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

1.

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

1- Equivalentes

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

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

2-Equivalentes

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

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

P = P3 = P2 = (A, C) (B, E) (D, H) (F) (G)
A B D F G

Tabela de estados mínima

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

2.

	EA			PE		
x	y_2	y_1	y_0	Y_2	Y_1	Y_0
0	0	0	0	0	0	0
0	0	0	1	0	0	1
0	0	1	0	0	1	0
0	0	1	1	0	1	1
0	1	0	0	1	0	0
0	1	0	1	1	0	1
0	1	1	0	1	1	0
0	1	1	1	x	x	x
1	0	0	0	0	0	1
1	0	0	1	0	1	0
1	0	1	0	0	1	1
1	0	1	1	1	0	0
1	1	0	0	1	0	1
1	1	0	1	1	1	0
1	1	1	0	0	0	0
1	1	1	1	x	x	x

Y_2

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	0	0
$x' y_2$	1	1	x	1
$x y_2$	1	1	x	0
$x y'_2$	0	0	1	0

$Y_{2sp} = x' y_2 + y_2 y'_1 + x y_1 y_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	0	0
$x' y_2$	1	1	x	1
$x y_2$	1	1	x	0
$x y'_2$	0	0	1	0

$Y_{2ps} = (x + y_2) (y_2 + y_1) (x' + y'_1 + y_0)$

Mesmo custo. Escolho arbitrariamente Y_{2sp}

Y_1

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	1	1
$x' y_2$	0	0	x	1
$x y_2$	0	1	x	0
$x y'_2$	0	1	0	1

$Y_{1sp} = x' y_1 + y'_2 y_1 y'_0 + x y'_1 y_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	1	1
$x' y_2$	0	0	x	1
$x y_2$	0	1	x	0
$x y'_2$	0	1	0	1

$Y_{1ps} = (y_1 + y_0) (x + y_1) (x' + y'_2 + y_0) (x' + y'_1 + y'_0)$

Escolho Y_{1sp} por ter menor custo (menor número de portas).

Y0

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	1	1	0
$x' y_2$	0	1	x	0
$x y_2$	1	0	x	0
$x y'_2$	1	0	0	1

$Y_{0sp} = x' y_0 + x\ y'_1 y'_0 + x\ y'_2 y'_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	1	1	0
$x' y_2$	0	1	x	0
$x y_2$	1	0	x	0
$x y'_2$	1	0	0	1

$Y_{0ps} = (x + y_0)\ (x' + y'_0)\ (y'_2 + y'_1)$

Escolho Y_{0ps} por ter menor custo (menor número de entradas).

Máquina de Moore saída igual ao estado.

$z_2 = y_2$
$z_1 = y_1$
$z_0 = y_0$

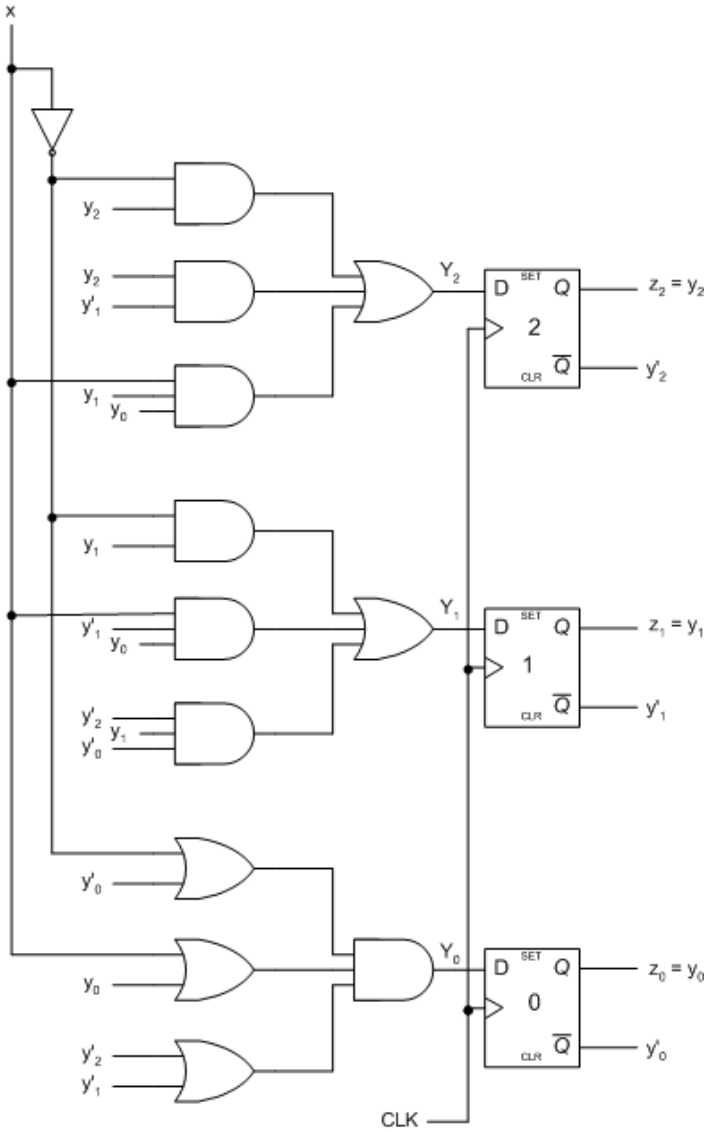

Figura 1: Diagrama esquemático do circuito do exercício 2.

3.

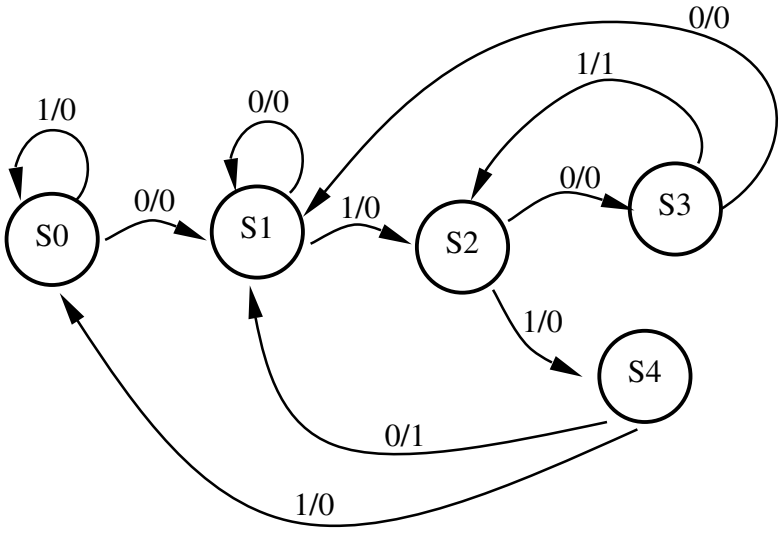

Figura 2: Diagrama de estados do reconhecedor do padrões do exercício 3.

|Minimização dos estados

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

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

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

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

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

5 estados $\Rightarrow$ 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)	$\rightarrow$	Q(t+1)	J	K
0	$\rightarrow$	0	0	X
0	$\rightarrow$	1	1	X
1	$\rightarrow$	0	X	1
1	$\rightarrow$	1	X	0

	PE			EA									
x	y_2	y_1	y_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	1	0	0	X	0	X	1	X
0	0	0	1	0	0	1	0	0	X	0	X	X	0
0	0	1	0	0	1	1	0	0	X	X	0	1	X
0	0	1	1	0	0	1	0	0	X	X	1	X	0
0	1	0	0	0	0	1	1	X	1	0	X	1	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	0	0	0	X	0	X	0	X
1	0	0	1	0	1	0	0	0	X	1	X	X	1
1	0	1	0	1	0	0	0	1	X	X	1	0	X
1	0	1	1	0	1	0	1	0	X	X	0	X	1
1	1	0	0	0	0	0	0	X	1	0	X	0	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

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	0	0
$x' y_2$	1	X	X	X
$x y_2$	0	X	X	X
$x y'_2$	0	0	1	0

$z_{sp} = x' y_2 + x y_1 y_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	0	0
$x' y_2$	1	X	X	X
$x y_2$	0	X	X	X
$x y'_2$	0	0	1	0

$z_{ps} = (x + y_2) (y'_1 + y_0) (x' + y_1)$

Escolho z_{sp} por ter menor custo.

J_2

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	0	0
$x' y_2$	X	X	X	X
$x y_2$	X	X	X	X
$x y'_2$	0	0	0	1

$J_{2sp} = x\ y_1\ y'_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	0	0
$x' y_2$	X	X	X	X
$x y_2$	X	X	X	X
$x y'_2$	0	0	0	1

$J_{2ps} = x\ y_1\ y'_0$

Expressões iguais.

K_2

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	X	X	X	X
$x' y_2$	1	X	X	X
$x y_2$	1	X	X	X
$x y'_2$	X	X	X	X

$K_{2sp} = 1$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	X	X	X	X
$x' y_2$	1	X	X	X
$x y_2$	1	X	X	X
$x y'_2$	X	X	X	X

$K_{2ps} = 1$

Expressões iguais.

J_1

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	X	X
$x' y_2$	0	X	X	X
$x y_2$	0	X	X	X
$x y'_2$	0	1	X	X

$J_{1sp} = x\ y_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	0	0	X	X
$x' y_2$	0	X	X	X
$x y_2$	0	X	X	X
$x y'_2$	0	1	X	X

$J_{1ps} = x\ y_0$

Expressões iguais.

K_1

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	X	X	1	0
$x' y_2$	X	X	X	X
$x y_2$	X	X	X	X
$x y'_2$	X	X	0	1

$K_{1sp} = x' y_0 + x y'_0$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	X	X	1	0
$x' y_2$	X	X	X	X
$x y_2$	X	X	X	X
$x y'_2$	X	X	0	1

$K_{1ps} = (x + y_0)\ (x' + y'_0)$

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

J_0

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	1	X	X	1
$x' y_2$	1	X	X	X
$x y_2$	0	X	X	X
$x y'_2$	0	X	X	0

$J_{0sp} = x'$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	1	X	X	1
$x' y_2$	1	X	X	X
$x y_2$	0	X	X	X
$x y'_2$	0	X	X	0

$J_{0ps} = x'$

Expressões iguais.

K_0

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	X	0	0	X
$x' y_2$	X	X	X	X
$x y_2$	X	X	X	X
$x y'_2$	X	1	1	X

$K_{0sp} = x$

	$y'_1 y'_0$	$y'_1 y_0$	$y_1 y_0$	$y_1 y'_0$
$x' y'_2$	X	0	0	X
$x' y_2$	X	X	X	X
$x y_2$	X	X	X	X
$x y'_2$	X	1	1	X

$K_{0ps} = x$

Expressões iguais.

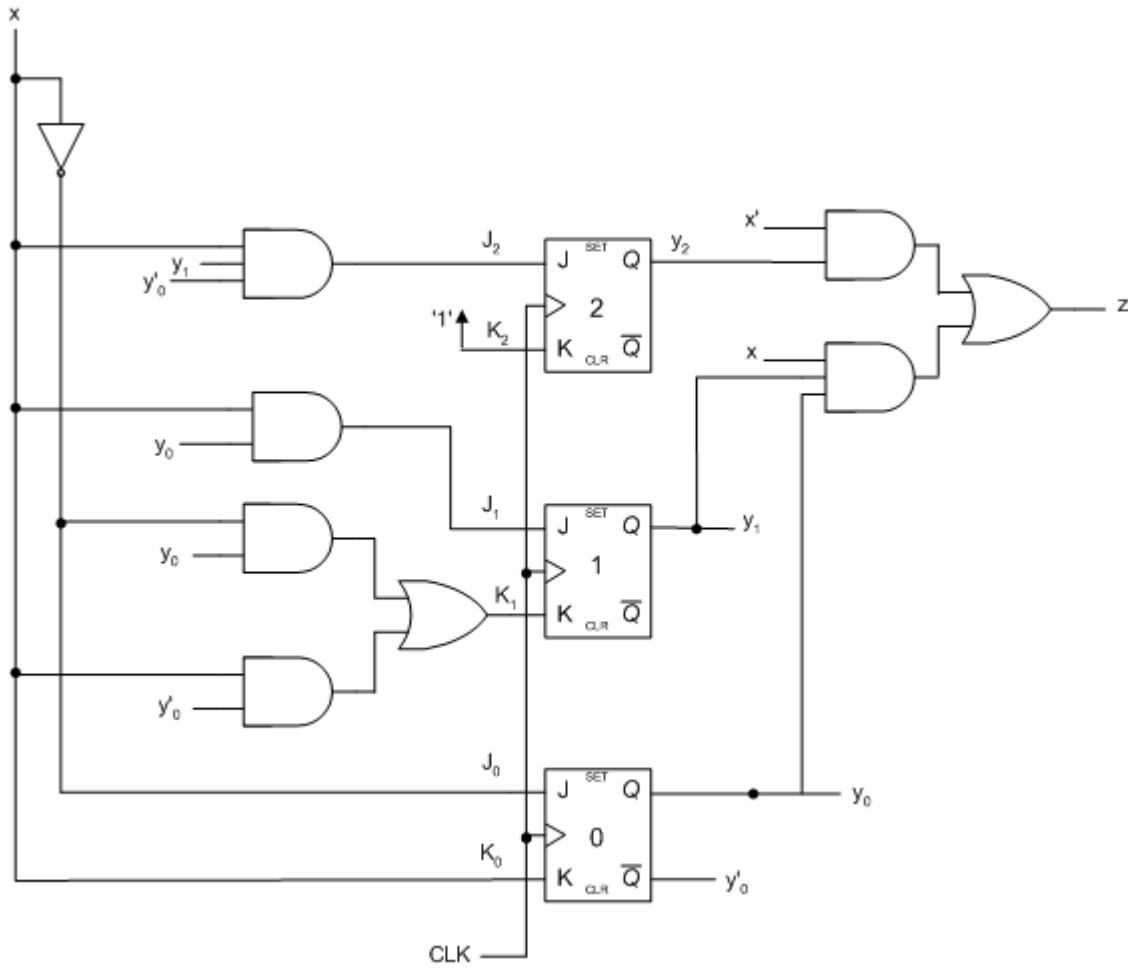

Figura 3: Diagrama esquemático do circuito do exercício 3.

4.

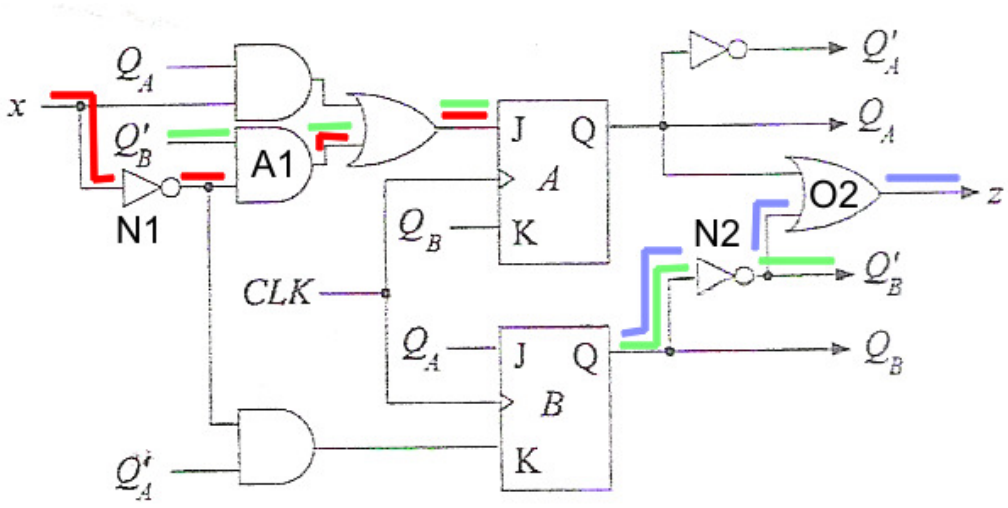

Figura 4: Identificação das portas e caminhos utilizados na solução do exercício 4.

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

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

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

$t_a = 2,78$ ns

Cálculo de t_b

$t_b = \max[t_{su}(FF) + t_{pLH}(O1) + t_{pLH}(A1) + t_{pLH}(N2) + tp_{HL}(FF),$
$t_{su}(FF) + t_{pHL}(O1) + t_{pHL}(A1) + t_{pHL}(N1) + tp_{LH}(FF)]$

$t_{pLH}(O1) = 0,12 + 0,037 . 1 = 0,157$ 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
$t_{su}(FF) + t_{pHL}(O1) + t_{pHL}(A1) + t_{pHL}(N1) + tp_{LH}(FF) = 0,3 + 0,219 + 0,177 + 0,084 + 0,566 = 1,346$ ns

$t_b = 1,346$ ns

Cálculo de t_c

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

$t_{pLH}(O2) = 0,12 + 0,037 \cdot 5 = 0,305$ ns
$t_{pHL}(O2) = 0,20 + 0,019 \cdot 5 = 0,295$ 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

$t_{pLH}(O2) + t_{pLH}(N2) + tp_{HL}(FF) + t_{out} = 0,305 + 0,096 + 0,578 + 2,0 = 2,979$ ns
$t_{pHL}(O2) + t_{pHL}(N2) + tp_{LH}(FF) + t_{out} = 0,295 + 0,084 + 0,566 + 2,0 = 2,945$ ns

$t_c = 2,979$ ns

$T_{min} = 2,979$ ns

$f_{max} = (T_{min})^{-1} \cong 336$ MHz