

Module 2

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Module 2 learning unit 5

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Instruction Description ➤ AAA Instruction - ASCII Adjust after Addition

- AAD Instruction - ASCII adjust before Division
- AAM Instruction - ASCII adjust after Multiplication
- AAS Instruction - ASCII Adjust for Subtraction
- ADC Instruction - Add with carry.
- ADD Instruction - ADD destination, source
- AND Instruction - AND corresponding bits of two operands

Example

➤ AAA Instruction:

AAA converts the result of the addition of two valid unpacked BCD digits to a valid 2-digit BCD number and takes the AL register as its implicit operand.

Two operands of the addition must have its lower 4 bits contain a number in the range from 0-9. The AAA instruction then adjust AL so that it contains a correct BCD digit. If the addition produce carry (AF=1), the AH register is incremented and the carry CF and auxiliary carry AF flags are set to 1. If the addition did not produce a decimal carry, CF and AF are cleared to 0 and AH is not altered. In both cases the higher 4 bits of AL are cleared to 0.

AAA will adjust the result of the two ASCII characters that were in the range from 30h ("0") to 39h("9"). This is because the lower 4 bits of those character fall in the range of 0-9. The result of addition is not a ASCII character but it is a BCD digit.

➤ **Example:**

```
MOV AH, 0 ; Clear AH for MSD
MOV AL, 6 ; BCD 6 in AL
ADD AL, 5 ; Add BCD 5 to digit in AL
AAA      ; AH=1, AL=1 representing BCD 11.
```

➤ **AAD Instruction:** AAD converts unpacked BCD digits in the AH and AL register into a single binary number in the AX register in preparation for a division operation.

Before executing AAD, place the Most significant BCD digit in the AH register and Last significant in the AL register. When AAD is executed, the two BCD digits are combined into a single binary number by setting $AL=(AH*10)+AL$ and clearing AH to 0.

➤ **Example:**

```
MOV AX, 0205h ; The unpacked BCD number 25
AAD          ; After AAD, AH=0 and
            ; AL=19h (25)
```

After the division AL will then contain the unpacked BCD quotient and AH will contain the unpacked BCD remainder.

➤ **Example:**

```
MOV AX, 0607h ; AX=0607 unpacked BCD for 67 decimal
MOV CH, 09h   ; CH=09H
AAD          ; Adjust to binary before division
            ; AX=0043 = 43H =67 decimal
DIV CH       ; Divide AX by unpacked BCD in CH
            ; AL = quotient = 07 unpacked BCD
            ; AH = remainder = 04 unpacked BCD
```

➤ **AAM Instruction** - AAM converts the result of the multiplication of two valid unpacked BCD digits into a valid 2-digit unpacked BCD number and takes AX as an implicit operand.

To give a valid result the digits that have been multiplied must be in the range of 0 – 9 and the result should have been placed in the AX register. Because both operands of multiply are required to be 9 or less, the result must be less than 81 and thus is completely contained in AL.

AAM unpacks the result by dividing AX by 10, placing the quotient (MSD) in AH and the remainder (LSD) in AL.

➤ **Example:**

```
MOV AL, 5
MOV BL, 7
MUL BL ; Multiply AL by BL, result in AX
AAM   ; After AAM, AX =0305h (BCD 35)
```

➤ **AAS Instruction:** AAS converts the result of the subtraction of two valid unpacked BCD digits to a single valid BCD number and takes the AL register as an implicit operand.

The two operands of the subtraction must have its lower 4 bit contain number in the range from 0 to 9. The AAS instruction then adjust AL so that it contain a correct BCD digit.

```

MOV AX, 0901H ; BCD 91
SUB AL, 9 ; Minus 9
AAS ; Give AX =0802 h (BCD 82)

```

(a)

```

; AL =0011 1001 =ASCII 9
; BL=0011 0101 =ASCII 5
SUB AL, BL ; (9 - 5) Result:
; AL = 00000100 = BCD 04, CF = 0
AAS ; Result:
; AL=00000100 =BCD 04
; CF = 0 NO Borrow required

```

(b)

```

; AL = 0011 0101 =ASCII 5
; BL = 0011 1001 = ASCII 9
SUB AL, BL ; ( 5 - 9 ) Result:
; AL = 1111 1100 = - 4
; in 2's complement CF = 1
AAS ; Results:
; AL = 0000 0100 =BCD 04
; CF = 1 borrow needed.

```

➤ **ADD Instruction:**

These instructions add a number from source to a number from some destination and put the result in the specified destination. The add with carry instruction ADC, also add the status of the carry flag into the result.

The source and destination must be of same type, means they must be a byte location or a word location. If you want to add a byte to a word, you must copy the byte to a word location and fill the upper byte of the word with zeroes before adding.

➤ **EXAMPLE:**

```

ADD AL, 74H ; Add immediate number 74H to content of AL
ADC CL, BL ; Add contents of BL plus
; carry status to contents of CL.
; Results in CL
ADD DX, BX ; Add contents of BX to contents
; of DX
ADD DX, [SI] ; Add word from memory at
; offset [SI] in DS to contents of DX
; Addition of Un Signed numbers
ADD CL, BL ; CL = 01110011 =115 decimal
; + BL = 01001111 = 79 decimal
; Result in CL = 11000010 = 194 decimal
; Addition of Signed numbers
ADD CL, BL ; CL = 01110011 = + 115 decimal

```

; + BL = 01001111 = +79 decimal
 ; Result in CL = 11000010 = - 62 decimal

; Incorrect because result is too large to fit in 7 bits.

➤ **AND** Instruction:

This Performs a bitwise Logical AND of two operands. The result of the operation is stored in the op1 and used to set the flags.

AND op1, op2

To perform a bitwise AND of the two operands, each bit of the result is set to 1 if and only if the corresponding bit in both of the operands is 1, otherwise the bit in the result is cleared to 0.

AND BH, CL ; AND byte in CL with byte in BH
 ; result in BH

AND BX, 00FFh ; AND word in BX with immediate
 ; 00FFH. Mask upper byte, leave
 ; lower unchanged

AND CX, [SI] ; AND word at offset [SI] in data
 ; segment with word in CX
 ; register. Result in CX register.

