PROBLEMS OF CHAPTER 5: RESONANT CIRCUITS.

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PROBLEM 5.1

By varying the frequency of the source in the resonant circuit of Figura 1, we observe that for $\omega_0 = 10^3$ rad/s the current $i(t)$ is maximum. Obtain:

a) Values for L and C in order to satisfy the conditions described.

b) Time-domain expression for current $i(t)$ at the resonance frequency.

c) Time-domain expressions for the current $i(t)$ when the frequency of the source is displaced 1% over, and 5% under the resonance frequency.

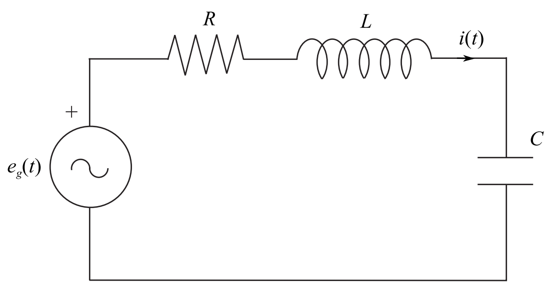

Figure 1

$$Data: \quad e_g\left(t\right) = 20\sqrt{2}\, sen\left(\omega t\right) \text{ V}; \quad Q = 5; \quad R = 2\,\Omega$$

Result

a) $L = 10$ mH, $C = 100$ μF.

b) $i\left(t\right) = 10\sqrt{2}\, sen\left(10^3 t\right)$ A

c) $i_{\delta_1}\left(t\right) = 9.95\sqrt{2}\, sen\left(1.01 \cdot 10^3 t - 0.0997\right)$ A; $i_{\delta_2}\left(t\right) = 8.944\sqrt{2}\, sen\left(0.95 \cdot 10^3 t + 0.464\right)$ A

PROBLEMA 5.2

$Q_b = 50$ for the inductor of the circuit shown in Figure 1 at the resonance frequency, $\omega_0 = 1\ Mrad/s$. We also know that the anti-resonance circuit receives the maximum power at the resonance frequency. Obtain:

a) Values of r, L and C.

b) Time-domain expression of the current though the inductor, when the frequency of the source increases a 2% with respect to the resonance frequency.

c) To triplicate the bandwidth of the circuit, we can use a resistor R. Indicate how to connect this resistor in the circuit, and determine its value.

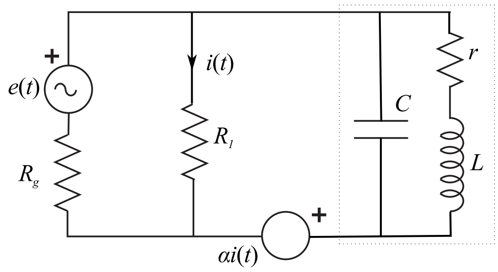

Figure 1

$$DATA: \quad e(t) = 10\ sen(\omega t)\ V \quad ; \quad R_g = 2\ k\Omega \quad ; \quad R_1 = 3\ k\Omega \quad ; \quad \alpha = \frac{1}{2}\ k\Omega$$

Result

a) $r = 0.4\ \Omega$; $L = 20\ \mu$H, $C = 50$ nF.

b) $i_L(t) = 86.6 \cdot sen\left(1.02 \cdot 10^6 t - 2.337\right)$ mA

c) Resistencia en paralelo de valor $R = 250\ \Omega$

PROBLEM 5.3

For the resonant circuit of Figure 1, it is known that changing the frequency of the source E_g the following voltages are obtained::

$\omega = 101000 rad/s$	$v(t) = \frac{1}{\sqrt{2}}\text{sen}(101000t - \frac{\pi}{4})$
$\omega = 99000 rad/s$	$v(t) = \frac{1}{\sqrt{2}}\text{sen}(99000t + \frac{\pi}{4})$

Determine:

a) Values of L and C.

b) Value of the resistor to be connected in parallel with R_L in order to duplicate the bandwidth of the given circuit.

