IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 08, 2016 | ISSN (online): 2321-0613

PWM Based PMDC Motor Control

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Abstract— The goal of this work is to control the speed of PMDC motor using PWM technique. The speed control of PMDC motor is very essential in application where precision and protection is necessary. PWM is method that may be used as an efficient DC motor speed control. This paper shows that precise and accurate control of small DC motors can be done efficiently without using costly components and complicated circuit.

Key words: PMDC motor, speed control, PWM, H-bridge

I. INTRODUCTION

Almost all the machines in industries operates using electrical motors. among them most are dc motors. As compared to the other motors dc motor is far more advantageous in terms of compactness, speed control facility, high starting torque. Among all the advantages the dc series motor is mostly used for its high starting torque & variable speed. DC series motor is specially used for traction, electric locomotive, and trolley system, cranes hoists and conveyor. All these work require frequent speed control for preparation of job. DC shunt motors are very much popular for constant speed operations. Therefore they are used for driving constant speed shafts, centrifugal pumps, blower & pumps etc.

Traditional methods of speed control are basically controlling the voltage to the armature or to the speed through rheostat methods, controlling flux to the field through rheostat method. But they are of low efficiency and, not accurate. Therefore they are discarded and electronics method of controlling the speed is adopted. They have more advantages like high reliability, quick response and also higher efficiency and no moving parts.

Among all the electronics method of controlling speed the PWM (pulse width modulation) method is the best one as it uses the variable conduction period or variable duty cycle to control the speed of the motor. When the motors are running from a DC source then the PWM method is quit suitable and most efficient method. In this project a PWM modulator is designed using simple operational amplifiers. But have greater efficiency up to 99% and speed control of resolution 1 percent can be achieved. It can easily varied from 0% to 100% to set the speed.

This is one sort of chopper drive. Chopper drives are widely used in traction application all over the world. A dc chopper is connected between a fixed voltage dc source and a dc motor to vary the armature voltage. In addition to armature voltage control, a dc chopper can provide regenerative braking of the motors and can return energy back to the supply. This energy saving feature is particularly attractive to transportation system with frequent stop such as mass rapid transits (mrt). Chopper drives are also used in battery electric vehicles (bevs).

II. DESIGN PRINCIPLE

The principle controlling the DC power is simple by controlling the voltage or by current. But here the voltage is not controlled and also current is not controlled. But here the conduction time to the load is controlled. The main principle is control of power by varying the duty cycle. Simple we can take an example of the switch so that we can understand the principle. When a switch SW is closed for a time t1, the input voltage appears across the load. If the switch is off for t2 time the voltage across the load is zero. The average voltage at output is given by

$$V0 = (1/T)\ vodt = t1/T\ Vs = ft1\ Vs = kVs$$

And the average load current, Ia = Va/ R, Where T is the Chopping period=t1/T is the duty cycle of chopper, and f is the chopping frequency. The rms value of output voltage is found from

$$V0 = (1/T\ \ V02/R\ dt\ )1/2 = kVs$$

Assuming the loss less system the input power to the system is same as the output power and is given by,

$$Pi = 1/Tv0\ idt = 1/T\ v02\ /R\ \ dt = k\ Vs\ 2\ /\ R$$

The duty cycle can be varied from 0 to 1 by Varying t1 and T we can vary the duty cycle from 0 to 1. Therefore, the output voltage V0 can be varied from 0 to Vs by controlling k, and the power flow can be controlled.

The frequency f is kept constant and the on-time t1 is varied. The width of the pulse is varied and this type of control is called pulse width modulation (PWM) control.

The most efficient method of power control to a dc load is the pulse width modulation method. This means that the load is supplied with a pulse having variable duty cycle.

The PWM modulator is designed and it s duty cycle can be varied by varying the reference voltage of the out put comparator. The PWM out put is connected to a PWM filter which converts the pulsating voltage into a steady state dc level which is applied to the PMDC motor to control the speed of the motor.

III. CIRCUIT DESCRIPTION

A. *Dual Power Supply (+ve & -Ve).*

The power supply designed for catering a fixed demand connected in this project. The basic requirement for designing a power supply is as follows,

1) The different voltage levels required for operating the devices. Here +5Volt required for operating microcontroller. And +12 and –12Volt is required for drivers and amplifiers and comparators etc
2) The current requirement of each device or load must be added to estimate the final capacity of the power supply.

