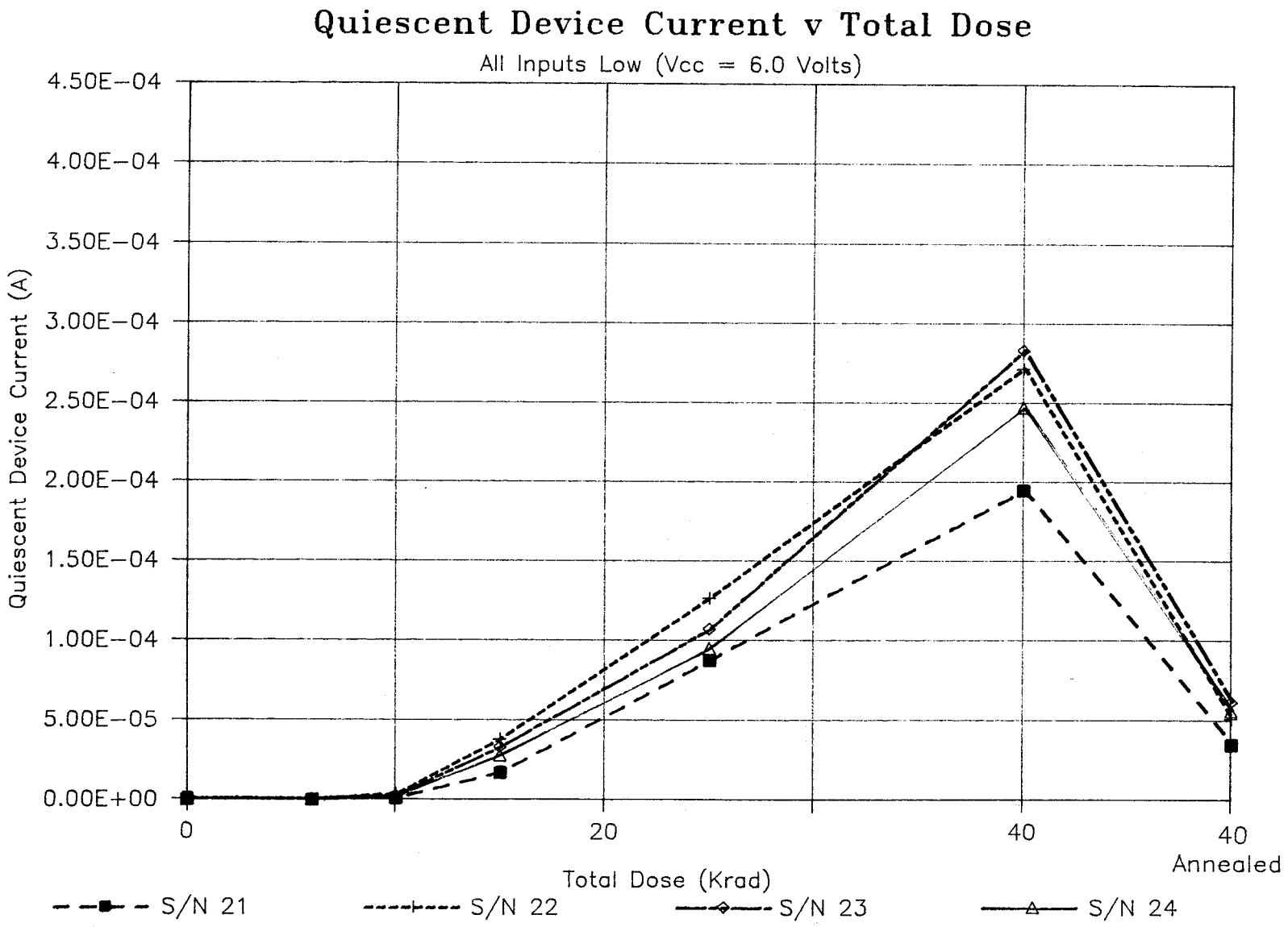
Quiescent Device Current v Total Dose
All Inputs Low (Vcc = 6.0 Volts)
Quiescent Device Current (A)
4.50E-04
4.00E-04
3.50E-04
3.00E-04
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
0
20
40
40
Annealed
Total Dose (Krad)
S/N 21
S/N 22
S/N 23
S/N 24

Figure 3

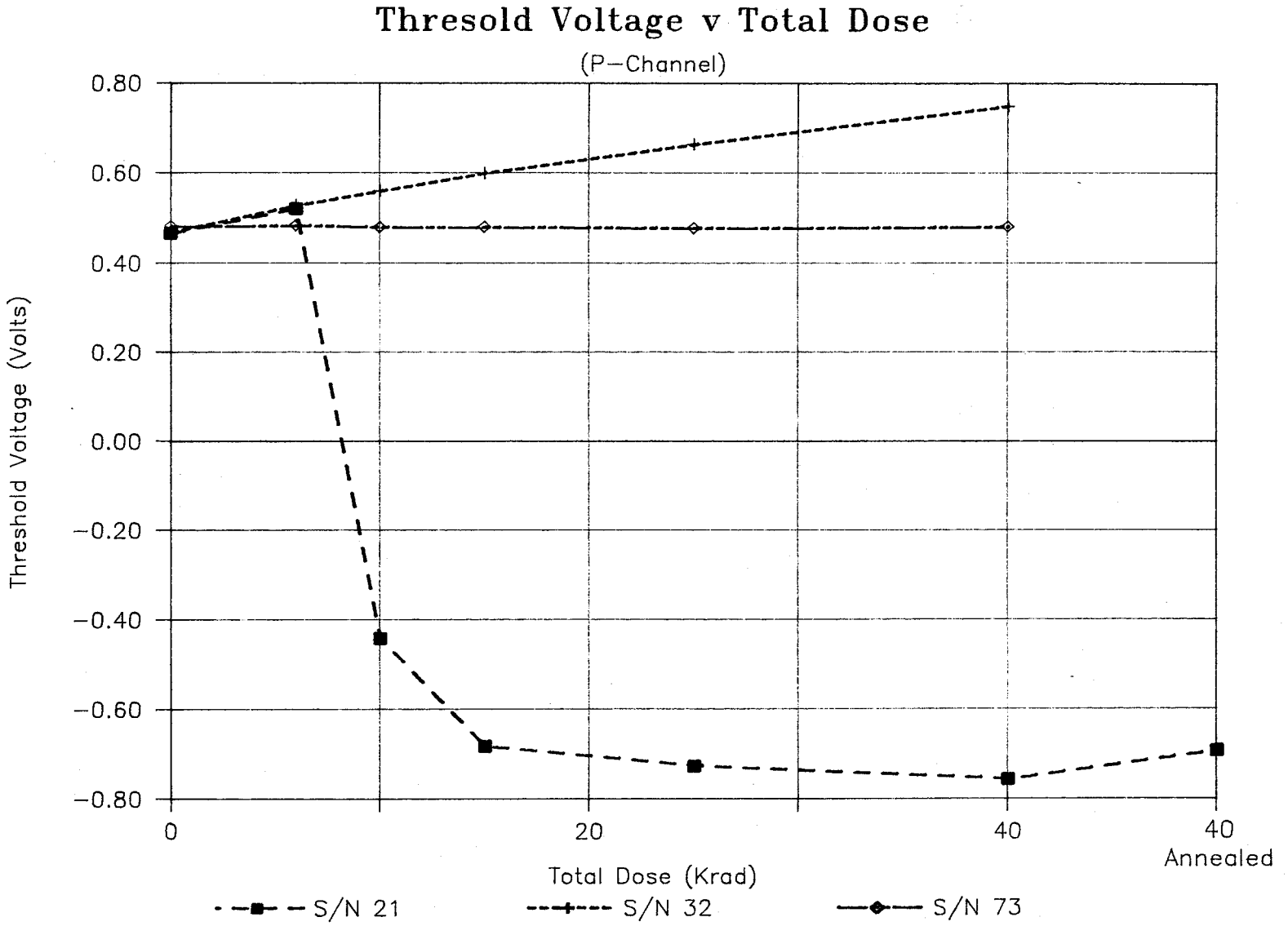
Thresold Voltage v Total Dose
(P-Channel)
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
Threshold Voltage (Volts)
0
20
40
40
Annealed
Total Dose (Krad)
S/N 21
S/N 32
S/N 73

Figure 4