DIGITAL DESIGN(DD)

INSTR F243/EEE F215 /ECE F215 /CS F215

19/09/2025- Tutorial # 6

Q1. A PN flip-flop has four operations: set to 1, no change, complement, and clear to 0, when inputs P and N are 00, 01, 10, and 11, respectively.

a) Tabulate the characteristic table.
b) Derive the characteristic equation.
c) Tabulate the excitation table.

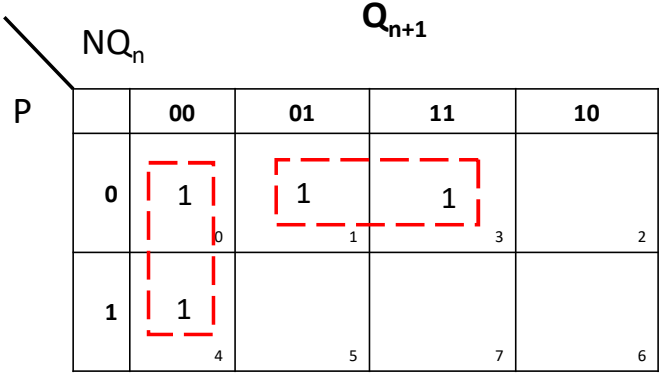
The truth table for PN flip-flop is

P	N	Q_{n+1}
0	0	1
0	1	Q_n
1	0	Q_n'
1	1	0

characteristic table

	P	N	Q_n	Q_{n+1}
0	0	0	0	1
1	0	0	1	1
2	0	1	0	0
3	0	1	1	1
4	1	0	0	1
5	1	0	1	0
6	1	1	0	0
7	1	1	1	0

characteristic equation



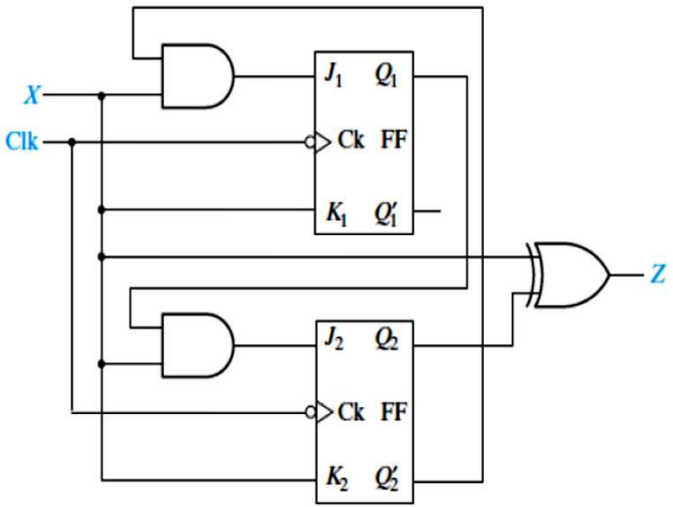
$Q_{n+1}=N'Q_n' + P'Q_n$

Excitation table

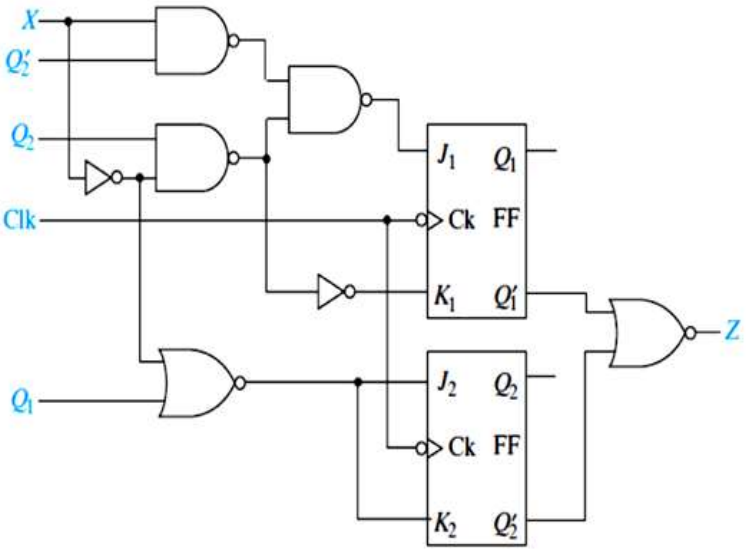
Q_n	Q_{n+1}	P	N
0	0	✕	1
0	1	✕	0
1	0	1	✕
1	1	0	✕

Q2. For the following sequential circuits, construct the state table and state diagram. Also, state whether they are Mealy or Moore machines?

