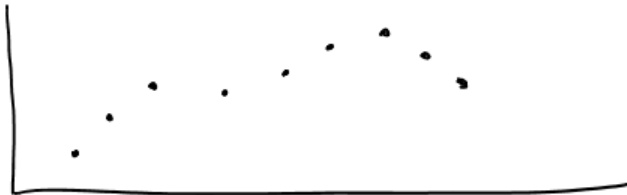


Analog versus Digital Quantities

Analog: Continuous values

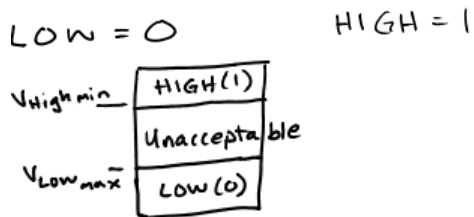


Digital: Discrete set of values



Binary Digits

- Digital: Binary Number System
- Two Digits: 0 and 1
- 0: Represented by a lower voltage
- 1: Represented by a higher voltage



Number Systems

- Decimal Number System: Base 10 weighted system

$10^1 \ 10^0 \leftarrow \text{Weights}$
 $3 \ 4$
 $34 = 3 \times 10^1 + 4 \times 10^0 = 30 + 4 = 34$

$\dots 10^4 \ 10^3 \ 10^2 \ 10^1 \ 10^0 \cdot 10^{-1} \ 10^{-2} \ 10^{-3} \ 10^{-4} \dots$
} Decimal Point

Convert $44_{10} \Rightarrow$ Binary

$44/2 = 22$	Remainder	
$22/2 = 11$	0	LSB
$11/2 = 5$	0	
$5/2 = 2$	1	
$2/2 = 1$	1	
$1/2 = 0$	0	
	1	MSB

$44_{10} = 101100_2$

Hexadecimal System

- Computers and microcontrollers use binary
- Shorthand and instructions use hexadecimal
- Base 16 weighted number system (10 numbers and 6 alphabetic characters)

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

$\dots \cdot 16^3 \quad 16^2 \quad 16^1 \quad 16^0 \cdot 16^{-1} \quad 16^{-2} \quad 16^{-3} \dots$
↖ Hexadecimal Point

Binary Coded Decimal (BCD)

- Code, not weighted
- Each decimal digit is represented by a 4-bit binary code

8421 Code

$$\begin{array}{l} 3 \quad 4_{10} \Rightarrow \text{BCD} \\ \swarrow \quad \downarrow \\ 0011 \quad 0100 \quad \Rightarrow \quad 0011 \quad 0100_{\text{BCD}} \\ \\ 0110 \quad | \quad 1000 \quad | \quad 0010_{\text{BCD}} \Rightarrow \text{Decimal} \\ 6 \quad \quad | \quad 8 \quad \quad | \quad 2 \\ \\ = 682_{10} \end{array}$$

Gray Code

- Not weighted

Decimal	Gray Code
0	000
1	001
2	011
3	010
4	110
5	111
6	101
7	100