

Complete 8086 instruction set

Quick reference:

AAA	CMPSB	JAE	JNBE	JPO	MOV		
AAD	CMPSW	JB	JNC	JS	MOVSB	RCR	SCASB
AAM	CWD	JBE	JNE	JZ	MOVSW	REP	SCASW
AAS	DAA	JC	JNG	JZ	MUL	REPE	SHL
ADC	DAS	JCXZ	JNGE	LAHF	NEG	REPNE	SHR
ADD	DEC	JE	JNL	LDS	NOP	REPZ	STC
AND	DIV	JG	JNLE	LEA	NOT	REPZ	STD
CALL	HLT	JGE	JNO	LES	OR	RET	STI
CBW	IDIV	JGE	JNO	LODSB	OUT	RETF	STOSB
CLC	IMUL	JL	JNP	LODSW	POP	ROL	STOSW
CLD	IN	JLE	JNS	LOOP	POPA	ROR	SUB
CLI	INC	JMP	JNZ	LOOPE	POPF	SAHF	TEST
CMC	INT	JNA	JO	LOOPNE	PUSH	SAL	XCHG
CMP	INTO	JNAE	JP	LOOPNZ	PUSHA	SAR	XLATB
	IRET	JNB	JPE	LOOPZ	PUSHF	SBB	XOR
	JA				RCL		

Operand types:

REG: AX, BX, CX, DX, AH, AL, BL, BH, CH, CL, DH, DL, DI, SI, BP, SP.

SREG: DS, ES, SS, and only as second operand: CS.

memory: [BX], [BX+SI+7], variable, etc...(see [Memory Access](#)).

immediate: 5, -24, 3Fh, 10001101b, etc...

Notes:

- When two operands are required for an instruction they are separated by comma. For example:

REG, memory

- When there are two operands, both operands must have the same size (except shift and rotate instructions). For example:

AL, DL
 DX, AX
 m1 DB ?
 AL, m1
 m2 DW ?
 AX, m2

- Some instructions allow several operand combinations. For example:

memory, immediate

REG, immediate

memory, REG

REG, SREG

- Some examples contain macros, so it is advisable to use **Shift + F8** hot key to *Step Over* (to make macro code execute at maximum speed set **step delay** to zero), otherwise emulator will step through each instruction of a macro. Here is an example that uses PRINTN macro:

```
include 'emu8086.inc'
ORG 100h
MOV AL, 1
MOV BL, 2
PRINTN 'Hello World!'    ; macro.
MOV CL, 3
PRINTN 'Welcome!'       ; macro.
RET
```



These marks are used to show the state of the flags:

- 1** - instruction sets this flag to **1**.
- 0** - instruction sets this flag to **0**.
- r** - flag value depends on result of the instruction.
- ?** - flag value is undefined (maybe **1** or **0**).

Some instructions generate exactly the same machine code, so disassembler may have a problem decoding to your original code. This is especially important for Conditional Jump instructions (see "[Program Flow Control](#)" in Tutorials for more information).

Instructions in alphabetical order:

Instruction	Operands	Description
		<p>ASCII Adjust after Addition. Corrects result in AH and AL after addition when working with BCD values.</p> <p>It works according to the following Algorithm:</p> <p>if low nibble of AL > 9 or AF = 1 then:</p>

AAA	No operands	<ul style="list-style-type: none">• $AL = AL + 6$• $AH = AH + 1$• $AF = 1$• $CF = 1$ <p>else</p> <ul style="list-style-type: none">• $AF = 0$• $CF = 0$ <p>in both cases: clear the high nibble of AL.</p> <p>Example:</p> <pre>MOV AX, 15 ; AH = 00, AL = 0Fh AAA ; AH = 01, AL = 05 RET</pre> <table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>r</td><td>?</td><td>?</td><td>?</td><td>?</td><td>r</td></tr></table> 	C	Z	S	O	P	A	r	?	?	?	?	r
C	Z	S	O	P	A									
r	?	?	?	?	r									
AAD	No operands	<p>ASCII Adjust before Division. Prepares two BCD values for division.</p> <p>Algorithm:</p> <ul style="list-style-type: none">• $AL = (AH * 10) + AL$• $AH = 0$ <p>Example:</p> <pre>MOV AX, 0105h ; AH = 01, AL = 05 AAD ; AH = 00, AL = 0Fh (15) RET</pre> <table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>?</td><td>r</td><td>r</td><td>?</td><td>r</td><td>?</td></tr></table> 	C	Z	S	O	P	A	?	r	r	?	r	?
C	Z	S	O	P	A									
?	r	r	?	r	?									
		<p>ASCII Adjust after Multiplication. Corrects the result of multiplication of two BCD values.</p> <p>Algorithm:</p> <ul style="list-style-type: none">• $AH = AL / 10$• $AL = \text{remainder}$												

Example:

```
MOV AL, 15    ; AL = 0Fh
AAM           ; AH = 01, AL = 05
RET
```

C	Z	S	O	P	A
?	r	r	?	r	?



AAM

No operands

ASCII Adjust after Subtraction.

Corrects result in AH and AL after subtraction when working with BCD values.

Algorithm:

if low nibble of AL > 9 or AF = 1 then:

- AL = AL - 6
- AH = AH - 1
- AF = 1
- CF = 1

else

- AF = 0
- CF = 0

in both cases:

clear the high nibble of AL.

Example:

```
MOV AX, 02FFh ; AH = 02, AL = 0FFh
AAS           ; AH = 01, AL = 09
RET
```

C	Z	S	O	P	A
r	?	?	?	?	r



AAS

No operands

Add with Carry.




Algorithm:

operand1 = operand1 + operand2 + CF





Example:



ADC

REG, memory
memory, REG
REG, REG

	memory, immediate REG, immediate	<pre>STC ; set CF = 1 MOV AL, 5 ; AL = 5 ADC AL, 1 ; AL = 7 RET</pre> <div> <div>CZSOPA</div> <div>rrrrrrr</div> </div> 
ADD	REG, memory memory, REG REG, REG memory, immediate REG, immediate	<p>Add.</p> <p>Algorithm:</p> $\text{operand1} = \text{operand1} + \text{operand2}$ <p>Example:</p> <pre>MOV AL, 5 ; AL = 5 ADD AL, -3 ; AL = 2 RET</pre> <div> <div>CZSOPA</div> <div>rrrrrrr</div> </div> 
AND	REG, memory memory, REG REG, REG memory, immediate REG, immediate	<p>Logical AND between all bits of two operands. Result is stored in operand1.</p> <p>These rules apply:</p> <pre>1 AND 1 = 1 1 AND 0 = 0 0 AND 1 = 0 0 AND 0 = 0</pre> <p>Example:</p> <pre>MOV AL, 'a' ; AL = 01100001b AND AL, 11011111b ; AL = 01000001b ('A') RET</pre> <div> <div>CZSOPA</div> <div>0rr0r</div> </div> 
		<p>Transfers control to procedure, return address is (IP) is pushed to stack. <i>4-byte address</i> may be entered in this form: 1234h:5678h, first value is a</p>

