EA772 Circuitos Lógicos
Prof. José Mario De Martino – Prova 02 – 1°. Semestre 2009

1.

	Entrada	
EA	x = 0	x = 1
A	F, 0	C, 0
B	H, 1	G, 1
C	H, 0	D, 1
D	B, 0	H, 0
E	B, 0	C, 0
F	C, 1	G, 1
G	H, 1	B, 1
H	C, 0	A, 1
	PE, z	

1- Equivalentes

P1 = (A, D, E) (B, F, G) (C, H)
A B C

	EA	x = 0	x = 1
A	A	B	C
	D	B	C
	E	B	C
B	B	C	B
	F	C	B
	G	C	B
C	C	C	A
	H	C	A
		PE	

2-Equivalentes

P = P1 = P2 = (A, D, E) (B, F, G) (C, H)
A B C

Tabela de estados mínima

	Entrada	
EA	x = 0	x = 1
A	B, 0	C, 0
B	C, 1	B, 1
C	C, 0	A, 1
	PE, z	

2.

a)

EA			PE
Q	S	R	D
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	X
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	X

D

	S´ R´	S´ R	S R	S R´
Q´	0	0	X	1
Q	1	0	X	1

$D_{sp} = S + Q\,R´$

	S´ R´	S´ R	S R	S R´
Q´	0	0	X	1
Q	1	0	X	1

$D_{ps} = R´\,(Q + S)$

Mesmo custo. Escolho arbitrariamente D_{sp}.

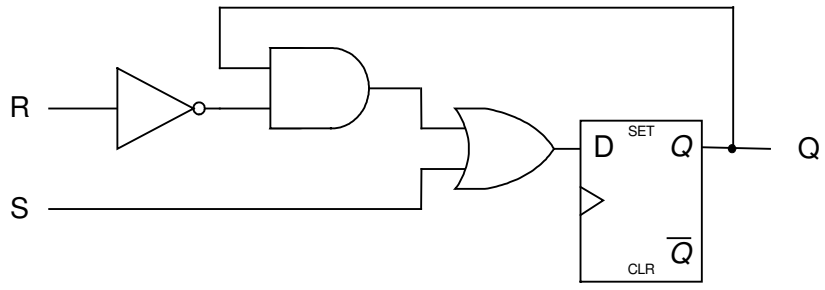

Figura 1: Diagrama esquemático do circuito do exercício 2.a.

b)

EA			PE
Q	J	K	D
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

D

	J´ K´	J´ K	J K	J K´
Q´	0	0	1	1
Q	1	0	0	1

$D_{sp} = Q´ J + Q K´$

	J´ K´	J´ K	J K	J K´
Q´	0	0	1	1
Q	1	0	0	1

$D_{ps} = (Q + J)\ (Q´ + K´)$

Mesmo custo. Escolho arbitrariamente D_{sp}.

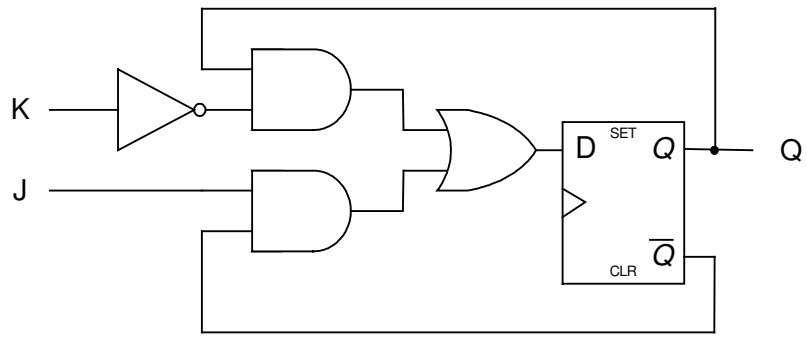

Figura 2: Diagrama esquemático do circuito do exercício 2.b.

3.

