2.7 Binary Arithmetic

Binary arithmetic is essential in all types of digital systems. To understand these systems, you must know the basics of binary addition, subtraction, multiplication, and division.

2.7.1 Binary Addition

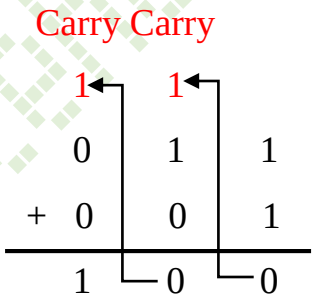
The four basic rules for adding binary digits (bits) are as follows:

0 + 0 = 0 Sum of 0 with a carry of 0
0 + 1 = 1 Sum of 1 with a carry of 0
1 + 0 = 1 Sum of 1 with a carry of 0
1 + 1 = 10 Sum of 0 with a carry of 1

Notice that the first three rules result in a single bit and in the fourth rule the addition of two 1s yields a binary two (10). When binary numbers are added, the last condition creates a sum of 0 in a given column and a carry of 1 over to the next column to the left, as illustrated in the following examples:

Example: Add 11 + 1

Sol.



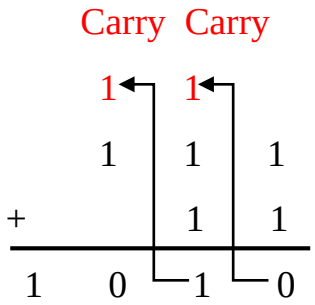
In the right column, 1 + 1 = 0 with a carry of 1 to the next column to the left. In the middle column, 1 + 1 + 0 = 0 with a carry of 1 to the next column to the left. In the left column, 1 + 0 + 0 = 1.

Carry bits

1 + 0 + 0 = 0 1 Sum of 1 with a carry of 0
1 + 1 + 0 = 1 0 Sum of 0 with a carry of 1
1 + 0 + 1 = 1 0 Sum of 0 with a carry of 1
1 + 1 + 1 = 1 1 Sum of 1 with a carry of 1

Example: Add 111 + 11

Sol.



2.7.2 Binary Subtraction

The four basic rules for subtracting bits are as follows:

0 - 0 = 0

1 - 1 = 0

1 - 0 = 1

10 - 1 = 1 0 - 1 with a borrow of 1

When subtracting numbers, you sometimes have to borrow from the next column to the left. A borrow is required in binary only when you try to subtract a 1 from a 0. In this case, when a 1 is borrowed from the next column to the left, a 10 is created in the column being subtracted, and the last of the four basic rules just listed must be applied.

Example: Subtract 011_2 from 101_2.

Sol.

Left column:

When a 1 is borrowed,

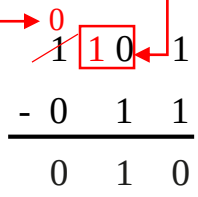
a 0 is left, so 0 - 0 = 0.

Middle column:

Borrow 1 from next column

to the left, making a 10 in

this column, then 10 - 1 = 1.



2.7.3 Binary Multiplication

The four basic rules for multiplying bits are as follows:

$$0 \times 0 = 0, \quad 0 \times 1 = 0, \quad 1 \times 0 = 0, \quad 1 \times 1 = 1$$

Multiplication is performed with binary numbers in the same manner as with decimal numbers. It involves forming partial products, shifting each successive partial product left one place, and then adding all the partial products.

Example**:** Perform the following binary multiplications:

(a) $11_2 \times 11_2$ (b) $101_2 \times 111_2$

Sol.

(a)

$$\begin{array}{r} 11 \\ \times\ 11 \\ \hline 11 \\ +11 \\ \hline \mathbf{1001} \end{array} \qquad \begin{array}{r} 3 \\ \times\ 3 \\ \hline 9 \end{array}$$

Partial products

(b)

$$\begin{array}{r} 111 \\ \times\ 101 \\ \hline 111 \\ 000 \\ +111 \\ \hline \mathbf{100011} \end{array} \qquad \begin{array}{r} 7 \\ \times\ 5 \\ \hline 35 \end{array}$$

Partial products

2.7.4 Binary Division

Division in binary follows the same procedure as division in decimal

Example**:** Perform the following binary divisions: (a) $110_2 \div 11_2$ (b) $110_2 \div 10_2$

Sol.

(a)

$$\begin{array}{r} \mathbf{10} \\ 11\overline{)110} \\ \underline{11} \\ 000 \end{array} \qquad \begin{array}{r} 2 \\ 3\overline{)6} \\ \underline{6} \\ 0 \end{array}$$

(b)

$$\begin{array}{r} \mathbf{11} \\ 10\overline{)110} \\ \underline{10} \\ 10 \\ \underline{10} \\ 00 \end{array} \qquad \begin{array}{r} 3 \\ 2\overline{)6} \\ \underline{6} \\ 0 \end{array}$$

MINISTRY OF HIGHER *EDUCATION* & *SCIENTIFIC RESEARCH*

AL-FURAT Al-Awsat TECHNICAL UNIVERSITY

Al- Sammawa Technical Institute
ICT DEPARTMENT
The second stage

SUBJECT: DIGITAL CIRCUIT

TIME: 3 HOURS

DATE: 22 / 2 / 2022

First Semester Exam for 2022-2023

Answer all the Following Questions

Q1\ define number system and explain each type of it with their range numbers. (20 marks)

Q2\ convert the following numbers to base 10 for five only. (25 marks)

Type of systems	numbers
Binary	010101010
	000111000
octal	67
	21
hexadecimal	7E3D
	8210

Q3\ solve all operations below (30 marks)

A\ addition the following binary number.

1) 111 + 011
2) 1001 +1100

B\ subtraction the following binary number.

1) 110 - 100
2) 110 -011

C\ multiplication the following binary number.

1) 11 ×11
2) 11 ×0111
3) 1010 ×0101111

D\ division the following binary number.

1) 10 ÷110
2) 11 ÷0111
3) 101 ÷1111

Q4\ Simplify the following expression as below (25 marks)

$(A+B).(A+C) = A + BC$

Good luck

Head of Department
Baydaa Hadi Al-Sauodi

Subject lecturer
yaqdhan Mahmood hussein