

SPEED CONTROL OF BLDC MOTOR USING PLC

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ABSTRACT

This paper deals with the speed control of BLDC motor using PLC. PLC is proposed as the essential tool in many different application. The brushless dc motor (BDCM) has been widely used in industrial applications because of its low inertia, fast response, high power density, high reliability, and maintenance free reputation. PLC proves themselves as a very versatile and effective tool in industrial control of electric drive. Based on hall sensor output signal of BLDC motor PLC triggers the driver circuit to generate the PWM signal which is given to the sensor of motor. Program is done in PLC to control speed and direction of BLDC motor. The PLC monitors input and activates the output control program.

Keywords: BLDC Motor, Inverter circuit, Programmable Logic Controller (PLC), PIC Controller, Driver IC.

I INTRODUCTION

1.1 Brushless DC Motor

Brushless Direct Current (BLDC) Motors are one of the motor types gaining popularity mainly because of their better linear characteristics and performance, the current to torque and frequency to speed relationship are linear of BLDC motor. It is used in industries such as Appliances, Automotive, Aerospace, Medical, Industrial Automation Equipment and Instrumentation. BLDC motor is a electric motor powered by direct current DC, it has a electronic commutation rather than mechanical commutation and Brushes. It has more poles on rotor rather than stator or reluctance motor. BLDC motor has many advantages over brushed DC motors and induction motors, it has better speed verses torque characteristics, high dynamic response, High efficiency, Long operating life, Noiseless operation, High speed ranges. BLDC motors are the type of synchronous motor. The Hall sensors are embedded on the stationary part of the motor, Whenever the rotor magnetic poles pass near the Hall sensors it gives high or low signal indicating the N or S pole is passing near the sensors.

1.2 Programmable logic controller

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. This use offers advantages such as lower voltage drop when turn on and the ability to control motors. Many factories use PLCs in automation processes to diminish production cost and to increase quality and reliability. To obtain accurate industrial electric drive systems, it is necessary to use PLCs interfaced with power converters, personal computers, and other electric equipments. Nevertheless, this makes the equipment more sophisticated, complex, and expensive.

The ratio of driving torque to the motor dimensions is very high in the BLDC motors and their speed torque curve is better than that of the brushed and induction motors. Such motors (BLDC) are therefore particularly suitable for applications where the volume available for drive installation is restricted. These advantages prompted the research into the control algorithm and control system simplification and drive fault detection. An industrial PLC was used for controlling BLDC motors in a five-axis rotor position, direction and speed, reducing the number of circuit components and lowering the cost. The rotor position can be sensed by a Hall-effect sensor providing three square-waves with phase shift in 120°. These signals are decoded by a combinatorial logic to provide the firing signals for 120° conduction on each of the three phases.

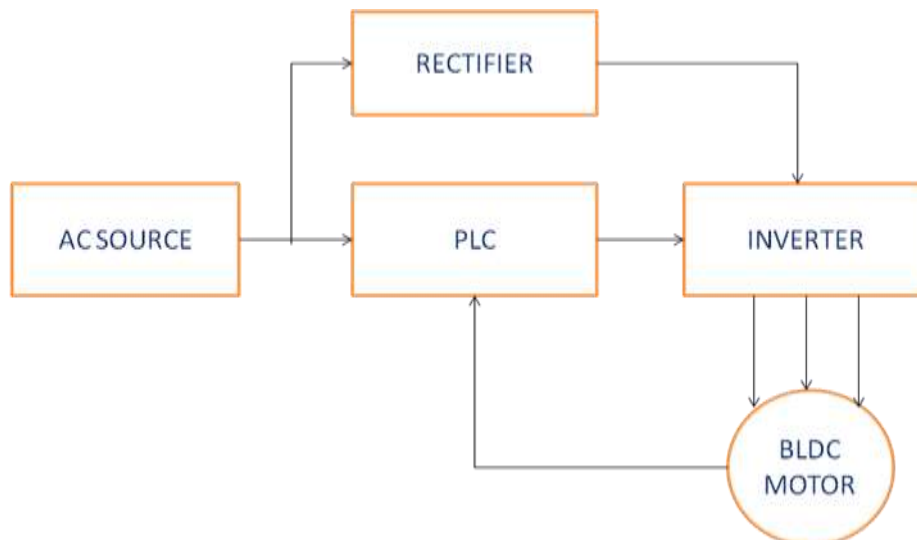


Fig 1 : Basic Block Diagram

II HARDWARE DESCRIPTION

The objective is to control the speed of BLDC Motor. The speed of the motor is sensed by Hall sensor which is embedded on the motor stator, the sensor output is in the form of High and Low, based on the sensor output the corresponding transistor are triggered to rotate the motor. PLC accepts 24Volts signal, the sensor output is in the form of 5 Volts, so the amplifier circuit is designed to drive PLC input. The transistor driver circuit requires 5V supply.

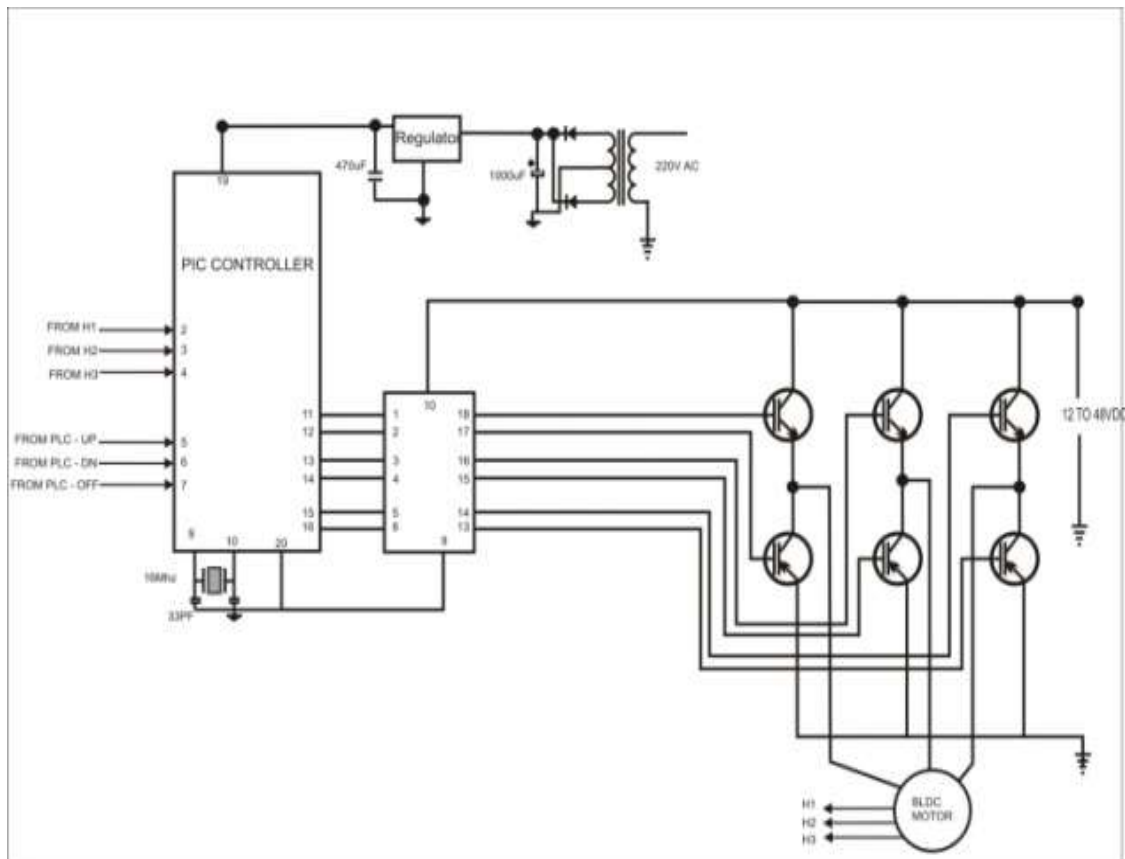


Fig 2: Circuit Diagram

The 230V ac supply is given to the step down transformer (230V/12V), which gives 12v output, which is to be converted into dc with the help of rectifier circuit. Voltage regulator IC's, IC 7805 and IC 7812 are used to obtain the constant output voltage of 5V and 12V respectively, which is required for the other components of the circuit. The 5V is given to the PIC controller and 12V is given to the inverter and driver IC which present in the circuit.

The input is given to the PLC, the output of PLC is digital signal which is fed to PIC controller. The function of PIC controller is to generate Pulse Width Modulation (PWM) signal and control the duty cycle of PWM signals. Then this signal is fed to the inverter circuit in which transistors are used. The ON and OFF operation of the transistor is decided by driver IC which is connected between PIC controller and inverter circuit .The function of driver IC is to provide isolation between controller and inverter circuit and it also decide on and off operation of transistors. The output of the inverter circuit fed to the stator windings of BLDC motor. The generated stator flux interacts with the rotor flux, which is generated by a rotor magnet defines the torque and thus the speed of motor.

There are always two phases on at any time to provide continuous torque. It is necessary to keep the angle between stator and rotor flux close to 90° for a BLDC motor to operate properly. Six step controls creates a total of six possible stator flux vectors. The stator flux vector must be changed at a certain rotor position. The rotor

position is usually sensed by Hall sensors. The hall sensors generate three signals that also comprise six states. The controller waits the signals supplied by the position sensors. Then the controller takes an action biasing the power transistor to switch them on or off so that the windings in the motor are powered according to the rotor position. The motor will run continuously as the system constructs a loop action and by varying the PIC controller output pulses speed of the BLDC motor is controlled.

III PLC 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.

