

**AY 2023-2024**

# **ARCHITECTURE AND ORGANIZATION**

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**UMak - CCS**

# WEEK 12 :

# ARITHMETIC INSTRUCTIONS



UMak - CCS



## Learning Outcomes:

At the end of the topic session, the students should be able to:

1. Understand the different types of arithmetic instructions.
2. Solve for the updated register content after arithmetic operations.



# ARITHMETIC INSTRUCTIONS

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## ADDITION

1. ADD ✓
2. ADC ✓
3. INC ✓

Carry → CF

## SUBTRACTION

1. SUB ✓
2. SBB ✓
3. DEC ✓

Borrow → CF



# ADD INSTRUCTION

**FORMAT:** ADD D, S

**ACTION:**  $D \leftarrow [D] + [S]$

**Example:**

ADD AX, BX

ADD [SI], DI

$AX + BX = AX$

$SI + DI = SI$

$P.A = SS \times 10H + [SI]$

→ memory map



# ADD INSTRUCTION- EXAMPLE

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Assume the following register content:

AX= 0015H

SS= 2000H

BX= 0019H

SI= 001EH

CX= 0012H

DI= 0017H

DX= 001BH

SP= 0035H

ADD AX, BX

ADD [SI], DI



# ADD INSTRUCTION- EXAMPLE

ADD AX, BX

$$\begin{array}{r}
 \text{AX} = 0015 = 0000\ 0000\ 0001\ 0101 \\
 \text{BX} = 0019 = 0000\ 0000\ 0001\ 1001 \\
 \hline
 001E
 \end{array}$$

$\rightarrow$  0 0 2 E

$$\boxed{\text{AX} = 002EH}$$

ADD [SI], DI

$$\begin{aligned}
 \text{P.A} &= 55 \times 10H + [001E] \\
 &= 20000 + 001E
 \end{aligned}$$

$$\begin{aligned}
 2001E &- 75 \quad L \\
 2001F &- 89 \quad H
 \end{aligned}$$

$$\text{P.A} = 2001FH$$

$$\begin{array}{r}
 8975 \\
 0017 \\
 \hline
 898C
 \end{array}$$

$$\begin{array}{r}
 8975 \quad \text{SI} = \\
 0017 \quad \text{DI} =
 \end{array}$$

$$\begin{array}{r}
 1000\ 1001\ 0111\ 0101 \\
 0000\ 0000\ 0001\ 0111 \\
 \hline
 1000\ 1001\ 1000\ 1100
 \end{array}$$

$$\text{SI} = 8975H$$

$$\boxed{898CH}$$





# ADC INSTRUCTION

(Add with Carry)

**FORMAT:** ADC D,S

**ACTION:**  $D \leftarrow [D] + [S] + [CF]$

**Example:**

CF - ✓ ADD AX, BX  
- ADC SI, DI + CF





# ADD INSTRUCTION- EXAMPLE

Assume the following register content:

AX= 0015H

SS= 2000H

BX= 0019H

SI= 001EH

CX= 0012H

DI= 0017H

DX= 001BH

SP= 0035H

MOV AX, FAFA

→ ~~AX= FAFAH~~

MOV BX, [SP]

→ P.A =  $SS \times 10H + 0035$   
=  $2000 + 0035$   
= 20035

20035 — 00

20036 — 70

SP= 7000

ADD AX, BX

ADC SI, DI

BX= 7000H



# ADC INSTRUCTION- EXAMPLE

MOV AX, FAFA  
MOV BX, [SP]

ADD AX, BX  
ADC SI, DI

①  $AX = \text{FAFA}$   
 $BX = 7000$   
 $\underline{\phantom{00}6AFA}$

①  $22 / 16 =$   

$$\begin{array}{r} 111110101111010 \\ 011100000000000 \\ \hline 011010101111010 \\ \phantom{0}6\phantom{0}A\phantom{0}F\phantom{0}A \end{array}$$

$AX = 6AFAH$   $CF = 1$

SI = 001E  
DI = 0017  
CF = 1  

$$\begin{array}{r} 1 \\ \hline SI = 0036 \end{array}$$

$22 / 16 = 1 \text{ r. } \underline{6}$



# INC INSTRUCTION

1010 — A

**FORMAT:** INC [D]

**ACTION:** D  $\leftarrow$  [D] + 1

0  $\rightarrow$  9  
A  $\rightarrow$  F

**EXAMPLE:** CX = 0029H    DX = 0027H

INC CX

INC DX

CX = 002AH

DX = 0028H



# INC INSTRUCTION- EXAMPLE

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Assume the following register content:

AX= 0015H	SS= 2000H
BX= 0019H	SI= 001EH
CX= 0012H	DI= 0017H
DX= 001BH	SP= 0035H

INC AX  
INC BX  
INC CX  
INC DX



# SUB INSTRUCTION

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**FORMAT:** SUB D,S

**ACTION:**  $D \leftarrow [D] - [S]$

**Example:**

SUB AX, BX  
SUB [SI], DI

$AX - BX = AX$   
 $SI - DI = SI$

$\rightarrow P.A = SS \times 10H + SI$   
memory



# SUB INSTRUCTION- EXAMPLE

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Assume the following register content:

AX= 0015H

SS= 2000H

BX= 0019H

SI= 001EH

CX= 0012H

DI= 0017H

DX= 001BH

SP= 0035H

SUB AX, BX

SUB [SI], DI



# SUB INSTRUCTION- EXAMPLE <sup>CF=1</sup>

SUB AX, BX

$$\begin{array}{r} \text{AX} = 0015 = \cancel{0000} \cancel{0000} \cancel{0000} \cancel{0101} \\ \text{BX} = 0019 = 0000 \ 0000 \ 0001 \ 1001 \end{array}$$

$$\begin{array}{r} \text{1111} \quad \text{1111} \quad \text{1111} \quad \text{1100} \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{C} \\ \hline \text{AX} = \text{FFFC H} \end{array}$$

SUB [SI], DI

$$\begin{aligned} \text{P.A.} &= \text{SS} \times 10\text{H} + \text{SI} \\ &= 20000 + 001\text{E} \\ &= 2001\text{E} \end{aligned}$$

$$\begin{array}{r} \text{SI} = 8975, \quad \text{6 16+5} = 21 \\ \text{DI} = 0017 \quad \quad \quad \text{7} \\ \hline \quad \quad \quad \text{14} \\ \hline \quad \quad \quad 895\text{E} \end{array}$$

$$\boxed{\text{SI} = 895\text{E}}$$

$$\begin{aligned} 2001\text{E} &- 75\text{H} \\ 2001\text{F} &- 89\text{H} \end{aligned}$$

$$\boxed{\text{SI} = 8975\text{H}}$$





# SBB INSTRUCTION

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**FORMAT:** SBB D,S

**ACTION:**  $D \leftarrow [D] - [S] - [CF]$

**Example:**

MOV AX, 7AFA

MOV BX, 913D

SUB AX, BX

SBB SI, DI



# SBB INSTRUCTION- EXAMPLE

Assume the following register content:

AX= 0015H

SS= 2000H

BX= 0019H

SI= 001EH

CX= 0012H

DI= 0017H

DX= 001BH

SP= 0035H

MOV AX, 7AFA

MOV BX, 913D

SUB AX, BX

SBB SI, DI

AX = 7AFAH  
BX = 913DH



# SBB INSTRUCTION- EXAMPLE

MOV AX, 7AFA  
MOV BX, 913D  
SUB AX, BX

$$\begin{array}{r}
 \overset{6}{\cancel{0}} \overset{2}{\cancel{1}} \overset{2}{\cancel{0}} \overset{2}{\cancel{0}} \overset{2}{\cancel{2}} \overset{2}{\cancel{0}} \overset{2}{\cancel{2}} \overset{2}{\cancel{0}} \\
 \text{AX} = 7\text{AFA} = \cancel{0}111\ 1010\ 1111\ 1010 \\
 \text{BX} = 913\text{D} = 1001\ 0001\ 0011\ 1101 \\
 \hline
 1110\ 1001\ 1011\ 1101 \\
 \text{E}\quad\text{9}\quad\text{B}\quad\text{D} \\
 \boxed{\text{CF} = 1, \text{AX} = \text{E9BDH}}
 \end{array}$$

SBB SI, DI

$$\begin{array}{r}
 \text{SI} = 001\text{E} \quad 14 \\
 \text{DI} = 0017 \quad 7 \\
 \text{CF} = 1 \quad 1 \\
 \hline
 0006 \quad 6 \\
 \boxed{\text{SI} = 0006\text{H}}
 \end{array}$$



# DEC INSTRUCTION

**FORMAT:** DEC [D]

**ACTION:**  $D \leftarrow [D] - 1$

**EXAMPLE:**

DEC AX

DEC BX

AX = 001FH

AX = 001EH

BX = 001FH

BX = 0020H

0020

- 1  
-----  
001F

15



# DEC INSTRUCTION- EXAMPLE

---

Assume the following register content:

AX= 0015H	SS= 2000H
BX= 0019H	SI= 001EH
CX= 0012H	DI= 0017H
DX= 001BH	SP= 0035H

DEC AX  
DEC BX  
DEC CX  
DEC DX



## REFERENCES:

- ✓ [https://www.tutorialspoint.com/java/java\\_encapsulation.htm](https://www.tutorialspoint.com/java/java_encapsulation.htm)
- ✓ <https://www.programiz.com/java-programming/encapsulation>
- ✓ <https://www.geeksforgeeks.org/encapsulation-in-java/>
- ✓ [https://www.w3schools.com/java/java\\_encapsulation.asp](https://www.w3schools.com/java/java_encapsulation.asp)

