INTELLEGENT SPEED CONTROL WITH VARIABLE FREQUENCY DRIVE

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ABSTRACT:

In general, all the industries require motors for their applications in specified area of domain for doing the mechanical work with different speed from minimum to maximum speed. Due its simple construction and low cost, among the different types of motors, 90% of motors are induction motors. The speed control of induction motor is controlled by various techniques including the constant v/f method. In the v/f method of speed control technique, the flux is maintained as constant. The frequency of the induction motor varied with input supply voltage using the variable frequency drive. By implementing the proposed new technique the start/stop, Jog operations are obtained in Forward/Reverse directions accurately using the buttons on the VFD, Remote control buttons and computer connected with the Programmed Logic Controller.

1. INTRODUCTION

An electrical motor is an electromechanical device that converts electrical energy into mechanical energy. In the case of 3-phase AC operation, the most-widely-used motor is the 3 Phase Induction Motor as this type of motor does not require any starting device, being a self-starting motor.

1.1 AC Induction Motor

An AC induction motor is constructed with a rotor that has windings which intersect the rotating magnetic field generated by the stator windings.

At full load speed, the rotor turns slightly slower than the synchronous speed of the motor. This is because the magnetic field causes currents to flow in the rotor windings and produces a torque which turns the rotor; so if the rotor turns at the same speed as the magnetic field, there would be no relative motion between the rotor and the magnetic field, and no torque would be produced.

The amount of speed by which the rotor lags the rotating magnetic field is known as the slip of the motor. The higher the slip, the more torque is produced by the motor. The following diagram shows the torque-speed relationship of a typical induction motor.

The speed at which the magnetic field rotates depends on the number of poles or coils distributed around the stator and the frequency of the supply current. This is called the synchronous speed.

Synchronous Speed = 120 x Frequency / Number of poles

Typical AC induction motor speeds are 3600, 1800, 1200, and 900 RPM.

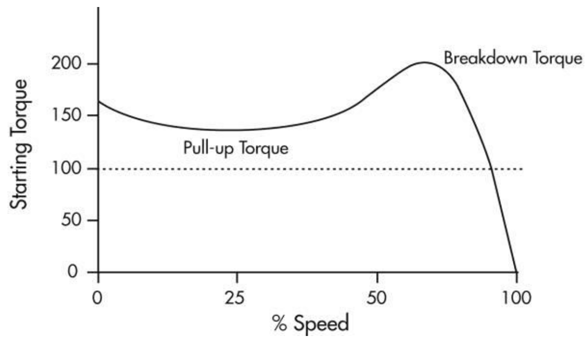

Figure 1: Torque-speed Curve of an Induction Motor

1.2 Squirrel Cage AC Induction Motors

Most AC induction motors are squirrel cage motors. The rotor windings in a squirrel cage motor are aluminum or copper alloy bars that are positioned along the direction of the shaft and short circuited by end rings as shown in the following diagram

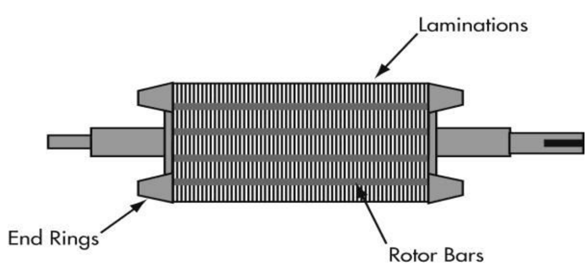

Figure 2: Diagram of a squirrel cage rotor

The shape of the bars and the resistance of the alloy used in their construction influences the torque-speed characteristics of the motor.

1.3 Pulse Width Modulated VariableFrequency Drive

When operated from constant frequency power source (typically 50Hz), AC induction motors are fixed speed devices. A variable frequency drive controls the speed of an AC motor by varying the frequency supplied to the motor. The drive also regulates the output voltage in proportion to the output frequency to provide a relatively constant ratio of voltage to frequency (V/Hz), as required by the characteristics of the AC motor to produce adequate torque.

