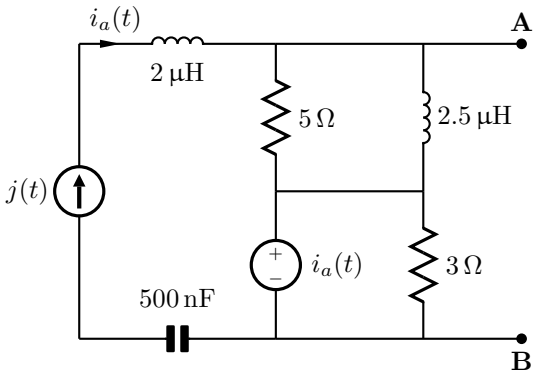
1. ARIKETA — DENBORA: 60 min (10 PUNTU)

Irudiko zirkuituan sarrera-sorgailua $j(t) = 5\cos(10^6 t)$ A da.



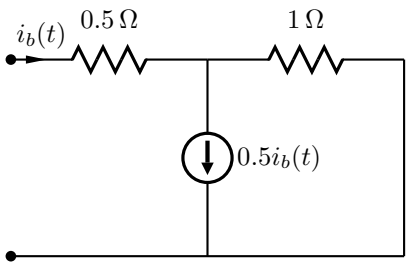
IRADOKIZUNA: sinplifikatu zirkuitua kalkuluekin hasi aurretik.

a Kalkulatu A eta B arteko Norton korrontea, definiziotik abiatuta. **(2 puntu)**

b Kalkulatu A eta B arteko Thevenin tentsioa, definiziotik abiatuta. **(2 puntu)**

c Kalkulatu A eta B arteko Thevenin inpedantzia, definiziotik abiatuta. Konprobatu aurreko hiru emaitzen arteko koherentzia. **(1 puntu)**

Irudiko zirkuitua, karga, (a)-(c) ataleko zirkuituaren A eta B terminaleen artean lotu da.

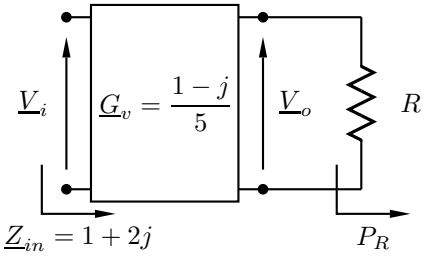


OHARRA: datozen ataletan erabili $\underline{V}_{TH} = 10\sqrt{2}\angle\frac{\pi}{4}$ (balio maximoa) eta $Z_{TH} = 1 + 2j$, (a)-(c) ataletan lortutako emaitzeak kontuan izan gabe.

d Kalkulatu potentzia kargan. **(1.5 puntu)**

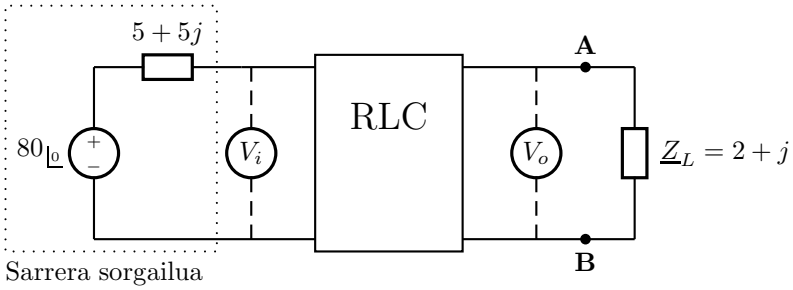
e Kalkulatu potentzia osagai bakoitzean eta egiaztatu aurreko ataleko emaitza. **(1.5 puntu)**

f Aurreko ataletako karga irudiko zirkuituarekin ordezkatu da. R erresistentzian erretako potentzia $P_R = 1\,\text{W}$ neurtu da. Kalkulatu R balioa. **(2 puntu)**



2. ARIKETA — DENBORA: 60 min (10 PUNTU)

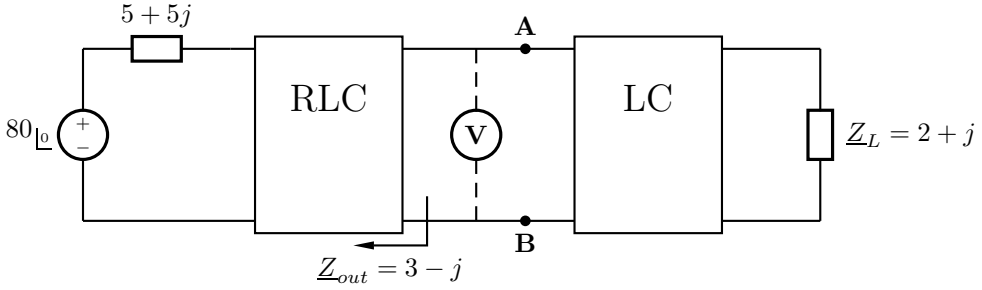
Irudiko zirkuituan fasoreak balio maximotan daude, irteerako voltmetroan $V_o = 10\,\text{V}$ neurtu dira eta RLC zirkuituaren transmisio galerak $\alpha_T = 6.02\,\text{dB}$ dira.



a Kalkulatu RLC zirkuituan erretako potentzia. **(1.5 puntu)**

b Kalkulatu sarrera sorgailu errealaren potentzia erabilgarria, eta V_i voltmetroan irakurriko den balioa. **(1.5 puntu)**

A eta B artean egokitzapen zirkuitua jarri da, eta RLC zirkuituaren irteera inpedantzia neurtu da: $\underline{Z}_{out} = 3 - j$.



c Kalkulatu potentzia berria $\underline{Z}_L$ kargan eta V voltmetroan irakurriko den balio berria. **(2 puntu)**

d Kalkulatu LC zirkuituaren insertzio-galerak. **(1 puntu)**

e Diseinatu LC zirkuitua $\omega = 10^6\,\text{rad/s}$ bada eta osagai kopuru minimoa erabiliz. Aukeratu osagai jarraitua eta maiztasun altuak pasatzen uzten ez dituen soluzioa. **(2 puntu)**

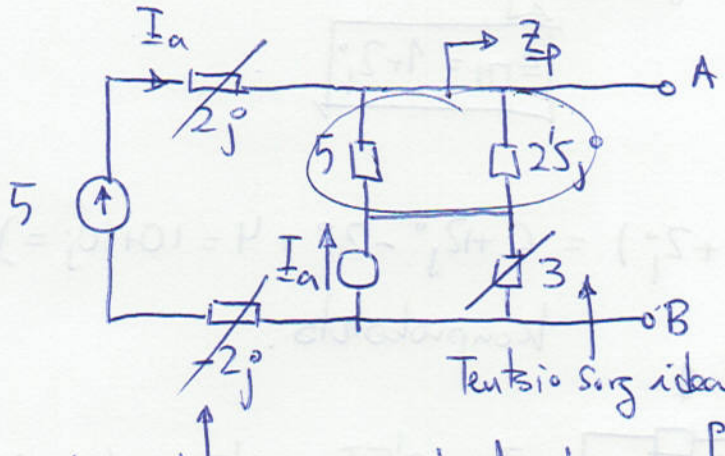
f $\underline{Z}_L$ inpedantzia aldatu eta $\underline{Z}_{L2} = 5 + 2j$ jarri dugu, baina beste zati guztiak berdin utzita (LC zirkuitu berdina). Kalkulatu kasu honetan LC zirkuituaren insertzio galera berriak. **(2 puntu)**

(1) $j(t) = 5\cos(10^6 t) \rightsquigarrow \underline{J} = 5\angle 0^\circ$ $\quad \omega = 10^6$ r/seg.

$L = 2\mu H \quad \underline{Z}_L = j\omega L = j \cdot 10^6 \cdot 2 \cdot 10^{-6} = +2j^\circ$

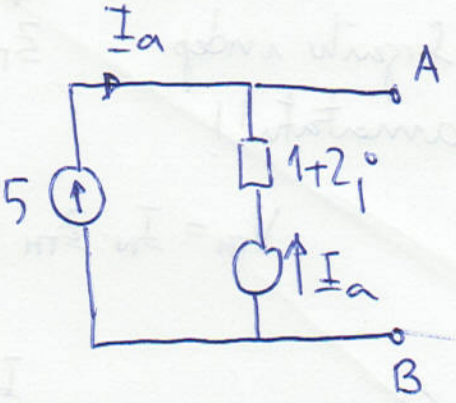
$L = 2.5\mu H \quad \underline{Z}_L = j\omega L = j\,10^6 \cdot 2.5 \cdot 10^{-6} = +2.5j^\circ$

