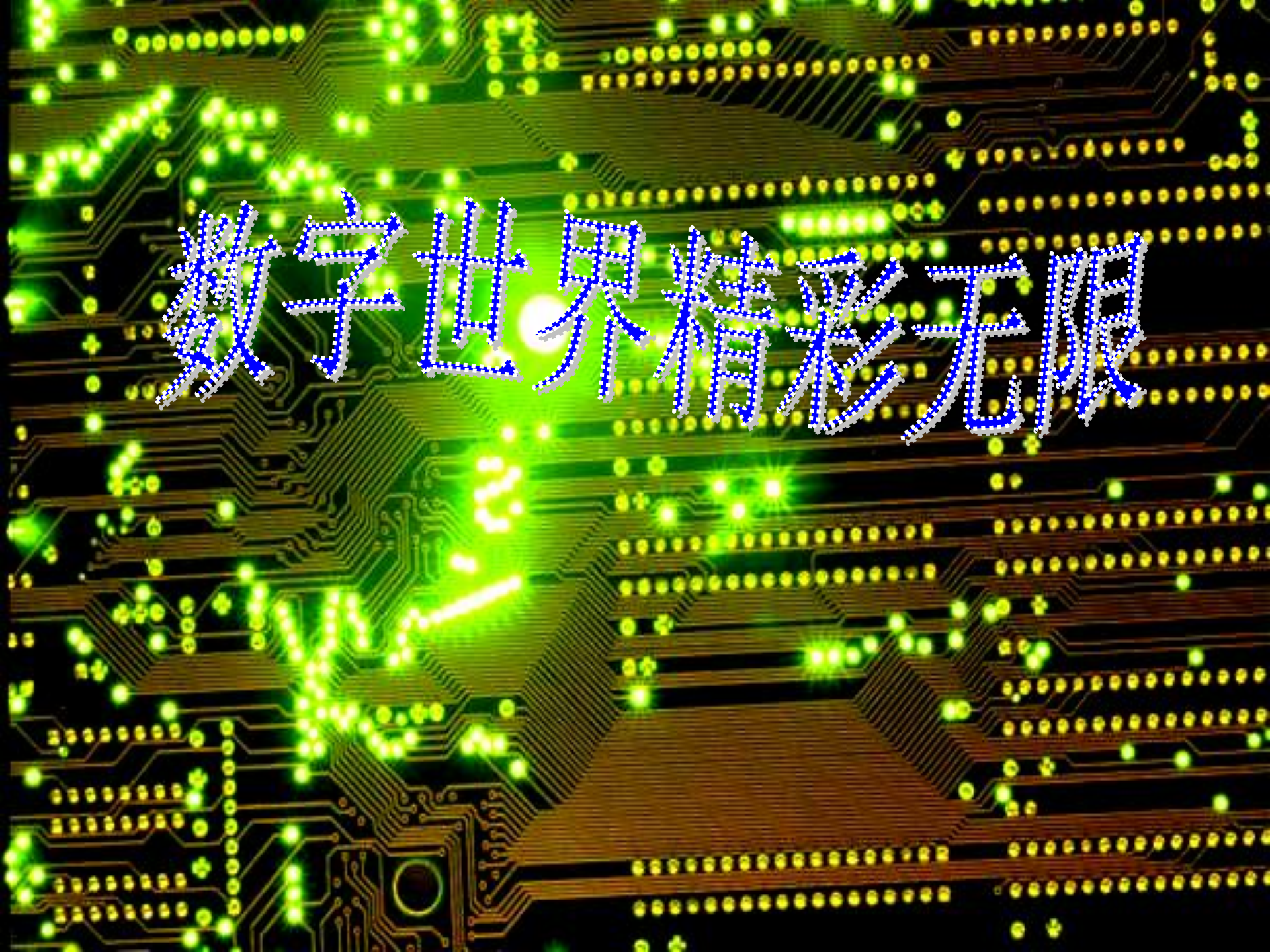
数字世界精彩无限

Unit 10 时序电路分析

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时序电路分析的一般方法

① 确定系统变量（输入变量、输出变量、状态变量）

② 列输入方程（驱动方程，控制函数）

③ 列输出方程（输出函数）

④ 列次态方程（状态方程）

⑤ 列状态转换表

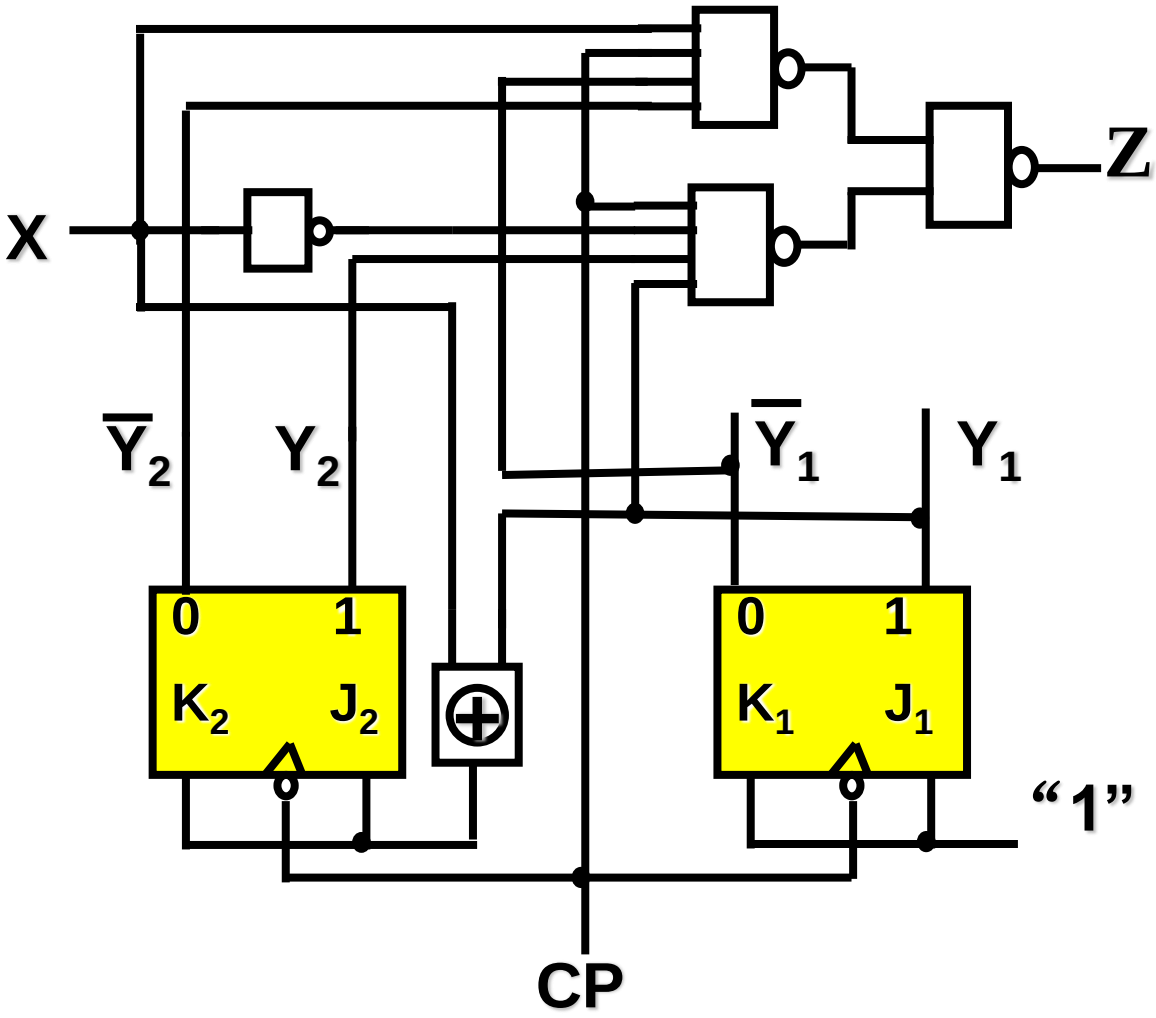
⑥ 画状态图、时序图（波形图）

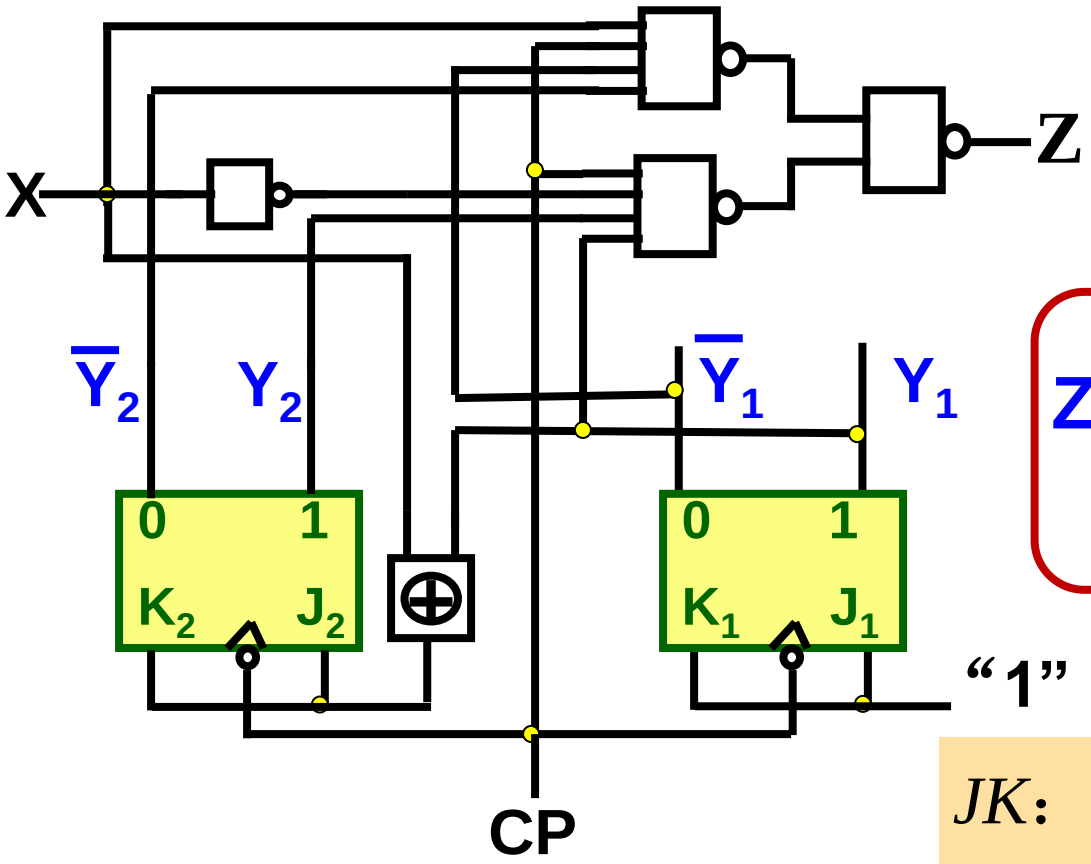
时序电路分析

1. XX二进制计数器
2. 非二进制计数器
3. 8421BCD码加法计数器

时序电路分析

