

EGC220

Class Notes

4/21/2023

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Division of Engineering Programs

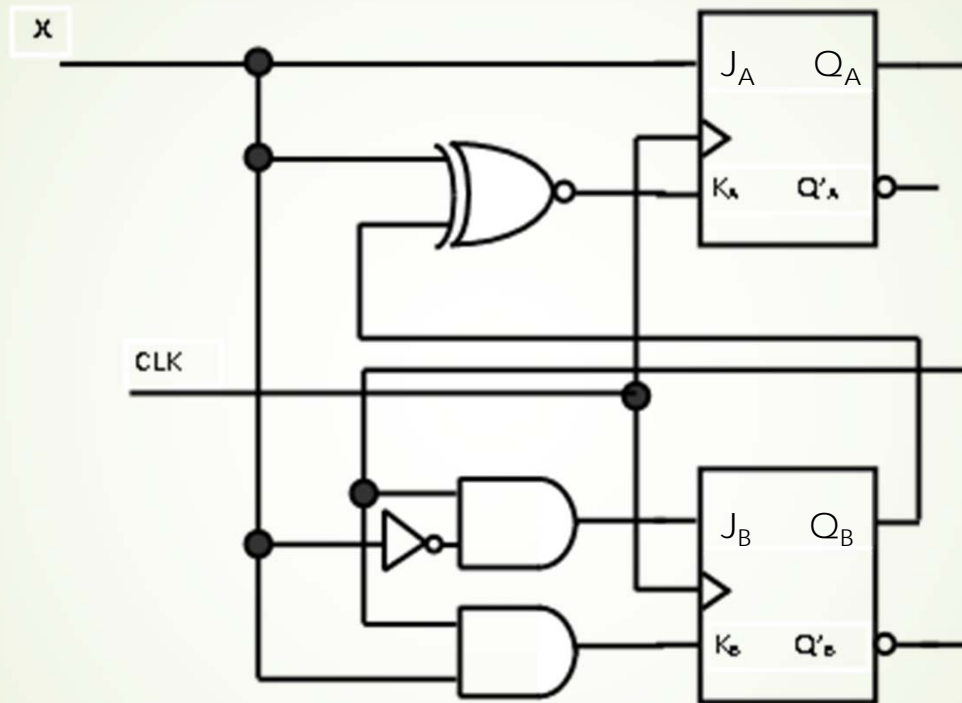
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Test Result

| | Test 1 | Test 2 |
|---------|---------------|---------------|
| Average | 70 | 69 |
| Median | 72 | 68 |
| MAX | 96 | 100 |
| Minimum | 0 | 0 |

Analysis Example:



Step 1: Flip-flop input equations and output equation

$$J_A = X$$

$$K_A = \overline{Q_B \oplus X}$$

$$J_B = Q_A X'$$

$$K_B = Q_A X$$

Step 2: Characteristic Table

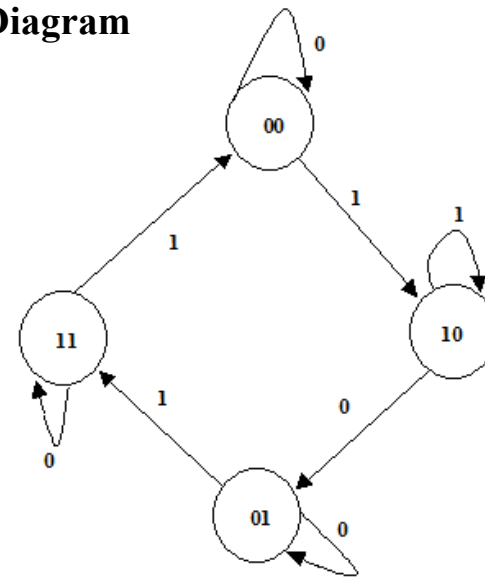
| J | K | Q(t+1) |
|---|---|--------|
| 0 | 0 | Q(t) |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | Q'(t) |

