Microprocessors and Interfaces: 2021-22
Lecture 16
8086 Branching & Program Control Instructions : Part-1

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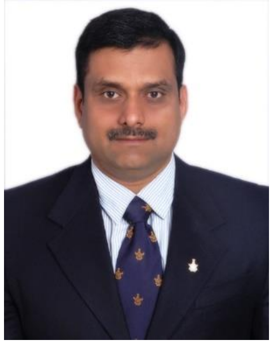


THE JUMP GROUP

- Allows programmer to skip program sections and branch to any part of memory for the next instruction.

- A conditional jump instruction allows decisions based upon numerical tests.
  - results are held in the flag bits, then tested by conditional jump instructions

- LOOP is also a form of the jump instruction.

Branching Instructions

- **Conditional Jump**

- JC/JNC → Carry
- JZ/JNZ → Zero
- JP/JNP → Parity
- JS/JNS → Sign
- JO/JNO → Overflow
- JCXZ → CX =0
- JE/JNE

Branching Instruction : Conditional Jump

Mnemonic	Meaning	Jump Condition
JA	Jump if Above	CF=0 and ZF=0
JAE	Jump if Above or Equal	CF=0
JB	Jump if Below	CF=1
JBE	Jump if Below or Equal	CF=1 or ZF=1
JC	Jump if Carry	CF=1
JCXZ	Jump if CX Zero	CX=0
JE	Jump if Equal	ZF=1
JG	Jump if Greater (signed)	ZF=0 and SF=OF
JGE	Jump if Greater or Equal (signed)	SF=OF
JL	Jump if Less (signed)	SF != OF
JLE	Jump if Less or Equal (signed)	ZF=1 or SF != OF
JMP	Unconditional Jump	unconditional
JNA	Jump if Not Above	CF=1 or ZF=1
JNAE	Jump if Not Above or Equal	CF=1
JNB	Jump if Not Below	CF=0
JNBE	Jump if Not Below or Equal	CF=0 and ZF=0

Branching Instruction : Conditional Jump

Mnemonic	Meaning	Jump Condition
JNC	Jump if Not Carry	CF=0
JNE	Jump if Not Equal	ZF=0
JNG	Jump if Not Greater (signed)	ZF=1 or SF != OF
JNGE	Jump if Not Greater or Equal (signed)	SF != OF
JNL	Jump if Not Less (signed)	SF=OF
JNLE	Jump if Not Less or Equal (signed)	ZF=0 and SF=OF
JNO	Jump if Not Overflow (signed)	OF=0
JNP	Jump if No Parity	PF=0
JNS	Jump if Not Signed (signed)	SF=0
JNZ	Jump if Not Zero	ZF=0
JO	Jump if Overflow (signed)	OF=1
JP	Jump if Parity	PF=1
JPE	Jump if Parity Even	PF=1
JPO	Jump if Parity Odd	PF=0
JS	Jump if Signed (signed)	SF=1
JZ	Jump if Zero	ZF=1

Branching Instruction : Conditional Jump

- **Conditional Jump**

Unsigned numbers:

JA

JAE

JB

JBE

Signed numbers:

JG

JGE

JL

JLE

Branching Instruction : Conditional Jump

Example 1

CMP AX, 0030H; compares by subtracting 0030H from the value in AX register

JA LABEL1; jumps to the address specified by LABEL1 if value in register AX is above the value 0030H

Example 2

CMP AX, 0030H; compares by subtracting 0030H from the value in AX register

JAE LABEL1; jumps to the address specified by LABEL1 if value in register AX is above or equal to the value 0030H

