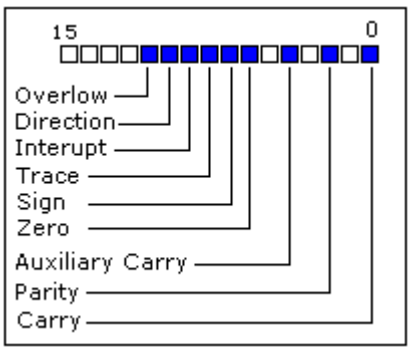
8086 assembler tutorial for beginners (part 6)

Arithmetic and Logic Instructions

Most Arithmetic and Logic Instructions affect the processor status register (or **Flags**)



As you may see there are 16 bits in this register, each bit is called a **flag** and can take a value of **1** or **0**.

- **Carry Flag (CF)** - this flag is set to **1** when there is an **unsigned overflow**. For example when you add bytes **255 + 1** (result is not in range 0...255). When there is no overflow this flag is set to **0**.
- **Zero Flag (ZF)** - set to **1** when result is **zero**. For none zero result this flag is set to **0**.
- **Sign Flag (SF)** - set to **1** when result is **negative**. When result is **positive** it is set to **0**. Actually this flag take the value of the most significant bit.
- **Overflow Flag (OF)** - set to **1** when there is a **signed overflow**. For example, when you add bytes **100 + 50** (result is not in range -128...127).
- **Parity Flag (PF)** - this flag is set to **1** when there is even number of one bits in result, and to **0** when there is odd number of one bits. Even if result is a word only 8 low bits are analyzed!
- **Auxiliary Flag (AF)** - set to **1** when there is an **unsigned overflow** for low nibble (4 bits).
- **Interrupt enable Flag (IF)** - when this flag is set to **1** CPU reacts to interrupts from external devices.
- **Direction Flag (DF)** - this flag is used by some instructions to process data chains, when this flag is set to **0** - the processing is done forward, when this flag is set to **1** the processing is done backward.

There are 3 groups of instructions.

First group: **ADD**, **SUB**,**CMP**, **AND**, **TEST**, **OR**, **XOR**

These types of operands are supported:

REG, memory
memory, REG
REG, REG
memory, immediate
REG, immediate

REG: AX, BX, CX, DX, AH, AL, BL, BH, CH, CL, DH, DL, DI, SI, BP, SP.

memory: [BX], [BX+SI+7], variable, etc...

immediate: 5, -24, 3Fh, 10001101b, etc...

After operation between operands, result is always stored in first operand. **CMP** and **TEST** instructions affect flags only and do not store a result (these instruction are used to make decisions during program execution).

These instructions affect these flags only:
CF, **ZF**, **SF**, **OF**, **PF**, **AF**.

- **ADD** - add second operand to first.
- **SUB** - Subtract second operand to first.
- **CMP** - Subtract second operand from first **for flags only**.
- **AND** - Logical AND between all bits of two operands. These rules apply:

  1 AND 1 = 1
  1 AND 0 = 0
  0 AND 1 = 0
  0 AND 0 = 0

  As you see we get **1** only when both bits are **1**.
- **TEST** - The same as **AND** but **for flags only**.
- **OR** - Logical OR between all bits of two operands. These rules apply:

  1 OR 1 = 1
  1 OR 0 = 1

0 OR 1 = 1
0 OR 0 = 0

As you see we get **1** every time when at least one of the bits is **1**.

- **XOR** - Logical XOR (exclusive OR) between all bits of two operands. These rules apply:

  1 XOR 1 = 0
  1 XOR 0 = 1
  0 XOR 1 = 1
  0 XOR 0 = 0

  As you see we get **1** every time when bits are different from each other.

Second group: **MUL**, **IMUL**, **DIV**, **IDIV**

These types of operands are supported:

REG
memory

REG: AX, BX, CX, DX, AH, AL, BL, BH, CH, CL, DH, DL, DI, SI, BP, SP.

memory: [BX], [BX+SI+7], variable, etc...

MUL and **IMUL** instructions affect these flags only:
CF, **OF**
When result is over operand size these flags are set to **1**, when result fits in operand size these flags are set to **0**.

For **DIV** and **IDIV** flags are undefined.

- **MUL** - Unsigned multiply:

  when operand is a **byte**:
  AX = AL * operand.

  when operand is a **word**:
  (DX AX) = AX * operand.

- **IMUL** - Signed multiply:

  when operand is a **byte**:
  AX = AL * operand.

  when operand is a **word**:
  (DX AX) = AX * operand.

- **DIV** - Unsigned divide:

  when operand is a **byte**:
  AL = AX / operand
  AH = remainder (modulus). .

  when operand is a **word**:
  AX = (DX AX) / operand
  DX = remainder (modulus). .

- **IDIV** - Signed divide:

  when operand is a **byte**:
  AL = AX / operand
  AH = remainder (modulus). .

  when operand is a **word**:
  AX = (DX AX) / operand
  DX = remainder (modulus). .

Third group: **INC**, **DEC**, **NOT**, **NEG**

These types of operands are supported:

REG
memory

REG: AX, BX, CX, DX, AH, AL, BL, BH, CH, CL, DH, DL, DI, SI, BP, SP.

memory: [BX], [BX+SI+7], variable, etc...

INC, **DEC** instructions affect these flags only:
ZF, **SF**, **OF**, **PF**, **AF**.

NOT instruction does not affect any flags!

NEG instruction affects these flags only:
CF, **ZF**, **SF**, **OF**, **PF**, **AF**.

- **NOT** - Reverse each bit of operand.

- **NEG** - Make operand negative (two's complement). Actually it reverses each bit of operand and then adds 1 to it. For example 5 will become -5, and -2 will become 2.

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