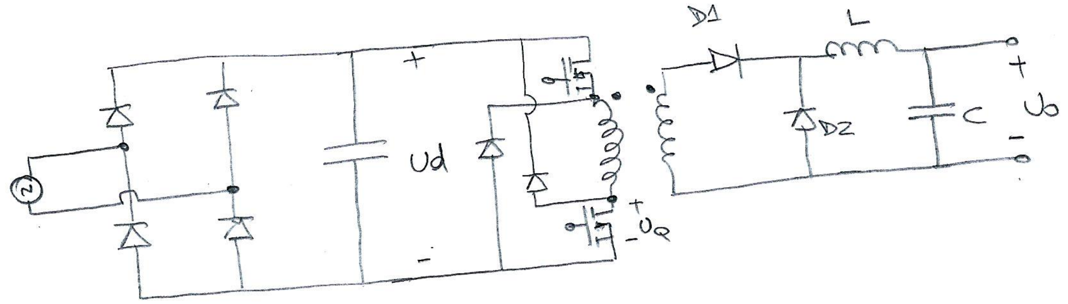
Examen de Electrónica de Potencia - Febrero 2022

Solución Problema 2

$f = 50\,kHz$
$L_\mu = 600\,\mu H$
$L = 80\,\mu H$
$U_o = 48\,V$
$I_{Omáx} = 20\,A$
$\frac{n_1}{n_2} = 1{,}25$
$T_{amáx} = 40\,°C$

a)



$U_{Qmáx} = 0{,}8 \cdot 500 = 400\,V$

Como $U_{Qmáx} = U_{dmáx} \Rightarrow U_{dmáx} = 400\,V$

Si asumo MCC: $\frac{U_o}{U_d} = \frac{n_2}{n_1} \cdot \delta$

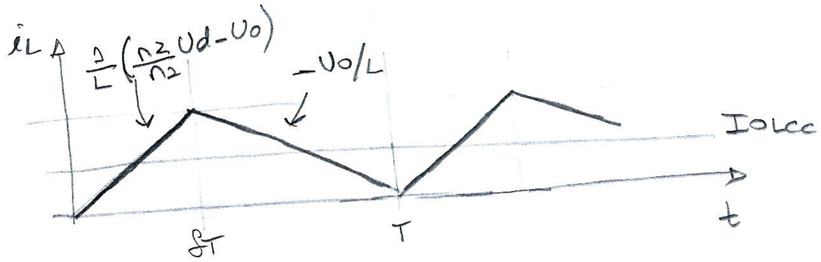
En este convertidor $\delta_{máx} = 0{,}5 \Rightarrow \frac{U_o}{U_{dmin}} = \frac{n_2}{n_1} \cdot \delta_{máx}$

$$U_{dmin} = \frac{U_o}{\delta_{máx}} \cdot \frac{n_1}{n_2} = \frac{48 \cdot 1{,}25}{0{,}5} = 120\,V$$

En una red de 110V $\rightarrow U_d = \sqrt{2} \cdot 110 \cong 156\,V$
En una red de 230V $\rightarrow U_d = \sqrt{2} \cdot 230 \cong 325\,V$ } $\Rightarrow$ puede funcionar

Conectado a una red de 110 V o de 230 V, aún con tolerancia +/- 20%
(124,8V – 390V)

b)

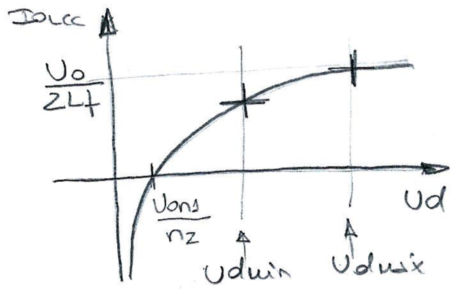


$$I_{OLcc} = \frac{1}{T}\int_0^T i_{Lcc}(t)\,dt$$

$$I_{OLcc} = \frac{1}{T} \cdot \frac{1}{2} \cdot \frac{T}{L}\left(\frac{n_2}{n_1}U_d - U_o\right)\delta T$$

En el LCC: $\frac{U_o}{U_d} = \frac{n_2}{n_1} \cdot \delta \Rightarrow \delta = \frac{n_1}{n_2} \cdot \frac{U_o}{U_d}$

$$I_{OLcc} = \frac{n_1}{n_2}\frac{U_o}{U_d} \cdot \frac{1}{2Lf}\left(\frac{n_2}{n_1}U_d - U_o\right) = \frac{1}{2Lf}\left(U_o - \frac{U_o^2 n_1}{U_d n_2}\right)$$

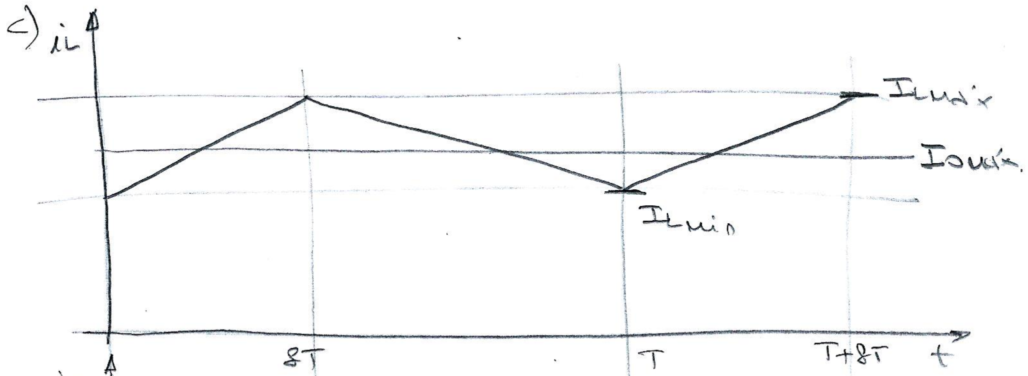


Si se impone LCC para $U_d = U_{dmáx} \Rightarrow$ si la carga consume $I_o > I_{OLcc} \Rightarrow$ el convertidor estará en MCC $\forall\, U_d / U_{dmin} \leq U_d \leq U_{dmáx}$