AND BX, 00FFh ; BX = 10110011 01011110
 ; Mask out upper 8 bits of BX
 ; Result BX = 00000000 01011110
 ; CF = 0, OF = 0, PF = 0, SF = 0,
 ; ZF = 0

➤ **CALL** Instruction

- Direct within-segment (near or intrasegment)
- Indirect within-segment (near or intrasegment)
- Direct to another segment (far or intersegment)
- Indirect to another segment (far or intersegment)

➤ **CBW** Instruction - Convert signed Byte to signed word

➤ **CLC** Instruction - Clear the carry flag

➤ **CLD** Instruction - Clear direction flag

➤ **CLI** Instruction - Clear interrupt flag

➤ **CMC** Instruction - Complement the carry flag

➤ **CMP** Instruction - Compare byte or word - CMP destination, source.

➤ **CMPS/CMPSB/CMPSW** Instruction - Compare string bytes or string words

➤ **CWD** Instruction - Convert Signed Word to - Signed Double word

Example

➤ **CALL** Instruction:

This Instruction is used to transfer execution to a subprogram or procedure. There are two basic types of CALL's: Near and Far.

A Near CALL is a call to a procedure which is in the same code segment as the CALL instruction.

When 8086 executes the near CALL instruction it decrements the stack pointer by two and copies the offset of the next instruction after the CALL on the stack. This offset

saved on the stack is referred as the return address, because this is the address that execution will return to after the procedure executes. A near CALL instruction will also load the instruction pointer with the offset of the first instruction in the procedure.

A RET instruction at the end of the procedure will return execution to the instruction after the CALL by copying the offset saved on the stack back to IP.

A Far CALL is a call to a procedure which is in a different segment from that which contains the CALL instruction. When 8086 executes the Far CALL instruction it decrements the stack pointer by two again and copies the content of CS register to the stack. It then decrements the stack pointer by two again and copies the offset contents of the instruction after the CALL to the stack.

Finally it loads CS with segment base of the segment which contains the procedure and IP with the offset of the first instruction of the procedure in segment. A RET instruction at end of procedure will return to the next instruction after the CALL by restoring the saved CS and IP from the stack.

; Direct within-segment (near or intrasegment)

CALL MULTO ; MULTO is the name of the procedure. The assembler determines displacement of MULTO from the instruction after the CALL and codes this displacement in as part of the instruction.

; Indirect within-segment (near or intrasegment)

CALL BX ; BX contains the offset of the first instruction of the procedure. Replaces contents of word of IP with contents of register BX.

CALL WORD PTR [BX] ; Offset of first instruction of procedure is in two memory addresses in DS. Replaces contents of IP with contents of word memory location in DS pointed to by BX.

; Direct to another segment- far or intersegment.

CALL SMART ; SMART is the name of the Procedure

SMART PROC FAR; Procedure must be declared as an far

➤ **CBW Instruction** - CBW converts the signed value in the AL register into an equivalent 16 bit signed value in the AX register by duplicating the sign bit to the left. This instruction copies the sign of a byte in AL to all the bits in AH. AH is then said to be the sign extension of AL.

Example:

; AX = 00000000 10011011 = - 155 decimal

CBW ; Convert signed byte in AL to signed word in AX.

; Result in AX = 11111111 10011011

; = - 155 decimal

➤ **CLC Instruction:**

CLC clear the carry flag (CF) to 0 This instruction has no effect on the processor, registers, or other flags. It is often used to clear the CF before returning from a procedure to indicate a successful termination. It is also used to clear the CF during rotate operation involving the CF such as ADC, RCL, RCR.

Example:

CLC ; Clear carry flag.

➤ **CLD Instruction:**

This instruction resets the direction flag to zero. This instruction has no effect on the registers or other flags. When the direction flag is cleared / reset SI and DI will

automatically be incremented when one of the string instruction such as MOVS, CMPS, SCAS, MOVSB and STOSB executes.

Example:

CLD ; Clear direction flag so that string pointers auto increment

➤ **CLI** Instruction:

This instruction resets the interrupt flag to zero. No other flags are affected. If the interrupt flag is reset, the 8086 will not respond to an interrupt signal on its INTR input. This CLI instruction has no effect on the nonmaskable interrupt input, NMI

➤ **CMC** Instruction:

If the carry flag CF is a zero before this instruction, it will be set to a one after the instruction. If the carry flag is one before this instruction, it will be reset to a zero after the instruction executes. CMC has no effect on other flags.

Example:

CMC; Invert the carry flag.

➤ **CWD** Instruction:

CWD converts the 16 bit signed value in the AX register into an equivalent 32 bit signed value in DX: AX register pair by duplicating the sign bit to the left.

The CWD instruction sets all the bits in the DX register to the same sign bit of the AX register. The effect is to create a 32-bit signed result that has same integer value as the original 16 bit operand.

Example:

Assume AX contains C435h. If the CWD instruction is executed, DX will contain FFFFh since bit 15 (MSB) of AX was 1. Both the original value of AX (C435h) and resulting value of DX: AX (FFFC435h) represents the same signed number.

Example:

```

CWD          ; DX = 00000000 00000000
             ; AX = 11110000 11000111 = - 3897 decimal
             ; Convert signed word in AX to signed double
             ; word in DX:AX
             ; Result DX = 11111111 11111111
             ; AX = 11110000 11000111 = -3897 decimal.

```

- **DAA** Instruction - Decimal Adjust Accumulator
- **DAS** Instruction - Decimal Adjust after Subtraction
- **DEC** Instruction - Decrement destination register or memory DEC destination.
- **DIV** Instruction - Unsigned divide-Div source
- **ESC** Instruction

When a double word is divided by a word, the most significant word of the double word must be in DX and the least significant word of the double word must be in AX.

After the division AX will contain the 16-bit result (quotient) and DX will contain a 16 bit remainder. Again, if an attempt is made to divide by zero or quotient is too large to fit in AX (greater than FFFFH) the 8086 will do a type of 0 interrupt.

Example:

```

DIV  CX      ; (Quotient) AX= (DX: AX)/CX
             ; (Reminder) DX= (DX: AX)%CX

```


For DIV the dividend must always be in AX or DX and AX, but the source of the divisor can be a register or a memory location specified by one of the 24 addressing modes.

If you want to divide a byte by a byte, you must first put the dividend byte in AL and fill AH with all 0's. The SUB AH, AH instruction is a quick way to do.

If you want to divide a word by a word, put the dividend word in AX and fill DX with all 0's. The SUB DX, DX instruction does this quickly.