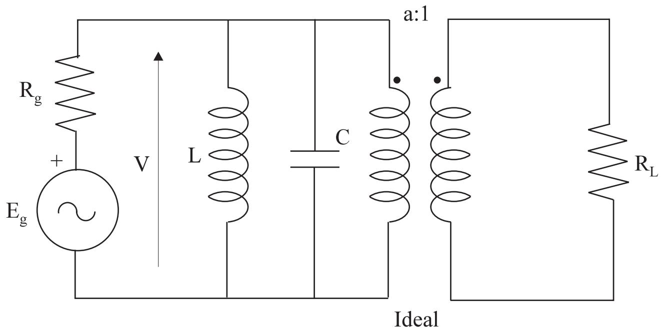

Figure 1

$$Data: \quad e_g(t) = 2\text{sen}(\omega t) \quad ; \quad R_g = 10k\Omega \quad ; \quad R_L = 2,5k\Omega \quad ; \quad a = 2$$

Result

a) $L = 1$ mH; $C = 100$ nF.

b) $R_P = 1250\ \Omega$.

PROBLEM 5.4

For the circuit in Figure 1, where we have a perfect transformer:

a) Obtain the value of C_2 in order to get the maximum current I_L for the frequency $\omega = 10^7\ rad/s$.

b) Determine the value of R_L so as to receive the maximum power in the load, at the frequency of the previous section.

c) Find the maximum and minimum frequencies for which the attenuation of the current I_L is under 6 dBs.

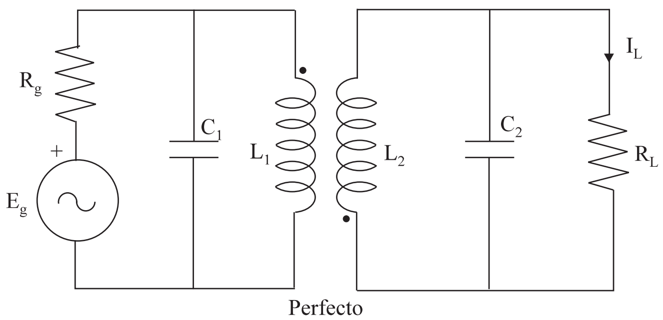

Figure 1

$$Data: \quad E_g = 40\ V \quad ; \quad R_g = 10\ k\Omega \quad ; \quad L_1 = 4\ \mu H \quad ; \quad L_2 = 1\ \mu H \quad ; \quad C_1 = 1.5\ nF$$

Result

a) $C_2 = 4$ nF.

b) $R_L = \frac{5}{2}$ kΩ.

c) $\omega_i = 9.93 \cdot$ Mrad/s; $\omega_s = 10.07 \cdot$ Mrad/s

PROBLEM 5.5

In order to build the resonant circuit shown in Figure 1, we have the components shown in Figure 2. We also know that $R_g = 40\ \Omega$ and $R_L = 80\ \Omega$.

a) Build a RLC series or a RLC parallel circuit to tune a signal whose frequency is in the interval defined by frequencies $\omega_1 = 975\ rad/s$ and $\omega_2 = 1025\ rad/s$.

b) Justify how to duplicate the bandwidth of the circuit using some of the components NOT used in the previous section, and considering the same value of ω_0.

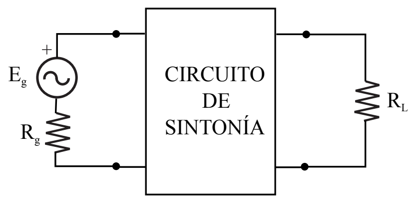

Figure 1

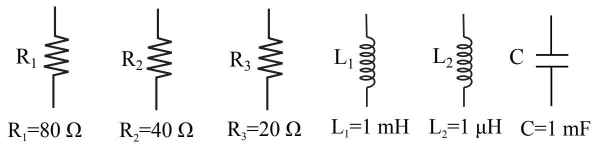

Figure 2

Result

a) RLC parallel with L_1, C and R_1.

b) Connect the resistor R_3 in parallel with the resonant circuit.

PROBLEM 5.6

We want to tune a signal of 10 Krad/s with a bandwidth at 3 dB of 100 rad/s. We use an antenna and the resonant circuit shown in Figure 1. The equivalent circuit corresponding to the antenna is the current source connected to terminals $A - B$, while the resonant circuit is the rest of the circuit from terminals $A - B$ towards the right.

a) Determine the value of a and the resistor R in order to be able to tune the proposed signal.

b) If we can change the values of R and C, justify if we have to increase, decrease or fix the values of R and/or C in order to tune a different signal with frequency 20 Krad/s, but maintaining the bandwidth at 3 dB of 100 rad/s.

