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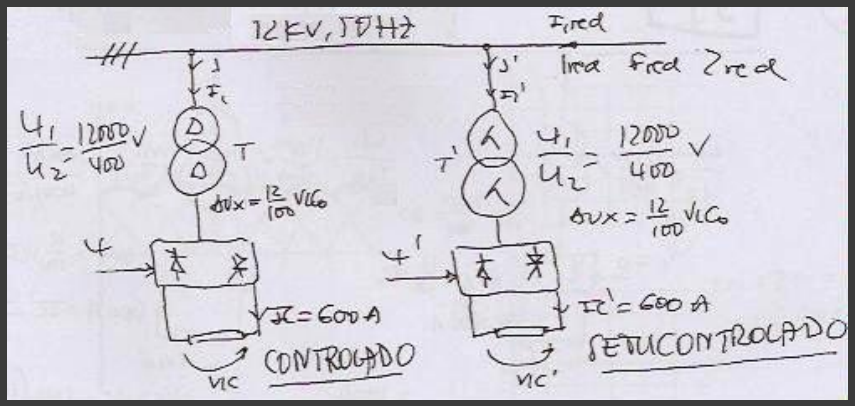
Estudio de Rectificadores Trifásicos

Ejercicio 1. Dos rectificadores no controlados

Oskar Casquero, F. Javier Maseda, Jesús Romo & Itziar Martija

Ejercicio 1. Dos rectificadores no controlados

En el circuito de la figura , se conectan dos rectificadores a una red de, uno controlado y otro semicontrolado. En cualquier situación cada rectificador consume en la carga 600A.



Siendo ψ=ψ'=0° :

1. Dibujar I_{RED}. Calcular su valor eficaz.
2. Calcular F_{RED} (factor de potencia).
3. Calcular ζ_{RED} (nivel de armónicos en la red).
4. Calcular la potencia de los transformadoresT y T'.

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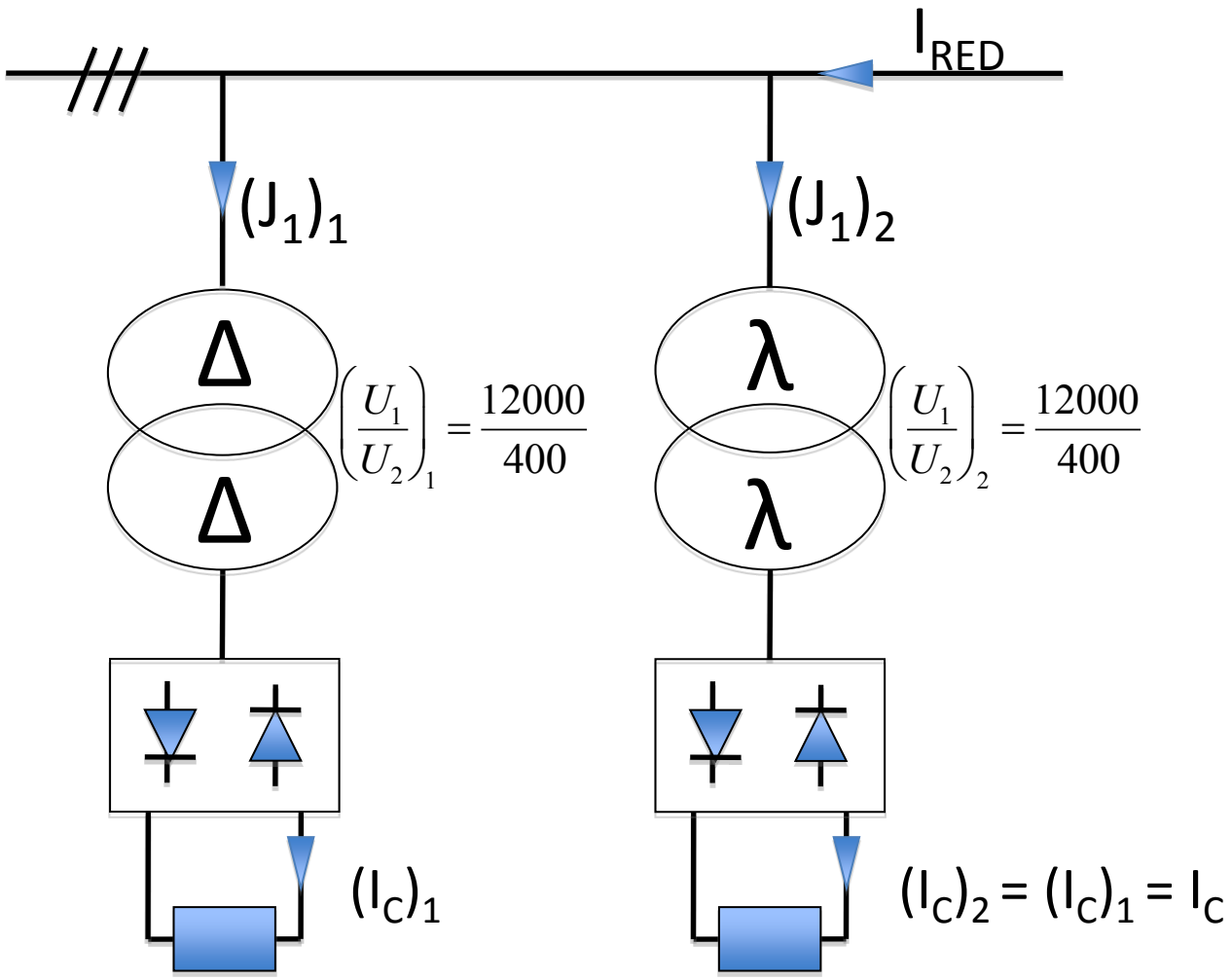
Circuito



