Familiarization with 8051/8052 Microcontroller

Brihat Ratna Bajracharya

Department of Electronics and Computer Engineering, IOE Central Campus, Pulchowk
Lalitpur, Nepal

070bct513@ioe.edu.np

***Abstract*—a computer in a single chip is called microcontroller. All necessary blocks of computer like central processing unit, memory, input and output ports, clock, timers/counters and registers are all embedded into a single chip that is used for various educational and other purposes. Intel first introduced MCS-51 microcontroller in 1980. Today various other vendors like Atmel, Infineon Technologies, NXP, Silicon Laboratories, Texas Instruments, Dallas Semiconductors, ASIX, etc. are manufacturing microcontroller compatible with Intel's MCS-51 that can be used in various embedded systems.**

I. INTRODUCTION

The Intel MCS-51 (commonly termed **8051**) is an internally Harvard with CISC (Complex Instruction Set Computing) architecture single chip microcontroller series developed by Intel in 1980 for use in embedded systems. The original MCS-51 family was made using N-type metal-oxide-semiconductor (NMOS) but later versions identified by letter 'C' in their name (e.g. 80C51) used complementary metal-oxide-semiconductor (CMOS) technology.

The 8051 architecture provides many functions (like CPU (Central Processing Unit), RAM (Random Access Memory), ROM (Read Only Memory), I/O (Input/Output), Interrupt logic, Timer, etc.) in a single chip/package.

MCS-51 based microcontrollers typically include one or two UARTs, two or three Timers, 128 or 256 bytes of internal data RAM, 128 bytes of I/O, 512 bytes to 64 kilo-bytes of internal program memory and external data space. The original 8051 runs at 12 MHz clock frequency. Today's 8051 microcontroller has clock frequencies of up to 100 MHz.

A. Registers

There are eight 8-bit general purpose registers (R0 – R7). 8051 also have 8-bit Stack Pointer (SP, 0x81), 16-bit Data Pointer (DP, 0x82-83) and 8-bit Program Status Word (PSW). PSW consists of status flags like Parity (PSW.0), Overflow (PSW.2), Register Select (PSW.3 and PSW.4), Auxiliary Carry (PSW.6) and Carry (PSW.7). PSW does not contain Negative and Zero flags.

Accumulator (A, 0xE0) stores all intermediate result and B register (0xF0) along with accumulator is used for multiplication and division instructions.

B. Memory Architecture

The MCS-51 has four distinct types of memory.

1) Internal RAM – It has an 8 bit address space that allows access through 0x00 to 0xFF. RAM from 0x00 to 0x7F can be accessed directly and rest is accessed indirectly.

2) Special Function Registers – They are located in the same address space as RAM from address location 0x80 to 0xFF and are accessed directly.

3) Program Memory – It uses up to 64 kilo-bytes of ROM starting at address 0x00 in separate address space. It is accessed by the `MOVC A,@DPTR` instruction.

4) External Data Memory – It is a third address space starting at address 0x00 and allowing 16 bits of address space and is accessed using `MOVX` (MOVe eXternal) instruction. The first 256 bytes can be accessed using `MOVX A,@R0` instruction whereas full 64 kilo-bytes can be accessed using `MOVX A,@DPTR` and `MOVX @DPTR,A` instructions.

C. Instruction Set

Instructions in 8051 are all one to three bytes long, consisting of op-code byte followed by two bytes of operands. The most significant nibble of op-code specifies the operation and least significant nibble specifies one of twelve addressing modes as follows.

- ✓ `x8-xF` – Register direct (R0-R7)
- ✓ `x6-x7` – Register indirect (@R0 and @R1)
- ✓ `x5` – Memory direct, next byte specifies RAM or SFR location
- ✓ `x4` – Immediate, next byte specifies 8-bit constant

The operation in 8051 uses mnemonics as follows:

- ✓ `0y – INC operand`, e.g. 04 specifies `INC A`
- ✓ `1y – DEC operand`, e.g. 14 specifies `DEC A`
- ✓ `2y – ADD A, operand`, adds operand to A
- ✓ `3y – ADDC A, operand`, adds with carry
- ✓ `4y – ORL A`, operand, (A ← A **or** operand)
- ✓ `5y – ANL A`, operand, (A ← A **and** operand)
- ✓ `6y – XRL A`, operand, (A ← A x**or** operand)
- ✓ `7y – MOV operand, #data`, e.g. 74 specifies `MOV A, #data`
- ✓ `8y – MOV address, operand`, Moves data to RAM or SFR
- ✓ `9y – SUBB A, operand`, Subtracts operand from A with borrow
- ✓ `Ay – MOV operand, address` Moves data from RAM or SFR
- ✓ `By – CJNE operand, #data, offset`, Compares operand to data and branch to PC + offset if not equal. B4 and B5 performs `CJNE A, operand, offset`. There is no compare and jump if equal instruction

- ✓ Cy – XCH A, operand, swaps A and operand
- ✓ Dy – DJNZ operand, offset
  Decrement the operand and branch to PC + offset if result is not zero
- ✓ Ey – MOV A, operand, moves operand to A
- ✓ Fy – MOV operand, A, moves A to operand

Only ADD, ADDC, and SUBB affects PSW flags and CJNE instruction modifies the carry bit only

D. AT89S52 Micro-controller

The AT89S52 is a low power, high performance CMOS eight bit microcontroller with 8 kilo-bytes of in-system programmable flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 instruction set. The Atmel AT89S52 is a powerful microcontroller which provides a highly flexible and cost effective solution to many embedded control applications.

The AT89S52 provides the following standard features:

- 8 kilo-bytes of flash memory,
- 256 bytes of RAM,
- 32 I/O lines,
- Watchdog timer,
- 2 data pointers (DP),
- 3 16-bit timer/counters,
- A six-vector two-level interrupt architecture,
- A full duplex serial port,
- On-chip oscillator, and
- Clock circuitry.

In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The **idle mode** stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The **power down mode** saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

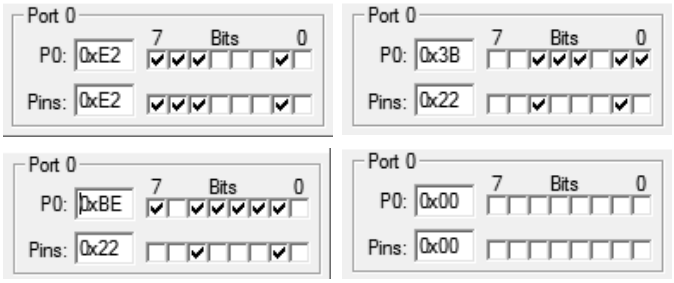
II. ACTIVITY I

Write code to add the numbers 897F9AH to 34BC48H and save the result in internal RAM starting at 40H. The result should be displayed continuously on the LEDs of the development board starting from least significant byte with an appropriate timing interval between each cycle. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
        ORG 00H

        MOV R0,#9AH
        MOV R1,#48H
        MOV R2,#7FH
        MOV R3,#0BCH
        MOV R4,#89H
        MOV R5,#34H
        MOV A,R0
        ADD A,R1
        MOV 40H,A
        MOV A,R2
        ADDC A,R3
        MOV 41H,A
        MOV A,R4
        ADDC A,R5
        MOV 42H,A
        MOV A,#0H
        ADDC A,#0H
        MOV 43H,A

AGAIN:  MOV R1,#04H
        MOV R0,#40H
NEXT:   MOV P0,@R0
        ACALL DELAY
        INC R0
        DJNZ R1,NEXT
        AJMP AGAIN

DELAY:  MOV R4,#7
HERE1:  MOV R5,#255
HERE2:  MOV R7,#255
HERE3:  DJNZ R7,HERE3
        DJNZ R5,HERE2
        DJNZ R4,HERE1
        RET

        END
```

Output:



Result of 89 7F 9A H plus 34 BC 48 H is 00 BE 38 E2 H

III. ACTIVITY II

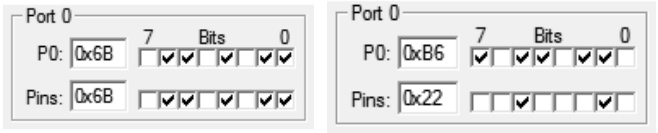
Implement a subroutine that replaces the SWAP instruction using rotate right instructions. Test your program on the contents of the accumulator when it contains the number 6BH. The original number and the result should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
        ORG 00H
```

```
AGAIN:    MOV A,#6BH
          MOV P0,A
          ACALL DELAY
          ACALL SWAP_RR
          MOV P0,A
          ACALL DELAY
          AJMP AGAIN

SWAP_RR:  RR A
          RR A
          RR A
          RR A
          RET

DELAY:    MOV R4,#7
HERE1:    MOV R5,#255
HERE2:    MOV R7,#255
HERE3:    DJNZ R7,HERE3
          DJNZ R5,HERE2
          DJNZ R4,HERE1
          RET

          END
```

Output:



Swapping upper and lower nibble of accumulator

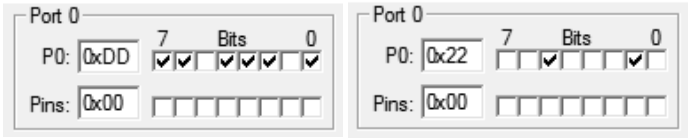
IV. Activity III

Multiply the data in RAM location 22H by the data in RAM location 15H and put the result in RAM locations 19H (low byte) and 1AH (high byte). Data in 22H should be FFH and data in 15H should be DEH. Use looping and successive addition technique. The product (high byte and low byte) should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
          ORG 00H

