SSG EMBEDDED SOLUTIONS

SSG

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# DEVELOPMENT KIT of PIC16f877a MCU DOCUMENTATION

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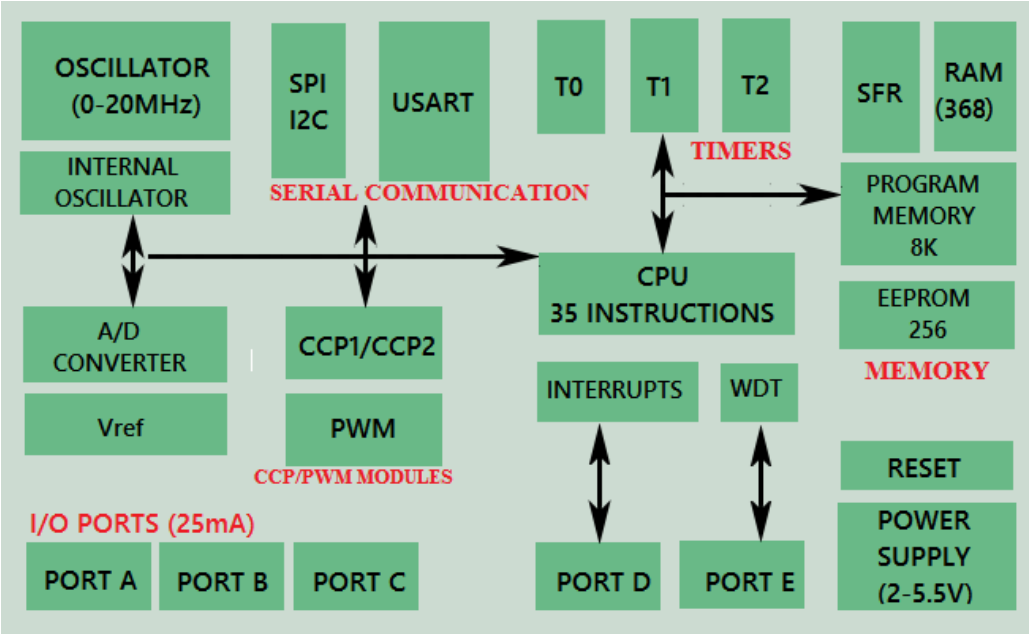
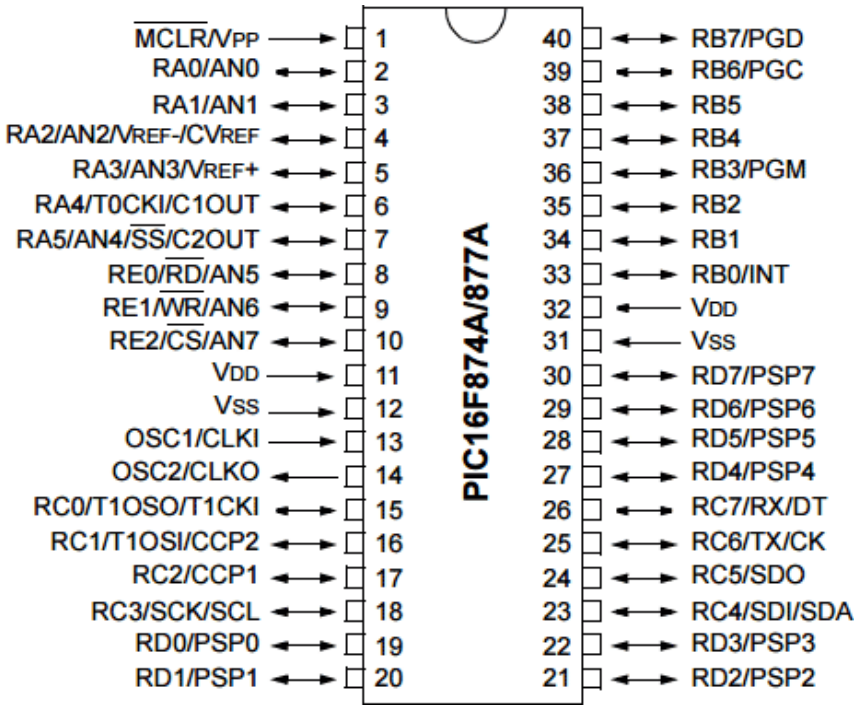
# Introduction

The PIC microcontroller from Microchip is one the famous and most used microcontrollers. Because of its reliability it is commonly preferred by embedded engineers for industrial applications. The PIC microcontroller **PIC16f877a** is one of the most renowned microcontrollers in the industry. This microcontroller is very convenient to use, the coding or programming of this controller is also easier. The **PIC16F877A Microcontroller** consists of an inbuilt CPU, I/O ports, memory organization, A/D converter, timers/counters, interrupts, serial communication, oscillator and CCP module which to gather makes the IC a powerful microcontroller for beginners to start with. The general block diagram of the PIC Architecture is shown below.




One of the main advantages is that it can be write-erase as many times as possible because it uses **FLASH memory technology**. It has a total number of 40 pins and there are 33 pins for input and output. PIC16F877A is used in many **pic microcontroller projects**. PIC16F877A also have much application in digital **electronics circuits**.

## Pin Diagram




## Specifications

- 8K of Code space
- 256 Bytes of EEPROM
- 384 bytes SRAM
- 8-level deep hardware stack
- Up to 20 MHz clock
- 1 16-bit, 2 8-bit timers
- Synchronous Serial Port – SPI and I2C
- USART
- 8 channel, 10-bit ADC
- Brown-Out Reset
- 2 Analog Comparators
- Capture, Compare, PWM module

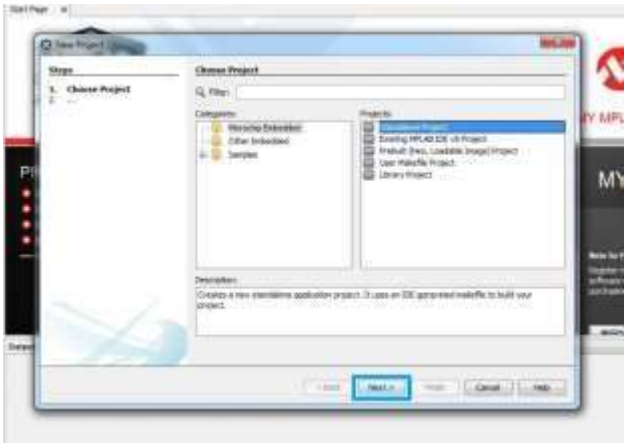
## Application

PIC16F877A also have much application in digital electronics circuits. PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and many industrial instruments.

