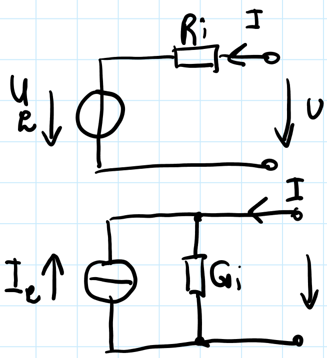
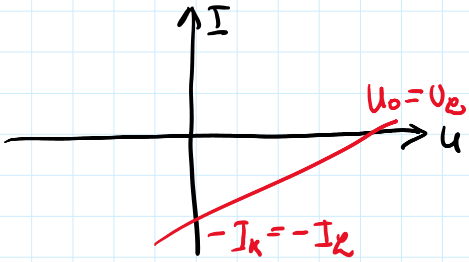
LINEARE QUELLE / ERSATZSCHALTUNG





DC $\quad U = 12V$

AC $\quad u = 230 \cdot \sqrt{2} \cos(2\pi f)\ V$

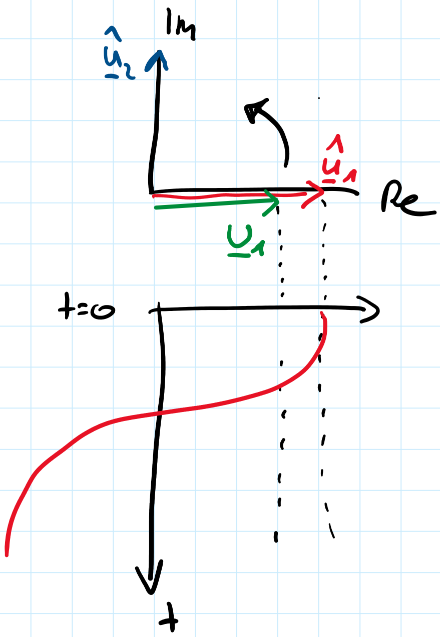
$U = 230V$

$\hat{u} = 230 \cdot \sqrt{2}\ V$

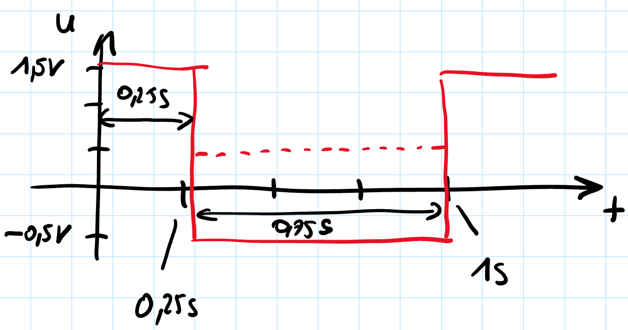
$\hat{\underline{u}}_1 = 230 \cdot \sqrt{2} \angle 0^\circ$

$\underline{U}_1 = 230V \angle 0^\circ$

$\hat{\underline{u}}_2 = 230 \cdot \sqrt{2} \angle 90^\circ$



$\boxed{\text{Bsp. E9}}$



$T = 1s$

$f = 1\ Hz$

$\omega = 2\pi f = 2\pi \frac{1}{s} = 2\pi\ s^{-1}$

$U_{max} = 1{,}5V \quad U_{min} = -0{,}5V \quad \hat{U} = 1{,}5V$

$U_{pp} = 2V$

$$\bar{u} = \frac{1}{T}\int_0^T u\, dt = \frac{1}{1s}\left(\int_0^{0,25} 1{,}5V\, dt + \int_{0,25}^{1} -0{,}5V\, dt\right) =$$

$$= \frac{1}{1s}\left(\left[1{,}5\,V\,t\right]_0^{0{,}25} + \left[-0{,}5\,V\,t\right]_{0{,}25}^{1}\right) = \frac{1}{1s}\left(0{,}375\,Vs - 0\,Vs - 0{,}5\,Vs + 0{,}125\,Vs\right) =$$

$$= \frac{1}{1s}\,0\,Vs = \underline{\underline{0\,V}}$$

$$|\bar{u}| = \frac{1}{T}\int_0^T |u|\,dt = \frac{1}{1s}\left(\int_0^{0{,}25} 1{,}5\,V\,dt + \int_{0{,}25}^{1} 0{,}5\,V\,dt\right) =$$

$$= \frac{1}{1s}\left(0{,}375\,Vs - 0\,Vs + 0{,}5\,Vs - 0{,}125\,Vs\right) = \underline{0{,}75\,V}$$

