

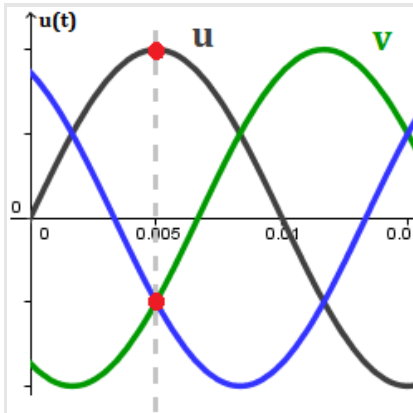
# AC

## 3-FASET

## SYMMETRISK

## BELASTNING

- Én definition
- Stjerneklede symmetriske belastninger
- Trekantsklede symmetriske belastninger



KELD DÝRMOSE

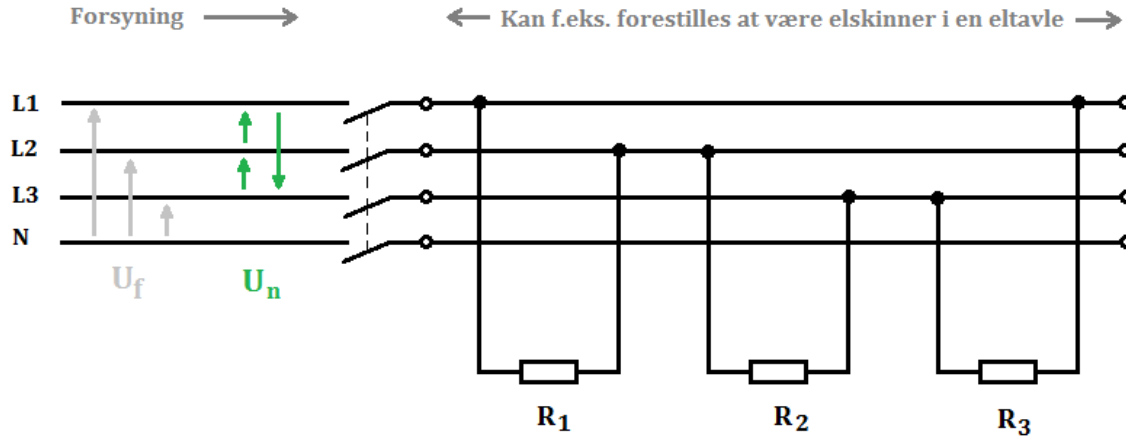


# AAMS

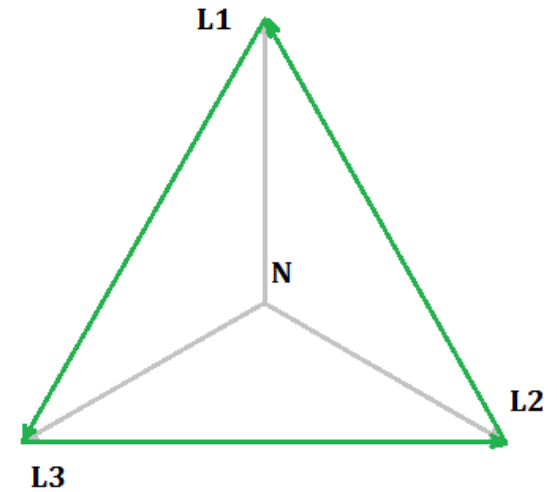
Aarhus Maskinmesterskole  
Aarhus School of Marine and Technical Engineering

# AC 3 faset symmetrisk belastning

Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:

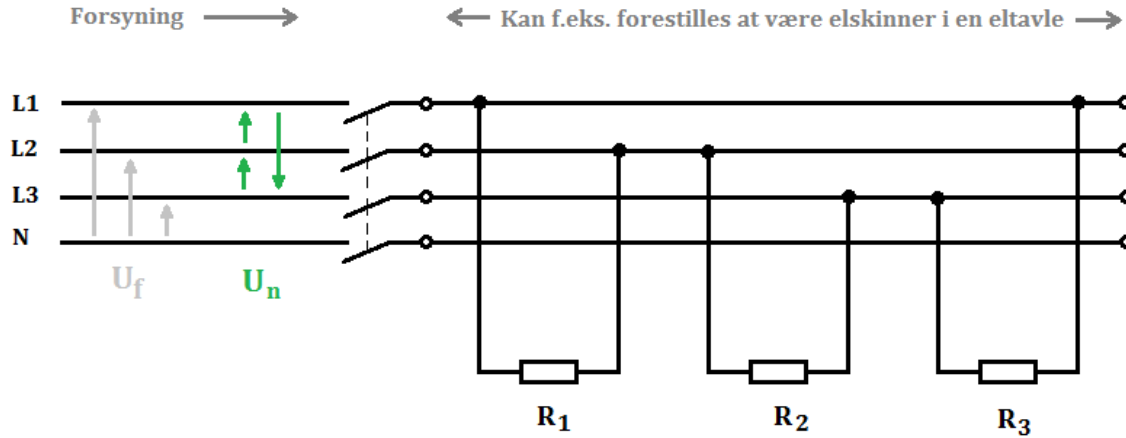


Vektordiagram:

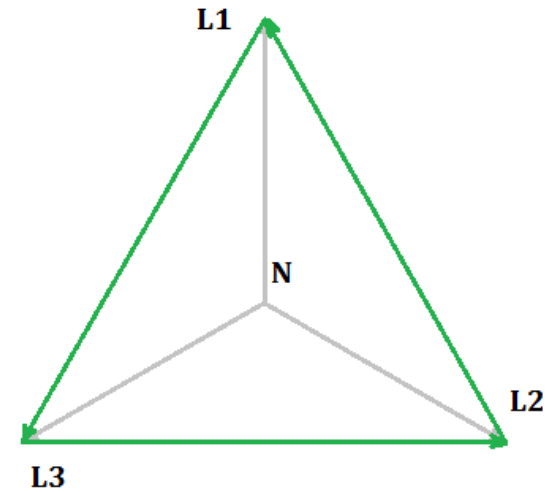


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Vektordiagram:



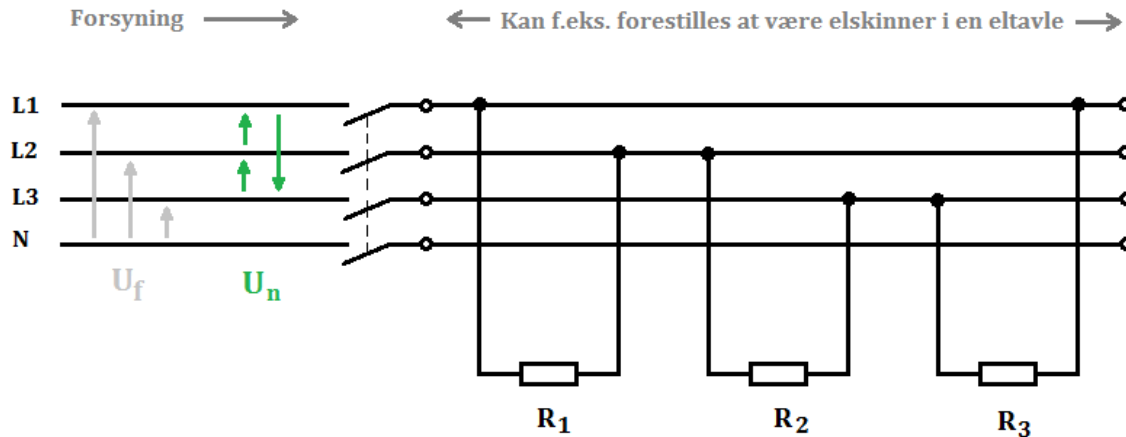
Lad os antage følgende om kredsens værdier:

$$U_n = 400 V$$

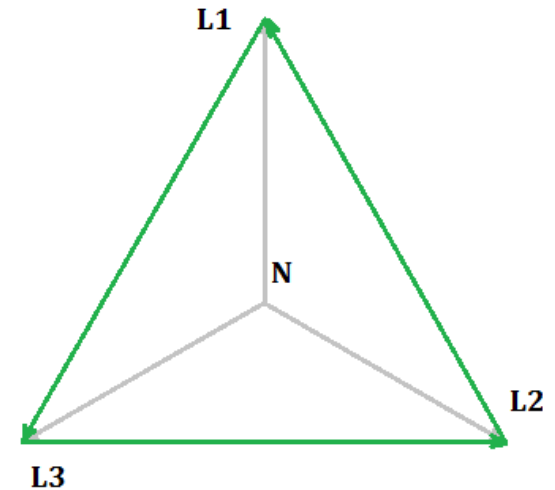
$$R_1 = R_2 = R_3 = 80 \Omega$$

# AC 3 faset symmetrisk belastning

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Vektordiagram:



Lad os antage følgende om kredsens værdier:

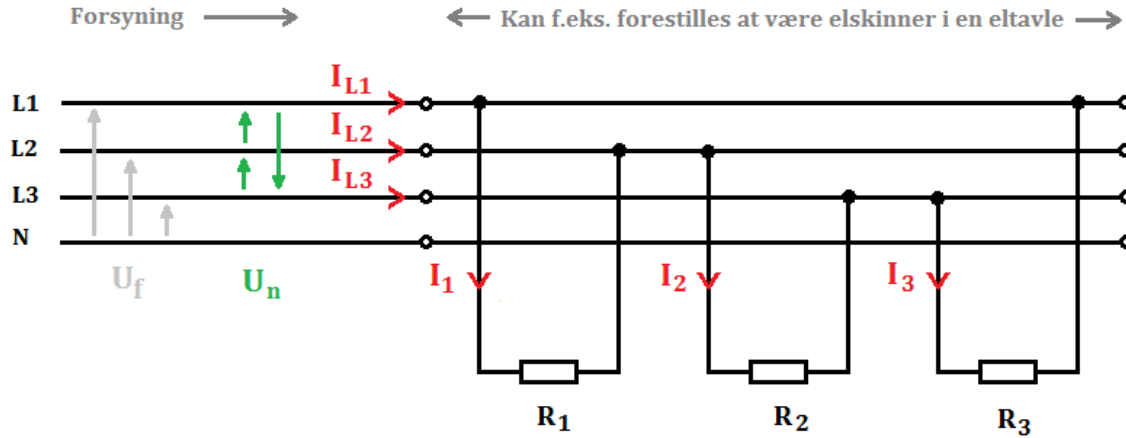
$$U_n = 400 \text{ V}$$

$$R_1 = R_2 = R_3 = 80 \text{ } \Omega$$

- vi slutter kredsen, og beregner strømmene:

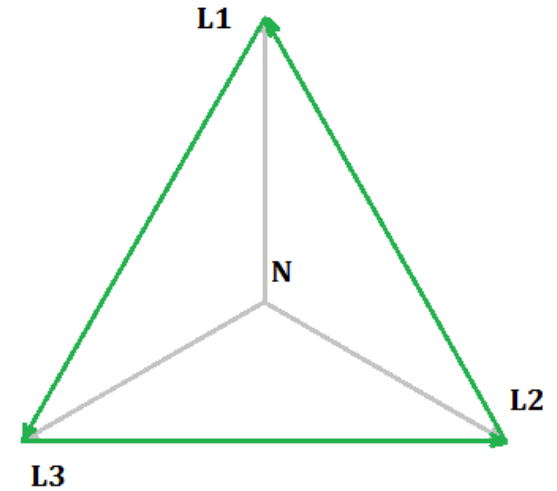
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Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \text{ } \Omega$$

Vektordiagram:

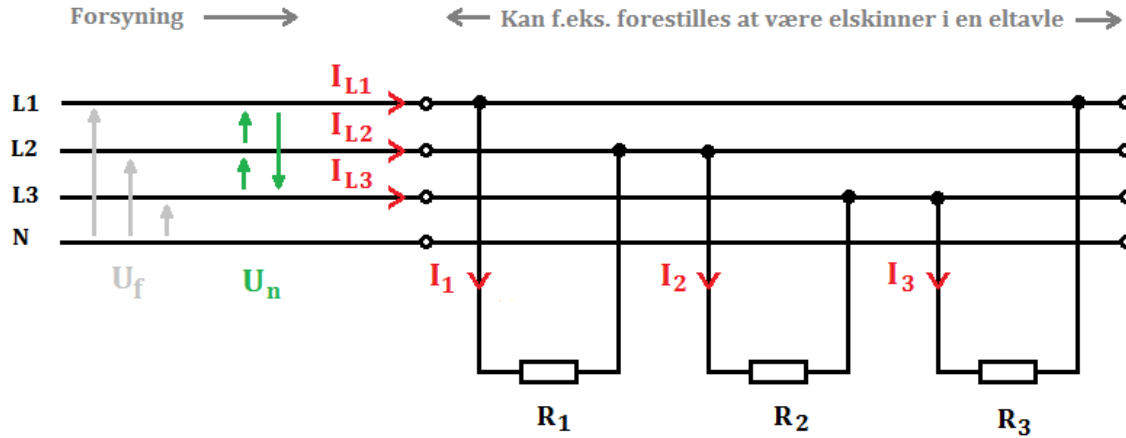


Strømmene:

$$I_1 = I_2 = I_3 = I_f = \frac{U_n}{R} \Rightarrow$$

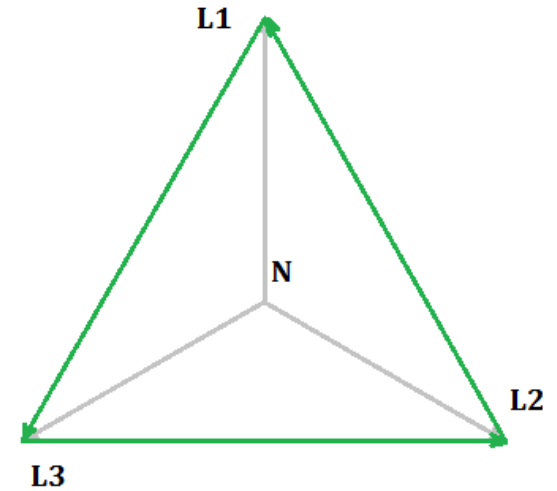
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$$U_n = 400 \text{ V}$$
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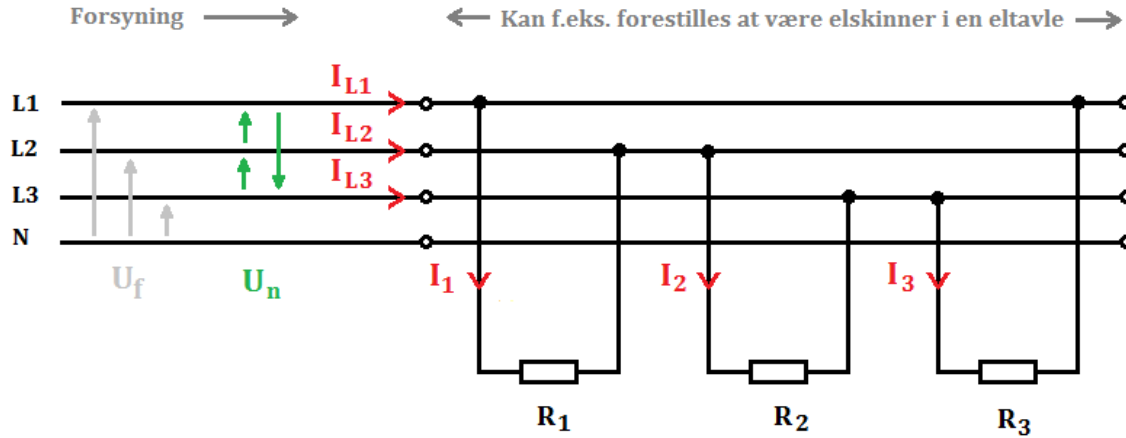
Strømmene:

$$I_1 = I_2 = I_3 = I_f = \frac{U_n}{R} \Rightarrow$$

$$I_f = \frac{400}{80} = 5 \text{ A}$$

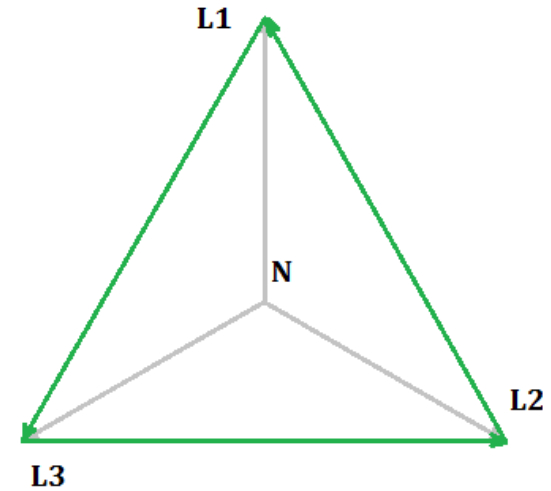
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$$U_n = 400 \text{ V}$$
$$R = 80 \text{ } \Omega$$

Vektordiagram:



Strømmene:

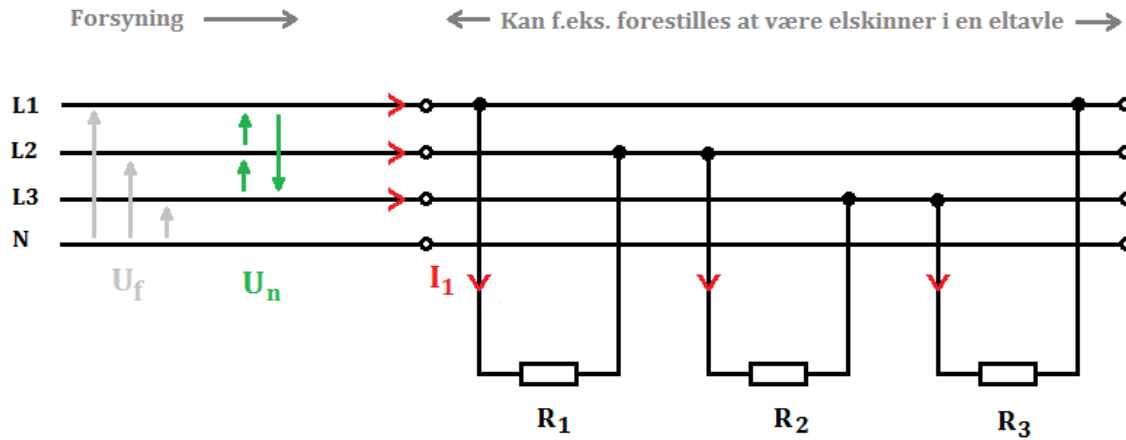
$$I_1 = I_2 = I_3 = I_f = \frac{U_n}{R} \Rightarrow$$

$$I_f = \frac{400}{80} = 5 \text{ A}$$

- strømmene indtegnes på vektordiagrammet:

# AC 3 faset symmetrisk belastning

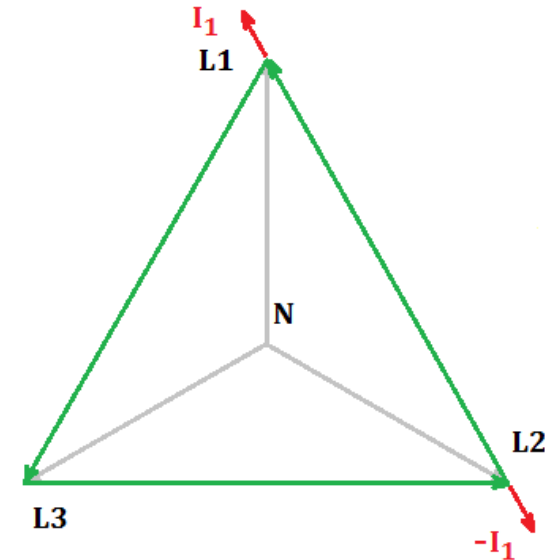
Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \Omega$$
$$I_f = 5 \text{ A}$$

Strømmene indtegnes hver for sig:

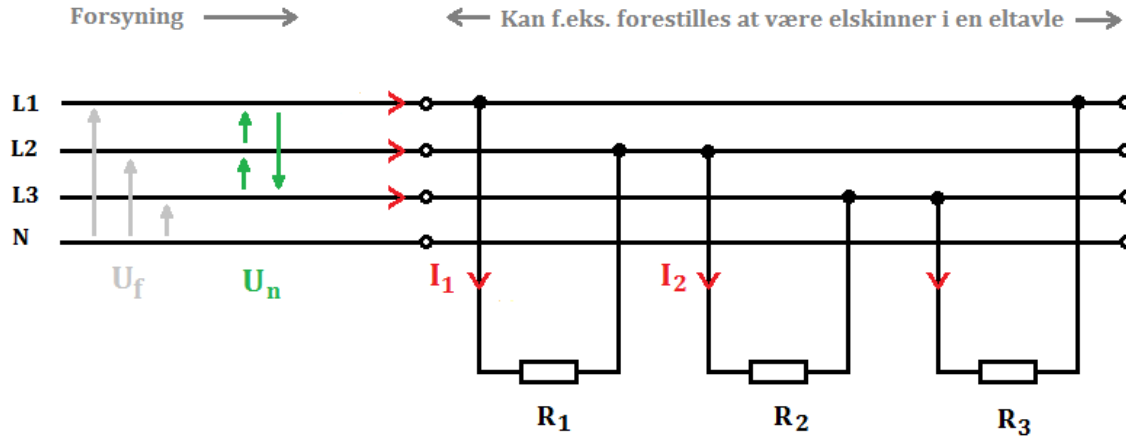
Vektordiagram:





# AC 3 faset symmetrisk belastning

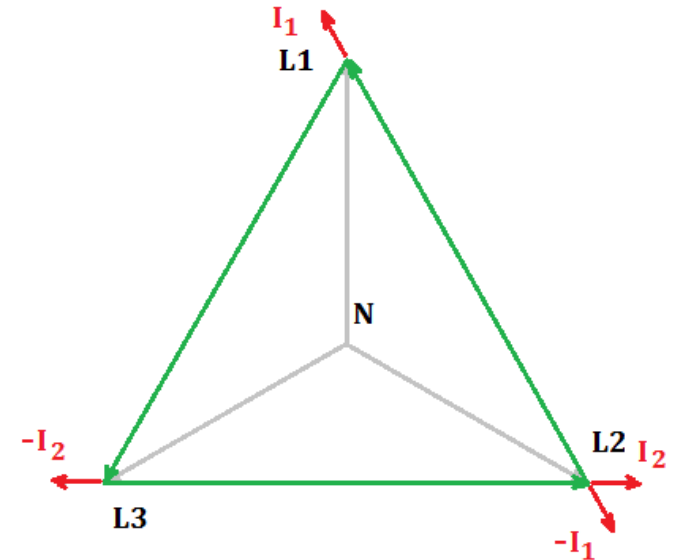
Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \Omega$$
$$I_f = 5 \text{ A}$$

