ESA-QCA00110T-C

Radiation test report RA 068

Comparative radiation test of Motorola, Texas Instruments and National Semiconductor AC 00, AC 138, AC 373, ACT 00, ACT 138 and ACT 373.

ESA/ESTEC, 16/5-91.

Prepared by:
Bengt Johlander,
Radiation effects and analysis techniques unit,
Components Division.

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Summary *:*

- *National Semiconductor and Motorola parts show parametric failures, principally on input leakages and input voltages after 25-50 Krad. They stay functional up to a total dose of 100 Krad even after annealing.*
- *Texas Instruments parts show first parametric failures after 10 krad. Rebound effects are observed after annealing.*

The National Semiconductor and Motorola fast logic family is preferable to equivalent Texas Instruments devices from the point of view of total ionizing dose.
However, the radiation performance of both National and Motorola depends on the design and complexity. The degradation of different functions need therefore to be assessed.
The long term stability of the process needs to be followed through a radiation control plan, primarily to ensure that the leakage currents do not degrade abnormally after total dose exposure.

In view of their total dose performance, we recommend National Semiconductor and Motorola for SCC qualification. Texas Instruments is not recommended due to low tolerance to ionizing irradiation and rebound effects. However, TI could also be considered for qualification if further testing on a larger number of samples with a low dose rate show a stable and predictable degradation to total dose exposure. In any case, the TI fast logic series must be considered sensitive to total dose exposure.

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2. Aims and objectives
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1. Introduction.

Fast logic devices have been identified for use in several future space projects. Due to the unknown radiation performance of these parts, the Radiation Effects and Analysis Techniques Unit, Components Division, was requested to perform a pre-screening radiation test of representative members of the AC and ACT fast logic families for future qualification by SCC.

The work was performed alongside a test of Motorola and National Semiconductor AC 240 and AC 244 devices requested by the SOHO project for coordination reasons.

Rood Testhouse was contracted for all electrical testing as well as annealing of all samples. Sample identification and test results can be found in the attached report from Rood Testhouse, while this section describes the radiation source and conditions, and includes a discussion of the test results.

2. Aims and objectives.

The aim of the test was to compare the functioning of similar fast logic devices from three manufacturers under similar and mission representative radiation conditions, and to make a recommendation to SCC of which manufacturer(s) to invite for a full qualification program. The objective of the work was to build and design biasing circuitry, expose the samples to ionizing radiation, and perform subsequent full parametric AC/DC test.

3. Radiation source and dosimetry.

The 1460 Curie Co-60 facility in ESTEC was used for exposing the samples to ionizing radiation (1.25 MeV gamma rays). The dose rate can be varied by placing the samples at different distance from the Co-60 pellets. The dose rate chosen for all irradiations in this test was 26 rad/min (H2O), which is a lower dose rate than specified by ESA/SCC 2900 and also proposed Mil. Std. 883/1019.4. The reasons for this are:
1. to keep the dose rate more applicable to space applications,
2. to allow a uniform dose for all samples irradiated,
3. practicality; to be able to complete the longest exposure in 16 hours (one night exposure).
The dose was monitored by a Ionex Dosemaster equipped with a 0.6 cc ion probe placed at the same distance from the Co-60 source as the samples. The Ionex Dosemaster is calibrated to +/- 0.5 %.

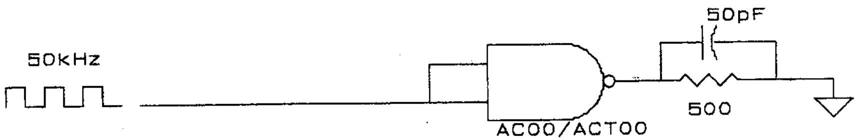
4. The biasing circuitry and sample allocation.

The biasing circuitry is shown in figure 1-3. The biasing conditions for different samples is shown below in table 1.
Due to uncertainty in exactly what bias condition constitute the worst case, several different conditions were used.

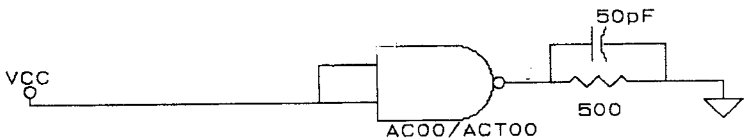
Table 1, Biasing conditions.

Manufacturer	Functions	Sample	Condition	Description
Motorola	AC 00 & ACT 00	1,2	A	Dynamic
Motorola	AC 00 & ACT 00	3,4	B	Static
Motorola	AC 00 & ACT 00	5	C	Grounded
National Sem.	AC 00	1,2	A	Dynamic
National Sem.	AC 00 (ACT00 not delivered)	3,4	B	Static
National Sem.	AC 00	5	C	Grounded
Texas Instr.	AC 00 & ACT 00	1,2	A	Dynamic
Texas Instr.	AC 00 & ACT 00	3,4	B	Static
Texas Instr.	AC 00 & ACT 00	5	C	Grounded
Motorola	AC 138 & ACT 138	1,2	A	Dynamic
Motorola	AC 138 & ACT 138	3,4	B	Static
Motorola	AC 138 & ACT 138	5	C	Grounded
National Sem.	AC 138 & ACT 138	1,2	A	Dynamic
National Sem.	AC 138 & ACT 138	3,4	B	Static
National Sem.	AC 138 & ACT 138	5	C	Grounded
Texas Instr.	AC 138 & ACT 138	1,2	A	Dynamic
Texas Instr.	AC 138 & ACT 138	3,4	B	Static
Texas Instr.	AC 138 & ACT 138	5	C	Grounded
Motorola	AC 373 & ACT 373	1,2	A	Dynamic
Motorola	AC 373 & ACT 373	3,4	B	Static
Motorola	AC 373 & ACT 373	5	C	Grounded
National Sem.	AC 373 & ACT 373	1,2	A	Dynamic
National Sem.	AC 373 & ACT 373	3,4	B	Static
National Sem.	AC 373 & ACT 373	5	C	Grounded
Texas Instr.	AC 373 & ACT 373	1,2	A	Dynamic
Texas Instr.	AC 373 & ACT 373	3,4	B	Static
Texas Instr.	AC 373 & ACT 373	5	C	Grounded

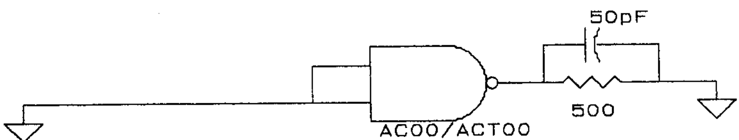
Fig. 1



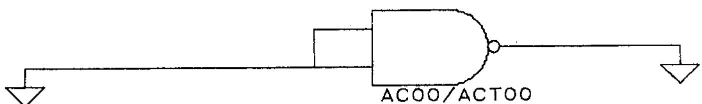
Condition A
2 devices - all gates



Condition B
2 devices - 2 gates



Condition B
2 devices - 2 gates



Condition C
1 device - all gates

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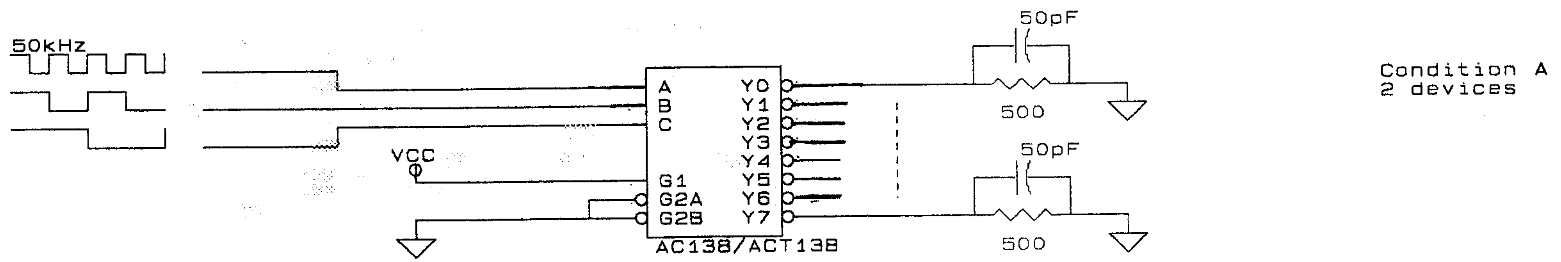
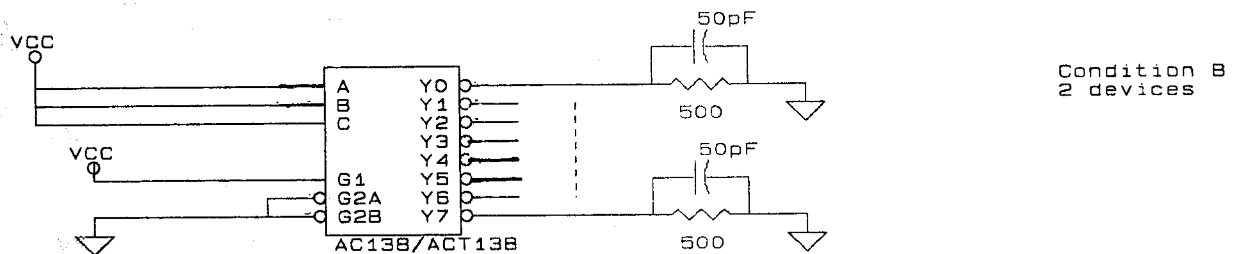
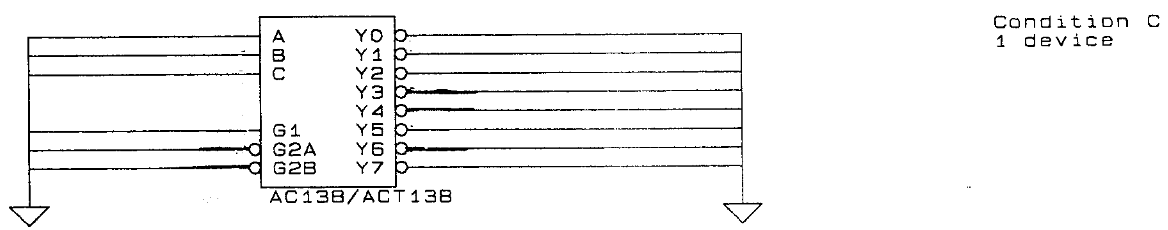
Fig. 2



Condition A
2 devices



Condition B
2 devices



Condition C
1 device

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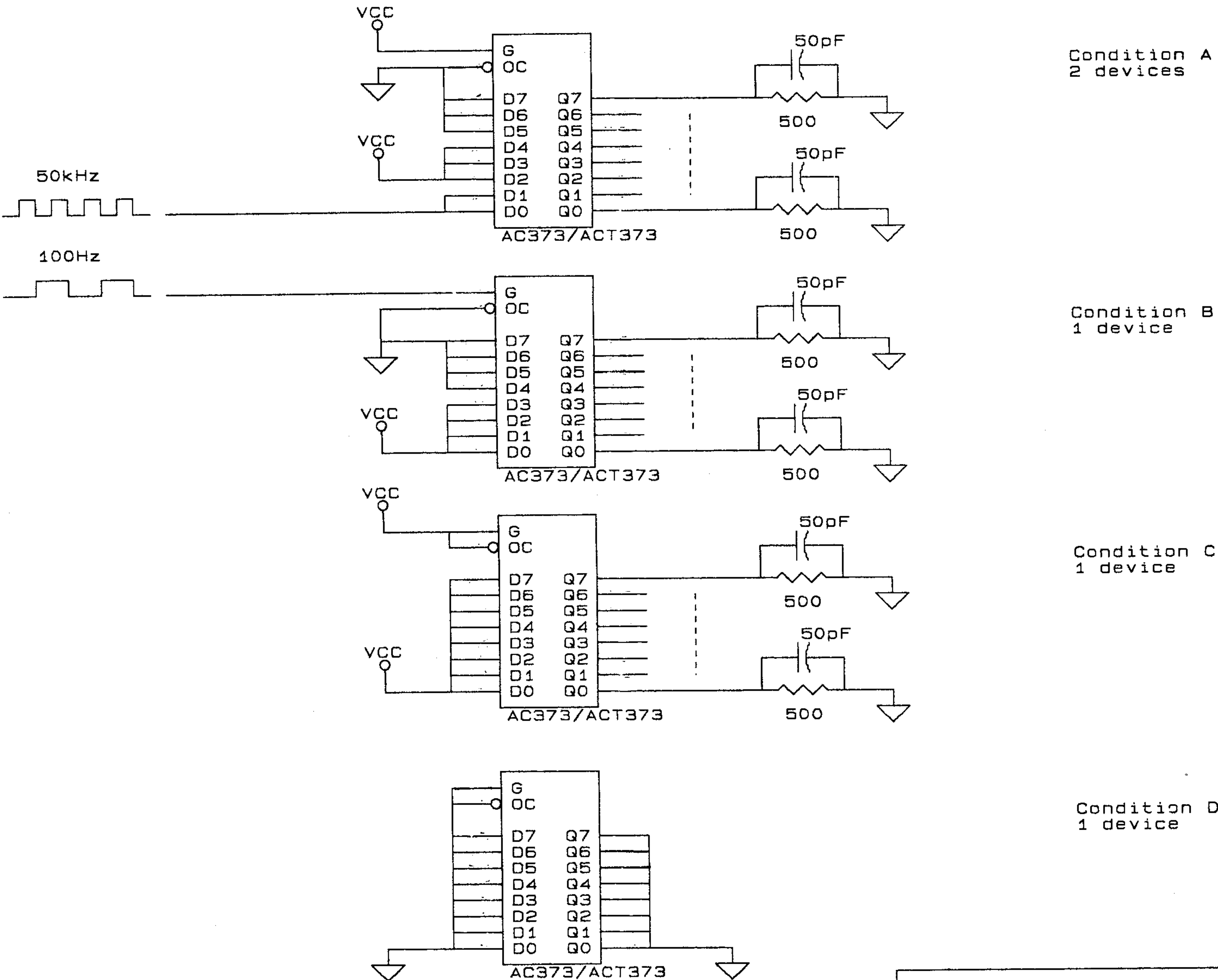
Fig. 3



5. Annealing conditions.

After all samples had received a total dose of 100 krad, they were placed in a oven for 168 hours at 100 degrees Celsius, with all pins grounded. All samples were again tested after annealing to check for any reverse annealing phenomena.

6. Time schedule.

The samples were irradiated during the nights while the transport to Rood Testhouse and electrical characterisation was done in the daytime. The Co-60 source was controlled by a timer, so a pre-set total dose was reached without requiring the attention of an operator.

Day Start time	Activity	Bias
24/2, 19.15	Irr. 0-5 krad	on
24/2, 22.20	5 krad reached	on
25/2, 8.45	Transport & meas.	off
25/2, 19.00	Irr. 5-10 krad	on
25/2, 22.07	10 krad reached	on
26/2, 8.45	Transport & meas.	off
26/2, 17.40	Irr. 5-15 krad	on
26/2, 21.00	15 krad reached	on
27/2, 8.45	Transport & meas.	off
27/2, 17.15	Irr. 15-25 krad	on
27/2, 23.55	25 krad reached	on
28/2, 8.45	Transport & meas.	off
28/2, 17.00	Irr. 25-50 krad	on
1/3, 8.50	Transport & meas	off
2/3, 18.00	Irr. 50-100 krad	on
4/3, 8.50	Transport & meas.	off
5/3, 9.00	Annealing, 100 C.	off
12/3, 9.00	Measurement	off

7. Test results and conclusions.

In view of the large amount of test data generated from the electrical measurements, only minimum and maximum values of each package are shown in the graphs for clarity. The method of plotting only minimum and maximum values gives a better estimate of what can be expected during most operating conditions. The average is indicated in the graphs as a solid line, while specification limits are drawn as broken lines.
Only the worst case measurements are plotted in graphs, e.g. worst-case Vcc for Tplz etc. All other measurements conditions for a parameter (listed in reference documents kept in ESTEC) degrade less with irradiation than that plotted.
The results displayed in the graphs are those where a parameter for at least one of the parts tested went outside the specification limits. The failing parameters and part numbers are listed in the tables in the Rood report. Some parts were failing from the outset due to too tight specification limits.
All raw data is stored on tape in Rood Testhouse for any required data analysis in the future.

A. One can observe from the plotted test results that the Texas Instruments (TI) parts are considerably more sensitive than Motorola and National. The TI show an increased power consumption or leakage current after approx 10 krad, while both the Motorola and National devices have a more stable power consumption/leakage current evolution. However, there is a variation in the results when comparing different functions.
On both the Motorola and National parts, one can observe a "hump" in the power consumption around 25-50 Krad. This is probably explained by a slow formation of compensating charge in interface states under the field oxide.
As such states form, the current leakage path under the field oxide is switched off (compare to a threshold voltage shift due to negative of positive charge build-up in the gate oxide of a MOSFET, see e.g. Sze: Physics of semiconductor devices).
The formation of such interface states after total dose exposure is generally considered to be very sensitive to small changes or drift in processing conditions.

B. Functional failure is observed in the TI parts after annealing due to the rebound effect. This kind of failure is of serious concern for operation in a low dose rate environment such as space, where the actual degradation can be more severe than in accelerated ground testing to the same total dose.

C. More complex parts like the 373's have a lower tolerance of ionizing radiation, for example the National AC373, National AC373 and Motorola ACT373, where the input voltage levels also fails after 25-50 Krad.

In general, we conclude that the National Semiconductor and Motorola fast logic family is preferable to equivalent Texas Instruments from a total ionizing dose point of view.
However, the radiation performance of both National and Motorola depends on the design and complexity. The degradation of different functions need therefore to be assessed.
The long term stability of the process needs to be followed through a radiation control plan, principally to ensure that the power consumption/leakage current does not degrade abnormally after total dose exposure.

8. Recommendations

In view of their total dose performance, we recommend National Semiconductor and Motorola for SCC qualification. Texas Instruments is not recommended due to low tolerance to ionizing irradiation and rebound effects. However, TI could also be considered for qualification if further testing on a larger number of samples with a low dose rate show a stable and predictable degradation to total dose exposure. In any case, the TI fast logic series must be considered sensitive to total dose exposure.

ROOD TESTHOUSE

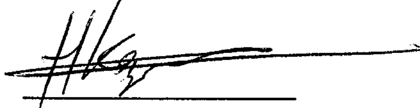
Quality and Reliability Investigation Report

of several AC/ACT 00/138/373 devices

for ESA/ESTEC, Noordwijk, The Netherlands

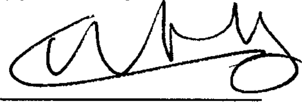
Heerde, March 20th 1991.

Originated by :



W.J. Kemper
Q&R Investigations Engineer

Approved by :



C.Th.A Revenberg
Q&R Investigations Manager

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1 General Information

The following Rood Testhouse numbers can be used for reference:

- Rood Testhouse report number : QRR91005 Revised Version.
- Rood Testhouse project number : 052187/03
- Rood Testhouse order number : 91000022/00

This report describes the results of a quality and reliability investigation that was performed for ESA/ESTEC, Noordwijk, The Netherlands. The test procedure and the used test equipment are listed in section 3 and 4. The results of the electrical tests are presented in tables with the device numbers that failed a specific electrical test and pictures of selected parameters.

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2 Summary

For this quality and reliability investigation several AC/ACT 00, AC/ACT 138 and AC/ACT 373 device types of Texas Instruments, National Semiconductor and Motorola were exposed to CO-60 radiation. The total number of electrical test read outs was eight: after 0, 5, 10, 15, 25, 50, 100 kRad and after 168 hours annealing at +100°C. The radiation exposure was performed at ESTEC and the electrical tests were performed at Rood Testhouse on a MCT 2000 tester.
The results of the electrical tests are as follows:

For the AC00 devices:

- The Texas Instruments devices showed hard failures on Iccl and Icch after 10 kRad, the National Semiconductor and Motorola devices showed no failures at all.

For the ACT00 devices:

- The Texas Instruments devices showed hard failures on Iccl and Icch after 15kRad and a failure on Tplh after 50 kRad, the Motorola devices showed failures on the Vol measurements were the setup was done with critical input levels.

For the AC138 devices:

- The Texas Instruments devices showed hard failures at Iccl and Icch after 10 kRad and after 50 kRad also failures at Iil, Vol, Voh and Tphl tests. One device was failing at a hard functional test after 100 kRad. The National Semiconductor and Motorola devices showed also some failures on Iccl and Icch but the measured current was just out of specification.

For the ACT138 devices:

- The Texas Instruments devices and the National Semiconductor devices had failures at the Iccl and Icch tests. The Texas Instruments devices had failures at Ilh after 50 kRad and Vol after 100 Krad. The Motorola device had failures at Vil after 100 kRad.

For the AC373 devices:

- Both the Texas Instruments and National Semiconductor devices showed failures on several parameters, all Texas Instruments devices failed easy functional fail after annealing. The Motorola devices had failures on Iccl and Icch but the electrical test limits of these parameters are more severe than the limits of Texas Instruments and National Semiconductor devices

For the ACT373 devices

- The Texas Instruments devices had failures on several parameters and they failed easy functional after annealing. The National devices had failures on Vil after 50 kRad and one hard functional failure after 100 kRad. The Motorola devices had failures on different parameters.

In general it can be concluded that the radiation has influenced the Texas Instruments devices more than the National Semiconductor and Motorola devices. There is no significant difference in radiation sensitivity between the National Semiconductor devices and the Motorola devices, in some cases the National Semiconductor devices are better and in some cases the Motorola devices are better.

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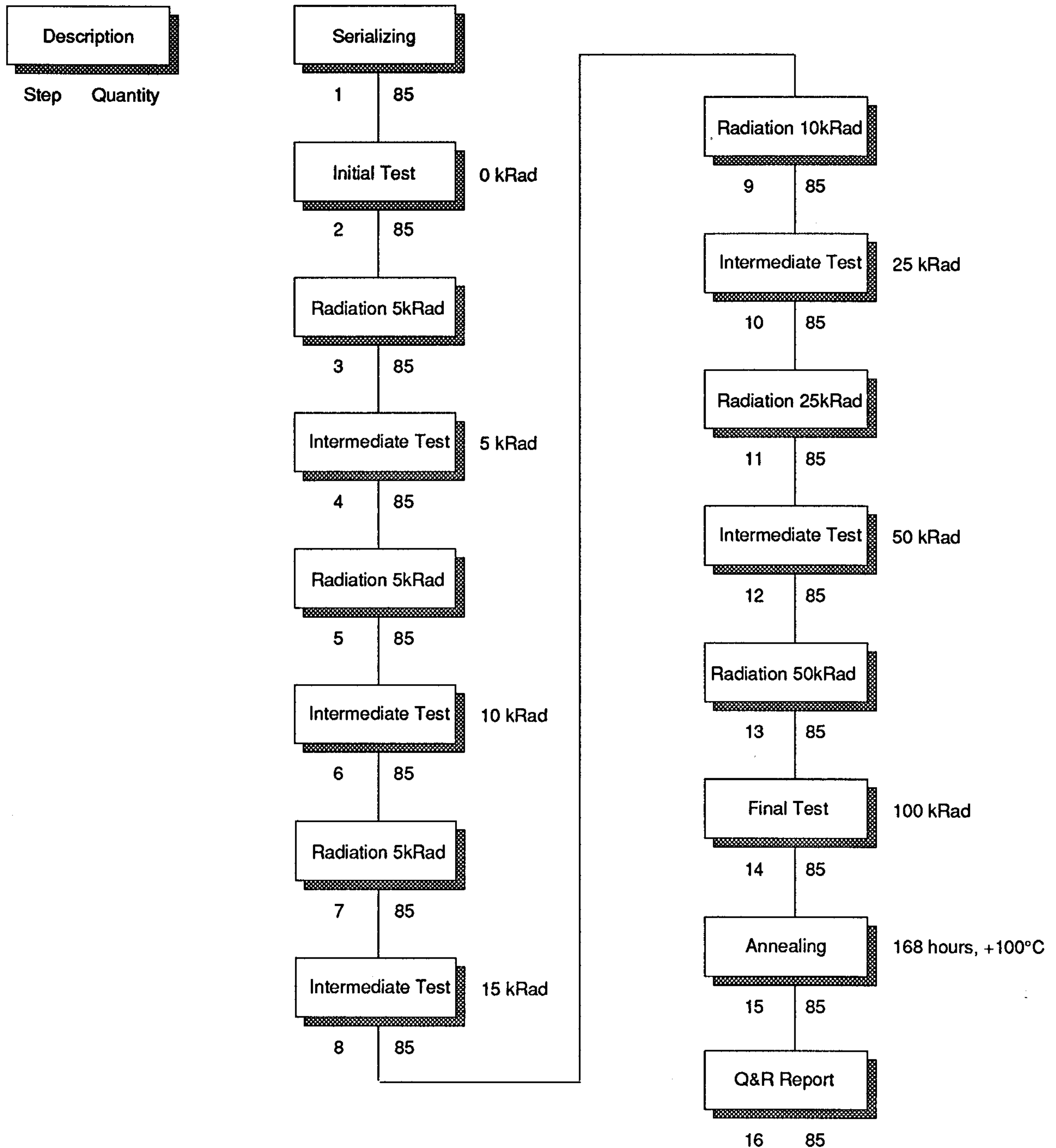
2.1 Procedure Flow

The following procedure diagram illustrates the used procedure.