$$U = \sqrt{\frac{1}{T}\int_0^T u^2\,dt} \quad \text{RMS-Wert}$$

$$\int_0^T u^2\,dt = \int_0^{0{,}25} 1{,}5^2\,V^2\,dt + \int_{0{,}25}^{1} 0{,}5^2\,V^2\,dt =$$

$$= \left[2{,}25\,V^2 t\right]_0^{0{,}25} + \left[0{,}25\,V^2 t\right]_{0{,}25}^{1} =$$

$$= 2{,}25 \cdot 0{,}25\,V^2 s - 0 + 0{,}25\,V^2 s - 0{,}0625\,V^2 s = \underline{\underline{0{,}75\,V^2 s}}$$

$$\underline{\underline{U}} = \sqrt{\frac{1}{1s}\,0{,}75\,V^2 s} = \underline{\underline{0{,}866\,V}}$$

Scheitelfaktor: $\dfrac{\text{Scheitelwert}}{\text{Effektivwert}} = \dfrac{\hat{U}}{U} = \dfrac{1{,}5\,V}{0{,}866\,V} = 1{,}732$

Formfaktor: $\dfrac{\text{Effektivwert}}{\text{Gleichrichtwert}} = \dfrac{U}{|\bar{u}|} = \dfrac{0{,}866\,V}{0{,}75\,V} = 1{,}154$

Schwingungsgehalt: $\dfrac{\text{Effektivwert AC}}{\text{Effektivwert}} = \dfrac{0{,}866\,V}{0{,}866\,V} = 1$

effektive Welligkeit $= \dfrac{\text{Effektivwert AC}}{\text{Gleichwert}}$ => kein Ergebnis

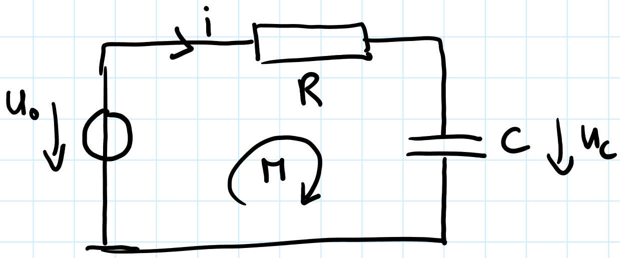
Riffelfaktor $= \dfrac{\text{Schwingbreite AC}}{\text{Gleichwert}} = \dfrac{U_{pp}}{\bar{u}}$ -> kein Ergebnis

Mischgrößen ($\bar{u} \neq 0$)

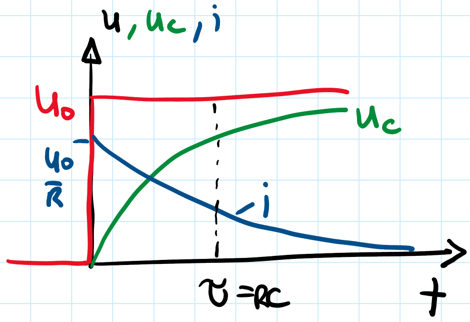
TRANSIENTENVERHALTEN

u, u_C, i

TRANSIENTENVERHALTEN



$$i_c = C \cdot \frac{du_c}{dt}$$



$$-U_0 + R \cdot C \cdot \frac{du_c}{dt} + u_c = 0$$

$$\frac{du_c}{dt} + \frac{1}{RC} u_c = \frac{1}{RC} U_0$$

$$u_c = u_c^h + u_c^p$$

1) homogene Lösung

$$\frac{du_c}{dt} + \frac{1}{RC} u_c = 0$$

$$\frac{du_c}{dt} = -\frac{1}{RC} u_c$$

$$\frac{1}{u_c} du_c = -\frac{1}{RC} dt \xrightarrow{\int} \ln(u_c) = -\frac{1}{RC} t + \ln(C)$$

$$u_c^h = C \cdot e^{-\frac{t}{RC}} = C \cdot e^{-\frac{t}{\tau}} \qquad \tau = R \cdot C \text{ Zeitkonstante}$$

2) Partikuläre Lösung

$$u_c^p = U_0$$

$$u_c = C \cdot e^{-\frac{t}{\tau}} + U_0$$

3) Anfangsbedingungen

$$t = 0 \rightarrow u_c = 0$$

$$u_c(t=0) = C + U_0 = 0 \Rightarrow C = -U_0$$

4) Lösung

$$\underline{\underline{u_c}} = -U_0 e^{-\frac{t}{\tau}} + U_0 = \underline{\underline{U_0 \left(1 - e^{-\frac{t}{\tau}}\right)}}$$

$$\underline{\underline{i}} = C \cdot \frac{du_c}{dt} = C \cdot \frac{d}{dt}\left(U_0 - U_0 e^{-\frac{t}{\tau}}\right) =$$

$$= C\left(+U_0 \frac{1}{\tau}\right) e^{-\frac{t}{\tau}} = \frac{\cancel{C}}{R\cancel{C}} U_0 e^{-\frac{t}{\tau}} = \frac{U_0}{R} e^{-\frac{t}{\tau}}$$

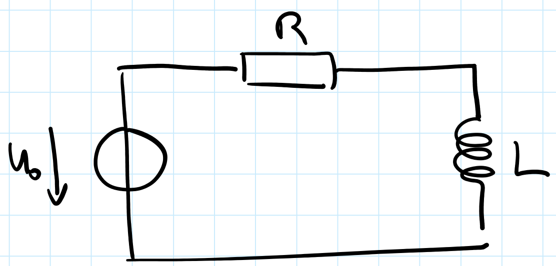
$$= C\left(+U_0 \frac{1}{\tau}\right) e^{-\frac{t}{\tau}} = \frac{\cancel{C}}{R\cancel{C}} U_0 e^{-\frac{t}{\tau}} = \underline{\underline{\frac{U_0}{R} e^{-\frac{t}{\tau}}}}$$

$$P_C = i_C \cdot u_C = \frac{U_0}{R} \cdot e^{-\frac{t}{\tau}} \cdot U_0\left(1 - e^{-\frac{t}{\tau}}\right) = \frac{U_0^2}{R}\left(e^{-\frac{t}{\tau}} - e^{-\frac{2t}{\tau}}\right)$$

$$W_C = \int_0^\infty P_C(t) \cdot dt = \int_0^\infty \frac{U_0^2}{R}\left(e^{-\frac{t}{\tau}} - e^{-\frac{2t}{\tau}}\right) dt =$$

$$= \frac{U_0^2}{R}\left[\frac{e^{-\frac{t}{\tau}}}{-\frac{1}{\tau}} - \frac{e^{-\frac{2t}{\tau}}}{-\frac{2}{\tau}}\right]_0^\infty = \frac{U_0^2}{R}\left[-\tau e^{-\frac{t}{\tau}} + \frac{\tau}{2} e^{-\frac{2t}{\tau}}\right]_0^\infty$$

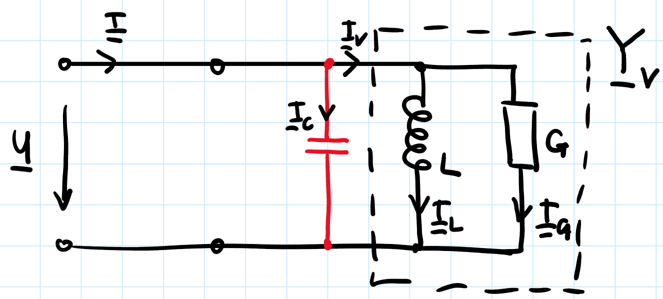
$$= \frac{U_0^2}{R}\left[0 + 0 + \tau - \frac{\tau}{2}\right] = \frac{U_0^2 \tau}{2R} = \frac{U_0^2 \cancel{R} C}{2\cancel{R}} = \frac{U_0^2 C}{2}$$

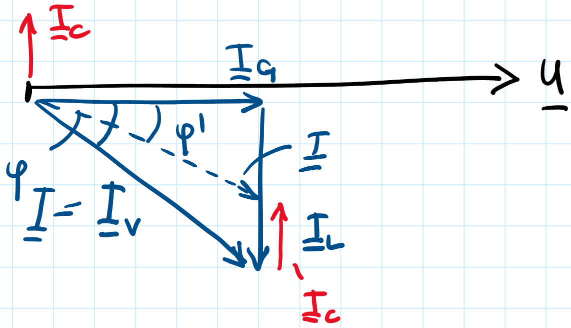


$$W_L = L\frac{I^2}{2} \qquad \tau = \frac{L}{R}$$

Blindleistungskompensation

$$\cos\varphi = \frac{P}{S}$$





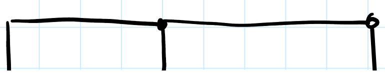
$\cos\varphi < 0{,}9 \rightarrow$ Verwarnung

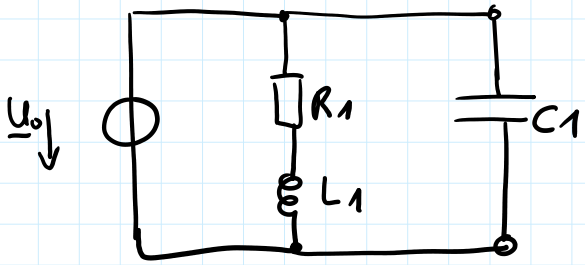
$\varphi \approx 25{,}8°$

Blindenergie > 48% der Wirkarbeit

BSP

$U_0 = 110V \qquad f = 60\ Hz$





$U_0 = 110\,V$ $f = 60\,Hz$

$R_1 = 10\,\Omega$ $L_1 = 20\,mH$

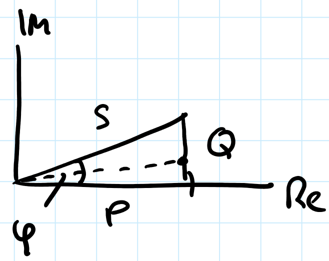
a) λ o. Blindleistungskompensation

$\underline{Z} = R_1 + j\omega L_1 = 10 + 7{,}54j\ \Omega \Rightarrow \varphi = 37{,}02^\circ$

$\cos\varphi = 0{,}80$ $\underline{I} = \frac{\underline{U}}{\underline{Z}} = \frac{110\,V}{10 + 7{,}54j\,\Omega} = 7{,}01 + 5{,}29j\,A = 8{,}78\,A \angle{-37^\circ}$

$P = U \cdot I \cdot \cos\varphi = 771{,}6\,W$ $Q = U \cdot I \cdot \sin\varphi = 581{,}2\,var$

b) Kompensation mit $C_1 \rightarrow \lambda = 0{,}98$



$\cos\varphi = 0{,}98 \rightarrow \varphi = 11{,}48^\circ$

$\tan\varphi = \frac{Q}{P}$ $Q = \tan\varphi \cdot P = 156{,}6\,var$

$\Delta Q = -(581{,}2 - 156{,}6)\,var = -424\,var$

$Q_C = -U^2\omega C \rightarrow C_1 = 9{,}317 \cdot 10^{-5}\,F = 93{,}17\,\mu F$

c) wie stark sinkt $\underline{I}$ durch Kompensation? $\underline{Z}_C = \frac{1}{j\omega C_1}$

$\underline{Z}_k = \frac{\underline{Z} \cdot \underline{Z}_c}{\underline{Z} + \underline{Z}_c} = 15{,}06 + 3{,}06j = 15{,}37\,\Omega \angle 11{,}48^\circ$

$\underline{I} = \frac{\underline{U}}{\underline{Z}_k} = 7{,}16\,A \angle{-11{,}48^\circ} \Rightarrow -18{,}5\,\%$ Reduktion

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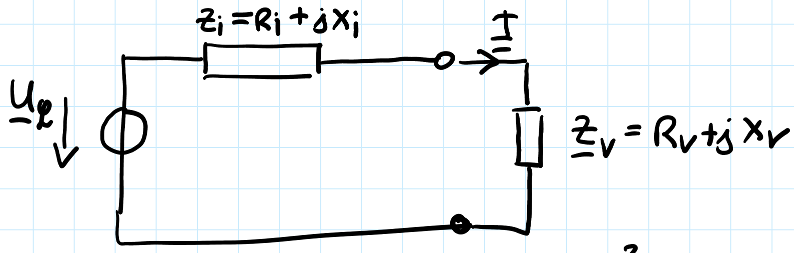
LEISTUNGSANPASSUNG



$P = R_V I^2 = R_V \frac{U_q^2}{(R_i + R_V)^2 + (X_i + X_V)^2}$

Optimum $X_i = -X_V$ (Resonanz)!

Optimum $X_i = -X_v$ (Resonanz)!

$P_{opt} = U_e^2 \frac{R_v}{(R_i + R_v)^2}$ $\rightarrow$ Ableitung für max.

$$\boxed{\begin{array}{l} R_v = R_i \quad X_v - X_i \quad \underline{Z}_v = \underline{Z}_i^* \\ P_{max} = \frac{U_e^2}{4R_i} \end{array}}$$