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DC Motor Driven Electric Skateboard using PWM

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Abstract:- Several problems are faced by today's generation. One of them is the increase in pollution in everyday life. We want it reduced by using some eco-friendly way like cycles which requires mechanical force. Another way to accomplish this is by using electricity to produce this force i.e. electric motors. This is where the concept of electric skateboard steps in. Using PWM to control the motor and connecting the motor with a skateboard.PWM circuit is used and improvised according to our own needs for higher voltage. Along with these the basic concept of skateboard parts is studied and manipulated to our needs so as to attach a motor to it. The skateboard is fabricated by keeping in mind the roads of India so that it can run on rough terrain, not only on well-developed roads.

Keywords:- *Pulse Width Modulation, DC Motor, 555 Timer, Electric Skateboard.*

I. INTRODUCTION

Pulse Width Modulation is a technique of modulation of the digital pulses. This method is used for controlling the power supply to any device. This is achieved by changing the width of the pulses. The ON and OFF time of the circuit is changed accordingly. The on and off time control the output voltage and thus help in controlling the connected device. This method of output voltage control is used being used to change the speed of the DC motor for this project.

The time period for which a device conducts is called as the ON time of the device. Similarly, the time period when the device does not conduct is called the OFF period. The ratio of this on time to the total time period (on time+ off time) is called as the Duty Ratio. In our project, we attempt to change this duty ratio of the PWM circuit and feed it to the motor. The change in duty cycle operates the turning on and off of the motor. This, thereby increases and decreases the speed of the motor. The switching characteristics is performed with the help of a potentiometer whose resistance value is changed. With increase in resistance, the speed decreases and with decrease in resistance, the speed increases. This potentiometer acts as a throttle for the electric skateboard.

PWM technique is a preferred speedcontrol techniques for a DC motor. A high frequency chopper signal with specific duty cycle is increased by switch signals.

When the power supply is on, the DC motor starts gaining speed and if we turn off the power supply before it reaches at rated speed, and its speed decreases. In fast succession of switch on and switch off steps, the motor speed is modulated. For this, paper we use PWM methodology thus it switches the motor on and off with a pulse wave. The motor voltage and revolutions per minutes (RPM) obtained at completely different duty cycle rates. Because the duty cycle will increase, additional voltage is applied to the motor. This contributes to the stronger magnetic flux within the coil windings and also the increases the revolutions per minute. The characteristics and performance of the DC motor speed system was studied.

II. PULSE WIDTH MODULATION

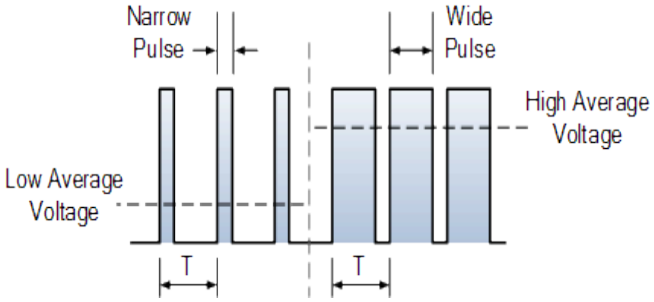

Fig 1:- Pulse Width Modulation

Pulse width modulation speed control works by driving the motor with a series of "ON-OFF" pulses. By 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.

This value of ON and OFF time can be manipulated as per the requirements. PWM is done by using electronic switches (transistors) which gives the following advantages:

- The power loss in the switching transistor is small because the transistor is either fully "ON" or fully "OFF". The transistor does not have an intermediate state.
- Amplitude of the motor voltage remains constant so the motor is always at full strength. The result is that the motor can be rotated much more slowly without it stalling.

The 555 timer is an IC which is used in a timers, pulse generation, and oscillations. They are used to provide time delays, as an oscillator, and as a flip-flop element.