CALL	procedure name label 4-byte address	<p>segment second value is an offset (this is a far call, so CS is also pushed to stack).</p> <p>Example:</p> <pre>ORG 100h ; for COM file. CALL p1 ADD AX, 1 RET ; return to OS. p1 PROC ; procedure declaration. MOV AX, 1234h RET ; return to caller. p1 ENDP</pre> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
CBW	No operands	<p>Convert byte into word.</p> <p>Algorithm:</p> <p>if high bit of AL = 1 then:</p> <ul style="list-style-type: none">• AH = 255 (0FFh) <p>else</p> <ul style="list-style-type: none">• AH = 0 <p>Example:</p> <pre>MOV AX, 0 ; AH = 0, AL = 0 MOV AL, -5 ; AX = 000FBh (251) CBW ; AX = 0FFFBh (-5) RET</pre> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
		<p>Clear Carry flag.</p> <p>Algorithm:</p> <p>CF = 0</p>												

CLC	No operands	<div> <div>C</div> <div>0</div> </div> 
CLD	No operands	<p>Clear Direction flag. SI and DI will be incremented by chain instructions: CMPSB, CMPSW, LODSB, LODSW, MOVSB, MOVSW, STOSB, STOSW.</p> <p>Algorithm:</p> $DF = 0$ <div> <div>D</div> <div>0</div> </div> 
CLI	No operands	<p>Clear Interrupt enable flag. This disables hardware interrupts.</p> <p>Algorithm:</p> $IF = 0$ <div> <div>I</div> <div>0</div> </div> 
CMC	No operands	<p>Complement Carry flag. Inverts value of CF.</p> <p>Algorithm:</p> <pre>if CF = 1 then CF = 0 if CF = 0 then CF = 1</pre> <div> <div>C</div> <div>r</div> </div> 
		<p>Compare.</p> <p>Algorithm:</p> $\text{operand1} - \text{operand2}$

CMP	REG, memory memory, REG REG, REG memory, immediate REG, immediate	<p>result is not stored anywhere, flags are set (OF, SF, ZF, AF, PF, CF) according to result.</p> <p>Example:</p> <pre>MOV AL, 5 MOV BL, 5 CMP AL, BL ; AL = 5, ZF = 1 (so equal!) RET</pre> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>r</td><td>r</td><td>r</td><td>r</td><td>r</td><td>r</td></tr></table></div> <div></div>	C	Z	S	O	P	A	r	r	r	r	r	r
C	Z	S	O	P	A									
r	r	r	r	r	r									
CMPSB	No operands	<p>Compare bytes: ES:[DI] from DS:[SI].</p> <p>Algorithm:</p> <ul style="list-style-type: none">• DS:[SI] - ES:[DI]• set flags according to result: OF, SF, ZF, AF, PF, CF• if DF = 0 then<ul style="list-style-type: none">◦ SI = SI + 1◦ DI = DI + 1else<ul style="list-style-type: none">◦ SI = SI - 1◦ DI = DI - 1 <p>Example: open cmpsb.asm from c:\emu8086\examples</p> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>r</td><td>r</td><td>r</td><td>r</td><td>r</td><td>r</td></tr></table></div> <div></div>	C	Z	S	O	P	A	r	r	r	r	r	r
C	Z	S	O	P	A									
r	r	r	r	r	r									
CMPSW	No operands	<p>Compare words: ES:[DI] from DS:[SI].</p> <p>Algorithm:</p> <ul style="list-style-type: none">• DS:[SI] - ES:[DI]• set flags according to result: OF, SF, ZF, AF, PF, CF• if DF = 0 then<ul style="list-style-type: none">◦ SI = SI + 2◦ DI = DI + 2else<ul style="list-style-type: none">◦ SI = SI - 2◦ DI = DI - 2												

example:

open **cmpsw.asm** from c:\emu8086\examples

C	Z	S	O	P	A
r	r	r	r	r	r



Convert Word to Double word.

Algorithm:

if high bit of AX = 1 then:

- DX = 65535 (0FFFFh)

else

- DX = 0

Example:

```
MOV DX, 0    ; DX = 0
MOV AX, 0    ; AX = 0
MOV AX, -5   ; DX AX = 00000h:0FFFFBh
CWD          ; DX AX = 0FFFFh:0FFFFBh
RET
```

C	Z	S	O	P	A
unchanged					



Decimal adjust After Addition.

Corrects the result of addition of two packed BCD values.

Algorithm:

if low nibble of AL > 9 or AF = 1 then:

- AL = AL + 6
- AF = 1

if AL > 9Fh or CF = 1 then:

- AL = AL + 60h
- CF = 1

Example:

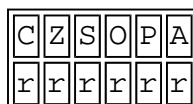
CWD

No operands

DAA

No operands

```
MOV AL, 0Fh ; AL = 0Fh (15)
DAA          ; AL = 15h
RET
```



DAS

No operands

Decimal adjust After Subtraction.
Corrects the result of subtraction of two packed BCD values.

Algorithm:

if low nibble of AL > 9 or AF = 1 then:

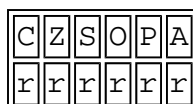
- AL = AL - 6
- AF = 1

if AL > 9Fh or CF = 1 then:

- AL = AL - 60h
- CF = 1

Example:

```
MOV AL, 0FFh ; AL = 0FFh (-1)
DAS          ; AL = 99h, CF = 1
RET
```



DEC

REG
memory

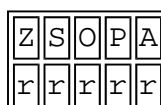
Decrement.

Algorithm:

operand = operand - 1

Example:




```
MOV AL, 255 ; AL = 0FFh (255 or -1)
DEC AL      ; AL = 0FEh (254 or -2)
RET
```



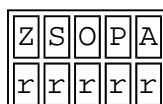
CF - unchanged!



DIV	REG memory	<div>Unsigned divide.</div> <div>Algorithm:</div> <div><div>when operand is a byte:</div><div>AL = AX / operand</div><div>AH = remainder (modulus)</div><div>when operand is a word:</div><div>AX = (DX AX) / operand</div><div>DX = remainder (modulus)</div></div> <div>Example:</div> <div>MOV AX, 203 ; AX = 00CBh</div> <div>MOV BL, 4</div> <div>DIV BL ; AL = 50 (32h), AH = 3</div> <div>RET</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>?</td><td>?</td><td>?</td><td>?</td><td>?</td><td>?</td></tr></table></div> <div></div>	C	Z	S	O	P	A	?	?	?	?	?	?
C	Z	S	O	P	A									
?	?	?	?	?	?									
HLT	No operands	<div>Halt the System.</div> <div>Example:</div> <div>MOV AX, 5</div> <div>HLT</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
IDIV	REG memory	<div>Signed divide.</div> <div>Algorithm:</div> <div><div>when operand is a byte:</div><div>AL = AX / operand</div><div>AH = remainder (modulus)</div><div>when operand is a word:</div><div>AX = (DX AX) / operand</div><div>DX = remainder (modulus)</div></div> <div>Example:</div> <div>MOV AX, -203 ; AX = 0FF35h</div> <div>MOV BL, 4</div> <div>IDIV BL ; AL = -50 (0CEh), AH = -3 (0FDh)</div> <div>RET</div>												

		<div> <div> CZSOPA ?? ?? ?? </div> <div>  </div> </div>
IMUL	REG memory	<p>Signed multiply.</p> <p>Algorithm:</p> <p>when operand is a byte: $AX = AL * \text{operand}$.</p> <p>when operand is a word: $(DX\ AX) = AX * \text{operand}$.</p> <p>Example:</p> <pre>MOV AL, -2 MOV BL, -4 IMUL BL ; AX = 8 RET</pre> <div> <div> CZSOPA r??r?? </div> <p>CF=OF=0 when result fits into operand of IMUL.</p> <div>  </div> </div>
IN	AL, im.byte AL, DX AX, im.byte AX, DX	<p>Input from port into AL or AX. Second operand is a port number. If required to access port number over 255 - DX register should be used.</p> <p>Example:</p> <pre>IN AX, 4 ; get status of traffic lights. IN AL, 7 ; get status of stepper-motor.</pre> <div> <div> CZSOPA unchanged </div> <div>  </div> </div>
INC	REG memory	<p>Increment.</p> <p>Algorithm:</p> <p>$\text{operand} = \text{operand} + 1$</p> <p>Example:</p> <pre>MOV AL, 4 INC AL ; AL = 5</pre>

RET



CF - unchanged!