2.2 Detailed Description

Table 2-1 Detailed Procedure Description

Step No.	Procedure Description	Quantity
1	Serialization of the devices.	85
2	Initial electrical test at ambient.	85
3	Radiation 5kRad at ESTEC.	85
4	Electrical test at ambient.	85
5	Radiation 5 kRad at ESTEC to a sub–total of 10 kRad.	85
6	Electrical test at ambient.	85
7	Radiation 5 kRad at ESTEC to a sub–total of 15 kRad.	85
8	Electrical test at ambient.	85
9	Radiation 10 kRad at ESTEC to a sub–total of 25 kRad.	85
10	Electrical test at ambient.	85
11	Radiation 25 kRad at ESTEC to a sub–total of 50 kRad.	85
12	Electrical test at ambient.	85
13	Radiation 50 kRad at ESTEC to a total of 100 kRad.	85
14	Electrical test at ambient.	85
15	Annealing 168 hours at +100 °C	85
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2.3 Specifications

The chapter describes which specifications were used for the electrical tests:

For the AC00 devices:

- All manufacturers: MIL-M-38510/750, March 15th 1989

For the ACT00 devices:

- Texas Instruments: T.I. Advanced CMOS Logic Data Book 1989, +25 °C
- Motorola: NAT. FACT. Advanced CMOS Logic Data Book 1989 -55/+125 °C

For the AC138 devices:

- All manufacturers: MIL-M-38510/758, December 28th 1989

For the ACT138 devices:

- Texas Instruments: T.I. Advanced CMOS Logic Data Book 1989, +25 °C
- National Semiconductor: NAT. FACT. Advanced CMOS Logic Data Book 1989 -55/+125 °C
- Motorola: NAT. FACT. Advanced CMOS Logic Data Book 1989 -55/+125 °C

For the AC373 devices:

- Texas Instruments: T.I. Advanced CMOS Logic Data Book 1989, +25 °C
- National Semiconductor: MIL-M-38510/754, April 13th 1990
- Motorola: MIL-M-38510/754, April 13th 1990

For the ACT373 devices:

- Texas Instruments: T.I. Advanced CMOS Logic Data Book 1989, +25 °C
- National Semiconductor: NAT. FACT. Advanced CMOS Logic Data Book 1989 -55/+125 °C
- Motorola: NAT. FACT. Advanced CMOS Logic Data Book 1989 -55/+125 °C

The testflows of the electrical tests are available on request.

3 Equipment List

Electrical Test Equipment

- MCT 2000

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4 Device Description

The following devices were submitted to this investigation:

- Of the AC00 types:
  - Texas Instruments SN54AC11000J
  - National Semiconductor 54AC00DMQB
  - Motorola 54AC00/BCA
- Of the ACT00 types:
  - Texas Instruments SNJ54ACT11000J
  - Motorola 54ACT00/BCA
- Of the AC138 types:
  - Texas Instruments SNJ54AC11138J
  - National Semiconductor 54AC138DMQB
  - Motorola 54AC138/BCA
- Of the ACT138 types:
  - Texas Instruments SNJ54ACT11138J
  - National Semiconductor 54ACT138DMQB
  - Motorola 54ACT138/BCA
- Of the AC373 types:
  - Texas Instruments 74AC11373NT
  - National Semiconductor 54AC373DMQB
  - Motorola 54AC373/BRA
- Of the ACT373 types:
  - Texas Instruments SNJ54ACT11373JT
  - National Semiconductor 54ACT373DMQB
  - Motorola 54ACT373/BRA

5 Test Results

This section gives a presentation of the measured data of this investigation.

The following items are included for each device type:

- a table with the device numbers that failed a certain test during the read-outs
- several pictures of selected parameters

The pictures represent the measured values at each read-out. Of each device only the minimum and maximum values are plotted. Each device has its own symbol.

The following parameters were selected:

- For the AC00 devices: Iil, Iih, Iccl, Icch, Icc
- For the ACT00 devices: Iil, Iih, Iccl, Icch, Icc, Tplh
- For the AC138 devices: Iil, Vol (2x), Voh, Iccl, Icch, Icc
- For the ACT138 devices: Iih, Vil, Vol, Iccl, Icch, Icc
- For the AC373 devices: Iih, Vil, Vih, Iozh, Iccl, Tplz
- For the ACT373 devices: Iih, Vil, Vol, Iozh, Iccl, Tplz

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Table 5-1 Fail devices Texas Instruments 54AC11000J

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	2	-	-
Iih	-	-	-	-	-	2	-	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	3,4	3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icch	-	-	3,4	3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Table 5-2 Fail devices National Semiconductor 54AC00DMQB

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	-	-	-	-
Icch	-	-	-	-	-	-	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Table 5-3 Fail devices Motorola 54AC00/BCA

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	-	-	-	-
Icch	-	-	-	-	-	-	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

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Figure 5-1 Iil Texas Instruments 54AC11000J

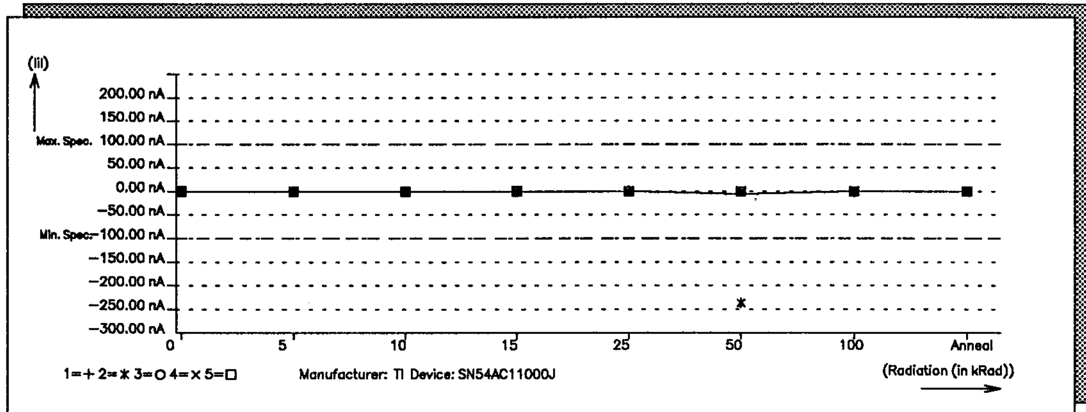

Figure 5-2 Iil National Semiconductor 54AC00DMQB

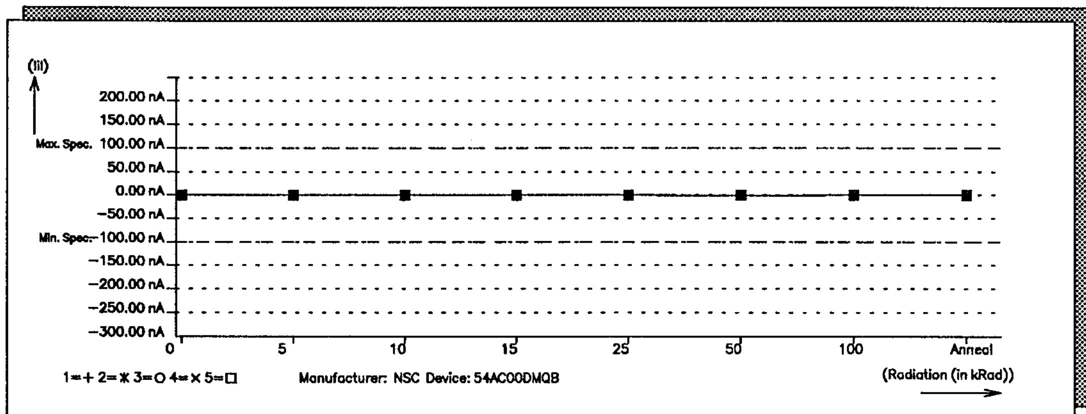

Figure 5-3 Iil Motorola 54AC00/BCA

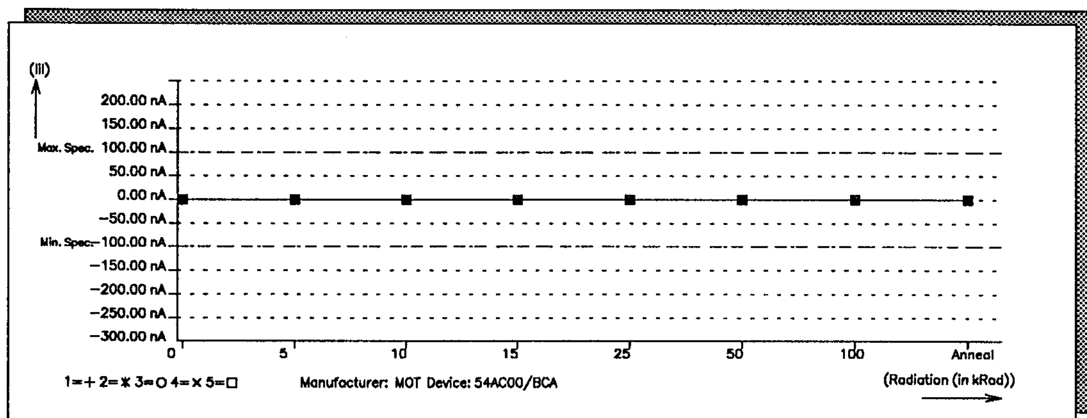

Figure 5-4 Iih Texas Instruments 54AC11000J

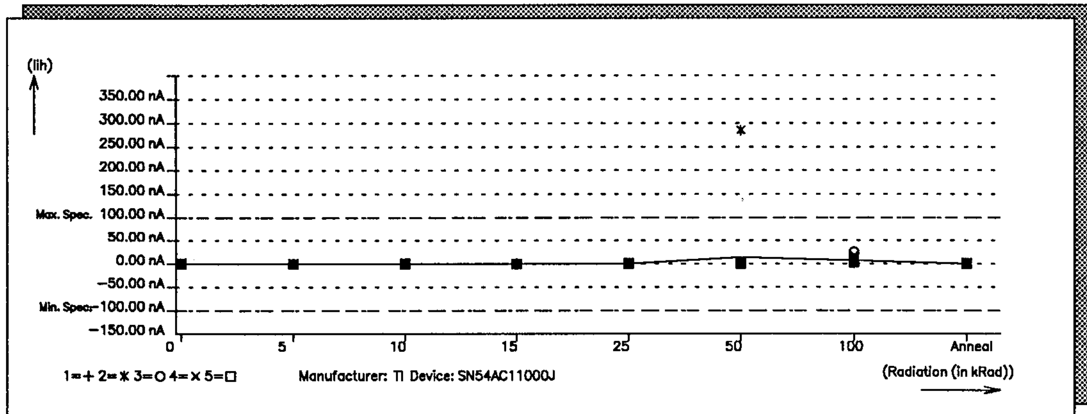

Figure 5-5 Iih National Semiconductor 54AC00DMQB

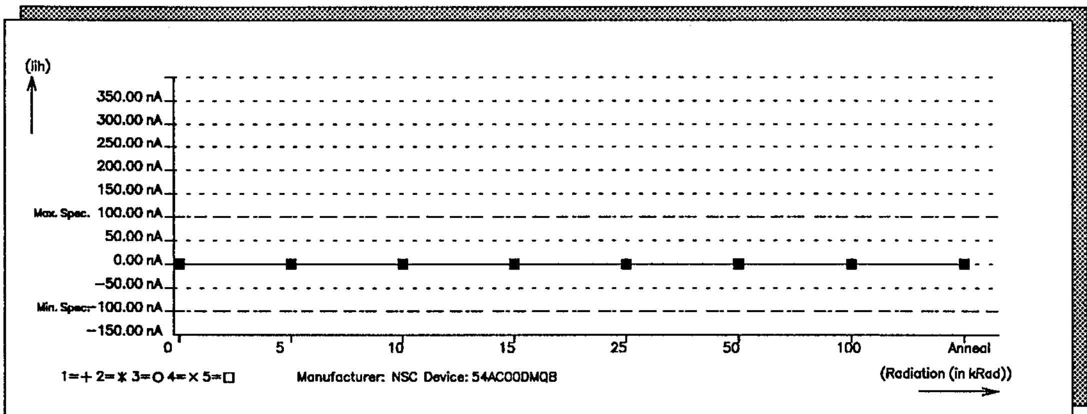

Figure 5-6 Iih Motorola 54AC00/BCA

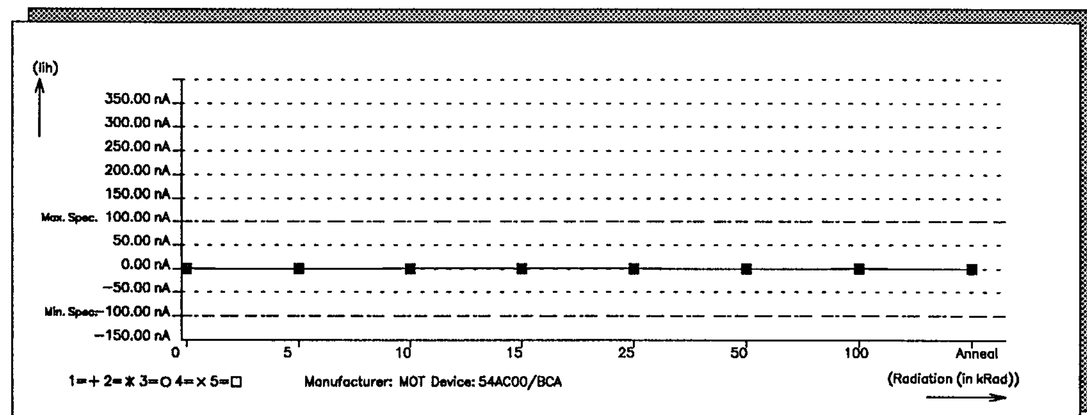

Figure 5-7 Iccl Texas Instruments 54AC11000J

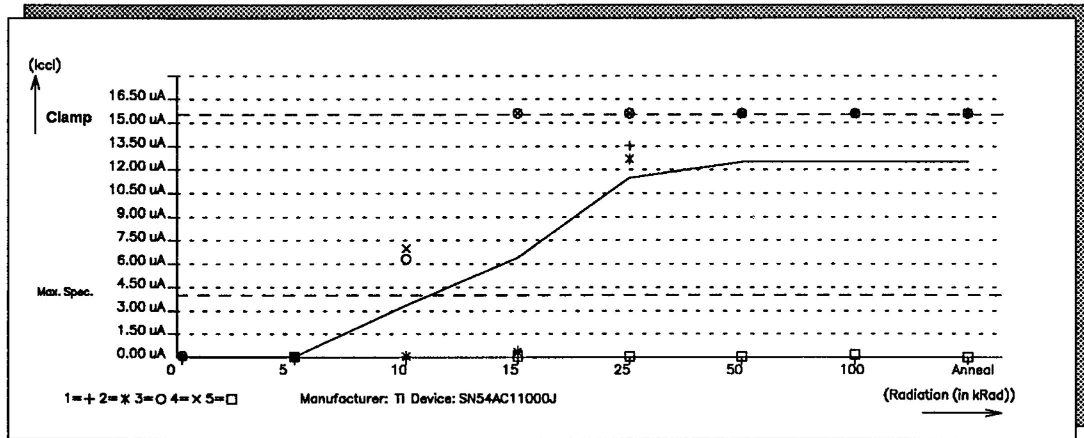

Figure 5-8 Iccl National Semiconductor 54AC00DMQB

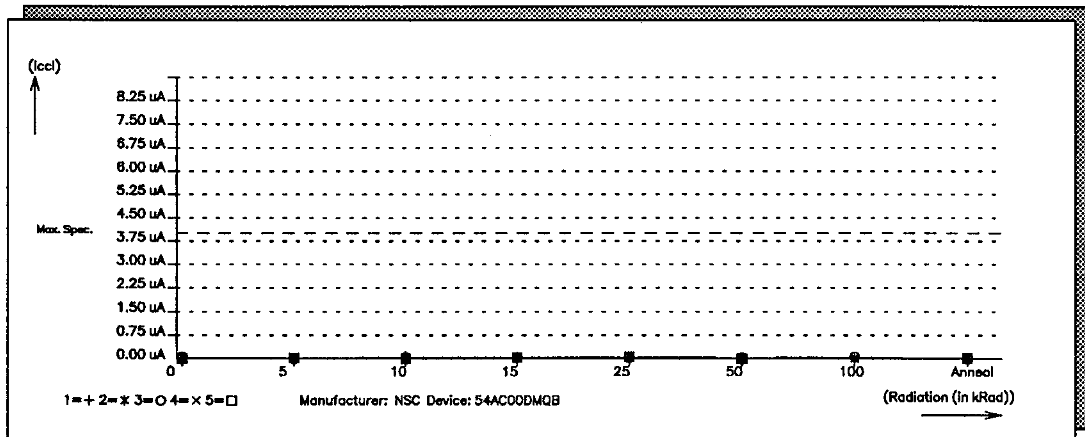

Figure 5-9 Iccl Motorola 54AC00/BCA

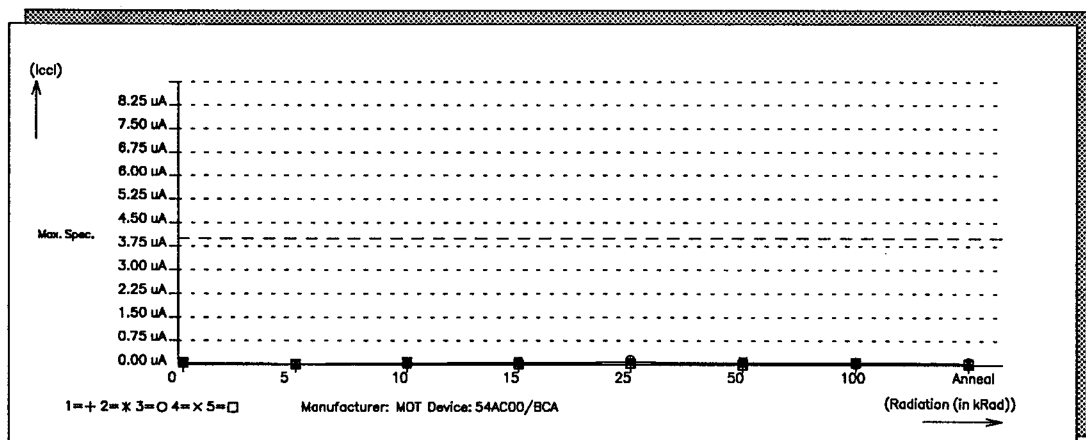

Figure 5-10 Icch Texas Instruments 54AC11000J

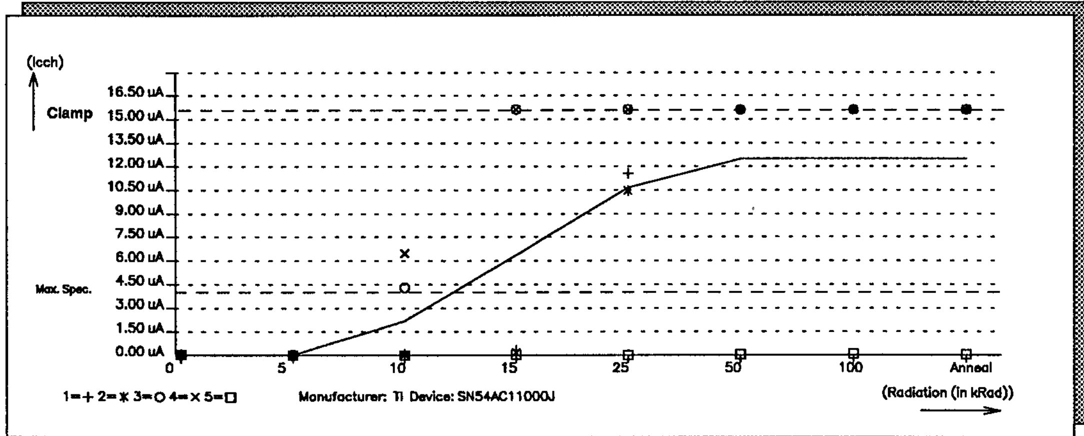

Figure 5-11 Icch National Semiconductor 54AC00DMQB

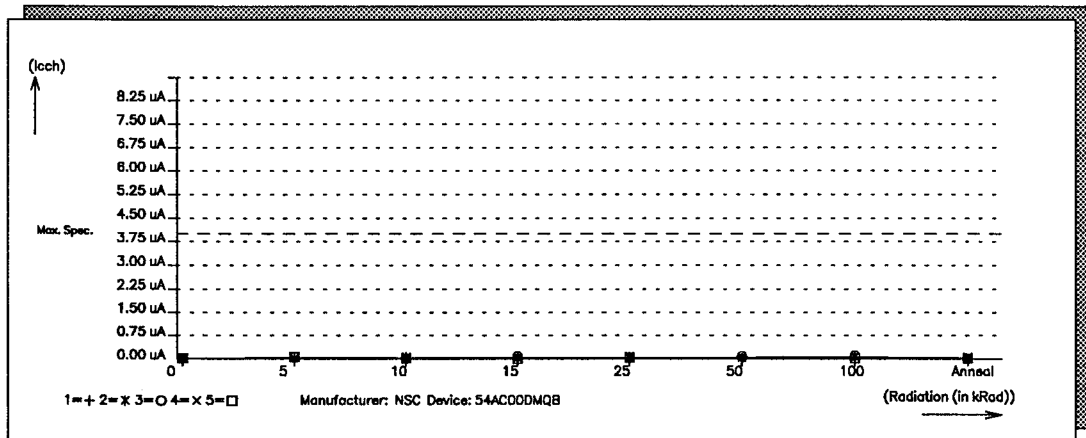

Figure 5-12 Icch Motorola 54AC00/BCA

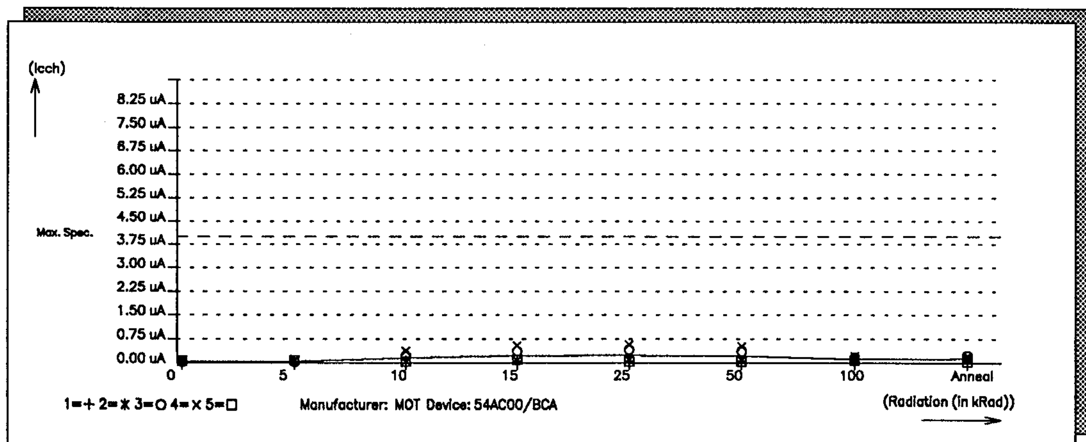

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Figure 5-13 Icc Texas Instruments 54AC11000J

