Istanbul Technical University
Department of Computer Engineering

October 16, 2022

BLG 231E - Digital Circuits

Assignment 5

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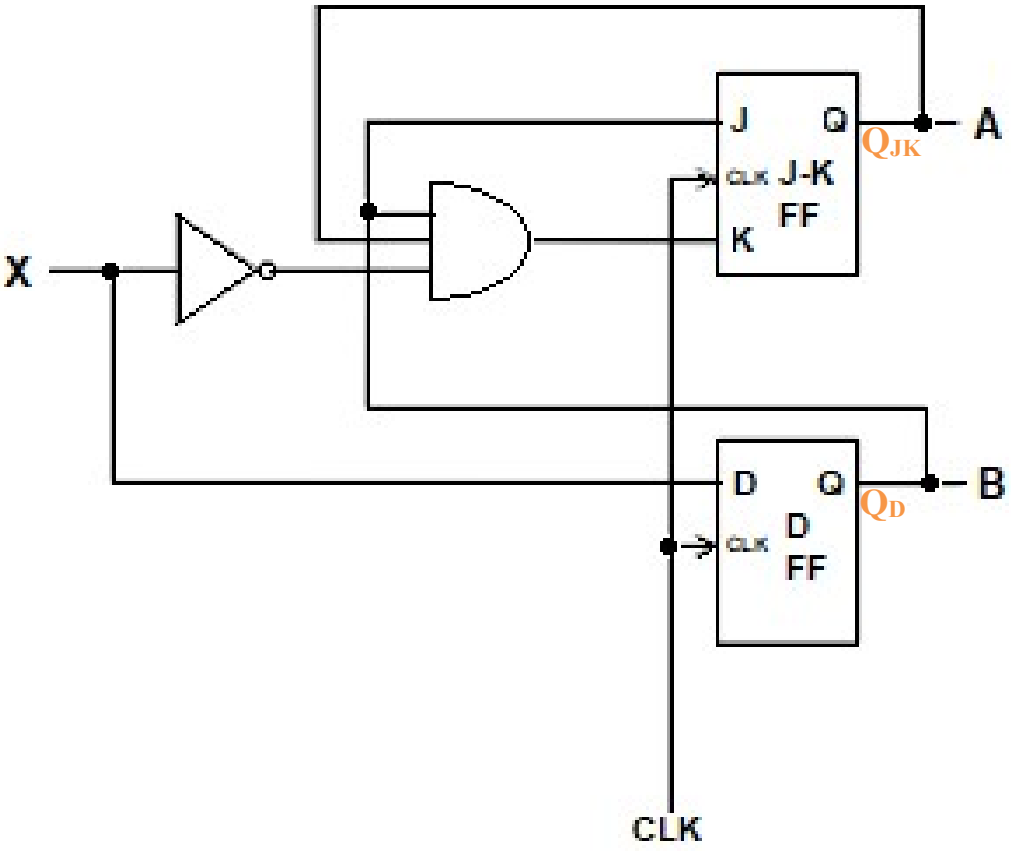
Analyze the synchronous sequential circuit with a single input (X) and two outputs (A, B) shown in the figure below. **(Note:** One flip-flop is a J-K flip-flop, the other is a D flip-flop).



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a) Write the next state equations, $S^+ = H(S,I)$.

$S^+ = \{Q_{JK}^+, Q_D^+\}$

$J = Q_D$
$K = X' \cdot Q_D \cdot Q_{JK}$ } $F(S,I)$
$D = X$

$Q_{JK}^+ = J \cdot Q_{JK}' + K' \cdot Q_{JK}$ (J-K flip-flop characteristic equation)
$Q_{JK}^+ = Q_D \cdot Q_{JK}' + (X' \cdot Q_D \cdot Q_{JK})' \cdot Q_{JK}$
$Q_{JK}^+ = Q_D \cdot Q_{JK}' + (X + Q_D' + Q_{JK}') \cdot Q_{JK}$
$Q_{JK}^+ = Q_D \cdot Q_{JK}' + X \cdot Q_{JK} + Q_D' \cdot Q_{JK} + Q_{JK}' \cdot Q_{JK}$
$Q_{JK}^+ = Q_D \cdot Q_{JK}' + Q_D' \cdot Q_{JK} + X \cdot Q_{JK}$
$Q_{JK}^+ = Q_D \oplus Q_{JK} + X \cdot Q_{JK}$

minimization

$Q_D^+ = D$ (D flip-flop characteristic equation)
$Q_D^+ = X$

$Q_{JK}^+ = Q_D \oplus Q_{JK} + X \cdot Q_{JK}$
$Q_D^+ = X$
$S^+ = H(S,I)$

b) Construct the state/output table.

$S^+ = \{Q_{JK}^+, Q_D^+\}$

$Q_{JK}^+ = Q_D \oplus Q_{JK} + X \cdot Q_{JK}$
$Q_D^+ = X$
$S^+ = H(S,I)$

Outputs A and B depend only on the state variables (Q_D, Q_{JK}).
The circuit is designed using the Moore model and output functions are in the form of $O = G(S)$
Output function for output A:
$A = Q_{JK}$
Output function for output B:
$B = Q_D$

$Q_{JK}^+ Q_D^+$ / $Q_{JK} Q_D$ \ X	0	1	A	B
00	00	01	0	0
01	10	11	0	1
10	10	11	1	0
11	00	11	1	1

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c) Draw the state diagram.