Seminar 8.

ARN - S-5

Pentru amplificatorul cu reacție din fig. 1 se cunosc:

Q_{1-6} $\begin{cases} |V_{EB}| \cong 0{,}6V \\ \beta_F = \beta_0 = 500 \\ r_0 = \infty \end{cases}$;

Q_7 $\begin{cases} I_{DSS} = 2mA \\ V_T = -2V \\ r_{ds} = \infty \end{cases}$;

D_{Z1} $\begin{cases} V_{Z1} = 1V \\ I_{Z1,min} = 0{,}05mA \\ R_Z \cong 0 \end{cases}$;

D_{Z2} $\begin{cases} V_{Z2} = 2V \\ I_{Z1,min} = 0{,}1mA \\ R_Z \cong 0 \end{cases}$;

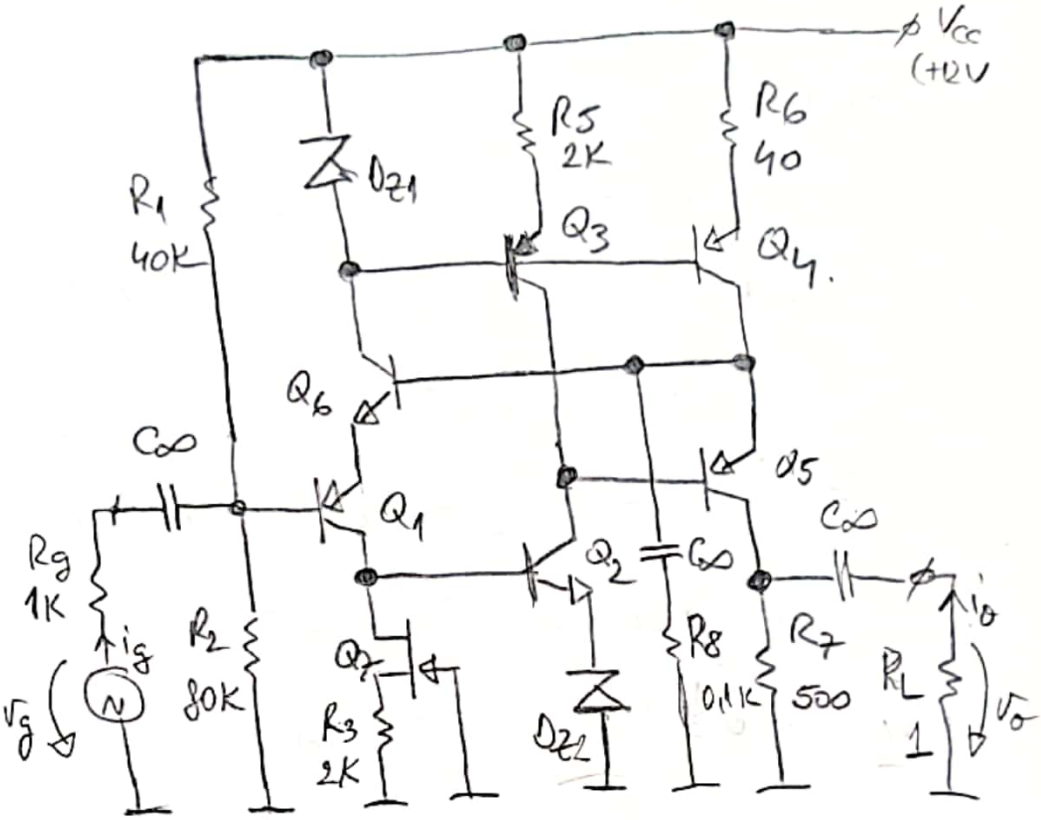


Fig. 1

Se cere să se calculeze: 1) p.s.f. ; 2) $A_{v,g} = ?$; 3) $R_i = ?$; 4) $R_0 = ?$ 5) Tensiunea minimă de alimentare pentru funcționarea liniară.

Pentru calculele de c.a. se va considera regimul de semnal mic și joasă frecvență.

1) p.s.f.

