CLOSED LOOP CONTROL FOR A BRUSHLESS DC MOTOR TO RUN AT THE EXACTLY ENTERED SPEED

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Abstract : The project is designed to control the speed of a BLDC motor using closed loop control technique. BLDC motor has various application used in industries like in drilling, lathes, spinning, elevators, electric bikes etc. The speed control of the DC motors is very essential. This proposed system provides a very precise and effective speed control system. The user can enter the desired speed and the motor will run at that exact speed.

Based on the principle of PWM speed can be controlled. This is achieved by keeping BLDC motor on closed loop feedback by giving RPM reference to the microcontroller upon a shaft mounted IR reflection arrangement. The pulse width modulation would be automatically adjusted to maintain the DC power to the motor such that entered speed percentage matches the RPM. An LCD duly interfaced to the microcontroller to display the running speed. The desired speed in percentage of full speed is fed with the help of keypad. The controller delivers desired pulse width to automatically adjust the DC power to the motor for required speed. The above operation is carried out by using one thyristor for driving the BLDC motor with IR sensing for getting the speed reference to the microcontroller. The power supply consists of a step down transformer 230/12V, which step down the voltage to 12V AC. This is converted to DC using a Bridge rectifier and it is then regulated to +5V using a voltage regulator. Which is required for the operation of the microcontroller and other components Further the project can be enhanced to a fully-fledged fuzzy logic control of a BLDC motor for industrial applications. It can also be developed for an intelligent cruise control used in modern automobiles these days.

***IndexTerms* - BLDC motors, Microcontroller AT89S52, Pulse Width Modulation**

I. INTRODUCTION

1.1 GENERAL BACKGROUND

Permanent magnet brushless DC motor is a superior speed performance, simple structure, reliable operation, easy maintenance electromechanical integration motor. It is now widely used in servo control, medical equipment, instrumentation, robotics, household appliances, computers and military and other fields. In general, there are three kinds of permanent magnet brushless DC motor control method currently such as the utilize of controller chip, on the basis of the series single-chip microcomputer control and applying the high performance digital signal processor control.

The control system constituted by ASIC controller chip is simple, low cost. Bur since the IC control chip can complete all the work from the position detection decoding to the PWM modulation output in the hardware, the system functions cannot be further expanded. In most cases SCM control system is applied. However, from the two aspects: the working speed and accuracy, brushless DC motor control system based on the general SCM could not be compared with high-performance digital signal processor. Rather than to obtain approximate results by look-up table method, rapid DSP computing capability enables the digital control system to calculate in real time. The internal structure of control system can achieve more complex control algorithms, so that the speed loop and current loop can be implemented in digital form, and a full digital brushless DC motor control system is achieved. In this paper, the control scheme based on the DS2 brushless DC motor is presented Current and speed double closed-loop control strategy is used to achieve precise control for whole system.

Brushless DC (BLDC) motors are preferred as small horsepower control motors due to their high efficiency, silent operation, compact form, reliability, and low maintenance. However, the problems are encountered in these motor for variable speed operation over last decades continuing technology development in power semiconductors, microprocessors, adjustable speed drivers control schemes and permanent-magnet brushless electric motor production have been combined to enable reliable, cost-effective solution for a broad range of adjustable speed applications.

1.2 PROJECT JUSTIFICATION

In a BLDC motor, the electromagnets do not move; instead, the permanent magnets rotate and the armature remains static. This gets around the problem of how to transfer current to a moving armature. In order to do this, the commutator assembly is replaced by an intelligent electronic controller. The controller performs the same power- distribution found in brushed DC-motor, but using a solid-state circuit rather than a commutator. BLDC motors have many advantages over DC motors. A few of these are:

•High dynamic response
•High efficiency
•Long operating life
•Noiseless operation
•Higher speed ranges

BLDC's main disadvantage is higher cost which arises from two issues. First, BLDC motors require complex electronic speed controllers to run. Brushed DC-motors can be regulated by a comparatively trivial variable resistor (potentiometer or rheostat), which is inefficient but also satisfactory for cost-sensitive applications.

II.PROPOSED METHOD

Closed loop control for a brushless dc motor to run at the exactly entered speed is a system that controls the BLDC (brushless dc) motor speed according to the user defined speed. In other words, this system runs the motor at 25%,50% or 75% of the total speed when user set this percentage of speed from digital keypad. Different variable speed drives are available in market which have been using different control techniques but here we have designed this system with the help of closed loop control technique. Normally to run the BLDC motor at desired speed is very difficult task but here we have made this so much easy with the help of this closed loop control for a BLDC motor to run at the exactly entered speed system. This system has designed with the help of, step down ac transformer, bridge rectifier, voltage regulator, LCD display, microcontroller belongs to 8051 family, MOSFET, speed sensors and OPTO isolator for driving the BLDC motor. It is less costly, more compact, controls the motor speed more precisely and effectively as compared to other system. The block diagram of this closed loop control for a brushless dc motor to run at the exactly entered speed system.

The proposed system uses a microcontroller of the 8051 family and a rectified-power supply. A set of IR transmitter and photodiode are connected to the microcontroller for counting the number of rotations per minute of the DC motor as a speed sensor. Opto coupler is connected to trigger the MOSFET for driving the BLDC motor which is duly interfaced to the microcontroller. A matrix keypad is interfaced to the microcontroller for controlling the speed of the motor. The speed control of the BLDC motor is archived by varying the duty cycles (PWM Pulses) from the microcontroller according to the program. The microcontroller receives the percentage of duty cycles from the keypad and delivers the desired output to switch the motor driver so as to control the speed of the BLDC motor. The speed sensed by the IR sensor is given to the microcontroller to display it on the LCD display.

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Though various control techniques are discussed in basically two methods are available for controlling BLDC motor. They are sensor control and sensor less control. To control the machine using sensors, the present position of the rotor is required to determine the next commutation interval. Motor can also be controlled by controlling the DC bus rail voltage or by PWM method. Some designs utilize both to provide high torque at high load and high efficiency at low load.

Such hybrid design also allows the control of harmonic current In case of common DC motors, the brushes automatically come into contact with the commutator of a different coil causing the motor to continue its rotation. But in case of BLDC motors the commutation is done by electronic switches which need the rotor position. The appropriate stator windings have to be energized when rotor poles align with the stator winding. The BLDC motor can also be driven with predefined commutation interval. But to achieve precise speed control and maximum generated torque, brushless commutation should be done with the knowledge of rotor position. In control methods using sensors, mechanical position sensors, such as a hall sensor, shaft encoder or resolver have been utilized in order to provide rotor position information.

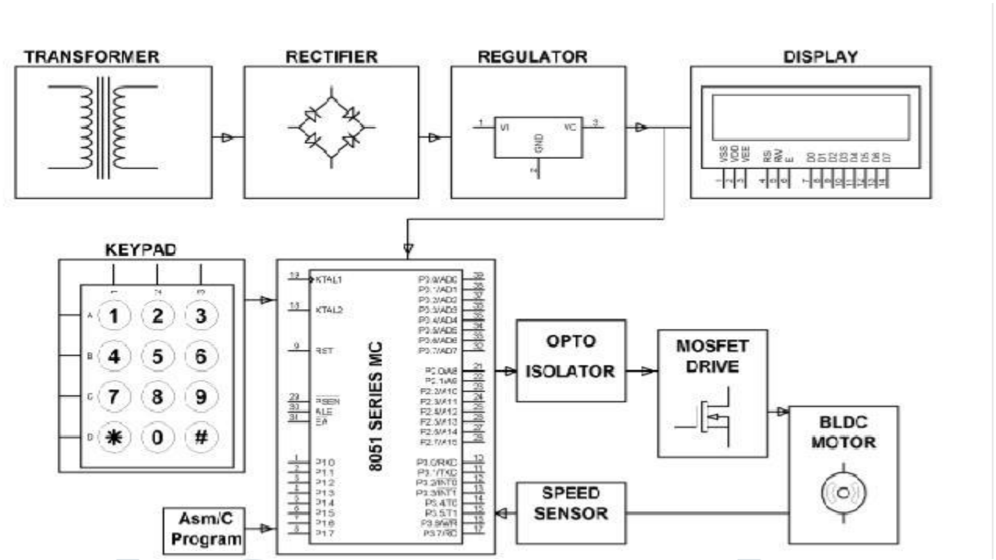


Fig.2.1: Block Diagram of Closed Loop Control for a Brushless DC Motor to Run at the Exactly Entered speed.

III. HARDWARE REQUIREMENT

Microcontroller AT89S52, IR pair Sensor, DC motors, LCD, Keypad, Thyristor, Power Supply, Misllaneous Component, Software Requirement

TOOL: The KEIL U version IDE which Keil C51 Product is a complete software development environment for the 8051 microcontroller family. Us Flash+ Ver. 4.0.0 programmer for MCS51 microcontrollers developed by UC micro systems.

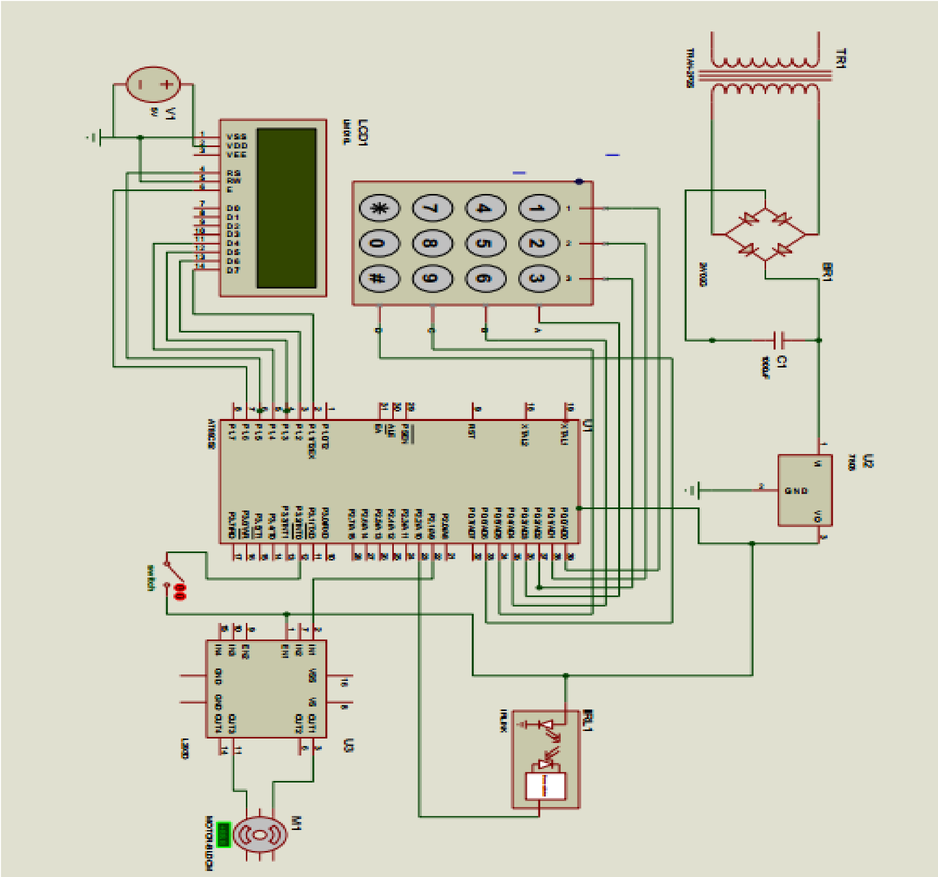
The development of semiconductor electronics in the 1970s allowed the commutator and brushes to be eliminated in DC motors. In brushless DC motors, an electronic servo system replaces the mechanical commutator contacts. An electronic sensor detects the angle of the rotor, and controls semiconductor switches such as transistors which switch current through the windings, either reversing the direction of the current, or in some motors turning it off, at the correct time each 180° shaft rotation so the electromagnets create a torque in one direction. The elimination of the sliding contact allows brushless motors to have less friction and longer life; their working life is only limited by the lifetime of their bearings.

Brushed DC motors develop a maximum torque when stationary, linearly decreasing as velocity increases. Some limitations of brushed motors can be overcome by brushless motors; they include higher efficiency and a lower susceptibility to mechanical wear. These benefits come at the cost of potentially less rugged, more complex, and more expensive control electronics. A typical brushless motor has permanent magnets which rotate around a fixed armature, eliminating problems associated with connecting current to the moving armature. An electronic controller replaces the brush/commutator assembly of the brushed DC motor, which continually switches the phase to the windings to keep the motor turning. The controller performs similar timed power distribution by using a solid-state circuit rather than the brush/commutator system.