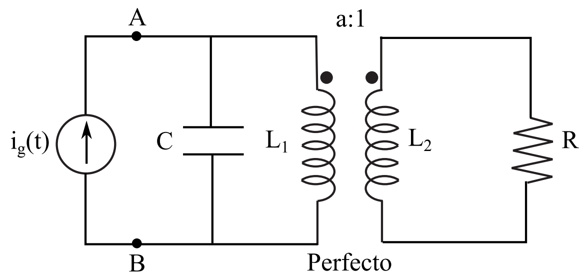

Figure 1

$$Data: \quad e_g(t) = 20\ sen(\omega t)\ V \quad ; \quad L_2 = 10\ mH \quad ; \quad C = 16\ \mu F.$$

Result

a) $a = \frac{1}{4}$; $R = 10\ k\Omega$

b) Decrease C. Increase R.

PROBLEM 5.7

For the circuit in Figure 1 we want to tune a signal provided by an antenna whose equivalent circuit is shown in Figure 1. At the resonance frequency it is known that the antenna delivers the maximum power.

a) Obtain the quality factor and bandwidth at 3 dB of the resonant circuit.

b) Determine the time-domain expressions for the voltage in the capacitor at the maximum and minimum frequencies that define the bandwidth.

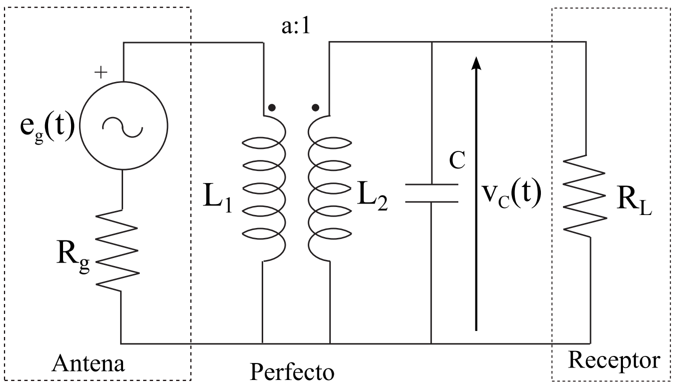

Figure 1

$$Data: \quad e_g(t) = 20\ sen(\omega t)\ V \quad ; \quad R_g = 200\ k\Omega \quad ; \quad L_1 = 1\ mH \quad ; \quad C = 4\ nF \quad ; \quad R_L = 50\ k\Omega.$$

Result

a) $Q = 100$; $B = 10$ krad/s.

b) $v_{C_1}(t) = \frac{5\sqrt{2}}{2} \cdot \text{sen}\left(995 \cdot 10^3 t + \frac{\pi}{4}\right)$ A; $v_{C_2}(t) = \frac{5\sqrt{2}}{2} \cdot \text{sen}\left(1005 \cdot 10^3 t - \frac{\pi}{4}\right)$ A

PROBLEM 5.8

For the circuit in Figure 1, we have analyzed its frequency response for the following situations:

- Situation 1: Load R_L is not connected.
- Situation 2: Load R_L is connected.

For these two situations, we obtained the plots (a and b), shown in Figure 2, which represent the normalized amplitude of voltage $v(t)$ ($|V|/|V|_{max}$), containing the bandwidths at 3 dB, whose values are shown in the figure.

a) Justify what graph corresponds to each of the situations described (1 and 2).

b) Obtain the values for L_1 and C.

c) Determine the value of R_L.

