lignes moyennes $80 \leq L \leq 160$ Km

dans ce Type de lignes on a : R_L, X_L, X_C

il existe deux Type de schémas possible en T et en π

Schéma équivalent en T

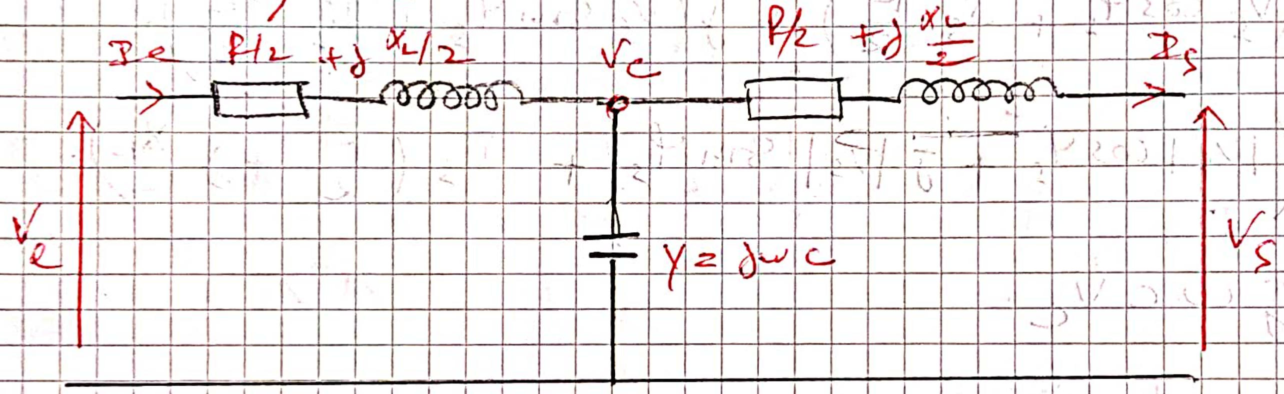


Schéma équivalent en π

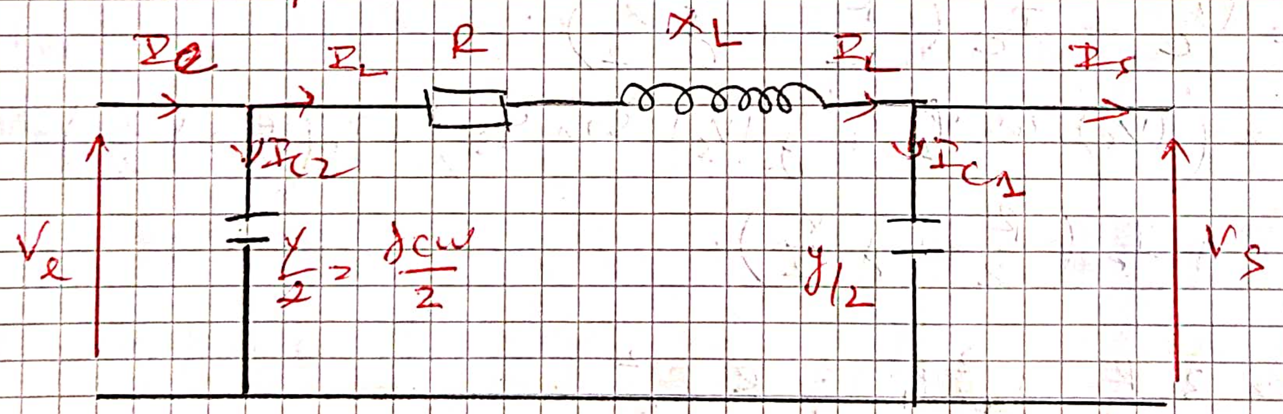
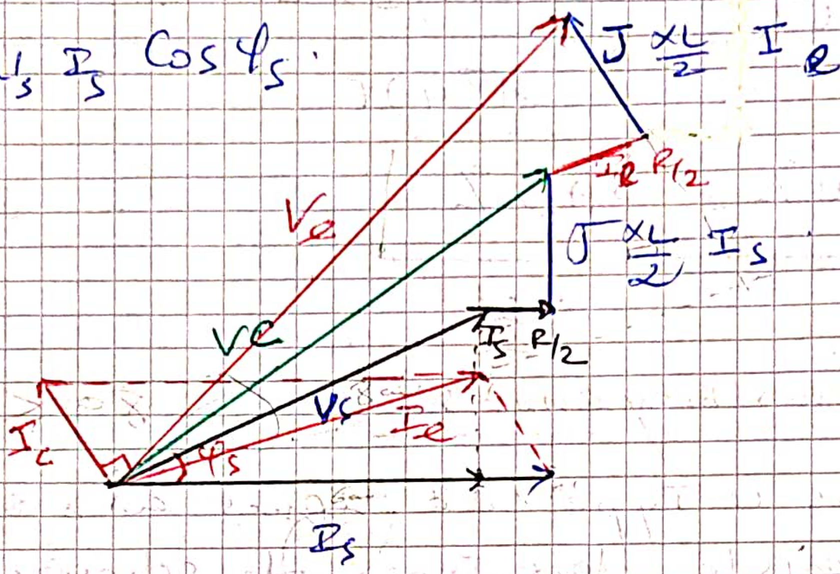


