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RELAY CONTACTOR SYSTEM AS A MEANS OF CONTROLLING A LINEAR ELECTRIC DRIVE

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Abstract

The energy sector is currently undergoing rapid change as a result of advances in technology, changes in consumer demand and the desire for more sustainable and efficient energy sources. Against the background of these changes, the problems of process management and optimization in the energy system are particularly relevant. One of the main directions in this field is the application of control systems through different-purpose control apparatus that can effectively react to changes in the environment and dynamically adapt to new conditions.The future development of the theory and practice of automatic control is related to the determination of the maximum possibilities of the systems and their construction, which are the best according to any technical and economic indicator. It is the research and development of control systems through apparatus in the energy sector, taking into account modern requirements and technological possibilities. Control systems are widely used in various fields of technology, they are applied in the automation of production processes and calculations. Positive results are obtained when simulating the system using different parameter values for different types of interference signals. Management systems with the use of hardware can be successfully applied in the real working conditions of energy enterprises and can ensure optimal use of resources, reduction of operating costs and minimization of negative effects on the environment. This article discusses the characteristics of relay-contactor control systems. Relay contactor equipment controls electric drives powered by electric motors from a network with a constant voltage, which are widely used in all industries. Relay-contactor control systems are control systems built on a relay-contactor element base and designed to automate the operation of engines. With the help of such control systems, operations such as turning the engine on and off, choosing the direction and speed of rotation, starting and braking the engine, creating temporary pauses in movement, protective shutdown of the engine and stopping the mechanism are automated. These operations are necessary to perform the movement of the working body of the mechanism according to technological conditions. An electric drive, made on the basis of a relay-contactor control system, is a simple, unregulated electric drive of direct or alternating current, mainly for general industrial use, for example, electric drive of cranes, elevators, conveyors, fans, pumps, some transport devices, etc.

Key words: relay, contactor, equipment, characteristics, control system, electric drive, network, input, output, voltage, load.

I. Introduction

Technological progress in the field of industrial development and research set the task of creating systems of extremely high accuracy and minimal complexity. Such automatic systems must find conditions for highly efficient process management in a certain environment without the presence of an operator. The energy sector is currently undergoing rapid change as a result of advances in technology, changes in consumer demand and the desire for more sustainable and efficient energy sources. Against the background of these changes, the problems of process management and optimization in the energy system are particularly relevant.

One of the main directions in this field is the application of management systems with equipment that can effectively respond to changes in the environment and dynamically adapt to new conditions. Currently, the main and most promising method of automated management of complex dynamic systems is control and data collection systems. Based on control principles, large-scale automated systems are established through control equipment in the industrial and energy, transport, space and military fields, and in various state institutions [13].

The unity of control theory methods enables the synthesis of control systems, they have the possibility of changing the parameters of the regulator or depending on the change of the parameters of the control object or the structure of the regulator depending on the external influences on the control object. Additional great opportunities for improving control processes, depending on the size and signs of the input values, which enter the control device from the measuring device, enable non-linear control of the object's activity by changing the structure of the control device. In this case, combinations of linear control laws can be used.

The direct control object for relay-claw control systems is a motor powered from the network. In relay-claw control systems, two parts can be distinguished according to their functional purpose: the control part (forming the control algorithm, including various relays) and the executive part, which directly carries out control actions on motor (contactors, magnetic starters). Relay-claw control systems include standard units that perform specific functions. In addition to them, non-standard units are involved to solve a specific technological problem, for example, a unit for protecting the working element from slipping of the drive pulley, overspeeding, etc [1]..

The most important typical function of relay-claw control systems is the protection of the electrical and mechanical parts of the electric drive from emergency modes. The task of the protection unit is to disconnect the engine from the power source and stop the working part of the production machine. The number of emergency modes in the mechanical part of the electric drive includes: exceeding the permissible torque in the mechanical transmission (jamming of the mechanism); disengagement of the working body from the engine shaft; exceeding the permissible speed of the engine or working body; exit of the working body beyond the permissible movement zone. The advantages of relay-claw control systems include: the presence of galvanic isolation of power circuits from control circuits; significant switching power (up to several kA); high noise immunity.The disadvantages of relay-claw control systems include: contact switching, which requires appropriate care of the equipment and limits its service life; limited performance; increased weight and size indicators and energy consumption [2]. Table 1 shows the parameters characterizing modern relay contactor equipment [3]..

Relay contactor circuits are presented in the form of finished products - control stations, which contain standard circuits for controlling the movement of an electric drive, as well as the necessary protections. Electric drives are controlled by relay contactor equipment using an electric motor powered from a constant voltage network, and are also widely used in automating the operating principles of electromechanical devices.

Table 1. Technical characteristics of relay contactor equipment

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Operating period $t_{op.}$, sec.	0.005 ÷ 0.4
Number included (in time), N	600.....1200 for contactors 1200....3600 for relay
Power S, VA	5.....50 for contactors 0.2....5 for relay
Service life (total number of starts per hour)	10^6......10^7
Weight m, kg.	0.03....5

II. Formulation of the problem

The low current relay can be controlled as an electromagnetic switch to perform overcurrent on and off operations. A relay made of two isolated circuits: a control circuit used to control the switch and another circuit from the switch. When voltage is applied to the control circuit, current flows through the coil and creates a magnetic field, which is used to turn the switch on and off. This magnetic field through a wire (current) is created by a flow of electrons and the flow of electrons when passing through the coil is enhanced [4].. A relay in a low voltage circuit allows control of a large electrical load. Because relays consist of two isolated circuits, low-voltage components are protected from extremely high electrical loads because the circuits are physically isolated [5].

This in turn, due to the increased power rating of low-voltage components, prevents any errors compared to high-voltage components. In addition, the relay also contributes to the control of systems via an electrical signal and this shows that it is also possible to control a linear electric drive using a sensor or microcontroller [10-15]. To control a linear electric drive using a relay, it is necessary to achieve the ability to switch the polarity of the input voltage of the electric drive. In this case, it is possible to use a DPDT relay or two SPDT relays.

The DPDT type relay consists of 8 connectors: 2 for the coil, 4 for the switch input and 2 for the output. As on a DPDT switch by switching positive or negative terminals, it is necessary to connect the drive to input jack 4 or to 2 output jacks and supply power to all 4 input jacks. Due to the use of only one relay, only one input signal is needed to control it. When voltage is applied to the coil, the drive moves, and when the supply stops, it comes together [6-9].

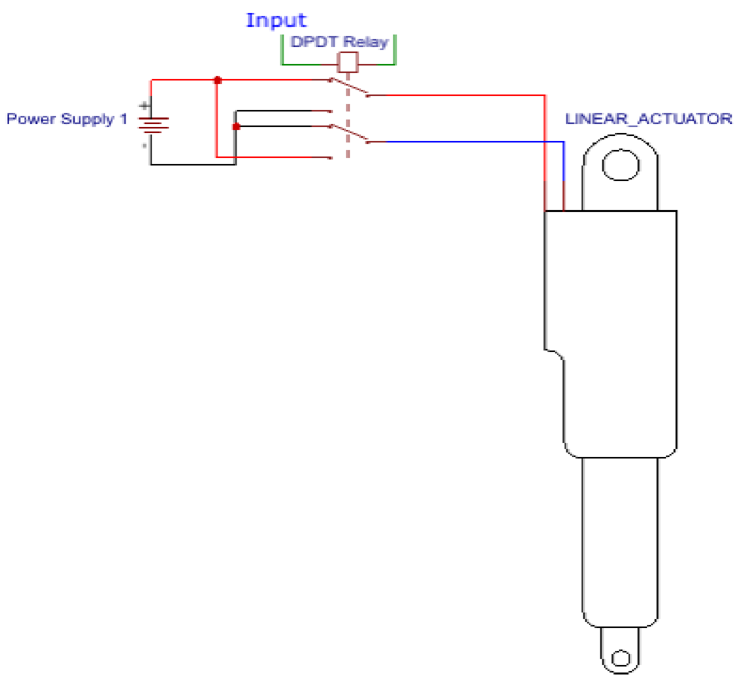

Figure 1. *Control of a linear electric drive using a relay*

In these relays, normal closed connections are connected to the grounding of the power supply, which ensures that in the event of failure of the control system, the actuator is immobilized. With this installation, to control the electric drive, power is supplied to one relay, and for reverse action it is necessary to strengthen the second relay - as shown in the figure (figure 2). It is necessary to ensure that both coils are supplied with power at the same time. Similar 4 SPST relays can be used to ground two relays and power two relays, but instead of a relay configuration with 2 SPDT relays there is no reason to use such a configuration, particularly if a relay module is available [18].

This means that there is no trip position and when certain limits are reached, a linear actuator with internal tip switches is used to trip the actuator. With this configuration, it is necessary to ensure that in the event of a control failure or loss of energy, the system can stop the movement (figure1). Otherwise, various other configurations may be used. If there is a need for a linear actuator for distinctive positions, then two positions can be used: a single pole relay configuration. In this configuration, 2 relays are used to change the polarity of the linear drive voltage, as well as to stop the power supply to the drive [16-17].

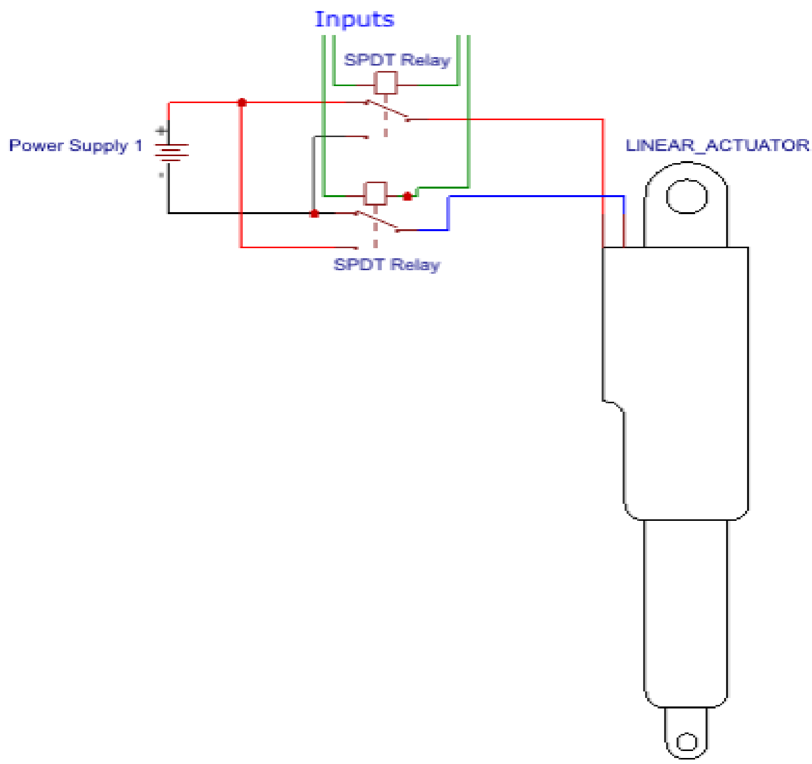

Figure 2. *Control of linear electric drive via relay (other configuration)*

III. Problem solution

Contactors have found wide applications for remote switching of power circuits. Such devices perform multiple reboots normally. Low-power relays with contactors, buttons, switches, etc. through which the remote control scheme of various loads can be realized. For example, in production, various electric motors and other loads are started, they are also used in powerful household equipment.

A contactor is an electromagnetic two-position switching device used for multiple distance switching of power circuits in normal operating modes. Its connection is performed due to electromagnetic transmission. The return (opening) of the contacts is carried out due to the effect of the spring, the mass of the moving structure or the combined effect of these factors. In all cases, the control circuit is connected the same as the coil. In order for the contactor to be connected, current must be applied to the winding, and then the armature is drawn towards the core, pulling the moving contacts towards itself, and they connect with the stationary contacts, closing the circuit. A simple connection diagram of the contactor is shown in figure 3. According to the working principle of the scheme, after the automatic switch QF is connected, the voltage is supplied to the SB 1 button and the upper contacts of the contactor KM 1 according to the scheme. When the SB 1 button is pressed, the control circuit is closed and the current flows through the coil KM 1, the contactor is connected, the contacts KM 1 are closed. Motor M (or any other connected load) is started. Coil and power circuits can be fed from different sources, different types of voltage and current. When the current from the coil is interrupted - the contactor stops, and its contacts open. That is, holding down the SB 1 button, the motor rotates. When you release the button or disconnect the voltage - the QF 1 button opens, the contactor is tripped and the motor stops [19].
Contactors are variously classified according to a number of parameters, one such parameter being the control circuit voltage or winding nominal voltage [20].

