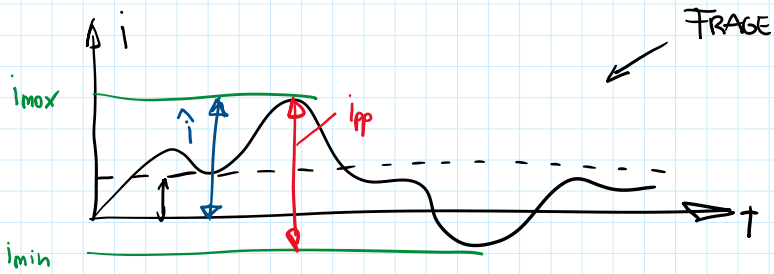
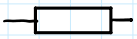


FRAGE ZEITABHÄNGIGKEIT

OHMSCHER WIDERSTAND R



$u = R \cdot i$

$$\hat{u}\cos(\omega t+\varphi_u) = R\cdot\hat{i}\cos(\omega t+\varphi_i)$$

$$\hat{u} = R\cdot\hat{i} \Rightarrow Z_R = \frac{\hat{u}}{\hat{i}} = R$$

$$\omega t+\varphi_u = \omega t+\varphi_i \Rightarrow \varphi_u = \varphi_i \Rightarrow \varphi_R = 0$$

$$\underline{Z}_R = R\angle 0°$$

IDEALE INDUKTIVER ZP L

$u = L\cdot\frac{di}{dt}$

$$\hat{u}\cos(\omega t+\varphi_u) = L\cdot\frac{d}{dt}\left(\hat{i}\cos(\omega t+\varphi_i)\right) =$$

$$= \omega L\hat{i}\left(-\sin(\omega t+\varphi_i)\right)$$

$$\hat{u}\cos(\omega t+\varphi_u) = \omega L\hat{i}\cos\left(\omega t+\varphi_i+\frac{\pi}{2}\right)$$

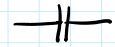
$$\hat{u} = \omega\cdot L\hat{i} \Rightarrow Z_L = \omega L$$

$$\omega t+\varphi_u = \omega t+\varphi_i+\frac{\pi}{2} \Rightarrow \varphi_L = \varphi_u-\varphi_i = \frac{\pi}{2}$$

