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Four Quadrant Dc Motor Drive

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Abstract: *DC motor drives are used drastically in adjustable pace drives and function manage programs. This paper proposes a way to govern the rate and route control of a DC motor with the help of a 4 quadrant DC-DC chopper. The speed under the base velocity may be controlled by way of armature voltage manage technique. MOSFETs are used for the switching operation of the chopper. The gates of those MOSFETs are given PWM which affords the 4 quadrant operation. This PWM (Pulse Width Modulation) is generated through programming. of microcontroller the use of embedded c program language period.*
Keywords: *Four quadrant DC-DC chopper, Pulse Width Modulation, mosfet.*

I. Introduction

Trends of high overall performance motor drives are very important for commercial packages. An excessive overall performance motor power gadget should have suitable dynamic pace command tracking and cargo regulating response. DC automobiles provide outstanding manipulate of speed for acceleration and deceleration. The energy delivered to a DC motor connects immediately to the field of the motor which permits for unique voltage control, and is vital for speed and torque manipulate packages. DC drives, because of their simplicity, ease of application, complicated compared to AC drives gadget. DC drives are typically much less high-priced for low horsepower rankings. AC drives with this capability could be greater complex and highly-priced. Protection of commutator is minimum. [1] The 4 quadrant chopper operates within the 4 quadrants in the following ways

1.1 Quadrant 1: In the first quadrant, the voltage and current are advantageous making the electricity effective. In this situation, the power flows from source to load. On this operation S1is ON, S4 is OFF, S2 is continuously ON and S3 is continuously OFF. S1 and S2 are conducting in this mode.
1.2 Quadrant 2: In the 2nd quadrant, the voltage remains superb but the current is poor consequently, the power is negative. In this example, the electricity flows from load to source and this could happen if the load is inductive or back emf source along with a dc motor. Right here S1 is OFF, S4 is ON, S2 is continuously ON and S3 is continuously OFF as the inductor current cannot be changed without delay, D4 and S2 might be freewheeling the current.
1.3 Quadrant 3: In the 3rd quadrant both the voltage and current are poor but the strength is effective. In this case, the strength flows from source to load. In this operation S3 is ON, S2 is OFF, S4 is continuously ON and S1 is constantly OFF. S3 and S4 are conducting in this mode.
1.4 Quadrant 4: within the fourth quadrant voltage is negative however current is positive. The power is therefore negative. Here S3 is OFF, S2 is ON, S4 is continuously ON and S1 is constantly OFF. Because the inductor current can't be changed instantaneously, D2 and S4 can be freewheeling the current.

II. Block Diagram

Figure1.shows block diagram of the system. The circuit uses standard power supply comprising of a step down transformer from 230V to 12V and the four diodes forming a bridge rectifier that delivers pulsating dc which is unregulated is regulated to constant 5V dc. The output of the power supply which is 5V is connected to the 40pin of microcontroller and ground is connected to 20pin.

