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STSP

Title	Radiation Report on Harris Semiconductor Integrated Circuits - Types 82C54 and 82C84				
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Issue of the document comprises the following pages at the issues shown :

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Radiation Report 82C54 82C84		1						

DOCUMENT CHANGE LOG

Issue No.	Change Notice No.	ECP No.	ECN	Revised Issue Date	Pages Affected	Relevant Information
1	-	-	-	20.08.92	All	Initial Issue

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1. OBJECT

The object of this report is to tabulate the results obtained during radiation testing of Harris Integrated Circuits used on Soho/Cluster projects. These results fulfil the requirements of STSP Procedure ST-BAS-PR-0002.

2. REFERENCE DOCUMENTS

2.1 STSP Radiation Procedure ST-BAS-PR-0002.

3. CPPA APPRAISAL OF RADIATION REPORT

CPPA have reviewed the attached report and concur that these results meet the objectives of ST-BAS-PR-0002. The report concludes that both of the devices are functional at 30K Rad (Si), but have some parametric degradations. The gamma dose rate used during the testing was low level at 15 Rads (Si)/S.

4. ATTACHED REPORT

See attached report British Defence Dynamics BT28770 dated June 1992.

BT28770
ISSUE 1
JUNE 1992

A GAMMA TOTAL DOSE ASSESSMENT OF THE HARRIS 82C54 AND THE 82C84

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A GAMMA TOTAL DOSE ASSESSMENT
OF THE HARRIS
82C54 AND THE 82C84

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ALTERATION & RECORD SHEET

ISSUE NO. & DATE	SUMMARY OF CHANGE	DATE OF CHANGE

ABSTRACT

This report details a total gamma dose assessment of the HARRIS 82C54 programmable interval timer and the HARRIS 82C84 clock generator. The objective of the assessment was to determine parametric degradation and level of failure up to a maximum total dose of 30 krad(Si).

Statistical analysis has been applied to the results to determine a set of derated parameters for each device.

1 INTRODUCTION

This report details a total gamma dose assessment of the Harris 82C54 programmable interval timer and the Harris 82C84 clock generator.

The assessment has been carried out by the Radiation Effects Group, British Aerospace Dynamics Division, Bristol on behalf of British Aerospace Space Systems, Stevenage.

The objective of the assessment was to determine the level of parametric degradation under the influence of a total gamma ionising dose up to a maximum of 30 krad(Si) for each device. It was also necessary to determine the failure level (functional failure) if it was less then 30 krad(Si).

The assessment was carried out using the Cobalt-60 source at RMCS Shrivenham using a dose rate of 15 rad(Si)/s. Dosimetry was provided by RMCS staff.

Devices

The Harris 82C54 is a high performance CMOS programmable interval timer.. It has three independently programmable and functional 16 bit counters, each capable of handling clock input frequencies of up to 8MHz. Six timer modes allow the device to be used as an event counter, elapsed time indicator, programmable one shot, as well as many other applications. The samples were marked ST290601B with a date code X9110A.

The Harris 82C84 is a high performance CMOS clock generator driver which is designed to service requirements of CMOS and NMOS microprocessors such as 80C86 and 80C88. The chip contains a crystal controlled oscillator, a divide by three counter and complete "Ready" synchronisation and reset logic. The samples were marked ST094401B with a date code X8915A.

Six samples of each device were provided by British Aerospace (Space Systems) Ltd. Five samples were to be irradiated, the sixth sample was used as an unirradiated control.

2 TEST PROCEDURE

The trial was carried out on a Co^{60} source at RMCS, Shrivenham. Five samples of each device were irradiated at a dose rate of 15 rad(Si)/s whilst powered up in the device's static burn in circuit (as detailed in ST-BAS-PS-2906 and ST-BAS-PS-0944). At 2 krad(Si) intervals the samples were removed from the cell and functionally and parametrically tested. The samples were then returned to the cell for further irradiations. This process was repeated until 30 krad(Si) had been accumulated. In order to carry out the functional and parametric tests, a test jig was developed for each device.

Harris 82C54

Functional and parametric tests were designed to monitor the DC parameters detailed in Table 2 of the detail specification (ST-BAS-PS-2906).

