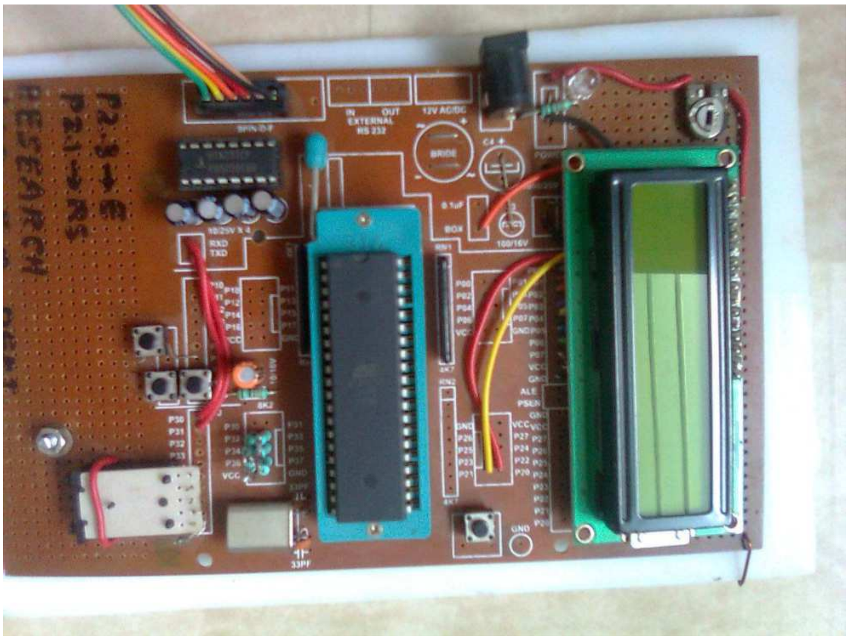
Microcontroller & Interfacing

Laboratory Manual



Enrollment No.: ________________

Name of the Student: __________________________________

Biomedical Engineering Department

Government Engineering College,

Sect-28, Gandhinagar

GOVERNMENT ENGINEERING COLLEGE, SECT-28, GANDHINAGAR

CERTIFICATE

This is to certify that Mr/Miss ________________________ ______________ Enrollment No. __________________ of B.E. (B.M.) SEM-V has satisfactorily completed the term work of the subject **Microcontroller and interfacing** prescribed by Gujarat Technological University during the academic term ____________________.

Date:_______________

Signature of the faculty

[Prof. P.V.Patel]

INDEX

Sr. No.	Name of Experiment	Date	Sign
1	Write a assembly language program to …. • Add two 8 bit numbers stored in register R6 and R7 • Multiply two 8 bit numbers stored in register R6 and R7. • To find 1's complement of number stored in register R0. • To perform AND operation between content of register R0 and R1.		
2	Write C language program to… • Read data from port P2 and P3. Add data and display result on port P0. Glow LED connected at port pinP1.1 if carry flag set after addition. • Read data from port P2 and P3. Multiply data and display result on port P0 and P1. • Write program to read switch connected at port pin P1.0, toggle it and send to port pin P1.1.		
3	Write program to… • To add two sixteen bit numbers stored in DPTR and at memory location 40h, 41h.Store result in DPTR. • Multiply two 16 bit numbers. Assume that first 16 bit number is stored in register R6 and R7, Second 16 bit number is stored in register R4 and R5. Store answer in register R0,R1,R2 and R3.		
4	Write a program to… • Add block of data stored at location 40h to 45h. • Transfer block of data from the location 40h-4Fh to external memory location 2000h-200Fh. • Arrange data stored at the location 40h-4Fh in ascending order.		
5	Write a program to perform following… • Keep monitoring port pin P1.2 until it becomes high. • When P1.2 becomes high, write data 45h to port P0. • Send high to low pulse on pin P2.3.		
6	Write a program to generate square wave of 50% duty cycle having frequency 5 KHz at port pin P1.0 using timer 1 in mode 2. Modify program to generate pulse waveform of 70% duty cycle using timer on the same pin.		
7	Generate external interrupt INT0 and INT1 by connecting push button switch. Glow LEDs connected at port 1 one by one when interrupt INT0 occurs. LEDs should flash when interrupt INT1 occurs.		

Sr. No.	Name of Experiment	Date	Sign
8.	Interface seven segment display with Port P2. Write program to display number 0 to 9 on the seven segment display at the interval of 1 second.		
9.	Interface LCD with the microcontroller. Display your name on the LCD.		
10.	Write a program to transmit letter “E” continuously using serial port. Modify program to transmit text “YES”. Use 8 bit UART mode with baud rate 19,200.		
11.	Write a program to receive bytes of data serially and display it on port P0. Use 8 bit UART mode with baud rate 9600.		
12.	Write a program to count external pulses given at the timer0 input pin. Display pulses on the seven segment display.		
13.	Interface matrix keyboard with 8051. Write program to display key pressed on seven segment display.		
14.	Interface stepper motor with port P0 of the microcontroller. Write a program to rotate motor in clockwise and anticlockwise direction in half step and full step mode.		
15.	Interface DC motor with 89C51 microcontroller. Write a program to rotate motor with different speed using PWM.		
16.	Interface ADC0808 with 89C51 microcontroller. Write program to read analog voltage applied at the input of ADC. Display it on LCD.		
17.	Interface 8 bit DAC chip with 89C51 microcontroller. Write a program to generate sine wave using look up table.		

Instructions to the students:

- Student has to construct microcontroller mini-project individually as per the given circuit diagram by the faculty. It is compulsory as a part of term work. List of components is given at the end of this lab manual.
- Mounting of RS-232 connector and MAX-232 chip is compulsory for all the students because it will help you to program your chip using Philips Flash Magic Utility (You have to download HEX files in your chip to test your hardware)
- Simulate assembly language programs on UMPS assembler and simulator.
- Simulate C programs using KEIL compiler and simulator.
- You may use free integrated development environment (IDE) for 8051 with Ubuntu Linux. Linux operating system is open source so it is convenient to use it. Many free simulators are available to work with Linux environment.
- Solve exercise given at end of each practical, write answers and execute it.
- Test your all programs with Simulator and actual hardware.

EXPERIMENT NO. 1

AIM: Write a program to ….

- Add two 8 bit numbers stored in register R6 and R7.
- Multiply two 8 bit numbers stored in register R6 and R7.
- To find 1's complement of number stored in register R0.
- To perform AND operation between content of register R0 and R1.

Assembly language programs:

Program 1: To add two 8 bit numbers stored in register R6 and R7.

```
ORG 00h
MOV R6,#55h     ; Transfer data 55h to register R6
MOV R7,#44h     ; Transfer data 44h to register R7
MOV A,R6        ; Transfer content of register R6 to accumulator
ADD R7          ; Add content of R7 with accumulator and store result in A
END             ; End of program
```

Program 2: To multiply two 8 bit numbers stored in register R6 and R7.

```
ORG 00h
MOV R6,#55h     ; Transfer data 55h to register R6
MOV R7,#44h     ; Transfer data 44h to register R7
MOV A,R6        ; Transfer content of register R6 to accumulator
MOV B, R7       ; Transfer content of R7 in register B
MUL AB          ; Multiply accumulator and register B, Store result in both
END             ; End of program
```

Program 3: To find 1's complement of number stored in register R0. Store result in register R1.

```
ORG 00h
MOV A,R0        ; Transfer number stored in R0 to Accumulator
CPL A           ; Complement the content of accumulator
MOV R1,A        ; Store result in register R1
END             ; End of program
```

Program 4: To perform AND operation between content of register R0 and R1. Store result in register R3.

```
ORG 00h
MOV A,R0        ; Transfer number stored in R0 to Accumulator
ANL A,R1        ; AND operation between A and register R1
MOV R3,A        ; Store result in register R3
END             ; End of program
```

Note: Check execution of program 3 and 4 by loading different values in registers.

:: WORKSHEET ::

A. Write assembly language program to add two 8 bit data stored at memory locations 60h and 61h. Store result at location 82h(LSB) and 83h (MSB).

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Write assembly language program to multiply two data stored at memory location 40h and 41h. Write result of multiplication at memory location 42h (LSB) and 43h (MSB).

Memory Location	HEX code	Label	Opcode	Operands	Comments

C. Write and execute instructions to
   a. Transfer content 1234h to DPTR.
   b. Select register bank 1 and transfer content 45h to register R0 and 54h to R2.

Memory Location	HEX code	Label	Opcode	Operands	Comments

D. Write and execute program to find 2’s complement of number stored in register R0. Store result in register R1.

Memory Location	HEX code	Label	Opcode	Operands	Comments

E. Write and execute program to perform OR operation between data stored at memory location 40h and 50h. Store result in register R7.

Memory Location	HEX code	Label	Opcode	Operands	Comments

F. Write and execute program to subtract content of register R6 from register R7 and store result in register R0.

Memory Location	HEX code	Label	Opcode	Operands	Comments

G. Write program to add registers R0,R1 and R2. Consider carry during the addition.

Memory Location	HEX code	Label	Opcode	Operands	Comments

H. Write program to add two BCD numbers stored at memory location 50h and 51h. Adjust result for BCD number and store it at memory location 52h.

Memory Location	HEX code	Label	Opcode	Operands	Comments

:: Rough Work ::

EXPERIMENT NO. 2

AIM: Write a C language programs to…

- Read data from port P2 and P3. Add data and display result on port P0. Glow LED connected at port pinP1.1 if carry flag set after addition.
- Read data from port P2 and P3. Multiply data and display result on port P0 and P1.
- Write program to read switch connected at port pin P1.0, toggle it and send to port pin P1.1.

C Language Programs:

Program 1: Read data from port P2 and P3. Add data and display result on port P0. Glow LED connected at port pinP1.1 if carry flag set after addition.

➢
```
# include <reg51.h>
void main(void)
{
unsigned char a,b,c;
P2=0xff;            //Define port P2 as an input port
P3=0xff;            //Define port P3 as an input port
P0=0x00;            //Define port P0 as an output port
P1=0x00;            //Define port P1 as an output port
P1=0x01;            //Make LED off
a=P2;               //Read port P2
b=P3;               //Read port P3
c=a+b;              //Add content of port P2 and P3
P0 = c;             //Display result on port P0
if(CY==1)
{
P1=0x00;            //Glow LED connected at P1.0 common anode mode
}
}
```

Program 2: Read data from port P2 and P3. Multiply data and display result on port P0 & P1.

➢
```
# include <reg51.h>
void main(void)
{
unsigned char a,b;
unsigned int c;
P2=0xff;            //Define port P2 as an input port
P3=0xff;            // Define port P3 as an input port
P0=0x00;            //Define port P0 as an output port
P1=0x00;            //Define port P1 as an output port
a=P2;               //Read port P2
b=P3;               //Read port P3
c=a*b;              //Multiply content of port P2 and P3
P0 = ACC;           //Display accumulator content on port P0
P1=B;               //Display register B content on port P1
}
```

Program 3: Write program to read switch connected at port pin P1.0, toggle it and send it to port pin P1.1.

```
# include <reg51.h>
sbit input = P1^0;              /* Define input pin P1.0*/
sbit output=P1^1;               /* Define output pin P1.1*/
void main(void)
{
while(1)                         //Continuous infinite loop
{
output=~input;                  //Read input pin, toggle it and send to output
}
}
```

:: WORKSHEET ::

Exercise:

A. Write C language program to continuously toggle pin P1.0 without disturbing other port pins.

B. Write C language program to perform OR operation between port pin P1.0 and P1.1. Display result on port pin P1.2.

C. Write C language program to read port P1, Compare content of port P1with data 80h. If data at port P1 is greater than 80h, make port P0=0x00 and if data at port P1 is less than or equal to 80h, make port P0=0xFF.

D. Write a program to sense lift door switch connected at port pin P2.0. Switch on the alarm connected at port pin P2.1 if lift door is open. Write program in assembly and C language.

EXPERIMENT NO. 3

AIM: Write programs to ….

- To add two sixteen bit numbers stored in DPTR and at memory location 40h,41h.Store result in DPTR.
- Multiply two 16 bit numbers. Assume that first 16 bit number is stored in register R6 and R7, Second 16 bit number is stored in register R4 and R5. Store answer in register R0,R1,R2 and R3.Load first value in R6 and R7

Program 1: To add two sixteen bit numbers stored in DPTR and at memory location 40h, 41h. Store result in DPTR.

```
ORG 00h
MOV DPTR,#2233h         ;Transfer 16 bit data to DPTR
MOV 40h,#11h            ;Transfer LSB of 16 bit data to location 40h
MOV 41h,#22h            ;Transfer MSB of 16 bit data to location 41h
MOV A,40h               ; Get LSB of 16 bit data in accumulator
ADD A,DPL               ;Add with LSB of second data which is stored in
                        ;DPTR
MOV DPL,A               ;Save result back in DPL
MOV A,41h               ;Get MSB of first data in accumulator
ADC A,DPH               ;Add with MSB of second data consider previous
                        ;carry.
MOV A,DPH               ;Save result back in DPH
END
```

Program 2:

```
;Load first 16 bit value in R6 and R7
            MOV R6,#11h
            MOV R7,#22h
;Load second 16 bit value in R4 and R5
            MOV R4,#11h
            MOV R5,#22h
;Multiply R5 by R7
            MOV A,R5            ;Move the R5 into the Accumulator
            MOV B,R7            ;Move R7 into B
            MUL AB              ;Multiply the two values
            MOV R2,B            ;Move B (the high-byte) into R2
            MOV R3,A            ;Move A (the low-byte) into R3
;Multiply R5 by R6
            MOV A,R5            ;Move R5 back into the Accumulator
            MOV B,R6            ;Move R6 into B
            MUL AB              ;Multiply the two values
            ADD A,R2            ;Add the low-byte into the value already in R2
            MOV R2,A            ;Move the resulting value back into R2
            MOV A,B             ;Move the high-byte into the accumulator
```

```
        ADDC A,#00h         ;Add zero (plus the carry, if any)
        MOV R1,A            ;Move the resulting answer into R1
        MOV A,#00h          ;Load the accumulator with zero
        ADDC A,#00h         ;Add zero (plus the carry, if any)
        MOV R0,A            ;Move the resulting answer to R0.
;Multiply R4 by R7
        MOV A,R4            ;Move R4 into the Accumulator
        MOV B,R7            ;Move R7 into B
        MUL AB              ;Multiply the two values
        ADD A,R2            ;Add the low-byte into the value already in R2
        MOV R2,A            ;Move the resulting value back into R2
        MOV A,B             ;Move the high-byte into the accumulator
        ADDC A,R1           ;Add the current value of R1 (plus any carry)
        MOV R1,A            ;Move the resulting answer into R1.
        MOV A,#00h          ;Load the accumulator with zero
        ADDC A,R0           ;Add the current value of R0 (plus any carry)
        MOV R0,A            ;Move the resulting answer to R1.
;Multiply R4 by R6
        MOV A,R4            ;Move R4 back into the Accumulator
        MOV B,R6            ;Move R6 into B
        MUL AB              ;Multiply the two values
        ADD A,R1            ;Add the low-byte into the value already in R1
        MOV R1,A            ;Move the resulting value back into R1
        MOV A,B             ;Move the high-byte into the accumulator
        ADDC A,R0           ;Add it to the value already in R0 (plus any carry)
        MOV R0,A            ;Move the resulting answer back to R0
;Answer is in R0, R1, R2, and R3.
```

:: WORKSHEET ::

Exercise:

A. Write assembly language program to find square of given number stored in register R0. Save result in register R1 and R2.

