MODELING OF ASYNCHRONOUS MOTOR STARTING PROCESS USING MATLAB/SIMULINK/SIMPOWERSYSTEMS

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Abstract- Asynchronous motors has an important and basic role in the performance of various technological processes and simultaneously performs many functions for the automation of technological processes and operations. Most of these processes can be solved only with the use of an automated electric drive, which uses the latest achievements of automation, power electronics, electrical engineering and electromechanics. In the scientific article, it is proposed to use a frequency converter for soft start and speed control of a three-phase asynchronous motor. At startup, in order to limit the inrush current, it is necessary to determine the laws of frequency and voltage changes. For this purpose, the model of an asynchronous electric drive on the MATLAB/Simulink/SimPowerSystems platform was compiled. By this model it is possible to control an asynchronous electric drive for a smooth start, as well as for speed control. To analyze various startup processes, models are compiled using a special SI block of an asynchronous machine. simulates an asynchronous electric machine in motor or generator modes. The main purpose of the work is to create a model in the MATLAB software package for studying the process of starting and regulating the speed of an asynchronous motor using a frequency converter under various laws of frequency and voltage change.

Keywords: Frequency Control, Electric Drive, Speed Control, Laws of Frequency and Voltage Changes, Static Torque.

1. INTRODUCTION

Currently, frequency control of the rotational velocity of an asynchronous electric drive is widely used, which provides a smooth change in the rotor rotation speed in a wide range both above and below the nominal values. Modern frequency converters are high-tech devices with a wide range of regulation, having an extensive set of functions for controlling asynchronous motors. The highest quality and reliability allow them to be used in various industries for controlling the drives of fans, pumps, conveyors, etc.

It is known that the rotation speed of the stator field is determined by two parameters: the voltage frequency applied to the winding of the stator and number of pairs of motor poles. Accordingly, in this paper, the frequency regulation of asynchronous electric drives with a change in the frequency of the supply voltage is analyzed [1, 2, 3, 5].

It is possible to estimate the starting current and the maximum electromagnetic torque of the drive, as well as the duration of the start. Using this method, the influence of the frequency and voltage growth rate on the above parameters is determined, thanks to this, it is possible to choose the optimal law of frequency and voltage change [4].

The task of controlling an asynchronous motor can be divided into the following parts:
1. Implementation of a smooth start of the engine;
2. Control of the engine speed with a given frequency and a large control range.

A lot of work is devoted to the first question, where an asynchronous motor is started using various methods and devices [5, 6, 7, 8, 9, 10]. However, this problem is successfully solved with the help of a soft starter device. Many works are devoted to modeling and studying this device [11, 12, 13, 14]. In these works, the process of starting a three-phase asynchronous motor using the MATLAB/Simulink application software package is studied in detail. To solve the second question, a frequency converter is used. In this case, vector and other torque control of an asynchronous motor is considered.

2. STATEMENT OF PROBLEM

Purpose of the work is to develop a model for studying the process of starting an induction motor at various frequencies and voltages using the MATLAB/Simulink software package.

As is known, when performing various technological processes, it is very often necessary to change the speed of the electric drive. Currently, it is widely implemented to change the frequency of input voltages to change the rotational speed of an asynchronous electric drive.

When the speed control of an asynchronous motor is performed with a change in frequency depending on the nature of the static torque, the frequency and voltage change in accordance with the law [1, 4, 6]:

$$\frac{U_1}{U_n} = \frac{f_1}{f_{1n}} \sqrt{\frac{M_{SN1}}{M_{S1}}} \tag{1}$$

where U_{1n}, f_{1n}, M_{SN1} are nominal values of voltage, frequency and static torque, respectively; and U_1, f_1, M_{S1} are voltage, frequency and static torque, respectively.

When deriving the Equation (1), the active resistance of the stator winding was assumed to be zero (r_1=0). To plot the torque and speed characteristics of an asynchronous motor at various frequencies and voltages, taking into account r_1, the MATLAB/Simulink software package is used. Moreover, the obtained characteristics allow us to analyze only the static operating modes of the asynchronous motor.

