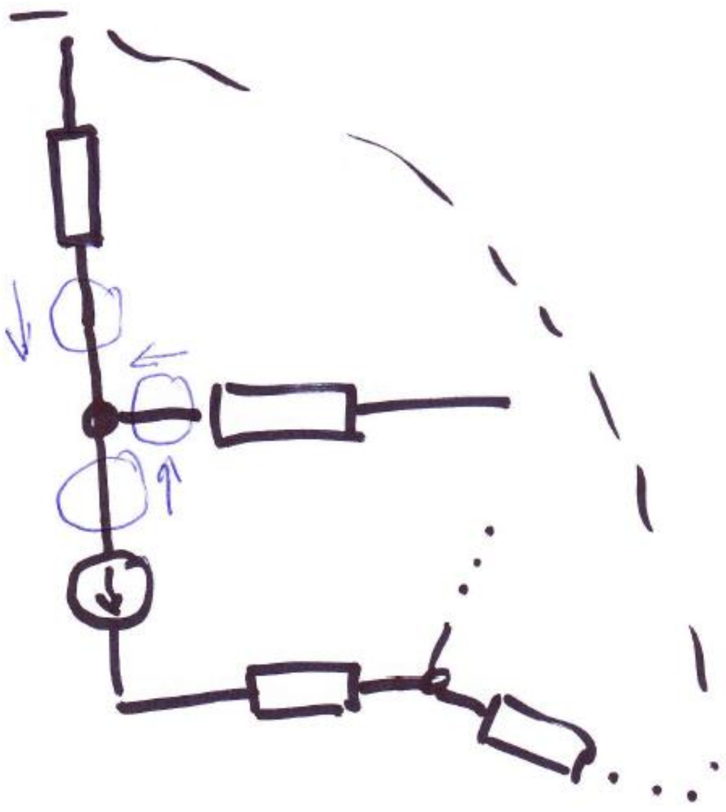
Základy elektroniky

Opakovanie
Teoretická elektrotechnika

Linus Michaeli

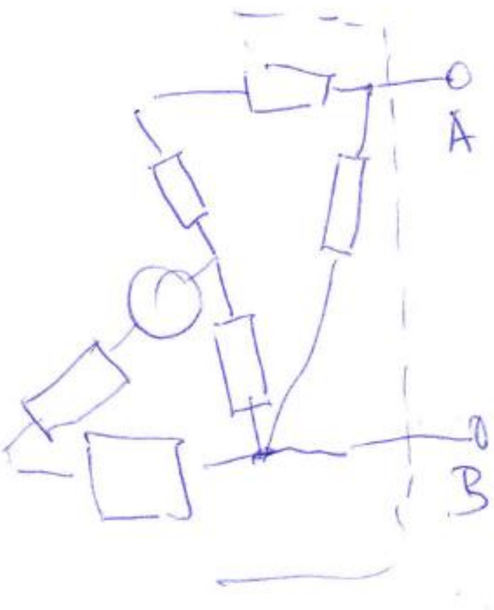
.: Využitie viet o premiestňovaní ideálnych zdrojov



