

Computer Architecture

Lecture 7

Arithmetic Instructions

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Arithmetic Instructions

- Arithmetic instructions include some mathematical operations such as addition, subtraction, increment, and decrement. For addition and subtraction the quantity is always stored in accumulator. Accumulator is a register which can hold 8 bit data where the arithmetic values can be stored in it. All flags are effected by the arithmetic instruction.

- **FLAGS REGISTER**

B7	B6	B5	B4	B3	B2	B1	B0
S	Z		AC		P		CY

- **(CY) Carry Flag:** If an arithmetic result in a carry, the flag is set otherwise the flag is reset.

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- **(P) Parity Flag:** After the arithmetic and logic operation, if the result have even number of (1's) the flag is set. If it has odd number of (1's) the flag is reset.
- **(AC) Auxiliary Carry Flag:** In arithmetic operation, when a carry is generated by digit B3 and passed on the digit B4, the AC is set else it is reset.
- **(Z) Zero Flag:** This flag is set if the result is zero, and reset if the result is not zero.
- **(S) Sign Flag:** After the execution the operation arithmetic or logical, if B7 of the result is 1 then the sign flag is set.

Arithmetic Instructions

1- Addition Instructions

(1)

ADD	R M	<ol style="list-style-type: none">1. Add register or memory to accumulator2. The contents of the operand (register or memory) are added to the contents of the accumulator and the result is stored in the accumulator.3. If the operand is a memory location, its location is specified by the contents of the HL registers.4. All flags are modified to reflect the result of the addition.5. Example: ADD B or ADD M
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Example: Write the 8085 program to perform the following function

1. Load the number $8B_H$ in register D and register C with $6F_H$
2. Add the contents of registers and display the result at the output 01

Arithmetic Instructions

Sol:

MVI D, 8B_H

MVI C, 6F_H

MOV A, D

ADD C

OUT 01_H

Result in A = F2H

CY	= 0	P	= 1	AC	= 1	Z	= 0	S	= 1
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Arithmetic Instructions

Example: Load the accumulator with 6CH and register D with 2EH. And then add these value use the Instruction ADD performs the addition:

```
2EH = 00101110
6CH = 01101100
-----
9AH = 10011010
```

The accumulator contains the value 9AH following execution of the ADD D instruction. The contents of the D register remain unchanged. The condition flags are set as follows:

```
Carry      = 0
Sign       = 1
Zero       = 0
Parity     = 1
Aux. Carry = 1
```

Arithmetic Instructions

(2)

ADC	R M	<ol style="list-style-type: none">1. Add register to accumulator with carry2. The contents of the operand (register or memory) and the Carry flag are added to the contents of the accumulator and the result is stored in the accumulator.3. If the operand is a memory location, its location is specified by the contents of the HL registers.4. All flags are modified to reflect the result of the addition.5. Example: ADC B or ADC M
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Example:

- If the memory location 2006 hold the data $(FF)_H$ and memory location 2002 holds $(01)_H$. Add these contents and if the carry is set add it then store the result in memory location 2001.

Arithmetic Instructions

LDA 2006

LXI H, 2002

ADC M

STA 2001

CY= P= AC= Z= S=

(3)

ADI 8-bit data	<ol style="list-style-type: none">1. Add immediate to accumulator2. The 8-bit data (operand) is added to the contents of the accumulator and the result is stored in the accumulator.3. All flags are modified to reflect the result of the addition.4. Example: ADI 45
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Arithmetic Instructions

Example: Write 8085 program to add the 05_H to register B that hold $F3_H$, and then output the result on port FF_H .

MOV A, B

ADI 05_H

OUT FF_H

CY= P= AC= Z= S=

(4)

ACI 8-bit data	<ol style="list-style-type: none">1. Add immediate to accumulator with carry2. The 8-bit data (operand) and the Carry flag are added to the contents of the accumulator and the result is stored in the accumulator.3. All flags are modified to reflect the result of the addition.4. Example: ACI 45
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Arithmetic Instructions

Example: Write 8085 program to add with carry the 05_H to register B that can be load with FF_H , and then store the result in memory location $EF00_H$.

```
MVI B,  $FF_H$ 
```

```
MOV A, B
```

```
ACI  $05_H$ 
```

```
STA  $EF00_H$ 
```

```
CY=   P=   AC=   Z=   S=
```

Arithmetic Instructions

(5)

DAD	Register pair R_B R_D	<ol style="list-style-type: none">1. Add register pair to H and L registers2. The 16-bit contents of the specified register pair are added to the contents of the HL register and the sum is stored in the HL register.3. The contents of the source register pair are not altered.4. If the result is larger than 16 bits, the CY flag is set. No other flags are affected.5. Example: DAD H, DAD B, DAD D
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Example

- Write the 8085 program to add the content of the memory location 2000 and 2001 to the content of memory location 3000 and 3001, then store the result to memory location 4000, 4001.

Arithmetic Instructions

Sol:

```
LHLD 2000H  
XCHG  
LHLD 3000H  
DAD D  
SHLD 4000H
```

2000 _H	51
2001 _H	1E
2002 _H	FF
3000 _H	44
3001 _H	BC
4000 _H	
4001 _H	
4002 _H	

NOTE

If there are carry, only carry flag is effect and other flags are not effect by this instruction

Arithmetic Instructions

2- Subtraction Instructions

- The 8085 perform subtraction by using the method of 2's complement. The 8085 performs the following steps internally to execute the instruction.

Step 1: Converts subtracted to its 1's complement by convert all (1 to 0) and (0 to 1)

Step 2: Add 1 to 1's complement to obtain the 2's complement of the subtracted value.

Step 3: Add the 2's complement to subtract value

Step 4: Complement the carry flag

Arithmetic Instructions

(6)

SUB	R M	<ol style="list-style-type: none">1. Subtract register or memory from accumulator2. The contents of the operand (register or memory) are subtracted from the contents of the accumulator, and the result is stored in the accumulator3. If the operand is a memory location, its location is specified by the contents of the HL registers.4. All flags are modified to reflect the result of the subtraction.5. Example: SUB B or SUB M
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Example

Load the register B with 65_H and the accumulator with 97_H . Add the content of register B from the accumulator and store the result to memory location 2001_H

Arithmetic Instructions

Answer

MVI A, 97_H

MVI B, 65_H

SUB B

STA 2001_H

Step 1	Subtracted (B): 65	0 1 1 0 0 1 0 1	
	1's complement of 65	1 0 0 1 1 0 1 0	
Step 2	Add 1 to obtain 2's Comp	+	0 0 0 0 0 0 0 1
	2's Complement of 65	1 0 0 1 1 0 1 1	
Step 3	Add to Accumulator 97 _H	1 0 0 1 0 1 1 1	
Step 4	Complement Cy	Cy = 1	0 0 1 1 0 0 1 0
	Result is 32 _H	Cy = 0	0 0 1 1 0 0 1 0
S= 0 Z=0 CY=0 p=1 AC=0			

Arithmetic Instructions

Example: Write the 8085 program to do the following:

1. Load the Register B with 30_H, and the Register C with 39_H
2. Subtract with register C from register B and display the result on output port 06_H.

Answer

MVI B, 30_H

MVI C, 39_H

MOV A,B

SUB C

OUT 06_H

Step 1	Subtracted : 39	00111001	
	1's complement of 39	11000110	
Step 2	Add 1 to obtain 2's Comp	+	00000001
	2's Complement of 39	11000111	
Step 3	Add to Accumulator 30 _H	00110000	
Step 4	Complement Cy	Cy = 0	11110111
	Result is F7 _H	Cy = 1	11110111
S=1 Z=0 CY=1 p=0 AC=0			

Arithmetic Instructions

Note: The subtract operation is performed by using 2's complement method. If the subtraction result is a negative number, the answer is in 2's complement and the carry (the Borrow flag) is set.

