DIGITAL SYSTEMS AND MICROPROCESSORS (ELE2002M)

Instructor:

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Module Specifications

- Lectures : Monday (12pm-2pm and 4pm-6pm)
- Labs : Thursdays (6pm-8pm)
- Slides and Assignments on Blackboard
- Tutorials will run alongside lectures
- Pre-requisite for advanced courses
- Emphasis on problem solving
- Lab component – Design, simulation and synthesis
- Hardware Description Language (Verilog or VHDL)

Textbooks

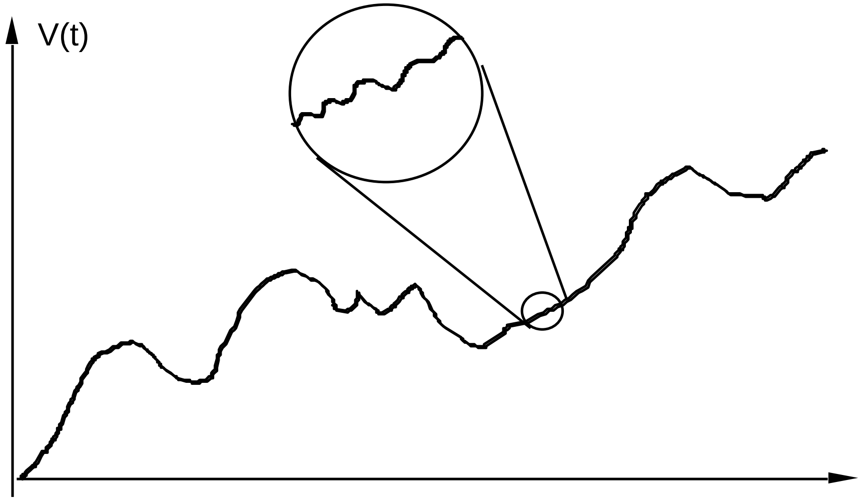
- **M Morris Mano, Michael D Ciletti (2013). Digital Design, 5th Edition, Pearson Prentice Hall.**

- Thomas L. Floyd (2014). Digital Fundamentals – A Systems Approach (First Edition). Pearson

- J. Bhasker. A Verilog HDL Primer (Third Edition). BSP

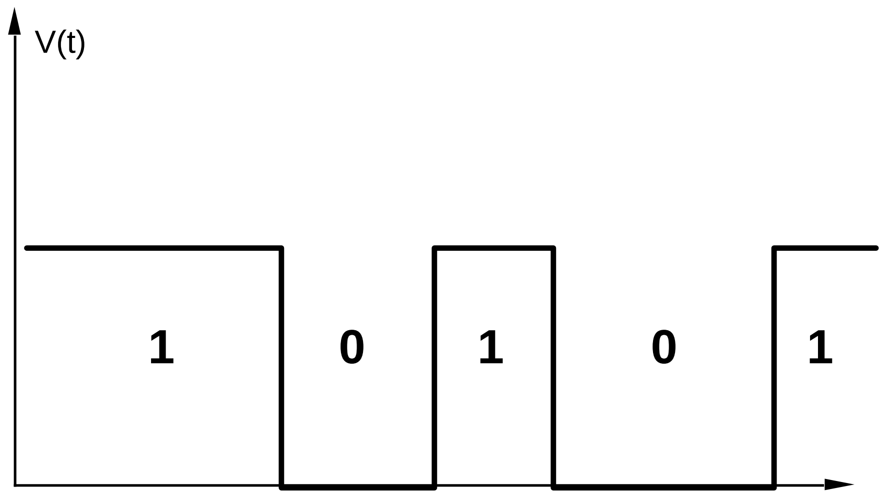
Analog System

- Analogue Systems
  - V(t) can have *any value* between its minimum and maximum value



Digital Systems

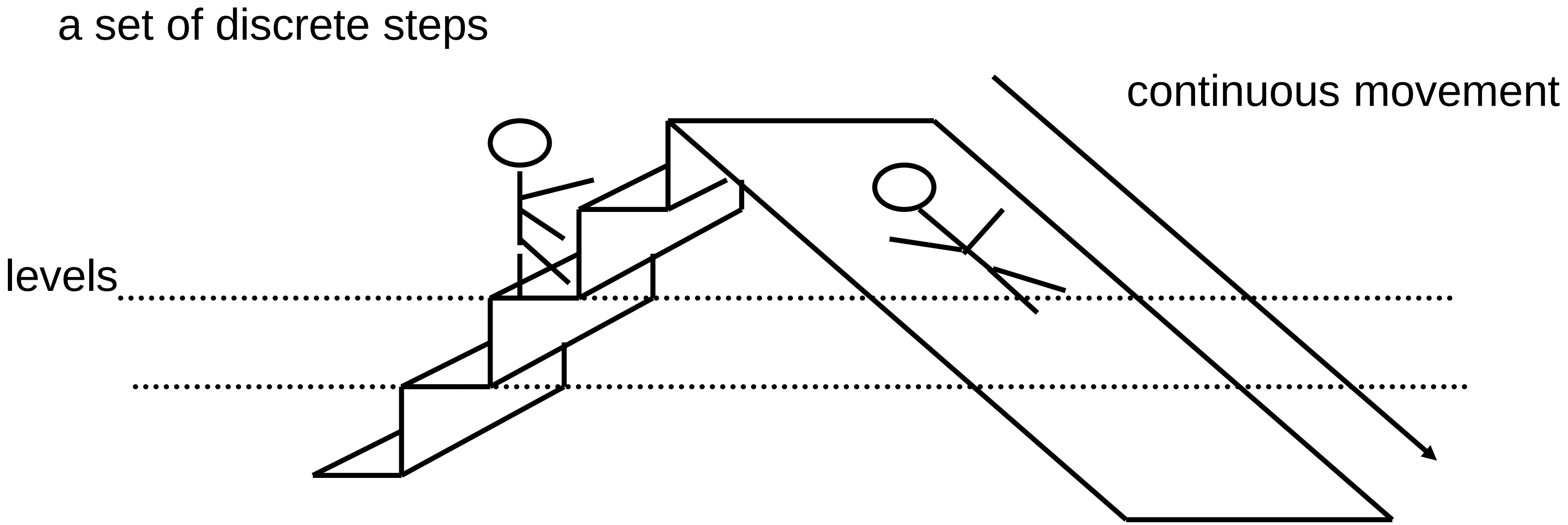
- **Digital Systems**
  - **V(t) must take a value selected from a set of values called an alphabet**
  - **Binary digital systems form the basis of almost all hardware systems currently**



For example, Binary Alphabet: 0, 1.

Slide Example

- Consider a child's slide in a playground:



Integrated Circuits

Levels of Integration

- SSI (Small scale integration) – less than 10 gates
- MSI (Medium scale integration) – 10-1000 gates
- LSI (Large scale integration) – 1000s of gates
- VLSI (Very large scale integration) – more than 100K gates

Digital Logic Families

- TTL – Transistor-Transistor logic (standard logic)
- ECL – Emitter-coupled logic (high speed)
- MOS – Metal-oxide semiconductor (high density)
- CMOS – Complementary MOS (low power)

More about these in the CMOS VLSI Design Course.

Computer Aided Design

- Electronic Design Automation covers all phases of design of Integrated Circuits.
- First step of EDA is design entry
- Variety of options available to create a physical realization of a digital circuit on Silicon
- Designer can choose between ASICs, FPGAs, PLDs, or a full custom IC (microcontrollers, microprocessors)
- Each device comes with a set of CAD tools
- Some CAD systems allow entering a design using schematics.
- Other CAD tools can use HDLs to describe a digital hardware.

