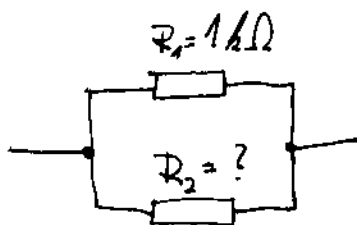


Doc. Daviděk

B2/526

budeme mít laboratorní den
mít s sebou index s posouzením TSO 2P
kromě 1. a posledního mají hesličky



$$R = 200\Omega$$

$$\frac{1}{R} = \frac{1}{1000} + \frac{1}{R_2}$$

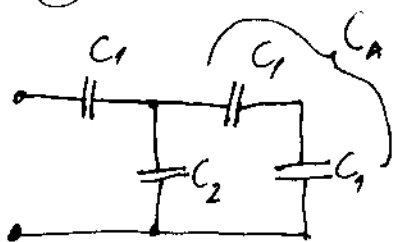
$$\frac{1}{200} = \frac{1}{1000} + \frac{1}{R_2}$$

$$\frac{1}{R_2} = \frac{1}{200} - \frac{1}{1000}$$

$$\frac{1}{R_2} = \frac{4}{1000}$$

$$R_2 = 250\Omega$$

kapacitany



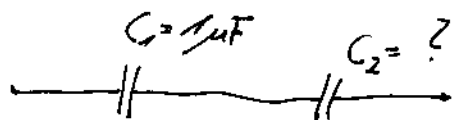
$$C_1 = 2\mu F$$

$$C_2 = 1\mu F$$

$$C_A = \frac{C_1^2}{2C_1} = 1\mu F$$

$$C_B = C_A + C_2 = 2\mu F$$

$$C = \frac{C_2 C_B}{C_2 + C_B} = 1\mu F$$



$$C = 0,8\mu F$$

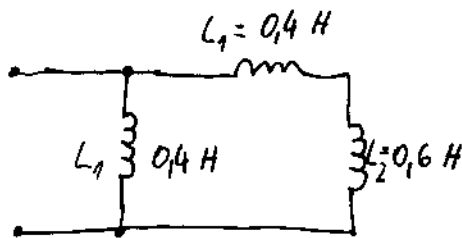
$$\frac{1}{0,8} = \frac{1}{1} + \frac{1}{C_2}$$

$$\frac{1}{C_2} = \frac{5}{4} - 1$$

$$\frac{1}{C_2} = \frac{1}{4}$$

$$C_2 = 4\mu F$$

induktory

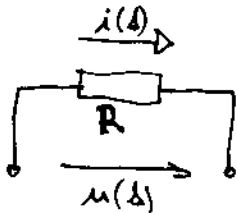


$$L_A = L_1 + L_2$$

$$L_A = 1 \text{ H}$$

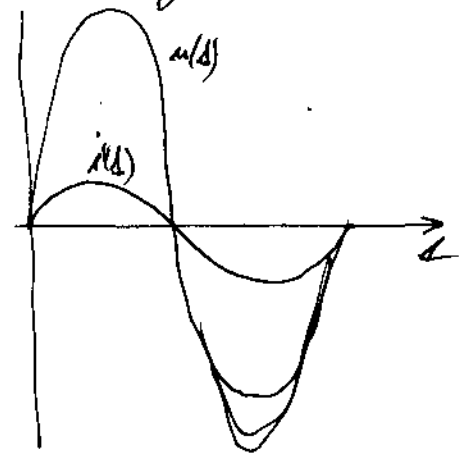
$$L = \frac{1}{2} \text{ H}$$

- Rezistor $R = 100 \Omega$ protéká proud časovým průběhem $i(t) = 2 \sin \omega t$
 $u(t) = ?$

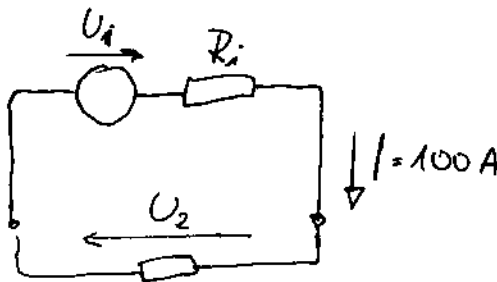


$$u(t) = R i(t)$$

$$u(t) = 100 i(t)$$



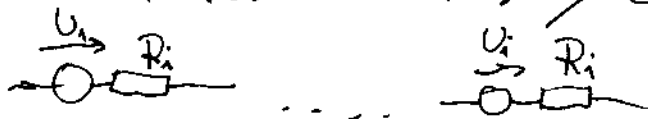
- akumulátor $U_1 = 100 \text{ V}$
 jestliže z něj odebíráme $I = 100 \text{ A}$, $U_2 = 95 \text{ V}$



$$R_i = \frac{U_1 - U_2}{I} = \frac{5}{100} = 0,05 \Omega$$

- akumulátor - série 6 článků, každý s EMF $U_i = 2 \text{ V}$,
 $R_i = 0,01 \Omega$

