Computer Science CSCI 355

Digital Logic and Computer Organization

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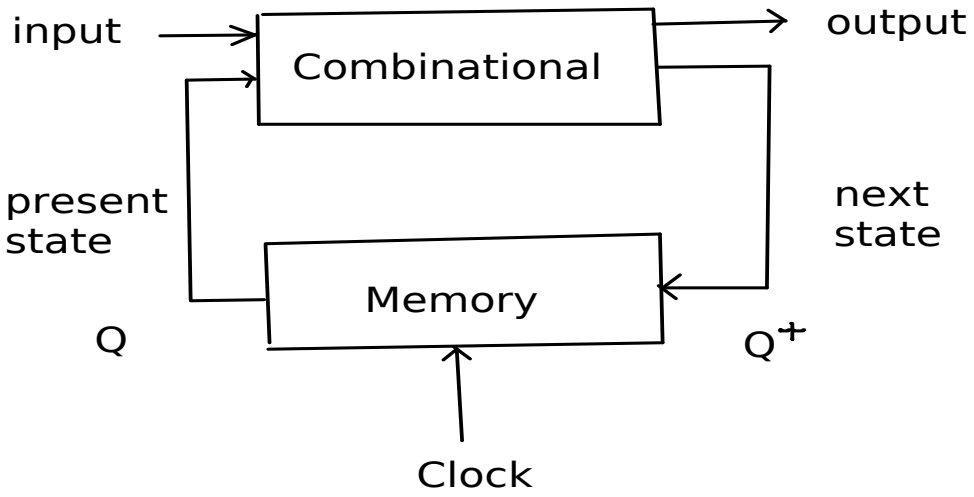
Synchronous Sequential Design

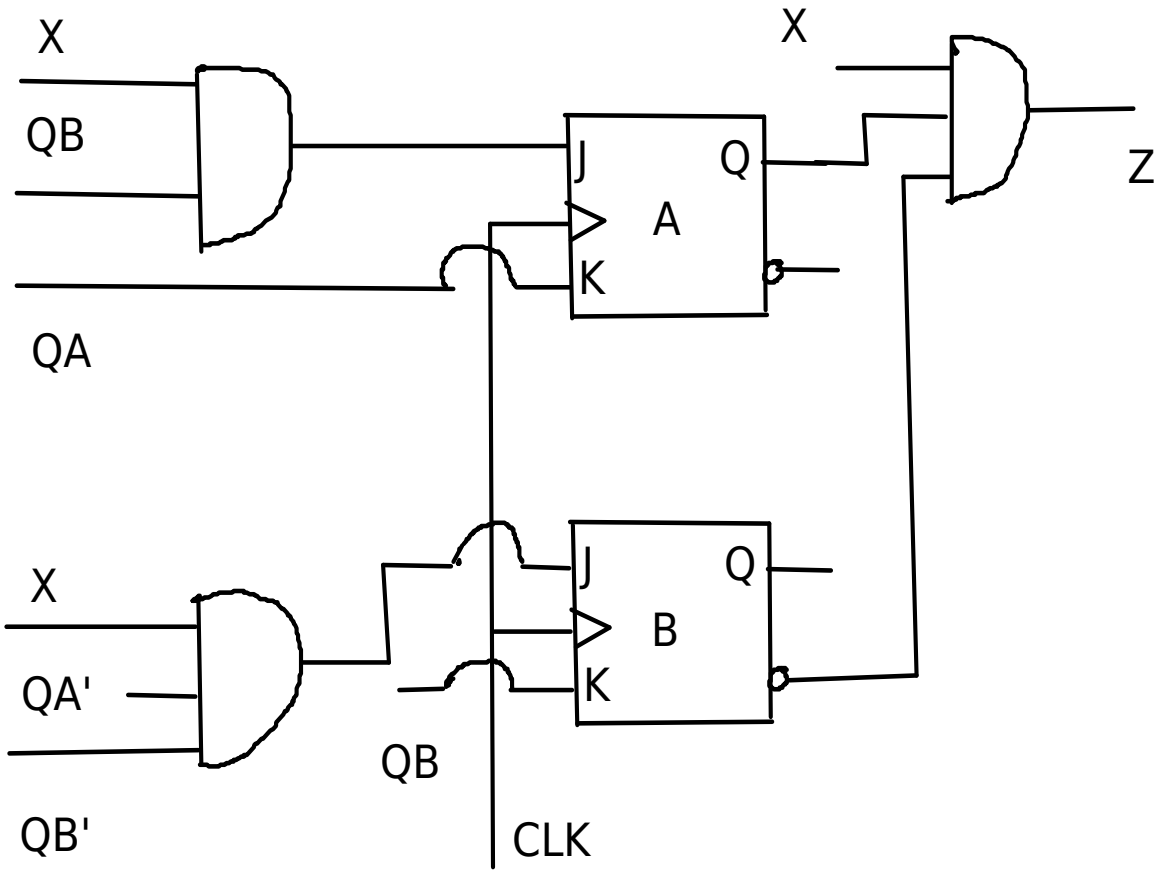


- Engineering Paradigm
  - Analyze
  - Design/Implement

FSM Symbolic Analysis

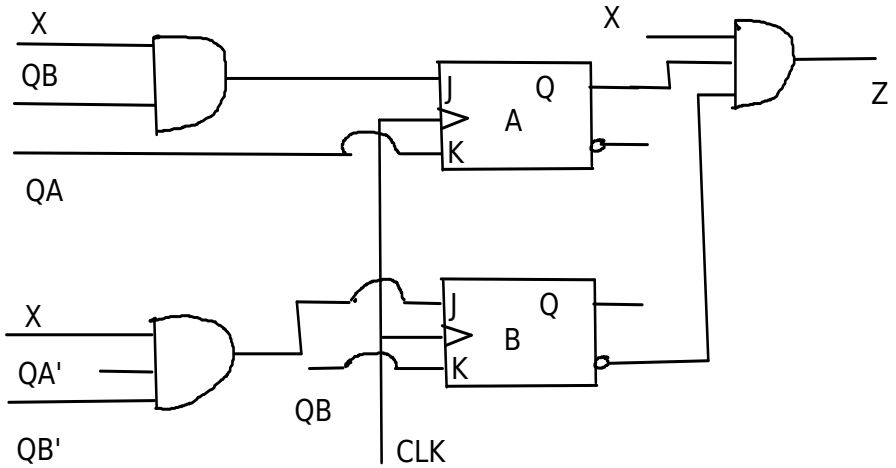
- Algorithm
  - 1. generate expressions describing outputs and FF inputs
  - 2. generate next state equations for each FF
  - 3. generate next state K maps for each FF and K maps for each output
  - 4. generate a state table
  - 5. generate state diagram or timing diagram

FSM Symbolic Analysis Example



Step 1

generate expressions describing outputs and FF inputs



$Z = X\ QA\ \overline{QB}$ $\quad JA = X\ QB$

$KA = QA$ $\quad JB = X\ \overline{QA}\ \overline{QB}$

$KB = QB$

Step 2a

generate next state equations for each FF

$$JA = X\,QB \qquad JB = X\,\overline{QA}\,\overline{QB}$$
$$KA = QA \qquad KB = QB$$

$$QA^{+} = JA\,\overline{QA} + \overline{KA}\,QA \quad \text{(Char. Eq.)}$$

$$= X.QB.\overline{QA} + \overline{QA}.QA$$
$$= X.QB.\overline{QA}$$

Step 2b

generate next state equations for each FF

$$JA = X\,QB \qquad JB = X\,\overline{QA}\,\overline{QB}$$
$$KA = QA \qquad KB = QB$$

$$QB^{+} = JB\,\overline{QB} + \overline{KB}\,QB \quad \text{(Char. Eq.)}$$

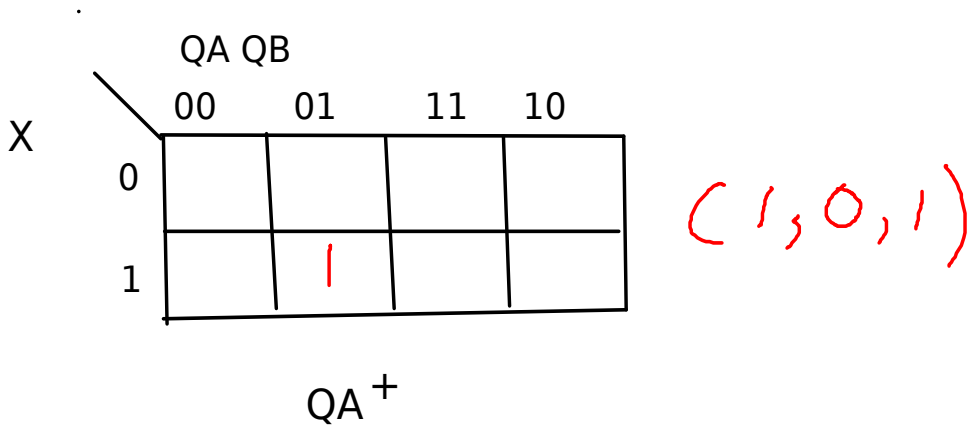
$$= X\,\overline{QA}\,\overline{QB}\,\overline{QB} + \overline{QB}\,QB$$

$$= X\,\overline{QA}\,\overline{QB}$$

Step 3a

generate next state K maps for each FF and K maps for each output

$$QA^{+} = X \cdot QB \cdot \overline{QA}$$

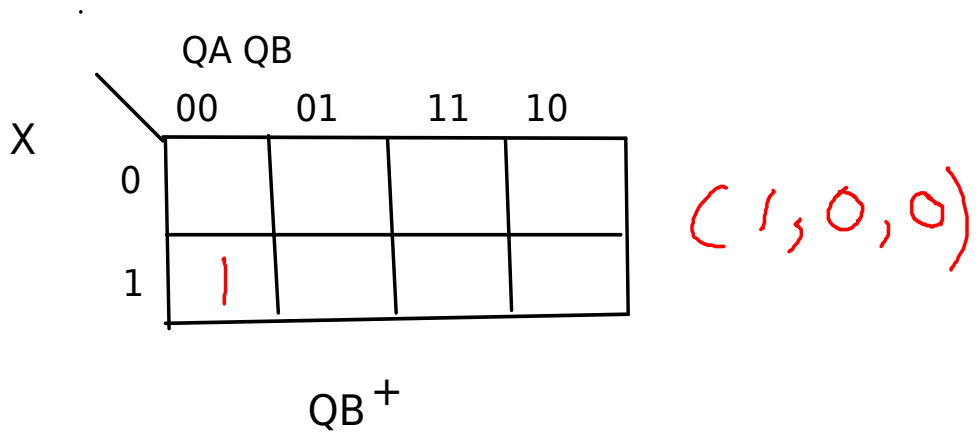


(1, 0, 1)

Step 3b

generate next state K maps for each FF and K maps for each output

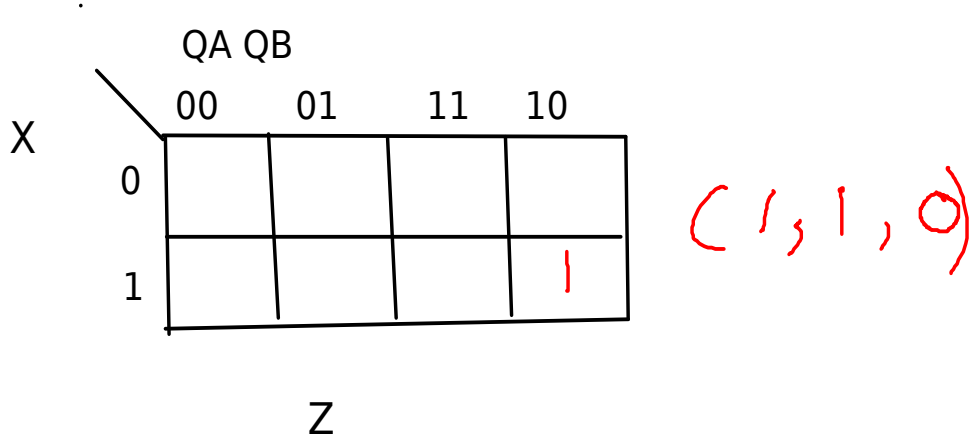
$$QB^+ = X \cdot \overline{QA} \cdot \overline{QB}$$