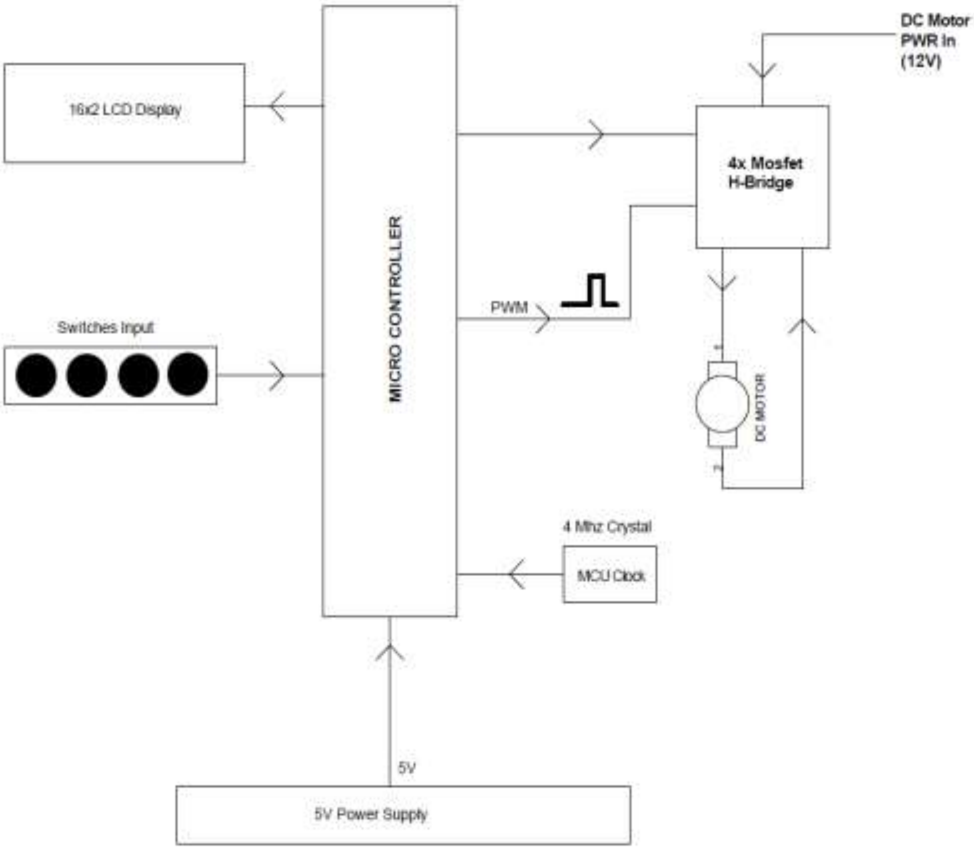


Figure 1. Block diagram of four quadrant DC motor drive

III. Methodology

3.1 CHOPPER OPERATION

Operation of a four quadrant chopper (Class E), is illustrated with a dc motor as load as shown in Fig.3. The circuit diagram is as shown in Fig. 2.

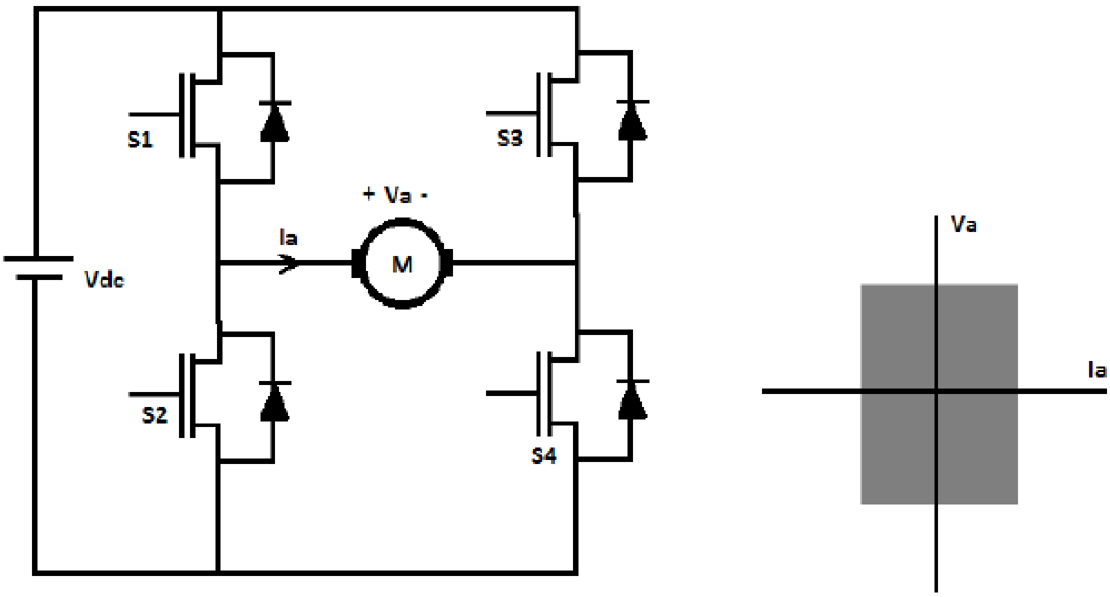


Figure 2. Chopper schematic and Quadrants of operation.

From Fig. 2, for the load to operate in first quadrant (forward motoring), the switches S1 and S4 are operated. Here, the switch S1 is switched whereas switch S4 is kept on. Therefore, both the voltage and current across and through the load are positive rotating the motor in forward direction. Now, the speed of the motor can be varied by varying the duty cycle of the switch S1. As the duty cycle varies, the voltage across the armature of motor varies proportionally thereby varying the motor speed as the N is proportion to armature voltage. Now to apply brake to the motor electrically, the chopper is to be operated in second quadrant. This can be done by operating switch S2. When the switch S2 is on, the inertial energy of the motor is stored in the armature inductance, the voltage across the inductor increases. Once the switch is turned off, the voltage across inductor adds with the back EMF of the motor feeding the inertial energy back to the source through freewheeling diodes D1 and D4. For the energy to be fed back to the source, the combined voltage of inductor and back EMF should be more than source voltage (Vs). To operate the chopper in the third quadrant, switches S3 and S2 are to be operated. Here, switch S3 is switched and switch S2 is kept on. Now the voltage and current across and through the load are negative driving the motor in reverse direction. Also the speed of the motor can be varied by varying the duty cycle (D) of the switch T3. In this quadrant, the motor is in reverse motoring mode.

Now to operate the motor in fourth quadrant, only switch S4 is operated. With the switch S4 turned on, the voltage across the armature inductance increases. When the switch S4 is turned off, voltage across the inductor adds to the back EMF. If the combined voltage is more than source voltage, the inertial energy is fed back to the supply as in [2].

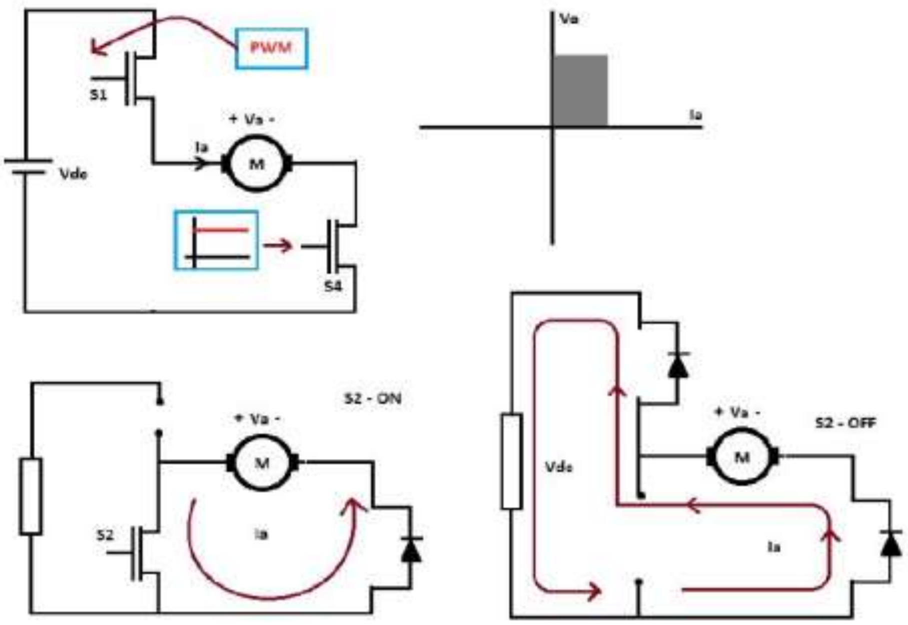


Fig3. Schematic showing type of triggering in quadrant one (top left), first quadrant representation (top right), Braking mode with S2 closed (bottom left), Braking mode with S2 opened (bottom right).

In this project we control the 12V dc motor using 230V power supply. As the system design to control the speed of a dc motor, so the desired goal is to achieve a system with constant speed and smooth operation at any load condition. That means motor will run at fixed speed at any load condition. Also LCD 16*2 provide real time dc motor speed data and voltage level of system at any time, which allows operator to make necessary change in system to prevent any fault or overload condition.

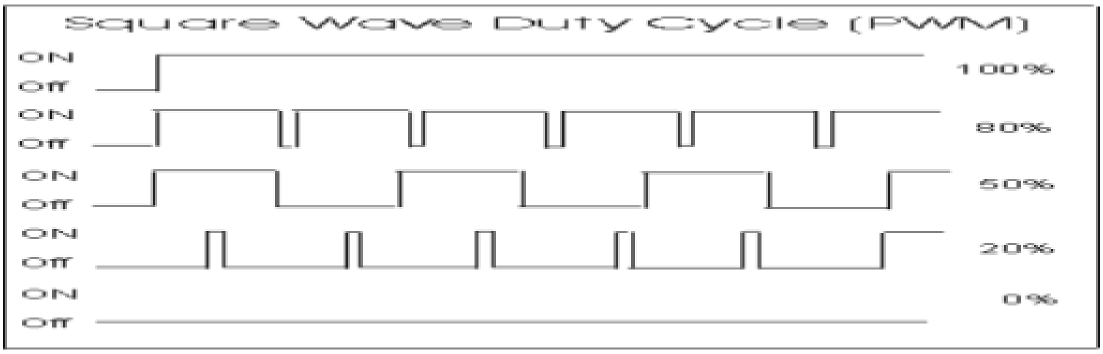
3.2 Power Delivery

The circuit uses trendy strength supply comprising of a step-down transformer from 230V to 12V and four diodes forming a bridge rectifier that grants pulsating dc which is then filtered via an electrolytic capacitor of approximately 470µF to 1000µF. The filtered dc being unregulated, IC LM7805 is used to get 5V DC regular at its pin no 3 irrespective of enter DC various from 7V to 15V. The input dc will be varying in the event of input ac at 230volts segment varies from 160V to 270V within the ratio of the transformer primary voltage V1 to secondary voltage V2 governed with the aid of the method V1/V2=N1/N2. As N1/N2 i.e. no. of turns in the primary to the no. of turns in the secondary remains unchanged V2 is at directly proportional to V1.hence if the transformer gives you 12V at 220V input it'll provide 8.72V at 160V.Further at 270V it's going to provide 14.72V.As a result the dc voltage on the input of the regulator changes from approximately 8V to 15V due to

A.C voltage variation from 160V to 270V the regulator output will stay regular at 5V. The regulated 5V DC is further filtered by a small electrolytic capacitor of 10μF for any noise so generated by using the circuit. One LED is attached of this 5V point in series with a current limiting resistor of 330Ω to the GND i.e., negative voltage to suggest 5V electricity deliver availability. The unregulated 12V point is used for different purposes as and whilst required.

3.3 PWM technique

Pulse-width modulation (PWM) is a typically used approach for controlling power to an electrical device, made practical via cutting-edge electronic energy switches. The average value of voltage (and current) fed to the load is managed via turning the switch among supply and load on and stale at a quick tempo. The longer the switch is on compared to the off intervals, the higher the power supplied to the weight is. The primary advantage of PWM is that power loss within the switching gadgets may be very low. Whilst a transfer is off there's practically no current, and while it's far on, there's nearly no voltage drop throughout the switch. Power loss, being the multiplication of voltage and current, is for that reason in each cases near zero. PWM works additionally properly with digital controls, which, because of their on/off nature, can easily set the wished duty cycle. The term duty cycle describes the proportion of on time to the regular interval or period of time; a low duty cycle corresponds to low power, because the power is off for maximum of the time. Duty cycle is expressed in percentage, 100% being absolutely on. The following figure indicates the output waveform of pulse width modulation approach. [3]



IV. Conclusion

It offers a reliable, long lasting, accurate and efficient way of speed control of a DC motor. This system is discovered to be efficient and the consequences with the designed hardware are promising. It is developed to control and power circuit capabilities properly and satisfies the application necessities. The motor is able to perform in all of the 4 quadrants effectively.

V. Acknowledgment

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