**ECE 271 Data Representation**

**Learning goals:**

1. Why do we use two’s complementary in most computer systems? Answer: **It simplifies hardware**.
2. Overflow and carry flags
   1. ***Carry*** is for adding and subtracting two ***unsigned*** numbers. For unsigned subtraction, the carry flag is the negate of the borrow flag.
   2. ***Overflow*** is for adding and subtracting two ***signed*** numbers.

**Hardware Adder & Subtraction**

Assume a 5-bit system:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Simple Addition (ignore sign)** | | | | | | | **Unsigned Addition** | | | **Signed Addition** | | |
|  | **1** | **0** | **1** | **1** | **1** |  |  |  |  |  |  |  |
| **+** | **0** | **0** | **1** | **1** | **0** |  |  | **+** |  |  | **+** |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Simple Subtraction (ignore sign)** | | | | | | | **Unsigned Subtraction** | | | **Signed Subtraction** | | |
|  | **1** | **0** | **1** | **1** | **1** |  |  |  |  |  |  |  |
| **-** | **0** | **0** | **1** | **1** | **0** |  |  | **-** |  |  | **-** |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

**Carry and Overflow**

In a 5-bit system

|  |  |
| --- | --- |
| **Representation of Unsigned Numbers** | **Representation of Signed Numbers**  **(Two’s Complement)** |
|  |  |
| **Unsigned Addition: 28 + 6** | **Signed Addition: 12 + 5** |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | **1** | **1** | **1** | **0** | **0** | | **+** | **0** | **0** | **1** | **1** | **0** | |  |  |  |  |  |  | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | **0** | **1** | **1** | **0** | **0** | | **+** | **0** | **0** | **1** | **0** | **1** | |  |  |  |  |  |  | |
| **When is the Carry flag set?** | **When is the Overflow flag set?** |
| **Unsigned Subtraction: 3 - 5** | **Signed Addition: (-13) + (-7)** |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | **0** | **0** | **0** | **1** | **1** | | **-** | **0** | **0** | **1** | **0** | **1** | |  |  |  |  |  |  | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | **1** | **0** | **0** | **1** | **1** | | **+** | **1** | **1** | **0** | **0** | **1** | |  |  |  |  |  |  | |
| **When is the carry flag set? (Carry = NOT Borrow)** | **When is the overflow flag set?** |