diagramme vectoriel du schéma en T

P_s, $\cos\varphi_s$, U_s → données connues

$P_s = \sqrt{3}\, U_s I_s \cos\varphi_s$



I_s → Donnée recherchée

$$I_s = \frac{P_s}{\sqrt{3}\, U_s \cos\varphi}$$

$$I_C = j V_C \omega C$$

$$V_C = \left(V_s \cos\varphi_s + I_s \frac{R}{2}\right) + j\left(V_s \sin\varphi_s + I_s \frac{X_L}{2}\right)$$

$$V_C = \left(|V_s| \cos\varphi_s + j|V_s| \sin\varphi_s\right) + I_s\left(\frac{R}{2} + j\frac{X_L}{2}\right)$$

$$I_C = j\omega C V_C$$

$$\bar{I}_e = \bar{I}_s + \bar{I}_C = \bar{I}_s + j\omega C V_C$$

$$\vec{V}_e = V_C + I_e\left(\frac{R}{2} + j\frac{X}{2}\right)$$

$$V_e = \left(|V_s| \cos\varphi_s + j|V_s| \sin\varphi_s\right) + I_s\left(\frac{R}{2} + j\frac{X}{2}\right) + I_e\left(\frac{R}{2} + j\frac{X}{2}\right)$$

$$\Delta p = 3\frac{R}{2} I_s^2 + \frac{3}{2} R I_e^2$$

$$\eta\,\% = \frac{P_s}{P_e} \times 100 = \frac{P_s}{P_s + \Delta P} \times 100$$

$$\eta\% = \frac{P_s}{P_s + 3\frac{R}{2}(I_s + I_e)^2}$$

$$\Delta U\% = \frac{V_c}{V_e - V_s} \times 100$$

$Z = R + jX$

$\frac{Z}{2} = \frac{R}{2} + j\frac{X}{2}$

$Y = j\omega C$

pour déterminer les paramètres A, B, C, D pour le schéma en T.

$$V_c = V_s + I_s \frac{Z}{2}$$

$$I_c = Y V_c = Y\left(V_s + I_s \frac{Z}{2}\right)$$

$$I_e = I_s + I_c$$

$$V_e = V_c + I_e \frac{Z}{2} = V_s + I_s \frac{Z}{2} + I_e \frac{Z}{2}$$

$$\begin{cases} I_e = I_s + I_c = I_s + Y\left(V_s + I_s \frac{Z}{2}\right) \\ V_e = V_s + I_s \frac{Z}{2} + \frac{Z}{2}\left(I_s + Y\left(V_s + I_s \frac{Z}{2}\right)\right) \end{cases}$$

$$V_e = V_s + I_s \frac{Z}{2} + I_s \frac{Z}{2} + \frac{YZ}{2} V_s + I_s Y \frac{Z^2}{4}$$

