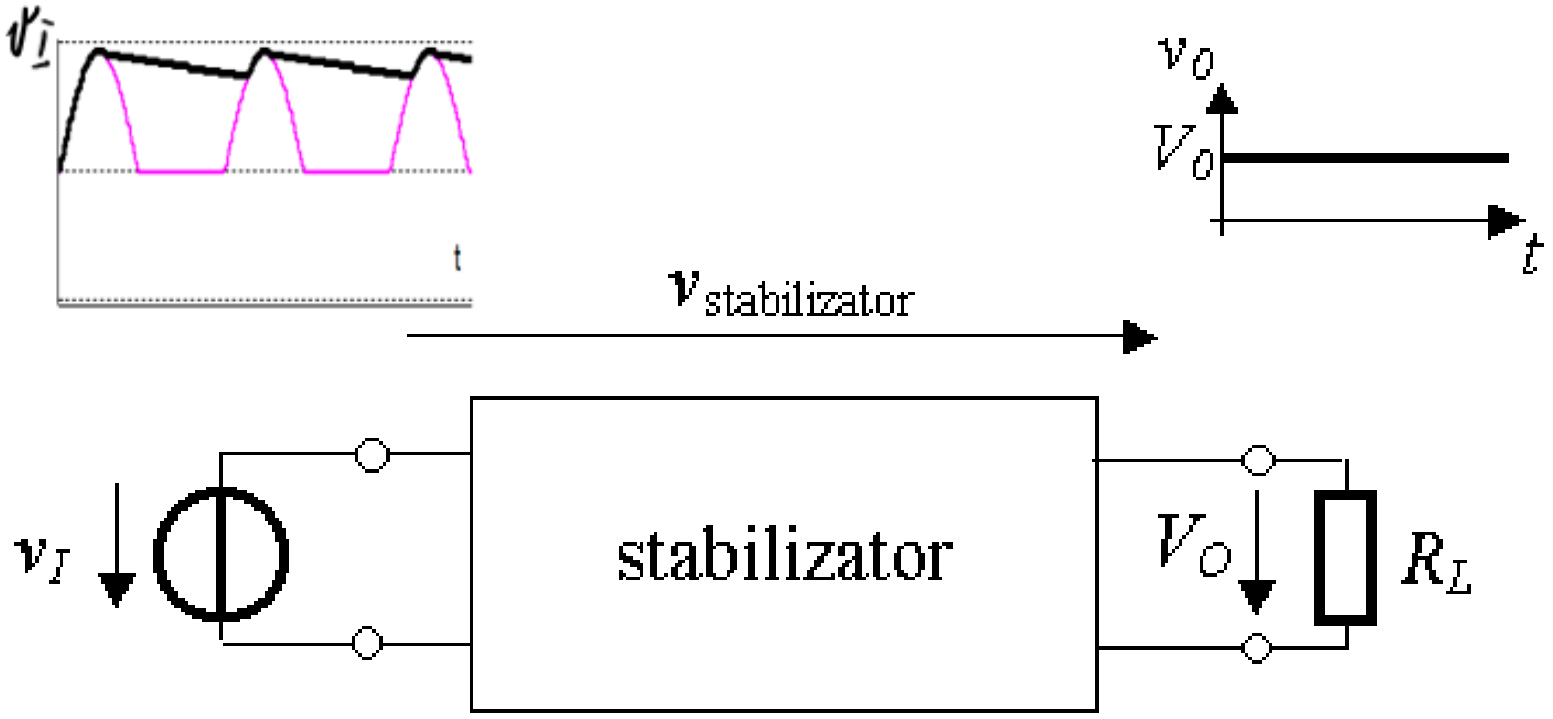
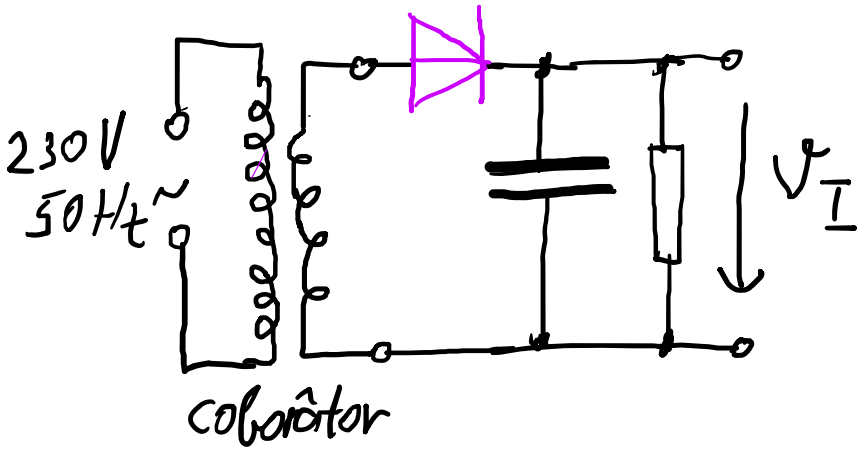
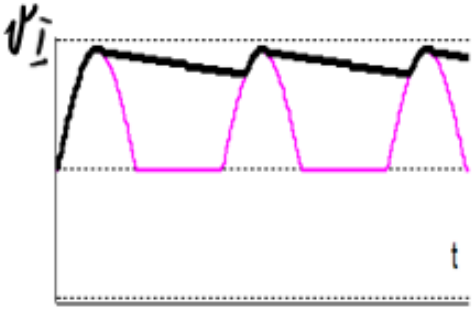
Stabilizatoare de tensiune continuă

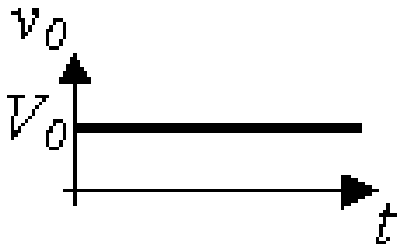
Un **stabilizator de tensiune** este un circuit electronic care **păstrează** (aproape) **constantă tensiunea** de ieșire la variaţia între anumite limite a tensiunii de intrare, curentului de ieşire, temperaturii, etc.

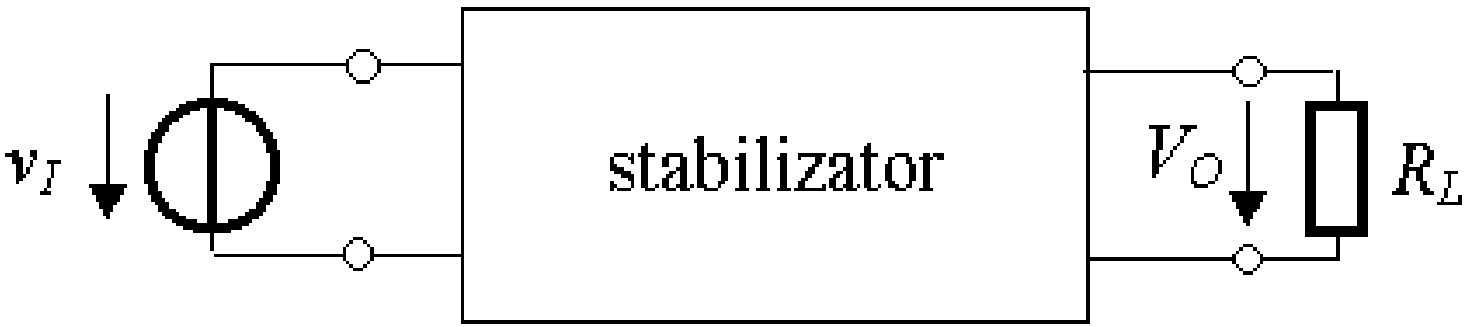


$$V_O = v_I - v_{stabilizator}$$









$$V_O = v_I - v_{regulator}$$

Tipuri de stabilizatoare

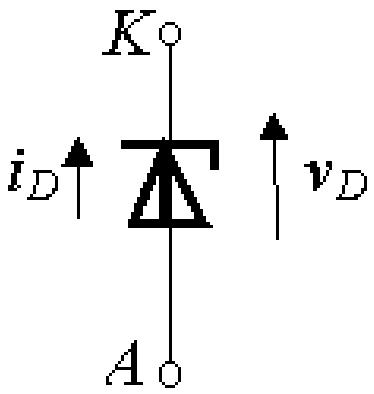
- **Stabilizatoare parametrice** (cu DZ, fara dispozitive active)

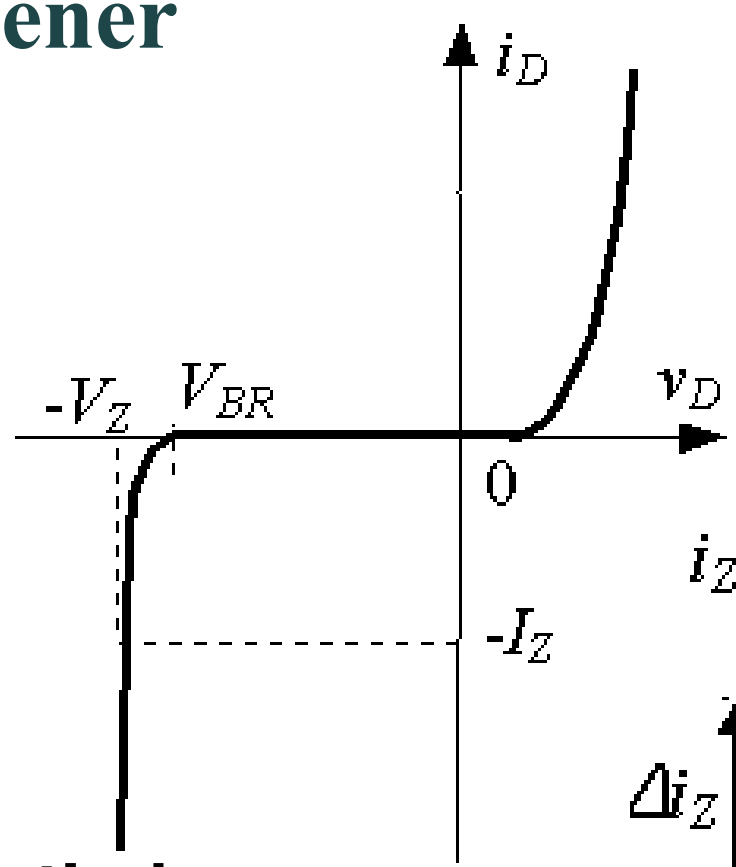
- **Stabilizatoare liniare** (cu dispozitive active) – tranzistoarele ce regleaza tensiunea de iesire la valoarea prestabilita lucreaza in regim liniar (in conductie permanenta), reactie negative

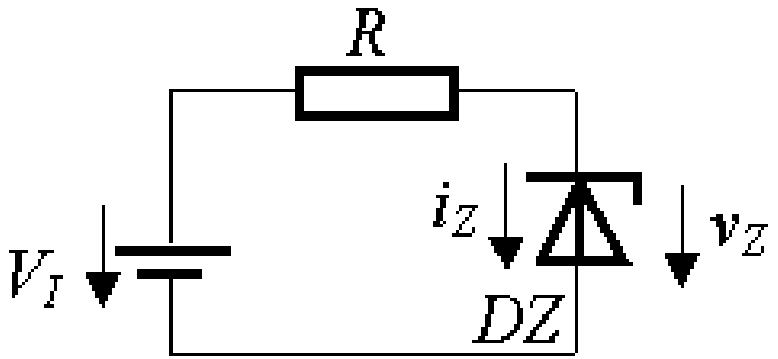
- **Stabilizatoare in comutare** (cu dispozitive active) tranzistoarele principale ce regleaza tensiunea de iesire la valoarea prestabilita lucreaza in comutare, in general la o frecventa $\geq$ 20KHz, reactie negativa

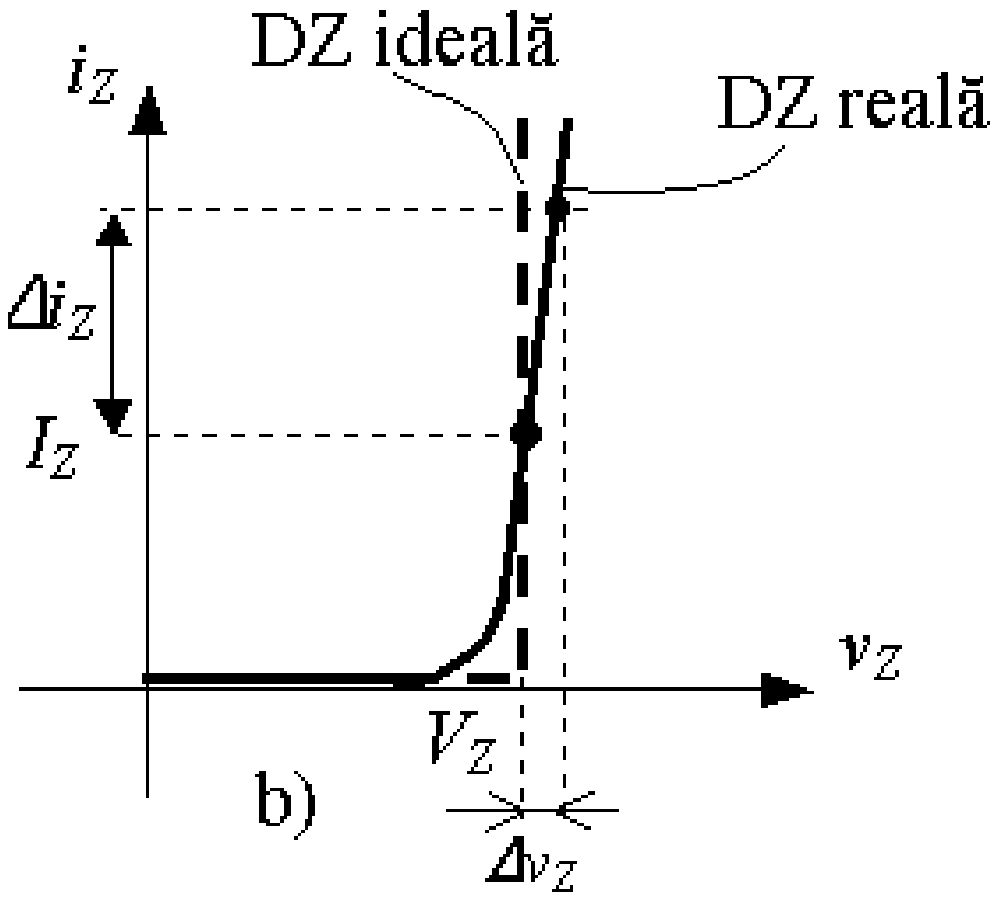
Stabilizator parametric de tensiune

Dioda Zener





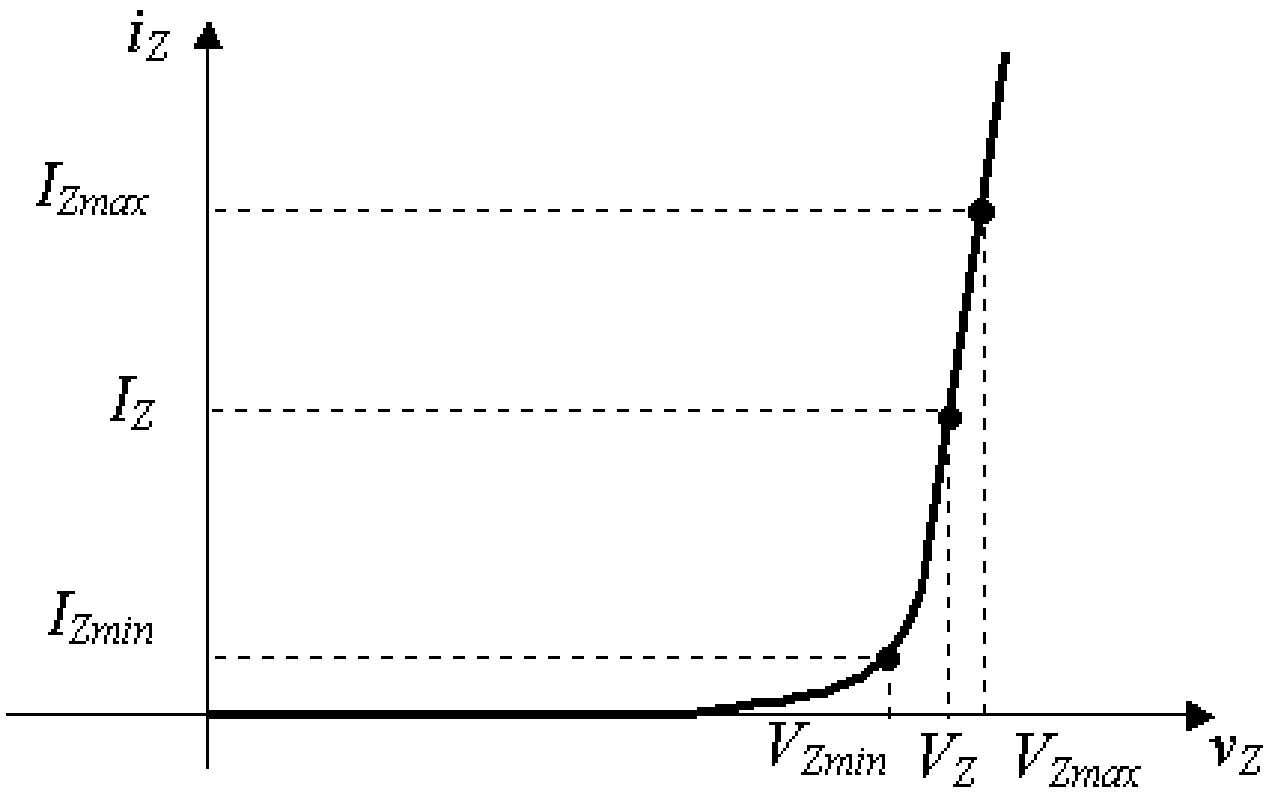




Factorul relativ de stabilizare al DZ

$$F_Z = \frac{\frac{\Delta v_Z}{V_Z}}{\frac{\Delta i_Z}{I_Z}} \qquad F_Z = \frac{r_z}{r_Z}$$

Domeniul de stabilizare al DZ



Pentru DZ in catalog se gasesc

$$P_{d\max}, V_Z @ I_Z$$

$$I_{Z\max} = \frac{P_{d\max}}{V_{Z\max}}$$

Se poate utiliza

$$I_{Z\max} = \frac{P_{d\max}}{V_Z}$$

Pentru a mentine DZ in regiunea de stabilizare

$$I_{Z\min} < I_Z < I_{Z\max}$$

Extras din foaia de catalog

FAIRCHILD SEMICONDUCTOR®

1N4728A - 1N4758A
Zener Diodes

Tolerance = 5%

DO-41 Glass case

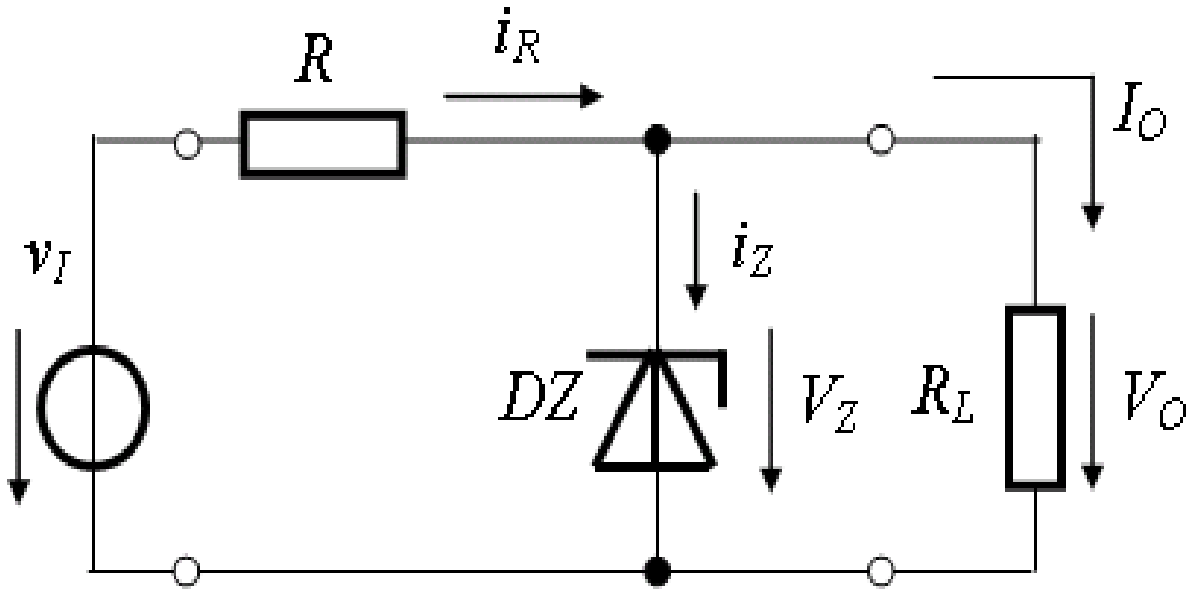
COLOR BAND DENOTES CATHODE

$P_{Dmax} = 1\text{W}$

Electrical Characteristics T_a = 25°C unless other

Device	V_Z (V) @ I_Z (Note 1)			Test Current I_Z (mA)
	Min.	Typ.	Max.	
1N4728A	3.135	3.3	3.465	76
1N4729A	3.42	3.6	3.78	69
1N4730A	3.705	3.9	4.095	64
1N4731A	4.085	4.3	4.515	58
1N4732A	4.465	4.7	4.935	53
1N4733A	4.845	5.1	5.355	49
1N4734A	5.32	5.6	5.88	45
1N4735A	5.89	6.2	6.51	41
1N4736A	6.46	6.8	7.14	37
1N4737A	7.125	7.5	7.875	34
1N4738A	7.79	8.2	8.61	31
1N4739A	8.645	9.1	9.555	28
1N4740A	9.5	10	10.5	25
1N4741A	10.45	11	11.55	23
1N4742A	11.4	12	12.6	21

Stabilizator parametric de tensiune - circuit



$$V_O = V_Z$$

$$v_I \in [\, V_{Imin} \,;\, V_{Imax} \,]$$

$$I_O \in [\, I_{Omin} \,;\, I_{Omax} \,]$$

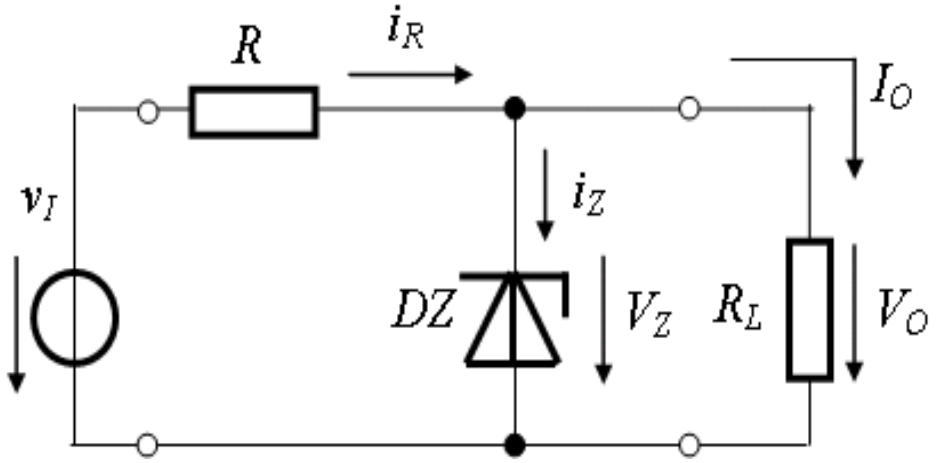
$$\Downarrow$$

$$i_Z \in [\, I_{Zmin} \,;\, I_{Zmax} \,]$$

$V_O \uparrow, I_O \uparrow, i_Z \downarrow, V_Z \downarrow, V_O \downarrow$

- Trebuie dimensionată *R*

Stabilizator parametric de tensiune. Dimensionare



Date de proiectare

$v_I \in (v_{I\min}, v_{I\max})$, V_O, $R_L \in (R_{L\min}, R_{L\max})$

$$i_Z = i_R - I_O = \frac{v_I - V_Z}{R} - I_O$$

Cazul cel mai defavorabil in care apare valoarea maxima a i_Z:

$$I_{O\min} = \frac{V_Z}{R_{L\max}} \qquad I_{O\max} = \frac{V_Z}{R_{L\min}}$$

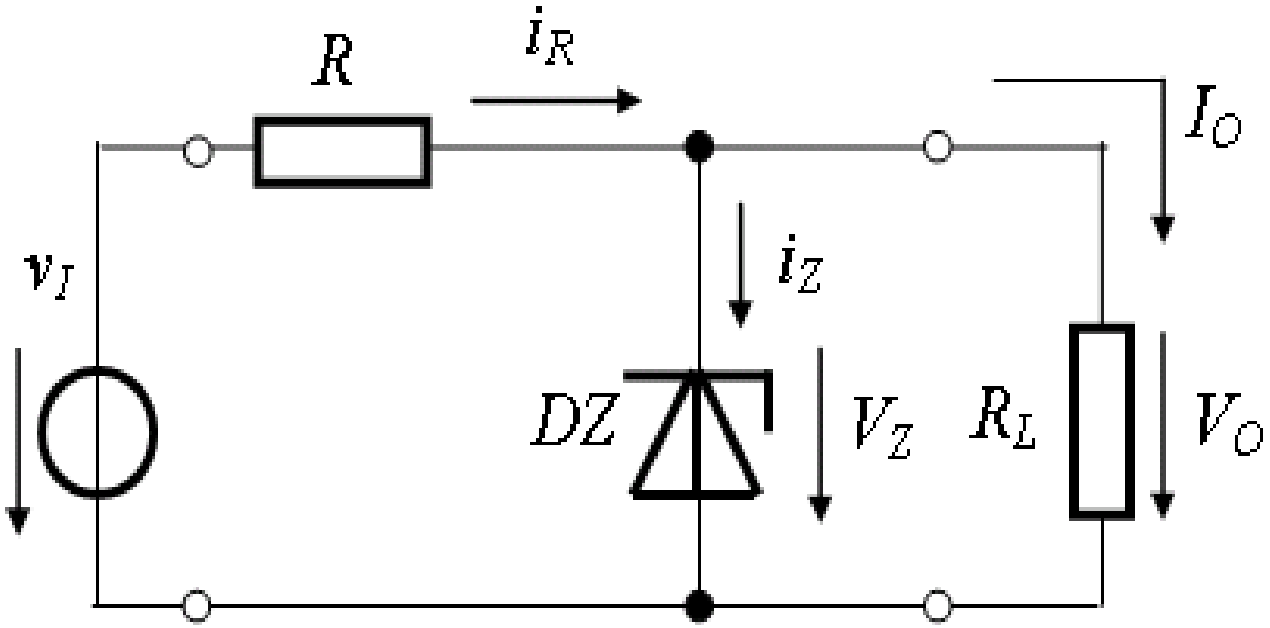
$$i_{Z\max} = \frac{v_{I\max} - V_Z}{R_{\min}} - I_{O\min}$$

$$R_{\min} = \frac{v_{I\max} - V_Z}{I_{Z\max} + I_{O\min}}$$

$$R_{\max} = \frac{v_{I\min} - V_Z}{I_{Z\min} + I_{O\max}}$$

$$\boxed{R \in (R_{\min}; R_{\max})}$$

Problemă



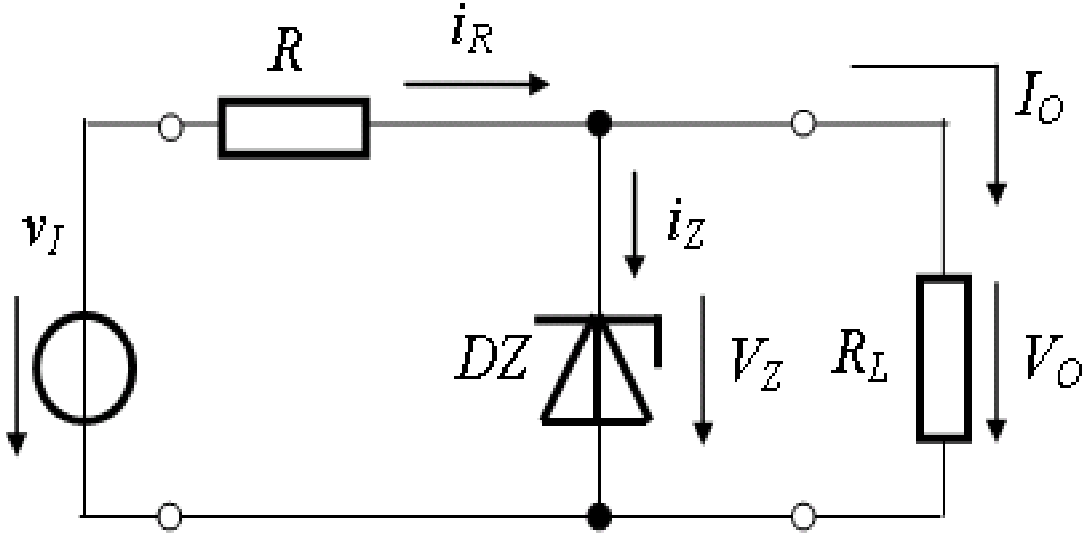
$v_I = 12 \pm 0{,}5\text{V},\ V_O = 7{,}5\text{V}$

$I_O = [25;50][\text{mA}]$

$R = ?$

$i_Z = ?$ pentru $v_I = 12\text{V}$, $I_O = 40\text{mA}$

Neajunsul stabilizatorului parametric. Soluții



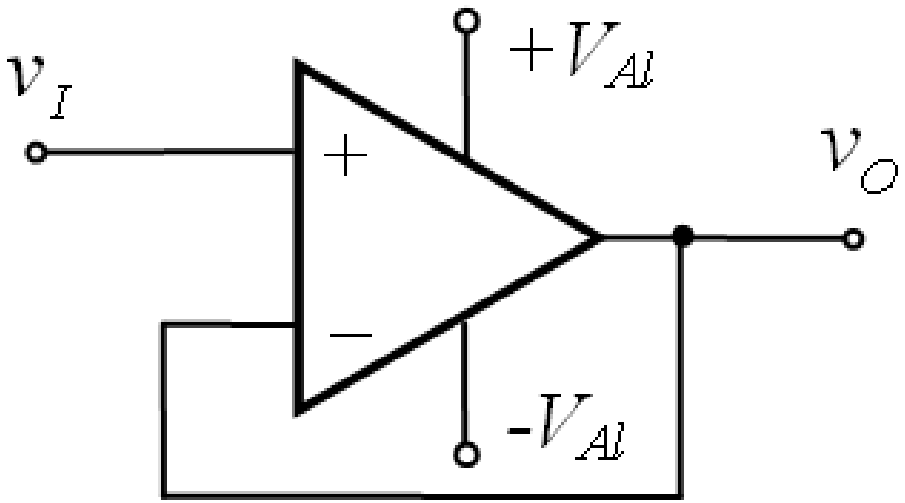
Neajuns:

I_O afecteaza direct i_Z

$$i_z = i_R - I_O$$

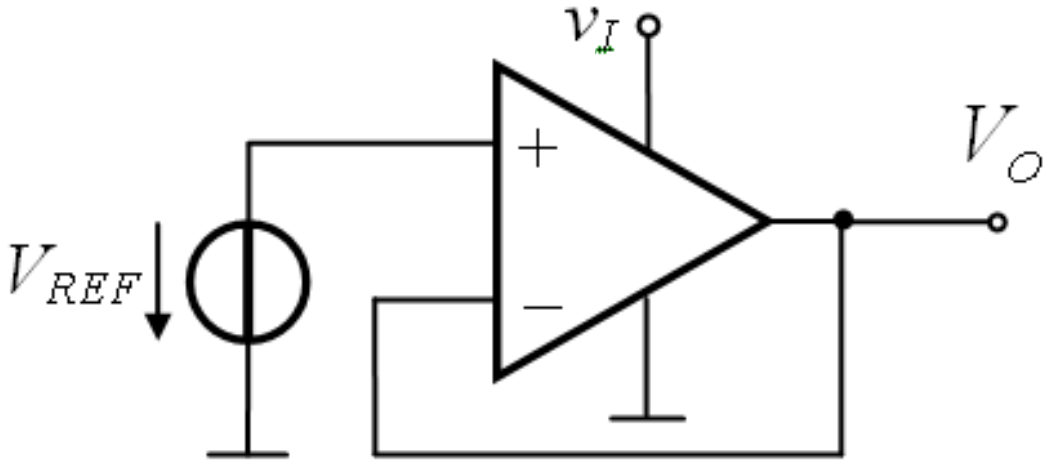
Domeniu limitat de variatie al I_O pentru a mentine *DZ* in regiunea de stabilizare

Solutie ? • Repetor de tensiune intre *DZ* si sarcina:



Repetor de tensiune cu AO

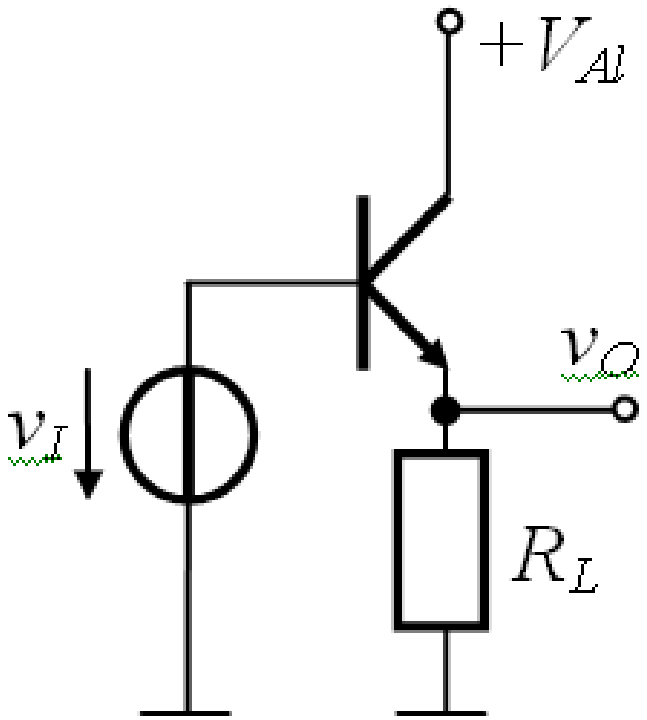
$$v_O = v_I$$



Stabilizator de tensiune cu AO

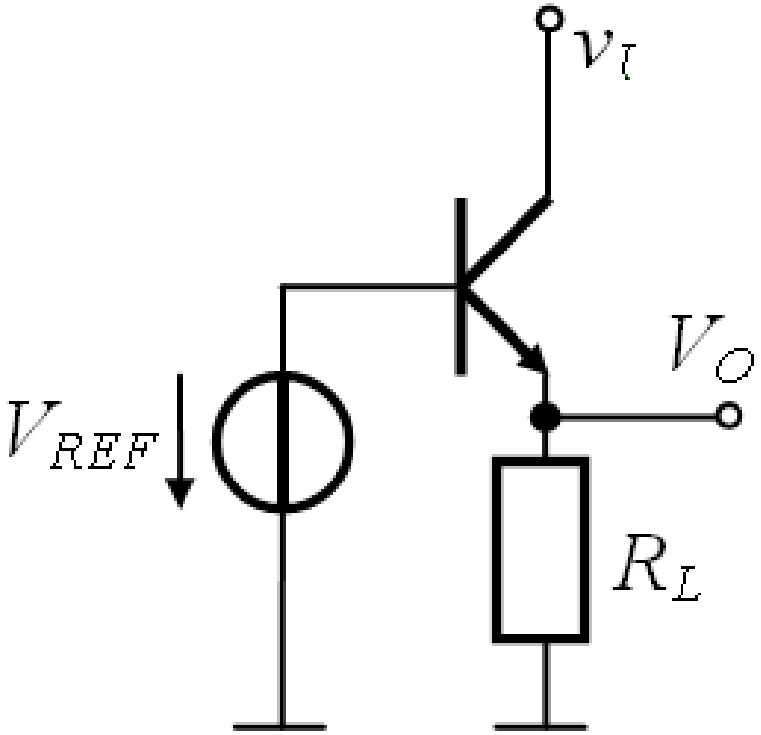
$$V_O = V_{REF}$$

Repetor cu TB



Repetor de tensiune cu TB, CC

Stabilizator ?



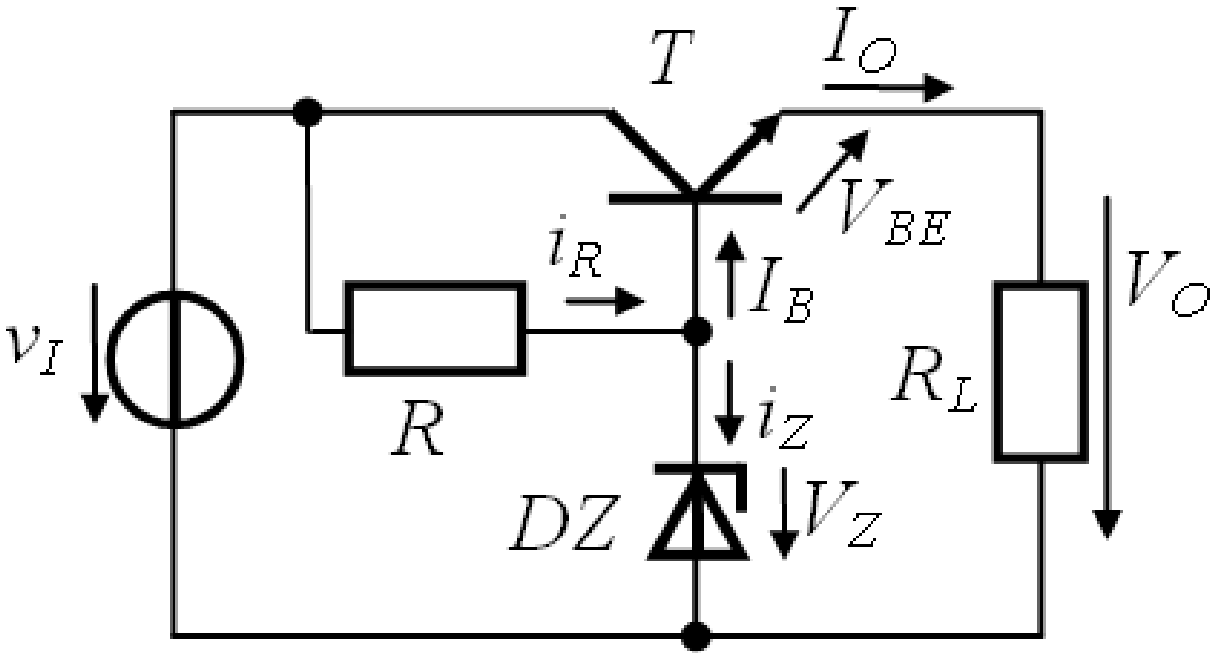
Stabilizator de tensiune

$$V_O = ?$$

$$V_O = V_{REF} - v_{BE}$$

Stabilizatoare liniare

Stabilizator de tensiune cu TB



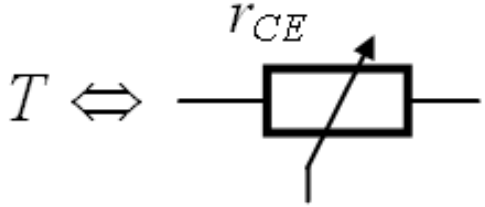
T – tranzistor regulator serie

$$V_O = V_{REF} - V_{BE}$$

$$i_R = i_Z + i_B = i_Z + \frac{I_O}{\beta}$$

Performantele de stabilizare sunt degradate de prezenta V_{BE} in expresia V_O

Mecanismul de stabilizare al V_O:

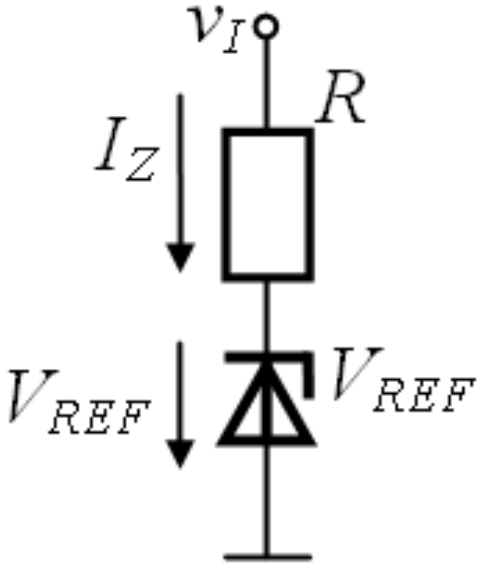


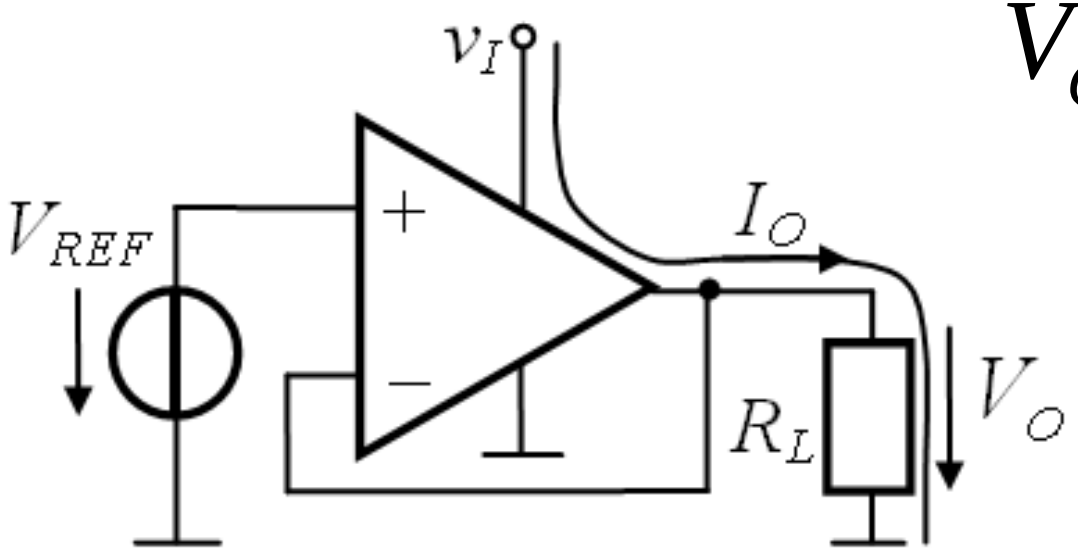
$$\underline{V_O \downarrow}\ I_O \downarrow\ I_B \downarrow\quad i_Z \uparrow\quad V_Z \uparrow\quad \underline{V_O \uparrow}$$

Mecanism de RN

Stabilizator de tensiune cu AO

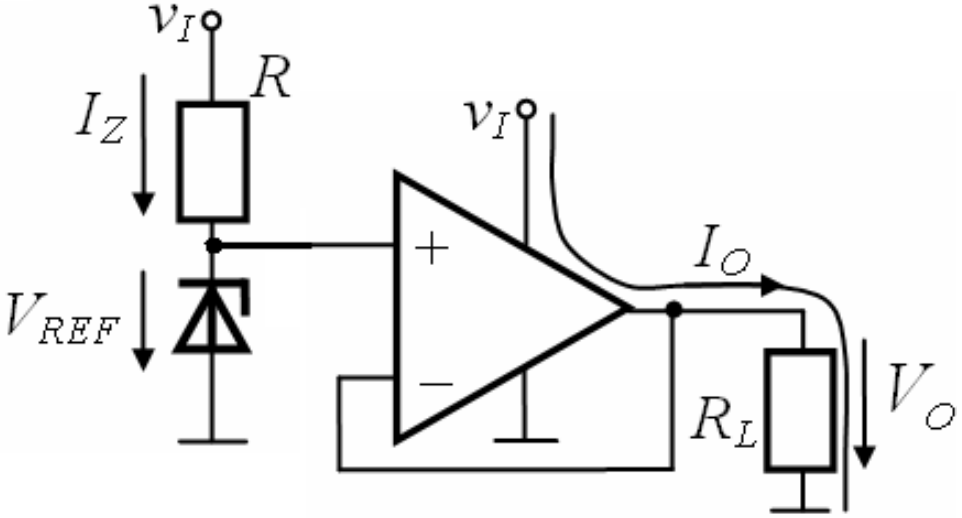
$$V_O = V_{REF}$$

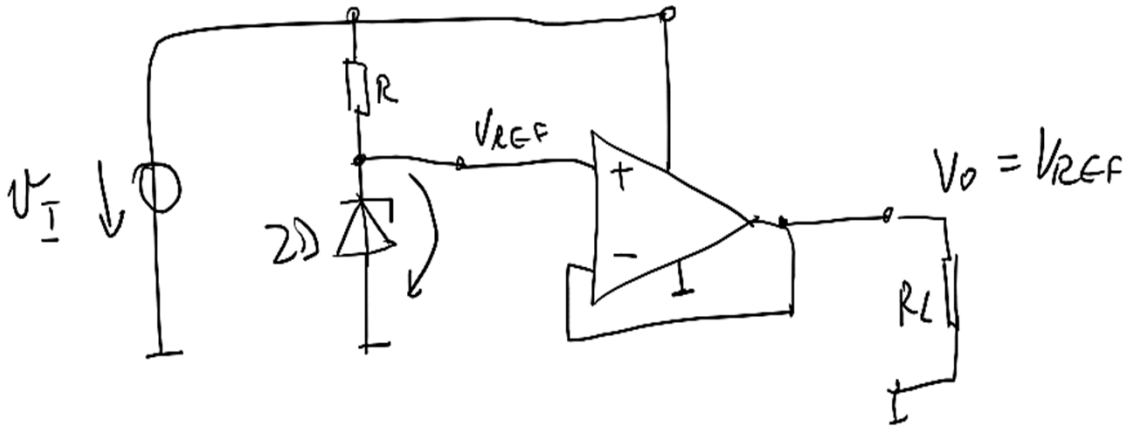




Se asigura o mai buna stabilizare daca *R* se inlocuieste cu o sursa de curent

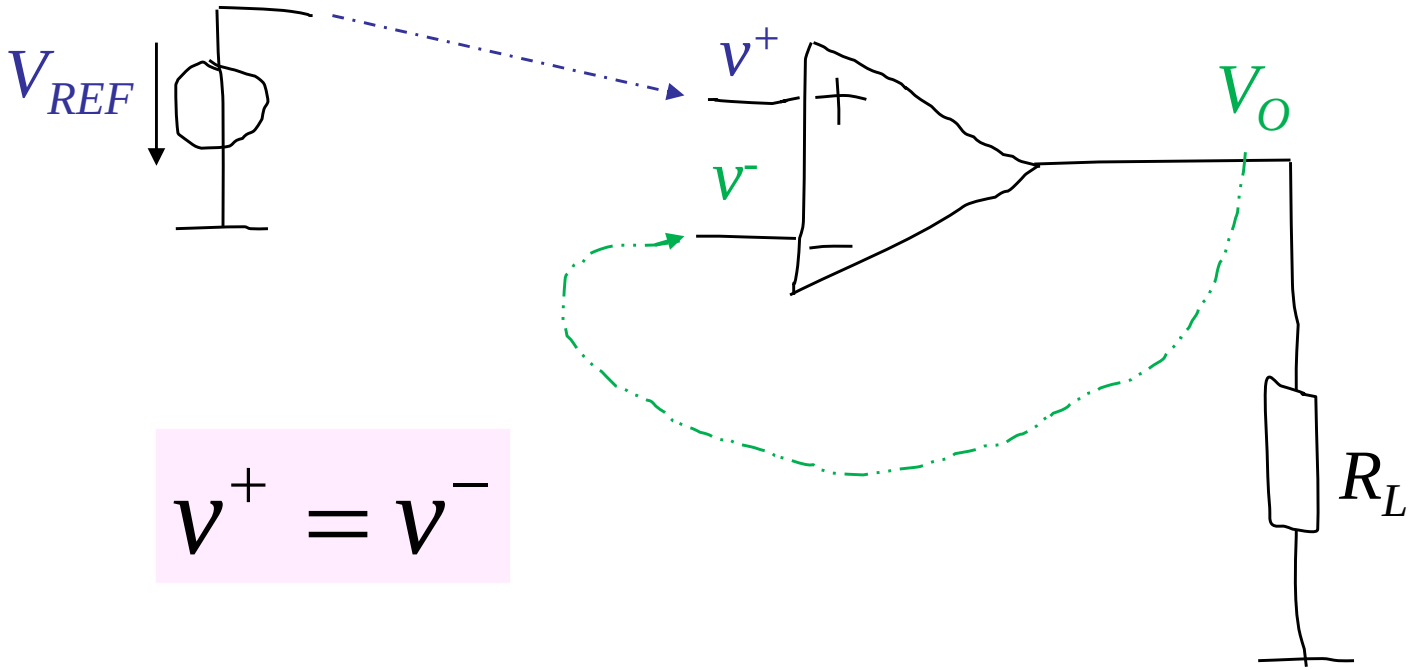
Cum arata schema completa?





Stabilizator de tensiune cu AO

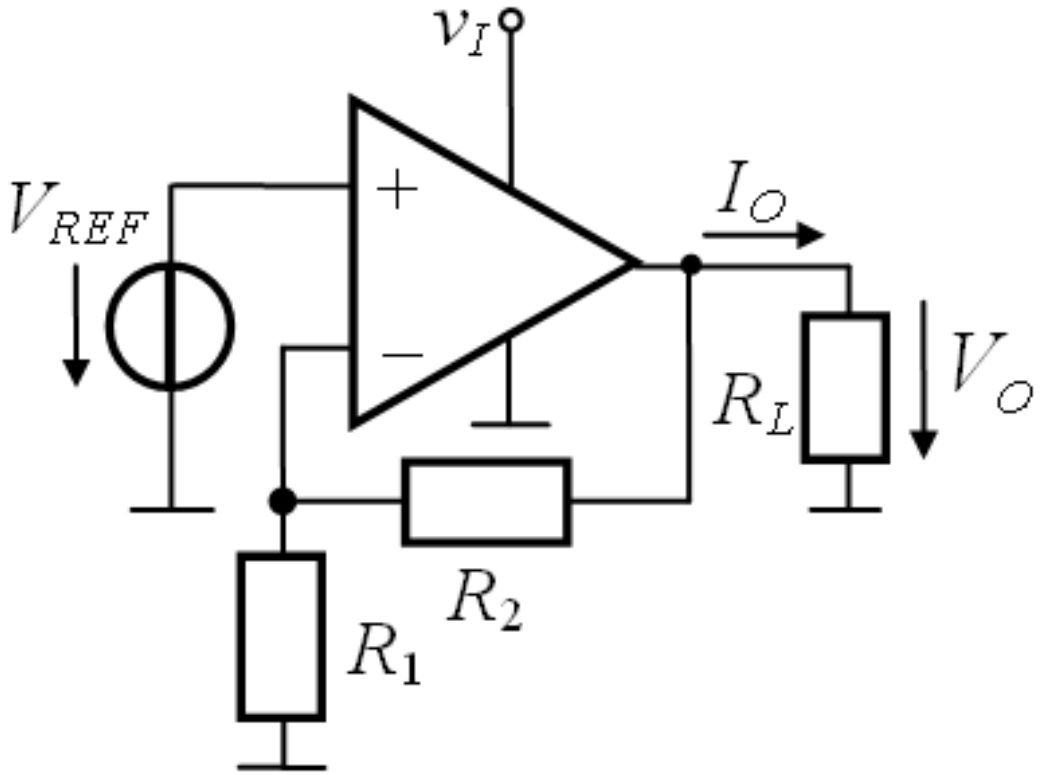
$$V_O \neq V_{REF}$$



$$v^+ = v^-$$

Stabilizator de tensiune cu AO - cont.

$$V_O > V_{REF}$$



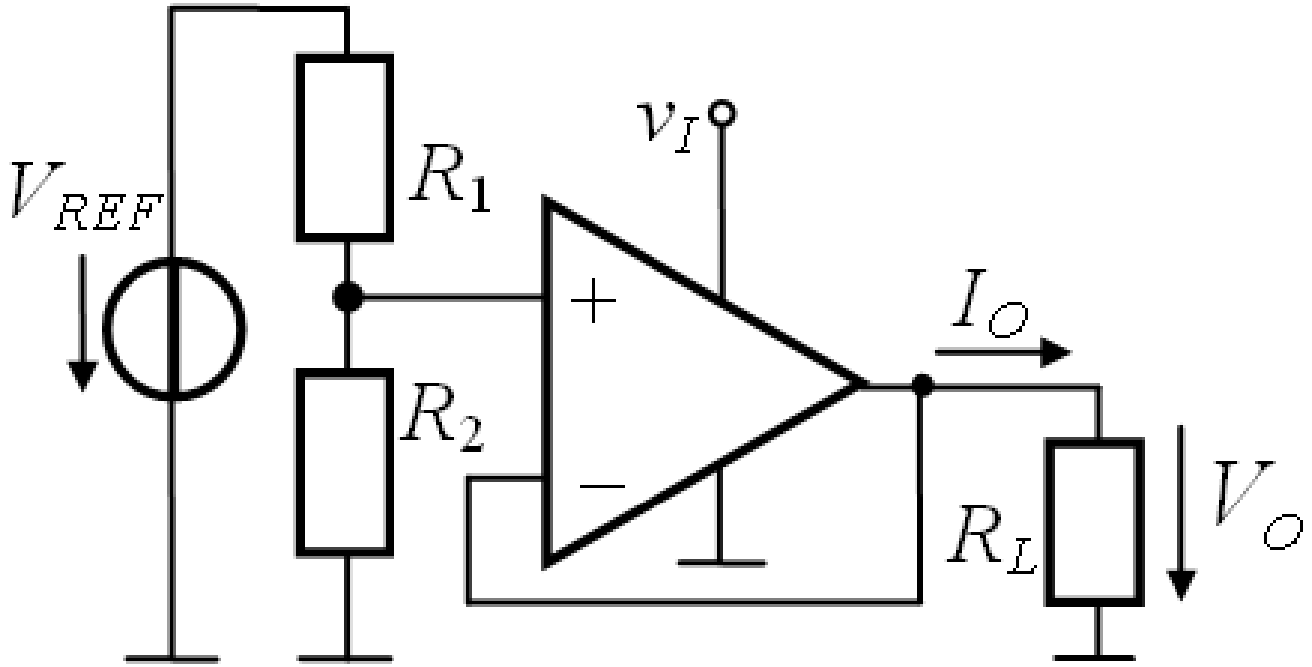
V_O=?

$$V_O = \left(1 + \frac{R_2}{R_1}\right) V_{REF}$$

Stabilizator de tensiune cu AO - cont.

$$V_O < V_{REF}$$

Se considera V_{REF} impusă

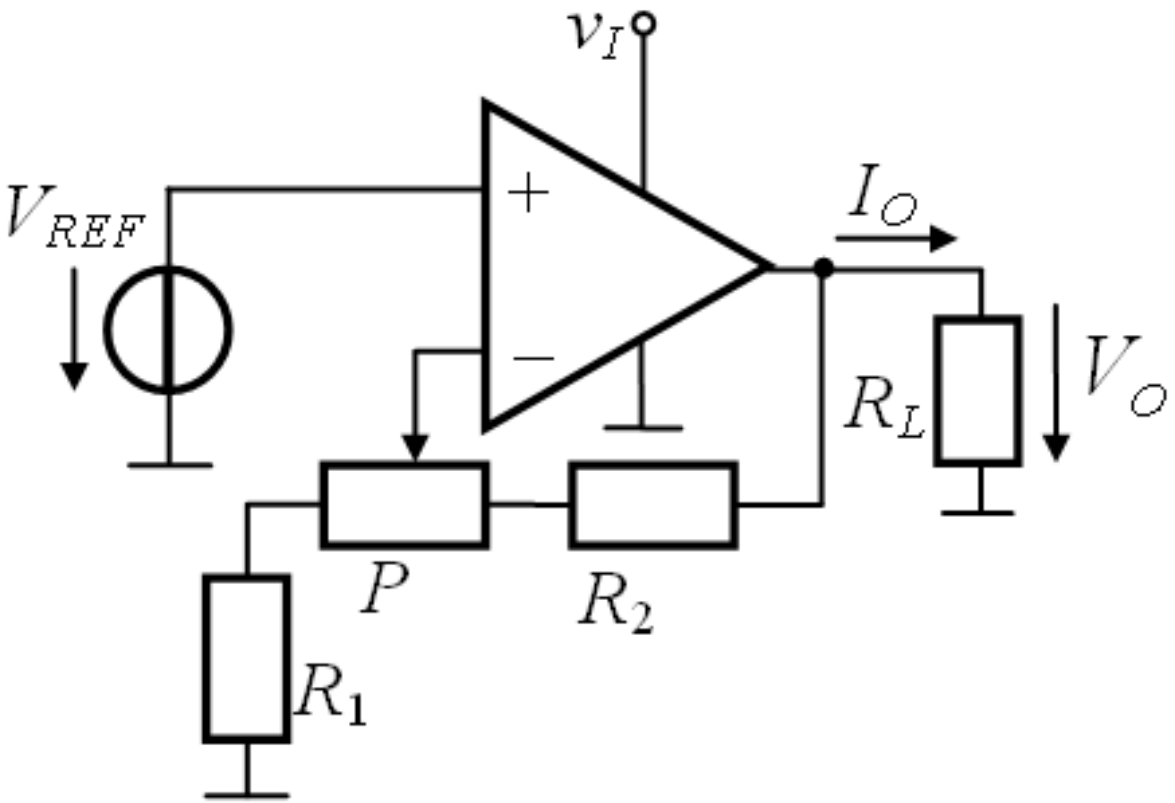


V_O=?

$$V_O = \frac{R_2}{R_1 + R_2} V_{REF}$$

Stabilizator de tensiune cu AO - cont.

V_O reglabil, $V_O > V_{REF}$



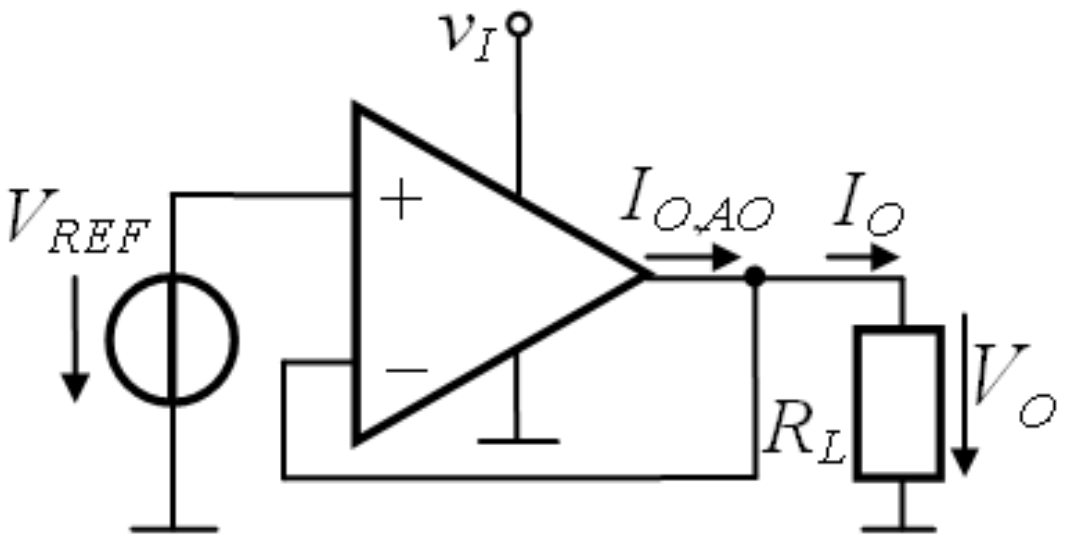
V_O=?

$$V_{O\min} = \left(1 + \frac{R_2}{P + R_1}\right) V_{REF}$$

$$V_{O\max} = \left(1 + \frac{R_2 + P}{R_1}\right) V_{REF}$$

- Cum arată schema stabilizatorului cu V_O reglabil, $V_O < V_{REF}$?
- Cum arată schema stabilizatorului cu V_O reglabil, $V_{O\min} < V_{REF}$ și $V_{O\max} > V_{REF}$?

Extinderea domeniului de curent



$$I_{O\max} = I_{O,AO\max}$$

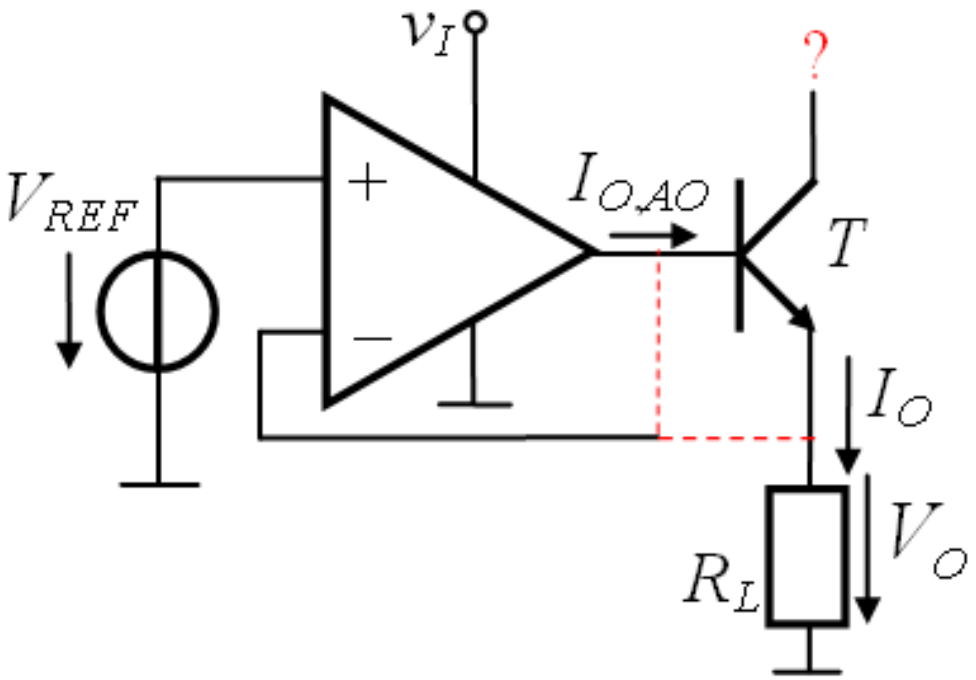
La AO, uzual:

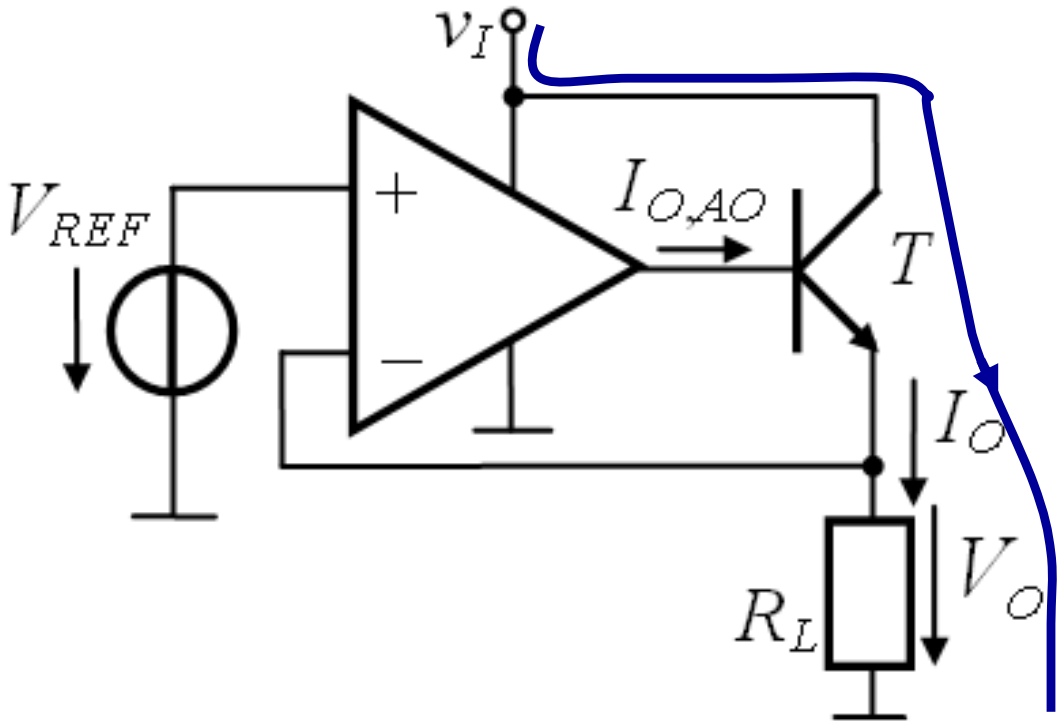
$$I_{O,AO\max} \approx 20\text{mA}$$

? Curent mai mare in sarcină

Soluții:

- AO de putere; ex. TDA2030, până la 3,5A
- amplificator de curent între AO și sarcină





$$I_O = \beta I_{O,AO}$$

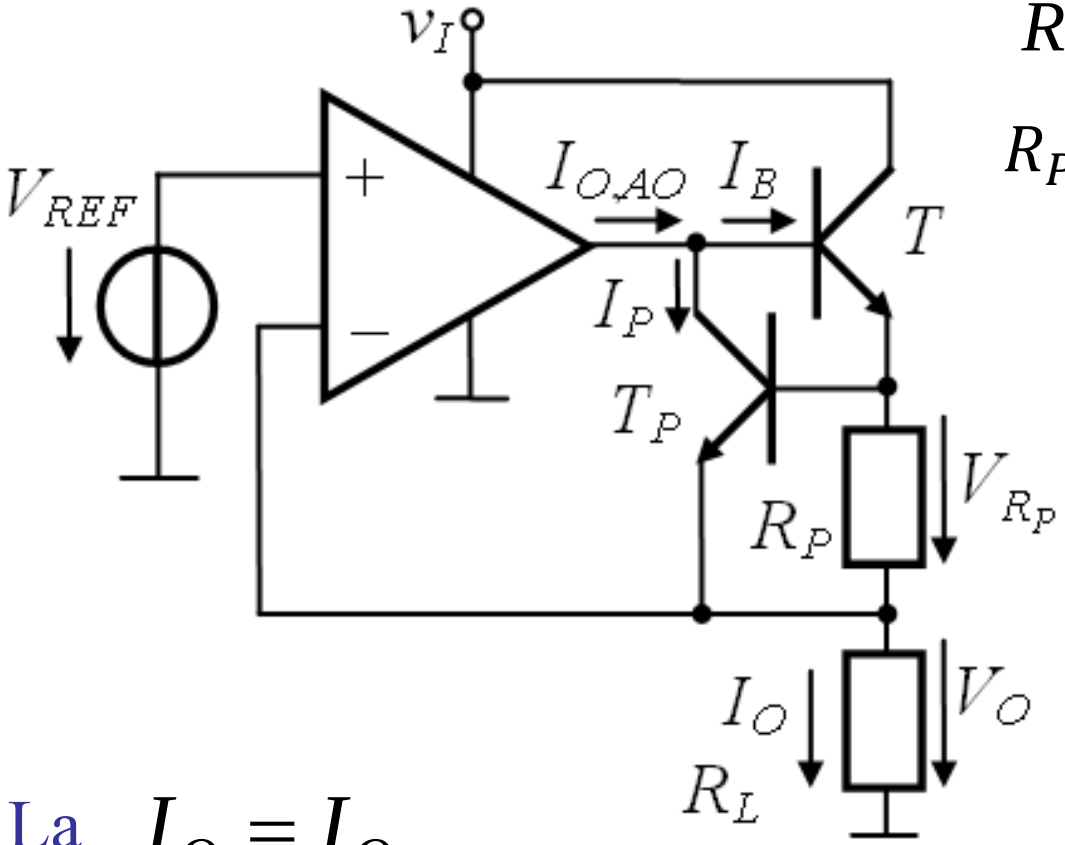
T – element
regulator serie, ERS

Protectie la supracurent

$R_L \to 0 \qquad I_O \to \infty$

Se impune limitarea curentului prin tranzistor:

- monitorizam I_O
- când I_O depășește valoarea prestabilită, acționează circuitul de limitare



$R_P I_O < 0{,}6\text{V}; \quad T_P - (b); \quad I_P = 0$

$R_P I_O > 0{,}6\text{V}; \quad T_P - (a_F); \quad I_P > 0$

$$I_{O\max} = \frac{V_{R_P}}{R_P} + I_P$$

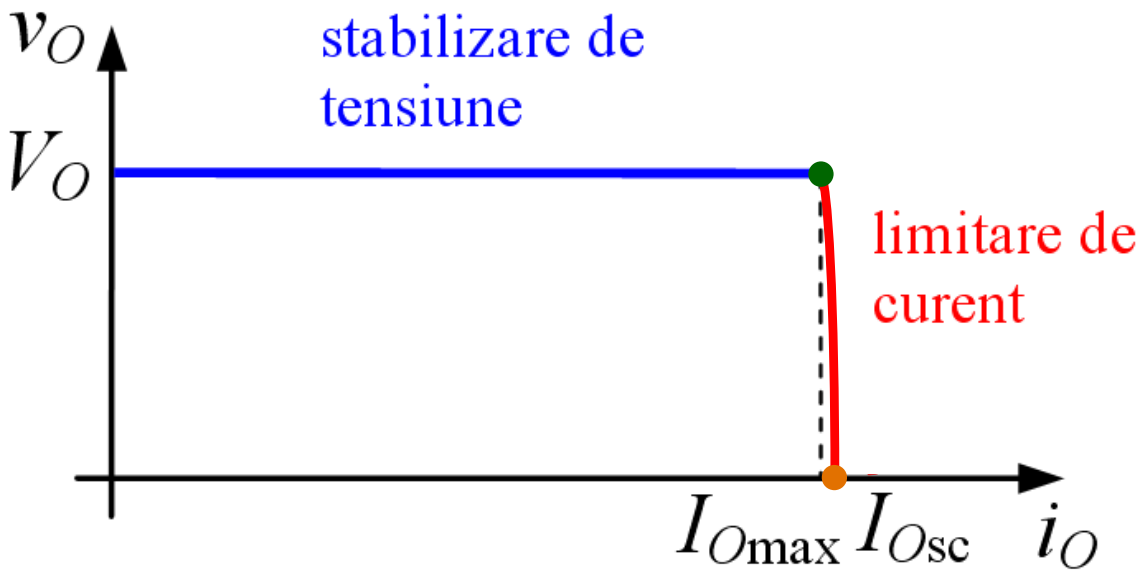
$$I_{Omax} = \frac{0{,}7\text{V}}{R_p} + I_p \approx \frac{0{,}7\text{V}}{R_p}$$

$$\boxed{I_{Omax} \approx \frac{0{,}7\text{V}}{R_p}}$$

La $I_O = I_{O\max}$

$R_L \downarrow, \underline{I_O \uparrow}, I_O R_P \uparrow, I_P \uparrow, I_B \downarrow, \underline{I_O \downarrow} \qquad V_O \downarrow$

Caracteristica de ieşire



- stabilizare de tensiune

$$v_O = V_O,\ I_O = \frac{V_O}{R_L}$$

- punctul de cot $v_O = V_O,\quad I_O = I_{O\max} = \frac{0{,}7\text{V}}{R_P}$

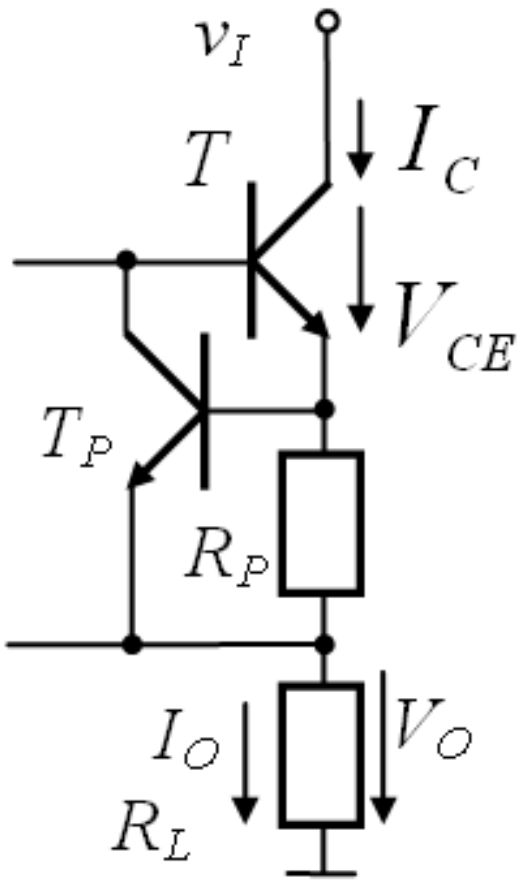
- limitare de curent $v_O < V_O,\ v_O = I_O R_L,\quad I_O = I_{Omax} + I_p \approx \frac{0{,}7\text{V}}{R_p}$

- scurt circuit la iesire $v_O = 0$

$$I_O = I_{Osc} = \frac{0{,}7\text{V}}{R_p} + I_{O,AOmax} - \frac{1}{\beta}\frac{0{,}7V}{R_p} \approx \frac{0{,}7\text{V}}{R_p} + I_{O,AOmax} \approx \frac{0{,}7\text{V}}{R_p}$$

Valori maxime ale marimilor electrice pentru *T*

$$v_I \in \left(V_{I\min}; V_{I\max}\right)$$



- **curentul maxim prin tranzistor:** $I_{O\max}$
- **tensiunea maxima colector emitor**

$$V_{CE} = V_I - V_{R_P} - V_O$$

$V_{CE\max}$ apare in regim de scurtcircuit la iesire

$$V_{CEmax} = V_{Imax} - V_{R_p} = V_{Imax} - 0{,}7\text{V} \approx V_{Imax}$$

$$V_{CE\max} \approx V_{I\max}$$

- **puterea maxima disipata pe tranzistor**

$$P_{dT} \approx I_C V_{CE}$$

$$P_{dT\max} \approx I_{O\max} V_{I\max}$$

apare in regim de scurtcircuit la iesire

Alegerea tranzistorului regulator serie

In foaia de catalog a tranzistoarelor se dau valorile maxime admise pentru

- curentul de colector $I_{C\max}$
- tensiunea colector emitor V_{CE0}
- puterea disipata $P_{d\,\mathrm{tot}}$

Tranzitorul se alege astfel incat:

$$I_{C\max} > 2I_{O\max}$$

$$V_{CE0} > V_{CE\max}$$

$$0{,}4P_{d\,\mathrm{tot}} \geq P_{dT\max}$$

Atentie la puterea disipata. Valoarea precizata in catalog se refera la putere disipata cand tranzistorul este montat pe un radiator plan de dimensiune infinita. In practica puterea maxima se considera $P_{d\max} \approx 0{,}4P_{d\mathrm{tot}}$ (radiator de dimensiuni acceptabile)

2N3055(NPN), MJ2955(PNP)

Preferred Device

Complementary Silicon Power Transistors

Complementary silicon power transistors are designed for general−purpose switching and amplifier applications.

