Q) f/f $0 \rightarrow 2 \rightarrow 4 \rightarrow 6 \rightarrow 8 \rightarrow 10 \rightarrow 12 \rightarrow 14$

counter using JK.

$\Rightarrow$

$$2^n \geq 14$$

$$= 2^4 = 16, \quad 16 \geq 14 \rightarrow T$$

$$2^3 = 8 < 14 \rightarrow F \quad 8 < 14 \rightarrow F$$
$$2^4 = 16 \qquad 16 \geq 14 \rightarrow T$$

No. of ff's = 4. JK flipflop's.

Excitation table for JK flipflop.

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

K-map for JD.

ΦDΦC \ ΦBΦA

	00	01	11	10
00	0₀	X₁	X₂	0₃
01	0₄	X₅	X₇	X₆
11	X₁₂	X₁₃	X₁₅	X₁₄
10	X₈	X₉	X₁₁	X₁₀

$JD = \Phi B \Phi C$

K-map for KD

ΦDΦC \ ΦBΦA

	00	01	11	10
00	X₀	X₁	X₃	X₂
01	X₄	X₅	X₇	X₆
11	0₁₂	X₁₃	X₁₅	1₁₄
10	0₈	X₉	X₁₁	0₁₀

$KD = \Phi B \Phi C$

K-map for JC

ΦDΦC \ ΦBΦA

	00	01	11	10
00	0₀	X₁	X₃	1₂
01	X₄	X₅	X₇	X₆
11	X₁₁	X₀	X₁₄	X₁₃
10	0₈	X₉	X₁₁	1₁₀

$JC = \Phi B$

K-map for KC

ΦDΦC \ ΦBΦA

	00	01	11	10
00	X₀	X₁	X₃	X₂
01	0₄	X₅	X₇	1₆
11	0₁₂	X₁₃	X₁₅	1₁₄
10	X₈	X₉	X₁₁	X₁₀

$KC = \Phi B$

K-map for JB

ΦDΦC \ ΦBΦA

	00	01	11	10
00	1₀	X₁	X₃	X₂
01	1₄	X₅	X₇	X₆
11	1₁₂	X₁₃	X₁₅	X₁₄
10	1₈	X₉	X₁₁	X₁₀

$JB = 1$

K-map for KB

ΦDΦC \ ΦBΦA

	00	01	11	10
00	X₀	X₁	X₃	1₂
01	X₄	X₅	X₇	X₆
11	X₁₂	X₁₃	X₁₅	1₁₄
10	X₈	X₉	X₁₁	X₁₀

$KB = 1$

K-map for JA

ΦDΦC \ ΦBΦA

	00	01	11	10
00	0₀	X₁	X₃	0₂
01	0₄	X₅	X₇	0₆
11	0₁₂	X₁₃	X₁₅	0₁₄
10	0₈	X₉	X₁₁	0₁₀

$JA = 0$

K-map for KA

ΦDΦC \ ΦBΦA

	00	01	11	10
00	X₀	X₁	X₃	X₂
01	X₄	X₅	X₇	X₆
11	X₁₂	X₁₃	X₁₅	X₁₄
10	X₈	X₉	X₁₁	X₁₀

$KA = 0$

Excitation table for counter

Present state				Next state										
Q_D	Q_C	Q_B	Q_A	Q_D'	Q_C'	Q_B'	Q_A'	J_D	K_D	J_C	K_C	J_B	K_B	$J_A K_A$
0	0	0	0	0	0	1	0	0	X	0	X	1	X	0
0	0	0	1	X	X	X	X	X	X	X	X	X	X	X X
0	0	1	0	0	1	0	0	0	X	1	X	X	1	0 X
0	0	1	1	X	X	X	X	X	X	X	X	X	X	X X
0	1	0	0	0	1	1	0	0	X	X	0	1	X	0 X
0	1	0	1	X	X	X	X	X	X	X	X	X	X	X X
0	1	1	0	1	0	0	0	1	X	X	1	X	1	0 X
0	1	1	1	X	X	X	X	X	X	X	X	X	X	X X
1	0	0	0	1	0	1	0	X	0	0	X	1	X	0 X
1	0	0	1	X	X	X	X	X	X	X	X	X	X	X X
1	0	1	0	1	1	0	0	X	0	1	X	X	1	0 X
1	0	1	1	X	X	X	X	X	X	X	X	X	X	X X
1	1	0	0	1	1	1	0	X	0	X	0	1	X	0 X
1	1	0	1	X	X	X	X	X	X	X	X	X	X	X
1	1	1	0	0	0	0	0	X	1	X	1	X	1	0 X
1	1	1	1	X	X	X	X	X	X	X	X	X	X	X

State Diagram.

Logic Circuit

$\phi_B \phi_C$

0		1					

J_A	ϕ_A	J_B	ϕ_B	J_C	ϕ_C	J_D	ϕ_D
K_A	$\overline{\phi_A}$	K_B	$\overline{\phi_B}$	K_C	$\overline{\phi_C}$	K_D	$\overline{\phi_D}$

CLK

ϕ_A ϕ_B ϕ_C ϕ_D
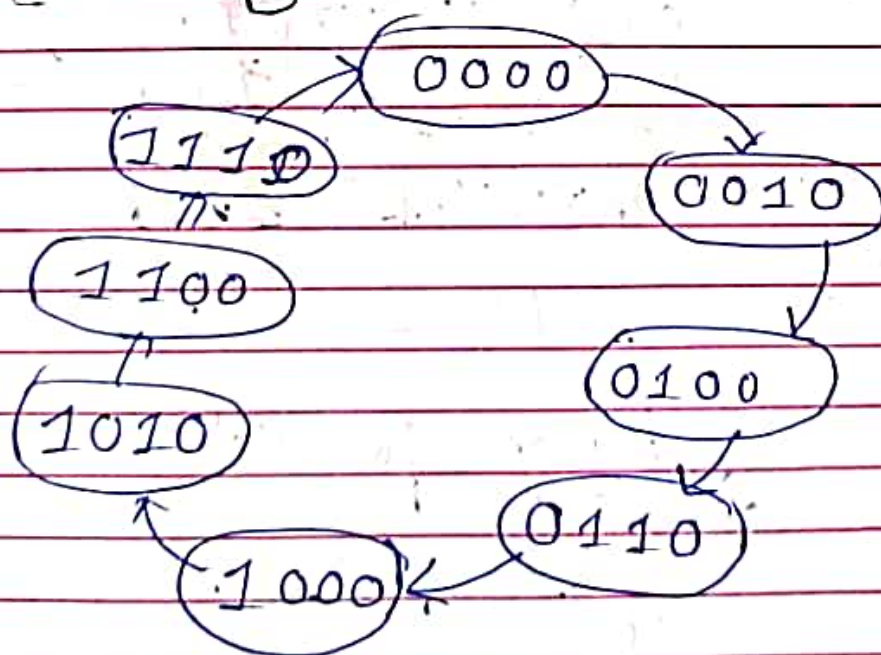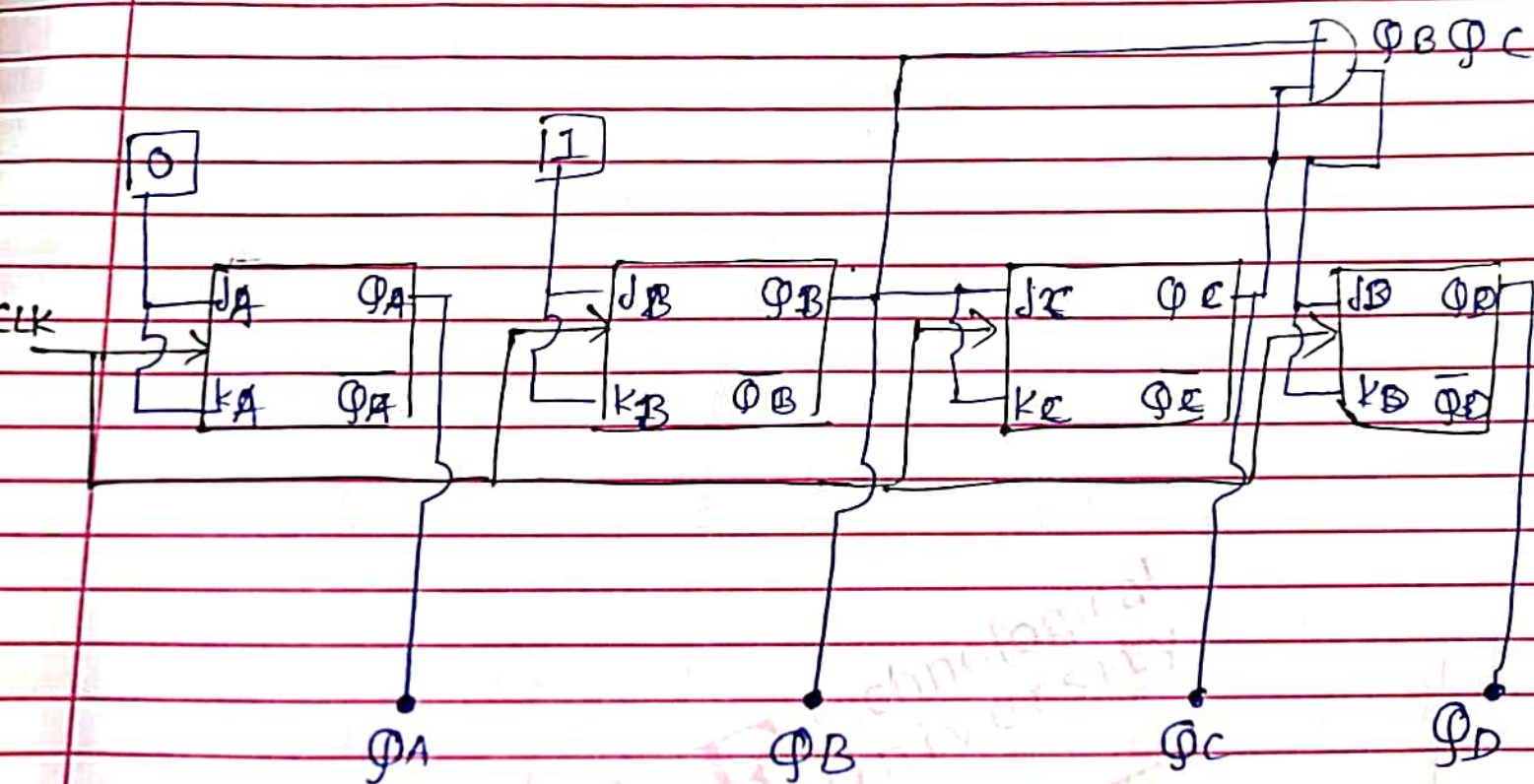
0->2->4->6->8->10->12->14   using JK Flip flop

QBQC

0
0

1
1

FFA
J   Q
0
K1en0

FFB
J   Q
0
K1en0

FFC
J   Q
0
K1en0

FFD
J   Q
0
K1en0

0
1
2