Sistemas Digitais

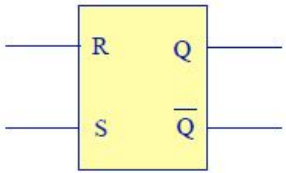
Flip-Flop, Latches e Registradores.

Apresentação baseada no material do prof. José Luís Güntzel

Latches, Flip-Flops e Registradores

O Latch RS

símbolo



circuito com portas nor

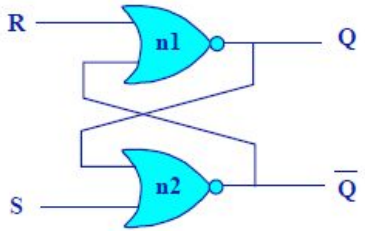


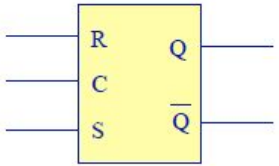
tabela de transição de estados

R	S	Q_{t+1}	comentário
0	0	Q_t	mantém estado anterior
0	1	1	estado set
1	0	0	estado reset
1	1	-	proibido

Latches, Flip-Flops e Registradores

O Latch RS Controlado

símbolo



circuito com portas nor e and

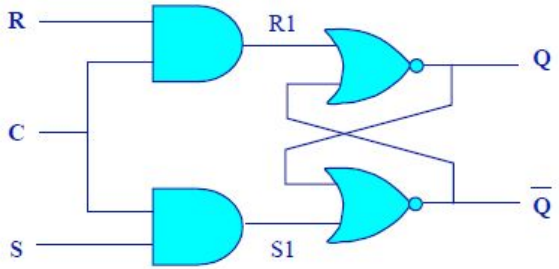
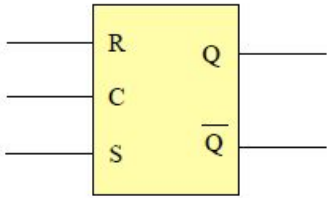


tabela de transição de estados

C	R	S	Q_{t+1}	comentário
0	X	X	Q_t	mantém estado anterior
1	0	0	Q_t	mantém estado anterior
1	0	1	1	estado set
1	1	0	0	estado reset
1	1	1	-	proibido

Latches, Flip-Flops e Registradores

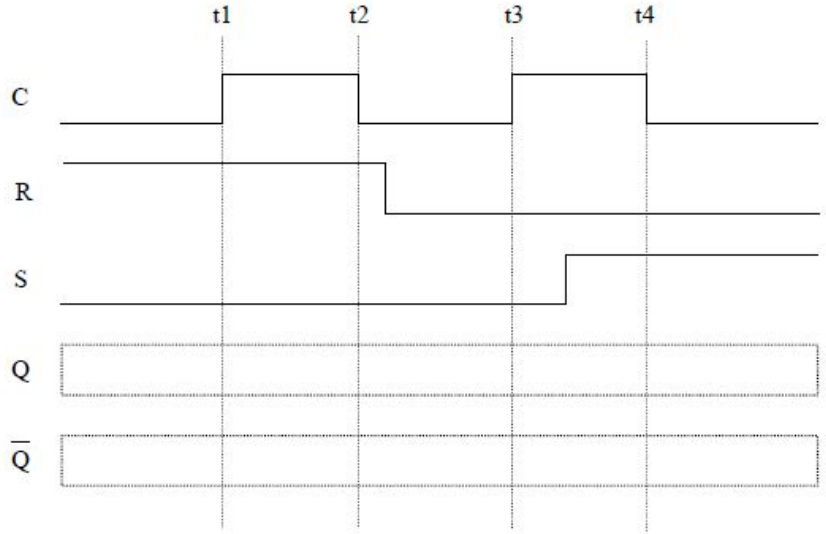
O Latch RS Controlado



C	R	S	Q_{t+1}
0	X	X	Q_t
1	0	0	Q_t
1	0	1	1
1	1	0	0
1	1	1	-

tabela de transição de estados

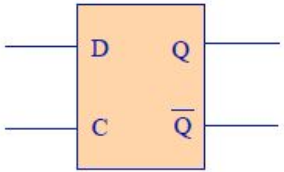
Exemplo



Latches, Flip-Flops e Registradores

O Latch D

símbolo



circuito a partir do latch RS controlado

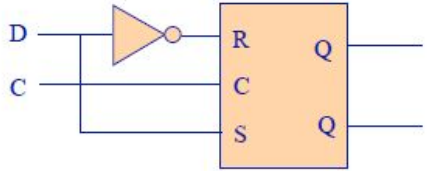


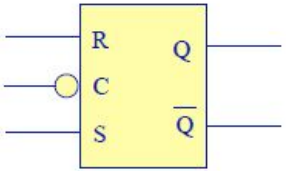
tabela de transição de estados

C	D	Q_{t+1}	comentário
0	X	Q_t	mantém estado anterior
1	0	0	estado reset
1	1	1	estado set

Latches, Flip-Flops e Registradores

Latches com ativação em lógica complementar

Latch RS

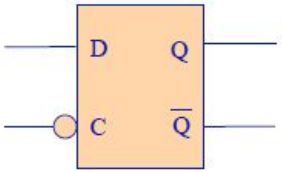


símbolo

C	R	S	Q_{t+1}
1	X	X	Q_t
0	0	0	Q_t
0	0	1	1
0	1	0	0
0	1	1	-

tabela de transição de estados

Latch D



símbolo

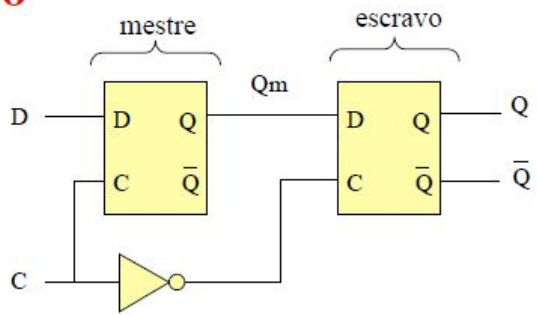
C	D	Q_{t+1}
1	X	Q_t
0	0	0
0	1	1

tabela de transição de estados

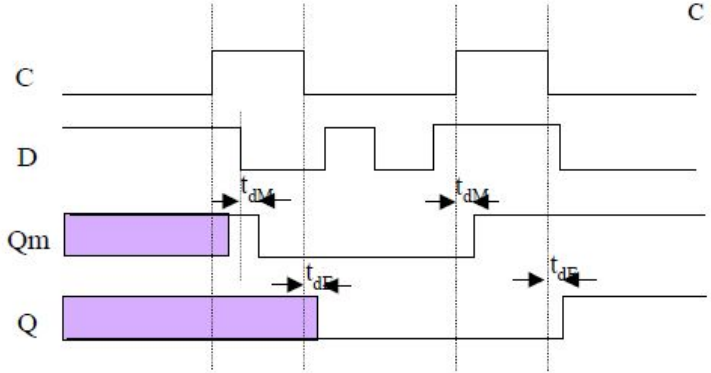
Latches, Flip-Flops e Registradores

O Flip-flop D mestre-escravo

circuito



análise dinâmica
(exemplo de funcionamento)



t_{dM} = atraso do latch mestre

t_{dE} = atraso do latch escravo

Latches, Flip-Flops e Registradores

O Flip-flop D disparado pela borda ascendente

(ou Flip-flop D sensível à borda ascendente)

