



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NASIENRIGLYN

NASIONALE SERTIFIKAAT

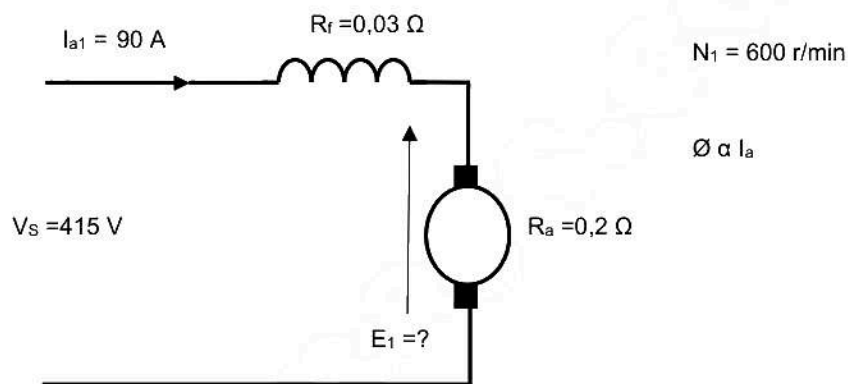
ELEKTROTEGNIIEK N6

2 Desember 2025

Hierdie nasienriglyn bestaan uit 12 bladsye.

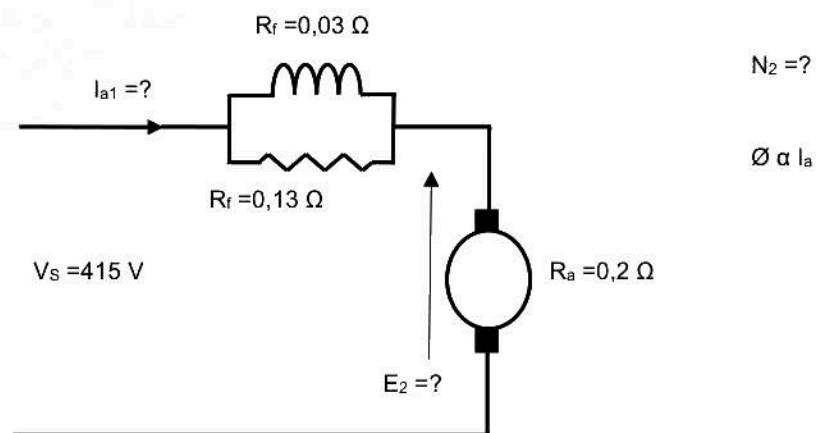
VRAAG 1: GS-MASJIENE

- 1.1
- Histereseverlies✓
 - Werwelstroomverlies✓
- (2)
- 1.2
- 1.2.1 Die spoed van 'n GS-motor verhoog met 'n verhoging van die ankerspanning,✓ maar nie in eweredige verhouding nie.✓
- 1.2.2 Die spoed sal omgekeerd eweredig aan die veldstroom✓ wissel indien die pole nie versadig is nie.✓
- (2 × 2) (4)
- 1.3 Gegee: 'n GS-seriemotor



$$E_1 = V - I_a(R_f + R_a) = 415 - 90(0,03 + 0,2) = 394,3 \text{ V}✓$$

Bereken N_2 wanneer $T_2 = 0,73T_1$ en 'n resistor van $0,13 \text{ ohm}$ parallel met die veldwikkling gekoppel is:



Bepaal I_{a2} :

$$T_1 = I_{a1} \cdot \Phi_1$$

$$T_2 \propto I_{a2} \cdot \Phi_2$$

$$T_2 = 0,73 T_1$$

$$I_{a2} \cdot \Phi_2 = 0,73 I_{a1} \cdot \Phi_1$$

$$\Phi_2 = I_{f2} = \frac{R_d}{R_d + R_f} I_{a2}$$

$$I_{a2} = \sqrt{\frac{0,73(I_{a1})^2}{0,8125}} \checkmark$$

$$= \sqrt{\frac{0,73 \times (90)^2}{0,8125}} = 85,308 \text{ A} \checkmark$$

$$R_{\text{par}} = \frac{R \cdot R_f}{R + R_f} = \frac{0,03 \times 0,13}{0,03 + 0,13} = 0,024 \Omega \checkmark$$

