Magnetisme

- **Magnetostatikk** (ingen tidsvariasjon):
- Kap 27. Magnetiske krefter
- Kap 28: Magnetiske kilder

- **Elektrodynamikk:**
- Kap 29: Elektromagnetisk induksjon
- Kap 30: Induktans
- Kap 31: Vekselstrømskretser
- Kap 32: Elektromagnetiske bølger

Kap 31: Vekselstrømskretser

31.1 Visere og kompleks notasjon

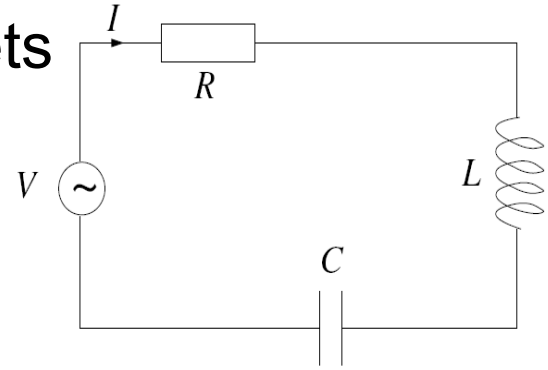
31.2 (Kompleks) reaktans

31.3 *RLC*-krets

31.5 Resonans (i *RLC*-krets).

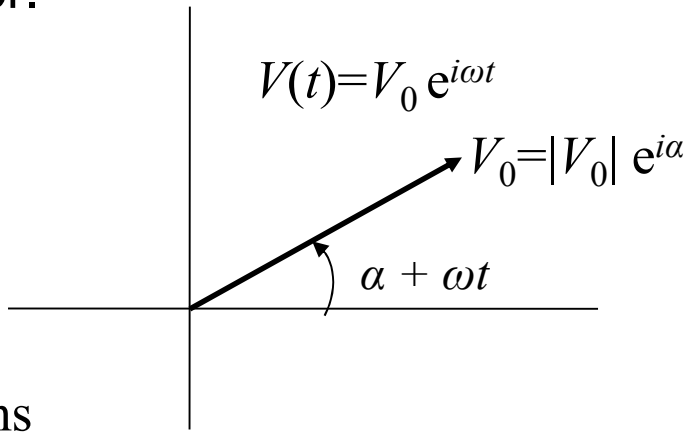
Kretslover for AC-signal

med eksempel i *RLC*-seriekrets



Regler:

1. $V(t) = V_0\, e^{i\omega t}$ (1)
   $I(t) = I_0\, e^{i\omega t}$ (2) osv. $V_R(t)$, $V_L(t)$, $V_C(t)$
   med lik frekvens ω og komplekse amplituder.



2. Resistans: $V_R = Z_R\, I = R\ \ I$ (6)
   $Z_R = R$ = resistans = resistiv impedans

3. Induktans: $V_L = Z_L\, I = i\omega L\ \ I$ (7)
   $Z_L = i\omega L$ = induktiv impedans, L = induktans

4. Kapasitans: $V_C = Z_C\, I = 1/i\omega C\ \ I$ (8)
   $Z_C = 1/i\omega C$ = kapasitiv impedans, C = kapasitans

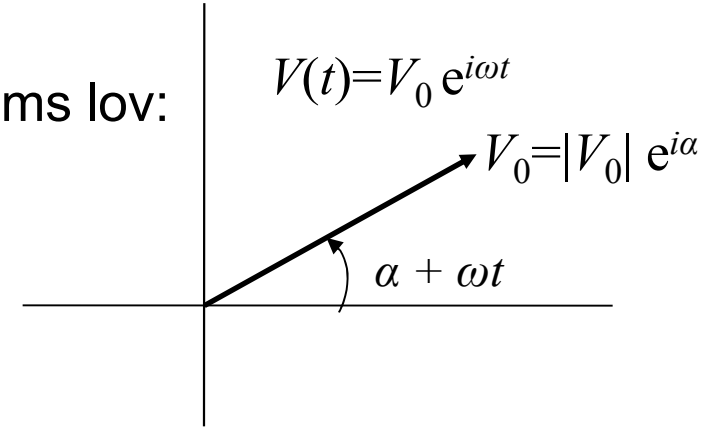
5. Kirchhoffs lover som vanlig.

