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Industrial Fully Control Dc Motor Drive without Microcontroller

Four Quadrant Speed Control of DC Motor Using MOSFET and Push Button Switch

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Abstract:-*Motors were mainly used for essentially constant speed and direction applications because of the unavailability of the variable frequency voltage supply. The advancement of power electronics has made it possible to vary the PWM of the voltage. There have been previously many researches with speed and directional control of DC motor. In this paper present four quadrant speed control model is designed by using MOSFET to control the speed of DC motor. The designed model provide four quadrant speed control of DC motor in both direction, i.e. clockwise direction, counter-clockwise direction with the braking of DC motor. The switching operation of MOSFET is done by can by using pulse width modulation (PWM) technique. In this designed model PWM signal can be generated by using of IC LM324 (Quad op-amp). The ultimate objective of this project is to design an easy speed control, efficient cost, precise and compact circuit for speed and directional control of DC motor without the use of microcontroller.*

Keyword:-*MOSFET, Speed and Direction Control, IC 555, Full wave Bridge, DC motor, Voltage Regulator*

I. INTRODUCTION

The speed control 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 by the chopper, IGBT (Insulated Gate Bipolar transistor) and microcontroller. They had disadvantage of large size and it's costly.

The main objective of this project is to design speed and direction control of DC motor which is easy speed control, efficient cost, 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.

Pulse width modulation is nothing but varying the duty cycle which is turn reduces the terminal voltage without any heat energy loss. Here I have used IC 555 to implement pulse width modulation. As a DC motor offers high starting torque and which is also proportional to the armature current, MOSFET switches along with a PWM can be used as a very good speed controller that would provide smooth and quiet motor operation.

As speed control method for DC motors are simpler and less expensive compare to AC motors, DC motors are preferredwhere wide speed range control is required.

Compare to the other device like IGBT, chopper and BJT, the MOSFET is high input or gate resistance, it's very fast switching speeds and the ease at which they can be driven makes them ideal to interface with op-amps or standard logic gates.

II. FOUR QUADRANT OPERATIONS

Four quadrant operations is shown in figure1. In the first quadrant operation power can be flow from source to load and hence, current and voltage in the first quadrant are assumed to be positive. Similarly, in secondquadrant operation voltage remain positive but change in direction of current i.e. negative this condition happened when load is inductive such as a DC motor in third quadrant operation current and the voltage are both in negative but the power is positive. Similarly in four quadrants operation current is positive and voltage is negative and there for power is negative which is shown in figure1.

At the first quadrant current and voltage are positive then the motor can rotate in the forward direction i.e. forward motoring. If the polarity of armature current and armature voltage changing then the motor can operated as reveres motoring i.e. (III Quadrant) and when direction of energy is reveres in II and IV Quadrant the motor can operated as a generator braking. The MOSFET will give the facility of regenerative braking. The regenerative braking is cause when the energy can return to the supply and the main condition for the regenerative braking is that EMF produced by the motor which is rotating EMF it must be greater than the applied voltage so that can be flow in the reverse direction the motor can operated at generating mode. The generating mode can be maintained over any particular duration of time only if the load is able to delivered power.

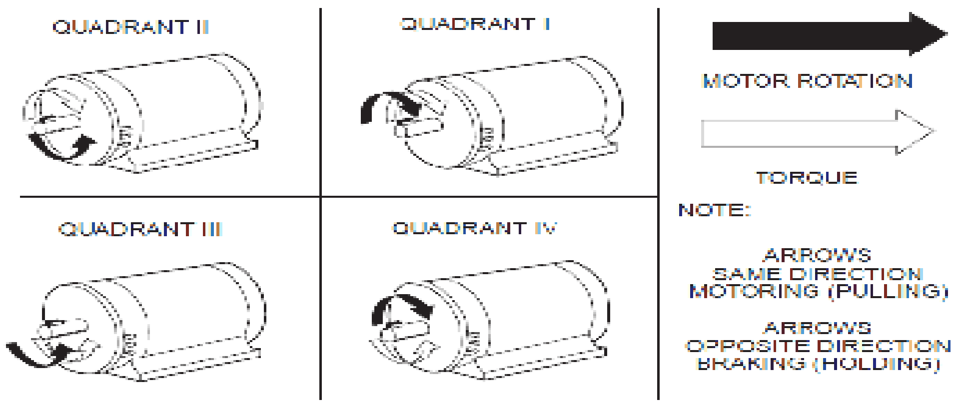

Figure 1 Four Quadrant Operation

III. DC MOTOR

When a conductor is placed in magnetic field and electric current is passed through it, a mechanical force is produced on the conductor .This force is given by

