RAD Hard System Guidance

Introduction

This section provides guidance concerning RHA, RHM, and RHS on system development issues.

These activities should be initiated as early as possible in the system development cycle to minimize cost and effort. Moreover, these efforts should be integrated to the maximum extent practicable in the system's testability requirements.

Indeed, if an aspect of an overall system development activity entails the development and demonstration of a "new" technology, this development effort should also extend to qualification, RHA, RHM, and RHS tasks as appropriate.

One example of such a situation would be the need to develop a radiation hardened cryogenic microelectronics technology to support a system development. Since the areas of radiation hardening and testing, reliability testing, process qualification, etc. are ill-defined for this type of technology, it would be highly desirable and cost effective to initiate technology qualification, reliability characterization testing, and RHA efforts in conjunction with the basic development tasks.

Clearly such a proactive approach is also appropriate for devices without radiation requirements. However, the imposition of this additional set of constraints greatly exacerbates the situation.

Radiation Hardness Assurance and System Radiation Hardening Considerations

RHA program - The microcircuit RHA program must include an allocation of radiation design margin in the part acceptance specification limits which can be combined with other parameter degradation stresses, such as time and temperature, to assure each system relevant parameter has tolerable end-of-line (EOL) limits.

As previously stated, the selection of devices for a particular application requires knowledge of the radiation response of that device, a description of the environment, an understanding of the specific device application, and a description of the system/subsystem where the device will be used.

Electronic pieceparts are normally obtained for a system through the implementation of a parts control plan (see the Selection Guidance section) and an integral part of such a plan is the radiation hardness assurance (RHA) program. The RHA program refers to all of the methods and procedures which control the acquisition to specified radiation performance levels. Specific RHA requirements for various classes of semiconductor suppliers are also discussed in the Selection Guidance section.

RHA activities are most apparent during the production phase of a program. However, RHA considerations (e.g., parts selection, parts control, etc.) should begin during the initial stage of a program (i.e., concept definition) and pervade all phases of a program. Such an approach should preclude the need to retrofit radiation hardening into a system which can be extremely costly. If radiation hardening is addressed during the initial stages of a systems development the cost of hardening can be less than 5% of the entire satellite cost.

In addition to RHA, hardness maintenance and surveillance programs are required to ensure that the robustness of a system is not compromised during its operational phase due to incorrect maintenance.

For suppliers that provide radiation hardened parts, in general all RHA SMDs require devices to be characterized to indicate device capability (not to system survivability) using the following MIL-STD-883 Test Methods 1017, 1019, 1020, and 1021; and ASTM Test Method 1192.

RHA designators have been developed to allow for the categorization of total ionizing dose capability levels, as follows:

M = 3×10^3 rad(Si)   F = 3×10^5 rad(Si)

D = 1×10^4 rad(Si)   G = 5×10^5 rad(Si)

P = 3×10^4 rad(Si)   R = 1×10^5 rad(Si)

L = 5×10^4 rad(Si)   H = 1×10^6 rad(Si)

For example, if a part is characterized to 5×10^4 rads(Si) the part would be listed as a D level part, but if that same part from a different manufacturer shows a capability to 5×10^5 rads(Si), the part would be listed as an R level on the same SMD.

The other test methods are handled within the MIL-PRF-38535, Group E paragraphs in each detailed specification as required by design or by the purchase order. The Mil-PRF-38535, Group E Table designates the test method, sample size, identify specific technology types that allow certain tests to be eliminated or retained and contain a variety of caveats concerning radiation testing in general.

It should be noted that the utmost care must be exercised before a specific test is eliminated. This warning is important since some technologies contain parasitic structures sensitive to radiation effects that don't affect the primary structure but are capable of affecting the overall circuit performance. An example of such a situation would be a combined MOS digital circuit and CCD device. In general, an MOS digital structure is insensitive to neutron irradiation, but neutrons can dramatically degrade the operation of a CCD. Thus, the deletion of neutron testing, which is normally allowed for MOS technology, would be inappropriate for this case.

By providing a fully characterized detailed device specification the user knows the device capability and can make a better judgment on which part best suits his particular application. However, for the situation where a device without an RHA specification is used in a situation where radiation hardness is required, as is often the case, a complete characterization of the device is required for those applicable environments (e.g., total ionizing dose, SEE, etc.) at the anticipated radiation levels. Also, any decisions concerning the appropriateness of the device must include the statistical variations associated with the device response, anticipated/statistical variations in the operating environment (e.g., solar max, solar min, solar flares, etc.) and the actual system parameters (e.g., shielding, shadowing, end-of-life performance needs, allowable number of upsets, etc.).