

Computer Structure and Language

The 8086/8088 Assembly Language

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8086/88 has 7 types of instructions:

1. **Data Transfer Instructions**
2. **Arithmetic Instructions**
3. **Bit Manipulation Instructions**
4. **String Instructions**
5. **Program Execution Transfer Instructions**
6. **Processor Control Instructions**
7. **Interrupt Instructions**

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Computer Structure & Language, Lecture#2: Data transfer instructions

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

-

- Register/Memory to/from Register**

mov

reg1,reg2

≡

reg1 ← (reg2);

mov

reg,memory

≡

reg1 ← (EA);

mov

memory,reg

≡

EA ← (reg);

100010

d w

Md

Reg

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Example 1:

mov

ax,si

≡

ax ← (si);

word transfer

Machine code:

10001011

dw

Md

Reg

R/M

11 000 110

≡

8BC6h

dw

Md

Reg

R/M

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Memory address calculation using Md and R/M fields

Memory mode

Register mode

Md = 00

Md = 01

Md = 10

Md = 11

SR : EA

SR : EA

SR : EA

W = 0

W = 1

000

001

010

011

100

101

110

111

DS : (BX)+(SI)

DS : (BX)+(DI)

SS : (BP)+(SI)

SS : (BP)+(DI)

DS : (SI)

DS : (DI)

DS : d16

DS : (BX)

DS : (BX)+(SI)+d8

DS : (BX)+(DI)+d8

SS : (BP)+(SI)+d8

SS : (BP)+(DI)+d8

DS : (SI)+d8

DS : (DI)+d8

SS : (BP)+d8

DS : (BX)+d8

DS : (BX)+(SI)+d16

DS : (BX)+(DI)+d16

SS : (BP)+(SI)+d16

SS : (BP)+(DI)+d16

DS : (SI)+d16

DS : (DI)+d16

SS : (BP)+d16

DS : (BX)+d16

AL

CL

DL

BL

AH

CH

DH

BH

AX

CX

DX

BX

SP

BP

SI

DI

000

001

010

011

100

101

110

111

R/M

Reg

SR: Segment Register

EA: Effective Address

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

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AF

PF

CF

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-

-

-

-

-

-

-

• Register/Memory to/from Register

mov reg1,reg2

≡ reg1 ← (reg2);

mov reg,memory

≡ reg1 ← (EA);

mov memory,reg

≡ EA ← (reg);

100010 d w

Md

Reg

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Example 1:

mov ax,si

≡ ax ← (si);

word transfer

Machine code:

dw

Md

Reg

R/M

10001011

11

000

110

≡ 8BC6h

Example 2:

mov cl,ah

≡ cl ← (ah);

byte transfer

Machine code:

dw

Md

Reg

R/M

10001000

11

100

001

≡ 88E1h

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

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-

-

-

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-

-

-

• Register/Memory to/from Register (cont.)

100010 d w

Md

Reg

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Example 3:

mov cx,word ptr [si -5]

≡ cx ← (M_{(si)-5});

word transfer

Machine code:

dw

Md

Reg

R/M

Disp. Low

10001011

01

001

100

11111011

≡ 8B4CFBh

Example 4:

mov array[bx+2][di-6],dx

≡ M_{array+(bx)+(di)-4} ← (dx);

@array = 260 of word type

Machine code:

dw

Md

Reg

R/M

Disp. Low

Disp. High

10001001

10

010

001

00000000

00000001

≡ 89910001h

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Memory address calculation using Md and R/M fields

		Memory mode			Register mode		
		Md = 00	Md = 01	Md = 10	Md = 11		
		SR : EA	SR : EA	SR : EA	W = 0	W = 1	
R/M	000	DS : (BX)+(SI)	DS : (BX)+(SI)+d8	DS : (BX)+(SI)+d16	AL	AX	000
	001	DS : (BX)+(DI)	DS : (BX)+(DI)+d8	DS : (BX)+(DI)+d16	CL	CX	001
	010	SS : (BP)+(SI)	SS : (BP)+(SI)+d8	SS : (BP)+(SI)+d16	DL	DX	010
	011	SS : (BP)+(DI)	SS : (BP)+(DI)+d8	SS : (BP)+(DI)+d16	BL	BX	011
	100	DS : (SI)	DS : (SI)+d8	DS : (SI)+d16	AH	SP	100
	101	DS : (DI)	DS : (DI)+d8	DS : (DI)+d16	CH	BP	101
	110	DS : d16	SS : (BP)+d8	SS : (BP)+d16	DH	SI	110
	111	DS : (BX)	DS : (BX)+d8	DS : (BX)+d16	BH	DI	111

SR: Segment RegisterEA: Effective Address

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

1100011 w

Md

000 R/M

Disp. Low-byte

Disp. High-byte

Imm. Low-byte

Imm. High-byte

for 16-bit displacement

for 16-bit (word) data

Example 1:

mov cx,256h ≡ cx ← 256h; i.e. (ch) = 2 (cl) = 56h

Machine code:

110001111

w

Md

11 000 001

R/M

Data Low

01010110

Data High

00000010

≡ C7C15602h

Example 2:

mov byte ptr [bx+2][si],-2 ≡ M_{(bx)+(si)+2} ← -2; byte transfer

Machine code:

11000110

w

Md

01 000 000

R/M

Disp. Low

00000010

Data Low

11111110

≡ C64002FEh

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

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-

-

-

-

-

-

-

• Immediate to Register

1011 w reg

Imm. Low-byte

Imm. High-byte

if w=1

Example 1:

mov dx,-1 ≡ dx ← FFFFh; word transfer

Machine code:

w reg

1011 1 010

Data Low

11111111

Data High

11111111

≡ BAFFFFh

Example 2:

mov bh,100 ≡ bh ← 100; byte transfer

Machine code:

w reg

1011 0 111

Data Low

01100100

≡ B764h

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Memory to Accumulator

mov al,address ≡ al ← (M_{address})_{byte}; if w=0

mov ax,address ≡ ax ← (M_{address})_{word}; if w=1

1010000 w

Address Low

Address High

Example 1:

mov ax,array+10 ≡ ax ← (M_{array+10})_{word}; @array = 1000h

Machine code:

w Addr. Low

10100001

00001010

Addr. High

00010000

≡ A10A10h

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Accumulator to Memory

mov

address,al

≡

$M_{\text{address}} \leftarrow (al);$

if w=0

mov

address,ax

≡

$M_{\text{address}} \leftarrow (ax);$

if w=1

1010001 w

Address Low

Address High

Example 1:

mov

array-2,al

≡

$M_{\text{array-2}} \leftarrow (al);$

@array = 1000h

Machine code:

w

Addr. Low

Addr. High

10100010 11111110 00001111

≡

A2FE0Fh

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Register/Memory to Segment register

10001110

Md

0SR

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Segment Register	SR
ES	00
CS	01
SS	10
DS	11

Example 1:

mov

ES,AX

≡

$ES \leftarrow (AX);$

Machine code:

Md

SR

R/M

10001110 11 000 000

≡

8EC0h

Example 2:

mov

SS,array[bx]

≡

$SS \leftarrow (M_{\text{array+(bx)}});$

@array = 100

Machine code:

Md

SR

R/M

Disp. Low

10001110 01 010 111 01100100

≡

8E5764h

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The 8086/88's Data Transfer Instructions:

Move Instructions: mov

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Segment Register to Register/Memory

10001100

Md

0SR

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Segment Register

SR

ES

00

CS

01

SS

10

DS

11

Example 1:

movAX,ES≡AX←(ES);

Machine code:1000110011000000≡8CC0h

Example 2:

movmyarr+3[di],DS≡M_{myarr+(di)+3}←(DS);@myarr=500h

Machine code:

10001100100111010000001100000101≡8C9D0305h

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The 8086/88's Data Transfer Instructions:

Exchange Instructions: xchg

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Register/Memory with Register

1000011w

Md

Reg

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Example 1:

xchg si,bx≡(si)↔(bx);

Machine code:1000011111110011≡87F3h

Example 2:

xchg byte ptr cam+30[si],dl≡(M_{cam+(si)+30})↔(dl);@cam=500h

Machine code:

10000110100101000001111000000101≡86941E05h

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The 8086/88's Data Transfer Instructions:

Exchange Instructions: xchg

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

-

• Register with Accumulator

10010 Reg

Example:

xchg ax,bx ≡ (ax) ↔ (bx);

Machine code: 10010 011 ≡ 93h

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The 8086/88's Data Transfer Instructions:

Special Instructions:

• Translate Byte to AL: XLAT

11010111

xlat ≡ al ← (M_{(bx)+(al)});

• Load Effective Address: LEA

10001101 Md Reg R/M Disp. Low-byte Disp. High-byte
for 16-bit displacement

Example:

lea ax,[di][bx-1] ≡ ax ← (di)+(bx)-1;

Machine code:

10001101 01 000 001 11111111 ≡ 8D41FFh

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The 8086/88's Data Transfer Instructions:

Special Instructions:

• Load Pointer to DS: LDS

OF	DF	IF	TF	SF	ZF	AF	PF	CF
-	-	-	-	-	-	-	-	-

11000101	Md	Reg	R/M	Disp. Low-byte	Disp. High-byte
				for 16-bit displacement	

Example 1:

lds

bx,p1[si]

