

THE SYSTEM FOR CONTROL OF AN ELECTRON BEAM WELDING MACHINES

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INTRODUCTION

A cathode unit of electron beam welding is a device that generates beams of electrons of required intensity. The report examines the main issues, that had to be overcome in developing this unit.

-the electronics of the unit is under cathodic potential of the accelerating voltage (60kV), therefore it required solving the problem of power transmission and control signals.

- the volume of the device had to be minimized as the room to put the electronics was limited.

- the electronics must be resistant to high voltage breakdowns as when breakdowns there may be a voltage

pulse of 60 kV with energy to 20 J in any electrode of the cathode unit.

- to control the current of the electron beam (welding current), a linear amplifier, which produces the voltage on the control electrode in the range 0 – 4kV, was developed. The amplifier bandwidth is 1 kHz.

- to control the current beam, current intensity, and to control the parameters of the gun, a specialized controller was developed. The connection of the controller with a computer is carried out with the help of optical links.

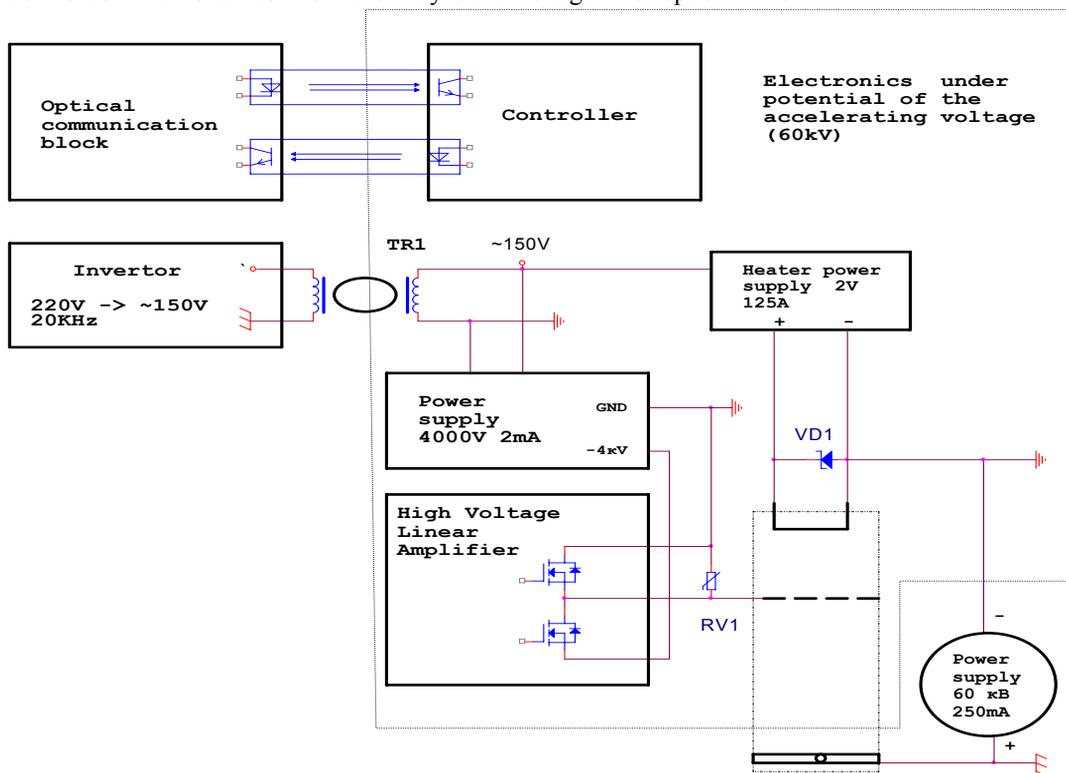


Figure 1: Block diagram of the electronics of the cathode unit.

TRANSFORMER

Power required to operate the power supply is passed through a special isolation transformer TR1. Voltage of isolation between the primary and secondary windings of the transformer is 100kV.

