



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NASIENRIGLYN

NASIONALE SERTIFIKAAT

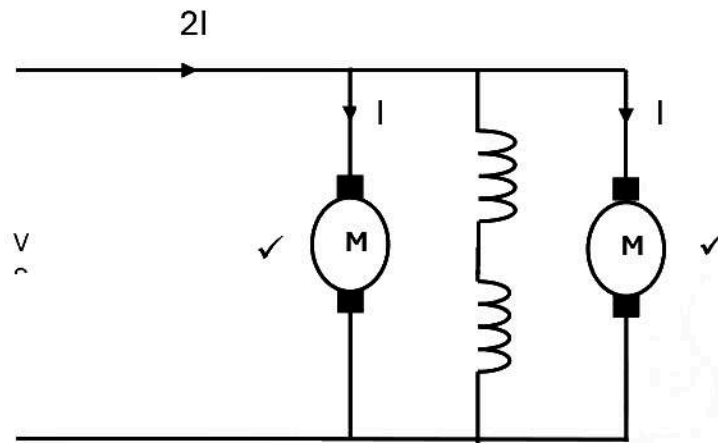
ELEKTROTEGNIIEK N6

9 April 2025

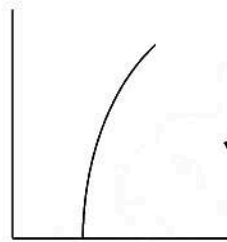
Hierdie nasienriglyn bestaan uit 11 bladsye.

VRAAG 1

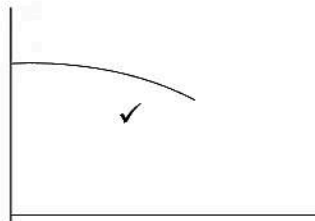
- 1.1 1.1.1 'n Paar identiese omtakmotors ('shunt motors') wat meganies aan dieselfde las gekoppel is en parallel verbind is.



- 1.1.2 Wringkrag-stroomkenkromme

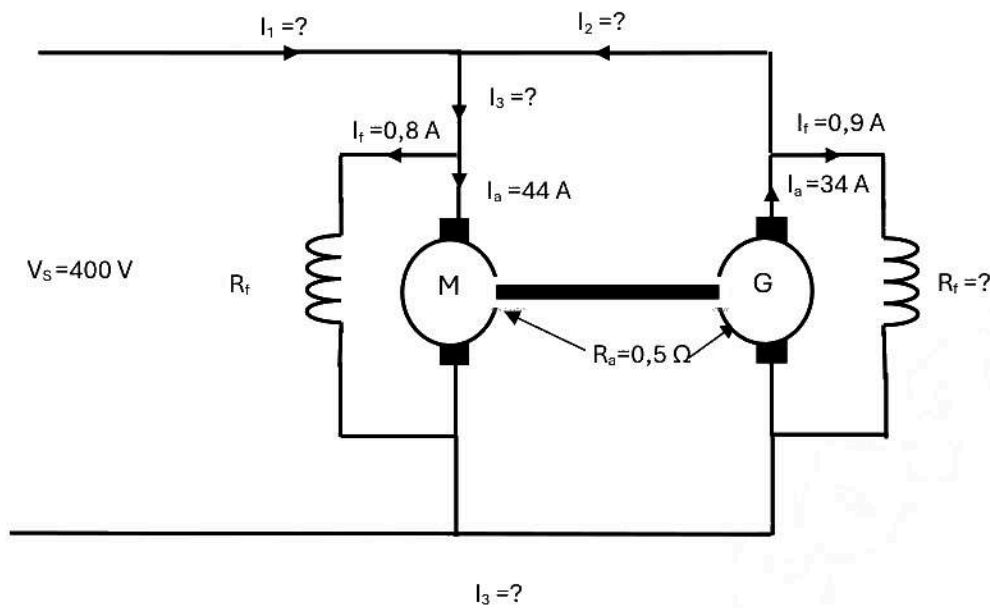


Spood-stroomkenkromme



(2 × 2) (4)