The power supply always specified with one or multiple voltage outputs along with a current capacity. As it is estimate the requirement of power is approximately as follows,

Out Put Voltage = +5Volt, +12Volt and –12Volt
Capacity = 1000mA

The power supply is basically consisting of three sections as follows,

1) Step down section
2) Rectifier Section

3) Regulator section

1) Design Principle

There are two methods for designing power supply, the average value method and peak value method. In case of small power supply peak value method is quite economical, for a particular value of DC output the input AC requirement is appreciably less. In this method the DC output is approximately equal to Vm. A full wave bridge rectifier is designed using four diodes and the output of the rectifier is filtered with a capacitor. There are two capacitors connected in this power supply, one for filtering and providing back up to positive power supply and other one for providing backup and filter action to the negative power supply. In this case the output with reference to the center tap of the transformer is taken in to consideration, though the rectifier designed is a full wave bridge rectifier but the voltage across the load is a half wave rectified output. The Regulator section used here is configured with a series regulator LM78XX and 79XX the XX represents the output voltage and 78 series indicates the positive voltage regulator 79 series indicates the negative regulator for power supply. The positive regulator works satisfactorily between the voltage XX+2 to 40 Volt DC. The output remains constant within this range of voltage. The negative regulator works satisfactorily between the voltage -(XX+2) to -40 Volt DC. The output remains constant within this range of voltage.

2) Circuit Connection

In this we are using Transformer (9-0-9) v / 1mA, IC 7805, 7912 & 7812, diodes IN 4007, LED & resistors.

Here 230V, 50 Hz ac signal is given as input to the primary of the transformer and the secondary of the transformer is given to the bridge rectification diode. The positive output of the bridge rectifier is given as i/p to the IC regulator (7805 &7812) through capacitor (1000mf/35v). The negative output of the rectifier section feed to the input of the IC 7912 through a capacitor of (1000mf/35v). The o/p of the IC regulator is given to the LED through resistors to act as indicator.

3) Circuit Explanations

When ac signal is given to the primary of the transformer, due to the magnetic effect of the coil magnetic flux is induced in the coil (primary) and transfer to the secondary coil of the transformer due to the transformer action. "Transformer is an electromechanical static device which transformer electrical energy from one coil to another without changing its frequency". Here the diodes are connected in a bridge fashion. The secondary coil of the transformer is given to the bridge circuit for rectification purposes.

During the +ve cycle of the ac signal the diodes D2 & D4 conduct due to the forward bias of the diodes and diodes D1 & D3 does not conduct due to the reversed bias of the diodes. Similarly, during the –ve cycle of the ac signal the diodes D1 & D3 conduct due to the forward bias of the diodes and the diodes D2 & D4 does not conduct due to reversed bias of the diodes. The output of the bridge rectifier is not a power dc along with rippled ac is also present. To overcome this effect, a capacitor is connected to the o/p of the diodes (D2 & D3). Which removes the unwanted ac signal and thus a pure dc is obtained. Here we need a fixed voltage, that's for we are using IC regulators (7805 & 7812 and 7912). "Voltage regulation is a circuit that supplies a constant voltage regardless of changes in load current." The o/p of the bridge rectifier is given as input to the IC regulator through capacitor with respect to GND and thus a fixed o/p is obtained. The o/p of the IC regulator (7805 & 7812 and 7912) is given to the LED for indication purpose through resistor. Due to the forward bias of the LED, the LED glows ON state, and the o/p are obtained from the pin no-3.

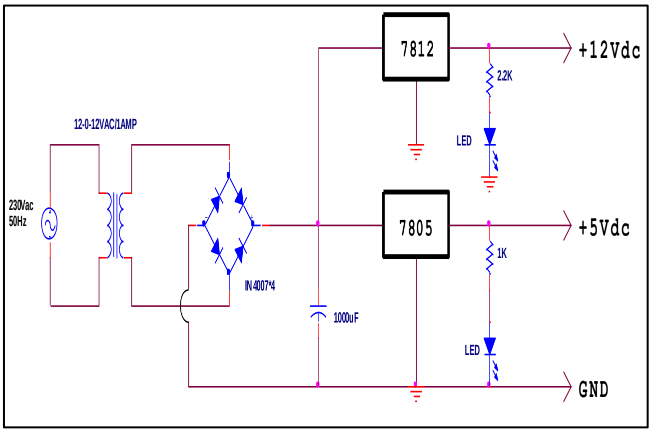

Fig. 1:

B. Pulse Width Modulator

This is an opamp based design for generating PWM output. There are four stages of Opamp running on a single-rail power supply. The saw tooth is generated with the circuit designed by 1st and 2nd opamp. The function of different sections is as follows.

