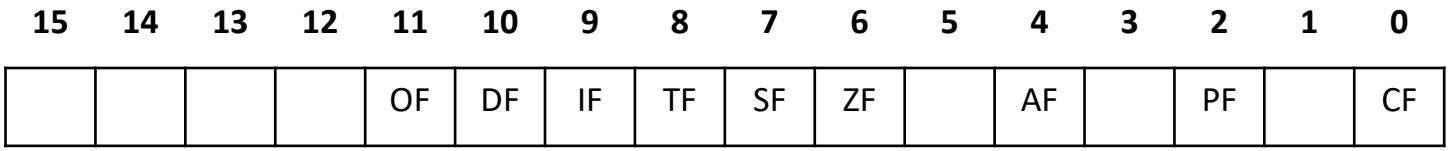
The Processor Status And The FLAGS Register

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



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
- 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**
+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	0	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**
+	0	1	1	1	1	1	1	1	1	1	1	1	1	1	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.