DIAGNOSIS AND INCREASE OF THE RELIABILITY OF GROUP ACTIVE
POWER CONTROL SYSTEMS OF HYDROELECTRIC STATIONS

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To increase the effectiveness of the group active power regulating (control) (GAPC) system of a hydroelectric station and the reliability of regulating intertied power systems (IPS), it is necessary to improve the methods of monitoring and protecting the GAPC system—methods of technical diagnosis of the technological process and its control system.

The present-day GAPC system of a hydrostation contains a central controller acting on the turbine-generator units with feedback with respect to the total actual active power of all operating generators. The central controller is an analog–digital control computer in which both the frequency and power deviation control law and control instructions are formed in conformity with information about the operating regimes of the hydrostation.

The integrated microcircuit central controller was developed in 1977 by the Special Design Department of the All-Union Association for Automation of Power Plants (Soyuzenergoavtomatika) jointly with the All-Union Power Industry Association (Soyuztekhenergo), All-Union Scientific-Research Institute of Electrical Machinery (VNIIÉlektromash), and the All-Union Planning, Surveying, and Scientific-Research Institute (Gidroproekt) on the basis of research performed by VNIIÉlektromash and Soyuztekhenergo for equipping hydrostations, especially those of large and medium capacity [1].

Despite the high reliability of this apparatus and system as a whole, there exists the probability of the occurrence of troubles which can lead to a spontaneous change of the output signal of the central controller. Furthermore, malfunctions in the technological system of the unit* leading to failure of the control system are possible. Both circumstances lead to an unforeseen change in the power of the hydrostation and, as a consequence of this, to complication of the operation of the IPS, even to the extent of disconnecting the transmission lines and cutting back the supply of power to an energy-deficient region.

The probability of troubles can be reduced by periodic operational inspection and continuous monitoring of the functioning of the GAPC system. The periodic inspection methods being used have a shortcoming: during each inspection it is necessary to set up a test time schedule, the GAPC system must be taken out of operation for a long time, and the inspection should be made by specialized personnel; this reduces the effectiveness of the GAPC system. The indicated shortcoming is the result of the absence in the GAPC system of apparatus and schemes which would enable the duty personnel to periodically check the state of the system without long shutdown of the GAPC system. The presence in some modern apparatuses of the GAPC system of control points for checking the operating regimes, as a rule, does not eliminate this shortcoming. Therefore operational and nonroutine checks in cases when faulty operation of the GAPC system is suspected are labor-intensive and require the presence or invitation of specialized personnel. This interferes with the timely detection of impending troubles, which is especially important in run-in and aging periods, when the probability of occurrence of trouble is high.

The existing methods of continuous monitoring of the system and its elements also have shortcomings. In view of the relative complexity of continuous monitoring of the state of the system as a whole, continuous monitoring is limited to the state of the most essential components (voltage of the power supply unit, integrity of the circuits coupling the central controller with the control devices of the units) [2] and specific regimes (detection of variations in the control system) [3].

*By technological system of the unit is meant the main and auxiliary equipment directly participating in the power control process.

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For a small or medium hydrostation monitoring can be limited to the indicated partial measures. However, for a large multiple-unit hydrostation such measures are insufficient, and monitoring of the correct functioning of the entire loop and protection from troubles in it are needed.

**Periodic Operational Check.** The possibility of detecting impending trouble by periodic check of the state of the GAPC system by the operating personnel (without long shutdown of the GAPC system) can be provided if additional apparatus is added to the GAPC system for such a check based on assigning to the system a calibrated disturbance, recording the transient realizing this disturbance, and comparing the transient obtained with the standard. A periodic check of the central controller, which operates in a closed loop, is the main task. For such a check, instead of the real object – the hydrostation with its units and control devices – it is possible to include in the control loop of the central controller a model of the hydrostation which simulates the object and is constructed on the same apparatus basis as the central controller and therefore does not require an additional power supply source. The transfer function of the model can contain only two series-connected first-order response times simulating the response times of the electromechanical turbine governor system operating in a servo regime and the water-hammer transfer function. Furthermore, the model should take into account the number of units operating in the GAPC system so that in combination with the change of the transfer function of the central controller a constant closed-loop transfer function is provided. The source of the calibrated disturbing signal (discrete assignment unit) should have the ability to repeat with a prescribed accuracy both the value of the step of the disturbance and the absolute value of the disturbing signal.

The device realizing the indicated method has presently been developed by the Special Design Department of Soyuzenergoavtomatika, and since 1981 has been part of the equipment of the GAPC system being made to order for regional power administrations (industrial–power associations).

Since this device is effective not only under conditions of operational control of hydrostations but also when conducting debugging and preventive maintenance works on the equipment of the GAPC system, it is expedient to introduce it at hydrostations equipped with the group active power control system.

**Simplified Automatic Check.** This check method is based on determining the time of the power transient, which usually does not exceed a previously known but sufficiently large value. An example of such a check scheme together with the technological system being checked is shown in a simplified form in Fig. 1. The latter contains a central controller with an adder of the assignment signals, added to the actual power of the units, frequency measuring transducer (FMT), controlled divider, intermediate adder, unit forming the control law (algorithm), and output adder; furthermore, the GAPC system includes turbine governors, the turbine-generator units, and power measuring transducers (PMT). The circuit for checking the functioning of the GAPC system contains a summing transducer, filter, and output unit with a time delay. Summation of the output signals of the adder assignment signals, and FMT occurs in the summing transducer of the check circuit in conformity with the offset of the GAPC system; this transducer produces a signal of the difference between the assigned and actual power. The output signal of the transducer is transmitted through the low-pass filter and goes to the input of the output unit. The latter can be made in various ways. In this case the output unit should provide the functions of rectification of the output signal of the filter, amplification of the signal with hysteresis, and integration with the controlled time, on expiration of which the signal is delivered.

When the control system is in working order there is a zero signal in a static regime at the output of the intermediate adder of the central controller. The summing transducer of the check circuit is constructed so that it combines the functions of controlled divider and intermediate adder of the central controller, and therefore there is also a zero signal at its output in a steady-state regime. Upon the occurrence of a disturbing action both on the part of the assignment and on the part of the load greater than the set value, the output signal of the summing transducer becomes nonzero, in connection with which the integrator of the output unit is triggered.

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*The transfer function of the controlled divider is inversely proportional to the number of units operating in the GAPC system.*