例1





1. 输入方程

$J_1=K_1=1$

$J_2=K_2=X\oplus Y_1$

2. 输出方程：

$$Z = \overline{XCP\overline{Y}_2\overline{Y}_1 \cdot \overline{XCPY_2Y_1}}$$

$$= XCP\overline{Y}_2\overline{Y}_1 + \overline{X}CPY_2Y_1$$

3. 次态方程：

$Y_2^{n+1} = X\oplus Y_1\oplus Y_2$

$Y_1^{n+1} = \overline{Y}_1$

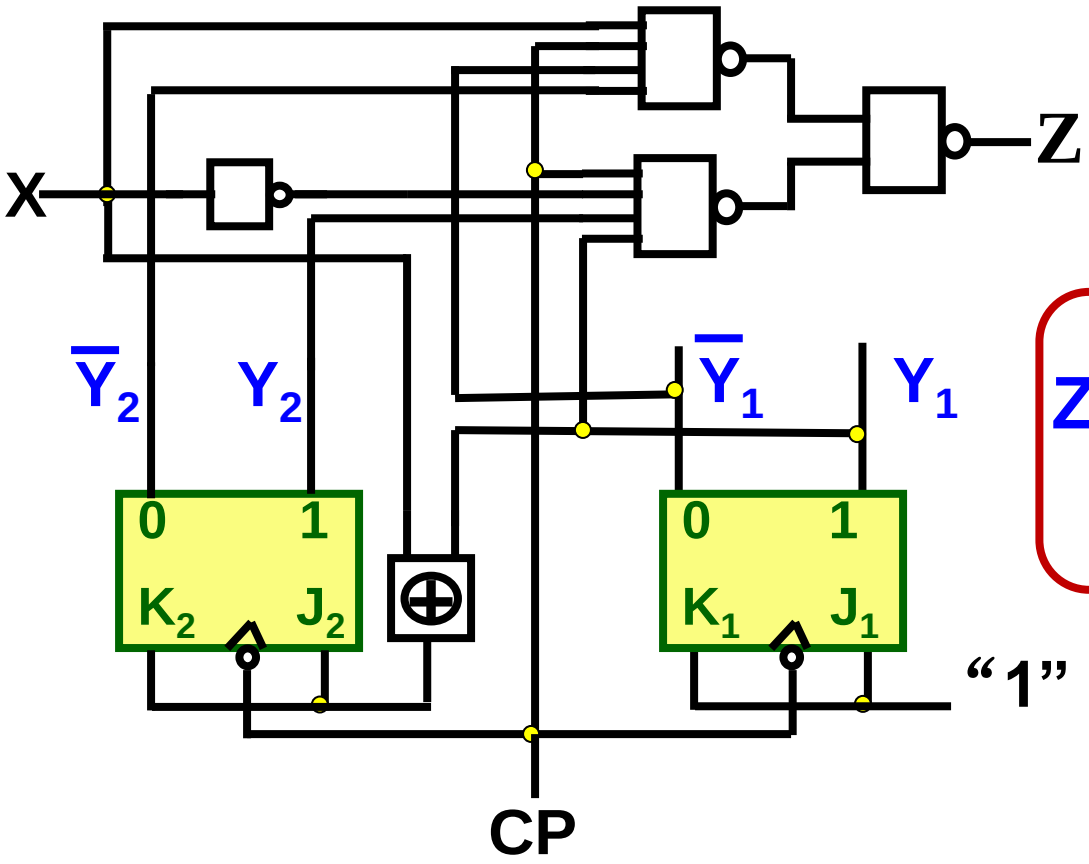
JK：$Q^{n+1} = J\ \overline{Q^n} + \overline{K}\ Q^n$

$$Y_2^{n+1} = J_2\ \overline{Y_2} + \overline{K_2}\ Y_2$$

$$= (X \oplus Y_1)\overline{Y_2} + \overline{X \oplus Y_1}\ Y_2$$

$$= X \oplus Y_1 \oplus Y_2$$

$$Y_1^{n+1} = J_1\ \overline{Y_1} + \overline{K_1}\ Y_1 = \overline{Y_1}$$



1. 输入方程

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$$Z = XCP\overline{Y}_2\overline{Y}_1 \cdot \overline{XCPY_2Y_1}$$

