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RESEARCH ARTICLE

Speed Control of Induction Motor using Plc Through VFD

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ABSTRACT

How to regulate the speed of a three-phase induction motor using a PLC (programmable logic controller) and a variable frequency drive (VFD) is discussed in this article (variable frequency drive). As a result, programmable logic controllers (PLCs) are primarily used in the automation sector as process control devices, and as a result, they are highly popular. PLCs are also used in a variety of other industries. In this article, we will illustrate how to control the output (the speed of a three-phase induction motor) by changing the input of a variable frequency drive (VFD) using a programmable logic controller (PLC). As a consequence, the VFD's input will vary, and as a result, the speed of the induction motor will change in accordance with that change. When it comes to the VFD, it's based on the V/f approach, which refers to a system in which voltage represents voltage and frequency represents frequency, with the flux being constant throughout the process

Keywords

Programmable logic controller, Variable frequency drive, V/f method, Induction motor.

Introduction

In order to minimize production costs while simultaneously improving the effectiveness and dependability of their industrial operations, an increasing number of organizations are using PLC automation technology. Manufacturers have only lately been able to attain a new level of success in their operations as a result of the evolution of automation technology, which is a direct consequence of the advancement of automation technology. As a result of the company's development and expansion, a number of technologies are being used to reduce the need for human engagement in the company's operations.

Please consult the section below for further information about induction motors. Induction motors are frequently used in industrial applications, and they may be controlled by a number of devices, including PLCs (programmable logic controllers) and variable frequency drives (VFDs). The use of induction motors, which are

controlled by process control systems (PLCs) and variable frequency drives (VFDs), may be found in a wide range of industrial applications, including the following: (variable frequency drive). (S. R. Venupriya, 2015)
Not only does this system save energy, but it also helps to minimize the heat and mechanical stress placed on the motor and drive system during operation, which is a key advantage of implementing such a design. This motor features a number of advantageous characteristics, including low starting current and simplicity of installation, as well as a low KVA rating and a good power factor, among other characteristics. Variable frequency drives (VFDs) are often employed in induction motor applications where the speed of the motor does not need to be maintained at a consistent level at all times. Various industrial applications for these drives exist, and they are employed in a number of diverse circumstances in addition to those listed above. A variety of induction motor applications that operate at variable speeds are possible, and this is primarily due to the fact that both the manufacturing process and the surrounding environment can have an impact on the performance of the motor. Induction motor applications that operate at variable speeds include: Those induction motor applications that run at varying speeds are also referred to as "variable speed induction motor applications." In addition to the uses listed above, as shown by the data provided above, variable frequency drives are needed in a wide range of other applications as well (VFDs). Because of this, any variation in the load given to the shaft must be regarded as a consequence of any variation in the rotational speed of the shaft, and any variation in the rotational speed of the shaft must be considered as a consequence of any variation in the load applied to the shaft. In order to do this, it is necessary to put a variable-speed drive on the machine's main shaft. (Hugh Jack, 2005)

Materials and methods

A. Stator Voltage Control Method

Induction motors operate at different speeds depending on how much power is supplied to them by the power grid. When the maximum torque is reached, torque is proportional to the square of the input voltage (supply voltage), and slip is independent of the supply voltage at that moment. Because of this difference in input voltage, the synchronous speed of the motor is not affected at all

B. Stator frequency control method.

As stated in this method, the speed of induction may be changed by adjusting the frequency of the stator. It is necessary to slow down the frequency of the mother in order to reduce her pace. For example, if the frequency is decreasing but the voltage remains constant, then the flow must be increased, which is a problem that stops this technology from being used more often.

B-1- Pole changing method

By adjusting the pole design of a squirrel cage induction motor, it is possible to change the speed of the motor. It will be necessary to use two or more than two stator windings in order to adjust the number of poles in the system. They used to be located in the same slot as the other windings, but they were also completely independent of one another at the time. This will assist in the modification of the speed since each winding will create a different number of poles from the previous one.

As the number of windings rises, the switching arrangements become more difficult, resulting in an increase in cost as a consequence.

Every one of the tactics that have been examined so far has disadvantages as a consequence of the fact that we are using them. It is necessary to use the V/f approach. To control the speed of an induction motor, a speed regulator is used.

