Counters

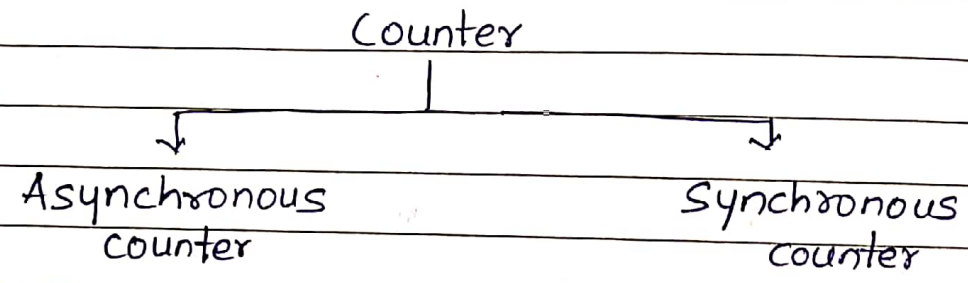
A sequential circuit used to count the clock pulses is called counter.

A flip flop can store 1 bit of information

If we want 2 bit binary counter, then it uses two flipflops.

If three bit binary output is required, the counter uses 3 flipflops.

Types of counters

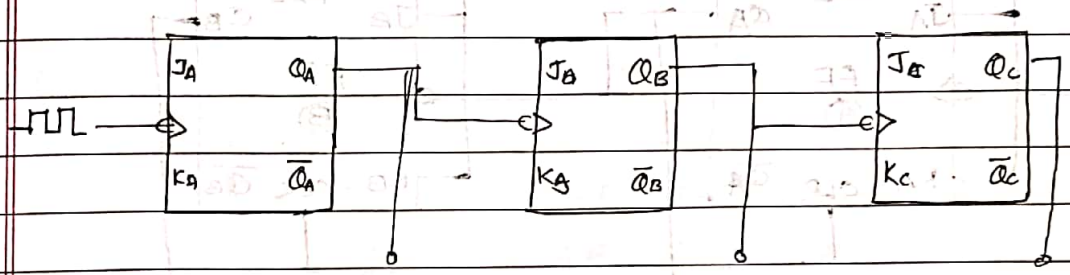


Classification of counter

1. Up- counter
2. Down- counter
3. Up/Down counter

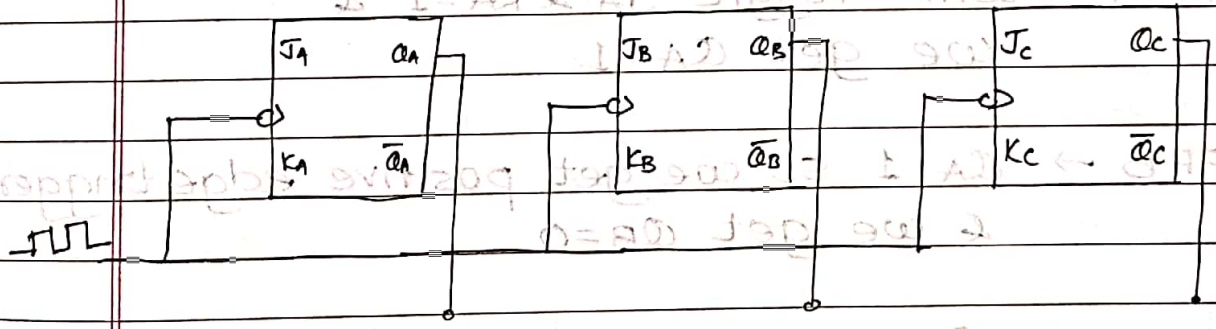
Asynchronous counter

In these external clk signal is applied to one FF and then o/p of preceding FF is connected to clk of next FF.



Synchronous counter

In these all FF receive the external clk pulse applied simultaneously.



Up counter count from small to big

0-1-2-3-4-5-6-7-0

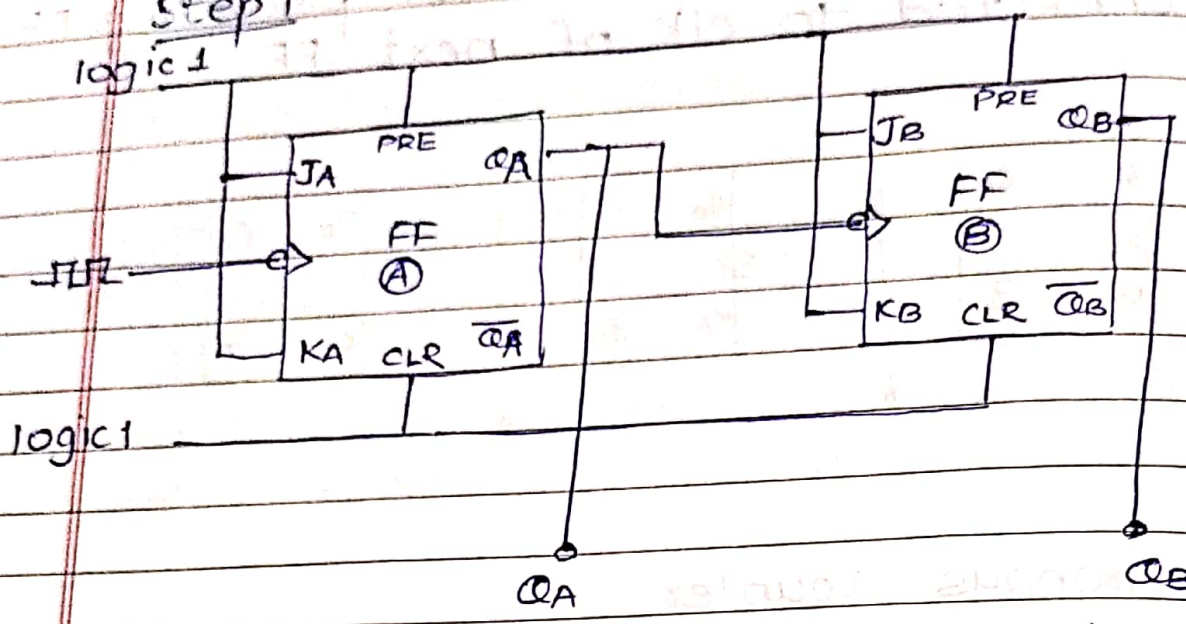
Down counter count from big to small

7-6-5-4-3-2-1-0-7

Up/Down counter is combination of Up & down Counte

Q Design 2 bit Asynchronous/Ripple counter using JKFF.

Step 1



Initial Condition of FF be reset

$Q_B Q_A = 00$

① On 1st -ve clock edge

FF A → will toggle JA & KA = 1 &

we get $Q_A = 1$

FFB → $Q_A = 1$ so we get positive edge trigger

& we get $Q_B = 0$

$Q_B Q_A = 01$

② On 2nd -ve clock pulse

FFA → will toggle & we get $Q_A = 0$

FFB → $Q_A = 0$ so FFB get negative edge trigger

& we get $Q_B = 1$

$Q_B Q_A = 10$

③ On 3rd -ve clock pulse
FFA → will toggle ← we get $Q_A = 1$
FFB → $Q_A = 1$ so FFB get +ve edge trigger
← we get $Q_B = 1$

$Q_B Q_A = 1\ 1$

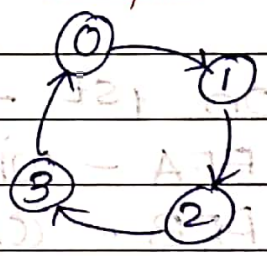
④ On 4th -ve clock pulse.
FFA → will toggle ← we get $Q_A = 0$
FFB → $Q_A = 0$ so FFB get -ve edge trigger
← toggle we get $Q_B = 0$

$Q_B Q_A = 00$

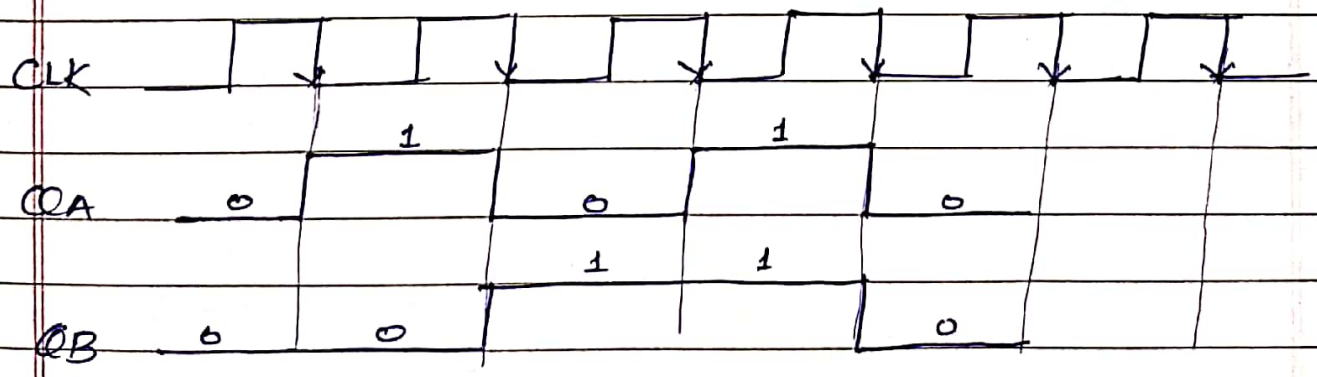
Step 2

CLK	Q_B	Q_A	state
↓	0	0	0
↓	0	1	1
↓	1	0	2
↓	1	1	3
↓	0	0	0

Step 3

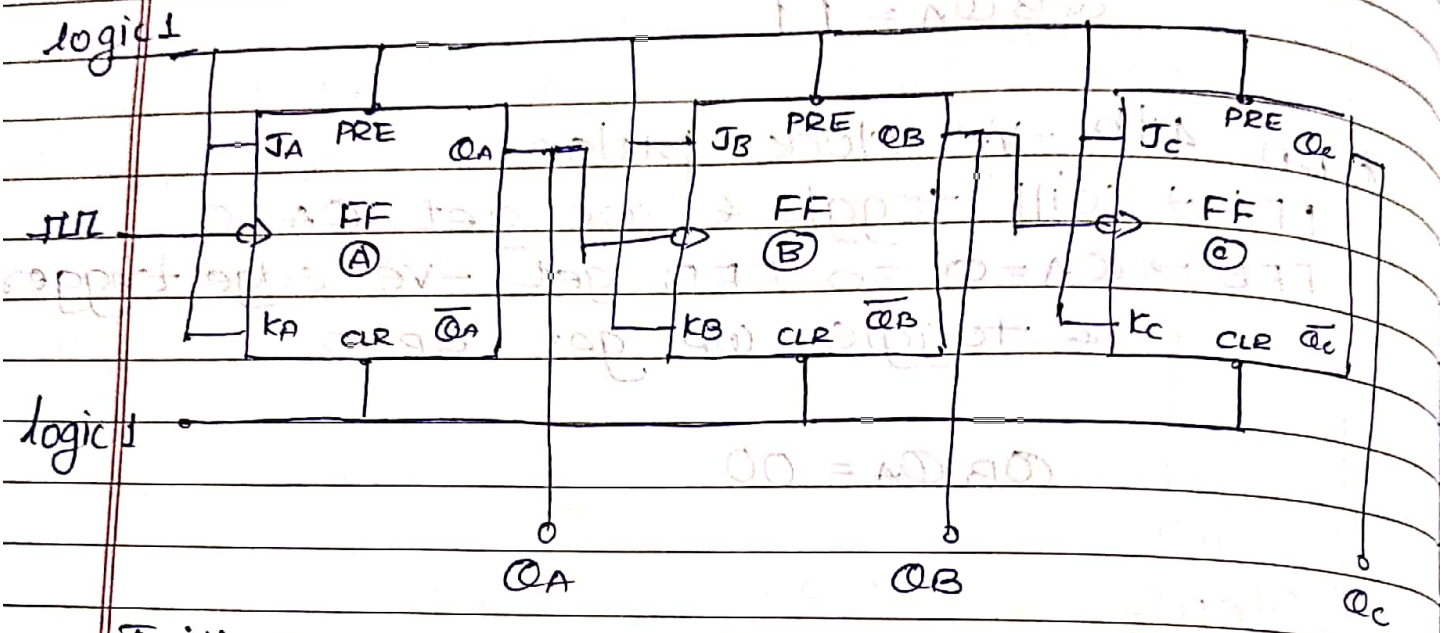


Step 4



Q Design 3 bit Asynchronous / Ripple Up counter using JKFF

Step1



Initial condition of FF be reset

$Q_C\ Q_B\ Q_A = 000$

① On 1st -ve clock edge

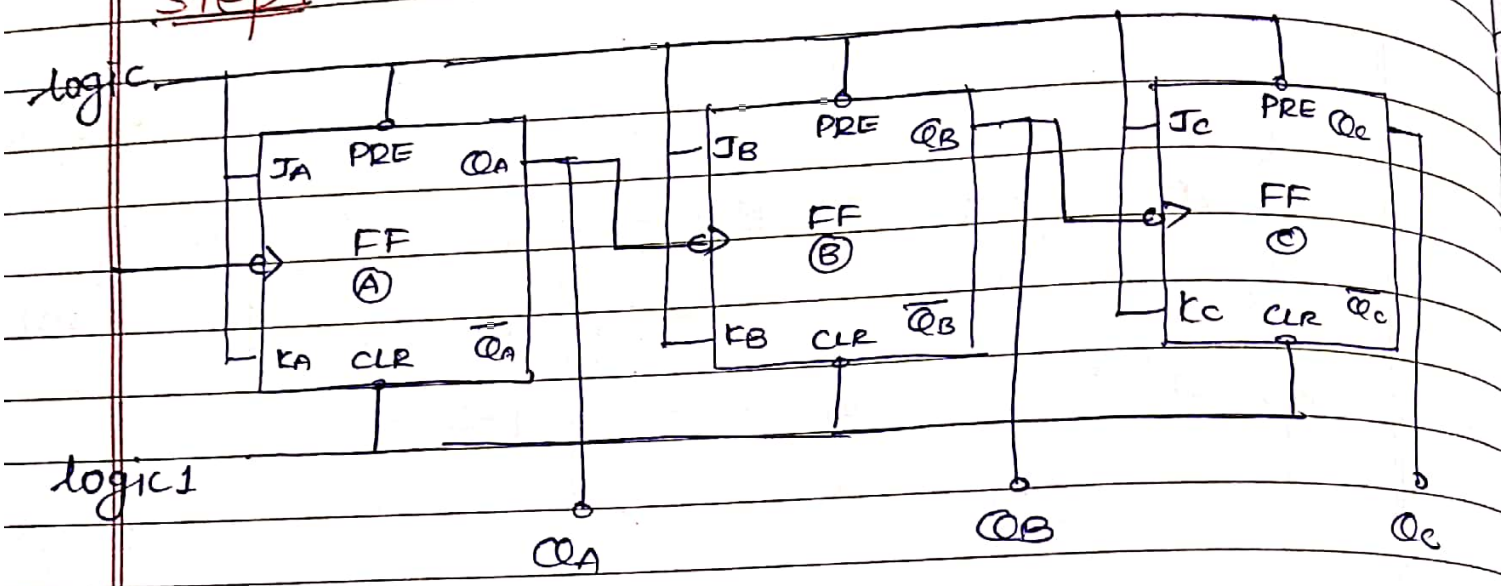
FFA - will toggle & we get $Q_A = 1$

FFB - $Q_A = 1$ & we get $Q_B = 0$

FFC -

Q Design 3 bit Asynchronous/Ripple Up counter using JKFF

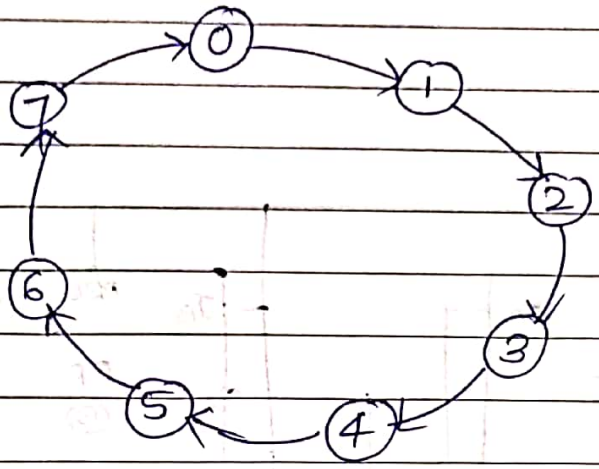
Step 1



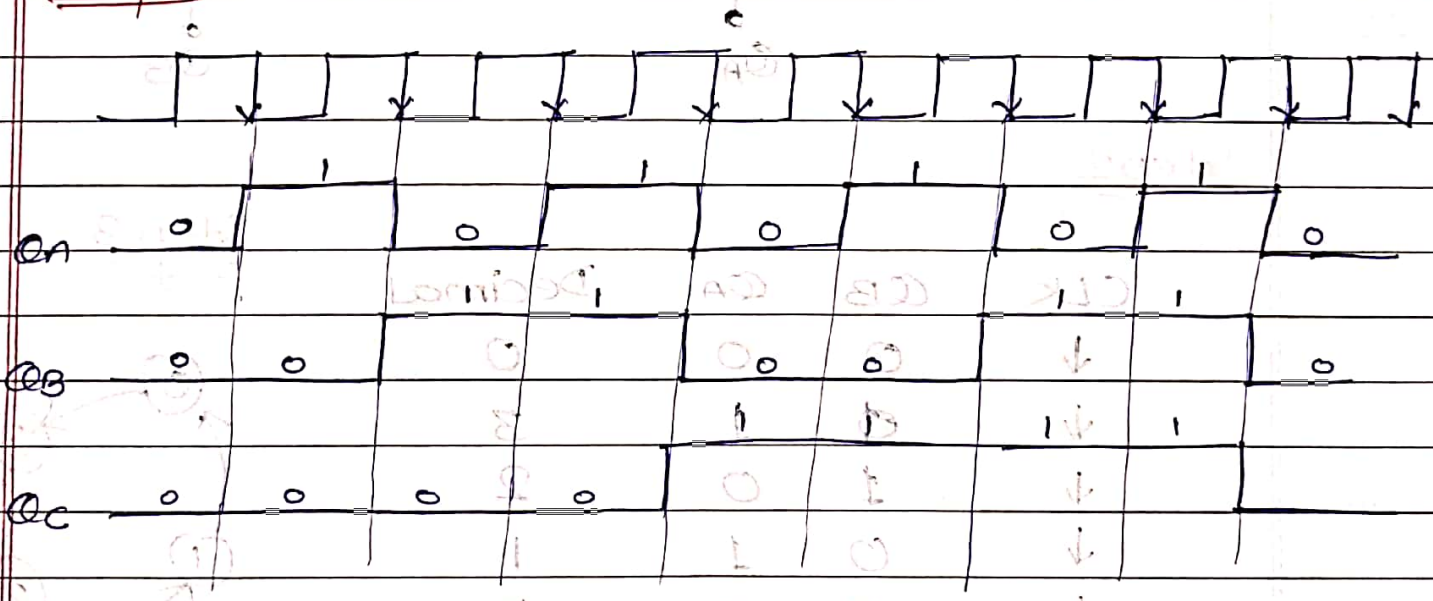
Step 2

CLR	QC	QB	QA	Decimal
↓	0	0	0	0
↓	0	0	1	1
↓	0	1	0	2
↓	0	1	1	3
↓	1	0	0	4
↓	1	0	1	5
↓	1	1	0	6
↓	1	1	1	7
↓	0	0	0	0

Step 3

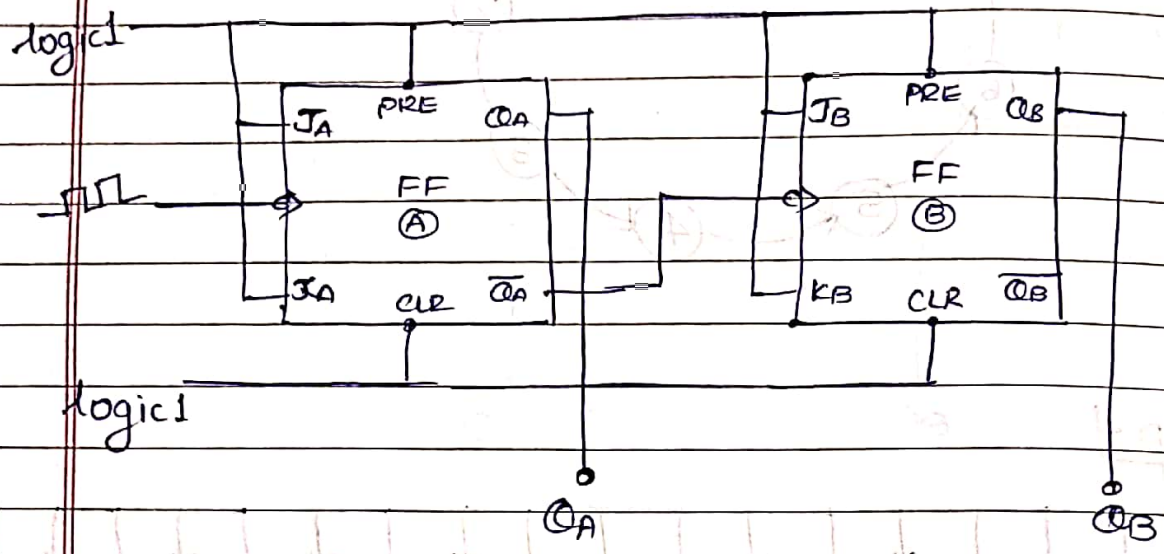


Step 4



Q Design 2 bit Asynchronous/Ripple Down Counter

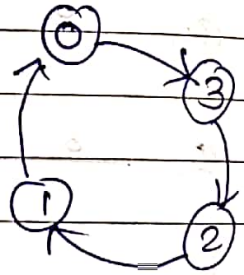
Step 1



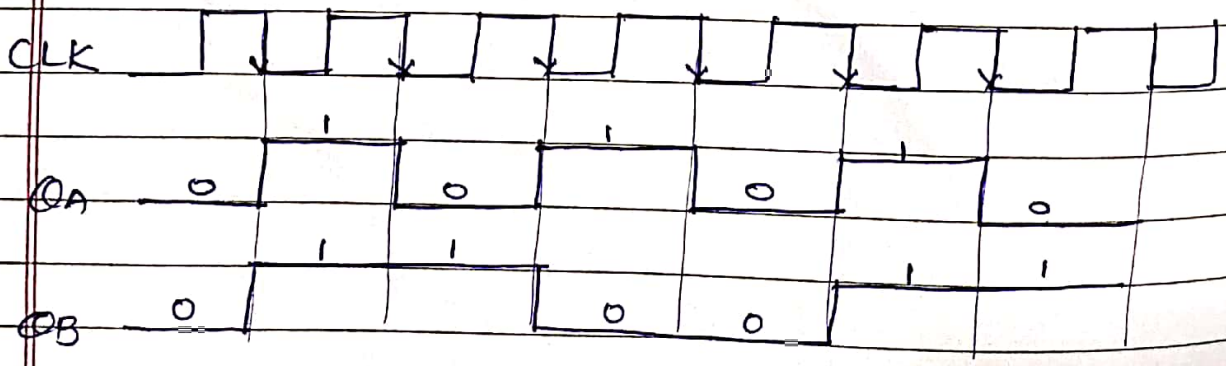
Step 2

CLK	Q_B	Q_A	Decimal
↓	0	0	0
↓	1	1	3
↓	1	0	2
↓	0	1	1
↓	0	0	0

Step 3

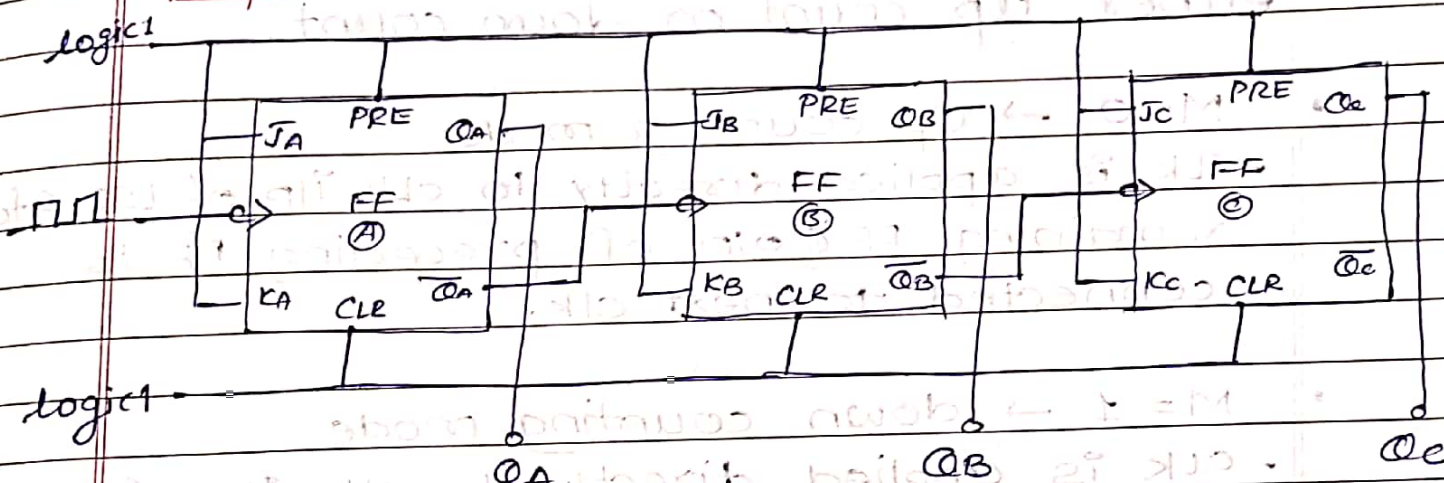


Step 4



Q Design 3 bit Asynchronous/Ripple Down Counter.

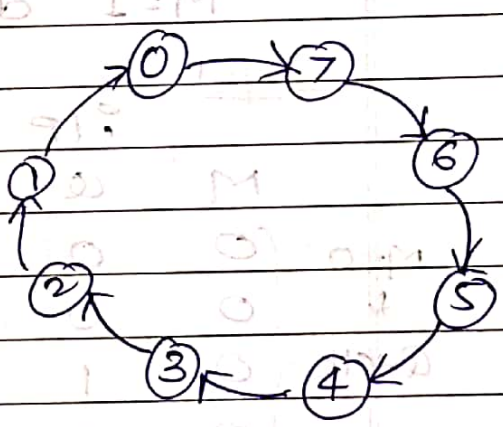
Step 1



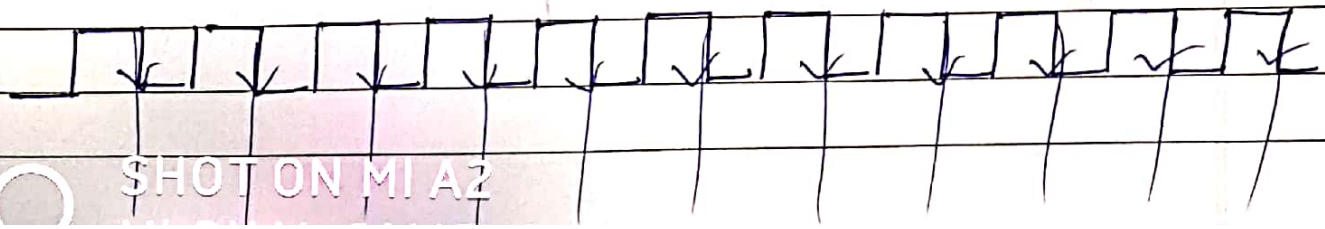
Step 2

CLK	Q_C	Q_B	Q_A	Decimal
↓	0	0	0	0
↓	1	1	1	7
↓	1	1	0	6
↓	1	0	1	5
↓	1	0	0	4
↓	0	1	1	3
↓	0	1	0	2
↓	0	0	1	1
↓	0	0	0	0

Step 3



Step 4



Design 2 bit Up/Down Asynchronous counter

A mode control (M) i/p is used to select either up count or down count.

- M=0 → Up counting mode
  - CLK is applied directly to clk i/p of LSB & for remaining FF Q o/p of preceding FF is connected to next clk.
- M=1 → down counting mode
  - clk is applied directly to clk i/p of LSB & remaining FF $\overline{Q}$ o/p preceding FF is connected to next clk.

if M=0 Up counting → Q to clk
M=1 down counting → $\overline{Q}$ to clk

Step 1.

	i/p		o/p
	M	Q	$\overline{Q}$	Y
M=0 ↓ Q→clk	0	0	0	0
	0	0	1	0
	0	1	0	1
	0	1	1	1
M=1 ↓ $\overline{Q}$→clk	1	0	0	0
	1	0	1	1
	1	1	0	0
	1	1	1	1

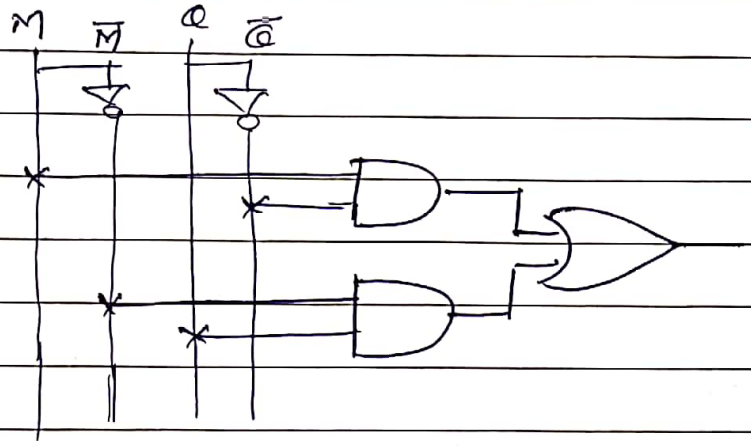
Step 2

K-Map for Y

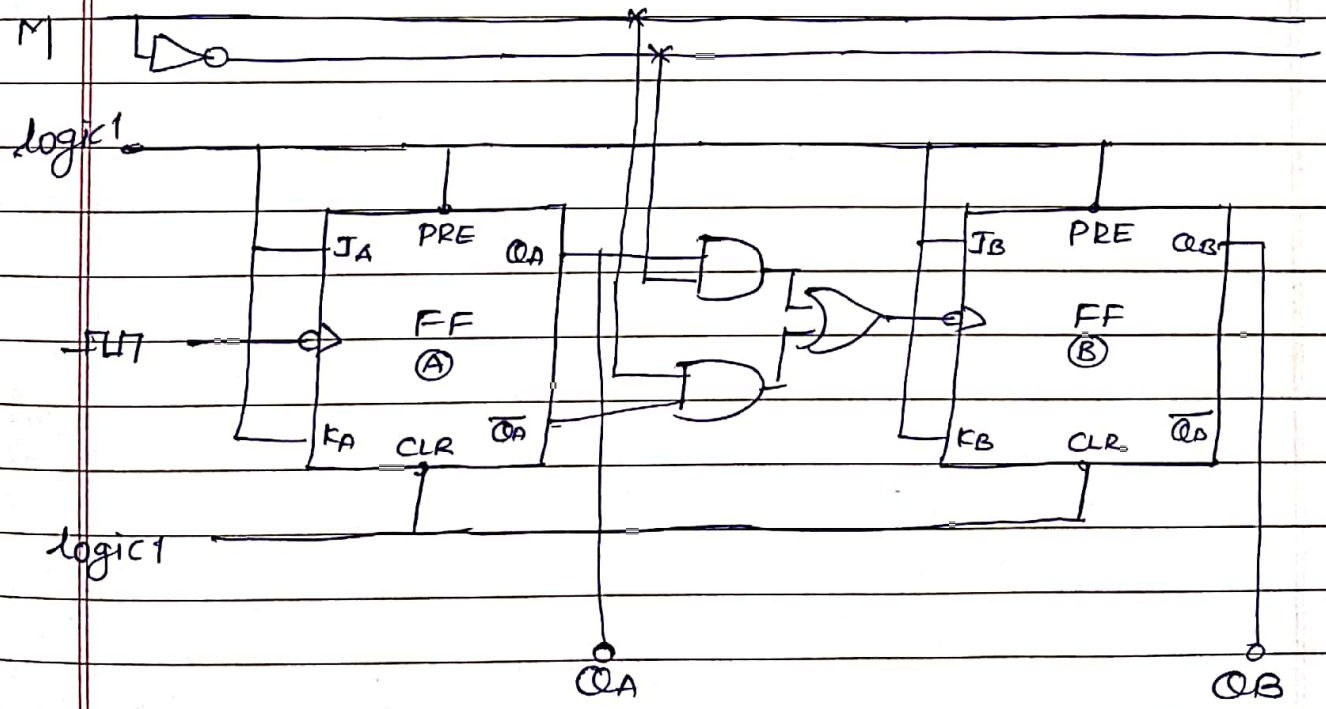
M \ $Q_A Q_B$	$\bar{Q}_A \bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A \bar{Q}_B$
$\bar{M}$	0	1	1 (3)	1 (2)
M	4	1 (5)	1 (7)	6

$$Y = M\bar{Q} + \bar{M}Q$$

Step 3



Step 4



Design 3 bit Asynchronous/Ripple Up-Down counter.