$$\underline{Z}_L = \omega L\angle\pi/2$$

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

IDEALE KAPAZITIVER ZP C

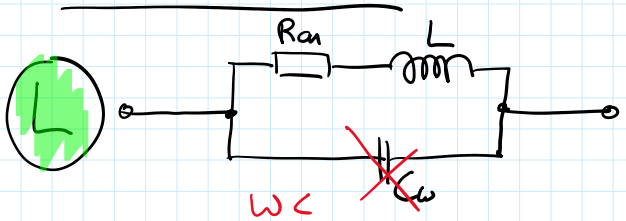


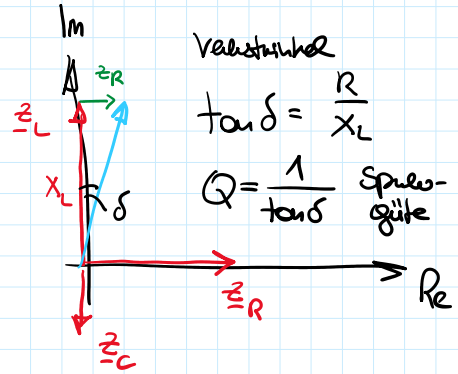
$i = C\cdot\frac{du}{dt}$

$$\underline{Z}_C = \frac{1}{\omega C}\angle -\pi/2$$

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

REALE BAUELEMENTE

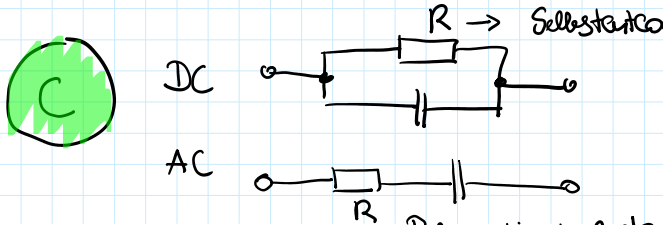




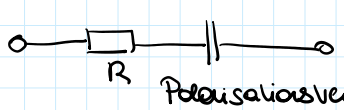
Verlustwinkel

$\tan\delta = \frac{R}{X_L}$

$Q = \frac{1}{\tan\delta}$ Spulen-güte



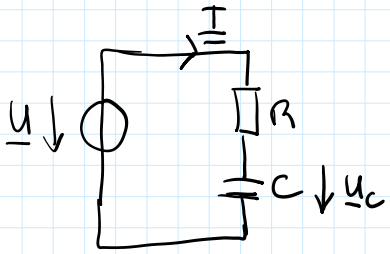
AC



GESPEICHERTE ENERGIE W_{max}

$L \rightarrow L|^2$

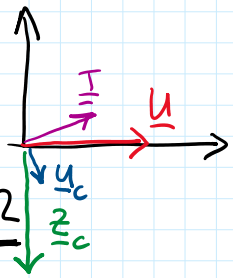
$C \rightarrow CU^2$



$\underline{U} = 10V\angle 0°$ $\quad f = 2000\,Hz$

$R = 10k\Omega$ $\quad C = 47\,nF$

$\underline{Z}_C = -j\frac{1}{\omega C} = -j\frac{1}{2\pi f \cdot C} = -j\,1693{,}14\,\Omega$



$$\underline{U}_C = \frac{\underline{Z}_C}{\underline{Z}_C + \underline{Z}_R} \cdot \underline{U} = \frac{-j1693{,}14}{-j1693{,}14 + 10k\Omega} \cdot 10V =$$

$$= \frac{1693{,}14\angle -90°}{10142{,}32\angle -9{,}6°} \cdot 10V = 0{,}166\angle -80{,}4° \cdot 10V =$$

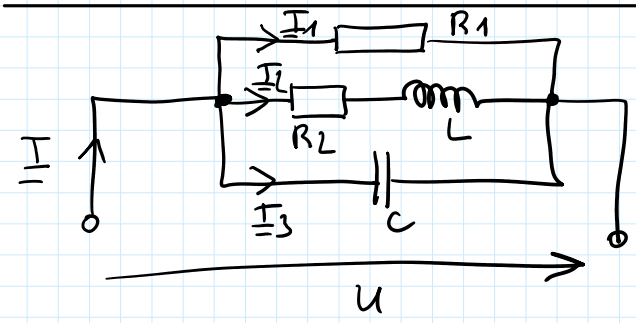
$$= 1{,}669\,V\angle -80{,}4°$$

$$\underline{Z}_e = \sum_{k=1}^{n} \underline{Z}_k = \sum_{k=1}^{n} R_k + j\sum_{k=1}^{n} X_k$$

REIHEN-SCHALTUNG

$$\frac{\underline{U}_1}{\underline{U}} = \frac{\underline{Z}_1}{\underline{Z}_e}$$ SPANNUNGSTEILER

$$\underline{I} = \frac{\underline{U}}{\underline{Z}_{Rc}} = \frac{\underline{U}}{10k\Omega - j1693\,\Omega} = \frac{10V\angle 0°}{10142\angle -9{,}6°} = 0{,}985\,mA\angle 9{,}6°$$



$R_1 = 50\Omega$ $\quad R_2 = 20\Omega$

$L = 0{,}1\,H$ $\quad C = 20\,\mu F$

$\underline{U} = 230V\angle 0°$ $\quad f = 50\,Hz$

$\underline{I} = ?$

$\underline{Y}_1 = \frac{1}{R_1} = 20\,mS$

$\underline{Y} = \frac{1}{\quad} - \frac{1}{\quad} = 14{,}47\,mS - j\,22{,}65\,mS$

$\underline{Y}_1 = \frac{1}{R_1} = 20\,mS$

$\underline{Y}_2 = \frac{1}{R_2 + j\omega L} = \frac{1}{20 + j 2\pi f\, 0{,}1}\,S = 14{,}42\,mS - j\,22{,}65\,mS$

$\underline{Y}_3 = \frac{1}{\frac{1}{j\omega C}} = j\omega C = j\,6{,}28\,mS$

$\underline{Y}_e = \underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3 = 34{,}42\,mS - j\,16{,}37\,mS =$

$= 38{,}11\,mS \angle -25{,}4°$

$\underline{I} = \underline{Y}_e \cdot \underline{U} = 8{,}77\,A \angle -25{,}4°$

$$\underline{Y}_e = \sum_{k=1}^{n} \underline{Y}_k = \sum_{k=1}^{n} G_k + j \sum_{k=1}^{n} B_k$$

$$\frac{\underline{I}_1}{\underline{I}} = \frac{\underline{Y}_1}{\underline{Y}_e}$$ STROMTEILER

PARALLEL-SCHALTUNG

"Einschub"

$1\,€ = 100\,ct = 10\,ct \times 10\,ct =$

$= 0{,}1\,€ \times 0{,}1\,€ = 0{,}01\,€ = 1\,ct$

?

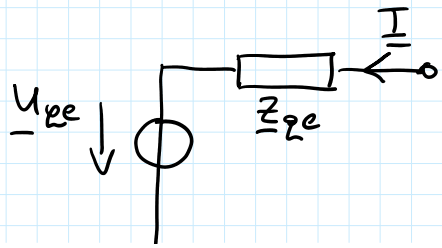
ERSATZQUELLSPANNUNG = Spannung zw. im Leerlauf

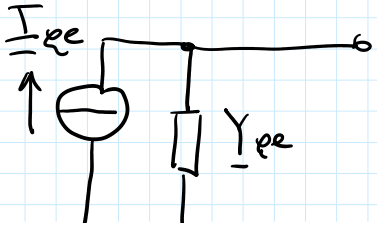
ERSATZQUELLSTROM = Strom zw. im Kurzschluss

ERSATZ-INNENWIDERSTAND = Quellspannung / Kurzschlussstrom

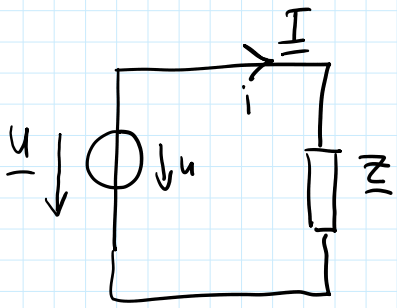
$\underline{U}_{qe} = \underline{U}_0 = \underline{U}\big|_{\underline{I}=0}$ $\quad \underline{I}_{qe} = \underline{I}_k = -\underline{I}\big|_{\underline{U}=0}$

$\underline{Z}_{qe} = \frac{1}{\underline{Y}_{qe}} = \frac{\underline{U}_{qe}}{\underline{I}_k}$





LEISTUNG



$$u = \hat{u}\sin(\omega t + \varphi)$$

$$i = \hat{i}\sin(\omega t)$$

$p(t) = p = u \cdot i$ AUGENBLICKSLEISTUNG

$$p = u \cdot i = \hat{u}\hat{i}\sin(\omega t + \varphi)\cdot\sin(\omega t) = *$$

$$\downarrow \quad \sin\alpha \cdot \sin\beta = \frac{1}{2}\left[\cos(\alpha-\beta) - \cos(\alpha+\beta)\right]$$

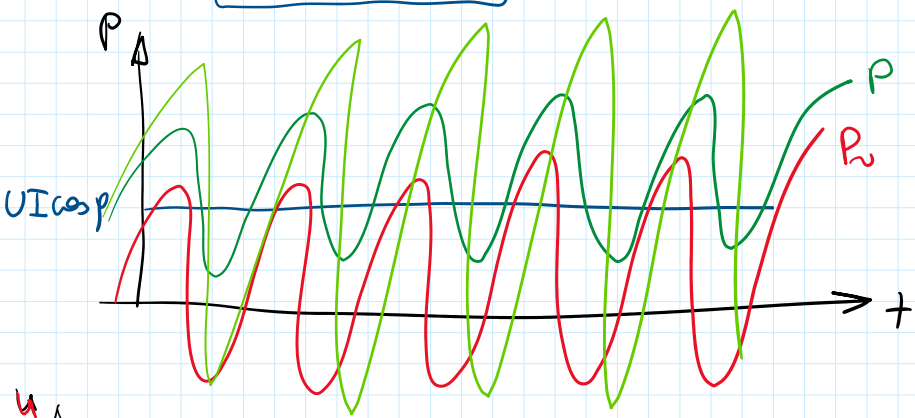
$$* = \frac{1}{2}\hat{u}\hat{i}\left[\cos\varphi - \cos(2\omega t + \varphi)\right] =$$

