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MODULATION METHODS IN ELECTROMECHANICAL DEVICES

Аннотация. Современные электромеханические устройства непрерывного управления технологическими процессами используются в различных промышленных приложениях. Система управления (или электромеханическое устройство), применяемая для управления скоростью и моментом электродвигателей переменного тока путем изменения частоты и напряжения питания, преобразует переменный ток одной частоты в переменный ток другой частоты. Основными элементами системы управления являются устройство управления и силовая часть. Электромеханическое устройство (или система управления), применяемое для управления скоростью и моментом электродвигателей переменного тока путем изменения напряжения и частоты питания электрооборудования, обеспечивает преобразование переменного тока одной частоты в переменный ток другой частоты. Примером такого устройства является преобразователь частоты – электромеханическое устройство, обеспечивающее непрерывное управление технологическим процессом. Как правило, это устройство осуществляет управление скоростью и моментом электротехнического оборудования (с асинхронным или синхронным двигателем). Такие устройства широко применяются в различных областях транспорта и промышленности. Исследование и разработка трехфазных автономных инверторов напряжения является актуальной задачей, и одним из основных этапов их разработки является проектирование систем управления. Различное управление силовым преобразователем приводит к регулировке времени работы силового транзистора в зависимости от коэффициента заполнения. Такой метод управления называется методом круговой импульсной модуляции [1-10].

Abstract. Modern electromechanical devices for continuous process control are used in a variety of industrial applications. A control system or electromechanical device used to control the speed and torque of AC motors by varying the frequency and supply voltage converts alternating current of one frequency to alternating current of another frequency. The control device and the power section are the main elements of the control system. An electromechanical device or control system applied to control the speed and torque of alternating current motors by changing the supply voltage and frequency of electrical equipment ensures the conversion of one frequency alternating current into another frequency alternating current. An example of such a device is a frequency converter, that is, an electromechanical device for ensuring continuous control of the process. Usually, this unit has speed and torque control of electrotechnical equipment (with asynchronous or synchronous motor). Such devices are widely used in various fields of transport and industry. The research and development of three-phase autonomous voltage inverters is an urgent issue, and one of the main stages of their development is the design of control systems. The different control of the power converter leads to the adjustment of the time of the power transistor according to the ratio of its duty cycle. Such a control method is the circular-pulse modulation method [1-10].

Ключевые слова: Электромеханическое устройство, система управления, преобразователь частоты, устройство управления, силовая часть, метод модуляции, выходное напряжение, автономный инвертор напряжения.

Keywords: Electromechanical device, control system, frequency converter, control device, power part, modulation method, output voltage, autonomous voltage inverter.

The main elements of the electromechanical device or control system are the power unit (electric power converter) and the control unit (controller). Modern frequency converters have a modular architecture, which affects the expansion of the device's capabilities, and also in most cases allows the installation of additional interface modules of input-output channels. The control is performed by the software in the system control unit (microcontroller), which controls the main parameters (speed or torque) [1-6]. The efficiency of the control system and the power unit is directly affected by the modulation method. The growth of research in the field of modulation is characterized by the extensive development of power-electrical converters, determining economic efficiency and productivity. The main goal of the modulation method is to achieve the best form of signals (voltages and currents) with minimal losses. Other additional control issues such as DC voltage rectification, reduction of input current ripple, reduction of voltage rise rate can be solved by applying proper modulation method. Modulation methods can be divided into 4 main groups: circular-pulse modulation; field-vector modulation; harmonic modulation; variable frequency switching methods.Research and development of three-phase autonomous voltage inverters are extremely relevant. Control system design is one of main stages of development of an autonomous voltage inverter. Any control of a power converter ultimately comes down to regulating the on-state time of the power transistor in relation to the period of its operation (pulse-width modulation method. Considering the trend towards building digital (digital-analog) control systems for power converters, a large number have been developed for the class of three-phase inverters control methods. When implementing them to solve practical problems that require the generation of output voltage with increased frequencies (1–2 kHz), the control system must be developed on its own due to the lack of ready-made integrated solutions in the form of three-phase pulse-width modulation controllers. [8-10].

