SISTEMAS ELÉCTRICOS DE POTENCIA

PRÁCTICA Nº1 CORTOCIRCUITOS

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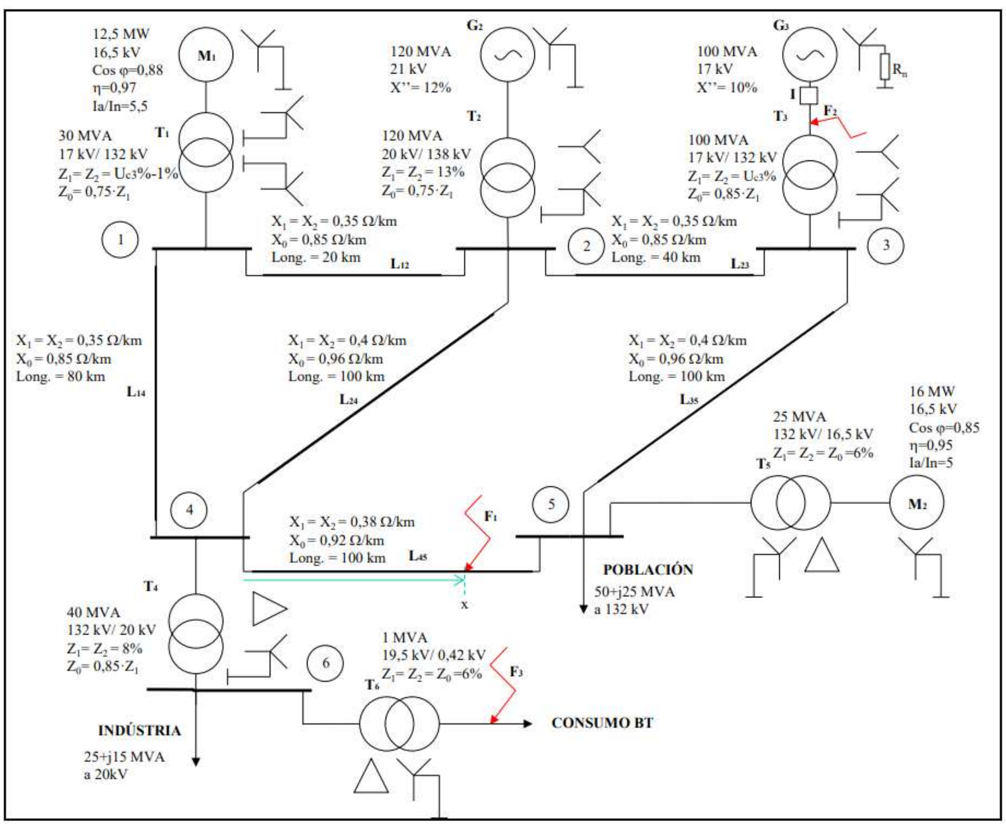
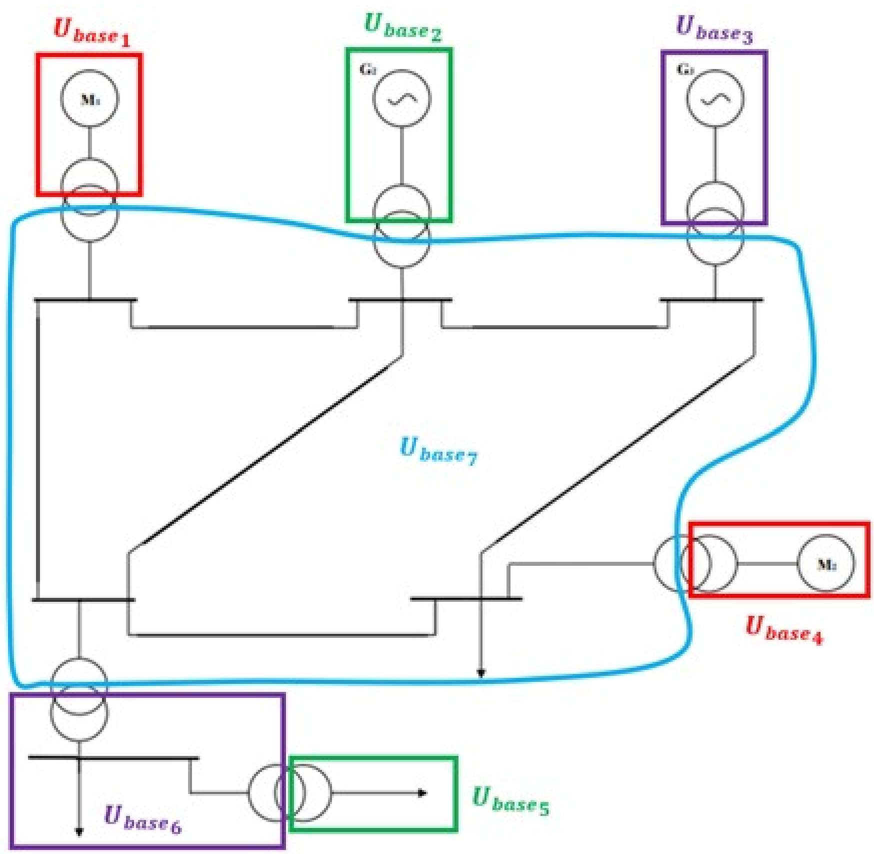
En la red representada en la figura:



Se pide:

a) Obtener los valores por unidad de todos los elementos de la red.

En primer lugar, tenemos que determinar la potencia y tensiones base de la red:



$S_{BASE} := 100 \cdot MVA$

$U_{BASE7} := 132kV$

$U_{BASE1} := \frac{17}{132} \cdot U_{BASE7} = 17 \cdot kV$ $\qquad$ $U_{BASE2} := \frac{20}{138} \cdot U_{BASE7} = 19.1304 \cdot kV$

$U_{BASE3} := \frac{17}{132} \cdot U_{BASE7} = 17 \cdot kV$ $\qquad$ $U_{BASE4} := \frac{16.5}{132} \cdot U_{BASE7} = 16.5 \cdot kV$

$U_{BASE6} := \frac{20}{132} \cdot U_{BASE7} = 20 \cdot kV$ $\qquad$ $U_{BASE5} := \frac{0.42}{19.5} \cdot U_{BASE6} = 0.4308 \cdot kV$

GENERADOR 2

$$S_{n\_G2} := 120MVA \qquad U_{n\_G2} := 21kV \qquad X''_{G2} := 12\%$$

$$Z_{1\_G2} := X''_{G2} i \cdot \left(\frac{U_{n\_G2}}{U_{BASE2}}\right)^2 \cdot \frac{S_{BASE}}{S_{n\_G2}} = 0.1205i \qquad Z_{2\_G2} := Z_{1\_G2} \qquad Z_{0\_G2} := Z_{1\_G2}$$

GENERADOR 3

$$S_{n\_G3} := 100MVA \qquad U_{n\_G3} := 17kV \qquad X''_{G3} := 10\%$$

$$Z_{1\_G3} := X''_{G3} i \cdot \left(\frac{U_{n\_G3}}{U_{BASE3}}\right)^2 \cdot \frac{S_{BASE}}{S_{n\_G3}} = 0.1i \qquad Z_{2\_G3} := Z_{1\_G3} \qquad Z_{0\_G3} := Z_{1\_G3}$$

$$R_{N\_G3} := \frac{\frac{55540}{10^5}\Omega}{\left(\frac{U_{BASE3}{}^2}{S_{BASE}}\right)} = 0.1922$$

MOTOR 1

$$P_{n\_M1} := 12.5MW \qquad U_{n\_M1} := 16.5kV \qquad fdp_{M1} := 0.88 \qquad \eta_{M1} := 0.97 \qquad I_{an.M1} := 5.5$$

$$S_{n\_M1} := \frac{P_{n\_M1}}{fdp_{M1} \cdot \eta_{M1}} = 14.6439 \cdot MVA$$

$$Z_{1\_M1} := \frac{1}{I_{an.M1}} \cdot \left(\frac{U_{n\_M1}}{U_{BASE1}}\right)^2 \cdot \frac{S_{BASE}}{S_{n\_M1}} i = 1.1696i \qquad Z_{2\_M1} := Z_{1\_M1} \qquad Z_{0\_M1} := Z_{1\_M1}$$

MOTOR 2

$$P_{n\_M2} := 16MW \qquad U_{n\_M2} := 16.5kV \qquad fdp_{M2} := 0.85 \qquad \eta_{M2} := 0.95 \qquad I_{an.M2} := 5$$

$$S_{n\_M2} := \frac{P_{n\_M2}}{fdp_{M2} \cdot \eta_{M2}} = 19.8142 \cdot MVA$$

$$Z_{1\_M2} := \frac{1}{I_{an.M2}} \cdot \left(\frac{U_{n\_M2}}{U_{BASE4}}\right)^2 \cdot \frac{S_{BASE}}{S_{n\_M2}} i = 1.0094i \qquad Z_{2\_M2} := Z_{1\_M2} \qquad Z_{0\_M2} := Z_{1\_M2}$$

