UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

DIGITAL ELECTRONICS II

COURSE CODE – E441

MAIN EXAMINATION DECEMBER 2010

DURATION OF THE EXAMINATION - 3 HOURS

INSTRUCTIONS TO CANDIDATES

1. There are FIVE questions in this paper. Answer any FOUR questions only.
2. Each question carries equal marks.
3. Show all your steps clearly in any calculations.
4. State clearly any assumptions made.
5. Start each new question on a fresh page.

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Question 1

Design a versatile 3-bit shift register capable of operating in the following modes:

(i) converting data from parallel to serial

(ii) converting data from serial to parallel

(iii) parallel input and output of data

(iv) shifting data from left to right and from right to left

Explain in detail how your design meets the above requirements. [25]

Question 2

(i) Explain the difference between level-triggered and edge-triggered circuits. [2]

(ii) With the aid of a diagram explain how a positive-edge-triggered flip-flop works. [5]

(iii) Derive the state table, state diagram, and boolean expressions for the outputs A0 to A3 in the circuit diagram shown in Figure Q2. Explain the function that the circuit performs. [10]

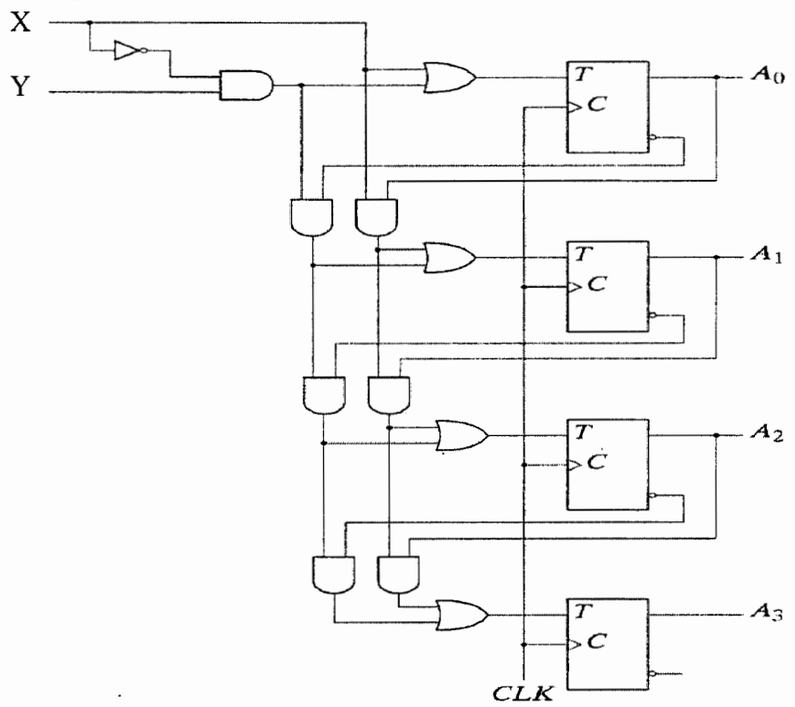

Figure Q2. Circuit diagram for Question 2(iii)

(iv) With the aid of a diagram (or diagrams), explain how a Master-Slave D flip-flop works. Explain the rationale for having this type of circuit edge-triggered rather than level-triggered. [8]

Question 3

a) A sequential circuit has three flip-flops A, B, C; and one input x. The state diagram is shown in Figure Q3. Analyze the circuit obtained and implement the design using T-Flip Flops. Treat any unused states as "don't cares". [15]

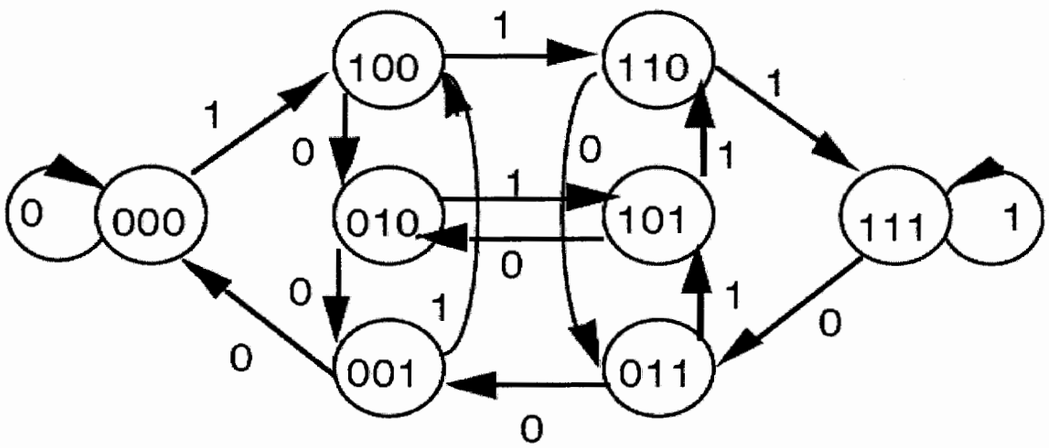

Figure Q3. State Diagram of Sequential Circuit

b) Draw circuit diagrams of a clocked R-S Flip-Flop and a clocked J-K Flip-Flop and explain the following:

i. Illustrating with a characteristic table, how a clocked R-S Flip-Flop works.

ii. Why a clocked J-K Flip-Flop is said to be an improvement to an R-S Flip-Flop?

