Computer Controlled DC Servo Motor

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Abstact

Servomotors are important in industry according to its ability to quick response and precise positioning. There are lots of places where the servomotors are used. In robotic applications servomotors are used to move the robotic part to a relevant position by means of controllers & as all most all most all automated manufacturing lines in industry also use servomotors. Those are available with various ratings in DC (and AC is also available).

If the cost of a servomotor compared with a general-purpose motor with the same capacity it can see that the servomotor will be much costly. That is because of its construction. The rotor has constructed with a special material which is of less weight but capable of producing the necessary magnetic flux. Then the resultant advantage is low inertia of the armature. So it is capable of starting and stopping immediately with the power on & off. This property leads to use the servomotors for above mentioned applications and different positioning capability.

High cost is the major drawback, therefore the small-scale manufacturers / users cannot afford those high prices. Objective of this project was to design a computer controlled servo drive, which is capable controlling low cost general-purpose permanent magnet DC motor.

1 INTRODUCTION

Out of the common methods used in industry for DC motor controlling H Bridge was selected for this project because it is capable of run the motor in both directions easily.

H Bridge was designed with high power capability therefore it can be used to drive motors with different power ratings. Special Driver circuit designed to drive the bridge. System is fully computer controllable. Speed and current feedbacks are taken to provide closed loop control for the system.

Both closed loop and open loop control algorithms have developed control the speed in both directions, quick start for given speed, sudden change of direction of rotation and quick stopping with different types of braking methods.
In addition to that the system includes open loop and closed loop algorithms for position control requirements. Basically our motor driver design consists of five sections. Figure 1 shows the basic block diagram of the system.

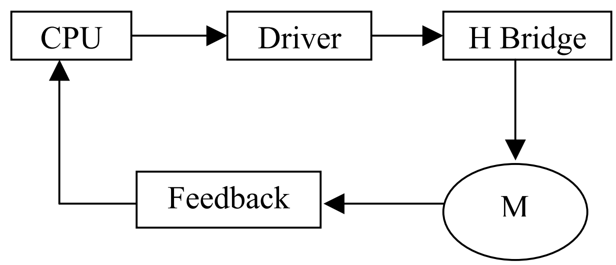

Figure 1 - Basic Block Diagram

2 POWER CIRCUIT

Power circuit is the H Bridge consists of four NPN type power Mosfets. The main concerns in this power circuit are high current charring capacity with low switch on resistance to enhance the high power capability of the circuit and higher switching speed.

Selection of Mosfets

Normally powers Mosfets are faster in switching and when they are ON they provide a low resistance acting as short circuited. But conventional bipolar transistors offer a high ON resistance eating away most of the voltage provided by the motor supply. Therefore Mosfets are selected for switching mode bridge. Also for braking operation the bridge transistors should be capable of reverse current handling. In this point significant difference now becomes apparent between the Mosfets smart power transistors and conventional bipolar configuratioin.

Since active Mosfet transistors have their build in body diode, they can be reversed conductive while bipolar transistors do not have this property. Also the Mosfets selected (IRF 640) for this circuit have a current rating of 18A. Therefore they can handle high current when the motor is loaded and during switching.

H Bridge

There are integrated with H bridge configuration, but they are not capable of handling high currents and they are provided with restricted operating conditions.

But developed H Bridge is provided with high power capability and high reliability. Most important feature of this circuit is easily adoptable to many systems with different varieties of driver circuits.

3 POWER CIRCUIT DRIVERS

To fire the MOSFETs it is needed to give a suitable gate voltage with respective to the source. As MOSFETs we used are n-channel type, two different gate voltages should be applied to the each pair of MOSFETs.

Two duel MOSFET drivers are used to drive the MOSFETs.

Low side driver-Max627

Duel non-inverting low side driver is used to drive the low side MOSFETs.

High side driver-Max1822

Step up driver is used with an analog switch (duel) to drive high side MOSFETs. Even it is possible to use two low side Drivers with two separate -power suppliers. But the important advantage of using two MOSFETs drivers as low /side and high side is there is no need to have two separate suppliers.

4 FEEDBACK CIRCUIT

To control the motor three feedbacks are taken from the motor.

Speed, Armature Current and Voltage

Speed Feedback: Tachometer is used to measure the speed. It generates DC voltage proportionate to the speed of the motor.

Armature Current Feedback: Current shunt is used to measure the current through the motor.

Voltage Feedback: Measure the voltage across motor terminals and using potential divider step down to appropriate value.

