UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

DIGITAL ELECTRONICS I

COURSE CODE – E362

MAY 2010

DURATION OF THE EXAMINATION - 3 HOURS

INSTRUCTIONS TO CANDIDATES

i. There are FIVE questions in this paper. Answer any FOUR questions only.

ii. Each question carries equal marks.

iii. Show all your steps clearly in any calculations.

iv. State clearly any assumptions made.

v. Start each new question on a fresh page.

Question 1

a) An 8 x 1 multiplexer has inputs A, B, and C connected to the selection inputs S_2, S_1, and S_0, respectively. The data inputs I_0 through I_7 are as follows: $I_1 = I_2 = I_7 = 0$; $I_3 = I_5 = 1$; $I_0 = I_4 = D$; and $I_6 = D'$. Determine the Boolean function that the multiplexer implements (express it is sum of products). [5]

b) The circuit in Figure 1 shows a BCD to 7-segment LED decoder connected to the 7-segment LED. In order to light a particular segment of the 7-segment LED, a logic 1 must be applied to the respective segment: a, b, c,....g. The purpose of the decoder is to convert a binary coded decimal (BCD) input applied at A0, A1, A2, and A3 into a corresponding output on: a, b, c, d, e, f, and g such that an appropriate decimal digit (0..9) is displayed on the 7-segment LED. Design a logic circuit to implement the decoder function using a minimum number of gates. The six invalid combinations should result in a blank display. [20]

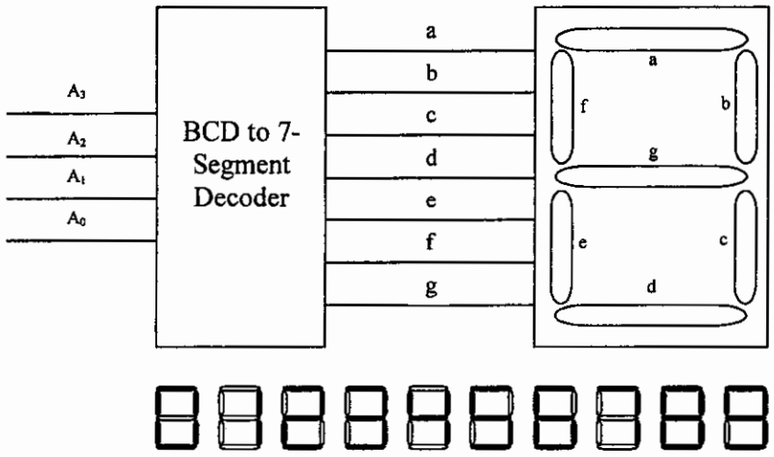

Figure 1.

Question 2

a) Design a half-subtractor circuit with inputs x and y and outputs D and B. The circuit subtracts the bits x – y and places the difference in D and the borrow in B. [4]

b) Derive the Boolean expressions for the output sum and output carry in a full adder circuit with inputs x_i, y_i, and c_i. [6]

c) Define the carry propagate and carry generate as

$$P_i = x_i + y_i$$
$$G_i = x_i y_i$$

respectively. Show that the output carry and output sum of a full adder becomes

$C_{i+1} = (C'_i G'_i + P'_i)'$ [8]
$S_i = (P_i G'_i) \oplus C_i$ [7]

Question 3

(a) Given the Boolean function: F = xy'z + x'y'z + w'xy + wx'y + wxy

i. Obtain the truth table of the function. [4]
ii. Draw the logic diagram using the original Boolean expression. [4]
iii. Simplify the function to a minimum number of literals using Boolean algebra. [3]
iv. Obtain the truth table of the function from the simplified expression and show that it is the same as the one in part (a). [3]
v. Draw the logic diagram from the simplified expression and compare the total number of gates with the diagram part in (b). [3]

(b) Using the tabular method, minimize the following Boolean function:
F = a'b'c' + a'b'c + ab'c + abc' + abc [8]

Question 4

a) Define the following terms as used in digital electronics:
i. Combinational circuit
ii. Sequential circuit
iii. Magnitude Comparator [6]

b) Design a 4-bit Magnitude Comparator which compares two 4-bit binary numbers A, B and determines whether A<B, A>B, or A=B. [10]

c) Design a combinational circuit with three inputs x, y, z and three outputs A, B, and C. When the binary input is 0, 1, 2, or 3, the binary output is one greater than the input. When the binary input is 4, 5, 6, or 7, the binary output is one less than the input. [9]

Question 5

a) Figure 2 depicts an intersection between two roads. Traffic through Road 1 is one way and in the direction shown by the arrow labeled 1. This traffic is controlled by traffic light TB. Traffic through Lane A flows in the direction shown by the arrow labeled 3. This traffic is controlled by traffic light TA. Each traffic light module has three lights (RED, GREEN, and AMBER).

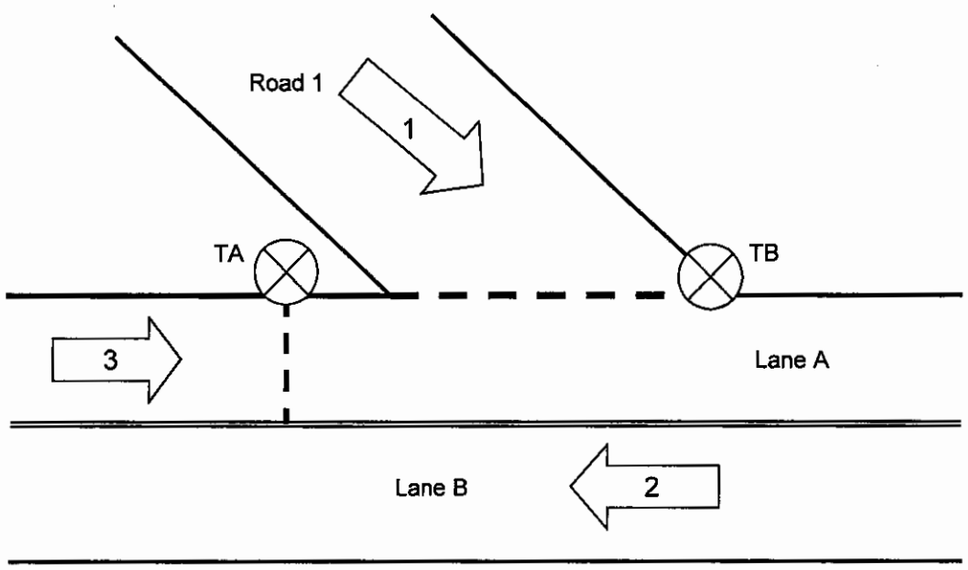

Figure 2. Road intersection for question 5

The design of the traffic controller consists of two modules: a *control* and an *interface* module. The control module provides control signals for switching the traffic lights on and off. The interface links the control module to the traffic lights. As shown in figure 2, there are six traffic lamps (3 in TA plus 3 in TB). Each lamp has a 1-bit memory unit that stores its current state. The traffic controller reads the values stored in the memory units to determine the current state of the traffic lamps. However, the control module has only six (6) pins for linking to the interface: three (3) pins are for output, and the other half for input.

Using SSI or MSI chips, suggest how the engineer can complete this design. Draw the necessary block diagram(s) of the system and a basic flow chart for the traffic control routine implemented in the control module.

[21]

b) What do you understand by the following terms as used in digital electronics:
   i. Encoder;
   ii. Decoder;
   iii. Multiplexer;
   iv. Demultiplexer.

[4]

END OF PAPER