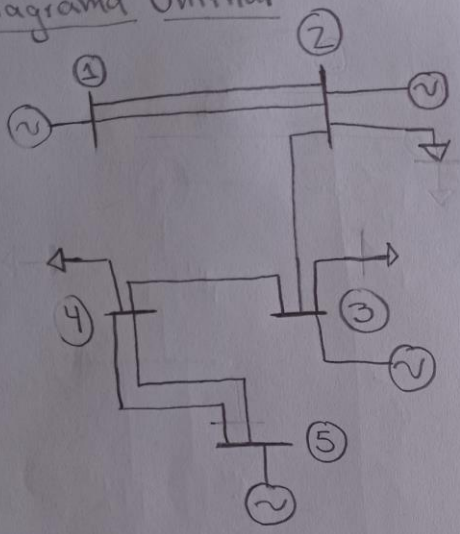
Diagrama Unifilar



Generadores:

① $10\ Kv \angle 0^\circ \quad z = (0 + j(0,05))\ \Omega$

② $8\ Kv \angle 5^\circ \quad z = (2 + j(0))\ \Omega$

$5\ Kv \angle 5^\circ \quad z = (0 + j(0,05))\ \Omega$

③ $10,2\ Kv \angle -10^\circ \quad z = (0 + j(0,05))\ \Omega$

⑤ $10,2\ Kv \angle 13 \quad z = (0 + j(0,05))\ \Omega$

Cargas:

② Inductiva $z_L = (1,8 + j(0,5))\ \Omega$

③ Inductiva $z_L = (0,9 + j(0,2))\ \Omega$

④ Capacitiva $z_C = (4 - j(2))\ \Omega$

Líneas:

① – ②:

100 Km $z_L = (0,03 + j(0,3))100\ \Omega$

$Y_b = 0\ \mho$

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$Y_b = 0\ \mho$

② – ③:

200 Km $z_L = (0,04 + j(0,3))200\ \Omega$

$Y_b = j(0,25)200\ \mho$

③ – ④:

250 Km $z_L = (0,05 + j(0,3))250\ \Omega$

$Y_b = j(0,3)250\ \mho$

④ – ⑤:

200 Km $z_L = (0,03 + j(0,3))200\ \Omega$

$Y_b = 0\ \mho$

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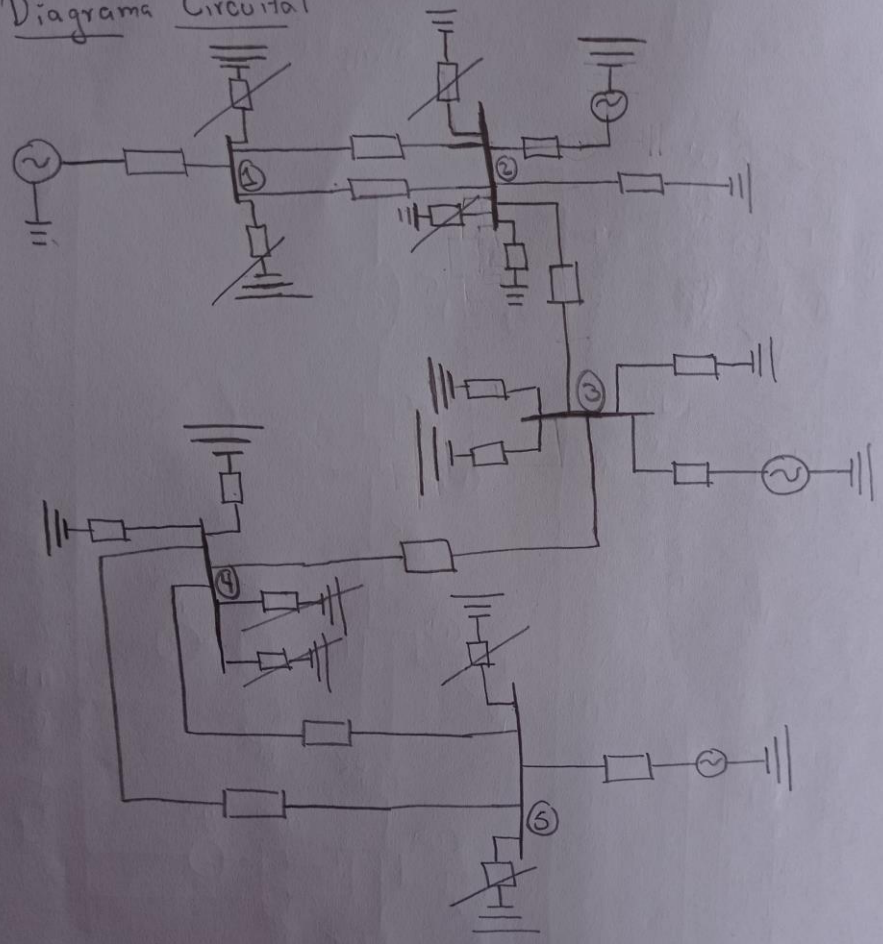
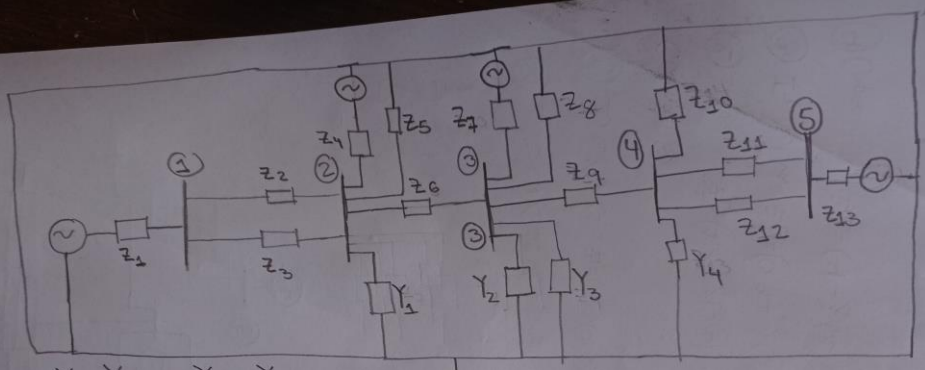
Diagrama Circuital



Simplificando el circuito debido a que las $Y_b = 0$ en las líneas ①–② y ④–⑤

Diagrama Circuital Simplificado:



$Y_1 = Y_2 \qquad Y_3 = Y_4$

$Z_2 \| Z_3 \quad \frac{1}{Zeq_1} = \frac{1}{Z_2} + \frac{1}{Z_3} \Rightarrow Zeq_1 = (1,5 + j\,15)\,\Omega = 15,0748 \angle 1,4713\,\Omega$

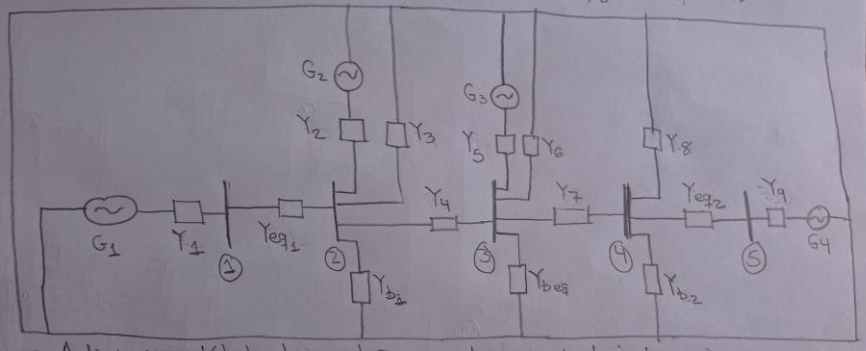
$Z_{11} \| Z_{12} \quad \frac{1}{Zeq_2} = \frac{1}{Z_{11}} + \frac{1}{Z_{12}} \Rightarrow Zeq_2 = (3 + j\,30)\,\Omega = 30,1496 \angle 1,4713\,\Omega$

