Designation: F773M – 96 (Reapproved 2003)

Standard Practice for Measuring Dose Rate Response of Linear Integrated Circuits (Metric)[1]

This standard is issued under the fixed designation F773M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the measurement of the response of linear integrated circuits, under given operating conditions, to pulsed ionizing radiation. The response may be either transient or more lasting, such as latchup. The radiation source is either a flash X-ray machine (FXR) or an electron linear accelerator (LINAC).

1.2 The precision of the measurement depends on the homogeneity of the radiation field and on the precision of the radiation dosimetry and the recording instrumentation.

1.3 The test may be considered to be destructive either for further tests or for other purposes if the total radiation dose exceeds some predetermined level or if the part should latch up. Because this level depends both on the kind of integrated circuit and on the application, a specific value must be agreed upon by the parties to the test. (See 6.10.)

1.4 Setup, calibration, and test circuit evaluation procedures are included in this practice.

1.5 Procedures for lot qualification and sampling are not included in this practice.

1.6 Because response varies with different device types, the dose rate range for any specific test is not given in this practice but must be agreed upon by the parties to the test.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E668 Practice for Application of Thermoluminescence-Dosimetry (TLD) Systems for Determining Absorbed Dose in Radiation-Hardness Testing of Electronic Devices

F526 Test Method for Measuring Dose for Use in Linear Accelerator Pulsed Radiation Effects Tests

3. Terminology

3.1 *Definitions:*

3.1.1 *dose rate*—energy absorbed per unit time and per unit mass by a given material from the radiation to which it is exposed.

3.1.2 *dose rate response*—the change that occurs in an observed characteristic of an operating linear integrated circuit induced by a radiation pulse of a given dose rate.

4. Summary of Practice

4.1 The test device and suitable dosimeters are irradiated by a pulse from either an FXR or a LINAC while the test device is operating under agreed-upon conditions. The responses of the test device and of the dosimeters are recorded.

4.2 The response of the test device to dose rate is recorded over a specified dose rate range.

4.3 A number of factors are not defined in this practice, and must be agreed upon beforehand by the parties to the test.

4.3.1 Total dose limit (see 1.3),

4.3.2 Electrical parameters of the test device whose responses are to be measured (see 10.10),

4.3.3 Temperature at which the test is to be performed (see 6.7),

4.3.4 Details of the test circuit, including output loading, power supply levels, and other operating conditions (see 7.4 and 10.3),

4.3.5 Choice of radiation pulse source (see 6.9 and 7.9),

4.3.6 Pulse width (see 6.9 and 7.9.2),

4.3.7 Sampling (see 8.1),

4.3.8 Need for total dose measurement (see 6.10, 7.8, and 10.1.1),

4.3.9 An irradiation plan which includes the dose rate range and the minimum number of dose rate values to be used in that range (see 10.6 and 10.9), and

[1] This practice is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.11 on Nuclear and Space Radiation Effects.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.3.10 Appropriate functional test (see 10.4 and 10.8).

5. Significance and Use

5.1 There are many kinds of linear integrated circuits. Any given linear integrated circuit may be used in a variety of ways and under various operating conditions within the limits of performance specified by the manufacturer. The procedures of this practice provide a standardized way to measure the dose-rate response of a linear integrated circuit, under operating conditions similar to those of the intended application, when the circuit is exposed to pulsed ionizing radiation.

5.2 Knowledge of the responses of linear integrated circuits to radiation pulses is essential for the design, production, and maintenance of electronic systems that are required to operate in the presence of pulsed radiation environments.

6. Interferences

6.1 *Air Ionization*—A spurious component of the signal measured during a test can result from conduction through air ionized by the radiation pulse. Such spurious contributions can be checked by measuring the signal while irradiating the test fixture in the absence of a test device. Air ionization contributions to the observed signal are generally proportional to applied field, while those due to secondary emission effects (6.2) are not. The effects of air ionization external to the device may be minimized by coating exposed leads with a thick layer of paraffin, silicone rubber, or nonconductive enamel, or by making the measurement in a vacuum.