TRANSFORMADOR 1

$S_{n\_T1} := 30MVA$ $\quad U_{n1\_T1} := 17kV$ $\quad X''_{T1} := \left(\frac{2\cdot 55540}{10^4} - 1\right)\%$

$$Z_{1\_T1} := X''_{T1} i\cdot\left(\frac{U_{n1\_T1}}{U_{BASE1}}\right)^2 \cdot\frac{S_{BASE}}{S_{n\_T1}} = 0.3369i$$

$Z_{2\_T1} := Z_{1\_T1}$

$Z_{0\_T1} := 0.75Z_{1\_T1} = 0.2527i$

TRANSFORMADOR 2

$S_{n\_T2} := 120MVA$ $\quad U_{n1\_T2} := 20kV$ $\quad X''_{T2} := 13\%$

$$Z_{1\_T2} := X''_{T2} i\cdot\left(\frac{U_{n1\_T2}}{U_{BASE2}}\right)^2 \cdot\frac{S_{BASE}}{S_{n\_T2}} = 0.1184i$$

$Z_{2\_T2} := Z_{1\_T2}$

$Z_{0\_T2} := 0.75Z_{1\_T2} = 0.0888i$

TRANSFORMADOR 3

$S_{n\_T3} := 100MVA$ $\quad U_{n1\_T3} := 17kV$ $\quad X''_{T3} := \frac{2\cdot 55540}{10^4}\%$

$$Z_{1\_T3} := X''_{T3} i\cdot\left(\frac{U_{n1\_T3}}{U_{BASE3}}\right)^2 \cdot\frac{S_{BASE}}{S_{n\_T3}} = 0.1111i$$

$Z_{2\_T3} := Z_{1\_T3}$

$Z_{0\_T3} := 0.85Z_{1\_T3} = 0.0944i$

TRANSFORMADOR 4

$S_{n\_T4} := 40MVA$ $\quad U_{n1\_T4} := 132kV$ $\quad X''_{T4} := 8\%$

$$Z_{1\_T4} := X''_{T4} i\cdot\left(\frac{U_{n1\_T4}}{U_{BASE7}}\right)^2 \cdot\frac{S_{BASE}}{S_{n\_T4}} = 0.2i$$

$Z_{2\_T4} := Z_{1\_T4}$

$Z_{0\_T4} := 0.85Z_{1\_T4} = 0.17i$

TRANSFORMADOR 5

$S_{n\_T5} := 25MVA$ $\quad U_{n1\_T5} := 132kV$ $\quad X''_{T5} := 6\%$

$$Z_{1\_T5} := X''_{T5} i \cdot \left(\frac{U_{n1\_T5}}{U_{BASE7}}\right)^2 \cdot \frac{S_{BASE}}{S_{n\_T5}} = 0.24i \qquad Z_{2\_T5} := Z_{1\_T5} \qquad Z_{0\_T5} := Z_{1\_T5}$$

TRANSFORMADOR 6

$S_{n\_T6} := 1MVA$ $\quad U_{n1\_T6} := 19.5kV$ $\quad X''_{T6} := 6\%$

$$Z_{1\_T6} := X''_{T6} i \cdot \left(\frac{U_{n1\_T6}}{U_{BASE6}}\right)^2 \cdot \frac{S_{BASE}}{S_{n\_T6}} = 5.7037i \qquad Z_{2\_T6} := Z_{1\_T6} \qquad Z_{0\_T6} := Z_{1\_T6}$$

LÍNEA 1-2

$Long_{L12} := 20km$

$$Z_{1\_L12} := \frac{0.35 \frac{\Omega}{km} \cdot Long_{L12}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)} i = 0.0402i$$

$Z_{2\_L12} := Z_{1\_L12}$

$$Z_{0\_L12} := \frac{0.85 \frac{\Omega}{km} \cdot Long_{L12}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)} i = 0.0976i$$

LÍNEA 1-4

$$Long_{L14} := 80km$$

$$Z_{1\_L14} := \frac{0.35\frac{\Omega}{km}\cdot Long_{L14}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.1607i$$

$$Z_{2\_L14} := Z_{1\_L14}$$

$$Z_{0\_L14} := \frac{0.85\frac{\Omega}{km}\cdot Long_{L14}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.3903i$$

LÍNEA 2-4

$$Long_{L24} := 100km$$

$$Z_{1\_L24} := \frac{0.4\frac{\Omega}{km}\cdot Long_{L24}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.2296i$$

$$Z_{2\_L24} := Z_{1\_L24}$$

$$Z_{0\_L24} := \frac{0.96\frac{\Omega}{km}\cdot Long_{L24}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.551i$$

LÍNEA 2-3

$$Long_{L23} := 40km$$

$$Z_{1\_L23} := \frac{0.35\frac{\Omega}{km}\cdot Long_{L23}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.0803i$$

$$Z_{2\_L23} := Z_{1\_L23}$$

$$Z_{0\_L23} := \frac{0.85\frac{\Omega}{km}\cdot Long_{L23}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.1951i$$

LÍNEA 3-5

$$Long_{L35} := 100km$$

$$Z_{1\_L35} := \frac{0.4\frac{\Omega}{km}\cdot Long_{L35}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.2296i$$

$$Z_{2\_L35} := Z_{1\_L35}$$

$$Z_{0\_L35} := \frac{0.96\frac{\Omega}{km}\cdot Long_{L35}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.551i$$

LÍNEA 4-5

$$Long_{L45} := 100km$$

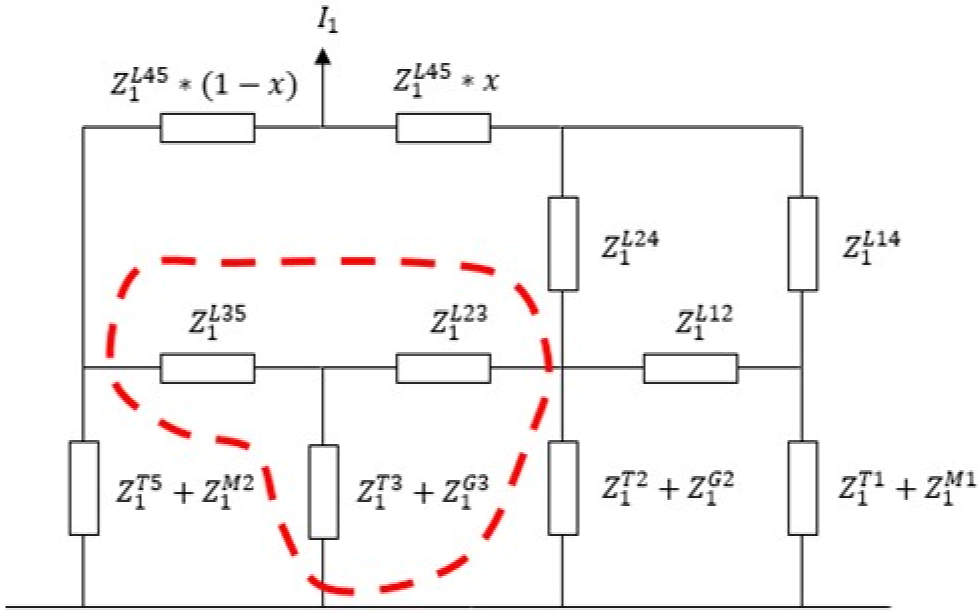
$$Z_{1\_L45} := \frac{0.38\frac{\Omega}{km}\cdot Long_{L45}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.2181i$$

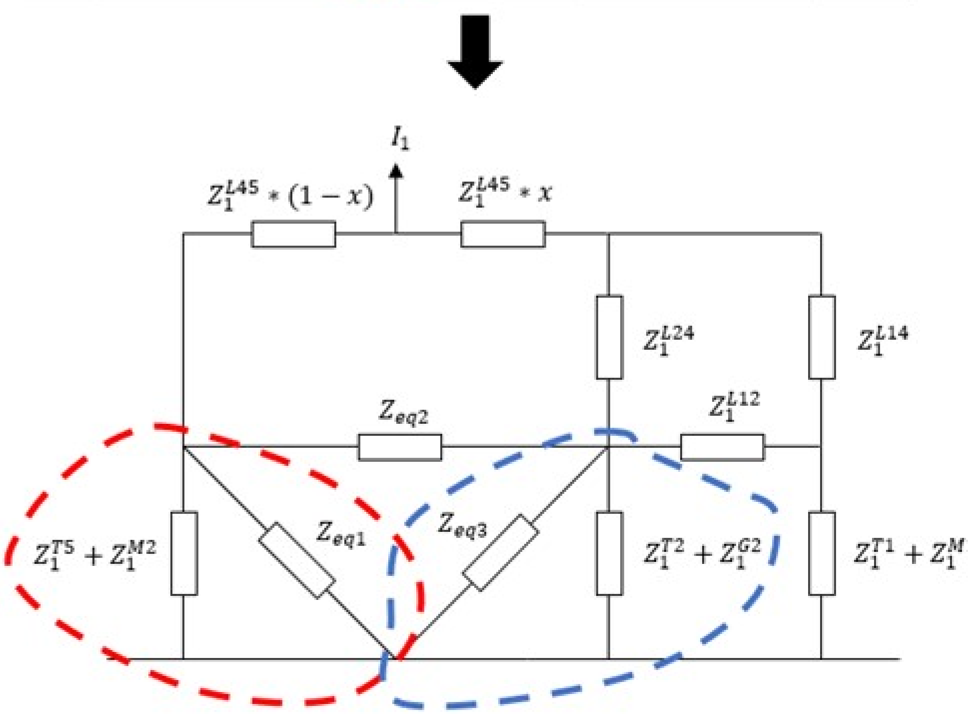
$$Z_{2\_L45} := Z_{1\_L45}$$

$$Z_{0\_L45} := \frac{0.92\frac{\Omega}{km}\cdot Long_{L45}}{\left(\frac{U_{BASE7}^{2}}{S_{BASE}}\right)}i = 0.528i$$

b) Obtener el valor de la corriente de cortocircuito si se produce una falta simétrica en F_1. Representar dicha corriente de falta en función de la variable *x* (varía entre el 10% y el 90% de la longitud total de la línea L_{45}).

Al ser una falta simétrica, solamente hay que calcular la impedancia Z1 de secuencia directa. El circuito de secuencia directa correspondiente es:

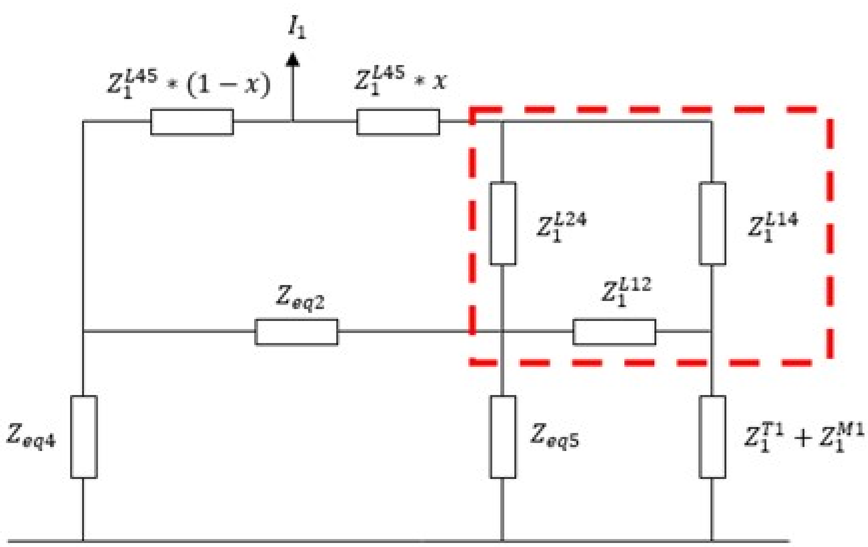




$$Z_{eq1} := \frac{Z_{1\_L35} \cdot Z_{1\_L23} + Z_{1\_L35} \cdot (Z_{1\_T3} + Z_{1\_G3}) + Z_{1\_L23} \cdot (Z_{1\_T3} + Z_{1\_G3})}{Z_{1\_L23}} = 1.0437i$$

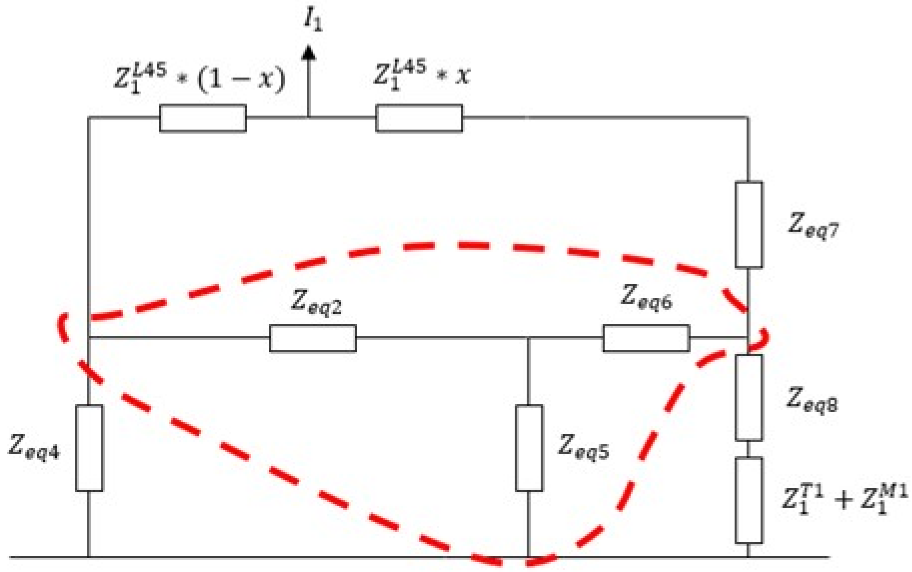
$$Z_{eq2} := \frac{Z_{1\_L35} \cdot Z_{1\_L23} + Z_{1\_L35} \cdot (Z_{1\_T3} + Z_{1\_G3}) + Z_{1\_L23} \cdot (Z_{1\_T3} + Z_{1\_G3})}{Z_{1\_T3} + Z_{1\_G3}} = 0.3973i$$

$$Z_{eq3} := \frac{Z_{1\_L35} \cdot Z_{1\_L23} + Z_{1\_L35} \cdot (Z_{1\_T3} + Z_{1\_G3}) + Z_{1\_L23} \cdot (Z_{1\_T3} + Z_{1\_G3})}{Z_{1\_L35}} = 0.3653i$$



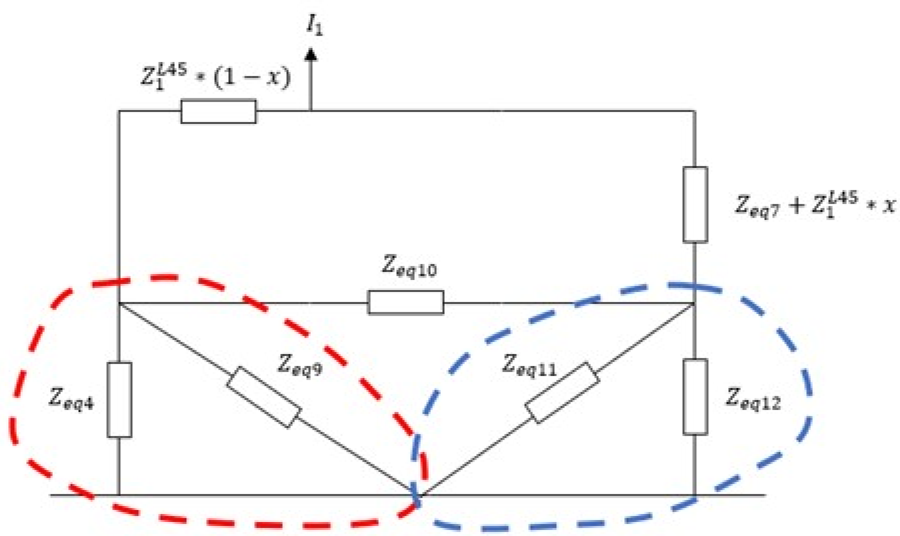
$$Z_{eq4} := \frac{Z_{eq1} \cdot (Z_{1\_T5} + Z_{1\_M2})}{Z_{eq1} + Z_{1\_T5} + Z_{1\_M2}} = 0.5687i$$

$$Z_{eq5} := \frac{Z_{eq3} \cdot (Z_{1\_T2} + Z_{1\_G2})}{Z_{eq3} + Z_{1\_T2} + Z_{1\_G2}} = 0.1444i$$



$$Z_{eq6} := \frac{Z_{1\_L24} \cdot Z_{1\_L12}}{Z_{1\_L24} + Z_{1\_L12} + Z_{1\_L14}} = 0.0214i \qquad Z_{eq7} := \frac{Z_{1\_L24} \cdot Z_{1\_L14}}{Z_{1\_L24} + Z_{1\_L12} + Z_{1\_L14}} = 0.0857i$$

$$Z_{eq8} := \frac{Z_{1\_L14} \cdot Z_{1\_L12}}{Z_{1\_L24} + Z_{1\_L12} + Z_{1\_L14}} = 0.015i$$

