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THE OPTIMIZATION OF THE OPERATING MODE OF A THREE-PHASE ASYNCHRONOUS MOTOR CONNECTED TO A SINGLE PHASE CIRCUIT

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In the typical scheme of switching on a three-phase asynchronous motor with a capacitor start it is suggested to use an automatic control scheme to change the capacitor's electrical capacitance depending on the moment of loading on the motor shaft. This will make the working section of the motor mechanical characteristics more rigid and increase the performance of the motor.

Introduction. Often there is a need to connect a three-phase asynchronous motor to a single-phase electrical circuit. There is a wide variety of schemes for connecting these motors to a single-phase electrical circuit, both with phase-shifting capacitors [1, 2] and with thyristors [3, 4].

One of the typical schemes of connecting a three-phase asynchronous motor to a single-phase circuit with a phase-shifting capacitor [1, 2] is shown in fig. 1.

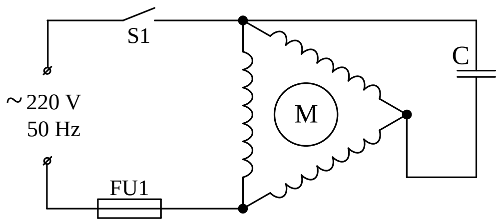

Fig. 1. Typical scheme of connecting a three-phase asynchronous motor to a single-phase electrical circuit

The capacitance of the capacitor is calculated by the formula [1]:

$$C = 4800 \cdot \frac{I}{U}, \qquad (1)$$

Where C – capacitance of the working capacitor in µF;

U – voltage in the electrical circuit, V;

I – the current consumed by the motor in A;

The current consumed by the electric motor in the formula (1) is calculated from the known power of the three-phase asynchronous motor according to the formula [1]:

$$I = \frac{P}{\sqrt{3} \cdot U \cdot \eta \cdot \cos(\varphi)}, \qquad (2)$$

where P – motor power in W, specified in its passport;

η – is the coefficient of efficiency;

cos (ϕ) – is the power factor.

The main disadvantages of such a scheme for connecting a three-phase asynchronous motor to a single-phase electrical circuit are reduction in motor power by approximately 35–40% and a softer mechanical characteristic, that is a significant reduction in motor speed with increasing torque on the shaft, which reduces the productivity of the machine.

A simplified view of the working section of the mechanical characteristic of an asynchronous motor when it is connected to a single-phase electrical circuit is shown in Fig. 2 [1].

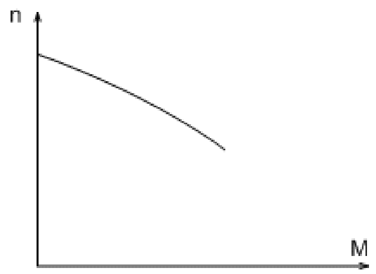

Fig. 2. An approximate view of the working section of the mechanical motor characteristics

Method of implementation. The stated goal can be achieved if the capacitor capacitance value is changed in the scheme with the asynchronous motor connection depending on the magnitude of the load torque on the motor shaft. Since the current consumed by the motor from electrical circuit increases with increasing load torque on the motor shaft, it is convenient to control the capacitance value depending on the strength of the indicated current.

Fig. 3 shows the functional diagram of connecting a three-phase asynchronous motor to a single-phase electrical circuit with an automatic switching capacitor capacitance value. This scheme improves the loaded operating mode of the motor.

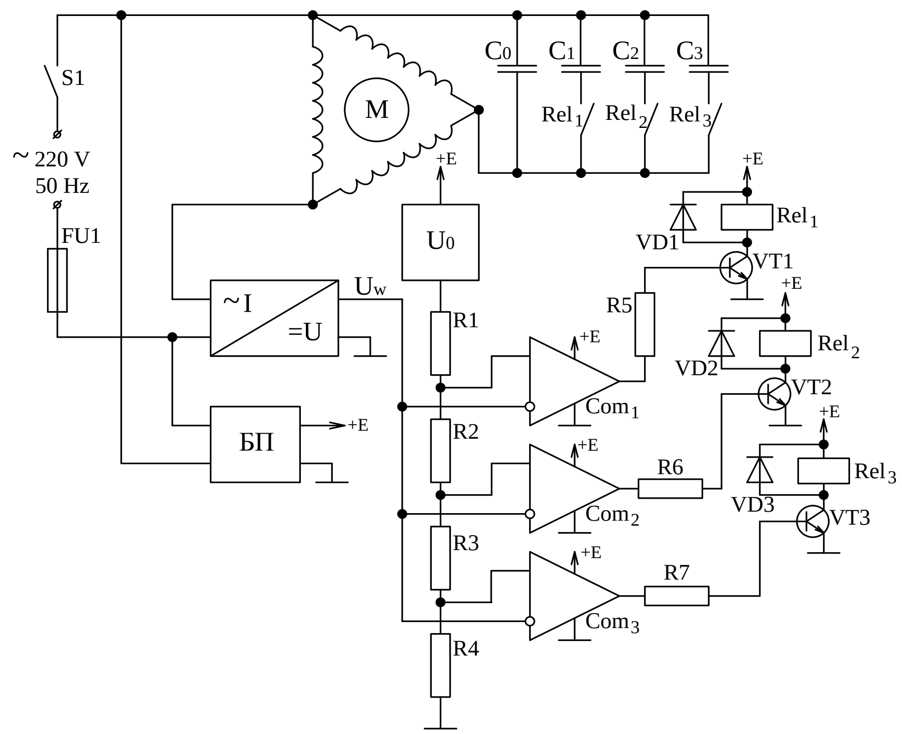

Fig. 3. Functional diagram of connecting a three-phase asynchronous motor to single-phase electrical circuit with the automatic control of the capacitance value depending on the load moment

In addition to the asynchronous motor M with a set of capacitors C_0, C_1, C_2 and C_3, the scheme includes the power supply unit BP, the current-voltage converter ~ I / = U, the reference voltage source U_0, the voltage divider for the resistors R_1, R_2, R_3 and R_4, the voltage comparators Com_1, Com_2 and Com_3, the amplifiers on the transistors VT_1, VT_2 and VT_3 for the relays Rel_1, Rel_2 and Rel_3.

The device for optimizing the loaded operating mode of the asynchronous motor operates as follows. After starting the motor, the S_1 switch is turned on, the motor uses a large current from the electrical circuit and the current-voltage converter ~ I / = U respectively generates a large voltage U_w. As a result, all the three voltage comparators Com_1, Com_2 and Com_3 are triggered, the transistors VT_1, VT_2 and VT_3 are opened and the relays

Rel_1, Rel_2 and Rel_3 are switched on. Also, the capacitors C_1, C_2 and C_3 are connected in parallel to the main capacitor C_0. Consequently, the maximum capacity close to the starting capacity is connected to the motor and it accelerates.

As the motor accelerates, the current consumed from the circuit decreases. Accordingly, the output voltage of the current-voltage converter U_w decreases and the voltage comparators Com_i, for which $U_w<U_{0i}$ are switched. VT_i disconnect the relay Rel_i via the transistors. As a result, the capacitors are turned off. The remaining equivalent capacity connected to the motor corresponds to the amount of current consumed from the electrical circuit and respectively to the magnitude of the load moment on the motor shaft.

With the increase in the load moment on the shaft of the asynchronous motor, the current consumed from the circuit increases. The output voltage of the current-voltage converter U_w also increases. And if for any Com_i comparator the condition $U_w> U_{0i}$ is fulfilled, it will start working, and through the transistor VT_i the relay Rel_i is switched on, which turns on the corresponding capacitor C_i parallel to the main capacitor C_0. The total value of the capacitance connected to the motor increases, and it increases the torque.

As the load torque on the shaft of the asynchronous motor decreases, the reverse process takes place. The current consumption from the circuit decreases, the output voltage of the voltage converter U_w also decreases, and if for any comparator Com_i the condition $U_w<U_{0i}$ is fulfilled, it will switch. Via the transistor VT_i the relay Rel_i is switched off, which disconnects the corresponding capacitor C_i from the main capacitor C_0. As a result, the total value of the capacitance connected to the motor will decrease, and this also increases the torque.

The working sector of the resulting mechanical characteristic of an asynchronous motor with such control over the value of the connected capacitance looks like this (Fig. 4).

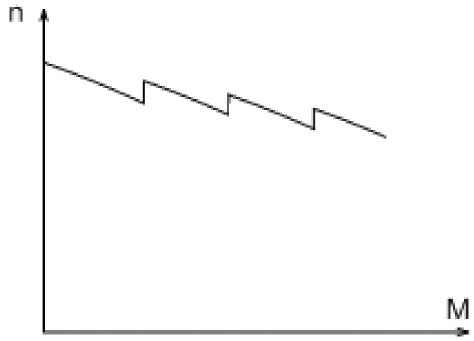

Fig. 4. An approximate view of the working section of the mechanical characteristic of a motor with the automatic control of capacitance depending on the load moment

Conclusions. The application of the scheme of automatic switching of capacitance when an asynchronous motor is connected to a single-phase circuit allows optimizing the loaded operating mode of the motor:

− prevents the decrease in the asynchronous motor speed with the increase in the load moment on the motor shaft, and consequently makes the mechanical characteristic of the engine stepped, but more rigid;

− increases the working section of the mechanical characteristic;

− increases the productivity of the mechanism driven by such a motor.

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