Pp TB în RAN, $D_{Z1,2}$ în blocarea lui Q_7 în saturație.

$$I_{C3} \cong I_{C2} \cong I_{Z2} \cong \frac{V_{Z1} - V_{EB3}}{R_5} = \frac{1V - 0{,}6V}{2k\Omega} = 0{,}2mA$$

$$I_{C4} \cong I_{C5} = I_{R7} = \frac{V_{Z1} - V_{EB4}}{R_6} = \frac{1V - 0{,}6V}{904\Omega} = 10mA$$

$$\begin{cases} V_{GS7} = -I_{D7} \cdot R_3 \\ I_{D7} = I_{DSS}\left(1 - \frac{V_{GS}}{V_T}\right)^2 \end{cases} \Rightarrow \begin{matrix} V_{GS7} = -1V \\ I_{D7} = 0{,}5mA \end{matrix}$$

$I_{D7} \cong I_{C1} \cong I_{Z1} = 0{,}5\,mA = I_{CC}$

$V_{B1} = V_{CC} \cdot \frac{R_2}{R_1+R_2} = 12 \cdot \frac{8}{12} V = 8V$

$V_{B1} + 2V_{BE} = V_{E5} = 9{,}2V$

$V_{EC5} = V_{E5} - R_7 \cdot I_{C5} = 4{,}2V$

$V_{EC4} = V_{CC} - R_6 \cdot I_{C4} = V_{E5} = 2{,}4V$

$V_{CE2} = V_{E5} - V_{EB5} - V_{Z2} = 6{,}6V$

$V_{EC3} = V_{CC} - R_5 \cdot I_{C3} - V_{CE2} - V_{Z2} = 2{,}4V$

$V_{DS7} = V_{Z2} + V_{BE2} - R_3 \cdot I_{D7} = 1{,}6V$

$V_{EC1} = V_{E5} - V_{BE6} - V_{DS7} - R_3 \cdot I_{D7} = 6V$

$V_{CE6} = V_{CC} - V_{Z1} - V_{EB1} - V_{B1} = 2{,}4V$

Q_1 { $I_{C1} = 0{,}5\,mA$; $V_{EB} = 0{,}6V$; $V_{EC1} = 6V > V_{EB}$ } $\Rightarrow$ RAN ;

Q_5 { $I_{C5} = 10\,mA$; $V_{EB5} = 0{,}6V$; $V_{EC5} = 4{,}2V > V_{EB}$ } $\Rightarrow$ RAN

Q_2 { $I_{C2} = 0{,}2\,mA$; $V_{BE2} = 0{,}6V$; $V_{CE2} = 6{,}6V > V_{BE}$ } $\Rightarrow$ RAN ;

Q_6 { $I_{C6} = 0{,}5\,mA$; $V_{BE6} = 0{,}6$; $V_{CE6} = 2{,}4V > V_{BE}$ } $\Rightarrow$ RAN

Q_3 { $I_{C3} = 0{,}2\,mA$; $V_{EB3} = 0{,}6V$; $V_{EC3} = 2{,}4V > V_{EB}$ } $\Rightarrow$ RAN ;

Q_7 { $I_{D7} = 0{,}5\,mA$; $V_{GS7} = -1V > V_T$; $V_{DS7} = 1{,}6V > V_{GS} - V_T$ } $\Rightarrow$ SAT

Q_4 { $I_{C4} = 10\,mA$; $V_{EB4} = 0{,}6V$; $V_{EC4} = 2{,}4V > V_{EB}$ } $\Rightarrow$ RAN ;

DZ_1 { $V_{Z1} = 1V$; $I_{Z1} = 0{,}5\,mA > I_{Z,min}$ } $\Rightarrow$ STAB.

DZ_2 { $V_{Z2} = 2V$; $I_{Z2} = 0{,}2\,mA > I_{Z,min}$ } $\Rightarrow$ STAB.

$g_{m1} = g_{m6} = 40 \cdot I_{C1} = 40 \cdot 0{,}5 \cdot k\Omega^{-1} = 20\ k\Omega^{-1}$

$r_{\pi 1} = r_{\pi 6} = \frac{\beta}{g_{m6}} = \frac{500}{20}\ k\Omega = 25\ k\Omega$

$g_{m2} = 40\, I_{C2} = 40 \cdot 0{,}2\ k\Omega^{-1} = 8\ k\Omega^{-1}$

$r_{\pi 2} = \frac{\beta}{g_{m2}} = \frac{500}{8}\ k\Omega = 62{,}5\ k\Omega$

$g_{m5} = 40\, I_{C5} = 40 \cdot 10\ k\Omega^{-1} = 400\ k\Omega^{-1}$

$r_{\pi 5} = \frac{\beta}{g_{m5}} = \frac{500}{400} = 1{,}25\ k\Omega$

2) Schema ck ca.

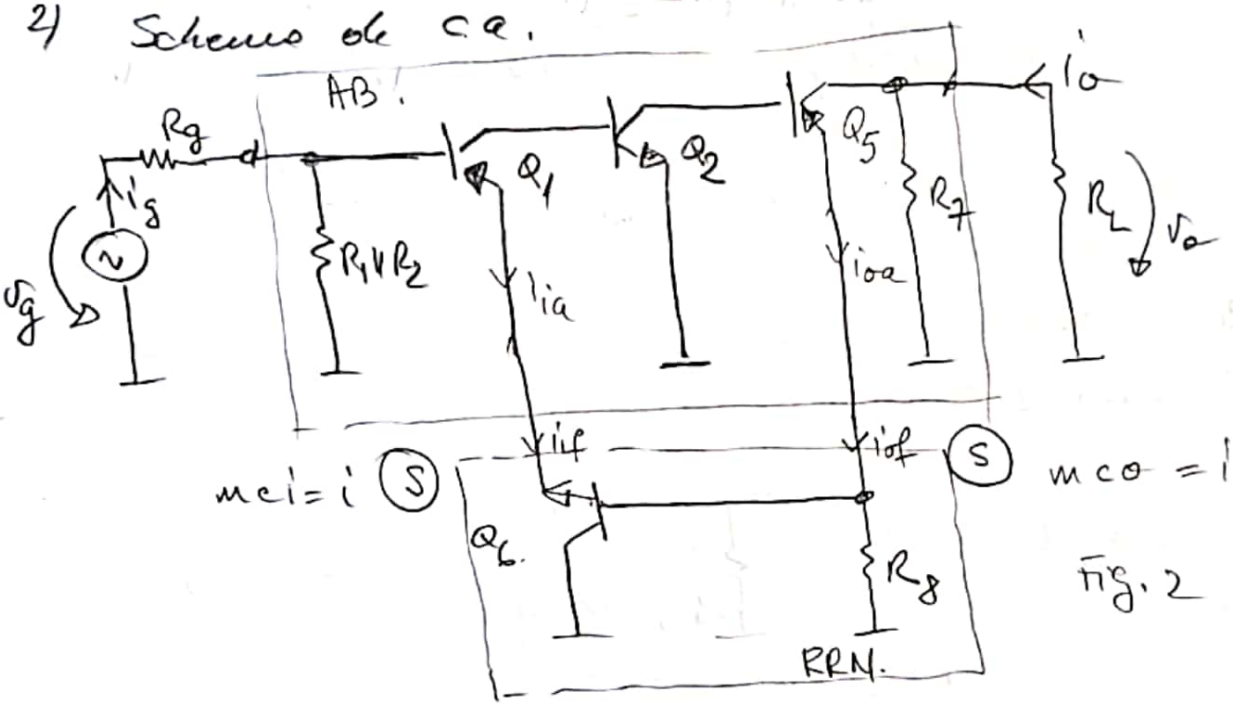


Fig. 2

RRN

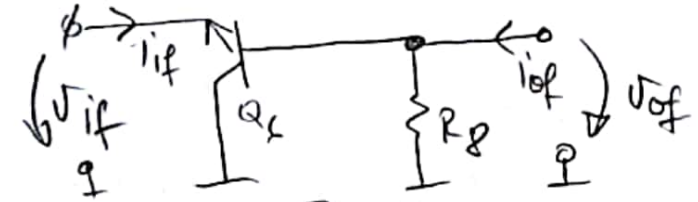


Fig. 3

$f = \left.\frac{m.u.i.}{m.co.}\right|_{mci=0}$

$f_z = \left.\frac{v_{if}}{i_{of}}\right|_{i_{if}=0}$

Deco $i_{if} = 0 \Rightarrow v_{if} \simeq i_{of} \cdot R_8 \Rightarrow f_z = \left.\frac{v_{if}}{i_{of}}\right|_{i_F=0} = R_8 = 0{,}1K$

$r_{if} = \left.\frac{v_{if}}{i_{if}}\right|_{i_{of}=0} = \frac{r_{\pi 6} + R_8}{\beta + 1} \simeq 50\ \Omega$

$$r_{of} = \frac{v_{of}}{i_{of}}\Big|_{m.c.i.=0} = \frac{v_{of}}{i_{of}}\Big|_{i_{if}=0} = R_8 = 0,1\,k\Omega$$

Se construiește ABO.

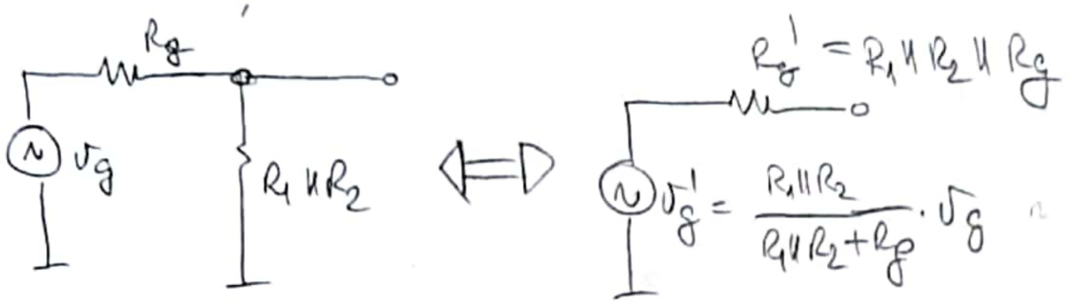


Fig. 4.

Prin această echivalare pe bucla de intrare curentul devine mărime comună între generator, AB și RR.

La ieșire:

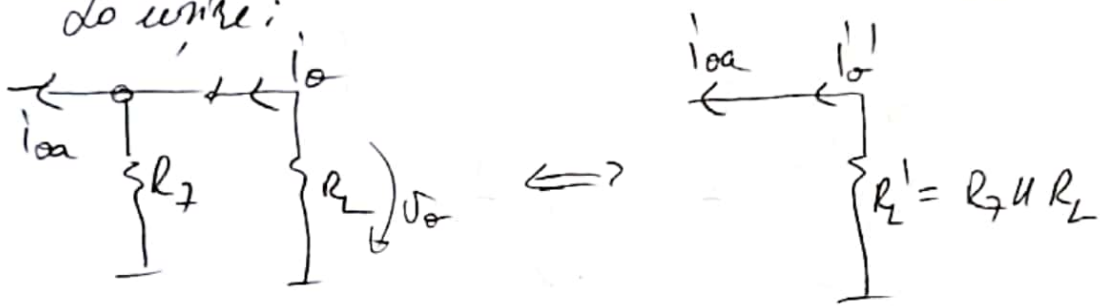
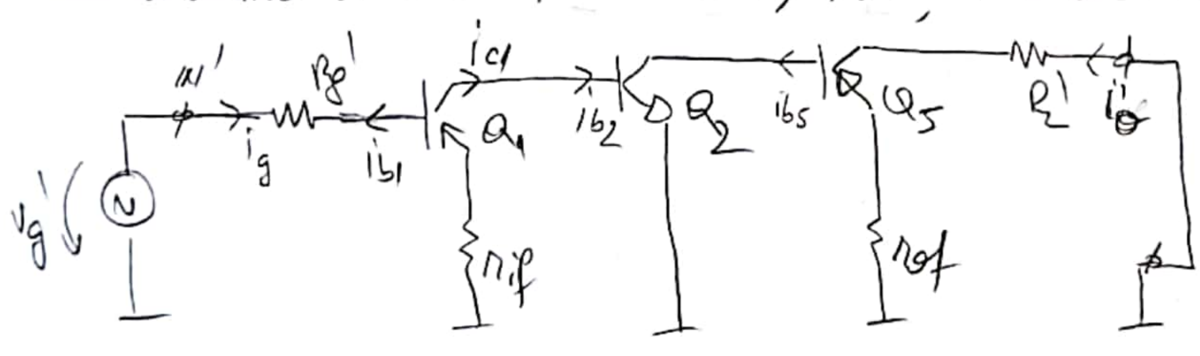


