

Closed loop speed control of DC motor

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Abstract— In this project, we designed a model which is capable of measuring the current speed of motor. And also it takes input from the user and based on the difference between entered(desired) speed and current speed the width of PWM pulses given to the motor is controlled until motor reaches desired speed. After completion of current execution, our model waits in the current state until an input is given by the user and the process continues until power supply is switched off.

Index Terms— Rotary Encoder, Light Dependant Resistor (LDR), Pulse Width Modulation (PWM), Arduino

1 Introduction

The Direct current (DC) motors have variable characteristics and are used extensively in variable-speed drives. DC motor can provide a high starting torque and it is also possible to obtain speed control over wide range. Why do we need a speed motor controller? For example, if we have a DC motor in a robot, if we just apply a constant power to each motor on a robot, then the robot will never be able to maintain a steady speed. It will go slower over carpet, faster over smooth flooring, slower up hill, faster downhill, etc. So, it is important to make a controller to control the speed of DC motor in desired speed.

DC motor plays a significant role in modern industrial. These are several types of applications where the load on the DC motor varies over a speed range. These applications may demand high-speed control accuracy and good dynamic responses. In home appliances, washers, dryers and compressors are good examples. In automotive, fuel pump control, electronic steering control, engine control and electric vehicle control are good examples of these. In aerospace, there are a number of applications, like centrifuges, pumps, robotic arm controls, gyroscope controls and so on.

2 Project Objective

1. To design a circuit for closed loop speed control of DC motor using Arduino.
2. To design a rotary encoder which identifies the speed of the motor and gives it as feed back to the controller.

3 Project Scope

1. Speed control of a DC motor.
2. Designing a rotary encoder using laser and LDR.
3. Using PWM method for controlling the speed of the motor.

4 Functioning of circuit

There are two different circuits

1. Rotary encoder circuit
2. Switches Module

4.1 Rotary Encoder Circuit

The sole purpose of this circuit is to find the speed of motor which is conveyed to the on board controller in form of pulses. When the laser fixed on the shaft of motor cuts the LDR on the circuit it gives a pulse to the Microcontroller. As the speed is measured in terms of revolutions per minute the above process of measuring is done for a span of one minute.

The circuit is powered by a 9 volt battery which is regulated to 5V using a voltage regulator popularly known as 7805. The output of LDR is connected to the non-inverting terminal (Vni) of comparator popularly known as LM324 which gives V when it receives light from laser but it gives somewhat higher voltage than zero when laser light is not incident on LDR.

In order to solve this problem a pulldown resistor of value 10KOHM is connected between Ground and non-inverting terminal. For giving the reference voltage to comparator a trimpot is used.

By adjusting the screw on trimpot output voltage is adjusted in such a way that it is lower than Vni when light is incident upon LDR and greater than the Vni when no light is incident upon LDR. The output pin of trimpot is connected to the inverting terminal of comparator (LM324). The output terminal of LM324 is connected to a pin of ArduinoMEGA and based on code in the arduino the speed of motor is adjusted.

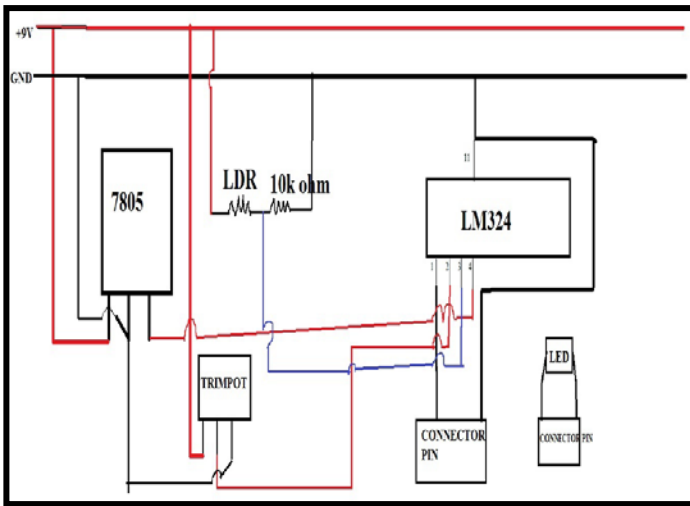


FIG1:Sensor Interfacing Circuit

4.2 Switches Module Circuit

In this Module, There are five switches

1. The first switch is to start and stop the process of execution of code in Arduino.
2. The second, third, fourth switches are used to enter the hundreds, tens, and units' place of desired speed.
3. The fifth switch is used to interrupt the process of execution such that user can enter the modified desired speed.

The outputs from all these switches are given as input to Arduino Uno via digital I/O pins of Arduino.