Q Design MOD-6 Asynchronous counter using JKFF

Step 1

No. of FF required to design MOD-6

$N = 6$

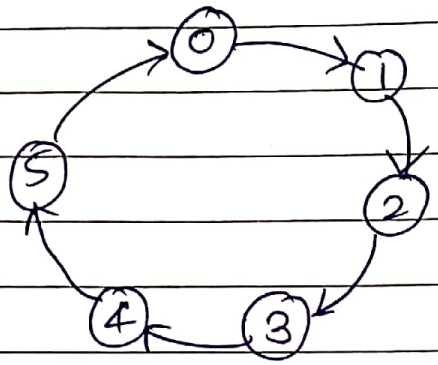
$2^n \geq N$

$2^n \geq 6$

$n = 3$

we need 3 flip flops.

Step 2 State diagram



Step 3

CLK	Q_C	Q_B	Q_A	O/P
0	0	0	0	1
1	0	0	1	1
2	0	1	0	1
3	0	1	1	1
4	1	0	0	1
5	1	0	1	1
6	1	1	0	0
7	1	1	1	0

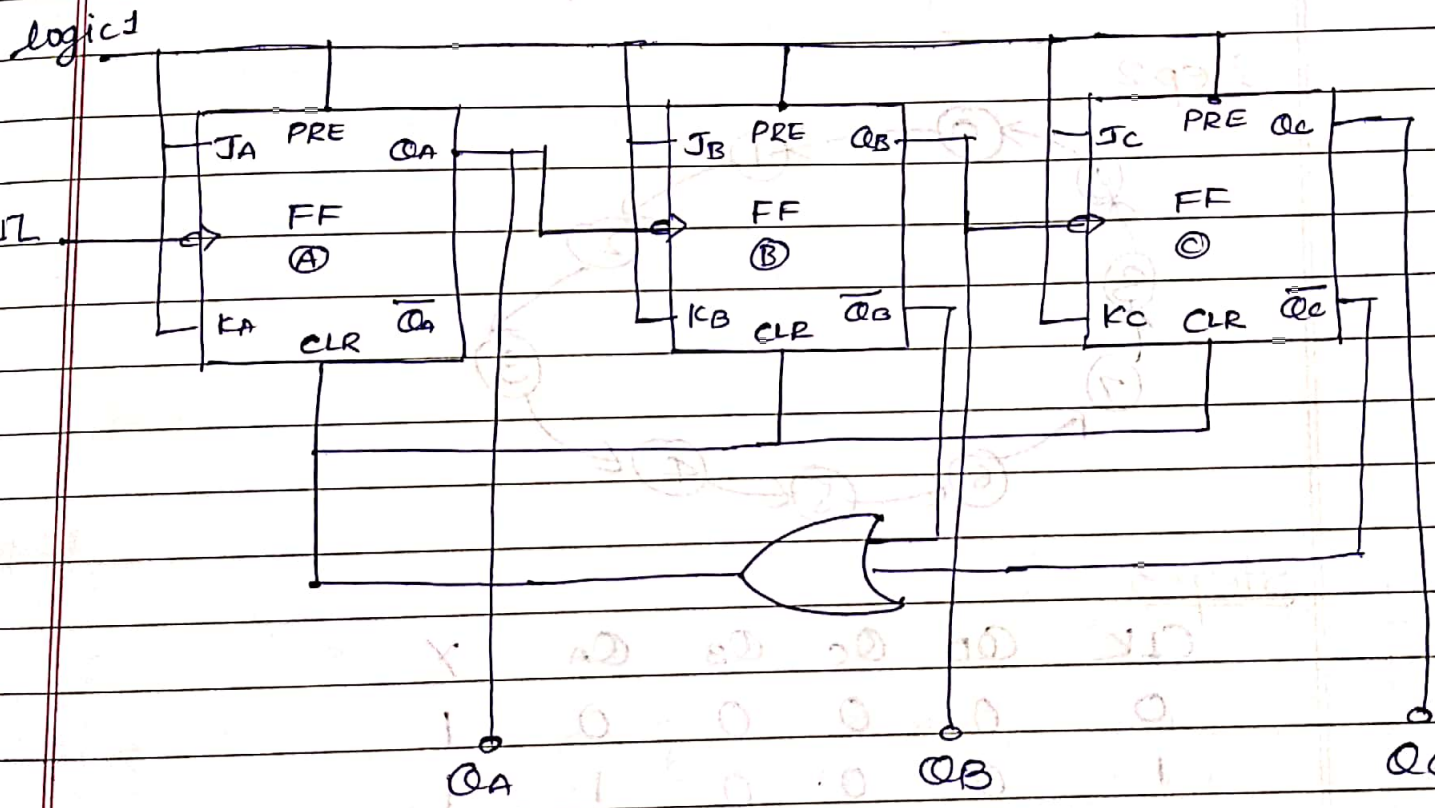
Step 4

K-Map for O/P

Q_C \ $Q_B Q_A$	$\overline{Q_B}\,\overline{Q_A}$	$\overline{Q_B} Q_A$	$Q_B Q_A$	$Q_B \overline{Q_A}$
$\overline{Q_C}$	1 (0)	1 (1)	1 (3)	1 (2)
Q_C	1 (4)	1 (5)	(7)	(6)

$$O/P = \overline{Q_C} + \overline{Q_B}$$

Step 5



Q Design MOD-10 Asynchronous counter
Decade counter / BCD counter.

Step1

No. of FF required to design MOD-10

$N = 10$

$2^n \geq N$

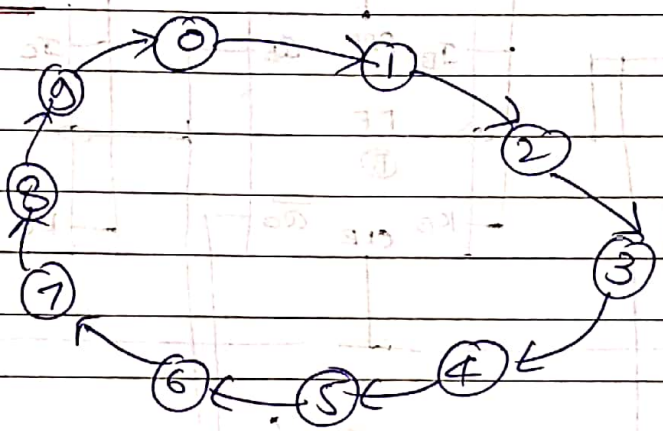
$2^n \geq 10$

$2^4 \geq 10$

$n = 4$

we need 4 flip flop

Step2



Step3

CLK	Q_D	Q_C	Q_B	Q_A	Y
0	0	0	0	0	1
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	1
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	1

CLK	Q_D	Q_C	Q_B	Q_A	Y
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	0
13	1	1	0	1	0
14	1	ϕ	1	0	0
15	1	ϕ	1	1	0

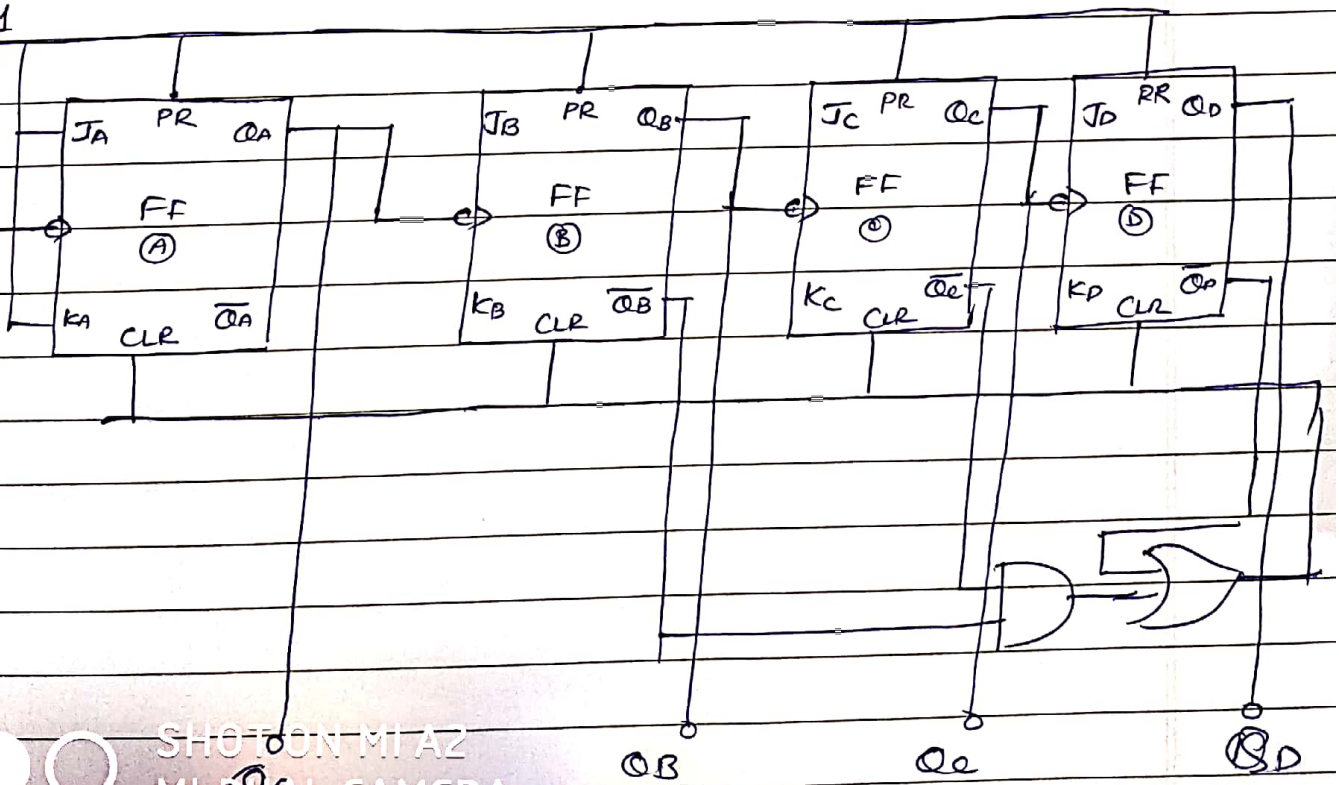
Step 4

$Q_D Q_C$ \ $Q_B Q_A$	$\bar{Q}_B \bar{Q}_A$	$\bar{Q}_B Q_A$	$Q_B Q_A$	$Q_B \bar{Q}_A$
$\bar{Q}_D \bar{Q}_C$	1 (0)	1 (1)	1 (3)	1 (2)
$\bar{Q}_D Q_C$	1 (4)	1 (5)	1 (7)	1 (6)
$Q_D Q_C$	0 (12)	(13)	(15)	(14)
$Q_D \bar{Q}_C$	1 (8)	1 (9)	(11)	(10)

$$Y = \bar{Q}_D + \bar{Q}_C \bar{Q}_B$$

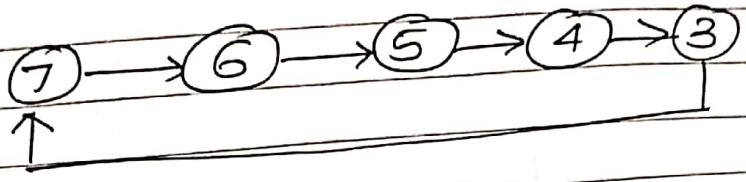
Step 5

logic 1



Q Design MOD-5 Asynchronous/Ripple Down counter

Q Design a ripple counter for the state shown in fig.



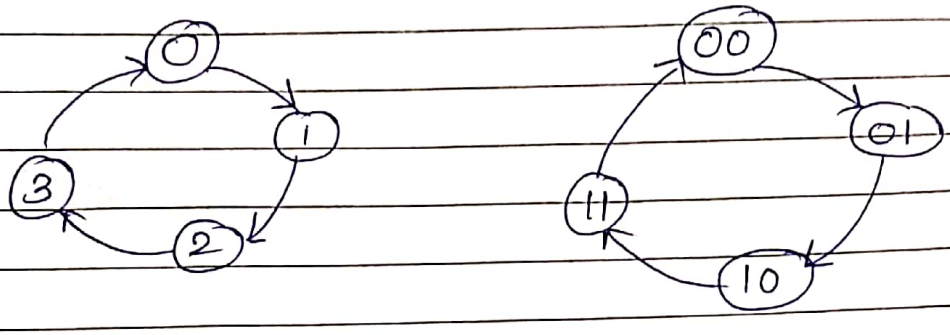
Q Design 2 bit synchronous Up Counter

Step1

No. of filp-flop required for 2 bit counter is 2 flip-flop.

Step2

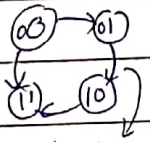
State diagram



Step 3

Excitation Table of JKFF

Qn	Qn+1	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0



Truth Table

	Present state		Next state		O/P			
CLK	Q_A	Q_B	Q_{AH}	Q_{BH}	J_A	K_A	J_B	K_B
0	0	0	0	1	0	X	1	X
1	0	1	1	0	1	X	X	1
2	1	0	1	1	X	0	1	X
3	1	1	0	0	X	1	X	1

Step 4

K-Map for J_A

Q_A \ Q_B	$\bar{Q}_B$	Q_B
$\bar{Q}_A$		1
Q_A	X	X

$J_A = Q_B$

K-Map for K_A

Q_A \ Q_B	$\bar{Q}_B$	Q_B
$\bar{Q}_A$	X	X
Q_A		1

$K_A = Q_B$

K-Map for J_B

Q_A \ Q_B	$\bar{Q}_B$	Q_B
$\bar{Q}_A$	1	X
Q_A	1	X

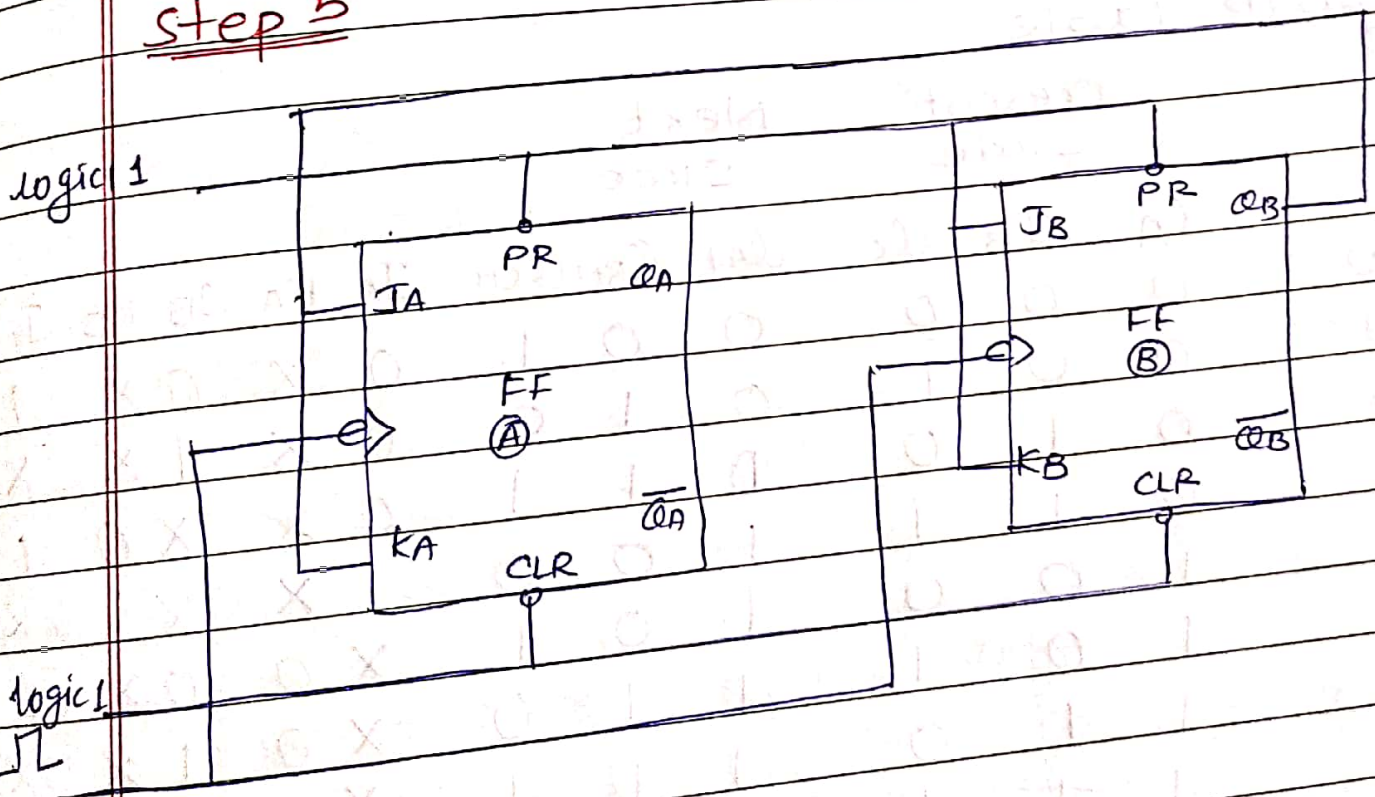
$J_B = 1$

K-Map for K_B

Q_A \ Q_B	$\bar{Q}_B$	Q_B
$\bar{Q}_A$	X	1
Q_A	X	1

$K_B = 1$

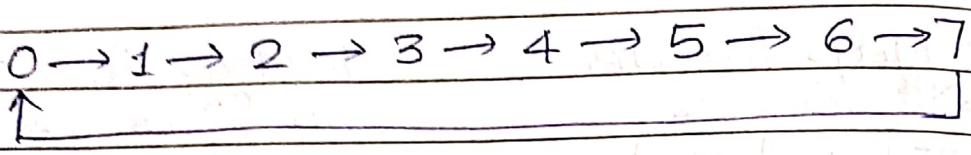
Step 5



Q.
Design 3 bit synchronous up counter

Step 1
No. of flip flops requires to design 3 bit counter are 3 flip flop.

