UNIVERSITY OF CALIFORNIA, RIVERSIDE

Department of Computer Science and Engineering
Department of Electrical Engineering
CS/EE120B – Introduction to Embedded Systems
Midterm 1 Version 2
April 25, 2001

26

Name:__Solution Key______________ **Student ID#:__________________**
Please print legibly

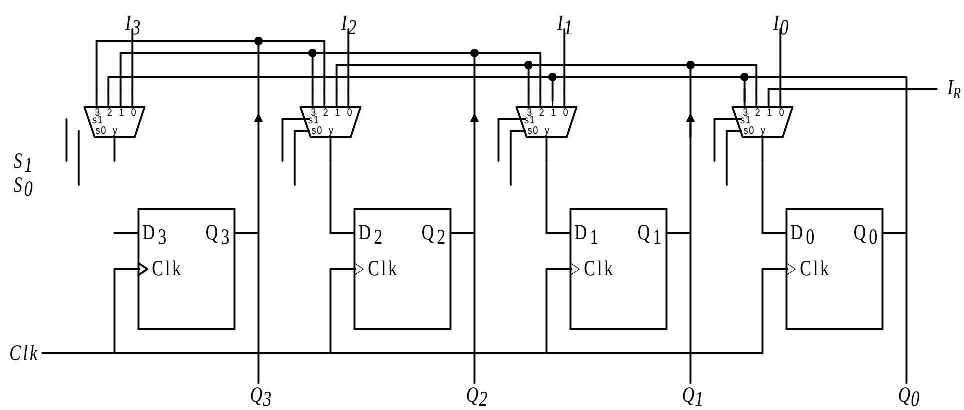
Lab Section: 21 (TR 6-10):_____ **22** (WF 6-10):_____ **23** (WF 2-6):_____

(Numbers in parenthesis denote total possible points for question.)

1. Draw a 4-bit shifter / rotator circuit having the following functional table (4)

S_1	S_0	Function
0	0	Load
0	1	Shift Left
1	0	Rotate Right
1	1	No Change

Answer



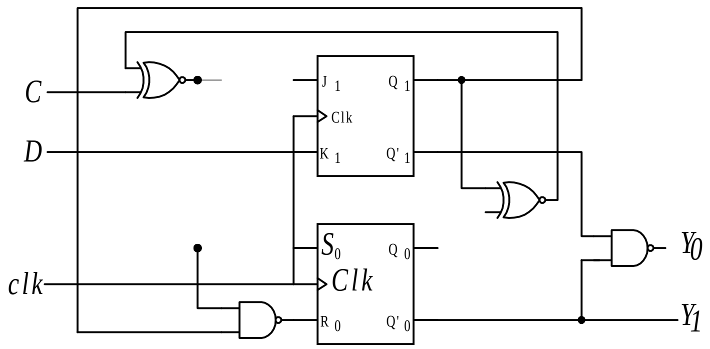
2. Are there any equivalent states in the following next-state/output table and if so, which states are equivalent? Give your reasons. (2)

Current State	Next State				Output
	CD = 00	CD = 01	CD = 10	CD = 11	
S1	S2	S1	S2	S3	0
S2	S4	S3	S1	S2	0
S3	S2	S1	S4	S3	0
S4	S4	S3	S1	S2	1

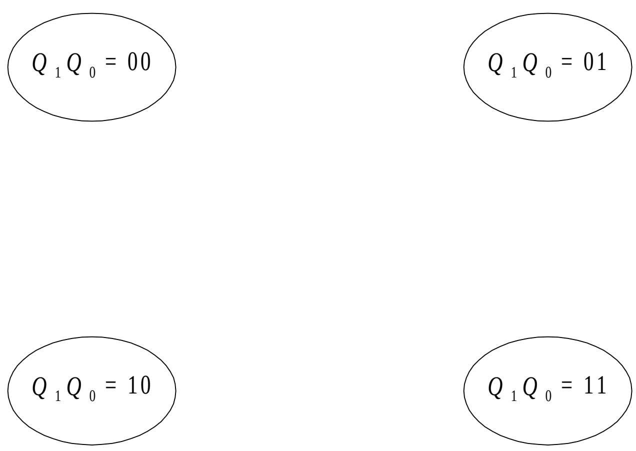
Answer

There are NO equivalent states.

3. Derive (a) excitation equations, (b) characteristic equations, (c) next-state equations, (d) output equations, (e) next-state/output table, and (f) a state diagram for the circuit shown below. Be consistent with the label order for the inputs, states, and outputs, i.e. use the order *CD*, Q_1Q_0, and Y_1Y_0 respectively; and use the state diagram template below to draw your state diagram. (12 points)



Circuit



State diagram template to use for part (f).

