High-voltage power supply with improved thermostability for Xenon gamma-ray spectrometer

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Abstract. In this article the high voltage power supply for xenon spectrometer is described. Result of time simulation for output voltage at different temperatures was shown. The experimental data is confirming results of the time simulations. The experimental data showed breadboard model provides a stability of voltage better than 1% of the generated voltage at different temperatures

1. Introduction
The development of a gamma spectrometer "Signal", based on the Xenon gamma ray spectrometer (HPXe spectrometer) is carrying out as part of the experiment "Interheliozond". Since the experiment will be carried out in hard environment it is required to increase the reliability and stability of the HPXe spectrometer [1]. To increase thermostability of HPXe spectrometer is necessary first of all to develop high voltage heat-stable power supply unit. We assume that the stability of 1.5% is sufficient.

2. The original high voltage supply module
The HPXe spectrometer is a pulse ionization chamber, so one of its features is a need to apply the high voltage to the grid and the cathode. The typical high voltage, which has to be applied to these electrodes are 15kV and 20kV. The high voltage supply based on push-pull converter.

![Figure 1. Block diagram of high voltage supply module.](attachment:diagram.png)

The original circuit is shown on the figure 2. It was analysed using OrCAD software. The work of this circuit has been revealed important shortcomings: voltage spikes of high amplitude which can
damage the FETs, voltage spikes on midpoint of transformer after the stack of control pulses and lasting fluctuations arises (see figure 3).

![Diagram of circuit](image)

**Figure 2.** Circuit of high voltage power supply model.

![Graph of voltage spikes](image)

**Figure 3.** Voltage spikes on midpoint of transformer after the stack of control pulses.

3. **The development of optimal circuit of the high voltage supply module**

During search of the optimal scheme of high voltage power supply module different variants were investigated, but in this article we will limit ourselves to a description of the final version of thermo-stable high voltage supply module (see figure 4).

The stabilization of the current is provided directly at the FET in the final circuit. Each FET has a feedback using a bipolar transistor. Thus resistors R48 and R49 determine the maximum current flowing through the transformer.
The optimum waveform observed when the time constant $\tau$ of the RC-circuit R42C10 (R44C11) and the period of the control signals are the same. The shape of the input transformer signals will be sinusoidal in case of equality of these values (see figure 5). This waveform is the most preferred for use in the high voltage supply module than rectangular, because it provides a much lower level of interference to nearby electronic components.

**Figure 4.** The final version of thermo-stable high voltage supply module.

**Figure 5.** Result of time simulation for transformer differential input voltage. The optimum waveform shown.

**Figure 6.** Result of time simulation for module output voltage at different temperatures. The voltage level is constant during simulation.
The voltage level was simulated for different temperatures. According to a simulation (see figure 5) developed circuit provides a change of voltage less than 30V when the temperature was increase from -50°C to 50°C, which is 1.5% of the generated voltage.

4. Experimental results
The developed model was verified with the breadboard. Figure 7 shows the experimental data confirming results of the time simulations. The experimental waveform has a shape close to an optimum waveform (sine wave).

![Figure 7. The experimental waveform.](image1)
**Figure 7.** The experimental waveform.
The dark line is differential voltage on transformer. The grey lines are input voltages on transformer.

![Figure 8. The voltage versus temperature.](image2)
**Figure 8.** The voltage versus temperature.

According to an experimental data (see figure 8) developed circuit provides a stability of voltage better than 1% of the generated voltage when the temperature was increase from 23°C to 100°C. These results confirm the simulation.

5. Conclusion
The circuit of thermo-stable high voltage supply unit for spectrometer "Signal" was developed using OrCAD software. It is experimentally shown that the breadboard of the new high voltage supply unit provides the expected performance.

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References
[1] Novikov A et al. 2015 Xenon gamma-ray spectrometer in the experiment Signal on board the spacecraft Interhelioprobe Proc. SPIE 9593 95930L-1