$C = 500nF \quad \underline{Z}_C = \frac{-j^\circ}{\omega C} = \frac{-j^\circ}{10^6 \cdot 500 \cdot 10^{-9}} = -2j^\circ$



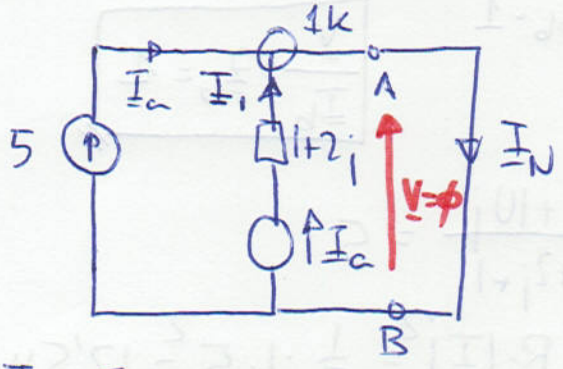
Tensio sorg idealarekin paralelo

Korronte sorgailu idealarekin serie



$$\underline{Z}_p = 5 /\!/ 2.5j^\circ = \frac{5 \cdot 2.5j^\circ}{5 + 2.5j^\circ} = \frac{5j^\circ(2-j^\circ)}{(2+j^\circ)(2-j^\circ)} = \frac{5(1+2j^\circ)}{5} = 1+2j^\circ$$

(a) Norton korrontea



$\underline{I}_a = 5\angle 0^\circ$

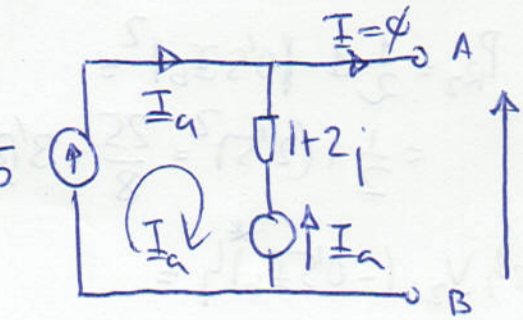
1k $\quad \underline{I}_N = \underline{I}_a + \underline{I}_1 = 5\angle 0^\circ + \underline{I}_1 = 5 + 1 - 2j^\circ = 6 - 2j^\circ$

$\underline{V} = 0 \Rightarrow \quad \underline{I}_a - \underline{I}_1(1+2j^\circ) = 0$

$$\underline{I}_1 = \frac{\underline{I}_a}{1+2j^\circ} = \frac{5(1-2j^\circ)}{(1+2j^\circ)(1-2j^\circ)} = 1-2j^\circ$$

$$\boxed{\underline{I}_N = 6 - 2j^\circ}$$

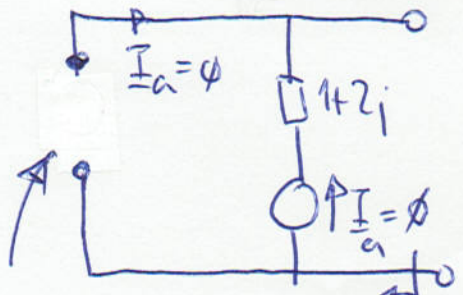
(b) Thevenin tentsioa



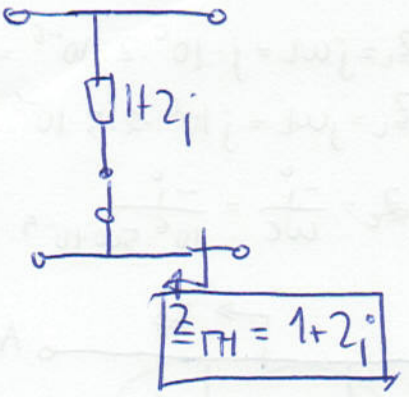
$$\underline{V}_{TH} = \underline{I}_a + (1+2j^\circ)\cdot\underline{I}_a = (2+2j^\circ)\cdot\underline{I}_a = \quad (\underline{I}_a = 5\angle 0^\circ)$$

$$= 10 + 10j = \boxed{10\sqrt{2}\angle \pi/4 = \underline{V}_{TH}}$$

(c) $\underline{Z}_{TH}$



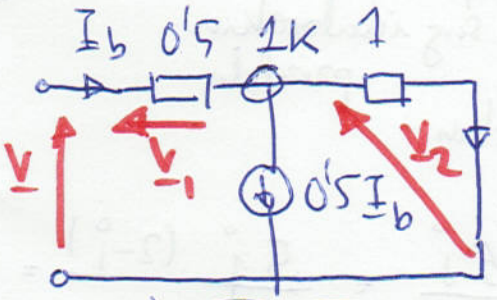
Sorgenik indep. $\underline{Z}_{TH}$
amatatu!!



$$\underline{V}_{TH} = \underline{I}_N \cdot \underline{Z}_{TH} = (6-2j^*)(1+2j^*) = 6+12j^* - 2j^* + 4 = 10+10j = \underline{V}_{TH}\ !!$$

konprobatuta.

(d) karga $\rightsquigarrow$



$\underline{I}_b - 0'5\underline{I}_b = 0'5\underline{I}_b$ (1k)

$\hookrightarrow$ ez du sorgenik independientenik

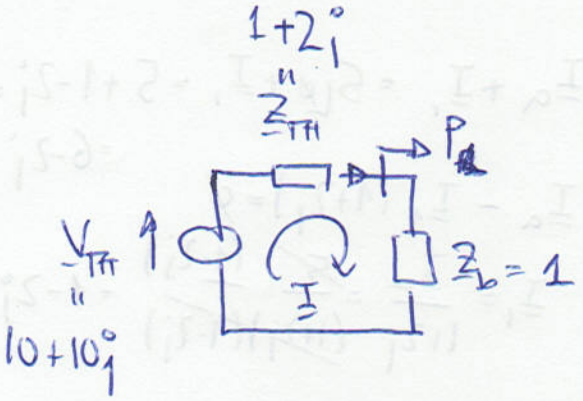
$\underline{Z}_b$

$\underline{V}_1 = 0'5 \cdot \underline{I}_b$

$\underline{V}_2 = 0'5\underline{I}_b \cdot 1$

$\underline{V} = 0'5\underline{I}_b + 0'5\underline{I}_b$

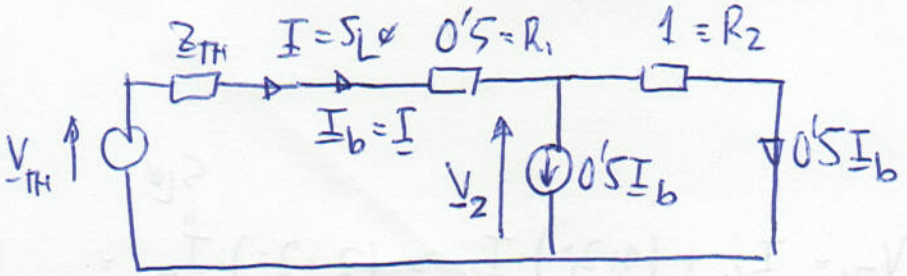
$$\frac{\underline{V}}{\underline{I}_b} = \underline{Z}_b = 1$$



$$\underline{I} = \frac{10+10j}{1+2j+1} = 5$$

$$P_L = \frac{1}{2} \cdot R \cdot |\underline{I}|^2 = \frac{1}{2} \cdot 1 \cdot 5^2 = 12'5\,W$$

(e) Osagai bakoitzean:



$\underline{I}_b = 5\angle 0$ (aurrekoetatik)

$$P_{R_1} = \frac{1}{2}\, 0'5 \cdot |\underline{I}_b|^2 = 6'25\,W.$$

$$P_{R_2} = \frac{1}{2}\, 1 \cdot |0'5\underline{I}_b|^2 =$$

$$= \frac{1}{2}\, 1\, (2'5)^2 = \frac{25}{8} = 3'125\,W$$

$$P_5 = \frac{1}{2}\, \mathrm{Re}\{\underline{V}_2 \cdot (-0'5\underline{I}_b)^*\} =$$