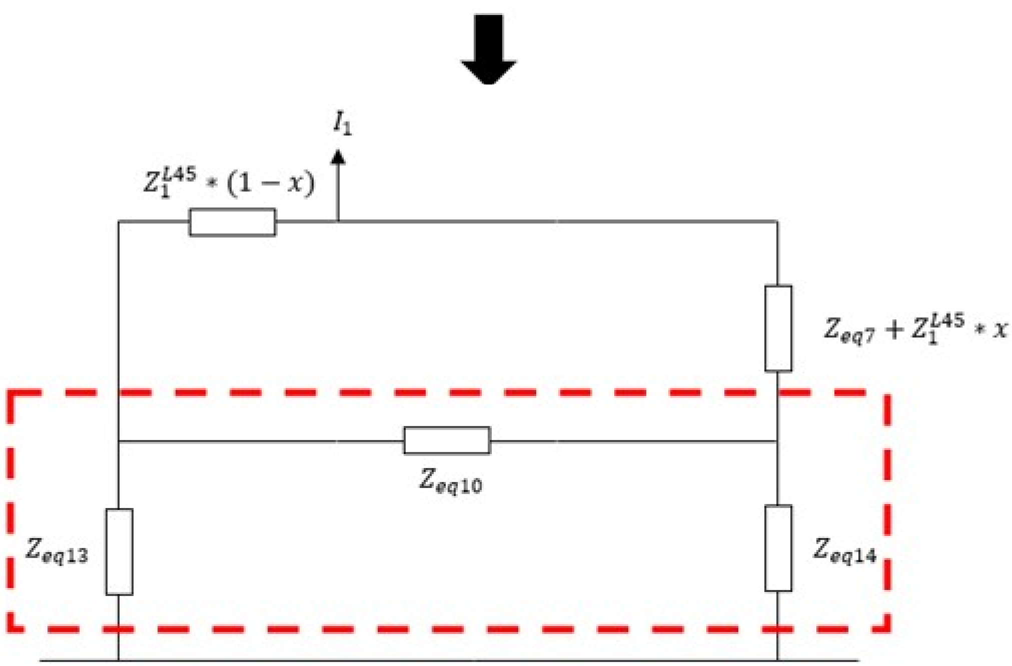


$$Z_{eq9} := \frac{Z_{eq2} \cdot Z_{eq6} + Z_{eq2} \cdot Z_{eq5} + Z_{eq6} \cdot Z_{eq5}}{Z_{eq6}} = 3.2201i$$

$$Z_{eq10} := \frac{Z_{eq2} \cdot Z_{eq6} + Z_{eq2} \cdot Z_{eq5} + Z_{eq6} \cdot Z_{eq5}}{Z_{eq5}} = 0.4777i$$

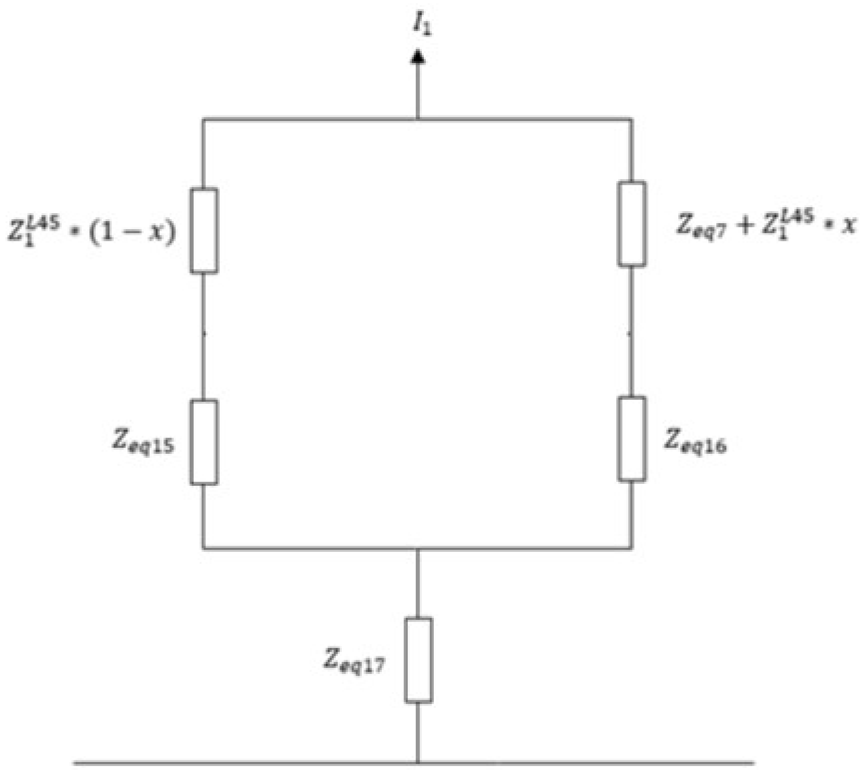
$$Z_{eq11} := \frac{Z_{eq2} \cdot Z_{eq6} + Z_{eq2} \cdot Z_{eq5} + Z_{eq6} \cdot Z_{eq5}}{Z_{eq2}} = 0.1737i$$

$$Z_{eq12} := Z_{eq8} + Z_{1\_T1} + Z_{1\_M1} = 1.5216i$$



$$Z_{eq13} := \frac{Z_{eq4} \cdot Z_{eq9}}{Z_{eq4} + Z_{eq9}} = 0.4833i$$

$$Z_{eq14} := \frac{Z_{eq11} \cdot Z_{eq12}}{Z_{eq11} + Z_{eq12}} = 0.1559i$$



$$Z_{eq15} := \frac{Z_{eq10} \cdot Z_{eq13}}{Z_{eq10} + Z_{eq13} + Z_{eq14}} = 0.2067i$$

$$Z_{eq16} := \frac{Z_{eq10} \cdot Z_{eq14}}{Z_{eq10} + Z_{eq13} + Z_{eq14}} = 0.0667i$$

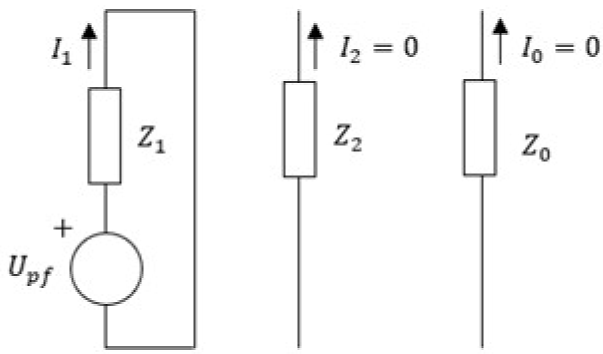
$$Z_{eq17} := \frac{Z_{eq14} \cdot Z_{eq13}}{Z_{eq10} + Z_{eq13} + Z_{eq14}} = 0.0675i$$

Por lo tanto, el valor de la z equivalente será:

$$x := 0.1, 0.11 .. 0.9$$

$$Z_{1\_F1}(x) := Z_{eq17} + \frac{\left[Z_{eq15} + Z_{1\_L45} \cdot (1 - x)\right] \cdot \left(Z_{eq7} + Z_{eq16} + Z_{1\_L45} \cdot x\right)}{Z_{eq15} + Z_{1\_L45} \cdot (1 - x) + Z_{eq7} + Z_{eq16} + Z_{1\_L45} \cdot x}$$

Finalmente, calculamos la corriente. Como se trata de una falta trifásica:



$$U_{pf} := 1.1$$

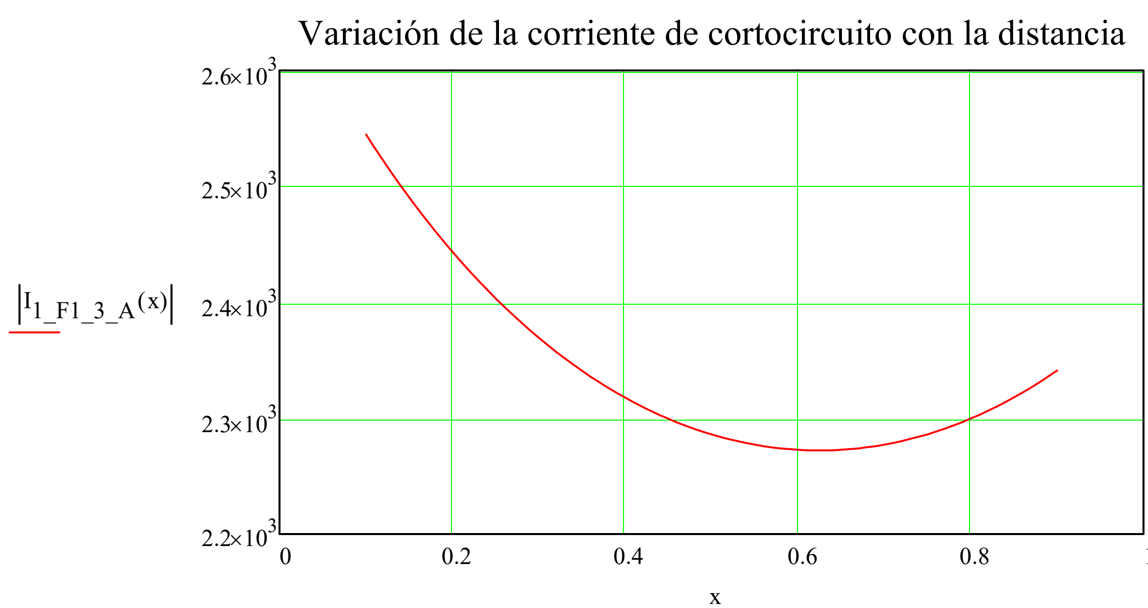
$$I_{1\_F1\_3\_pu}(x) := \frac{U_{pf}}{Z_{1\_F1}(x)}$$

Para convertir el valor a Amperios, multiplicamos por la corriente base:

$$I_{BASE7} := \frac{S_{BASE}}{\sqrt{3} \cdot U_{BASE7}} = 0.4374 \cdot kA$$

$$I_{1\_F1\_3\_A}(x) := I_{1\_F1\_3\_pu}(x) \cdot I_{BASE7}$$

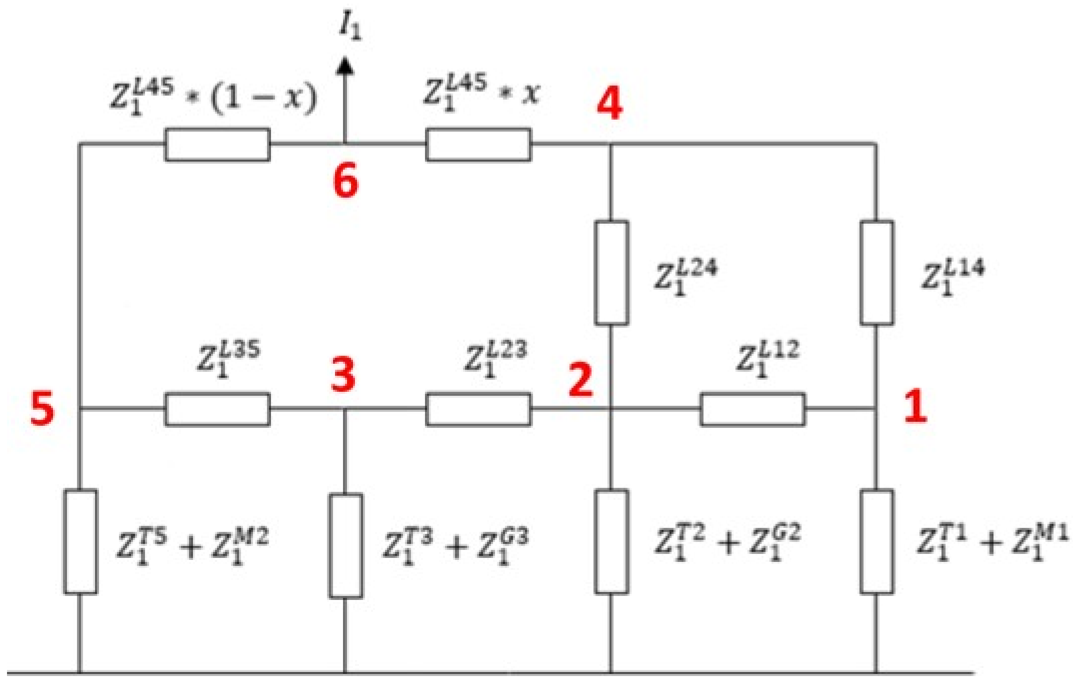
Si representamos la corriente para los diferentes valores de x (del 10% al 90%):



PRÁCTICA Nº2 CORTOCIRCUITOS

Repetir el apartado b) de la práctica 1 calculando los equivalentes de la red mediante la matriz de impedancia de barras Z_{barras}, obtenida a partir de la matriz admitancia Y_{barras}.

Tenemos que calcular Z1 otra vez pero usando la matriz de admitancias.



$$y_{1F1\_11} := \frac{1}{Z_{1\_L14}} + \frac{1}{Z_{1\_L12}} + \frac{1}{Z_{1\_T1} + Z_{1\_M1}} \qquad y_{1F1\_12} := \frac{-1}{Z_{1\_L12}} \qquad y_{1F1\_14} := \frac{-1}{Z_{1\_L14}}$$

$$y_{1F1\_22} := \frac{1}{Z_{1\_L12}} + \frac{1}{Z_{1\_L24}} + \frac{1}{Z_{1\_L23}} + \frac{1}{Z_{1\_T2} + Z_{1\_G2}} \qquad y_{1F1\_23} := \frac{-1}{Z_{1\_L23}}$$

$$y_{1F1\_24} := \frac{-1}{Z_{1\_L24}}$$

$$y_{1F1\_33} := \frac{1}{Z_{1\_L23}} + \frac{1}{Z_{1\_L35}} + \frac{1}{Z_{1\_T3} + Z_{1\_G3}} \qquad y_{1F1\_35} := \frac{-1}{Z_{1\_L35}}$$

$$y_{1F1\_44}(x) := \frac{1}{Z_{1\_L14}} + \frac{1}{Z_{1\_L24}} + \frac{1}{Z_{1\_L45} \cdot x} \qquad y_{1F1\_46}(x) := \frac{-1}{Z_{1\_L45} \cdot x}$$

$$y_{1F1\_55}(x) := \frac{1}{Z_{1\_L35}} + \frac{1}{Z_{1\_T5} + Z_{1\_M2}} + \frac{1}{Z_{1\_L45}\cdot(1-x)} \quad y_{1F1\_56}(x) := \frac{-1}{Z_{1\_L45}\cdot(1-x)}$$

$$y_{1F1\_66}(x) := \frac{1}{Z_{1\_L45}\cdot x} + \frac{1}{Z_{1\_L45}\cdot(1-x)}$$

$$Y_{barras1\_F1}(x) := \begin{pmatrix} y_{1F1\_11} & y_{1F1\_12} & 0 & y_{1F1\_14} & 0 & 0 \\ y_{1F1\_12} & y_{1F1\_22} & y_{1F1\_23} & y_{1F1\_24} & 0 & 0 \\ 0 & y_{1F1\_23} & y_{1F1\_33} & 0 & y_{1F1\_35} & 0 \\ y_{1F1\_14} & y_{1F1\_24} & 0 & y_{1F1\_44}(x) & 0 & y_{1F1\_46}(x) \\ 0 & 0 & y_{1F1\_35} & 0 & y_{1F1\_55}(x) & y_{1F1\_56}(x) \\ 0 & 0 & 0 & y_{1F1\_46}(x) & y_{1F1\_56}(x) & y_{1F1\_66}(x) \end{pmatrix}$$

La matriz de impedancia será la inversa de la matriz de admitancias:

$$Z_{barras1\_F1}(x) := Y_{barras1\_F1}(x)^{-1}$$

En nuestro caso, el elemento que representa la impedancia Z1 es el 6x6. Por lo tanto:

$$Z_{1\_F1\_matriz}(x) := Z_{barras1\_F1}(x)_{5,5}$$

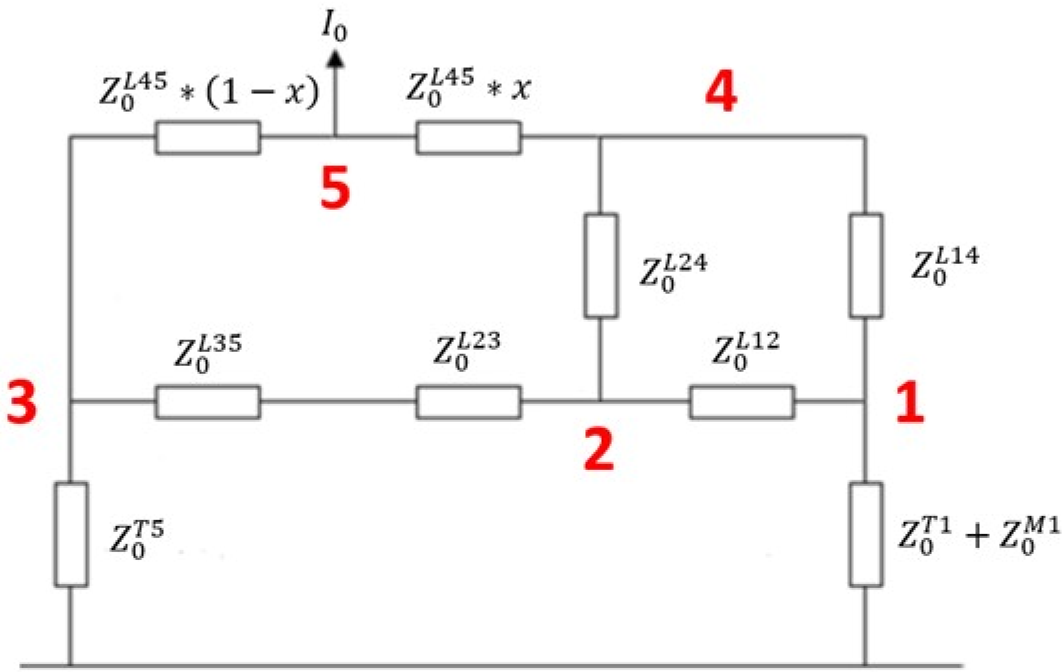
Si comparamos la impedancia nueva (calculada mediante la matriz) con la del apartado anterior (obtenida mediante simplificación del circuito equivalente), se observa que sale exactamente igual.

$\left\|Z_{1\_F1}(x)\right\| =$	$\left\|Z_{1\_F1\_matriz}(x)\right\| =$
0.1891	0.1891
0.1899	0.1899
0.1908	0.1908
0.1916	0.1916
0.1924	0.1924
0.1932	0.1932
0.194	0.194
...	...

Como la impedancia es la misma, la corriente obtenida será igual a la del apartado b.

c) Repetir el apartado b, suponiendo una falta monofásica.

