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Speed and Direction Control of DC Motor Without using Microcontroller

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ABSTRACT: Speed and direction control of DC motor is always a crucial process. This looks simple but when this comes to applications it has to be more precise and accurate. The speed and direction in mainly applied in stator motor and wiper motor of 2 wheelers apart from that it is also used in many paper mills, printing machine tools and cranes. There have been previously many researches with speed and direction control in a single circuit or separate circuit. The ultimate objective of this project is to design a cost efficient, precise and compact circuit for speed and direction control of DC motor without the use of microcontroller. Designing a circuit without microcontroller will reduce the cost also overcomes other drawbacks like limited range. This circuit has used transistorized H-Bridge for controlling the direction and 555 Timer for controlling the speed. By adjusting the duty cycle by means of Pulse Width Modulation is the basic principle in the speed control of DC motor.

KEYWORDS*:* Pulse Width Modulation, 555 Timer, H- Bridge, Speed and direction control.

I. INTRODUCTION

The speed of the DC motor can be varied by means of either electrical or mechanical way. The previous research about speed and direction control of DC motor includes controlling the speed by means of PC. Software was developed, fed into a PC and consequently, commands were given to the chopper via the computer for control of motor speed. The use of standalone micro controller for the speed control of DC motor is past gaining ground. In one more research a microcontroller was used for speed control. The operation of the system can be summarized as, the drive form rectified voltage, and it consists of chopper driven by a modulated signal generated from a microcontroller unit (MCU).

They had disadvantage of large size. The main objective of this project is to design speed and direction control of DC motor which is cost efficient, precise and compact circuit without the use of microcontroller. In order to make this circuit at a less cost, this has used simple electronic components. Here for the input voltage we give the corresponding speed will be obtained and controlling the direction is nothing but reversing the input terminals, then we get a precise output. This can be implemented in two wheelers so I have used components which can easily reduced in size when designed in surface mounting technology. Microprocessor has also been used for speed control of DC motor, here the actual speed of the motor by sensing the terminal voltage and the current; it then compares the actual speed of the motor with the reference speed and generates a suitable signal control signal which is fed into the triggering unit.

Pulse Width Modulation is nothing but varying the duty cycle which in turn reduces the terminal voltage without any heat energy loss. Here I have used 555 timer to implement Pulse Width Modulation. In order to simply change the direction we can also use DPDT (Double Pole Double Through) switch. Here I have used an H-Bridge. Itsfunction is similar to that of the DPDT. However a semiconductor-based H bridge would be preferable to the relay where a smaller physical size, high speed switching, or low driving voltage (or low driving power) is needed.

II. PERMANENT MAGNET DC MOTOR

I have done my project in such a way that it can be implemented in two wheelers. I will briefly discuss about the permanent magnet DC (PMDC) motor, since PMDC motor is usually used in the two wheelers. At the same time my project can also be used for all types of DC motor.

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Basic working principle of DC motor is based on the fact that whenever a current carrying conductor is placed inside a magnetic field, there will be mechanical force experienced by that conductor. The equivalent circuit is given below.

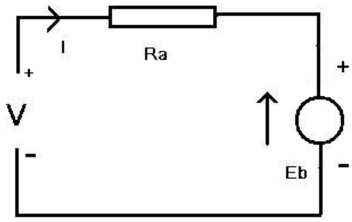

Fig 1. Equivalent circuit of PMDC motor

The PMDC motor does not have any field circuit; it has only the armature circuit that is the major difference of it from other DC motor.

Fig 2. 15V PMDC motor

III. FACTORS INFLUENCING SPEED AND DIRECTION OF DC MOTOR

According to the speed equation of a DC motor we can write,

$$N \alpha \frac{E_b}{\varphi} \alpha \frac{V - I_a R_a}{\varphi}$$

The factors Z, P, A are constants for a DC motor.

But as the value of armature resistance R_a and series field resistance R_{se} is very small, the drop $I_a R_a$ and $(R_a + R_{se})$ is very small compared to applied voltage V. Hence neglecting these voltage drops the speed equation can be modified as,

$$N \alpha \frac{V}{\varphi} \text{ as } E_b = V$$

Thus the factors affecting the speed of a DC motor are,

- The flux Φ
- The voltage across the armature
- The applied voltage V

Depending upon these factors the various methods of speed control are,

- Changing the flux Φ by controlling the current through the field winding called flux control methods.
- Changing the armature path resistance which in turn changes the voltage applied across the armature called rheostatic control.
- Changing the applied voltage called voltage control method.

Regarding the direction control of DC motor we have to change the input terminals by any one of the feasible method. This method should not anyway affect the speed control technique.

