THE APPLIED VALUE OF SOFT START IN ELECTRIC MOTORS

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Abstract. *In industry asynchronous electric motors are widely used. There are issues associated with commissioning. Failure of electric motors occurs if these problems are not eliminated. In this article, we will look at some of the most effective and efficient methods.*

Keywords: *asynchronous electric motor, soft starter, microcontroller.*

The most common type of device that converts electricity into rotational motion is an asynchronous electric motor, which is widely used in various industries and agriculture. Asynchronous electric motors are used in metal-cutting machines, lifting transport machines, fans. On the other hand, low-power motors are used in automation devices.

When using asynchronous electric motors, there are some problems associated with their operation. The first of them is the impossibility of combining the torque of the motor with the torque of the load, and the second is the high value of the starting current.

The starting current is the current required to start the motor, several times higher than the rated current consumed by the motor. According to the data given in the literature, the starting current ($I_{work}=K_{work}\, I_{name}$) will be 3.5-8.5 times higher than the nominal. The K_{work} coefficient of the inrush current is called. The starting current coefficient will depend on the power of the motor and the number of pairs of poles. The lower the power, the lower the inrush current. The smaller the pairs of poles, the greater the inrush current. A large inrush current can lead to the failure of the electric motor itself, the power supply system, as well as devices connected to the power supply system. Therefore, it will be necessary to limit the value of the inrush current.

Various methods are used to start the electric motor: direct start, low voltage start and frequency start.

A simple scheme for starting an asynchronous motor with a short-circuited rotor is a direct connection to the network. The voltage is transmitted to the stator winding due to the closure of high-power contacts. With direct start of electric motors, the torque force on the shaft will be much less than the nominal. Starting at full voltage causes current surges and voltage drops. This method is used when the power of electric motors is small and no soft start is required.

Depending on the type of load connected to it when starting electric motors, the following most frequent cases may be observed with direct connection [1-3]:

1. Overload and overheating of the motor stator 31 %;
2. Short circuit between windings - 15%;
3. Bearing damage-12%;
4. Damage to the windings or insulation of the stator-11 %;
5. Uneven air gap between stator and rotor – 9%;
6. Operation of the electric motor in two phases – 8%;

7. Weakening of the stiffeners of the stator windings-4%;
8. Rotor imbalance – 3%;
9. Shaft displacement – 2%.

Asynchronous motors are started at low voltage using several circuits:

- With the stator moving “from the star to the three corners” ;
- With connection via transformer;
- With connection of the starting resistor or reactor to the stator circuit.

Considering connection schemes, in the first scheme, the spark plug of an electric motor is triggered by connecting in the form of a “star”, and after the engine accelerates, the “three corners” are transferred to the connection using a switching device. This achieves a 3-fold reduction in the launch current. In doing so, the launch moment in the shaft is reduced by 30%. In addition, disconnecting connection before the required time also causes the current to increase to the magnitude of the current generated when directly starting. This method is unsuitable for inertial devices and devices that can be launched under loading.

In the autotransformer start-up circuit, an auxiliary device for changing the voltage is connected in series to the electric motor circuit. This circuit provides smooth acceleration and reduction of the inrush current. Depending on the cost of the element used in the circuit, the current surge resistance limits increase when switching to full voltage.

A start-up circuit with a reactor and a resistor is also widely used. To reduce the voltage, a resistor or a coil with a reactive resistance is connected in series to the coil. The start is carried out when an element with an active or inductive resistance is connected in series to the circuit. When the engine accelerates, the reactor and the starting resistance are slowly shunted and removed from the circuit. One of the main drawbacks is a small starting torque.