$$V_e = V_s\left(1 + \frac{YZ}{2}\right) + I_s\left(\frac{Z}{2} + \frac{Z}{2} + Y\frac{Z^2}{4}\right)$$

$$V_e = \left(1 + \frac{YZ}{2}\right)V_s + \left(1 + \frac{YZ}{4}\right)Z I_s$$

$$V_c = V_s + I_s \frac{Z}{2}$$

$$I_c = V_c Y \Rightarrow I_c = \left(V_s Y + I_s \frac{Z}{2} Y\right)$$

$$V_e = V_c + I_e \frac{Z}{2}$$

$$I_e = I_s + I_c = I_s + I_c = I_s + V_s Y + I_s \frac{ZY}{2}$$

$$I_e = V_s Y + I_s \left(1 + \frac{ZY}{2}\right)$$

$$V_e = V_s + I_s \frac{Z}{2} + \left(I_s + V_s Y + I_s \frac{Z}{2} Y\right) \frac{Z}{2}$$

$$V_e = V_s + I_s \frac{Z}{2} + I_s \frac{Z}{2} + V_s \frac{YZ}{2} + I_s \frac{Z^2}{4} Y$$

$$\begin{cases} V_e = V_s \left(1 + \frac{YZ}{2}\right) + I_s Z \left(1 + \frac{YZ}{4}\right) \\ I_e = V_s Y + I_s \left(1 + \frac{ZY}{2}\right) \end{cases}$$

$$\begin{cases} A = 1 + \frac{YZ}{2} \\ B = Z\left(1 + \frac{YZ}{4}\right) \\ C = Y \\ D = \left(1 + \frac{YZ}{2}\right) \\ AD - BC = 1 \end{cases}$$

$$\begin{cases} V_e = A V_s + B I_s \\ I_e = C V_s + D I_s \\ AD - BC = 1 \end{cases}$$

$$\left(1 + \frac{YZ}{2}\right)^2 - YZ\left(1 + \frac{YZ}{4}\right)$$

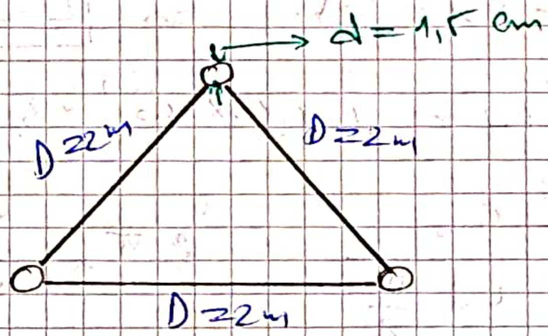
$$= 1 + YZ + \frac{Y^2 Z^2}{4} - YZ - \frac{Y^2 Z^2}{4} = 1$$

Exercice :

Determiner le rendement ainsi que la chute de tension d'une ligne de transmission triphasé de 100 Km. avec une frequence de 50 HZ. a la fin de cette ligne on a une puissance de 20 MW avec une tension de 66 KV et un $\cos\varphi = 0,8$, cette ligne est en cuivre avec une resistance lineique de $0,1\ \Omega/Km$. Sa configuration est donnée par la figure suivante

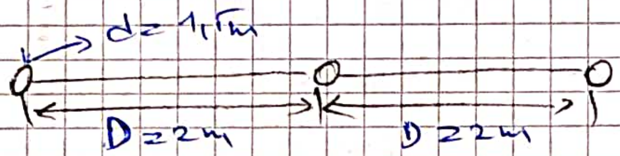
$\eta = ?$

$\Delta U\% = ?$



en utilisant le schéma en T

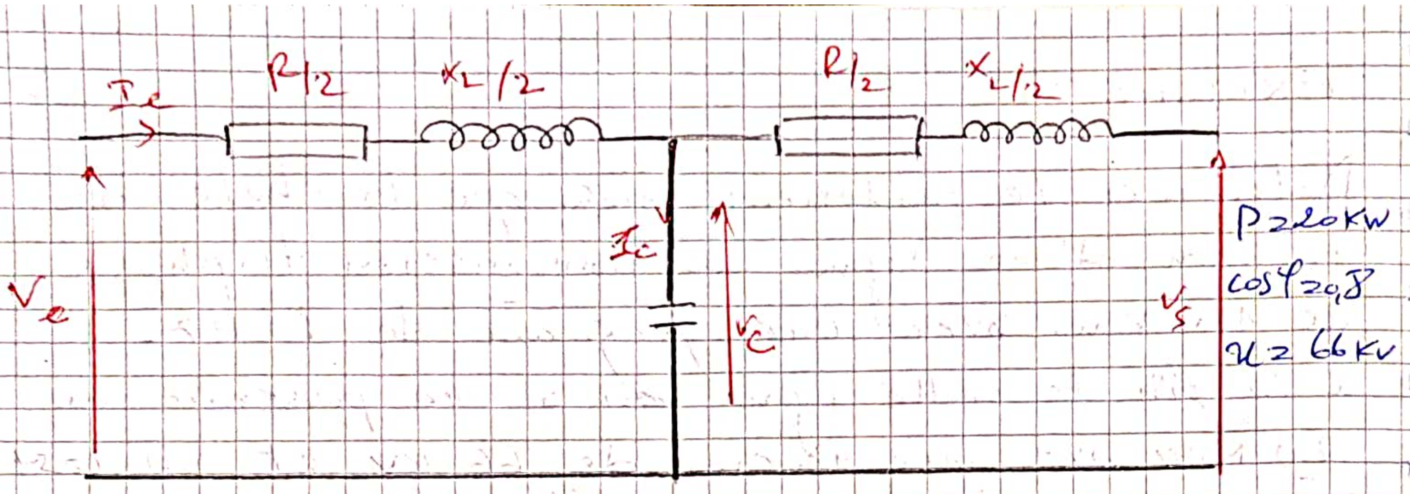
" " " " en π



$$D_m = \sqrt[3]{D \times D \times 2D}$$

$$L = 2\times10^{-7} \ln \frac{D}{R} \qquad L = 2\times10^{-7} \ln \frac{D_m}{R}$$

$$C = 2\pi \frac{\varepsilon_0}{\ln \frac{D_m}{R}}$$



$$L_0 = 2 \times 10^{-7} \ln \frac{200}{0,75} = 1,11 \times 10^{-6} \, H/m.$$

$$L = L_0 \times l = 1,11 \times 10^{-6} \times 100 \times 10^{3} = 1,11 \times 10^{-1} \, H.$$

$$L = 1,17 \times 10^{-1} \, H. \Rightarrow \boxed{L = 11,17 . 10^{-2} \, H}$$

$$X_L = L\omega = 1,11 \times 10^{-1} \times 3,14 = 34,85 \, \Omega = 35,1 \, \Omega$$

$$C_0 = 2\pi \frac{\varepsilon_0}{\ln \frac{D}{R}} = 2\pi \times \frac{8,85 \times 10^{-12}}{\ln \frac{200}{0,75}}$$

$$\boxed{C_0 = 9,95 \times 10^{-12} \, F}$$

$$C = C_0 l = 9,95 \times 10^{-12} \times 100 \times 10^{3} = 9,95 \times 10^{-7} \, F$$

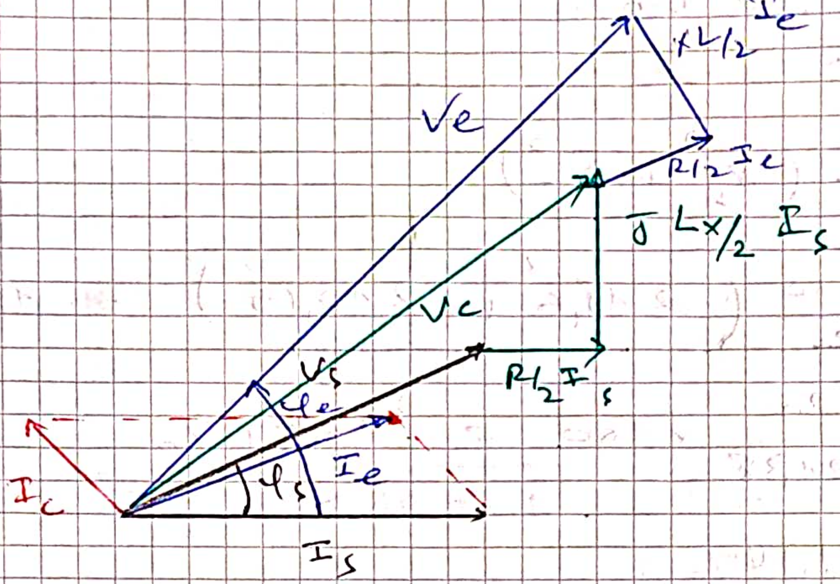
$$\boxed{C = 0,995 \, \mu F}$$

$$\boxed{R = 0,1 \times 100 = 10 \, \Omega}$$

$$I_s = \frac{20 . 10^{-6}}{\sqrt{3} \times 66 \times 10^{3} \times 0,8} = 2,18,68 \, A$$

$$V_s = \frac{U_s}{\sqrt{3}} = \frac{66 \times 10^{-3}}{\sqrt{3}} = 38104 \, V.$$

le 11/02/2020



$V_c = (V_s \cos\varphi_s + I_s R/_2) + j(V_s \sin\varphi + I_s x_L/_2)$.

$V_c = (38104 \times 0,8 + 218,6 \times 5 + j(38104 \times 0,6 + 218,6 \times 17,55)$

$V_c = 31576,2 + j\ 26688,83$

$I_c = j \cancel{V_c} \omega c \qquad I_c = j V_c \omega C$.

$I_c = j(31576,2 + j\ 26698,83) \times 314 \times 0,995 \times 10^{-6}$

$= j\ 9,86 - 8,31$

$I_c = -8,31 + j\ 9,86$

$I_e = I_s + I_c = 218,68 - 8,31 + j\ 9,86$.

$= 210,3 + j\ 9,86$.

$I_e = \sqrt{(210,3)^2 + (9,86)^2} = 210,59\ A$

$I_e = 210,59\ A$

$$\eta = \frac{P_s}{P_e} \times 100.$$

$$\Delta P = \frac{3R}{2}\left(I_s^2 + I_e^2\right)$$

$$\Delta P = \frac{3 \times 10}{2}\left(218{,}6^2 + 210{,}19^2\right) = 1{,}38\ MW.$$

$$\eta\ \% = \frac{20}{21{,}38} \times 100 = 91{,}74\ \%$$

$$\eta\% = 91{,}74\%$$

$$V_e = V_c + I_e\,(Z/2) = (31576{,}2 + j\,26698{,}83) + (210{,}3 + j\,9{,}86)\,(5 + j\,17{,}5).$$

$$V_e = 31576 + j\,26698{,}83 + 1051{,}3 - 173{,}08 + j\,49{,}3 + j\,3690{,}76$$

$$V_e = 32454{,}45 + 30438{,}89$$

$$|V_e| = \sqrt{(32454{,}45)^2 + (30438{,}89)^2} = 44495{,}13\ V.$$

$$\Delta U\% = \frac{V_e - V_s}{V_s} \times 100$$

$$\Delta U\% = \frac{44495{,}13 - 38105}{38105} \times 100 = 16{,}77\ \%$$

$$\Delta U\% = 16{,}77\ \%$$

$$A = D = 1 + \frac{YZ}{2}$$

$$B = Z\left(1 + \frac{YZ}{4}\right).$$

$$C = Y.$$

$$V_e = A V_s + B I_s.$$

$$I_e = C V_s + D I_s$$

$$Z = \sqrt{R^2 + (L\omega)^2} = \sqrt{10^2 + 35{,}1^2} = 36{,}44\ \Omega.$$

$$Y = C\omega = 314 \times 0{,}995 \times 10^{-6} = 3{,}126 \times 10^{-4}$$

$$YZ = 36{,}44 \times 3{,}12 \times 10^{-4} = 1{,}13 \times 10^{-2}$$

$$A = D = 1 + \frac{1{,}13}{2} \times 10^{-6} = 1{,}0056.$$

$$B = 36{,}44\left(1 + \frac{1{,}13 \times 10^{-2}}{4}\right) = 36{,}54.$$

$$C = 3{,}126 \times 10^{-4}$$

$$D = 1{,}0056.$$

207,94 A ⊖

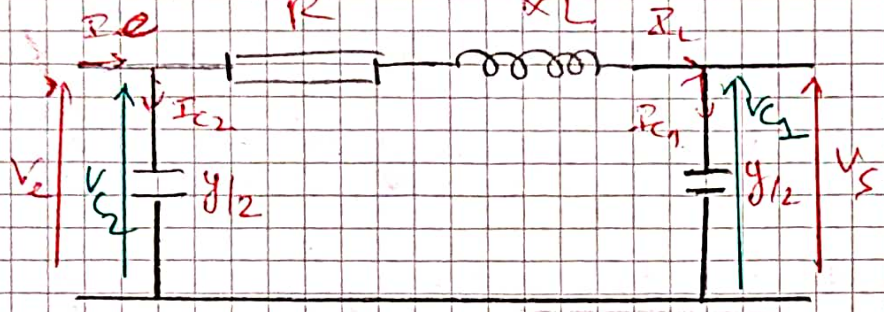
$$I_e = 3{,}126 \times 10^{-4} \times 38105 + 1{,}0056 \times 218{,}63 = 231{,}76\ A.\ \oplus$$

⊖ ⊕

$$V_e = 1{,}0056 \times 38105 + 36{,}54 \times 218{,}63 = 46{,}307\ kV$$

les ligne Moyenne en π

calcul des paramètres d'une ligne moyenne en π



$V_s = V_{C1}$

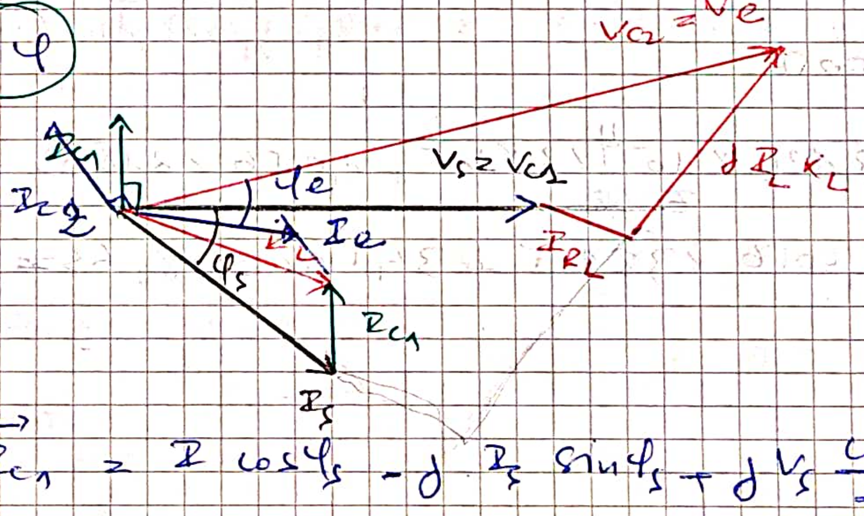
$I_{C1} = V_{C1}\frac{y}{2} = j V_s \frac{\omega C}{2}$

$I_{C2} = V_{C2}\frac{y}{2} = j V_e \frac{\omega C}{2}$

$I_L = I_s + I_{C1}$

$I_e = I_L + I_{C2}$

$P_s = \sqrt{3}\, U I \cos\varphi$



$\vec{I_L} = \vec{I_s} + \vec{I_{C1}} = I\cos\varphi_s - j I_s \sin\varphi_s + j V_s \frac{\omega C}{2}$

$I_C = I_s \cos\varphi_s - j I_s \sin\varphi_s + j V_s \frac{\omega C}{2}$ 34

$I_e = I_L + I_{C2} = I_s \cos\varphi_s - I_s \sin\varphi_s + j V_s \frac{\omega C}{2} + j V_e \frac{\omega C}{2}$

$$V_e = V_{C_2} = V_s + Z I_C$$

$$V_e = V_s + (R + j X_L)(I_L)$$

$$V_e = V_s (R + j X_L) \left[(I_s \cos \varphi_s - I_s \sin \varphi_s) + j V_s \frac{C\omega}{2} \right]$$

$$I_e = I_s \cos \varphi_s - I_s \sin \varphi_s + V_s j \frac{\omega C}{2} + j \frac{\omega C}{2} \left[V_s + (I_s \cos \varphi_s - I_s \sin \varphi_s) + (R + j X_L) + j V_s \frac{\omega C}{2} \right]$$

$$V_e = V_s + (R + j X_L) \left[(I_s \cos \varphi_s - I_s \sin \varphi_s) + j V_s \frac{\omega C}{2} \right]$$

$$\boxed{\Delta U\% = \frac{V_e - V_s}{V_s} \times 100}$$

$$\boxed{\eta\% = \frac{P_s}{P_e} \times 100 = \frac{P_s}{P_s + \Delta P} \times 100}$$

$$\boxed{\eta\% = \frac{P_s}{P_s + 3 R I_C^2}}$$

$$I_{C_1} = V_s \frac{Y}{2}$$

$$I_L = I_s + I_{C_1} = I_s + V_s \frac{Y}{2}$$

$$V_e = V_s + I_L (Z) = V_s + Z \left(I_s + V_s \frac{Y}{2} \right)$$

$$\Rightarrow V_e = V_s + I_s Z + V_s \frac{YZ}{2} + I_s Z = V_s \left(1 + \frac{YZ}{2} \right) + I_s Z$$

$$\begin{cases} A = 1 + \frac{YZ}{2} \\ B = Z \end{cases}$$

$$I_e = I_L + I_{C_2} = I_L + V_e \frac{Y}{2}$$

$$I_e = I_s + V_s \frac{Y}{2} + \left(V_s + I_s Z + V_s \frac{YZ}{2}\right) \frac{Y}{2}$$

$$I_e = I_s + V_s \frac{Y}{2} + V_s \frac{Y}{2} + I_s \frac{ZY}{2} + V_s \frac{Y^2}{4} Z$$

$$I_e = V_s\left(\frac{Y}{2} + \frac{Y}{2} + \frac{Y^2 Z^2}{4}\right) + I_s\left(1 + \frac{ZY}{2}\right)$$

$$I_e = V_s Y\left(1 + \frac{YZ}{4}\right) + I_s\left(1 + YZ\right)$$

$$\begin{cases} C = Y\left(1 + \frac{YZ}{4}\right) \\ D = \left(1 + \frac{YZ}{2}\right) \end{cases}$$

$$AD - BC = 1$$

$$\Rightarrow \left(1 + \frac{YZ}{2}\right)^2 - ZY\left(1 + \frac{YZ}{4}\right) \overset{?}{=} 1$$

$$\Rightarrow 1 + \frac{2YZ}{2} + \frac{Y^2Z^2}{4} - ZY -$$

Exercice

$P = 20\,MW$

$\cos\varphi = 0{,}8$

$R = 10\,\Omega$

$X_L = 35{,}1\,\Omega$

$C = 0{,}995\,\mu F$

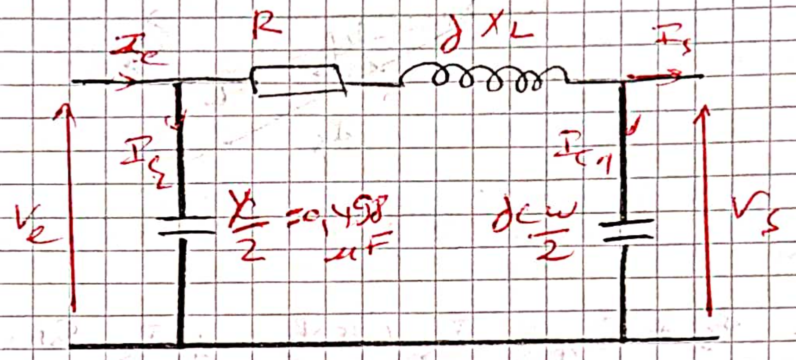
$U_s = 66\,KW$

$V_e = ?$

$I_e = ?$

$\eta\% = ?$

$\Delta U\% = ?$

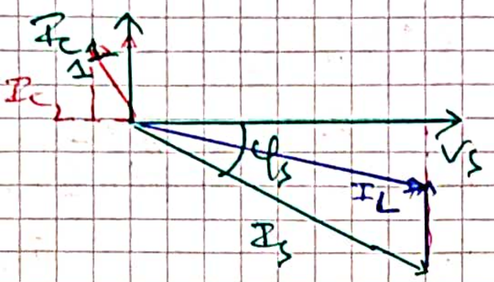


$$V_s = \frac{U_s}{\sqrt{3}} = \frac{66 \times 10^3}{\sqrt{3}} = 38106\,V.$$

$$I_s = \frac{P}{\sqrt{3}\,U_s \cos\varphi} = \frac{20 \times 10^6}{1{,}732 \times 66 \times 10^3 \times 0{,}8} = 218{,}6\,A$$

$$I_{c_1} = j V_s \frac{C\omega}{2} = j \times 38106 \times 314 \times 0{,}498 \times 10^{-6} = j\,5{,}96\,A$$

$I_s = 218{,}6\,A.$
$I_{c_1} = j\,5{,}96\,A$



$$I_L = I_S + I_{C1} = I_S \cos\varphi_S - j I_S \sin\varphi_S + I_{C1}$$

$$I_L = 218{,}69 \times 0{,}8 - j\, 218{,}69 \times 0{,}6 + j\, 5{,}96$$

$$I_L = 174{,}95 - j\, 125{,}25$$

$$V_e = V_s + Z\, I_L = 38106 + (10 + j\, 35{,}1)(174{,}95 - j\, 125{,}25)$$

$$= 38106 + 1749{,}5 + 4396{,}275 - j\, 1252{,}5 + j\, 6140{,}75$$

$$V_e = 44251{,}77 + 4915{,}25\, j$$

$$|V_e| = \sqrt{(44251{,}77)^2 + (4915{,}25)^2} = 44523{,}9\ V$$

$$|V_e| = 44523{,}9\,V$$

$$\Delta P = 3 R I_L^2 = 3 \times 10 \times (215{,}16)^2 = 1{,}388\ MW$$

$$\eta\,\% = \frac{20 \times 10^6}{20\times 10^6 + 1{,}388 \times 10^6} = 93{,}5\ \%$$

$$I_L = \sqrt{174{,}95^2 + 125{,}25^2} = 215{,}16\ A$$

$I_L = 215,16 \text{ A}$.

$\Delta P = 1,388 \text{ MW}$.

$\eta\% = 93,5\%$

$I_{C_2} = j V_e \frac{c\omega}{2} = j\left(44251,77 + j\,4915,25\right)\left(\frac{314 \times 0,995 \times 10^{-6}}{2}\right)$

$= j\left(44251,77 + j\,4915,25\right)\left(156,21 \times 10^{-6}\right)$.

$I_{C_2} = j\,6,91 - 0,76$

$I_e = I_L + I_{C_2}$.

$I_e = (174,95 - j\,125,25) + (j6,91 - 0,76)$

$I_e = 174,19 - j\,118,34$.

$|I_e| = \sqrt{(174,19)^2 + (132,16)^2} = 210,58 \text{ A}$.

$\Delta U\% = \frac{(V_e - V_s)}{V_s} \times 100 = \frac{44523,9 - 38106}{38106} \times 100$

$\Delta U\% = 16,86\%$