# **Introduction to Digital Logic**

#### Prof. Nizamettin AYDIN

naydin@yildiz.edu.tr http://www.yildiz.edu.tr/~naydin

### **Course Outline**

- 1. Digital Computers, Number Systems, Arithmetic Operations, Decimal, Alphanumeric, and Gray Codes
- 2. 3.
- 4.
- 5.
- Alphanumeric, and Gray Codés Binary Logic, Gates, Boolean Algebra, Standard Forms Circuit Optimization, Two-Level Optimization, Map Manipulation, Multi-Level Circuit Optimization Additional Gates and Circuits, Other Gate Types, Exclusive-OR Operator and Gates, High-Impedance Outputs Implementation Technology and Logic Design, Design Concepts and Automation, The Design Space, Design Procedure, The major design steps Programmable Implementation Technologies: Read-Only Memories, Programmable Logic Arrays, Programmable Array Logic,Technology mapping to programmable Logic devices 6.
- Combinational Functions and Circuits 7. 8.
- 9
- Arithmetic Functions and Circuits Sequential Circuits Storage Elements and Sequential Circuit Analysis Sequential Circuits, Sequential Circuit Design State Diagrams, State Tables 10.
- Counters, register cells, buses, & serial operations Sequencing and Control, Datapath and Control, Algorithmic State Machines (ASM) Memory Basics 11. 12. 13.

**Introduction to Digital Logic** 

#### Lecture 6

# **Programmable Implementation Technologies**

Read-Only Memories, Programmable Logic Arrays, Programmable Array Logic Technology mapping to programmable logic devices



### Why Programmable Logic?

- · Facts:
  - It is most economical to produce an IC in large volumes - Many designs required only small volumes of ICs
- Need an IC that can be:
  - Produced in large volumes
  - Handle many designs required in small volumes
- A programmable logic part can be:
  - made in large volumes
  - programmed to implement large numbers of different lowvolume designs

#### **Programmable Logic - Additional Advantages**

- · Many programmable logic devices are fieldprogrammable, i. e., can be programmed outside of the manufacturing environment
- Most programmable logic devices are erasable and reprogrammable.
  - Allows "updating" a device or correction of errors
  - Allows reuse the device for a different design the ultimate in reusability!
  - Ideal for course laboratories
- · Programmable logic devices can be used to prototype design that will be implemented for sale in regular ICs. - Complete Intel Pentium designs were actually prototype with specialized systems based on large numbers of VLSI

programmable devices!

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# **Programming Technologies**

- Programming technologies are used to:
  - -Control connections
  - -Build lookup tables
  - -Control transistor switching
- · The technologies
  - -Control connections
    - Mask programming
    - Fuse
    - Antifuse
    - Single-bit storage element

#### **Programming Technologies**

- The technologies (continued)
  - -Build lookup tables
  - Storage elements (as in a memory)
  - Transistor Switching Control
  - Stored charge on a floating transistor gate
    - Erasable
      Electrically erasable
    - -Flash (as in Flash Memory)
    - Storage elements (as in a memory)



- Erasable
- Electrically erasable
- Flash (as in Flash Memory)

# **Programmable Configurations**

- *Read Only Memory (ROM)* a fixed array of AND gates and a programmable array of OR gates
- *Programmable Array Logic (PAL)* a programmable array of AND gates feeding a fixed array of OR gates.
- *Programmable Logic Array (PLA)* a programmable array of AND gates feeding a programmable array of OR gates.
- Complex Programmable Logic Device (CPLD) /Field- Programmable Gate Array (FPGA) complex enough to be called "architectures" - See VLSI Programmable Logic Devices reading supplement





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# **Programmable Array Logic (PAL)**

- The PAL is the opposite of the ROM, having a programmable set of ANDs combined with <u>fixed</u> ORs.
  Disadvantage
  - ROM guaranteed to implement any M functions of N
  - inputs. PAL may have too few inputs to the OR gates.

#### Advantages

- For given internal complexity, a PAL can have larger N and M
   Some PALs have outputs that can be complemented, adding POS functions
- No multilevel circuit implementations in ROM (without external connections from output to input). PAL has outputs from OR terms as internal inputs to all AND
- terms, making implementation of multi-level circuits easier.









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# some relevant links

- <u>http://www.latticesemi.com</u>
- <u>http://www.xilinx.com</u>
- <u>http://www.ti.com/sc/docs/products/proglgc</u>
- http://www.altera.com
- http://www.actel.com
- http://www.atmel.com
- http://ece.ut.ac.ir/Classpages/F86/ECE045/FP GA%20Tutorial.pdf
- <u>http://www.klabs.org/richcontent/Tutorial/tutor</u> <u>ial.htm#ProgrammableLogic</u>

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