Design and Development of PLC and SCADA Based Control Panel for Continuous Monitoring of Induction Motor

T Mukesh Raj[1] | Swathi Gopan S[2]

[1](PG Scholar, Power Electronics and Drives, SCAD College of Engineering and Technology, Tirunelveli, India, tmukeshraj@gmail.com)

[2](PG Scholar, Power Electronics and Drives, SCAD College of Engineering and Technology, Tirunelveli, India, Swathi24engg@gmail.com)

Abstract— *Squirrel cage induction motors are widely used motors in industry because of its rugged construction and negligible maintenance. To operate this kind of this motor star-delta starters are used .But ,because of its constant speed characteristics, many a times it is driven with the help of variable frequency drives. To have reliable operation its performance must be monitored continuously. The implementation of monitoring and control system for the induction motor based on programmable logic controller technology is described. Also the implementation of a hardware and software for speed control and protection with the result obtained from the test on induction motor performance is provided. Other performance parameters of three phase induction motors can also be monitored by the other control devices. Variable Frequency Drives (VFD) can also used to control the motor rotation direction and rotation speed of the three phase induction motor. All the required control and motor performance data will be taken to a personal computer via PLC for further analysis. Speed control from control side and protection from performance side will be priority.*

Keywords— Computer-controlled systems; Computerized monitoring; Electric drives; Induction motors; Programmable Logic Controllers (PLCs); Variable Frequency Drives; Voltage Control; SCADA (Citect Software)

1. INTRODUCTION

Since technology for motion control of electric drives became available, the use of programmable logic controllers (PLCs) with power electronics in electric machines applications has been introduced in the manufacturing automation [1], [2].AC induction motors (IMs) are used as actuators in many industrial processes. Although IMs are reliable, they are subjected to some undesirable stresses, causing faults resulting in failure. Monitoring of an IM is a fast emerging technology for the detection of initial faults. It avoids unexpected failure of an industrial process. Monitoring techniques can be classified as the conventional and the digital techniques. Classical monitoring techniques for three-phase IMs are generally provided by some combination of mechanical and electrical monitoring equipment. Mechanical forms of motor sensing are also limited in ability to detect electrical faults, such as stator insulation failures. In addition, the mechanical parts of the equipment can cause problems in the course of operation and can reduce the life and efficiency of a system.

In study, a computer based protection system has been introduced. Measurements of the voltages, currents, temperatures, and speed were achieved and transferred to the computer for final protection decision. In this paper, although all the variables of the motor were considered, usage of an analog-to-digital conversion (ADC) card increases the cost and the size of the system. A programmable integrated circuit (PIC) based protection system has been introduced in. The solutions of various faults of the phase currents, the phase voltages, the speed, and the winding temperatures of an IM occurring in operation have been achieved with the help of the microcontroller, but these electrical parameters have not been displayed on a screen.

Nowadays, the most widely used area of programmable logic controller (PLC) is the control circuits of industrial automation systems. In this method, all contactors, timers, relays, and the conversion card are eliminated.

Moreover, the voltages, the currents, the speed, and the temperature values of the motor, and the problems occurred in the system, are monitored and warning messages are shown on the computer screen.

PLC provides higher accuracy as well as safe and visual environment compared with the classical, the computer, and the PIC-based protection system. This use offers many advantages such as1)lower voltage drop when turned on and the ability to control motors and other equipment with a virtually unity power factor.2)Many factories use PLCs in automation processes to diminish production cost and to increase quality and reliability.3) Fault or error detection and correction is easy.4)It has very less amount of component. 5) Maintenance is easy. Other applications include machine tools with improved precision computerized numerical control (CNC) due to the use of PLCs.

To obtain accurate industrial electric drive systems, it is necessary to use PLCs interfaced with power converters, personal computers, and other electric equipment. Disadvantage of this method is that this makes the equipment more sophisticated, complex, and expensive.