Proud a svorkové napětí při připojení $R_s = 2 \Omega$

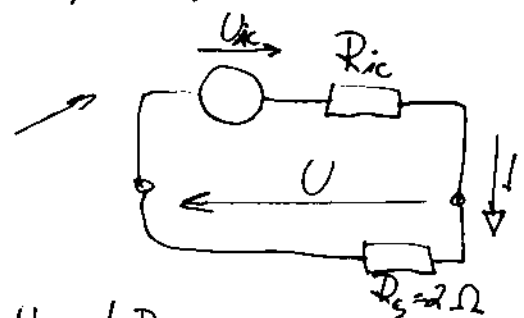


$$R_{ic} = 6 \cdot R_i = 0,06 \Omega$$

$$U_{ic} = 6 U_i = 12 \text{ V}$$

$$I = \frac{U}{R} = \frac{12}{2,06} = 5,825 \text{ A}$$

$$U_s = I \cdot R_s = 11,65 \text{ V}$$



připraven na lab. práci

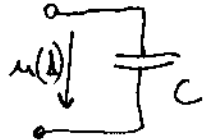
mají si

1. nějaký číselný, ef. hodnota ...

$$2. u(t) = R \cdot i(t)$$

$$i(t) = \frac{1}{R} \cdot u(t)$$

• kapacitor



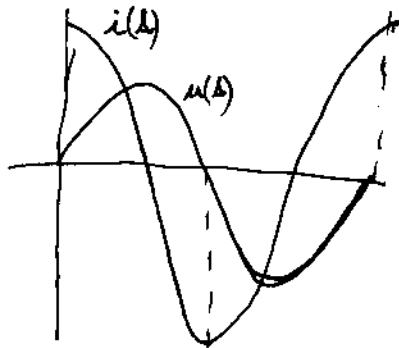
$$C = \frac{Q}{u}$$

$$u(t) = \frac{1}{C} \int_0^t i(\tau) d\tau + u(0)$$

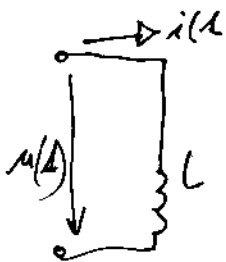
$$i(t) = C \frac{du(t)}{dt}$$

$$u(t) = U_m \sin \omega t$$

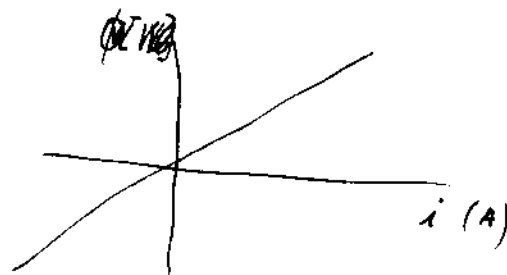
$$i(t) = C \omega \cos \omega t$$



• induktor



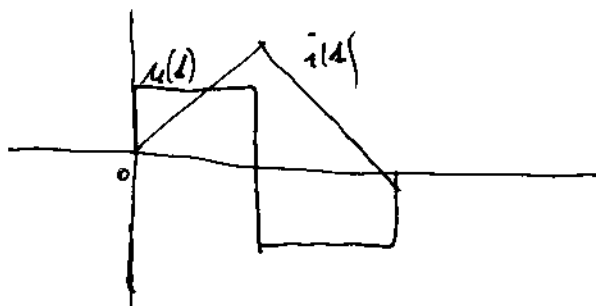
$$L = \frac{\Phi}{i}$$



AVB charakteristika

$$u(t) = \frac{d\Phi}{dt} = L \frac{di(t)}{dt}$$

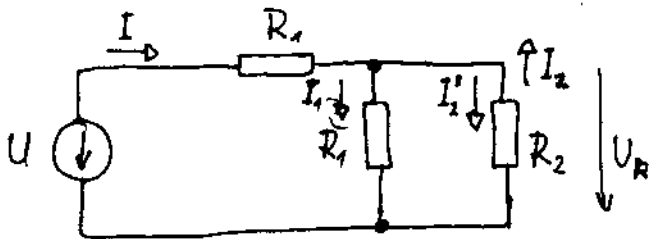
$$i(t) = \int_0^t u(\tau) d\tau + i(0)$$



