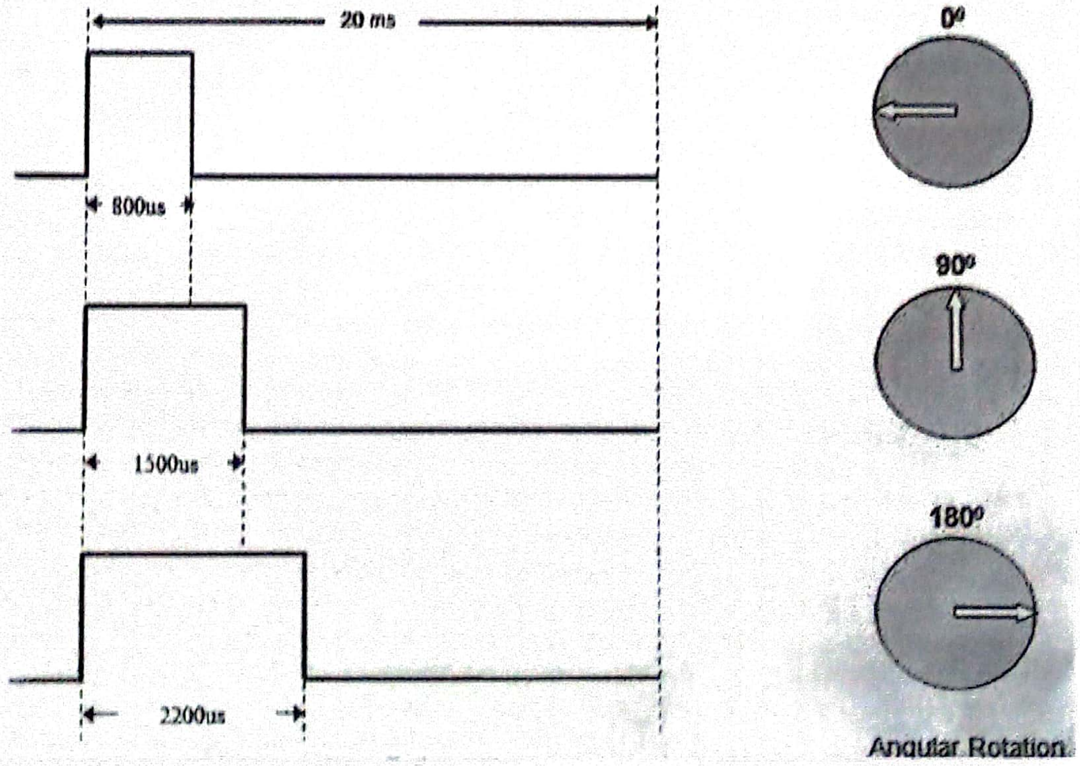
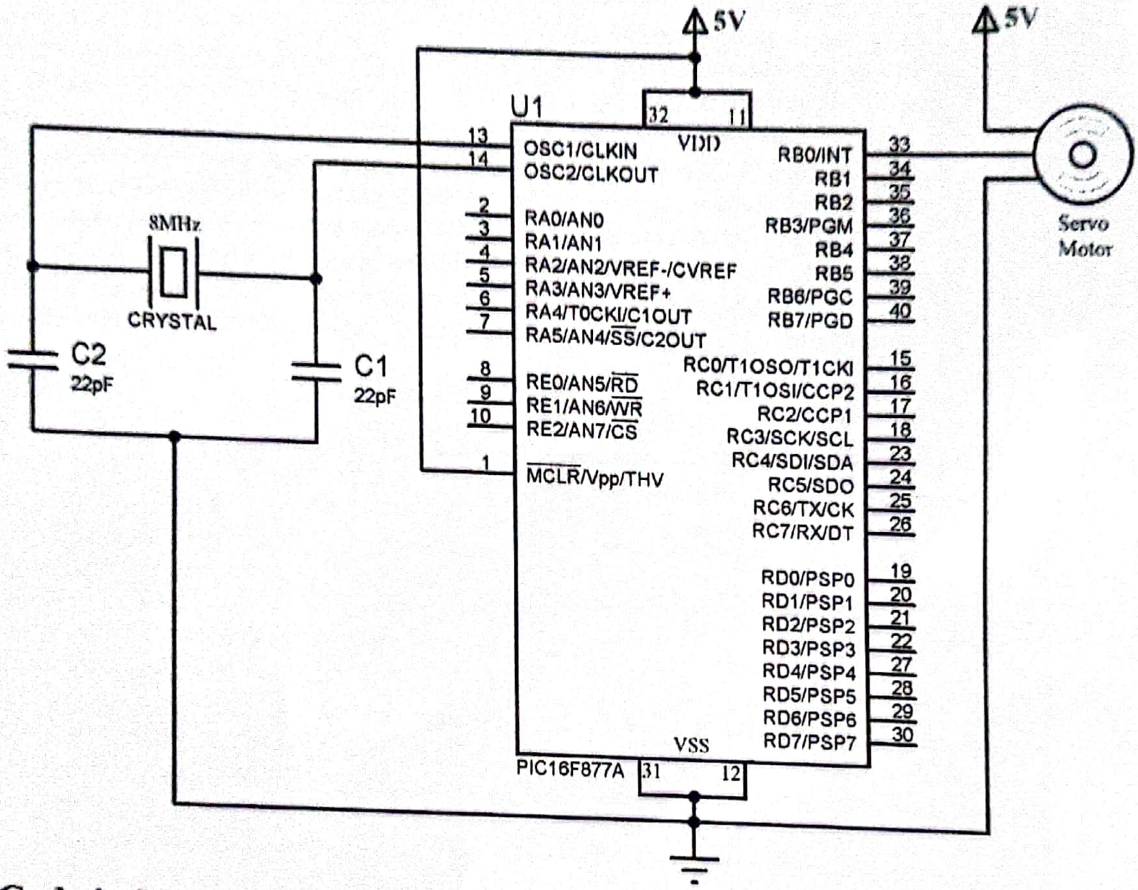
Problem Name: Interfacing Servo Motor with PIC Microcontroller