En este caso, hay que calcular las impedancias Z2 y Z0. En nuestro caso, Z2 es la misma que Z1 ya que todos los elementos de la red tienen Z1=Z2. El circuito homopolar equivalente es:



$$y_{0F1\_11} := \frac{1}{Z_{0\_L14}} + \frac{1}{Z_{0\_L12}} + \frac{1}{Z_{0\_T1} + Z_{0\_M1}} \qquad y_{0F1\_12} := \frac{-1}{Z_{0\_L12}} \qquad y_{0F1\_14} := \frac{-1}{Z_{0\_L14}}$$

$$y_{0F1\_22} := \frac{1}{Z_{0\_L12}} + \frac{1}{Z_{0\_L23} + Z_{0\_L35}} + \frac{1}{Z_{0\_L24}} \qquad y_{0F1\_23} := \frac{-1}{Z_{0\_L23} + Z_{0\_L35}}$$

$$y_{0F1\_24} := \frac{-1}{Z_{0\_L24}}$$

$$y_{0F1\_33}(x) := \frac{1}{Z_{0\_T5}} + \frac{1}{Z_{0\_L23} + Z_{0\_L35}} + \frac{1}{Z_{0\_L45} \cdot (1-x)} \qquad y_{0F1\_35}(x) := \frac{-1}{Z_{0\_L45} \cdot (1-x)}$$

$$y_{0F1\_44}(x) := \frac{1}{Z_{0\_L24}} + \frac{1}{Z_{0\_L14}} + \frac{1}{Z_{0\_L45} \cdot x} \qquad y_{0F1\_45}(x) := \frac{-1}{Z_{0\_L45} \cdot x}$$

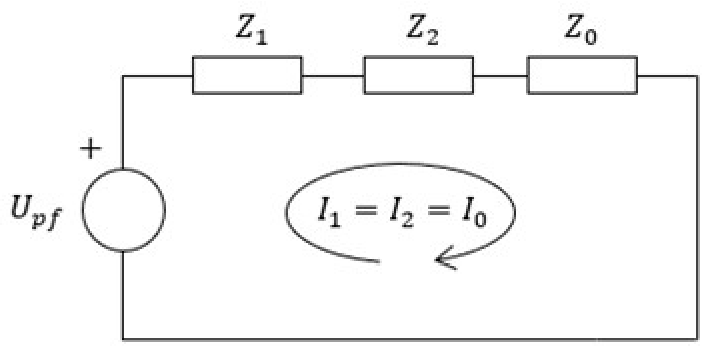
$$y_{0F1\_55}(x) := \frac{1}{Z_{0\_L45} \cdot (1-x)} + \frac{1}{Z_{0\_L45} \cdot x}$$

$$Y_{barras0\_F1}(x) := \begin{pmatrix} y_{0F1\_11} & y_{0F1\_12} & 0 & y_{0F1\_14} & 0 \\ y_{0F1\_12} & y_{0F1\_22} & y_{0F1\_23} & y_{0F1\_24} & 0 \\ 0 & y_{0F1\_23} & y_{0F1\_33}(x) & 0 & y_{0F1\_35}(x) \\ y_{0F1\_14} & y_{0F1\_24} & 0 & y_{0F1\_44}(x) & y_{0F1\_45}(x) \\ 0 & 0 & y_{0F1\_35}(x) & y_{0F1\_45}(x) & y_{0F1\_55}(x) \end{pmatrix}$$

$$Z_{barras0\_F1}(x) := Y_{barras0\_F1}(x)^{-1}$$

$$Z_{0\_F1}(x) := Z_{barras0\_F1}(x)_{4,4}$$

Finalmente, calculamos la corriente. Como se trata de una falta monofásica:



$$I_{1\_F1\_1\_pu}(x) := \frac{U_{pf}}{2 \cdot Z_{1\_F1}(x) + Z_{0\_F1}(x)}$$

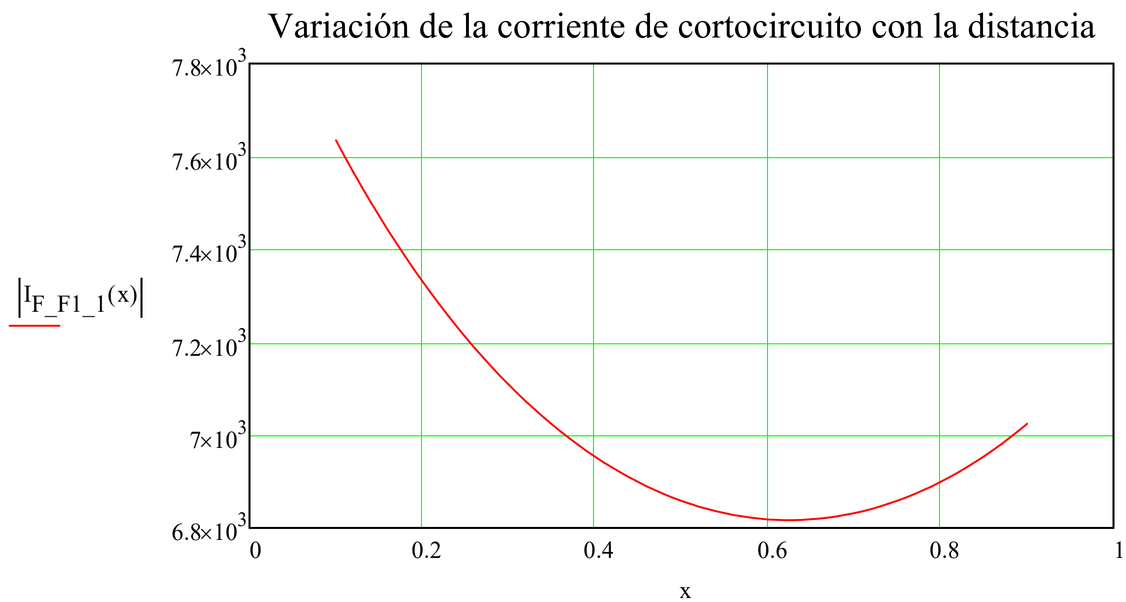
Sabiendo que la corriente de falta 3 veces la corriente homopolar:

$$I_{F\_F1\_1}(x) := 3\, I_{1\_F1\_3\_pu}(x) \cdot I_{BASE7}$$

$I_{F\_F1\_1}(x) =$ $\cdot kA$

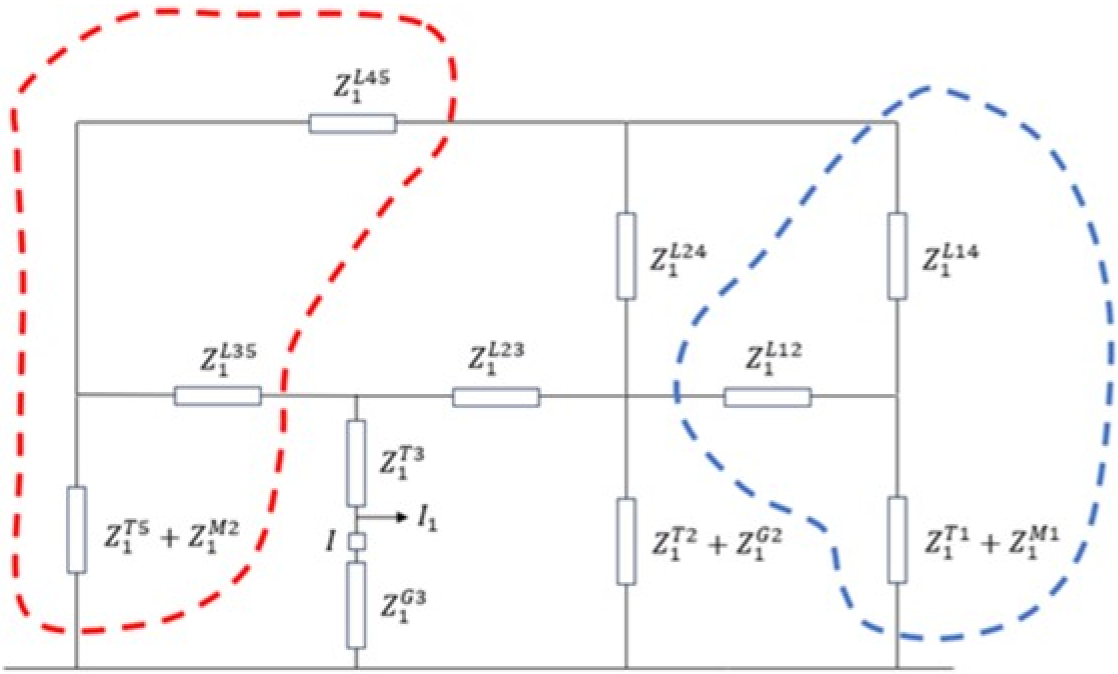
	0
0	-7.6342i
1	-7.5998i
2	-7.5663i
3	-7.5338i
4	-7.5022i
5	...