III. BLOCK DIAGRAM

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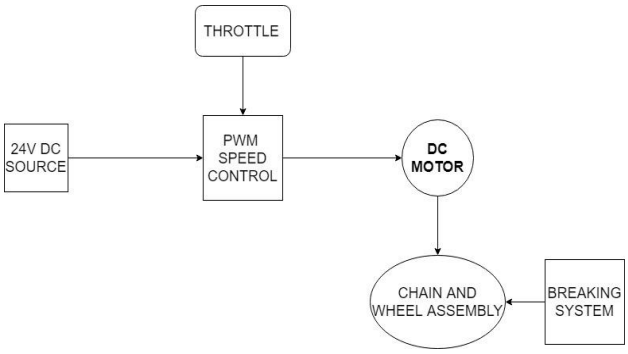

Fig 2:- Block Diagram

IV. EXPLANATION OF BLOCK DIAGRAM

A 24 volt DC battery supplies power to the PWM speed control circuit. The speed controller circuit receives input resistance from the throttle which modulates the pulse width. The output of this Pulse Width Modulation circuit is fed to a DC motor. The voltage changes caused by the PWM circuit in turn alters the speed of the DC motor.

The change in level of voltage is decided by a user or rider through throttle connected to the circuit.

The level of voltage is directly proportional to the motor speed, i.e., with increase in the voltage, the speed o the motor increases and vice versa.

The dc motor is connected to the chain and wheel assembly through a sprocket chain system and a subsequent mechanical braking system to stop the motor all together.

V. CIRCUIT DIAGRAM

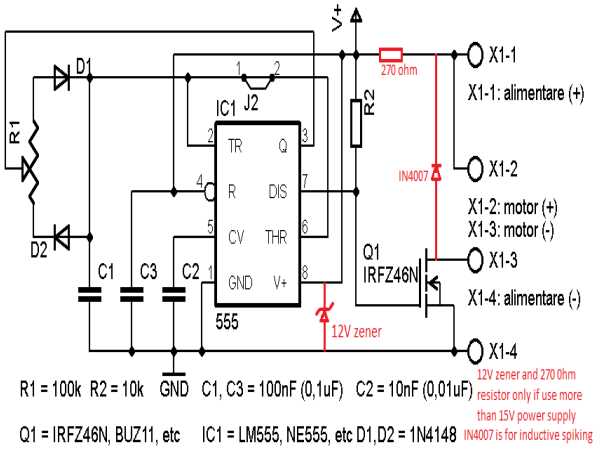

Fig 3:- Circuit Diagram

The control of this on and off period causes change in the waveform's width. If period of being on is greater than period of being off the speed increases and vis versa.

There are two methods to change the on and the off period. One is changing the capacitance of the capacitor i.e. if we increase the capacitance then it will take more time to charge the capacitor so the off period will increase and if we decrease the capacitance the off period will reduce. Second method is to use a resistor in series with the capacitor.

If the resistance is more during charging then it will take more time to charge so more off time and if it's less during charging then it will take less time to charge so less off time. Similarly, if the during discharging if resistance is more then on time will be more and if it's less then lesser on time. Manipulating this method, we can change the on and off time so in turn changing the speed accordingly.

In the circuit, we have used a potentiometer to apply the second method. So during charging the current is through D1 and during discharge it's from D2. Turning the potentiometer, we can change the resistance during charging and discharging therefor controlling the speed.

Additional two more components are used which are 12v Zener diode and 270ohm resistor. 12v Zener diode is to protect the IC from high voltage.

VI. FREQUENCY CALCULATION

The potentiometer is 100Kohm which can be divided in two parts
R= 100k = Ra + Rb

Ra is the resistance during charging of capacitor through D1 diode and Rb is the resistance during discharging of capacitor through D2 diode.

(Time period) T= Tc + Td

Tc is charging time from 1/3Vcc to 2/3Vcc and Td is discharging time from 2/3Vcc to 1/3Vcc

Tc=0.69*Ra*C
Td=0.69*Rb*C
(Frequency) F=1/T
=1/(Tc+Td)
=1/0.69(Ra+Rb) C
=1.45/(Ra+Rb)C
=1.45/(100Kohm)100nF
=145Hz

VII. DC MOTOR

A. Friction Calculation
Taking total weigh as 80kg
M is static friction coefficient
G is gravitational acceleration
F= m*g*m
=80*9.8*0.6
=470.4N
Now for each wheel

F/4=118(approx.)