## MPLAB IDE

**Step 1:** The first step is to run the MPLAB IDE.exe file on your desktop or whatever the installation path is.

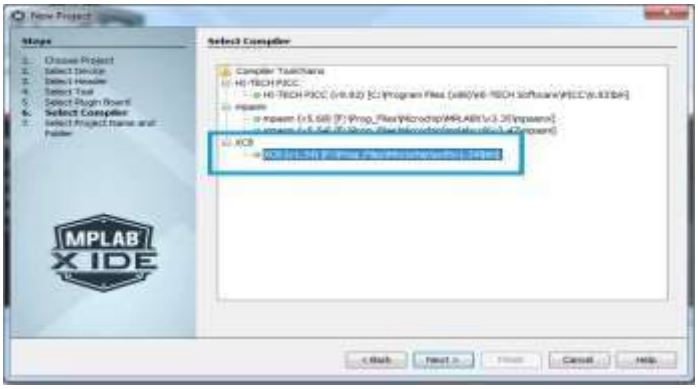

**Step 2:** From the "Project" choose "New Project", Choose **Embedded Standalone Project**. Then **Next.**



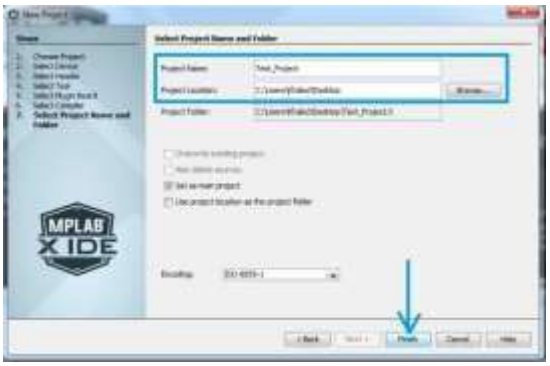
**Step 3: Choose** the family of the MCU which is **8-bit Mid-range.** Then write the name of the chip in the box below which will be **PIC16F877A**. Then **Next.**

**Step 4:** Here you'll choose the debugging hardware tool for your project **Pick any one** then click **Next.**


**Step 5:** Choose the compiler for your project. We'll be using **XC8 compiler** for our projects. Then **Next.**

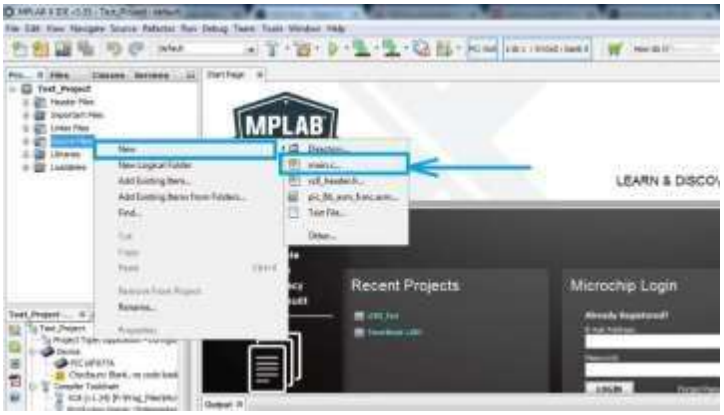



**Step 6:** Choose the path to save your project into. And give your project a relevant name.



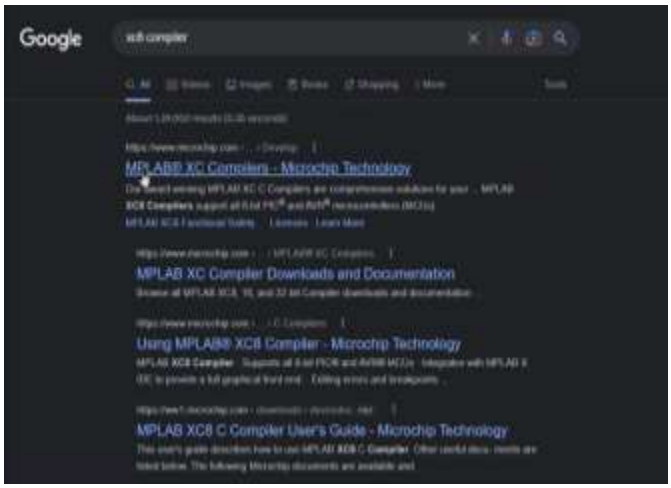
Click **Finish** and you should see something like this screen down below.


**Step 7:** Now, let's create the file in which we'll write our source C-Code. Right-Click on the source files and choose to create a new main.c file. And give it a relevant name. It's usually named as **main.c**