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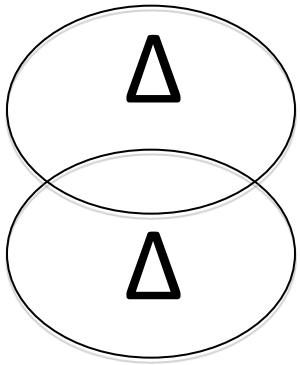
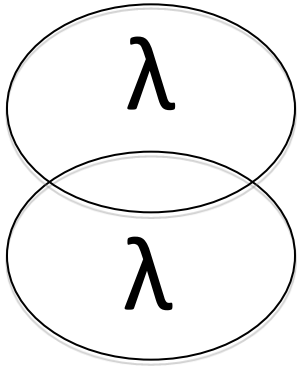
Resolución

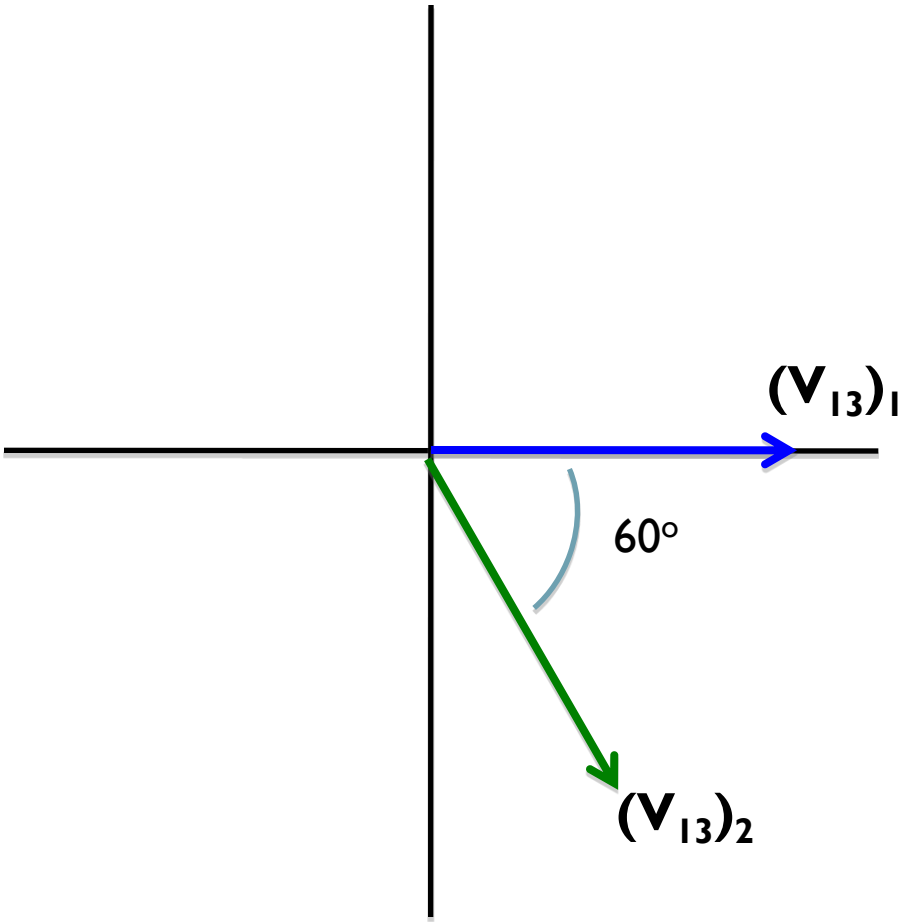


$$\left(\frac{U_1}{U_2}\right)_1 = \frac{12000}{400} \Rightarrow \left(\frac{n_1}{n_2}\right)_1 = \frac{U_1}{U_2} = \frac{12000}{400} = 30$$

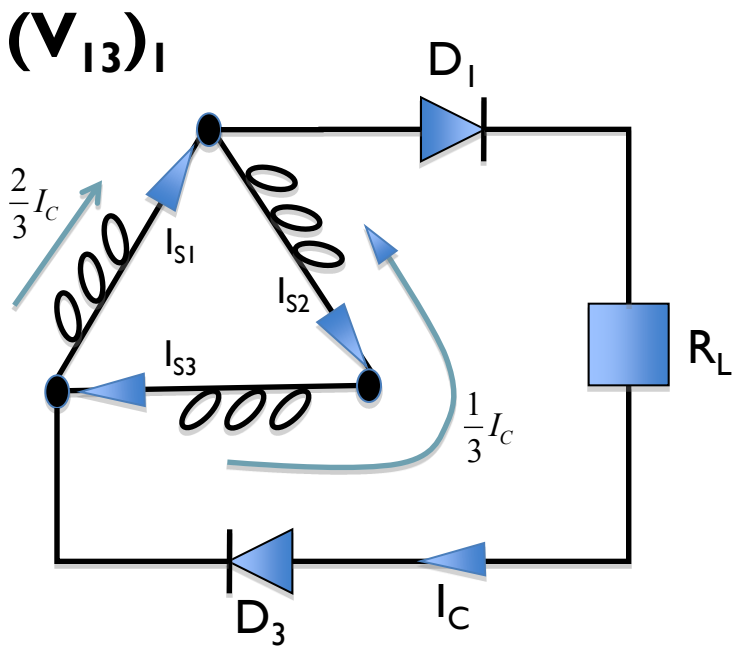


$$\left(\frac{U_1}{U_2}\right)_2 = \frac{12000}{400} \Rightarrow \left(\frac{n_1}{n_2}\right)_2 = \frac{U_1/\sqrt{3}}{U_2/\sqrt{3}} = \frac{12000/\sqrt{3}}{400/\sqrt{3}} = 30$$