$$= XCP\overline{Y}_2\overline{Y}_1 + \overline{XCPY_2Y_1}$$

3. 次态方程：

$$Y_2^{n+1} = X\oplus Y_1\oplus Y_2$$

$$Y_1^{n+1} = \overline{Y}_1$$

4. 状态转换表：

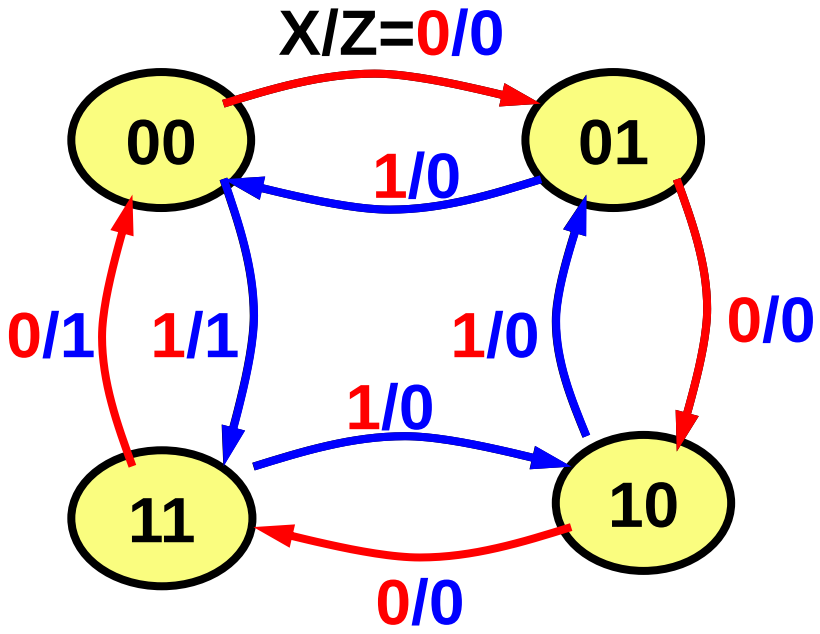
CP	X	Y_2	Y_1	Y_2^{n+1}	Y_1^{n+1}	Z
1	0	0	0	0	1	0
2	0	0	1	1	0	0
3	0	1	0	1	1	0
4	0	1	1	0	0	1
5	1	0	0	1	1	1
6	1	0	1	0	0	0
7	1	1	0	0	1	0
8	1	1	1	1	0	0

时序电路分析

CP	X	Y_2	Y_1	Y_2^{n+1}	Y_1^{n+1}	Z
1	0	0	0	0	1	0
2	0	0	1	1	0	0
3	0	1	0	1	1	0
4	0	1	1	0	0	1
5	1	0	0	1	1	1
6	1	0	1	0	0	0
7	1	1	0	0	1	0
8	1	1	1	1	0	0

States Y_2 Y_1	Y_2^{n+1} Y_1^{n+1} / Z	
	X=0	X=1
0 0	0 1 / 0	1 1 / 1
0 1	1 0 / 0	0 0 / 0
1 0	1 1 / 0	0 1 / 0
1 1	0 0 / 1	1 0 / 0

5. 状态图



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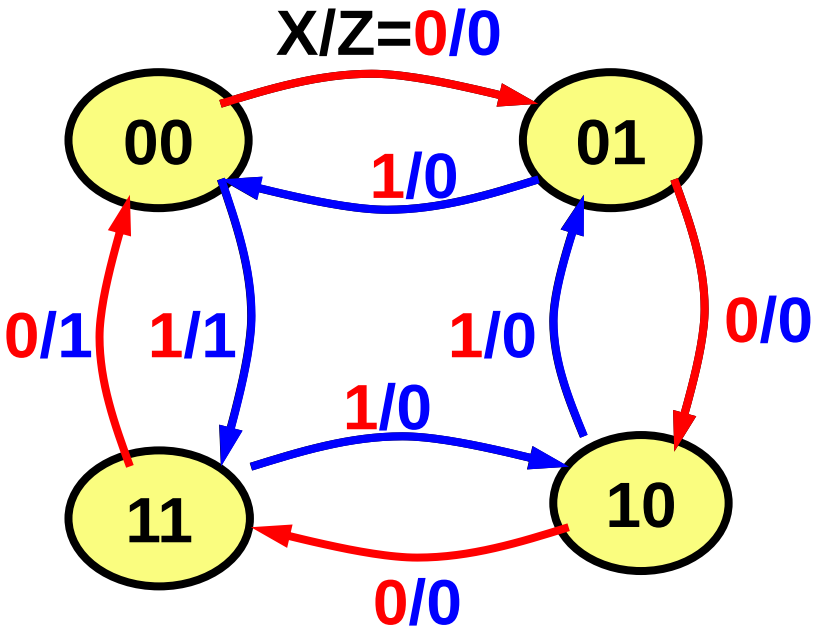
可逆计数器



