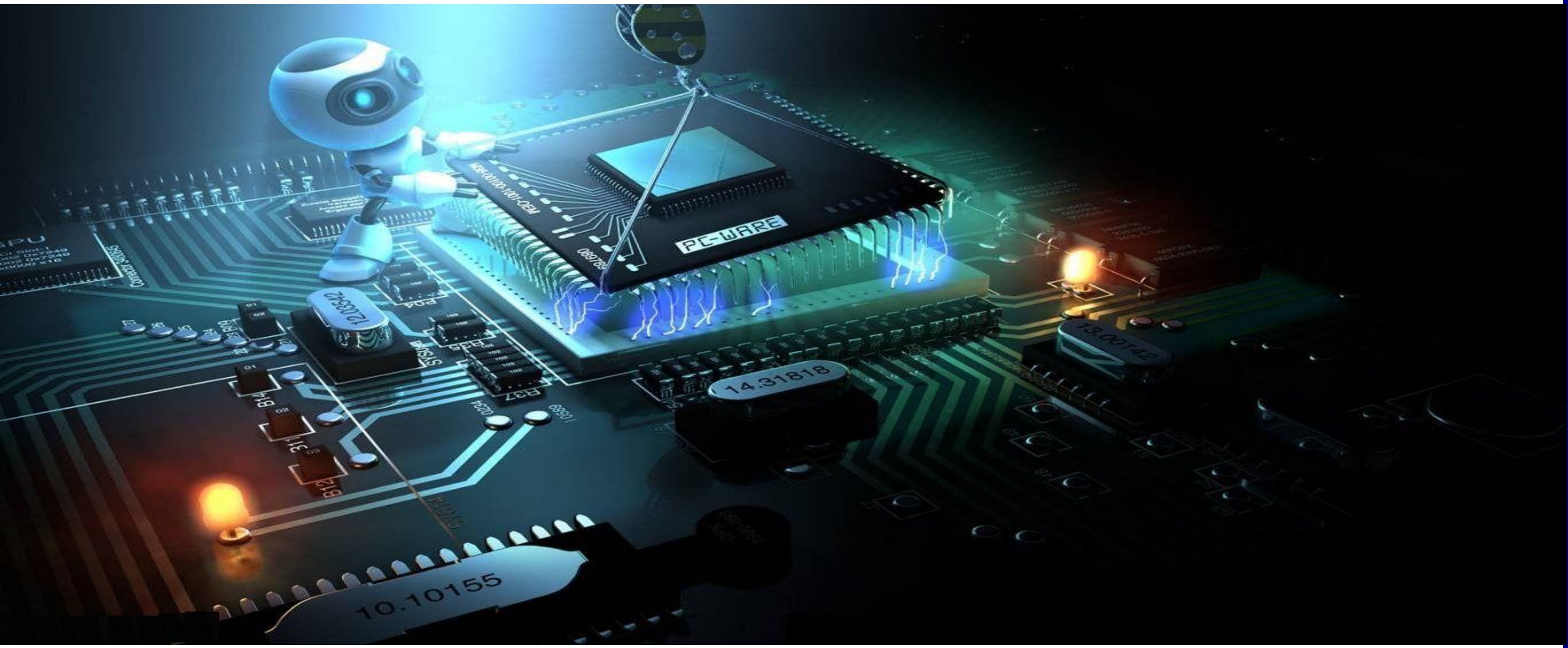
جامعة القاهرة الجديدة
التكنولوجية

Fall 2023

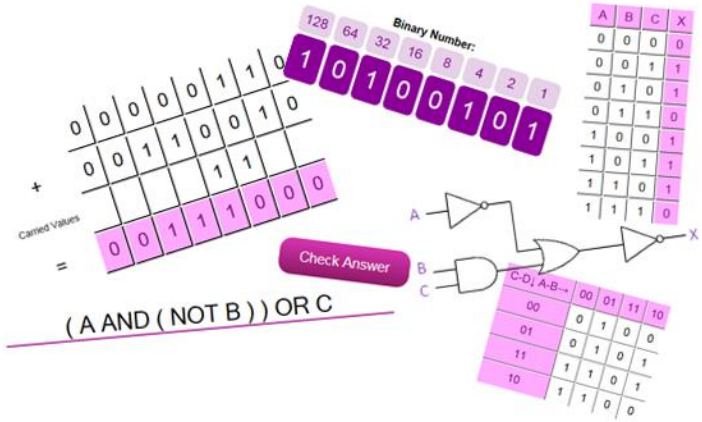
(1)



