Switching DC-DC converters' TID and SEE hardness investigation

Alexander Y. Nikiforov, Dmitry V. Boychenko, Leonid N. Kessarinskiy

Total dose and SEE experimental data for switching DC-DC converters and its basic parts (MOSFETs, error amplifiers, PWMs, optocouplers) is presented. The most total dose and SEE sensitive parts are revealed.

The sufficient information on DC-DC converter total dose and SEE behavior is essential for space applications [1-3].

We conducted over 50 different total dose experiments on switching DC-DC converters and found its hardness levels vary drastically from 1 to 360 krad depending on manufacturing process and electrical conditions (fig. 1).

Over 60 experiments were done for MOSFETs, error amplifiers (operational amplifiers and comparators), PWMs and optocouplers in order to find the most dose and SEE sensitive parts of the DC-DC and to suggest the hardness improvements. In every experiment electrical regime inherent to switching DC-DC converter was taken into account.

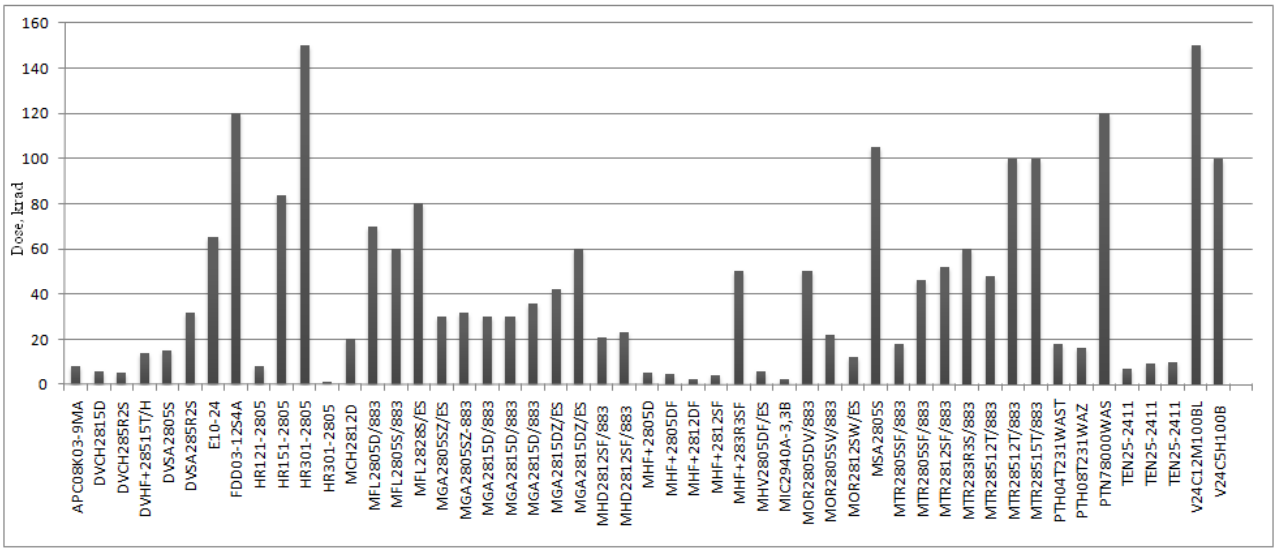


Fig. 1. Experimentally obtained DC-DC converters total dose hardness levels

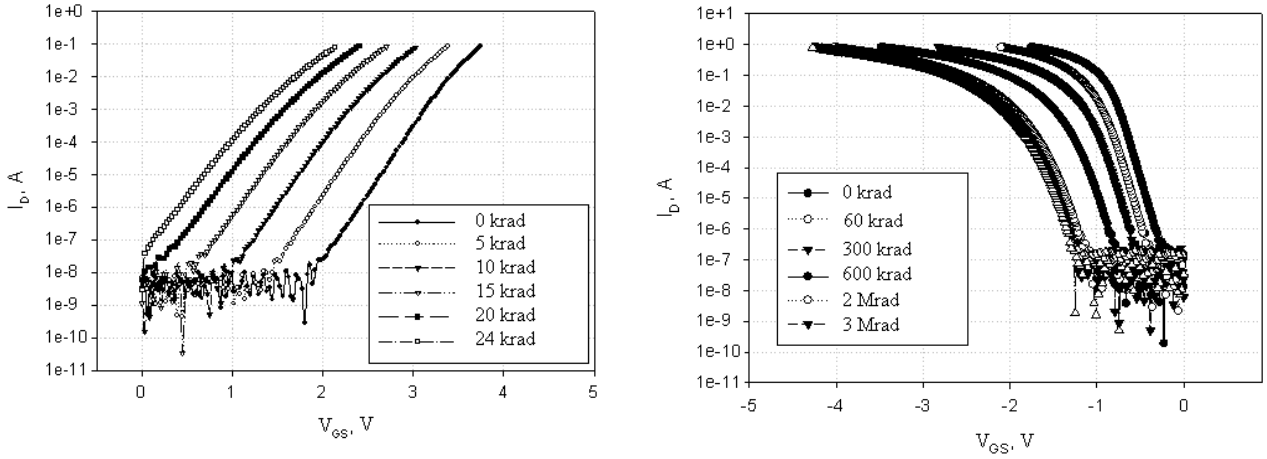
Manuscript received April 12, 2012

Dmitry. V. Boychenko is with the National Research Nuclear University (MEPhI) and SPELS, Russia, 115409 Moscow Kashirskoe shosse 31 (corresponding author to provide phone: +7903-520-20-60; fax: +7-495-324-0420; e-mail: dvboy@spels.ru).

Leonid N. Kessarinskiy is with the National Research Nuclear University (MEPhI) and SPELS, Russia, 115409 Moscow Kashirskoe shosse 31 (e-mail: lnkes@spels.ru).

Alexander Y. Nikiforov is with the National Research Nuclear University (MEPhI) and SPELS, Russia, 115409 Moscow Kashirskoe shosse 31 (e-mail: aynik@spels.ru).

Power MOSFETs are used in DC-DC converters as switching elements. It is well known that threshold voltage decreases for n-channel and increases for p-channel MOSFETs during gamma irradiation. The total dose experiments for modern power MOSFETs with respect to the electrical regime in DC-DC converters exhibit similar degradation (fig. 2). Usage of the p-channel MOSFETS with additional gate-source voltage level pull-up unit (in order to equalize the threshold voltage degradation) can improve total dose hardness of the DC-DC converter.



n-channel IRFI640GPBF p-channel IRLML6401

Fig. 2. Power MOSFETs total dose degradation

The error amplifiers in the DC-DC converters are usually built on operational amplifiers or voltage comparators. More than 20 total dose experiments on operational amplifiers and voltage comparators with respect to the electrical regime in DC-DC converters showed no degradation up to 80 krad which could affect the proper converter operation. Corresponding experimental data will be included in the final paper.

Over 20 experiments have found optocouplers (Avago Technologies, Agilent Technologies, Fairchild, etc.) to be potentially total dose and SEE sensitive. In some cases employment of the transformers instead of optocouplers can improve DC-DC converter total dose and SEE hardness. Corresponding experimental data will be included in the final paper.

Bipolar PWMs are experimentally proved to be less total dose sensitive regarding CMOS and BiCMOS devices. Therefore bipolar PWM employment can improve DC-DC converter total dose hardness.

Ion irradiation experiments revealed that power MOSFETs and PWM controllers are the most SEE sensitive parts of the DC-DC converters. In order to distinguish the response of each part, separate irradiation experiments were conducted (fig. 3, 4).

