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Digital Control of BLDC Motor By Using MOSFET and Microcontroller

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ABSTRACT

Now a day BLDC motor is becoming very famous in the department of aerospace, automation, computers, military, household appliances and traction applications because of its high competency and low maintenance cost. Because of this the four quadrant operation of BLDC motor is extremely important. BLDC motor control requires rotor position and speed measurements. In this paper the modeling of BLDC motor drive system along with its control system have been presented using H-bridge type arrangement MOSFET work like a drive and for controlling purpose we use microcontroller AT 89S52.

Keywords— BLDC motor, H-bridge, MOSFET, Microcontroller AT 89S52.

1. INTRODUCTION

BLDC motors are used extensively in adjustable-speed drives and position control applications. Their speeds below the base speed can be controlled by armature-voltage control. Speeds above the base speed are obtained by field-flux control. As speed control method for BLDC motors are simpler and less expensive than those for the AC motors, DC motors are preferred where wide speed range control is required. DC choppers also provide variable dc output voltage from a fixed dc input voltage. The Chopper circuit used can operate in all the four quadrants of the V-I plane. The output voltage and current can be controlled both in magnitude as well as in direction so the power flow can be in either direction. The chopper circuit shown in fig.1 can operate in all four quadrants of the Vo-Io plane. That is the output voltage and current can be controlled both in magnitude and direction. Therefore, the power flow can be in any direction. The four-quadrant chopper is widely used in reversible BLDC motor drives. By applying chopper it is possible to implement regeneration and dynamic braking for BLDC motors. The four quadrant chopper with four switching devices where diodes are connected in anti-parallel with the switching devices is also referred to as full bridge converter topology. The input to the full bridge converter is fixed magnitude dc voltage Vdc. The output of the converter can be a variable dc voltage with either polarity. The circuit is therefore called as four quadrant chopper circuit or dc to dc converter. The output of the full bridge converter can also be an ac voltage with variable frequency and amplitude in which case the converter is called as dc- to-ac conversion (inverter). In a full bridge converter when a gating signal is given to a switching device either the switching device or the diode only will conduct depending on the directions of the output load current.

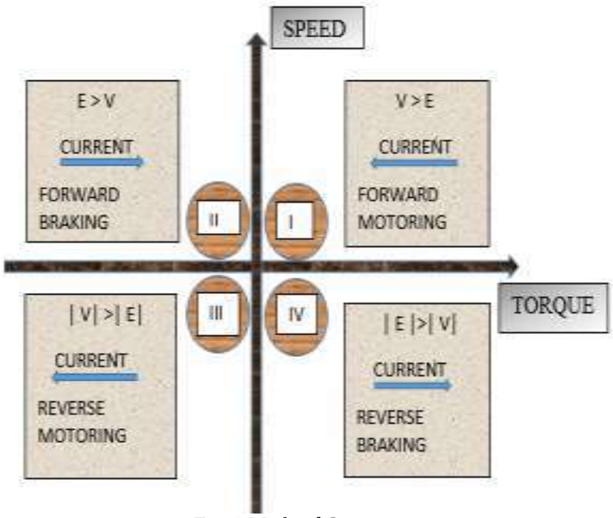

Fig. 1 Mode of Operation

2. BLDC MOTOR AND CONTROLLER

BLDC motor can be projected as a brushed DC motor twisted inside out, where the permanent magnets are fixed on the rotor and windings on the stator. As a result, there are no brushes and commutator in this motor and thus all the drawbacks are connected with the flashing of brushes are eliminated. This motor is denoted to as a DC motor because its coils are driven power source. The Dc power is given to the windings on the stator. Here MOSFET and microcontroller is use for controlling speed as well as direction

3. FOUR QUADRANT OPERATION.

For a BLDC motor, four modes of operations namely forward motoring, forward braking, reverse motoring and reverse braking are possible. The operating modes are shown in the fig 1. In the first quadrant, both speed and torque is positive so motor rotates in forward direction. In second quadrant speed remains in positive direction but torque is in reverse direction. Reverse torque is used to brake the motor. Third quadrant is just opposite of the first quadrant. i.e., both speed and torque is negative so rotating in reverse direction. Exactly opposite of second quadrant is fourth where power is being produced. The supplied voltage is greater than back EMF during the motoring mode and is less than back EMF during generating mode.