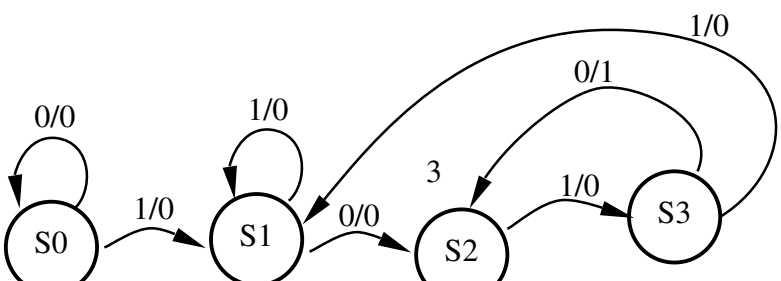

Figura 3: Diagrama de estados do reconhecedor do padrões do exercício 3.

Minimização dos estados

EA	x=0	x=1
S0	S0, 0	S1, 0
S1	S2, 0	S1, 0
S2	S4, 0	S3, 0
S3	S2, 1	S1, 0
S4	S0, 0	S1, 1
	PE, z	

P1 = (S0, S1, S2) (S3) (S4)

	EA	x=0	x=1
	S0	S0	S0
S0	S1	S0	S0
	S2	S4	S3
S3	S3	S0	S0
S4	S4	S0	S0
		PE	

P1 = (S0, S1) (S2) (S3) (S4)

	EA	x=0	x=1
S0	S0	S0	S0
	S1	S0	S2
S2	S2	S4	S3
S3	S3	S2	S0
S4	S4	S0	S0
		PE	

P1 = (S0) (S1) (S2) (S3) (S4)

Não há estados equivalentes, portanto, o sistema já tem um número mínimo de estados.

5 estados ⇒ 3 flip-flops

Codificação binária dos estados

	Código		
Estado	y_2	y_1	y_0
S0	0	0	0
S1	0	0	1
S2	0	1	0
S3	0	1	1
S4	1	0	0

Flip-flop JK

Q(t)	→	Q(t+1)	J	K
0	→	0	0	X
0	→	1	1	X
1	→	0	X	1
1	→	1	X	0

	PE			EA									
x	Q_2	Q_1	Q_0	Y_2	Y_1	Y_0	z	J_2	K_2	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	X	0	X	0	X
0	0	0	1	0	1	0	0	0	X	1	X	X	1
0	0	1	0	1	0	0	0	1	X	X	1	0	X
0	0	1	1	0	1	0	1	0	X	X	0	X	1
0	1	0	0	0	0	0	0	X	1	0	X	0	X
0	1	0	1	X	X	X	X	X	X	X	X	X	X
0	1	1	0	X	X	X	X	X	X	X	X	X	X
0	1	1	1	X	X	X	X	X	X	X	X	X	X
1	0	0	0	0	0	1	0	0	X	0	X	1	X
1	0	0	1	0	0	1	0	0	X	0	X	X	0
1	0	1	0	0	1	1	0	0	X	X	0	1	X
1	0	1	1	0	0	1	0	0	X	X	1	X	0
1	1	0	0	0	0	1	1	X	1	0	X	1	X
1	1	0	1	X	X	X	X	X	X	X	X	X	X
1	1	1	0	X	X	X	X	X	X	X	X	X	X
1	1	1	1	X	X	X	X	X	X	X	X	X	X

z

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	0	1	0
$x' Q_2$	0	X	X	X
$x Q_2$	1	X	X	X
$x Q'_2$	0	0	0	0

$z_{sp} = x Q_2 + x' Q_1 Q_0$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	0	1	0
$x' Q_2$	0	X	X	X
$x Q_2$	1	X	X	X
$x Q'_2$	0	0	0	0

$z_{ps} = (x' + Q_2) (x + Q_0) (x + Q_1)$

Escolho z_{sp} por ter menor custo.

J_2

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	0	0	1
$x' Q_2$	X	X	X	X
$x Q_2$	X	X	X	X
$x Q'_2$	0	0	0	0

$J_{2sp} = x' Q_1 Q'_0$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	0	0	1
$x' Q_2$	X	X	X	X
$x Q_2$	X	X	X	X
$x Q'_2$	0	0	0	0

$J_{2ps} = x' Q_1 Q'_0$

Expressões iguais.

K_2

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	X	X	X	X
$x' Q_2$	1	X	X	X
$x Q_2$	1	X	X	X
$x Q'_2$	X	X	X	X

$K_{2sp} = 1$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	X	X	X	X
$x' Q_2$	1	X	X	X
$x Q_2$	1	X	X	X
$x Q'_2$	X	X	X	X

$K_{2ps} = 1$

Expressões iguais.

J_1

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	1	X	X
$x' Q_2$	0	X	X	X
$x Q_2$	0	X	X	X
$x Q'_2$	0	0	X	X

$J_{1sp} = x' Q_0$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	1	X	X
$x' Q_2$	0	X	X	X
$x Q_2$	0	X	X	X
$x Q'_2$	0	0	X	X

$J_{1ps} = x' Q_0$

Expressões iguais.

K_1

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	X	X	0	1
$x' Q_2$	X	X	X	X
$x Q_2$	X	X	X	X
$x Q'_2$	X	X	1	0

$K_{1sp} = x Q_0 + x' Q'_0$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	X	X	0	1
$x' Q_2$	X	X	X	X
$x Q_2$	X	X	X	X
$x Q'_2$	X	X	1	0

$K_{1ps} = (x' + Q_0)\ (x + Q'_0)$

Mesmo custo. Escolho arbitrariamente Escolho K_{1sp}.

J_0

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	X	X	0
$x' Q_2$	0	X	X	X
$x Q_2$	1	X	X	X
$x Q'_2$	1	X	X	1

$J_{0sp} = x$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	0	X	X	0
$x' Q_2$	0	X	X	X
$x Q_2$	1	X	X	X
$x Q'_2$	1	X	X	1

$J_{0ps} = x$

Expressões iguais.

K_0

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	X	1	1	X
$x' Q_2$	X	X	X	X
$x Q_2$	X	X	X	X
$x Q'_2$	X	0	0	X

$K_{0sp} = x'$

	$Q'_1 Q'_0$	$Q'_1 Q_0$	$Q_1 Q_0$	$Q_1 Q'_0$
$x' Q'_2$	X	0	0	X
$x' Q_2$	X	X	X	X
$x Q_2$	X	X	X	X
$x Q'_2$	X	1	1	X

$K_{0ps} = x'$

Expressões iguais.