símbolo

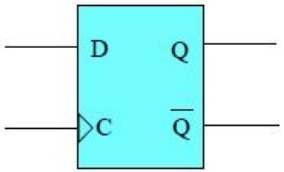
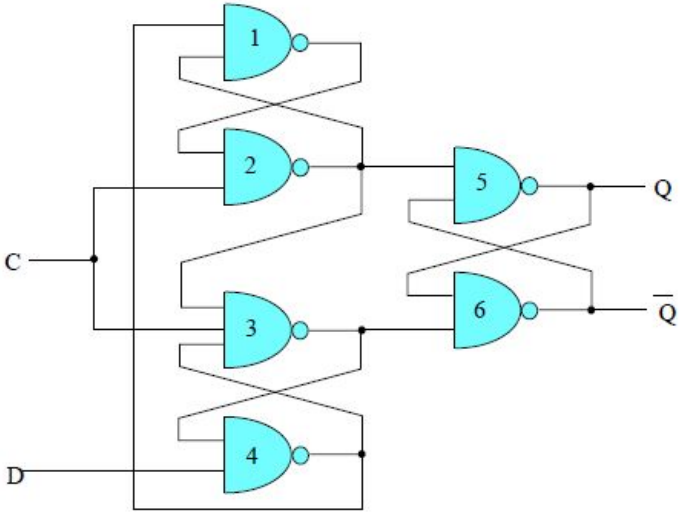


tabela de transição de estados

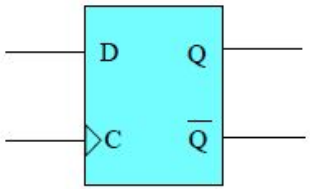
C	D	Q_{t+1}
$\neq\uparrow$	X	Q_t
$\uparrow$	0	0
$\uparrow$	1	1

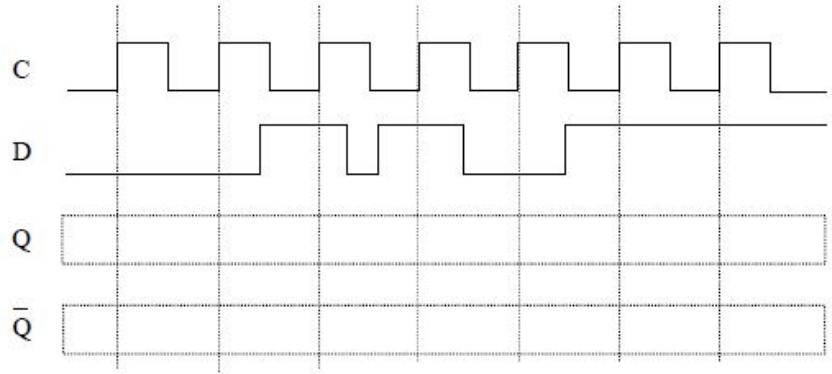
circuito com portas nand



Latches, Flip-Flops e Registradores

O Flip-flop D disparado pela borda ascendente





C	D	Q_{t+1}
$\neq\uparrow$	X	Q_t
$\uparrow$	0	0
$\uparrow$	1	1

tabela de transição de estados

Latches, Flip-Flops e Registradores

O Flip-flop JK (disparado pela borda ascendente)

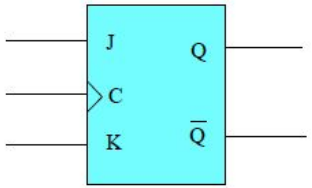
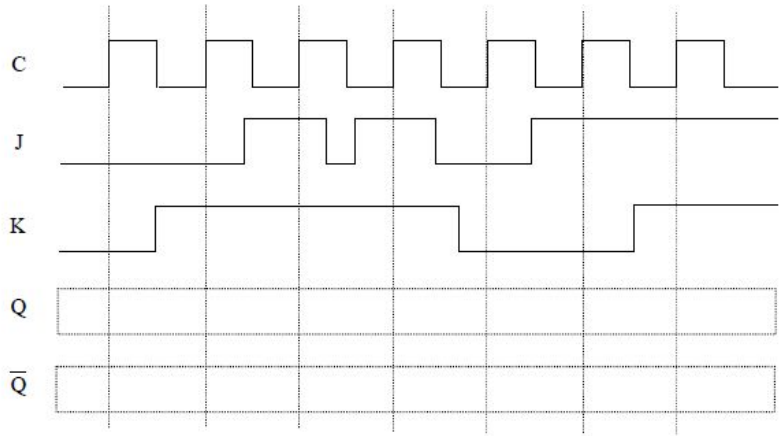


tabela de transição de estados

C	J	K	Q_{t+1}
$\neq\uparrow$	X	X	Q_t
$\uparrow$	0	0	Q_t
$\uparrow$	0	1	0
$\uparrow$	1	0	1
$\uparrow$	1	1	$\overline{Q_t}$

Exemplo

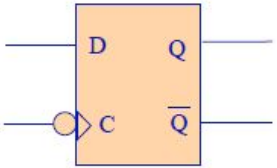


Latches, Flip-Flops e Registradores

Flip-flops disparados pela borda descendente

(ou Flip-flops sensíveis à borda descendente)

Flip-flop D

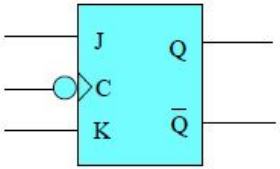


símbolo

C	D	Q_{t+1}
≠↓	X	Q_t
↓	0	0
↓	1	1

tabela de transição de estados

Flip-flop JK



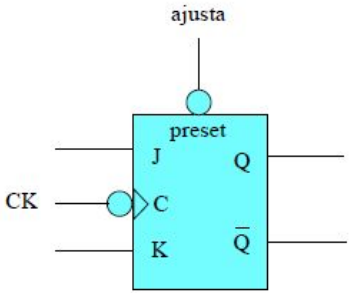
símbolo

C	J	K	Q_{t+1}
≠↓	X	X	Q_t
↓	0	0	Q_t
↓	0	1	0
↓	1	0	1
↓	1	1	$\overline{Q_t}$

tabela de transição de estados

Latches, Flip-Flops e Registradores

Flip-flops com set e reset assíncronos



C	J	K	Q_{t+1}
≠↓	X	X	Q_t
↓	0	0	Q_t
↓	0	1	0
↓	1	0	1
↓	1	1	Q_t

Exemplo

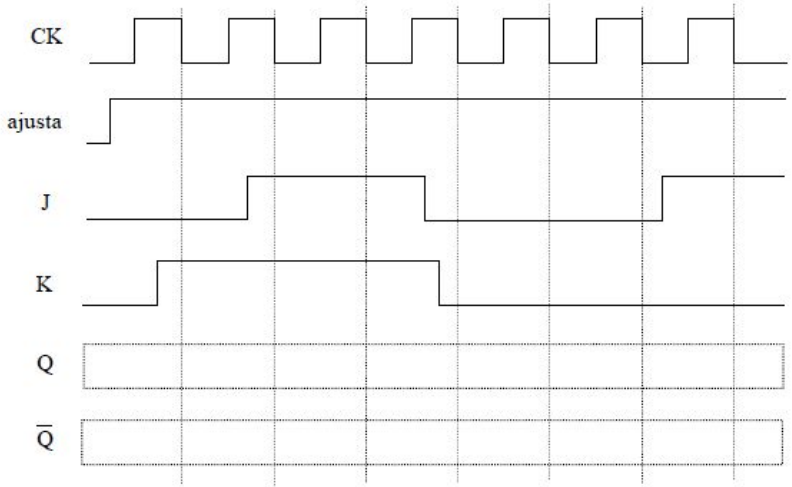
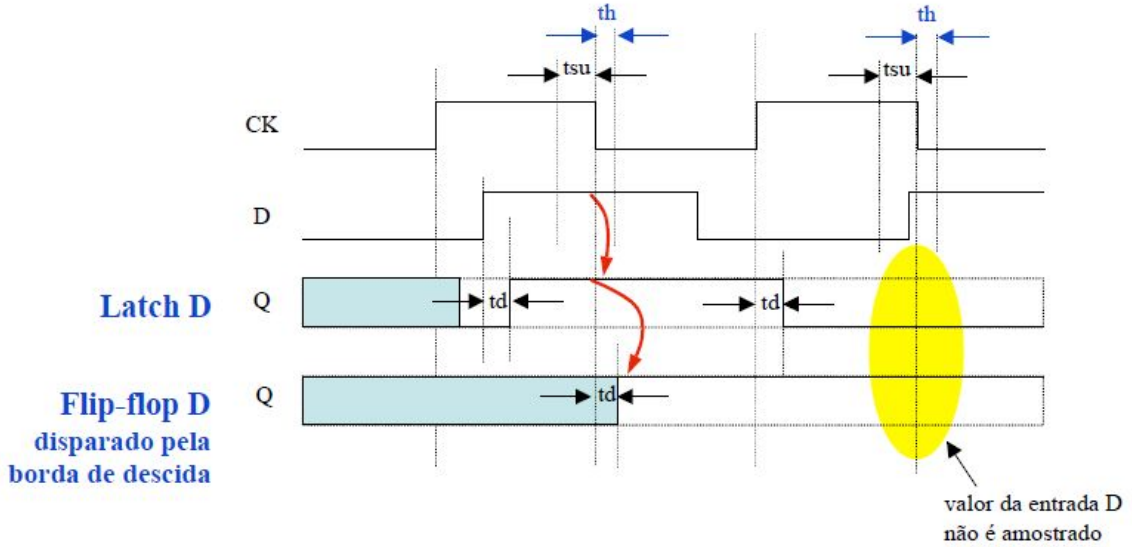


tabela de transição de estados

Latches, Flip-Flops e Registradores

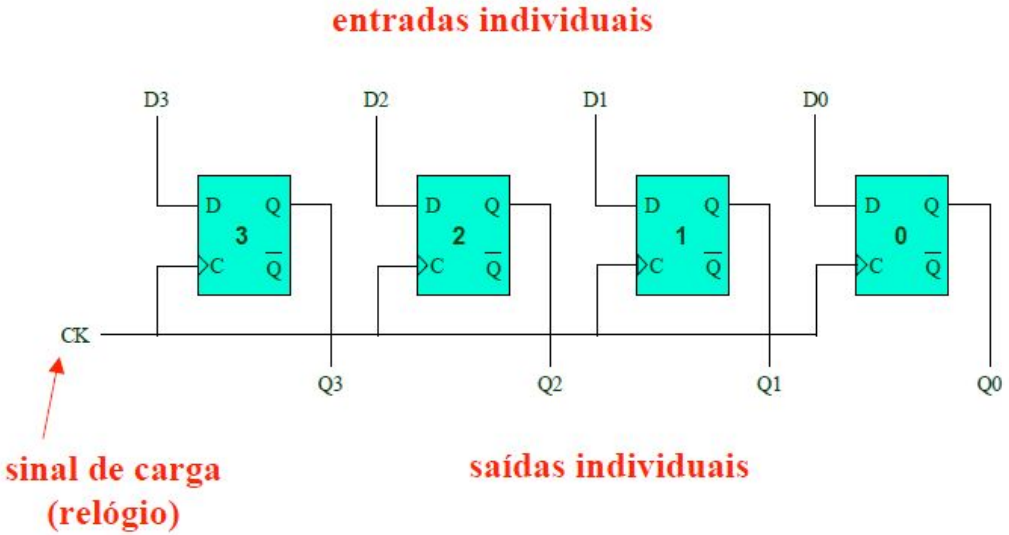
Tempo de Preparação - tp (*setup time*)
Tempo de Manutenção - tsu (*hold time*)
Atraso de Propagação - td ou tp (*propagation delay*)



Latches, Flip-Flops e Registradores

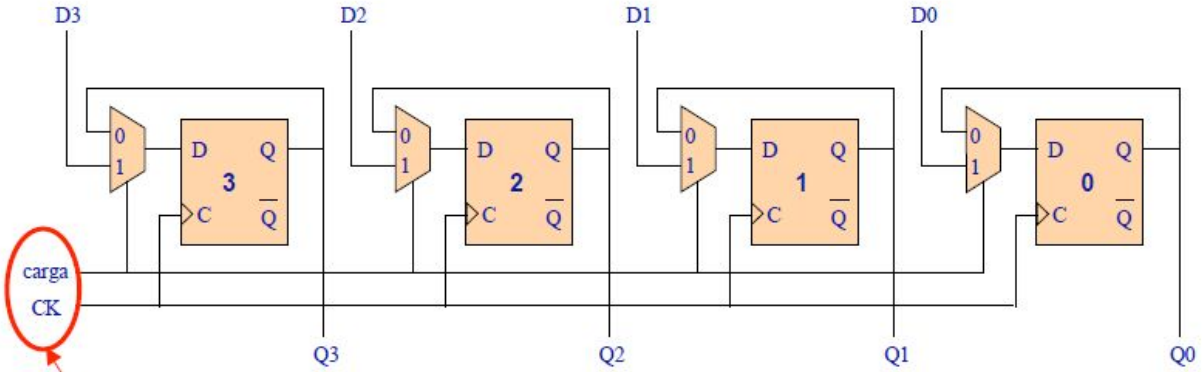
Registradores

Registrador com carga paralela (versão 1)



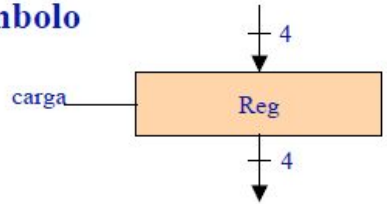
Latches, Flip-Flops e Registradores

Registrador com carga paralela (versão 2)



sinal de carga
separado do relógio

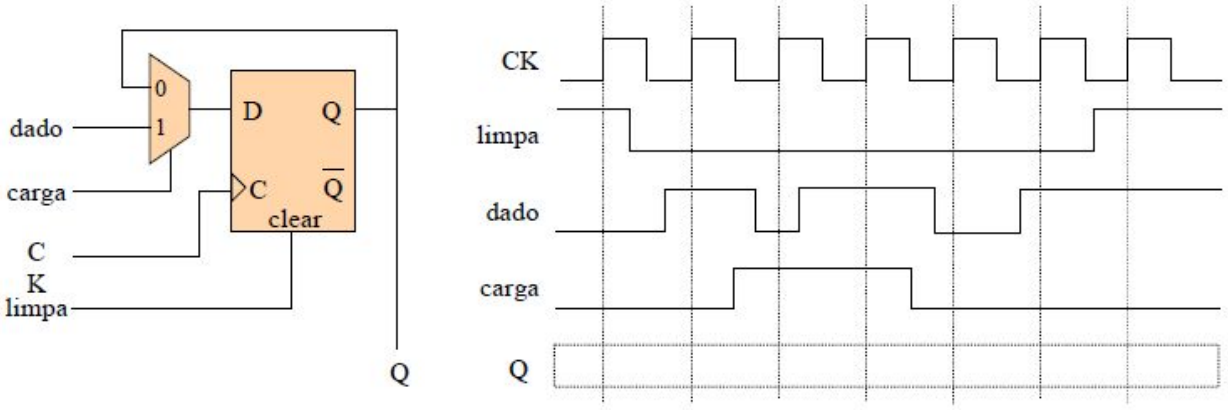
símbolo



Latches, Flip-Flops e Registradores

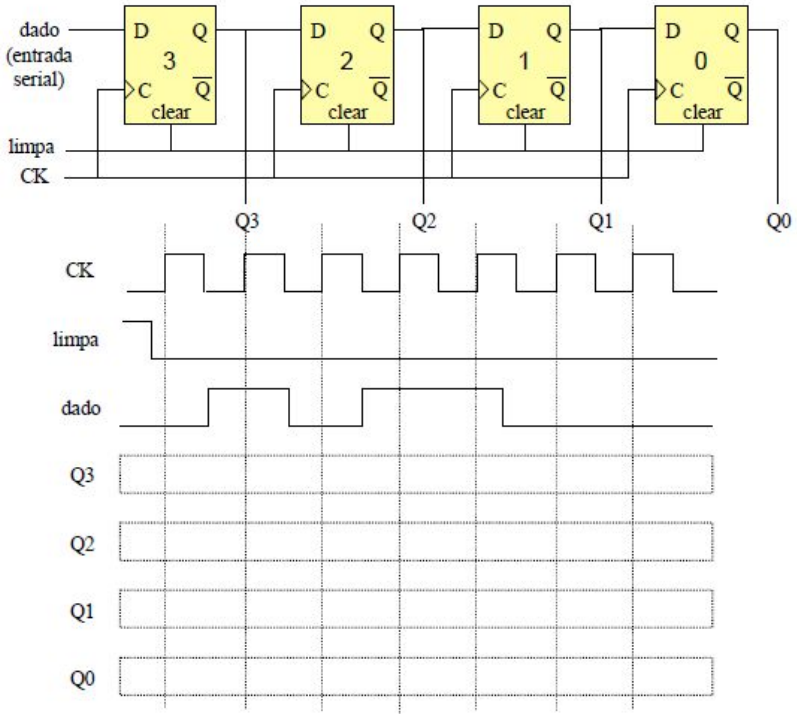
Registrador com carga paralela (versão 2)

Exemplo



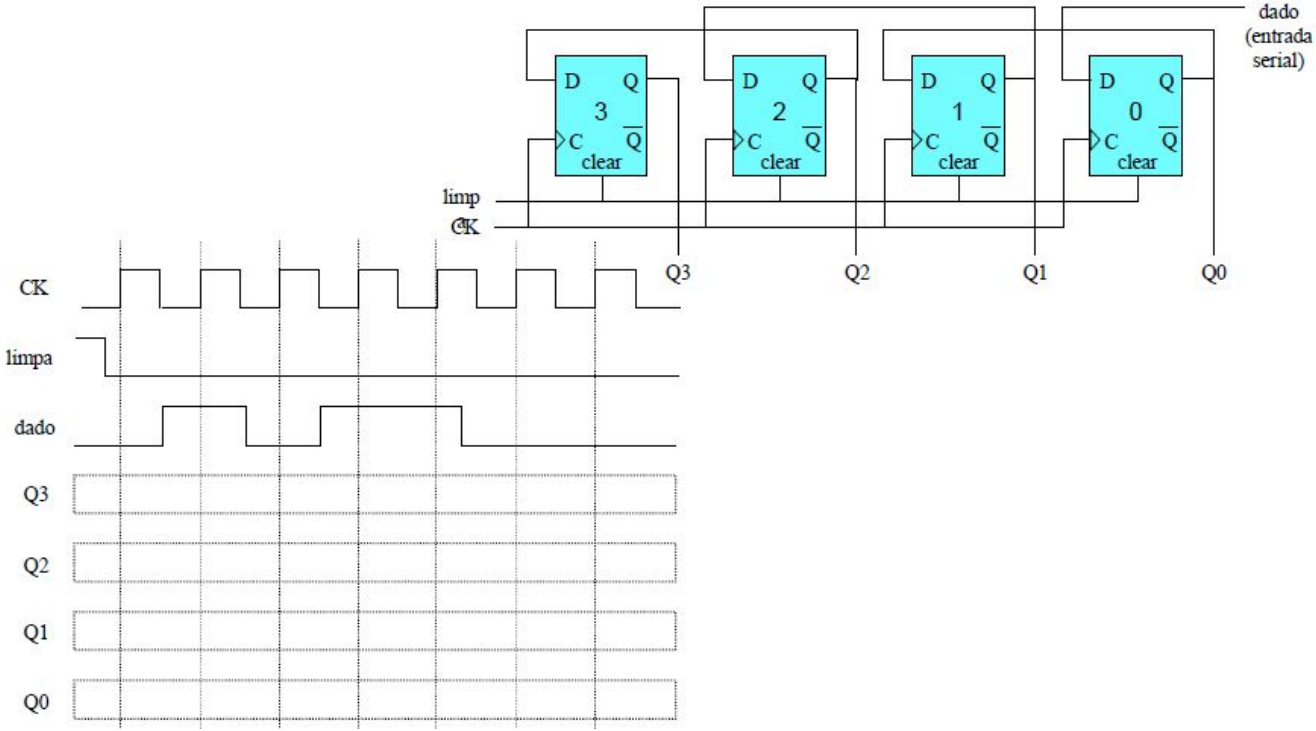
Latches, Flip-Flops e Registradores

Registrador de deslocamento (à direita)



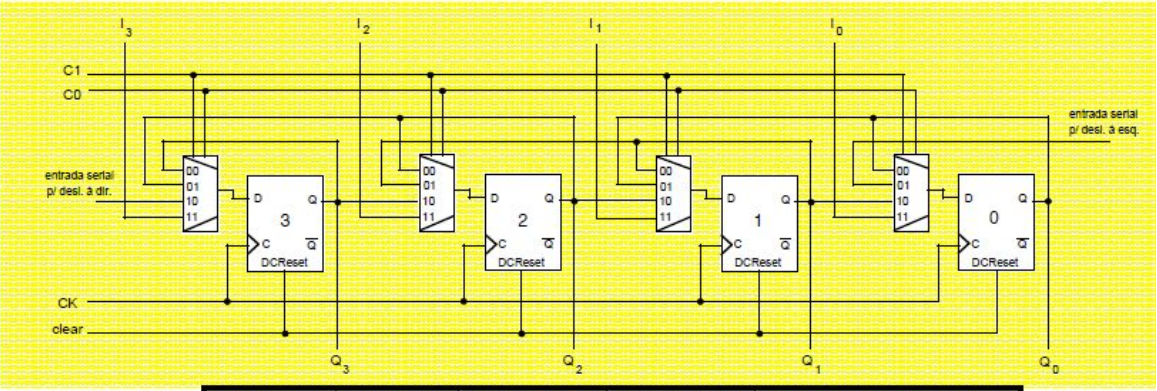
Latches, Flip-Flops e Registradores

Registrador de deslocamento (à esquerda)



Latches, Flip-Flops e Registradores

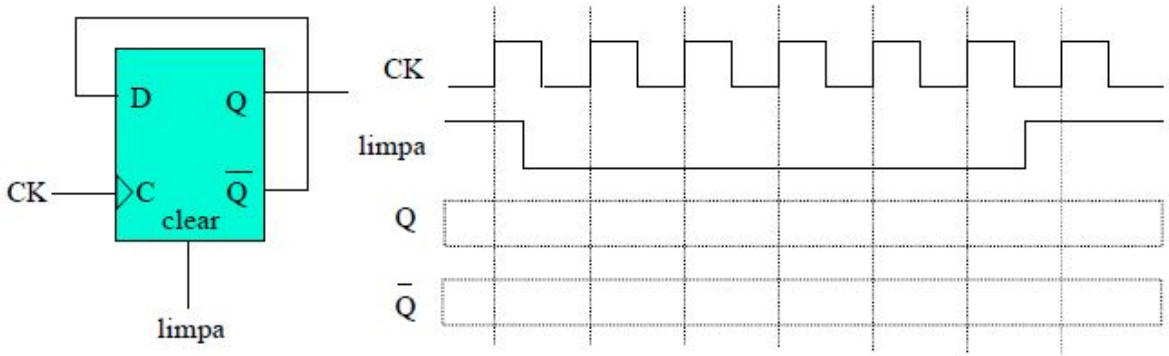
Registrador de deslocamento com carga paralela



clear	CK	C1	C0	operação
0	≠↑	X	X	mantém conteúdo
0	↑	0	0	mantém conteúdo
0	↑	0	1	desloca à esquerda
0	↑	1	0	desloca à direita
0	↑	1	1	carga paralela
1	X	X	X	zera conteúdo

Latches, Flip-Flops e Registradores

Registrador contador (1 bit)



Latches, Flip-Flops e Registradores

Registrador contador (3 bits)