F=B.I.L Newton.Where, B = magnetic flux density in Weber

I= current in conductor in amperes, L=length of conductor in meters

The electric motor is convert electrical energy into mechanical energy by using principle of electromagnetic induction.When the field magnet of the motor excited and it's armature conductor are supplied with current from the supply mains, then they experience a force tending o rotate the armature. The direction of the force is given by Fleming's left hand rule.

Figure 2. DC motor

IV. FUNCTION OF MOSFET

This is the very popular IRFZ44N MOSFET.Power MOSFETs can be used to control the movement of DC motors.we have considered a small DC series motor control by P-MOSFET. In this instance the MOSFET switch is connected between the load and the positive supply high-side switching as we do with PNP transistors.In a P-channel device the conventional flow of drain current is in the negative direction so a negative gate-source voltage is applied to switch the transistor "ON".This is achieved because the P-channel MOSFET is "upside down" with its source terminal tied to the positive supply $+V_{dd}$. Then when the switch goes LOW, the MOSFET turns "ON" and when the switch goes HIGH the MOSFET turns "OFF".This upside down connection of a P-channel enhancement mode MOSFET switch allows us to connect it in series with a N-channel enhancement mode MOSFET to produce a complementary or CMOS switching device as shown across a dual supply.

Figure 3. P-MOSFET

V. BLOCK DIAGRAM

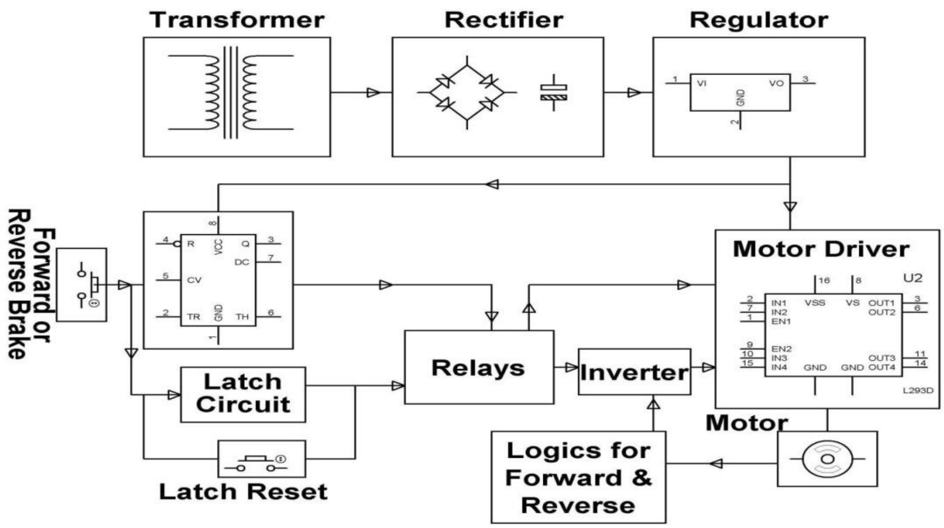

Figure 4. Block Diagram

DC motor which can be operated in clockwise direction, anticlockwise direction and also speed control by providing instantaneous stop. Instantaneous stop in clockwise direction and also instantaneous stop in anticlockwise direction. Motor will try to operate, this now once we operate this motor is rotating at a full speed and supposing we will like to make a forward brakes top instantaneously. We are full to reset again and to put forward brake stop instantaneously. Put it, stop instantaneously. Forward brake are very best. Also preset very briefly best and the all is operated. In the reverse direction, now suppose its rotate in reverse direction and we are reset in again and preset a very briefly to motor stop instantaneously. Suppose a motor rotate in normal speed to find a text time to stop a normal speed and speed control also possible by providing certain speed control arrangements.

