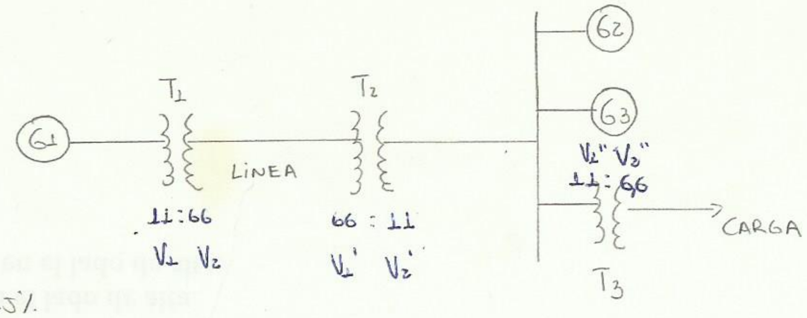
1) Dibujar el diagrama de reactancias en por unidad del siguiente sistema



G1: 11 KV, 20 MVA, 15%

T1: 11/66 KV, 30 MVA, 15%

LINEA: j60 Ω

T2: 66/11 KV, 30 MVA, 15%

G2: 11 KV, 10 MVA, 10%

G3: 11 KV, 10 MVA, 10%

T3: 11/6.6 KV, 2.5 MVA, 8%

USAR COMO BASE 20 MVA y 66 KV

SOLUCIÓN

$$Z_{pu} = \% \left(\frac{KV_{viejo}}{KV_{nuevo}}\right)^2 \left(\frac{MVA_{nuevo}}{MVA_{viejo}}\right)$$

$$Z_{pu} = \frac{Z_{VIESA}}{\frac{KV_{Base}^2}{MVA_{Base}}}$$

PARA G1

$$Z_{pu} = 0.15\left(\frac{11}{11}\right)^2\left(\frac{20}{20}\right) = j\,0.15\,[\Omega]\,pu$$

PARA G2

$$Z_{pu} = 0.1\left(\frac{11}{11}\right)^2\left(\frac{20}{10}\right) = j\,0.2\,[\Omega]\,pu$$

PARA T1

$$Z_{pu} = 0.15\left(\frac{11}{11}\right)^2\left(\frac{20}{30}\right) = j\,0.1\,[\Omega]\,pu$$

PARA G3

$$Z_{pu} = 0.1\left(\frac{11}{11}\right)^2\left(\frac{20}{10}\right) = j\,0.2\,[\Omega]\,pu$$

PARA T3

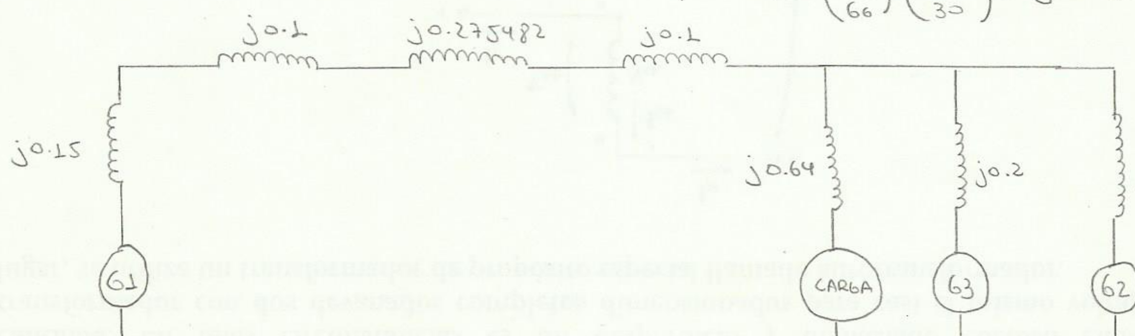
$$Z_{pu} = 0.08\left(\frac{11}{11}\right)^2\left(\frac{20}{2.5}\right) = j\,0.64\,[\Omega]\,pu$$

PARA LINEA

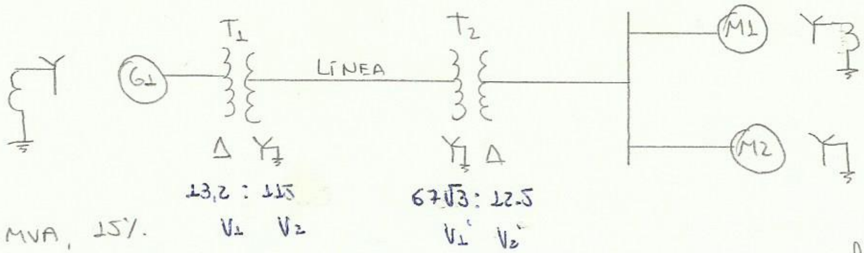
$$Z_{pu} = \frac{j60}{\frac{66^2}{20}} = j\,0.275482\,[\Omega]\,pu$$

PARA T2

$$Z_{pu} = 0.15\left(\frac{66}{66}\right)^2\left(\frac{20}{30}\right) = j\,0.1\,[\Omega]\,pu$$



2) En el siguiente sistema de potencia



G1: 13.8 KV, 30 MVA, 15%.

T1: 13.2 Δ / 115 Y KV, 35 MVA, 10%.

LÍNEA: j80 Ω

T2: 3 Transformadores 1φ c/u de 12.5/67 KV, 10 MVA, 10%.