1.2



$$\begin{aligned}
 1.2.1 \quad I_2 &= I_{a(gen)} - I_{f(gen)} = 34 - 0,9 = 33,1 \text{ A} \\
 I_3 &= I_{a(mot)} + I_{f(mot)} = 44 - 0,8 = 43,2 \text{ A} \\
 I_1 &= I_3 - I_2 = 43,2 - 33,1 = 10,1 \text{ A}
 \end{aligned}$$

Vir 'n motor:

Vir 'n generator:

$$\begin{aligned}
 \text{Veldstroomverlies} &= V I_f = 400 \times 0,8 = 320 \text{ W} \checkmark \\
 \text{Veldstroomverlies} &= V I_f = 400 \times 0,9 = 360 \text{ W} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Ankerstroomverlies} &= (I_a)^2 \cdot R_a = 44^2 \times 0,5 = 968 \text{ W} \checkmark \\
 \text{Ankerstroomverlies} &= (I_a)^2 \cdot R_a = 34^2 \times 0,5 = 578 \text{ W} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Totale stroomverlies van motor a} &= 320 + 968 + 360 + 578 \\
 &= 2\,226 \text{ W}
 \end{aligned}$$

$$\begin{aligned}
 \text{Totale verliese van motor en gen.} &= I_1 \cdot V_s = 10,1 \times 400 \\
 &= 4\,040 \text{ W} \checkmark
 \end{aligned}$$

$$\text{Totale yster- en wrywingsverliese} = 4\,040 - 2\,226 = 1\,814 \text{ W} \checkmark$$

$$\begin{aligned}
 \text{Yster en wryging van elke masjien} &= \frac{1814}{2} \\
 &= 907 \text{ W} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \eta_{\text{motor}} &= 1 - \frac{P_{\text{out}}}{P_{\text{in}}} = 1 - \frac{968 + 320 + 907}{400 \times 43,2} \\
 &= 0,873 \text{ pu} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \eta_{\text{gen}} &= \frac{\text{lewing}}{\text{lewing} + \text{verliese}} = \frac{400 \times 33,1}{(400 \times 33,1) + (360 + 578 + 907)} \\
 &= 0,878 \text{ pu} \checkmark
 \end{aligned}$$

(9)

1.2.2

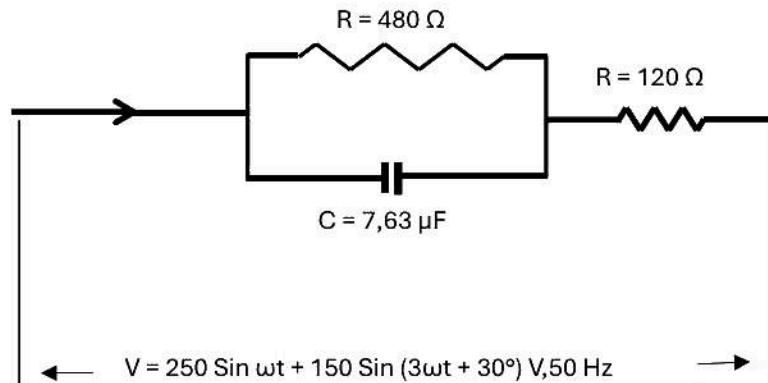
$$\begin{aligned}
 \eta_{\text{elke masjien}} &= \sqrt{\frac{I_2}{I_3}} = \sqrt{\frac{33,1}{43,2}} \\
 &= 0,875 \text{ pu} \checkmark
 \end{aligned}$$

(1)

1111

VRAAG 2

Gegee: 'n Serieparallele kring.



2.1 Berekening van 'n uitdrukking vir die oombliklike waarde van die stroom:

Fundamenteel:

$$X_{C1} = \frac{1}{2 \cdot \pi \cdot f \cdot C} = \frac{1}{2 \times \pi \times 50 \times 7,63 \times 10^{-6}} = 417,182 \, \Omega \checkmark$$

$$Z_{P1} = \frac{R_p \cdot X_C}{R_p + X_{C1}} = \frac{480 \angle 0^\circ \times 417,182 \angle -90^\circ}{480 \angle 0^\circ + 417,182 \angle -90^\circ} \checkmark$$

$$= 314,876 \angle -49,005 \, \Omega \checkmark$$

$$Z_{T1} = R_{ser} + Z_{T1} = 120 \angle 0^\circ + 314,876 \angle -49,005 \checkmark$$

$$= 403,882 \angle -36,046 \checkmark$$

$$I_{M1} = \frac{E_{M1}}{Z_{T3}} = \frac{250 \angle 0}{403,882 \angle -36,046^\circ} = 0,619 \angle 36,046 \, A \checkmark$$

Derde bolfrekwensies:

$$X_{C3} = \frac{X_{C1}}{3} = \frac{417,182}{3} = 139,061 \, \Omega$$

$$Z_{P3} = \frac{R_p \cdot X_{C3}}{R_p + X_{C3}} = \frac{480 \angle 0^\circ \times 139,061 \angle -90^\circ}{480 \angle 0^\circ + 139,061 \angle -90^\circ} \checkmark$$

$$= 133,569 \angle -73,843^\circ \, \Omega \checkmark$$

$$Z_{T3} = R_{ser} + Z_{T3} = 120 \angle 0^\circ + 133,569 \angle -73,843^\circ \checkmark$$

$$= 202,881 \angle -39,224^\circ \checkmark$$

$$I_{M3} = \frac{E_{M3}}{E_{M3}} = \frac{150 \angle 30}{202,881 \angle -39,224^\circ} = 0,739 \angle 69,224^\circ \text{ A} \checkmark$$

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

$$= 0,619 \sin(314t + 36,046^\circ) + 0,739 \sin(942t + 69,224^\circ) \text{ A} \checkmark \quad (13)$$

2.2 Berekening van die WGK-waarde van die stroom en spanning:

(a)

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

$$= \sqrt{\frac{0,619^2 + 0,739^2}{2}} \checkmark$$

$$= 0,682 \text{ A} \checkmark$$

(b)

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

$$= \sqrt{\frac{250^2 + 150^2}{2}} \checkmark$$

$$= 206,155 \text{ V} \checkmark$$

(2 + 2) (4)
[17]

VRAAG 3

- 3.1
- Die koper- of I^2R -verliese in die wikkeling $\checkmark \checkmark$
 - Werwelstroom of strooiverliese in die wikkelings en kern $\checkmark \checkmark$ (4)

- 3.2 Gegee: $S = 15 \text{ kVA}$ $P_o = 140 \text{ W}$
 $V_1 = 3\,000$ $P_{sc} = 150 \text{ W}$
 $V_2 = 500 \text{ V}$ $V_{sc2} = 35 \text{ V}$
 $f = 50 \text{ Hz}$

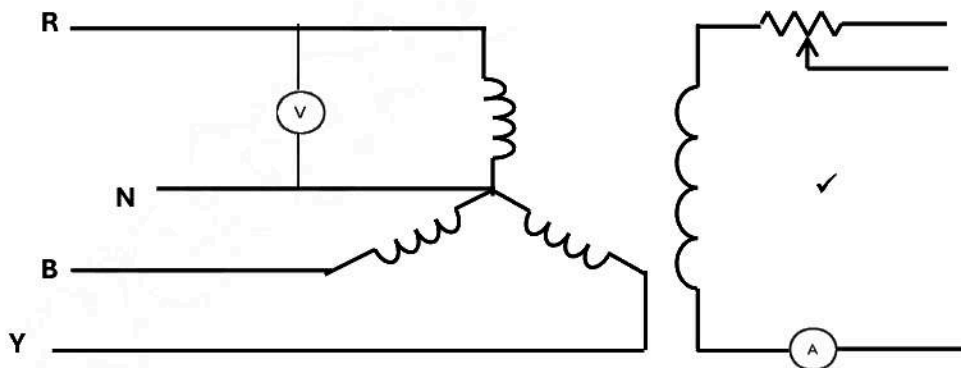
$$\begin{aligned}
 3.2.1 \quad S &= V_2 I_2 & V_{sc1} &= I_2 Z_{e2} \\
 I_2 &= S/V_2 & Z_{e2} &= V_{sc}/I_2 \checkmark \\
 &= 15\,000/500 = 30\,A \checkmark & &= 35/30 = 1,167\,\Omega \checkmark \\
 P_{sc} &= (I_2)^2 \cdot R_{e2} & Z_{e2} &= \sqrt{(R_{e2})^2 + (X_{e2})^2} \\
 R_{e2} &= P_{sc}/(I_2)^2 \checkmark & X_{e2} &= \sqrt{(Z_{e2})^2 - (R_{e2})^2} \checkmark \\
 &= 150/(30)^2 = 0,167\,\Omega \checkmark & &= \sqrt{(1,167)^2 - (0,167)^2} \\
 & & &= 1,155\,\Omega \checkmark \checkmark \quad (8)
 \end{aligned}$$

