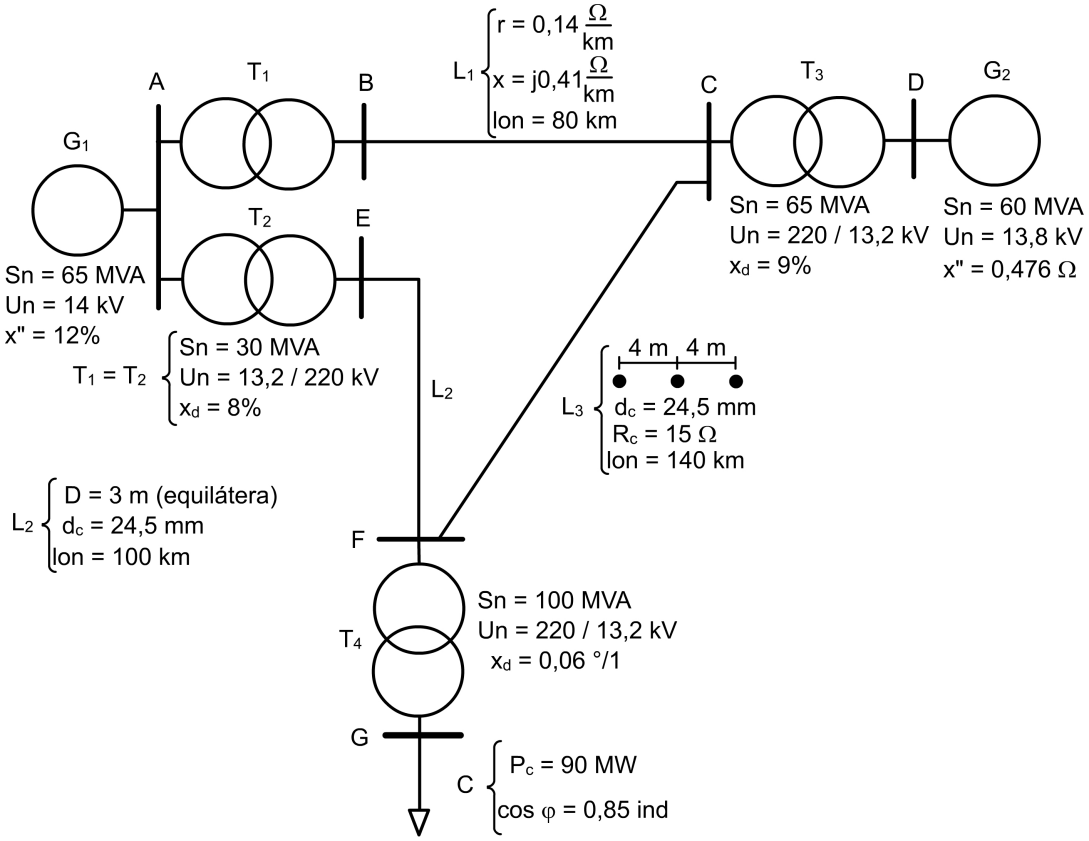
Problemas Resueltos: Representación de Sistemas de Potencia

1) Hacer el diagrama de impedancias poniendo todos los valores en por unidad, refiriéndose a las siguientes bases:

a) Sb = 30 MVA; Ub_A = 5 KV
b) Sb = 4 MVA; Ub_A = 2,3 KV
c) Sb = 100 MVA; Ub_A = 13,2 KV



a) Sb = 30 MVA

$Ub_A = 5\,kV$

$$E_{G1} = \frac{14}{5} = 2{,}8\ ^{o}/_{1}$$

$$E_{G2} = \frac{13{,}8}{5} = 2{,}76\ ^{o}/_{1}$$

$$Ub_B = Ub_A \cdot r_{T1} = 5 \cdot \frac{220}{13{,}2} = 83{,}3\,kV = Ub_C$$

$$Ub_D = Ub_C \cdot r_{T3} = 83{,}3 \cdot \frac{13{,}2}{220} = 5\,kV$$

$$Ub_E = Ub_A \cdot r_{T2} = 5 \cdot \frac{220}{13{,}2} = 83{,}3\,kV = Ub_F$$

$$Ub_G = Ub_F \cdot r_{T4} = 83{,}3 \cdot \frac{13{,}2}{220} = 5\,kV$$

Cambio de base de las reactancias de los componentes:

$$x_{G1} = j0{,}12 \cdot \frac{(14)^2}{50} \cdot \frac{30}{5^2} = j0{,}564 \qquad x_{G2} = j0{,}476 \cdot \frac{30}{5^2} = j0{,}571$$

$$x_{T1} = j0{,}08 \cdot \frac{(13{,}2)^2}{30} \cdot \frac{30}{5^2} = j0{,}558$$

$$x_{T3} = j0{,}09 \cdot \frac{(220)^2}{65} \cdot \frac{30}{(83{,}3)^2} = j0{,}29$$

$$x_{T4} = j0{,}06 \cdot \frac{(13{,}2)^2}{100} \cdot \frac{30}{5^2} = j0{,}125$$

$$R_{L1} = 0{,}14 \cdot 80 \cdot \frac{30}{(83{,}3)^2} = 0{,}048 \qquad x_{L1} = j0{,}41 \cdot 80 \cdot \frac{30}{(83{,}3)^2} = j0{,}142$$

$$L_{L2} = 2 \cdot 10^{-4} \cdot \ln \frac{3}{\frac{24{,}5}{2} \cdot 10^{-3} \cdot e^{-\frac{1}{4}}} = 1{,}15 \cdot 10^{-3} \ \frac{Hy}{km}$$

$$x_{L2} = j2 \cdot \pi \cdot 50 \cdot 100 \cdot 1{,}15 \cdot 10^{-3} = j36{,}13\,\Omega \qquad x_{L2} = j36{,}13 \cdot \frac{30}{(83{,}3)^2} = j0{,}156$$

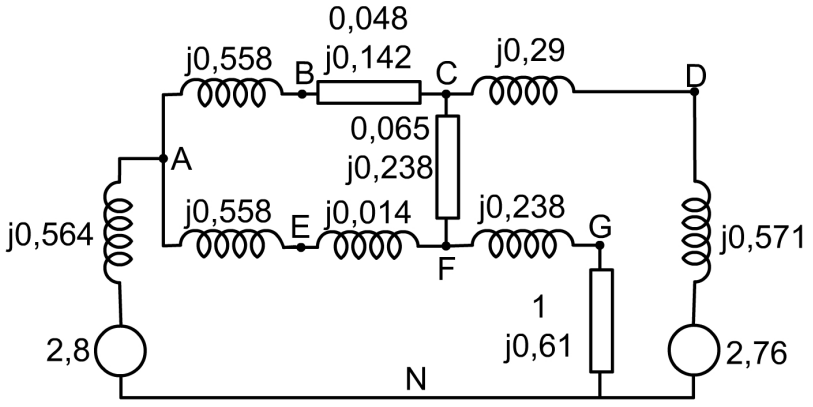
$$L_{L3} = 2 \cdot 10^{-4} \cdot \ln \frac{\sqrt[3]{4 \cdot 4 \cdot 2 \cdot 4}}{\frac{24{,}5}{2} \cdot 10^{-3} \cdot e^{-\frac{1}{4}}} = 1{,}254 \cdot 10^{-3} \ \frac{Hy}{km}$$

$$R_{L3} = 15 \cdot \frac{30}{(83{,}3)^2} = 0{,}065 \qquad x_{L3} = j2 \cdot \pi \cdot 50 \cdot 140 \cdot 1{,}254 \cdot 10^{-3} = j55{,}154\,\Omega$$

$$x_{L3} = j55{,}154 \cdot \frac{30}{(83{,}3)^2} = j0{,}238$$

$$Z_C = \frac{(Un_G)^2}{S_C} = \frac{(13{,}2)^2}{\frac{90}{0{,}85}} = 0{,}97^{\lfloor 31{,}8} = (0{,}825 + j0{,}51)\,\Omega$$

