

CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN – MADISON

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Midterm Examination 2

In Class (50 minutes)

Wednesday, March 9

Weight: 15%

NO BOOK(S), NOTE(S), CALCULATOR(S) OF ANY SORT

This exam has 6 front-and-back pages, including a blank page at the end. Plan your time carefully, since some problems are longer than others. You must turn in pages 1 to 5.

LAST NAME: _____

FIRST NAME: _____

SECTION: _____

ID #: _____

| Question | Maximum Points | Points |
|-----------------|-----------------------|---------------|
| 1 | 4 | |
| 2 | 4 | |
| 3 | 8 | |
| 4 | 8 | |
| 5 | 4 | |
| 6 | 4 | |
| 7 | 8 | |
| Total | 40 | |

Problem 1 (4 points)

Use the truth table to answer the following questions.

| A | B | C | Z |
|----------|----------|----------|----------|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

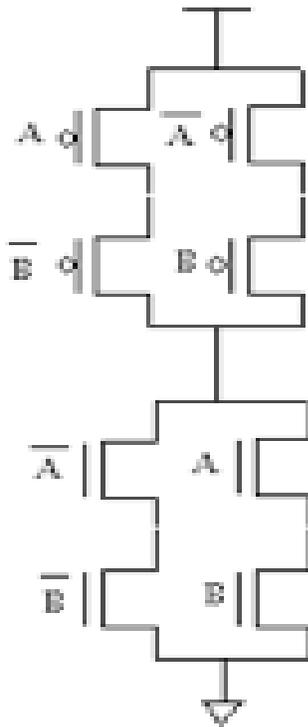
- a) Write the boolean expression which corresponds to the truth table. Do not simplify the expression.

Hint: Format your answer like: $Z = _____ + _____ + \dots$

- b) Draw the logic gate-level circuit which corresponds to the truth table. Do not simplify the expression.

Problem 2 (4 points)

Use the CMOS circuit below to answer the following questions. Inputs with the same name are assumed to be connected to each other. Names with a bar indicate the inversion of that input.



- a) Does the circuit below have any flaw? (Yes or No)
Hint: Evaluate the circuit for all sets of inputs

- b) If it does, identify it. If not, identify the logic function the circuit implements.

Problem 3 (8 points)

None of the pictures are drawn to scale. Suppose a 32-bit instruction takes the following format (not drawn to scale):

| | | | | |
|--------|------------|------|------|------|
| OPCODE | --UNUSED-- | DEST | SRC1 | SRC2 |
|--------|------------|------|------|------|

If there are 242 opcodes and 64 registers:

- a) What is the minimum number of bits required to represent the opcode?

- b) What is the minimum number of bits required to represent the SRC1, SRC2, and DEST registers?
(Provide the total number of bits)

- c) What is the maximum number of UNUSED bits in the instruction encoding?

- d) For these questions, you may (and it is probably easier to) provide your answers as 2^n .

If we decided to redesign the ISA and actually use the UNUSED bits, how many:

- i. opcodes could we have if we turned all the UNUSED bits into more opcode bits?

| | | | |
|--------|------|------|------|
| OPCODE | DEST | SRC1 | SRC2 |
|--------|------|------|------|

- ii. registers could we have in our computer if we turned all the UNUSED bits into more bits for the DEST, SRC1, and SRC2 fields? Remember, you must distribute the bits across SRC1, SRC2, and DST.

| | | | |
|--------|------|------|------|
| OPCODE | DEST | SRC1 | SRC2 |
|--------|------|------|------|

Problem 4 (8 points)

Show that a NAND gate (by itself) is logically complete. To do so,

a) Make a NOT gate from only NAND gates (use exactly 1 NAND gate)

b) Make an AND gate from only NAND gates (use exactly 2 NAND gates)

c) Make an OR gate from only NAND gates (use exactly 3 NAND gates)

Hint: Think DeMorgan's Law

d) Make a NOR gate from only NAND gates (use exactly 4 NAND gates)

Hint: Think DeMorgan's Law...again

Problem 5 (4 points)

With a 2:1 MUX, we can implement any two-variable function $F(A,B)$ by appropriately connecting 0, 1, A , \bar{A} , B , or \bar{B} to the various inputs.

