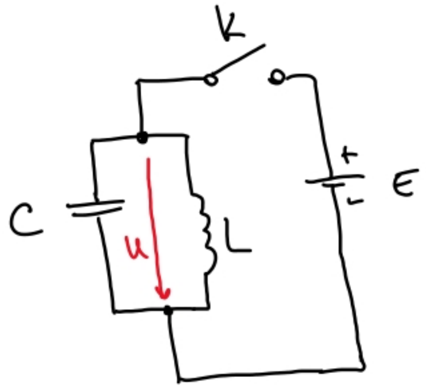
Seminar 6:

Oscilatori:

Rețeaua LC „LC Tank circuit"



La rezonanță:

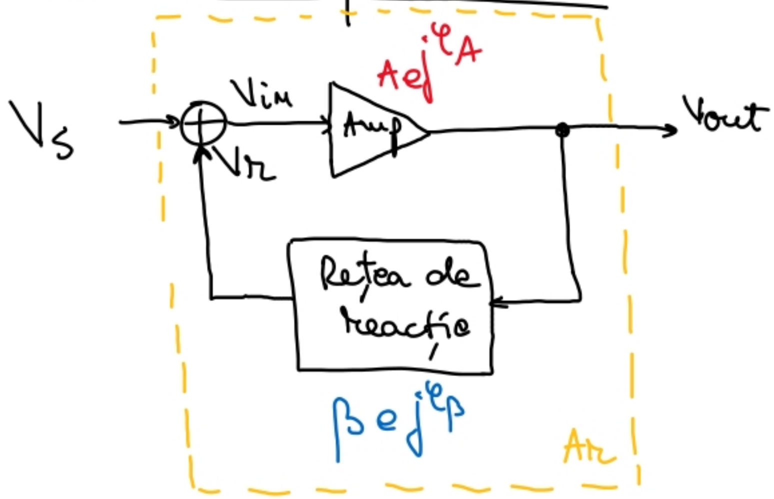
$X_L = X_C$ → frecv. de rezonanță

$$f_0 = \frac{1}{2\pi\sqrt{LC}} =$$

$$= \frac{1}{6.28\times\sqrt{1\times10^{-5}}} =$$

$$= 0.159 \times \frac{1}{10^{-3}} = 159 Hz$$

Schemă bloc pt. oscilator:



Aej^{φ_A} – factorul de amplificare

βej^{φ_β} – factorul de transfer al rețelei

Condiții:

- amplificare
- r. pozitivă în fază
- f_0 e determinată de rețeaua de reacție.

$$V_{out} = A \cdot e^{j\varphi_A} V_{in}$$
$$V_r = \beta e^{j\varphi_\beta} V_{out}$$
$$V_{in} = V_s + V_r$$

Factorul de amplificare al conexiunii:

$$A_r = \frac{V_{out}}{V_s} = \frac{Ae^{j\varphi_A} V_{in}}{V_{in} - V_r} = \frac{Ae^{j\varphi_A} V_{in}}{V_{in} - \beta e^{j\varphi_\beta} V_{out}} =$$

$$= \frac{Ae^{j\varphi_A} V_{in}}{V_{in} - A\beta e^{j(\varphi_A + \varphi_\beta)} V_{in}}$$

not. $\varphi_A + \varphi_\beta = \varphi_\Sigma$

$$A_r = \frac{Ae^{j\varphi_A} \cancel{V_{in}}}{\cancel{V_{in}} - \beta A \cdot e^{j\varphi_\Sigma} \cancel{V_{in}}}$$

$$A_r = \frac{Ae^{-\varphi_A}}{1 - \beta A e^{j\varphi_\Sigma}}$$

$$|A_r| = \frac{A}{\sqrt{1 - 2\beta A \cos\varphi_\Sigma + \beta^2 A^2}}$$

$$1 - \beta A e^{j\varphi_\Sigma} = 1 - \beta A \cos\varphi_\Sigma - j\beta A \sin\varphi_\Sigma$$

$$|1 - \beta A e^{j\varphi_\Sigma}| = \sqrt{(1 - \beta A \cos\varphi_\Sigma)^2 + \beta^2 A^2 \sin^2\varphi_\Sigma} =$$

$$= \sqrt{1 - 2\beta A \cos\varphi_\Sigma + \beta^2 A^2 \cos^2\varphi_\Sigma + \beta^2 A^2 \sin^2\varphi_\Sigma} =$$

$$= \sqrt{1 - 2\beta A \cos\varphi_\Sigma + \beta^2 A^2}$$

•) Dacă $\varphi_\Sigma = (2k+1)\pi \Rightarrow \cos\varphi_\Sigma = -1 \Rightarrow$

