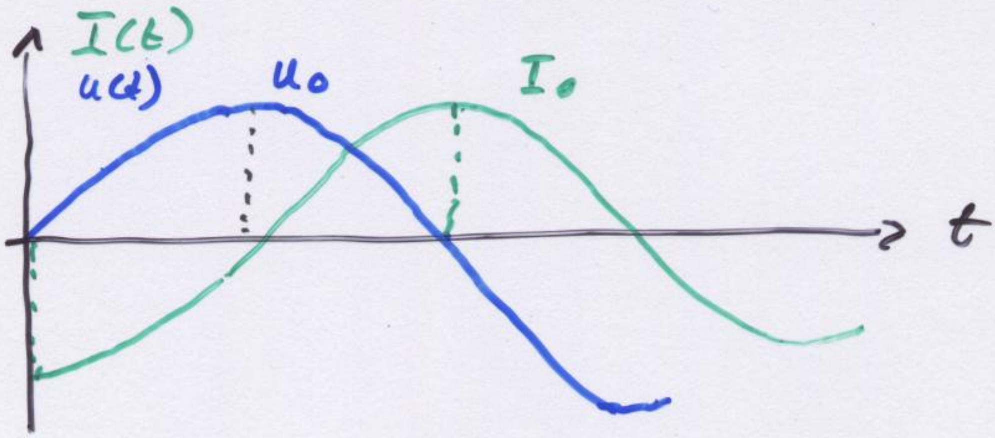
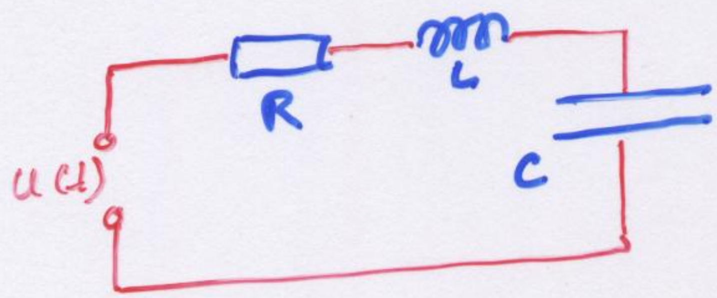


