Research Article

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A Synchronous Electric Motors Resistor and Denistor Smooth Launch Device

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Abstract
This article, it is experimentally shown that by equipping asynchronous electric motors with a new resistor and denistor smooth starting device, it is possible to effectively limit the current. In addition, as a result of using resistor and denistor smooth starting device in practice, it was determined that electrical energy wastage is saved and mechanical breakdowns are prevented.

Keywords: Asynchronous Motor, Resistor, Denistor, Energy Losses, Mechanical Breakdowns, Frequency Inverters, Delta-Star Method, Smooth Start-Up

Introduction

It is known that the real essence of the problem is that in the process of starting asynchronous electric motors, that is, when connecting it to the source, more power than the nominal power is required. This law of physics is valid for all objects in the world - after all, it has always been more difficult to start a movement than to continue it. Today, asynchronous electric motors with a short-circuited rotor are the most widely used devices in production enterprises. Therefore, prevention of energy wastage and mechanical damage caused by overcurrent during the start-up and shutdown of these devices is one of the urgent problems of the traditional energy system. Scientists have published many scientific articles aimed at solving the problem of smooth start-up of asynchronous electric motors [1-4].

During the smooth start-up of electric motors, the current slowly reaches the nominal value based on the non-linear dependence on time and decreases from the nominal value to zero value during the shutdown. Figure 1 shows the time dependence of the current in the process of starting and stopping the asynchronous electric motor.

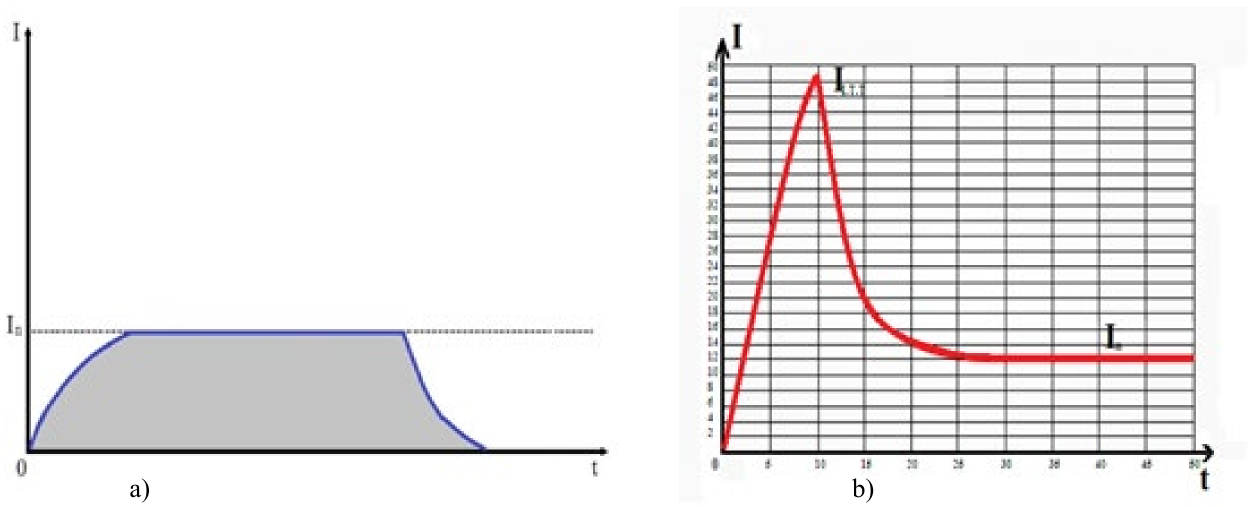


Figure 1: Time dependence of the current in the process of starting and stopping the asynchronous electric motor. (A-ideal state, b-real state)

In fact, the current should ideally be as shown in Figure. 1 a). But we can see in Figure. 1 b) that this is not the case in reality. As can be seen from the graph, the starting current of the asynchronous electric motor is more than the nominal current. So, it can be seen that the current is much higher than the nominal value when encountering inductive resistance. In this case, the question arises as to how the starting current of electric motors is determined. We can determine and calculate the starting current of the electric motor with the following formula.

$$I_{ish.t} = I_n * K$$

Here $I_{ish.t}$ - the value of the current during the start-up process of the electric motor, I_n- pre-calculated rated current, K – the duration of the electric motor starting current (obtained from the passport data of the electric motor). If we know the power values of the electric motor in the passport, it will not be difficult to calculate its current values. For example, let us know the nominal current of a 45 kW electric motor. In this case, we determine the current of the electric motor by power as follows. If the electric motor is connected to a 380 Volt three-phase system, its current can be determined completely.

