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Assignment 1: Design an up-down decade counter using JK-Flip Flop

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For a Decade UP-Down counter it can count 0→9 in both directions.

In this counting there are 10 stages so,

$16 > 10$

$2^4 > 10$

∴ We need four JK-Flip Flops for this counter

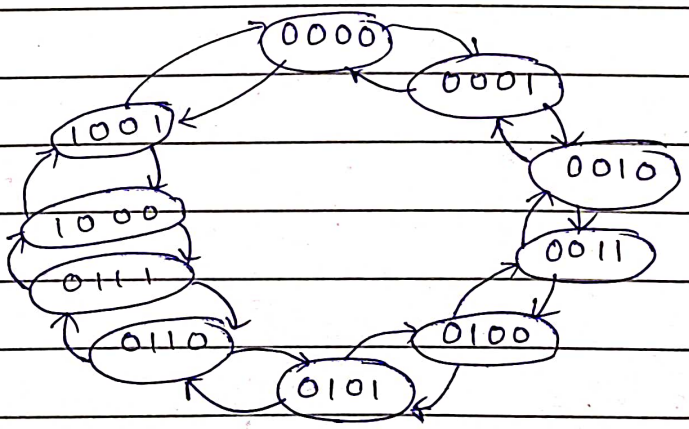
We will implement both Up and Down counter in a single circuit using a ~~sle~~ select line.

If the select line is M let's say-

M = 0 → Up counting

M = 1 → Down counting

The states→



Now, we will draw the truth tables →

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For $M = 0$

Q_A	Q_B	Q_C	Q_D	Q_{A+1}	Q_{B+1}	Q_{C+1}	Q_{D+1}
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

* other combinations are dont cares

Non excitation table of JK flip flop

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

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for M=0

Q_A	Q_B	Q_C	Q_D	Q_{A+1}	Q_{B+1}	Q_{C+1}	Q_{D+1}	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

$J_A = \Sigma m(7) + d(8,9,10,11,12,13,14,15)$

$K_A = \Sigma m(9) + d(0,1,2,3,4,5,6,7,10,11,12,13,14,15)$

$J_B = \Sigma m(3) + d(4,5,6,7,10,11,12,13,14,15)$

$K_B = \Sigma m(7) + d(0,1,2,3,8,9,10,11,12,13,14,15)$

$J_C = \Sigma m(1,5) + d(2,3,6,7,10,11,12,13,14,15)$

$K_C = \Sigma m(3,7) + d(0,1,4,5,8,9,10,11,12,13,14,15)$

$J_D = \Sigma m(0,2,4,6,8) + d(1,3,5,7,9,10,11,12,13,14,15)$

$K_D = \Sigma m(1,3,5,7,9) + d(0,2,4,6,8,10,11,12,13,14,15)$

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For $M=0$

for J_A

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00				
01			1	
11	X	X	X	X
10	X	X	X	X

$J_A = Q_B Q_C Q_D$

for K_A

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X	X	X
01	X	X	X	X
11	X	X	X	X
10		1	X	X

$K_A = Q_D$

for J_B

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00			1	
01	X	X	X	X
11	X	X	X	X
10			X	X

$J_B = Q_C Q_D$

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for K_B

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X	X	X
01			1	
11	X	X	X	X
10	X	X	X	X

$K_B = Q_C Q_D$

for J_C

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00		1	X	X
01		1	X	X
11	X	X	X	X
10			X	X

$J_C = \overline{Q_A} Q_D$

for K_C

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X	1	
01	X	X	1	
11	X	X	X	X
10	X	X	X	X

$K_C = Q_D$

for J_D

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	1	X	X	1
01	1	X	X	1
11	X	X	X	X
10	1	X	X	X

$J_D = 1$

Samely,

$K_D = 1$

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for M=1

Q_A Q_B Q_C Q_D	Q_{A+1} Q_{B+1} Q_{C+1} Q_{D+1}	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 0 x x 0 1 x
0 1 0 1	0 1 1 0	0 x 1 x x 1 x 1
0 1 1 0	0 1 1 1	0 x 1 x x 1 x 1
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 x 1
1 0 0 1	0 0 0 0	x 0 0 x 0 x x 1

for M=1

for J_A

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	1			
01				
11	x	x	x	x
10	x	x	x	x

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

for K_A

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	x	x	x	x
01	x	x	x	x
11	x	x	x	x
10	1		x	x

$$K_A = \bar{Q}_D$$

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for J_B :-

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00				
01	X	X	X	X
11	X	X	X	X
10	1		X	X

$J_B = Q_A \overline{Q_D}$

for K_B :-

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X	X	X
01	1			
11	X	X	X	X
10	X	X	X	X

