task_d9io924n0e3du21g_with_calculation

Student Group

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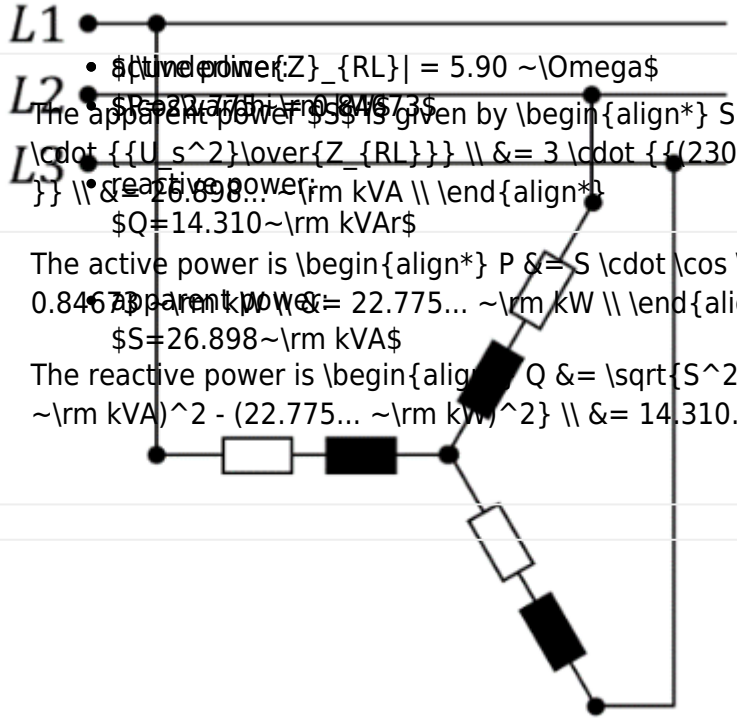
Exercise E20 Magnetic Circuit
(written test, approx. 10 % of a 120-minute written test, SS2024)

A symmetrical and balanced three-phase power net, driven with $230 ~\rm V$ / $400 ~\rm V$ / $50 ~\rm Hz$ three-phase power net. Each single string has a resistor $R=5 ~\Omega$ and an inductance of $L=10 ~\rm mH$.



1. Calculate the $\cos \varphi$, and the magnitude of the impedance $|Z|$ for a single string.

2. Calculate the total power, the apparent power, and the reactive power.

Result

- active power: $P=22.775~\rm kW$
- apparent power: $S=26.898~\rm kVA$
- reactive power: $Q=14.310~\rm kVAr$

Path

1. Calculate the $\cos \varphi$, and the magnitude of the impedance $|Z|$ for a single string.

Path

- $|\underline{Z}_{RL}| = 5.90 ~\Omega$
- $\cos \varphi = 0.8467...$

The apparent power S is given by \begin{align*} S &= 3 \cdot U_s \cdot I_s \\ &= 3 \cdot {{U_s^2}\over{Z_{RL}}} \\ &= 3 \cdot {{(230~\rm V)^2}\over{ 5.90 ~\Omega }} \\ &= 26.898... ~\rm kVA \\ \end{align*}

The active power is \begin{align*} P &= S \cdot \cos \varphi \\ &= 26.898... \cdot 0.8467... \\ &= 22.775... ~\rm kW \\ \end{align*}

The reactive power is \begin{align*} Q &= \sqrt{S^2 - P^2} \\ &= \sqrt{ (26.898... ~\rm kVA)^2 - (22.775... ~\rm kW)^2} \\ &= 14.310...~\rm kVAr \\ \end{align*}

The phase φ is given by: \begin{align*} \varphi &= \arctan \left({{X_{L}}\over{R}} \right) \\ &= \arctan \left({{2\pi \cdot f \cdot L}\over{R}} \right) \\ &= \arctan \left({{2\pi \cdot 50 {~\rm Hz} \cdot 10 \cdot 10^{-3} {~\rm H}}\over{5 ~\Omega}} \right) \\ &= 0.5609 ... \hat{=} +32° \\ \end{align*}

With this, the $\cos \varphi$ becomes \begin{align*} \cos \varphi &= \cos(0.5609 ...) \\ &= 0.84673...\\ \end{align*}

The impedance is given by: \begin{align*} |\underline{Z}_{RL}| &= \sqrt{X_{L}^2 + R^2} \\ &= \sqrt{(2\pi \cdot f \cdot L)^2 + R^2} \\ &= \sqrt{(2\pi \cdot 50 {~\rm Hz} \cdot 10 \cdot 10^{-3} {~\rm H})^2 +(5 ~\Omega)^2} \\ &= 5.905... ~\Omega\\ \end{align*}