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COURSE: CEG2136/CEG2536
Computer Architecture I

SEMESTER: Fall 2012

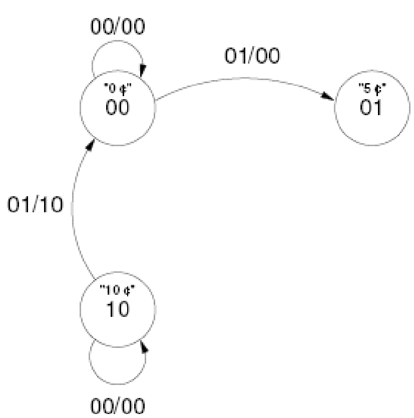
Assignment 1

Q1. Design of a vending machine

Design and draw the logical diagram of a vending machine for pop drinks. Each can cost 15 cents. Only coins of 5 cents and of 10 cents are accepted. The circuit has two inputs X_1X_0, and two outputs Y_1Y_0. The behaviour of the circuit is described below:

X_1X_0	Description	
0 0	No money is deposited in the machine	Y1 = 1 => Dispense a can
0 1	1 nickel is deposited in the machine	Y0 = 1 => Give change a nickel
1 0	1 dime is deposited in the machine	

1. Assuming that the machine starts from state 00, complete the state diagram of the sequential circuit given in the following figure:



2. Derive the state table and then the excitation table, given that JK flip-flops are used for the state register of this sequential circuit.

3. Derive the simplified excitation equations of the JK flip-flops and the output equations.

4. Draw the logic diagram of the circuit, using only NAND gates and JK flip flops.

Q2. Conceive a 3-bit multifunction register that can perform the following operations:

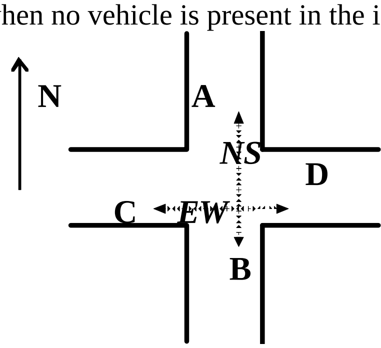
c_1	c_0	Function
0	0	Store (preserve) register's content
0	1	Right shift (register's *serial input* is connected to an external input *I*)
1	0	Increment by 1
1	1	Swap the most significant bit (msb) with the least significant bit (lsb)

Use T-type flip flops and any logic gates or other combinational digital circuits.

Q3. Implement $\boldsymbol{f}\,(A,B,C,D)= \Sigma(1,4,5,7,9,12,13)$ using a MUX(8x1) where *A*, *C*, and *D* are connected to the multiplexor's select inputs.

Q4. The figure below represents an intersection of two streets. Sensors have been placed in the proximity of the intersection, along A, B, C and D lanes to detect vehicles' presence. A sensor's output is **1** when there is <u>no</u> vehicle on its monitored lane (indicated as *free* in the following) and **0** when a vehicle is present (*busy* lane). The two sets of intersection lights (East-West or *EW*, and North-South or *NS*) observe the following logic:

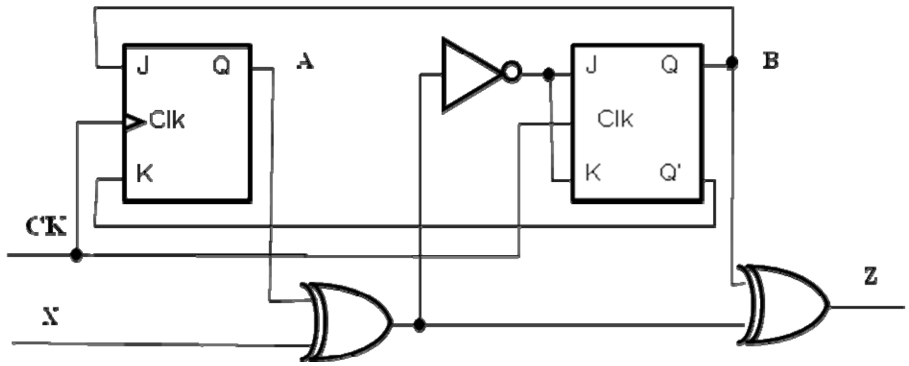
1) The *EW* lights will turn green when vehicles will be simultaneously detected on both C and D lanes.
2) The *EW* lights will also be green when either C is *busy* or D is *busy*, and, if A and B are not both *busy* at the same time.
3) The *NS* lights will be green when vehicles will be sensed on both A and B lanes, and, if C and D are not simultaneously *busy*.
4) The *NS* lights will also turn green when either A is *busy* or B is *busy*, but C and D are both *free*.
5) The *EW* lights will also be green when no vehicle is present in the intersection.



a) Using sensors A, B, C, D as input variables, implement a logical combinational circuit that controls the lights. There will be 2 output functions *NS(A,B,C,D)* and *EW(A,B,C,D)* whose values will be 1 when the light is green (and **0** for the red!). Simplify the 2 functions and derive their Sum-of-Products minimal form (no logic diagram asked).

b) Realize NS(A,B,C,D) and EW(A,B,C,D) using a 4-to-16 decoder and 2 OR gates; draw the circuit diagram.

Q5. A sequential circuit has two *JK* flip-flops *A* and *B*, one input *X* and one output *Z*. The circuit **logic diagram is shown below**. Derive the circuit **State Table** as well as the **State diagram**.



Q6. Using *D flip-flops*, design and implement (devise the logic diagram) the sequential circuit specified by the following state table:

Present State	Next State X=0	Next State X=1	Output Z X=0	Output Z X=1
00	00	01	0	0
01	00	11	0	0
10	10	11	0	0
11	00	01	0	1

Q7. Using *JK flip-flops*, design and implement (devise the logic diagram) the sequential circuit specified by the following state table:

Present State		Input	Next State	
A	B	X	A	B
0	0	0	0	0
0	0	1	0	1
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	1
1	1	1	0	0