Speed Control of Induction Motor by using V/F Control Method in Matlab Simulink

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***Abstract*—** As the power supply which is available at the utility side is mostly AC supply. Therefore, the motors used in industries and in domestic appliances are Induction Motors. Hence researchers are attracted towards the speed control issues of Induction Motor. The speed control method of Induction Motor includes the variable stator voltage, variation in supply frequency, vector control, slip recovery and V/F control method. In this paper we are focusing only on the V/F control method, in this method we are maintaining the V/F ratio constant. The electrical areas which are mostly required to control Induction Motor are Control, Power Electronics, and Electrical Machines. Thus, by using Power Electronics devices such as MOSFET's or IGBT's we can easily control the speed of Induction Motor. This technique of speed control we are going to represent with help of MATLAB Simulation.

Keywords- SVPWM, VSI, V/F & Induction motor.

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I. INTRODUCTION

Electrical Energy has the contribution more than 40 % of all energy sources usage on Earth. In the upcoming years the percentage contribution of Electrical Energy will be increase. More utilization of Electrical Energy is to convert the Electrical Energy into Mechanical Energy via different kinds of electric motors like DC Motors, Induction Motors and Synchronous Motors. From the economic point of view Induction Motor are cheap compared to DC and Synchronous Motors. Induction Motors are most popular and widely used drives in industries as well as for domestic applications. It is very important to control the speed of induction motors in industrial and domestic applications. Speed control techniques of induction motors can be broadly classified into two types – scalar control and vector control. By using scalar control method we can control the magnitude of voltage or frequency of the induction motor.

To maintain torque of the motor closer to the rated torque at any frequency, the air gap flux, φag is maintained constant. Any change in the supply frequency i.e. reduction in supply frequency without changing the supply voltage will increase the air gap flux and the motor may go to saturation. This will increase the magnetizing current and increases the core losses and copper losses, due to which system becomes noisy. So to avoid these problems we are changing the supply voltage as well as supply frequency [3].

II. CONVENTIONAL METHODS OF SPEED CONTROL

1. Pole Changing
2. Variable Supply Frequency Control
3. Variable Supply Voltage Control
4. Variable Rotor Resistance Control
5. V/f Control
6. Slip Recovery
7. Vector Control

III. SELECTION OF V/F CONTROL METHOD

V/f Control method is mostly used rather than the other conventional methods of speed control, due to its ease of implementation and having various advantages as given below-

1. It provides wide range of speed.
2. It has low starting current requirement.
3. The acceleration can be controlled by controlling the rate of Change of supply frequency.
4. It is economical and easy to implement.
5. It gives good running and transient performance.
6. Voltage and frequencies reach rated values at base speed.

IV. SPEED CONTROL USING ELECTRONICS DEVICES

As we are using electronics devices for the speed control of Induction Motor first we have to convert the ac supply into dc supply by using rectifier and then fed to the inverter via the DC bus filter. Inverter circuit is having switching devices such as MOSFET or IGBT. The output of inverter is connected to the Induction Motor whose speed is to be control as shown in the figure 1.

The DC bus filter is used to take out the ripples from the dc supply which is coming out from the rectifier [1].

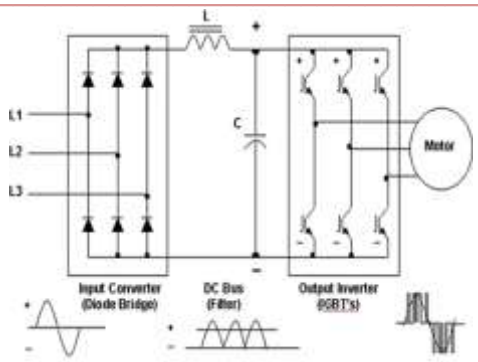

Figure 1.Block diagram of speed control drive

V. V/F CONTROL METHOD OF THREE-PHASE INDUCTION MOTOR

As the synchronous speed is denoted as;

$Ns = 120f/P$

Where f = supply frequency

P = number of poles

From this we say that supply frequency is directly proportional to the synchronous speed.

And the air gap voltage is related to φag and the frequency f as,

$$Eag = k1\ \Phi ag\ f$$

Input voltage, $Vs \approx k1\ \Phi ag\ f$

Or,

$$\Phi ag = constant \approx Vsf$$

Where k1 is a constant.

The torque developed by the motor is directly proportional to the magnetic field produced by the stator.

So the voltage applied to the stator is directly proportional to the product of stator flux and angular velocity. This makes the flux produced by the stator proportional to the ratio of applied voltage and frequency supply. By varying the voltage and frequency by the by the same ratio, flux and hence, the torque can be kept constant throughout the speed range. This makes constant V/F ratio the most common speed control of an induction motor [7].

Stator Voltage (V) α [Stator Flux (φ)]*[Angular Velocity (ω)]

$$V \alpha \varphi * 2\pi f$$

$$\Phi \alpha V/F$$

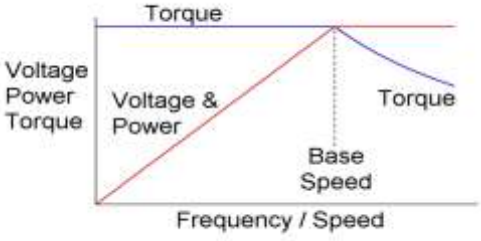

Figure 2. Torque – Speed characteristics

VI. SIMULATION MODEL OF V/F CONTROL METHOD

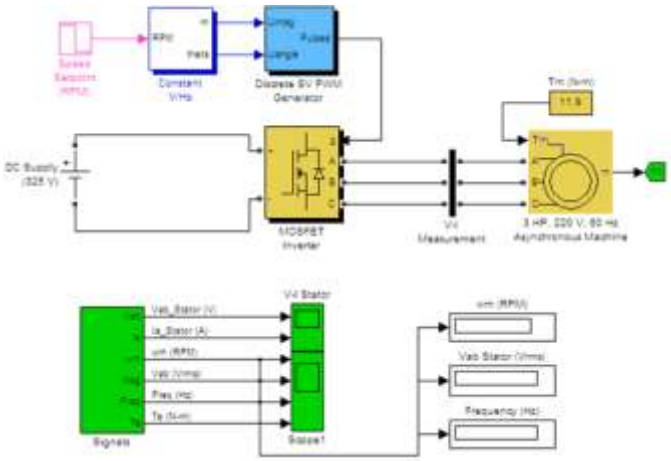

Figure 3. MATLAB Simulation Model

Speed control of the motor is performed by the "Constant V/Hz" block. The magnitude and frequency of the stator voltages are set based on the speed set-point. By varying the stator voltages magnitude in proportion with frequency, the stator flux is kept constant. The PWM inverter is built entirely with standard Simulink® blocks. Its output goes through Controlled Voltage Source blocks before being applied to the Asynchronous Machine block's stator windings. As the MOSFET is a voltage control device hence we used the MOSFET as a switching device in an inverter which is also called as Voltage Source Inverter.

VII. SIMULATION AND RESULT ANALYSIS

The change in speed of the motor can be shown in ωm block w.r.t change in voltage and frequency of supply to the stator. The corresponding waveforms can be shown in scope1. From the waveforms we can conclude that speed of the motor decreases with the corresponding decrease in voltage and frequency but at constant ratio and vice versa. The magnitude of voltage and phase angle changes according to the set-speed in constant V/Hz block. SVPWM generator generates pulses according to the output of constant V/Hz. These pulses required for the gate terminal of the MOSFET to get turn on means to switch into conduction mode [5].

