Microprocessor Lab Report

Abhiroop Mukherjee
Enrl. No: 510519109

Department of Computer Science and Technology
Indian Institute of Engineering Science and Technology, Shibpur

Contents

1 Assignment 1

1.1 Objective

Find out the sum of the first 30 natural numbers.

1.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

1.3 Procedure

We know that

$$1 + 2 + 3 + ... + 29 + 30 = \frac{30 \times 29}{2} = 435 = 01D1H$$

This result is not possible to store in a single register, so we need to use register pair to store the result.

1.4 Program

```
;end result is 465, more than 255 hence we need to do extended additions
        MVI D,1E; setup D, the counter as 30
        MVI C,01; setup BC as 1

L1:     DAD B; Double add BC to HL
        INX B; extended increment BC
        DCR D; decrement D
        JNZ L1; if D becomes 0, Z flag becomes 0 and we break
        HLT
; Ans will be in HL
```

Listing 1: assembly program to find sum of the first 30 natural numbers

1.5 Experimentation

Register	Value	7	6	5	4	3	2	1	0
Accumulator	00	0	0	0	0	0	0	0	0
Register B	00	0	0	0	0	0	0	0	0
Register C	1F	0	0	0	1	1	1	1	1
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	01	0	0	0	0	0	0	0	1
Register L	D1	1	1	0	1	0	0	0	1
Memory(M)	00	0	0	0	0	0	0	0	0

Figure 1: Register configuration after execution (observe HL)

1.6 Conclusion

We see that after the execution of program, the data stored in HL register pair is 01D1H, which is the hexadecimal value of 435.
Hence the program is working as expected.

2 Assignment 2

2.1 Objective

From an array of 10-byte size integers (unsigned) find out the maximum and minimum.

2.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

2.3 Procedure

The idea is to linearly iterate through all the values of the arr, and update the register for minimum(C) and maximum(B) values.

2.4 Program

```
;Actual Program
# ORG 5000H
# ARR: DB 5,2,3,4,F,C,7,A,B,1
# ORG 0000
       LXI H,ARR
       MOV B,M  ;B is maximum val
       MOV C,M  ;C is minimum val
       MVI D,0A
;CMP R does (A - R) in background
;If A - R > 0 then Cy = 0, Z = 0
;If A - R = 0 then Cy = 0, Z = 1
;If A - R < 0 then Cy = 1, Z = 1

LP:    MOV A,M
       CMP B
       JC MIN   ;will Jump when Cy = 1, A - B < 0, A < B
       MOV B,A  ;will only happen if A > B

MIN:   CMP C
       JNC SKIP ;will Jump when Cy = 0, A - C > 0, A > C
       MOV C,A  ;will only happen if A < C

SKIP:  INX H
       DCR D
       JNZ LP
       HLT
```

Listing 2: assembly program to find minimum and maximum number in 10-byte unsigned array

2.5 Experimentation

Register	Value	7	6	5	4	3	2	1	0
Accumulator	01	0	0	0	0	0	0	0	1
Register B	0F	0	0	0	0	1	1	1	1
Register C	01	0	0	0	0	0	0	0	1
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	50	0	1	0	1	0	0	0	0
Register L	0A	0	0	0	0	1	0	1	0
Memory(M)	00	0	0	0	0	0	0	0	0

(a) result for {5,2,3,4,F,C,7,A,B,1}

Register	Value	7	6	5	4	3	2	1	0
Accumulator	06	0	0	0	0	0	1	1	0
Register B	0F	0	0	0	0	1	1	1	1
Register C	06	0	0	0	0	0	1	1	0
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	50	0	1	0	1	0	0	0	0
Register L	0A	0	0	0	0	1	0	1	0
Memory(M)	00	0	0	0	0	0	0	0	0

(b) result for {F,E,D,C,B,A,9,8,7,6}

Figure 2: Result for different inputs

2.6 Conclusion

We see that that after program execution, B has the maximum value of array, and C has the minimum value of the array.
Hence the program is working as expected.

3 Assignment 3

3.1 Objective

Write a routine that produces a delay. The delay value must be passed to register pair DE.

3.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

3.3 Procedure

Idea is to assign DE a very big value (say FFFF), and decrement it in a loop till DE becomes 0 to produce delay in execution.

3.4 Program

```
       LXI D,FFFF
       CALL DELAY
       HLT
;delay: this subroutine produces delay
;in: value in DE pair
;out: none
;destroys: A

DELAY: DCX D    ;doesn't affect any flags, that's why doing OR
       MOV A,E
       ORA D    ;will give 0 only when both D and E 00
       JNZ DELAY
       RET
```

Listing 3: assembly program to produce delay

3.5 Conclusion

We see that the code runs for sometime, then completes it's execution, signifying that the delay function worked and delayed execution of CPU for some time.
Hence the program is working as expected.

4 Assignment 4

4.1 Objective

Write a subroutine to move a block of bytes from location X to location Y.
Note that the caller would specify

- X, the source address
- Y, the destination address
- Z, the block size

Note that X, Y and Z are 16-bit quantities.

4.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

4.3 Procedure

Start reading numbers from location X and save them to location Y, after each iteration, update address of X and Y to next byte. Do this Z times and the whole block is copied.

4.4 Program

```
;setup of data
#ORG 2500
#ARR: DB 4,2,6,7,8

# DESTLOC EQU 4500
#ORG 0000
;let BC = 5, X = 2500, Y = 4500
;hence add data from 2500 to 2504
       LXI B,0005
       LXI D, ARR
       LXI H,DESTLOC
       CALL MOVE
       HLT
;MOVE: move Z number of bytes from loc (X to X+Z) to loc (Y to Y+Z)
;Z store in BC
;X store in DE
;Y store in HL

MOVE:  LDAX D   ;A = Mem[DE]
       MOV M,A  ;Mem[HL] = A
       INX H    ;HL++
       INX D    ;DE++
       DCX B    ;BC--
;DCX doesn't set flags so do manual check by OR
       MOV A,B
       ORA C
       JNZ MOVE
       RET
```

Listing 4: assembly program to move block

4.5 Experimentation

Memory Editor

Memory Range: 0000 ---- FFFF

Memory Address	Value
0000	01
0001	05
0003	11
0005	25
0006	21
0008	45
0009	CD
000A	0D
000C	76
000D	1A
000E	77
000F	23
0010	13
0011	0B
0012	78
0013	B1
0014	C2
0015	0D
0017	C9
2500	04
2501	02
2502	06
2503	07
2504	08
4500	04
4501	02
4502	06
4503	07
4504	08
FFFE	0C

(a) result for {4,2,6,7,8}

Memory Editor

Memory Range: 0000 ---- FFFF

Memory Address	Value
0000	01
0001	0A
0003	11
0005	25
0006	21
0008	45
0009	CD
000A	0D
000C	76
000D	1A
000E	77
000F	23
0010	13
0011	0B
0012	78
0013	B1
0014	C2
0015	0D
0017	C9
2500	04
2501	02
2502	06
2503	07
2504	08
2505	01
2506	02
2507	04
2508	05
2509	06
4500	04
4501	02
4502	06
4503	07
4504	08
4505	01
4506	02
4507	04
4508	05
4509	06
FFFE	0C

(b) result for {4,2,6,7,8,1,2,4,5,6}

Figure 3: Result for different inputs

4.6 Conclusion

We see that all the data from location 2500(X) to (2500 + Z) has been copied to location 4500(Y) to (4500 + Z) [Z is 5 in 3a and 10 in 3b].
Hence the program is working as expected.

5 Assignment 5

5.1 Objective

Write a function isODD(unsigned n) in assembly that takes an unsigned integer (a byte) and determines if it is odd (returns 1) or 0 if it is even.

5.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

5.3 Procedure

Odd numbers will always be in the form of $2x + 1$, which means that they will have 1 as their LSB. So we just check if $number \wedge 01$ is 1 or not. If the result is 1, then the number is odd, else it is even.

5.4 Program

```
# NUM EQU 49 ;73 in hex
      MVI B,NUM
      CALL ISODD
      HLT
;isODD(n): function which tell if n is odd or even
;in: n = B
;out: ans in C, if n even C = 0,else 1
;destroys: A
;idea: X AND 01 = 0 if X is even, 1 is X is Odd

ISODD: MOV A,B
      ANI 01   ;A = A and 01
      MOV C,A  ;store result in C
      RET
```

Listing 5: assembly program to check if given number isOdd or not

5.5 Experimentation

Register	Value	7	6	5	4	3	2	1	0
Accumulator	01	0	0	0	0	0	0	0	1
Register B	49	0	1	0	0	1	0	0	1
Register C	01	0	0	0	0	0	0	0	1
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	00	0	0	0	0	0	0	0	0
Register L	00	0	0	0	0	0	0	0	0
Memory(M)	06	0	0	0	0	0	1	1	0

(a) result for odd number(73)

Register	Value	7	6	5	4	3	2	1	0
Accumulator	00	0	0	0	0	0	0	0	0
Register B	4A	0	1	0	0	1	0	1	0
Register C	00	0	0	0	0	0	0	0	0
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	00	0	0	0	0	0	0	0	0
Register L	00	0	0	0	0	0	0	0	0
Memory(M)	06	0	0	0	0	0	1	1	0

(b) result for even number(73)

Figure 4: Result for both even and odd numbers

5.6 Conclusion

We see that in case of odd number, C is 1 after execution and in case of even number, C is 0 after execution.
Hence the program is working as expected.

6 Assignment 6

6.1 Objective

Write a function to add two multi-byte numbers stored in location X and Y. The result is stored in X. Pass a parameter Z indicating the no. of bytes to be added.

6.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

6.3 Procedure

We simulate the default way of adding numbers, we go from right to left, adding (with carry) the numbers and adding it to stack, then we keep popping the elements and save it in X.