[10]

Question 4

a) Compare and contrast the features of Microcontrollers and microprocessors? [6]

b) Figure Q4 shows a two lane busy road that passes over a narrow bridge. Due to the narrow bridge, traffic coming from opposite directions (Traffic A and B) cannot pass over the bridge at the same time. To ensure an orderly flow of traffic over the bridge, the traffic control lights have been introduced. Each traffic light has a RED, AMBER, and GREEN lamps.

The traffic control lights are required to operate so that traffic flows as follows: Traffic B is allowed 1 minute to pass through, while traffic A is allowed 2 minutes. Traffic A is allowed to pass through the bridge when the GREEN light in Control Lights A is ON,

otherwise the Traffic A is stopped. Similarly traffic B can only pass through the bridge when the GREEN lamp in traffic control B is on. When a traffic control light turns from GREEN to RED, for 3 seconds, it turns ON the AMBER light and then switch on the RED lamp. Assume that, initially (before the control regime come into effect), all traffic is stopped for 10 seconds.

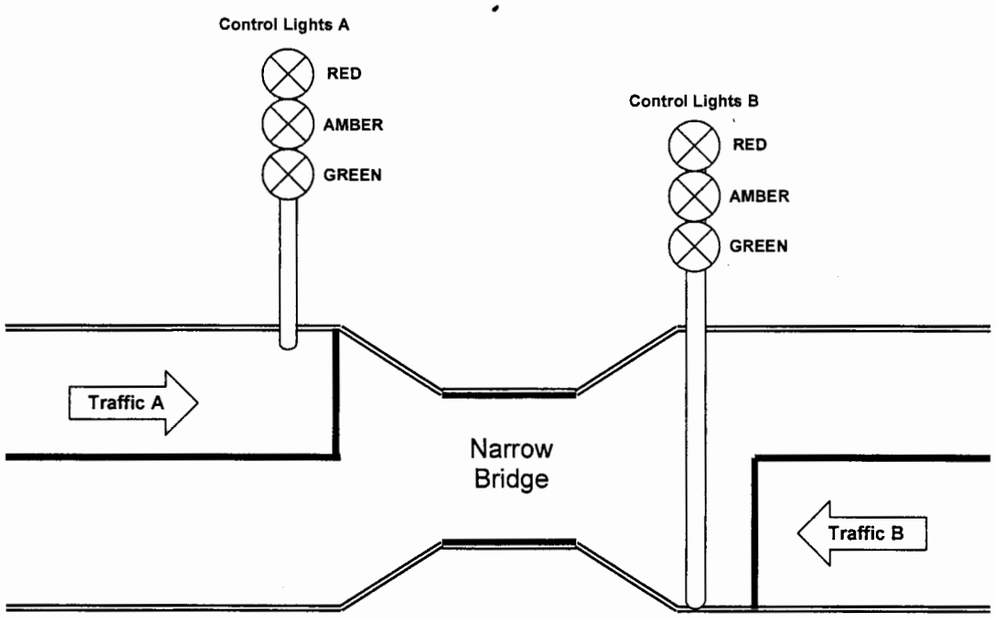

Figure Q4. Traffic control lights diagram for Question 5 (b)

You are required to design a machine language-based program that when executed by a microprocessor would make sure that the control lights control the traffic through the bridge according to the above control regime. As part of your solution produce the following artefacts:

(i) A state chart modeling the behavior of the traffic control system. [7]

(ii) A truth table that shows a sequence of how the six lights would be switched ON and OFF. [6]

(iii) Write a machine code program (to be executed by the microprocessor) based on the table in (iii) to meet the requirements of the traffic lights control regime. [6]

In writing your program, assume that the instruction set of the microprocessor has ONLY the following low-level instructions:

```
CC AB
DE YY
F5 XXXX
```

The meanings of the above instructions are as follows:

- The instruction *CC* sends control data to turn ON and OFF the traffic lights. It takes as an operand the hexadecimal control value defined in AB, converts it into a binary equivalent, and sends it to output port B, where the traffic control interface is connected. The assignment of the traffic lamps to the bits in the control word AB is as shown in the table below:

Traffic Lamp	X	X	Red A	Amber A	Green A	Red B	Amber B	Green B
Bit Assigned	A_3	A_2	A_1	A_0	B_3	B_2	B_1	B_0

X = Not used

- The instruction *DE* delays execution of the next instruction in the program for a time period equivalent to the seconds stated in the hexadecimal operand YY.

- Instruction *F5* is a GOTO instruction which redirects program execution to the address specified by hexadecimal address XXXX. For example, the following instructions will redirect program execution to start at address 1005:

```
F5
10
05
```

Also assume that the execution of your program starts at address 1000 and that immediate addressing is used.

State clearly any other assumptions you have made in your solution.

Question 5

(a) Design an up-down counter that counts in the following sequence: 0,1,3,5,6,7. When counting-up the next states for unused states should be 0, and when counting-down the next states for unused states should be 7. Implement your design using J-K Flip Flops. Show all diagrams and working in your design. [20]

(b) Using examples, compare and contrast Mealy and Moore models of Finite State Machines. [5]

END OF PAPER