Review

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Finishing up

- **Final exam:**
  - *Tuesday, 5/4/2010, from 1pm to 3pm*
    - Get there before 12:45pm
  - Closed-book
    - No computing devices
    - Only one sheet (letter-size, hand-written) is allowed

- Check your grades on WebCT
  - All grades will be posted before the exam

- Office hour: 10am – noon, Monday
What you will learn …

• Basic concepts and methods in digital circuit designs
  – Number systems
  – Boolean logic
  – Combinational circuit
  – Sequential circuit
  – LogicWorks to design and simulate circuit
• How to learn and how to solve problems
  – Read and think
    • A little more time in the design stage may lead to a better solution, which saves you a lot of time later in the implementation stage
• Write good reports
• Teamwork
  – Find a good partner and be a good partner
Digital design levels

• Behavioral level
  – $e = 2 ((b + c) + 1)$

• Register Transfer Level (RTL)
  – Registers and their connectivity are defined
  – Clock-to-clock behavior is defined
  – Control logic for the transfer is synthesized
    
    $a = b + c$
    $d = a + 1$
    $e = d * 2$

• Gate level (logic diagram)
• Transistor level
• Device physics and IC manufacturing
Number systems

- Conversions between any number systems of radices
  - Binary, octal, and Hexadecimal
- Computation of binary numbers
- Two’s complement numbers
  - Addition and subtraction
- Similarity and difference between unsigned binary numbers and two’s complement numbers
  - E.g., extension, overflow
  - Example: generate $A<B$ in the last lab

- Other coding systems
Boolean algebra

• Logic manipulation and reduction with axioms and theorems
  – DeMorgan’s law
  – Shannon’s expansion
Combinational circuit

- Basic gates
  - NOT, AND, NAND, OR, NOR, XOR, XNOR

- Different representations of a logic functions

- Karnaugh map
  - Assumptions are important
    - E.g., two levels, AND and OR gates

- Design constraints
  - Area, delay, and power
  - Critical path
Combinational circuit modules

- Three-state buffers
- Decoder
- Multiplexer
- Shifter
- Encoder
- Comparator
- Adder
  - Carry ripple
  - Carry lookahead
- Multiplier
Sequential circuit

- Basic bistate element
- Many latches and flip-flops
- State machines (Mealy and Moore machines)
  - Analysis of state machines
    - Circuit $\rightarrow$ State/output table or State diagram
  - Design of state machines
    - State/output table or State Diagram
    - State assignment
    - Transition/output table
    - Excitation table
    - Excitation equations
- Counters and registers
Topics not covered and future courses

• Memory
• Programmable logic
  – PLA, PAL, …, and FPGA
• A/D and D/A conversion
• Computer architecture
  – Build processors with gates and modules
• VLSI
  – Build gates and larger systems
  – Consider area, delay, and power
• Sequential systems
  – More on state machines (e.g. state assignment)
• CAD
  – Let computers do the job
• Testing
  – How do you know your circuits are working as expected?
• Security
  – Not everyone is nice