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IV. PULSE WIDTH MODULATIONTECHNIQUE FOR SPEED CONTROL

A Pulse Width Modulation (PWM) Signal is a method for generating an analog signal using a digital source. A PWM signal consists of two main components that define its behaviour: a duty cycle and a frequency. The duty cycle describes the amount of time the signal is in a high (on) state as a percentage of the total time of it takes to complete one cycle. The mathematical representation of the duty cycle is given below

$$\text{Duty cycle} = \frac{T_{on}}{T_{on}+T_{off}} \times 100(\%)$$

Where,

T_{on} =Time period when the signal is in high (on) state.

T_{off}= Time period when the signal is in low (off) state.

$$\text{Duty cycle} = \frac{T_{on}}{T_{total}} \times 100(\%)$$

Where,

$T_{total} = T_{on}+T_{off}$

The frequency determines how fast the PWM completes a cycle (i.e. 1000 Hz would be 1000 cycles per second), and therefore how fast it switches between high and low states. By cycling a digital signal off and on at a fast enough rate, and with a certain duty cycle, the output will appear to behave like a constant voltage analog signal when providing power to devices.

V. H-BRIDGE FOR DIRECTION CONTROL

H-Bridge is a simple circuit which consist of a transistor along with the load at the centre. This arrangement is in the form of H letter hence it is named as H-Bridge. The diagrammatic representation of H-Bridge is given below the operation of H-Bridge is also given by means of the simple tabular column.

The basic operating mode of an H-bridge is fairly simple: if Q1 and Q4 are turned on, the left lead of the motor will be connected to the power supply, while the right lead is connected to ground. Current starts flowing through the motor which energizes the motor in i.e. the forward direction and the motor shaft starts spinning. If Q2 and Q3 are turned on, the reverse will happen, the motor gets energized in the reverse direction, and the shaft will start spinning backwards. In a bridge, you should never ever close both Q1 and Q2 (or Q3 and Q4) at the same time. If you did that, you just have created a really low-resistance path between power and GND, effectively short-circuiting your power supply.

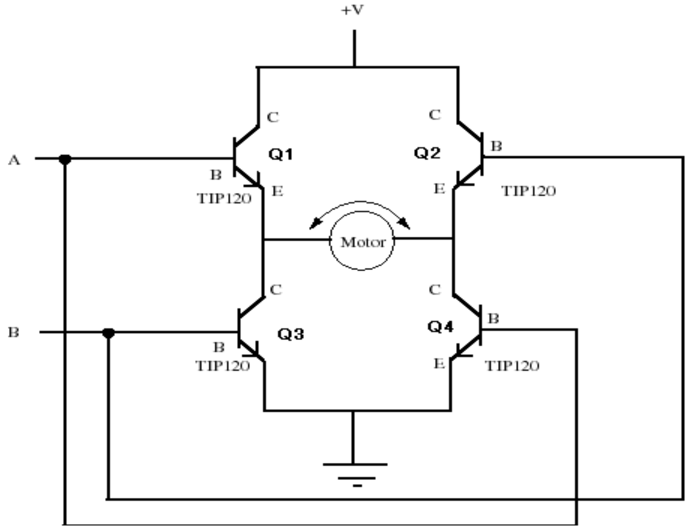

Fig 3.The diagrammatic representation of H-Bridge

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A	B	DIRECTION
0	0	STOP
0	1	ANTI-CLOCKWISE
1	0	CLOCK WISE
1	1	NOT ALLOWED

Table 1.Tabulation for working of H-Bridge

VI. 555 TIMER AS ASTABLE MULTIVIBRATOR

The 555 is connected for astable operation. Here the timing resistor is now split into two sections, R_1 and R_2+VR_1, with the discharge pin 7 connected to the junction of R_1 and R_2+VR_1. When the power supply connected, the timing capacitor C_1 charge towards 2/3 V_{CC} through R_1 and R_2+VR_1. When the capacitor voltage reaches 2/3 V_{CC}, the upper comparator triggers the flip-flop and the capacitor start to discharge towards ground R_2+VR_1. When the discharge reaches 1/3 V_{CC}, the lower comparator is triggered and a new cycle is started.
The capacitor is then periodically charged and discharged between 2/3 V_{CC} and 1/3 V_{CC} respectively. The output state is High during the charging cycle for a time period t1, so that

$$T_1=0.693(R_1+R_2+VR_1)C_1$$

The output state is low during the discharge cycle for a time period t2, given by

$$T_2=0.693(R_2+VR_1)C_1$$

Thus, the total period charge and discharge is

$$T=T_1+T_2$$
$$=0.693[R_1+2(R_2+VR_1)]C_1 \textit{ (seconds)}$$

Hence the output frequency is given as

$$f = \frac{1}{T}=1.443/\{[R_1+2(R_2+VR_1)]C_1\}$$

(You can get frequency in KHz, when R1, R2, VR1 in KΩ and C in µF)