Resolución



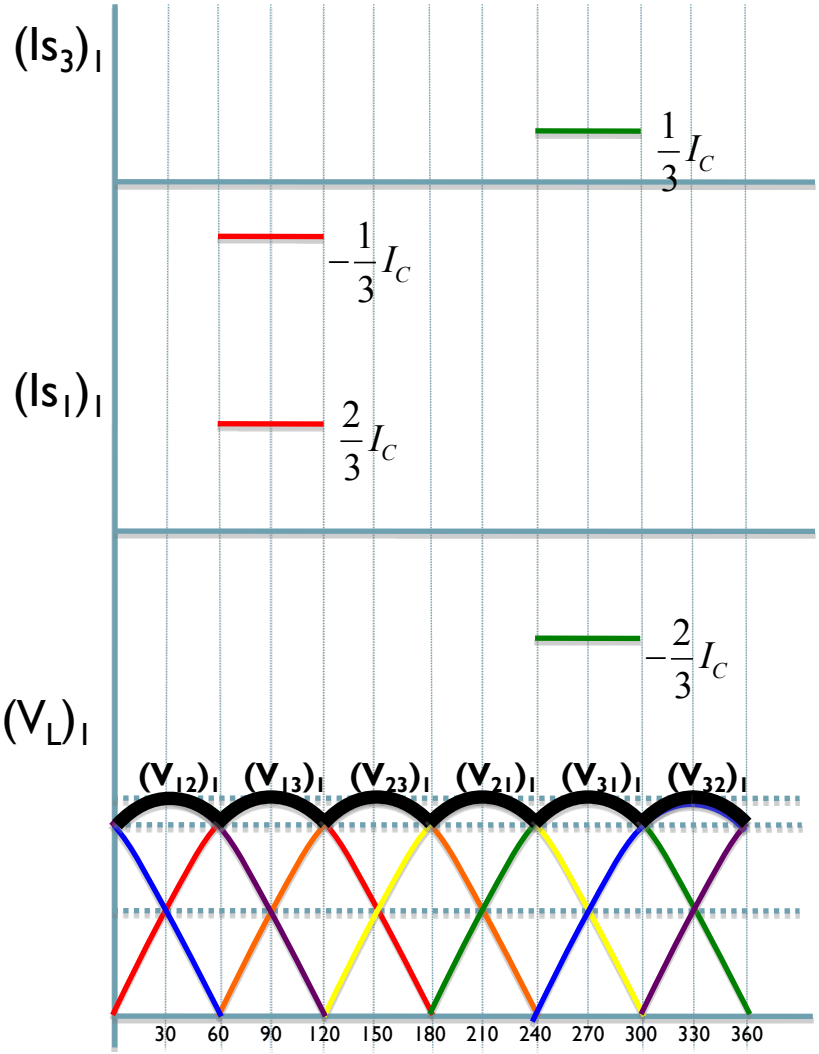
Resolución



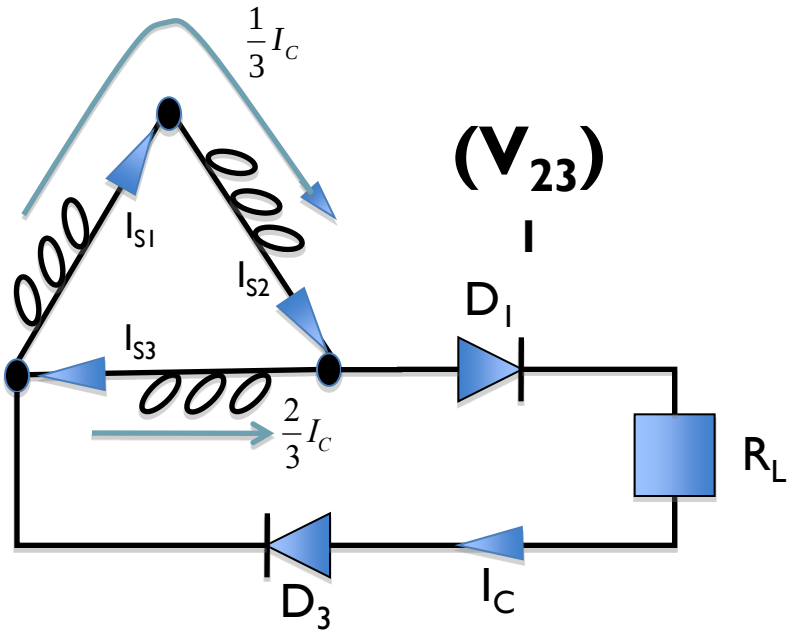
$$I_{S1} = \frac{2}{3} I_C$$

$$I_{S2} = -\frac{1}{3} I_C$$

$$I_{S3} = -\frac{1}{3} I_C$$



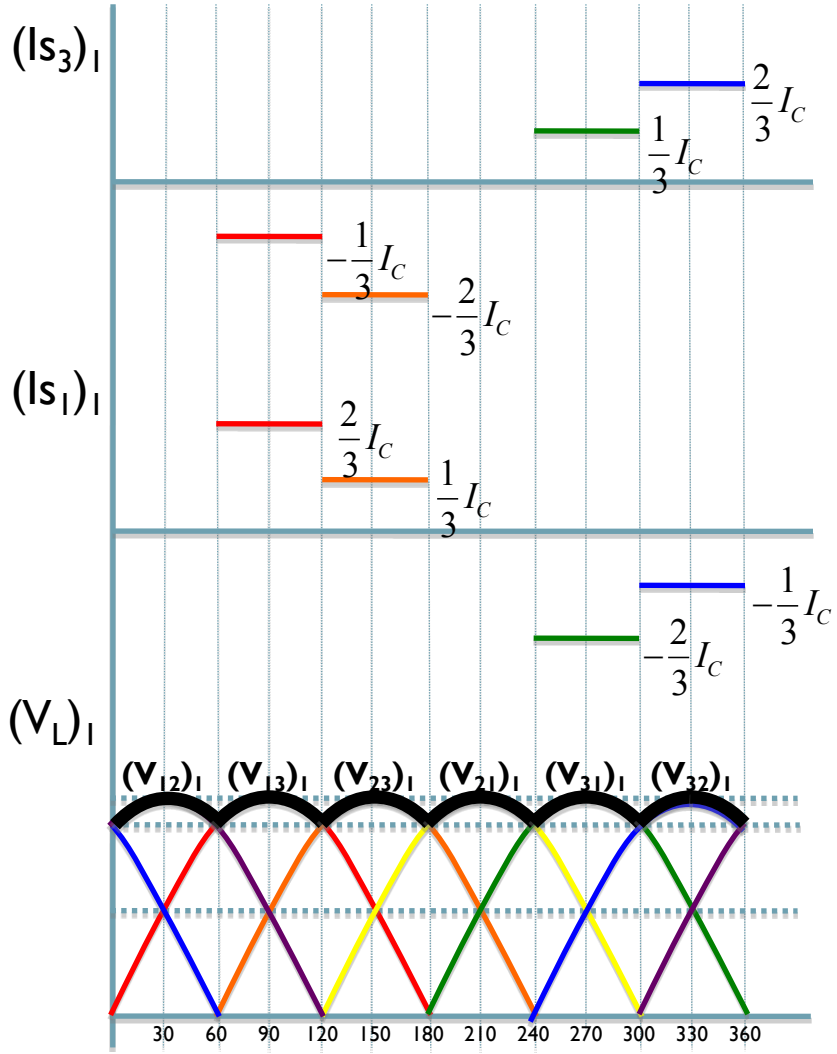
