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Protection and Control of Three-Phase Induction Motor using Crouzet Millenium PLC

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Abstract

Induction Motors (IM) are used in many industrial applications in a wide range of operating areas as they have simple and robust structure, and low production costs. The knowledge about fault behavior of an Induction Motor drive is extremely important from standpoint of improved system design, protection, and fault tolerant control. Here different problems are dealt such as overvoltage, overcurrent, over speed which are being faced by IM's during their course of operation. There are various methods for fault detection and protection of Induction Motors. Some of them are On-line fault detection, Stator fault monitoring techniques, Microcontroller based protection system and Programmable Logic Controller (PLC) based protection system. In this context, protection for three-phase Induction Motor is enabled using Crouzet Millenium PLC. The PLC correlates the operational parameters of the 3-Ø Induction Motor with the desired values preset by the user in the PLC that continuously monitor the system and isolate it during fault conditions. Thus, PLC proves an effective tool in industrial control of electric drives.

Keywords: PLC, Three-Phase Induction Motor, AC Current Sensor, Proximity Sensor, AC Voltage Sensor.

Introduction

Electric machines in general provide energy transformation. Although machines using electrostatic forces can be built, the magnetic field is the medium of choice because energy densities 10^4 times that of the electrostatic field are possible. The three phase induction motors, especially those with squirrel-cage rotors, are the simplest and least expensive electrical machines devised. These motors are well known for their reliability and possess the features of robust construction and ease of control, due to which, they are widely preferred over many other motors for the AC motor driven applications. This three-phase motor is accountable for larger load operations in several applications like goods and lift hoists, conveyors, compressors, pumps, ventilation systems, industrial fan controllers, etc. Three-phase induction motors are accountable for 85 percent of the installed capacity of the industrial driving systems. Therefore, the protection of these motors is necessary for reliable operation of loads. Motor failures are mainly divided into three groups: electrical, mechanical and environmental. Mechanical stresses cause overheating resulting in the rotor bearings' wear and tear.

When the mechanical load on the IM increases, it draws heavy currents due to which the temperature

also increases. Electrical failures occur due to various reasons such as phase-to-phase and phase-to-ground faults, single-phasing, over and under frequency, etc. In addition to the motor protection systems for the above mentioned faults, it is also necessary to use three-phase motor starter to limit the starting current of the induction motor. To protect the motor from the high-starting current, there are different starting methods available like reduced voltage, rotor resistance, DOL, star-delta starter, auto transformer, soft starter, etc. And, for protecting the motor from the above discussed faults; various protection equipment like relays, circuit breakers, contactors and various drives are implemented. Further, an operator for switching on/off the motor is always not possible, especially when the motor has to be operated round the clock. This problem can be solved by using a PLC-based monitoring and control system for the automatic protection of three-phase induction motors.

Sensors

A sensor is an element in a measurement system that detects the magnitude of a physical parameter and changes it into a signal that can be processed by the system. Often the active element of a sensor is referred to as a transducer. Monitoring and control systems

require sensors to measure physical quantities such as position, distance, force, strain, temperature, acceleration, voltage, current, etc. Analog sensors produce a variation in an electrical property to show a change in the environment. For the data collected from an analog sensor to be processed, or to be used in digital equipment, it needs to be converted to a digital signal using analog- to-digital converter. Whereas, if the output of the sensor is digital, the digital circuits can be directly connected to sensor devices as the sensor devices are intrinsically digital themselves. Input signals of ADC are analog electrical signals such as voltage or current and the output is a binary. In a process control system ADC and DAC systems are used to provide complete interface with analog sensors, computers and output devices for controlling the system as shown in Figure 1.

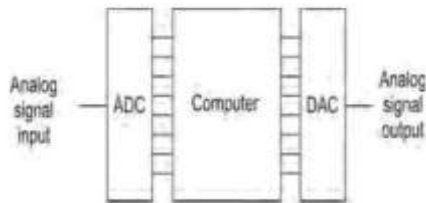


Figure 1 : Computer aided control using ADC and DAC

In this project, AC Voltage Sensor and AC Current Sensors are employed to protect the 3-Ø Induction Motors from over voltage, under voltage and over currents. And the speed control is achieved using the proximity sensor. These sensors are interfaced to the M3 PLC which detect the abnormal conditions and protect the 3-Ø Induction motors from faults. The technical specifications of AC Voltage Sensor and AC Current Sensors are as follows:-

AC Voltage Sensor

Figure 2 shows an AC Voltage Sensor with the following specifications:



Figure 2 : AC Voltage Sensor

- a. Input Signal – 0-300V AC.
- b. Output Signal – 0-10V DC.
- c. Aux. Power Supply – 240V AC.

