Lecture Notes # 10

Outline of the Lecture

- **Arithmetic and Logic Instructions and Programs**
- **COMPARE of unsigned numbers**

ARITHMETIC AND LOGIC INSTRUCTIONS AND PROGRAMS

XOR

XOR dest,source

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

Solution:    54H    01010100
             78H    01111000
             2C     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
```

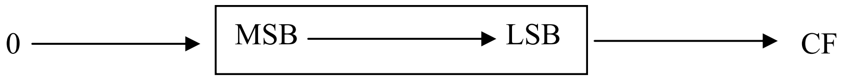
- The XOR instruction can be used to **toggle** bits of an operand.

```
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**

```
SHR  dest,source           ;shift right
```



This is the logical shift right. The 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.

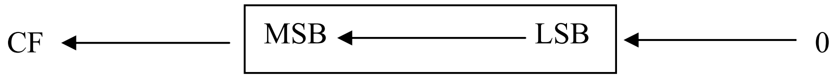
```
Ex:     MOV  AL,9AH
        MOV  CL,3                         ;set number of times to shift
        SHR  AL,CL

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.

SHL dest,source ;shift left



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

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.

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

Flag settings of the CMP instruction.

```
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(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.

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

- **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,0F0F                ;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
```

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 47H

```
                ORG   0010H
VAL_ASC         DB    '47'
VAL_BCD         DB     ?
                …
;reminder: the DB will put 34 in 0010H location 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
```

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
```