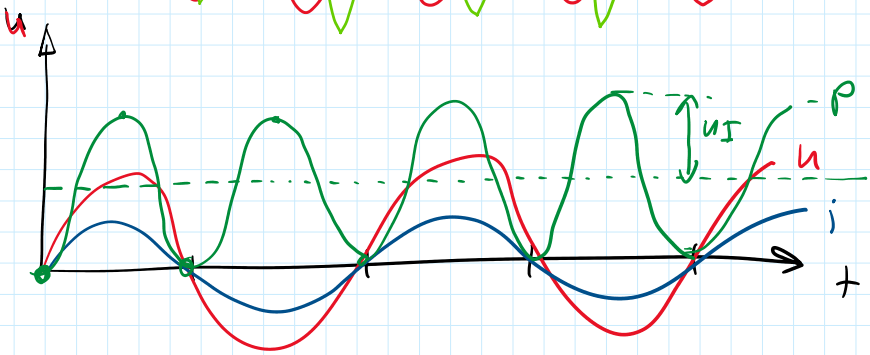
$$= UI\cos\varphi - UI\cos(2\omega t + \varphi)$$

$UI\cos\varphi$ → P Wirkleistung, $[P] = 1\,W$ (= Gleichanteil)

$UI\cos(2\omega t + \varphi)$ → $P_\sim(t)$ Wechselanteil

S Scheinleistung, $[S] = 1\,VA$ (= Amplitude Wechselanteil)





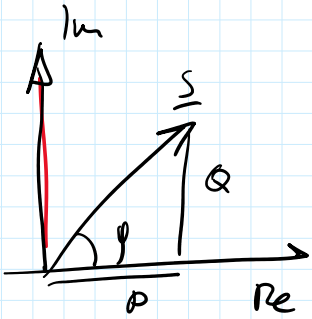
$P = U \cdot I \cdot \cos\varphi = UI$

Bsp. Widerstand / Glühbirne

KOMPLEXE LEISTUNG

$\underline{S} = P + jQ = S\angle\varphi$ (Winkelgeschwindigkeit 2ω) $= *$

Leistungsfaktor $\lambda = \frac{P}{S} = \frac{U \cdot I \cdot \cos\varphi}{U I} = \cos\varphi$



Verbraucher $-90° < \varphi < 90°$

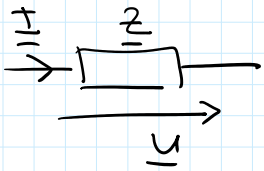
$[Q] = 1\ \text{var}$

$P > 0$ Verbraucher $\quad Q > 0$ induktiv

$P < 0$ Erzeuger $\quad Q < 0$ kapazitiv

$* = S \cdot \cos\varphi + j\, S \sin\varphi$

$\underline{U} = 12{,}4\,V\angle 28°$ $\quad \underline{I} = 1{,}5\,A\angle -76°$ $\quad \underline{I}^* = 1{,}5\,A\angle 76°$



$\underline{S} = \underline{U} \cdot \underline{I}^* = 12{,}4\,V\angle 28° \cdot 1{,}5A\angle 76° = 18{,}6\,VA\angle 104° =$

$= -4{,}488\,W + j\,18{,}048\,var$

P $\quad Q$

$S = 18{,}6\,VA \quad \varphi = 104°$

$P = -4{,}488\,W$ Erzeuger

$Q = 18{,}048\,var$ induktiv