Úvod do Matlabu

amber.feld.cunt.cz/vyu/201/labs/matlab.htm

$$\Rightarrow a = [1, 2, \pi, \sqrt{2}, 2.51]$$



$$U = 9V$$

$$R_1 = 1k\Omega$$

$$R_2 = 4k\Omega$$

$$I_2 = ?$$

podle Ohmova zákona

$$R_A = \frac{4}{5} k\Omega$$

$$R = 1 + \frac{4}{5} = \frac{9}{5} k\Omega$$

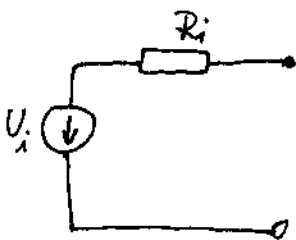
$$I = \frac{U}{R} = \frac{9V}{\frac{9}{5} \cdot 1000\Omega} = \frac{5}{1000} A = 0,005 A = 5mA$$

$$U_R = R_1 I_1 = I_2' R_2 = I \cdot \frac{R_1 R_2}{R_1 + R_2}$$

$$I_2' = I \cdot \frac{R_1}{R_1 + R_2} = 0,005 \cdot \frac{1000}{5000} = 0,001 A = 1mA$$

$$\underline{I_2 = -1mA}$$

podle Thévenina

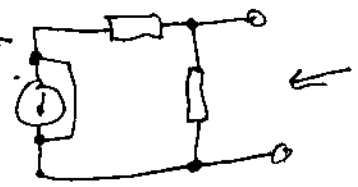


$$R_i = \frac{R_1^2}{R_1 + R_2}$$

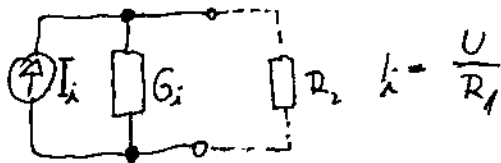
$$R_i = 500\Omega$$

$$U_i = U \cdot \frac{R_1}{R_1 + R_2} = \frac{9}{2} = 4,5V$$

$$I_2 = \frac{U_i}{R_1 + R_2} = \frac{4,5}{4500} = -0,001 A = \underline{-1mA}$$



podle Nortona



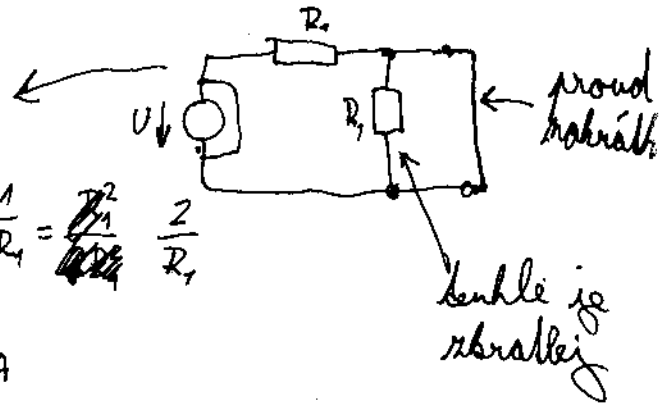
$$G_N = \frac{1}{R_1} + \frac{1}{R_1} = \frac{2}{R_1}$$

$$I_N = \frac{9}{1000} = 9 \text{ mA}$$

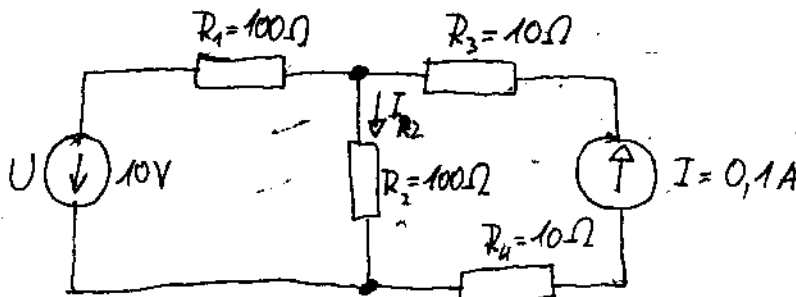
$$G_N = \frac{1}{1000} = 2 \text{ mS}$$

$$I_2' = \frac{I_N \cdot R_1}{R_1 + R_2} = \frac{9 \text{ mA} \cdot 500 \Omega}{500 \Omega + 4500 \Omega} = 1 \text{ mA}$$