AC Current Sensor

Figure 3 shows an AC Voltage Sensor with the following specifications:



Figure 3 : AC Current Sensor

- a. Input Signal – 0-5A AC.
- b. Output Signal – 0-10V DC.
- c. Aux. Power Supply – 240V AC.

Proximity Sensor

Because most applications involve measuring and controlling shaft rotation (e.g., in motors, generators, numerically controlled lathe and mill axes) rotary position sensors are more common than linear sensors. Speed measurements can be obtained by taking consecutive position measurements at known time intervals and computing the time rate of change of the position values. A tachometer is an example of a speed sensor that does this for a rotating shaft.

Proximity detectors are electronic sensors that indicate the presence of an object without making physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The detector normally does not respond by producing a linear output signal proportional to the distance of the object to the sensor. Instead, the output turns on or off. That is why these devices are commonly called proximity switches. Proximity sensors are roughly classified into the following three types according to the operating principle: the high-frequency oscillation type using electromagnetic induction, the magnetic type using a magnet, and the capacitance type using the change of capacitance. KEYENCE proximity sensors are of the

high-frequency oscillation type. Some of the features of proximity sensors are as follows:

- Non-contact detection, eliminating damage to sensor head and target.
- Non-contact output, ensuring long service life.
- Stable detection even in harsh environments exposed to water or oil splash.
- High response speed.

Figure 4 shows a proximity sensor. The following are the technical specifications of proximity switch.



Figure 4 : Proximity Sensor

- Type – PNP NO
- Sensing Range – 08mm
- Output Diameter – 18mm
- Operating Voltage – 05-40V DC
- Maximum Load – 300mA

Programmable logic controller (PLC)

Programmable Logic Controller or PLC is a computing system used to control electromechanical processes. It is designed for multiple input and output arrangements. It endures harsh environments and controls output for various devices such as displays, lights and valves. It is an example of hard real time system; the output results are produced in response to input within targeted time. PLCs are used to control machinery in factories, amusement parks, hospitals, hotels, military, traffic signals and construction. 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-oriented instructions for implementing specific functions such as arithmetic, counting, logic, sequencing, and timing. Following are the advantages of PLC:-

1. Increased Reliability
2. More Flexibility
3. Lower Cost
4. Communications Capability

A typical PLC can be divided into parts as illustrated in fig. These components are the Central Processing Unit (CPU), the input/output (I/O) section, the power supply, and the programming device. The term architecture can refer to PLC hardware, to PLC software, or to a combination of both. Figure 5(a) and Figure 5(b) show the parts and architecture of a PLC.

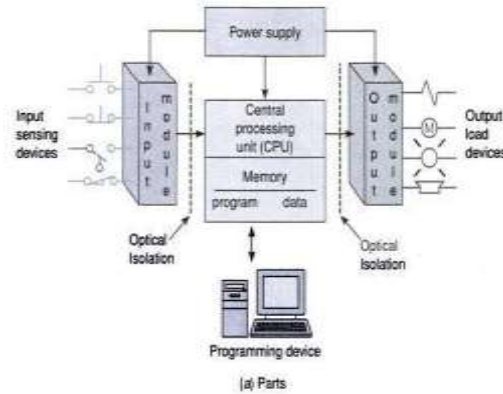
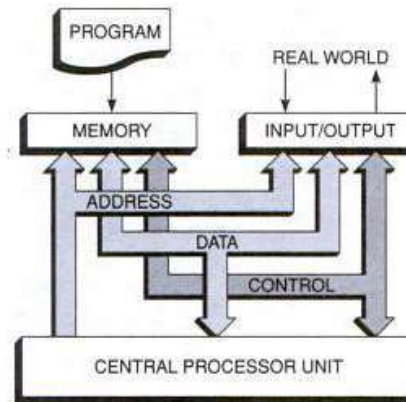


Figure 5(a) : Parts of a PLC



The structure of a PLC is based on the same principles as those employed in computer architecture.

(b) Architecture

Figure 5(b) : Architecture of a PLC

Programming software

Here the protection of 3-Ø Induction Motor is achieved using XD-26 Crouzet Millennium PLC. Fig.6 shows the XD-26 PLC. It works on the software of MILLENNIUM 3 Programming Language. The new Millennium 3, gives us an opportunity to take advantage of all the most recent developments in the latest generation of logic controllers. For quick, simple programming, the Millennium 3 software prioritizes dedicated application-specific functions such as pump

switching, PID control, movement, pressure, level and flow. All the basic functions, such as counting, timing, comparison and display, are also available. The M3 SOFT programming software incorporates error checking, so that when the slightest data entry error is made, it flags the incorrect item in red.

Crouzet Millenium PLC-88970162 (XD-26)



Figure 6 : XD-26 PLC

Table 1. Description of XD-26 PLC

Type	Reference	Inputs	Outputs
XD 26S 24V DC ESSENTIAL	88970162	10 DISCR +6 (0-10V)	10 DISCRETE STATIC

The numbering for the XD 26 PLC is given in such a way that as it is containing 16 Digital (of which 6 are analog) inputs and 10 discrete static relay outputs. And the total number of these inputs and outputs account to 26.

The controller offers two programming languages: switch.

1. LD Language : Ladder Language
2. FBD Language : Functional Block Diagram

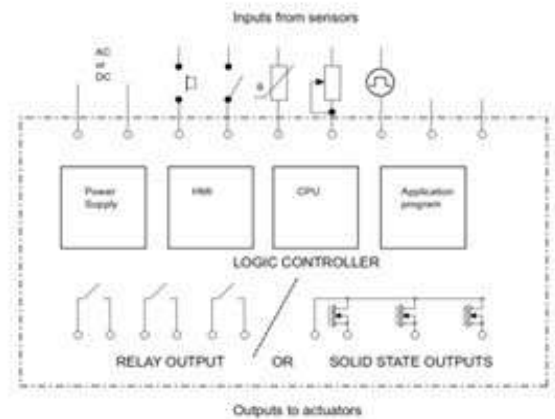


Figure 7 : Typical Logic Controller Architecture

FBD mode allows graphic programming based on the use of predefined function blocks. It offers a large range of basic functions: timer, counter, logic etc.

Operating Modes:

There are several operating modes for the programming workshop.

- Edit Mode: Edit Mode is used to construct programs in FBD mode, which corresponds to the development of the application.
- Simulation Mode: In simulation mode the program is executed offline directly in the programming workshop (simulated on the PC). In this mode, each action on the chart (changing the state of an input, output forcing) updates the simulation windows.
- Monitoring Mode: In Monitoring mode, the program is executed on the controller, the programming workshop is connected to the controller (PC ↔ controller connection). The different windows are updated cyclically.

The schematic arrangement of the experimental setup is as shown in Figure 8.

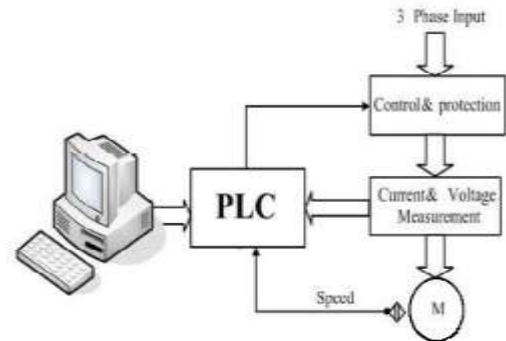


Figure 8 : Schematic Arrangement of the proposed system

Hardware setup

The Hardware Setup consists of:-

- 1) 3-Phase, 0.5HP Induction Motor with load arrangement
- 2) Crouzet Millenium3 XD-26 Programmable Logic Controller
- 3) 8-Channel Relay Module
- 4) Contactor
- 5) Voltage Sensor
- 6) Current Sensor
- 7) Proximity Sensor
- 8) Computer

Figure 9 shows the hardware setup of the proposed system implemented.



Figure 9 : General View of the proposed system implemented

Results

In this context, the programming software is implemented in FBD mode, since it involves functional blocks which can be pictorially understood and easy for verification.

