University Of Diyala
College Of Engineering
Computer Engineering Department

Introduction
Digital System Design

Dr. Yasir Amer Abbas

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System

- System

  System: a set of related parts that actuate as a whole to achieve a given goal.

- System has:
  - Inputs
  - Outputs
  - Behaviour
- Behaviour: a function that translates inputs to outputs.

System

- An entity consisting of Hardware and Software
  - Hardware:
    - High speed
    - Low power consumption
    - Less price (probably)
  - Software:
    - Flexible
    - Easy to modify and upgrade

What are digital circuits and systems?

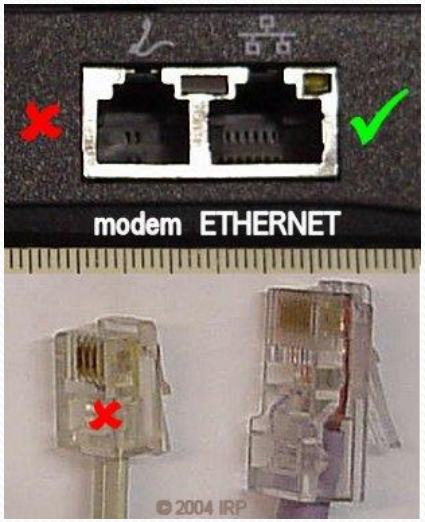
- What are digital circuits and systems?
  - Any system that can be implemented with digital circuits
- What kinds of systems can be implemented with digital circuits?
  - This depends on the complexity of the problem to be solved
  - For those who has complexity proportional to polynomial functions, they are generally solvable with digital systems
    - E.g. The inversion of a N × N matrix

- What is a digital system?
  - A system that implements functions using digital logics

What is a digital system?

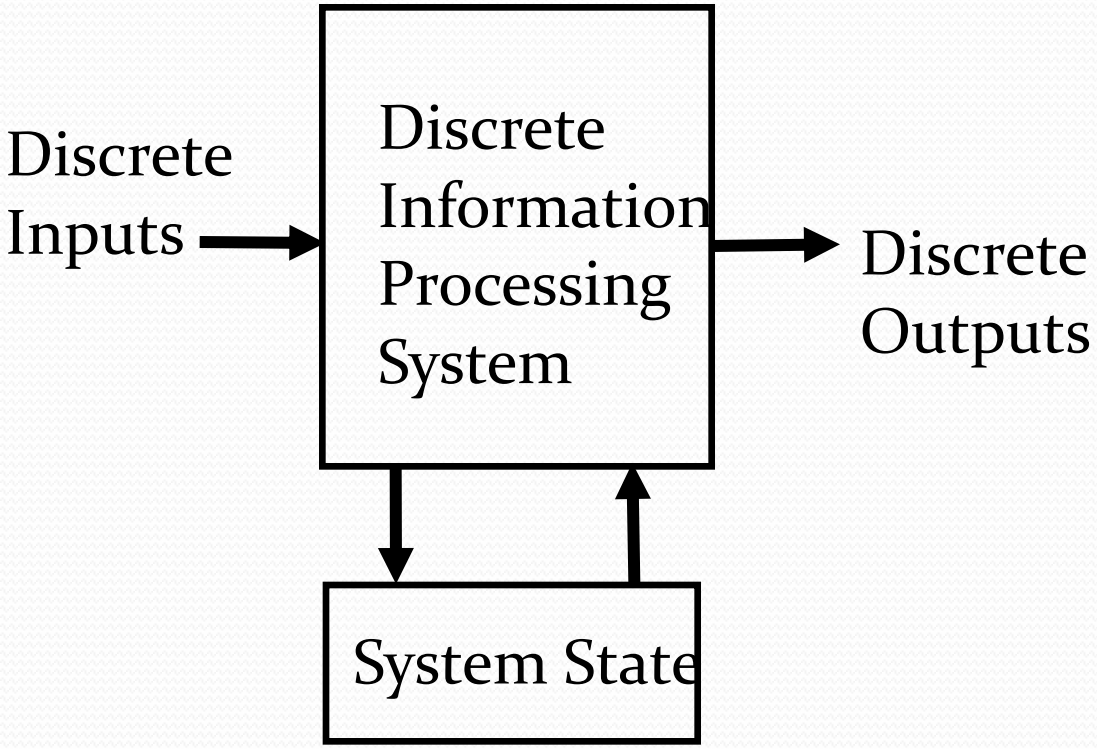
- Even a power plant control system is a digital system

- What are the constitutional blocks of a digital system?
  - It has input interfaces
    - Key boards, antennas, wire jackets, sensors and microphones
  - It also has output interferences
    - Monitors, speakers, motors, printers, antennas, wire jackets and actuators
  - It definitely has signal processing units, or, in other words, arithmetic and logic units.



Digital and Computer Systems

- **Takes a set of discrete information inputs and discrete internal information (system state) and generates a set of discrete information outputs.**



Types of Digital Systems

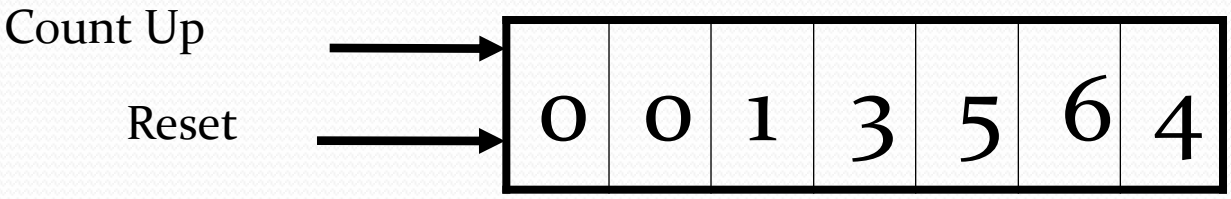
- **No state present**
  - **Combinational Logic System**
  - **Output = Function(Input)**
- **State present**
  - **State updated at discrete times**

    => Synchronous Sequential System
  - **State updated at any time**

    =>Asynchronous Sequential System
  - **State = Function (State, Input)**
  - **Output = Function (State, Input)**

Digital System Example:

A Digital Counter (e. g., odometer):

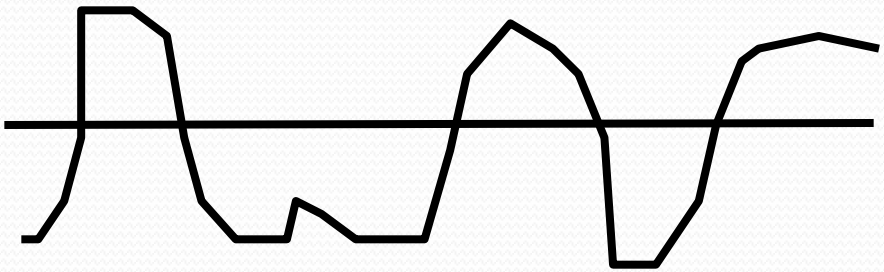


Inputs: **Count Up, Reset**

Outputs: **Visual Display**

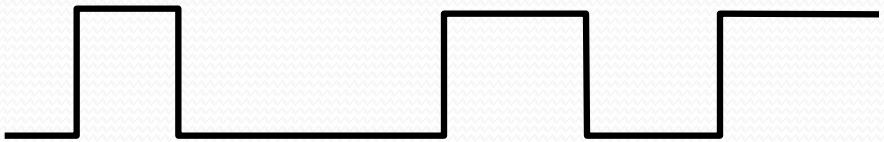
State: **"Value" of stored digits**

Signal Examples Over Time



Continuous in value & time

Digital



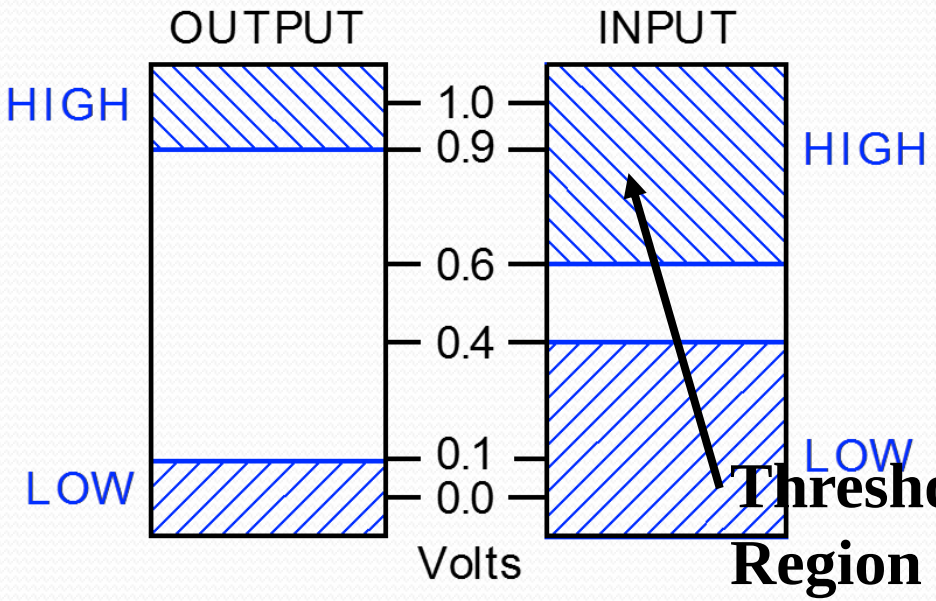
Discrete in value & continuous in time

Discrete in value & time

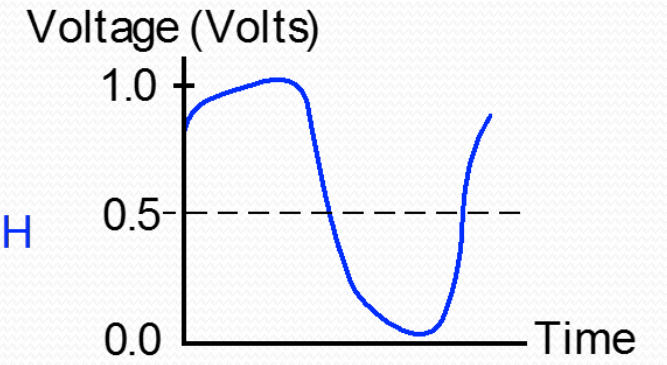
Information representation - signals

- **Information variables represented by physical quantities.**
- **For digital systems, the variables take on discrete values.**
- **Two level, or binary values are the most prevalent values in digital systems.**
- **Binary values are represented abstractly by:**
  - **digits 0 and 1**
  - **words (symbols) False (F) and True (T)**
  - **words (symbols) Low (L) and High (H)**
  - **and words On and Off.**
- **Binary values are represented by values or ranges of values of physical quantities**

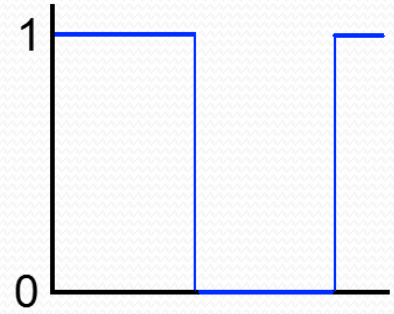
Signal Example – Physical Quantity: Voltage



(a) Example voltage ranges



(b) Time-dependent Voltage



(c) Binary model of time-dependent voltage

- How to develop a digital system?
  - First, it is not only designing a digital circuit
  - A digital circuit is designed to realize functions that serve systems' requirements
  - A system may involves knowledge of control theories, communications, biology, mechanics, chemistries and etc.
- Digital circuits can be categorized into
  - General purpose circuits
    - Computers, Digital signal processors
  - Application specific circuits
    - Modems, GPS, cellphones

- How to develop a digital circuit?
  - We need knowledge about digital logic
  - We need tools to explore the ideas, to simulations the operational conditions, to realize circuits and to validate functionalities
  - We need platforms to field test, emulate, the designs
- Do we have a language that can specify these purposes?
  - This language is called hardware description language (HDL), e.g. VHDL and Verilog HDL
- In addition to language, we need translators, simulators, synthesizers and hardware evaluation and development systems

- Translators :
  - To compile VHDL or Verilog HDL languages into a language that can be understand by a computer
- Simulators:
  - To simulate the system response according to input signals
- Synthesizers:
  - To synthesize VHDL or Verilog language into digital circuits
- Validations:
  - Digital circuit development systems

- Digital circuits developments
  - There are many of them
    - ***Altera DE1-SoC***

- What we are going to learn?
  - Design a general purpose logic circuit
  - Design a application specific logic circuit
- Systematic ways of designing digital systems
  - More advanced topics in logic designs
  - Modeling logic problems with HDLs
  - Simulating logic functions
  - Synthesizing logic circuits with HDLs
  - Validating designs with programmable logic devices on a hardware development system
- The concept of a digital system