M1: 12,5 KV, 20 MVA, 20%.

M2: 12,5 KV, 10 MVA, 20%.

Bases, los valores de placa del generador

SOLUCIÓN

PARA G1

$$Z_{pu} = 0.15\left(\frac{13.8}{13.8}\right)^2\left(\frac{30}{30}\right) = j0.15\ [\Omega]\ pu$$

PARA T1

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \Rightarrow V_2 = 13.8\left(\frac{115}{13.2}\right) = 120,227273\ [V]$$

$$Z_{pu} = 0.1\left(\frac{115\sqrt{3}}{120,227273}\right)^2\left(\frac{30}{35}\right) = j0.078423\ [\Omega]\ pu$$

PARA LÍNEA

$$Z_{pu} = \frac{j80}{\frac{120,227273^2}{30}} = j0,166037\ [\Omega]\ pu$$

PARA T2

$$\frac{V_1'}{V_2'} = \frac{N_1'}{N_2'} \Rightarrow V_2' = 120,227273\left(\frac{12.5}{67\sqrt{3}}\right) = 12,950233\ [V]$$

$$Z_{pu} = 0.1\left(\frac{12.5}{12,950233}\right)^2\left(\frac{30}{30}\right) = j0,096523\ [\Omega]\ pu$$

PARA M1

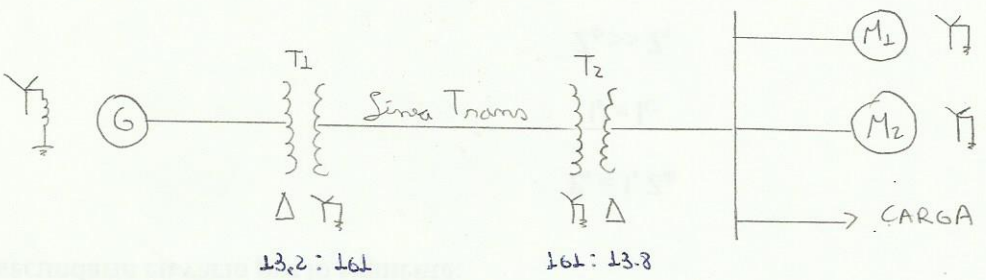
$$Z_{pu} = 0.2\left(\frac{12.5}{12.950233}\right)^2\left(\frac{30}{20}\right) = j0,279503\ [\Omega]\ pu$$

PARA M2

$$Z_{pu} = 0.2\left(\frac{12.5}{12,950233}\right)^2\left(\frac{30}{10}\right) = j0,559006\ [\Omega]\ pu$$

③ El diagrama unifilar del sistema mostrado en la figura, tomando como voltaje base 161 KV para la línea de transmisión, y una base de 20 MVA en el sistema. Encontrar los valores en por unidad de todos sus componentes. Los valores de placa de los componentes del sistema son:

Generador G:	15 MVA, 13.8 KV,	X = 0,15 pu
Motor M_1:	5 MVA, 13.2 KV,	X = 0.15 pu
Motor M_2:	5 MVA, 13.2 KV,	X = 0.15 pu
Trans T_1:	25 MVA, 13.2 KV - 161 KV,	X = 0.10 pu
Trans T_2:	15 MVA, 13.8 KV - 161 KV,	X = 0.10 pu
Carga:	4 MVA, fp = 0.8 (adelanto)	
Línea Trans:	X = j100 Ω	



Solución

Para Generador

$$Z_{pu} = 0{,}15\left(\frac{13.8}{13.8}\right)^2\left(\frac{15}{15}\right) = j\,0.15\,[\Omega]\,pu$$

Para T_1

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \Rightarrow V_2 = 13.8\left(\frac{161}{13.2}\right) = 168.318182\,[\Omega]\,pu$$

$$Z_{pu} = 0.10\left(\frac{161}{168.318182}\right)^2\left(\frac{15}{25}\right) = j\,0{,}054896\,[\Omega]\,pu$$

Para Línea

$$Z_{pu} = \frac{j100}{\frac{168.318182^2}{15}} = j\,0{,}052946\,[\Omega]\,pu$$

Para T_2

$$\frac{V_1'}{V_2'} = \frac{N_1'}{N_2'} \Rightarrow V_2' = 168.318182\left(\frac{13.8}{161}\right) = 14.427273\,[V]$$

$$Z_{pu} = 0.10\left(\frac{13.8}{14.427273}\right)^2\left(\frac{15}{15}\right) = j\,0.091493\,[\Omega]\,pu$$

Para M_1

$$Z_{pu} = 0.15\left(\frac{13.2}{14.427273}\right)^2\left(\frac{15}{5}\right) = j\,0{,}376697\,[\Omega]\,pu$$

PARA M_2

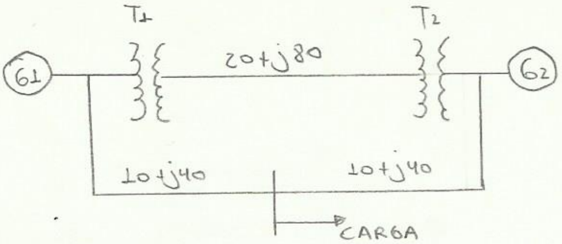
$$Z_{pu} = 0.15\left(\frac{13.2}{14.427273}\right)^2\left(\frac{15}{5}\right) = j0.376697\ [\Omega]\ pu$$