3. MODELING THE PROCESS OF STARTING AN ASYNCHRONOUS ELECTRIC DRİVE

To simulate the process of starting a frequency-controlled asynchronous motor, frequency and voltage changes are taken into account when starting. Consider possibility of modeling this process in the MATLAB/Simulink software package. To obtain sinusoidal signals the trigonometric functions "Sin" or "Sine Wave Function" are selected from the library "Math Operations" and the sinusoidal wave "Sine Wave" is selected from the "Sources". When the "Sine Wave" block is used in the "Source Block Parameters" window for the Time (*t*) parameter, the value "Use external signal" is set in the command line [6, 8, 11, 15]. The models shown in Figure 1 allow us to study the obtained sinusoidal functions with different frequency values, for example, at *f*=50 Hz.
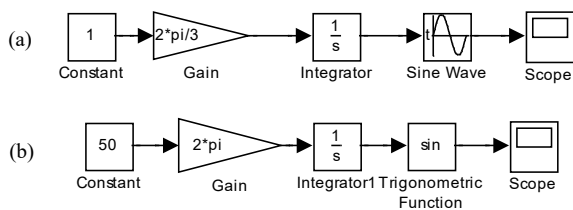

Figure 1. Models for the study of sinusoidal signals

"Integrator" block changes the argument of the sinusoidal function in time in Figure 1a and 1b. As a result of Scope and Scope1, identical sinusoidal functions with a frequency of 50 Hz are obtained (Figure 2). If it is necessary to change the frequency of the sinusoidal function in time from zero to a certain value, it is possible to use the scheme shown in Figure 1a or b with the addition of additional blocks (Figure 3). In Figure 3, the "Ramp" block changes the set value in accordance with the linear law. In addition, it is possible to perform a frequency change in accordance with another law using the corresponding blocks from the MATLAB/Simulink library. If it is necessary to change the frequency according to the linear law by 0.065 sec from zero to 65 Hz, the slope

parameter of the "Ramp" block is set: *Slope*=60/0.065=923. To simulate of asynchronous motors, existed in the list of the "SimPowerSystems" library, depending on the work performed, the maximum frequency value is set to *f*=60 Hz, in accordance with the parameters of the motors of the "Asynchronous Machine SI Units" block. The "Saturation" block limits the maximum frequency (60 Hz) and therefore, in the window of this block, *Upper limit*=60; *Lower limit*=0 is set. When running the model (Figure 3), a sinusoidal waveform is obtained, varying in frequency, shown in Figure 4.

If it is necessary to take into account the change in the voltage of the power supply, in addition to the change in frequency, the following blocks are added to the model shown in Figure 3: "Ramp1", "Saturation1" and "Product" (Figure 5). Here, "Ramp" performs a change in the frequency growth rate, and "Ramp1" takes into account the growth rate of the voltage change, "Saturation 1" limits the maximum voltage value. The "Product " block combines channels for changing the set parameters (frequency and voltage).
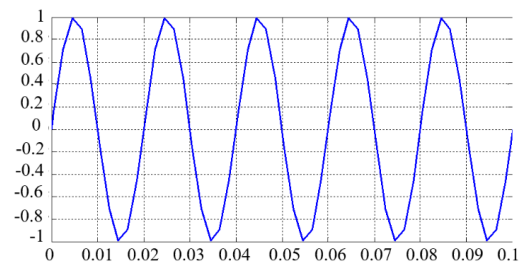

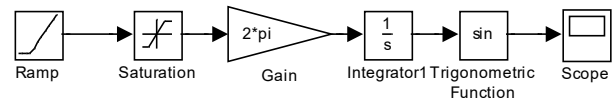Figure 2. Time characteristic of the sinusoidal function