OBS:
$d/dt\,(e^{i\omega t}) = i\omega\, e^{i\omega t}$

$1/i = -i$

Kompleks impedans med AC-signal

1. $V(t) = V_0 \, e^{i\omega t}$ og $I(t) = I_0 \, e^{i\omega t}$
   med lik frekvens ω og komplekse amplituder V_0 og I_0 gir en utvidet Ohms lov:
2. Resistans: $V_R = Z_R \, I = R \;\; I$
3. Induktans: $V_L = Z_L \, I = i\omega L \;\; I$
4. Kapasitans: $V_C = Z_C \, I = 1/i\omega C \;\; I$

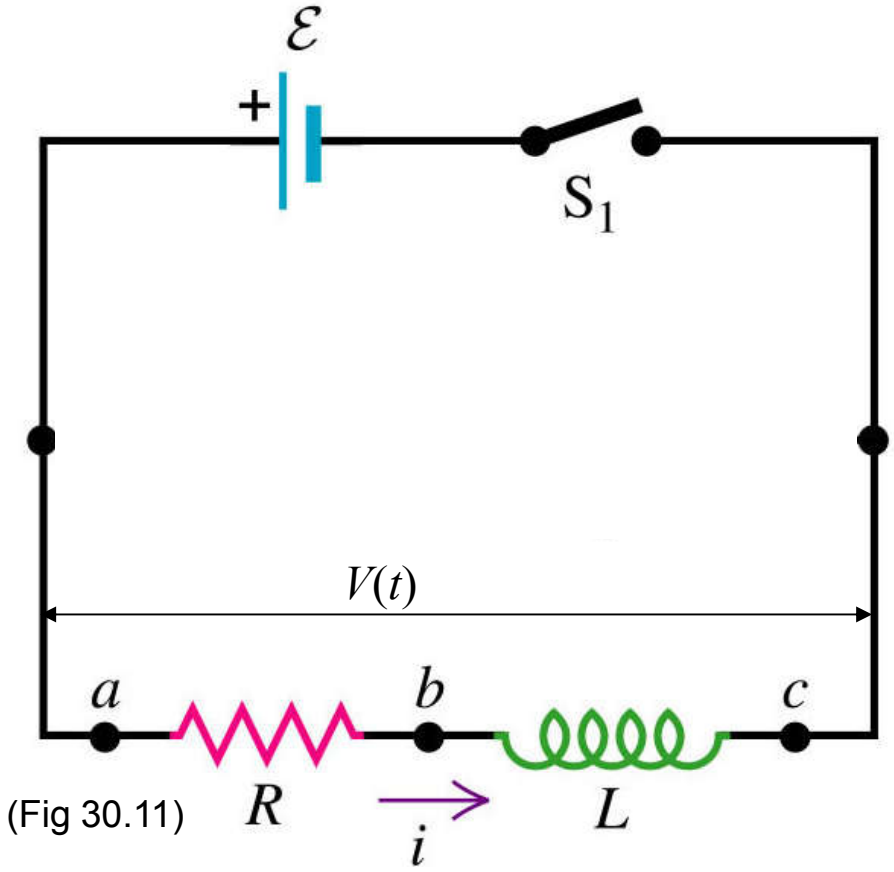


- Seriekopling: $Z = Z_1 + Z_2$
- Parallellkopling: $1/Z = 1/Z_1 + 1/Z_2$

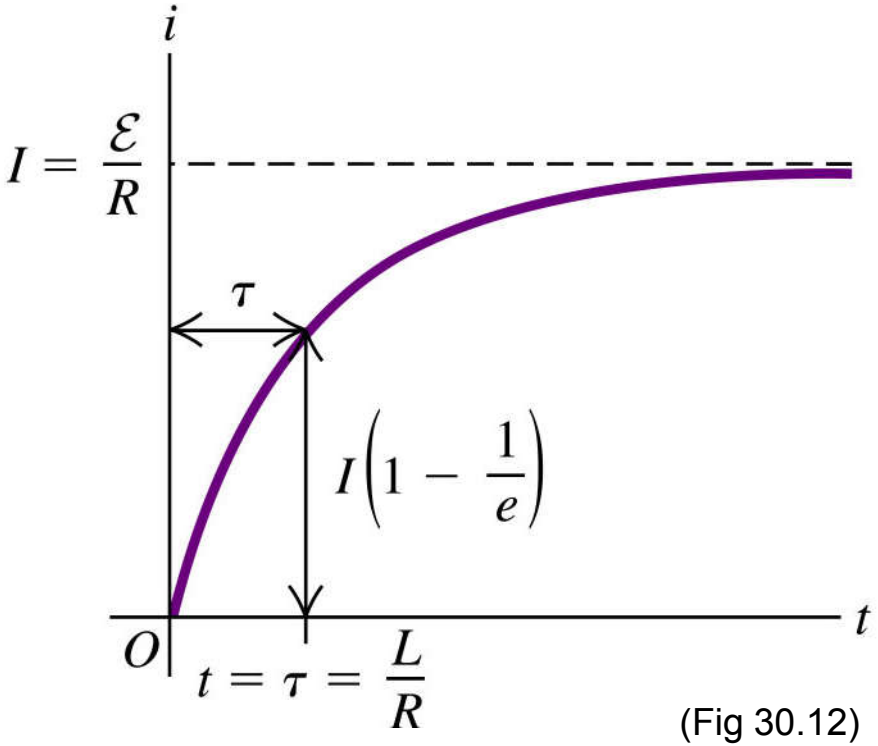
- Alle kretslover gjelder for AC når Z brukes:
  Kirchoff 1 (strømlov)
  Kirchoff 2 (spenningslov)
  Ohms lov

- **OBS:**
  Z gjelder kun AC (harmonisk variasjon), ikke andre periodiske signal som f.eks. firkantpuls.

