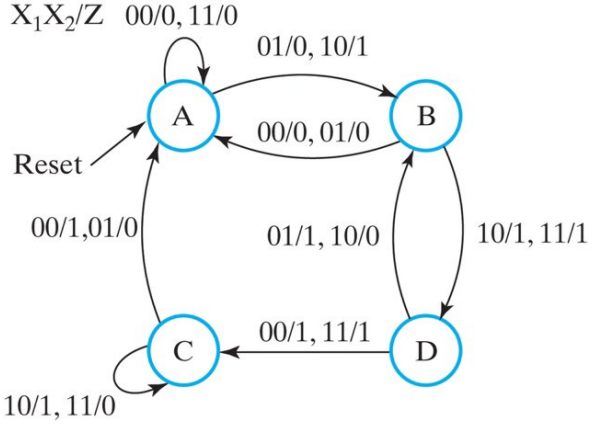
The University of New South Wales

ELEC2141: Digital Circuit Design

Tutorial Week 7 – Sequential Circuit Design

1. **(4-13)** Design a sequential circuit with two D flip-flops A and B and one input X. When $X = 0$, the state of the circuit remains the same. When $X = 1$, the circuit goes through the state transitions from 00 to 10 to 11 to 01, back to 00, and then repeats. Draw the logic diagram for the circuit.

2. **(4-14)** The state diagram of a sequential circuit is shown below



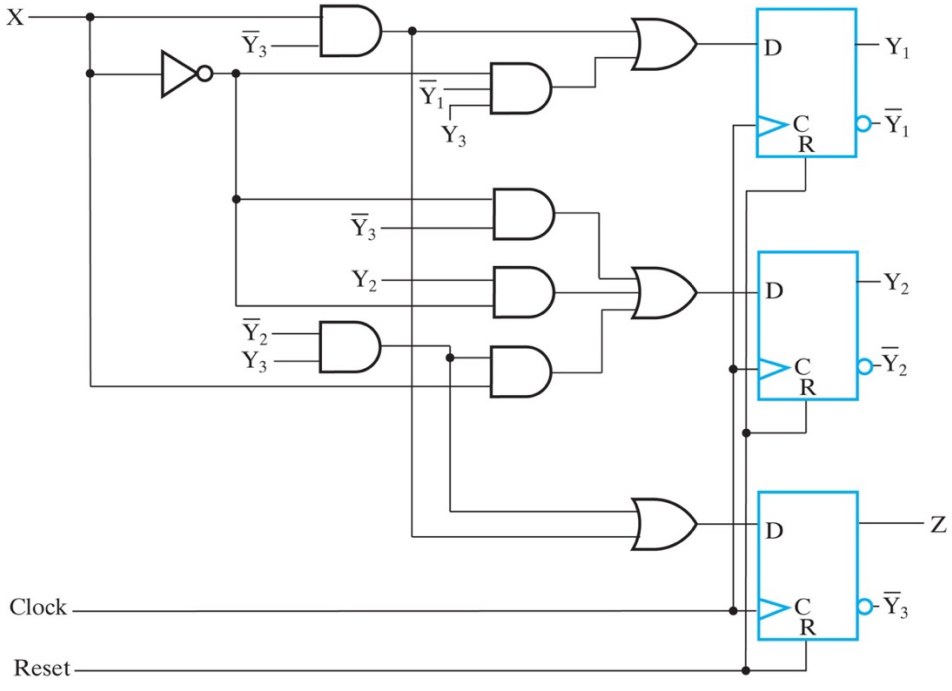
   a. Find the state table for the circuit
   b. Make a state assignment for the circuit using 2-bit codes and find the encoded state table
   c. Find an optimized circuit implementation using D flip-flops, NAND gates and inverters
   d. Repeat parts (b) and (c) using one-hot encoding for the state assignment

3. **(4-16)** The circuit below is to be redesigned to cut its cost.