Transmission capacity is up to 300W. The transformation ratio is 1:1. It should be noted that the voltage between the primary and secondary windings is 60 kV, so structurally transformer consists of two cores. The primary winding was wound on one core, the secondary

winding is on the other one. Coupling between cores is carried out by the volume coil. It is easier to provide high-voltage isolation.

CONTROLLER

Management of all parts of the unit is carried out by a specialized controller made with a microprocessor ADUC 842.

The controller sets the following parameters:

- The current gun (welding current), is set during the welding process in the range of 0 - 250 mA. The

voltage on the control electrode varies from -4kV to zero. During setting and testing the voltage can be set directly on the control electrode.

- Filament current is regulated from 0 - 125A. Operating filament current is usually in the range of 50 - 100 A, it may depend on the type of cathode, and even the degree of deterioration of the cathode

During the welding process, the controller measures the following parameters: welding current, the voltage on the control electrode, heater voltage, control electrode current, and the stability of power supply.

The permanent control of the welding current is required in order to make sure that the session of welding is for a given scenario. The cathode may lose the emission as a result of "poisoning" or deterioration, in this case the gun will not be able to produce set current.

Current control of control electrode is necessary for the early detection of pollution of gun insulators by welding products. The fact is that, when the pollution, the resistance of the insulators falls and there comes a moment when the power supply (4kV) is not able to maintain the blocking voltage on the electrode. Thus there is an uncontrolled gun current (welding). Obviously, this is an emergency, which is inadmissible to allow.

Control of the heater voltage gives the information concerning the degree of wear of the cathode and thus predicts its remaining life time.

Communication with the controller is carried out by fiber-optic cables. Electric-to-optical conversion and back is exercised by the block of optical communications – OCB.

All in all between the unit of optical communication and the controller of the gun there are following fiber-optic cables:

- Two cables for CAN interface through which information is exchanged.
- Two cables for RS232 – are used to set-up and test the equipment.
- Cable lock current gun on an external signal, bypassing the processor
- Reserve cable.

THE HEATING POWER SUPPLY

As a regulatory element in the power supply a magnetic amplifier is used. There are several reasons for this decision:

- the magnetic amplifier controls the amplitude of the high frequency voltage, which is supplied by an isolating transformer, so there is no need of additional converters.
- the scheme operates as a current generator, and is protected against overload and short circuit
- the scheme is resistant to high voltage breakdown.

THE HIGH-VOLTAGE MODULATOR

To adjust the welding current in the specified range (0 - 250 mA), the voltage on the control electrode should vary in the range 0 - 4 kV. Frequency band can reach 1kHz. To solve this problem a high-voltage linear amplifier was developed.

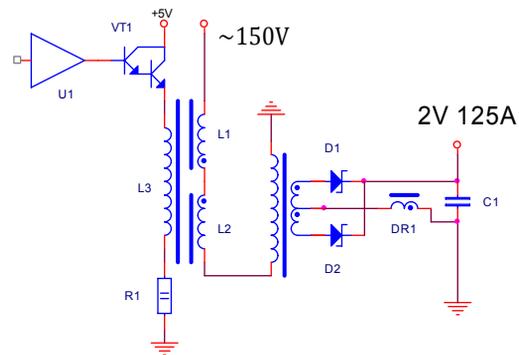


Figure 2: The heating power supply.

The output voltage of the amplifier must be changed from 0 to 4kV

Since the industry does not produce low-power transistors and of voltage higher than 1500 volts, it is necessary to set these transistors in series. It causes 2 problems. First, we must make sure that the voltage at each transistor does not exceed its certified value, and second, we need the scheme of transistor to control in the chain.

The basis of the scheme consists of two identical parts, each of which consists of four series-connected field-effect transistors. Varistors RV1-RV8 protect transistors from overvoltage. Resistors R11 - R18, and capacitors C1 - C8 provide DC and AC mode of transistors.

Due to the fact that the voltage of power supply is negative, we have to manage both stages through optocouplers U4, U5. To power the output transistor of optocouplers, DC-DC converters with isolation 6 kV (U2, U3) are used.

IC U1 - error amplifier. The control signal goes through resistor R1 to the input of this chip, and the feedback is taken either from the amplifier through resistor R2, or with a current sensor through resistor R3. Thus, the amplifier can operate in the constant current mode of welding machine or in the constant voltage mode on the control electrode.

This amplifier allows to stabilize the current of the welding machine in the band up to 1kHz. In the mode of constant voltage on the control electrode pulses 200mks and amplitude of up to 4 kV can be produced.

REFERENCES

- [1] A. Bryazgin, B. Factorovich, E. Kuper, V. Repkov, Modulator for the electron injector of the industrial Accelerator ILU-10, RuPAC 2006 proceedings.
- [2] Yu.I.Semenov, et al., 60 keV 30 kW electron beam facility for electron beam technology. Proc. Of EPAC08, Genoa, Italy

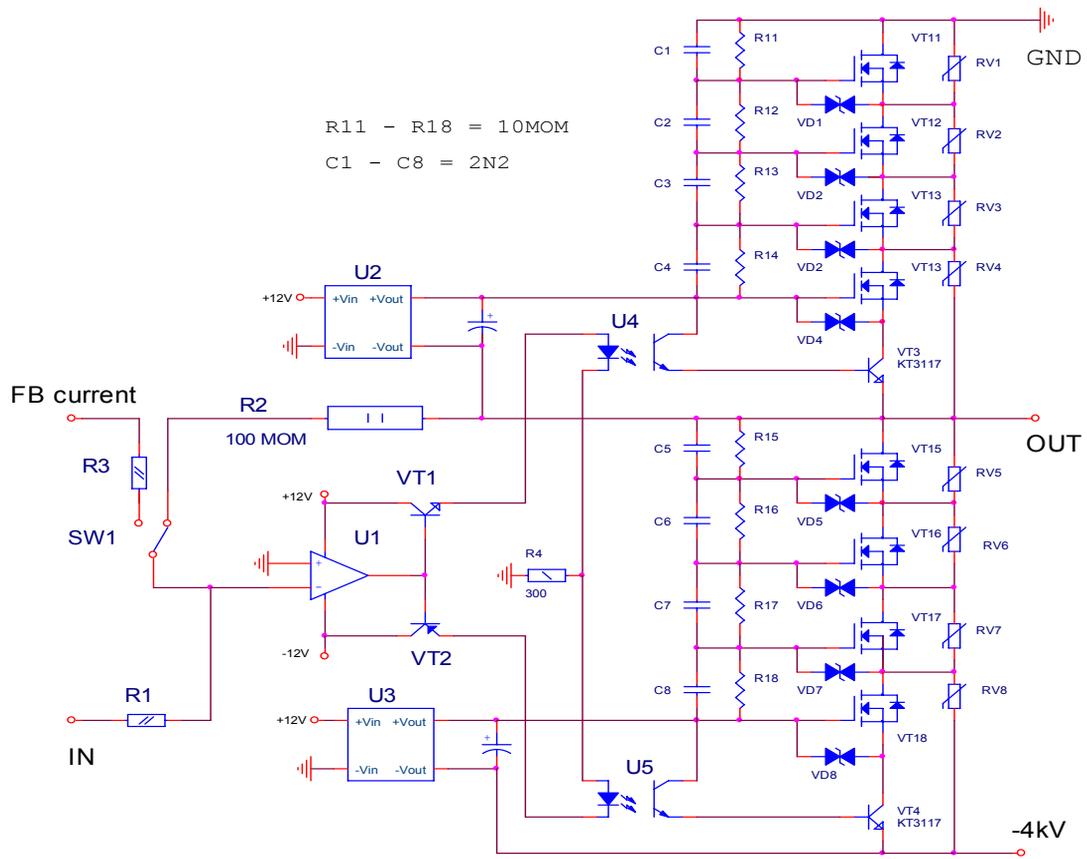


Figure 3: High voltage amplifier.