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THE NATIONAL UNIVERSITY OF IRELAND, CORK

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UNIVERSITY COLLEGE, CORK

Summer Examination 2010

Second Science

CS2502: Logic Design

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Answer all questions.

90 minutes

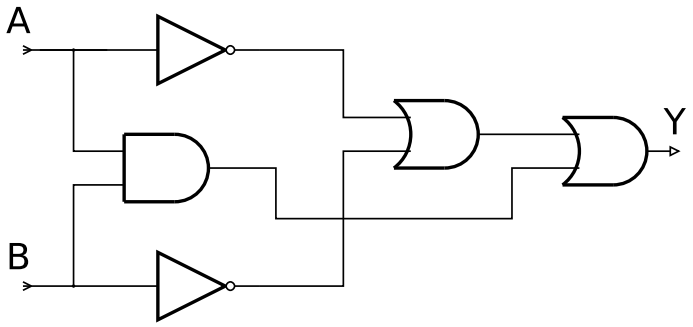
1. The questions deal with two well-known switching functions.

   a) Draw a circuit realization of the *exclusive OR* function (XOR) with two inputs. You may use AND, OR and NOT-gates. (*2 marks*)

   b) Draw a circuit realization of the *equivalence* function (EQ) with two inputs. You may use AND, OR and NOT-gates. (*2 marks*)

   c) Consider the two switching functions from a) and b). Give a formula that shows their relation, i.e. a formula that shows how one of these two functions can be expressed in terms of the other. (*3 marks*)

2. Consider the combinational circuit given in the diagram below.



   a) Determine the switching function of this circuit. (*3 marks*)

   b) Could this circuit ever be a part of a real technical device? Justify your answer. (*3 marks*)

3. Consider a combinational circuit with 4 inputs A, B, C, D and one output Y. Its switching function expressed as the *canonical sum of products* (CSOP) is given by

$$Y = f(A, B, C, D) = m_2 + m_3 + m_4 + m_5 + m_{10} + m_{11} + m_{13} + m_{15}$$

For clarification, the minterm m_2 is a short notation for the product $\overline{A} \cdot \overline{B} \cdot C \cdot \overline{D}$.

a) Rewrite f in CPOS form (*canonical product of sums*). You may use the short notation. (*4 marks*)

b) Use your answer to a) and a Karnaugh-map to express f in SPOS form (as a *simplified product of sums*). (*4 marks*)

c) Rewrite your result from b) into an expression that contains only OR and NOT operations and draw the corresponding circuit diagram. This circuit diagram should only contain NOR gates. (*3 marks*)

d) Rewrite your result from b) into an expression that contains only AND and NOT operations and draw the corresponding circuit diagram. This circuit diagram should only contain NAND gates. (*3 marks*)

4. The following questions deal with the properties of a *sequential circuit* which is given by the following specification:

The circuit is a *Moore machine* with one binary input X and one binary output Y. The output Y depends on the two values of X sampled at the two most recent clock pulses. Y should always be the result of the XOR combination of these two input values.

For example, lets assume we have $X = 1$ when a clock pulse occurs. Lets assume that X has not changed when the next clock pulse occurs. Since the last two sampled values of X are *equal*, the output now assumes $Y = 0$, regardless of its previous value. Now consider the next clock pulse and lets assume that X has meanwhile changed to $X = 0$. This means the last two sampled input values are *opposite* and therefore the output now changes to $Y = 1$.

a) Draw the state diagram for this circuit. Make sure that all arcs and all states are correctly labelled.
Hint: Your diagram should contain 4 states. However, a *Mealy machine* with similar behaviour could be realized with two states only. (*4 marks*)

b) Develop the *transition table* of this sequential circuit. Make sure the rows and columns carry the correct labels. (*3 marks*)

c) Give an input sequence for X that causes the output Y to alternate with every clock pulse ($Y = 0, 1, 0, 1, 0, 1, \ldots$). (*3 marks*)

d) Lets assume the input X changes several times *between two subsequent clock pulses*. How do such changes affect the output Y? Justify your answer. (*3 marks*)