- a) Design a 2-input OR gate using only a 2:1 MUX

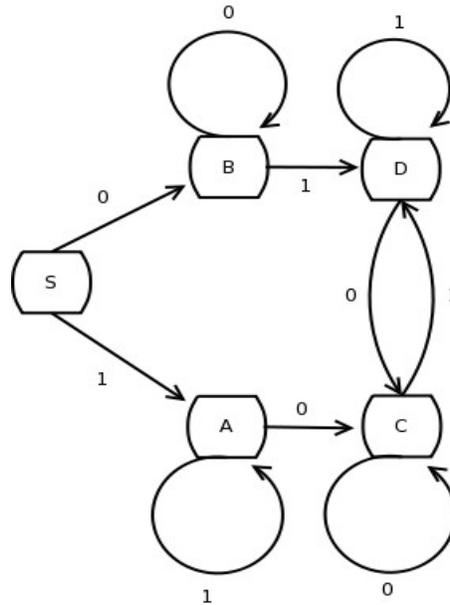
(Note: No additional logic elements are to be used)

- b) Design a 2-input AND gate using only a 2:1 MUX

(Note: No additional logic elements are to be used)

Problem 6 (4 points)

The figure below is a finite state machine (FSA) diagram where the start state is S. The machine reads binary input streams from **LEFT TO RIGHT**. Complete the questions below according to the behavior of this machine.



- a) For the following input sequences, what is the ending state (i.e. what state is the machine in after all of the input is read)?
- 1 0 0 0
 - 0 1 1 0 1 1
 - 0 1 0 1 0
- b) Assume the current state is B. What input sequence of length exactly 2 will get the machine to state C?

Problem 7 (1 point each – 8 points total)

Choose and circle the best answer for each question. Each question has exactly one correct answer.

Multiple Choice

1. If the number of address bits in a memory is increased by 2 and the addressability is halved, the size of memory (i.e. the number of bits stored in the memory)
 - a. Doubles
 - b. Remains unchanged
 - c. Halves
 - d. Increases by $2^{(\text{address bits})/\text{addressability}}$
2. The minimum number of transistors required to implement a CMOS 3-input AND gate is
 - a. 4
 - b. 6
 - c. 8
 - d. 10
3. The Decode step of the Instruction Cycle always examines which part of the instruction?
 - a. Immediate (literal) value
 - b. Opcode
 - c. Offset
 - d. Register
4. What is the difference between a Combinational logic circuit and a Sequential logic circuit?
 - a. A change in input for a Sequential logic circuit will propagate immediately to the output, while a Combinational circuit requires a clock pulse before the output changes
 - b. A Combinational logic circuit's output depends solely on the values that are present on the inputs now, while a Sequential logic circuit can depend on previous inputs
 - c. Combinational logic circuits are built from logic gates (e.g. AND, OR, NOT), while Sequential logic circuits are built from their inversions (e.g. NAND, NOR)
 - d. A Combinational logic circuit may have or implement memory, while a Sequential logic circuit operates only based on its current inputs

True/False

1. The MAR is where we put the data we are about to write out to memory.
 - a. True
 - b. False
2. DeMorgan's Law shows that if one inverts both the inputs and output of an AND gate, one has implemented an OR gate.
 - a. True
 - b. False
3. A Decoder would be a standard mechanism for interpreting the opcode part of an instruction.
 - a. True
 - b. False
4. A Gated-D Latch (with inputs D and Write-Enable) has a restricted combination of inputs; that is, there is a set of inputs which are illegal.
 - a. True
 - b. False

Extra Scratch Paper

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