6.4 Program

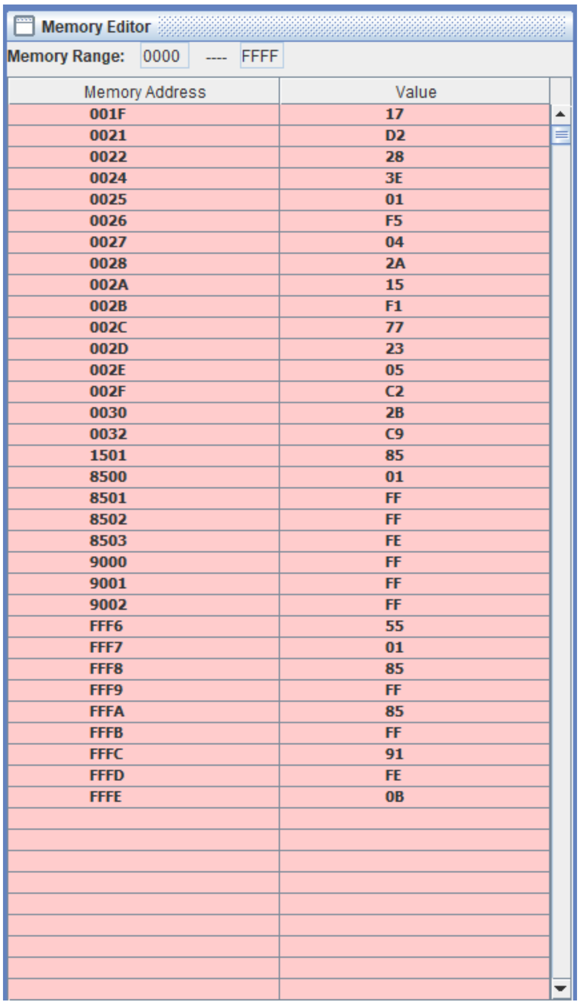
```
# ORG 8500
# NUM1: DB FF,FF,FF
# ORG 9000
# NUM2: DB FF,FF,FF
# NUMBYTE EQU 3
# ORG 0000
       MVI C,NUMBYTE    ;C <- 03
       LXI H,NUM1       ;HL <- 8500
       LXI D,NUM2       ;DE <- 9000
       CALL ADDB
       HLT
;add Z bytes, first number starts from X, other number starts from Y
;Z->C
;X->HL
;Y->DE
;destroys -> B
# SAVELOC EQU 1500
ADDB:  SHLD SAVELOC ;save start of X to 1500 addr to be read later
       MVI B,00     ;set B as 0, will act as counter afterward
;now we need to put HL and DE pair to back of array
       XCHG         ;swap HL and DE
       DAD B        ;HL = HL + BC [with B = 0] [HL now is DE]
       DCX H
       XCHG         ;swap HL and DE again
       DAD B        ;HL = HL + BC
       DCX H
;now both DE and HL are in the end of their array
LOOP:  LDAX D   ;A -> Mem[DE]
       ADC M    ;A -> A+ Mem[HL] + carry
       PUSH PSW ;push AF data to SP, first A, then F
       INR B
       DCX H
       DCX D
       DCR C
       JNZ LOOP ;jump to Loop till C!=0
;now addition done and saved to Stack, need to check if carry exist
       JNC SKIP
;these will execute only when there is a carry
       MVI A,01
       PUSH PSW
       INR B

SKIP:  LHLD SAVELOC   ;read saved LH data to go to start of X

L1:    POP PSW  ;pop SP to AF, first F then A
       MOV M,A
       INX H
       DCR B
       JNZ L1
       RET
```

Listing 6: assembly program to add multi-byte numbers

6.5 Experimentation

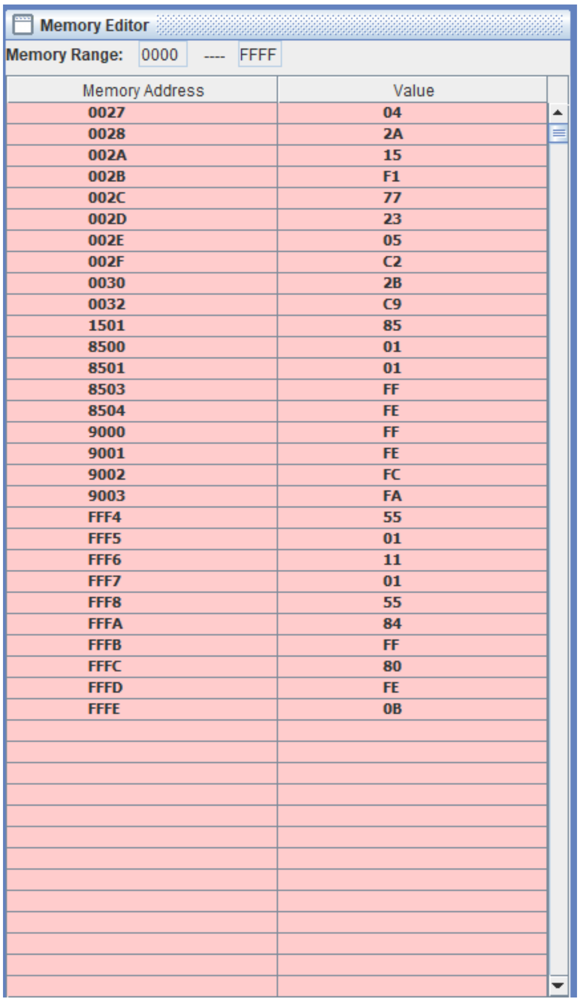


Memory Editor

Memory Range: 0000 ---- FFFF

Memory Address	Value
001F	17
0021	D2
0022	28
0024	3E
0025	01
0026	F5
0027	04
0028	2A
002A	15
002B	F1
002C	77
002D	23
002E	05
002F	C2
0030	2B
0032	C9
1501	85
8500	01
8501	FF
8502	FF
8503	FE
9000	FF
9001	FF
9002	FF
FFF6	55
FFF7	01
FFF8	85
FFF9	FF
FFFA	85
FFFB	FF
FFFC	91
FFFD	FE
FFFE	0B

(a) result for {FF,FF,FF} + {FF,FF,FF}



Memory Editor

Memory Range: 0000 ---- FFFF

Memory Address	Value
0027	04
0028	2A
002A	15
002B	F1
002C	77
002D	23
002E	05
002F	C2
0030	2B
0032	C9
1501	85
8500	01
8501	01
8503	FF
8504	FE
9000	FF
9001	FE
9002	FC
9003	FA
FFF4	55
FFF5	01
FFF6	11
FFF7	01
FFF8	55
FFFA	84
FFFB	FF
FFFC	80
FFFD	FE
FFFE	0B

(b) result for {01,02,03,04} + {FF,FE,FC,FA}

Figure 5: Result of multi-byte addition (start looking from address 8500)

6.6 Conclusion

We see that the result of multi-byte addition is correct.
Hence the program is working as expected.

7 Assignment 7

7.1 Objective

Write a fast sub-routine to multiply 9 by 15.

7.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

7.3 Procedure

We use the Shift-and-Add Multiplication to fast multiply 15 and 9, as register size is 8 bits, we can do this multiplication by using a loop which runs 8 times, i.e O(1)
This method is faster than default loop method, which run in O(min(m, n)), where m and n are the numbers that will be multiplied.

7.4 Program

```
       LXI D,000F   ;15 in hex
       MVI A,09
       LXI H,0000   ;result will be in HL
       MVI B,08     ;8 bit data, 8 rotations to iterate through all the bits of A

LP:    DAD H    ;HL = HL + HL (multiply by 2)(assume left shift)
       RAL      ;rotate A left(<-), leftmost value in C flag
       JNC SKIP
       DAD D    ;if 1 in A's bit, we add D also
SKIP:  DCR B
       JNZ LP
       SHLD 2500
       HLT
;ans in HL register
```

Listing 7: assembly program to fast multiply 15 times 9

7.5 Experimentation

Register	Value	7	6	5	4	3	2	1	0
Accumulator	04	0	0	0	0	0	1	0	0
Register B	00	0	0	0	0	0	0	0	0
Register C	00	0	0	0	0	0	0	0	0
Register D	00	0	0	0	0	0	0	0	0
Register E	0F	0	0	0	0	1	1	1	1
Register H	00	0	0	0	0	0	0	0	0
Register L	87	1	0	0	0	0	1	1	1
Memory(M)	00	0	0	0	0	0	0	0	0

Figure 6: Register configuration after execution (look at HL)

7.6 Conclusion

$9 \times 15 = 135 = 0087H$
We see that the result in HL register is same as what we expected.
Hence the program is working as expected.

8 Assignment 8

8.1 Objective

Write a subroutine to sort a 5-element byte array (Any algorithm will do)

8.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

8.3 Procedure

We use bubble sort algorithm to sort the array.