Theory:

Servo Motor uses error sensing negative feedback to control the precise angular position. Servos are used for precise positioning in robotic arms, legs, RC Aeroplanes, Helicopters etc. Please read the article Servo Motor for more information about its working and construction. Hobby Servo Motors have three wires, two of them (RED and BLACK) are used to given power and the third one is used to give control signals. Servo can be easily be controlled using microcontrollers using Pulse Width Modulated (PWM) signals on the control wire. Here we are using a servo whose angular rotation is limited to 0 – 180°. We can control the exact angular position by using a pulse, whose width varying from 1 millisecond to 2 millisecond on the control wire. The actual behavior of a particular motor depends upon its manufacture, please refer the datasheet of the particular motor for that.



Circuit Diagram:



Code in Mikro C:

```
void servoRotate0() //0 Degree
{
 unsigned int i;
 for(i=0;i<50;i++)
 {
  PORTB.F0 = 1;
  Delay_us(800);
  PORTB.F0 = 0;
  Delay_us(19200);
 }
}

void servoRotate90() //90 Degree
{
 unsigned int i;
 for(i=0;i<50;i++)
```

```
  {
   PORTB.F0 = 1;
   Delay_us(1500);
   PORTB.F0 = 0;
   Delay_us(18500);
  }
}

void servoRotate180() //180 Degree
{
  unsigned int i;
  for(i=0;i<50;i++)
  {
   PORTB.F0 = 1;
   Delay_us(2200);
   PORTB.F0 = 0;
   Delay_us(17800);
  }
}

void main()
{
  TRISB = 0; // PORTB as Ouput Port
  do
  {
   servoRotate0(); //0 Degree
   Delay_ms(2000);
   servoRotate90(); //90 Degree
   Delay_ms(2000);
   servoRotate180(); //180 Degree
  }while(1);
}
```

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7 Segment LED Counter Design

Project Name: Single digit 7 Segment LED Counter Design

Objectives:

I) To understand pin configuration and different types of 7 segment LED Display.

II) To design a counter controlled by time or delay and display the corresponding numeric increment.

Apparatus List:

I) PIC16F877A Microcontroller
II) Crystal Oscillator 20 MHz
III) 2 pcs 22 pf capacitor
IV) 10K Resistor
V) 8 pcs 470 Ohm Resistor
VI) 1 push button
VII) 7 Segment CC/ CA LED Display
VIII) Power supply

Theory:

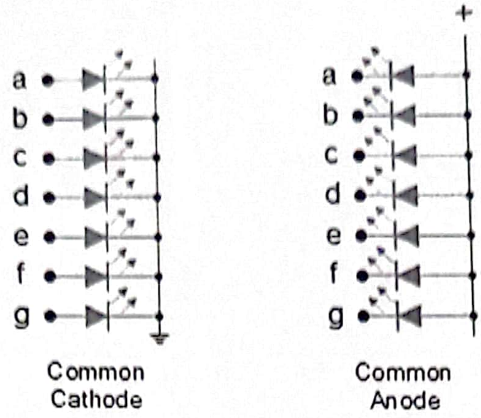
7-segment LED (Light Emitting Diode) or LCD (Liquid Crystal Display) type displays, provide a very convenient way of displaying information or digital data in the form of numbers, letters or even alpha-numerical characters. Typically 7 segment display consist of seven individual colored LED's (called the segments), within one single display package. In order to produce the required numbers or HEX characters from 0 to 9 and A to F respectively, on the display the correct combination of LED segments need to be illuminated and BCD to 7-segment Display Decoders such as the 74LS47 just do that.