The working of a switch module goes in this way:

1. When the switch is pressed then the +5V supply from switch is transferred to a Arduino I/O pin which goes HIGH and when switch is released the Arduino I/O pin goes LOW.
2. The current state of output is conveyed to user through Light Emitting Diode (LED).
3. In order to prevent problem due to de-bouncing a pull down resistor is connected in parallel to LED.

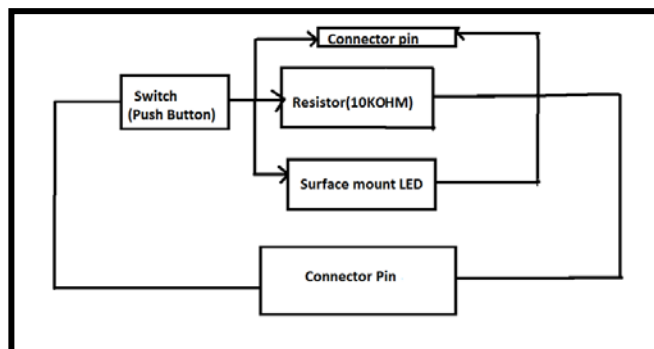


FIG2:Switches Interfacing Circuit

5 Block diagram of project

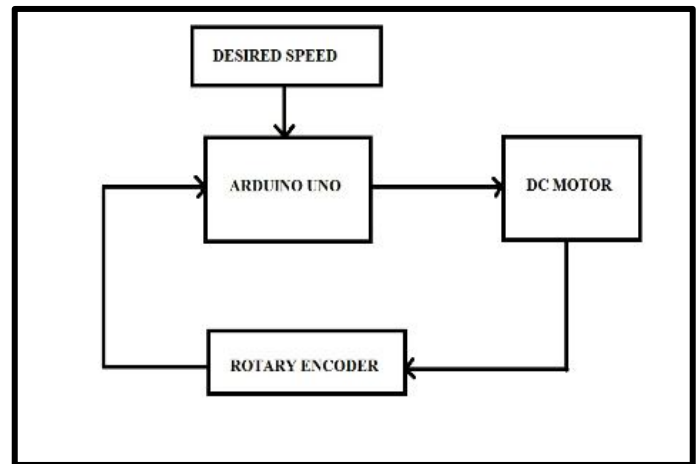


FIG3:Block Diagram

6 Process Involved

First the entire code is made to start using start/stop button by pressing button for two times. Now the user gets an opportunity to enter the desired speed. For example if user requires to rotate his motor at say 213 rpm then user has to press hundreds switch for 2 times, tens switch for one time, units switch for 3 times.

After this user entered speed is stored in a variable known as "Desired speed." Based on algorithm the entire module finds out the current speed of motor for 1minute using a rotator encoder and is stored in a variable known as "Current speed" in Arduino.

Now the difference between current speed and desired speed is calculated and stored in a variable known as "Error". Now it is observed that whether error is positive or negative or zero.

If the error is positive, then a variable is incremented and that variable is converted into its digital equivalent and is given as input to analogwrite() which gives corresponding PWM pulse as output. The process of conversion to digital equivalent is, as the no-load speed of motor corresponds to 300 RPM it is considered equivalent to value of 255(as 8bit AD conversion is followed.)

Then the required speed of motor let's say "x" rpm is considered equivalent to the value of cp.

$$\text{So } x = (255/300) * cp;$$

Which gives rise to,
 $x = 1.7 * cp;$

Here cp will be incremented if error is positive and will be decremented if error is negative and this process continues until error becomes zero.

If once error becomes zero then the code jumps into an infinite (while(1)) loop and desired speed of motor is achieved which is printed on LCD.

The code comes out of 8 statement if interrupt button is pressed two times which causes initialisation of some variables and the process of execution starts from first statement.

If the start/stop button is pressed for two more times, then the entire system comes to halt and microcontroller no longer takes input from user.

7 Algorithm

Desired speed is entered.

Current speed is determined with rotary encoder.

Error is calculated.

If $\text{error} > 0$ then speed is incremented until $e=0$.

If $\text{error} < 0$ then speed is decremented until $e=0$.

If $\text{error} = 0$ then it enters into infinite loop.

If interrupted, then go to step 1.

8 Results

The speed measurements done using this model are almost equal to the speed measurements done using an optical rotary encoder.

9 References

1. <http://en.wikipedia.org/wiki/LDR>
2. http://en.wikipedia.org/wiki/Light-emitting_diode
3. <http://www.jeremyblum.com>
4. <http://www.arduino.cc>

10 Conclusion

In this project we are incorporating a novel rotary encoder design which measures the instantaneous speed of motor and is compared with desired speed entered by user. Based on the user defined algorithm the motor is made to reach the desired speed. Even though there is slight difference between desired speed entered and the speed achieved by the motor but when compared to the existing systems it is highly appreciable due to its qualities of being economical and simple to control.

11 Working Model

