ASSIGNMENT 1

[Design a **UP/DOWN DECADE COUNTER** using **J-K flip flops**]

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Objective :- To design a UP/Down Decade Counter using J-K flip flops

Theory :- A decade counter is a sequential circuit that counts from 0 to 9 and returns back to 0 from 9.

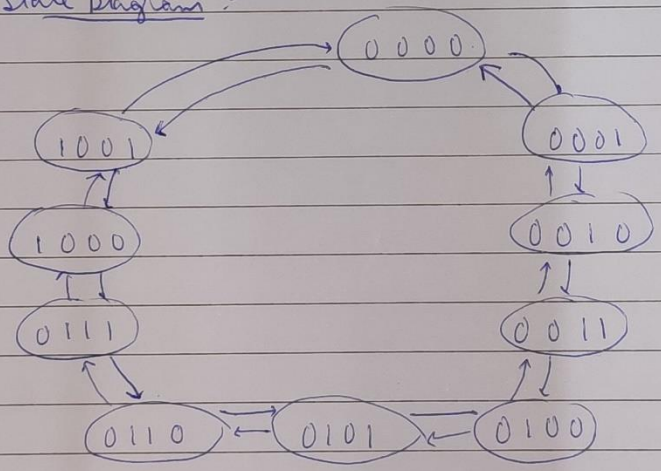
No. of states = 10

Range = 0 to 9

No. of flip flops required = 4.

We use a control line to control if the counter is UP or Down. When it is 0 the counter is UP and when it is 1 the counter is Down.

State Diagram :-



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Excitation Table for J K Flipflop:-

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

Decimal Excitation Table:-

CL	Present				Next				F-f							
M	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	0	1	0	X	0	X	0	X	1	X
0	0	0	0	1	0	0	1	0	0	X	0	X	1	X	X	1
0	0	0	1	0	0	0	1	1	0	X	0	X	X	0	1	X
0	0	0	1	1	0	1	0	0	0	X	1	X	X	1	X	1
0	0	1	0	0	0	1	0	1	0	X	X	0	0	X	1	X
0	0	1	0	1	0	1	1	0	0	X	X	0	1	X	X	1
0	0	1	1	0	0	1	1	1	0	X	X	0	X	0	1	X
0	0	1	1	1	1	0	0	0	1	X	X	1	X	1	X	1
0	1	0	0	0	1	0	0	1	X	0	0	X	0	X	1	X
0	1	0	0	1	0	0	0	0	X	1	0	X	0	X	X	1
1	0	0	0	0	1	0	0	1	1	X	0	X	0	X	1	X
1	0	0	0	1	1	0	0	0	X	0	0	X	0	X	X	1
1	0	0	1	0	0	1	1	1	X	1	1	X	1	X	1	X
1	0	0	1	1	0	1	1	0	0	X	X	0	X	0	X	1
1	0	1	0	0	0	1	0	1	0	X	X	0	X	1	1	X
1	0	1	0	1	0	1	0	0	0	X	X	0	0	X	X	1

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CL.	Present				Next				F-F							
M	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
1	0	1	0	0	0	0	1	1	0	x	x	1	1	x	1	x
1	0	0	1	1	0	0	1	0	0	x	0	x	x	0	x	1
1	0	0	1	0	0	0	0	1	0	x	0	x	x	1	1	x
1	0	0	0	1	0	0	0	0	0	x	0	x	0	x	x	1

K-Maps :

For J_A

M = 0

$q_A q_B$ \ $q_C q_D$	00	01	11	10
00	0	0	0	0
01	0	0	1	0
11	x	x	x	x
10	x	x	x	x

M = 1

$q_A q_B$ \ $q_C q_D$	00	01	11	10
00	1	0	0	0
01	0	0	0	0
11	x	x	x	x
10	x	x	x	x

$$J_A = M' q_A' q_B q_C q_D + M q_B' q_C' q_D'$$

For K_A

M = 0

$q_A q_B$ \ $q_C q_D$	00	01	11	10
00	x	x	x	x
01	x	x	x	x
11	x	x	x	x
10	0	1	x	x

M = 1

$q_A q_B$ \ $q_C q_D$	00	01	11	10
00	x	x	x	x
01	x	x	x	x
11	x	x	x	x
10	1	0	x	x

$$K_A = M' q_D + M q_D'$$

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For J_B :-

M = 0

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	0	0	1	0
01	x	x	x	x
11	x	x	x	x
10	0	0	x	x

M = 1

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	0	0	0	0
01	x	x	x	x
11	x	x	x	x
10	1	0	x	x

$$J_B = M' Q_C Q_D + M Q_A Q_D'$$

For K_B :-

M = 0

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	x	x	x	x
01	0	0	1	0
11	x	x	x	x
10	x	x	x	x

M = 1

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	x	x	x	x
01	1	0	0	0
11	x	x	x	x
10	x	x	x	x

$$K_B = M Q_C' Q_D' + M' Q_C Q_D$$

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For J_C :-

M = 0

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	0	1	X	X
01	0	1	X	X
11	X	X	X	X
10	0	0	X	X

M = 1

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	0	0	X	X
01	1	0	X	X
11	X	X	X	X
10	1	0	X	X

$$J_C = M Q_B Q_D' + M Q_A Q_D' + M' Q_A' Q_D$$

For K_C

M = 0

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X	1	0
01	X	X	1	0
11	X	X	X	X
10	X	X	X	X

M = 1

$Q_A Q_B$ \ $Q_C Q_D$	00	01	11	10
00	X	X	0	1
01	X	X	0	1
11	X	X	X	X
10	X	X	X	X

$$K_C = M' Q_D + M Q_D'$$

For J_D :-

M = 0

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

M = 1

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

$$J_D = 1$$

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For K_D :-

M = 0

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

M = 1

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

$K_D = 1$

Final Expressions:-

$J_A = M Q_B' Q_C' Q_D' + M' Q_B Q_C Q_D$

$K_A = M Q_D' + M' Q_D$

$J_B = M Q_A Q_D' + M' Q_C Q_D$

$K_B = M Q_C' Q_D' + M' Q_C Q_D$

$J_C = M Q_A Q_D' + M Q_B Q_D' + M' Q_A' Q_D$

$K_C = M Q_D' + M' Q_D$

$J_D = 1$

$K_D = 1$

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CIRCUIT DIAGRAM: