Fall 2018/19 – Lecture Notes # 10

- Logic Instructions
- Shift Instructions
- Compare of unsigned numbers
- BCD and ASCII Numbers

Logic Instructions

- **Arithmetic and Logic Instructions and Programs**
  - **XOR (Exclusive-OR) Instruction**

Format: **XOR dest, source** ; dest = dest ӿ source

Ex: MOV DH,54H
XOR DH,78H

Solution:

54H	01010100		
ӿ 78H	ӿ 01111000		
2CH	00101100		SF=0, ZF=0, PF=0, CF=OF=0

- The XOR instruction can be used to **clear** contents of a register by XORing it with itself.

Ex: Assume CH=35H

XOR CH,35H

Solution:

35H	00110101		
35H	00110101		
00	00000000		SF=0, ZF=1, PF=1, CF=OF=0

Logic Instructions

- **Arithmetic and Logic Instructions and Programs**
  - **XOR (Exclusive-OR) Instruction**

Format: **XOR dest, source** ; dest = dest ⊕ source

- The XOR instruction can be used to **toggle** bits of an operand.

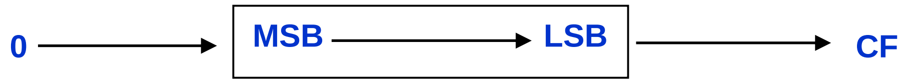
Ex: XOR BL,04H ;XOR BL with 000 0100

Solution: This will cause bit 2 of BL to change to the **opposite value**; all other bits would remain **unchanged**.

Shift Instructions

▪ SHR (Shift Right) Instruction

Format: **SHR dest, count** ; **shift** dest **right** count times



- This is the logical **shift right**. The dest operand is shifted right **bit by bit**, and for every shift the LSB will go to the CF and MSB is filled with a zero.

Ex:
```
MOV    AL,9AH
MOV    CL,3                      ;set number of times to shift
SHR    AL,CL
```

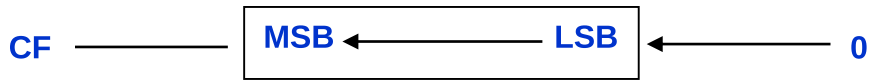
Solution:
```
9AH    10011010
       01001101      CF=0    (shifted once)
       00100110      CF=1    (shifted twice)
       00010011      CF=0    (shifted three times)
```
After three times of shifting AL=13H and CF=0

•dest operand can be in a register or memory. Immediate addressing mode is not possible.
•If the dest. operand is to be shifted once only 1 can be used instead of CL.

Shift Instructions

- **SHL (Shift Left) Instruction**

Format: **SHL dest, count** ; **shift** dest **left** count times



- **SHL** is also a logical shift instruction. The operand is shifted left bit by bit, and for every shift the LSB is filled with a zero (0) and the MSB goes into CF.

```
Ex:        MOV     DH,6
           MOV     CL,4              ;set number of times to shift
           SHL     DH,CL

Solution:          00000110
    CF=0           00001100          (shifted left once)
    CF=0           00011000
    CF=0           00110000
    CF=0           01100000          (shifted left 4 times)
           After the 4 shifts DH=60H and CF=0.
```

- dest operand can be in a register or memory. Immediate addressing mode is not possible.
- If the dest. operand is to be shifted once only 1 can be used instead of CL.

Compare of unsigned numbers

- **Compare Instructions**
  - **CMP (Compare) Instruction**

Format: **CMP dest, source** ; compare dest and source

- The **operands** themselves remain **unchanged**.
- The dest operand can be in register or memory. The source operand can be in register, memory or an immediate number.
- CMP instruction compares two operands and changes the flags accordingly.
- Although CF,AF,SF,PF,ZF and OF flags reflect the result of the comparison, only the CF and ZF are affected.

Flag settings of the CMP instruction.