Fig. 5

Echivalarea de la ieșire face ca $i_{oa} = i_o' = i_{of}$ => curentul este mărime comună între RB, AB și rez. de sarcină R_L'.



ABO Fig. 6

$$a = \frac{m.c.o}{m.g}$$

$$a'_{yg} = \frac{i_o'}{v_g'} = \frac{i_o'}{i_{b5}}\cdot\frac{i_{b5}}{i_{b2}}\cdot\frac{i_{b2}}{i_{c1}}\cdot\frac{i_{c1}}{i_{b1}}\cdot\frac{i_{b1}}{v_g'} =$$

$$= -\beta\cdot\beta\cdot 1\cdot\beta\cdot\frac{-1}{R_g' + r_{\pi1} + (\beta+1) r_{if}} \cong \beta^3\cdot\frac{1}{r_{\pi1} + \beta r_{if}} =$$

$a'_{yg} \cong 2{,}5 \cdot 10^6 \ \Omega^{-1}$

$r'_i = R_g' + r_{\pi 1} + (\beta+1) r_{if} \cong 50 \ k\Omega$

$r'_{oa} = \infty$ (vedi fig. 7)

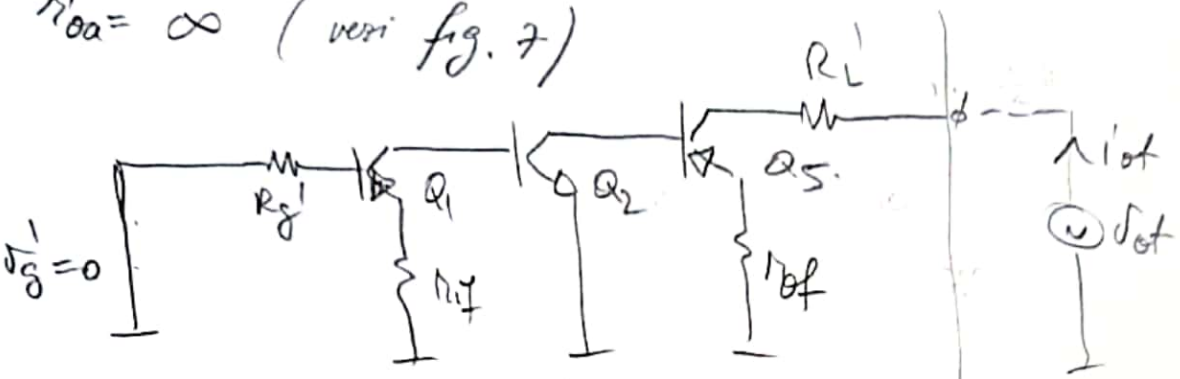


Fig. 7

$$r'_o = r_{oa} = \left.\frac{v_{ot}}{i_{ot}}\right|_{v_g' = 0}$$

$v_g' = 0 \Rightarrow i_{b1} = 0 \Rightarrow i_{c1} = \beta \cdot i_{b1} = 0 \Rightarrow$

$\Rightarrow i_{b2} = 0 \Rightarrow i_{c2} = \beta \cdot i_{b2} = 0 \Rightarrow i_{b5} = 0 \Rightarrow i_{c5} = \beta \cdot i_{b5} = 0 \Rightarrow i_{bf} = 0.$

$T = a'_{yg} \cdot f_z = 2{,}5 \cdot 10^6 \cdot 0{,}1 = 2{,}5 \cdot 10^5 > 0 \Rightarrow$ RN. adimensionale.