          MOV 22H,#0FFH
          MOV 15H,#0DEH

          MOV A,#0H
          MOV R1,#0H

          MOV R0,51H
AGAIN:    ADD A,50H
          JNC SKIP
          INC R1
SKIP:     DJNZ R0,AGAIN
          MOV 19H,A
          MOV 1AH,R1

LOOP:     MOV P0,A
          ACALL DELAY
          MOV P0,R1
          ACALL DELAY
          AJMP LOOP

DELAY:    MOV R4,#7
HERE1:    MOV R5,#255
HERE2:    MOV R7,#255
HERE3:    DJNZ R7,HERE3
          DJNZ R5,HERE2
          DJNZ R4,HERE1
          RET

          END
```

Output:



Product of FF H and DE H is DD 22 H

V. Activity IV

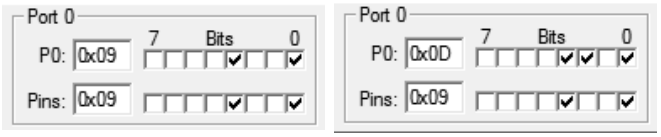
Divide the data in RAM location 3EH by the number 12H; put the quotient in R4 and the remainder in R5. Data in 3EH should be AFH. Use looping and successive subtraction technique. The quotient and remainder should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
          ORG 00H

          MOV 3EH,#0AFH
          MOV A,3EH
          MOV R4,#0H

AGAIN:    SUBB A,#12H
          JC DONE
          INC R4
          AJMP AGAIN
DONE:     ADD A,#12H
          MOV R5,A

LOOP:     MOV P0,R4
          ACALL DELAY
          MOV P0,R5
          ACALL DELAY
          AJMP LOOP

DELAY:    MOV R1,#7
```

```
HERE1:    MOV R2,#255
HERE2:    MOV R3,#255
HERE3:    DJNZ R3,HERE3
          DJNZ R2,HERE2
          DJNZ R1,HERE1
          RET

          END
```

Output:



Dividing AF H by 12 H gives quotient = 9 H and remainder = D H

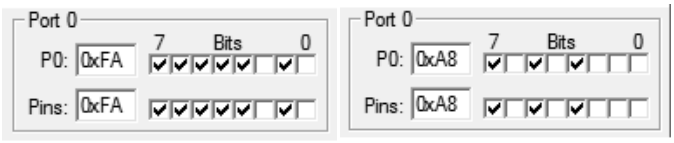
VI. Activity V

Store ten hexadecimal numbers in internal RAM starting from memory location 50H. The list of numbers to be used is: D6H, F2H, E4H, A8H, CEH, B9H, FAH, AEH, BAH, CCH. Implement a subroutine that extracts both the smallest and largest numbers from the stored numbers. The smallest and largest numbers should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
          ORG 00H

          MOV 50H,#0D6H
          MOV 51H,#0F2H
          MOV 52H,#0E4H
          MOV 53H,#0A8H
          MOV 54H,#0CEH
          MOV 55H,#0B9H
          MOV 56H,#0FAH
          MOV 57H,#0AEH
          MOV 58H,#0BAH
          MOV 59H,#0CCH

          MOV R0,#50H
          MOV A,@R0
          MOV R7,A     ;SMALLEST
          MOV R1,A     ;LARGEST

          MOV R2,#09H
NEXT:     INC R0
          MOV A,R7
          SUBB A,@R0
          JNC NO_SMALL
          MOV A,@R0
          MOV R7,A
NO_SMALL: MOV A,R1
          SUBB A,@R0
          JC NO_BIG
          MOV A,@R0
          MOV R1,A
NO_BIG:   DJNZ R2,NEXT

LOOP:     MOV P0,R7
          ACALL DELAY
          MOV P0,R1
          ACALL DELAY
          AJMP LOOP

DELAY:    MOV R3,#7
HERE1:    MOV R4,#255
HERE2:    MOV R5,#255
HERE3:    DJNZ R5,HERE3
          DJNZ R4,HERE2
          DJNZ R3,HERE1
          RET

          END
```

Output:



Largest number = FA H and smallest number = A8 H

VII. Activity VI

Store ten hexadecimal numbers in internal RAM starting from memory location 60H. The list of numbers to be used is: A5H, FDH, 67H, 42H, DFH, 9AH, 84H, 1BH, C7H, 31H.

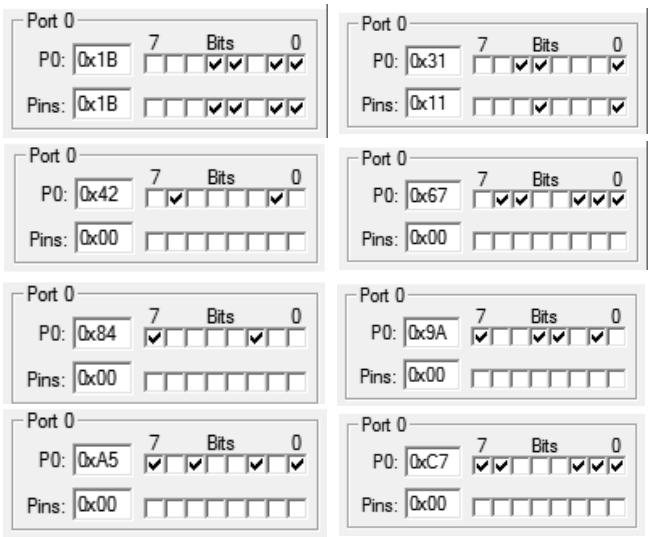
1. Implement a subroutine that orders the numbers in ascending order using bubble sort algorithm. The sorted list of numbers should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

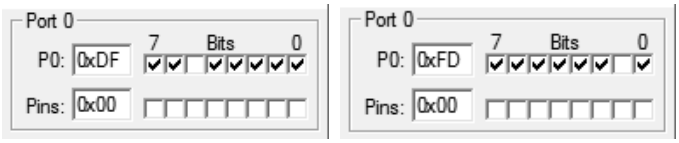
Assembly Code:

```
          ORG 00H

          MOV 60H,#0A5H
          MOV 61H,#0FDH
          MOV 62H,#67H
          MOV 63H,#42H
          MOV 64H,#0DFH
          MOV 65H,#9AH
          MOV 66H,#84H
          MOV 67H,#1BH
          MOV 68H,#0C7H
          MOV 69H,#31H

          MOV R1,#09H
AGN2:     MOV A,R1
          MOV R2,A
```

```
            MOV R0,#60H
            MOV A,@R0

AGN1:       INC R0
            MOV R3,A
            MOV A,@R0
            MOV R4,A
            MOV A,R3
            SUBB A,R4
            JC SKIP
            MOV A,R3
            MOV @R0,A
            MOV A,R4
            DEC R0
            MOV @R0,A
            INC R0
SKIP:       MOV A,@R0
            DJNZ R2,AGN1
            DJNZ R1,AGN2

REP:        MOV R1,#0AH
            MOV R0,#60H
LOOP:       MOV A,@R0
            MOV P0,A
            ACALL DELAY
            INC R0
            DJNZ R1,LOOP
            AJMP REP

DELAY:      MOV R3,#7
HERE1:      MOV R4,#255
HERE2:      MOV R5,#255
HERE3:      DJNZ R5,HERE3
            DJNZ R4,HERE2
            DJNZ R3,HERE1
            RET

            END
```

Output:





Sorted order (Ascending) using Bubble sort algorithm

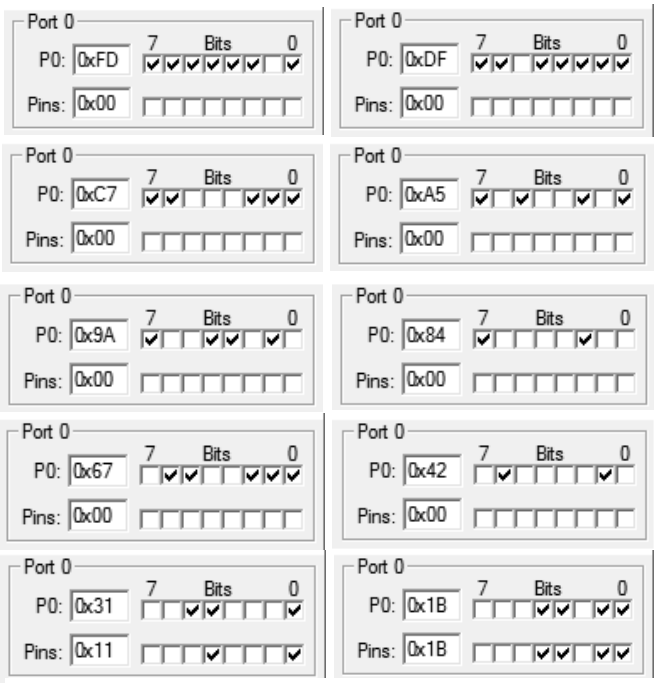
2. Implement a subroutine that orders the numbers in descending order using selection sort algorithm. The sorted list of numbers should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
            ORG 00H

            MOV 60H,#0A5H
            MOV 61H,#0FDH
            MOV 62H,#67H
            MOV 63H,#42H
            MOV 64H,#0DFH
            MOV 65H,#9AH
            MOV 66H,#84H
            MOV 67H,#1BH
            MOV 68H,#0C7H
            MOV 69H,#31H

            MOV R0,#60H
            MOV R6,#09H
AGN:        ACALL F_LARGE
            MOV @R0,A
            INC R0
            DJNZ R6,AGN

AGAIN:      MOV R1,#0AH
            MOV R0,#60H
LOOP:       MOV A,@R0
            MOV P0,A
            ACALL DELAY
            INC R0
            DJNZ R1,LOOP
            AJMP AGAIN

F_LARGE:    MOV B,R0
            MOV A,R6
            MOV R2,A
            MOV A,@R0
            MOV R1,A

NEXT:       INC R0
            MOV R4,A
            SUBB A,@R0
            JNC SKIP
            MOV A,@R0
            MOV R1,A
            MOV A,R4
```

```
            MOV @R0,A
SKIP:       MOV A,R1
            DJNZ R2,NEXT
            MOV R0,B
            RET

DELAY:      MOV R3,#7
HERE1:      MOV R4,#255
HERE2:      MOV R5,#255
HERE3:      DJNZ R5,HERE3
            DJNZ R4,HERE2
            DJNZ R3,HERE1
            RET

            END
```

