Complex for Automation System for High-Current Generator MIG

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Abstract – This paper considers urgent problems and presents the results thus far achieved in designing an automation control system for the high-current generator MIG.

1. Introduction

The MIG setup is a transformer-type high-current generator designed to produce short (tens of nanoseconds) electromagnetic pulses of voltage ~ 2 MV and current ~ 3 MA. A block diagram of the generator is shown in Fig. 1.

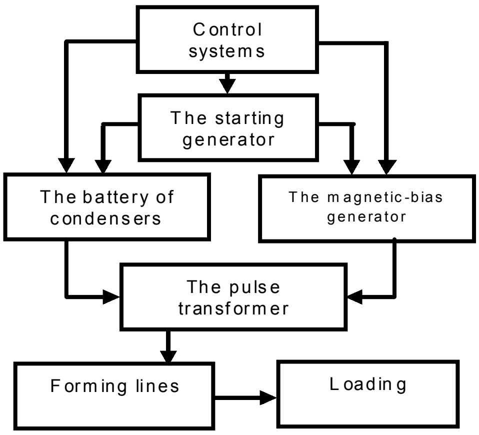

Fig. 1. Block diagram of the MIG setup

The core of the MIG setup is a pulse transformer (PT) which transforms the capacitor discharge current flowing though its primary turns into a high-voltage pulse.

The setup incorporates a great number of elements which operate at a time. They are a bank of more than 100 capacitors with switching elements, charging and discharging circuits. All elements operate in critical modes close to the regime of short-circuiting (SC). In this connection, much of the energy is transmitted in all circuits and a damage of any element, apart from failure of this element and its discharge circuit, may cause spontaneous operations of the generator.

2. Brief Description of the Generator System

Figure 2 shows the charging and discharge circuit of a capacitor pair.

The high-voltage capacitors C1 and C2 are charged by voltages of different polarity. When a triggering pulse is applied to the controllable switch K2, the current flowing in the circuits induces a magnetic field in the pulse transformer core.

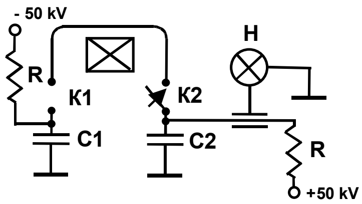

Fig. 2. Circuit of the capacitors

A stub of the "ground" braid of the charging cable which ensures a capacitive coupling with a bus-bar is connected to the neon lamp N through the capacitive coupler. In the case of trouble in the circuit of the capacitors C1 and C2 or in the capacitors themselves, the neon lamp flashes or lights brightly. This may results, e.g., either from failure of the circuit (Fig. 2) or from partial breakdowns in the capacitor or from other troubles.

A peculiarity of this circuit lies in the fact that troubles in the capacitors and switches show themselves up at high voltages (~50 kV), while those in the discharge circuit can be found only within the current pulse.

3. Operation and Control

At present, the high-current pulsed generator MIG is operated from a control console in the manual mode and this is too inconvenient. First, at least two persons whose coordinated actions govern to a great extent the conditions of generation of an appropriate pulse are to participate in the process. Second, the operators control the charging of the bank in a visual way with the use of indicators and lamps. With such a method, there is a high probability of a mistake or fault that may cause improper operation of the personnel and thus possible spontaneous startup of the setup or even failure of the equipment.

4. Drawbacks of the Previous System

To control the charging of the capacitors and preclude partial breakdowns in this process, a computer control system of the MIG generator was designed several years ago. This system included a personal computer with a printed circuit board of a multichannel analogue-to-digital converter (32 channels) built in it, and a channel switching system.

When operated, the system revealed the following drawbacks:

1. Because the number of channels of the analogue-to-digital converter was much smaller than that of capacitors, four capacitors were alternately con-

nected to each channel to control the voltage across them.

2. The low-speed PC did not ensure the required rate of interrogation of the entire capacitor bank (it was of the order of one time per second). Therefore, abrupt voltage spikes on a capacitor were likely to be missed while are interrogated the others.

3. The program written for MS-DOS was inconvenient to run.

5. Tasks

Reasoning from the specificity of the MIG setup, the following urgent problems on its modernization can be posed:

1. Establishment of conditions for optimal operation of the generator units (optimal mechanisms of charging the capacitors).
2. Control over charging and discharging of the capacitor bank.
3. Tracing of troubles and faulty elements of the high-current generators for routine maintenance and repairing.

6. Proposed Control System

According to the tasks and problems posed, a block diagram of the complex of automation systems of the MIG setup has been proposed (Fig. 3).