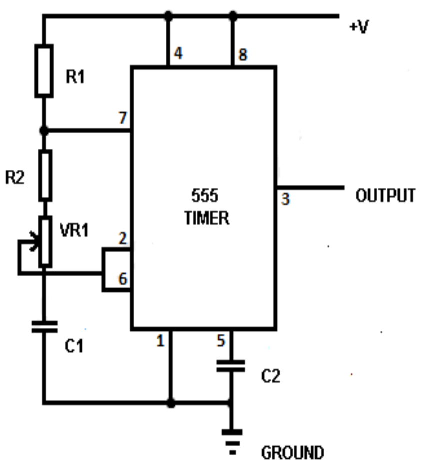

Fig 5.555 Timer as astable multivibrator

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VII. CIRCUIT DIAGRAM FOR SPEED AND DIRECTION CONTROL OF DC MOTOR

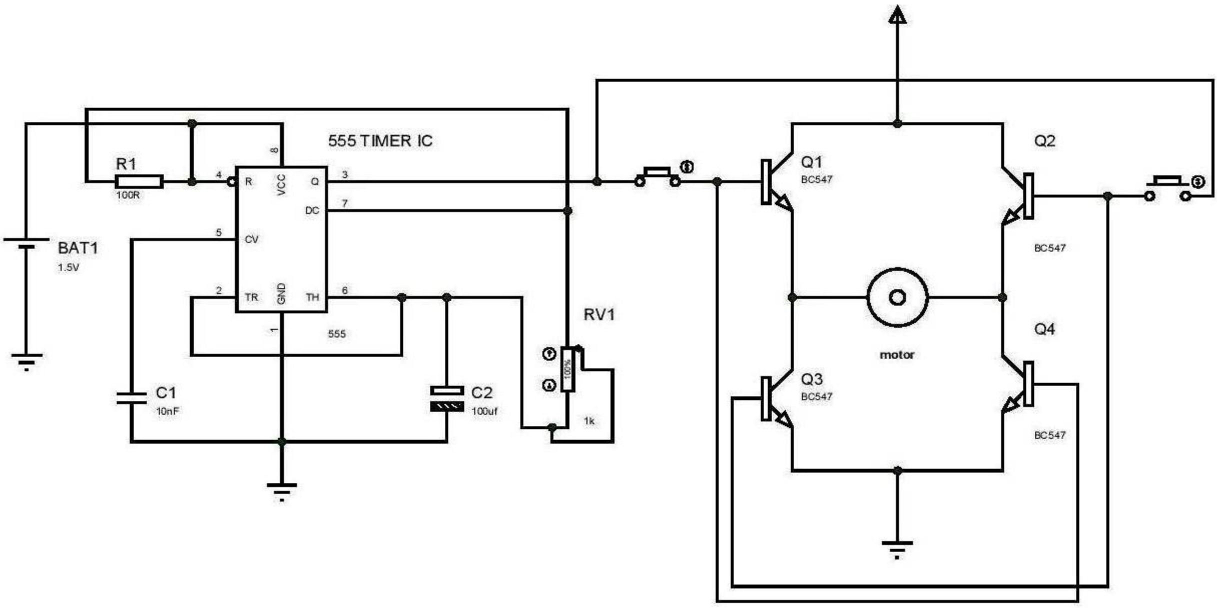

Fig 4. Circuit diagram for speed and direction control of DC motor

The circuit diagram for the combined speed and direction control using 555 Timer and H-Bridge is given below. Here the 555 timer is connected as astable multivibrator. By varying the variable resistor VR1 the input terminal voltage is adjusted hence by means of setting the frequency at higher value for example 10KHz, there will be continuous supply of voltage. The amount of voltage given determines the value of the speed. Hence speed of DC motor is controlled. H-Bridge is used in the direction control of DC motor. Here based on the switch which is open and closed the current flows through Q1, Q4 or Q2, Q3 respectively. This makes the motor rotate in forward and reverse direction respectively. The circuit is completely hardware implementation without microcontroller and any other programming techniques.

VI. CONCLUSION

Hence speed and direction control of DC motor is achieved my means 555 Timer with Pulse Width Modulation technique and H-Bridge circuit. Without using microcontroller and any other programming technique the cost of the circuit is reduced. The control which is obtained is more precise and of wide range. Since I have used small electronic component this circuit can be easily converted to compact circuit. Thus the speed and direction is controlled successfully.

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