Digital Engineering

Dr. Hatem Yousry

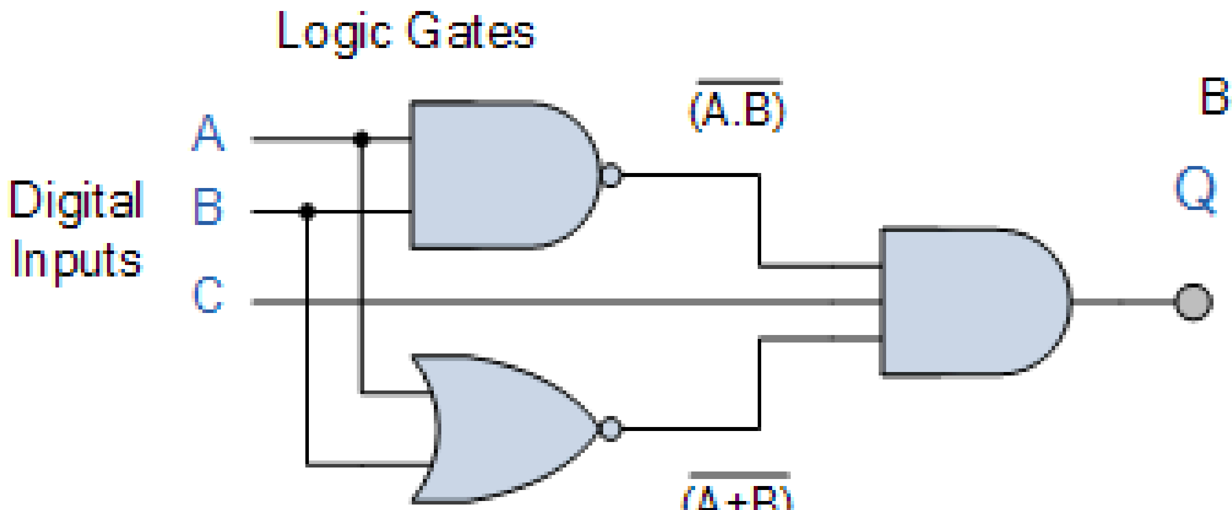
Agenda



- **Digital Systems and Binary Numbers**
- **Binary Operations.**
- **Conversions.**
- **Digital Engineering (Logic).**

Digital Engineering (Logic)

1. **Boolean Algebra** – This forms the algebraic expression showing the operation of the logic circuit for each input variable either True or False that results in a logic "1" output.
2. **Truth Table** – A truth table defines the function of a logic gate by providing a concise list that shows all the output states in tabular form for each possible combination of input variable that the gate could encounter.
3. **Logic Diagram** – This is a graphical representation of a logic circuit that shows the wiring and connections of each individual logic gate, represented by a specific graphical symbol, that implements the logic circuit.



Logic Diagram

Boolean Expression

$$Q = \overline{(A.B)}.\overline{(A+B)}.C$$

Typical Truth Table

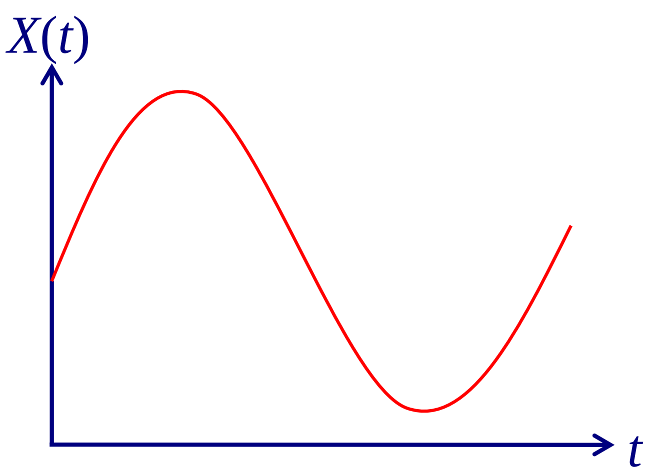
C	B	A	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

Digital Systems and Binary Numbers

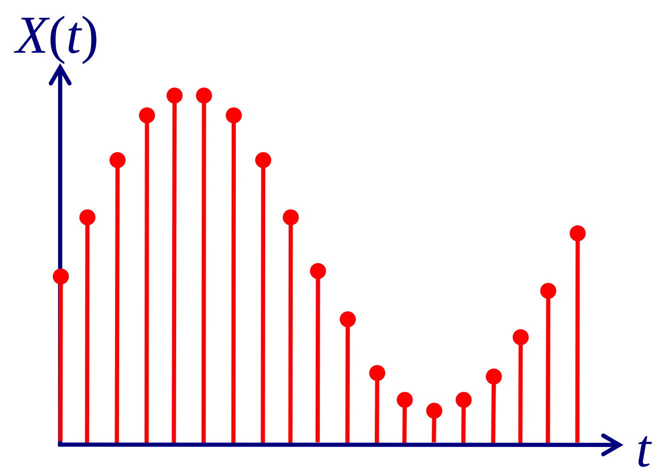
- Digital age and information age
- **Digital computers**
  - General purposes
  - Many scientific, industrial and commercial applications
- **Digital systems**
  - Telephone switching exchanges
  - Digital camera
  - Electronic calculators, PDA's
  - Digital TV
- **Discrete information-processing systems**
  - Manipulate discrete elements of information
  - For example, {1, 2, 3, …} and {A, B, C, …}…

Analog and Digital Signal

- **Analog system**
  - The physical quantities or signals may vary continuously over a specified range.
- **Digital system**
  - The physical quantities or signals can assume only discrete values.
  - Greater accuracy



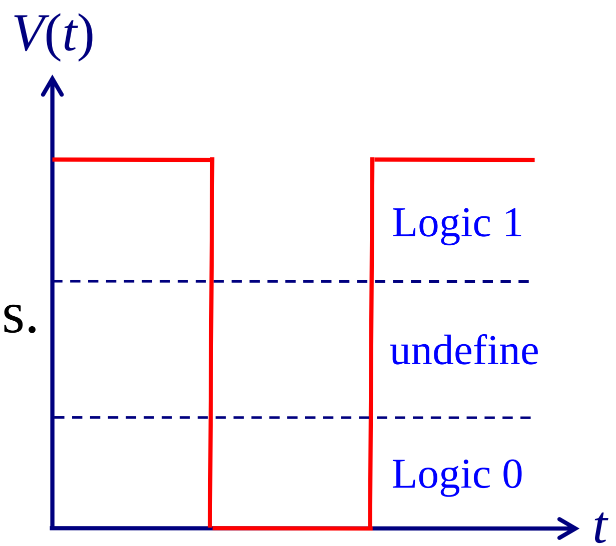
Analog signal



Digital signal

Binary Digital Signal

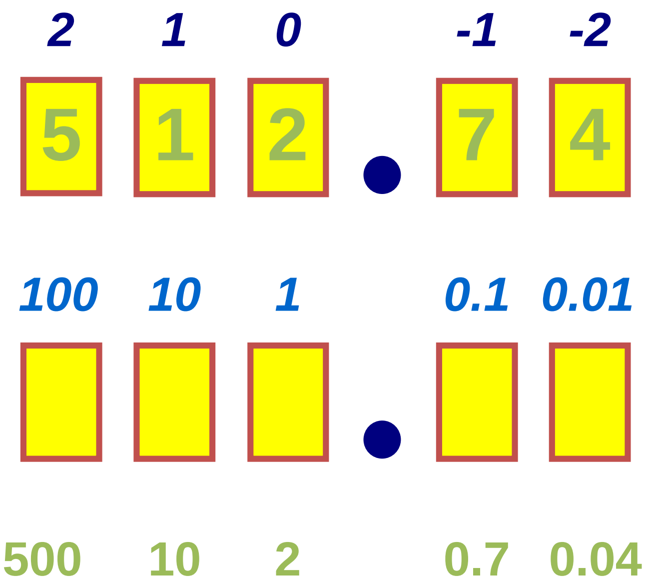
- An information variable represented by physical quantity.
- For digital systems, the variable takes on discrete values.
  - **Two level, or binary values are the most prevalent values.**
- Binary values are represented abstractly by:
  - **Digits 0 and 1**
  - **Words (symbols) False (F) and True (T)**
  - **Words (symbols) Low (L) and High (H)**
  - **And words On and Off**
- Binary values are represented by values or ranges of values of physical quantities.



Binary digital signal

Decimal Number System

- **Base (also called radix) = 10**
  - 10 digits { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 }
- **Digit Position**
  - Integer & fraction
- **Digit Weight**
  - Weight = $(Base)^{Position}$
- **Magnitude**
  - Sum of "*Digit* x *Weight*"
- Formal Notation



$$d_2{*}B^2+d_1{*}B^1+d_0{*}B^0+d_{-1}{*}B^{-1}+d_{-2}{*}B^{-2}$$

$$(512.74)_{10}$$

Octal Number System

- **Base = 8**
  - 8 digits { 0, 1, 2, 3, 4, 5, 6, 7 }
- **Weights**
  - Weight = (*Base*) ^{Position}
- **Magnitude**
  - Sum of "*Digit* x *Weight*"
- Formal Notation

64	8	1		1/8	1/64
5	1	2	.	7	4
2	1	0		-1	-2

$$5 * 8^{2} + 1 * 8^{1} + 2 * 8^{0} + 7 * 8^{-1} + 4 * 8^{-2}$$

$$=(330.9375)_{10}$$

$$(512.74)_{8}$$

Binary Number System

- **Base = 2**
  - 2 digits { 0, 1 }, called *b*inary dig*its* or “*bits*”
- **Weights**
  - Weight = (*Base*) $^{\textit{Position}}$
- **Magnitude**
  - Sum of “*Bit* x *Weight*”
- Formal Notation
- Groups of bits   4 bits = *Nibble*

  8 bits = *Byte*

4	2	1		1/2	1/4
1	0	1	.	0	1
2	1	0		-1	-2

$$1 * 2^2 + 0 * 2^1 + 1 * 2^0 + 0 * 2^{-1} + 1 * 2^{-2}$$

$$= (5.25)_{10}$$

$$(101.01)_2$$

1 0 1 1

1 1 0 0 0 1 0 1

Hexadecimal Number System

- **Base = 16**
  - 16 digits { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F }
- **Weights**
  - Weight = (*Base*) ^{Position}
- **Magnitude**
  - Sum of "*Digit* x *Weight*"
- Formal Notation

256	16	1		1/16	1/256
1	E	5	.	7	A
2	1	0		-1	-2

$$1 \cdot 16^{2} + 14 \cdot 16^{1} + 5 \cdot 16^{0} + 7 \cdot 16^{-1} + 10 \cdot 16^{-2}$$

$$=(485.4765625)_{10}$$

$$(1E5.7A)_{16}$$

The Power of 2

n	2^n
0	$2^0=1$
1	$2^1=2$
2	$2^2=4$
3	$2^3=8$
4	$2^4=16$
5	$2^5=32$
6	$2^6=64$
7	$2^7=128$

n	2^n	
8	$2^8=256$	
9	$2^9=512$	
10	$2^{10}=1024$	Kilo
11	$2^{11}=2048$	
12	$2^{12}=4096$	
20	$2^{20}=1M$	Mega
30	$2^{30}=1G$	Giga
40	$2^{40}=1T$	Tera

Addition

- **Decimal Addition**

	1	1	
		5	5
+		5	5
	1	1	0

← **Carry**

= Ten ≥ Base

➔ Subtract a Base

Binary Addition

- **Column Addition**

$$
\begin{array}{rccccccccl}
 & 1 & 1 & 1 & 1 & 1 & 1 & & & \\
 & & 1 & 1 & 1 & 1 & 0 & 1 & & = 61 \\
+ & & & 1 & 0 & 1 & 1 & 1 & & = 23 \\
\hline
 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & & = 84
\end{array}
$$

$\geq (2)_{10}$

Binary Subtraction

- **Borrow a "Base" when needed**

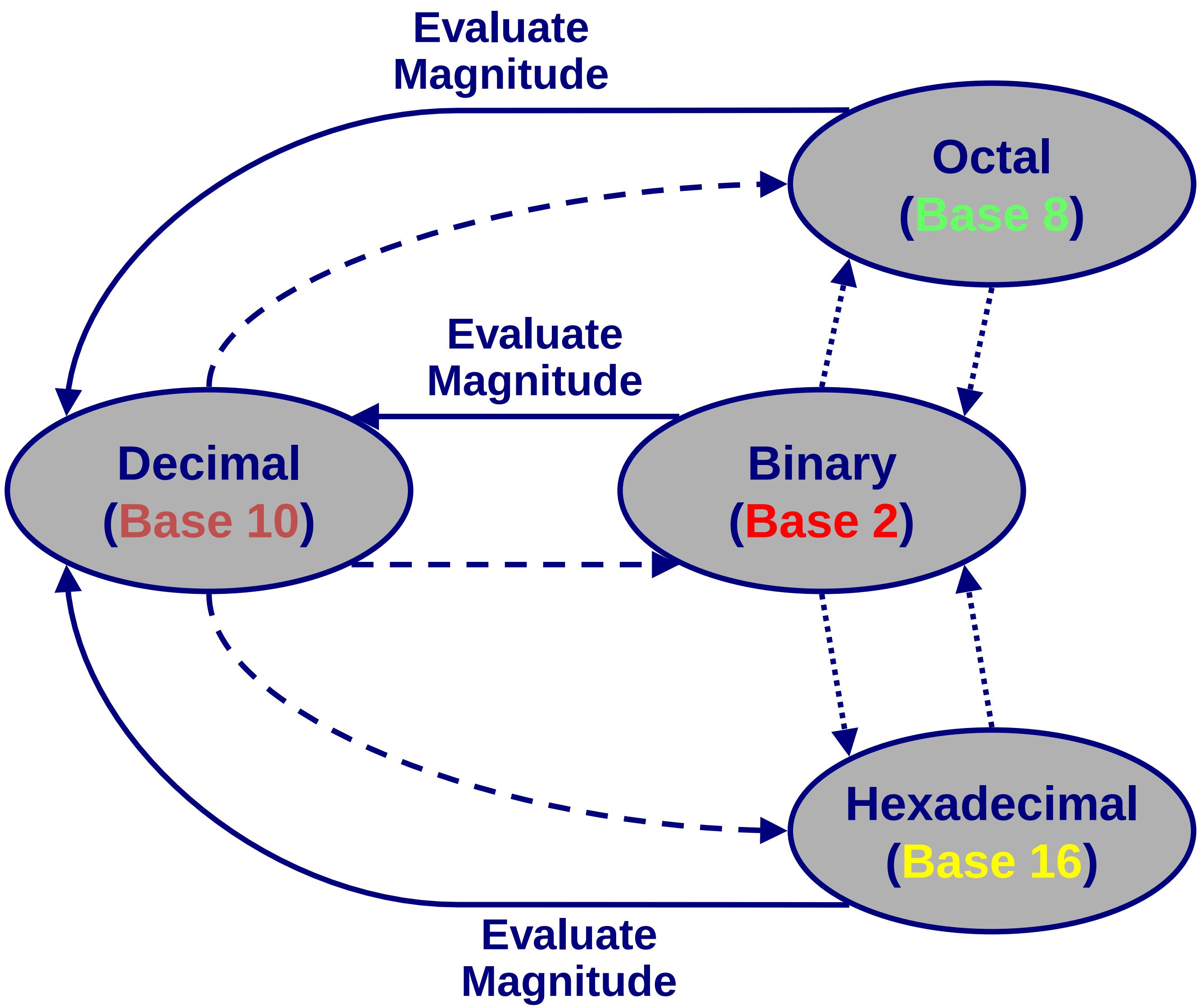
		1			2			
	0	~~2~~	2	0	0	2		$= (10)_2$
	~~1~~	0	0	~~1~~	~~1~~	0	1	= 77
−			1	0	1	1	1	= 23
	0	1	1	0	1	1	0	= 54

