Digital Logic Design
(EE227)

Musawar Ali

Binary Addition

Example Add the binary numbers 00111 and 10101 and show the equivalent decimal addition.

Solution

$$\begin{array}{r} {\scriptstyle 0\ 1\ 1\ 1} \\ 00111 \\ 10101 \\ \hline 11100 \end{array} \quad \begin{array}{r} 7 \\ 21 \\ \hline = 28 \end{array}$$

Binary Subtraction

The rules for binary subtraction are

$$0 - 0 = 0$$
$$1 - 1 = 0$$
$$1 - 0 = 1$$
$$10 - 1 = 1 \quad \text{with a borrow of 1}$$

Example Subtract the binary number 00111 from 10101 and show the equivalent decimal subtraction.

Solution

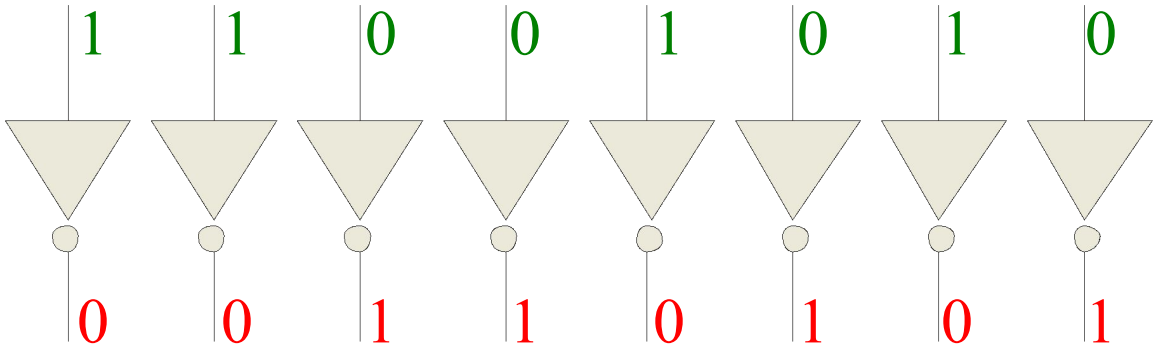
$$\begin{array}{r} {\scriptstyle 1\,1\,1} \\ 10101 \\ 00111 \\ \hline 01110 \end{array} \quad \begin{array}{r} 21 \\ 7 \\ \hline = 14 \end{array}$$

1's Complement

The 1's complement of a binary number is just the inverse of the digits. To form the 1's complement, change all 0's to 1's and all 1's to 0's.

For example, the 1's complement of 11001010 is 00110101

In digital circuits, the 1's complement is formed by using inverters:



2's Complement

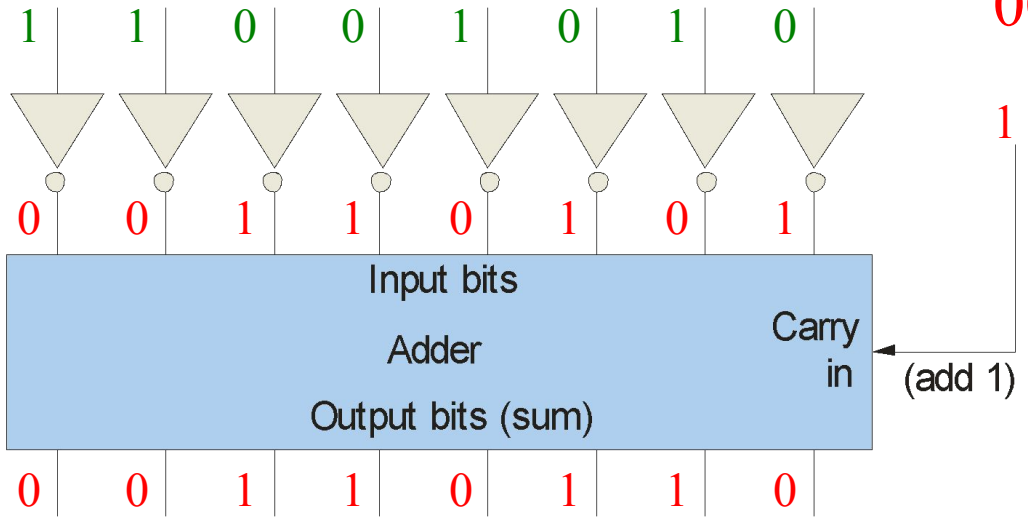
The 2's complement of a binary number is found by adding 1 to the LSB of the 1's complement.

Recall that the 1's complement of 11001010 is 00110101 (1's complement)

To form the 2's complement, add 1:

$$\begin{array}{r} 00110101 \\ +1 \\ \hline 00110110 \end{array}$$

(2's complement)



Signed Binary Numbers

There are several ways to represent signed binary numbers. In all cases, the MSB in a signed number is the sign bit, that tells you if the number is positive or negative.

Computers use a modified 2's complement for signed numbers. Positive numbers are stored in *true* form (with a 0 for the sign bit) and negative numbers are stored in *complement* form (with a 1 for the sign bit).

For example, the positive number 58 is written using 8-bits as 00111010 (true form).

Sign bit

Magnitude bits

Signed Binary Numbers

Negative numbers are written as the 2's complement of the corresponding positive number.

The negative number −58 is written as:

−58 = 11000110 (complement form)

Sign bit — Magnitude bits

An easy way to read a signed number that uses this notation is to assign the sign bit a column weight of −128 (for an 8-bit number). Then add the column weights for the 1's.

Example Assuming that the sign bit = −128, show that 11000110 = −58 as a 2's complement signed number:

Solution Column weights: −128 64 32 16 8 4 2 1.

1 1 0 0 0 1 1 0

−128 +64 +4 +2 = −58