OBSTACLE AVOIDANCE MOBILE ROBOT

KHAIRUL A'ALAM BIN ABDUL GHANI

UNIVERSITI MALAYSIA PAHANG

KHAIRUL A'ALAM BIN ABDUL GHANI BACHELOR OF ELECTRICAL ENGINEERING (POWER SYSTEMS) 2007 UMP

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **OBSTACLE AVOIDANCE MOBILE ROBOT**

SESI PENGAJIAN: **2007/2008**

Saya **KHAIRUL A'ALAM BIN ABD GHANI (8))**
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ /~~Doktor Falsafah~~)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

[ ]	**SULIT**	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
[ ]	**TERHAD**	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
[√]	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)	(TANDATANGAN PENYELIA)

Alamat Tetap:

W117 PARIT HAJI WAHAB
34250 TANJUNG PIANDANG
PERAK DARUL RIDZUAN

NOR MANIHA BT ABD GHANI
(Nama Penyelia)

Tarikh: **28 NOVEMBER 2007**

Tarikh: : **28 NOVEMBER 2007**

CATATAN: * Potong yang tidak berkenaan.

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.

♦ Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power Systems)"

Signature : ______________________________

Name : NOR MANIHA BT ABD GHANI

Date : 28 NOVEMBER 2007

OBSTACLE AVOIDANCE MOBILE ROBOT

KHAIRUL A'ALAM BIN ABDUL GHANI

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power Systems)

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

NOVEMBER, 2007

“All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly; otherwise the information presented in this report is solely work of the author.”

Signature : ____________________________

Author : KHAIRUL A’ALAM BIN ABDUL GHANI

Date : 30 NOVEMBER 2007

DEDICATION

"To my beloved parent and
For those who love me
The joy we had…the pain we shared
Always in my mind"

ACKNOWLEDGEMENT

Alhamdulillah, thank to my lord, Allah S.W.T for giving me the strength and showing me the way to complete this project.

In the process of making this project, I was very happy to have collaboration with many colleagues to make this project happen. Special thanks to my parent and family who's always support me financially and mentally. Without this, I wasn't able to make this project on time.

Thanks also to my supervisor, Mrs. Nor Maniha Bt Abd Ghani for the greatest support and supervision given in finishing this project.

I would like to thank my colleagues, Nurul Izzati, Mohd Firdaus and Haris Hamidi, Joe and Syathir for always hold my back up. Without this, I wouldn't able to make this project happen.

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.

ABSTRAK

Tujuan projek ini dijalankan adalah untuk membina sebuah robot mudah alih dengan kebolehan untuk mengelak halangan. Robot ini merupakan kenderaan empat tayar dengan sebuah ‘ultrasonic sensor’ dipasang dihadapannya untuk mengesan keadaan hadapan robot. Apabila halangan dikesan, robot ini akan menghantar input kepada ‘PIC16F877A microcontroller’. Pergerakan robot ini akan dikawal oleh sebuah ‘dc motor’ yang mendapat arahan daripada ‘PIC16F877A microcontroller’. ‘Dc motor’ ini akan mengawal arah robot mudah alih ini apabila halangan dikesan. Dua buah tayar lagi merupakan ‘dc motor’ yang hanya digunakan untuk menggerakkan robot mudah alih ini. ‘Dc motor’ ini hanya akan berpusing tanpa dipengaruhi oleh halangan dihadapan.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF SYMBOLS

E_{stored}	: Energy stored
C	: Capacitance
V	: Voltage level
Q	: Amount of charge
Z_c	: Impedance
I_c	: Current level
X_c	: Capacitive reactance
f	: Frequency
j	: Imaginary unit

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.

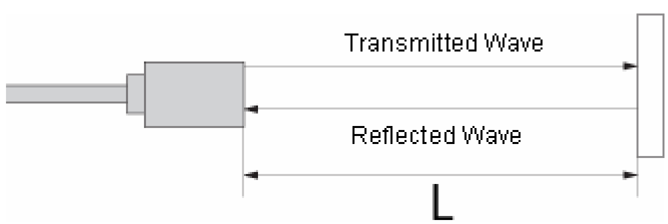


Figure 1.01: Principle use of ultrasonic sensor

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.

