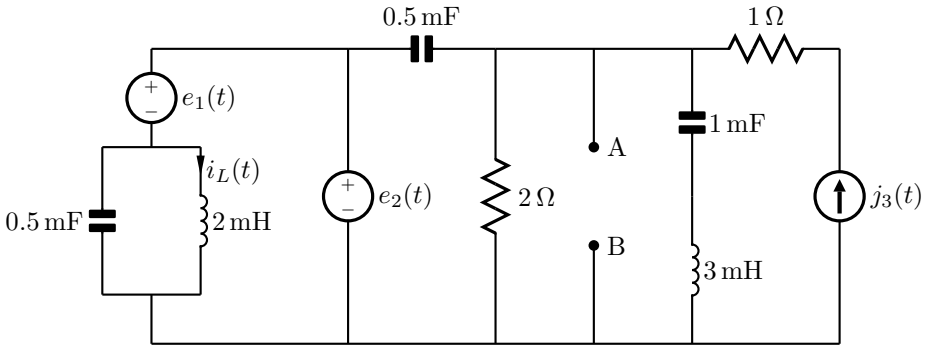
1. ARIKETA — DENBORA: 45 min (10 PUNTU)

Irudiko zirkuituko sorgailuak hauek dira:

$$e_1(t) = 0.5\sin(10^3 t)\,\mathrm{V} \quad e_2(t) = 2\cos(10^3 t + \pi)\,\mathrm{V} \quad j_3(t) = \cos(10^3 t)\,\mathrm{A}$$



Kalkulatu:

a $i_L(t)$, 2 mH-tako harilean korrontea. A eta B artean karga jarrita korrontea aldatuko al da? Arrazoitu zure erantzuna. **(0.5 puntu)**

b Kalkulatu A eta B arteko Thevenin baliokidea. **(3 puntu)**

c Kalkulatu A eta B arteko Norton korrontea. Egiaztatu emaitza. **(2 puntu)**

Aurreko ataleko emaitzak edozein izanda ere, hurrengo ataletarako hartu $\underline{V}_{TH} = 2\sqrt{2}\big|_{-\frac{\pi}{4}}$ (balio maximoa, erreferentzia cosinuetan) eta $Z_{TH} = 2$. A eta B artean karga jarrita hurrengo tentsioa neurtu da $V_{\mathrm{AB}}(t) = \cos(10^3 t)\,\mathrm{V}$. Kalkulatu:

d Kargaren inpedantzia. **(1 puntu)**

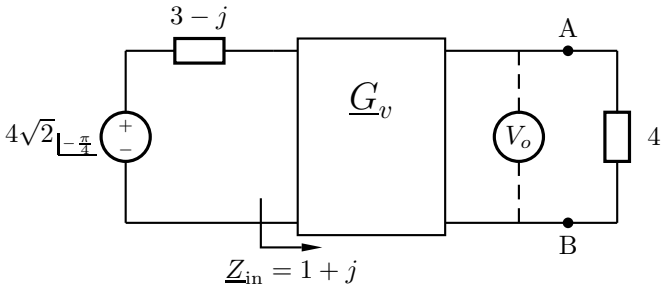
e Potentzia aktiboa kargan. **(0.5 puntu)**

f Adierazi karga bi osagai paralelo bezela, eta kalkulatu osagai horiek. **(1 puntu)**

g $j_3(t)$ sorgailuak emandako potentzia, karga konektatuta dagoenean. **(2 puntu)**

2. ARIKETA — DENBORA: 45 min (10 PUNTU)

Irudiko zirkuituan fasoreak balio maximotan daufe, lan maiztasuna $\omega = 2 \cdot 10^3\,\text{rad/s}$ da, eta potentzia kargan maximoa da.



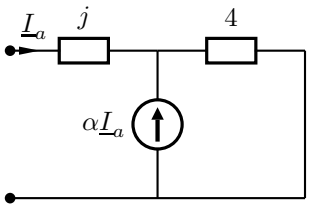
a Voltimetroan 10 V neurtu dira. Kalkulatu zirkuituaren insertzio eta transmisio-galerak, eta zirkuituaren $|\underline{G}_v|$. **(2 puntu)**

b Karga aldatu eta $\underline{Z}_L = 2 + j$ jarri da. Kalkulatu voltimetroan irakurritako balioa. **(2 puntu)**

c $\underline{Z}_L$ kargan potentzia maximoa izan dadin LC zirkuitua erabili da. Kalkulatu LC zirkuituaren insertzio-galerak. **(2 puntu)**

d Diseinatu LC zirkuitua, aukeratu maiztasun altuak kargara pasatzen uzten ez duen soluzioa. **(2 puntu)**

e $\underline{Z}_L = 2 + j$ karga lortzeko irudiko zirkuitua erabili da. Kalkulatu α. **(2 puntu)**



