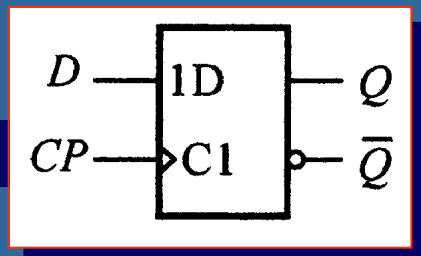
触发器的脉冲工作特性

触发器的脉冲工作特性：在考虑到构成触发器的门电路存在的时间延迟，为使触发器能正确地变化到预定的状态，输入信号与时钟脉冲之间应满足的时间关系。



（以D触发器为例，但不局限于D触发器）

t_{set}—建立时间

t_h—保持时间

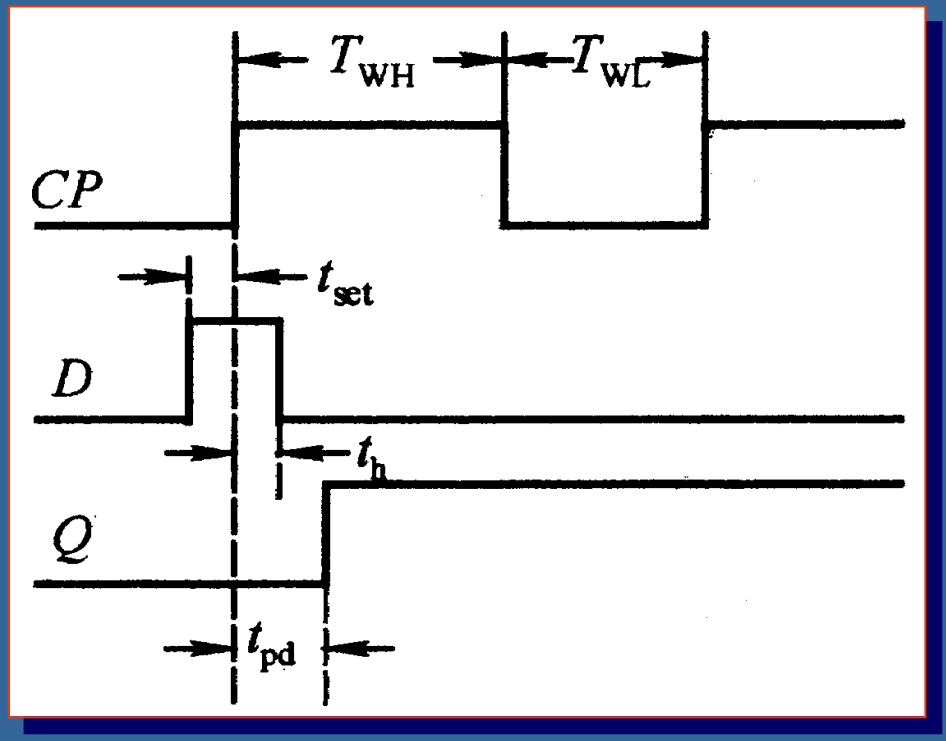
T_{WH}—时钟高电平持续时间

T_{WL}—时钟低电平持续时间

最高工作频率

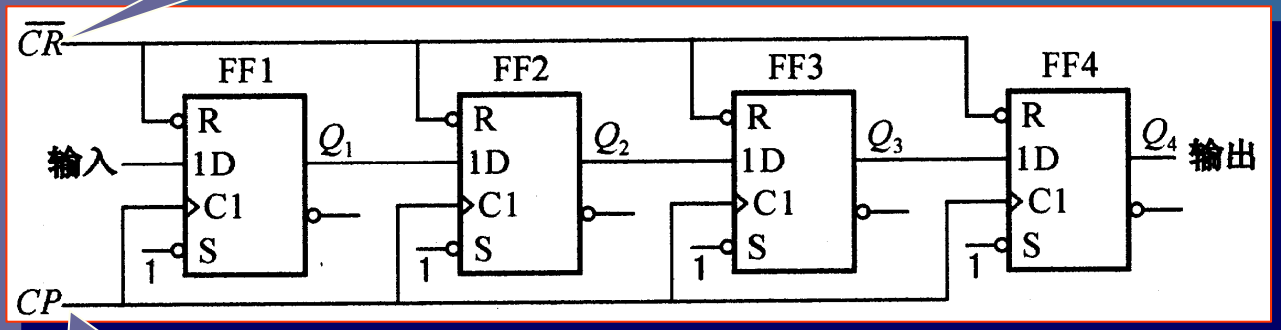
$$f_{CP\max} \le \frac{1}{T_{WH}+T_{wL}} = \frac{1}{5t_{pd}}$$