$$\begin{aligned}
 3.2.2 \quad \% \text{Regulasie} &= \frac{I_2 (R_{e2} \cos \theta_2 + X_{e2} \sin \theta_2)}{V_2} \\
 &= \frac{30([0,167 \times 0,8] + [1,155 \times 0,6])}{500} \checkmark \\
 &= 4,960\% \checkmark \quad (2)
 \end{aligned}$$

$$\begin{aligned}
 3.2.3 \quad \eta &= \frac{S \cos \theta}{S \cos \theta + P_o + P_{sc}} \times 100\% \\
 &= \frac{15\,000 \times 0,85}{(15\,000 \times 0,85) + 140 + 150} \times 100\% \checkmark \\
 &= 97,776\% \checkmark \quad (2) \\
 & \quad [16]
 \end{aligned}$$

VRAAG 4

4.1



Die alternator word teen normale spoed op oop kring aangedryf. ✓ 'n Reeks lesings word geneem van ooreenstemmende waardes van veldstroom en fase-emk. ✓ Fase-emk word dan vertikaal teen veldstroom geteken. ✓ (4)

4.2

$$\begin{aligned}
 4.2.1 \quad f &= \frac{N \cdot p}{60} \\
 \therefore N &= \frac{60 \cdot f}{p} = \frac{60 \times 50}{4} \checkmark \\
 &= 750\,r/min \checkmark \quad (2)
 \end{aligned}$$

$$4.2.2 \quad \text{Aantal gleuwe per pool} = \text{Aantal gleuwe} / \text{aantal pole} \\ = 72/8 = 9 \checkmark$$

$$\alpha = 180^\circ / \text{Aantal gleuwe per pool} = 180^\circ / 9 = 20^\circ \checkmark$$

$$n = \text{Aantal gleuwe per pool} / \text{Fases} = 9/3 = 3 \checkmark$$

$$Z_p = Z_T/3 = (72 \times 10)/3 = 240 \checkmark$$

$$\text{Vir volsteekwikkeling:} \quad K_p = 1$$

$$K_d = \frac{\sin\left(\frac{n \cdot \alpha}{2}\right)}{n \sin\left(\frac{\alpha}{2}\right)} = \frac{\sin\left(\frac{3 \times 20^\circ}{2}\right)}{3 \sin\left(\frac{20^\circ}{2}\right)} \checkmark = 0,96 \checkmark$$

$$E_p = 2 \cdot K_f \cdot K_d \cdot K_p \cdot f \cdot \phi \cdot Z_p = 2 \times 1,11 \times 0,96 \times 1 \times 50 \times 0,08 \times 240 \checkmark \\ = 2\,045,952 \text{ V} \checkmark$$

$$E_L = \sqrt{3} \cdot E_p = \sqrt{3} \times 2\,045,952 = 3\,543,693 \text{ V} \checkmark$$

(9)
[15]

VRAAG 5

5.1 Gegee: 'n Driefase-induksiemotor

Aantal pole = 4
f = 50 Hz

$R_{\text{rotor}} = 0,3 \text{ ohm/fase}$
 $T_{\text{max}} = 186,5 \text{ N.m}$
 $N_1 = 1\,350 \text{ r/min}$