$I_n = P_н/\sqrt{3}(U_н*\eta*\cos\varphi)$
$I_n = 45000/\sqrt{3}\ (380*0,\ 92*0,\ 85) = 45000/514,696 = 87,43A$
I_n – current power of an asynchronous electric motor
P_n – The nominal power of the electric motor is 45 kW
$\sqrt{3}$ – square root of one third = 1, 73205080757
U_n – voltage in the circuit 380 V
η – efficiency of 92% (calculated 0.92)

If the FIK and power factor of the electric motor are unknown, we can find its rated current with a small error of two amperes per kilowatt. We determine the current of the electric motor by the following formula:

$$I_n = P * 2$$

Now let's talk about the consequences of overcurrent in the process of starting asynchronous electric motors. This is quite a problem and can lead to:
• leads to overloading of the electrical network, heating (up to the melting of contacts) and voltage drop;
• Overloading and overheating of the engine leads to its premature wear. Some manufacturers indicate the maximum number of starts per hour or day due to overheating among the parameters of the electric motor;
• premature wear and overloading of mechanical mechanisms, especially when moving with a large moment of inertia (bearings, reducers, tapes);
• noise caused by adding contactors, transmitted not only through wires, but also through the electromagnetic field;
• Technology issues - multiple processes cannot be started at once.
• Each device is overloaded by the starting current, and the starting torque is an overload for all participants of the process.

It is at this critical moment that the "weak link" may appear. In addition, many consumers of electricity in this network face problems such as dimming of light bulbs due to low voltage, and contactors may stop due to strong noise. From this we can conclude that the current in the process of starting and stopping is an unavoidable problem. If this condition is not treated using effective methods, it can lead to bad consequences.

This article talks about the fact that the resistor and denistor smooth starting device of asynchronous electric motors is a device that effectively limits the starting current compared to other methods, and the types of smooth starting devices of asynchronous electric motors used in industrial enterprises and their characteristics. In addition, it has been experimentally shown that by using resistor and denistor smooth starting device, electricity waste can be saved as a result of current reduction and mechanical breakdowns can be prevented.

Before proceeding to the discussion of the results obtained in the work, we will dwell on the features and shortcomings of devices for reducing excess currents in the startup process that have been used so far.

In the first method, a reduced voltage is supplied to the electric motor, and then, when the electric motor accelerates, it is necessary to increase the voltage and rotation speed to the nominal value. This method is used in electronic devices for starting electric motors - soft starters (SCP) and frequency inverters (frequency). Figure 2 shows the time dependence of the starting current of electric motors when using the softstarterax method. It can be seen from the graph that the starting current is much higher than the nominal value [7-10].