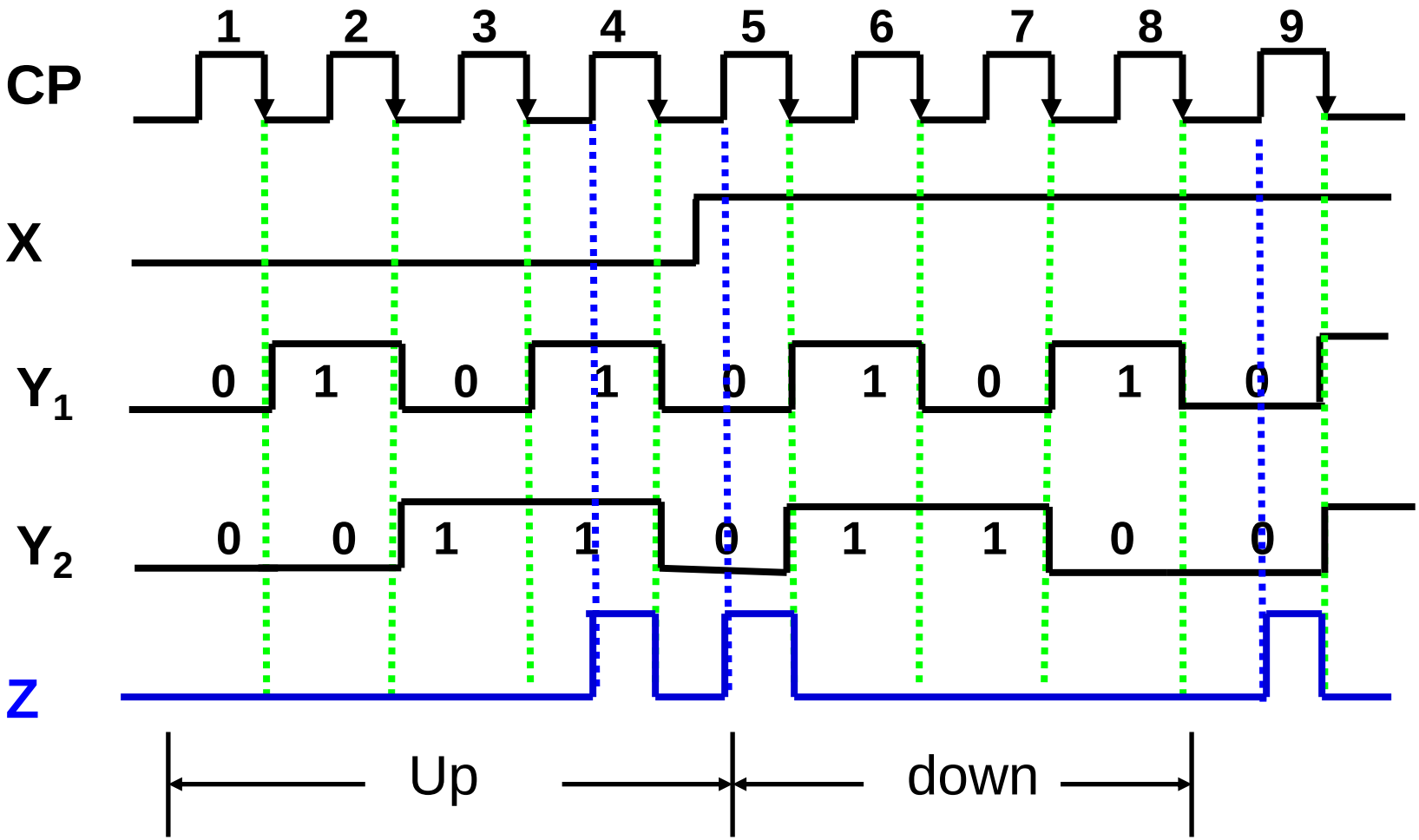
- X=0： CP， Mode-4 up counter

00 → 01 → 10 → 11　　仅在$11 \to 00$时，$Z=1$

- X=1： CP， Mode-4 down counter

00 → 11 → 10 → 01　　仅在$00 \to 11$时，$Z=1$

6. 波形图



