TET4100 Kretsanalyse – Løsning

Institutt: Elkraftteknikk Dato: 2012.08.15

Øving 4

14) Effekt 4.A

14.1) $\phi_v - \phi_i = \phi > 0 \quad \rightarrow \quad \textit{Induktiv}$

14.2) $pf = \cos(\phi)$

14.3) Spenningsviser: $\hat{\boldsymbol{V}}_{\boldsymbol{k}} = \hat{V}_k \measuredangle \phi_v$

Strømviser: $\hat{\boldsymbol{I}}_{\boldsymbol{k}} = \hat{I}_k \measuredangle \phi_i$

Kompleks effekt: $\boldsymbol{S}_{\boldsymbol{k}} = \dfrac{\hat{\boldsymbol{V}}_{\boldsymbol{k}} \cdot \hat{\boldsymbol{I}}^*_{\boldsymbol{k}}}{2}$

Tilsynelatende effekt: $|\boldsymbol{S}_{\boldsymbol{k}}| = \dfrac{\hat{V}_k \cdot \hat{I}_k}{2}$

Aktiv effekt: $P_k = \Re(\boldsymbol{S}_{\boldsymbol{k}})$ or $P_k = |\boldsymbol{S}_{\boldsymbol{k}}| \cdot \cos(\phi)$ forbrukt

Reaktiv effekt: $Q_k = \Im(\boldsymbol{S}_{\boldsymbol{k}})$ or $Q_k = |\boldsymbol{S}_{\boldsymbol{k}}| \cdot \sin(\phi)$ forbrukt

14.4) kompleks effekt: $\boldsymbol{S}'_k = P'_k + jQ'_k$

Tilsynelatende effekt: $|\boldsymbol{S}'_k|$

14.5) $\hat{I}'_k = \dfrac{2|\boldsymbol{S}'_k|}{\hat{V}_k} \qquad \phi'_i = \phi_v - \tan^{-1}\dfrac{Q'_k}{P'_k}$

15) Effekt 4.B

15.1) $Z_T = R_T + j\omega_f L_T$

$Z_L = R_L + j\omega_f L_L$

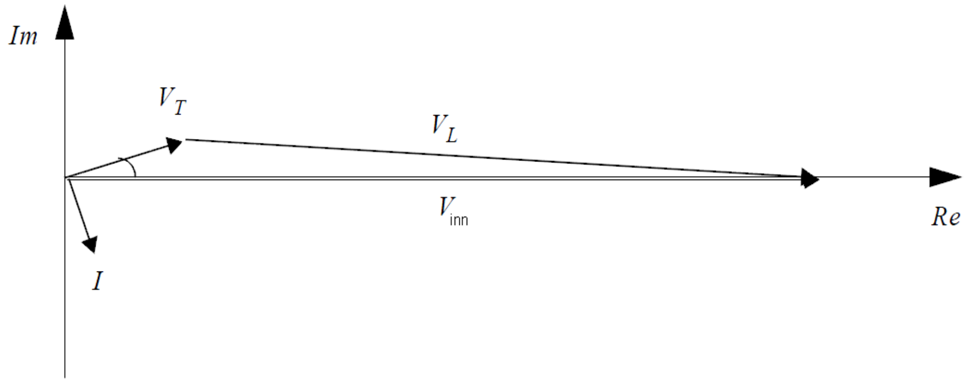
$Z = Z_T + Z_L$

$\boldsymbol{I} = \frac{\boldsymbol{V}_{inn}}{Z} = \frac{V_{inn}}{|Z|} \measuredangle \phi_v - \phi_Z = I \measuredangle \phi_i$

$i(t) = I \cdot \sqrt{2} \cdot \cos(\omega t + \phi_i)$

15.2) $\boldsymbol{V}_{\boldsymbol{T}} = \boldsymbol{I} \cdot Z_T = I \cdot |Z_T| \measuredangle \phi_i + \phi_{Z_T}$

$\boldsymbol{V}_{\boldsymbol{L}} = \boldsymbol{I} \cdot Z_L = I \cdot |Z_L| \measuredangle \phi_i + \phi_{Z_L}$



15.3) $\phi_L = \phi_{v,L} - \phi_i$

$|\boldsymbol{S}_{\boldsymbol{L}}| = V_L \cdot I$

$P_L = |\boldsymbol{S}_{\boldsymbol{L}}| \cdot \cos(\phi_L)$

$Q_L = |\boldsymbol{S}_{\boldsymbol{L}}| \cdot \sin(\phi_L)$

15.4) $\phi = \phi_v - \phi_i$

$pf = \cos(\phi)$

16) Effekt 4.C

16.1) $|\boldsymbol{S}|=\sqrt{P^2+Q^2}$

$$\cos(\phi)=\frac{P}{|\boldsymbol{S}|}$$

$$\phi=\cos^{-1}\left(\frac{P}{|\boldsymbol{S}|}\right)$$

$$\phi=\phi_v-\phi_i$$

$$\phi_v=\phi+\phi_i$$

$$|\boldsymbol{S}|=I_{eff}\cdot V_{g,eff}$$

$$V_{g,eff}=\frac{|\boldsymbol{S}|}{I_{eff}}$$

$$\boldsymbol{V_g}=V_{g,eff}\measuredangle\phi_v$$

17) Effekt 4.D

17.1) $X_{L_1} = \omega_f L_1 \quad X_{C_1} = -\frac{1}{\omega_f C_1} \quad X_{L_2} = \omega_f L_2 \quad X_{C_2} = -\frac{1}{\omega_f C_2}$

$$Z_{par} = \left(R_1 + j X_{C_1}\right) || \left(R_2 + j\left(X_{L_2} + X_{C_2}\right)\right)$$

$$R_a = R_1 \quad X_a = X_{C_1} \quad R_b = R_2 \quad X_b = X_{L_2} + X_{C_2}$$

$$R_{par} = \frac{R_a^2 R_b + R_a R_b^2 + R_a X_b^2 + X_a^2 R_b}{(R_a + R_b)^2 + (X_a + X_b)^2}$$

$$X_{par} = \frac{R_a^2 X_b + X_a R_b^2 + X_a X_b^2 + X_a^2 X_b}{(R_a + R_b)^2 + (X_a + X_b)^2}$$

$$Z_{par} = R_{par} + j X_{par}$$

$$Z = R_{par} + j\left(X_{par} + X_{L_1}\right)$$

$$R = R_{par} \quad X = X_{par} + X_{L_1}$$

$$Z = R + j X$$

$$Z = \sqrt{R^2 + X^2} \measuredangle atan\left(\frac{X}{R}\right) = |Z| \measuredangle \phi_Z$$

17.2) $\boldsymbol{V}_s = \frac{\hat{V}_s \measuredangle 0}{\sqrt{2}}$

$$\boldsymbol{I} = \frac{\boldsymbol{V}_s}{Z} = \frac{V_s}{|Z|} \measuredangle \phi_v - \phi_Z = I \measuredangle \phi_i$$

$$\hat{I} = \sqrt{2}\, I$$

$$i(t) = \hat{I} \cos(\omega_f t + \phi_i)$$

17.3) $\phi = \phi_v - \phi_i$

$$|\boldsymbol{S}| = V_s \cdot I$$

$$P = |\boldsymbol{S}| \cdot \cos(\phi)$$

$$Q = |\boldsymbol{S}| \cdot \sin(\phi)$$

18) Effekt 4.E

18.1) $V_g = \frac{\hat{V}_g}{\sqrt{2}}$

$$X_L = \omega_f L \qquad X_C = -\frac{1}{\omega_f C}$$

$$Z = R + j(X_L + X_C) = |Z| \measuredangle \phi$$

$$I = \frac{V_g}{|Z|}$$

$$P_{Last} = I^2 \cdot R$$

$$Q_{Last} = I^2 \cdot X_C$$

$$|\boldsymbol{S}_{\boldsymbol{Last}}| = \sqrt{P_L^2 + Q_L^2}$$

18.2) $P_L = 0$

$$Q_L = I^2 X_L$$

18.3) $\boldsymbol{I} = \frac{\boldsymbol{V}_{\boldsymbol{g}}}{Z} = I \measuredangle -\phi$

$$\boldsymbol{S}_{\boldsymbol{g}} = -\boldsymbol{V}_{\boldsymbol{g}} \boldsymbol{I}^* = V_g I \measuredangle \pi + \phi$$

$$P_g = \Re(\boldsymbol{S}_{\boldsymbol{g}})$$

$$Q_g = \Im(\boldsymbol{S}_{\boldsymbol{g}})$$

18.4) $P_{Last} + P_L + P_g = 0$

$$Q_{Last} + Q_L + Q_g = 0$$

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19) Effekt 4.F

19.1) $Z_{Li}=R_{Li}+j\,X_{Li}$

$Z_{La}=R_{La,1}+\left(\left(R_{La,2}+j\,X_{La,1}\right)\|\,j\,X_{La,2}\right)$

$$Z_{La}=R_{La,1}+\frac{R_{La,2}\,X_{La,2}^{2}}{R_{La,2}^{2}+(X_{La,1}+X_{La,2})^{2}}+j\,\frac{R_{La,2}^{2}\,X_{La,2}+X_{La,1}\,X_{La,2}^{2}+X_{La,1}^{2}\,X_{La,2}}{R_{La,2}^{2}+(X_{La,1}+X_{La,2})^{2}}$$

$$R_{La}=R_{La,1}+\frac{R_{La,2}\,X_{La,2}^{2}}{R_{La,2}^{2}+(X_{La,1}+X_{La,2})^{2}}$$

$$X_{La}=\frac{R_{La,2}^{2}\,X_{La,2}+X_{La,1}\,X_{La,2}^{2}+X_{La,1}^{2}\,X_{La,2}}{R_{La,2}^{2}+(X_{La,1}+X_{La,2})^{2}}$$

$Z_{La}=R_{La}+j\,X_{La}$

$Z_{tot}=Z_{Li}+Z_{La}=R_{Li}+R_{La}+j\left(X_{Li}+X_{La}\right)$

$$\boldsymbol{I_1}=\frac{\boldsymbol{V_s}}{Z_{tot}}$$

Spenningsdeler: $\boldsymbol{V_{La}}=\boldsymbol{V_s}\cdot\frac{Z_{La}}{Z_{tot}}$

19.2) $\boldsymbol{S_{La}}=\boldsymbol{V_{La}}\cdot\boldsymbol{I_1^{*}}$

$P_{La}=\Re(\boldsymbol{S_{La}})$

$Q_{La}=\Im(\boldsymbol{S_{La}})$

$$pf_{La}=\frac{P_{La}}{|\boldsymbol{S_{La}}|}$$

19.3) $I_1=|\boldsymbol{I_1}|$

$P_{Li}=R_{Li}\cdot I_1^{2}$

$Q_{Li}=X_{Li}\cdot I_1^{2}$

19.4) $Z_{La,Komp} = Z_{La} || Z_C = \left(R_{La} + j X_{La}\right) || j X_C$

$$Z_{La,Komp} = \frac{X_C^2 R_{La}}{R_{La}^2 + \left(X_{La} + X_C\right)^2} + j \frac{\left(R_{La}^2 X_C + X_{La}^2 X_C + X_C^2 X_{La}\right)}{R_{La}^2 + \left(X_{La} + X_C\right)^2}$$

$pf_{La,Komp} = 1 \rightarrow Z_{La,komp}\ må\ være\ reell$

$R_{La}^2 X_C + X_{La}^2 X_C + X_C^2 X_{La} = 0$

$$X_C = -\frac{X_{La}^2 + R_{La}^2}{X_{La}} \qquad \left(Teoretisk\ også\ X_C = 0\right)$$

$$C = -\frac{1}{\omega_f X_C}$$

19.5) $$Z_{La,Komp} = \frac{X_C^2 R_{La}}{R_{La}^2 + \left(X_{La} + X_C\right)^2}$$

$Z_{tot,Komp} = Z_{Li} + Z_{La,Komp}$

$$I_{1,Komp} = \frac{V_s}{\left|Z_{tot,Komp}\right|}$$

$P_{Li,Komp} = R_{Li} \cdot I_{1,Komp}^2$

$Q_{Li,Komp} = X_{Li} \cdot I_{1,Komp}^2$