$\Rightarrow$ r. negativă $\Rightarrow A_r = \dfrac{1}{1 + \beta A}$

•) Dacă $\varphi_\Sigma = 2k\pi \Rightarrow \cos\varphi_\Sigma = 1 \Rightarrow$

$\Rightarrow$ r. pozitivă $\Rightarrow$

$$\Rightarrow A_r = \frac{A}{1 - \beta A}$$

•) $\beta A < 1 \Rightarrow A_r > A$

•) $\beta A = 1 \Rightarrow A_r \to \infty$

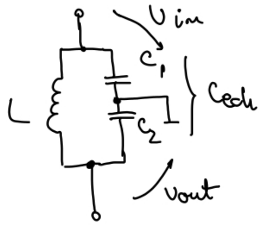
Amplificatorul este un oscilator dacă:

1.) R. poz. în fază
2.) $\beta A = 1 \rightarrow$ criteriul lui Barkhausen

Aplicații audio $\rightarrow$ rețele RC
Aplicații RF $\rightarrow$ rețele LC și XC (cristal, „crystal oscillator")

Oscilatorul Colpitts:

- rețea LC

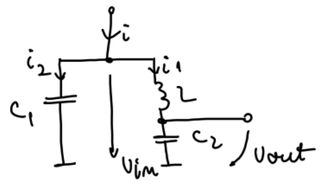


$$\frac{V_{out}}{V_{in}} = ?$$

$$C_{ech} = \frac{C_1 C_2}{C_1 + C_2}$$

$$f_0 = \frac{1}{2\pi\sqrt{L C_{ech}}}$$

schema echivalentă:



$$V_{in} = i_1 (Z_L + Z_{C_2})$$

$$V_{out} = i_1 \cdot Z_{C_2}$$

$$\frac{V_{out}}{V_{in}} = \frac{Z_{C_2}}{Z_L + Z_{C_2}} =$$

$$= \frac{-\frac{j}{\omega C_2}}{j\omega L - \frac{j}{\omega C_2}} = -\frac{\cancel{j}}{\omega C_2} \cdot \frac{1}{\cancel{j}(\omega L - \frac{1}{\omega C_2})} =$$

$$= \frac{1}{1 - \omega^2 C_2 L}$$

La rezonanță

$$\omega L = \frac{1}{\omega C_{ech}} \Rightarrow L = \frac{1}{\omega^2 C_{ech}}$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{1}{1 - \cancel{\omega^2} C_2 \cdot \frac{1}{\cancel{\omega^2} C_{ech}}} = \frac{1}{1 - \cancel{C_2} \cdot \frac{C_1 + C_2}{C_1 \cancel{C_2}}} =$$

$$= \frac{1}{\frac{\cancel{C_1} - \cancel{C_1} - C_2}{C_1}} \Rightarrow$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = -\frac{C_1}{C_2} \rightarrow \text{defazaj de } \pi \text{ indus de rețea.}$$

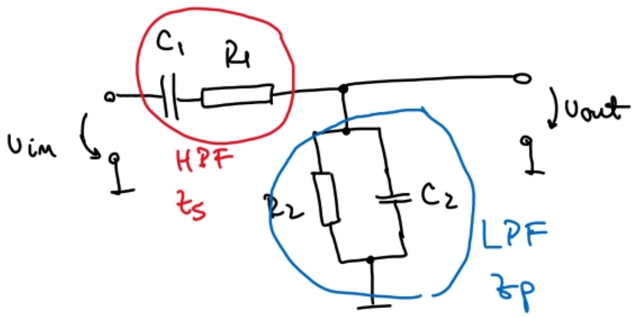
$$f_0 = \frac{1}{2\pi\sqrt{L C_{ech}}}$$

ex:

$L = 10\ mH$
$C_1 = 24\ nF$
$C_2 = 240\ nF$

$\Rightarrow C_{ech} = 21.82\ nF$
$f_0 = 10.8\ kHz$

Rețeaua RC Wien:



$$f_0 = \frac{1}{2\pi RC}$$

De regulă $R_1 = R_2 = R$
$C_1 = C_2 = C$

$$\frac{V_{out}}{V_{in}} = \frac{Z_p}{Z_s + Z_p}$$

$$Z_s = R - \frac{j}{\omega C} = \frac{R\omega C - j}{\omega C}$$

$$Z_p = \frac{1}{\frac{1}{R} + j\omega C} = \frac{1}{\frac{1 + jR\omega C}{R}} = \frac{R}{1 + jR\omega C}$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + \frac{Z_s}{Z_p}} = \frac{1}{1 + \frac{\frac{R\omega C - j}{\omega C}}{\frac{R}{1 + j\omega CR}}} =$$

$$= \frac{1}{1 + \frac{(R\omega C - j)(1 + jRC\omega)}{R\omega C}} =$$

$$= \frac{1}{\frac{2R\omega C + j(R\omega C)^2 - j - j^2 R\omega C}{R\omega C}} = \frac{1}{\frac{3R\omega C}{R\omega C} + j(R\omega C - 1)} =$$

$$= \frac{1}{3 + j(2\pi f RC - 1)}$$

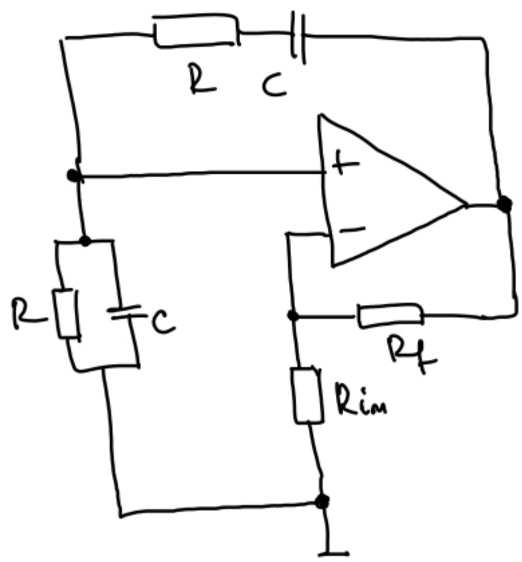
$$V_{out} = \frac{1}{3 + j(2\pi RCf - 1)} V_{in} = \frac{1}{3 + j\left(\frac{f}{f_0} - 1\right)}$$

Dacă $f = f_0 \Rightarrow \boxed{V_{out} = \frac{1}{3} \cdot V_{in}}$

$$\boxed{\varphi = 0 - \operatorname{arctg} \frac{\frac{f}{f_0} - 1}{3}}$$

La $f = f_0$ $\varphi = 0$.

Oscilator cu punte Wien:



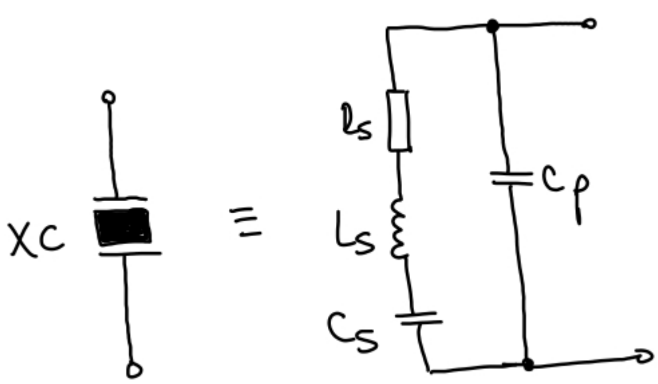
$$A = 1 + \frac{R_f}{R_{in}}$$

Pt. ca circuitul să fie un oscilator

$$A \geq 3$$

$$\left(\beta = \frac{1}{3} \Rightarrow \beta A = 1\right)$$

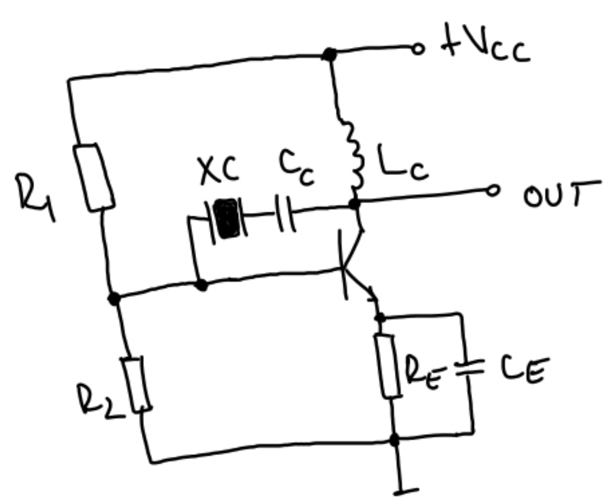
Oscilator cu cristal:



serie: $f_s = \frac{1}{2\pi\sqrt{L_s C_s}}$

paralel: $f_p = \frac{1}{2\pi\sqrt{L_s \frac{C_p C_s}{C_p + C_s}}}$

serie:



paralel: