DEVELOPMENT OF CURRENT CONVERTERS IN THE POWER SUPPLY CONTROL AND MANAGEMENT SYSTEM USING RENEWABLE ENERGY SOURCES THROUGH ARTIFICIAL INTELLIGENCE IN THE SPHERE OF TELECOMMUNICATIONS

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***Abstract* — In the management of continuous processes of production, transmission, distribution and consumption of electrical energy, the accuracy and uniformity of elements and devices of the control system with the widespread use of primary means of current conversion are of great importance, since inadequate control and management of electricity and power leads to significant economic damage.**

Keywords— : primary converters, an integrated approach, power systems, current converters, electromagnetic converters, electrical networks, power plant, energy balance.

I. INTRODUCTION

When managing the continuous processes of production, transmission, distribution and consumption of electrical energy, especially when using renewable sources, the accuracy and uniformity of elements and devices of the control system with the widespread use of primary means of current conversion is of great importance, since inadequate control and management of electricity and power leads to significant economic damage. The development of an integrated approach that provides high accuracy and efficiency of combined control of reactive power sources, expanding functionality, simplifying the design, reducing weight and dimensions, improving manufacturing technology, ensuring contactless measurement processes, current conversion based on the use of modern primary measuring transducers in renewable energy sources are relevant tasks of power systems management [3].

At the same time, primary measuring current transducers in renewable energy sources, being the main elements of information-measuring and control systems, almost completely determine the technical and economic indicators of power systems.

II. MAIN PART

A1, A2, A3 - automatic switches, KM1. KM2. KM3 - switching devices; TA, TV - current and voltage converters; TC - block of current compensation; IO - measuring body; U1, U2 - amplifiers; KT1, KT2 - time delay elements; KL1, KL2 - executive bodies; MA - governing body; ЦАР - digital automatic regulator of reactive power source; SM (GS, MS) - synchronous machine (generator - GS and motor - MS), KS - synchronous compensator, KKU - reactive power source - cosine capacitor unit, EMPTN with FEC and EMMN - electromagnetic current and voltage converters with flat measuring windings.

Due to the current compensation, the so-called "counter control" is provided, which is necessary to maintain the voltage on the busbars at the consumer of electrical energy. The TK current compensation unit connected to the EMPTN with FEC and EMPN takes into account the voltage drop in the line supplying the consumer.

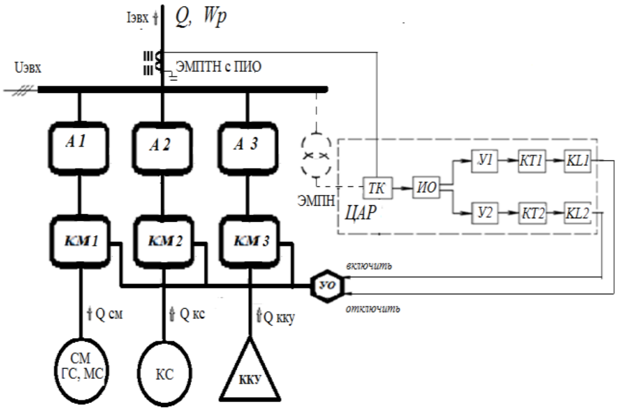

Fig. 1. Functional diagram of the system of automatic combined control of reactive power sources in the power plant.

The voltage, taking into account the current compensation, is supplied to the measuring device of the

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EUT, which, depending on the measurement results, sends information to the amplifier A1 in the "Add" path or A2 in the "Subtract" path. With the help of elements KT1 and KT2, a response time delay is created, which ensures detuning of the controlled voltage from short-term surges. Further, the signal goes to the executive body KL1 and KL2 and to the control body - the KM switching device, which controls the power network of the KKU reactive power source.

Traditionally, in practice, one of the main characteristics of control systems for CSC is considered to be their transient response - a response to a single step input signal.

Diagrams of controlled and uncontrolled sections of cosine capacitor units (CCU) can be composed of various compensating devices (CC), depending on the power of the capacitors installed in them and the design features, but each section must have a switch for operational control; short circuit protection equipment; a device for automatic shutdown in the event of a power failure, including unregulated permanently switched on sections.

Combined power control by switching on and off the entire installation or its individual sections allows achieving an economical mode of operation of electrical networks and at the same time using the KKU as a means of local voltage control. Reactive power control can be performed: manually by operating personnel; automatically from the action of various electrical parameters and non-electrical sensors; forced power of capacitor units, high-speed, adjustable, static and dynamic sources of reactive power ES.

The most economical modes of operation of networks can be achieved when using a KKU with automatic combined power control. Depending on the characteristics of the network, the requirements of the consumer and the power system, the automatic combined power control of the KKU is performed:

1) by the time of day, when it is important to limit the output of reactive power to the power plant network during the day according to a certain program with an established production technology;

2) according to the voltage level, if it is necessary to reduce the deviation of the voltage level of the electrical network of the ES from the optimal value;

3) by load current, if the increase and decrease in the full load change during the working day and are accompanied by a corresponding change in reactive power;

4) by the value of the power factor, if its change is proportional to a certain change in reactive power;

5) by the magnitude and direction of reactive power, when it is important to limit the return of reactive power to the power plant network;

6) depending on the production technology, the power control of the WHB can be carried out from non-electrical sensors (temperature, pressure, etc.);

7) according to various combined schemes: depending on the time of day with voltage correction, time of day, voltage and direction of reactive power, voltage with current correction, using non-electrical sensors from various devices;

8) in connection with the introduction of dispatch control and telemechanization of power supply, it is advisable to carry out centralized control of the power of the CCU by the dispatcher directly or indirectly by ordering by phone based on the analysis of the ES load schedule;

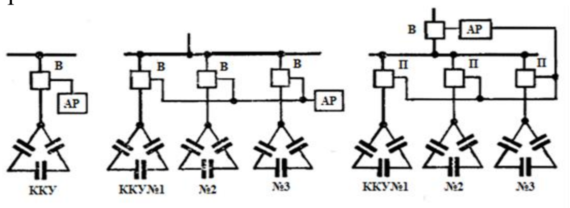
9) to eliminate fast oscillations and surges of reactive loads. In this case, power forcing of the KKU can be used by automatic switching of parallel-series connections of capacitors to an increased or reduced voltage in relation to the nominal voltage, as well as other high-speed adjustable sources of reactive power can be used.

Automatic combined power control of the KKU depends on various electrical parameters and non-electrical sensors and can be single-stage or multi-stage. With single-stage combined control, the entire KKU is automatically turned on or off, or several KKUs are simultaneously turned on or off at a certain time of the day.

With multi-stage combined control, it is allowed to alternately automatically turn on or off several KKU with one-stage control or turn on and off individual sections of the condensing unit according to a given program or in a specific sequence.

Single-stage combined control is the simplest way to control the power of the CCU, requires less capital costs compared to multistage control due to a simpler circuit and the absence of additional switching equipment. With multi-stage combined control, individual condensing units or sections, equipped with their own switch [1,3], are automatically switched off or on.

Multistage automatic combined control of KKU voltage 0.4 and 6-10 kV is performed with one main switch and several switches for automatic section control. The greater the number of sections in the installation, the smoother the control, but the greater the cost of additional switching equipment.



a) b) c)

Fig. 1.2 Control circuits of cosine capacitor units.

a - single-stage control: b - multi-stage control: c - multi-stage combined control with one main switch C and three switches P for switching the unit sections into a no-current pause.

If several individual KKU installations with single-stage control are installed, then using a sequential circuit, they can be automatically switched off and on at different times and, thus, multistage control of the total power of all KKUs can be performed. Thus, the automatic combined power control of the MCC can be performed in one-stage according to simple and, therefore, reliable control schemes.

KKU with a capacity of more than 50 kvar must be equipped with automatic reactive power regulators. This is achieved by dividing the entire power of the KKU into separate (no more than three or four) sections, which allow for both single-stage and multi-stage combined control.

Single-stage combined power control of the KKU, in which all the power of the KKU is turned on and off at a certain time of the day in accordance with the load schedule or at a certain voltage level in the network, is easier. This method of single-stage combined control is advisable with a

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uniform schedule of reactive power consumption and when using a 6-10 kV KKU with oil switches, in which the number of switching should be limited.