$$A'_{yg} = \left.\frac{a'_{yg}}{1 + a'_{yg} \cdot f_z}\right|_{T \gg 1} \cong \frac{1}{f_z} = 10 \ k\Omega$$

$$A'_{yg} = \frac{i'_o}{v_g'}$$

$$R_i' = (1+T) r_i' - R_g' \cong T \cdot r_i' = 125 \cdot 10^5 \ k\Omega$$

$$R_o' = (1+T) r'_{oa} - R_L' = \infty$$

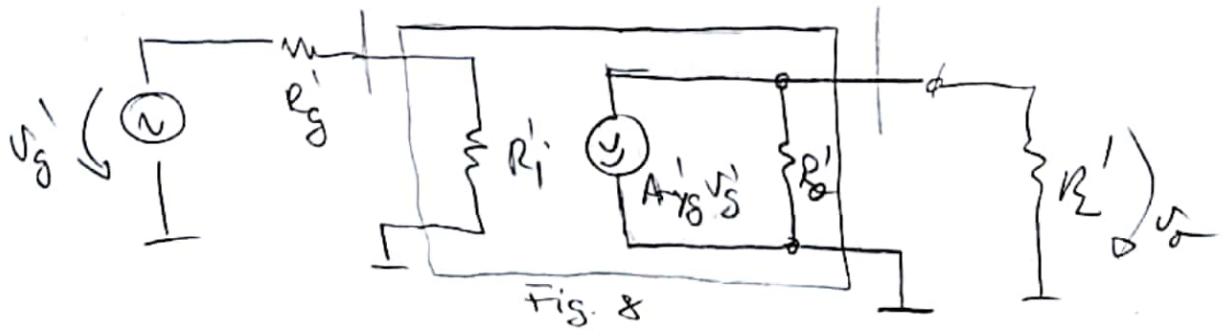


Fig. 8

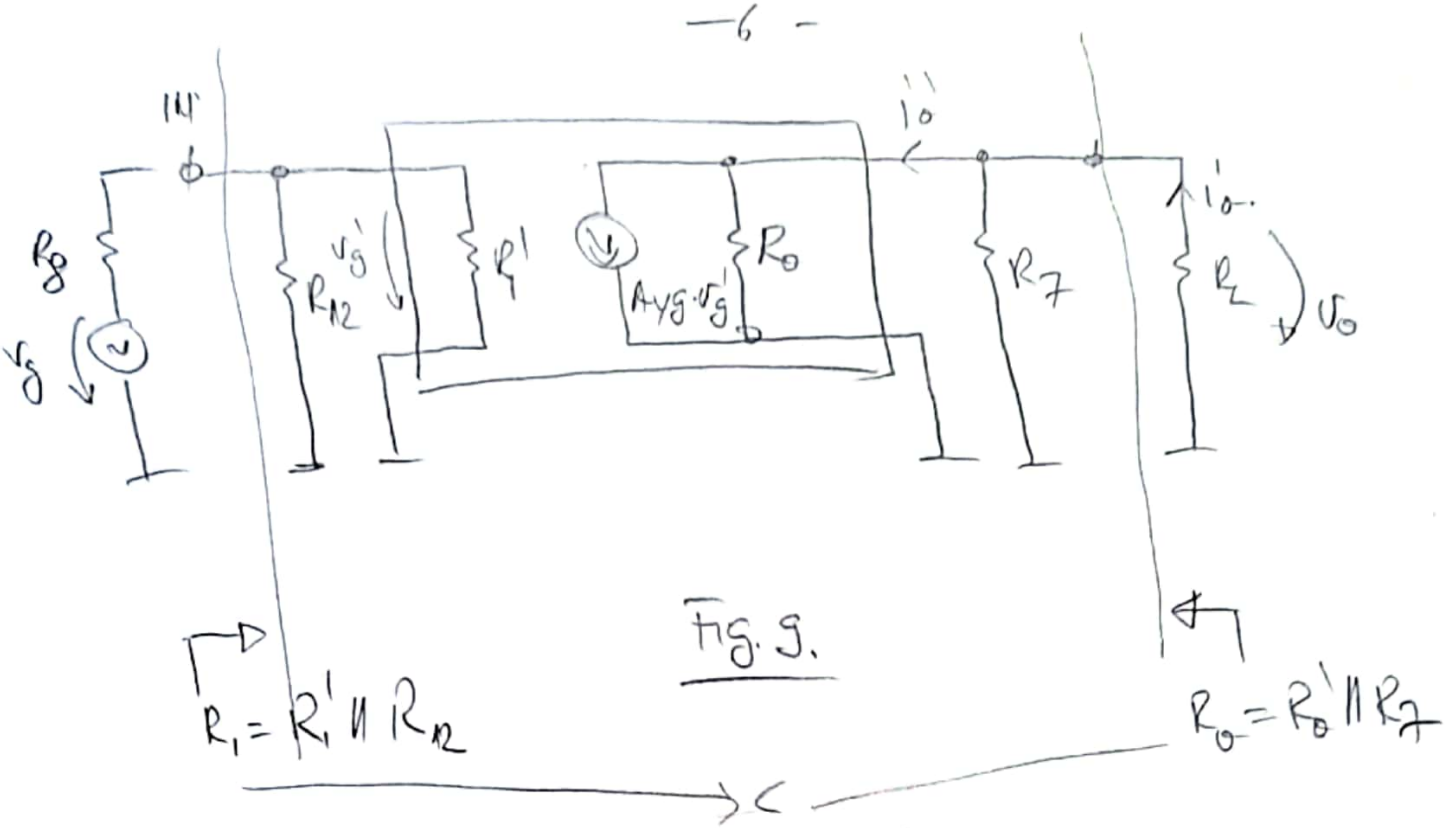


Fig. 9.

$R_1 = R_1' \| R_{12}$

$R_o = R_o' \| R_7$

$R_{i/o}$ duale

$$A_{vg} = \frac{i_o}{v_g} = \underbrace{\frac{i_o}{i_o'}}_{\frac{R_7}{R_7+R_L}} \cdot \underbrace{\frac{i_o'}{v_g'}}_{A_{vg}'} \cdot \underbrace{\frac{v_g'}{v_g}}_{\frac{R_1 \| R_2}{R_1 \| R_2 + R_g}} = \underbrace{\frac{R_7}{R_7+R_L}}_{\simeq 1.} \cdot A_{vg}' \cdot \underbrace{\frac{R_1 \| R_2}{R_1 \| R_2 + R_g}}_{\simeq 1}$$

$$A_{vg} \simeq A_{vg}'$$

5) Daca V_{cc} scade, sunt afectate de dispozitivele active. Limita de funcționare în RAN pt. TB este $|V_{CE}| = |V_{BE}|$ cât pentru funcț. de rez. la TEC-J, $|V_{DS}| = |V_{GS} - V_T|$. La divizorul format $I_2 = I_{2,min}$.

Daca $V_{cc} \downarrow \Rightarrow V_{E5} \downarrow$

$$V_{E5} = V_{cc} \cdot \frac{R_2}{R_2+R_1} + V_{EB1} + V_{BE6.} = V_{EC5} + R_7 \cdot I_{C5}.$$

$$V_{cc,min_1} \cdot \frac{R_2}{R_2+R_1} + V_{EB1} + V_{BE6} = V_{EC5sat} + R_7 \cdot I_{C5}.$$

$$V_{cc,min1} = \left(1 + \frac{R_1}{R_2}\right)\left(V_{EC5sat} + R_7 I_{C5} - 2 V_{BE}\right)$$

$V_{CC,mi1} = 1,5 \cdot (0,6V + 5V - 1,2V) = 6,6V$

$V_{CC,mi2} = R_3 \cdot I_{B7} + V_{BS1,mi} + V_{EC1,mi1} + V_{CE,mi6} + V_{Z1} = 6,2V$

$V_{CC,mi3} = V_{Z2} + V_{CE2,mi} + V_{EC3,mi} + R_5 \cdot I_{C3} = 3,6V$

$V_{CC,mi4} = R_7 \cdot I_{C5} + V_{EC,mi5} + V_{EC4} + R_6 \cdot I_{C4} = 6,6V.$

$V_{CC,mi} = \max\{V_{CC,mi1,2,3,4}\} = V_{CC,mi1} = \underline{6,6V}$