Week 4 – Worked Example

Subtract 19 from 23 using the two's complement system.

So $23 - 19 = 23 + (-19)$, we need (-19)

$23_{10} = 10111_2$, as we are dealing with signed numbers, a leading '0' is added for +23 giving 010111

$19_{10} = 010011_2$. There are 3 ways to obtain the 2's complement.

1. Copy down the bits from the LSB until you have written the first '1' then invert the remaining bits

$$\begin{array}{r} \overbrace{0100}^{\text{invert}}11 \leftarrow \text{first '1'} \\ \hline 101101 \end{array}$$

(pen & paper method)

2. Invert all of the bits and add '1'

$$\begin{array}{rr} & 010011 \\ \text{invert} \rightarrow & 101100 + \leftarrow \text{add '1'} \\ & 1 \\ \hline & 101101 \end{array}$$

(digital hardware method)

3. $2^n - A$ 010011 ⇒ 6 bits so $n = 6$, $2^6 = 1000000$

$$\begin{array}{rr} & 1000000 - \\ & 010011 \\ \hline \text{ignore} \rightarrow & (0)\,101101 \end{array}$$

(theoretical method)

Thus $-19_{10} \equiv 101101$ in 2's complement.

Leading '1' indicates a -ve number

If asked to use 8 bit arithmetic extend the sign bit as shown

$$\begin{array}{r} 23_{10} \\ - \; 19_{10} \\ \hline 4 \end{array} \equiv \begin{array}{r} 010111 + \\ 101101 \\ \hline (1)\,000100 \end{array} \checkmark \qquad \begin{array}{r} 00010111 + \\ 11101101 \\ \hline (1)\,00000100 \end{array}$$

ignore   = +4   ignore

For 19 − 23 ⇒ 23 = 010111, −23 = 101001

$$\begin{array}{r} 19 + \\ (-23) \\ \hline -4 \end{array} = \begin{array}{r} 010011 + \\ 101001 \\ \hline 111100 \end{array}$$

Sign bit is negative

convert again to find the decimal value of the -ve 2's complement number

111100 ⇒ 000100

i.e. −4