$Y_2 \| Y_3 \quad Yeq = Y_2 + Y_3 \Rightarrow Yeq = 2Y_2 \Rightarrow Yeq = j(150)\,\mho$

$= 150 \angle 1,5708\,\mho$

Convertimos la impedancias Z en Admitancias Y, y nos queda:

Diagrama Circuital aún más simplificado:



Aplicamos método de nodos en cada una de las barras

Asumimos que todos las corrientes salen de las barras:

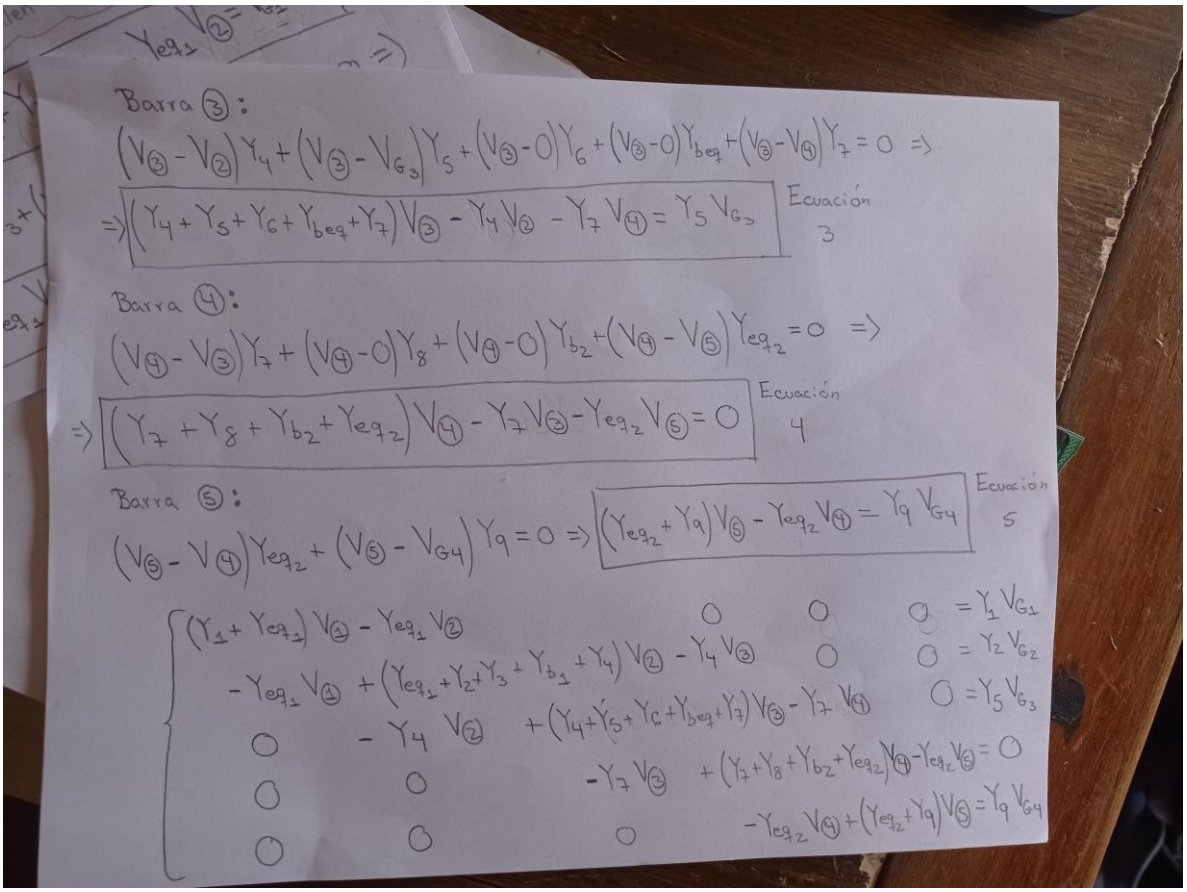
Barra ①:

$$(V_② - V_{G_1})Y_1 + (V_① - V_②)Y_{eq_1} = 0 \Rightarrow \boxed{(Y_1 + Y_{eq_1})V_① - Y_{eq_1}V_② = V_{G_1}Y_1}$$ Ecuación 1