5.1.1 Berekening van die glip waarteen maksimum wringkrag geproduseer word:

$$N_1 = 60 \cdot f/p = 60 \times 50/2 = 1\,500 \text{ r/min} \checkmark$$

$$S = \frac{N_1 - N_2}{N_1} \times 100\%$$

$$= \frac{1\,500 - 1\,350}{1\,500} \times 100\%$$

$$= 10\% \checkmark$$

(2)

5.1.2 $R_2 = S \cdot X_0$

$$\therefore X_0 = R_2/S = 0,3/0,1$$

$$= 3 \Omega \checkmark$$

(1)

5.1.3

Rotorinset

$$= 2 \cdot \pi \cdot N_1 T / 60 = 2 \times \pi \times 1\,500 \times 186,5 / 60 = 29\,295,351 \text{ W} \checkmark$$

$$\begin{aligned} \text{Rotorstroomverlies} &= S \cdot \text{rotorinset} = 0,1 \times 29\,295,351 \\ &= 2\,929,535 \text{ W} \checkmark \end{aligned}$$

$$\text{Rotorstroomverlies} = 3 \cdot I_2^2 R_2$$

$$\therefore I_2 = \sqrt{\frac{\text{Rotorstroomverlies}}{3 \cdot R_2}} = \sqrt{\frac{2\,929,535}{3 \times 0,3}} = 57,053 \text{ A} \checkmark$$

$$Z_2 = \sqrt{R_2^2 + (S \cdot X_0)^2} = \sqrt{0,3^2 + (0,1 \times 3)^2} = 0,424 \Omega \checkmark$$

$$E_2 = I_2 \cdot Z_2 = 57,053 \times 0,424 = 24,190 \text{ V} \checkmark$$

$$E_2 = S \cdot E_0$$

$$\therefore E_0 = E_2 / S = 24,190 / 0,1 = 241,9 \text{ V} \checkmark$$

(6)

5.1.4

Metode 1:

$$n_1 = N_1 / 60 = 1\,500 / 60 = 25 \text{ r/sec} \checkmark$$

$$\begin{aligned} T_{\text{start}} &= \frac{3 \cdot S \cdot E_0^2 \cdot R_2}{2 \cdot \pi \cdot n_1 \cdot (R_2^2 + [S \cdot X_0]^2)} = \frac{3 \times 1 \times 241,9^2 \times 0,3}{2 \times \pi \times 25 \times (0,3^2 + [1 \times 3]^2)} \\ &= 36,883 \text{ N} \cdot \text{m} \checkmark \end{aligned}$$

Metode 2:

$$\begin{aligned} \frac{T_{\text{max}}}{T_{\text{start}}} &= \frac{S_1 \cdot R_2}{R_2^2 + (S_1 \cdot X_0)^2} \times \frac{R_1^2 + (S_2 \cdot X_0)^2}{S_2 \cdot R_2} \\ \frac{186,5}{T_{\text{start}}} &= \frac{0,1 \times 0,3}{0,3^2 + (0,1 \times 3)^2} \div \frac{1 \times 0,3}{0,3^2 + (1 \times 3)^2} = 5,05 \checkmark \\ T_{\text{start}} &= \frac{186,5}{5,05} = 36,931 \text{ N} \cdot \text{m} \checkmark \end{aligned}$$

(2)

5.2

Kraglewering	= 130 kW
Toevoerspanning	= 3,3 kV
Frekwensie	= 50 Hz
Sinchrone spoed	= 600 r/min
Vollasglip	= 1,5%
Vollasarbeidsfaktor	= 0,85
Statorkoperverliese	= 2,4 kW
Statorysterverliese	= 3,3 kW
Wrywing- en wikkeling- (rotasie) verliese	= 1,4 kW

$$\begin{aligned}
 5.2 \quad 5.2.1 \quad P_{\text{mech}} &= \text{Kraglewering} - \text{Wrywing} - \text{en wikkelingverliese} \\
 &= 130 + 1,4 \\
 &= 131,4 \text{ kW} \checkmark
 \end{aligned}$$