Resolución



$$I_{S1} = \frac{1}{3} I_C$$

$$I_{S2} = \frac{1}{3} I_C$$

$$I_{S3} = -\frac{2}{3} I_C$$



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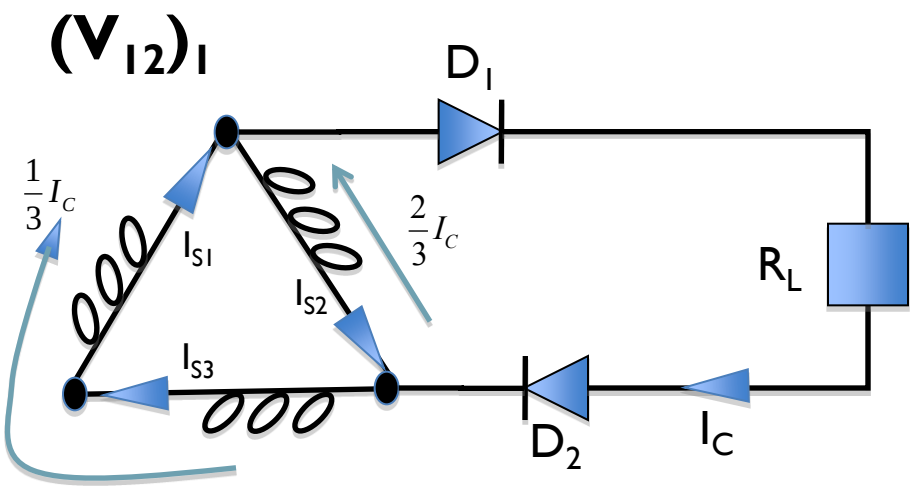
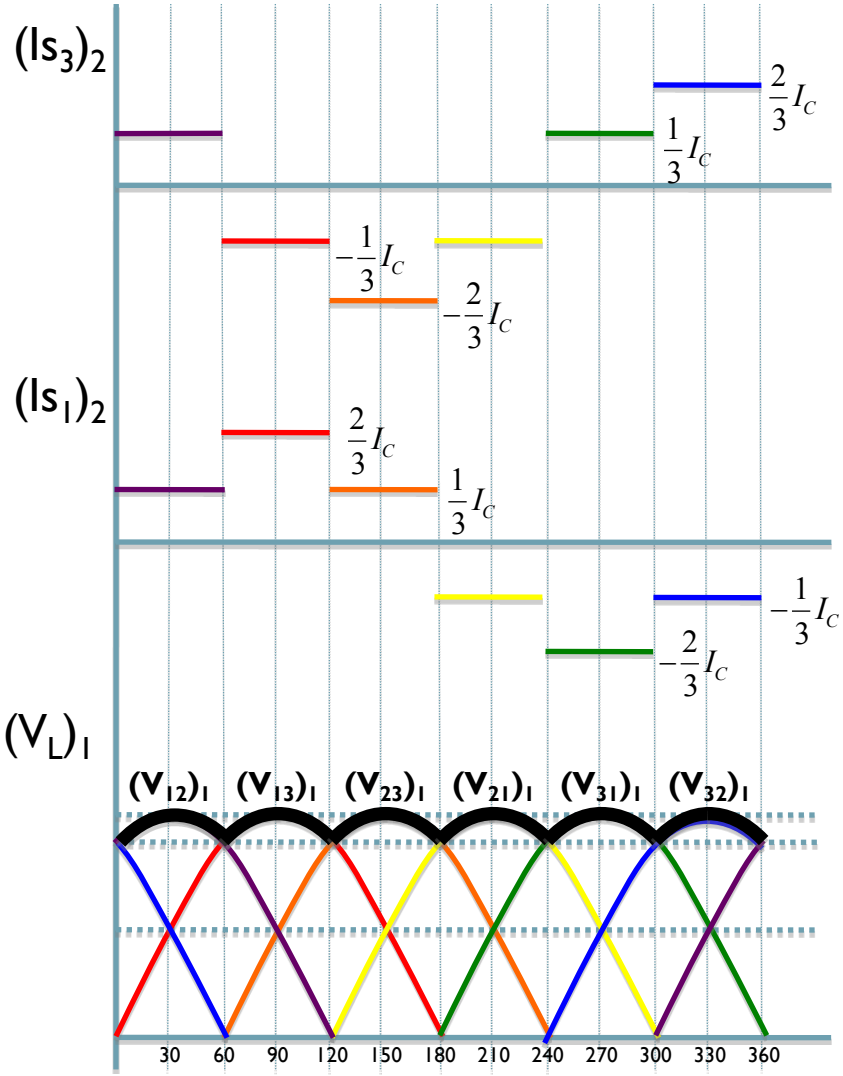
Resolución



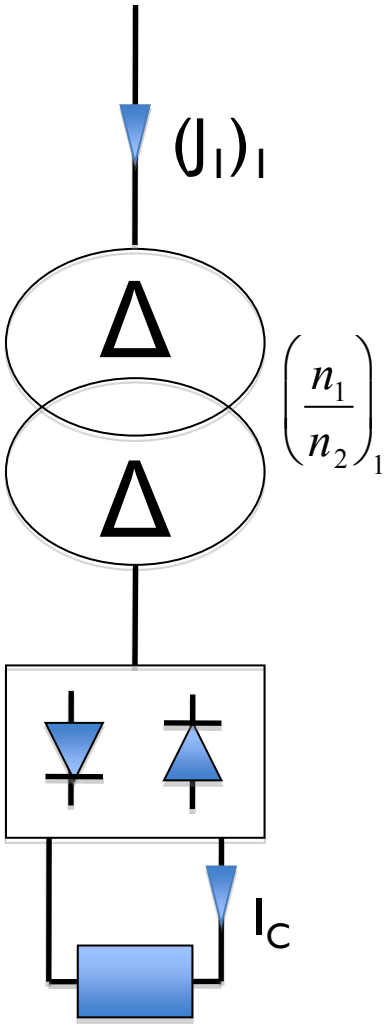
$$I_{S1} = \frac{1}{3} I_C$$

$$I_{S2} = -\frac{2}{3} I_C$$

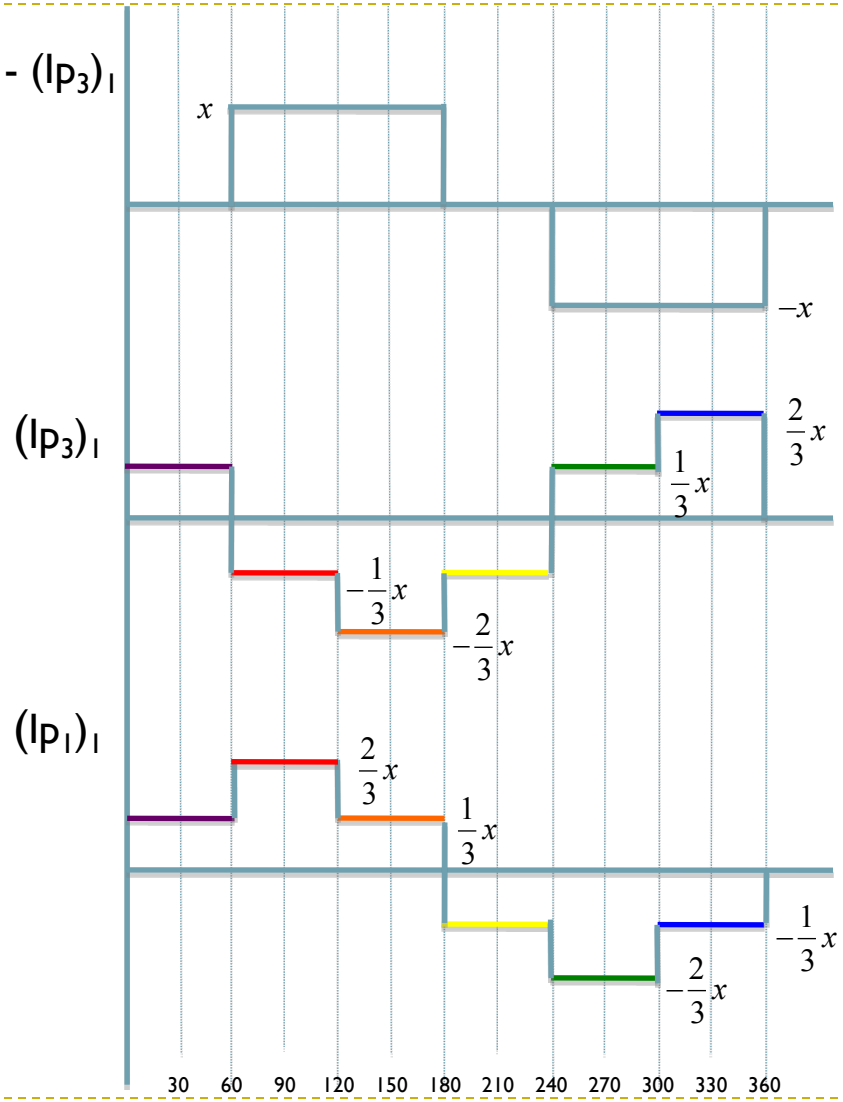
$$I_{S3} = \frac{1}{3} I_C$$



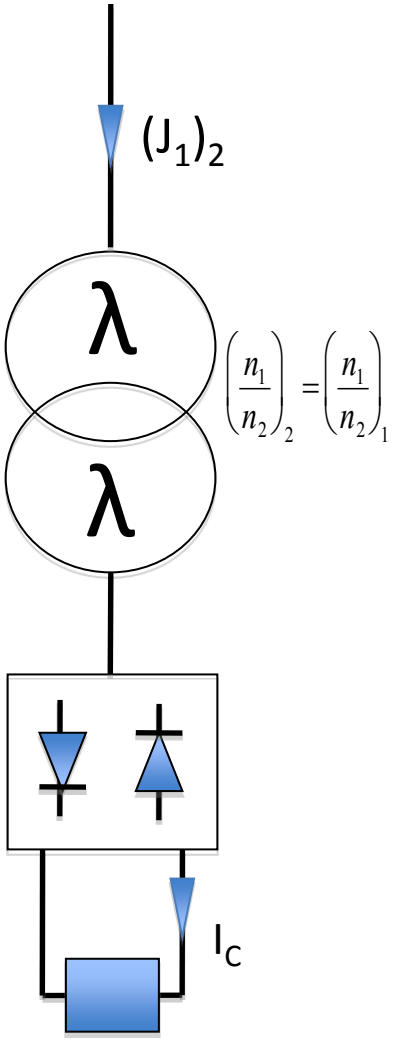
Resolución

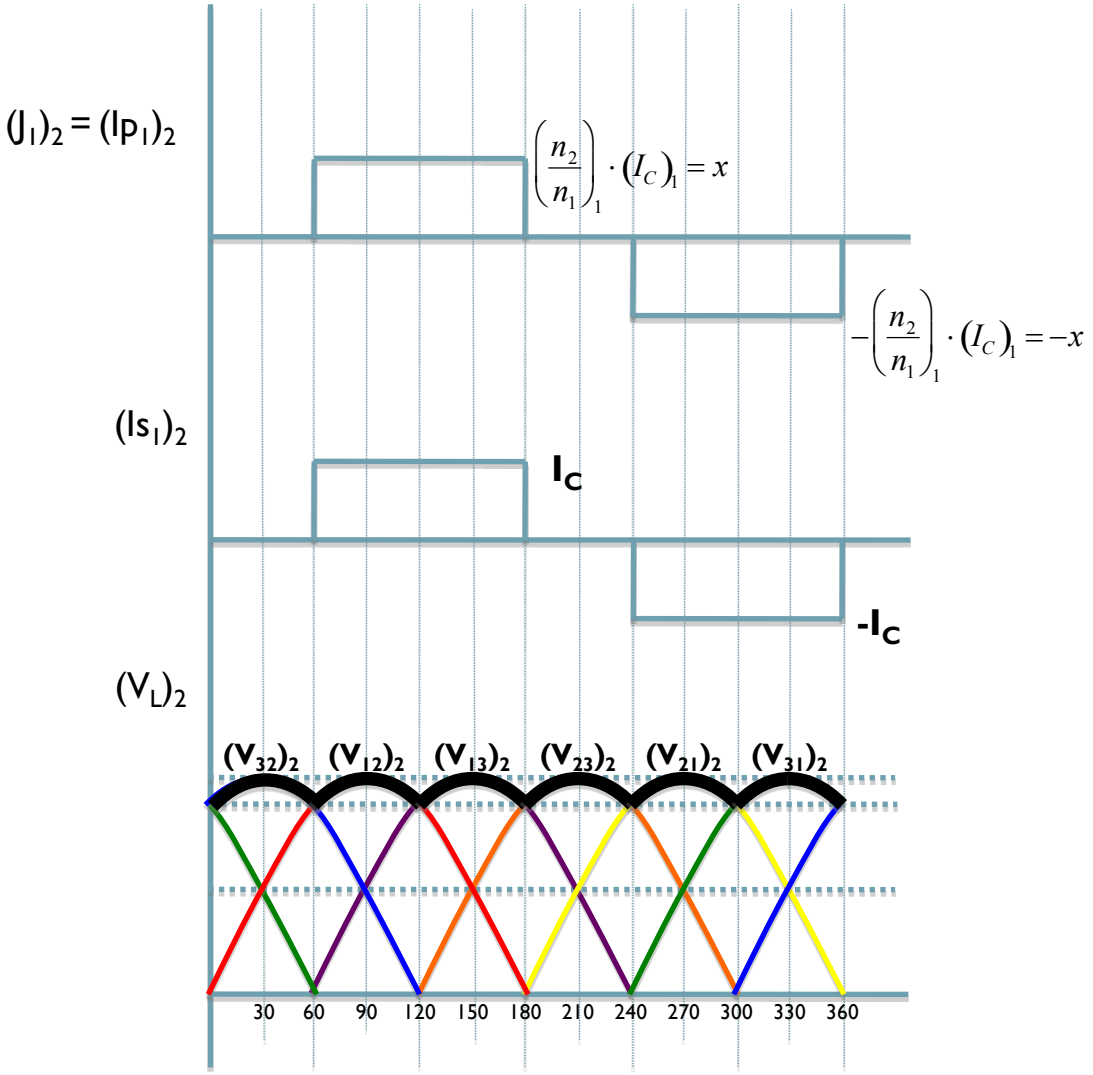


$(J_1)_1 = (Ip_1)_1 - (Ip_3)_1$

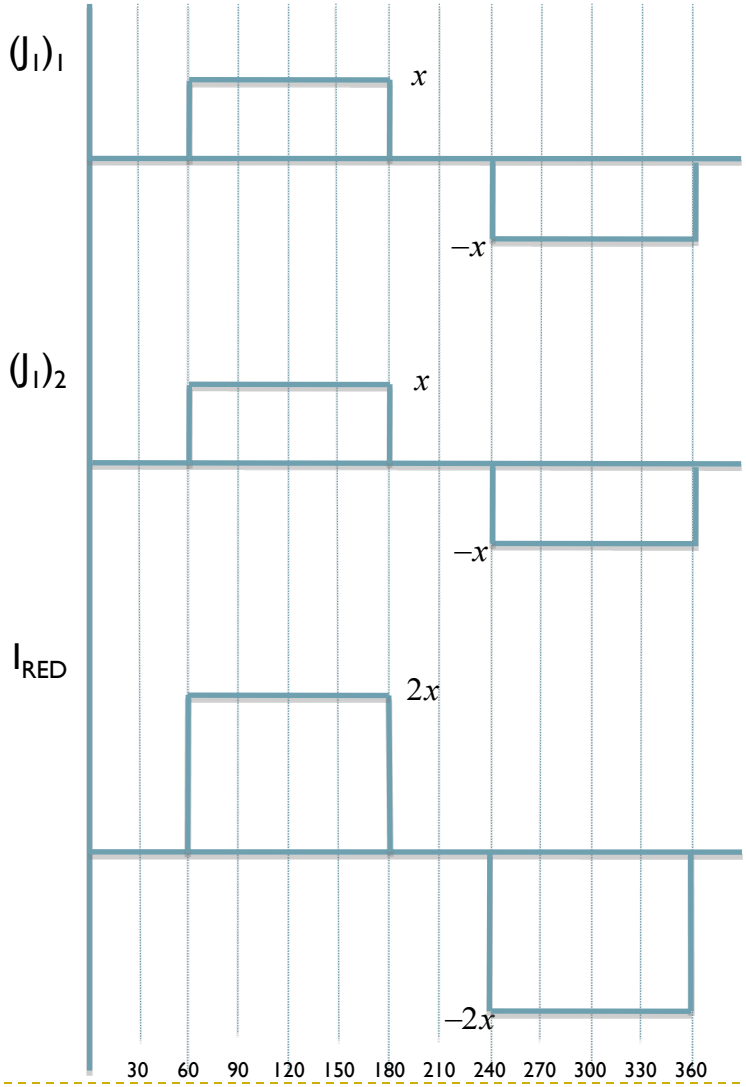


Resolución


$(J_1)_2$
λ
λ
$\left(\frac{n_1}{n_2}\right)_2 = \left(\frac{n_1}{n_2}\right)_1$
I_C


$(J_1)_2 = (Ip_1)_2$
$\left(\frac{n_2}{n_1}\right)_1 \cdot (I_C)_1 = x$
$-\left(\frac{n_2}{n_1}\right)_1 \cdot (I_C)_1 = -x$
$(Is_1)_2$
I_C
$-I_C$
$(V_L)_2$
$(V_{32})_2$ $(V_{12})_2$ $(V_{13})_2$ $(V_{23})_2$ $(V_{21})_2$ $(V_{31})_2$
30 60 90 120 150 180 210 240 270 300 330 360

Resolución



