

ACOL 215

( 02 Sept . 2025 )

Digital Circuits and their logical function

operates on a given data

Digital systems are everywhere

program

special purpose digital computer

it can follow a sequence of instructions

a general computing device

ability to represent and manipulate  
discrete elements of information

represented in a digital system  
by physical quantities, called  
signals

typically enabled by  
electronic devices called  
transistors

↓  
Electrical signals  
such as voltages and  
current } most common

In most present-day digital systems,  
the signals use just two discrete values  
binary

A binary digit — bit —  
has two numerical values —

0 and 1.

binary code

to represent information

the decimal  
numbers 0  
to 9 can be  
represented  
using 4-bit  
binary  
codes.

groups of bits

$$7 = \left( \begin{matrix} 0 & 1 & 1 & 1 \end{matrix} \right)_2$$

Digital devices

↓ made with  
digital circuits  
programmable

the same  
hardware can be  
used for many different  
applications

we need to understand  
the operation of each  
digital component in  
a digital device

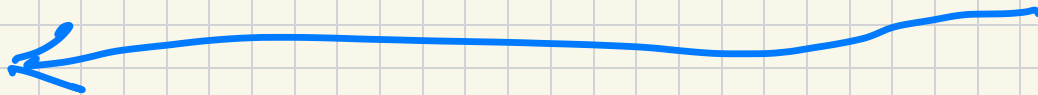
# Binary Numbers

$(7392)_{10}$

7 3 9 2

7 thousands 3 hundred 9 tens and 2 ones

$$\underline{7} \times 10^3 + \underline{3} \times 10^2 + \underline{9} \times 10^1 + \underline{2} \times 10^0$$



$$\boxed{87392.4513}$$

0

$$\begin{aligned}
 & 8 \times 10^4 + 7 \times 10^3 + 3 \times 10^2 + 9 \times 10^1 + 2 \times 10^0 \\
 & \quad + 4 \times 10^{-1} + 5 \times 10^{-2} + 1 \times 10^{-3} + 3 \times 10^{-4}
 \end{aligned}$$

$\leftarrow$  increase       $\rightarrow$  decrease

$$7 = \underbrace{(0111)}_2$$

$$\frac{0 \times 2^3}{0} + \frac{1 \times 2^2}{4} + \frac{1 \times 2^1}{2} + \frac{1 \times 2^0}{1}$$

$$= 7$$

$$\underbrace{26.75}_{10}$$

$$\underbrace{11010.11}_2$$

$$\frac{1 \times 2^4}{16} + \frac{1 \times 2^3}{8} + \cancel{0 \times 2^2} + \frac{1 \times 2^1}{2} + \cancel{0 \times 2^0} + \frac{1 \times 2^{-1}}{0.5} + \frac{1 \times 2^{-2}}{0.25}$$

The radix of a number system determines the number of distinct values that can be used to represent any number.

The decimal number system has a radix 10

base The binary number system has radix 2. 0 to 9  
0, 1



base - r

//

different  
number

system  
with different  
bases.

← →

{ //  $a_n \dots a_2 a_1 a_0 . a_{-1} a_{-2} a_{-3} \dots a_{-m}$

$$// a_n \cdot r^n + a_{n-1} \cdot r^{n-1} + \dots + a_2 r^2 + a_1 r^1 + a_0 r^0 + \\ a_{-1} r^{-1} + a_{-2} r^{-2} + a_{-3} r^{-3} + \dots + a_{-m} r^{-m}$$

$$\underline{(4021.2)}_5$$

$$= 4 \times 5^3 + 0 \times 5^2 + 2 \times 5^1 + 1 \times 5^0 + 2 \times 5^{-1}$$

$$= 500 + 0 + 10 + 1 + \cancel{\frac{2}{5}} 0.4$$

$$= (511.4)_{10}$$

$$\underline{\underline{0 \dots 4}}$$

$$0 \dots 9$$

Octal

$$(127.4)_8$$

$$= 1 \times 8^2 + 2 \times 8^1 + 7 \times 8^0 + \frac{4}{8}$$

$$= 64 + 16 + 7 + 0.5$$

$$= (87.5)_{10}$$

# Hexadecimal number system

0 ... 9

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| A  | B  | C  | D  | E  | F  |
| 10 | 11 | 12 | 13 | 14 | 15 |

(B65F)<sub>16</sub>

$$= B \times 16^3 + 6 \times 16^2 + 5 \times 16^1 + F \times 16^0$$

$$= 11 \times 16^3 + 6 \times 16^2 + 5 \times 16^1 + 15 \times 16^0$$
$$= \text{11010}$$

How do we add, subtract, and  
multiply numbers in  
a different base?  
(different from base 10)

How do we convert from one  
base to another?