On electric drives with uneven graphs of reactive power consumption, multistage combined control is used, in which it becomes possible to turn on and off a different number of sections of the CCU. Moreover, a part of the power of the KKU, equal to the smallest reactive load, must remain unregulated, i.e. always on.

Currently, there are practically no tools with a simple design and measuring circuit for combined control and measurement of the speed of rotation of dynamic sources of reactive power - electric machines such as SD and KS, which would combine the indicated qualities: high accuracy when taking into account the asymmetry of the three-phase current of the electric network of the ES ; uniformity of the output value and extended functionality. The increase in the number of works devoted to the combined control and measurements of the output parameters and values of the SD and CS as, the rotation speed, which has been observed in recent years, testifies to the efforts aimed at solving this contradiction.

The existing means using direct or indirect methods of controlling the rotation speed of synchronous machines (SM - SD and KS) have the indicated disadvantages: the first - large errors, the second - low reliability. Increasing the accuracy of indirect measurements by compensating for the influencing physical quantities leads to the complication and decrease in the reliability of controls. Increasing the reliability of the means of direct control of SD and CS using unreliable electronic elements is also impractical due to the complexity of the design. The solution to this contradiction is associated with the creation of new tools that should ensure high accuracy with simplicity and reliability of the design.

The connection of EMPTN with PIO with electric machines like SM and CS, having high reliability and simplicity of design, provide high accuracy of control and measurement of rotation speed and can be successfully applied in various control systems of dynamic sources of reactive power [5,7].

The accuracy of the used means of control and measurement of the speed of rotation of the SM or CS, in many cases determines the development of devices using rotary motion. Further development of modern technology in many of its areas is inextricably linked with the development of new means of increased control accuracy and measurement of rotation speed. Suffice it to point out that reducing the error in measuring the rotation speed to + 0.01% solves a number of important technical problems: ensuring the stability of the parallel operation of high-speed SM and CS, increasing the accuracy of the current frequency in electrical networks, etc.

All these tasks are directly related to the problem of ensuring the exact relationship and correspondence between two related quantities: oscillatory and rotational motions - the value of the current frequency in electrical systems with the value of the rotation speed of reactive power sources. Therefore, the development of the above areas of technology poses two tasks for the EMPTN with FEC: a significant increase in the accuracy of control and measurement of the rotation speed by simple and reliable devices; ensuring an accurate relationship between related quantities - the frequency of the secondary current of the EMPTH with the PIO and the mechanical speed of rotation. The solution of these problems makes it possible to interconnect the current frequency, in various kinds of electronic devices (reference frequency generators, Doppler speed meters, etc.), with the rotation speed of the SD, CS and mechanisms (jet engines, internal combustion engines, DC motors , gearboxes, etc.), which creates the possibility of combined control with different circuits of the speed of rotation of motors by the current frequency generated by electronic and other devices.

When developing and using modern current converters, one should proceed from the principles and requirements of GOSTs (GOST CIS 13109 - 97, EN-50160, IEC 1000-3x) to instrument systems and automation equipment, the main of which are:

- block-modular design principle, which ensures the versatility of current converters with the use of a rational minimum of structural elements, facilitating the use of modern technology;
- creation of primary current converters, normalizing modules while ensuring their information, energy, metrological, constructive, structural compatibility on the basis of consistent unification and standardization.

Currently, in renewable energy sources, the use of electromagnetic converters of three-phase current with high accuracy, linearity of output characteristics, unified output quantities, the expansion of the spectrum of converted electrical quantities is limited due to insufficient formation of principles of construction, methods of calculation and design of distributed magnetic systems of converters. The applied classical methods of studying magnetic circuits and conversion systems do not provide the required accuracy, especially with asymmetry of the three-phase primary current of the electrical network, do not have sufficient generality, covering only the values and parameters of circuits of electrical and magnetic nature. Magnetic conversion systems with nonlinear and inhomogeneous parameters are considered in calculations as objects with lumped parameters [1].

Classic single-phase current transformers, without which the operation of renewable energy sources is still impossible, have a complex conversion part, large weight and size indicators, are laborious in design and operation in control systems, do not ensure the unification of the output value when working together with modern information processing technology. They do not take into account the mutual influence of magnetic fluxes and fields created by the currents of the three-phase electrical network of power systems.