Eks: *RL*-krets



(Fig 30.11)



(Fig 30.12)

$$V(t) = R\,I(t) + L\,\mathrm{d}I(t)/\mathrm{d}t \qquad (30.12)$$

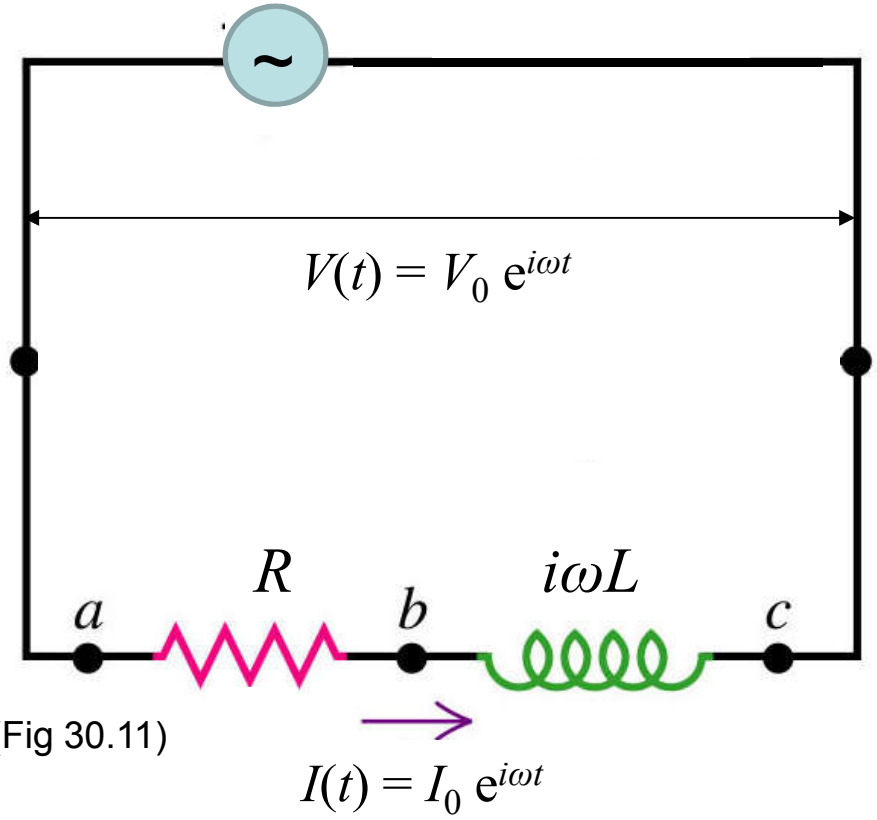
1) Lukke bryter S_1
2) Åpne bryter S_1

} Kap. 30.4

3) $\mathcal{E}$ = AC-spenning

} Nå (kap 31.2)

Detaljer for *RL*-krets



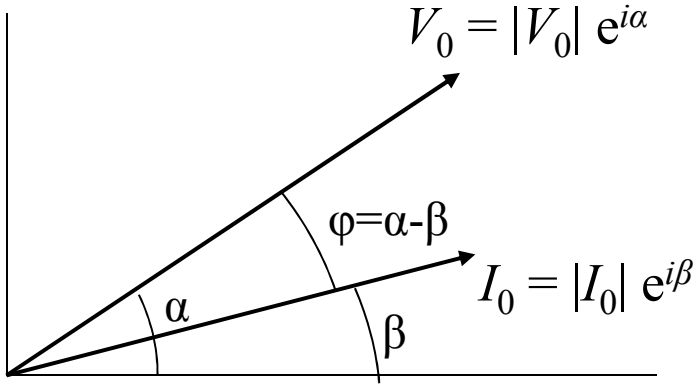
(Fig 30.11)

Ohms lov: $V(t) = Z\ I(t)$

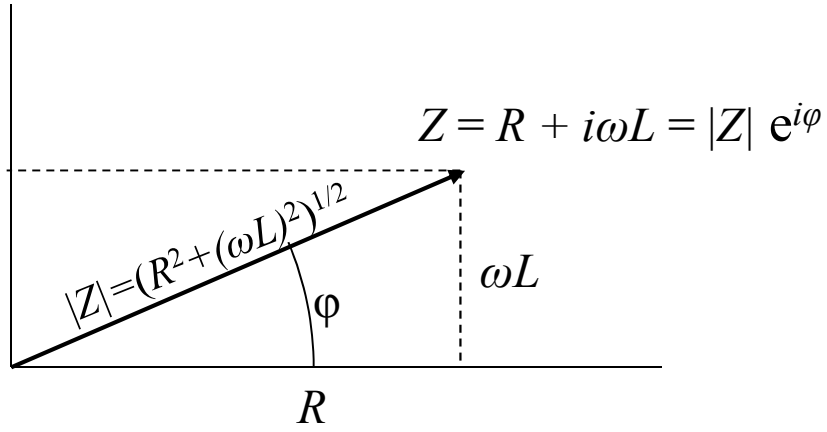
Impedans = $Z = R + i\omega L = |Z|\ e^{i\varphi}$