A standard 7-segment LED display generally has 8 input connections, one for each LED segment and one that acts as a common terminal or connection for all the internal display segments. Some single displays have also have an additional input pin to display a decimal point in their lower right or left hand corner.

In electronics there are two important types of 7-segment LED digital display.

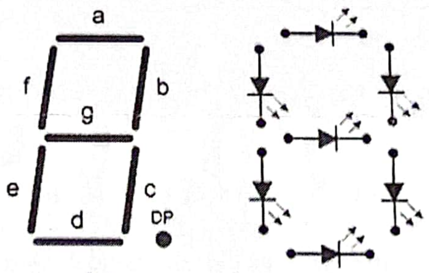
- 1. The Common Cathode Display (CCD) – In the common cathode display, all the cathode connections of the LED's are joined together to logic "0" or ground. The individual segments are illuminated by application of a "HIGH", logic "1" signal to the individual Anode terminals.
- 2. The Common Anode Display (CAD) – In the common anode display, all the anode connections of the LED's are joined together to logic "1" and the individual segments are illuminated by connecting the individual Cathode terminals to a "LOW", logic "0" signal.

Common Cathode and Common Anode Format:



Electrical connection of the individual diodes for a common cathode display and a common anode display and by illuminating each light emitting diode individually, they can be made to display a variety of numbers or characters.

7-Segment Display Format:

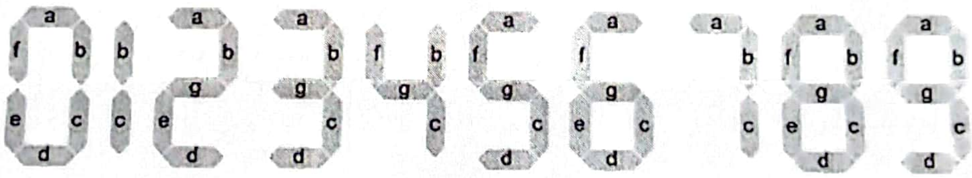


So in order to display the number 3 for example, segments a, b, c, d and g would need to be illuminated. If we wanted to display a different number or letter then a different set of segments would need to be illuminated. Then for a 7-segment display, we can produce a truth table giving the segments that need to be illuminated in order to produce the required character as shown below.

Truth Table for a 7-segment display:

Individual Segments							Display	Individual Segments							Display
a	b	c	d	e	f	g		a	b	c	d	e	f	g	
×	×	×	×	×	×		0	×	×	×	×	×	×	×	8

	×	×					1	×	×	×	×		×	×	9
×	×		×	×		×	2	×	×	×		×	×	×	A
×	×	×	×			×	3			×	×	×	×	×	b
	×	×			×	×	4	×			×	×	×		C
×		×	×		×	×	5		×	×	×	×		×	d
×		×	×	×	×	×	6	×			×	×	×	×	E
×	×	×					7	×				×	×	×	F



7-Segment Display Elements for all Numbers.

It can be seen that to display any single digit number from 0 to 9 in binary or letters from A to F in hexadecimal, we would require 7 separate segment connections plus one additional connection for the LED's "common" connection. Also as the segments are basically a standard light emitting diode, the driving circuit would need to produce up to 20mA of current to illuminate each individual segment and to display the number 8, all 7 segments would need to be lit resulting a total current of nearly 140mA, (8 x 20mA).

Advantages Liquid crystal displays (LCD´s) have one major advantage over similar LED types in that they consume much less power and nowadays, both LCD and LED displays are combined together to form larger Dot-Matrix Alphanumeric type displays which can show letters and characters as well as numbers in standard Red or Tri-colour outputs.