Metode 1:

$$\begin{aligned}
 \text{Rotorkoperverliese} &= \frac{S}{(1-S)} \times P_{\text{mech}} \checkmark \\
 &= \frac{0,015}{(1-0,015)} \times 131,4 \checkmark \\
 &= 2,001 \text{ kW} \checkmark
 \end{aligned}$$

Metode 2:

$$\begin{aligned}
 N_2 &= N_1 - SN_1 = 600 - (0,015 \times 600) = 591 \text{ r/min} \checkmark \\
 P_{\text{mec}} &= \frac{2 \cdot \pi \cdot N_2 \cdot T}{60} = \frac{2 \times \pi \times 591 \times T}{60} \\
 \therefore T &= \frac{60 \times 131,4 \times 10^3}{2 \times \pi \times 591} = 2\,123,143 \text{ N.m} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Rotorkoperverlies} &= \frac{2 \cdot \pi \cdot (N_1 - N_2) \cdot T}{60} \\
 &= \frac{2 \times \pi \times (600 - 591) \times 2\,123,143 \checkmark}{60} \\
 &= 2,001 \text{ kW} \checkmark \quad (4)
 \end{aligned}$$

$$\begin{aligned}
 5.2.2 \quad \text{Statorlewering} &= \text{Rotorinset} \\
 &= \frac{2 \cdot \pi \cdot N_1 T}{60} = \frac{2 \times \pi \times 600 \times 2\,123,143}{60} \\
 &= 133,401 \text{ kW} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Statorverliese} &= \text{Statorkoper} - + \text{Statoryesterverliese} \\
 &= 2\,400 + 3\,300 = 5\,700 \text{ W}
 \end{aligned}$$

$$\begin{aligned}
 \text{Statorinset} &= \text{Statorlewering} + \text{Statorverliese} = 133,401 + 5,7 \\
 &= 139,101 \text{ kW} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 P_{\text{in}} &= \sqrt{3} \cdot V_L \cdot I_L \cos \theta \quad [\text{Laat } P_{\text{in}} = \text{Statorinset}] \\
 \therefore I_L &= \frac{P_{\text{in}}}{\sqrt{3} \cdot V_L \cdot \cos \theta} = \frac{139,101 \times 10^3}{\sqrt{3} \times 3\,300 \times 0,85} = 28,631 \text{ A} \checkmark
 \end{aligned}$$

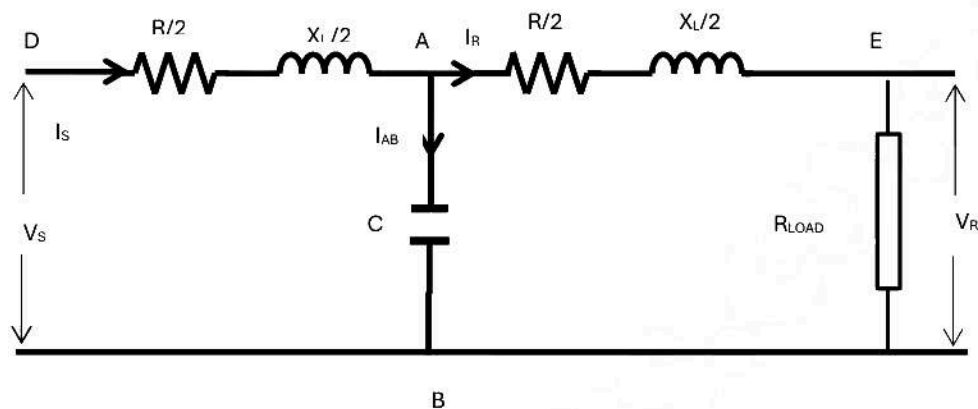
(3)
[18]

VRAAG 6

6.1 Regulering van 'n transmissielyn - is die styging of daling in spanning✓ aan die ontvangkant wanneer die vallas afgeskakel word,✓ terwyl die sendkantspanning konstant bly✓.