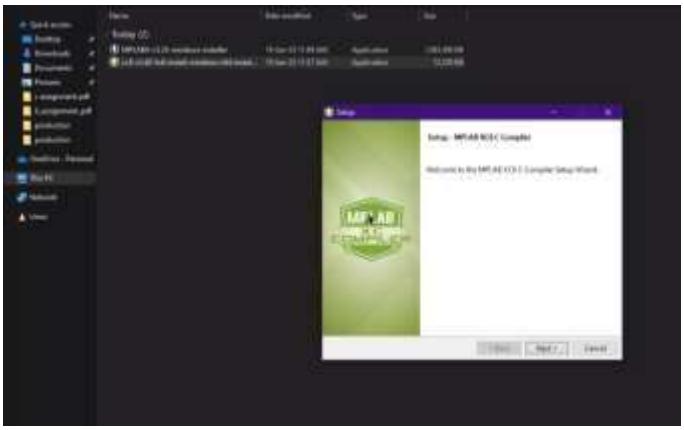

# XC8 Compiler

**Step 1:** Open browser and search XC8 compiler




**Step 2:** Click on MPLAB XC8 compiler


**Step 3:** After downloading open xc8 compiler



**Step 4:** ready to install

**Step 5:** installation complete

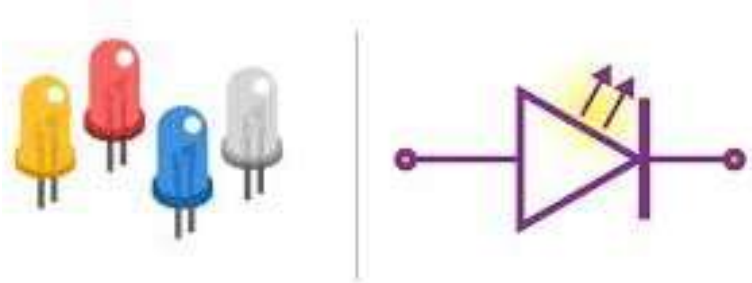

**NOTE:**

**PICKIT2 PROGRAMMER SETUP ARE GIVE IN TOOL FOLDER**

**MICROC IDE ALSO AVAILABLE FOR PIC CONTROLLER**

## LED

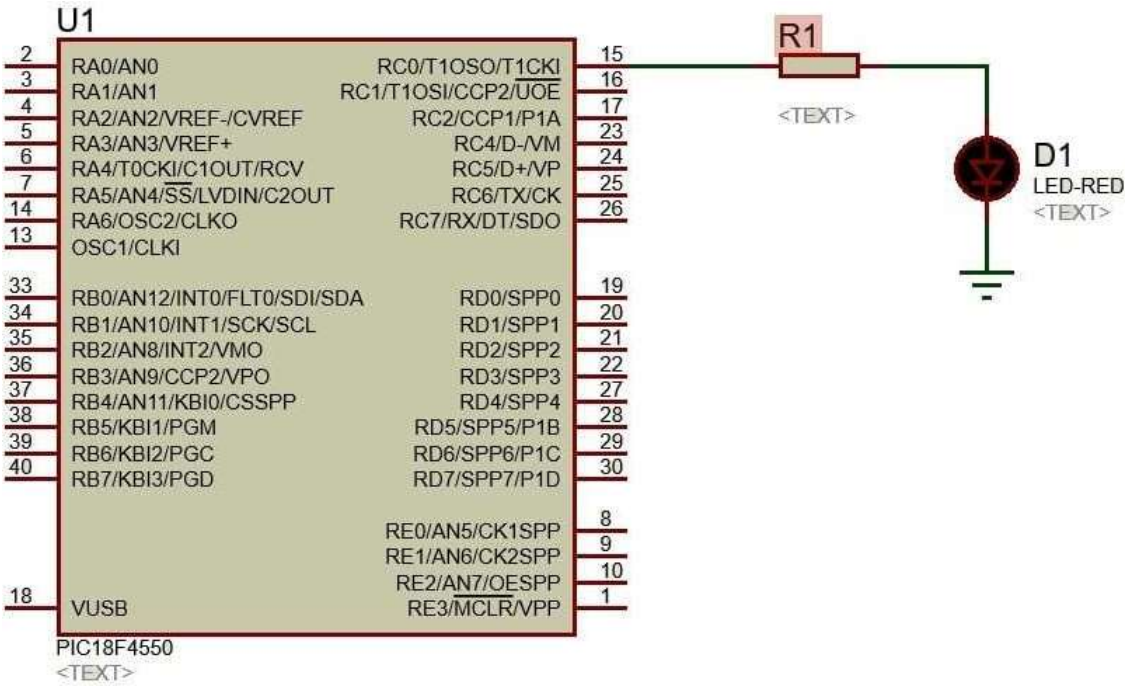
It is most widely used semiconductor which emit either visible light or invisible infrared light when forward biased. Remote controls generate invisible light. A Light emitting diodes (LED) is an optical electrical energy into light energy when voltage is applied.



These are the applications of LEDs:

- Digital computers and calculators.
- Traffic signals and Burglar alarms systems.
- Camera flashes and automotive heat lamps
- Picture phones and digital watches.

## LED Schematic

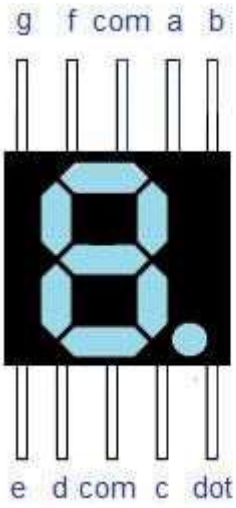


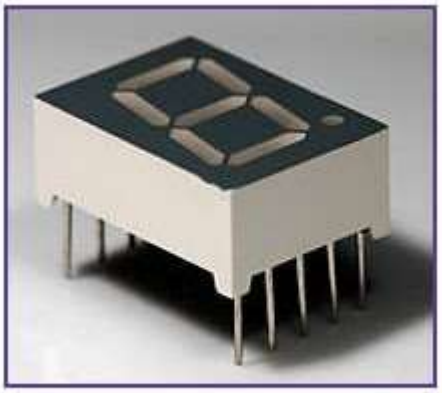
## LED Code

```
#define _XTAL_FREQ 4000000

#include <xc.h>

void init_config(void);
// CONFIG
#pragma config FOSC = XT      // Oscillator Selection bits (XT oscillator)
#pragma config WDTE = ON        // Watchdog Timer Enable bit (WDT enabled)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config BOREN = ON       // Brown-out Reset Enable bit (BOR enabled)
#pragma config LVP = OFF        // Low-Voltage (Single-Supply) In-Circuit
Serial Programming Enable bit (RB3 is digital I/O, HV on MCLR must be used for
programming)
#pragma config CPD = OFF        // Data EEPROM Memory Code Protection bit
(Data EEPROM code protection off)
#pragma config WRT = OFF        // Flash Program Memory Write Enable bits
(Write protection off; all program memory may be written to by EECON control)
#pragma config CP = OFF         // Flash Program Memory Code Protection bit
(Code protection off)

// #pragma config statements should precede project file includes.
// Use project enums instead of #define for ON and OFF.
#define LED_ARRAY_DDR TRISC
#define LED_ARRAY     PORTC

int main()
{
    init_config();
    unsigned int delay;
    unsigned char led_mask = 0b00000001; // Start with RC0 (bit 0)

    while(1)
    {LED_ARRAY = led_mask;
        led_mask <<= 1; // Shift the mask to the left
        if (led_mask == 0b00010000) // If all LEDs have been lit, reset to RC0
            led_mask = 0b00000001;

        for(delay = 10000; delay > 0; delay--);
    }
}
void init_config(void)
{
   LED_ARRAY_DDR = 0X00;
   LED_ARRAY = 0x00;}
```

## Seven Segment Display

Seven segment displays are important display units in Electronics and widely used to display numbers from 0 to 9. It can also display some character alphabets like A,B,C,H,F,E etc. It's the simplest unit to display numbers and characters. It just consists 8 LEDs, each LED used to illuminate one segment of unit and the 8th LED used to illuminate DOT in 7 segment display. We can refer each segment as a LINE, as we can see there are 7 lines in the unit, which are used to display a number/character. We can refer each line/segment "a,b,c,d,e,f,g" and for dot character we will use "h". There are 10 pins, in which 8 pins are used to refer a,b,c,d,e,f,g and h/dp, the two middle pins are common anode/cathode of all he LEDs. These common anode/cathode are internally shorted so we need to connect only one COM pin.