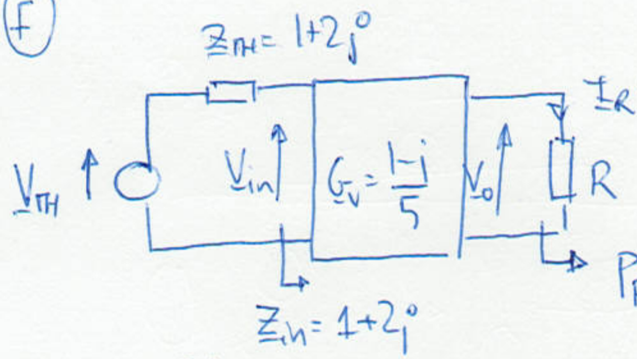
$= \frac{1}{2} \mathrm{Re}\{0'5 \underline{I}_b \cdot (-0'5 \underline{I}_b)^* \} = \frac{1}{2} \mathrm{Re}\{0'5 \cdot 5 \cdot (-0'5 \cdot 5)\} = -3'125 W$

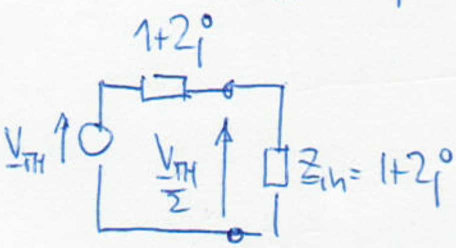
aurreko atala $\underline{I}_b = 5$

Potentzia totala $P_{R_1} + P_{R_2} - P_S = 6'25 + 3'125 + 3'125 = 12'5 W = P_L$

P_S eurendakoa bait; P_L egiaztatuta.

(F)





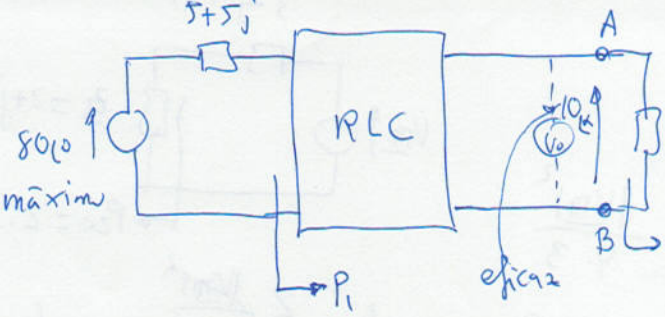
$\underline{V}_{in} = \frac{\underline{V}_{TH}}{2} = 5+5j$ $\quad \underline{V}_o = G_v \cdot \underline{V}_i = \frac{1-j}{5} \times 5(1+j) = 2\angle 0$

$\underline{I}_R = \frac{\underline{V}_o}{R} = \frac{2}{R} \Rightarrow P_R = \frac{1}{2} R \cdot |\underline{I}_R|^2 = \frac{1}{2} R \frac{|\underline{V}_o|^2}{R^2} = \frac{4}{2R} = 1W$

$\boxed{R = 2\Omega}$

PROBLEMA 2

a)

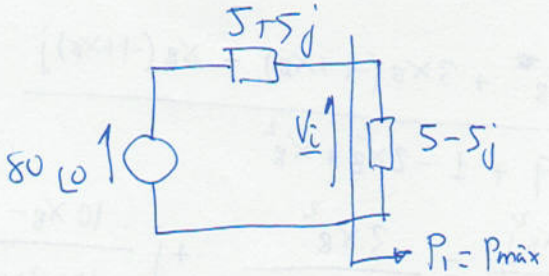


$d_T(dB) = 10 \log \frac{P_1}{P_2} = 6'02 dB$ $\quad \frac{P_1}{P_2} = 10^{0'602}$ $\quad P_1 = P_2 \cdot 10^{0'602} = 160 w$

$P_1 = P_{disp} + P_2$ $\quad P_{disp} = P_1 - P_2 = 160 - 40 = \boxed{120 w}$

b) $P_{disp} = \frac{1}{2} \frac{80^2}{4 \cdot 5} = \frac{6400}{40} = \boxed{160}$

$P_1 = P_{disp} = P_{max}$ → tiene que estar adaptada la entrada.



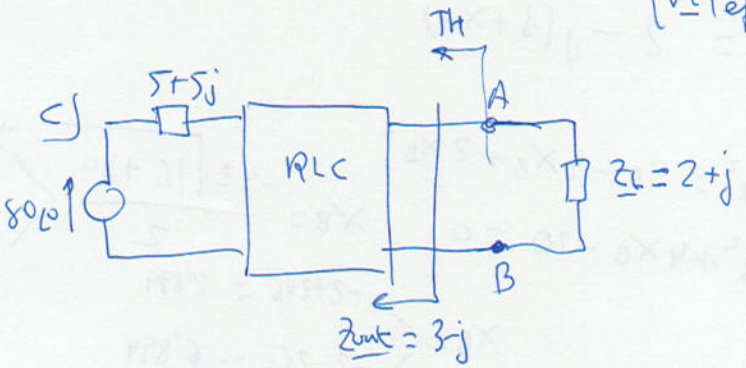
$\underline{V_i} = (5-5j) \cdot \frac{80\angle 0}{10} = 8(5-5j)$

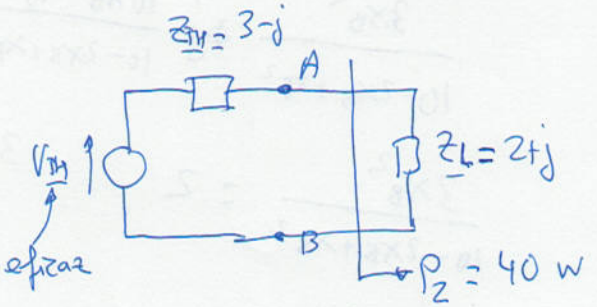
$\underline{V_i} = 8 \cdot 5\sqrt{2} \angle -\pi/4 = 40\sqrt{2} \angle -\pi/4$

$|\underline{V_i}|_{max} = 40\sqrt{2}$

$|\underline{V_i}|_{eficaz} = \boxed{40 \text{ voltios}}$

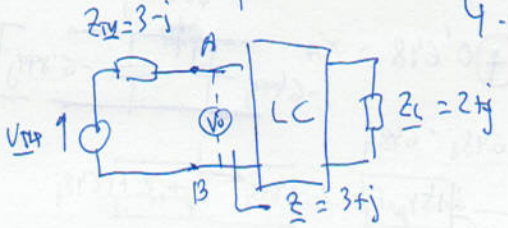
c)

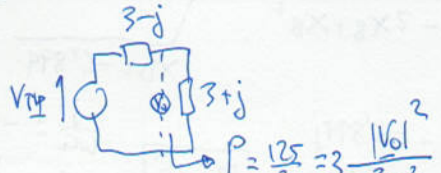




$P_2 = 2 \frac{|V_{TH}|^2}{5^2 + 0^2} = 40$

La $P_{disponible} = \frac{|V_{TH}|^2}{4 \cdot 3} = \frac{500}{12} = \boxed{\frac{125}{3} w}$ $\quad |V_{TH}|^2 = \frac{40 \cdot 25}{2} = 500$



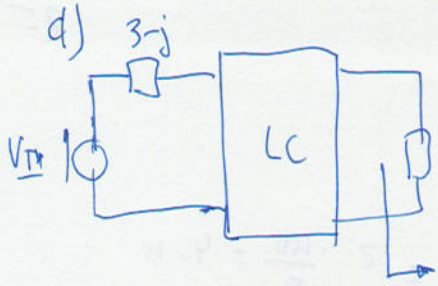


$|\underline{V_o}|^2 = \frac{125 \cdot 10}{9} =$

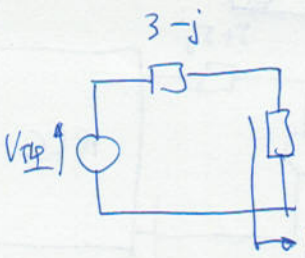
$|\underline{V_o}|^2 = 138'89$

$|V_o| = 11'78 V$

d)