Output:



Sorted order (Descending) using Selection sort algorithm

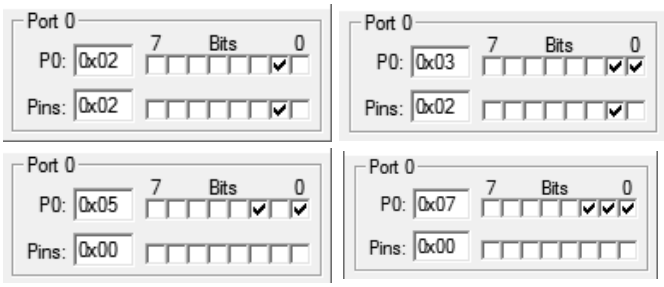
VIII. ACTIVITY VII

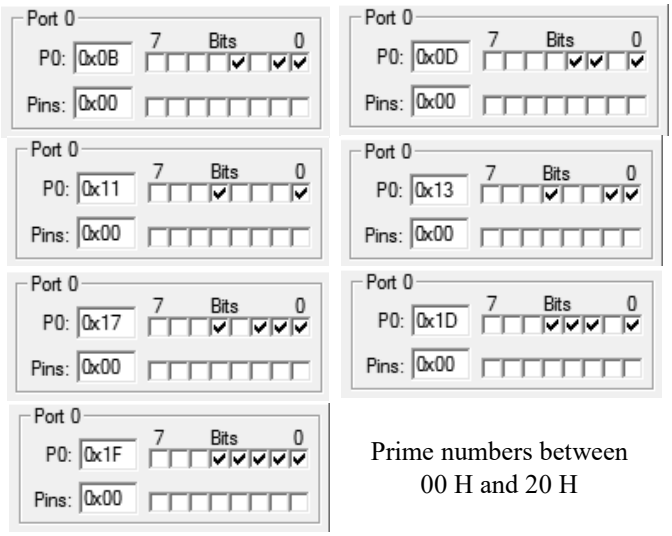
Store numbers from 00H to 20H in internal RAM starting from memory location 40H. Implement a subroutine that extracts only the prime numbers. The prime numbers should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
            ORG 00H

            MOV R0,#40H
            MOV A,#00H
AGAIN:      MOV @R0,A
            INC A
            INC R0
            MOV R1,A
            SUBB A,#20H
            JZ DONE2
            MOV A,R1
            AJMP AGAIN
DONE2:      MOV A,42H
            MOV P0,A
            ACALL DELAY
            MOV A,43H
            MOV P0,A
            ACALL DELAY

            MOV R0,#44H
            MOV R1,#1DH
NEXT:       ACALL PRIME
            INC R0
            DJNZ R1,NEXT
            AJMP DONE2

PRIME:      MOV A,@R0
            MOV R4,A ; SAVE A
            MOV R2,#02H
INC_B:      MOV A,R4
            MOV B,R2
            DIV AB
            MOV A,B
            JNZ N_RET
            RET

N_RET:      INC R2
            MOV A,R2
            SUBB A,@R0
            JNZ INC_B
            MOV A,R4
            MOV P0,A
            ACALL DELAY
            RET

DELAY:      MOV R7,#7
HERE1:      MOV R6,#255
HERE2:      MOV R5,#255
HERE3:      DJNZ R5,HERE3
            DJNZ R6,HERE2
            DJNZ R7,HERE1
            RET

            END
```

Output:





Prime numbers between 00 H and 20 H

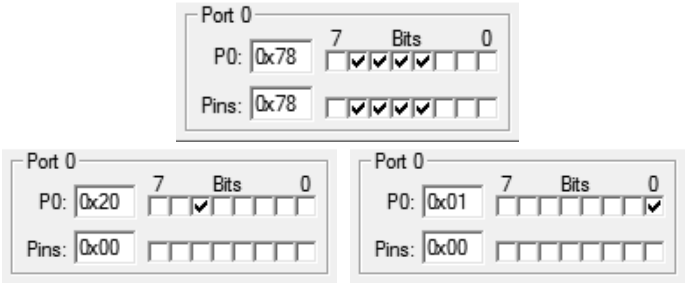
IX. Activity VIII

Find the factorial of a number stored in R3. The value in R3 could be any number in the range from 00H to 05H. Implement a subroutine that calculates the factorial. The factorial needs to be represented in both hexadecimal and decimal formats. The factorials in hexadecimal and decimal formats should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

Assembly Code:

```
            ORG 00H

            MOV R3,#05H
            MOV B,R3
            MOV R1,B
            ACALL FACTO

            MOV R1,A
AGAIN:      MOV A,R1
            MOV P0,A
            ACALL DELAY
            ACALL HTOD
            MOV P0,A
            ACALL DELAY
            MOV A,B
            MOV P0,A
            ACALL DELAY
            SJMP AGAIN

HTOD:       MOV R4,#00H
            MOV B,#0AH
            DIV AB
            MOV R2,A
            SUBB A,#0AH
            JC SKIP
            MOV A,R2
            MOV R3,B
            MOV B,#0AH
            DIV AB
            MOV R4,A
            MOV P0,A
            MOV A,B
            MOV B,R3
            MOV R2,A
SKIP:       MOV A,R2
            SWAP A
            ADD A,B
            MOV B,R4
            RET

DELAY:      MOV R7,#7
HERE1:      MOV R6,#255
HERE2:      MOV R5,#255
HERE3:      DJNZ R5,HERE3
            DJNZ R6,HERE2
            DJNZ R7,HERE1
            RET

FACTO:      MOV A,#01H
LOOP:       MOV B,R1
            MUL AB
            DJNZ R1,LOOP
            RET
            END
```

Output:



Factorial of 5 is 78 H or 120 D

X. Activity IX

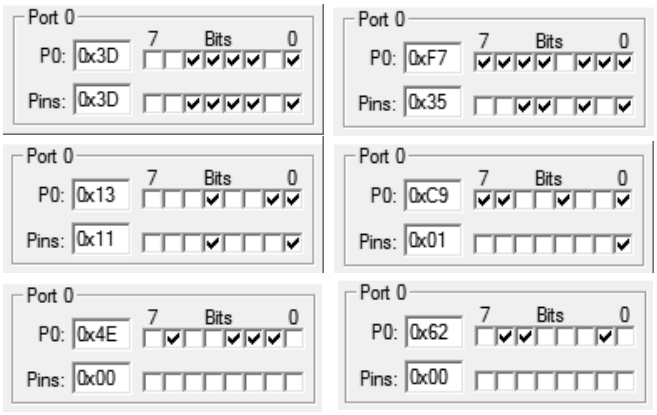
Store ten hexadecimal numbers in internal RAM starting from memory location 55H. The list of numbers to be used is: 25H, 3DH, F7H, 13H, C9H, 4EH, 62H, 77H, B8H, EBH. Implement a subroutine that searches for the occurrence of the binary sequence $(11)_2$ within a number amongst the given list of numbers. Only those numbers that contain the specified binary sequence should be displayed continuously on the LEDs of the development board one-by-one with an appropriate timing interval between them. Use port zero (P0) of the microcontroller to interface the LEDs.

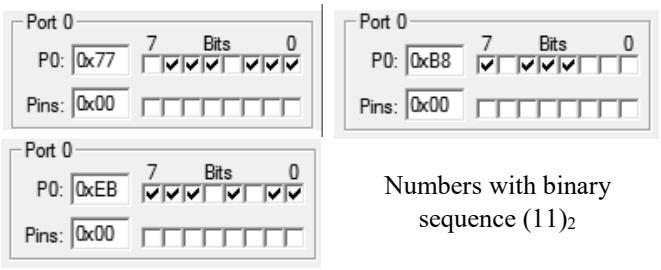
Assembly Code:

```
            ORG 00H

            MOV 55H,#25H
```

```
        MOV 56H,#3DH
        MOV 57H,#0F7H
        MOV 58H,#13H
        MOV 59H,#0C9H
        MOV 5AH,#4EH
        MOV 5BH,#62H
        MOV 5CH,#77H
        MOV 5DH,#0B8H
        MOV 5EH,#0EBH


LOOP:   MOV R0,#55H
        MOV R6,#0AH
AGN:    ACALL B_SEQ
        INC R0
        DJNZ R6,AGN
        AJMP LOOP

B_SEQ:  MOV A,@R0
        MOV R1,A
        MOV R2,#08H
BITT:   RLC A
        DEC R2
        JC CHK_NXT
        DJNZ R2,BITT
        RET
CHK_NXT: RLC A
        DEC R2
        JNC BITT
        MOV A,R1
        MOV P0,A
        ACALL DELAY
        RET

DELAY:  MOV R3,#7
HERE1:  MOV R4,#255
HERE2:  MOV R5,#255
HERE3:  DJNZ R5,HERE3
        DJNZ R4,HERE2
        DJNZ R3,HERE1
        RET

