

COMPUTER ORGANIZATION AND ARCHITECTURE

UNIT –III

TOPIC- DATA REPRESENTATION-BINARY ARITHMETIC

Binary Arithmetic

Binary arithmetic is an essential part of various digital systems. You can add, subtract, multiply, and divide binary numbers

Binary Addition

Adding two binary numbers will give us a binary number itself. It is the simplest method.

Binary Numbers		Addition
0	0	0
0	1	1
1	0	1
1	1	0;Carry→1

Example:

$$(111101)_2 + (10111)_2 = (1010100)_2$$

For example: Add 1101_2 and 1001_2 .

$$\begin{array}{r} 1101 \\ +1001 \\ \hline 10110 \end{array}$$

Binary subtraction

Binary subtraction is one of the four binary operations, where we perform the subtraction method for two binary numbers (comprising only two digits, 0 and 1). This operation is similar to the basic arithmetic subtraction performed on decimal numbers in Maths. Hence, when we subtract 1 from 0, we need to borrow 1 from the next higher order digit, to reduce the digit by 1 and the remainder left here is also 1

When you subtract several columns of binary digits, you must take into account the borrowing. When 1 is to be subtracted from 0, the result is 1 where 1 is borrowed from the next highest order bit or digit.

Binary Number	Subtraction Value
0 – 0	0
1 – 0	1
0 – 1	1 (Borrow 1 from the next high order digit)
1 – 1	0

Note:

The addition of two binary numbers 1 and 1 is 10, where we consider 0 and carry forward 1 to the next high order. But in the case of subtraction of 1 and 1, the answer is equal to 0, and nothing is carried forward.

In the case of decimal subtraction, when 1 is subtracted from 0, then we borrow 1 from the next preceding number and make it 10, and after subtraction, it results in 9, i.e. $10 - 1 = 9$. But for binary subtraction, it results in 1 only.

Example1: Subtract 110 from 1110

Step 1: You subtract the numbers in the one's column and not down the result. In this case, the value of $0 - 1 = 0$. We borrow 1 from the number in the ten's place and continue with the subtraction.

$$\begin{array}{r} 1110 \\ 110(-) \\ \hline 0 \end{array}$$

Step 2: Now you subtract the values in the 10's place. Apply the aforementioned binary subtraction rules.

$$\begin{array}{r}
 1110 \\
 110(-) \\
 \hline
 00
 \end{array}$$

Step 3: Subtract the value that is present in the hundreds place value.

$$\begin{array}{r}
 1110 \\
 110(-) \\
 \hline
 000
 \end{array}$$

Step 4: Since we don't have anything in the thousand's place, we retain it as it is.

$$\begin{array}{r}
 1110 \\
 110(-) \\
 \hline
 1000
 \end{array}$$

Example 2: $1011010 - 001010$

$$\begin{array}{r}
 1011010 \\
 001010(-) \\
 \hline
 1010000
 \end{array}$$

Binary Multiplication

- Binary multiplication is similar to decimal multiplication.
- However, as there are only bits, 0 and 1, it is much simpler than decimal multiplication because there are only two possible results of multiplying two bits.

There are four rules of binary multiplication.

1. $0 \times 0 = 0$
2. $0 \times 1 = 0$
3. $1 \times 0 = 0$
4. $1 \times 1 = 1$

Example: $(10111)_2 \times (1010)_2 = (0110110)_2$

				1	0	1	1	1	
					1	0	1	0	
x									
				0	0	0	0	0	
			1	0	1	1	1		
		0	0	0	0	0			
	1	0	1	1	1				
	1	1	1	0	0	1	1	0	

Binary Division

The division is probably one of the most challenging operations of the basic arithmetic operations. There are different ways to solve division problems using binary operations. Long division is one of them and the easiest and the most efficient way.

The main rules of the binary division include:

- $1 \div 1 = 1$
- $1 \div 0 = \text{Meaningless}$
- $0 \div 1 = 0$
- $0 \div 0 = \text{Meaningless}$

Similar to the decimal number system, the binary division is similar, which follows the four-step process:

- Divide
- Multiply
- Subtract
- Bring down

Example 1.

Question: Solve $01111100 \div 0010$

Solution: Given $01111100 \div 0010$

Here the dividend is 01111100, and the divisor is 0010

Remove the zero's in the **Most Significant Bit** in both the dividend and divisor, that doesn't change the value of the number.

So the dividend becomes 1111100, and the divisor becomes 10.

Now, use the long division method.

$$\begin{array}{r}
 10 \overline{) 1111100} \quad (111110 \\
 \begin{array}{l}
 (-) 10 \\
 \hline
 11 \\
 \end{array} \\
 \begin{array}{l}
 (-) 10 \\
 \hline
 11 \\
 \end{array} \\
 \begin{array}{l}
 (-) 10 \\
 \hline
 11 \\
 \end{array} \\
 \begin{array}{l}
 (-) 10 \\
 \hline
 10 \\
 \end{array} \\
 \begin{array}{l}
 (-) 10 \\
 \hline
 00 \\
 00
 \end{array}
 \end{array}$$