COE 202: Digital Logic Design Introduction

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Objectives

1. Introduction
2. "*Analog*" versus "*Digital*" parameters and systems.
3. Digitization of "*Analog*" signals.
4. Digital representation of information.
5. Effect of noise on the reliability and choice of digital system representation.

Digital Logic Design

Computers:

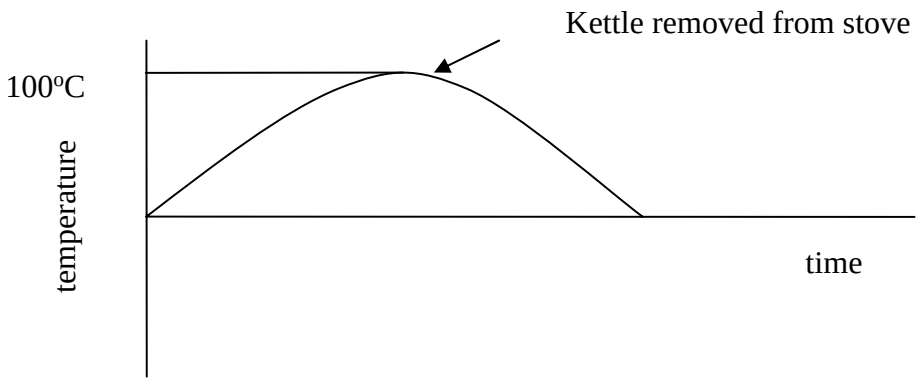
- are found everywhere
- are a part of our daily lives
- are *digital systems*

Logic Design is the study of concepts and tools used to design hardware consisting of logic circuits

Computer Design is the study of additional concepts and tools used for designing computers and other digital systems (such as chips in cars, airplanes, sensors..)

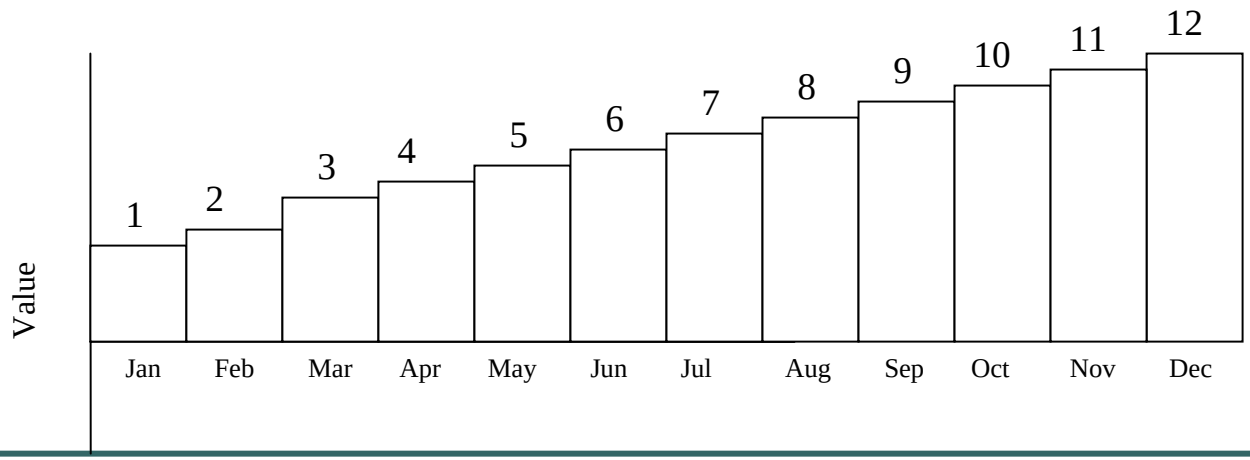
Digital vs. Analog Systems

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



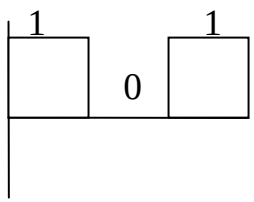
Digital vs. Analog Systems

- 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,….,10,11,12} note that 11.3 or 4.9 are invalid here.
  - Abrupt transition (jumping) from one digit to another



Digital Computers

- Simple devices
- 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



Digitization

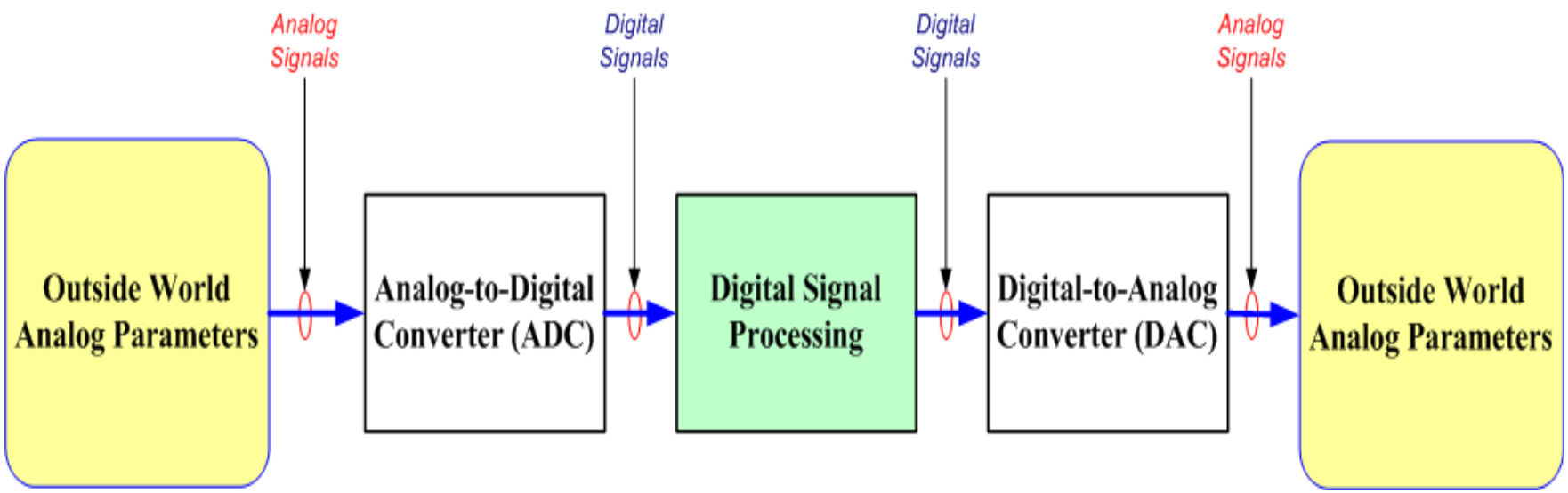
- The world around us is analog
- Digital systems are simple to understand & comprehend
- Thus …. Common practice is to convert analog parameters into digital form for efficient processing of signals
- Inevitable to avoid loss of some accuracy (information) due to this conversion

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

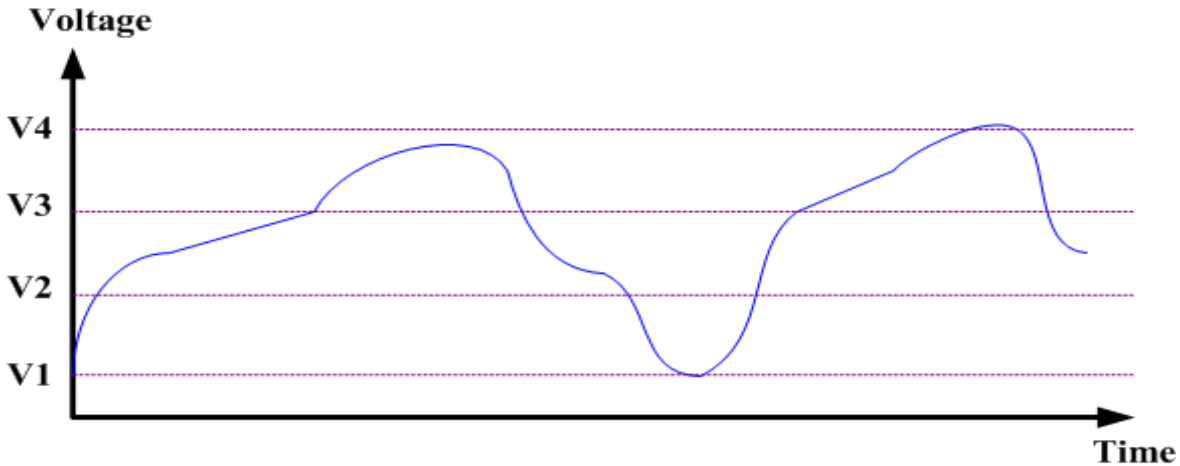
Digitization

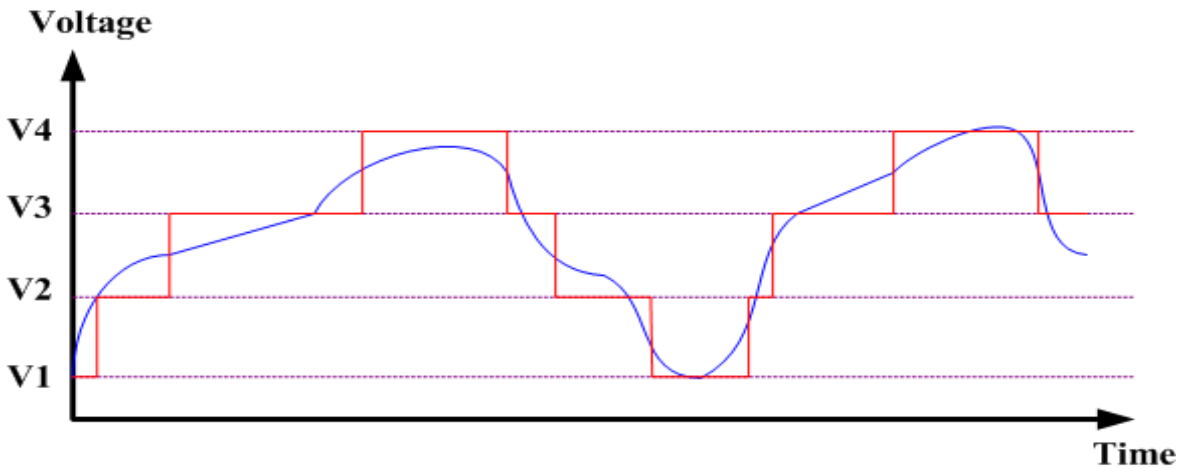
- Process of conversion from analog to digital is called digitization
- Analog to digital (ADC) converters perform digitization
- Digital to analog (DAC) converters regenerate the analog signals from their digitized form

Analog to Digital to Analog

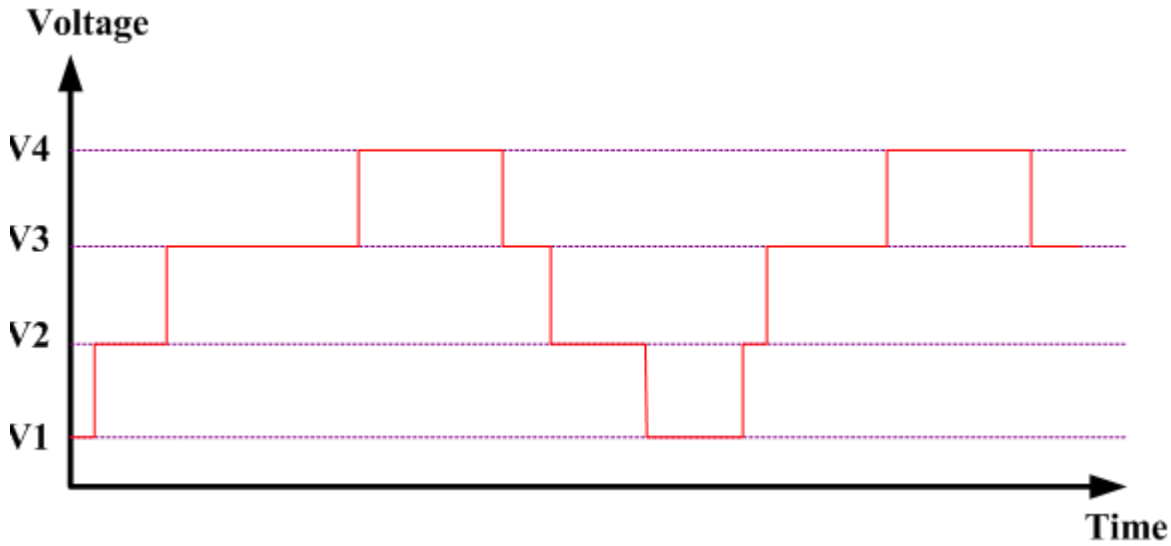


Digitization Example





Digitization Example



- 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

Data representation

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

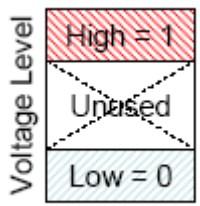
- Electrical voltages (processors, memory)
- Magnetism (hard disks, floppy)
- Light (CD, DVD)

Signal representation (Voltage)