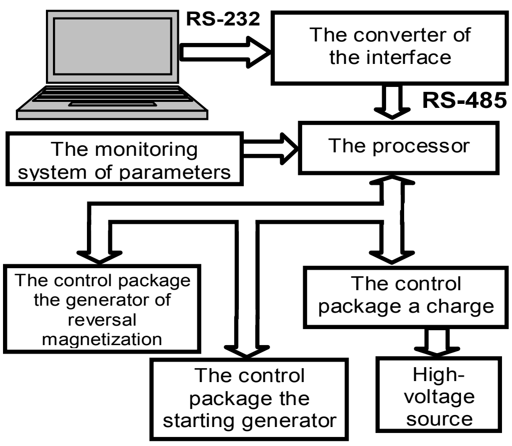

Fig. 3. Block diagram of the complex of automation systems of the MIG setup

Control of the setup implies gradual charging of the capacitor bank according to a definite law, charging and triggering of the magnetic-bias generator and control of the start-up generator. The control system is correspondingly divided into units which control these parts of the setup.

The control room should be remote from the room where the generator is located. In this connection, with the manual mode of control available to date a great number of cables and wires are to be pulled from the control console to the units of the MIG generator. This is too inconvenient to arrange. Therefore it is proposed to locate the developed system in one room with the MIG setup. For communication of the control system and the personal computer, it is suggested to employ a commercially available interface RS-485.

Such a choice is dictated by the fact that the RS-485 communication protocol is the most widely used commercial standard which utilizes two bidirectional balanced line. The protocol ensures multipoint connections and plexes (nets) with up to 32 nodes and data transfer for a distance of up to 1200 m. The use of RS-485 translators allows increasing the transfer distance by 1200 m or adding 32 nodes. The RS-485 standard is capable of half-duplex communication. For data transfer and receipt, one twisted pair of conductors is sufficient. For pulse noise protection during the operation of the setup, the interface converter should be provided with galvanic decoupling of the control system and personal computer form the communication line.

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A high-speed microprocessor controls over all units and provides communication between the system and PC. Due to the built-in system of control of the parameters, the processor traces changes in the state of all generator systems in the real-time operation mode. If any value goes beyond the acceptable limits, the system automatically responses to it and, if necessary, turns off the setup to preclude possible failure. Moreover, the values of the main parameters are transferred to PC and displayed on the screen for direct control by the operator.

The personal computer controls the entire system or individual units, should the need arise to check or tune them. The control program for PC should be written in a high-level computer language and possess an intelligible and convenient interface. Before triggering the MIG generator, the operating mode of all its units should be set by the program. The program should control whether the mode is specified properly or not to insure against errors.

7. Results Achieved

By now a mockup of the main processor block for the system has been made. The control program for the microcontroller, which realizes the functions of control of the power supply, has been written and debugged. Moreover, the block of the interface converter and the control block of the high voltage source for charging the capacitors is already available. In designing the unit, particular attention was given to the problems of electromagnetic compatibility, since high-power pulsed devices are sources of severe electromagnetic noise, which may lead to malfunction or faulty operation of the system and cause failure of the equipment.

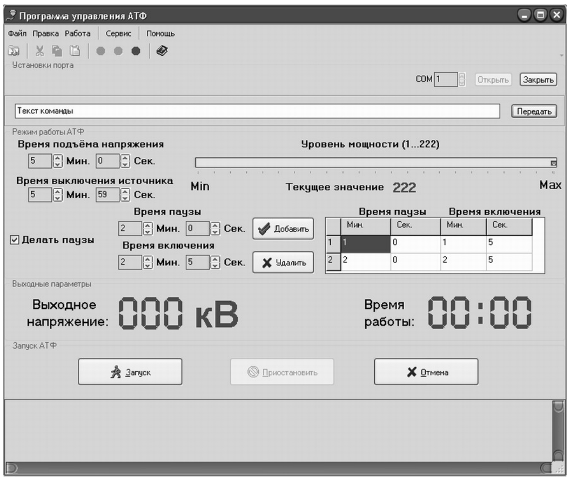

Fig. 4. Window of the control program

A control program capable of realizing all functions required to control the charging of the capacitors has been written for Windows. The program allows control of the entire process in the manual mode and upon setting the required mode and triggering there is no need in manual intervention. The program setting make it possible to preset the time of the voltage rise up to a required level, specify pauses of any duration during charging, turn off automatically the source after a laps of the specified time or when the maximum voltage level is exceeded.

During the operation, the program displays the output voltage, the time of operation, and creates a file of the operation protocol which then is saved on the PC disk.

The window of the main program is shown in Fig. 4.

The designed units of the system are now being tested in real operation conditions.

8. Conclusion

Devices like the high-current pulse generator MIG are finding ever-increasing and diverse applications. In our country there exist several setups of this type and new ones comprising much more elements become a necessity. At the same time, the requirements imposed on the power and precision of the parameters become more and more stringent and the reliability of control systems which provide stable, precise and proper operation are brought to forefront. Moreover, automatics should provide a possibility of effectively tracing troubles, faulty or unstable elements in the course of maintenance.

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