$$R_L = \omega L$$ Impedanz

6. Spule + ohmscher Widerstand

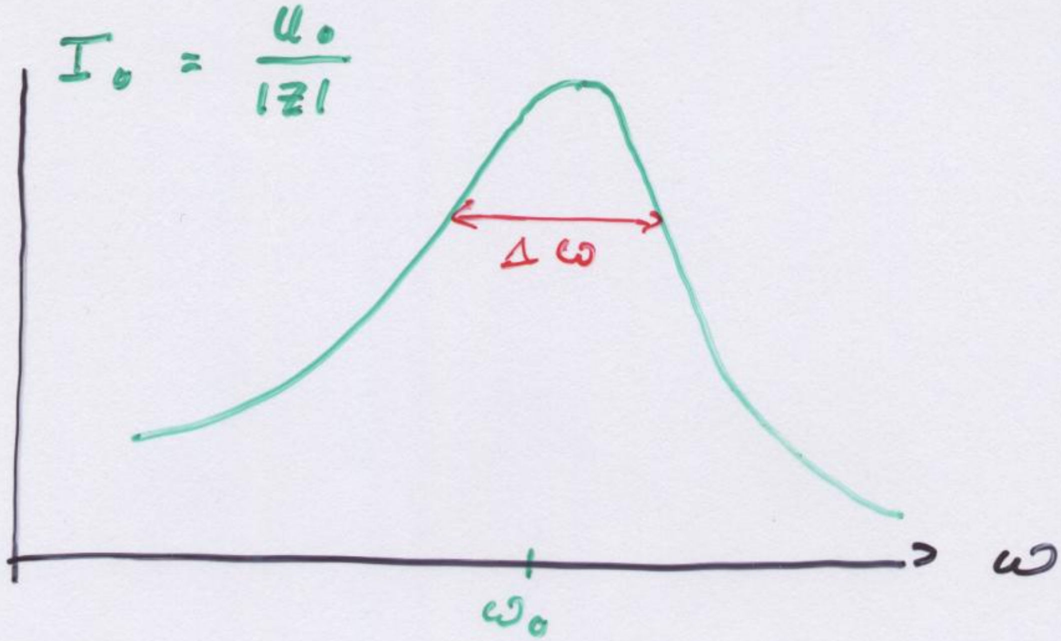
$$R_L = \sqrt{R^2 + (\omega L)^2}$$

7. Serienkreis mit R, L, C



$$\frac{du}{dt} = R \cdot \frac{dI}{dt} + L \frac{d^2 I}{dt} + \frac{I}{C}$$

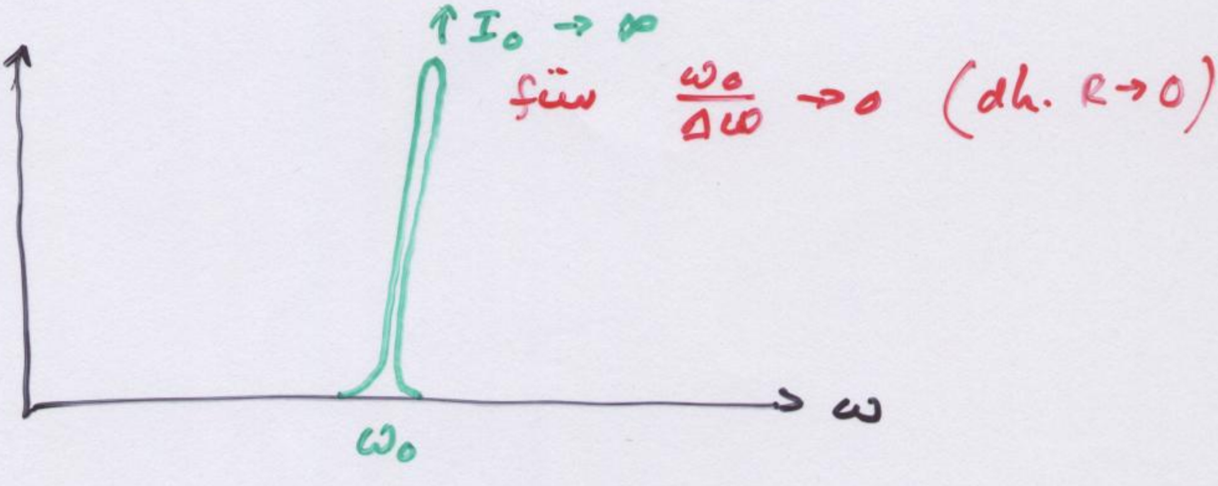
Impedanz: $\frac{u_0}{I_0} = |Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$



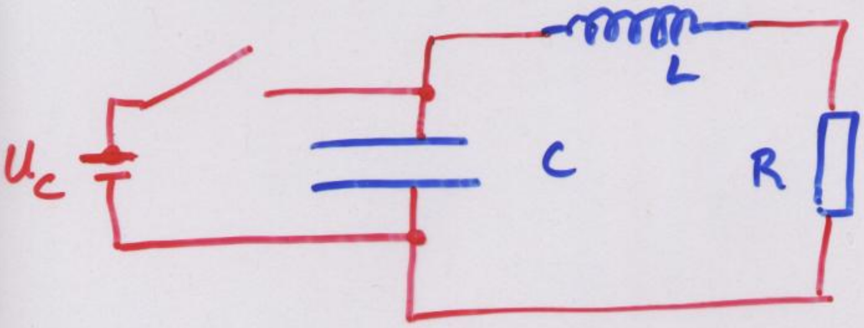
Strommaximum bei $\omega_0 L = \frac{1}{\omega_0 \cdot C}$