Step 3: State Table

| PS | | | | | NS |
|---------------------------------|----------------|----------------|----------------|----------------|-------------------------------|
| Q _A Q _B X | J _A | K _A | J _B | K _B | Q _A Q _B |
| 000 | 0 | 1 | 0 | 0 | 00 |
| 001 | 1 | 0 | 0 | 0 | 10 |
| 010 | 0 | 0 | 0 | 0 | 01 |
| 011 | 1 | 1 | 0 | 0 | 11 |
| 100 | 0 | 1 | 1 | 0 | 01 |
| 101 | 1 | 0 | 0 | 1 | 10 |
| 110 | 0 | 0 | 1 | 0 | 11 |
| 111 | 1 | 1 | 0 | 1 | 00 |

unknown

Step 4: State Diagram



Design of Sequential Circuits

Design Procedure:

1. Word description.
2. State diagram.
3. Assign binary values.
4. Decide on type of flip flops.
5. Excitation table for the flip flop.
6. State table ✓
7. Generate simplified logic equations for flip flop inputs and system outputs.
8. Draw logic diagram. ✓

| J | K | $Q(t+1)$ unknown |
|-----|-----|------------------|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

| $Q(t)$ | $Q(t+1)$ | J | K |
|--------|----------|-----|-----|
| 0 | 0 | | |
| 0 | 1 | | |
| 1 | 0 | | |
| 1 | 1 | | |

Handwritten notes: A red circle is drawn around the first row of the second table. A red arrow points from the word 'unknown' in the first table to the first row of the second table. A red question mark is written in the bottom right cell of the second table.

Flip-Flop Excitation Tables

no set
set
reset
no reset

| PRESENT STATE | NEXT STATE | S | R |
|---------------|------------|---|---|
| Q(t) | Q(t+1) | | |
| 0 | 0 | 0 | X |
| 0 | 1 | 0 | 0 |
| 1 | 0 | X | 0 |
| 1 | 1 | X | X |

NC
C
C
NC

| Q(t) | Q(t+1) | T |
|------|--------|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

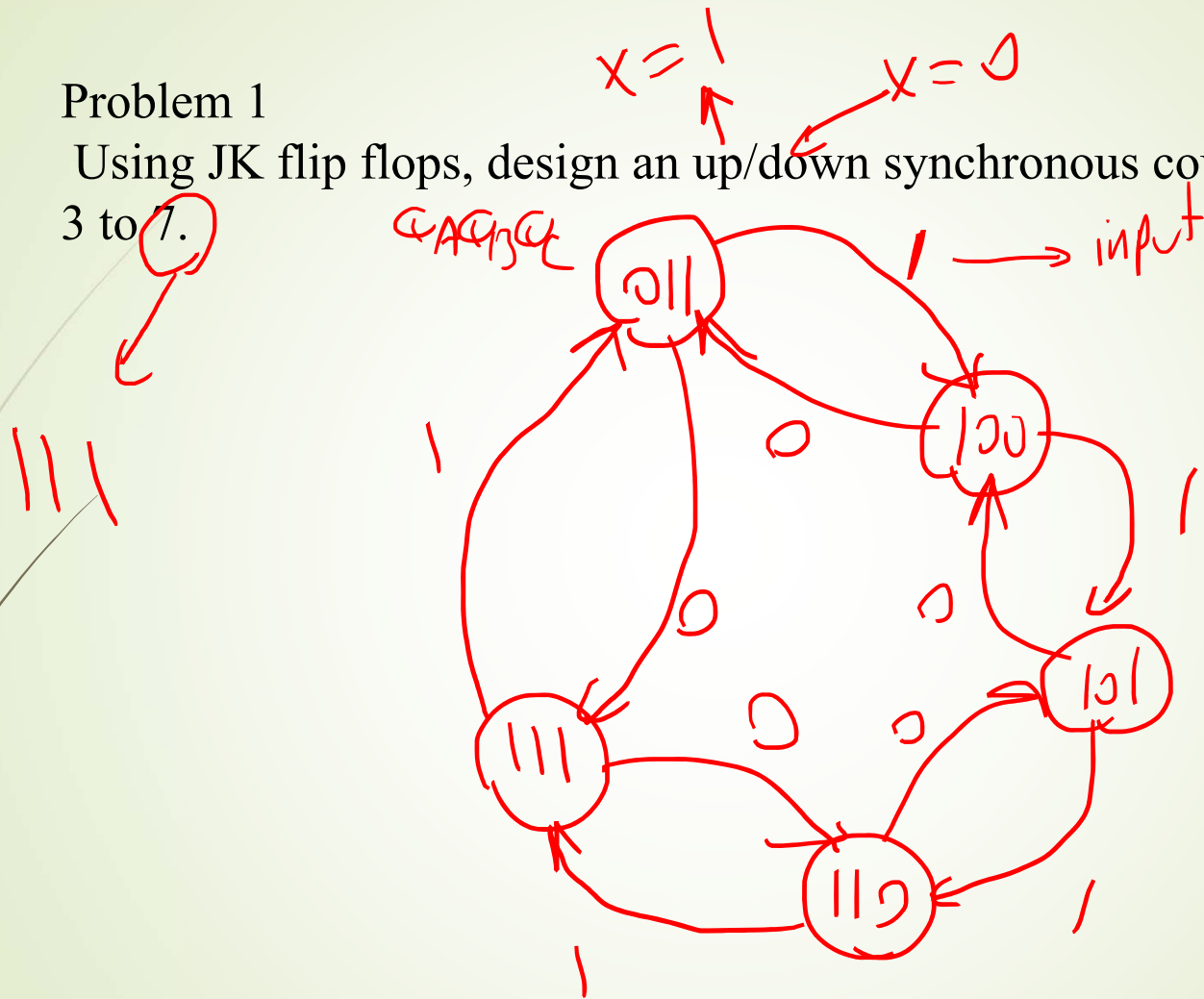
no set
set
reset
no reset

| PRESENT STATE | NEXT STATE | J | K |
|---------------|------------|---|---|
| Q(t) | Q(t+1) | | |
| 0 | 0 | 0 | X |
| 0 | 1 | 1 | X |
| 1 | 0 | X | 1 |
| 1 | 1 | X | 0 |

| Q(t) | Q(t+1) | D |
|------|--------|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Problem 1

Using JK flip flops, design an up/down synchronous counter that counts from 3 to 7.



| Q _A (t) | Q _B (t) | Q _C (t) | J | K |
|--------------------|--------------------|--------------------|---|---|
| 0 | 0 | 0 | 0 | X |
| 0 | 1 | 0 | 1 | X |
| 0 | 1 | 1 | X | 1 |
| 1 | 1 | 1 | X | 0 |

| PS input | | NS | JK | | | | | | | | | |
|----------|-------|-------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Q_A | Q_B | Q_C | X | Q_A | Q_B | Q_C | J_A | K_A | J_B | K_B | J_C | K_C |
| 0 | 0 | 0 | 0 | x | x | x | x | x | x | x | x | x |
| 0 | 0 | 0 | 1 | x | x | x | x | x | x | x | x | x |
| 0 | 0 | 1 | 0 | x | x | x | x | x | x | x | x | x |
| 0 | 0 | 1 | 1 | x | x | x | x | x | x | x | x | x |
| 0 | 1 | 0 | 0 | x | x | x | x | x | x | x | x | x |
| 0 | 1 | 0 | 1 | x | x | x | x | x | x | x | x | x |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | x | 1 | x | 0 | x | 1 |

Q_A (01) Q_B (01) Q_C (11) Q_D (10)

| | | | |
|---|---|---|---|
| x | x | x | x |
| x | x | x | x |
| 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 |

