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Speed control of I.M Using PLC AND SCADA

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Abstract: *Automation is referred to as creation of technology in a form such that the work is done by machines controlled by applications and software which can replace the humans. Automation is the need of today's World in all fields of Technology. This paper presents a novel approach to provide automation in the field of Electrical Engineering. The proposed work presents a speed control of induction motor which is conventionally controlled by a driver circuit and is an Open loop System There is a need to remove all the disadvantages of driver circuits and the aim is to make a more accurate closed loop control of motor speed. The proposed work will use a tachometer (revolution-counter, tach, rev-counter, RPM gauge) to measure the speed and feed it back to the PLC, which compares to the desired value and take a control action, then the signal is transferred to the motor – via driver – to increase / decrease the speed. We will measure the speed of the motor using an incremental rotary encoder by adjusting parameters (PLC, driver) and also, we need to reduce the overall cost of the system. This control system will be held using the available Siemens PLC. In addition, we will monitor motor parameters via SCADA system. Automation is used in various sectors like industries, machineries , factories , boilers , networking , small and large scale manufacturing units.The motor speed is controlled via the driver as an open loop control. To make a more precise closed loop control of motor speed we will use a tachometer to measure the speed and feed it back to the PLC, which compares to the desired value and take a control action, then the signal is transferred to the motor – via driver – to increase / decrease the speed. We will measure the speed of the motor using an incremental rotary encoder by adjusting parameters (PLC, driver) and also we need to reduce the overall cost of the system. Our control system will be held using the available Siemens PLC.*
Keywords: *PLC, SCADA, Automation, Induction Motor, Speed Control*

I. Introduction

Induction motor plays an important role due to its are simple and rugged in construction. Advantage of induction motors are that they are robust and can operate in any environmental condition. Induction motors are cheaper in cost due to the absence of brushes, commutators, and slip rings. They are maintenance free motors unlike dc motors and synchronous motors due to the absence of brushes, commutators and slip rings. Induction motors can be operated in polluted and explosive environments as they do not have brushes which can cause sparks.3 phase induction motors will have self-starting torque unlike synchronous motors, hence no starting methods are employed unlike synchronous motor. By implementing a monitoring and control system for the speed of motor, the induction motor can be used in high performance variable-speed applications. To control the speed of these motor, a motor drive and control system with different methods can be used. An induction motor's speed enables affected by the supply frequency, change the number of motor stators, adjust the power input. In an induction motor, there is no electrical connection to the rotor, but currents are induced in the rotor circuit. The rotor conductors carry current in the stator magnetic field and thereby have a force exerted upon them tending to move them at right angles to the field. When the stator winding of a three phase AC supply, a rotating magnetic field is established and rotates at synchronous speed. The direction of rotation of the field can be reversed by interchanging the connection to the supply of any two leads of a 3- phase induction motor[1]. The control of equipment has been performed through the use of computers. Most equipment's use programmable logic controllers (PLC) to connect with computers to monitor each load and electricity consuming devices. A PLC interacts with the external world through its inputs and outputs. Distributed management can be realized through Supervisory Control and Data Acquisition (SCADA) system. It is a common process control application that collects data from sensors. A SCADA system includes input/output signal hardware, controllers, Human Machine Interface (HMI), networks, communication, database and software.. The bulk of the site control is actually performed automatically by a Programmable Logic Controller (PLC). A PLC-SCADA based monitoring and control system for a Variable Frequency Drive system was developed which controls a three-phase induction motor. The integration of PLC and SCADA for industrial automation comprises of a human-machine interface which is the device presenting processed data to a human operator, who monitors and controls the process; a Remote Terminal Unit collects the information by connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system after which that information is displayed on a number of operator screens; PLC used as field devices for their economical, versatile, flexible and configurable attributes.[2,3]. PLC have now become the first choice for automation projects owing to the ease of use and efficient as well as reliable performance. The failure rate of PLC is very less hence it is very much preferred at industrial level. The Ideal choice for Speed control of Induction motor is therefore PLC.