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Write assembly language program to add 4 digit BCD numbers. First 4 digit number stored at 40h-41h (LSB at 41h), second 4 digit number stored at location 42h-43h (LSB at 43h). Store result in DPTR and carry flag.

Memory Location	HEX code	Label	Opcode	Operands	Comments

C. Divide content of register R1 by 8 using logical shift instruction.

Memory Location	HEX code	Label	Opcode	Operands	Comments

EXPERIMENT NO. 4

AIM: Write a program to ….

- Add block of data stored at location 40h to 45h.
- Transfer block of data from the location 40h-4Fh to external memory location 2000h-200Fh.
- Arrange data stored at the location 40h-4Fh in ascending order.

Assembly language programs:

Program 1: Add block of data stored at location 40h to 45h.

- In this program, we assume that the result may be 16 bit so it is saved in register pair A and B with LSB in register A and MSB in register B.

```
        ORG 00h
        MOV B,#00h           ; Clear B to save the result
        MOV R0,#40h          ; Use R0 as a pointer to first memory location
        MOV A,@R0            ; Transfer data from first memory location to accumulator
        AGAIN: INC R0        ; Point to next memory location
        ADD A,@R0            ; Add data and store result in accumulator
        JNC LOOP             ; If no carry do not increment B
        INC B
LOOP:   CJNE R0,#45h,AGAIN ;Add up to memory location 45h
        END                  ; End of program
```

Program 2: Transfer block of data from the location 40h-4Fh to external memory location 2000h-200Fh.

```
        ORG 00h
        MOV B,#00h           ; Clear B to save the result
        MOV R0,#40h          ; Use R0 as a pointer to first memory location
        MOV DPTR,#2000h      ; Point to external memory location 2000h
NEXT:   MOV A,@R0            ; Transfer data from memory to accumulator
        MOVX @DPTR,A         ; Transfer data from accumulator to external memory
                             ; location pointed by DPTR
        INC R0               ; Increment R0 to point next location
        INC DPTR             ; Increment DPTR to point next ext. memory loc.
        CJNE R0,#50h,NEXT    ;Add up to memory location 4Fh
        END                  ; End of program
```

Program 3: Arrange data stored at the location 40h-4Fh in ascending order.

```
        ORG 30h              ;Start program from the location 30h (why?)
        MOV R0,#40h          ;Point for first location of data
        MOV R1,#40h
loop:   MOV b,@R0
start:  INC R0               ;Point to next data
        CLR PSW.7            ;Clear carry flag CY before subtraction
        MOV A, B             ;Transfer data to accumulator for comparison
        SUBB A,@R0           ;Subtract for comparison
        JC next               ;If A<next data then check next data
        MOV 60h,R0            ;Save smallest location at RAM address 60h
        MOV b,@R0             ;If A>next data then transfer next data to accumulator
next:   CJNE R0,#4Fh,start    ;Check for last location
        MOV R0,60h            ;Get smallest location again
        MOV a,@R0             ;Exchange first data with location of smallest no.
        XCH A,@R1
        MOV @R0,A
        INC R1
        MOV A,R1              ;Start search for small number from next location
        MOV R0,A
        CJNE R1,#4Fh,loop     ;Check for last location
        END
```

:: WORKSHEET ::

Exercise:

A. Write an assembly language program to transfer data from external memory locations 5000h-500Fh to the internal memory locations 30-3Fh.

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Write program to arrange data stored in the location 20h-2Fh in descending order.

Memory Location	HEX code	Label	Opcode	Operands	Comments

C. Write program to count number of negative numbers in the array of numbers stored at external memory location 4000h to 40FFh.

Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

:: Rough Work ::

EXPERIMENT NO. 5

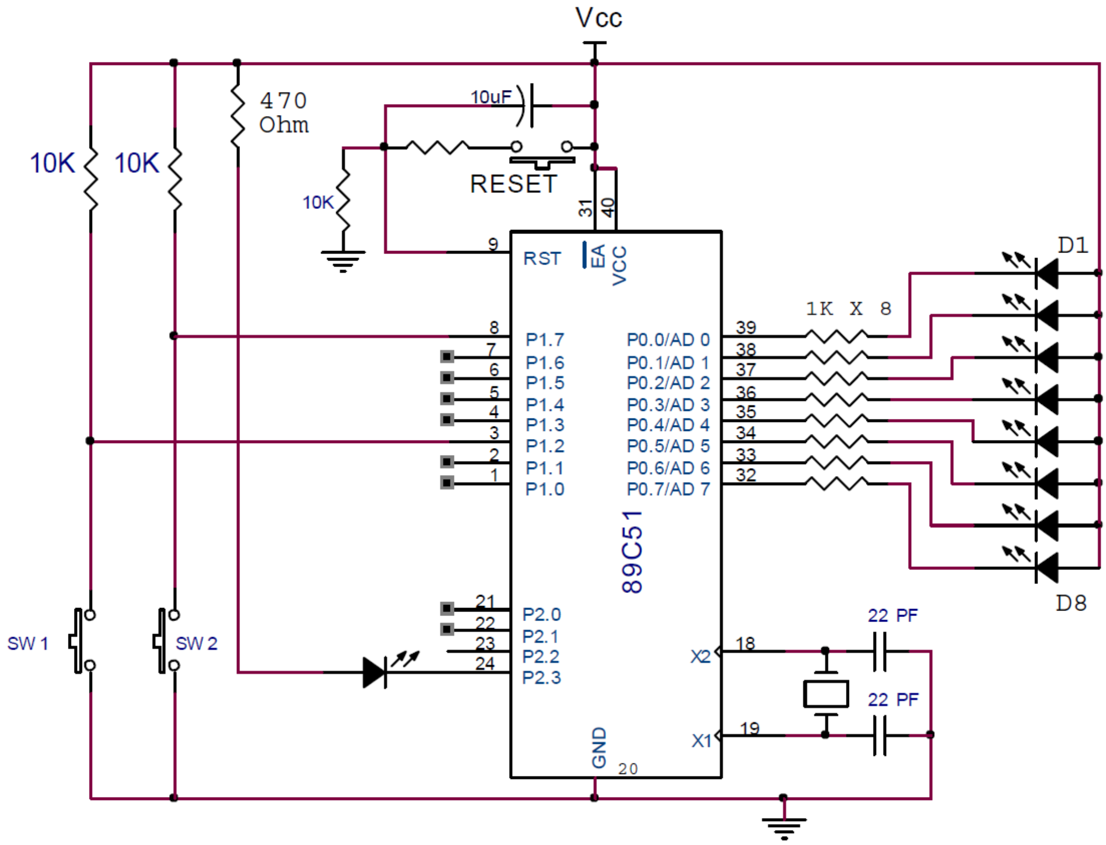
AIM: Write a program to ….

- Keep monitoring port pin P1.2 until it becomes high.
- When P1.2 becomes low, write data 45h to port P0.
- Send high to low pulse on pin P2.3.

Program 1: Keep monitoring port pin P1.2 until it becomes high.

```
       ➢ ORG 30h
         MOV P1,#0FFh          ; Configure port P1 as input port
         MOV P0,#00h           ; Configure port P0 as output port
         CLR P2.3              ; Make port pin P2.3 low
CHECK:   JNB P1.2, CHECK
         MOV P0,#45h
         CLR P2.3
         END
```

Circuit Diagram:



- Construct circuit diagram on general purpose microcontroller board /simulator software.
- Assemble and link the program to generate HEX file. Download HEX file into Flash memory of microcontroller chip 89C51.
- Press the reset button and write your comment about which LEDs are ON and OFF.

:: WORKSHEET ::

A. Write assembly language and C program to make ALL LEDs connected at port P1 ON.

B. Write assembly language and C program to make ALL LEDs connected at port P1 OFF.

C. Write assembly language and C program to read input switch connected at port pin P3.2 and make all LEDs ON if this switch is pressed and OFF if this switch is released.

D. A switch is connected to P3.2. Write a program to perform following:

   a. If Switch is OFF, send data 0x88 to P0.
   b. If Switch is ON, send data 0x55 to P0.

Assembly language program:

Memory Location	HEX code	Label	Opcode	Operands	Comments

C language program:

EXPERIMENT NO. 6

AIM: Write a program to generate square wave of 50% duty cycle having frequency 5 KHz at port pin P1.0 using timer 1 in mode 2. Modify program to generate pulse waveform of 70% duty cycle using timer on the same pin.

Calculation of delay:

Time = 1/Frequency = 1/(5x10^3) = 200 µS

For 50% duty cycle ON time and OFF time are equal

$T_{ON} = T_{OFF}$ = 100 µS

Time delay required is 100.

If we consider crystal frequency 12 MHz, time to execute one cycle is

$$T = \frac{1\times 12}{12\times 10^6} = 1\ \mu S$$

If we will use pure software delay to generate delay of 100 µS

Program:

```
        ORG 00h                 ; Start program from location 00h
        CLR P1.0                ; Make P1.0 output pin
next:   ACALL delay             ; Call delay of 100 µS
        CPL P1.0                ; Complement P1.0 to generate square wave
        SJMP next
delay:  MOV R7,#30h             ; Load count value 48 (30h)
loop:   DJNZ R7, loop           ; Decrement R7 until it becomes zero
        NOP                     ; No operation
        RET                     ; Return to main routine
        END
```

Total number of cycles in delay loop:

Total number if cycles $C_T = C_O + C_L + C_R$ = 1 + 4 8×2 + 1+2 = 100

Where, C_O = Number of cycles outside the loop

C_L = Number of cycles inside the loop

C_R = Number of cycles for return instruction.

Total time = C_T x 1 µS = 100 µS

Note: Execute this program using Keil and observe waveforms at port pin P1.0. (Measure frequency and verify whether it is giving correct value or not)

:: WORKSHEET ::

Exercise:

A. Modify program for 80% duty cycle.

Hint: Use separate delay loop for ON time and OFF time. Total time is 200 µS, so use 160 µS for ON time and 40 µS for OFF time. You can also prepare delay subroutine of 10 µS. Call delay subroutine 16 times for ON time and 4 times for OFF time.

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Execute following C program in Keil and measure frequency of the square wave.

```
# include <reg51.h>
sbit wave_pin P1^0;
void sqdelay(unsigned int);
void main(void)
{
while(1)
{
wave_pin=1;
sqdelay(100);
wave_pin=0;
sqdelay(100);
}
}
void sqdelay(unsigned int t)
{
unsigned int i,j;
for(i=0;i<t;i++)
for(j=0;j<1000;j++);
}
```

Draw waveform (show on time and off time)

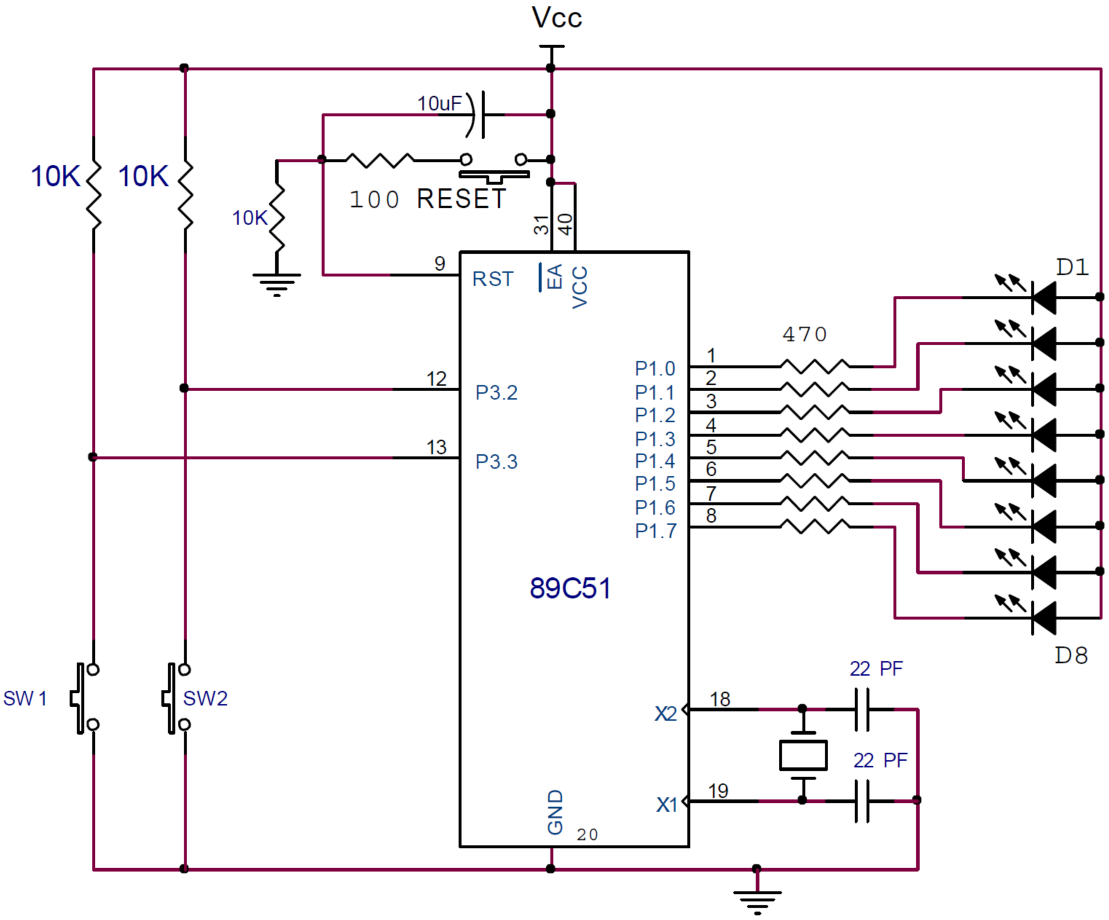
C. What modifications you suggest in above program to reduce frequency of square wave to half?

D. Suggest modification in the program to achieve duty cycle 60% without changing frequency of the square wave.

EXPERIMENT NO. 7

Aim: Generate external interrupt INT0 and INT1 by connecting push button switch. Glow LEDs connected at port P1 one by one when interrupt INT0 occurs. LEDs should flash when interrupt INT1 occurs.

Circuit Diagram:



Program:

```
            org 00h
            ajmp start
            org 03h                 ; Vector location for External interrupt INT0
            ajmp sequence           ; Jump to sequence program
            reti
            org 13h                 ; Vector location for External interrupt INT1
            ajmp flash              ; Jump to flash program
            reti
start:      mov IE,#10000101B ;Enable External interrupts
            setb IT1                ; Negative edge trigger for INT1
            setb IT0                ; Negative edge trigger for INT0
            mov P1,#00h             ; Port P1 output port
flash:      mov P1,#0ffh            ; Make all LEDs OFF
            acall delay
            mov P1,#00h             ; Make all LEDs ON
            acall delay
```

```
        ajmp flash
sequence:
        mov a,#0FEh         ; Bit pattern for First LED ON, others OFF
next:   mov P1,a            ; Transfer bit pattern to port P1
        rl a                ; Rotate for next LED
        acall delay         ; Delay
        ajmp next           ; Repeat loop
delay:  mov R4,#02h
loop3:  mov R6,#0ffh
loop2:  mov R5,#0ffh
loop1:  djnz R5,loop1
        djnz R6,loop2
        djnz r4,loop3
        ret
        end
```

:: WORKSHEET ::

Exercise: Modify program such that when INT0 occurs, LEDs flash ten times and then stop. When INT1 occurs LEDs glows one by one sequentially only once and then stop.