其中：t_{pd}为Q端相对于CP上升沿(触发沿)的延迟时间

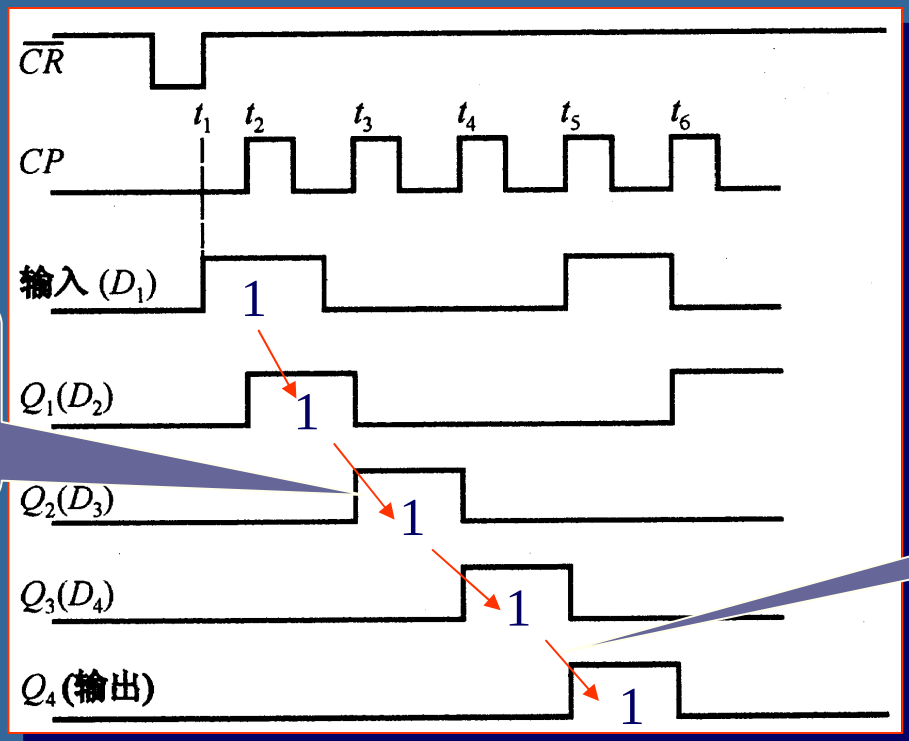


D触发器的应用（1）

移位寄存器

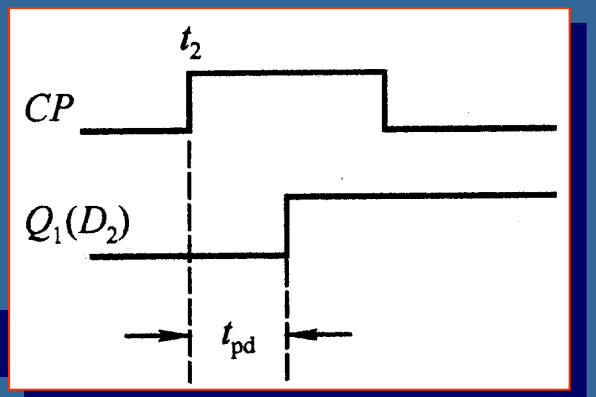


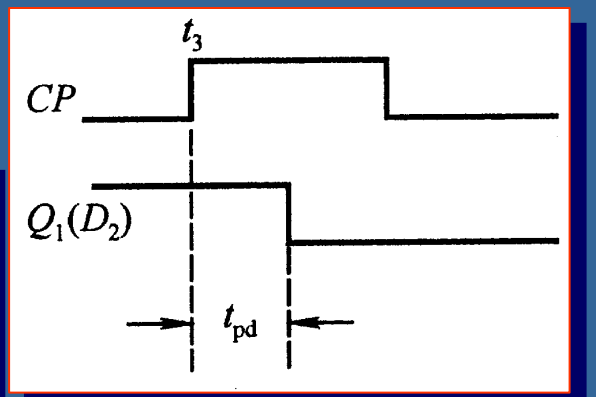
所有触发器CP端都连在一起——同步时序电路



由于Q_1（D_2）相对于t_3有t_{pd}延迟，故到达t_3时，D_2仍为1，则D_3=1

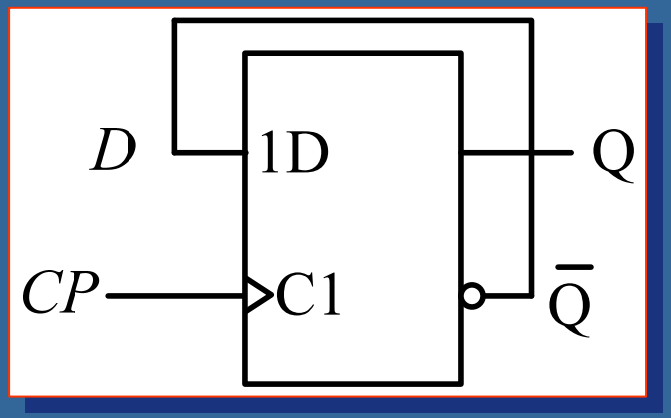
右移的移位寄存器

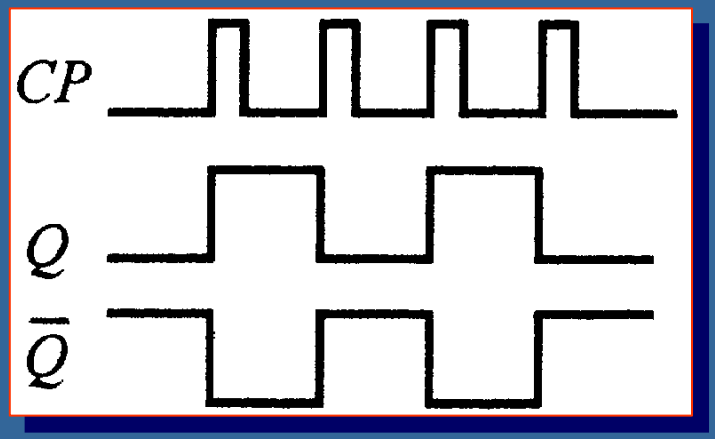




D触发器的应用（2）

二进制计数器

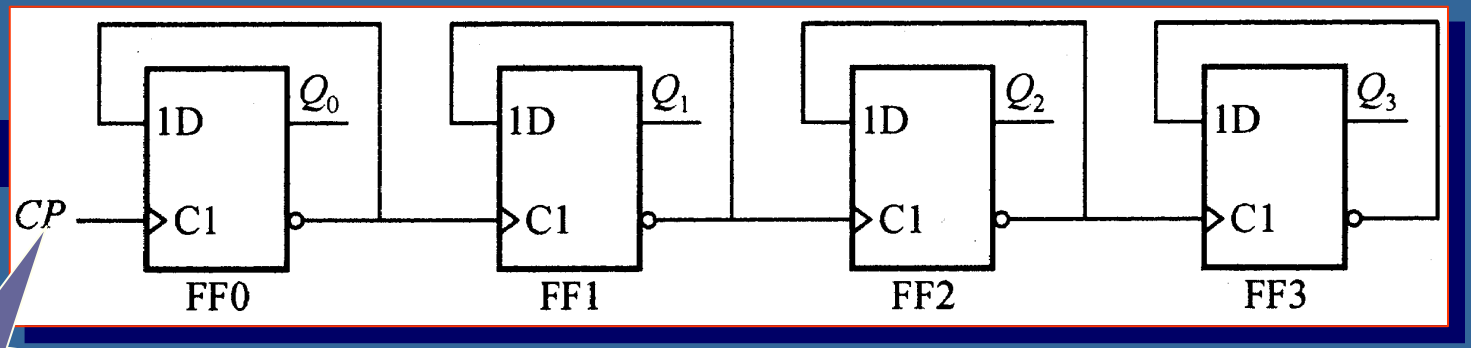




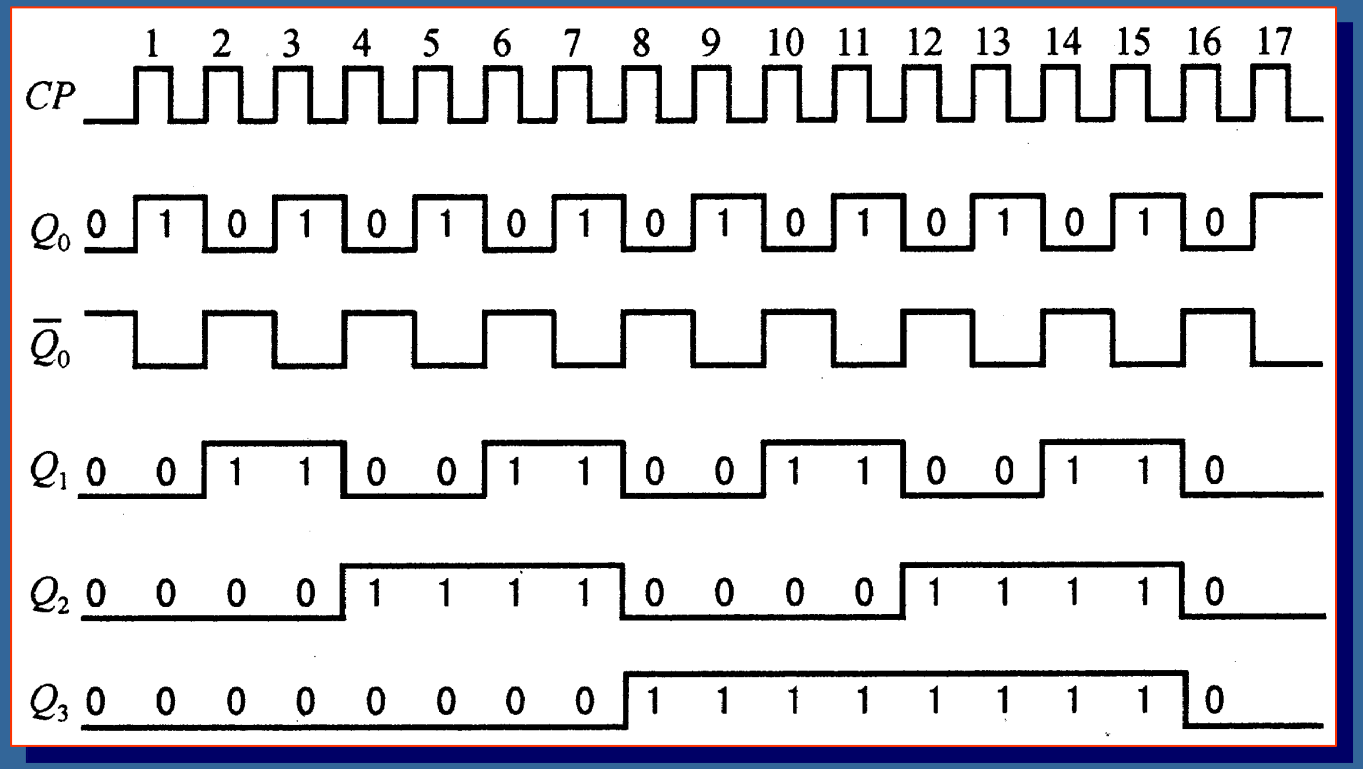
二进制计数器=模2计数器=2分频器

D触发器的应用（2）

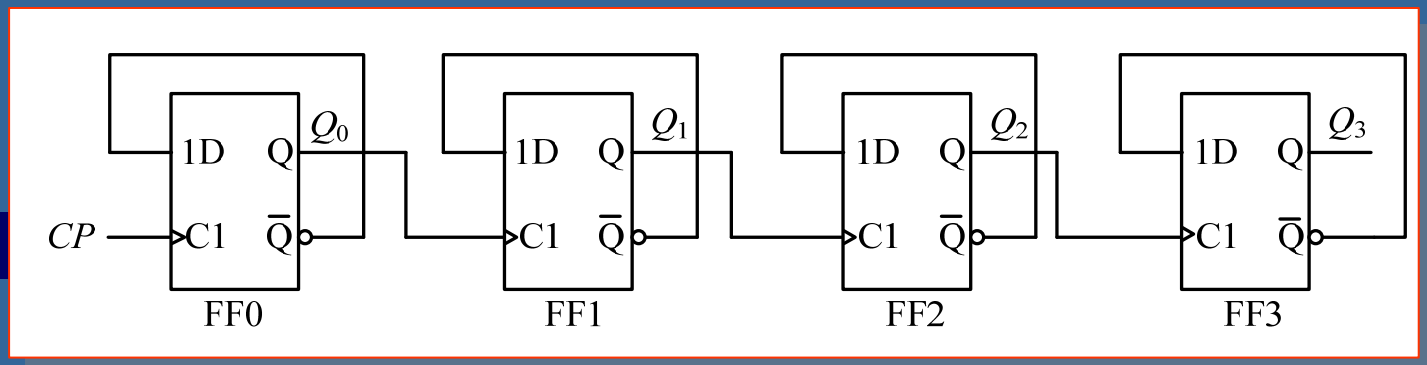
十六进制加法计数器（模16计数器、16分频器）

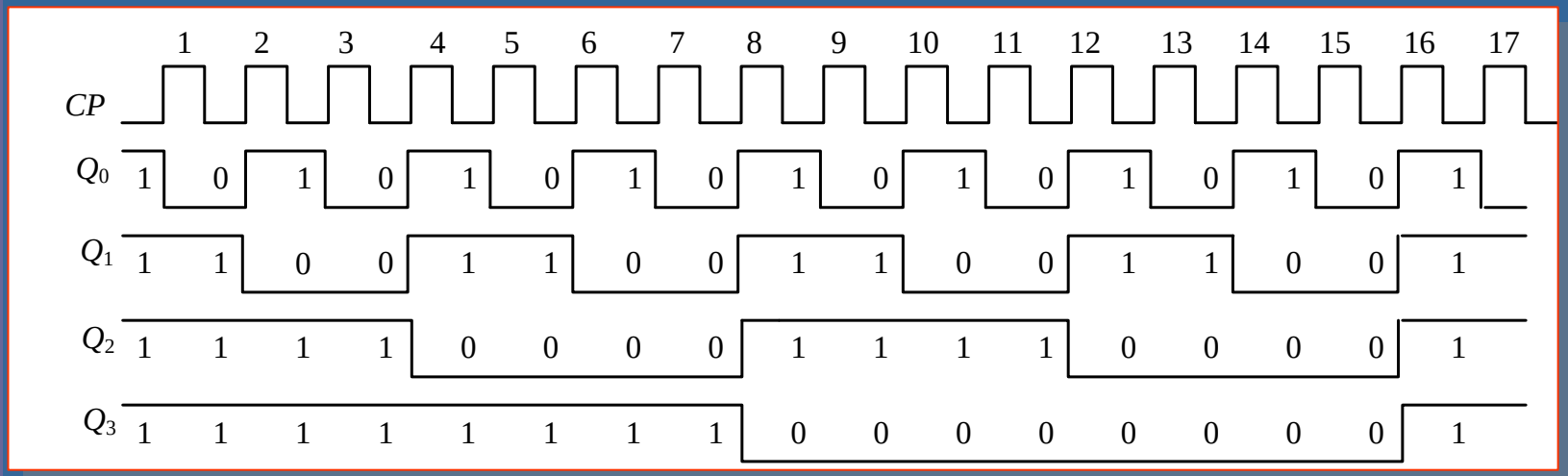


