Review on Speed and Direction Control of DC Motor By Using Single MOSFET and Two SPDT Relay

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Abstract – *The DC motor is backbone of industrial application. in industry DC motor is widely used for speed control and load characteristics the DC motor are used because it provide a reliability, simplicity and low cost. Nowadays a 1phase or 3 phase motors are used but it is quite difficult to regulate the speed of AC motors. hence when there is need of to regulate the speed of motor for different application then at that time the DC motor is more useful than a AC motor. The speed of DC motor is controlled by various methods like armature voltage controlled method, field flux control method, armature resistance controlled method, but these methods are previous method and they require manual operation. Generally to control the speed and direction of dc motor the h-bridge circuit is used. These both the function of dc motor can be performed by using only one MOSFET and two SPDT relay. This paper demonstrate the proposed model for motor driving circuit which is control the speed as well as direction control of the motor. it consist of two SPDT relay for direction control and single MOSFET for speed control.*

Key Words: H-bridge, MOSFET, Pulse width modulation, relay, speed and direction control.

1. INTRODUCTION

Generally H-bridge circuit is used to control the speed as well as the direction of rotation of DC motor either in clockwise or in anticlockwise direction. H-bridge is made by using four switches like BJT's, IGBT's Relays, MOSFET etc. [5] if there is need of to vary the speed of the motor then it is necessary that the switches must be turn ON and OFF periodically at sufficiently high frequency using the mechanism like pulse width modulation (PWM).in case of relays it cannot be used in H-bridge circuit for to control the speed, because it cannot be switched at high frequency. Hence the H-bridge generally made up of four MOSFET's or BJT's. if the H-bridge is constructed with the four MOSFET's then H-bridge is consist of either four N-channel MOSFET's or two P-channel MOSFET's when all MOSFET's Are N-channel MOSFET's then the H-bridge is need a special driving circuitry like 'Bootstrap circuit'[1].because of these the H-bridge circuit become complex. Therefore to reduce the complexity, we designed circuit that replaces the MOSFET with the two SPDT relay that carries the Direction control and the single MOSFET to carry the speed control of the motor this motor driver provide a several advantages over the conventional motor drivers such as compact size, high reliability, fewer component, low cost and less susceptibility to electrostatic discharge. As there is a use of relay therefore it is quite reliable as compared to the MOSFET Also "Shoot-through effect" is completely reduced.

2. DIFFERENT METHODS

2.1 Armature Voltage Control Method

The speed is directly proportional to the voltage applied across the armature. As the supply voltage is normally constant, the voltage across the armature can be controlled by adding a variable resistance in series with the armature. The field winding is excited by the normal voltage hence shunt current is rated and constant in this method. Initially the rheostat position is minimum and rated voltage gets applied across the armature. So speed is also rated.

For a given load, armature current is fixed. So when extra resistance is added in the armature circuit, armature current, remains same and there is voltage drop across the resistance added (Ia R). Hence voltage across the armature decreases, decreasing the speed below normal value. By varying this extra resistance, various speeds below rated value can be obtained. So far a constant load torque, the speed is directly proportional to the voltage across the armature. The relationship between speed and voltage across the armature is shown in the Fig.1. In this way by varying the armature voltage we can control the speed of motor because the armature voltage is directly proportional to the speed. So as the voltage across the armature increases then there is increase in speed, as the armature voltage is reduced the speed of motor also reduced.

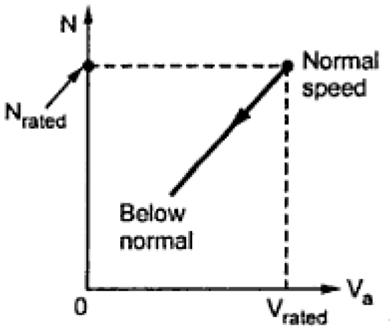

Fig.-1: Armature voltage control

2.2: Field Flux Control Method

In this method field circuit resistance is varied to control the speed of a DC shunt motor. If we vary, flux φ will change, hence speed will vary. To change If an external resistance is connected in series with the field windings. The resistance is called the shunt field regulator .the field coil produces rated flux when no external resistance is connected and rated voltage is applied across field coil. It should be understood that we can only decrease flux from its rated value by adding external resistance. Thus the speed of the motor will rise as we decrease the field current and speed control above the base speed will be achieved. Speed versus armature current characteristics as shown in Fig 2.