$\hat{=} \quad \omega_0 = \frac{1}{\sqrt{LC}}$ Resonanzfrequenz

Kreisgüte : $Q = \frac{\omega_0}{\Delta\omega}$



8. Serienschwingkreis

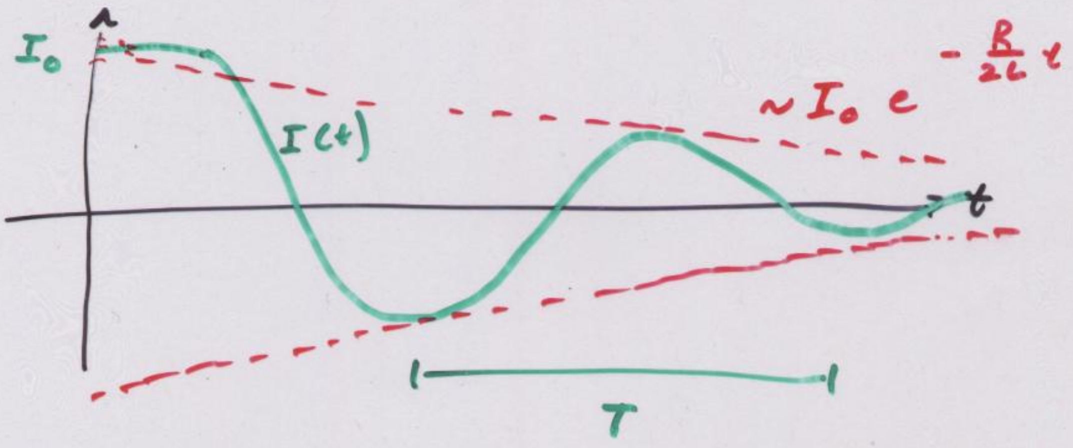


$$U_C + U_R + „U_L" = 0$$

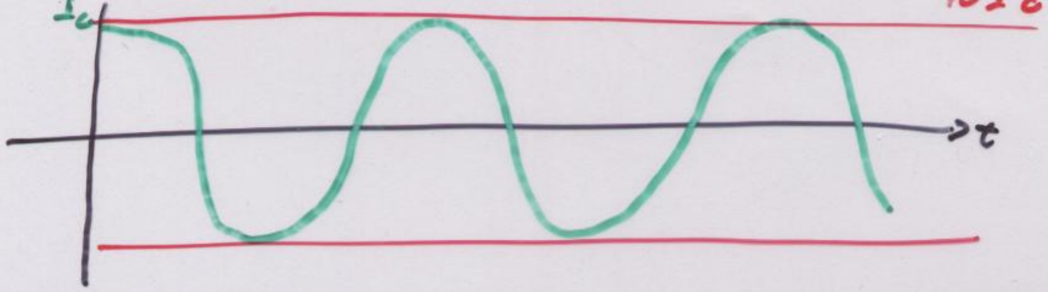
Bem.: U_L nicht definiert, siehe Einschub

$$\Rightarrow \frac{Q}{C} + R \cdot I + L \cdot \dot{I} = 0$$

$$I(t) = I_0 \cdot e^{-\frac{R}{2L} t} \cdot \cos \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}\, t$$

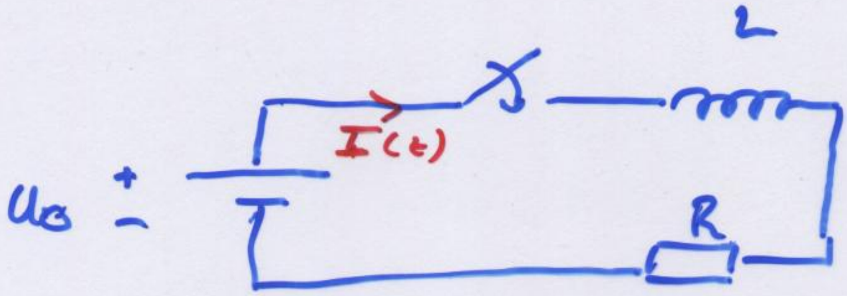


Sonderfall: $R \to 0$:



Einschub

Schaltkreis mit induktiven Komponenten



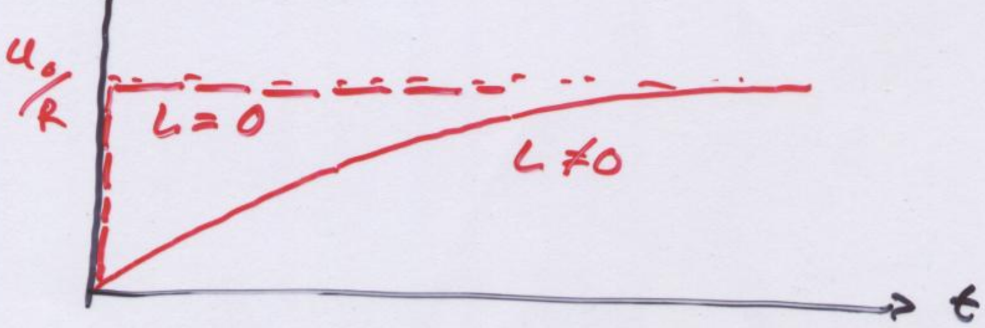
Kirchhoff: $\sum U_i = 0$ $\left(\oint \vec{E}(\vec{r})\, d\vec{s} = 0 \right)$

