Hoofdstuk 29:

Wisselstroom circuits

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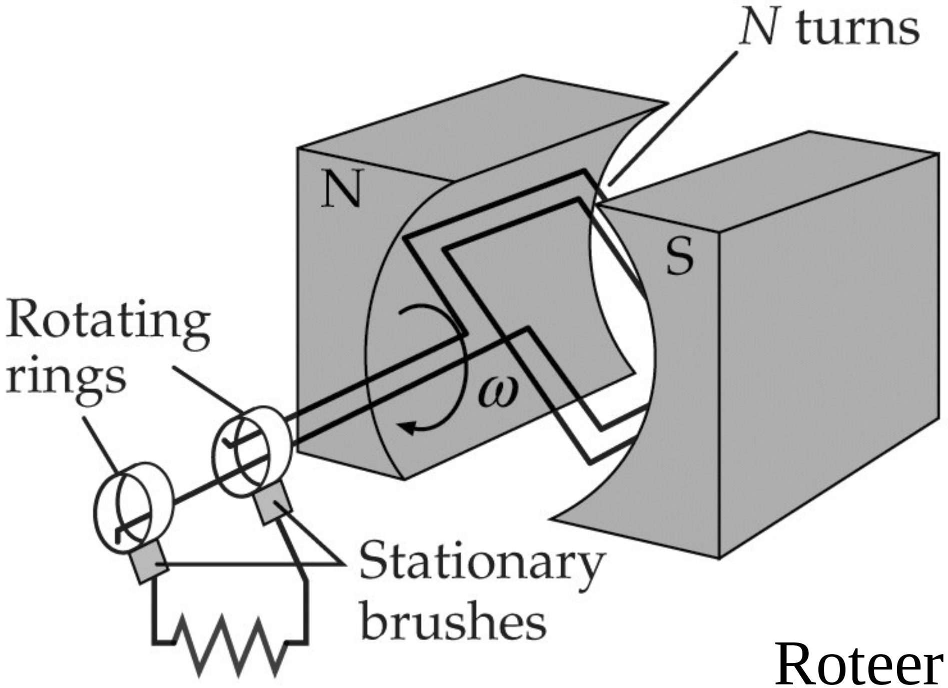
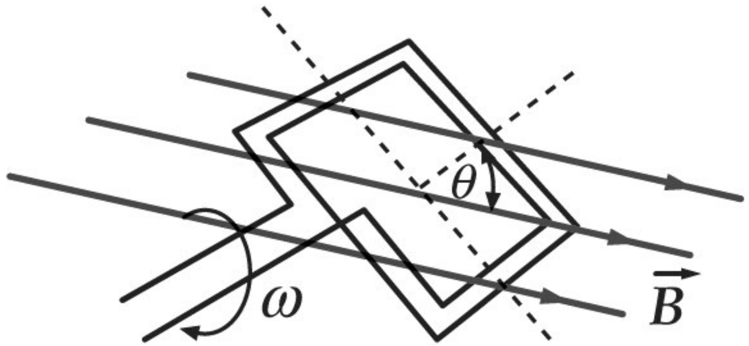
29-1 Wisselstroom Generatoren





Roteer de spoel met hoekfrequentie ω

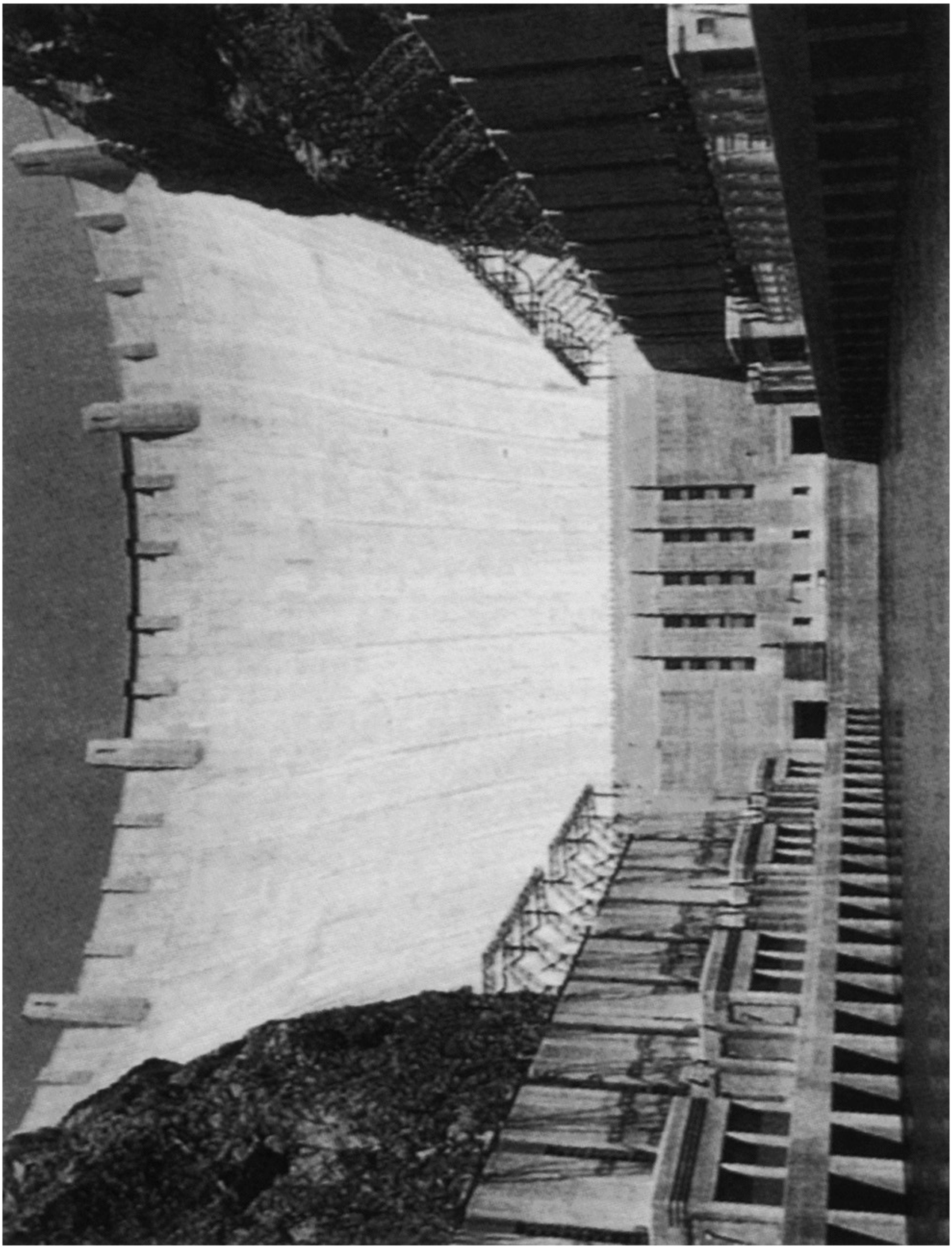
$$\phi_m = NBA\cos\theta \quad \longrightarrow \quad \theta = \omega t + \delta$$