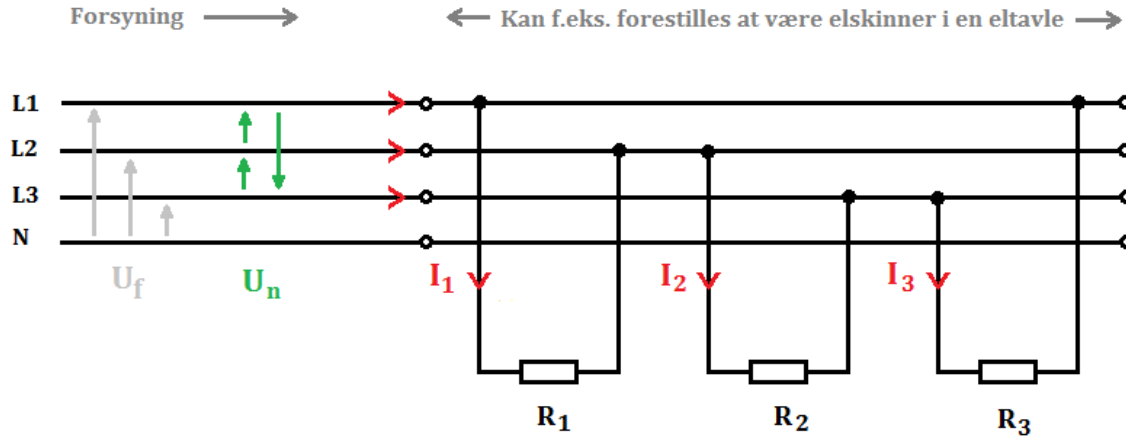
Strømmene indtegnes hver for sig:

Vektordiagram:



# AC 3 faset symmetrisk belastning

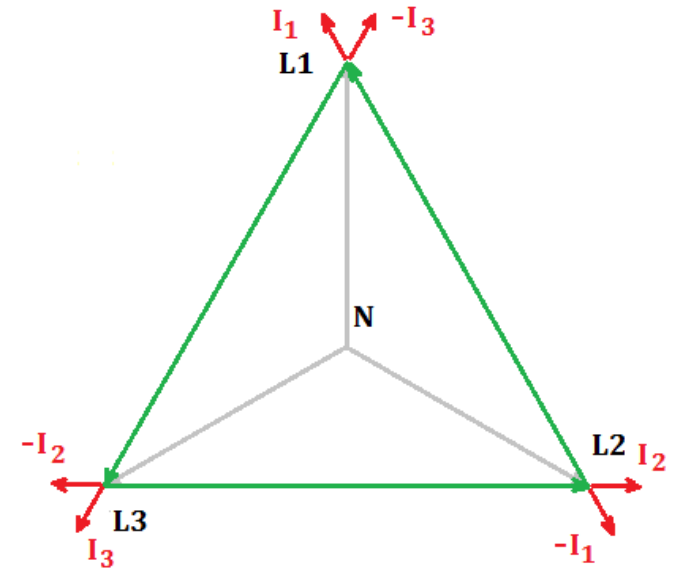
Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \Omega$$
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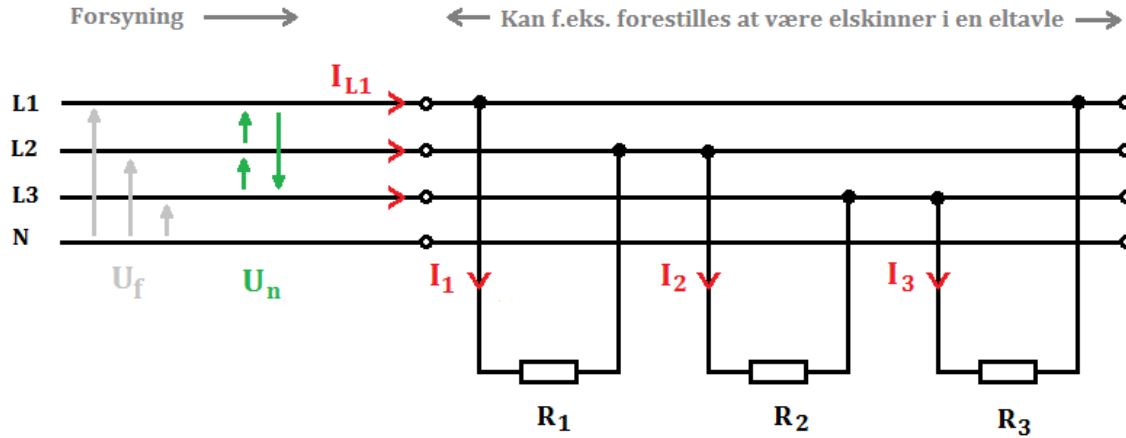
Strømmene indtegnes hver for sig:

Vektordiagram:



# AC 3 faset symmetrisk belastning

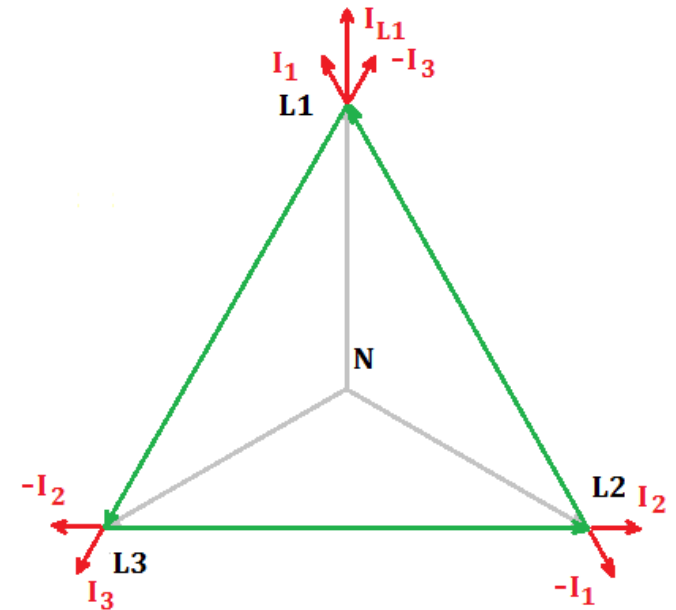
Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \text{ } \Omega$$
$$I_f = 5 \text{ A}$$

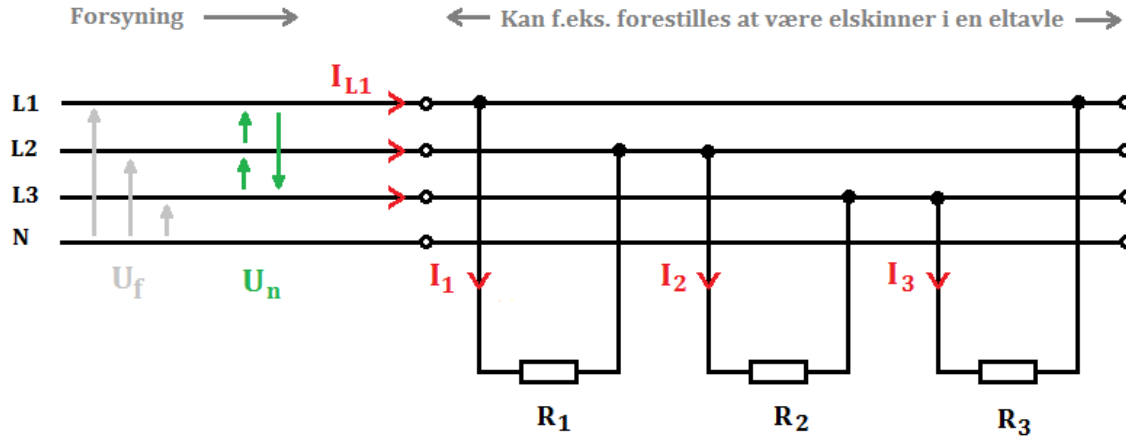
Strømmene indtegnes hver for sig:

Vektordiagram:



# AC 3 faset symmetrisk belastning

Et fuldstregs kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \Omega$$
$$I_f = 5 \text{ A}$$

Strømmene indtegnes hver for sig:

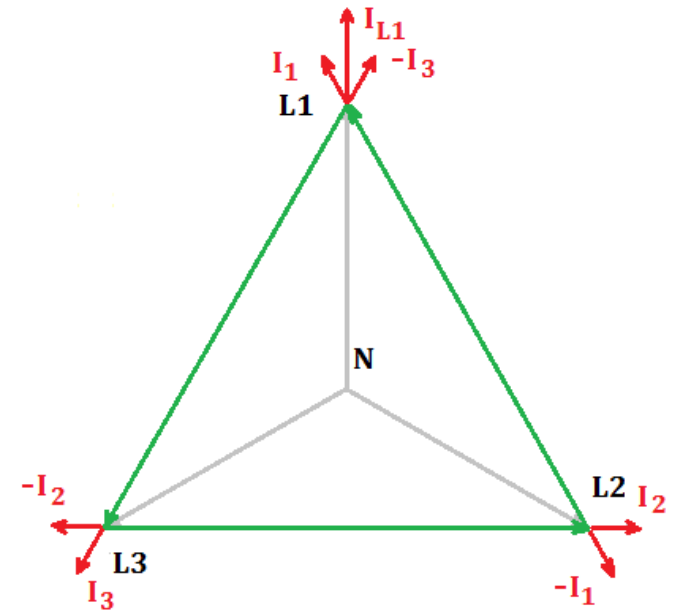
Beregningen af netstrømmen:

$$\bar{I}_{L1} = \bar{I}_1 + (-\bar{I}_3) \Rightarrow \bar{I}_{L1} = 5 \angle 30 + 5 \angle -30 = \mathbf{8,66 \text{ A}}$$

Eller blot:

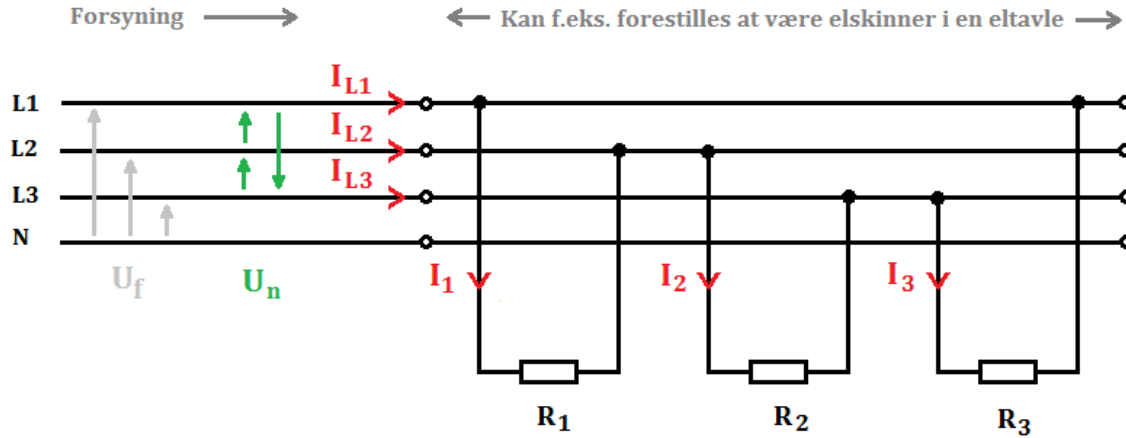
$$I_n = \sqrt{3} \cdot I_f \quad (\text{samme begrundelse som } U_n \text{ og } U_f)$$

Vektordiagram:



# AC 3 faset symmetrisk belastning

Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:

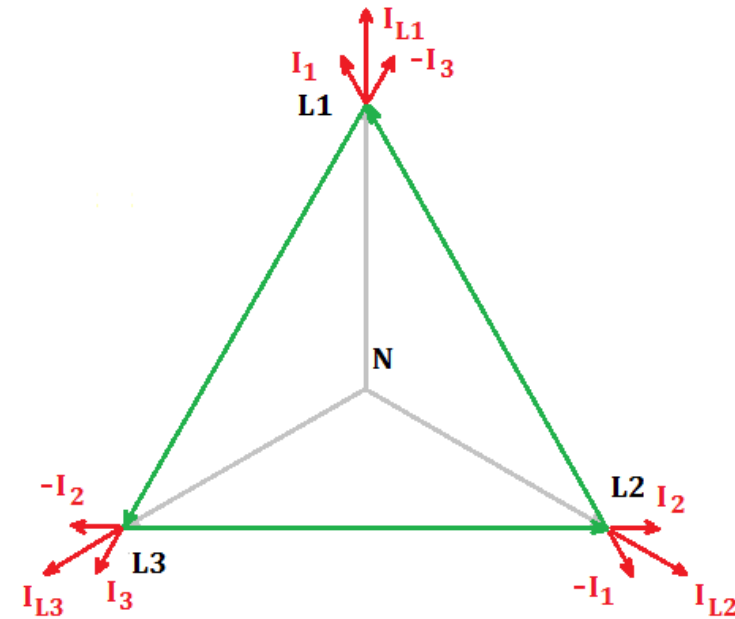


$$\begin{aligned}U_n &= 400 \text{ V} \\R &= 80 \Omega \\I_f &= 5 \text{ A} \\I_n &= 8,66 \text{ A}\end{aligned}$$

Strømmene indtegnes hver for sig:

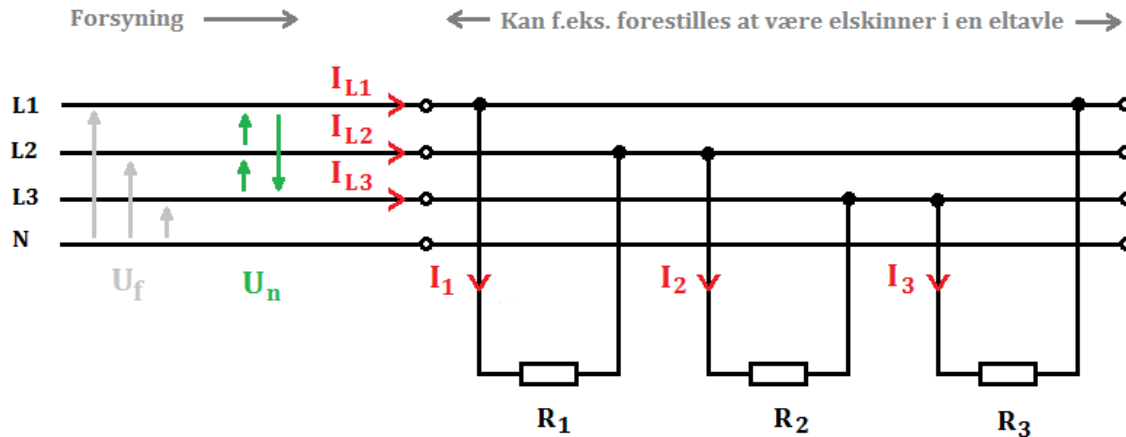
- og på samme måde med de to sidste netstrømme..

Vektordiagram:



# AC 3 faset symmetrisk belastning

Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:

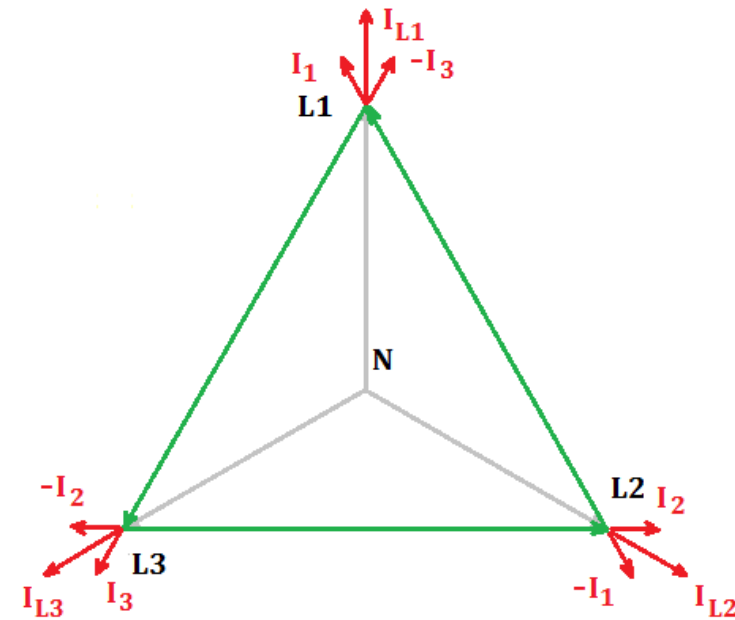


$$\begin{aligned}U_n &= 400 \text{ V} \\R &= 80 \Omega \\I_f &= 5 \text{ A} \\I_n &= 8,66 \text{ A}\end{aligned}$$

Læg mærke til at netstrømmen endvidere **altid** vil vise sig at være faseforskudt vinkel  $\varphi$  i forhold fasespændingen!!!