AC drives accurately control torque, smoothly handle increased load and provide numerous custom control and configuration operating modes. A VFD can be used to vary speed, direction and other parameters of a 3-phase motor. We use the 2-wire method for controlling the speed and direction of the motor The first step in this process is to convert the AC supply voltage into DC by the use of a rectifier. DC power contains voltage ripples which are smoothed using filter capacitors. This section of the VFD is often referred to as the DC link. This DC voltage is then converted back into AC. This conversion is typically achieved through the use of power electronic devices such as IGBT power transistors using a technique called Pulse Width Modulation (PWM). The output voltage is turned on and off at a high frequency, with the duration of on-time, or width of the pulse, controlled to approximate a sinusoidal waveform. Older drive technologies like Current Source Inverters and Variable Voltage Controllers used SCRs or Thyristors ascontrol devices. These technologies have now been replaced by the PWM VFD.The entire processis controlled by a microprocessor which monitors the:

- Incoming voltage supply,
- Speed set-point,
- DC link voltage,

- Output voltage and current to ensure operation of the motor within established parameters

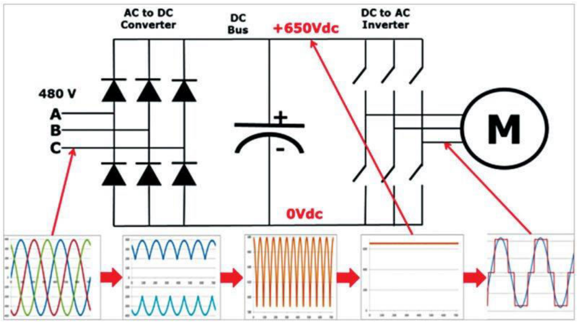

Figure 3: Circuit model of a VFD

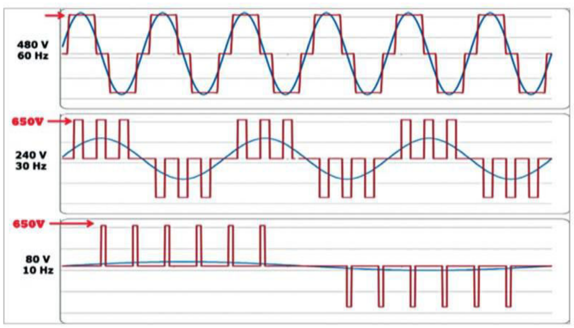

Figure 4: Waveforms at different operating frequencies and average voltage

Notice that, the output from the VFDis a rectangular waveform. VFDs do not produce a sinusoidal output. This rectangular waveform would not be a good choice for a general-purpose distribution system, but is perfectly adequate for a motor. If we want to reduce motor frequency, we simply switch the inverter output transistors more slowly. But if we reduce frequency, we must also reduce voltage in order to maintain V/Hz ratio. Pulse width modulation (PWM) does this. Imagine, we could control the pressure in a water line by turning the valve on and off at high speed. While this would not be practical for plumbing systems, it works very well for VFD. Notice that, during the first half-cycle, voltage is on half the time and off the rest. Thus, the average voltage is half of 480V, that is, 240V. By pulsing the output, we can achieve any average voltage on the output of the VFD.

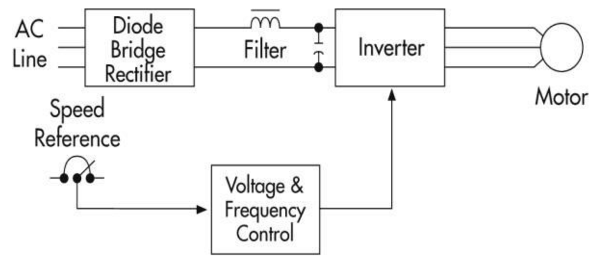

Figure 5: Block diagram of a typical PWM VFD

In the simplest drives or applications, the speed reference is simply set-point; however, in more complex applications, the speed reference comes from a process controller such as a Programmable Logic Controller (PLC) tachometer.

Often in the industry, need arises for controlling the speed of a 3 Phase Induction Motor. Siemen's AC motor drives are able to efficiently control motor speed, improve machine automation and save energy. Each drive in its variable frequency drive (VFD) series is designed to meet specific application needs.

This drive can have numerous applications like a packing machine, dumpling machine, treadmill, temperature/humidity-control fan for agriculture and aquaculture, mixer for food processing, grinding machine, drilling machine, small-size hydraulic lathe, elevator, coating equipment, small-size milling machine, robot arm of an injection machine (clamp), wood machine (two-side woodworking planer), edge-bending machine, elasticiser and so on.

2.ALGORITHM

2.1 Circuit Diagram

This circuit diagram or schematic diagram shown in Figure describes the methodology of the motor speed control using VFD. It consists of VFD

Drive, PLC, Induction motor, SMPS andinput/output devices etc.

Three phase Induction motor is connected with the input supply through the main contacts of the VFD. All the remote control signals like Run/Stop and Forward/Reverse direction of motor are given through the PLC. Also, computer is connected to the PLC through the USB cable for controlling of motor using the PLC r programming languages

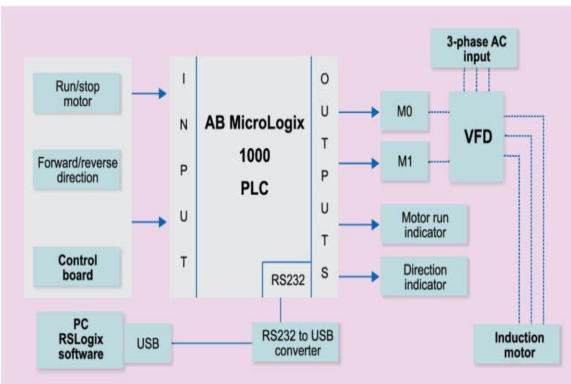

Figure 6: Block Diagram for Proposed Methodology

2.2Variable Frequency Drive:

SIEMENS SINAMICS V20 is a sensor-less vector micro AC drive. Its compact design is ideal for small- and medium-horsepower applications. This drive is designed to provide an ultra-low-noise operation and includes several innovative technologies that reduce interference

2.2.1. Inverter Parameters Overview:

The Inverter contains a number of settings which can be changed to tailor it for use in awide range of applications. These settings are known as parameters. Parameters are typically referred to by code or number (eg. P0305 = Rated Motor Current). The parameters contain critical information essential to the correct operation of the Inverter. Set the following parameters to allow the V20 to control a motor with Run, Stop and Speed Control from the integrated keypad.

2.3 Program logic controller:

OMRON –CP1E-N30DR-A PLC is used. Supply voltage is 100-230V AC. including CPU Units with built-in three ports: USB, RS-232C.Easy connection with computers using commercially available USB cables.

Product name	SPECIFICATION						External power supply (24 VDC) (A)	Current consumption (A)		MODEL
	Power Supply	Inputs	Outputs	Output type	Program capacity	Data memory capacity		5 V	24 V	
N30-type CPU Units with 30 I/O Points	100 to 240 VAC	18	12	Relay	8K steps	8K words	0.3	0.21	0.07	CP1E-N30DR-A
				Transistor (sinking)			0.3	0.27	0.02	CP1E-N30DT-A
				Transistor (sourcing)			0.3	0.27	0.02	CP1E-N30DT1-A
	24 VDC			Relay			---	0.21	0.07	CP1E-N30DR-D

3. CONCLUSION

In this work the speed control method for three phase induction motor is presented using the VFD integrated with PLC. The induction motor speed can be controlled by varying the ratios of v/f. The frequency of the input supply is varied from 5Hz to 50Hz.The Run/Stop, Forward/ReverseJog operation and Forward/Reverse speed control of motor are obtained from the buttons on the Inverter. The same type of operations may be obtained from the remote controlled switches. If we connect the computer through the USB cable with PLC the above mentioned operations may be obtained using the suitable PLC programming languages. The proposed speed control of three phase induction motor can be used for different applications like automobile industry, compressor, continuous process control industries, mine steel and cement mills.

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