OBSTACLE AVOIDANCE MOBILE ROBOT

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ABSTRACT

The purpose of this project is to develop a mobile robot with an obstacle avoidance capability. The mobile robot will be built with an onboard sensor to get information about the surrounding environment. The mobile robot is a four wheeled robot platform. The robot has an ultrasonic sensor which is mounted in front of it to scan the front environment. The ultrasonic sensor will trigger a signal to the main controller, which is a PIC16F877A microcontroller. The direction of the mobile robot will be controlled by one stepper motor that connected to the output of PIC16F877A microcontroller. The stepper motor will change the direction of mobile robot when an obstacle is detected. The other two wheels are dc motor which is only for motion purpose. The dc motor will be only run forward without influenced by the obstacle senses by ultrasonic sensor.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The purpose of this project is to develop a mobile robot with an obstacle avoidance capability. The mobile robot will be built as a fully autonomous vehicle with onboard sensor to get information about the surrounding environment.

The mobile robot is a four wheeled robot platform. The robot has an ultrasonic sensor which is mounted in front of it to scan the front environment. The ultrasonic sensor will trigger a signal to the main controller, which is a PIC16F877A microcontroller.

The motion of the mobile robot will be controlled by one dc motor. The dc motor will change the direction of the mobile robot. The other two wheels is a dc motor which is only for motion purpose. The stepper motor will be only run forward without influenced by the obstacle senses by ultrasonic sensor.

1.2 Problem Statement

Nowadays, robotic technologies have become more important since a lot of industry is trying to improve their machinery weapons. This technology has developed year by year to make sure an excellent result. Recently, by time goes by, a lot of mechanical robots have been invented to help peoples running their daily life.

Obstacles Avoidance Mobile Robot is actually a simple collision avoidance machines. Besides that, its future development is very big to explore. By using this simple collision avoidance system, a lot of new and variety mobile robot with multiple functions can be invented.

Real-time obstacle avoidance is one of the key issues to successful applications of mobile robot systems. All mobile robots feature some kind of collision avoidance, ranging from primitive algorithms that detect an obstacle and steer the robot short of it in order to avoid a collision, through sophisticated algorithms, that enable the robot to detour obstacles. The latter algorithms are much more complex, since they involve not only the detection of an obstacle, but also some kind of quantitative measurements concerning the obstacle's dimensions. Once these have been determined, the obstacle avoidance algorithm needs to steer the robot around the obstacle and resume motion toward the original target.

1.3 Objective

The aim of this project is to design a mobile robot with an ability to avoid obstacles. This mobile robot will react with the surrounding to avoid any collision with obstacles. Ultrasonic sensor will be the input for the whole process while the PIC16F84A acts as the steering control for the steering wheel.

The main objectives of this project are;

i. To design a Mobile Robot with an ability to avoid obstacle
ii. To develop a mobile robot using PIC microcontroller and Ultrasonic sensor

1.4 Scope of Project

The scopes of this project are;

i. Develop an obstacle avoidance mobile robot with onboard sensors and microcontroller. The designed mobile robot will be able to avoid obstacle perfectly like programmed. The mobile robot has four wheels which are two dc motor in the rear and two steering wheel connected to one dc motor at the front.

ii. Develop an algorithm of Potential Field method to avoid obstacle. The algorithm will be implemented in the main controller which is PIC microcontroller. The input of this algorithm is the readings scan by ultrasonic sensor in the front of mobile robot. With this method, the mobile robot can avoid the obstacle without having a collision.

iii. Develop the output of this system which is the dc motor that can reflect with the input from the sensor. When an obstacle is detected, the main controller will trigger an input to the dc motor to change the steering wheel to the correct direction. Thus, the obstacle can be avoided.

1.5 Literature Review

1.5.1 Introduction

Before start doing the project, some articles reviewed from the internet or book must be added to make sure the information from that sources can be used to analyze and to make a comparison with our project. This article used as a guideline to create this system function.

This subtopic will summarize and highlight the contents of papers, reports and articles that are related to this project. Some related theories to the proposed project will be discussed in this chapter.

1.5.2 The Fundamental of Sensor

Sensor is an electrical/mechanical/chemical device that maps an environmental attribute to a quantitative measurement. It’s created to collect information about the world. Each sensor is based on a transduction principle which is conversion of energy from one form to another form.