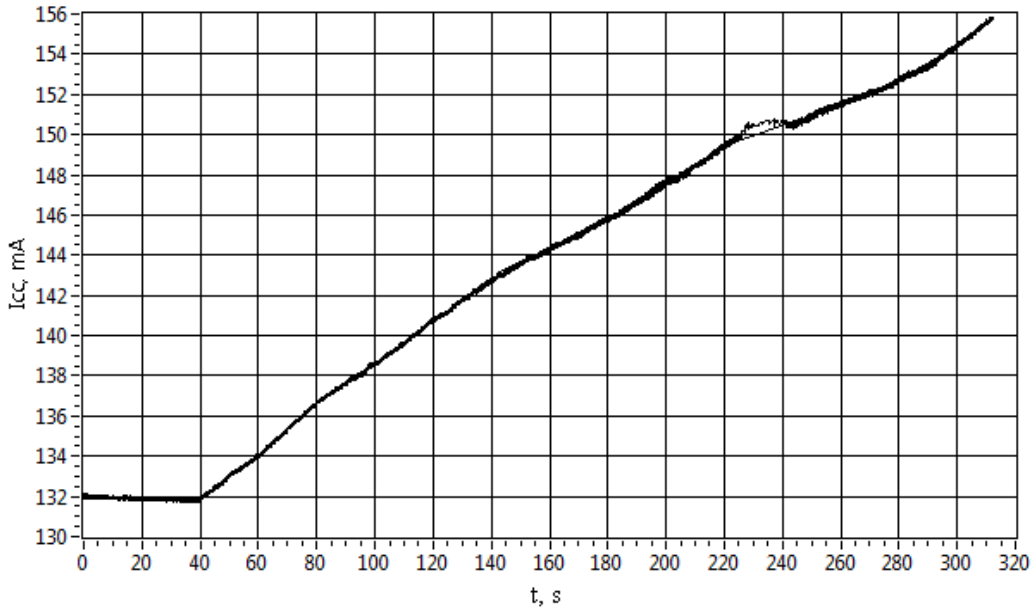


Fig.3. PTH03060WAH supply current vs. time during Xe-ion irradiation (only MOSFET is irradiated)

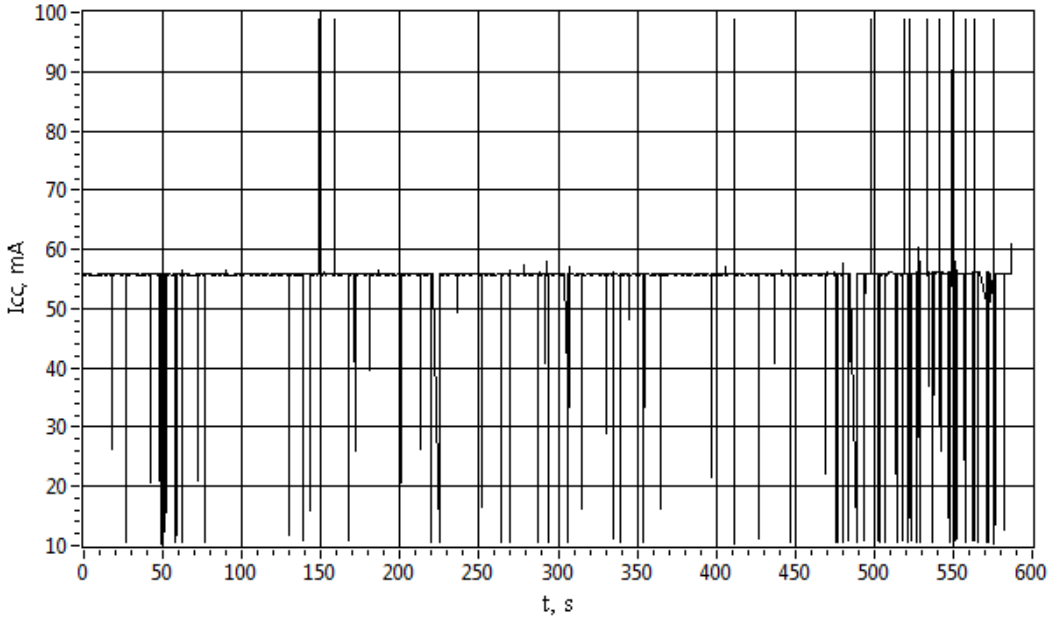


Fig.4. PTH03060WAH supply current vs. time during Xe-ion irradiation (only PWM is irradiated)

I. DATA ANALYSIS

Power MOSFETs and PWM controllers are experimentally proved to be the most total dose and SEE sensitive parts of the DC-DC converters. Usage of the p-channel MOSFETS with additional gate-source voltage level pull-up unit, transformers and bipolar PWM controllers can improve total dose hardness of the DC-DC converters.

REFERENCES

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