PARA CARGA

Asumimos que el voltaje de la Carga es 13.2KV ya que no se especifica

$$\bar{S} = \bar{V}\bar{I}^* \Rightarrow \bar{S} = \frac{|\bar{V}||\bar{V}^*|}{Z^*} \Rightarrow \bar{S} = \frac{|V|}{Z^*}$$

Dibujar el diagrama de impedancias en por unidad del sistema mostrado en la figura tomando como bases 100MVA y 154KV base en la línea de transmisión



G1: 50MVA, 13.8KV, X=0.15

G2: 20MVA, 14.4KV, X=0.15

T1: 60MVA, 13.2KV/161KV, X=0.10

T2: 25MVA, 13.2KV/161KV, X=0.10

CARGA: 25MVA, 0.8 fp (atraso)

Para G1

$$\frac{V_1}{V_2} = \frac{13.2}{161} \Rightarrow V_1 = 154\left(\frac{13.2}{161}\right) = 12.62608696\ \text{KV}$$

$$Z_{pu} = 0.15\left(\frac{13.8}{12.62608696}\right)^2\left(\frac{100}{50}\right) = j\,0.3583784407$$

Para T1

$$Z_{pu} = 0.10\left(\frac{161}{154}\right)^2\left(\frac{100}{60}\right) = j\,0.1821625344$$

Para línea (20+j80)

$$Z_{pu} = \frac{20+j80}{\frac{154^2}{100}} = 0.08433125316 + j0.337325016$$

Para T2

$$Z_{pu} = 0.10\left(\frac{161}{154}\right)^2\left(\frac{100}{25}\right) = j\,0.4371900826$$

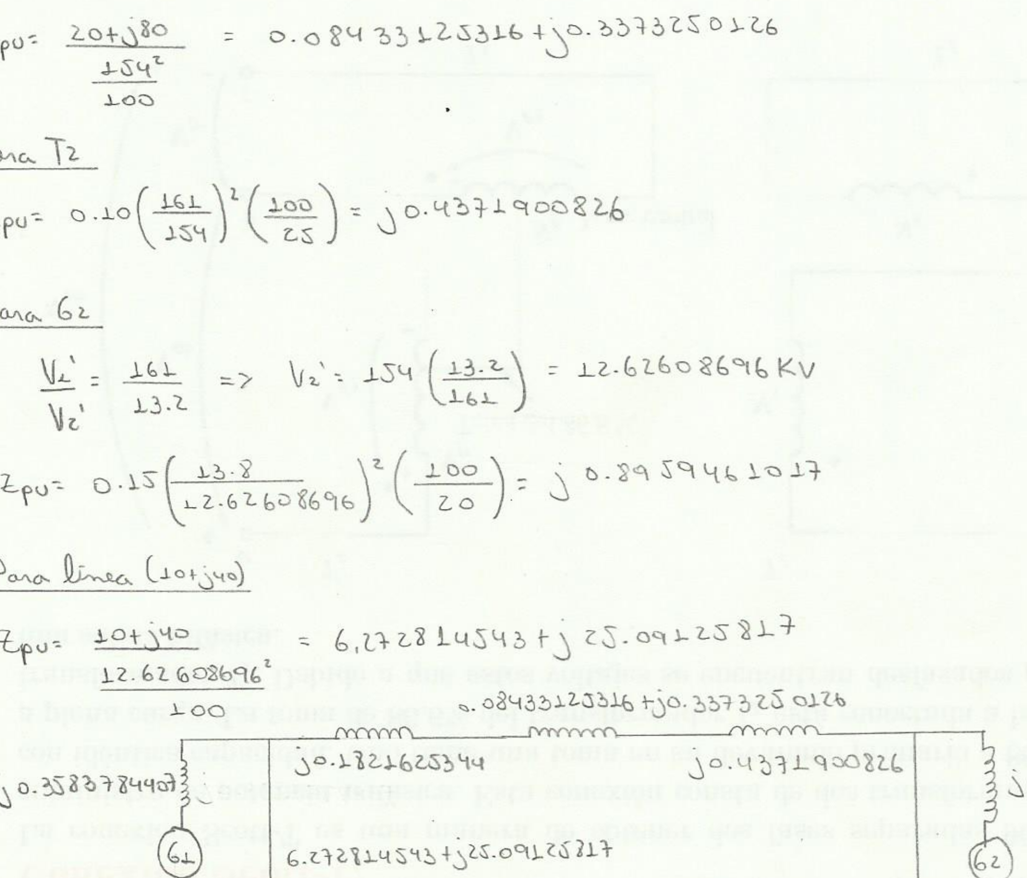
Para G2

$$\frac{V_1'}{V_2'} = \frac{161}{13.2} \Rightarrow V_2' = 154\left(\frac{13.2}{161}\right) = 12.62608696\ \text{KV}$$

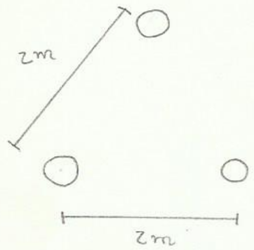
$$Z_{pu} = 0.15\left(\frac{13.8}{12.62608696}\right)^2\left(\frac{100}{20}\right) = j\,0.8959461017$$