异步计数器



思考题：分析如下电路。

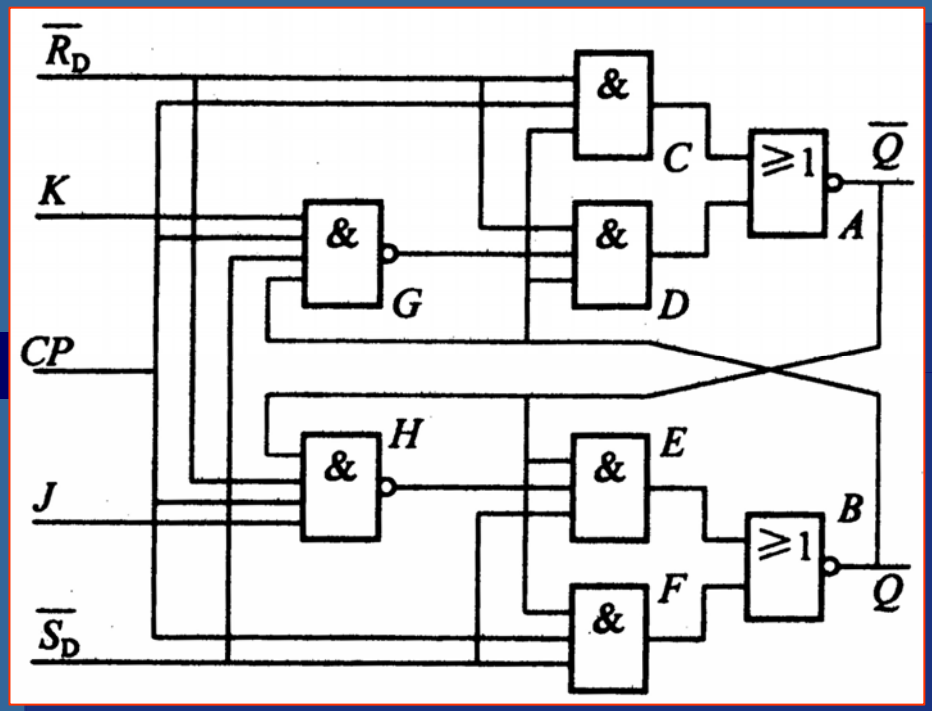


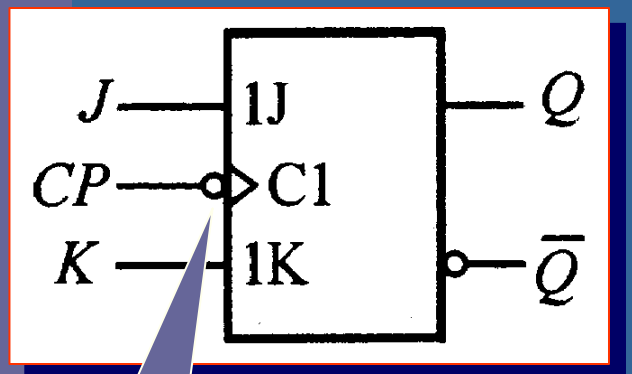


十六进制减法计数器

J—K触发器

JK触发器的内部电路



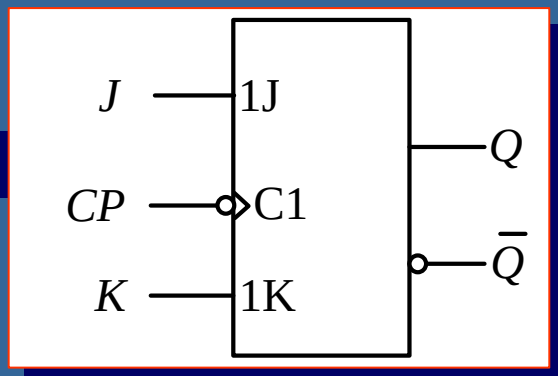


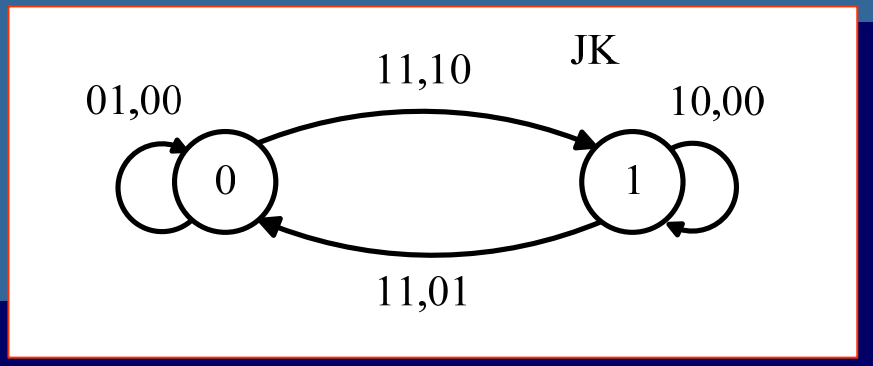
下降沿触发

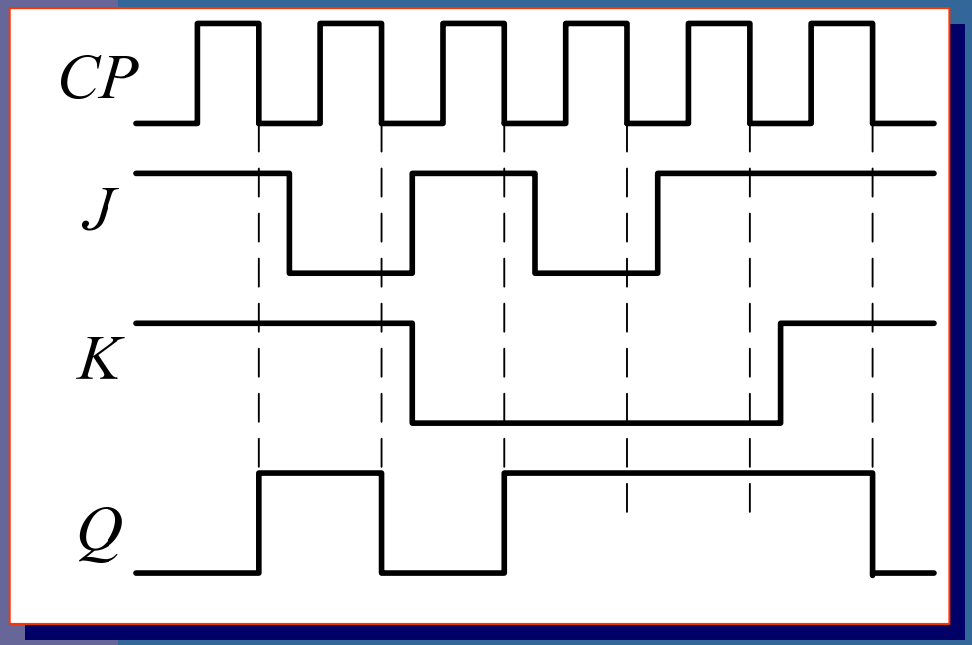
JK触发器的真值表

J	K	Q^{n+1}
0	0	Q^n
0	1	0
1	0	1
1	1	$\overline{Q}^n$

J—K触发器







Q^n \ JK	00	01	11	10
0	0	0	1	1
1	1	0	0	1

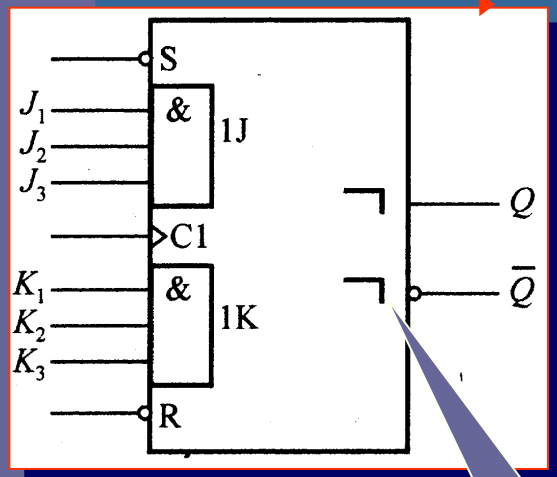
Q^{n+1}

JK触发器的次态方程或特征方程为

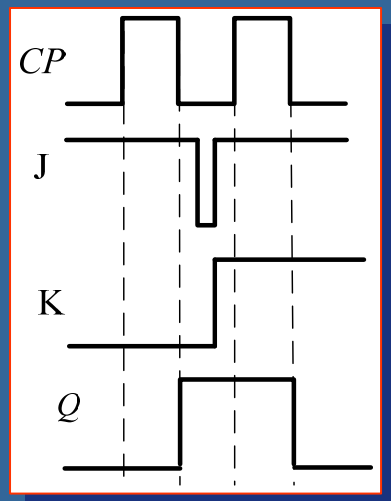
$$Q^{n+1} = J\overline{Q}^n + \overline{K}Q^n$$

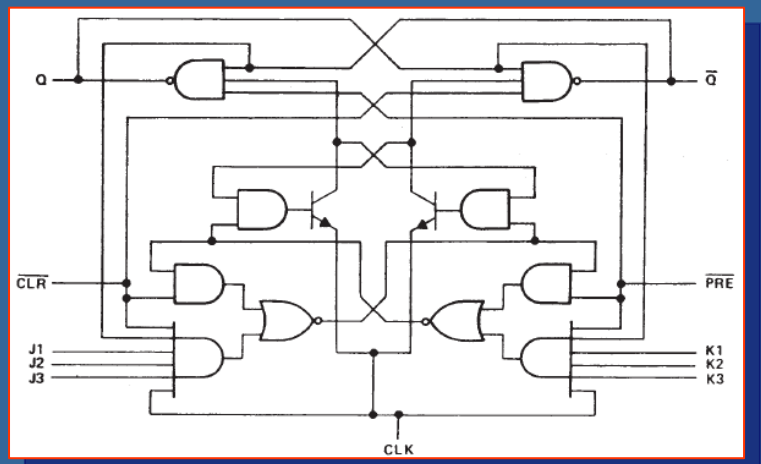
常用的J—K触发器

型　号	触发器数	结　构	J	K	输　出
7472	1	主从	$J_1 \cdot J_2 \cdot J_3$	$K_1 \cdot K_2 \cdot K_3$	Q、$\overline{Q}$
74109	2	边沿	J	K	Q、$\overline{Q}$
74111	2	主从	J	K	Q、$\overline{Q}$
74276	4	边沿	J	K	Q
74376	4	边沿	J	K	Q
CD4027	2	主从	J	K	Q、$\overline{Q}$