1.5.2.1 Basic principle of operation:

An ultrasonic sensor typically utilizes a transducer that produces an electrical output in response to received ultrasonic energy. The normal frequency range for human hearing is roughly 20 to 20,000 hertz. Ultrasonic sound waves are sound waves that are above the range of human hearing and, thus, have a frequency above about 20,000 hertz. Any frequency above 20,000 hertz may be considered ultrasonic.

Most industrial processes, including almost all sources of friction, create some ultrasonic noise. The ultrasonic transducer produces ultrasonic signals. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals.

Ultrasonic sensors typically have a piezoelectric ceramic transducer that converts an excitation electrical signal into ultrasonic energy bursts. The energy bursts travel from the ultrasonic sensor, bounce off objects, and are returned toward the sensor as echoes. Transducers are devices that convert electrical energy to mechanical energy, or vice versa. The transducer converts received echoes into analog electrical signals that are output from the transducer.

Ultrasonic transducers operate to radiate ultrasonic waves through a medium such as air. Transducers generally create ultrasonic vibrations through the use of piezoelectric materials such as certain forms of crystals or ceramic polymers.

1.5.2.2 Basic of Ultrasonic Sensor

The ultrasonic transducer produces ultrasonic signals. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals. In most applications, the sensing medium is simply air. An ultrasonic sensor typically comprises at least one ultrasonic transducer which transforms electrical energy into sound and, in reverse, sound into electrical energy, a housing enclosing the ultrasonic transducer or transducers, an electrical connection and, optionally, an electronic circuit for signal processing also enclosed in the housing.

1.5.2.3 Measurement Principle / Effective Use of Ultrasonic Sensor

Ultrasonic sensors transmit ultrasonic waves from its sensor head and again receive the ultrasonic waves reflected from an object. By measuring the length of time from the transmission to reception of the sonic wave, it detects the position of the object.

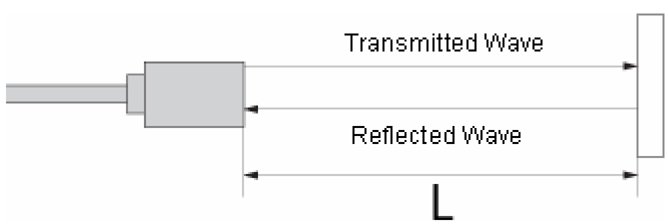


Figure 1.01: Principle use of ultrasonic sensor

1.5.2.4 The advantages of Ultrasonic sensor

Ultrasonic sensor has some advantages which are;

i. Measures and detects distances to moving objects.
ii. Impervious to target materials, surface and color.
iii. Solid-state units have virtually unlimited, maintenance-free lifespan.
iv. Detects small objects over long operating distances.
v. Resistant to external disturbances such as vibration, infrared radiation, ambient noise and EMI radiation.
vi. Ultrasonic sensors are not affected by dust, dirt or high-moisture environments.
vii. Discrete distances to moving objects can be detected and measured.
viii. Less affected by target materials and surfaces, and not affected by color. Solid-state units have virtually unlimited, maintenance free life. Can detect small objects over long operating distances.

1.5.2.5 The disadvantages of Ultrasonic sensor

Some disadvantages of ultrasonic sensor are;

i. Overheating of a wave emitter precludes the energy of ultrasonic waves emitted there from being enhanced to a practical level.
ii. Interference between the projected waves and the reflected waves takes place, and development of standing waves provides adverse effects.
iii. It is impossible to discern between reflected waves from the road surface and reflected waves from other places or objects.
iv. There is no effective measure for removing the influences of factors other than road surface irregularities such as, for example, winds, temperature variations, etc., which can change the intensity of reflected waves.

1.5.2.6 Limitation Ultrasonic Sensor

Ultrasonic range measurements suffer from some fundamental drawbacks which limit the usefulness of these devices in mapping or in any other task requiring high accuracy in a domestic environment. These drawbacks are not related to the product of a specific manufacturer, but are inherent to the principle of ultrasonic range finders and their commonly used wavelengths.