Other performance parameters of three phase induction motors can also be monitored by the other control devices. Variable Frequency Drives (VFD) can also used to control the motor rotation direction and rotation speed of the three phase induction motor. Many applications of induction motors require besides the motor control functionality, the handling of several specific analog and digital I/O signals, home signals, trip signals, on/off/reverse commands. In such cases, a control unit involving a PLC must be added to the system structure. In this paper presents a PLC-based monitoring and control system for a three-phase induction motor. It describes the design and implementation of the configured hardware and software. This configuration is interfaced on SCADA through PLC via RS232. Thus, the PLC correlates and controls the operational parameters to the speed set point requested by the user and monitors the induction motor system during normal operation and under condition of trip.

2. Control System of Induction Motor

In Fig. 1, the block diagram of the experimental system is illustrated. The following configurations can be obtained from this setup.

1) A closed-loop control system for constant speed operation, configured with speed feedback and load current feedback. The induction motor drives a variable load, is fed by an inverter, and the PLC controls the inverter V/f output.

2) An open-loop control system for variable speed operation. The induction motor drives a variable load and is fed by an inverter in constant V/f control mode. The PLC is inactivated.

3).The standard variable speed operation. The induction motor drives a variable load and is fed by a constant voltage-constant frequency standard three-phase supply.

3. Hardware Description

The control system is implemented and tested for a Squirrel cage induction motor, having the technical specifications given in Table I. The three-phase power supply is connected to a three-phase main switch and then to 3 pole MCB which provides protection against current overloads. Then it is connected to variable frequency drives(VFD) which control speed of motor and we change direction of motor through PLC and this is interface on SCADA. Its technical specifications are summarized in Table II. Due to its versatility and compact dimensions the FR-E 500 EC is a frequency inverter(VFD) solving most effectively your individual drive tasks. Its extensive functions allow flexible applications.

Motor type:

Single phase induction Motor

0.25 Hp, Squirrel cage type

Output delta type

Current sensor:

Maximum withstand voltage: 230V AC

Maximum Allowable current: 2A

Sensing range: for 1 Amps current it can generate 4v AC as it's output voltage.

Voltage sensor:

Primary 230v and secondary voltage 9v AC

Temperature sensor:

LM35 type, sensing range -20 deg to 150 deg Celsius.

Circuit breaker:

SPDT relay type 5V DC for coil, 230v Ac for Contactor pin.

PLC:

DVP20EX

SCADA: Wonderware intouch

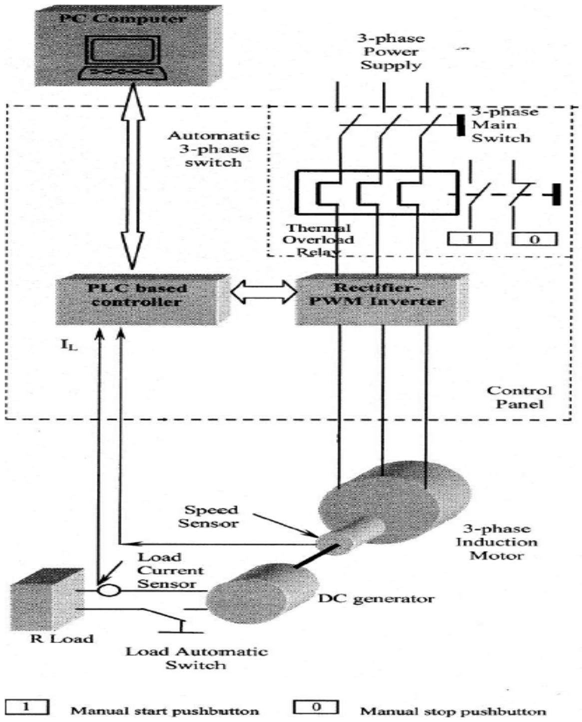


Fig.1. Electrical diagram of experiment system

4. PLC as System Controller

A PLC is a microprocessor-based control system, designed for automation processes in industrial environments.