$$Z = X\ CP\ \overline{Y_2}\ \overline{Y_1} + \overline{X}\ CP\ Y_2 Y_1$$

时序电路分析

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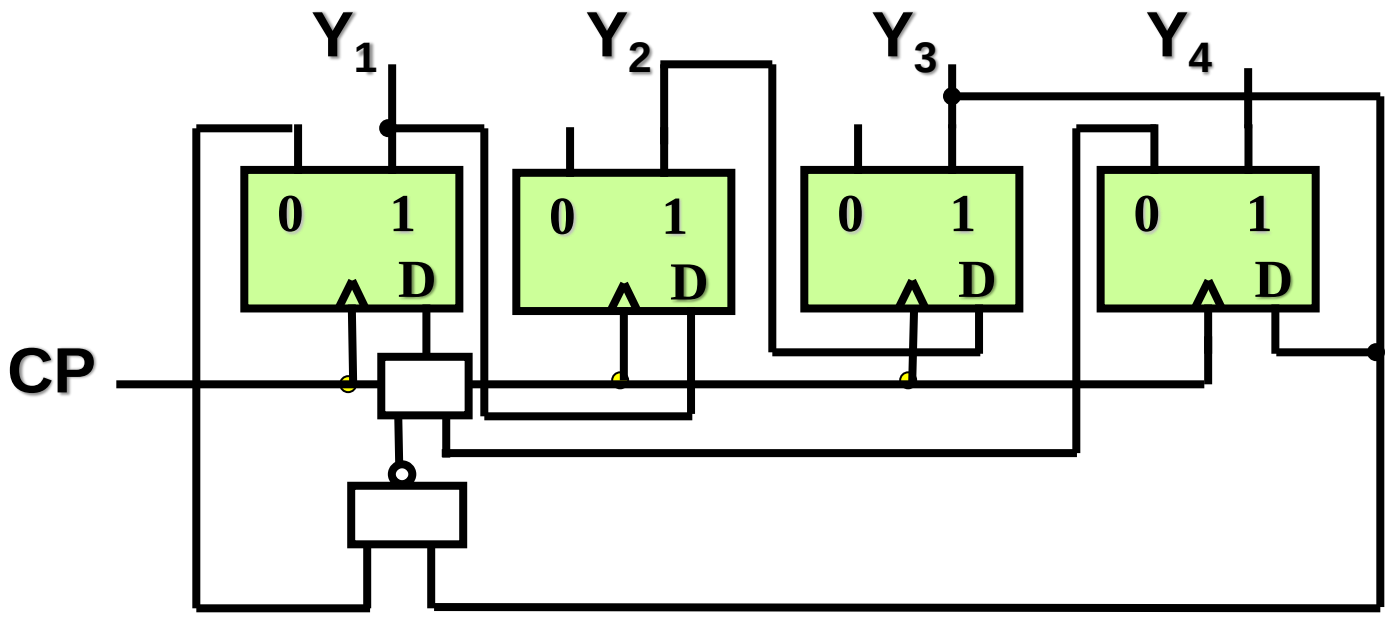
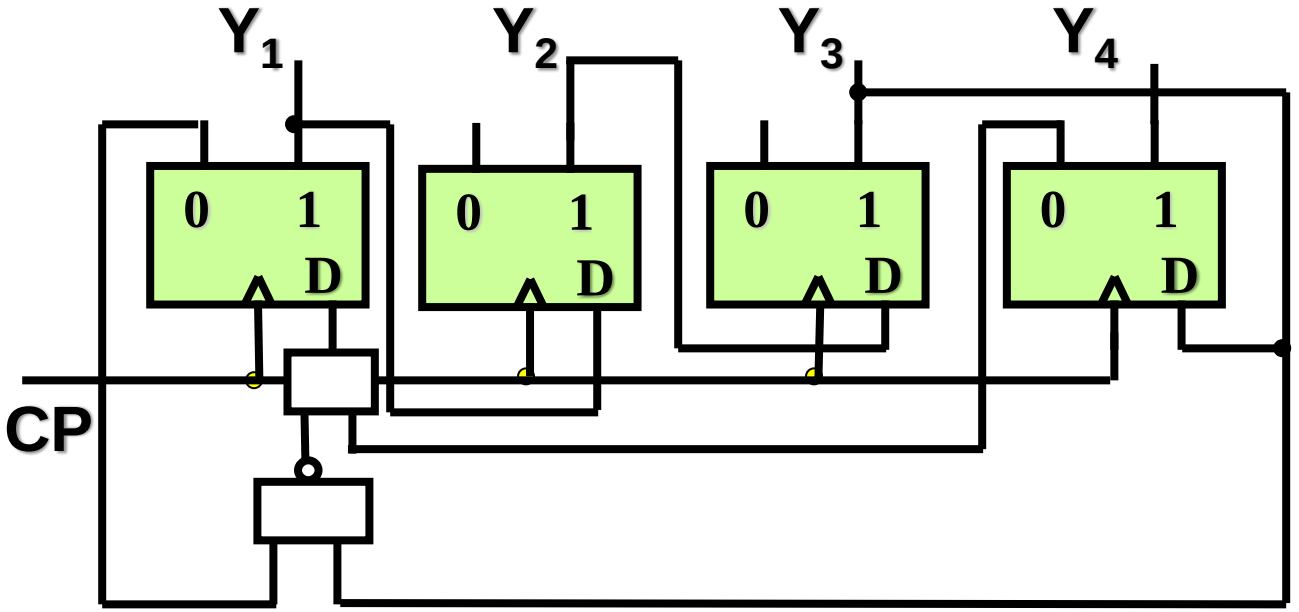
时序电路分析

