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EHB 205E: Introduction to Logic Design

MIDTERM I

Duration: 120 Minutes

Grading: 1) 15%, 2) 30%, 3) 25%, 4) 30%

Exam is in closed-notes and closed-books format; calculators are allowed

For your answers please use the space provided in the exam sheet

GOOD LUCK!

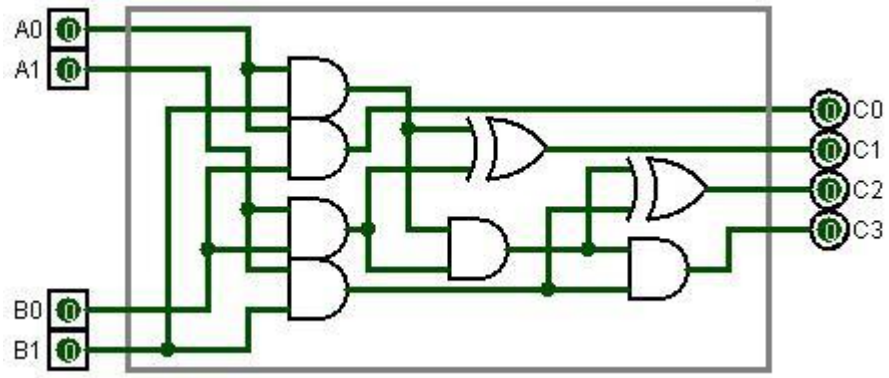
1) Consider a 4-variable Boolean function $f(x_1, x_2, x_3, x_4) = \sum(1,3,4,5,9,11,12,13,14,15)$; x_1 is the most significant bit. Obtain a minimal sum-of-products (SOP) expression for f using a **Karnaugh** map. Show all prime and essential prime implicants.

2) Consider a 6-variable Boolean function $f = f_1(x_1, x_2, x_3, x_4) \cdot f_2(x_4, x_5, x_6)$ where $f_1 = \prod(1,2,3,5,7,12,14)$ - x_1 is the most significant bit, and $f_2 = \prod(3,4,5,6,7)$ - x_4 is the most significant bit.

a) Obtain a minimal product-of-sum (SOP) expression for f.

b) Implement f using only **two-input NAND** (NAND-2) gates; use minimal number of gates. Use only variables as inputs (**not their negated forms)**.

3) Consider a circuit consisting of AND-2 and XOR-2 gates with 4 inputs , **A0**, **A1**, **B0**, **B1**, and 4 outputs, **C0**, **C1**, **C2**, **C3**.



a) Derive truth table of this circuit.

b) Suppose that for a certain application, always **A0=1** and **B0=0**. For this scenario, simplify the circuit by only using NOR-2 gates.

4) Consider 4 binary inputs representing decimal numbers from 0 to 15. Also consider a 7-segment display as shown below. It only shows two letters: H (stands for high), and L (stands for low). If the decimal number is below 5, the segment shows L; if the decimal number above 10 the segment shows H; otherwise the segment shows nothing. Design a circuit consisting of minimal number of NAND-2 gates for this operation. Note that the circuit has 4 inputs and 7 outputs; 7 outputs of the circuit are connected to 7 segments **a**, **b**, **c**, **d**, **e**, **f**, and **g**. If an output is logic 1 then the corresponding segment is illuminated or lit.