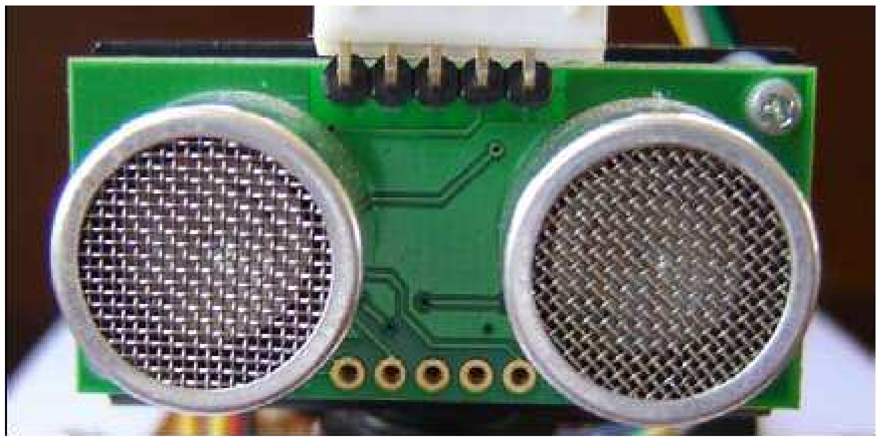


Figure 1.02: Ultrasonic sensor

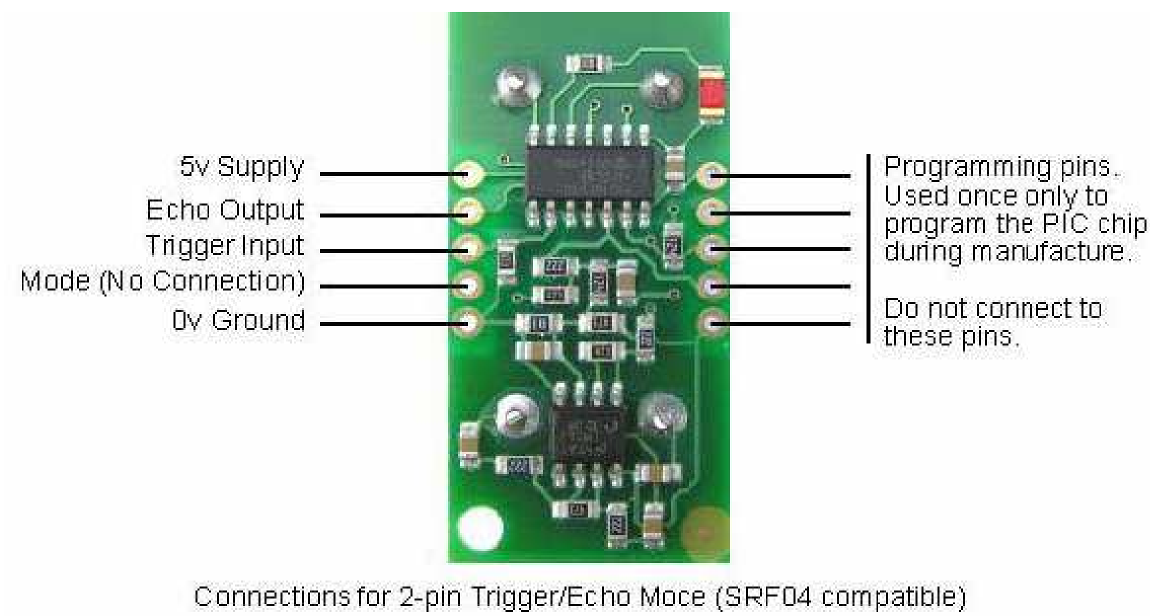


Figure 1.03: Ultrasonic Sensor connection

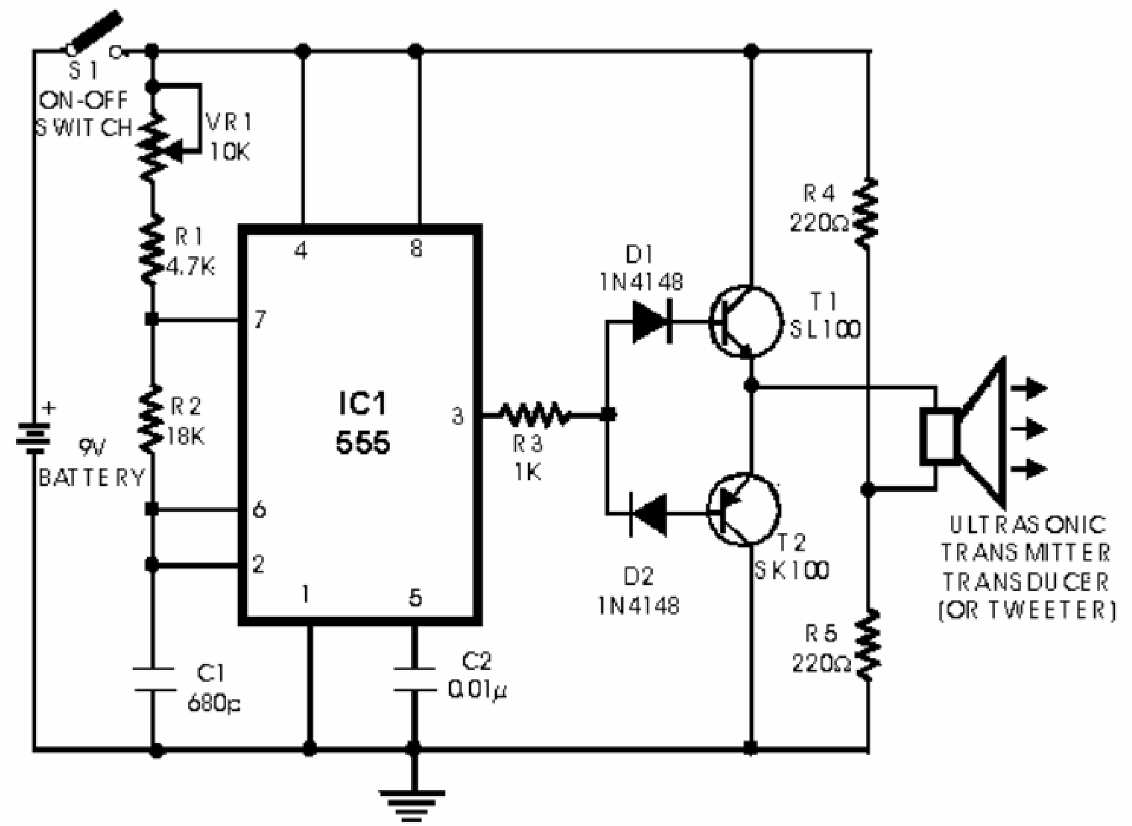


Figure 1.04: Transmitter of ultrasonic sensor circuit diagram

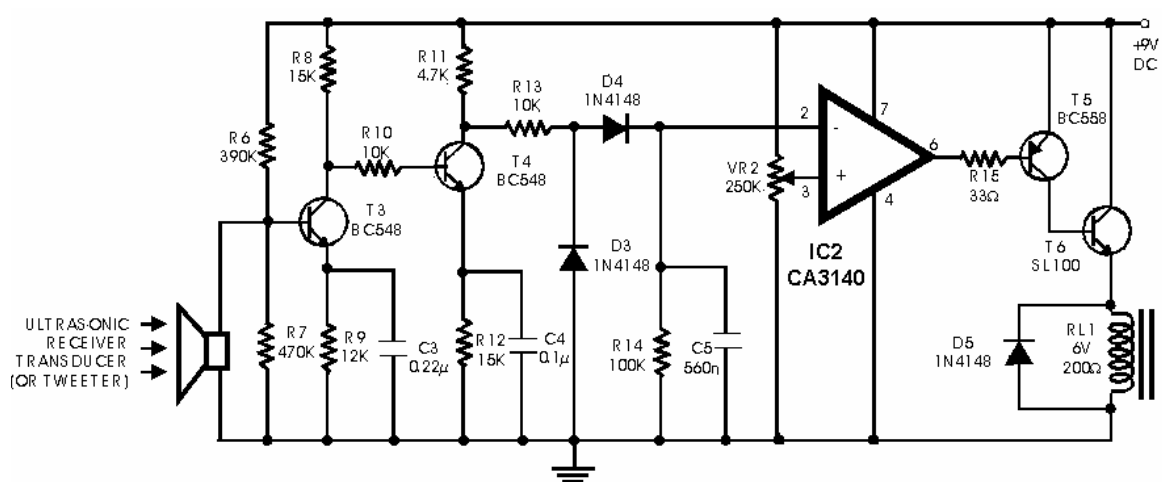


Figure 1.05: Receiver of ultrasonic sensor circuit diagram

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.

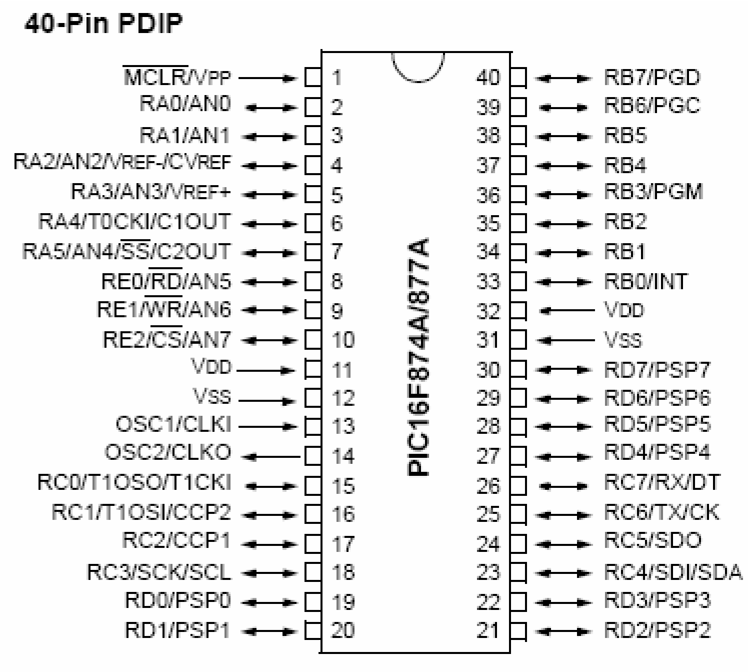
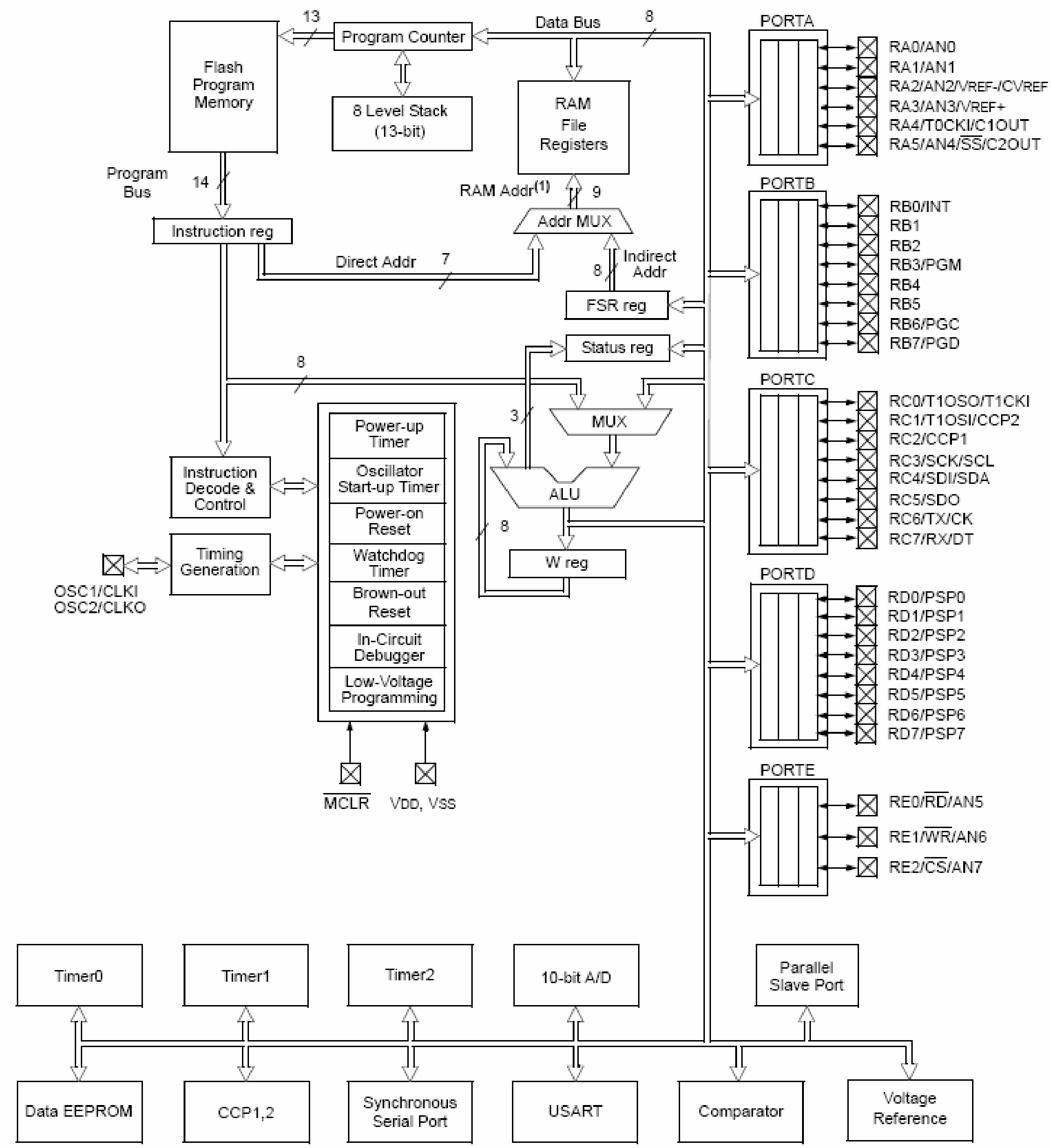


Figure 1.06: PIC16F877A pin connection

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

.

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.

