After doing this state assignment, the state table becomes

1 picture

Present State (y_1y_2)	Next State, (Y_1Y_2)		O/P (z)	
	X = 0	= 1	= 0	= 1
00	00	01	0	0
01	11	01	0	0
11	00	10	0	0
10	11	01	1	0

From this state assignment table, the digital function can easily be derived as follows.

2 picture

Y_1

X / y_1y_2	0	1
00	0	0
01	1	0
11	0	1
10	1	0

Y_2

X / y_1y_2	0	1
00	0	1
01	1	1
11	0	0
10	1	1

z

X / y_1y_2	0	1
00	0	0
01	0	0
11	0	0
10	1	0

$$Y_1 = X'y_1'y_2 + Xy_1y_2 + X'y_1y_2'$$
$$Y_2 = y_1'y_2 + y_1'X + y_1y_2'$$
$$z = X'y_1y_2'$$

Y_1 and Y_2 are the next states, which are the memory elements. These will be feedbacked to the input as states y_1 and y_2 with some delay by D flip flop. The circuit diagram is shown in Fig. 4.6.

3 picture

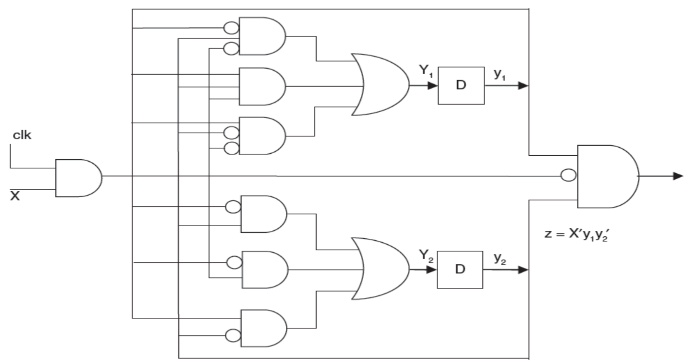

Fig. 4.6 *Digital Circuit Diagram*

4.2 Binary Counter

The binary counter counts in binary.

Example 4.3 Design a Modulo 3 binary counter.

Solution: A Modulo 3 binary counter can count up to 3. The binary representation of 3 is 11. It can count 00, 01, 10, and 11. There will be an external input x, which will act as a control variable and determine when the count should proceed. After counting 3, if it has to proceed, then it will come back to 00 again. The state diagram for a Mod 3 binary counter is given in Fig. 4.7.

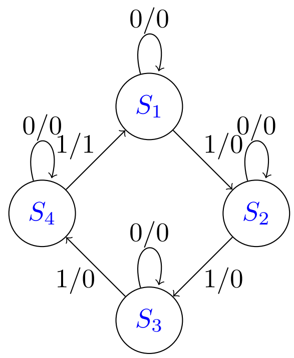

Fig. 4.7 `State Diagram of a Mod 3 Binary Counter`

The state table for Mod 3 binary counter is

	$Next State, O/P$	
$Present State$	$X = 0$	$X = 1$
S_1	$S_1, 0$	$S_2, 0$
S_2	$S_2, 0$	$S_3, 0$
S_3	$S_3, 0$	$S_4, 0$
S_4	$S_4, 0$	$S_1, 1$

There are four states in the machine. Two bits are sufficient to assign four states into the binary number.

Let us assign S_1 to 00, S_2 to 01, S_3 to 10, and S_4 to 11. After doing this state assignment, the state table becomes

4 picture

Present State	Next State, (Y_1Y_2)		O/P (z)	
(y_2y_1)	X = 0	= 1	= 0	= 1
00	00	01	0	0
01	01	10	0	0
10	01	11	0	0
11	11	00	0	1

Binary Counter

4.2.1 Designing Using Flip Flop (T Flip Flop and SR Flip Flop)

The excitation table for T fl ip fl op is given in the following:

$CircuitFrom$	$ChangedTo$	T
0	0	0
0	1	1
1	0	1
1	1	0

In state assignment, 00 is changed to 00 for input 0. Here, y_1 is changed from 0 to 0, and so T1 will be 0. y_2 is changed from 0 to 1, and so T_1 will be 0. 00 is changed to 01 for input 1. Here, y_1 is changed from 0 to 1, and so T1 will be 1. y_2 is changed from 0 to 0, and so T_1 will be 0. By this process, the excitation table of the counter using T fl ip fl op is given in the following table.

$PresentState$	T_2T_1	
(Y_2Y_1)	$X = 0$	$X = 1$
00	00	01
01	00	11
10	00	01
11	00	11

$$T_1 = X$$
$$T_2 = Xy_1$$
$$z = Xy_1y_2$$

The circuit diagram for this is presented in Fig. 4.8.

5 picture

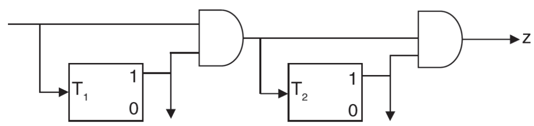

Fig. 4.8 *Circuit Diagram Using T Flip Flop*

The excitation table for SR flip flop is denoted in the following table.

$CircuitFrom$	$ChangedTo$	S	R
0	0	0	–
0	1	1	0
1	0	1	1
1	1	–	0

Binary Counter

In state assignment, 00 is changed to 00 for input 0. Here, y_1 is changed from 0 to 0, and so R_1 will be don't care and S_1 will be 0. y_2 is changed from 0 to 0, and so R_2 will be don't care and S_2 will be 0.
In the state assignment table, 00 is changed to 01 for input 1. Here, y_1 is changed from 0 to 1, and so R_1 will be 0 and S_1 will be 1. y_2 is changed from 0 to 0, and so R_2 will be don't care and S_2 will be 0. By this process, the excitation table of the counter using SR flip flop is given as follows.

6 picture

Present State (y_2y_1)	X = 0		X = 1	
	S_1R_1	S_2R_2	S_1R_1	S_2R_2
00	0 –	0 –	1 0	0 –
01	– 0	0 –	0 1	1 0
10	0 –	– 0	1 0	– 0
11	– 0	– 0	0 1	0 1

$$S_1 = Xy_1' \quad R_1 = Xy_1$$
$$S_2 = Xy_1y_2' \quad R_2 = Xy_1y_2$$

The circuit diagram for this is presented in Fig. 4.9.

7 picture

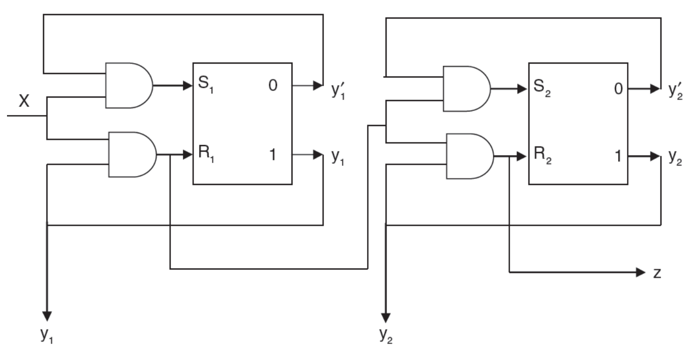

Fig. 4.9 *Circuit Diagram Using SR Flip Flop*

Example 4.4 `Design a Modulo 8 binary counter`

Solution: A Modulo 8 binary counter can count up to 8 from 000 to 111. There will be an external input x, which will act as a control variable and determine when the count should proceed. After counting 8, if it has to proceed, then it will come back to 000 again.