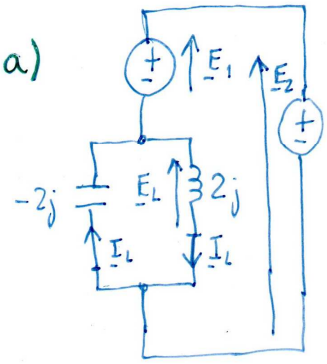
SOLUCIÓN DEL EXAMEN 20-12-2018

PROBLEMA 1

$e_1 = 0{,}5 \cdot \sin(10^3 t) = 0{,}5 \cdot \cos(10^3 t - \frac{\pi}{2}) \Rightarrow \underline{E}_1 = -0{,}5j$

$e_2 = 2 \cdot \cos(10^3 t + \pi) \Rightarrow \underline{E}_2 = -2$

a)



ERROR TÍPICO:

$-2j \,//\, 2j = \infty \Rightarrow$ La misma corriente que baja por la bobina es la que sube por el condensador, pero eso no significa que sea 0.

2ª Kirchoff: $\underline{E}_L + \underline{E}_1 - \underline{E}_2 = 0 \Rightarrow \underline{E}_L = \underline{E}_2 - \underline{E}_1$

Ohm: $\underline{I}_L = \frac{\underline{E}_L}{2j} = \frac{-2-(-0{,}5j)}{2j} = 0{,}25 + j$

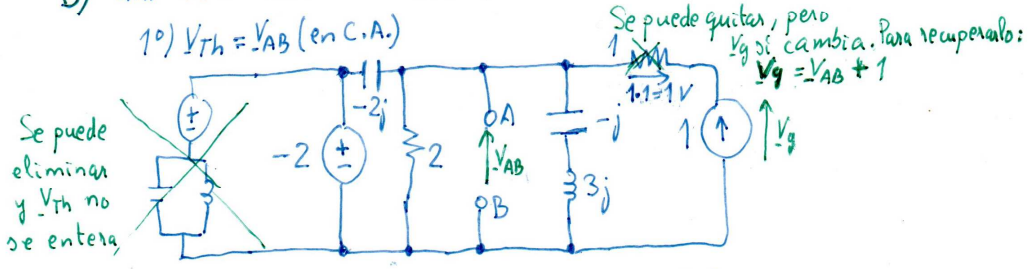
pero no se pide $\underline{I}_L$, sino $i_L(t)$:

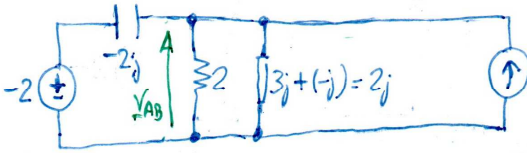
$\underline{I}_L = 1{,}03 \angle 1{,}3258 \Rightarrow \boxed{i_L(t) = 1{,}03 \cdot \cos(10^3 t + 1{,}3258)\ (A)}$

SI SE PONE UNA CARGA ENTRE A Y B, NO VARÍA $\underline{E}_2$ POR ESTAR ESE GENERADOR EN PARALELO ⇒ TAMPOCO VARÍA $i_L(t)$, PORQUE EL RESTO DEL CIRCUITO A LA DERECHA DE $\underline{E}_2$ SE PUEDE ELIMINAR PARA CALCULAR LA CORRIENTE $i_L(t)$.

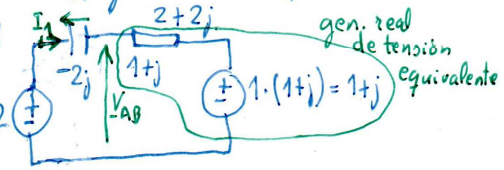
b) HAY QUE CALCULAR $\underline{V}_{Th}$ Y $\underline{Z}_{Th}$:

1º) $\underline{V}_{Th} = \underline{V}_{AB}$ (en C.A.)