Binary Multiplication

- **Bit by bit**

				1	0	1	1	1
x					1	0	1	0
				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

Number Base Conversions



Decimal (Integer) to Binary Conversion

- Divide the number by the 'Base' (=2)
- Take the remainder (either 0 or 1) as a coefficient
- Take the quotient and repeat the division

Example: $(13)_{10}$

	Quotient	Remainder	Coefficient
13/ 2 =	6	1	$a_0 = 1$
6 / 2 =	3	0	$a_1 = 0$
3 / 2 =	1	1	$a_2 = 1$
1 / 2 =	0	1	$a_3 = 1$

Answer: $(13)_{10} = (a_3\, a_2\, a_1\, a_0)_2 = (1101)_2$

MSB LSB

Decimal (Fraction) to Binary Conversion

- Multiply the number by the 'Base' (=2)
- Take the integer (either 0 or 1) as a coefficient
- Take the resultant fraction and repeat the division

Example: $(0.625)_{10}$

	Integer		Fraction	Coefficient
0.625 * 2 =	1	.	25	$a_{-1} = 1$
0.25 * 2 =	0	.	5	$a_{-2} = 0$
0.5 * 2 =	1	.	0	$a_{-3} = 1$

Answer: $(0.625)_{10} = (0.a_{-1}\ a_{-2}\ a_{-3})_2 = (0.101)_2$

MSB LSB

Decimal to Octal Conversion

Example: $(175)_{10}$

	Quotient	Remainder	Coefficient
175 / 8 =	21	7	$a_0 = 7$
21 / 8 =	2	5	$a_1 = 5$
2 / 8 =	0	2	$a_2 = 2$

Answer: $(175)_{10} = (a_2\, a_1\, a_0)_8 = (257)_8$

Example: $(0.3125)_{10}$

	Integer		Fraction	Coefficient
0.3125 * 8 =	2	.	5	$a_{-1} = 2$
0.5 * 8 =	4	.	0	$a_{-2} = 4$

Answer: $(0.3125)_{10} = (0.a_{-1}\, a_{-2}\, a_{-3})_8 = (0.24)_8$

Binary – Octal Conversion

- 8 = 23
- Each group of 3 bits represents an octal digit

Octal	Binary
0	0 0 0
1	0 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

Example:

Assume Zeros

$$(\ 1\ 0\ 1\ 1\ 0\ .\ 0\ 1\ )_2$$

$$(\ 2\quad 6\ .\ 2\ )_8$$

Works both ways (Binary to Octal & Octal to Binary)

Binary – Hexadecimal Conversion

- 16 = 24
- Each group of 4 bits represents a hexadecimal digit

Example:

Assume Zeros

$(\,1\,0\,1\,1\,0\,.\,0\,1\,)_2$

$(\,1\quad 6\quad .\quad 4\,)_{16}$

Hex	Binary
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
A	1 0 1 0
B	1 0 1 1
C	1 1 0 0
D	1 1 0 1
E	1 1 1 0
F	1 1 1 1

Works both ways (Binary to Hex & Hex to Binary)

Octal – Hexadecimal Conversion

- Convert to Binary as an intermediate step

Example:

$$(2\ \ 6\ .\ 2)_8$$

Assume Zeros

$$(0\,1\,0\,1\,1\,0\,.\,0\,1\,0)_2$$

Assume Zeros

$$(1\ \ 6\ .\ 4)_{16}$$

Works both ways (Octal to Hex & Hex to Octal)