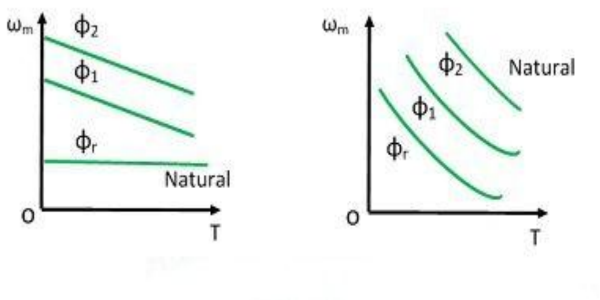

Fig.-2: Field Flux Control

3. PROPOSED SYSTEM

3.1. Circuit Diagram

In that model the motor driver circuit consist of N-channel power MOSFET, two electromagnetic relay, micro-controller (Atmega2560), relay driving IC (ULN2003), filtering capacitor and resistors. Fig 3 shows the schematic diagram of prototype of circuit in which H-bridge is made up of two SPDT relay. Connector (CON1) provides the input to the circuit the signals D1 and D2 which are used for direction control are provided to the input of IC ULN2003 and their corresponding output are provided to the coils of two relays. PWM signal from pin 3 is directly provided to the gate terminal of MOSFET So as to control the speed of motor. At the output of the relay the common terminal (C) is connected to M+ and M- of the motor.NC terminal of both relays are connected to the drain (D) of the MOSFET and their terminals are shorted to VCC, which is 24 volt in our case.

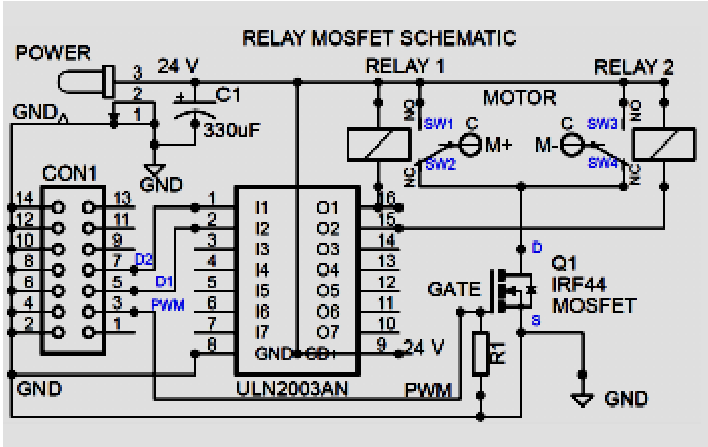

Fig.-3.1: Circuit Schematic Diagram

3.2: Block Diagram

For the speed control and the direction control of motor driver require 3 signals D1,D2 and PWM Respectivelly.in that model the micro-controller (At mega 2560) is used as Motherboard to generate the signal D1,D2 for to control the direction of motor and PWM for to control the speed of motor.

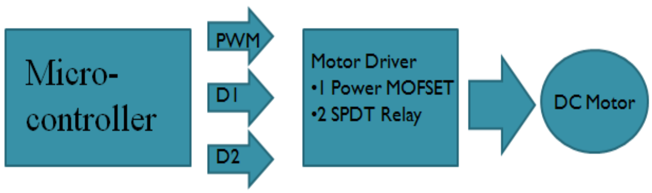

Fig.-3.2: Block Diagram of Proposed System

To facilitate the speed control, the MOSFET is connected in series with the relay and its source terminal connected to the ground. The PWM signal is supplied to the gate terminal of the MOSFET.by varying the duty cycle the ON and OFF time of MOSFET is control. Therefore by varying duty cycle the speed of the motor can be control. The signal D1 and D2are provided by the micro-controller to the SPDT relay 1 and the SPDT relay 2 through the relay driving IC ULN2003.if the micro-controller gives the signal D1 then the coil of relay1energised and the motor will rotate in anticlockwise direction, and if the micro-controller gives the D2 signal then coil of relay2 is energized and the motor is rotate in clockwise direction.in these way the signal D1 and D2 control the direction of rotation of motor according to the control logic tabulated in figure which shows all possible combination and their resultant outcomes in terms of operation of the motor.

4. CONTROL LOGIC TABLE

Table -1: Control Logic Table

PWM	D1	D2	EFFECT
H	0	0	Motor Brake
H	0	1	Motor rotates in one direction
H	1	0	Motor rotates in opposite direction
H	1	1	Motor brake
L	0	0	Motor brake
L	0	1	Motor freewheel
L	1	0	Motor freewheel
L	1	1	Motor brake

5. ADVANTAGES

The proposed motor driver having several advantages over the conventional motor drivers like it is having a low cost, compact in size because while designing the H-bridge the relays are used for high side instead of traditionally used MOSFET. Therefore corresponding intricate MOSFET driving circuit is also eliminated. Also it is simple circuit as compared to other motor driver's circuit. Heat sinking is moderate because only one MOSFET require heat sinking rather than four thus the elimination of bulky heat sinks makes a motor driver compact.

6. CONCLUSION

The paper demonstrates a new method for speed and direction control of DC Motor by using single MOSFET and two SPDT relay. The reliability of the system is high as compared to traditional Motor drivers. The driver is compact and less complex since the MOSFET driving circuitry is eliminated. Also this circuit is more robust to failures caused by damages to the MOSFET's due to ESD (electrostatic discharge).Thus Motor driver can be used in different application for effectively controlling the speed.

ACKNOWLEDGEMENT

I express my sense of gratitude and sincere regards to my guide Prof. Apurva A. Bhalerao for guiding me properly in my project work and for helping to solve the project work difficulties. I would also like to thanks all the staff members of Electrical (Electronics & Power) Department for supporting and guiding me in my project work whenever required.

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