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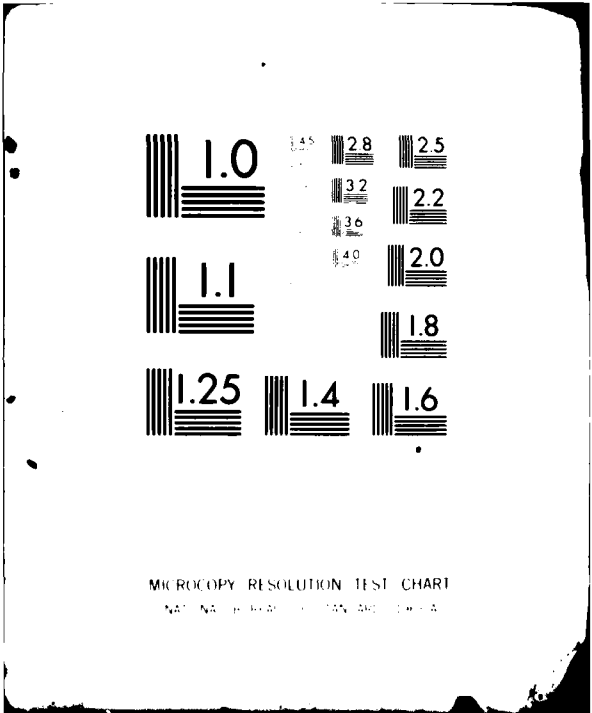
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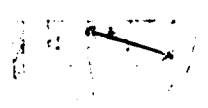


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HARDNESS ASSURANCE LATCHUP TEST PROCEDURE

TRW Defense and Space Systems Group
One Space Park
Redondo Beach, California 90278

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28 August 1978

Final Report for Period 25 April 1977-28 August 1978

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SECTION 1

PURPOSE

This test procedure defines the detailed requirements for gamma dose rate testing of semiconductor integrated circuits to determine if they are susceptible to radiation-induced latchup. This test is not deleterious and devices which have been subjected to and passed the test may be used as production hardware.

1-1 DEFINITION OF RADIATION-INDUCED LATCHUP.

There are two types of radiation-induced latchup: (1) a hard latchup, and (2) an incipient latchup. A hard latchup is a sustained functional failure. The erroneous operational condition can be stopped by cycling bias power if burnout has not occurred in the interim. Incipient latchup is characterized by a functional failure which is not sustained, but which lasts longer than can be explained by normal circuit time constants. Identification of a latchup-susceptible IC is accomplished by identifying erroneous operating states immediately after radiation exposure by exercising the device with a functional test (defined in paragraph 3-5.1).

SECTION 2

APPARATUS

2-1 INSTRUMENTATION.

The instrumentation required to command and monitor the device under test generally consists of one or more of the following or equivalent:

<u>Description</u>	<u>Model No.</u>
DVM	HP 3440A
DC Current Probe	Tek P 6042
Pulse Generator	HP 8005A
Regulated Power Supply 0-60 VDC, 0-7.5 A	Harrison 810B
Oscilloscope	Tek 7844

All instrumentation shall be periodically calibrated in accordance with General Standard MIL-C-45662A.

2-2 TIMING CIRCUITRY.

The circuitry shall provide electrical stimulus to functional test circuitry and recording equipment for the range of 50 μ s to 300 μ s (unless otherwise specified) after radiation test in accordance with the performance requirements (see paragraph 3.6). A typical latchup system block diagram is shown in Figure 1.

2-3 DEVICE HOLDING FIXTURE.

The holding fixture must provide an electromechanical interface between the test device and the latchup system. It must be sufficiently adaptable to accept the IC package configuration to be tested.

2-4 BIAS CIRCUITRY.

The bias circuitry shall provide loads and bias for the device under test in accordance with the specified performance requirements. The bias circuitry shall provide a stiffening capacitor for each bias supply voltage at the device. The capacitor shall assure that the voltage at the device is maintained within 10% for the duration of the transient response.

The bias circuitry should be located on a removable universal circuit card and should be located as close as practical to the device under test to avoid the effects of cable impedances and should be shielded from the radiation.

2-5 RECORDING EQUIPMENT.

Recording equipment shall be sufficient to record critical parameter data (dosimetry, input current, output voltages, etc.).