1) The 1st opamp is configured as a Schmitt Trigger
2) The 2nd opamp is configured as a Miller Integrator
3) The 3rd opamp is used as a low gain amplifier
4) The 4th opamp is used as a comparator to compare the saw tooth with the reference voltage and generate PWM with different pulse width.

The 1st opamp is used as a Schmitt Trigger. The reference voltage for the Schmitt Trigger is set at Vcc/2 due to the potential divider input given to the inverting input of the opamp1. The Upper limit voltage is dependant on the integrator output. Also the lower limit depends on the integrator out put.

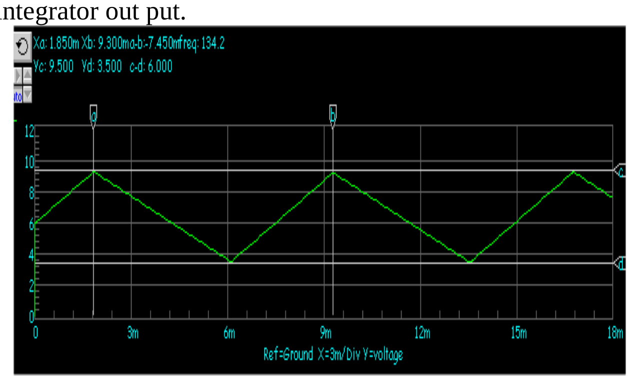

Fig. 2:

The opamp2 acts as a miller's integrator this inverting type integrator. The slope of the integrated output depends on RC of the circuit. The opamp1 and opamp2 together generates one triangle wave with Vcc/2 as reference line of symmetry.

The 1st two sections of the quad op-amp form a triangle-wave generator, but now the third section is used as a low-gain amplifier, bringing the trough of the wave to just above zero volts and the peak to about 10v or as required by the design.

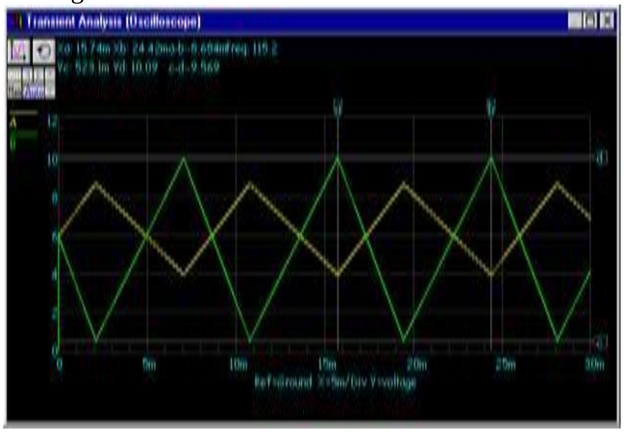

Fig. 3:

The fourth op-amp section is connected as a comparator, comparing the triangle wave voltage with a reference voltage set by the potential divider R8 & VR1. When the wave voltage goes above the voltage at the pot wiper, the comparator output goes high, else the comparator output goes low.

With the pot turned fully clock-wise the wiper voltage is below about 0.5v and the load is on 100% of the time. Increasing the wiper voltage (by turning the pot anti-clockwise) reduces the duty cycle, and it's easy to set a minimum speed just by changing the value of R8.

Above is the effect of a low reference voltage, with the output "on" for most of the time, and below the reference voltage is near maximum giving a low duty cycle.