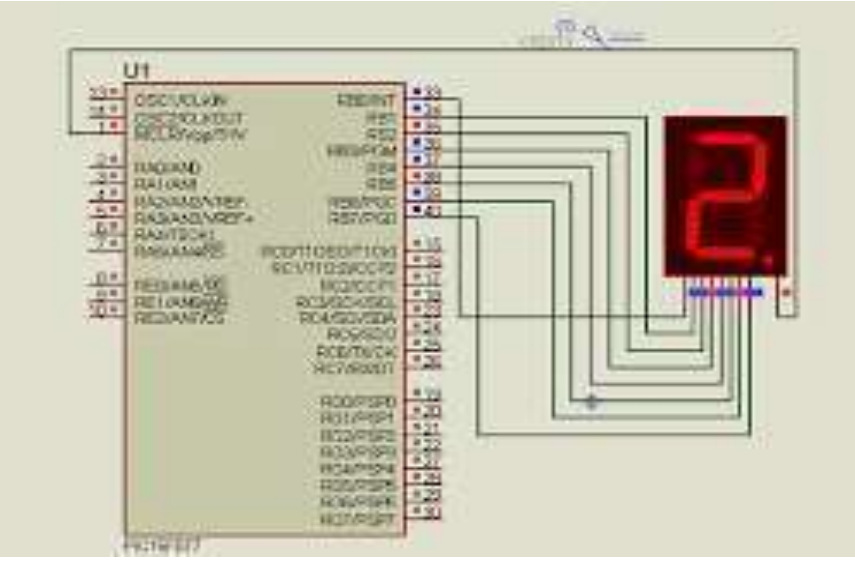



There are two types of 7 segment displays: Common Anode and Common Cathode:

**Common Anode:** In this all the Negative terminals (cathode) of all the 8 LEDs are connected together (see diagram below), named as COM. And all the positive terminals are left alone.

**Common Cathode:** In this all the positive terminals (Anodes) of all the 8 LEDs are connected together, named as COM. And all the negative thermals are left alone.

## Seven Segment Display Schematic




## Seven Segment Display Code

```
// CONFIG
#pragma config FOSC = XT        // Oscillator Selection bits (HS oscillator)
#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config BOREN = OFF      // Brown-out Reset Enable bit (BOR disabled)
#pragma config LVP = OFF        // Low-Voltage (Single-Supply) In-Circuit
Serial Programming Enable bit (RB3 is digital I/O, HV on MCLR must be used for
programming)
#pragma config CPD = OFF        // Data EEPROM Memory Code Protection bit
(Data EEPROM code protection off)
#pragma config WRT = OFF        // Flash Program Memory Write Enable bits
(Write protection off; all program memory may be written to by EECON control)
#pragma config CP = OFF         // Flash Program Memory Code Protection bit
(Code protection off)

// #pragma config statements should precede project file includes.
// Use project enums instead of #define for ON and OFF.

#include <xc.h>

#define _XTAL_FREQ 4000000  // 4MHz Crystal oscillator frequency (Change this
to match your oscillator)

#include <pic16f877a.h>
```

```
#define  bcd1  RD4
#define  bcd2  RD5
#define  bcd3  RD6
#define   bcd4 RD7

void main()
{
    // Set PORTD as input for BCD inputs
    TRISD = 0x0F;

    while(1)
    {
       // Display 0
        bcd1 = 0;
        bcd2 = 0;
        bcd3 = 0;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 1
        bcd1 = 1;
        bcd2 = 0;
        bcd3 = 0;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 2
        bcd1 = 0;
        bcd2 = 1;
        bcd3 = 0;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 3
        bcd1 = 1;
        bcd2 = 1;
        bcd3 = 0;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 4
        bcd1 = 0;
        bcd2 = 0;
        bcd3 = 1;
        bcd4 = 0;
```

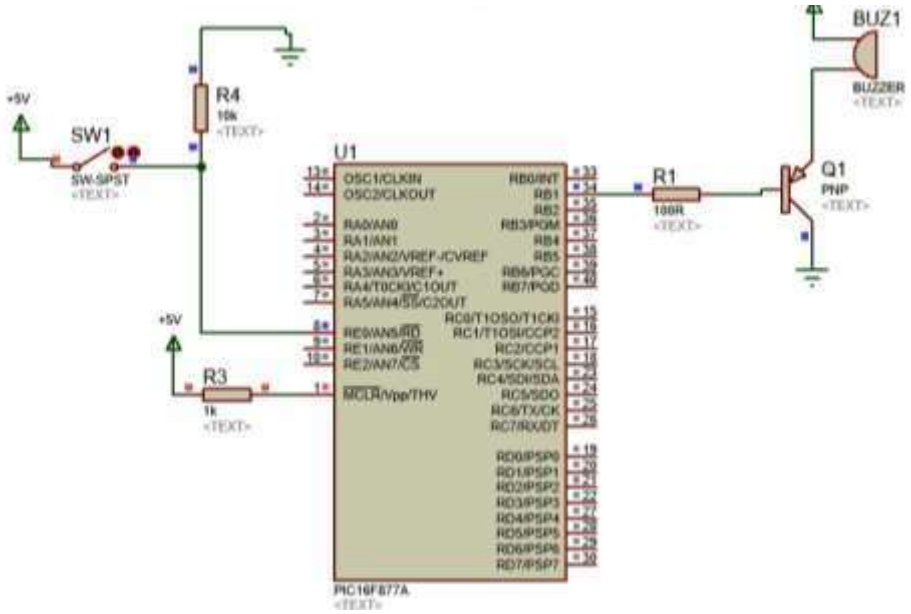
```
        __delay_ms(1000);

        // Display 5
        bcd1 = 1;
        bcd2 = 0;
        bcd3 = 1;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 6
        bcd1 = 0;
        bcd2 = 1;
        bcd3 = 1;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 7
        bcd1 = 1;
        bcd2 = 1;
        bcd3 = 1;
        bcd4 = 0;
        __delay_ms(1000);

        // Display 8
        bcd1 = 0;
        bcd2 = 0;
        bcd3 = 0;
        bcd4 = 1;
        __delay_ms(1000);

         // Display 9
        bcd1 = 1;
        bcd2 = 0;
        bcd3 = 0;
        bcd4 = 1;
        __delay_ms(1000);
    }
}
```

## Buzzer

A **buzzer** is an electronic device that generates sound by converting electrical energy into sound energy. It typically consists of a piezoelectric crystal, which expands and contracts when an alternating current is applied to it, creating sound waves.

**Buzzers** are commonly used in a wide range of applications such as alarms, timers, and warning systems. They can also be used in electronic devices such as mobile phones, computers, and other electronic devices to generate different sounds and tones.

## Buzzer Schematic

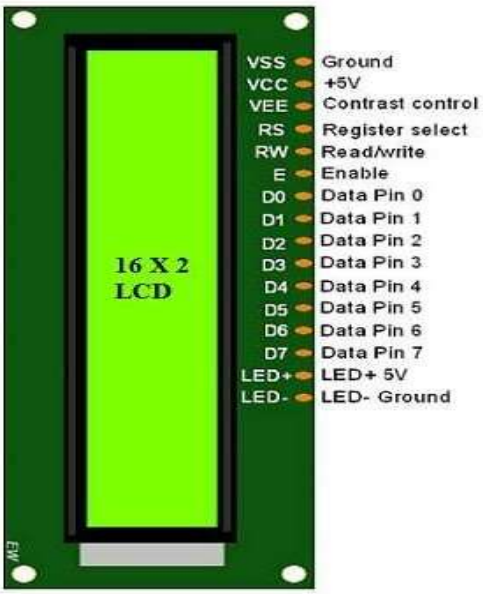


## Buzzer Code

```
// CONFIG
#pragma config FOSC = HS        // Oscillator Selection bits (HS oscillator)
#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config BOREN = OFF      // Brown-out Reset Enable bit (BOR disabled)
#pragma config LVP = OFF        // Low-Voltage (Single-Supply) In-Circuit
Serial Programming Enable bit (RB3 is digital I/O, HV on MCLR must be used for
programming)
#pragma config CPD = OFF        // Data EEPROM Memory Code Protection bit
(Data EEPROM code protection off)
#pragma config WRT = OFF        // Flash Program Memory Write Enable bits
(Write protection off; all program memory may be written to by EECON control)
#pragma config CP = OFF         // Flash Program Memory Code Protection bit
(Code protection off)

// #pragma config statements should precede project file includes.
// Use project enums instead of #define for ON and OFF.

#include <xc.h>

#define _XTAL_FREQ 4000000  // 20MHz crystal oscillator frequency

void main() {
    TRISD0 = 0;  // Set RB0 as an output
    RD0 = 0;     // Initially, turn off the buzzer

    while (1) {
        RD0 = 1;     // Turn on the buzzer (active high)
        __delay_ms(5000); // Delay for 500 ms (adjust as needed)
        RD0 = 0;     // Turn off the buzzer
        __delay_ms(5000); // Delay for 500 ms (adjust as needed)
    }
}
```

# LCD

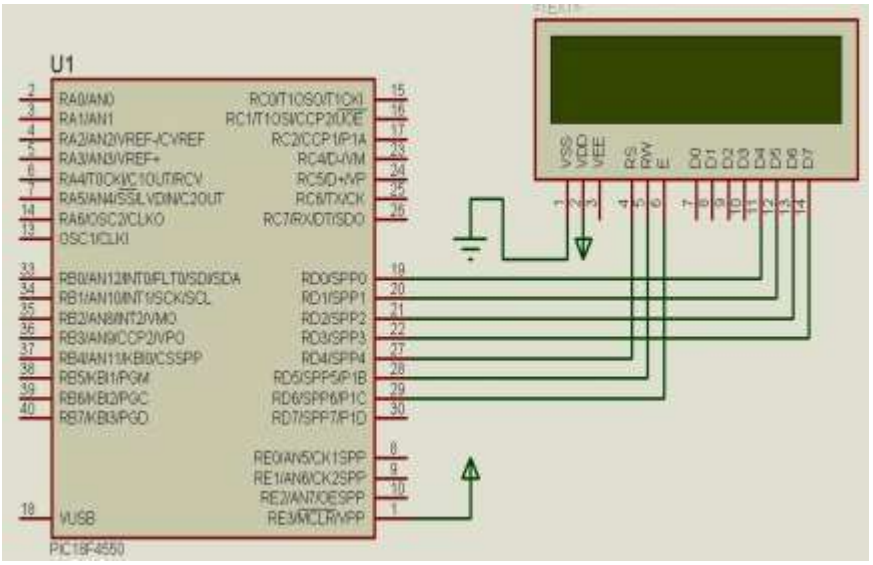
The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.




