

# **Capitolul 5**

## **Etaje de iesire**

## **5.1. Notiuni generale**

## **5.1. Caracteristici generale**

- debiteaza putere intr-o sarcina, avand un randament ridicat si putere disipata redusa pe tranzistoarele finale
- impedanta redusa de iesire
- excursie maxima a tensiunii de iesire
- distorsiuni minime

### **Clasa A:**

- distorsiuni foarte reduse
- randament redus

### **Clasa B:**

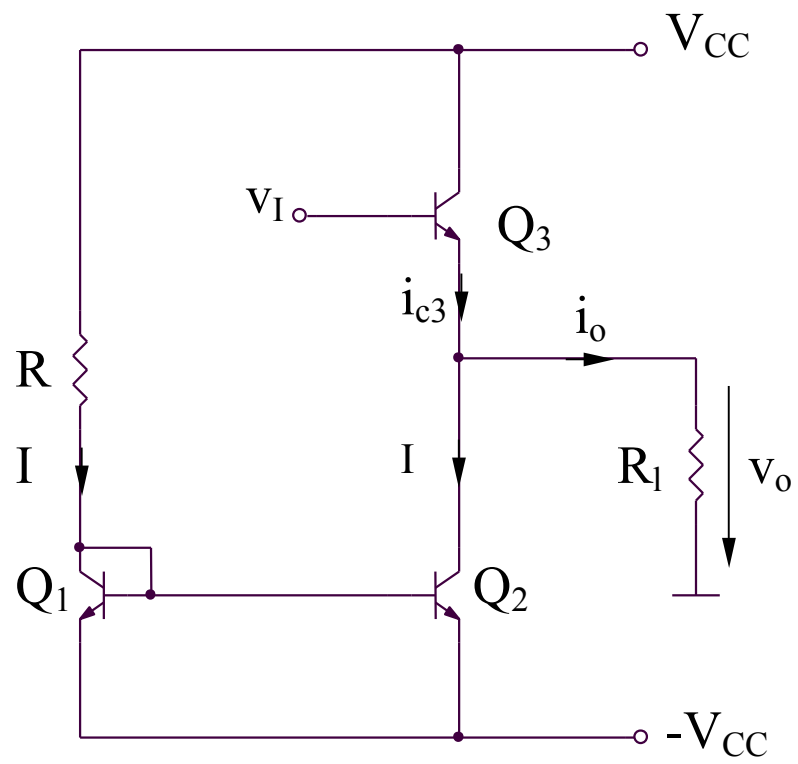
- distorsiuni importante
- randament foarte bun

### **Clasa AB:**

- distorsiuni reduse
- randament bun

## **5.2. Etajul de iesire in clasa A, configuratie colector comun**

# 5.2. Etajul de iesire in clasa A, configuratie colector comun



In repaus:

$$v_O = 0; i_O = 0$$

$$I_{C3} = I; V_{CE3} = V_{CC}$$

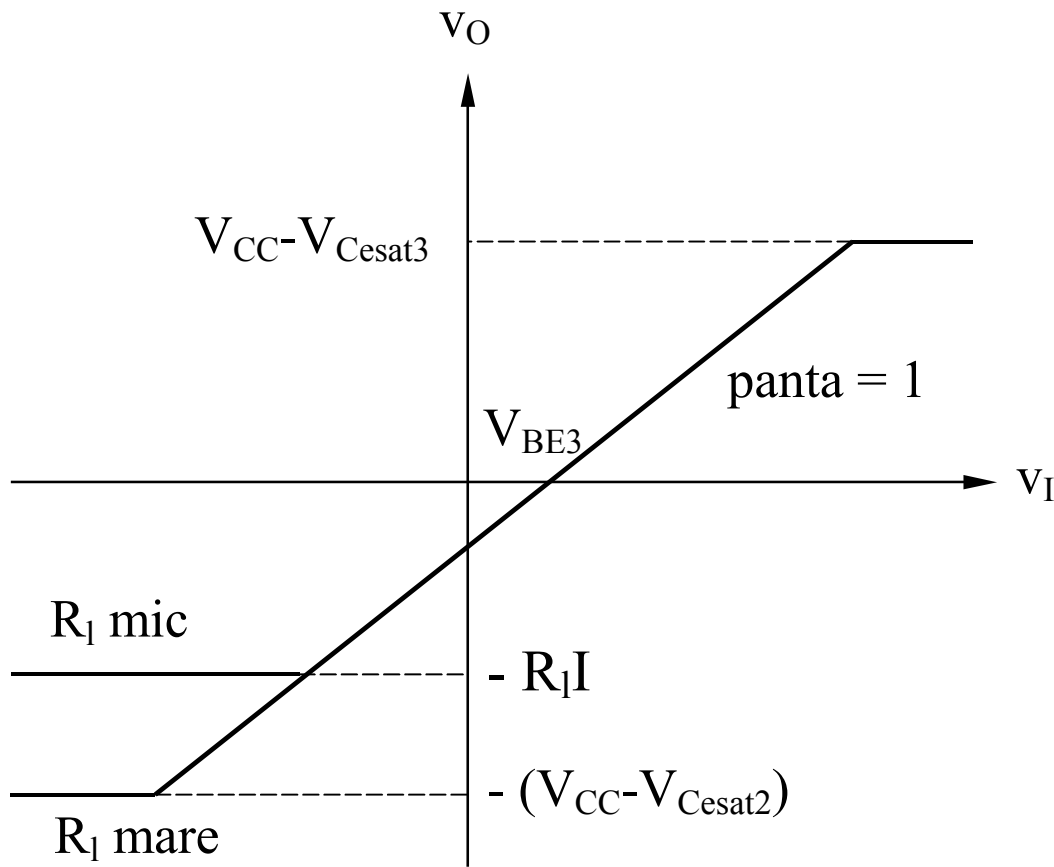
$$V_I = V_{BE3} = V_{th} \ln\left(\frac{I}{I_S}\right)$$