Interrupt numbered by immediate byte (0..255).

Algorithm:

Push to stack:

- flags register
- CS
- IP
- IF = 0
- Transfer control to interrupt procedure

Example:

```
MOV AH, 0Eh ; teletype.
MOV AL, 'A'
INT 10h      ; BIOS interrupt.
RET
```



Interrupt 4 if Overflow flag is 1.

Algorithm:



if OF = 1 then INT 4

Example:

```
; -5 - 127 = -132 (not in -128..127)
; the result of SUB is wrong (124),
; so OF = 1 is set:
MOV AL, -5
SUB AL, 127 ; AL = 7Ch (124)
INTO       ; process error.
RET
```



Interrupt Return.

IRET	No operands	<p>Algorithm:</p> <p>Pop from stack:</p> <ul style="list-style-type: none">o IPo CSo flags register <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">popped</td></tr></table></div> <div></div>	C	Z	S	O	P	A	popped					
C	Z	S	O	P	A									
popped														
JA	label	<p>Short Jump if first operand is Above second operand (as set by CMP instruction). Unsigned.</p> <p>Algorithm:</p> <p>if (CF = 0) and (ZF = 0) then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 250 CMP AL, 5 JA labell PRINT 'AL is not above 5' JMP exit labell: PRINT 'AL is above 5' exit: RET</pre> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
JAE	label	<p>Short Jump if first operand is Above or Equal to second operand (as set by CMP instruction). Unsigned.</p> <p>Algorithm:</p> <p>if CF = 0 then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 5 CMP AL, 5 JAE labell PRINT 'AL is not above or equal to 5' JMP exit labell:</pre>												

```

    PRINT 'AL is above or equal to 5'
exit:
    RET

```



Short Jump if first operand is Below second operand (as set by CMP instruction). Unsigned.

Algorithm:

if CF = 1 then jump

Example:

```

include 'emu8086.inc'
ORG 100h
MOV AL, 1
CMP AL, 5
JB  label1
PRINT 'AL is not below 5'
JMP exit
label1:
    PRINT 'AL is below 5'
exit:
    RET

```



Short Jump if first operand is Below or Equal to second operand (as set by CMP instruction). Unsigned.

Algorithm:

if CF = 1 or ZF = 1 then jump

Example:

```

include 'emu8086.inc'
ORG 100h
MOV AL, 5
CMP AL, 5
JBE label1
PRINT 'AL is not below or equal to 5'
JMP exit
label1:
    PRINT 'AL is below or equal to 5'
exit:
    RET

```






JB

label

JBE

label

		<div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JC	label	<p>Short Jump if Carry flag is set to 1.</p> <p>Algorithm:</p> <p>if CF = 1 then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 255 ADD AL, 1 JC label1 PRINT 'no carry.' JMP exit label1: PRINT 'has carry.' exit: RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JCXZ	label	<p>Short Jump if CX register is 0.</p> <p>Algorithm:</p> <p>if CX = 0 then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV CX, 0 JCXZ label1 PRINT 'CX is not zero.' JMP exit label1: PRINT 'CX is zero.' exit: RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
		<p>Short Jump if first operand is Equal to second operand (as set by CMP instruction).</p>

Signed/Unsigned.

Algorithm:

if ZF = 1 then jump

Example:

```
include 'emu8086.inc'
ORG 100h
MOV AL, 5
CMP AL, 5
JE label1
PRINT 'AL is not equal to 5.'
JMP exit
label1:
PRINT 'AL is equal to 5.'
exit:
RET
```



JE

label

Short Jump if first operand is Greater then second operand (as set by CMP instruction). Signed.

Algorithm:

if (ZF = 0) and (SF = OF) then jump

Example:

```
include 'emu8086.inc'
ORG 100h
MOV AL, 5
CMP AL, -5
JG label1
PRINT 'AL is not greater -5.'
JMP exit
label1:
PRINT 'AL is greater -5.'
exit:
RET
```







JG

label

Short Jump if first operand is Greater or Equal to second operand (as set by CMP instruction). Signed.

Algorithm:

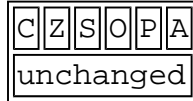
JGE	label	<div>if SF = OF then jump</div> <div>Example:</div> <div><pre>include 'emu8086.inc' ORG 100h MOV AL, 2 CMP AL, -5 JGE label1 PRINT 'AL < -5' JMP exit label1: PRINT 'AL >= -5' exit: RET</pre></div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
JL	label	<div>Short Jump if first operand is Less then second operand (as set by CMP instruction). Signed.</div> <div>Algorithm:</div> <div>if SF <> OF then jump</div> <div>Example:</div> <div><pre>include 'emu8086.inc' ORG 100h MOV AL, -2 CMP AL, 5 JL label1 PRINT 'AL >= 5.' JMP exit label1: PRINT 'AL < 5.' exit: RET</pre></div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
		<div>Short Jump if first operand is Less or Equal to second operand (as set by CMP instruction). Signed.</div> <div>Algorithm:</div> <div>if SF <> OF or ZF = 1 then jump</div> <div>Example:</div>												

JLE	label	<pre>include 'emu8086.inc' ORG 100h MOV AL, -2 CMP AL, 5 JLE label1 PRINT 'AL > 5.' JMP exit label1: PRINT 'AL <= 5.' exit: RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JMP	label 4-byte address	<p>Unconditional Jump. Transfers control to another part of the program. <i>4-byte address</i> may be entered in this form: 1234h:5678h, first value is a segment second value is an offset.</p> <p>Algorithm:</p> <p>always jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 5 JMP label1 ; jump over 2 lines! PRINT 'Not Jumped!' MOV AL, 0 label1: PRINT 'Got Here!' RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JNA	label	<p>Short Jump if first operand is Not Above second operand (as set by CMP instruction). Unsigned.</p> <p>Algorithm:</p> <p>if CF = 1 or ZF = 1 then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 2</pre>

```

    CMP AL, 5
    JNA label1
    PRINT 'AL is above 5.'
    JMP exit
label1:
    PRINT 'AL is not above 5.'
exit:
    RET

```



Short Jump if first operand is Not Above and Not Equal to second operand (as set by CMP instruction). Unsigned.

Algorithm:

```
if CF = 1 then jump
```

Example:

```
include 'emu8086.inc'
```

```

ORG 100h
MOV AL, 2
CMP AL, 5
JNAE label1
PRINT 'AL >= 5.'
JMP exit
label1:
    PRINT 'AL < 5.'
exit:
    RET

```



Short Jump if first operand is Not Below second operand (as set by CMP instruction). Unsigned.

Algorithm:

```
if CF = 0 then jump
```

Example:

```
include 'emu8086.inc'
```

```

ORG 100h
MOV AL, 7
CMP AL, 5
JNB label1
PRINT 'AL < 5.'

```

JNAE

label

JNB

label

```

    JMP exit
label1:
    PRINT 'AL >= 5.'
exit:
    RET

```



Short Jump if first operand is Not Below and Not Equal to second operand (as set by CMP instruction). Unsigned.

Algorithm:

if (CF = 0) and (ZF = 0) then jump

Example:

```
include 'emu8086.inc'
```

```

ORG 100h
MOV AL, 7
CMP AL, 5
JNBE label1
PRINT 'AL <= 5.'
JMP exit

```

```

label1:
    PRINT 'AL > 5.'
exit:
    RET

```



Short Jump if Carry flag is set to 0.

Algorithm:

if CF = 0 then jump

Example:

```
include 'emu8086.inc'
```

```

ORG 100h
MOV AL, 2
ADD AL, 3
JNC label1
PRINT 'has carry.'
JMP exit

```

```

label1:
    PRINT 'no carry.'
exit:



```

JNBE

label

JNC

label

		<p>RET</p> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JNE	label	<p>Short Jump if first operand is Not Equal to second operand (as set by CMP instruction). Signed/Unsigned.</p> <p>Algorithm:</p> <p>if ZF = 0 then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 2 CMP AL, 3 JNE label1 PRINT 'AL = 3.' JMP exit label1: PRINT 'Al <> 3.' exit: RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JNG	label	<p>Short Jump if first operand is Not Greater then second operand (as set by CMP instruction). Signed.</p> <p>Algorithm:</p> <p>if (ZF = 1) and (SF <> OF) then jump</p> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 2 CMP AL, 3 JNG label1 PRINT 'AL > 3.' JMP exit label1: PRINT 'Al <= 3.' exit: RET</pre>

C	Z	S	O	P	A
unchanged					



Short Jump if first operand is Not Greater and Not Equal to second operand (as set by CMP instruction). Signed.

Algorithm:

```
if SF <> OF then jump
```

Example:

```
include 'emu8086.inc'

ORG 100h
MOV AL, 2
CMP AL, 3
JNGE label1
PRINT 'AL >= 3.'
JMP exit
label1:
PRINT 'Al < 3.'
exit:
RET
```

C	Z	S	O	P	A
unchanged					



Short Jump if first operand is Not Less then second operand (as set by CMP instruction). Signed.

Algorithm:

```
if SF = OF then jump
```

Example:

```
include 'emu8086.inc'

ORG 100h
MOV AL, 2
CMP AL, -3
JNL label1
PRINT 'AL < -3.'
JMP exit
label1:
PRINT 'Al >= -3.'
exit:
RET
```

C	Z	S	O	P	A
---	---	---	---	---	---

unchanged



Short Jump if first operand is Not Less and Not Equal to second operand (as set by CMP instruction). Signed.

Algorithm:

if (SF = OF) and (ZF = 0) then jump

Example:

```
include 'emu8086.inc'

ORG 100h
MOV AL, 2
CMP AL, -3
JNLE label1
PRINT 'AL <= -3.'
JMP exit
label1:
  PRINT 'Al > -3.'
exit:
  RET
```

C	Z	S	O	P	A
unchanged					



Short Jump if Not Overflow.

Algorithm:

if OF = 0 then jump

Example:

```
; -5 - 2 = -7 (inside -128..127)
; the result of SUB is correct,
; so OF = 0:
```

```
include 'emu8086.inc'

ORG 100h
MOV AL, -5
SUB AL, 2    ; AL = 0F9h (-7)
JNO label1
PRINT 'overflow!'
JMP exit
label1:
  PRINT 'no overflow.'
exit:
  RET
```



C	Z	S	O	P	A
---	---	---	---	---	---

JNLE



label

JNO

label

		<div>unchanged</div> 
JNP	label	<p>Short Jump if No Parity (odd). Only 8 low bits of result are checked. Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.</p> <p>Algorithm:</p> <pre>if PF = 0 then jump</pre> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 00000111b ; AL = 7 OR AL, 0 ; just set flags. JNP label1 PRINT 'parity even.' JMP exit label1: PRINT 'parity odd.' exit: RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
JNS	label	<p>Short Jump if Not Signed (if positive). Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.</p> <p>Algorithm:</p> <pre>if SF = 0 then jump</pre> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 00000111b ; AL = 7 OR AL, 0 ; just set flags. JNS label1 PRINT 'signed.' JMP exit label1: PRINT 'not signed.' exit: RET</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div>

		<div>↑</div>												
JNZ	label	<div>Short Jump if Not Zero (not equal). Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.</div> <div>Algorithm:</div> <div>if ZF = 0 then jump</div> <div>Example:</div> <div>include 'emu8086.inc'</div> <div>ORG 100h</div> <div>MOV AL, 00000111b ; AL = 7</div> <div>OR AL, 0 ; just set flags.</div> <div>JNZ label1</div> <div>PRINT 'zero.'</div> <div>JMP exit</div> <div>label1:</div> <div>PRINT 'not zero.'</div> <div>exit:</div> <div>RET</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div>↑</div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
JO	label	<div>Short Jump if Overflow.</div> <div>Algorithm:</div> <div>if OF = 1 then jump</div> <div>Example:</div> <div>; -5 - 127 = -132 (not in -128..127)</div> <div>; the result of SUB is wrong (124),</div> <div>; so OF = 1 is set:</div> <div>include 'emu8086.inc'</div> <div>org 100h</div> <div>MOV AL, -5</div> <div>SUB AL, 127 ; AL = 7Ch (124)</div> <div>JO label1</div> <div>PRINT 'no overflow.'</div> <div>JMP exit</div> <div>label1:</div> <div>PRINT 'overflow!'</div> <div>exit:</div> <div>RET</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div>↑</div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														

JP	label	<p>Short Jump if Parity (even). Only 8 low bits of result are checked. Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.</p> <p>Algorithm:</p> <pre>if PF = 1 then jump</pre> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 00000101b ; AL = 5 OR AL, 0 ; just set flags. JP label1 PRINT 'parity odd.' JMP exit label1: PRINT 'parity even.' exit: RET</pre> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
JPE	label	<p>Short Jump if Parity Even. Only 8 low bits of result are checked. Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.</p> <p>Algorithm:</p> <pre>if PF = 1 then jump</pre> <p>Example:</p> <pre>include 'emu8086.inc' ORG 100h MOV AL, 00000101b ; AL = 5 OR AL, 0 ; just set flags. JPE label1 PRINT 'parity odd.' JMP exit label1: PRINT 'parity even.' exit: RET</pre> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
		<p>Short Jump if Parity Odd. Only 8 low bits of result</p>												

are checked. Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.

Algorithm:

if PF = 0 then jump

Example:

```
include 'emu8086.inc'

ORG 100h
MOV AL, 00000111b    ; AL = 7
OR  AL, 0             ; just set flags.
JPO label1
PRINT 'parity even.'
JMP exit
label1:
PRINT 'parity odd.'
exit:
RET
```

C	Z	S	O	P	A
unchanged					



Short Jump if Signed (if negative). Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.

Algorithm:

if SF = 1 then jump

Example:



```
include 'emu8086.inc'



ORG 100h
MOV AL, 10000000b    ; AL = -128
OR  AL, 0             ; just set flags.
JS label1
PRINT 'not signed.'
JMP exit
label1:
PRINT 'signed.'
exit:
RET
```


C	Z	S	O	P	A
unchanged					



Short Jump if Zero (equal). Set by CMP, SUB, ADD, TEST, AND, OR, XOR instructions.