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So, torque will be

T=118*(radius of wheel in meter) =118*0.1016=12Nm

From this we can conclude that we need more than 12Nm torque to move the object.

Also gear ratio will also determine how much torque will be given out from a particular motor.

So, taking care of the radius of the wheel we will take a sprocket with radius less then, the wheel radius, therefore assuming a 33T sprocket having radius 0.066m. Having 11T on motor.
So, gear ratio will be:

GR (gear ratio) =33T/11T=3

We know that motor torque should such that wheel torque is more than 12Nm therefore,

Torque on wheel> (3*motor torque)

This concludes the need of a motor with stalling torque greater than 4Nm i.e. either 5Nm or more.

After some search for motors of required specification, a 250w 24V dc motor with 5Nm stalling torque was decided to be implemented.

A. Battery

Two 1500mAh 3S 30C (11.1 v) Lithium Polymer Battery Pack (LiPo) is attached in series to provide 22.2Volt.

B. Specifications

3s; 30c; 1500mAh

C. Trucks

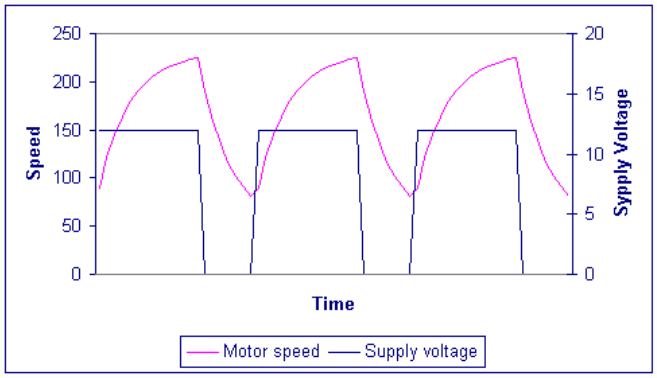
Trucks are mechanical part of skate boards to give directions. Channel trucks design is used. These metal parts are made up of an axle mounted to the bottom piece of the truck.

They are mounted to the deck using nuts and bolts, on an angle, (usually 45°).

When the board is tilted laterally the axles turn together to angle the wheels in the direction of the turn. With this mechanism in place, the skateboard axles will angle itself such that on any turn, the skateboard will not overturn and will always stay parallel to the ground.

Springs are mounted between the hanger and the axle housing on each truck to provide resistance to the lean of the rider during turning. Springs are there to return the deck to initial state after a turn has been performed.

VIII. RESULTS AND DISCUSSION



A. Pulse Width Modulation With Change In Voltage

As shown in the above graph, with the duration of the o time, the speed of the motor increases towards its rated voltage. As soon as the off period starts, the speed of the motor starts decreasing till the switch turns on again and the on period begins.

B. Software Simulation

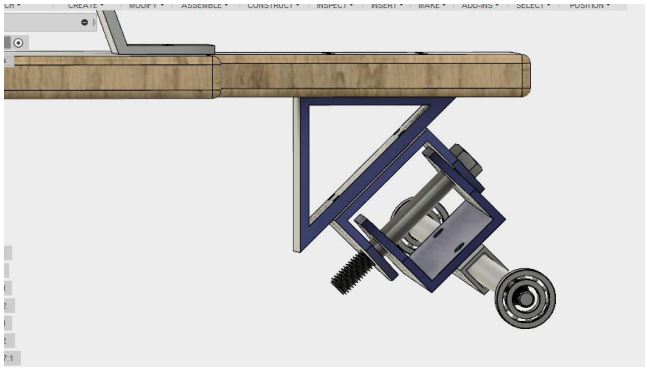
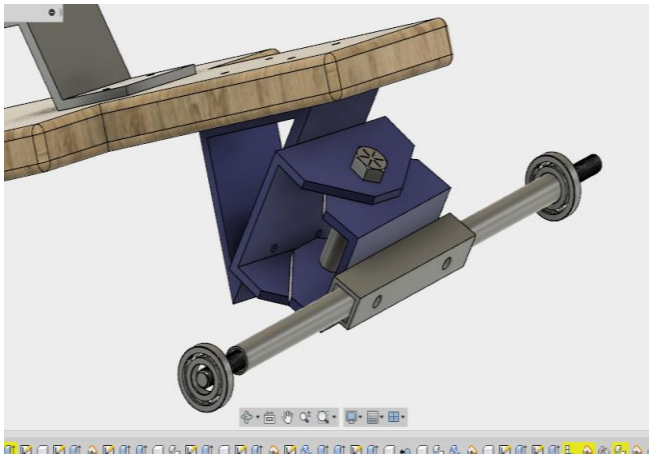


Fig 4:- Software Simulation



a.