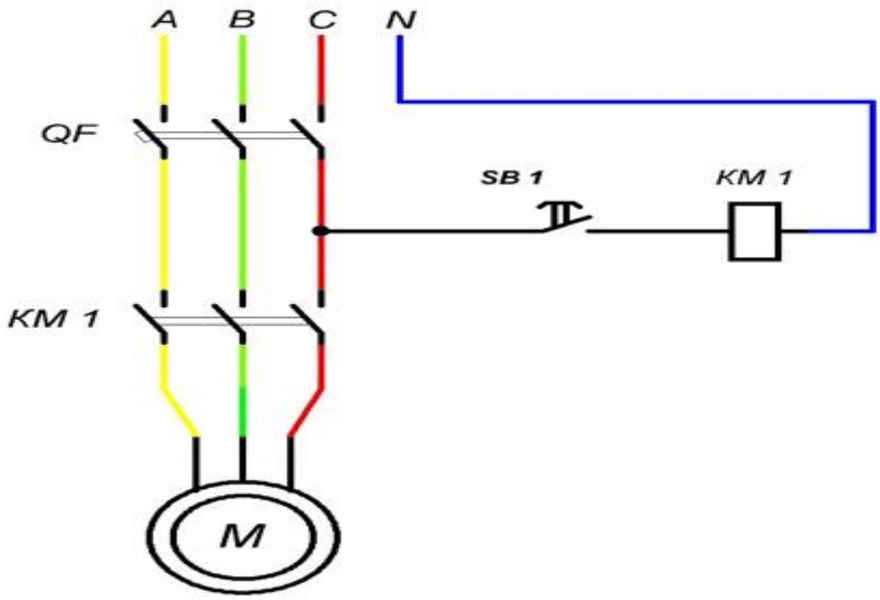

Figure 3. *Contactor coil connection scheme (220V)*

As an electromagnetic inverter, a relay can be controlled at low current to perform high current switching and opening operations. A relay consisting of two isolated circuits: a control circuit used to control the inverter and another circuit consisting of the inverter. When voltage is applied to the control circuit, a current flows through the coil and a magnetic field is created, which is used to open and close the inverter (1). This magnetic field is created by the flow of electrons (current) through the wire (2) and is amplified when the flow of electrons passes through the coil (3) (figure 4) [22]..

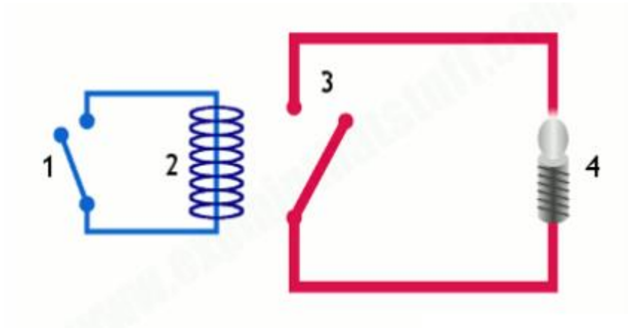

Figure 4. *Electromagnetic relay*

In a low-voltage circuit, the relay has the ability to handle a large electrical load. Because relays consist of two isolated circuits, small voltage components are protected from high electrical loads because the two circuits are physically isolated. This also avoids any errors due to the nominal power increase of the low-voltage components compared to the high-voltage components. In addition, the relay also allows the control of systems through an electrical signal, which indicates that the line can be controlled by electrical transmission through a transmitter or a microcontroller [21].
Variable frequency transmission control is divided into two types: vector and scalar. Scalar controls are used in the transmission of equipment, machines, fans, pumps, which do not require precise adjustment of torque and control of torque and speed at the same time (figure 5). Vector control is the regulation of quantity, frequency and phase of supply voltage. This method allows for virtually inertialess rotational speed and torque changes (figure 6). In the scalar method, control of the supply voltage value and its frequency is carried out. In the vector method, in addition to the value and frequency, the control of the phase is also carried out, that is, the control of the angle and value of the spatial vector is carried out [9]. Compared to the scalar method, the vector method has higher efficiency, adjustment accuracy and range. Any method is selected depending on the requirements, which are given for the technological process - the depth and accuracy of regulation, torque control, the state of the transmission during transition processes - starting, stopping, braking, etc.

