Principles of Logic Systems

Lecture 1

Introduction:

Principles of Logic Systems is a fundamental course in Computer Engineering that explains how computers represent, process, and control information at the hardware level.

Instead of focusing on software, this course introduces the logical principles used to build computer systems.

Throughout this course, we will study methods of representing information, different numbering systems, and logical operations that are combined to design computer circuits.

These concepts form the foundation for understanding how computer hardware works and are essential for advanced courses such as computer organization and computer architecture.

By the end of this course, you will understand how simple logical elements are combined to form complex systems.

1. Number systems

1.1 Decimal number system

In the decimal number system, the digits 0 to 9 are used to represent quantities. The value of a digit depends on its position in the number, which

[redacted] [redacted] ([redacted]).

determines its magnitude (weight).

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted]

By combining digits in different positions, quantities greater than nine can

[redacted] [redacted] [redacted] 23 [redacted] 2 [redacted] [redacted] [redacted] 3 [redacted]

be represented, such as 23 where 2 represents twenty and 3 represents

[redacted].

three.





[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted]

In the decimal number system, the position of each digit determines its

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted].

weight, which is a positive power of ten.

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] 100 = 1

These weights increase from right to left, starting with 100 = 1

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted]

For fractional numbers, the weights are negative powers of ten that

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] 10-1.

decrease from left to right beginning with 10-1.

[redacted] 1:

Example 1:

[redacted] 2:

Example 2:

[redacted] 3:

Example 3:

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] 939

Determine the value of each digit in 939

[redacted]

Solution

9 [redacted] 900

9 has a value of 900

3 [redacted] [redacted] 30

3 has a value of 30

9 [redacted] [redacted] 9

9 has a value of 9

■■■■ 4:

Example 4:

■■■■■ ■■■■ ■■ ■■■ ■■ 67.924.

Determine the value of each digit in 67.924.

■■:

Solution:

6 ■■■■ ■■■■ 60

6 has a value of 60

7 ■■ ■■■■ 7

7 has a value of 7

9 ■■ ■■■■ 9/10 (0.9)

9 has a value of 9/10 (0.9)

2 ■■■■■ 2/100 (0.02)

2 has a value of 2/100 (0.02)

4 ■■■■■ 4/1000 (0.004).

4 has a value of 4/1000 (0.004).

■■■■■■■■:

Exercises:

■■■■■ ■■ ■■■■■■:

Homework:





1.2 ■■■■ ■■■■■■■ ■■■■■■■■

1.2 Binary number system

■■■■ ■■■■ ■■■■■■■ ■■■■■■■■ ■■■■■■■ ■■■■■■■■ ■■■■■ ■■■■ 0

The binary number system represents quantities using only two digits, 0

■1■ ■■■■■■■■ ■■■ ■■■■ ■■ ■■■■■ ■■■■■■. ■■■■ ■■ ■■■ ■■■■■

and 1, and is therefore a base-two system. The value of each binary digit

■■■■■ ■■■ ■■■■■■ ■■■■■■■■ ■■ ■■■ ■■■■■.

depends on its position, and the weights are powers of two.

■■■■■■■ ■■■■■■■■ ■■ ■■■■■ ■■■■■■. ■■■■■■■ ■■■■■■■ ■■■■■■■■ ■■■■■■■■ ■■■

Binary numbers are weighted numbers. For whole binary numbers, the

■■■■ ■■■■■■■ ■■ ■■■■ ■■■■■■ (■■■■ ■■■■■ ■■■■■ (LSB)) ■■■■ ■■■■ 20=1 ■

right-most bit (Least Significant Bit (LSB)) has a weight of 20=1 and the

■■■■■ ■■■■■■■ ■■ ■■■■■■ ■■■ ■■■■■■ ■■■■ ■■■■■.

weights increase from right to left as powers of two.

■■■■ ■■■■■■■ ■■ ■■■■ ■■■■■■ ■■ (■■■■ ■■■■■■ ■■■■■ (MSB))■ ■■■■■

The left-most bit is the (Most Significant Bit (MSB)), and its weight

■■■■■ ■■■ ■■■ ■■■■■■.

depends on the number of bits.