It uses a programmable memory for the internal storage of user-orientated instructions for implementing specific functions such as arithmetic, counting, logic, sequencing, and timing. A PLC can be programmed to sense, activate, and control industrial equipment and, therefore, incorporates a number of I/O points, which allow electrical signals to be interfaced. Input devices and output devices of the process are connected to the PLC and the control program is entered into the PLC memory.

In our application, it controls through analog and digital inputs and outputs the varying load-constant speed operation of an induction motor.

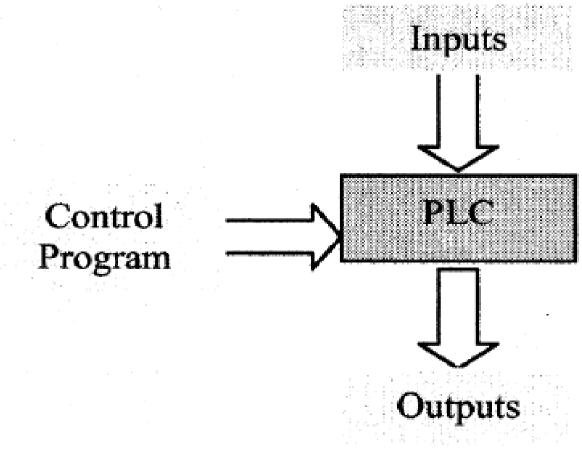


Fig. 2. Control action of a PLC

Also, the PLC continuously monitors the inputs and activates the outputs according to the control program. This PLC system is of modular type composed of specific hardware building blocks (modules), which plug directly into a proprietary bus: a central processor unit (CPU), a power supply unit, input-output modules I/O, and a program terminal. Such a modular approach has the advantage that the initial configuration can be expanded for other future applications such as multi machine systems or computer linking.PLC configuration is shown.

5. Software Description

PLC's programming is based on the logic demands of input devices and the programs implemented are predominantly logical rather than numerical computational algorithms. Most of the programmed operations work on a straightforward two-state "on or off" basis and these alternate possibilities correspond to "true or false" (logical form) and "1 or 0" (binary form), respectively. Thus, PLCs offer a flexible programmable alternative to electrical circuit relay-based control systems built using analog devices.

The programming method used is the ladder diagram method. The PLC program uses a cyclic scan in the main program loop such that periodic checks are made to the input variables.

The program loop starts by scanning the inputs to the system and storing their states in fixed memory locations (input image memory I). The ladder program is then executed rung-by-rung. Scanning the program and solving the logic of the various ladder rungs determine the output states. The updated output states are stored in fixed memory locations (output image memory Q).

The output values held in memory are then used to set and reset the physical outputs of the PLC simultaneously at the end of the program scan. For the given PLC, the time taken to complete one cycle or the scan time is 0, 18 ms/K (for 1000 steps) and with a maximum program capacity of 1000 steps.

A. *PLC Speed Control Mode*

In Fig. 4, the flowchart of the speed control software is illustrated. The software regulates the speed and monitors the constant speed control regardless of load variation. The inverter being the power supply for the motor executes this while, at the same time, it is controlled by PLC's software. The inverter alone cannot keep the speed constant without the control loop with feedback and PLC.

From the SCADA, the operator selects the speed set point and the forward/backward direction of rotation. Then, by pressing the start button, the motor begins the rotation.

If the stop button is pushed, then the rotation stops. The corresponding input signals are interfaced to the DI and the output signals to the DO.

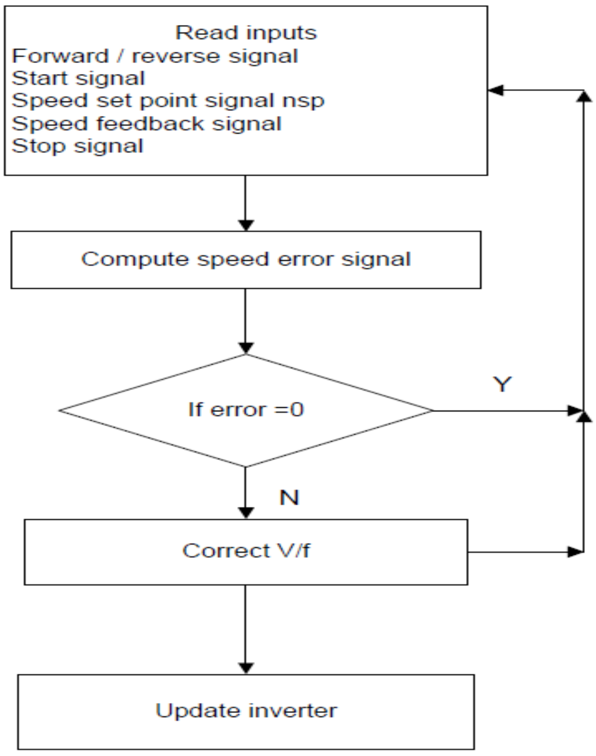


Fig.3. Flowchart of speed control software

The AIM receives the speed feedback signal from the tacho generator, and the signal from the control panel. In this way, the PLC reads the requested speed and the actual speed of the motor. The difference between the requested speed by the operator and the actual speed of the motor gives the error signal. If the error signal is not zero, but positive or negative, then the PLC according to the computations carried out by the CPU decreases or increases the of the inverter and, as a result, the speed of the motor is corrected

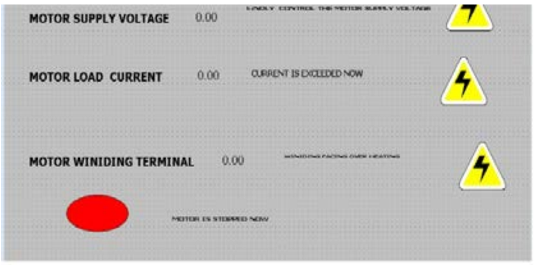
The implemented control is of proportional and integral (PI) type (i.e., the error signal is multiplied by gain Kp , integrated, and added to the requested speed). As a result, the control signal is sent to the DOM and connected to the digital input of the inverter to control V/f variations. At the beginning, the operator selects the gain

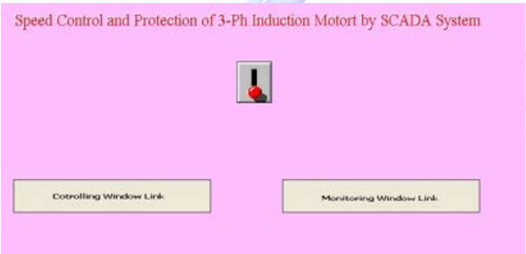
Kp by using SCADA programming and the AIM receives its voltage drop as controller gain signal.

The requested speed is selected using SCADA programming and the AIM reads this signal. Its value is sent to the AOM and displayed at the control panel (speed set point display). Another display of the control panel shows the actual speed computed from the speed feedback signal.

6. Results

The system is tested during operation with varying loads including tests on induction motor speed control performance. The PLC monitors the motor operation and correlates the parameters according to the software. At the beginning, for reference purposes, the performance of Induction motor supplied from a standard 415 V, 50- Hz network is measured.





7. Conclusion

The monitoring control system of the induction motor driven by VFD and controlled by PLC proves its high accuracy in speed regulation at constant-speed-variable-load operation. The PLC proved to be a versatile and efficient control tool in industrial electric drives applications. The effectiveness of the PLC-based control software is satisfactory up to 96% of the synchronous speed.

Despite the simplicity of the speed control method used, this system presents:

- constant speed for changes in load ,
- Full torque available over a wider speed range;
- Very good accuracy in closed-loop speed control scheme;
- overload protection.

Thus, the PLC proved to be a versatile and efficient control tool in industrial electric drives applications.

References

[1] Maria G. Ioannides (S'85–M'86–SM'90) graduated from the Electrical Engineering Department of the National Technical University of Athens (NTUA), Athens, Greece. Currently, she is Professor of Electric Drives at NTUA. Her research interests include control of electric machines, renewable energy systems, small and special electric motors, new materials.

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