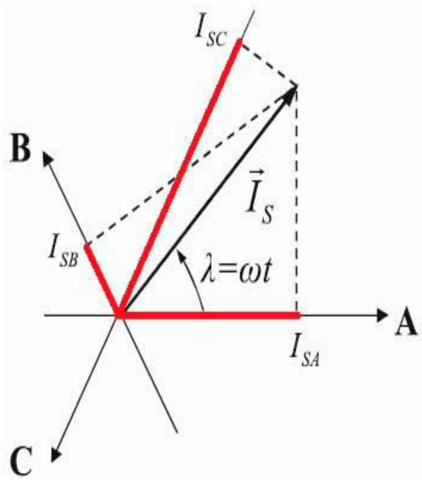

Figure 5. *Vector control method*

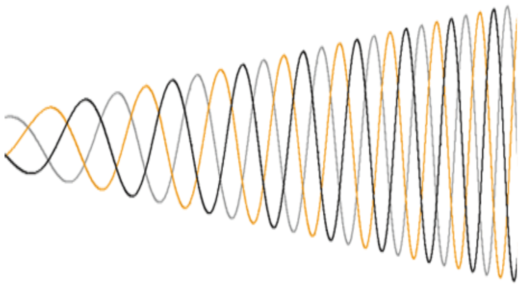

Figure 6. *Scalar control method (variation of feed voltage)*

The scalar method is used for small and medium power transmissions with fan loads. In the application of this method, there is the possibility of using multi-engine transmissions. The stability of the static characteristics of the transmission is practically close to the natural characteristic [23].
The range of the scalar control principle is no more than 1:10 with the lossless resistance moment. For this reason, a constant load capacity of the motor is achieved, and the applied voltage does not depend on the frequency, but at low frequencies the motor may overheat and the generated torque decreases. To prevent this, restrictions are placed on the minimum value of the output frequency [11]. Different analog and pulse speed transmitters are used in order to expand the stiffness of the characteristic and the adjustment limits. Therefore, discrete-analog controlled inputs are available in the frequency converters. Compared to the scalar method, the vector control method has the following advantages:

- high speed accuracy and a wide adjustment range;
- smooth regulation of engine rotation speed in the entire frequency range;
- the ability to maintain speed stability in the load change of electric transmission;
- reduction of losses in transition processes in transmission (increased engine efficiency).

In addition to the advantages, it should also be noted that the computational complexity of the vector control method is high, and the number of parameters must be taken into account in the calculation of the optimal operating modes of the transmission. But only to ensure a wide range and accuracy of regulation, especially at low frequencies of rotation, a vector frequency converter becomes indispensable [18].

IV. Conclusions

An electric motor fed from a constant voltage network through a relay-contactor apparatus provides control of electric transmissions and is also widely used in automating the working principles of electromechanical devices. Relay-contactor circuits are presented as finished products of control stations, on which typical circuits and necessary protections are assembled for the control of electric transmission movement. In many cases, it is required to connect any powerful load through a low-power relay. Sometimes they are needed for direct switching. In such cases, the contactor is simply installed and the output of the relay is connected to its coil. This can be implemented not only with a single voltage relay, but also with other devices of automation, for example, through a low-power intermediate relay or with another voltage type and value from the circuit (for example, in automation in different controllers.

As a reference to the literature reviewed on the basis of the scientific and technical base, it can be noted that in practice, in the choice of methods of adjusting the rotation speed of the electric transmission, it is necessary to evaluate the requirements for the control object, which is the range and accuracy of the adjustment of technological quantities, the need to maintain the torque on the motor shaft (especially small rotation frequencies), are the requirements for traffic control in emergency conditions.

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