Digital Systems

CE212

HW 5

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Question 1

Step 1: the number of J-K F.Fs that are needed is 4

Step 2 : State table

Q_A	Q_B	Q_C	Q_D	Q_A^+	Q_B^+	Q_C^+	Q_D^+
0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	1	1
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	0
1	0	0	0	1	0	0	1
1	0	0	1	0	0	0	0
1	0	1	0	X	X	X	X
1	0	1	1	X	X	X	X
1	1	0	0	X	X	X	X
1	1	0	1	X	X	X	X
1	1	1	0	X	X	X	X
1	1	1	1	X	X	X	X

Step 3: transition table

Q_A	Q_B	Q_C	Q_D	Q_A^+	Q_B^+	Q_C^+	Q_D^+	J_A	K_A	J_B	K_B	J_C	K_C	J_D	K_D
0	0	0	0	0	0	0	1	0	X	0	X	0	X	1	X
0	0	0	1	0	0	1	0	0	X	0	X	1	X	X	1
0	0	1	0	0	0	1	1	0	X	0	X	X	0	1	X
0	0	1	1	0	1	0	0	0	X	1	X	X	1	X	1
0	1	0	0	0	1	0	1	0	X	X	0	0	X	1	X
0	1	0	1	0	1	1	0	0	X	X	0	1	X	X	1
0	1	1	0	0	1	1	1	0	X	X	0	X	0	1	X
0	1	1	1	1	0	0	0	1	X	X	1	X	1	X	1
1	0	0	0	1	0	0	1	X	0	0	X	0	X	1	X
1	0	0	1	0	0	0	0	X	1	0	X	0	X	X	1
1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X
1	0	1	1	X	X	X	X	X	X	X	X	X	X	X	X
1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X
1	1	0	1	X	X	X	X	X	X	X	X	X	X	X	X
1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X
1	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X

AB \ CD	00	01	11	10
00	X	X	X	X
01	0	0	1	0
11	X	X	X	X
10	X	X	X	X

KB = QC·QD

JC

AB \ CD	00	01	11	10
00	0	1	X	X
01	0	1	X	X
11	X	X	X	X
10	0	0	X	X

JC = Q'A.QD

KC

AB \ CD	00	01	11	10
00	X	X	1	0
01	0	X	1	0
11	X	X	X	X
10	X	X	X	X

KC = QD

JD

AB \ CD	00	01	11	10
00	1	X	X	1
01	1	X	X	1
11	X	X	X	X
10	1	X	X	X

JD = 1

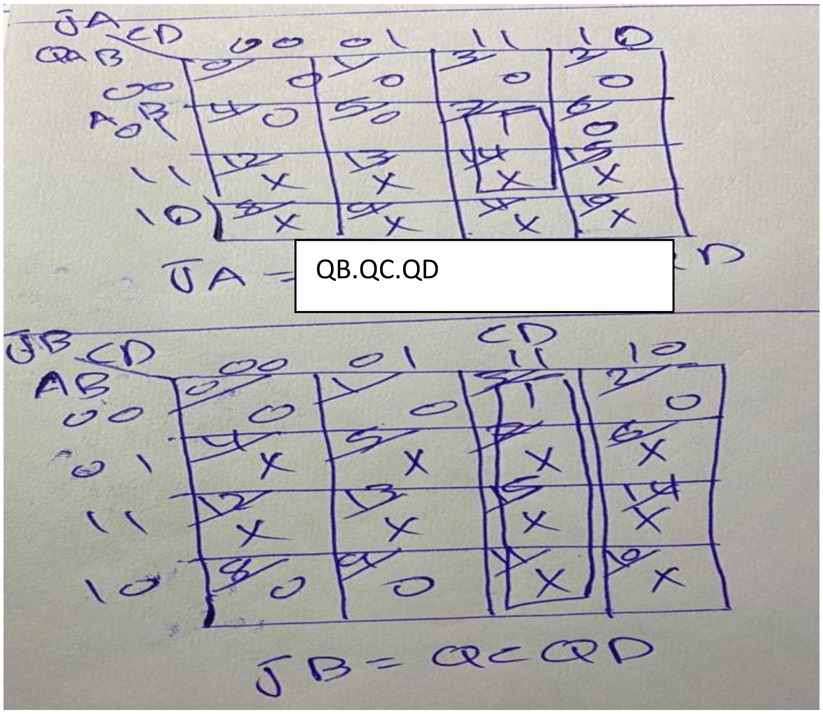
AB \ CD	00	01	11	10
00	X	X	X	X
01	X	1	1	X
11	X	X	X	X
10	X	1	X	X

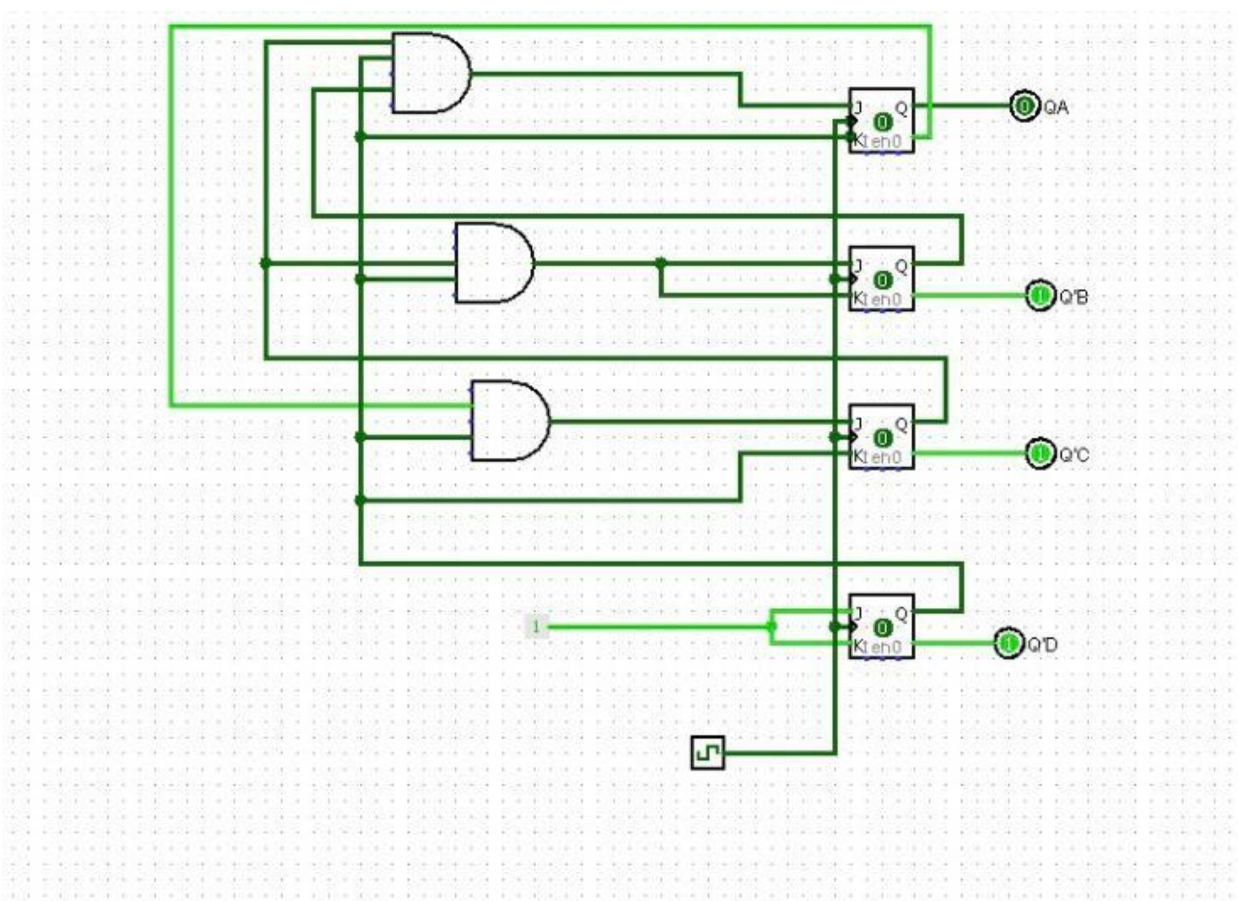
$\boxed{KD = 1}$

KA

AB \ CD	00	01	11	10
00	X	X	X	X
01	X	X	X	X
11	X	X	X	X
10	0	1	X	X

KA = QD


JA
CD
QAB
00
01
11
10
QB.QC.QD
JA =
JB
CD
AB
00
01
11
10
JB = QCQD


QA
Q'B
Q'C
Q'D
1

Question 2

a.