JZ	label	<div>Algorithm:</div> <div>if ZF = 1 then jump</div> <div>Example:</div> <div>include 'emu8086.inc'</div> <div>ORG 100h</div> <div>MOV AL, 5</div> <div>CMP AL, 5</div> <div>JZ label1</div> <div>PRINT 'AL is not equal to 5.'</div> <div>JMP exit</div> <div>label1:</div> <div>PRINT 'AL is equal to 5.'</div> <div>exit:</div> <div>RET</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
LAHF	No operands	<div>Load AH from 8 low bits of Flags register.</div> <div>Algorithm:</div> <div>AH = flags register</div> <div>AH bit: 7 6 5 4 3 2 1 0</div> <div>[SF] [ZF] [0] [AF] [0] [PF] [1] [CF]</div> <div>bits 1, 3, 5 are reserved.</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
		<div>Load memory double word into word register and DS.</div> <div>Algorithm:</div> <div><ul style="list-style-type: none">REG = first wordDS = second word</div> <div>Example:</div> <div>ORG 100h</div>												

LDS	REG, memory	<pre>LDS AX, m RET m DW 1234h DW 5678h END</pre> <p>AX is set to 1234h, DS is set to 5678h.</p> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
LEA	REG, memory	<p>Load Effective Address.</p> <p>Algorithm:</p> <ul style="list-style-type: none"> REG = address of memory (offset) <p>Example:</p> <pre>MOV BX, 35h MOV DI, 12h LEA SI, [BX+DI] ; SI = 35h + 12h = 47h</pre> <p>Note: The integrated 8086 assembler automatically replaces LEA with a more efficient MOV where possible. For example:</p> <pre>org 100h LEA AX, m ; AX = offset of m RET m dw 1234h END</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
		<p>Load memory double word into word register and ES.</p> <p>Algorithm:</p>

LES	REG, memory	<ul style="list-style-type: none">• REG = first word• ES = second word <p>Example:</p> <pre>ORG 100h LES AX, m RET m DW 1234h DW 5678h END</pre> <p>AX is set to 1234h, ES is set to 5678h.</p> <div><div>CZSOPA</div><div>unchanged</div></div> <div></div>
LODSB	No operands	<p>Load byte at DS: [SI] into AL. Update SI.</p> <p>Algorithm:</p> <ul style="list-style-type: none">• AL = DS:[SI]• if DF = 0 then<ul style="list-style-type: none">◦ SI = SI + 1else<ul style="list-style-type: none">◦ SI = SI - 1 <p>Example:</p> <pre>ORG 100h LEA SI, a1 MOV CX, 5 MOV AH, 0Eh m: LODSB INT 10h LOOP m RET a1 DB 'H', 'e', 'l', 'l', 'o'</pre> <div><div>CZSOPA</div><div>unchanged</div></div>



Load word at DS:[SI] into AX. Update SI.

Algorithm:

- $AX = DS:[SI]$
- if $DF = 0$ then
 - $SI = SI + 2$
- else
 - $SI = SI - 2$

Example:

```
ORG 100h
```

```
LEA SI, a1
```

```
MOV CX, 5
```

```
REP LODSW ; finally there will be 555h in AX.
```

```
RET
```

```
a1 dw 111h, 222h, 333h, 444h, 555h
```

C	Z	S	O	P	A
unchanged					



Decrease CX, jump to label if CX not zero.

Algorithm:

- $CX = CX - 1$
- if $CX \neq 0$ then
 - jump
- else
 - no jump, continue

Example:

```
include 'emu8086.inc'
```

```
ORG 100h
```

```
MOV CX, 5
```

```
label1:
```

```
PRINTN 'loop!'
```

```
LOOP label1
```

```
RET
```

C	Z	S	O	P	A
unchanged					

LODSW

No operands

LOOP

label



Decrease CX, jump to label if CX not zero and Equal (ZF = 1).

Algorithm:

- CX = CX - 1
- if (CX <> 0) and (ZF = 1) then
 - jump
 - else
 - no jump, continue

Example:

```
; Loop until result fits into AL alone,
; or 5 times. The result will be over 255
; on third loop (100+100+100),
; so loop will exit.
```

```
include 'emu8086.inc'
```

```
ORG 100h
MOV AX, 0
MOV CX, 5
```

```
label1:
  PUTC '*'
  ADD AX, 100
  CMP AH, 0
  LOOPE label1
  RET
```



LOOPE

label

Decrease CX, jump to label if CX not zero and Not Equal (ZF = 0).

Algorithm:

- CX = CX - 1
- if (CX <> 0) and (ZF = 0) then
 - jump
 - else
 - no jump, continue

Example:

```
; Loop until '7' is found,
; or 5 times.
```

```
include 'emu8086.inc'
```

```
ORG 100h
```

LOOPNE

label

```

MOV SI, 0
MOV CX, 5
label1:
  PUTC '*'
  MOV AL, v1[SI]
  INC SI          ; next byte (SI=SI+1).
  CMP AL, 7
  LOOPNE label1
  RET
v1 db 9, 8, 7, 6, 5

```

C	Z	S	O	P	A
unchanged					



Decrease CX, jump to label if CX not zero and ZF = 0.

Algorithm:

- $CX = CX - 1$
- if $(CX \neq 0)$ and $(ZF = 0)$ then
 - jump
 - else
 - no jump, continue

Example:

```

; Loop until '7' is found,
; or 5 times.

```

```
include 'emu8086.inc'
```

```

ORG 100h
MOV SI, 0
MOV CX, 5
label1:
  PUTC '*'
  MOV AL, v1[SI]
  INC SI          ; next byte (SI=SI+1).
  CMP AL, 7
  LOOPNZ label1
  RET
v1 db 9, 8, 7, 6, 5

```

C	Z	S	O	P	A
unchanged					



Decrease CX, jump to label if CX not zero and ZF = 1.

Algorithm:

- $CX = CX - 1$

LOOPNZ

label



--	--	--	--	--	--

C	Z	S	O	P	A
unchanged					



MOVSB

No operands

Copy byte at DS:[SI] to ES:[DI]. Update SI and DI.

Algorithm:

- ES:[DI] = DS:[SI]
- if DF = 0 then
 - SI = SI + 1
 - DI = DI + 1
- else
 - SI = SI - 1
 - DI = DI - 1

Example:

```
ORG 100h
```

```
CLD
LEA SI, a1
LEA DI, a2
MOV CX, 5
REP MOVSB
```

```
RET
```

```
a1 DB 1,2,3,4,5
a2 DB 5 DUP(0)
```

C	Z	S	O	P	A
unchanged					





Copy **word** at DS:[SI] to ES:[DI]. Update SI and DI.

Algorithm:

- ES:[DI] = DS:[SI]
- if DF = 0 then
 - SI = SI + 2
 - DI = DI + 2
- else
 - SI = SI - 2
 - DI = DI - 2

Example:

MOVSW	No operands	<div>ORG 100h</div> <div>CLD</div> <div>LEA SI, a1</div> <div>LEA DI, a2</div> <div>MOV CX, 5</div> <div>REP MOVSW</div> <div>RET</div> <div>a1 DW 1,2,3,4,5</div> <div>a2 DW 5 DUP(0)</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
MUL	REG memory	<div>Unsigned multiply.</div> <div>Algorithm:</div> <div>when operand is a byte:</div> <div>AX = AL * operand.</div> <div>when operand is a word:</div> <div>(DX AX) = AX * operand.</div> <div>Example:</div> <div>MOV AL, 200 ; AL = 0C8h</div> <div>MOV BL, 4</div> <div>MUL BL ; AX = 0320h (800)</div> <div>RET</div> <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>r</td><td>?</td><td>?</td><td>r</td><td>?</td><td>?</td></tr></table></div> <div>CF=OF=0 when high section of the result is zero.</div> <div></div>	C	Z	S	O	P	A	r	?	?	r	?	?
C	Z	S	O	P	A									
r	?	?	r	?	?									
NEG	REG memory	<div>Negate. Makes operand negative (two's complement).</div> <div>Algorithm:</div> <div><ul style="list-style-type: none">• Invert all bits of the operand• Add 1 to inverted operand</div> <div>Example:</div> <div>MOV AL, 5 ; AL = 05h</div> <div>NEG AL ; AL = 0FBh (-5)</div> <div>NEG AL ; AL = 05h (5)</div>												

RET



NOP

No operands

No Operation.