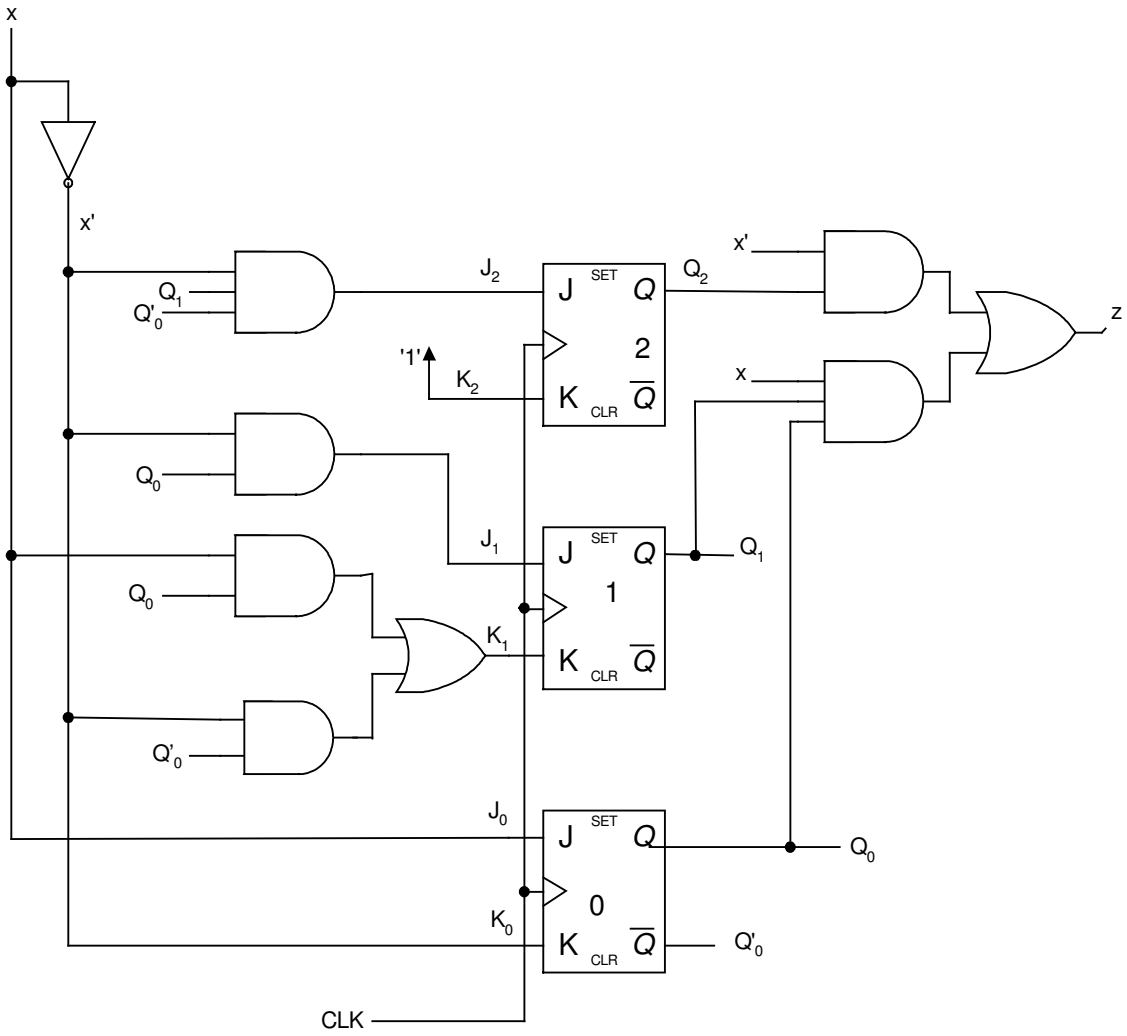

Figura 4: Diagrama esquemático do circuito do exercício 3.

4.

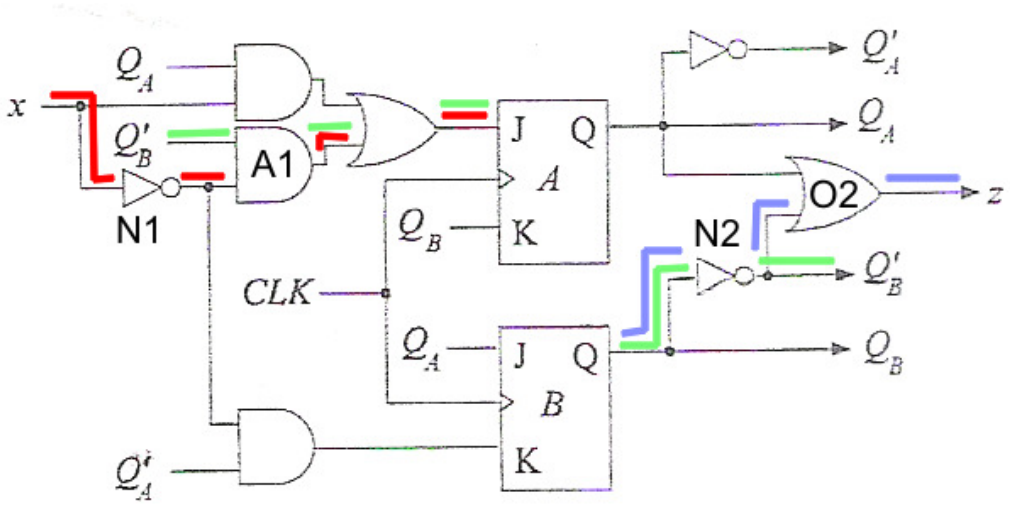

Figura 5: Identificação das portas e caminhos utilizados na solução do exercício 4.