Binary fractional numbers are represented using bits to the right of the

■■■■ ■■■■■■. ■■■■■ ■■■■■■■ ■■■■■■■■ ■■ ■■■■ ■■■■■■ (MSB) ■■■ ■■■ 2-1 = 0.5■

binary point. The left-most fractional (MSB) bit has a weight of 2-1 = 0.5,

■■■■■■■ ■■■■■■■ ■■ ■■■■■■ ■■■ ■■■■■■ ■■■■ ■■■■■ ■■■■■ ■■■■■.

and the weights decrease from left to right as negative powers of two.

■■■■ ■■■■■ ■■■■ ■■■■■ ■■:

The weight structure of a binary number is:

■■■■■■ 1: ■■■■■■■ ■■■■■■■■

Table 1: Binary Weights



■■■■■■■ ■■■■■■ ■■■■■ ■■■■■ ■■■■■■■■ MSC. ■■■■ ■ ■■■

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■/ ■■■ ■■■ ■■■■ ■■■■■■■■■

Q/ how to count in binary?

■/ ■■■■ ■■ ■■■■■■ ■■■■■■■ ■■■■ ■■■■ ■■■■■■

A/ Counting in the binary system is similar to counting in the decimal

■■■■■■■ ■■■■ ■■■ ■■■■■■■ ■■■■■ ■■■ (0 ■1).

system, but only two digits (0 and 1) are used.

■■■ ■■■■■■■ ■■■■ ■■■■■■■■■ ■■■■■■■ ■■■■ ■■■■ ■■ ■■■■■■■ ■■■ ■■■■■■■

When all possible combinations of a given number of bits are used, an

■■■ ■■■■■ ■■■■ ■■ ■■■■■ ■■■■■■■ ■■■■.

additional bit position is added to continue counting.

■■ ■■■■■■ ■■■■■■■■ ■■■■ ■■■■■■ ■■■■■ ■■■■ ■■■■ ■■■■■■ ■■■■■■■■ n

In a binary system, the maximum number that can be represented using n

■■■■■■ ■■ 2n-1. ■■■ ■■■■ ■■■ ■■ ■■■ ■ ■■■ ■■■■ ■■ ■■■■ ■■■■■ ■■ 0 ■■■ 2n-1

bits is 2n-1. This means that with ■ bits, values from 0 up to 2n-1 can be

■■■■■.

represented.

■■■ ■■■■ ■■■■■■: ■■■■ 5 ■■■■ ■■■■■ ■■ 0 ■■■ 31■ ■■■■■ 6 ■■■■

For example: 5 bits represent values from 0 to 31, and 6 bits represent

■■■■■ ■■ 0 ■■■ 63

values from 0 to 63

1.3 ■■■■■■■ ■■ ■■■■■■■ ■■■ ■■■■■■

1.3 Binary-to-Decimal Conversion

■■■■ ■■■■■■ ■■■ ■■■■■■ ■■■■■■■ ■■■ ■■■ ■■■■■ ■■ ■■■■ ■■■■■

The decimal value of any binary number can be found by adding the

■■■■■ ■■■■ ■■■■■■ ■■■■ ■■■■ 1 ■■■■■■■ ■■ ■■■■■ ■■■■ ■■■■■■ ■■■■■■■■

weights of all bits that are 1 and discarding the weights of all bits that are

0.

0.

■■■■:

Example:

■■■■■ ■■■■■ ■■■■■■■ 1101101 ■■■ ■■■ ■■■■.

Convert the binary whole number 1101101 to decimal.





■■■■:

Example:

■■■■■ ■■■■■ ■■■■■■■ ■■■■■■ 0.1011 ■■■ ■■■ ■■■■.

Convert the fractional binary number 0.1011 to decimal.

■■■■■■■■:

Exercises:

1. ■■■■■ ■■■■■ ■■■■■■■ 10010001 ■■■ ■■■ ■■■■.

1. Convert the binary number 10010001 to decimal.

2. ■■■■■ ■■■■■ ■■■■■■■ 10.111 ■■■ ■■■ ■■■■.

2. Convert the binary number 10.111 to decimal.

■■■■■ ■■ ■■■■■■:

Homework: