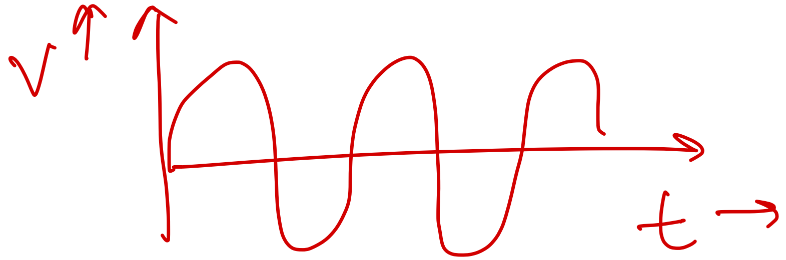
# DIGITAL ELECTRONICS

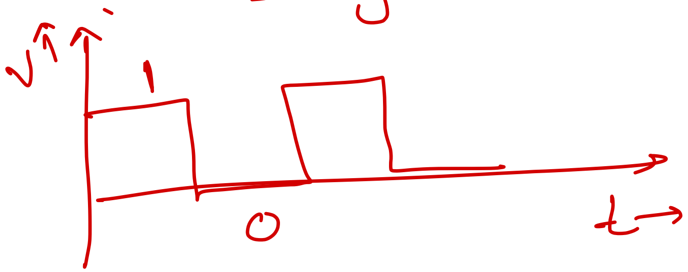
# Signals

- A signal is an electromagnetic or electrical current that is used for carrying data from one system to another.. Signals are of two types.
  - Analog Signal
  - Digital Signal
- Analog signal is a continuous signal in which one time-varying quantity represents another time-based variable.
- A digital signal is a signal that is used to represent data as a sequence of separate values at any point in time.

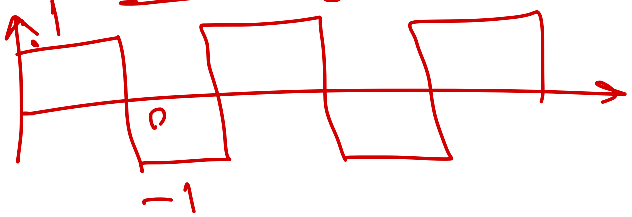
Analog




Digital → 0 & 1 ,




Analog



# Difference Between Analog and Digital Signal

| Analog Signal | Digital Signal |
|---|---|
| 1) An analog signal is a continuous range of values that help you to represent information | Digital signal uses discrete 0 and 1 to represent information |
| It is denoted by sine waves | It is denoted by square waves |
| 2) Temperature sensors, FM radio signals, Photocells, Light sensor, Resistive touch screen are examples of Analog signals. | Computers, CDs, DVDs are some examples of Digital signal. |
| The analog signal bandwidth is low | The digital signal bandwidth is high |
| The analog signal more distortion | The digital signal less distortion |
| The analog signals are not  Accurate measurement | The digital signals gives Accurate measurement |
| The analog signal have more noise effect | The digital signal have less noise effect |

# Number System

## Number System

1 2 3 4 5

In digital electronics, the number system is used for representing the information in digits.

## Non-positional Number System

- In Non-positional number system, each symbol represents the same value regardless of its position. Symbols such as I for 1, II for 2, III for 3, IIII for 4, etc.
- To find the value of number, one has to count the number of symbols present in the number.
- To perform arithmetic operation with such a number system is very difficult, hence positional number system were developed.

## Positional Number System

- In positional number system, each symbol represents different values, depending on the position they occupy in the number.
- The value of each digit in a number can be determined using
  - The digit
  - The position of the digit in the number
  - The base of the number system (where base is defined as the total number of digits available in the number system).

# Non-Positional No.

1 - I

2 - II

3 - III

4 - IIII

5 - IIIII

# Number System

- **Decimal Number** → 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 → Base 10.

The number system is having digit 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, total ten digits are involved. The base of the decimal number system is 10

- **Binary number** 0, 1 → Base 2

$$\begin{array}{cccc} 1 & 1 & 0 & 1 \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array}$$

The binary number system has two digits that is 0 and 1. The base of the binary number system is represent as 2

- **Octal Decimal Number** 0, 1, 2, 3, 4, 5, 6, 7 → Base 8

$$\begin{array}{ccc} 2 & 5 & 1 \\ 8^2 & 8^1 & 8^0 \end{array}$$

The octal number system has eight digits 0, 1, 2, 3, 4, 5, 6, 7. The base of the octal number system is represents as 8. Each octal digit corresponds to three binary digits.

$8 = 2^3$

- **Hexadecimal Number** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.

The hexadecimal number system consists of the following sixteen number of digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F. The base of the hex number system has a base of 16. Each hexadecimal digit corresponds to four binary digits.

$16^3\ 16^2\ 16^1\ 16^0 \Rightarrow 2^4 = 16$

6245

Thus . hundreds . tens . Unit

$10^3$ $10^2$ $10^1$ $10^0$

$= 6 \times 10^3 + 2 \times 10^2 + 4 \times 10^1 + 5 \times 10^0$.

$=$ 6245

# Numeral systems conversion table

$2^3 \; 2^2 \; 2^1 \; 2^0$

| Decimal Number | Binary Number | Octal Number | Hexa-Decimal Number |
|---|---|---|---|
| 0 | 0000 | 0 | 0 |
| 1 | 0001 | 1 | 1 |
| 2 | 0010 | 2 | 2 |
| 3 | 0011 | 3 | 3 |
| 4 | 0100 | 4 | 4 |
| 5 | 0101 | 5 | 5 |
| 6 | 0110 | 6 | 6 |
| 7 | 0111 | 7 | 7 |
| 8 | 1000 | 10 | 8 |
| 9 | 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 |

Decimal

Binary

6 —— $2^3\ 2^2\ 2^1\ 2^0$

0 1 1 0

# Converting from Another Base to Decimal

- $(11010)_2$
- $(264)_8$
- $(3CA)_{16}$
- $(2142)_6$

$(1\ 1\ 0\ 1\ 0)_2 \longrightarrow (?)_{10}$

$2^4\ 2^3\ 2^2\ 2^1\ 2^0$

$= 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

$= (26)_{10}$

$\Rightarrow (264)_8 \Rightarrow 2 \times 8^2 + 6 \times 8^1 + 4 \times 8^0$

$8^2\ 8^1\ 8^0$

$= (180)_{10}$

(3). $(3CA)_{16}$

$16^2\ 16^1\ 16^0$ = .

$A \to 10.$

$C \to 12.$

$= 3 \times 16^2 + C \times 16^1 + A \times 16^0.$

$= 3 \times 16^2 + 12 \times 16^1 + 10 \times 16^0.$

$16^2 = \underline{256}.$

$= \underline{3} \times 16^2 + 12 \times 16$

$= (\underline{970})_{10}$

(4). $(2142)_6$

$6^3\ 6^2\ 6^1\ 6^0$

$6^0 = 1,$

$8^0 = 1$

$16^0 = 1$

$= 2 \times 6^3 + 1 \times 6^2 + 4 \times 6^1 + 2 \times 6^0.$

$= 2 \times 216 + 36 + 24 + 2$

$= (494)_{10}$

# Converting from Decimal to Another Base

- $(48)_{10}$ ---> Binary form
- $(824)_{10}$ ---> octal form
- $(528)_{10}$ ---> Hex form
- $(225)_{10}$ ---> $(?)_5$

$(48)_{10} \rightarrow (?)_2$

| | | Remainder |
|---|---|---|
| 2 | 48 | 0 |
| 2 | 24 | 0 |
| 2 | 12 | 0 |
| 2 | 6 | 0 |
| 2 | 3 | 1 |
| 2 | 1 | 1 |
| | 0 | |

$(110000)_2$

$$\begin{array}{r} \boxed{24} \rightarrow 0 \\ 2\,\overline{)\,48} \\ 4\phantom{8} \\ \hline 8 \\ 8 \\ \hline \boxed{0} \end{array}$$

$\Rightarrow$

| | | |
|---|---|---|
| 8 | 824 | 0 |
| 8 | 103 | 7 |
| 8 | 12 | 4 |
| 8 | 1 | 1 |
| | 0 | |

$(1470)_8$.

$\Rightarrow (528)_{10} \rightarrow (\quad)_{16}$.

| | | |
|---|---|---|
| 16 | 528 | 0 |
| 16 | 33 | 1 |
| 16 | 2 | 2 |
| | 0 | |

$(210)_{16}$.

$(225)_{10} \to (\quad)_5$

| | | |
|---|---|---|
| 5 | 225 | |
| 5 | 45 | 0 |
| 5 | 9 | 0 |
| 5 | 1 | 4 |
| | 0 | 1 |

$(1400)_5$

# Converting from a base Other than 10 to Another Base Other than 10

- $(423)_6 \rightarrow (?)_4$

$\downarrow$

Base 10 → Decimal.

$\downarrow$

Base 4.

$(423)_6$

$6^2\ 6^1\ 6$

$\Rightarrow 4 \times 6^2 + 2 \times 6^1 + 3 \times 6^0$.

$= (159)_{10}$ → Decimal.

| | | |
|---|---|---|
| 4 | 159 | |
| 4 | 39 | 3 |
| 4 | 9 | 3 |
| 4 | 2 | 1 |
| | 0 | 2 |

$(2133)_4$.

$(2132)_8 \longrightarrow (\quad\quad)_2$.

decimal.

↓

binary.

$2^{\boxed{3}} = 8$

$$
\begin{array}{cccc}
2 & 1 & 3 & 2 \\
\downarrow & \downarrow & \downarrow & \downarrow \\
010 & 001 & 011 & 010
\end{array}
$$

# Binary to Octal And Octal to Binary

Octal to Binary

$(4\,2\,5\,6)_8 \rightarrow (\quad)_2$

100 010 101 110

$(100010101110)_2$

Binary to Octal:

$(101\ 011\ 010\ 110)_2$

5 3 2 6

$(5326)_8$

$(001\ 101\ 110\ 101\ 111)_2$

1 5 6 5 7

# Binary to Hexadecimal and Hexadecimal to Binary

$2^4 = 16$

Binary to Hex :

$(1110\ 1010\ 1001\ 1000)_2$

$\downarrow$ E $\quad \downarrow$ A $\quad \downarrow$ 9 $\quad \downarrow$ 8

EA98

A - 1010

B - 1011

C - 1100

D - 1101

E - 1110

F - 1111

## Hex to Binary

$$(AD56)_{16}$$

1010 1101 0101 0110

$$(1010110101010110)_2$$

# Fractional Numbers

$(1010)_2 \to (9)_{10}$

$2^3\ 2^2\ 2^1\ 2^0$

3 2 1 0 -1 -2 -3

$.\ -1\ -2\ -3$

- Convert Binary to Decimal
  - $(110.101)_2$

$2^{-1} = \frac{1}{2} = 0.5$

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

$2^2\ 2^1\ 2^0\ \ 2^{-1}\ 2^{-2}\ 2^{-3}$

$= 1\times2^2 + 1\times2^1 + 0\times2^0 + 1\times2^{-1} + 0\times2^{-2} \times 1\times2^{-3}$

$2^{-2} = \frac{1}{4} = 0.25$

$= 4 + 2 + 0.5 + 0.125$

$2^{-3} = \frac{1}{8} = 0.0125$

$= 6.625$

$$\begin{array}{r} 4 \\ +\ 2 \\ +\ 0.5 \\ 0.125 \\ \hline 6.625 \end{array}$$

# Binary Addition

- 0 + 0 = 0
- 0 + 1 = 1
- 1 + 0 = 1
- 1 + 1= 10 with carry

$1 + 1 = 10$

$2 + 3$

$1 + 1 = 10$

$10 + 1 = 11$

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 1 = 10$

$10101 + 11101 = 110010$

$1111 + 1101 = 11100$

# Binary Subtraction

- 0 - 0 = 0
- 0 - 1 = 1 with borrow
- 1 - 0 = 1
- 1 – 1= 0

$$10 - 1 = 1$$

$$10 - 8 = 02$$

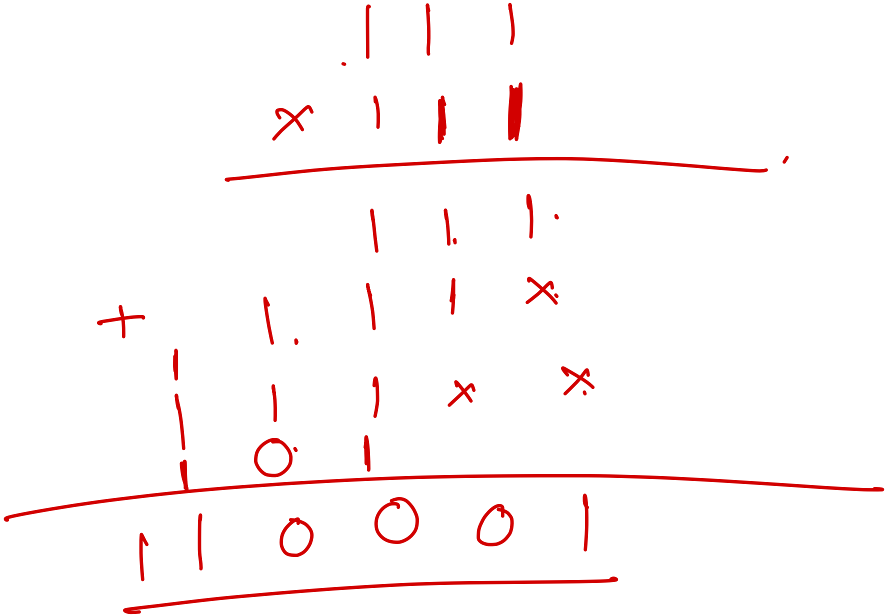
$$10101 - 01110 = 00111$$

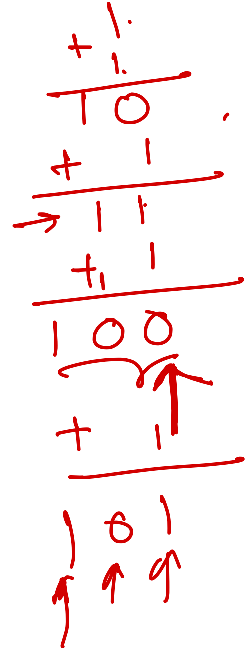
$$1011100 - 0111000 = 0100100$$

# Binary Multiplication

- Binary multiplication is similar to decimal multiplication.