(6)

SBB	R M	<ol style="list-style-type: none">1. Subtract register and borrow from accumulator2. The contents of the operand (register or memory) and the Borrow flag are subtracted from the contents of the accumulator and the result is placed in the accumulator.3. If the operand is a memory location, its location is specified by the contents of the HL registers.4. All flags are modified to reflect the result of the subtraction.5. Example: SBB B or SBB M
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Arithmetic Instructions

Example: If the register B holds the FE value, subtract with barrow the content $(89)_H$ of memory location $30AB_H$ form Register B.

MOV A, B

LXI H, $30AB_H$

SBB M

(9)

SUI	8-bit data	<ol style="list-style-type: none">1. Subtract immediate from accumulator2. The 8-bit data (operand) is subtracted from the contents of the accumulator and the result is stored in the accumulator.3. All flags are modified to reflect the result of the subtraction.4. Example: SUI 89_H
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Arithmetic Instructions

Example: Write the 8085 program to subtract the $5E_H$ from the memory location 2000_H that hold 55_H and then send the result to output port $1F_H$.

LDA 2000_H

SUI $5E_H$

(10)

SBI	8-bit data	<ol style="list-style-type: none">1. Subtract immediate from accumulator with borrow2. The 8-bit data (operand) and the Borrow flag are subtracted from the contents of the accumulator and the result is stored in the accumulator.3. All flags are modified to reflect the result of the subtraction.4. Example: SBI 45
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Arithmetic Instructions

Example: Write the 8085 program to subtract with borrow the 47_H from register H that hold 12_H and then store the result in memory location 2100_H .

Answer

```
MOV A, H  
SBI  $47_H$   
STA  $2100_H$ 
```

3- Increment and Decrement Instruction

(11)

INR	R M	<ol style="list-style-type: none">1. Increment register or memory by 12. The contents of the designated register or memory) are incremented by 1 and the result is stored in the same place.3. If the operand is a memory location, its location is specified by the contents of the HL registers.4. Example: INR B or INR M
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Arithmetic Instructions

Example: Load the memory location 3012_H with $5F_H$ and the accumulator with 73_H , increment the content of the memory and then add it to the accumulator.

answer

MVI A, 73_H

LXI H, 3012_H

MVI M, $5F_H$

INR M

ADD M

Arithmetic Instructions

(12)

INX	Register Pair R _B R _D R _H	<ol style="list-style-type: none">1. Increment register pair by 12. The contents of the designated register pair are incremented by 1 and the result is stored in the same place.3. Example: INX H
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Example: Write the 8085 program to subtract the content of memory location 2001_H from 2002_H and store the result in memory location 2003.

Answer

```
LXI H, 2001H  
MOV B, M  
INX H  
MOV A, M  
SUB B  
STA 2003H
```

Arithmetic Instructions

(13)

DCR	R M	<ol style="list-style-type: none">1. Decrement register or memory by 12. The contents of the designated register or memory are decremented by 1 and the result is stored in the same place.3. If the operand is a memory location, its location is specified by the contents of the HL registers.4. Example: DCR B or DCR M
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Example: Write 8085 program to load the accumulator with 94H, registers B, C with FE, 7A respectively, then decrement the content of both B, C and add them to the Accumulator.

Arithmetic Instructions

Answer

MVI A, 94H

MVI B, FEH

DCR B

MVI C

DCR C

ADD B

(14)

DCX	Register pair R_B R_D R_H	<ol style="list-style-type: none">1. The contents of the designated register pair are decremented by 1 and the result is stored in the same place.2. Example: DCX H
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Arithmetic Instructions

Example: Write the 8085 program to subtract the content of memory location 2002_H from 2001_H and store the result in memory location 2003.

Answer

LXI H, 2002

MOV M, B

DCX H

MOV A, M

SUB B

STA 2003

Arithmetic Instructions

Example: Write 8085 program to add the data $(9F, 33)_H$ from input port $00_H, 01_H$.
And then decrement the result and store the result in memory location $3F54_H$.

Answer

IN 00_H

MOV C, A

IN 01_H

ADD C

DCR A

STA $3F54_H$



The End