Med kompleks amplityde: $V_0 = Z\ I_0$,

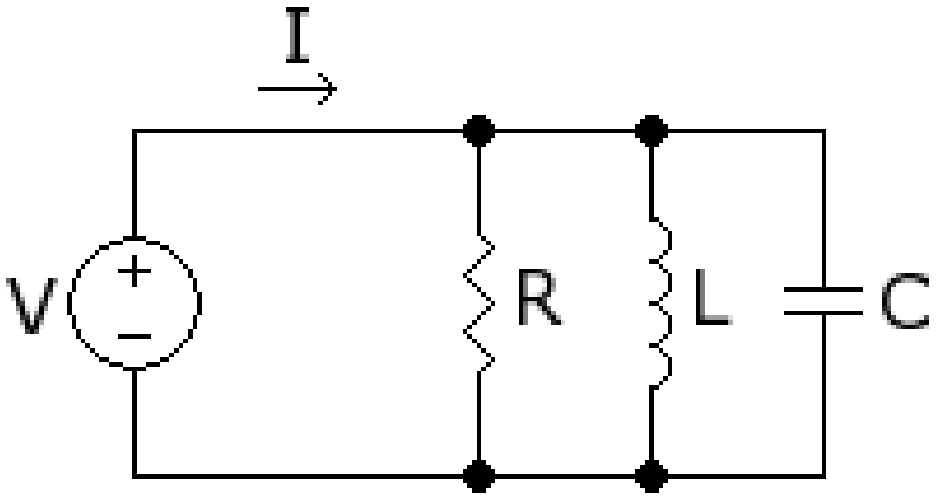
der:



Her:
velger
$\beta = 0$
=>
$\alpha = \varphi$



AC-spenning på *RLC*-parallellkrets



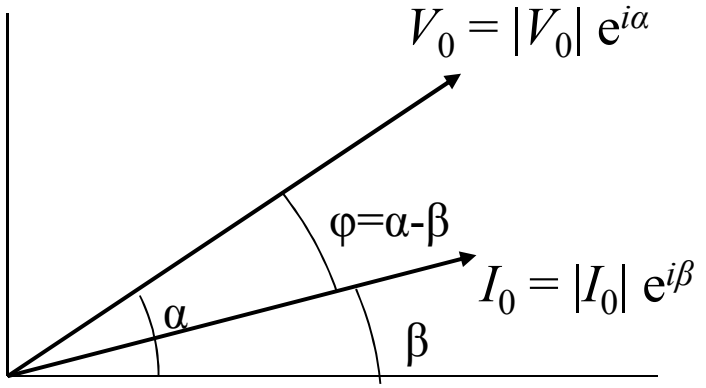
$$V(t) = V_0 \, e^{i\omega t} \qquad (1)$$
$$I(t) = I_0 \, e^{i\omega t} \qquad (2)$$

Kirchhoffs strømlov:

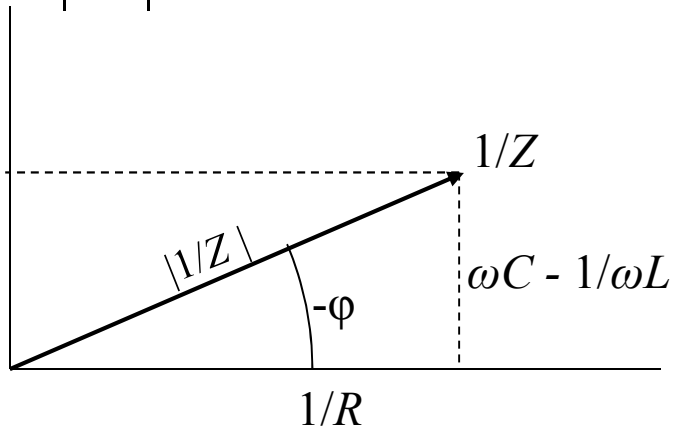
$$I(t) = I_R + I_L + I_C = V(t) / Z$$

bestemmer kretsens komplekse impedans Z:

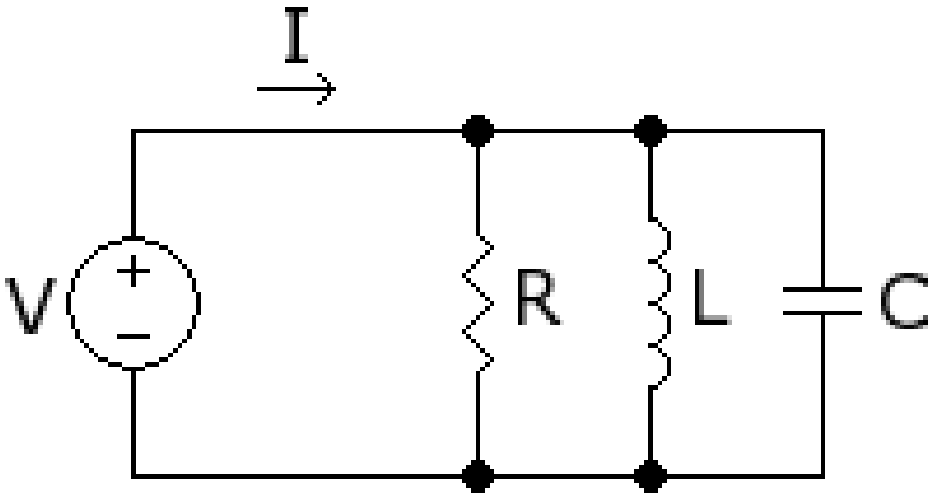
$$1/Z = 1/R + 1/i\omega L + i\omega C$$
$$= 1/R + i(\omega C - 1/\omega L)$$
$$= |1/Z| \, e^{-i\varphi}$$



Velger
α = 0
=>
β = - φ



AC-spenning på *RLC*-parallellkrets

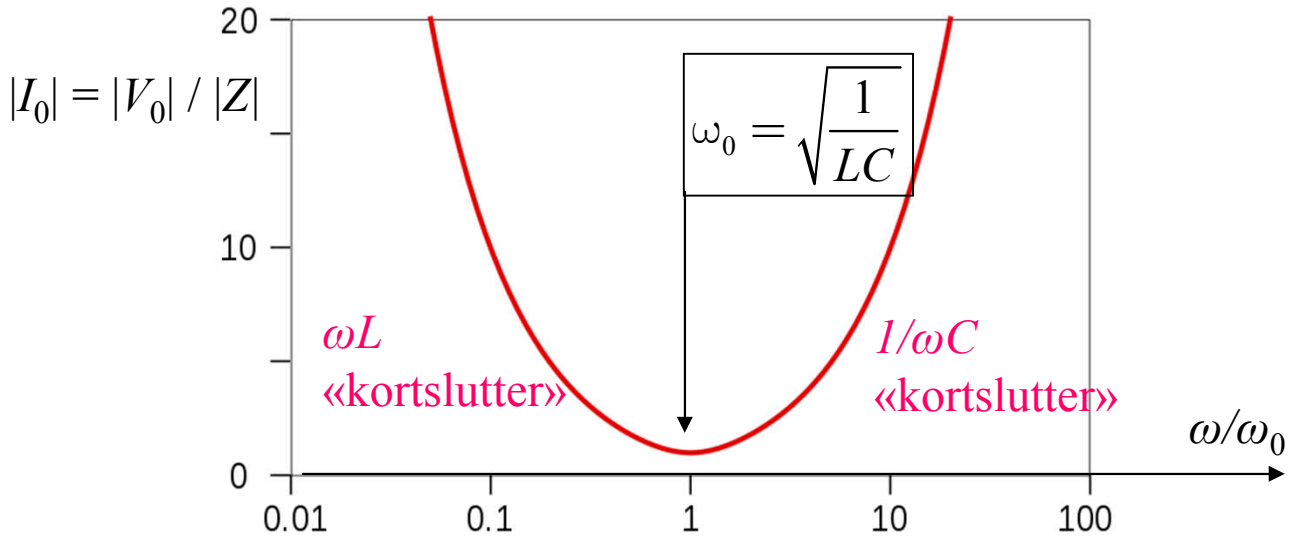


$$1/Z = 1/R + 1/i\omega L + i\omega C$$
$$= 1/R + i(\omega C - 1/\omega L)$$

$$I_0 = \frac{|V_0|e^{i0}}{|Z|e^{i\varphi}} = \frac{|V_0|}{|Z|}e^{-i\varphi} = |I_0|e^{i\beta}$$