➤ **Example:**

```

; AX = 37D7H = 14, 295 decimal
; BH = 97H = 151 decimal
DIV BH ; AX / BH
; AX = Quotient = 5EH = 94 decimal
; AH = Remainder = 65H = 101 decimal

```

➤ **ESC Instruction** - Escape instruction is used to pass instruction to a coprocessor such as the 8087 math coprocessor which shares the address and data bus with an 8086. Instruction for the coprocessor is represented by a 6 bit code embedded in the escape instruction. As the 8086 fetches instruction byte, the coprocessor also catches these bytes from data bus and puts them in its queue. The coprocessor treats all of the 8086 instruction as an NOP. When 8086 fetches an ESC instruction, the coprocessor decodes the instruction and carries out the action specified by the 6 bit code. In most of the case 8086 treats ESC instruction as an NOP.

➤ **HLT Instruction** - HALT processing

➤ **IDIV Instruction** - Divide by signed byte or word IDIV source

➤ **IMUL Instruction** - Multiply signed number-IMUL source

➤ **IN Instruction** - Copy data from a port
IN accumulator, port

➤ **INC Instruction** - Increment - INC destination

➤ **HALT Instruction** - The HLT instruction will cause the 8086 to stop fetching and executing instructions. The 8086 will enter a halt state. The only way to get the processor out of the halt state are with an interrupt signal on the INTR pin or an interrupt signal on NMI pin or a reset signal on the RESET input.

➤ **IDIV Instruction** - This instruction is used to divide a signed word by a signed byte or to divide a signed double word by a signed word.

➤ **Example:**

```

IDIV BL ; Signed word in AX is divided by signed byte in BL

```

➤ **IMUL Instruction** - This instruction performs a signed multiplication.

IMUL op ; In this form the accumulator is the multiplicand and op is the multiplier. op may be a register or a memory operand.

IMUL op1, op2 ; In this form op1 is always be a register operand and op2 may be a register or a memory operand.

➤ **Example:**

```

IMUL BH ; Signed byte in AL times multiplied by
; signed byte in BH and result in AX.

```

➤ **Example:**

```

; 69 * 14
; AL = 01000101 = 69 decimal
; BL = 00001110 = 14 decimal

```

IMUL BL ; **AX = 03C6H = + 966 decimal**
; **MSB = 0 because positive result**

; **- 28 * 59**

; **AL = 11100100 = - 28 decimal**

; **BL = 00001110 = 14 decimal**

IMUL BL ; **AX = F98Ch = - 1652 decimal**

; **MSB = 1 because negative result**

➤ **IN Instruction:** This IN instruction will copy data from a port to the AL or AX register.
For the Fixed port IN instruction type the 8 – bit port address of a port is specified directly in the instruction.

➤ **Example:**

IN AL, 0C8H ; **Input a byte from port 0C8H to AL**

IN AX, 34H ; **Input a word from port 34H to AX**

A_TO_D EQU 4AH

IN AX, A_TO_D ; **Input a word from port 4AH to AX**

For a variable port IN instruction, the port address is loaded in DX register before IN instruction. DX is 16 bit. Port address range from 0000H – FFFFH.

➤ **Example:**

MOV DX, 0FF78H ; **Initialize DX point to port**

IN AL, DX ; **Input a byte from a 8 bit port**
; **0FF78H to AL**

IN AX, DX ; **Input a word from 16 bit port to**
; **0FF78H to AX.**

➤ **INC Instruction:**

INC instruction adds one to the operand and sets the flag according to the result.
INC instruction is treated as an unsigned binary number.

➤ **Example:**

; **AX = 7FFFh**

INC AX ; **After this instruction AX = 8000h**

INC BL ; **Add 1 to the contents of BL register**

INC CL ; **Add 1 to the contents of CX register.**

➤ **INT Instruction** - Interrupt program

➤ **INTO Instruction** - Interrupt on overflow.

➤ **IRET Instruction** - Interrupt return

➤ **JA/JNBE Instruction** - Jump if above/Jump if not below nor equal.

➤ **JAE/JNB/JNC Instructions-** Jump if above or equal/ Jump if not below/

Jump if no carry.

➤ **JA / JNBE** - This instruction performs the Jump if above (or) Jump if not below or equal operations according to the condition, if CF and ZF = 0.

➤ **Example:**

(1)

CMP AX, 4371H ; **Compare by subtracting 4371H**
; **from AX**

**JA RUN_PRESS ; Jump to label RUN_PRESS if
; AX above 4371H**

(2)

CMP AX, 4371H ; Compare (AX – 4371H)

**JNBE RUN_PRESS ; Jump to label RUN_PRESS if
; AX not below or equal to 4371H**

➤ **JAE / JNB / JNC** - This instructions performs the Jump if above or equal, Jump if not below, Jump if no carry operations according to the condition, if CF = 0.

➤ **Examples:**

1. **CMP AX, 4371H ; Compare (AX – 4371H)**
**JAE RUN ; Jump to the label RUN if AX is
; above or equal to 4371H.**
2. **CMP AX, 4371H ; Compare (AX – 4371H)**
**JNB RUN_1 ; Jump to the label RUN_1 if AX
; is not below than 4371H**
3. **ADD AL, BL ; Add AL, BL. If result is with in JNC OK
; acceptable range, continue**

➤ **JB/JC/JNAE Instruction** - Jump if below/Jump if carry/
Jump if not above nor equal

➤ **JBE/JNA Instructions-** Jump if below or equal /
Jump if not above

➤ **JCXZ Instruction** - Jump if the CX register is zero

➤ **JE/JZ Instruction** - Jump if equal/Jump if zero

➤ **JG/JNLE Instruction-** Jump if greater/Jump if not
less than nor equal

➤ **JB/JC/JNAE Instruction** - This instruction performs the Jump if below (or)
Jump if carry (or) Jump if not below/ equal operations according to the condition,
if CF = 1

➤ **Example:**

1. **CMP AX, 4371H ; Compare (AX – 4371H)**
**JB RUN_P ; Jump to label RUN_P if AX is
; below 4371H**

2. **ADD BX, CX ; Add two words and Jump to
JC ERROR ; label ERROR if CF = 1**

➤ **JBE/JNA Instruction** - This instruction performs the Jump if below or
equal (or) Jump if not above operations according to the condition, if CF and ZF = 1

➤ **Example:**

CMP AX, 4371H ; Compare (AX – 4371H)
**JBA RUN ; Jump to label RUN if AX is
; below or equal to 4371H**

CMP AX, 4371H ; Compare (AX – 4371H)
**JNA RUN_R ; Jump to label RUN_R if AX is
; not above than 4371H**

➤ **JCXZ Instruction:**

This instruction performs the Jump if CX register is zero. If CX does not contain all zeros, execution will simply proceed to the next instruction.

➤ **Example:**

```
JCXZ SKIP_LOOP; If CX = 0, skip the process
NXT: SUB [BX], 07H ; Subtract 7 from data value
      INC BX       ; BX point to next value
LOOP  NXT        ; Loop until CX = 0
      SKIP_LOOP   ; Next instruction
```

➤ **JE/JZ Instruction:**

This instruction performs the Jump if equal (or) Jump if zero operations according to the condition if ZF = 1

➤ **Example:**

```
NXT: CMP     BX, DX ; Compare ( BX – DX )
      JE     DONE ; Jump to DONE if BX = DX,
      SUB    BX, AX ; Else subtract Ax
      INC    CX   ; Increment counter
      JUMP   NXT  ; Check again
DONE: MOV AX, CX; Copy count to AX
```

➤ **Example:**

```
IN   AL, 8FH ; read data from port 8FH
SUB  AL, 30H ; Subtract minimum value
JZ   STATR   ; Jump to label if result of
              ; subtraction was 0
```

➤ **JG/JNLE Instruction:**

This instruction performs the Jump if greater (or) Jump if not less than or equal operations according to the condition if ZF = 0 and SF = OF

➤ **Example:**

```
CMP     BL, 39H ; Compare by subtracting
              ; 39H from BL
JG      NEXT1  ; Jump to label if BL is
              ; more positive than 39H
CMP     BL, 39H ; Compare by subtracting
              ; 39H from BL
JNLE   NEXT2  ; Jump to label if BL is not
              ; less than or equal 39H
```

➤ **JGE/JNL Instruction** - Jump if greater than or equal/
Jump if not less than

➤ **JL/JNGE Instruction** - Jump if less than/Jump if not
greater than or equal

➤ **JLE/JNG Instruction** - Jump if less than or equal/
Jump if not greater

➤ **JMP Instruction** - Unconditional jump to -
specified destination

➤ **JGE/JNL Instruction** - This instruction performs the Jump if greater than
or equal / Jump if not less than operation according to the condition if SF = OF

➤ **Example:**

CMP	BL, 39H	; Compare by the
		; subtracting 39H from BL
JGE	NEXT11	; Jump to label if BL is
		; more positive than 39H
		; or equal to 39H
CMP	BL, 39H	; Compare by subtracting
		; 39H from BL
JNL	NEXT22	; Jump to label if BL is not
		; less than 39H

➤ **JL/JNGE** Instruction - This instruction performs the Jump if less than / Jump if not greater than or equal operation according to the condition, if SF ≠ OF

➤ **Example:**

CMP	BL, 39H	; Compare by subtracting 39H
		; from BL
JL	AGAIN	; Jump to the label if BL is more
		; negative than 39H
CMP	BL, 39H	; Compare by subtracting 39H
		; from BL
JNGE	AGAIN1	; Jump to the label if BL is not
		; more positive than 39H or
		; not equal to 39H

➤ **JLE/JNG** Instruction - This instruction performs the Jump if less than or equal / Jump if not greater operation according to the condition, if ZF=1 and SF ≠ OF

➤ **Example:**

CMP	BL, 39h	; Compare by subtracting 39h
		; from BL
JLE	NXT1	; Jump to the label if BL is more
		; negative than 39h or equal to 39h
CMP	BL, 39h	; Compare by subtracting 39h
		; from BL
JNG	AGAIN2	; Jump to the label if BL is not
		; more positive than 39h

➤ **JNA/JBE** Instruction - Jump if not above/Jump if below or equal

➤ **JNAE/JB** Instruction - Jump if not above or equal/Jump if below

➤ **JNB/JNC/JAE** Instruction - Jump if not below/Jump if no carry/Jump if above or equal

➤ **JNE/JNZ** Instruction - Jump if not equal/Jump if not zero

➤ **JNE/JNZ** Instruction - This instruction performs the Jump if not equal / Jump if not zero operation according to the condition, if ZF=0

➤ **Example:**

NXT: IN	AL, 0F8H	; Read data value from port
	CMP AL, 72	; Compare (AL – 72)

```

                JNE  NXT          ; Jump to NXT if AL ≠ 72
                IN   AL, 0F9H      ; Read next port when AL = 72
                MOV  BX, 2734H     ; Load BX as counter
NXT_1:         ADD  AX, 0002H     ; Add count factor to AX
                DEC  BX           ; Decrement BX
                JNZ  NXT_1        ; Repeat until BX = 0
➤ JNG/JLE Instruction - Jump if not greater/ Jump
                        if less than or equal
➤ JNGE/JL Instruction - Jump if not greater than nor
                        equal/Jump if less than
➤ JNL/JGE Instruction - Jump if not less than/ Jump
                        if greater than or equal
➤ JNLE/JG Instruction - Jump if not less than nor
                        equal to /Jump if greater than
➤ JNO Instruction - Jump if no overflow
➤ JNP/JPO Instruction - Jump if no parity/ Jump if parity odd
➤ JNS Instruction - Jump if not signed (Jump if positive)
➤ JNZ/JNE Instruction - Jump if not zero / jump if not equal
➤ JO Instruction - Jump if overflow
➤ JNO Instruction - This instruction performs the Jump if no overflow
operation according to the condition, if OF=0

```

➤ Example:

```

                ADD  AL, BL        ; Add signed bytes in AL and BL
                JNO  DONE         ; Process done if no overflow
                MOV  AL, 00H      ; Else load error code in AL
                DONE: OUT 24H, AL ; Send result to display
➤ JNP/JPO Instruction - This instruction performs the Jump if not parity /
Jump if parity odd operation according to the condition, if PF=0

```

➤ Example:

```

                IN   AL, 0F8H      ; Read ASCII char from UART
                OR   AL, AL        ; Set flags
                JPO  ERROR1       ; If even parity executed, if not
                                ; send error message
➤ JNS Instruction - This instruction performs the Jump if
not signed (Jump if positive) operation according to the condition, if SF=0

```

➤ Example:

```

                DEC  AL           ; Decrement counter
                JNS  REDO         ; Jump to label REDO if counter has not
                                ; decremented to FFH
➤ JO Instruction - This instruction performs Jump if overflow
operation according to the condition OF = 0

```

➤ Example:

```

                ADD  AL, BL        ; Add signed bits in AL and BL
                JO   ERROR        ; Jump to label if overflow occur
                                ; in addition