$$R_C = 0{,}825 \cdot \frac{30}{5^2} = 1 \qquad x_C = j0{,}51 \cdot \frac{30}{5^2} = j0{,}61$$



b) Sb = 4 MVA

$$E_{G1} = \frac{14}{2{,}3} = 6{,}09\ ^{o}/_{1}$$

$$Ub_A = 2{,}3KV$$

$$E_{G2} = \frac{13{,}8}{2{,}3} = 6\ ^{o}/_{1}$$

$$Ub_B = Ub_A \cdot r_{T1} = 2{,}3 \cdot \frac{220}{13{,}2} = 38{,}33KV = Ub_C$$

$$Ub_D = Ub_C \cdot r_{T3} = 38{,}33 \cdot \frac{13{,}2}{220} = 2{,}3KV$$

$$Ub_E = Ub_A \cdot r_{T2} = 2{,}3 \cdot \frac{220}{13{,}2} = 38{,}33KV = Ub_F$$

$$Ub_G = Ub_F \cdot r_{T4} = 38{,}33 \cdot \frac{13{,}2}{220} = 2{,}3KV$$

Cambio de base de las reactancias de los componentes:

$$x_{G1} = j0{,}12 \cdot \frac{(14)^2}{50} \cdot \frac{4}{(2{,}3)^2} = j0{,}356 \qquad x_{G2} = j0{,}476 \cdot \frac{4}{(2{,}3)^2} = j0{,}36$$

$$x_{T1} = j0{,}08 \cdot \frac{(13{,}2)^2}{30} \cdot \frac{4}{(2{,}3)^2} = j0{,}351$$

$$x_{T3} = j0{,}09 \cdot \frac{(220)^2}{65} \cdot \frac{4}{(38{,}33)^2} = j0{,}182$$

$$x_{T4} = j0{,}06 \cdot \frac{(13{,}2)^2}{100} \cdot \frac{4}{(2{,}3)^2} = j0{,}079$$

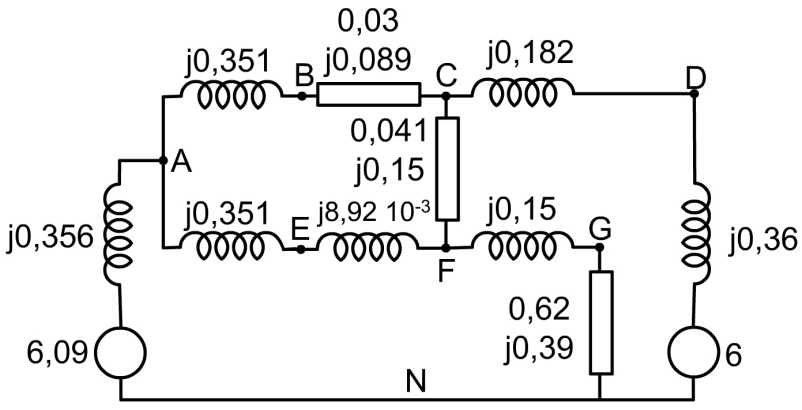
$$R_{L1} = 0{,}14 \cdot 80 \cdot \frac{4}{(38{,}33)^2} = 0{,}03 \qquad x_{L1} = j0{,}41 \cdot 80 \cdot \frac{4}{(38{,}33)^2} = j0{,}089$$

$$x_{L2} = j2 \cdot \pi \cdot 50 \cdot 100 \cdot 1{,}043 \cdot 10^{-4} = j3{,}278\,\Omega$$

$$x_{L2} = j36{,}13 \cdot \frac{4}{(83{,}3)^2} = j0{,}021$$

$$R_{L3} = 15 \cdot \frac{4}{(38{,}33)^2} = 0{,}041 \qquad x_{L3} = j55{,}154 \cdot \frac{4}{(83{,}3)^2} = j0{,}032$$

$$R_C = 0{,}825 \cdot \frac{4}{(2{,}3)^2} = 0{,}62 \qquad x_C = j0{,}51 \cdot \frac{4}{(2{,}3)^2} = j0{,}39$$



c) Sb = 100 MVA

$$E_{G1} = \frac{14}{13{,}2} = 1{,}06\ ^{o}/_{1}$$

$$Ub_A = 13{,}2KV$$

$$E_{G2} = \frac{13{,}8}{13{,}2} = 1{,}045\ ^{o}/_{1}$$

Como la tensión base elegida corresponde a la nominal de la barra A, en las otras barras las tensiones base serán las nominales correspondientes.