Para línea (10+j40)

$$Z_{pu} = \frac{10+j40}{\frac{12.62608696^2}{100}} = 6.272814543 + j25.09125817$$



Determine la eficiencia y regulación de una línea 3ϕ, 150Km de longitud, 50Hz la línea transmite 20MW a un fp= 0.8 (atraso) y 66KV dirigido a la carga, la resistencia de la línea es 0,075 Ω/Km, 1,5 cm de diametro del conductor 2m entre conductor



$r = 0{,}75\,cm$

$r' = 0{,}584\,cm$

$D_{eq} = 2m$

$D_{SL} = 0{,}5841\times10^{-2}\ m$

$D_{SC} = 0{,}75\,cm$

$$L = 2\times10^{-7}\ln\frac{D_{eq}}{D_{SL}} = 2\times10^{-7}\ln\left(\frac{2}{0{,}5841\times10^{-2}}\right) \Rightarrow L = 1{,}16720089\times10^{-6}\ H/m$$

$$C_{LN} = \frac{2\pi K}{\ln\frac{D_{eq}}{D_{SC}}} = \frac{2\pi K}{\ln\left(\frac{2}{0{,}075}\right)} = 9{,}959063426\times10^{-12}\ F/m$$

$$X_L = 2\pi f L = 3{,}666867225\times10^{-4}\ \Omega/m \Rightarrow X_{LT} = 55.00300837\,\Omega$$

$$X_C = 319618294\ \Omega\times m \Rightarrow X_{CT} = 2130{,}788627\,\Omega$$

LÍNEA MEDIA

$$Z = (0{,}075\times150) + j(55.00300837) = 11{,}25 + j\,55{,}00300837$$

$$Y = \frac{1}{X_C} = 4{,}693098073\times10^{-4}\angle{+90}$$

$$D = A = 1 + \frac{ZY}{2} = 1 + \frac{\left[(11.25 + j55.00300837)(4{,}693098073\times10^{-4}\angle{+90})\right]}{2}$$

$$\boxed{A = D = 0{,}9870932744 + j\,2{,}639867666\times10^{-3}}$$

$$\boxed{B = Z = 11{,}25 + j\,55.00300837}$$

$$C = Y\left(1 + \frac{ZY}{4}\right) = 4{,}693098073\times10^{-4}\angle{90}\left[1 + \frac{(11.25 + j55.00300837)(4{,}693098073\times10^{-4}\angle{90})}{2}\right]$$

$$\boxed{C = -6{,}194578928\times10^{-7} + j\,4{,}662811808\times10^{-4}}$$

$$V_S = A V_R + B I_R$$

$$V_S = 0.9870968044\angle{0.1532306207}\times\frac{66000}{\sqrt{3}}\angle{0} + 56.14172628\angle{78.44048446}\times\frac{20\times10^6}{\sqrt{3}\times66\times10^3(0.8)}\angle{-36.86}$$

$$V_{S_{LN}} = 47518.88198\angle{9.996893844}\ [V]$$

$$V_{S_{LL}} = 82305.1179\angle{9.996893844}\ [V]$$

$$\% \text{ Regulación} : \frac{\frac{V_S}{A} - V_R}{V_R} = \frac{\frac{82305.1179}{0.9870968044} - 66000}{66000}$$

$$\left[\% \text{ Regulacion} : 26,33484739\,\% \right]$$

$$\eta = \frac{P_{out}}{P_{in}} \qquad P_{erd} = I_R^{\,2}(R) = \left(\frac{20\times10^6}{\sqrt{3}\times66\times10^3(0.8)}\right)^2 (11.25) = 0.5380509642\ MW$$

$$P_{in} = P_{erd} + P_{out}$$

$$P_{in} = 0.5380509642 + \frac{20}{3} = 7,204717631\ MW$$

$$\eta = \frac{\frac{20}{3}}{7,204717631} \times 100\% \Rightarrow \left[\eta = 92.5319632\,\%\right]$$

Un generador 1ϕ a 60Hz de carga inductiva 4500 KW a $f_p = 0.8$ en atraso a 20 Km de longitud $R = 0,0195\ \Omega/Km$, $L = 0.60mH/Km$ y el voltaje de recepción se fija en 10,2 KV

a) V_S y $V_{Regulación}$

b) Agregue un capacitor para que la regulación sea el 60% del $V_{Regulación}$ en a)

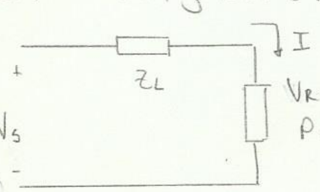
c) Eficiencia del literal a) y b)