```

**MOV SUM, AL ; else put the result in memory
; location named SUM**

- **JPE/JP** Instruction - Jump if parity even/ Jump if parity
- **JPO/JNP** Instruction - Jump if parity odd/ Jump if no parity
- **JS** Instruction - Jump if signed (Jump if negative)
- **JZ/JE** Instruction - Jump if zero/Jump if equal
- **JPE/JP** Instruction - This instruction performs the Jump if parity even / Jump if parity operation according to the condition, if PF=1

Example:

```
IN AL, 0F8H ; Read ASCII char from UART
OR AL, AL ; Set flags
JPE ERROR2 ; odd parity is expected, if not
; send error message
```

- **JS** Instruction - This instruction performs the Jump if sign operation according to the condition, if SF=1

➤ **Example:**

```
ADD BL, DH ; Add signed bytes DH to BL
JS JJS_S1 ; Jump to label if result is
; negative
```

- **LAHF** Instruction - Copy low byte of flag register to AH
- **LDS** Instruction - Load register and DS with words from memory – LDS register, memory address of first word
- **LEA** Instruction - Load effective address-LEA register, source
- **LES** Instruction
Load register and ES with words from memory –LES register, memory address of first word.

➤ **LAHF** Instruction:

LAHF instruction copies the value of SF, ZF, AF, PF, CF, into bits of 7, 6, 4, 2, 0 respectively of AH register. This LAHF instruction was provided to make conversion of assembly language programs written for 8080 and 8085 to 8086 easier.

➤ **LDS** Instruction:

This instruction loads a far pointer from the memory address specified by op2 into the DS segment register and the op1 to the register.

LDS op1, op2

➤ **Example:**

LDS BX, [4326] ; copy the contents of the memory at displacement 4326H in DS to BL, contents of the 4327H to BH. Copy contents of 4328H and 4329H in DS to DS register.

- **LEA** Instruction - This instruction indicates the offset of the variable or memory location named as the source and put this offset in the indicated 16 – bit register.

➤ **Example:**

```

LEA BX, PRICE ; Load BX with offset of PRICE
                ; in DS
LEA BP, SS:STAK; Load BP with offset of STACK
                ; in SS
LEA CX, [BX][DI] ; Load CX with EA=BX + DI

```

➤ **LOCK** Instruction - Assert bus lock signal

➤ **LODS/LODSB/**

LODSW Instruction - Load string byte into AL or
Load string word into AX.

➤ **LOOP** Instruction - Loop to specified
label until CX = 0

➤ **LOOPE /**

LOOPZ Instruction - loop while CX ≠ 0 and
ZF = 1

➤ **LODS/LODSB/LODSW** Instruction - This instruction copies a byte from a string location pointed to by SI to AL or a word from a string location pointed to by SI to AX. If DF is cleared to 0, SI will automatically incremented to point to the next element of string.

➤ **Example:**

```

CLD ; Clear direction flag so SI is auto incremented
MOV SI, OFFSET SOURCE_STRING ; point SI at start of the string
LODS SOURCE_STRING ; Copy byte or word from
                ; string to AL or AX

```

➤ **LOOP** Instruction - This instruction is used to repeat a series of instruction some number of times

➤ **Example:**

```

MOV BX, OFFSET PRICE
                ; Point BX at first element in array
MOV CX, 40 ; Load CX with number of
                ; elements in array
NEXT: MOV AL, [BX] ; Get elements from array
ADD AL, 07H ; Ad correction factor
DAA ; decimal adjust result
MOV [BX], AL ; Put result back in array
LOOP NEXT ; Repeat until all elements
                ; adjusted.

```

➤ **LOOPE / LOOPZ** Instruction - This instruction is used to repeat a group of instruction some number of times until CX = 0 and ZF = 0

➤ **Example:**

```

MOV BX, OFFSET ARRAY
                ; point BX at start of the array
DEC BX
MOV CX, 100 ; put number of array elements in
                ; CX
NEXT: INC BX ; point to next element in array

```


CMP [BX], 0FFH ; Compare array elements FFH
LOOP NEXT

➤ **LOOPNE/LOOPNZ Instruction** - This instruction is used to repeat a group of instruction some number of times until CX = 0 and ZF = 1

➤ **Example:**

```
MOV BX, OFFSET ARRAY1 ; point BX at start of the array
DEC BX
MOV CX, 100 ; put number of array elements in
; CX
NEXT: INC BX ; point to next elements in array
CMP [BX], 0FFH ; Compare array elements 0DH
LOOPNE NEXT
```

➤ **MOV Instruction** - MOV destination, source

➤ **MOVS/MOVSIB/**

MOVSW Instruction - Move string byte or string word-MOVS destination, source

➤ **MUL Instruction** - Multiply unsigned bytes or words-MUL source

➤ **NEG Instruction** - From 2's complement – NEG destination

➤ **NOP Instruction** - Performs no operation.

➤ **MOV Instruction** - The MOV instruction copies a word or a byte of data from a specified source to a specified destination.

MOV op1, op2

➤ **Example:**

MOV CX, 037AH ; MOV 037AH into the CX.

MOV AX, BX ; Copy the contents of register BX ; to AX

MOV DL, [BX] ; Copy byte from memory at BX ; to DL, BX contains the offset of byte in DS.

➤ **MUL Instruction:**

This instruction multiplies an unsigned multiplication of the accumulator by the operand specified by op. The size of op may be a register or memory operand.

```
MUL op
Example: ; AL = 21h (33 decimal)
; BL = A1h(161 decimal )
MUL BL ; AX =14C1h (5313 decimal) since AH≠0,
; CF and OF will set to 1.
MUL BH ; AL times BH, result in AX
MUL CX ; AX times CX, result high word in DX,
; low word in AX.
```

➤ **NEG Instruction** - NEG performs the two's complement subtraction of the operand from zero and sets the flags according to the result.

```
; AX = 2CBh
NEG AX ; after executing NEG result AX =FD35h.
```

Example:

NEG AL ; Replace number in AL with its 2's complement

NEG BX ; Replace word in BX with its 2's complement

**NEG BYTE PTR[BX]; Replace byte at offset BX in
; DS with its 2's complement**

➤NOP Instruction:

This instruction simply uses up the three clock cycles and increments the instruction pointer to point to the next instruction. NOP does not change the status of any flag. The NOP instruction is used to increase the delay of a delay loop.

➤NOT Instruction - Invert each bit of operand –NOT destination.

➤OR Instruction - Logically OR corresponding of two operands- OR destination, source.

➤OUT Instruction - Output a byte or word to a port – OUT port, accumulator AL or AX.

➤POP Instruction - POP destination

➤NOT Instruction - NOT perform the bitwise complement of op and stores the result back into op.

NOT op

Example:

NOT BX ; Complement contents of BX register.

; DX =F038h

NOT DX ; after the instruction DX = 0FC7h

➤OR Instruction - OR instruction perform the bit wise logical OR of two operands. Each bit of the result is cleared to 0 if and only if both corresponding bits in each operand are 0, other wise the bit in the result is set to 1.

OR op1, op2

Examples:

OR AH, CL ; CL ORed with AH, result in AH.

; CX = 00111110 10100101

OR CX, FF00h ; OR CX with immediate FF00h

; result in CX = 11111111 10100101

; Upper byte are all 1's lower bytes

; are unchanged.

➤OUT Instruction - The OUT instruction copies a byte from AL or a word from AX or a double from the accumulator to I/O port specified by op. Two forms of OUT instruction are available: **(1)** Port number is specified by an immediate byte constant, (0 - 255). It is also called as fixed port form. **(2)** Port number is provided in the DX register (0 - 65535)

➤Example: (1)

OUT 3BH, AL ; Copy the contents of the AL to port 3Bh

OUT 2CH, AX ; Copy the contents of the AX to port 2Ch

(2)

MOV DX, 0FFF8H ; Load desired port address in DX

OUT DX, AL ; Copy the contents of AL to

; FFF8h

**OUT DX, AX ; Copy content of AX to port
; FFF8H**

➤ **POP Instruction:**

POP instruction copies the word at the current top of the stack to the operand specified by op then increments the stack pointer to point to the next stack.

➤ **Example:**

**POP DX ; Copy a word from top of the stack to
; DX and increments SP by 2.**

**POP DS ; Copy a word from top of the stack to
; DS and increments SP by 2.**

**POP TABLE [BX]
; Copy a word from top of stack to memory in DS with
; EA = TABLE + [BX].**

➤ **POPF Instruction** - Pop word from top of stack to flag - register.

➤ **PUSH Instruction** - PUSH source

➤ **PUSHF Instruction** - Push flag register on the stack

➤ **RCL Instruction** - Rotate operand around to the left through CF –
RCL destination, source.

➤ **RCR Instruction** - Rotate operand around to the right
through CF- RCR destination, count

➤ **POPF Instruction** - This instruction copies a word from the two memory
location at the top of the stack to flag register and increments the stack pointer by 2.

➤ **PUSH Instruction:**

PUSH instruction decrements the stack pointer by 2 and copies a word from a
specified source to the location in the stack segment where the stack pointer points.

➤ **Example:**

PUSH BX ; Decrement SP by 2 and copy BX to stack

PUSH DS ; Decrement SP by 2 and copy DS to stack

**PUSH TABLE[BX] ; Decrement SP by 2 and copy word
; from memory in DS at
; EA = TABLE + [BX] to stack.**

➤ **PUSHF Instruction:**

This instruction decrements the SP by 2 and copies the word in flag register to the
memory location pointed to by SP.

➤ **RCL Instruction:**

RCL instruction rotates the bits in the operand specified by op1 towards left by
the count specified in op2. The operation is circular, the MSB of operand is rotated into a
carry flag and the bit in the CF is rotated around into the LSB of operand.

RCR op1, op2

➤ **Example:**

CLC ; put 0 in CF

RCL AX, 1 ; save higher-order bit of AX in CF

RCL DX, 1 ; save higher-order bit of DX in CF

ADC AX, 0 ; set lower order bit if needed.

➤ **Example:**

- RCL DX, 1** ; Word in DX of 1 bit is moved to left, and
; MSB of word is given to CF and
; CF to LSB.
; CF=0, BH = 10110011
- RCL BH, 1** ; Result: BH =01100110
; CF = 1, OF = 1 because MSB changed
; CF =1, AX =00011111 10101001
- MOV CL, 2** ; Load CL for rotating 2 bit position
RCL AX, CL ; Result: CF =0, OF undefined
; AX = 01111110 10100110
- **RCR Instruction** - RCR instruction rotates the bits in the operand specified by op1 towards right by the count specified in op2. **RCR op1, op2**
- **Example: (1)**
RCR BX, 1 ; Word in BX is rotated by 1 bit towards
; right and CF will contain MSB bit and
; LSB contain CF bit.
- (2)
; CF = 1, BL = 00111000
RCR BL, 1 ; Result: BL = 10011100, CF =0
; OF = 1 because MSB is changed to 1.
- **REP/REPE/REPZ/REPNE/REPNZ** - (Prefix) Repeat String instruction until specified condition exist
- **RET Instruction** - Return execution from procedure to calling program.
- **ROL Instruction** - Rotate all bits of operand left, MSB to LSB ROL destination, count.
- **ROL Instruction** - ROL instruction rotates the bits in the operand specified by op1 towards left by the count specified in op2. ROL moves each bit in the operand to next higher bit position. The higher order bit is moved to lower order position. Last bit rotated is copied into carry flag.
ROL op1, op2
- **Example: (1)**
ROL AX, 1 ; Word in AX is moved to left by 1 bit
; and MSB bit is to LSB, and CF
; CF =0, BH =10101110
ROL BH, 1 ; Result: CF, Of =1, BH = 01011101
- **Example: (2)**
; BX = 01011100 11010011
; CL = 8 bits to rotate
ROL BH, CL ; Rotate BX 8 bits towards left
; CF =0, BX =11010011 01011100
- **ROR Instruction** - Rotate all bits of operand right, LSB to MSB – ROR destination, count
- **SAHF Instruction** - Copy AH register to low byte of flag register

➤ **ROR Instruction** - ROR instruction rotates the bits in the operand op1 towards right by count specified in op2. The last bit rotated is copied into CF.

ROR op1, op2

➤ **Example:**

(1)
ROR BL, 1 ; Rotate all bits in BL towards right by 1
 ; bit position, LSB bit is moved to MSB
 ; and CF has last rotated bit.

(2)
 ; CF = 0, BX = 00111011 01110101
ROR BX, 1 ; Rotate all bits of BX of 1 bit position
 ; towards right and CF = 1,

BX = 10011101 10111010

➤ **Example** (3)

MOVE CL, 04H ; CF = 0, AL = 10110011,
 ; Load CL
ROR AL, CL ; Rotate all bits of AL towards right
 ; by 4 bits, CF = 0, AL = 00111011

➤ **SAHF Instruction:**

SAHF copies the value of bits 7, 6, 4, 2, 0 of the AH register into the SF, ZF, AF, PF, and CF respectively. This instruction was provided to make easier conversion of assembly language program written for 8080 and 8085 to 8086.