$$(J_1)_1 = (J_1)_2 = \sqrt{\frac{1}{2\pi}\cdot\left[2\cdot\frac{2\pi}{3}\cdot(x)^2\right]}$$

$$(J_1)_1 = (J_1)_2 = \sqrt{\frac{2}{3}}\cdot\left(\frac{n_2}{n_1}\right)_1\cdot I_C$$

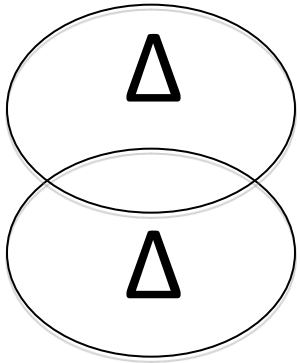
$$(J_1)_1 = (J_1)_2 = \sqrt{\frac{2}{3}}\cdot\frac{1}{30}\cdot 600 = 16.33A$$

$$I_{RED} = \sqrt{\frac{1}{2\pi}\cdot\left[2\cdot\frac{2\pi}{3}\cdot(2x)^2\right]}$$

$$I_{RED} = 2\cdot\sqrt{\frac{2}{3}}\cdot\left(\frac{n_2}{n_1}\right)_1\cdot I_C$$

$$I_{RED} = 2\cdot\sqrt{\frac{2}{3}}\cdot\frac{1}{30}\cdot 600 = 32.66A$$

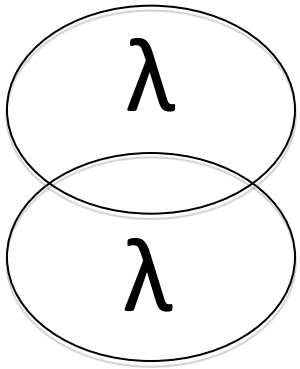
Resolución



$$(V_{LC})_1 = (V_{LC0})_1 - (\Delta V_X)_1 = (V_{LC0})_1 - 0.12(V_{LC0})_1$$
$$= (1-0.12)\cdot(V_{LC0})_1 = 0.88\cdot 540 = 475v$$

