SPEED CONTROL OF INDUCTION MOTOR USING PLC THROUGH VFD

UNDER THE GUIDANCE OF DR. D S BANKAR AND PROFESSOR SWAPNIL NAMEKAR

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Abstract: The paper is about speed control of three phase induction motor using PLC (programmable logic controller) through VFD (variable frequency drive). Basically, Programmable logic controller is used as a process controlling device which is mainly used by automation industries. The purpose of this paper is about controlling the output (Speed of three phase Induction motor) by changing the input of VFD using PLC and therefore as the outcome input of VFD will be changed and thus the speed of induction motor also changes accordingly. VFD is work is based on the principle of V/f method, where V stands for voltage & f stands for frequency while the flux remains constant.

Keywords: Programmable logic controller (NEXGINE), Variable frequency drive, V/f method, Induction motor.

1. INTRODUCTION

Many industries nowadays are using PLC automation process to decrease the cost of production & parallel increasing the quality and reliability of the process. Industries are attaining a new level only due to the advancement in the automation technology. Automation in the plants become a necessity for the survival of manufacturing industries manual controls are reducing day by day due to growth in industries.
This paper is about speed control of induction motor which has very vast application in industrial sector using PLC (programmable logic controller) and VFD(variable frequency drive).
VFD is chosen due to many advantage like energy saving , deduction in thermal & mechanical stress on drive and motor , during starting low starting current of motor , easy installation , low KVA rating with high power factor. Generally, VFD are required because many applications of induction motor do not require the same speed for all time due to production and surrounding circumstances. At the time of load changes, the RPM of the shaft should be changed.

Methods of Speed Control: -

- **Stator Voltage Control Method**

When the supply voltage is varied in the three-phase induction motor's speed can be varied. Torque is proportional to the square of input voltage (supply voltage) and slip is independent of the supply voltage at the time of maximum torque. This variation in input voltage does not affect the synchronous speed of motor.

- **Stator frequency control method.** This Method State that by varying the stator frequency speed of induction can also be varied. In order to decrease the speed of mother frequency has to be decreased.

If frequency is reducing while the voltage is constant. Then flux has to be increase due to this disadvantage this method is not used much widely.

- **Pole changing method.**

In squirrel cage induction motor, by changing the pole of the motor the speed can be changed. To change the no. Of pole, two or more than two stator winding will be used. They used to be in same slot as well as independent from other winding. Due to each winding will give a different number of pole that will help to vary the speed.
With more no. Of winding the switching arrangements will be complex & also result in increments in cost.
These all methods which are explained above have disadvantages due to that we are using. V/f method. For speed control of induction motor.

- **V/f method: -**

'V' referred as voltage & 'f' is referred as frequency for speed change operations, changes made in frequency by the supply voltage which is set in a inverter results in charge in speed of induction motor.

COMPONENTS USED IN PROJECT 1.1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

PLC is a type of digital computer. Which has been widely used by industries in various manufacturing process .PLC replace the conventional hard-wired relays, timer etc from industries sector.
In this application, we are using Mitsubishi electrical compact PLC which has ultra-fast CPU.

Table-1: PLC specifications

Number of I/O	**20 inputs,12 outputs**
Power supply voltage	24 V DC
Power supply inrush current	24 V DC,15 A for 20 ms
consumption	60 W

NEXGINE NG16DL has following features: -

1. Base variant options has digital input + analogue
   Inputs + HSC input (high speed counting)
2. Expandable up to 4 modules with 80 input /output
3. It contains. Visual access. window which contains-
4. Key for navigation.
5. 64 User programmable screens.
6. Password protected access.
7. Configuration analogue input option is available for
   Analog control
   (AI(0-10vdc)/DI(24vdc)-4I/P
   HSC(4hsc)/DI(24vdc) – 4I/P
8. Connectivity through 2Serial ports memory application: 128 kB , data 28kb
   Port1: RS 232/RS485/modern connectivity
   Port2: RS 232/RS485/modern connectivity
9. Real time operation control.
10. Integrated with a consolidated storage Space. Storage of complete project in real time as well as comments on CPU.
    Storage of complete project in real time as well as comments on CPU. Storage of complete project in real time as well as comments on CPU. On external cassette an alternate project backup is present.

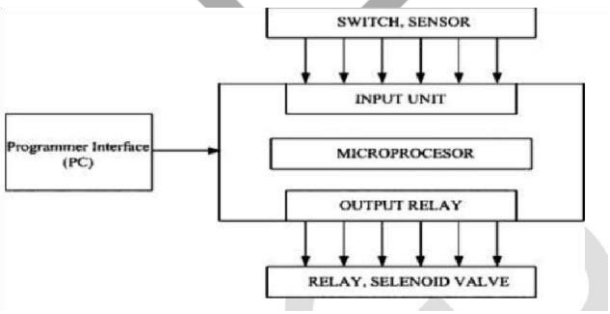


Figure no.2: Block diagram of PLC

1.2 VFD AND ITS WORKING

VFD exemplifies as variable frequency drive. Other names of the VFD are Variable Speed Drive, Adjustable Frequency Drive or Inverter Drive. But they all are referring to the same device. They are used to run AC motors at variable speed or it also helps in smooth starting by ramping their speed. They adjust their speed by tuning the frequency which in turn changes the RPM of the Induction Motor. The VFD works in three stages, first one being the Converter section, then comes the filtering stage or DC Bus and at last we have the Inverter section. It works by changing the voltages twice in the circuit. First, the three phase AC voltage is being converted to DC with the help of a diode. After this the cleansing of this DC voltage takes place with the help of capacitor

filter. After this again our DC voltage is converted back to AC voltage by using the transistors acting as switches. Transistors are a kind of switch which helps in turning the voltage ON and OFF by changing the switching Firing angle. All this is achieved by keeping the frequency as desired value. According to the formula 120f/p the Speed of the Induction Motor is directly proportional to the frequency. This desired vale is obtained with the calculation done for frequency as per the required speed value. For full speed characteristics we need to give the 50Hz value, but if we need only half the speed then in that case we will provide the circuit with only 25Hz frequency and apparently we will be able to vary the according to the required speed.

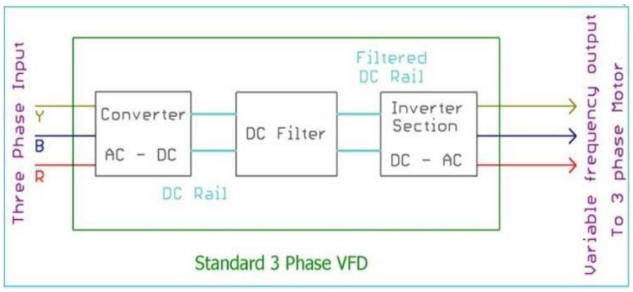
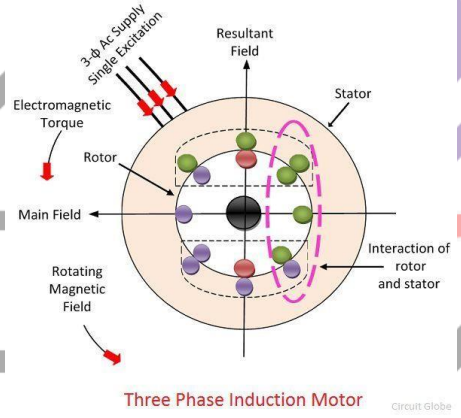


Figure 3. Variable Frequency Drive

1.3 INDUCTION MOTOR

Induction Motor is a kind of rotating transformer. Induction Motor consists of two parts which are Stator and Rotor. Here the stator is given AC supply to produce Magnetic flux in the Rotor due to which the EMF is generated. Now due the interaction Magnetic flux due to the EMF and the magnetic flux due to the three Phase supply interacts and hence the motor moves . And It is a very rugged device i.e. it requires less maintenance. And it is also a very cheaper and most efficient motor used. Here the specification of the Induction Motor to be controlled as as follows: 3 Phase,415 V,1100 RPM, 0.5 HP, 4.8 A. Formula for speed for induction motor is 120f/p. Hence we will use this method to change the speed of Induction Motor.



1.4 HUMAN MACHINE INTERFACE

Human Machine Interface is the touchpoint between the human and the machine. The operators use this as a device to monitor and coordinate the industrial processes in the plant. This is used to maintain a constant flow of the inputs fed in and the output of the plant regarding generating the end product. It is the interface that shows real-time information by integrating the machinery inputs. The internal processing and computation can then be seen on the HMI monitor. There is a series of monitor and HMI software solution that can be programmed to be used with every component. Hence here we are using a 4 inch HMI which will be communicating through RS232 communication protocol.

1.5 ENERGY METER

The Energy Meter is an Instrument which is used for Measuring the energy utilises by the electric load is known by the name Energy Meter. The energy is termed as the total power consumed and utilised by the load in between a particular interval of time. It is used in different circuits for measuring the power. Meter is less expensive and accurate.

2. EXPRIMENTAL WORK

A. Experimental setup

In this project, we are using three phase supply which is connect to three single phase MCB (miniature circuit breaker) which are connected to different-different devices. One single phase supply is given to the SMPS (Switch Mode Power System) which is connected to PLC for the supply. PLC is connected to the HMI (Human Machine Interface) by RS-232 communication system. PLC is connected to the Analog Module which is further connected to the VFD. While the PLC is also connected to the Energy

Meter via RS-485 communication system. The VFD receives the power from the three single phase power supply after that Contactor is connected between Induction Motor and variable frequency drive.

