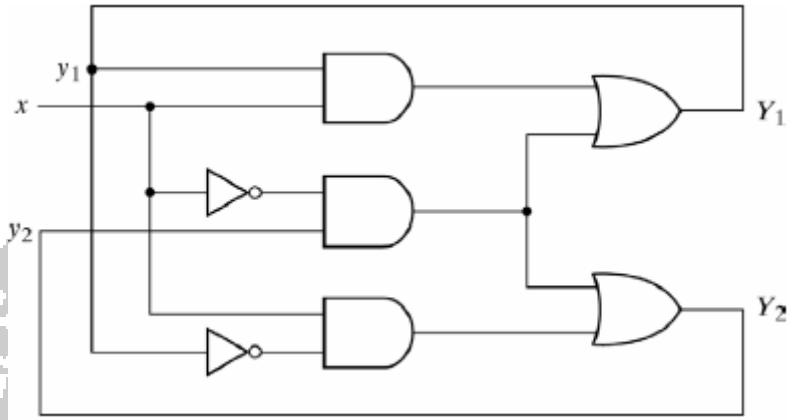
4.2 Analysis Procedure

Transition Table

An example of an asynchronous sequential circuit is shown below:



The analysis of the circuit starts by considering the excitation variables (*Y*1 and *Y*2) as outputs and the secondary variables (*y*1 and *y*2) as inputs.

The Boolean expressions are:

$$Y_1 = xy_1 + x'y_2$$
$$Y_2 = xy_1' + x'y_2$$

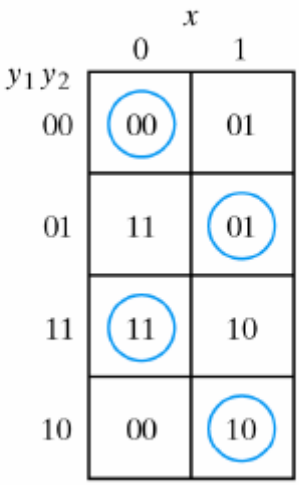
$y_1 y_2$ \ x	0	1
00	0	0
01	1	0
11	1	1
10	0	1

Map for $Y_1 = xy_1 + x'y_2$

$y_1 y_2$ \ x	0	1
00	0	1
01	1	1
11	1	0
10	0	0

Map for $Y_2 = xy'_1 + x'y_2$

Combining the binary values in corresponding squares the following *transition table* is obtained:



The transition table shows the value of $Y = Y1Y2$ inside each square. Those entries where $Y = y$ are circled to indicate a stable condition. The circuit has four stable *total states* – $y1y2x$ = 000, 011, 110, and 101 – and four unstable total states – 001, 010, 111, and 100. The state table of the circuit is shown below:

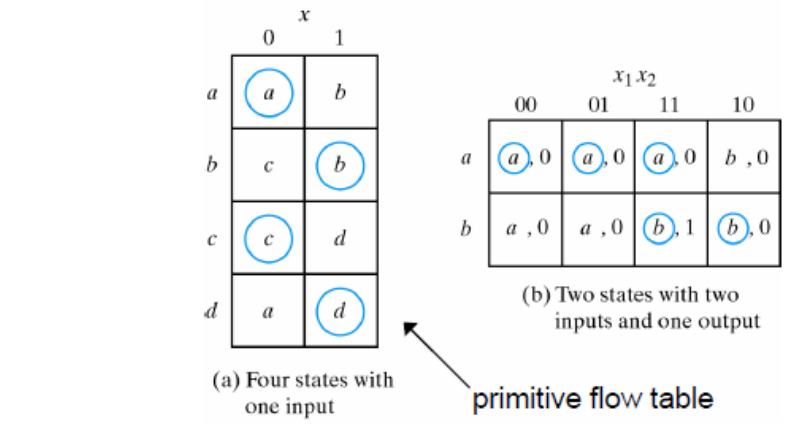
Present State		Next State			
		$x = 0$		$x = 1$	
0	0	0	0	0	1
0	1	1	1	0	1
1	0	0	0	1	0
1	1	1	1	1	0

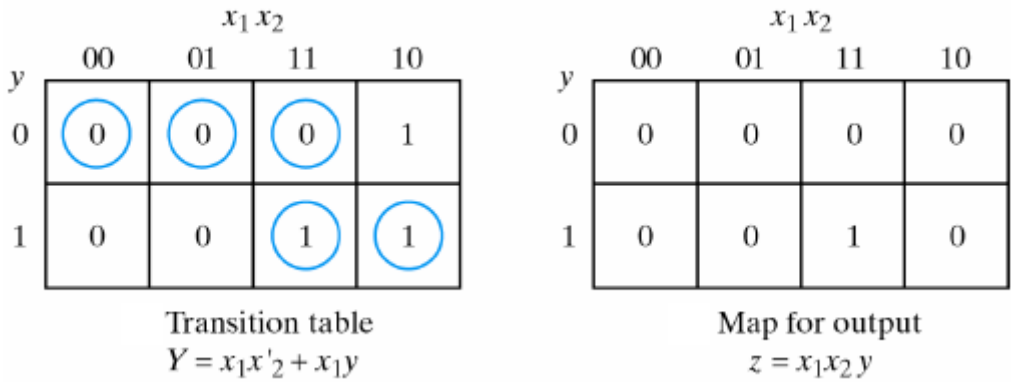
This table provides the same information as the transition table.

Flow Table

In a *flow table* the states are named by letter symbols. Examples of flow tables are as follows:

In order to obtain the circuit described by a flow table, it is necessary to assign to each state a distinct value.





The resulting logic diagram is shown below:

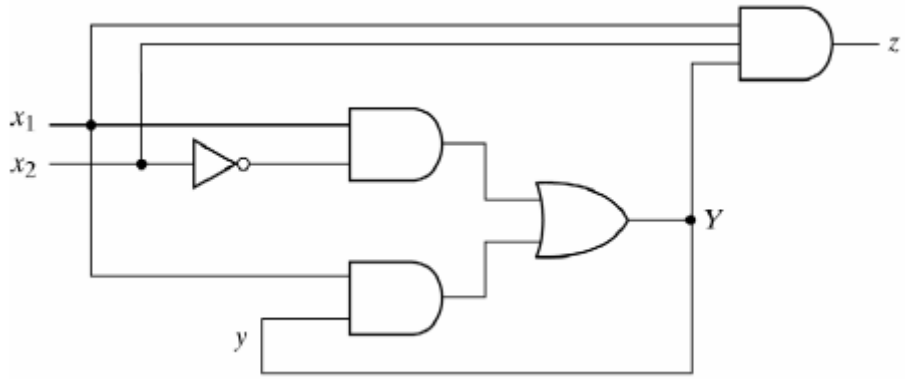
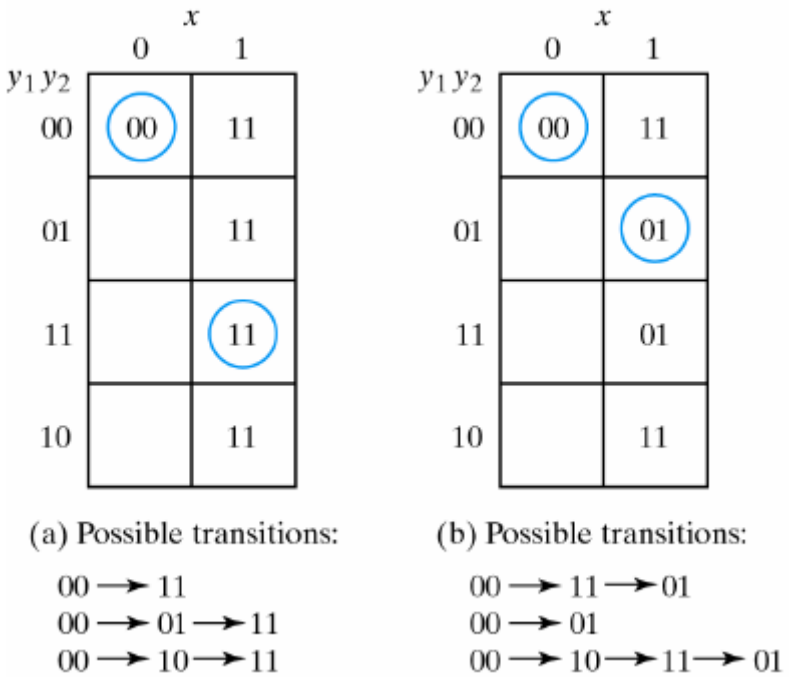


Fig 4.2.1 Logic diagram

Race Conditions

A *race* condition exists in an asynchronous circuit when two or more binary state variables change value in response to a change in an input variable. When unequal delays are encountered, a race condition may cause the state variable to change in an unpredictable manner. If the final stable state that the circuit reaches does not depend on

the order in which the state variables change, the race is called a *noncritical race*. Examples of noncritical races are illustrated in the transition tables below:



$y_1 y_2$	$x=0$	$x=1$
00	(00)	11
01		11
11		(11)
10		11

(a) Possible transitions:

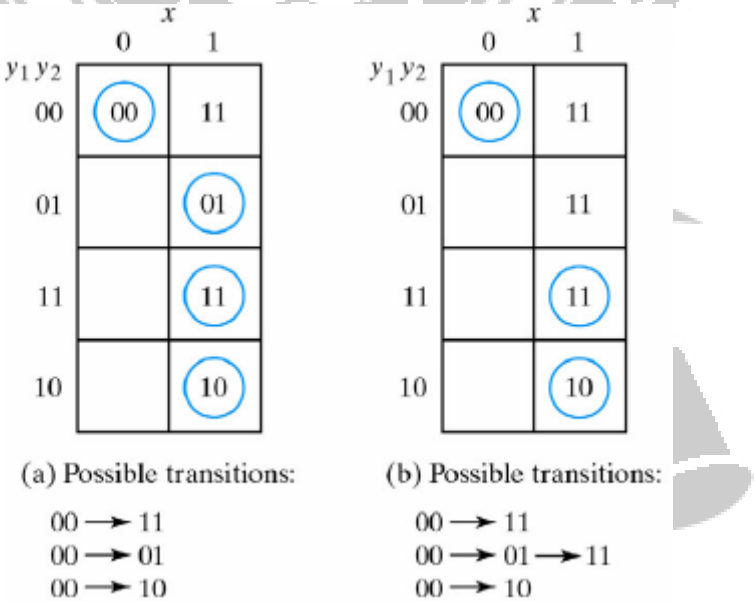
$00 \rightarrow 11$
$00 \rightarrow 01 \rightarrow 11$
$00 \rightarrow 10 \rightarrow 11$

$y_1 y_2$	$x=0$	$x=1$
00	(00)	11
01		(01)
11		01
10		11

(b) Possible transitions:

$00 \rightarrow 11 \rightarrow 01$
$00 \rightarrow 01$
$00 \rightarrow 10 \rightarrow 11 \rightarrow 01$

The transition tables below illustrate critical races:



$y_1 y_2$	$x=0$	$x=1$
00	(00)	11
01		(01)
11		(11)
10		(10)

(a) Possible transitions:

$00 \rightarrow 11$
$00 \rightarrow 01$
$00 \rightarrow 10$

$y_1 y_2$	$x=0$	$x=1$
00	(00)	11
01		11
11		(11)
10		(10)

(b) Possible transitions:

$00 \rightarrow 11$
$00 \rightarrow 01 \rightarrow 11$
$00 \rightarrow 10$

Races can be avoided by directing the circuit through a *unique* sequence of intermediate unstable states. When a circuit does that, it is said to have a *cycle*. Examples of cycles are:

$y_1 y_2$ \ x	0	1
00	(00)	01
01		11
11		10
10		(10)

(a) State transition: 00 → 01 → 11 → 10

$y_1 y_2$ \ x	0	1
00	(00)	01
01		11
11		(11)
10		(10)

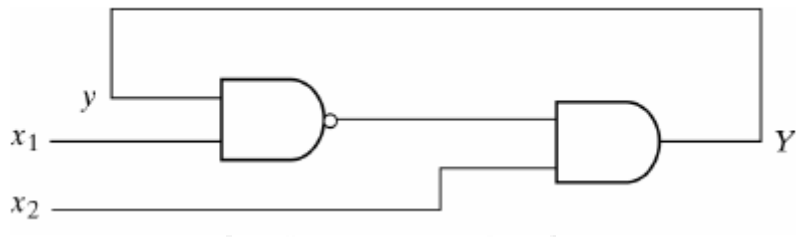
(b) State transition: 00 → 01 → 11

$y_1 y_2$ \ x	0	1
00	(00)	01
01		11
11		10
10		01

(c) Unstable → 01 → 11 → 10 →

Stability Considerations

An asynchronous sequential circuit may become unstable and oscillate between unstable states because of the presence of feedback. The instability condition can be detected from the transition table. Consider the following circuit:



The excitation function is: Y = (x1y)'x2 = (x1' + y')x2 = x1'x2 + x2y' and the transition table for the circuit is:

y \ $x_1 x_2$	00	01	11	10
0	(0)	1	1	(0)
1	0	(1)	0	0

Those values of *Y* that are equal to *y* are circled and represent stable states. When the input *x*1*x*2 is 11, the state variable alternates between 0 and 1 indefinitely.