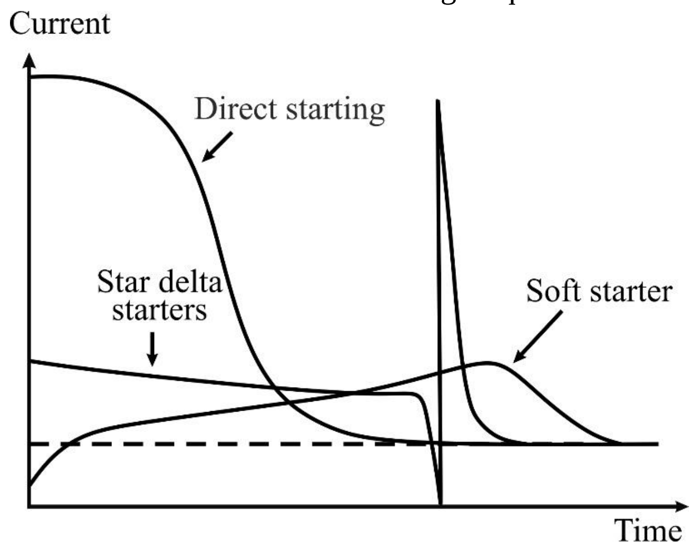

Figure 1. Variation of motor current at different starts

It is based on the use of the dependence of the rotation frequency and the torque of the motor shaft during frequency start-up on the frequency of the supply voltage in the winding. A frequency converter is used for this. Starting via a frequency converter eliminates problems with starting and accelerating the asynchronous motor.

In fig.1 shows the change in the motor current when it is started in various ways. As can be seen from the figure, when the oxyst asynchronous motor is started, there is a smooth change in the current value without jumps. When starting directly, the motor first consumes a large current, which then decreases to the value of the operating current. When starting the engine using the “star

– three corners" method, a sharp jump in current is observed. Direct start, as can be seen from the figure, requires additional energy consumption.

Due to the smooth start, overheating of the wheels is prevented due to the starting current, a voltage drop in the mains, as well as the destruction of engine parts as a result of sudden excitation.

Looking at a soft starter, the simplest one has three settings: acceleration time, stop time and start voltage. The voltage acting on the motor when it is started is determined by adjusting the starting voltage. It is equal to 30 rated voltage...80 %. Voltage reduction and its adjustment is carried out by a thyristor. By changing the opening phase of the thyristor, we can change the voltage on the motor (fig. 2).

Thus, it will be possible to change the current and torque of the motor ($M \sim U^2$) by adjusting the opening phase of the thyristors. Figure 3 shows a graph showing the change in motor current and torque when the stator voltage changes.

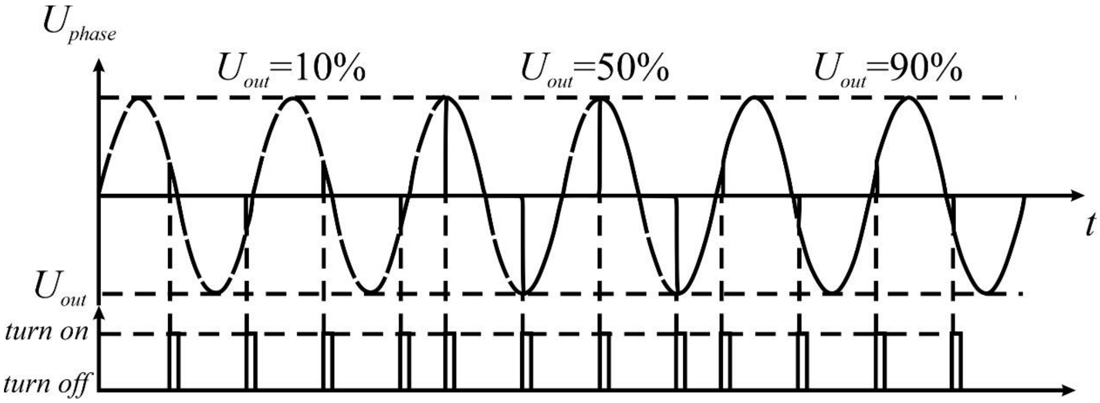

Figure 2. The dependence of the output voltage on the opening phase of the thyristor

Depending on the specific situation, a large starting torque may be required to start the engine. To reduce the starting current, it will be necessary to set the lowest value of the starting voltage.

In order to obtain the required output voltage in a quiet starting device, it will be necessary to ensure that thyristor pairs or triacs are started with pulses at a certain interval. Modern soft launchers are manufactured on the basis of microcontrollers, in which control pulses are formed in accordance with the program.

