Design and Development of LabVIEW Based DC Motor Speed and Direction Control System

Md. Selim Reza
Department of EEE
University of Dhaka
Dhaka-1000, Bangladesh

Md. Atiar Rahman
Electronics Division
Atomic Energy Centre
Dhaka-1000, Bangladesh

Md. Abdullah Al Mamun
Electronics Division
Atomic Energy Centre
Dhaka-1000, Bangladesh

Mohaimina Begum
Electronics Division
Atomic Energy Centre
Dhaka-1000, Bangladesh

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. Speed of a DC motor varies proportional to the input voltage. With a fixed supply voltage the speed of the motor can be changed by switching the supply on and off so frequently that the motor notices only the average voltage effect and not the switching operation. This paper focuses on controlling the speed and direction of a DC motor using PWM technique (varying duty cycle of a square wave) and Data Acquisition Systems. DAQ card along with LabVIEW are used to create the virtual instrument for designing a real time embedded controller for controlling the speed and direction of a DC motor.**

Keywords- LabVIEW; VI; Sub VI; DC Motor; L293D; DAQ Card; PWM

I. INTRODUCTION

DC motors are used for certain applications where ac motors cannot fulfill the need. They are in general much more adaptable to adjustable speed drives than ac motors which are associated with a constant speed rotating fields. Indeed this susceptibility of dc motors to adjust their operating speed over wide ranges and by a variety of methods is one of the important reasons for strong competitive position in modern industrial drives [1].

There are many different ways to control the speed of dc motors but one very simple and easy way is to use Pulse Width Modulation. The speed control can be made based on microcontroller. There exists a lot of company to provide microcontroller based dc motor speed control system. Kits'n'Spares is providing such systems. The price of such a system is USD 30 [2]. However, they are not easy to design and modifications, up-gradations are also difficult. On the other hand, the LabVIEW software can be used to create the virtual instrument (VI) to control the speed and direction of a dc motor. This kind of system is flexible, chip and easy to modify.

So the objective of this paper is to design and develop a LabVIEW based speed and direction control of dc motor. This paper is illustrated as follows: Section 2 describes the design methodology. Results and analysis is demonstrated in section 3. Finally conclusions are drawn in section 4.

II. DESIGN METHODOLOGY

A number of software and hardware implementation techniques were used to design and develop the system. Fig. 1 shows the block diagram of our system. We used a 12v dc motor, L293D IC and DAQ card to develop our system. But before we start looking at the in's and out's of our system we need to understand a little more about how a DC motor works.

A dc motor basically consists of two parts, the stationary body of the motor called the "Stator" and the inner part which rotates producing the movement called the "Rotor". For DC machines the rotor is commonly termed the "Armature". Generally in small light duty DC motors the stator consists of a pair of fixed permanent magnets producing a uniform and stationary magnetic flux inside the motor giving these types of motors their name of "permanent-magnet direct-current" (PMDC) motors. The motors armature consists of individual electrical coils connected together in a circular configuration around its metallic body producing a North-Pole then a South-Pole then a North-Pole etc, type of field system configuration. The current flowing within these rotor coils producing the necessary electromagnetic field. The circular magnetic field produced by the armatures windings produces both north and south poles around the armature which are repelled or attracted by the stator's permanent magnets producing a rotational movement around the motors central axis as shown in fig. 2. As the armature rotates electrical current is passed from the motors terminals to the next set of armature windings via carbon brushes located around the commutator producing another magnetic field and each time the armature rotates a new set of armature windings are energized forcing the armature to rotate more and more and so on.