Figure 3. Model for changing a given frequency value in accordance with a linear law
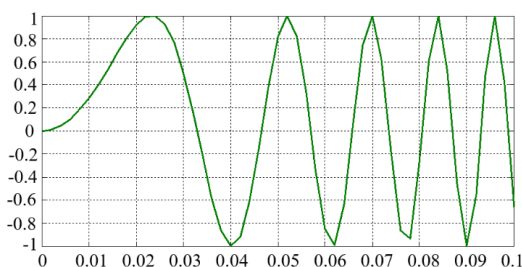

Figure 4. Sinusoidal waveform that varies in frequency

If there is a need to change of voltage from zero to 460 V for 0.07 sec. the parameter is set in the "Ramp1" block:

$$Slope = \frac{460}{0.07} = 6571$$

In the "Saturation1" block, the maximum voltage is set to 460 V. The sinusoidal waveform of frequency and voltage changes obtained from the model shown in Figure 5.

4. MODELLING OF THREE-PHASE POWER SUPPLY

Figure 6 shows a model of a three-phase power supply that varies in frequency and voltage. Figure 7 shows the time characteristics of a three-phase voltage varying in frequency and voltage, obtained from the model shown in Figure 6.

Consider the start-up process of an asynchronous electric drive when the frequency and voltage change according to certain laws. The model of this mode shown in Figure 8. Figure 9 shows curves of the stator current I_{Sa}, I_{Sb}, I_{Sc}, speed and electromagnetic torque of the asynchronous motor at start-up in accordance with the parameters of the "Asynchronous Machine SI Units" block: 5 HP 460 V 60 Hz 1750 RPM. This model allows to study the following modes of operation of an asynchronous electric drive at start-up [7, 9, 15, 16]:
1. Frequency start of an asynchronous motor under different laws of frequency and voltage change.
2. Smooth start of the asynchronous motor at a fixed frequency and in various laws of change of the supply voltage (Figure 10).

Comparison with Figure 8 and Figure 10 shows the model in which the Ramp block performing the frequency change is replaced by the Constant block.

As a result, the engine is started at a fixed frequency, and the voltage change is carried out by the Ramp1 block. This allows the asynchronous motor to start smoothly. It should be noted that in the above modes, the influence of static torque is an important factor. Since the static torque on the motor shaft, according to expression (1), determines the laws of voltage and frequency changes, it is necessary to send a signal characterizing the static torque of the motor to the input "Tm" of the "SI blocks of an asynchronous machine" block.

Figure 11 shows the model of the start-up process of the asynchronous electric drive-in various laws of changing of static torque, for example, M_{S1}=const or M_{S2}=$A\sin(\omega t+\beta)$, where the input is switched to M_{S1} or M_{S2} using the "Manual Switch" block and changing the parameters of the static torque, the opportunity to perform investigation in various modes is created. Thus, the study of the process of starting an asynchronous electric drive with different laws of voltage, frequency and static torque changes is possible using the compiled model [6, 7, 8]. Using these models, it is possible to perform calculations and perform smooth start - up and regulation for various types of asynchronous motors presented in the SimPowerSystems section of the MATLAB platform.
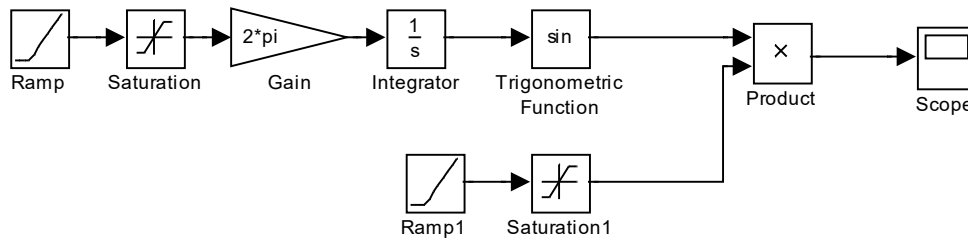