Hint: Use separate register as a counter.

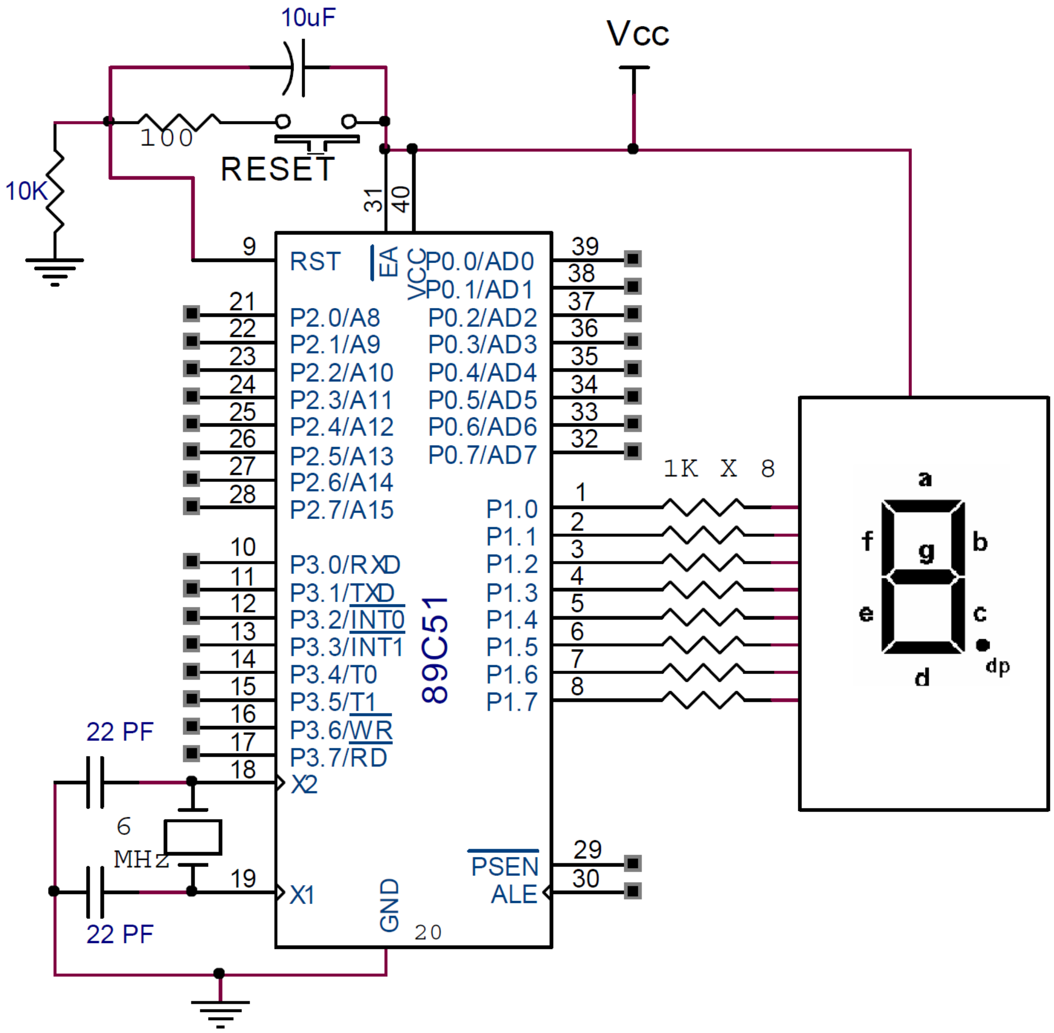
Memory Location	HEX code	Label	Opcode	Operands	Comments

EXPERIMENT NO. 8

Aim: Interface seven segment display with Port P1. Write program to display number 0 to 9 on the seven segment display. Use delay between two counts.

Program 1: Display Count value on seven segment display.

Circuit diagram:



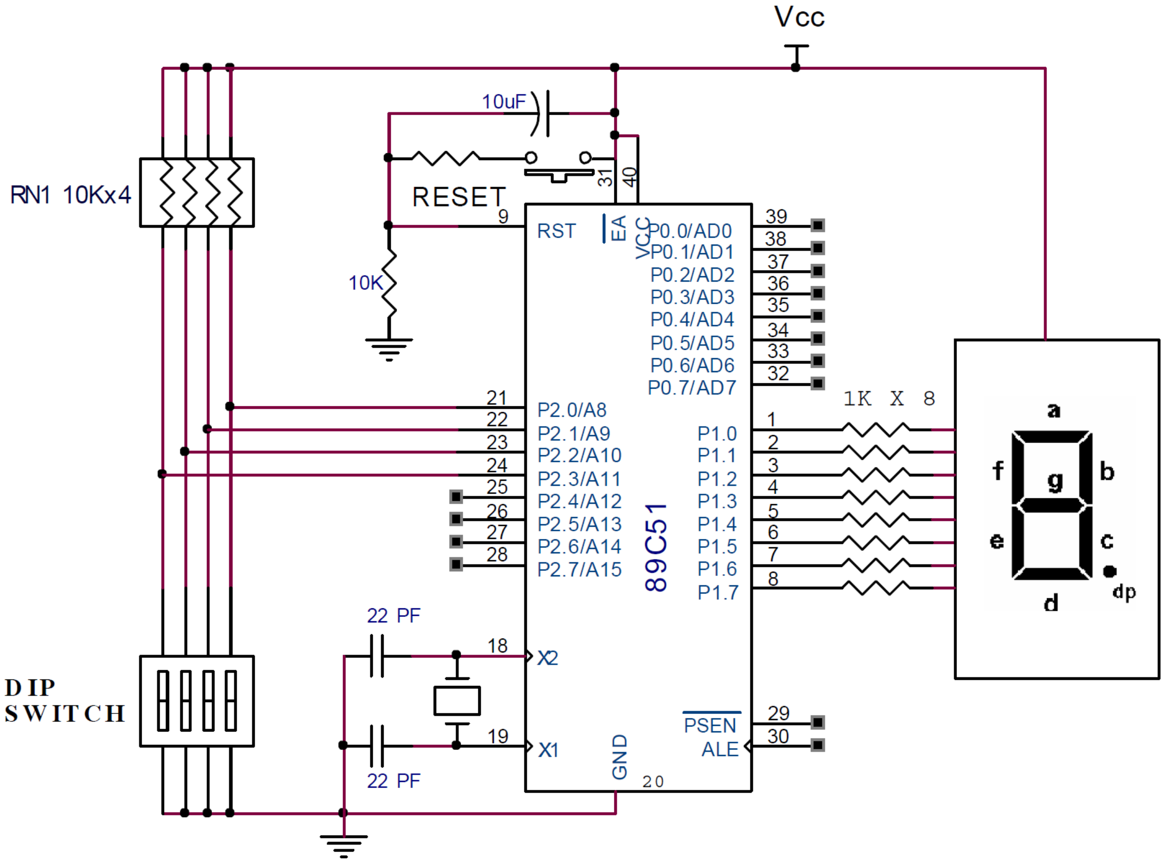
Program:

```
➢     ORG 00h
      AJMP start
      ORG 03h
      RETI
      start:
      MOV P1,#00h                    ;Configure port 1 as output port
again: MOV DPTR,#CODE          ;Initialize DPTR as a base address for code
      next: CLR A
      MOVC A,@A+DPTR                 ; Get seven segment code
      JZ AGAIN
      MOV P1,A                 ;Display count value
      ACALL DELAY
```

```
            INC DPTR
            AJMP next                   ; Next digit
DELAY:      MOV R7,#22h
L3:         MOV R6,#0FFh
L2:         MOV R5,#0FFh
L1:         DJNZ R5,L1
            DJNZ R6,L2
            DJNZ R7,L3
            RET
CODE:       db 0C0h,0F9h,0A4h,0B0h,99h,92h,82h,0F8h,80h,90h,00h,
            END
```

Program 2: Interface DIP Switch with port P2 (P2.0 to P2.3). Write a program to read status of the switch and display its HEX value on the seven segment display connected at port P1.

Circuit diagram:



Program:

```
start:      ORG 00h
            AJMP start
            ORG 03h
            RETI
            MOV P1,#00h             ;Configure port 1 as output port
            MOV P2,#0FFh            ;Configure port 2 as input port
again:      MOV DPTR,#CODE          ;Initialize DPTR as a base address for code
            MOV A,P2                ;Read status of the switch
            ACALL DELAY
            MOVC A,@A+DPTR
            MOV P1,A ;Display count value
            AJMP again ;Continue DIP switch reading process
DELAY:      MOV R6,#0ffh
LOOP1:      DJNZ R6,LOOP1
            RET
CODE:       db 0C0h,0F9h,0A4h,0B0h,99h,92h,82h,0F8h,80h,90h,0C8h,
            db 83h,0C6h,0A1h, 86h, 8Eh, 00h
            END
```

:: WORKSHEET ::

Exercise:

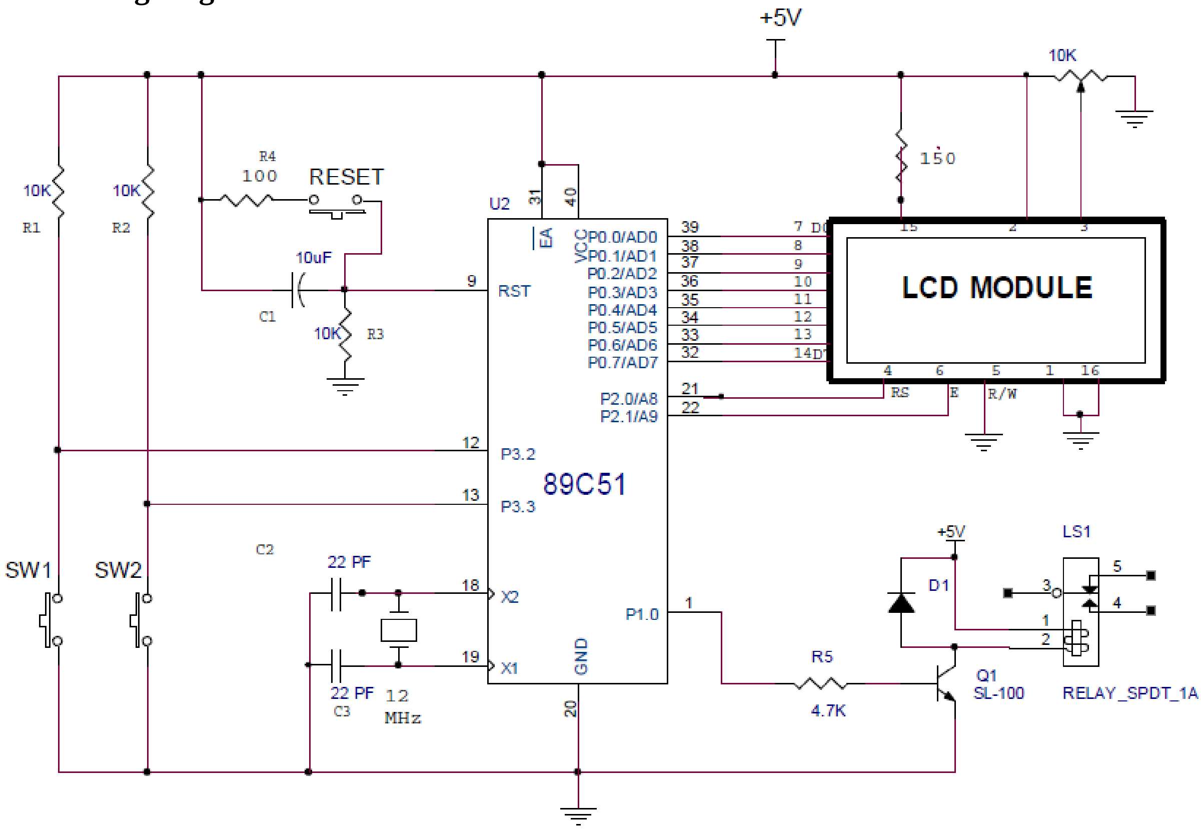
A. Write program to display count value F to 0 at the interval of 1 second on seven segment display connected at port P1.

Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

EXPERIMENT NO. 9

AIM: Interface LCD with the microcontroller. Display your name on the LCD.

Interfacing diagram:



Pin connections:

- Data lines of LCD are connected with port P0.
- RS (Register Select) line is connected with port pin P2.0.
- R/W pin is directly connected to ground.
- Enable line is connected with port pin P2.1.
- Relay is driven by transistor SL-100. Transistor SL-100 is controlled by port pin P1.0.
- Push button switches SW1 and SW2 are connected with port Pin P3.2 and P3.3 (External interrupts pins)

Programming steps:

- Initialize the LCD. For example send command word #38h to initialize LCD for 5×7 dots/character and 2 rows. Send command word #3Ch for 5×10 dots/character and two rows. Send other command words like 01h to clear LCD screen, 06h to make LCD ON & Cursor ON, 80h to start from first line and first character etc.
- Write separate routine to send command in which we will make RS=0 and after transferring command word to port P1, we will enable LCD by sending pulse at port pin P3.1. We will use this command routine whenever we want to issue certain commands during initialization, to clear display, for movement of cursor to display data at particular position etc.
- Write separate routine to send data to the LCD in which we will make RS=1 and after transferring data to port P1, we will enable LCD to display data. We will not check whether LCD is busy or not but we will put certain amount of delay (about 5 ms)

between two data which gives enough time to LCD for its operation and does not require to check the status whether it is busy or not.

Program:

```
; For Kit prepared for LAB
; Program to Display text message on LCD
; Port 1 Drives data lines, P2.1-RS, P2.0 EN,RW is grounded
        RS EQU P2.1
        RW EQU P2.1
        EN EQU P2.0
        DATA equ P0

        org 00h
        MOV P0,#00h         ; Port P0 output port
        MOV P2,#00h         ; Port P2 output port
        MOV A,#38h          ;Initialize LCD, 2 lines, 5X7 matrix
        acall command       ;Issue command to the LCD
        MOV A,#0eh
        acall command       ;LCD ON, Cursor ON
        MOV A,#01h
        acall command       ;Clear LCD
        MOV A,#06h
        acall command       ;Shift cursor right
        MOV A,#80h
        acall command       ;Force cursor at beginning of the first line
        MOV DPTR,#msg       ;Point to text message
        acall disp_msg      ;Display message on second line
here:   sjmp here
command:
        acall delay         ;Write when display not busy
        clr RS              ;Select command register
        clr RW
        mov DATA,A
        setb EN             ;Set Enable terminal of LCD
        nop
        nop
        clr EN
        ret
disp_data:
        acall delay
        mov DATA,a          ;Get data for display
        clr RW
        setb RS             ;Select data register
        setb EN             ;Enable LCD (Strobe LCD)
        nop
        nop
        clr EN              ;Clear Enable and latch data
        ret
disp_msg:
        acall delay
        clr a
        movc a,@a+dptr
        jz exit
        acall disp_data
        inc dptr
        sjmp disp_msg
        exit: ret
        delay:
        mov R6,#0ffh
loop1: djnz R6,loop1
        ret
msg:    DB ‘ Your name ',0
        END
```

:: WORKSHEET ::

Exercise:

A. Modify LCD program to display two lines: “WELCOME TO B.M.” on first line and “GEC GANDHINAGAR” on the second line. Execute program in your hardware.

Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

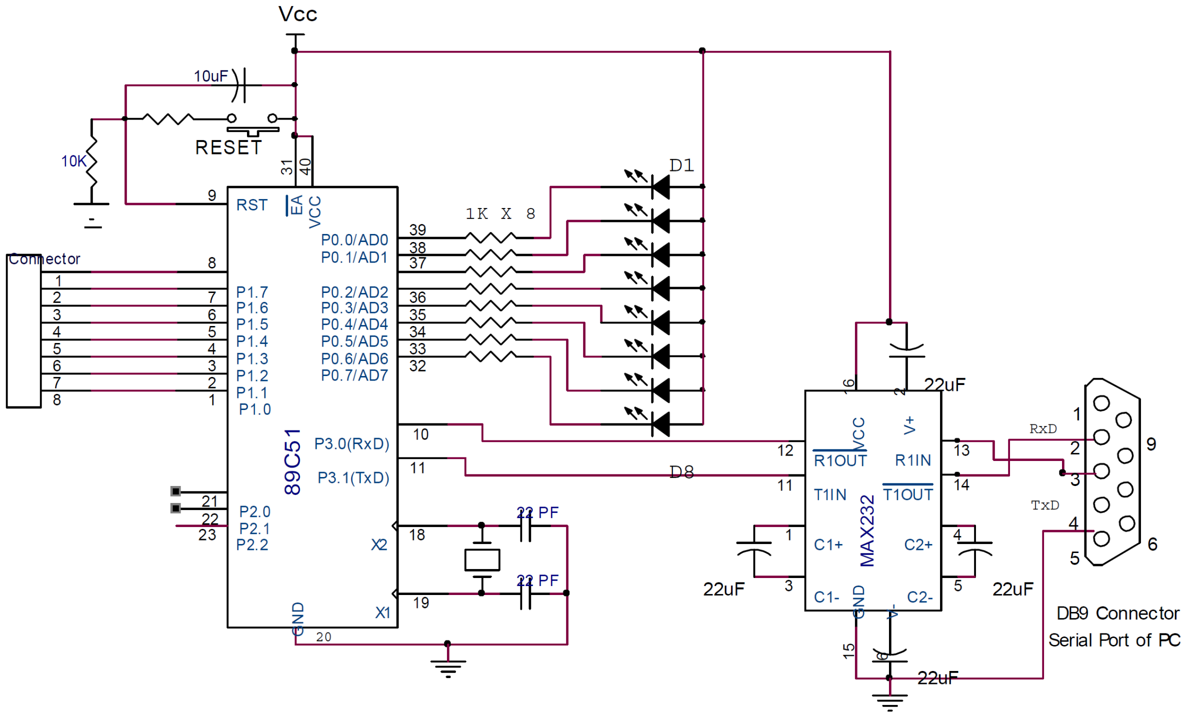
B. Modify program to read status of the switches connected to the port pins P3.2 and P3.3. If switch SW1 is pressed display “DEVICE ON” and make relay ON. If switch SW2 is pressed display “DEVICE OFF” and make relay OFF. Execute in your hardware.

Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

EXPERIMENT NO. 10

AIM: Write a program to transmit letter “E” continuously using serial port. Modify program to transmit text “YES”. Use 8 bit UART mode with baud rate 19,200.

Circuit diagram:



Serial data transmission:

Data transmission is unidirectional from microcontroller to the destination device. Each character takes 33.3 to 0.5 milliseconds for the transmission depending of the baud rate used. The program must wait until transmission of character is over before loading the next character in the SBUF. If program does not wait, data will be lost. This can be prevented with any one of the following method mentioned here.

- Use time delay between transmissions of two characters. Time delay can be chosen slightly higher than known transmission time of one character. This method is simplest.
- Monitor TI flag of t he SCON special function register (SFR) to check whether character transmission is completed or not. Next character should be place d only after TI flag is set i.e. transmission is over.
- TI Flag must be cleared by the program before transmission of next character.
- We can also use interrupt method to check whether transmission is over or not. Serial interrupt can be invoked by TI or RI flag of SCON special function register. The vector location for the serial interrupt is 0023h. The serial interrupt bit ES (IE.4) and Enable interrupts bit EA (IE.7) are set in IE (Interrupt Enable) SFR. When transmission is over, TI flag will set and serial interrupt will be invoked. Program will jump to the location 0023h where user should writ e a routine to clear TI flag and load S BUF register by new character. In this practical, we will first write a program using polling method i.e. continuously checking TI flag and then we will write a program using interrupt method.

Program:

```
ORG 00H
AJMP START
```

```
START:      MOV TMOD,#20h          ;Configure Timer 1 in mode 2 auto reload mode.
            MOV TH1,#0fdh          ;Load TH1 with FDh to achieve baud rate 9600
            MOV SCON,#50h          ;8 bit, 1 stop bit, REN Enabled.
            MOV A,PCON             ; Transfer content of PCON to accumulator
            SETB ACC.7             ; Set bit 7 of accumulator
            MOV PCON,A             ; Set SMOD bit to 1 to double the baud rate
            SETB TR1
NEXT:       MOV SBUF,#'E'          ;Transfer alphabet 'A' to SBUF
HERE:       JNB TI,HERE            ;Wait for the last bit
            CLR TI                 ;Clear TI for next 'A'
            SJMP NEXT
            END
```

Modified program:

```
        ;Program to transmit text "YES" using Look up table in ROM through
        ;serial port of the microcontroller using 8 bit UART mode with baud rate
        ;19,200. TI flag is checked in this program to know whether transmission
        ;is over or not?
            ORG 00H
            AJMP START
START:      MOV TMOD,#20h          ;Configure Timer 1 in mode 2 auto reload mode.
            MOV TH1,#0fdh          ;Load TH1 with FDh to achieve baud rate 9600
            MOV SCON,#50h          ;8 bit, 1 stop bit, REN Enabled.
            MOV A,PCON             ; Transfer content of PCON to accumulator
            SETB ACC.7             ; Set bit 7 of accumulator
            MOV PCON,A             ; Set SMOD bit to 1 to double the baud rate
            SETB TR1
REPT:       MOV DPTR,#0400h
NEXT:       CLR A
            MOVC A,@A+DPTR         ; Get letter from look up table
            JZ REPT
            MOV SBUF,A             ;Transfer letter from look up table
HERE:       JNB TI,HERE            ;Wait for the last bit
            CLR TI                 ;Clear TI for next character
            INC DPTR
            SJMP NEXT
            ORG 0400h
            DB 'YES',0
EXIT:       END
        ;Modified program for Serial transmission using interrupt method:
        ;Program to transmit data from RAM through serial port of
        ;the microcontroller using 8 bit UART mode with baud rate 9600
        ;Serial port interrupt is used for data transmission.
            ORG 00h
            AJMP start
            ORG 23h                ;Location for serial interrupt
            ajmp serial
            RETI                   ;Return from the ISR
start:
```

```
            MOV P1,#0ffh            ;Make P1 output port
            MOV P2,#00h             ;Make P2 output port
            MOV TMOD,#20h           ;Timer 1, mode-2 ( auto reload mode)
            MOV TH1,#0FDh           ;Count value for baud rate 9600
            MOV SCON,#50h           ;8 bit UART mode, REN enable
            MOV IE,#90h             ; Enable serial interrupt and EA bit
            MOV R0,#20h             ;Pointer to the RAM location
            SETB TR1                ;Start timer 1 to generated baud rate.
next:       MOV A,@R0
            MOV SBUF,A
            INC R0
            CJNE R0,#2Fh,next
serial:     JB TI, transmit
            MOV A, SBUF
            MOV P0, A
            CLR RI
            RETI
transmit:   CLR TI
            RETI
            END
```

:: WORKSHEET::

Exercise:

A. Modify program to transmit string “WELCOME TO GEC GANDHINAGAR” using serial port. Use interrupt method and baud rate 9600.

Memory Location	HEX code	Label	Opcode	Operands	Comments

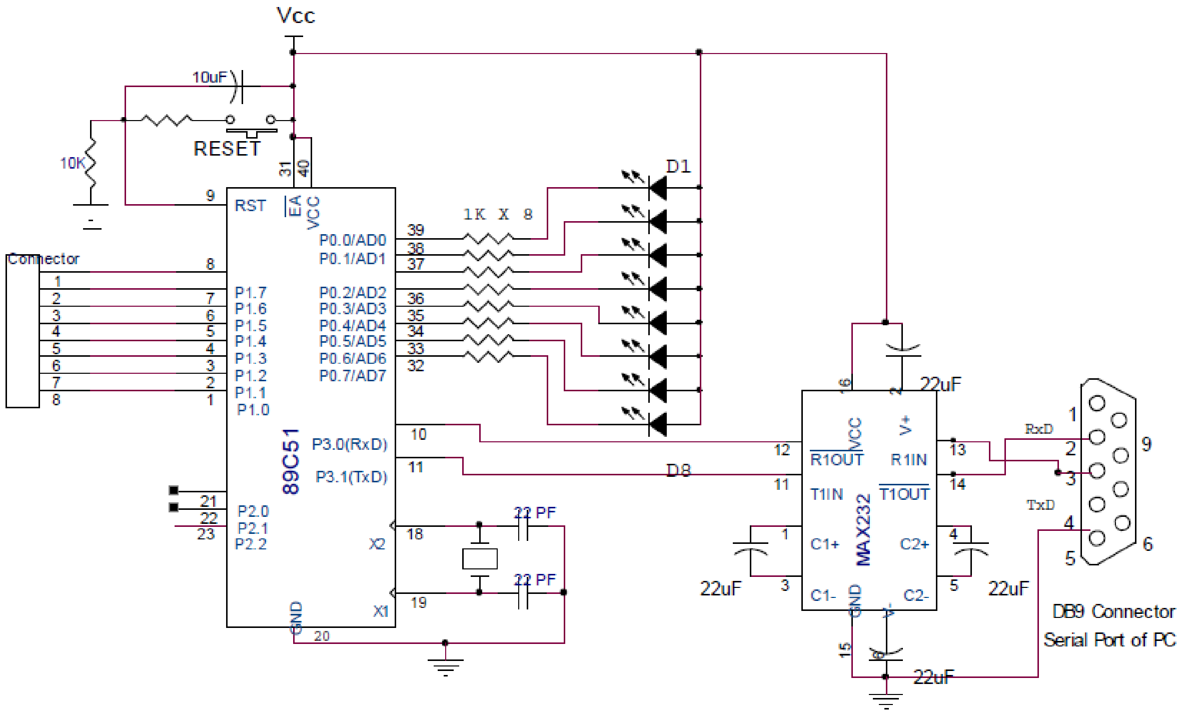
B. Write C program to transfer the message “GTU” 255 times serially at 9600 buad, 8-bit data, 1 stop bit.

Memory Location	HEX code	Label	Opcode	Operands	Comments

EXPERIMENT NO. 11

AIM: Write a program to receive bytes of data serially and display it on port P0. Use 8 bit UART mode with baud rate 9600.

Interfacing diagram:



Pin connections:

- LEDs are connected to port 0 to display received data from the serial port.
- Serial data transfer pins RxD and TxD are connected to the serial port of the computer thorough IC MAX 232. Max 232 provides necessary voltage conversion from TTL to serial port standards. As per RS232 standard, logic 1 has voltage range -3 to -25 V and logic 0 has voltage range +3 to +25 V.

Programming steps:

- The TMOD special function register is loaded with the value 20h to use timer 1 in mode 2 (8 bit auto-reload) to set baud rate. The value FDh is loaded in TH1 register to generate baud rate 9600 for the crystal of 11.059 MHz.
- The SCON register is loaded with the value 50h, indicating serial mode 1 in which 8 bit data is framed with start and stop bits.
- The timer 1 run control bit TR1 is set to high.
- The RI flag is cleared with the instruction CLR RI.
- The RI flag is monitored with the instruction:
  "**CHECK: JNB RI, CHECK**" instruction to check whether entire character has been received or not.
- When reception is over, RI is raised by microcontroller which indicates that SBUF has a byte and we can read it and display it at LEDs connected at Port P0.

Program 1: Serial data reception using polling method:

```
            ORG 00h             ; Start program from memory location 00h
            MOV TMOD,#20h       ;Timer 1, mode-2 ( auto reload mode)
```

```
                MOV TH1,#0FDh       ;Count value for baud rate 9600
                MOV SCON,#50h       ;8 bit UART mode, REN enable
                MOV P0,#00h         ;Port P0 output port
                SETB TR1            ;Start timer 1 to generated baud rate.
 CHECK:
                JNB RI,CHECK        ; Check whether data byte is received or not
                MOV P0,SBUF         ; Display received data on port P0
                CLR RI              ; Clear RI flag
                SJMP CHECK          ;Repeat task
                END
```

Program 2: Serial data reception using interrupt method:

In interrupt method, instead of checking RI flag continuously we use serial port interrupt. When RI flag set, program will automatically jump to the location 0023h which is vector location of serial interrupt. In this program we read port P1 continuously and display its content on port P2.

```
                ORG 00h
                AJMP start
                ORG 23h             ;Location for serial interrupt
                MOV P0,SBUF         ; Display received data on port P0.
 start:         CLR RI
                RETI                ;Return from the ISR
                MOV P1,#0ffh        ;Make P1 output port
                MOV P2,#00h         ;Make P2 output port
                MOV TMOD,#20h ;Timer 1, mode-2 ( auto reload mode)
                MOV TH1,#0FDh ;Count value for baud rate 9600
                MOV SCON,#50h ;8 bit UART mode, REN enable
                MOV IE,#90h ; Enable serial interrupt and EA bit
                SETB TR1 ;Start timer 1 to generated baud rate.
                next: MOV A, P1 ; Read port P1
                MOV P2,A ; Display content of port P1 on port P2.
                SJMP next ;Repeat task
                END
```

Program 3: Program at computer side:

Program for serial communication in "C" language is given here. Alternately we can use hyper terminal or XTalk software for serial communication.

```
                #include <dos.h>
                #include <stdio.h>
                #include <conio.h>
                #define PORT1 0x3F8
        /* Defines Serial Ports Base Address */
        /* COM1 0x3F8 COM2 0x2F8 COM3 0x3E8 COM4 0x2E8 */
                void main(void)
                {
                int c,ch;
                outportb(PORT1 + 1 , 0);            /* Turn off interrupts - Port1 */
                outportb(PORT1 + 0 , 0x0C);         /* Baud rate 9600 */
        /* Set Baud rate - Divisor Latch Low Byte */
        /* Default 0x03 = 38,400 BPS 0x01 = 115,200 BPS 0x02 = 57,600 BPS
        /* 0x06 = 19,200 BPS 0x0C = 9,600 BPS 0x18 = 4,800 BPS */
        /* 0x30 = 2,400 BPS */
                outportb(PORT1 + 1 , 0x00);          /* Set Baud rate - Divisor Latch High Byte
                outportb(PORT1 + 3 , 0x03);          /* 8 Bits, No Parity, 1 Stop Bit */
                outportb(PORT1 + 2 , 0xC7);          /* FIFO Control Register */
                outportb(PORT1 + 4 , 0x0B);          /* Turn on DTR, RTS, and OUT2 */
                printf("\nSerial Communication with microcontroller. Press ESC to quit \n");
                do { c = inportb(PORT1 + 5);         /* Check to see if char has been received */
                if (c & 1) {ch = inportb(PORT1);     /* If so, then get Char */
                printf("%c",ch);}                    /* Print Char to Screen */
                if (kbhit()){ch = getch();           /* If key pressed, get Char */
                outportb(PORT1, ch);}                /* Send Char to Serial Port */
                } while (ch !=27);
        /* Quit when ESC (ASC 27) is pressed */
                }
```