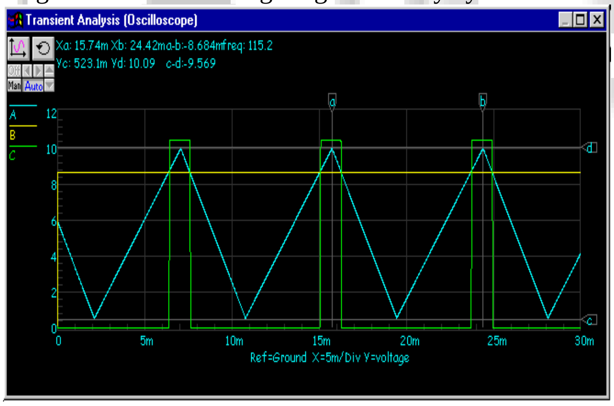

Fig. 4:

Above is the effect of a low reference voltage, with the output "on" for most of the time, and below the reference voltage is near maximum giving a low duty cycle.

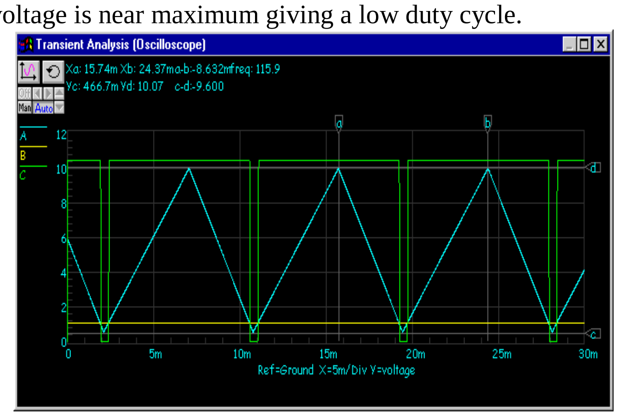

Fig. 5:

IV. Operation

R8 – This sets the minimum speed. With the 10k pot, a 1k resistor will give 0–100% control which is OK for model motors or lighting, 10k will give around 5v–12v range, more suitable for cooling fans.

VR1 can be changed to a 47k pot if it suits you better, changing R8 to 4k7–47k depending on your required minimum.

C1 – This is the timing capacitor, and with the 47k timing resistor R1 and wave amplitude control resistors R2 (22k) & R3 (10k) gives a PWM frequency of around 117Hz according to the formula

FREQUENCY = R2 / (4 X R3 X R1 X C1)

Don't change R2 or R3, but you can alter R1 and/or C1 if you want to try different frequencies.

A 5mm lead pitch fits the board spacing, so a fair selection of miniature polyester types (or the cheaper mylar) will fit.

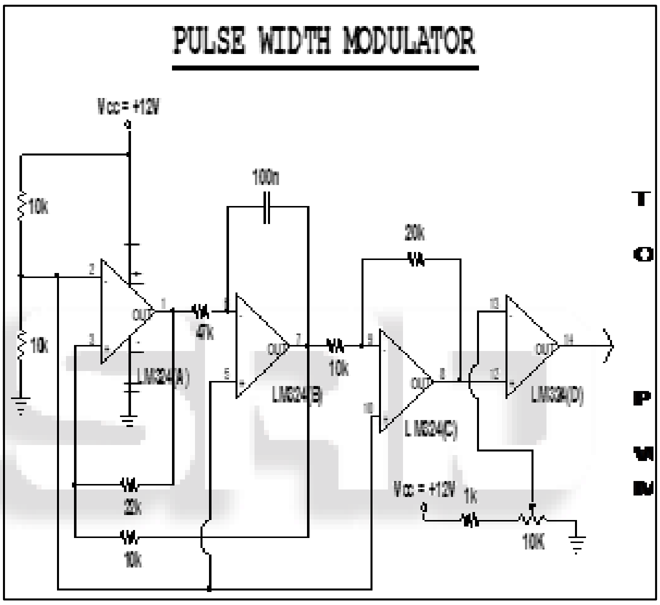

Fig. 6: Pulse Width Modulator

A. Motor Driver

The D.C. Motor used in this project operates at 12 volt and carries approximately 400mA of current. The motor driver is designed to inter face the motor with micro controller. The micro controller output is +5volt and can maximum give a current of 5mA. The driver stage changes the current and voltage level suitably to drive the motor. The driver stage not only drives the motor but also helps to control the direction of rotation. As the output current (Ic) is large the driver section requires a Darlington pair to switch the load. The Darlington pair I.C. TIP 122 is used here for designing. There are four ICs used here but two of those switched for one direction and other two will be switched for opposite direction rotation of the D.C. motor. The design principle of the driver section is as follows.

