OSCILATOARE RC – 1 → Seminar 13

OSCILATOR RC – rețea Wien

Pentru circuitul din fig.1 se cunosc:

$Q_{1,2}$: $\begin{cases} V_T = 2V \\ K_n = 0{,}5\,mA/V^2 \end{cases}$;

Q_{3-6}: $\begin{cases} V_T = 2V \\ K_{n3} = 1\,mA/V^2 \\ K_{n4} = 2\,mA/V^2 \\ K_{n5} = 4\,mA/V^2 \\ K_{n6} = 0{,}5\,mA/V^2 \end{cases}$;

Q_7 $\begin{cases} V_{EB} \simeq 0{,}6V \\ \beta_F = \beta_0 = 200 \end{cases}$;

Q_8 $\begin{cases} V_{BE} = 0{,}6V \\ \beta_F = \beta_0 = 100 \end{cases}$

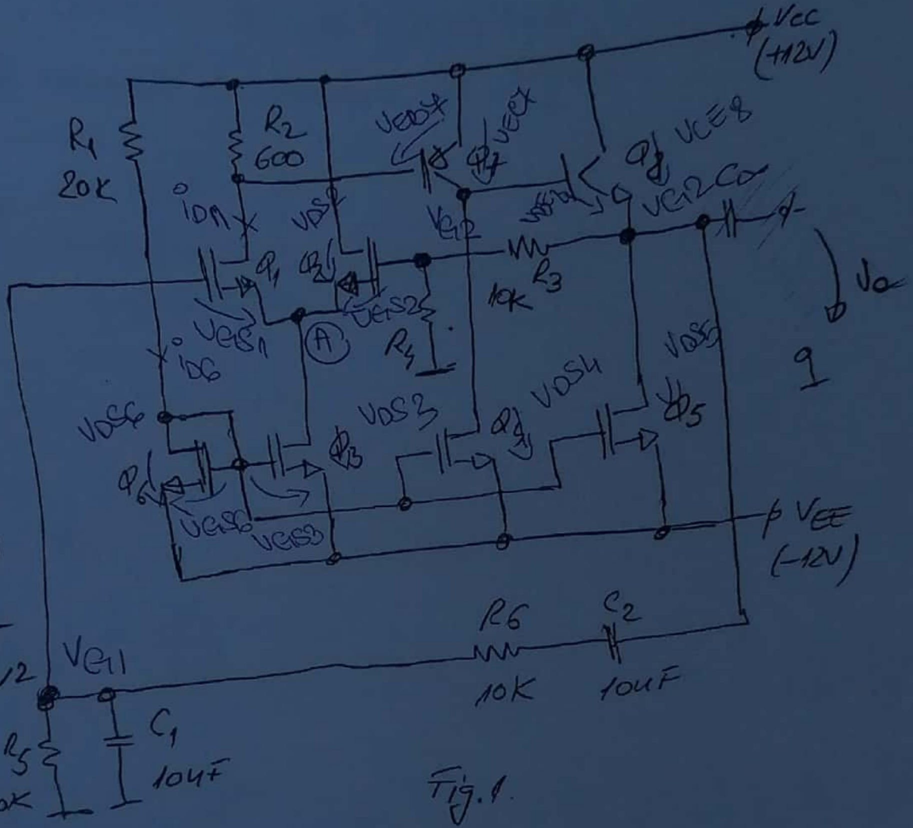

Fig.1

Cerințe:

a) PSF

b) Să se calculeze valoarea rez. R_4. Să se precizeze ce fel de termistor trebuie înlocuită astfel încât să fie posibilă amorsarea oscilațiilor iar oscilatorul să fie unul armonic.

c) Să se calculeze f_0;

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Seminar 13

Osc armonice

/ circuit cu RR pozitivă

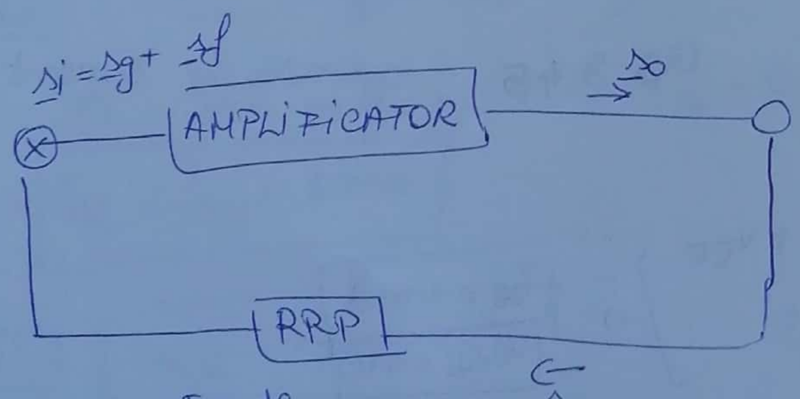
circuit ce generează semnal sinusoidal de tipul

$$\boxed{v(t) = V_{osc} \cos w_0 t}$$

V_{osc} → amplitudinea oscilațiilor

w_0 → pulsația osc

Parametrii → V_{osc} → f_0 / w_0 → $\frac{\Delta V_{osc}}{V_{osc}}$, $\frac{\Delta f_0}{f_0}$



rețea de reacție pozitivă → RC, LC (reacția este cunoscută)

CONDIȚII BARKHAUSEN

① condiția de modul $\boxed{|\underline{A} \cdot \underline{\beta}\,(w_0)| = 1}$

$\underline{A}$ → câștigul amplificatorului.

$\underline{\beta}$ → transferul pe buclă

② condiția de fază

$$\boxed{\varphi_A + \varphi_B = 0 / 2\pi}$$

φ_A = defazajul introdus amplific. la $f = f_0$

φ_B = defazajul introdus de RRP la $f = f_0$.

Ori
- $\varphi_A, \varphi_B > 0 \Rightarrow$ defazaj 0
- $\varphi_A, \varphi_B < 0 \Rightarrow$ defazaj 2π

Dacă:

$\boxed{A \cdot \beta(\omega_0) = 1}$ (osc. în reg permanent)

$\boxed{A \cdot \beta(\omega_0) > 1}$ (amorsarea oscilațiilor)

$\boxed{A \cdot \beta(\omega_0) < 1}$ (stabilizarea oscilațiilor)

Problema:

Pp: Q_{1-6} SAT

$Q_{7,8}$ - RAN

Q_{6} - 3, 4, 5 - oglindă de curent

$\boxed{T2K}$

$$\left.\begin{array}{l} V_{CC} = i_{D6} R_1 + V_{GS6} + V_{EE} \\ i_{D6} = \frac{k_{m6}}{2}(V_{GS6} - V_T)^2 \end{array}\right\} \Rightarrow \boxed{i_{D6} = 1mA} \quad \boxed{V_{GS6} = 4V}$$

$\boxed{T2K}$: $\boxed{V_{GS6} = V_{GS3}}$

$$i_{D3} = \frac{k_{m3}}{2}(V_{GS6} - V_T)^2 \Rightarrow (V_{GS6} - V_T)^2 = \frac{2 i_{D3}}{k_{m3}}$$

Deci $\Rightarrow \frac{\cancel{2} i_{D3}}{k_{m3}} = \frac{\cancel{2} i_{D6}}{k_{m6}} \Rightarrow i_{D3} = \frac{i_{D6} \cdot k_{m3}}{k_{m6}}$

$$i_{D3} = \frac{i_{D6} \cdot 1 \cdot 2}{0.5}$$

$$\Rightarrow \boxed{i_{D3} = 2 i_{D6}}$$

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$\boxed{i_{D3} = 2\ mA}$

$K_{m4} = 4K_{m6} \Rightarrow i_{D4} = 4\, i_{D6} \Rightarrow \boxed{i_{D4} = 4 mA}$

$K_{m5} = 8K_{m6} \Rightarrow i_{D5} = 8 i_{D6} \Rightarrow \boxed{i_{D5} = 8\ mA}$

T2K $\quad i_{D1} R_2 = V_{EB7} \Rightarrow \Rightarrow i_{D1} = \frac{0{,}6}{600} \Rightarrow \boxed{i_{D1} = 1 mA}$

T1K (A) $\quad i_{D2} = i_{D3} - i_{D1} \Rightarrow i_{D2} = 2 - 1 \Rightarrow \boxed{i_{D2} = 1\ mA}$

$\boxed{i_{C7} = i_{D4} = 4 mA}$

T2K : $-V_{G1} + \cancel{V_{GS1}} \cancel{+ V_{GS2}} = V_{G2} \Rightarrow V_{G2} = 0\ V$

