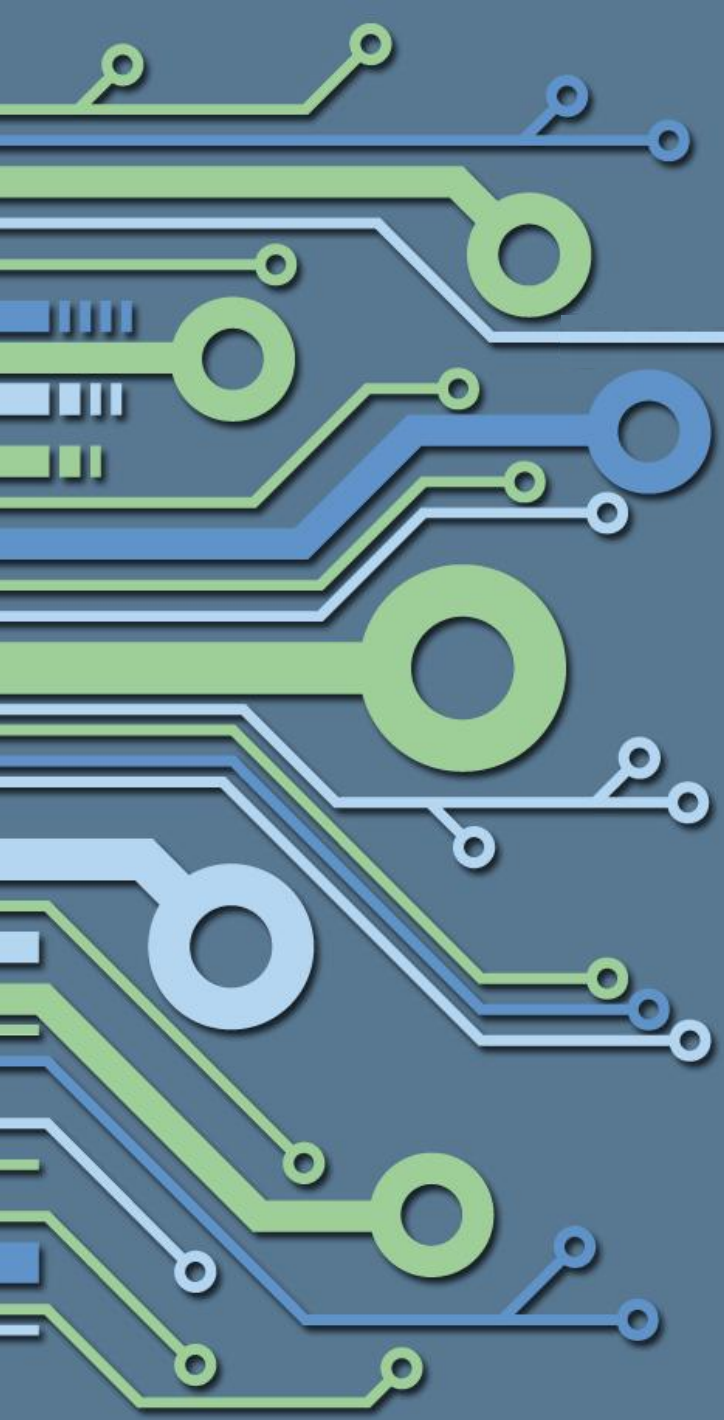


Chapter 1

DATA REPRESENTATION

Data Representation

- There are two basic ways of representing information, which we term analog and digital.
- They are distinguished by the nature of the values that they allow information variables to assume.

Analog vs. Digital

Analog quantities

- can vary over a continuous range of values
- Examples: voltage, room thermostat

Digital quantities

- represented by symbols called digits.
- Example: digital watch

Analog and Digital Systems

Analog System

- contains devices that manipulate physical quantities that are represented in continuous range of values.
- Examples: audio amplifiers, automobile odometer

Digital System

- is a combination of devices designed to manipulate physical quantities that are represented in discrete values.
- Examples: digital computers, digital audio/video equipment

Examples – Digital Systems

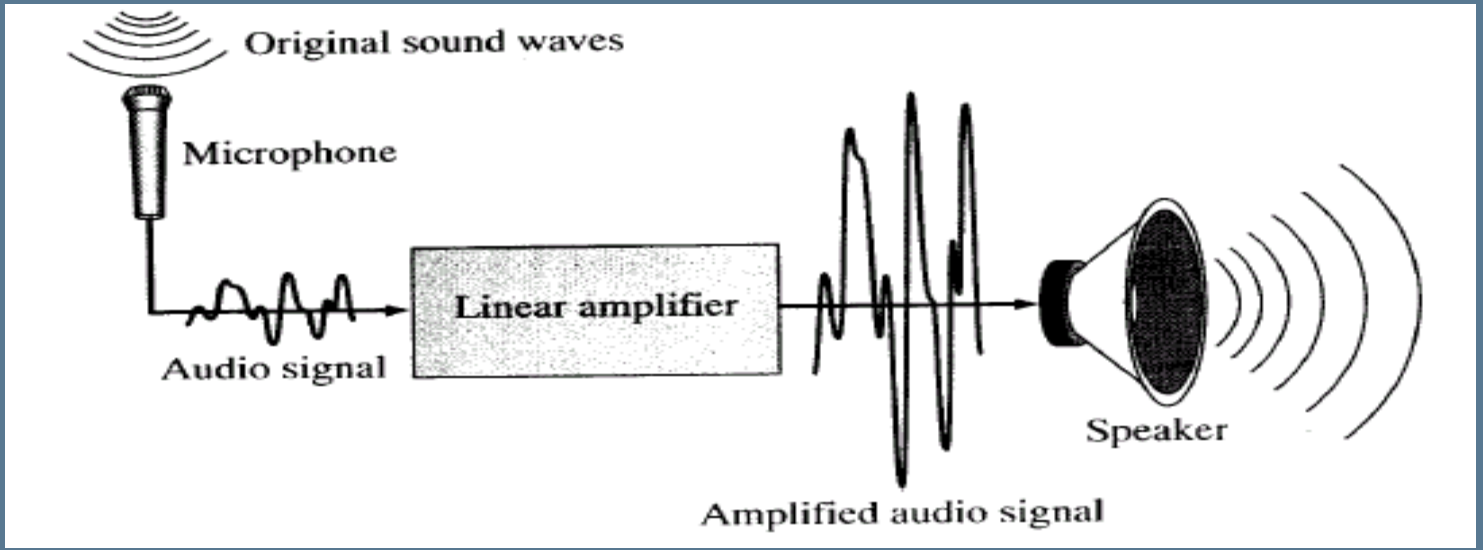
- Digital counters

- Calculators

- Digital computers

Example – Analog System

- A basic public address system



Advantages of Digital Techniques

- Digital system design is easier
- Information storage is easy
- Greater precision and accuracy
- Programmability
- Less susceptible to noise
- Digital circuitry can be fabricated on IC chips.

Limitation of Digital Techniques

- There is one major drawback when using digital techniques:

The real world is mainly analog.

Limitation of Digital Techniques

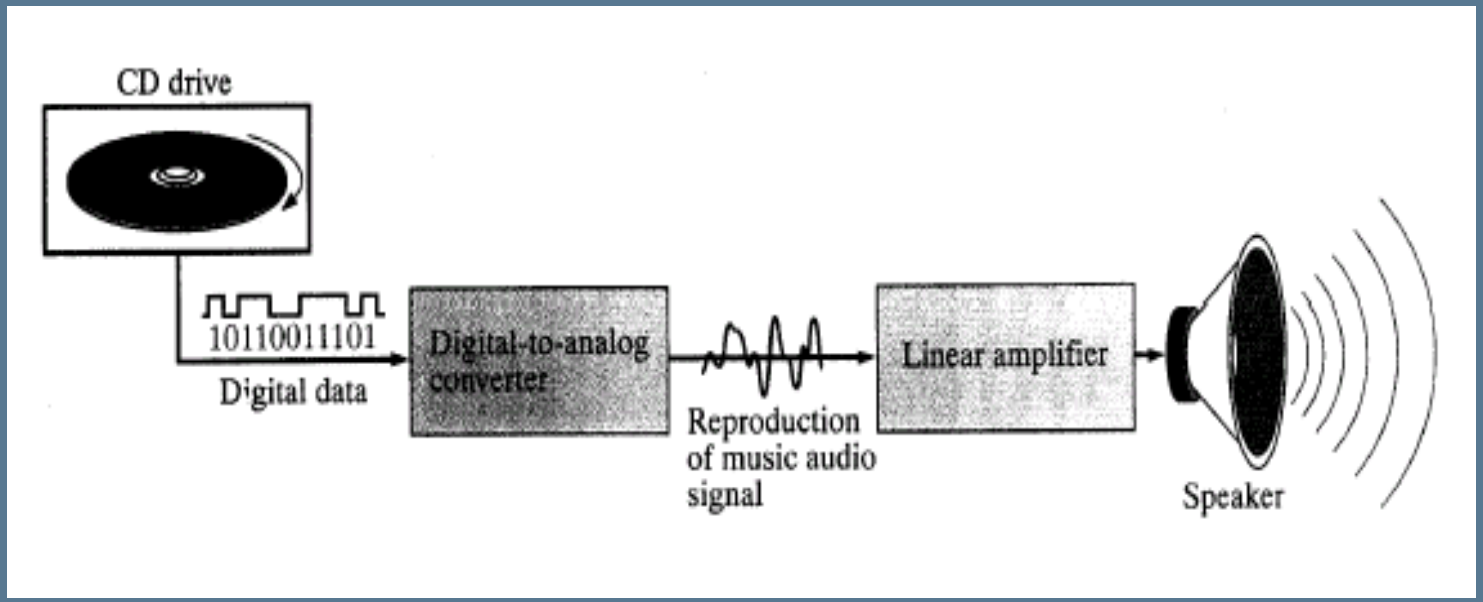
- There is one major drawback when using digital techniques:

