TECHNICAL SCIENCES

ELECTROMECHANICAL COMPLEX OF A WIND POWER PLANT WITH A VERTICAL AXIS OF ROTATION

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Introductions. Global trends in energy development are aimed at decarbonization and the development of decentralized power supply systems. One of the options for implementing modern renewable sources of electricity is wind power complexes. Their use is very widespread in the world and has extensive practical experience of implementation in the power supply system. Meanwhile, attention should be paid to the features of the implementation and operation of wind power complexes as part of existing power supply systems. This approach has a number of features related to the quality of electricity in the network.

Given the current realities on the territory of Ukraine, the implementation of additional autonomous and local energy systems and complexes remains relevant. Based on the experience of implementing and operating wind power plants, there are excellent chances of developing the necessary energy capacities in the conditions of Ukraine.

One of the problems of implementing renewable energy is the accumulation of electrical energy that cannot be used immediately after its generation. However, today there are modern solutions for the accumulation of electrical energy with a fairly good level of efficiency. These electrical energy storage systems include electrical energy storage systems based on the principles of hydrogen energy, such as fuel cells.

The implementation of such electrical energy storage systems enables the active implementation of renewable sources of electrical energy, including wind power plants and complexes [1].

Aim. The implementation structure of the electromechanical complex of a wind power plant with a vertical axis of rotation and the principles of its control are proposed.

Materials and methods. Certainly, the combination of such systems as wind power plants and modern systems for storing electrical energy requires the development and modernization of modern existing control systems for such complexes. The proposed approach will enable the modern implementation of the urgent scientific and practical task of providing electricity to both the population and responsible facilities and individual electrical consumers.

In a generator intended for wind power plants, specific features should be taken into account: the non-stationary nature of the wind force and speed in relatively short periods of time; significant dynamic moments on the generator shaft and wind turbine; the absence of a multiplier as a mechanical link capable of damping axial forces on the shaft; transient processes constantly operating in the generator and the currents associated with them, electrodynamic forces, additional energy losses and heating of the active parts of the electric machine; low circular rotor speeds [1].

The above circumstances bring to the fore the tasks of designing an electromechanical converter for wind power plants (WPPs) the maximum simplification of the design, ensuring maximum strength and reliability, increasing cooling efficiency, ease of maintenance.

The use of microprocessors in the energy industry, and wind power in particular, is a justified and even necessary step. Since this allows processing a significant number of signals that often change and controlling the power plant according to given algorithms [2].

Based on the above, it is necessary to develop a structure of a microprocessor device, which, together with control algorithms, sensors, signal converters, software, forms a microprocessor control system for a wind power plant.

To solve many problems, the hardware part that is built into the microcontroller is enough, since it contains a multiplexer, ADC, comparator, memory blocks, etc. But if the built-in hardware is not enough to solve the problem, then it is possible to use additional external expansion modules, which will allow expanding the functional capabilities of the microcontroller [2, 3].

According to the developed structure of the device for controlling the excitation current of the wind turbine, we will make a transition to the corresponding microprocessor structure of the device for controlling the excitation current of the electromechanical converter of the wind turbine. For this, it is necessary to provide for the removal of information from n parameter sensors, processing of information and its display on the screen for visual control of operational personnel, as well as the formation of a control effect, with its application to the cascade amplifier, for controlling the excitation current of the wind turbine [4].

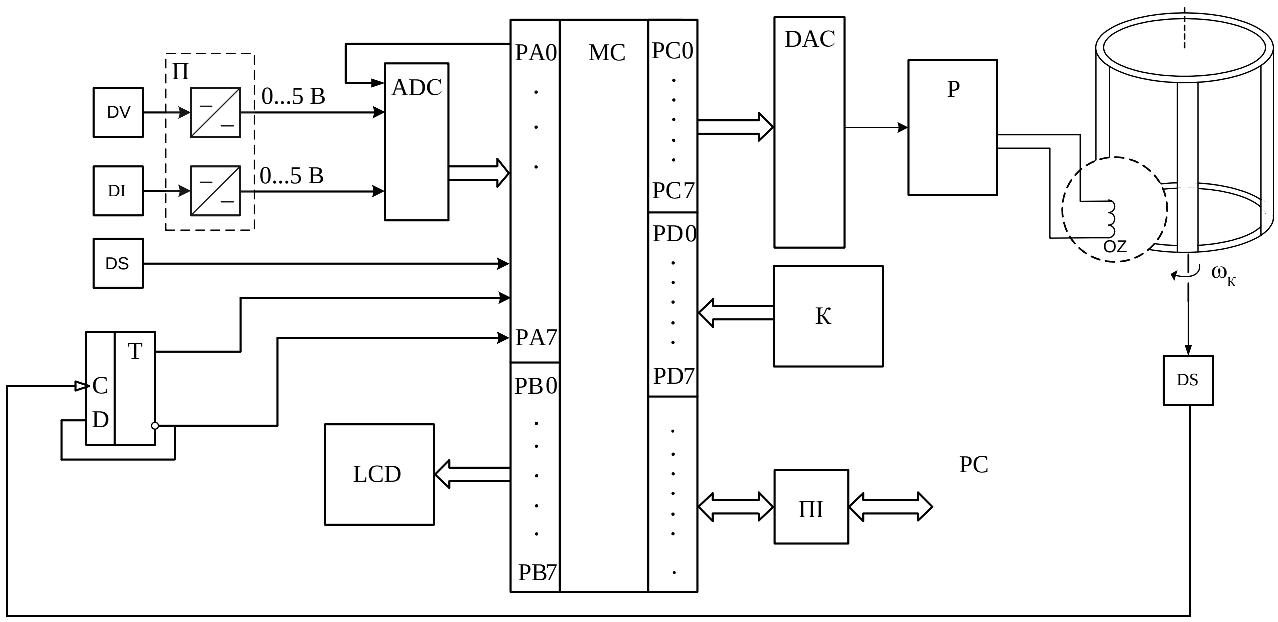

Fig. 1. Block diagram of a microprocessor device for controlling the excitation current of a wind turbine generator

Fig. 1 shows a block diagram of a microprocessor-based device for controlling the excitation current of a wind turbine, for its operation at the point of maximum power selection with stabilization of the output voltage of the wind turbine.

DS – wind speed sensor; DS – angular velocity sensor of rotation of the wind turbine; DV – load voltage sensor; DI – load current sensor; MC – microcontroller; K–keyboard; PI – serial interface; PP – cascade excitation current amplifier; OZ-excitation winding of the wind turbine; ADC – analog-to-digital converter; DAC–digital-to-analog converter, T – D – trigger.

The device provides measurement and analysis of the parameters of the wind turbine operation and, on this basis, exerts a regulatory influence through a cascade amplifier on the excitation winding of the wind turbine. The device provides operation for two modes - fuzzy and clear logic, depending on the speed of rotation of the wind wheel, which is described in detail in section 3.

The signals from the output of the sensors of the parameters the voltage value at the output of the wind turbine and the current supplied to the load are fed through the signal level converter P, which brings the input signals to the voltage level necessary for the normal operation of the microcontroller MC, to the corresponding inputs PA0–PA7 of the 8-channel ADC. In this case, the signal from SSh is fed to the input of the MK through a D-trigger, which serves to receive information about the speed in the presence of a pulse from the sensor, as well as during a pause.

The microcontroller MK alternately connects each measuring channel and processes the received signal according to the established algorithm.

The liquid crystal programmable indicator LCD and the keyboard K allow you to organize data exchange between the microcontroller MK and the operator. The PI signal level converter provides communication between the microcontroller MK and the upper-level computer. Signals from the outputs PC0–PC7 are fed to the digital-to-analog converter DAC, from which the output analog signal is fed to the cascade amplifier PP, the amplified signal from the amplifier is fed to the excitation winding of the wind turbine generator.

Results and discussion. The use of the model will allow you to quickly search for optimal parameters for tuning the regulator to work with wind turbines of different power (where the limits of current compensation in the regulation law should be determined), different voltage levels, and with variable requirements for the network mode in terms of power.

Conclusions. The structure of the control system of a wind electrotechnical complex with a vertical axis of rotation of the wind wheel is proposed, which ensures its operation at the point of maximum power extraction of the wind wheel. The proposed structure provides for the use of both a PI controller and a fuzzy controller, each of which is included in the operation depending on the ratio of the setpoint and the real wind speed and allows for control simultaneously in the function of voltage and maximum power extraction.

LITERATURE

1. Boyko S. M. Theoretical principles of the formation of electric power systems with sources of distributed generation of mining enterprises: Monograph Kremenchuk: [PP Shcherbatykh O. V.], 2020. 263 p.
2. Kuznetsov N. P. Modeling of the work of the combined energy system using stochastic differential equations/ Alternative energy and ecology. 2012. No. 7. P. 64–67.
3. Pekur P. P. Analytical representation of the probability density and wind speed distribution function. Renewable Energy. 2005. No. 2. P. 53–58.
4. Sinchuk O. N., Boyko S. N. Neural networks and control of the process of controlling the power supply of objects from combined electrical networks. Technical Electrodynamics. 2014 (5): P. 53-55.