1.1.PROGRAMMABLE LOGIC CONTROLLER (PLC)

Richard E. Morley, who was the founder of the Modicum Corporation, invented the first PLC in 1969.A PLC is a solid-state device designed to perform the logic functions previously accomplished by components such as electromechanical relays, drum switches, mechanical timers/counters etc. for the control and operation of manufacturing process equipment and machinery. Even though the electromechanical relay (control relays, pneumatic timer relays, etc.) have served well for many generations often under adverse conditions, the ever-increasing sophistication and complexity of modern processing equipment requires faster acting, more reliable control functions that electromechanical relays or timing devices cannot offer. Relays have to be hardwired to perform a specific function, and when the system requirements change, the relay wiring has to be changed or modified.

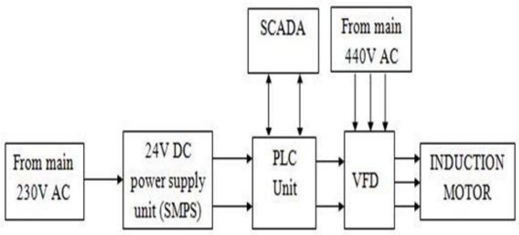


Fig Block Diagram

1.2 SUPERVISORY CONTROL AND DATA ACQUISITION

SCADA stands for Supervisory Control and Data Acquisition. The main purposes for the use of a SCADA system would be to collect the needed data from remote sites and even the local site, displaying them on the monitor of the master computer in the control room, storing the appropriate data to the hard drive of the master computer and allowing the control of field devices (remote or local) from the control room. SCADA systems are equipped to make immediate corrections in the operational system, so they can increase the life-period of your equipment and save on the need for costly repairs. It also translates into man-hours saved and personnel enabled to focus on tasks that require human involvement

1.2 VARIABLE FREQUENCY DRIVE (VFD)

A Variable Frequency Drive is used for applications wherein speed control is of an essential importance due to load changes wherein the speed needs to be increased or decreased accordingly. V/f method of speed control -The motor speed can be controlled by varying the supply frequency. The voltage induced in the stator is directly proportional to product of supply frequency and air-gap flux. If stator drop is neglected, terminal voltage can be considered proportional to product of frequency and flux. $V1 \alpha f.\Phi$ Effect of supply frequency change without terminal voltage change:

1. Reduction of supply frequency without change in terminal voltage will cause an increase in the air gap flux thereby saturating the motor. This will cause the increase in magnetizing current, core loss and stator. copper loss and cause distortion in line current and voltage and produce high-pitch noise.
2. An increase of supply frequency without change in terminal voltage will cause decrease in flux, therefore leading to reduction of torque capability of the motor.A driver used in control system is Siemens (micromaster 440). [5]

1.3 ENCODER

Controlling the speed of a motor is a basic functionality of modern electric drives. In order to precisely control the speed of an electric motor, it is necessary to measure the actual speed of the motor. This measurement can be done with various tools and methods. Encoders can be used inapplications, where long positions, speed or an angular position are measured. They transform mechanical movements into electrical signals and can be divided into incremental and absolute measuring systems.

1.4 CONTACTOR

Contactor is an electrically-controlled switch used for switching an electrical power circuit A contactor is typically controlled by a circuit, which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch.

II. Methodology

The first step in Speed Control of Induction Motor is to select the motor according to the rating and application in which it has to be used. The second step is to program the drive in Open Loop Configuration . Program is written to control the motor which is then connected to an encoder. Once it is connected to the encoder , the drive is then programmed to run in closed loop configuration. It is then programmed to control the speed of Induction Motor.The SCADA screen is then designed to control the Induction Motor remotely.In the hardware design part, overall component such as PLC S7-300 (Siemens), Encoder, motor, and drive micro master 440 (Siemens) will be integrated to form the complete prototype. The hardware components are the backbone of the system. The normally closed part of the FORWARD push button is connected in series with R coil, and the normally closed part of the REVERSE push button is connected in series with F coil. If the motor should be running in the forward direction and the REVERSE push button is pressed, the normally closed part of the push button will open and disconnect F coil from the line before the normally open part closes to energize R coil. The normally closed section of either push button has the same effect on the circuit as pressing the STOP button. In any industry the induction motor plays an important role due to its low cost and simplicity. By implementing a monitoring and control system for the speed of motor, the induction motor can be used in high performance variable-speed applications. To control the speed of these motor, a motor drive and control system with different methods can be used.

2.1 THREE PHASE INDUCTION MOTOR

Induction motors are the most common motors used for various equipment in the industry. Their popularity is due to their simple design, they are inexpensive and easy to maintain, and can be directly connected to an AC power source. An inductionmotor has two main electrical components A- Rotor (Squirrel-cage rotor and Wound rotor) B- Stator.Induction motors are the most common motors used for various equipment in the industry. Their popularity is due to their simple design, they are inexpensive and easy to maintain, and can be directly connected to an AC power source. An inductionmotor has two main electrical componentsA- Rotor (Squirrel-cage rotor and Wound rotor) B- Stator.

III. Speed Of An Induction Motor

The magnetic field created in the stator rotates at a synchronous speed (NS).

$$Ns = 120 * f/p \quad (1)$$

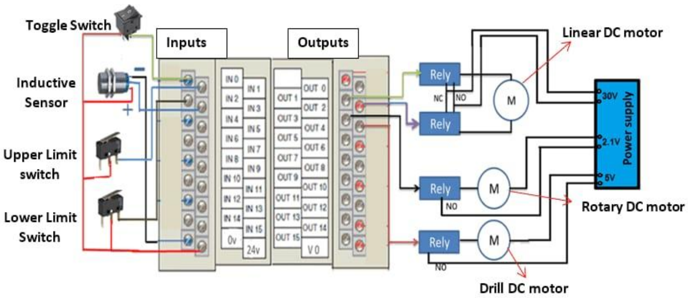
Where:
NS = the synchronous speed of the stator magnetic field in RPM
P = the number of poles on the stator
F = the supply frequency in Hertz

The magnetic field produced in the rotor because of the induced voltage is alternating in nature. To reduce the relative speed, with respect to the stator, the rotor starts running in the same direction as that of the stator flux and tries to catch up with the rotating flux.However, in practice, the rotor never succeeds in “catching up” to the stator field. The rotor runs slower than the speed of the stator field. This speed is called the Base Speed (Nb). The difference between NS and Nb is called the slip. The slip varies with the load. An increase in load will cause the rotor to slow down or increase slip. A decrease in the Lord will cause the rotor to speed up or decrease slip. The slip is expressed as a percentage and can be determined with the following formula:

$$\%Slip = \frac{N_s - N_b}{N_s} x100 \quad (2)$$

Where:
NS = the synchronous speed in RPM
N b = the base speed in RPM. [7]
We controlled the speed of an AC induction motor in our application by using:-
1- Open loop control system. 2- Closed loop control system

Fig – Induction Motor



IV. Process Flowchart

Selection of induction motor rating

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programming the drive to operate it in open loop

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Writing the program of PLC to control induction motor

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Connect the encoder with a PLC

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Programming the drive to operate it in closed loop

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Writing the program of PLC to control the speed of induction motor

↓

Development of the SCADA control screen using suitable software to control the process of induction motor remotely

V. Software Configurations

The experiments were conducted based on ladder logic programming which is a software installed on a personal computer according to which the PLC takes the sensor inputs, processes them according to the program and gives the output to the VFD which again processes this input within the drive and finally controls the speed and position of the motor Through this project, we used SFB 48 (system function block) for controlling the Frequency Measurement and Continuous Control with SFB 41 "Continues control" to control technical processes with continuous input and output variables on SIMATIC S7-300 programmable logic controllers.

VI. Conclusion

The goal of this project was motivated to control Speed of motor using PLC (Siemens) S7-300, converter micro master 440, incremental rotary encoder instead of the encoder (Siemens) because the incremental encoder is cheaper than encoder (Siemens) and performs the same action as encoder (Siemens) so that we adjust the parameters of count in hardware configuration for controlling the frequency measurement and adjust the parameters of PI control to obtain the determine the speed in PLC programming as shown in the results of the above figures. Also in this project we were motivated to monitor the speed of three phase induction motor using a SCADA system. The control system is designed based on the most advanced technology which gives a high amount of flexibility and efficiency. Monitoring system gives facility of analyzing the operation of induction motor in an online / offline mode, which makes the system to be safe from any fault/error conditions.The PLC systems are reliable and efficient to be used in Industries as well as for controlling Induction motor efficiently.

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