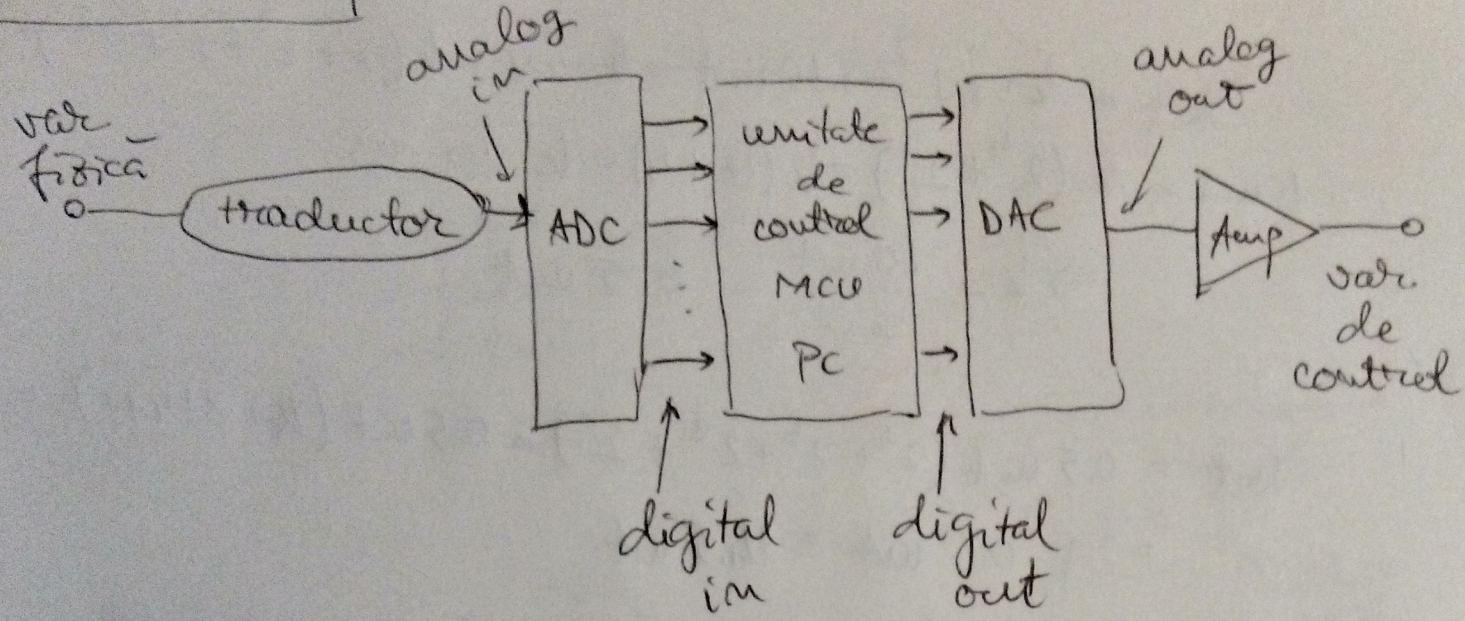
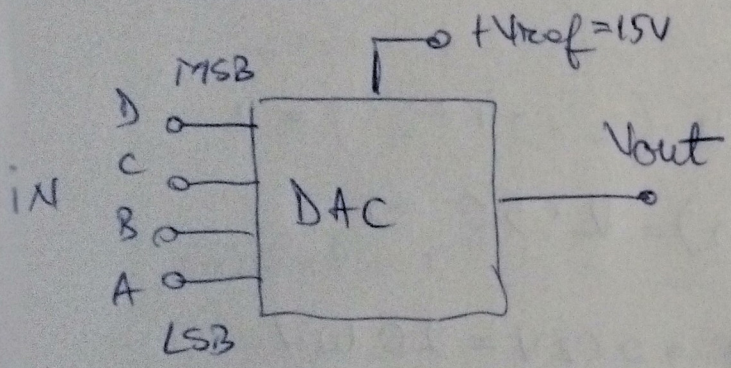
CURS 11 SIS



Conversia digital-analogică:



$V_{out} = K \cdot IN_{Digital}$

$[K] = V, A.$

Full-scale output: A_{fs}.

DCBA	Vout (V)
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

$K = 1$; $K = f(V_{ref})$.

(P1.) DAC pe 5 biți cu output în curent.

I_{out} = 10 mA pt. 10100 = IN

I_{out} = ? pt. IN = 11101

$I_{out} = k \cdot iN \Rightarrow$ ~~$I_{out} = k \cdot iN = k(2^4+2^3+2^2+2^0)$~~.

$10mA = k(2^4+2^2) = k(16+4) = k \cdot 20 \Rightarrow$

$\Rightarrow k = \frac{10mA}{20} = 0.5mA$

$I_{out} = 0.5mA(2^4+2^3+2^2+2^0) = 0.5mA(16+8+4+1) =$

$= 29 \cdot 0.5mA = 14.5mA$

(P2) DAC pe 8 biți ; $V_{out} = 1V$ pt. $iN = 00110010$.

$A_{fs} = ?$

$V_{out} = k \cdot iN \Rightarrow 1V = k \cdot (2^5+2^4+2^1) \Rightarrow$

$\Rightarrow 1V = k(32+16+2) = k \cdot 50 \Rightarrow$

$\Rightarrow k = \frac{1}{50} V = 0.02V = 20mV.$

$A_{fs} = V_{out}^{max} = 20mV(11111111) = 20mV \cdot 255 =$

$= 5.1V$

) Ponderea intrărilor:

D	C	B	A	
0	0	0	1	1V
0	0	1	0	2V
0	1	0	0	4V
1	0	0	0	8V

(P3) DAC 5 biți | $V_{out} = 0.2V$ pt. $iN = 00001$

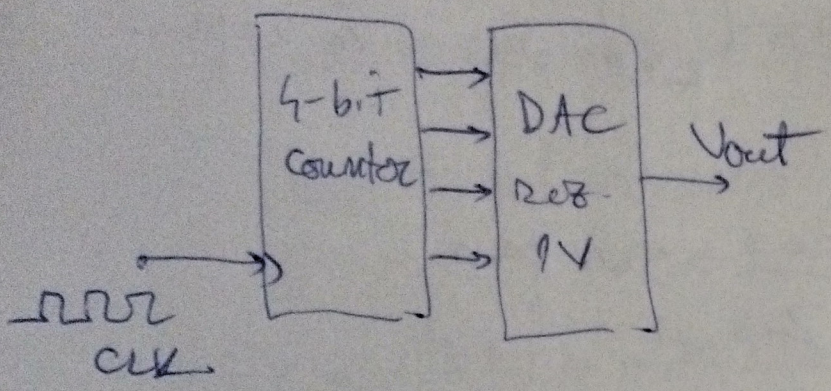
$A_{fs} = ?$

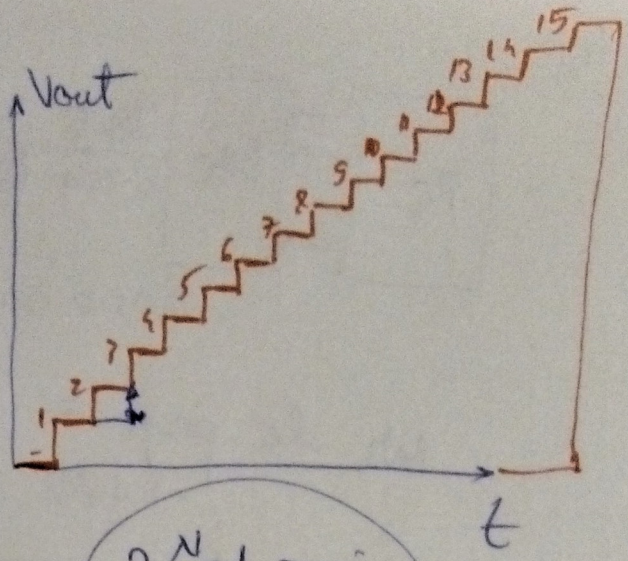
$A_{fs} \rightarrow 11111$

$A_{fs} = 0.2V + 0.4V + 0.8V + 1.6V + 3.2V =$

$= 6.2V$

Rezoluția (step size):





$2^N - 1$ pași ← step size.

$$\text{Rezoluția} = K = \frac{A_{fs}}{2^N - 1}$$

N - nr de biți.

$$\text{Rezoluția (\%)} = \frac{\text{step size}}{A_{fs}} \cdot 100\%$$

$$\text{Rezoluția (\%)} = \frac{\cancel{\text{step size}}}{\cancel{\text{step size}} \times \text{nr. de pași}} \Rightarrow$$

$$\Rightarrow \boxed{\text{Rezoluția (\%)} = \frac{1}{2^N - 1}}$$

Ex:

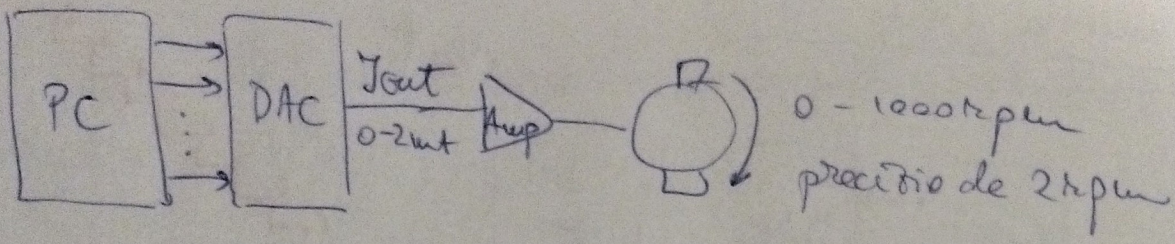
step = 1V

$A_{fs} = 15V$

$$\text{Rez (\%)} = \frac{1}{15} \cdot 100\% = 0.06666 \cdot 100\%$$

$$\text{Rez (\%)} = 6.67\%$$

P4.



Nr. de pași $= \frac{1000}{2} = 500$ pași

$2^N - 1 \geq 500 \Rightarrow$ 9 biți minim $\Rightarrow$

$\Rightarrow 2^9 - 1 = 511$ pași

precizia $\frac{1000}{511} = 1.96$ rpm

DAC → output negativ.

ex: 8 biți, MSB → bit de semn.

1 → +
0 → −

11111111 → +Vref	128
10000000 → 0	0
00000000 → −Vref	−127

a) Acuratețea: (Y.FS).

- full-scale error

0,01Y.FS. } → 0.01Y. × 9.375V = ±0.9375mV

$A_{fs} = 9.375V$

- linearity error

0.01Y.FS.

$A_{fs} = 9.375V$; step size ± 0.9375 mV.

5) DAC 8 biți

$A_{fs} = 2\,mA$

full-scale error: 0.5% FS

$I_{out} = ? \pm ?$ pt. $iN = 1000\,0000$

$$k = \frac{A_{fs}}{2^{N-1}} = \frac{2\,mA}{255} = 7.84\,\mu A$$

$I_{out} = k \cdot 128 \cong 1004\,\mu A$

eroarea: $\pm 0.5\% \times 2\,mA = \pm 10\,\mu A$

$I_{out} = 1004\,\mu A \pm 10\,\mu A = 994\,\mu A - 1014\,\mu A$

i) Eroarea de offset:

DAC offset error 2 mV.

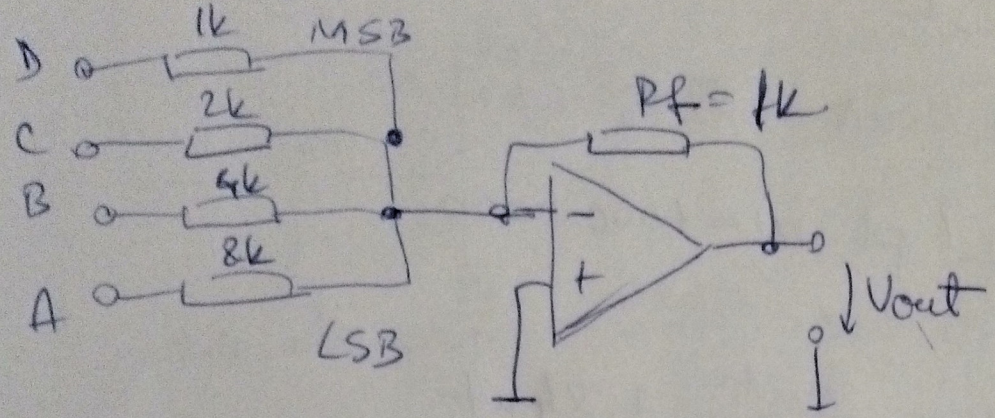
output ideal 100 mV → output real 102 mV

offset error → + / −

i) timp de stabilizare (settling time)
→ timpul în care OUT se stabilizează la valoarea $V_{out}, I_{out} \pm \frac{1}{2}K$. (±0.5LSB).

i) monotonicitate.
→ derivata V_{out}, I_{out} are același semn ca și derivata mărimii de intrare

) DAC cu AO sumator:



$$V_{out} = -\left(V_D + \frac{1}{2}V_C + \frac{1}{4}V_B + \frac{1}{8}V_A\right)$$

MSB LSB

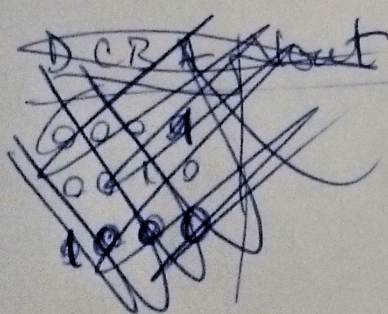
$V_{A,B,C,D} = 0,5V.$

$$A_{fs} = -5\left(\frac{8}{1} + \frac{4}{2} + \frac{2}{4} + \frac{1}{8}\right) = -\frac{75}{8} = -9.375V$$

$$Rez = \frac{1}{8}\cdot 5V = 0.625V$$

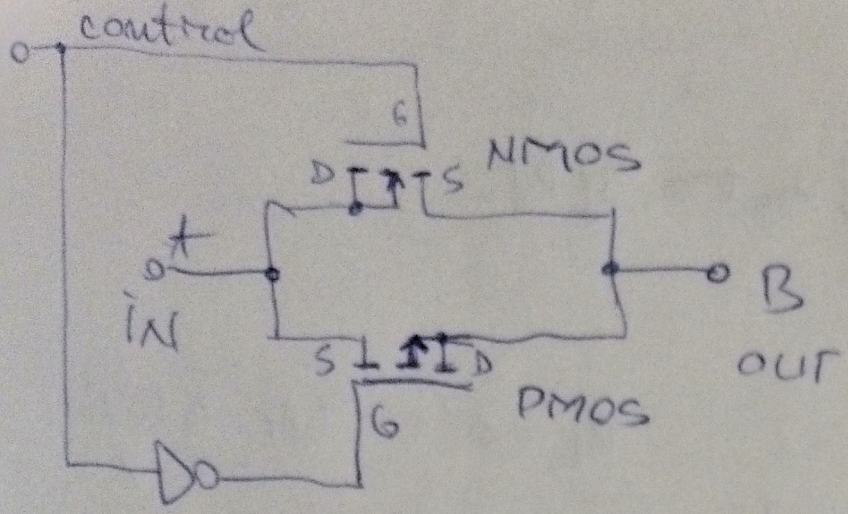
$$V = -0.625V.$$

Ponderile intrărilor:



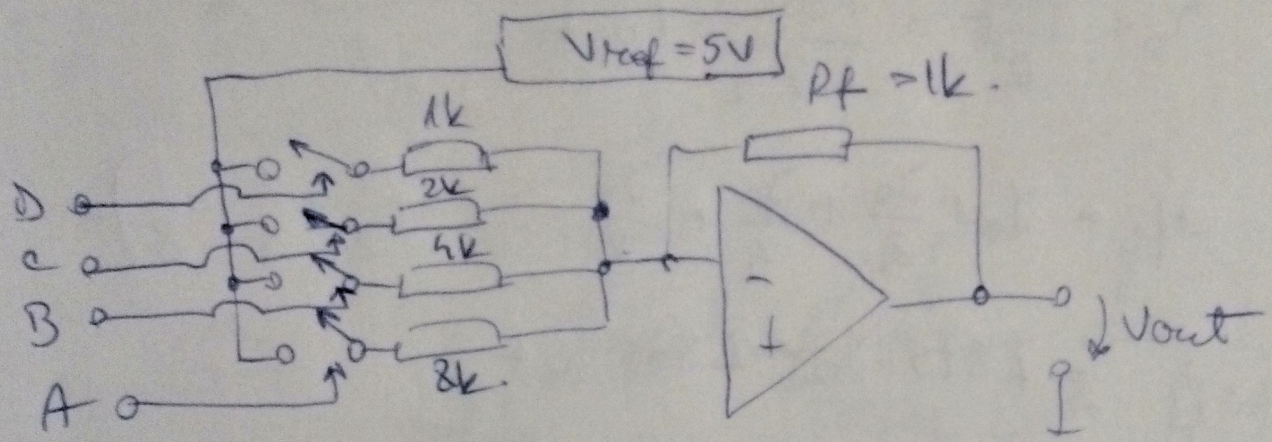
D C B A	Vout
0 0 0 1	-9.625V
0 0 1 0	-1.25V
0 1 0 0	-2.5V
1 0 0 0	-5V

Poartă de transmisie CMOS.

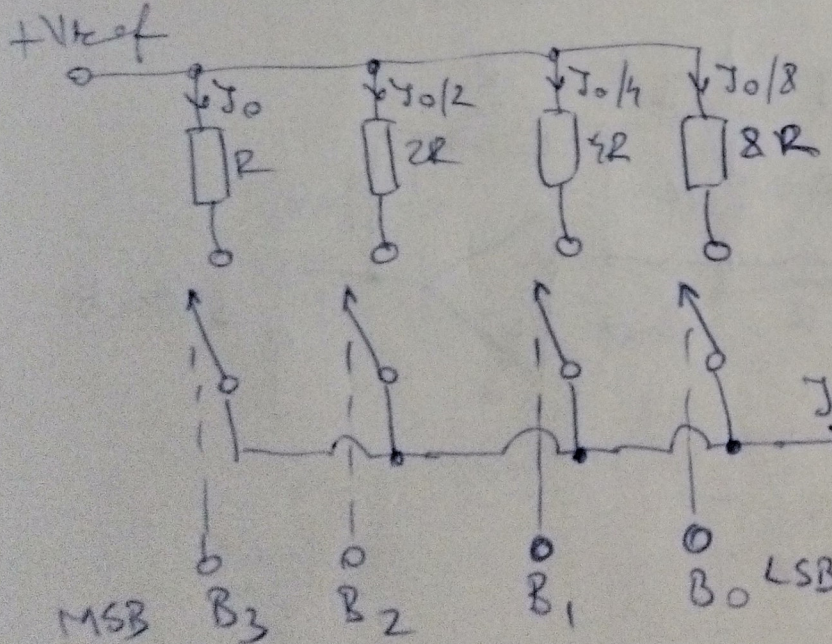


control	A	B
1	0	0
1	1	1
0	0	High-Z
0	1	High-Z

.) Schema DAC derivat:

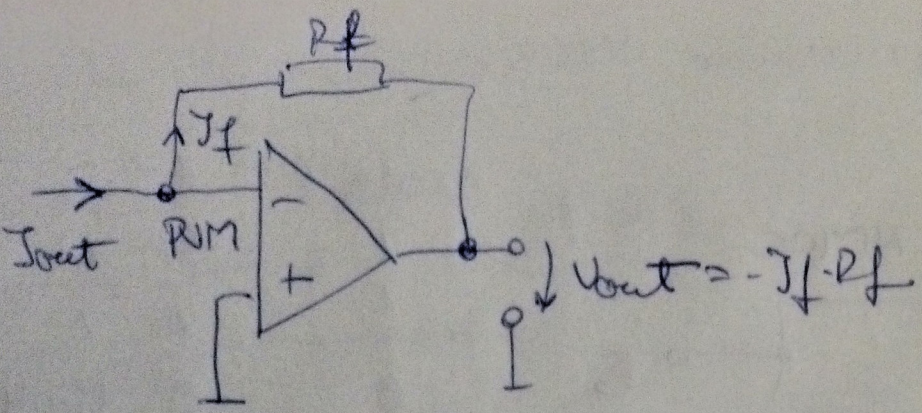


.) DAC cu ieșire în curent:



$$J_{out} = B_3 \cdot J_0 + B_2 \frac{J_0}{2} + B_1 \cdot \frac{J_0}{4} + B_0 \frac{J_0}{8}$$

$$J_0 = \frac{V_{ref}}{R}$$



(P6.) $R = 10k\Omega$ $R_{ez} = ?$ $R_L = 0$ DAC 4 biti

$V_{ref} = 10V$ $A_{fs} = ?$

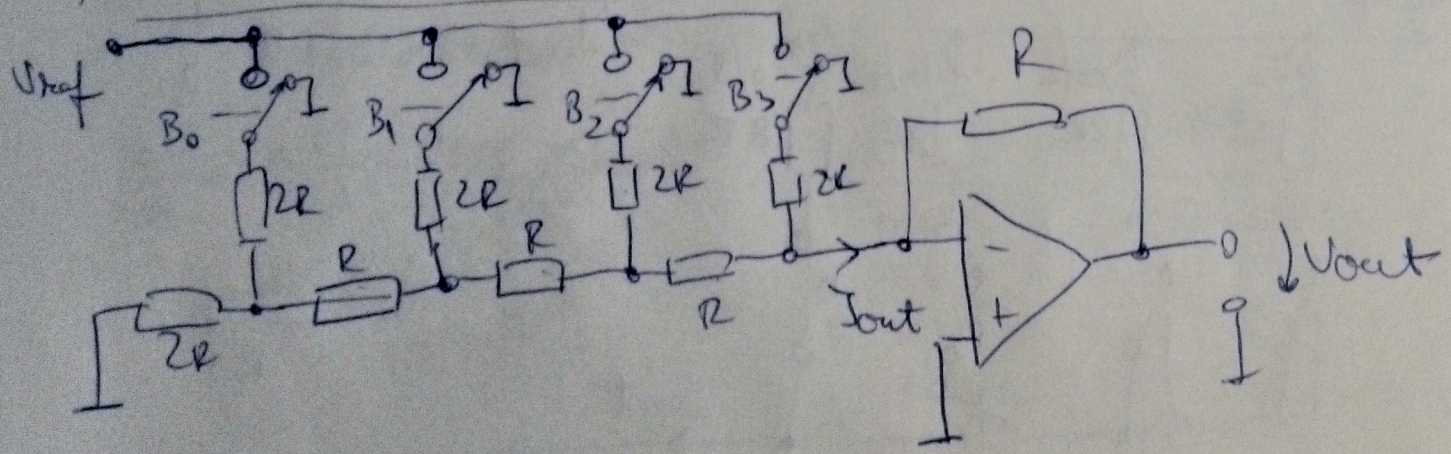
$$I_0 = \frac{V_{ref}}{R} = \frac{10V}{10k\Omega} = 1mA$$

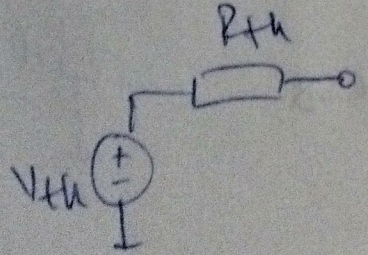
$$A_{fs} = I_0 + \frac{I_0}{2} + \frac{I_0}{4} + \frac{I_0}{8} = I_0\left(1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\right) =$$

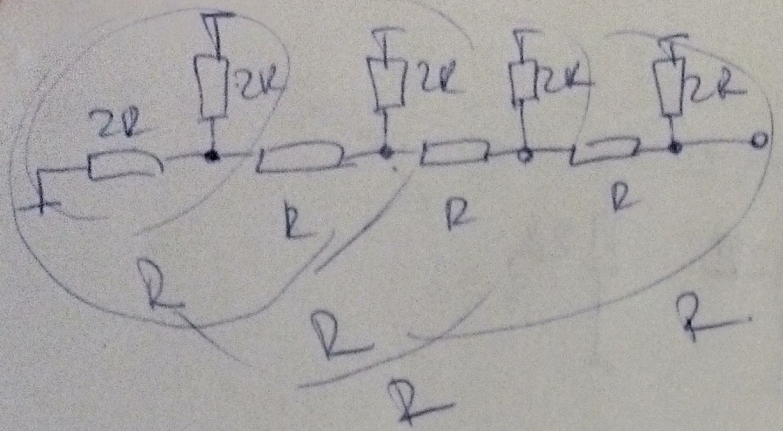
$$= 1.875 \cdot I_0 = 1.875\ mA$$

$$R_{ez} = \frac{1}{8} I_0 = 0.125\ mA$$

a) DAC cu scară R-2R:

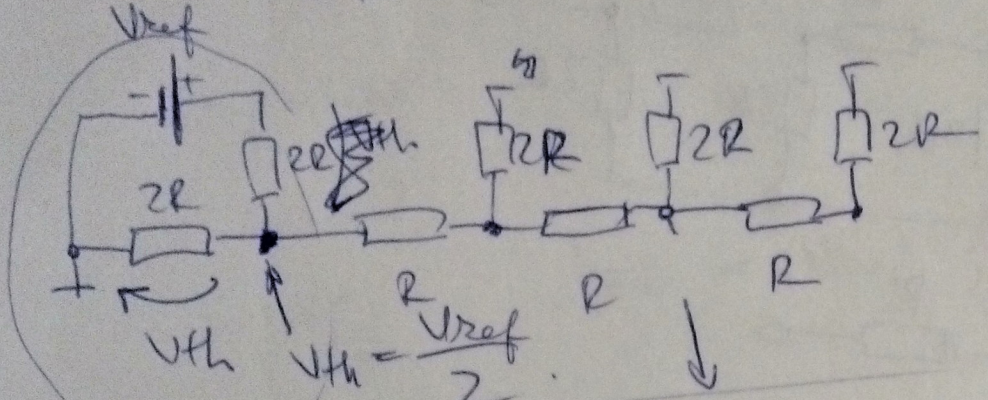




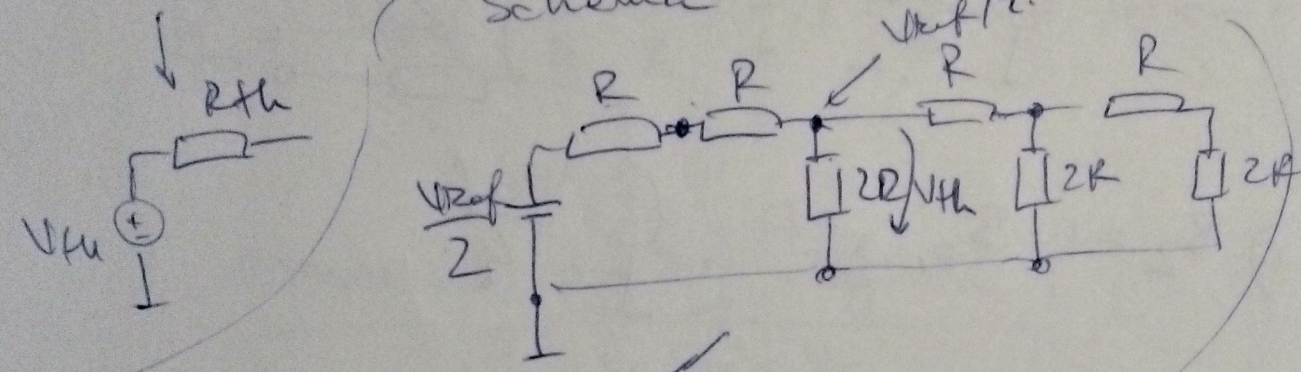


$R_{th} = R$

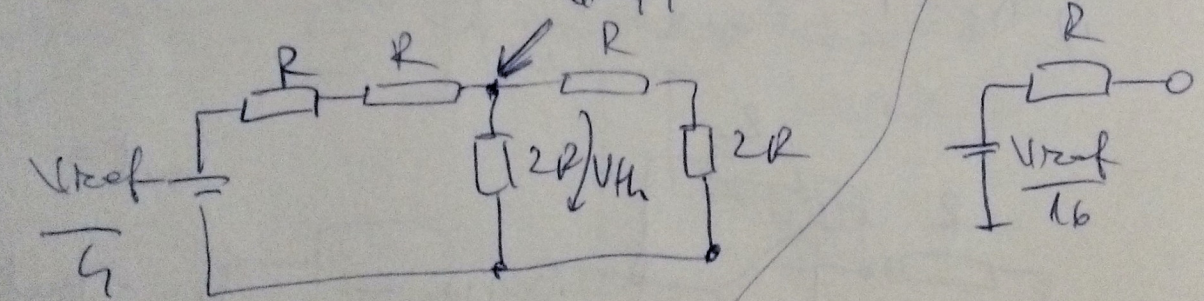
1) $B_0 = 1$; $B_{1,2,3} = 0$

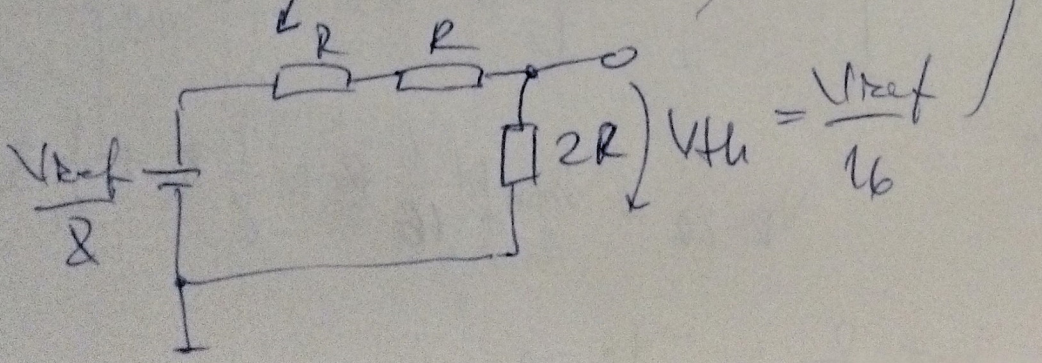


schema derivee: $V_{ref}/2$

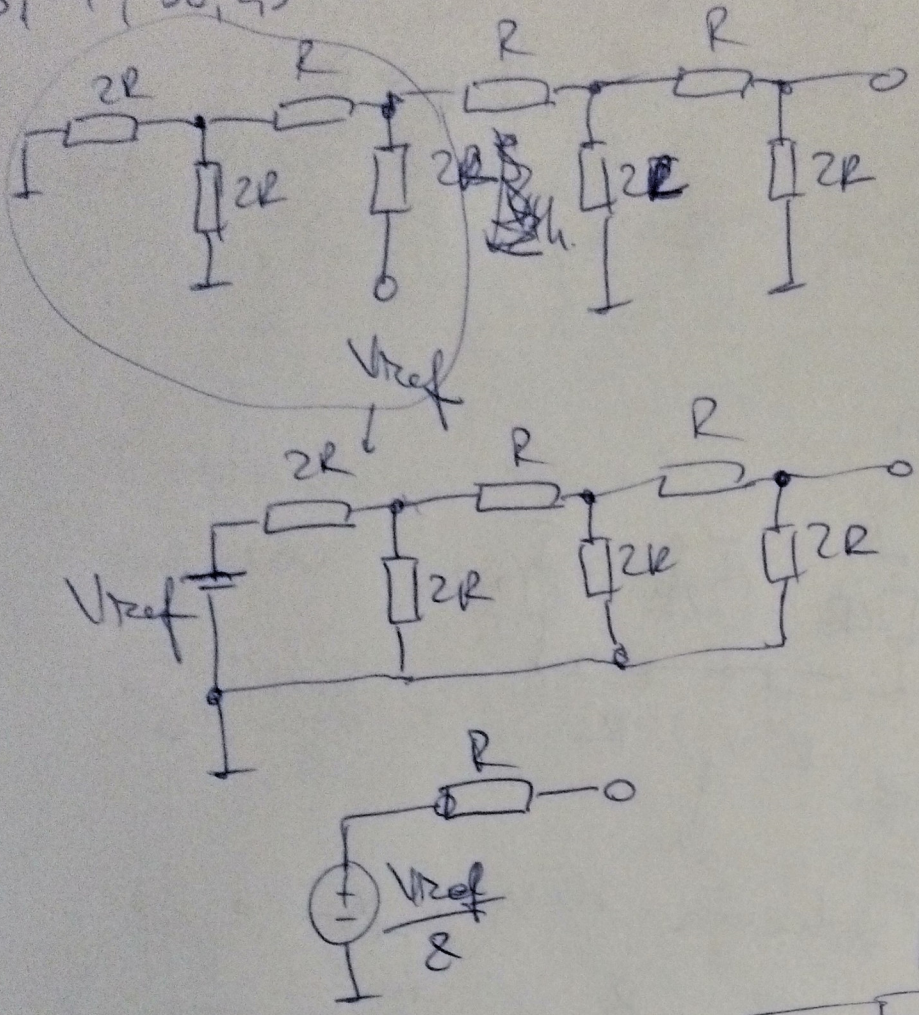


schema derivee $V_{ref}/3$

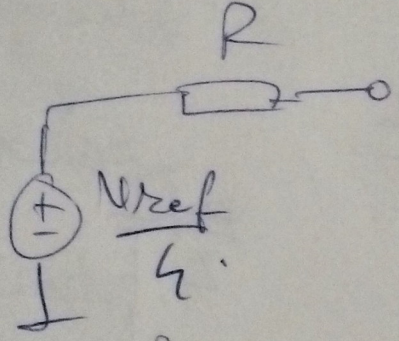




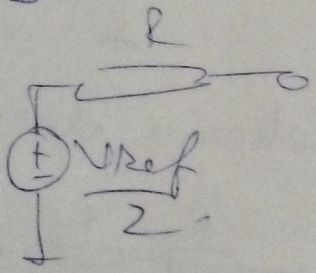
1) $B_1 = 1$; $B_{0,2,3} = 0$

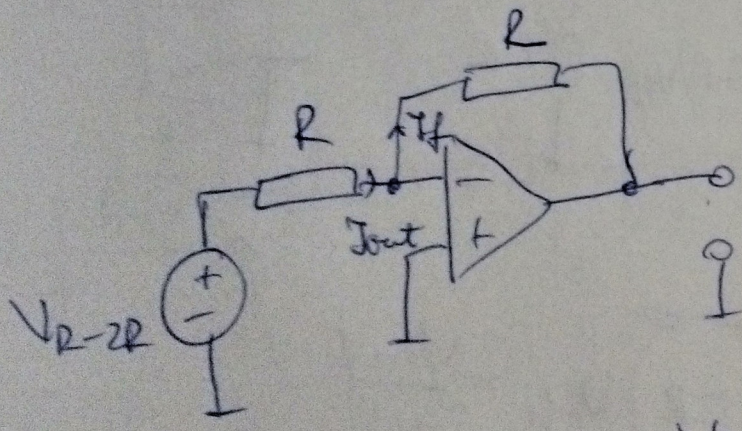


1) $B_2 = 1$; $B_{0,1,3} = 0$



1) $B_3 = 1$; $B_{0,1,2} = 0$





$$I_{out} = \frac{V_{R-2R}}{R}$$

$$I_f = -I_{out}$$

$$V_{R-2R} = V_{ref}\left(\frac{1}{16}B_0 + \frac{1}{8}B_1 + \frac{1}{4}B_2 + \frac{1}{2}B_3\right)$$

$$V_{out} = -I_{out} \cdot R = -V_{R-2R}$$

$$V_{out} = -V_{ref}\left(\frac{B_0}{2^4} + \frac{B_1}{2^3} + \frac{B_2}{2^2} + \frac{B_3}{2^1}\right)$$

LSB MSB.

P7.)

DAC R-2R pe 4 biti

$V_{ref} = 10V$

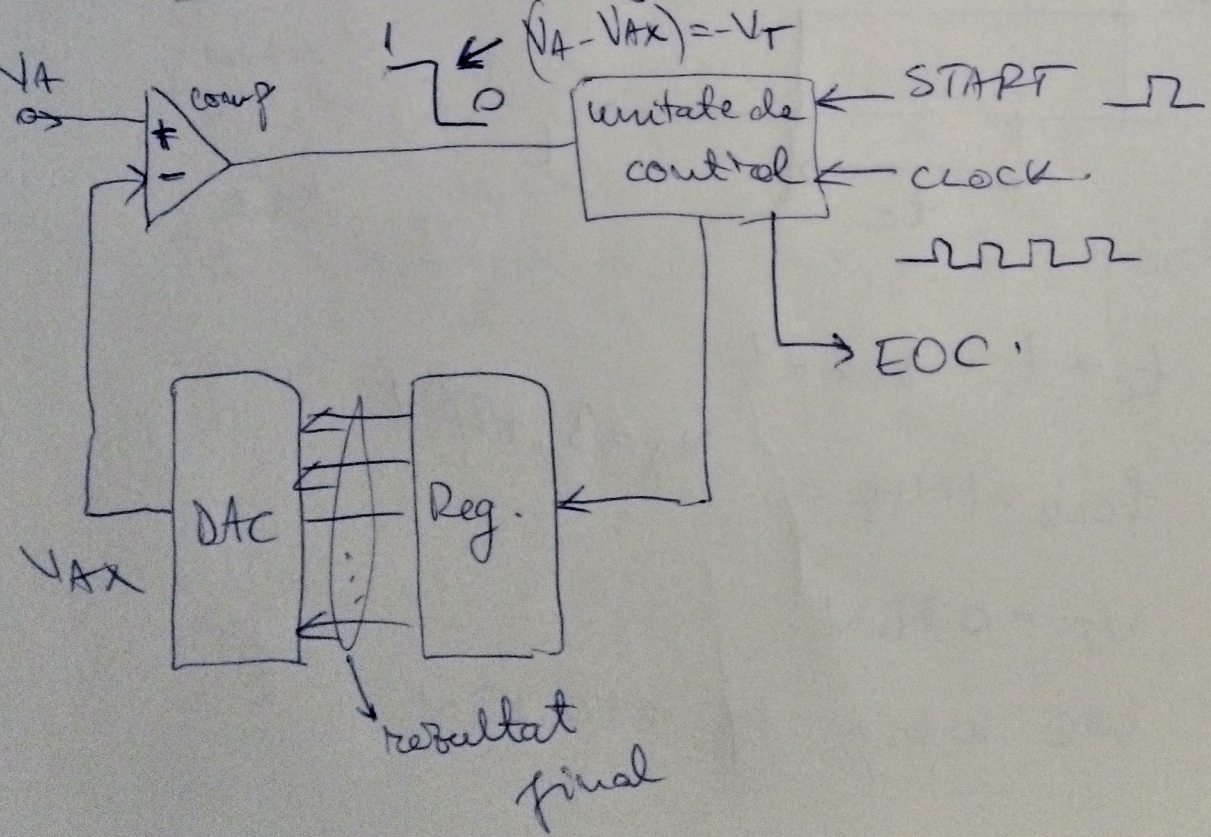
$r_{eR} = ?$

A_{fs}

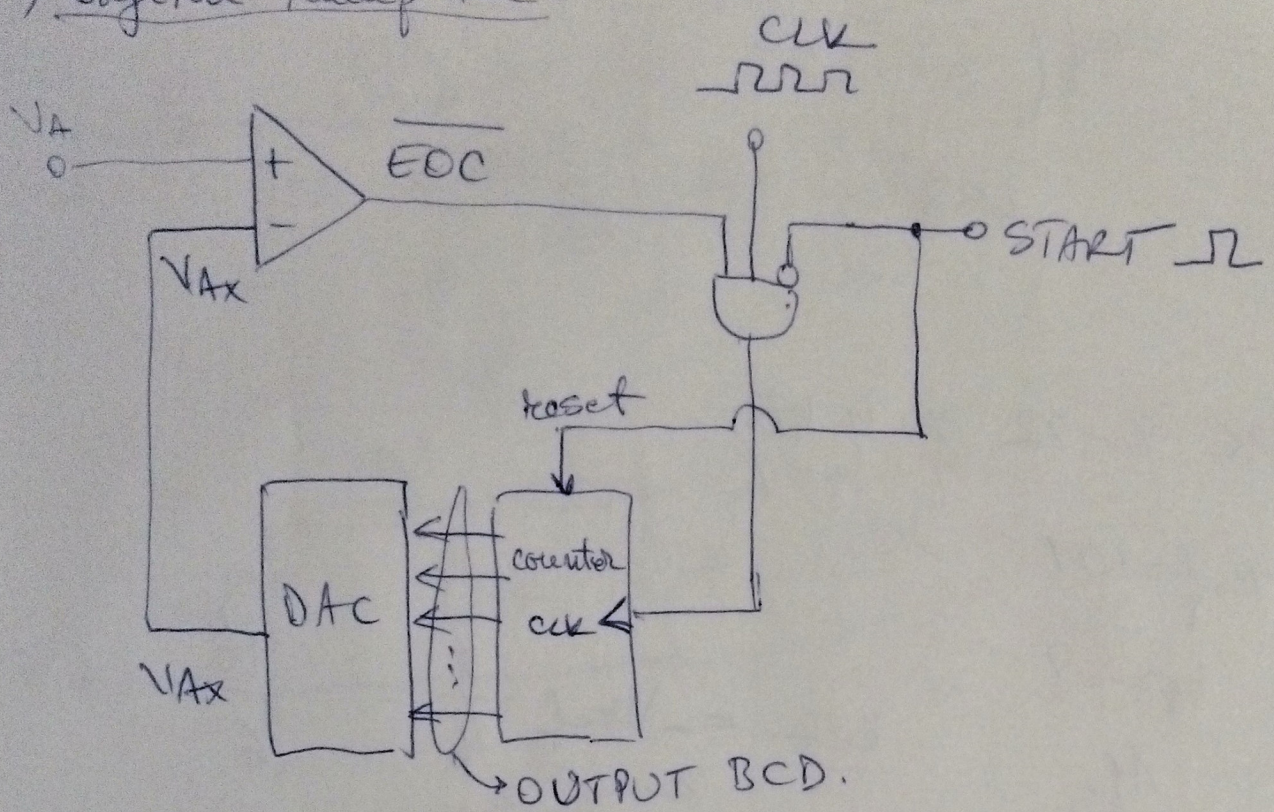
$$r_{eR.} = -V_{ref} \cdot \frac{1}{16} = -\frac{10}{16} = -0625V$$

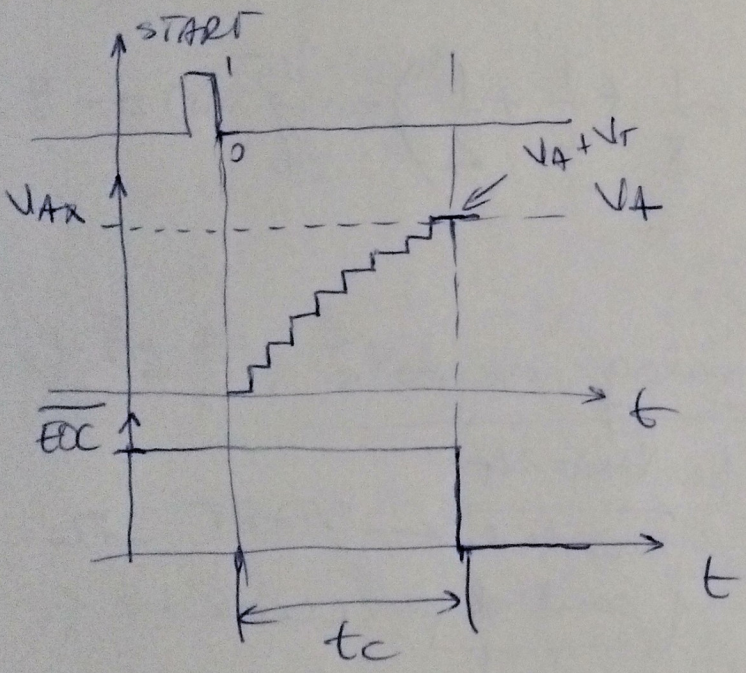
$$A_{fs} = -V_{ref}\left(\frac{1}{16} + \frac{1}{8} + \frac{1}{4} + \frac{1}{2}\right) = -\frac{15}{16} \cdot 10 = -9.375V$$

Conversia analog-digitală,



·) Digital ramp ADC.





P8

$t_c = ?$ $res = ?$

$V_A = 3.728V$

$f_{CLK} = 1MHz$.

$V_T = 0.1mV$

DAC 10 bit $A_{fs} = 10.23V$

Nr. de pași pt. DAC: $2^{10} - 1 = 1023$

$$k = \frac{10.23}{1023} = 10\,mV = Reb.$$

$V_A = 3.728V$

$V_A + V_T = 3.728V + 0.0001V = 3.72281V$

$$\text{nr. de pași} = \frac{3.72281}{10\,mV} = 372.81 \approx 373 \text{ pași}$$

$T_{CLK} = 1\mu S. \Rightarrow t_c = 1\mu S. 373 = \boxed{373\,\mu S}$

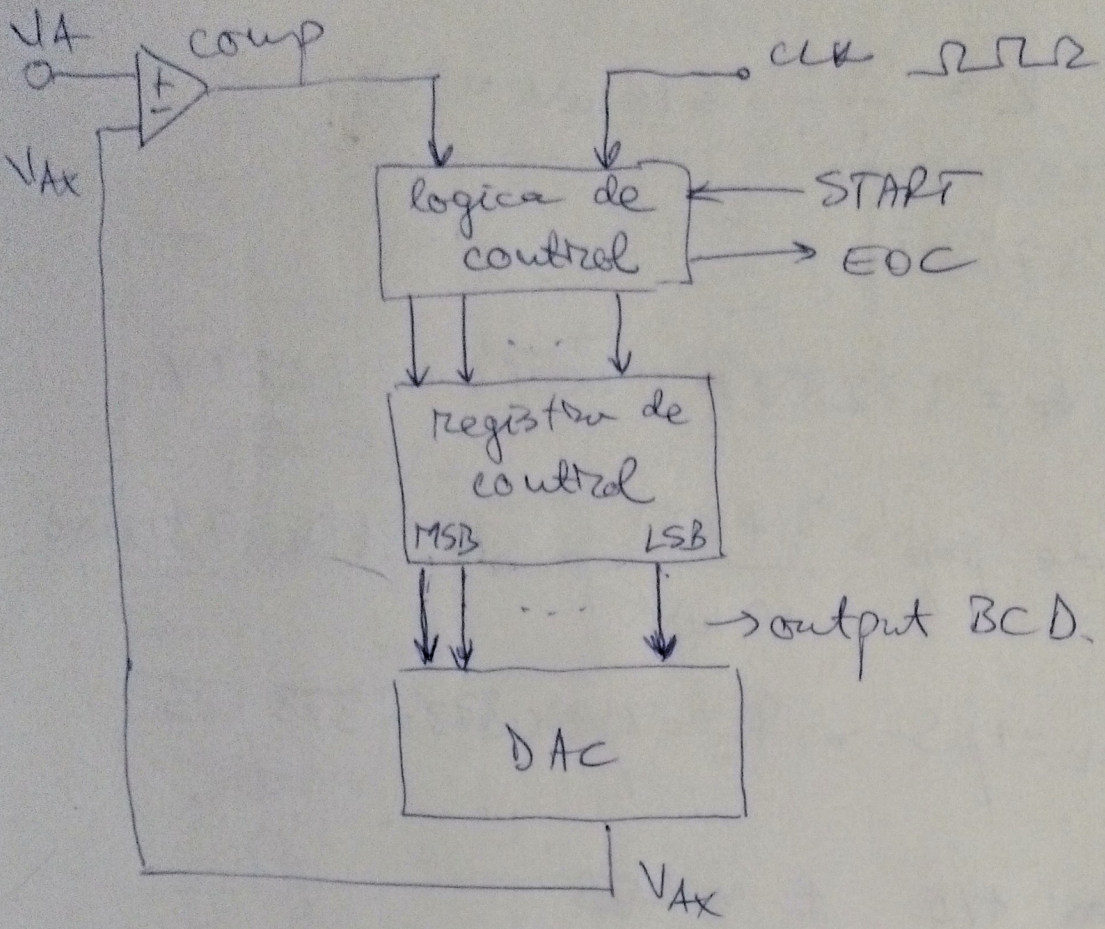
e) Acuratetea A/D. $\pm n$ LSB
$n < 1.$

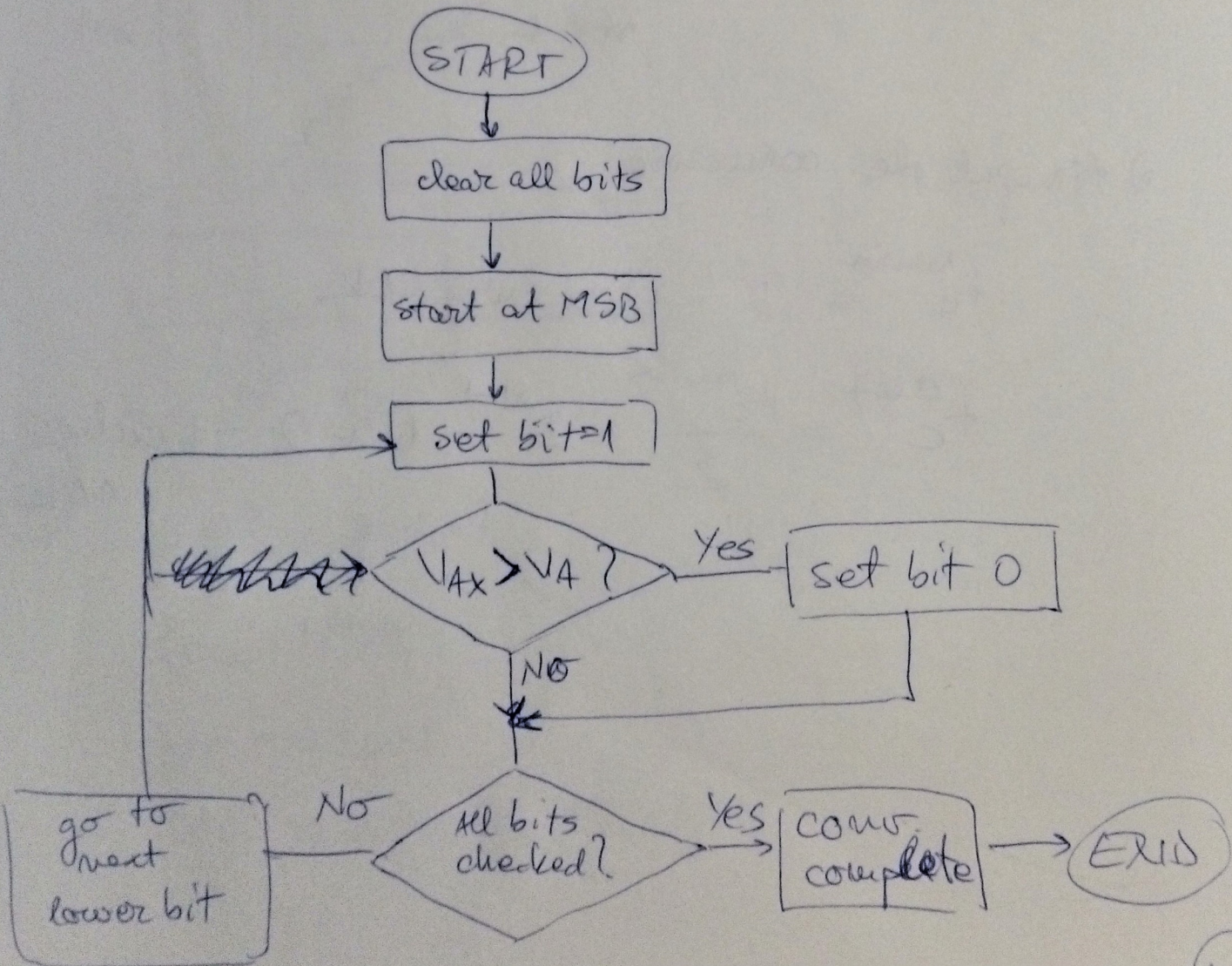
f) timpul de conversie

$$t_c^{max} = (2^N - 1) \text{ cicluri CLK}$$

$$t_c^{avg} = \frac{t_c^{max}}{2} = 2^{N+1} - 1 \approx 2^N - 1. \text{ cicluri CLK}$$

c) convertorul A/D cu aproximații succesive

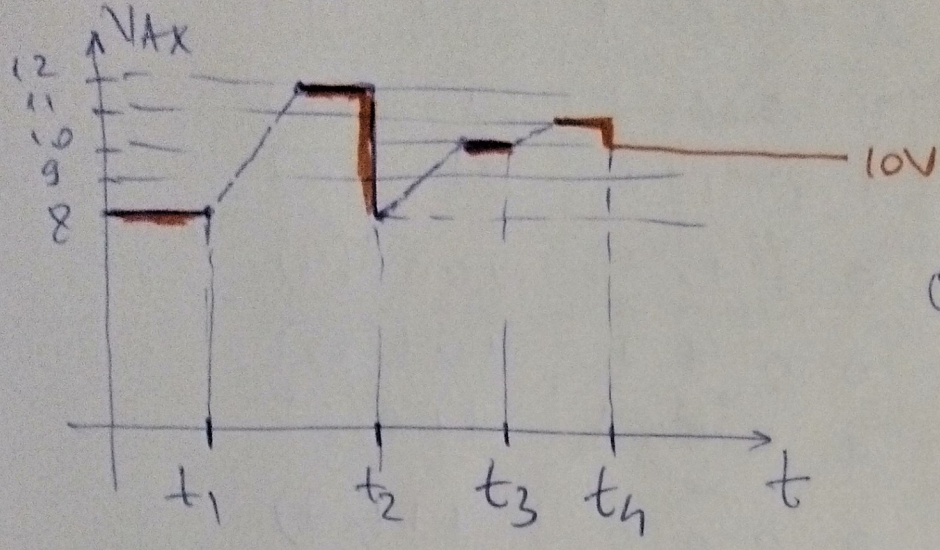




DAC 4 biti

$V_A = 10.4\,V$

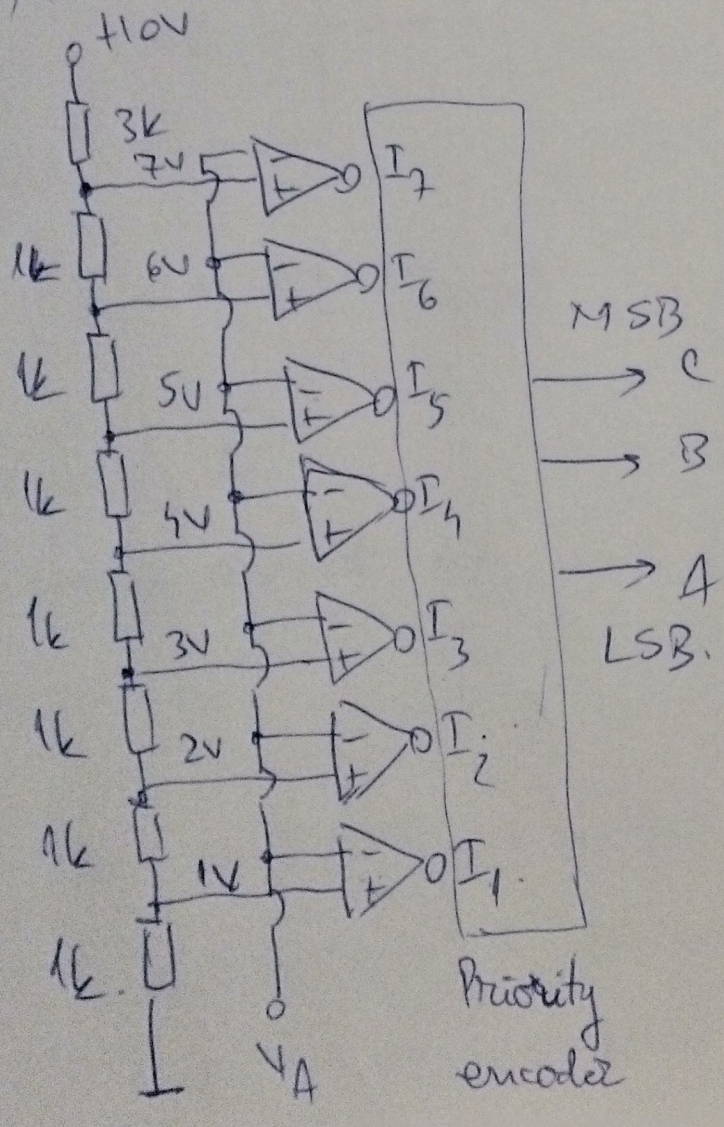
~~set~~ step size 1V



OUT = 1010

$t_c = N \cdot T_{clk}$

1) convertoral flash



V_A	C_1	C_2	C_3	C_4	C_5	C_6	C_7	CBA
0-1	1	1	1	1	1	1	1	000 (0)
1-2	0	1	1	1	1	1	1	001 (1)
2-3	0	0	1	1	1	1	1	010 (2)
3-4	0	0	0	1	1	1	1	011 (3)
4-5	0	0	0	0	1	1	1	100 (4)
5-6	0	0	0	0	0	1	1	101 (5)
6-7	0	0	0	0	0	0	1	110 (6)
27	0	0	0	0	0	0	0	111 (7)