4. BLOCK DIAGRAM

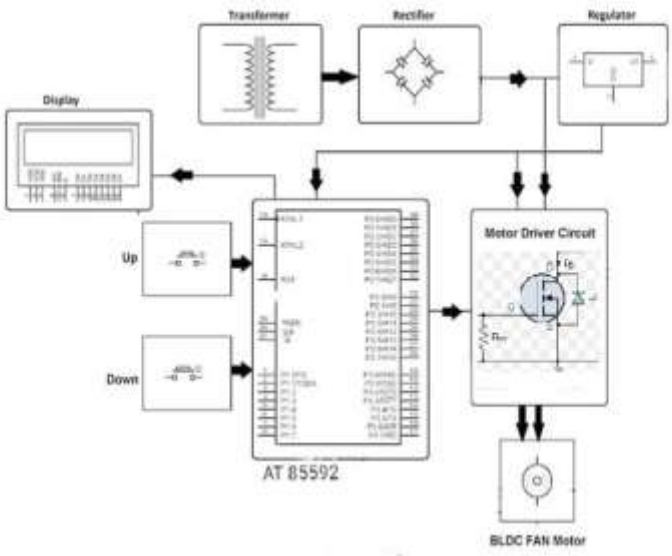

Fig. 2 Block Diagram

4.1 BLDC Motor

A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor. DC motors are used extensively in adjustable-speed drives and position control applications. Their speeds below the base speed can be controlled by armature-voltage control. Speeds above the base speed are obtained by field-flux control. As speed control methods for DC motors are simpler and less expensive than those for the AC motors, DC motors are preferred where wide speed range control is required.

Fig. 3 BLDC Motor

4.2 LCD Display

Fig. 4 LCD Display

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.

LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they do not suffer image burn-in. LCDs are, however, susceptible to image persistence.
The LCD screen is more energy efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.

4.3 Microcontroller (AT 89S52)

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM con-tents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset. 8-bit Microcontroller with 8K Bytes In-System Programmable Flash AT89S52.

4.5 Power MOSFET

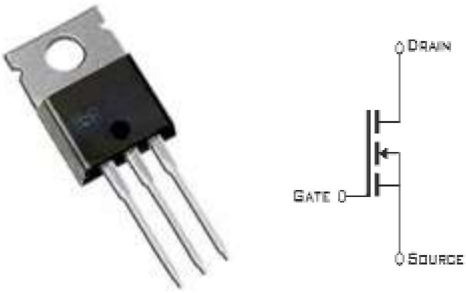

Fig. 5 MOSFET

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness. The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

4.6 Voltage Regulator

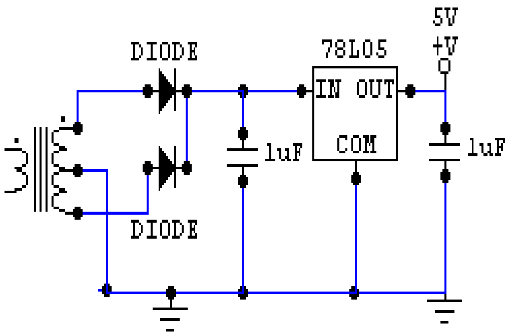

Fig. 7 Voltage Regulator

4.7 LM7805 Series Voltage Regulator:-

A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. It may use an electromechanical mechanism, or passive or active electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. With the exception of shunt regulators, all voltage regulators operate by comparing the actual output voltage to some internal fixed reference voltage. Any difference is amplified and used to control the regulation element. This forms a feedback servo. If the output voltage is too low, the regulation element is commanded to produce a higher voltage. If the output voltage is too high, the regulation element is commanded to produce a lower voltage. In this way, the output voltage is held roughly constant.

4.8 Power Supply:-

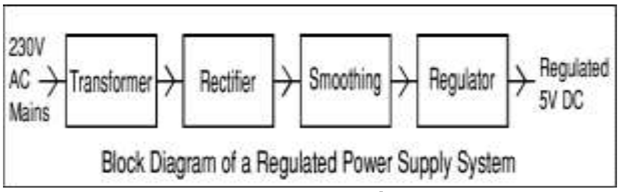

Fig. 6 Power Supply

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. For example a 5V regulated supply: Each of the blocks is described in more detail below

- Transformer - steps down high voltage AC mains to low voltage AC.
- Rectifier - converts AC to DC, but the DC output is varying.
- Smoothing - smoothes the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage.
  Power supplies made from these blocks are described below with a circuit diagram and a graph of their output:
- Transformer only
- Transformer + Rectifier
- Transformer + Rectifier + Smoothing
  Transformer + Rectifier + Smoothing + Regulator

4.9 Projection Operation Code

```
#include<reg52.h>
#include<stdio.h>
#include<lcd.h>

sbit motor_pin_1 = P1^0;
sbit motor_pin_2 = P1^1;
sbitmotor_en = P1^2;


sbit START = P3^0; //FE
sbit STOP = P3^1; // FD
sbit CW = P3^2; // FB
sbit CCW = P3^3; // F7
sbit FB = P3^4; // EF
sbit RB = P3^5; // DF
sbit HALF_SPEED = P3^6; // BF
sbit FREERUN = P3^7; // 7F
sfr input = 0xB0;

voidmsdelay(unsigned int value)
{
unsignedintx,y;
for(x=0;x<value;x++)
for(y=0;y<1275;y++);
}

void main()
{
lcd_ini();
motor_en = 0;
motor_pin_1 = 0;
motor_pin_2 = 0;
lcd_command(0x80);
lcd_dataa("DIGITAL CONTROL ");
lcd_command(0xC0);
lcd_dataa(" FOR BLDC MOTOR ");
msdelay(1000);
while(1)
{
if(input==0xFE) // MOTOR START   -  MOMENT SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR START     ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
motor_pin_1 = 0;
motor_pin_2 = 1;
}
else if(input==0xFD) //MOTOR STOP  - MOMENT SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR STOP      ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
motor_pin_1 = 0;
motor_pin_2 = 0;
}
else if(input==0xFB) //MOTOR CW    MOMENT SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR CW        ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
```

```
motor_pin_1 = 0;
motor_pin_2 = 1;
}
else if(input==0xF7) //MOTOR CCW  -  MOMENT SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR CCW       ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
motor_pin_1 = 1;
motor_pin_2 = 0;
}
else if(input==0xEF) //MOTOR RB  - MOMENT SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR RB        ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
motor_pin_1 = 0; //cw
motor_pin_2 = 1;
msdelay(300);
motor_pin_1 = 0; //cw
motor_pin_2 = 0;
}
else if(input==0xDF) //MOTOR FB - MOMENT SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR FB        ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
motor_pin_1 = 1; //cw
motor_pin_2 = 0;
msdelay(300);
motor_pin_1 = 0; //cw
motor_pin_2 = 0;
}
else if(input==0xBF) //MOTOR HALF SPEED  -
LATCHED SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR HALF SPEED");
lcd_command(0xC0);
lcd_dataa("                ");
motor_pin_1 = 0; //fw
motor_pin_2 = 1;
while(input==0xBF)
{
motor_en = 1;
msdelay(200);
motor_en = 0;
msdelay(200);
}
motor_pin_1 = 0; //STOP
motor_pin_2 = 0;
}
else if(input==0x7F) //MOTOR FREE RUN  - LATCHED
SWT
{
lcd_command(0x80);
lcd_dataa("MOTOR FREE RUN  ");
lcd_command(0xC0);
lcd_dataa("                ");
motor_en = 1;
motor_pin_1 = 0;
motor_pin_2 = 1;
}
else
{
motor_en = 1;
}
}
}
```

5. RESULTS

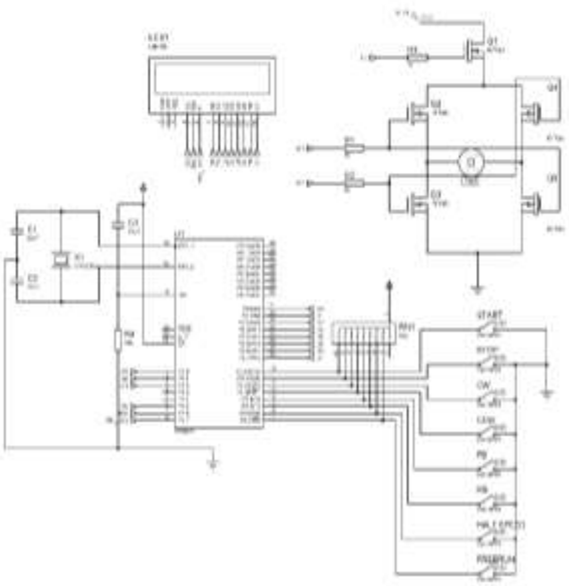

Fig.8 Simulation View

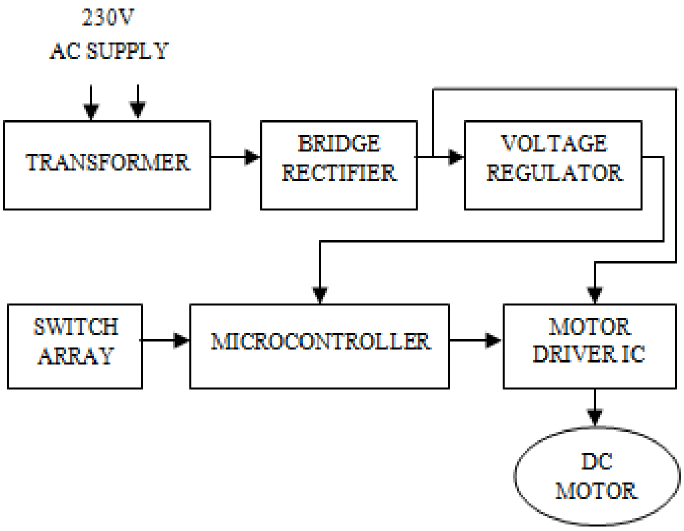

Fig. 9 Block Diagram

6. CONCLUSION

In this paper we had completely studies about four quadrant operation of BLDC motor. We can achieve all four quadrant operations like forward motoring, forward braking, reverse motoring and reverse braking with the help of MOSFET IRF 730 and microcontroller AT 89S52.

We can conclude following points:-

- Speed varies directly with the armature voltage by keeping field voltage constant.
- Speed varies inversely with field voltage by keeping armature voltage constant.
- Armature voltage control gives the speed below the base speed varies field control gives the speed control above the base speed.
- Device have drawn closer to ideal switch with typical voltage rating of 600-1700V on-state voltage of 1.7-20V at current of upto 1000A and switching speed 200-500NS.

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