8.4 Program

```
# ORG 2500
# ARR: DB 4,2,5,6,7
# LEN EQU 5
# ORG 0000

START:      LXI H,ARR   ;start of array
            MVI C,LEN
            DCR C       ;c-- as we will only go through first 4
            MVI D,00    ;d acts a bool, if any swap happend, d = 1

CHECK:      MOV A,M
            INX H
            CMP M    ;compare a[i] with a[i+1]
;if a[i] - a[i+1] > 0 -> Cy = 0, Z = 0 (we swap)
;if a[i] - a[i+1] = 0 -> Cy = 0, Z = 1 (we don't swap)
;if a[i] - a[i+1] < 0 -> Cy = 1, Z = 0 (we don't swap)
            JC NEXTBYTE
            JZ NEXTBYTE
;here swap occurs
            MOV B,M ;a[i] = A, a[i+1] = B
            MOV M,A ;a[i+1] = A
            DCX H
            MOV M,B ;a[i] = B
            INX H
            MVI D,01    ;set flag that swap occured

NEXTBYTE:   DCR C
            JNZ CHECK
            MOV A,D
            CPI 01   ;comapare immediate A and 01
;if A - 01 > 0 -> Cy = 0, Z = 0 -> A(D) is zero, no swap taken place, exit
;if A - 01 = 0 -> Cy = 0, Z = 1 -> A or D is 1, swap taken place redo
            JZ START
            HLT
```

Listing 8: assembly program to bubble sort array

8.5 Experimentation

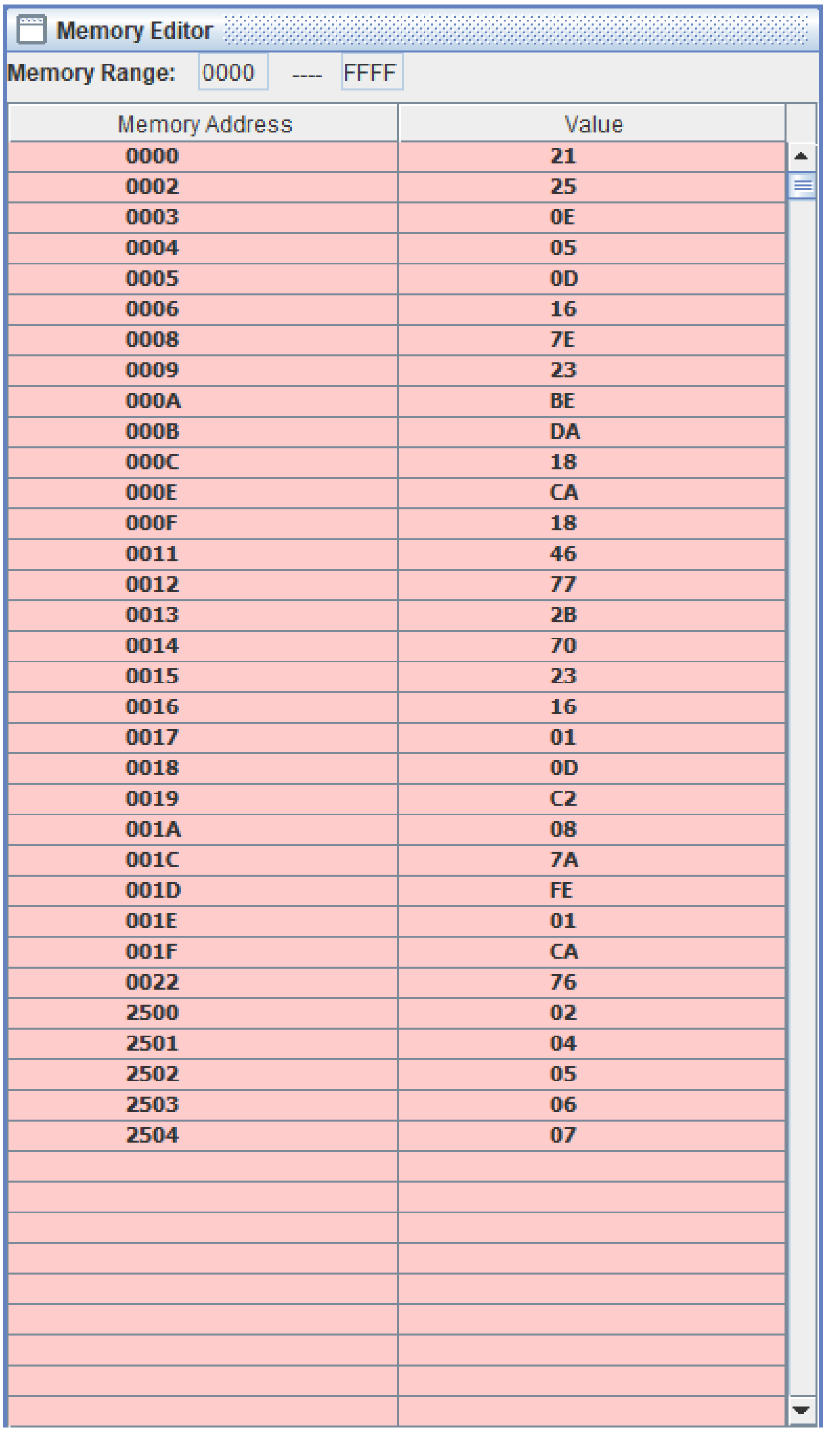


Figure 7: Register configuration after execution (look from address 2500)

8.6 Conclusion

We see that after program execution, values of address 2500 - 2504 is sorted in ascending order. Hence the program is working as expected.

9 Assignment 9

9.1 Objective

Write a sub-routine to store all the registers (A, F, B, C, D, E, H, L, I, SPL, SPH, PCL, PC, in that order) starting from location MYREGISTERS.

9.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

9.3 Program

```
       MVI A,10     ;set A
       LXI B,5092   ;set BC
       LXI D,2794   ;set DE
       LXI H,3792   ;set HL
       SIM          ;set inturrept mask as value of A
       LXI SP,F001
       CALL DEBUG
       HLT

# MYREGISTERS EQU 2000H
DEBUG: PUSH H
       PUSH D
       PUSH B
       PUSH PSW
       LXI H,MYREGISTERS
       POP D
       CALL STORE   ;store AF
       POP D
       CALL STORE   ;store BC
       POP D
       CALL STORE   ;store DE
       POP D
       CALL STORE   ;store HL
       RIM
       MOV M,A      ;store I
       INX H
       XCHG         ;swap HL and DE
       LXI H,0000
       DAD SP       ;now HL <- SP
       XCHG         ;now HL-> save addr, DE<- SP
;problem, SP also has this function call stuff, so we need to remove it's info from DE
;(DE = DE + 2 [remember SP stack works reverse that's why +])
       INX D
       INX D
;now store DE
       CALL STORE
;now we need to store PC, which will be in Stack due to function call
       XCHG         ;swap HL and DE to store HL stuff in DE
       XTHL         ;get PC data from SP (stack mem has garbage now)
       XCHG         ;now HL has save addr, DE has data
       CALL STORE
       XCHG         ;PC data back in HL
       XTHL         ;PC data back in stack
       XCHG         ;save addr back in HL
       RET

;Procedure STORE
;stores data in DE to memory whose address is in HL
STORE: MOV M,D
       INX H
       MOV M,E
       INX H
       RET
```

Listing 9: assembly program to store register configuration

9.4 Experimentation

Memory Editor

Memory Range: 0000 ---- FFFF

Memory Address	Value
0036	42
0038	EB
0039	E3
003A	EB
003B	CD
003C	42
003E	EB
003F	E3
0040	EB
0041	C9
0042	72
0043	23
0044	73
0045	23
0046	C9
2000	10
2002	50
2003	92
2004	27
2005	94
2006	37
2007	92
2009	F0
200A	11
200C	12
EFF7	1E
EFF9	22
EFFB	26
EFFD	3E
EFFF	12

Figure 8: Register configuration after execution (look from address 2000)

9.5 Conclusion

We see that after program execution, all the predefined value of registers are stored in memory starting from address 2000.
Hence the program is working as expected.

10 Assignment 10

10.1 Objective

Implement a POST or power-on-self-test where each RAM location is tested for stuck-at-zero or stuck-at-one fault. In your case the function takes the start address of the RAM block and the block size in bytes. The function sets CY in case of any error (else it is set to 0); HL contains the faulty location and Acc contains 0 for stuck at zero fault and 1 for stuck at one fault. [Note: usually there wont be any error as your RAM is not faulty, so direct checking may not set CY flag]

10.2 Tool/Experimental setup considered

- Jubin's 8085 Simulator

10.3 Procedure

We iteratively go through STARTLOC to (STARTLOC + LEN) and check if any value is 1 or not, if it is, we exit from there setting the C flag.

10.4 Program

```
#STARTLOC EQU 6400
#LEN EQU 05
;let position 6403 have stuck at one fault
        LXI H,6403
        MVI M,01
;let we start out search from 6400 an search 05 addresses
        LXI H,STARTLOC
        MVI B,LEN
        CALL POST
        HLT

POST:   MOV A,M
        CPI 01
;A will be 0 or 1, if 1 we need to exit
;A zero -> A - 1 < 0, Cy =1
;A one -> A - 1 = 0, Z = 1, we exit here
        JZ ERR  ;if 1 found, we exit are set Cy 1 directly
        INX H
        DCR B
        JNZ POST
;we will reach here only if there is no 1 found, so we need to set Cy 0
        JC REVERT   ;if Cy 1 , we revert, else we direct return
        RET
;we reach here when 1 found

ERR:    STC ;set Cy 1
        RET
;we reach here if no 1 found but Cy 1 due to previous CMP stuff

REVERT: CMC ;complements Cy, if Cy 1, Cy becomes 0
        RET
```

Listing 10: assembly program for POST for stuck at 1 fault

10.5 Experimentation

Register	Value	7	6	5	4	3	2	1	0
Accumulator	01	0	0	0	0	0	0	0	1
Register B	02	0	0	0	0	0	0	1	0
Register C	00	0	0	0	0	0	0	0	0
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	64	0	1	1	0	0	1	0	0
Register L	03	0	0	0	0	0	0	1	1
Memory(M)	01	0	0	0	0	0	0	0	1

Resister	Value	S	Z	*	AC	*	P	*	CY
Flag Resister	55	0	1	0	1	0	1	0	1

Type	Value
Stack Pointer(SP)	0000
Memory Pointer (HL)	6403
Program Status Word(PSW)	0155
Program Counter(PC)	000D
Clock Cycle Counter	221
Instruction Counter	29

(a) result of the program

Register	Value	7	6	5	4	3	2	1	0
Accumulator	00	0	0	0	0	0	0	0	0
Register B	00	0	0	0	0	0	0	0	0
Register C	00	0	0	0	0	0	0	0	0
Register D	00	0	0	0	0	0	0	0	0
Register E	00	0	0	0	0	0	0	0	0
Register H	64	0	1	1	0	0	1	0	0
Register L	05	0	0	0	0	0	1	0	1
Memory(M)	00	0	0	0	0	0	0	0	0

Resister	Value	S	Z	*	AC	*	P	*	CY
Flag Resister	54	0	1	0	1	0	1	0	0

Type	Value
Stack Pointer(SP)	0000
Memory Pointer (HL)	6405
Program Status Word(PSW)	0054
Program Counter(PC)	0008
Clock Cycle Counter	266
Instruction Counter	37

(b) result of the program if we comment line 4 and 5

Figure 9: Result of Program Execution

10.6 Conclusion

We see that if there exist a 1 in some memory location, the program sets Cy flag and HL register to stuck address; when there is no 1 in whole array, C is unset
Hence the program is working as expected.