Application of PLC for Controlling the Operation of Induction Motor

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***Abstract*— The implementation of PLC for controlling the operation of induction motor using an ac voltage controller is stated in this paper. The ac voltage controller is used to control the supply voltage using three pairs for of anti-parallel SCR to run the motor at desired speed. The controlling signal is generated using PLC and pulse transformer is used to provide gating signal and isolation to the SCR based driver circuit. A three phase induction motor was used to test the results. Also a circuit was designed to reverse the direction of rotation of the induction motor. This paper describes the methodology, implementation and operation of the use of PLC to control the motor operation by controlling the supply voltage.**

***Keywords*—PLC, induction motor, SCR, FBD, I/O modules.**

I. INTRODUCTION

The automation has become the necessity of today's industrial world when it comes to reducing the production cost, mass production, fast operation and safety. When considering automation PLC being an intelligent controller plays major role in it as it has become preferable choice of many automation engineers because of its ruggedness, ease of programming, flexibility in programming, ability to work in any industrial harsh environment and mainly fail safe operation.

Also while talking about industrial automation, motors plays major role in carrying out number of process operation such in cement industry, chemical industry, food and beverages industry, power plants, rolling machines, saw machines, etc. Although PLC is mainly about controlling sequential operations, it can also be used to control the speed of motor rather than just performing switching on and off motor operation and hence the efficiency of the production system can be improved and the cost can be reduces as there be no need to use a separate controller for controlling the motor. Induction motor is mostly used motor in industries because of its simple construction, low cost, ruggedness and reliable operation.

Here the speed of three phase induction motor is controlled by controlling the supply voltage using an ac voltage controller and control signal is provided by PLC. Many papers have used PWM control method, but in this paper stator voltage control method is used. Also instead of using ladder logic for programming PLC, Function Block Diagram is used which works very efficiently with the drive system and easy to model also. A pair of anti-parallel SCRs is connected to each phase of the supply voltage and pulse transformers are used to providing gating signal to the SCRs and also isolation between the power circuit and the control circuit.

II. PLC BASED CONTROL SYSTEM

PLC can be called as a workhorse in the manufacturing and automation industries and when interfaced with different process elements it ensures smooth and fail-safe operation and can manage multiple machine operation at a time. With its ability to communicate effectively via industrial communication network like Ethernet, profibus, modbus etc. the control becomes more precise and makes real time operation and monitoring possible.

It basically works three main cycles that are input scan, program scan and output scan. In input scan it checks the availability of any input signal and updates the input status table. In program scan the inputs from the status table are applied to the user program, program is executed rung by rung and output table is updated accordingly. In output scan data associated with the output status table is transferred to the output terminals. The basic block diagram of PLC is shown in fig.1.

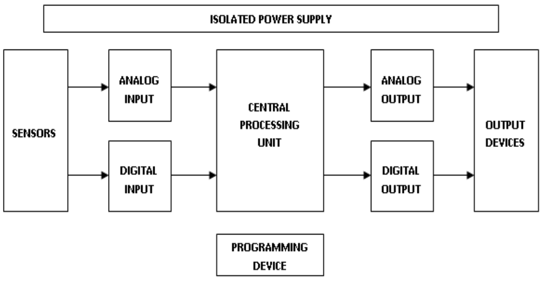

Fig.1. Block diagram of Programmable Logic Controller

III. AC VOLTAGE CONTROLLER DRIVE

Fig.2. shows the ac voltage controller drive containing three pairs of anti-parallel SCRs connected at each phase of the supply voltage. This method is used in applications when the load torque decrease with speed. It is suitable for the intermittent operation of the drive like for the load such as fan and pumps as in these applications load torque varies with the square of the speed, these type of drives require lower torque at lower speeds.

This method uses the principle that torque developed in an induction motor at a given slip varies with the square of stator voltage without changing the supply frequency.

$$T \alpha V^2$$

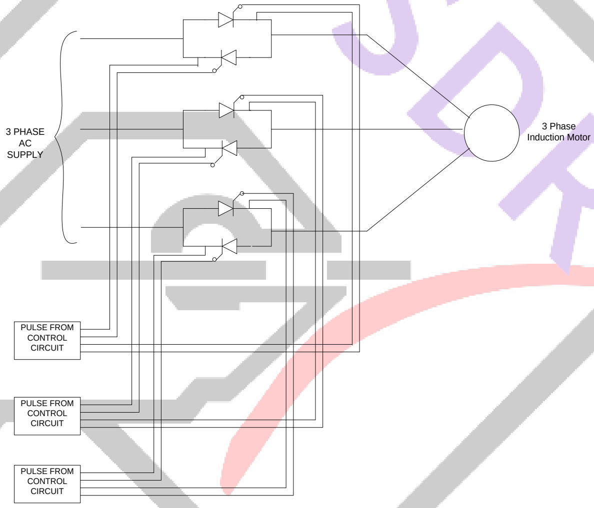

Fig.2. Basic circuit diagram of SCR based drive.

The voltage of each phase is controlled by the thyristor pair connected to that particular phase. The speed of the motor is controlled by the conduction period of these thyristors. A 120^0 phase displacement should be maintained between the gating pulses of each set of the thyristors connected at each leg of the three phases.

IV. HARDWARE DESCRIPTION OF THE PROPOSED WORK

The block diagram of the hardware that was to be developed for proposed work is shown in the fig.3.

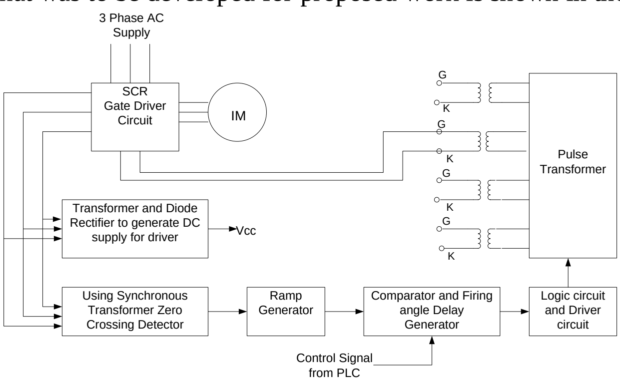

Fig.3. Block diagram of the hardware model to be prepared

Here a synchronizing center tap transformer is used to step down the supply voltage to suitable low value and the rectifying diodes are used to generate the DC power supply Vcc required to power other components in the driver circuit. This Vcc is used for gate triggering and pulse transformer. The zero crossing detector is composed of an operational amplifier which converts the AC synchronizing input voltage into a square wave signal. Diodes are used at the output stage of each OPAM to eliminate the negative pulses. The ZCD signal is given to another operational amplifier which generates ramp signal. This ramp voltage is compared with the control voltage coming from the controller i.e. PLC to generate firing angle delay for the gates of the SCRs.

The pulses of required duration will be generated at the instant when ramp voltage amplitude will be equal to the control voltage. If the control voltage is less than the ramp voltage the firing control signal will not be generated. This firing signal is given to the gates through the pulse transformers which also provide isolation between the low voltage control circuit and high voltage power circuit for protection.

V. FORWARD AND REVERSE DIRECTION CONTROL

To reverse the direction of rotation of an induction motor two of the supply lines from three phase supply is to be reversed. Suppose the R-Y-B are the three phases of the supply voltage and if phase Y is interchanged with phase B then the sequence will become R-B-Y and hence the power will also flow according to the changed sequence which will rotate the motor in opposite direction.

A circuit was designed using two SPDT relays to interchange two of the supply line. It contains three contact lines labeled as COM, NO and NC. COM is the moving contact of the switch. It is connected to NC when relay is off and its get connected to NO when relay is on. A 3 to 5V supply is enough to energies the relay.

VI. CONTROL SYSTEM

A Crouzet PLC having four inputs and outputs was used to generate the control signal required to produce the firing pulses. Millennium 3 software is used to develop the logic using Function Block Diagram. The FBD uses a comparator block to compare the set input value with the current input value and accordingly generate the digital output. This digital output is then converted to analog signal by digital to analog converter and then given to the comparator OPAM which compare it with the ramp signal to generate the delay firing pulse. The PLC works on 24V DC supply.

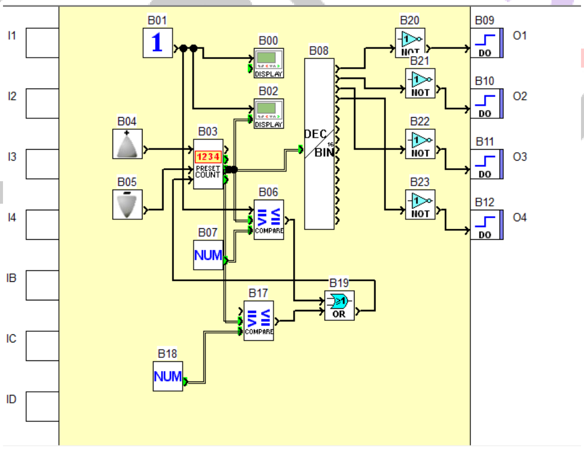

Fig.4. Programming using Function Block Diagram

The fig.3 shows the programming done in the millennium 3 software using Function Block Diagram. The up /down counter is used to increment or decrement the input value through the plus and minus buttons.

VII. HARDAWARE MODEL

Fig.5. shows the hardware model of the proposed system. The induction motor used to test the hardware is a three phase, 1hP, and 1415 rpm motor.

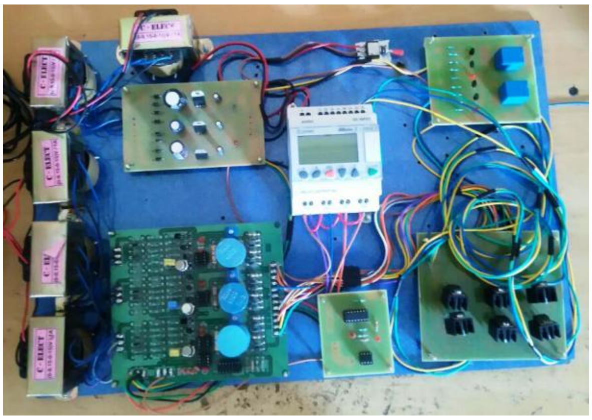

Fig.5. Hardware model

VIII. RESULTS

The FBD simulation results are shown in fig.6, fig.7 and 8.

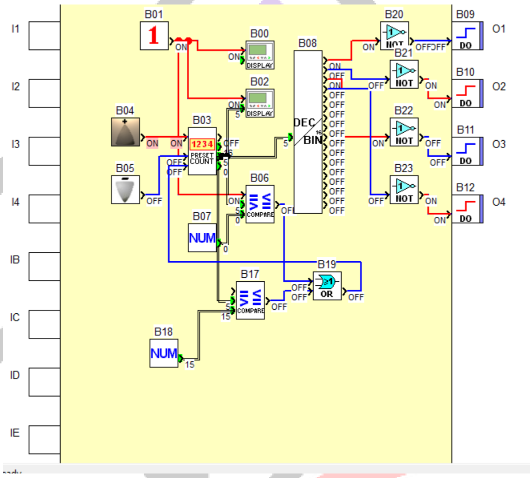

Fig.6. Simulation of FBD for input value 5

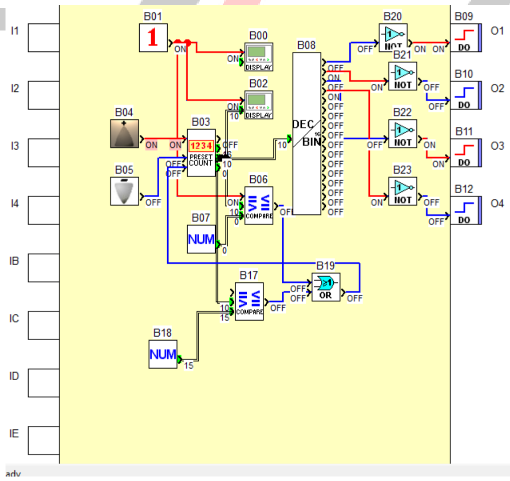

Fig.7. Simulation of FBD for input value 10

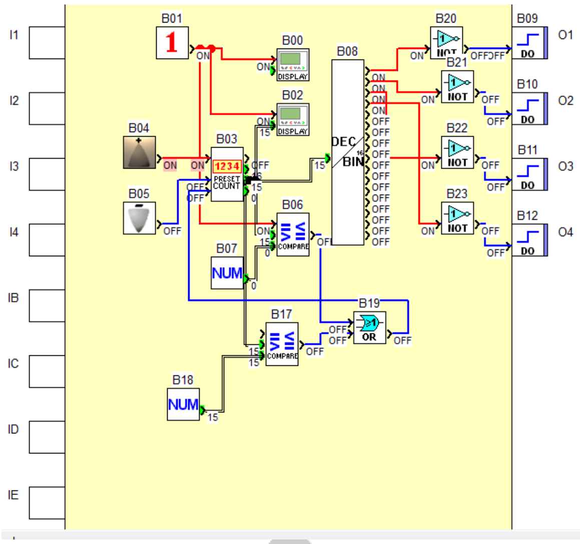

Fig.8. Simulation of FBD for input value 15

The simulation results for the different incremental values showed the change in digital values at the output terminals of the program as can be seen in the above figures.

IX. CONCLUSION

At the incremental value of 15 motor is supposed to run at the full rated speed as it is the maximum input value that has been programmed. Accordingly at the input values of 10, 5 etc. the motor is expected to run at relatively lower speeds respectively. Also the SPDT relays effectively switches the direction of rotation of the motor.

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