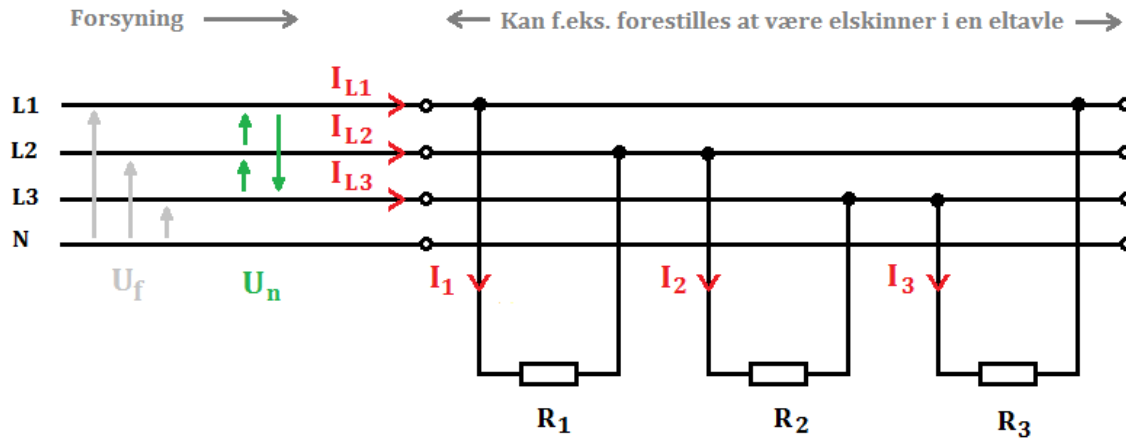
Her er faseforskydningen 0 grader, men en faseforskydning vil blot rotere vektorerne omkring L1, L2 og L3 som en samlet enhed. Betingelsen er symmetri.

Vektordiagram:



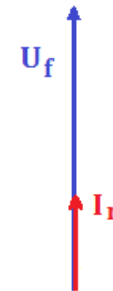
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Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$
$$R = 80 \text{ } \Omega$$
$$I_f = 5 \text{ A}$$
$$I_n = 8,66 \text{ A}$$

Vektordiagram:

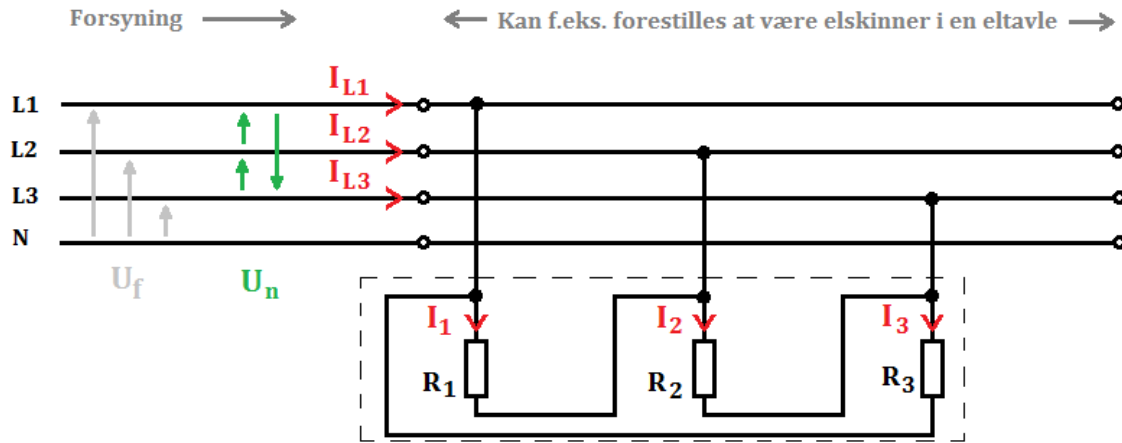


Læg mærke til at netstrømmen endvidere altid vil vise sig at være faseforskudt vinkel  $\varphi$  i forhold fasespændingen!!!

Også ved trekantskoblede symmetriske belastninger kan det være tilstrækkeligt blot at tegne en enkelt fase:

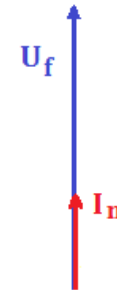
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$$\begin{aligned}U_n &= 400 \text{ V} \\R &= 80 \ \Omega \\I_f &= 5 \text{ A} \\I_n &= 8,66 \text{ A}\end{aligned}$$

Vektordiagram:

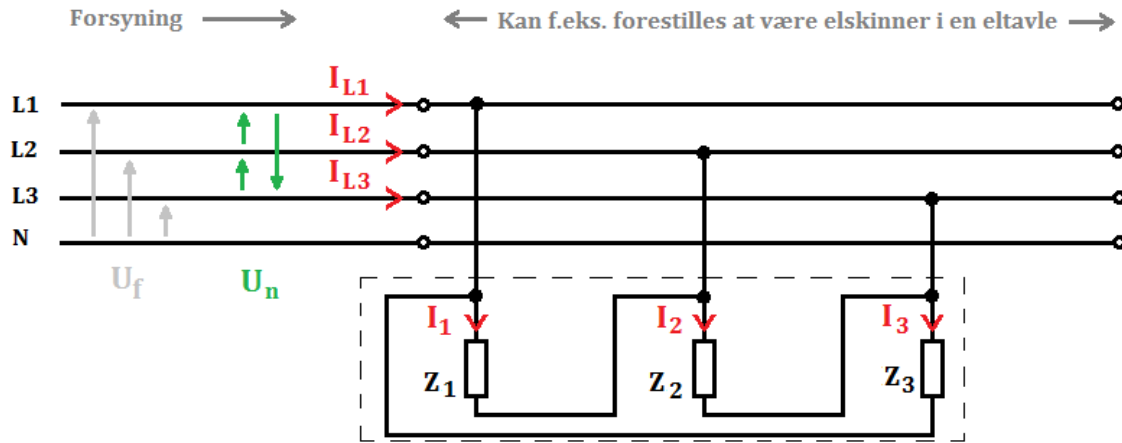


Kredsskemaet kan evt. også ændres hvis man f.eks. ønsker at vise de 3 symmetriske belastninger som én trefaset komponent



# AC 3 faset symmetrisk belastning

Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$U_n = 400 \text{ V}$$

Vektordiagram:

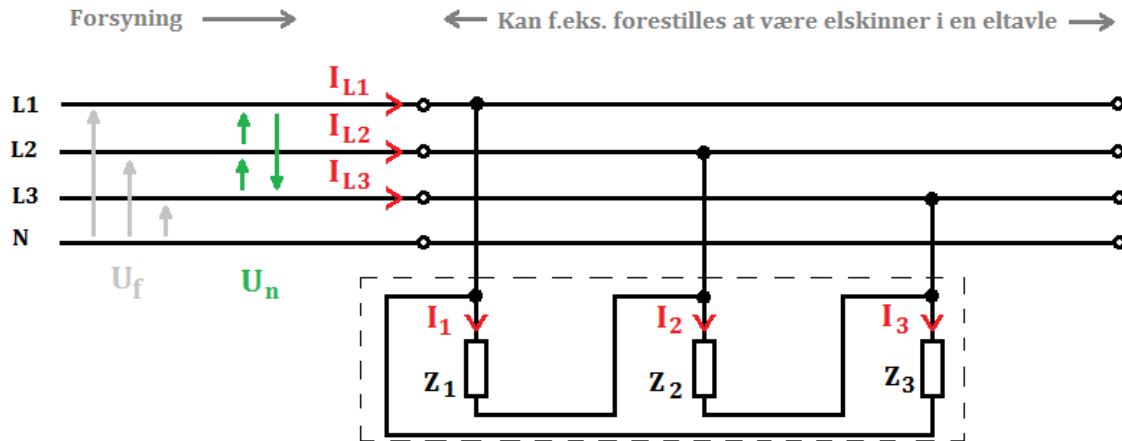
Effekterne (S, P og Q) med 3 ens impedanser:

$$Z_1 = Z_2 = Z_3 = 30 \Omega \angle 20^\circ \text{ induktiv}$$

- ønskes fundet for den 3 fasede belastning / komponent som enhed, men først må strømmene beregnes..

