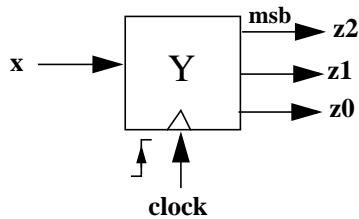


SEQUENTIAL CIRCUIT ANALYSIS

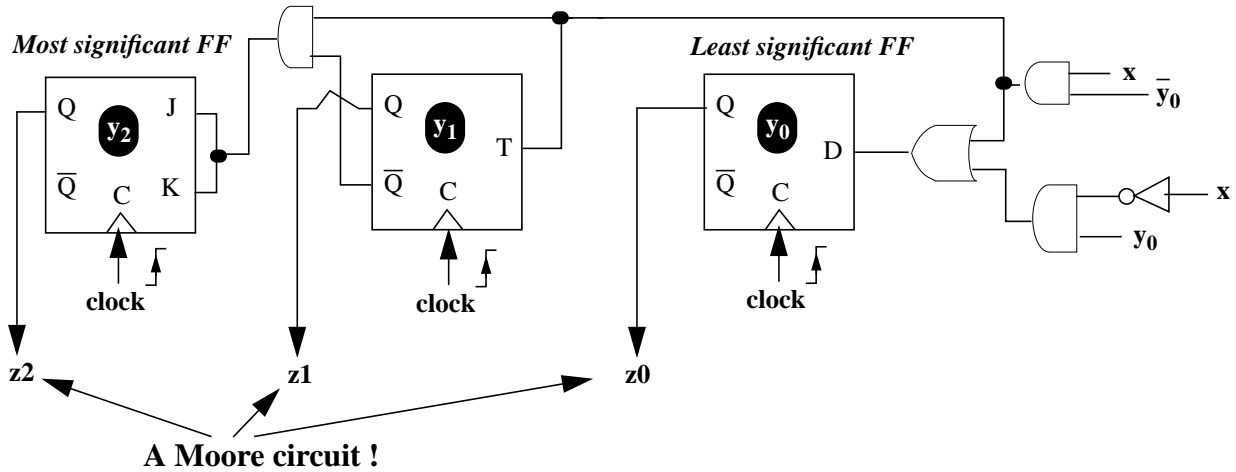
**Example I**

The sequential circuit :



What is the **purpose** of this sequential circuit ?

What does it **do** ?



a) Flip-flop input and sequential circuit output equations :

$$D_0 = x\bar{y}_0 + \bar{x}y_0 \qquad T_1 = x\bar{y}_0 \qquad J_2 = K_2 = x\bar{y}_1\bar{y}_0$$

$$z_0 = y_0 \qquad z_1 = y_1 \qquad z_2 = y_2$$

**A Moore circuit !**

It is a **Moore** circuit since the sequential circuit outputs are independent of the sequential circuit input. This is seen by observing the sequential circuit output equations which do **not** have the sequential circuit input “x” and also by observing that the sequential circuit output circuits do not have “x” connected to them.

**b) Next flip-flop output (next state) equations :**

$$\rightarrow y_0 = D_0 = x\bar{y}_0 + \bar{x}y_0$$



$$\begin{aligned} \rightarrow y_1 &= T_1\bar{y}_1 + \bar{T}_1y_1 = (x\bar{y}_0)\bar{y}_1 + (\overline{x\bar{y}_0})y_1 \\ &= x\bar{y}_1\bar{y}_0 + (\bar{x} + \bar{\bar{y}}_0)y_1 \\ &= x\bar{y}_1\bar{y}_0 + \bar{x}y_1 + y_1y_0 \end{aligned}$$



$$\begin{aligned} \rightarrow y_2 &= J_2\bar{y}_2 + \bar{K}_2y_2 = (x\bar{y}_1\bar{y}_0)\bar{y}_2 + (\overline{x\bar{y}_1\bar{y}_0})y_2 \\ &= x\bar{y}_2\bar{y}_1\bar{y}_0 + [\bar{x} + \bar{\bar{y}}_1 + \bar{\bar{y}}_0]y_2 \\ &= x\bar{y}_2\bar{y}_1\bar{y}_0 + \bar{x}y_2 + y_2y_1 + y_2y_0 \end{aligned}$$

**c) The excitation table :**

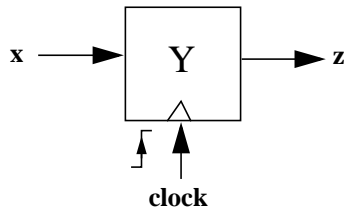
$y_2y_1y_0$	$\rightarrow y_2 \quad \rightarrow y_1 \quad \rightarrow y_0$		$z_2 z_1 z_0$	
	$x = 0$	$x = 1$	$x = 0$	$x = 1$
<b>q<sub>0</sub></b> 0 0 0	0 0 0	1 1 1	0 0 0	0 0 0
<b>q<sub>1</sub></b> 0 0 1	0 0 1	0 0 0	0 0 1	0 0 1
<b>q<sub>2</sub></b> 0 1 0	0 1 0	0 0 1	0 1 0	0 1 0
<b>q<sub>3</sub></b> 0 1 1	0 1 1	0 1 0	0 1 1	0 1 1
<b>q<sub>4</sub></b> 1 0 0	1 0 0	0 1 1	1 0 0	1 0 0
<b>q<sub>5</sub></b> 1 0 1	1 0 1	1 0 0	1 0 1	1 0 1
<b>q<sub>6</sub></b> 1 1 0	1 1 0	1 0 1	1 1 0	1 1 0
<b>q<sub>7</sub></b> 1 1 1	1 1 1	1 1 0	1 1 1	1 1 1

**d) The State table :**

PS	NS		OUT	
	$x = 0$	$x = 1$	$x = 0$	$x = 1$
q <sub>0</sub>	q <sub>0</sub>	q <sub>7</sub>	0	0
q <sub>1</sub>	q <sub>1</sub>	q <sub>0</sub>	1	1
q <sub>2</sub>	q <sub>2</sub>	q <sub>1</sub>	2	2
q <sub>3</sub>	q <sub>3</sub>	q <sub>2</sub>	3	3
q <sub>4</sub>	q <sub>4</sub>	q <sub>3</sub>	4	4
q <sub>5</sub>	q <sub>5</sub>	q <sub>4</sub>	5	5
q <sub>6</sub>	q <sub>6</sub>	q <sub>5</sub>	6	6
q <sub>7</sub>	q <sub>7</sub>	q <sub>6</sub>	7	7

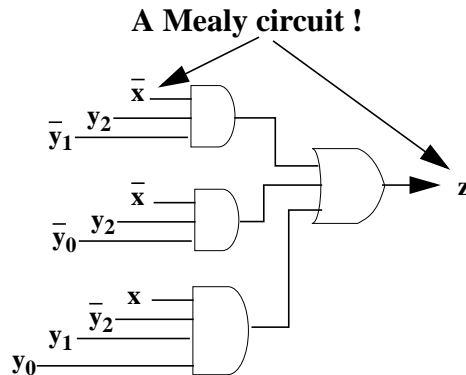
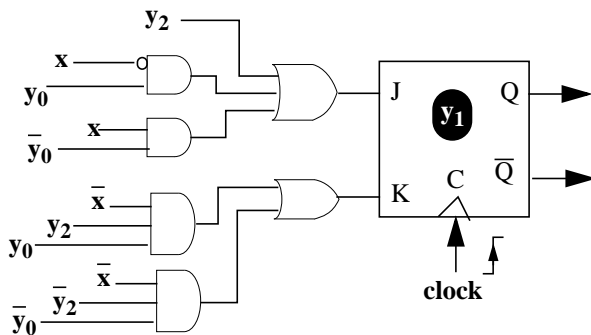
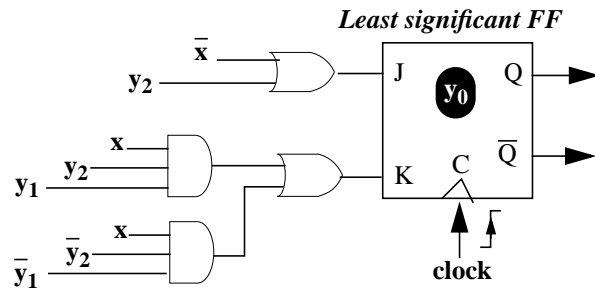
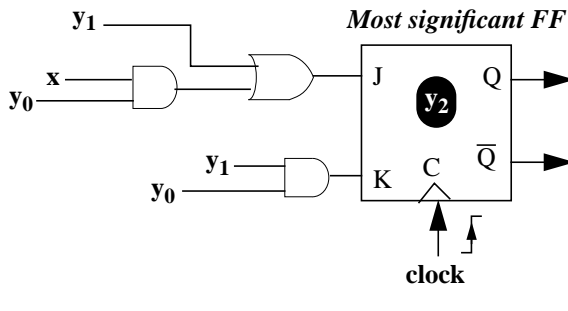
## Example II

The sequential circuit :



What is the **purpose** of this sequential circuit ?