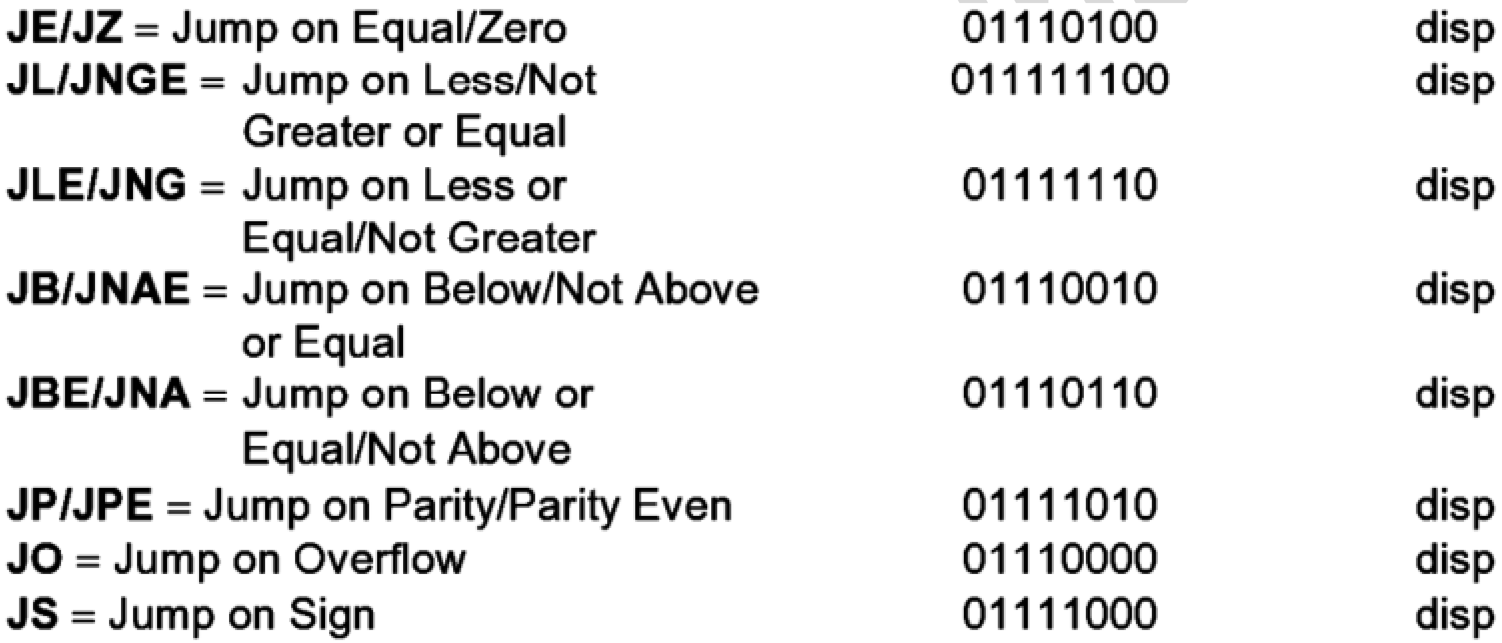
Example 3

CMP AX, 0030H; compares by subtracting 0030H from the value in AX regsiter

JB LABEL1; jumps to the address specified by LABEL1 if value in register AX is below the value 0030H

Branching Instruction : Conditional Jump

All conditional jumps have one big limitation, unlike **JMP** instruction they can only jump **127** bytes forward and **128** bytes backward (note that most instructions are assembled into 3 or more bytes).



JE/JZ = Jump on Equal/Zero	01110100	disp
JL/JNGE = Jump on Less/Not Greater or Equal	011111100	disp
JLE/JNG = Jump on Less or Equal/Not Greater	01111110	disp
JB/JNAE = Jump on Below/Not Above or Equal	01110010	disp
JBE/JNA = Jump on Below or Equal/Not Above	01110110	disp
JP/JPE = Jump on Parity/Parity Even	01111010	disp
JO = Jump on Overflow	01110000	disp
JS = Jump on Sign	01111000	disp

Branching Instruction : Conditional Jump

Example 1:

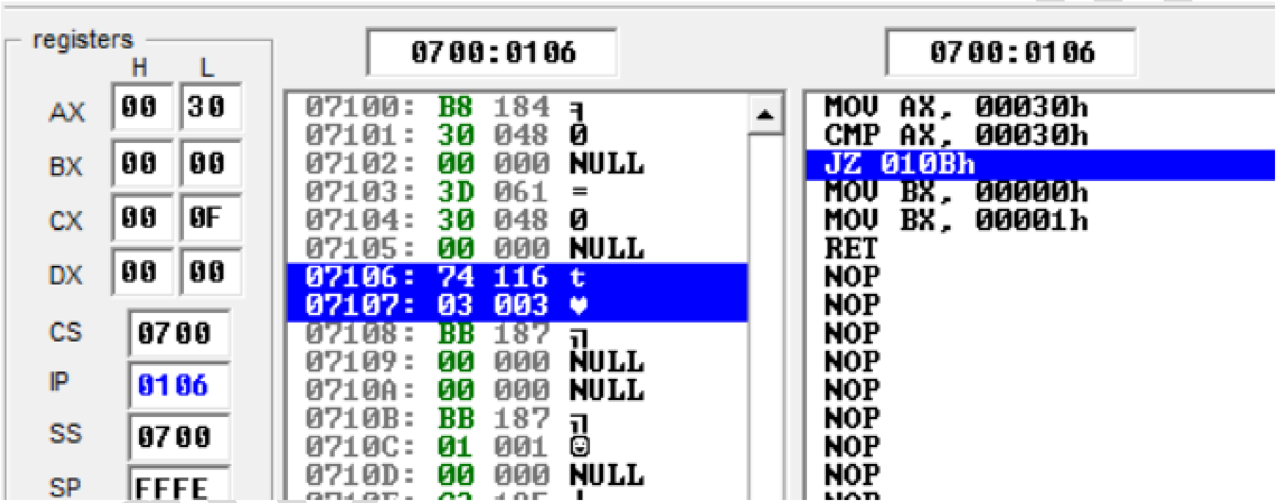
Mov AX, 0030H;

CMP AX, 0030H;

JE Label1;

Mov BX, 0000H;

Label1: Mov BX, 0001H;



```
registers
     H   L
AX  00  30
BX  00  00
CX  00  0F
DX  00  00
CS  0700
IP  0106
SS  0700
SP  FFFE
```

```
0700:0106

07100: B8 184 ╕
07101: 30 048 0
07102: 00 000 NULL
07103: 3D 061 =
07104: 30 048 0
07105: 00 000 NULL
07106: 74 116 t
07107: 03 003 ♥
07108: BB 187 ╗
07109: 00 000 NULL
0710A: 00 000 NULL
0710B: BB 187 ╗
0710C: 01 001 ☺
0710D: 00 000 NULL
```

```
0700:0106

MOV  AX, 00030h
CMP  AX, 00030h
JZ 010Bh
MOV  BX, 00000h
MOV  BX, 00001h
RET
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
```

JE/JZ = Jump on Equal/Zero	01110100	disp
JL/JNGE = Jump on Less/Not	011111100	disp

Branching Instruction : Conditional Jump

Example 2:

Mov AX, 0030H;

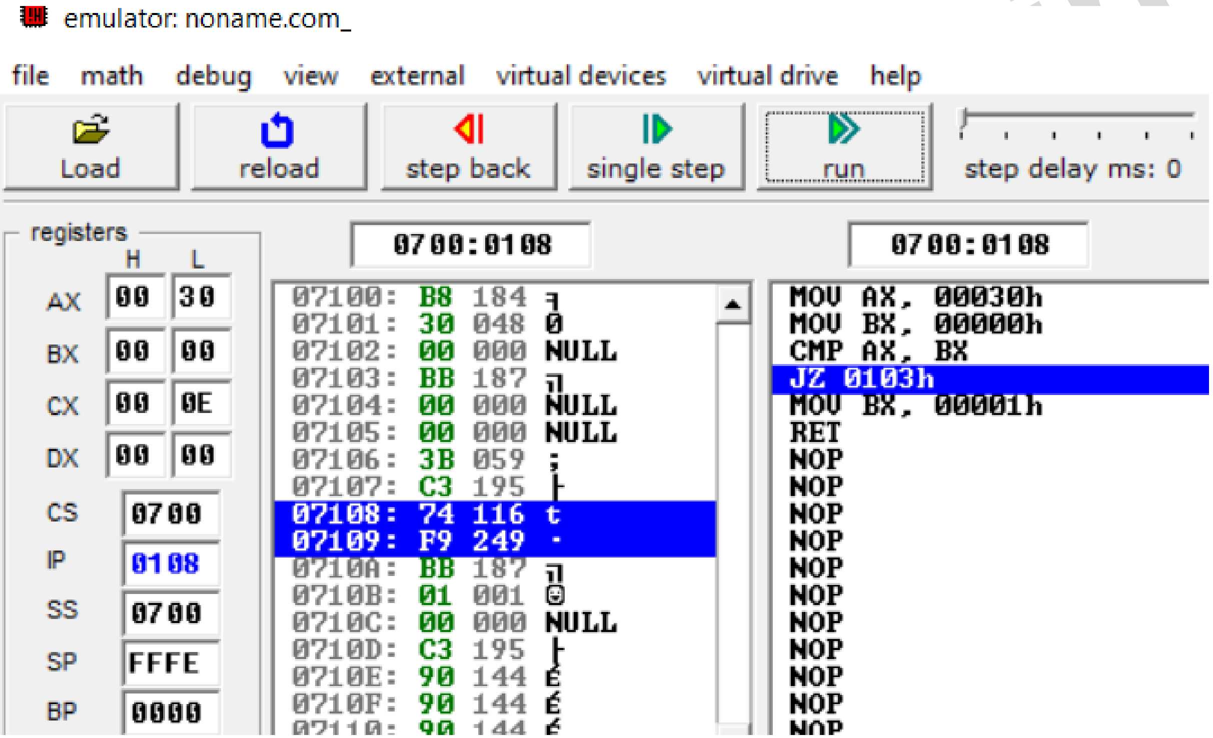
Label1:

Mov BX, 0000H;

CMP AX, BX;

JE Label1;

Mov BX, 0001H;



	H	L
AX	00	30
BX	00	00
CX	00	0E
DX	00	00

CS	0700
IP	0108
SS	0700
SP	FFFE
BP	0000

```
0700:0108

07100: B8 184 ╕
07101: 30 048 0
07102: 00 000 NULL
07103: BB 187 ╗
07104: 00 000 NULL
07105: 00 000 NULL
07106: 3B 059 ;
07107: C3 195 ├
07108: 74 116 t
07109: F9 249 ·
0710A: BB 187 ╗
0710B: 01 001 ☺
0710C: 00 000 NULL
0710D: C3 195 ├
0710E: 90 144 É
0710F: 90 144 É
07110: 90 144 É
```

```
0700:0108

MOV  AX, 00030h
MOV  BX, 00000h
CMP  AX, BX
JZ 0103h
MOV  BX, 00001h
RET
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
```

JE/JZ = Jump on Equal/Zero	01110100	disp
JL/JNGE = Jump on Less/Not	011111100	disp

Branching Instruction : Unconditional Jump

Unconditional jump Instructions

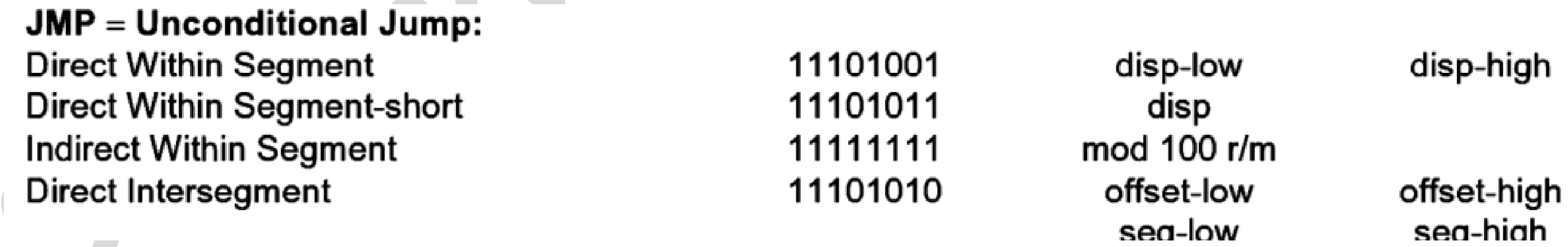
- Short or Near jump or **Intra segment** jump
- Far or **Intersegment** jump
- Near and Far jumps are further divided into **Direct** or **Indirect**
  - Direct -Destination address specified as a part of the instruction
  - Indirect-Destination address specified in a register or memory location

Branching Instruction : Unconditional Jump

Short Jump

- ➢ If the target label (address) is within –128 to 127 locations (bytes) of the instruction following the JMP (remember, the offset is added to the current value of the IP, which is pointing to the next instruction)

- ➢ It is assembled as a SHORT instruction (2 bytes). Only eight bits are needed to specify the address (these eight bits are added to the IP)



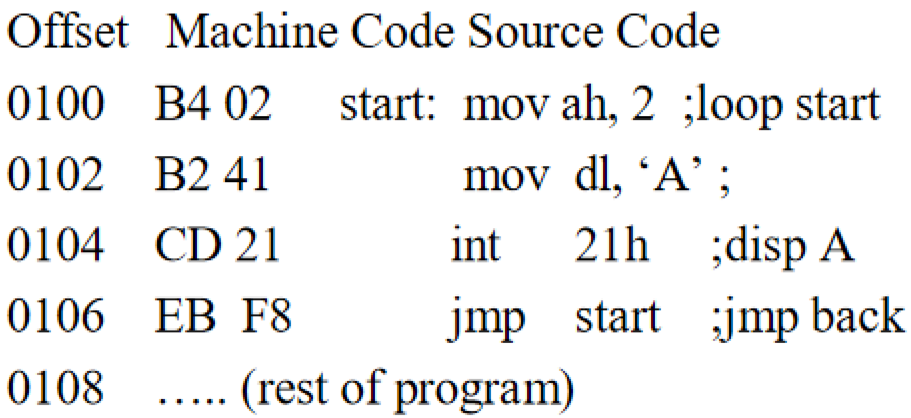
JMP = Unconditional Jump:

Direct Within Segment	11101001	disp-low	disp-high
Direct Within Segment-short	11101011	disp	
Indirect Within Segment	11111111	mod 100 r/m	
Direct Intersegment	11101010	offset-low	offset-high
		seg-low	seg-high

Branching Instruction : Unconditional Jump

Short Jump

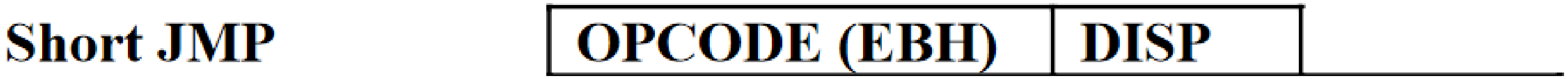
Example



```
Offset   Machine Code Source Code
0100     B4 02      start:  mov ah, 2   ;loop start
0102     B2 41              mov  dl, 'A' ;
0104     CD 21             int     21h     ;disp A
0106     EB  F8            jmp    start    ;jmp back
0108     ….. (rest of program)
```

How does the compiler know it's a SHORT jump?

0100 –0108 = -8 = F8

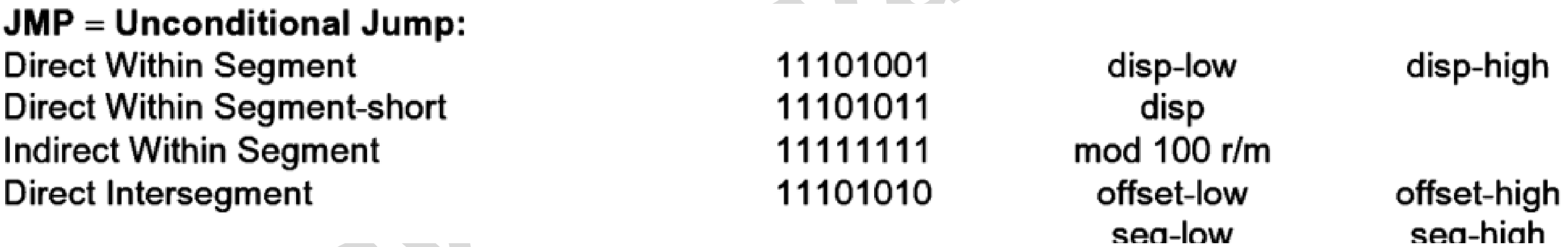


Short JMP | OPCODE (EBH) | DISP

Branching Instruction : Unconditional Jump

Near Jump

3-byte **Near jump** allows a branch or jump within ±32K bytes from the instruction in the current code segment.

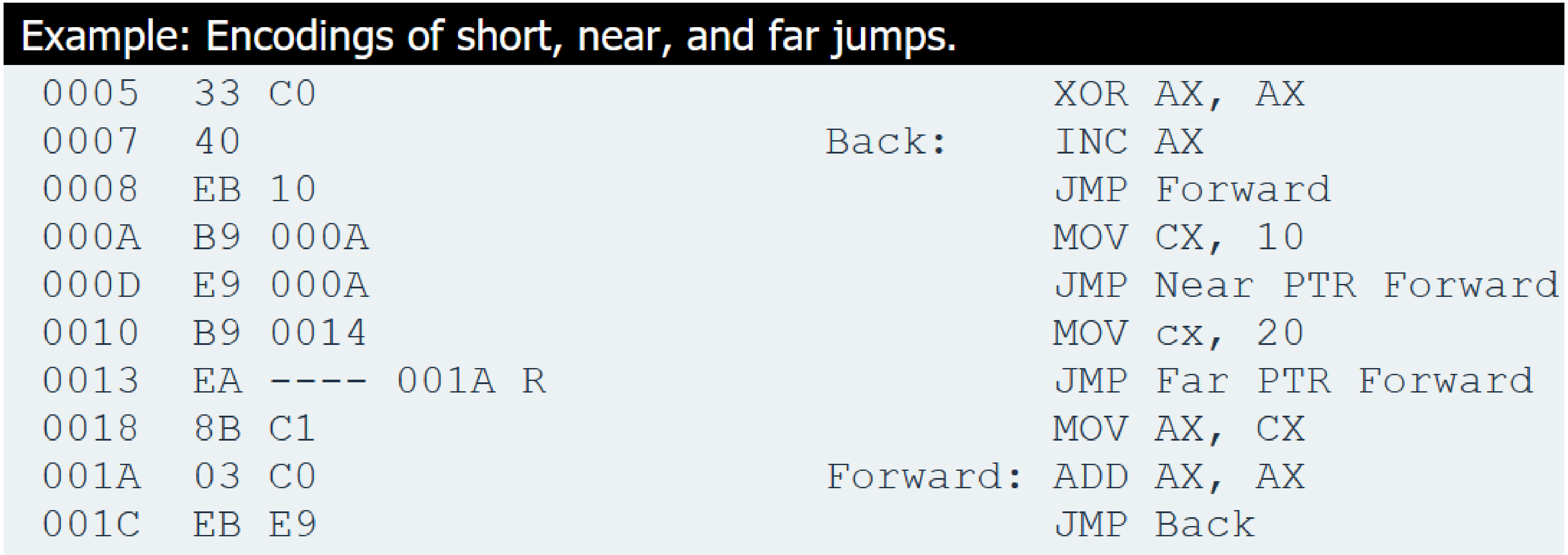


JMP = Unconditional Jump:

Direct Within Segment	11101001	disp-low	disp-high
Direct Within Segment-short	11101011	disp	
Indirect Within Segment	11111111	mod 100 r/m	
Direct Intersegment	11101010	offset-low	offset-high
		seg-low	seg-high

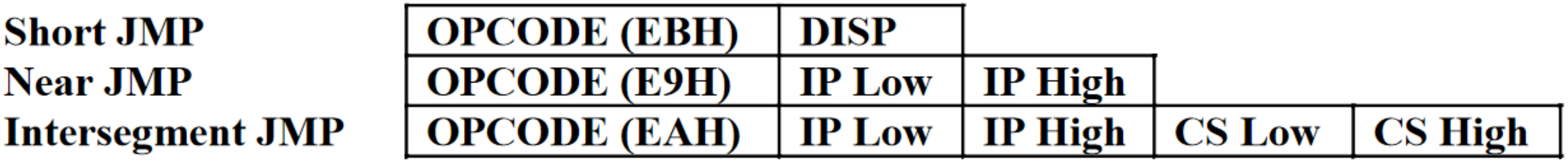
Short and Near jumps are relocatable because they are relative jump.

Branching Instruction : Unconditional Jump



Example: Encodings of short, near, and far jumps.

```
0005   33 C0                               XOR AX, AX
0007   40                        Back:     INC AX
0008   EB 10                               JMP Forward
000A   B9 000A                             MOV CX, 10
000D   E9 000A                             JMP Near PTR Forward
0010   B9 0014                             MOV cx, 20
0013   EA ---- 001A R                      JMP Far PTR Forward
0018   8B C1                               MOV AX, CX
001A   03 C0                     Forward:  ADD AX, AX
001C   EB E9                               JMP Back
```

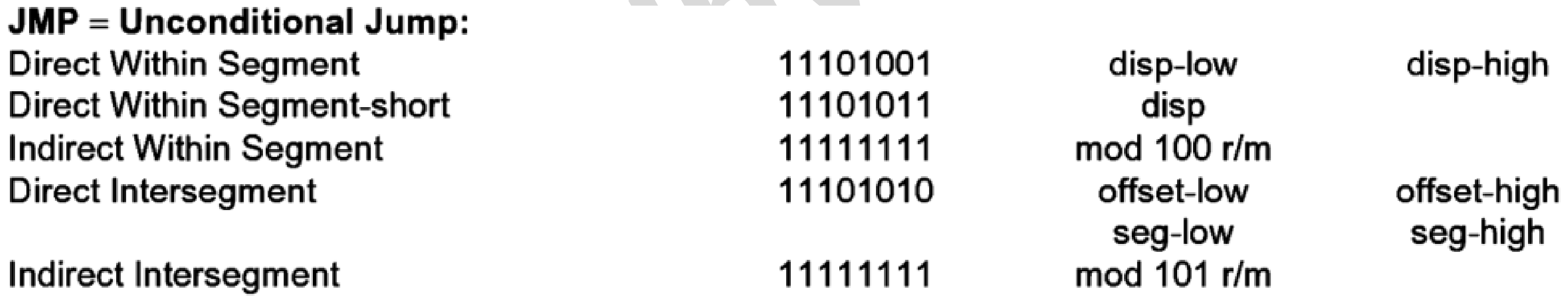


Short JMP	OPCODE (EBH)	DISP			
Near JMP	OPCODE (E9H)	IP Low	IP High		
Intersegment JMP	OPCODE (EAH)	IP Low	IP High	CS Low	CS High

Branching Instruction : Unconditional Jump

Indirect Program Memory Addressing • If a 16-bit register holds the address of a JMP instruction, the jump is near.

For example, if the BX register contains 1000H and a JMP BX instruction executes, the microprocessor jumps to offset address 1000H in the current code segment.



JMP = Unconditional Jump:

Direct Within Segment	11101001	disp-low	disp-high
Direct Within Segment-short	11101011	disp	
Indirect Within Segment	11111111	mod 100 r/m	
Direct Intersegment	11101010	offset-low	offset-high
		seg-low	seg-high
Indirect Intersegment	11111111	mod 101 r/m	

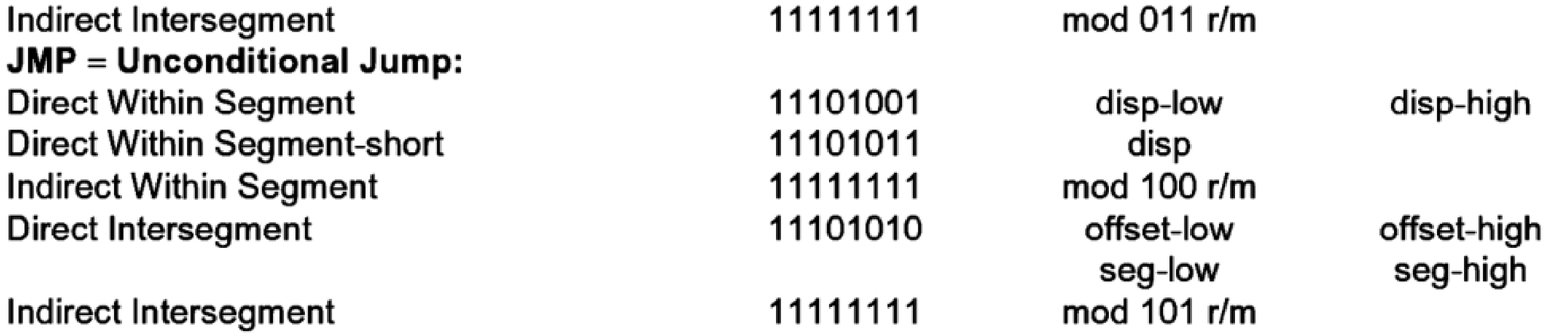
Branching Instruction : Unconditional Jump

Far Jump

- 5-byte **far jump** allows a jump to any memory location within the real memory system.

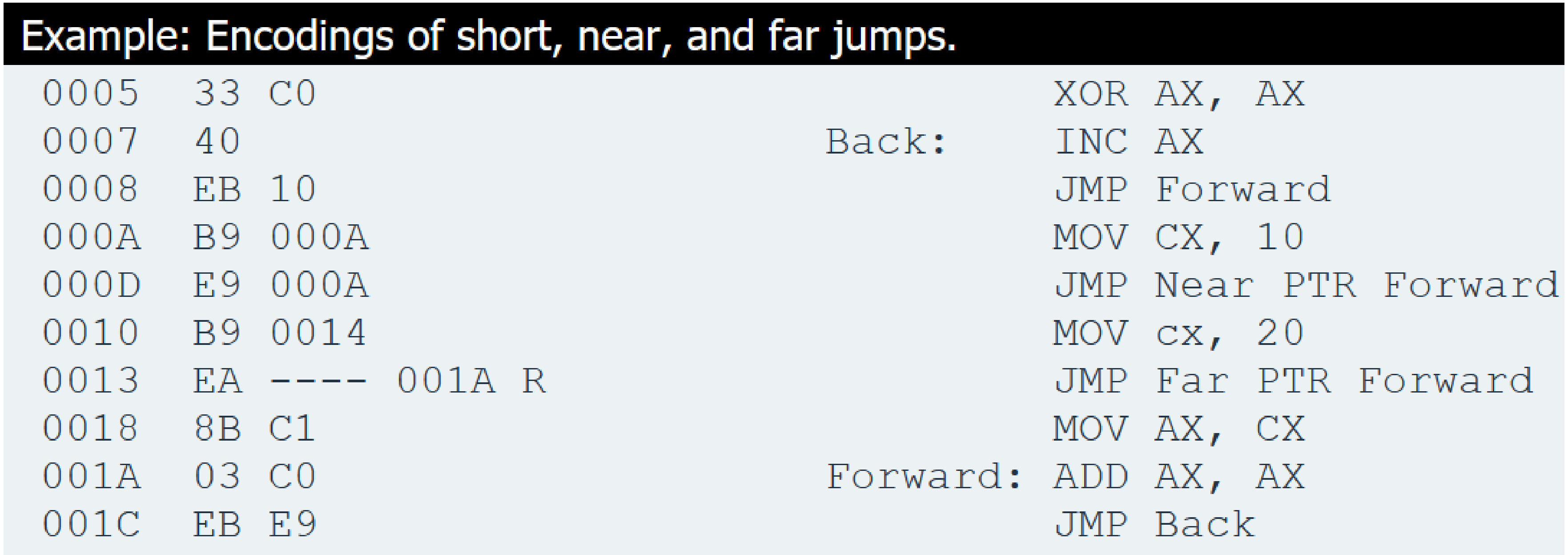
- The short and near jumps are often called **intrasegment jumps.**

- Far jumps are called **intersegment jumps**.



Indirect Intersegment	11111111	mod 011 r/m	
JMP = Unconditional Jump:			
Direct Within Segment	11101001	disp-low	disp-high
Direct Within Segment-short	11101011	disp	
Indirect Within Segment	11111111	mod 100 r/m	
Direct Intersegment	11101010	offset-low seg-low	offset-high seg-high
Indirect Intersegment	11111111	mod 101 r/m	

Branching Instruction : Unconditional Jump



Example: Encodings of short, near, and far jumps.

```
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0007   40                          Back:  INC AX
0008   EB 10                              JMP Forward
000A   B9 000A                            MOV CX, 10
000D   E9 000A                            JMP Near PTR Forward
0010   B9 0014                            MOV cx, 20
0013   EA ---- 001A R                     JMP Far PTR Forward
0018   8B C1                              MOV AX, CX
001A   03 C0                    Forward:  ADD AX, AX
001C   EB E9                              JMP Back
```

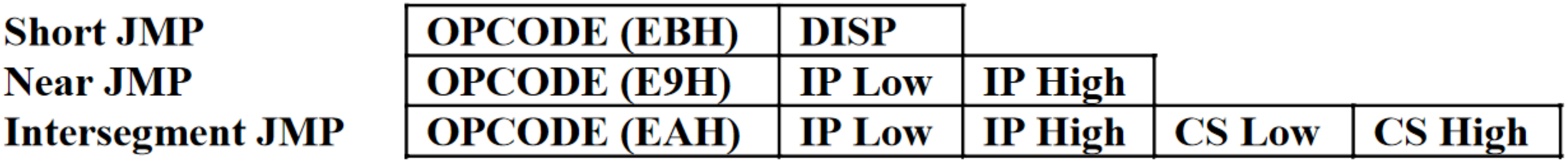

Short JMP	**OPCODE (EBH)**	**DISP**			
Near JMP	**OPCODE (E9H)**	**IP Low**	**IP High**		
Intersegment JMP	**OPCODE (EAH)**	**IP Low**	**IP High**	**CS Low**	**CS High**

Thankyou