$$
\begin{array}{r}
11 \\
\times\ 11 \\
\hline
11 \\
+\ 11\times \\
\hline
1001
\end{array}
\qquad
\begin{array}{r}
1111 \\
\times\ 111 \\
\hline
1111 \\
+\ 1111\times \\
1111\times\times \\
\hline
1101001
\end{array}
\qquad
\begin{array}{r}
23 \\
\times\ 2 \\
\hline
\end{array}
\qquad
\begin{array}{r}
1 \\
+\ 1 \\
\hline
10 \\
+\ 1 \\
\hline
11 \\
+\ 1 \\
\hline
100
\end{array}
$$





# Binary Division

- Binary division is similar to decimal division.
- Divide $100001_2$ by $110_2$

0101 → Q.

110 ) 100001

$-$ 000

1000

$-$ 110

00100

$-$ 000

1001

$-$ 110

$\boxed{0011}$ → Remainder.

→ 110 → 100

6 < 4

0

→ 110 → 1000

6 < 8

1

→ 110 → 100

6 < 4

0

→ 110 → 1001

6 < 9

= 1

# 1’s complement and 2’s complement

## 1's complement

- The 1's complement of a number is found by changing all 1's to 0's and all 0's to 1's. This is called as 1's complement.

1 → 0 ,
0 → 1 ,

## 2's complement

- The 2's complement of binary number is obtained by adding 1 to the Least Significant Bit (LSB) of 1's complement of the number.
- 2's complement = 1's complement + 1

1's comp.

→ 1 1 0 0 1 0 1

1's comp.

0 0 1 1 0 1 0

0 1 0 1 1 0 1.

1's comp.

1 0 1 0 0 1 0

2's comp.

1 1 0 0 1 0 1 → 0 0 1 1 0 1 0.

1's comp.

+ 1

$$
\begin{array}{r}
0011010 \\
+\quad 1 \\
\hline
0011011
\end{array}
$$

2's comp. , 1st method

0 1 0 1 1 0 1

→ 1's comp.

1 0 1 0 0 1 0

\+ 1

1 0 1 0 0 1 1 ✓

2nd method

0 1 0 1 1 0 1

1's comp.

1 0 1 0 0 1 1 ✓

1 0 1 0 1 1 1 0 0

1's comp.

0 1 0 1 0 0 1 0 0

# 9's complement and 10's complement

- Solve by using 9's complement $52520_{10}$

$$\boxed{(\text{Base})^{\text{no of digit}} - 1 - \text{Given value}}$$

$(10)^5 - 1 - 52520$

$100000 - 1 - 52520$

$= 99999 - 52520$

$= 47479$

$(38)_{10}$

$= 10^2 - 1 - 38$

$= 99 - 38$

$= 61$

$6_8$

$= 8^1 - 1 - 6$

$= 1$

10's comp.

$(52520)_{10}$.

$(\text{Base})^{\text{no of digit}} - \text{given Value}$.

$= 10^5 - 52520$.

$= 47480$

# WEIGHTED AND NON-WEIGHTED CODES

## Weighted codes

- Weighted binary codes are those binary codes which obey the positional weight principle. Each position of the number represents a specific weight.
- Examples of weighted code is BCD. In these codes each decimal digit is represented by a group of four bits.

## Non-Weighted codes

$2^1 2^0$ X

- In this type of binary codes, the positional weights are not assigned. The examples of non-weighted codes are Excess-3 code and Gray code.

# BCD Number

2-bit 4-bit 32bit

- BCD – Binary Coded Decimal
- In this code each decimal digit is represented by a 4-bit binary number.
- BCD is a weighted code its weight are 8421.BCD code are used only till 9(0000 to 1001).
- Convert BCD to decimal and Convert decimal to BCD ?

Decimal to BCD.

$\rightarrow (5)_{10}$

0101

$\rightarrow (26)_{10}$

0010 0110

$2^3\ 2^2\ 2^1\ 2^0$

8 4 2 1

0 – 0000
1 – 0001
2 – 0010
3 – 0011
4 – 0100
5 – 0101
6 – 0110
7 – 0111

8 - 1000
9 - 1001

# BCD to Decimal.

$$(\underbrace{1000}\ \underbrace{0110})_{BCD}.$$

$$\downarrow \quad \downarrow$$

$$(8 \quad 6)_{10}$$