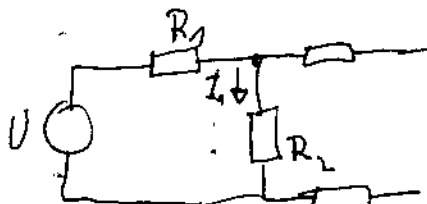
$$I_2 = -1 \text{ mA}$$



pr. na princip superpozice

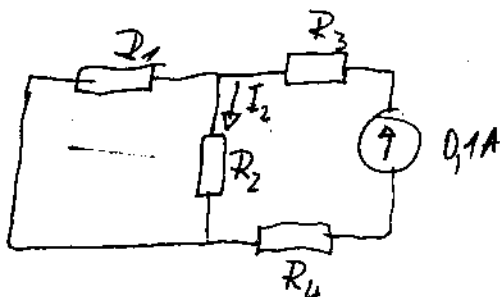


nejprve příspěvek z U



$$I_1 = \frac{U}{R_1 + R_2} = \frac{10 \text{ V}}{100 + 100} = \frac{1}{20} = \underline{0,05 \text{ A}}$$

příspěvek z I



$$I_2 = I \cdot \frac{R_1}{R_1 + R_2} = \frac{100}{200} = \underline{0,05 \text{ A}}$$

$$I_{R_2} = I_1 + I_2 = \underline{0,1 \text{ A}}$$

HUS

$$u(t) = A \cdot \sin(\omega t + \varphi) \quad \text{čas. oblast}$$

↓

$$\hat{U} = A e^{j\varphi}$$

kompl. rovina (frekv. oblast)

$$u_1(t) = 50 \cdot \sin(\omega t + \frac{\pi}{6}) \quad f = 50 \text{ Hz}$$

$$u_2(t) = 30 \cdot \sin(\omega t - 1,22)$$

$$u(t) = u_1(t) + u_2(t)$$

$$\hat{U}_1 = 50 e^{j\frac{\pi}{6}} = 50 \left(\cos \frac{\pi}{6} + j \sin \frac{\pi}{6} \right) = 50 \left(\frac{\sqrt{3}}{2} + j \frac{1}{2} \right) = 43,3 + 25j$$

$$\begin{aligned} \hat{U}_2 &= 30 e^{-j1,22} = 30 \left(\cos(-1,22) + j \sin(-1,22) \right) = 30(0,34 - 0,94j) \\ &= 10,31 - 28,2j \end{aligned}$$

$$\hat{U} = \hat{U}_1 + \hat{U}_2 = 53,61 - 3,2j$$

$$|\hat{U}| = 53,71$$

$$\varphi = \arctg \frac{-3,2}{53,61} = -0,06$$

$$\hat{U} = 53,71 e^{-j0,06}$$

$$\underline{u(t) = 53,71 (\omega t - 0,06)}$$

$$f = 50 \text{ Hz}$$

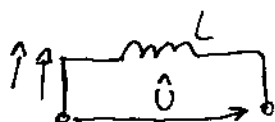
$$\omega = 314 \text{ [rad.s}^{-1}\text{]}$$

$$a = 3 + 3j \quad \dots \quad \varphi = \arctg \frac{3}{3} = \frac{\pi}{4}$$

$$b = -3 - 3j \quad \dots \quad \varphi = \arctg \frac{-3}{-3} = \frac{\pi}{4} \quad \left(\frac{\pi}{4} + \pi \right)$$

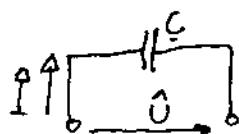
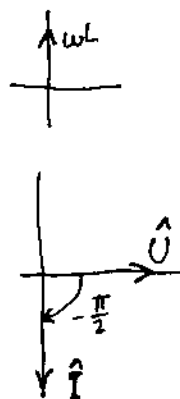
↑
pohľad káporná reálná časť, prídane π