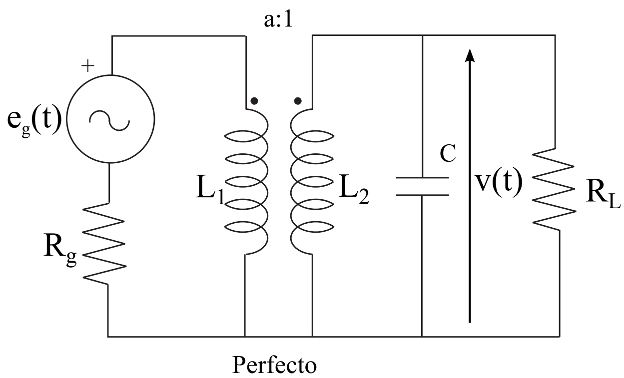

Figure 1

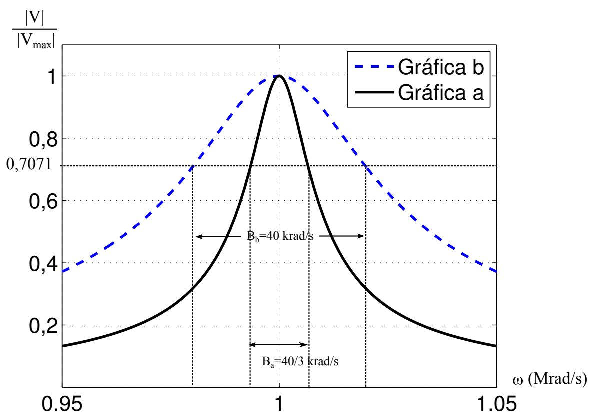

Figure 2

$$Data: \quad R_g = 675\ k\Omega \quad ; \quad L_2 = 1\ mH.$$

Result

a) Situation 2: figure b. Situation 1: figure a.

b) $L_1 = 9$ mH; $C = 1$ nF.

c) $R_L = 37.5$ KΩ.

PROBLEM 5.9

When we change the value of capacitor C of the circuit shown in Figure 1, we observa that for the value of 2.5 nF voltage $V_1 = 48\ V$ is maximum, while $I_1 = 3\ mA$.

a) Determine the value of L_1 and the quality factor fo the circuit.

b) Find the time-domain expression of the current passing through the load R_L, if we increase the frequency of the source by a 3.125 %

c) Obtain the value of the resistor to be connected between points A and B in the circuit, in order to guarantee that the source ($e_g(t)$, R_g) delivers the maximum powder at the resonance frequency.

d) Determine the relation of the two bandwidths, before and after the connection of this new resistor between A and B .

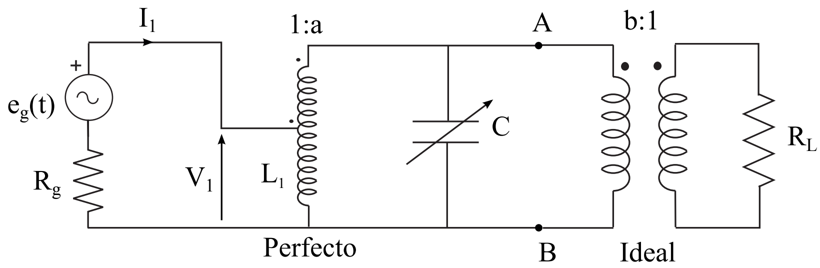

Figure 1

$$Data: \quad e_g(t) = E_g\ sen\left(10^6 t\right)\ V \quad ; \quad R_g = 4\ k\Omega \quad ; \quad R_L = 16\ k\Omega \quad ; \quad b = 2$$

Result

a) $L_1 = 100\ \mu$H; $Q = 32$.

b) $i_{R_L}(t) = \frac{3}{\sqrt{5}} \cdot \text{sen}\left(1.03125 \cdot 10^6 t - atan(2)\right)$ mA.

c) $R_p = \frac{64}{3}$ kΩ

d) $\frac{B'}{B} = \frac{5}{8}$

PROBLEM 5.10

In the circuit of Figure 1 we observe that the voltage $v(t)$ reaches a maximum for $\omega_0 = 500$ Krad/s, being the bandwidth defined at 3 dB, $B_{3\text{dB}} = 12.5$ Krad/s.

a) Determine the values of C and R_L.

b) Compute the time-domain expresison of $v(t)$ when the source works at $\omega_1 = 505$ Krad/s.

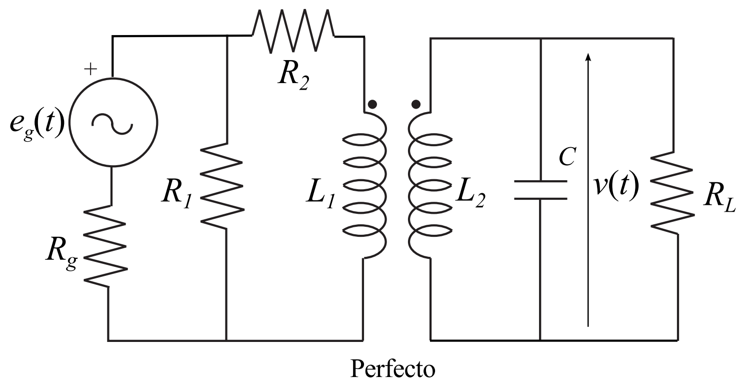

Figure 1

$Data: \ e_g(t) = 10 \text{ sen}(\omega t)$ V, $R_1 = R_g = 320$ KΩ, $R_2 = 200$ KΩ, $L_1 = 9$ mH, $L_2 = 1$ mH.

