Control System for the RADUGA-5 High-Current Vacuum Arc Ion Source

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Abstract – In the present study, an automatic control system for the Raduga-5 source of accelerated metal ions [1] is described. The system is built around microcontrollers of Mega series produced by the Atmel Corporation. An automatic pulse-position frequency control of triggering pulses is used for a high-voltage pulse generator (HVPG). This allows the stability of high-voltage pulse amplitude to be increased. Smooth pulse frequency regulation allows shock loading on the HVPG power supply unit to be decreased under conditions of current overload in the diode system of the Raduga-5 source.

1. Introduction

Installations for ionic implantation and deposition of coatings are complex technological systems equipped with different automatic technological process control systems. The present paper is devoted to modernization of the control system for the Raduga-5 high-current source of accelerated metal ions aimed at increasing the source reliability under conditions of electromagnetic noise.

A new approach to the design of the automated control system for the source of the given type based on new-generation microcontrollers of Mega series ATmega2313 and ATmega8535 produced by the Atmel Corporation [2-3] whose technical parameters are improved in comparison with the microcontrollers of AT90 series Classic [4-5] is considered, and a number of circuits and units have been developed for the control system.

2. System of automation of control processes for the Raduga-5 source of ions and plasma

Figure 1 shows the unit diagram of the control system. As can be seen from the diagram, the system comprises three units connected with each other through the RS-232 galvanically decoupled standard interface. The given standard is widely used in all models of microcontrollers of Mega series; this standard is realized on the hardware and physical levels.

3. Brief description of blocks of the automation system for the source

The panel of the control unit (Fig. 2) is intended for visual display of information from the controller of the power supply unit (PSU) and for display and input of commands from the computer or keyboard. In the presence of the RS-232 interface, the priority of control belongs to the computer.

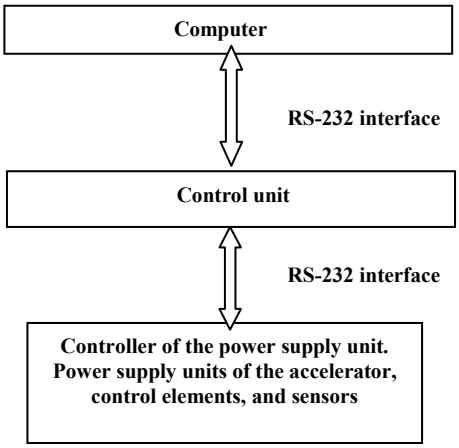

Fig. 1. Block diagram of the control system for the ACS

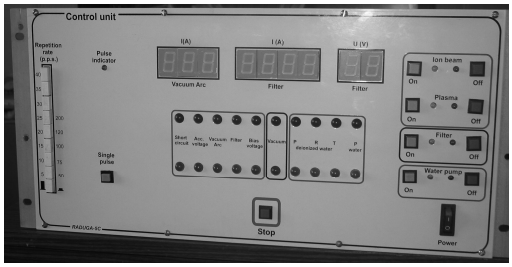

Fig. 2. Panel of the automatic control system for the Raduga-5 source of accelerated metal ions

The displayed parameters are:

- vacuum-arc discharge current,
- plasma filter current,
- bias voltage applied to the plasma filter,
- blocking signals from sensors,
- control signals.

The trigger pulse generator for the HVPG of the Raduga-5 source is placed on the panel. Generation of trigger pulses for the HVPG with frequency up to 200 pulses/s is controlled programmatically; the frequency smoothly increases to the working frequency, and the load current is monitored simultaneously. For a certain number of overloading pulses from the current sensor, the frequency is smoothly reduced, and for long-term overloading of the power

supply system, the command is given to switch off the HVPG from the power supply circuit.

The controller of the power supply unit (PSU) (Fig. 3) of the automatic control system for the Raduga-5 source transmits information from sensors to the panel and commutates units by commands from the control unit.

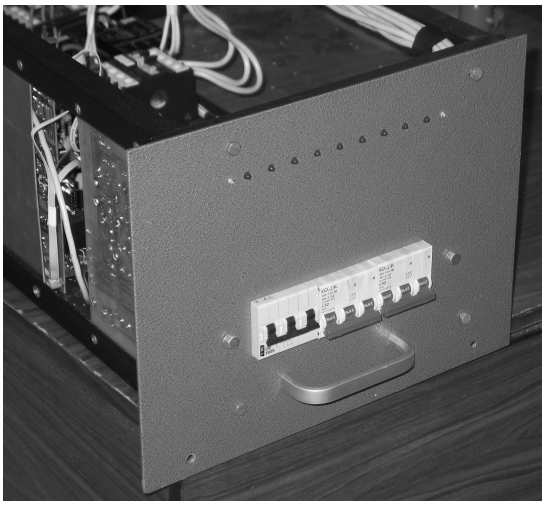

Fig. 3. Power supply unit of the automatic control system for the Raduga-5 source of accelerated metal ions

4. Software for the control system

The software for the personal computer was written in the Borland C++ Builder 6 Programming Support Environment for Windows 95/98, NT. The main window of the program reproduces graphically the panel of the control system for the Raduga-5 source with some additions.

Microcontroller programs were based on CodeVisionAVR Evolution developed by the HP InfoTech. The generated code size did not exceed the limit for this version.

5. Conclusions

The developed automatic control system for the Raduga-5 high-current source of accelerated metal ions differs by the following parameters:

1. Program control through the RS-232 interface.
2. Pulsations of high-voltage pulses are significantly reduced.
3. The power supply unit is based on MOSFET transistors controlled on the logic level, which allows thermal losses to be reduced.
4. Control logic is based on AVR microcontrollers of the Mega series.

The main advantage of the ACS design based on AVR microcontrollers of the Mega series is that under conditions of increased reliability of the control system as a whole, its further modernization needs neither additional complete units nor changes in the design of the entire system. The microcontrollers of the Mega series have the most advanced periphery and the greatest AVR memory for programs and data among all microcontrollers. Thus, the developed automatic control system has much wider functional capabilities of control and much better technical parameters.

References

[1] Ryabchikov A.I., Dektyarev S.V., *in Proc. 4th Int. Conf. on Modification of Materials with Particle Beams and Plasma Flow*, 1996, pp. 93–95.

[2] *8-bit RISC Microcontroller*, Data Book, Atmel Corporation, August 2005.

[3] V.V. Grebnev, *Microcontrollers family AVR Firm Atmel*, RadioSoft, Moscow, 2002, p. 172

[4] Dektyarev S.V., Shaposhnikov P.A., *in Proc. 6th Int. Conf. on Modification of Materials with Particle Beams and Plasma Flow*, 2002, pp. 161–164.

[5] Dektyarev S.V., *in Proc. 7th Int. Conf. on Modification of Materials with Particle Beams and Plasma Flows*, 2004, pp. 101–103.