

数字逻辑设计

Digital Logic Design

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时序逻辑元件

- 锁存器 (Latch)
- 触发器 (Flip-Flop)
- 带附加输入端的边沿触发器
- 触发器类型转换

触发器类型转换——代数法

- 触发器类型主要有5种，用到最多的是D触发器
- 触发器类型可以相互转换（例如，设计中手头没有需要的触发器类型）

转换方法 {

- 代数法
- 卡诺图法

代数法 从次态方程入手

1. JK → D、T (T')、SR

(1) JK → D

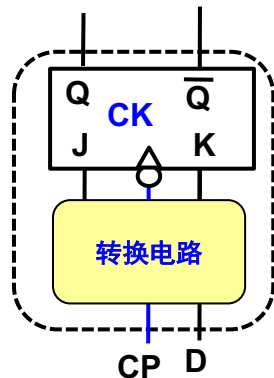
$$\left. \begin{array}{l} \text{JK: } Q_{n+1} = J \bar{Q}_n + \bar{K} Q_n \\ \text{D: } Q_{n+1} = D \end{array} \right\}$$

$$D = J \bar{Q}_n + \bar{K} Q_n$$

$$D(Q_n + \bar{Q}_n) = J \bar{Q}_n + \bar{K} Q_n$$

$$J = f(D, Q)$$

$$K = f(D, Q)$$



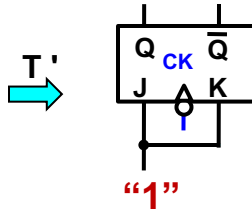
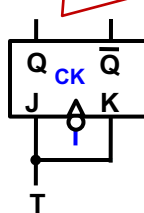
$$\left\{ \begin{array}{l} J=D \\ \bar{K}=D \quad (K=\bar{D}) \end{array} \right.$$

触发器类型转换——JK转其他

(2) JK \rightarrow T

$$\left. \begin{array}{l} \text{JK: } Q_{n+1} = J \bar{Q}_n + \bar{K} Q_n \\ \text{T: } Q_{n+1} = T \bar{Q}_n + \bar{T} Q_n \end{array} \right\} \begin{array}{l} J=T \\ K=T \end{array}$$

JK触发器的特例



T触发器的特例

(3) JK \rightarrow SR

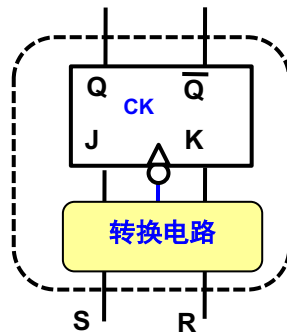
$$\text{JK: } Q_{n+1} = J \bar{Q}_n + \bar{K} Q_n$$

$$\begin{aligned} \text{SR: } Q_{n+1} &= S + \bar{R} Q_n = S(Q_n + \bar{Q}_n) + \bar{R} Q_n \\ &= S Q_n + S \bar{Q}_n + \bar{R} Q_n \\ &= S Q_n (R + \bar{R}) + S \bar{Q}_n + \bar{R} Q_n \\ &= R S Q_n + \bar{R} S Q_n + S \bar{Q}_n + \bar{R} Q_n \\ &= R S Q_n + S \bar{Q}_n + \bar{R} Q_n \end{aligned}$$

RS=0

$$J = f(R, S, Q)$$

$$K = f(R, S, Q)$$



$$J=S$$

$$K=R$$

触发器类型转换——D转其他

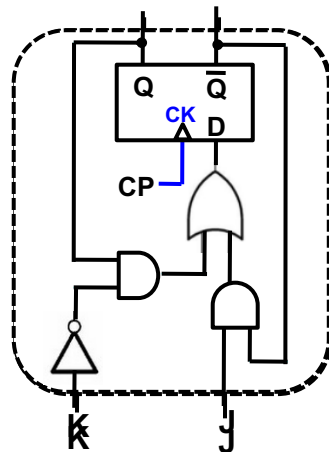
2. $D \rightarrow JK$ 、 T (T')、 SR

(1) $D \rightarrow JK$

$$\left. \begin{array}{l} JK: \quad Q_{n+1} = J \bar{Q}_n + \bar{K} Q_n \\ D: \quad Q_{n+1} = D \end{array} \right\}$$