主从J—K触发器

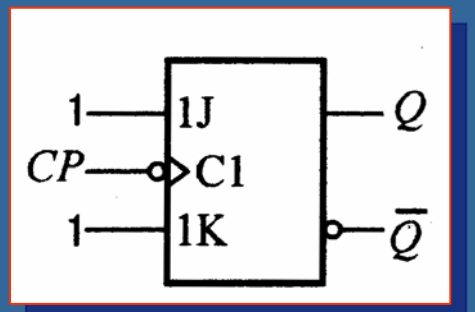


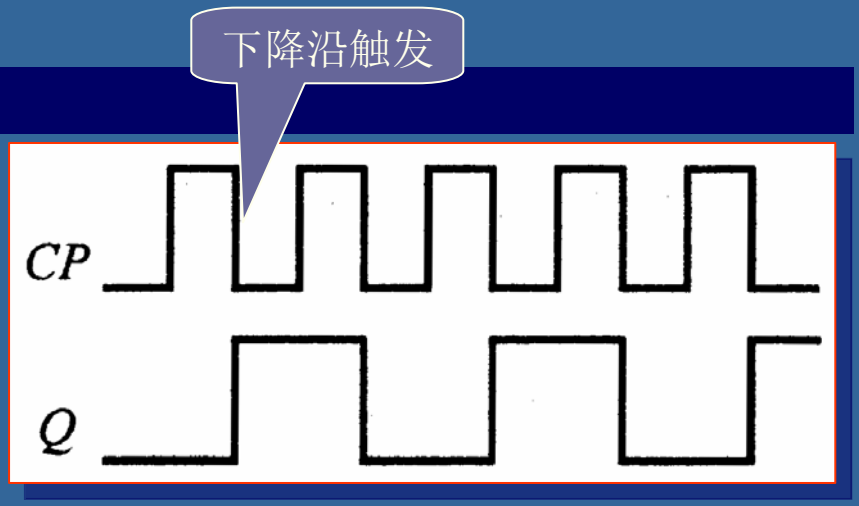


延迟输出

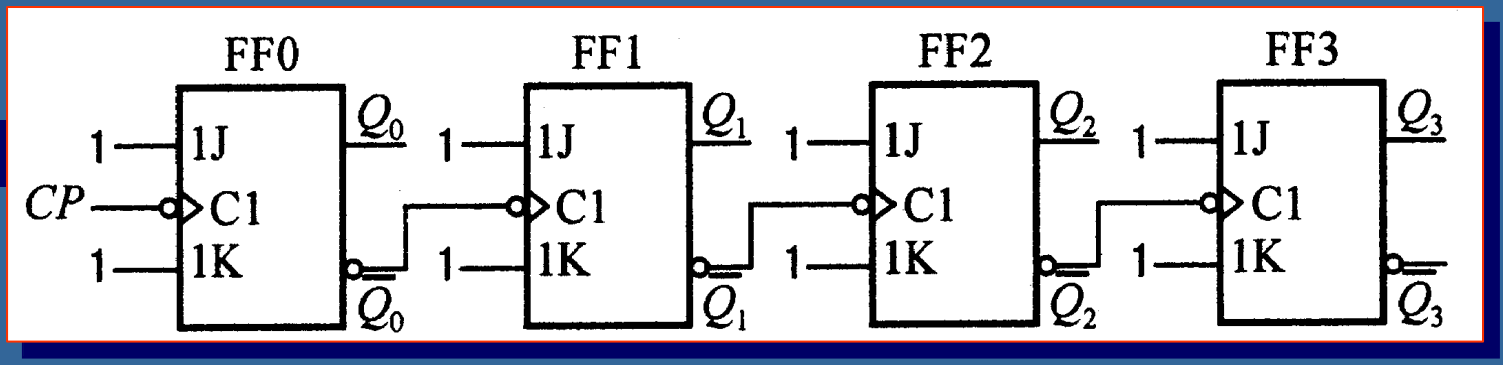
J—K触发器的应用

二进制计数器





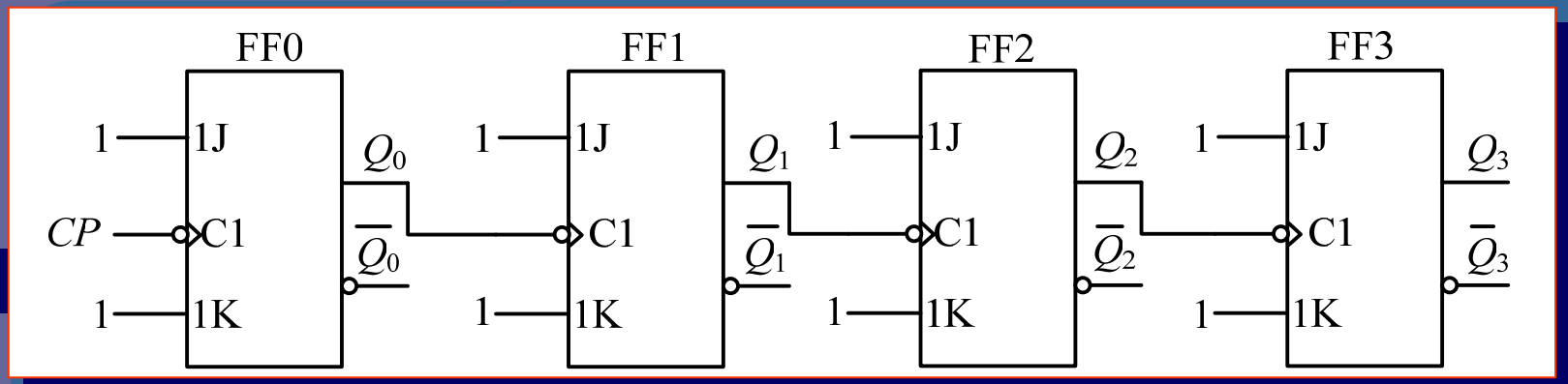
J—K触发器的应用

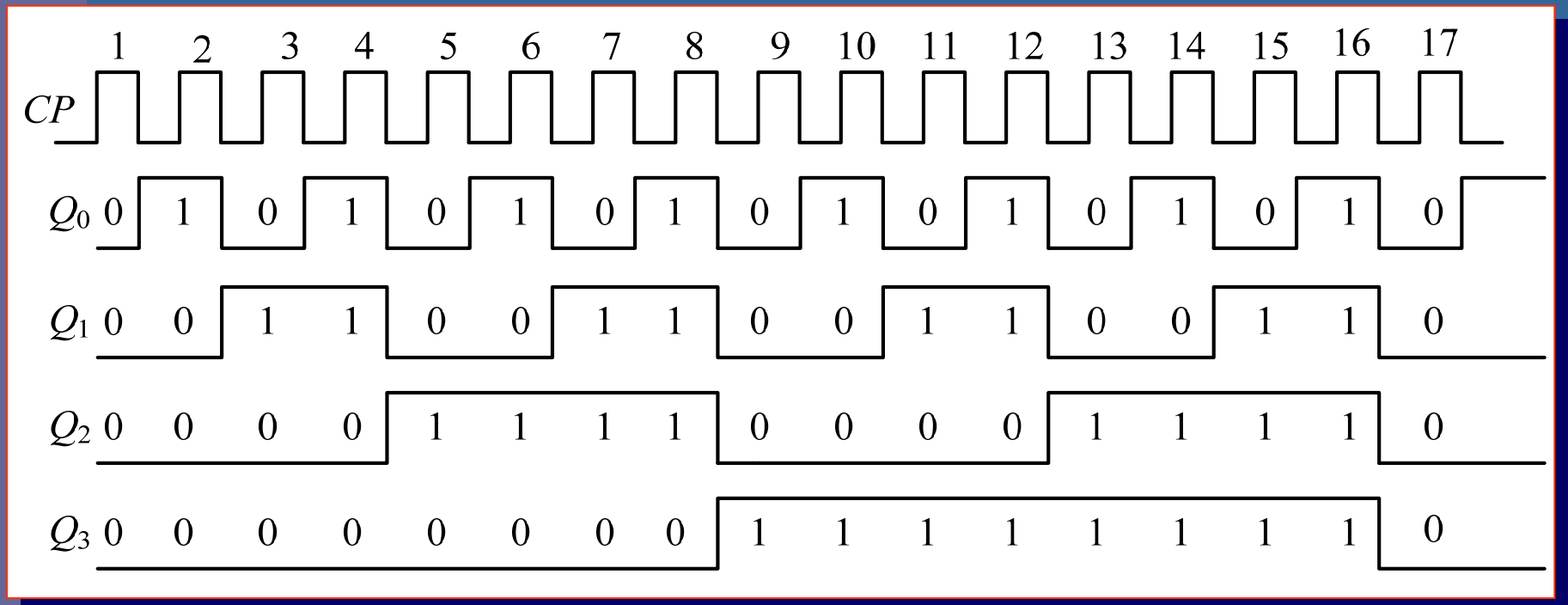


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CP																	
Q_0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Q_1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1
Q_2	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1
Q_3	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1

