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Controlling DC Motor using Microcontroller (PIC16F72) with PWM

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***Abstract*—Motion control plays a vital role in industrial atomization. Different types of motors AC, DC, SERVO or stepper are used depending upon the application; of these DC motors are widely used because of easier controlling. Among the different control methods for DC motor armature voltage control method using pulse width modulation (PWM) is best one. We can realize the PWM using H-bridge built with IGBT switches or transistors. To generate PWM signals we use PIC16F72 microcontroller.**

***Index Terms*—**Microcontroller, H-bridge, PWM, DC motor.

INTRODUCTION

Direct current (DC) motor has already become an important drive configuration for many applications across a wide range of powers and speeds. The ease of control and excellent performance of the DC motors will ensure that the number of applications using them will continue grow for the foreseeable future. This project is mainly concerned on DC motor speed control system by using microcontroller PIC 16F72. It is a closed-loop real time control system, where optical encoder (built in this project) is coupled to the motor shaft to provide the feedback speed signal to controller. Pulse Width Modulation (PWM) technique is used where its signal is generated in microcontroller. The PWM signal will send to motor driver to vary the voltage supply to motor to maintain at constant speed.

MICROCONTROLLER (PIC16F72)

A **microcontroller** (sometimes abbreviated **μC**, **uC** or **MCU**) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, and other systems. Microcontroller used here is **PIC16F72.**

The program memory contains 2K words, which translate 2048 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 128 bytes. It has high performance RISC CPU with only 35 single word instructions to learn. All single cycle instructions except for program branches, which are two-cycle. The Operating speed is DC - 20 MHz clock input DC 200 ns, 128 x 8 bytes of Data Memory (RAM).Interrupt capability Eight-level deep hardware stack Direct, Indirect and Relative Addressing modes. It has High Sink/Source Current: 25 mA

Timer0: 8-bit timer/counter with 8-bit prescaler

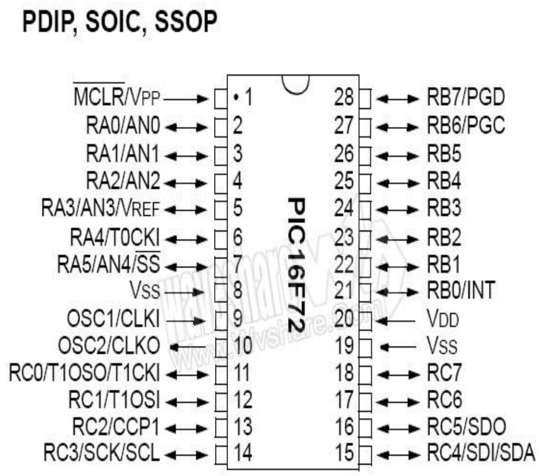
Timer1:16-bit timer/counter with prescaler, can be incremented during SLEEP via external Crystal/clock

Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler Capture, Compare, PWM (CCP) module

Capture is 16-bit, max. resolution is 12.5 ns - Compare is 16 bit, max. resolution is 200 ns PWM max. resolution is 10-bit 8-bit, 5-channel analog-to-digital converter Synchronous Serial Port (SSP) with SPI™ (Master/Slave) and I2C™ (Slave) Brown-out detection circuitry for Brown-out Reset (BOR)

Special Microcontroller Features:

- 1,000 erase/write cycle FLASH program memory typical Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection Power saving SLEEP mode Selectable oscillator options
- Processor read access to program memory

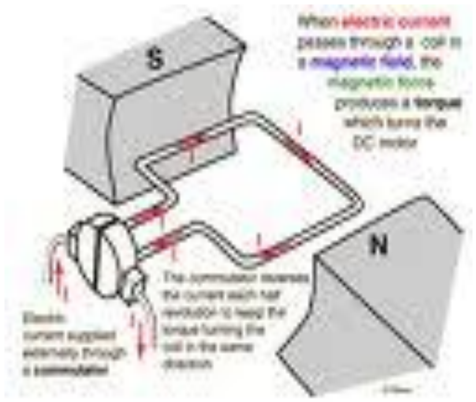


DC MOTOR CONTROL

A **DC motor** is an electric motor that runs on direct current (DC) electricity. DC motors were used to run machinery, often eliminating the need for a local steam engine or internal combustion engine. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Modern DC motors are nearly always operated in conjunction with power electronic devices. It works on the principle of electromagnetism. A current carrying conductor when placed in an external magnetic field will experience a force proportional to the current in the conductor.**D**C motor speed controllers are very useful for controlling the motion of robotic and industrial automation systems.DC motor can provide a high starting torque and it is also possible to obtain speed control over wide range. For precise speed control of servo system, closed-loop control is normally used. The speed, which is sensed by sensing devices, is compared with the reference speed to generate the error signal and to vary the armature voltage of the motor. There are several controllers that can used to control the speed of the motor such as by using thyristor, phase-locked-loop control, chopper circuit, Fuzzy Logic Controller and etc. Here, we will use PWM technique.