Result

a) $C = 4$ nF, $R_L = 40$ KΩ.

b) $v(t) = 0.6507 \text{ sen}\left(505 \cdot 10^3 t - 06747\right)$ V.

PROBLEM 5.11

For the circuit of Figure 1, we know that for the frequency $\omega_0 = 1000$ rad/s the amplitude of the voltage of the capacitor $v_C(t)$ reaches a maximum value of 7.5 V. If we augment 10 rad/s that frequency, we observe that the amplitude of $v_C(t)$ decreases to 3.75 V.

a) Obtain the quality factor of the circuit and the bandwidth defined at 3 dB.

b) Determine the values for R, L and C.

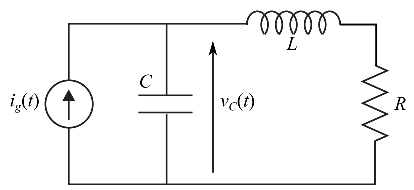

Figure 1

$Data: \ i_g(t) = \text{sen}(\omega t)$ mA

Result

a) $Q = 50\sqrt{3}$, $B_{3\,\text{dB}} = \frac{20\sqrt{3}}{3}$ rad/s.

b) $L = 50\sqrt{3}$ mH, $C = \dfrac{20\sqrt{3}}{3}$ μF y $R = 1\ \Omega$.

PROBLEM 5.12

In the circuit of Figure 1, for $\omega_0 = 10$ Krad/s the modulus of the voltage of the resistor$R$, $|V_R|$ is 0. Knowing that for that frequency the value of the modulus of the voltage of the capacitor is $|V_C| = 5$ V:

a) Obtain L, C and Q (the quality factor of the circuit).

b) Determine the value of the modulus of the voltage of the resistor R, $|V_R|$ if we increase the frequency of the source a 1% with respect to the resonance frequency.

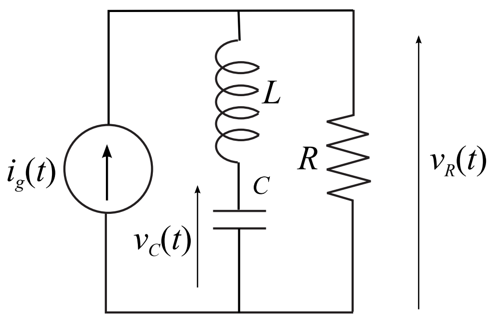

Figure 1

Data : $i_g(t) = \text{sen}(\omega t)$ mA; $R = 100\ \Omega$.

Result

a) $C = 20$ nF, $L = \dfrac{1}{2}$ H, $Q = 50$.

b) $v_R(t) = 50\sqrt{2}\,\text{sen}\left(1.01 \cdot 10^4 t + \dfrac{\pi}{2}\right)$ mV.

c) $\alpha_2 = 48.5194$ dB.

PROBLEM 5.13

Using the resonant circuit in Figure 1, we want to tune a signal whose spectrum is defined by the frequencies $\omega_1 = 497500$ rad/s and $\omega_2 = 502500$ rad/s.

a) Determine the values of L_1 and L_2.

b) Find the time-domain expression of current $i(t)$ is we increase the frequency a 0.5% with respect to the resonance frequency.

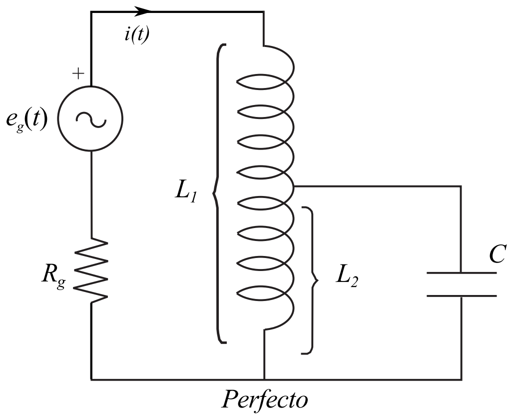

Figure 1

Data : $e_g(t) = \text{sen}(\omega t)$ V; $R_g = 100\ \Omega$; $C = 8\ \mu$F.