Figure 5. Model of the process of changing the frequency and voltage of the power source
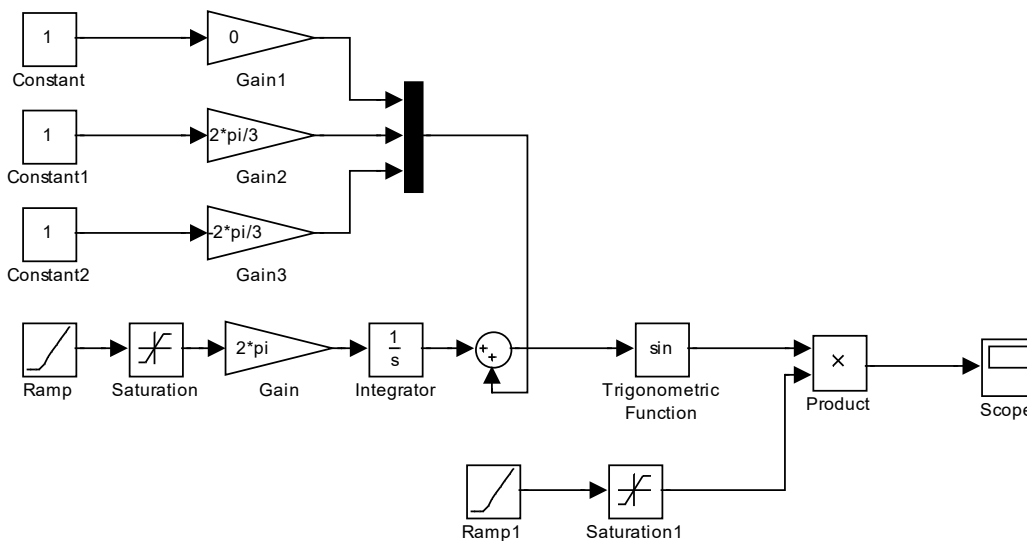

Figure 6. Model of the process of changing frequency and voltage using a three-phase power supply
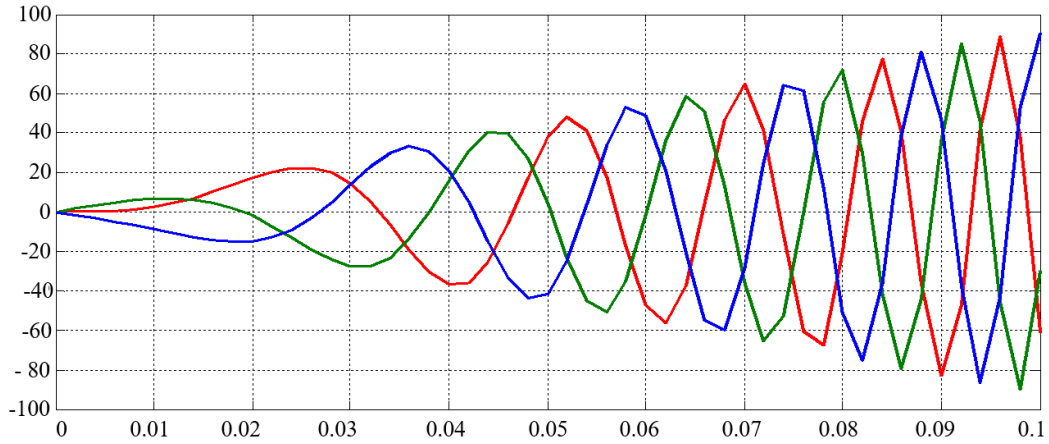
Figure 7. Time characteristics of three-phase voltage with frequency and voltage changes
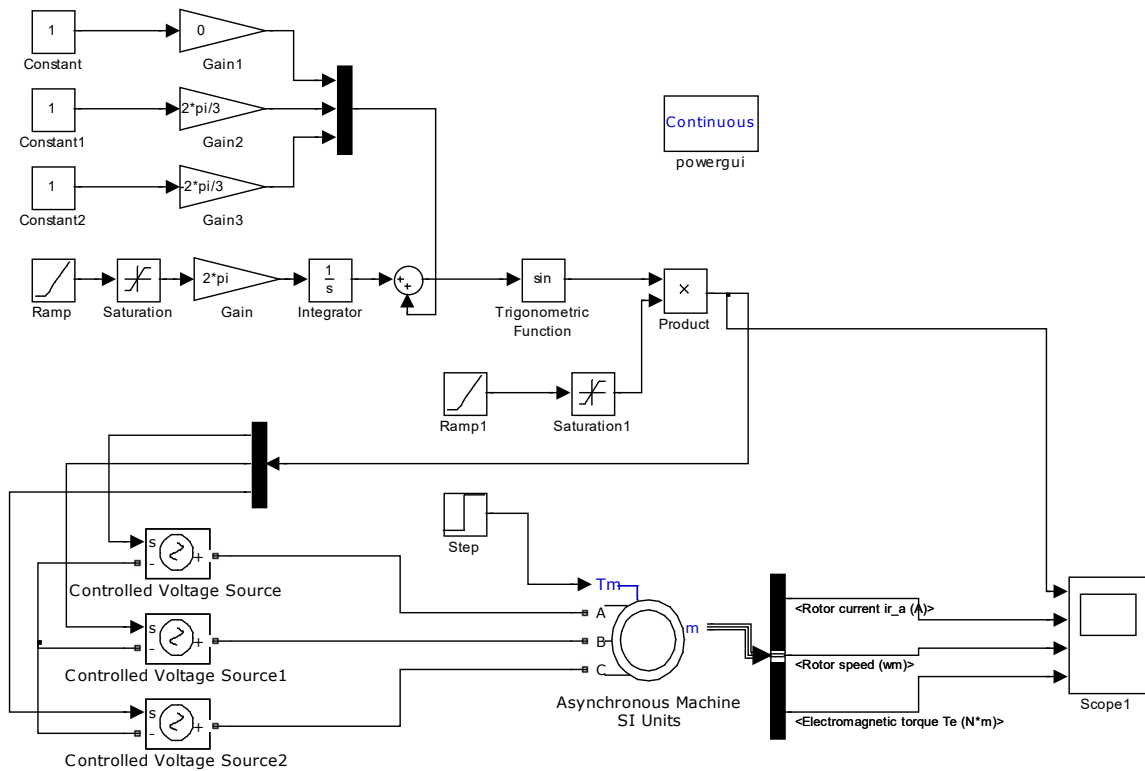

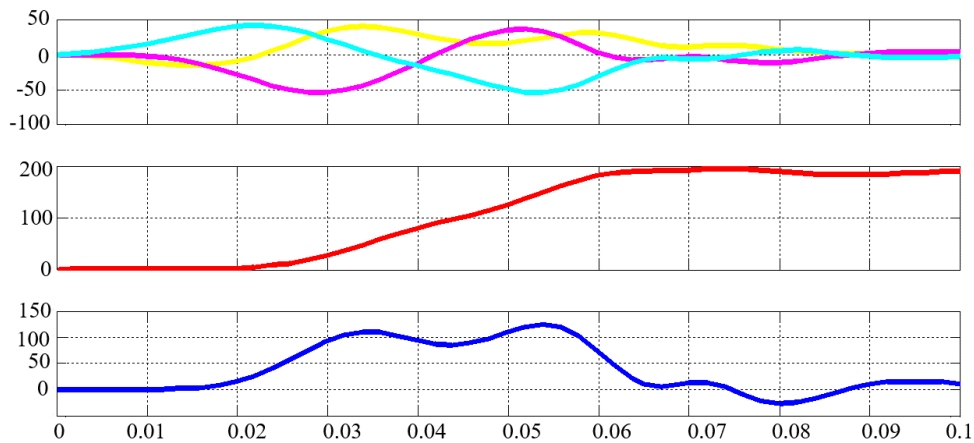Figure 8. Model of the starting process of an asynchronous motor