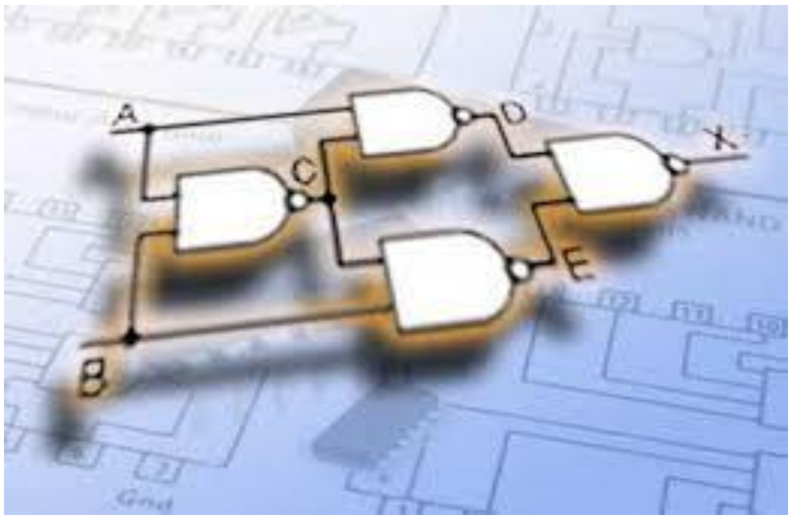
Decimal, Binary, Octal and Hexadecimal

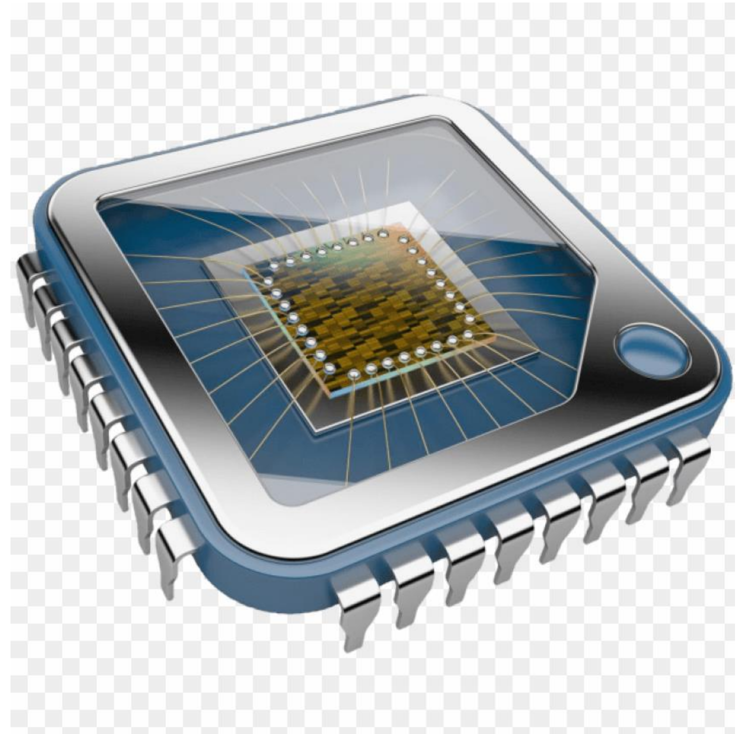
Decimal	Binary	Octal	Hex
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5
06	0110	06	6
07	0111	07	7
08	1000	10	8
09	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Portfolio

- Selective Lecture Slides.
- Your Private Notes from Lectures , Sections, Trips, Reports, Labs, and Recommendations.
- Complete answers Tasks and Assignments.
- Complete answers to Quizzes, Midterm.
- Final Project Paper.
- In addition to, any related Course martials.

Thank You





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Recommended Resources

- **M. Morris R. Mano, Charles R. Kime. Logic and Computer Design Fundamentals, 4th Edition Year: 2008. ISBN-10: 013198926X.**
- **Arijit Saha , Nilotpal Manna. Digital Principles and Logic Design. ISBN-10: 1934015032.**