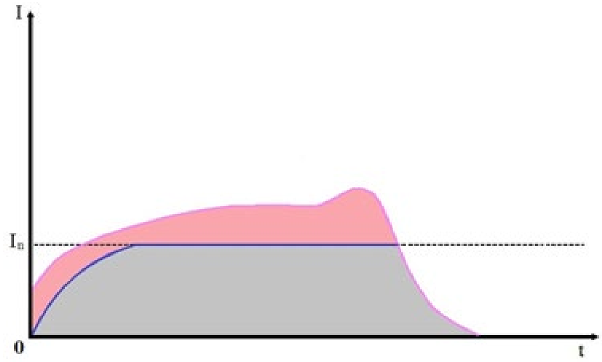
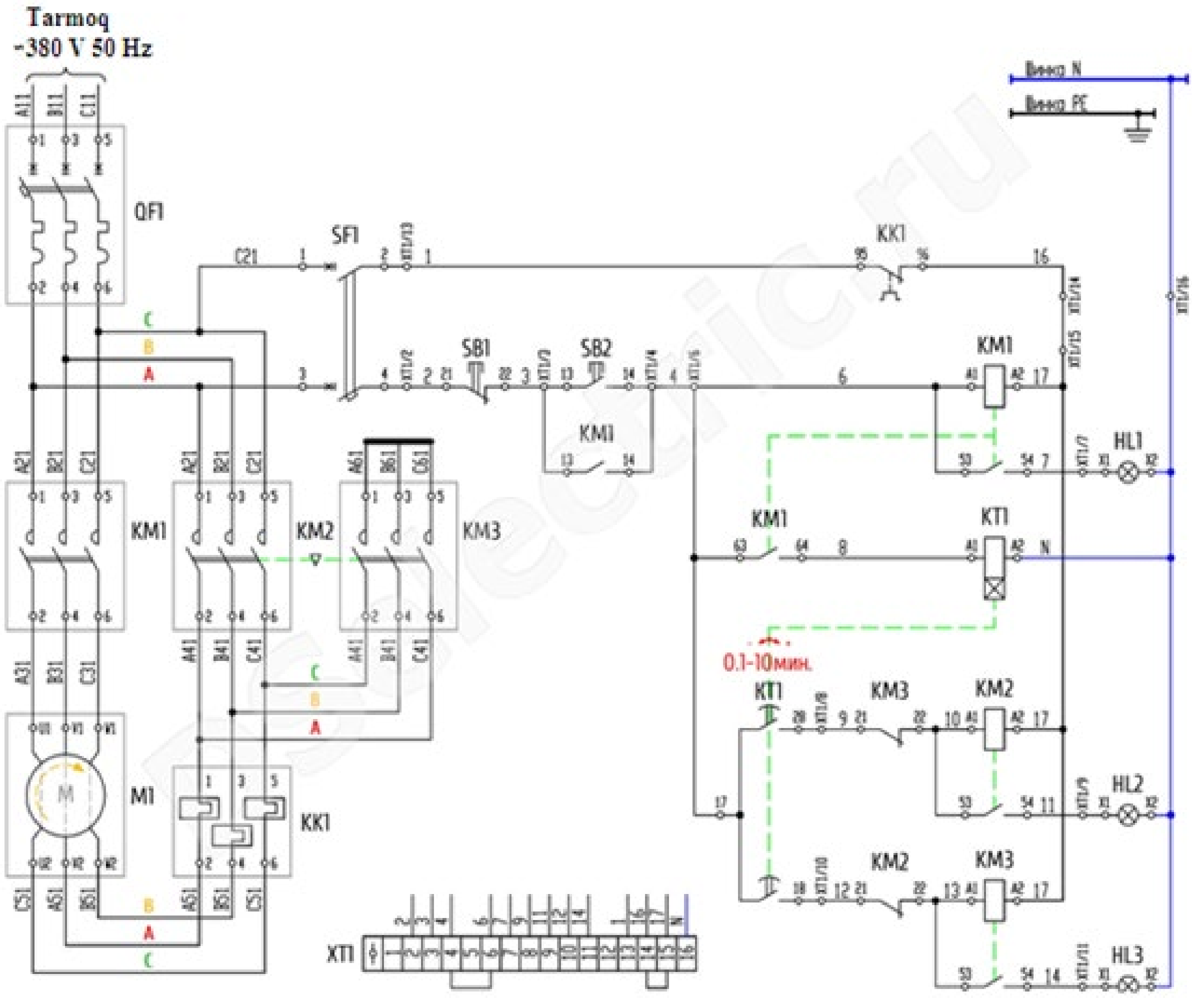


Figure 2: Time dependence Graph of Electric Motor Start-Up Current When Using the First Method

This is shown in red. The disadvantages of this method are as follows:
• First of all, the electronic part for high-power asynchronous electric motors has not been developed today;
• Secondly, as a result of the influence of the external environment, the parameters of the electric motor change and lead to limitations in the management of large capacities;
• Thirdly, the price of the device is very high.

In the second method, it is necessary to use current limiters during the start-up process. At first, the electric motor is powered by powerful resistors, and then it is transferred to the nominal value by a timer. The resistance of the resistors corresponds to the resistance of the starter coils. This device is very easy to make (contactor and time relay). The advantage is that the electrical circuit of the device is very simple. [10, 11].



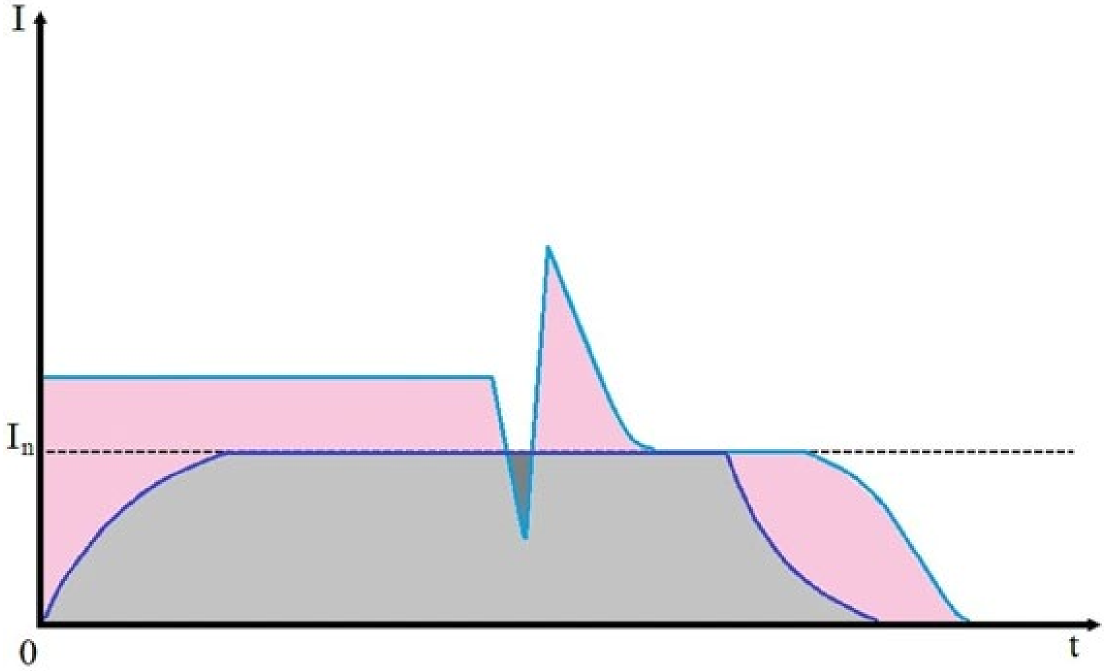


Figure 3: Time Dependence Graph of Electric Motor Starting Current When Using the Second Method

The third method. In this method, the electric motor is given full voltage at once, but first it is necessary to connect the coils in such a way that the electric motor does not rotate at full power. This scheme is called the **Triangle-Star** method. The disadvantages of this method are as follows:

- Firstly, not all asynchronous electric motors can be connected in this way;
- Secondly, it is necessary to carry two cables to connect asynchronous electric motors to the network;
- Three contactors are used to switch an asynchronous electric motor from a star connection to a delta connection.

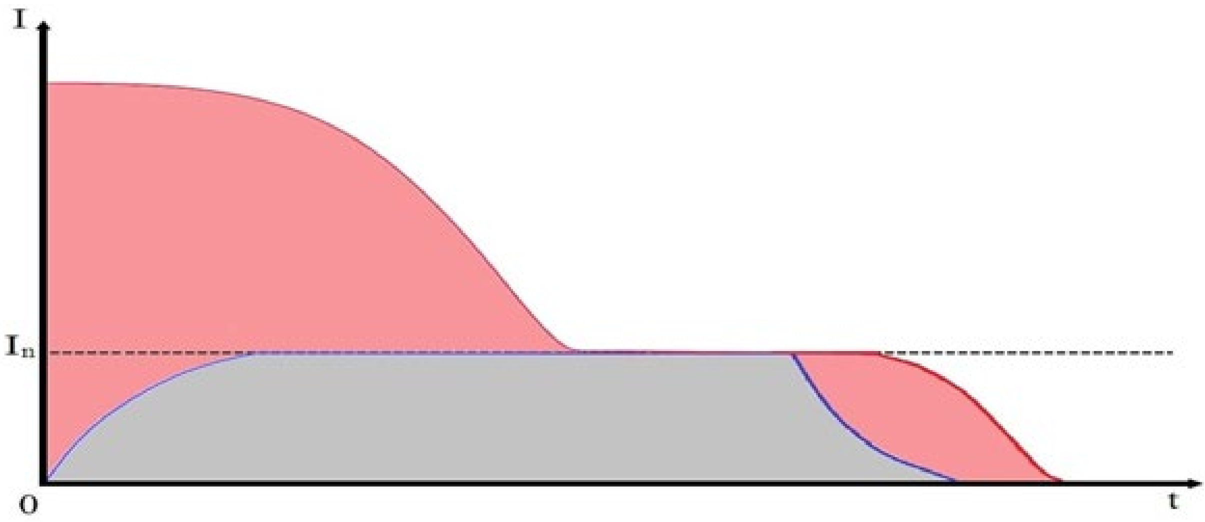


Figure 4: Time Dependence Graph of Electric Motor Start-Up Current When Using the Third Method

The Cheapest and Most Energy-Efficient Device among the Above Three Connection Methods Is the Contactor and Time Relay Connection

In this work, the start-up current was brought to the minimum value by using the electronic switch (dynistor) that connects depending on the voltage change in the internal electrical processes instead of the time relay in the electrical circuit using the connection method we chose. [11, 12]

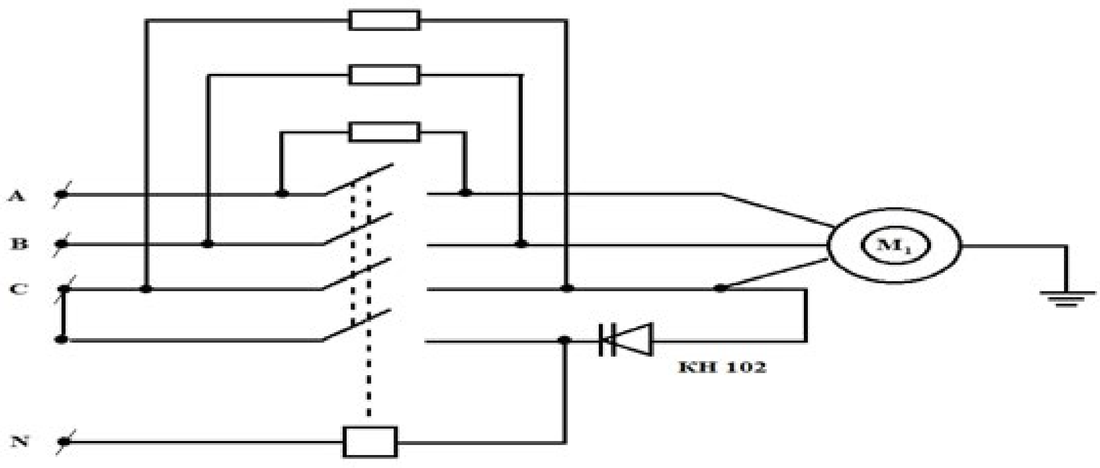


Figure 5: Electrical Diagram of the Proposed Resistor and Denistor Smooth Starter

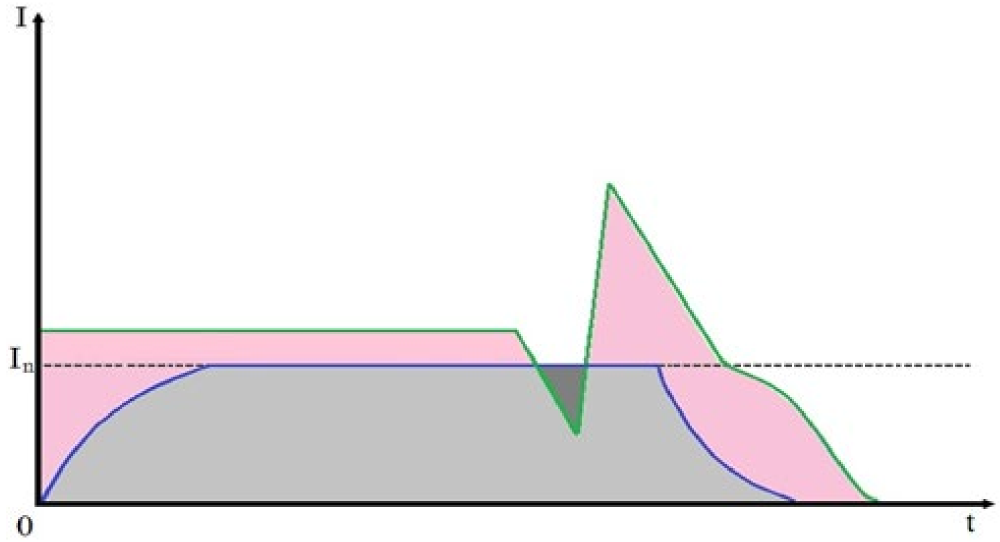


Figure 6: Plot of Current versus Time during Starting Using the Proposed Resistive and Denistor Soft Starter

From the above graph, it can be seen that the RESISTOR and DENSISTOR smooth starting device that we have chosen is more effective than other devices and methods. That is, the surface of the work performed by wasted electrical energy is the smallest. This is the surface shown in red in the graph.

