# Method of compensating of sensitivity degradation of magnetically operated switches

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*Abstract* – **Circuitry of current compensation of degradation of total sensitivity of magnetically operated semiconducting switches during gamma irradiation we suggest.**

*Keywords* - **Magnetically operated switch, Degradation, Gamma irradiation, Method of compensating.**

## I. Introduction

Aging degradation of parameters of semiconductors after an exposure by a hard radiation is being significantly accelerated. Therefore the methods of compensating of irradiation effects for semiconductor devices allow to prolong its service life at standard working conditions. For growing reliability of magnetically operated switches a changing its parameters after an exposure by a gamma quanta stream we explored.

## II. Discussion of outcomes of experiment

The switch is executed as an industrial chip of series К1116. The microchip contains a Hall's magnetic transducer, a two-transistor differential amplifier, a trigger and an output transistor. At lack of an external magnetic field the Hall transducer does not produce voltage therefore the trigger is in switched off position, and the output transistor is closed. In a magnetic field the Hall transducer starts to generate voltage $U_{H,}$ which is being magnified by a differential amplifier to magnitude $U_C$ necessary for switching the trigger in a switched on position. Thus the output transistor is being unclosed.

Sensitivity of the switch is being characterised by threshold value of magnetic induction $B_T$ since which the trigger can be switched. Period of trouble-free service life of the switch is limited by a sensitivity's decreasing due to reduction of Hall voltage in time. The differential amplifier of a chip is used for switch sensitivity increasing, that's should prolong a working period of the switch.

The gamma radiation which can get through the plastic chip package, changes both Hall voltage, and a gain factor of the differential amplifier.

For the stabilised voltage of a power supply of chip $U_0$ the Hall voltage of a transducer is being described by expression:

$$U_H = \frac{BhU_0}{l}\mu, \qquad (1)$$

where $B$ - magnetic induction of external field, $h$ - height, and $l$ - base length of Hall transducer.

As we can see from a relation (1) the reduction of Hall voltage after the radiation exposure, is related exclusively with decreasing of mobility of charge carriers $\mu$ due to increasing of quantity of irradiation-induced defects in the semiconductor.

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For verification of the given assumption we have compared two experimental dependence of voltage of Hall $U_H(\Phi)$ and mobility of charge carriers $\mu(\Phi)$ from intensity of an exposure of a magnetic transducer $\Phi$. Both curves have the typical sharp decreasing at radiation flux of the order of $10^{16}$ quantum/sm. Thus, we concluded that reduction of voltage of Hall during an exposure of the switch by a gamma quanta is uniquely determined by a decreasing of mobility of charge carriers in the semiconductor of a magnetic transducer of a chip.

The probable reasons of a modification of an amplification factor of a differential amplifier during an exposure we have tried to estimate by means of the experimental dependence of a current's transmission coefficient of bipolar transistor from a lifetime of charge carriers $\tau$ and their mobility $\mu$. For the common-emitter circuit we have:

$$h_{21E} = c \cdot \tau \cdot \mu, \qquad (2)$$

here $c$ – constant coefficient.

Irradiation-induced defects in the semiconductor diminish not only mobility of charge carriers $\mu$, but also their lifetime $\tau$. From comparison (1) and (2) it is visible, that with magnification of intensity of an exposure the coefficient is being decreased faster, than Hall voltage. Thus, a parameters of a differential amplifier of a chip degrade faster, than of a Hall transducer, that considerably diminishes effect of working life prolongation of the switch.

To compensate of the reduction of an amplification coefficient of a differential amplifier of a microchip a standard circuitry of a temperature stabilizer of parameters of semiconducting sensors we have suggested to use. For this purpose, to a differential amplifier circuit we include a setting current transistor that will increase a control transistor current. Input voltage of the setting current transistor we apply from base contacts of a transducer of Hall.

In a result of a degradation of a Hall transducer both resistance of a transducer and a voltage drop on its base contacts are being increased. This magnification of voltage leads to magnification of a current of the setting current transistor and as a result of a current that is flowing through a control transistor of the amplifier. Reduction of transmission coefficient of a current of transistors of a differential amplifier is compensated. When we used the Darlington circuit with two setting current transistors we achieved the full compensating of a decreasing of sensitivity of the magnetic switch even at an exposure fluxes to $10^{18}$ quantum/sm.

## III. Conclussion

Irradiation-induced degradation of mobility of Hall transducer can be used for total compensation of decreasing of sensitivity of magnetically operated switch during the gamma irradiation up to fluxes $10^{18}$ quantum/sm.