十六进制减法计数器

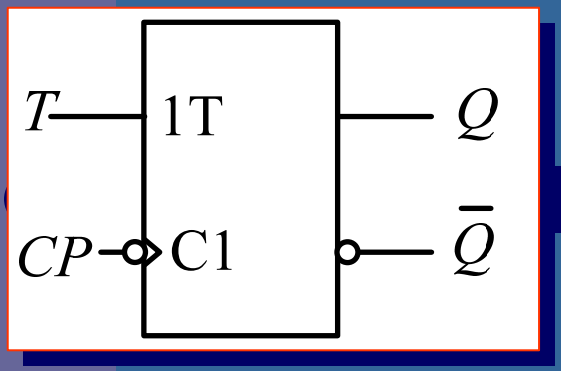
思考题：分析如下电路

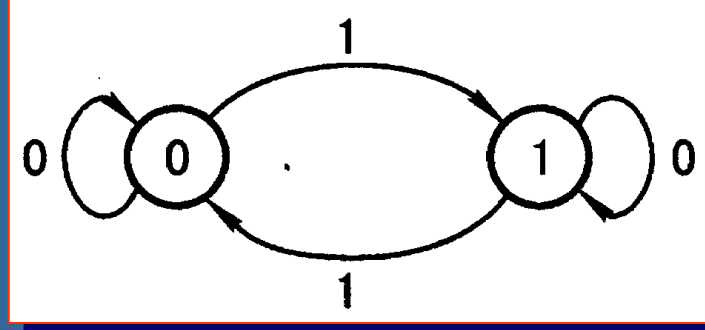




十六进制加法计数器

T触发器





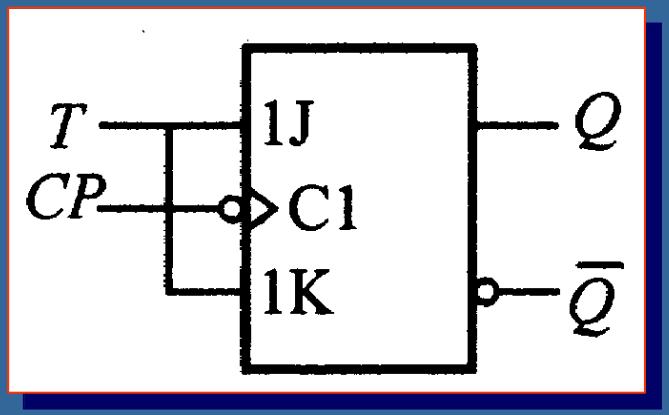
当T=0时，$Q^{n+1}=Q^n$

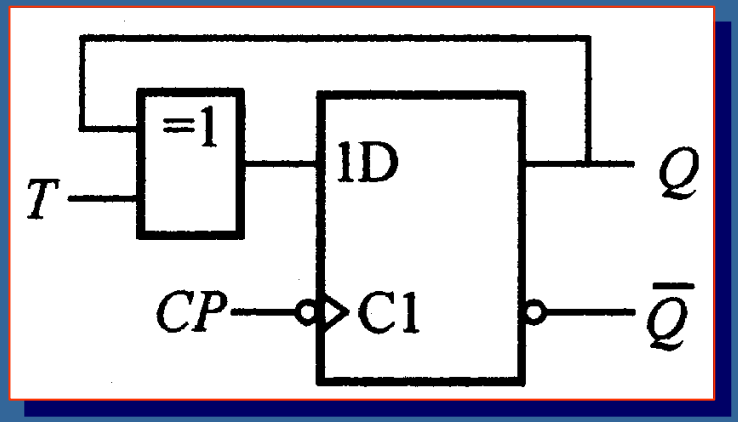
当T=1时，$Q^{n+1}=\bar{Q}^n$

Q^n \ T^n	0	1
0	0	1
1	1	0

Q^{n+1}

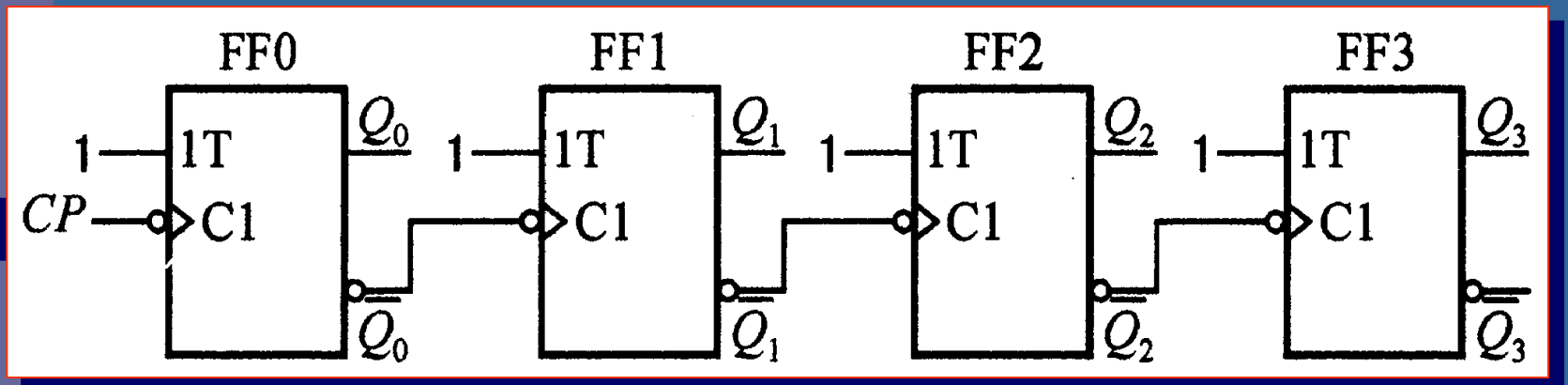
特征方程 $Q^{n+1}=T\oplus Q^n$

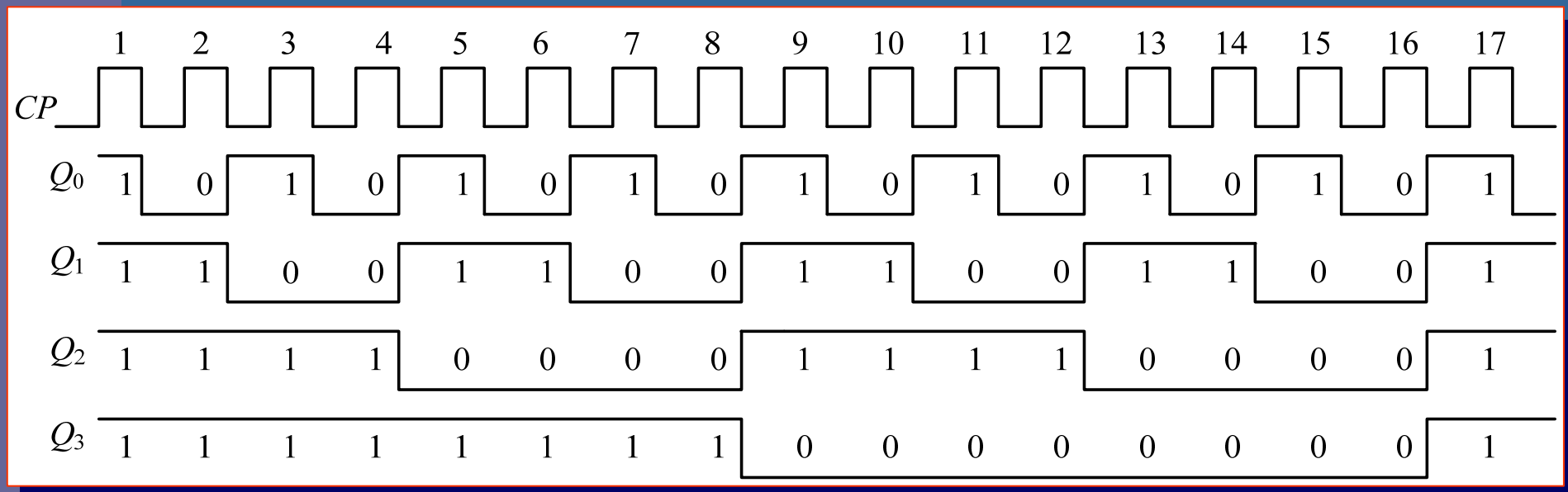




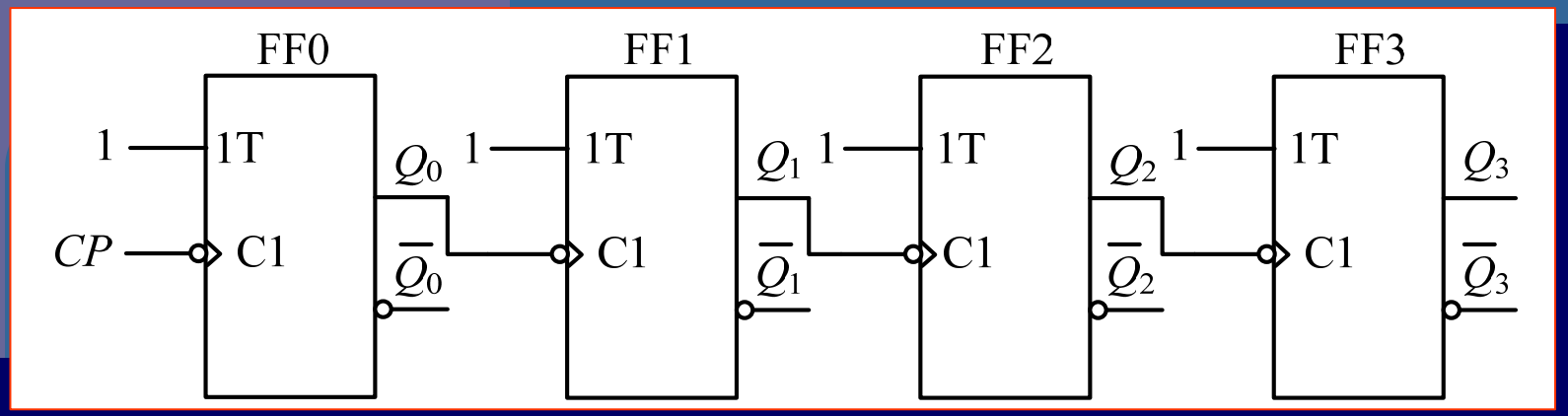
T触发器的应用

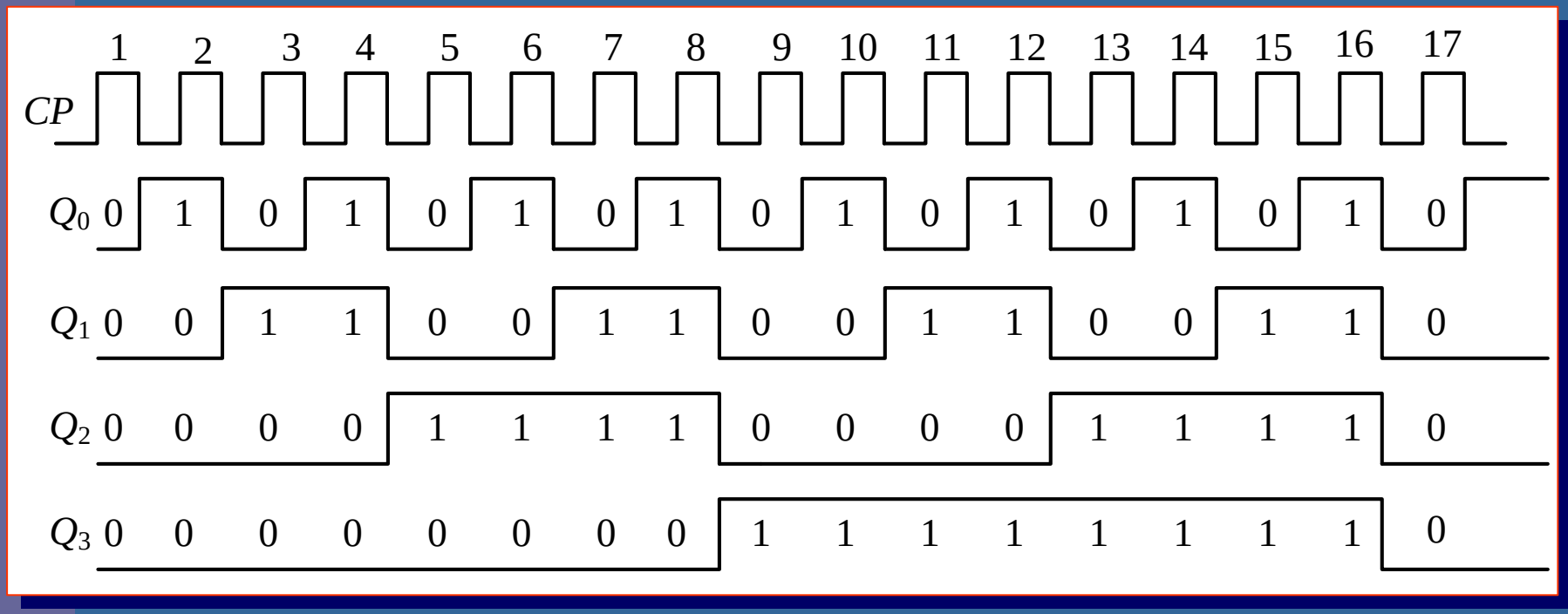
构成的异步计数器





十六进制减法计数器

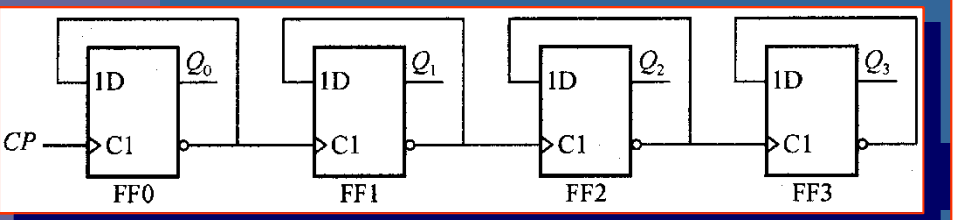

FF0
FF1
FF2
FF3
1
1T
C1
CP
Q_0
$\overline{Q}_0$
Q_1
$\overline{Q}_1$
Q_2
$\overline{Q}_2$
Q_3
$\overline{Q}_3$


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
CP
Q_0 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0
Q_1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0
Q_2 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0
Q_3 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0

