Estudio de Rectificadores Trifásicos

15.- Acoplamientos: PD3 en paralelo con S3 (2T)

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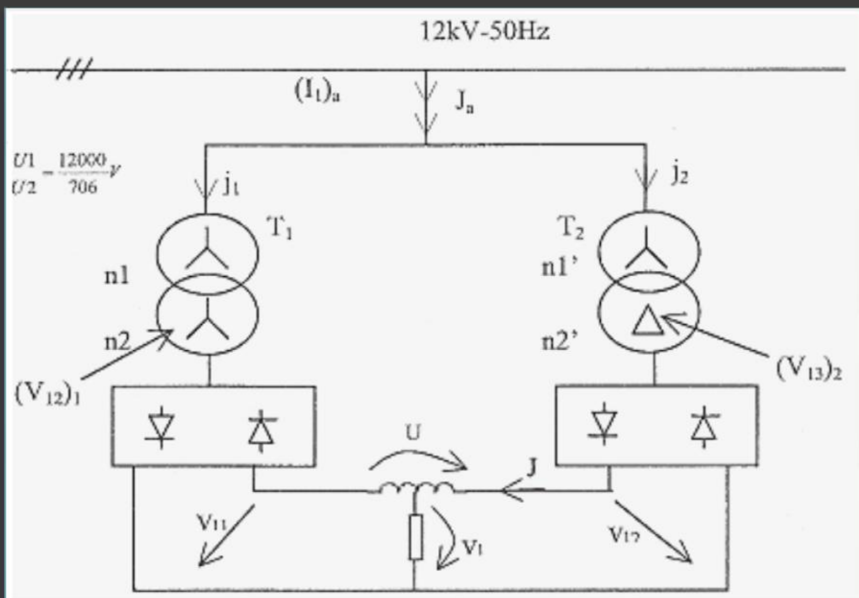
Acoplamientos: PD3 | | S3 (2T) Primario en estrella

En la imagen se puede ver un esquema unifilar de dos rectificadores conectados a una red de 12kV/50Hz. A los rectificadores PD3 y S3conectados en paralelo llega a la carga una tensión de 12p/c cuyo valor medio es 600V, siendo la corriente que absorbe la carga de 10.000A:



1. Representa el diagrama vectorial de las tensiones $(V_{12})_1$, $(V_{13})_2$.
2. Calcula las relaciones $\left(\frac{n_2}{n_1}\right)_1$, $\left(\frac{n_2}{n_1}\right)_2 = f\left(\frac{n_2}{n_1}\right)_1$
3. Calcula $(\Delta V_x)_a$
4. Dibuja v_{11}, v_{12}, v_1, U y J (Tensión y corriente entre fases). Representa gráficamente el valor máximo y mínimo de v_{11}, v_{12} y v_1, y sus valores numéricos en voltios. Calcula el valor medio de la tensión U, la expresión del valor eficaz y su frecuencia. Calcula J_{max} e $I_{CCrítico}$ sabiendo que el coeficiente de autoinducción entre fases es $L_B=1{,}75 \cdot 10^{-4}$ H.
1. Dibuja J_a, calcula la expresión de su valor eficaz y su valor numérico.
2. Calcula F_a.

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Acoplamientos: PD3 || S3 (2T)

Relación de transformación entre las tensiones compuestas: $\frac{U_1}{U_2} = \frac{12000}{706}$

$T_1 \Rightarrow$  $\Rightarrow \frac{n_1}{n_2} = \frac{V_p}{V_s} = \frac{12000/\sqrt{3}}{706/\sqrt{3}} = 17$

$$V_o = \sqrt{2} \cdot \left(U_2 / \sqrt{3} \right) \Rightarrow V_o = \sqrt{2} \cdot \left(706 / \sqrt{3} \right) = 576.4v$$

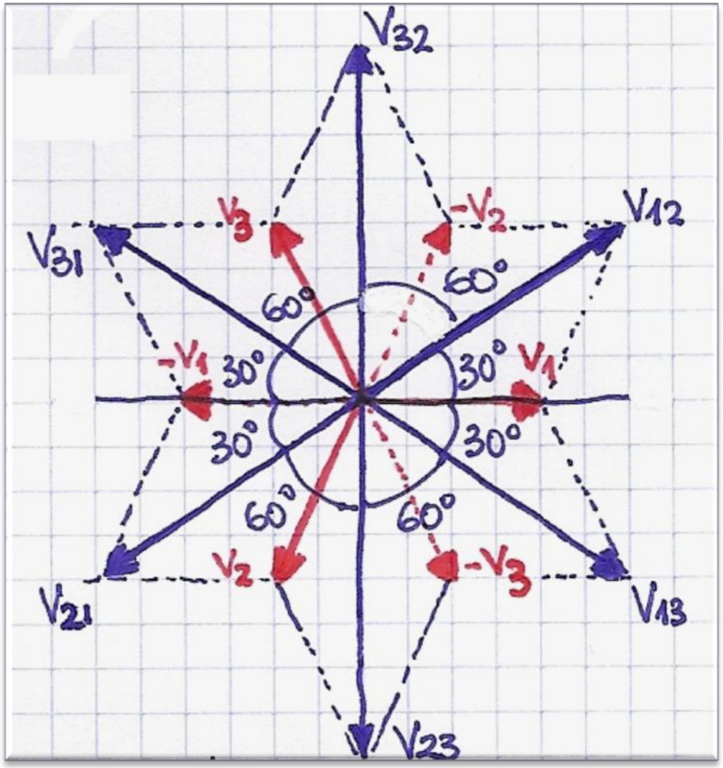
$T_2 \Rightarrow$  $\Rightarrow \frac{n_1}{n_2^{'}} = \frac{V_p}{V_s^{'}} = \frac{12000/\sqrt{3}}{706} = \frac{17}{\sqrt{3}}$

$$\Rightarrow \frac{n_1}{n_2^{'}} = \frac{1}{\sqrt{3}} \cdot \frac{n_1}{n_2}$$

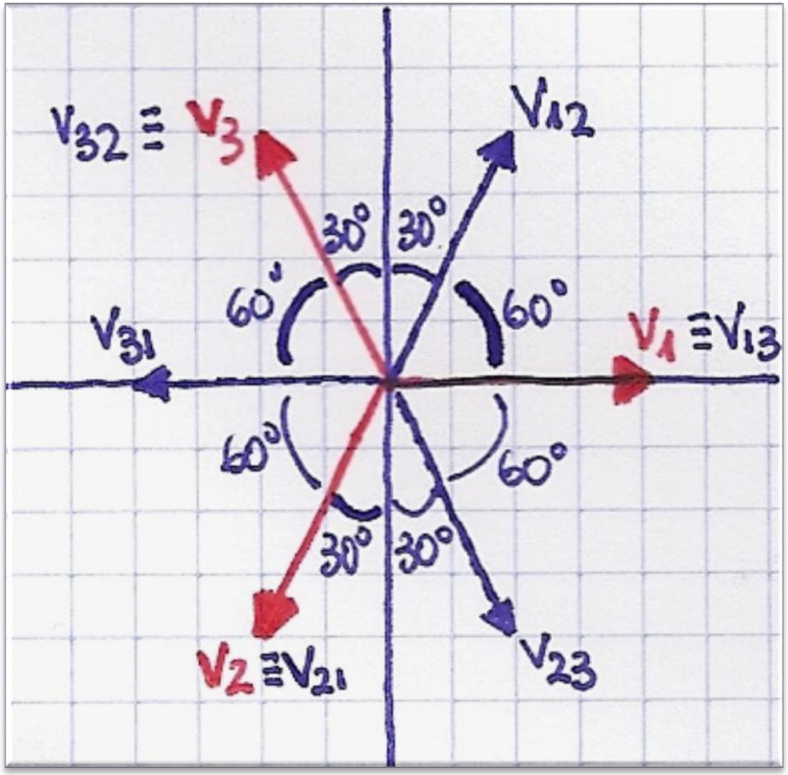
$$V_o^{'} = \sqrt{2} \cdot U_2 \Rightarrow V_o^{'} = \sqrt{2} \cdot 706 = 998.4v$$

Acoplamientos: PD3 || S3 (2T)

PD3



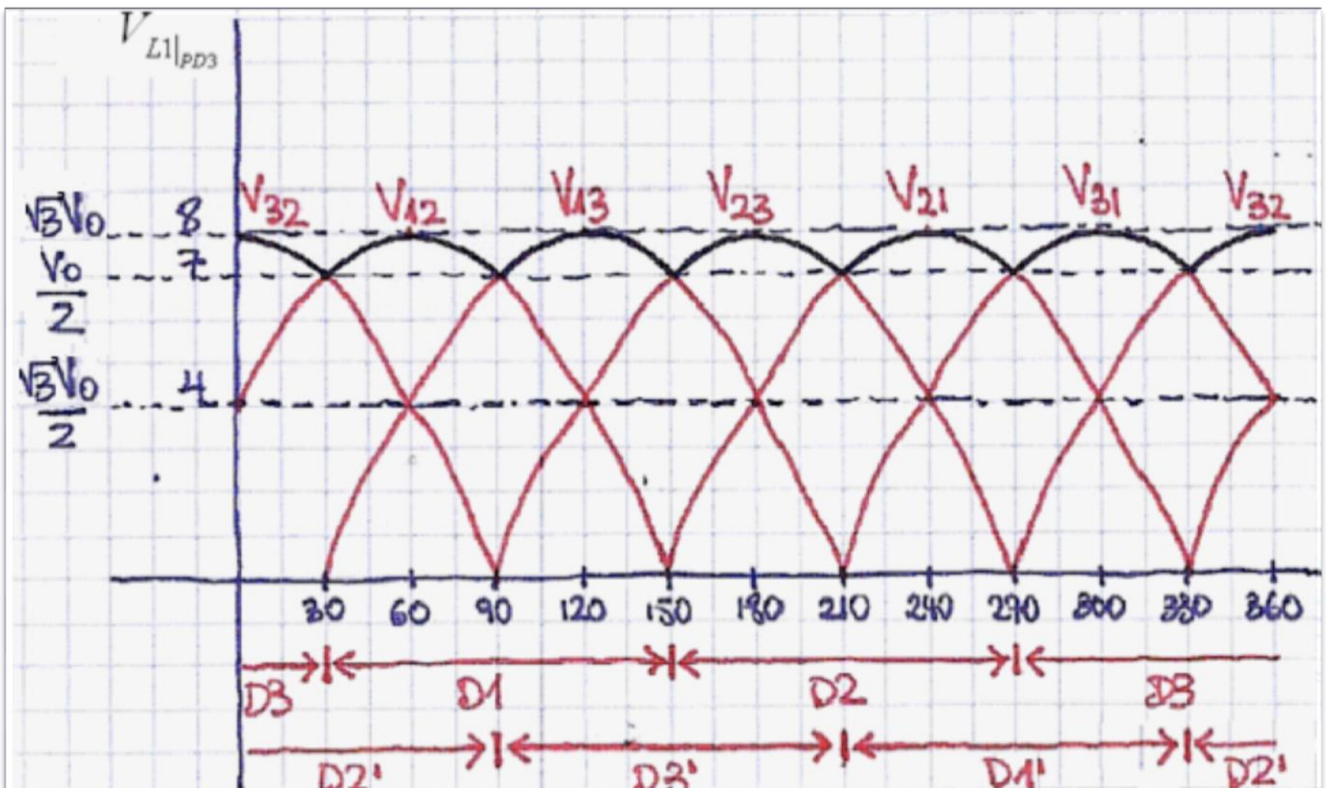
S3



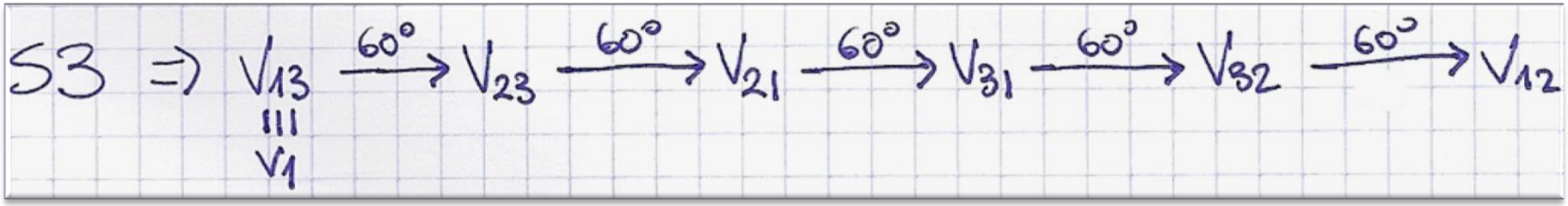
$$V_{LC0}\Big|_{PD3} = V_{LC0}\Big|_{S3} \Rightarrow \frac{3\sqrt{3}\cdot V_o}{\pi} = \frac{3\cdot V_o^{'}}{\pi} \Rightarrow V_o^{'} = \sqrt{3}\cdot V_o$$

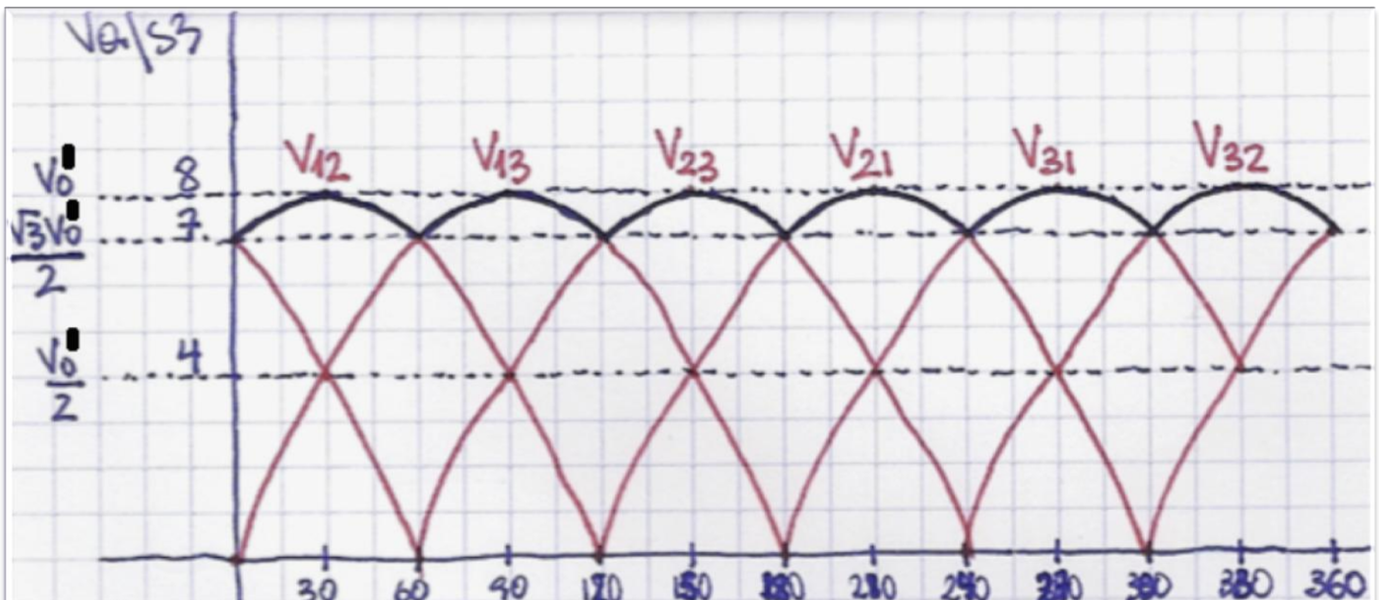
Acoplamientos: PD3 | | S3 (2T)

$$PD3 \Rightarrow V_1 \xrightarrow{30^\circ} V_{13} \xrightarrow{60^\circ} V_{23} \xrightarrow{60^\circ} V_{21} \xrightarrow{60^\circ} V_{31} \xrightarrow{60^\circ} V_{32} \xrightarrow{60^\circ} V_{12}$$



Acoplamientos: PD3 || S3 (2T)





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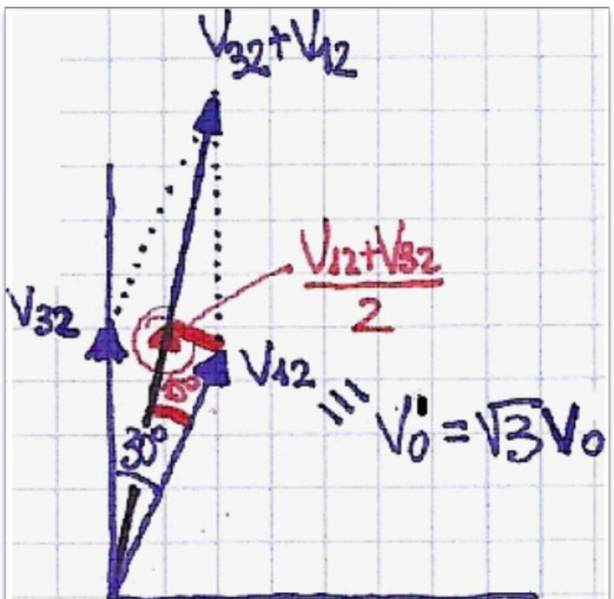
Acoplamientos: PD3 | | S3 (2T)

$$V_\ell = \frac{V_a + V_b}{2}$$

$$0 \div 30^\circ \qquad V_\ell = \frac{V_{12} + V_{32}}{2}$$



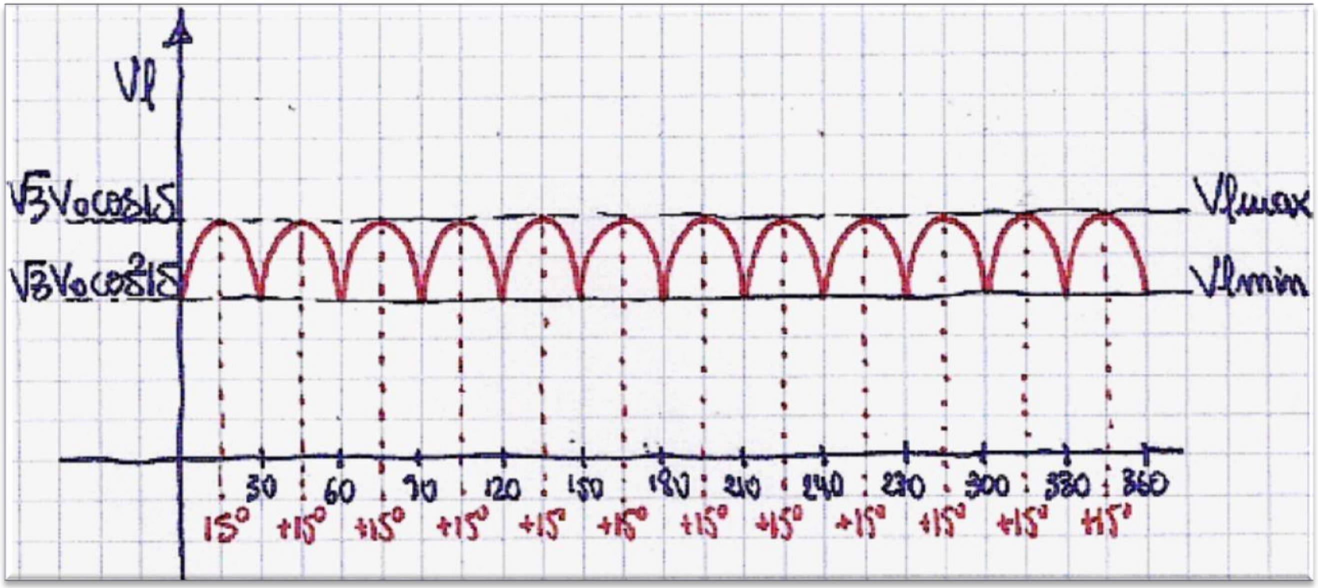
$$V_\ell\Big|_{0\div30^\circ} = \sqrt{3}V_0 \cos 15^\circ \cos(\alpha - 15^\circ)$$