$$E_2 = V - I_{a2}(R_{\text{par}} + R_a) = 415 - 85,308(0,024 + 0,2) \checkmark$$

$$= 395,891 \text{ V} \checkmark$$

$$\frac{N_2 \cdot \Phi_2}{N_1 \cdot \Phi_1} = \frac{E_2}{E_1} \checkmark$$

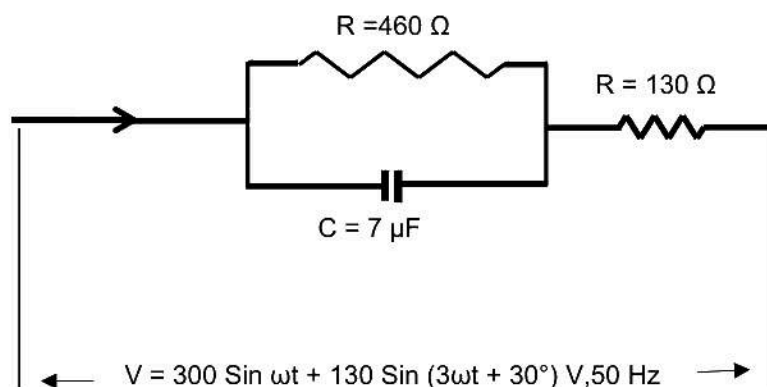
$$N_2 = \frac{E_2 \cdot N_1 \cdot \Phi_1}{E_1 \cdot \Phi_2} = \frac{395,891 \times 600 \times 90}{394,3 \times 85,308 \times 0,8125} = 728,22 \text{ r/min} \checkmark \checkmark$$

(9)
[15]

VRAAG 2: WS-TEORIE

Bereken 'n uitdrukking vir die oombliklike waarde van die stroom:

Gegee: 'n Serie-parallellekring



2.1 Fundamenteel:

$$X_{C1} = \frac{1}{2 \cdot \pi \cdot f \cdot C} = \frac{1}{2 \times \pi \times 50 \times 7 \times 10^{-6}} = 454,728 \Omega \checkmark$$

$$Z_{P1} = \frac{R_p \cdot X_{C1}}{R_p + X_{C1}} = \frac{460 \angle 0^\circ \times 454,728 \angle -90^\circ}{460 \angle 0^\circ + 454,728 \angle -90^\circ} \checkmark = \frac{209174,88 \angle -90^\circ}{646,821 \angle -44,67^\circ}$$

$$= 323,389 \angle -45,33 \Omega \checkmark$$

$$Z_{T1} = R_{ser} + Z_{T1} = 130 \angle 0^\circ + 323,389 \angle -45,33 \Omega \checkmark$$

$$= 424,961 \angle -32,765^\circ \Omega \checkmark$$

$$I_{M1} = \frac{E_{M1}}{Z_{T3}} = \frac{300 \angle 0^\circ}{424,961 \angle -32,765^\circ} = 0,706 \angle 32,765^\circ \text{ A} \checkmark$$

Derde harmoniek:

$$X_{C3} = \frac{X_{C1}}{3} = \frac{454,728}{3} = 151,576 \Omega$$

$$Z_{P3} = \frac{R_p \cdot X_{C3}}{R_p + X_{C3}} = \frac{460 \angle 0^\circ \times 151,576 \angle -90^\circ}{460 \angle 0^\circ + 151,576 \angle -90^\circ} \checkmark = \frac{69724,96 \angle -90^\circ}{484,33 \angle -18,238^\circ}$$

$$= 143,961 \angle -71,762^\circ \Omega \checkmark$$

$$Z_{T3} = R_{ser} + Z_{T3} = 130 \angle 0^\circ + 143,961 \angle -71,762^\circ \checkmark$$

$$= 222,124 \angle -37,992^\circ \checkmark$$

$$I_{M3} = \frac{E_{M3}}{E_{M3}} = \frac{180 \angle 50}{222,124 \angle -37,992^\circ} = 0,81 \angle 87,992^\circ \text{ A} \checkmark$$

$$i = I_{M1} \sin(314t + \theta_1) + I_{M3} \sin(942t + \theta_3) \checkmark$$

$$= 0,706 \sin(314t + 32,765^\circ) + 0,81 \sin(942t + 87,992^\circ) \text{ A} \checkmark \quad (13)$$

2.2

$$I_{RMS} = \sqrt{\frac{I_{M1}^2 + I_{M3}^2}{2}}$$

$$= \sqrt{\frac{0,706^2 + 0,81^2}{2}} \checkmark$$

$$= 0,76 \text{ A} \checkmark$$

(2)
[15]

VRAAG 3: TRANSFORMATORS

- 3.1
- Ster-deltaverbinding✓
 - Ster-sterverbinding✓
 - Delta-deltaverbinding✓
 - Delta-sterverbinding✓

(4)

3.2 Gegee: 'n Enkelfasige transformator

$$pf = 1$$

$$S = 270 \text{ kVA}$$

$$\eta = 94\% \text{ teen half- en vollas}$$

$$f = 50 \text{ Hz}$$

3.2.1 Bereken die ysterverlies en vollaskoperverlies:

$$\eta = \frac{k \cdot S \cdot \cos \theta}{k \cdot S \cdot \cos \theta + P_o + k^2 P_{sc}}$$

$$0,94 = \frac{0,5 \times 270 \times 1}{(0,5 \times 270 \times 1) + P_o + 0,5^2 P_{sc}} \checkmark = \frac{135}{135 + P_o + 0,5^2 P_{sc}} \checkmark$$

$$P_o + 0,5^2 P_{sc} = \frac{135}{0,94} - 135 = 8,617 \text{ --- (1)} \checkmark$$

η teen vollas:

$$\eta = \frac{S \cdot \cos \theta}{S \cdot \cos \theta + P_o + P_{sc}}$$

$$0,94 = \frac{270 \times 1}{(270 \times 1) + P_o + P_{sc}} \checkmark = \frac{270}{270 + P_o + 0,5^2 P_{sc}} \checkmark$$

$$P_o + P_{sc} = \frac{270}{0,94} - 270 = 17,234 \text{ --- (2)} \checkmark$$

$$(2) - (1): \quad P_o + P_{sc} = 17,234$$

$$P_o + 0,5^2 P_{sc} = 8,617$$

$$\underline{0,75 P_{sc} = 8,617} \checkmark$$

$$\therefore P_{sc} = \frac{8,617}{0,75} = 11,489 \text{ kW} \checkmark$$

Vervang P_{sc} in (1) of (2):

$$P_o + 11,489 = 17,234 \checkmark$$

$$P_o = 5,745 \text{ kW} \checkmark$$

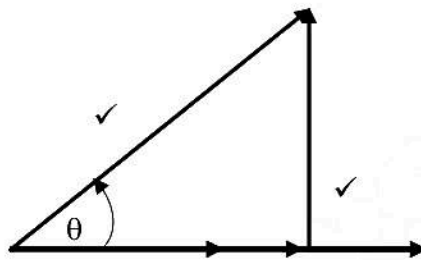
3.2.2 Die rendement teen 80% van vollas en 0,8 nalooparbeidsfaktor:

$$\begin{aligned}\eta &= \frac{k.S.\cos\theta}{k.S.\cos\theta + P_o + k^2P_{sc}} \times 100\% \\ &= \frac{0,8 \times 270 \times 0,8}{(0,8 \times 270 \times 0,8) + 5,745 + (0,8^2 \times 11,489)} \times 100\% \checkmark \\ &= 92,954\% \checkmark\end{aligned}$$

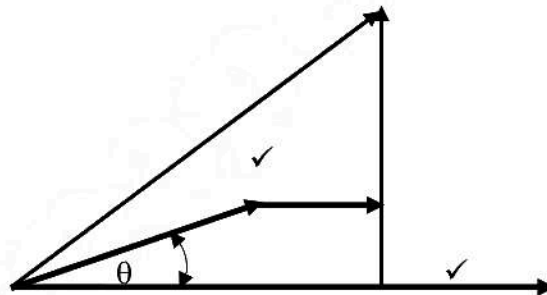
(2)
[16]

VRAAG 4: WS-MASJIENE

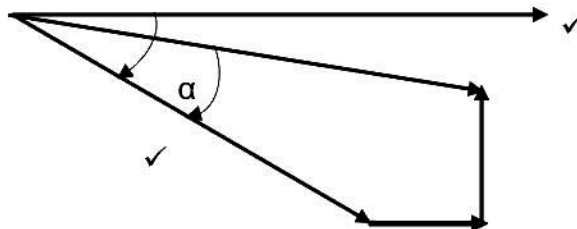
4.1 4.1.1



4.1.2



4.1.3



(3 × 2) (6)

4.2 Gegee: 'n Stergekoppelde alternator

Aantal pole = 12

$f = 50 \text{ Hz}$

$E_o = 11 \text{ kV}$

$\Phi/\text{pool} = 0,18 \text{ Webber}$

$K_f = 1,2$

4.2.1 Aantal gleuwe per pool
 = aantal gleuwe/aantal pole
 = $144/12$
 = 12
 $\alpha = 180/\text{aantal gleuwe per pool} = 180/12 = 15^\circ \checkmark$
 $n = \text{aantal gleuwe per pool/fase} = 12/3 = 4 \checkmark$

$$k_d = \frac{\sin \frac{n\alpha}{2}}{n \sin \frac{\alpha}{2}} = \frac{\sin \frac{4 \times 15}{2}}{4 \sin \frac{15}{2}} = 0,958 \checkmark \quad (3)$$

4.2.2 Steek = aantal gleuwe per pool = 12 $\checkmark$
 $\Psi = 2/\text{steek} \times 180^\circ = 1/12 \times 180^\circ = 30^\circ$
 $k_p = \cos \frac{\Psi}{2} = \cos \frac{15^\circ}{2} = 0,966 \checkmark \quad (2)$

4.2.3 $E_p = 11\,000/\sqrt{3} = 6\,350,853\,V \checkmark$
 Ook: $E_p = 2 \cdot k_f \cdot k_d \cdot k_p \cdot f \cdot \Phi \cdot \frac{Z}{p}$

$$\frac{Z}{p} = \frac{E_p}{2 \cdot k_f \cdot k_d \cdot k_p \cdot f \cdot \Phi}$$

$$= \frac{6\,350,853}{2 \times 1,2 \times 0,958 \times 0,966 \times 50 \times 0,18} \checkmark$$

$$= 317,714 \checkmark \quad (3)$$

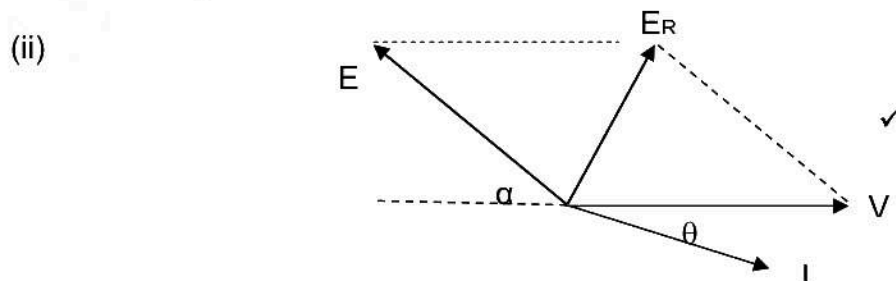
[14]

VRAAG 5: WS-MASJIENE

5.1 Laat 'n sinchrone motor oor 'n voorlooparbeidsfaktor beskik:

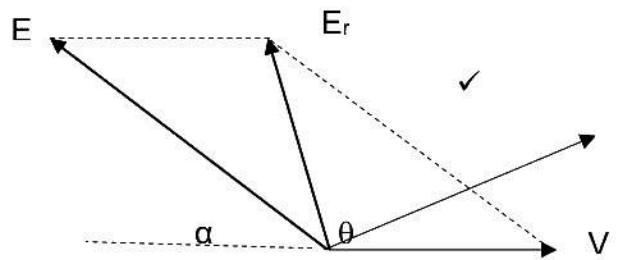
(i) $E \longleftrightarrow V \quad \checkmark$

Die sinchrone motor is gesinchroniseer. E en V is gelyk in grootte maar teenoorgestel in fase. $\checkmark$



Die meganiese aandrywing van die motor word verwyder en E vertraag teen hoek α . E bly steeds gelyk aan V. E_r laat stroom I deur die motor vloei. $\checkmark$

(iii).



Die opwekking van die motor word versterk en 'E' verhoog. Die verhoging in 'E' lei tot 'n verhoging van 'Er'. I is ongeveer 90° uit fase met Er en lei V teen hoek .θ✓

(6)

5.2 'n Driefasige stergekoppelde sinchrone motor:

$$P = 600 \text{ kW}$$

$$V = 2,2 \text{ kV}$$

$$\text{Aantal pole} = 6$$

$$Z_{\text{sync}} = (1,8 + j11) \text{ ohm}$$

$$\text{pf} = 0,8 \text{ voorloop}$$

$$\text{Rendement} = 93\%$$

5.2.1 Die EMK waartoe die masjien opgewek word:

$$P_{\text{in}} = P_{\text{out}} / \eta = 600\,000 / 0,93 = 645\,161,29 \text{ W} \checkmark$$

$$V_p = V_L / \sqrt{3} = 2\,200 / \sqrt{3} = 1\,270,171 \text{ V} \checkmark$$

$$I_L = P / \sqrt{3} \cdot V_L \cdot \cos \theta = 645\,161,29 / \sqrt{3} \times 2\,200 \times 0,8 = 211,639 \text{ A} \checkmark$$

$$\cos \theta = 0,8 \text{ (voorloop)}$$

$$\therefore \theta = 36,87^\circ$$

Metode 1

$$I_L = 211,639 \angle 36,87^\circ \text{ A}$$

$$Z_{\text{synch}} = 1,8 + j11 = 11,146 \angle 80,707^\circ \Omega \checkmark$$

$$E_r = I_L \cdot Z_{\text{syn}} = 211,639 \angle 36,87^\circ \times 11,146 \angle 80,707^\circ \\ = 2\,358,928 \angle 117,577^\circ \text{ V} \checkmark$$

$$E_p = E_r - V_p = 2\,358,928 \angle 117,577^\circ - 1\,270,171 \angle 0^\circ \\ = 3\,154,685 \angle 138,486^\circ \text{ V} \checkmark$$

$$E_L = \sqrt{3} \cdot E_p = \sqrt{3} \times 3\,154,685 = 5,464 \text{ kV} \checkmark$$

Metode 2

$$E_p = V_p \angle \theta^\circ + I_L R_a \angle 180^\circ + I_L X_{\text{synch}} \angle -90^\circ \\ = 1\,270,171 \angle -36,87^\circ + (211,639 \times 1,8) \angle 180^\circ + (211,639 \times 11) \angle -90^\circ$$

$$= 3154,74 \angle -78,384^\circ \text{ V} \checkmark \checkmark$$

$$E_L = \sqrt{3} E_p = \sqrt{3} \times 3\,154,74 = 5,464 \text{ kV} \checkmark$$

(6)

5.2.2 Die lashoek in elektriese en meganiese grade:

$$\alpha = 78,384^\circ - 36,87^\circ = 41,514^\circ \quad (\text{elektries}) \checkmark$$

$$\alpha = 41,514 / 3 = 13,838^\circ \quad (\text{meganies}) \checkmark$$

(2)

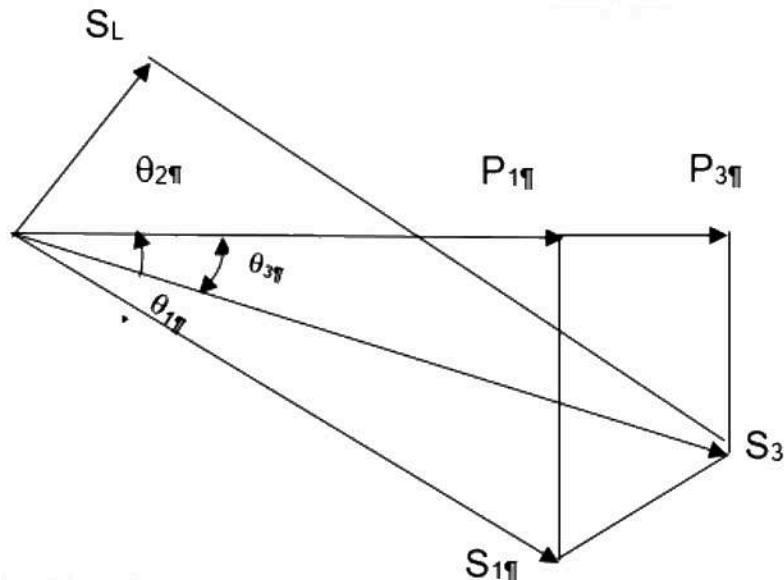
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VRAAG 6: OPWEKKING EN VOORSIENING VAN WS-KRAG

- 6.1
- Teen 'n swak arbeidsfaktor is die kVA-aanvraag hoog en Eskom hef per kVA.✓ Teen verbeterde arbeidsfaktor word die kVA verminder en dus ook die heffing.✓
 - Teen 'n swak arbeidsfaktor is die stroom hoog en siende dat die val van lyn- en kabelvolt op die stroom✓ berus, word die verbruikerspanning ook laag.✓ (4)
- 6.2 6.2.1 $P_{\text{motor}} = 270 \text{ kW}$, teen 0,8 pf naloop $V_L = 3,3 \text{ kV}$
 $S_{\text{motor.}} = 320 \text{ kVA}$ teen 0,9 pf voorloop

Konstante verbetering van kVA:

Metode 1



$$S_1 = \frac{P}{\cos \theta} = \frac{270}{0,8} = 337,5 \angle -36,87 \text{ kVA} \checkmark$$

$$S_2 = 320 \angle 25,842 \text{ kVA}$$

$$S_3 = S_1 + S_2$$

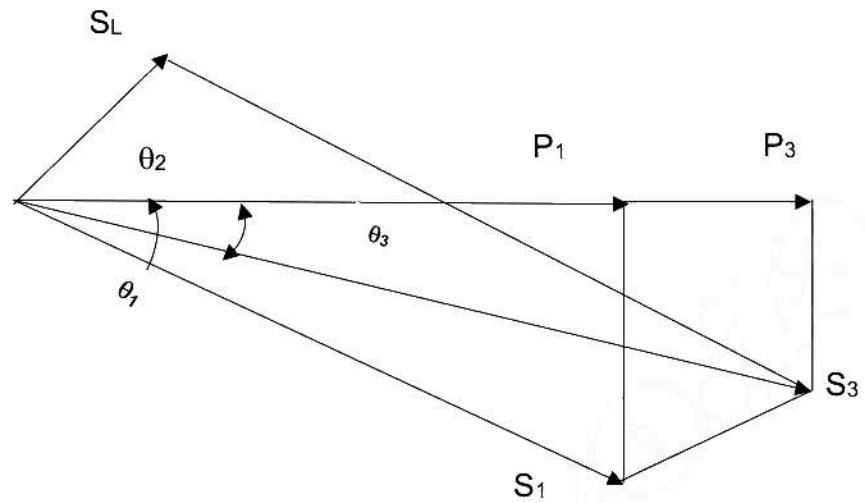
$$= 337,5 \angle -36,87 + 320 \angle 25,842 \checkmark$$

$$= 561,547 \angle -6,443 \text{ kVA} \checkmark$$

$$S_3 = \sqrt{3} \cdot V_L \cdot I_{L3} \therefore I_{L3} = \frac{S_3}{\sqrt{3} \times V_L} = \frac{561,547 \times 10^3}{\sqrt{3} \times 3300} = 98,245 \text{ A} \checkmark$$

$$\text{Arbiedsfaktor} = \cos 6,443 = 0,994 \text{ naloop} \checkmark$$

Metode 2



$$I_{L1} = \frac{P}{\sqrt{3} \cdot V_L \cdot \cos \theta} = \frac{270\,000}{\sqrt{3} \times 3\,300 \times 0,8}$$

$$= 59,047 \angle -36,87^\circ \text{ A} \checkmark$$

$$S_2 = \sqrt{3} \cdot V_L \cdot I_{L2}$$

$$I_{L2} = \frac{S_2}{\sqrt{3} \cdot V_L} = \frac{320 \times 10^3}{\sqrt{3} \times 3\,300}$$

$$= 55,985 \angle 25,842^\circ \text{ A} \checkmark$$

$$I_{L3} = I_{L1} + I_{L2}$$

$$= 59,047 \angle -36,87^\circ + 55,985 \angle 25,842^\circ \checkmark$$

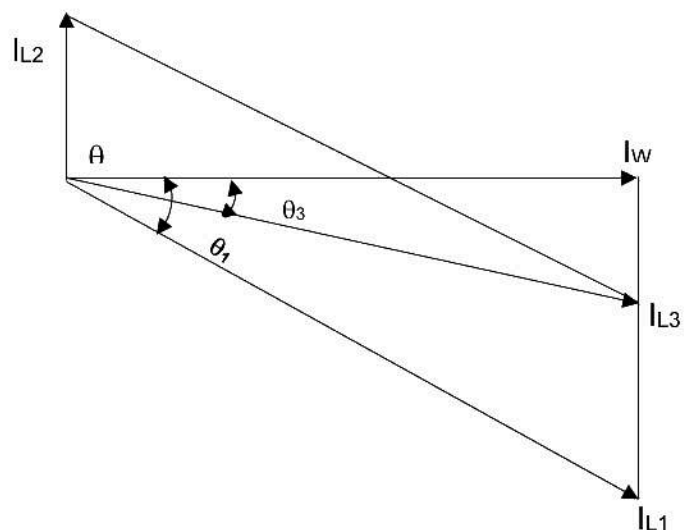
$$= 98,245 \angle -6,443^\circ \text{ A} \checkmark$$

$$\text{Arbeidsfaktor} = \cos 6,443 = 0,994 \checkmark$$

(5)

6.2.2

Metode 1



$$\cos \theta_1 = 0,8 \text{ naloop} \quad \therefore \theta_1 = 36,887^\circ$$

$$\cos \theta_3 = 0,9 \text{ naloop} \quad \therefore \theta_3 = 25,842^\circ$$

$$P = \sqrt{3} \cdot V_L \cdot I_{L1} \cdot \cos \theta_1$$

$$I_{L1} = \frac{P}{\sqrt{3} \cdot V_L \cdot \cos \theta_1} = \frac{270\,000}{\sqrt{3} \times 3\,300 \times 0,8} = 59,047 \text{ A} \checkmark$$

$$\cos \theta_1 = I_W / I_{L1}$$

$$\therefore I_W = I_{L1} \cdot \cos \theta_1 = 59,047 \times 0,8 = 47,238 \text{ A} \checkmark$$

$$I_{L2} = I_W (\tan \theta_1 - \tan \theta_3)$$

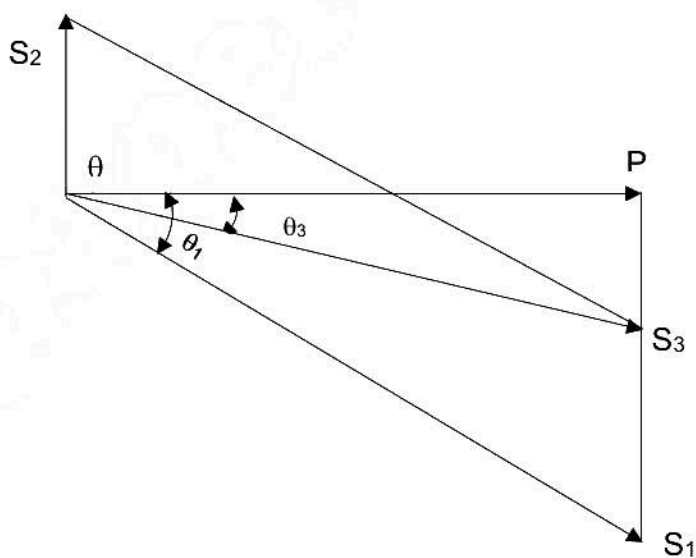
$$= 47,238 (\tan 36,87^\circ - \tan 25,842^\circ) = 12,55 \text{ A} \checkmark$$

$$S = \sqrt{3} \cdot V_L \cdot I_{L2}$$

$$= \sqrt{3} \times 3\,300 \times 12,55$$

$$= 71,733 \text{ kVA} \checkmark$$

Metode 2



$$S_1 = 337,5 \angle -36,87^\circ \text{ kVA} \checkmark$$

Na installasie van 'n kapasitorbank:

$$\cos \theta_3 = P / S_3$$

$$\therefore S_3 = P / \cos \theta_3 = 270 / 0,9$$

$$= 300 \text{ kVA} \checkmark$$

$$S_3 = S_1 + S_2$$

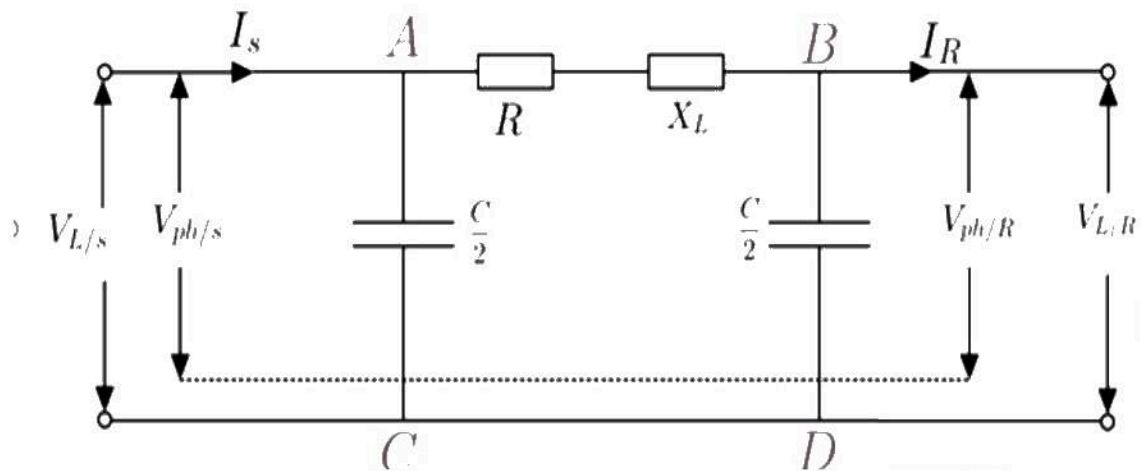
$$\therefore S_2 = S_3 - S_1$$

$$= 300 \angle -25,842^\circ - 337,5 \angle -36,87^\circ \checkmark$$

$$= 71,733 \angle 90^\circ \text{ kVA} \checkmark$$

(11)

6.3



$$R = 0,12 \, \Omega/\text{km} \times 350 \, \text{km} = 42 \, \Omega$$

$$L = 1,25 \, \text{mH}/\text{km} \times 350 \, \text{km} = 437,5 \, \text{mH}$$

$$C = 4,15 \, \text{nF}/\text{km} \times 350 \, \text{km} = 1452 \, \text{nF}$$

$$X_L = 2\pi fL = 2\pi \times 50 \times 0,4375 = 137,445 \, \Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2 \times \pi \times 1452 \times 10^{-9}} = 2195,241 \, \Omega \checkmark$$

$$V_{ph/s} = V_{L/R}/\sqrt{3} = 145000/\sqrt{3} = 83715,789 \angle 0^\circ \, \text{V} \checkmark$$

$$Z_{AB} = 42 + j137,445 = 143,719 \angle 73,008^\circ \, \Omega \checkmark$$

$$Z_C = 0 - j \frac{2195,241}{2} = 1097,62 \angle -90^\circ \, \Omega \checkmark$$

$$I_{BD} = V_{BD}/Z_{BD} = 83715,789 \angle 0^\circ / 1097,62 \angle -90^\circ = 76,27 \angle 90^\circ \, \text{A} \checkmark$$

$$I_S = \frac{S}{\sqrt{3} \times V_L} = \frac{100 \times 10^6}{\sqrt{3} \times 145 \times 10^3} = 398,173 \angle -36,87^\circ \checkmark$$

$$I_{AB} = I_S + I_{BD} = 398,173 \angle -36,87^\circ + 76,27 \angle 90^\circ \\ = 357,476 \angle -27,062^\circ \, \text{A} \checkmark$$

$$V_{AB} = I_{AB} \cdot Z_{AB} = 357,476 \angle -27,062^\circ \times 143,719 \angle 73,008^\circ \\ = 51376,093 \angle 45,946^\circ \, \text{V} \checkmark$$

$$V_{AC} = V_{AB} + V_{BD} = 51376,093 \angle 45,946^\circ + 83715,789 \angle 0^\circ \\ = 125016,411 \angle 17,178^\circ \, \text{V} \checkmark$$

$$V_S = \sqrt{3} \cdot V_{PH/S} = \sqrt{3} \times 125016,411 = 216,535 \, \text{kV} \checkmark$$

$$I_{AC} = V_{AC}/Z_{AC} = 125016,411 \angle 17,178^\circ / 1097,62 \angle -90^\circ = 113,898 \angle 107,178^\circ \, \text{A} \checkmark$$

$$I_S = I_{AB} + I_{AC} = 357,476 \angle -27,062^\circ + 113,898 \angle 107,178^\circ \checkmark \\ = 289,741 \angle -10,704^\circ \, \text{A} \checkmark$$

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TOTAAL: 100