(a)



(b)



(a)

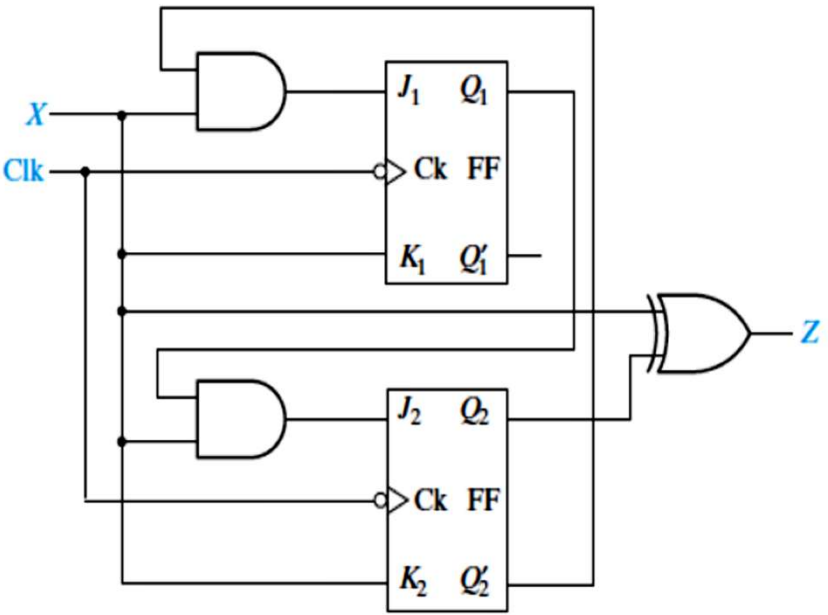
(i) Find the Boolean expressions for the JK flip-flop inputs

$$J_1 = \bar{Q}_2 X$$

$$J_2 = Q_1 X$$

$$K_1 = K_2 = X$$

$$Z = X \oplus Q_2$$



(ii) Use the Boolean expressions to find the actual JK flip-flop input values and output Z for each possible combination of present states and input

(iii) Use the JK flip-flop characteristic tables to find the next states (NS), based on the JK flip-flop input vales and the present states (PS).

PS		I/P					NS		O/P
Q1	**Q2**	**X**	**J1**	**K1**	**J2**	**K2**	**Q1+**	**Q2+**	**Z**
0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	0	1	1	0	1
0	1	0	0	0	0	0	0	1	1
0	1	1	0	1	0	1	0	0	0
1	0	0	0	0	0	0	1	0	0
1	0	1	1	1	1	1	0	1	1
1	1	0	0	0	0	0	1	1	1
1	1	1	0	1	1	1	0	0	0

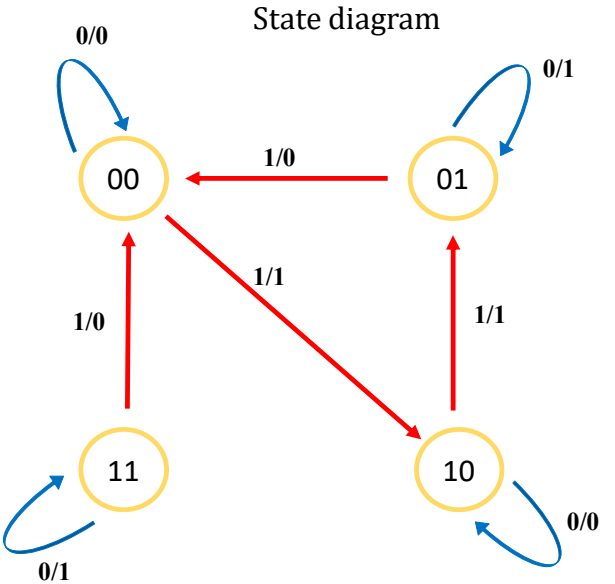
J	K	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	Q_n'

$$J_1 = \bar{Q}_2 X \qquad J_2 = Q_1 X \qquad K_1 = K_2 = X \qquad Z = X \oplus Q_2$$

State table

			X=0		X=1	
PS			NS	Z	NS	Z
0	0	**0**	0	0	2	1
0	1	**1**	1	1	0	0
1	0	**2**	2	0	1	1
1	1	**3**	3	1	0	0

State diagram



Since the output depends on the present states and the present input, the given circuit is a Mealy machine

(b)

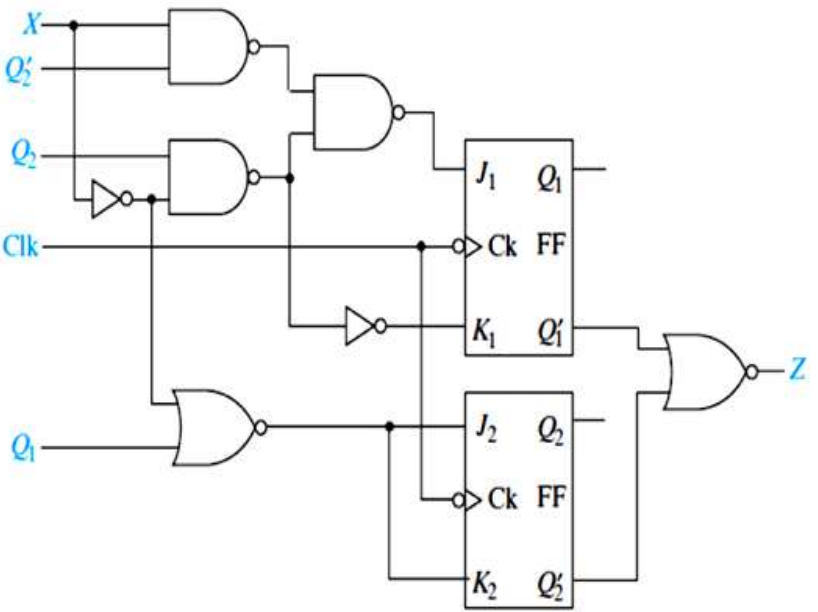
$$J_1 = X \oplus Q_2$$

$$J_2 = \bar{Q}_1 X$$

$$K_1 = \bar{X} Q_2$$

$$K_2 = \bar{Q}_1 X$$

$$Z = Q_1 Q_2$$



PS I/P NS O/P

Q1	Q2	X	J1	K1	J2	K2	Q1+	Q2+	Z
0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	1	1	1	1	0
0	1	0	1	1	0	0	1	1	0
0	1	1	0	0	1	1	0	0	0
1	0	0	0	0	0	0	1	0	0
1	0	1	1	0	0	0	1	0	0
1	1	0	1	1	0	0	0	1	1
1	1	1	0	0	0	0	1	1	1

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

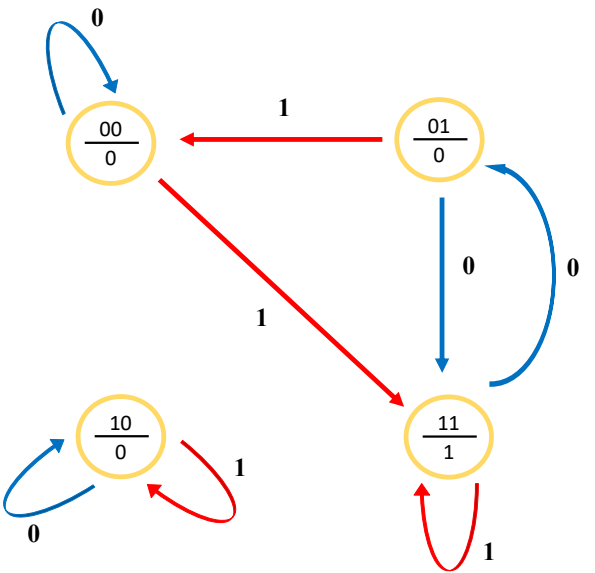
$$J_1 = X \oplus Q_2 \qquad J_2 = \bar{Q}_1 X \qquad K_1 = \bar{X} Q_2 \qquad K_2 = \bar{Q}_1 X$$

$$Z = Q_1 Q_2$$

State table

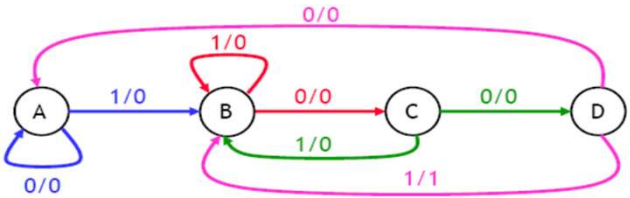
			X=0		X=1	
PS			NS	Z	NS	Z
0	0	**0**	0	0	3	0
0	1	**1**	3	0	0	0
1	0	**2**	2	0	2	0
1	1	**3**	1	1	3	1

State diagram



Since the output depends only on the present states, the given circuit is a Moore machine

Q3. Design a sequential circuit using JK flip-flops with logic gates for the following state diagram.



Four states are present in the state diagram, so two JK flip-flops are required.

Tabulate the state table with present states (PS) and next states (NS) along with input and output, as shown in the state diagram.

	PS		I/P	NS		O/P
	Q1	**Q2**	**X**	**Q1+**	**Q2+**	**Z**
A	0	0	0	0	0	0
	0	0	1	0	1	0
B	0	1	0	1	0	0
	0	1	1	0	1	0
C	1	0	0	1	1	0
	1	0	1	0	1	0
D	1	1	0	0	0	0
	1	1	1	0	1	1

	PS		I/P	NS		O/P
	Q1	**Q2**	**X**	**Q1+**	**Q2+**	**Z**
A	0	0	0	0	0	0
	0	0	1	0	1	0
B	0	1	0	1	0	0
	0	1	1	0	1	0
C	1	0	0	1	1	0
	1	0	1	0	1	0
D	1	1	0	0	0	0
	1	1	1	0	1	1

J1	**K1**	**J2**	**K2**
0	✕	0	✕
0	✕	1	✕
1	✕	✕	1
0	✕	✕	0
✕	0	1	✕
✕	1	1	✕
✕	1	✕	1
✕	1	✕	0

Excitation table

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

- From the present states (PS) and next states (NS) fill out the JK flip-flop inputs using the excitation table for JK flip-flop.
- Then use the K maps to find the expressions for both the JK flip-flop inputs

$$J_1 = Q_2\overline{X} \qquad K_1 = Q_2 + X \qquad J_2 = Q_1 + X \qquad K_2 = \overline{X} \qquad Z = Q_1Q_2X$$

Draw the sequential circuit