Step 2



Step 3

Excitation table JK FF

0	0	0	x
0	1	1	x
1	0	x	1
1	1	x	0

Truth Table

	Present state			Next state								
	Q_A	Q_B	Q_C	Q_{A+1}	Q_{B+1}	Q_{C+1}	J_A	K_A	J_B	K_B	J_C	K_C
0	0	0	0	0	0	1	0	X	0	X	1	X
1	0	0	1	0	1	0	0	X	1	X	X	1
2	0	1	0	0	1	1	0	X	X	0	1	X
3	0	1	1	1	0	0	1	X	X	1	X	1
4	1	0	0	1	0	1	X	0	0	X	1	X
5	1	0	1	1	1	0	X	0	1	X	X	1
6	1	1	0	1	1	1	X	0	X	0	1	X
7	1	1	1	0	0	0	X	1	X	1	X	1

Step 4

K-Map for J_A

Q_n \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
Q_A	0	1	1 (3)	2
$\bar{Q}_A$	X (4)	X (5)	X (7)	X (6)

$J_A = Q_B Q_C$

K-Map for K_A

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	X 0	X 1	X (3)	X 2
Q_A	4	5	1 (7)	6

$K_A = Q_B Q_C$

K-Map for J_B

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	0	1 (1)	X (3)	X 2
Q_A	4	1 5	X (7)	X 6

$J_B = Q_C$

K-Map for K_B

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	X 0	X (2)	1 3	3
Q_A	X 4	X 5	1 (7)	6

$K_B = Q_C$

K-Map for J_C

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	1 0	X 1	X 3	1 2
Q_A	1 4	X 5	X 7	1 6

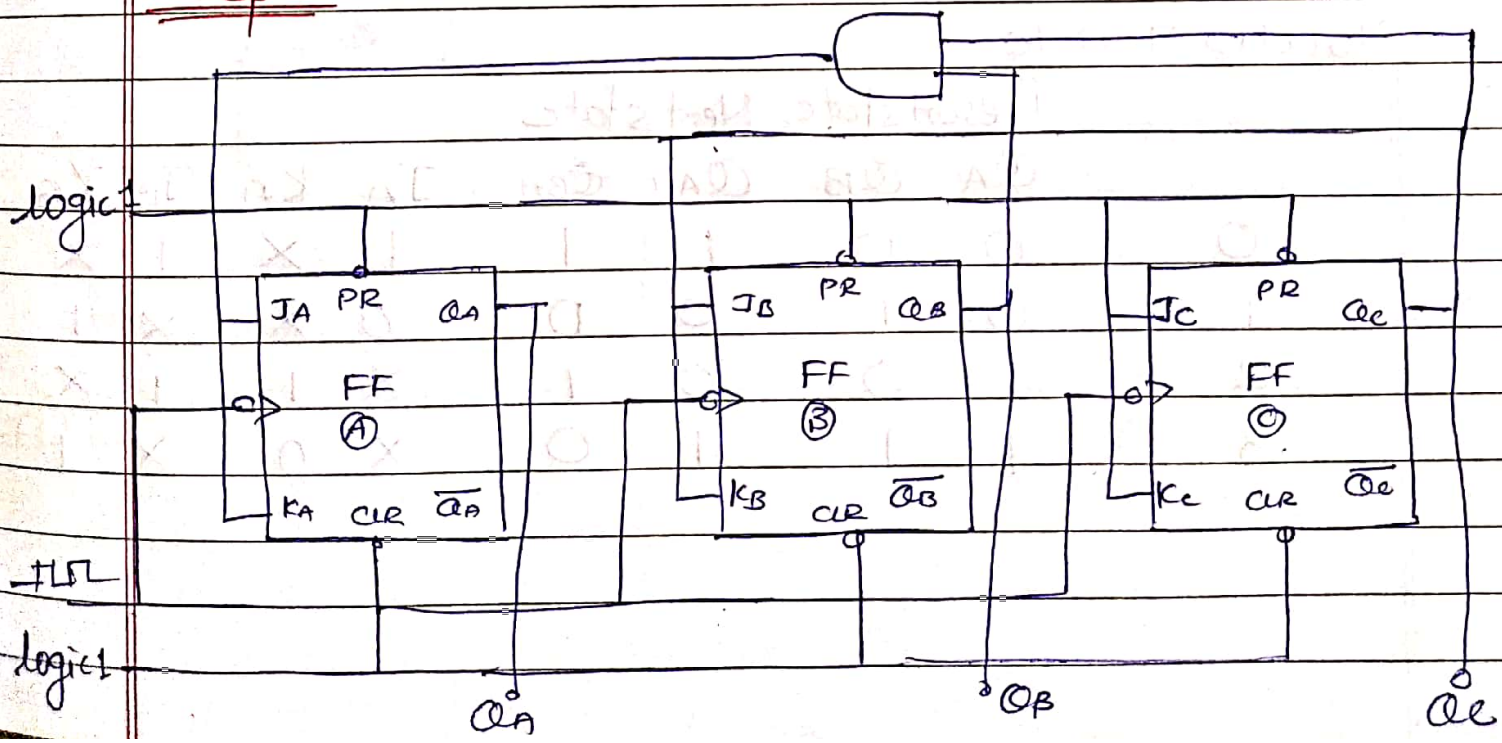
$J_C = 1$

K-Map for K_C

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	X 0	1 1	1 3	X 2
Q_A	X 4	1 5	1 7	X 6

$K_C = 1$

Step 5

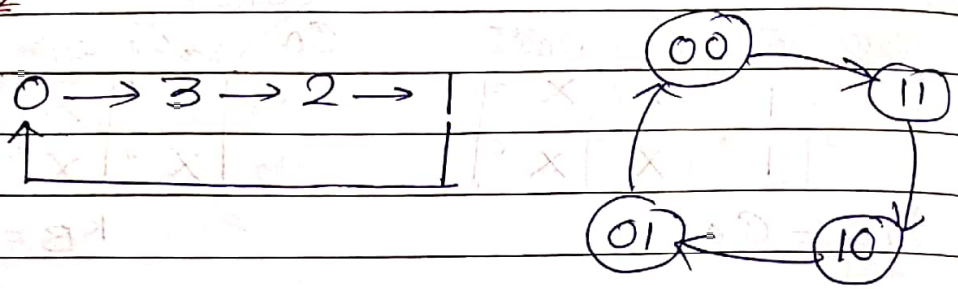


Design 2 bit synchronous down counter

Step 1

No. of flip flops required to design 2 bit counter are 2 flip flop

Step 2



Step 3

Excitation table of JKFF

J	K	Q	$\bar{Q}$
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Truth Table

	Present state		Next state					
	Q_A	Q_B	Q_{AH}	Q_{BH}	J_A	K_A	J_B	K_B
0	0	0	1	1	1	X	1	X
1	0	1	0	0	0	X	X	1
2	1	0	0	1	X	1	1	X
3	1	1	1	0	X	0	X	1

Step 1

K-Map for J_A

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	1 (0)	(1)
Q_A	X (2)	X (3)

$J_A = \overline{Q_B}$

K-Map for K_A

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	X (0)	X (1)
Q_A	X (2)	0 (3)

$K_A = \overline{Q_B}$

K-Map for J_B

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	1 (0)	X (1)
Q_A	1 (2)	X (3)

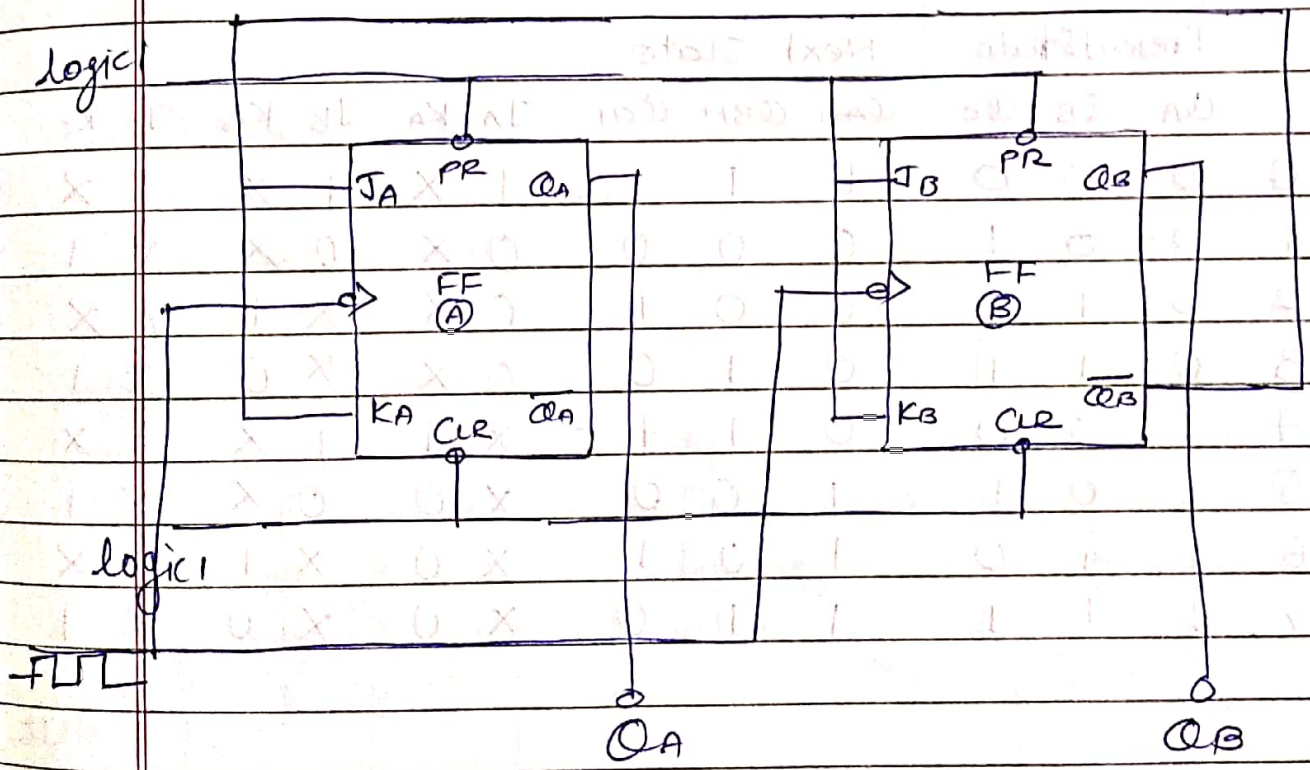
$J_B = 1$

K-Map for K_B

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	X (0)	1 (1)
Q_A	1 (2)	X (3)

$K_B = 1$

Step 5

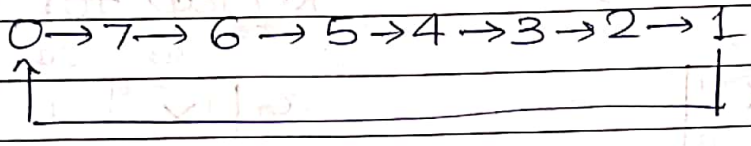


Design 3bit synchronous down counter using JKFF

Step 1

No. of flip flop are required to design 3 bit counters are 3 flip flop

Step 2



Step 3 Excitation Table JKFF

0	0	0 X
0	1	1 X
1	0	X 1
1	1	X 0

Present State			Next State							
Q_A	Q_B	Q_C	Q_{AH}	Q_{BH}	Q_{CH}	J_A K_A	J_B K_B	J_C K_C
0	0	0	1	1	1	1 X	1 X	1 X
1	0	0	1	0	0	0 X	0 X	X 1
2	0	1	0	0	1	0 X	X 1	1 X
3	0	1	1	0	1	0 X	X 0	X 1
4	1	0	0	0	1	1 X	1 X	1 X
5	1	0	1	1	0	0 X	0 X	X 1
6	1	1	0	1	0	1 X	X 1	1 X
7	1	1	1	1	1	0 X	X 0	X 1

Step 4

K-Map for J_A

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	1 (0)	(1)	3	2
Q_A	X (4)	X (5)	X (7)	X (6)

$J_A = \bar{Q}_B\bar{Q}_C$

K-Map for K_A

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	X (0)	X (1)	X (3)	X (2)
Q_A	1 (4)	(5)	(7)	(6)

$K_A = \bar{Q}_B\bar{Q}_C$

K-Map for J_B

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	1 (0)	(1)	X (3)	X (2)
Q_A	1 (4)	(5)	X (7)	X (6)

$J_B = \bar{Q}_C$

K-Map for K_B

Q_A \ $Q_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$
$\bar{Q}_A$	X (0)	X (1)	(3)	1 (2)
Q_A	X (4)	X (5)	(7)	1 (6)

$K_B = \bar{Q}_C$

K-Map for J_C

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	1 (0)	X (1)	X (3)	1 (2)
Q_A	1 (4)	X (5)	X (7)	1 (6)

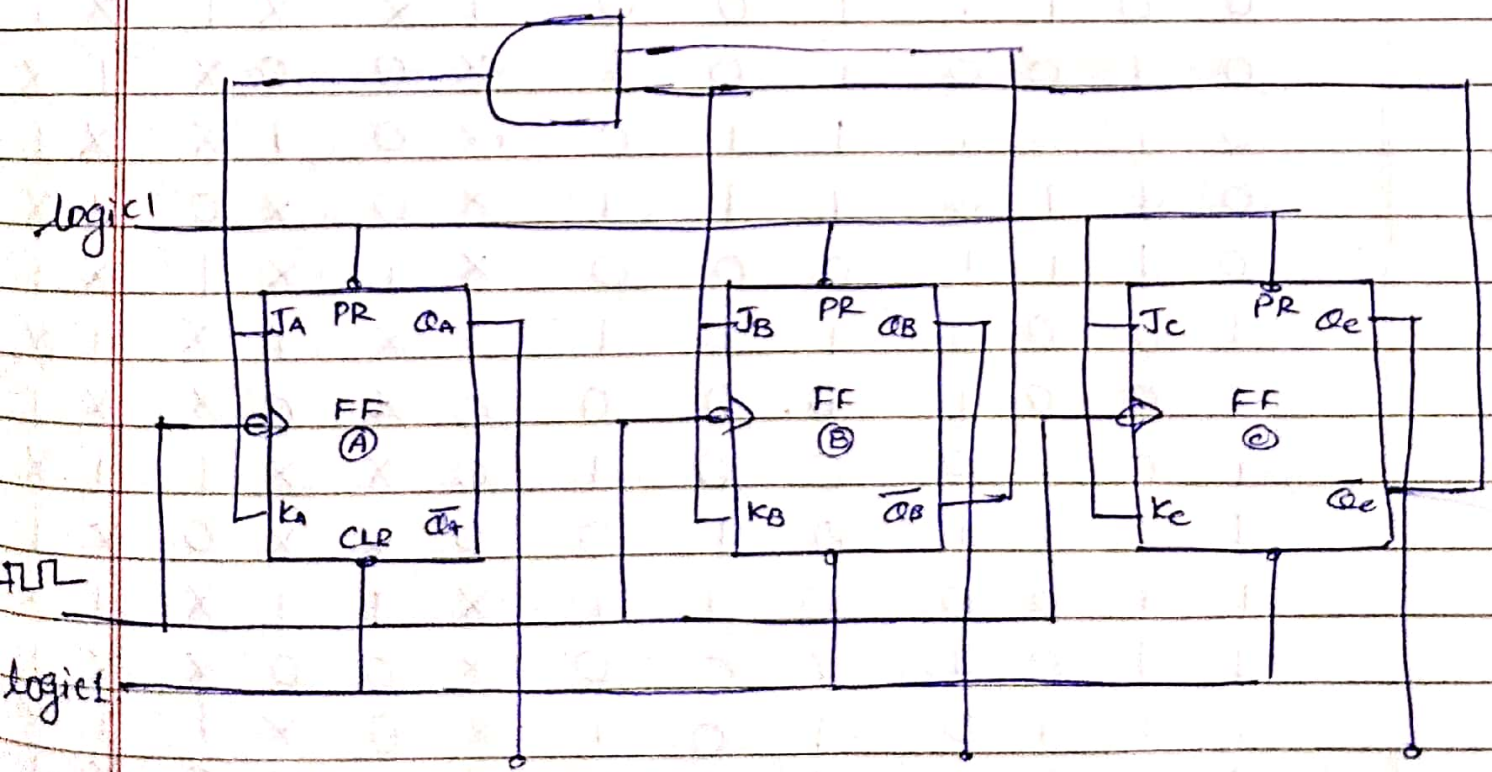
$J_C = 1$

K-Map for K_C

Q_A \ $Q_B Q_C$	$Q_B Q_C$	$\bar{Q}_B Q_C$	$Q_B\bar{Q}_C$	$\bar{Q}_B\bar{Q}_C$
$\bar{Q}_A$	X (0)	1 (1)	1 (3)	X (2)
Q_A	X (4)	1 (5)	1 (7)	X (6)

