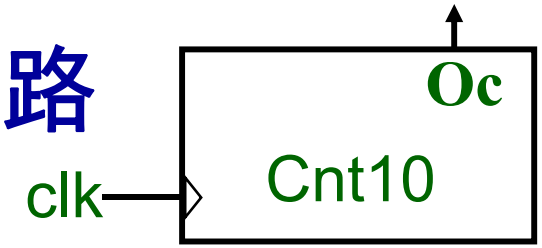
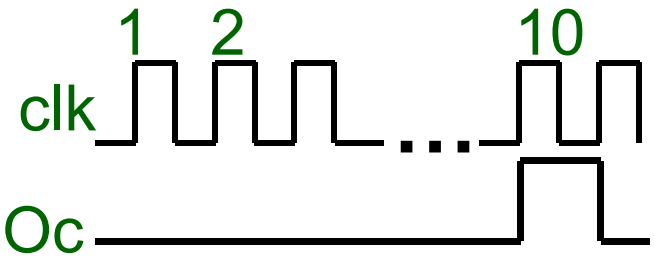
第六章 时序逻辑电路

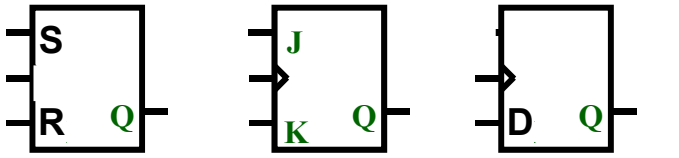


（第六章）

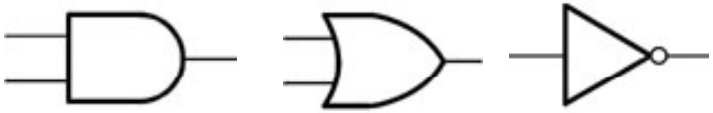
时序逻辑电路 { 计数器 寄存器

有记忆





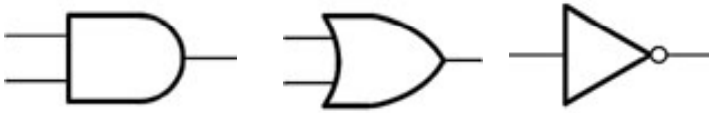
触发器



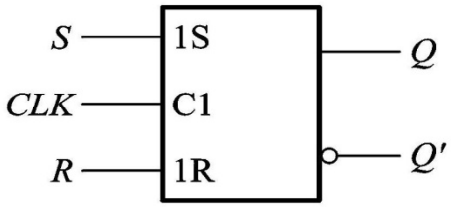
与门， 或门， 非门

组合逻辑电路 { 加法器 编码器 译码器 选通器

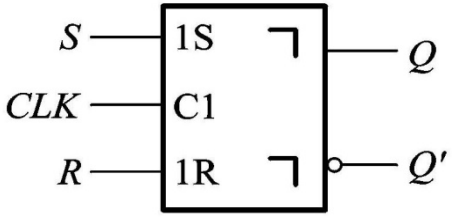
无记忆



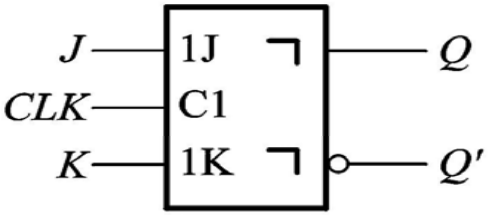
与门， 或门， 非门



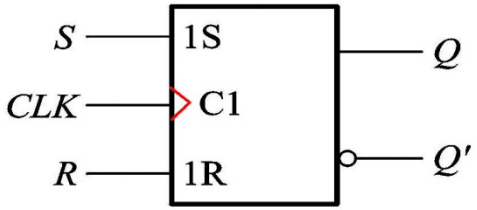
钟控SRFF(电平触发)



主从SRFF(脉冲触发)

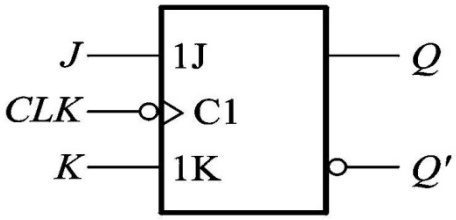


主从JKFF(脉冲触发)

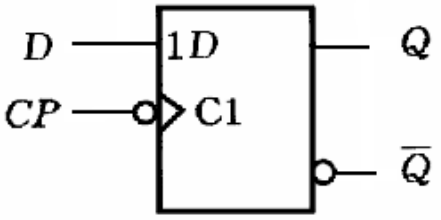


边沿SRFF(边沿触发)

不同时刻



边沿JKFF

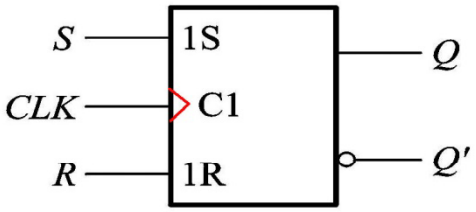


边沿DFF

S R	Q*
0 0	Q
0 1	0
1 0	1
1 1	1 ①

$Q^* = S + R'Q$

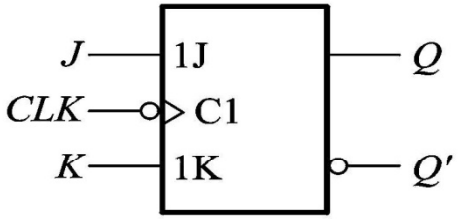
$SR = 0$



边沿SRFF

JK	Q*
0 0	Q
0 1	0
1 0	1
1 1	Q'

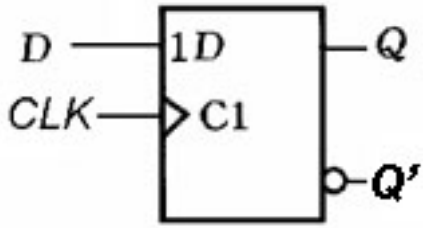
$Q^* = JQ' + K'Q$



边沿JKFF

D	Q*
0	0
1	1

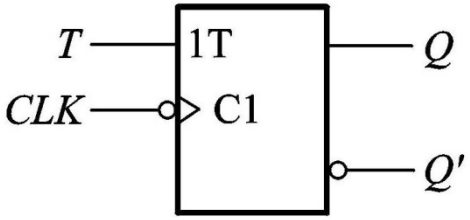
$Q^* = D$



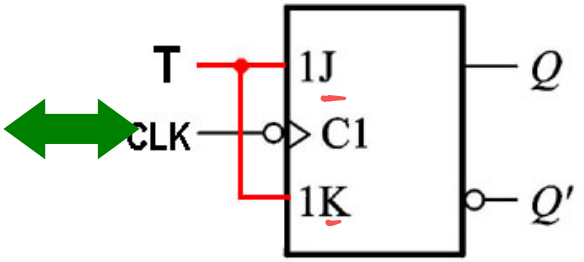
边沿DFF

T	Q*
0	Q
1	Q'

$Q^* = TQ' + T'Q$



边沿TFF



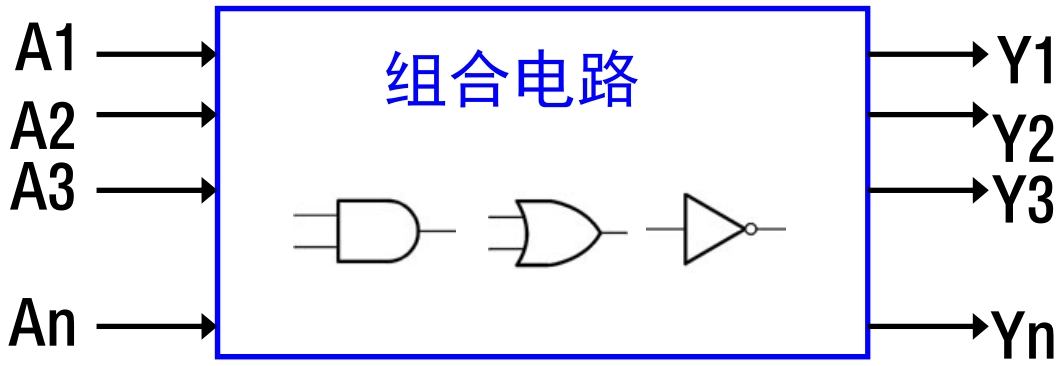
T：JK改

D：SR改

第六章　时序逻辑电路

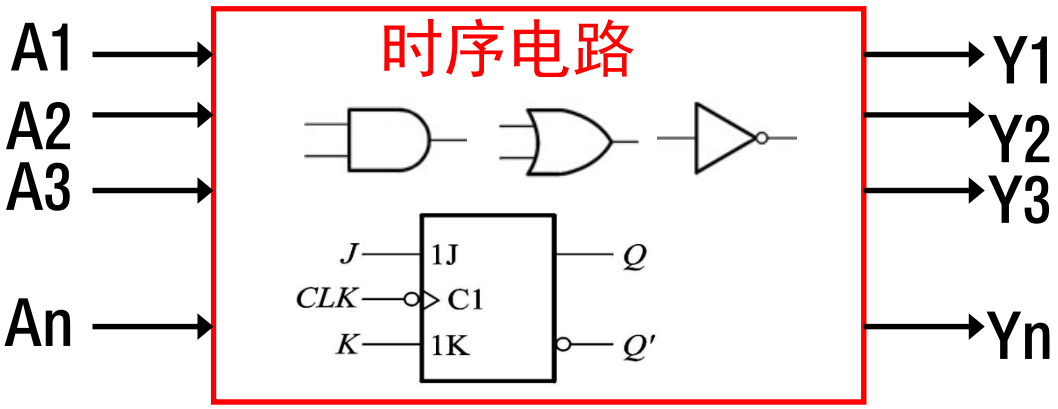
6.1 概述

一、组合电路与时序电路的区别



无记忆

某一给定时刻的输出，
取决于该时刻的输入22



有记忆

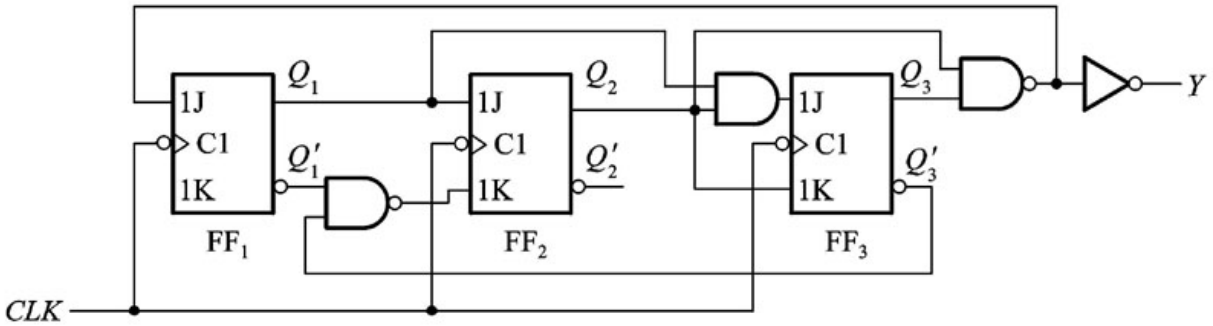
某一给定时刻的输出，
取决于该时刻的输入
以及前一时刻电路的状态
(触发器的状态)

6.1 概述

二、时序逻辑电路的分类

同步时序电路

电路中所有触发器使用统一的*CLK*，
所有触发器状态在同一时刻更新

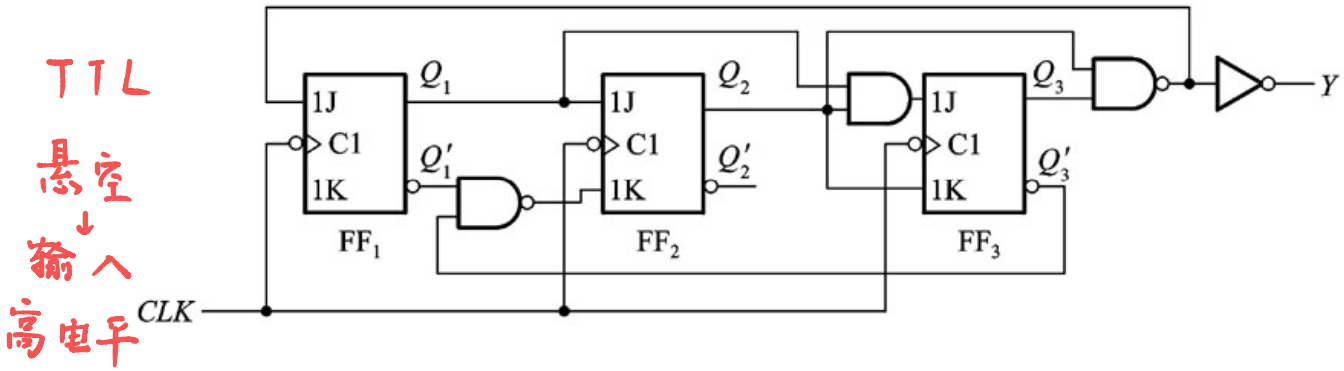


异步时序电路

电路中所有触发器没有统一的*CLK*，
各个触发器状态不在同一时刻更新，
更新有先有后

6.2 时序逻辑电路的分析

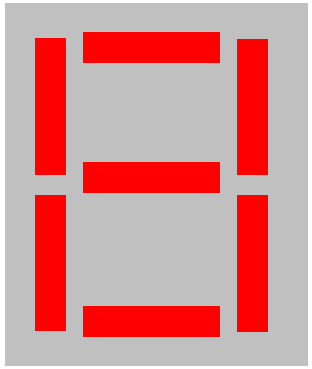
已知电路 → 发现逻辑功能

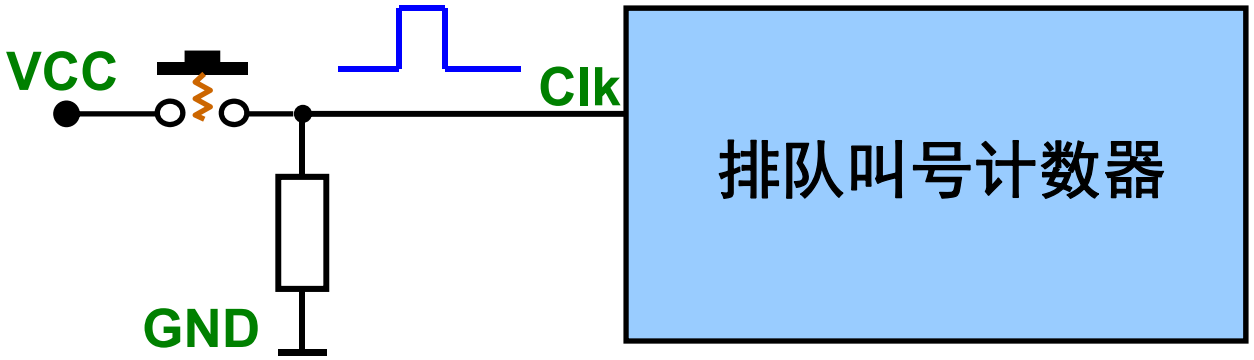


做什么用的？

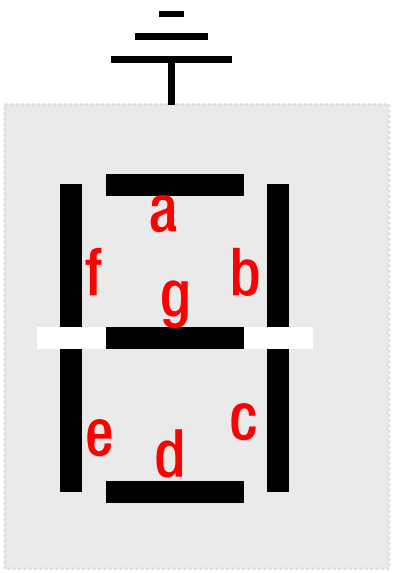
1. 触发器驱动方程、状态方程，电路输出方程
2. 状态转换表
3. 状态转换图
4. 分析逻辑功能
5. 检查自启动

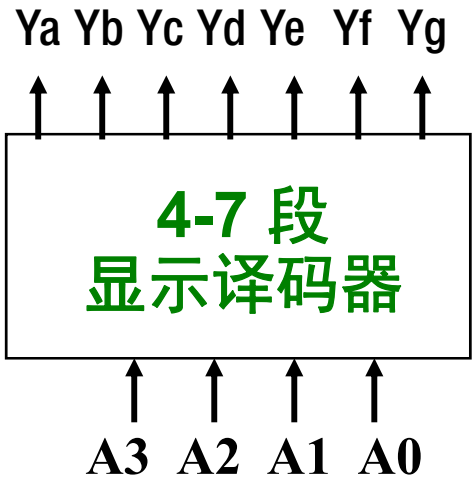
6.2 时序逻辑电路的分析





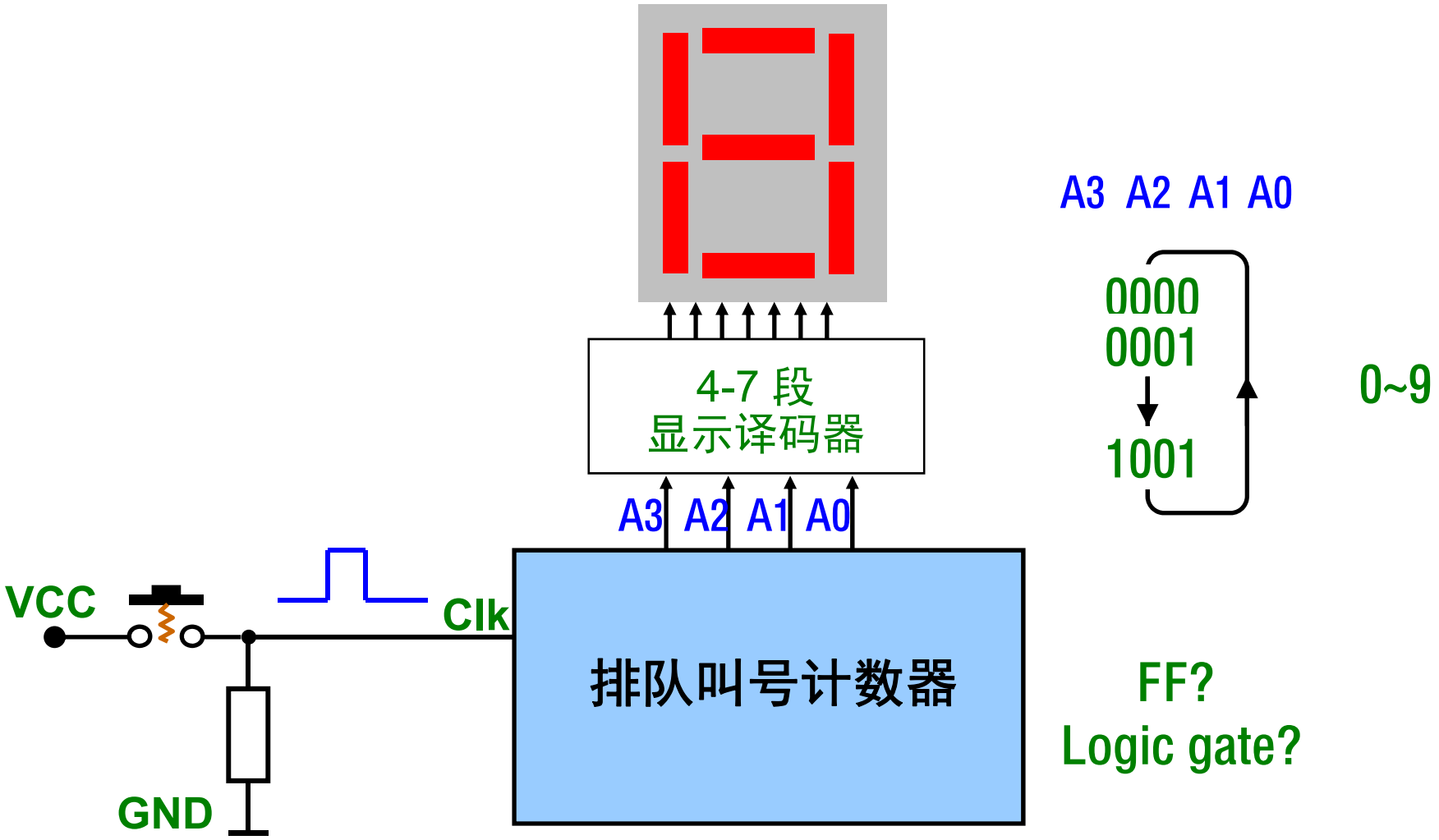
BCD－七段显示译码器





A3A2A1A0	abcdefg	LED
0000	1111110	0
0001	0110000	1
0010	1101101	2
0011	1111001	3
0100	0110011	4
0101	1011011	5
0110	1011111	6
0111	1110000	7
1000	1111111	8
1001	1111011	9
1010	1110111	A
1011	0011111	b
1100	1001110	C
1101	0111101	d
1110	1001111	E
1111	1000111	F

6.2 时序逻辑电路的分析



常用时序电路简介

- 计数器

时钟

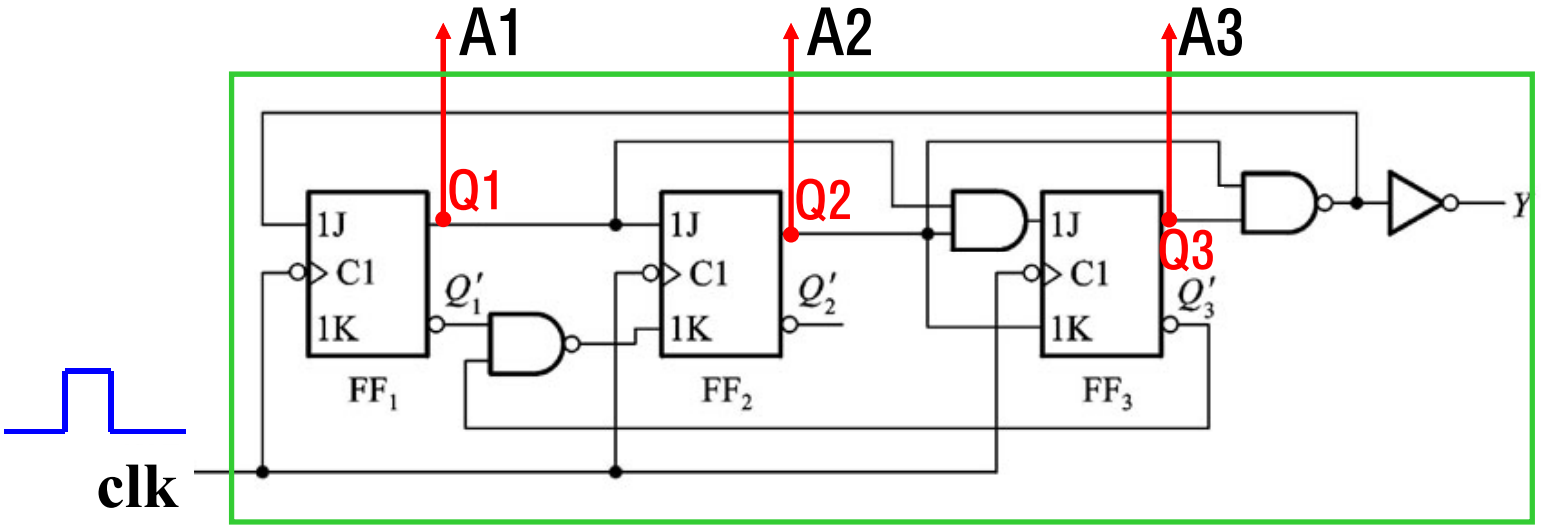
计数器是通过电路的状态来反映输入脉冲数目的电路。

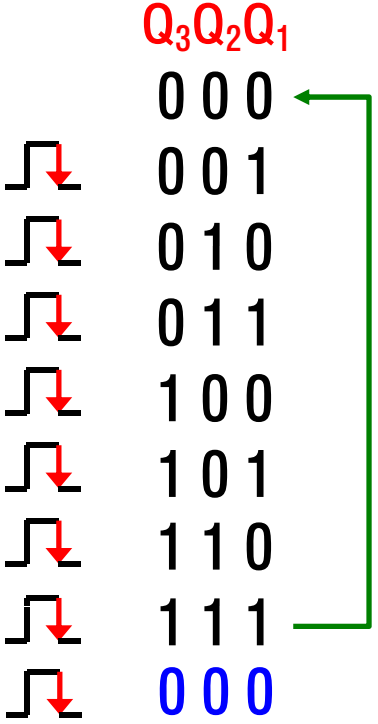
电路中的触发器通常采用JK触发器 。

1. **计数器的功能**: 记忆时钟脉冲的个数.
2. **计数器的模*M***: 能记忆时钟脉冲的最大数目.
3. **计数器的分类**:
   - 按计数模值: 二进制/十进制/任意进制计数器
   - 按计数值的变化方式: 加法/减法/可逆计数器
   - 按时钟控制方式: 同步/异步计数器

中断→计时

例1：试分析下图时序电路的逻辑功能。



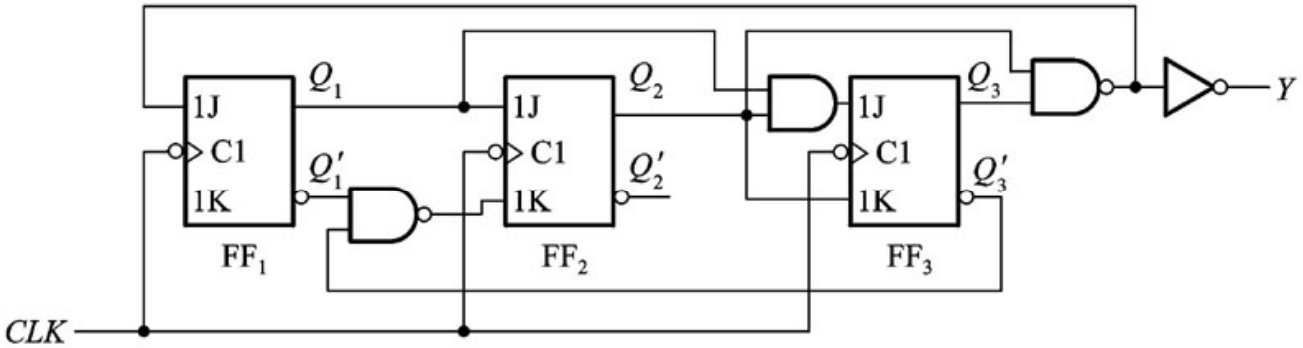


Q_3	Q_2	Q_1	clk	Q_3^*	Q_2^*	Q_1^*	Y
0	0	0	↓	0?	0?	1?	
0	0	1	↓	0?	1?	0?	
0	1	0	↓	0?	1?	1?	
0	1	1	↓	1?	0?	0?	
1	0	0	↓	1?	0?	1?	
1	0	1	↓	1?	1?	0?	
1	1	0	↓	1?	1?	1?	
1	1	1	↓	0?	0?	0?	

任何一个时刻触发器状态必是其中的一组值

6.2 时序逻辑电路的分析

已知电路 → 发现逻辑功能

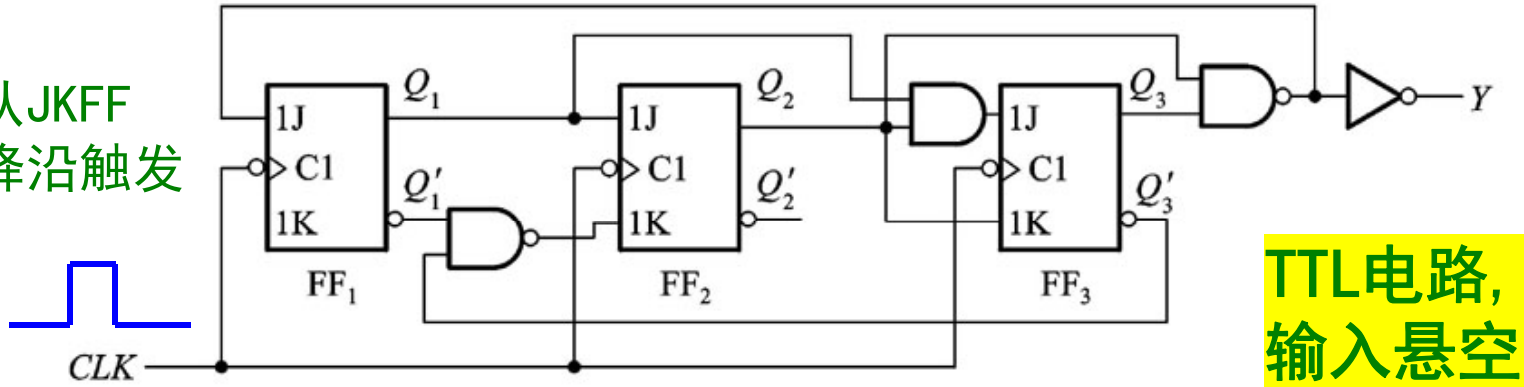


做什么用的？

1. 触发器驱动方程、状态方程，电路输出方程
2. 状态转换表
3. 状态转换图
4. 分析逻辑功能
5. 检查自启动
6. 时序波形图

例：试分析下图时序电路的逻辑功能。

主从JKFF
下降沿触发



TTL电路，
输入悬空＝1

1.写方程

1) 驱动方程：

$$\begin{cases} J_1 = \quad\quad K_1 = \\ J_2 = \quad\quad K_2 = \\ J_3 = \cdots\cdots, \quad K_3 = \cdots \end{cases}$$

3) 输出方程：

$Y = Q_2 Q_3$

2) 代入JK触发器的特性方程($Q^* = JQ' + K'Q$)，得状态方程：

$$\begin{cases} Q_1^* = 1Q_1Q_2'Q_3' \\ Q_2^* = Q_1Q_2' + Q_1'Q \\ Q_3^* = Q_3'Q_2Q_1 + Q_2'Q_3 \end{cases}$$

$Q_3^* = Q_1Q_2Q_3' + Q_2'Q_3$

$Q_2^* = Q_1Q_2' + Q_1'Q_2Q_3'$

$Q_1^* = (Q_2Q_3)' \cdot Q_1'$

$Y = Q_3Q_2$

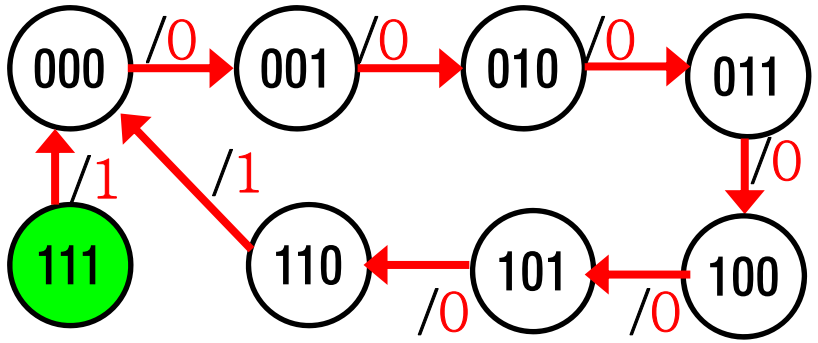
2.列状态转换表

Q_3	Q_2	Q_1	clk	Q_3^*	Q_2^*	Q_1^*	Y
0	0	0	↓	0	0	1	0
0	0	1	↓	0	1	0	0
0	1	0	↓	0	1	1	0
0	1	1	↓	1	0	0	0
1	0	0	↓	1	0	1	0
1	0	1	↓	1	1	0	0
1	1	0	↓	0	0	0	1
1	1	1	↓	0	0	0	1

现在状态下的Y

3.画状态转换图

$Q_3Q_2Q_1/Y$



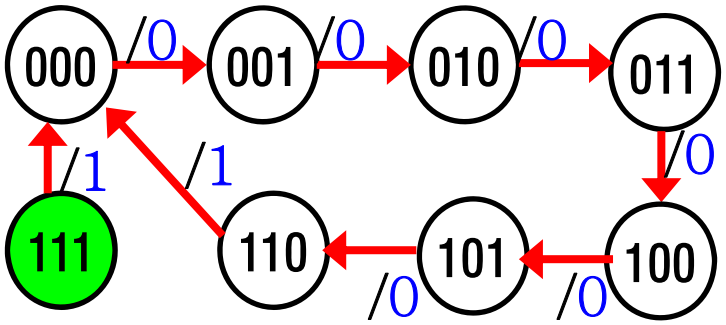
CLK	Q_3	Q_2	Q_1	Y
0	0	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	1	1	0
4	1	0	0	0
5	1	0	1	0
6	1	1	0	1
7	0	0	0	0
0	1	1	1	1
1	0	0	0	0