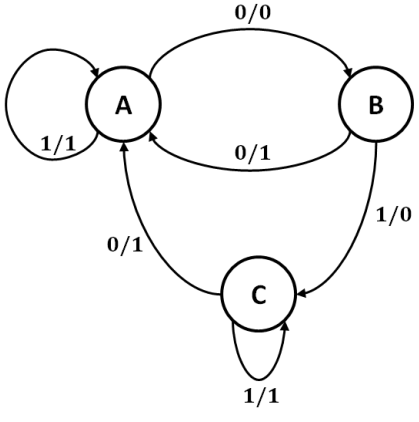
   a. Find the state table for the circuit and replace the state codes with single letter identifiers. States 100 and 111 were unused in the original design
   b. Check for and combine equivalent states
   c. Make a state assignment such that the output is one of the state variables
   d. Find the gate input costs of the original circuit and your circuit, assuming that the gate input cost of the D flip-flop is 14. Is the cost of the new circuit reduced?

Where referenced, questions are taken from the textbook:

M. Mano, C. R. Kime and T. Martin, Logic and Computer Design Fundamentals, 5th Edition (Global Edition), Pearson, 2016

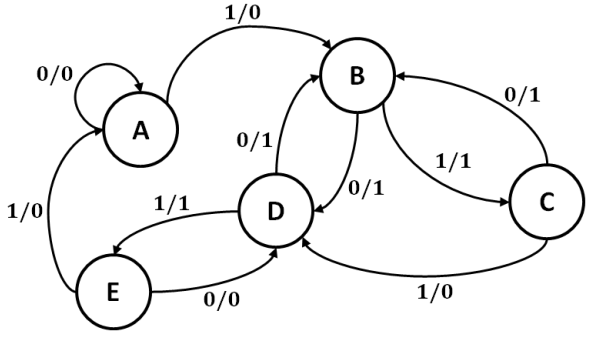


4. Design a circuit that implements the following state diagram:



a. Using D flip-flops
b. Using T flip-flops

5. Design a circuit that implements the following state diagram:



a. Using D flip-flops
b. Using JK flip-flops

6. Find a minimal state machine equivalent to the state machine whose state table is given below.

Current State	Next State, Output	
	X = 0	X = 1
A	H, 1	A, 0
B	E, 1	H, 1
C	E, 1	D, 1
D	A, 0	G, 0
E	C, 0	E, 1
F	D, 1	F, 0
G	E, 1	H, 1
H	F, 0	B, 0

7. Find a minimal state machine equivalent to the state machine whose state table is:

Current State	Next State		Output
	X = 0	X = 1	Z
A	E	C	0
B	B	C	1
C	A	E	1
D	E	D	0
E	D	B	0

8. **(4-20)** A Universal Serial Bus (USB) communicator link requires a circuit that produces the sequence 00000001. You are to design a synchronous sequential circuit that starts producing this sequence for input $E = 1$. Once the sequence starts, it completes. If $E = 1$, during the last output in the sequence, the sequence repeats. Otherwise, if $E = 0$, the output remains the constant at 1.

   a. Draw the Moore state diagram for the circuit
   b. Find the state table and make a state assignment
   c. Design the circuit using D flip-flops and logic gates. A reset should be included to place in the circuit in the appropriate initial state at which E is examined to determine if the sequence of constant 1s is to be produced.

9. **(4-23)** In many communication and networking systems, the signal transmitted on the communication line uses a non-return-to-zero (NRZ) format. USB uses a specific version referred to as non-return-to-zero inverted (NRZI). A circuit that converts any message sequence of 0s and 1s to a sequence in the NRZI format is to be designed. The mapping for such a circuit is as follows:

   a. If the message bit is a 0, then the NRZI format message contains an immediate change from 1 to 0 or from 0 to 1, depending on the current NRZI value.

b. If the message bit is a 1, then the NRZI format message remains fixed at 0 or 1, depending on the current NRZI value.

This transformation is illustrated by the following example, which assumes that the initial value of the NRZI message is 1:

Message: 10001110011010
NRZI Message: 10100001000110

a. Find the Mealy model state diagram for the circuit.
b. Find the state table for the circuit.
c. Find an implementation of the circuit using D flip-flops and logic gates.
d. Find an equivalent Moore model implementation of the circuit.