

The Processor Status and the FLAGS Register

Outline

- The FLAGS register
- Overflow
- How instructions affect the flags
- The DEBUG program

The FLAGS Register

- In 8086, the processor state is implemented as nine individual bits called flags.
- Each decision made by 8086 is based on the values of these flags.
- The flags are placed in the FLAGS register.
- Two types of flags: Status flags and control flags.
- Status flags reflect the result of a computation. They are located in bits 0, 2, 4, 6, 7 and 11.
- Control flags enable or disable certain operations of the processor. They are located in bits 8, 9 and 10.
- The other bits have no significance.

The FLAGS Register

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
				OF	DF	IF	TF	SF	ZF		AF		PF		CF

Bit	Name	Symbol
0	Carry Flag	CF
2	Parity Flag	PF
4	Auxiliary Carry Flag	AF
6	Zero Flag	ZF
7	Sign Flag	SF
11	Overflow Flag	OF
8	Trap Flag	TF
9	Interrupt Flag	IF
10	Direction Flag	DF

Status Flag

Control Flag

The Status Flags

- Carry Flag(CF)
 - CF=1 if there is a carry out in the MSB on addition, if there is a borrow into the MSB on subtraction.
 - Otherwise CF=0.
 - It is also affected by shift and rotate instructions.
- Parity Flag(PF)
 - PF=1 if the low byte of a result has even parity.
 - PF=0 if the low byte of a result has odd parity.
- Auxiliary Carry Flag(AF)
 - AF=1 if there is a carry out from bit 3 on addition or a borrow into bit 3 on subtraction.
 - Otherwise AF=0.
 - AF is used in BCD operations.

The Status Flags

- Zero Flag(ZF)
 - ZF=1 for a zero result.
 - ZF=0 for a non-zero result.
- Sign Flag(SF)
 - SF=1 if the MSB of a result is 1 that means the result is negative.
 - SF=0 if the MSB of a result is 0 that means the result is positive.
- Overflow Flag(OF)
 - OF=1 if signed overflow occurred.
 - Otherwise OF=0.

Overflow

- The range of signed numbers that can be represented by a
 - 16-bit word is -32768 to 32767.
 - 8-bit byte is -128 to 127.
- The range of unsigned numbers that can be represented by a
 - 16-bit word is 0 to 65535.
 - 8-bit byte is 0 to 255.
- If the result of an operation falls out of these ranges then overflow occurs and the truncated result that is saved will be incorrect.

Overflow

- When we perform an arithmetic operation such as addition there are four possible outcomes:
 - No overflow.
 - Signed overflow only.
 - Unsigned overflow only.
 - Both signed and unsigned overflows.

Example of Unsigned Overflow Only

- Suppose AX contains FFFFh(-1), BX contains 0001h(1). Add the contents of AX and BX.
- Solution: ADD AX,BX

	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
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	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- If it is an unsigned interpretation the correct answer 10000h=65535 but this is out of range for a word operation.
- A 1 is carried out of the MSB and the answer stored in AX is 0000h which is wrong so unsigned overflow occurs.
- But signed overflow does not occur as the stored answer is correct as a signed number.

Example of Signed Overflow Only

- Suppose AX contains 7FFFh(32767), BX contains 7FFFh(32767). Add the contents of AX and BX.
- Solution: ADD AX,BX

	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
+	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

- If it is a signed interpretation the answer is FFFEh = -2 but this incorrect as the result should be 65534. So signed overflow occurs.
- The unsigned interpretation of FFFEh is 65534, which is the right answer. So unsigned overflow does not occur.

Overflow Indicates by Processor

- The processor sets OF=1 for signed overflow.
- The processor sets CF=1 for unsigned overflow.

Overflow Occur Determination by Processor

- Unsigned overflow
 - On addition when there is a carry out in the MSB. This means the result is larger than the biggest unsigned number.
 - On subtraction when there is a borrow in the MSB. This means the correct answer is smaller than 0.
- Signed overflow
 - On addition the numbers with the same sign produces result of different sign.
 - On subtraction the result has a different sign than expected.
 - Subtraction of numbers with different signs means addition of number with same sign.

How Instructions Affect the Flags

Instruction	Affected flags
MOV/XCHG	None
ADD/SUB	all
INC/DEC	All except CF
NEG	All CF=1 unless result is 0, OF=1 if word operand is 8000h or byte operand is 80h

How Instructions Affect the Flags

- ADD AX,BX where AX contains FFFFh and BX contains FFFFh
- Solution

	F	F	F	F	h
+	F	F	F	F	h
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1	F	F	F	E	h

- The result stored in AX is FFFEh = 1111 1111 1111 1110
 - SF=1 because the MSB is 1.
 - PF=0 because there are odd number of 1 bits in the low byte of the result.
 - ZF=0 because the result is non zero.
 - CF=1 because there is a carry out of the MSB on addition.
 - OF=0 There is a carry into the MSB and also a carry out.