$\Rightarrow$ Tens pe $R_4 = 0\ V \Rightarrow i_4 = 0\ A \Rightarrow$ prin $R_3 \Rightarrow i_3 = 0\ A$

$\Rightarrow \boxed{i_{C8} = i_{D5} = 8 mA}$

T2K $\quad \boxed{V_{DS6} = V_{GS6} = 4V}$

T2K : $V_{G2} = V_{GS2} + V_{DS3} + V_{EE}$

$\cancel{V_{GS2} = \pm\frac{1}{4}(}$ $\quad V_{GS2} = \pm\sqrt{\frac{2 i_{D2}}{K_{m2}}} + V_T \Rightarrow V_{GS2} = \pm\sqrt{\frac{2 \cdot 1}{0{,}5}} + 2$

$\Rightarrow V_{GS2} = \pm 2 + 2 \Rightarrow V_{GS21} = 0V$

$V_{GS22} = 4V > V_T \Rightarrow$ sol $\Rightarrow$

$\boxed{V_{GS2} = 4V}$

$V_{DS3} = -V_{EE} - V_{GS2}$

$V_{DS3} = 12 - 4 \Rightarrow \boxed{V_{DS3} = 8V}$

$\boxed{V_{GS1} = V_{GS2} = 4V}$

$\boxed{T2K}$ $V_{CC} = V_{DS2} + V_{DS3} + V_{EE}$

$V_{DS2} = V_{CC} - V_{EE} - V_{DS3}$

$V_{DS2} = 12 + 12 - 8 \Rightarrow \boxed{V_{DS2} = 16V}$

$\boxed{T2K}$: $V_{CC} = i_{D1} R_1 + V_{DS1} + V_{DS3} + V_{EE} \Rightarrow \boxed{V_{DS1} = 15,4V}$

$\boxed{T2K}$: $V_{G2} = V_{DS5} + V_{EE} \Rightarrow V_{DS5} = -V_{EE}$

$\boxed{V_{DS5} = 12V}$

$\boxed{T2K}$: $V_{CC} = V_{CE8} + \cancel{V_{DS5}} + \cancel{V_{EE}}$

$\boxed{V_{CE8} = 12V}$

$\boxed{T2K}$ $\cancel{V_{R4}}$ $V_{BE5} + V_{DS5} - V_{DS4} = 0$

$\boxed{V_{DS4} = 12,6V}$

$\boxed{T2K}$ $V_{CC} = V_{EC7} + V_{DS4} + V_{EE} \Rightarrow \boxed{V_{EC7} = 11,4V}$

verificare regim:

$Q_1: \begin{cases} V_{GS1} = 4V \\ V_{DS1} = 15,4V \end{cases}$ COND. SAT: $|V_{DS1}| \geq |V_{GS1} - V_T|$

