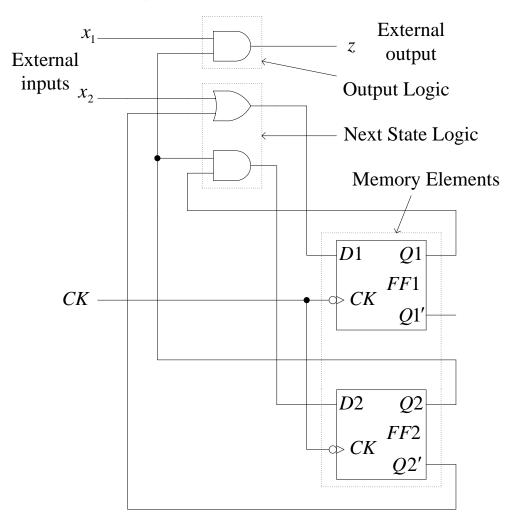
Chapter 10 Sequential Logic Design

Analysis

Representation of Sequential Circuits

There are three main methods to represent the analytical properties of a sequential circuit:

- State equations and output equations.
- Transition table and state table.
- Transition diagram and State diagram.



Output Equation:

$$z = x_1 Q 2_n$$

Excitation Equations:

$$D1_n = x_2 + Q2'_n$$

$$D2_n = Q1_nQ2_n$$

Next State Equations:

$$Q1_{n+1} = D1_n = x_2 + Q2'_n$$

 $Q2_{n+1} = D2_n = Q1_nQ2_n$

Transition Table:

Q1_{n+1} = D1_n =
$$\frac{\chi_2}{1} + \frac{Q2n}{0'=1}$$

Q2_{n+1} = D2_n = Q1_nQ2_n
Z = $\frac{\chi_1}{2}$ Q2_n
1 1

	Present State Odn Q2n	Nex	t Sta Inpu	te,Q1, t X17	ntsQ2n+1 (2 10	In oo	put 01	7/1X 1/1	2_
-	00		1	1			-		
İ	01		1-	1				1	1
	11		1	1				1	1
1	10		1	1				1	t -
- 11				•		•			

Qin+1 = Dir	= 72	+ Q24	1				700 (84) 100 100 100
Q2n+1 = D2n	= Q1m	Q2n					
Z= 24Q2n							
1 1							
Present State	1	LIND	te,Q1	-2		7 747 11	10
Proesent Stat	1	Inp O1	nt 1	-2			
Present State	00	101	1 11	120			
Present Stat Odn Odn	00	1	1	120		11	10

```
Q1_{n+1} = D1_n = \frac{72 + Q2_n}{1}
Q2_{n+1} = D2_n = Q1_nQ2_n
Z = \frac{74}{1}Q2_n
1 1
```

Present Stat	e Nes	4 56	te,Q1	n+102n+1	In	put.	747	2
QInQ2n	00	101	1 11	110	00	01	11	10
00	1	1	1	1	0	0	0	0
01	0	1	1	0	0	0	1	1
11	0	1	1	0	0	0	1	1
	-	1	1	1	1	1	1	1
10	-	1		[1	•	•	

$$Q_{1n+1} = D_{1n} = \frac{\chi_2 + Q_{2n}}{1}$$
 $Q_{2n+1} = D_{2n} = Q_{1n}Q_{2n}$
 $Z = \chi_1 Q_{2n}$
 1

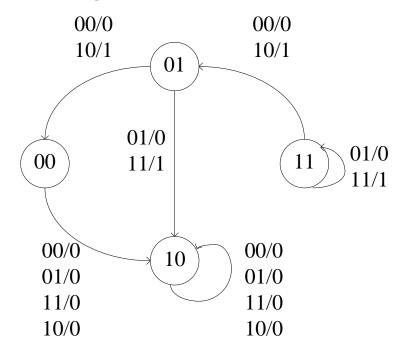
Present State	Nex	d Sla Inpu	te,Q1,	n+102n+1		elpu put,	741	2
	100	01	11	10	00	01	11	10
00	12	1	1	1			0	0
01	0	1	1	0	0	0	1	1
11	01	11	11	01	0	0	1	1
10	1	1	1	1	1			

A SECTION AND		Q22		LE BARRET		ê Ares gi Diy		
Q2n+1 = D2n=		12n	b-x	10-k				
	1	1 × 1	A.C.	101			Ä	
Z = 24Q2n	2X	OX	100	1 1 1		2	ř	
1 1	KO	0 X	1 11	101		Ó	I.	
Present State QInQ2n	00	Inpu 01	111 1	10	In 00	tput out	211	10
00	10	10	-	10	0	0	0	0
01		10		00	0	0	1	1
11	01	11	11	01	0	0	1	1
10	10	10	10	10	0	0	0	0

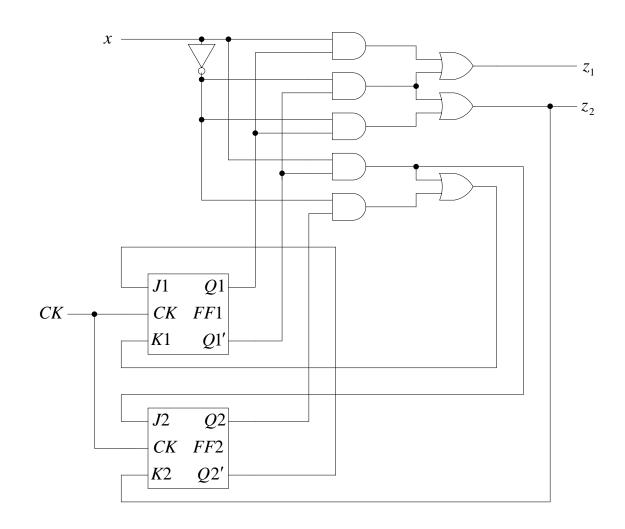
Table 10.1 Transition table for the sequential circuit of Figure 10.1.

Present state	Next state $Q1_{n+1}Q2_{n+1}$		Out	put :	3
$Q1_n Q2_n$	Input x_1x_2	Iı	iput	x_1	c_2
	00 01 11 10	00	01	11	10
00	10 10 10 10	0	0	0	0
01	00 10 10 00	0	0	1	1
1 1	01 11 11 01	0	0	1	1
10	<u>10 10</u> 10 10	0	0	0	0

Transition Diagram:



Analyze this sequential circuit:



Step 1. The excitation equations of the flip-flops are written from the combinational circuit as:

$$J1_{n} = Q2'_{n}$$

$$K1_{n} = xQ1'_{n} + x'Q2_{n}$$

$$J2_{n} = xQ1'_{n}$$

$$K2_{n} = x'Q1'_{n} + x'Q1_{n} = x'$$

The output equations are written from the combinational logic circuits as:

$$z_1 = xQ\mathbf{1}_n + x'Q\mathbf{1}'_n$$
$$z_2 = x'Q\mathbf{1}'_n + x'Q\mathbf{1}_n = x'$$

Step 2. The next state equations of the J-K flip-flops are written from the excitation equations in conjunction with characteristic equation of J-K flip-flops as:

$$Q1_{n+1} = J1_{n}Q1'_{n} + K1'_{n}Q1_{n}$$

$$= Q2'_{n}Q1'_{n} + (xQ1'_{n} + x'Q2_{n})'Q1_{n}$$

$$= Q1'_{n}Q2'_{n} + (x' + Q1_{n})(x + Q2'_{n})Q1_{n}$$

$$= Q1'_{n}Q2'_{n} + x'Q1_{n}Q2'_{n} + xQ1_{n} + Q1_{n}Q2'_{n}$$

$$= Q1'_{n}Q2'_{n} + Q1_{n}Q2'_{n}(x' + 1) + xQ1_{n}$$

$$= Q2'_{n}(Q1'_{n} + Q1_{n}) + xQ1_{n}$$

$$= Q2'_{n} + xQ1_{n}$$

$$Q2_{n+1} = J2_{n}Q2'_{n} + K2'_{n}Q2_{n}$$

$$= xQ1'_{n}Q2'_{n} + xQ2$$

Step 3. The transition table for the circuit is prepared from the next state equations and output equations and shown in Table 10.3.

Table 10.3 Transition table for the sequential circuit of Figure 10.4.

Present state Q1,,Q2,	Next state ($21_{n+1}Q2_{n+1}$ at x		puts $z_1 z_2$ Input x	
1	- 0	1	0	1	
00	10	11	11	00	
01	00	01	11	00	
11	00	11	01	10	
10	10	10	01	10	

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Step 4. The transition diagram for the circuit is prepared from the transition table of Table 10.3 and is shown in Figure 10.5.

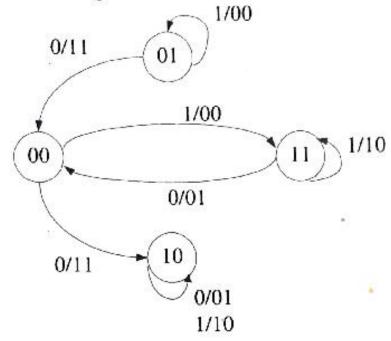


Figure 10.5 Transition diagram for the sequential circuit of Figure 10.4.