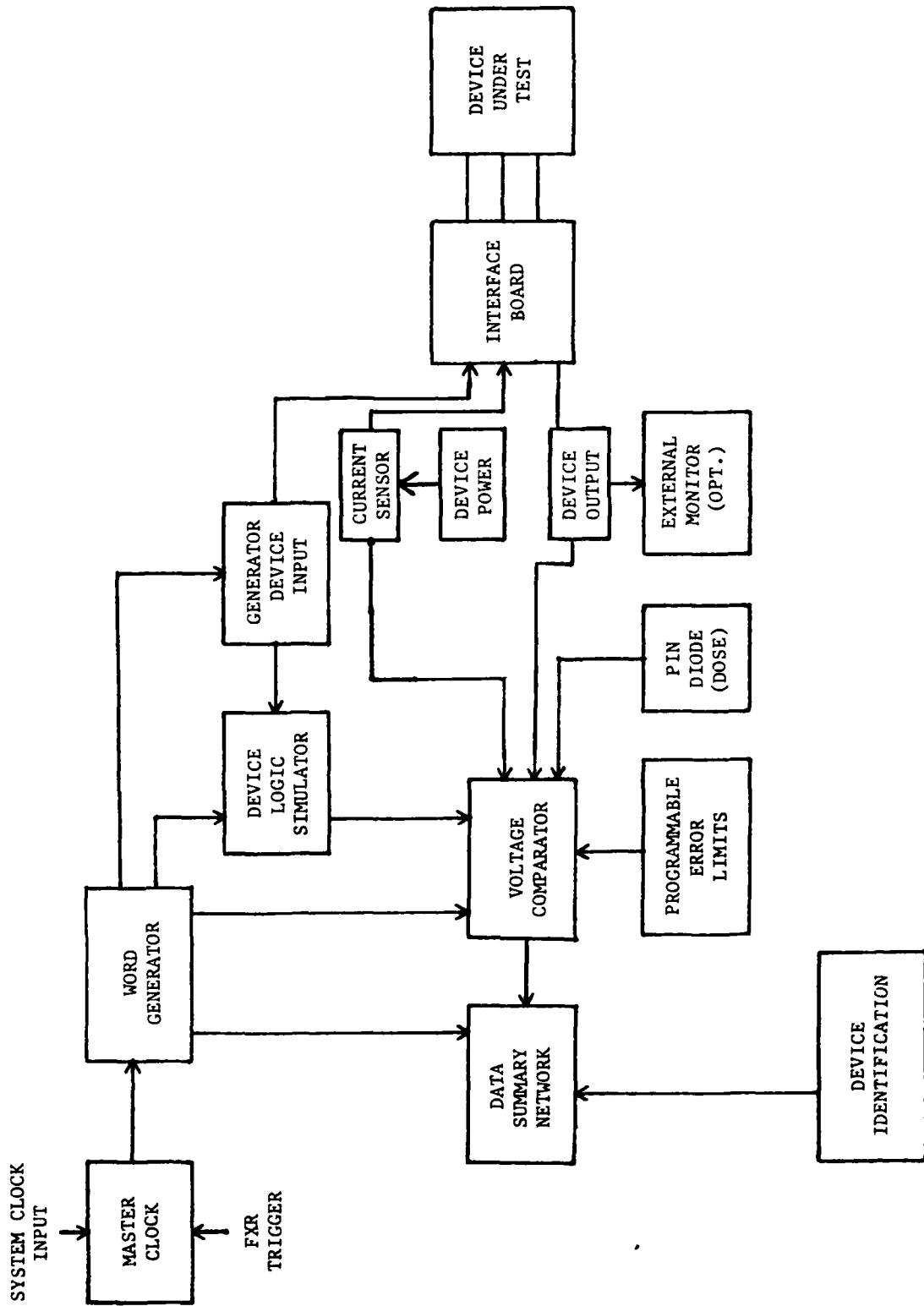


Figure 1. Latchup System

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RADIATION SOURCE.

One of two radiation sources may be used with the latchup system: (1) a flash X-ray (FXR) machine, or (2) a linear accelerator (LINAC). The FXR shall be used in the photon mode and the LINAC in the e-beam mode. The LINAC beam energy must be greater than 10 MeV to insure that beam electrons are not captured in the device materials. The radiation source shall provide a uniform radiation level across the surface of the device within 20%. The dose per radiation exposure shall be 500 ± 200 rad(Si) (unless otherwise specified) with a pulse width between 20 and 100 ns or as required.