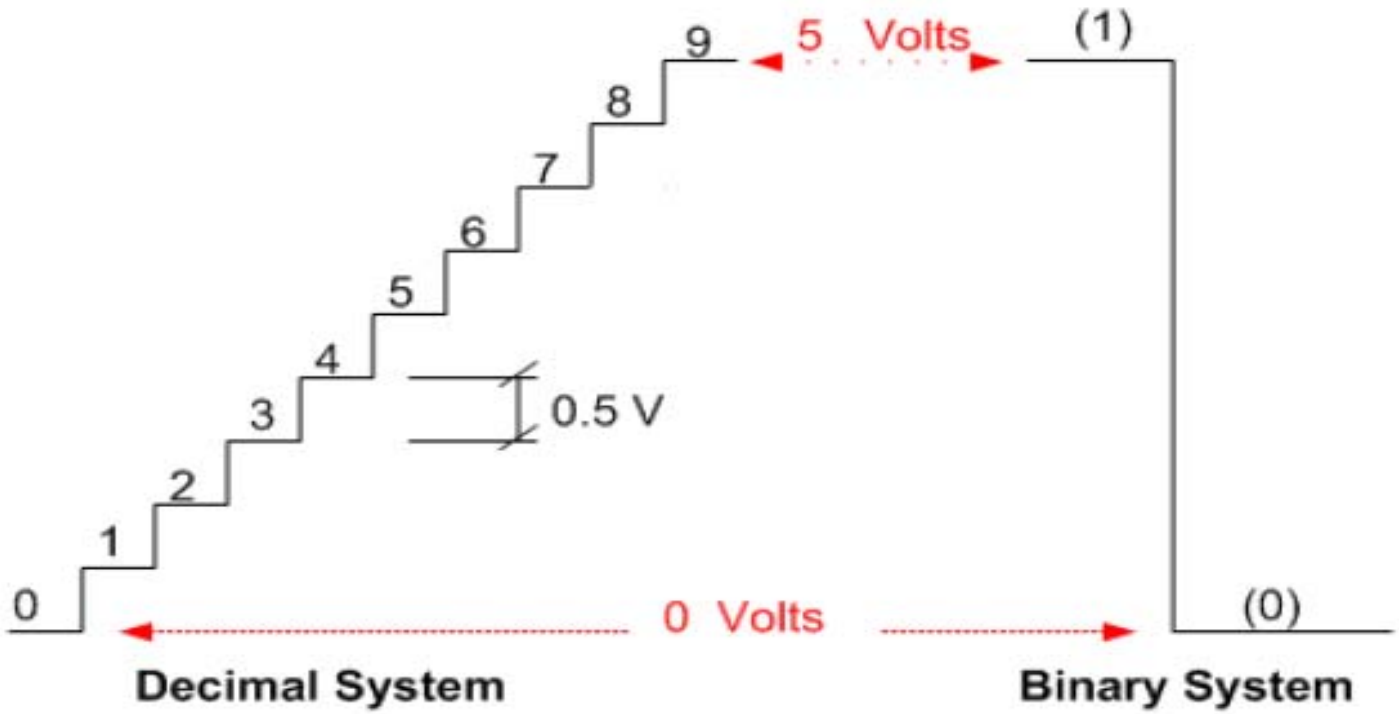
- Computers use low power supply voltage, typically from 0V to 5V
- In decimal numbering system, the voltage levels are divided into 10 equal parts. Therefore:
  - 0 represents 0 – 0.5V
  - 1 represents 0.5 – 1.0V
  - 2 represents 1.0-1.5V and so forth.
- Only 0.5V separate two consecutive voltage ranges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

Signal representation (Voltage)

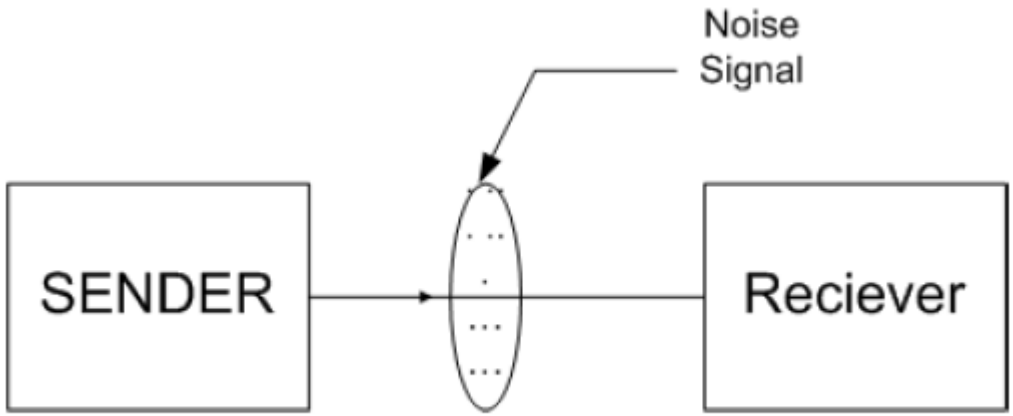
- Using the binary system, as is the case with all computers, and a low power voltage range from 0-5V
  - A binary ‘0’ is represented with 0 Volts
  - A binary ‘1’ is represented with 5 Volts
- A larger range of Volts differentiate between the two values (0 and 1) in the binary system



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

- Computers represent data using the binary system
- Processing of digital data is flexible, reliable, simple and powerful
- Discretization of data (converting from analog to digital) is essential to reduce the chances of data corruption in noisy communication environments

Next Lecture: Numbering systems (representation and manipulation)