$$(V_{LC0})_1 = V_{LC0}\big|_{S3} = \frac{3V_O\big|_{S3}}{\pi} = \frac{3\cdot\left(400\sqrt{2}\right)}{\pi} = 540v$$

$$V_O\big|_{S3} = \sqrt{2}\cdot U_2 = 400\sqrt{2}$$



$$(V_{LC})_2 = (V_{LC0})_2 - (\Delta V_X)_2 = (V_{LC0})_2 - 0.12(V_{LC0})_2$$
$$= (1-0.12)\cdot(V_{LC0})_2 = 0.88\cdot 540 = 475v$$

$$(V_{LC0})_2 = V_{LC0}\big|_{PD3} = \frac{3\sqrt{3}\cdot V_O\big|_{PD3}}{\pi} = \frac{3\cdot\sqrt{3}\cdot\left(400\sqrt{\frac{2}{3}}\right)}{\pi} = 540v$$

$$V_O\big|_{PD3} = \sqrt{2}\cdot\left(U_2/\sqrt{3}\right) = 400\sqrt{\frac{2}{3}}$$

Resolución

$$F_{RED} = \frac{(P_{LC})_1 + (P_{LC})_2}{\sqrt{3}\cdot U_1 \cdot I_{RED}} = \frac{[(V_{LC})_1 \cdot (I_C)_1] + [(V_{LC})_2 \cdot (I_C)_2]}{\sqrt{3}\cdot U_1 \cdot I_{RED}} = \frac{[475\cdot 600] + [475\cdot 600]}{\sqrt{3}\cdot 12000 \cdot 32.66} = 0.84$$