A/D Converter and Analog Multiplexer

8-Bit analog to digital converter is used to convert the analog inputs. 4 Channel Analog Multiplexer is used to choose the relevant value to Analog to Digital Converter. Analog to Digital converter converts the analog value to the digital value in the pre running mode.

5 APPLICATION SOFTWARE

Visual Basic is used as the programming language to implement the application software. The most important part of the program is to generate PWM output. Standard Parallel port is used as interfacing devices. Servo characteristics are obtained by changing the switching pattern of the MOSFETs as appropriately.

Speed controlling of the servo is done in following methods.

1.Open loop Controlling Method (Normal operation)
2.Open loop Controlling Method (Quick Response)
3.Open loop Controlling Methods (Quick Brakings)
4.Closed loop Controlling Method with PIDcontroller

Position controlling of the servo is done in following methods.

1.Open loop Controlling Methods (Quick Brakings)
2.Closed loop Controlling Method with PID Controller

For each controlling method of operation current feedback is used to limit the current for safe operation. Note: Even for open loop controlling over current is limited

6 CONTROL MODES

Basically two control modes are possible in the case of dc motor speed control.

- Voltage control
- Current control

Controlling Methods

A simplest method to control the rotation speed of a DC motor is to control its driving voltage. The higher the voltage is the higher speed the motor tries to reach. In many applications a simple voltage regulation would cause lots of power loss on control circuit, so a pulse width modulation method (PWM) is used in many DC motor-controlling applications. In the basic Pulse Width Modulation (PWM) method, the operating power to the motors is turned on and off to modulate the current to the motor.

The PWM control method uses the widths of pulses in a pulse train to control the speed of the motor.

The pulses are arranged such that only one pulse occurs for every period of the system clock. The duty cycle of the pulses determines the speed of the motor. Therefore, the higher the duty cycle the higher the speed. This would give the motor the ability to safely vary the speed from stand still to its maximum safe speed. For this reason the PWM method was chosen to be implemented in this design.

Sometimes the rotation direction needs to be changed. In normal permanent magnet motors, this rotation is changed by changing the polarity of operating power (for example by switching from negative power supply to positive or by interchanging the power terminals going to power supply). This direction changing is typically implemented using relay or a circuit called an H bridge.

When a motor speed controller is used, it varies the voltage fed to the motor. Initially, at zero speed, the controller will feed no voltage to the motor, so no current flows. As the motor speed controller's output voltage increases, the motor will start to turn. At first the voltage fed to the motor is small, so the current is also small, and as the motor speed controller's voltage rises, so too does the motor's back EMF. The result is that the initial current surge is removed, acceleration is smooth and fully under control.

The motor controllers are to be used in this design are to control the main drive and steering systems. Since similar motor types are to be used for the steering and drive systems, a single controller can be used for both functions.

A micro controller can be used to produce the PWM signal. There are micro controllers designed to But produce PWM output and others that can be are programmed to do so. But programming the computer to produce the PWM out put could assemble eliminate the need for additional hardware, saving on the overall cost of the motor drive circuit.

RESULTS

Our objective is to make a driver circuit for a permanent magnet DC motor and to control the motor using a computer interface. Popular H Bridge is used to run the motor.

We were able to make a successful power circuit suitable for our project. It can handle 400V voltage and 18A according to the MOSFETs ratings of the bridge. But it is not suitable to operate at that level with out snubbers. We did not include any snubbers because we did not observe much voltage spikes between source and drain under normal operation.

But when sudden direction changes occurring MOSFETs produces a little spike. By considering the ratings of the MOSFETs we can neglect that. In high power applications it is required to include snubbers across each MOSFET. To drive the H Bridge driver circuit is used. For above Bridge two MOSFETs driver circuits were made by us. First on consist of two identical low side MOSFETs drivers, which should operate with two voltage levels. For that it is needed to use two power suppliers or single supplier with external step down or step up device Then we were able to use High side MOSFETs driver with Low side MOSFETs driver by using a single supply. For that circuit we had to include an analog switch. It is suitable for any DC motor with rated voltage of up to 24V. For closed loop operation three feedbacks were needed. The feedback circuit was designed to take all three feedbacks using same analog to digital converter using an analog multiplexer, but up to now we were able to measure motor current only. The problem associated is that we are using only one parallel port It is very difficult to spare time for read three feedback data as output ports are active all the time.

CONCLUSION

Remedy for the problems associated with single parallel is to use two parallel ports. Then additional one can be used to data input purpose only. When considering additional cost required for parallel port it is very economical to use a micro controller. The other reason for the timing problem is that we are using VB a low-level language. We feel that it is most suitable to use high-level language like assemble for this application to overcome above-mentioned timing problem.

REFERENCES

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