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Control of Pulse Width Modulation ON Direction and Speed of DC Motor using Arduino

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Abstract: This research presents the use of PWM (Pulse Width Modulation) of microcontroller (Arduino Uno 328) for controlling on Direct Current (DC) motor. DC motor speed is controlled using PWM technique. The signal of PWM is produced by an Arduino Uno board. L293D DC motor driver is utilized because it has dual full bridge driver where it also can control on the DC motor direction. Micro C language is utilized for programming and controlling the Arduino Uno board. The aims of this research are to control on DC motor direction and speed, so that can be used in automation system and also industrial field.

Key words: Motor speed control, motor direction control, PWM, Arduino Uno 328, L293D, DC motor

INTRODUCTION

DC motor is commonly used in a recent industrial situation owing to the low initiatory amount, good drive performance, low maintenance and the limiting noise. speed, torque and direction of rotation of DC motors can be adjusted at any time to meet another limitation. DC motor has varying features and utilized widely in varying-speed drives (Zulkefli, 2012). Conventional control theory is very limited and hard in modeling and controlling on DC motor. On the other hand, this research has tended to focus on controlling a motor in any system, a microcontroller is wanted to give input to driver of gate. Running due of DC motor can be varied by varying the duty-cycle value of the PWM signals that controls the transistors of the H-bridge that supplies the DC motor. PWM control is a very commonly used method for controlling the power across loads (Petru and Mazen, 2005).

Literature review: By Preeti and Jain (2012), an eight bit PIC (Peripheral Interface Controller) series microcontroller based control for DC drives to effectively control the output when the input parameters is sudden change in is presented. microcontroller is programmed by assembly language. By Petru and Mazen (2005), wireless receiver and transmitter compound with dual dc motor control system is built that will tell the two independent motors at which speed they should operate and in what direction. By Petru and Mazen (2005), controlling PWM on DC motor that utilizes for driving a conveyor belt is presented. The signal of PWM is generated by an Arduino Uno board, associated with an ATmega 328 microcontroller. The LabVIEW is utilized for controlling and programming Arduino Uno board. By Boaz *et al.* (2016), system consists of ATmega328 microcontroller, 8 bit RF module, ULN2803A and one eight channel relay module is proposed. This method is used to change the direction and speed of the DC motor.

General description of equipment: The equipment that used in this research are:

Arduino: It's an open-source physical computing display place based on a simple microcontroller board includes an ATmega328 microcontroller and a development environment for writing software for the board. Arduino can be used to develop communicating objects, taking inputs from a selection of switches or sensors and controlling a selection of lights, motors and other physical outputs. Projects of Arduino can be fulfilled-alone or they can be associating with software running on computer (e.g., flash, processing, Proteus and MaxMSP) (Islam and Saiduzzaman, 2013; Budijono *et al.*, (2014).

The Arduino Uno board has a 16 MHz ceramic resonator, a USB connection, a power jack an ICSP header, a reset button, 6 analog inputs and 14 digital input/output pins (of which 6 can be used as PWM outputs) as shown in Fig. 1 (Sushma *et al.*, 2015).

H-bridge (L293D): An H-bridge is an electronic circuit that allows a voltage to be applied across a load in either direction. Speed and direction of DC motor are controlled by switches in H-bridge. This circuit is used to enable DC motor to run forwards and backward. H-bridge drivers are composed by connecting a four switches. In Fig. 2, when switches "S1" and "S4" closed, the motor will operate in

