# 1.6 Signed Binary Numbers

## 1. Representation of Signed and Unsigned Binary Numbers

- **Unsigned Numbers:** Represent only positive integers (including zero). All bits are used to represent the magnitude.
- **Signed Numbers:** Represent both positive and negative integers.
  - The **leftmost bit (MSB)** represents the sign:
    - 0 indicates a positive number.
    - 1 indicates a negative number.
- **Example:**
  - 01001 (Unsigned) = 9 (Signed) = +9
  - 11001 (Unsigned) = 25 (Signed) = −9

## 2. Signed Number Representations

### (a) Signed-Magnitude Representation

- Leftmost bit is the **sign bit**.
- Remaining bits represent the **magnitude**.
- Example (8 bits):

$$+9 = 00001001$$
$$-9 = 10001001$$

### (b) 1's Complement Representation

- Negative numbers are represented by **flipping all bits** of the positive number.
- Example:

$$+9 = 00001001$$
$$-9 = 11110110$$

### (c) 2's Complement Representation

- Obtain by adding 1 to the 1's complement.
- Simplifies arithmetic operations.
- Example:

$$+9 = 00001001$$
$$-9 = 11110111$$

## 3. Arithmetic Operations

### (a) Addition in 2's Complement

- Add numbers including the sign bit.
- Discard carry out of the MSB.
- Example:

$$\begin{aligned} & (+6) + (-13) : \\ 00000110 + 11110011 = 11111001 \quad & (Result = -7) \end{aligned}$$

### (b) Subtraction in 2's Complement

- Take 2's complement of the subtrahend and add it to the minuend.
- Discard carry out of the MSB.
- Example:

$$\begin{aligned} & (-6) - (-13) : \\ 11111010 + 00001101 = 00000111 \quad & (Result = +7) \end{aligned}$$

# 4. Overflow Conditions

- Occurs when the result exceeds the range that can be represented with the given number of bits.
- Detection Rule:
  - Adding two positive numbers gives a negative result.
  - Adding two negative numbers gives a positive result.