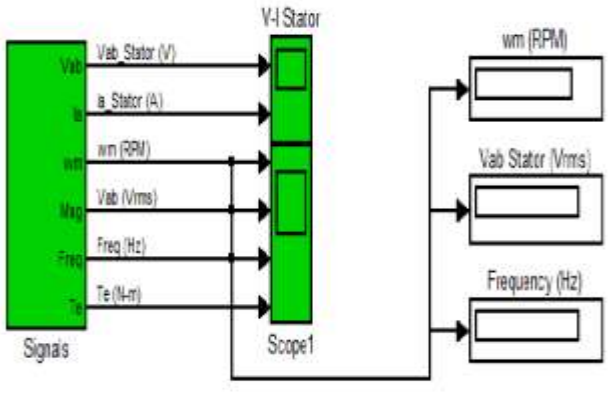

Figure 4. Schematic of scope and V-I stator

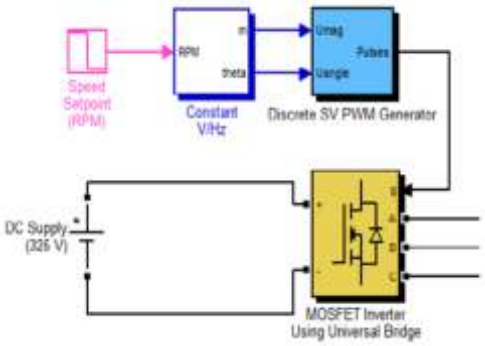

Figure 5. Connection of MOSFET and PWM Generator

From figure 6 we can see that results of the simulation based model this results clearly shows that as we need the change in voltage and frequency simultaneously to maintain the V/F ratio constant. Therefore the voltage and frequency is directly proportional to speed as voltage and frequency decreases the speed also decreases and vice versa. The relation between torque and voltage is that the torque is directly proportional to the square of voltage [3].

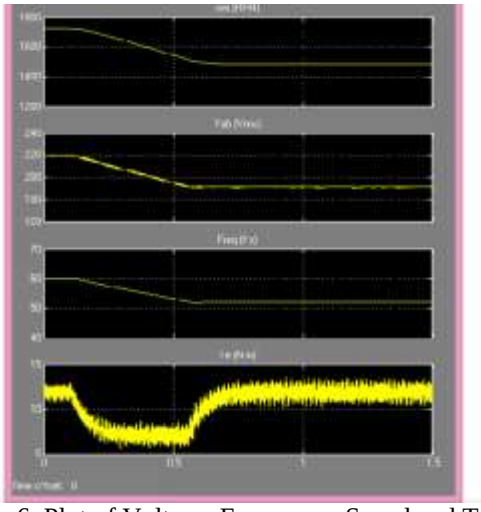

Figure 6. Plot of Voltage, Frequency, Speed and Torque

VIII. ADVANTAGES OF V/F CONTROLLER MODEL

1. Power electronics devices are less energy consumption devices as they work on less voltage and less current.
2. Speed control of motor can be easily achieved by using these devices (MOSFET, IGBT) as there is no presence of any heat dissipating device (resistor).
3. Controlling circuit is very compact as compare to the devices used in the conventional method and hence they take less space.
4. It is less costly to control the speed because the electronic components which we have used are less costly and easily available.

IX. DISADVANTAGES

As owing to the advantages of this project there is some disadvantages i.e. the power electronic devices work up to a specified power rating beyond this rating the device burns out and the other important disadvantage it injects the harmonics in the power system due to which supply voltage get distorted.

X. REMEDIES

Provide artificial cooling system and also take measures that current of electronics devices should not exceeds the permissible limit, so that after some intervals the readings must be taken to verify the limit. Filters must be used to reduce the distortion of voltage due to harmonics.

XI. FUTURE WORK

In future the main focus is on prevention of harmonics injected into the power system due to use of nonlinear Variable frequency drives also effective hardware can be constructed.

XII. CONCLUSION

In this paper we explained the V/F control method to control the speed of Induction Motors with the help of MATLAB Simulation. From this we can say that this method is reliable and efficient with negligible losses. As the magnetizing current remain constant by maintaining the V/F ratio constant with the help of V/Hz block so the variable speed drive with variable voltage and frequency control method will offer new low-cost solutions for commercial and industrial applications without change in the internal design of drive.

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