B-2- **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. (Yasar Birbir, 2008)

Components Used in Project 1.1 Programmable Logic Controller (Plc)

A PLC is a sort of digital computer that operates on a digital signal. Which has been extensively employed by companies in a broad range of production processes for many years. PLCs are replacing hard-wired relays, timers, and other similar devices in the industrial sector. In this application, we are using a Mitsubishi electrical small PLC with an ultra-fast central processing unit (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

VFD and its working

The variable frequency drive (VFD) is an example of this kind of technology. In addition to variable speed drives, adjustable frequency drives (AFDs) and inverter drives are also used to describe these devices (Inverter Drives). The fact is that they are all referring to the same piece of machinery. They are used to drive alternating current motors at a variable speed, and they also help in the smooth start-up of the motor by gradually increasing the speed of the motor. They may change their rotational speed by modifying the frequency of the Induction Motor, which in turn changes the rotating speed of the Induction Motor (RPM). Each step of the VFD's operation is divided into three parts: the Converter section, the Filtering stage, or DC Bus, and the Inverter segment. The Converter section is the first of these three parts, and it is the first of these three parts. As soon as the circuit is turned on, the voltages in the circuit are modified twice. A diode is used to convert the three-phase alternating current voltage to direct current (DC) before it is used in the next step. In order to clean up the direct current voltage that has come from this procedure, capacitor filters are utilised. In the next step, our direct current voltage is converted back to an alternating current voltage with the help of transistors acting as switches. In electronic circuits, transistors are a kind of switch that assists in the switching of voltage on and off by altering its firing angle throughout the switching process. It's possible to do all of this by keeping the frequency at an optimum level. The speed of an induction motor is perfectly proportional to the frequency of operation, according to the formula 120f/p. This desired value is obtained by completing a frequency calculation in accordance with the required speed value and then recording the results of the computation. While the circuit must be constructed to have entire speed characteristics, it is possible to build the circuit to have just half of the required speed characteristics. The circuit will be offered with a 25Hz frequency in this case, and we will be able to alter the frequency to fit the required speed characteristics. (Dorjee, 2014)

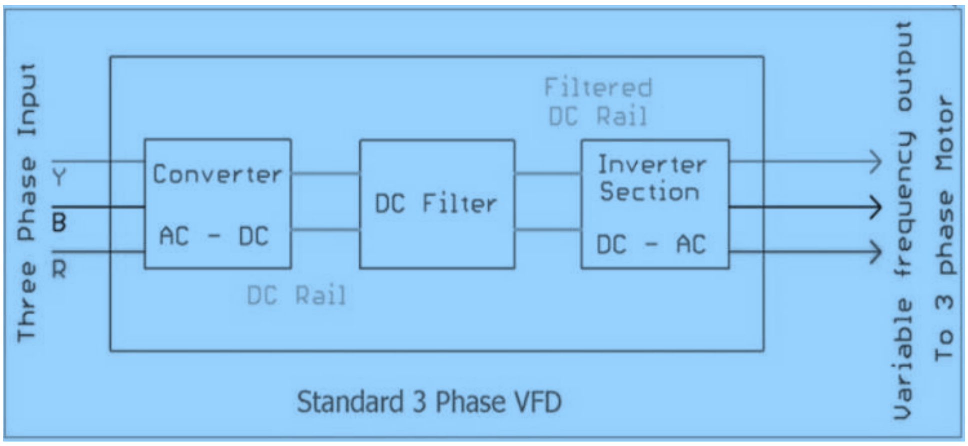

Figure 1 Variable Frequency Drive

Induction motor

It is a kind of spinning transformer that is used in induction motors. The Stator and Rotor of an induction motor are the two major components of the motor. The stator is supplied with alternating current in order to create magnetic flux in the rotor, which results in the generation of EMF. Now, as a result of the interaction between the magnetic flux caused by the EMF and the magnetic flux caused by the three-phase supply, the motor moves. Furthermore, it is a highly durable gadget, which means that it needs less maintenance. Furthermore, it is the most cost-effective and energy-efficient motor available. The following is the specification of the

Induction Motor that will be regulated in this case: 3 phase, 415 volts, 1100 revolutions per minute, 0.5 horsepower, 4.8 amps the speed of an induction motor may be calculated using the formula 120f/p. As a result, we shall use this strategy to alter the speed of the Induction Motor. (S. R. Venupriya, 2015)

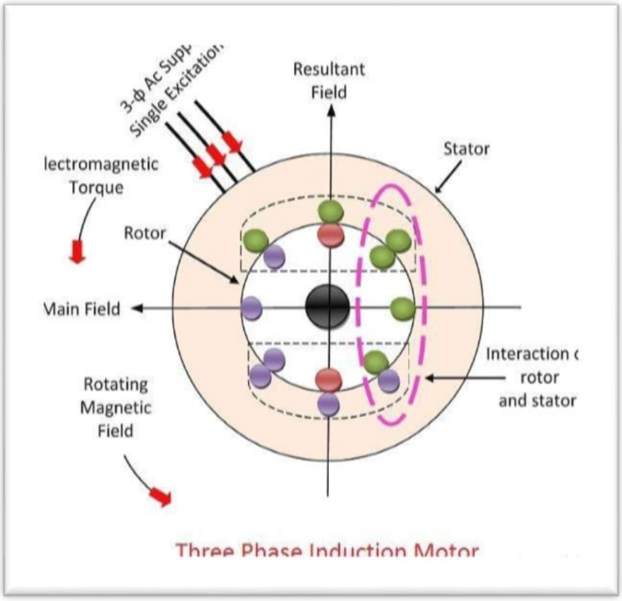

Figure 2 Three Phase Induction Motor

Human machine interface

This interface serves as the point of contact between a person and an electronic device. This is a gadget that the plant's operators use to monitor and coordinate the many industrial operations that take place there. This is used to maintain a continuous flow of inputs into the plant as well as the output of the plant in terms of manufacturing the finished goods. Because the inputs from the equipment are integrated, it is the interface that displays real-time information. The results of the internal processing and calculations are shown on the HMI monitor. There are a variety of monitors and human-machine interface (HMI) software solutions available that may be customized to work with each component. As a result, we are using a 4-inch graphical user interface (GUI) that will communicate using the RS232 communication protocol. (Dorjee, 2014)

Kilowatt-hours per person

This instrument, which is used for measuring the amount of energy used by an electric load, is referred to as the "energy meter" in the industry. When referring to energy, it is defined as the entire amount of power used and utilized by the load within a certain period of time. It is used in a variety of circuits for the purpose of power measurement. The meter is less costly and more precise.

Experimental work

Experimental setup

Throughout this project, we will be utilizing a three-phase power supply that will be linked to three single phase MCBs (miniature circuit breakers) that will be connected to three separate devices. A single phase supply is provided to the SMPS (Switch Mode Power System), which is linked to the PLC for the purpose of supplying power to the system. Through the use of an RS-232 communication system, the PLC communicates with the HMI (Human Machine Interface). The PLC is linked to the Analog Module, which is in turn connected to the variable frequency drive (VFD). However, the PLC is also in contact with the Energy Meter, which is done using the RS-485 communication standard. It is necessary to connect a contactor between the induction motor and the variable frequency drive after the VFD gets electricity from a three-phase single-phase power source.

The actual methodology of the project

In order for this project to function properly, we must first comprehend the underlying idea on which it is based. When there is a change in the frequency of the input supply, there is a change in the speed. As a result of obtaining their Product of flux and supply frequency, the induced stator voltage is exactly proportional to the product.

Due to the fact that E or V =4.44 KT.f is induced by a three phase induction motor by means of Faraday's law (induction), the electromagnetic field produced by the motor is identical to the transformer equation. When the Stator voltage drop is considered to be zero, the following equation is obtained: EV V f, where K is the winding constant and T and f are the number of turns per phase and frequency, respectively.

When we vary the frequency, the synchronous speed varies, but when we reduce the frequency, the flux increases and the synchronous speed decreases. Increased no-load current is caused by rotor and stator core saturation as a result of the change in flux value. This means that the flux must be maintained constant in relation to voltage changes at the same time throughout this procedure. If we reduce the frequency, the flux will rise; but, if we reduce the voltage, the flux will fall as well, resulting in no change in flux and, as a result, it stays constant. The V/f approach is named as such because we are maintaining a constant ratio of V/f in this situation.

Induction motors have a changeable speed when they are supplied with variable voltage and frequency; thus, we will utilize the V/f ratio approach to regulate their speed when this is the case.

With this equation, T = V/f, it is possible to get a constant torque for a constant V/f ratio.

$$N_s=120f/p$$

Because the poles are integral and cannot contribute to speed control, adjusting the frequency will result in a change in the speed of a three-phase induction motor, according to the preceding relationship. We may conclude from the definition of these words that the V/f ratio torque created remains constant during the operation. For this study, we are primarily concerned with the V/f technique.

Various devices such as foot switches, limit switches, and other similar devices provide input to the PLC, and the PLC receives that input and displays the results with the assistance of an HMI (Human Machine Interface) that communicates with the PLC using the RS232 communication protocol. In this case, the PLC's output is linked to the Analog Module, which is responsible for converting digital signals to analogue signals since the VFD is unable to read digital information. Aside from that, the Energy Meter is linked to both the PLC and the VFD. It is used to measure the Power factor, VA/VAh rating, and VAR/VARh rating. The Energy metre is a versatile device that may be configured with a password. The VFD, which receives power from three single phase MCBs that are connected at different-different places, as well as the PLC output, which is received via the Analog Module, are both controlled by the PLC. It will now be possible to modify the V/f ratio with the use of input signals from the PLC and a variable frequency drive (VFD). The change in speed of the Induction Motor is accomplished over the course of this procedure, which may be watched in real time. (Hugh Jack, 2005)

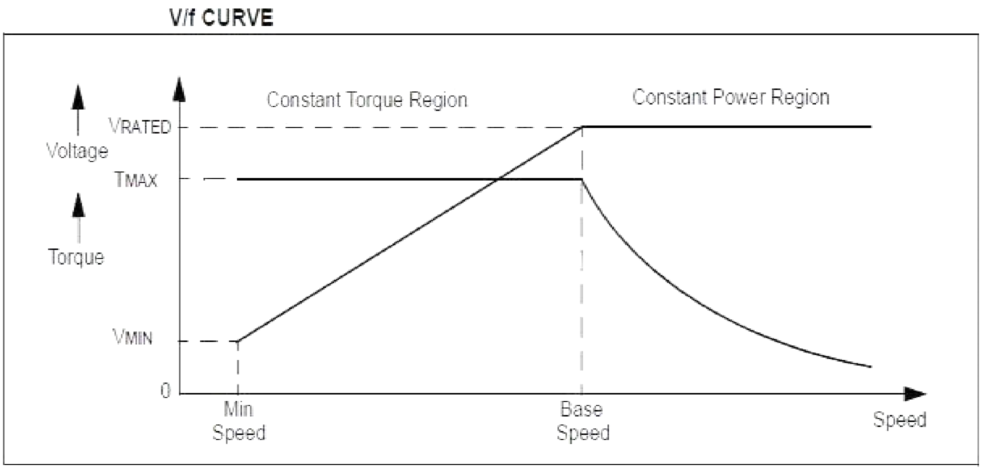

Figure 3 Torque –speed characteristics with V/f control

Figure 4 Picture of complete setup

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

Table -2: VFD specifications used in experiment

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-3: Motor specifications

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-4: Motor output at different Frequency

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

Conclusion

The conclusion reached in this research is that a tachometer can be used to monitor the speed of an induction motor and that a variable frequency drive and a PLC can be used to control the speed of an induction motor. Thanks to the help of variable frequency drives, power quality is being enhanced, power factor is being improved, and energy is being conserved in the process (VFD). We are using a variety of various components for the goal of controlling the system (input module, contractor, and so on). Additionally, we are saving energy through the use of a variable frequency drive (VFD) and safeguarding the induction motor from transient currents and short circuit faults through the use of protective devices such as (contractor, MCB) in the event that there is an uninterruptible spike in voltage or a fluctuation in voltage that occurs continuously in this project. Managing the speed of an induction motor is the purpose of this project, which aims to minimize the cost of manufacturing, conserve energy, and enhance the power factor of the system.

References

[1]S. R. Venupriya, K .P. Thanusre, P. Saranya, "A Novel Method Of Induction Motor Speed Control Using PLC", International Journal for Research in Applied Science & Engineering Technology (IJRASET), 2015

[2]Yasar Birbir, H.Selcuk Nogay, "Design and Implementation of PLC-Based Monitoring Control System for Three-Phase Induction Motors Fed by PWM Inverter", international journal of systems applications, engineering &development, 2008

[3]Ali Gulabi," Development of an Embedded SCADA System with PLC and Java Application for Synchronous Operation of Standard Servo Drives", Master thesis, Faculty of Engineering and Computer Science of the University of Applied Sciences Hamburg, May 2007

[4]Hugh Jack, "automating manufacturing systems with PLCs", April 2005

[5]Rinchen Geongmit Dorjee, "Monitoring and Control of a Variable Frequency Drive Using PLC and SCADA", International Journal on Recent and Innovation Trends in Computing

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