Brushless motors offer several advantages over brushed DC motors, including high torque to weight ratio, more torque per watt (increased efficiency), increased reliability, reduced noise, longer lifetime (no brush and commutator erosion),

elimination of ionizing sparks from the commutator, and overall reduction

of electromagnetic interference(EMI). With no windings on the rotor, they are not subjected to centrifugal forces, and because the windings are supported by the housing, they can be cooled by conduction, requiring no airflow inside the motor for cooling. This in turn means that the motor's internals can be entirely enclosed and protected from dirt or other foreign matter. Brushless motor commutation can be implemented in software using a microcontroller or microprocessor computer, or may alternatively be



3.1 Circuit Diagram

implemented in analogue hardware, or in digital firmware using an FPGA. Commutation with electronics instead of brushes allows for greater flexibility and capabilities not available with brushed DC motors, including speed limiting, "micro stepped" operation for slow and/or fine motion control, and a holding torque when stationary. Controller software can be customized to the specific motor being used in the application, resulting in greater commutation efficiency.

The maximum power that can be applied to a brushless motor is limited almost exclusively by heat too much heat weakens the magnets and will damage the winding's insulation.

When converting electricity into mechanical power, brushless motors are more efficient than brushed motors. This improvement is largely due to the frequency at which the electricity is switched determined by the position sensor feedback. Additional gains are due to the absence of brushes, which reduces mechanical energy loss due to friction. The enhanced efficiency is greatest in the no-load and low-load region of the motor's performance curve. Under high mechanical loads, brushless motors and high- quality brushed motors are comparable in efficiency.

Environments and requirements in which manufacturers use brushless- type DC motors include maintenance-free operation, high speeds, and operation where sparking is hazardous (i.e. explosive environments) or could affect electronically sensitive equipment.

The construction of a brushless motor may resemble that of a stepper motor. Unlike a stepper, a brushless motor is usually intended to produce continuous rotation. Stepper motors generally do not include a shaft position sensor for internal feedback of the rotor position. Instead a stepper controller will rely on a sensor to detect the position of the driven device. They are frequently stopped with the rotor in a defined angular position while still producing torque. A well designed brushless motor system can also be held at zero rpm and finite torque.

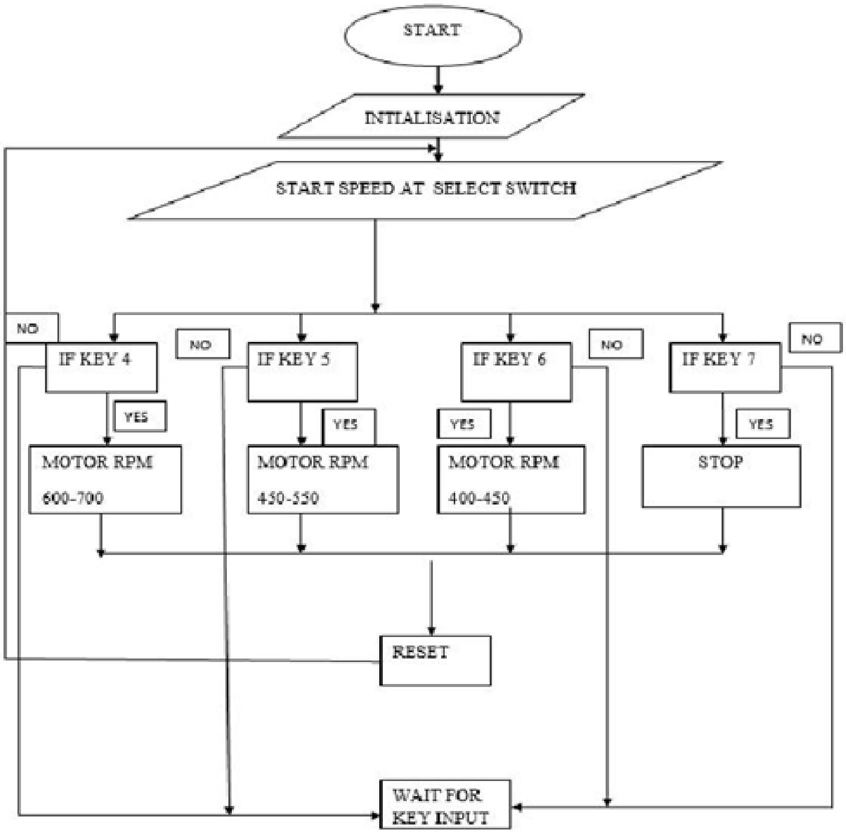


Fig.4.2: Flow Chart

IV. RESULTS AND DISCUSSION

The hybrid integrator back stepping controller is proposed for robotic manipulators actuated with brushless dc motors in the presence of arbitrary uncertain inertia parameters of the manipulator and the electrical parameters of the actuators.

However, the study of the control of robots actuated by the BLDCM was relatively Recent. In a robust feedback linearizing control was proposed. By using integrator back stepping techniques, robust and adaptive controllers are proposed, respectively. It should be noted however that all those results are suitable only for a single-link manipulator (an inertial load).

The objective of this study is to develop a control scheme for a rigid n-link manipulator where the joint actuators are driven by BLDCM's. Based on the integrator

back stepping techniques, a hybrid integrator back stepping controller (i.e., adaptive and robust adaptive) is proposed. The proposed controller has the following features: • It does not require joint acceleration feedback.

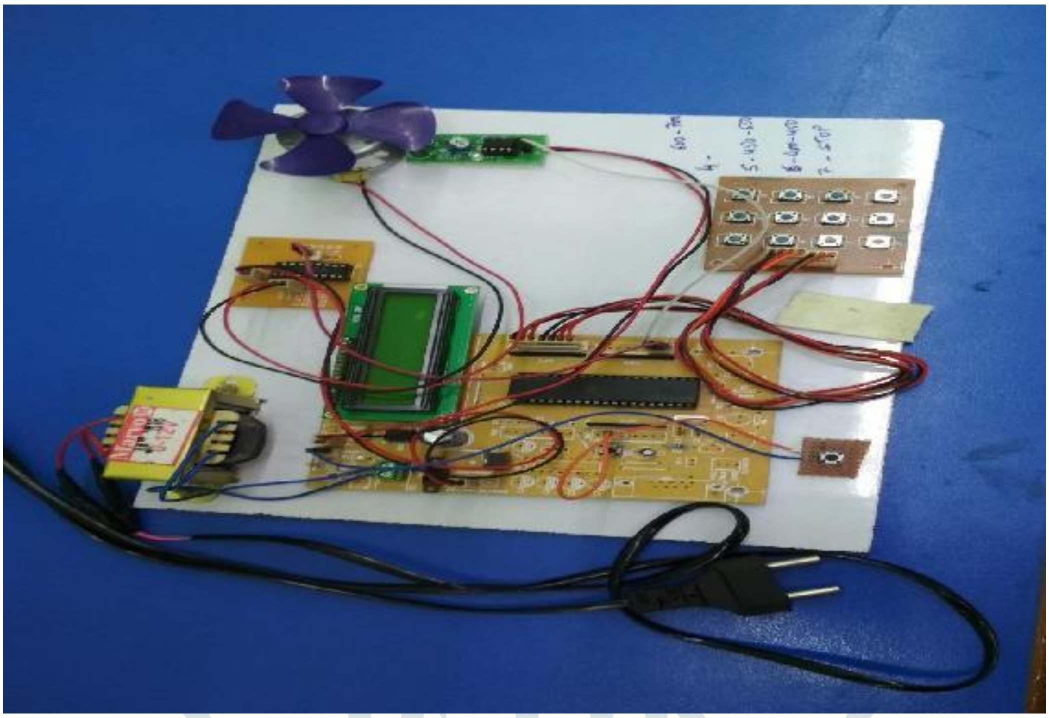


Fig.4.1 Proto Type Modal Of Closed Loop Control For A Brushless Dc Motor To Run At The Exactly Entered Speed

4.2 APPLICATION AND ADVANTAGES:
1.By using this closed loop control for BLDC motor system, the user can easily run BLDC motor any speed.
2.This closed loop control for BLDC motor system could be used in drilling machines, lath machines, spinning machines, elevators and electric bikes.
3.This system controls the BLDC motor speed more efficiently and precisely as compared to other systems.
4.It is friendly to use no need of any expert person.
5.It is less costly as compared to other systems.
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V.CONCLUSION

The hardware for closed loop control of BLDC motor using microcontroller is designed. By using the PWM technique speed of the BLDC motor was controlled and it was made to run at exactly entered speed. In future this hardware will be implemented in dSPACE and the speed control will be observed.

By this paper, the working of BLDC motor which is controlled by microcontroller is shown. BLDC motors possess high efficiency. In BLDC motor PM are on the rotor & electromagnets are on the stator controlled by software

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