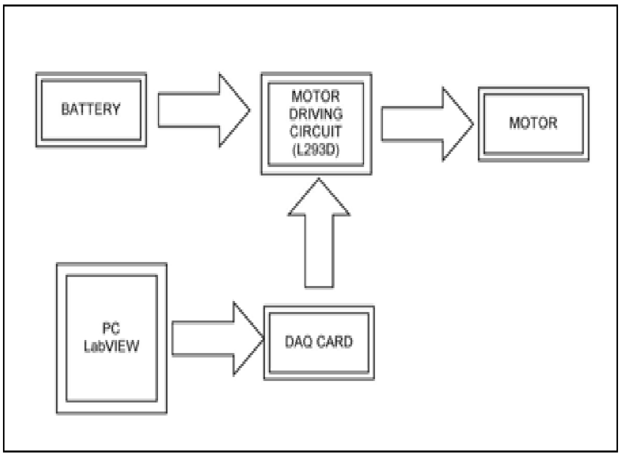


Fig.1. Block Diagram of our system

So the rotational speed of a DC motor depends upon the interaction between two magnetic fields, one set up by the stator's stationary permanent magnets and the other by the armatures rotating electromagnets and by controlling this interaction we can control the speed of rotation. The magnetic field produced by the stator's permanent magnets is fixed and therefore can't be changed but if we change the strength of the armatures electromagnetic field by controlling the current flowing through the windings more or less magnetic flux will be produced resulting in a stronger or weaker interaction and therefore a faster or slower speed. Then the rotational speed of a DC motor (N) is proportional to the back emf (V_b) of the motor divided by the magnetic flux (which for a permanent magnet is a constant) times an electromechanical constant depending upon the nature of the armatures windings (K_e) giving us the equation of: $N \propto V_b/K_e\phi$.

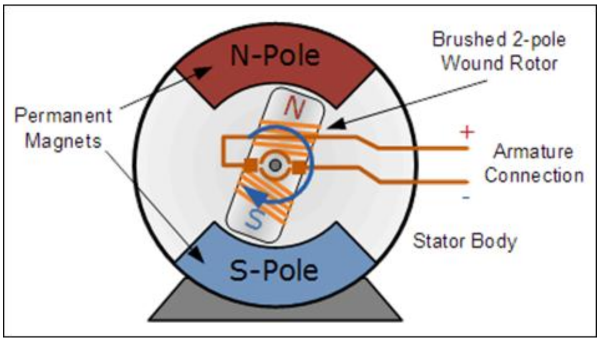


Fig.2. A 2-Pole Permanent Magnet Motor

So how do we control the flow of current through the motor? One simple and easy way to control the speed of a motor is to regulate the amount of voltage across its terminals and this can be achieved using "Pulse Width Modulation" or PWM. As its name suggests, pulse width modulation speed control works by driving the motor with a series of "ON-OFF" pulses and varying the duty cycle, the fraction of time that the output voltage is "ON" compared to when it is "OFF", of the pulses while keeping the frequency constant. The power applied to the motor can be controlled by varying the width of these applied pulses and thereby varying the average DC voltage applied to the motors terminals. By changing or modulating the timing of these pulses the speed of the motor can be controlled, i.e. the longer the pulse is "ON", the faster the motor will rotate and likewise, the shorter the pulse is "ON" the slower the motor will rotate. In other words, the wider the pulse width, the more average voltage applied to the motor terminals, the stronger the magnetic flux inside the armature windings and the faster the motor will rotate and this is shown in fig. 3.

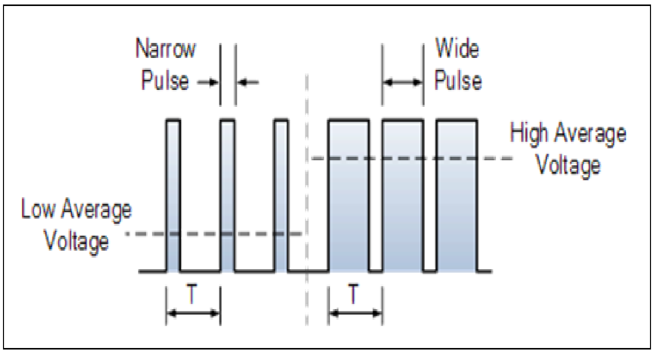
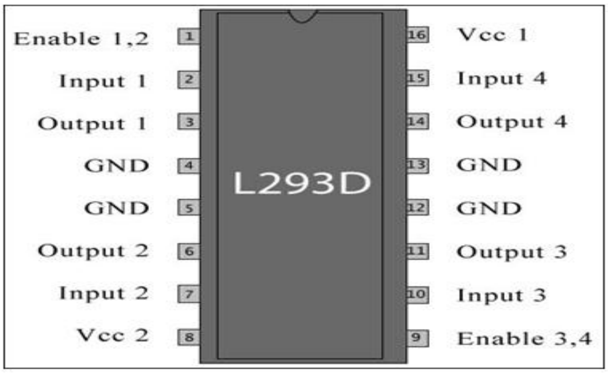


Fig.3. A pulse width modulated waveform

The use of pulse width modulation to control a small motor has the advantage in that the power loss in the switching transistor is small because the transistor is either fully "ON" or fully "OFF". As a result the switching transistor has a much reduced power dissipation giving it a linear type of control which results in better speed stability [3, 4 and 5].

To drive dc motor we need some kinds of driving circuit. A very easy and safe is to use popular L293D chip. It is a 16-pin chip. The pin configuration of a L293D along with the behaviors of motor for different input conditions is given in fig. 4. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled. Also their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications [6].

The DAQ card was used to control the system using Labview software. It is based on the principle of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. The components of data acquisition systems include: Transducers and sensors, Signals, Signal conditioning, DAQ hardware, Driver and application software [7].

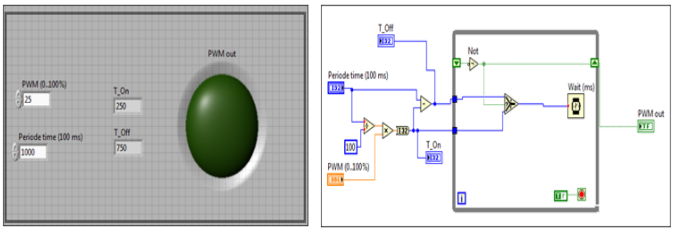


	A	B
Stop	Low	Low
Clockwise	Low	High
Anti Clockwise	High	Low
Stop	High	High

A= input 1, B = input 2

Fig.4. (A) Pin configuration of L293D and (B) Behaviors of motor for different input conditions

The main control has been designed using LabVIEW. LabVIEW (stands for Laboratory Virtual Instrumentation Engineering Workbench) is a system design platform and development environment for a visual programming language from National Instruments, USA. The graphical approach also allows non-programmers to build programs by dragging and dropping virtual representations of lab equipment with which they are already familiar. The LabVIEW programming environment, with the included examples and documentation, makes it simple to create small applications [8]. This is a benefit of one side, but there is also a certain danger of underestimating the expertise needed for high-quality G programming.



(A) (B)

Fig.5. (A) The front panel and (B) The block diagram of the PWM signal generator

PWM signals can be generated as a digital signal, using counters or digital output line(s), or as an analog signal, using, for instance, an arbitrary waveform generator or an RF signal generator. Several National Instruments multifunction data acquisition (DAQ) devices are capable of producing PWM signals. The LabVIEW graphical development environment, combined with NI-DAQmx, gives the tools needed to easily construct applications using counters to generate PWM signals. The front panel of the PWM signal generator is given in fig. 5(A). It contains the period time, percentage of PWM, PWM out palettes. The block diagram is also given in fig. 5(B). We can select the percentage of modulation and period to get the desired PWM signal.

We designed PWM generator as a SUBVI. To operate the DAQ card as a digital output device we need to program it. Fig. 6 gives the front panel and block diagram of our DAQ digital output SUBVI.

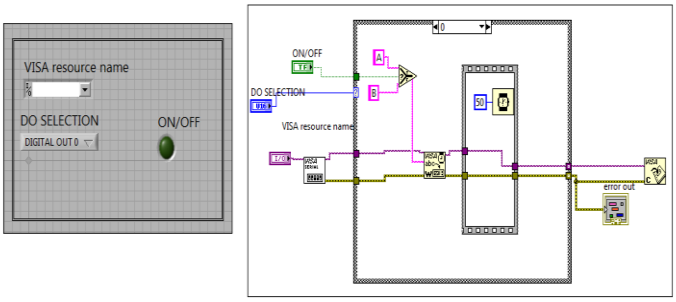


Fig.6. The front panel and the block diagram of the DAQ digital output SUBVI

The front panel and block diagram of our system is given in fig. 7 and fig. 8 respectively. The front panel consists of a MASTER STOP button to stop the entire program if necessary, %PWM knob to control the percentage of PWM, PERIOD button to get the output according to the defined period, etc. It also contains a MOTOR CONTROL button from which we can stop the motor and move it to either forward or reverse direction.

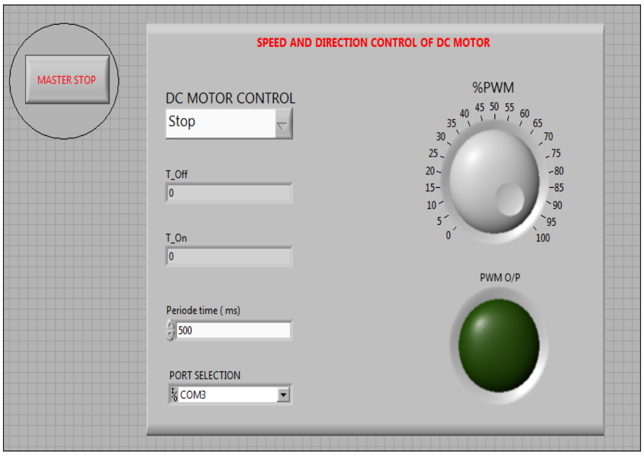


Fig.7. The Front Panel of our system

The dc motor and L293D IC has been connected according to the fig. 9. The circuit schematic as shown has been designed using Proteus 7. The DAQ card has been interfaced with the PC by communication port 3 (optional).