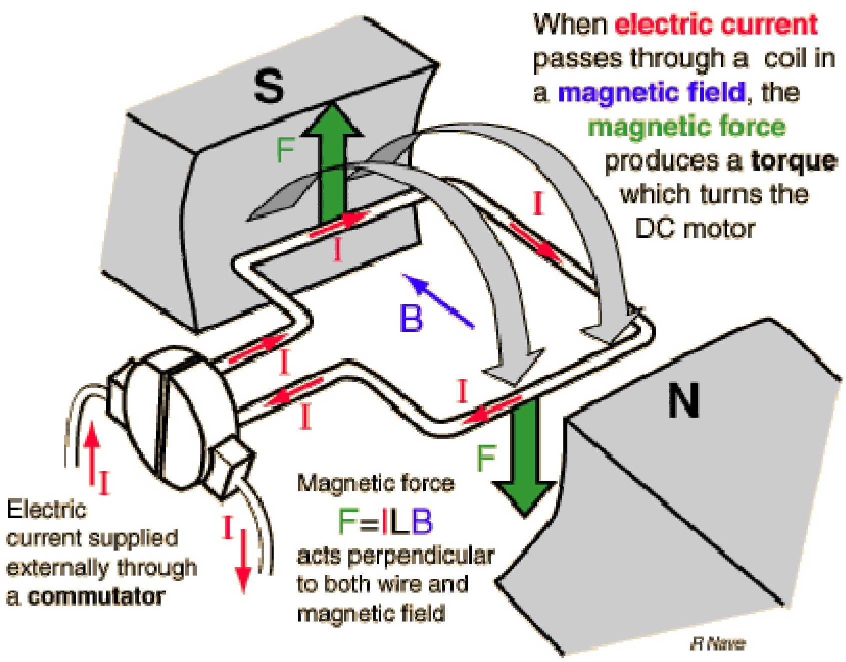


Figure 1.09: Basic operation

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

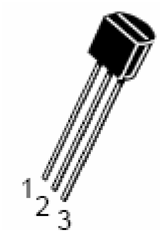


Figure 1.10: Typical Voltage Regulator IC

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.

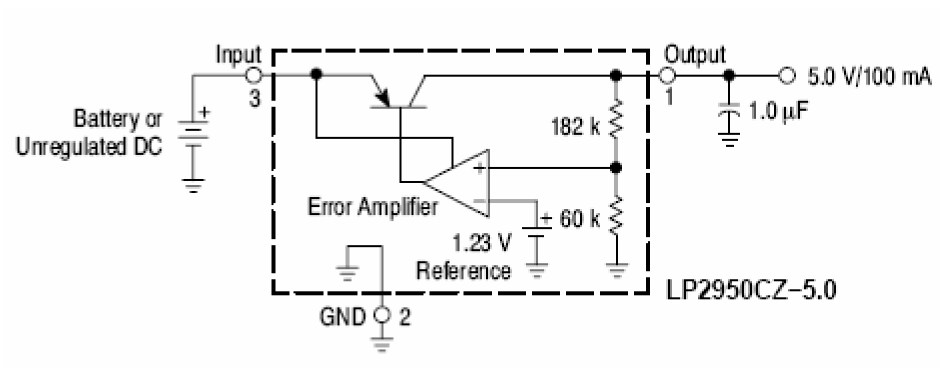


Figure 1.11: Circuitry of Voltage Regulator IC

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.

The series 78 regulators provide fixed regulated voltages from 5V to 24V. In this particular project, the voltage regulator IC is used to provide voltage regulation with output from this unit of +5V. An unregulated input voltage Ví is filtered by capacitor Cí and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated +5V, which is filtered by capacitor C_2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). Whereas the input voltage may vary over some permissible voltage range and the output load may vary over some acceptable range, the output voltage remains constant within specified voltage variation limits. These limitations are spelled out in the manufacturer's specification sheets.

1.5.6 Capacitor

Figure 1.12: Typical capacitors used in circuit

A capacitor is an electrical/electronic device that can store energy in the electric field between a pair of conductors (called "plates"). The process of storing energy in the capacitor is known as "charging", and involves electric charges of equal magnitude, but opposite polarity, building up on each plate.

Capacitors are often used in electrical circuit and electronic circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals. This property makes them useful in electronic filters.

Capacitors are occasionally referred to as condensers. This is considered an antiquated term in English, but most other languages use an equivalent, like the German word "*Kondensator*".

1.5.6.1 History

In October 1745, Ewald Georg von Kleist of Pomerania invented the first recorded capacitor: a glass jar coated inside and out with metal. The inner coating was connected to a rod that passed through the lid and ended in a metal sphere. By having this thin layer of glass insulation (a dielectric) between two large, closely spaced plates, von Kleist found the energy density could be increased dramatically compared with the situation with no insulator.

In January 1746, before Kleist's discovery became widely known, a Dutch physicist Pieter van Musschenbroek independently invented a very similar capacitor. It was named the Leyden jar, after the University of Leyden where van Musschenbroek worked. Daniel Gralath was the first to combine several jars in parallel into a "battery" to increase the total possible stored charge.

The earliest unit of capacitance was the 'jar', equivalent to about 1 nF.

Early capacitors were also known as *condensers*, a term that is still occasionally used today. It was coined by Alessandro Volta in 1782 (derived from the Italian *condensatore*), with reference to the device's ability to store a higher density of electric charge than a normal isolated conductor. Most non-English languages still use a word derived from "condensatore", as the 'in other languages' links from this article testify.

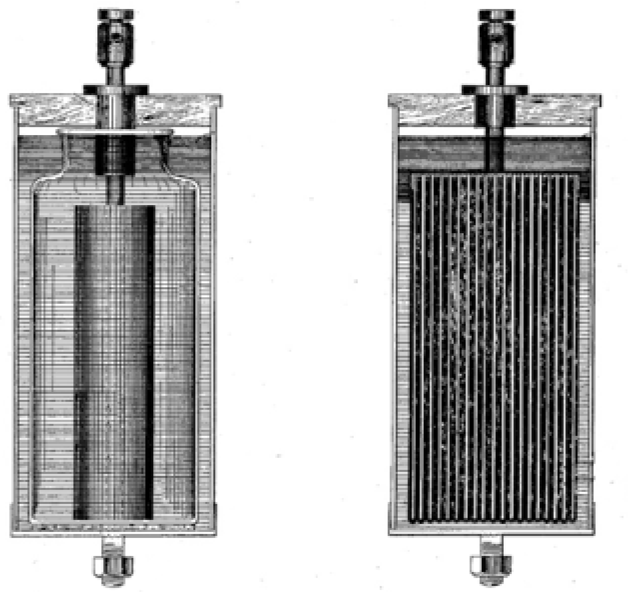


Figure 1.13: Condenser patented by Nikola Tesla

1.5.6.2 Stored energy

As opposite charges accumulate on the plates of a capacitor due to the separation of charge, a voltage develops across the capacitor due to the electric field of these charges. Ever-increasing work must be done against this ever-increasing electric field as more charge is separated. The energy (measured in joules, in SI) stored in a capacitor is equal to the amount of work required to establish the voltage across the capacitor, and therefore the electric field. The energy stored is given by:

$$E_{\text{stored}} = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}VQ$$

where *V* is the voltage across the capacitor.

The maximum energy that can be (safely) stored in a particular capacitor is limited by the maximum electric field that the dielectric can withstand before it breaks down. Therefore, all capacitors made with the same dielectric have about the same maximum energy density (joules of energy per cubic meter).

1.5.6.3 DC sources

The dielectric between the plates is an insulator and blocks the flow of electrons. A steady current through a capacitor deposits electrons on one plate and removes the same quantity of electrons from the other plate. This process is commonly called 'charging' the capacitor. The current through the capacitor results in the separation of electric charge within the capacitor, which develops an electric field between the plates of the capacitor, equivalently, developing a voltage difference between the plates. This voltage V is directly proportional to the amount of charge separated Q. Since the current I through the capacitor is the rate at which charge Q is forced through the capacitor (dQ/dt), this can be expressed mathematically as:

$$I = \frac{dQ}{dt} = C\frac{dV}{dt}$$

Where

I is the current flowing in the conventional direction, measured in amperes,

dV/*dt* is the time derivative of voltage, measured in volts per second, and

C is the capacitance in farads.

For circuits with a constant (DC) voltage source and consisting of only resistors and capacitors, the voltage across the capacitor cannot exceed the voltage of the source.

Thus, an equilibrium is reached where the voltage across the capacitor is constant and the current through the capacitor is zero. For this reason, it is commonly said that capacitors block DC.

1.5.6.4 Impedance

The ratio of the phasor voltage across a circuit element to the phasor current through that element is called the impedance *Z*. For a capacitor, the impedance is given by

$$Z_C = \frac{V_C}{I_C} = \frac{-j}{2\pi f C} = -jX_C,$$

where

$X_C = \frac{1}{\omega C}$ is the *capacitive reactance*,

$\omega = 2\pi f$ is the angular frequency,

f is the frequency),

C is the capacitance in farads, and

j is the imaginary unit.

While this relation (between the *frequency domain* voltage and current associated with a capacitor) is always true, the ratio of the *time domain* voltage and current *amplitudes* is equal to X_C only for sinusoidal (AC) circuits in steady state.

See derivation Deriving capacitor impedance.

Hence, capacitive reactance is the negative imaginary component of impedance. The negative sign indicates that the current leads the voltage by 90° for a sinusoidal signal, as opposed to the inductor, where the current lags the voltage by 90°.

The impedance is analogous to the resistance of a resistor. The impedance of a capacitor is inversely proportional to the frequency -- that is, for very high-frequency alternating currents the reactance approaches zero -- so that a capacitor is nearly a short circuit to a very high frequency AC source. Conversely, for very low frequency alternating currents, the reactance increases without bound so that a capacitor is nearly an open circuit to a very low frequency AC source. This frequency dependent behaviour accounts for most uses of the capacitor (see "Applications", below).