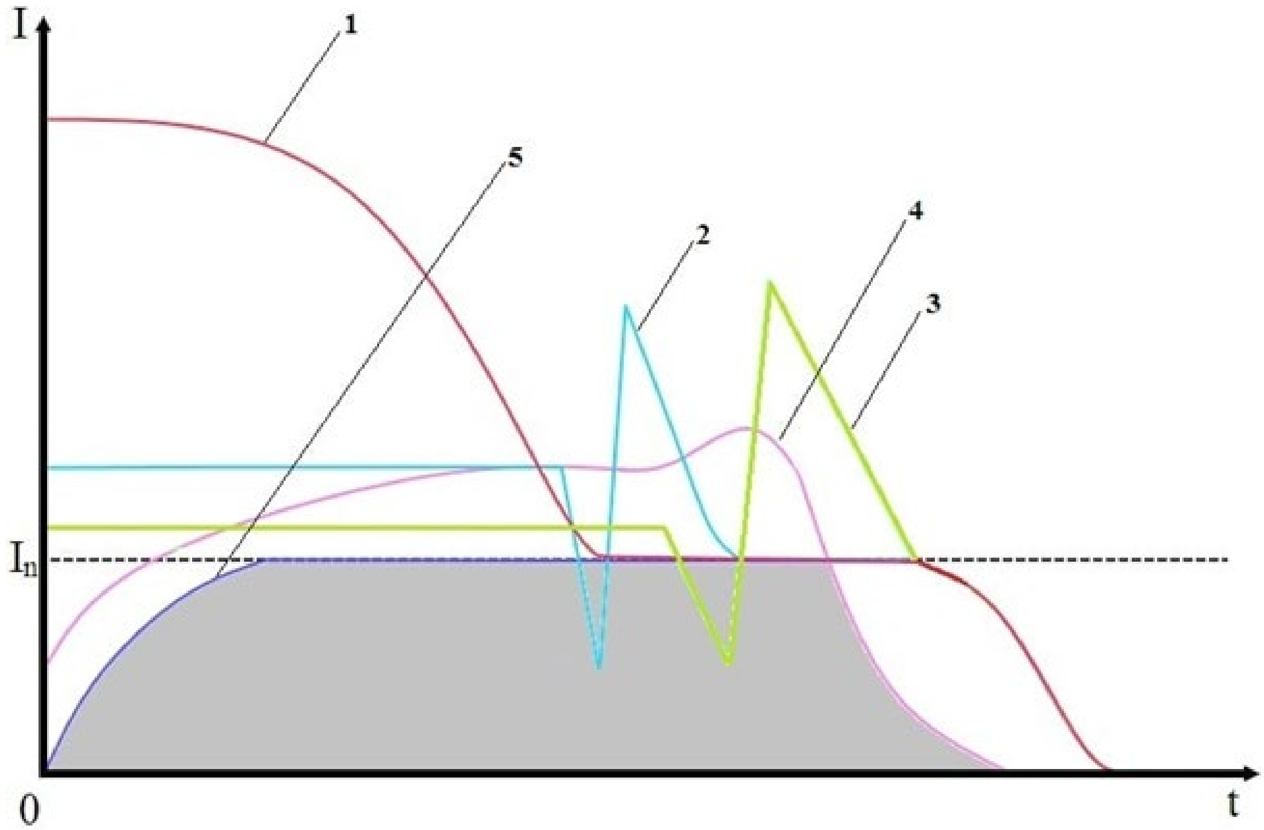


Figure 7: 1- Direct connection, 2- Star-delta connection, 3- Resistor and denistor connection, 4- Soft start (softstarterax) connection.

In conclusion, it can be said that several times the starting current of asynchronous electric motors is considered a big problem and has negative consequences. It can cause overloading, heating and voltage drop of the electric network, wear and overheating of electric motors, wear and overload of mechanical mechanisms (bearings, reducers, belts), noise caused by connecting contactors, and other similar consequences. It is. The smooth starting device for asynchronous electric motors with resistors and denistors is effective in solving this problem, and the sharp increase in current during starting is eliminated. As a result, excess electrical energy losses and mechanical breakdowns occurring in the system are prevented.

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