Logică computațională
Curs 13

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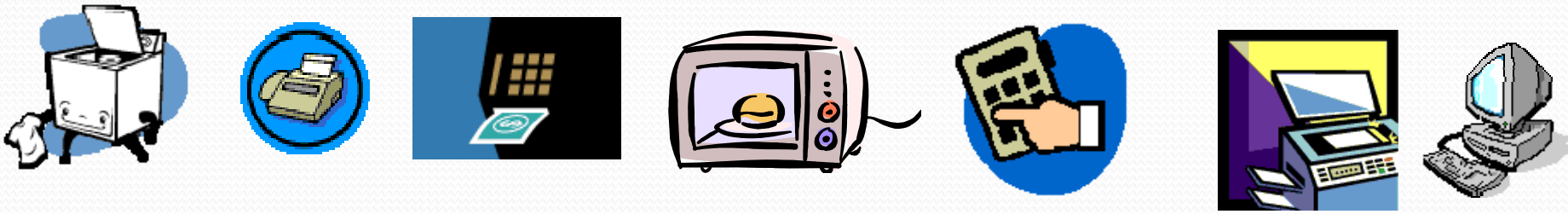
Circuite logice

- circuite electronice simple

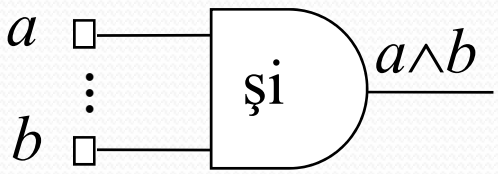


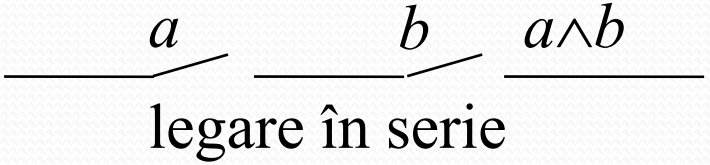
- modelarea – se face cu ajutorul *funcţiilor booleene* şi a *circuitelor logice* care descriu algebric şi grafic funcţionarea acestora.

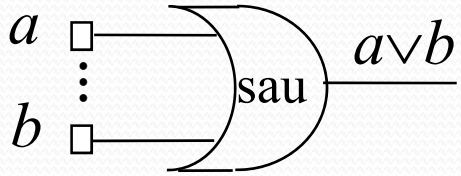
Porțile logice

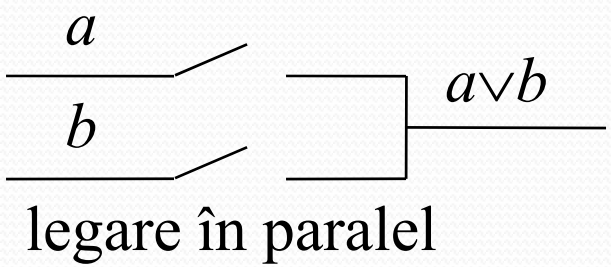
- sunt elementele de bază ale unui circuit logic
- sunt utilizate pentru modelarea circuitelor
- **Definiție:** O ***poartă*** este un minicircuit logic care realizează una dintre operaţiile logice de bază: $\wedge$, $\vee$, $\bar{}$.

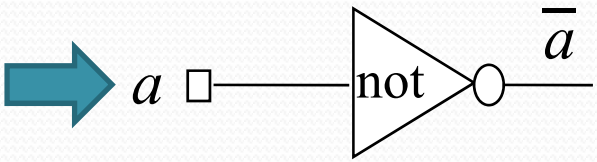
Porțile logice – conform standardelor IEEE









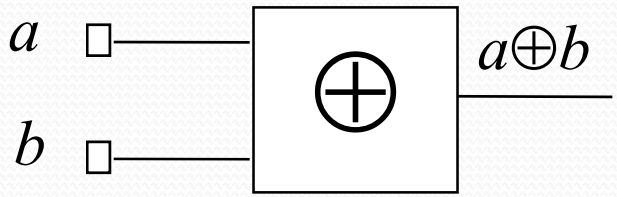


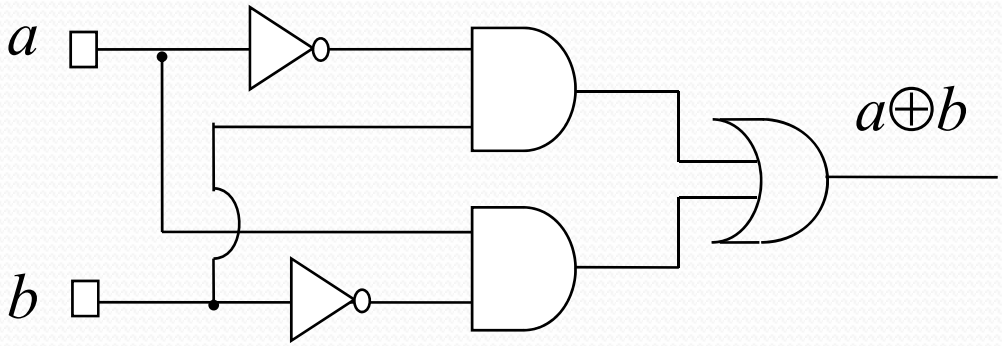
Circuite integrate

- 14-16 ”pini”
  - o parte porți de intrare
  - o parte sunt utilizate pentru conexiunea la curent

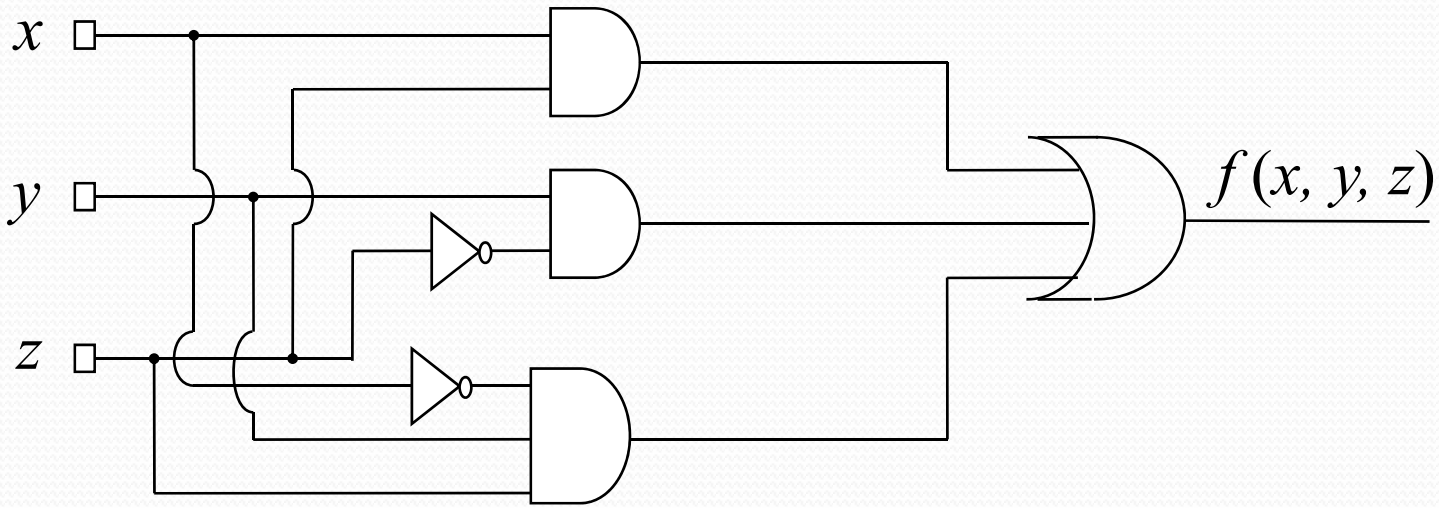
- Observație: forma disjunctivă este cel mai simplu de realizat

Exercițiu



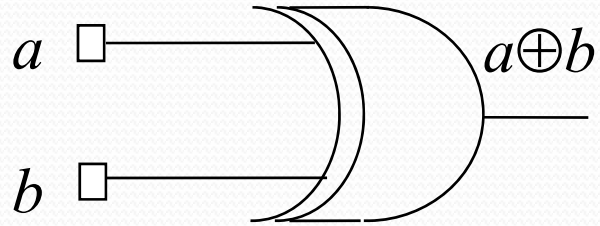


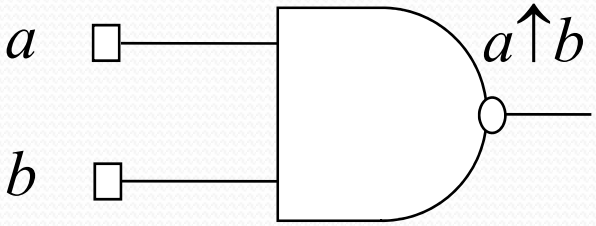
Exercițiu

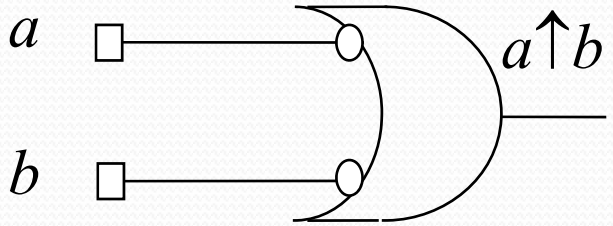


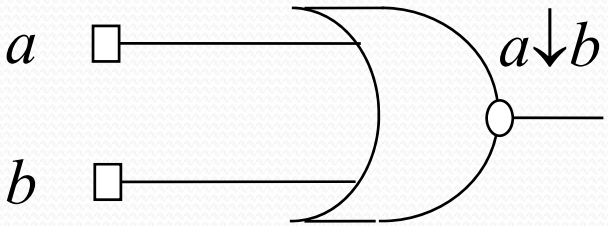
$$f(x, y, z) = x\,z \vee y\,\bar{z} \vee \bar{x}\,y\,z$$

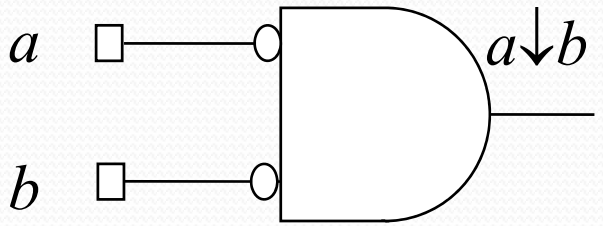
Porți derivate





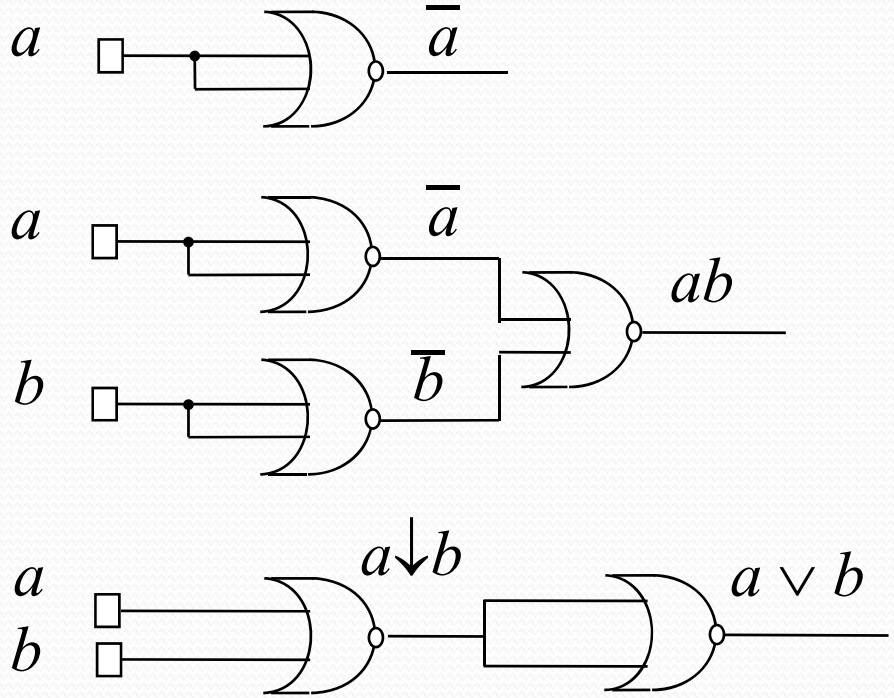






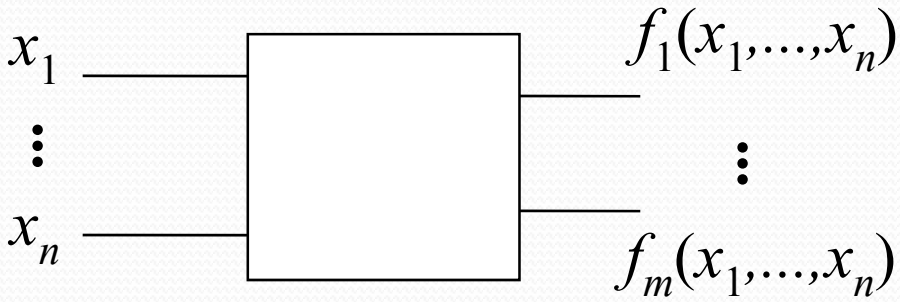
Exercițiu

- Desenați circuitele operaţiilor logice „şi”, „sau”, „not” folosind doar poartă „nor” / „nand”



Circuit combinațional

- Un circuit logic cu *m* ieşiri se numeşte ***circuit combinaţional***.



Circuite logice combinaționale ∈ Hard-ul calculatorului

- decodorul
- codorul
- circuitul comparator
- circuitul sumator

- detectorul de paritate
- ”shift”
- …

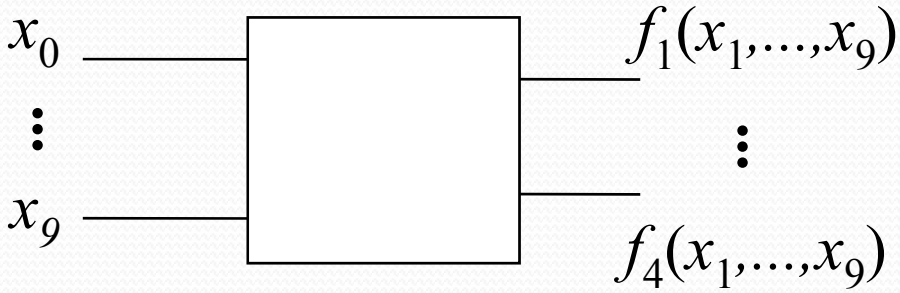
Pașii principali pentru desenarea circuitelor

1. identificarea intrărilor (variabilelor) / ieșirilor (funcțiilor)
2. construirea tabelei de valori asociate
3. obținerea expresiilor funcțiilor
4. simplificarea funcțiilor
5. desenarea circuitului

Codorul

- este circuitul binar de codificare a cifrelor zecimale

1.



2. Tabela de valori

Cifră zecimală	x_0	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	f_1	f_2	f_3	f_4
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	1	0	0	0	0	0	0	0	0	0	1	0
3	0	0	0	1	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	1	0	0	0	0	0	0	1	0	0
5	0	0	0	0	0	1	0	0	0	0	0	1	0	1
6	0	0	0	0	0	0	1	0	0	0	0	1	1	0
7	0	0	0	0	0	0	0	1	0	0	0	1	1	1
8	0	0	0	0	0	0	0	0	1	0	1	0	0	0
9	0	0	0	0	0	0	0	0	0	1	1	0	0	1

3. Expresiile funcțiilor

- $f_1(x_0,\ldots,x_9) = x_8 \vee x_9$
- $f_2(x_0,\ldots,x_9) = x_4 \vee x_5 \vee x_6 \vee x_7$
- $f_3(x_0,\ldots,x_9) = x_2 \vee x_3 \vee x_6 \vee x_7$
- $f_4(x_0,\ldots,x_9) = x_1 \vee x_3 \vee x_5 \vee x_7 \vee x_9$

4. –
5. …

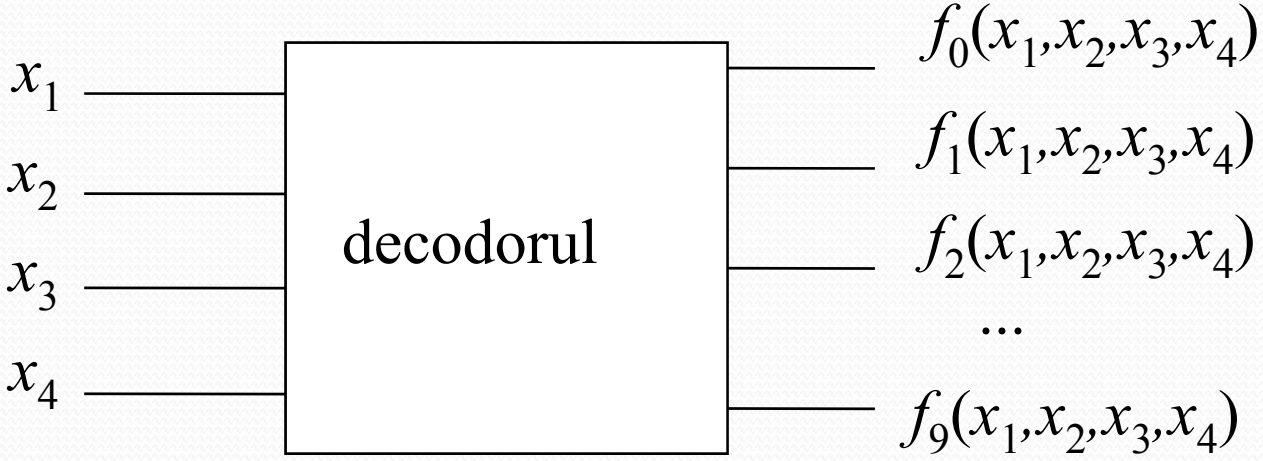
Decodorul

- inversul codorului
- intrare: 4 cifre binare - x_1, x_2, x_3, x_4
- ieșire: $f_i(x_1, x_2, x_3, x_4) = 1$ pentru $x_1x_2x_3x_4{}_{(2)} = i_{(10)}$, $i = \overline{0, 9}$

Decodorul (2)

x_1	x_2	x_3	x_4	f_0	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	FCD (cu un singur element)
0	0	0	0	1	0	0	0	0	0	0	0	0	0	$f_0(x_1,x_2,x_3,x_4) = \overline{x}_1\overline{x}_2\overline{x}_3\overline{x}_4$
0	0	0	1	0	1	0	0	0	0	0	0	0	0	$f_1(x_1,x_2,x_3,x_4) = \overline{x}_1\overline{x}_2\overline{x}_3x_4$
0	0	1	0	0	0	1	0	0	0	0	0	0	0	$f_2(x_1,x_2,x_3,x_4) = \overline{x}_1\overline{x}_2x_3\overline{x}_4$
0	0	1	1	0	0	0	1	0	0	0	0	0	0	$f_3(x_1,x_2,x_3,x_4) = \overline{x}_1\overline{x}_2x_3x_4$
0	1	0	0	0	0	0	0	1	0	0	0	0	0	$f_4(x_1,x_2,x_3,x_4) = \overline{x}_1x_2\overline{x}_3\overline{x}_4$
0	1	0	1	0	0	0	0	0	1	0	0	0	0	$f_5(x_1,x_2,x_3,x_4) = \overline{x}_1x_2\overline{x}_3x_4$
0	1	1	0	0	0	0	0	0	0	1	0	0	0	$f_6(x_1,x_2,x_3,x_4) = \overline{x}_1x_2x_3\overline{x}_4$
0	1	1	1	0	0	0	0	0	0	0	1	0	0	$f_7(x_1,x_2,x_3,x_4) = \overline{x}_1x_2x_3x_4$
1	0	0	0	0	0	0	0	0	0	0	0	1	0	$f_8(x_1,x_2,x_3,x_4) = x_1\overline{x}_2\overline{x}_3\overline{x}_4$
1	0	0	1	0	0	0	0	0	0	0	0	0	1	$f_9(x_1,x_2,x_3,x_4) = x_1\overline{x}_2\overline{x}_3x_4$

Circuitul decodor – forma generală

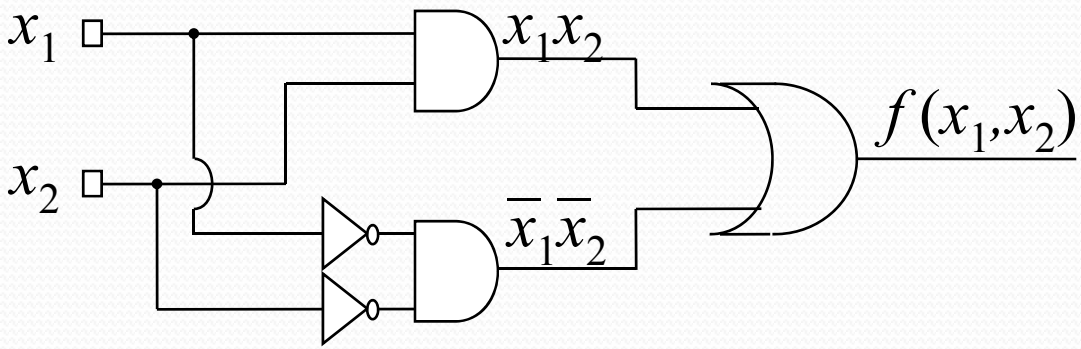


Circuitul comparator

- verifică dacă două cifre binare sunt sau nu identice

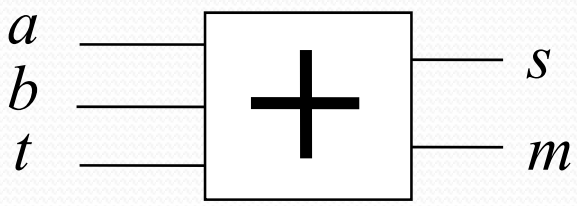
x_1	x_2	$f(x_1,x_2)$
0	0	1
0	1	0
1	0	0
1	1	1

$$f(x_1,x_2)= \overline{x}_1\overline{x}_2 \vee x_1x_2$$



Sumatorul binar

- calculează suma a două cifre binare: *a* şi *b* de pe aceeaşi poziţie dintr-un număr binar
- intrare: *a*, *b*, transportul *t*
- ieșire: *s* (= *a* + *b*), transportul *m*



$$s(a,b,t) = \overline{t}\ \overline{a}b \vee \overline{t}\, a\overline{b} \vee t\overline{a}\ \overline{b} \vee tab$$

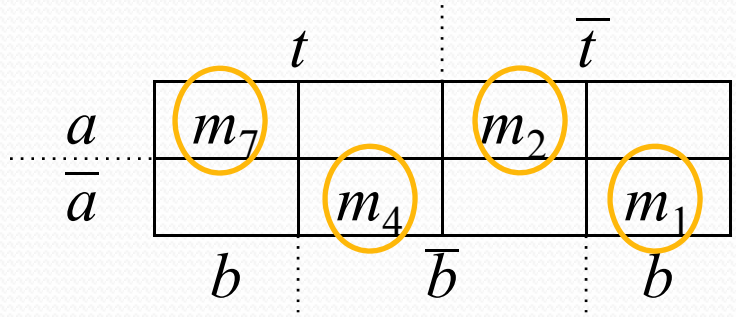
$$m(a,b,t) = \overline{t}\, ab \vee t\overline{a}\ b \vee ta\overline{b} \vee tab$$

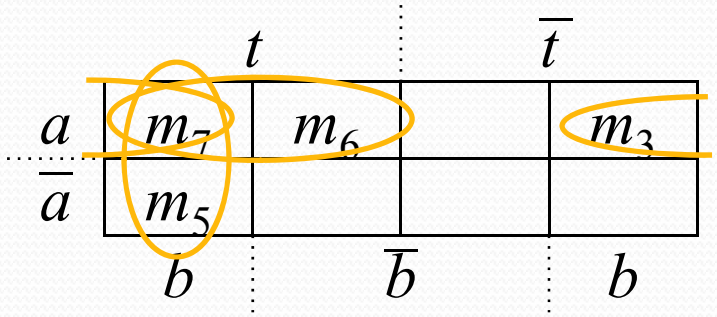
t	*a*	*b*	*s*	*m*
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Simplificarea

$$m(a,b,t)= \overline{t}\,ab \vee t\overline{a}\,b \vee ta\overline{b} \vee tab$$

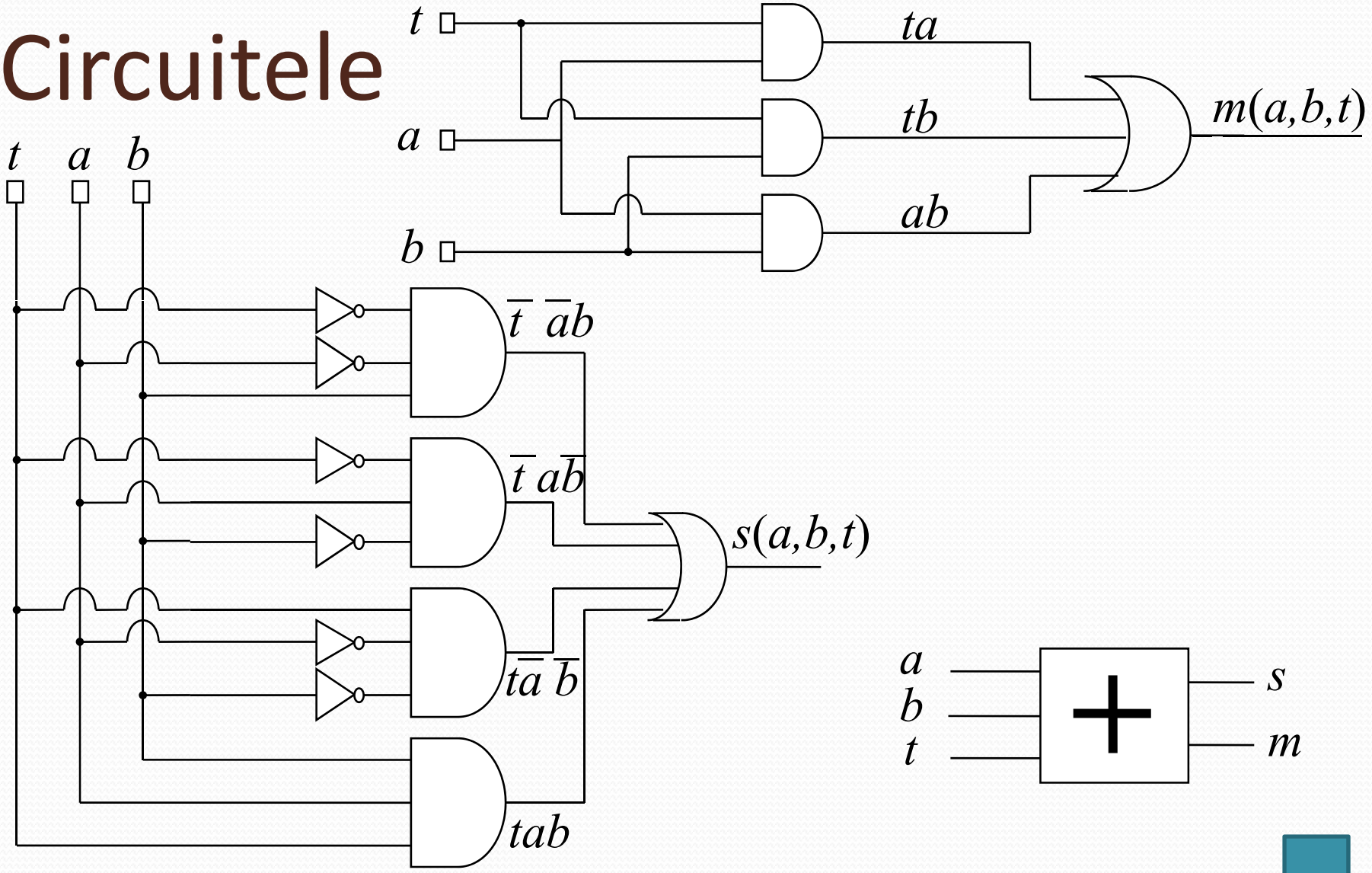
$$s(a,b,t)= \overline{t}\;\overline{a}b \vee \overline{t}\,a\overline{b} \vee t\overline{a}\,\overline{b} \vee tab$$





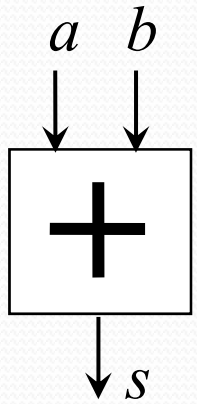
$$m(a,b,t)= ta \vee tb \vee ab$$

Circuitele

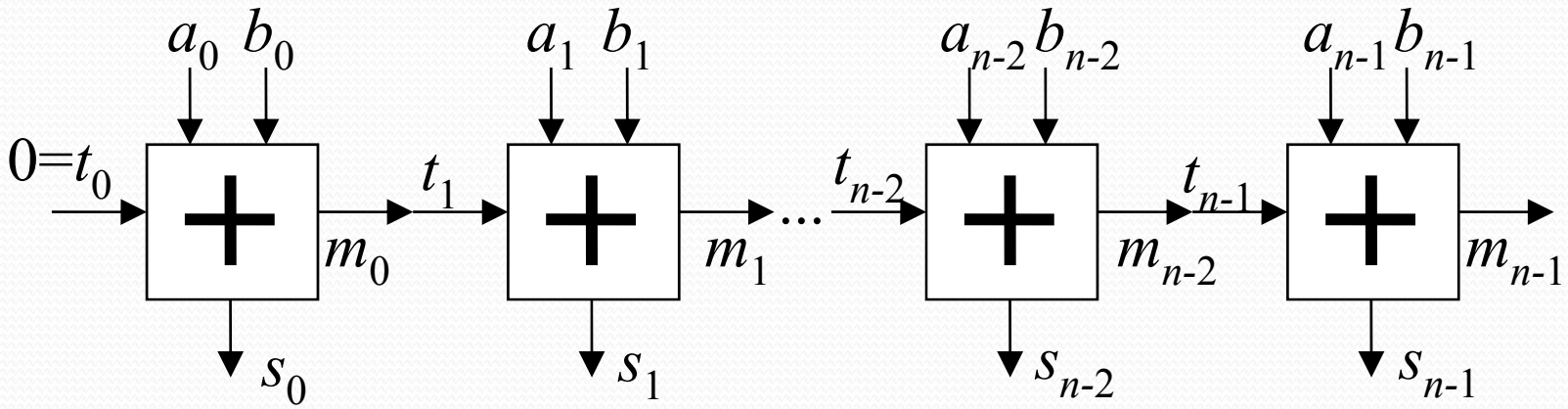


Sumatorul binar cu *n* poziții

- $a = a_{n-1} \ldots a_{0\,(2)}$ și $b = b_{n-1} \ldots b_{0\,(2)}$
- $s = s_{n-1} \ldots s_{0\,(2)}$

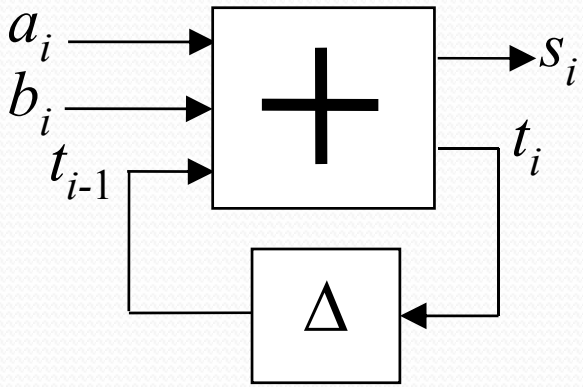


Compunere de sumatoare simple



Circuit cu întârziere

- cifra de transport obţinută la un pas se foloseşte în pasul următor



Indicații ”anti încâlcire”