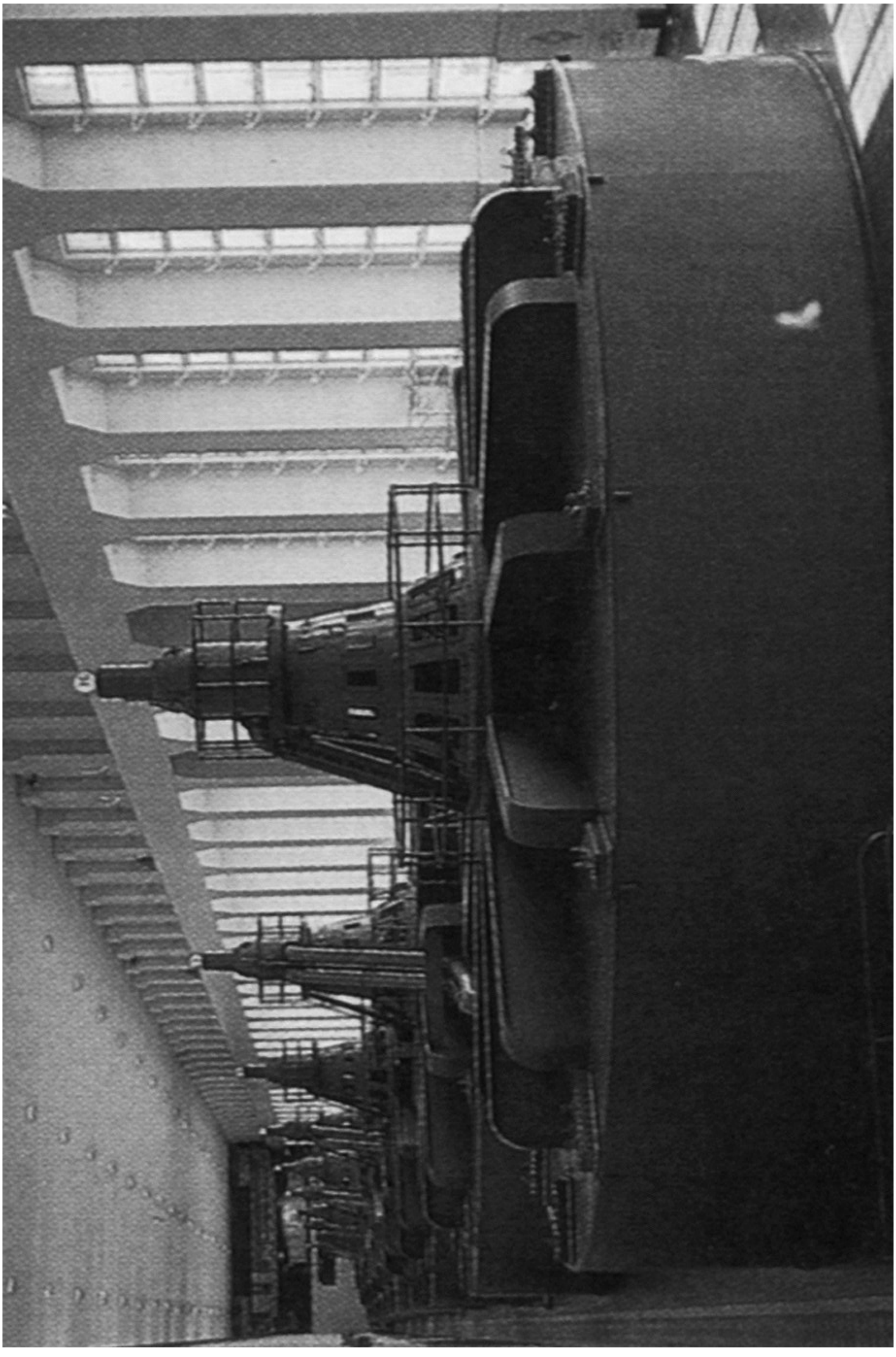
$$\phi_m = NBA\cos(\omega t + \delta) = NBA\cos(2\pi ft + \delta)$$

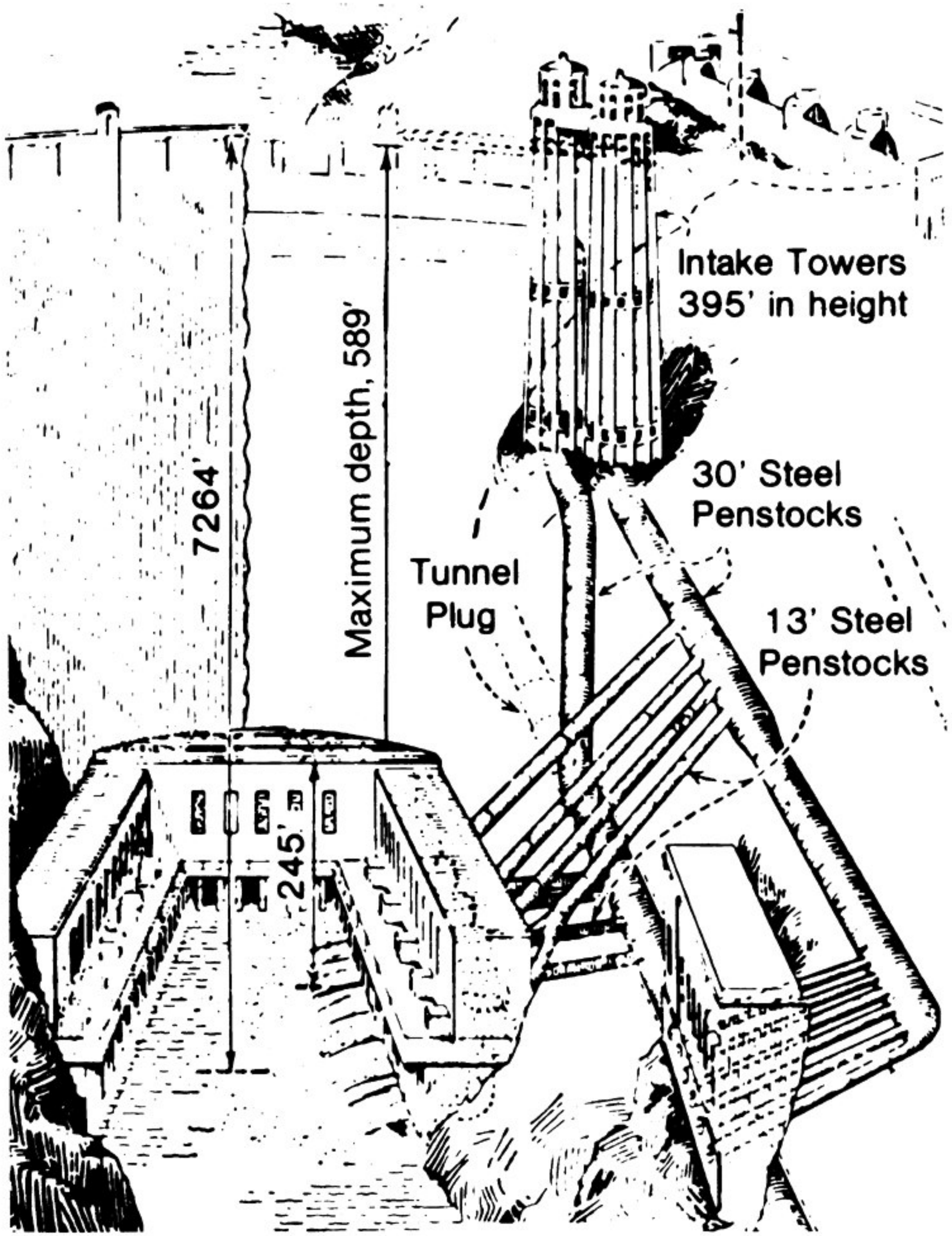
$$EMF = -\frac{d\phi_m}{dt} = -NBA\frac{d}{dt}\cos(\omega t + \delta) = +\underbrace{NBA\omega}_{V_{\text{peak}}}\sin(\omega t + \delta)$$