It was not possible to check all parameters on all pins, and therefore only the more important parameters were considered. Figure 1 shows the configuration of the test circuit.

The functional test assessed the samples in two modes of operation: Mode 0 and Mode 1. To correctly function in Mode 0, the samples had to receive and understand data from the data bus, be able to select the right counter (from the address bus) and control the output (OUT) so that it changed state after the correct period of time. Mode 1 tested an extra feature, namely the trigger function. All three counters were assessed in each Mode.

The parametric assessment monitored the following parameters: Supply Current, Output Voltage (high and low), Input Voltage (high and low) and Output Current (high). The Input Voltage levels were measured using the Clock Input.

A control sample, which was unirradiated, was assessed before and after the trial to ensure external environmental conditions had not affected the results.

Harris 82C84

Functional and parametric tests were designed to monitor the DC parameters detailed in Table 2 of the specification (ST-BAS-PS-0944). It was not possible to check all parameters on all pins, and therefore, only the more important parameters have been considered. Figure 2 shows the configuration of the test circuit.

The 82C84 has two modes of operation. It could operate using an external clock or it could use its own oscillator with an attached crystal; both modes were assessed.

The parametric assessment monitored the following parameters: Supply Current, Input Voltage (high and low), Output Voltage (high and low) and Output Current (high).

A control sample, which was unirradiated, was assessed before and after the trial to ensure external environmental conditions had not affected the results.

3 TEST RESULTS

Harris 82C54

The results of the total dose trial are shown in Table 1. The variation for each parameter has been determined by comparing the pre-irradiated values with the corresponding values after irradiation to 30 krad(Si); this was carried out for each sample. The mean and standard deviation of the degradations have been determined for each parameter.

The functional check assessed all three counters in two modes (mode 0 and 1). After irradiation to 30 krad(Si), all of the samples continued to operate correctly.

Figures 3-5 show the variation of some of the parameters over the total dose range. The supply current increased significantly as the total dose increased. Partial recovery took place between 18 to 20 krad(Si) characterised by the decrease in supply current. This was due to annealing. However only one sample degraded sufficiently to cause the supply current to shift outside the manufacturer's specification. The input threshold voltages varied linearly with total dose irradiation. The mean degradation was approximately 16.67mV/krad(Si).

Harris 82C84

The results of the total dose trial are shown on Table 2. The data for this device has been presented in a similar way to that of the previous device. Minimal degradation in performance occurred in all samples.

The functionality test consisted of two checks: external clock mode and crystal oscillator mode. After irradiation to 30 krad(Si), all of the samples continued to operate correctly. The output frequency in external clock mode showed negligible variation. The output frequency variation in crystal oscillator mode was measurable but small.

The input threshold voltages exhibited small changes in magnitude with the input high threshold increasing as a result of the radiation and the input low threshold decreasing. The output voltage high exhibited little change during the irradiation. The output voltage low increased by approximately 0.5 mV after irradiation to 30 krad(Si).

4 RESULTS ANALYSIS

In the previous section the results of the assessments have highlighted that a number of parameters will degrade after exposure to gamma radiation up to 30 krad(Si). In this section it is necessary to apply the information obtained from the samples to the total population.

Harris 82C54

By applying statistics (in the form of a one sided tolerance limit) it is possible to determine maximum degradation for certain percentages of the total population.

Using the mean and standard deviation of the parametric degradation given in Table 1, the manufacturer's specifications can be amended to take account of radiation degradation. Appendix A gives an example of the calculations required. The derated parameters at 30 krad(Si) are shown in Table 3. The derated parameter column specifies the limits (for each parameter) which 95% of devices' parameters will remain within after irradiation to 30 krad(Si). It was not possible to calculate the derated Input Voltage levels, since the clock input was used to determine the thresholds. Where a parameter improved after irradiation derating has not been applied.

Harris 82C84

In a similar way to that described above, the derated parameters have been calculated for the 82C84 at 30 krad(Si). These values are given in Table 4.