The block diagram representation of the PLC logic is as shown in Figure 10.

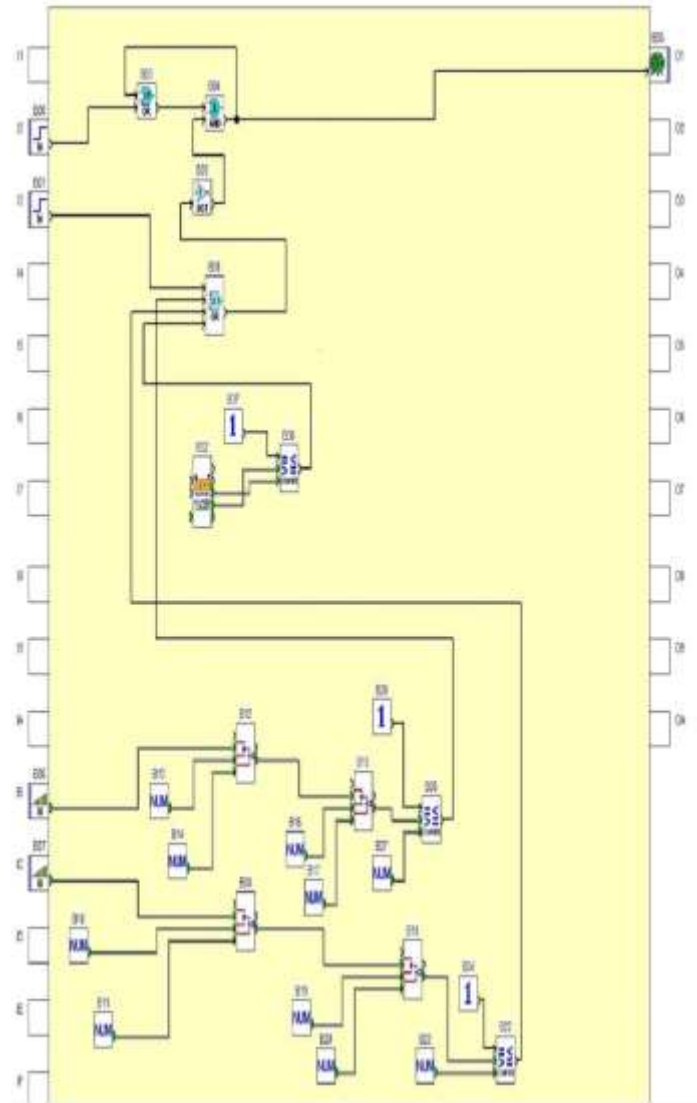


Figure 10 : PLC Block Diagram

Conclusion

The protection and control of 3-phase IM is achieved using the M3 XD-26 controller which is programmed using FBD logic. The connection between PLC and PC is achieved using the communication cable. After the communication is made successful, the contactor switches the relay module, with which the three-phase induction motor operates. The voltage, current and the proximity sensors interfaced, collect the data of the 3-phase induction motor and sends the information to the PC. With the changing load, the operating conditions of the 3-phase induction motor also changes which are recorded and the information received is compared with preset values from time to time. In the course of operation, when the values exceed the preset value, the

3-phase IM's are isolated from the 3-phase supply and the information is sent to the operator. Thus the results obtained from the proposed of using PLC are more effective when compared to conventional methods.

References

- [1] Handbook of Electric Motors, 2nd edition, edited by Hamid A. Toliyat, Gerald B. Kliman, 2004.
- [2] Basic Types of Three-Phase Motor Protection Systems and Operations, Author-Tarun Agarwal [Online], Available: <http://www.elprocus.com/three-phase-induction-motor-protection-systems-and-its-applications/>
- [3] Introduction to Mechatronics and Measurement Systems, 3E, by David G Alciatore, Michael B. Hstand, TMH Edition, 2007.
- [4] Digital Electronics, Principles and Applications by Soumitra Kumar Mandal, TMH Edition, 2010.
- [5] Proximity Sensor Operating Principles and Types – KEYENCE Corporation [Online], Available: <http://www.sensorcentral.com/photoelectric/proximity01.php>
- [6] Programmable Logic Controller, 3rd edition, by Frank D.Petruzella, TMH Edition, 2010.