

## Conference Paper

# The Application of Schematic Compensation Technique for Increasing of Radioelectronic Devices Reliability

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## Abstract

The schematic method development of radiation degradation compensation of operating amplifiers' input currents and offset voltages on basis of radiation-sensitive parameter degradation research of integral microcircuits and discrete transistors is presented and experimentally verified.

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## 1. Introduction

In the process of exploitation of spacecraft on-board radioelectronic devices are subjected to the exposure of solar and galactic radiation which consist of high-energetic protons and nuclear of different elements. Influence of ionization radiation causes functional and parametric failures of integral microcircuits that are the basic elements of modern spacecraft electronics. At the present time, the microcircuits of operational amplifiers, which basic radiation-sensitive parameters are input currents and offset voltages are widely used for analog signal processing. Degradation of these parameters under the impact of ionization radiation leads to the failures of automatize spacecraft control systems. This work's objective is to increase spacecraft analog electronic radiation hardness by the schematic method of compensation of radiation degradation of operational amplifier's parameters.

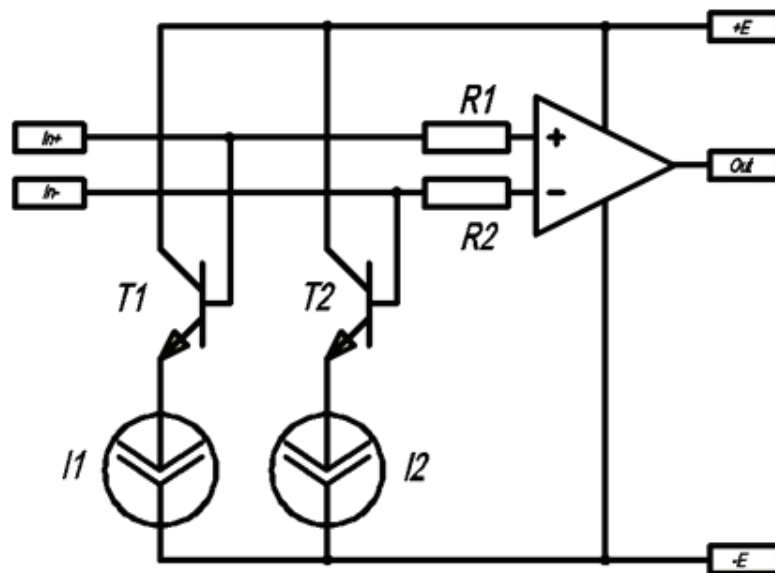
## 2. Materials and Methods

The schematic method of compensation of radiation degradation is presented. This works the method of spacecraft operational amplifier's radiation hardness increasing is vital both in science terms and from practical perspective. Integral microcircuits

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are widely used in satellite communication devices, GLONASS and GPS and also in providing of telecasting and radiocasting. Operational amplifiers are used in spacecraft hardware, which is insisted to be especially reliable and have high radiation hardness. At present times, there is a huge interest in the Mars exploration that can take several years and because of this electronic research equipment has to have high hardness to the impact of space ionization radiation. These requirements are especially relevant in case of human expedition because their lives will rely on spacecraft on-board electronic reliability.

Schematic method of spacecraft operational amplifier's lifetime increase requires evaluation of radiation degradation characteristics of input currents and offset voltages obtained during qualification tests in order to calculate parameters of the circuit for external compensation.



**Figure 1:** Circuit of operating amplifier's external compensation of radiation degradation of input currents and offset voltages (operational amplifier LM124).

Base currents of  $T1$  and  $T2$  transistors, which increase under the radiation impact, compensates current radiation increment of non-inverting and inverting inputs of operational amplifier correspondingly. Direct-current sources  $I1$  and  $I2$  establish emitter and base currents of compensating transistors. Nominal values  $I1$  and  $I2$  are calculated according to results of qualification test of the transistors and the operational amplifier. Resistors  $R1$  and  $R2$  are proposed for compensation of the offset voltage radiation

drift and their nominal are calculated according to input currents increment caused by radiation by following expression:

$$R = \frac{\Delta U_{CM.0}}{\Delta I_{BX}},$$

where  $\Delta U_{CM.0}$  – offset voltage increment,  $\Delta I_{BX}$  – input current increment obtained during operational amplifier's qualification tests. Since electrical parameters of integrated circuits (ICs) depend on operation temperature, the devices [1, 2] for temperature control and monitoring are usually used during radiation test experiments. In our case we didn't use the devices because the temperature dependence of electrical parameters for our devices under test is not significant.

This work's experimental research results, that were carried out on operational amplifier LM124 and transistors 2N2222, show that usage of this method allows to increase parametric failure dose more than in five times.

### 3. Conclusion

Schematic method of compensation of operating amplifier's parameter radiation degradation allows repetitively increase spacecraft analog radioelectronic devices radiation hardness without expensive changes in operational amplifier's chip, which requires intensive development of new microcircuit topology and production method of the fabrication.

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