Figure 1.02: Ultrasonic sensor

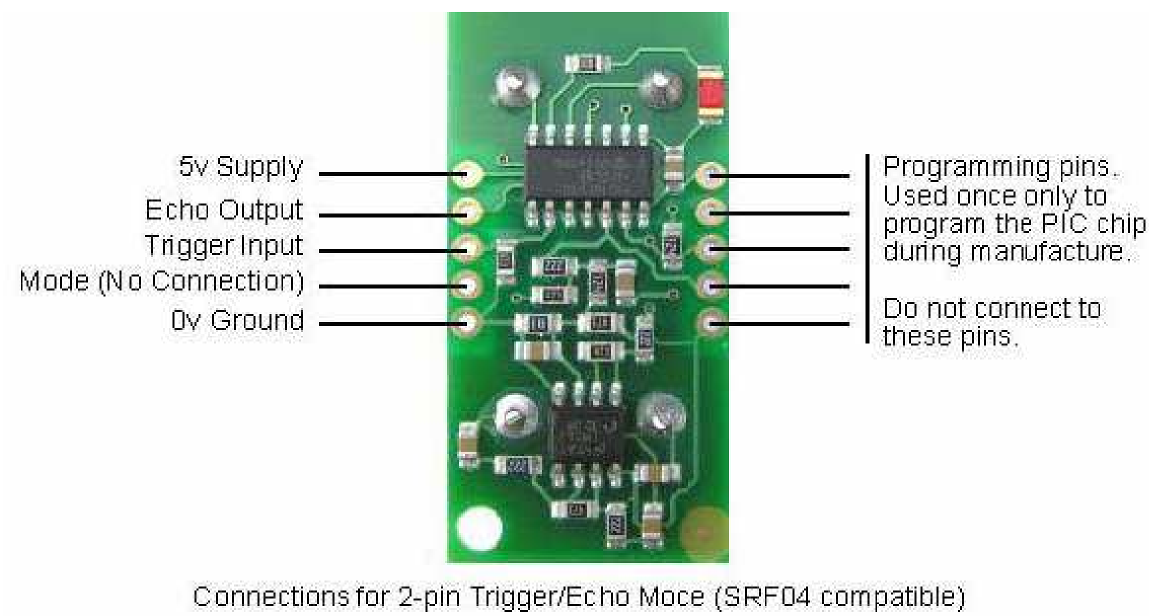


Figure 1.03: Ultrasonic Sensor connection

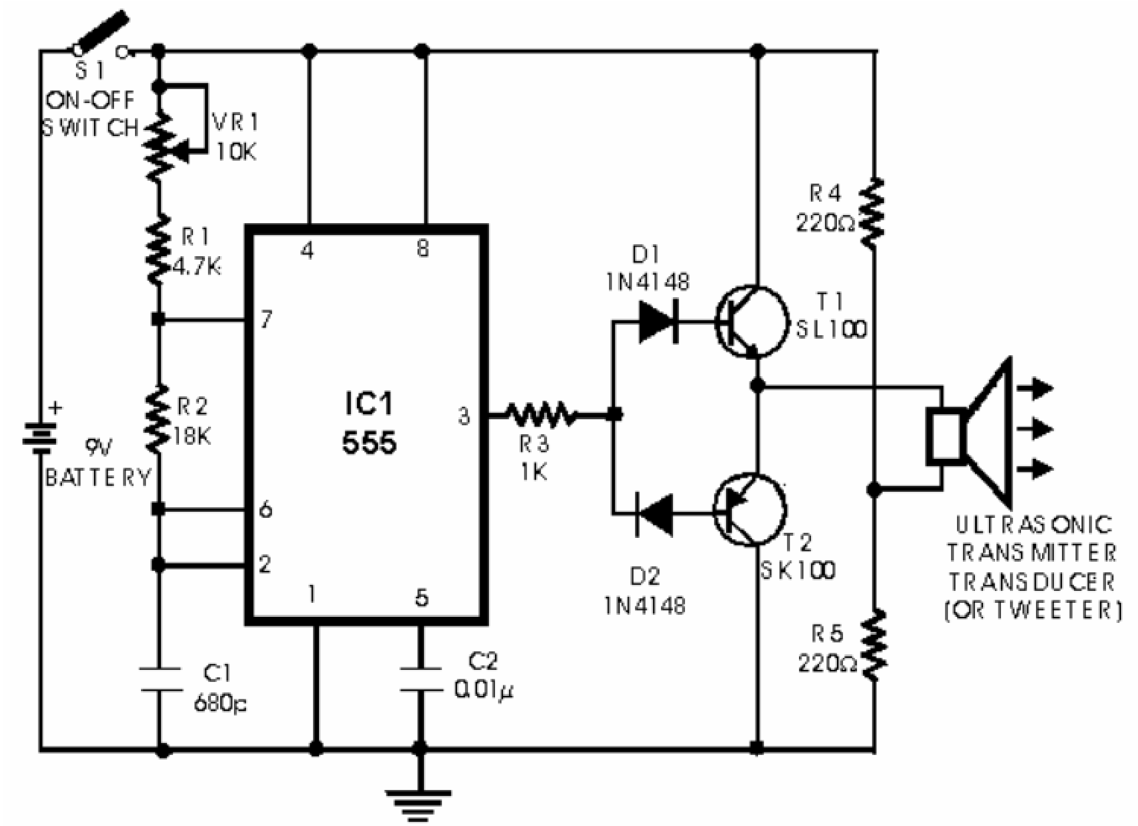


Figure 1.04: Transmitter of ultrasonic sensor circuit diagram

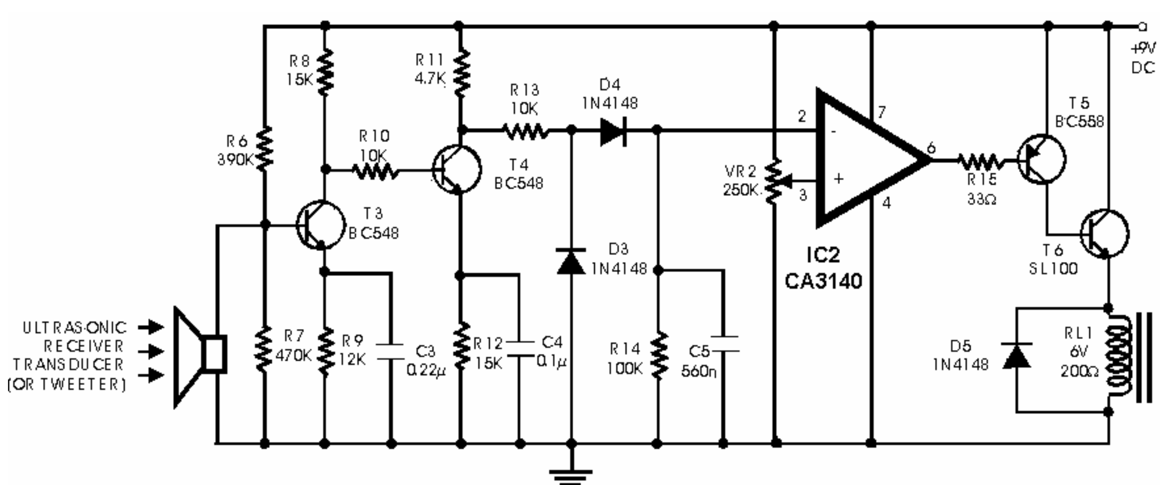


Figure 1.05: Receiver of ultrasonic sensor circuit diagram

1.5.3 PIC16F877A Microcontroller

This is the main controller of the mobile robot. When the robot is turned on, the main controller is ready to receive an obstacle scanned by the ultrasonic sensor. Once the data is received, it will be placed into the conventional potential field algorithm as described earlier. This algorithm will decide the direction to which the mobile robot should turn. Then the appropriate signal will be sent to the servo motor to get the desired direction.

A microcontroller is an amazingly useful device. Akin to a very specialized CPU, a microcontroller is small, consumes very little power, and can be programmed to quickly and reliably perform a wide variety of tasks. Microcontrollers can be found in things used every day such as microwaves, remote controls, and vending machine. Programming a microcontroller, however, can often be frustrating. A developer has no way to look inside of the chip to see what is going on while his code is running, making debugging very difficult without the aid of expensive equipment (in the range of thousands of dollars). Furthermore, microcontrollers must traditionally be programmed, or “burned,” with the code they are to run. This requires a special piece of equipment to do and requires that the chip be taken out of the circuit it is being used in, placed into the programmer, have data “burned” to it (which can take several minutes), then be replaced back in the circuit. This process is time consuming and risky, as the pins on a microcontroller are easily bent out of their proper position. A special piece of code, called a bootloader, can alleviate the problem of having to use an external programmer to program and test code.

One basic application of PIC microcontrollers is their use to control motion based on input from a sensor. This is applicable to many different fields, from manufacturing to aeronautics to robotics.

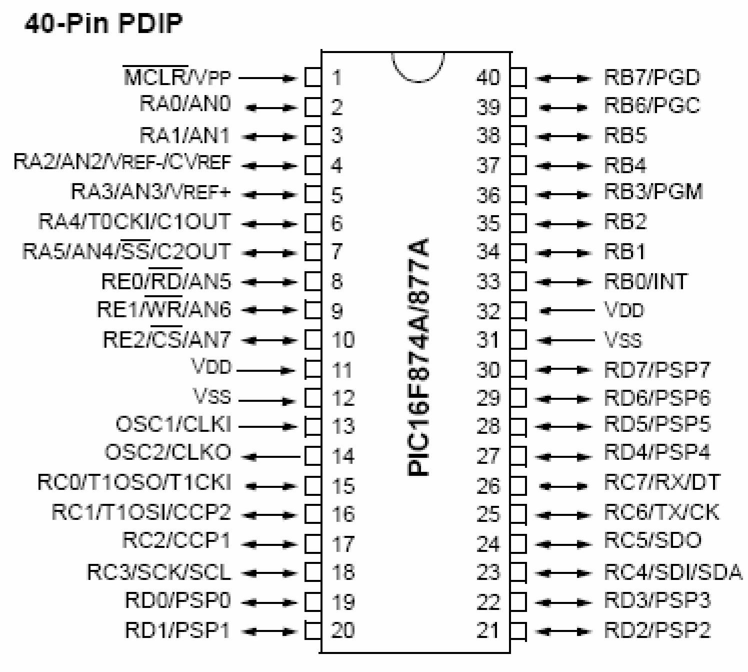
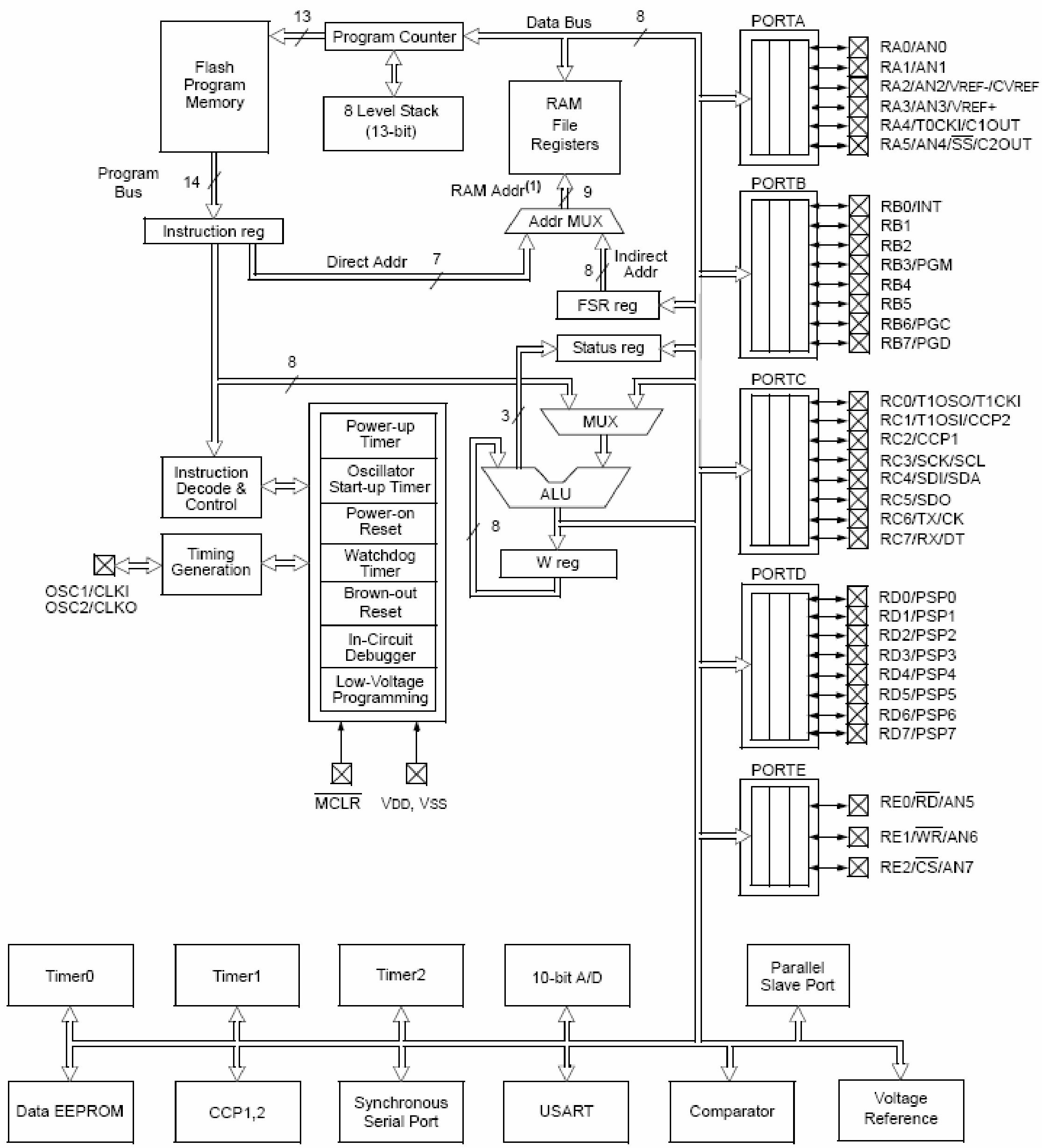


Figure 1.06: PIC16F877A pin connection

The figure shows the pin connection of the PIC16F877A.

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

i) The PIC16F873A and PIC16F874A have one-half
   a. of the total on-chip memory of the PIC16F876A
   b. and PIC16F877A
ii) The 28-pin devices have three I/O ports, while the
   a. 40/44-pin devices have five
iii) The 28-pin devices have fourteen interrupts, while
   a. the 40/44-pin devices have fifteen
iv) The 28-pin devices have five A/D input channels,
   a. while the 40/44-pin devices have eight
v) The Parallel Slave Port is implemented only on
   a. the 40/44-pin devices



Device	Program Flash	Data Memory	Data EEPROM
PIC16F874A	4K words	192 Bytes	128 Bytes
PIC16F877A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.

Figure 1.07: PIC16F874A block diagram

1.5.4 DC Motor

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Figure 1.08: Typical DC motor

1.5.4.1 Introduction of DC motor

An **electric motor** converts electrical energy into mechanical energy. The reverse process that of converting mechanical energy into electrical energy is accomplished by a generator or dynamo. Traction motors used on locomotives often perform both tasks if the locomotive is equipped with dynamic brakes. Electric motors are found in household appliances such as fans, refrigerators, washing machines, pool pumps, floor vacuums, and fan-forced ovens.

Most electric motors work by electromagnetism, but motors based on other electromechanical phenomena, such as electrostatic forces and the piezoelectric effect, also exist. The fundamental principle upon which electromagnetic motors are based is that there is a mechanical force on any current-carrying wire contained within a magnetic field. The force is described by the Lorentz force law and is perpendicular to both the wire and the magnetic field. Most magnetic motors are rotary, but linear motors also exist. In a rotary motor, the rotating part (usually on the inside) is called the rotor, and the stationary part is called the stator. The rotor rotates because the wires and magnetic field are arranged so that a torque is developed about the rotor’s axis. The motor contains electromagnets that are wound on a frame. Though this frame is often called the armature, that term is often erroneously applied. Correctly, the armature is that part of the motor across which the input voltage is supplied. Depending upon the design of the machine, either the rotor or the stator can serve as the armature.

The principle of conversion of electrical energy into mechanical energy by electromagnetic means was demonstrated by the British scientist Michael Faraday in 1821 and consisted of a free-hanging wire dipping into a pool of mercury. A permanent magnet was placed in the middle of the pool of mercury. When a current was passed through the wire, the wire rotated around the magnet, showing that the current gave rise to a circular magnetic field around the wire. This motor is often demonstrated in school physics classes, but brine (salt water) is sometimes used in place of the toxic mercury. This is the simplest form of a class of electric motors called homopolar motors. A later refinement is the Barlow's Wheel. These were demonstration devices, unsuited to practical applications due to limited power.

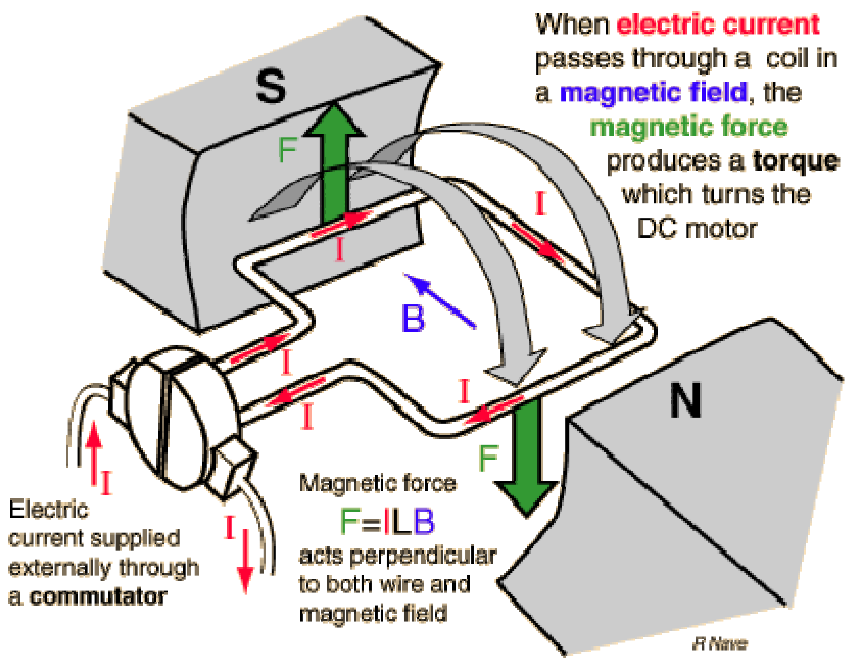

Figure 1.09: Basic operation

The first commutator-type direct-current electric motor capable of a practical application was invented by the British scientist William Sturgeon in 1832. Following

Sturgeon's work, a commutator-type direct-current electric motor made with the intention of commercial use was built by the American Thomas Davenport and patented in 1837. Although several of these motors were built and used to operate equipment such as a printing press, due to the high cost of primary battery power, the motors were commercially unsuccessful and Davenport went bankrupt. Several inventors followed Sturgeon in the development of DC motors but all encountered the same cost issues with primary battery power. No electricity distribution had been developed at the time. Like Sturgeon's motor, there was no practical commercial market for these motors.

1.5.4.2 Brushless DC motor

The modern DC motor was invented by accident in 1873, when Zénobe Gramme connected the dynamo he had invented to a second similar unit, driving it as a motor. The Gramme machine was the first electric motor that was successful in the industry.

In 1888 Nikola Tesla invented the first practicable AC motor and with it the polyphase power transmission system. Tesla continued his work on the AC motor in the years to follow at the Westinghouse Company.

The classic division of electric motors has been that of DC types vs AC types. This is more a *de facto* convention, rather than a rigid distinction. For example, many classic DC motors run happily on AC power.

The ongoing trend toward electronic control further muddles the distinction, as modern drivers have moved the commutator out of the motor shell. For this new breed of motor, driver circuits are relied upon to generate sinusoidal AC drive currents, or some approximation of. The two best examples are: the brushless DC motor, and the stepping motor, both being polyphase AC motors requiring external electronic control.

A more clear distinction is between synchronous and asynchronous types. In the synchronous types, the rotor rotates in synchrony with the oscillating field or current (eg. permanent magnet motors). In contrast, an asynchronous motor is designed to slip; the most ubiquitous example being the common AC induction motor which must slip in order to generate torque.

A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homopolar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty. By far the most common DC motor types are the brushed and brushless types, which use internal and external commutation respectively to create an oscillating AC current from the DC source -- so they are not purely DC machines in a strict sense.

Many of the limitations of the classic commutator DC motor are due to the need for brushes to press against the commutator. This creates friction. At higher speeds, brushes have increasing difficulty in maintaining contact. Brushes may bounce off the irregularities in the commutator surface, creating sparks. This limits the maximum speed of the machine. The current density per unit area of the brushes limits the output of the motor. The imperfect electric contact also causes electrical noise. Brushes eventually wear out and require replacement, and the commutator itself is subject to wear and maintenance. The commutator assembly on a large machine is a costly element, requiring precision assembly of many parts.

These problems are eliminated in the brushless motor. In this motor, the mechanical "rotating switch" or commutator/brushgear assembly is replaced by an external electronic switch synchronised to the rotor's position. Brushless motors are typically 85-90% efficient, whereas DC motors with brushgear are typically 75-80% efficient.

Midway between ordinary DC motors and stepper motors lies the realm of the brushless DC motor. Built in a fashion very similar to stepper motors, these often use a permanent magnet **external** rotor, three phases of driving coils, one or more Hall effect sensors to sense the position of the rotor, and the associated drive electronics. The coils are activated, one phase after the other, by the drive electronics as cued by the signals from the Hall effect sensors. In effect, they act as three-phase synchronous motors containing their own variable-frequency drive electronics. A specialized class of brushless DC motor controllers utilize EMF feedback through the main phase connections instead of Hall effect sensors to determine position and velocity. These motors are used extensively in electric radio-controlled vehicles, and referred to by modelists as **outrunner** motors (since the magnets are on the outside).

Brushless DC motors are commonly used where precise speed control is necessary, computer disk drives or in video cassette recorders the spindles within CD, CD-ROM (etc.) drives, and mechanisms within office products such as fans, laser printers and photocopiers. They have several advantages over conventional motors:

i. Compared to AC fans using shaded-pole motors, they are very efficient, running much cooler than the equivalent AC motors. This cool operation leads to much-improved life of the fan's bearings.
ii. Without a commutator to wear out, the life of a DC brushless motor can be significantly longer compared to a DC motor using brushes and a commutator. Commutation also tends to cause a great deal of electrical and RF noise; without a commutator or brushes, a brushless motor may be used in electrically sensitive devices like audio equipment or computers.
iii. The same Hall effect sensors that provide the commutation can also provide a convenient tachometer signal for closed-loop control (servo-controlled) applications. In fans, the tachometer signal can be used to derive a "fan OK" signal.
iv. The motor can be easily synchronized to an internal or external clock, leading to precise speed control.
v. Brushless motors have no chance of sparking, unlike brushed motors, making them better suited to environments with volatile chemicals and fuels.
vi. Brushless motors are usually used in small equipment such as computers and are generally used to get rid of unwanted heat.
vii. They are also very quiet motors which is an advantage if being used in equipment that is affected by vibrations.
viii. Modern DC brushless motors range in power from a fraction of a watt to many kilowatts. Larger brushless motors up to about 100 kW rating are used in electric vehicles. They also find significant use in high-performance electric model aircraft.

1.5.5 Voltage Regulator

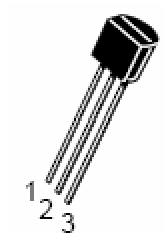

Figure 1.10: Typical Voltage Regulator IC

Referring to the figure 1.10, voltage regulator is used to provide regulated 5V to power the PIC16F877A microcontroller. This is very essential since the microcontroller will blow if the voltage supplied to it is exceeding its voltage rating.

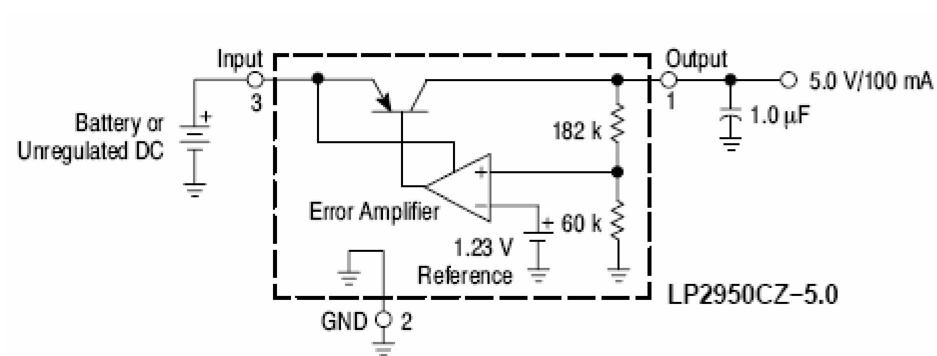

Figure 1.11: Circuitry of Voltage Regulator IC

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuits, the external operation is much the same. IC unit provide regulation of a fixed positive voltage, a fixed negative voltage or an adjustably set voltage.

A power supply can be built using a transformer connected to the ac supply line to step the ac voltage to desired amplitude, then rectifying that ac voltage, filtering with a capacitor and RC filter, if desired, and finally regulating the dc voltage using an IC regulator. The regulators can be selected for operation with load currents from hundreds of milliamperes to tens of amperes, corresponding to power ratings from milliwats to tens of watts.