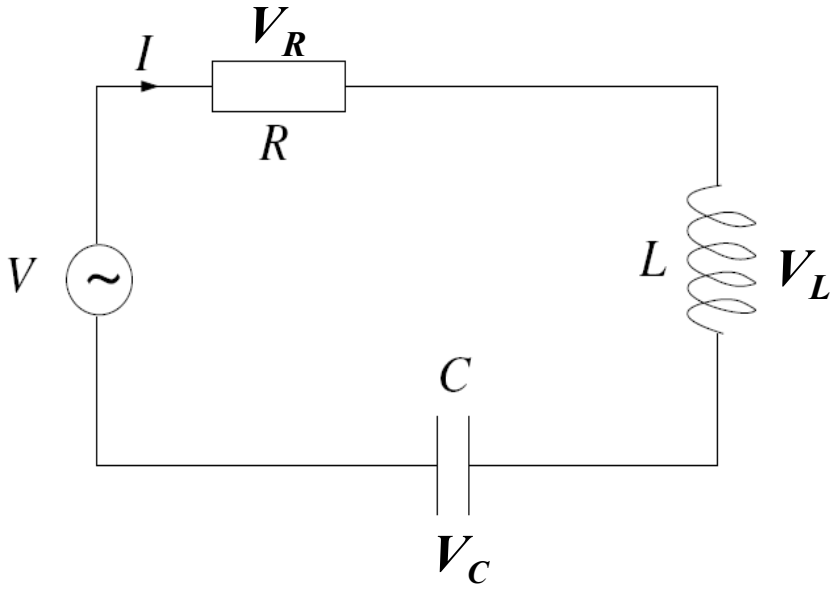
$$|I_0| = \left|\frac{1}{Z}\right||V_0| \qquad \beta = -\varphi$$

$|I_0|$ liten når $|1/Z|$ liten.



AC-spenning på *RLC*-seriekrets

Øving 13, oppgave 5



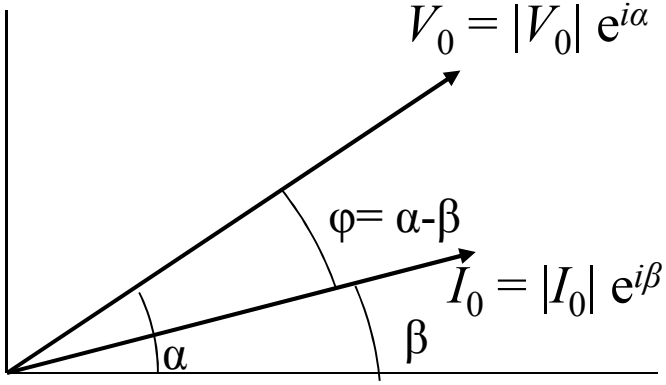
$$V(t) = V_0 \, e^{i\omega t} \qquad (1)$$
$$I(t) = I_0 \, e^{i\omega t} \qquad (2)$$

Ohm og Kirchhoff:

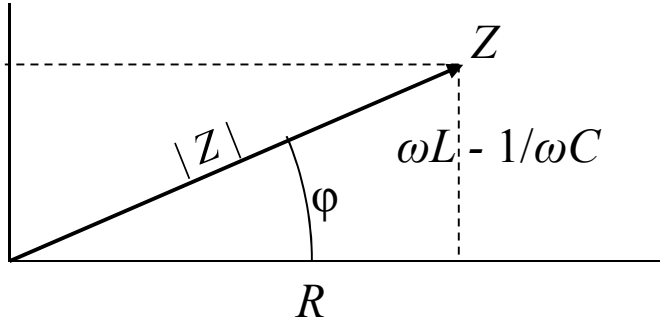
$$V_R = Z_R I = R \; I \qquad (6)$$
$$V_L = Z_L I = i\omega L \; I \qquad (7)$$
$$V_C = Z_C I = 1/i\omega C \; I \qquad (8)$$
$$V(t) = V_R + V_L + V_C = Z \, I(t) \qquad (9)$$

gir seriekretsens komplekse impedans:

$$Z = R + Z_L + Z_C$$
$$= R + i\omega L + 1/i\omega C$$
$$= R + i(\omega L - 1/\omega C) \qquad (10)$$
$$|Z| = (R^2 + (\omega L - 1/\omega C)^2)^{1/2}$$

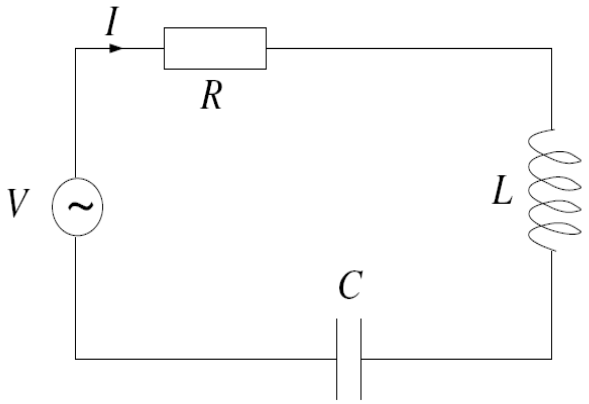


Velger
α = 0
=>
β = - φ



RLC-seriekrets

Øving 13, oppgave 5



Velger $\alpha = 0$, slik at $\beta = -\varphi$:

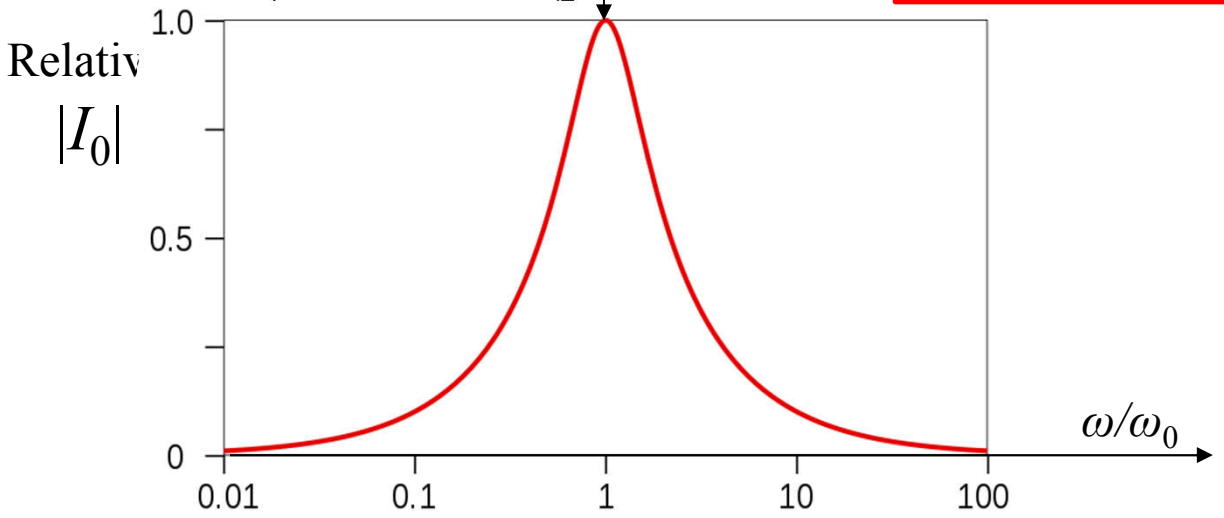
$$I_0 = \frac{|V_0|e^{i0}}{|Z|e^{i\varphi}} = \frac{|V_0|}{|Z|}e^{-i\varphi} = |I_0|e^{i\beta}$$

$$|I_0| = \frac{|V_0|}{|Z|} \qquad \beta = -\varphi$$

Svært stor strøm = RESONANS

$$\omega_0 = \sqrt{\frac{1}{LC}}$$

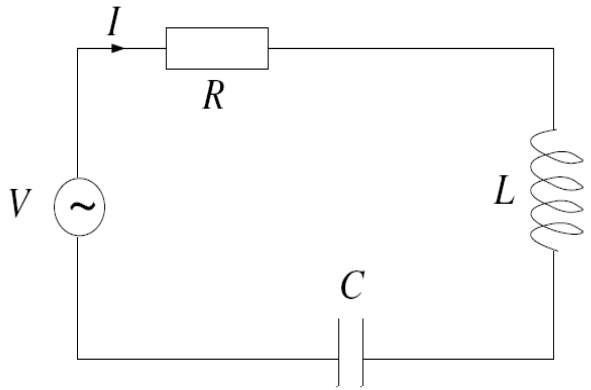
$|I_0|$ stor når $|Z|$ liten.



1/ωC dominerer

ωL dominerer

RLC-seriekrets



Kirchhoffs spenningslov:

$$V(t) = V_R + V_L + V_C = Z\ I(t)$$

gir $Z = R + i\omega L + 1/i\omega C$

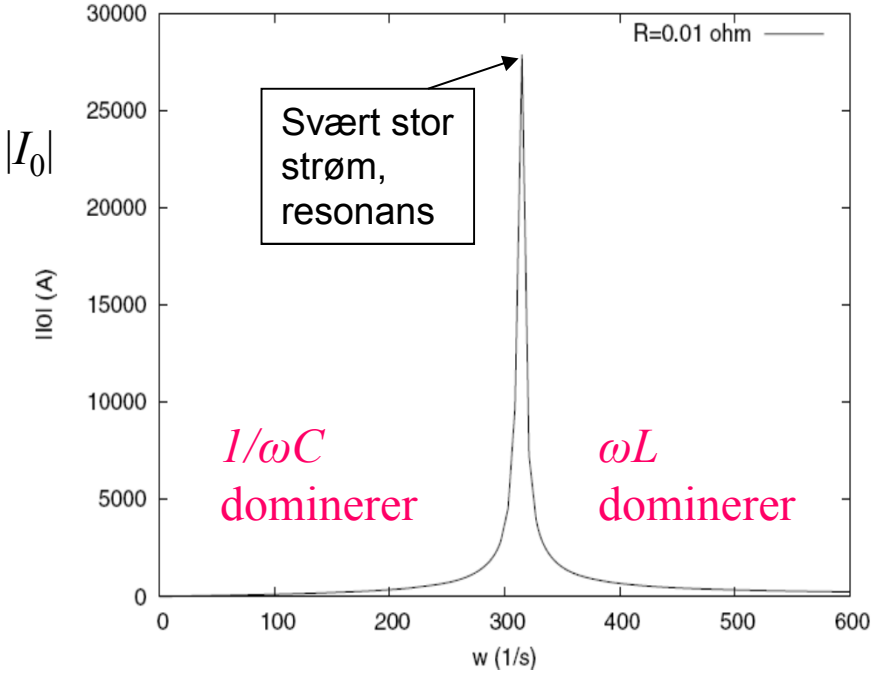
$$\Rightarrow |Z| = (R^2 + (\omega L - 1/\omega C)^2)^{1/2}$$