The real world is mainly analog.

- *Hybrid systems* – both digital and analog techniques employed within the same system.

Example – Hybrid System

- CD-player



Digital Number Systems

- Many number systems are in use in digital technology.
- The most common are the *decimal, binary, octal, and hexadecimal systems.*

Number Systems

Number system	Base	Coefficients
Decimal	10	0 – 9
Binary	2	0 , 1
Octal	8	0 – 7
Hexadecimal	16	0 – 9, A – F

Base conversion

- From any *base-r* to Decimal
- From Decimal to any *base-r*
- From Binary to either Octal or Hexadecimal
- From either Octal or Hexadecimal to Binary

Conversion: Base-r to Decimal

Procedure

- **Step 1:**

  Multiply each coefficient with the corresponding power of r.

- **Step 2:**

  Get the sum.

Conversion: Base-r to Decimal

Procedure

- **Step 1:**

  Multiply each coefficient with the corresponding power of r.

- **Step 2:**

  Get the sum.

Examples

1. $(1010.011)_2 = \_\_\_\__{10}$

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

$= (10.375)_{10}$

Conversion: Base-r to Decimal

Procedure

- **Step 1:**

  Multiply each coefficient with the corresponding power of r.

- **Step 2:**

  Get the sum.

Examples

1. $(1010.011)_2 =$ _____ $_{10}$

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

$= (10.375)_{10}$

2. $(630.4)_8 =$ _____ $_{10}$

$= 6 \times 8^2 + 3 \times 8^1 + 0 \times 8^0 + 4 \times 8^{-1}$

$= (408.5)_{10}$

Binary to Decimal

Examples

1. $(10110110)_2 =$ _____ $_{10}$

Binary to Decimal

Examples

1. $(10110110)_2 =$ _____ $_{10}$

128	64	32	16	8	4	2	1
1	0	1	1	0	1	1	0

Binary to Decimal

Examples

1. $(10110110)_2 = (182)_{10}$

128	64	32	16	8	4	2	1
1	0	1	1	0	1	1	0

2. $(100110)_2 =$ _____$_{10}$

Binary to Decimal

Examples

1. $(10110110)_2 = (182)_{10}$

128	64	32	16	8	4	2	1
1	0	1	1	0	1	1	0

2. $(100110)_2 =$ _____$_{10}$

32	16	8	4	2	1
1	0	0	1	1	0

Binary to Decimal

Examples

1. $(10110110)_2 = (182)_{10}$

128	64	32	16	8	4	2	1
1	0	1	1	0	1	1	0

2. $(100110)_2 = (38)_{10}$

32	16	8	4	2	1
1	0	0	1	1	0

Conversion: Decimal to Base-r

Procedure

- **Step 1:**
  Separate integer from fraction
- **Step 2:**
  Convert integer to base-r
- **Step 3:**
  Convert fraction to base-r

Integer to base-r

- Divide integer by r
- Accumulate remainders

Fraction to base-r

- Multiply fraction by r
- Accumulate integers

Examples

Examples

1. $(41.6875)_{10}$ = _____ $_2$

Step 1:

Integer = 41

Fraction = 0.6875

Step 2:

41 / 2 = 20 rem 1

20 / 2 = 10 rem 0

10 / 2 = 5 rem 0

5 / 2 = 2 rem 1

2 / 2 = 1 rem 0

1 / 2 = 0 rem 1

Examples

Step 3:

$0.6875 \times 2 = 1.3750$ → 1

$0.3750 \times 2 = 0.7500$ → 0

$0.7500 \times 2 = 1.5000$ → 1

$0.5000 \times 2 = 1.0000$ → 1

Thus: $(41.6875)_{10} = (101001.1011)_2$

Examples

Examples

2. $(153.513)_{10}$ = _____ 8

Step 1:

Integer = 153

Fraction = 0.513

Step 2:

Examples

Examples

2. $(153.513)_{10}$ = _____ 8

Step 1:

Integer = 153

Fraction = 0.513

Step 2:

153 / 8 = 19 rem 1

Examples

Examples

2. $(153.513)_{10}$ = _____ 8

Step 1:

Integer = 153

Fraction = 0.513

Step 2:

153 / 8 = 19 rem 1

19 / 8 = 2 rem 3

Examples

Examples

2. $(153.513)_{10}$ = _____ 8

Step 1:

Integer = 153

Fraction = 0.513

Step 2:

153 / 8 = 19 rem 1

19 / 8 = 2 rem 3

2 / 8 = 0 rem 2

Examples

Examples

2. $(153.513)_{10}$ = _____ 8

Step 1:

Integer = 153

Fraction = 0.513

Step 2:

153 / 8 = 19 rem 1

19 / 8 = 2 rem 3

2 / 8 = 0 rem 2

Examples

Step 3:

0.513 x 8	=	4.104	4
0.104 x 8	=	0.832	0
0.832 x 8	=	6.656	6
0.656 x 8	=	5.248	5
0.248 x 8	=	1.984	1
0.984 x 8	=	7.872	7

Thus: $(153.513)_{10} = (231.406517)_{8}$

Decimal to Binary

Examples

1. $(150)_{10} =$ _____ $_2$

Decimal to Binary

Examples

1. $(150)_{10} =$ _____ $_2$

128	64	32	16	8	4	2	1

Decimal to Binary

Examples

1. $(150)_{10}$ = _____ 2

128	64	32	16	8	4	2	1
1							

Decimal to Binary

Examples

1. $(150)_{10} =$ _____ 2

128	64	32	16	8	4	2	1
1	0	0	1				

Decimal to Binary

Examples

1. $(150)_{10}$ = _____ 2

128	64	32	16	8	4	2	1
1	0	0	1	0	1	1	0

2. $(123)_{10}$ = _____ 2

Decimal to Binary

Examples

1. $(150)_{10} =$ _____ $_2$

128	64	32	16	8	4	2	1
1	0	0	1	0	1	1	0

2. $(123)_{10} =$ _____ $_2$

64	32	16	8	4	2	1

Decimal to Binary

Examples

1. $(150)_{10} =$ _____ $_2$

128	64	32	16	8	4	2	1
1	0	0	1	0	1	1	0

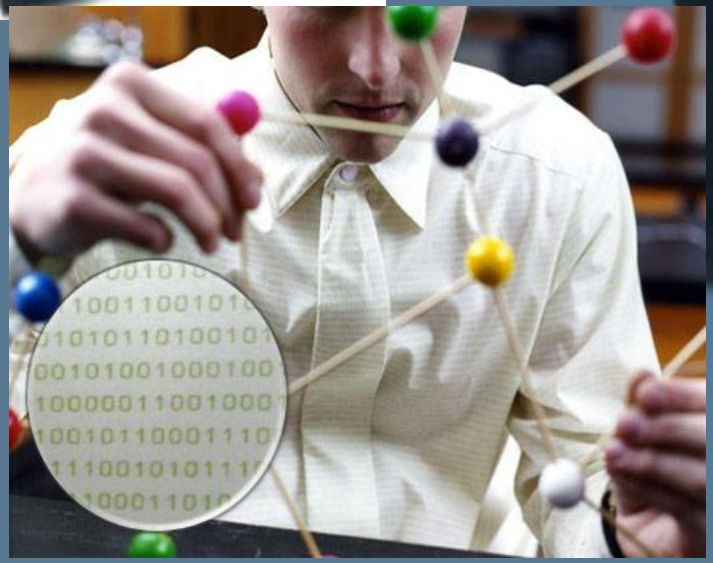
2. $(123)_{10} =$ _____ $_2$

64	32	16	8	4	2	1
1	1	1	1	0	1	1

Binary Shop

Binary Shop


There are only 10 types
of people in the world:
Those who understand binary
and those who don't.



Binary Shop

Binary Shop