Reactance is so called because the capacitor doesn't dissipate power, but merely stores energy. In electrical circuits, as in mechanics, there are two types of load, resistive and reactive. Resistive loads (analogous to an object sliding on a rough surface) dissipate the energy delivered by the circuit as heat, while reactive loads (analogous to a spring or frictionless moving object) store this energy, ultimately delivering the energy back to the circuit.

Also significant is that the impedance is inversely proportional to the capacitance, unlike resistors and inductors for which impedances are linearly proportional to resistance and inductance respectively. This is why the series and shunt impedance formulae (given below) are the inverse of the resistive case. In series, impedances sum. In parallel, conductances sum.

CHAPTER 2

SYSTEM MODEL

2.1 Introduction

System model shows the progress of the system particularly in the hardware approach. Here, how the mobile robot reacts according to the surrounding is explained. Although the construction of this hardware is hard to be done, the system model can explain the theory that need to be conveyed.

The obstacle avoidance system is actually based on obstacle detection. Meaning here, the vital part of this system is the obstacle detection scheme. The overall process cannot be done without an ability to detect an obstacle. When the ultrasonic sensor detects an obstacle, it will activate an input to the microcontroller. Then, the microcontroller will trigger an output to dc motor. When the dc motor running, it will make the steering wheels steer aside and eventually avoid collision with an obstacle.

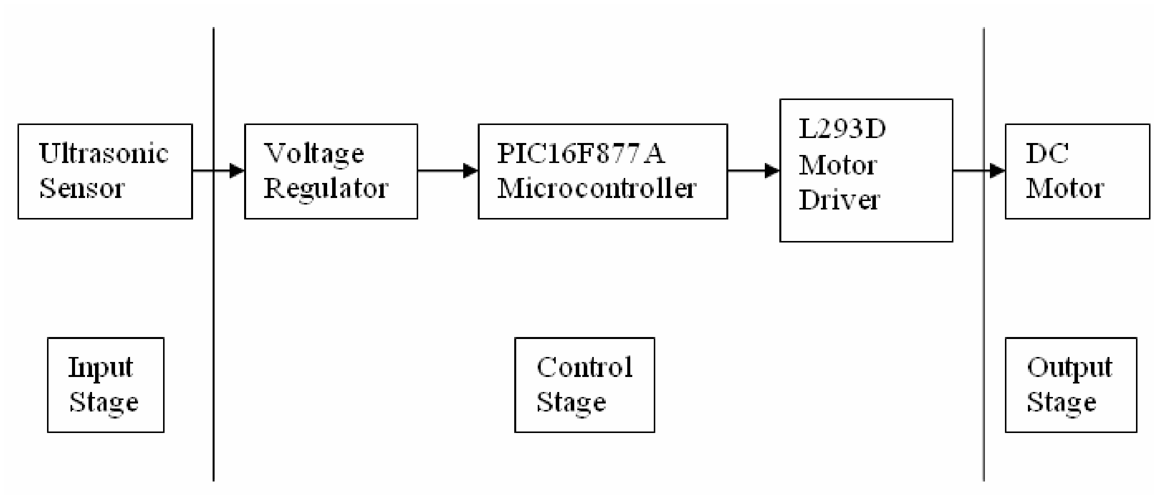


Figure 2.01: Hardware Block Diagram

The Electronic Structure has been divided into three stages. Each stage plays a different role in the system. There are input stages, control stage and the last one is output stage.

In input stage, there is ultrasonic sensor there. The ultrasonic sensor is responsible in providing an input to the whole system. It will scan the front environment of the mobile robot is there any obstacle or not.

In control stage, there are voltage regulator, microcontroller and motor driver. This stage is responsible to process the input and producing a required output. Voltage regulator is needed to step down the voltage from ultrasonic sensor less than 5V. This is very essential since the voltage rating of microcontroller just about 5V. Motor driver is used to control the dc motor. The dc motor cannot be connected directly through the microcontroller since the microcontroller can not supply current that high enough to make the dc motor running.

In output stage, there is dc motor. Dc motor is needed to make the steering wheels steer aside. Thus, the collision will be able to avoid by the mobile robot.

2.2 Hardware Model

Obstacle avoidances mobile robot consist a hardware model to make it operate. Several mechanicals part needs to be constructed and aligned together. Thus, the mobile robot will work together according to the program instruction.

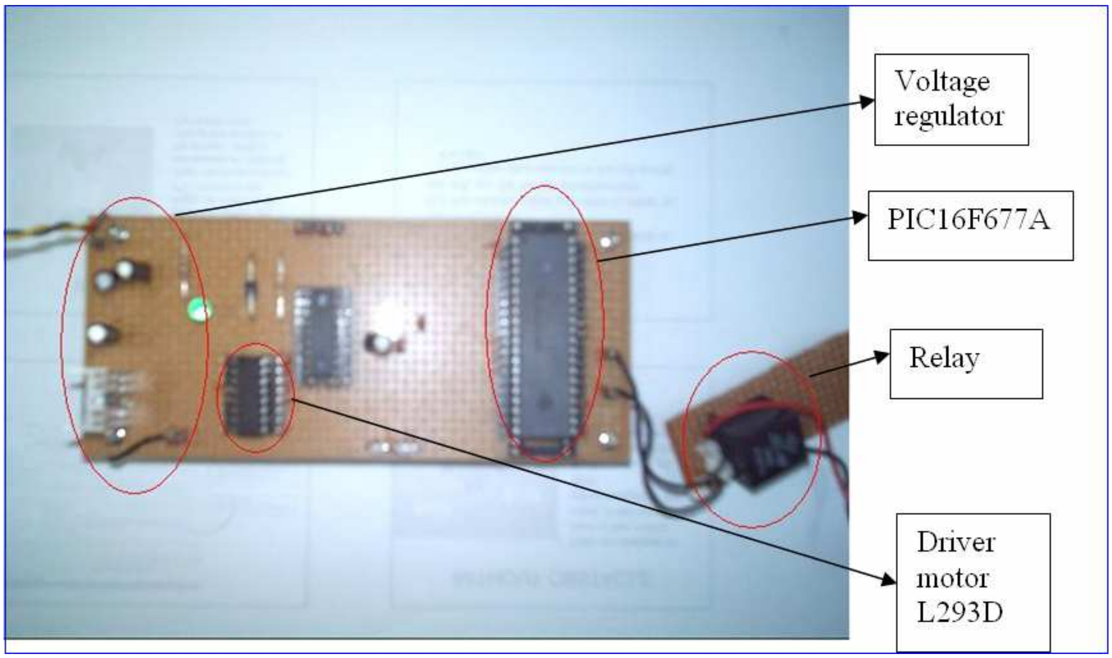


Figure 2.02: Hardware circuit

2.2.1 Voltage Regulator

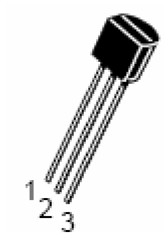


Figure 2.03: Typical Voltage Regulator IC

Referring to the figure 2.2, 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.

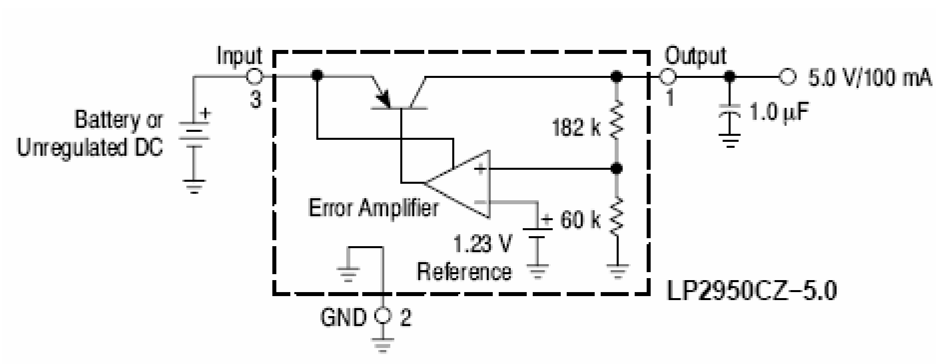


Figure 2.04: Circuitry of Voltage Regulator IC

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.

The series 78 regulators provide fixed regulated voltages from 5V to 24V. In this particular project, the voltage regulator IC is used to provide voltage regulation with output from this unit of +5V. An unregulated input voltage Ví is filtered by capacitor Cí and connected to the IC’s IN terminal. The IC’s OUT terminal provides a regulated +5V, which is filtered by capacitor C_2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). Whereas the input voltage may vary over some permissible voltage range and the output load may vary over some acceptable range, the output voltage remains constant within specified voltage variation limits. These limitations are spelled out in the manufacturer’s specification sheets.

2.2.2 PIC16F877A Microcontroller

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.

2.2.3 L293D Motor Driver

Motor drivers are essentially little current amplifiers; their function is to take a low-current control signal, and turn it into a proportionally higher-current signal that can drive a motor. Note here that the control signal is likely on the order of 10 mA, and the motor may require 100's of mA to make it turn.

You can think of motor drivers connecting control circuits and motors, very simply, as a "wrapper" around the motor. Schematically, the arrangement looks like this:

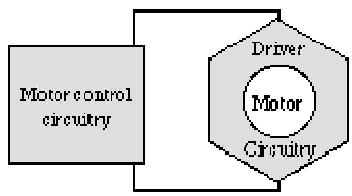


Figure 2.05: Driver Motor schematic

There are a whole slew of motor driver designs available to meet most any robotic need they all vary in the requirements they try to meet (so read their descriptions very closely).

There are some things to look for in a driver design, based on your requirements (bear in mind that there are **always** trade-offs):

i. Output power capability -- as a rule you don't want overkill here; higher-gain drivers generally also have higher power consumption, among other costs

ii. Number of circuit connections -- this is a good indication of how difficult it will be to build the circuit. This is particularly important if you're making your own PCB, since drilling lots of holes can be a pain if you don't have a drill press (and honestly, it gets to be a pain even with one).

iii. "Smoke proof" (or not) design -- unless you're amplifying a signal from a bicore, your bridge design needs to be "smoke proof". Drivers generally have two control inputs; "smoke proof" designs won't self-destruct if both control inputs are "low", or if both inputs are "high".

iv. Cost and availability of parts

v. Size -- more-compact designs are easier to fit into an arbitrary BEAMbot design

vi. Reversability -- most (but not all) motor driver designs allow your motor to run in both forward and reverse

vii. Output voltage -- some drivers provide (or at least allow for) output voltages higher than the input (control signal) voltage

viii. Braking circuitry -- if you are using *really good* motors, you'll need to provide an electronic motor brake to keep the motors from moving around when no control signal is being applied.

2.2.4 Relay

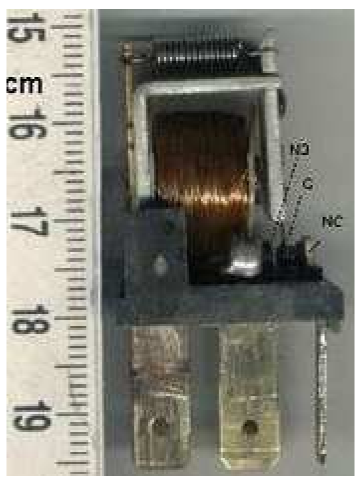


Figure 2.06: Typical Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of an electrical amplifier.

When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned by a force approximately half as strong as the magnetic force to its relaxed position. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

If the coil is energized with DC, a diode is frequently installed across the coil, to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a spike of voltage and might cause damage to circuit components. Some automotive relays already include that diode inside the relay case. Alternatively a contact protection network, consisting of a capacitor and resistor in series, may absorb the surge. If the coil is designed to be energized with AC, a small copper ring can be crimped to the end of the solenoid. This "shading ring" creates a small out-of-phase current, which increases the minimum pull on the armature during the AC cycle.[1]

By analogy with the functions of the original electromagnetic device, a solid-state relay is made with a thyristor or other solid-state switching device. To achieve electrical isolation an optocoupler can be used which is a light-emitting diode (LED) coupled with a photo transistor.

Relays are used:

i. To control a high-voltage circuit with a low-voltage signal, as in some types of modems,
ii. To control a high-current circuit with a low-current signal, as in the starter solenoid of an automobile,
iii. To detect and isolate faults on transmission and distribution lines by opening and closing circuit breakers (protection relays),
iv. To isolate the controlling circuit from the controlled circuit when the two are at different potentials, for example when controlling a mains-powered device from a low-voltage switch. The latter is often applied to control office lighting as the low voltage wires are easily installed in

partitions, which may be often moved as needs change. They may also be controlled by room occupancy detectors in an effort to conserve energy,

v. To perform logic functions. For example, the boolean AND function is realised by connecting NO relay contacts in series, the OR function by connecting NO contacts in parallel. The change-over or Form C contacts perform the XOR (exclusive or) function. Similar functions for NAND and NOR are accomplished using NC contacts. The Ladder programming language is often used for designing relay logic networks.

vi. To perform time delay functions. Relays can be modified to delay opening or delay closing a set of contacts. A very short (a fraction of a second) delay would use a copper disk between the armature and moving blade assembly. Current flowing in the disk maintains magnetic field for a short time, lengthening release time. For a slightly longer (up to a minute) delay, a dashpot is used. A dashpot is a piston filled with fluid that is allowed to escape slowly. The time period can be varied by increasing or decreasing the flow rate. For longer time periods, a mechanical clockwork timer is installed.

2.3 Ultrasonic Sensor

For this project, there are two part of ultrasonic sensor that needs to be done. One part is **transmitter** and the other one is **receiver.** Without one of this part, ultrasonic sensor cannot operate like ordered.

Transmitter is used to transmit signal. The signal is used to senses any obstacles in front of the mobile robot. When the obstacle is detected, it will fed back to the ultrasonic sensor particularly receiver part.

Receiver is used to receive the fed back signal. Then, it will react to the system and if the input is confirmed as an obstacle, it will produce an output to the PIC16F877A. Then, the PIC will respond to the dc motor like programmed.

2.3.1 Transmitter

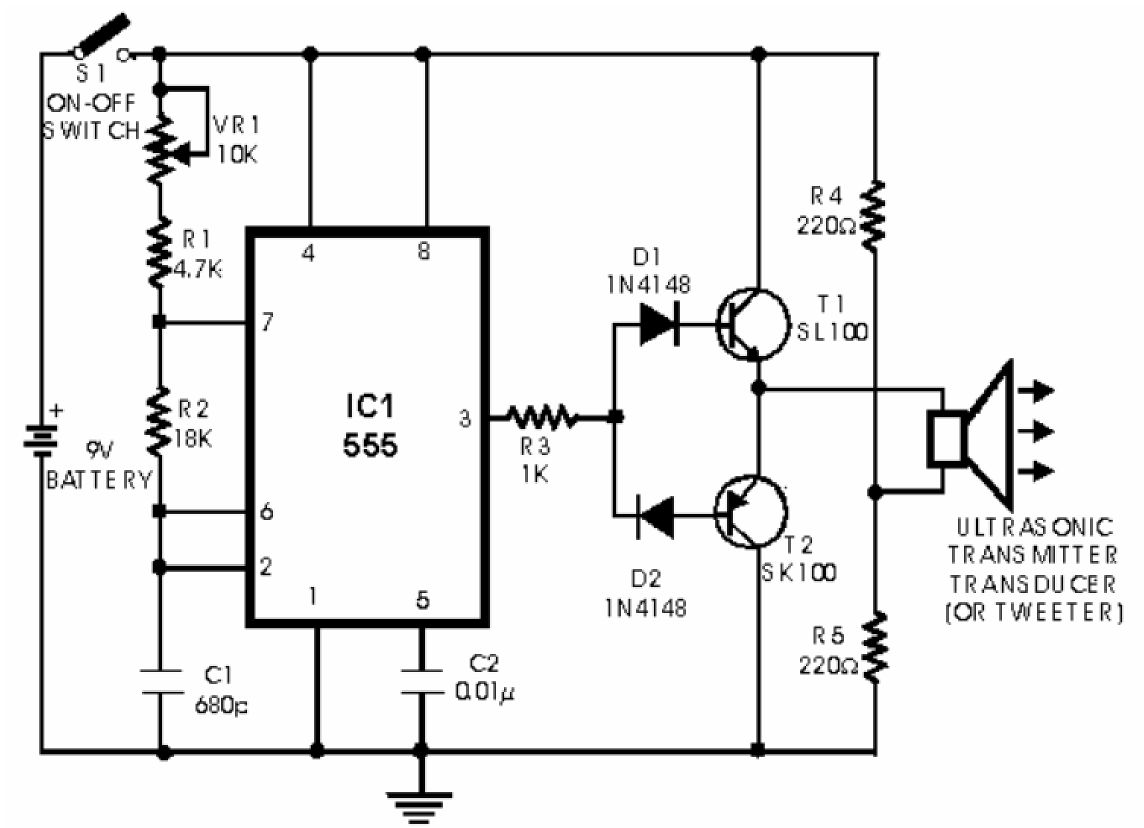


Figure 2.07: Circuit diagram for transmitter

In the transmitter part, it has timer that can produces PWM signal. Control of the servo is achieved by generating a PWM signal. A PWM signal is simply a pulse of varying length that can be translated into a position requested of the servo.

2.3.2 Receiver

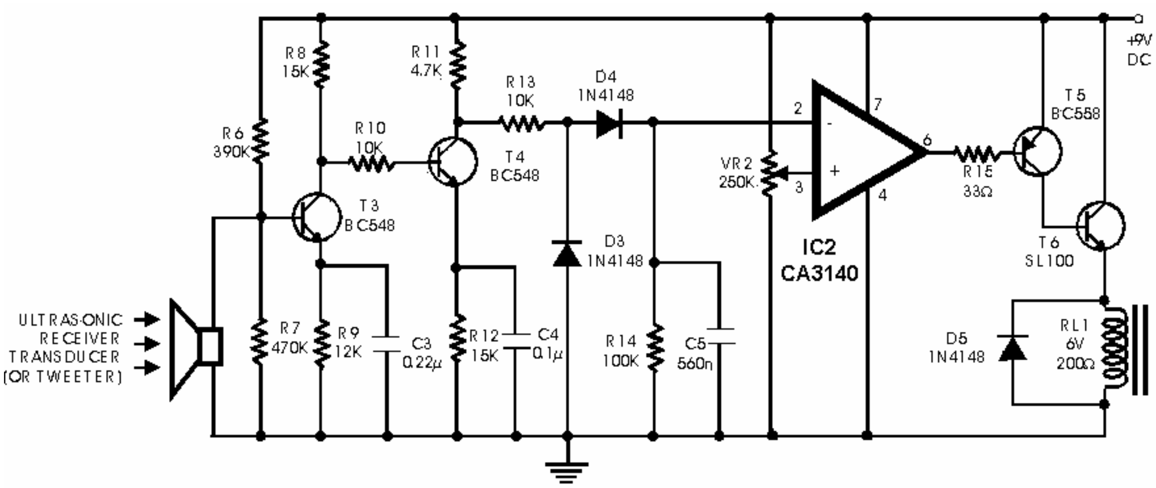


Figure 2.08: Circuit diagram for receiver

In receiver part, it will react to the fed back signal that produces by transmitter. When the obstacle is senses, it will give an output to relay and relay will give an input to microcontroller. Then, the microcontroller will commence the output to the dc motor that will control the steering of mobile robot.

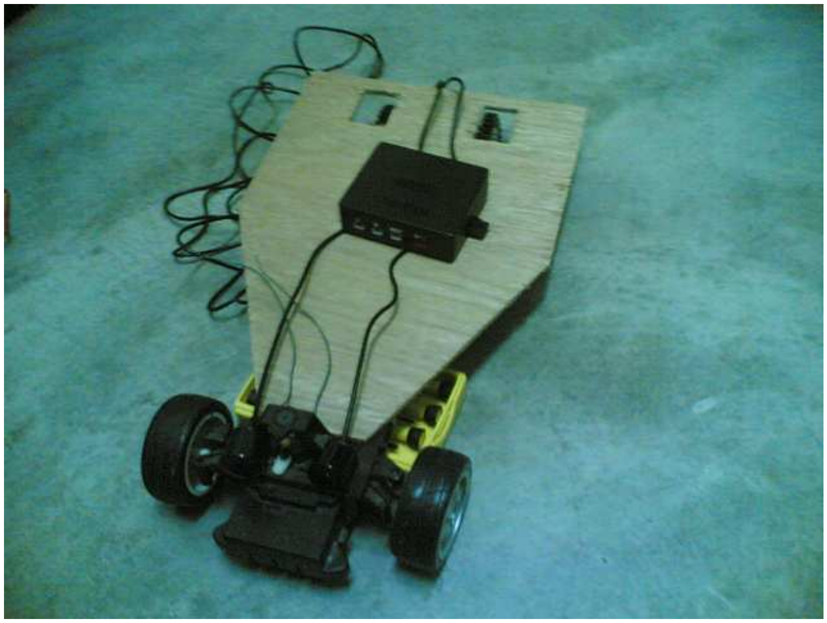


Figure 2.09: Ultrasonic Sensor onboard of the mobile robot

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 servo motor. The servo motor will change the direction of mobile robot according to the appropriate angel given by main controller. The other two wheels is a 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.

2.4 Dc Motor

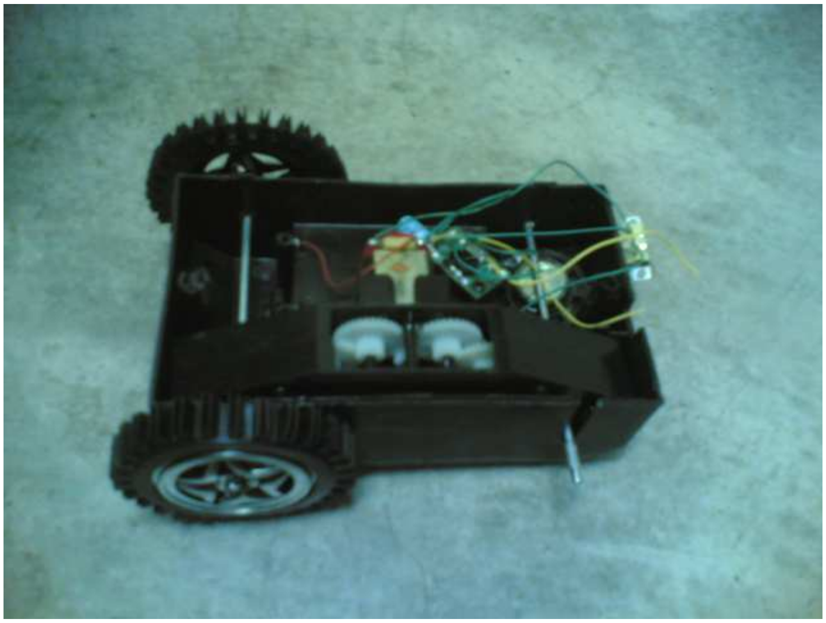


Figure 2.10: Dc Motor

Dc Motor is used to make the mobile robot to move forward. Several gears are connected in an appropriate arrangement to make the wheels rotate. Two wheels are used as the prime mover of the mobile robot.

The battery is placed under this device. The battery will supply energy to the stepper motor. Total voltage needed to make this device operate is about 4.5V.

2.5 Steering Wheels

Figure 2.11: Steering Wheels

Steering wheels is used for steering purpose. This is an important device to make the robot to avoid the obstacle. Two wheels is aligned together to have a better stability when cornering. One dc motor is located above the platform as the major controller of the device. This dc motor is connected to the PIC16F877A microcontroller. It will receive the output from the microcontroller and react with the steering movement.

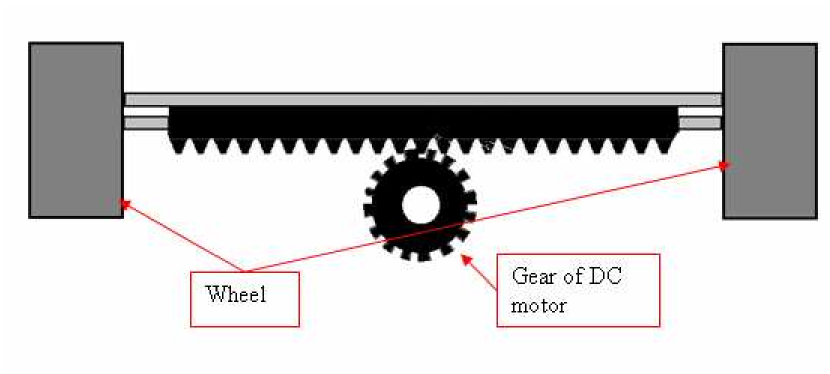


Figure 2.12: Wheels condition when there is no obstacle

When there is no obstacle in front of the mobile robot, the microcontroller can not activate a signal to the dc motor. Thus, the dc motor is not running and make the steering wheels can not steer aside.

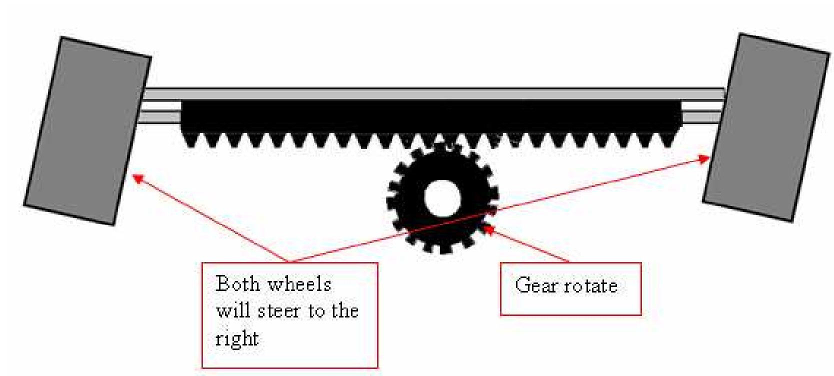


Figure 2.13: Wheels condition when there is obstacle

When there is an obstacle in front of the mobile robot, the microcontroller will activate a signal to the dc motor. Thus, the dc motor will running and makes the steering wheels steer aside to avoid obstacle.

CHAPTER 3

SOFTWARE

3.1 Introduction

The suitable software needs to be programmed in the microcontroller to smooth the progress of the system. For this particular project, the program needs to be written to control the dc motor by using the PIC16F877A. With that, the dc motor can act as a steering for the movement of the mobile robot. The input of the PIC16F877A is exactly from the ultrasonic sensor.

The PicBasic Pro Compiler (or PBP) makes it even quicker and easier for you to program Microchip Technology’s powerful PICmicro microcontrollers (MCUs). The English-like BASIC language is much easier to read and write than the quirky Microchip assembly language.

The PicBasic Pro Compiler is “BASIC Stamp II like” and has most of the libraries and functions of both the BASIC Stamp I and II. Being a true compiler, programs execute much faster and may be longer than their
Stamp equivalents.

PBP is not quite as compatible with the BASIC Stamps as our original PicBasic Compiler is with the BS1. Decisions were made that we hope improve the language overall. One of these was to add a real **IF..THEN..ELSE..ENDIF** instead of the **IF..THEN(GOTO)** of the Stamps. These differences are spelled out later in this manual.

PBP defaults to create files that run on a PIC16F84-04/P clocked at 4MHz. Only a minimum of other parts are necessary: 2 22pf capacitors for the 4MHz crystal, a 4.7K pull-up resistor tied to the

/MCLR pin and a suitable 5- volt power supply. PICmicro MCUs other than the 16F84, as well as oscillators of frequencies other than 4MHz, may be used with the PicBasic Pro Compiler.