Program 4 : Receive and store data in RAM using interrupt

```
        ;Program to receive data through serial port of microcontroller at the
        ;baud rate 9600. Store data from the RAM location 20h
        ;This program uses interrupt method for reception of data
 start:         ORG 00h
                AJMP start
                ORG 23h                     ;Location for serial interrupt
                ACALL store
                RETI                        ;Return from the ISR
                MOV P1,#0ffh                ;Make P1 output port
                MOV P2,#00h                 ;Make P2 output port
                MOV TMOD,#20h               ;Timer 1, mode-2 ( auto reload mode)
                MOV TH1,#0FDh               ;Count value for baud rate 9600
                MOV SCON,#50h               ;8 bit UART mode, REN enable
                MOV IE,#90h                 ; Enable serial interrupt and EA bit
                MOV R0,#20h                 ;Pointer to the RAM location
                SETB TR1                    ;Start timer 1 to generated baud rate.
 next:          MOV A, P1
                MOV P2,A
                SJMP next                   ;Repeat task
 store:         MOV A,SBUF
                MOV @R0,A
                INC R0
                CLR RI
                RET
                END
```

Program 5: Receive and store data using polling (status checking)

```
        ;Program to receive data through serial port of microcontroller at the
        ;baud rate 9600. Store data from the RAM location 20h
        ;This program uses polling method.
                ORG 00h
                AJMP start
 start:         MOV TMOD,#20h               ;Timer 1, mode-2 ( auto reload mode)
```

```
            MOV TH1,#0FDh          ;Count value for baud rate 9600
            MOV SCON,#50h          ;8 bit UART mode, REN enable
            MOV R0,#20h            ;Pointer to the RAM location
            SETB TR1               ;Start timer 1 to generated baud rate.
next:       MOV A,SBUF
HERE:       JNB RI,HERE
            CLR RI
            MOV @R0,A
            INC R0
            SJMP next              ;Repeat task
            END
```

:: WORKSHEET ::

A. Modify program to display received data on the LCD connected at port P1. Assume control lines of LCD RS, EN and WR are connected to P2.0, P2.1 and P2.2 respectively.

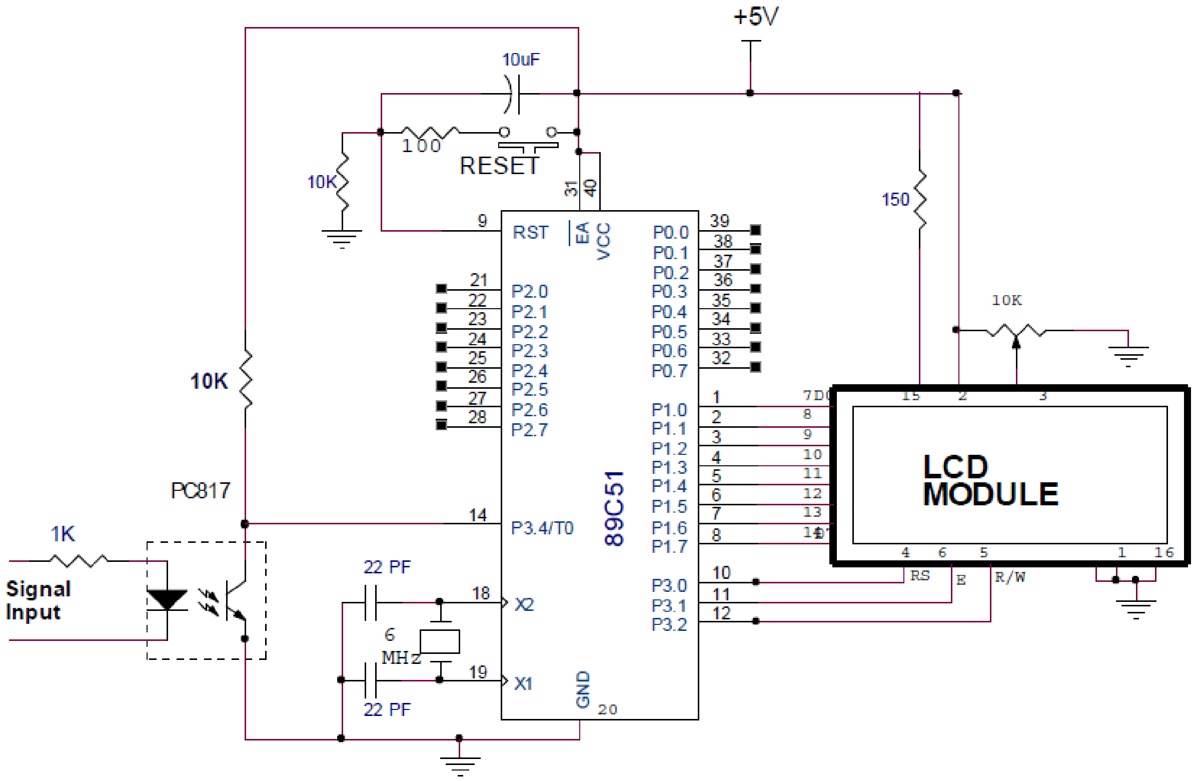
Memory Location	HEX code	Label	Opcode	Operands	Comments

:: Rough Work ::

EXPERIMENT NO. 12

AIM: Write a program to measure frequency of external pulses given at the timer 0 input pin. Display pulses on the LCD connected at port P1.

Circuit diagram:



Interfacing details:

- LCD data lines are connected to port P1.
- Control lines RS (Register select) is connected with port pin P3.0, Enable line connected with pin P3.1, read/write line connected with P3.2.
- Opto-coupler PC817 is used to provide optical isolation between signal to be measured and microcontroller. We can connect input signal with amplitude up to 12V to the opto-coupler. We may connect 230V AC signal by using series resistor of 47K at the input of opto-coupler. Pulses from the opto-coupler PC817 connected to timer input pin T0.

Program:

```
;To measure frequency of external pulses using 89C51
;LCD Interfacing details:
;Port 1 Drives data lines, P3.0-RS,P3.1 EN,P3.2 RW
;Signal connected through optocoupler PC817 at pin T0 (P3.4)
        ORG 00H
        AJMP START
        ORG 03H
        RETI
        ORG 0BH
        RETI
        ORG 13H
        RETI
```

```
          ORG 1BH
          RETI
          ORG 23H
          RETI
START:
          MOV SP,#60H
          MOV P1,#00H              ;Set P1 as an output port
          MOV P3,#00h              ;Set P3 as an output port
          MOV A,#38H               ;Initialize LCD, 2 lines, 5X7 matrix
          ACALL COMMAND            ;Issue command to the LCD
          MOV A,#0EH
          ACALL COMMAND            ;LCD ON, Cursor ON
          MOV A,#01H
          ACALL COMMAND            ;Clear LCD
          MOV A,#06H
          ACALL COMMAND            ;Shift cursor right
          MOV A,#80H
          ACALL COMMAND            ;Force cursor at begining of the first line
          MOV DPTR,#MSG            ;Point to message "Freq:"
          ACALL DISP_MSG           ;Display message on first line
          MOV TCON,#00H            ;Timer 0 & Timer 1 off, flags in reset condition
          MOV TMOD,#15H            ;Timer 1 as a timer in mode 2 &
                                   ;Timer 0 as a counter in mode 1.
LOOP:     MOV TL1,#0E0H            ;Load Timer 1 with 45535(B1E0h)
          MOV TH1,#0B1H            ;results in 0.01 second delay)
          MOV TL0,#00H             ;Reset counter for counting operation
          MOV TH0,#00H
          MOV A,#088H              ;Move cursor to line 2, position 8
          ACALL COMMAND
          MOV R1,#00H              ;Clear R1 for overflow counting
          MOV TCON,#50H            ;Start timer 0 and timer 1
CHECK:    JNB TF1,CHECK
          CLR TF1
          MOV TL1,#0E0H            ;Load Timer 1 with 45536(b1e0h) results
                                   ;in 0.01 SECOND DELAY)
          MOV TH1,#0B1H
          SETB TR1
          INC R1
          CJNE R1,#64H,CHECK       ;Count 100 interrupts to provide delay
                                   ;100X0.01 =1second
READ_FREQ:
          CLR TR0                  ;Stop timer 0
          CLR TR1                  ;Stop timer 1
          MOV 30H,TL0              ;Transfer LSB of 16 bit count value at RAM
                                   ;location30h
          MOV 31H,TH0              ;Transfer MSB of 16 bit count value at RAM
                                   ;location 31h
          ACALL HEXBCD             ;Convert hex number into binary numbers
```

```
                MOV A,37H                   ;Convert the number stored at 37h into ASCII
                ACALL HEXASCI
                ACALL DISP_DATA             ; Display ASCII code of number at LCD
                MOV A,36H
                ACALL HEXASCI
                ACALL DISP_DATA
                MOV A,35H
                ACALL HEXASCI
                ACALL DISP_DATA
                MOV A,34H
                ACALL HEXASCI
                ACALL DISP_DATA
                MOV A,33H
                ACALL HEXASCI
                ACALL DISP_DATA
                AJMP LOOP
HEXASCI:
                ADD A,#36H
                JNB PSW.6,SKIP
                ADD A,#07H
SKIP:           SUBB A,#06H
                RET
                HEXBCD:
                MOV 35h,#0
                MOV 36h,#0
                MOV 37h,#0
                MOV A,30h
                MOV B,#10
                DIV AB
                MOV 33h,B
                MOV 34h,A
                MOV A,31h
                JZ GO_NEXT
                MOV B,#10
                DIV AB
                MOV 35h,B
                MOV 36h,A
       ; Value in 35h is 256 times higher than value standing in 33h, 34h. Mply 35h with 6,
       ; add to 33h, mply 35h with 5, add to 34h, mply 35h with 2 and replace itself in 35h
                MOV R0,#35h                 ; Point to 35h
                ACALL TRANSF                ; Transform 35h to 3 lower position
                INC R0                      ; Repeat from 36h, now all registers are 1 higher
                ACALL TRANSF                ; Transform 36h to 3 higher positions
GO_NEXT:
                MOV R0,#33h                 ; Point to lowest digit i.e. first digit
                ACALL DECADJ
                RET
TRANSF:
```

```
            MOV A,@R0
            MOV B,#6
            MUL AB
            DEC R0
            DEC R0
            ADD A,@R0
            MOV @R0,A
            INC R0
            INC R0
            MOV A,@R0
            MOV B,#5
            MUL AB
            DEC R0
            ADD A,@R0
            MOV @R0,A
            INC R0
            MOV A,@R0
            RL A                    ; Mply with 2
            MOV @R0,A
            RET
DECADJ:
            MOV A,@R0
            DECLOP:
            MOV B,#10
            DIV AB
            MOV @R0,B
            INC R0
            ADD A,@R0
            MOV @R0,A
            CJNE R0,#37h,DECLOP
            RET
COMMAND:
            PUSH DPH
            PUSH DPL
            MOV P1,A
            ACALL DELAY             ;Write when when display not busy
            CLR P3.0                ;Select command register
            CLR P3.2                ;Write Enable
            SETB P3.1               ;Set Enable terminal of LCD
            NOP
            NOP
            CLR P3.1
            POP DPL
            POP DPH
            RET
DISP_DATA:
            PUSH DPH
            PUSH DPL
```

```
                ACALL DELAY
                MOV P1,A                ;Get data for display
                SETB P3.0               ;Select data register
                CLR P3.2                ;Enable Write
                SETB P3.1               ;Enable LCD (Strobe LCD)
                CLR P3.1                ;Clear Enable and latch data
                POP DPL
                POP DPH
                RET
DISP_MSG:
                ACALL DELAY
                CLR A
                MOVC A,@A+DPTR
                JZ EXIT
                ACALL DISP_DATA
                INC DPTR
                SJMP DISP_MSG
EXIT:           RET
DELAY:          MOV R7,#22H
LOOP2:          MOV R6,#0FFH
LOOP1:          DJNZ R6,LOOP1
                DJNZ R7,LOOP2
                RET
MSG:            DB 'FREQ:',0
                END
```

Connect signal from the function generator to the input of opto-coupler and measure frequency of the signal.

:: WORKSHEET ::

Exercise:

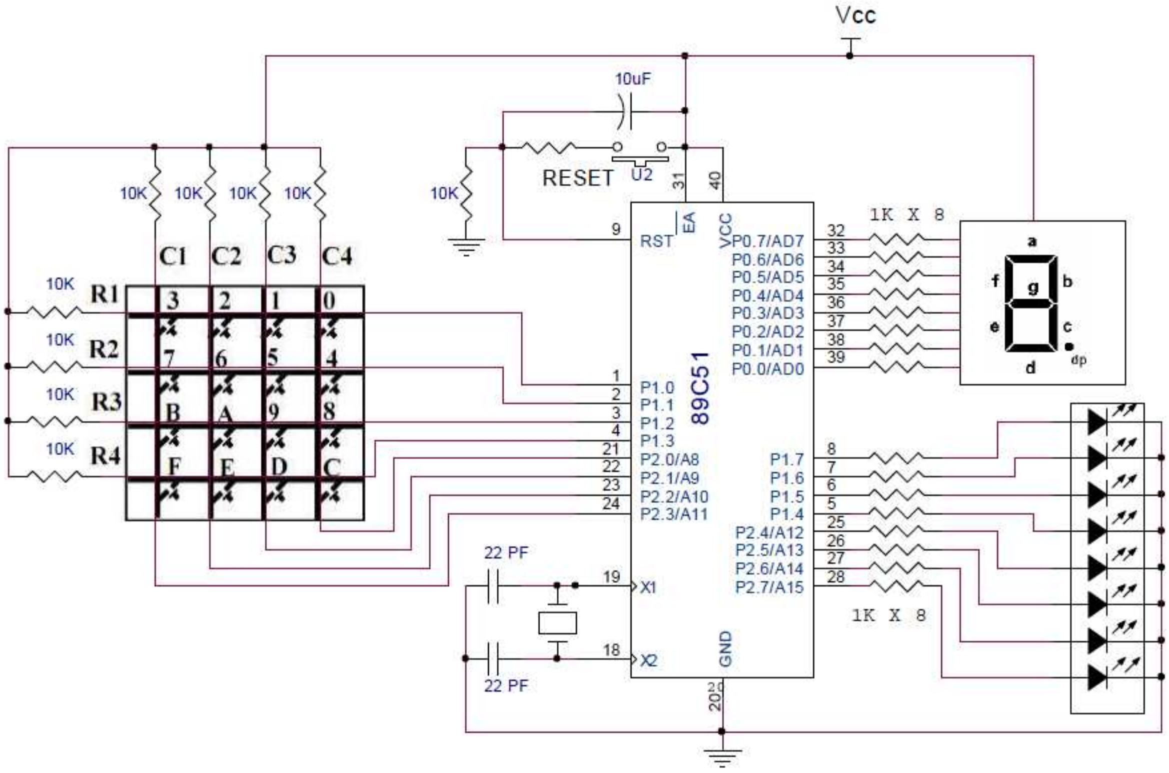
A. Simplify program to count external pulses given at T0 pin. Display this pulses on seven segment display connected at port P0.