Recap – World of Binary

- Binary Number System
- Difference between Binary and Decimal Number System
- Octal and Hexadecimal Number System
- Conversion between different number systems
- Binary Coding

Recap - Conversions

- Decimal to Binary
- Decimal to Octal
- Decimal to Hexadecimal

- Binary to Decimal
- Octal to Decimal
- Hexadecimal to Decimal

Recap - Complements

- 9's Complement of Decimal Number
- 10's Complement of Decimal Number

  (Add 1 to 9's Complement)

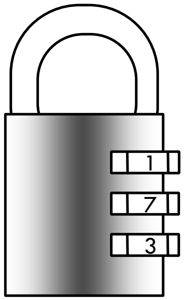
- 1's Complement of Binary Number
- 2's Complement of Binary Number

  (Add 1 to 1's Complement)

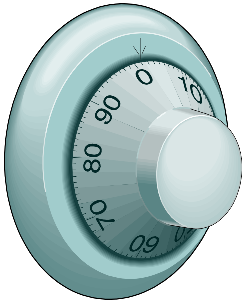
Recap - Binary Logic

Two main types

- Combinational
  - Outputs dependent only on current input

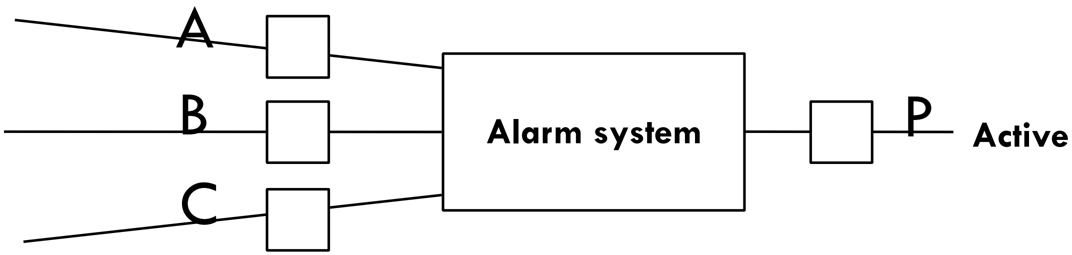


- Sequential
  - Outputs dependent on both past and present inputs



Recap - Design Example using AND Gate

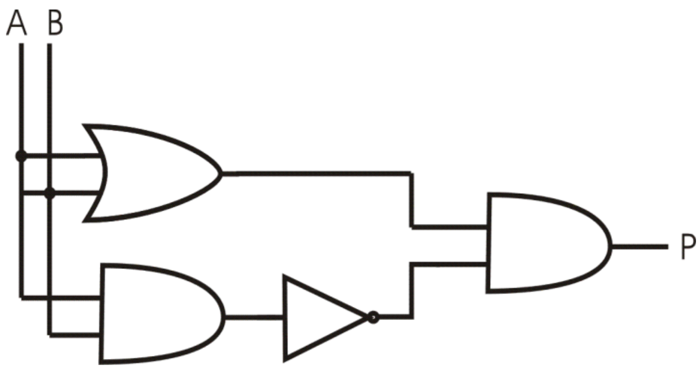
- Consider a buzzer which sounds when :
  - The lights are on **and**
  - The door is open **and**
  - No key is in the ignition



Variable	Value	Situation
A	1	Lights are on
	0	Lights are off
B	1	Door is open
	0	Door is closed
C	1	Key is in ignition
	0	Key is out of ignition
P	1	Buzzer is on
	0	Buzzer is off

Exercise

Complete the truth table for this circuit and name the equivalent primitive function/gate.



A	B	A+B	A.B	$\overline{A.B}$	P
0	0				
0	1				
1	0				
1	1				

Recap - Laws of Boolean Algebra

Tautology (Idempotent)	A . A = A A + A = A
Complementary	A . A′ = 0 A + A′ = 1
Operating with logic 0 and logic 1	A . 0 = 0 A . 1 = A A + 0 = A A + 1 = 1
Commutative	A . B = B . A A + B = B + A
Associative	(A.B).C = A.B.C = A.(B.C)
Distributive	A.(B + C) = A.B + A.C A + (B.C) = (A + B).(A + C)

Summary

- A circuits desired outputs can be specified in terms of inputs
- An Boolean (logical) expression can be derived from the truth table.
- The Boolean expression can then be simplified using either
  1. Boolean Algebra
  2. Karnaugh Maps

Exercises

- You should be able to:
  - Construct truth tables given boolean expressions
  - Compare expressions using truth tables
  - Produce a sum-of-products form from a truth table by combining minterms
  - Simplify the resulting expression algebraically
  - Represent the expression as a circuit using logic gates