任意个状态

都能跳进主

循环。

$Q_3Q_2Q_1/Y$



4.分析电路功能

计数长度为7的计数器

七进制计数器

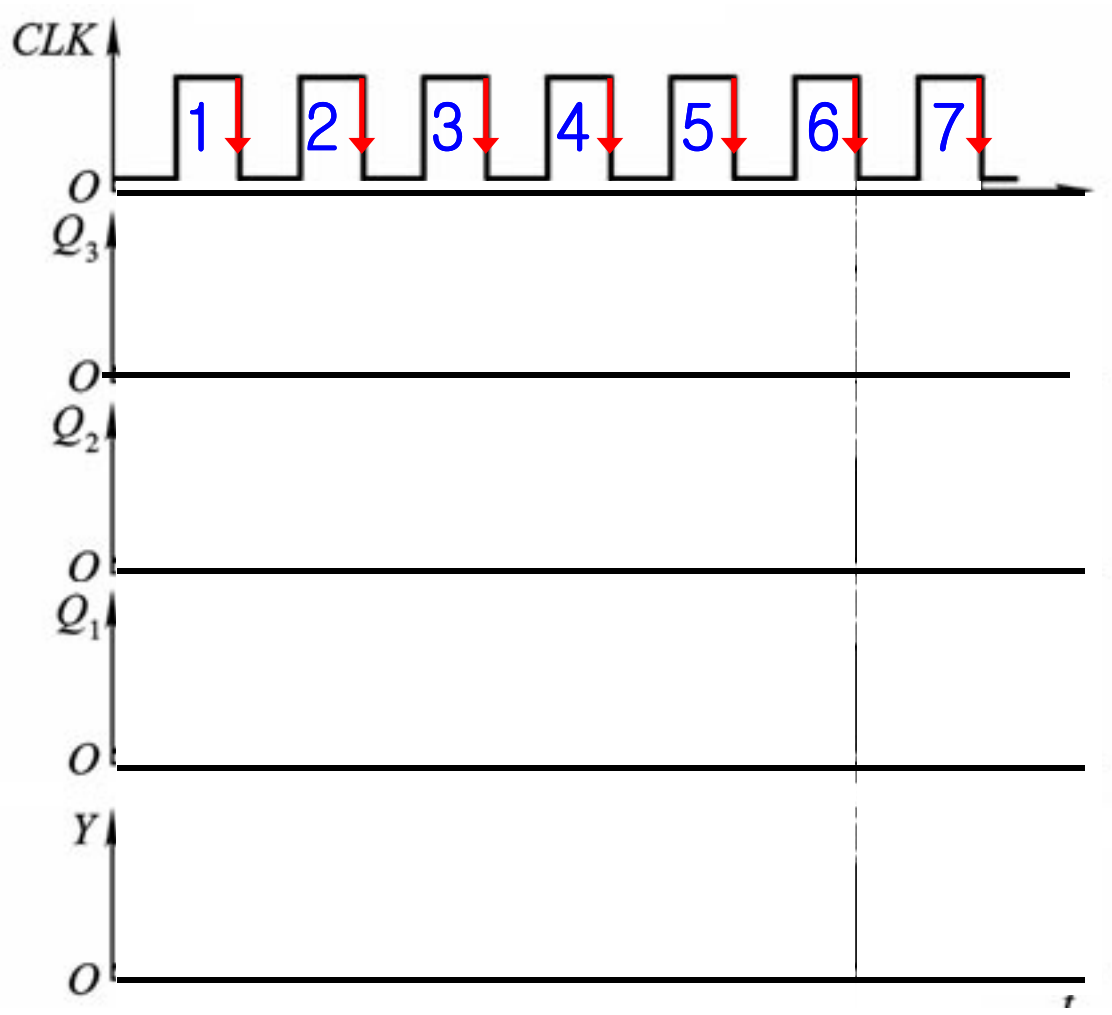
Y是指示信号，

每计7个数，就输出一个1

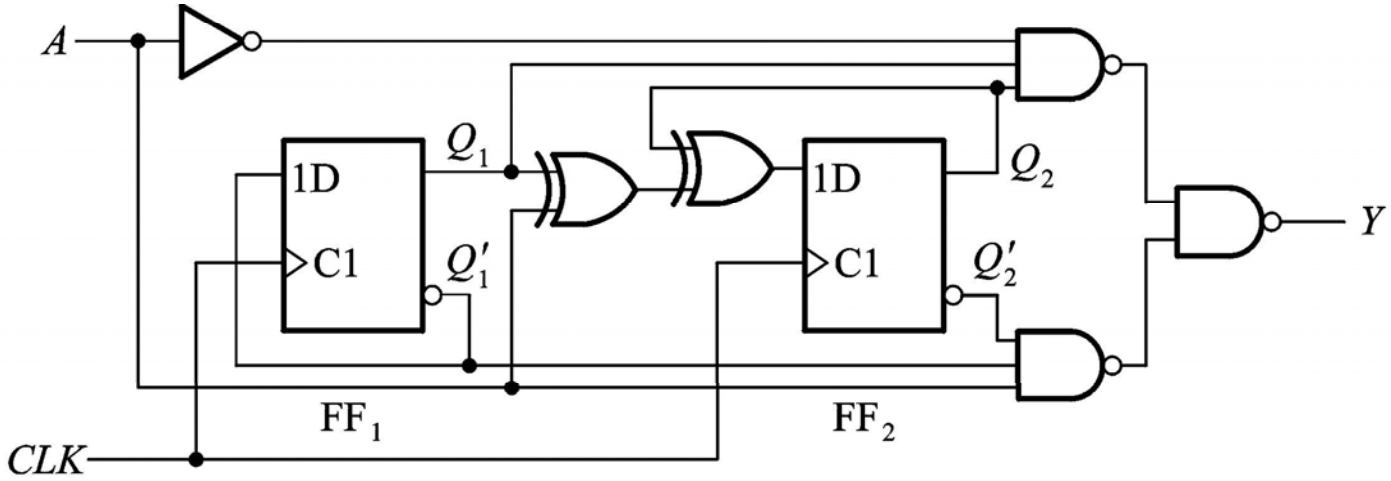
5.检查自启动

7个有效状态，1个无效状态”111”；经过一个时钟后能自动进入有效循环，所以能自启动

6.画时序图



练习1　试分析下图时序电路的逻辑功能。



1. 写方程

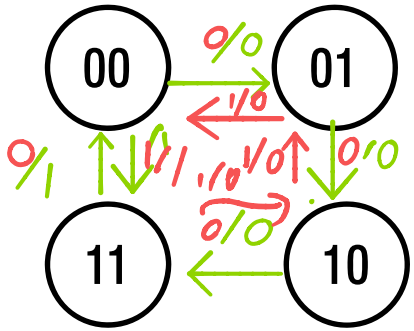
1)驱动方程：$\begin{cases} D_1 = Q_1' \\ D_2 = Q_1 \oplus A \oplus Q_2 \end{cases}$

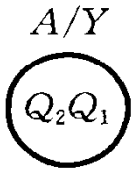
2)状态方程：$\begin{cases} Q_1^* = Q_1' \\ Q_2^* = Q_1 \oplus A \oplus Q_2 \end{cases}$

3)输出方程：$Y = [(A'Q_1Q_2)'(Q_2'Q_1'A)']' = A'Q_1Q_2 + Q_2'Q_1'A$

2. 列状态转换表

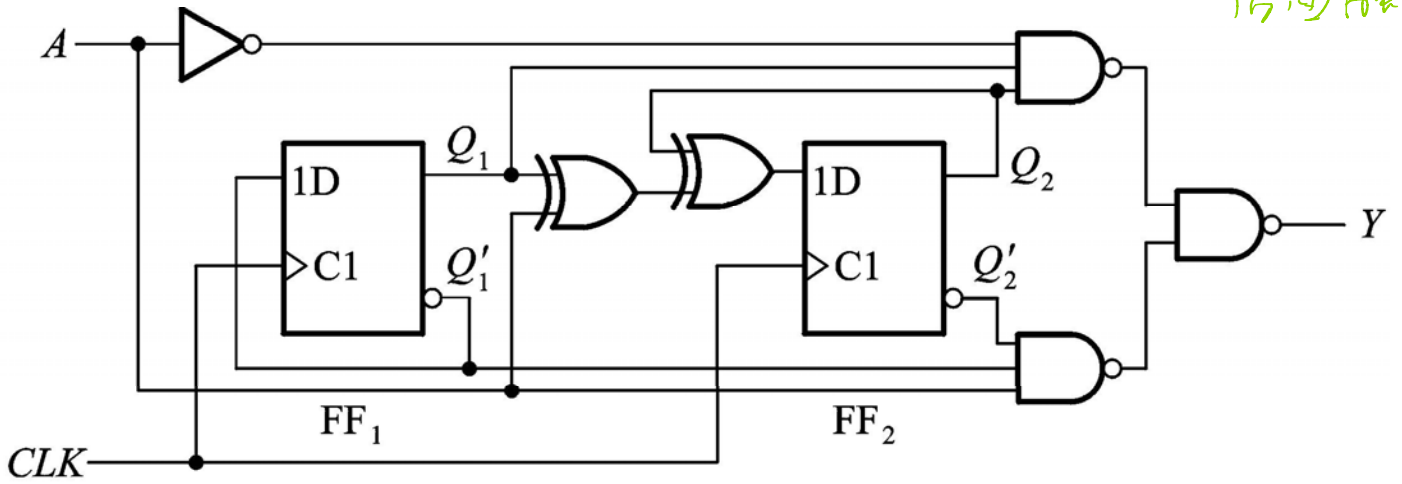
3. 画状态图





现态			次态		现态
A	Q_2	Q_1	Q_2^*	Q_1^*	Y
0	0	0	0	1	0
0	0	1	1	0	0
0	1	0	1	1	0
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	0	0	0
1	1	0	0	1	0
1	1	1	1	0	0

练习1　试分析下图时序电路的逻辑功能。



1. 写方程

1)驱动方程：$\begin{cases} D_1 = Q_1' \\ D_2 = A \oplus Q_1 \oplus Q_2 \end{cases}$

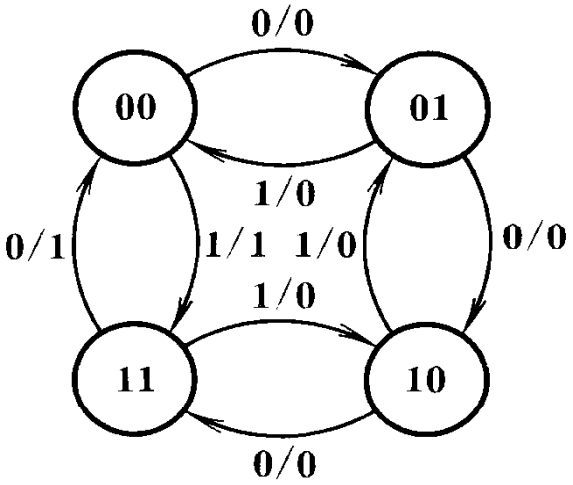
2)状态方程：$\begin{cases} Q_1^* = Q_1' \\ Q_2^* = A \oplus Q_1 \oplus Q_2 \end{cases}$

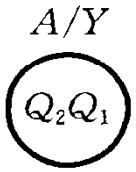
3)输出方程：$Y = [(A'Q_1Q_2)' \cdot (AQ_1'Q_2')']' = A'Q_1Q_2 + AQ_1'Q_2'$

2)状态方程：$\begin{cases} Q_1^* = Q_1' \\ Q_2^* = A \oplus Q_1 \oplus Q_2 \end{cases}$

3)输出方程：$Y = [(A'Q_1Q_2)' \cdot (AQ_1'Q_2')']' = A'Q_1Q_2 + AQ_1'Q_2'$

2. 列状态转换表





现态			次态		现态
A	Q_2	Q_1	Q_2^*	Q_1^*	Y
0	0	0	0	1	0
0	0	1	1	0	0
0	1	0	1	1	0
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	0	0	0
1	1	0	0	1	0
1	1	1	1	0	0

3. 画状态图

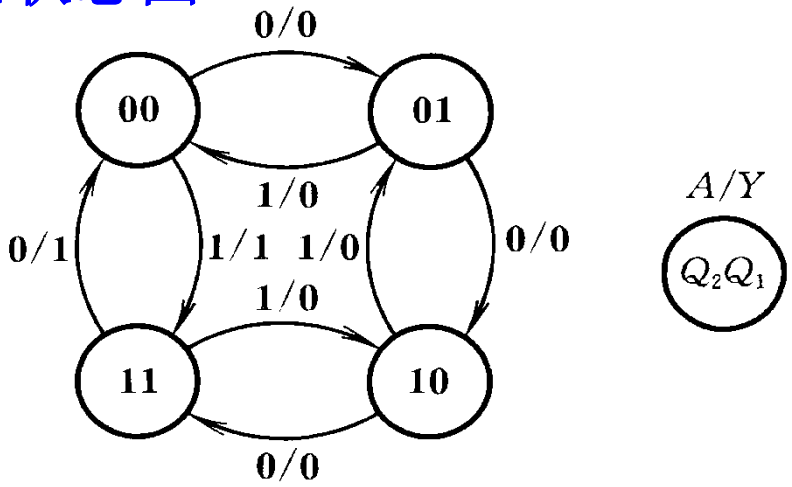
2)状态方程：$\begin{cases} Q_1^* = Q_1' \\ Q_2^* = A \oplus Q_1 \oplus Q_2 \end{cases}$

3)输出方程：$Y = [(A'Q_1Q_2)' \cdot (AQ_1'Q_2')']' = A'Q_1Q_2 + AQ_1'Q_2'$

2. 列状态转换表

$Q_2^*Q_1^*/Y$ (Q_2Q_1 / A)	00	01	10	11
0	01/0	10/0	11/0	00/1
1	11/1	00/0	01/0	10/0

3. 画状态图



4. 分析电路的功能

A=0时，加法计数器

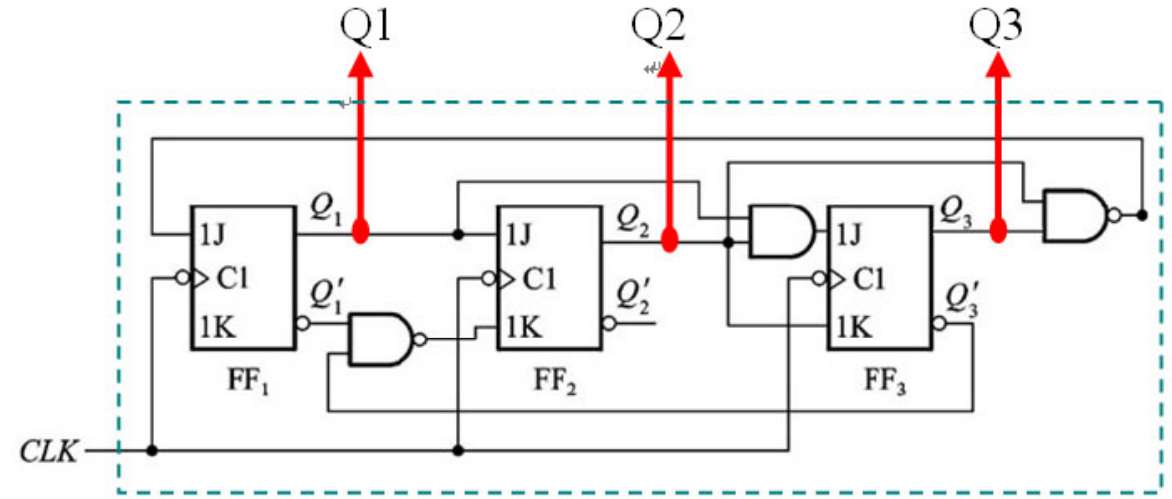
A=1时，减法计数器

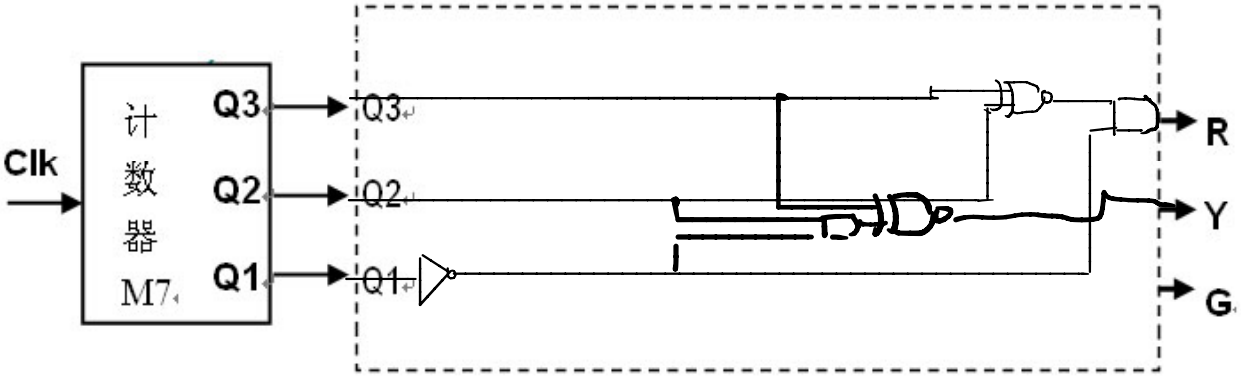
即可控模4计数器

练习2　彩灯控制器

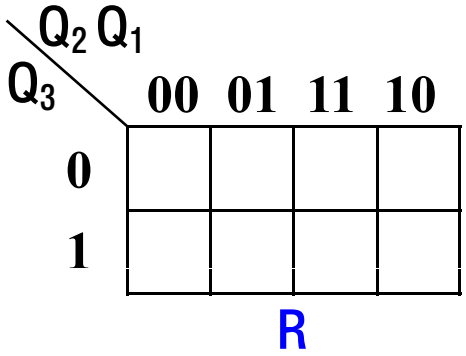
clk	$Q_3Q_2Q_1$	R	Y	G
0	000	1	0	0
1	001	0	1	0
2	010	0	0	1
3	011	0	0	0
4	100	0	0	1
5	101	0	1	0
6	110	1	0	0
7	111	x	x	x

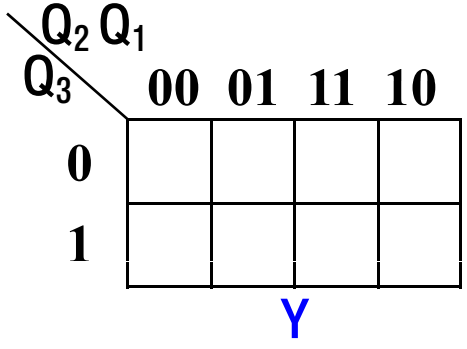
方法 I :计数器+门电路

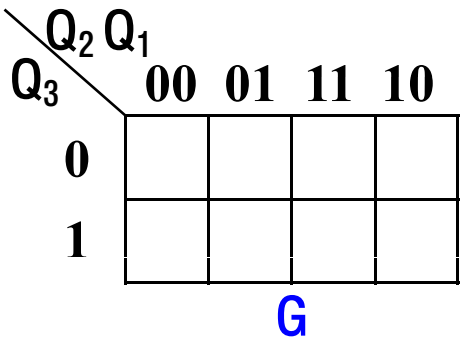




$Q_3Q_2Q_1$

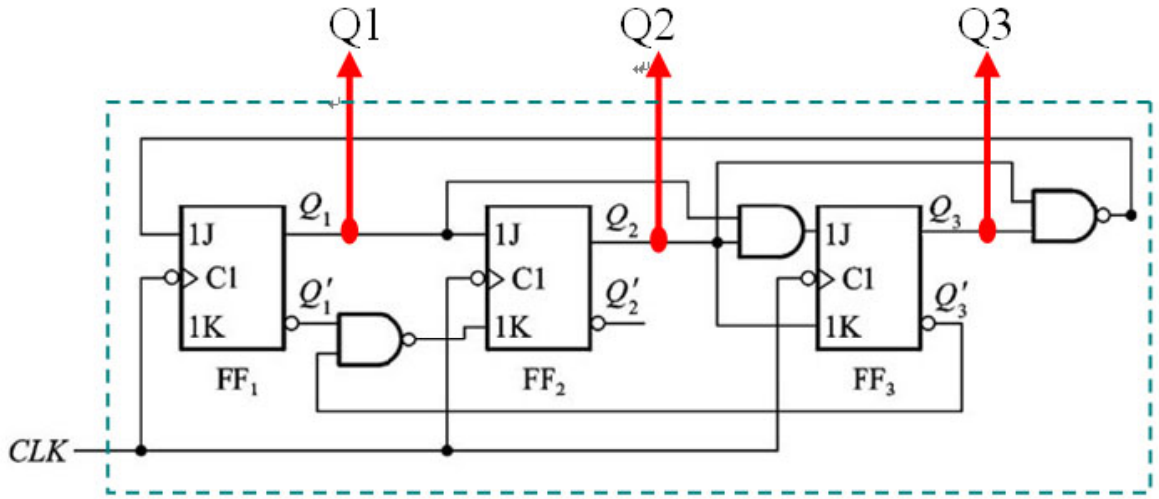




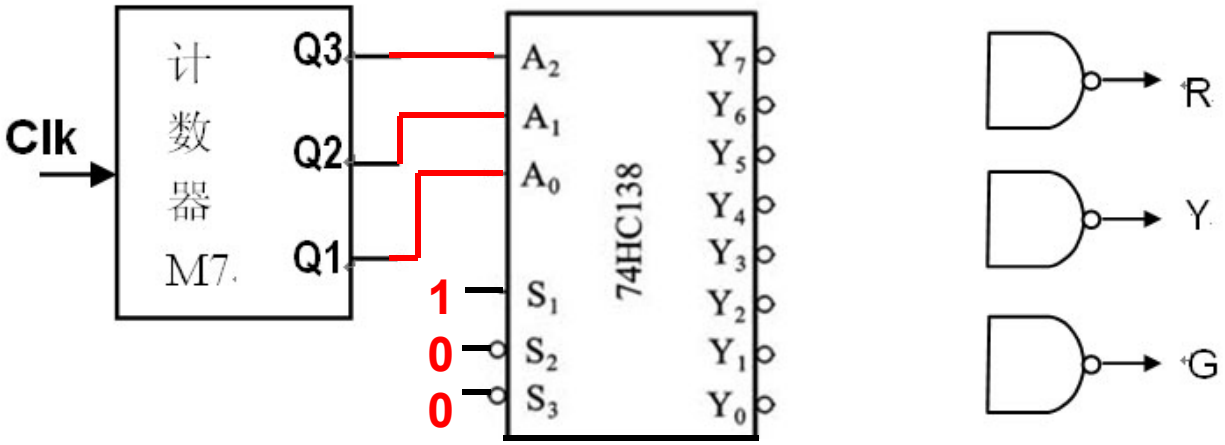


练习2　彩灯控制器

clk	$Q_3Q_2Q_1$	R	Y	G
0	000	1	0	0
1	001	0	1	0
2	010	0	0	1
3	011	0	0	0
4	100	0	0	1
5	101	0	1	0
6	110	1	0	0
7	111	x	x	x