Algorithm:

- Do nothing

Example:

```
; do nothing, 3 times:
NOP
NOP
NOP
RET
```



NOT

REG
memory

Invert each bit of the operand.

Algorithm:

- if bit is 1 turn it to 0.
- if bit is 0 turn it to 1.

Example:

```
MOV AL, 00011011b
NOT AL    ; AL = 11100100b
RET
```



Logical OR between all bits of two operands.
Result is stored in first operand.




These rules apply:



```
1 OR 1 = 1
1 OR 0 = 1
0 OR 1 = 1
0 OR 0 = 0
```



REG, memory



OR	memory, REG REG, REG memory, immediate REG, immediate	<p>Example:</p> <pre>MOV AL, 'A' ; AL = 01000001b OR AL, 00100000b ; AL = 01100001b ('a') RET</pre> <div><div>CZSOPA</div><div>0rr0r?</div></div> <div></div>
OUT	im.byte, AL im.byte, AX DX, AL DX, AX	<p>Output from AL or AX to port. First operand is a port number. If required to access port number over 255 - DX register should be used.</p> <p>Example:</p> <pre>MOV AX, 0FFFh ; Turn on all OUT 4, AX ; traffic lights. MOV AL, 100b ; Turn on the third OUT 7, AL ; magnet of the stepper-motor.</pre> <div><div>CZSOPA</div><div>unchanged</div></div> <div></div>
POP	REG SREG memory	<p>Get 16 bit value from the stack.</p> <p>Algorithm:</p> <ul style="list-style-type: none">operand = SS:[SP] (top of the stack)SP = SP + 2 <p>Example:</p> <pre>MOV AX, 1234h PUSH AX POP DX ; DX = 1234h RET</pre> <div><div>CZSOPA</div><div>unchanged</div></div> <div></div>
		Pop all general purpose registers DI, SI, BP, SP, BX, DX, CX, AX from the stack.

POPA	No operands	<p>SP value is ignored, it is Popped but not set to SP register).</p> <p>Note: this instruction works only on 80186 CPU and later!</p> <p>Algorithm:</p> <ul style="list-style-type: none">• POP DI• POP SI• POP BP• POP xx (SP value ignored)• POP BX• POP DX• POP CX• POP AX <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table></div> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
POPF	No operands	<p>Get flags register from the stack.</p> <p>Algorithm:</p> <ul style="list-style-type: none">• flags = SS:[SP] (top of the stack)• SP = SP + 2 <div><table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">popped</td></tr></table></div> <div></div>	C	Z	S	O	P	A	popped					
C	Z	S	O	P	A									
popped														
PUSH	REG SREG memory immediate	<p>Store 16 bit value in the stack.</p> <p>Note: PUSH immediate works only on 80186 CPU and later!</p> <p>Algorithm:</p> <ul style="list-style-type: none">• SP = SP - 2• SS:[SP] (top of the stack) = operand <p>Example:</p> <pre>MOV AX, 1234h PUSH AX POP DX ; DX = 1234h RET</pre> <div></div>												

		<div> <div>CZSOPA</div> <div>unchanged</div> </div> 
PUSHA	No operands	<p>Push all general purpose registers AX, CX, DX, BX, SP, BP, SI, DI in the stack. Original value of SP register (before PUSHA) is used.</p> <p>Note: this instruction works only on 80186 CPU and later!</p> <p>Algorithm:</p> <ul style="list-style-type: none"> • PUSH AX • PUSH CX • PUSH DX • PUSH BX • PUSH SP • PUSH BP • PUSH SI • PUSH DI <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
PUSHF	No operands	<p>Store flags register in the stack.</p> <p>Algorithm:</p> <ul style="list-style-type: none"> • $SP = SP - 2$ • $SS:[SP]$ (top of the stack) = flags <div> <div>CZSOPA</div> <div>unchanged</div> </div> 
		<p>Rotate operand1 left through Carry Flag. The number of rotates is set by operand2. When immediate is greater than 1, assembler generates several RCL xx, 1 instructions because 8086 has machine code only for this instruction (the same principle works for all other shift/rotate instructions).</p> <p>Algorithm:</p>

RCL	memory, immediate REG, immediate memory, CL REG, CL	<p>shift all bits left, the bit that goes off is set to CF and previous value of CF is inserted to the right-most position.</p> <p>Example:</p> <pre>STC ; set carry (CF=1). MOV AL, 1Ch ; AL = 00011100b RCL AL, 1 ; AL = 00111001b, CF=0. RET</pre> <div><div>C</div><div>O</div><div>r</div><div>r</div></div> <p>OF=0 if first operand keeps original sign.</p> <div></div>
RCR	memory, immediate REG, immediate memory, CL REG, CL	<p>Rotate operand1 right through Carry Flag. The number of rotates is set by operand2.</p> <p>Algorithm:</p> <p>shift all bits right, the bit that goes off is set to CF and previous value of CF is inserted to the left-most position.</p> <p>Example:</p> <pre>STC ; set carry (CF=1). MOV AL, 1Ch ; AL = 00011100b RCR AL, 1 ; AL = 10001110b, CF=0. RET</pre> <div><div>C</div><div>O</div><div>r</div><div>r</div></div> <p>OF=0 if first operand keeps original sign.</p> <div></div>
		<p>Repeat following MOVSB, MOVSW, LODSB, LODSW, STOSB, STOSW instructions CX times.</p> <p>Algorithm:</p> <p>check_cx:</p> <p>if CX <> 0 then</p> <ul style="list-style-type: none">do following <u>chain instruction</u>

REP	chain instruction	<ul style="list-style-type: none"> • CX = CX - 1 • go back to check_cx <p>else</p> <ul style="list-style-type: none"> • exit from REP cycle <div style="border: 1px solid black; padding: 2px; display: inline-block;"> <div style="border: 1px solid black; padding: 2px; display: inline-block;">Z</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">r</div> </div> <div style="text-align: right;">  </div>
REPE	chain instruction	<p>Repeat following CMPSB, CMPSW, SCASB, SCASW instructions while ZF = 1 (result is Equal), maximum CX times.</p> <p>Algorithm:</p> <p>check_cx:</p> <p>if CX <> 0 then</p> <ul style="list-style-type: none"> • do following <u>chain instruction</u> • CX = CX - 1 • if ZF = 1 then: <ul style="list-style-type: none"> ◦ go back to check_cx else <ul style="list-style-type: none"> ◦ exit from REPE cycle <p>else</p> <ul style="list-style-type: none"> • exit from REPE cycle <p>example: open cmpsb.asm from c:\emu8086\examples</p> <div style="border: 1px solid black; padding: 2px; display: inline-block;"> <div style="border: 1px solid black; padding: 2px; display: inline-block;">Z</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">r</div> </div> <div style="text-align: right;">  </div>
		<p>Repeat following CMPSB, CMPSW, SCASB, SCASW instructions while ZF = 0 (result is Not Equal), maximum CX times.</p> <p>Algorithm:</p> <p>check_cx:</p> <p>if CX <> 0 then</p> <ul style="list-style-type: none"> • do following <u>chain instruction</u>