$$V_\ell\Big|_{\alpha=0^\circ} = \sqrt{3}V_0 \cos 15 \cos(-15) = \sqrt{3}V_0 \cos^2 15$$

$$V_\ell\Big|_{\alpha=15^\circ} = \sqrt{3}V_0 \cos 15 \cos 0 = \sqrt{3}V_0 \cos 15$$

$$V_\ell\Big|_{\alpha=30^\circ} = \sqrt{3}V_0 \cos 15 \cos 15 = \sqrt{3}V_0 \cos^2 15$$

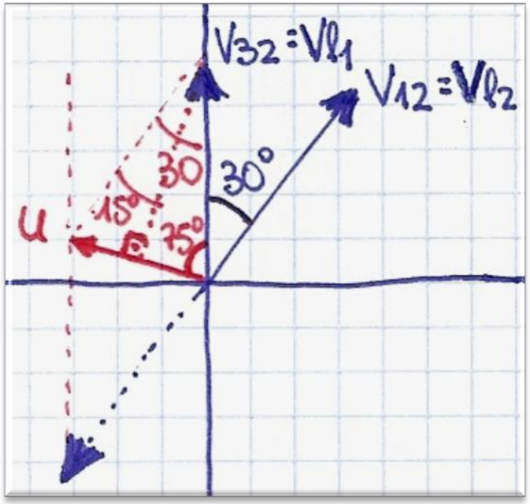
Acoplamientos: PD3 || S3 (2T)



$$V_{l,\max} = \sqrt{3} \cdot V_o \cdot \cos 15 = 964.4v$$

$$V_{l,\min} = \sqrt{3} \cdot V_o \cdot \cos^2 15 = 931.5v$$

Acoplamientos: PD3 | | S3 (2T)



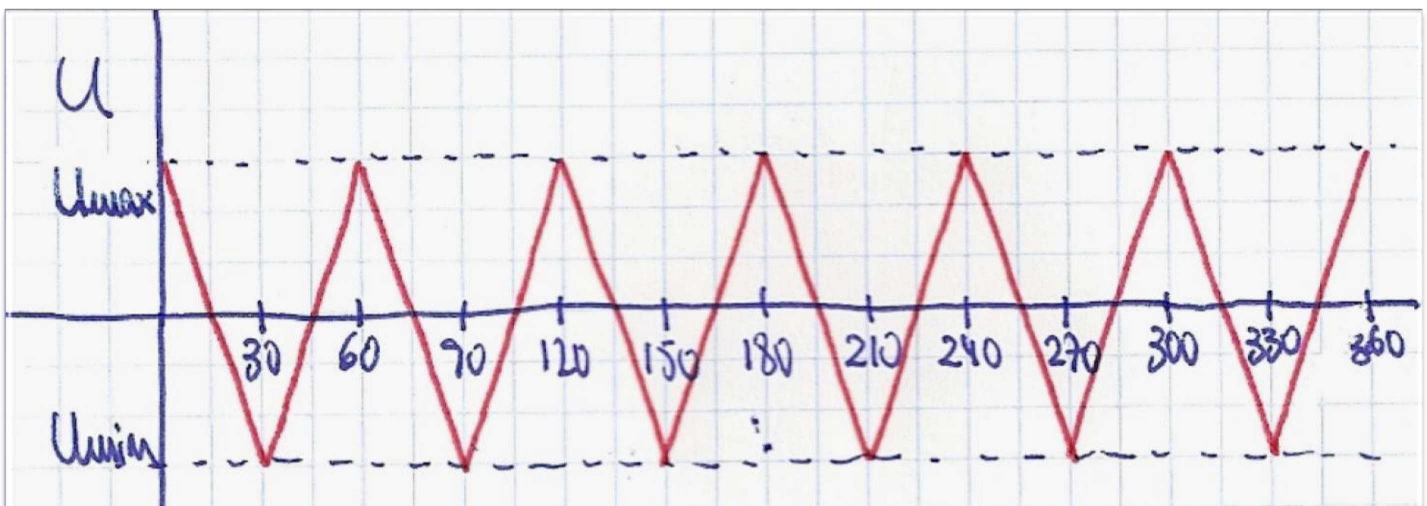
$$U = V_{l1} - V_{l2} \Rightarrow 0 \div 30^{o} \Rightarrow U = (V_{32})_1 - (V_{12})_2$$

$$U = 2 \cdot V_o' \cdot \cos 75 \cdot \sin(\alpha + 165)$$

$$\alpha = 0^{o} \Rightarrow U_{\max} = 2 \cdot V_o' \cdot \cos^2 75 = 133.7v$$

$$\alpha = 15^{o} \Rightarrow U = 0$$

$$\alpha = 30^{o} \Rightarrow U_{\min} = -2 \cdot V_o' \cdot \cos^2 75 = -133.7v$$



Acoplamientos: PD3 || S3 (2T)

$$U = \omega \cdot L_B \cdot \frac{d(J_B)}{d\alpha}$$

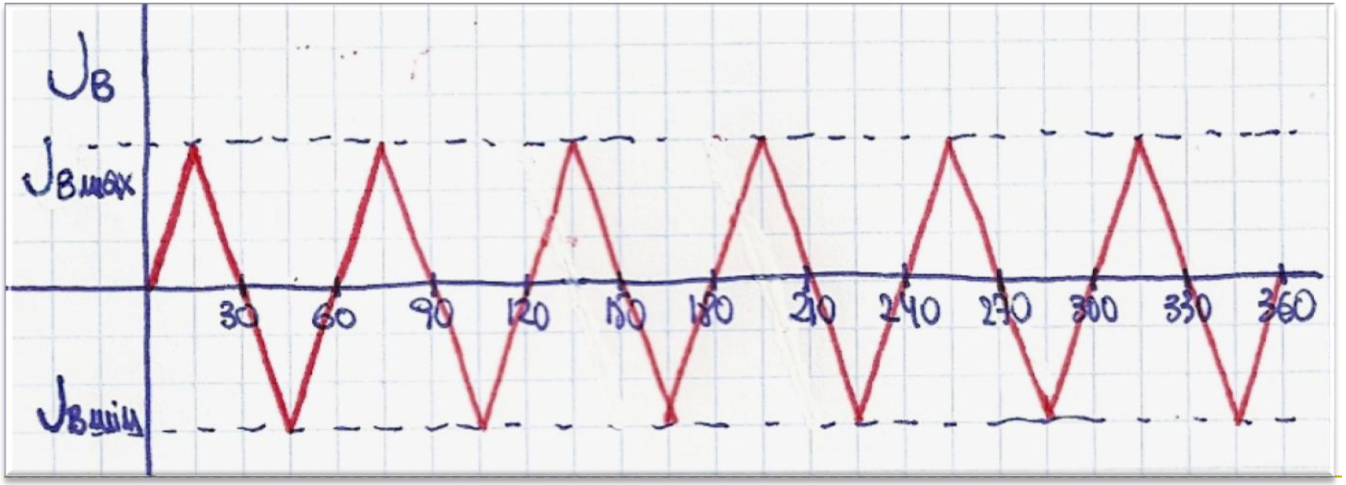
$$0 \div 30^o \Rightarrow J_B = \int_0^\alpha \frac{U}{\omega \cdot L_B} \cdot d\alpha = \int_0^\alpha \frac{-2 \cdot V_o' \cdot \cos 75 \cdot \sin(\alpha - 15)}{\omega \cdot L_B} \cdot d\alpha$$

$$J_B = \frac{2 \cdot V_o' \cdot \cos 75}{\omega \cdot L_B} \cdot [\cos(\alpha - 15) - \cos 15]$$

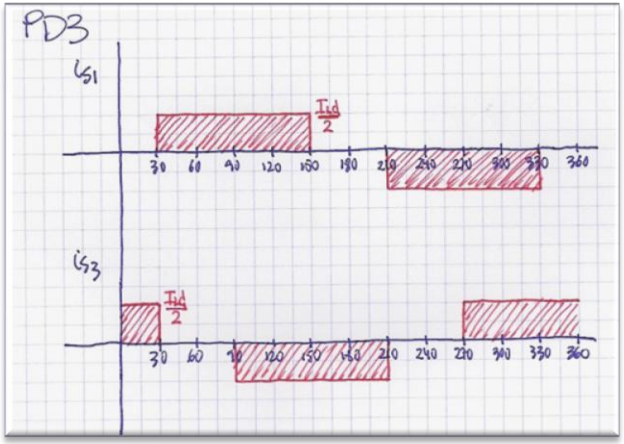
$$\alpha = 0^o \quad y \quad \alpha = 30^o \Rightarrow J_B = 0$$

$$\alpha = 15^o \Rightarrow J_{B,\max} = \frac{2 \cdot V_o' \cdot \cos 75}{(2 \cdot \pi \cdot f_{RED}) \cdot L_B} \cdot [1 - \cos 15] = 320A$$

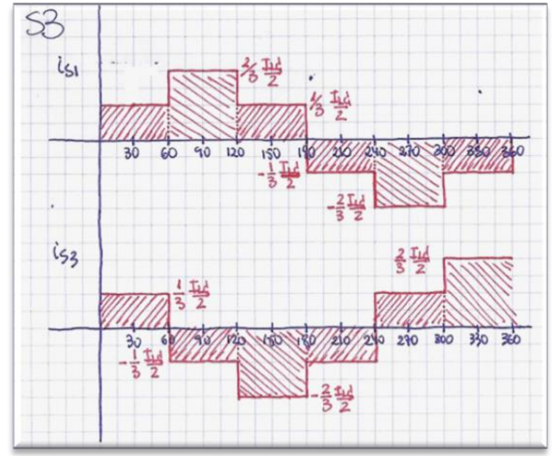
$$I_{C,critica} = 2 \cdot J_{B,\max} = 640A \; f_{J_B} = 6 \cdot f_{RED}$$



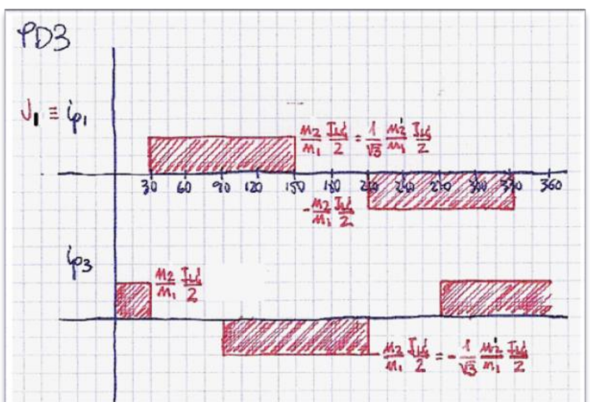
Acoplamientos: PD3 || S3 (2T)



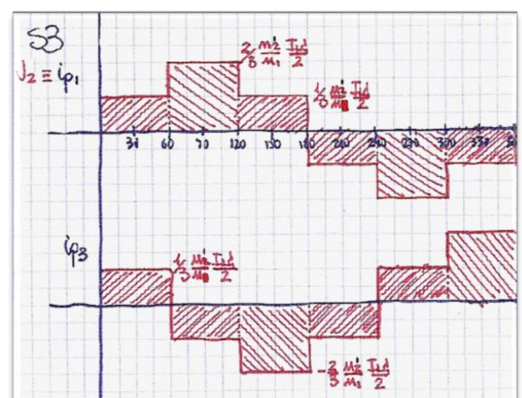
$$I_S = \sqrt{\frac{1}{2\Pi}\cdot\left[4\times\frac{\Pi}{3}\times\left(\frac{I_C}{2}\right)^2\right]} = \sqrt{\frac{2}{3}}\cdot\frac{I_C}{2}$$



$$I_S = \sqrt{\frac{1}{2\Pi}\cdot\left[4\times\frac{\Pi}{3}\times\left(\frac{1}{3}\cdot\frac{I_C}{2}\right)^2 + 2\times\frac{\Pi}{3}\times\left(\frac{2}{3}\cdot\frac{I_C}{2}\right)^2\right]} = \frac{\sqrt{2}}{3}\cdot\frac{I_C}{2}$$

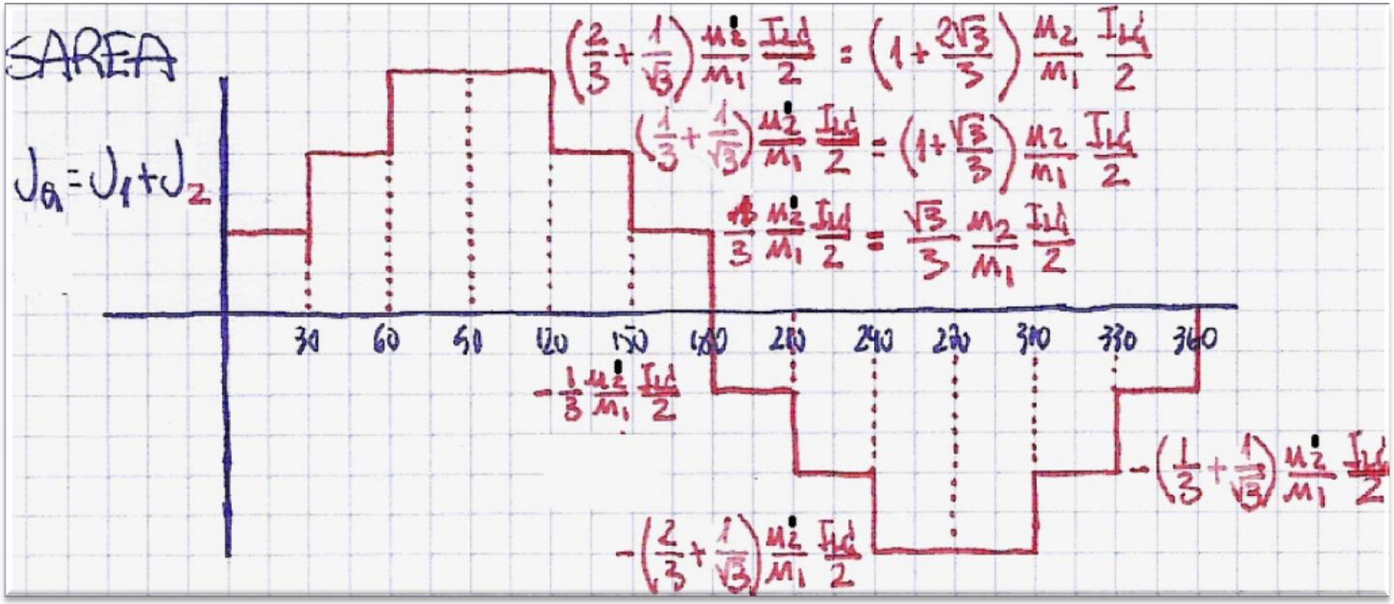


$$I_P = \sqrt{\frac{2}{3}}\cdot\frac{n_2}{n_1}\cdot\frac{I_C}{2} = \frac{\sqrt{2}}{3}\cdot\frac{n_2'}{n_1}\cdot\frac{I_C}{2} = J_1$$



$$I_P = \frac{\sqrt{2}}{3}\cdot\frac{n_2'}{n_1}\cdot\frac{I_C}{2} = J_2$$

Acoplamientos: PD3 || S3 (2T)



$$J_a = \sqrt{\frac{1}{2\Pi}\cdot\left[4\times\frac{\Pi}{6}\times\left(\frac{1}{3}\cdot\frac{n_2^{'}}{n_1}\cdot\frac{I_C}{2}\right)^2 + 4\times\frac{\Pi}{6}\times\left(\left(\frac{1}{3}+\frac{1}{\sqrt{3}}\right)\cdot\frac{n_2^{'}}{n_1}\cdot\frac{I_C}{2}\right)^2 + 4\times\frac{\Pi}{6}\times\left(\left(\frac{2}{3}+\frac{1}{\sqrt{3}}\right)\cdot\frac{n_2^{'}}{n_1}\cdot\frac{I_C}{2}\right)^2\right]}$$

$$J_a = \frac{n_2^{'}}{n_1}\cdot\frac{I_C}{2}\cdot\sqrt{\frac{1}{3}\cdot\left[\left(\frac{1}{3}\right)^2+\left(\frac{1}{3}+\frac{1}{\sqrt{3}}\right)^2+\left(\frac{2}{3}+\frac{1}{\sqrt{3}}\right)^2\right]} = \frac{n_2^{'}}{n_1}\cdot\frac{I_C}{2}\cdot\sqrt{\frac{1}{3}\cdot\left[\frac{1}{9}+\left(\frac{1}{9}+\frac{2}{3\sqrt{3}}+\frac{1}{3}\right)+\left(\frac{4}{9}+\frac{4}{3\sqrt{3}}+\frac{1}{3}\right)\right]}$$

$$J_a = \frac{n_2^{'}}{n_1}\cdot\frac{I_C}{2}\cdot\sqrt{\frac{1}{3}\cdot\frac{4+2\sqrt{3}}{3}} = \frac{n_2}{n_1}\cdot\frac{I_C}{2}\cdot\sqrt{\frac{4+2\sqrt{3}}{3}}$$

Acoplamientos: PD3 || S3 (2T)

$$J_a = \sqrt{\frac{4+2\sqrt{3}}{3}} \cdot \frac{n_2}{n_1} \cdot \frac{I_C}{2} = \sqrt{\frac{4+2\sqrt{3}}{3}} \cdot \frac{1}{17} \cdot \frac{10000}{2} = 464A$$

$$V_{LC0}\Big|_{PD3} = \frac{3 \cdot \sqrt{3} \cdot V_O}{\pi} = \frac{3 \cdot \sqrt{3} \cdot 576.4}{\pi} = 953.4v$$

$$V_{LC} = V_{LC0} - \Delta V_X \Rightarrow \Delta V_X = V_{LC0} - V_{LC} = 953.4 - 600 = 353.4v$$

$$P_{LC} = V_{LC} \cdot I_C = 600 \cdot 10000 = 6000000w$$

$$S_{RED} = \sqrt{3} \cdot U \cdot J_a = \sqrt{3} \cdot 12000 \cdot 464 = 9644059w$$

$$F_{RED} = \frac{P_{LC}}{S_{RED}} = \frac{6000000}{9644059} = 0.622$$