$15,4 > 4 - 2$

$15,4 > 2$

$|V_{GS1}| > |V_T|$ (A) $\Rightarrow$ SAT

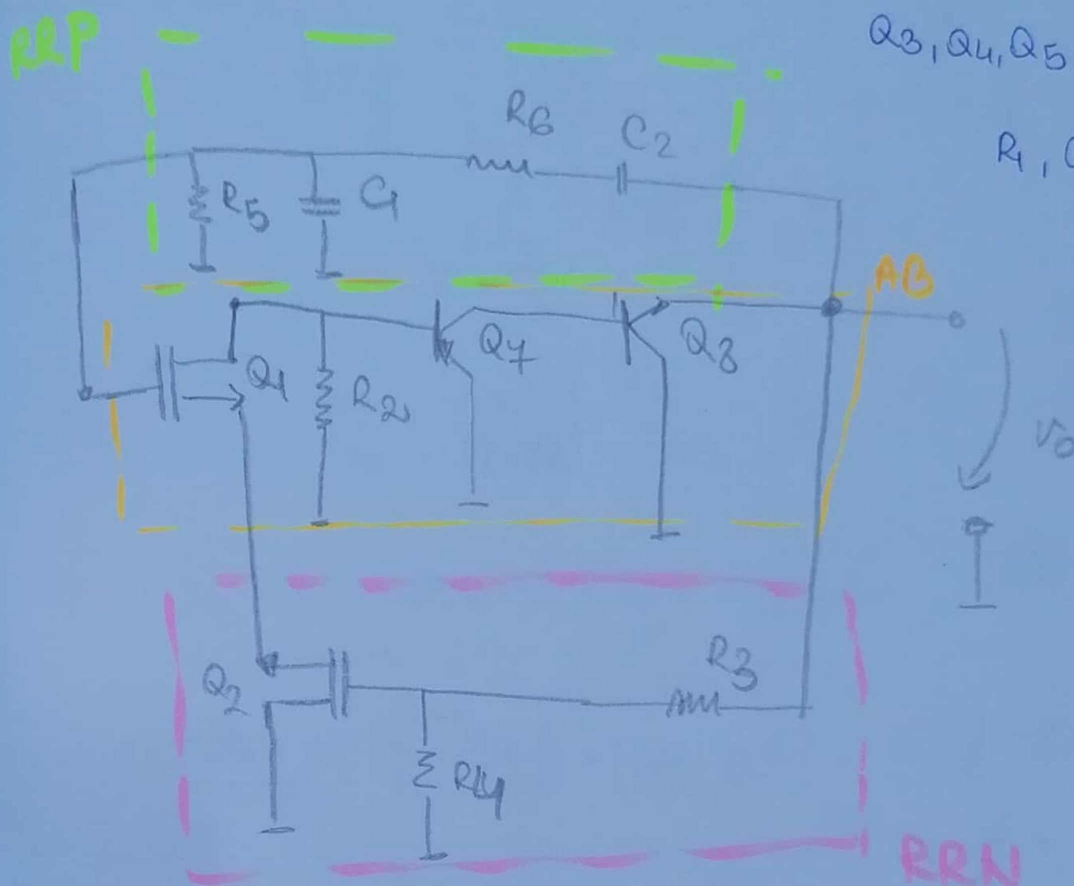
$Q_8: \begin{cases} V_{BE8} = 0,6V \\ V_{CE8} = 12V \end{cases}$ $V_{BE} \geq 0$ (A)

$V_{CE8} \geq V_{BE8}$ (A) $\Rightarrow$ RAN

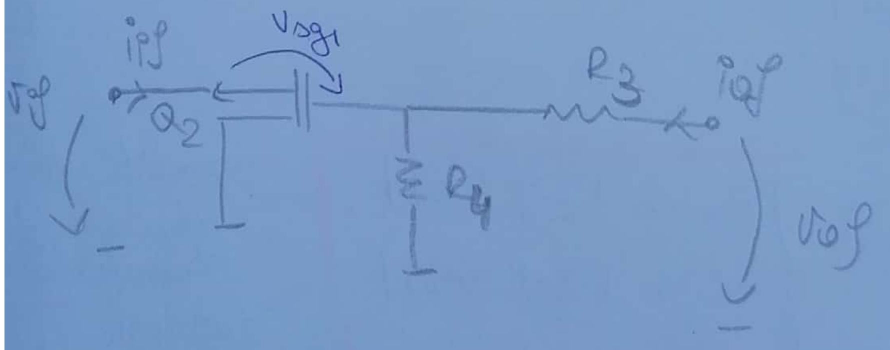
Schema de CA:

RRP [Wien cu transfer în tens
R5, C1   R6, C2

RRN: Q2, R4, R2
AB : Q1, R2, Q7, Q8
Q3, Q4, Q5 dispar (otocate în D)
R1, Q6, dispar



RRN: serie paralel: ANALIZĂM RRN



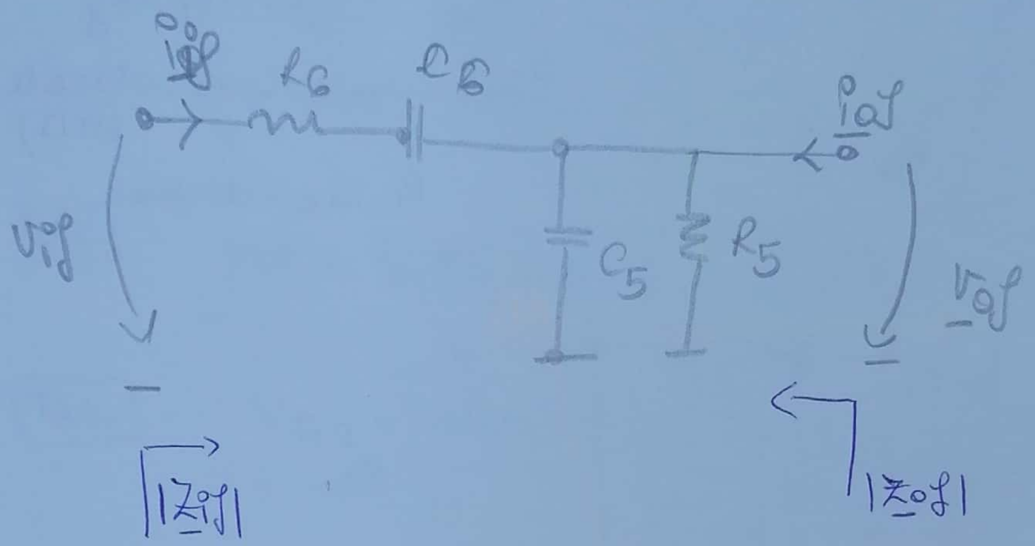
• $f_r = \frac{m.mi}{mco}\Big|_{m.ci=0} = \frac{vif}{vof}\Big|_{iif=0} = \frac{R_4}{R_4+R_3} = \frac{R_4}{10+R_4}$