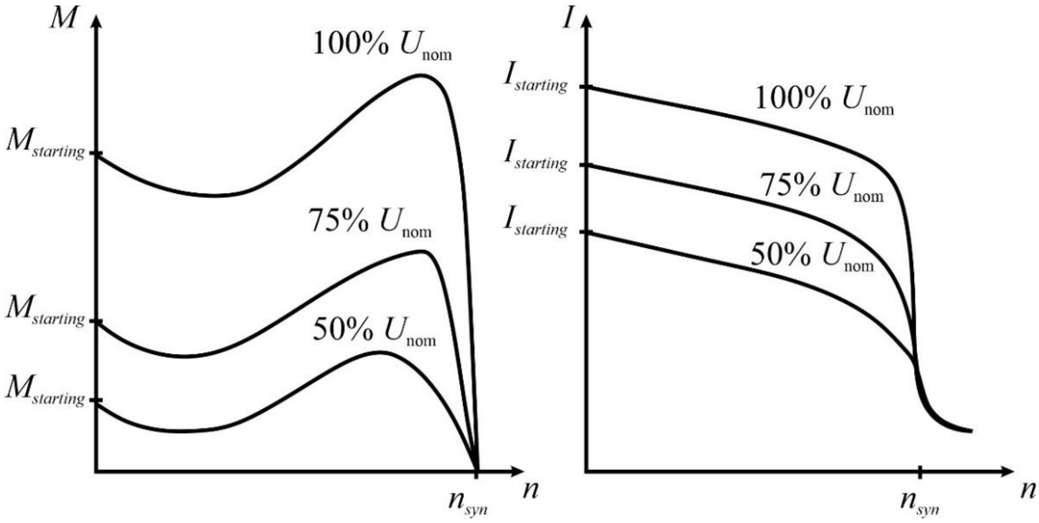

Figure 3. Voltage dependence of motor current and torque

As you know, when controlling thyristor circuits, a special control circuit is required. The reason is that the thyristors continue to enter a closed state with each half-cycle switching. Because when the electric current passing through the thyristor stops, it closes. At the same time, each time it must be opened through the control electrode. This means that when working with thyristors, a circuit is required that accurately calculates the time, knowing when they stopped, when they need to be added. Nowadays, it is possible to solve this problem with the help of microcontrollers by creating software using their capabilities [4-6]. A system with a microcontroller has been developed that determines the sequence of phases of a three-phase network, zero points and, in accordance with them, thyristors transmit a signal to the control electrodes (fig.4).

With a slow start of asynchronous motors, temporary use of a thyristor control circuit is provided during the pre-activation process. For a three-phase network, the thyristor is connected symmetrically by 2 to each phase. In this case, the signals from the control circuit are fed to a pair of tristors at the specified time, according to this signal, the tristors open. The opening of a pair of thyristors is controlled in each half-cycle, and their opening allows you to control the average voltage. It is necessary to pay attention to the fact that the value of the average voltage is sufficient for the rotation of the rotor. A decrease in the opening angle of the thyristors in each phase leads to an increase in engine speed. As soon as the motor reaches the maximum rotation speed, a signal is sent from the thyristor control board to a relay that directly connects the motor to the 3-phase network, and the motor is connected directly to the network. After that, the signal supply to the thyristor circuit stops, and the system maintains the state of the 3-phase relay. We can use tristors with higher power when high-power motors need to be started. The developed scheme allows for a slow start of electric motors with a capacity of up to 11 kW. The system has a built-in Wi-Fi connection management function that allows you to remotely disconnect the Wi-Fi connection during operation.