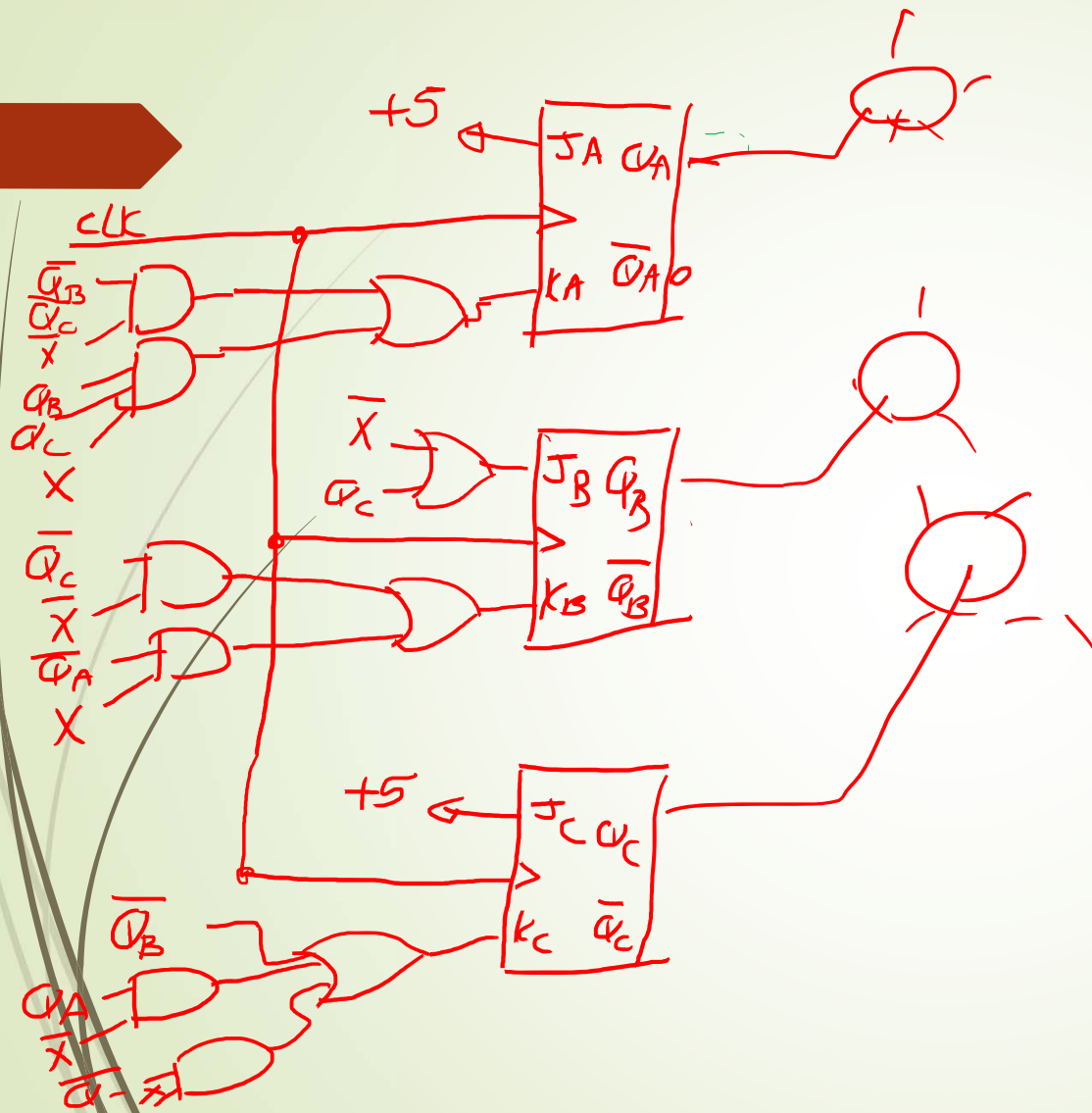
J_A K_A J_B K_B J_C K_C

$K_A = \overline{Q_B} \overline{Q_C} \overline{X} + Q_B Q_C X$
 $J_A = 1$
 $J_C = 1$

| | | | |
|---|---|---|---|
| x | x | x | x |
| x | x | x | x |
| x | x | x | x |
| 1 | 0 | 0 | 1 |

$J_B = \overline{X} + Q_C$

3
3



$$K_B = \overline{Q_C} X + \overline{Q_A} X$$

| | | | |
|---|---|---|---|
| X | X | X | X |
| X | X | 1 | 0 |
| 1 | 0 | 0 | 0 |
| X | X | X | X |

| | | | |
|---|---|---|---|
| X | X | X | X |
| X | X | 1 | 0 |
| X | X | 0 | 1 |
| X | 1 | 1 | X |

$$K_C = \overline{Q_B} + Q_A X + \overline{Q_A} X$$

Problem

Using SR flip-flops, design a circuit for the following state diagram. 2 F/F

| | | | |
|---|---|---|---|
| X | X | X | 0 |
| X | X | 1 | 1 |

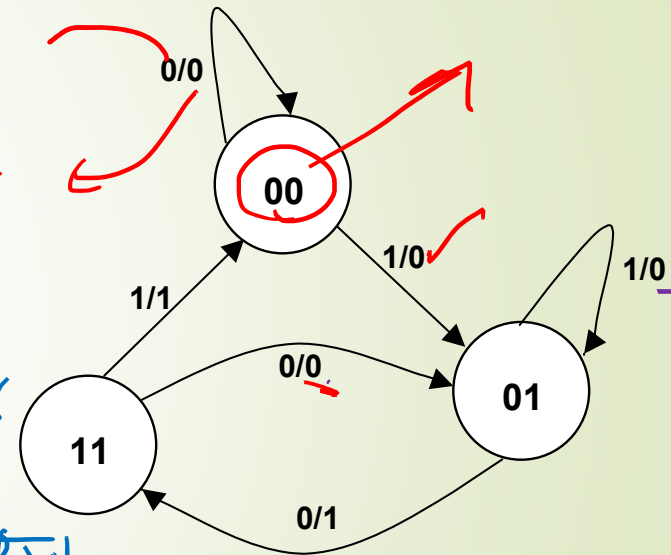
$RA = Q_A$

| $Q(t)$ | $Q(t+1)$ | S | R |
|--------|----------|---|---|
| 0 | 0 | 0 | X |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | X | 0 |

$SA = \overline{Q_A} Q_B X$

| Q_A | Q_B | X | Q_A | Q_B | SA | RA | SB | RB | Z |
|-------|-------|---|-------|-------|----|----|----|----|---|
| 0 | 0 | 0 | 0 | 0 | 0 | X | 0 | X | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | X | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 | X | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 | X | X | 0 | 0 |
| 1 | 0 | 0 | X | X | X | X | X | X | X |
| 1 | 0 | 1 | X | X | X | X | X | X | X |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | X | 0 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |

input X
output Z



$SB = \overline{Q_A} X$

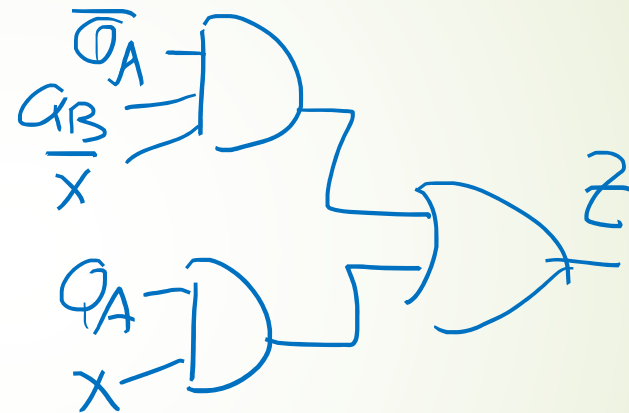
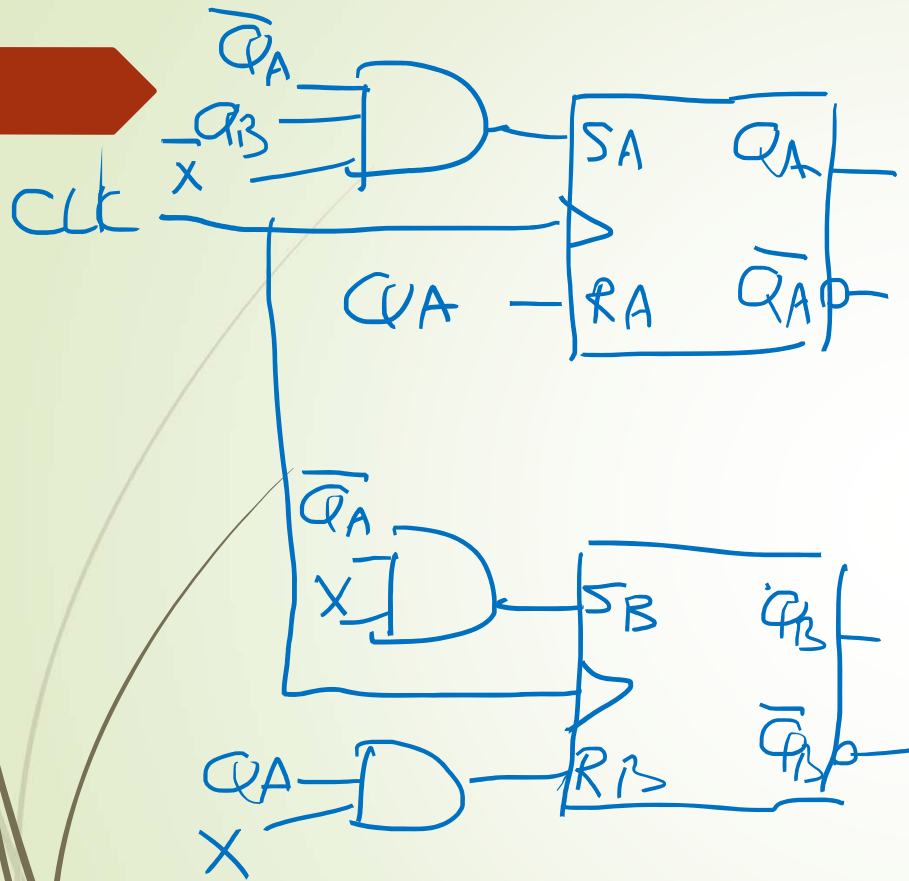
| | | | |
|---|---|---|---|
| 0 | 0 | X | X |
| X | X | 0 | X |

$RB = \overline{Q_A} X$

| | | | |
|---|---|---|---|
| X | 0 | 0 | 0 |
| X | X | 1 | 0 |

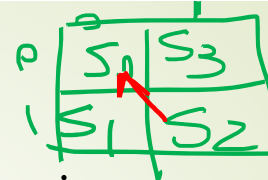
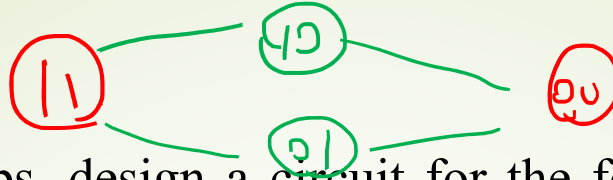
| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| X | X | 1 | 0 |

$Z = \overline{Q_A} Q_B X + Q_A X$

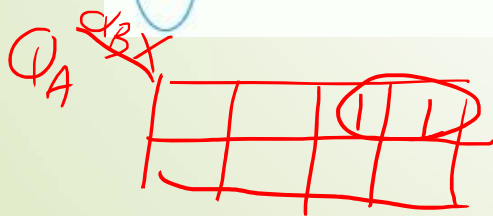
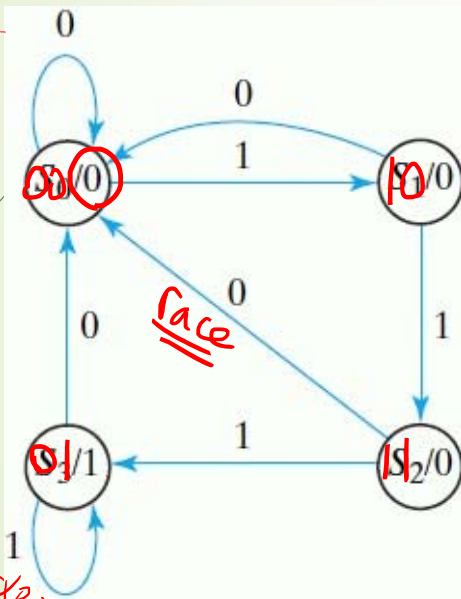


Problem 3

Using D flip-flops, design a circuit for the following state diagram. You may make the following state assignments: $S_0 = 00$, $S_1 = 10$, $S_2 = 11$, $S_3 = 01$



Moore



| P_s | | | $D \setminus S$ | | Z |
|-------|-------|-----|-----------------|-------|-----|
| Q_A | Q_B | X | Q_A | Q_B | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 0 | 1 | 0 |

| Q_A | Q_B | X | Z |
|-------|-------|-----|-----|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 |

$D_A = \overline{Q_B} X$

| | | | |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 |

$D_B = Q_A X + Q_B X$

$Z = \overline{Q_A} Q_B$