REPNE	chain instruction	<ul style="list-style-type: none"> • $CX = CX - 1$ • if $ZF = 0$ then: <ul style="list-style-type: none"> ◦ go back to <code>check_cx</code> else <ul style="list-style-type: none"> ◦ exit from REPNE cycle <div style="border: 1px solid black; padding: 2px; display: inline-block;"> <div style="border: 1px solid black; padding: 2px; display: inline-block;">Z</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">r</div> </div> 
REPNZ	chain instruction	<p>Repeat following CMPSB, CMPSW, SCASB, SCASW instructions while $ZF = 0$ (result is Not Zero), maximum CX times.</p> <p>Algorithm:</p> <p><code>check_cx:</code></p> <p>if $CX \neq 0$ then</p> <ul style="list-style-type: none"> • do following <u>chain instruction</u> • $CX = CX - 1$ • if $ZF = 0$ then: <ul style="list-style-type: none"> ◦ go back to <code>check_cx</code> else <ul style="list-style-type: none"> ◦ exit from REPNZ cycle <p>else</p> <ul style="list-style-type: none"> • exit from REPNZ cycle <div style="border: 1px solid black; padding: 2px; display: inline-block;"> <div style="border: 1px solid black; padding: 2px; display: inline-block;">Z</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">r</div> </div> 
		<p>Repeat following CMPSB, CMPSW, SCASB, SCASW instructions while $ZF = 1$ (result is Zero), maximum CX times.</p> <p>Algorithm:</p> <p><code>check_cx:</code></p> <p>if $CX \neq 0$ then</p>

REPZ	chain instruction	<ul style="list-style-type: none"> do following <u>chain instruction</u> $CX = CX - 1$ if $ZF = 1$ then: <ul style="list-style-type: none"> go back to check_cx else <ul style="list-style-type: none"> exit from REPZ cycle <p>else</p> <ul style="list-style-type: none"> exit from REPZ cycle <div> <div>Z</div> <div>r</div> </div> <div></div>
RET	No operands or even immediate	<p>Return from near procedure.</p> <p>Algorithm:</p> <ul style="list-style-type: none"> Pop from stack: <ul style="list-style-type: none"> IP if <u>immediate</u> operand is present: <ul style="list-style-type: none"> $SP = SP + \text{operand}$ <p>Example:</p> <pre>ORG 100h ; for COM file. CALL p1 ADD AX, 1 RET ; return to OS. p1 PROC ; procedure declaration. MOV AX, 1234h RET ; return to caller. p1 ENDP</pre> <div> <div>CZSOPA</div> <div>unchanged</div> </div> <div></div>
RETF	No operands or even immediate	<p>Return from Far procedure.</p> <p>Algorithm:</p> <ul style="list-style-type: none"> Pop from stack: <ul style="list-style-type: none"> IP CS if <u>immediate</u> operand is present:

$$SP = SP + \text{operand}$$


ROL

memory, immediate
REG, immediate

memory, CL
REG, CL

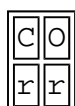
Rotate operand1 left. The number of rotates is set by operand2.

Algorithm:

shift all bits left, the bit that goes off is set to CF and the same bit is inserted to the right-most position.

Example:

```
MOV AL, 1Ch      ; AL = 00011100b
ROL AL, 1        ; AL = 00111000b, CF=0.
RET
```



OF=0 if first operand keeps original sign.



ROR

memory, immediate
REG, immediate

memory, CL
REG, CL

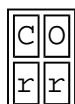
Rotate operand1 right. The number of rotates is set by operand2.

Algorithm:

shift all bits right, the bit that goes off is set to CF and the same bit is inserted to the left-most position.

Example:

```
MOV AL, 1Ch      ; AL = 00011100b
ROR AL, 1        ; AL = 00001110b, CF=0.
RET
```



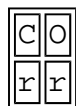
OF=0 if first operand keeps original sign.



Store AH register into low 8 bits of Flags register.

Algorithm:

SAHF	No operands	<p>flags register = AH</p> <p>AH bit: 7 6 5 4 3 2 1 0 [SF] [ZF] [0] [AF] [0] [PF] [1] [CF]</p> <p>bits 1, 3, 5 are reserved.</p> <table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>r</td><td>r</td><td>r</td><td>r</td><td>r</td><td>r</td></tr></table> <div></div>	C	Z	S	O	P	A	r	r	r	r	r	r
C	Z	S	O	P	A									
r	r	r	r	r	r									
SAL	<p>memory, immediate REG, immediate</p> <p>memory, CL REG, CL</p>	<p>Shift Arithmetic operand1 Left. The number of shifts is set by operand2.</p> <p>Algorithm:</p> <ul style="list-style-type: none">• Shift all bits left, the bit that goes off is set to CF.• Zero bit is inserted to the right-most position. <p>Example:</p> <pre>MOV AL, 0E0h ; AL = 11100000b SAL AL, 1 ; AL = 11000000b, CF=1. RET</pre> <table><tr><td>C</td><td>O</td></tr><tr><td>r</td><td>r</td></tr></table> <p>OF=0 if first operand keeps original sign.</p> <div></div>	C	O	r	r								
C	O													
r	r													
SAR	<p>memory, immediate REG, immediate</p> <p>memory, CL REG, CL</p>	<p>Shift Arithmetic operand1 Right. The number of shifts is set by operand2.</p> <p>Algorithm:</p> <ul style="list-style-type: none">• Shift all bits right, the bit that goes off is set to CF.• The sign bit that is inserted to the left-most position has the same value as before shift. <p>Example:</p> <pre>MOV AL, 0E0h ; AL = 11100000b SAR AL, 1 ; AL = 11110000b, CF=0. MOV BL, 4Ch ; BL = 01001100b SAR BL, 1 ; BL = 00100110b, CF=0. RET</pre>												



OF=0 if first operand keeps original sign.



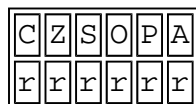
Subtract with Borrow.

Algorithm:

$\text{operand1} = \text{operand1} - \text{operand2} - \text{CF}$

Example:

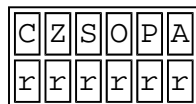
```
STC
MOV AL, 5
SBB AL, 3      ; AL = 5 - 3 - 1 = 1
RET
```



Compare bytes: AL from ES:[DI].

Algorithm:




- $\text{AL} - \text{ES}:[\text{DI}]$
- set flags according to result:
OF, SF, ZF, AF, PF, CF
- if DF = 0 then
 - $\text{DI} = \text{DI} + 1$
- else
 - $\text{DI} = \text{DI} - 1$



Compare words: AX from ES:[DI].