$$V = V_{peak}\sin(\omega t + \delta)$$

We kunnen ook V(t) aanbrengen → motor





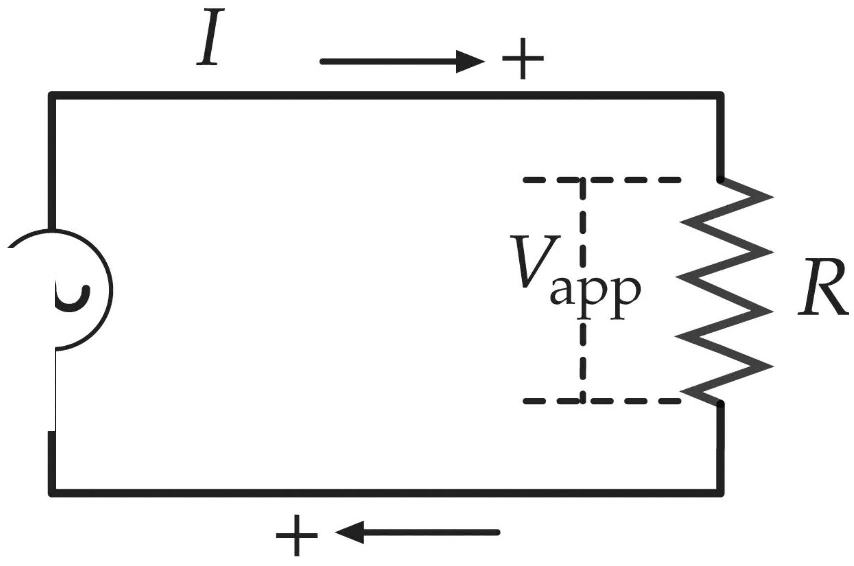


Intake Towers
395' in height
30' Steel
Penstocks
13' Steel
Penstocks
Tunnel
Plug
Maximum depth, 589'
7264'
245'

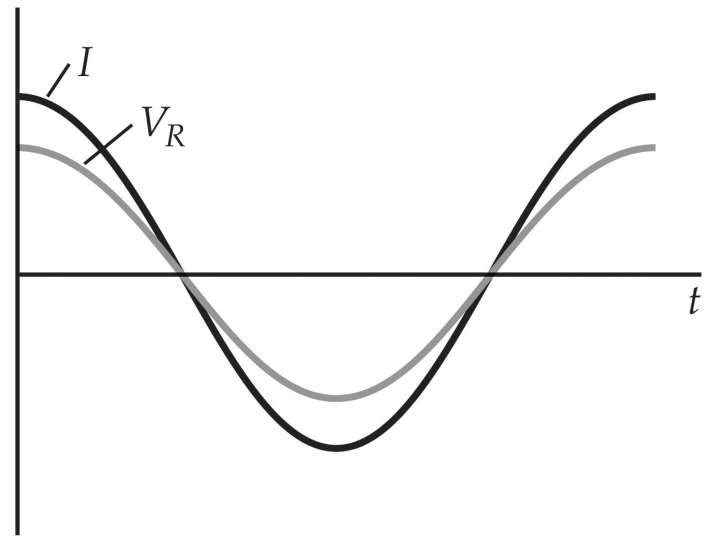
29-2 Wisselstroom in een weerstand

$$V_R = EMF = V_{R,peak}\sin(\omega t + \delta)$$

Kies $\delta = \pi/2$



Er geldt $V = IR$ en dus



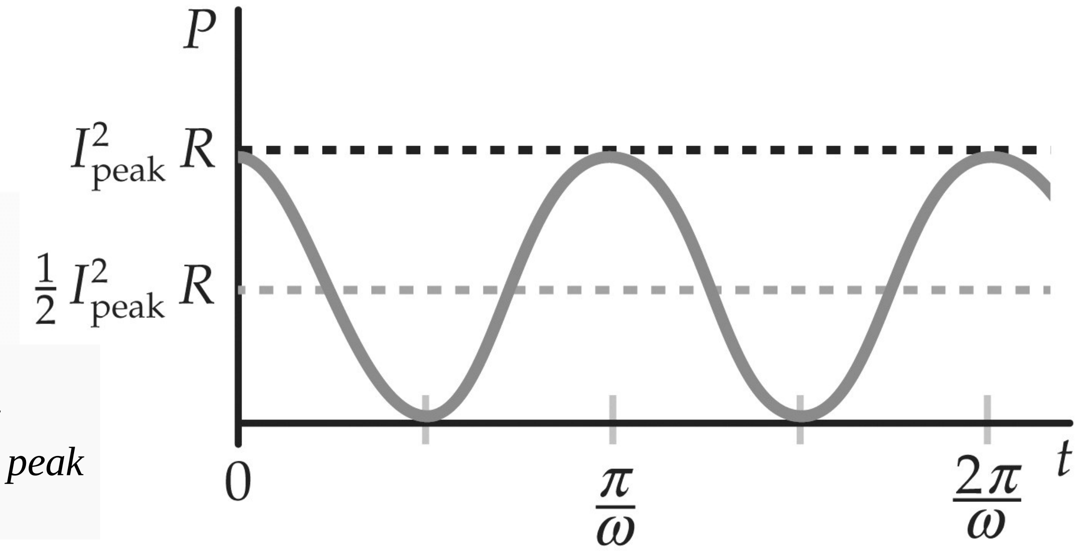
Vermogen:

RMS waarden

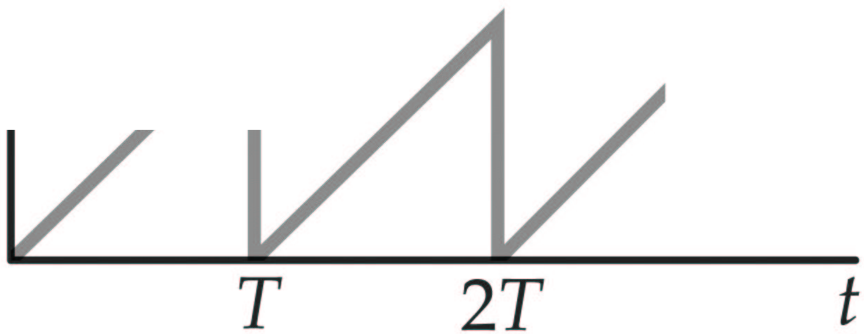
Definitie:

$$I_{\text{rms}} = \sqrt{(I^2)_{\text{av}}}$$

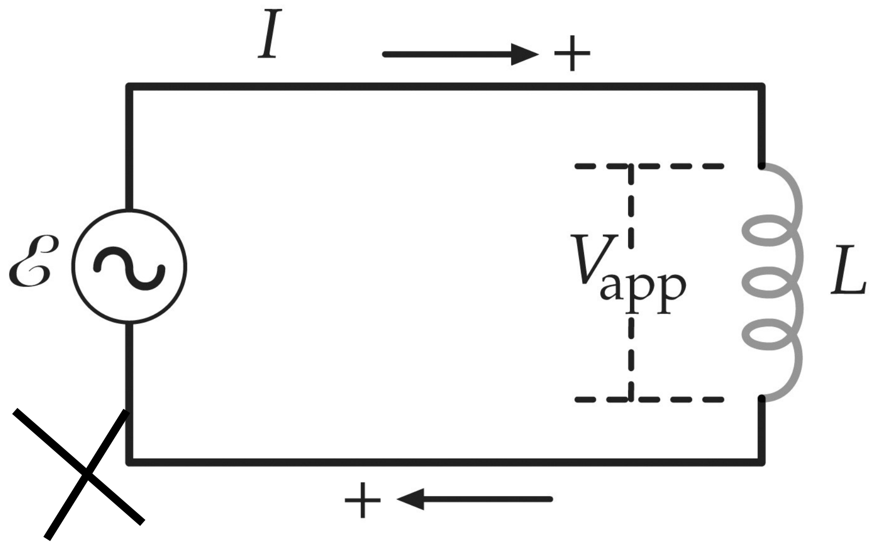
$$I_{rms} = \frac{1}{\sqrt{2}} I_{peak} \approx 0.707 I_{peak}$$



$$I_{rms} = \sqrt{(I^2)_{av}} = \frac{I_0}{\sqrt{3}}$$

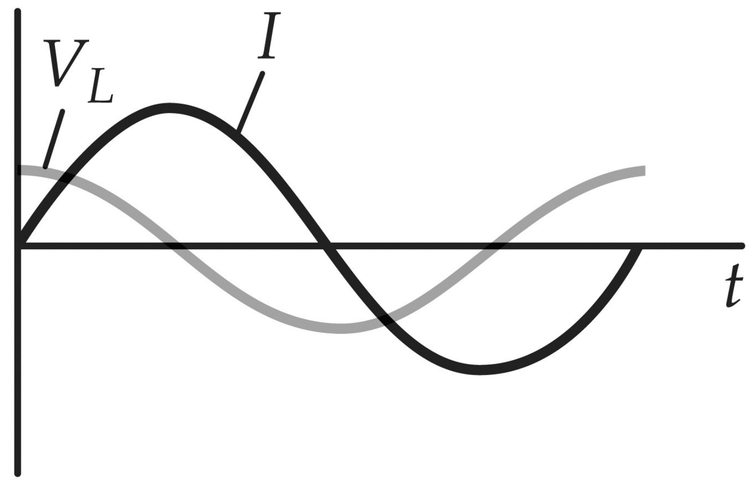


29-3 AC circuits



I_{peak}

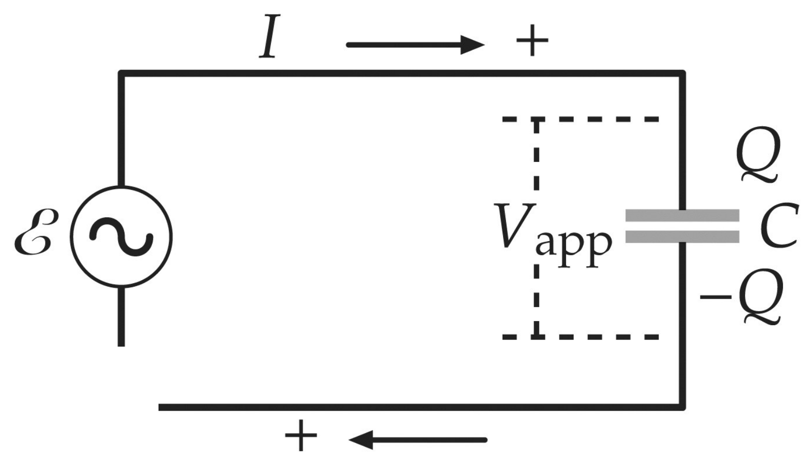
Stroom en spanning zijn 90º uit fase!



$$I_{peak} = \frac{V_{L,peak}}{\omega L} = \frac{V_{L,peak}}{X_L}$$

Inductieve reactantie

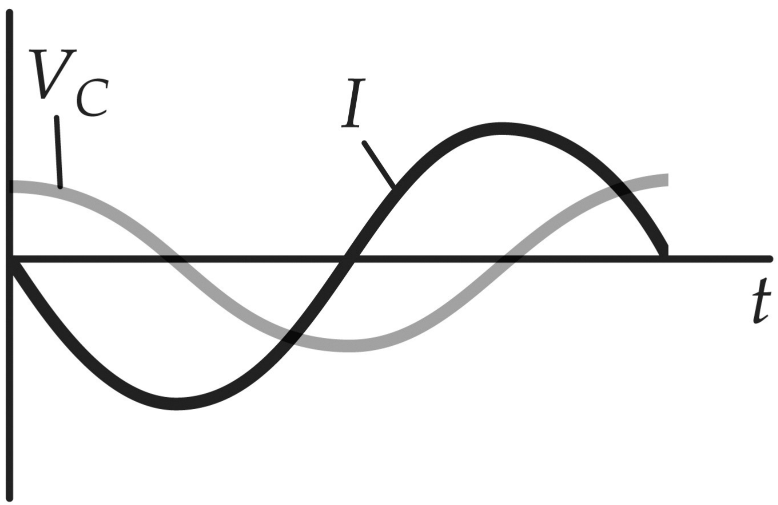
Capacitieve reactantie



Stroom en spanning zijn 90º uit fase!

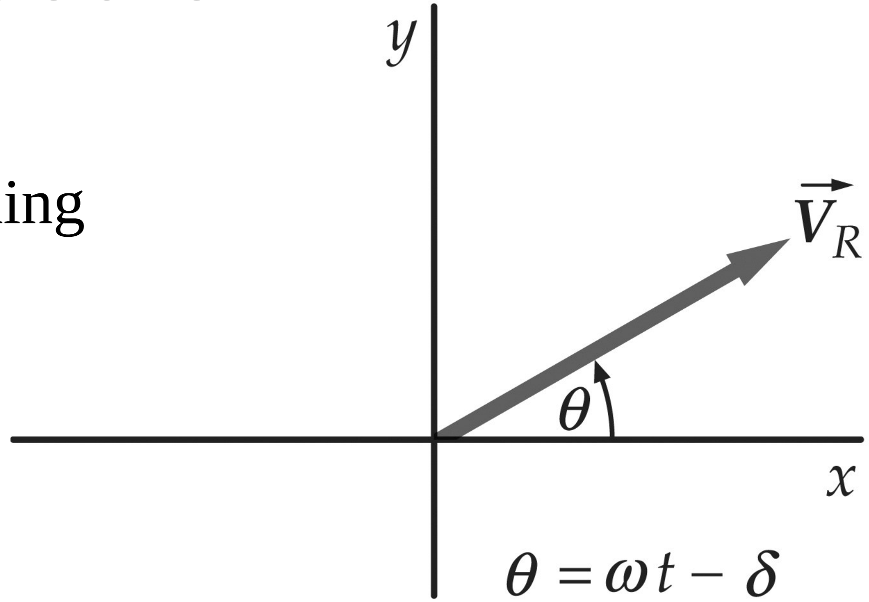
$$I_{peak} = \omega C V_{C,peak} = \frac{V_{C,peak}}{1/(\omega C)} = \frac{V_{C,peak}}{X_C}$$

Capacitieve reactantie



29.4 Phasors

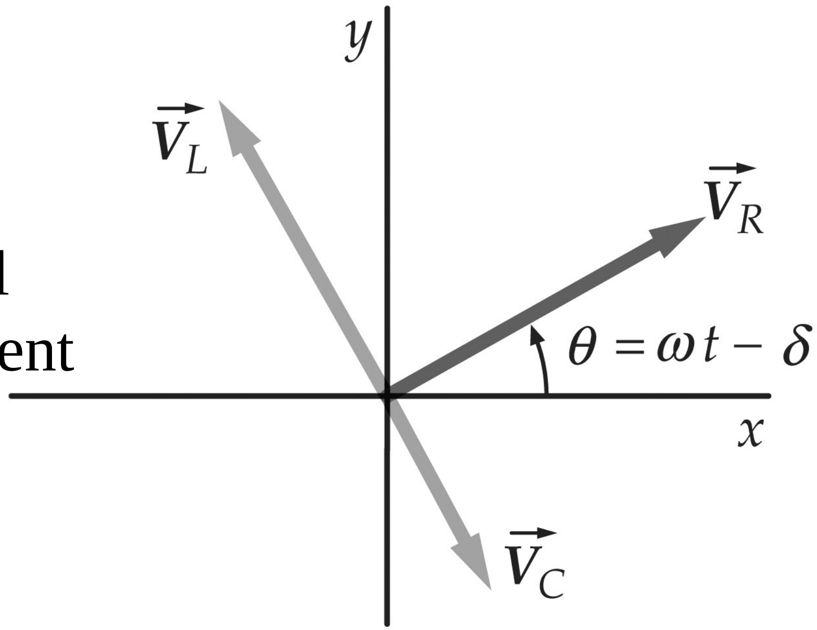
Phasor is een 2D vector, waarmee we de faserelaties tussen stroom en spanning kunnen representeren



Spanningsval over een weerstand

RLC serieschakeling:

De vectoren roteren tegen de klok in met hoekfrequentie ω. De spanningsval op elk tijdstip wordt door de *x*-component van de bijbehorende phasor gegeven.

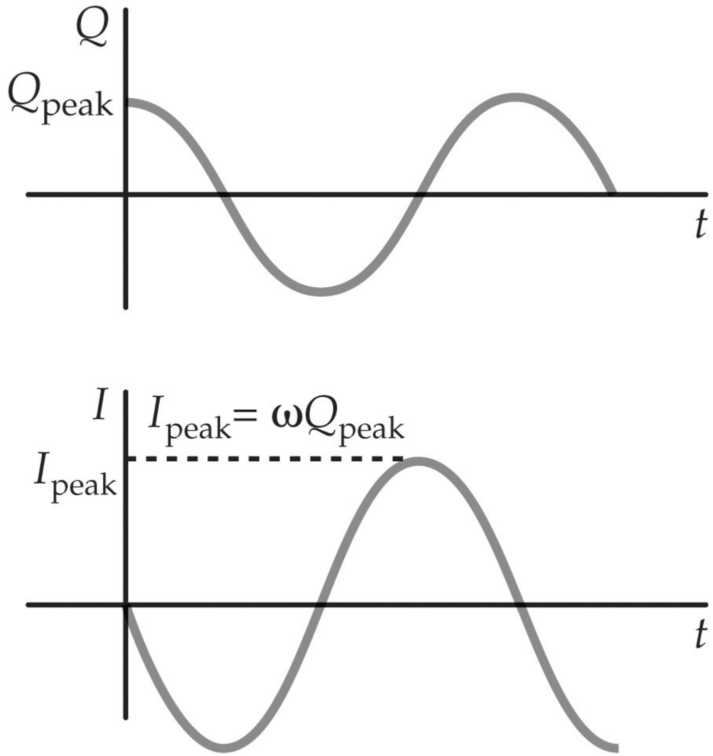


ELI the ICE man

29-5 *LC* circuit zonder een generator

Na sluiten van de schakelaar:

L



Regel van Kirchhoff levert

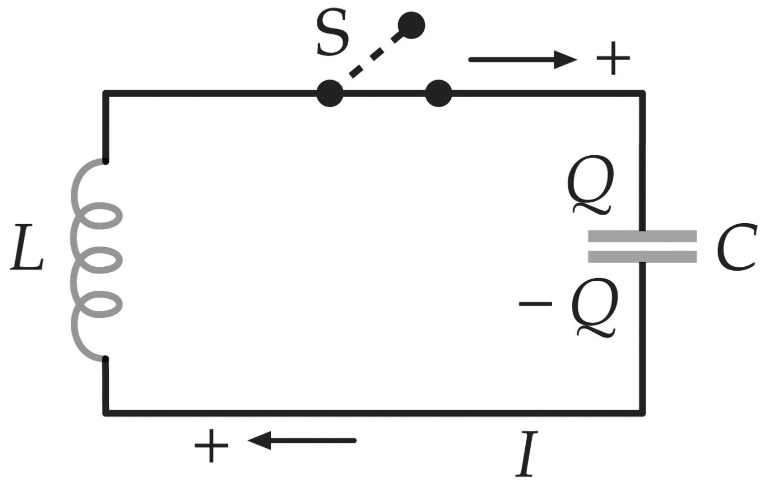
Dit heeft als oplossing

De stroom is dan

We kiezen $Q=Q_{peak}$ en $I=0$ voor $t=0$. Dan is $\delta=0$ en $A=Q_{peak}$

Dan geldt en

LC circuit en energie



Energie in condensator

Energie in spoel

Energie oscilleert tussen magnetische en elektrostatische energie

Totale energie

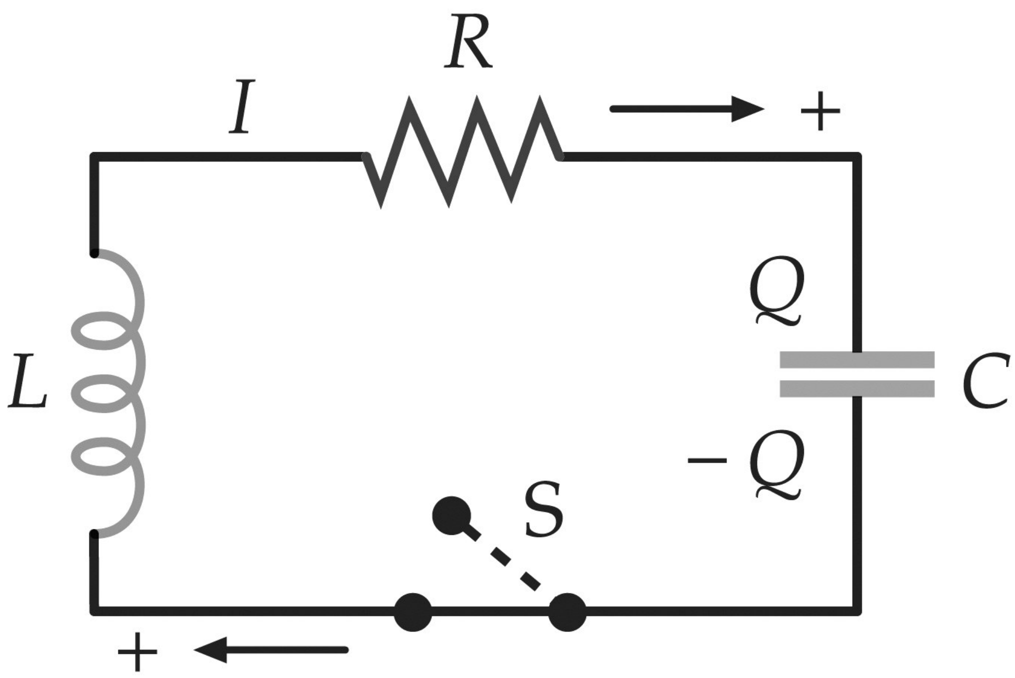
$$\boxed{U = U_e + U_m = \frac{1}{2}\frac{Q_{peak}^2}{C}\cos^2 \omega t + \frac{1}{2}\frac{Q_{peak}^2}{C}\sin^2 \omega t = \frac{1}{2}\frac{Q_{peak}^2}{C}}$$

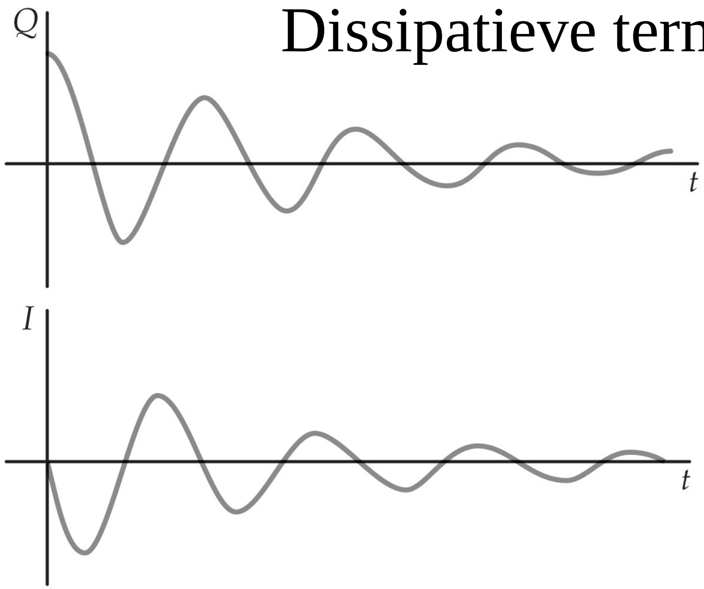
RLC circuits zonder een generator

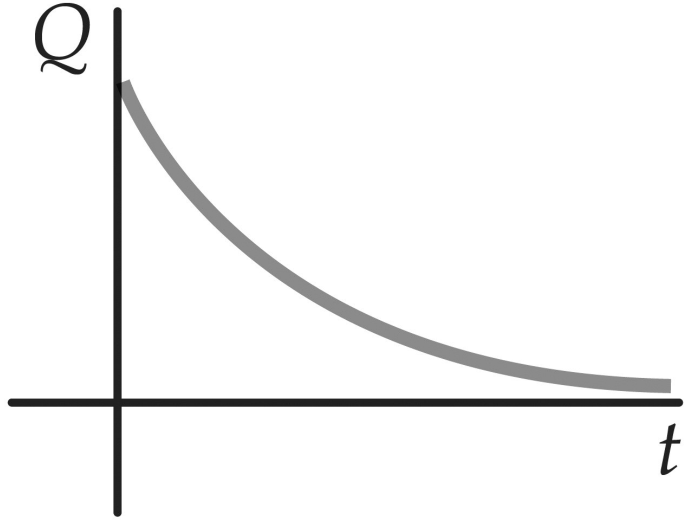
Kirchhoff levert

ook

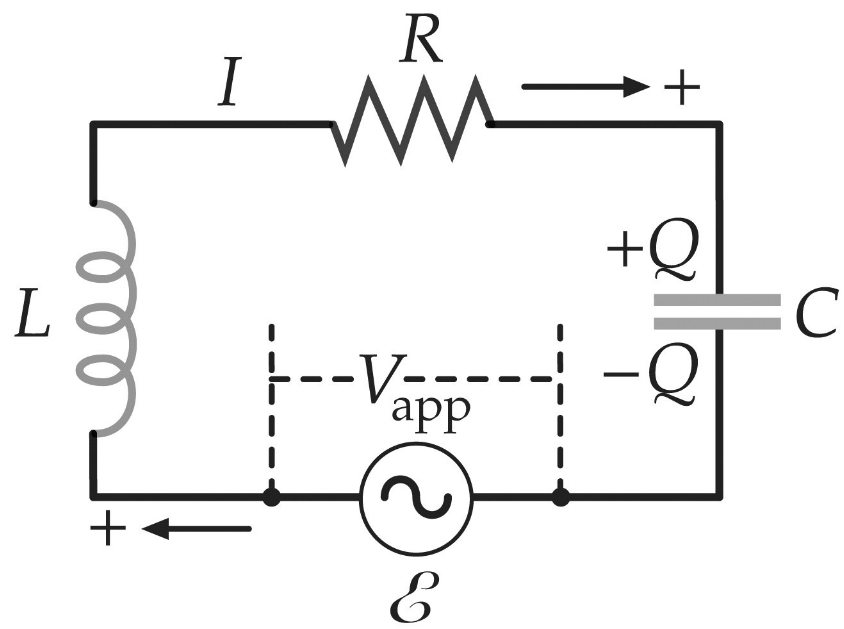
Als *R* klein,
Dissipatieve term







29.6 *RLC* circuits met een generator



Generator levert

Kirchhoff

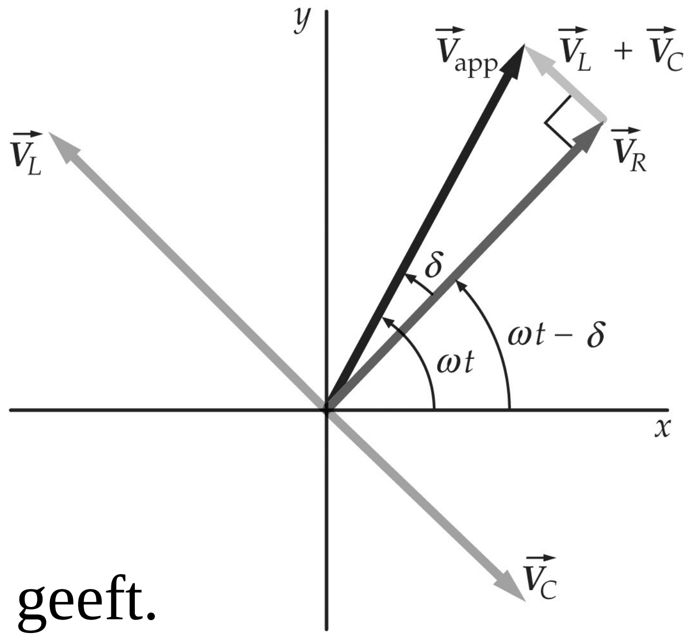
Herschrijven levert

De stroom na inschakeleffecten kan geschreven worden als

met fasehoek

en

impedantie totale reactantie



We kunnen dit ook met phasors vinden, waarbij de *x*-component van elke vector het spanningsverschil over de component geeft.

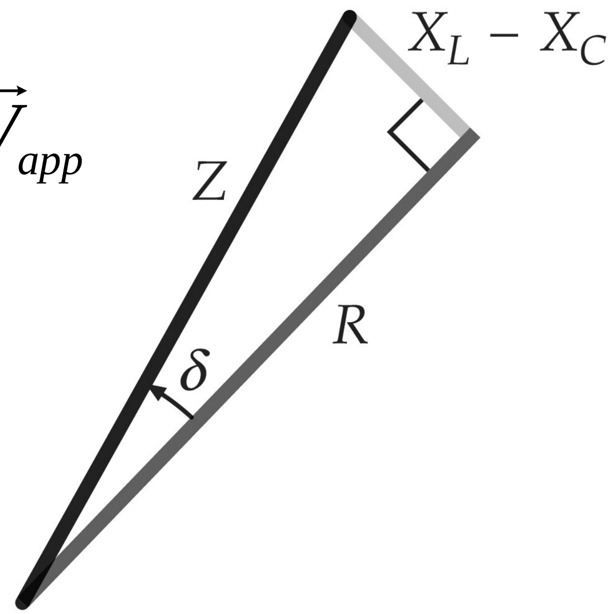
In ons voorbeeld is V_{L} groter dan V_{C}

Spanning door phasor $\vec{V}_{app}$

We hebben $\vec{V}_{app} = \vec{V}_R + \vec{V}_L + \vec{V}_C$

Grootte

$$V_{app,peak} = \left|\vec{V}_R + \vec{V}_L + \vec{V}_C\right| = \sqrt{V_{R,peak}^2 + \left(V_{L,peak} - V_{C,peak}\right)^2}$$

