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Speed Control of Single-Phase Induction Motor using V/f Method

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Abstract:
There is different method of speed control of single phase induction motor and to control the speed of single phase induction motor generally using V/F control strategy. Out of the a number of methods of speed control of an induction such as pole changing, frequency variation, variable rotor resistance, variable stator voltage, constant V/f control, slip recovery method etc., the constant V/f speed control method is the majority generally used. In this method, the V/f ratio is kept constant which in turn maintains the magnetizing flux constant so that the maximum torque remains unchanged. Thus, the motor is totally utilized in this method. This paper include with hardware of V/f speed control of single-phase induction motor .The performance of the volt per hertz strategy were evaluated. In constant V/f control, by use PWM inverter, we can vary the supply voltage as well as the supply frequency such that the V/f ratio remains constant so that the flux remains constant too. So, we can get different operating zone for various speeds and torques and also we can get different synchronous speed with almost same maximum torque. Thus the motor is fully utilized and also we have a good variety of speed control. It is effortless, cost-effective to easier to design in open loop. But the drawbacks of open loop is it doesn't correct the change in output also it doesn't reach the steady state quickly.

I. INTRODUCTION

Induction motors are the most widely used motors for appliances, industrial control, and automation hence, they are often called the workhorse of the motion industry. They are robust, reliable, and durable. When power is supplied to an induction motor at the recommended specifications, it runs at iterated speed. However, many applications need variable speed operations. Historically, mechanical gear systems were used to obtain variable speed. Recently, electronic power and control systems have matured tallow these components to be used for motor control in place of mechanical gears. These electronics not only control the motor's speed, but can improve the motor's dynamic and steady state characteristics. In addition, electronics can reduce the system's average power consumption and noise generation of the motor. Induction motor control is complex due to its nonlinear characteristics. While there are different methods for control, Variable Voltage Variable Frequency or Volts/Hertz is the most common method of speed control in open loop. This method is most suitable for applications without position control requirements or the need for high accuracy of speed control.

II. V/f CONTROL THEORY

The induction motor draws the rated current and delivers the rated torque at the base speed. When the loads increased (over-rated load), while running at base speed, the speed drops and the slip increases. The motor can take up to 2.5 times the rated torque with around 20% drop in the speed. Any further increase of load on the shaft can stall the motor. 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 pro portional to the ratio of applied voltage and frequency of supply. By varying the frequency, the speed of the motor can be varied. Therefore, by varying the voltage and frequency by the same ratio, flux and hence, the torque can be kept constant throughout the speed range.

III. EQUATIONS-

Stator Voltage (V) =[Stator Flux (Φ)] x [Angular Velocity]

$$V = \Phi * 2\Pi f$$

Therefore, Stator Flux(Φ) = V/f

IV. SPEED- TORQUE CHARCTERISTICS WITH V/f CONTROL-

This makes constant Volts/ hertz the most common speed control of an induction motor. Figure shows the relation between the voltage and torque versus frequency. It demonstrates torque voltage and frequency being increased up to the base speed. At base speed, the voltage and frequency reach the rated values as listed in the nameplate. The motor can be driven beyond base speed by increasing the frequency further. However, the voltage applied cannot be increased beyond the rated voltage. Therefore, only the frequency can be increased, which results in the field weakening and the torque available being reduced. Above base speed, the factors governing torque become complex, since friction and wind age losses increase significantly at higher speeds. Hence, the torque curve becomes nonlinear with respect to speed or frequency.