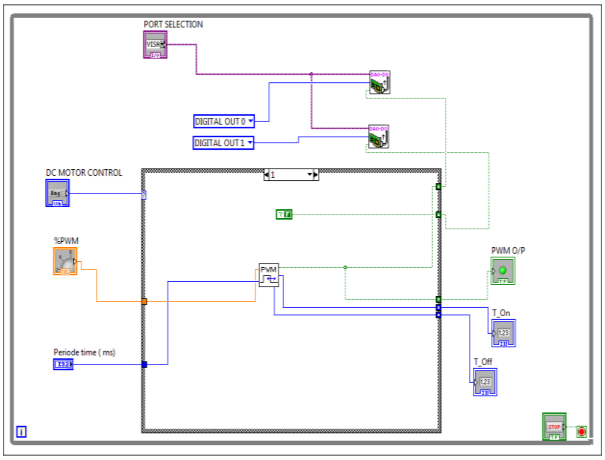


Fig.8. The Block Diagram of our system

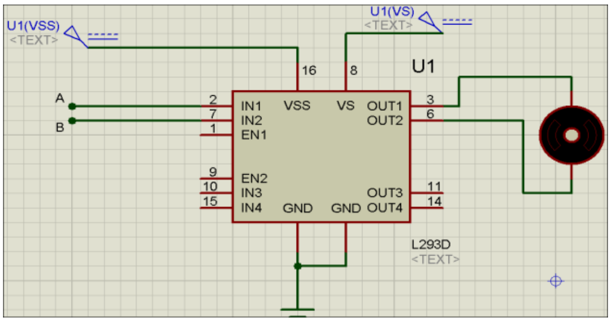


Fig.9. DC motor and L293D IC interfacing circuit

III. RESULT AND ANALYSIS

The aim of this paper is to design and develop a LabVIEW based speed and direction control of dc motor. The following test was conducted to evaluate the success of the developed monitoring system. The rotation of the motor according to the PWM signal has been tested. By increasing or decreasing the %PWM and Period button on the front panel it has been found that the system worked accordingly as shown in TABLE I. Also by selecting three options (forward, reverse, and stop) within the DC MOTOR CONTROL button of the front panel, it has been found that the motor responded very quickly and accurately as shown in TABLE II. Our full development system is given in fig. 10.

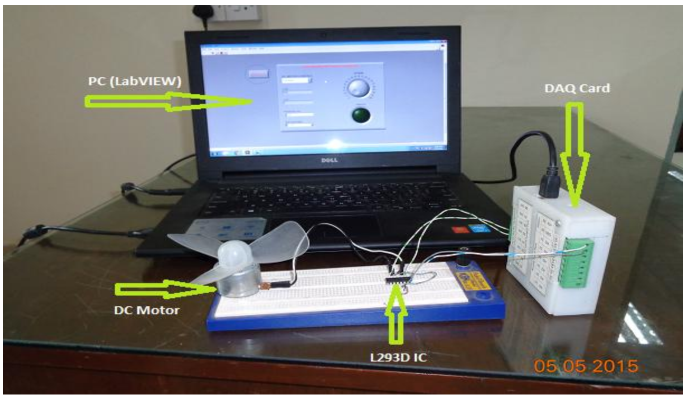


Fig.10. Our full Development System.

TABLE I. Observation of the Motor According to DC MOTOR CONTROL Button

ITEMS	RESPONSE
Forward	Fine
Reverse	Fine
Stop	Fine

TABLE II. Observation of the Motor According to %PWM and Period Time Button

CHANGE OF	**RESPONSE**
%PWM	Fine
Period Time	Fine

IV. CONCLUSION

The current research work illustrates the design and development of a LabVIEW based speed and direction control of a dc motor. PWM was programmed using LabVIEW to control the motor speed. The application of virtual instruments makes data analyzing more accurate, and decreases the measuring time significantly. The L293D chip was used to drive the motor. The system has been tested for various input values and worked properly. So from the analysis with experimental results we can mention that the designed motor control established with LabVIEW is able to control the speed and direction of the motor very effectively.

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