What does it **do** ?



a) Flip-flop input and sequential circuit output equations :

$$J_0 = \bar{x} + y_2$$

$$J_1 = y_2 + \bar{x}y_0 + x\bar{y}_0$$

$$J_2 = y_1 + xy_0$$

$$K_0 = xy_2y_1 + x\bar{y}_2\bar{y}_1$$

$$K_1 = \bar{x}y_2y_0 + \bar{x}\bar{y}_2\bar{y}_0$$

$$K_2 = y_1y_0$$

A Mealy circuit !

$$z = \bar{x}y_2\bar{y}_1 + \bar{x}y_2\bar{y}_0 + x\bar{y}_2y_1y_0$$

It is a **Mealy** circuit since the sequential circuit outputs are dependent on the sequential circuit input "x." This is seen by observing the sequential circuit output equation which has the sequential circuit input "x" and also by observing that the sequential circuit output circuit has "x" connected to it.

**b) Next flip-flip output (next state) equations :**

$$\begin{aligned}
 \overrightarrow{y_0} &= J_0 \overline{y_0} + \overline{K_0} y_0 = (\overline{x} + y_2) \overline{y_0} + \overline{(x y_2 y_1 + x \overline{y_2} \overline{y_1})} y_0 \\
 &= \overline{x} \overline{y_0} + y_2 \overline{y_0} + [(\overline{x y_2 y_1}) (\overline{x \overline{y_2} \overline{y_1}})] y_0 \\
 &= \overline{x} \overline{y_0} + y_2 \overline{y_0} + [(\overline{x} + \overline{y_2} + \overline{y_1}) (\overline{x} + y_2 + y_1)] y_0 \\
 &\quad \dots \dots \dots \\
 &= \overline{x} \overline{y_0} + y_2 \overline{y_0} + [\overline{x} + \overline{y_2} y_1 + y_2 \overline{y_1}] y_0 \\
 &\quad \dots \dots \dots \\
 &= \overline{x} + y_2 \overline{y_0} + \overline{y_2} y_1 y_0 + y_2 \overline{y_1}
 \end{aligned}$$



$$\begin{aligned}
 \overrightarrow{y_1} &= J_1 \overline{y_1} + \overline{K_1} y_1 = (y_2 + \overline{x} y_0 + x \overline{y_0}) \overline{y_1} + \overline{(x y_2 y_0 + \overline{x} \overline{y_2} \overline{y_0})} y_1 \\
 &= y_2 \overline{y_1} + \overline{x} \overline{y_1} y_0 + x \overline{y_1} \overline{y_0} + [(\overline{x y_2 y_0}) (\overline{x \overline{y_2} \overline{y_0}})] y_1 \\
 &= y_2 \overline{y_1} + \overline{x} \overline{y_1} y_0 + x \overline{y_1} \overline{y_0} + [(x + \overline{y_2} + \overline{y_0}) (x + y_2 + y_0)] y_1 \\
 &\quad \dots \dots \dots \\
 &= y_2 \overline{y_1} + \overline{x} \overline{y_1} y_0 + x \overline{y_1} \overline{y_0} + [x + \overline{y_2} y_0 + y_2 \overline{y_0}] y_1 \\
 &\quad \dots \dots \dots \\
 &= y_2 \overline{y_1} + x \overline{y_0} + x y_1 + y_2 \overline{y_0} + \overline{x} \overline{y_2} y_0
 \end{aligned}$$



$$\begin{aligned}
 \overrightarrow{y_2} &= J_2 \overline{y_2} + \overline{K_2} y_2 = (y_1 + x y_0) \overline{y_2} + \overline{(y_1 y_0)} y_2 \\
 &= \overline{y_2} y_1 + x \overline{y_2} y_0 + [\overline{y_1} + \overline{y_0}] y_2 \\
 &= \overline{y_2} y_1 + x \overline{y_2} y_0 + y_2 \overline{y_1} + y_2 \overline{y_0}
 \end{aligned}$$

**c) The excitation table :**

	$y_2 y_1 y_0$	$\overrightarrow{y_2} \quad \overrightarrow{y_1} \quad \overrightarrow{y_0}$		$z$	
		$x = 0$	$x = 1$	$x = 0$	$x = 1$
<b>a</b>	0 0 0	0 0 1	0 1 0	0	0
<b>b</b>	0 0 1	0 1 1	1 0 0	0	0
<b>c</b>	0 1 0	1 0 1	1 1 0	0	0
<b>d</b>	0 1 1	1 1 1	1 1 1	0	1
<b>e</b>	1 0 0	1 1 1	1 1 1	1	0
<b>f</b>	1 0 1	1 1 1	1 1 1	1	0
<b>g</b>	1 1 0	1 1 1	1 1 1	1	0
<b>h</b>	1 1 1	0 0 1	0 1 0	0	0