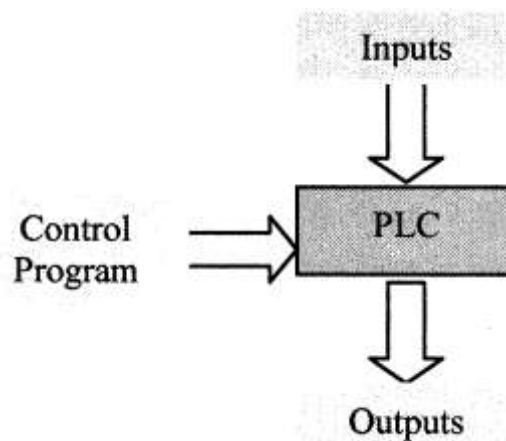
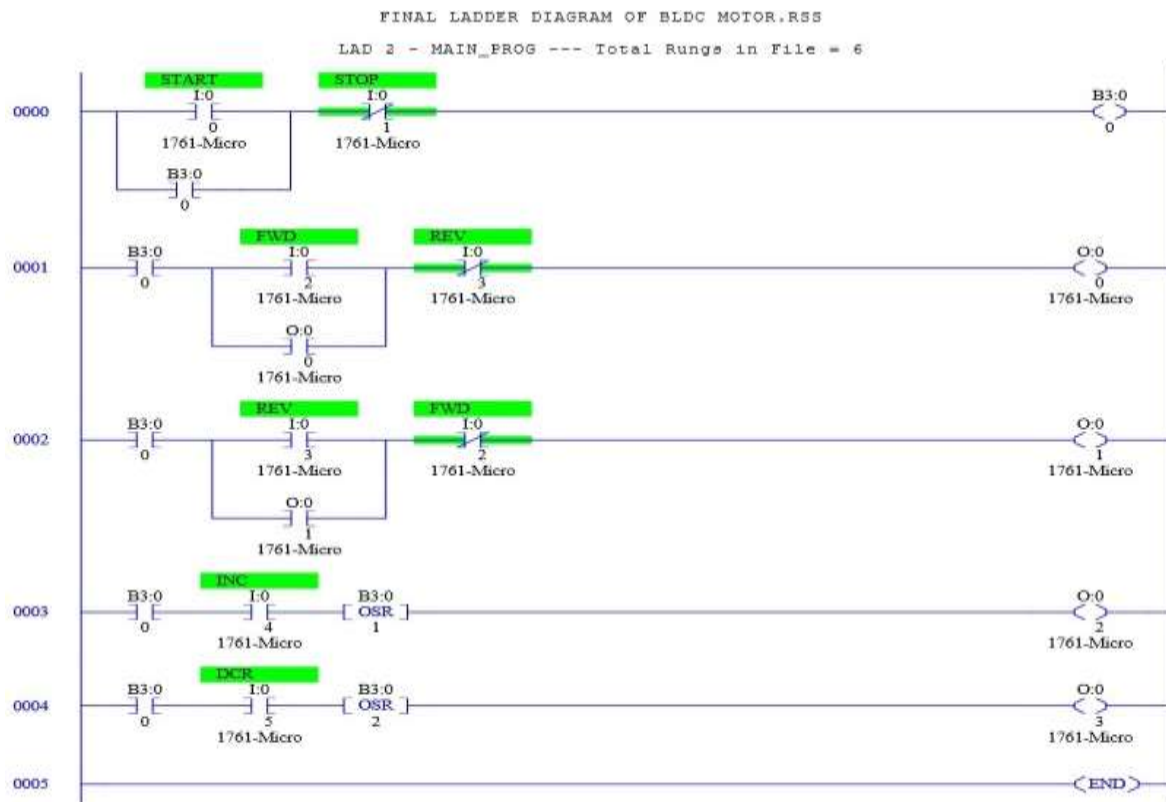


Fig. 3. Control Action of a PLC.

In our project Allen Bradley PLC Micrologix 1000 is used. The PLC has 10 inputs, and 6 outputs and two transistors which are mainly used to provide clock signal or PWM. Most of the outputs are relay outputs which are not fast enough to provide fast switching and have short life span. To overcome this, a transistor output card is attached to the PLC, so that all the output signals are taken from these transistors. The driving circuit is implemented to drive transistor controlling the BLDCM. Only two transistor are switched on at a time receiving the driving signal from the transistor outputs of the PLC. The circuit is built with six dual input NAND gates. The upper half utilizes three NAND gates, where one pin of each NAND gate is common to the PWM and the second pin receives 1 or 0 based on the rotor position. 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.



IV PLC PROGRAM

The PLC position is programmed so that only two output transistors are switched on based on the feedback sensors with the addition of programming the dedicated transistors to provide the PWM signal for the speed control. The rest of the program is to switch the output transistors on and off according to the three input statuses.

V RESULT

Thus the programming is done in PLC to control the speed of Brushless DC Motor. The various speeds are achieved by changing the duty cycles. Table below shows the speed of BLDC motor at different duty cycles.

Duty cycle	Speed (rpm)
20%	295
40%	398
60%	790
80%	990
100%	1200

VI CONCLUSION

This paper deals with the speed control of BLDC motor using PLC.. The aim of this paper is to develop a drive by using BLDC motor instead of Induction motor. In some cases IM are inefficient than BLDC motor. Due to the simplistic nature of this control, it has the potential to be implemented in a low-cost application-specific integrated circuit. The controller exploits the characteristic of most electromechanical systems. Furthermore, this control strategy does not require a state observer. Under dynamic load conditions, the proposed controller was found to be capable of regulating speed without the use of an observer. This results in a considerable reduction of size and the cost of the system.

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