➤ **SAL/SHL Instruction** - Shift operand bits left, put zero in LSB(s)
 SAL/AHL destination, count

➤ **SAR Instruction** - Shift operand bits right, new MSB = old MSB
 SAR destination, count.

➤ **SBB Instruction** - Subtract with borrow SBB destination, source

➤ **SAL / SHL Instruction** - SAL instruction shifts the bits in the operand specified by op1 to its left by the count specified in op2. As a bit is shifted out of LSB position a 0 is kept in LSB position. CF will contain MSB bit.

SAL op1, op2

➤ **Example:**

SAL BX, 1 ; CF = 0, BX = 11100101 11010011
 ; Shift BX register contents by 1 bit
 ; position towards left
 ; CF = 1, BX = 11001011 1010011

➤ **SAR Instruction** - SAR instruction shifts the bits in the operand specified by op1 towards right by count specified in op2. As bit is shifted out a copy of old MSB is taken in MSB

MSB position and LSB is shifted to CF.

SAR op1, op2

➤ **Example:** (1)

SAR AL, 1 ; AL = 00011101 = +29 decimal, CF = 0
 ; Shift signed byte in AL towards right
 ; (divide by 2)

; AL = 00001110 = + 14 decimal, CF = 1

(2)

; BH = 11110011 = - 13 decimal, CF = 1

SAR BH, 1 ; Shifted signed byte in BH to right

; BH = 11111001 = - 7 decimal, CF = 1

➤SBB Instruction - SUBB instruction subtracts op2 from op1, then subtracts 1 from op1 is CF flag is set and result is stored in op1 and it is used to set the flag.

➤Example:

SUB CX, BX ; CX – BX. Result in CX

SUBB CH, AL ; Subtract contents of AL and
; contents CF from contents of CH.
; Result in CH

SUBB AX, 3427H ; Subtract immediate number
; from AX

➤Example:

•Subtracting unsigned number

; CL = 10011100 = 156 decimal

; BH = 00110111 = 55 decimal

SUB CL, BH

; CL = 01100101 = 101 decimal

; CF, AF, SF, ZF = 0, OF, PF = 1

•Subtracting signed number

; CL = 00101110 = + 46 decimal

; BH = 01001010 = + 74 decimal

SUB CL, BH

; CL = 11100100 = - 28 decimal

; CF = 1, AF, ZF = 0,

; SF = 1 result negative

➤STD Instruction - Set the direction flag to 1

➤STI Instruction - Set interrupt flag (IF)

➤STOS/STOSB/

STOSW Instruction - Store byte or word in string.

➤SCAS/SCASB/

SCASW Instruction - Scan string byte or a
string word.

➤SHR Instruction - Shift operand bits right, put
zero in MSB

➤STC Instruction - Set the carry flag to 1

➤SHR Instruction - SHR instruction shifts the bits in op1 to right by the
number of times specified by op2.

➤Example:

(1)

SHR BP, 1 ; Shift word in BP by 1 bit position to right
; and 0 is kept to MSB

(2)

MOV CL, 03H ; Load desired number of shifts into CL

SHR BYTE PTR [BX] ; Shift bytes in DS at offset BX and

; rotate 3 bits to right and keep 3 0's in MSB

(3)

```
SHR SI, 1      ; SI = 10010011 10101101, CF = 0
               ; Result: SI = 01001001 11010110
               ; CF = 1, OF = 1, SF = 0, ZF = 0
```

- **TEST** Instruction – AND operand to update flags
- **WAIT** Instruction - Wait for test signal or interrupt signal
- **XCHG** Instruction - Exchange XCHG destination, source
- **XLAT/**
XLATB Instruction - Translate a byte in AL
- **XOR** Instruction - Exclusive OR corresponding bits of two operands –
XOR destination, source
- **TEST** Instruction - This instruction ANDs the contents of a source byte or word with the contents of specified destination word. Flags are updated but neither operand is changed. TEST instruction is often used to set flags before a condition jump instruction

➤ **Examples:**

```
TEST AL, BH    ; AND BH with AL. no result is
               ; stored. Update PF, SF, ZF
TEST CX, 0001H ; AND CX with immediate
               ; number
               ; no result is stored, Update PF,
               ; SF
```

➤ **Example:**

```
TEST AL, 80H   ; AL = 01010001
               ; AND immediate 80H with AL to
               ; test if MSB of AL is 1 or 0
               ; ZF = 1 if MSB of AL = 0
               ; AL = 01010001 (unchanged)
               ; PF = 0, SF = 0
               ; ZF = 1 because ANDing produced is 00
```

- **WAIT** Instruction - When this WAIT instruction executes, the 8086 enters an idle condition. This will stay in this state until a signal is asserted on TEST input pin or a valid interrupt signal is received on the INTR or NMI pin.

```
FSTSW STATUS   ; copy 8087 status word to memory
FWAIT          ; wait for 8087 to finish before-
               ; doing next 8086 instruction
MOV AX, STATUS ; copy status word to AX to
               ; check bits
```

- In this code we are adding up of FWAIT instruction so that it will stop the execution of the command until the above instruction is finishes it's work.so that you are not loosing data and after that you will allow to continue the execution of instructions.

- **XCHG** Instruction - The Exchange instruction exchanges the contents of the register with the contents of another register (or) the contents of the register with the contents of the memory location. Direct memory to memory exchange are not supported.

XCHG op1, op2

The both operands must be the same size and one of the operand must always be a register.

Example:

```

XCHG    AX, DX           ; Exchange word in AX with word in DX
XCHG    BL, CH           ; Exchange byte in BL with byte in CH
XCHG    AL, Money [BX]    ; Exchange byte in AL with byte
                                ; in memory at EA.

```

➤ **XOR Instruction** - XOR performs a bit wise logical XOR of the operands specified by op1 and op2. The result of the operand is stored in op1 and is used to set the flag.

XOR op1, op2**Example: (Numerical)**

```

                                ; BX = 00111101 01101001
                                ; CX = 00000000 11111111
XOR    BX, CX           ; Exclusive OR CX with BX
                                ; Result BX = 00111101 10010110

```

Module 2 learning unit 6:**Assembler Directives** ➤ **ASSUME**

- **DB** - Defined Byte.
- **DD** - Defined Double Word
- **DQ** - Defined Quad Word
- **DT** - Define Ten Bytes
- **DW** - Define Word

➤ **ASSUME Directive:**

The ASSUME directive is used to tell the assembler that the name of the logical segment should be used for a specified segment. The 8086 works directly with only 4 physical segments: a Code segment, a data segment, a stack segment, and an extra segment.