$$Ub_B = 220KV$$

$Ub_C = 220KV$

$Ub_D = 13{,}2KV$

$Ub_E = 220KV$

$Ub_F = 220KV$

$Ub_G = 13{,}2KV$

Cambio de base de las reactancias de los componentes:

$$x_{G1} = j0{,}12 \cdot \frac{(14)^2}{50} \cdot \frac{100}{(13{,}2)^2} = j0{,}27$$

$$x_{G2} = j0{,}476 \cdot \frac{100}{(13{,}2)^2} = j0{,}273$$

$$x_{T1} = j0{,}08 \cdot \frac{(13{,}2)^2}{30} \cdot \frac{100}{(13{,}2)^2} = j0{,}267$$

$$x_{T3} = j0{,}09 \cdot \frac{(220)^2}{65} \cdot \frac{100}{(220)^2} = j0{,}138$$

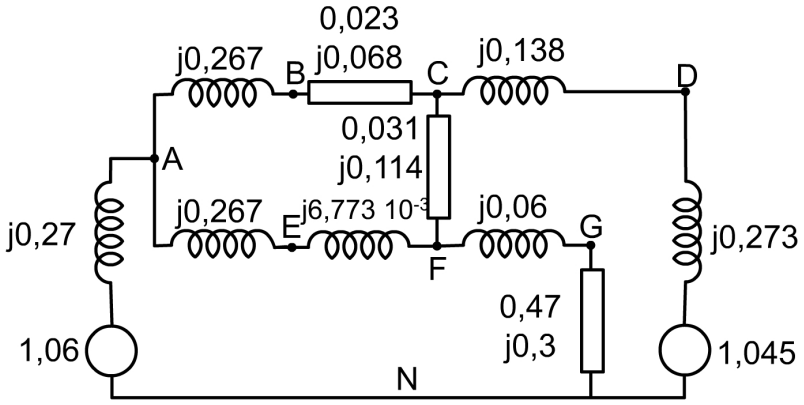
$$x_{T4} = j0{,}06 \cdot \frac{(13{,}2)^2}{100} \cdot \frac{100}{(13{,}2)^2} = j0{,}06$$

$$R_{L1} = 0{,}14 \cdot 80 \cdot \frac{100}{(220)^2} = 0{,}023 \qquad x_{L1} = j0{,}41 \cdot 80 \cdot \frac{100}{(220)^2} = j0{,}068$$

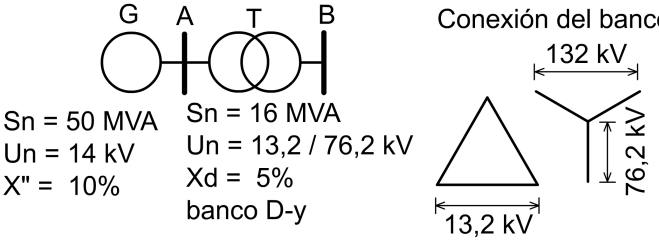
$$x_{L2} = j36{,}13 \cdot \frac{100}{(220)^2} = j0{,}281$$

$$R_{L3} = 15 \cdot \frac{100}{(220)^2} = 0{,}031 \qquad x_{L3} = j55{,}154 \cdot \frac{100}{(220)^2} = j0{,}114$$

$$R_C = 0{,}825 \cdot \frac{100}{(13{,}2)^2} = 0{,}47 \qquad x_C = j0{,}51 \cdot \frac{100}{(13{,}2)^2} = j0{,}3$$



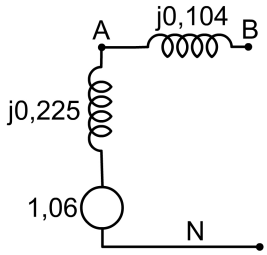
2) Hacer el diagrama de impedancias poniendo todos los valores en por unidad, refiriéndose a las siguientes bases: Sb = 100 MVA; U_{bA} = 13,2 KV.



Como se trata de un banco de transformadores monofásicos conectados para funcionar como un transformador trifásico, los datos se dan por fase, la potencia total será:

$S_T = 3 \cdot 16MVA = 48MVA$

Si Ub_A = 13,2 KV, tomando valores de línea:



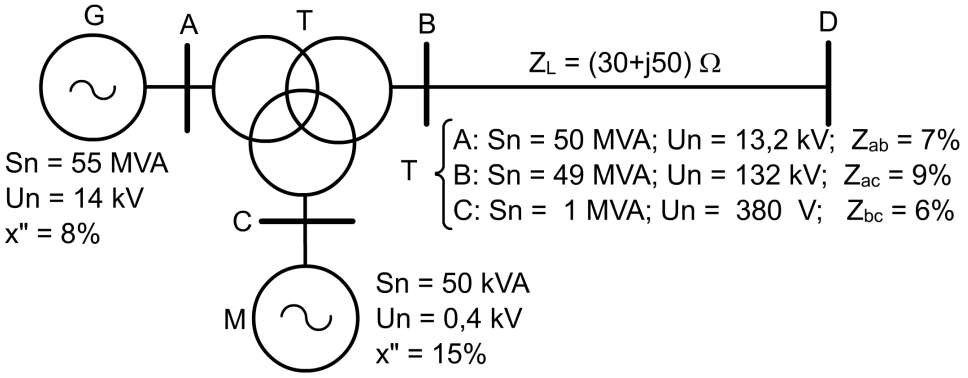
Ub_B = 132 KV

$$E_G = \frac{14}{13,2} = 1,06$$

$$x_T = j0,05 \cdot \frac{(132)^2}{48} \cdot \frac{100}{(132)^2} = j0,104$$

$$x_G = j0,1 \cdot \frac{(14)^2}{50} \cdot \frac{100}{(13,2)^2} = j0,225$$

3) Hacer el diagrama de impedancias poniendo todos los valores en por unidad:



Tomando como base: Sb = 100 MVA y Ub_A = 13,2 KV:
Ub_B = 132 KV = Ub_D y Ub_C = 0,38 KV

$$E_G = \frac{14}{13,2} = 1,06 \qquad x_G = j0,08 \cdot \frac{(14)^2}{55} \cdot \frac{100}{(13,2)^2} = j0,164$$

$$E_M = \frac{0,4}{0,38} = 1,05 \qquad x_M = j0,15 \cdot \frac{(0,4)^2}{0,05} \cdot \frac{100}{(0,38)^2} = j332,41$$

$$R_L = 30 \cdot \frac{100}{(132)^2} = 0,172 \qquad x_L = 50 \cdot \frac{100}{(132)^2} = 0,287$$

Transformador: Si no hay aclaración, suponemos que los valores de impedancias están referidos al primero de los devanados:

$$Z_{ab} = j0,07 \cdot \frac{(13,2)^2}{50} \cdot \frac{100}{(13,2)^2} = j0,14$$ (j0,07 esta referido al devanado : a)

$$Z_{ac} = j0{,}09 \cdot \frac{(13{,}2)^2}{50} \cdot \frac{100}{(13{,}2)^2} = j0{,}18 \quad (\text{j0,09 esta referido al devanado : a})$$

$$Z_{bc} = j0{,}06 \cdot \frac{(132)^2}{49} \cdot \frac{100}{(132)^2} = j0{,}122 \quad (\text{j0,06 esta referido al devanado : b})$$

$$Z_a = j\frac{1}{2} \cdot (0{,}14 + 0{,}18 - 0{,}122) = j0{,}099$$

$$Z_b = j\frac{1}{2} \cdot (0{,}14 + 0{,}122 - 0{,}18) = j0{,}041$$

$$Z_c = j\frac{1}{2} \cdot (0{,}18 + 0{,}122 - 0{,}14) = j0{,}081$$