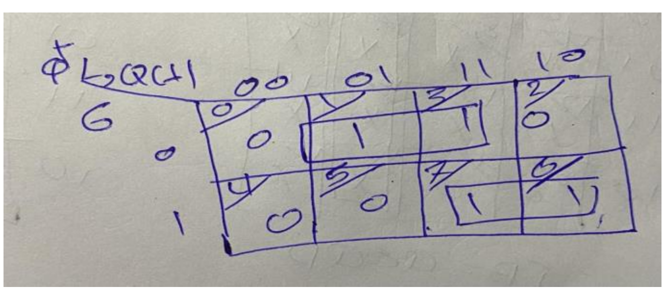
Step 1 : truth table

G	L	Q(t)	Q(t+1)
0	0	Q(t-1)	Q'(t-1)
0	1	Q(t-1)	Q'(t-1)
1	0	0	1
1	1	1	0

Step 2 : Next state table

G	L	Q(t)	Q(t+1)
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

Deriving the characteristic equation using K-map



Q(t+1) = G'Q(t) + G.L

b.

Step 1 : Build the next state table of the G-L f.f

G	L	Q(t)	Q(t+1)
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

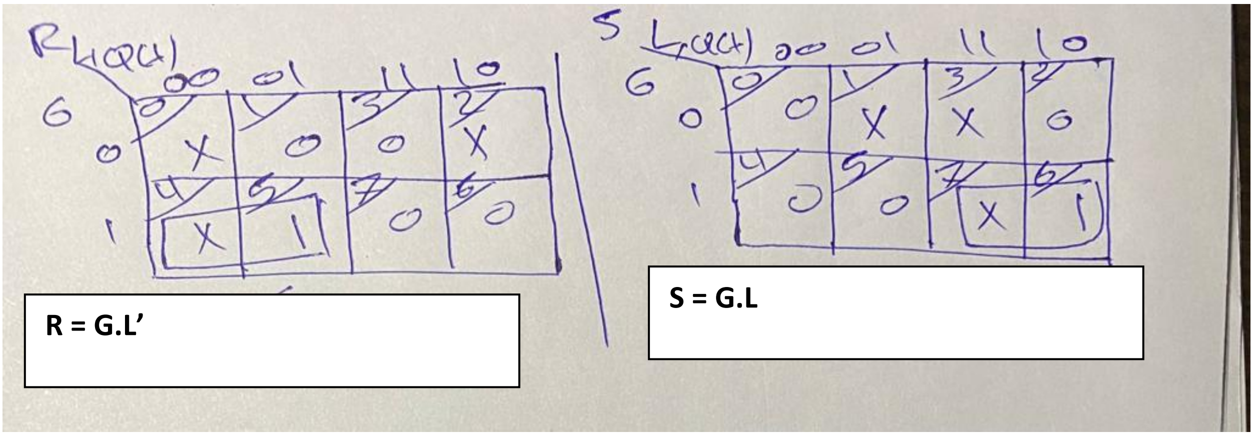
Step 2 : Build the excitation table of the S-R f.f

Q(t)	Q(t+1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

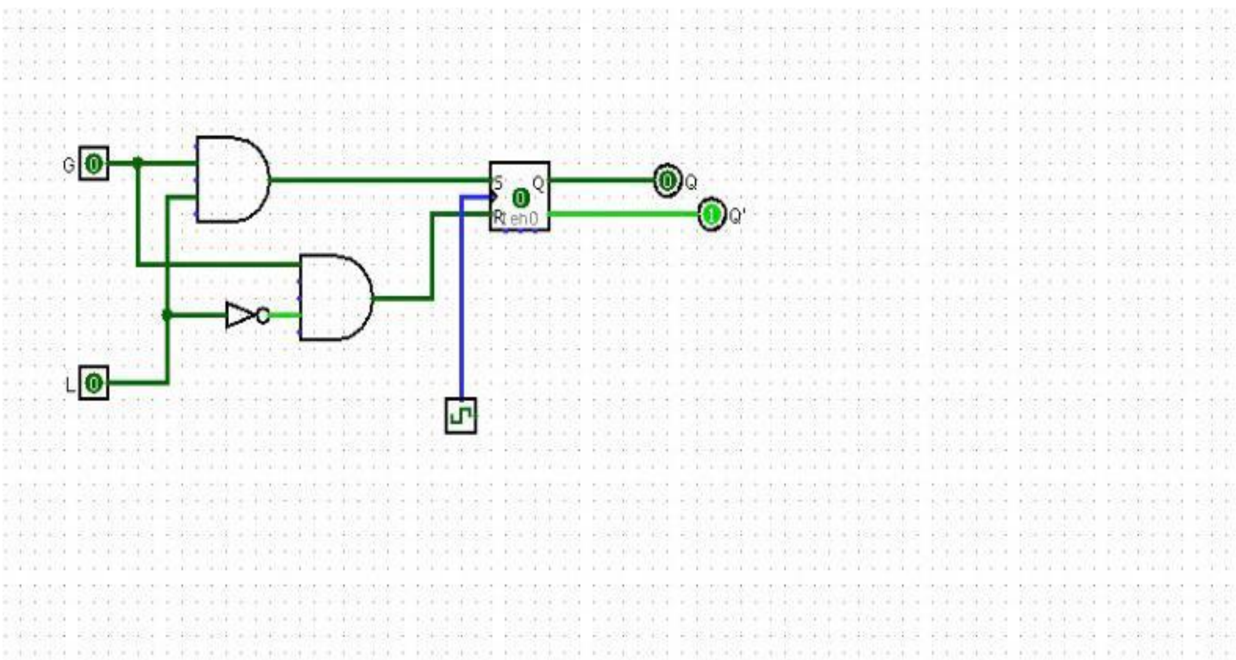
Step 3 :

G	L	Q(t)	Q(t+1)	S	R
0	0	0	0	0	X
0	0	1	1	X	0
0	1	0	0	0	X
0	1	1	1	X	0
1	0	0	0	0	X
1	0	1	0	0	1
1	1	0	1	1	0
1	1	1	1	X	0

Step 4: find the equation of the S-R



Step 5 : Build the circuit



Question 3

Step1 : # of f.fs that are needed is 3

Step 2: State table

Q_A	Q_B	Q_C	Q_A^+	Q_B^+	Q_C^+
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	1	0	0
0	1	1	0	0	0
1	0	0	1	1	1
1	0	1	0	0	0
1	1	0	0	0	0
1	1	1	0	0	0

Step 3 : Transition table

Q_A	Q_B	Q_C	Q_A^+	Q_B^+	Q_C^+	J_A	K_A	J_B	K_B	J_C	K_C
0	0	0	0	0	1	0	X	0	X	1	X
0	0	1	0	1	0	0	X	1	X	X	1
0	1	0	1	0	0	1	X	X	1	0	X
0	1	1	0	0	0	0	X	X	1	X	1
1	0	0	1	1	1	X	0	1	X	1	X
1	0	1	0	0	0	X	1	0	X	X	1
1	1	0	0	0	0	X	1	X	1	0	X
1	1	1	0	0	0	X	1	X	1	X	1