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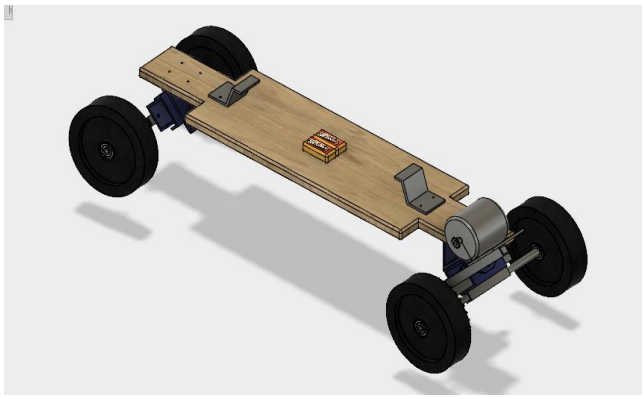
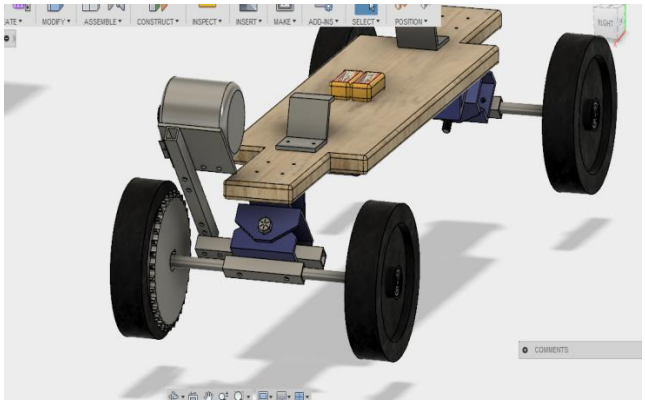
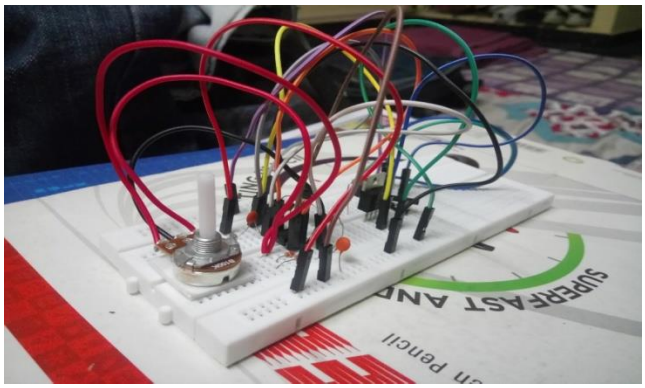


b.



c.

Hardware



d.

e.

f.

g.

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h.

IX. CONCLUSION

The speed of the DC motor was controlled by PWM circuit with a 555 timer. The simulated model of the skateboard was made and studied. The speed is successfully controlled by a potentiometer which changes the duty ratio of the circuit. The given circuit proves to be efficient as PWM results in very low loss of power due to the use of transistors and less voltage drop across itself. The motor voltage and revolutions per minutes (RPM) obtained at completely different duty cycle rates. Because the duty cycle will increase, additional voltage is applied to the motor. This contributes to the stronger magnetic flux within the coil windings and also the increases the revolutions per minute. The characteristics and performance of the DC motor speed system was studied. The skateboard is constructed out of wood and the metal parts for the truck system. The truck system, regulates the turning of the board. The wheels used are chosen according to Indian roads and will be able to move on off-roads and is highly cost efficient as compared to mountain boards.

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