The motor takes approximately 400mA at 12 volt D.C., The power transistors can have amplification factor maximum 60 to 70 as per this assumption the base current required to switch on the transistor is approximately

Ib= (Ic/beta) =400mA/60 =6.7 mA

This current is too high to supply as a base current, more over the Microcontroller can not supply that much current to drive the transistor so, a darling ton pair is required to limit the base current within 100 micro amp. To 2 mA.

V. H. DC MOTOR

The motor being dissected here is a simple PMDC electric motor that is typically find applications in robotics and control systems also used for techo generator in the industries.

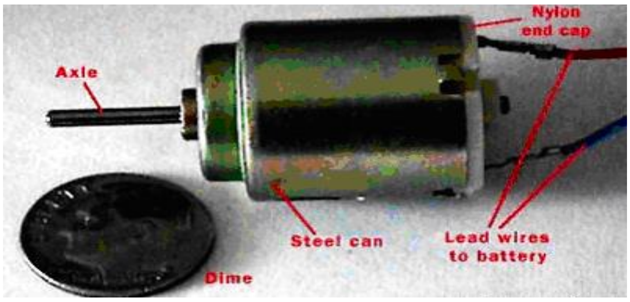

Fig. 7:

This is a small motor, about as big around as a coin. From the outside the body of the motor is shown in the picture along with its axle and two battery leads. If the motor is connected to the battery then , the axle will spin. If the leads are reversed then, it will spin in the opposite direction. Here are two other views of the same motor. (Note the two slots in the side of the steel can in the second shot -- their purpose will become more evident in a moment.)

Fig. 8:

e nylon end cap is held in place by two tabs that are part of the steel can. By bending the tabs back, end cap can be free and removed. Inside the end cap are the motor's brushes. These brushes transfer power from the battery to the commutator as the motor spins:

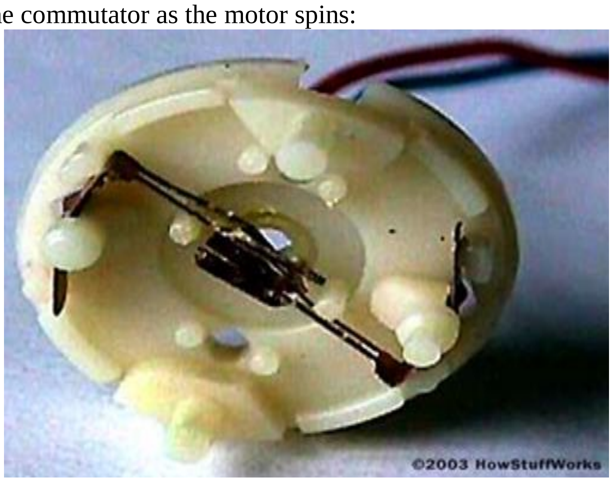

Fig. 9:

The axle holds the armature and the commutator. The armature is a set of electromagnets in this case three. The armature in this motor is a set of thin metal plates stacked together, with thin copper wire coiled around each of the three poles of the armature. The two ends of each wire (one wire for each pole) are soldered onto a terminal, and then each of the three terminals is wired to one plate of the commutator. The figures below make it easy to see the armature, terminals and commutator:

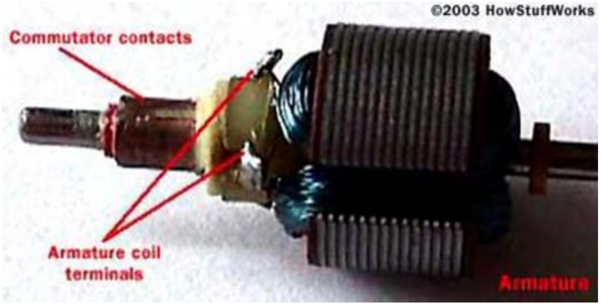

Fig. 10:

The final piece of any DC electric motor is the field magnet. The field magnet in this motor is formed by the can itself plus two curved permanent magnets:

Fig. 11:

One end of each magnet rests against a slot cut into the can, and then the retaining clip presses against the other ends of both magnets.

