ELEC 2200 Digital Logic Circuits
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Text: Digital Logic Circuit Analysis & Design
Nelson, Nagle, Irwin & Carroll, Prentice Hall, ‘95
Class web page: www.eng.auburn.edu/~strouce
Some Basic Digital System Concepts

• Levels of design abstraction & hierarchy
  – System (behavioral) level – highest level
  – Register level – widely used for design in industry today
  – Gate level – level we will deal with most in this class
  – Transistor level – lowest level

• Top-down design
  – Begins at system level & moves toward transistor level
    • Typical way complex digital systems are designed in industry
  – CAD tools can synthesize lower levels of design abstraction from higher level descriptions
    • So what is the point of logic design?
      – CAD tools are not a magic wand, they don’t design the circuit for you!
Example of Digital System Design

- The integrated circuit design process
Hierarchical System Design

• Hierarchy is everywhere
  – Systems consist of units
  – Units consist of printed circuit boards (PCBs)
  – PCBs consist of integrated circuits (ICs)
  – ICs consist of logic gates
  – Logic gates consist of transistors

• Allows us to partition big designs into manageable components

• Once the circuit design works, why redesign it?
  – Instead, reuse it through hierarchical design
  – Reduces design time and design errors
Analog vs. Digital Systems

• Analog
  – Continuous time-varying voltages and/or currents
  – Basic elements of analog circuits:
    • Resistors
    • Capacitors
    • Inductors
    • Transistors

• Digital
  – Discrete signals sampled in time
  – Two possible values
    • 0V, low, false (logic 0)
    • 5V, high, true (logic 1)
  – Basic elements of digital circuits:
    • Logic gates: AND, OR, NOT
Elementary Logic Gates

**Name**
- Inverter (NOT Gate)

**Symbol**

**Truth Table**

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<th>In</th>
<th>Out</th>
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**Logic Equation**
- Out = In’

**AND Gate**

<table>
<thead>
<tr>
<th>In 1</th>
<th>In 2</th>
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<tr>
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**Logic Equation**
- Out = In1 • In2

**OR Gate**

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**Logic Equation**
- Out = In1 + In2
Advantages of Digital Systems

- Reproducible results
- Relative ease of design
- Flexibility and functionality
- High speed
- Small size
- Low cost
- Low power
- Steadily advancing technology
- Programmable logic devices
Digital Systems

• Most general model of a digital system
  – Often referred to as *General Sequential Logic*
    • aka *Huffman model*
  – Consists of:
    • Combinational logic
      – Performs logical operations
    • Memory elements
      – Stores data
  • These two items will be the focus of this course
    – Beginning with combinational logic
Stored Program Digital Computer

- Good example of a digital system
- Basic architecture consists of:
  - CPU
    - Control Unit
    - ALU
  - Memory
  - Input/Output (I/O) Devices

![Diagram of a digital computer system]

Central Processing Unit (CPU)

Control Unit

Arithmetic Logic Unit (ALU)

Memory

I/O Devices
Stored Program Digital Computer

**Memory:**
- Program Memory (MEM)
- Data Register (DR)

**I/O Devices:**
- Input Register (IN)
- Output Register (OR)

**Arithmetic-Logic Unit:**
- Arithmetic/Logic Unit (ALU)
- Accumulator (AC)
- ALU Carry Register (C)

**Control Unit:**
- Program Counter (PC)
- Address Register (AR)
- Instruction Register (IR)
- Timing Counter (TC)
- Control Logic
Stored Program Digital Computer

**Sequential Logic:**
- Program Memory (MEM)
- Program Counter (PC)
- Address Register (AR)
- Data Register (DR)
- Input Register (IN)
- Output Register (OR)
- Accumulator (AC)
- ALU Carry Register (C)
- Instruction Register (IR)
- Timing Counter (TC)

**Combinational Logic:**
- Control Logic
- Arithmetic/Logic Unit (ALU)
- Multiplexers 1&2 (MUX)
Digital Computer Basic Operation

• Consists of a series of instructions cycles, each consisting of:
  – Fetch
    • Fetch instruction from Program Memory (MEM) to Data Register (DR)
  – Decode
    • Pass instruction from DR to Instruction Register (IR) and decode using Control Logic
  – Execute
    • Perform operations decoded by Control Logic such as:
      – Get operands from MEM or Input Register (IN)
      – Arithmetic/logic operations
      – Store results in MEM or Output Register (OR)