≡

$bx \leftarrow (M_{p1+(si)}); DS \leftarrow (M_{p1+(si)+2});$

@p1 = 1234h

Machine code:

	Md	Reg	R/M	Disp. Low	Disp. High	
11000101	10	011	100	00110100	00010010	≡ C59C3412h

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The 8086/88's Data Transfer Instructions:

Special Instructions:

• Load Pointer to ES: LES

OF	DF	IF	TF	SF	ZF	AF	PF	CF
-	-	-	-	-	-	-	-	-

11000100	Md	Reg	R/M	Disp. Low-byte	Disp. High-byte
				for 16-bit displacement	

Example 1:

les

bx,pip+10[di]

≡

$bx \leftarrow (M_{pip+(di)+10}); ES \leftarrow (M_{pip+(di)+2+10});$

@pip = 1234h

Machine code:

	Md	Reg	R/M	Disp. Low	Disp. High	
11000100	10	011	101	00111110	00010010	≡ C49D3E12h

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The 8086/88's Data Transfer Instructions:

Special Instructions:

• Load AH with Flags: LAHF

10011111

lahf ≡ ah ← (F_{7..0});

• Store AH into Flags: SAHF

10011110

sahf ≡ F_{7..0} ← (ah);

OF DF IF TF SF ZF AF PF CF

- - - - - - - - -

OF DF IF TF SF ZF AF PF CF

- - - - 1 1 1 1 1

r: restored from prev. saved value

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The 8086/88's Data Transfer Instructions:

Push Instructions: PUSH

• Push Register/Memory into Stack

11111111 Md 110 R/M Disp. Low-byte Disp. High-byte

Example 1:

push dx ≡ sp ← (sp)-2; M_(sp) ← (dx);

Machine code: 11111111 11 110 010 ≡ FFF2h

Example 2:

push array+2 ≡ sp ← (sp)-2; M_(sp) ← (M_{array+2});

@array = 11h of word type

Machine code:

11111111 Md R/M Disp. Low Disp. High ≡ FF361300h

OF DF IF TF SF ZF AF PF CF

- - - - - - - - -

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The 8086/88's Data Transfer Instructions:

Push Instructions: PUSH (cont.)

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Push Register into Stack

01010 Reg

Example:

push dx ≡ $sp \leftarrow (sp)-2; M_{(sp)} \leftarrow (dx);$

Machine code:

01010

Reg

010

 ≡ 52h

• Push Segment Register into Stack

000 SR 110

Example:

push DS ≡ $sp \leftarrow (sp)-2; M_{(sp)} \leftarrow (DS);$

Machine code:

000

SR

11

110

 ≡ 1Eh

• Push Flags into Stack: PUSHF

10011100

pushf ≡ $sp \leftarrow (sp)-2; M_{(sp)} \leftarrow (F_{15..0});$

Segment Register

SR

ES

00

CS

01

SS

10

DS

11

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The 8086/88's Data Transfer Instructions:

Pop Instructions: POP

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

• Pop Register/Memory from Stack

10001111

Md

000

R/M

Disp. Low-byte

Disp. High-byte

for 16-bit displacement

Example 1:

pop dx ≡ $dx \leftarrow (M_{(sp)}); sp \leftarrow (sp)+2;$

Machine code:

10001111

Md

11

R/M

000

010

 ≡ 8FC2h

Example 2:

pop arc-2 ≡ $M_{arc-2} \leftarrow (M_{(sp)}); sp \leftarrow (sp)+2;$

@arc = 100h of word type

Machine code:

10001111

Md

00

R/M

000

110

Disp. Low

11111110

Disp. High

00000000

 ≡ 8F06FE00h

11

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The 8086/88's Data Transfer Instructions:

Pop Instructions: POP (cont.)

• Pop Register from Stack

01011 Reg

OF

DF

IF

TF

SF

ZF

AF

PF

CF

-

-

-

-

-

-

-

-

-

Example:

pop dx ≡ dx ← (M_(sp)); sp ← (sp)+2;

Machine code: 01011 010^{Reg} ≡ 5Ah

• Pop Segment Register from Stack

000 SR 111

Segment Register	SR
ES	00
CS	01
SS	10
DS	11

Example:

pop DS ≡ DS ← (M_(sp)); sp ← (sp)+2;

Machine code: 000 11^{SR} 111 ≡ 1Fh

• Pop Flags from Stack: POPF

10011101

OF

DF

IF

TF

SF

ZF

AF

PF

CF

r

r

r

r

r

r

r

r

r

popf ≡ F_{15..0} ← (M_(sp)); sp ← (sp)+2;

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End of Slides

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