Impedance



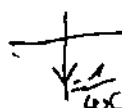
$$\hat{Z}_L = \frac{\hat{U}}{\hat{I}} = j\omega L = \sqrt{\omega^2 L^2} e^{j\frac{\pi}{2}}$$

$$\hat{I} = \frac{\hat{U}}{\hat{Z}_L} = \frac{\hat{U}}{\omega L e^{j\frac{\pi}{2}}} = \frac{\hat{U} e^{-j\frac{\pi}{2}}}{\omega L}$$

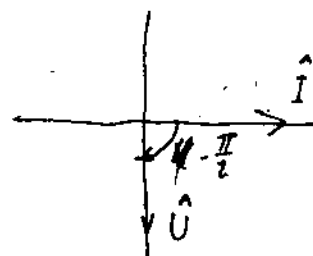


$$\hat{Z}_C = \frac{\hat{U}}{\hat{I}} = \frac{1}{j\omega C} = \frac{j}{-\omega C}$$

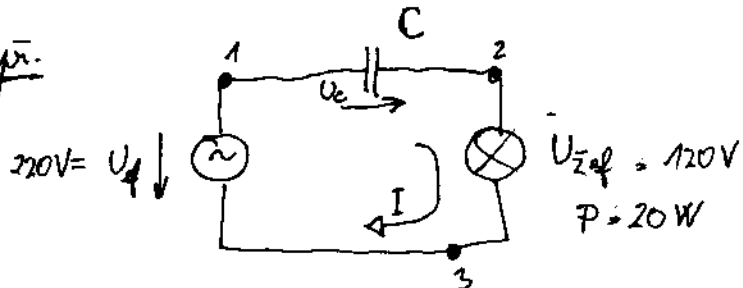
$$= \frac{1}{\omega C} e^{-j\frac{\pi}{2}}$$



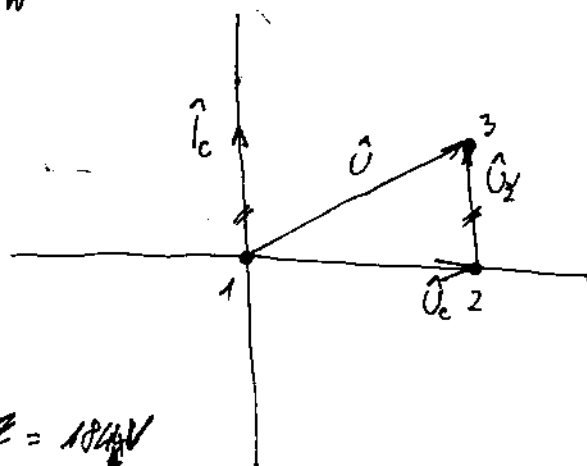
$$\hat{U} = \hat{Z}_C \cdot \hat{I} = \frac{1}{\omega C} e^{-j\frac{\pi}{2}} \cdot \hat{I}$$



pr.



? C



$$U_C = \sqrt{U^2 - U_{Zef}^2} = \sqrt{220^2 - 120^2} = 184V$$

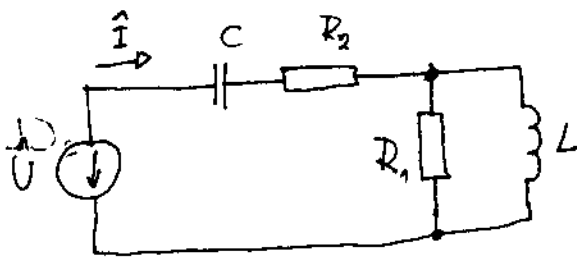
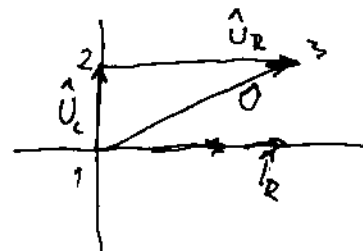
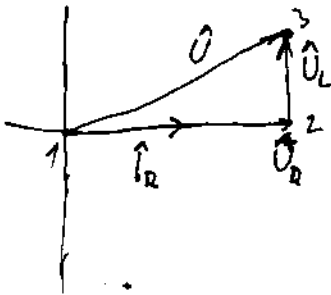
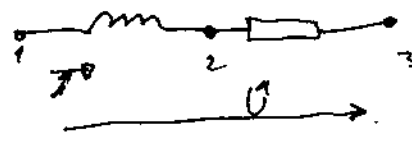
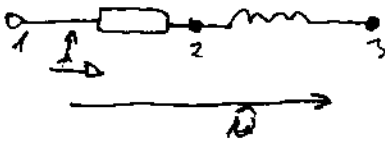
$$P = U \cdot I \quad I = \frac{P}{U} = \frac{20W}{120V} = \frac{1}{6} A$$