6.2 *Secondary Emission* [3]—Another spurious component of the measured signal can result from charge emission from, or charge injection into, the test device and test circuit. This may be minimized by shielding the surrounding circuitry and irradiating only the minimum area necessary to ensure irradiation of the test device. Reasonable estimates of the expected magnitude of current resulting from secondary-emission effects can be made based on the area of metallic target materials irradiated.

NOTE 1—For dose rates in excess of 10^8 Gy (Si)/s the photocurrents developed by the package may dominate the device photocurrent. Care should be taken in the interpretation of the measured photoresponse for these high dose rates.

Values of current density per unit dose rate generally range between 10^{-11} and 10^{-10} A/cm^2 per Gy/s. The use of a scatter plate (7.9.2) may increase these values.

6.3 *Orientation*—The effective dose to a semiconductor junction can be altered by changing the orientation of the test device with respect to the irradiating beam. Most integrated circuits may be considered "thin samples" (in terms of the range of the radiation). However, some devices may have cooling studs or thick-walled cases that can act to scatter the incident beam, thereby modifying the dose received by the semiconductor chip. Position such devices carefully with the die normal to the beam.

6.4 *Dose Enhancement*—High atomic number materials near the active regions of the integrated circuit (package, metallization, die attach materials, etc.) can deliver an enhanced dose to the sensitive regions of the device when it is irradiated with an FXR. The possibility and extent of this effect should be considered.

6.5 *Electrical Noise*—Since radiation test facilities are inherent sources of r-f noise, good noise-minimizing techniques such as singlepoint ground, filtered dc supply lines, etc., must be used in these measurements (see Fig. 1).

6.6 *Dosimetry*—Accurate, reproducible calibration of dose-rate monitors is difficult. For this reason, dosimetry is apt to provide the single most substantial source of error in dose-rate determinations.

6.7 *Temperature*—Device characteristics are dependent on junction temperature; hence, the temperature of the test should

[3] Sawyer, J. A., and van Lint, V. A. J., "Calculations of High-Energy Secondary Electron Emission," *Journal of Applied Physics* , Vol 35, No. 6, June 1964, pp. 1706–1711.

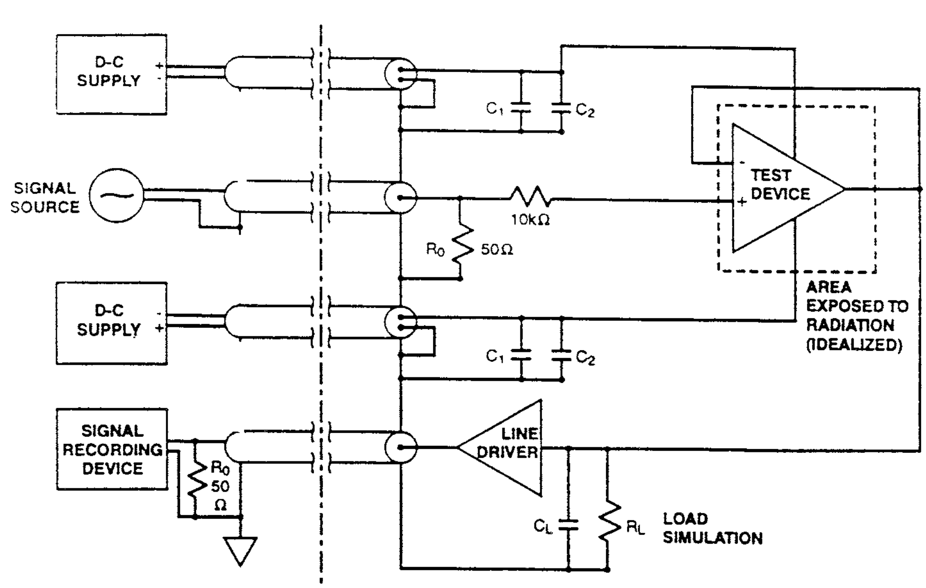

FIG. 1 Example of a Test Circuit