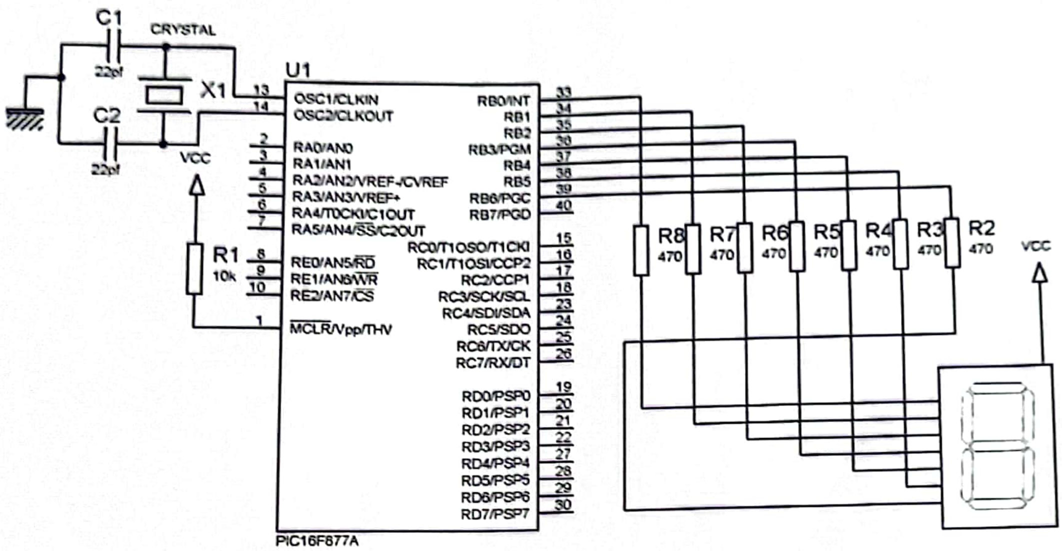
Micro C Code:

```
unsigned char display(char digit);

void main()
{
    unsigned char i;   //Declearing Variable i as char type
    TRISB=0x00;
    portb=0xff;
    while(1)
    {
      for(i=0;i<=9;i++)
      {
        portb=display(i);
        delay_ms(1000);
      }
      if(i==10)
            i=0;
    }
}

unsigned char display(char digit)
{
    unsigned char pattern;
    unsigned char number[10]={0xC0,0xF9,0xA4,0xB0,0x99,0x92,0x82,0xF8,0x80,0x90};
    pattern = number[digit];
    return pattern;
}
```

Circuit diagram & Simulation in Proteus ISIS:



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Interfacing Microcontroller with Relays

Project Name: Interfacing microcontroller with relay.

Objectives:

I) To understand the mechanism of a relay.
II) To operate high voltage circuit/ voltage using low voltage.
III) Successful burning process in the targeted microcontroller using PICkit 2

Apparatus List:

I) PIC16F877A Microcontroller
II) Crystal Oscillator 20 MHz
III) 2 pcs 22 pf capacitor
IV) 10K Resistor
V) 4.7K Resistor
VI) 1N4007 Diode
VII) BC547 NPN Transistor
VIII) 5 volt relay
IX) AC current source
X) 220 volt Lamp

Theory:

A relay is a simple **electromechanical switch** made up of an electromagnetand a set of contacts. Relays are found hidden in all sorts of devices. In fact, some of the first computers ever built used relays to implement Boolean gates.

Types of relay:

There are 3 main types of relays-

i) *Mechanical Relay*
ii) *Reed Relay*
iii) *Solid-State Relay*

a) Mechanical Relay: Mechanical relays are usually the largest and most rugged of all relays. For a typical mechanical relay, a current sent through a coil magnet acts to pull a flexible, spring-loaded conductive plate from one switch contact to another.

In general, mechanical relays are designed for high currents (typically 2A to 15A), but they have relatively slow switching (typically 10ms to 100ms).

Figure-1: A typical mechanical relay.

b) ***Reed Relays:*** Reed relays are smaller than most mechanical relays and are somewhere in the middle between mechanical and solid-state relays. They are kind of the median. They are designed for moderate currents (typically 500mA to 1A) and moderately fast switching (0.2ms to 2ms).

Reed relays are switches that use electromagnets to control one or more reed switch. Reed relays, like electromechanical relays, have physical contacts that are mechanically actuated to open/close a path. For reed relays, however, the contacts are much smaller and lower mass than those used in electromechanical relays. Dry reed relays are made of coils wrapped around reed switches. The reed switch is composed of two overlapping ferromagnetic blades (called reeds) hermetically sealed within a glass or ceramic capsule that is filled with an inert gas. The reeds have contacts on their overlapping ends. When the coil is energized, the two reeds are drawn together such that their contacts complete a path through the relay. When the coil is de-energized, the spring force in the reeds pulls the contacts apart.

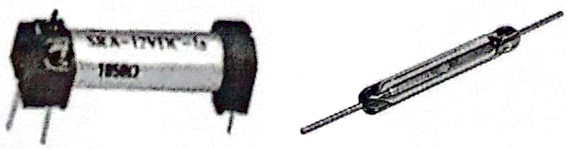

Figure-2: Typical reed relays.

Because the moving parts are small and lightweight, reed relays can switch faster than armature relays and tend to require very little power. However, they are susceptible to damage from arcing. When a spark jumps across the contacts, it can melt a small section of the reed. If the contacts are still closed when the molten section re-solidifies, the contacts may weld together. The spring force in the reeds is often insufficient to mechanically break the weld, causing the reeds to stick in the "on" position.

