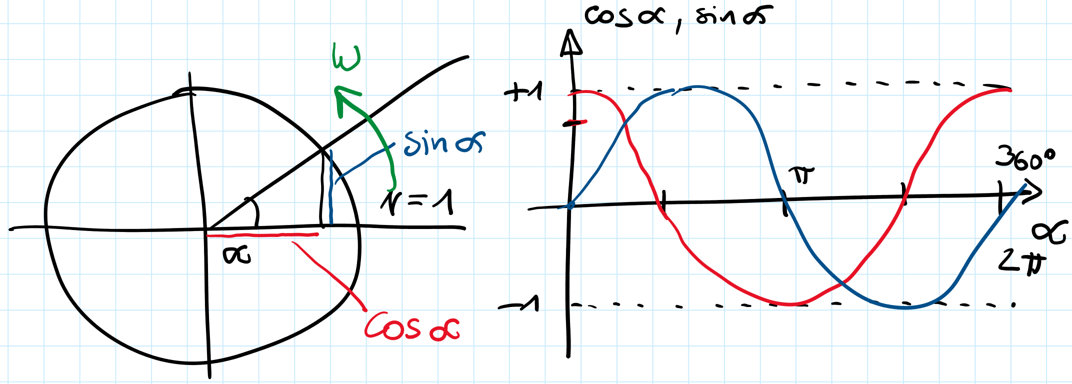
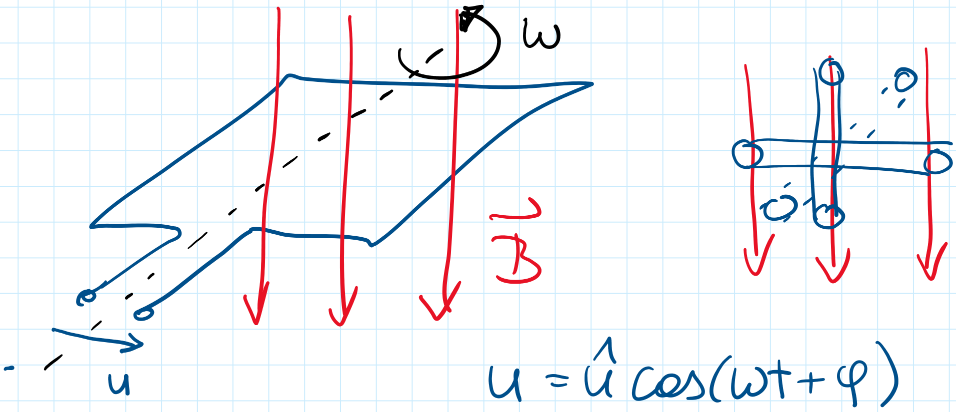
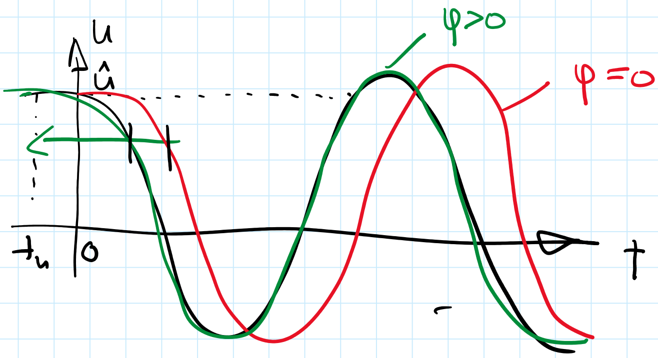




$$u = \hat{u}\cos(\omega t + \varphi)$$



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

$\hat{u}$ … Amplitude

U_{pp} … $2\hat{u}$

φ … Nullphasenwinkel

$t_u = -\frac{\varphi}{\omega}$ … Nullphasenzeit

$\varphi = 0$ nullphasig

$\varphi_1 > \varphi_2$ → u_1 eilt u_2 voraus

$\varphi_1 - \varphi_2$ → Phasenverschiebung

$$\bar{u} = \frac{1}{T}\int_0^T u \, dt = 0$$

$$U = \sqrt{\frac{1}{T}\int_0^T u^2 dt} = \frac{\hat{u}}{\sqrt{2}}$$

$$|\bar{u}| = \frac{1}{T}\int_0^T |u| dt = \frac{2}{\pi}\hat{u}$$

für sinusförmige Funktion

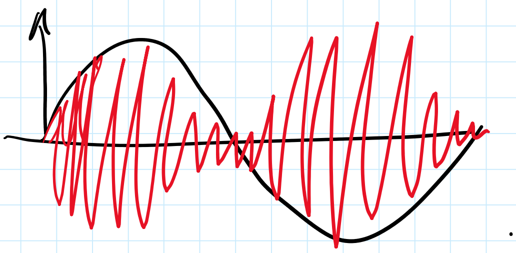
ÜBERLAGERUNG SIN-FUNKTIONEN

ÜBERLAGERUNG SIN-FUNKTIONEN

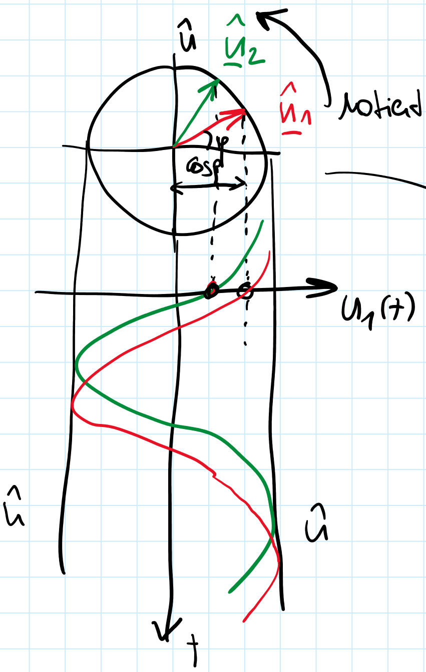
$\omega_1 = \omega_2 \longrightarrow u_3 = u_1 + u_2$ wieder sinusförmig

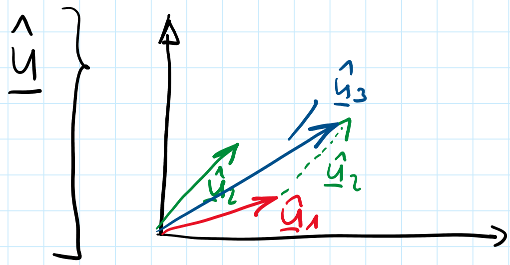
$\omega_1 \neq \omega_2 \longrightarrow u_3$ nicht sinusförmig

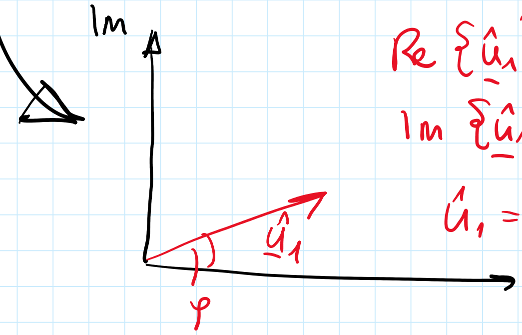
$\omega_1 \approx \omega_2 \qquad \omega = \frac{\omega_1 + \omega_2}{2} \qquad \Delta\omega = \frac{\omega_1 - \omega_2}{2}$



"Schwebung"







$Re\{\hat{\underline{u}}_1\} = \hat{u} \cdot \cos\varphi$

$Im\{\hat{\underline{u}}_1\} = \hat{u} \cdot \sin\varphi$

$\hat{u}_1 = \sqrt{Re\{\hat{\underline{u}}_1\}^2 + Im\{\hat{\underline{u}}_1\}^2}$

$\varphi = \arctan \frac{Im\{\hat{\underline{u}}_1\}}{Re\{\hat{\underline{u}}_1\}}$

$u(t) = \hat{u}\cos(\omega t + \varphi) + j\,\hat{u}\sin(\omega t + \varphi) = *$

$e^{j\varphi} = \cos\varphi + j\sin\varphi$ Eulersche Formel

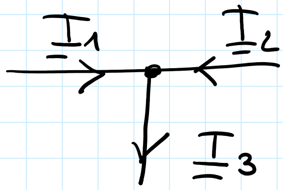
$* = \hat{u}e^{j(\omega t + \varphi)} = \hat{u}\,e^{j\omega t}\,e^{j\varphi}$

✗ ✓ ✗

$\underline{\hat{u}} = \hat{u}e^{j\varphi} = \hat{u}\angle\varphi$

$\underline{U} = U e^{j\varphi} = U\angle\varphi \qquad i^2 = -1 \qquad i = \sqrt{-1}$

E33 Summe zweier Ströme



$\underline{I}_1 = 1{,}5A \angle 0°$ $\quad i_1 = \sqrt{2}\, 1{,}5A\, e^{j(\omega t + 0°)}$

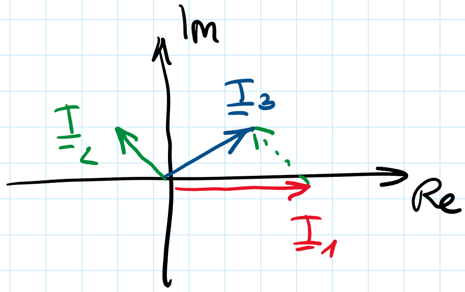
$\underline{I}_2 = 0{,}5A \angle 120°$ $\quad i_2 = \sqrt{2}\, 0{,}5A\, e^{j(\omega t + 120°)}$

$\underline{I}_1 = 1{,}5A + j\,0A$

$\underline{I}_2 = -0{,}25A + j\,0{,}433A$

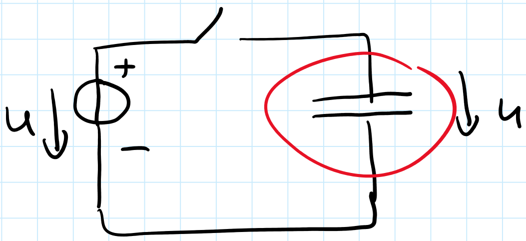
$\underline{I}_3 = \underline{I}_1 + \underline{I}_2 = 1{,}25A + j\,0{,}433A$

$= 1{,}32A \angle 19{,}1°$



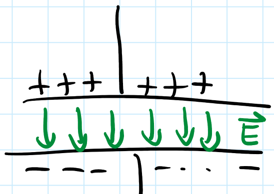
Kondensator | Kapazität

$C = \frac{Q}{u} \qquad [C] = 1F$



$dQ = C\,du$

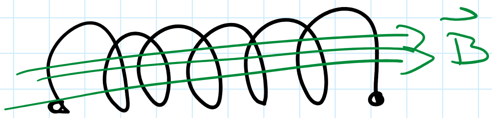
$$i = \frac{dQ}{dt} = C\,\frac{du}{dt}$$



Serie / Reihe: $\frac{1}{C_{ges}} = \frac{1}{C_1} + \dots + \frac{1}{C_n}$

||: $C_{ges} = C_1 + C_2 + \dots + C_n$

Spule | Induktivität



$[L] = 1H$

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

Reihe / Serie: $L_{ges} = L_1 + \dots + L_n$

||: $\frac{1}{L_{ges}} = \frac{1}{L_1} + \dots + \frac{1}{L_n}$

$L_{ges} = L_1 + \dots + L_n$ $\qquad$ $\frac{1}{L_{ges}} = \frac{1}{L_1} + \dots + \frac{1}{L_n}$

LINEARE ZWEIPOLE R, L, C

$$\underline{Z} = \frac{\underline{U}}{\underline{I}} = \frac{U \angle \varphi_u}{I \angle \varphi_i} = \frac{U}{I} \angle \varphi_u - \varphi_i$$

IMPEDANZ (=komplexer Widerstand)

$$\underline{Z} = Z \angle \varphi_Z = R + jX$$

Z: Scheinwiderstand, R: Resistanz, X: Reaktanz

$$\underline{Y} = Y \angle \varphi_Y = \frac{I}{U} \angle \varphi_i - \varphi_u = G + jB$$

ADMITTANZ (=komplexer Leitwert)

G: Konduktanz, B: Suszeptanz

$[Z] = \Omega$ $\qquad$ $[Y] = S$

$Z = \sqrt{R^2 + X^2}$ $\qquad$ $Y = \sqrt{G^2 + B^2}$

$\varphi_Z = \arctan \frac{X}{R}$ $\qquad$ $-\varphi_Z = \arctan \frac{B}{G}$ $\qquad$ $\varphi_Z = \varphi$

$R = Z \cdot \cos \varphi_Z$ $\qquad$ $G = Y \cos(-\varphi_Z)$

$X = Z \cdot \sin \varphi_Z$ $\qquad$ $B = Y \sin(-\varphi_Z)$

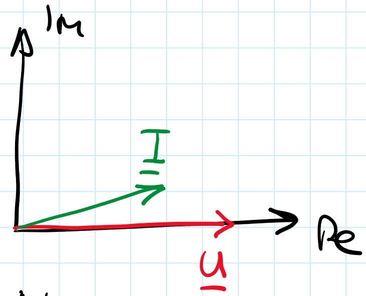
BSP $\quad \underline{U} = 230\,V \angle 0°$, $\underline{I} = 1{,}2\,A \angle 10°$

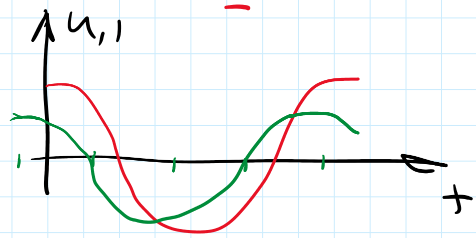
$$\underline{Z} = \frac{\underline{U}}{\underline{I}} = \frac{230V \angle 0°}{1{,}2A \angle 10°} =$$

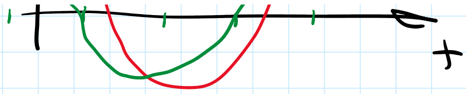
$$= 191{,}6\,\Omega \angle -10° =$$

$$= 188{,}7 - j\,33{,}28$$

$$\underline{Y} = \frac{1}{\underline{Z}} = \frac{1}{Z} \angle -\varphi = 5{,}21\,mS \angle +10°$$







$\underline{Y} = \frac{1}{\underline{Z}} = \frac{1}{Z} \angle -\varphi = 5{,}21\,mS \angle +10°$

$u(t) = 230V \cdot \sqrt{2} \cdot \cos(\omega t)$

$f = 50\,Hz$ $\omega t = 2\pi \cdot 50 \cdot 4ms$

$t = 4ms$

Radiant!