Step 3c

generate next state K maps for each FF and K maps for each output

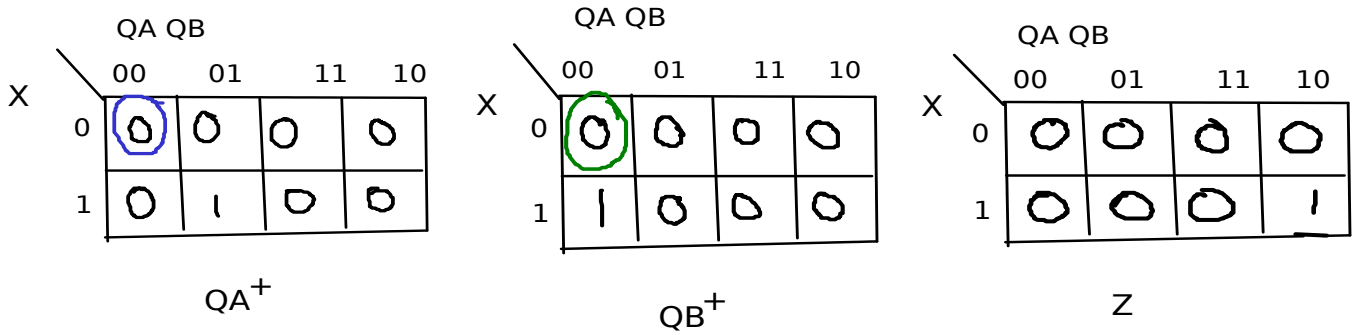
$$Z = X\,QA\,\overline{QB}$$



(1, 1, 0)

Step 4

generate a state table

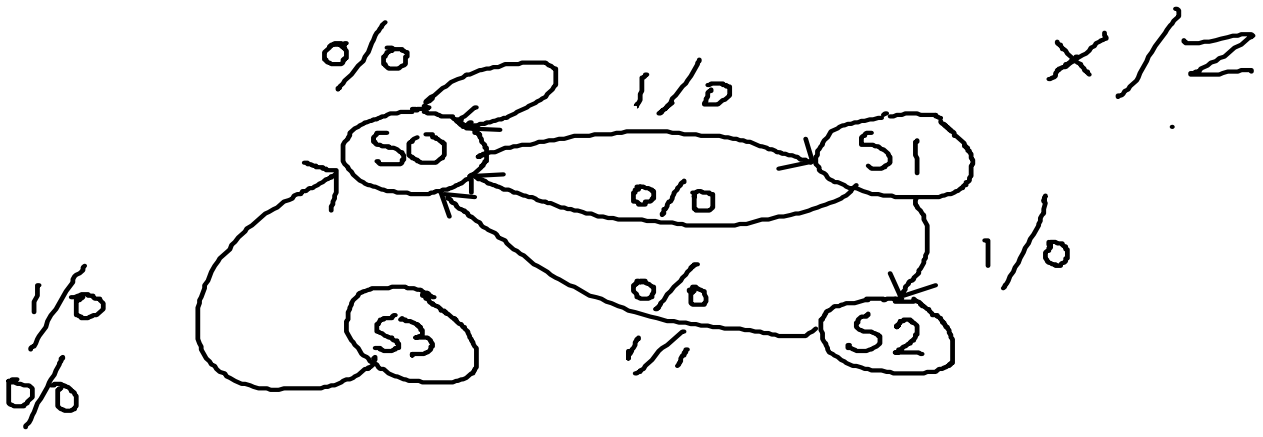


Presen State		$QA^+ QB^+$ Next State		$QA^+ QB^+$ Output	
QA	QB	X=0	X=1	X=0	X=1
0	0	0 0	0 1	0	0
0	1	0 0	1 0	0	0
1	0	0 0	0 0	0	1
1	1	0 0	0 0	0	0