The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit

## LCD Schematic



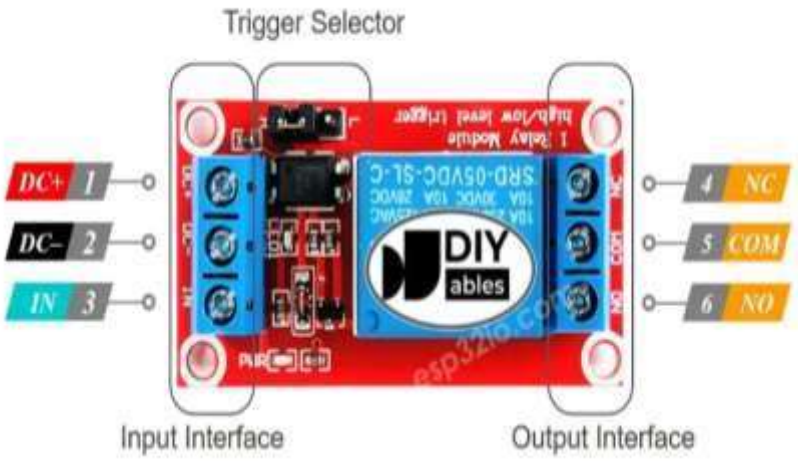

## LCD Code

```
#include <stdio.h>
#include <stdlib.h>
#include <xc.h>
#include "config.h"

#define RS RB0
#define RW RB1
#define EN RB2
#define D4 RB4
#define D5 RB5
#define D6 RB6
#define D7 RB7

#include "lcd.h"

void main()
{
    TRISB = 0x00;
    Lcd_Init();
    while(1)
    {
        Lcd_Clear();
        Lcd_Set_Cursor(1,1);
        Lcd_Write_String("Welcome");
```

```
        __delay_ms(2000);
        Lcd_Set_Cursor(1,1);
        Lcd_Write_String("All");

        Lcd_Clear();
        Lcd_Set_Cursor(2,1);
        Lcd_Write_String("..Hello World..");

        for(int i=0; i<14; i++)
        {
            __delay_ms(350);
            Lcd_Shift_Right();
        }

        for(int i=0; i<14; i++)
        {
            __delay_ms(350);
            Lcd_Shift_Left();
        }
    }
}
```

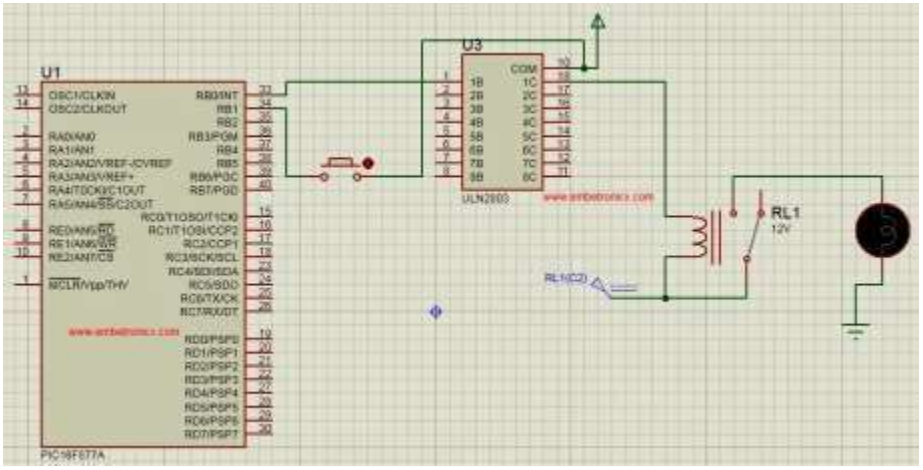
## Relay

Relays are the switches that aim at closing and opening the circuits electronically as well as electromechanically. It controls the opening and closing of the circuit contacts of an electronic circuit. When the relay contact is open (NO), the relay isn't energized with the open contact. However, if it is closed (NC), the relay isn't energized given the closed contact. However, when energy (electricity or charge) is supplied, the states are prone to change.




Relays are normally used in the control panels, manufacturing, and building automation to control the power along with switching the smaller current values in a control circuit. However, the supply of amplifying effect can help control the large amperes and voltages because if low voltage is applied to the relay coil, a large voltage can be switched by the contacts.

## Relay Schematic




## Relay Code

```
// CONFIG

#pragma config FOSC = XT        // Oscillator Selection bits (HS oscillator)

#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled)

#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)

#pragma config BOREN = ON       // Brown-out Reset Enable bit (BOR enabled)

#pragma config LVP = OFF         // Low-Voltage (Single-Supply) In-Circuit
Serial Programming Enable bit (RB3/PGM pin has PGM function; low-voltage
programming enabled)

#pragma config CPD = OFF        // Data EEPROM Memory Code Protection bit
(Data EEPROM code protection off)

#pragma config WRT = OFF        // Flash Program Memory Write Enable bits
(Write protection off; all program memory may be written to by EECON control)

#pragma config CP = OFF         // Flash Program Memory Code Protection bit
(Code protection off)
```

```c
#include <xc.h>

// Hardware related definition
#define _XTAL_FREQ 4000000 // Crystal Frequency, used in delay
#define RELAY RB0

void main(void)
{
   RELAY = 0;

   TRISB0 = 0x00;


    while(1) {
        // Toggle the relay state based on the LED state

        RELAY = 1;
         __delay_ms(500);
         RELAY = 0;
         __delay_ms(500);
    }
    return;
}
```

## Stepper Motor

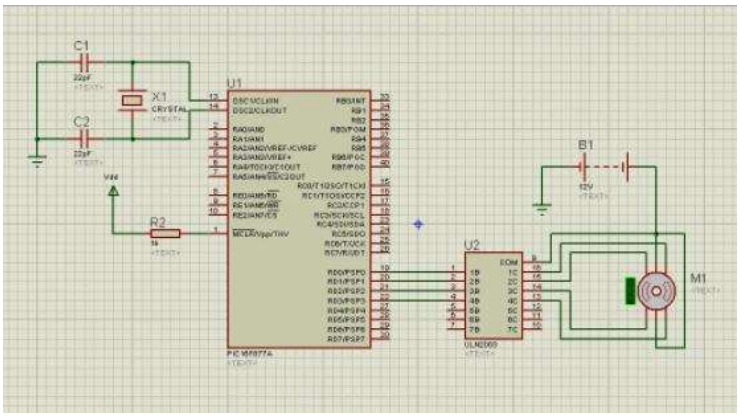
Stepper Motor is a brushless DC Motor. Control signals are applied to stepper motor to rotate it in steps.

Its speed of rotation depends upon rate at which control signals are applied. There are various stepper motors available with minimum required step angle.

Stepper motor is made up of mainly two parts, a stator and rotor. Stator is of coil winding and rotor is mostly permanent magnet or ferromagnetic material.

Step angle is the minimum angle that stepper motor will cover within one move/step. Number of steps required to complete one rotation depends upon step angle. Depending upon stepper motor configuration, step angle varies e.g. 0.72°, 3.8°, 3.75°, 7.5°, 35° etc.