➤ **Example:**

ASUME CS:CODE ; This tells the assembler that the logical segment named CODE contains the instruction statements for the program and should be treated as a code segment.

ASUME DS:DATA ; This tells the assembler that for any instruction which refers to a data in the data segment, data will found in the logical segment DATA.

➤ **DB:** DB directive is used to declare a byte-type variable or to store a byte in memory location.

➤ **Example:**

1. **PRICE DB 49h, 98h, 29h** ; Declare an array of 3 bytes, ; named as PRICE and initialize.
2. **NAME DB 'ABCDEF'** ; Declare an array of 6 bytes and ; initialize with ASCII code for letters
3. **TEMPDB 100 DUP(?)** ; Set 100 bytes of storage in memory and ; give it the name as TEMP, but leave the 100 bytes uninitialized. Program instructions will load values into these locations.

➤ **DW**: The DW directive is used to define a variable of type word or to reserve storage location of type word in memory.

➤ **Example:**

MULTIPLIER DW 437Ah ; this declares a variable of type word and named it as MULTIPLIER. This variable is initialized with the value 437Ah when it is loaded into memory to run.

EXP1 DW 1234h, 3456h, 5678h ; this declares an array of 3 words and initialized with specified values.

STOR1 DW 100 DUP(0); Reserve an array of 100 words of memory and initialize all words with 0000. Array is named as STOR1.

➤ **END**: END directive is placed after the last statement of a program to tell the assembler that this is the end of the program module. The assembler will ignore any statement after an END directive. Carriage return is required after the END directive.

➤ **ENDP**: ENDP directive is used along with the name of the procedure to indicate the end of a procedure to the assembler

➤ **Example:**

SQUARE_NUM PROC ; It start the procedure
; Some steps to find the square root of a number

SQUARE_NUM ENDP ; Hear it is the End for the procedure

➤ **END** - End Program

➤ **ENDP** - End Procedure

➤ **ENDS** - End Segment

➤ **EQU** - Equate

➤ **EVEN** - Align on Even Memory Address

➤ **EXTRN**

➤ **ENDS** - This ENDS directive is used with name of the segment to indicate the end of that logic segment.

➤ **Example:**

CODE SEGMENT ; Hear it Start the logic
; segment containing code
; Some instructions statements to perform ;
the logical operation

CODE ENDS ; End of segment named as
; CODE

➤ **EQU**: This EQU directive is used to give a name to some value or to a symbol. Each time the assembler finds the name in the program, it will replace the name with the value or symbol you given to that name.

➤ **Example:**

FACTOR EQU 03H ; you has to write this statement at the starting of your program and later in the program you can use this as follows

ADD AL, FACTOR ; When it codes this instruction the assembler will code it as ADDAL, 03H

; The advantage of using EQU in this manner is, if FACTOR is used many no of times in a program and you want to change the value, all you had to do is change the EQU statement at beginning, it will changes the rest of all.

➤ **EVEN**: This **EVEN** directive instructs the assembler to increment the location of the counter to the next even address if it is not already in the even address. If the word is at even address 8086 can read a memory in 1 bus cycle.

If the word starts at an odd address, the 8086 will take 2 bus cycles to get the data. A series of words can be read much more quickly if they are at even address. When **EVEN** is used the location counter will simply incremented to next address and **NOP** instruction is inserted in that incremented location.

➤ **Example**:

```
DATA1 SEGMENT
```

```
        ; Location counter will point to 0009 after assembler reads
        ; next statement
```

```
SALES DB 9 DUP(?) ; declare an array of 9 bytes
```

```
EVEN ; increment location counter to 000AH
```

```
RECORD DW 100 DUP(0) ; Array of 100 words will start from an even
```

address for quicker read

```
DATA1 ENDS
```

➤ **GROUP** - Group Related Segments

➤ **LABLE**

➤ **NAME**

➤ **OFFSET**

➤ **ORG** - Originate

➤ **GROUP** - The **GROUP** directive is used to group the logical segments named after the directive into one logical group segment.

➤ **INCLUDE** - This **INCLUDE** directive is used to insert a block of source code from the named file into the current source module.

➤ **PROC** - Procedure

➤ **PTR** - Pointer

➤ **PUBLIC**

➤ **SEGMENT**

➤ **SHORT**

➤ **TYPE**

➤ **PROC**: The **PROC** directive is used to identify the start of a procedure. The term near or far is used to specify the type of the procedure.

➤ **Example**:

```
SMART PROC FAR ; This identifies that the start of a
procedure named as SMART and instructs the assembler that the procedure is far.
```

```
SMART ENDP
```

This **PROC** is used with **ENDP** to indicate the break of the procedure.

➤ **PTR**: This **PTR** operator is used to assign a specific type of a variable or to a label.

➤ **Example**:

```
INC [BX] ; this instruction will not know whether to increment the
byte pointed to by BX or a word pointed to by BX.
```

INC BYTE PTR [BX] ; increment the byte
; pointed to by BX

This PTR operator can also be used to override the declared type of variable. If we want to access the a byte in an array **WORDS DW 437Ah, 0B97h,**

MOV AL, BYTE PTR WORDS

➤ **PUBLIC** - The **PUBLIC** directive is used to instruct the assembler that a specified name or label will be accessed from other modules.

➤ **Example:**

PUBLIC DIVISOR, DIVIDEND; these two variables are public so these are available to all modules.

If an instruction in a module refers to a variable in another assembly module, we can access that module by declaring as **EXTRN** directive.

➤ **TYPE** - **TYPE** operator instructs the assembler to determine the type of a variable and determines the number of bytes specified to that variable.

➤ **Example:**

Byte type variable – assembler will give a value 1

Word type variable – assembler will give a value 2

Double word type variable – assembler will give a value 4

ADD BX, TYPE WORD_ARRAY; here we want to increment BX to point to next word in an array of words.

DOS Function Calls ➤ **AH 00H** : Terminate a Program

➤ **AH 01H** : Read the Keyboard

➤ **AH 02H** : Write to a Standard Output Device

➤ **AH 08H** : Read a Standard Input without Echo

➤ **AH 09H** : Display a Character String

➤ **AH 0AH** : Buffered keyboard Input

➤ **INT 21H** : Call DOS Function.