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The operational amplifiers radiation hardness experimental study

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Abstract. The radiation hardness of the operational amplifiers IS-OU2 and LM358 has been performed experimentally using X-ray research complex. It was found that the measured characteristics of operational amplifiers (input offset voltage, consumption current, voltage gain) for the IS-OU2 and its analogue LM358 are similar and demonstrate radiation hardness. As result, the designed and produced IS-OU2 operational amplifier can be used for producing of energy-efficient power energy systems electronic components that can operate under radiation conditions.

Keywords: operational amplifiers, X-ray irradiation, ionizing dose effects.

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Introduction

As well known the operational amplifiers are important parts of modern electronics devices that are used widely in many industrial applications such as power engineering, energy systems, electrical engineering, etc. [1]. For development of industries (nuclear engineering, aircraft building, cosmonautics, satellite systems, etc.) it is necessary to achieve reliable functioning of the electronic components that used under some radiation conditions [2]. Therefore, with taking into account, the main goal of this work is to study the radiation hardness to the effects of the total ionizing dose of operational amplifier IS-OU2 using the developed X-ray research hardware and software complex (XRC).

Materials and Methods

The objects of the study were operational amplifier IS-OU2 (manufactured by JSC "GRUPPA KREMNY EL" [3]) and its analogue LM358 in the SO-8 type metal-polymeric package. For radiation behaviour study was used the developed XRC consisting of the following parts: X-ray equipment RIK-0401, X-ray comparator DRI-0401, a set of measuring equipment (sources-measuring instruments PXIe-4143, PXIe-4139), and the developed software. The developed XRC is described in detail in [4, 5]. Earlier, for instance, the above-mentioned XRC was successfully approved for studying of the radiation behaviour of the linear LDO positive voltage regulators [4, 5]. For operational amplifier microcircuit, the XRC allows monitoring the main characteristics (consumption current, input offset voltage, voltage gain, input offset current etc.). The radiation behaviour study of operational amplifiers IS-OU2 and LM358 was performed the following operating mode of RIK-0401: anode voltage – 70 kV, anode current – 220 μA, the radiation absorbed dose rate was 250 un./s (un. – units of the DRI-0401 comparator), the distance between the X-ray tube window and the sample – 25 mm.

Results and Discussion

The operational amplifiers IS-OU2 and foreign analogue LM358 [6] during irradiation process were in the active electrical mode (at supply voltage ± 16 V). During the study, the main parameters of the IS-OU2 have been measured (input offset voltage, consumption current, voltage gain etc.). For instance, in Figure 1*a* and Figure 1*b* are shown the dependencies of the input offset voltage at the minimum and maximum supply voltage on the total ionizing radiation dose for samples of IS-OU2 and LM358 amplifiers. As follows from Figure 1, the input offset voltage at the minimum (*a*) and maximum (*b*) supply voltage for the developed IS-OU2 and LM358 amplifiers increases very slightly with an increase in the total ionizing radiation dose. It should be noted that input offset voltage values for developed amplifier IS-OU2 do not exceed

maximum (± 3.5 mV [3, 6]) and are comparable with LM358. Also it was found that the consumption current and voltage gain for the samples of the IS-OU2 and LM358 amplifiers are quite close.

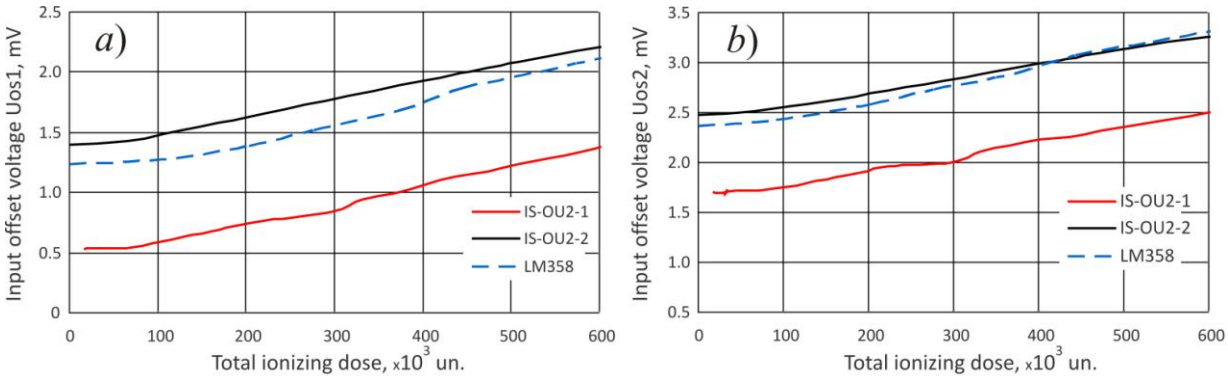

Fig. 1. Dependence of the input offset voltage at the minimum (*a*) and maximum (*b*) supply voltage on the total ionizing dose for operational amplifiers: IS-OU2 (IS-OU2-1 - the first sample and IS-OU2-2 - second sample) and LM358.

Thus, the operational amplifier IS-OU2 samples and its foreign analogue LM358 in studied radiation exposure interval demonstrate radiation hardness to the effects of the total ionizing dose and therefore can operate under radiation conditions such as spice and others [2].

Conclusion

The experimental study of the radiation hardness of the integrated circuit of the operational amplifiers IS-OU2 and analogue LM358 has been performed using X-ray research complex. Based on the results of experimental studies it was found that the measured characteristics (input offset voltage, consumption current, voltage gain) for the samples of the IS-OU2 and LM358 amplifiers are quite close. Therefore, with taking into account, the designed and developed IS-OU2 operational amplifier demonstrates radiation hardness and can operate under radiation conditions and, for instance, can be used for producing of energy-efficient power energy systems electronic components and devices.

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