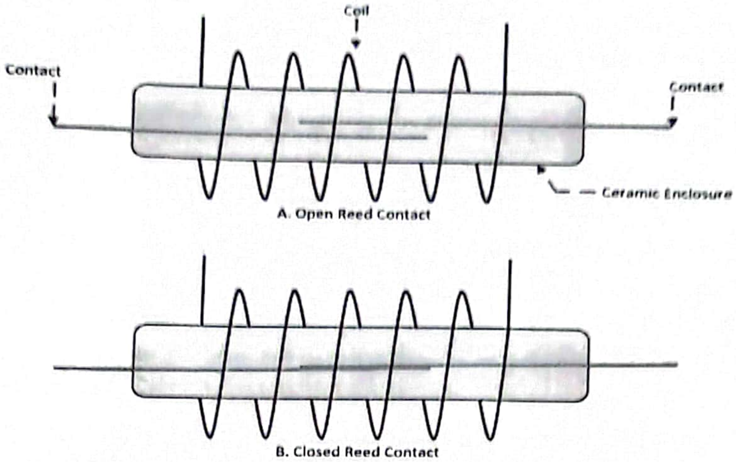

Figure: Open and Close operation of a reed relay.

c) **Solid-state Relays:** A Solid-state relay (SSR) allows you to control high-current AC loads from lower voltage DC control circuitry. Solid state relays have several advantages over mechanical relays. One such advantage is that they can be switched by a much lower voltage and at a much lower current than most mechanical relays. Also, because there's no moving contacts, solid state relays can be switched much faster and for much longer periods without wearing out.

This particular SSR can switch current loads of up to 40A with a 3-32V DC input and a zero cross trigger control method. Each one of these relays is equipped with four screw terminals (for use with ring or fork connectors) and a plastic cover that slides over the top of the relay to protect the terminals.

Figure-3: Typical SSR (Solid-state-relay)

The SSR is basically a circuit with various electronic components that has the same function as an electromechanical relay. The advantage of using SSR is that it doesn't have moving parts so it lasts longer and doesn't make any noise. So if your project needs silent operation then you can use SSR or a solid relay. The circuit diagram of a SSR is given below.

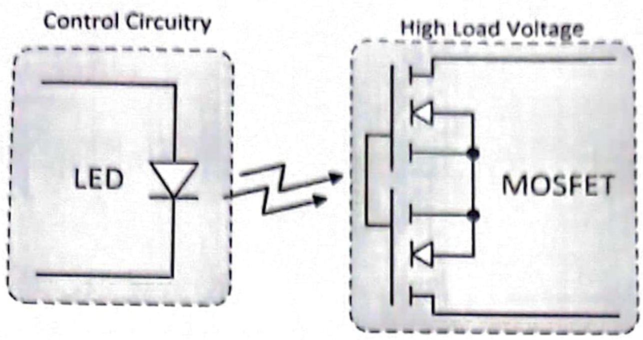

Figure: Block diagram of a Solid State Relay

d) **Latching Relay:** Latching relays are also called impulse relays. They work in the bistable mode, and thus have two relaxing states. They are also called keep relays or stay relays because as soon as the current towards this relay is switched off, the relay continues the process that it was doing in the last state. This can be achieved only with a solenoid which is operating in a ratchet and cam mechanism. It can also be done by an over-center spring mechanism or a permanent magnet mechanism in which, when the coil is kept in the relaxed point, the over-center spring holds the armature and the contacts in the right spot. This can also be done with the help of a remanent core.

In the ratchet and cam method, power consumption occurs only for a particular time. Hence it is more advantageous than the others.

e) **Polarized Relay:** These types of relays have been given more importance in the contacts. In order to protect them from atmospheric protection they are safely kept inside a vacuum or inert gas. Though these types of relays have a very low switching current and voltage ratings, they are famous for their switching speeds.

f) **Buchholz Relay:** This relay is actually used as a safety device. They are used for knowing the amount of gas present in large oil-filled transformers. They are designed in such a way that they produce a warning if it senses either the slow production of gas or fast production of gas in the transformer oil.

g) **Overload Protection Relay:** As the name implies, these relays are used to prevent the electric motors from damage by over current and short circuits. For this the heating element is kept in series with the motor. Thus when over heat occurs the bi-metallic strip connected to the motor heats up and in turn releases a spring to operate the contacts of the relay.

h) **Mercury Wetted Relay:** This relay is almost similar to the reed relay explained earlier. The only difference is that instead of inert gases, the contacts are wetted with mercury. This makes them more position sensitive and also expensive. They have to be vertically mounted for any operation. They have very low contact resistance and so can be used for timing applications. Due to these factors, this relay is not used frequently.