Disadvantages of such converters: imbalance of capacitors that create asymmetry in the device, this problem is solved by changing the modulation method; uneven distribution of losses - depending on the operating mode, the losses due to switching of external and central switches differ. The shown converter output can be scaled to achieve more than three signal levels, by dividing the voltage of the DC bridge by more than two values through the capacitors. Each of the split voltages can be connected to a load using a wide variety of switches and limiting diodes. The advantages of multi-level converters with increased power: the quality of electrical energy, the rate of voltage increase and the cost of the associated electromagnetic barriers are low. The dependence of the phase voltage of the converter is shown in figure 1 [2-5].

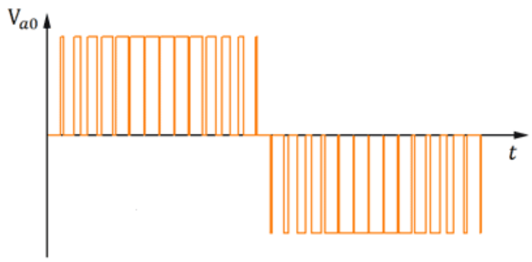

Figure 1. Phase voltage of three-level converter with neutral point

Any control of the power converter ultimately leads to the adjustment of the period of the power transistor in the open state relative to the period of the operating mode. As is known, such a control method is called en-circular-pulse modulation. The construction of control systems with power schemes is covered by a wide class of integrated controllers produced in the industry without causing difficulties. In this case, taking into account the tendency to build digital (digital-analog) control systems with power converters, many control methods of the class of three-phase inverters have been developed. However, in order to solve practical problems, in their implementation, which require the formation of output voltage with increased frequencies (1-2Hz.), the control system is implemented as three-phase circular pulse modulation controllers. An autonomous voltage inverter is a static converter that converts a constant voltage into an alternating voltage by means of semiconductor switches. With the development of microprocessor technology, vector circular-pulse modulation algorithms have found wide application. Due to the fully digital design of the pulse shaping system, the comparison is carried out in digital comparators, a triangular digital opening is used as a two-way opening at the interval of π/24, and this is provided by a reverse counter (figure 2). In the implementation of this type of vector circular pulse modulation, they passivate each phase control twice in the π-difference period of the output frequency during the (π/3) intervals, that is, there is no switching of the power switches with the modulation frequency. In this case, according to the control algorithm, either the upper or lower phase switch is open. The other two phases are controlled by extending the duration of the pulses according to the sinusoidal law through modulation. Thus, the average switching frequency of each power switch is 1.5 times lower than that of classical circular-pulse modulation, which reduces switching losses accordingly.

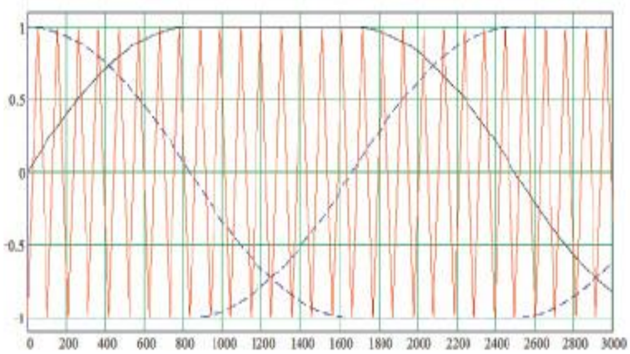

Figure 2. Reference sinusoidal functions and opening signal

For each phase of the output voltage, there is a period equal to (π/6) in the binary period of the output frequency, and the voltage of this phase is maximal according to the module. The three-phase autonomous voltage inverter digital-analog control system developed by the vector circular pulse modulation method has the necessary speed to stabilize and shape the high-frequency (1-2kHz) output voltage, improved mass-size indicators, and can be used for various three-phase autonomous voltage inverters with symmetrical loads can.The main elements of the electromechanical device or control system are the power unit (electric power converter) and the control unit (controller). Modern frequency converters have a modular architecture, which affects the expansion of the device's capabilities, and also in most cases allows the installation of additional interface modules of input-output channels.

The power unit (electric power converter) and the control device (controller) are the main elements of the control system or electromechanical device. A frequency converter is an example of such devices, that is, an electromechanical device that provides process control. The software is executed in the control unit (microcontroller) of the control system, which controls the main parameters.In order to check the speed of the system, a sinusoidal signal of different frequency is transmitted to the input of the autonomous digital converter, and oscillograms are extracted from the output of the inverter. From the presented oscillograms, it is confirmed that the control system has stability and good dynamic characteristics.

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