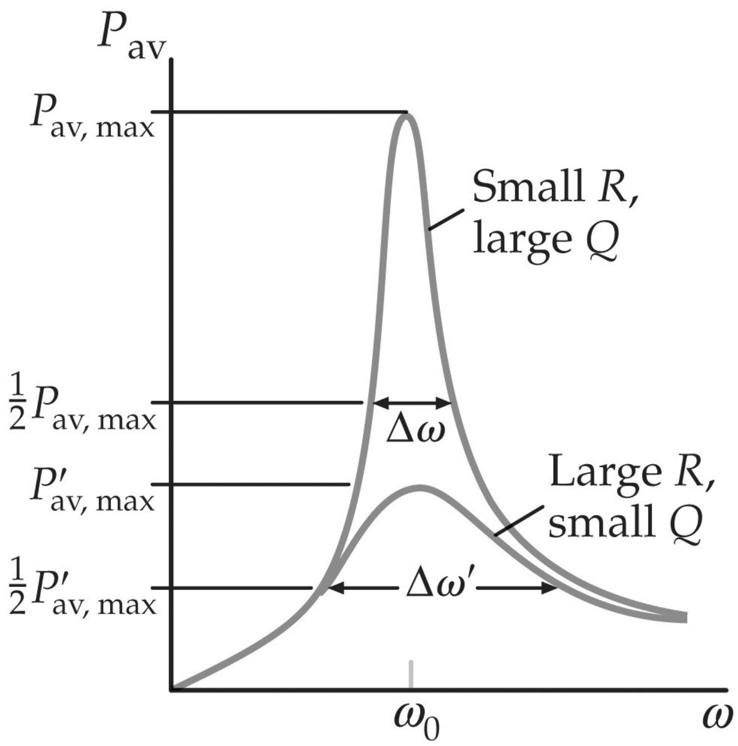


RLC circuits in resonantie

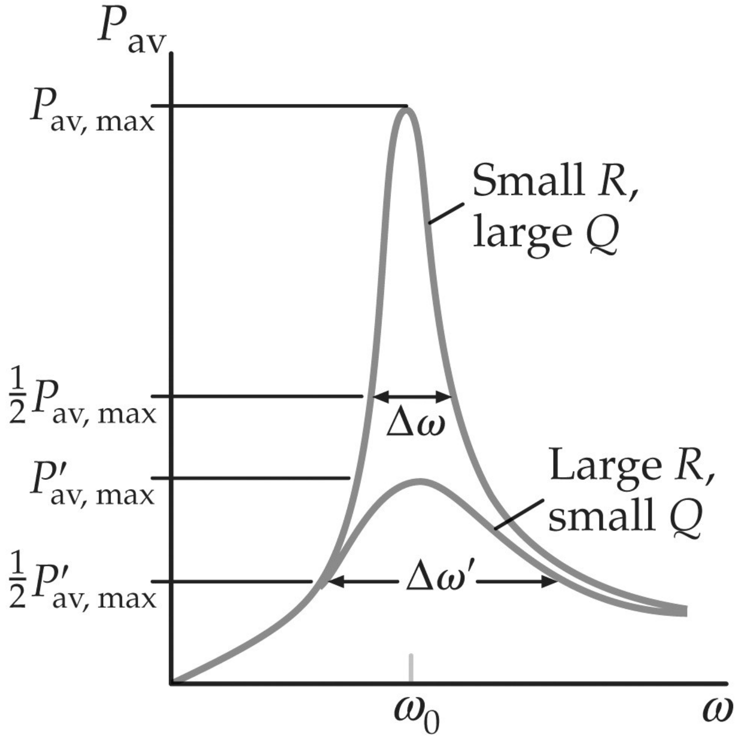
Stel

Dan reactantie = 0 en Z is minimaal (=R)

Bij deze frequentie hebben we maximale stroom en spreken we van resonantie



RLC circuits in resonantie



Voor het instantane vermogen geldt

Gemiddeld vermogen via

Power factor

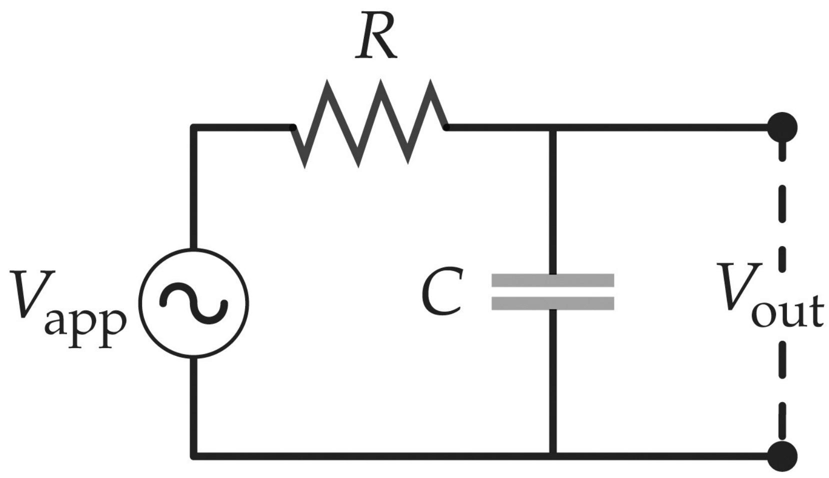
Met

Vinden we

$$\boxed{P_{av} = \frac{V_{app,rms}^2 R\omega^2}{L^2(\omega^2-\omega_0^2)^2+\omega^2R^2}}$$

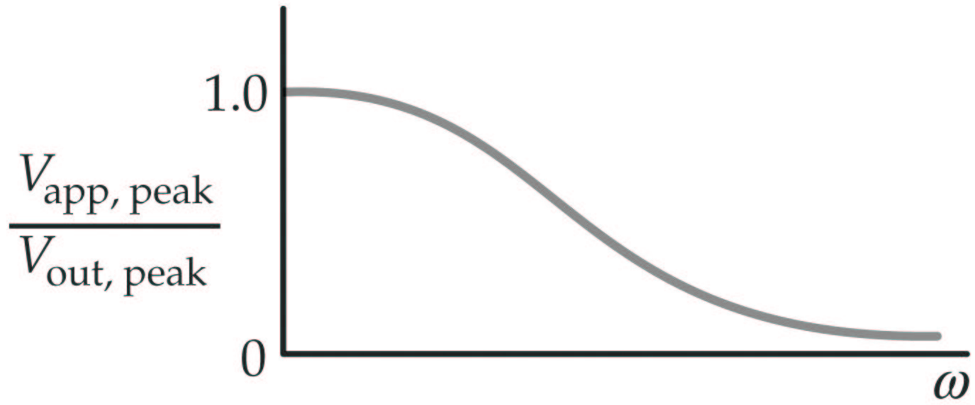
Q-factor

RC laag-doorlaat filter

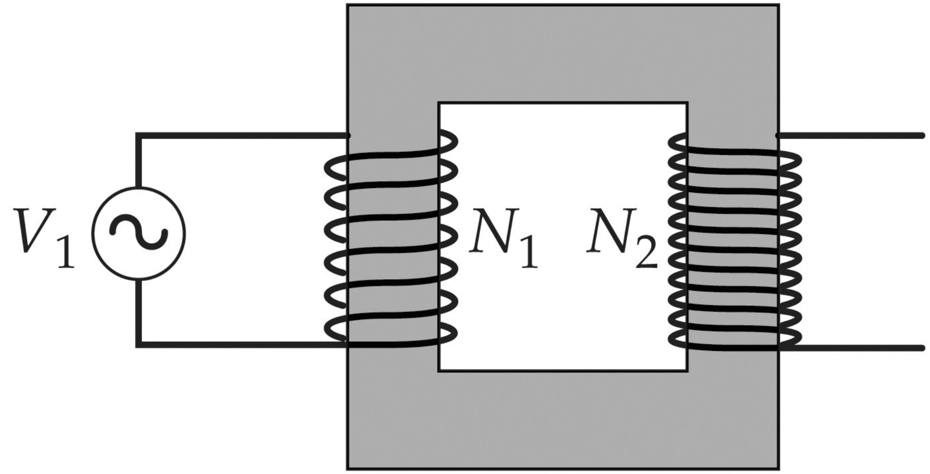


Gebruik

$$\boxed{V_{out,rms} = \frac{V_{app,rms}}{\sqrt{1+\omega^2 (RC)^2}}}$$



29-7 De transformator



Dus

Verder geldt

En ook