        END
```

Output:





Numbers with binary sequence $(11)_2$

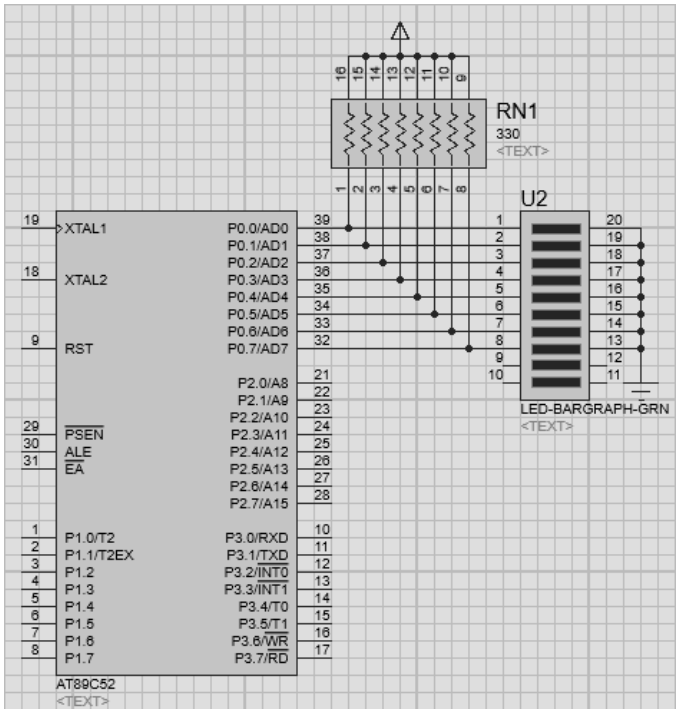
CONCLUSION

To be familiar with 8051 microcontroller and assembly language, various lab activities were done in assembly as well as in C programming Language. Keil IDE and Proteus Simulation Software were used to verify the result. Schematic diagram made in Proteus is included in Appendix section. Codes to all activities in assembly language are included in this report. In addition, all activities are also done in C programming language and their source code is given in Appendix section.

APPENDIX

Appendix A

Proteus Schematic Capture



Appendix B

Programs in C programming language

1. **C code for Activity I**

```
#include <reg51.h>
char data d[4] _at_ 0x40;
```

```
void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main(void)
{
  unsigned long a = 0x897f9a;
  unsigned long b = 0x34bc48;
  unsigned long c = a + b;
  unsigned int i;

  for(i=0; i<4; i++)
  {
        d[i] = c%0x100;
        c >>= 8;
  }

  while(1)
        for(i=0; i<4; i++)
        {
              P0 = d[i];
              delay(1000);
        }
}
```

2. C code for Activity II

```
#include<reg51.h>

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main()
{
  unsigned char value = 0xb6;
  unsigned char ivalue;
  unsigned char a,b;
  a = value / 0x10;
  b = value % 0x10;
  ivalue = b * (0x10) + a;

  while(1)
  {
        P0 = value;
        delay(1000);
        P0 = ivalue;
        delay(1000);
  }
}
```

3. C code for Activity III

```
#include <reg51.h>
char data multiplicand _at_ 0x22;
char data multiplier _at_ 0x15;
char data answer[2] _at_ 0x19;

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main(void)
{
  unsigned int result = 0x0;
  unsigned char i;

  multiplicand = 0xff;
  multiplier = 0xde;

  for(i=0x0; i<multiplier; i++)
        result += multiplicand;

  answer[0] = result % 0x100;
  result >>= 8;
  answer[1] = result % 0x100;

  while(1)
  {
        P0 = answer[0];
        delay(1000);
        P0 = answer[1];
        delay(1000);
  }
}
```

4. C code for Activity IV

```
#include <reg51.h>
unsigned int data dividend _at_ 0x3e;
unsigned char data reg4 _at_ 0x04;
unsigned char data reg5 _at_ 0x05;

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main(void)
{
  unsigned char divisor = 0x12;
  unsigned char quotient = 0x00;
  unsigned char remainder;

  dividend = 0x00af;

  while(1)
```

```
  {
        dividend -= divisor;
        if(dividend < 0x0)
              break;
        quotient += 0x1;
  }
  remainder = dividend + divisor;

  reg4 = quotient;
  reg5 = remainder;

  while(1)
  {
        P0 = quotient;
        delay(1000);
        P0 = remainder;
        delay(1000);
  }
}
```

5. C code for Activity V

```
#include <reg51.h>
unsigned char data d[10] _at_ 0x50;

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main(void)
{
  unsigned char smallest, largest;
  unsigned char i;

  d[0] = 0xd6; d[1] = 0xf2;
  d[2] = 0xe4; d[3] = 0xa8;
  d[4] = 0xce; d[5] = 0xb9;
  d[6] = 0xfa; d[7] = 0xae;
  d[8] = 0xba; d[9] = 0xcc;

  smallest = largest = d[0];
  for(i=1; i<10; i++)
  {
        if(d[i] < smallest)
              smallest = d[i];
        if(d[i] > largest)
              largest = d[i];
  }

  while(1)
  {
        P0 = smallest;
        delay(1000);
        P0 = largest;
        delay(1000);
  }
}
```

6. C code for Activity VI - 1

```
#include <reg51.h>
unsigned char data a[10] _at_ 0x60;

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main(void)
{
  unsigned char i, j, temp;
  a[0] = 0xa5; a[1] = 0xfd;
  a[2] = 0x67; a[3] = 0x42;
  a[4] = 0xdf; a[5] = 0x9a;
  a[6] = 0x84; a[7] = 0x1b;
  a[8] = 0xc7; a[9] = 0x31;

  for(i=0; i<10; i++)
        for(j=0; j<i; j++)
              if(a[j] > a[i])
              {
                    temp = a[i];
                    a[i] = a[j];
                    a[j] = temp;
              }

  while(1)
  {
        for(i=0; i<10; i++)
        {
              P0 = a[i];
              delay(1000);
        }
  }
}
```

7. C code for Activity VI 2

```
#include <reg51.h>
unsigned char data a[10] _at_ 0x60;

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main(void)
{
  unsigned char i, j, temp;
  unsigned char largest = a[0];

  a[0] = 0xa5; a[1] = 0xfd;
```

```
  a[2] = 0x67; a[3] = 0x42;
  a[4] = 0xdf; a[5] = 0x9a;
  a[6] = 0x84; a[7] = 0x1b;
  a[8] = 0xc7; a[9] = 0x31;

  for(i=0; i<10; i++)
  {
        for(j=i; j<10; j++)
              if(a[j] > a[i])
              {
                    temp = a[i];
                    a[i] = a[j];
                    a[j] = temp;
              }

  }

  while(1)
  {
        for(i=0; i<10; i++)
        {
              P0 = a[i];
              delay(1000);
        }
  }
}
```

8. C code for Activity VII

```
#include <reg51.h>
unsigned char data d[21] _at_ 0x40;

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

int isprime(unsigned char val)
{
  unsigned char j;
  for(j=0x2; j<val; j++)
        if(val % j == 0x0)
              break;
  if(j==val)
              return 1;
  return 0;
}


void main(void)
{
  unsigned char a[20];
  unsigned char i, count=0;
  for(i=0x0; i<0x21; i++)
        d[i] = i;

  a[count++] = 0x2;
  for(i=0x3; i<0x21; i++)
  {
        if(isprime(d[i]))
              a[count++] = d[i];
  }

  while(1)
  {
        for(i=0; i<count; i++)
        {
              P0 = a[i];
              delay(1000);
        }
  }
}
```

9. C code for Activity VIII

```
#include<reg51.h>

void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

void main()
{
  unsigned int val = 0x5;
  unsigned int fact = 0x1;
  unsigned char i;
  unsigned char x, d1, d2, d3;

  for(i=0x1; i<=val; i++)
        fact *= i;

  x = fact / 0xa;
  d1 = fact % 0xa;
  d2 = x % 0xa;
  d3 = x / 0xa;

  while(1)
  {
        P0 = fact;
        delay(1000);
        P0 = d1;
        delay(1000);
        P0 = d2;
        delay(1000);
        P0 = d3;
        delay(1000);
  }
}
```

10. C code for Activity IX

```
#include <reg51.h>
char data a[10] _at_ 0x55;
```

```
void delay(int time)
{
  unsigned int i,j;
  for (i=0; i<time; i++)
        for (j=0; j<125; j++);
}

int check_seq(unsigned char val)
{
  unsigned char j;
  for(j=0; j<8; j++)
        if((val & 0x3) == 0x3)
              return 1;
        else
              val >>= 1;
  return 0;
}

void main(void)
{
  unsigned char i, count = 0, b[10];
  a[0] = 0x25; a[1] = 0x3d;
  a[2] = 0xf7; a[3] = 0x13;
  a[4] = 0xc9; a[5] = 0x4e;
  a[6] = 0x62; a[7] = 0x77;
  a[8] = 0xb8; a[9] = 0xeb;

  for(i=0;i<10;i++)
        if(check_seq(a[i]))
              b[count++] = a[i];

  while(1)
        for(i = 0;i<count;i++)
        {
              P0 = b[i];
              delay(1000);
        }
}
```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This lab and the report is prepared to be familiar with the assembly language programming as well as C programming for 8051 microcontroller using Keil IDE. This report is made accurate and professional as far as possible. I would like to express our deepest gratitude to our teacher, Mr. Dinesh Baniya Kshatri, for guiding us in the practical. I am very grateful to the Department of Electronics and Computer Engineering (DoECE) of IOE Central Campus, Pulchowk for arranging such a schedule on our academic side. I would also like to thank my friends who helped me on understanding certain things in assembly and C programming in this lab.

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