Signed and Unsigned Binary

**Signed Number:** A number that can be either positive or negative, i.e. requires a positive or negative sign

*Binary Addition:*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 8 | 4 | 2 | 1 |  |
|  | 0 | 0~~1~~ | 1~~1~~ | 1 | = 3 |
| + | 0 | 0 | 1 | 1 | = 3 |
|  | 0 | 1 | 1 | 0 | = 6 |

*Binary Multiplication:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | 1 | 1 | 0 | 1 | 1 |
|  |  |  |  |  | 1 | 1 |
|  | ~~1~~ | 1~~1~~ | 1~~1~~ | 0~~1~~ | 1 | 1 |
|  | 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 |

# *Two’s Compliment*

With signed numbers, the first bit is the **signed bit**. With a two’s compliment binary number of length n, the first bit represents -2n-1.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Unsigned*** | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| ***Two’s Compliment*** | -128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

1. 1001 0011 = 1 + 2 + 16 - 128 = -109
2. 0111 0010 = 2 + 16 + 32 + 64 = 114
3. 1101 0011 = 1 + 2 + 16 + 64 - 128 = -45
4. 1000 1100 = 4 + 8 – 128 = -116
5. 0111 0011 = 1 + 2 + 16 + 32 + 64 = 115

To convert a negative denary number to two’s compliment binary, work out as if it were positive, make the signed bit 1, and reverse all the other bits.

1. -8610 = - (0101 01102) = 1010 1001
2. -610 = - (0000 01102) = 1111 1001
3. 7810 = 0100 11102
4. -10910 = - (0110 11012) = 1001 0010