Compare operands	CF	ZF
Destination >source	0	0
Destination = source	0	1
Destination < source	1	0

Ex:
```
DATA1       DW      235FH
      ...
      MOV     AX,CCCCH
      CMP     AX,DATA1;compare CCCC with 235F
      JNC     OVER    ;jump if CF=0
      SUB     AX,AX
OVER: INC     DATA1
```

BCD and ASCII Numbers

- **BCD(Binary Coded Decimal) and ASCII (American Standard Code for Information Interchange) Instructions**
  - Binary representation of 0 to 9 (used by human beings) is called BCD. There are two types of BCD numbers,
    (1) unpacked BCD **(2) packed BCD**
  - **Unpacked BCD:** 1 byte is used to store 4 bit BCD code. E.g. 0000 1001 is unpacked BCD for 9.
  - **Packed BCD:** 1 byte is used to store two 4 bit BCD codes. E.g. 0101 1001 is packed BCD for 59. More efficient in storing data.

BCD Digits

Digit	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

ASCII Numbers

Key	ASCII(Hex)	Binary	BCD (Unpacked)
0	30	011 0000	0000 0000
1	31	011 0001	0000 0001
2	32	011 0010	0000 0010
3	33	011 0011	0000 0011
4	34	011 0100	0000 0100
5	35	011 0101	0000 0101
6	36	011 0110	0000 0110
7	37	011 0111	0000 0111
8	38	011 1000	0000 1000
9	39	011 1001	0000 1001

BCD and ASCII Numbers

- **ASCII to BCD Conversion**
  - **ASCII to Unpacked BCD Conversion**
    - ➢ In order to convert ASCII to BCD the programmer must get rid of tagged “011” in the higher four bits of the ASCII.
    - ➢ To do that each ASCII number is ANDed with ‘0000 1111’ (0FH).

Ex:

```
                :
        ASC     DB      ‘9562481273’
                ORG     0010H
        UNPACK  DB      10 DUP(?)
                :
                MOV     CX,5                ;CX is the loop counter
                MOV     BX,OFFSET ASC       ;BX points to ASCII data
                MOV     DI,OFFSET UNPACK    ;DI points to unpacked BCD data
        AGAIN:  MOV     AX,WORD PTR [BX]    ;move next 2 ASCII numbers to AX
                AND     AX,0F0FH            ;remove ASCII 3s (011)
                MOV     WORD PTR [DI],AX    ;store unpacked BCD
                ADD     DI,2                ;point to next unpacked BCD data
                ADD     BX,2                ;point to next ASCII data
                LOOP AGAIN
```

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BCD and ASCII Numbers

- **ASCII to BCD Conversion**
  - **ASCII to Packed BCD Conversion**
    - To convert ASCII to packed BCD, it is first converted to unpacked BCD (to get rid of the 3) and then combined to make packed BCD.

Key	ASCII	Unpacked BCD	Packed BCD
4	34	00000100	
7	37	00000111	**01000111 or 47**

Ex:

```
:
ORG        0010H
VAL_ASC    DB        '47'
VAL_BCD    DB         ?
:
;note that DB will put 34 in offset 0010H and 37 in 0011H.
MOV        AX,WORD PTR VAL_ASC        ;AH=37    AL=34
AND        AX,0F0FH                   ;mask 3 to get unpacked BCD
XCHG       AH,AL                      ;swap AH and AL
MOV        CL,4                       ;CL=04 to shift 4 times
SHL        AH,CL                      ;shift left AH to get AH=40H
OR         AL,AH                      ;OR them to get packed BCD
MOV        VAL_BCD,AL                 ;save the result
```

BCD and ASCII Numbers

- **BCD to ASCII Conversion**
  - Packed BCD to ASCII Conversion
    - ➢ To convert packed BCD to ASCII, it must be first converted to unpacked and then the unpacked BCD is tagged with 011 0000 (30H).

Packed BCD	**Unpacked BCD**	**ASCII**
29H	02 & 09	32 & 39
0010 1001	0000 0010 & 0000 1001	0011 0010 & 0011 1001

Ex:

```
:
VAL1_BCD        DB        29H
VAL3_ASC        DW         ?
:
MOV     AL,VAL1_BCD
MOV     AH,AL             ;copy AL to AH. Now AH=29 and AL=29
AND     AX,F00FH          ;mask 9 from AH and 2 from AL
MOV     CL,04             ;CL=04 for shift
SHR     AH,CL             ;shift right AH to get unpacked BCD
OR      AX,3030H          ;combine with 30 to get ASCII
XCHG    AH,AL             ;swap for ASCII storage convention
MOV     VAL3_ASC,AX       ;store the ASCII
```