gilt nicht für Schaltkreise mit $L \neq 0$

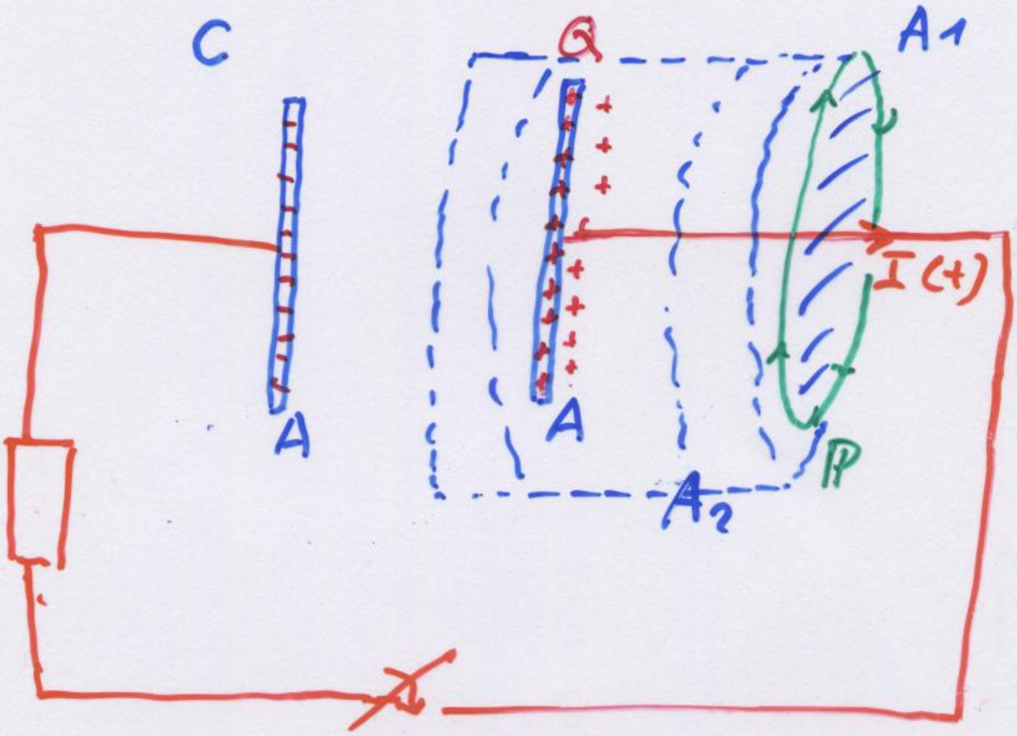
Faraday: $$\oint \vec{E}\, d\vec{s} = -\frac{d\phi_B}{dt}$$

$$U_0 - R \cdot I(t) - L \frac{dI}{dt} = 0$$

$$\Rightarrow \quad I(t) = \frac{U_0}{R} \cdot \left(1 - e^{-R/L\, t}\right)$$



5.3 Maxwellscher Verschiebungsstrom



Ampere'sches Gesetz:

$$\oint_{P} \vec{B}\, d\vec{s} = \mu_0 \cdot I$$

$$\hat{=} \quad \int_{A_1} \nabla \times \vec{B}\, d\vec{A} = \mu_0 \int_{A_1} \vec{j}\, d\vec{A} \quad \text{(stokes)}$$

Fläche: A_1: $\mu_0 \int_{A_1} \vec{j}\, d\vec{A} = I$

A_2: $\mu_0 \int_{A_2} \vec{j}\, d\vec{A} = 0$

↯

Zwischen den Kondensatorplatten:

zeitl. veränderliches $\vec{E}$ - Feld

$$\frac{dQ}{dt} = \frac{d}{dt}\left(\varepsilon_0 \cdot \vec{A}\,\vec{E}\right) = \varepsilon_0 \cdot \vec{A} \cdot \frac{\partial \vec{E}}{\partial t}$$

