1. (a) Using the minimum 2-level SoP logic required, design a sequential circuit with three T flip-flops, A, B and C, and two inputs E and X that performs as follows:
   - If E = 0 the circuit remains in the same state regardless the value of X,
   - When E = 1 and X = 1 the circuit goes through the state transitions 000 to 001 to 010 to 011 to 100 back to 000, and repeats,
   - When E = 1 and X = 0 the circuit goes through the state transitions 111 to 110 to 101 to 100 to 011 back to 111, and repeats.

   (b) Is the countup self-starting, *i.e.* if X remains at 1? Justify. Include state transition diagram.

   (c) Is the countdown self-starting, *i.e.* if X remains at 0? Justify. Include state transition diagram.

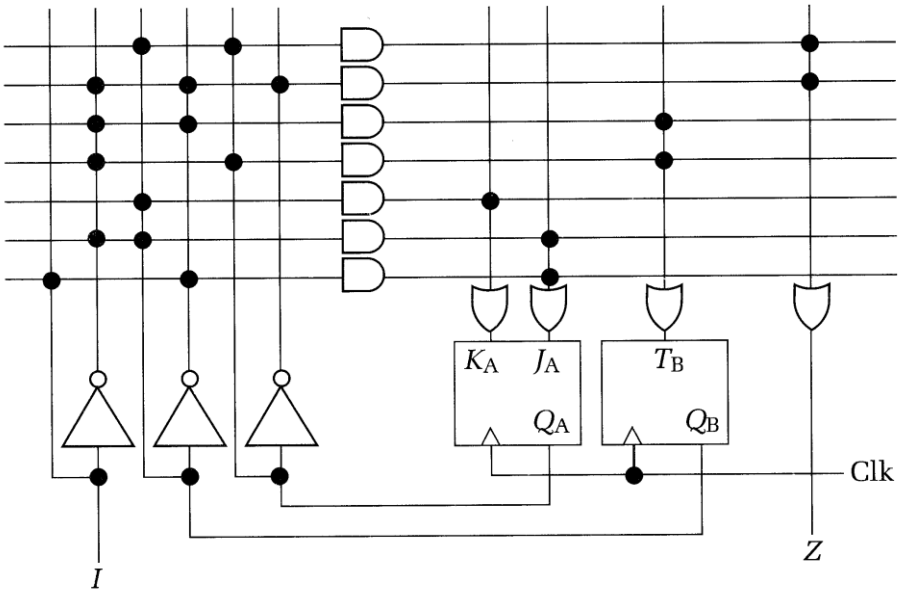
2. The finite state machine (FSM) shown in the figure below is implemented with one toggle (T) flip-flop and one JK flip-flop. It has one input I and one output Z. The combinational logic required for the next state and output functions is implemented by a PLA structure.

   (a) Write the logic expressions for J_A, K_A, T_B and Z.

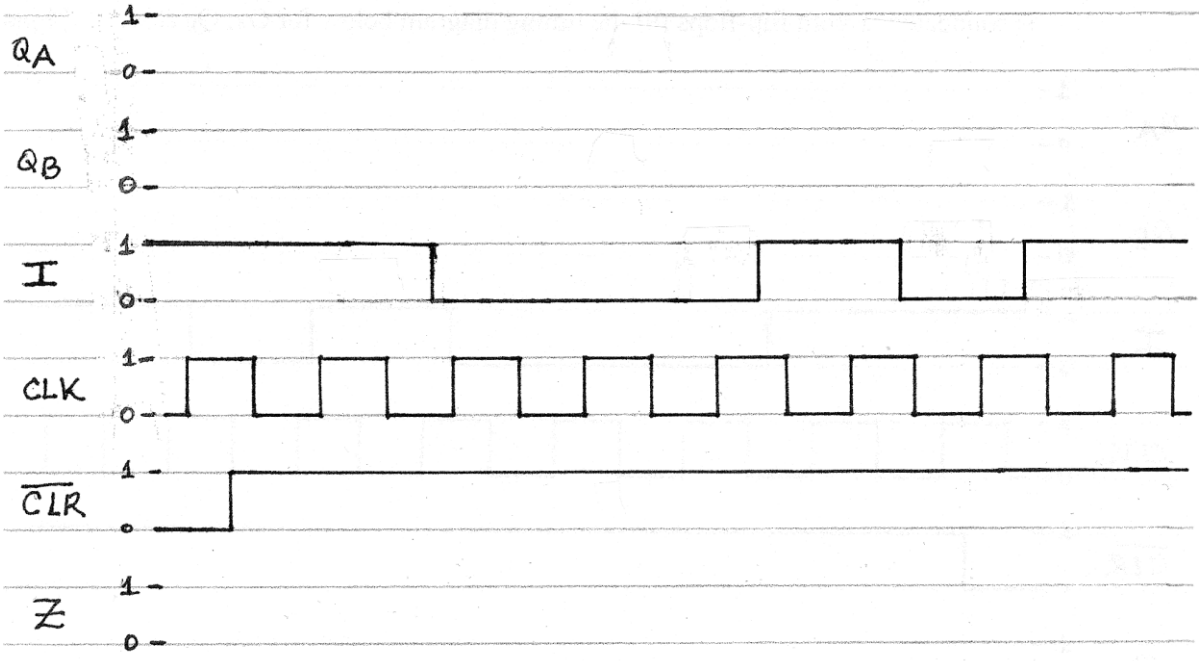
   (b) Which of the two types of FSM seen in classes is this? Justify.

   (c) Obtain the state transition table including the output Z.

   (d) Draw the complete state transition diagram of the FSM.



   (e) Assuming the $\overline{PR}$ is deasserted (HIGH) and the active-low clear $\overline{CLR}$ below is connected to both flip-flops fill the timing diagram below for Q_A, Q_B & Z.



3. Design a Mealy finite state machine controller for the simple vending machine example learnt in class (coursenotes pp. 217-226).