$$\cos(\varphi_1)_1 = 1 - \left(\frac{\Delta V_X}{V_{LC0}}\right)_1$$

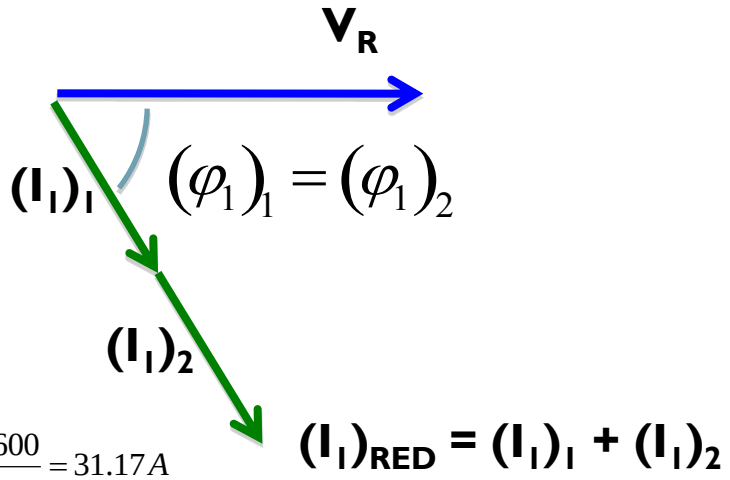
$$\cos(\varphi_1)_1 = 1 - 0.12 = 0.88$$

$$(\varphi_1)_1 = \arccos(0.88) = 28.35^\circ$$

$$\cos(\varphi_1)_2 = 1 - \left(\frac{\Delta V_X}{V_{LC0}}\right)_2$$

$$\cos(\varphi_1)_2 = 1 - 0.12 = 0.88$$

$$(\varphi_1)_2 = \arccos(0.88) = 28.35^\circ$$



$$(I_1)_{RED} = (I_1)_1 + (I_1)_2 = \frac{(V_{LC0})_1 \cdot (I_C)_1}{\sqrt{3}\cdot U_1} + \frac{(V_{LC0})_2 \cdot (I_C)_2}{\sqrt{3}\cdot U_1} = \frac{540\cdot 600 + 540\cdot 600}{\sqrt{3}\cdot 12000} = 31.17A$$

$$\tau_{RED} = \frac{(I_{\approx})_{RED}}{(I_1)_{RED}} = \frac{\sqrt{I_{RED}^2 - (I_1)_{RED}^2}}{(I_1)_{RED}} = \sqrt{\left(\frac{I_{RED}}{(I_1)_{RED}}\right)^2 - 1} = \sqrt{\left(\frac{32.66}{31.17}\right)^2 - 1} = 0.31$$

$$P_T = \sqrt{3}\cdot 12000 \cdot 16.33 = P_{T'} = 339412.6VA = 340kVA$$

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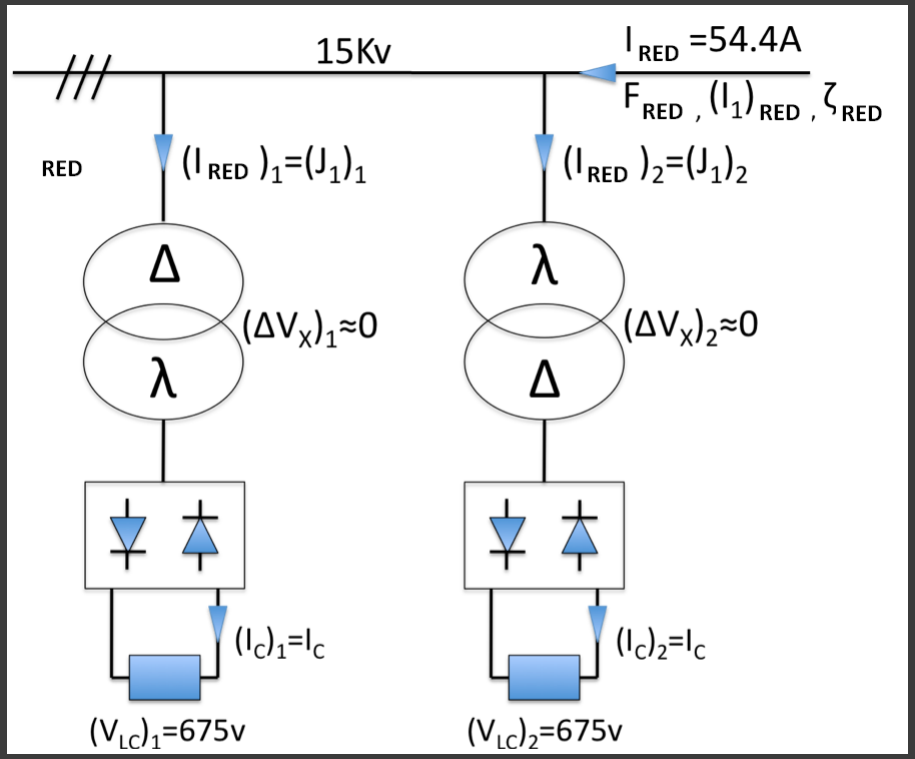
Ejercicio propuesto



1. Dibujar el diagrama vectorial de tensiones para $(V_{13})_1$ y $(V_{13})_2$
2. Calcular $\left(\frac{U_1}{U_2}\right)_1$ y $\left(\frac{U_1}{U_2}\right)_2$
3. Calcular la relación inversa de transformación $\left(\frac{n_2}{n_1}\right)_1$ y $\left(\frac{n_2}{n_1}\right)_2 = f\left(\frac{n_2}{n_1}\right)_1$
4. Dibujar $(J_1)_1$, $(J_1)_2$ y I_{RED}.
5. Calcular el valor eficaz de las corrientes $(J_1)_1$ y $(J_1)_2$.
6. Calcular F_1, F_2 y F_{RED}.
7. Calcular $(\varphi_1)_1$ y $(\varphi_1)_2$.
8. Calcular $(I_1)_{RED}$ y τ_{RED}.
9. Calcular la potencia de cada transformador.

Resultados:

$$\left(\frac{U_1}{U_2}\right)_1 = \left(\frac{U_1}{U_2}\right)_2 = \frac{15000}{500}$$

$$ILC = 1000A$$

$$\left(\frac{n_2}{n_1}\right)_2 = 3 \cdot \left(\frac{n_2}{n_1}\right)_1$$

$$\tau_{SARE} = \frac{(I_{\approx})_{SARE}}{(I_1)_{SARE}} = \frac{16.23}{51.92} = 0.31$$

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