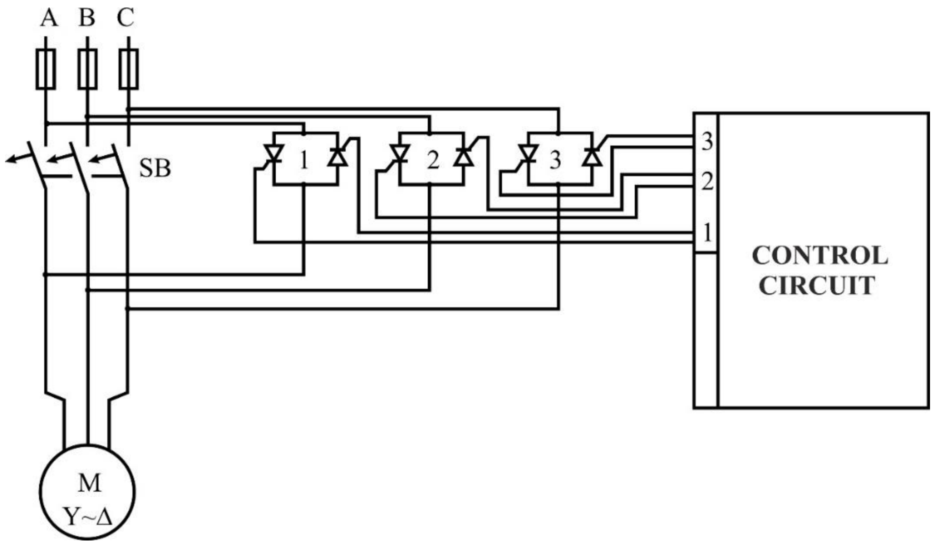

Figure 4. Network connection of thyristor control unit

The program algorithm is based on the C programming language. The program is written for the ATmega328P microcontroller (fig.5). First, the operating states of the microcontroller ports are set. Then signals from external devices are constantly recorded. A special algorithm is based on checking the state of phase interruption, phase interchangeability. Depending on the result obtained, the signal applied to the thyristors is triggered.

The developed slow start system can be used in the metallurgical industry, light industry, component cutting machines, fans and water pumps, mills and other industries. With the help of the circuit, asynchronous motors can be switched on and off over long distances at a given time. Currently, research is underway to further improve the device.

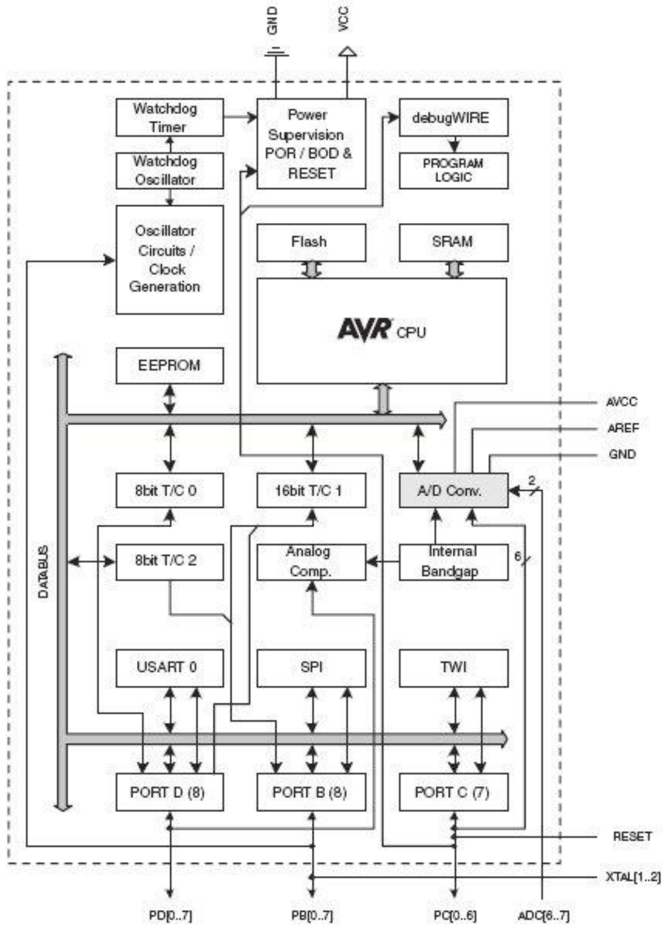

Figure 5. Block diagram of ATmega328P microcontroller [7]

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