Caution: Some devices subject to latchup may have thresholds above these levels.

SECTION 3

PROCEDURE

3-1 DEVICE IDENTIFICATION.

In all cases, devices must be individually identified and traceable to the applicable recorded test data for verification of pass/fail status.

3-2 DOSIMETRY.

Dosimetry shall be used to measure the dose in rad(Si) of the radiation pulse used in the latchup test. Any dosimetry technique may be used which provides a measurement accuracy of $\pm 20\%$.

3-3 TEST SET-UP.

Apply and verify the bias voltages at the holding fixture with the device removed. Adjust timing circuitry to provide the required time interval between radiation pulse and post-test measurement. Remove bias voltage and install a control sample device, identical to the devices to be tested, into the holding fixture. Restore bias voltage and verify proper device function in accordance with the performance requirements (paragraph 3-5). Verify proper operation of all recording equipment. Perform a complete dry run using an electrical simulation of the radiation pulse to initiate the timing circuitry. Verify a pass status for all requirements except dosimetry. Remove bias voltage and control sample device, in that order. Perform a dry run radiation exposure. Check dose and dose recording equipment by verifying a pass status for the dosimetry in the recorded data.

- Exercise caution when handling devices, particularly with regard to pin alignment in the carriers and holding fixture.
- Exercise caution when attaching devices to the test circuit. Insure that bias voltages are off before attachment.

Identify test devices by serial number before insertion into the holding fixture so that traceability is maintained between the test device and its unique data set. Verify proper operation of the latchup system using the first device of each batch of common devices. Apply all appropriate voltages after the first device has been placed in the proper position in front of the radiation source. Verify proper functional operation. Bias the device in accordance with paragraph 3-5.2 and initiate the radiation environment and record all required data. Verify a pass status for all elements of the required data set. If a pass status is verified, proceed with screen test. If a failure is indicated, verify proper system operation and perform an additional radiation test. A test device exposed to 3000 rad(Si) (or as specified) or more is rejected as a failed device.

Caution: Some devices experience significant degradation at levels less than 3000 rad(Si).

3-4 SAFETY REQUIREMENTS.

All test personnel shall adhere to the health and safety requirements established by the local radiation safety officer or health physicist.

3-5 PERFORMANCE REQUIREMENTS.

3-5.1 Functional Test Requirements.

Functional test requirements shall be specified including load and bias requirements, functional test input levels and corresponding output requirements with pass/fail limits. Power supply current at the device shall be monitored before, during, and after test.

3-5.2 Small-Scale Integrated (SSI) Digital Circuit Tests.

Small-scale integrated (SSI) digital circuits shall be exposed to radiation once in each logic state. The post-irradiation functional test shall demonstrate proper device functional operation 50 to 300 μ s after radiation exposure in accordance with performance requirements. The post-irradiation functional test shall demonstrate that the device will respond properly to input commands. Proper power supply current shall also be verified as part of the post-irradiation functional test.

There are two groups of digital integrated circuit devices which are latched tested: (1) determined and (2) non-determined. Determined devices are those whose output is uniquely a function of the input, i.e., AND- and OR-gates. If the input changes, the output changes; and if the input does not change, the output does not change. Non-determined devices are those whose output is not a unique function of data inputs. For example, a J-K flip-flop output will change only with clock signal transitions when the DC set and reset inputs are inactive.

Functional tests for determined devices shall be performed as follows:

- Step 1: Set device input to one of the two logic states and verify proper output.
- Step 2: Radiate device, maintaining device input condition.
- Step 3: Monitor device output after time interval specified in requirements and verify proper output logic state while maintaining initial logic input condition.
- Step 4: Change input condition and verify a change in output condition.
- Step 5: Repeat steps 1 through 4 and change the initial logic state.

A determined device whose output after radiation is not in the proper logic state or which fails to respond properly to a change in input is a failed device.

Functional tests for non-determined devices shall be performed as follows:

- Step 1: Set and/or exercise device inputs and verify correct output condition.
- Step 2: Radiate device, maintaining initial set input condition.
- Step 3: At the prescribed time after the radiation pulse, monitor the output condition. If the output has changed from the initial condition set in Step 1, then change the input condition to properly correspond with the new output condition.

Step 4: Change the input conditions so that the output should change and verify a change in the output.

Step 5: Repeat steps 1 through 4 and change the initial input condition.

A non-determined device which fails to respond properly after radiation to the second change in input is a failed device; i.e., the first change in input may not change the output since the output may have already changed due to radiation. However, the second change in input condition must change the output.

3-5.3 Small-Scale Integrated (SSI) Linear Circuit Tests

A functional test shall be performed after radiation exposure and shall demonstrate proper device operation and power supply current. Power supply current shall be monitored before, during, and after exposure. There are two acceptable methods for verifying proper operation.

The first method shall employ an oscilloscope and camera to record the output of the device under test after radiation exposure. Visual examination of the output behavior after radiation exposure is then used to determine failure status. A typical photograph is shown in Figure 2. Trace A shows a device output which operated properly after the radiation screen test. Trace B shows an output which failed. Note that the device output will not respond properly to the oscillating input after the radiation exposure.

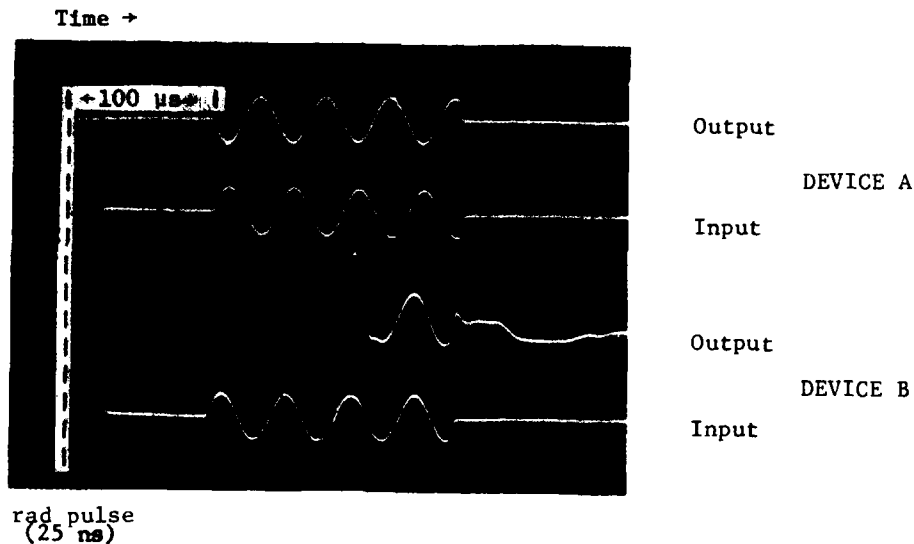


Figure 2. Linear device latchup screen test photograph (50 μs/div)

The second method uses pre-set comparators to evaluate the device output. The functional test consists of at least two different DC levels input into the device under test. The corresponding output levels are fed into the pre-set comparators for failure status determination.

3-5.4 Medium- and Large-Scale Integrated Circuit Tests.

Medium- and large-scale integrated (MSI, LSI) circuit devices normally contain more output states than can be practically monitored. An evaluation of the application of the device in the system in which the device is used must be employed to identify the input/output functions to be monitored for latchup. The selection of monitored device pins and the associated parameter limits shall be specified.

3-6 REPORTING.

Latchup test reports shall, at a minimum, include parts identification by serial number and the recorded data reporting pass/fail status.

SECTION 4

SUMMARY

The following details shall be specified in the applicable procurement document:

- a. Part types (including package types) and quantities to be tested.
- b. Temperature for test. The temperature shall be the highest operating temperature for the system application.
- c. Requirements for data reporting and submission.
- d. Test instrument requirements if other than those indicated in paragraph 2-1.
- e. Electrical parameters to be measured and device operating conditions during screen test.
 - (1) Worst case bias conditions for test.
 - (a) Power supply voltages
 - (b) Input bias
 - (c) Output loading
 - (d) Feedback network
 - (e) External compensation network
 - (f) Highest operating temperature for system
- f. Time interval between radiation exposure and post-exposure functional test, if other than 50 μ s.
- g. Radiation dose and limits to be applied in rad(Si).
 - (1) Dose limits per pulse
 - (2) Total dose limits

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