## Stepper Motor Schematic



## Stepper Motor Code

```
#include <xc.h>
#include <stdio.h>
#include "config.h"

#define _XTAL_FREQ  4000000


#define speed 1 // Speed Range 10 to 1  10 = lowest , 1 = highest

#define steps 250 // how much step it will take

#define clockwise 0 // clockwise direction macro

#define anti_clockwise 1 // anti clockwise direction macro

 //FUNCTION TO OPERATE MOTOR

void system_init (void); // This function will initialise the ports.

void full_drive (char direction); // This function will drive the motor in
full drive mode

void half_drive (char direction); // This function will drive the motor in
full drive mode

void wave_drive (char direction); // This function will drive the motor in
full drive mode

void ms_delay(unsigned int val);


void main(void)

{

system_init();

while(1){

/* Drive the motor in full drive mode clockwise */

for(int i=0;i<steps;i++)

{
```

```
            full_drive(clockwise);

}

ms_delay(1000);


/* Drive the motor in wave drive mode anti-clockwise */

for(int i=0;i<steps;i++)

{

            wave_drive(anti_clockwise);

            //full_drive(anti_clockwise);

}

ms_delay(1000);

}

}

/*System Initialising function to set the pin direction Input or Output*/
void system_init (void){

    TRISB = 0x00;     // PORT B as output port

    PORTB = 0x0F;

}

/*This will drive the motor in full drive mode depending on the direction*/
void full_drive (char direction){

    if (direction == anti_clockwise){

        PORTB = 0b00000011;

        ms_delay(speed);

        PORTB = 0b00000110;

        ms_delay(speed);
```

```
        PORTB = 0b00001100;
        ms_delay(speed);
        PORTB = 0b00001001;
        ms_delay(speed);
        PORTB = 0b00000011;
        ms_delay(speed);
    }
    if (direction == clockwise){
        PORTB = 0b00001001;
        ms_delay(speed);
        PORTB = 0b00001100;
        ms_delay(speed);
        PORTB = 0b00000110;
        ms_delay(speed);
        PORTB = 0b00000011;
        ms_delay(speed);
        PORTB = 0b00001001;
        ms_delay(speed);
    }
}
/* This method will drive the motor in half-drive mode using direction input
*/
void half_drive (char direction){
    if (direction == anti_clockwise){
```

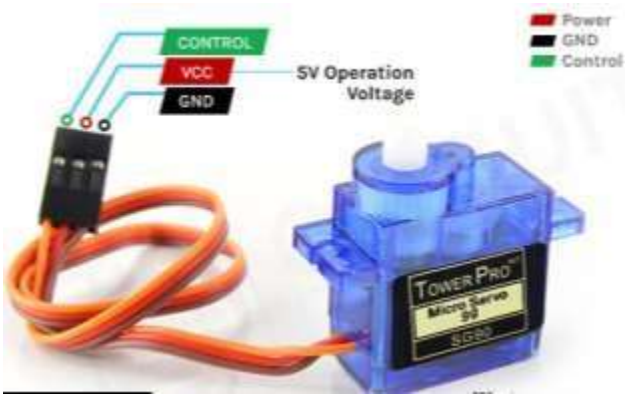
```
        PORTB = 0b00000001;
        ms_delay(speed);
        PORTB = 0b00000011;
        ms_delay(speed);
        PORTB = 0b00000010;
        ms_delay(speed);
        PORTB = 0b00000110;
        ms_delay(speed);
        PORTB = 0b00000100;
        ms_delay(speed);
        PORTB = 0b00001100;
        ms_delay(speed);
        PORTB = 0b00001000;
        ms_delay(speed);
        PORTB = 0b00001001;
        ms_delay(speed);
    }
    if (direction == clockwise){
       PORTB = 0b00001001;
       ms_delay(speed);
       PORTB = 0b00001000;
       ms_delay(speed);
       PORTB = 0b00001100;
```

```
        ms_delay(speed);

        PORTB = 0b00000100;

        ms_delay(speed);

        PORTB = 0b00000110;

        ms_delay(speed);

        PORTB = 0b00000010;

        ms_delay(speed);

        PORTB = 0b00000011;

        ms_delay(speed);

        PORTB = 0b00000001;

        ms_delay(speed);
    }

}

/* This function will drive the the motor in wave drive mode with direction
input*/
void wave_drive (char direction){

    if (direction == anti_clockwise)
    {
        PORTB = 0b00000001;

        ms_delay(speed);

        PORTB = 0b00000010;

        ms_delay(speed);

        PORTB = 0b00000100;

        ms_delay(speed);

        PORTB = 0b00001000;

        ms_delay(speed);
```

```
    }
     if (direction == clockwise){

        PORTB = 0b00001000;

        ms_delay(speed);

        PORTB = 0b00000100;

        ms_delay(speed);

        PORTB = 0b00000010;

        ms_delay(speed);

        PORTB = 0b00000001;

        ms_delay(speed);

    }



}

/*This method will create required delay*/
void ms_delay(unsigned int val)
{

     unsigned int i,j;

        for(i=0;i<val;i++)

            for(j=0;j<1650;j++);

}
```

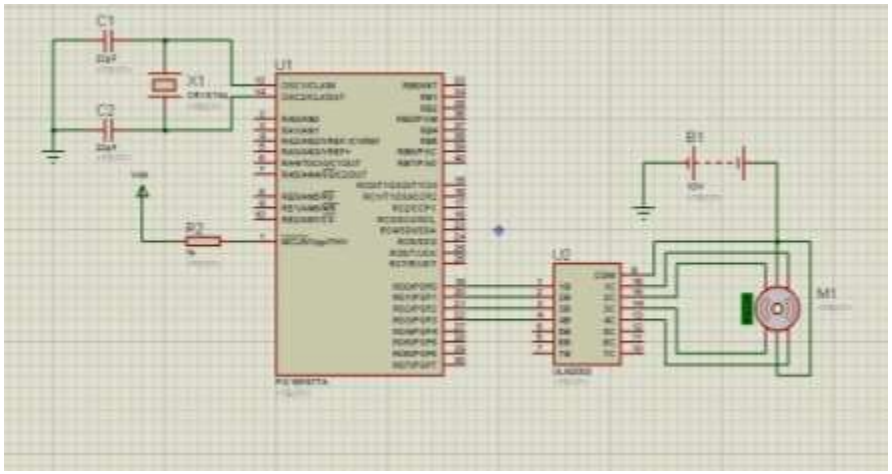
## Servo Motor

Servo motor is an electrical device which can be used to rotate objects (like robotic arm) precisely.Servo motor consists of DC motor with error sensing negative feedback mechanism. This allows precise control over angular velocity and position of motor. In some cases, AC motors are used.