VI. CIRCUIT DIAGRAM

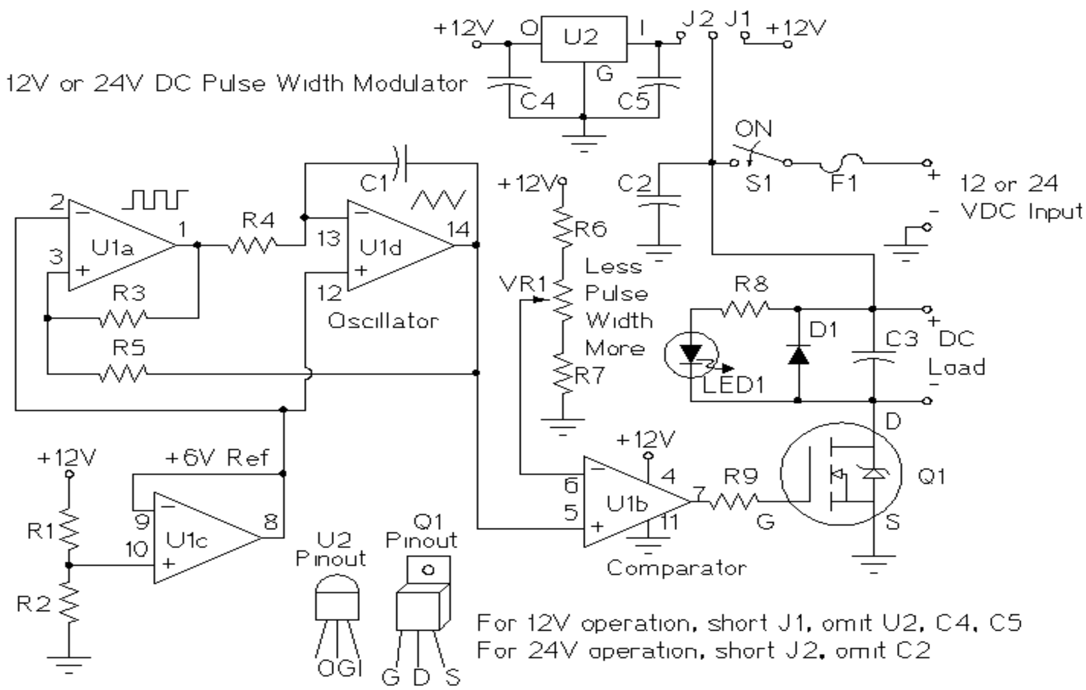

Figure 5. Circuit Diagram

The PWM circuit requires a steadily running oscillator to operate. U1a and U1d form a square/triangle waveform generator with a frequency of around 400 Hz.

U1c is used to generate a 6 Volt reference current which is used as a virtual ground for the oscillator, this is necessary to allow the oscillator to run off of a single supply instead of a +/- voltage dual supply.

U1b is wired in a comparator configuration and is the part of the circuit that generates the variable pulse width. U1 pin 6 receives a variable voltage from the R6, VR1, R7 voltage ladder. This is compared to the triangle waveform from U1-14. When the waveform is above the pin 6 voltage, U1 produces a high output. Conversely, when the waveform is below the pin 6 voltage, U1 produces a low output. By varying the pin 6 voltage, the on/off points are moved up and down the triangle wave, producing a variable pulse width. Resistors R6 and R7 are used to set the end points of the VR1 control, the values shown allow the control to have a full on and a full off setting within the travel of the potentiometer. These part values may be varied to change the behavior of the potentiometer.

Finally, Q1 is the power switch, it receives the modulated pulse width voltage on the gate terminal and switches the load current on and off through the Source-Drain current path. When Q1 is on, it provides a ground path for the load, when Q1 is off; the load's ground is floating. Care should be taken to insure that the load terminals are not grounded or a short will occur.

The load will have the supply voltage on the positive side at all times. LED1 gives a variable brightness response to the pulse width. Capacitor C3 smooth out the switching waveform and removes some RFI, Diode D1 is a flywheel diode that shorts out the reverse voltage kick from inductive motor loads.

In the 24 Volt modes, regulator U2 converts the 24 Volt supply to 12 Volts for running the PWM circuit, Q1 switches the 24 Volt load to ground just like it does for the 12 Volt load. See the schematic for instructions on wiring the circuit for 12 Volts or 24 Volts.

When running loads of 1 amp or less, no heat sink is needed on Q1, if you plan to switch more current, a heat sink with thermal grease is necessary. Q1 may be replaced with a higher current device; suitable upgrades include the IRFZ34N, IRFZ44N, or IRFZ48N. All of the current handling devices switch S1, fuse F1, and the wiring between the FET, power supply, and load should be rated to handle the maximum load current.

VII. LM324 QUD OP-AMP

Now a day the advancement in the comparator can be done hence the comparator is easily found such as National Semiconductor LM324 quad Op-Amps .Comparator is the modified version of Op-Amps.

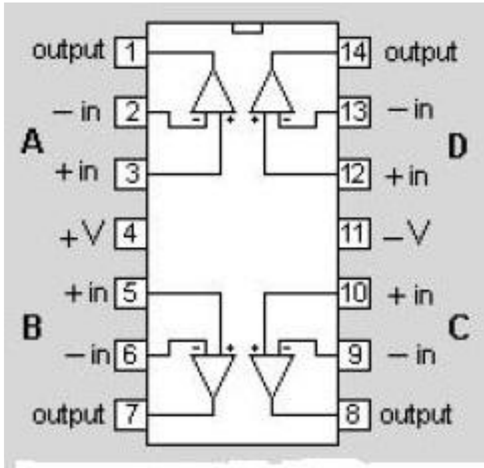

Figure 6. Pin Diagram of LM324 IC

LM324 Combine the four op-amp IC i.e. IC-A,ICB,IC-C and IC-D as show in the pin diagram of the IC LM324.The ramp voltage signal can be control by the potentiometer vie IC-A. Increasing and decreasing of the ramp voltage change the position of triangular wave. Op-amp IC-B use as a triangular wave generator which can provide the trigger signal to the voltage comparator. IC-C and IC-D is the voltage comparator, the reference voltage for IC-D is provided to non-inverting (+input) terminal and inverting terminal (-input) is connected to the IC-C. Due to that IC-D is triggered by a voltage which is greater than its reference voltage and IC-C is triggered by voltage less than its reference. It is not possible to trigger the both comparator at the same time because the peak to peak or maximum output level of triangular wave is less than the difference between to voltage references otherwise the all IGBT are conduct Causes the short circuit and get damage. Triggering of the IC-D and IC-C is depend upon the position of the triangular wave when triangular wave shift up then comparator IC-D trigger and triangular wave shifted down Causes comparator IC-C to trigger. When the triangular wave is between the two voltage references then no one comparator is triggered.

VIII. 555 TIMER AS ASTABLE MULTIVIBRATOR

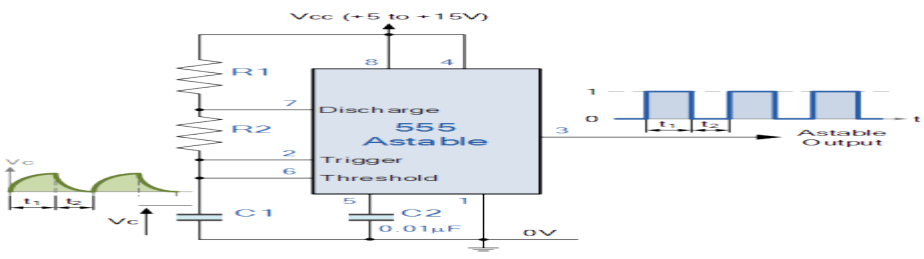

Figure 7. Pin Diagram of IC 555

The 555 is connected for astable operation. Here the timing resistor is now split into two sections, R1 and R2+VR1, with the discharge pin 7 connected to the junction of R1 and R2+VR1. When the power supply connected, the timing capacitor C1 charge towards 2/3 VCC through R1 and R2+VR1. When the capacitor voltage reaches 2/3 VCC, the upper comparator triggers the flip-flop and the capacitor start to discharge towards ground R2+VR1. When the discharge reaches 1/3 VCC, the lower comparator is triggered and a new cycle is started.