3.2 Software Program

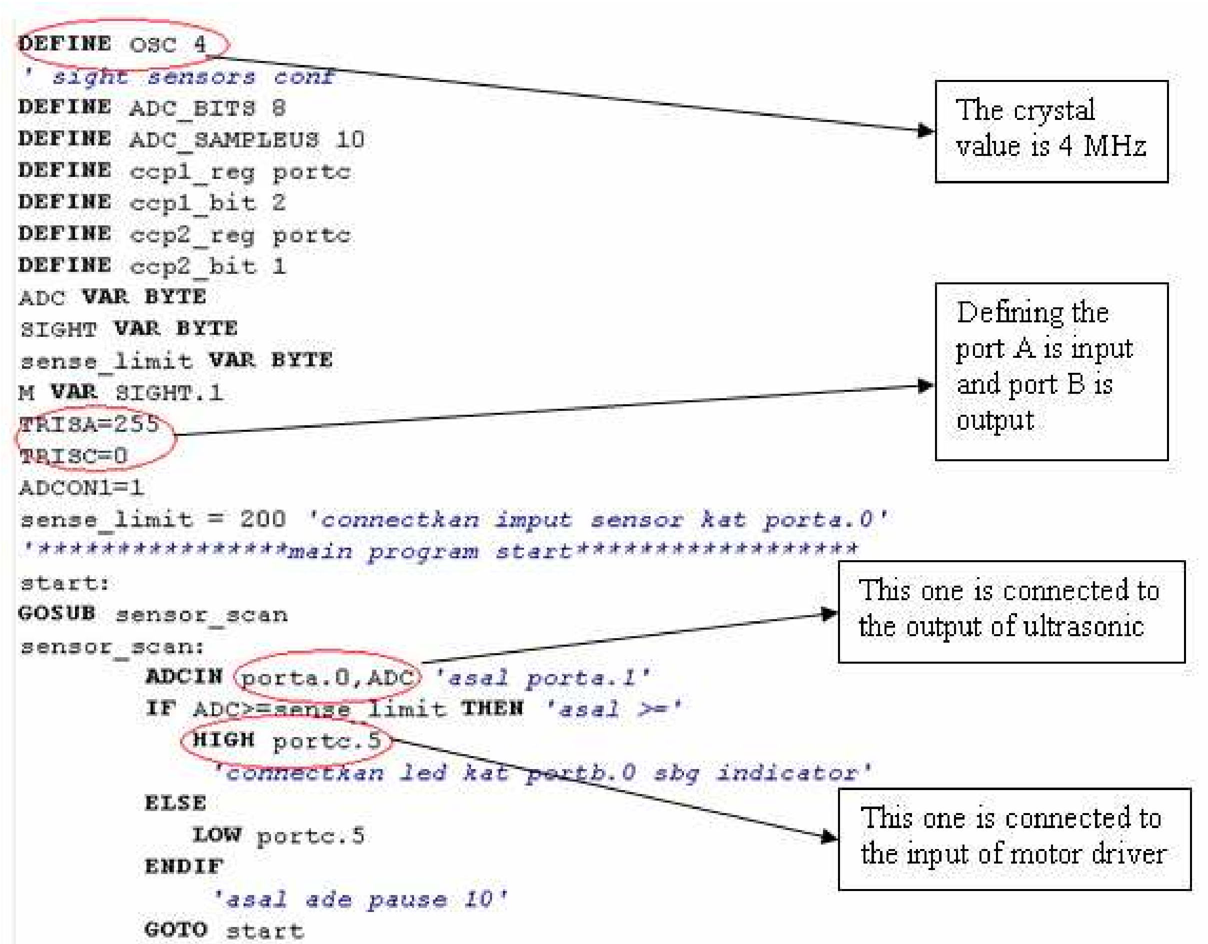


Figure 3.01: Software programming

Figure above show the pbasic programming for microcontroller software. The programming acts as the brain of this hardware. Proper programming need to be done or else, the mobile robot are unable to operate precisely.

```
DEFINE OSC 4
' sight sensors conf
DEFINE ADC_BITS 8
DEFINE ADC_SAMPLEUS 10
DEFINE ccp1_reg portc
DEFINE ccp1_bit 2
DEFINE ccp2_reg portc
DEFINE ccp2_bit 1
```

Figure 3.02: DEFINE codes

The word **DEFINE** is used when we need to define the programming. As an example, the sentence **DEFINE** OSC 4 meaning we are using oscillator with the value of 4MHz. If one of these **DEFINE**s is used on an erased part, it will cause the program to loop endlessly.

Some elements, like the clock oscillator frequency and the LCD pin locations, are predefined in PBP. **DEFINE** allows a PBP program to change these definitions, if desired. **DEFINE** may be used to change the predefined oscillator value, the **DEBUG** pins and baud rate and the LCD pin locations, among other things.

These definitions must be in all upper case, exactly as shown. If not, the compiler may not recognize them. No error message will be produced for **DEFINE**s the compiler does not recognize.

DEFINE OSC 4 ‘ Oscillator speed in MHz

```
ADC VAR BYTE
```

Figure 3.03: ADC code

Read the on-chip analog to digital converter *Channel* and store the result in *Var*. While the ADC registers can be accessed directly, **ADCIN** makes the process a little easier.

```
TRISA=255
TRISC=0
```

Figure 3.04: Input Output determination

Before **ADCIN** can be used, the appropriate TRIS register must be set to make the desired pins inputs. ADCON1 or ANSEL also needs to be set to assign the desired pins to analog inputs and in some cases to set the result format and clock source. See the Microchip data sheets for more information on these registers and how to set them for the specific device.

```
start:
GOSUB sensor_scan
```

Figure 3.05: GOSUB code

GOSUB is normally used to execute a PicBasic Pro subroutine. The main difference between **GOSUB** and **CALL** is that with **CALL**, *Label*'s existence is not checked until assembly time. Using **CALL**, a *Label* in an assembly language section can be accessed that is otherwise inaccessible to PBP.

```
sensor_scan:
        ADCIN porta.0,ADC 'asal porta.1'
        IF ADC>=sense_limit THEN 'asal >='
           HIGH portc.5
```

Figure 3.06: The main operation codes

This is the components of **GOSUB** sensor_scan. **IF** there mean if the sensor sense a limit, or there is an input to the microcontroller, it will trigger a high output at portc.5. **THEN** there mean the next execute need to be done. **HIGH** portc.5 means, the microcontroller will send an output signal at portc.5.

```
ELSE
   LOW portc.5
```

Figure 3.07: No output code

When there is no signal to the input, the microcontroller will not send an output to the portc.5. Thus, there is no signal will be trigger to the output.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This chapter will show the result for following test

i. Ultrasonic sensor
ii. Voltage Regulator
iii. Steering wheels when there is no obstacle
iv. Steering wheels when there is an obstacle

4.2 Ultrasonic Sensor

From this project, ultrasonic sensor has been test several times to make it able to work properly. Even though the information about the sensor circuit is easily can be found in internet, but the circuit is not absolutely function correctly. The manufacturer of the sensor might be thinking that the original circuit blueprint is not for others. So, the circuit must be done all by me with a little help from internet as well.

The result for the ultrasonic sensor test is as follows;

i. Ultrasonic detection range : 0m to 1.5m
ii. Operating voltage range : 12V DC
iii. Rated current : 100mA
iv. Highest output : 7.4V DC
v. Ultrasonic frequency : 40kHz

4.3 Voltage Regulator

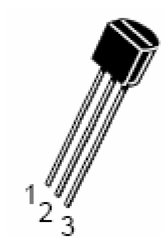


Figure 4.01: Typical Voltage Regulator IC

Referring to the figure 2.2, 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.

4.4 Steering wheels when no obstacle exist

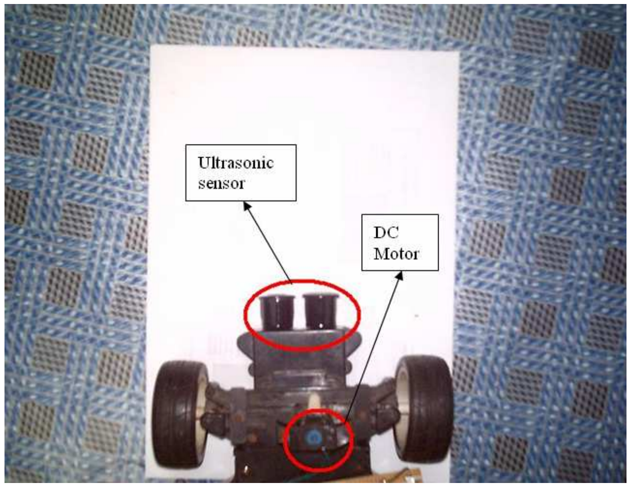


Figure 4.02: Mobile robot without obstacle

To figure out what will happen to the steering wheels when there is no obstacle in front of the mobile robot, one simple experiment has been done. The mobile robot was putted in a yard without any other obstacle in front of it. The result is, the steering wheels are not steering to other direction.

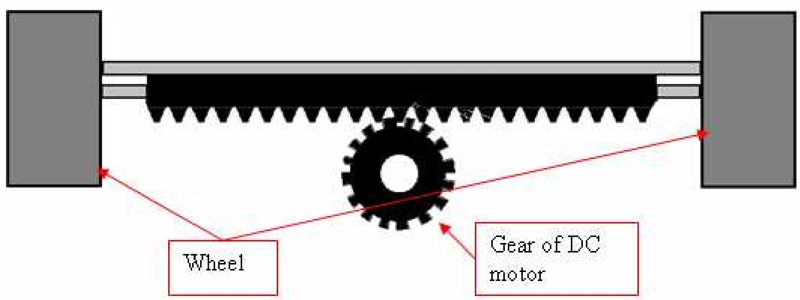


Figure 4.03: Wheels condition when no obstacle exist

When there is no obstacle in front of the mobile robot, the microcontroller can not activate a signal to the dc motor. Thus, the dc motor is not running and make the steering wheels can not steer aside.