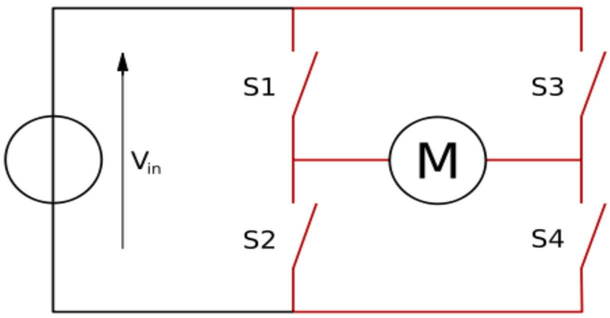
DIRECTION CONTROL OF DC MOTOR

There are two magnetic fields produced in the motor. One magnetic field is produced by the permanent magnets and the other magnetic field is produced by the electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor. As the rotor turns, the current in the windings is commutated to produce a continuous Torque output this makes the motor to run. Direction control of a DC motor is very simple; just reverse the polarity, means every DC motor has two terminals out. When we apply DC voltage with proper current to a motor, it rotates in a particular direction but when we reverse the connection of voltage between two terminals, motor rotates in another direction.



WORKING THEORY OF H- BRIDGE

An **H bridge** is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards.



An H bridge is built with four switches (solid-state or mechanical). When the switches S1 and S4 (according to the first figure) are closed (and S2 and S3 are open) a positive voltage will be applied across the motor. By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed, allowing reverse operation of the motor.

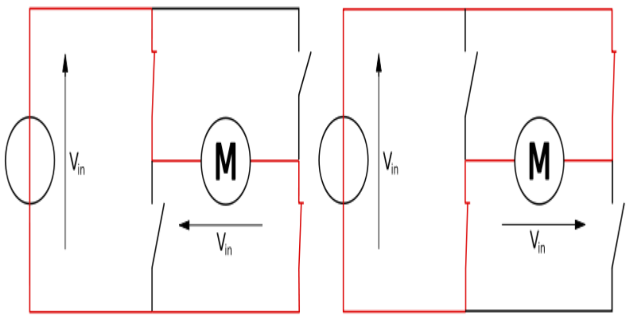
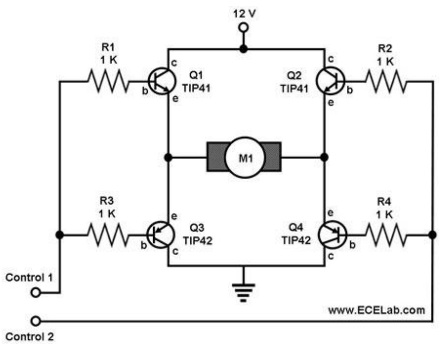


Table for working of H-bridge-

S4	S3	S2	S1	Operation performed
1	0	0	1	Motor moves right
0	1	1	0	Motor moves left
0	0	0	0	Motor free runs
0	1	0	1	Motor brakes
1	0	1	0	Motor brakes

A full bridge circuit is shown in the diagram below. Each side of the motor can be connected either to battery positive, or to battery negative.



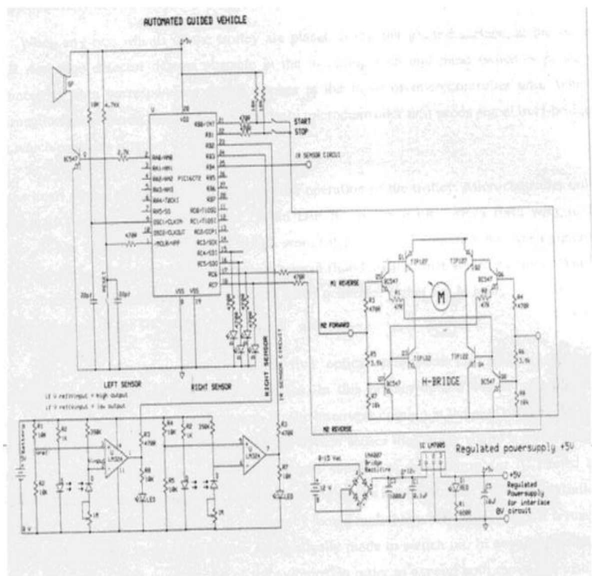
To make the motor go forwards, Q4 is turned on, and Q1 has the PWM signal applied to it. Meanwhile, to make the motor go backwards, Q3 is turned on, and Q2 has the PWM signal applied to it.

CONTROLLING DC WITH PWM

PWM is an effective method for adjusting the amount of power delivered to the load. PWM technique allows smooth speed variation without reducing the starting torque and eliminates harmonics. In PWM method, operating power to the motors is turned on and off to modulate the current to the motor. The ratio of on to off time is called as duty cycle. The duty cycle determines the speed of the motor. The desired speed can be obtained by changing the duty cycle. The Pulse-Width-Modulation (PWM) in microcontroller is used to control duty cycle of DC motor drive.

PWM is an entirely different approach to controlling the speed of a DC motor. Power is supplied to the motor in square wave of constant voltage but varying pulse-width or duty cycle. Duty cycle refers to the percentage of one cycle during which duty cycle of a continuous train of pulses. Since the frequency is held constant while the on-off time is varied, the duty cycle of PWM is determined by the pulse width. Thus the power increases duty cycle in PWM.

CIRCUIT DIAGRAM



A constant +5 volt supply is given to the microcontroller when the power supply is fed to the microcontroller it generates an appropriate PWM signal. The reference sped is given as the input to the microcontroller. Digital output of the microcontroller makes the transistors on, the transistor bridge would regulate the speed of the dc motor .the required speed can be obtained by varying the duty cycle.

CONCLUSION

With the very basic concept of PWM and H-bridge the direction and the speed of the motor can be controlled. It is practical one and highly feasible according to economic point of view, reliability and accuracy. It is programmable one therefore it can control various motors.

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