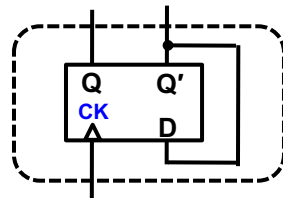
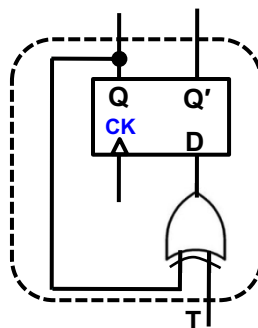
$$D = f(J, K, Q)$$

$$D = J \bar{Q}_n + \bar{K} Q_n$$



(2) $D \rightarrow T$ (T')

$$\left. \begin{array}{l} T: \quad Q_{n+1} = T \oplus Q_n \\ D: \quad Q_{n+1} = D \\ T': \quad Q_{n+1} = \bar{Q}_n \end{array} \right\} \quad \begin{array}{l} D = T \oplus Q_n \\ D = \bar{Q}_n \end{array}$$



(3) $D \rightarrow SR$?

触发器类型转换——卡诺图法

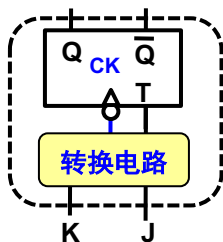
□ 卡诺图法

1. $T \rightarrow JK$ 、 D 、 SR

(1) $T \rightarrow JK$

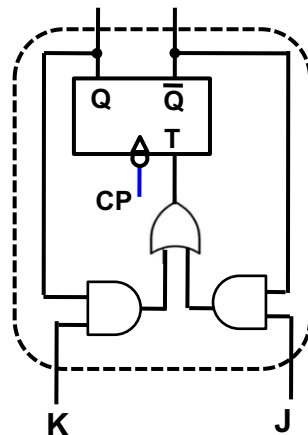
$Q_n \rightarrow Q_{n+1}$	T	J	K
0 \rightarrow 0	0	0	X
0 \rightarrow 1	1	1	X
1 \rightarrow 0	1	X	1
1 \rightarrow 1	0	X	0

$$T = f(J, K, Q)$$



$$T = J\bar{Q}_n + KQ_n \rightarrow$$

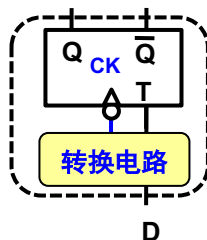
$Q_n \backslash JK$	00	01	11	10
0	0	0	1	1
1	0	1	1	0



(2) $T \rightarrow D$

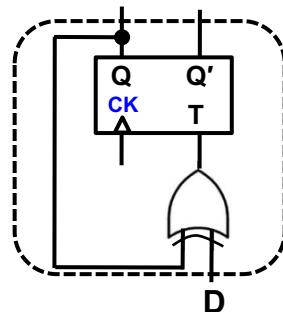
$Q_n \rightarrow Q_{n+1}$	T	D
0 \rightarrow 0	0	0
0 \rightarrow 1	1	1
1 \rightarrow 0	1	0
1 \rightarrow 1	0	0

$$T = f(D, Q)$$



$$T = D \oplus Q_n \rightarrow$$

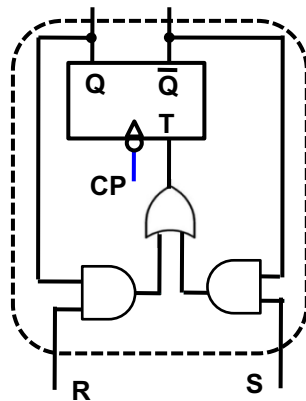
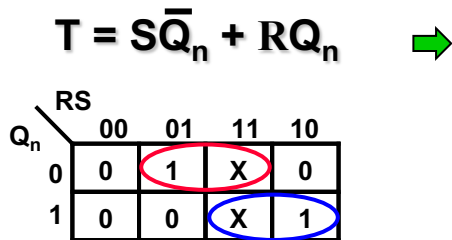
$Q_n \backslash D$	0	1
0	0	1
1	1	0



触发器类型转换——卡诺图法

(3) $T \rightarrow SR$

Q_n	\rightarrow	Q_{n+1}	T	R	S
0	\rightarrow	0	0	X	0
0	\rightarrow	1	1	0	1
1	\rightarrow	0	1	1	0
1	\rightarrow	1	0	0	X



2. $SR \rightarrow JK$ 、 D 、 $T(T')$