That is why the demand for research in this direction is justified by the fact that classical single-phase primary measuring transducers of current and voltage in renewable energy sources do not allow providing monitoring and control devices with reliable and simultaneous information about the values and parameters of electrical energy in a single- and three-phase electrical network. These circumstances necessitate the development and implementation of reliable, unified, accurate electromagnetic current-to-voltage converters, taking into account the asymmetry of the currents of a three-phase electrical network, which differ from each other both in magnitude and in phase, which explains the relevance of this direction [2].

The low accuracy of the analyzed available devices is due to a number of shortcomings of existing current

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conversion systems, since the measuring complexes were created earlier, and are also being created now according to standard projects developed in the twentieth century, in which solutions were not provided for ensuring high accuracy with current converters and the unification of the output signal of primary measuring transducers.

A comprehensive analysis of the elements and control systems for reactive power sources and their modes, the principles of their construction, testifies to the insufficient knowledge of the problem in the field of electromagnetic conversion of currents into voltage and combined control of reactive power sources of power systems in renewable energy sources.

However, the formation of priority methods for the construction and study of electromagnetic converters of primary current into a secondary voltage, ensuring the adequacy of the output voltage to the primary current, modeling and research algorithms, focused on solving a set of problems to ensure the unification of the output value and taking into account the asymmetry of three-phase currents in combined reactive power control systems power systems require deeper and more comprehensive research. This circumstance is associated with large errors in the transformation of the values of the primary currents of power systems, which lead to the irrational use of electricity sources, complicate the control and management of their operation modes, lead to unnecessary financial losses, both for producers and consumers of electricity. The main factors for the appearance of errors for current converters are: asymmetry of currents and voltages in magnitude and phases, frequency swing, changes in ambient temperature, the appearance of harmonics of currents and voltages of the electrical network, vibration loads during the operation of converters and others [4].

The system analysis of electromagnetic primary current converters also made it possible to establish that the classic designs of current converters of reactive power control systems - current transformers - provide an output current of 5 A and, with the primary rating, have:

- restrictions on the range of the converted current;
- significant errors;
- complex and low-tech designs;
-large dimensions;
- mass;
- consumption of materials and cost.

When the input current is rated, a matching element is required - an additional transformer for unification of joint work with modern microprocessor technology and a control personal computer. Existing electromagnetic current converters when controlling reactive power sources of power systems do not provide the required accuracy of data on currents of a three-phase electrical network due to: single-phase design of magnetic conversion systems; asymmetry of the converted three-phase current; nonlinearity of saturation characteristics of magnetic systems and non-standardization of values of output quantities.

The above factors limited the use of classical electromagnetic current converters in the corresponding control systems for the values and parameters of electrical networks. Therefore, the development, research and practical implementation of electromagnetic converters with flat measuring windings of the primary single- and three-phase current into the secondary voltage with extended functionality and unified output values, taking into account the asymmetry of the three-phase current and the creation on their basis of systems for combined control of reactive power, are a solution to the problem of improving and development of existing technologies for monitoring and controlling the quantities and parameters of the electric power of the power system. [6]

III. CONCLUSION

The main relevant areas that need to be introduced into the development for more efficient production, transmission, distribution and consumption of electrical energy:

- development of technologies for converting primary one- and three-phase currents into voltage based on electromagnetic current converters with flat measuring windings and receiving and processing devices for combined control of reactive power of power systems;

- development of graph models that allow to study visually, efficiently and with high formalization the problems of combined control of reactive power of power systems based on electromagnetic converters;

- development of algorithms and methods for constructing characteristics of electromagnetic transducers with flat measuring windings: static with inhomogeneous and nonlinear parameters of magnetic systems; dynamic with symmetrical and asymmetrical electrical loads;

- development of a methodology for constructing designs of electromagnetic converters of one- and three-phase primary current into the secondary voltage of the electrical network of power systems with combined control of reactive power sources that meet the requirements of rational energy and resource-saving systems, taking into account asymmetries in monitoring and controlling the magnitude and phase of the currents of a three-phase electrical network, ensuring the adequacy of quality indicators and changes in primary and secondary values.

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