$2 // 2j = \frac{2 \cdot 2j}{2+2j} = 1+j$



(2)

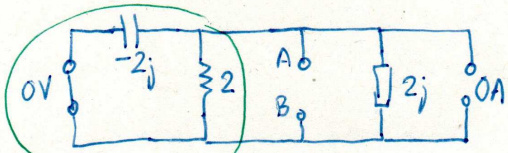
$2^a K: \; +(-2) - (-2j)\cdot \underline{I}_1 - (1+j)\underline{I}_1 - (1+j) = 0$

$\Rightarrow \underline{I}_1 = \dfrac{-3-j}{1-j} = -1-2j$

$\Rightarrow \boxed{\underline{V}_{AB} = +(-2) - (-2j)\underline{I}_1 = -2 + 2j\cdot(-1-2j) = 2-2j}$

$\Rightarrow \boxed{\underline{V}_{Th} = 2-2j}$

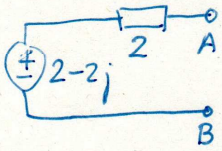
2º) $\underline{Z}_{Th} = \underline{Z}_{AB}$ (con generadores independientes apagados)



$2 // (-2j) = 1-j$

$\boxed{\underline{Z}_{AB} = (1-j) // (2j) = 2}$

$\Rightarrow \boxed{\underline{Z}_{Th} = 2}$

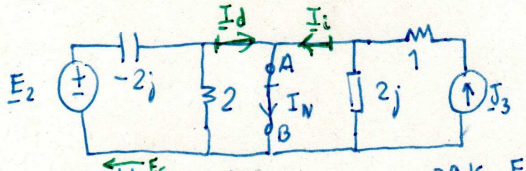
$\Rightarrow$ 

c) HAY QUE CALCULAR $\underline{I}_N$ y $\underline{Z}_N$

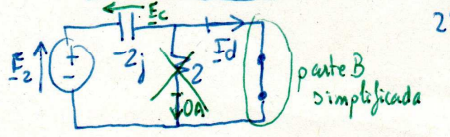
1º) $\underline{Z}_N = \underline{Z}_{AB}$ (con generadores independientes apagados)

$\Rightarrow \boxed{\underline{Z}_N = \underline{Z}_{Th} = 2}$

2º) $I_N = \underline{I}_{AB}$ (en C.C.)



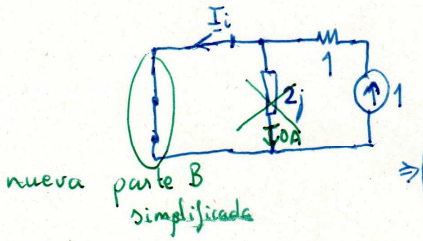
$\underline{I}_N = \underline{I}_d + \underline{I}_i$



parte B simplificada

$2^a K: \; \underline{E}_c - \underline{E}_2 = 0 \Rightarrow \underline{E}_c = \underline{E}_2 \Rightarrow \boxed{\underline{I}_d = \dfrac{\underline{E}_2}{(-2j)} = \dfrac{-2}{-2j} = -j}$

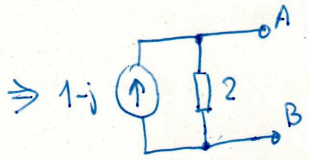
(3)



nueva parte B simplificada

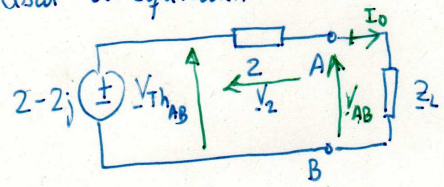
$\Rightarrow \boxed{I_i = 1}$

$\Rightarrow \boxed{I_N = I_d + I_i = 1-j}$



COMPROBACIÓN: $\boxed{I_N = \frac{V_{Th}}{Z_N} = \frac{2-2j}{2} = 1-j}$

d) Para calcular la impedancia de la carga que hace $V_{AB} = 1\angle 0$, podemos usar el equivalente Thevenin entre A y B:



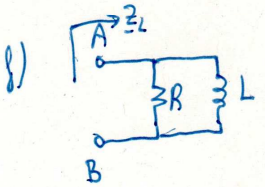
$V_{AB} = I_0 \cdot Z_L$

$I_0 = \frac{V_2}{2} = \frac{V_{Th_{AB}} - V_{AB}}{2} = \frac{2-2j-1}{2}$

$\Rightarrow V_{AB} = I_0 \cdot Z_L = (0,5-j) \cdot Z_L = 1$

$\Rightarrow \boxed{Z_L = \frac{1}{(0,5-j)} = 0,4+0,8j}$

e) $\boxed{P_L = \frac{1}{2} \cdot |I_0|^2 \cdot Re(Z_L) = \frac{1}{2} |0,5-j|^2 \cdot 0,4 = \frac{1}{2} \cdot (0,5^2+1^2) \cdot 0,4 = 0,25W}$

f) 

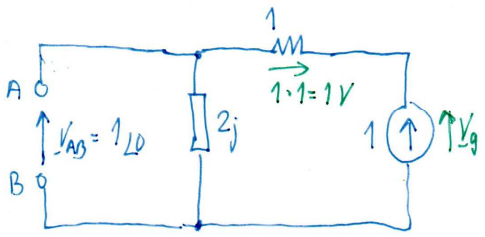
$\frac{1}{Z_L} = Y_L = \frac{1}{R} + \frac{1}{j\omega L} = \boxed{\frac{1}{R} - \frac{j}{\omega L}} = \frac{1}{0,4+0,8j} = 0,5-j$

$\Rightarrow \frac{1}{R} = 0,5 \Rightarrow \boxed{R = 2\Omega}$

$\Rightarrow \frac{1}{\omega L} = 1 \Rightarrow \boxed{L = \frac{1}{\omega} = 10^{-3} H}$

(4)

g)



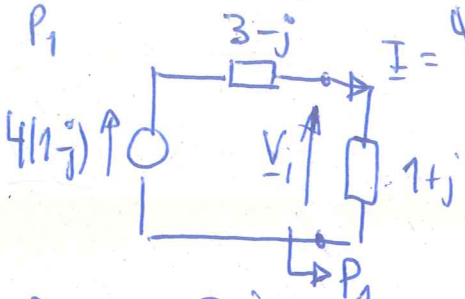
2ª K: $1 + 1 - \underline{V}_g = 0 \Rightarrow \underline{V}_g = 2\angle 0\ V$

$$P_g = \frac{1}{2}\,\mathrm{Re}\left(\underline{V}_g \cdot \underline{I}_g^*\right) = \frac{1}{2}\,\mathrm{Re}\left(2 \cdot 1^*\right) = 1\ W$$

FALLO TÍPICO: DECIR QUE $\underline{V}_g$ ES IGUAL QUE $\underline{V}_{AB}$ POR HABER ELIMINADO LA IMPEDANCIA EN SERIE CON EL GENERADOR DE CORRIENTE, SIN DARSE CUENTA QUE LA TENSIÓN EN EL GENERADOR DE CORRIENTE SÍ CAMBIA

(a) P_1, P_{20} y P_2

P_1

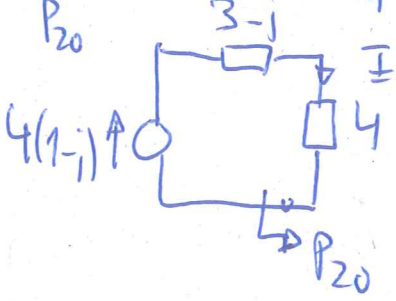


$$\underline{I} = \frac{4(1-j)}{4} = 1-j^\circ$$

$$P_1 = \frac{1}{2}\cdot 1 \cdot |\underline{I}|^2 = \frac{1}{2}\cdot 1\cdot 2 = 1\,W$$

$$\underline{V}_i = \frac{1+j}{4}\cdot 4(1-j^\circ) = 2\angle\varnothing$$

P_{20}

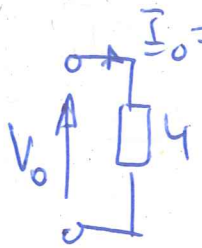


$$\underline{I}_{20} = \frac{4(1-j)}{7-j}$$

$$P_{20} = \frac{1}{2}\cdot 4\cdot |\underline{I}_{20}|^2 = 2\cdot\left|\frac{4(1-j)}{7-j}\right|^2 = 2\cdot\frac{16\cdot 2}{49+1}$$