After exposure to gamma radiation of 30 krad(Si) a number of devices may have parametric values in the region of the derated values shown in tables 3 and 4. It is therefore important from a designer's view point to ensure that the system design can tolerate such changes.

5 CONCLUSIONS

This report has discussed a total gamma dose assessment of the Harris 82C54 programmable interval counter/timer and the Harris 82C84 clock generator.

The assessment has determined that degradation of certain parameters will occur after irradiation to 30 krad(Si).

Harris 82C54

The results of the trial on the 82C54 have concluded that after irradiation to 30 krad(Si), the device will continue to function with some parametric degradation. Statistical analysis has been used to provide a list of derated parameters at 30 krad(Si). The value of these derated parameters is given in Table 3. The derated Input Voltage levels were not determined since the clock input was used to determine the threshold levels.

Harris 82C84

The results of the trial on the 82C84 have also concluded that after irradiation to 30 krad(Si), the device will continue to function with some parametric degradation. A list of derated parameters has been derived after irradiation to 30 krad(Si) and is given in Table 4.

SAMPLE NO/ BATCH CODE	MODE 0 TIME VARIATION	MODE 1 TIME VARIATION	ΔI_{cc} (mA)	ΔV_{OL} (mV)	ΔV_{OH} (mV)	ΔV_{THL} (mV)	ΔV_{THH} (mV)	ΔI_{OH} (µA)
1/9110	NC	NC	7.2	82.5	-80.0	-480.0	-470.0	-90.0
2/9110	NC	NC	5.3	8.9	-40.0	-440.0	-430.0	-60.0
3/9110	NC	NC	5.8	55.5	-10.0	-420.0	-410.0	-20.0
4/9110	NC	NC	11.2	17.6	-20.0	-490.0	-460.0	-50.0
5/9110	NC	NC	7.0	33.6	-10.0	-460.0	-430.0	-30.0
Mean Variation	NC	NC	7.3	39.6	-32.0	-458.0	-440.0	-50.0
SD of Variation	0	0	2.3	29.8	29.5	28.6	24.5	27.4
Mean Pre-irradiation Values	60.8ms	22.6ms	0.7mA	4.5mV	5.0V	1.5V	1.4V	-4.9mA

Notes: Dose rate = 15 rad(Si)/s.

"NC" indicates no change.

Control sample variations were negligible.

Positive values represent an increase in value.

Negative values represent a decrease in value.

ΔV_{THL} and ΔV_{THH} refer to the change in clock input threshold voltage (low and high)

TABLE 1 : PARAMETRIC VARIATION FOR THE HARRIS 82C54 AT 30 krad(Si)

SAMPLE NO/ BATCH CODE	OUTPUT FREQUENCY VARIATION		ΔI_{cc} (mA)	ΔV_{OL} (µV)	ΔV_{OH} (mV)	ΔV_{THL} (mV)	ΔV_{THH} (mV)	ΔI_{OH} (µA)
	EXT.CLK	XTAL						
1/8915	NC	-7.0 kHz	0.48	418.0	NC	-10.0	20.0	-10.0
2/8915	NC	NC	0.39	448.0	NC	NC	40.0	NC
3/8915	NC	NC	0.99	519.0	NC	-10.0	10.0	-10.0
4/8915	NC	-11.0 kHz	0.89	694.0	NC	NC	NC	-10.0
5/8915	NC	NC	1.14	360.0	NC	NC	NC	NC
Mean Variation	NC	-3.6 kHz	0.78	488.0	NC	-4.0	14.0	-6.0
SD of Variation	0	5.1 kHz	0.33	128.7	0	5.5	16.7	5.5
Mean Pre-irradiation Values	167kHz	1.1MHz	2.43mA	318.5µV	4.99V	1.6V	3.5V	-4.9mA

Notes: Dose rate = 15 rad(Si)/s.

"NC" indicates no change.

Control sample variations were negligible.

Positive values represent an increase in value.

Negative values represent a decrease in value.

ΔV_{THL} and ΔV_{THH} refer to the change in clock input threshold voltage (low and high)

TABLE 2 : PARAMETRIC VARIATION FOR THE HARRIS 82C84 AT 30 krad(Si)

Parameter	D.C. parameters (Detailed Specifications)	Derated Values at 30 krad(Si)
Supply Current	10 mA (max)	25.23 mA
Output Voltage-low	0.4 V (max)	0.54 V
Output Voltage-high	Vcc-0.4 V (min)	Vcc-0.53 V
Input Voltage-low	0.8 V (max)	V_{INL} -360 mV
Input Voltage-high	2.2 V (min)	V_{INH} -360 mV
Output Current-high	---------	-4.76 mA

Notes: Min/Max value for Output Current is not specified.
Confidence, C = 90%
Proportion, P = 95%
* - Derating cannot be applied to specified parameter values

TABLE 3: DERATED PARAMETERS FOR THE 82C54 AT 30 krad(Si)

Parameter	D.C. parameters (Detailed Specifications)	Derated Values at 30 krad(Si)
Supply Current	40mA (max)	41.89 mA
Output Voltage-low	0.4 (max)	0.5 V
Output Voltage-high	Vcc -0.4 (min)	Vcc -0.4
Input Voltage-low	0.8V (max)	0.78 V
Input Voltage-high	2.2V (min)	2.27 V
Output Current-high	2.5mA (max)	2.48 mA

Notes: Max/Min value for Output Voltage is not specified
Confidence, C = 90%
Proportion, P = 95%

TABLE 4: DERATED PARAMETERS FOR THE 82C84 AT 30 krad(Si)

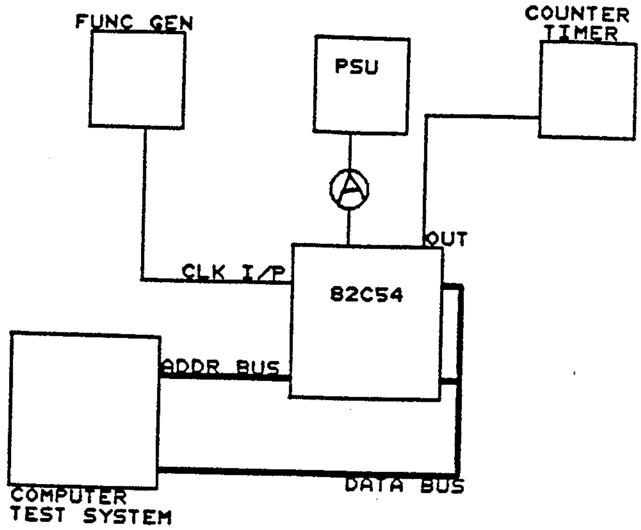

FIGURE 1 : TEST SCHEMATIC FOR THE 82C54

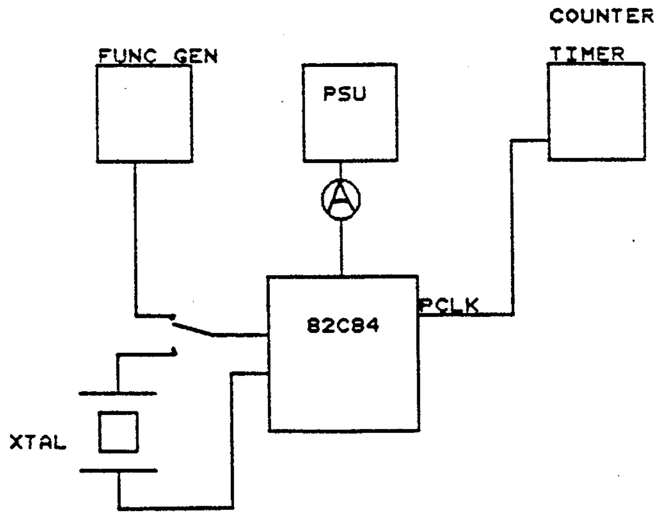

FIGURE 2 : TEST SCHEMATIC FOR THE 82C84

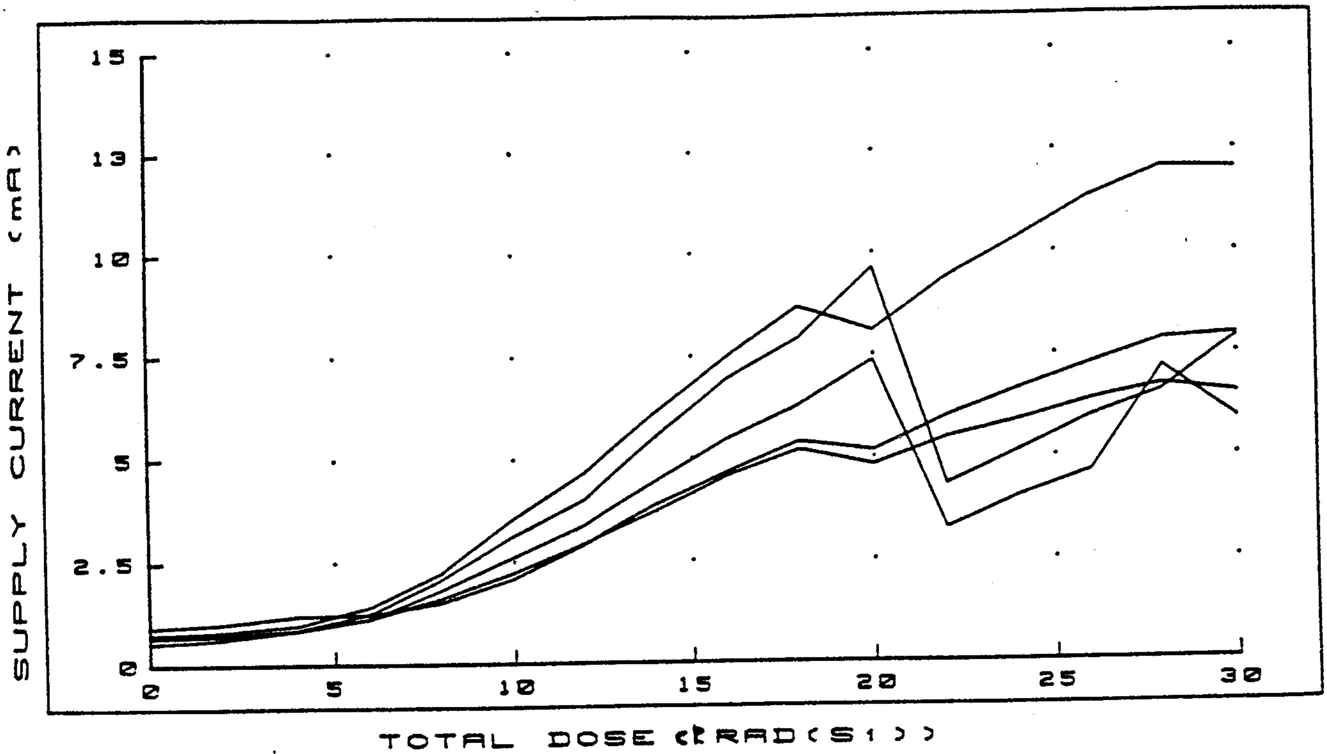

FIGURE 3 : SUPPLY CURRENT VARIATION WITH TOTAL DOSE FOR THE 82C54

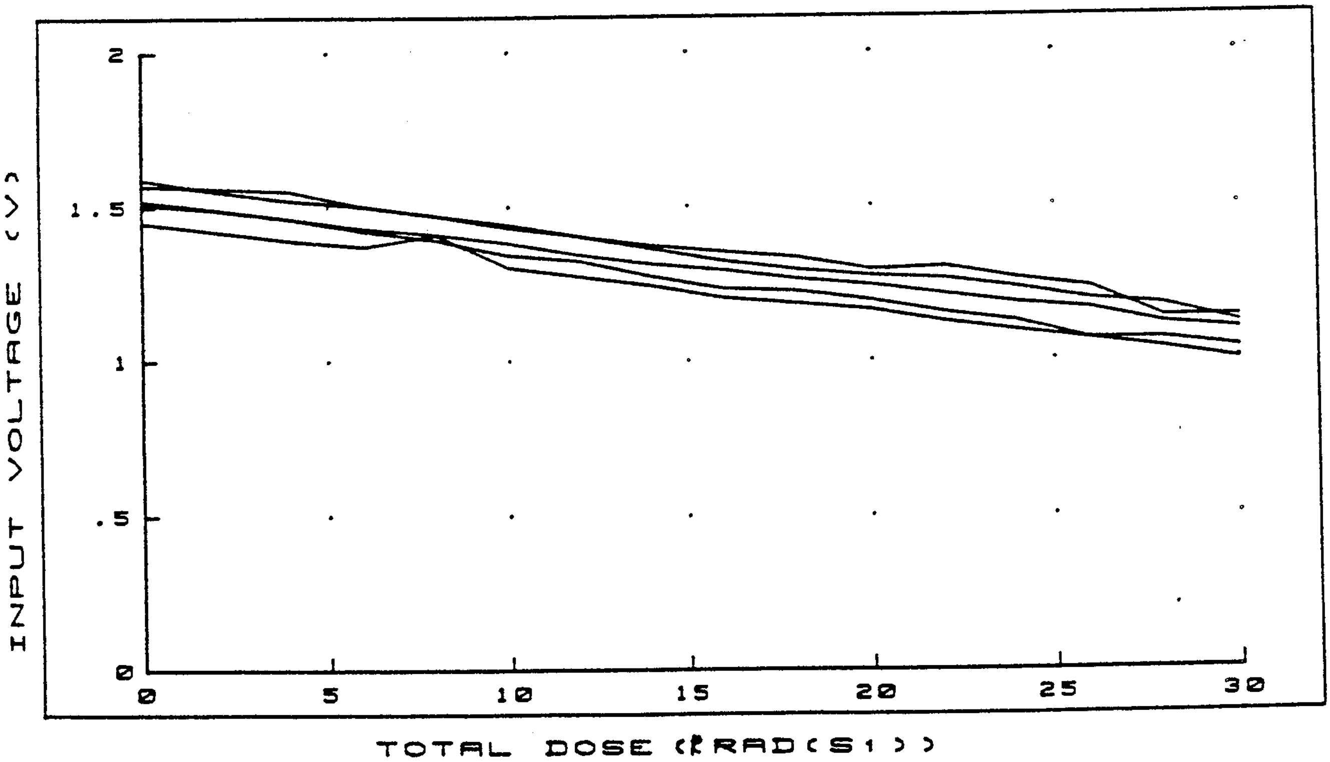

FIGURE 4 : INPUT LOW VOLTAGE THRESHOLD VARIATION WITH TOTAL DOSE FOR THE 82C54

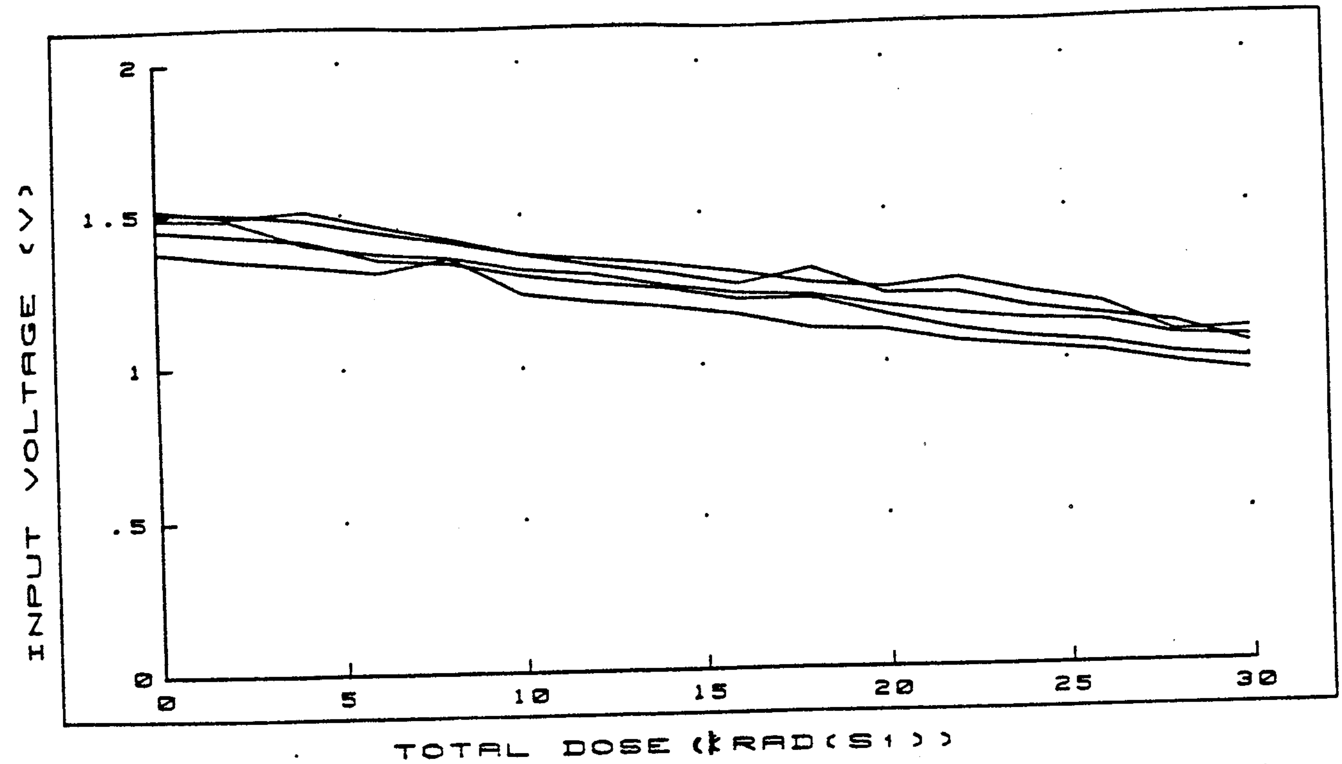

FIGURE 5 : INPUT HIGH VOLTAGE THRESHOLD VARIATION WITH TOTAL DOSE FOR THE 82C54

APPENDIX A

Determination of the derated parameter based upon one side tolerance limits

From the calculations of the mean and standard deviation it is possible to determine the tolerance limit of a given parameter.

For example

From Table 1 it can be seen that after irradiation to 30 krad(Si) the supply current increases by the following amounts for each sample:

Sample No	Increase in Supply current (mA)
1	7.2
2	5.32
3	5.79
4	11.23
5	7.0
Mean	7.31
S.D.	2.33

Assuming a normal distribution, the one sided tolerance limit can be determined using equation:

$$L = M + KTL\ (n,C,P) S.D. \qquad (1)$$

where
L is the tolerance limit
M is the mean of increases in supply current
S.D. is the standard deviation of the increases in supply current
KTL is the one sided tolerance factor determined from tables and is a function of

n = number of samples
C = confidence in repeatability of the results
P = proportion of total population which will have a supply current increase less than the tolerance limit, L.

Table A1 shows the value of KTL with a sample size of 5 for various confidence and proportion values. For the assessment, confidence and proportion values of 90% and 95% respectively yield a KTL value of 3.4.

Substituting in equation (1)

L = 15.23mA

This means that 95% of the total number of devices (if all could be tested) would exhibit a supply current increase less then 15.23 mA with 90% confidence.

Initially all devices will have a supply current within the manufacturer's specification (less then 10mA). Therefore after irradiation to 30 krad(Si), the supply current may have increased to 25.23mA (if a device initially had a supply current of 10mA and exhibited the tolerance limit increase of 15.23mA). This value becomes the derated parameter at 30 krad(Si). Hence it can be stated that 95% of the 82C54 devices will have a supply current of less then 25.23 mA after irradiation to 30 krad(Si) with 90% confidence.

This example has been repeated for all parameters for both devices. The values are given in Tables 3 and 4.

P% / C%	90	95	99	99.9	99.99
90	2.742	3.400	4.666	6.111	7.311
95	3.406	4.202	5.741	7.502	8.966
99	5.362	6.579	8.939	11.649	13.906
99.9	9.781	11.970	16.223	21.114	25.190

TABLE A1 : ONE SIDED TOLERANCE LIMITS, KTL FOR A SAMPLE NUMBER OF 5

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