$$\delta = \frac{n_1}{n_2}\frac{U_o}{U_{dmáx}} = \frac{1{,}25 \cdot 48}{400} = 0{,}15$$

$$I_{OLcc} = \left(48 - \frac{48^2}{400} \cdot 1{,}25\right) \cdot \frac{1}{2 \cdot 80\times10^{-6} \cdot 50\times10^3} \Rightarrow I_{OLcc} = 5{,}1\,A$$

c)

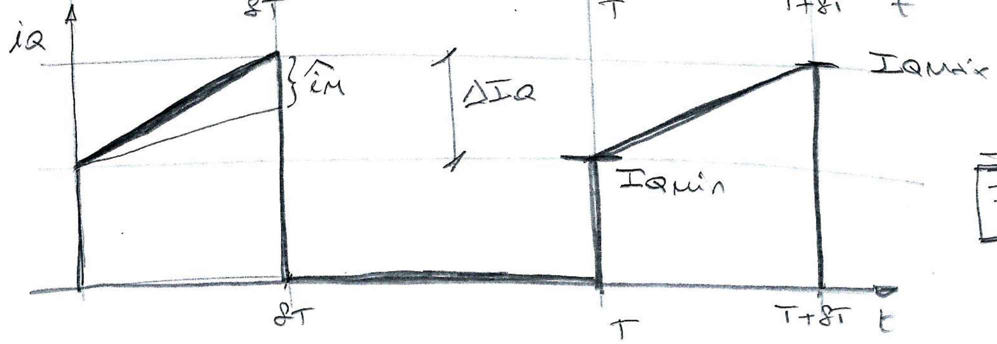


$$I_{Lmin} = I_{Omáx} - \frac{\Delta I_{Máx}}{2}$$

$$I_{Lmáx} = I_{Omáx} + \frac{\Delta I_{Máx}}{2}$$

$$I_{Lmin} = 20 - \frac{5,1}{2} = 17,45A$$

$$I_{Lmáx} = 20 + \frac{5,1}{2} = 22,55A$$



$$\Rightarrow I_{Qmin} = \frac{n_2}{n_1} I_{Lmin}$$

$$\boxed{I_{Qmin} = \frac{17,45}{1,25} = 13,96A}$$

$$I_{Qmáx} = I_{Lmáx}\cdot\frac{n_2}{n_1} + \frac{U_d}{L_m}\cdot\delta T = \frac{22,55}{1,25} + \frac{400\cdot 0,15}{600\times10^{-6}\cdot 50\times10^{3}} \Rightarrow \boxed{I_{Qmáx} = 20,04A}$$

e) $T_j - T_a = P(R_{\theta jc} + R_{\theta cs} + R_{\theta sa})$ Si asumo $T_j = 150°C$ (peor caso)

$$\Rightarrow R_{DS(on)} = 2,5\cdot 0,27 = 0,675\Omega$$

$P = P_{enc} + P_{ap} + P_{cond}$

$$\underline{P_{enc}} = \frac{U_{dmáx}\cdot I_{Qmin}\cdot t_r\cdot f}{2} = \frac{400\cdot 13,96\cdot 59\times10^{-9}\cdot 50\times10^{3}}{2} = \underline{8,24W}$$

$$\underline{P_{ap}} = \frac{U_{dmáx}\cdot I_{Qmáx}\cdot t_f\cdot f}{2} = \frac{400\cdot 20,04\cdot 58\times10^{-9}\cdot 50\times10^{3}}{2} = \underline{11,62W}$$

$$P_{cond} = R_{DS(on)} I_{Qeff}^2 \rightarrow i_Q(t) = I_{Qmin} + \frac{\Delta I_Q\cdot t}{\delta T} \rightarrow I_{Qeff}^2 = \frac{1}{T}\int_0^T i_Q^2(t)\,dt$$

$$i_Q^2(t) = I_{Qmin}^2 + \frac{\Delta I_Q^2 t^2}{\delta^2T^2} + \frac{2 I_{Qmin}\cdot\Delta I_Q\cdot t}{\delta T} \Rightarrow I_{Qeff}^2 = \frac{1}{T}\left(I_{Qmin}^2\,\delta T + \frac{\Delta I_Q^2\,\delta^3T^3}{3\delta^2T^2} + \frac{2 I_{Qmin}\Delta I_Q\,\delta^2T^2}{2\,\delta T}\right)$$

$$I_{Qeff}^2 = \delta\left(I_{Qmin}^2 + \frac{\Delta I_Q^2}{3} + I_{Qmin}\cdot\Delta I_Q\right)$$

$$\underline{P_{cond}} = 0,675\cdot 0,15\left(13,96^2 + \frac{6,08^2}{3} + 13,96\cdot 6,08\right) = \underline{29,57W}$$

$$\Rightarrow P = 8,24 + 11,62 + 29,57 = 49,43$$

$$R_{\theta sa} = \frac{T_j - T_a}{P} - R_{\theta jc} - R_{\theta cs} = \frac{150-40}{49,43} - 0,45 - 0,24 = 1,54$$

Como el disipador instalado tiene $R_{\theta sa} = 1,3°C/W < 1,54°C/W \Rightarrow$ es suficiente para que no lleguen a la $T_{jmáx} = 150°C$