$$|I_0| = \frac{|V_0|}{|Z|} \qquad \beta = -\varphi$$

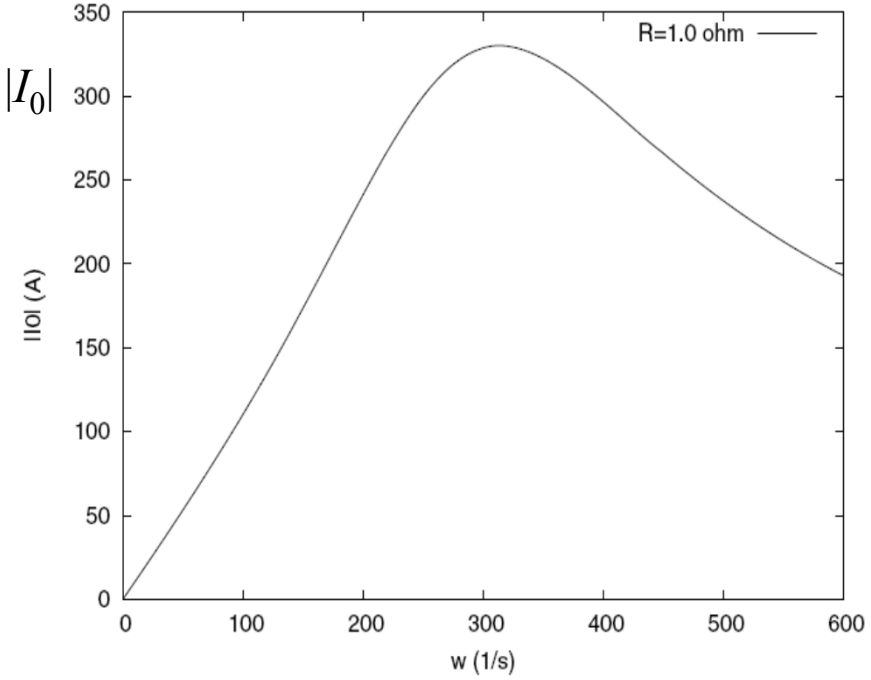
Øving 13, oppgave 5

$|I_0|$ stor når $|Z|$ liten.
Toppen smal når R er liten

Med $R = 1/100\ \Omega$:

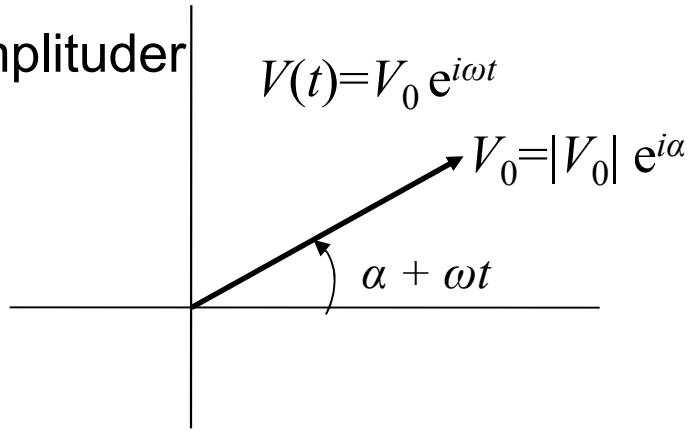


Med $R = 1\ \Omega$:



Kompleks impedans med AC-signal

1. $V(t) = V_0 \, e^{i\omega t}$ og $I(t) = I_0 \, e^{i\omega t}$
   med lik frekvens ω og komplekse amplituder V_0 og I_0 gir en utvidet Ohms lov:
2. Resistans: $V_R = Z_R \, I = R \;\; I$
3. Induktans: $V_L = Z_L \, I = i\omega L \;\; I$
4. Kapasitans: $V_C = Z_C \, I = 1/i\omega C \;\; I$



- Seriekopling: $Z = Z_1 + Z_2$
- Parallellkopling: $1/Z = 1/Z_1 + 1/Z_2$

- Alle kretslover gjelder for AC når Z brukes:
  Kirchoff 1 (strømlov)
  Kirchoff 2 (spenningslov)
  Ohms lov

- OBS:
  Z gjelder kun AC-signal, ikke andre periodiske signal eller ikke-periodiske signal.