Caracteristica de transfer  $v_O = f(v_I)$

$$\left. \begin{aligned} v_I &= v_{BE3} + v_O \\ v_{BE3} &= V_{th} \ln\left(\frac{i_{c3}}{I_S}\right) \\ i_{c3} &= I + \frac{v_O}{R_L} \end{aligned} \right\} \Rightarrow v_I = v_O + V_{th} \ln\left(\frac{I + \frac{v_O}{R_L}}{I_S}\right)$$

Cu  $\frac{v_O}{R_L} \ll I, V_{th} \ln\left(\frac{I}{I_S}\right) = V_{BE3}$ , expresia caracteristici de transfer

devine, in consecinta  $v_I = v_O + v_{BE3}$ , deci liniara.



$$i_{C3} = I + \frac{v_O}{R_l}$$

$$i_{C3} = I + \frac{V_{CC} - v_{CE3}}{R_l}$$

$$i_{C3} = 0 \Rightarrow v_{CE3} = V_{CC} + IR_l$$

Valoarea maxima pozitiva a tensiunii de iesire este:

$$V_{O_{max}}^{++} = V_{CC} - V_{CEsat3}$$

Valoarea maxima negativa a tensiunii de iesire depinde de valoarea  $R_1$ :

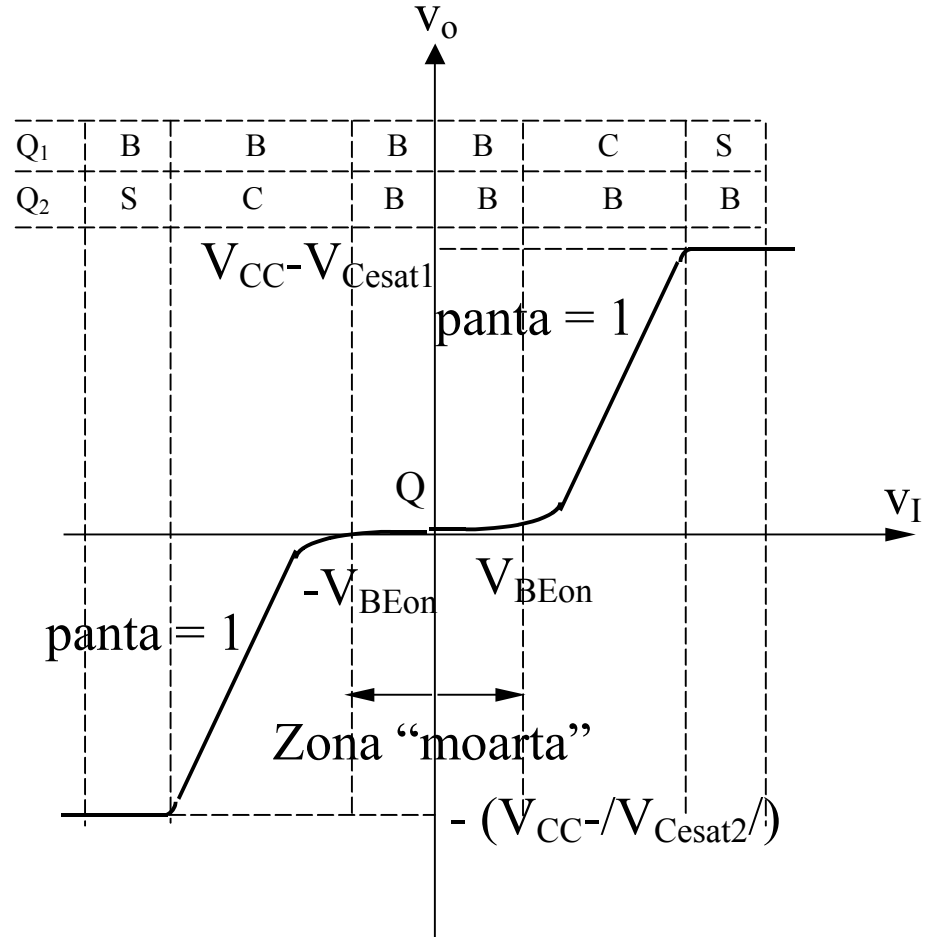
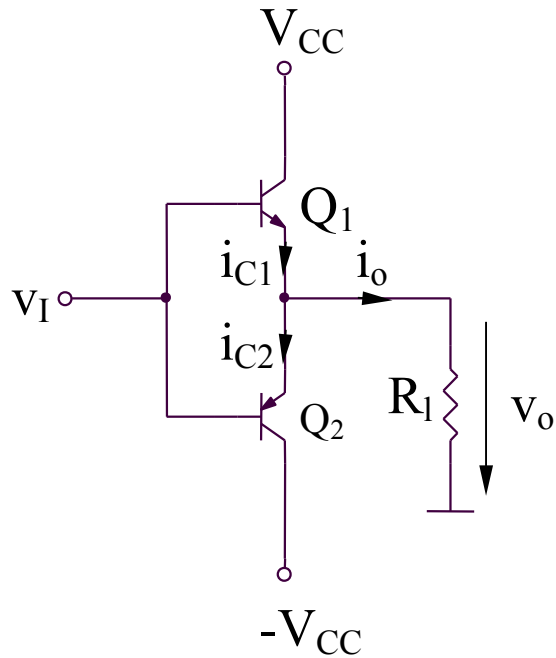
- pentru valori mari ale  $R_1$ , limita negativa a tensiunii de iesire este data de:

$$\left| V_{O_{max}}^- \right| = V_{CC} - V_{CEsat 2}$$

- pentru valori mici ale  $R_1$ , limita negativa a tensiunii de iesire este data de:

$$\left| V_{O_{max}}^- \right| = IR_l < V_{CC} - V_{CEsat 2}$$

## 5.3. Etajul de iesire elementar in clasa B



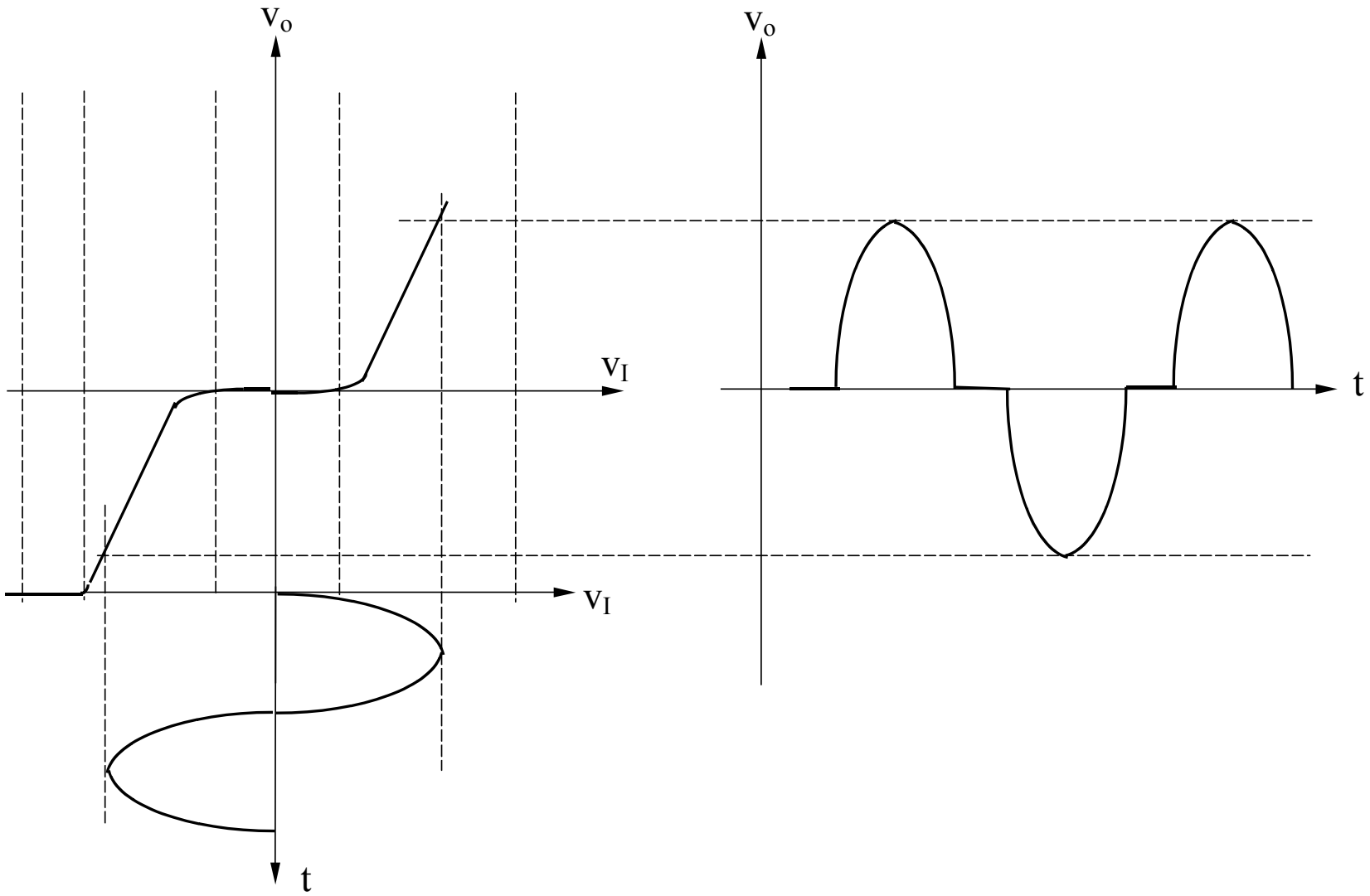
In repaus:

$$v_o = 0; i_o = 0; i_{c1} = i_{c2} = I; v_{BE1} + v_{EB2} = 0$$

Daca:

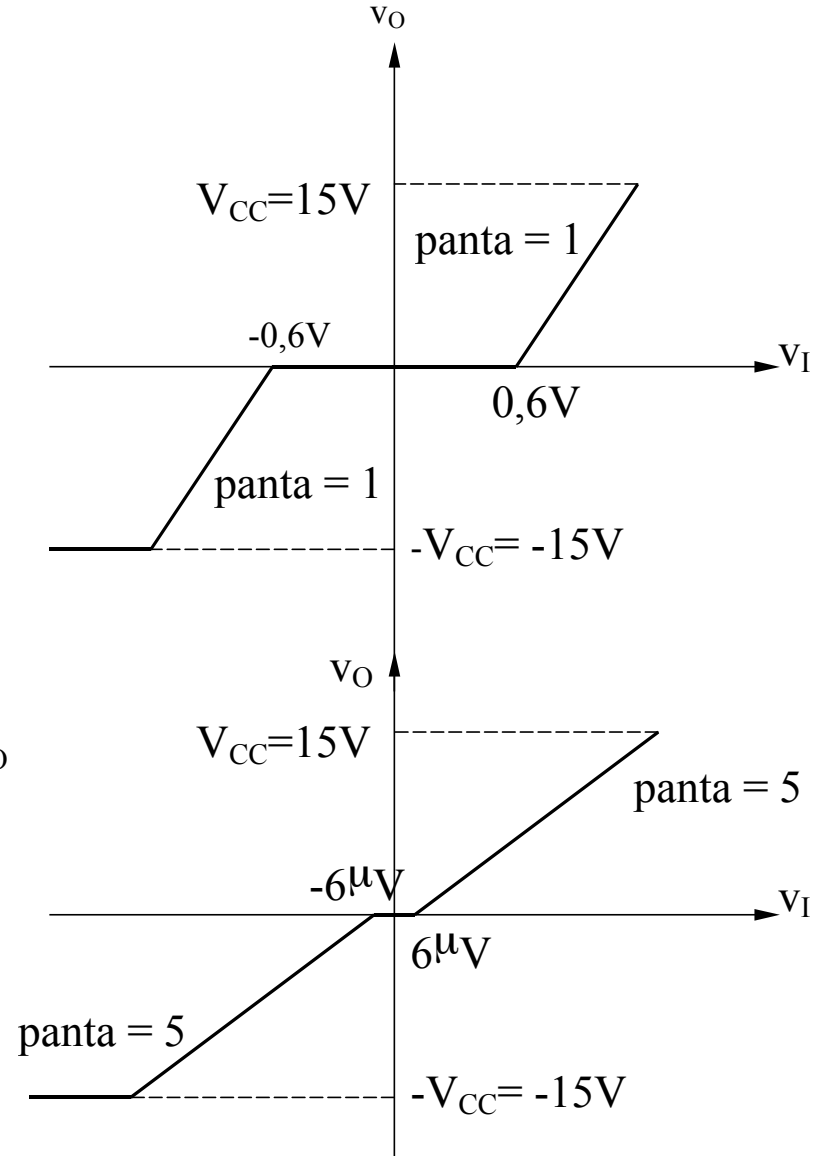
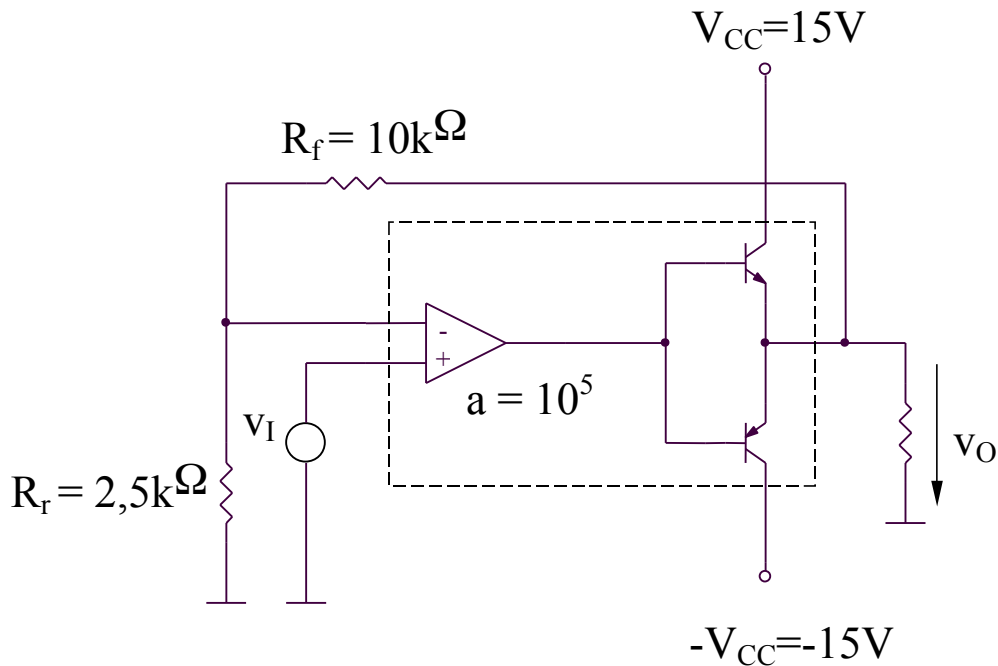
$$Q_1 \equiv Q_2; I_{S1} = I_{S2} = I_S \Rightarrow 2V_{th} \ln\left(\frac{I}{I_S} + 1\right) = 0 \Rightarrow I = 0 \Rightarrow i_{c1} = i_{c2} = 0$$





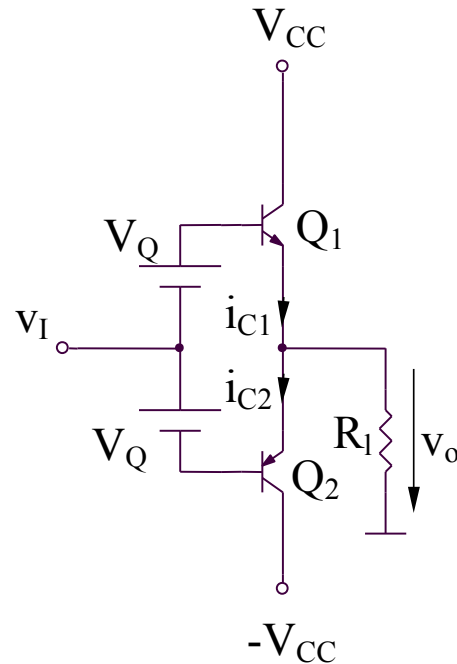
Caracteristica de transfer

## 5.4. Reducerea neliniaritatii etajului de iesire in clasa B prin utilizarea rectiei negative



## **5.5. Etajul de iesire in clasa AB**

## 5.5. Etajul de iesire in clasa AB

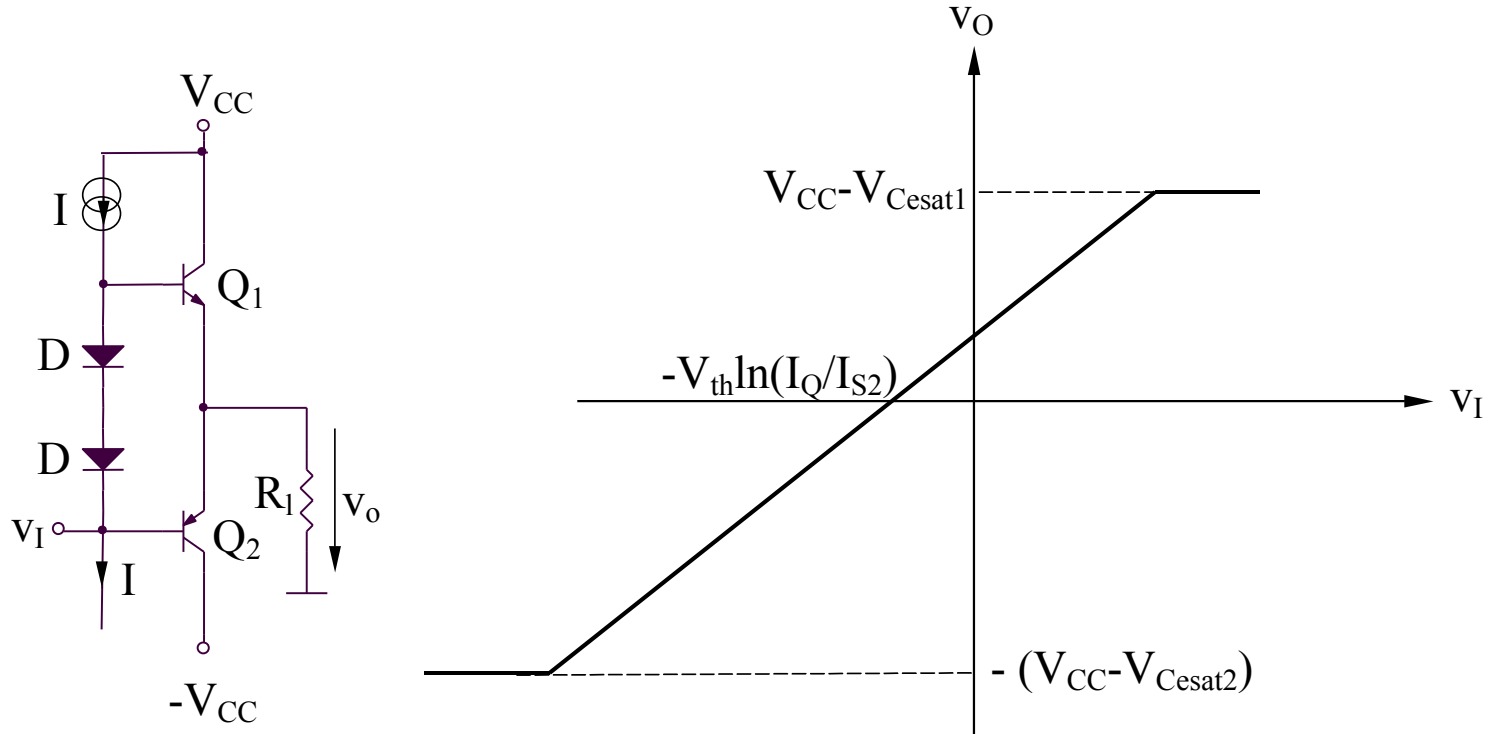


Pentru obtinerea unei bune liniaritati a functiei de transfer, este necesar:

- sa existe o imperechere cat mai buna intre parametrii tranzistoarelor complementare
- sa se realizeze o pre-polarizare corespunzatoare a etajului de iesire in repaus
- pre-polarizarea implementata sa asigure evitarea ambalarii termice a etajului

# Circuit pentru evitarea ambalarii termice a etajului de iesire (1)

Tensiunea care asigura pre-polarizarea etajului de iesire trebuie sa prezinte o variatie particulara cu temperatura (de exemplu, o tensiune baza-emitor)

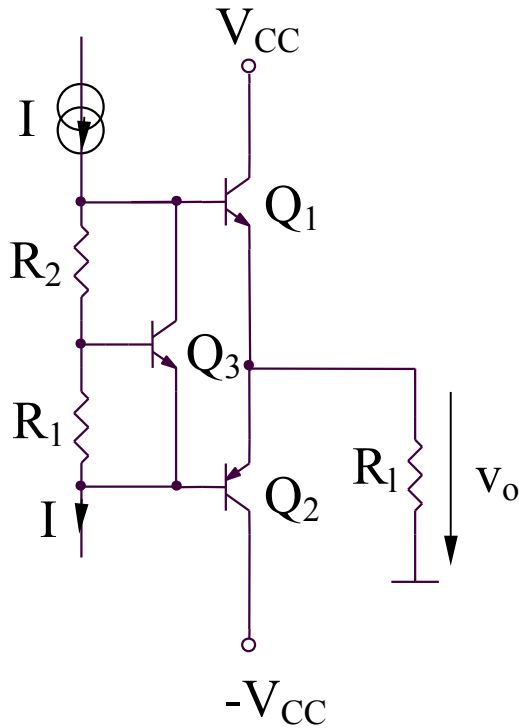


Tranzistoarele conectate ca diode trebuie sa prezinte o dependenta de temperatura similara cu cea a tranzistoarelor finale. In repaus:

$$v_o = 0$$

$$V_{BE1} + V_{EB2} = 2V_D \Rightarrow V_{th} \ln\left(\frac{I_Q}{I_{S1}} \frac{I_Q}{I_{S2}}\right) = 2V_{th} \ln\left(\frac{I}{I_{SD}}\right) \Rightarrow I_Q = I \frac{\sqrt{I_{S1} I_{S2}}}{I_{SD}}$$

## Circuit pentru evitarea ambalarii termice a etajului de iesire (2)

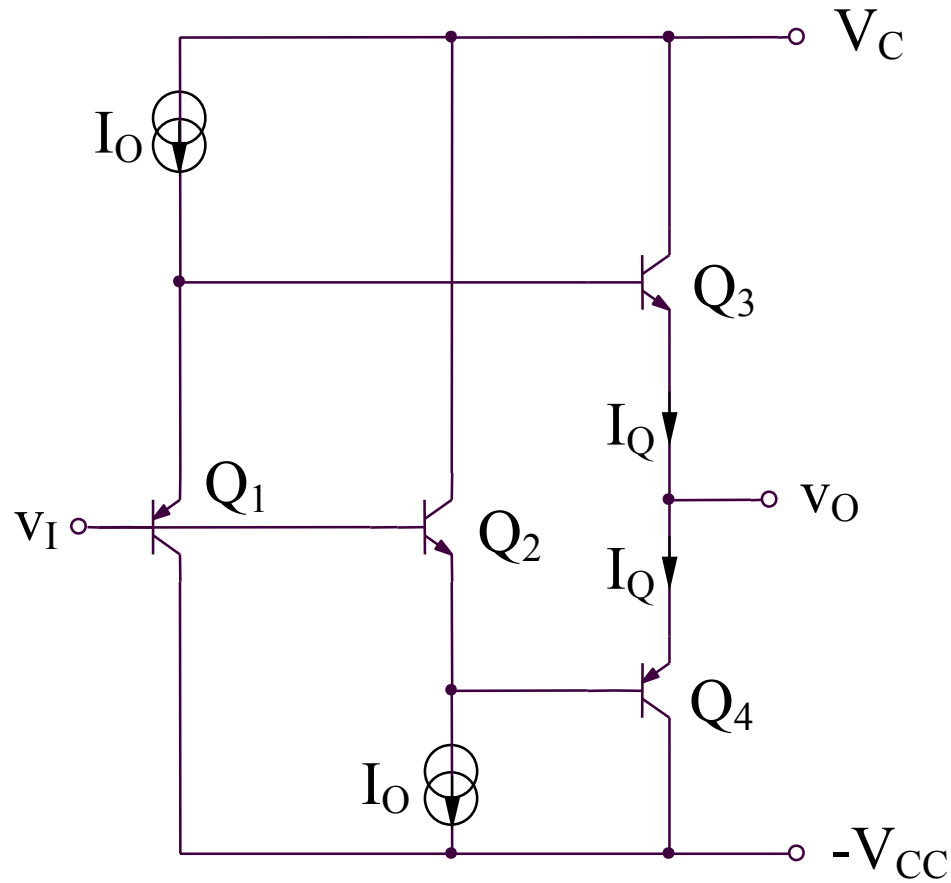


$$\left. \begin{aligned} v_{BE1} + v_{EB2} &= v_{CE3} \\ v_{CE3} &= \frac{v_{BE3}}{R_1} (R_1 + R_2) \end{aligned} \right\} \Rightarrow$$

$$\Rightarrow V_{th} \left( \ln \frac{I_Q}{I_{S1}} + \ln \frac{I_Q}{I_{S2}} \right) = \left( 1 + \frac{R_2}{R_1} \right) V_{th} \ln \frac{I}{I_{S3}}$$

$$\Rightarrow I_Q = \sqrt{I_{S1} I_{S2} \left( \frac{I}{I_{S3}} \right)^{1 + \frac{R_2}{R_1}}}$$

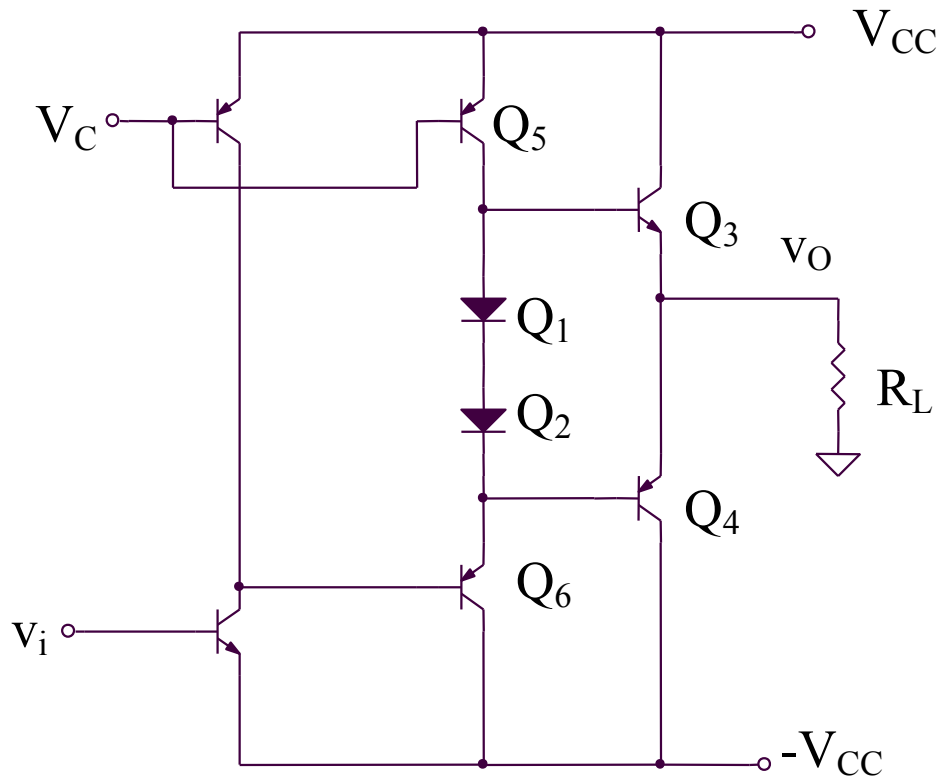
# Circuit pentru evitarea ambalarii termice a etajului de iesire (3)



$$|V_{BE1}| + V_{BE2} = V_{BE3} + |V_{BE4}|$$

$$2V_{th} \ln \frac{I_Q}{I_S} = 2V_{th} \ln \frac{I_O}{I_S} \Rightarrow I_Q = I_O$$

# Circuit pentru evitarea ambalarii termice a etajului de iesire (4)



$$V_{BE1} + V_{BE2} = V_{BE3} + V_{EB4}$$

$$V_{th} \ln \frac{I_{C1}}{I_{S1}} + V_{th} \ln \frac{I_{C2}}{I_{S2}} = V_{th} \ln \frac{I_{C3}}{I_{S3}} + V_{th} \ln \frac{I_{C4}}{I_{S4}}$$

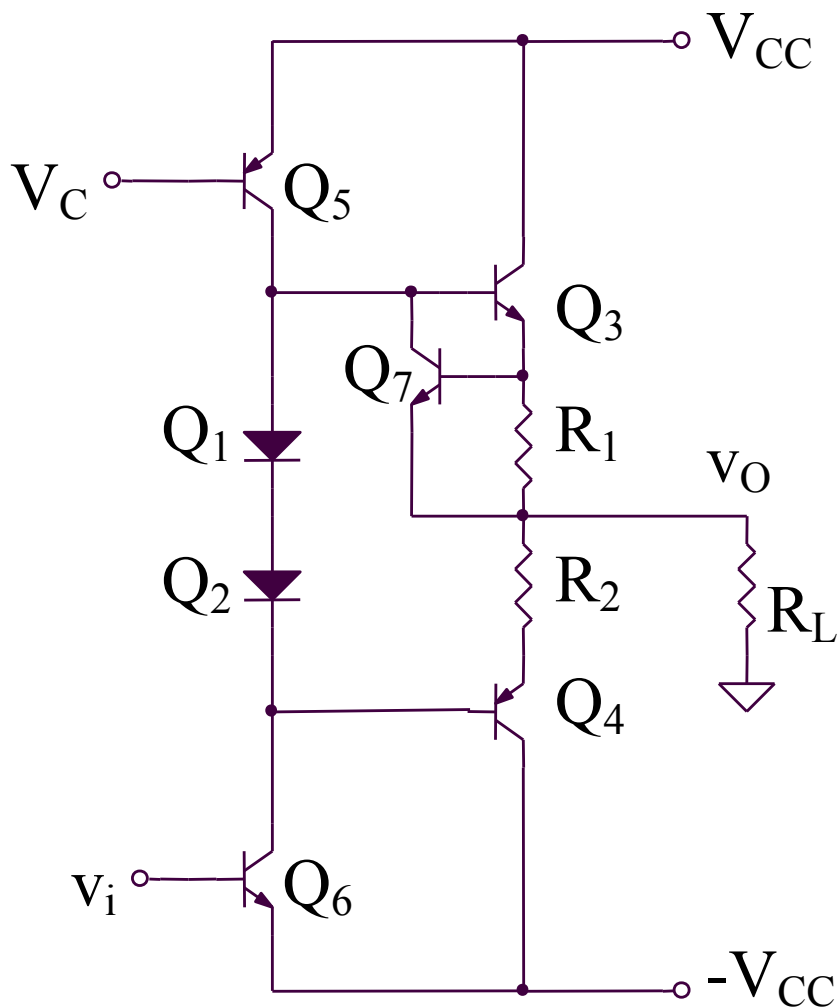
$$\Rightarrow I_{C3} = I_{C4} = I_{C1} \sqrt{\frac{I_{S3} I_{S4}}{I_{S1} I_{S2}}}$$

$$V_{O_{max}^+} = V_{CC} - V_{EC5sat} - V_{BE3}$$

$$V_{O_{max}^-} = -V_{CC} + V_{EC6sat} + V_{EB4}$$

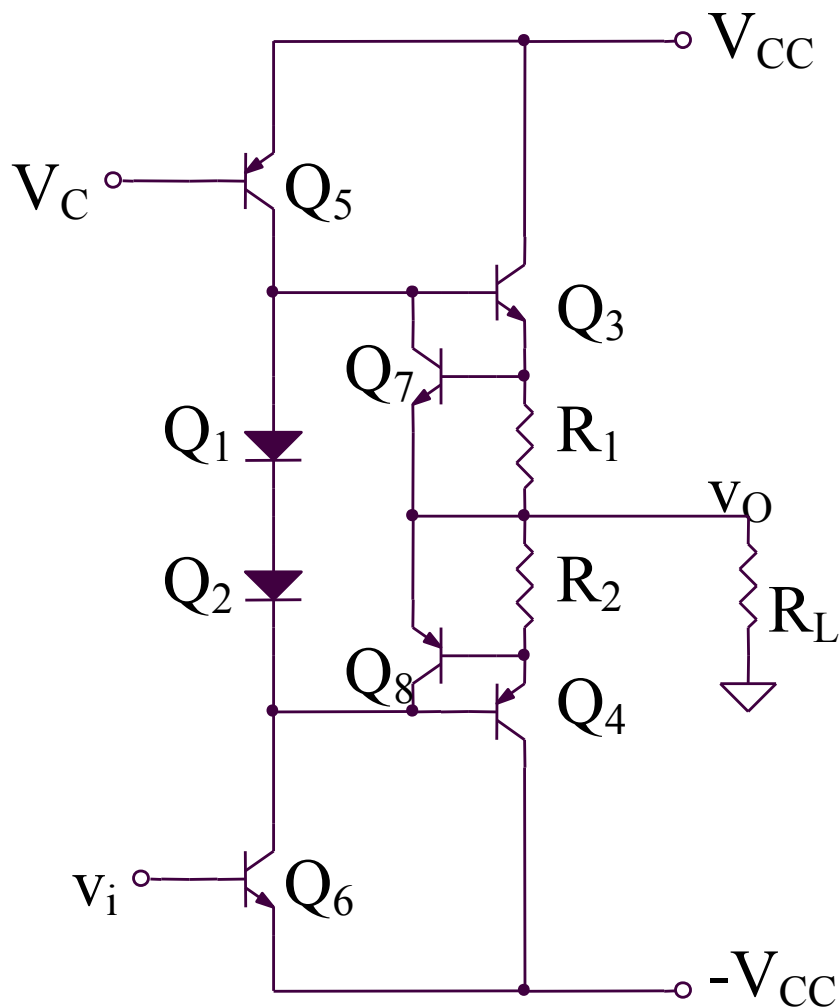


# Circuit pentru protectia la suprasarcina (1)



$$I_{Omax}^+ = \frac{V_{BE7}}{R_1}$$

## Circuit pentru protectia la suprasarcina (2)



$$I_{O_{max}}^+ = \frac{V_{BE7}}{R_1}$$

$$I_{O_{max}}^- = \frac{V_{EB8}}{R_2}$$