- **i) Machine Tool Relay:** This is one of the most famous industrial relay. They are mainly used for the controlling of all kinds of machines. They have a number of contacts with easily replaceable coils. This enabkesthem to be easily converted from NO contact to NC contact. Many types of these relays can easily be setup in a control panel. Though they are very useful in industrial applications, the invention of PLC has made them farther away from industries.
- **j) Contactor Relay:** This is one of the most heavy load relay ever used. They are mainly used in switching electric motors. They have a wide range of current ratings from a few amps to hundreds. The contacts of these relays are usually made with alloys containing a small percentage of silver. This is done so as to avoid the hazardous effects of arcing. These type of relays are mainly categorized in the rough use areas. So, they produce loud noises while operated and hence cannot be used in places where noise is a problem.
- **k) Solid State Contractor Relay:** These relays combine both the features of solid state relays and contactor relays. As a result they have a number of advantages. They have a very good heat sink and can be designed for the correct on-off cycles. They are mainly controlled with the help of PLC, micro-processors or microcontrollers.

Factor for Selecting an Appropriate Relay:

1. The voltage and current needed to energize the coil.
2. The maximum voltage which we will get at output.
3. Number of armature.
4. Number of contacts for the armature.
5. Number of electrical contracts (N/O and N/C).

Micro C Code:

```
void main()
{
   TRISB=0x00;
   PORTB=0x00;
       while(1)
       {
               portb.f0 = 1;   //Turn on relay
               delay_ms(3000); //3s delay
               portb.f0 = 0;   //Turn off relay
               delay_ms(3000); //3s delay
       }
}
```

Circuit diagram & Simulation in Proteus ISIS:

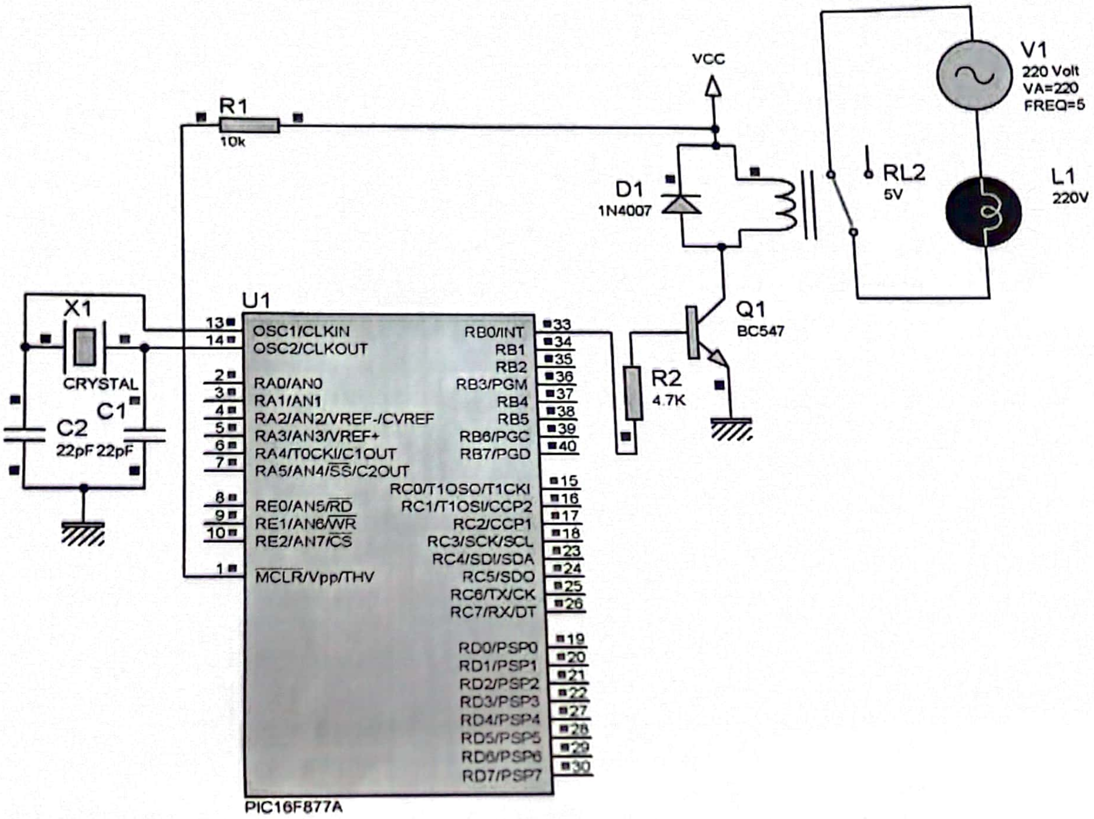

Figure-4: Relay in ON state & the lamp will glow for 3000 ms.

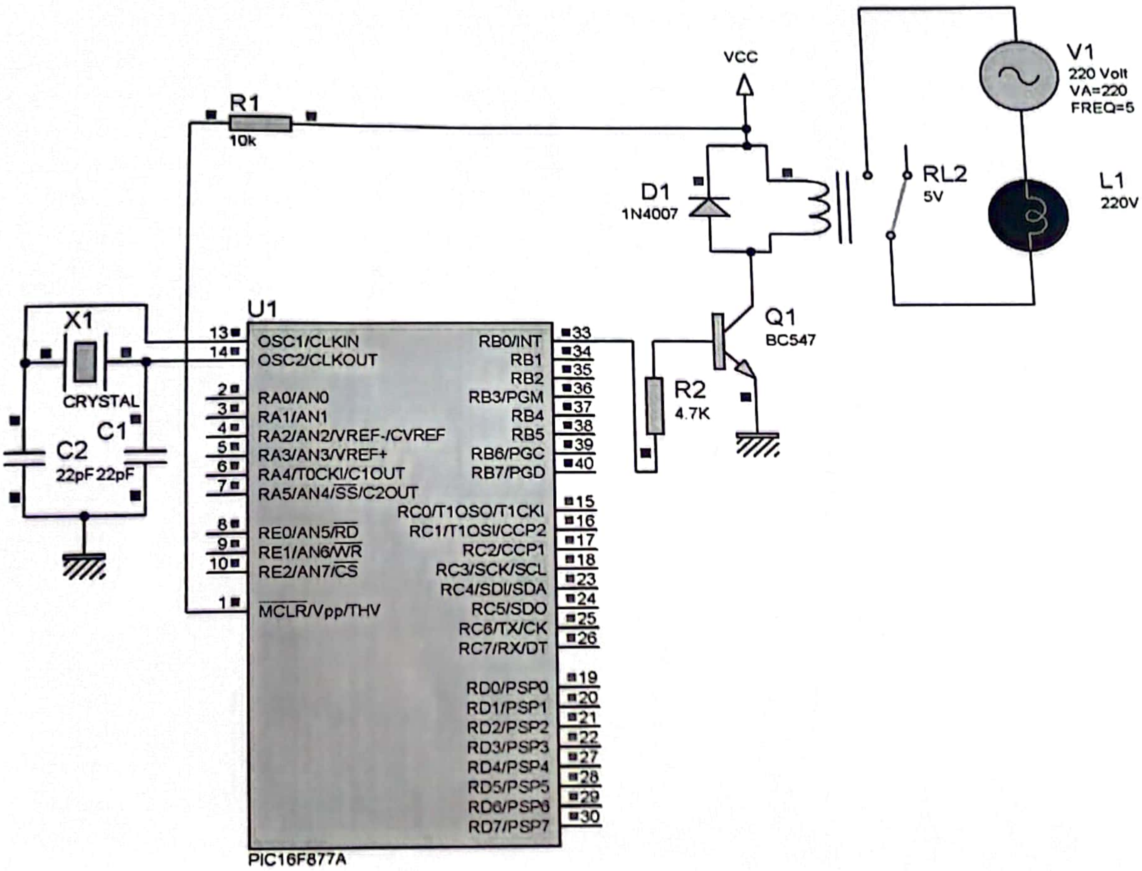

Figure-5: Relay in OFF state & the lamp will not provide light for 3000ms.

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Experiment Name: Multiplexing 7 segment displays using PIC Microcontroller

Theory: The seven segments were driven individually through separate I/O pins of the microcontroller. If we do just like that then for 4 seven segment LED displays, 28 I/O pins will be required, which is quite a bit of resources and is not affordable by mid-range PIC microcontrollers. That's why a multiplexing technique is used for driving multiple seven segment displays. This tutorial shows how to multiplex 4 common anode type seven segment LED displays with a PIC16F628A microcontroller.

