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Response of the Three-Terminal Voltage Regulator Irradiated by Pulse Neutrons

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Abstract: The terminal evolution of the output voltage of the three-terminal voltage regulator in the irradiation of pulse neutrons was investigated by the experiments and the circuit simulation in this paper. Experiments was performed at Xi’an Pulsed Reactor and the short-term annealing was observed. The time-dependent effective neutron fluence was developed to simulate the terminal evolution of the output voltage of the three-terminal voltage regulator in the circuit simulator. The simulated result was shown to agree with the experiments.

Introduction

It is indicated that the damage in electronic devices from pulse neutrons irradiation is considerably more severe immediately after the neutron pulse. The damage decreases with time on a time scale varying from milliseconds to seconds. This phenomenon is referred to as short-term, transient, or rapid annealing.

The response of the three-terminal voltage regulator was investigated by experiments and the numeical simulation in this paper.

Experiments

Experiments were performed at Xi'an pulsed reactor (XAPR). XAPR operared at the maximum power 4200MW, the reactivity insertion was ＄3, the pulse width was 13.6ms, and the neutron fluence (>10 keV) was 1.5e13 cm^{-2} .

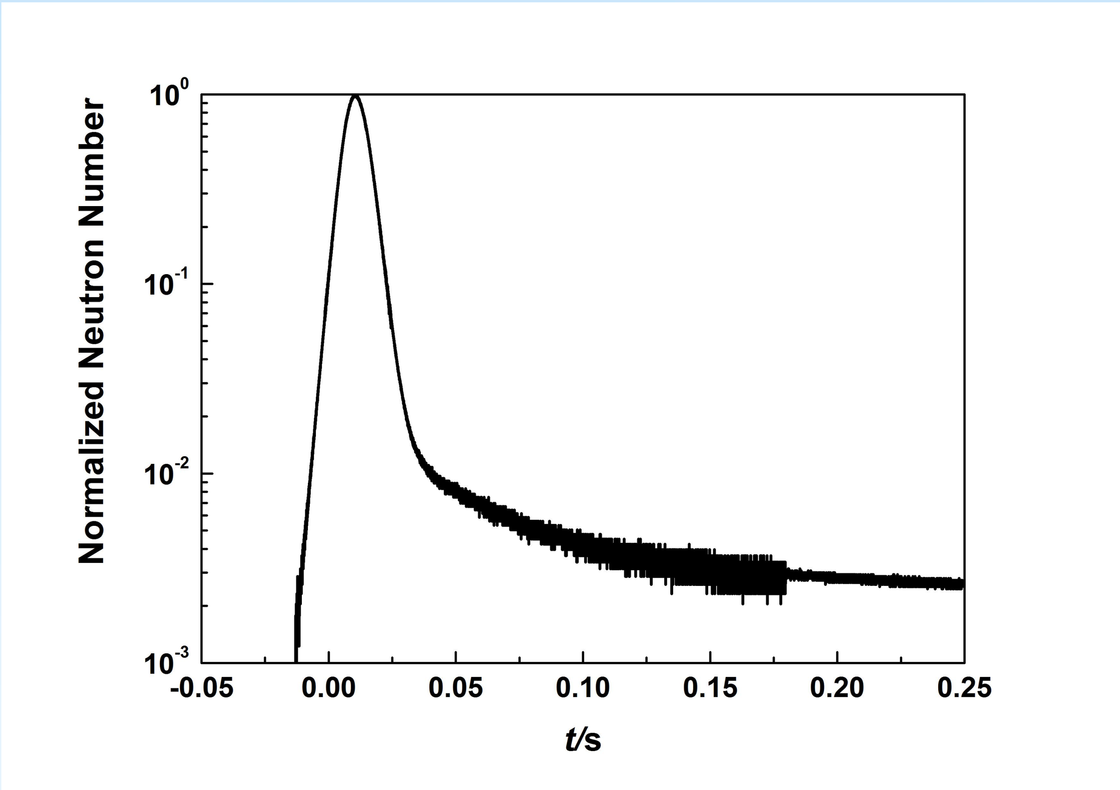

Fig. 1 The normalized neutron number via time in XAPR

Four of CJ79L0511 three-terminal voltage regulators were used and the input voltage was -10V and the output voltage was about -5.10V before the irradiation. Under the irradiation of the pulsed neutrons, the output volatage firstly increased, then decreased, and finallly tended to be stable.

