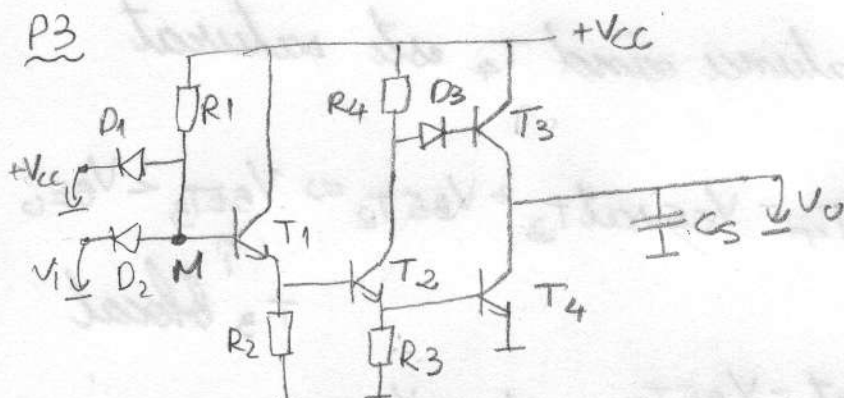
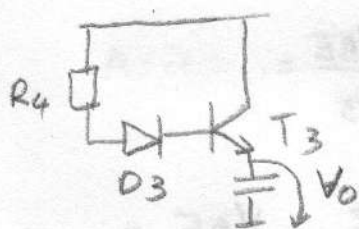


Temă 1

- 1) - circuitul are rol de inversor
cazul 1 : V_i conectat la nivelul logic „0” $\Rightarrow$ dioda D_2 este deschisă ; D_1 blocată ; $V_M = V_{D_2} = 0,8V$; dacă T_1, T_2, T_4 ar fi deschise atunci $V_M = V_{BE_{T1}} + V_{BE_{T2}} + V_{BE_{T4}}$ imposibil $\Rightarrow$
 $\Rightarrow T_1, T_2, T_4$ blocate ; T_3 deschis $\rightarrow$ asigură tensiunea mare la ieșire $\Rightarrow$ nivel logic „1”



$$V_O = V_{OH} = V_{CC} - R_4 I_{B3} - V_{BE_{T3}} - V_{D3}$$

cazul 2 : V_i conectat la nivelul logic „1”

$V_i = V_{CC} \Rightarrow D_1, D_2$ bb ; T_1, T_2, T_4 deschise

$$V_{CE_{T1}} = V_{BE_{T1}} + V_{BE_{T2}} = 1,6V \Rightarrow T_1 \text{ este în RAN}$$

$$I_{B1} = \frac{V_{CC} - V_{BE_{T1}} - V_{BE_{T2}} - V_{BE_{T3}}}{R_1} = \frac{V_{CC} - 3V_{BE}}{R_1} = \frac{5 - 2,4}{4} = 0,65mA$$

$$i_{B2} = (\beta_0 + 1) \cdot i_{B1} - \frac{V_{BE T2} + V_{BE T4}}{R_2} = (\beta_0 + 1) \cdot i_{B1} - \frac{2V_{BE}}{R_2} \Rightarrow$$

$$\Rightarrow i_{B2} = 21 \cdot 0,65 - \frac{1,6}{10} = 13,49 \approx 13,5 \text{ mA}$$

- D_3 blochează T_3 atunci când T_4 este saturat

$$V_{D3} + V_{BE T3} + V_{CE sat T4} = V_{CE sat T2} + V_{BE T2} \Rightarrow V_{BE T3} < V_{BE0}$$

$\uparrow$
 T_3 blocat

$$i_{C2 si} = \frac{V_{CC} - V_{CE sat} - V_{BE T4}}{R_4} = \frac{V_{CC} - V_{BE}}{R_4} \Rightarrow$$

$$\Rightarrow i_{C2 si} = \frac{4,2}{2} = 2,1 \text{ mA}$$

$$i_{B2 si} = \frac{i_{C2 si}}{\beta_0} = \frac{2,1}{40} = 0,0525 \text{ mA}$$

$$i_{B2} > i_{B2 si} \Rightarrow T_2 \text{ sat.}$$

$$i_{B4} = i_{E2} - \frac{V_{BE}}{R_3} = i_{B2} + i_{C2 sat} - \frac{V_{BE}}{R_3} = 1,3 \text{ mA}$$

$$= (\beta_0 + 1) \cdot \frac{V_{CC} - 3V_{BE}}{R_1} - \frac{2V_{BE}}{R_2} + \frac{V_{CC} - V_{BE}}{R_4} - \frac{V_{BE}}{R_3} =$$

$$= 13,5 + 2,1 - \frac{0,8}{1} = 14,8 \text{ mA} > i_{B4 si} \Rightarrow T_4 \text{ saturat}$$

$$i_{B4 si} = \frac{1}{\beta_0} \cdot i_{C sat 4} \leq \frac{1}{\beta_0} \cdot N_{max} \cdot i_{IL}$$

$$T_4 \text{ sat} \Rightarrow V_O = V_{CE sat T4} \Rightarrow V_O = V_{OL} \approx 0 \text{ V}$$

• $v_i = 0 \Rightarrow T_1, T_2, T_4$ bl. ; T_3 deschis $\Rightarrow v_o = V_{OH}$

• $0 \leq v_i \leq V_{i1}$; $v_o = V_{OH}$ V_{i1} - tensiunea la care se deschide T_2

$$V_M = V_{i2} + V_{D2} = V_{BE T1} + V_{BE T2} \Rightarrow V_{i1} \approx 0,6V$$

• $V_{i1} \leq v_i \leq V_{i2} \Rightarrow T_2$ se deschide în RAN, T_3 funcționează ca repetor pe emitor ; v_o scade cu pantă $-\frac{R_4}{R_3} = -2$;

V_{i2} este tensiunea la care se deschide T_4

$$V_M = V_{i2} + V_{D2} = V_{BE T1} + V_{BE T2} + V_{BE T4} \Rightarrow$$

$$\Rightarrow V_{i2} = 2V_{BE} + V_{BE0} - V_D \approx 1,4V$$

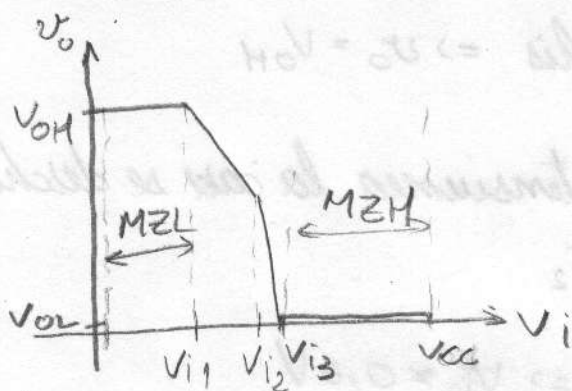
• $V_{i2} \leq v_i < V_{i3} \Rightarrow T_2$ tot în RAN ; se deschide T_4 și tensiunea din colectorul lui T_2 scade repede ; T_4 se saturează $\Rightarrow$ din colectorul lui T_2 scade cu o pantă mai mare până la valoarea tensiunii de saturație a lui T_4

V_{i3} - tens. la care se saturează T_2 și T_4

$$V_M = V_{i3} + V_{D2} = V_{BE T1} + V_{BE T2} + V_{BE T4} \Rightarrow$$

$$\Rightarrow V_{i3} = 3V_{BE} - V_D \Rightarrow V_{i3} = 1,6V$$

• $V_{i3} \leq v_i \leq V_{CC} \rightarrow T_4$ sat $\rightarrow v_o = V_{OL} = V_{CE sat T4} \approx 0V$



$$MZL = V_{i1} - V_{OL} = 0,6V$$

$$MZH = V_{OH} - V_{i3} = 5 - 1,6 = 3,4V$$

$V_{PCL} \rightarrow$ cuprinsă între V_{i2} și V_{i3} ; se poate considera

$$V_{PCL} \approx 1,5V$$

2) Caracteristica de alimentare

$$i_{CCH} = \frac{V_{CC} - V_D}{R_1} \quad (V_i = 0 : T_1, T_2, T_4 \text{ bl}) \quad i_{CCH} = \frac{5 - 0,8}{4} = 1,05mA$$

$$i_{CCL} = i_{B1} + i_{C1} + i_{C2Si} = i_{E1} + i_{C2Si}$$

$$i_{B1} = \frac{V_{CC} - 3V_{BE}}{R_1}$$

$$T_1 \text{ in RAN} \Rightarrow i_{B1} + i_{C1} = i_{E1}$$

$$i_{E1} = (B_0 + 1) i_{B1}$$

$$i_{C2Si} = \frac{V_{CC} - V_{BE}}{R_4}$$

$$i_{CCL} = (B_0 + 1) \cdot \frac{V_{CC} - 3V_{BE}}{R_1} + \frac{V_{CC} - V_{BE}}{R_4} = 13,65 + 2,1 = 15,75mA$$

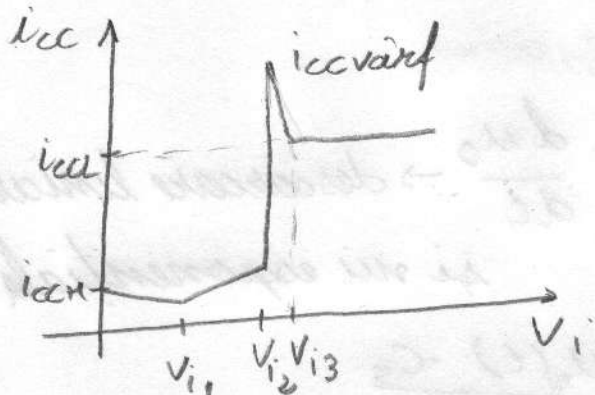
$$P_d = \frac{1}{2} (i_{CCL} + i_{CCH}) \cdot V_{CC} = \frac{1}{2} \cdot 16,8 \cdot 5 = 42mW$$

$$0 < v_i < V_{i1} \rightarrow i_{cc} = i_{ccH} - \frac{v_i}{R_1}$$

$V_{i1} < v_i < V_{i2} \rightarrow$ se adaugă cel prin T_2

$V_{i2} < v_i < V_{i3} \rightarrow$ varf de curent de alimentare $\rightarrow$ toate tranzistoarele sunt deschise

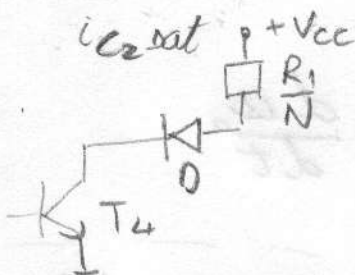
$$V_{i3} < v_i < V_{cc} \rightarrow i_{cc} = i_{ccL}$$



3) N_{masa}

iesire - "1" $\rightarrow$ putem conecta o infinitate
"0" $\rightarrow T_4$ saturat

$$i_{B4} = i_{E2} - \frac{V_{BE}}{R_3} = i_{B2} + i_{C2 sat} - \frac{V_{BE}}{R_3} = (\beta_0 + 1) \cdot \underbrace{\frac{V_{CC} - 3V_{BE}}{R_4} - \frac{2V_{BE}}{R_2}}_{i_{B2}} + \frac{V_{CC} - V_{BE}}{R_4} - \frac{V_{BE}}{R_3}$$



$$i_{B4si} = \frac{V_{CC} - V_D - V_{CEsatT4}}{\frac{R_1}{N}} = \frac{N}{R_1} \cdot (V_{CC} - V_D)$$

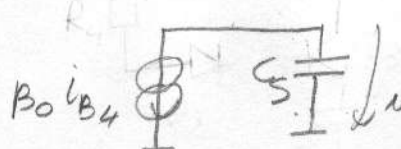
$$i_{B4si} = \frac{i_{C4si}}{\beta_0} = \frac{N}{R_1 \cdot \beta_0} \cdot (V_{CC} - V_D)$$

$$I_{B4} = (n+1) I_{B4Si} = N \cdot \frac{(n+1)}{R_1 \beta_0} \cdot (V_{CC} - V_D)$$

$$N = \frac{R_1 \beta_0}{(n+1)(V_{CC} - V_D)} \cdot \left[(B_0 + 1) \cdot \frac{V_{CC} - 3V_{BE}}{R_1} - \frac{2V_{BE}}{R_2} + \frac{V_{CC} - V_{BE}}{R_4} - \frac{V_{BE}}{R_3} \right] =$$

$$N \leq \frac{4 \cdot 40}{3 \cdot 4,2} \cdot 14,8 \approx 187,9 \approx 188$$

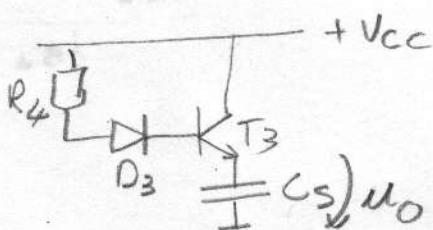
4) comutare directă


 $B_0 I_{B4} = C \cdot \frac{du_O}{dt} \rightarrow$ descărcare liniară
 și nu exponențială

$$u_O(t) = \frac{B_0 I_{B4}}{C_S} \cdot t \Rightarrow t = \frac{u_O(t) \cdot C_S}{B_0 \cdot I_{B4}}$$

$$u_O(t) = V_{OH} - V_{OL}$$

comutare inversă



$$(B_0 + 1) \cdot \frac{V_{CC} - V_D - V_{BE} - u_O}{R_4} = C_S \frac{du_O}{dt}$$

$$\frac{du_O}{dt} + u_O \cdot \left(\frac{(B_0 + 1)}{C_S R_4} \right) = \frac{(V_{CC} - V_D - V_{BE}) (B_0 + 1)}{C_S R_4}$$

$$u_O(\infty) = V_{CC} - V_D - V_{BE} \left(\frac{Q}{P} \right)$$

$$u_O(0) = u_{CE sat} \approx 0; \quad \tau = \frac{1}{P} = \frac{C_S R_4}{B_0 + 1}$$

⑥

$$u_o(t) = u_o(\infty) + [u_o(0) - u_o(\infty)] \cdot e^{-\frac{t}{\tau}}$$

$$u_o(t) = (V_{CC} - V_D - V_{BE}) \left(1 - e^{-\frac{t \cdot (\beta_0 + 1)}{C_{SR4}}} \right)$$

Time de stocare pt T_4 :

$$\frac{dQ_D(t)}{dt} + \frac{Q_D(t)}{\tau_D} = -I_{B0} - I_{BSi}$$

$$Q_D(0) = \tau_D (I_B - I_{BSi})$$

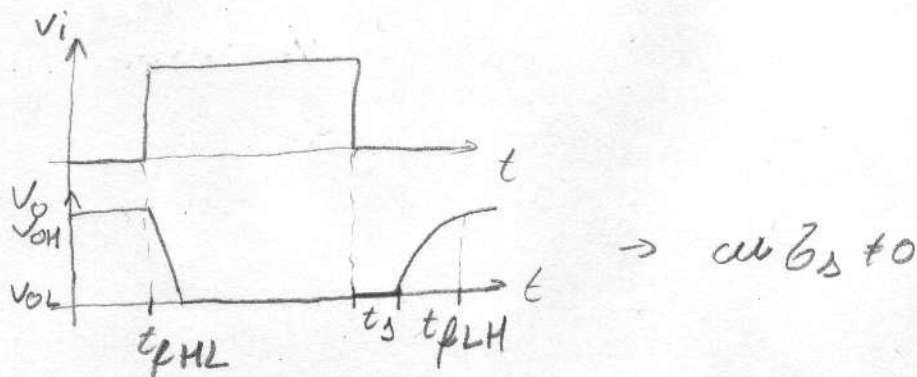
$$Q_D(t) = \tau_D (-I_{B0} - I_{BSi}) + [\tau_D (I_B - I_{BSi}) - \tau_D (-I_{B0} - I_{BSi})] e^{-\frac{t}{\tau_D}}$$

$$Q_D(t_D) = 0$$

$$0 = -\tau_D (I_B + I_{BSi}) + \tau_D (I_B + I_{B0}) \cdot e^{-\frac{t_D}{\tau_D}}$$

$$t_D = \tau_D \cdot \ln \frac{I_B + I_{B0}}{I_{BSi} + I_{B0}}$$

$$I_{B0} - \text{relativ mic} = \frac{V_{BE}}{R_3}$$



Dacă considerăm $\tau_D = 0$