Result

a) $L_1 = 2\ \mu$H y $L_2 = \dfrac{1}{2}\ \mu$H.

b) $i(t) = 5\sqrt{2} \cdot \text{sen}\left(5.025 \cdot 10^5 t + \dfrac{\pi}{4}\right)$ mA

PROBLEM 5.14

For the circuit in Figure 1, it is known that for the frequency $\omega = 10^3\, rad/s$ the current $i(t)$ is maximum. Moreover, for that frequency, the source $(e_g(t), R_g)$ delivers the maximum power.

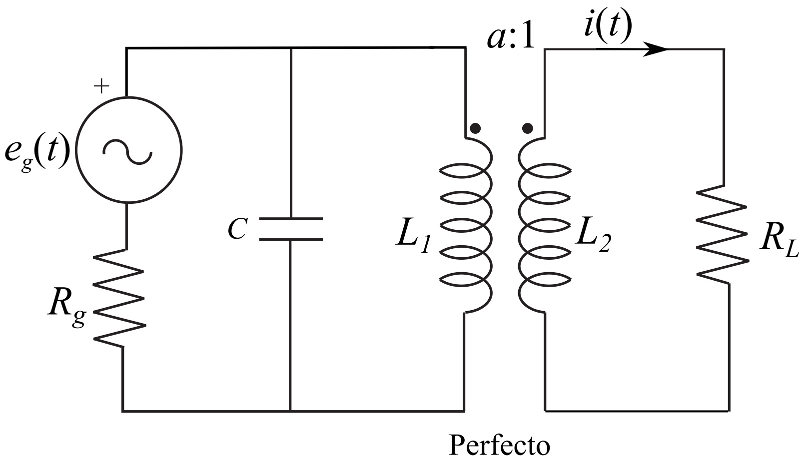

Figure 1

a) Determine the values of L_1 and C.

b) Find the quality factor and the bandwidth of the resonant circuit.

c) Obtain the time-domain expression for $i(t)$ when the frequency of the source is increased a 1% with respect to the resonance frequency.

Data:

$$e_g(t) = 20 \cdot \text{sen}(\omega t) \text{ V}; \quad R_g = 100\ \Omega; \quad R_L = 25\ \Omega; \quad L_2 = 250\mu H$$

Result

a) $L_1 = 1$ mH y $C = 1$ mF.

b) $Q = 50$ and $B_{3\text{ dB}} = 20$ rad/s.

c) $i(t) = \frac{\sqrt{2}}{10} \cdot \text{sen}\left(1.01 \cdot 10^3 t - \frac{\pi}{4}\right)$ A

PROBLEM 5.15

With the circuit in Figure 1, we want to tune a set of frequencies centered at $\omega_0 = 10^6$ rad/s.

a) Determine the value of L_1.

b) Bandwidth of the circuit and the maximum and minimum frequencies.

c) Voltage V (modulus and phase) if we increase the frequency a 2% with respect to ω_0.

d) We would like to double the bandwidth. What component should we include in the circuit? Where should we include it? What should be its value?

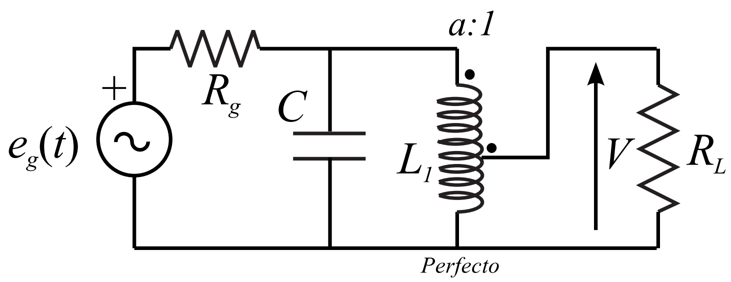

Figure 1

Data : $e_g(t) = 10\ \text{sen}(\omega t)$V; $\quad C = 4$ nF; $\quad R_g = 50$ kΩ; $\quad a = 5$; $R_L = 2$ kΩ

Result

a) $L = \frac{1}{4}$ mH

b) $B|_{3dB} = 10^4$ rad/s.

$$\begin{cases} \omega_{c_i} = 950 \text{ krad/s} \\ \omega_{c_s} = 1050 \text{ krad/s} \end{cases}$$

c) $V \simeq \frac{1}{\sqrt{17}} \cdot e^{-j3.258}$ V

d) $R_x = R_T = 25$ kΩ