Answer

(a) The **excitation equations**

$J_1 = C \oplus Q_1 \oplus Q_0$
$K_1 = D$
$S_0 = C \oplus Q_1 \oplus Q_0$
$R_0 = [(C \oplus Q_1 \oplus Q_0)\ Q_1]'$

(b) The **characteristic equations**

For the JK flip-flop: $Q_{1next} = K'Q + JQ'$
For the SR flip-flop: $Q_{0next} = S + R'Q$

(c) The **next-state equations**

$$
\begin{aligned}
Q_{1next} &= K_1'Q_1 + J_1Q_1' \\
&= D'Q_1 + (C \oplus Q_1 \oplus Q_0)Q_1' \\
Q_{0next} &= S_0 + R_0'Q_0 \\
&= (C \oplus Q_1 \oplus Q_0) + (C \oplus Q_1 \oplus Q_0)\, Q_1Q_0 \\
&= (C \oplus Q_1 \oplus Q_0)
\end{aligned}
$$

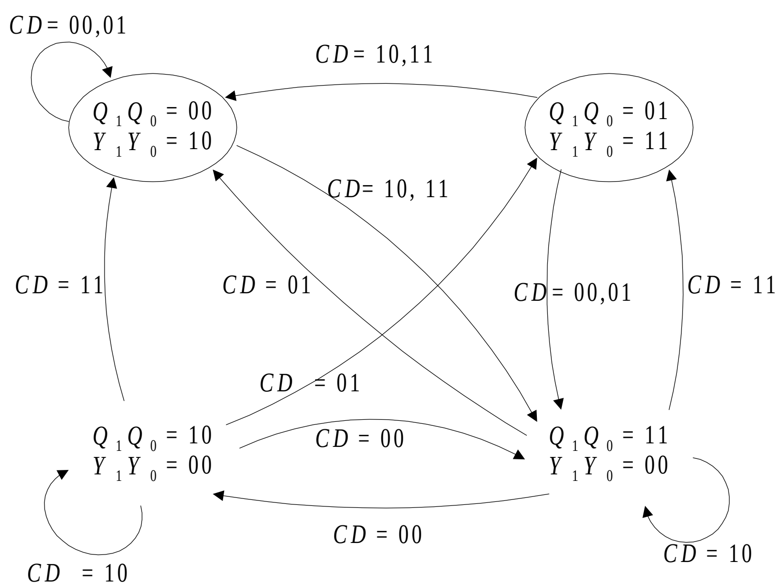
(d) The **output equations**

$$
\begin{aligned}
Y_1 &= Q_0' \\
Y_0 &= (Q_1'Q_0')' = Q_1 + Q_0
\end{aligned}
$$

(e) The **next-state/output table**

Present State	Next State $Q_{1\ next}\, Q_{0\ next}$				Outputs
Q_1Q_0	CD=00	CD=01	CD=10	CD=11	Y_1Y_0
00	00	00	11	11	10
01	11	11	00	00	01
10	11	01	10	00	11
11	10	00	11	01	01

(f) The **state diagram**



4. Use the "almost-one-hot" encoding and D flip-flops to synthesize a modulo-4 up counter with a count enable input C. The state for count 0 is also the initial state. The initial state is the next state for all the unused state combinations. The count is outputted as two bits y_1 and y_0. You need to do the following:
   (a) Derive the next-state/output table and the implementation tables. (2)
   (b) Derive the excitation equations for the inputs to the D flip-flops. Do not simplify the equations. (2)
   (c) Derive the output equations. Do not simplify the equations. (2)
   (d) Draw the circuit. (2)

Answer

(a) The next-state/output table (which is the same as the implementation table is shown below:

Current State	Next State $Q_{2next}\ Q_{1next}\ Q_{0next}$		Output
$Q_2Q_1Q_0$	$C = 0$	$C = 1$	$y_1\ y_0$
000	000	001	00
001	001	010	01
010	010	100	10
100	100	000	11

(b) $D_2 = Q_2Q_1'Q_0'C' + Q_2'Q_1Q_0'C$
$D_1 = Q_2'Q_1Q_0'C' + Q_2'Q_1'Q_0C$
$D_0 = Q_2'Q_1'Q_0'C + Q_2'Q_1'Q_0C'$

(c) $y_1 = Q_2'Q_1Q_0' + Q_2Q_1'Q_0'$
$y_0 = Q_2'Q_1'Q_0 + Q_2Q_1'Q_0'$

(d)