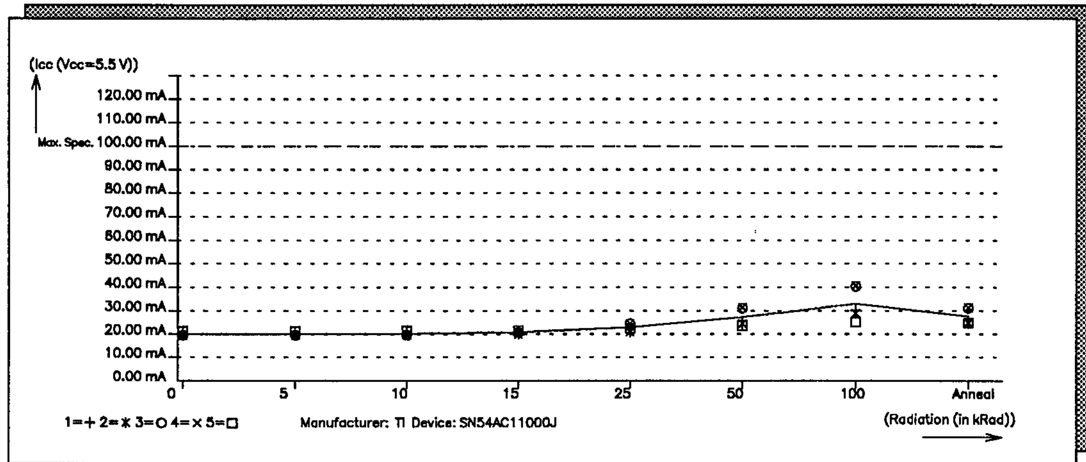

Figure 5-14 Icc National Semiconductor 54AC00DMQB

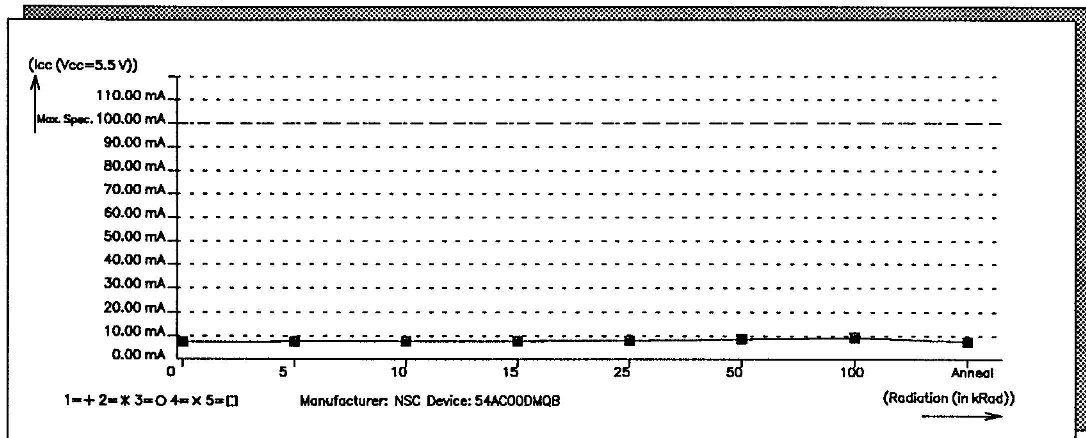

Figure 5-15 Icc Motorola 54AC00/BCA

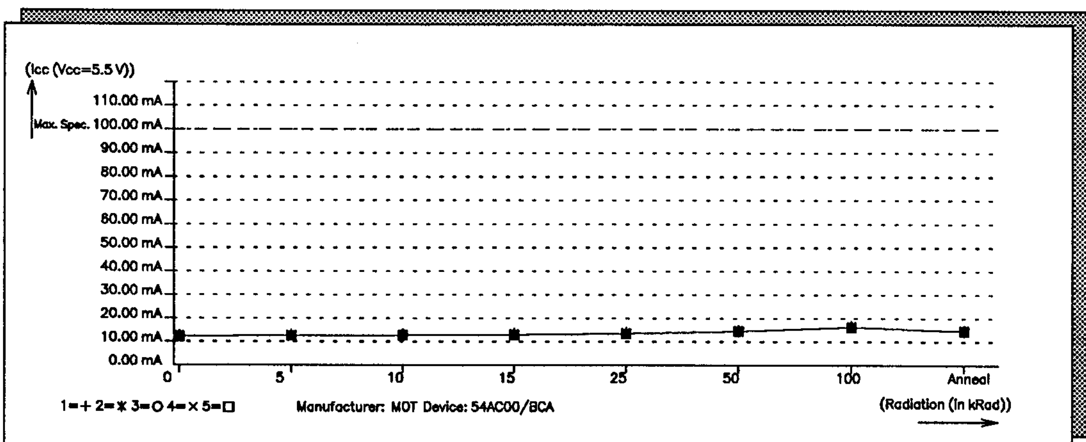

Table 5-4 Fail devices Texas Instruments 54ACT11000J

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	3	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	4	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	3,4	1,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icch	-	-	-	3,4	1,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	3	3	-
tPHL	-	-	-	-	-	-	-	-

Table 5-5 Fail devices Motorola 54ACT00/BCA

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	All	-
Vih	-	-	-	-	-	-	-	-
Vol	All	All	All	All	All	All	-	1
Voh	1	1	1,2	1	-	-	3	-
Iccl	-	-	-	-	-	-	-	-
Icch	-	-	-	-	-	-	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Remarks:

- The failures at the Vol and Voh measurements of the Motorola devices are caused by a setup problem and not by radiation. If the input levels are set according to the specification these devices does not recognize them correctly. With less critical input levels these devices behave normal.
- Device #4 of Texas Instruments had an increased Vol level at pin 6 after 100kRad. The measured value was 508.49 mV at the conditions: Vcc=4.5 V, Iol=24 mA. The specification for this test is 360 mV maximum.

Figure 5-16 Iil Texas Instruments 54ACT11000J

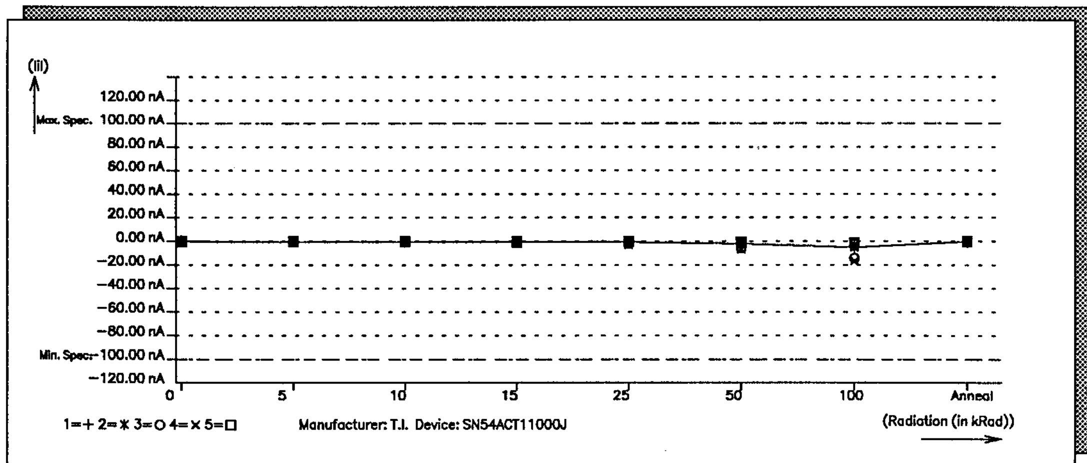

Figure 5-17 Iil Motorola 54ACT00/BCA

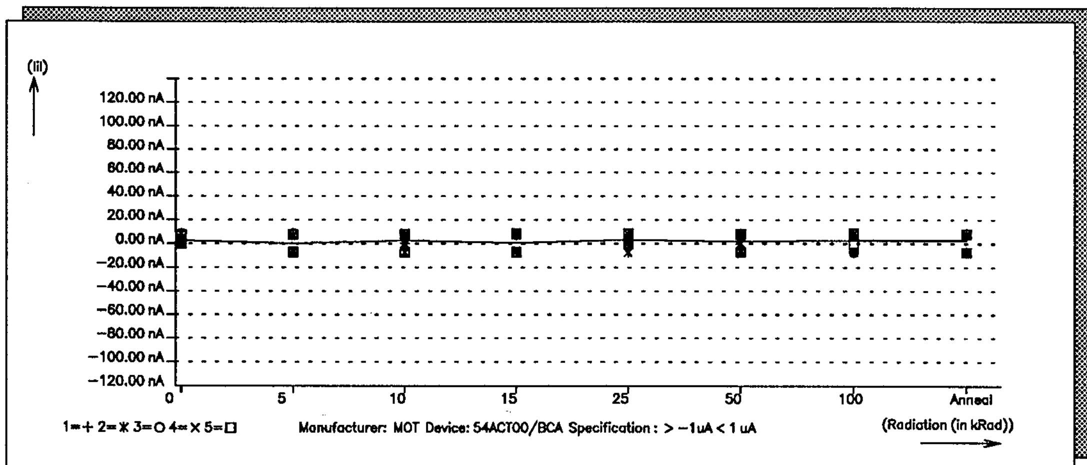

Figure 5-18 Iih Texas Instruments 54ACT11000J

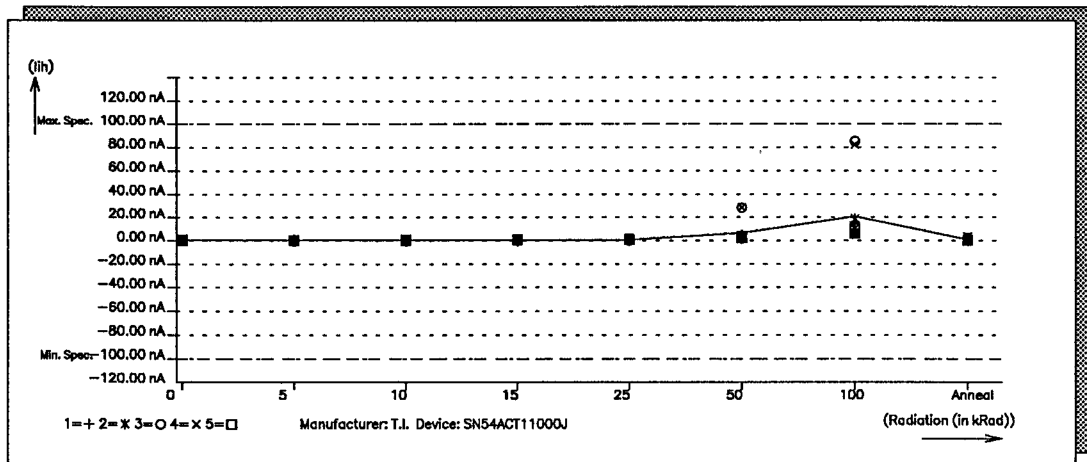

Figure 5-19 Iih Motorola 54ACT00/BCA

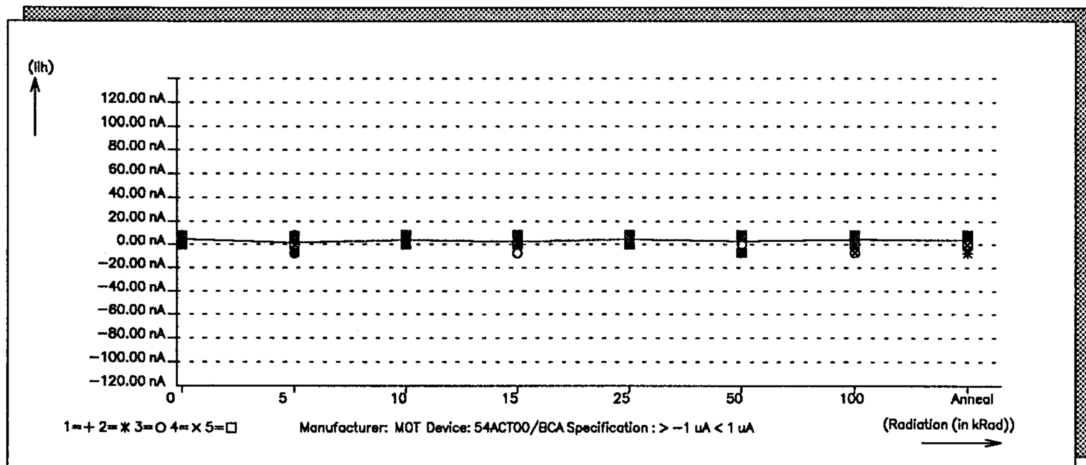

Figure 5-20 Iccl Texas Instruments 54ACT11000J

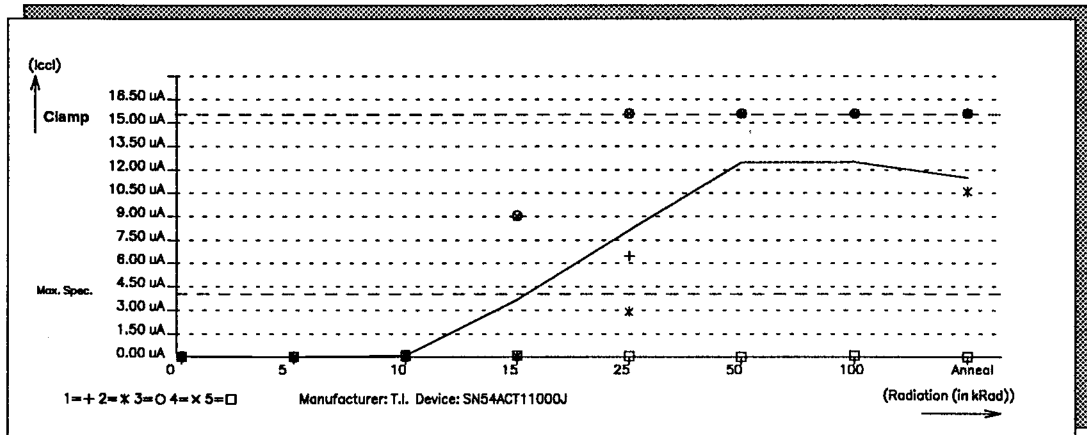

Figure 5-21 Iccl Motorola 54ACT00/BCA

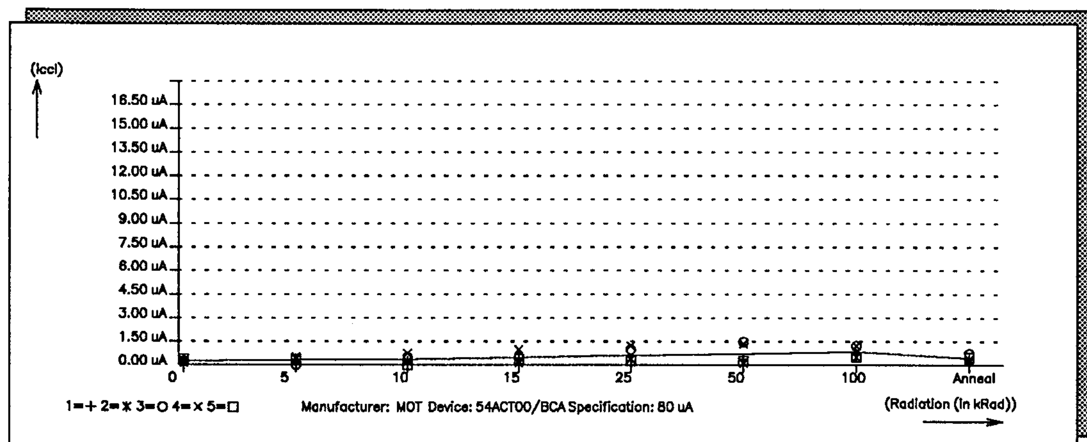

Figure 5-22 Icch Texas Instruments 54ACT11000J

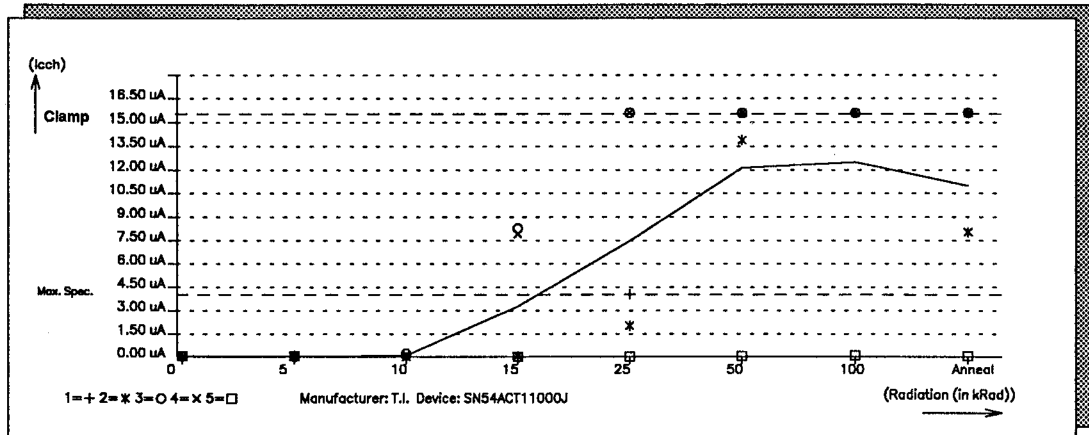

Figure 5-23 Icch Motorola 54ACT00/BCA

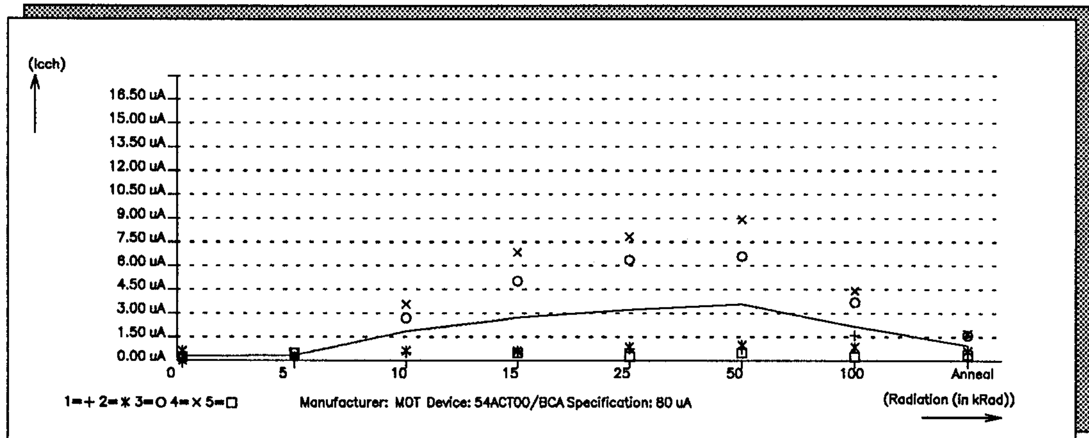

Figure 5-24 Icc Texas Instruments 54ACT11000J

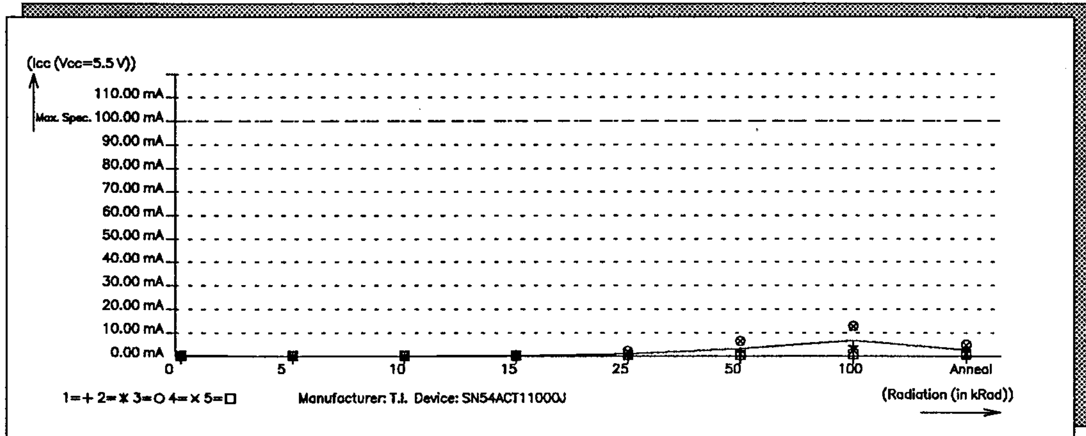

Figure 5-25 Icc Motorola 54ACT00/BCA

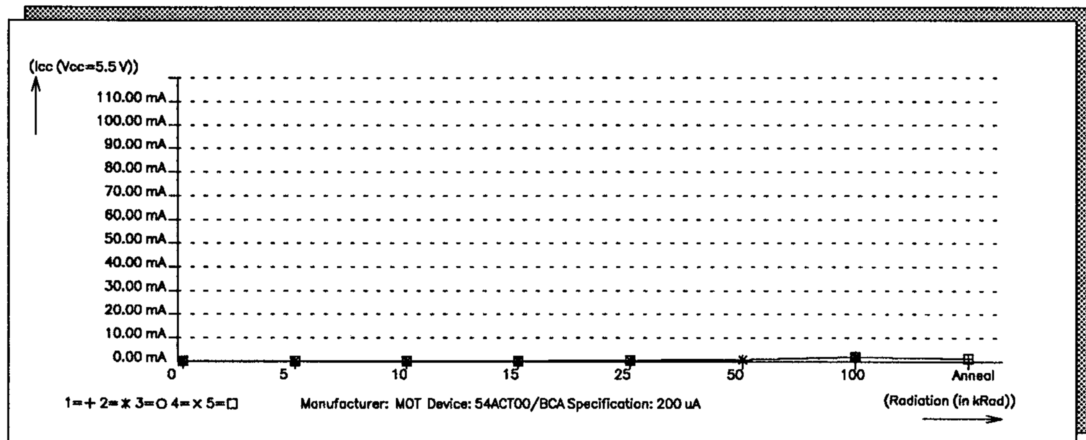

Figure 5-26 Tplh Texas Instruments 54ACT11000J

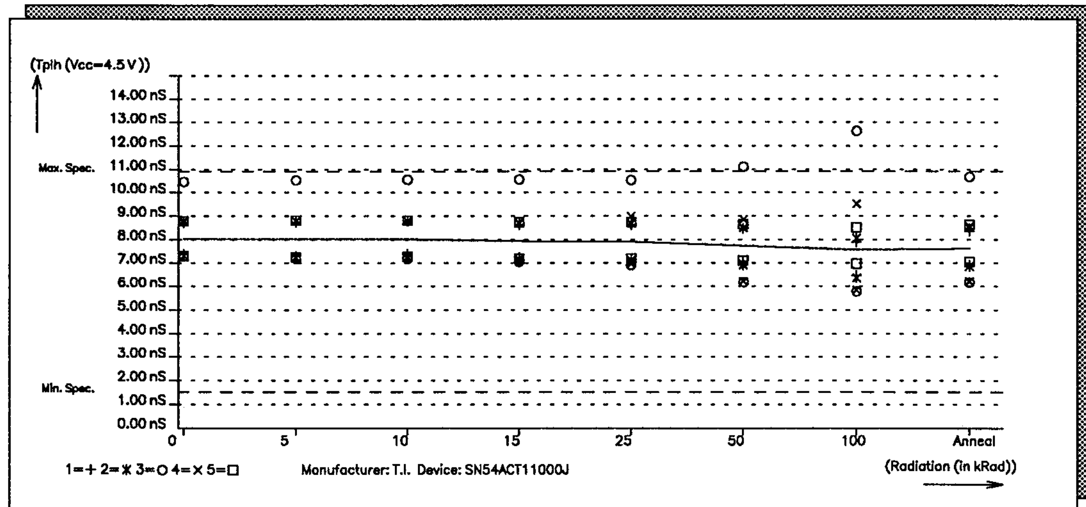

Figure 5-27 Tplh Motorola 54ACT00/BCA

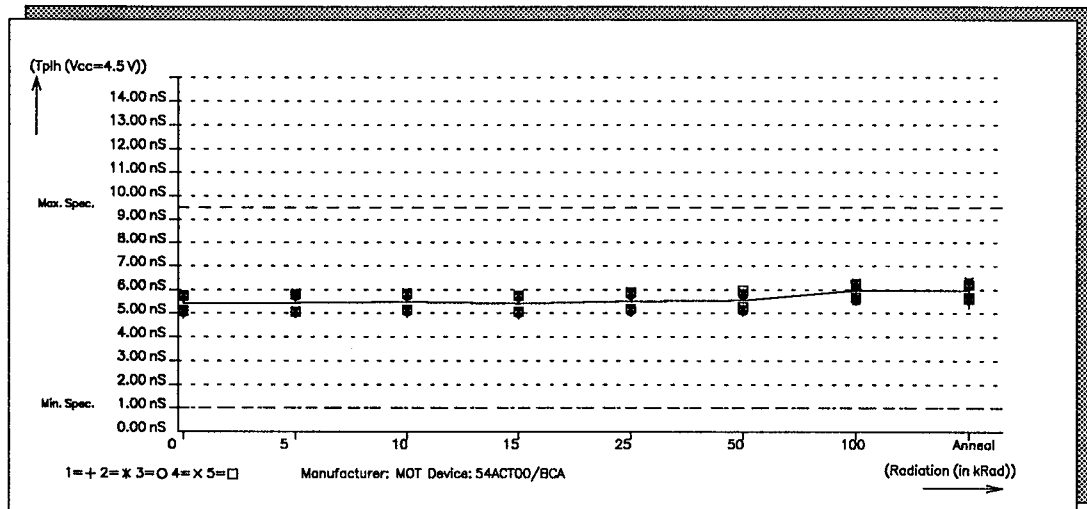

Table 5-6 Fail devices Texas Instruments 54AC11138J

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	3,4	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	3	2,3,4	3
Voh	-	-	-	-	-	-	3	-
Iccl	-	-	3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icch	-	-	3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	3	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	3	-

Table 5-7 Fail devices National Semiconductor 54AC138DMQB

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	4	4	-	-
Icch	-	-	-	-	4	4	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Table 5-8 Fail devices Motorola 54AC138/BEA

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	3,4	3,4	3,4	-	-
Icch	-	-	-	3,4	3,4	3,4	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Remark:

- The Texas Instruments Device #3 failure at Voh after 100 kRad is a critical failure. The specification limit is 2.90 V and the measured value was 2.89 V. Conditions: Vcc=3.0 V, Ioh= 50 uA.

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Figure 5-28 Iih Texas Instruments 54AC11138J

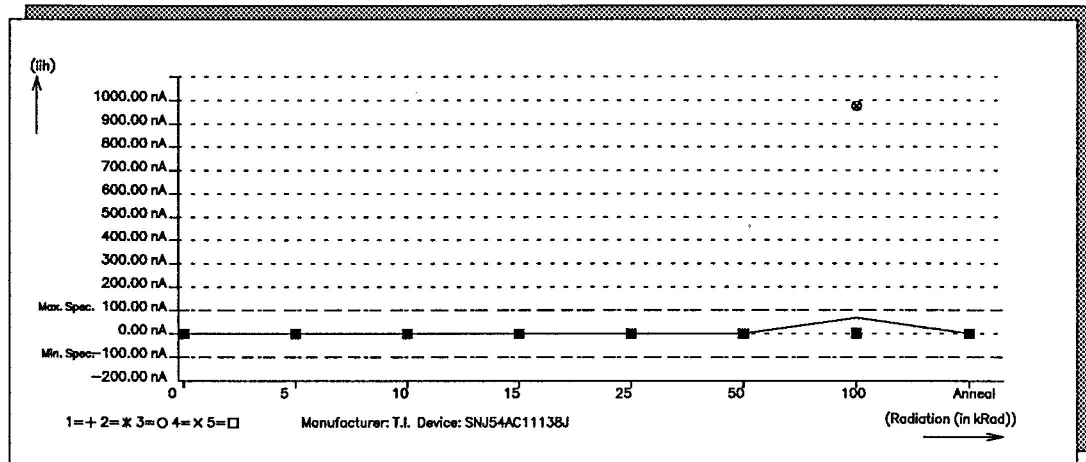

Figure 5-29 Iih National Semiconductor 54AC138DMQB

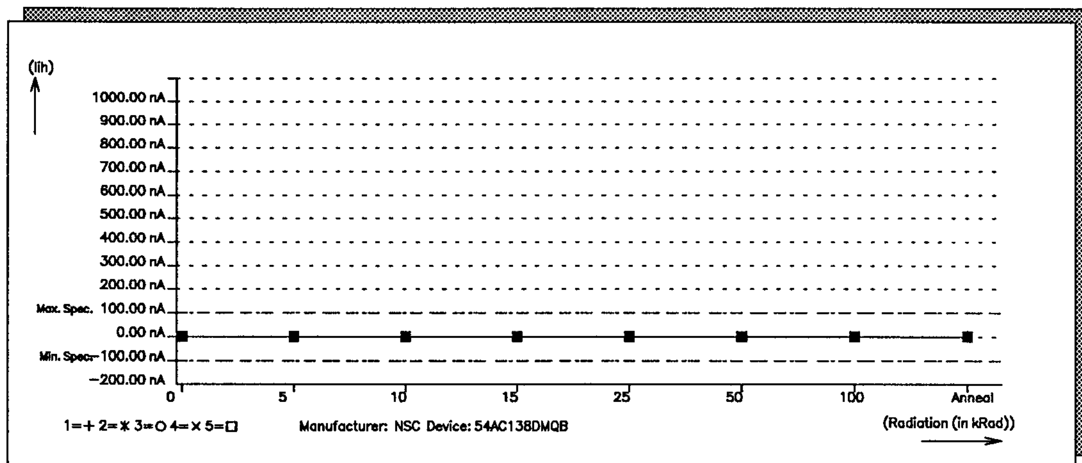

Figure 5-30 Iih Motorola 54AC138/BCA

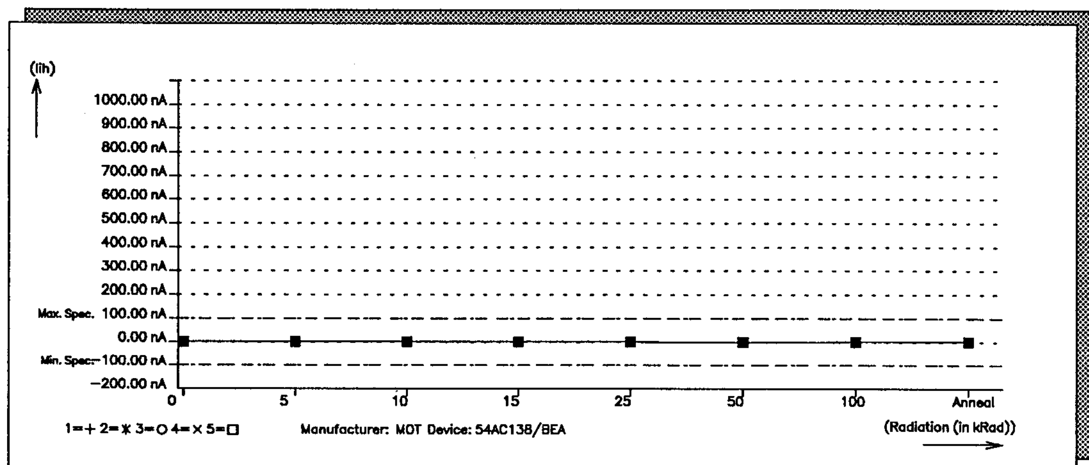

Figure 5-31 Vol1 Texas Instruments 54AC11138J

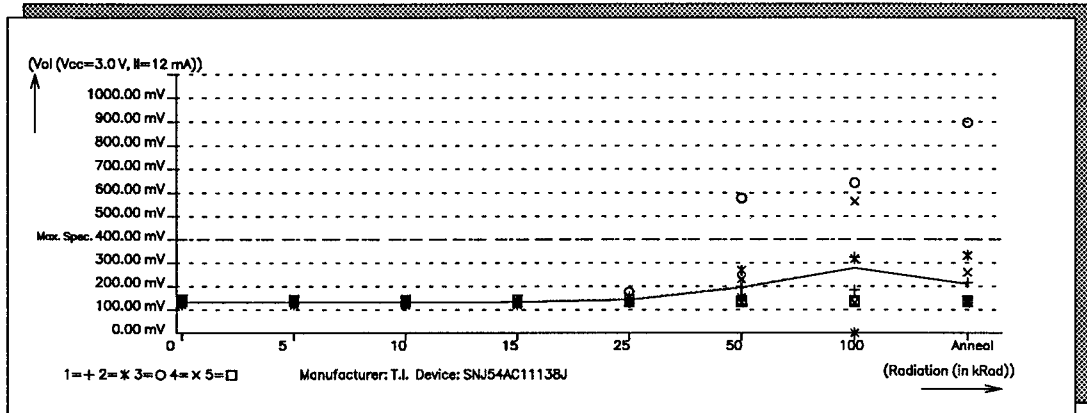

Figure 5-32 Vol1 National Semiconductor 54AC138DMQB

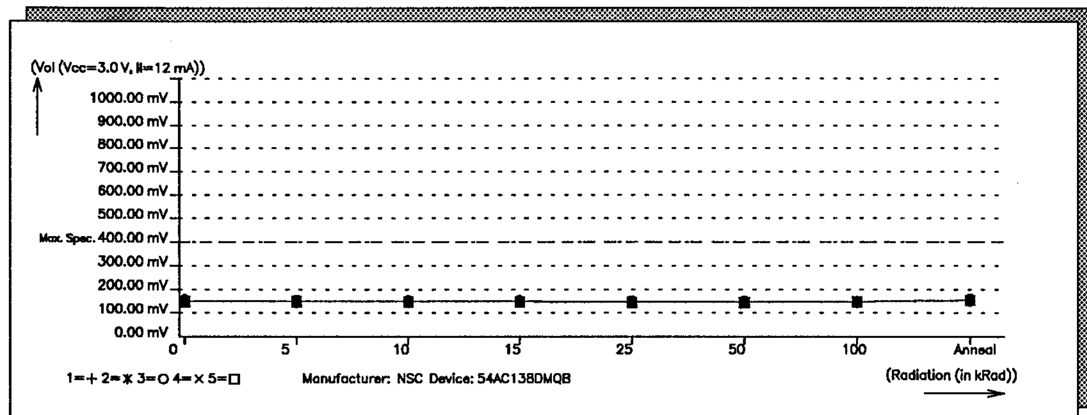

Figure 5-33 Vol1 Motorola 54AC138/BCA

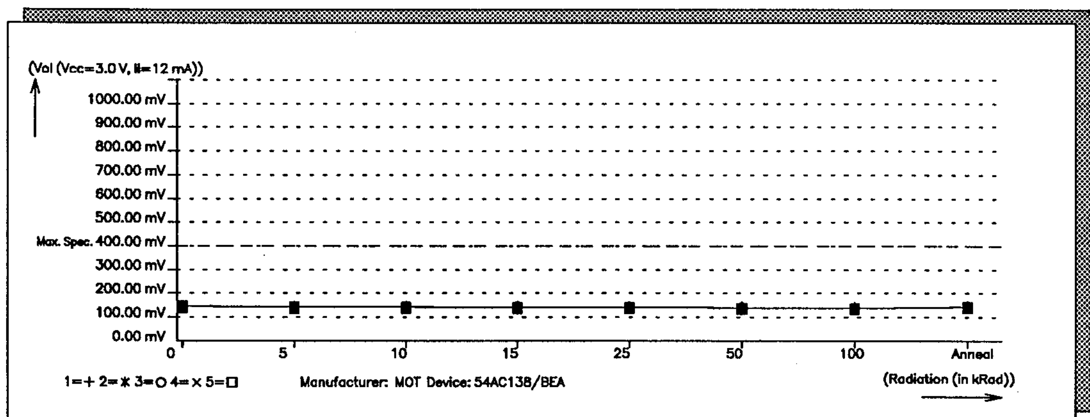

Figure 5-34 Vol2 Texas Instruments 54AC11138J

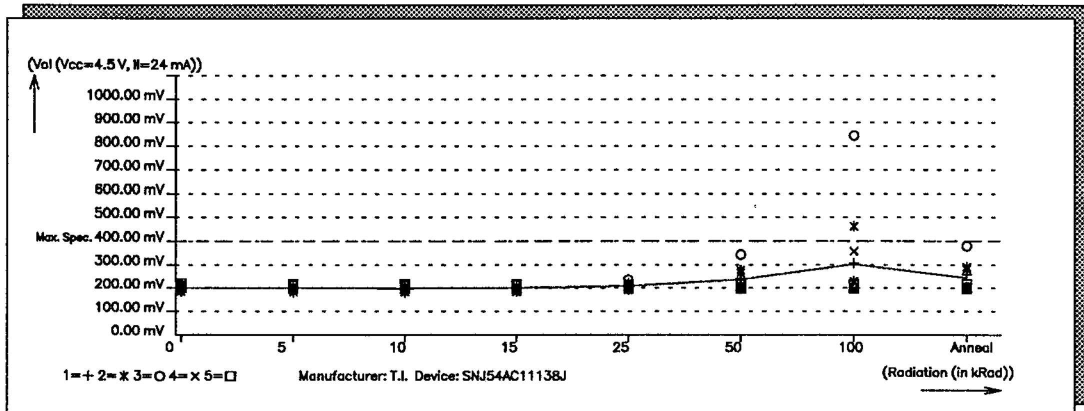

Figure 5-35 Vol2 National Semiconductor 54AC138DMQB

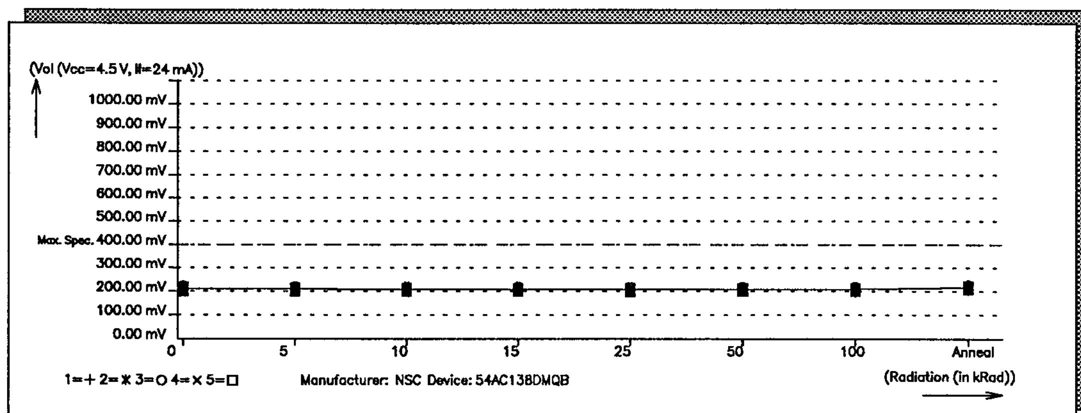

Figure 5-36 Vol2 Motorola 54AC138/BCA

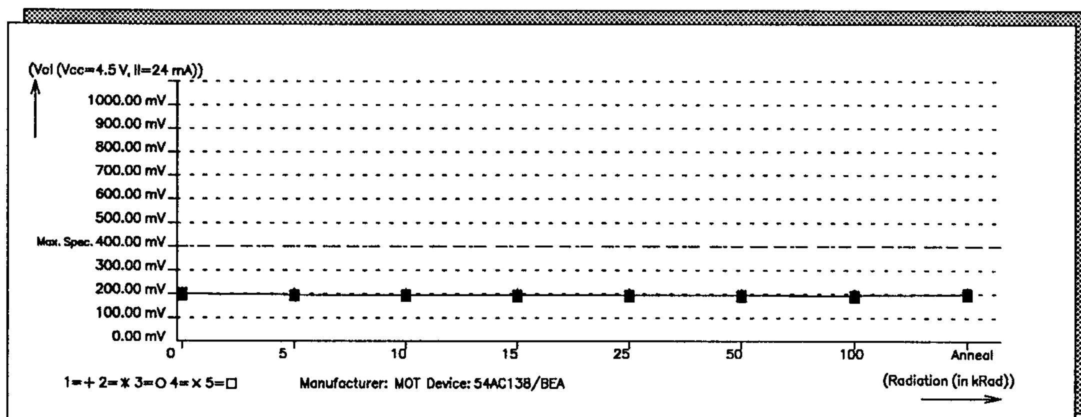

Figure 5-37 Voh Texas Instruments 54AC11138J

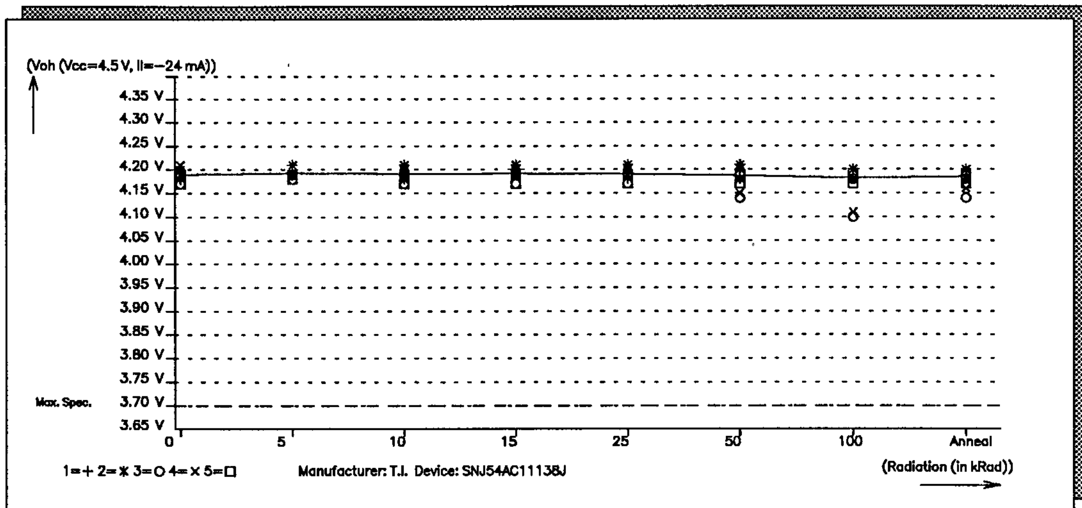

Figure 5-38 Voh National Semiconductor 54AC138DMQB

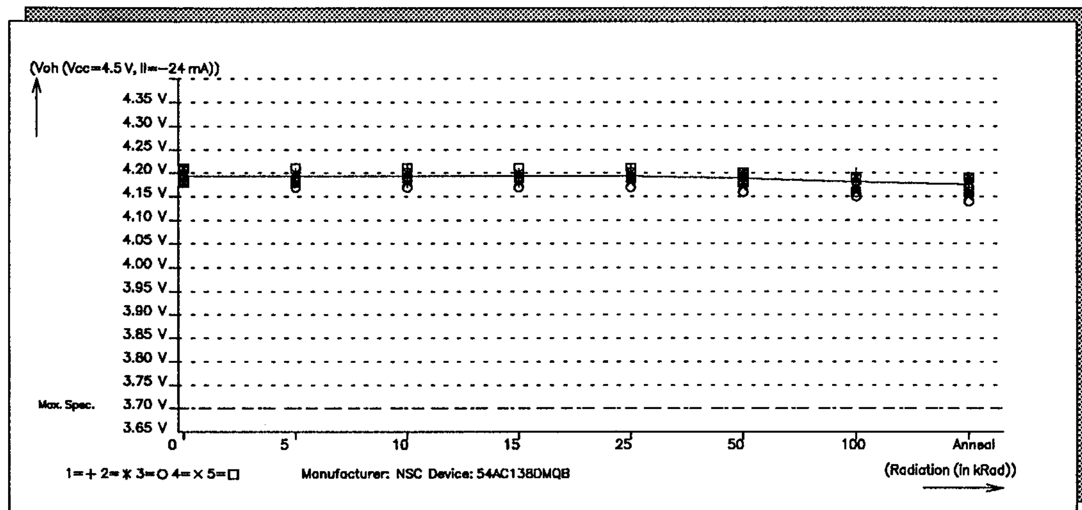

Figure 5-39 Voh Motorola 54AC138/BCA

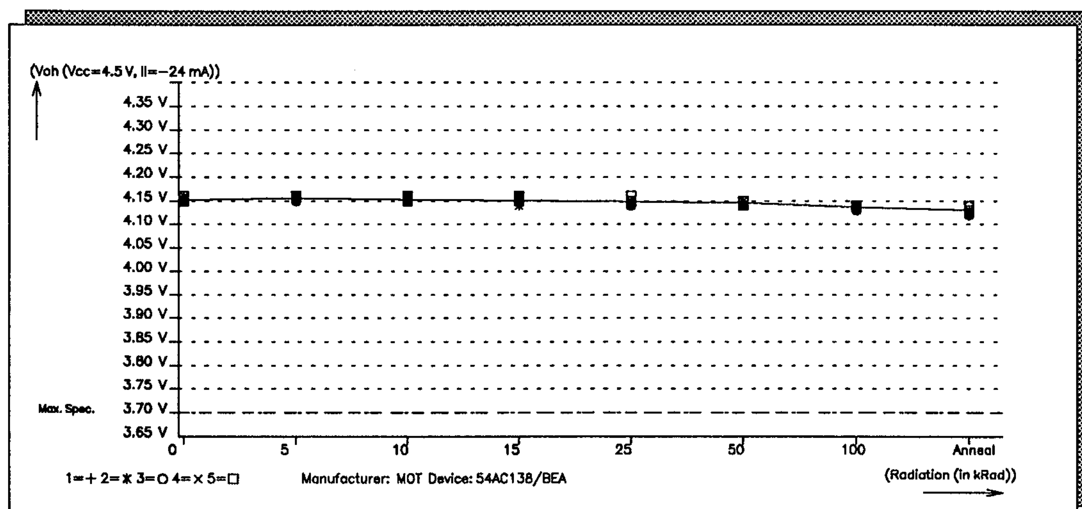

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Figure 5-40 Iccl Texas Instruments 54AC11138J

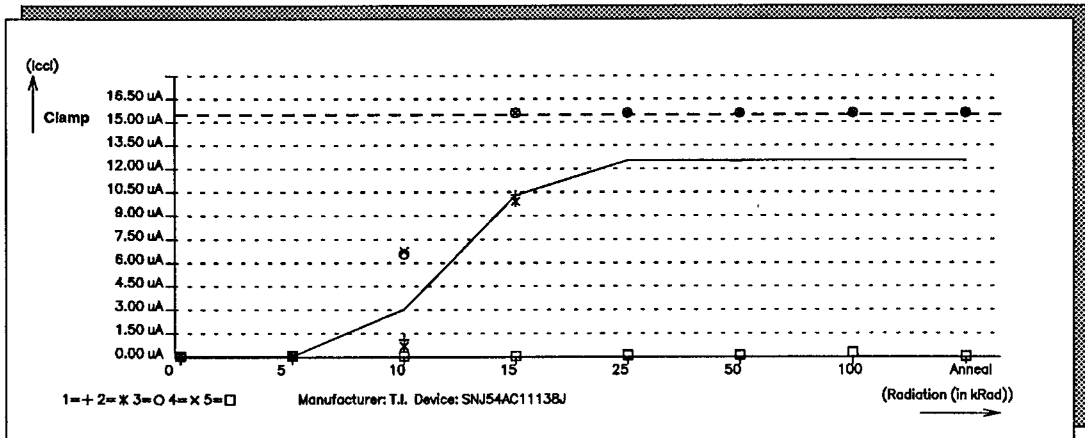


Figure 5-41 Iccl National Semiconductor 54AC138DMQB

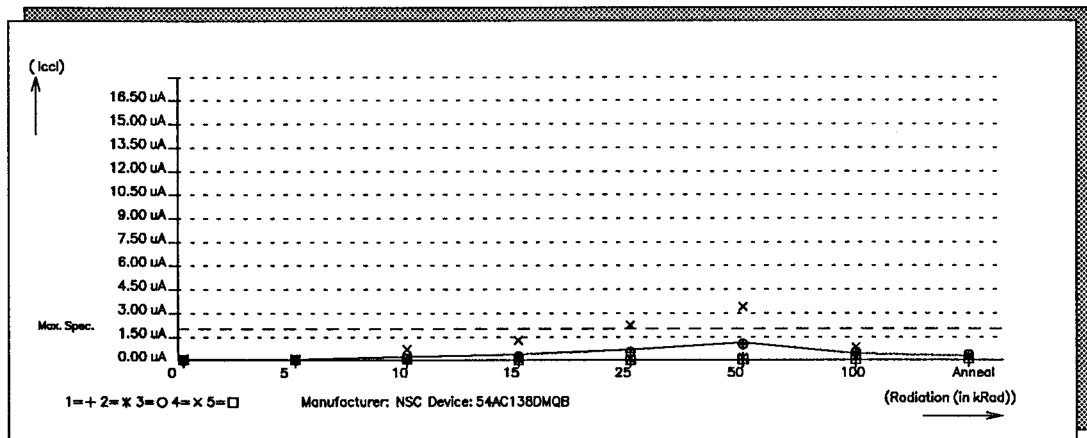


Figure 5-42 Iccl Motorola 54AC138/BCA

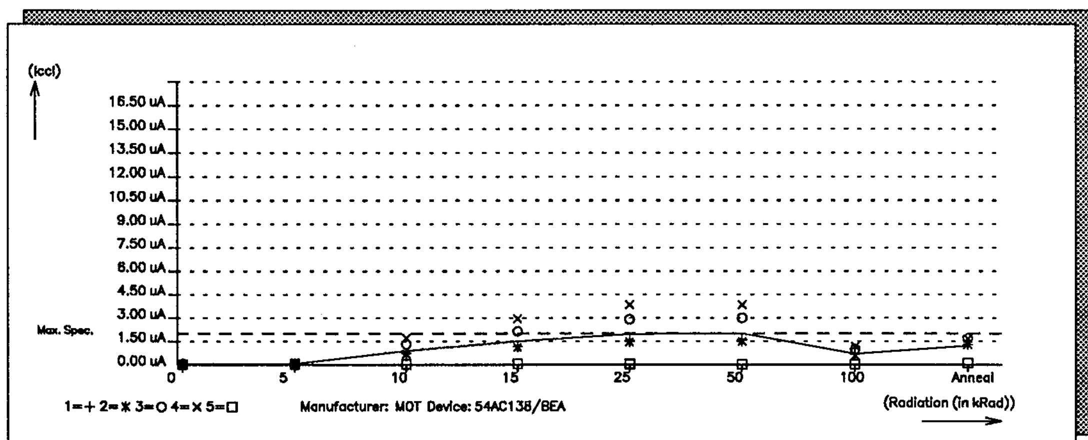


Figure 5-43 Icch Texas Instruments 54AC11138J

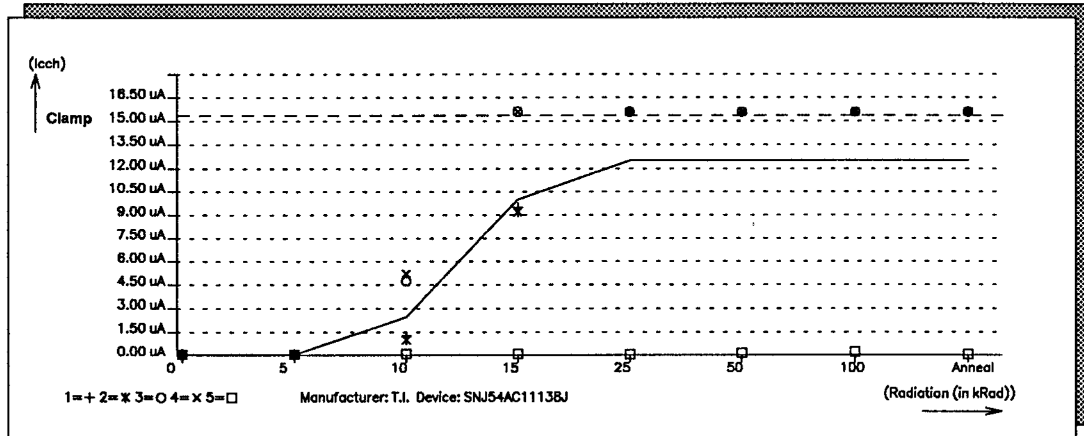


Figure 5-44 Icch National Semiconductor 54AC138DMQB

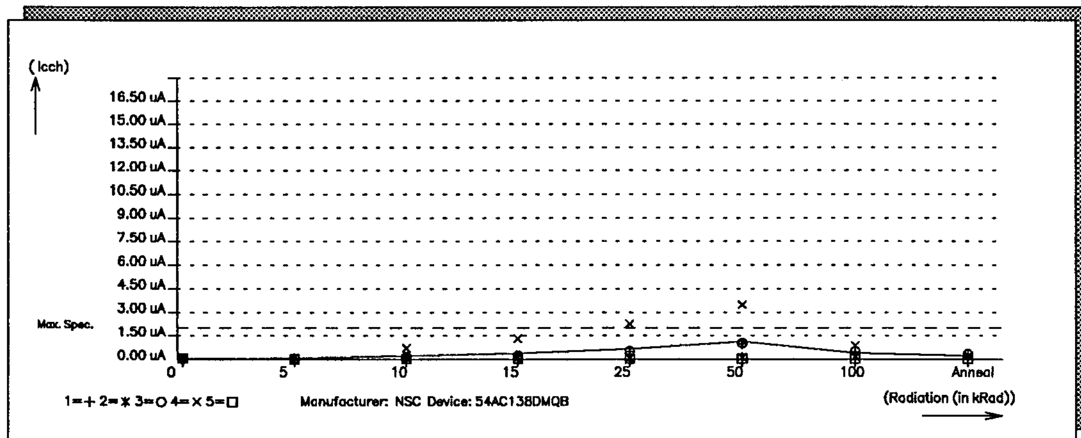


Figure 5-45 Icch Motorola 54AC138/BCA

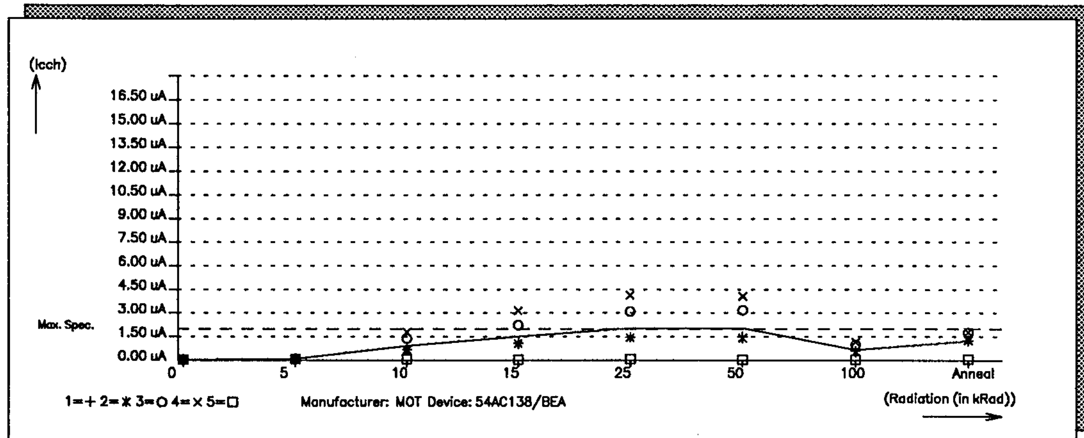


Figure 5-46 Icc Texas Instruments 54AC11138J

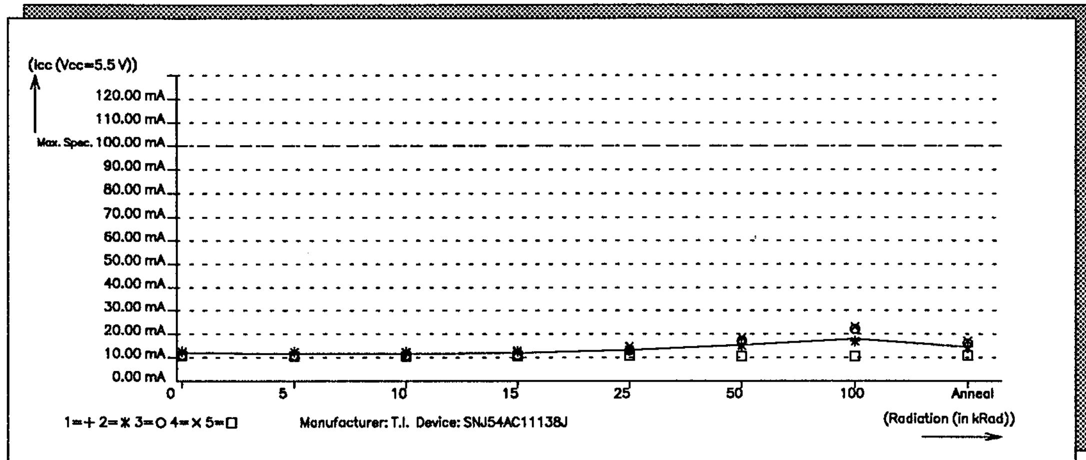


Figure 5-47 Icc National Semiconductor 54AC138DMQB

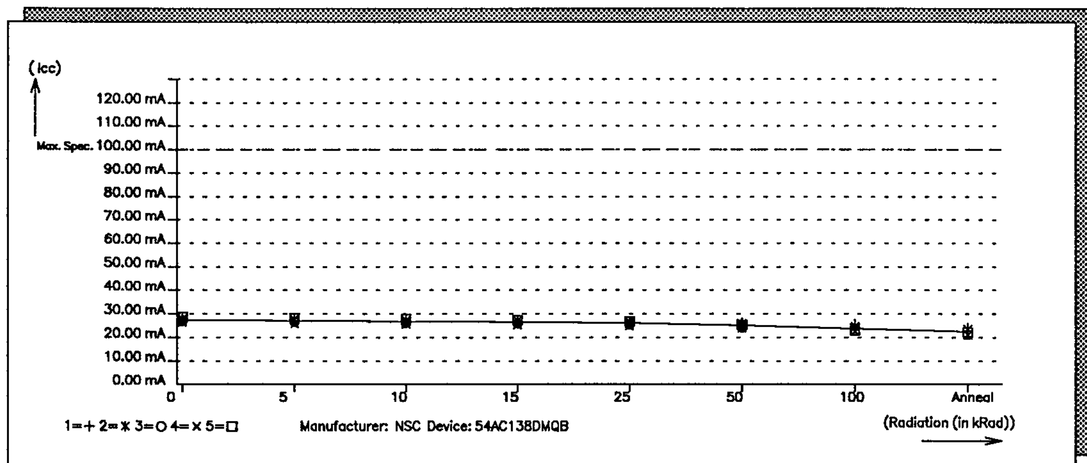


Figure 5-48 Icc Motorola 54AC138/BCA

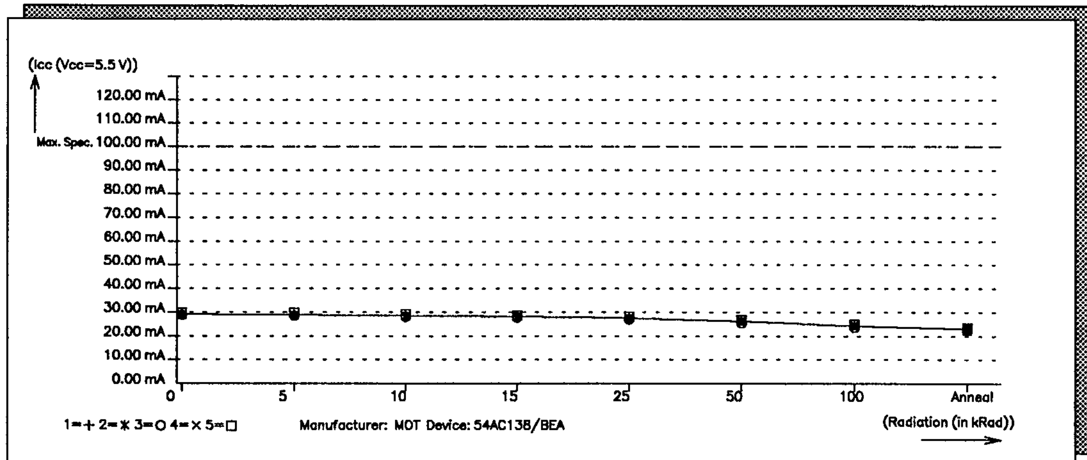


Table 5-9 Fail devices Texas Instruments 54ACT11138J

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	3	3,4	3
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	4	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icch	-	-	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Table 5-10 Fail devices National Semiconductor 54ACT138DMQB

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	5	1,3,4,5	All	1,3,5
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	-	1,3	1,2,3	-
Icch	-	-	-	-	-	1,3	1,2,3	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Table 5-11 Fail devices Motorola 54ACT138/BEA

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	All	1,4,5,
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	-	-	-	-
Icch	-	-	-	-	-	-	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-

Figure 5-49 Iih Texas Instruments 54ACT11138J

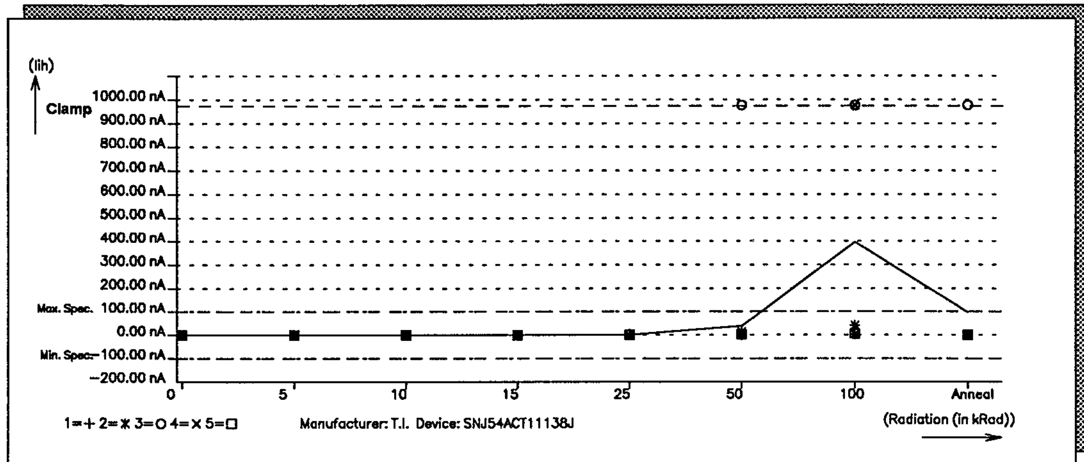


Figure 5-50 Iih National Semiconductor 54ACT138DMQB

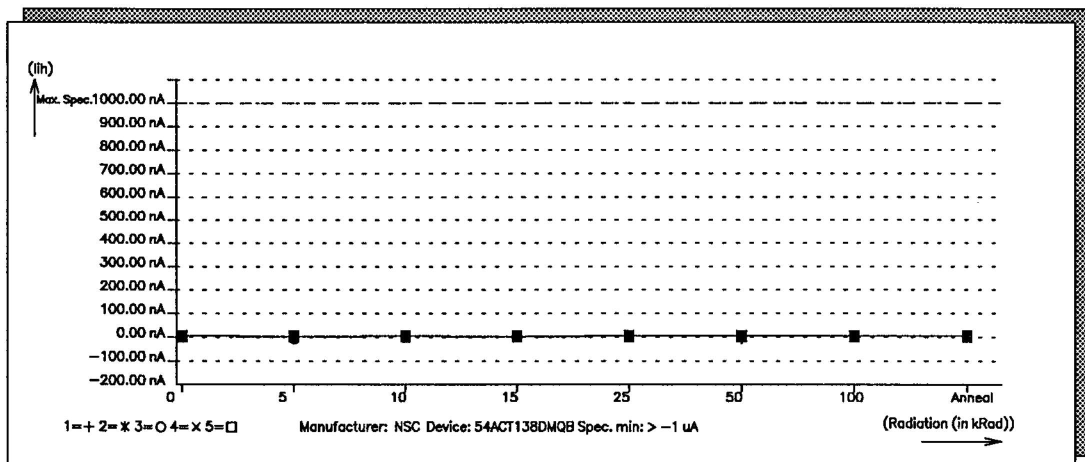


Figure 5-51 Iih Motorola 54ACT138/BCA

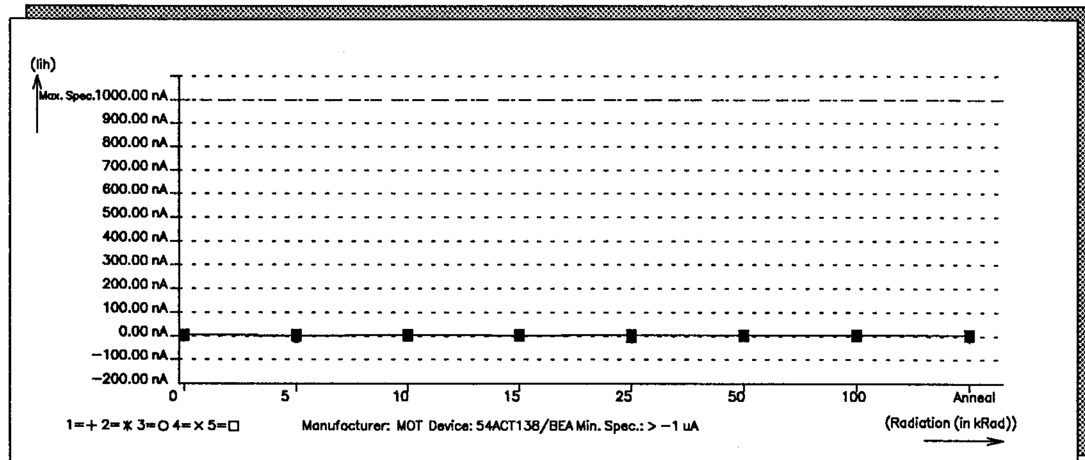


Figure 5-52 Vil Texas Instruments 54ACT11138J

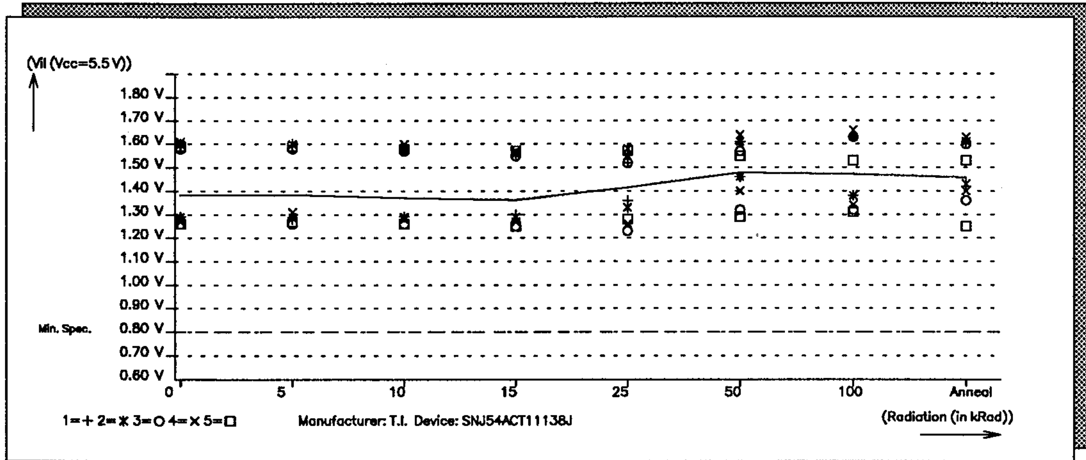


Figure 5-53 Vil National Semiconductor 54ACT138DMQB

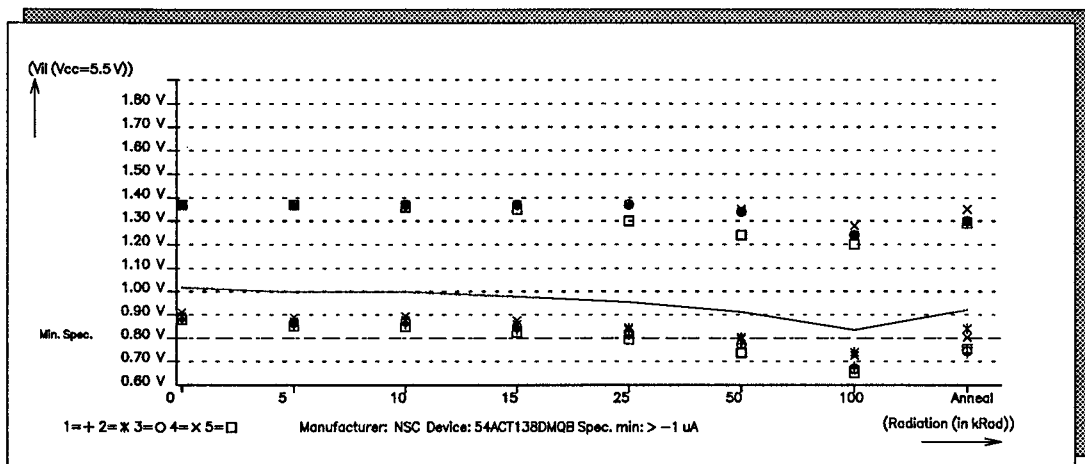


Figure 5-54 Vil Motorola 54ACT138/BCA

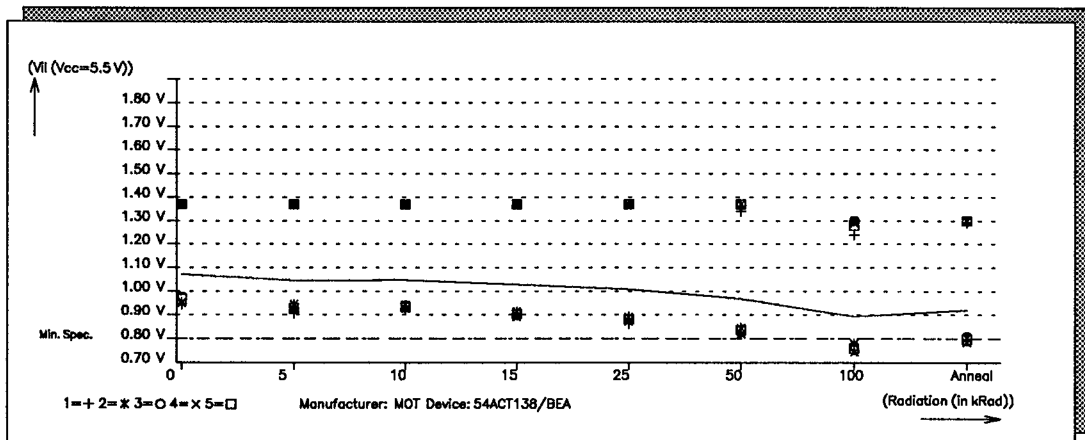


Figure 5-55 Vol Texas Instruments 54ACT11138J

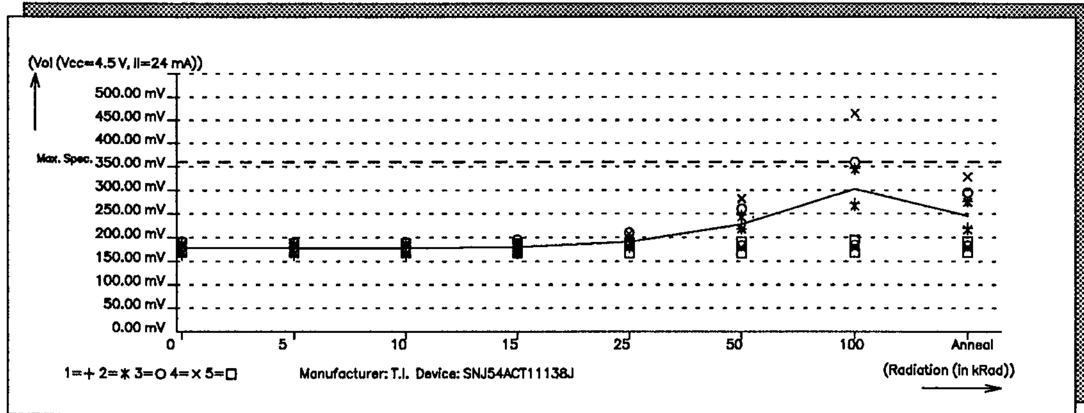


Figure 5-56 Vol National Semiconductor 54ACT138DMQB

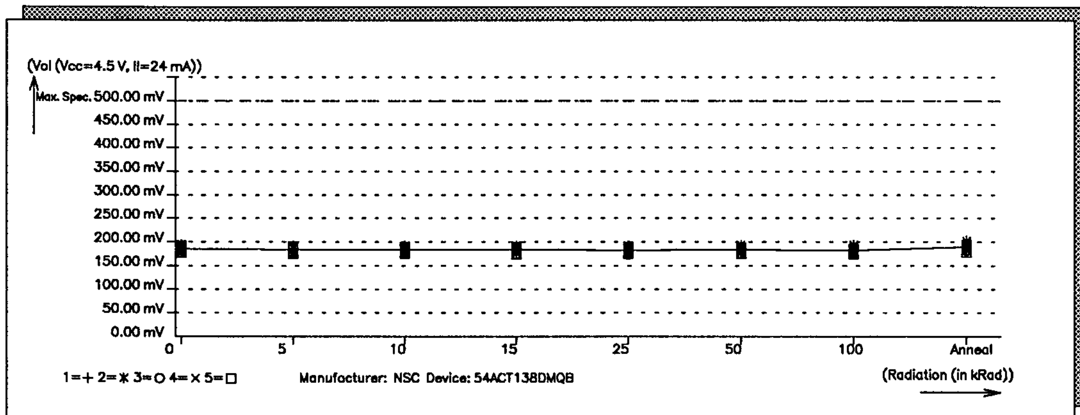


Figure 5-57 Vol Motorola 54ACT138/BCA

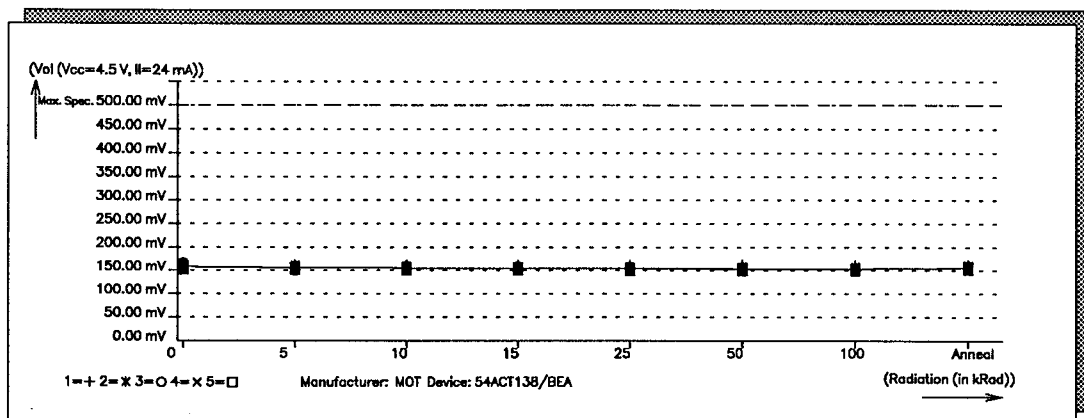


Figure 5-58 Iccl Texas Instruments 54ACT11138J

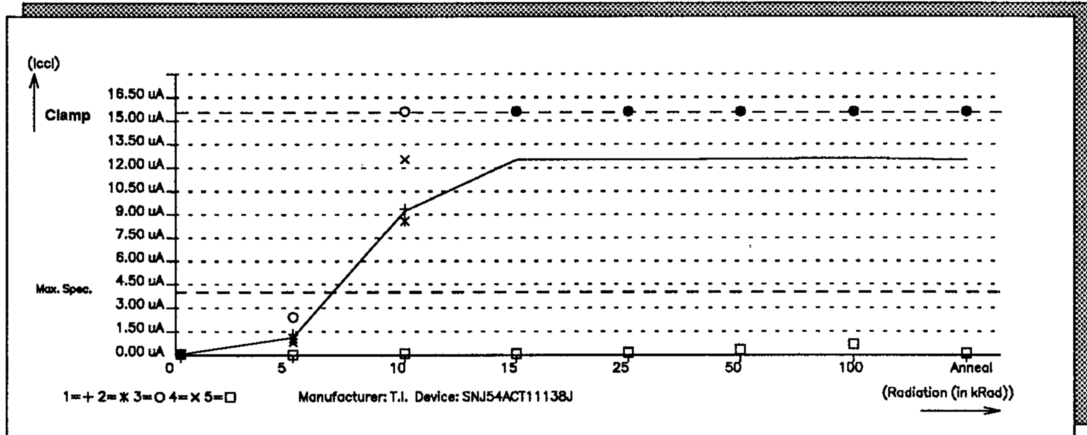


Figure 5-59 Iccl National Semiconductor 54ACT138DMQB

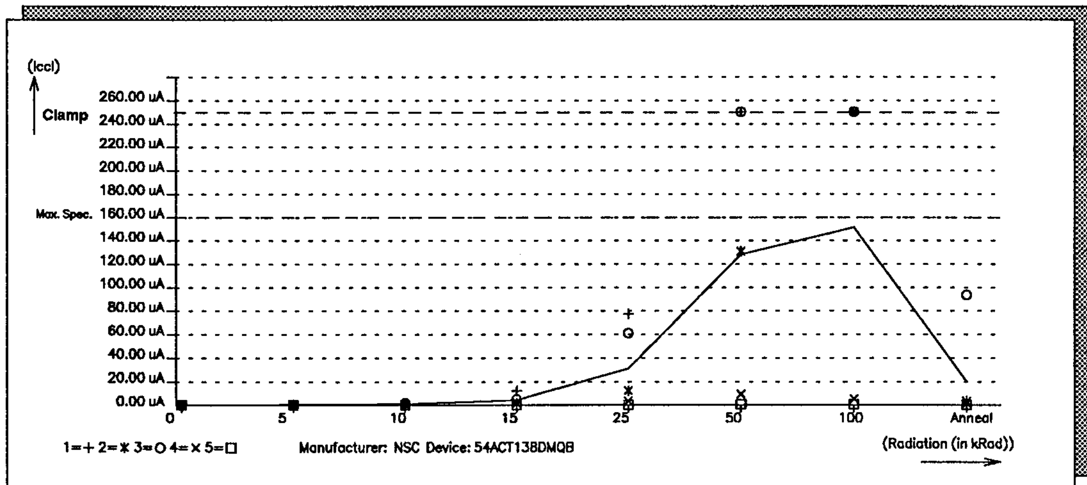
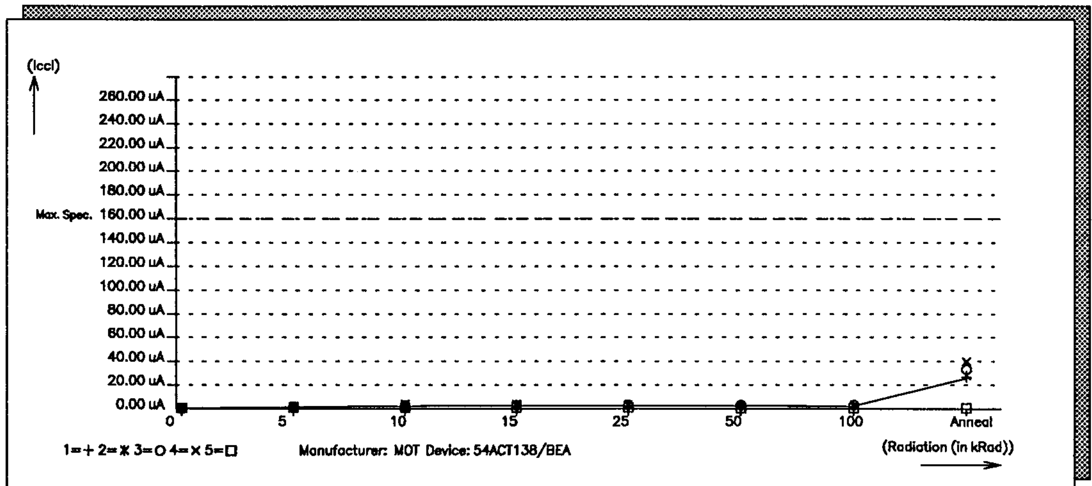


Figure 5-60 Iccl Motorola 54ACT138/BCA



Remark: The range of the Texas Instruments picture differs from the National Semiconductor and the Motorola pictures.

Figure 5-61 Icch Texas Instruments 54ACT11138J

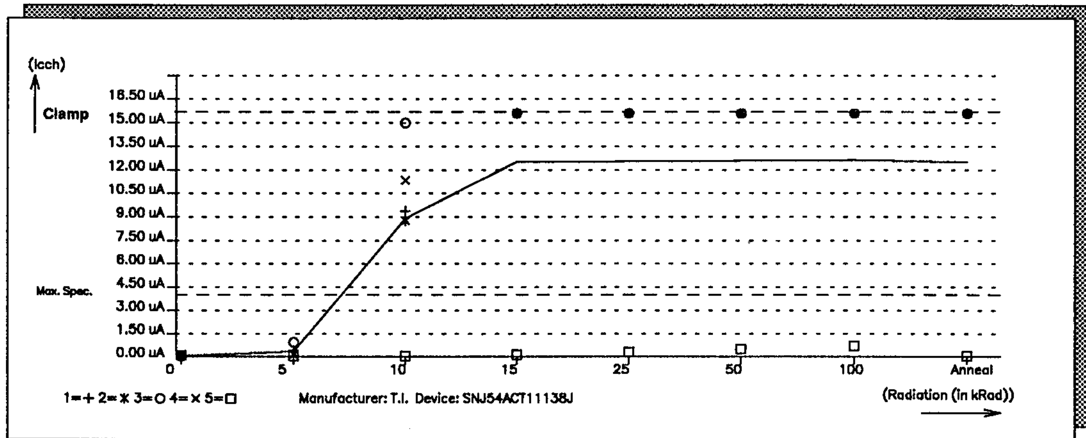


Figure 5-62 Icch National Semiconductor 54ACT138DMQB

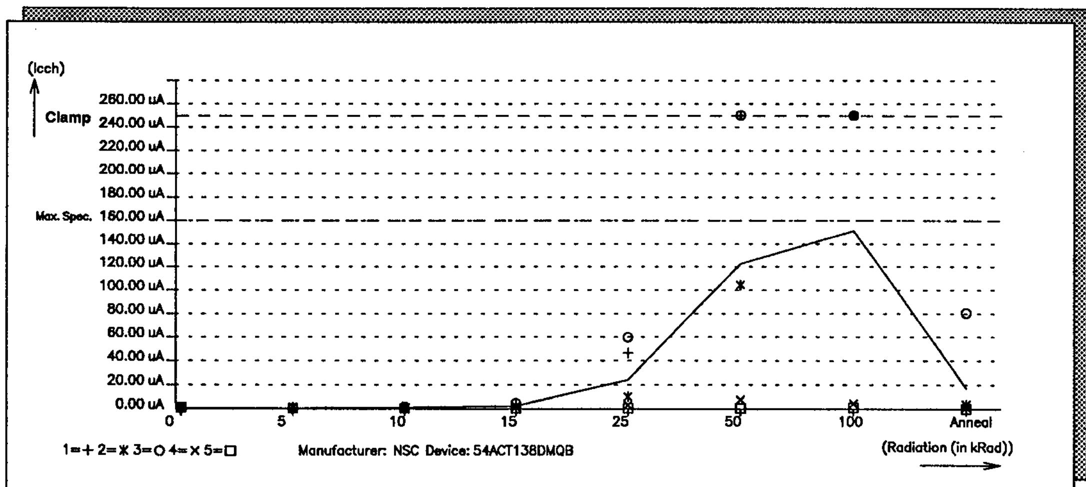
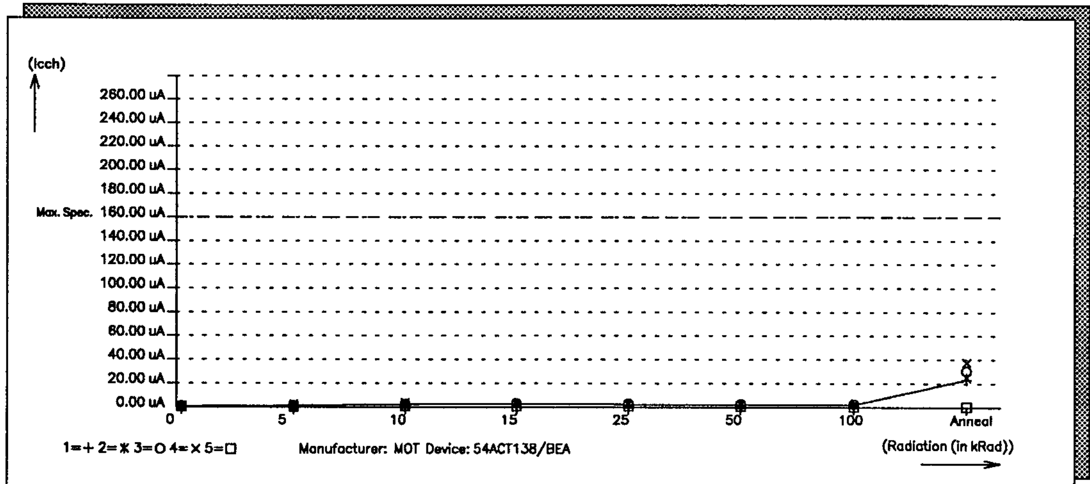


Figure 5-63 Icch Motorola 54ACT138/BCA



Remark: The range of the Texas Instruments picture differs from the National Semiconductor and the Motorola pictures.

Figure 5-64 Icc Texas Instruments 54ACT11138J

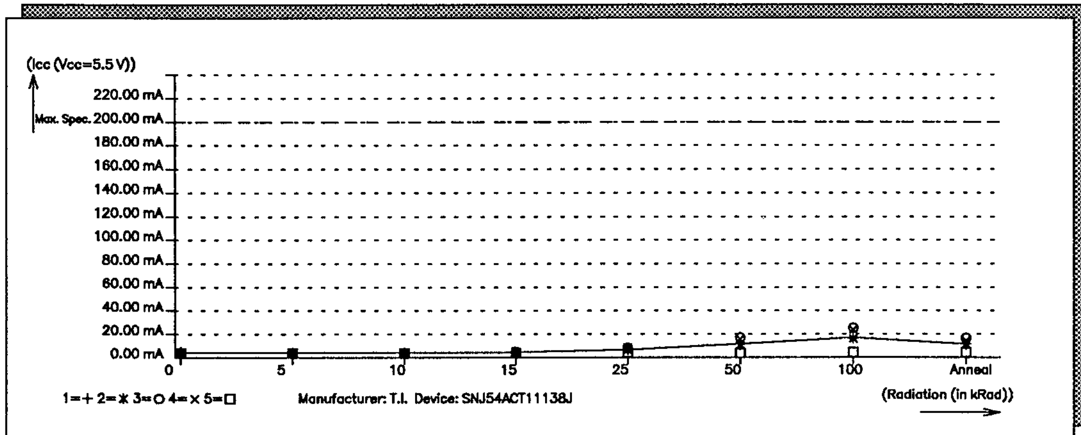


Figure 5-65 Icc National Semiconductor 54ACT138DMQB

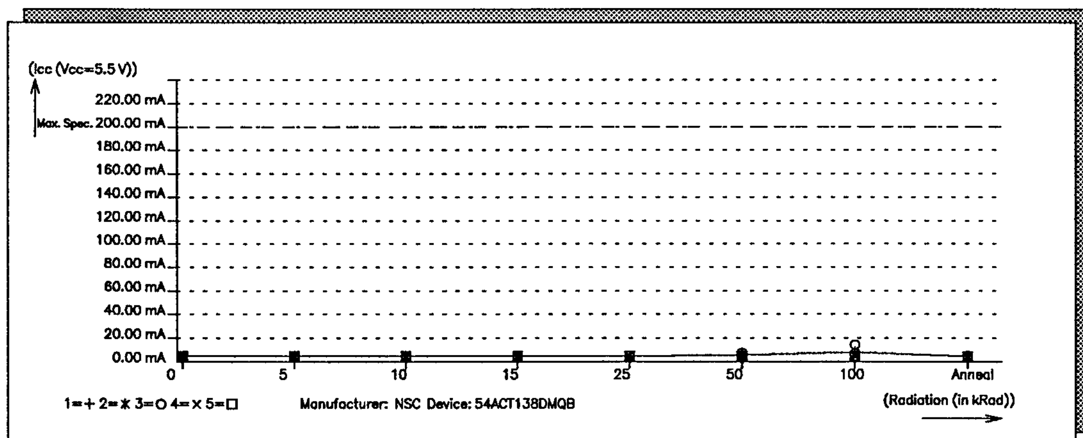


Figure 5-66 Icc Motorola 54ACT138/BCA

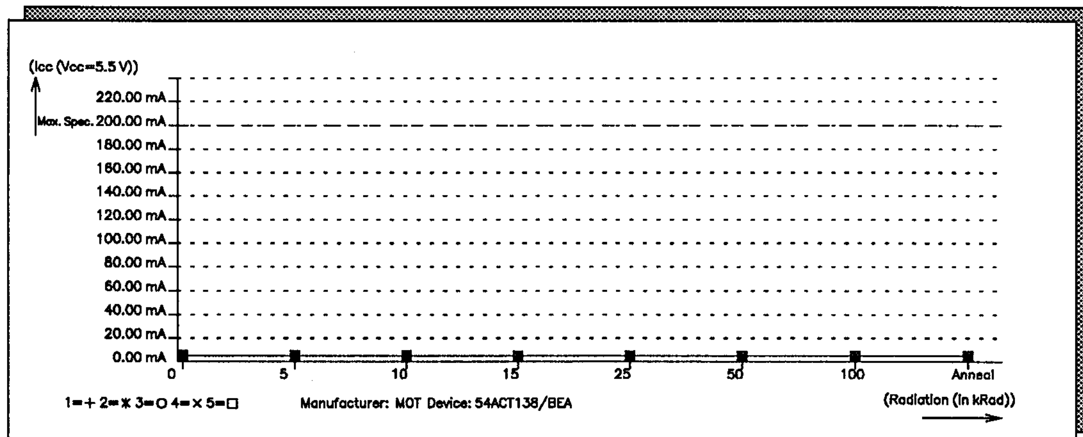


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Table 5-12 Fail devices Texas Instruments 74AC11373NT

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	1,2,3,4	1,2,3,4
Vil	-	-	-	-	-	1,2,3	1,2,3	All
Vih	-	-	-	-	-	1,2,3	1,2,3	All
Vol	-	-	-	-	-	-	4	-
Voh	-	-	-	-	-	-	-	All
Iozl	-	-	-	-	-	-	1,2,3	1,2,3
Iozh	-	-	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Iccl	-	-	-	-	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icch	-	-	-	-	1,2,3	1,2,3	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	All
tPLH	-	-	-	-	-	-	-	All
tPHL	-	-	-	-	-	-	-	All
tPLZ	1,2,3,5	1,2,3,5	1,2,3,5	1,2,3,5	1,2,3,5	1,2,3,5	1,2,3,5	All
tPZL	-	-	-	-	-	-	4	All
tPHZ	-	-	-	-	-	-	-	All
tPZH	-	-	-	-	-	-	-	All

Table 5-13 Fail devices National Semiconductor 54AC373DMQB

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	4	1,2,3,4	4
Vil	-	-	-	-	1,2,3	1,2,3	1,2,3	1,2,3
Vih	-	-	-	-	1,2,3	1,2,3	1,2,3	1,2,3
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iozl	-	-	-	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Iozh	-	-	-	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Iccl	-	3	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	All	1,2,3,4
Icch	-	-	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4,	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-
tPLZ	-	-	-	-	-	-	-	-
tPZL	-	-	-	-	-	-	-	-
tPHZ	-	-	-	-	-	-	-	-
tPZH	-	-	-	-	-	-	-	-

Table 5-14 Fail devices Motorola 54AC373/BRA

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	-	-	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iozl	-	-	-	-	-	-	-	-
Iozh	-	-	-	-	-	-	-	-
Iccl	-	-	2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	-	1,2,3
Icch	-	-	2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	-	1,2,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-
tPLZ	-	-	-	-	-	-	-	-
tPZL	-	-	-	-	-	-	-	-
tPHZ	-	-	-	-	-	-	-	-
tPZH	-	-	-	-	-	-	-	-