Step 5

generate state diagram or timing diagram

Presen State			$QA^+ QB^+$ Next State		Output	
QA	QB		X=0	X=1	X=0	X=1
0	0	S0	0 0	0 1	0	0
0	1	S1	0 0	1 0	0	0
1	0	S2	0 0	0 0	0	1
1	1	S3	0 0	0 0	0	0

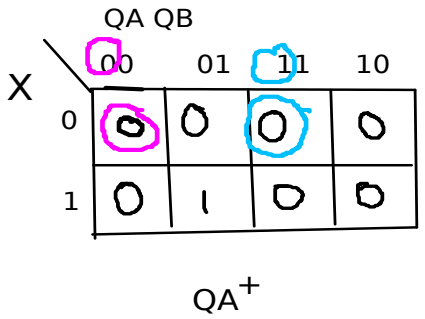


FSM Implementation

- Algorithm
  - r1. reverse the steps used in symbolic analysis up to (and including) step 3
  - r2. use excitation tables to determine FF inputs
  - r3. draw the resulting network diagram

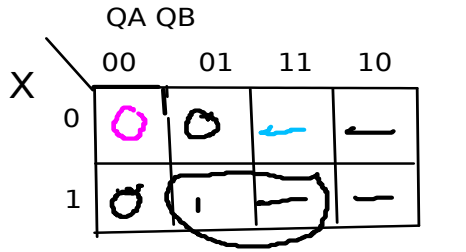
Reverse Step 2a

use excitation tables to determine FF inputs

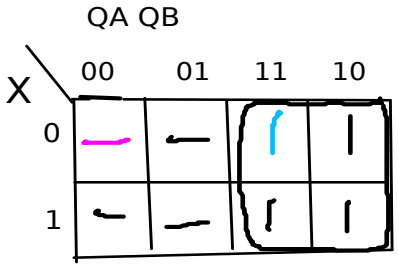


Excitation Table

Q	Q^+	J	K
0	0	0	-
0	1	1	-
1	0	-	1
1	1	-	0



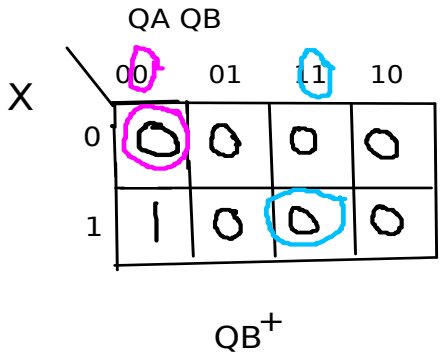
JA = XQB



KA = QA

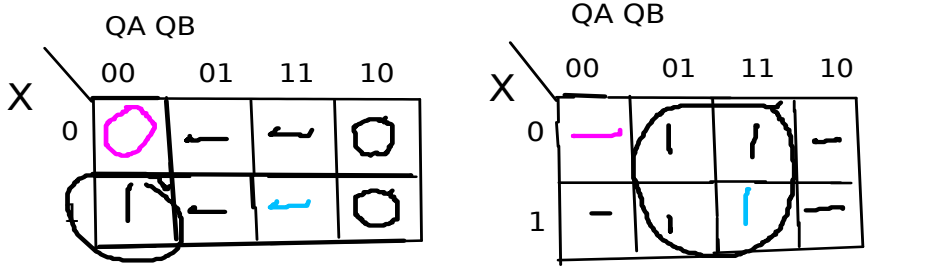
Reverse Step 2b

use excitation tables to determine FF inputs



Excitation Table

Q	Q^+	J	K
0	0	0	-
0	1	1	-
1	0	-	1
1	1	-	0



$JB = X \oplus QA \cdot \overline{QB}$ $\quad KB = QB$