Features

- DC Current Gain − h_{FE} = 20−70 @ I_C = 4 Adc
- Collector−Emitter Saturation Voltage − $V_{CE(sat)}$ = 1.1 Vdc (Max) @ I_C = 4 Adc
- Excellent Safe Operating Area
- Pb−Free Packages are Available*

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector−Emitter Voltage	V_{CEO}	60	Vdc
Collector−Emitter Voltage	V_{CER}	70	Vdc
Collector−Base Voltage	V_{CB}	100	Vdc
Emitter−Base Voltage	V_{EB}	7	Vdc
Collector Current − Continuous	I_C	15	Adc
Base Current	I_B	7	Adc
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	115 0.657	W W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

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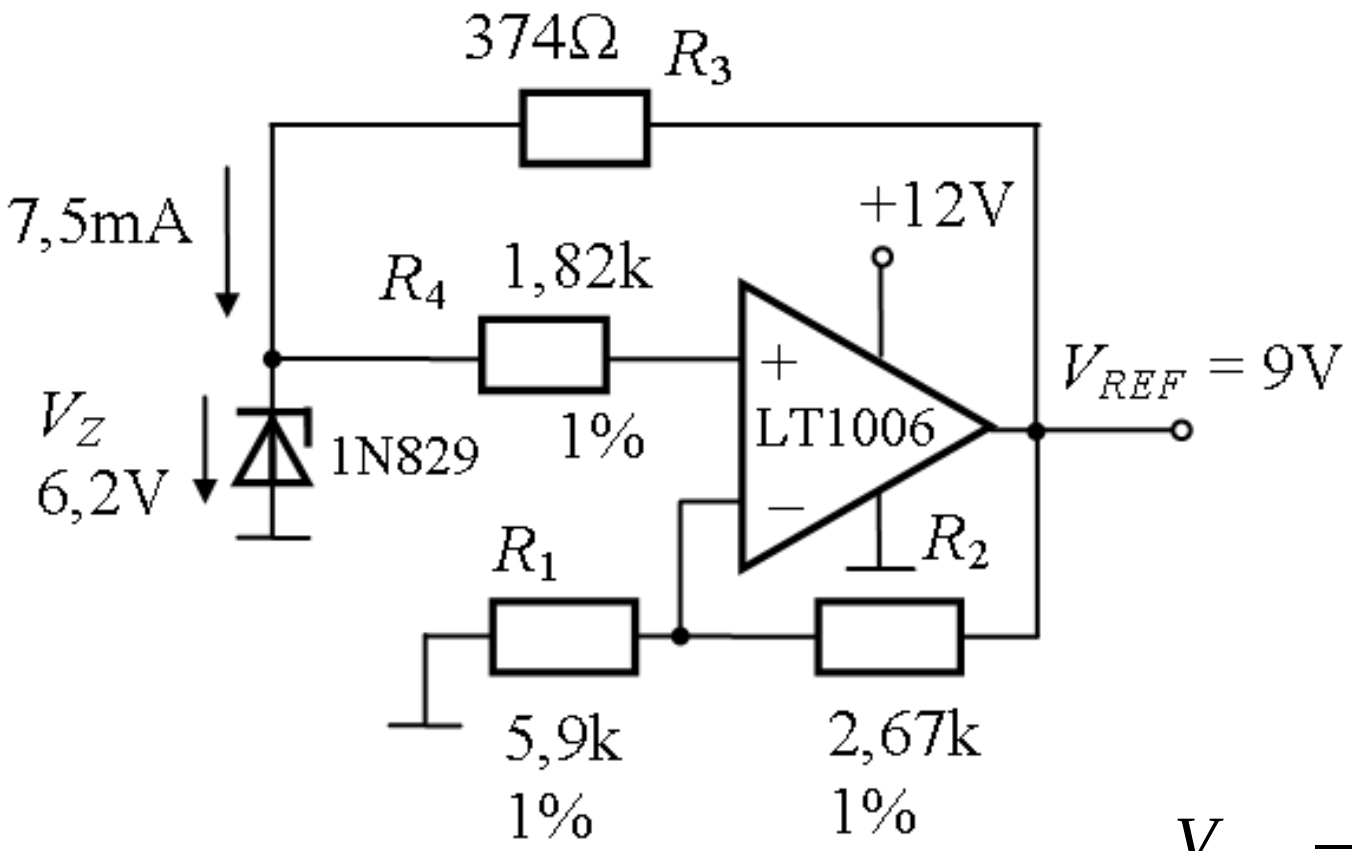
15 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON 60 VOLTS, 115 WATTS

TO−204AA (TO−3)
CASE 1−07
STYLE 1

MARKING DIAGRAM

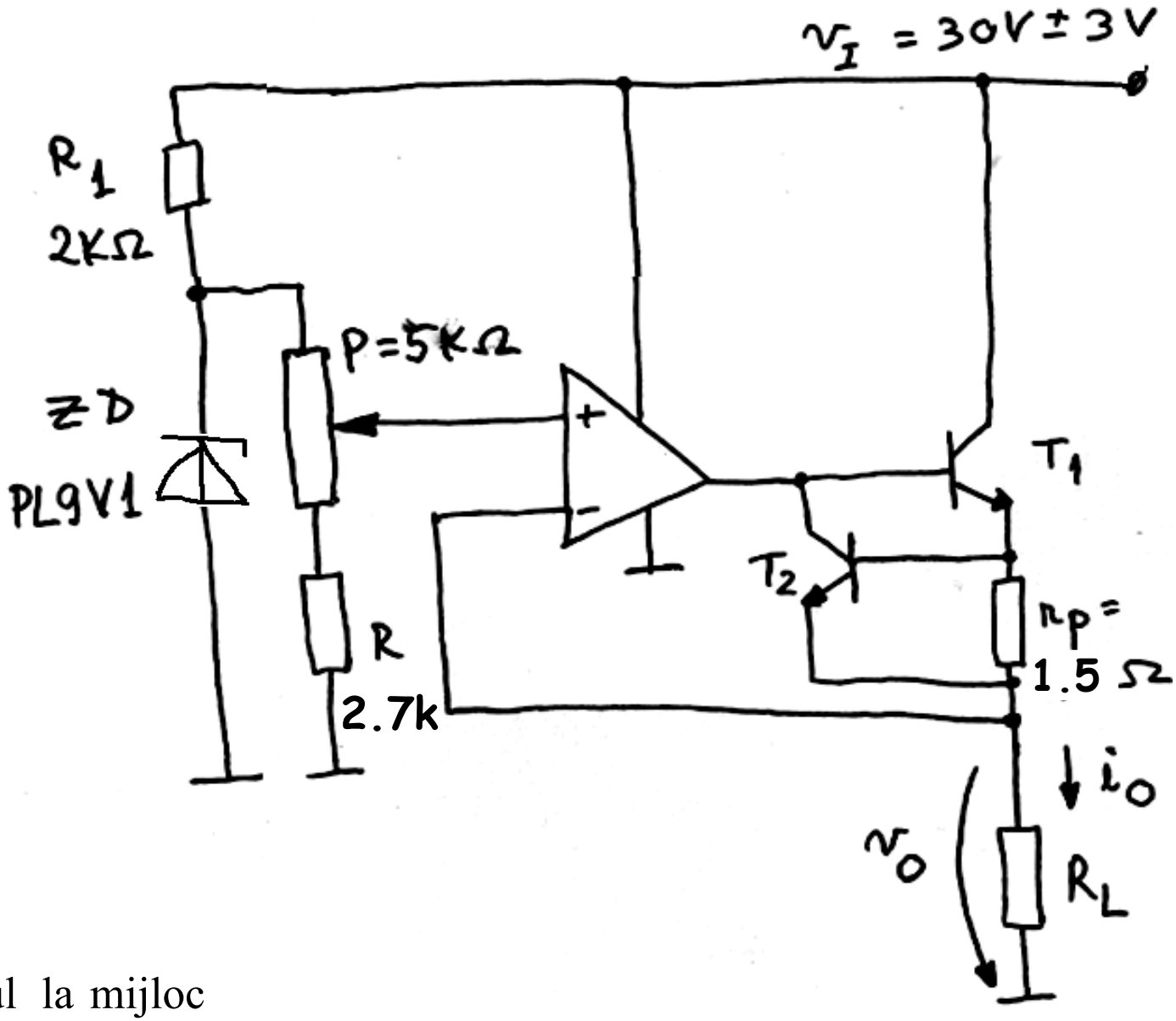
Referință de tensiune



$$I_Z = \frac{V_{REF} - V_Z}{R_3} = \frac{9 - 6{,}3}{374} = 7{,}5\text{mA}$$

$$V_{REF} = \left(1 + \frac{R_2}{R_1}\right) V_Z = \left(1 + \frac{2{,}67}{5{,}9}\right) \cdot 6{,}2 = 9\text{V}$$

Problema



Curentul prin dioda Zener ?

Domeniul V_O ?

$v_O(i_O)$ considerand cursorul la mijloc

Puterea maxima disipata de T_1 pentru $R_L = 500\Omega$; $R_L = 12\ \Omega$, scurtcircuit la iesire considerand

i) cursorul la capatul de sus al potentiometrului

ii) cursorul la mijloc

Care este caracteristica de iesire a stabilizatorului in fiecare din cazurile i) si ii)?