4.5 Steering wheels when an obstacle exists

Figure 4.04: Mobile robot with an obstacle

When there is an obstacle in front of the mobile robot, the steering wheels will steer aside. The steering wheels start to steer at the range of 1.5m from the obstacle.

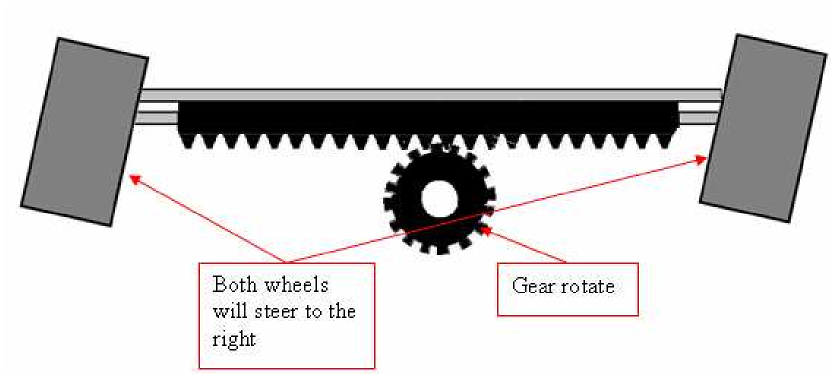


Figure 4.05: Wheels condition when obstacle exists

When there is an obstacle in front of the mobile robot, the microcontroller will activate a signal to the dc motor. Thus, the dc motor will running and makes the steering wheels steer aside to avoid obstacle.

CHAPTER 5

CONCLUSION AND FUTURE DEVELOPMENT

5.1 Conclusion

After creating the mobile robot, implementing the collision avoidance algorithm on the microcontroller, testing and with modifications, I was able to achieve my project scope and objective that is to design a collision avoidance robot. My final version of the mobile robot was able to avoid collisions 50% of the time (according to test results). Since it is quite difficult to develop a 100% collision avoidance system, I believe that the achieved collision avoidance rate is satisfactory.

The mobile robot also able to bring future development in ultrasonic system integration. Even though the ultrasonic sensor is not a quite popular system device, but it has a big opportunity to increase in usage rate. There is a lot of its usage potential are still undiscovered.

5.2 Limitation and Future Development

There are several limitations that exist in the current system which should be addressed in further developments. The mobile robot has information only about its local environment and does not localize itself in a global environment. Thus it is impossible to introduce a define goal to the mobile robot to reach in global environment.

For future development, the mobile robot should be able to operate in every type of environment. With that, the mobile robot can be used in several types of application either for industry or education program.

Also sometimes some obstacles are not detected when the obstacle surface is not in an angle to sufficiently reflect the waves sent by the sonar sensor.

A proper attention should be paid to the above matters in a further development of this project. Even though the ultrasonic sensor has limitation in its detection scheme, but we could make the system that can integrate with its system such as, detection potential in every type of obstacle surfaces.

5.2.1 Cost and commercialization

The overall cost of this project earns about RM250. This cost is only for model of mobile robot only. For a real robot that can be commercialize into the real world, the cost might be increase timely. This robot can be commercialized into the new era of transportation safety standard. With this idea, the accident of car regarding to the human mistake can be reduced to zero. By using this system, the car will be able to avoid obstacle without having a fatal collision.

List of References

1. H. R. Everett, A. K. Peters. *Sensors for mobile robots: theory and applications*, Ltd, C1995, ISBN: 1-56881-048-2
2. Jacob Fraden. *Handbook of Modern Sensors: Physics, Designs and Applications*, 2ndedition, AIP Press/Springer, 1996. ISBN 1-56396-538-0
3. 17 Feruary 2007, Citing Internet sources URL. *Control a servo using PIC Microcontroller*. www.pages.drexel.edu/
4. 21 February 2007, Citing Internet sources URL. *PIC Data sheets*.www.datasheetcatalog.com

5. Dangampola D.L, D. Abrew K.N.T. *Collision Avoidance Mobile Robot*. B.Sc. Engineering. University of Moratuwa. 1993
6. Chan Yet, Wong. *Intelligent Sensor Network for Obstacle Avoidance Strategy*. Tulane University, New Orleans, USA. 1992.
7. J. Boreinstein, Y. Koren. *Real-Time Obstacle Avoidance for Fast Mobile Robot*. Members of IEEE. 1989.
8. Uvais Qidwai. *Intelligent Sensor Network*. University of Qatar, Doha, Qatar.1992.
9. Hiroshi, K., Akio, M., Kazuo,H., and Shiro, N. *Development of Quantitative Evaluation Method of Vehicle Stability and Controllability.* SEI Technical Review No. 59. 2005.
10. 24 October 2007, Citing Internet URL. *Wikipedia.Org.PIC Microcontroller.* http://en.wikipedia.org/wiki
11. 24 October 2007, Citing Internet URL. *Wikipedia.Org. 7805 voltage regulator circuit diagram.* http://en.wikipedia.org/wiki
12. 27 October 2007, Citing Internet URL. *Wikipedia.Org. L293D motor driver circuit diagram.* http://en.wikipedia.org/wiki
13. 27 October 2007, Citing Internet URL. *Wikipedia.Org. relay circuit diagram.* http://en.wikipedia.org/wiki

APPENDICES

APPENDIX A

PROGRAMMING CODE

ADCIN	Read on-chip analog to digital converter.
ASM..ENDASM	Insert assembly language code section.
BRANCH	Computed **GOTO** (equiv. to ON..GOTO).
BRANCHL	**BRANCH** out of page (long **BRANCH**).
BUTTON	Debounce and auto-repeat input on specified pin.
CALL	Call assembly language subroutine.
CLEAR	Zero all variables.
CLEARWDT	Clear (tickle) Watchdog Timer.
COUNT	Count number of pulses on a pin.
DATA	Define initial contents of on-chip EEPROM.
DEBUG	Asynchronous serial output to fixed pin and baud.
DEBUGIN	Asynchronous serial input from fixed pin and baud.
DISABLE	Disable **ON DEBUG** and **ON INTERRUPT** processing.
DISABLE DEBUG	Disable **ON DEBUG** processing.
DISABLE INTERRUPT	Disable **ON INTERRUPT** processing.
DTMFOUT	Produce touch-tone frequencies on a pin.
EEPROM	Define initial contents of on-chip EEPROM.
ENABLE	Enable **ON DEBUG** and **ON INTERRUPT** processing.
ENABLE DEBUG	Enable **ON DEBUG** processing.
ENABLE INTERRUPT	Enable **ON INTERRUPT** processing.
END	Stop program execution and enter low power mode.
ERASECODE	Erase block of code memory.
FOR..NEXT	Repeatedly execute statements in a loop.
FREQOUT	Produce 1 or 2 frequencies on a pin.
GOSUB	Call BASIC subroutine at specified label.
GOTO	Continue execution at specified label.
HIGH	Make pin output high.
HPWM	Output hardware pulse width modulated pulse train.
HSERIN	Hardware asynchronous serial input.
HSERIN2	Hardware asynchronous serial input, second port.
HSEROUT	Hardware asynchronous serial output.
HSEROUT2	Hardware asynchronous serial output, second port.
I2CREAD	Read from I C 2 device.

I2CWRITE	Write to I2C device.
INPUT	Make pin an input.
LCDIN	Read from LCD RAM.
LCDOUT	Display characters on LCD.
{LET}	Assign result of an expression to a variable.
LOOKDOWN	Search constant table for value.
LOOKDOWN2	Search constant / variable table for value.
LOOKUP	Fetch constant value from table.
LOOKUP2	Fetch constant / variable value from table.
LOW	Make pin output low.
NAP	Power down processor for short period of time.
ON DEBUG	Execute BASIC debug monitor.
ON INTERRUPT	Execute BASIC subroutine on an interrupt.
OWIN	One-wire input.
OWOUT	One-wire output.
OUTPUT	Make pin an output.
PAUSE	Delay (1 millisecond resolution).

APPENDIX B

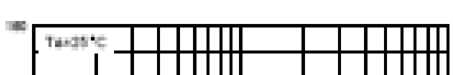
DIODE CHARACTERISTIC

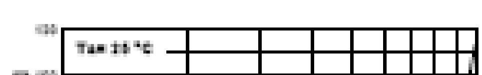
Electrical Characteristics

T_A = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Max	Units
V_R	Breakdown Voltage	I_R = 100 µA	100		V
		I_R = 5.0 µA	75		V
V_F	Forward Voltage 1N914B/4448	I_F = 5.0 mA	620	720	mV
	1N916B	I_F = 5.0 mA	630	730	mV
	1N914/916/4148	I_F = 10 mA		1.0	V
	1N914A/916A	I_F = 20 mA		1.0	V
	1N916B	I_F = 20 mA		1.0	V
	1N914B/4448	I_F = 100 mA		1.0	V
I_R	Reverse Current	V_R = 20 V		25	nA
		V_R = 20 V, T_A = 150°C		50	µA
		V_R = 75 V		5.0	µA
C_T	Total Capacitance 1N916A/B/4448	V_R = 0, f = 1.0 MHz		2.0	pF
	1N914A/B/4148	V_R = 0, f = 1.0 MHz		4.0	pF
t_{rr}	Reverse Recovery Time	I_F = 10 mA, V_R = 6.0 V (60mA), I_{rr} = 1.0 mA, R_L = 100Ω		4.0	ns

Typical Characteristics





APPENDIX C

PIC16F877A BLOCK DIAGRAM

FIGURE 1-1: PIC16F873A/876A BLOCK DIAGRAM