ACTUAL MECHANISM OF THE PROJECT

For the working of this project, first we need to understand the principle on which this project is working When there is a Variation in input supply frequency leads to change in speed. As getting their Product of flux and supply frequency is directly proportional to the induced stator voltage.

Emf is induced by 3 phase induction motor through the faraday's law (induction) is similar to the transformer equation given that

$$E \text{ or } V = 4.44 \phi K.T.f$$

Here from the above equation when Stator voltage drop consider zero then

$E \approx V$ $V \alpha f \phi$ whereas K is winding constant with T and f are the number of turns per phase and frequency.

When we changing the frequency, it's synchronous speed changes but with decrease in frequency, it's flux will increase and Due to changing in the change in value of flux causes saturation of rotor and stator cores which will further cause increase in no load current of the induction motor .So in this process it is necessary to maintain the flux ϕ constant with respect to the change in the voltage simultaneously .If we decrease the frequency ,the flux will increases but at the same time if we decrease the voltage ,the flux will also decrease causing no change in flux and hence it remains constant. So, here we are keeping the ratio of V/f as constant and this is called V/ f method.

When we are supplying variable voltage and frequency the speed of motor will varies, for controlling the speed of induction motor we will use V/f ratio method.

In this Equation

$$T \alpha V/f;$$

for constant V/f ratio a constant torque can be Obtained.

$$Ns = 120f/p$$

From above relation the 3-phase induction motor speed will be changed by varying the frequency because poles are integral and cannot contribute in speed control. By defining all terms, we can say that V/f ratio torque developed is constant in entire operation. We are focused on the V/f method for this project.

By giving the input to the PLC with the help of numerous devices like Foot switch, Limit switch etc and PLC reads that input shows the readings by the help of HMI (Human Machine Interface) through RS232 communication protocol. The output of the PLC is connected to the Analog Module which is used to convert digital signals into analog signals because VFD cannot read the digital signals. Apart from this Energy Meter is connected to both PLC & VFD. Here the Energy meter is multifunctional device configurable with the password which is used to measure the Power factor, VA/VAh rating, VAR/VARh rating. The VFD which is receiving the power supply from three single phase MCB which are connected at different-different positions and PLC output, which is received through Analog Module. Now with the help of input signals from PLC the V/f ratio will be changed by the help of VFD. Through this whole process change in speed of Induction Motor is achieved & can be monitored on Real Time basis.

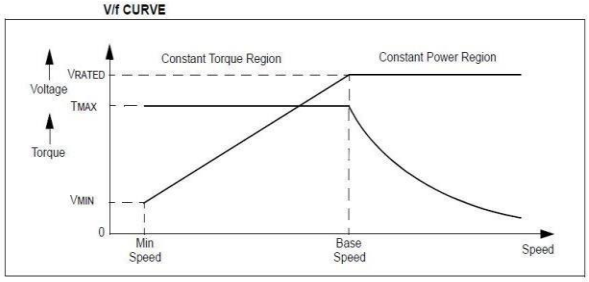


Figure no.4: Torque –speed characteristics with V/f control

Figure no.5: Picture of complete setup

Power supply is used in this experiment which is cost effective and smallest which provides powerful speed control.

Motor rating (max)	1.5kW/0.75kW
Output	3 phase,0-480V 0-400Hz
AC voltage range (Input)	3 phase ,380-480V 50/60Hz
Current Input	4.3A/3.2A
Current Output	4.1A/3.4A

Table -2: VFD specifications used in experiment

KW	0.37(0.5 HP)
RPM	2820
Frequency	50±5%
Voltage	415±10%
Ambient temperature	50˚C
Ampere	1.1
Efficiency	88.6%

Table-3: Motor specifications

Input supply frequency in Hz	**Motor speed in RPM**
15	900
25	1410
30	1750
45	2500

Table-4: Motor output at different Frequency

3. CONCLUSION

In this project we are concluding that speed of induction motor is measured using tachometer and easy to control through variable frequency drive and plc. We are enhancing the power quality, power factor improvement, saving energy with the help of variable frequency drive. In this project we are using various component (input module, contractor, etc) for controlling the system. this project we are also saving the energy from VFD and protecting the induction motor from the transients currents and short circuit faults through protecting devices like (contractor, MCB) if occurrence of spike in voltage or fluctuation in voltage continuously. the purpose of this project is use to control the speed of induction motor, reducing the cost of production, saving energy and increase the power factor of the system.

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