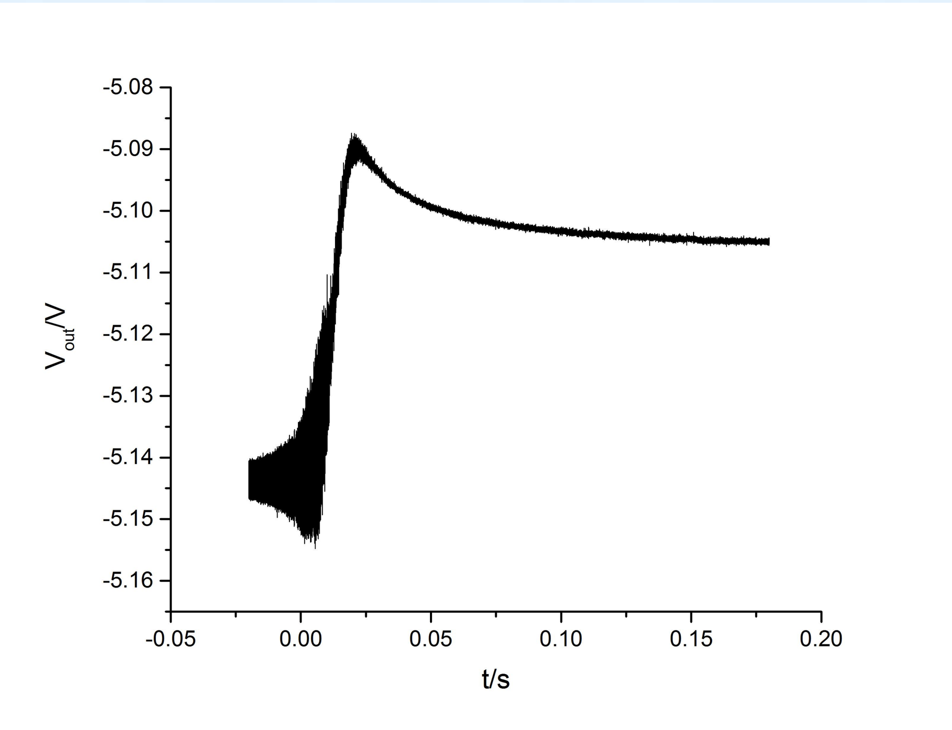

Fig. 2 The ourput voltage of the three-terminal voltage regulator via time in XAPR

Circuit Simulation

The time-dependent effective neutron fluence was developed to simulate the reponse of the three-terminal voltage regulatior irradiated by pulsed neutrons in the circuit simulator.

$$A_F(t) = \frac{\phi_n^*(t)}{\phi_{n\infty}^*}$$

$$A_F(t) = 1 + \sum_i A_i \exp(-t/\tau_i)$$

$$\phi_n^*(t) = \int_{-\infty}^{t} F_n(t')A_F(t-t')dt' = \int_{-\infty}^{t} F_n(t')dt' + \sum_i \int_{-\infty}^{t} F_n(t')A_i \exp\left(-\frac{t-t'}{\tau_i}\right)dt'$$

The short-term annealing curve obtained from the bipol;ar transistors in XAPR was used as the annealing factor in the ciucuit simulation of the voltage regulator. It was indicated that the simulated result agreed well with the experimental result.

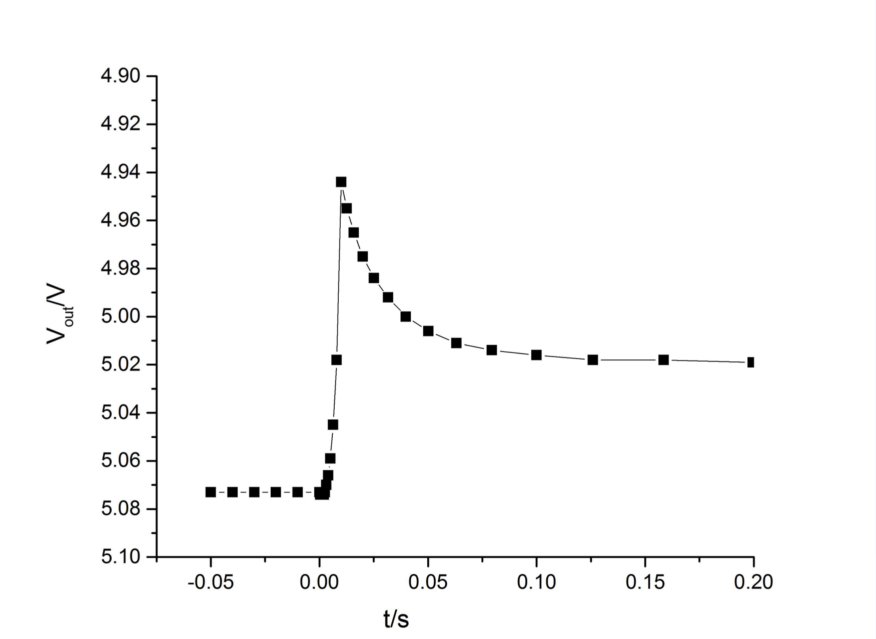

Fig. 2 The ourput voltage of the three-terminal voltage regulator via time by the ciucuit simulation

Conclusion

The response of the three-terminal voltage regulator was investaged by experiments and numerical simulation. the experimens were performed in XAPR and the short-term annealing was observed. The circuit simulator was used and the time-dependent effective neutron fluence was developed for the simulation. It was indicated that the simulated result agreed with the experimental result.

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