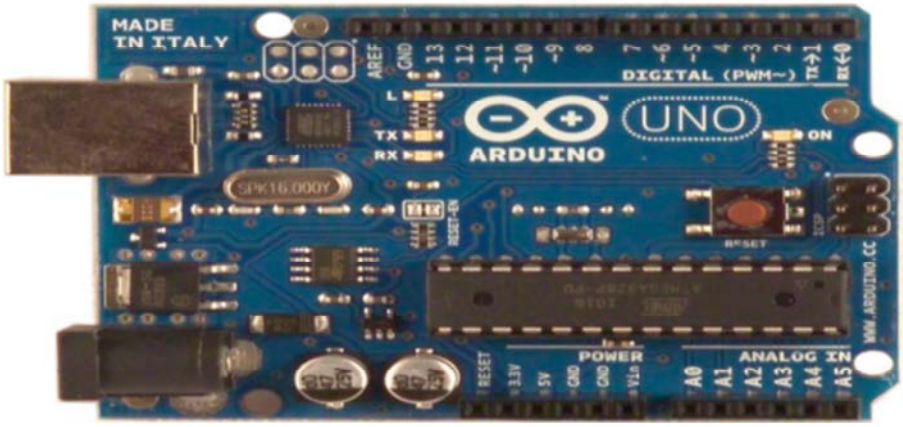


Fig. 1: Arduino Uno board

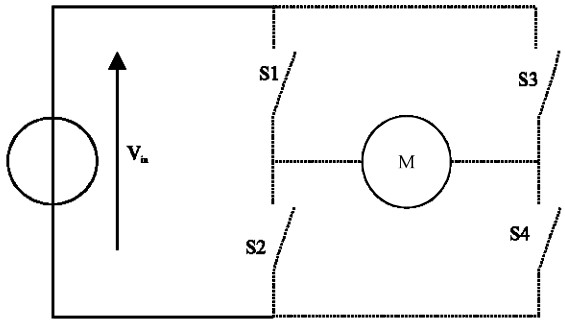


Fig. 2: H-bridge configuration

Table 1: Switching technique for H-bridge (Petru and Mazen, 2005)

Results	S1	S2	S3	S4
Forward	1	0	0	1
Reverse	0	1	1	0
Motor free	0	0	0	0
Motor brake	0	1	0	1
Motor brake	1	0	1	0

Table 2: Specifications DC motor model FC-280SA-08600

Characteristic	Values
Motor characteristic	FC-280SA-08600
Rated voltage	6 V DC
No load speed	12000±15% rpm
No load current	≤280 mA
Operating voltage	1.5-6V DC
Weight	28 g (approach)

a clockwise direction. The motor will operate in the counter clockwise direction when "S2" and "S3" is closed. Table 1 summarizes all the operation of the H-bridge configuration (Zulkefli, 2012; Poovathody *et al*., 2014).

Real hardware DC motor: A Direct Current (DC) motor converts DC electrical energy into mechanical energy (Zulkefli, 2012). The model of DC motor that used in this project is FC-280SA-08600 as shown in Fig. 3 is used. The specifications of DC motor are listed in Table 2.

Fig. 3: Real DC motor model FC-280SA-08600

MATERIALS AND METHODS

Proposed system: The proposed system consists of 2 cases:

PWM DC motor speed and direction control using Arduino: In this case, speed of DC motor changed By changing the value of variable resistance that controls on an Arduino analog output (PWM). The proposed system in this case consists L293D motor driver chip (its control pins allow us to do the equivalent of swapping over the motor terminals to reverse the direction of the motor), microcontroller (Arduino Uno 328), potentiometer to measure the speed of the motor and a switch to control the direction of DC motor as shown in Fig. 4.

PWM DC motor speed control using Arduino: Figure 5 shows the control on speed of small DC motor by an Arduino and a transistor. Small 6 V DC motor, 2N2222 Transistor, 1N4001 diode, 0.1 μf capacitor and 2200 Ω Resistor are needed. The 2N2222 transistor can be utilized as a switch to control the much bigger current of the motor. Diode connected across the connections of the motor to allow flowing of electricity in one direction. When a motor is turned to the power off, a negative spike of voltage is get that can cause destroy for Arduino or the transistor. The diode guards against this by shorting out any such reverse current from the motor 0.1 μf for putting the electric spark on the end of motor brushes.

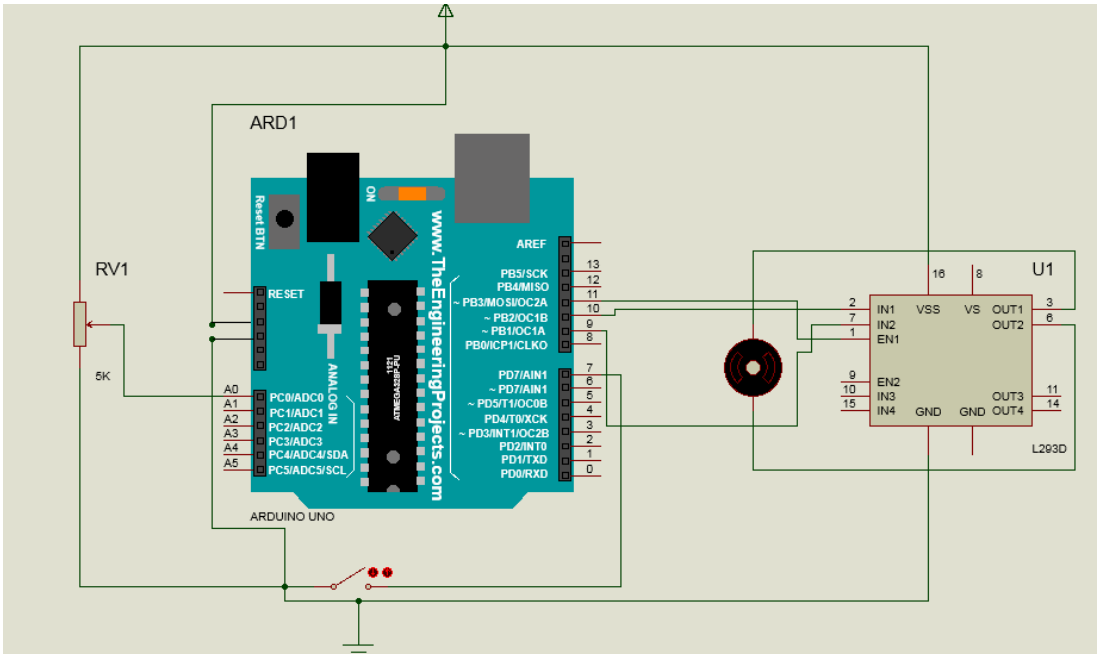


Fig. 4: Electronic circuit of controlling speed and direction of DC motor

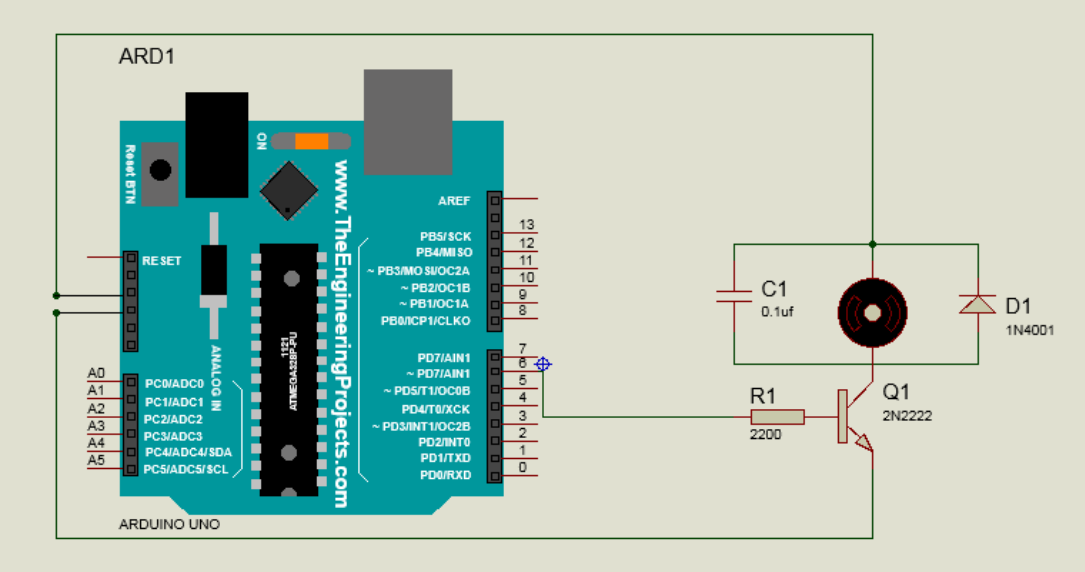
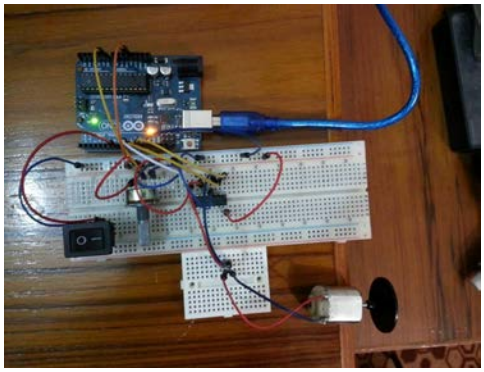


Fig. 5: Electronic circuit of controlling speed of DC motor

RESULTS AND DISCUSSION

Motor speed and direction control using Arduino: In this case, the revolutions per min (rpm) of DC motor is controlled by changing The duty cycle of PWM square wave on Arduino. Performance of rpm variety is achieved by increasing or decreasing the time interval. So, at a duty-cycle of 100% (maximum), the motor will have the maximum rpm and verse vise changing. The duty cycle of PWM square wave on Arduino is achieved by controlling on the value of variable resistance (5 kΩ) when value of resistance increased, the rpm increased and verse visa. The hardware of this case can be shown in Fig. 6. A digital tachometer is utilized to measure rpm values of the DC motor as shown in Table 3 and Fig. 7.

(a)



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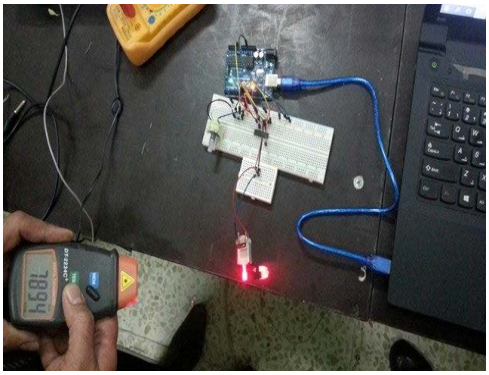

Fig. 6a, b: Measurement of rpm of DC motor

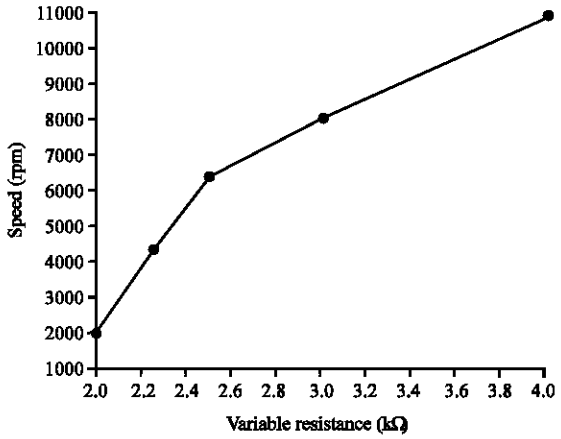

Fig. 7: Relation between variable resistance and rpm

Table 3: Resulting values of speed DC motor and variable resistance

Variable resistance (kΩ)	Speed DC motor (rpm)
2	1963
2.25	4296
2.5	6372
3	800
4	10900

Motor speed control using Arduino: In this case, the revolutions per min (rpm) of DC motor is controlled by changing. The duty cycle of PWM square wave on

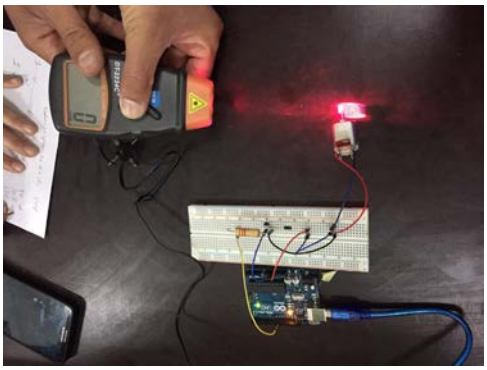

Fig. 8: Measurement of rpm of DC motor

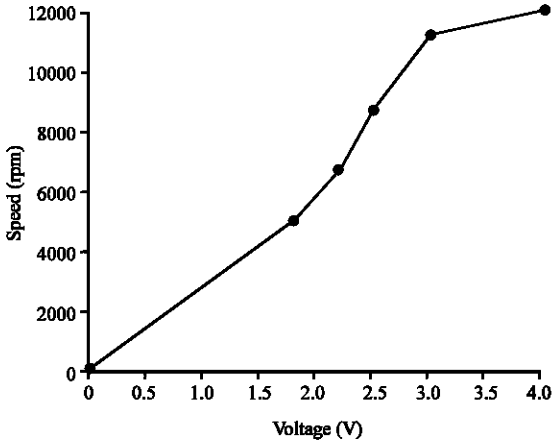

Fig. 9: Relation between voltage and rpm

Table 4: Resulting values of speed DC motor

Voltage values (1-5) V	Speed DC motor (rpm)
0	0
1.8	5000
2.2	6700
2.5	8700
3	11200
4	12000

Arduino. The variety of motor rpm is achieved by increasing or decreasing the time interval. Thus, at a duty-cycle of 100% (maximum), the motor will have the maximum rpm and verse vise. The duty cycle for the PWM output is controlled with the commands of programming Arduino in C language where it increases by increasing the voltage difference (1-5) V. The hardware of this case can be shown in Fig. 8. A digital tachometer is utilized to measure rpm values of the DC motor as shown in Fig. 9 and Table 4.

CONCLUSION

The experimental results for this research is the control of PWM on DC motor. H-bridge is utilized for

supplying the DC motor to allow the reversal of the motor rotation wise. To control on the Arduino Uno board, micro C language is used. The running duty of a DC motor can be changed by changing the duty-cycle value of the PWM signals to control on the H-bridge transistors that supplies the DC motor and by modifying the variable resistance. By this experimental results that study the running characteristics of DC motor under laboratory conditions, so that, the research is easy to implement and can be used in industrial applications, robot system and kid's toys. Furthermore, the control on DC motor is precise and faster in operation as it depends on the microcontroller programming.

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