Algorithm:

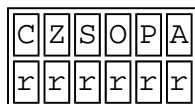
- $\text{AX} - \text{ES}:[\text{DI}]$
- set flags according to result:
OF, SF, ZF, AF, PF, CF
- if DF = 0 then
 - $\text{DI} = \text{DI} + 2$

		<div><div><div>C</div><div>O</div><div>r</div><div>r</div></div></div> <div>OF=0 if first operand keeps original sign.</div> <div></div>
SBB	REG, memory memory, REG REG, REG memory, immediate REG, immediate	<div>Subtract with Borrow.</div> <div>Algorithm:</div> <div>operand1 = operand1 - operand2 - CF</div> <div>Example:</div> <div>STC MOV AL, 5 SBB AL, 3 ; AL = 5 - 3 - 1 = 1 RET</div> <div><div><div>C</div><div>Z</div><div>S</div><div>O</div><div>P</div><div>A</div><div>r</div><div>r</div><div>r</div><div>r</div><div>r</div><div>r</div></div></div> <div></div>
SCASB	No operands	<div>Compare bytes: AL from ES:[DI].</div> <div>Algorithm:</div> <div><ul style="list-style-type: none">• AL - ES:[DI]• set flags according to result: OF, SF, ZF, AF, PF, CF• if DF = 0 then<ul style="list-style-type: none">◦ DI = DI + 1else<ul style="list-style-type: none">◦ DI = DI - 1</div> <div><div><div>C</div><div>Z</div><div>S</div><div>O</div><div>P</div><div>A</div><div>r</div><div>r</div><div>r</div><div>r</div><div>r</div><div>r</div></div></div> <div></div>
SCASW	No operands	<div>Compare words: AX from ES:[DI].</div> <div>Algorithm:</div> <div><ul style="list-style-type: none">• AX - ES:[DI]• set flags according to result: OF, SF, ZF, AF, PF, CF• if DF = 0 then<ul style="list-style-type: none">◦ DI = DI + 2</div>


```

else
    o DI = DI - 2

```



SHL

```

memory, immediate
REG, immediate

```

```

memory, CL
REG, CL

```

Shift operand1 Left. The number of shifts is set by operand2.

Algorithm:

- Shift all bits left, the bit that goes off is set to CF.
- Zero bit is inserted to the right-most position.

Example:

```

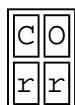
MOV AL, 11100000b
SHL AL, 1          ; AL = 11000000b, CF=1.

```

```

RET

```



OF=0 if first operand keeps original sign.



SHR

```

memory, immediate
REG, immediate

```

```

memory, CL
REG, CL

```

Shift operand1 Right. The number of shifts is set by operand2.

Algorithm:

- Shift all bits right, the bit that goes off is set to CF.
- Zero bit is inserted to the left-most position.

Example:

```

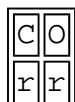
MOV AL, 00000111b
SHR AL, 1          ; AL = 00000011b, CF=1.

```

```




RET

```



OF=0 if first operand keeps original sign.



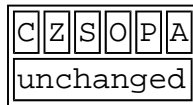
STC	No operands	<p>Set Carry flag.</p> <p>Algorithm:</p> $CF = 1$ <div> <div>C</div> <div>1</div> </div> 
STD	No operands	<p>Set Direction flag. SI and DI will be decremented by chain instructions: CMPSB, CMPSW, LODSB, LODSW, MOVSB, MOVSW, STOSB, STOSW.</p> <p>Algorithm:</p> $DF = 1$ <div> <div>D</div> <div>1</div> </div> 
STI	No operands	<p>Set Interrupt enable flag. This enables hardware interrupts.</p> <p>Algorithm:</p> $IF = 1$ <div> <div>I</div> <div>1</div> </div> 
STOSB	No operands	<p>Store byte in AL into ES:[DI]. Update DI.</p> <p>Algorithm:</p> <ul style="list-style-type: none"> • $ES:[DI] = AL$ • if $DF = 0$ then <ul style="list-style-type: none"> ◦ $DI = DI + 1$ else <ul style="list-style-type: none"> ◦ $DI = DI - 1$ <p>Example:</p> <pre>ORG 100h LEA DI, a1</pre>

```
MOV AL, 12h
MOV CX, 5

REP STOSB

RET

a1 DB 5 dup(0)
```



STOSW

No operands

Store word in AX into ES:[DI]. Update DI.

Algorithm:

- $ES:[DI] = AX$
- if $DF = 0$ then
 - $DI = DI + 2$
- else
 - $DI = DI - 2$

Example:

```
ORG 100h

LEA DI, a1
MOV AX, 1234h
MOV CX, 5

REP STOSW

RET

a1 DW 5 dup(0)
```



SUB

REG, memory
memory, REG
REG, REG
memory, immediate
REG, immediate

Subtract.




Algorithm:

$operand1 = operand1 - operand2$

Example:

```
MOV AL, 5
SUB AL, 1           ; AL = 4

RET
```

		<div> <div> <div>C</div><div>Z</div><div>S</div><div>O</div><div>P</div><div>A</div> </div> <div> <div>r</div><div>r</div><div>r</div><div>r</div><div>r</div><div>r</div> </div> </div> 
TEST	REG, memory memory, REG REG, REG memory, immediate REG, immediate	<p>Logical AND between all bits of two operands for flags only. These flags are effected: ZF, SF, PF. Result is not stored anywhere.</p> <p>These rules apply:</p> <pre> 1 AND 1 = 1 1 AND 0 = 0 0 AND 1 = 0 0 AND 0 = 0 </pre> <p>Example:</p> <pre> MOV AL, 00000101b TEST AL, 1 ; ZF = 0. TEST AL, 10b ; ZF = 1. RET </pre> <div> <div> <div>C</div><div>Z</div><div>S</div><div>O</div><div>P</div> </div> <div> <div>0</div><div>r</div><div>r</div><div>0</div><div>r</div> </div> </div> 
XCHG	REG, memory memory, REG REG, REG	<p>Exchange values of two operands.</p> <p>Algorithm:</p> <pre> operand1 < - > operand2 </pre> <p>Example:</p> <pre> MOV AL, 5 MOV AH, 2 XCHG AL, AH ; AL = 2, AH = 5 XCHG AL, AH ; AL = 5, AH = 2 RET </pre> <div> <div> <div>C</div><div>Z</div><div>S</div><div>O</div><div>P</div><div>A</div> </div> <div>unchanged</div> </div> 
		<p>Translate byte from table. Copy value of memory byte at DS:[BX + unsigned AL] to AL register.</p> <p>Algorithm:</p>

XLATB	No operands	<p>AL = DS:[BX + unsigned AL]</p> <p>Example:</p> <p>ORG 100h LEA BX, dat MOV AL, 2 XLATB ; AL = 33h</p> <p>RET</p> <p>dat DB 11h, 22h, 33h, 44h, 55h</p> <table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td colspan="6">unchanged</td></tr></table> <div></div>	C	Z	S	O	P	A	unchanged					
C	Z	S	O	P	A									
unchanged														
XOR	REG, memory memory, REG REG, REG memory, immediate REG, immediate	<p>Logical XOR (Exclusive OR) between all bits of two operands. Result is stored in first operand.</p> <p>These rules apply:</p> <p>1 XOR 1 = 0 1 XOR 0 = 1 0 XOR 1 = 1 0 XOR 0 = 0</p> <p>Example:</p> <p>MOV AL, 00000111b XOR AL, 00000010b ; AL = 00000101b RET</p> <table><tr><td>C</td><td>Z</td><td>S</td><td>O</td><td>P</td><td>A</td></tr><tr><td>0</td><td>r</td><td>r</td><td>0</td><td>r</td><td>?</td></tr></table> <div></div>	C	Z	S	O	P	A	0	r	r	0	r	?
C	Z	S	O	P	A									
0	r	r	0	r	?									