Para a)

$$R_T = 0,0195 \times 20 = 0.39\,\Omega$$

$$X_{L_T} = 2\pi f L = 2\pi(60)\left(0.60\times10^{-3}\times20\right) = 4,523893421\,\Omega$$

$$Z_{LT} = 0.39 + j4523.893421$$



$$P = VI\cos\theta$$

$$|I| = \frac{4500K}{10,2K(0.8)} = 551.4705882\,A$$

$$I = 551.4705882\ \angle -36.86\ A$$

$$V_S = IZ_L + V_R = 551.4705882\angle -36.86 * (0.39 + j4,523893421) + 10,2\times10^3\angle 0^\circ$$

$$V_S = 12014.57265\ \angle 8.9400676\ [V]$$

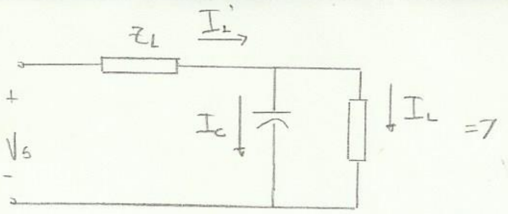
$$V_{Reg}\% = \frac{V_{sc} - V_{cc}}{V_{cc}} = \frac{12014.57265 - 10.2\times10^3}{10.2\times10^3} = 17,78992794\,\%$$

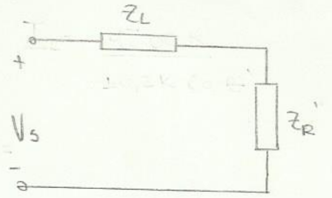
Para b)

$$V_{Reg_N} = 60\%\,(17,78992794\%) \Rightarrow V_{Reg_N} = 10,67395676\%$$

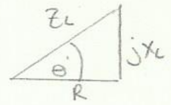
$$V_{Reg_N} = \frac{|V_{sc}| - 10.2K}{10.2K} \Rightarrow |V_{sc}| = 10,67395676\%\,(10,2K) + 10,2K$$

$$|V_{sc}| = 11,28874359\ [KV]$$





$P' = 4500\,KW$
$V_R' = 10{,}2\,KV$
$fp' = ??$



$V_S = I_L' Z_L + V_R' \Rightarrow |V_S| = |I_L'||Z_L| + |V_R'|$; $|I_L'| = \dfrac{4500\,K}{10{,}2K \cos\theta'}$; $|Z_L| = R\cos\theta' + X_L \operatorname{Sen}\theta'$

$11{,}28874359\,K = \dfrac{4500K}{10{,}2K \cos\theta'}\left(R\cos\theta' + X_L \operatorname{Sen}\theta'\right) + 10.2K$

$1{,}08874359\,K = \dfrac{441{,}1764706}{\cos\theta'}\left(0.39\cos\theta' + 4{,}523893421 \operatorname{Sen}\theta'\right)$

$\dfrac{1{,}08874359\,K \cos\theta'}{441{,}1764706} = 0.39\cos\theta' + 4.523893421 \operatorname{Sen}\theta'$

$2{,}467818804 \cos\theta' = 0.39\cos\theta' + 4.523893421 \operatorname{Sen}\theta'$

$2{,}077818804 \cos\theta' = 4.523893421 \operatorname{Sen}\theta'$

$\operatorname{Tan}\theta' = \dfrac{2{,}077818804}{4{,}523893421} \Rightarrow \theta' = 24{,}66926194$

$fp' = 0.9087322242$

$\bar{I}_L' = \bar{I}_C + \bar{I}_L$

$551.4705882\angle{-36.86} = \bar{I}_C + \dfrac{4500}{10{,}2(0.9087322242)}\angle{-24.66926194}$

$\bar{I}_C = 551.4705882\angle{-36.86} - 485.4856677\angle{-24{,}66926194}$

$\bar{I}_C = 128{,}174327\angle{-89{,}97445218}$

$\bar{V}_C = \bar{I}_C \bar{X}_C \Rightarrow X_C = \dfrac{10{,}2K\angle 0°}{128{,}174327\angle{-89{,}97445218}} = 79{,}57911881\angle 90°$

$X_C = \dfrac{1}{2\pi f C} \Rightarrow C = \dfrac{1}{X_C\, 2\pi f} = \dfrac{1}{79.57911881(2\pi)(60)}$

$\left[C = 3{,}333264334 \times 10^{-5}\,F\right]$ //

Para c)

De a) $P_{out} = 4500\,KW$; $P_{in} = I^2 R = 551.4705882^2(0.39) = 118.6067258\,KW$

$\eta\% = \dfrac{4500}{118.6067258 + 4500}\,\% \Rightarrow \left[\eta\% = 97.4319804\,\%\right]$ //

De b) $P_{out} = 4500\,kW$; $P_{in} = \left[\dfrac{4500}{10{,}2\cos(24{,}66926194)}\right]^2(0.39) = 91.92157006\,KW$

$\eta\% = \dfrac{4500}{4500 + 91.92157006} \times 100\% \Rightarrow \left[\eta\% = 97.99818946\,\%\right]$ //

Determine el voltaje generado y factor de potencia de un Sist 3ϕ, 50 Hz; esta transmitiendo en una linea de 160 Km de longitud y su carga de 100 MVA a 0.8 fp en atraso y 132 KV. La resistencia por Km es 0,16 Ω, inductancia por Km es 1.2 mH y la capacitancia por Km es 0,0082 μF