方法 II :计数器+译码器



$R(Q_3Q_2Q_1) = m0 + m6$

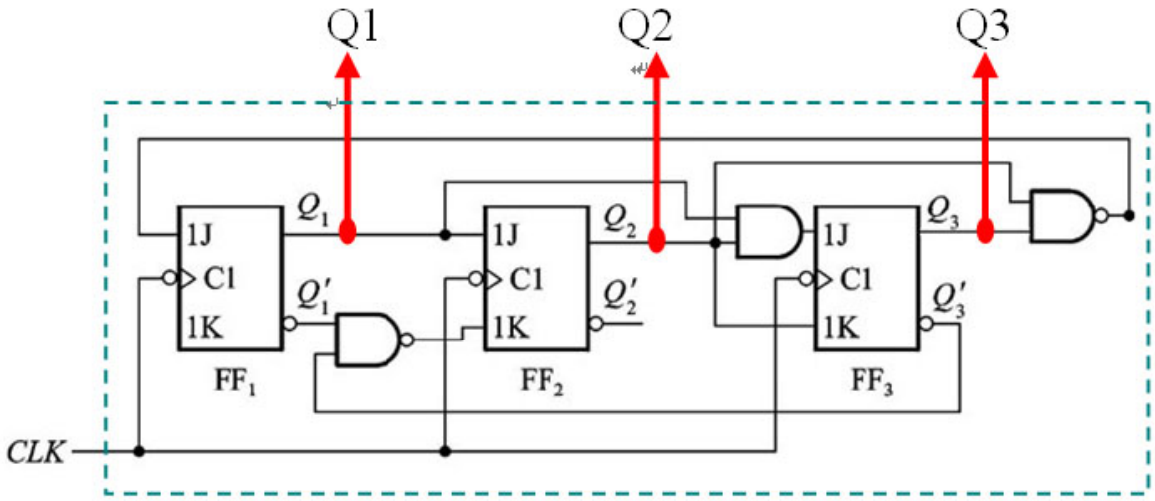
$Y(Q_3Q_2Q_1) = m1 + m5$

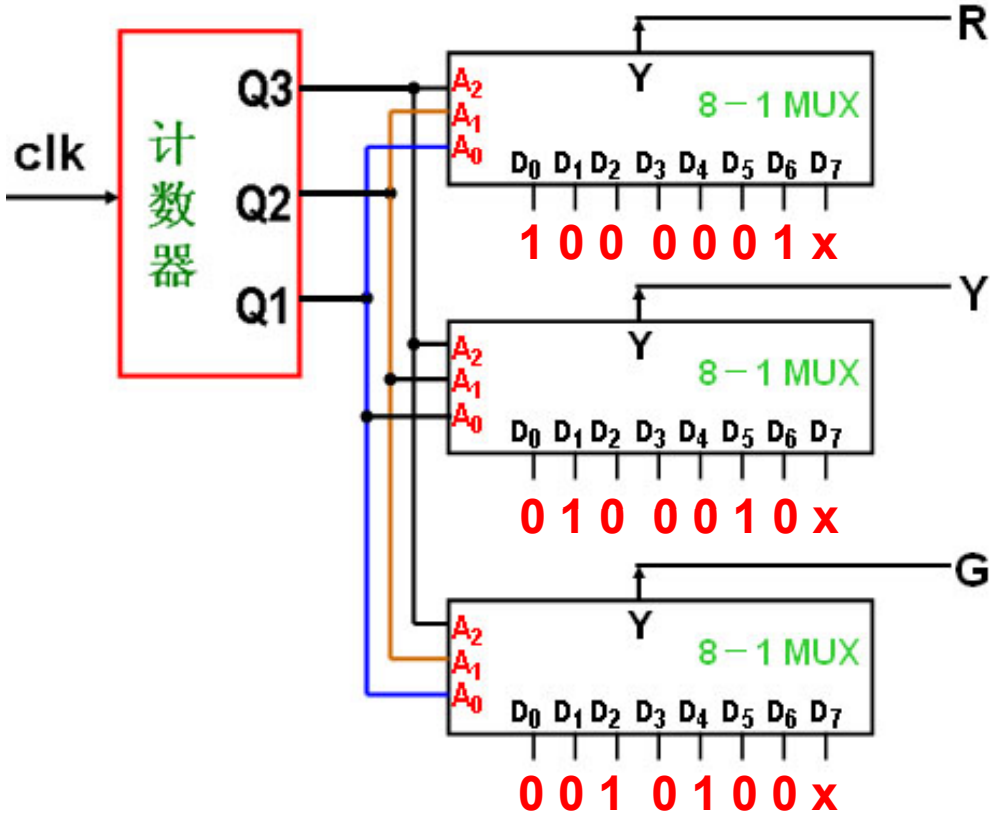
$G(Q_3Q_2Q_1) = m2 + m4$

练习2　彩灯控制器

clk	$Q_3Q_2Q_1$	R	Y	G
0	000	1	0	0
1	001	0	1	0
2	010	0	0	1
3	011	0	0	0
4	100	0	0	1
5	101	0	1	0
6	110	1	0	0
7	111	x	x	x

方法 III :计数器+MUX

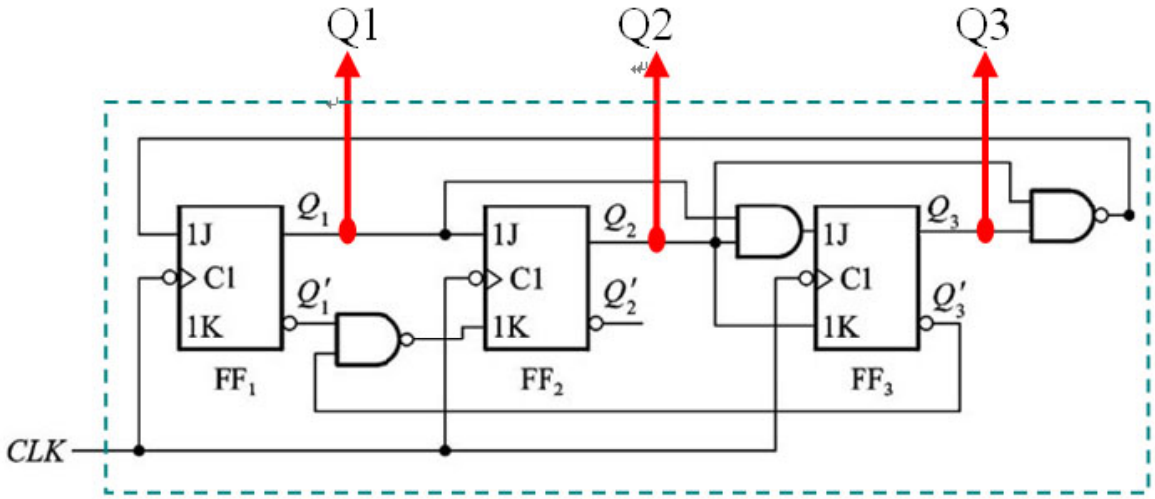


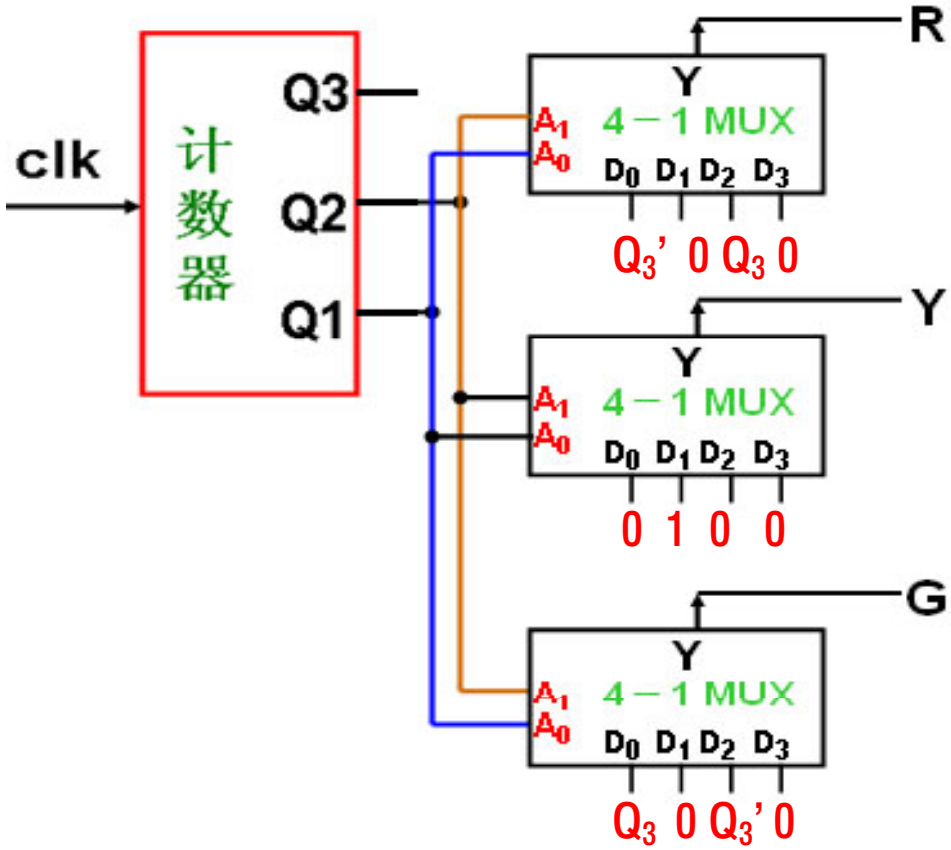


练习2　彩灯控制器

clk	$Q_3Q_2Q_1$	R	Y	G
0	000	1	0	0
1	001	0	1	0
2	010	0	0	1
3	011	0	0	0
4	100	0	0	1
5	101	0	1	0
6	110	1	0	0
7	111	x	x	x

方法 IV :计数器+MUX





作 业

6.3、6.5 、6.6