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MODES OF OPERATIONS OF A MINIMUM OF CURRENT OF STATORA OF THE FREQUENCY-MANAGED ASYNCHRONOUS ENGINES.

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ANNOTATION.

Theoretical bases of control of minimum stator current in operating mode of asynchronous motors controlled by changing the speed are considered, in the example of a concrete motor the minimum values of stator current for different values of frequency and load moment are calculated, descriptions are constructed and analyzed.

Keywords:*asynchronous motor, speed, frequency, magnetic flux, stator voltage, loading torque, energy saving, asynchronous electric drive.*

Given that the magnetic flux is connected to the stator winding voltage by a nonlinear coefficient, then we express the expression of the ratio of the stator current to the nominal value corresponding to the rated operating mode by differentiating the magnetic flux to zero:

$$\frac{d\left(\frac{I_1}{I_{1H}}\right)}{d\phi}=0 , \quad (1)$$

I_1, I_{1H} – where the current and nominal values of the stator current, respectively. $\phi=\frac{\Phi_1}{\Phi_{1H}}$ – the natural value of the magnetic flux between the stator and rotor of an asynchronous motor, Φ_1 and Φ_{1H} – current and nominal values of magnetic flux, respectively.

A decrease in the active component of the stator current as a result of an increase in the magnetic flux leads to a decrease in the total value of the stator current. At a certain value of the magnetic flux, the stator current operates in the minimum value mode, and the implementation of this mode is based on the fulfillment of condition [1, 2].

Figure 1 shows the characteristics of the change in the asynchronous motor stator current depending on the magnetic flux when the speed is adjusted by changing the relative value of the frequency in the range of 0.2 to 1.0 when there is a load moment. The presence of the value of the magnetic flux when the induction motor is operating at rated frequency and rated load ensures that the stator current is kept to a minimum. As the frequency value decreases, the minimum point of the stator current characteristic shifts towards the decreasing side of the magnetic flux. For example, when it is 0.2, the minimum value of the stator current corresponds to the value of the magnetic flux[3,4,5].

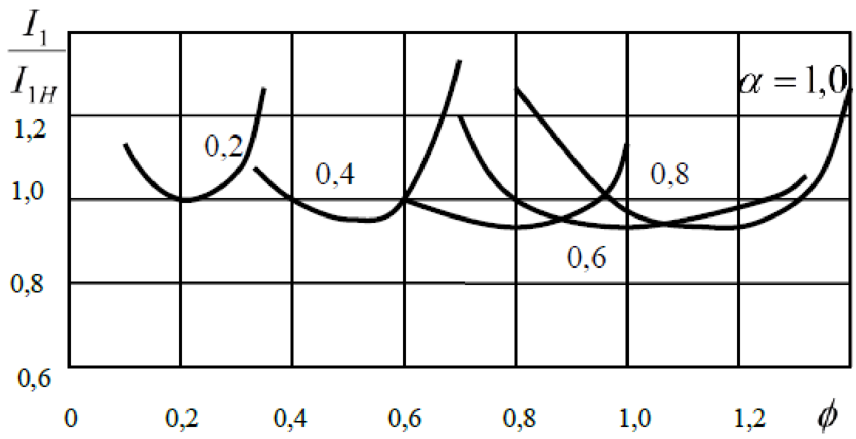

Figure-1. Characteristics of change depending on the magnetic field of the stator current when the speed of the asynchronous motor axis of the model 4A100L4U3 is equal to the frequency change of 0.2 - 1.0 when the load torque is equal.

The analysis of the descriptions shows that when the speed of the induction motor is adjusted by changing the frequency at the rated load moment, the magnetic system of the motor is saturated when the frequency values are 0.8 and 1.0, and the voltage applied to the stator winding must be adjusted above the rated value.

Figure 2 shows the characteristics of the change in stator current depending on the magnetic flux when the speed is adjusted by changing the relative value of the frequency in the range $\alpha = 0{,}2$ -1,0 when the loading moment $\mu_C = 0{,}8$. When the asynchronous motor is operating at a frequency of $\alpha = 1{,}0$ the magnetic flux at $\phi = 1{,}15$ ensures that the stator current is minimal and the magnetic system of the motor is saturated[6,7,8].

At other values of frequency, i.e. as the frequency decreases from the nominal value, the minimum points of the stator current characteristics shift towards the decreasing side of the magnetic flux and the magnetic system of the motor becomes unsaturated. For example, when $\alpha = 0.2$, the minimum value of the stator current corresponds to the value of the magnetic flux $\phi = 0{,}21$.

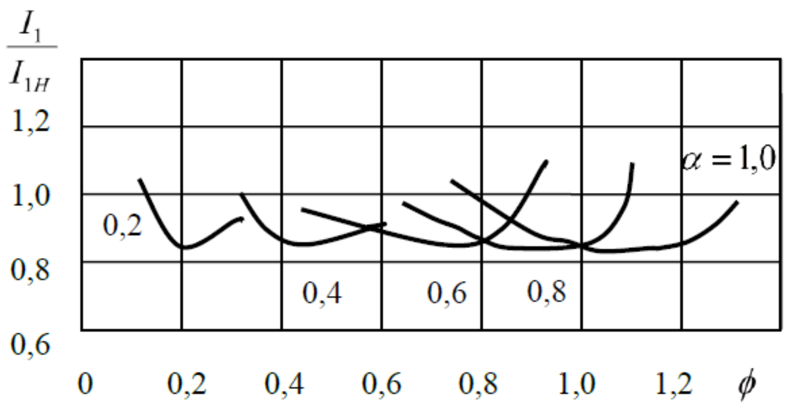

Figure 2 Characteristics of the change in the asynchronous motor of type 4A100L4U3 depending on the magnetic field of the stator current when the load torque is set in the range of frequency $\alpha = 0{,}2 - 1{,}0$ when the load moment $\mu_C = 0{,}8$.

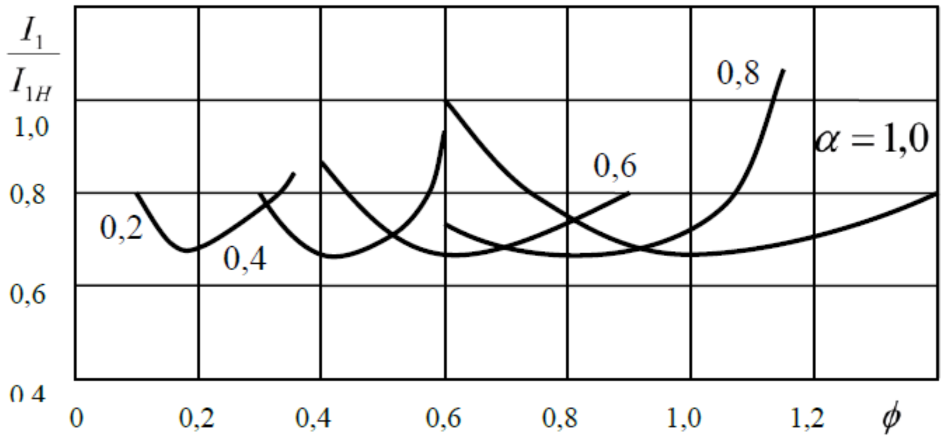

Figure 3. 4A100L4U3 asynchronous motor shaft load moment $\mu_C = 0{,}6$ Variation characteristics depending on the magnetic field of the stator current when the speed is adjusted in the range of frequency $\alpha = 0{,}2 - 1{,}0$.

When the asynchronous motor operates at a relative frequency of $\alpha = 1.0$, having a magnetic flux at a relative value of $\phi = 1{,}0$ ensures that the stator current is minimal and the magnetic system of the motor is unsaturated.

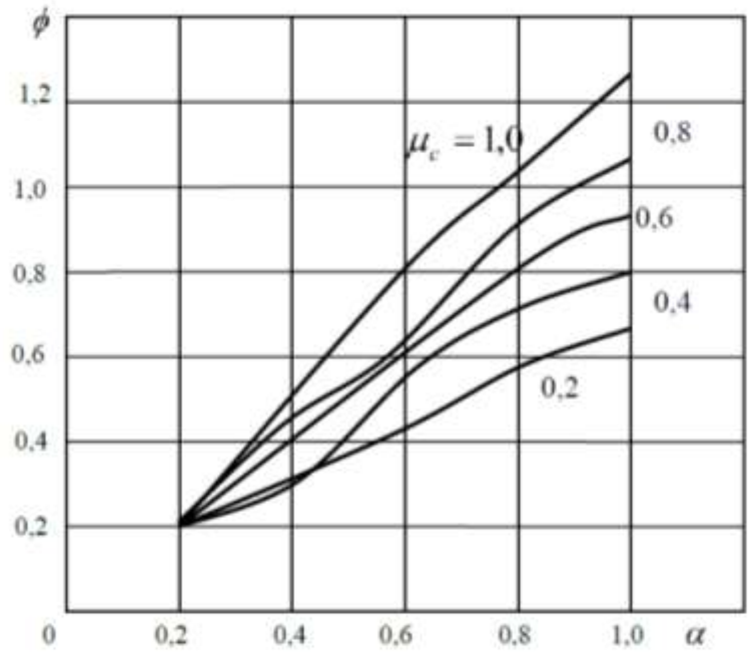

Figure 4. Characteristics of frequency-dependent changes in the optimal values of the magnetic field that ensure that the stator current is at minimum values when the speed of the asynchronous motor type 4A100L4U3, which varies in the range of load torque $\mu_C = 0{,}2 \div 1{,}0$ is set at frequency $\alpha = 0{,}2 \div 1{,}0$.

As the frequency decreases from the nominal value, the minimum points of the stator current characteristics shift towards the decreasing side of the magnetic flux, at all visible values of the frequency the value of the magnetic flux is less than the nominal, and the motor magnetic system is unsaturated[9,10,11].

Figure 4 shows the characteristics of the frequency-dependent change of the optimal values of the magnetic flux, which ensures that the value of the stator current is minimal for different values of the load torque of the asynchronous motor, whose speed is adjusted by changing the frequency.

An asynchronous motor magnetic system operating at different frequencies at a value less than the nominal load on the axis operates in the unsaturated part of the magnetization characteristic, and therefore by substituting the magnetic flux in equation (1) with the stator voltage it can be written as follows:

$$\frac{d\left(\frac{I_1}{I_{1H}}\right)}{d\gamma} = 0, \qquad (2)$$

where $\gamma = \frac{U_1}{U_{1H}}$ – the relative value of the stator voltage, U_1 and U_{1H} are the nominal values of the stator voltage, respectively.

According to equation (1) it is necessary to use a measuring current transformer and a Hall measuring converter as primary measuring transducers to create energy-efficient automated asynchronous electric drives, while according to equation (2) it is sufficient to have current and voltage measuring transducers [3].

Figure 5 shows a block diagram of an automated asynchronous electric drive whose speed is controlled by changing the frequency and operating in the mignimum stator current mode[12,13].

Components of automated electric drive system: asynchronous motor M, indirect thyristor frequency converter FC and its power scheme PS and frequency and voltage control systems FS and VS, functional converter FO, memory device XQ, partition block BB, differential devices 1DD and 2DD, voltage and current measurement converters VMT and CMC.

Asynchronous electric drive works as follows. The activating signal transmits a signal corresponding to the control frequency to the U_V FS, and this signal is simultaneously transmitted to 1FC and transmitted to the VB by adjusting the expression $\gamma = \alpha$ according to the nature of the load torque. The power circuit of the FC is supplied with a frequency voltage corresponding to the loading moment on the motor shaft from the output of the PS to the stator winding of the induction motor M.

If the load on the motor shaft is at the nominal value, i.e. when $\mu_C = 1{,}0$ then the signal at the output of the HQ is $\frac{dI_1}{dt}$ = 0. If the loading moment $\mu_C < 1{,}0$ then an equivalent signal corresponding to the stator current is generated at the CMC. This signal is sent to the input of 2DD, where it is time-differentiated and sent to the first input of $\frac{dI_1}{dt}$ BB, and also to the second input of BB, which is a time-differentiated $\frac{dU_Л}{dt}$ signal from the voltage from VMT at 2DD. The division operation in BB is performed and a time-bound $\frac{dI_1}{dU_Л}$ signal is generated. Fulfillment of the condition $\frac{dI_1}{dU_Л} = 0$ ensures that the induction motor operates in the minimum stator current mode.

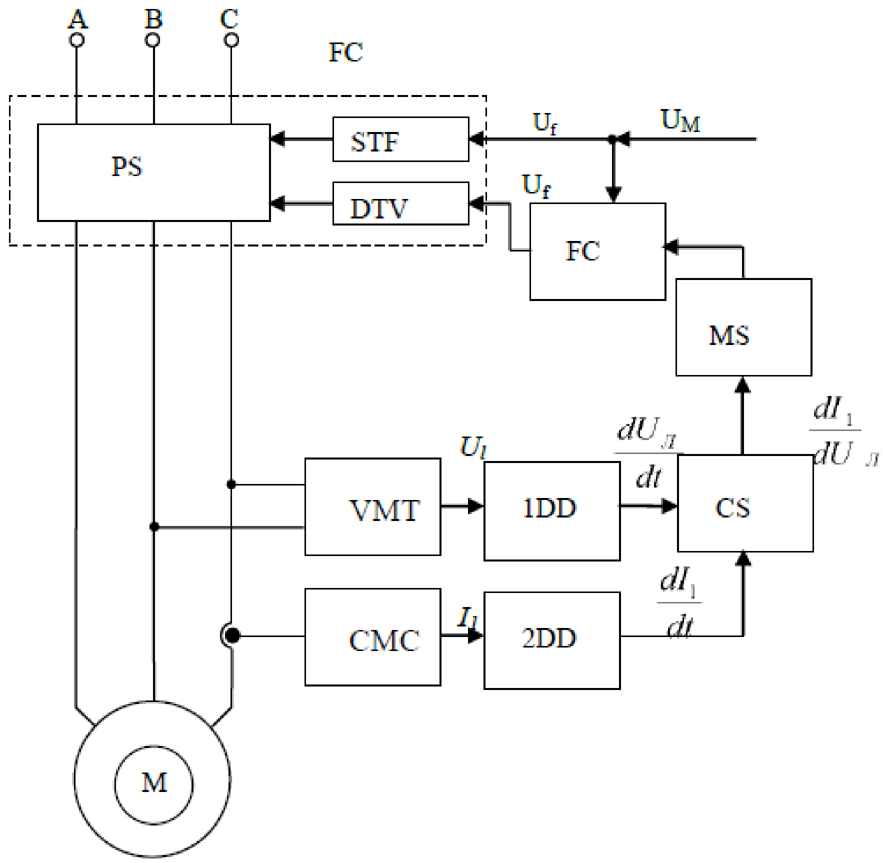

Figure 5. The operating frequency at the lowest value of the stator current
automated asynchronous with adjustable speed
block diagram of an electric drive.

Failure to do so will result in $\frac{dI_1}{dU_Л}$ having a certain value, and this signal will be transmitted via MS to the second input of the FC. Here it is involved in generating a control voltage that ensures that the motor operates in minimum stator current mode, taking into account the actual load torque and frequency $U_M = U_M \mp \frac{dI_1}{dU_l}$. The signal is maintained at $\frac{dI_1}{dU_l}$ HQ until the next load torque as well as the frequency value changes[14,15].

The integration of devices and blocks in this automated asynchronous electric drive block diagram into a single microprocessor system not only increases the functionality and speed of the electric drive, but also leads to design compactness.

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