IX. H-BRIDGE FOR DIRECTION CONTROL

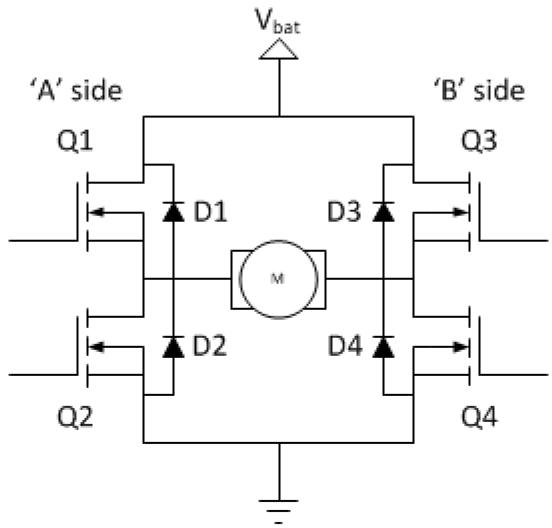

Figure 8. H Bridge Circuit

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.

X. CONCLUSION

Hence speed and direction control of DC motor is achieved by 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.

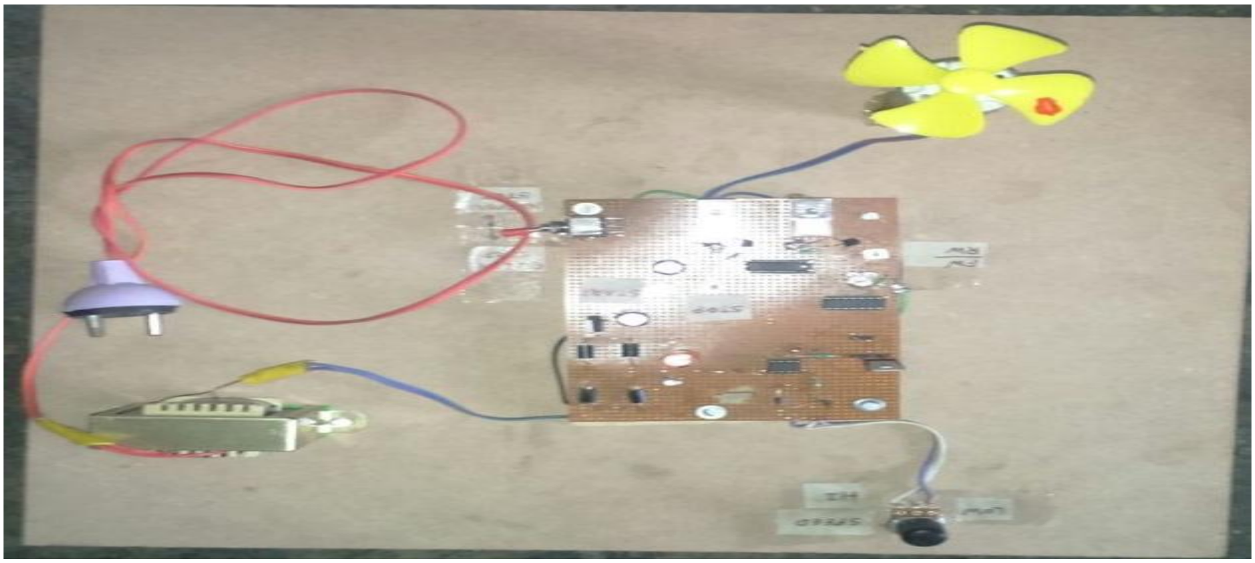

Figure 9. Project Model

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