Figure 9. Time characteristics of the starting process of the asynchronous motor
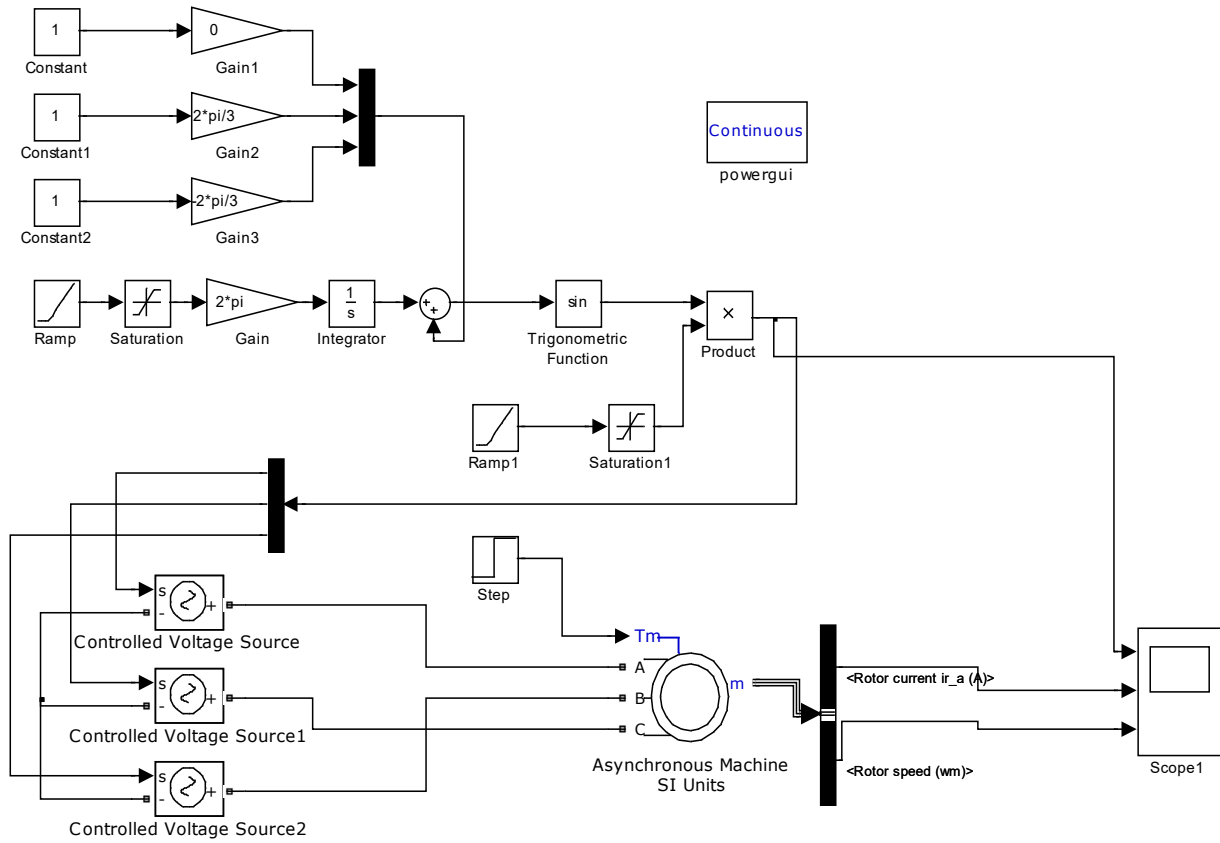
Figure 10. Simulink model of an asynchronous drive with a fixed frequency under different laws of voltage change
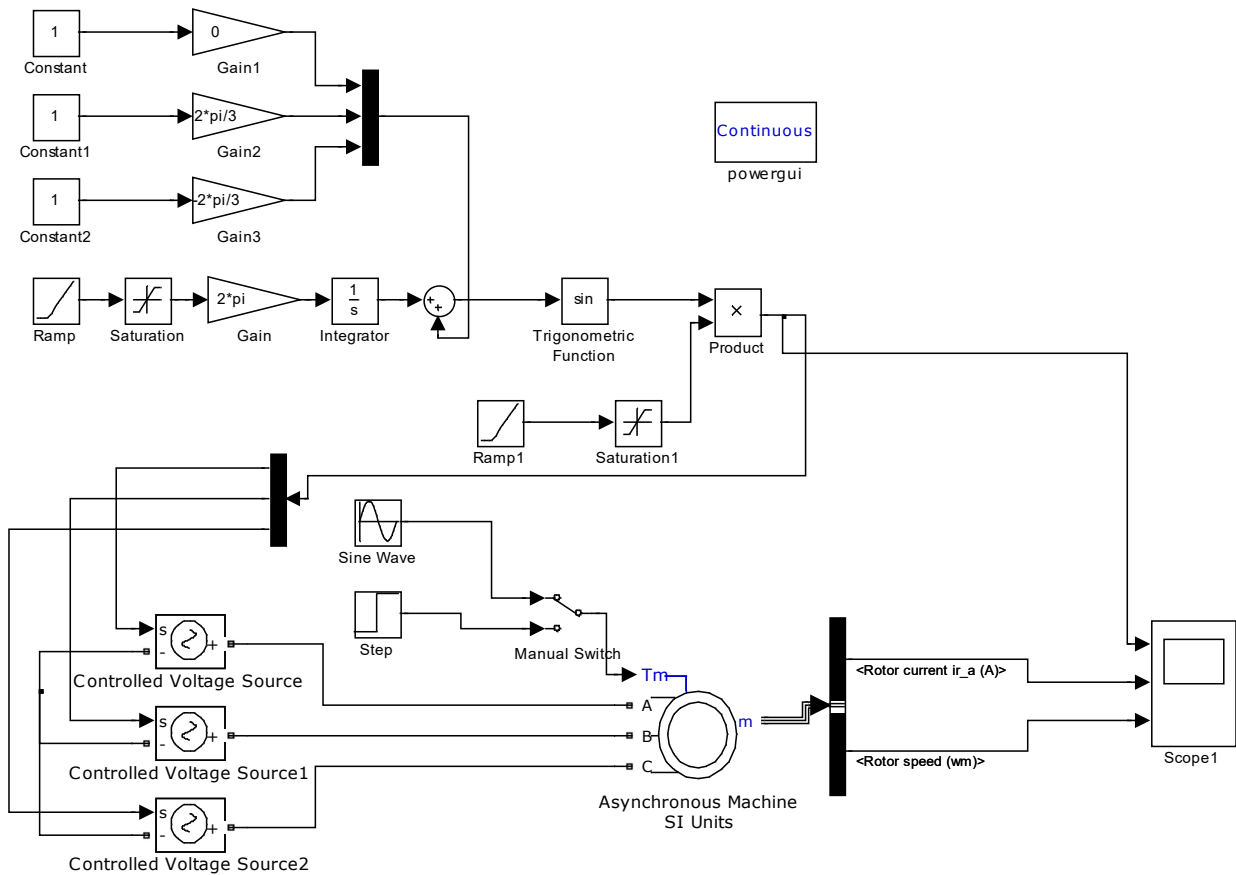

Figure 11. Modelling of an asynchronous drive with a fixed frequency in various laws of voltage change

5. CONCLUSION

1. In the MATLAB/Simulink/SimPowerSystems software package, an engine start model with a change in frequency value was developed, which took into account changes in frequency and voltage according to various laws.

2. A model has been developed that provides a study of the process of starting an asynchronous drive with different laws of voltage change at a fixed frequency. the process of the smooth start of asynchronous electric drives with different laws of voltage change at a constant frequency is implemented using the proposed models (Figure 11).

3. The article presents studies of models of an asynchronous motor with parameters 5 HP 460 V 60 Hz, 1750 RPM. The developed models make it possible to conduct research taking into account changes in the static torque for various motors, since the static torque on the motor shaft determines the laws of voltage and frequency changes. According to the obtained characteristics, it is possible to analyze the process of starting an asynchronous motor.

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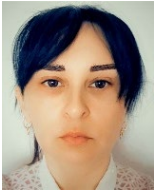<u>Master</u>: Electrical Engineering, Department of Electric Machines, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan, 1971
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