JA = $\sum_m(2) + \sum_d (4,5,6,7)$

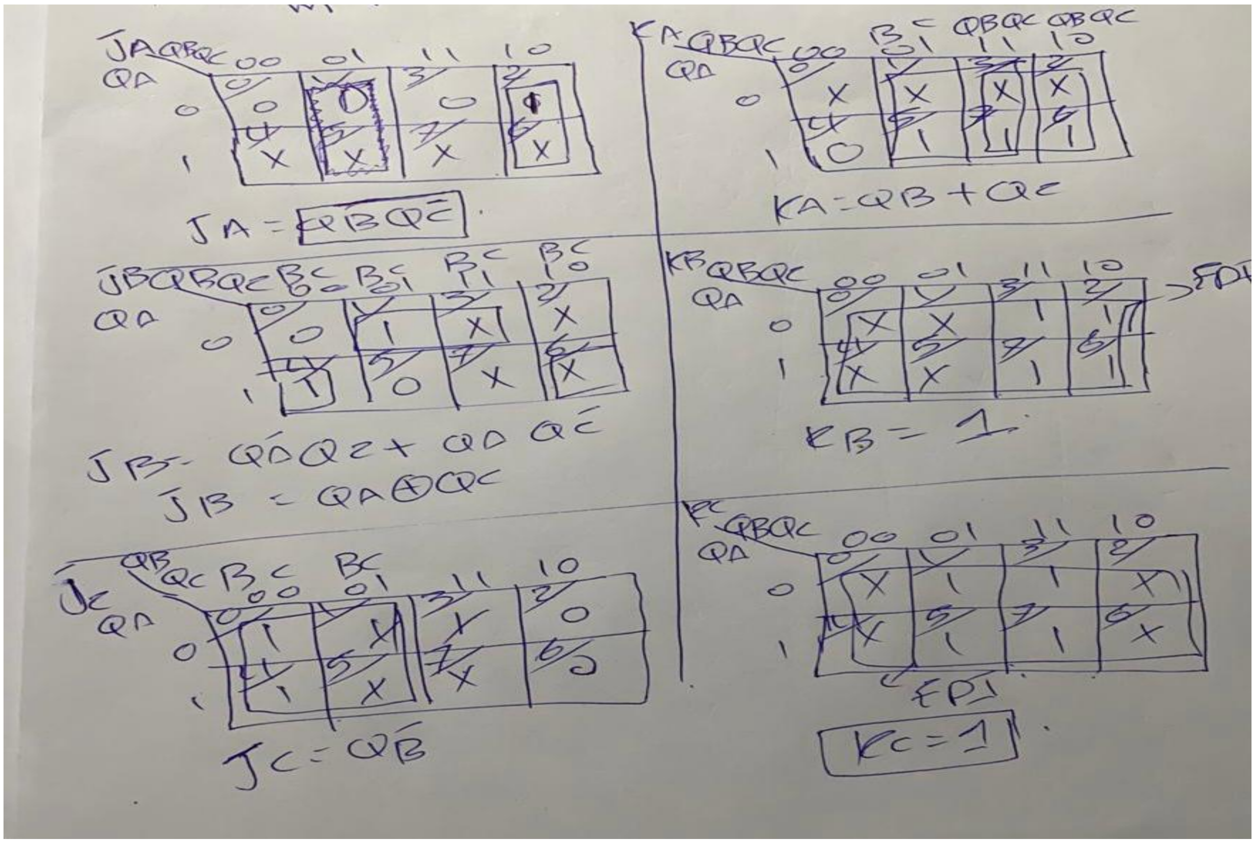
KA = $\sum_m(5,6,7) + \sum_d (0,1,2,3)$

JA = $\sum_m(1,4) + \sum_d (2,3,6,7)$

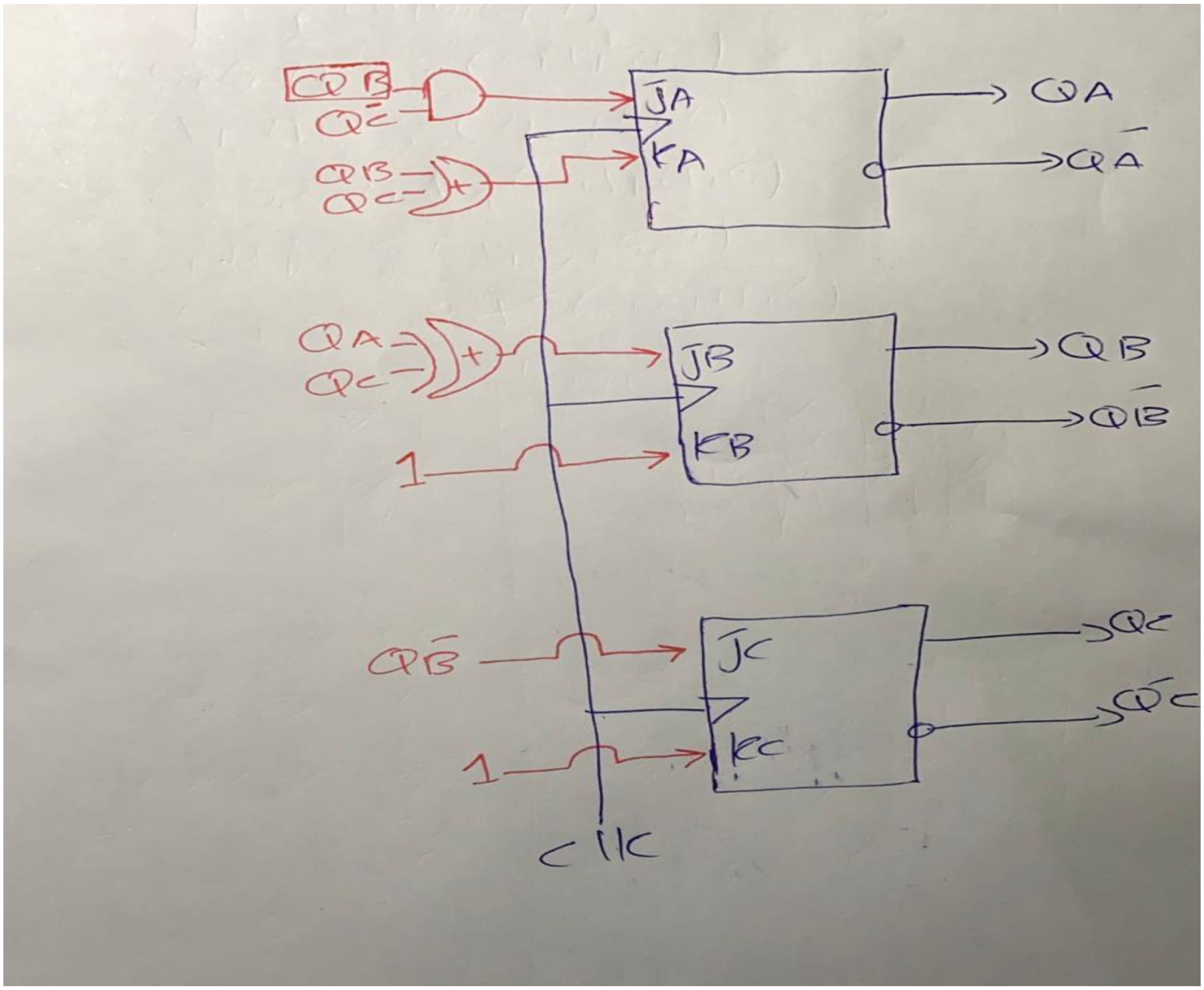
$JA = \sum_{m}(2,3,6,7) + \sum_{d} (0,1,4,5)$

$JA = \sum_{m}(0,4) + \sum_{d} (1,3,5,7)$

$JA = \sum_{m}(1,3,5,7) + \sum_{d} (0,2,4,6)$

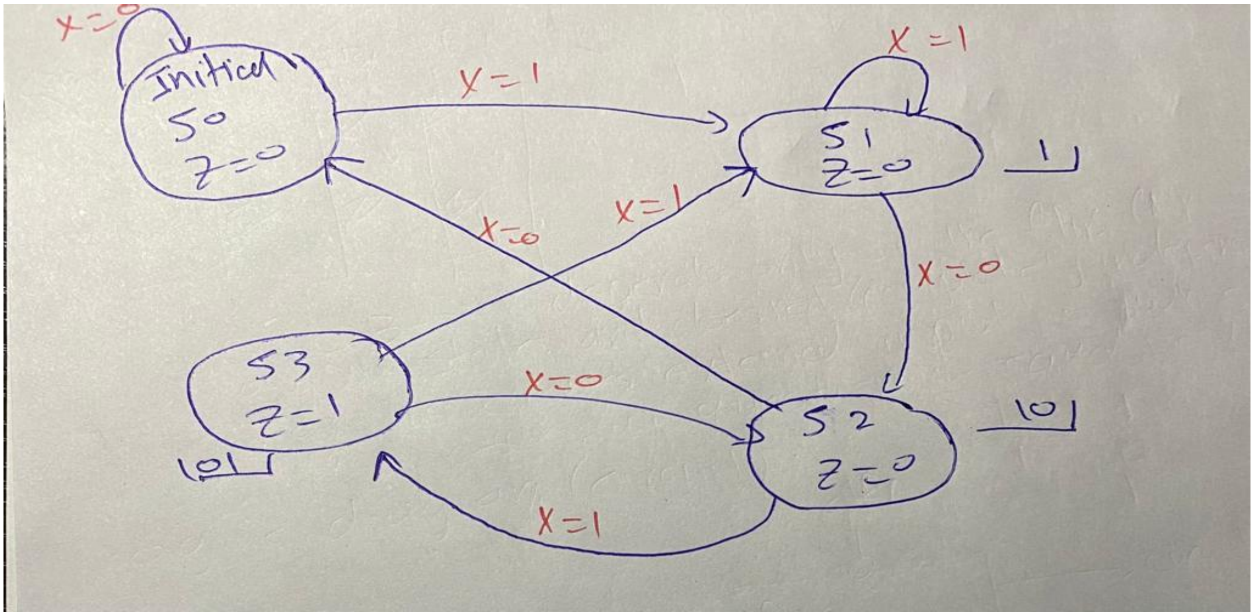


Step 5 : logic circuit



Question 4

a.



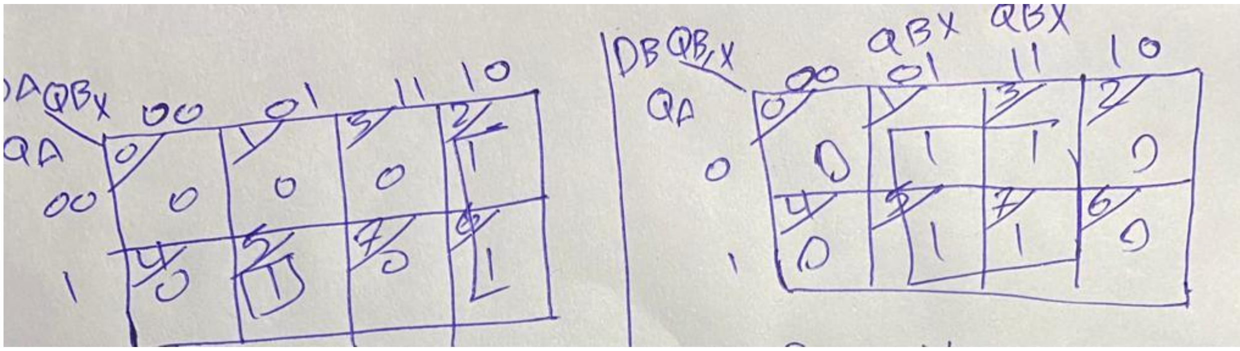
b. The number of D-F.F that are needed is equal to:

#of F.Fs = Log_2 (#of states) = $\text{Log}_2 4$ = 2.

c.

Q_A	Q_B	X	Q_A^+	Q_B^+	Z	D_A	D_B
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	1
0	1	0	1	0	0	1	0
0	1	1	0	1	0	0	1
1	0	0	0	0	0	0	0
1	0	1	1	1	0	1	1
1	1	0	1	0	1	1	0
1	1	1	0	1	1	0	1

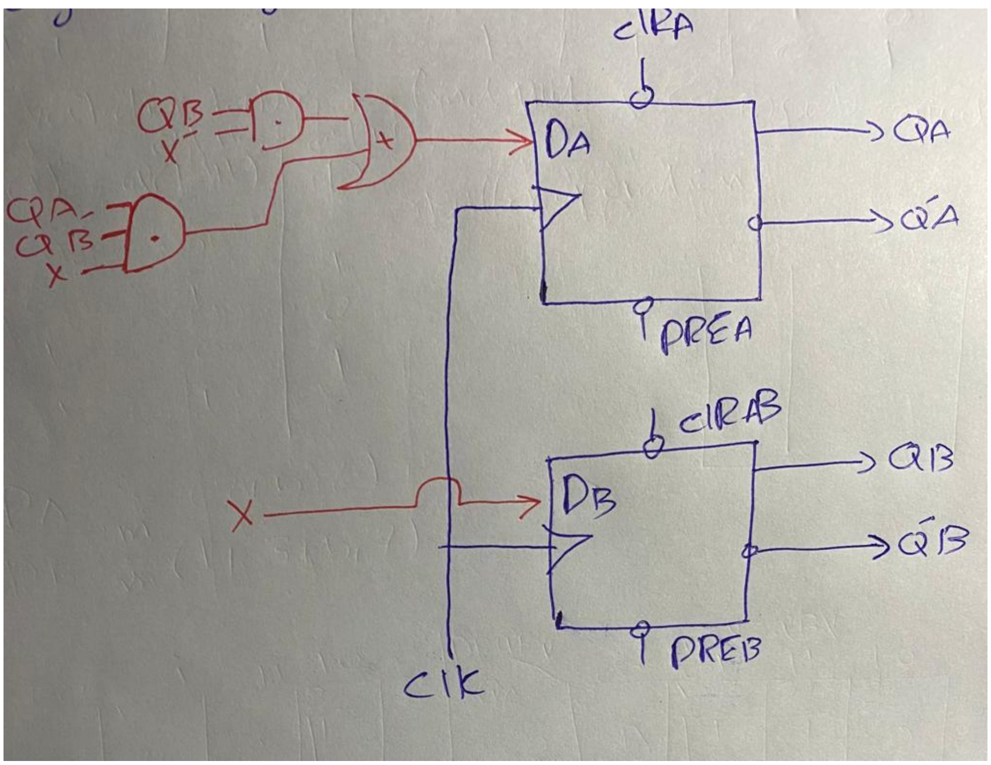
d.



D_A(QA,QB,X) = QB.X'+QA.Q'B.X

D_B(QA,QB,X) = X

e.



Question 5

a.

Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

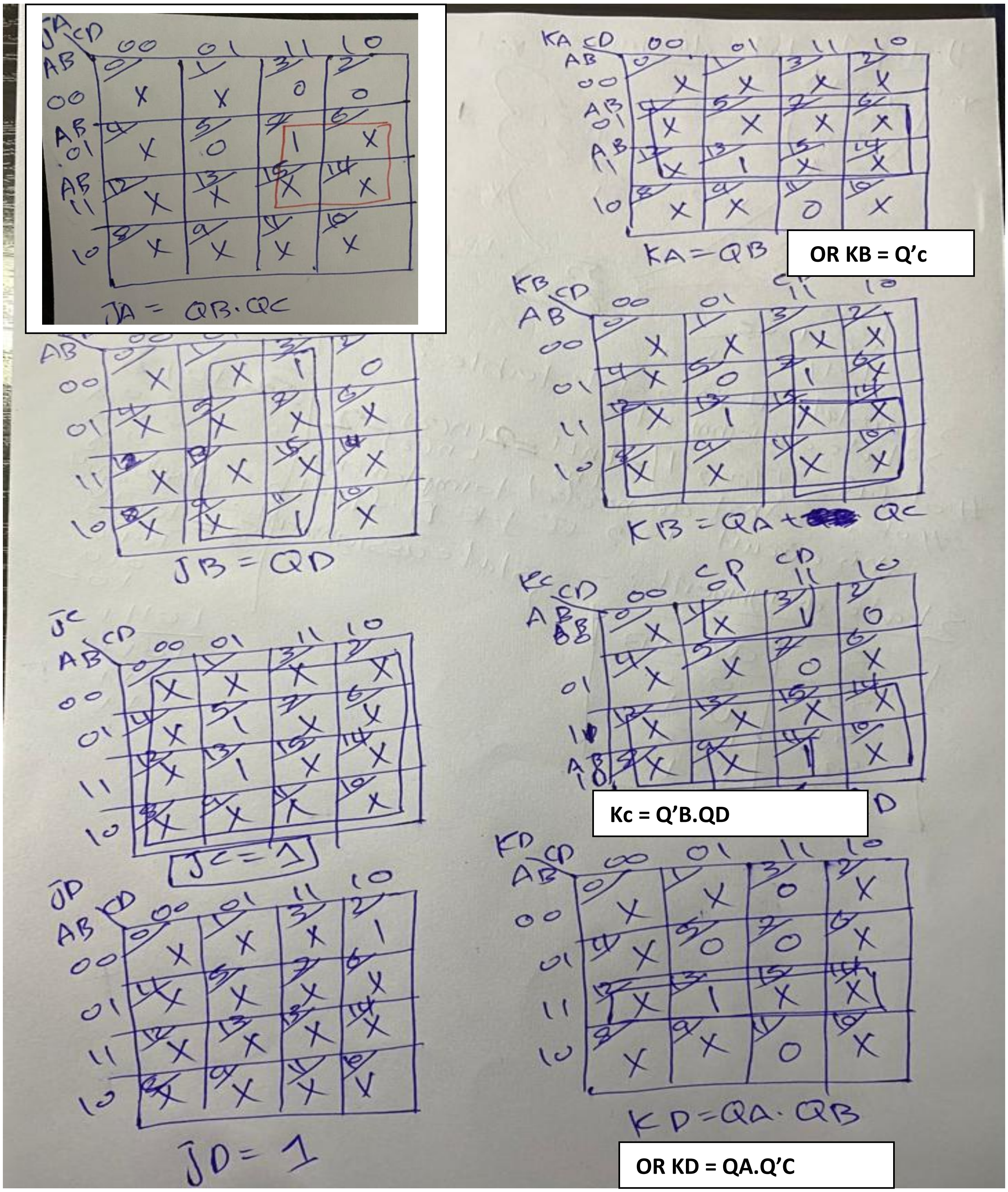
b.

c. The number of the F.Fs that are required to implement this circuit is 4 since we it is a 4-bit counter and each F.F represent one bit(each F.F has one stable output).

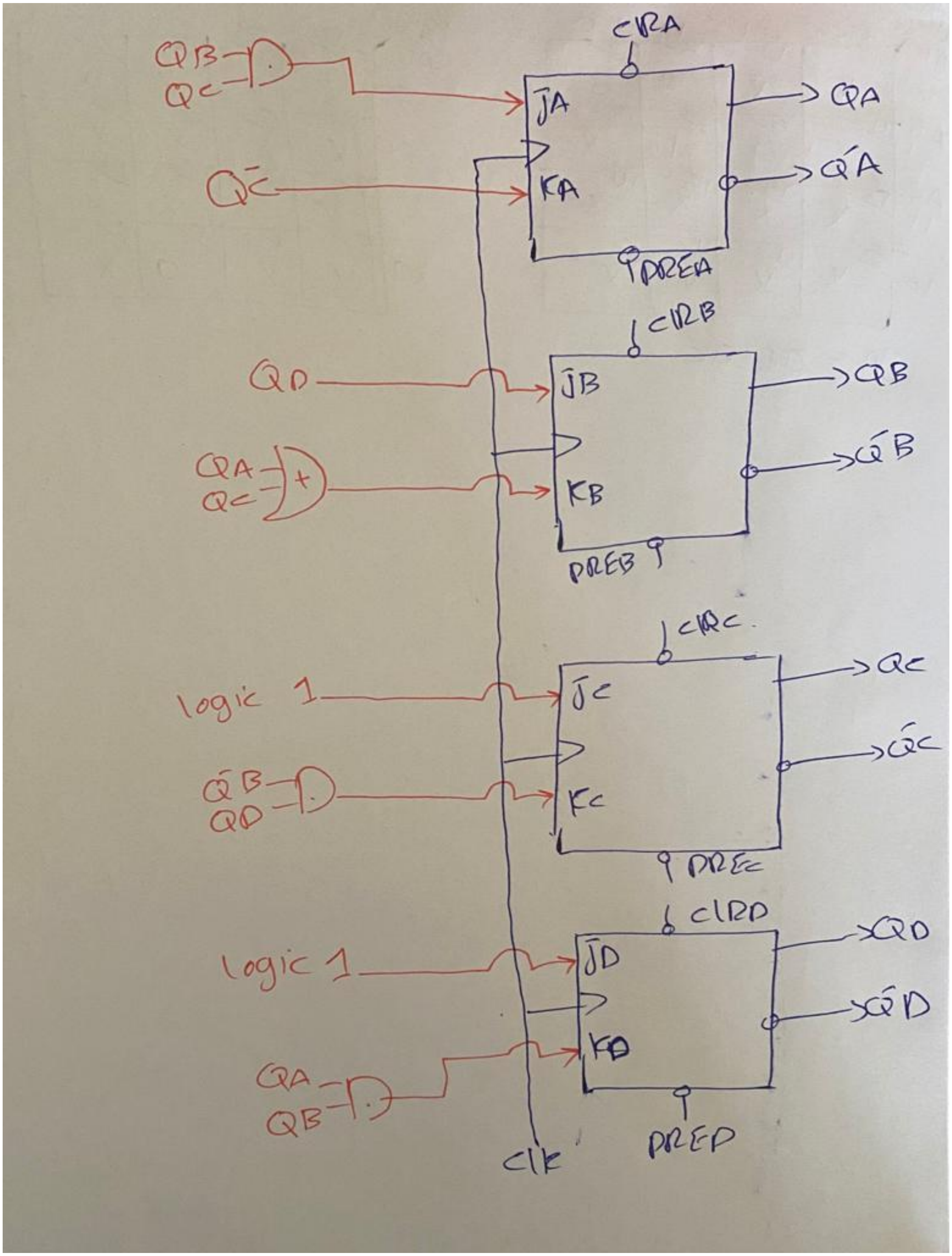
d.

Q_A	Q_B	Q_C	Q_D	Q_A^+	Q_B^+	Q_C^+	Q_D^+	J_A	K_A	J_B	K_B	J_C	K_C	J_D	K_D
0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X
0	0	0	1	X	X	X	X	X	X	X	X	X	X	X	X
0	0	1	0	0	0	1	1	0	X	0	X	X	0	1	X
0	0	1	1	0	1	0	1	0	X	1	X	X	1	X	0
0	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X
0	1	0	1	0	1	1	1	0	X	X	0	1	X	X	0
0	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X
0	1	1	1	1	0	1	1	1	X	X	1	X	0	X	0
1	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X
1	0	0	1	X	X	X	X	X	X	X	X	X	X	X	X
1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X
1	0	1	1	1	1	0	1	X	0	1	X	X	1	X	0
1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X
1	1	0	1	0	0	1	0	X	1	X	1	1	X	X	1
1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X
1	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X

e.

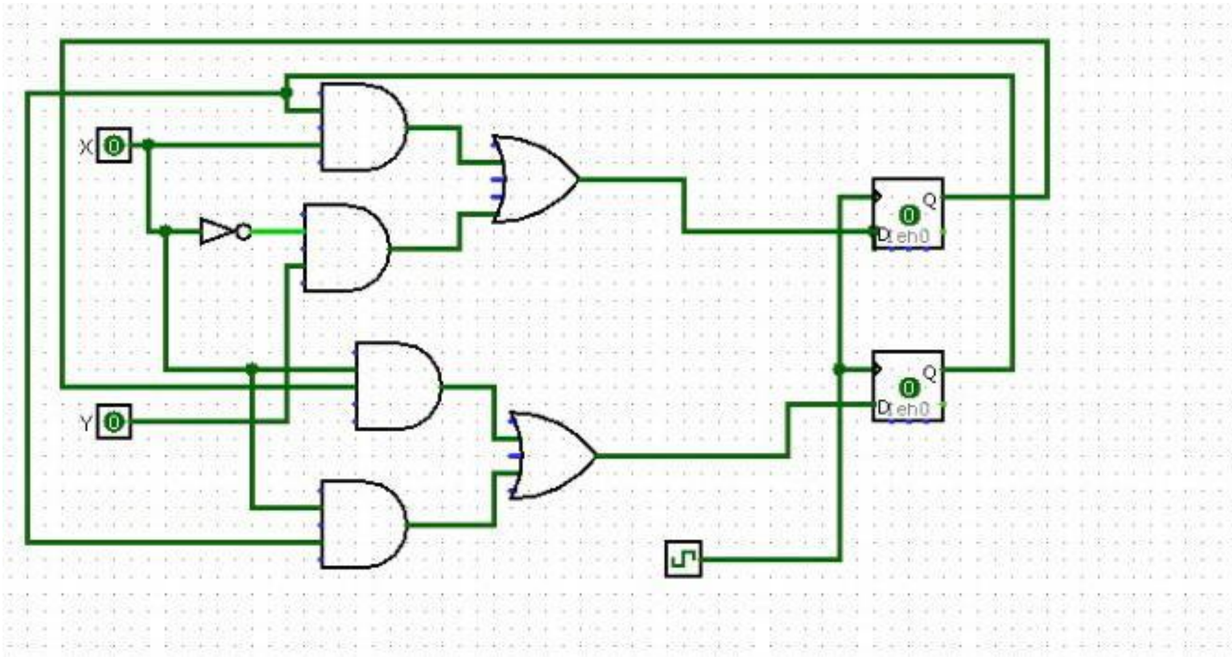

JA = QB.QC
KA = QB
OR KB = Q'c
JB = QD
KB = QA + QC
JC = 1
Kc = Q'B.QD
JD = 1
KD = QA.QB
OR KD = QA.Q'C

f.



CLRA
QB
QC
JA
KA
QA
Q'A
PREA
CLRB
QD
JB
QA
QC
+
KB
QB
Q'B
PREB
CLRC
logic 1
JC
Q'B
QD
KC
QC
Q'C
PREC
CLRD
logic 1
JD
KD
QA
QB
QD
Q'D
PRED
Clk

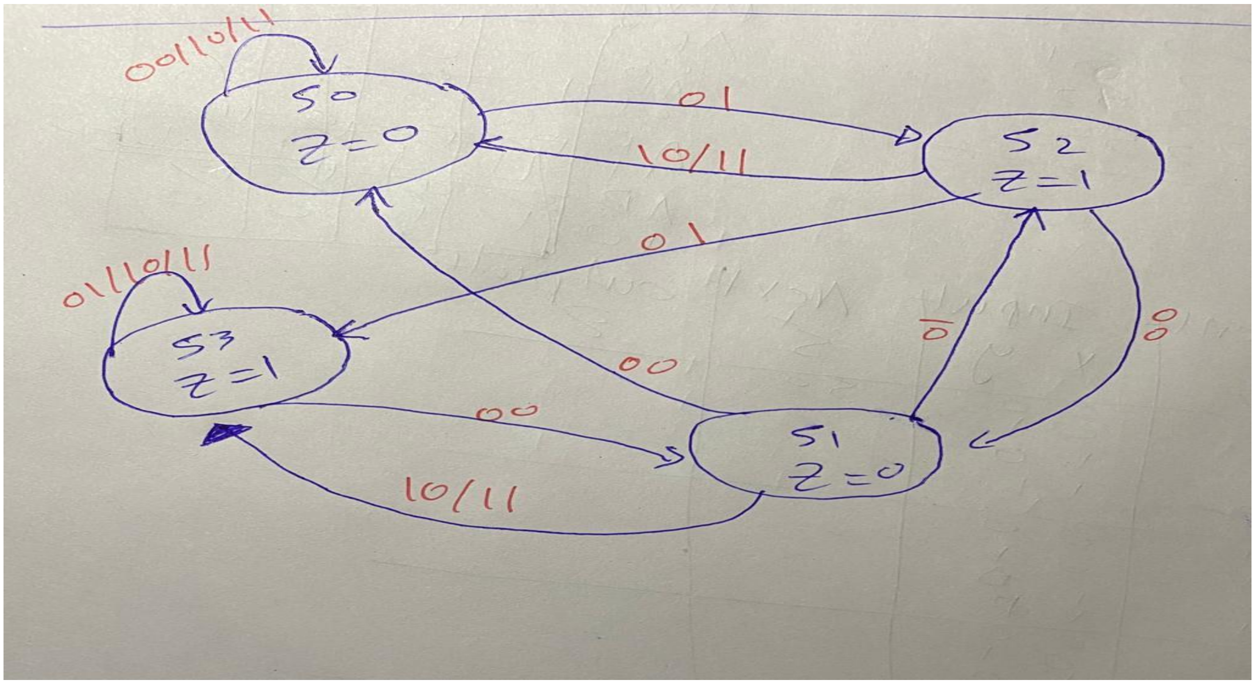
Question 6 .a.



b.

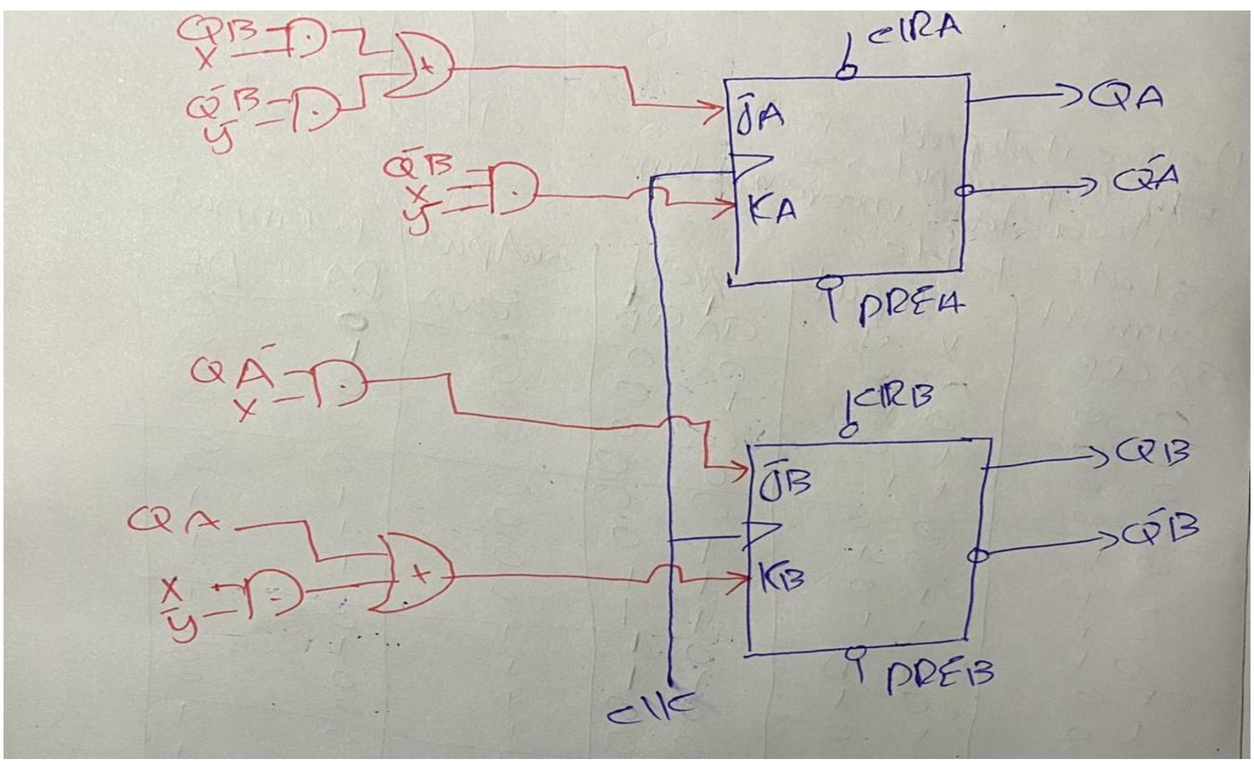
Q_A	Q_B	X	Y	Q_A^+	Q_B^+	Z	D_A	D_B
0	0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	1	0
0	0	1	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0
0	1	0	0	0	0	0	0	0
0	1	0	1	1	0	0	1	0
0	1	1	0	1	1	0	1	1
0	1	1	1	1	1	0	1	1
1	0	0	0	0	1	1	0	1
1	0	0	1	1	1	1	1	1
1	0	1	0	0	0	1	0	0
1	0	1	1	0	0	1	0	0
1	1	0	0	0	1	1	0	1
1	1	0	1	1	1	1	1	1
1	1	1	0	1	1	1	1	1
1	1	1	1	1	1	1	1	1

c.



Question 7

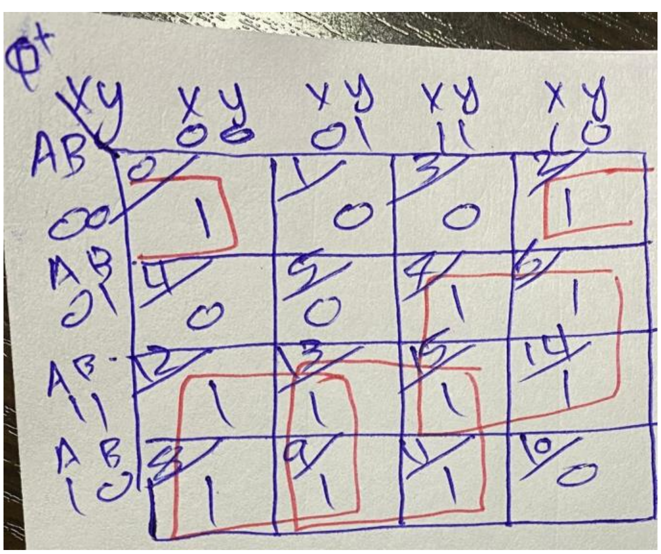
a.



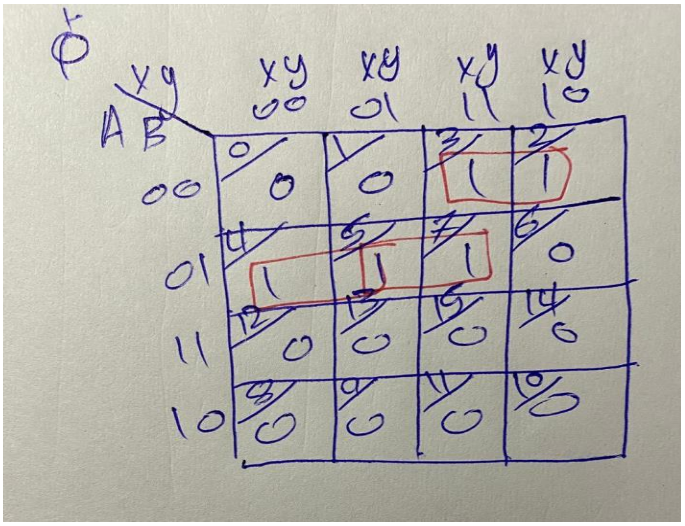
b.

Q_A	Q_B	X	Y	Q_A^+	Q_B^+	Z	J_A	K_A	J_B	K_B
0	0	0	0	1	0	0	1	X	0	X
0	0	0	1	0	0	0	0	X	0	X
0	0	1	0	1	1	0	1	X	1	X
0	0	1	1	0	1	0	0	X	1	X
0	1	0	0	0	1	1	0	X	X	0
0	1	0	1	0	1	0	0	X	X	0
0	1	1	0	1	0	0	1	X	X	1
0	1	1	1	1	1	0	1	X	X	0
1	0	0	0	1	0	0	X	0	0	X
1	0	0	1	1	0	0	X	0	0	X
1	0	1	0	0	0	0	X	1	0	X
1	0	1	1	1	0	0	X	0	0	X
1	1	0	0	1	0	1	X	0	X	1
1	1	0	1	1	0	0	X	0	X	1
1	1	1	0	1	0	0	X	0	X	1
1	1	1	1	1	0	1	X	0	X	1

C.



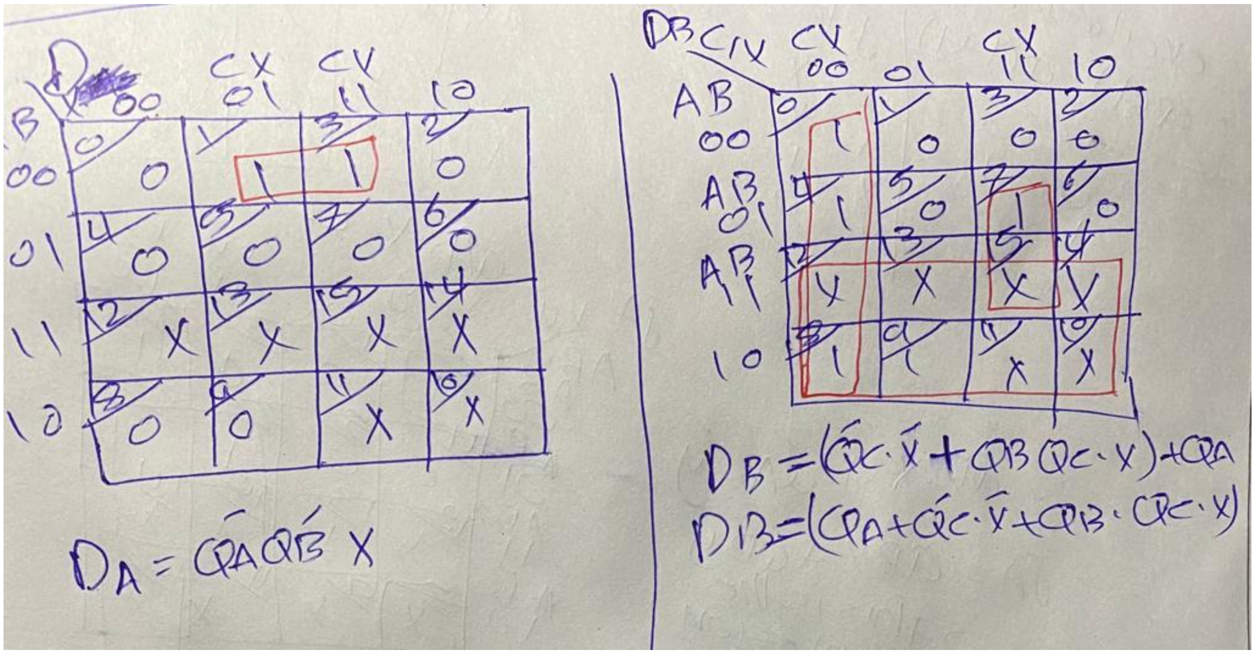
$Q_A(t+1) = Q_Ax'+Q_AY+Q_BX+Q'_AQ'_BY'$

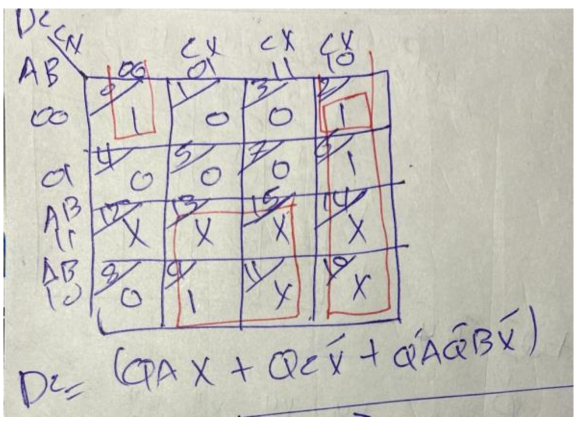


$Q_B(t+1) = Q'_AQ_BX'+Q'_AQ_BY+Q'_AQ'_BX$

Question 8

Q_A	Q_B	Q_C	X	Q_A^+	Q_B^+	Q_C^+	Z	D_A	D_B	D_C
0	0	0	0	0	1	1	0	0	1	1
0	0	0	1	1	0	0	1	1	0	0
0	0	1	0	0	0	1	0	0	0	1
0	0	1	1	1	0	0	1	1	0	0
0	1	0	0	0	1	0	0	0	1	0
0	1	0	1	0	0	0	1	0	0	0
0	1	1	0	0	0	1	0	0	0	1
0	1	1	1	0	1	0	1	0	1	0
1	0	0	0	0	1	0	0	0	1	0
1	0	0	1	0	1	1	0	0	1	1
1	0	1	0	X	X	X	X	X	X	X
1	0	1	1	X	X	X	X	X	X	X
1	1	0	0	X	X	X	X	X	X	X
1	1	0	1	X	X	X	X	X	X	X
1	1	1	0	X	X	X	X	X	X	X
1	1	1	1	X	X	X	X	X	X	X





Unused States

QA QB QC → Next

1 0 1 → 0 1 1

$D_A = 0$, $D_B = 1$, $D_C = 1$.

QA QB QC → Next

1 1 0 →

$D_A = 0$, $D_B = 1$, $D_C = X$ (it is not a do not care condition ... it points to the input x .However, we have to values of x (i.e x = 0, x = 1).

For x = 1

QA QB QC → Next

1 1 0 → 0 1 1

For x = 0

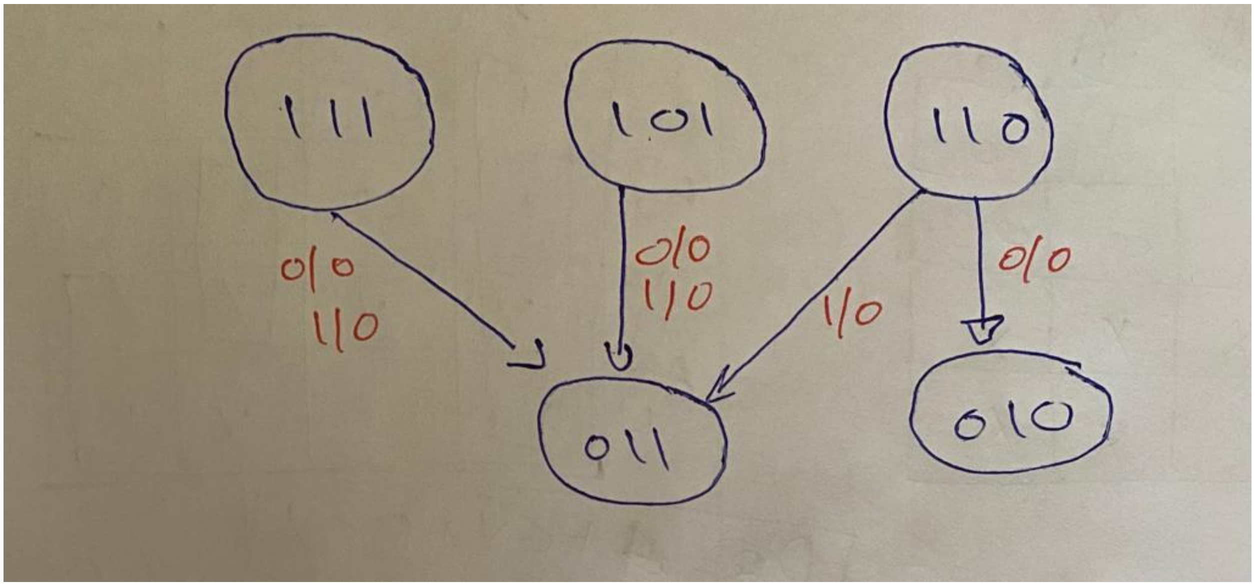
QA QB QC → Next

1 1 0 → 0 1 0

QA QB QC → Next

1 1 1 → 0 1 1

$D_A = 0$, $D_B = 1$, $D_C = 1$



Using J-K-F-F

Q_A	Q_B	Q_C	X	Q_A^+	Q_B^+	Q_C^+	Z	J_A	K_A	J_B	K_B	J_C	K_C
0	0	0	0	0	1	1	0	0	X	1	X	1	X
0	0	0	1	1	0	0	1	1	X	0	X	0	X
0	0	1	0	0	0	1	0	0	X	0	X	X	0
0	0	1	1	1	0	0	1	1	X	0	X	X	1
0	1	0	0	0	1	0	0	0	X	X	0	0	X
0	1	0	1	0	0	0	1	0	X	X	1	0	X
0	1	1	0	0	0	1	0	0	X	X	1	X	0
0	1	1	1	0	1	0	1	0	X	X	0	X	1
1	0	0	0	0	1	0	0	X	1	1	X	0	X
1	0	0	1	0	1	1	0	X	1	1	X	1	X
1	0	1	0	X	X	X	X	X	X	X	X	X	X
1	0	1	1	X	X	X	X	X	X	X	X	X	X
1	1	0	0	X	X	X	X	X	X	X	X	X	X
1	1	0	1	X	X	X	X	X	X	X	X	X	X
1	1	1	0	X	X	X	X	X	X	X	X	X	X
1	1	1	1	X	X	X	X	X	X	X	X	X	X