Memory Location	HEX code	Label	Opcode	Operands	Comments

EXPERIMENT NO. 13

AIM: Interface matrix keyboard with 8051. Write program to display key pressed on seven segment display.

Circuit Diagram:



Interfacing details:

- Rows of matrix keyboard are connected to port pins P1.0 to P1.3
- Columns of matrix keyboard are connected to port pins P2.0 to P2.3
- Common anode seven segment display is connected to port P0
- LEDs are connected to port P1.7 to P1.4 and P2.4 to P2.7. These LEDs may be used to indicate which row is scanned and which column is read by the program. It may be used to indicate which key is pressed at present.

Program:

```
        ; Program to interface matrix keyboard 4x4. Rows are connected to the Port pins
        ; P1.0-P1.3 & Columns are connected to Port pins P2.0-P2.3. Rows are grounded
        ; one by one and read columns
        ; Seven segment display is connected at port P0
                ORG 00h
                AJMP START
                ORG 13h
                RETI
  START:
                MOV P0,#00h
                MOV P2,#0FH         ; Port Pins P2.0 to P2.3 i/p pins and P2.4 to P2.7 o/p pins
                MOV P1,#00H         ;Port P0 output port
                REL: MOV P1,#00H    ; Make All Rows Ground To Check All Keys
                MOV A,P2            ;Read Port P2 To Ensure That All Keys Released
                ANL A,#0FH           ;Maks Upper Bits Because They Are Not Used
                CJNE A,#0FH,REL      ;Check Till All Keys Released
AGAIN:
                ACALL DELAY
                MOV A,P2             ;See If Any Key Pressed Or Not?
                ANL A,#0FH           ;Mask Upper Bits
                CJNE A,#0FH,KPRESS ; If A Is Not Equal To 0fh Then Key Is
                                     ; Pressed
                SJMP AGAIN           ; Check Again If Key Is Not Pressed
KPRESS:
                ACALL DELAY
                MOV A,P2
                ANL A,#0FH           ;MASK UNUSED UPPER BITS
                CJNE A,#0FH,KPRESS1 ; if a is not equal to 0fh then key is
                                     ;pressed
                SJMP AGAIN           ; CHECK AGAIN IF KEY IS NOT PRESSED
KPRESS1:
                MOV P1,#0FEH         ; Ground ROW 0
                MOV A,P2             ;Read All Columns
                ANL A,#0FH           ;Mask Unused Upper Bits
                CJNE A,0FH,R_0       ;key is pressed in first row (row 0),check
                                     ; columns
                MOV P1,#0FDH         ; Ground ROW 1
                MOV A,P2             ;READ ALL COLUMNS
                ANL A,#0FH           ;MASK UNUSED UPPER BITS
                CJNE A,0FH,R_1       ;KEY IS PRESSED IN SECOND ROW (ROW 1),CHECK
                                     ; COLUMNS
                MOV P1,#0FBH         ; Ground ROW 2
                MOV A,P2             ;READ ALL COLUMNS
                ANL A,#0FH           ;MASK UNUSED UPPER BITS
                CJNE A,0FH,R_2       ;KEY IS PRESSED IN THIRD ROW (ROW 2),CHECK
                                     ; COLUMNS
                MOV P1,#0F7H         ; Ground ROW 0
                MOV A,P2             ;READ ALL COLUMNS
                ANL A,#0FH           ;MASK UNUSED UPPER BITS
                CJNE A,0FH,R_3       ;KEY IS PRESSED IN FOURTH ROW (ROW 3),CHECK
                                     ; COLUMNS
                LJMP AGAIN
R_0:            MOV DPTR,#KCODE0 ;SET DPTR=START OF ROW 0
                SJMP CHECK_C
R_1:            MOV DPTR,#KCODE1 ;SET DPTR=START OF ROW 1
                SJMP CHECK_C
R_2:            MOV DPTR,#KCODE2 ;SET DPTR=START OF ROW 2
                SJMP CHECK_C
R_3:            MOV DPTR,#KCODE3 ;SET DPTR=START OF ROW 3
CHECK_C:
                RRC A                ;CHECK WHETHER CARRY OCCURS OR NOT
                JNC GET_CODE
```

```
            INC DPTR
            SJMP CHECK_C
GET_CODE:   CLR A
            MOVC A,@A+dptr
            MOV P0,A
            LJMP REL
DELAY:      MOV R7,#0FFh
DLOOP:      MOV R6,#0FFh
D_LOOP:     DJNZ R6,D_LOOP
            DJNZ R7,DLOOP
            RET
KCODE0:     DB '0','1','2','3' ;These codes are for LCDs
KCODE1:     DB '4','5','6','7' ;Replace this code by seven
KCODE2:     DB '8','9','A','B' ;segment code as per your
KCODE3:     DB 'C','D','E','F' ;Circuit.
```

:: WORKSHEET ::

Exercise:

A. Prepare seven segment code for common anode seven segment display and replace it with ASCII code in look up table as shown in the program. Run the program and see the result.

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Modify program such that LEDs connected at P1.4 to P1.7 shows which row is scanned by the program and P2.4 to P2.7 shows which key is pressed in each row.

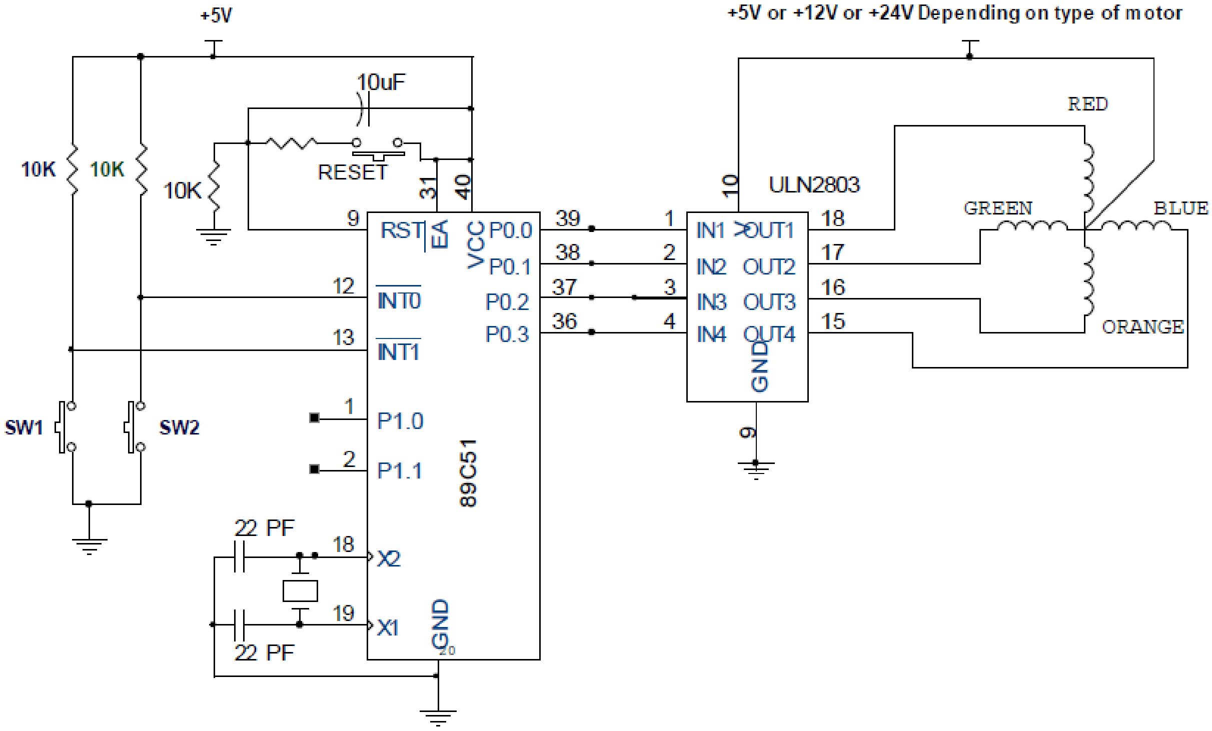
Memory Location	HEX code	Label	Opcode	Operands	Comments

:: Rough Work ::

EXPERIMENT NO. 14

AIM: Interface stepper motor with port P0 of the microcontroller. Write a program to rotate motor in clockwise and anticlockwise direction in half step and full step mode.

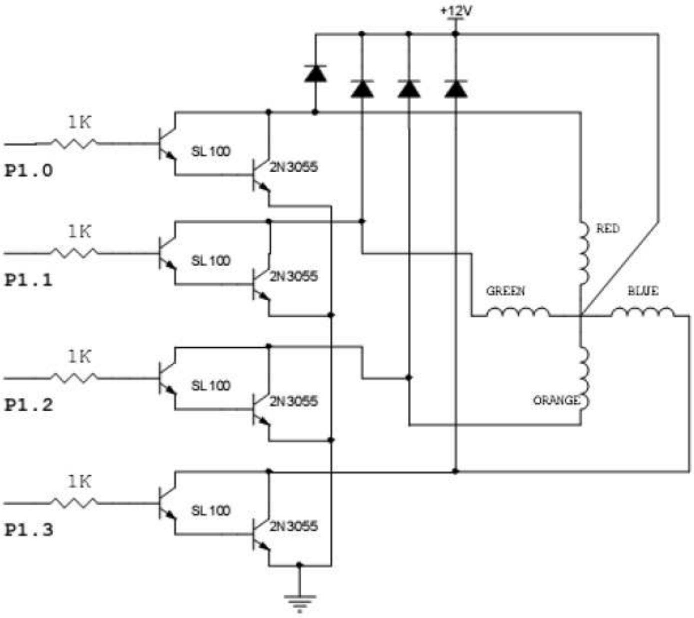
Circuit diagram:



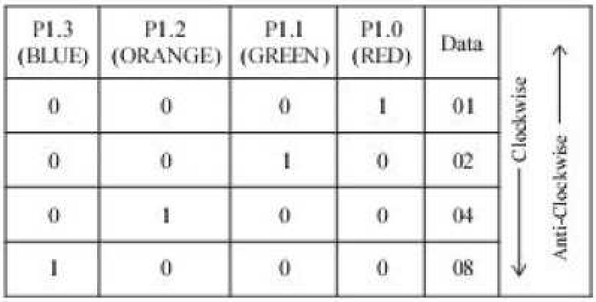
Interfacing details:

Interfacing of small torque stepper motor with torque of 2Kg-cm is shown in above diagram. Such motor requires current rating of 0.5 A per phase. Four terminals of the stepper motor are controlled with PORT P0. As PORT P0 cannot supply desired current, IC ULN 2803 is used to supply necessary drive current to the motor. ULN2803 is high voltage high current Darlington arrays consists of eight Darlington open collector transistors. Each Darlington pair can drive load current upto 500 mA. This IC consists of internal suppression diodes for the inductive loads. These diodes are used to protect switching transistor from breakdown. When transistor switched from ON to OFF state, large voltage induced across coil of stepper motor can damage the transistor. The suppression diode discharge energy stored in the inductor when transistor is in OFF condition.

To drive stepper motor with torque 7 kg-cm, +12V it requires current of 2A/phase. This stepper motor requires combination of transistor SL-100 and 2N3055 as shown in the following circuit diagram. Program will remain same. Control signals may come from any port of microcontroller. In this circuit control signals from port pins P1.0 to P1.3 are shown.



Sequence of pulses required to send on port P0 to rotate motor in clockwise and anticlockwise direction for full step mode:

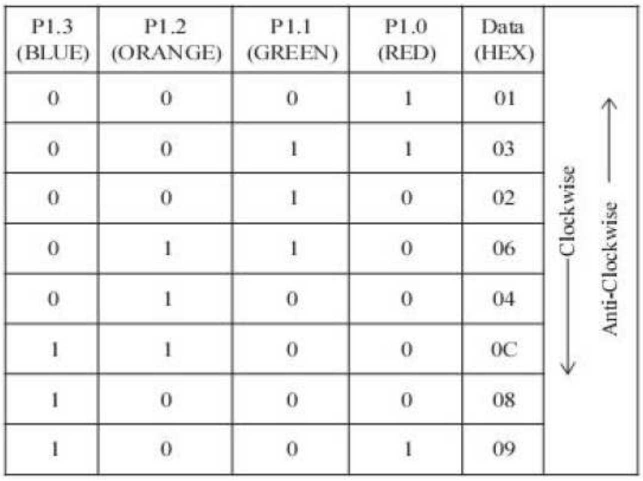


P1.3 (BLUE)	P1.2 (ORANGE)	P1.1 (GREEN)	P1.0 (RED)	Data	Clockwise ↓ Anti-Clockwise ↑
0	0	0	1	01	
0	0	1	0	02	
0	1	0	0	04	
1	0	0	0	08	

Program 1: To rotate motor for 100 steps in clockwise direction (Full step)

```
            ORG 30h
            MOV P0,#00h         ;Configure port P0 as an output port
            MOV R0, #64h        ;Load count value for 100 steps
            MOV A,#11h          ;Load accumulator with 11h
loop:       MOV P0,A            ;Sent data to port 1 (stepper motor)
delay:      ACALL delay         ;Delay to control speed
            RL A                ;Next data
            DJNZ R0, loop       ;Continue rotation if no. of steps<100
            MOV R2,#0FFh        ;Change this count to change speed
d_loop:     DJNZ R2,d_loop
            RET
            END
```

Sequence of pulses required to send on port P0 to rotate motor in clockwise and anticlockwise direction for half step mode:



P1.3 (BLUE)	P1.2 (ORANGE)	P1.1 (GREEN)	P1.0 (RED)	Data (HEX)
0	0	0	1	01
0	0	1	1	03
0	0	1	0	02
0	1	1	0	06
0	1	0	0	04
1	1	0	0	0C
1	0	0	0	08
1	0	0	1	09

Clockwise
Anti-Clockwise

Program 2: To rotate motor in half step mode continuously in clockwise direction.

```
                ORG 40h
 LOOP:
                MOV P0,,#00h        ;Define port P0 as output port
                MOV P0,#01h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#03h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#02h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#06h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#04h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#0Ch         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#08h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                MOV P0,#09h         ;Sent data to port 1 (stepper motor)
                CALL DELAY          ;Delay to control speed
                JMP LOOP            ;Continue rotation
 DELAY:         MOV R2,#0FFh        ;Change this count to change speed
 d_loop:        DJNZ R2,d_loop
                RET
                END
```

:: WORKSHEET ::

A. Consider that two push-button switches are connected at port pins P3.2 and P3.3. Write a program so that speed of the motor increases if switch connected at P3.2 pressed and speed of the motor reduces if switch connected at port pin P3.3 is pressed.
(**Hint:** use polling method or interrupt method to monitor key press event, reduce timer delay counter if switch connected at P3.2 is pressed. Increase time delay counter if switch connected at P3.3 is pressed)