Figure 5-67 Iih Texas Instruments 74AC11373NT

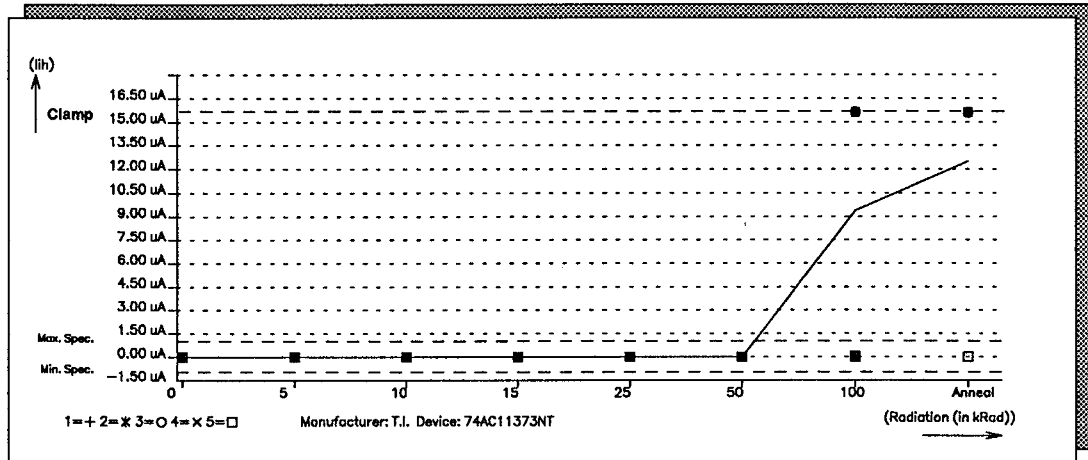

Figure 5-68 Iih National Semiconductor 54AC373DMQB

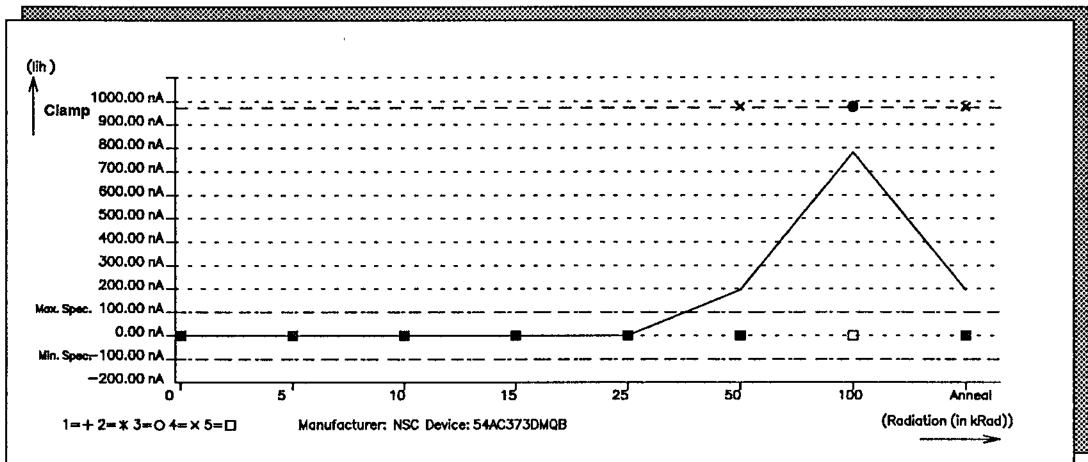

Figure 5-69 Iih Motorola 54AC373/BRA

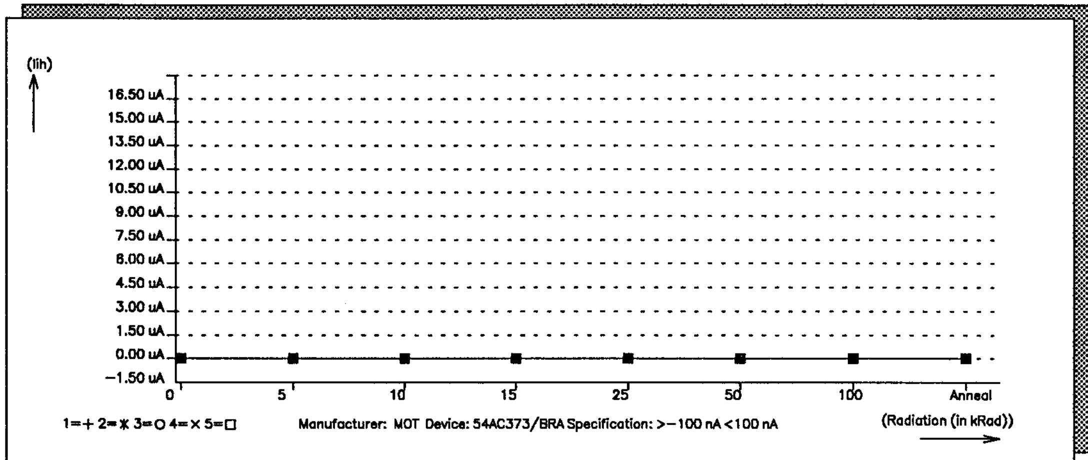

Figure 5-70 Vil Texas Instruments 74AC11373NT

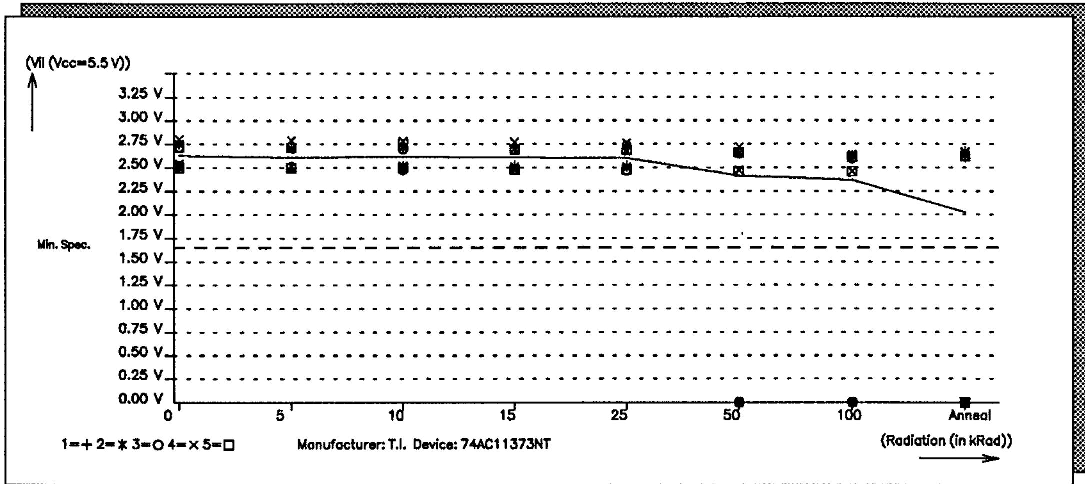

Figure 5-71 Vil National Semiconductor 54AC373DMQB

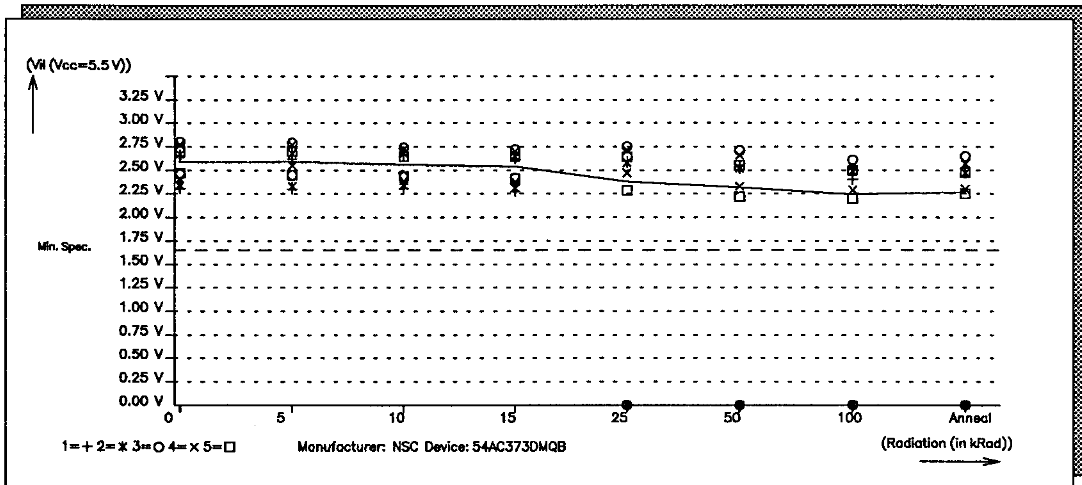

Figure 5-72 Vil Motorola 54AC373/BRA

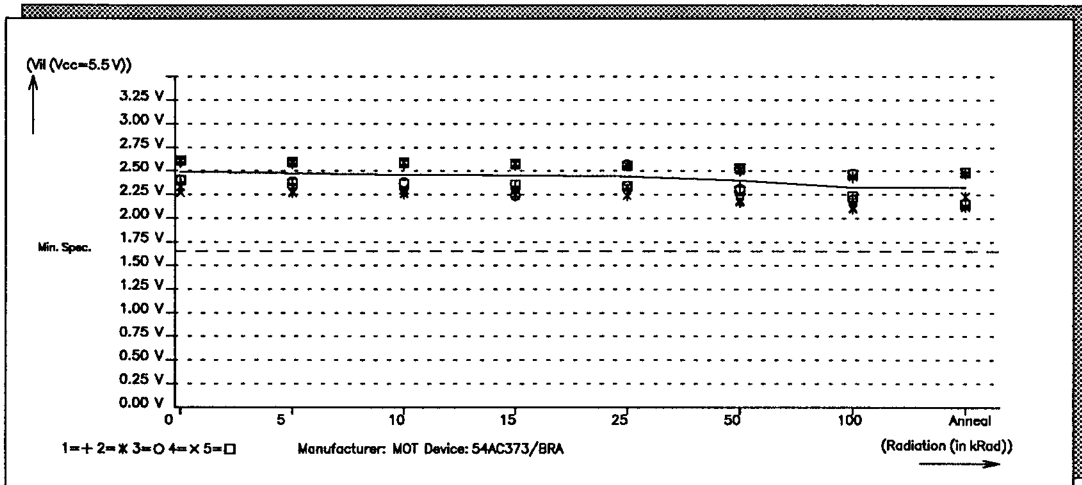

Figure 5-73 Vih Texas Instruments 74AC11373NT

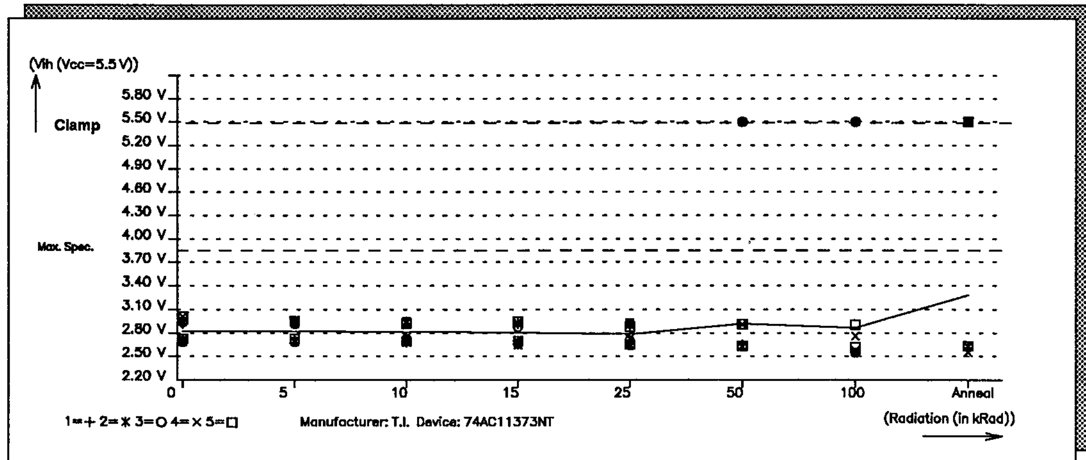

Figure 5-74 Vih National Semiconductor 54AC373DMQB

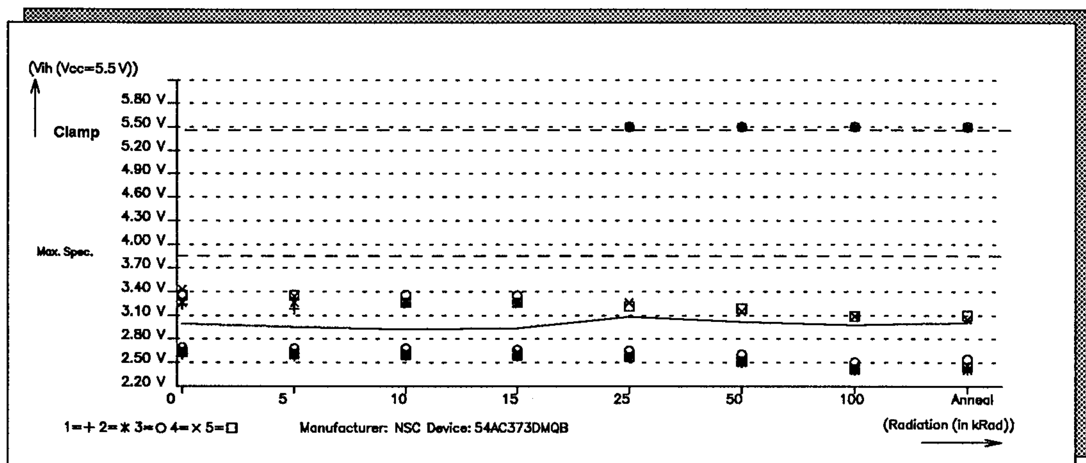

Figure 5-75 Vih Motorola 54AC373/BRA

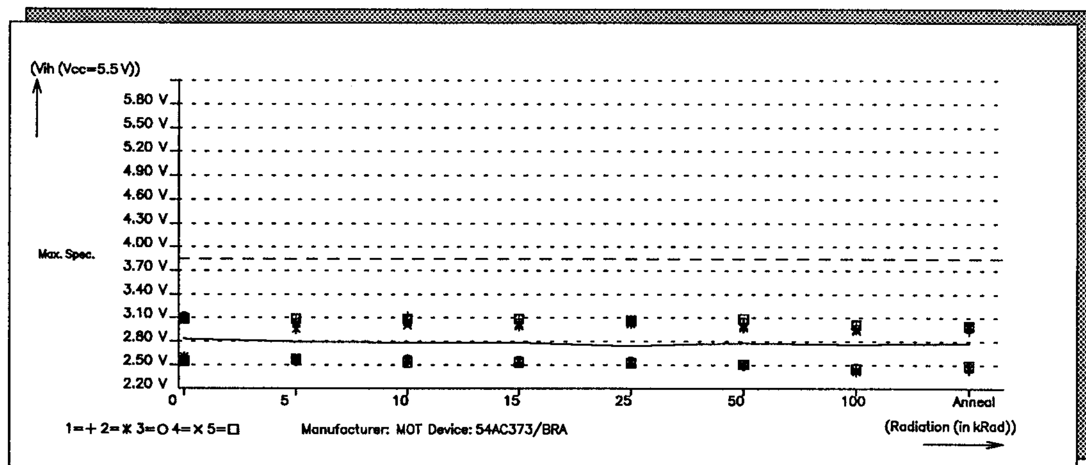

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Figure 5-76 Iozh Texas Instruments 74AC11373NT

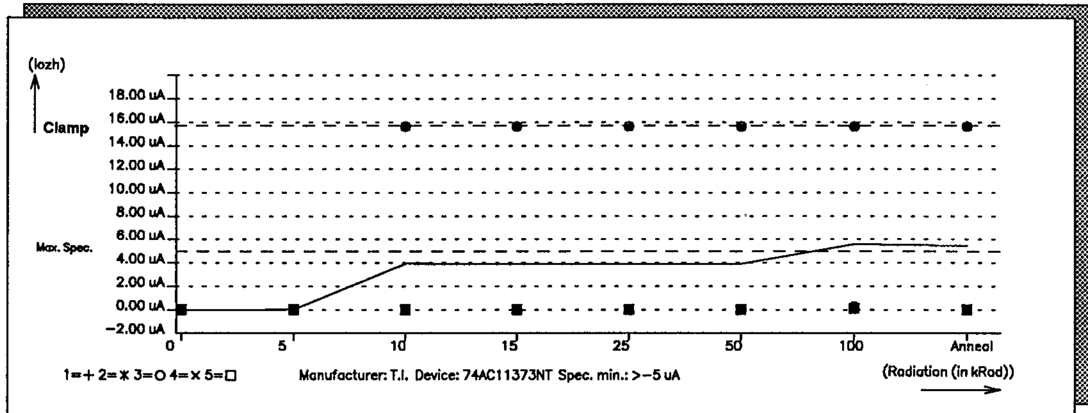


Figure 5-77 Iozh National Semiconductor 54AC373DMQB

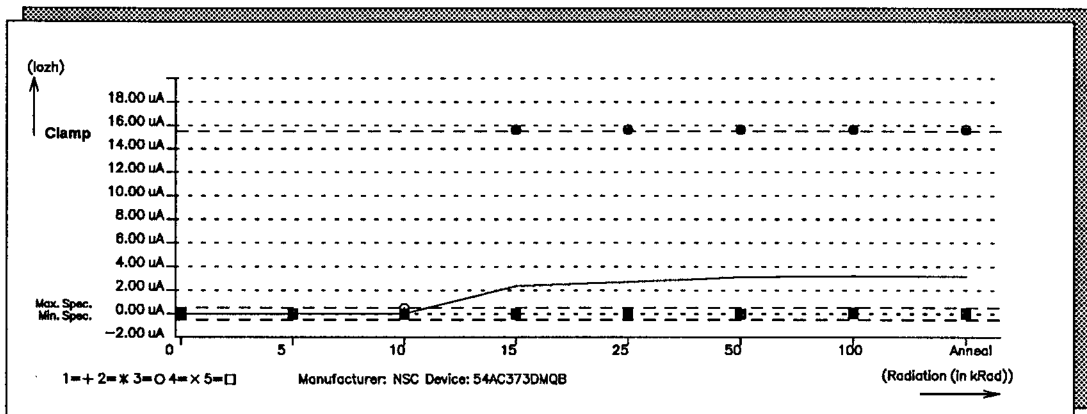


Figure 5-78 Iozh Motorola 54AC373/BRA

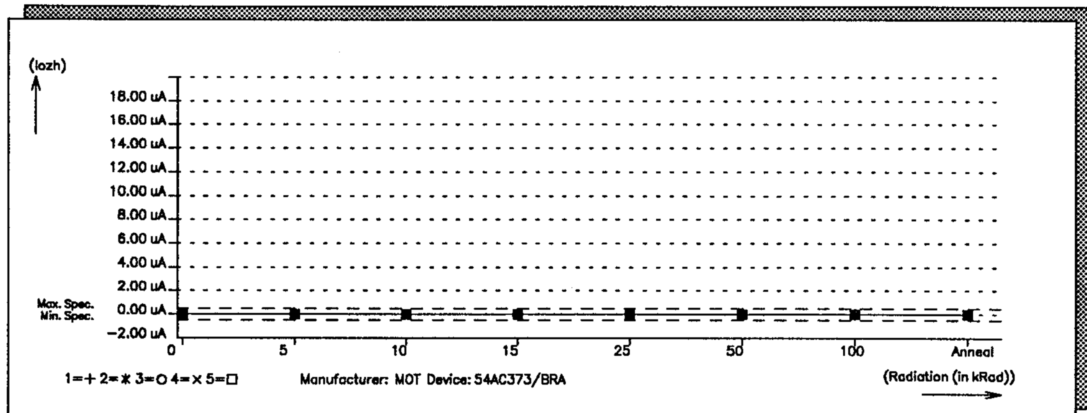


Figure 5-79 Iccl Texas Instruments 74AC11373NT

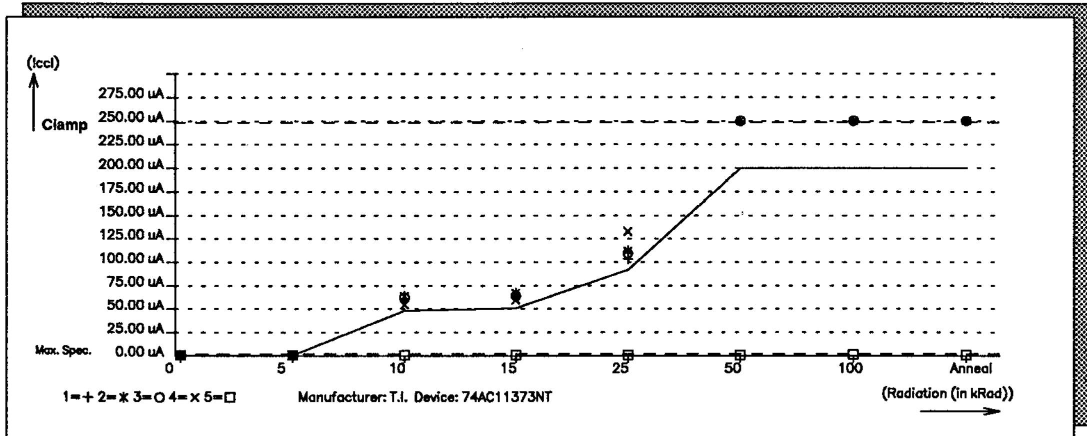


Figure 5-80 Iccl National Semiconductor 54AC373DMQB

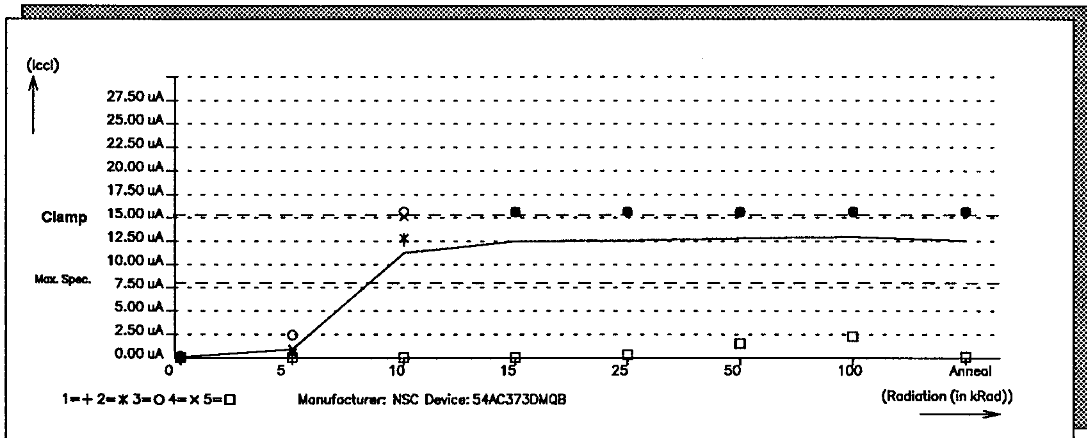
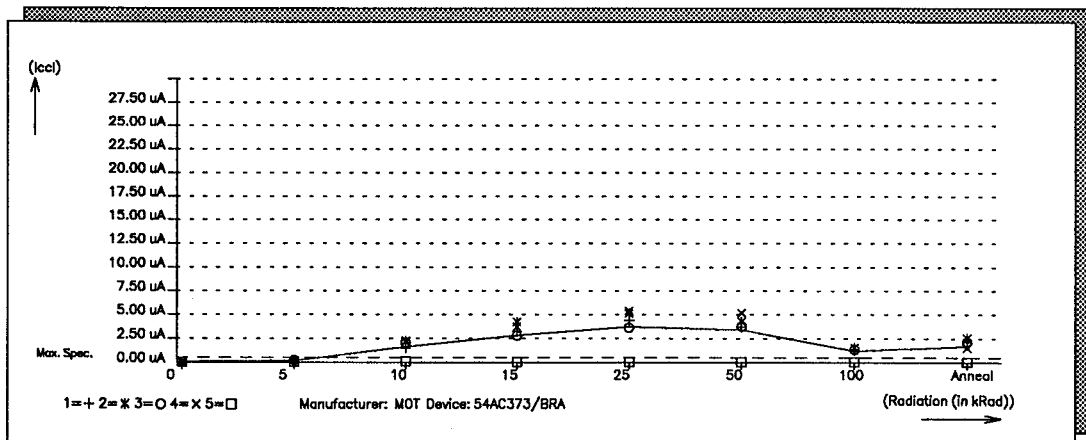


Figure 5-81 Iccl Motorola 54AC373/BRA



Remark: The scale of the Texas Instruments picture differs from the National and Motorola pictures.

Figure 5-82 Tplz Texas Instruments 74AC11373NT

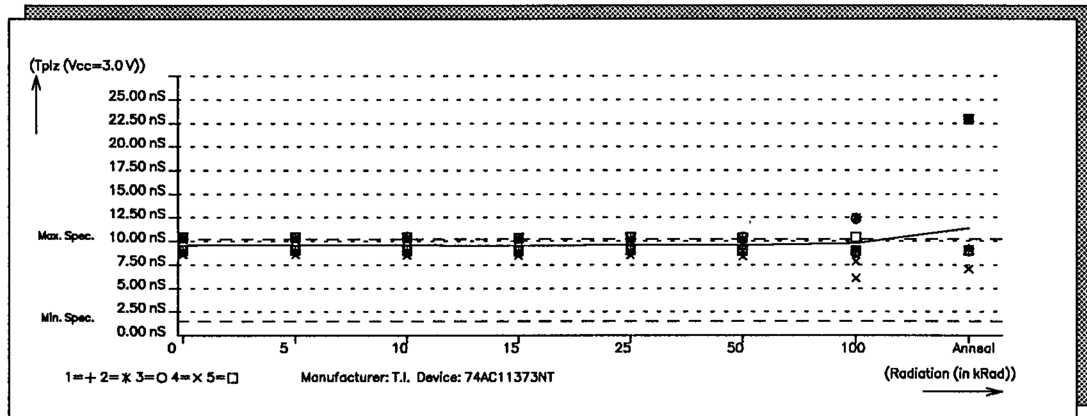


Figure 5-83 Tplz National Semiconductor 54AC373DMQB

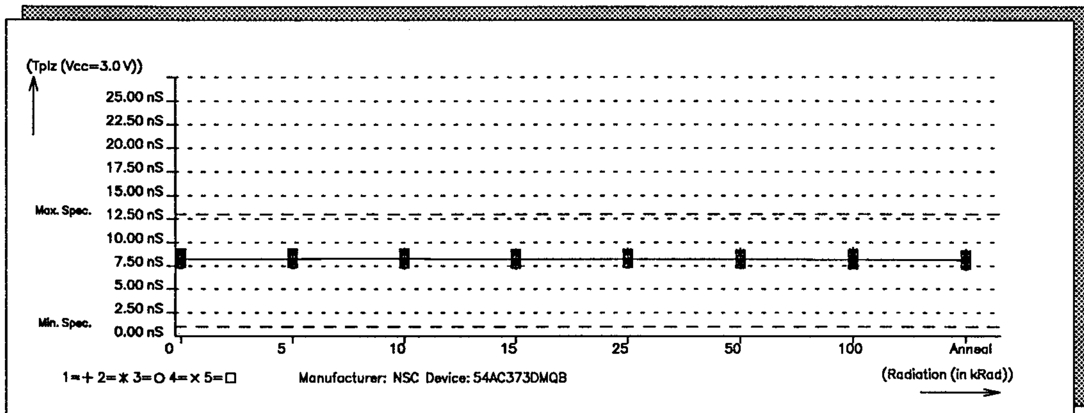


Figure 5-84 Tplz Motorola 54AC373/BRA

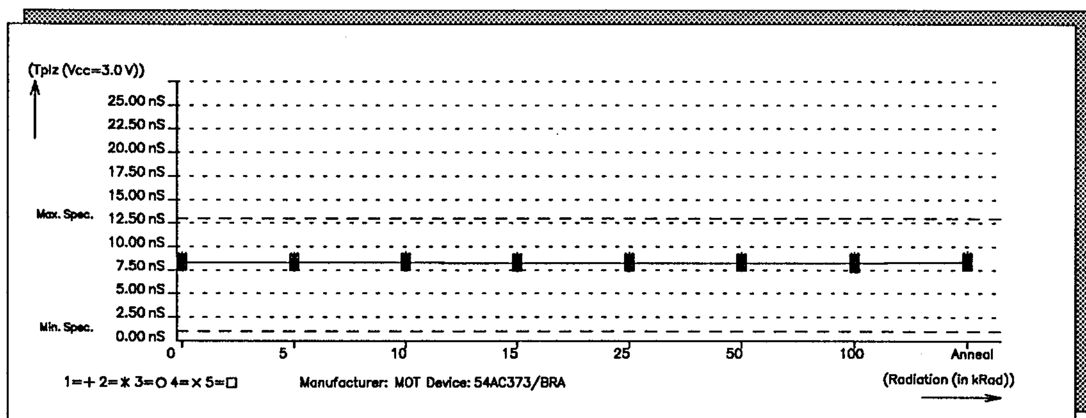


Table 5-15 Fail devices Texas Instruments 54ACT11373JT

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	1,2,3,4	1,2,3,4
Vil	-	-	-	-	-	1,2	1,2,3	All
Vih	-	-	-	-	-	2,3	1,2,3	All
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	All
Iozl	-	-	-	-	-	1,2,3	1,2,3	1,2,3
Iozh	-	-	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Iccl	-	-	4	-	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Icch	-	-	-	-	1,2,3	1,2,3	1,2,3,4	1,2,3,4
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	All
tPLH	-	-	-	-	-	-	-	All
tPHL	-	-	-	-	-	-	-	All
tPLZ	All	All	All	All	All	All	1,2,3,5	All
tPZL	-	-	-	-	-	-	-	All
tPHZ	-	-	-	-	-	-	-	All
tPZH	-	-	-	-	-	-	-	All

Table 5-16 Fail devices National Semiconductor 54ACT373DMQB

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	-	-	3,5	All	-
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	-	-	-
Voh	-	-	-	-	-	-	-	-
Iozl	-	-	-	-	-	-	-	-
Iozh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	-	-	-	-
Icch	-	-	-	-	-	-	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	4	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-
tPLZ	-	-	-	-	-	-	-	-
tPZL	-	-	-	-	-	-	-	-
tPHZ	-	-	-	-	-	-	-	-
tPZH	-	-	-	-	-	-	-	-

Table 5-17 Fail devices Motorola 54ACT373/BRA

Test	0kRad	5kRad	10kRad	15kRad	25kRad	50kRad	100kRad	Anneal
Cont	-	-	-	-	-	-	-	-
Iil	-	-	-	-	-	-	-	-
Iih	-	-	-	-	-	-	-	-
Vil	-	-	-	1,2,3,4	All	All	All	All
Vih	-	-	-	-	-	-	-	-
Vol	-	-	-	-	-	All	All	All
Voh	-	-	-	-	-	-	4	-
Iozl	-	-	-	-	-	-	-	-
Iozh	-	-	-	-	-	-	-	-
Iccl	-	-	-	-	-	-	-	-
Icch	-	-	-	-	-	-	-	-
Icc	-	-	-	-	-	-	-	-
Func	-	-	-	-	-	-	-	-
tPLH	-	-	-	-	-	-	-	-
tPHL	-	-	-	-	-	-	-	-
tPLZ	-	-	-	-	-	-	-	-
tPZL	-	-	-	-	-	-	-	-
tPHZ	-	-	-	-	-	-	-	-
tPZH	-	-	-	-	-	-	-	-

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Figure 5-85 Iih Texas Instruments 54ACT11373J