$K_C = 1$

Step 5

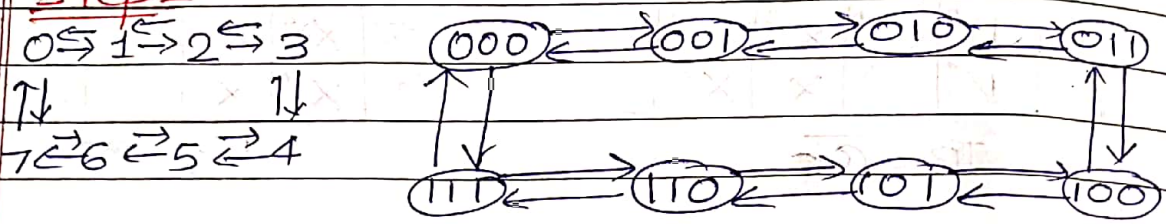


Design 3 bit synchronous up/down counter using JKFF

Step1

No. of flipflops required to design 3bit up-down counter are 3 flipflop

Step2



M=0 Up counting from 0 to 7

M=1 down counting from 7 to 0

M	Q_A	Q_B	Q_C	Q_{AH}	Q_{BH}	Q_{CH}	J_A	K_A	J_B	K_B	J_C	K_C
0	0	0	0	0	0	1	0	X	0	X	1	X
0	0	0	1	0	1	0	0	X	1	X	X	1
0	0	1	0	0	1	1	0	X	X	0	1	X
0	0	1	1	1	0	0	1	X	X	1	X	1
0	1	0	0	1	0	1	X	0	0	X	1	X
0	1	0	1	1	1	0	X	0	1	X	X	1
0	1	1	0	1	1	1	X	0	X	0	1	X
0	1	1	1	0	0	0	X	1	X	1	X	1
1	0	0	0	1	1	1	1	X	1	X	1	X
1	0	0	1	0	0	0	0	X	0	X	X	1
1	0	1	0	0	0	1	0	X	X	1	1	X
1	0	1	1	0	1	0	0	X	X	0	X	1
1	1	0	0	0	1	1	X	1	1	X	1	X
1	1	0	1	1	0	0	X	0	0	X	X	1
1	1	1	0	1	0	1	X	0	X	1	1	X
1	1	1	1	1	1	0	X	0	X	0	X	1

Step3

K-Map for J_A

$M\bar{Q}_A$ \ Q_BQ_C	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_BQ_C$	Q_BQ_C	$Q_B\bar{Q}_C$
$\bar{M}\bar{Q}_A$	0	1	1 (3)	2
$\bar{M}Q_A$	X (4)	X (5)	X (7)	X (6)
MQ_A	X (12)	X (13)	X (15)	X (14)
$M\bar{Q}_A$	1 (8)	9	11	10

$J_A = M\bar{Q}_B\bar{Q}_C + \bar{M}Q_BQ_C$

K-Map for K_A

MQ_A \ Q_BQ_C	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_BQ_C$	Q_BQ_C	$Q_B\bar{Q}_C$
$\bar{M}\bar{Q}_A$	X 0	X 1	X (3)	X 2
$\bar{M}Q_A$	4	5	1 (7)	6
MQ_A	1 (12)	13	15	14
$M\bar{Q}_A$	X (8)	X 9	X 11	X 10

$K_A = M\bar{Q}_B\bar{Q}_C + \bar{M}Q_BQ_C$

K-Map for J_B

MQ_A \ Q_BQ_C	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_BQ_C$	Q_BQ_C	$Q_B\bar{Q}_C$
$\bar{M}\bar{Q}_A$	0	1 1	X 3	X 2
$\bar{M}Q_A$	4	1 5	X 7	X 6
MQ_A	1 (12)	13	X 15	X (14)
$M\bar{Q}_A$	1 (8)	9	X 11	X (10)

$J_B = M\bar{Q}_C + \bar{M}Q_C$

K-Map for K_B

MQ_A \ Q_BQ_C	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_BQ_C$	Q_BQ_C	$Q_B\bar{Q}_C$
$\bar{M}\bar{Q}_A$	X 0	X 1	1 (3)	2
$\bar{M}Q_A$	X 4	X 5	1 (7)	6
MQ_A	X (12)	X 13	15	1 (14)
$M\bar{Q}_A$	X (8)	X 9	0 11	1 10

$K_B = M\bar{Q}_C + Q_C\bar{M}$

K-Map for J_C

MQ_A \ Q_BQ_C	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_BQ_C$	Q_BQ_C	$Q_B\bar{Q}_C$
$\bar{M}\bar{Q}_A$	1 0	X 1	X 3	1 2
$\bar{M}Q_A$	1 4	X 5	X 7	1 6
MQ_A	1 12	X 13	X 15	1 14
$M\bar{Q}_A$	1 8	X 9	X 11	1 10

$J_C = 1$

K-Map for K_C

MQ_A \ Q_BQ_C	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_BQ_C$	Q_BQ_C	$Q_B\bar{Q}_C$
$\bar{M}\bar{Q}_A$	X 0	1 1	1 3	X 2
$\bar{M}Q_A$	X 4	1 5	1 7	X 6
MQ_A	X 12	1 13	1 15	X 14
$M\bar{Q}_A$	X 8	1 9	1 11	X 10

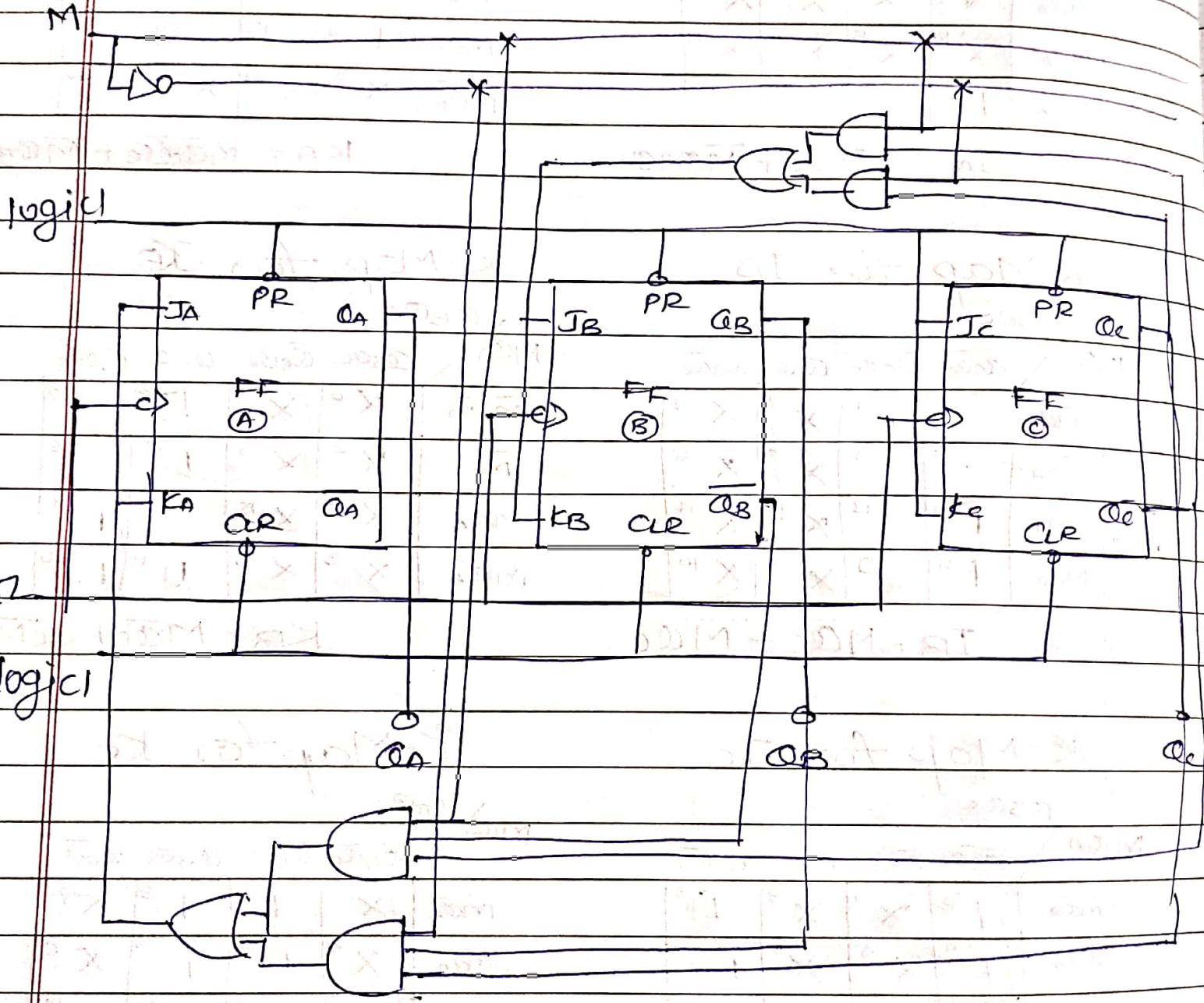
$K_C = 1$

Step 4

$J_A = M\overline{Q_B}\,\overline{Q_C} + \overline{M}\,Q_B Q_C$ $\quad K_A = M\overline{Q_B}\,\overline{Q_C} + \overline{M}\,Q_B Q_C$

$J_B = M\overline{Q_C} + \overline{M}\,Q_C$ $\quad K_B = M\overline{Q_C} + \overline{M}\,Q_C$

$J_C = 1$ $\quad K_C = 1$

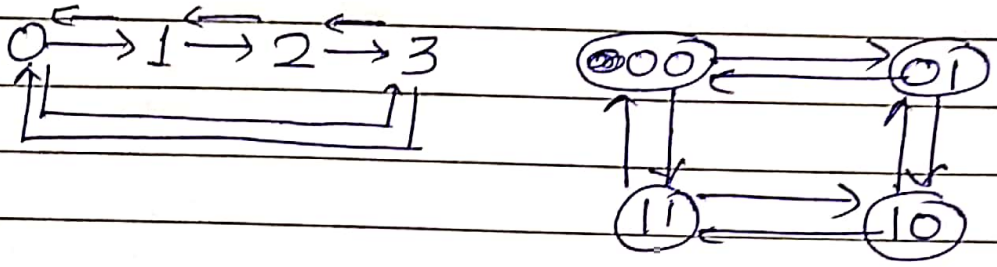


Design 2 bit synchronous Updown counter using JKFF

Step1

No. of flipflops required to design 2 bit updown counters are 2 flip-flop

Step2



M = 0 Up counting from 0 to 3
M = 1 down counting from 3 to 0

Step3

					0 0	0 X		
					0 1	1 X		
					1 0	X 1		
					1 1	X 0		

M	Q_A	Q_B	Q_{A+1}	Q_{B+1}	J_A	K_A	J_B	K_B
0	0	0	0	1	0	X	1	X
0	0	1	1	0	1	X	X	1
0	1	0	1	1	X	0	1	X
0	1	1	0	0	X	1	X	1
1	0	0	1	1	1	X	1	X
1	0	1	0	0	0	X	X	1
1	1	0	0	1	X	1	1	X
1	1	1	1	0	X	0	X	1

Step 4

K-Map for J_A

M \ $Q_A Q_B$	$Q_A\bar{Q}_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$
$\bar{M}$	0	1 1	X 3	X 2
M	1 4	5	X 7	X 6

$J_A = \bar{M}Q_B + M\bar{Q}_B$

K-Map for K_A

M \ $Q_A Q_B$	$Q_A Q_B$	$\bar{Q}_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$Q_A\bar{Q}_B$
$\bar{M}$	X 0	X 1	1 3	2
M	X 4	X 5	7	1 6

$K_A = \bar{M}Q_B + M\bar{Q}_B$

K-Map for J_B

M \ $Q_A Q_B$	$Q_A\bar{Q}_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$
$\bar{M}$	1 0	X 1	X 3	1 2
M	1 4	X 5	X 7	1 6

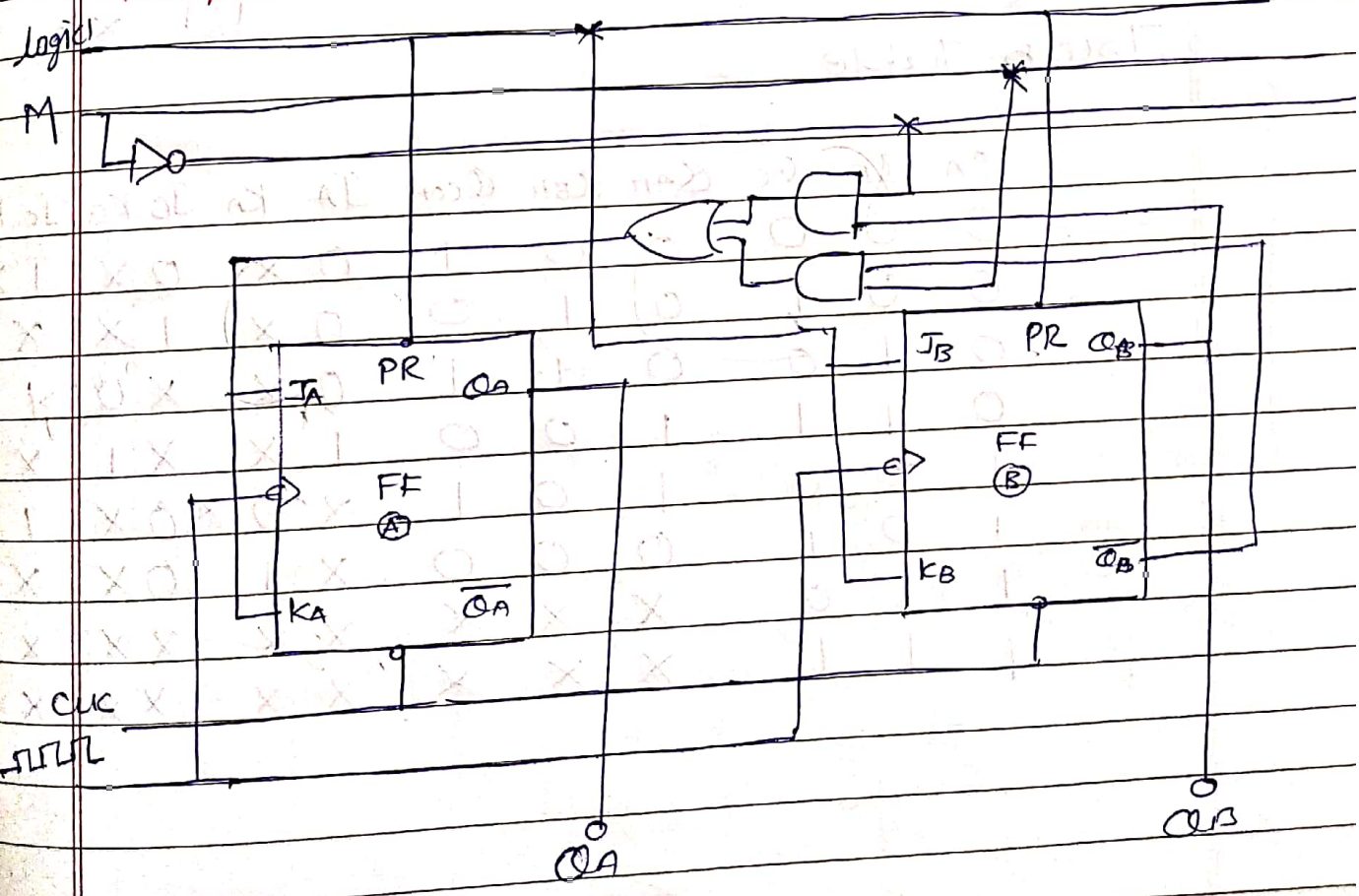
$J_B = 1$

K-Map for K_B

M \ $Q_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$
$\bar{M}$	X 0	1 1	1 3	X 2
M	X 4	1 5	1 7	X 6

$K_B = 1$

Step 5



Design MOD-6 synchronous counter.