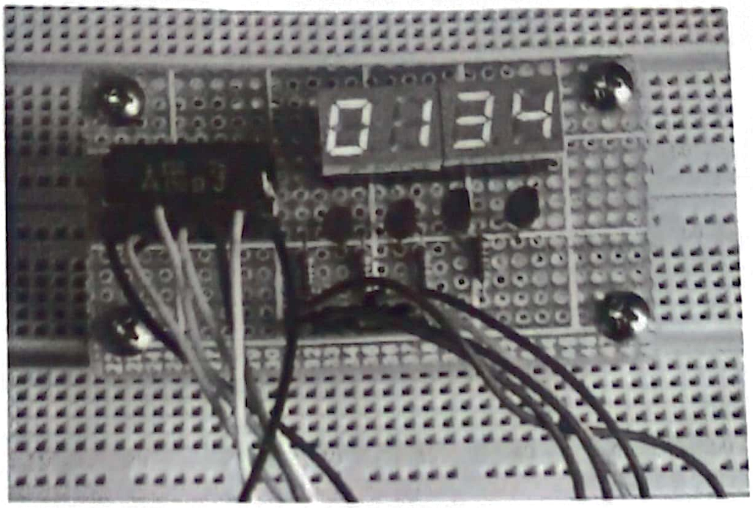

Figure-1: Multiplexing 4 common anode seven segment LED displays

The theory behind the multiplexing technique is simple. All the similar segments of multiple LED displays are connected together and driven through a single I/O pin. In the circuit below, the seven segments are connected to PORTB through current limiting resistors Rs. A particular segment is active when the corresponding PORTB pin is low. However, it will not glow until it's anode is connected to Vcc. You can see the anodes of the four LED displays are not directly connected to Vcc. Instead, 4 PNP transistors are used as switches to connect or disconnect the anode terminals from Vcc. When the base of the PNP transistor is low, the transistor conducts and corresponding digit's common anode is connected to Vcc. Therefore, the transistor selects which displays is active. The conduction of the transistors are controlled by RA0 through RA3 pins of PORTA. Suppose, if we want to display 7 in the units digit place, then segments a, b, and c should be turned on first (which means RB0, RB1, RB2 are 0 and RB3-RB6 are 1) and then RA0 should be pulled low (while keeping RA1-RA3 high) so that only units digit display will be active. In order to display all 4 digits, each seven-segment display is activated sequentially using an appropriate refresh frequency so that it will appear that all they are turned on at the same time.

Circuit Diagram:

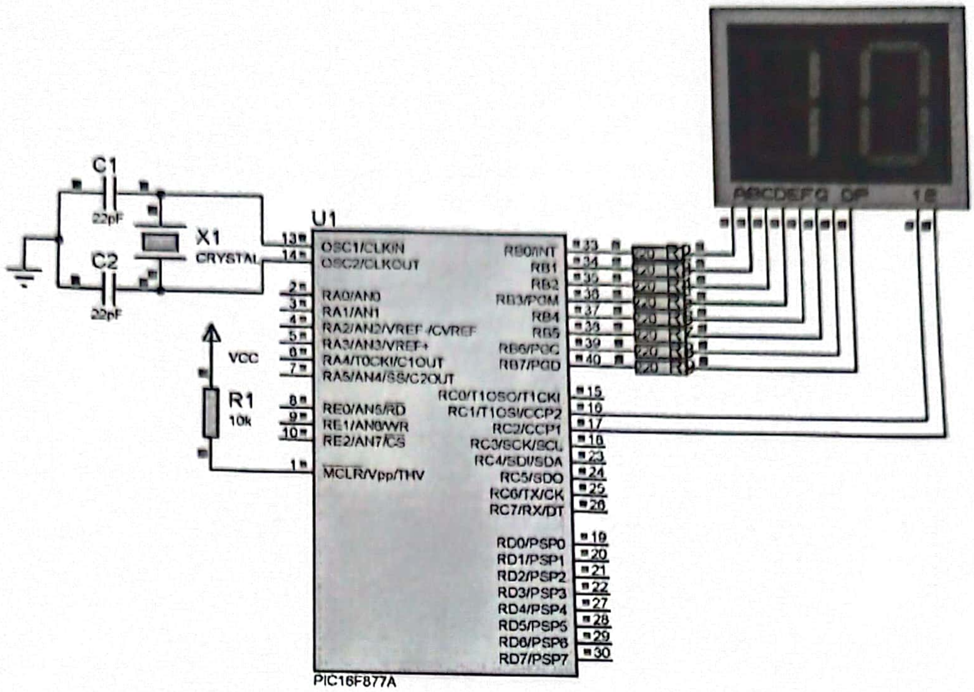

Figure-2: Multiplex of 7 segment display using PIC16F877A

MikroC Code:

```
#define digitL portc.f1
#define digitR portc.f2
unsigned char array[]={0x3f, 0x06, 0x5b, 0x4f, 0x66, 0x6d, 0x7d, 0x07, 0x7f, 0x6f};
void main()
{
   int i=0;
   int j, Left_digit=0, Right_digit=0,count;
   TRISB=0x00;
   TRISC=0x00;

  portb=0x00;
  portc=0x00;
  while(1)
  {
      Left_digit=i/10;
      Right_digit=i%10;

      for(j=0;j<50;j++)
      {
```

```
            portb=array[Left_digit];
            digitL=0;
            delay_ms(10);
            digitL=1;

            portb=array[Right_digit];
            digitR=0;
            delay_ms(10);
            digitR=1;
        }
        i++;
        if(i>99)
          i=0;
    }
}
```