$$P_2 = P_{max} = \frac{|V_{Th}|^2}{4 \cdot 3}$$

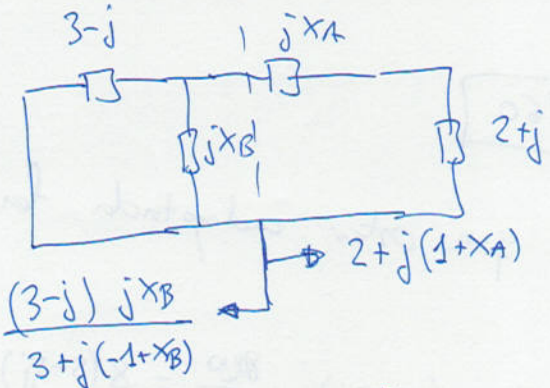


$$P_{20} = 2 \cdot \frac{|V_{Th}|^2}{5^2 + 0^2}$$

$$\alpha_{I(dB)} = 10 \log \frac{P_{20}}{P_2} = 10 \log \frac{2 \frac{|V_{Th}|^2}{25}}{\frac{|V_{Th}|^2}{12}} = 10 \log \frac{24}{25}$$

$$\boxed{\alpha_{I(dB)} = -0'177 \text{ dB}}$$

e)



$$\frac{(3X_B j + X_B^2)(3 - j(-1+X_B))}{3^2 + (-1+X_B)^2} = \frac{9X_B j + 3X_B^2 + 3X_B(-1+X_B) - X_B(-1+X_B)j}{9 + 1 - 2X_B + X_B^2}$$

$$= \frac{9X_B j + 3X_B - 3X_B + 3X_B^2 + X_B j - X_B^2 j}{9+1-2X_B+X_B^2} = \frac{3X_B^2}{10-2X_B+X_B^2} + j\,\frac{10X_B - X_B^2}{10-2X_B+X_B^2}$$

$$\frac{3X_B^2}{10-2X_B+X_B^2} + j\,\frac{10X_B - X_B^2}{10-2X_B+X_B^2} = 2 - j(1+X_A)$$

$$\frac{3X_B^2}{10-2X_B+X_B^2} = 2$$

$$3X_B^2 = 20 - 4X_B + 2X_B^2$$

$$X_B^2 + 4X_B - 20 = 0$$

$$X_B = \frac{-4 \pm \sqrt{16+80}}{2} \quad \begin{cases} \frac{-4+4\sqrt{6}}{2} \\ \frac{-4-4\sqrt{6}}{2} \end{cases}$$

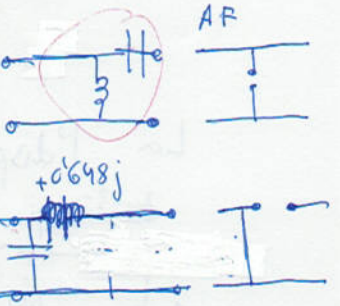
$$X_B = \begin{cases} -2+2\sqrt{6} = 2'899 \\ -2-2\sqrt{6} = -6'899 \end{cases}$$

$$\frac{10X_B - X_B^2}{10-2X_B+X_B^2} = -(1+X_A) = -1 - X_A$$

$$X_A = -1 - \frac{10X_B - X_B^2}{10-2X_B+X_B^2}$$

$X_B = 2'899 \rightarrow -2'633 = X_A$

$X_B = -6'899 \rightarrow +0'648 = X_A$



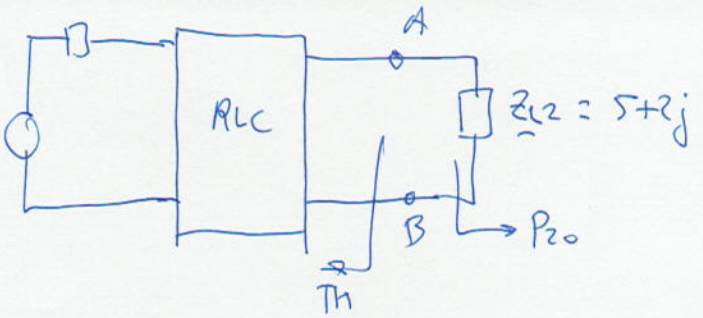
$$\frac{-j}{\omega C} = -6'899j$$

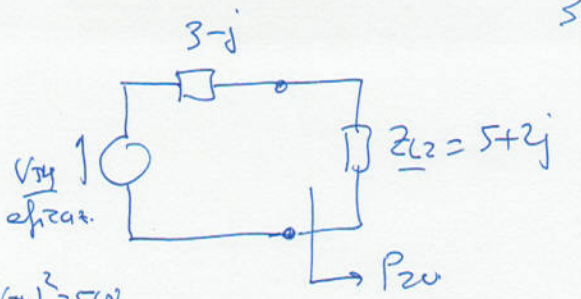
$$C = \frac{1}{2\pi \cdot 1000 \cdot 1'15} = \boxed{145 \text{ nF}}$$

$$j\omega L = 0'648j$$

$$L = \frac{0'648}{2\pi \cdot 1000} = \boxed{0'648\ \mu\text{H}}$$

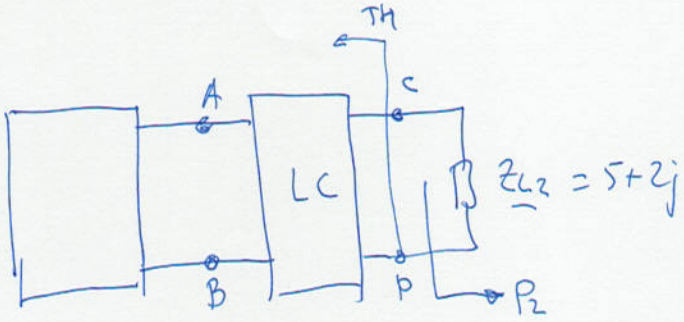
f)

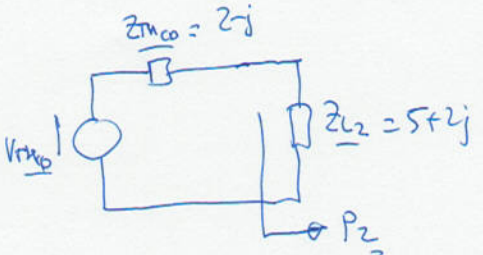




$|V_{TH}|^2 = 50$

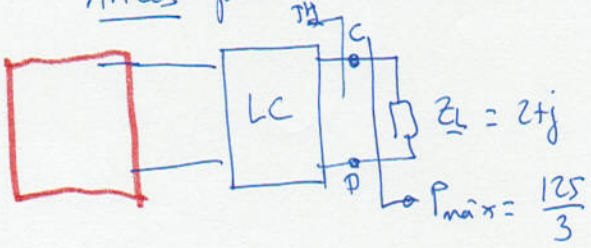
$$P_{20} = 5 \frac{|V_{TH}|^2}{8^2+1^2} = \frac{5 \cdot 50}{65}$$

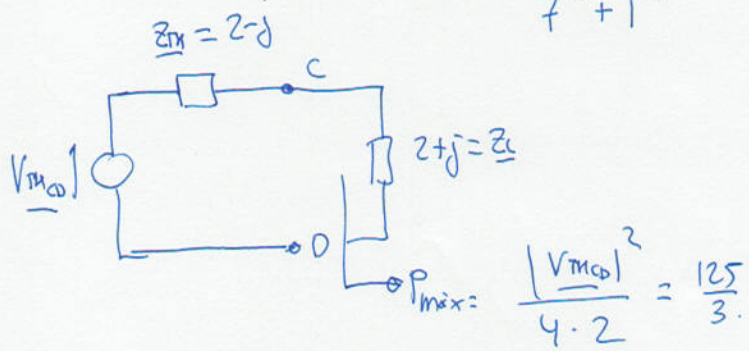




$$P_2 = 5 \cdot \frac{|V_{TH_{CD}}|^2}{7^2+1^2}$$

Antes para el diseño de LC





$$|V_{TH_{CD}}|^2 = \frac{125 \cdot 8}{3}$$

$$P_2 = 5 \cdot \frac{\frac{125 \cdot 8}{3}}{50} =$$

$$\alpha_{I(dB)} = 10 \log \frac{P_{20}}{P_2} = 10 \log \frac{\frac{8 \cdot 50}{65}}{\frac{125 \cdot 8}{3 \cdot 50}} = 10 \log \frac{50 \cdot 3 \cdot 50}{65 \cdot 125 \cdot 8}$$

$\alpha_{I(dB)} = 0'621$ dB.