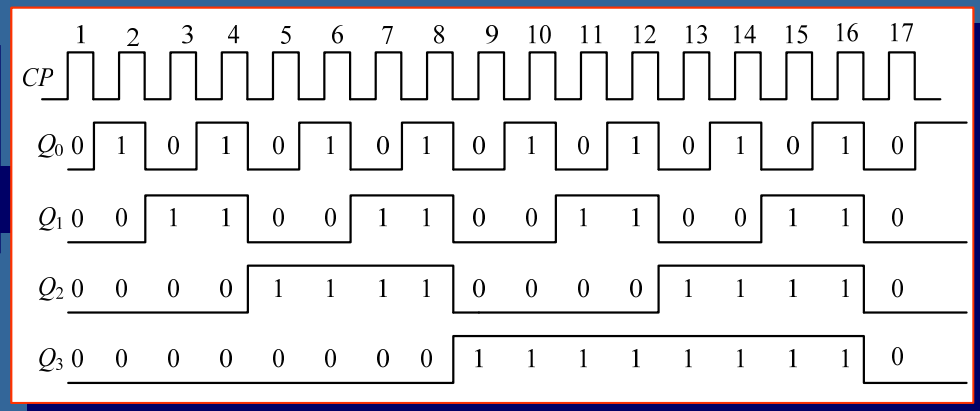
十六进制加法计数器

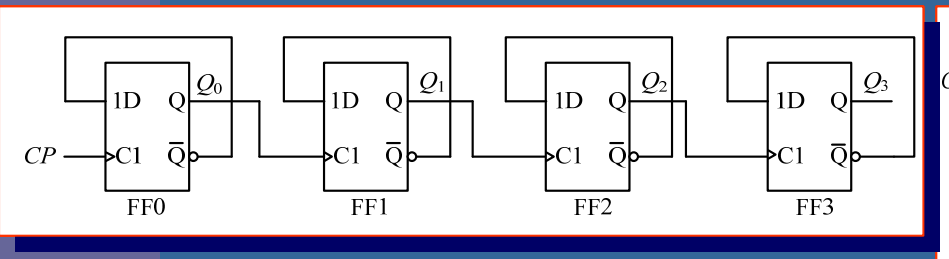
异步计数器小结

D触发器

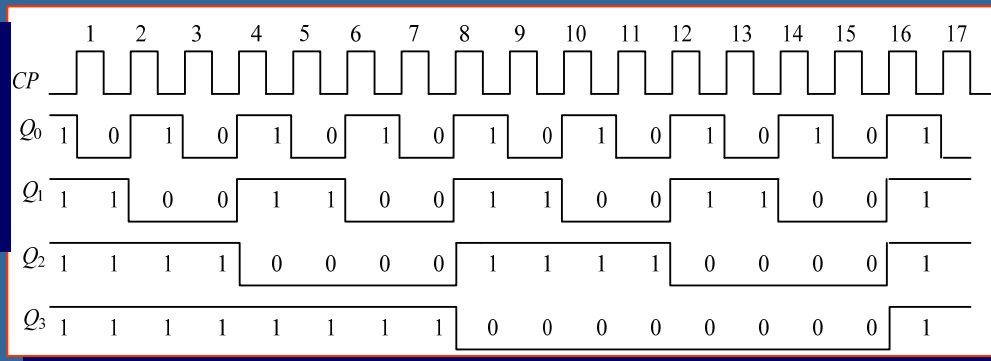


十六进制加法计数器



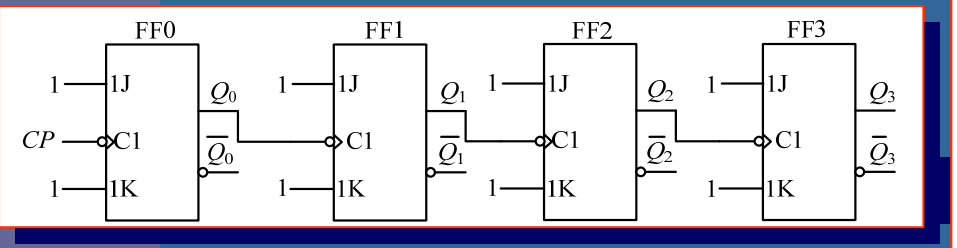


十六进制减法计数器

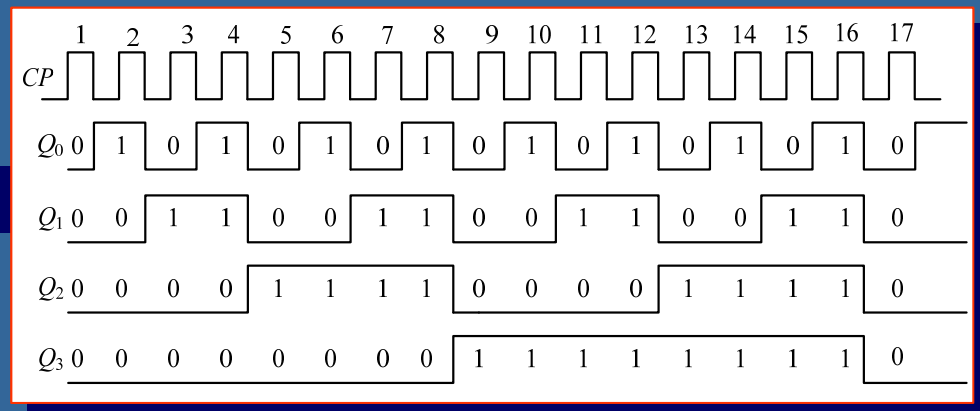


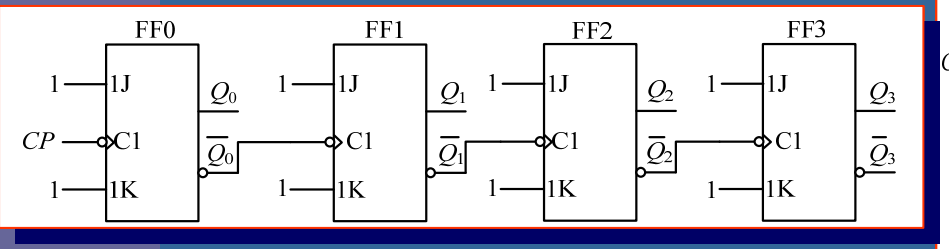
异步计数器小结

J-K触发器

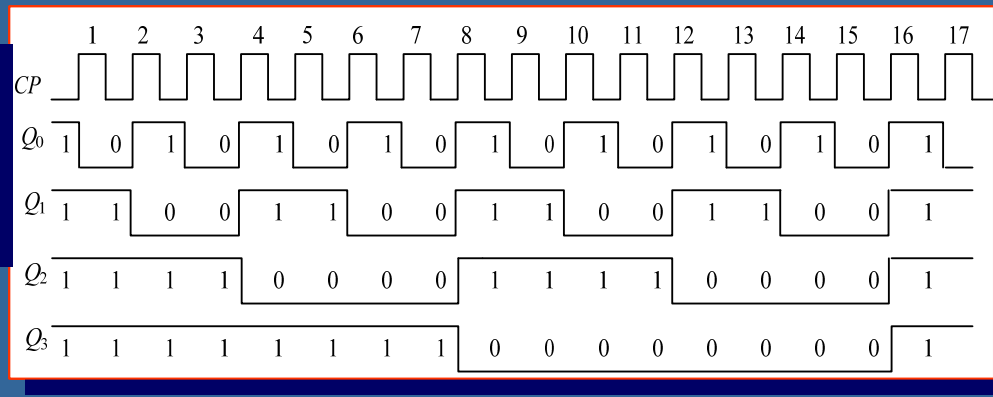


十六进制加法计数器



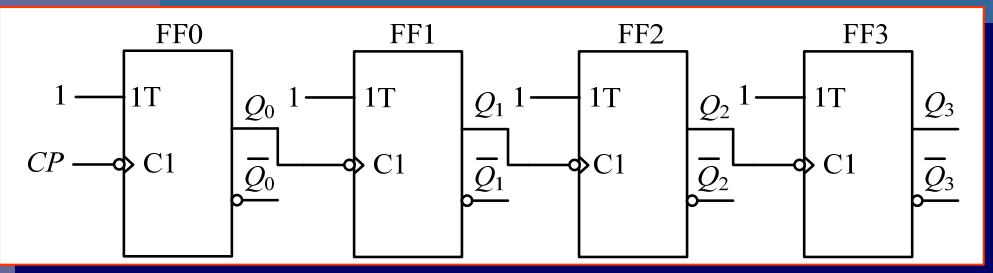


十六进制减法计数器

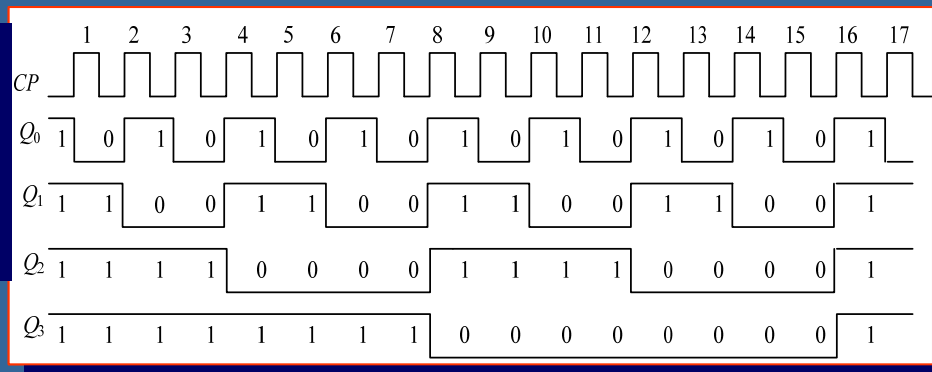


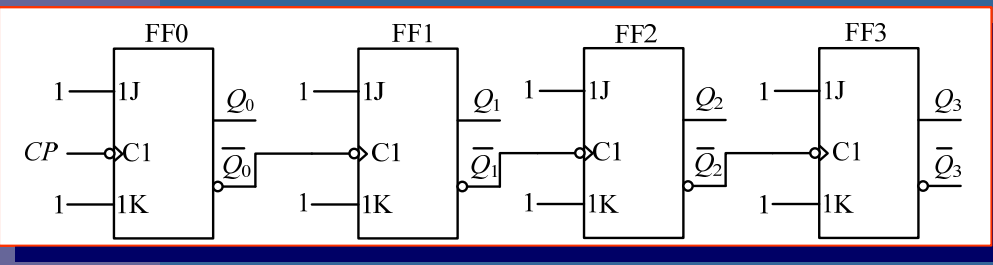
异步计数器小结

T触发器

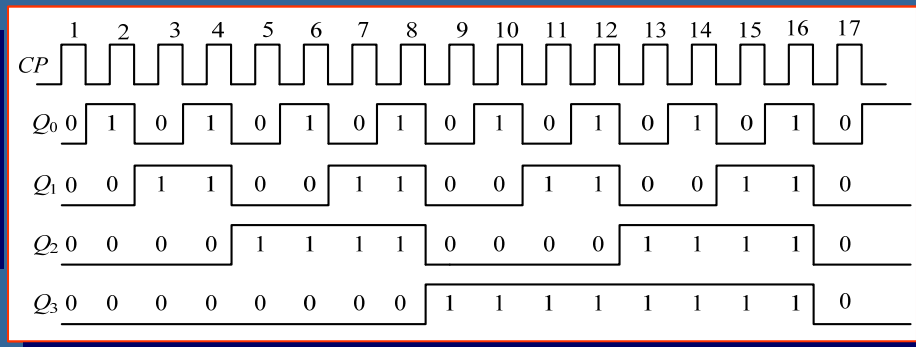


十六进制加法计数器





十六进制减法计数器

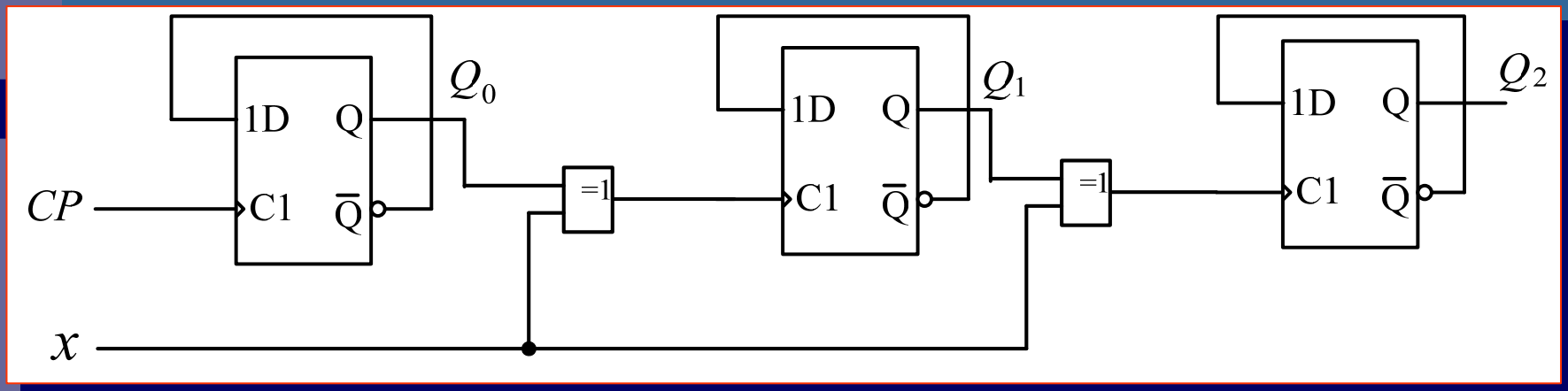


异步计数器

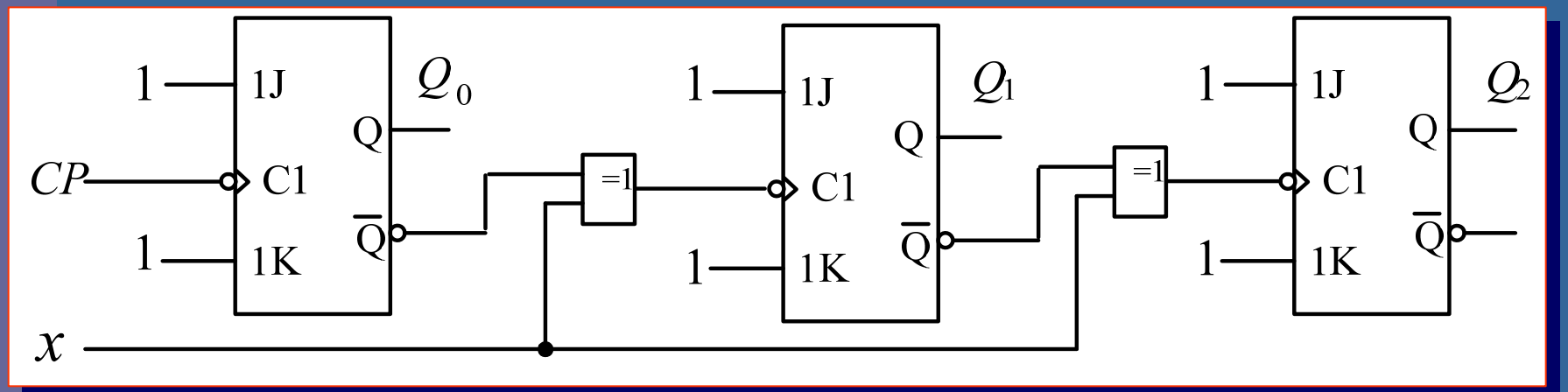
异步2^k进制计数器的结构

触发方式 / 计数规律	上升沿	下降沿
加　法	$CP_i = \overline{Q}_{i-1}$	$CP_i = Q_{i-1}$
减　法	$CP_i = Q_{i-1}$	$CP_i = \overline{Q}_{i-1}$

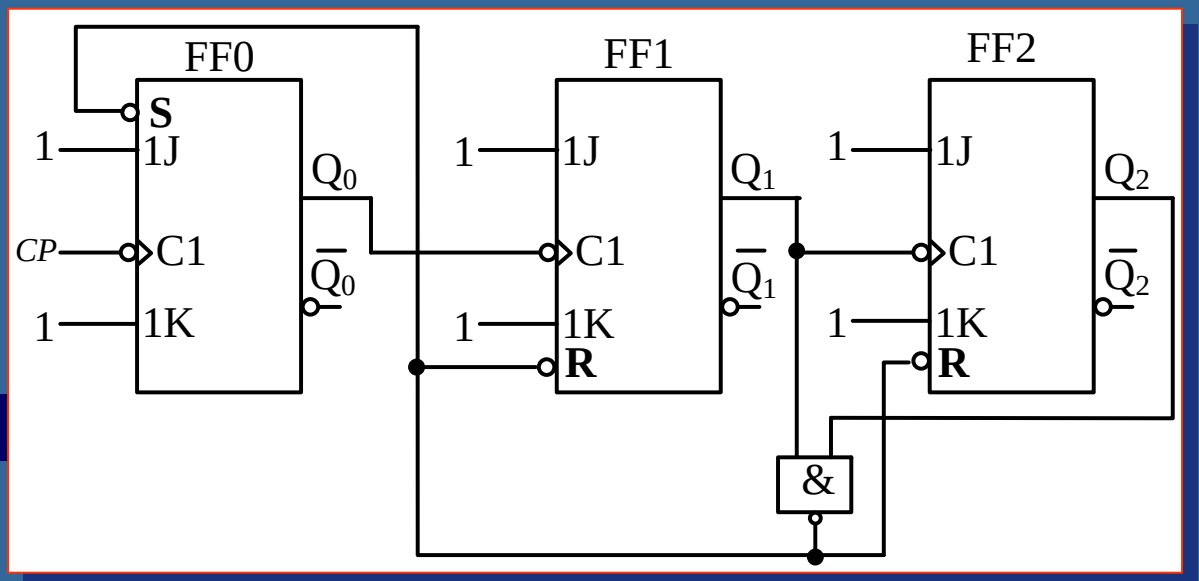
例1 试用D触发器设计一个异步二进制模8加/减计数器。当控制信号 $x=1$ 时，计数器进行加法计数，反之做减法计数。



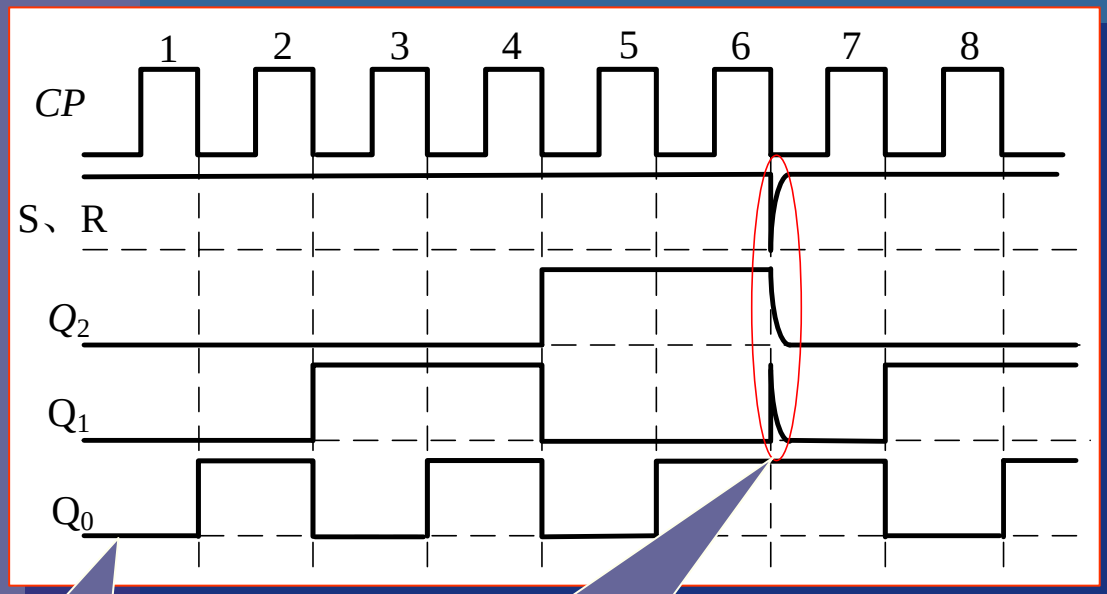
例2 试用J-K触发器设计上题的模8加/减计数器。



例3 教材P152 例4-1-1



波形图



设初态为000

状态110时瞬间变换到001

电路状态图