$$= \frac{64}{50}$$

P_2



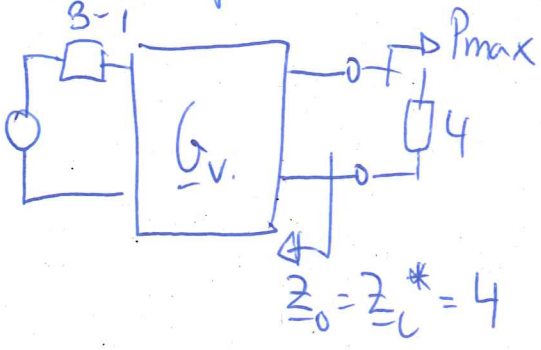
$$P_2 = \underset{\text{ef.}}{1}\cdot 4\cdot|\underline{I}_o|^2 = 4\cdot\left|\frac{\underline{V}_o}{4}\right|^2 = \frac{|\underline{V}_o|^2}{4} = \frac{10^2}{4} = 25\,W$$

$$\alpha_I = 10\log\frac{P_{20}}{P_2} = 10\log\left(\frac{64}{50}\cdot\frac{1}{25}\right) = -12'9\,dB$$

$$\alpha_T = 10\log\frac{P_1}{P_2} = 10\log\left(\frac{1}{25}\right) = -14\,dB$$

$$|\underline{G}_v| = \left|\frac{\underline{V}_o}{\underline{V}_i}\right| = \frac{|\underline{V}_o|}{|\underline{V}_i|} = \frac{10\cdot\sqrt{2}}{2} = \boxed{5\sqrt{2} = |\underline{G}_v|}$$

(b) Adaptado en (a)

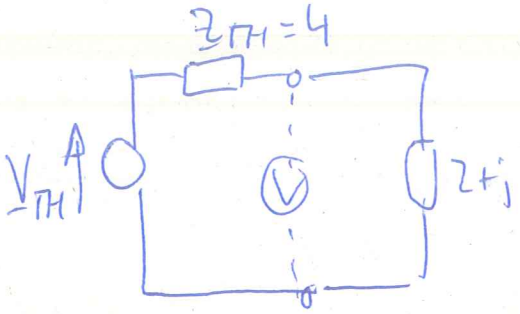


y $P_{max} = \dfrac{|\underline{V}_{TH}|^2}{4\cdot R_{TH}} = 25$

$$|\underline{V}_{TH}|^2 = 25\cdot 4^2$$

$$|\underline{V}_{TH}| = 5\cdot 4 = 20$$

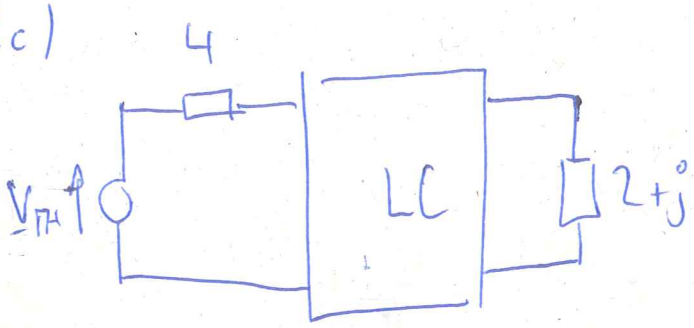
$$\underline{Z}_{TH} = 4$$



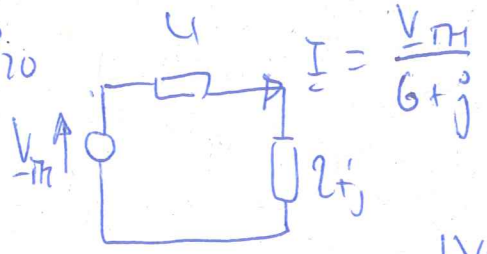
$$\underline{V} = \frac{2+j}{2+j+4}\cdot \underline{V}_{TH}$$

$$|\underline{V}| = \left|\frac{2+j}{6+j}\right| \cdot |\underline{V}_{TH}| = \frac{\sqrt{5}}{\sqrt{37}}\cdot 20 = 7'35\ V$$

(c)



P_{20}



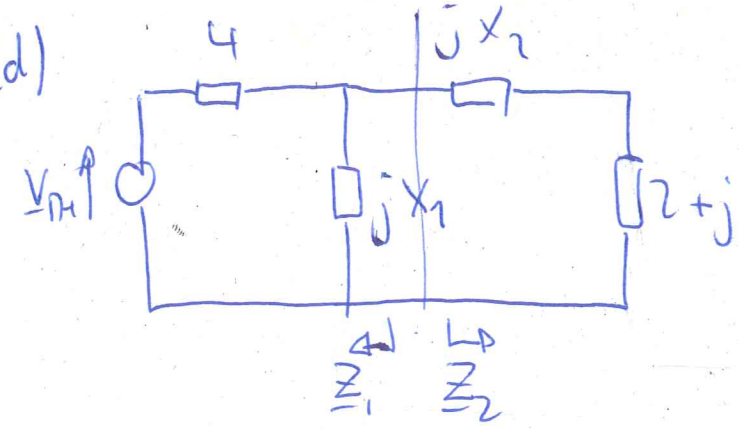
$$\underline{I} = \frac{\underline{V}_{TH}}{6+j}$$

$$P_{20} = 1\cdot 2\cdot \frac{|\underline{V}_{TH}|^2}{37} = \frac{800}{37}$$

$$P_2 = P_{disp} = \frac{|\underline{V}_{TH}|^2}{4\cdot 4} = \frac{20^2}{16} = \frac{400}{16} = 25$$

$$\alpha_I = 10\log\left(\frac{P_{20}}{P_2}\right) = -0'63\ dB$$

(d)



$$\underline{Z}_2 = 2+j+jX_2 = 2+j(1+X_2)$$

$$\underline{Z}_1 = jX_1 /\!/ 4 = \frac{4(jX_1)(4-jX_1)}{(4+jX_1)(4-jX_1)} =$$

$$= \frac{4X_1^2 + j16X_1}{16+X_1^2} = \underline{Z}_1$$

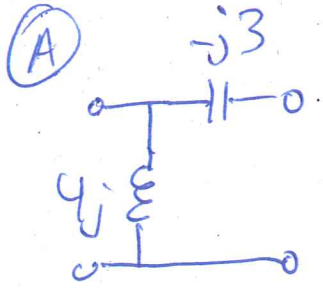
$$\underline{Z}_1 = \underline{Z}_2^* \equiv \begin{cases} \dfrac{4X_1^2}{16+X_1^2} = 2 \\ 1+X_2 = -\dfrac{16X_1}{16+X_1^2} \end{cases}$$

$$4X_1^2 = 32 + 2X_1^2 \qquad 2X_1^2 = 32$$

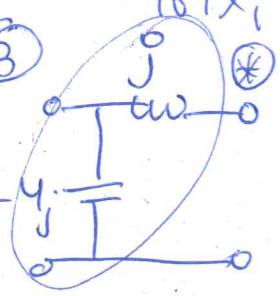
$$X_1 = \pm 4$$

$$X_2 = -1 - \frac{16X_1}{16+X_1^2} \equiv \begin{cases} -3 \\ 1 \end{cases}$$

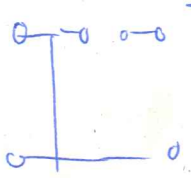
(A)



(B)



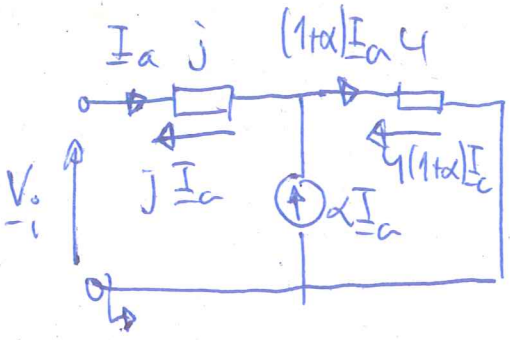
$-1-(\pm 2)$



$-4j = -j/\omega C$ $\quad 4 = \frac{1}{\omega C}$ $\quad C = \frac{1}{4\omega} = \frac{1}{4 \cdot 2 \cdot 10^3} = 125\,\mu F$

$j = j\omega L$ $\quad \omega L = 1$ $\quad \boxed{L = \frac{1}{\omega} = 500\,\mu H}$

(e)



$\underline{Z}_{in} = 2 + j^0$

$\underline{V}_i = j\,\underline{I}_a + 4(1+\alpha)\underline{I}_a$

$\frac{\underline{V}_i}{\underline{I}_a} = \underline{Z}_i = j^0 + 4(1+\alpha) = 2 + j$

$4(1+\alpha) = 2$

$\boxed{\alpha = \frac{2}{4} - 1 = -\frac{1}{2}}$