Automatic voltage regulation system construction for synchronous generator of a small hydro power plant using thyristor pathogens

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Abstract. The article presents indicators of the hydropower potential of Kyrgyzstan, shows the share of small hydropower plants in the production of electric energy in the energy sector of the republic, reveals the problematic issues that need to be revealed in this work. A brief description of the existing automatic voltage regulation system and automatic field blanking system is given. Based on the analysis of existing systems, their shortcomings were identified and the main functions formulated for automatic voltage regulation systems in both static and dynamic modes associated with starting and stopping the generator, loading and dumping, as well as protective measures taken to ensure reliability operation of the hydraulic unit. The result of the research is the development of the main functional blocks in the system of automatic voltage regulation with a thyristor pathogen and a brief explanation of their work. The synthesis technique of the excitation current regulator of a synchronous generator and the main indicators obtained in the modernization process are shown. In conclusion, all the functions inherent in the modernized system for automatically controlling the excitation of a synchronous generator, aimed at the safe operation of the hydraulic unit, are noted.

1 Introduction

At present, the hydropower potential of Kyrgyzstan is concentrated in 252 large and medium-sized rivers and is estimated at 18.5 million kW of power and more than 140-160 billion kWh of electricity. Moreover, the average slope of mountain rivers varies from 5 to 20 m per 1 km of length, and the average specific power is from 2227 to 5322 kW / km. therefore, the possibilities for building small hydropower stations in the country are unlimited. So far, according to general statistics, the gross share of small hydropower plants in the production of electric energy in the energy sector of the republic is only 1 %.

The above figures are useful for investors who invest in priority sectors of the economy, such as the construction of small hydropower plants. Naturally, these small hydropower plants will be equipped with modern equipment with a perfect control system for the economical and safe operation of the hydraulic unit. In this article, we consider the issue of constructing automatic voltage regulation systems operated by small hydropower plants taking into account the realities of today.

Electricity production by several small hydropower plants, concentrated mainly in the Chui oblast of Kyrgyzstan, is carried out by the generating company OJSC «Chakan HPP». The main consumers of these products are companies and business entities of the Chui region and the southern regions of Kazakhstan.

The first several small hydropower plants were put into operation in 1945, and the rest over the next 10 years.

Consequently, the age of the main equipment in these several small hydropower plants is over 60 years old; therefore, they are practically obsolete and require modernization. This primarily concerns the system for automatically controlling the excitation of generators, since in this system the generators themselves become unusable and require continuous inspection and maintenance, most often major repairs. At the same time, frequent blackouts occurring due to the failure of direct current generators and downtime caused by the repair of a machine require the replacement of machine exciters with alternative semiconductor exciters [1-3].

The problem of constructing a system for automatic voltage regulation (AVR) considered in this article, taking into account the replacement of the DC generator with a static thyristor exciter, as a way to extend the life of hydrogenerators.

The experience gained in the development of control systems for frequency-controlled electric drives of excavators proved to be useful in the construction of AVR for synchronous generators, since the control objects in both cases are high-power alternating current machines [4-6].

The proportional stator current regulator is implemented using the Operational Amplifier 1, and proportionally, the integral rotor current regulator is implemented using the Operational Amplifier2. The current compounding unit with a proportional device for automatic control of excitation carries out the process of regulating the stator current of a synchronous generator according to characteristic 2 shown in Fig. 4.

A controlled thyristor exciter operating on the excitation winding of a synchronous generator can be represented by a first-order linear link, as shown in the block diagram (Fig.). The absence of intermittent currents contributes to this idea, since the pathogen load is a large inductance [14]. It should be noted that if the thyristor exciter is represented as an inertial unit with a small uncompensated time constant T_{ta} = 0.01 s, and the excitation coil of the SG by an inertial unit with a large time constant T_f = 0.7 s, then as a result of the synthesis of the control system of the automatic excitation control device by the method of sequential correction, the excitation current controller adopts the structure of the P– link.

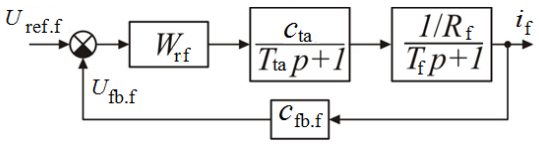

Fig. 8. Block diagram of a field circuit of a synchronous generator.

The oscillogram of the transient process of the increase in the excitation current to the nominal at a single push of the input action is shown in Fig. 9. The proportional part of the regulator ensures the excitation of the pathogen by voltage, reaching up to four times the nominal. With such forcing, an increase in current is achieved for t_p = 0.07 s, which indicates the advantages achieved as a result of the modernization of the automatic excitation control device. [19-25].

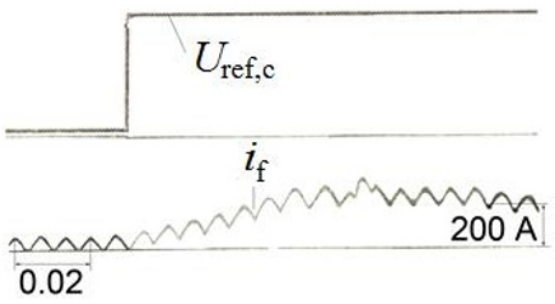

Fig. 9. Oscillogram of the increase in current in the excitation circuit during an abrupt action.

Fig. 10 a shows a schematic diagram of a device for automatically controlling the excitation of a synchronous generator, which shows that the pathogen is assembled according to a bridge circuit and connected to a three-phase network through a matching transformer (not shown in the diagram). In this scheme, the task for the stator current, which must be regulated, is carried out using the potentiometer R_{v1}. The feedback signal on the stator current is taken from the output of the diode bridge VD2, and the signal proportional to the rotor current is taken at the output of the diode bridge VD2. The emergency currents calculated by the the unit for calculating the emergency current of the rotor of the synchronous generator and unit for calculating the emergency current of the synchronous generator are stored and signaled with the help of LEDs, respectively: VD5 - excess of stator current; VD8 - excess current of the rotor.

Fig. 10, *b* shows a prototype of a device for automatically controlling the excitation of a synchronous generator, in which the control board is shown at the top, the power block in the middle, and the switching and protection equipment below. As can be seen from fig. 11, *b*, the thyristor exciter is compactly placed in a small cabinet.

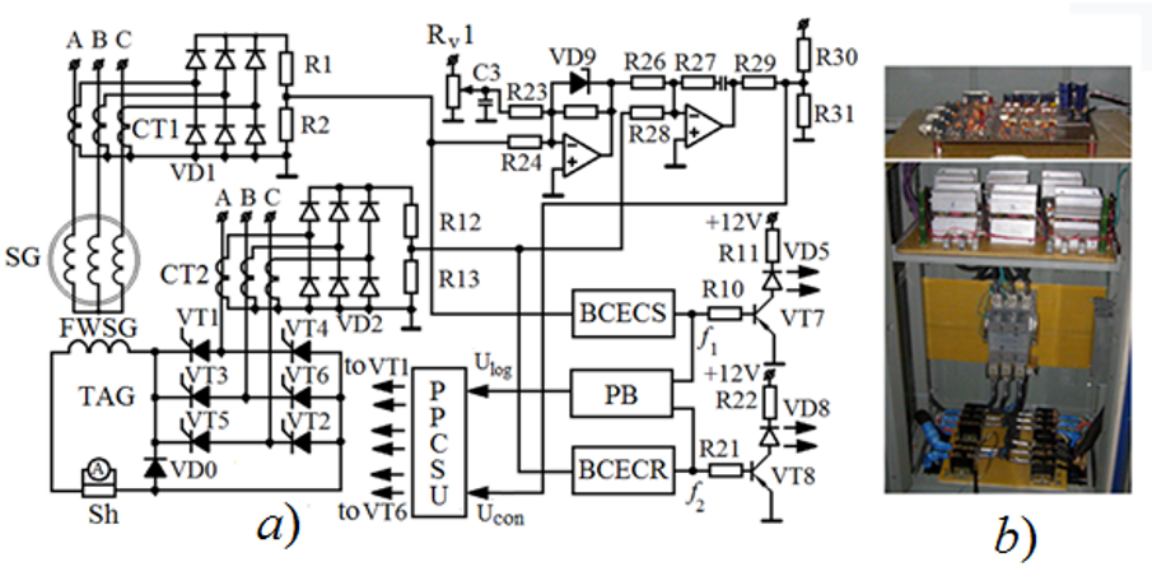

Fig. 10. A device for automatically controlling the excitation of a synchronous generator: a) - schematic diagram; b) - control board and power unit.

3 Conclusion

The current compounding unit, together with the stator and rotor emergency current calculation units, is a system for automatically controlling the excitation of a synchronous generator of small hydroelectric stations, provides the required operating modes of the synchronous generator and performs the necessary protection functions from emergency situations. The forcing of the pathogen by voltage, reaching up to four times the nominal one, ensures high speed of the pathogen, i.e. the current rises and falls during s., which is necessary both in the processes of retraction into synchronism at the time of start-up, and for the quick damping of the generator field in emergency conditions. In its dimensions and adjusting properties, an automatic excitation control device has a noticeable advantage compared to an electric machine exciter.

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