It is a closed loop system where it uses negative feedback to control motion and final position of the shaft.It is not used for continuous rotation like conventional AC/DC motors.It has rotation angle that varies from 0° to 380°.

## Servo Motor Schematic



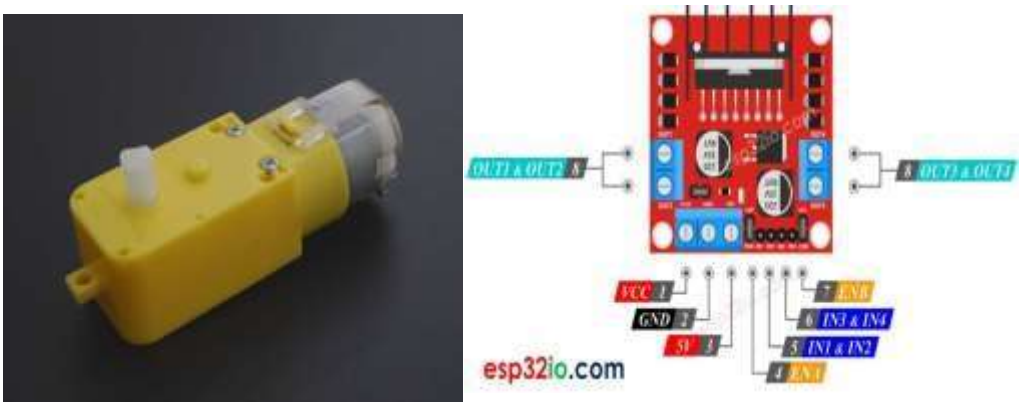
## Servo Motor Code

```
// CONFIG
#pragma config FOSC = XT        // Oscillator Selection bits (XT oscillator)
#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config BOREN = OFF      // Brown-out Reset Enable bit (BOR disabled)
#pragma config LVP = OFF        // Low-Voltage (Single-Supply) In-Circuit
Serial Programming Enable bit (RB3 is digital I/O, HV on MCLR must be used for
programming)
#pragma config CPD = OFF        // Data EEPROM Memory Code Protection bit
(Data EEPROM code protection off)
#pragma config WRT = OFF        // Flash Program Memory Write Enable bits
(Write protection off; all program memory may be written to by EECON control)
#pragma config CP = OFF         // Flash Program Memory Code Protection bit
(Code protection off)

// #pragma config statements should precede project file includes.
// Use project enums instead of #define for ON and OFF.

#include <xc.h>

#define _XTAL_FREQ 4000000

void servo0(){
 unsigned int i;
 for(i=0;i<50;i++)
 {
PORTAbits.RA4 = 1;
__delay_us(800);
 PORTAbits.RA4 = 0;
 __delay_us(19200);}}

void servo90(){
unsigned int i;
for(i=0;i<50;i++)
 {
PORTAbits.RA4 = 1;
__delay_us(1500);
PORTAbits.RA4 = 0;
__delay_us(18500);
 }}

void servo180(){
```

```
unsigned int i;
for(i=0;i<50;i++)
 {
PORTAbits.RA4 = 1;
__delay_us(2200);
PORTAbits.RA4 = 0;
__delay_us(17800);
}}

void main() {
  TRISA4=0x00;
  PORTAbits.RA4 = 0; // Ensure RA4 is initially low


  while(1){
   __delay_ms(1000);
  servo0();
  __delay_ms(1000);
  servo90();
  __delay_ms(1000);
  servo180();
  __delay_ms(1000);
  }}
```

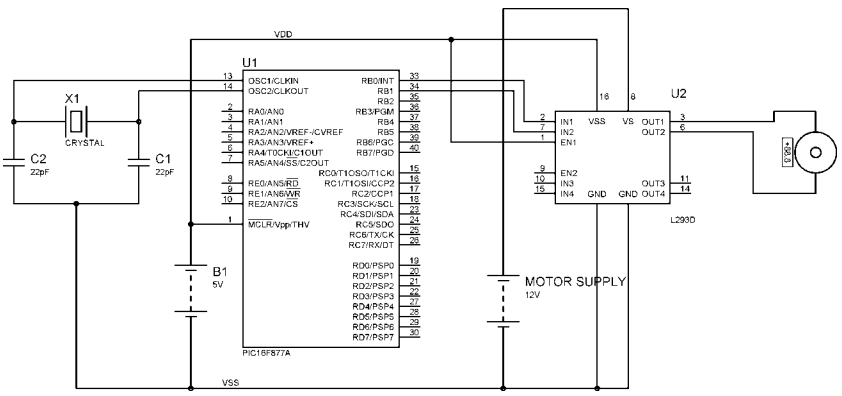
## DC Motor

DC motor uses Direct Current (electrical energy) to produce mechanical movement i.e. rotational movement. When it converts electrical energy into mechanical energy then it is called as DC motor and when it converts mechanical energy into electrical energy then it is called as DC generator.




The working principle of DC motor is based on the fact that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force and starts rotating. Its direction of rotation depends upon Fleming's Left Hand Rule.DC motors are used in many applications like robot for movement control, toys, quadcopters, CD/DVD disk drive in PCs/Laptops etc.

## DC Motor Schematic



## DC Motor Code

```
// CONFIG
#pragma config FOSC = XT        // Oscillator Selection bits (XT oscillator)
#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config BOREN = ON       // Brown-out Reset Enable bit (BOR enabled)
#pragma config LVP = OFF        // Low-Voltage (Single-Supply) In-Circuit
Serial Programming Enable bit (RB3 is digital I/O, HV on MCLR must be used for
programming)
#pragma config CPD = OFF        // Data EEPROM Memory Code Protection bit
(Data EEPROM code protection off)
#pragma config WRT = OFF        // Flash Program Memory Write Enable bits
(Write protection off; all program memory may be written to by EECON control)
#pragma config CP = OFF         // Flash Program Memory Code Protection bit
(Code protection off)

// #pragma config statements should precede project file includes.
// Use project enums instead of #define for ON and OFF.

#include <xc.h>
#include <pic.h>

#define MOTOR1 RB3
#define MOTOR2 RB4

void main()
{
    unsigned int i;
    TRISB = 0x00;

    while(1)
    {
      MOTOR1 = 1;
      MOTOR2 = 0;

      for (i=0; i<60; i++);

      MOTOR1 = 0;
      MOTOR2 = 1;
    }
}
```