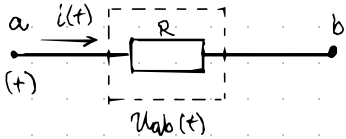
1.2. DVOPOLI

Omski otpor R

- linearni pasivni dvopol : $u_{ab}(t) = R \cdot i(t)$ — struja ulazi na + stezaljku dvopola [Ω]



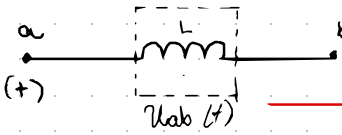
napon na stezaljkama dvopola

pretvara se u izvora u Q

$W = I^2 R t \rightarrow \boxed{W(t) = R \int_0^t i^2(t')dt'}$

Induktivitet L

- linearni pasivni dvopol : $u_{ab}(t) = L \cdot \frac{d}{dt} i(t)$ — struja [H]



napon različit od nule ako je struja promjenjiva s vremenom!

* može spremiti energiju iako je pasivni element (mag polje)

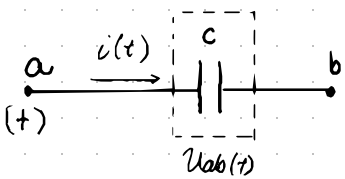
$$\boxed{w(t) = \frac{L\, i^2(t)}{2}}$$

Kapacitet C

napon na kondenzatoru u trenutku t_0

$$u_{ab}(t) = \frac{1}{C}\int_{t_0}^{t} i(t')dt' + u_c(t_0) \quad [F]$$

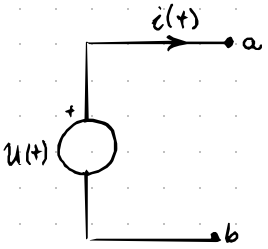
$$i(t) = C \frac{d}{dt} u_{ab}(t)$$ — napon na stezaljkama otpora



* u svome el. polju može spremiti energiju

$$\boxed{w(t) = \frac{C\, u_{ab}^2(t)}{2}}$$

Idealni naponski izvor



- aktivni dvopol : $u_{ab}(t) = u(t)$

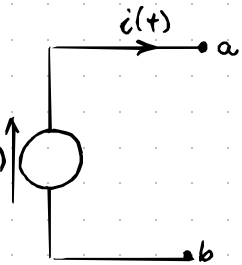
→ struja može biti bilo koje vrijednosti

$u(t) = U$ ili $u(t) = E$

=> idealni istosmjerni naponski izvor

- napon uvijek jednak $u(t)$

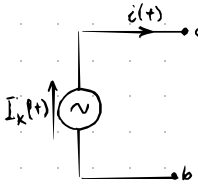
▸ Idealni strujni izvor

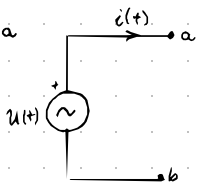


- aktivni dvopol: $i_k(t) = i(t)$

→ ako je $i_k(t) = I$ => idealni strujni izvor, istosmjerni

Idealni sinusni izvor





$$i_k(t) = \hat{I}_m \sin(\omega t + \alpha_i)$$

$$u_k(t) = U_m \sin(\omega t + \alpha_u)$$

=> struja i napon ovise o t i mogu se opisati mat. funkcijama koje opisuju izmjenične struje i napone => harmoničke funkcije (sinus i kosinus)

1. referentni polaritet (t) → stalni i ne ovise o vremenu

2. - kod izmjeničnih struja i napona polaritet napona $u_{ab}(t)$ i smjer struje $i(t)$ mijenja se u vremenu

   → referentni i stvarni polariteti se ne podudaraju u svakom trenu

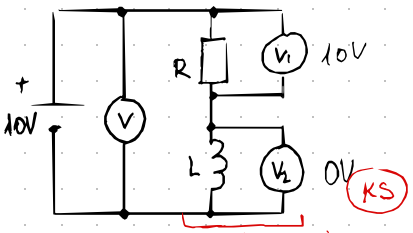
3. Za jednadžbe Kircht. zakona → uzimaju se ref smjerovi $L(t)$ za napon i odgovarajući ref. smjer struje

1.3. RJEŠAVANJE MREŽA SA SINUSNIM IZVORIMA

ALM - Aktivne Linearne Mreže

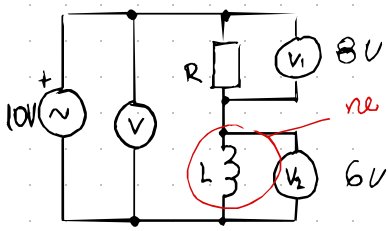
- analiza je složenija od one u istosmjernim krugovima
  - ↳ u njima = induktivitet L ⇒ kratki spoj
  - = kapacitet C ⇒ prazni hod

POKUS serija RL s istosmjernim i sinusnim izvorom



$U_V = U_R + U_L$

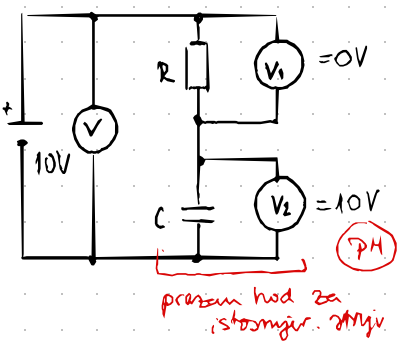
↳ alg. suma pada napona na trošilu i elementima



→ nije primjenjivo u izmjeničnom ($8+6 \neq 10$)