$i_{if}=0 \Rightarrow i_{s1}=0 \Rightarrow v_{gs1}=0 \Rightarrow$ v_{if} cade pe R_4

• $r_{if} = \frac{v_{if}}{i_{if}}\Big|_{v_{of}=0}$ = (rez. văz. din sursă) = $\frac{1}{g_{m2}}$

• $r_{of} = \frac{v_{of}}{i_{of}} \Big| _{i_{if}=0} = R_4 + R_3$

ANALIZĂM RRP de la pentru opere întrare



$R_5 = R_6 = R$

$C_5 = C_6 = C$

$\Rightarrow \beta_v(\omega_0) = \frac{1}{3} \Rightarrow \bullet\ |Z_{if}(\omega_0)| = \frac{3}{\sqrt{2}} R^{=10k} = \underline{21,3\,k\Omega}$

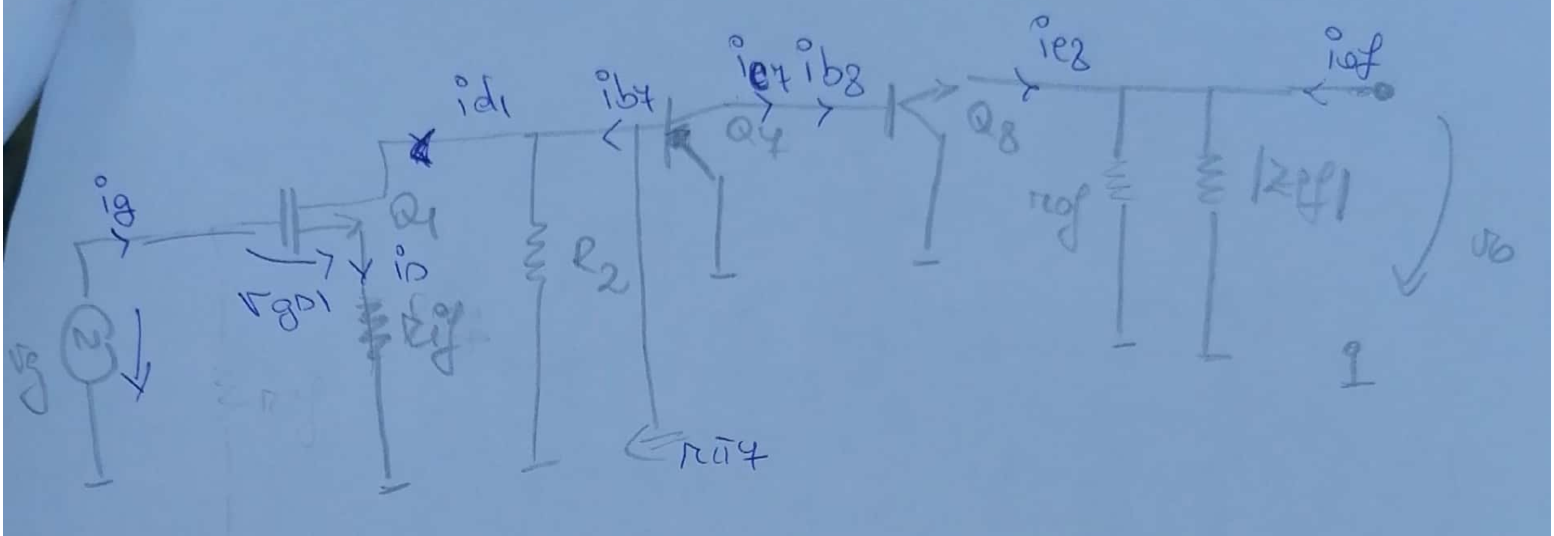
• $|Z_{of}| = \frac{\sqrt{2}}{3} \cdot R^{=10k} = \underline{4,7\,k\Omega}$

CONDIȚII general: $\begin{cases} A_v \cdot \beta_v(\omega_0) = 1 \\ \varphi_A + \varphi_B = 0 \,|\, 2\pi \end{cases}$

doar pt topologia cu transfer în tens

$\boxed{\begin{cases} R_o \ll |Z_{if}(\omega_0)| \\ R_i \gg |Z_{of}(\omega_0)| \end{cases}}$ condiții de adaptare pt transfer în tensiune

Construirea ABS - ului



$$a_{vg} = \frac{v_o}{v_g} = \frac{v_o}{i_{e8}} \cdot \frac{i_{e8}}{i_{b8}} \cdot \frac{i_{b8}}{i_{e7}} \cdot \frac{i_{c7}}{i_{b7}} \cdot \frac{i_{b7}}{i_{d1}} \cdot \frac{i_{d1}}{v_{gs1}} \cdot \frac{v_{gs1}}{v_g}$$

$$a_{vg} = r_{of} \| |Z_{if}| \cdot (\beta+1) \cdot 1 \cdot \beta_0 \cdot \frac{r_{\pi 7}}{r_{\pi 7} \| r_2} \cdot \cancel{g_m} \cdot g_{m1} \cdot \frac{1}{1 + r_{if} g_m}$$

$$\begin{cases} i_{e8} = i_b + i_e = \beta + 1 \\ i_{d1} = g_{m1} \cdot v_{gs1} \end{cases}$$

$\boxed{TK}$ $v_g = v_{gs1} + r_{if} g_{m1} v_{gs1} \Rightarrow v_g = v_{gs1}(1 + r_{if} g_{m1})$

$r_i = \infty$ (rez. văz din G)

$r_{of} = \frac{v_o}{i_o}\Big|_{v_g = 0} = r_{of} \| |Z_{if}|$

$a_{vg} = 8{,}8\,k\Omega \cdot 100 \cdot 200 \cdot \frac{0{,}6}{0{,}6 + 1{,}25} \cdot 1\,k\Omega^{-1} \cdot \frac{1}{1+1} \simeq 28540$

$$\begin{cases} R_i = r_i(1+T) = \infty \\ R_o^{-1} = r_o^{-1}(1+T) - |Z_{if}(\omega_0)| = 0{,}92\,\Omega \end{cases}$$

$$avg = \frac{avg}{1+avg \cdot fv} \approx \frac{1}{fv} \Rightarrow fv = \frac{1}{avg} \Rightarrow$$

$$\frac{R_4}{R_4+R_3} = \frac{1}{avg} \Rightarrow \quad R_4 \cdot avg = 1 \cdot R_4 + R_3$$

$T = avg \cdot fv > 0$
adimensional.

$$\left(1 + \frac{R_3}{R_4}\right) \cdot \frac{1}{3} = 1$$

$$1 + \frac{R_3}{R_4} = 3 \Rightarrow \frac{R_3}{R_4} = 2 \Rightarrow \boxed{R_4 = \frac{R_3}{2} = 5k\Omega}$$

COND:

- Amplificarea poz și β poz $\Rightarrow$ $\varphi_A + \varphi_B = 0$
- $A_{vg} \cdot \beta_v(\omega_0) = 1V$
- $R_o = 0{,}92\,\Omega \ll |Z_{if}(\omega_0)| = 21{,}3\,k\Omega$
- $R_i = \infty \gg |Z_{of}(\omega_0)| = 4{,}7\,k\Omega$

$\Rightarrow$ OSC ARMONIC

c) $f_0 = \frac{1}{2\pi RC} = 1{,}6\,kHz$

b) PT AMORSARE: $\quad A_v \cdot \beta_v(\omega_0) > 1 \Rightarrow \left(1 + \frac{R_3}{R_4}\right) \cdot \frac{1}{3} > 1 \Rightarrow$

$\Rightarrow \boxed{R_4 < 5k\Omega}$

R_4 la $t=0$ să fie $< 5k$

după pt $t>0 \Rightarrow R_4$ să tindă către $5k$. $\Rightarrow$ Termistor PTC.