An electromagnet is the basis of an electric motor. You can understand how things work in the motor by imagining the following scenario. Say that you created a simple electromagnet by wrapping 100 loops of wire around a nail and connecting it to a battery. The nail would become a magnet and have a north and south pole while the battery is connected.

Now say that you take your nail electromagnet, run an axle through the middle of it and suspend it in the middle of a horseshoe magnet as shown in the figure below. If you were to attach a battery to the electromagnet so that the north end of the nail appeared as shown, the basic law of magnetism tells you what would happen: The north end of the electromagnet would be repelled from the north end of the horseshoe magnet and attracted to the south end of the horseshoe magnet. The south end of the electromagnet would be repelled in a similar way. The nail would move about half a turn and then stop in the position shown.

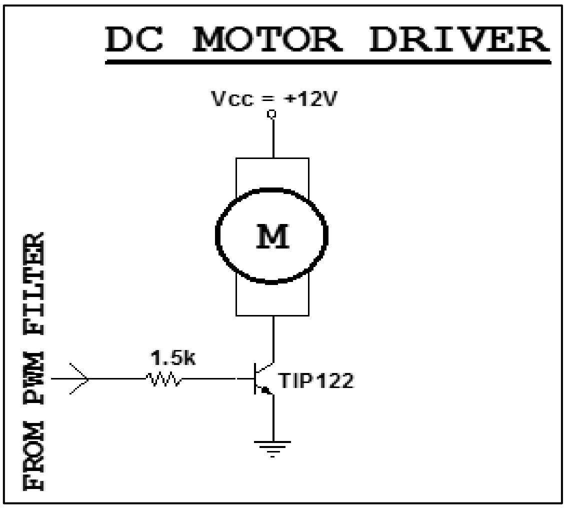

Fig. 12:

VI. FUTURE EXPANSION

The system is designed with in limited time and cost. This project can be expanded to transmit the PWM control signal through an fable optic cable or by wireless media.

VII. CONCLUSION

The project is designed in the laboratory, and found to be operating very stably in the laboratory condition. The variation of duty cycle is quit linear between 0 to 100% for low frequency PWM.

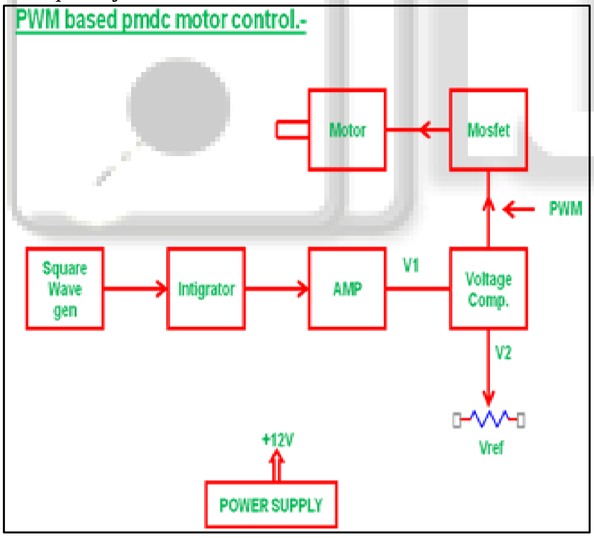

Fig. 13:

REFERENCES

[1] I.G.A.P. Raka Agung, S. Huda & I.W. Arta Wijaya, University of Udayana, Bukit Jimbaran, Bali, Indonesia, IEEE, Smart Green Technology in Electrical and Information Systems (ICSGTEIS), 2014 International Conference
[2] Khan Masoom Raza1 , Mohd. Kamil1 , Pushpendra Kumar1 "Speed Control of DC Motor by using PWM", IJARCCE
[3] Muhammad Rasid,"Power Electronics circuits, Devices and Applications" Prentice Hall, 3rd edition. [
[4] Atul Dewangan, Nibbedita, Sashi,Vinod Yadu,"PWM Based Automatic closed loop speed Of DC motor" , international journal of engineering trends and technology- volume 3 issue2-2012.
[5] Speed control of dc motor using pulse width modulation by professor janusz zalewaski
[6] http://www.ijert.org/view-pdf/1641/speed-control-of-dc-motorusing-analog-pwm-technique
[7] http://www.ijera.com/papers/Vol3_issue1/DP31778783.pdf