$$\sum u_i = 0$$

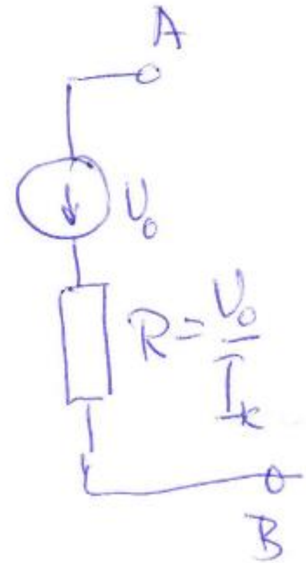
$$\sum i_i = 0$$

EO s js. zdrojmi, základné zákony v EO s js. zdrojmi



$U_0 =$

$I_k =$



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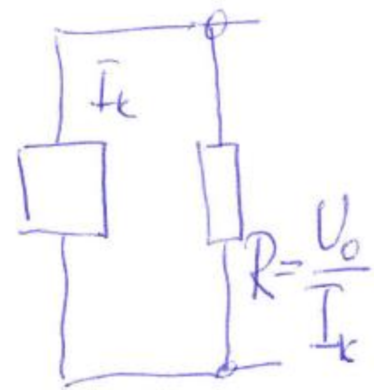
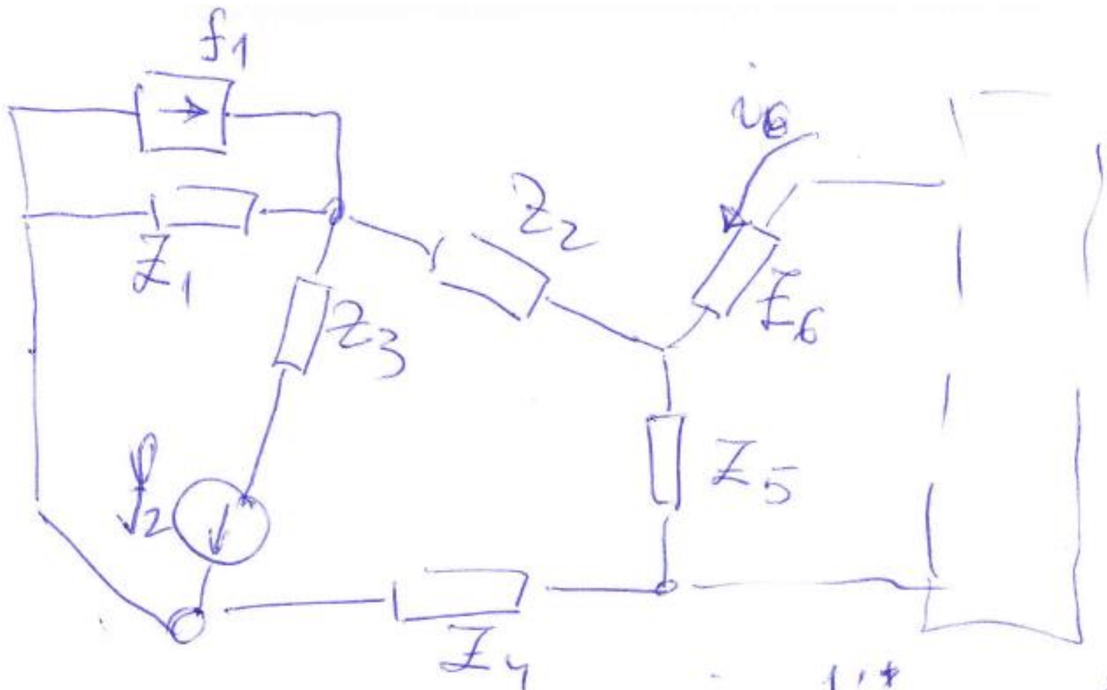


Analýza EO pomocou princípu superpozície



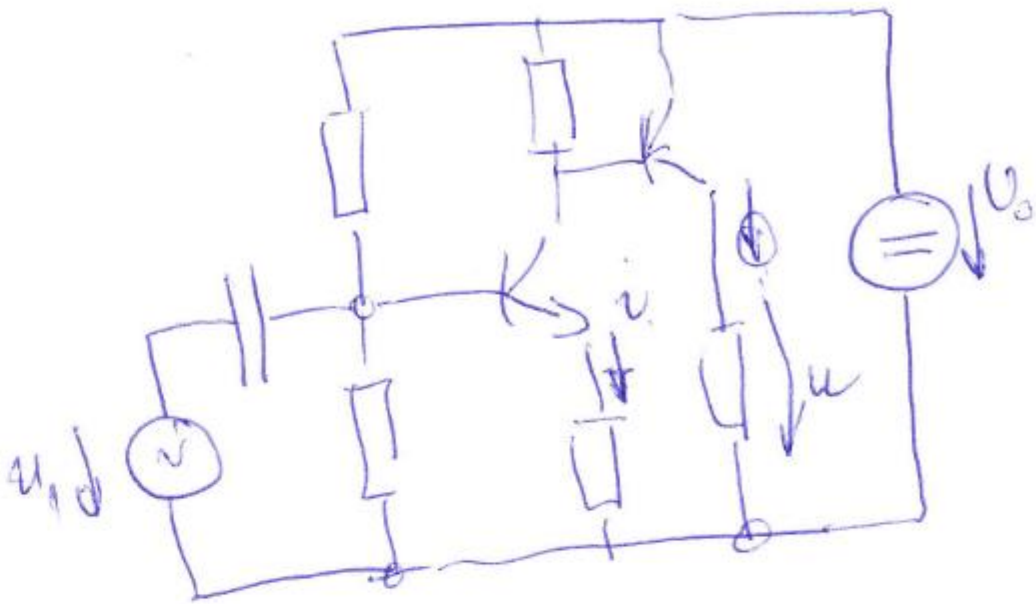
$$i_6 = {}^{1}i_6 + {}^{2}i_6$$

~~od zdroja~~

$f_1 \neq 0$ $\qquad$ $f_1 = 0$

$f_2 = 0$ $\qquad$ $f_2 \neq 0$

Analýza EO pomocou princípu superpozície



(3)

$u_i = U_i + u_{i\,dif}$

od $U_0 \neq 0$ $\quad$ $U_0 = 0$

$u_1 = 0$ $\quad$ $u_1 \neq 0$

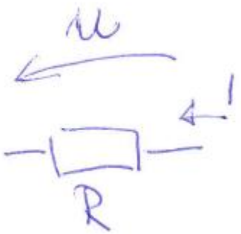
Praktický dopad

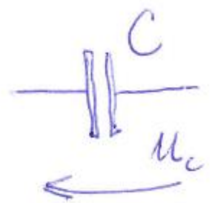
$y = f(x)$

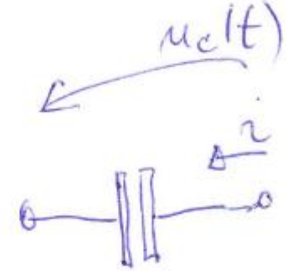
$y = f(x_0) + \frac{\partial f}{\partial x} \cdot dx$

Obvodové prvky v EO a striedavom signále

Odpor | Kondenzátor (kapacitor) | Cievka (Induktor)







$u = R \cdot i$

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

$i_L = \frac{\Psi}{L} = \frac{N \cdot \Phi}{L}$

$$u_c(t)\, C = \underbrace{\int_0^t i(t)\,dt}_{Q(t)}$$

$$\Downarrow$$

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

Komplikovaný výpočet

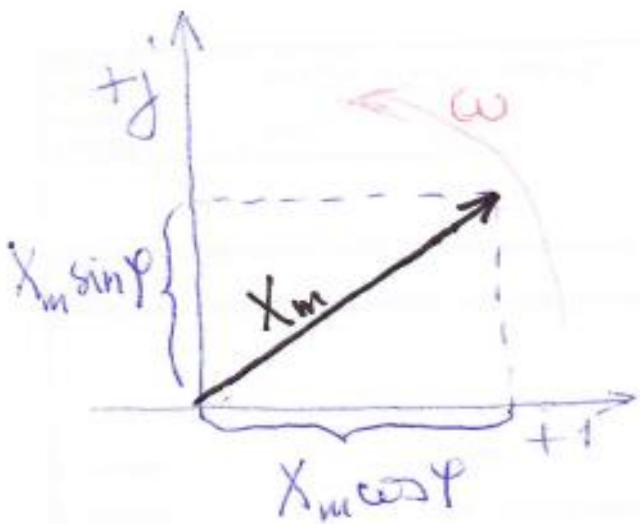
- musíme poznať priebeh $u_c(t)$ vyjadrený analyticky
- Periodický priebeh ľubovoľného tvaru v ustálenom režime vieme vyjadriť ako

$$f(t) = \sum_{n=1}^{\infty} B_n \sin n\omega t + \sum_{n=0}^{\infty} A_n \cos n\omega t = \sum_{n=0}^{\infty} \dot{C}_n e^{jn\omega t}$$

Operácie s fázormi

$$x = X_m \sin(\omega t + \varphi) = \mathrm{Im}\{X_m e^{j(\omega t+\varphi)}\} = \mathrm{Im}\{\underbrace{X_m e^{j\varphi}} \cdot e^{j\omega t}\}$$

$$\underbrace{\mathring{X}_m}_{\hat{X}_m,\ \mathbf{X}_m} = X_m e^{j\varphi} = X_m\cos\varphi + jX_m\sin\varphi$$



I. kz

$$\sum_1 \dot{I}_{m_i} = 0$$

II. kz

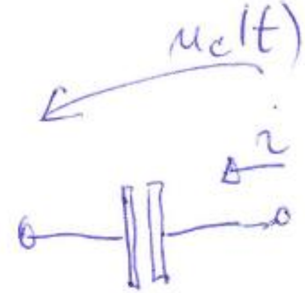
$$\sum_2 \mathring{U}_{m_i} = 0$$

$$x = x_1(t) + x_2(t) = X_{m1}\sin(\omega t+\varphi_1) + X_{m2}\sin(\omega t+\varphi_2) =$$

$$= \mathrm{Im}\{X_{m1}e^{j(\omega t+\varphi_1)}\} + \mathrm{Im}\{X_{m2}e^{j(\omega t+\varphi_2)}\}$$

$$\Rightarrow \dot{X} = X_{m1}e^{j\varphi_1} + X_{m2}e^{j\varphi_2} = \dot{X}_{m1} + \dot{X}_{m2}$$

Vyjadrenie impedancie komplexným číslom



$$u_c(t)\,C = \underbrace{\int_0^t i(t)\,dt}_{Q(t)}$$

$$\Downarrow$$

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

Ustálený stav

$$u_c = U_c \sin\omega t$$

$$i_c(t) = C\omega U_c \cos\omega t = \omega C U_c \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$\dot{I}_c = \omega C \dot{U}_c \underbrace{e^{j\frac{\pi}{2}}}_{j} = \underbrace{j\omega C}_{\dot{Y}_c = j\omega C} \cdot \dot{U}_c \Rightarrow \dot{U}_c = \frac{1}{j\omega C} \cdot \dot{I}_c = -j\frac{1}{\omega C} \cdot \dot{I}_c$$

Vyjadrenie impedancie komplexným číslom

$$i_L(t)\,L = \Psi = \int_0^t u_L(t)\,dt$$

$$u_L(t) = L\frac{di_L(t)}{dt}$$

ustálený stav

$$i_L = I_L \sin\omega t$$

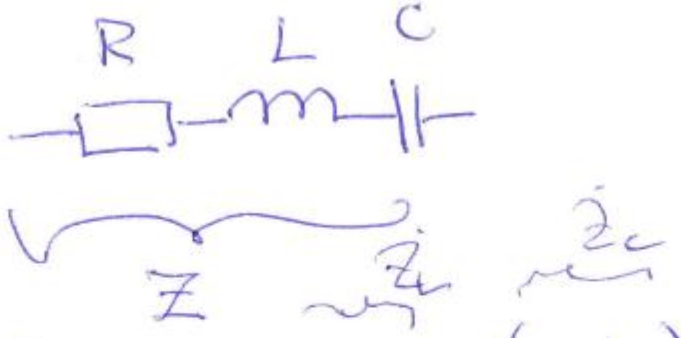
$$u_L = L\omega I_L \cos\omega t$$

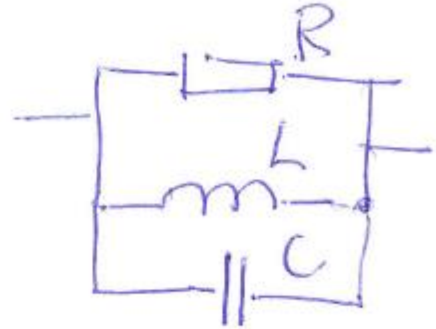
$$u_L = \omega L\, I_L \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$\dot{U}_L = \omega L \cdot \dot{I}_L e^{j\frac{\pi}{2}} = \underbrace{j\omega L}_{\dot{Z}_L} \cdot \dot{I}_L$$

$$\dot{Z}_L = j\omega L$$

Výsledné impedancie

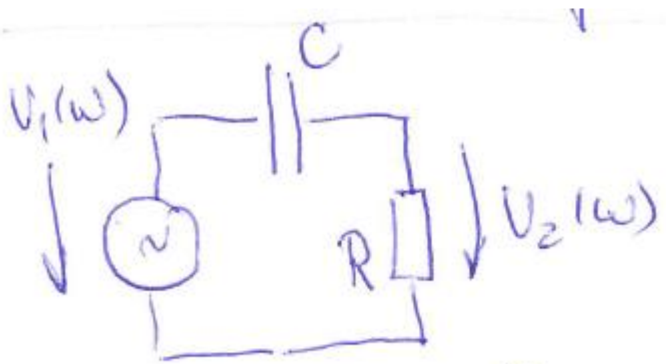




$$\dot{Z} = R + j\omega L + \left(-j\frac{1}{\omega C}\right) = R + j\omega L + \frac{1}{j\omega C}$$

$$\dot{Y} = \underbrace{\frac{1}{R}}_{\dot{Y}_R} + \underbrace{j\omega C}_{\dot{Y}_C} + \underbrace{\left(-j\frac{1}{\omega L}\right)}_{\dot{Y}_L}$$

C-R obvod



$$U_2(\omega) = \frac{R}{R + \frac{1}{j\omega C}} U_1(\omega)$$

Odporový delič

Frekvenčný prenos C- R

$$\dot{U}_2(\omega) = \frac{j\omega RC}{jR\omega C + 1}\,\dot{U}_1(\omega)$$

Medza $R\omega C = 1$

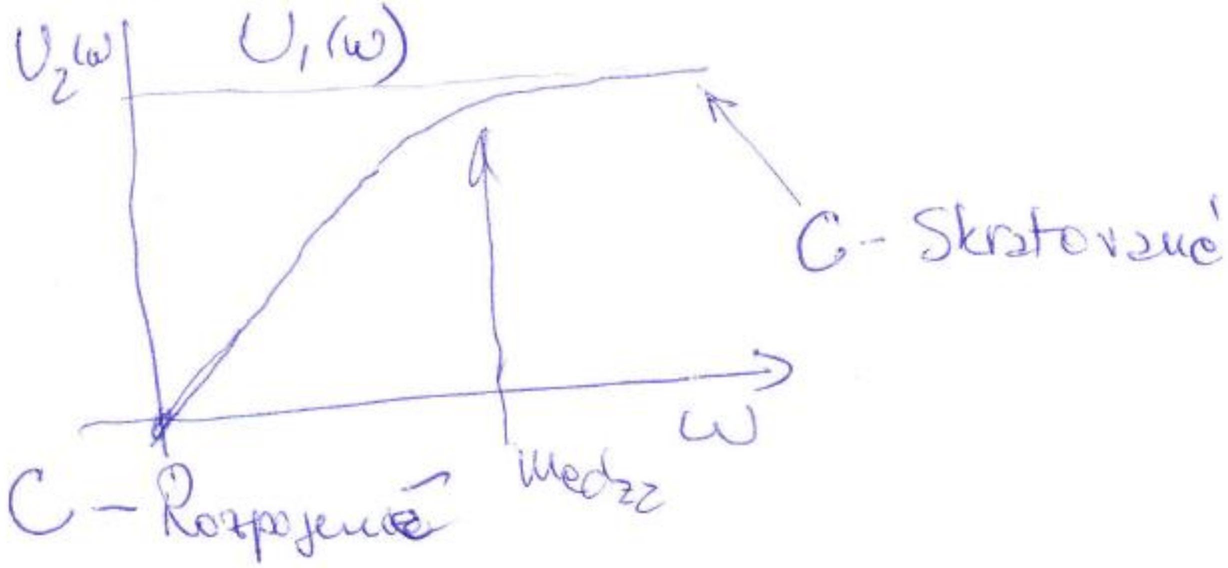
$$\omega = \frac{1}{RC}$$

$RC\cdot\omega \ll 1$

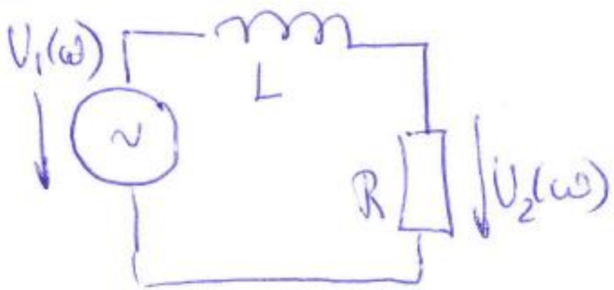
$$\dot{U}_2(\omega) = j\omega RC \cdot U_1(\omega)$$