Memory Location	HEX code	Label	Opcode	Operands	Comments

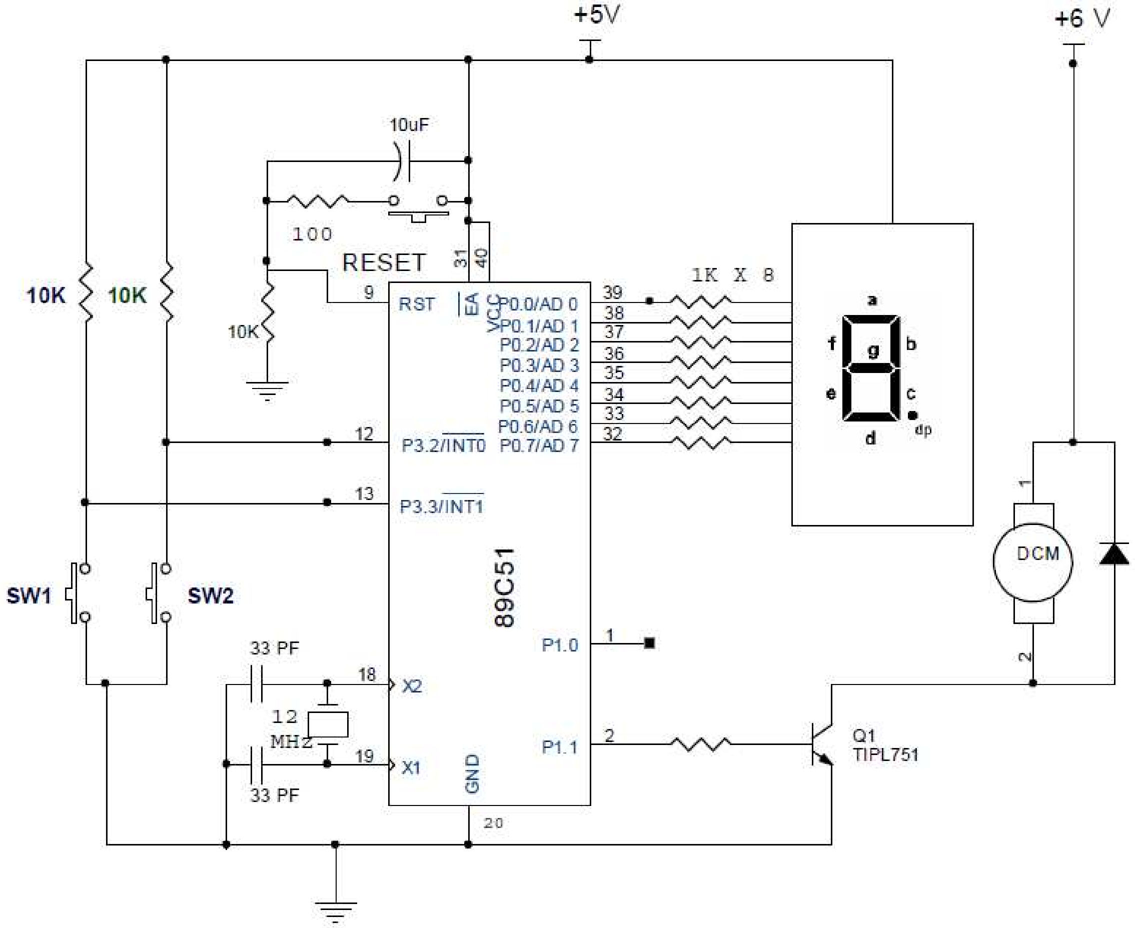
B. Consider that switch SW1 and SW2 shown in the circuit are two limit switches are connected at external interrupt pins P3.2 and P3.3. Write a program so that when switch SW1 is pressed, stepper motor rotates clockwise and when switch SW2 pressed, stepper motor rotates anticlockwise.
(**Hint:** Use external interrupt vector location. Prepare clockwise routine and call it at location 03h. Prepare anticlockwise routine and call it at vector location 13h. Enable external interrupt bits in IE SFR)

Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

EXPERIMENT NO. 15

AIM: Interface DC motor with AT89C51 microcontroller. Write a program to rotate motor with different speed using PWM.

Circuit Diagram:



Basic concept:

DC motor speed control is useful in controlling motion in industrial control systems as well as arm of robots. To control speed of DC motor, we can use variable DC voltage source. When supply is given to DC motor, it takes some time to reach at full speed. If we switch OFF DC power supply before it gets maximum speed, it starts to slow down. If we switch ON and OFF DC power supply continuously, speed of DC motor will be in between zero and full rated speed. If duty cycle is more (i.e. ON time is more than OFF time) speed is more and if duty cycle is less (ON time is less than OFF time), speed of the motor is also less. Thus, if we apply PWM (Pulse Width Modulated) waveform to the motor, we can change speed of the motor. When width of pulse is highest, speed of motor is also highest and when width of pulse is lowest, speed of motor is also lowest.

Interfacing details:

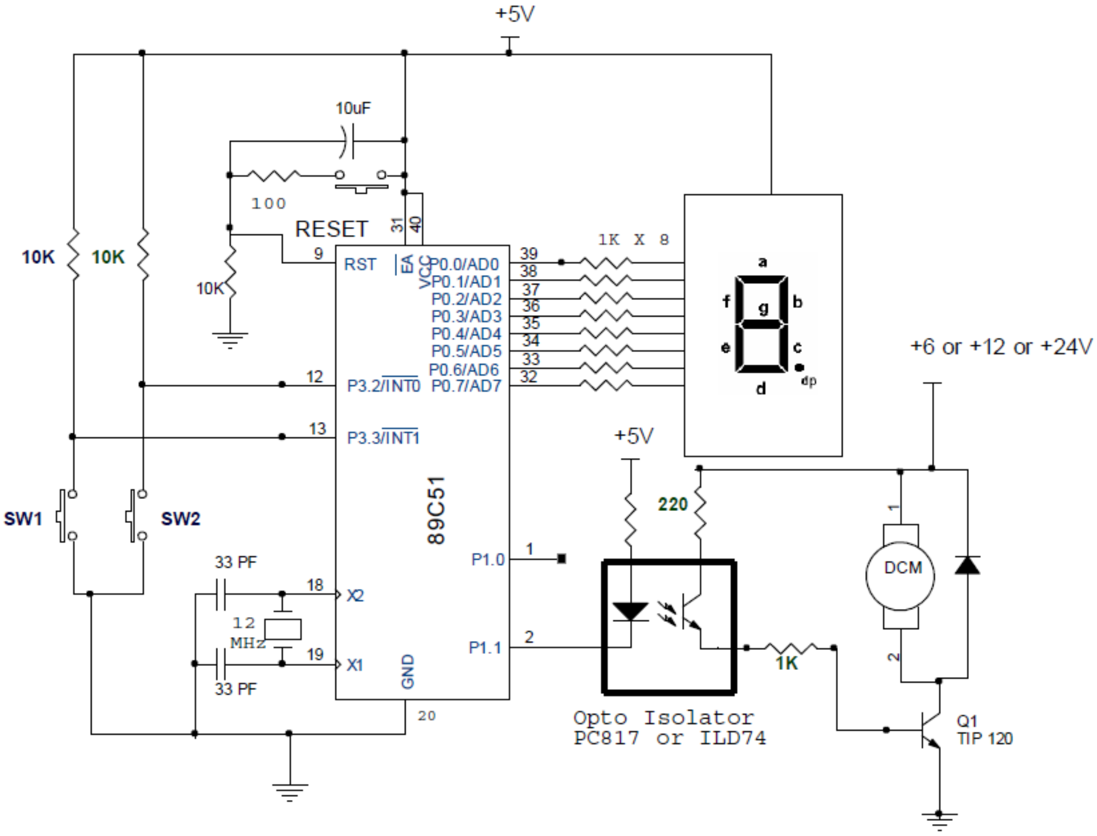
Simple DC motor control circuit is shown in the circuit diagram. Common anode seven segment display is connected to port P0 to show the speed of the motor in numeric form. DC motor is connected to the collector of transistor (We can use transistor TIP122 or 2N 3055). Transistor is controlled by signal from microcontroller port pin P1.1. Two push button switches SW1 and SW2 are connected at external interrupt pins to control speed of the DC motor. We can write program such that width of pulses increases when we press switch SW1 and width of pulses decreases when we press the switch SW2. This will control speed of the motor. Transistor acts as a switch which becomes ON when port pin P1.1 is set and becomes OFF when port pin P1.1 is reset.

Program:

```
            ORG 00h
            SJMP START
            ORG 03h
            INC B               ; Increase R7 to increase width of pulse
            RETI
            ORG 13h
            DEC B               ;Decrease R7 to decrease width of pulse
            RETI
START:      MOV IE,#85h         ; Enable external interrupt 0 and 1
            SETB IT0            ; Negative edge triggered interrupt
            SETB IT1            ;Negative edge triggered interrupt
            CLR P1.1            ; Make P1.1 output pin
            MOV B,#80h          ; Initial speed
next:       SETB P1.0
            ACALL ON_delay      ; Call delay for ON time
            CLR P1.0            ; Complement P1.0 to generate square wave
            ACALL OFF_delay     ; Call delay for OFF time
            SJMP next
OFF_delay:
            MOV R4,#00h
L1:         DJNZ R4, L1
            RET
ON_delay:
            MOV R7,B            ; Load count value from register B
L3:         MOV R6,#0FFh
L2:         DJNZ R6, L2         ; Decrement R6 until it becomes zero
            DJNZ R7,L3
            NOP                 ; No operation
            RET                 ; Return to main routine
            END
```

Optical isolation:

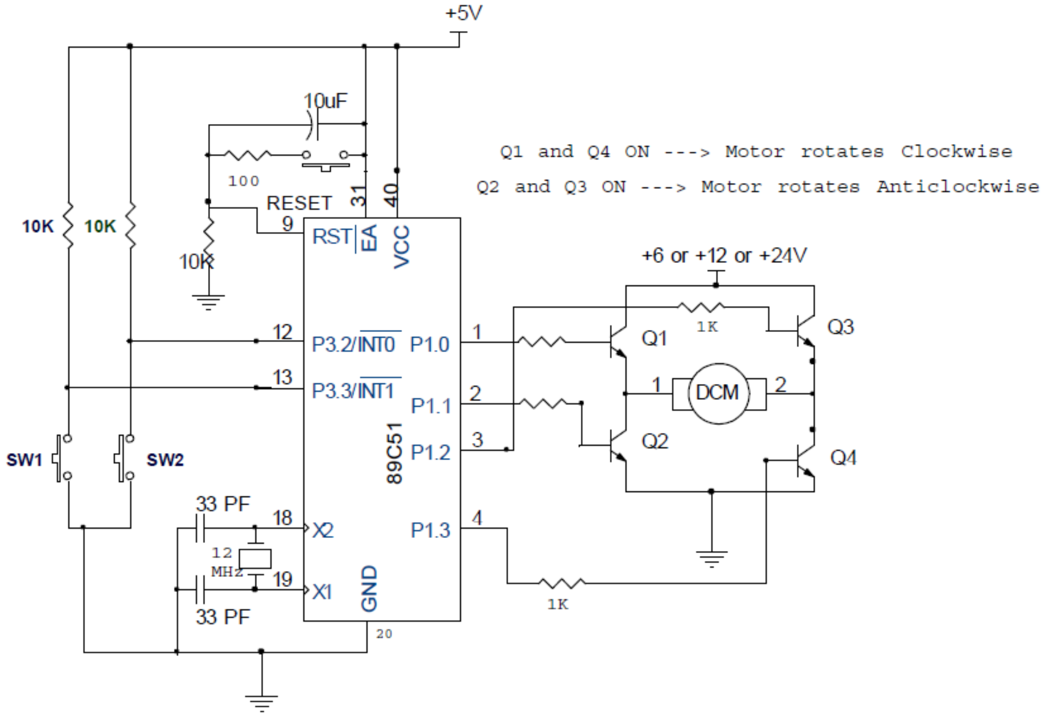
It is better to use opto-isolator between motor circuit and microcontroller because it will protect microcontroller from EMI created by the motor brushes. If motor voltage rating is higher than the voltage used for microcontroller then opto-isolator prevents damage to the microcontroller by providing optical isolation. If there is any fault in motor circuit or power supply, microcontroller is safe. Modified circuit using optoisolator is shown below:



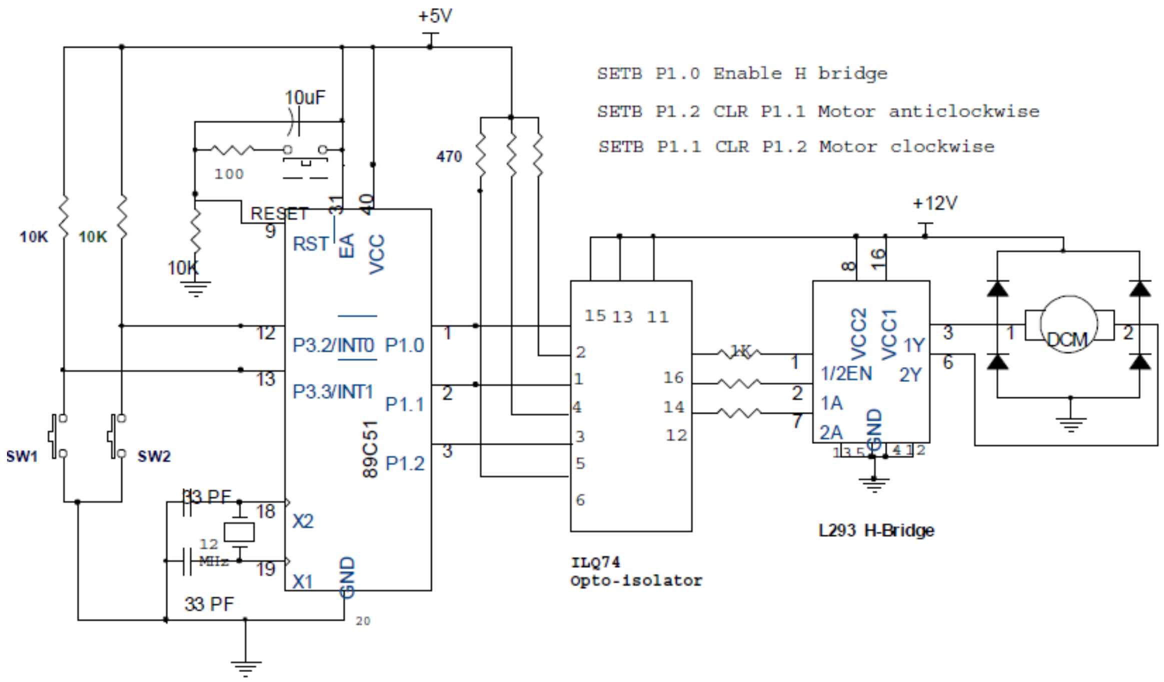
When port pin P1.1 is low, LED of opto-isolator will glow which makes transistor of opto-isolator ON. Current flows through base of transistor TIP120 and motor gets DC supply. Transistor of opto-isolator and TIP120 forms Darlington pair. When port pin P1.1 is high (i.e. set), LED will not glow, both transistors remains off and motor will not get DC supply. By controlling ON and OFF time of the LED, we can control speed of the DC motor. Program will be very much similar to the previous program, except we will interchange SETB P1.1 and CLR P1.1.

H-Bridge configuration for bi-directional rotation:

Direction of DC motor can be changed by changing polarity of DC voltage. H-Bridge configuration is very popular for bi-directional speed control. Interfacing of H-bridge with microcontroller is shown in the following circuit diagram. We need four microcontroller pins to control direction and speed of the DC motor. When port pins P1.0 and P1.4 are high, motor rotates in clockwise direction and when pins P1.1 and P1.2 are high; motor rotates in anticlockwise direction because of reversal in current. Optical isolation is not shown in the circuit but it is better to use optical isolation for safety of microcontroller.



H-bridge is available in single IC form such as L293. Four transistors are inbuilt in this IC. This IC produces heat during the operation, hence it requires heat sink for continuous operation. Interfacing of H-bridge IC with microcontroller using Quad optocoupler IC ILQ74 is shown in the following Circuit diagram. Quad optocoupler IC has four in-built optocoupler which provides optical isolation between H-bridge circuit and microcontroller 89C51. Separate power supply can be used for microcontroller and motor circuit.



Program: Write a program to rotate DC motor connected in above circuit such that when switch SW1 is pressed, motor rotates in clockwise direction and when SW2 is pressed, motor rotates in anti-clockwise direction. Use external interrupts for the program.

```
                ORG 00h
                AJMP START
                ORG 03h             ; Vector location for external interrupt 0
                SETB P1.1           ; Rotate motor in clockwise direction
                CLR P1.0            ; -- do --
                RETI
                ORG 13h             ; Vector location for external interrupt 1
                SETB P1.1           ; Rotate motor in anticlockwise direction
                CLR P1.0            ; -- do --
                RETI
  START:        CLR P1.0            ; Make P1.0 output pin
                CLR P1.1            ; Make P1.1 output pin
                CLR P1.2            ; Make P1.2 output pin
                MOV IE,#85h         ; Enable external interrupt 0 and 1
                SETB IT0            ; Negative edge triggered interrupt
                SETB IT1            ; Negative edge triggered interrupt
                SETB P1.0           ; Enable chip L293 (H-bridge)
  HERE:         SJMP HERE
```

:: WORKSHEET ::

A. Modify previous program without using interrupts.
   (Hint: using polling method to check whether switch is pressed or not like JNB P3.2, clockwise.)

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Modify the first program of this practical, so that speed of the DC motor displayed on the seven segment display.
(Hint: Use look up table method to display 0 for minimum speed and 9 to display maximum speed.)

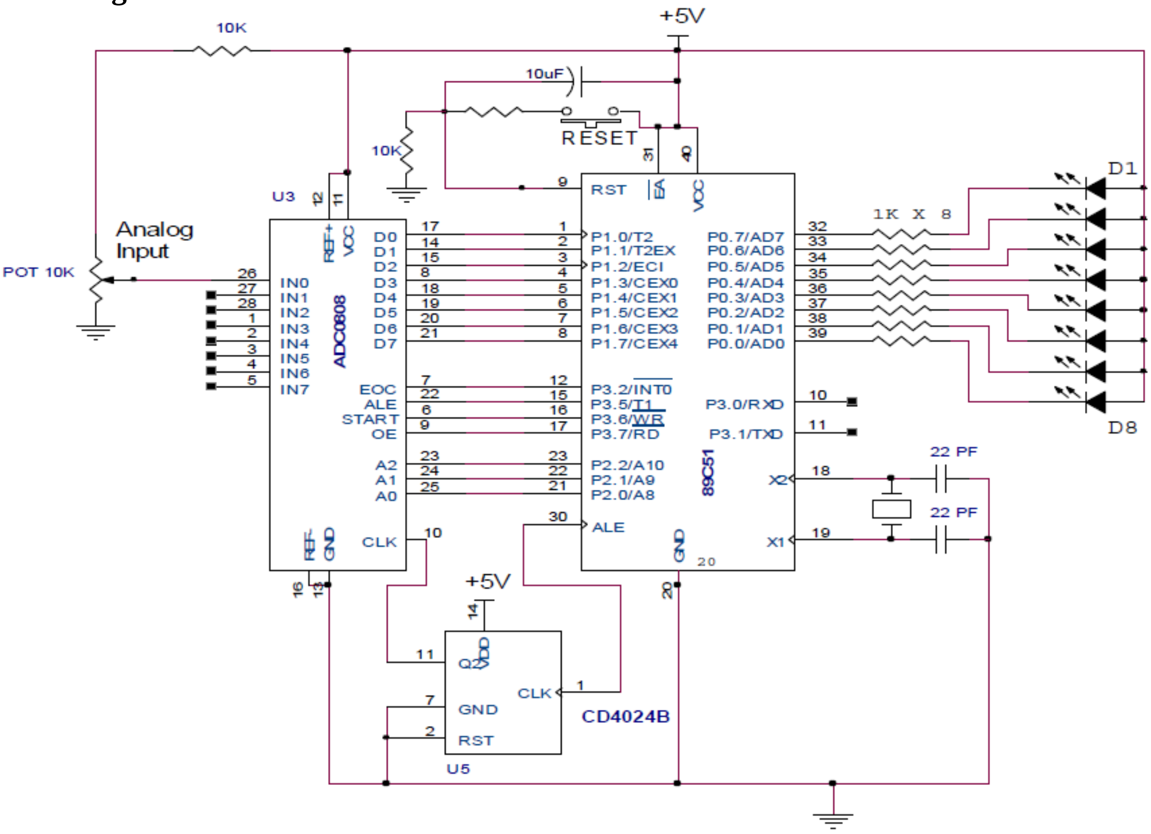
Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

:: Rough Work ::

EXPERIMENT NO. 16

AIM: Interface ADC0808 with AT89C51 microcontroller. Write a program to read analog voltage applied at the input of ADC. Display hex code of analog value on LEDs connected at port P0.

Circuit diagram:



Program:

```
; Microcontroller connections to ADC0808/9 lines.
   START        EQU P3.6              ; Pin 6 Start
   EOC          EQU P3.2              ; Pin 7 EOC
   OE           EQU P3.7              ; Pin 9 Output Enable
   ALE          EQU P3.6              ; Pin 22 ALE

                ORG 00h
                MOV P0,#00h           ; P0 OUTPUT PORT TO DRIVE LEDs
                MOV P1,#0FFH          ; P1 INPUT PORT TO READ ADC
                MOV P2,#00H           ; P2 OUTPUT PORT TO SELECT CHANNEL
                MOV R0,#05H
   LOOP:        MOV P0,#0FFH
                ACALL DELAY
                MOV P0,#00H
                ACALL DELAY
                DJNZ R0,LOOP
   BACK:
                MOV P2,#00H           ; SELECT ADC CHANNEL 0
                ACALL SDELAY
                SETB EOC            ; MAKE EOC INPUT
                CLR ALE
                CLR OE CLR
                START SETB
                START ACALL
                SDELAY CLR
                START
HERE:           JB EOC,HERE
HERE1:          JNB EOC,HERE1
                SETB OE
                ACALL SDELAY
                MOV A,P1
                CPL A
                MOV P0,A
                CLR OE
                AJMP BACK
DELAY:          MOV R7,#02h
L3:             MOV R6,#00h
L2:             MOV R5,#00h
L1:             DJNZ R5,L1
                DJNZ R6,L2
                DJNZ R7,L3
                RET
SDELAY:
                MOV R6,#00h
SL2:            MOV R5,#00h
SL1:            DJNZ R5,SL1
                DJNZ R6,SL2
                RET
                END
```

Observations:

Input Voltage	LED Status (ON/OFF)								Hex Value
	D7	D6	D5	D4	D3	D2	D1	D0	
0.5 V									
1 V									
2 V									
2.5 V									
3 V									
4 V									
5 V									

:: WORKSHEET::

A. Write a program to read analog value at the interval of 1 second and store it at memory location 50h onwards. Store total 16 values.

Memory Location	**HEX code**	**Label**	**Opcode**	**Operands**	**Comments**

B. Draw interfacing diagram to interface ADC0804 with AT89C51 microcontroller. Write program to read analog data and display its digital value on seven segment display connected at port P0.

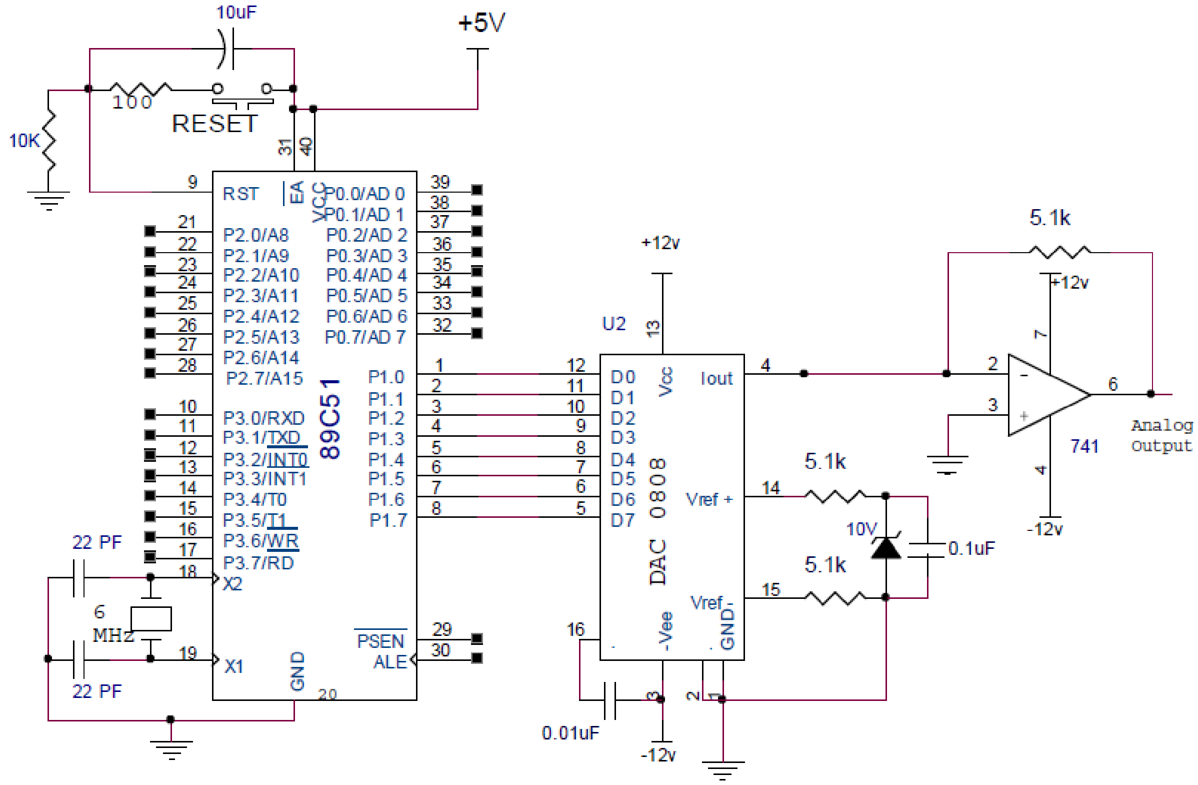
Memory Location	HEX code	Label	Opcode	Operands	Comments

:: Roght Work ::

EXPERIMENT NO. 17

AIM: Interface 8 bit DAC chip with 89C51 microcontroller. Write a program to generate sine wave using look up table.

Circuit diagram:



Interfacing details:

- Data lines of DAC-0808 are connected with Port P1 of the microcontroller AT89C51.
- Zener diode is used to provide reference voltage to the DAC.
- Current output of the DAC is converted into voltage by I to V converter circuit formed by Op-AMP 741.
- Connect C.R.O. at the output of DAC to observe analog signal.

Program:

```
            org 30h
rept:       mov dptr,#0400h
            mov P1,#00h
start:      clr a
            movc a,@a+dptr
            jz rept
            add a,#127
            mov P1,a
            setb P0.7
            acall delay
            inc dptr
            ajmp start
delay:      mov R7,#0ffh
loop:       djnz R7,loop
            ret
```

```
org 0400h
DB 1,8,16,24,32,40,47,54,62,69,75,82,88,93,99,104,108,112,116,119,122,124,124
DB 126,127,127,127,126,124,124,122,119,116,112,108,104,99,93,88,82,75,69,62,54
DB 47,40,32,24,16,8,1,-8,-16,-24,-32,-40,-47,-54,-62,-69,-75,-82,-88,-93,-99,-104
DB -108,-112,-116,-119,-122,-123,-124,-125,-126,-127,-127,-127,-126,-124,-122,-119
DB -116,-112,-108,-104,-99,-93,-88,-82,-75,-69,-62,-54,-47,-40,-32,-24,-16,-8,1,0
end
```

:: WORKSHEET::

Exercise:

A. Modify DAC program to generate ramp waveform at the output.

Memory Location	HEX code	Label	Opcode	Operands	Comments

B. Modify DAC program to generate Full wave rectifier waveform at the output.

Memory Location	HEX code	Label	Opcode	Operands	Comments

Component list for microcontroller mini-project and practical:

Part 1: List of components compulsory for all the students

1. Microcontroller IC Phillips 89V51RD2 with socket
2. Crystal 11.059 MHz
3. IC Max232 with socket
4. Male female connectors strip (According to PCB)
5. Capacitors:
    a. 33pF ---- 2
    b. 1000µF, 25V ---- 1
    c. 10µF, 25V ---- 6
    d. 100µF, 25V ---- 1
6. Resistors
    a. 10K ---- 12
    b. 470Ω ---- 8
    c. 1 K ---- 8
    d. 100 Ω ---- 2
    e. RN10K ---- 2
    (Resistor network, eight resistors in array, 10K Ω)
7. Transistor SL-100 ---- 1
8. Tactile push-button switch ---- 9
9. LED (Red and Green) ---- 4 each
10. General purpose microcontroller PCB
11. Serial cable
12. DC power supply socket (Female)
13. IC LM7805
14. Bridge rectifier 1 A
15. Transformer 0-12V

(Student can purchase +5V DC adapter (charger) instead of item no. 13 to 15)

Part 2: Components as per group:

Group 1: 1. LCD Module 16 character*2 line (With socket) and necessary connectors.
2. 10K preset

Group 2: 1. Common anode seven segment display --- 2
2. Resistors 680Ω --- 2

Group 3: 1. IC L293D
2. Small DC motor
3. ILQ 74 opto-isolator

Group 4: 1. DIP Switch (array of 4 switch) --- 2

Group 5: 1. Matrix keyboard
2. Common anode seven segment display

Group 6: 1. Relay 12V, 100 Ω (PCB mounted), Bulb holder

Group 7: 1. PC817 opto-coupler and LCD module with socket

Group 8: 1. Small stepper motor
2. IC ULN 2803

Group 9: 1. Thumb wheel switch, Common anode seven segment display and PCB mounted relay

Group 10: 1. DAC 0808,
2. Op-amp 741 (with socket),
3. Zener diode 10V,
4. Resistors 5.1K --- 2,
5. Capacitors 0.01µF and 0.1 µF

Group 11: 1. ADC0808 (with socket),
2. IC CD4024 with socket,
3. POT 10K.