例2



时序电路分析



1. 输入方程

$$D_4 = Y_3$$

$$D_3 = Y_2$$

$$D_2 = Y_1$$

$$D_1 = \overline{Y_3}\,\overline{Y_1}\,\overline{Y_4}$$

$$= Y_1\overline{Y_4} + \overline{Y_3}\,\overline{Y_4}$$

2. 次态方程

$$Y_4^{n+1} = Y_3$$

$$Y_3^{n+1} = Y_2$$

$$Y_2^{n+1} = Y_1$$

$$Y_1^{n+1} = Y_1\overline{Y_4} + \overline{Y_3}\,\overline{Y_4}$$

Moore

2. 次态方程

$$Y_4^{n+1} = Y_3$$

$$Y_3^{n+1} = Y_2$$

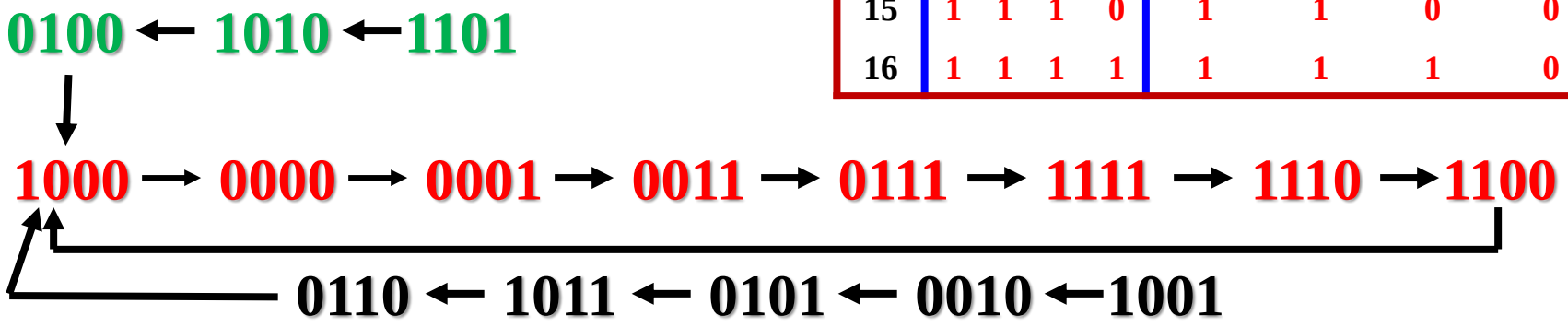
$$Y_2^{n+1} = Y_1$$

$$Y_1^{n+1} = Y_1\overline{Y}_4 + \overline{Y}_3\overline{Y}_4$$

3. 状态转换表

CP	Y_4	Y_3	Y_2	Y_1	Y_4^{n+1}	Y_3^{n+1}	Y_2^{n+1}	Y_1^{n+1}
1	0	0	0	0	0	0	0	1
2	0	0	0	1	0	0	1	1
3	0	0	1	0	0	1	0	1
4	0	0	1	1	0	1	1	1
5	0	1	0	0	1	0	0	0
6	0	1	0	1	1	0	1	1
7	0	1	1	0	1	0	0	0
8	0	1	1	1	1	1	1	0
9	1	0	0	0	0	0	0	0
10	1	0	0	1	0	0	1	0
11	1	0	1	0	0	1	0	0
12	1	0	1	1	0	1	1	0
13	1	1	0	0	1	0	0	0
14	1	1	0	1	1	0	1	0
15	1	1	1	0	1	1	0	0
16	1	1	1	1	1	1	1	0

4. 状态图



时序电路分析

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时序电路分析

例3

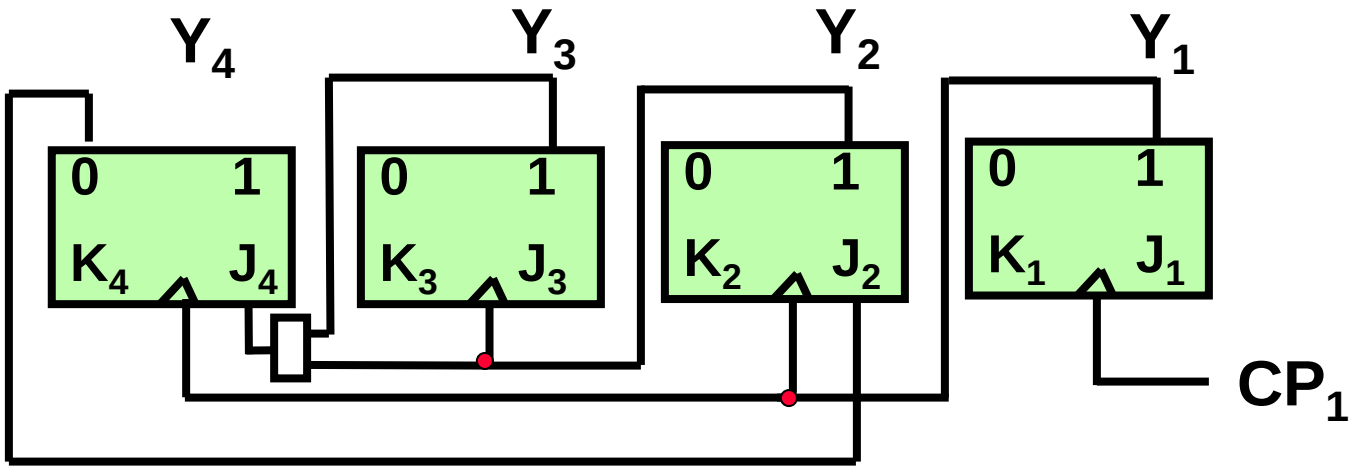
1. 输入方程

$$\begin{cases} J_4 = Y_3 Y_2 \\ K_4 = 1 \end{cases}$$

$$J_3 = K_3 = 1$$

$$\begin{cases} J_2 = \overline{Y_4} \\ K_2 = 1 \end{cases}$$

$$J_1 = K_1 = 1$$



CP_1，$CP_2 = CP_4 = Y_1$（↓），$CP_3 = Y_2$（↓）

2. 次态方程

$$Y_4^{n+1} = J_4\overline{Y}_4 + \overline{K}_4 Y_4 = \overline{Y}_4 Y_3 Y_2 \quad Y_1 \downarrow$$

$$Y_3^{n+1} = J_3\overline{Y}_3 + \overline{K}_3 Y_3 = \overline{Y}_3 \quad Y_2 \downarrow$$

$$Y_2^{n+1} = J_2\overline{Y}_2 + \overline{K}_2 Y_2 = \overline{Y}_4\overline{Y}_2 \quad Y_1 \downarrow$$

$$Y_1^{n+1} = J_1\overline{Y}_1 + \overline{K}_1 Y_1 = \overline{Y}_1 \quad CP_1 \downarrow$$

2. 次态方程

$$Y_4^{n+1} = J_4\bar{Y}_4 + \bar{K}_4 Y_4 = \bar{Y}_4 Y_3 Y_2$$

$$Y_3^{n+1} = J_3\bar{Y}_3 + \bar{K}_3 Y_3 = \bar{Y}_3$$

$$Y_2^{n+1} = J_2\bar{Y}_2 + \bar{K}_2 Y_2 = \bar{Y}_4\bar{Y}_2$$

$$Y_1^{n+1} = J_1\bar{Y}_1 + \bar{K}_1 Y_1 = \bar{Y}_1$$

Y_1 ⤵ Y_2 ⤵ Y_1 ⤵ CP_1 ⤵

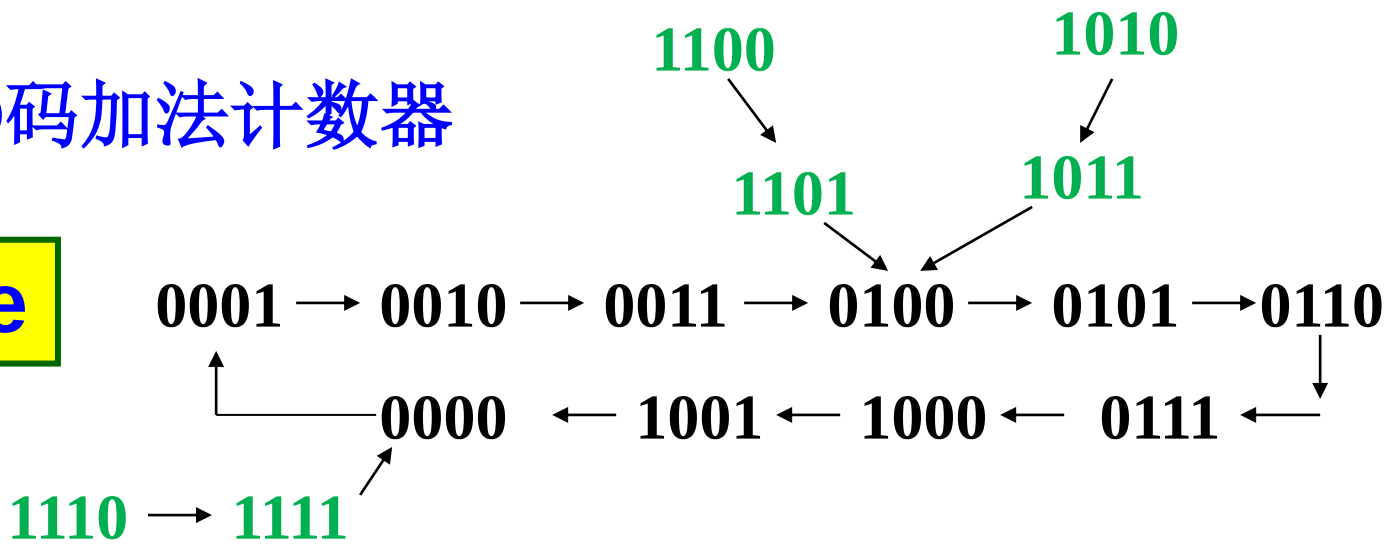
3. 状态转化表

	Y_4	Y_3	Y_2	Y_1	Y_4^{n+1}	Y_3^{n+1}	Y_2^{n+1}	Y_1^{n+1}	CP_4	CP_3	CP_2	CP_1
1	0	0	0	0	0	0	0	1				⤵
2	0	0	0	1	0	0	1	0	⤵		⤵	⤵
3	0	0	1	0	0	0	1	1				⤵
4	0	0	1	1	0	1	0	0	⤵	⤵	⤵	⤵
5	0	1	0	0	0	1	0	1				⤵
6	0	1	0	1	0	1	1	0	⤵		⤵	⤵
7	0	1	1	0	1	1	1	1				⤵
8	0	1	1	1	1	0	0	0	⤵	⤵	⤵	⤵
9	1	0	0	0	0	0	0	1				⤵
10	1	0	0	1	0	0	0	0	⤵		⤵	⤵

	Y_4 Y_3 Y_2 Y_1	Y_4^{n+1}	Y_3^{n+1}	Y_2^{n+1}	Y_1^{n+1}	CP_4 CP_3 CP_2 CP_1
11	1 0 1 0	1	0	1	1	
12	1 0 1 1	0	1	0	0	
13	1 1 0 0	1	1	0	1	
14	1 1 0 1	0	1	0	0	
15	1 1 1 0	1	1	1	1	
16	1 1 1 1	0	0	0	0	

8421BCD码加法计数器

Moore



1. 可逆计数器

2. 非二进制计数器

3. 8421BCD码加法计数器