$(Q = C \cdot U = C \cdot E \cdot d)$ $\quad (\vec{E} = \vec{E}(\vec{r}, t))$

$$= I_v$$

$$\vec{j}_v = \varepsilon_0 \frac{\partial \vec{E}}{\partial t}$$

$$\Rightarrow \int_R \vec{B}\, d\vec{s} = \mu_0 \int_A (\vec{j} + \vec{j}_v)\, d\vec{A}$$

$$\Rightarrow \nabla \times \vec{B} = \mu_0 \vec{j} + \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t}$$

Betrachten Divergenzen der Gesamtstromdichte:

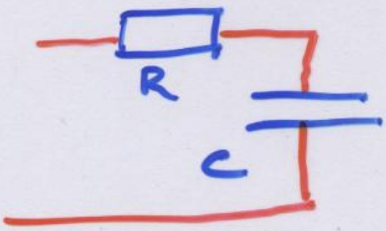
$$\mu_0 \nabla \vec{j} + \mu_0 \varepsilon_0 \frac{\partial}{\partial t} \nabla \vec{E} = 0$$

$$(\vec{\nabla}(\operatorname{rot} \vec{B}) = 0)$$

Kontinuitätsgleichung: $\nabla \vec{j} + \frac{\partial}{\partial t} \rho = 0$

5.4. Energie des elektrischen und des magnetischen Feldes

Erinnerung:



Aufladung von C

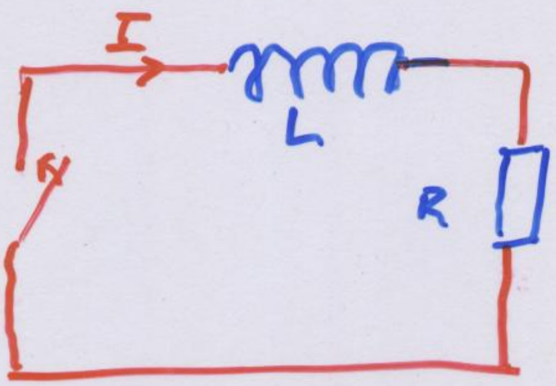
$$dW = dQ \cdot U$$
$$= dQ \cdot \frac{Q}{C}$$
$$W = \frac{1}{C} \int Q \, dQ$$
$$= \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} C U^2$$

Beispiel Plattenkondensator:

$$W = \frac{1}{2} \frac{\varepsilon_0 A}{d} \cdot E^2 d^2$$
$$= \frac{1}{2} \varepsilon_0 E^2 \cdot \underbrace{V}_{\text{Volumen}}$$

Energiedichte $\quad w = \frac{W}{V} = \frac{1}{2} \varepsilon_0 E^2$

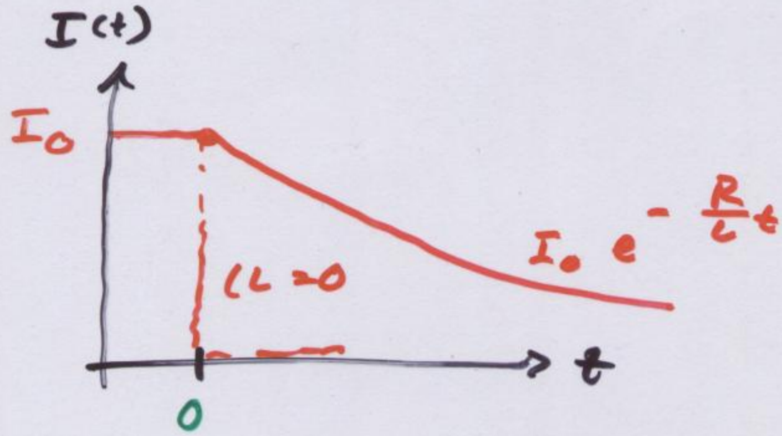
Analog für Magnetfelder:



$$W = \int_0^\infty I\, U\, dt = \int_0^\infty I^2 R\, dt$$

$$= \int_0^\infty R \cdot I_0^2 e^{-\frac{2R}{L}t}\, dt$$

$$= \frac{1}{2} L I_0^2$$



Spule: $W = \frac{1}{2}\mu_0 n^2 A l \cdot \left(\frac{B}{\mu_0 n}\right)^2$

$$= \frac{1}{2\mu_0} B^2 \cdot V$$

$\Rightarrow$ Energiedichte: $w = \frac{1}{2\mu_0} B^2$