Solución

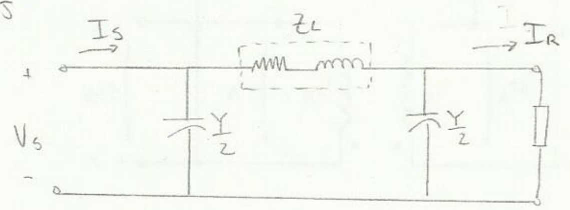
$$R = 0.16\frac{\Omega}{Km}(160) = 25.6\,\Omega$$

$$X_L = 2\pi f L = 2\pi(50)\left(1.2\frac{mH}{Km}\right)(160) = j60.31857895\,\Omega$$

$$X_{C_{LN}} = \frac{1}{2\pi f C} = \frac{1}{2\pi(50)(0.0082\times10^{-6})} \quad \Omega * Km\left(\frac{1}{160\,Km}\right) = -j2426.142425\,\Omega$$

$$Z = (25.6 + j60.31857895)\,\Omega$$

$$Y = \frac{1}{X_C} = \frac{1}{-j2426.142425} = 4.121769562\times10^{-4}\angle 90\ \mho$$



$$D = A = 1 + \frac{ZY}{2} = 1 + \frac{(25.6+j60.31857895)(4.121769562\times10^{-4}\angle 90)}{2} = 0.9875831283\angle 0.3060868794$$

$$B = Z = 65.52626166\angle 67.00299233$$

$$C = Y\left(1+\frac{ZY}{4}\right) = 1 + \frac{(65.52626166\angle 67.00299233)(4.121769562\times10^{-4}\angle 90)}{2} = 4.070590078\times10^{-4}\angle 90.30608688$$

$$V_R = \frac{132K\angle 0}{\sqrt{3}} = 76.21023553\angle 0^\circ\ [KV]$$

$$S_{3\phi} = \sqrt{3}V_{LL}I_R^* \Rightarrow I_R = \frac{100\times10^6}{\sqrt{3}\times132\times10^3}\angle -36.86 = 437.3865676\angle -36.86\ [A]$$

$$V_S = AV_R + BI_R = 0.9875831283\angle 0.3060868794\,(76.21023553\times10^3\angle 0) + 65.52626166\angle 67.00299233\,(437.3865676\angle -36.86)$$

$$V_{S_{LN}} = 101.1354775\angle 8.411425501\ [KV]$$

$$I_S = CV_R + DI_R = 4.070590078\times10^{-4}\angle 90.30608688\,(76.21023553\angle 0^\circ) + 0.9875831283\angle 0.3060868794\,(437.3865676\angle -36.86)$$

$$I_S = 431.9369865\angle -36.55062067$$

$$V_{SLL} = \sqrt{3}V_{SLN} \Rightarrow \left[V_{SLL} = 175.1717855\angle 8.411425501\,[KV]\right]$$

$$fp = \cos\left[8.411425501 - (-36.55062067)\right]$$

$$\left[fp = 0.7075750275\ (\text{atraso})\right]$$

Una linea de transmision de un circuito a 60Hz tiene una longitud de 370 Km (230 millas). Los conductores son del tipo Rook con espaciamiento plano horizontal y 7.25 m (23.8 pies) entre ellos. La carga en la linea es de 125MW a 215KV con un factor de potencia de 100%. Encuentre el voltaje, la corriente, la potencia en el extremo generador y la regulación de voltaje de la linea. Determine tambien la longitud y la velocidad de propagación de la onda de la linea

Solución

$$D_{eq} = \sqrt[3]{(23.8)^2(2\times 23.8)} = 29.98612099 \text{ pies}$$

* De la tabla

$$X_{a_L} = j0.415\ \Omega/\text{milla} \quad ; \quad R_{50°} = 0.1603\ \Omega/\text{milla} \quad ; \quad X_{d_L} = 0.4127 \quad ; \quad X_{ac} = 0.0950\ M\Omega * \text{milla}$$

$$Z = 0.1603 + j(0.415 + 0.4127) = 0.8430796997 \angle 79.03926517\ \Omega/\text{milla}$$

$$X = -j(0.0950 + 0.1009) = 0.1959 \angle -90\ M\Omega * \text{milla}$$

$$X_c = 0.1959 \times 10^6 \angle -90\ \Omega$$

$$Y = 5.104645227 \times 10^{-6} \angle 90\ S/\text{milla}$$

$$A = \cosh \gamma l \quad ; \quad B = Z_c \,\text{Senh}\, \gamma l \quad ; \quad C = \frac{\text{Senh}\,\gamma l}{Z_c} \quad ; \quad D = \cosh \gamma l$$

$$\gamma l = \sqrt{YZ}\, l = 230\sqrt{5.104645227\times 10^{-6} \times 0.84307969} \angle \frac{79.03926517 + 90}{2}$$

$$\gamma l = 0.4771390171 \angle 84.51963259 = 0.045569 + j0.474958$$

$$Z_c = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{0.8430796997}{5.104645227\times 10^{-6}}} \angle \frac{79.03926517 - 90}{2}$$

$$Z_c = 406.3979739 \angle -5.480367415$$

$$\cosh \gamma l = \frac{1}{2} e^{0.045569} \angle \frac{0.474958(180)}{\pi} + \frac{1}{2} e^{-0.045569} \angle \frac{0.474958(180)}{\pi}$$

$$\cosh \gamma l = 0.5233116096 \angle 27.21308885 + 0.477726837 \angle -27.21308885$$

$$\cosh \gamma l = 0.8904794656 \angle 1.341406584$$

$$\text{Senh}\,\gamma l = 0.5233116096 \angle 27.21308885 - 0.477726837 \angle -27.21308885$$