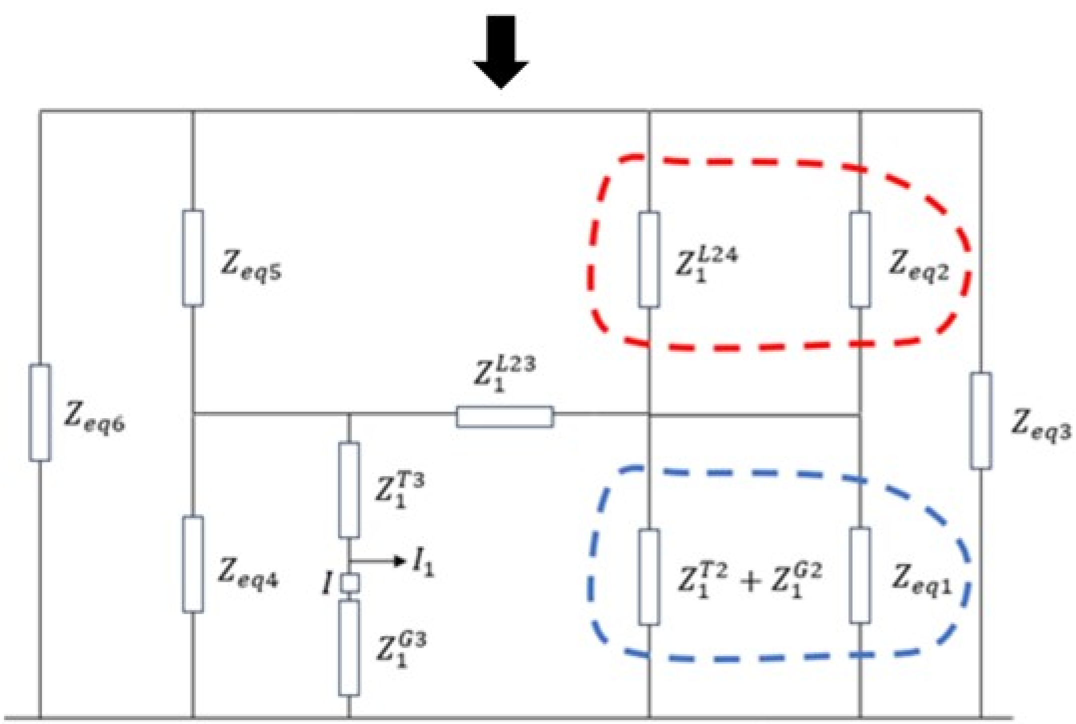
Si representamos la corriente para los diferentes valores de x (del 10% al 90%):



d) Obtener el valor de la corriente que circularía por el interruptor I en el caso de cortocircuito bifásico a tierra en F_2.

<u>SECUENCIA DIRECTA</u>





$$Z''_{eq1} := \frac{Z_{1\_L14} \cdot Z_{1\_L12} + Z_{1\_L14} \cdot (Z_{1\_T1} + Z_{1\_M1}) + Z_{1\_L12} \cdot (Z_{1\_T1} + Z_{1\_M1})}{Z_{1\_L14}} = 1.9234i$$

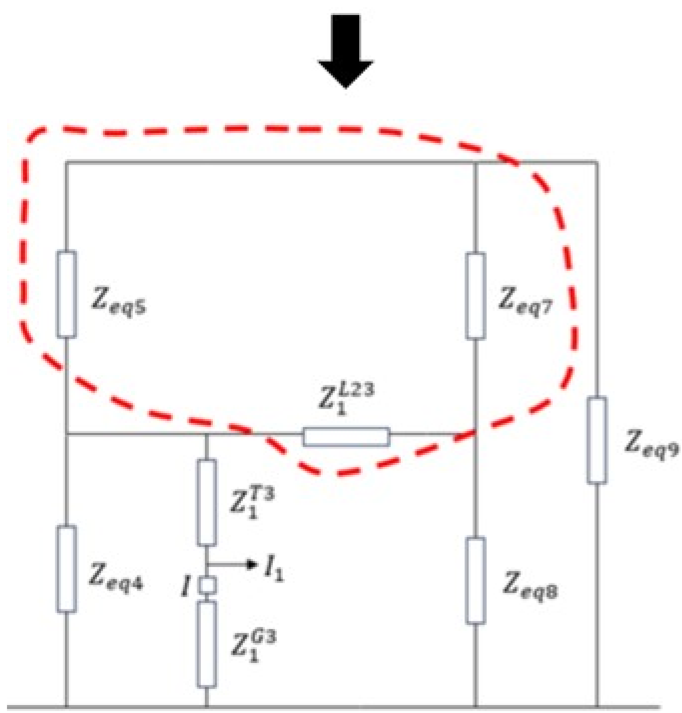
$$Z''_{eq2} := \frac{Z_{1\_L14} \cdot Z_{1\_L12} + Z_{1\_L14} \cdot (Z_{1\_T1} + Z_{1\_M1}) + Z_{1\_L12} \cdot (Z_{1\_T1} + Z_{1\_M1})}{Z_{1\_T1} + Z_{1\_M1}} = 0.2052i$$

$$Z''_{eq3} := \frac{Z_{1\_L14} \cdot Z_{1\_L12} + Z_{1\_L14} \cdot (Z_{1\_T1} + Z_{1\_M1}) + Z_{1\_L12} \cdot (Z_{1\_T1} + Z_{1\_M1})}{Z_{1\_L12}} = 7.6936i$$

$$Z''_{eq4} := \frac{Z_{1\_L45} \cdot Z_{1\_L35} + Z_{1\_L45} \cdot (Z_{1\_T5} + Z_{1\_M2}) + Z_{1\_L35} \cdot (Z_{1\_T5} + Z_{1\_M2})}{Z_{1\_L45}} = 2.7941i$$

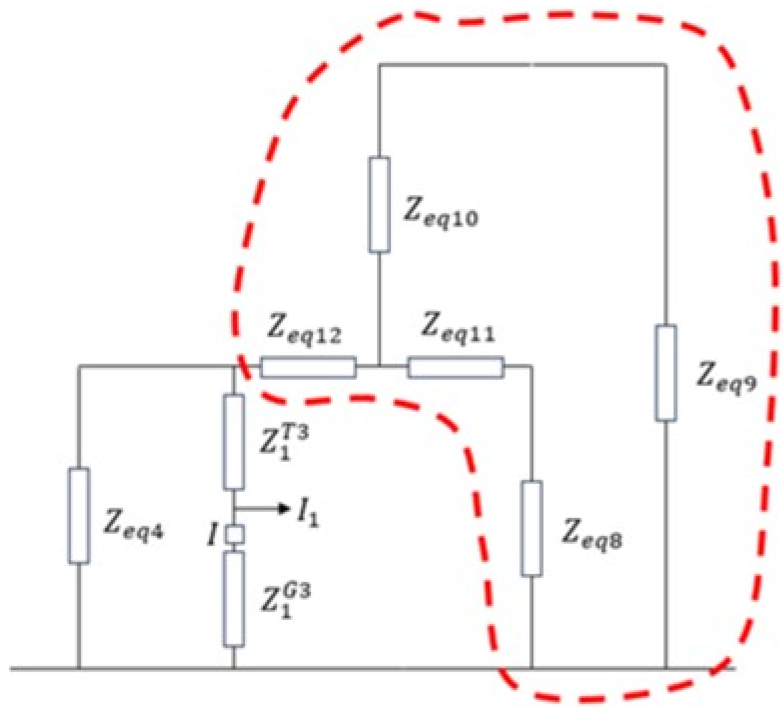
$$Z''_{eq5} := \frac{Z_{1\_L45} \cdot Z_{1\_L35} + Z_{1\_L45} \cdot (Z_{1\_T5} + Z_{1\_M2}) + Z_{1\_L35} \cdot (Z_{1\_T5} + Z_{1\_M2})}{Z_{1\_T5} + Z_{1\_M2}} = 0.4877i$$

$$Z''_{eq6} := \frac{Z_{1\_L45} \cdot Z_{1\_L35} + Z_{1\_L45} \cdot (Z_{1\_T5} + Z_{1\_M2}) + Z_{1\_L35} \cdot (Z_{1\_T5} + Z_{1\_M2})}{Z_{1\_L35}} = 2.6544i$$



$$Z''_{eq7} := \frac{Z''_{eq2} \cdot Z_{1\_L24}}{Z''_{eq2} + Z_{1\_L24}} = 0.1083i \qquad Z''_{eq8} := \frac{Z''_{eq1} \cdot (Z_{1\_T2} + Z_{1\_G2})}{Z''_{eq1} + Z_{1\_T2} + Z_{1\_G2}} = 0.2125i$$

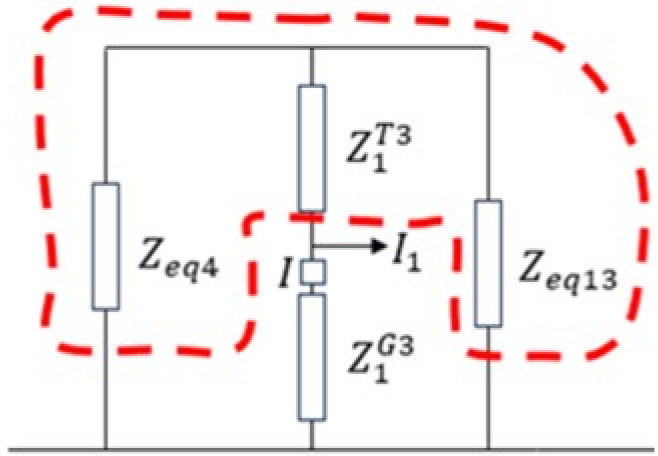
$$Z''_{eq9} := \frac{Z''_{eq3} \cdot Z''_{eq6}}{Z''_{eq3} + Z''_{eq6}} = 1.9735i$$