$$\left(\hat{Z} = \frac{\hat{U}}{\hat{I}} = \frac{1}{j\omega C} \right) \quad \left| \frac{1}{j\omega C} \right| = \frac{U_C}{I}$$

$$\frac{1}{\omega C} = \frac{U_C}{I}$$

$$C = \frac{I}{\omega U_C} = \frac{\frac{1}{6}}{314 \cdot 184} = 2,18 \cdot 10^{-6} F \quad (2,17 \mu F)$$

pr.



$$R_1 = 1k\Omega, R_2 = 2k\Omega$$

$$L = 3,183H, C = 1,5915\mu F$$

$$\hat{U} = 100V, f = 50Hz$$

berechnen S, P, Q

$$\hat{Z} = \frac{1}{j\omega C} + R_2 + \frac{R_1 \cdot j\omega L}{R_1 + j\omega L}$$

$$\hat{Z} = 2500 - j1500 (\Omega) \quad (\text{Matlab...})$$

$$\hat{I} = 0,0294 + j0,0176 (A)$$

$$S = |\hat{U} \cdot \hat{I}^*| = 3,4299 [VA]$$

$$\hat{S} = 2,9411 - j1,7648 = 3,4299 e^{-j0,5405} \quad \text{final}$$

$$P = 2,9411 [W] \quad Q = -1,7648 [var]$$

$$\hat{S} = P + jQ$$

$$= \hat{U} \cdot \hat{I}^*$$

$$P = \operatorname{Re}\{\hat{S}\}$$

$$Q = \operatorname{Im}\{\hat{S}\}$$

$$P = UI \cos \varphi$$

$$Q = UI \sin \varphi$$

$$X_L = \omega L$$

$$X_C = -\frac{1}{\omega C}$$

Matlab

conj(x) .. komplex schwarz

abs(x)

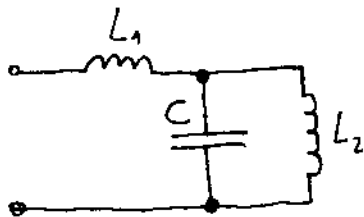
$$P = UI \cos \varphi = 2,9411 [W]$$

$$Q = UI \sin \varphi = -1,7648 [var]$$

a ještě jinak

$$P = R_2 I^2 + \frac{U_2^2}{R_1}$$

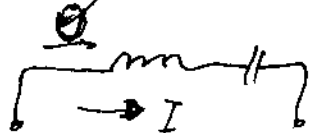
$$Q = \frac{-1}{\omega C} \cdot I^2 + \frac{U_2^2}{\omega L}$$



$$\begin{aligned} \hat{Z} &= j\omega L_1 + \frac{\frac{1}{j\omega C} \cdot j\omega L_2}{\frac{1}{j\omega C} + j\omega L_2} = j\omega L_1 + \frac{\frac{L_2}{C}}{\frac{1 - \omega^2 L_2 C}{j\omega C}} = \\ &= j\omega L_1 + \frac{j\omega L_2}{1 - \omega^2 L_2 C} = \frac{j\omega L_1 - j\omega^3 L_1 L_2 C + j\omega L_2}{1 - \omega^2 L_2 C} = \end{aligned}$$

$$= \frac{j\omega(L_1 + L_2 - \omega^2 L_1 L_2 C)}{1 - \omega^2 L_2 C}$$

Sériový rezonanční obvod

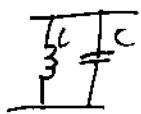


$$U_C = U_L$$

$$L_1 + L_2 - \omega^2 L_1 L_2 C = 0$$

$$\omega_{\text{rn}} = \sqrt{\frac{L_1 + L_2}{L_1 L_2 C}}$$

Paralelní



$$Y=0 \Rightarrow 1 - \omega^2 L_2 C = 0$$

$$\omega_{\text{rp}} = \sqrt{\frac{1}{L_2 C}}$$

$$= 0$$