<http://www.shsu.edu/~csc_tjm/spring2005/cs272/flags.html>

**Processor Status and the FLAGS Register**

**Module 5**   
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**FLAGS Register**

* Individual bits control the action or represent the status of the processor
  + Control flags (TF, IF, DF)
    - Determine how the processor responds to certain situations
  + Status flags (CF, PF, AF, ZF, SF, OF)
    - Set to represent the result of certain operations
    - Used to control conditional jump instructions

**FLAG Register Bits** 

|  |  |  |
| --- | --- | --- |
| ***Bit*** | ***Name*** | ***Symbol*** |
| 0 | Carry flag | **cf** |
| 2 | Parity flag | **pf** |
| 4 | Auxiliary carry flag | **af** |
| 6 | Zero flag | **zf** |
| 7 | Sign flag | **sf** |
| 8 | Trace flag | **tf** |
| 9 | Interrupt flag | **if** |
| 10 | Direction flag | **df** |
| 11 | Overflow flag | **of** |

**Control Flags**

* DF - Direction flag
  + STD: direction = down
  + CLD: direction = up
* IF - Interrupt enable
  + STI: enable external interrupts
  + CLI: disable maskable external interrupts
* TF - Trace flag
  + Interrupt 1 after executing instruction, if set

**Status Flags**

* Carry
  + carry or borrow at MSB in add or subtract
  + last bit shifted out
* Parity
  + low byte of result has even parity
* Auxiliary
  + carry or borrow at bit 3
* Zero
  + result is 0
* Sign
  + result is negative
* Overflow
  + signed overflow occurred during add or subtract

**The Carry Flag (CF)**

* CF = 1 if there is a carry out from the msb (most significant bit) on addition, or there is a borrow into the msb on subtraction
* CF = 0 otherwise
* CF is also affected by shift and rotate instructions

**The Parity Flag (PF)**

* PF = 1 if the low byte of a result has an even number of one bits (even parity)
* PF = 0 otherwise (odd parity)

**The Auxiliary Carry Flag (AF)**

* AF = 1 if there is a carry out from bit 3 on addition, or there is a borrow into the bit 3 on subtraction
* AF = 0 otherwise
* AF is used in binary-coded decimal (BCD) operations

**The Zero Flag (ZF)**

* ZF = 1 for a zero result
* ZF = 0 for a non-zero result

**The Sign Flag (SF)**

* SF = 1 if the msb of a result is 1; it means the result is negative if you are giving a signed interpretation
* SF = 0 if the msb is 0

**The Overflow Flag (OF)**

* OF = 1 if signed overflow occurred
* OF = 0 otherwise

**(Signed) Overflow**

* Can only occur when adding numbers of the same sign (subtracting with different signs)
* Detected when carry into MSB is not equal to carry out of MSB
  + Easily detected because this implies the result has a different sign than the sign of the operands
* Programs can ignore the Flags!

**Signed Overflow Example**

**10010110**   
**+ 10100011**   
**00111001**

*Carry in = 0, Carry out = 1*   
*Neg+Neg=Pos*   
*Signed overflow occurred*   
*OF = 1 (set)*

**00110110**   
**+ 01100011**   
**10011001**

*Carry in = 1, Carry out = 0*   
*Pos+Pos=Neg*   
*Signed overflow occurred*   
*OF = 1 (set)*

**Examples of No Signed Overflow**

**10010110**   
**+ 01100011**   
**11111001**

*Carry in = 0, Carry out = 0*   
*Neg+Pos=Neg*   
*No Signed overflow occurred*   
*OF = 0 (clear)*

**10010110**   
**+ 11110011**   
**10001001**

*Carry in = 1, Carry out = 1*   
*Neg+Neg=Neg*   
*No Signed overflow occurred*   
*OF = 0 (clear)*

**Unsigned Overflow**

* The carry flag is used to indicate if an unsigned operation overflowed
* The processor only adds or subtracts - it does not care if the data is signed or unsigned!

**10010110**   
**+ 11110011**   
**10001001**

*Carry out = 1*   
*Unsigned overflow occurred*   
*CF = 1 (set)*

**Instructions and Flags**

* MOV and XCHG - no flags are changed
* ADD and SUB - all flags affected
* INC and DEC - all except CF
* NEG - all flags affected
  + CF=0 only if value is 0
  + OF=1 only if value is -MAXINT
    - 80h or 8000h