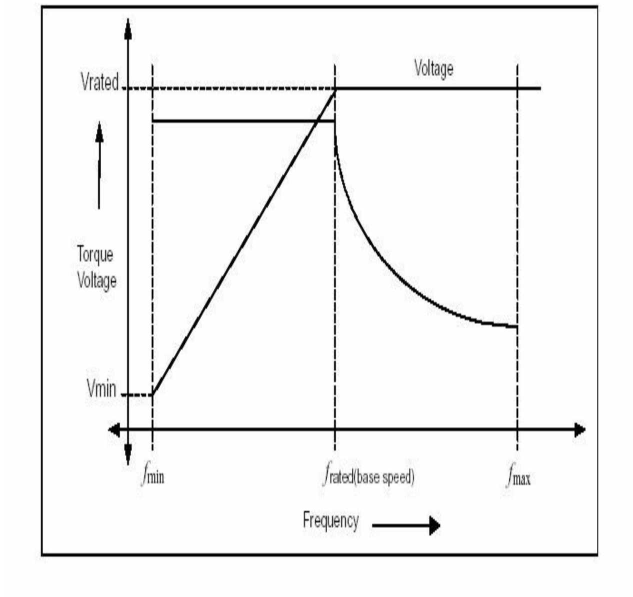

Figure.1. speed or frequency

V. WORKING OF HARDWARE MODEL-

Our circuit is speed controlling of induction motor using V/F. We are using one 8 bit microcontroller (PIC16F886) to drive lcd display & one mosfet to control speed of induction motor. Two different type of switch is using to control speed for up & down. First, we know about power supply. We are using 1 different type of power supply. One is 5V dc & another is 15V dc. Our microcontroller, lcd, op amp’s are operation on 5 v dc. 15v dc is using to drive mosfet gate voltage, which will control speed of induction motor. The 15V supply powers the LM358 dual op amp, IC1. One of these operational amplifiers, IC1a, is used to drive the gate of MOSFET Q1. This op amp is connected in a feedback control loop that monitors both a divided versionof the voltage between Q1’s drain and source and the voltage provided by speed potentiometer VR1b. Op amp adjusts its output voltage at the MOSFET gate so that the divided drain-source voltage across the MOSFET matches that set by the provided voltage by microcontroller. In more detail, a 220kΩ 1W resistor and a 5.1kΩ resistor form a voltage divider across Q1 (ignoring the series 1Ω resistor). This effectively reduces the voltage across Q1 to about 1/44 its original value, calculated as (5.1k + 220k) ÷ 5.1k. The resulting voltage is fltered with a 10µF capacitor providing a DC voltage from the full-wave rectified waveform. The resistive divider is there to produce a suitable low voltage for monitoring by IC1a. The maximum voltage needs to be several volts below the positive supply for IC1 at 15V. That’s because the op amp is designed to operate with inputs that can go down to the negative supply, but not as high as the positive supply. Maximum voltage from the divider occurs when Q1 is at a high resistance. Then the full 230VAC of the mains supply is across the MOSFET. The peak of the 230V RMS waveform is 325V and after reduction by a factor of 44, brings the voltage down to 7.39V peak. This becomes 4.7V DC after filtering with the 10µF capacitor. Note that this average voltage of the full-wave rectifed waveform is 0.63 of the waveform peak as the resistance of Q1 is decreased; there is more voltage across the fan motor and less across the MOSFET. The voltage from the divider is therefore also lower.

VI. LAYOUT OF THE HARDWARE MODEL-

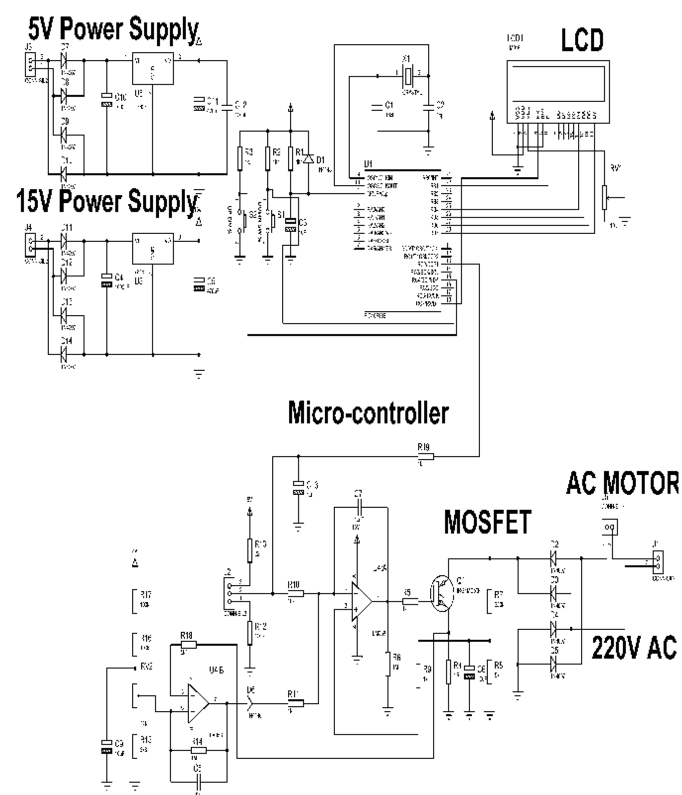

Figure.2.Layout of the Hardware Model

MICROCONTROLLER USED-

Figure.3. Microcontroller PIC16F886

HARDWARE MODEL-

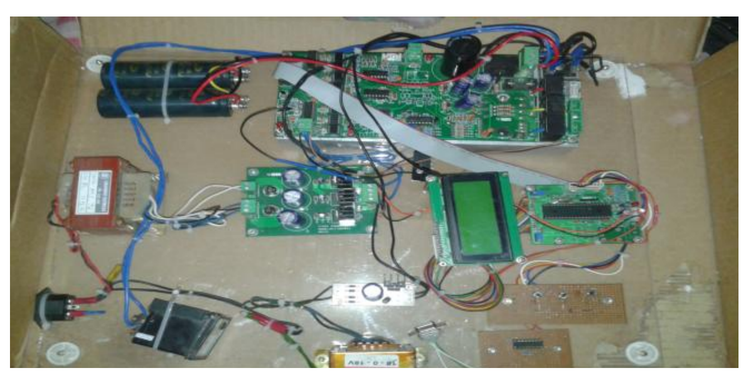

Figure.4.Hardware Model

VI. CONCLUSION-

In this paper the speed of three-phase induction motor is being controlled by varying supply voltage and frequency with constant (V/F) ratio. It is simple, economic to easier to design and implement in open loop. But the drawbacks of open loop is it doesn't correct the change in output also it doesn't reach the steady state quickly. These drawbacks can be overcome by modifying an open loop into a closed loop system. In this project only open loop was implemented in hardware. The project can be extended in future to control the speed of induction motor in closed loop.

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