$T_{min} = \max[t_a , t_b, t_c]$

Cálculo t_a

$ta = \max[t_{in} + t_{pLH}(O1) + t_{pLH}(A1) + t_{pLH}(N1) + t_{su}(FF),$
$t_{in} + t_{pHL}(O1) + t_{pHL}(A1) + t_{pHL}(N1) + t_{su}(FF)]$

$t_{pLH}(O1) = 0,12 + 0,037 . 1 = 0,157$ ns
$t_{pHL}(O1) = 0,20 + 0,019 . 1 = 0,219$ ns

$t_{pLH}(A1) = 0,15 + 0,037 . 1 = 0,187$ ns
$t_{pHL}(A1) = 0,16 + 0,017 . 1 = 0,177$ ns

$t_{pLH}(N1) = 0,02 + 0,038 . 2 = 0,096$ ns
$t_{pHL}(N1) = 0,05 + 0,017 . 2 = 0,084$ ns

$t_{in} + t_{pLH}(O1) + t_{pLH}(A1) + t_{pLH}(N1) + t_{su}(FF) = 2,0 + 0,157 + 0,187 + 0,096 + 0,3 = 2,74$ ns
$t_{in} + t_{pHL}(O1) + t_{pHL}(A1) + t_{pHL}(N1) + t_{su}(FF) = 2,0 + 0,219 + 0,177 + 0,084 + 0,3 = 2,78$ ns

$t_a = 2,78$ ns

Cálculo de t_b

$t_b = \max[t_{su}(FF) + t_{pLH}(O1) + t_{pLH}(A1) + t_{pLH}(N2) + tp_{HL}(FF),$
$t_{su}(FF) + t_{pHL}(O1) + t_{pHL}(A1) + t_{pHL}(N2) + tp_{LH}(FF)]$

$t_{pLH}(O1) = 0,12 + 0,037 . 1 = 0,157$ ns
$t_{pHL}(O1) = 0,20 + 0,019 . 1 = 0,219$ ns

$t_{pLH}(A1) = 0,15 + 0,037 . 1 = 0,187$ ns
$t_{pHL}(A1) = 0,16 + 0,017 . 1 = 0,177$ ns

$t_{pLH}(N2) = 0,02 + 0,038 . 2 = 0,096$ ns
$t_{pHL}(N2) = 0,05 + 0,017 . 2 = 0,084$ ns

$tp_{LH}(FF) = 0,49 + 0,038 . 2 = 0,566$ ns
$tp_{HL}(FF) = 0,54 + 0,019 . 2 = 0,578$ ns

$t_{su}(FF) + t_{pLH}(O1) + t_{pLH}(A1) + t_{pLH}(N2) + tp_{HL}(FF) = 0,3 + 0,157 + 0,187 + 0,096 + 0,578 = 1,318$ ns
$t_{su}(FF) + t_{pHL}(O1) + t_{pHL}(A1) + t_{pHL}(N2) + tp_{LH}(FF) = 0,3 + 0,219 + 0,177 + 0,084 + 0,566 = 1,346$ ns

$t_b = 1,346$ ns

Cálculo de t_c

$t_c = \max[\ t_{pLH}(O2) + t_{pLH}(N2) + tp_{HL}(FF) + t_{out},$
$t_{pHL}(O2) + t_{pHL}(N2) + tp_{LH}(FF) + t_{out}\ ]$

$t_{pLH}(O2) = 0,12 + 0,037 \cdot 10 = 0,49$ ns
$t_{pHL}(O2) = 0,20 + 0,019 \cdot 10 = 0,39$ ns

$t_{pLH}(N2) = 0,02 + 0,038 \cdot 2 = 0,096$ ns
$t_{pHL}(N2) = 0,05 + 0,017 \cdot 2 = 0,084$ ns

$tp_{LH}(FF) = 0,49 + 0,038 \cdot 2 = 0,566$ ns
$tp_{HL}(FF) = 0,54 + 0,019 \cdot 2 = 0,578$ ns

$t_{pLH}(O2) + t_{pLH}(N2) + tp_{HL}(FF) + t_{out} = 0,49 + 0,096 + 0,578 + 1,0 = 2,164$ ns
$t_{pHL}(O2) + t_{pHL}(N2) + tp_{LH}(FF) + t_{out} = 0,39 + 0,084 + 0,566 + 1,0 = 2,04$ ns

$t_c = 2,164$ ns

$T_{min} = 2,78$ ns

$f_{max} = (T_{min})^{-1} \cong 360$ MHz