COE 202: Digital Logic Design
Introduction

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Objectives

1. Digital Systems
2. “Analog” versus “Digital” parameters and systems.
3. Digitization of “Analog” signals.
5. Effect of noise on the reliability and choice of digital system representation.
Digital Systems

• Digital Systems exist everywhere
  • Communication, banks, hospitals, Internet etc.
• Computers are digital systems
  • Programmable, flexible
Digital vs. Analog Systems

- We live in an analog world (continuous)
- Analog signals are continuous in nature
  - Smooth transition over a period of time
  - Represent a physical quantity or phenomenon
  - E.g. temperature of a cup of tea being boiled

![Diagram showing temperature change over time with a note: Kettle removed from stove.]
Digital vs. Analog Systems

• Digital signals are non-continuous i.e. discrete
  • Consist of fixed set of digits. E.g. number of months in a year = 12; digits = \{1, 2, 3, \ldots, 10, 11, 12\} note that 11.3 or 4.9 are invalid here.
  • Abrupt transition (jumping) from one digit to another
Digital vs. Analog Systems

Q: Digital or Analog?

- Earth movement
- English letters
- Internet IP addresses
- Human voice
- Week days
Digitization

- Process of conversion from analog to digital is called digitization
- Analog to digital (ADC) converters perform digitization
- Digital to analog (DAC) converters regenerate the analog signals from their digitized form
Digitization (Why?)

- The world around us is analog
- Digital systems are simple to understand & comprehend
- Thus …. Common practice is to convert analog signals into digital form for efficient processing of signals
- Inevitable to avoid loss of some accuracy (information) due to this conversion

Reason: digital systems can only represent fixed (finite or discrete) set of values
Analog to Digital to Analog


Ahmad Almulhem, KFUPM 2010
Digitization Example

Ahmad Almulhem, KFUPM 2010
The digital signal can contain a combination of only one of four voltage values – V1, V2, V3, V4

Analog values are mapped to the closest discrete voltage value
Computers

- Computers are digital systems
- Deal with a vocabulary of two elements namely 0 and 1 – also known as the binary system of numbers
- Binary digits i.e. 0 and 1 are called **bits**
- Decimal digits 0, 1, 2, 3, …., 9 are simply called ‘digits’ – these digits constitute the decimal number system
Data representation

Computers represent data (V1, V2, V3, V4) in binary system using:

- Electrical voltages (processors, memory)
- Magnetism (hard disks, floppy)
- Light (CD, DVD)
Signal representation (Voltage)

● Computers use low power supply voltage, typically from 0V to 5V
● In decimal numbering system, the voltage levels are divided into 10 equal parts. Therefore:
  • 0 represents 0 – 0.5V
  • 1 represents 0.5 – 1.0V
  • 2 represents 1.0-1.5V and so forth.
● Only 0.5V separate two consecutive voltage ranges if decimal digits are used.
Signal representation (Voltage)

- Using the binary system, as is the case with all computers, and a low power voltage range from 0-5V
  - A binary ‘0’ is represented with 0 Volts
  - A binary ‘1’ is represented with 5 Volts
- A larger range of Volts differentiate between the two values (0 and 1) in the binary system
Signal representation (Voltage)
Noise

- Noise exists in environments (mobile & TV)
- Noise can change voltage level (higher or lower)
Noise

- Noise exists in the environment
- Causes disruption in the voltage levels.
- If the range of differentiation between consecutive values is low, the data can be disrupted

Example: 1.6V (represented using decimal digit 3) when transmitted in a noisy environment becomes 1.5V (i.e. decimal digit 2), thus corrupting the data

Conclusion: Digital systems (using binary digits) are more reliable than the decimal system
Conclusions

- Information can be represented using analog and digital form
- Processing of digital data is flexible, reliable, simple and powerful
- Computers represent data using the binary system
- Digitization of data (converting from analog to digital)

Next Lecture: Numbering systems (representation and manipulation)