$RC\omega \gg 1$

$$\dot{U}_2(\omega) = 1 \cdot U_1(\omega)$$

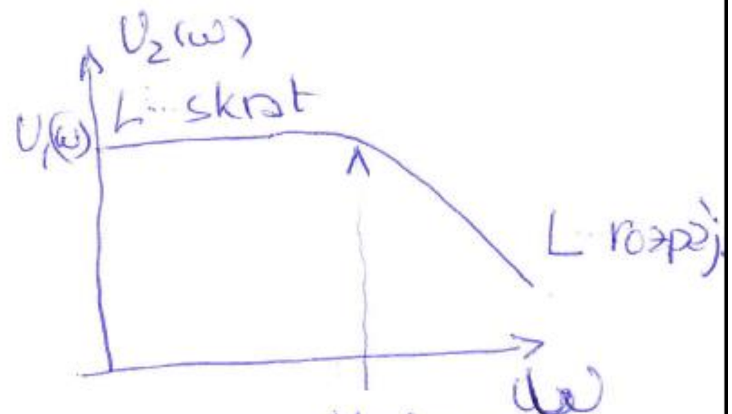


L-R obvod a jeho prenos



$$U_2(\omega) = \frac{R}{R + j\omega L} \cdot U_1(\omega)$$

$$U_2(\omega) = \frac{\frac{R}{j\omega L}}{\frac{R}{j\omega L} + 1} U_1(\omega)$$



Medza:

$$\frac{R}{\omega L} \gg 1 \Rightarrow \omega \to 0$$

$$U_2(\omega) = U_1(\omega)$$

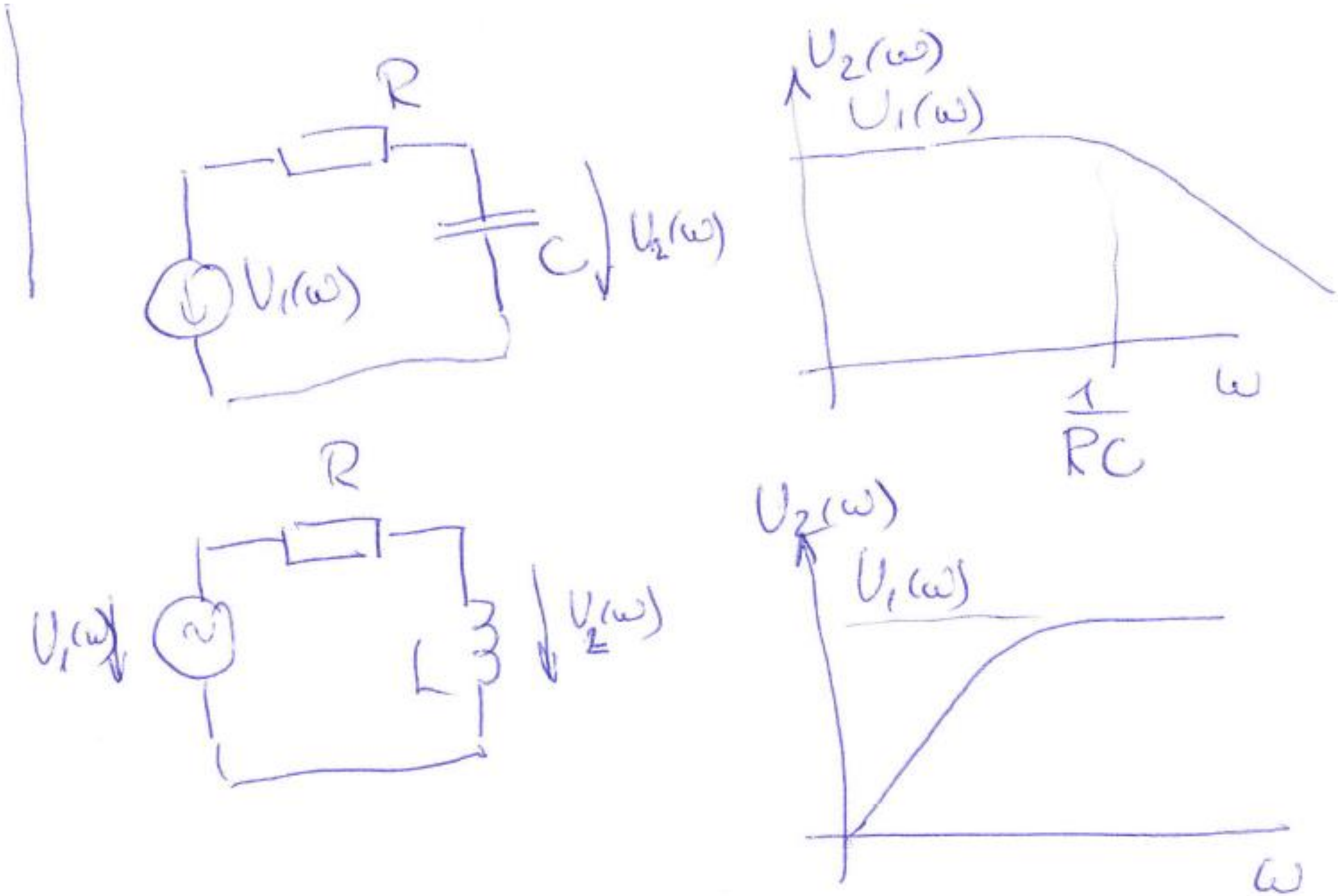
$$\frac{R}{\omega L} \ll 1 \Rightarrow \omega \to \infty$$

$$U_2(\omega) = U_1(\omega) \frac{R}{j\omega L}$$

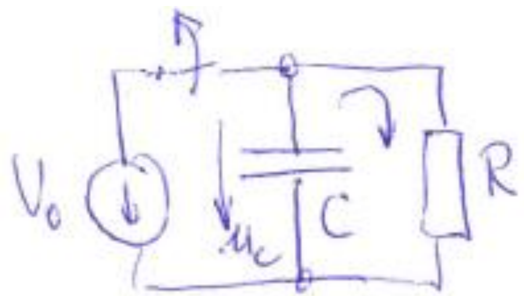
$$\frac{R}{\omega L} = 1$$

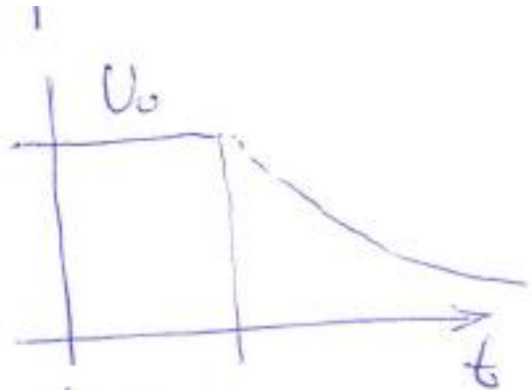
$$\omega_m = \frac{R}{L}$$

Prenosy RC a RL obvodov



Prechodové deje





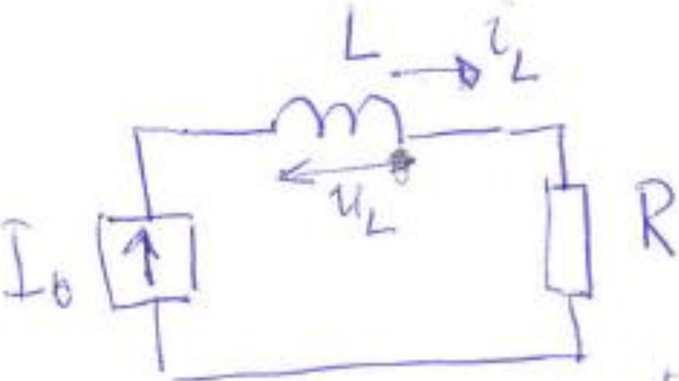
$$u_c = \frac{\int_0^t i\,dt}{C} = \frac{\int_0^t -\frac{u_c}{R}\,dt}{C}$$

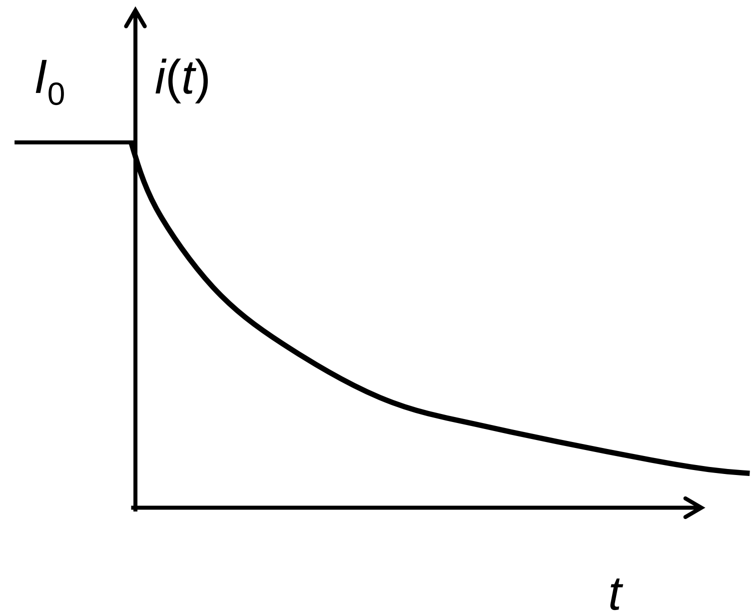
$$\frac{du_c}{dt} = -\frac{u_c}{RC}$$

Riešenie

$$u_c = U_0 e^{-\frac{t}{RC}}$$

Prechodové deje





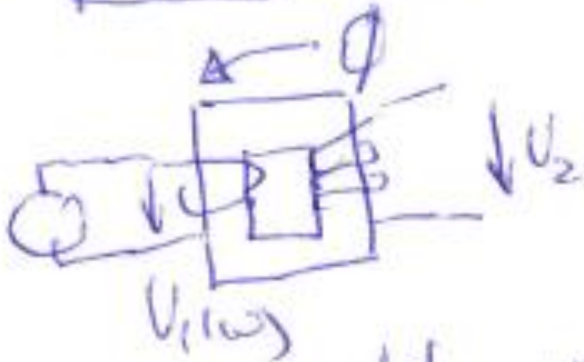
$$i_L = \frac{\int_0^t u_L\,dt}{L} = \frac{\int_0^t -R\,i_L\,dt}{L}$$

$$\frac{di_L}{dt} = -\frac{R}{L}\,i_L$$

Riešenie

$$i_L = I_0\, e^{-\frac{tR}{L}}$$

Transformátorová väzba

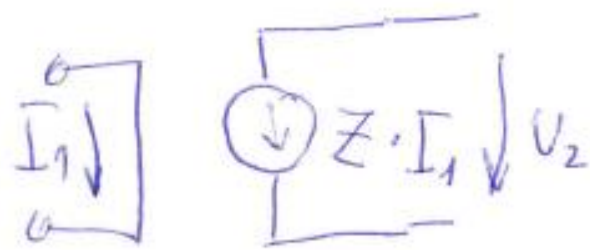


$$\left.\begin{aligned} U_1(\omega) &= N_1 \frac{d\Phi}{dt} \\ U_2(\omega) &= N_2 \frac{d\Phi}{dt} \end{aligned}\right\} \quad \frac{U_1(\omega)}{U_2(\omega)} = \frac{N_1}{N_2}$$

Riadené zdroje

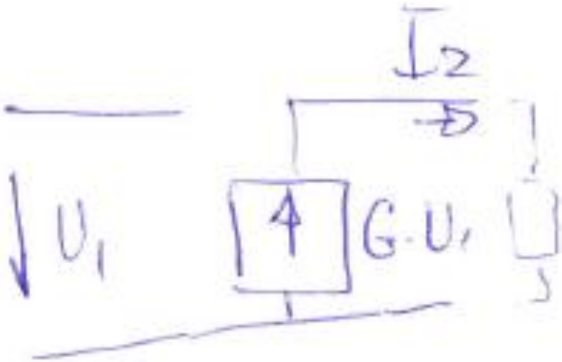
Zosilňovač:

Napätím riadený napäťový zdroj



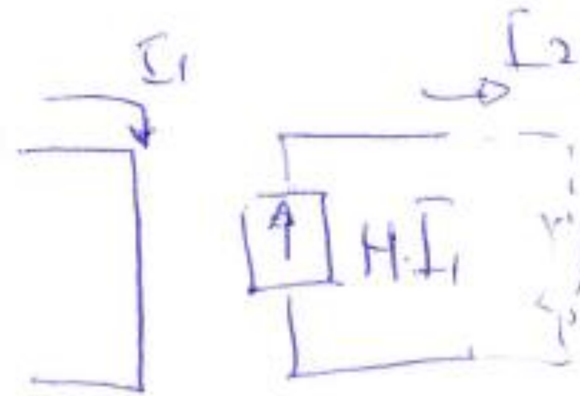
Prúdom riadený napäťový zdroj

Riadené zdroje



$$I_2 = G\,U_1$$

Napätím riadený prúdový zdroj



$$I_2 = H \cdot I_1$$