PC BASED SPEED CONTROLLING OF A DC MOTOR

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ABSTRACT

The DC motor is an attractive piece of equipment in many industrial applications requiring variable speed and load characteristics due to its ease of controllability. The "Chopper drive" based speed controlling method is superior in comparison to "Thyristor Controlled Bridge Rectifier" method as far as DC motor speed controlling is concerned. PC based software controlling is adopted to retain simplicity & ease of implementation.

This paper is written with the objective of illustrating how the speed of a DC motor can be controlled using a chopper drive. It further explains the methodology used in obtaining the speed feedback, software implementation of the PID controller and the required signal generation to drive the chopper. A Closed-loop Feedback Control System adopted, brings the motor to the speed set by the user irrespective of the load.

1. INTRODUCTION

Standard shunt motors are classified as either constant speed or adjustable speed motors. Adjustable speed motors may be operated over a wide speed range by controlling armature voltage and/or field excitation. The speed below the base speed can be controlled by armature voltage control method and field control method is used for speeds above the base speed.

For the last thirty years, the development of various solid state switching devices in the Thyristor/Transistor families along with varieties of analog/digital chips used in control/firing circuits, has made an impact in the area of DC drives. These power electronic (solid state) controllers are of two types:

1. Thyristor Bridge Rectifiers (Converters) supplied from ac supply).
2. Chopper Drives fed from DC supply.

The Chopper Driver method has the following advantages over Thyristor Bridge Rectifiers method:

1. High energy efficiency
2. Flexibility in control
3. Quick Response
4. Light weight & compact control unit.
5. Less ripple in the armature current.
6. Small discontinuous conduction region in the Speed-Torque plane.
7. Small discontinuous conduction region improves the speed regulation and transient response of the drive.
8. Less amount of machine losses due to less ripple in the armature current.
9. Ability to control down to very low speeds.

2. AIM AND OBJECTIVES OF THE PROJECT

The aim of our project was to implement a complete automatic speed control system for a DC motor. Having obtained a 0.5kW DC motor (considered to be a suitable prototype for a typical industrial application) from the Electrical Machine Lab, the project was carried out with the following objectives:

1. Implementation of Speed and Current Feedback circuitry
2. Software Implementation of the closed loop controller. (Including PID controller)
3. Implementation of the Chopper Drive.
4. Implementation of a PWM Signal Generator.

3. SCHEMATIC DIAGRAM OF THE SPEED CONTROL SYSTEM.

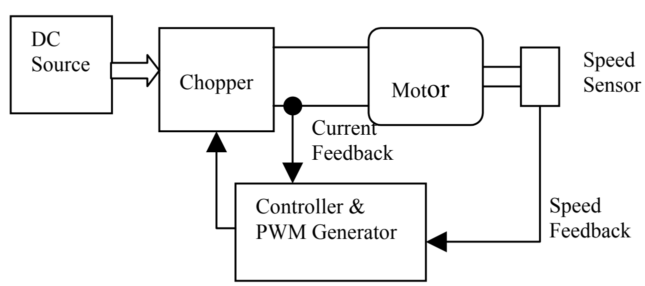

Fig: 3.1

The hardware and software implementation of each part is discussed in detail in the following sections.

4. PWM CHOPPER DRIVE

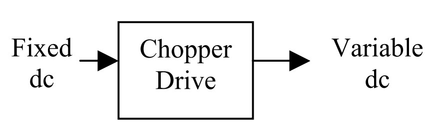

Fig: 4.1

The action of a DC Chopper is to apply a train of unidirectional voltage pulses to the armature winding of the dc motor as shown in the following diagram.

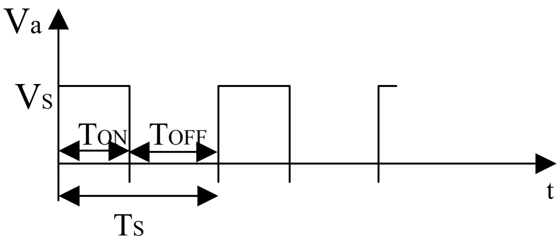

Fig: 4.2

By varying the duty factor, average armature voltage can be controlled.

$$(V_a)_{avg} = \frac{T_{ON}}{T_s} V_s$$

If T_{ON} is varied, with T_S kept constant, the resultant voltage wave represents a form of “Pulse Width Modulation” or PWM and hence the Chopper is named as the PWM Chopper.

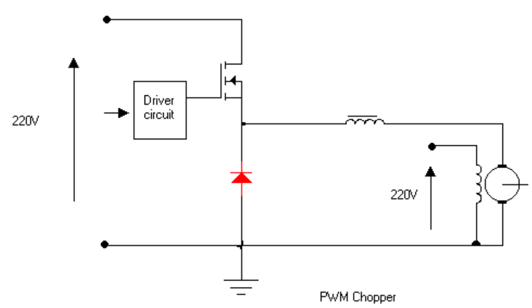

Fig: 4.3 Basic (Class A) Chopper circuit

The basic Chopper circuit, often referred to as a Class ‘A’ Chopper is shown in Fig.4.3. This form of chopper connection is sometimes called a “buck” or “step down” converter because the output voltage cannot exceed the input voltage level.

The Chopper switch ‘S’ in earlier days was a Thyristor, which required an additional Thyristor to switch OFF. Nowadays, a GTO is used which can be turned OFF through its gate. Also, a Power Transistor/ Power MOSFET can be used instead and a high Chopping frequency can be obtained as a result.

We implemented a Class ‘A’ Chopper with an IGBT, which served well enough to demonstrate our project objectives.

The whole implementation of chopper can be divided into the following steps.

1. Selection of devices. (IGBT and Freewheeling Diode)
2. Implementation of suitable driver circuit for the IGBT.
3. Determination of suitable heat sink sizes.
4. Design and implementation suitable protection schemes.

5. PWM SIGNAL GENERATION

The PWM control algorithm generates a signal corresponding to the speed error input. This 12-bit digital signal is sent out via parallel port to a Digital to Analog converter(DAC). Analog output is used as a reference level to a comparator which compares the voltage level with a **saw-tooth** waveform.
The output of the comparator gives the required PWM output. As speed changes, the duty factor of the PWM signal is changed.

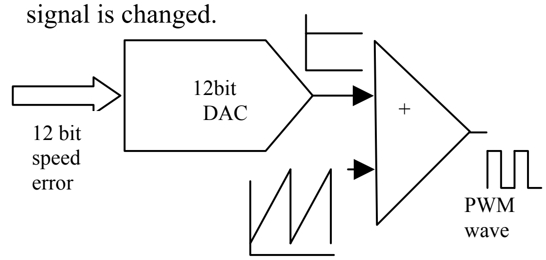

Fig: 5.1

In order to make the circuit more reliable and compact, **TL 494 SMPS** controller IC was used. The analog output of DAC was directly fed into this IC to obtain the PWM signal to drive the chopper.

6. DATA ACQUISITION

This refers to the reading of the speed of the motor and over current detection.

6.1 Speed Feedback

A photo sensor is used as the key element in detecting the speed. The number of clock signals that falls within a period of high state of phototransistor output is fed to a counter. The counter output is fed into PC via parallel port having passed through latches. This is a 12-bit number and once fed, is converted to the corresponding rpm value by the program running on the PC.

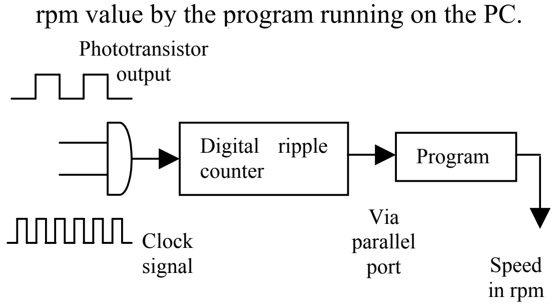

Fig: 6.1

6.2 Over Current Detection

A circuit was design to set a pin in the parallel port of the PC to high state, in case of an over current in the motor. Program detects the state of this pin regularly. If an over current occurs, program, having picked up this signal, uses it to either reduce the armature voltage or stop the motor.

7.CONTROL SIGNAL GENERATI-ON AND IMPLEMENATION OF PID CONTRLOLLER IN SOFT-WARE.

The program runs on a windows based platform. The coding was done in Visual Basic. Since VB does not have the capability in directly accessing the ports, a special DLL file was added to the system.

The program code included the commands to generate various control signals required to drive the hardware circuitry and the implementation the PID controller on the speed error input in order to achieve fast and smooth speed response.

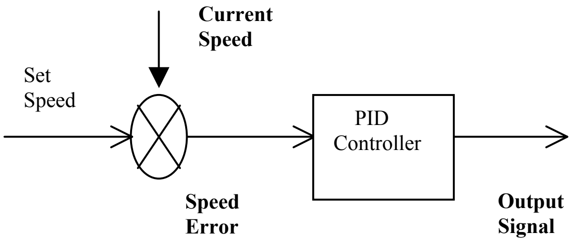

Fig: 6.2

In addition, the program has the functionality to detect motor over-current and reduce the armature voltage accordingly.

8. CONCLUSION

Considering the available time frame and other constrains we could conclude that

- The motor can be started/stopped and made to retain a set speed irrespective of the load.
- The motor can be run as low as 100rpm and as high as 1500rpm.
- Program interface is user-friendly enabling flexible and simple operation.
- PID controller enable the motor to reach the speed smoothly and within an acceptable period of time.
- Since we control the average armature voltage, speed could be control only below the rated speed.
- Though PC was used in controlling due to ease of programming and simplicity, in particular as a demonstrative prototype, a suitable microcontroller could be used in industrial applications

9. ACKNOWLEDGMENT

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