Barra ②:

$$(V_② - V_①)Y_{eq_1} + (V_② - V_{G_2})Y_2 + (V_② - 0)Y_3 + (V_② - 0)Y_{b_1} + (V_② - V_③)Y_4 = 0 \Rightarrow$$

$$\Rightarrow \boxed{(Y_{eq_1} + Y_2 + Y_3 + Y_{b_1} + Y_4)V_② - Y_{eq_1}V_① - Y_4V_③ = Y_2V_{G_2}}$$ Ecuación 2



Barra ③:

$$(V_③ - V_②)Y_4 + (V_③ - V_{G_3})Y_5 + (V_③ - 0)Y_6 + (V_③ - 0)Y_{beq} + (V_③ - V_④)Y_7 = 0 \Rightarrow$$

$$\Rightarrow \boxed{(Y_4 + Y_5 + Y_6 + Y_{beq} + Y_7)V_③ - Y_4 V_② - Y_7 V_④ = Y_5 V_{G_3}} \quad \text{Ecuación } 3$$

Barra ④:

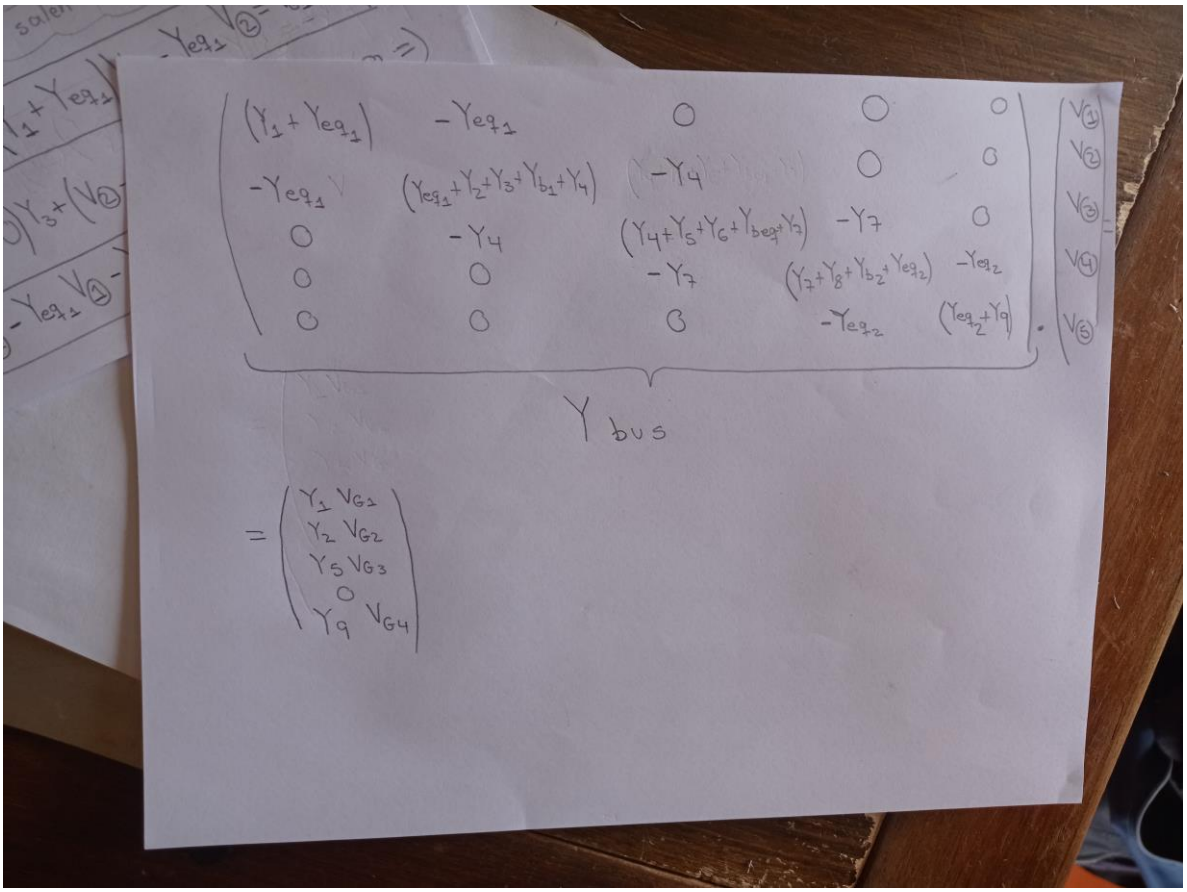
$$(V_④ - V_③)Y_7 + (V_④ - 0)Y_8 + (V_④ - 0)Y_{b_2} + (V_④ - V_⑤)Y_{eq_2} = 0 \Rightarrow$$

$$\Rightarrow \boxed{(Y_7 + Y_8 + Y_{b_2} + Y_{eq_2})V_④ - Y_7 V_③ - Y_{eq_2} V_⑤ = 0} \quad \text{Ecuación } 4$$

Barra ⑤:

$$(V_⑤ - V_④)Y_{eq_2} + (V_⑤ - V_{G4})Y_9 = 0 \Rightarrow \boxed{(Y_{eq_2} + Y_9)V_⑤ - Y_{eq_2} V_④ = Y_9 V_{G4}} \quad \text{Ecuación } 5$$

$$\begin{cases} (Y_1 + Y_{eq_1})V_① - Y_{eq_1} V_② & 0 & 0 & 0 = Y_1 V_{G_1} \\ -Y_{eq_1} V_① + (Y_{eq_1} + Y_2 + Y_3 + Y_{b_1} + Y_4)V_② - Y_4 V_③ & 0 & 0 = Y_2 V_{G_2} \\ 0 - Y_4 V_② + (Y_4 + Y_5 + Y_6 + Y_{beq} + Y_7)V_③ - Y_7 V_④ & 0 = Y_5 V_{G_3} \\ 0 \quad 0 \quad -Y_7 V_③ + (Y_7 + Y_8 + Y_{b_2} + Y_{eq_2})V_④ - Y_{eq_2} V_⑤ = 0 \\ 0 \quad 0 \quad 0 \quad -Y_{eq_2} V_④ + (Y_{eq_2} + Y_9)V_⑤ = Y_9 V_{G4} \end{cases}$$


$\begin{pmatrix} (Y_1 + Y_{eq_1}) & -Y_{eq_1} & 0 & 0 & 0 \\ -Y_{eq_1} & (Y_{eq_1} + Y_2 + Y_3 + Y_{b_1} + Y_4) & -Y_4 & 0 & 0 \\ 0 & -Y_4 & (Y_4 + Y_5 + Y_6 + Y_{beq_1} + Y_3) & -Y_7 & 0 \\ 0 & 0 & -Y_7 & (Y_7 + Y_8 + Y_{b_2} + Y_{eq_2}) & -Y_{eq_2} \\ 0 & 0 & 0 & -Y_{eq_2} & (Y_{eq_2} + Y_9) \end{pmatrix} \cdot \begin{pmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \end{pmatrix}$
Y_{bus}
$= \begin{pmatrix} Y_1 V_{G1} \\ Y_2 V_{G2} \\ Y_5 V_{G3} \\ 0 \\ Y_9 V_{G4} \end{pmatrix}$