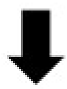
$$Z''_{eq10} := \frac{Z''_{eq5} \cdot Z''_{eq7}}{Z''_{eq5} + Z''_{eq7} + Z_{1\_L23}} = 0.0781i$$

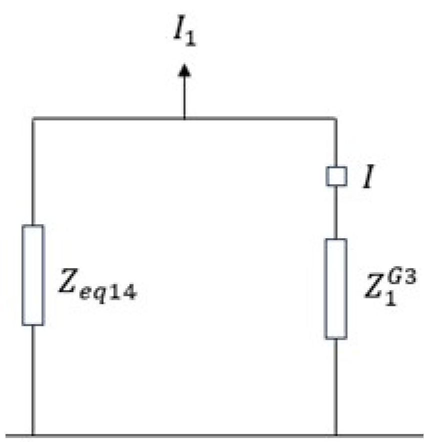
$$Z''_{eq11} := \frac{Z_{1\_L23} \cdot Z''_{eq7}}{Z''_{eq5} + Z''_{eq7} + Z_{1\_L23}} = 0.0129i$$

$$Z''_{eq12} := \frac{Z''_{eq5} \cdot Z_{1\_L23}}{Z''_{eq5} + Z''_{eq7} + Z_{1\_L23}} = 0.0579i$$



$$Z''_{eq13} := Z''_{eq12} + \frac{\left(Z''_{eq11} + Z''_{eq8}\right)\cdot\left(Z''_{eq10} + Z''_{eq9}\right)}{Z''_{eq11} + Z''_{eq8} + Z''_{eq10} + Z''_{eq9}} = 0.261i$$





$$Z''_{eq14} := Z_{1\_T3} + \frac{Z''_{eq4}\cdot Z''_{eq13}}{Z''_{eq4} + Z''_{eq13}} = 0.3498i$$

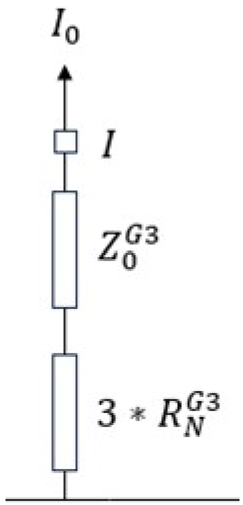
$$Z_{1\_F2} := \frac{Z''_{eq14}\cdot Z_{1\_G3}}{Z''_{eq14} + Z_{1\_G3}} = 0.0778i$$

<u>SECUENCIA INVERSA</u>

Igual que en secuencia directa:

$$Z_{2\_F2} := Z_{1\_F2}$$

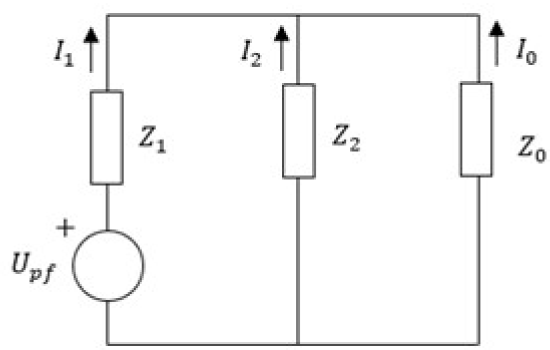
SECUENCIA HOMOPOLAR



$$Z_{0\_F2} := Z_{0\_G3} + 3 \cdot R_{N\_G3} = 0.5765 + 0.1i$$

CORRIENTE DE FALTA

Como se trata de una falta bifásica a tierra:



$$I_{1\_F2} := \frac{U_{pf}}{Z_{1\_F2} + \frac{Z_{2\_F2} \cdot Z_{0\_F2}}{Z_{2\_F2} + Z_{0\_F2}}} = 0.4508 - 7.181i$$

$$I_{2\_F2} := -I_{1\_F2} \cdot \frac{Z_{0\_F2}}{Z_{0\_F2} + Z_{2\_F2}} = 0.4508 + 6.9638i$$

$$I_{0\_F2} := -I_{1\_F2} \cdot \frac{Z_{2\_F2}}{Z_{0\_F2} + Z_{2\_F2}} = -0.9016 + 0.2172i$$

Nos piden la corriente por el interruptor, la cual no es la misma que la de cortocircuito:

$$I_{1\_I} := I_{1\_F2} \cdot \frac{Z''_{eq14}}{Z''_{eq14} + Z_{1\_G3}} = 0.3506 - 5.5845i$$

$$I_{2\_I} := I_{2\_F2} \cdot \frac{Z''_{eq14}}{Z''_{eq14} + Z_{1\_G3}} = 0.3506 + 5.4155i$$

$$I_{0\_I} := I_{0\_F2} = -0.9016 + 0.2172i$$

Definimos α como un giro de 120º y obtenemos las corrientes por fase:

$$\alpha := 1 \cdot e^{i \cdot 120deg} = -0.5 + 0.866i$$

$$I_{AI} := I_{0\_I} + I_{1\_I} + I_{2\_I} = -0.2005 + 0.0483i$$

$$I_{BI} := I_{0\_I} + I_{1\_I} \cdot \alpha^2 + I_{2\_I} \cdot \alpha = -10.7785 + 0.3017i$$

$$I_{CI} := I_{0\_I} + I_{1\_I} \cdot \alpha + I_{2\_I} \cdot \alpha^2 = 8.274 + 0.3017i$$

$$I_{BASE3} := \frac{S_{BASE}}{\sqrt{3} \cdot U_{BASE3}} = 3.3962 \cdot kA$$

$$I''_{AI} := \left|I_{AI}\right| \cdot I_{BASE3} = 0.7003 \cdot kA$$

$$I''_{BI} := \left|I_{BI}\right| \cdot I_{BASE3} = 36.6201 \cdot kA$$

$$I''_{CI} := \left|I_{CI}\right| \cdot I_{BASE3} = 28.1188 \cdot kA$$

e) Obtener el valor de la corriente de cortocircuito en el caso de una falta monofásica en F_3.

SECUENCIA DIRECTA

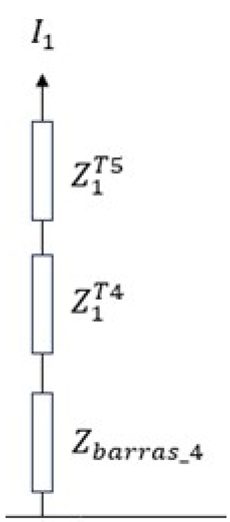
Observando el circuito equivalente, la impedancia es la vista desde el nudo 4 (el nudo 4 usado para calcular la matriz de impedancias) más las impedancias de T4 y T6. Observando la matriz del nudo 4, evidentemente no depende de x por lo que cogemos el primer elemento:

$Z_{barras1\_F1}(x)_{3,3} =$

	0
0	0.1796i
1	0.1796i
2	0.1796i
3	0.1796i
4	0.1796i
5	0.1796i
6	0.1796i
7	...

$$Z_{1\_nudo4} := Z_{barras1\_F1}(0.1)_{3,3} = 0.1796i$$

Por lo tanto, la impedancia en secuencia directa es:



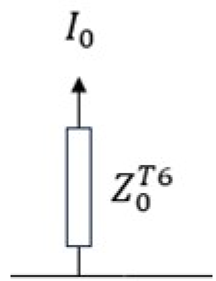
$$Z_{1\_F3} := Z_{1\_T4} + Z_{1\_T5} + Z_{1\_nudo4} = 0.6196i$$

SECUENCIA INVERSA

Igual que en secuencia directa:

$$Z_{2\_F3} := Z_{1\_F3}$$

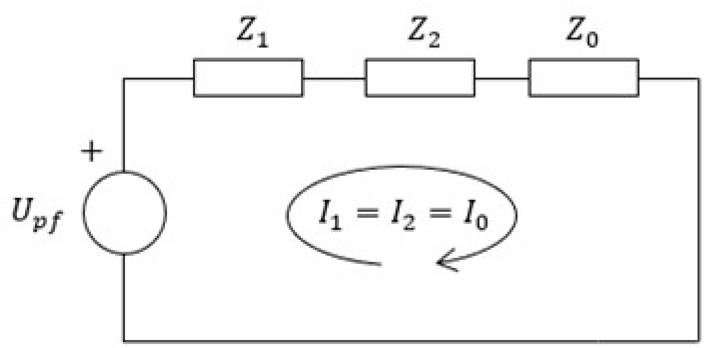
SECUENCIA HOMOPOLAR



$$Z_{0\_F3} := Z_{0\_T6} = 5.7037i$$

CORRIENTE DE FALTA

Como se trata de una falta monofásica:



$$I_{F3\_pu} := \frac{U_{pf}}{Z_{1\_F3} + Z_{2\_F3} + Z_{0\_F3}} = -0.1584i$$

Para convertir el valor a Amperios, multiplicamos por la corriente base:

$$I_{BASE5} := \frac{S_{BASE}}{\sqrt{3} \cdot U_{BASE5}} = 134.0277 \cdot kA$$

$$I_{F\_F3\_A} := 3 \cdot \left| I_{F3\_pu} \right| \cdot I_{BASE5} = 63.7038 \cdot kA$$