(3)

6.2 Gegee: 'n Lang transmissielyn



$S = 80 \text{ MVA}$; $V_L = 145 \text{ kV}$; $\text{pf} = 0,8 \text{ naloop}$

$$R = 0,15 \, \Omega/\text{km} \times 200 \text{ km} = 30 \, \Omega$$

$$L = 1,5 \text{ mH/km} \times 200 \text{ km} = 300 \text{ mH}$$

$$X_C = 10,66 \, \Omega/\text{km} \times 200 \text{ km} = 2132 \, \Omega$$

$$R/2 = 30/2 = 15 \, \Omega \checkmark$$

$$X_L = 2 \cdot \pi \cdot f \cdot L = 2 \times \pi \times 50 \times 0,3 = 94,248 \, \Omega$$

$$X_L/2 = 94,248/2 = 47,124 \, \Omega \checkmark$$

$$V_R = V_L/\sqrt{3} = 145\,000/\sqrt{3} = 83\,715,789 \angle 0^\circ \text{ V} \checkmark$$

(i) Bepaling van die sendkantstroom:

Metode 1:

$$S = \sqrt{3} \cdot V_L \cdot I_L$$

$$I_L = S/\sqrt{3} \cdot V_L$$

$$= 80 \times 10^6 / \sqrt{3} \times 145\,000$$

$$= 318,538 \angle -36,87^\circ \text{ A} \checkmark$$

Metode 2:

$$P = S \cdot \cos \theta = 80 \times 10^6 \times 0,8 = 64 \text{ MW}$$

$$P = \sqrt{3} \cdot V_L \cdot I_L \cdot \cos \theta$$

$$\therefore I_L = P/\sqrt{3} \cdot V_L \cos \theta$$

$$= 64 \times 10^6 / \sqrt{3} \times 145 \times 10^3 \times 0,8$$

$$= 318,538 \angle -36,87^\circ \text{ A} \checkmark$$

(ii) Bepaling van die sendkantspanning:

$$Z_{AE} = \frac{R}{2} + \frac{jX_L}{2} = 15 + j47,124 = 49,454 \angle 72,343^\circ \Omega \checkmark$$

$$V_{AE} = I_R \cdot Z_{AE} = 318,538 \angle -36,87^\circ \times 49,454 \angle 72,343^\circ \\ = 15752,978 \angle 35,473^\circ \text{ V} \checkmark$$

$$V_{AB} = V_{AE} + V_R = 15752,978 \angle 35,473^\circ + 83715,789 \angle 0^\circ \checkmark \\ = 96976,689 \angle 5,409^\circ \text{ V} \checkmark$$

$$Z_{AB} = R - jX_C = 0 - j2132 = 2132 \angle -90^\circ \Omega \checkmark$$

$$I_{AB} = V_{AB} / Z_{AB} = 96976,689 \angle 5,409^\circ / 2132 \angle -90^\circ = 45,486 \angle 95,409^\circ \text{ A} \checkmark \\ I_S = I_{AB} + I_R = 45,486 \angle 95,409^\circ + 318,538 \angle -36,87^\circ \checkmark \\ = 289,898 \angle -30,204^\circ \text{ A} \checkmark$$

$$V_{DA} = I_S \cdot Z_{DA} = 289,898 \angle -30,204^\circ \times 49,454 \angle 72,343^\circ \\ = 14336,616 \angle 42,139^\circ \text{ V} \checkmark$$

$$V_S = V_{DA} + V_{AB} = 14336,616 \angle 42,139^\circ + 96976,689 \angle 5,409^\circ \checkmark \\ = 108805,293 \angle 9,929^\circ \text{ V} \checkmark$$

$$V_L = \sqrt{3} \cdot V_S = \sqrt{3} \times 108805,293 = 188,456 \text{ kV} \checkmark$$

(iii) Bepaling van die arbeidsfaktor:

$$\text{Arbeidsfaktor} = \cos(30,204^\circ + 9,929^\circ) = \cos 40,133^\circ = 0,765 \text{ naloop} \checkmark \quad (17) \\ [20]$$

TOTAAL: 100