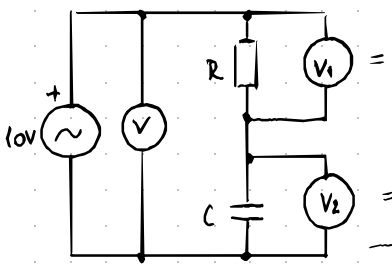
- pad napona na R uvijek postoji
- pad napona na L postoji samo u spoju sa sinusnim naponskim izvorom

POKUS serija RL s istosmjernim i sinusnim izvorom



$U_V = U_R + U_C$

- na R nema pada napona kada je RC serija spojena na istosmjerni naponski izvor

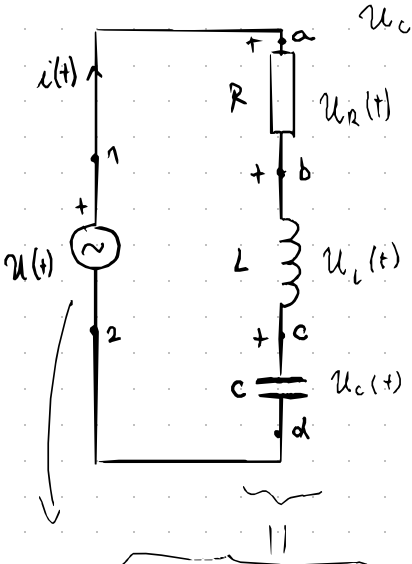


- pad napona na kapacitetu C postoji u oba slučaja

⇒ izmjenična sinusna struja stvara padove napona na mel L i kap. C

+ nailazi na otpor kad prolazi ishima

Primjer: sinusni izvor i serija RLC



napon na kondenzatoru

$u_C(t) = U_{Cm} \sin(\omega t + \alpha_{uc})$

$i(t)$, $u_R(t)$, $u_L(t)$ i $u(t)$ = ?

$U_{Cm} = 30V$

$\alpha_{uc} = -60° \rightarrow -\frac{\pi}{3}$ pomak

$R = 2\Omega$

$L = 1{,}6mH$

$C = 20\mu F$

$\omega = 5000 s^{-1}$

$*R = \frac{U}{I}$ $\quad u_L(t) = L\frac{di}{dt}$

$u_C(t) = \frac{1}{C}\int_{t_0}^{t} i(t')dt' + u_C(t_0)$

$u_{12}(t) = u_{ab} + u_{bc} + u_{cd}$

$u_{12}(t) = R \cdot i(t) + L\frac{di}{dt} + \frac{1}{C}\int_{t_0}^{t} i(t')dt' + u_C(t_0)$

$i(t) = C\frac{d}{dt} \cdot u_C(t)$

$\boxed{u_C(t) = 30 \cdot \sin(5000t - \frac{\pi}{3})}$

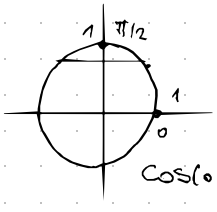
$\Rightarrow i(t) = C \cdot \frac{d}{dt} \cdot U_{Cm} \sin(\omega t + \alpha_{uc})$

$i(t) = C \cdot U_{C_m} \cos(\omega t + \alpha_{uc}) \cdot \omega = 20 \times 10^{-6} \cdot 30 \cdot \cos(5000t - \frac{\pi}{6}) \cdot 5000$

$i(t) = 3\cos(5000t - \frac{\pi}{6})\ A \rightarrow I_{max} = 3A$

$i(t) = 3\sin(5000 - \frac{\pi}{6} + \frac{\pi}{2})\ A$

$\boxed{i(t) = 3\sin(5000 + \frac{\pi}{6})\ A}$ $\rightarrow \alpha_i = \frac{\pi}{6}$



$\cos(0) = \sin(\frac{\pi}{2})$

$\rightarrow \cos(x) = \sin(x + \frac{\pi}{2})$

$\boxed{u_R = R \cdot i(t) = 6\sin(5000t + \frac{\pi}{6})\ \Omega}$

$u_L = L \cdot \frac{d}{dt} i(t) = 1{,}6 \times 10^{-3} \cdot \frac{d}{dt}(I_{max} \sin(\omega t + \alpha_i))$

$u_L = 1{,}6 \times 10^{-3} \cdot I_{max} \cos(\omega t + \alpha_i) \cdot \omega = 1{,}6 \times 10^{-3} \cdot 3\cos(5000t + \alpha_i) \cdot 5000$

$u_L = 4{,}8 \times 10^{-3} \cdot 5000 \cdot \sin(5000t + \frac{\pi}{6} + \frac{\pi}{2}) =$

$\boxed{u_L = 24 \cdot \sin(5000t + \frac{2\pi}{3})V}$

$u(t) = 6\sin(5000t + \frac{\pi}{6})\Omega + 30 \cdot \sin(5000t - \frac{\pi}{3}) + 24 \cdot \sin(5000t + \frac{2\pi}{3})V$

$\boxed{u(t) = 8{,}49\sin(5000t - \frac{\pi}{12})V}$

↳ $6\sin(5000t + \frac{\pi}{6}) + 6\sin(5000t - \frac{\pi}{3})$ u protufazi su ($\varphi = \pi$)

$\rightarrow \sin(x) + \sin(y) = 2\sin(\frac{x+y}{2}) \cdot \cos(\frac{x-y}{2}) \rightarrow 8{,}49\sin(5000t - \frac{\pi}{12})V$

nepraktican način rješavanja