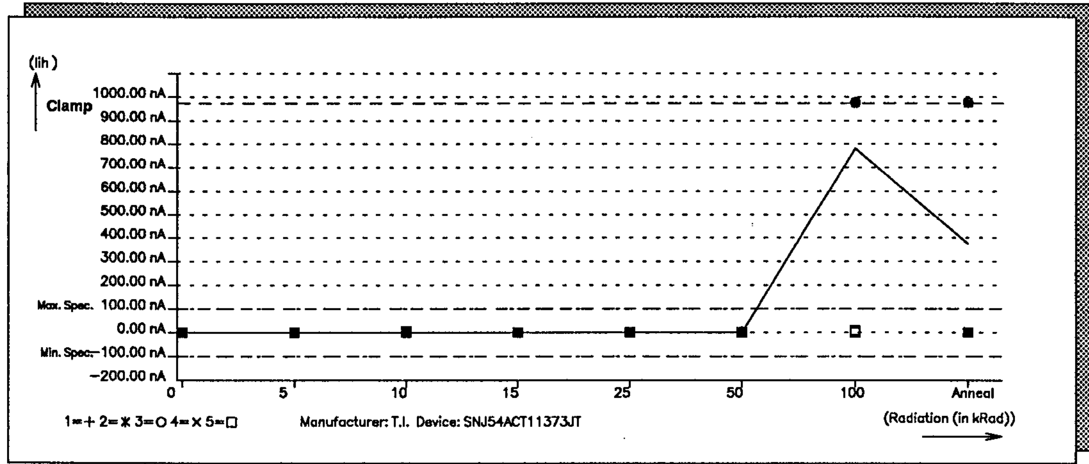

Figure 5-86 Iih National Semiconductor 54ACT373DMQB

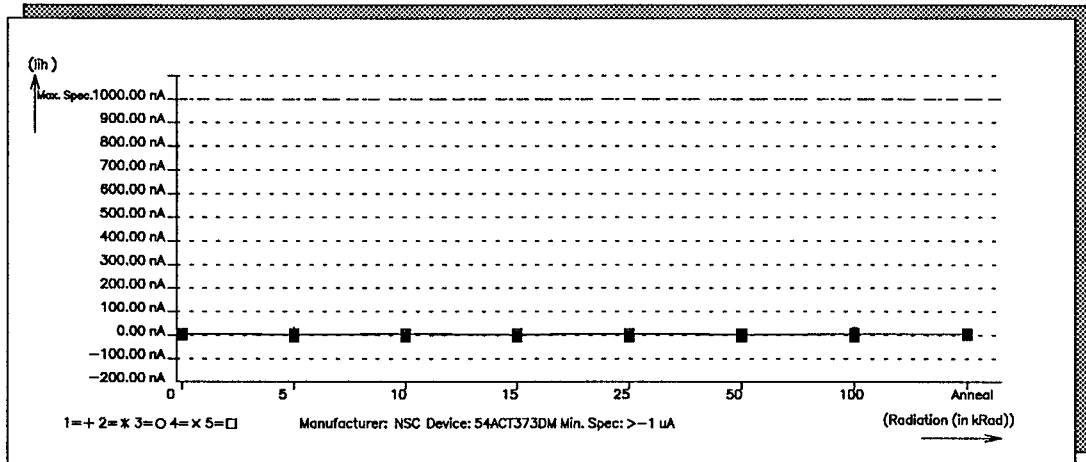

Figure 5-87 Iih Motorola 54ACT373/BRA

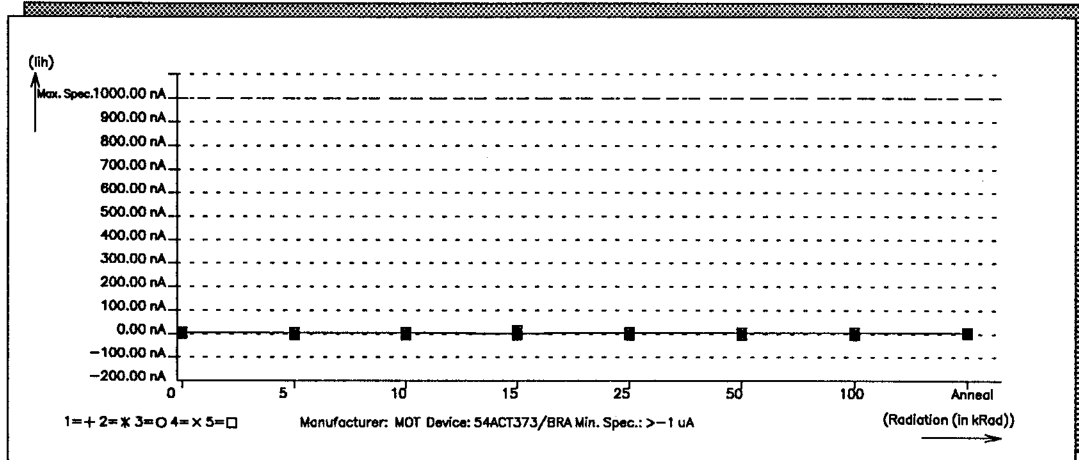

Figure 5-88 Vil Texas Instruments 54ACT11373J

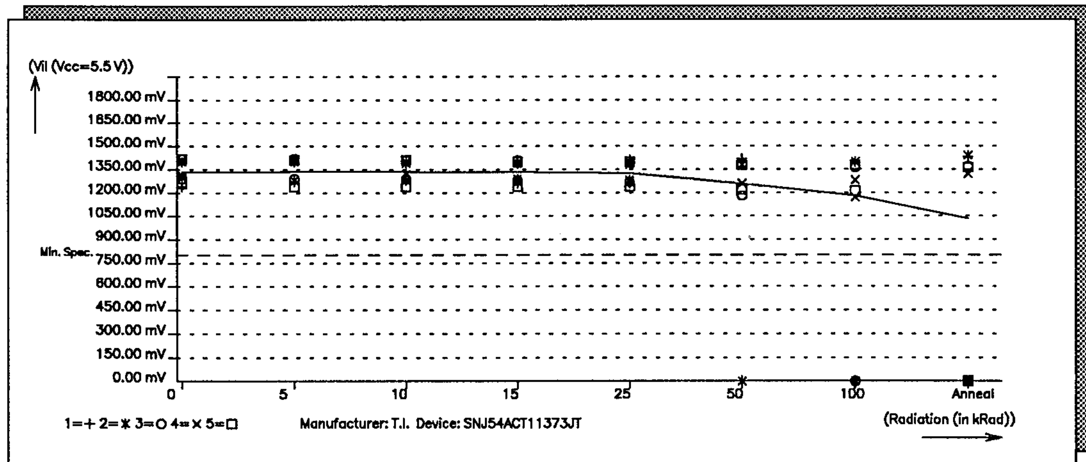

Figure 5-89 Vil National Semiconductor 54ACT373DMQB

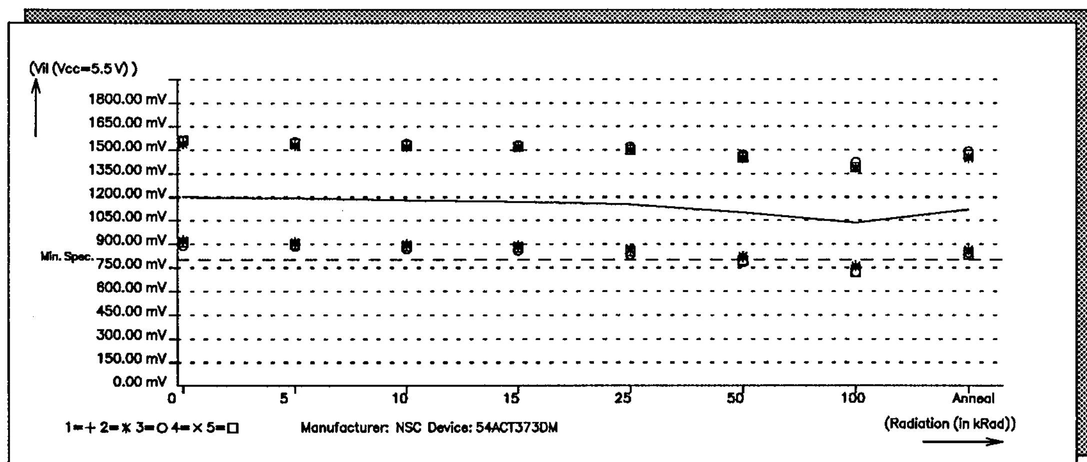

Figure 5-90 Vil Motorola 54ACT373/BRA

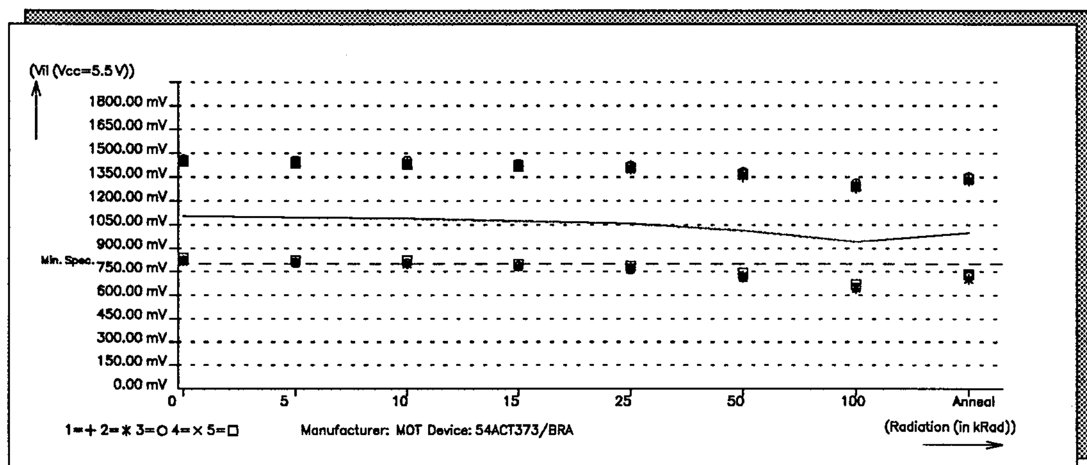

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Figure 5-91 Vol Texas Instruments 54ACT11373J

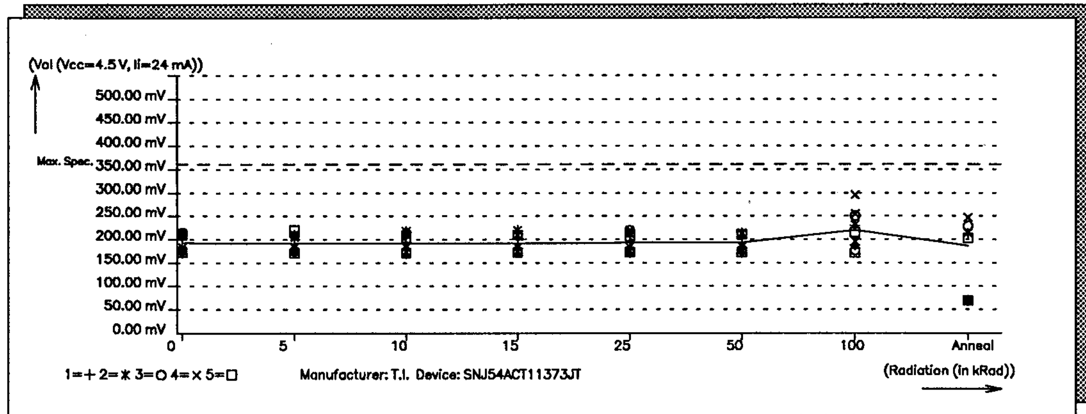


Figure 5-92 Vol National Semiconductor 54ACT373DMQB

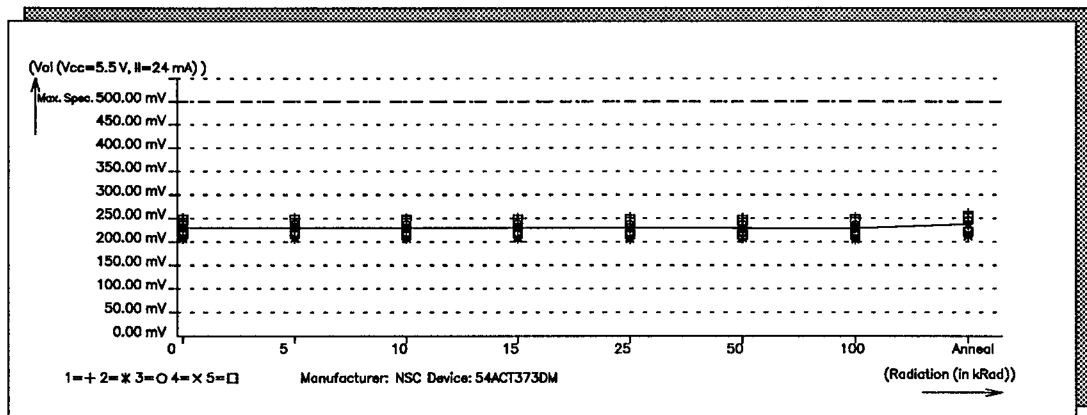
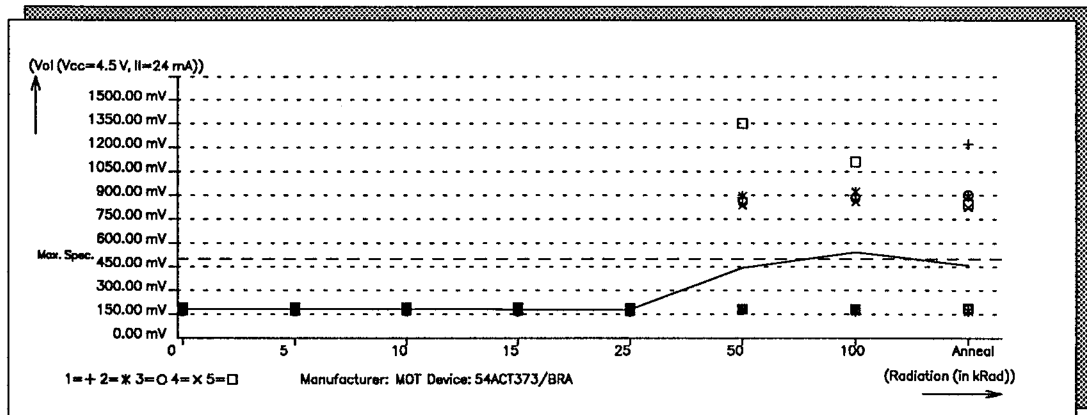


Figure 5-93 Vol Motorola 54ACT373/BRA



Remark: The scale of the Motorola picture differs from the scale of the Texas Instruments and National Semiconductor pictures

Figure 5-94 Iozh Texas Instruments 54ACT11373J

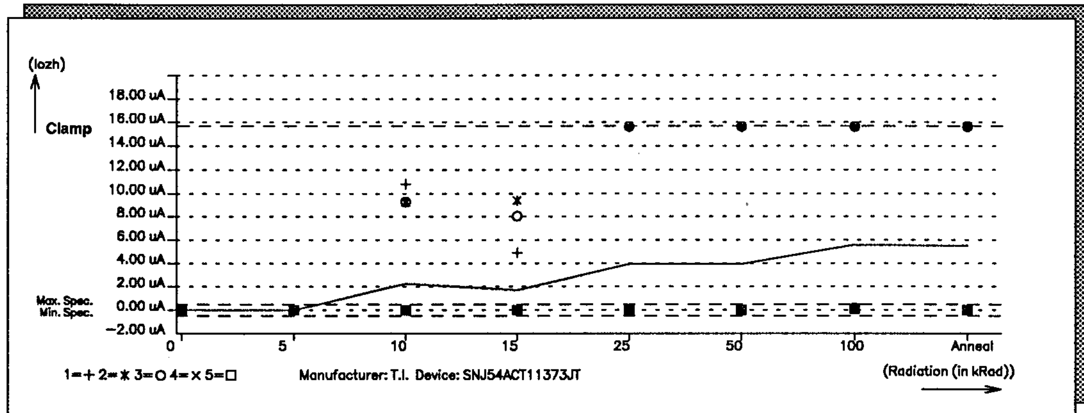


Figure 5-95 Iozh National Semiconductor 54ACT373DMQB

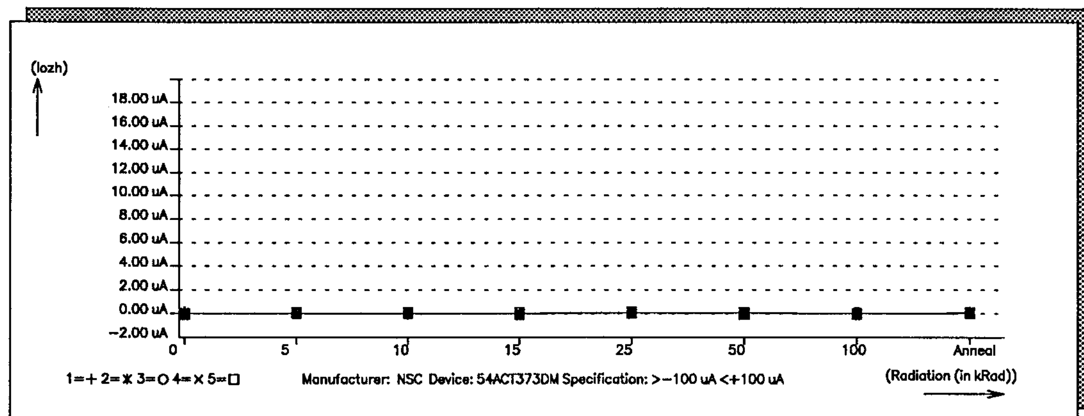


Figure 5-96 Iozh Motorola 54ACT373/BRA

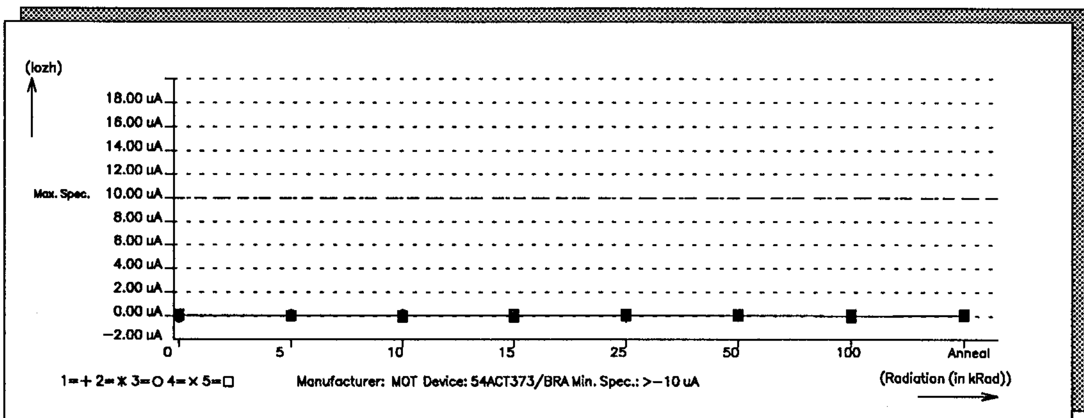


Figure 5-97 Iccl Texas Instruments 54ACT11373J

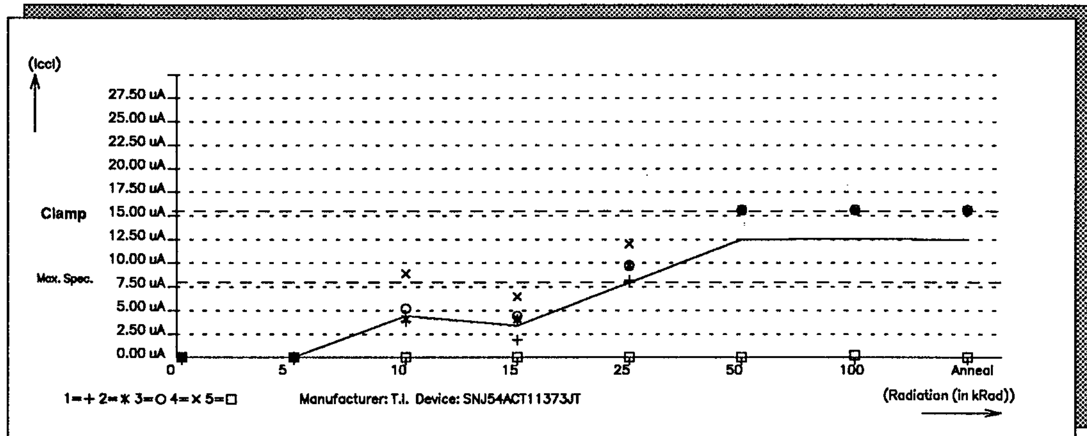


Figure 5-98 Iccl National Semiconductor 54ACT373DMQB

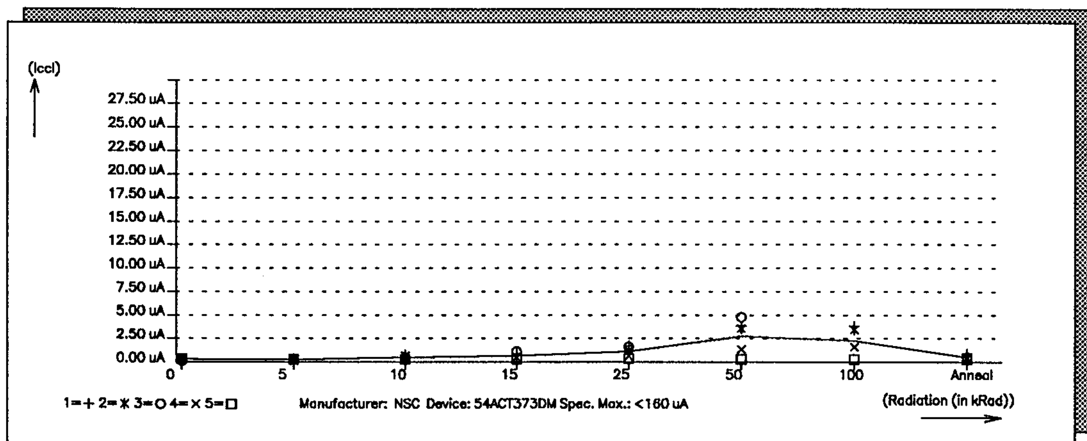


Figure 5-99 Iccl Motorola 54ACT373/BRA

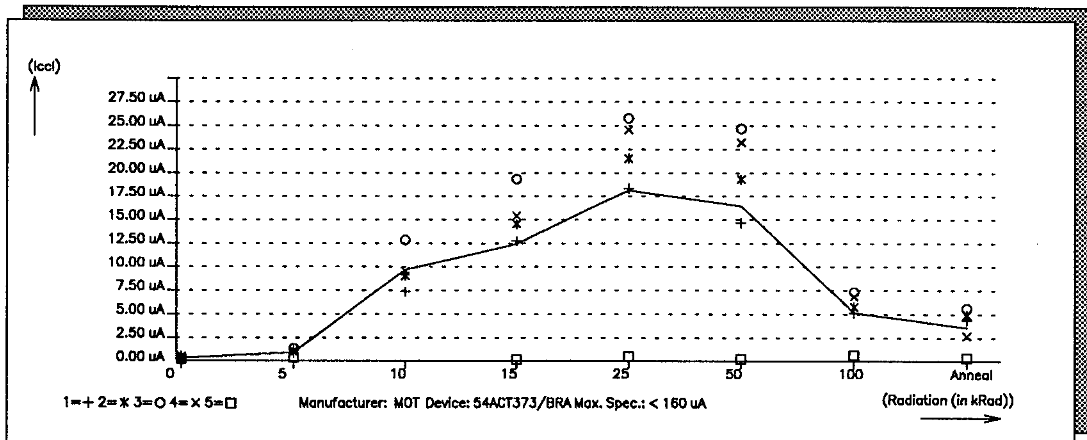


Figure 5-100 Tplz Texas Instruments 54ACT11373J

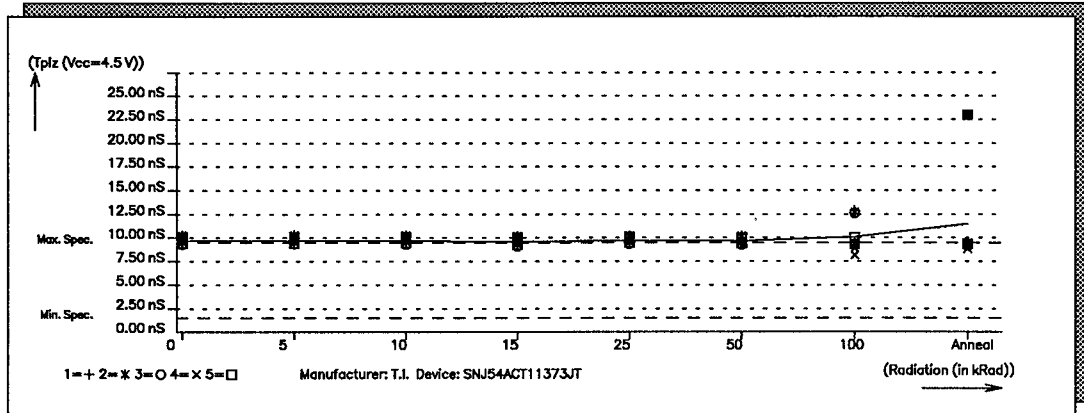


Figure 5-101 Tplz National Semiconductor 54ACT373DMQB

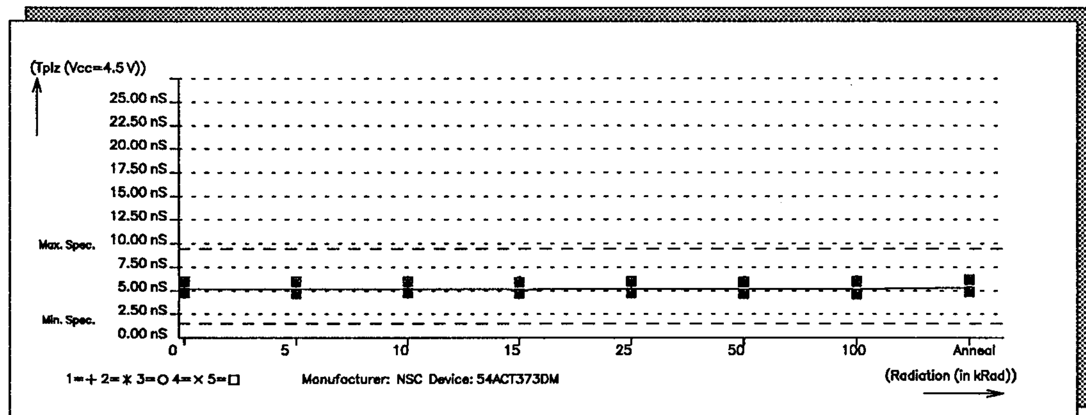


Figure 5-102 Tplz Motorola 54ACT373/BRA