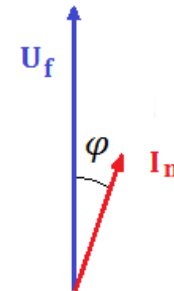
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Vektordiagram:



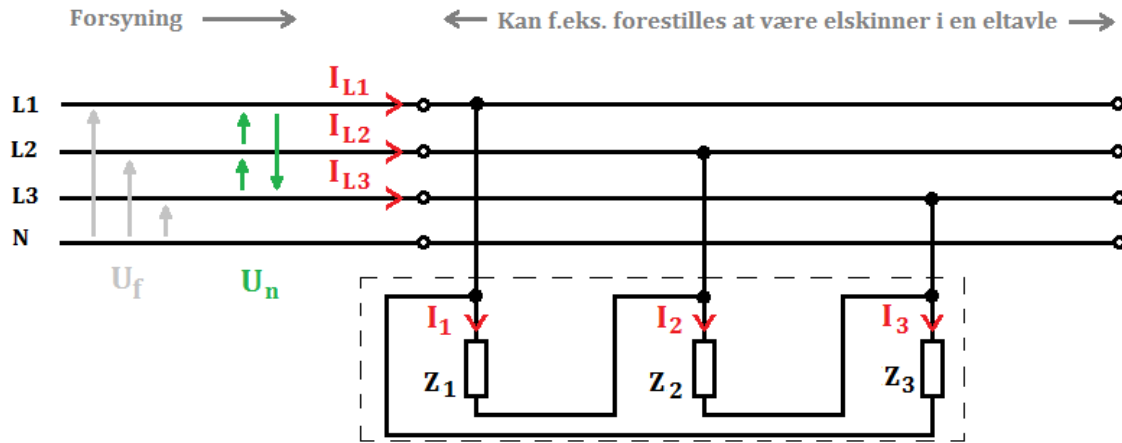
Strømmene:

$$I_f = \frac{U_n}{Z} = \frac{400}{30} = 13,3 \text{ A}$$

$$I_n = \sqrt{3} \cdot I_f = \sqrt{3} \cdot 13,3 = 23,1 \text{ A}$$

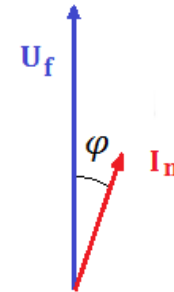
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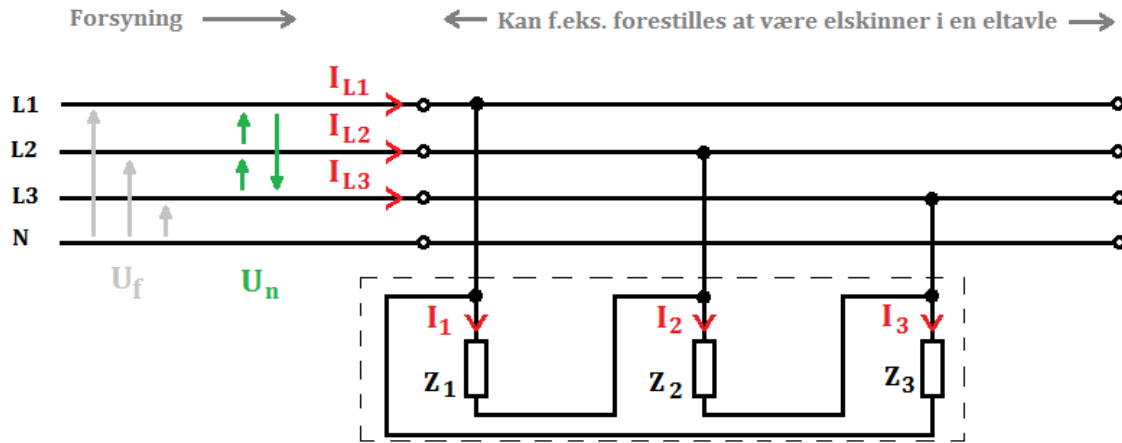


Den tilsyneladende effekt (S):

$$S = 3 \cdot U_n \cdot I_f \quad \Leftrightarrow$$

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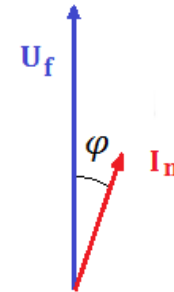


$$U_n = 400 \text{ V}$$

$$Z = 30 \angle 20^\circ$$

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Vektordiagram:



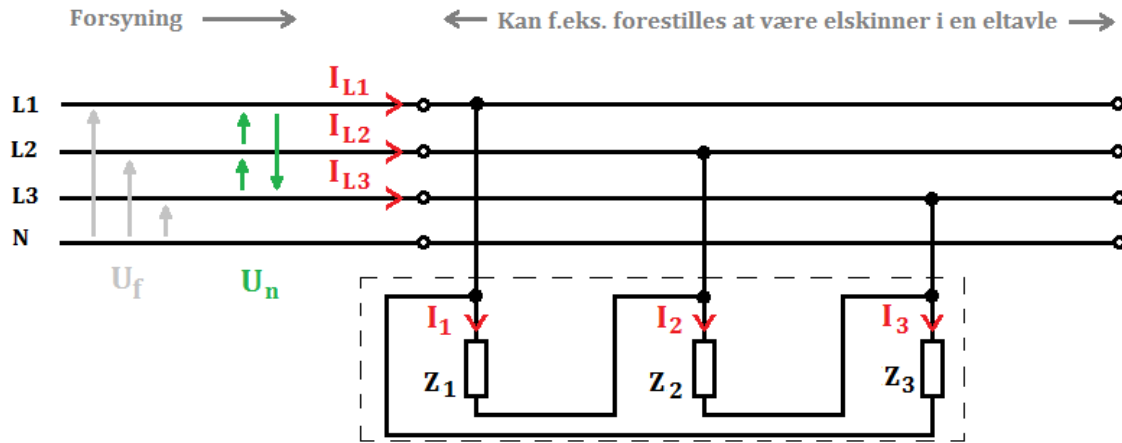
Den tilsyneladende effekt (S):

$$S = 3 \cdot U_n \cdot I_f \Leftrightarrow$$

$$S = 3 \cdot U_n \cdot \frac{I_n}{\sqrt{3}} \Leftrightarrow$$

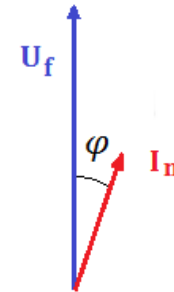
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$$\begin{aligned}U_n &= 400 \text{ V} \\Z &= 30 \angle 20^\circ \\I_n &= 23,1 \text{ A}\end{aligned}$$

Vektordiagram:



Den tilsyneladende effekt (S):

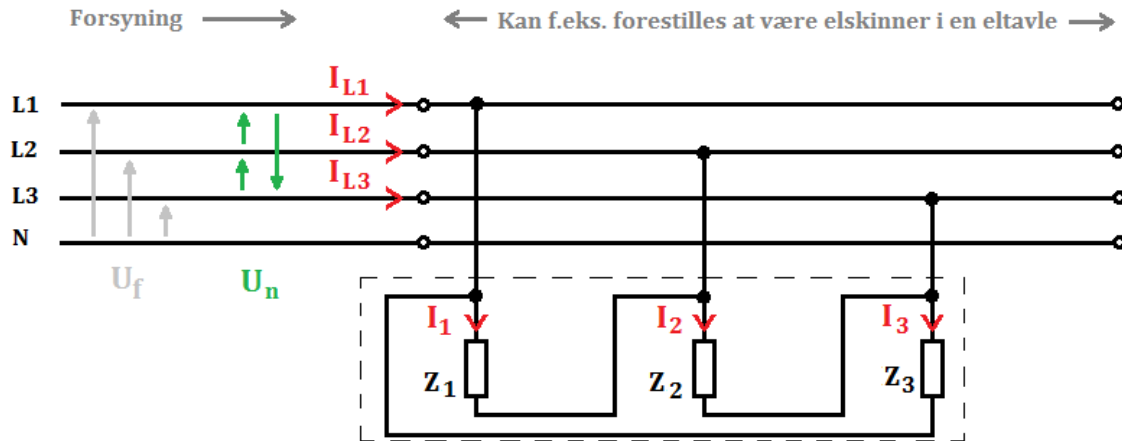
$$S = 3 \cdot U_n \cdot I_f \quad \Leftrightarrow$$

$$S = 3 \cdot U_n \cdot \frac{I_n}{\sqrt{3}} \quad \Leftrightarrow$$

$$S = \sqrt{3} \cdot U_n \cdot I_n \quad [\text{VA}]$$

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Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:

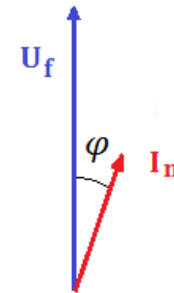


$$U_n = 400 \text{ V}$$

$$Z = 30 \angle 20^\circ$$

$$I_n = 23,1 \text{ A}$$

Vektordiagram:



Virkeeffekten (P):

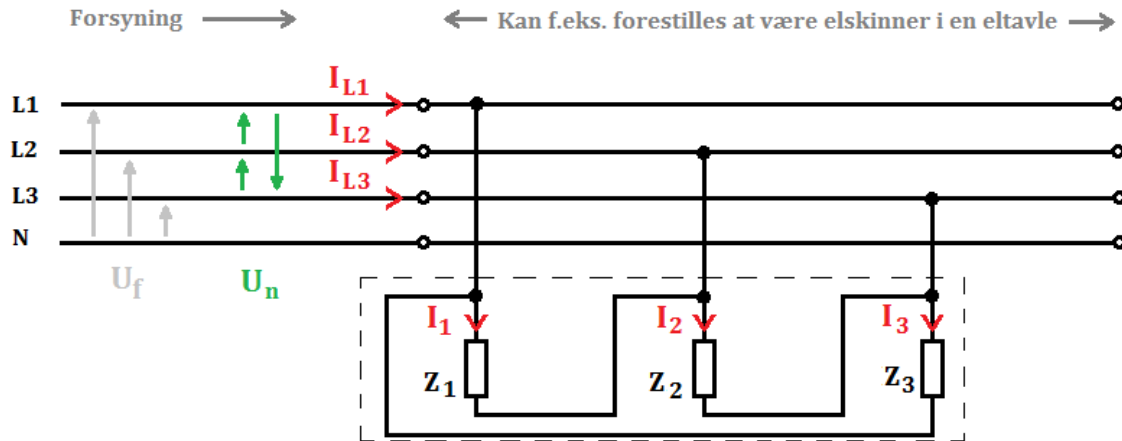
$$P = 3 \cdot U_n \cdot I_f \cdot \cos(\varphi) \quad \Leftrightarrow$$

$$P = 3 \cdot U_n \cdot \frac{I_n}{\sqrt{3}} \cdot \cos(\varphi) \quad \Leftrightarrow$$

$$P = \sqrt{3} \cdot U_n \cdot I_n \cdot \cos(\varphi) \quad [W]$$

# AC 3 faset symmetrisk belastning

Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:

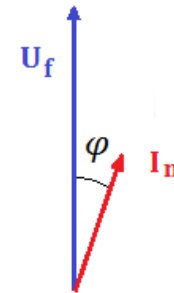


$$U_n = 400 \text{ V}$$

$$Z = 30 \angle 20^\circ$$

$$I_n = 23,1 \text{ A}$$

Vektordiagram:



Den reaktive effekt (Q):

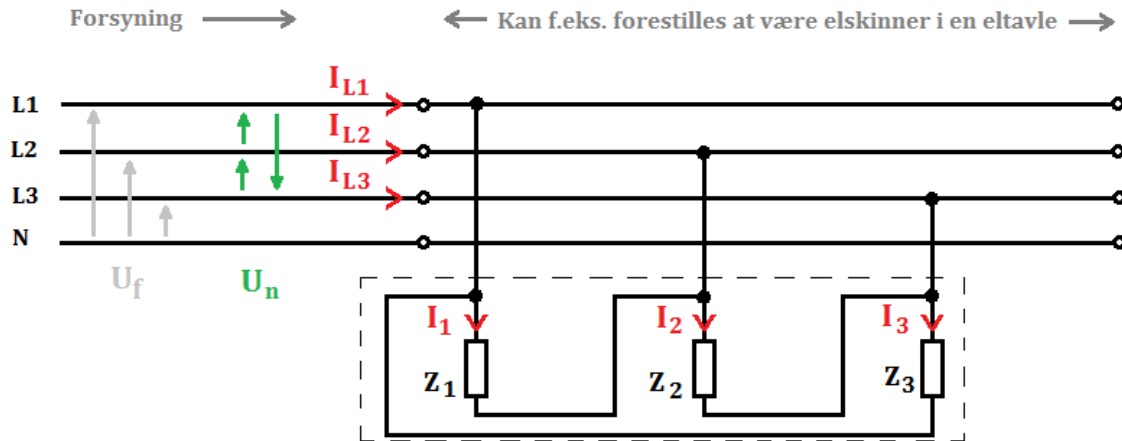
$$Q = 3 \cdot U_n \cdot I_f \cdot \sin(\varphi) \quad \Leftrightarrow$$

$$Q = 3 \cdot U_n \cdot \frac{I_n}{\sqrt{3}} \cdot \sin(\varphi) \quad \Leftrightarrow$$

$$Q = \sqrt{3} \cdot U_n \cdot I_n \cdot \sin(\varphi) \quad [\text{var}]$$

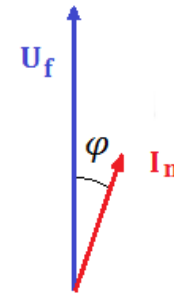
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Et fuldstreks kredsskema over trekantskoblet symmetrisk belastning:



$$\begin{aligned}U_n &= 400 \text{ V} \\Z &= 30 \angle 20^\circ \\I_n &= 23,1 \text{ A}\end{aligned}$$

Vektordiagram:



Effekterne i der afsættes i aktuelle 3 fase de komponent:

$$S = \sqrt{3} \cdot U_n \cdot I_n = \sqrt{3} \cdot 400 \cdot 23,1 = \mathbf{16,0 \text{ kVA}}$$

$$P = \sqrt{3} \cdot U_n \cdot I_n \cdot \cos(\varphi) = \sqrt{3} \cdot 400 \cdot 23,1 \cdot \cos(20) = \mathbf{15,0 \text{ kW}}$$

$$Q = \sqrt{3} \cdot U_n \cdot I_n \cdot \sin(\varphi) = \sqrt{3} \cdot 400 \cdot 23,1 \cdot \sin(20) = \mathbf{5,5 \text{ kvar}}$$