Step1

No. of flip flop required to design MOD-6

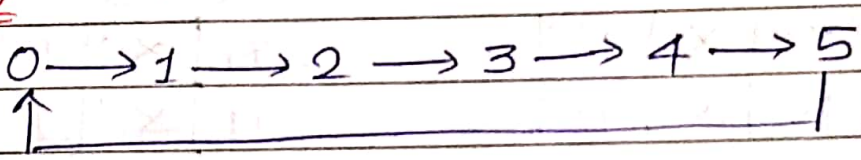
$N = 6$

$2^n \geq 6$

$n = 3$

we need 3 flip flop.

Step2



Step3 Excitation Table of JKFF

0 0	0 X
0 1	1 X
1 0	X 1
1 1	X 0

Truth Table

Q_A	Q_B	Q_C	Q_{A+1}	Q_{B+1}	Q_{C+1}	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	0	1	1	0	X	X	0	1	X
0	1	1	1	0	0	1	X	X	1	X	1
1	0	0	1	0	1	X	0	0	X	1	X
1	0	1	0	0	0	X	1	0	X	X	1
1	1	0	X	X	X	X	X	X	X	X	X
1	1	1	X	X	X	X	X	X	X	X	X

Step 4

K-Map for J_A

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	0	1	3	2
Q_A	X 4	X 5	X 7	X 6

$J_A = Q_B Q_C$

K-Map for K_A

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	X 0	X 1	X 3	X 2
Q_A	4	1 5	X 7	X 6

$K_A = Q_C$

K-Map for J_B

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	0	1 1	X 3	X 2
Q_A	4	5	X 7	X 6

$J_B = Q_A Q_C$

K-Map for K_B

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	0	1	1 3	2
Q_A	X 4	X 5	X 7	X 6

$K_B = Q_B Q_C$

K-Map for J_C

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	1 0	X 1	X 3	1 2
Q_A	1 4	X 5	X 7	X 6

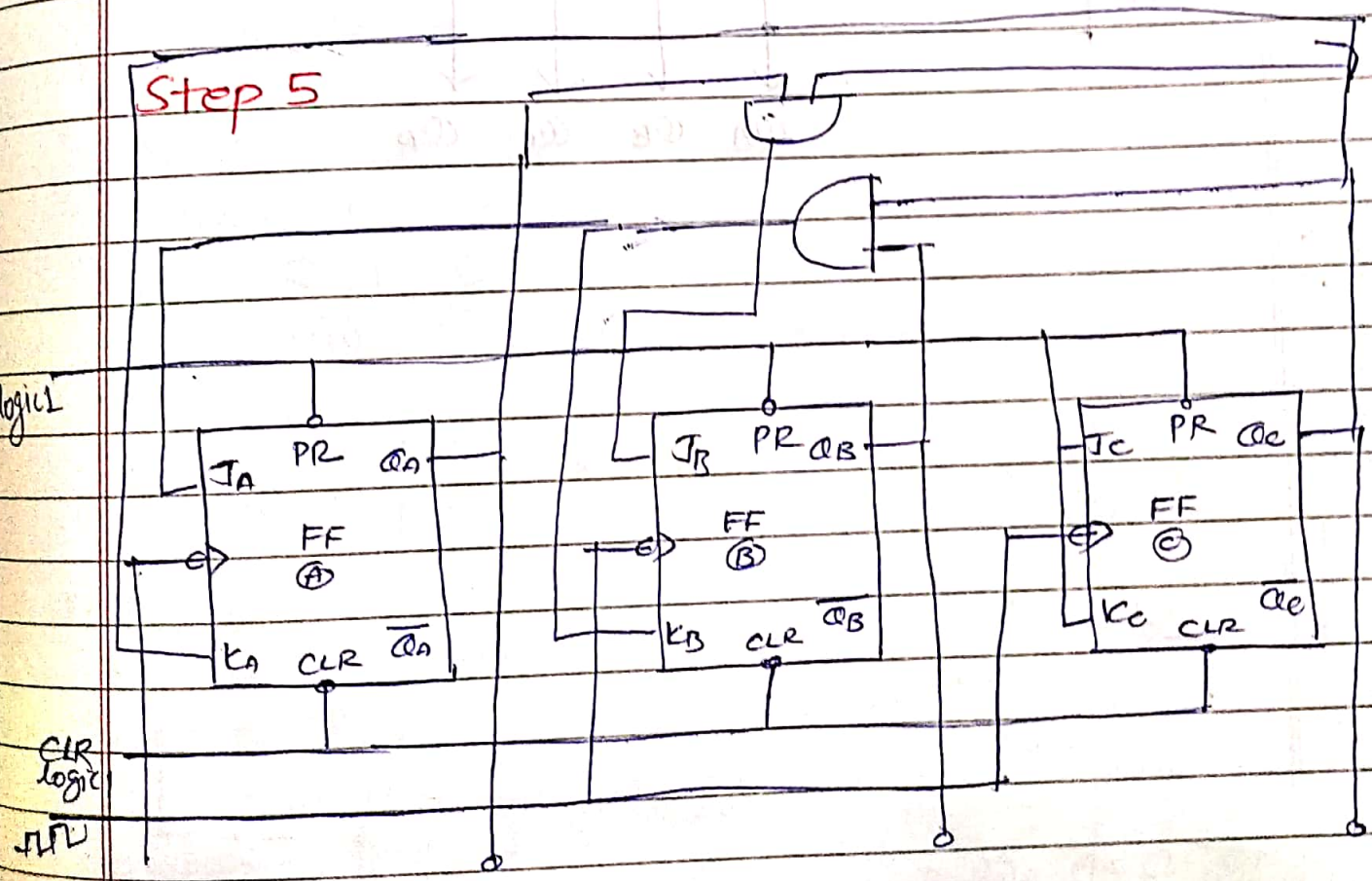
$J_C = 1$

K-Map for J_C

Q_A \ $Q_B Q_C$	$\bar{Q}_B\bar{Q}_C$	$\bar{Q}_B Q_C$	$Q_B Q_C$	$Q_B\bar{Q}_C$
$\bar{Q}_A$	X 0	1 1	1 3	X 2
Q_A	X 4	1 5	X 7	X 6

$K_C = 1$

Step 5

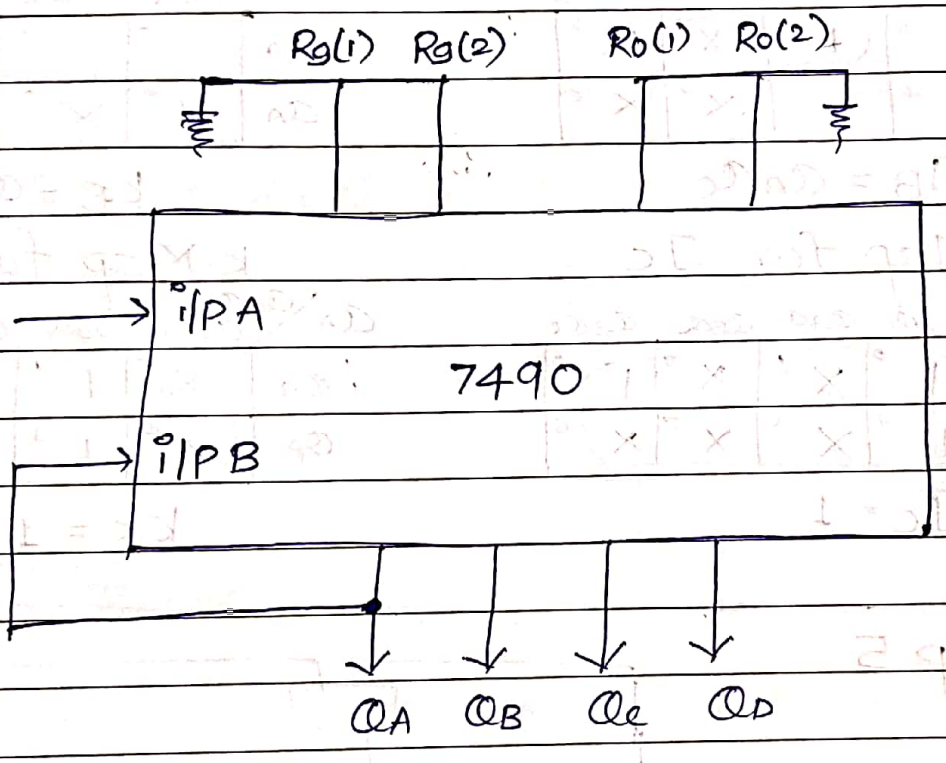


Design MOD-10 Counter using 7490

IC 7490 is a mod 10 counter(Decade counter/ BCD counter)

Q_D	Q_C	Q_B	Q_A
1	0	0	1

7490 ①

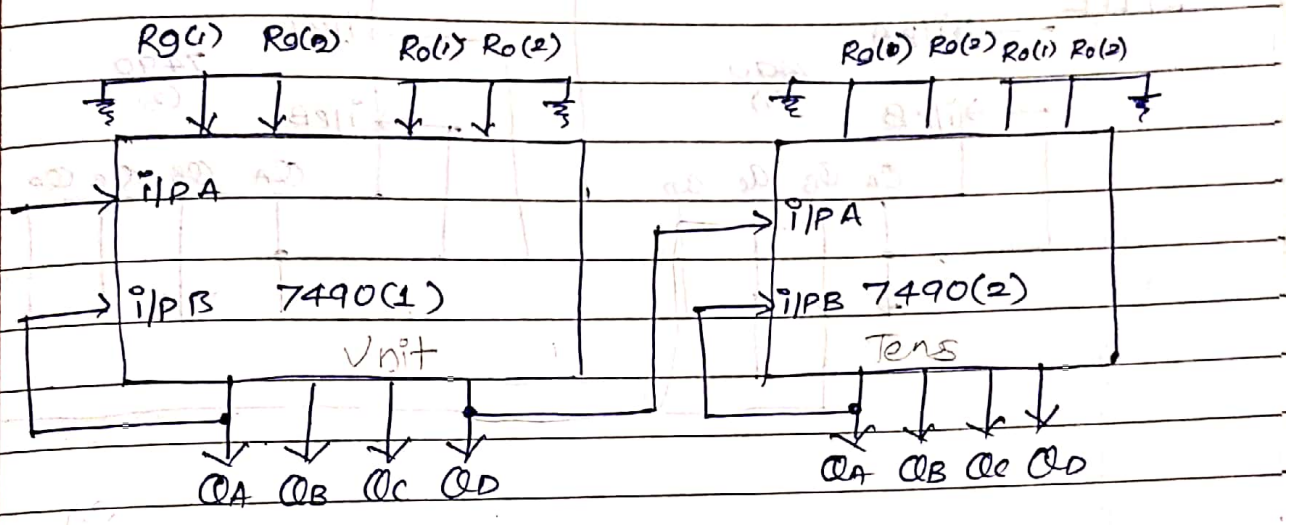


Design MOD-100 Counter using IC 7490

$Q_D\ Q_C\ Q_B\ Q_A$ $\quad$ $Q_B\ Q_C\ Q_B\ Q_A$

1 0 0 1 1 $\quad$ 1 0 0 1

7490(2) $\quad$ 7490(1)

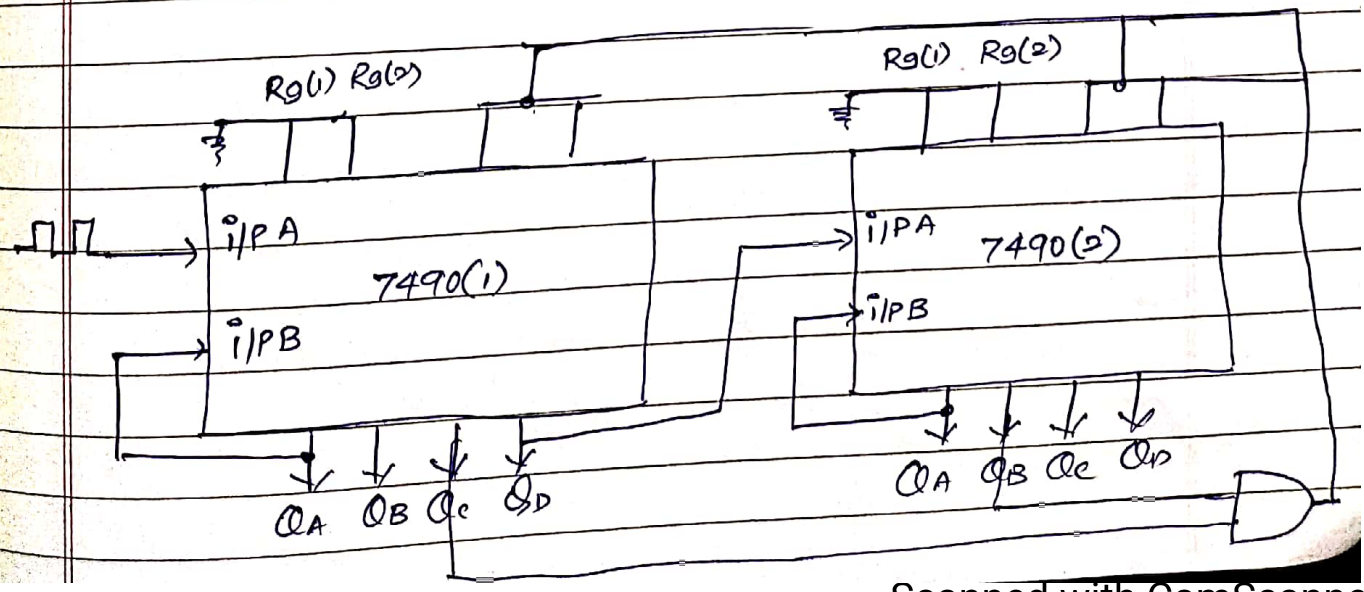


Design ~~24~~ MOD-24 using IC 7490

$Q_D\ Q_C\ Q_B\ Q_A$ $\quad$ $Q_D\ Q_C\ Q_B\ Q_A$

0 0 1 0 $\quad$ 0 1 0 0

7490(2) $\quad$ 7490(1)



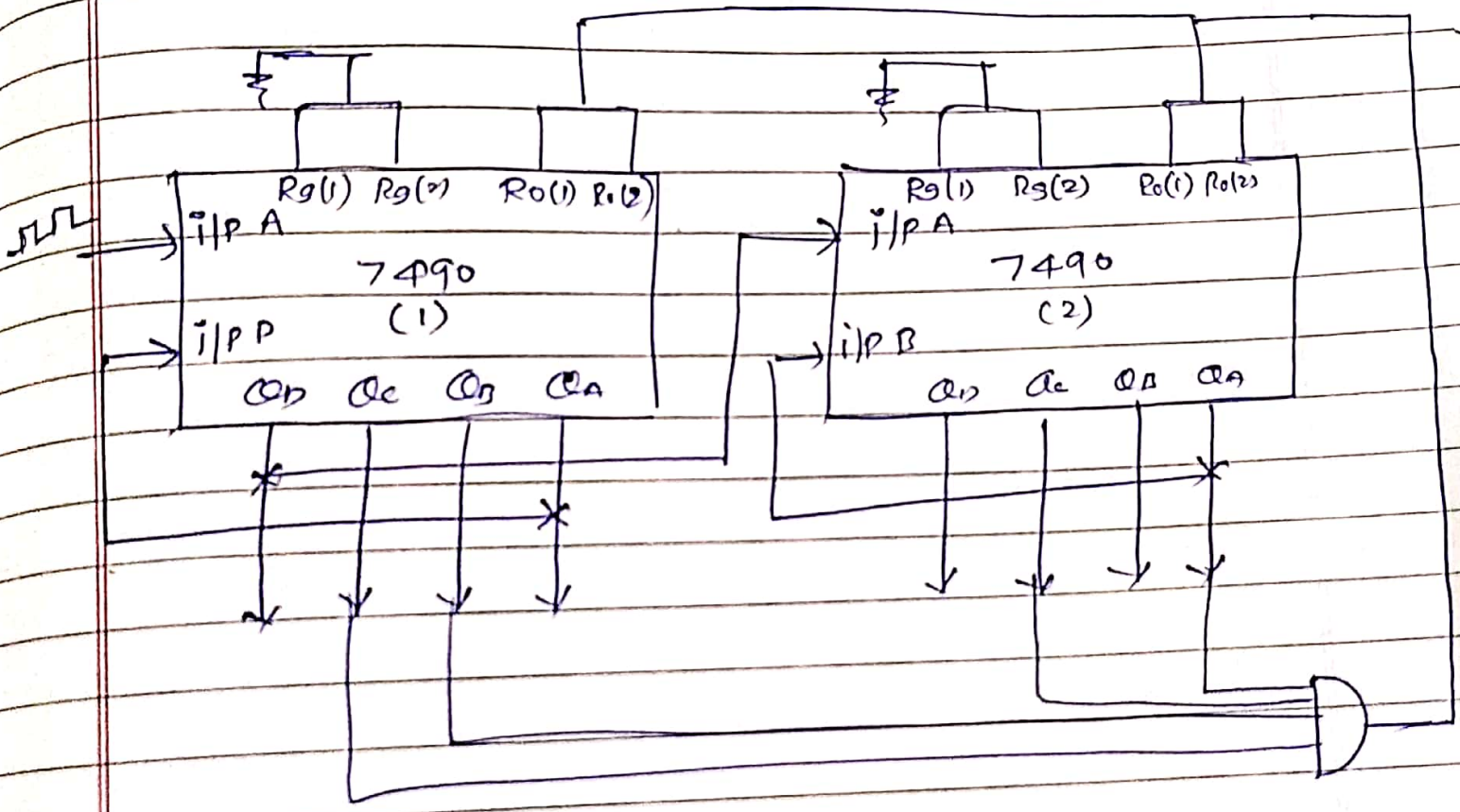
Design MOD-56 Using IC 7490

Q_D	Q_C	Q_B	Q_A
0	1	0	1

(2)

Q_D	Q_C	Q_B	Q_A
0	1	1	0

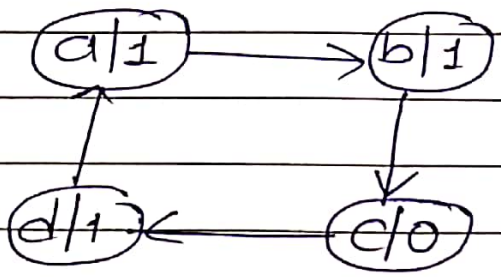
(1)



Design sequence generator for sequence 1101

Sequence generator for sequence 1101

State diagram



a = 00
b = 01
c = 10
d = 11

State table

	Present state	Next state
1	a	b
1	b	c
0	c	d
1	d	a

Excitation table

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

	Present state		Next state					
	Q_A	Q_B	Q_{A+1}	Q_{B+1}	J_A	K_A	J_B	K_B
0	1	0	0	1	0	X	1	X
1	1	0	1	1	0	1	X	1
2	0	1	0	1	1	X	0	X
3	1	1	1	0	0	X	1	X

K-Map JA

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	0 (0)	1 (1)
Q_A	X (2)	X (3)

$J_A = Q_B$

K-Map for KA

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	X (0)	X (1)
Q_A	0 (2)	1 (3)

$K_A = Q_B$

K-Map for JB

Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	1 (0)	X (1)
Q_A	1 (2)	X (3)

$J_B = 1$

K-Map for KB

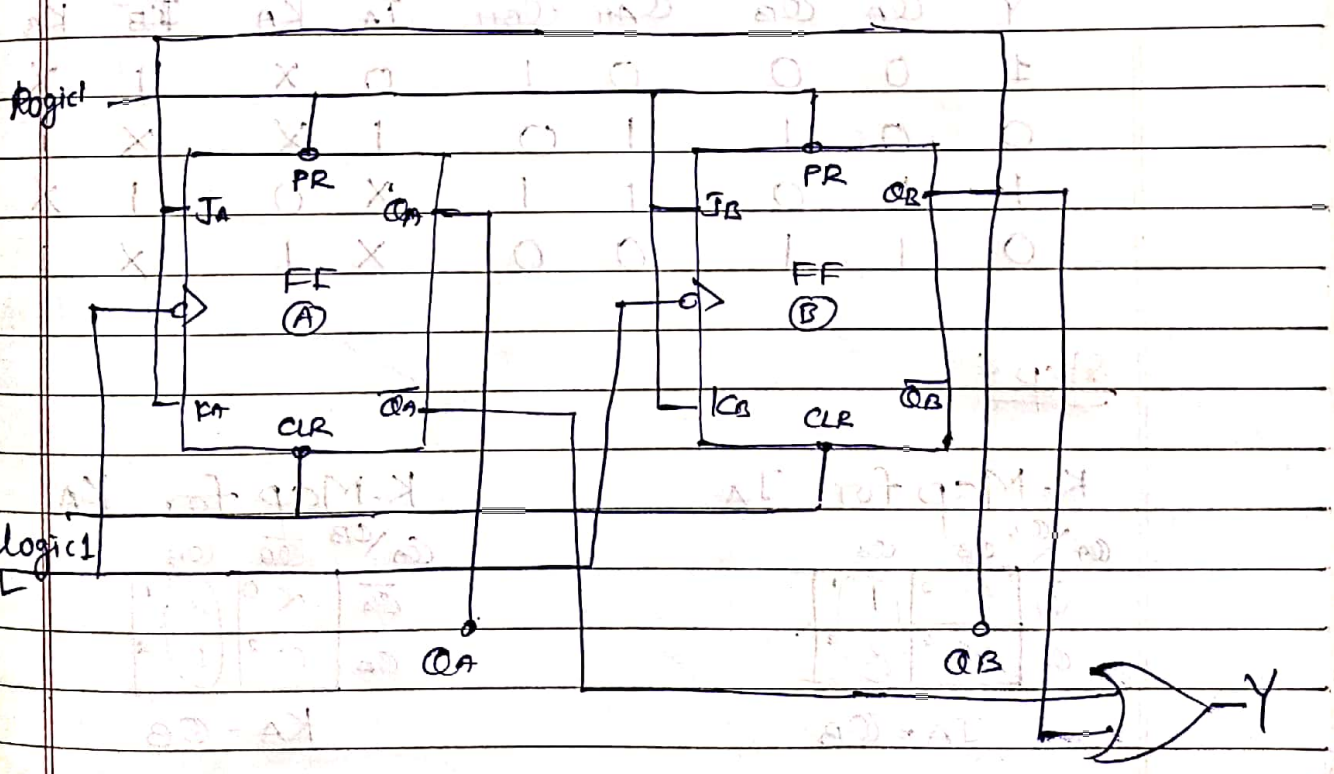
Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	X (0)	1 (1)
Q_A	X (2)	1 (3)

$K_B = 1$

K-Map for Y

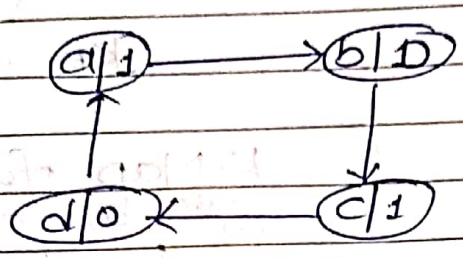
Q_A \ Q_B	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	1 (0)	1 (1)
Q_A	0 (2)	1 (3)

$Y = \overline{Q_A} + Q_B$



Design sequence generator for sequence 1010

Step1 state diagram



a = 00
b = 01
c = 10
d = 11

Step2 state table

	Present	Next
1	a (00)	b (01)
0	b (01)	c (10)
1	c (10)	d (11)
0	d (11)	a (00)

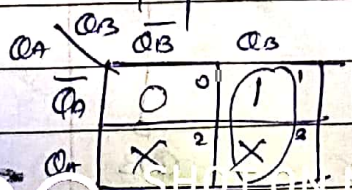
Excitation table	
0 0	0 X
0 1	1 X
1 0	X 1
1 1	X 0

Step3 Excitation table

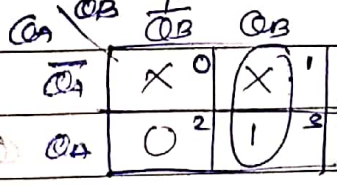
Y	Q_A	Q_B	Q_{AH}	Q_{BH}	J_A	K_A	J_B	K_B
1	0	0	0	1	0	X	1	X
0	0	1	1	0	1	X	X	1
1	1	0	1	1	X	0	1	X
0	1	1	0	0	X	1	X	1

Step 4

K-Map for J_A



K-Map for K_A



$K_A = Q_B$

K-Map for J_B

$Q_A Q_B$ / Q_n	$\overline{Q_B}$	Q_B
$\overline{Q_A}$	X (0)	X (1)
Q_n	1 (2)	X (3)

$J_B = 1$

K-Map for K_B

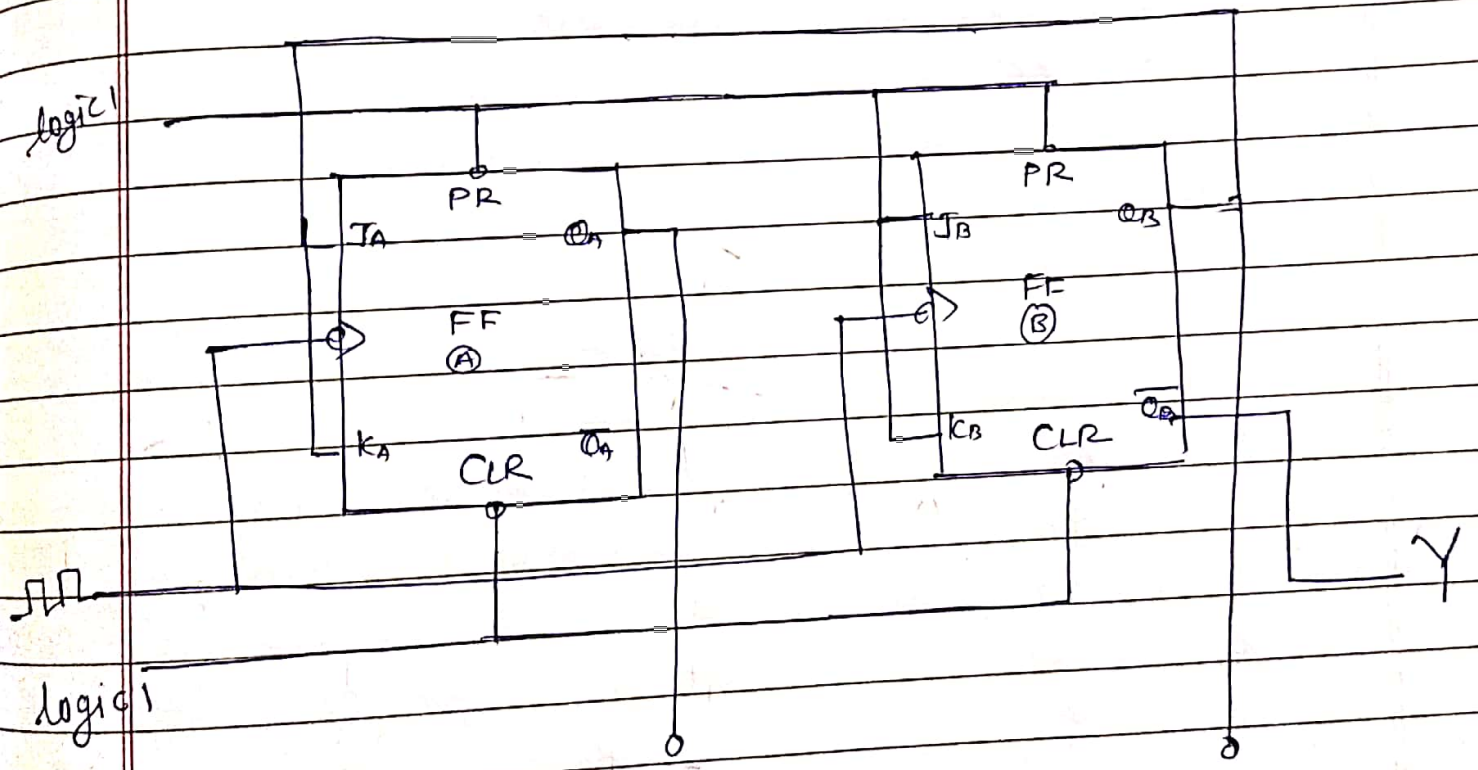
$Q_A Q_B$ / Q_n	$\overline{Q_B}$	Q_B
$\overline{Q_n}$	X (0)	1 (1)
Q_n	X (2)	1 (3)

$K_B = 1$

K-Map for Y

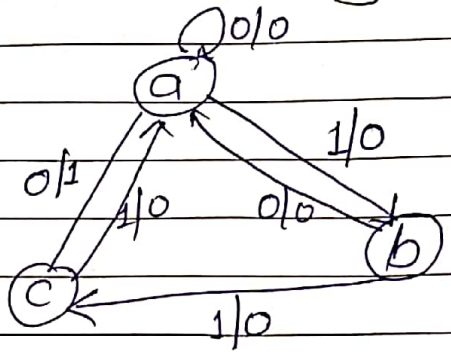
Q_B / Q_n	$\overline{Q_B}$	Q_B
$\overline{Q_n}$	1 (0)	0 (1)
Q_n	1 (2)	0 (3)

$Y = \overline{Q_B}$



Design a sequence detector for sequence 110 without overlap

Step 1 state diagram



Step 2

a = 00 X = I/P = 0 or 1

b = 01 Y = O/P

c = 10

Step 3

Excitation Table

	X = 0	X = 1	Y
a (00)	a (00)	b (01)	0
b (01)	a (00)	c (10)	0
c (10)	a (00)	a (00)	1

Excitation JK FF			
Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

	Present state		Next state					
Y	X	Q_A	Q_B	Q_{A+1}	Q_{B+1}	J_A	K_A	J_B	K_B
0	0	0	0	0	0	0	X	0	X
0	0	0	1	0	0	0	X	X	1
0	0	1	0	0	0	X	1	0	X
0	0	1	1	X	X	X	X	X	X
0	1	0	0	0	1	0	X	1	X
0	1	0	1	1	0	1	X	X	1
1	1	1	0	0	0	X	1	0	X
0	1	1	1	X	X	X	X	X	X

K-Map for J_A

X \ Q_AQ_B	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_AQ_B$	Q_AQ_B	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	0 (1)	X (3)	X (2)
X	0 (4)	1 (5)	X (7)	X (6)

$J_A = XQ_B$

K-Map for K_A

X \ Q_AQ_B	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_AQ_B$	Q_AQ_B	$Q_A\bar{Q}_B$
$\bar{X}$	X (0)	X (1)	X (3)	1 (2)
X	X (4)	X (5)	X (7)	1 (6)

$K_A = 1$

K-Map for J_B

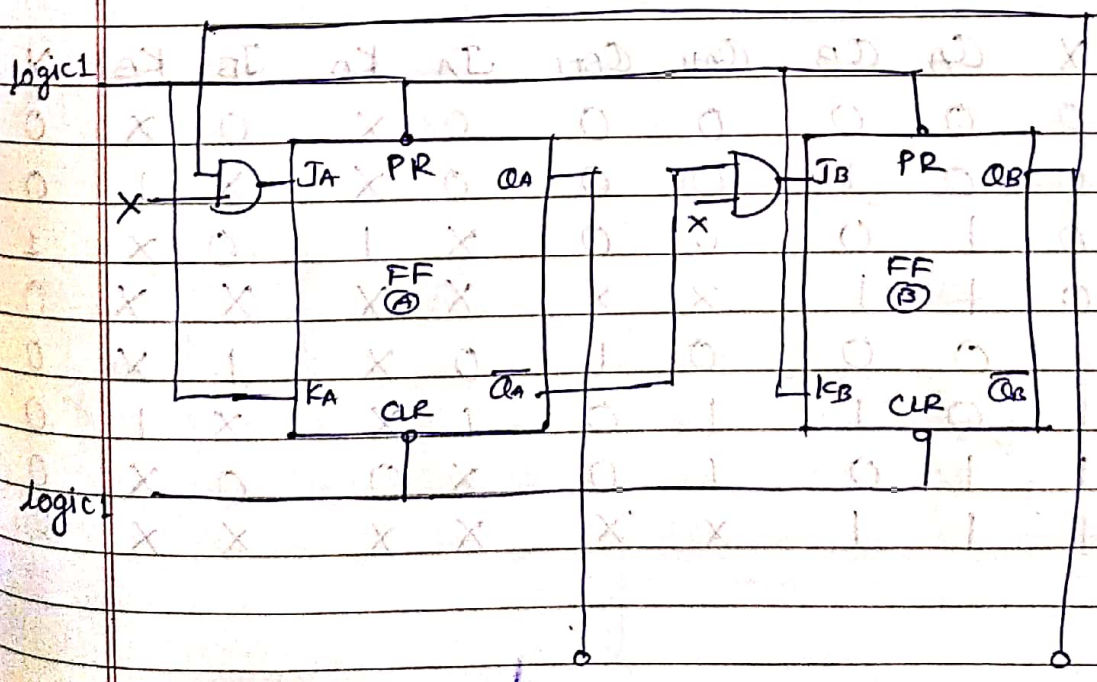
X \ Q_AQ_B	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_AQ_B$	Q_AQ_B	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	X (1)	X (3)	0 (2)
X	1 (4)	X (5)	X (7)	0 (6)

$J_B = X\bar{Q}_A$

K-Map for K_B

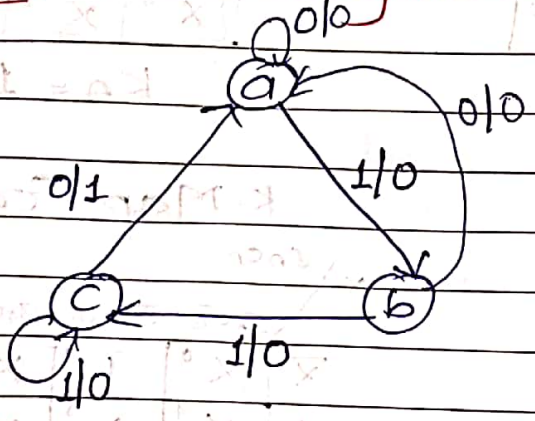
X \ Q_AQ_B	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_AQ_B$	Q_AQ_B	$Q_A\bar{Q}_B$
$\bar{X}$	X (0)	1 (1)	X (3)	X (2)
X	X (4)	1 (5)	X (7)	X (6)

$K_B = 1$



Design a sequence detector for sequence 110 with overlap.

Step 1 State diagram



Step 2

a = 00
b = 01
c = 10

X < 0 / 1

Y = O/P

	X=0	Y	X=1	Y
a(00)	a(00)	0	b(01)	0
b(01)	a(00)	0	c(10)	0
c(10)	a(00)	1	c(10)	0

Excitation			
Q_n	Q_{n+1}	J_A	K_A
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Y	X	Q_A	Q_B	Q_{A+1}	Q_{B+1}	J_A	K_A	J_B	K_B	Y
0	0	0	0	0	0	0	X	0	X	0
0	0	1	0	0	0	0	X	X	1	0
0	1	0	0	0	X	1	0	X	1	
0	1	1	X	X	X	X	X	X	X	0
1	0	0	0	1	0	X	1	X	0	
1	0	1	1	0	1	X	X	1	0	
1	1	0	1	0	X	0	0	X	0	
1	1	1	X	X	X	X	X	X	0	

K-Map for J_A

$Q_A Q_B$ / X	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A \bar{Q}_B$
$\bar{X}$	0 (0)	0 (1)	X (3)	X (2)
X	0 (4)	1 (5)	X (7)	X (6)

$J_A = X Q_B$

K-Map for K_A

$Q_A Q_B$ / X	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A \bar{Q}_B$
$\bar{X}$	X (0)	X (1)	X (3)	1 (2)
X	X (4)	X (5)	X (7)	0 (6)

$K_A = \bar{X} Q_B$

K-Map for J_B

$Q_A Q_B$ / X	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A \bar{Q}_B$
$\bar{X}$	0 (0)	X (1)	X (3)	0 (2)
X	1 (4)	X (5)	X (7)	0 (6)

$J_B = X \bar{Q}_A$

K-Map for K_B

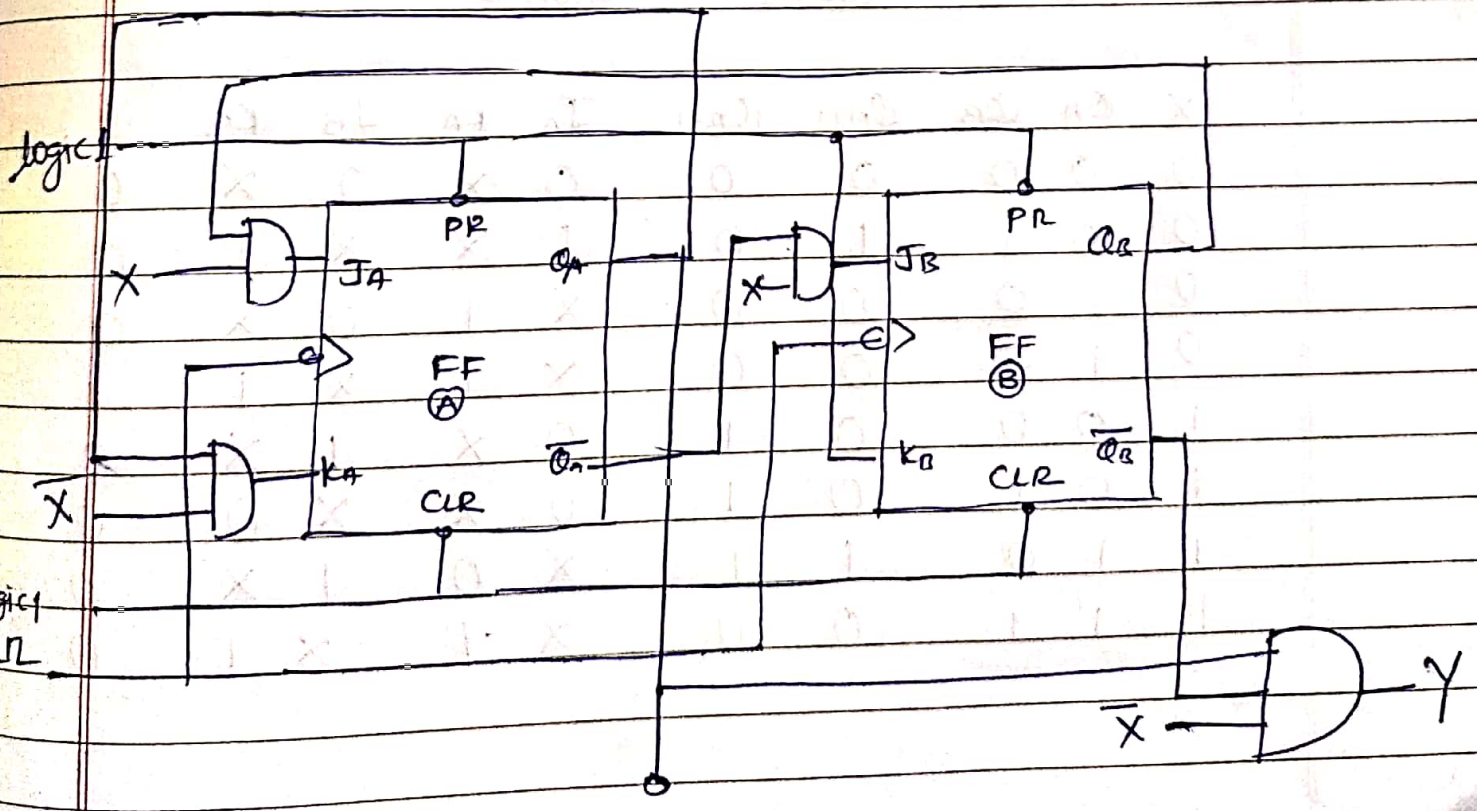
$Q_A Q_B$ / X	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A \bar{Q}_B$
$\bar{X}$	X (0)	1 (1)	X (3)	X (2)
X	X (4)	1 (5)	X (7)	X (6)

$K_B = 1$

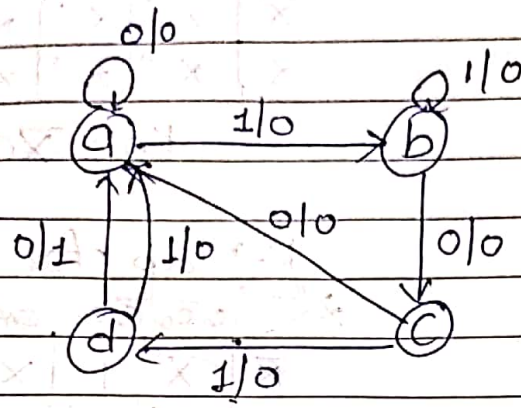
K-Map for Y

$Q_A Q_B$ / X	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A \bar{Q}_B$
$\bar{X}$	0 (0)	0 (1)	0 (3)	1 (2)
X	0 (4)	0 (5)	0 (7)	0 (6)

$Y = \bar{X} Q_A \bar{Q}_B$



Design a sequence detector for sequence 1010 with overlap



Step2

a = 00
b = 01
c = 10
d = 11

x → 0, 1

Y = o/p

	X=0	Y	X=1	Y
a(00)	a(00)	0	b(01)	0
b(01)	b(10)	0	b(01)	0
c(10)	a(00)	0	d(11)	0
d(11)	a(00)	1	a(00)	0

Excitation Table

0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

X	Q_A	Q_B	Q_{A+1}	Q_{B+1}	J_A	K_A	J_B	K_B	Y
0	0	0	0	0	0	X	0	X	0
0	0	1	1	0	1	X	X	1	0
0	1	0	0	0	X	1	0	X	0
0	1	1	0	0	X	1	X	1	1
1	0	0	0	1	0	X	1	X	0
1	0	1	0	1	0	X	X	0	0
1	1	0	1	1	X	0	1	X	0
1	1	1	0	0	X	1	X	1	0

Step3

K-Map for J_A

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	1 (1)	X (3)	X (2)
X	0 (4)	0 (5)	X (7)	X (6)

$J_A = \bar{X} Q_B$

K-Map for K_A

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	X (0)	X (1)	1 (3)	1 (2)
X	X (4)	X (5)	1 (7)	0 (6)

$K_A = \bar{X} + Q_B$

K-Map for J_B

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	X (1)	X (3)	0 (2)
X	1 (4)	X (5)	X (7)	1 (6)

$J_B = X$

K-Map for K_B

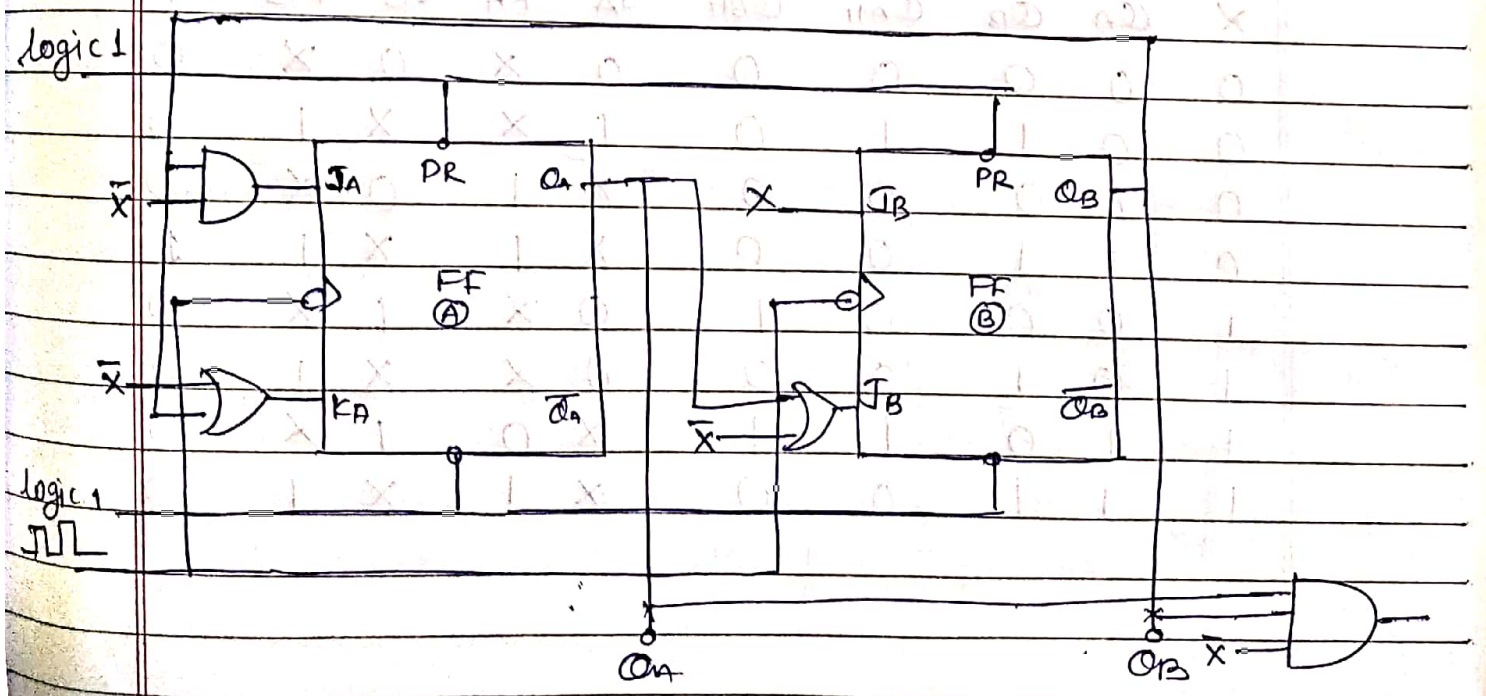
X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	X (0)	1 (1)	1 (3)	X (2)
X	X (4)	0 (5)	1 (7)	X (6)

$K_B = \bar{X} + Q_A$

K-Map for Y

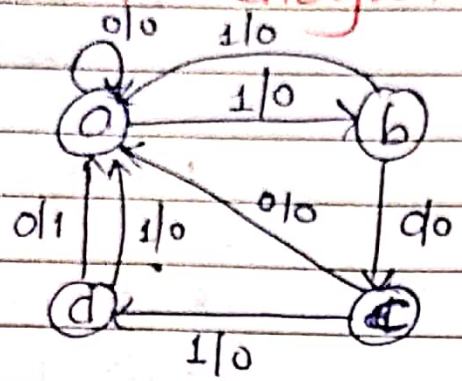
X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	0 (1)	1 (3)	0 (2)
X	0 (4)	0 (5)	0 (7)	0 (6)

$Y = \bar{X} Q_A Q_B$



Design a sequence detector for sequence 1010 without overlap.

Step1 state diagram



a = 00
b = 01
c = 10
d = 11

Step2

	X=0	Y	X=1	Y
a(00)	a(00)	0	b(01)	0
b(01)	c(10)	0	a(00)	0
c(10)	a(00)	0	d(11)	0
d(11)	a(00)	1	a(00)	0

Excitation

Q_A	Q_{AH}	J_A	K_A
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

X	Q_A	Q_B	Q_{AH}	Q_{BH}	J_A	K_A	J_B	K_B	Y
0	0	0	0	0	0	X	0	X	0
0	0	1	1	0	1	X	X	1	0
0	1	0	0	0	X	1	0	X	0
0	1	1	0	0	X	1	X	1	1
1	0	0	0	1	0	X	1	X	0
1	0	1	0	0	0	X	X	1	0
1	1	0	1	1	X	0	1	X	0
1	1	1	0	0	X	1	X	1	0

Step 3

K-Map for J_A

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	1 (1)	X (3)	X (2)
X	0 (4)	0 (5)	X (7)	X (6)

$J_A = \bar{X} Q_B$

K-Map for K_A

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	X (0)	X (1)	1 (3)	1 (2)
X	X (4)	X (5)	1 (7)	0 (6)

$K_A = \bar{X} + Q_B$

K-Map for J_B

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	X (1)	X (3)	0 (2)
X	1 (4)	X (5)	X (7)	1 (6)

$J_B = X$

K-Map for K_B

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	X (0)	1 (1)	1 (3)	X (2)
X	X (4)	1 (5)	1 (7)	X (6)

$K_B = 1$

K-Map for Y

X \ $Q_A Q_B$	$\bar{Q}_A\bar{Q}_B$	$\bar{Q}_A Q_B$	$Q_A Q_B$	$Q_A\bar{Q}_B$
$\bar{X}$	0 (0)	0 (1)	1 (3)	0 (2)
X	0 (4)	0 (5)	0 (7)	0 (6)

$Y = \bar{X} Q_A Q_B$