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OPTIMIZATION OF SATELLITE SPACE RADIATION SHIELDING

Abstract

Ensuring space radiation hardness of satellites remains a complex scientific and engineering challenge, encompassing a wide range of issues related to both understanding space environment and the mechanisms of its impact on a satellite. The introduction of new technologies, combined with the widespread use of commercial components and materials not intended for space, force the designers to reimagine traditional practices for ensuring space radiation hardness of satellites and, under the severe constraints inherent in space projects, find rational schematic and design solutions that guarantee the success of the satellite's mission in the harsh space environment. The risks inherent in such solutions are mitigated mainly by thorough radiation shield design, where one of the key places is taken by the optimization of the protection field around the critical elements of the satellite. In the most general form, the problem of optimization of the satellite space radiation shielding is formulated as follows: "How should the protection field around the critical elements of the satellite be transformed so that space radiation hardness requirements are met under the constraints adopted in the project?" The minimum space radiation hardness requirements include ionization and non-ionization doses, destructive and non-destructive single events, and internal charge. Standard design models and experimental techniques currently used to ensure space radiation hardness of satellites are not very suitable for solving the problem in such a formulation. The sector analysis methodology, widely used in radiation shield design, is acceptable only for aluminum shields and does not allow adequate reproduction of the protective properties of actual materials. The well-known Monte-Carlo-based space radiation transport codes such as GEANT4, FLUKA, HZETRN, etc. solve the problem fully, but the time required for the computation makes their use in engineering practice impossible. The purpose of the research whose results are presented in this paper is to create a toolkit for solving the problems of ensuring space radiation hardness in the standard satellite design practice. Using the sector analysis methodology as a basis, design and empirical methods have been created to optimize the protection against the whole complex of cosmic radiation within a single design model. The intensity of single events is estimated taking into account the actual configuration of the protection field surrounding a component and for an arbitrary geometry of the critical volume where charge accumulation can initiate single events. The research results have been introduced into the practices of Yuzhnoye State Design Office.