$$\text{Senh}\,\gamma l = 0.4595674754 \angle 84.93928247$$

* $A = 0.8904794656 \angle 1.341406584$

* $B = 406.3979739 \angle -5.480367415 * 0.4595674754 \angle 84.93928247 = 186.7672909 \angle 79.45891506$

$$V_R = \frac{215\times 10^3}{\sqrt{3}} = 124.1303079 \angle 0°\ kV \qquad I_R = \frac{125\times 10^6}{\sqrt{3}\times 215\times 10^3 (1)} = 335.6687612 \angle 0°\ A$$

$$V_S = 0.8904794656 \angle 1.341406584 \,(124.1303079 \times 10^3) + 186.7672909 \angle 79.45891506 \,(335.6687612)$$

$$V_{S_{LN}} = 137848.0699 \angle 27.76761744$$

$$V_{reg} = \frac{\frac{V_S}{A} - V_R}{V_R} \times 100\% = \frac{\frac{137848.0699}{0.8904794656} - 124.1303079 \times 10^3}{124.1303079 \times 10^3}$$

$$\left[V_{reg} = 24.70933055\,\%\right]$$

OTRA MANERA EN P.U

Cojemos como bases 125 MVA, 215 KV

$$Z_{base} = \frac{215^2}{125} = 369.8$$

$$S_{3\phi\, Base} = \sqrt{3}\, V_{Base}\, I_{Base}\, f_p \Rightarrow I_{base} = \frac{125 \times 10^6}{\sqrt{3} \times 215 \times 10^3 (1)} = 335.6687612$$

$$V_{Rpu} = 1 \angle 0^\circ \qquad Z_{cpu} = \frac{406.3979739}{369.8} = 1.098966939$$

$$I_{Rpu} = 1 \angle 0^\circ$$

$$V_S = \left(\frac{V_R + Z_c I_R}{2}\right) e^{\gamma l} + \left(\frac{V_R - Z_c I_R}{2}\right) e^{-\gamma l}$$

$$I_S = \left(\frac{V_R/Z_c + I_R}{2}\right) e^{\gamma l} + \left(\frac{V_R/Z_c - I_R}{2}\right) e^{-\gamma l}$$

$$\frac{V_R + Z_c I_R}{2} = \frac{1\angle 0^\circ + 1.098966939 \angle -5.480367415\,(1\angle 0^\circ)}{2} = 1.048286151 \angle -2.86948259$$

$$\frac{V_R - Z_c I_R}{2} = \frac{1\angle 0^\circ - 1.098966939 \angle -5.480367415\,(1\angle 0^\circ)}{2} = 0.07042948743 \angle 131.8308145$$

$$\frac{V_R/Z_c + I_R}{2} = \frac{1\angle 0^\circ / (1.098966939 \angle -5.480367415) + 1\angle 0^\circ}{2} = 0.9538832457 \angle 2.6108848$$

$$\frac{V_R/Z_c - I_R}{2} = \frac{1\angle 0^\circ / (1.098966939 \angle -5.480367415) + 1\angle 0^\circ}{2} = 0.06408699382 \angle 137.3111819$$

$$e^{\gamma l} = e^{0.045569} \angle \frac{0.474958\,(180)}{\pi} = 1.0466623219 \angle 27.21308885$$

$$e^{-\gamma l} = e^{-0.045569} \angle -27.21\ldots = 0.955453674 \angle -27.2130885$$

$$V_{S_{pu}} = 1.048286151 \angle -2.86948259 \,(1.0446623219 \angle 27.21308885) + 0.07042948743 \angle 131.8308145 \,(0.955453674 \angle -27.2130885)$$

$$V_{Spu} = 1.11051098 \angle 27.76761745 \,[V]$$

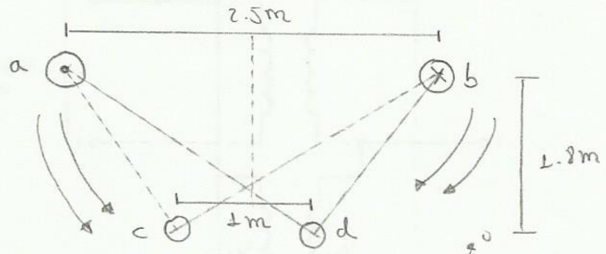
$$V_{SLN} = V_{spu} \times \frac{125K}{\sqrt{3}} = \frac{215K}{\sqrt{3}} \left(1.11051098 \angle 27.76761745\right) = 137.8480698 \angle 27.76761745 \text{ KV}$$

Una línea 1ϕ aérea de 60 Hz esta sostenida simetricamente por una cruceta horizontal. El espacio entre los centros de los conductores (a y b) es de 2.5m. Una línea telefónica tambien esta simetricamente sostenida por una cruceta horizontal a 1.8m directamente abajo de la línea de potencia. El espacio entre los centros de estos conductores (c y d) es de 1m

a) Calcule la inductancia mutua por Kilómetro entre la línea de potencia y la telefónica

b) Encuentre el voltaje por kilómetro de 60 Hz, inducido en la línea telefónica cuando la línea de potencia lleva 150 A

Para a)



$$\lambda_c = 2\times10^{-7}\left(I_a \ln\frac{1}{D_{ac}} + I_b \ln\frac{1}{D_{bc}} + \cancel{I_c}^{\,0} \ln\frac{1}{r'_c} + \cancel{I_d}^{\,0} \ln\frac{1}{D_{dc}}\right)$$

$$\lambda_c = 2\times10^{-7}\left(I_a \ln\frac{1}{D_{ac}} + I_b \ln\frac{1}{D_{bc}}\right) \quad ; \quad I_b = -I_a$$

$$\lambda_c = 2\times10^{-7}\, I_a \ln\left(\frac{D_{bc}}{D_{ac}}\right)$$

$$\lambda_d = 2\times10^{-7}\left(I_a \ln\frac{1}{D_{ad}} + I_b \ln\frac{1}{D_{bd}} + \cancel{I_c}^{\,0} \ln\frac{1}{D_{cb}} + \cancel{I_d}^{\,0} \ln\frac{1}{r'_d}\right)$$

$$\lambda_d = 2\times10^{-7}\left(I_a \ln\frac{1}{D_{ad}} + I_b \ln\frac{1}{D_{bd}}\right)$$

$$\lambda_d = 2\times10^{-7}\, I_a \ln\left(\frac{D_{bd}}{D_{ad}}\right)$$

$$\lambda_c - \lambda_d = 2\times10^{-7}\, I_a \ln\left(\frac{D_{bc}}{D_{ac}}\right) - I_a \ln\left(\frac{D_{bd}}{D_{ad}}\right)$$

$$\lambda_{c-d} = 2\times10^{-7}\, I \ln\left(\frac{D_{bc}D_{ad}}{D_{ac}D_{bd}}\right) \ Wb/m$$

$$L = \frac{\lambda_{c-d}}{I} \Rightarrow L = 2\times10^{-7} \ln\left(\frac{D_{bc}D_{ad}}{D_{ac}D_{bd}}\right) \times \frac{2}{2}$$

$$L_{c-d} = 4\times10^{-7} \ln\sqrt{\frac{D_{bc}D_{ad}}{D_{ac}D_{bd}}} \ H/m$$

$$D_{bc} = D_{ad} = \sqrt{1.75^2 + 1.8^2} = 2.510478042\ m$$

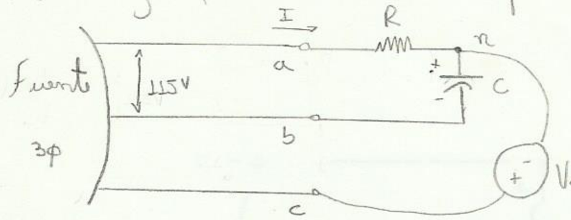
$$D_{ac} = D_{bd} = \sqrt{0.75^2 + 1.8^2} = 1.95\ m$$

$$L_{c-d} = 4\times10^{-7} \ln\frac{2.510478042}{1.95} \Rightarrow \left[L_{c-d} = 1.01057527\times10^{-7}\ H/m\right]$$

Para b)

$$V_{cd} = 2\pi f L_{c-d} I = 2\pi(60)(1.0157527\times10^{-7})(150) \Rightarrow \left[V_{cd} = 5.714668517\ V/Km\right]$$

Los terminales de una fuente trifásica son designados como a, b y c. Entre cualquier par un voltímetro mide 115V. Una resistencia de 100 Ω y un capacitor de 100 Ω a la frecuencia de la fuente se conecta en serie entre los puntos a y b con la resistencia conectada en a. El punto de conexión de los elementos se etiqueta como n. Determine en forma analítica y gráfica la lectura del voltímetro entre c y n, si la secuencia de fases es abc y si la secuencia de fases es acb



Secuencia (+) $V_{ab} = V\angle 0$

$V_{bc} = V\angle 240$

$V_{ca} = V\angle 120$

Secuencia (−) $V_{ab} = V\angle 0$

$V_{bc} = V\angle 120$

$V_{ca} = V\angle 240$

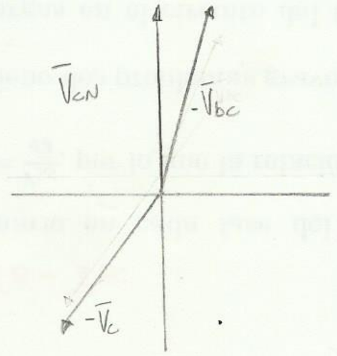
$$\bar{V} = \bar{I}\bar{Z} \Rightarrow \bar{I} = \frac{V_{ab}}{R + X_c} = \frac{115}{100 - j100} = 0.8131727984\angle +45$$

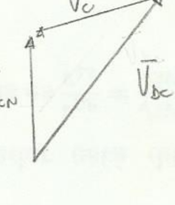
$$\bar{V}_c = I(-jX_c) = 0.8131727984\angle 45\,(100\angle -90) = 81.31727984\angle -45$$

$$\bar{V}_{bc} + \bar{V}_{cN} + \bar{V}_c = 0 \Rightarrow \bar{V}_{cN} = -(\bar{V}_{bc} + \bar{V}_c)$$

* Secuencia (+)

$$\bar{V}_{cN} = -(115\angle 240 + 81,31727984\angle -45) \Rightarrow \bar{V}_{cN} = 157,0929214\angle 90 \text{ [V]}$$





* Secuencia (−)

$$\bar{V}_{cN} = -(115\angle 120 + 81,31727984\angle -45) = 42,09292143\angle -90$$