$K_B = \overline{Q_C}\,\overline{Q_D}$

For J_C :-

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	1		X	X
01	1		X	X
11	X	X	X	X
10	1		X	X

$J_C = Q_B \overline{Q_D} + Q_A \overline{Q_D}$

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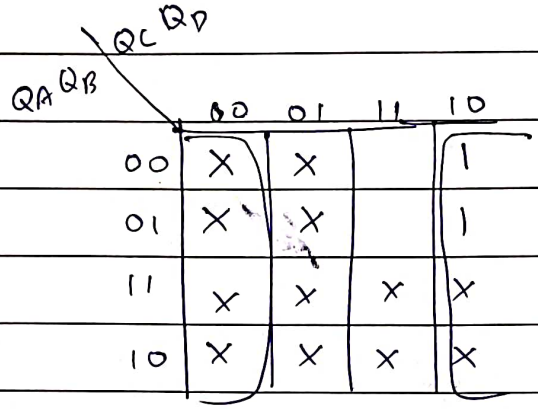
for K_C :-



$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X		1
01	X	X		1
11	X	X	X	X
10	X	X	X	X

$K_C = \overline{Q_D}$

for J_D and K_D →

$J_D = 1$, $K_D = 1$

So, Finally

$$J_A = \overline{M} Q_B Q_C Q_D + M \overline{Q_B} \overline{Q_C} \overline{Q_D}$$

$$K_A = \overline{M} Q_D + M \overline{Q_D} = M \oplus Q_D$$

$$J_B = \overline{M} Q_C Q_D + M Q_A \overline{Q_D}$$

$$K_B = \overline{M} Q_C Q_D + M \overline{Q_C} \overline{Q_D}$$

$$J_C = \overline{M} \overline{Q_A} Q_D + M \overline{Q_D} (Q_B + Q_A)$$

$$K_C = \overline{M} Q_D + M \overline{Q_D} = M \oplus Q_D$$

$$J_D = M + \overline{M} = K_D = 1$$

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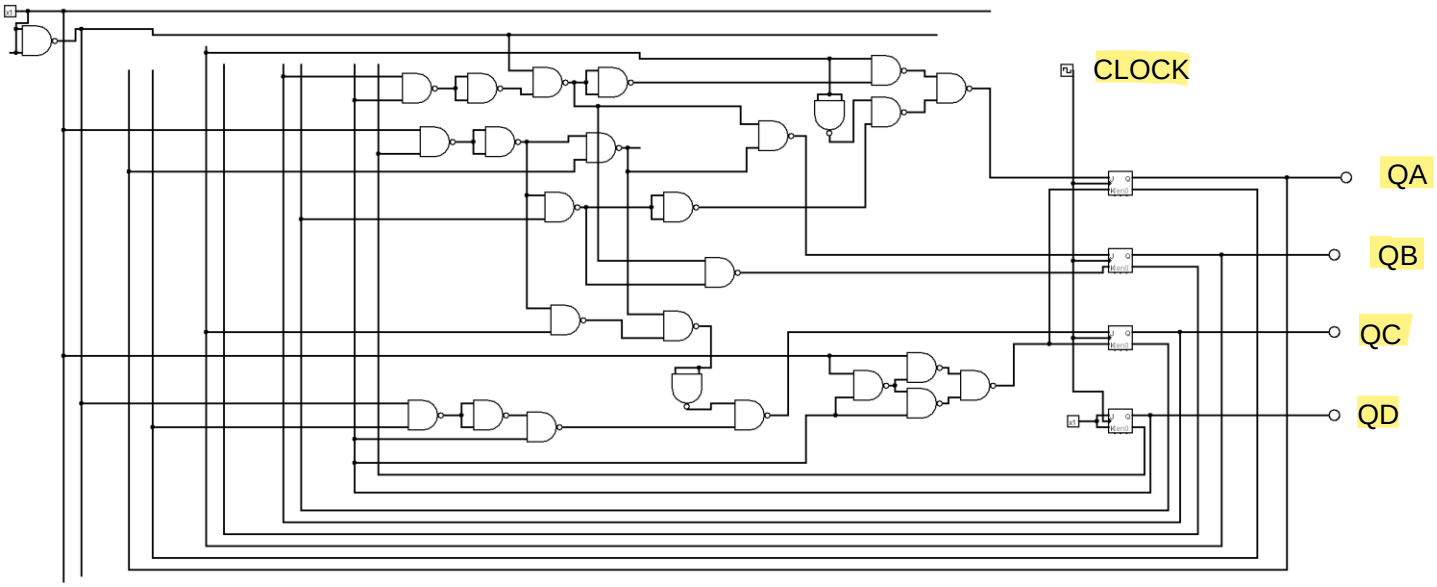
M and M'



CIRCUIT DESIGN