Universidad de las Fuerzas Armadas

E.S.P.E.

CIRCUITOS ELECTRICOS

LABORATORIO #8
INDUCTOR Y CAPACITOR

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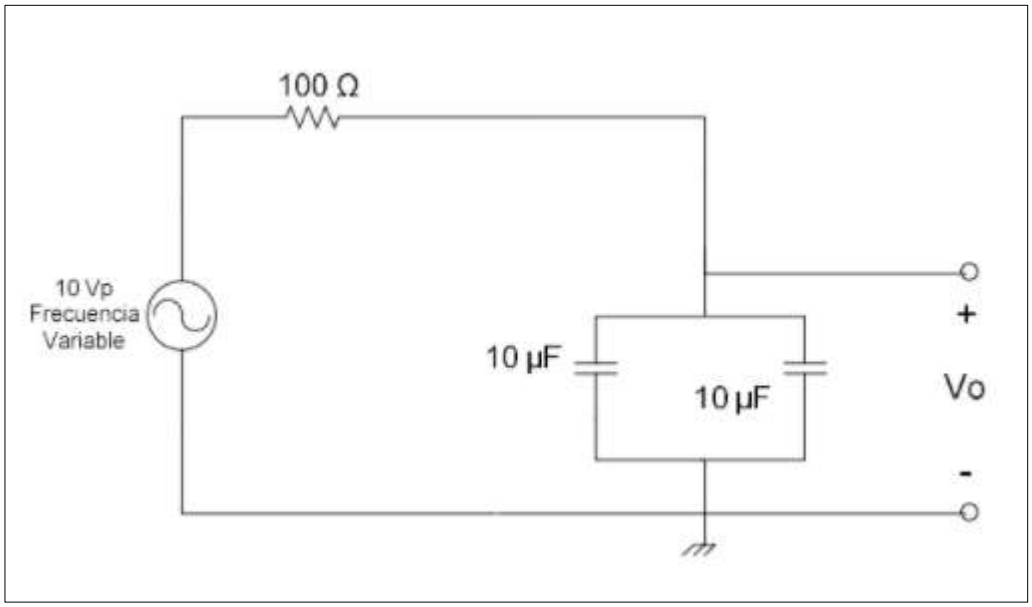
Cálculos Laboratorio 8.

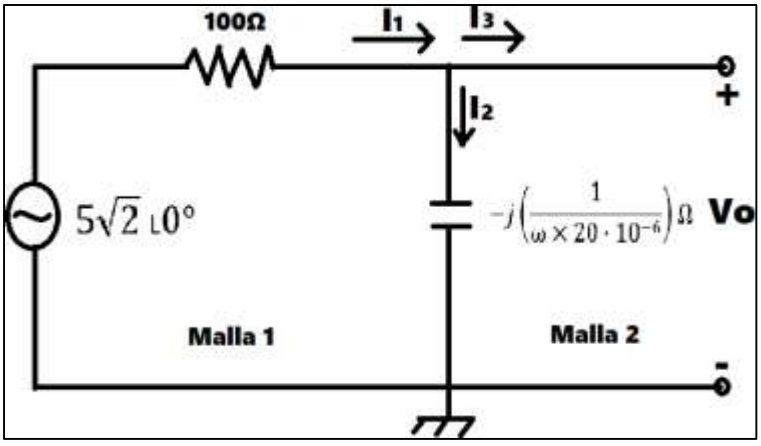
Procedimiento:

1. Construya en el protoboard el circuito mostrado en la Figura 1.

a) Utilice el osciloscopio para observar el voltaje Vo variando la frecuencia entre los valores de 0, 10, 50, 100, 500, 1000 Hz. Anote los valores pico de las ondas observadas.
b) Utilice un multímetro para medir el voltaje Vo variando la frecuencia entre los valores de 0, 10, 50, 100, 500, 1000 Hz. Anote los resultados.
c) Utilice un multímetro para medir la corriente que atraviesa la resistencia variando la frecuencia entre los valores 0, 10, 50, 100, 500, 1000 Hz. Anote los resultados.



1.- Calculo teórico de Vo y corriente en la figura 1



Valor del capacitor:

$$C_{eq} = C_1 + C_2$$
$$C_{eq} = 10\mu F + 10\mu F$$
$$C_{eq} = 20\mu F \ = \ 20 \ * \ 10^{-6} F$$

- Para $\boldsymbol{f = 0Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 0$

$\omega = 0$

$C_{eq} = -\frac{1}{\omega \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -\frac{1}{0 \cdot 20 \cdot 10^{-6}}$

$C_{eq} = \infty$

- Para $\boldsymbol{f = 10Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 10$

$\omega = 20\pi$

$C_{eq} = -\frac{1}{\omega \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -\frac{1}{20\pi \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -795{,}77 \ \Omega$

Malla 1

$$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 \ - \ j795{,}77\bar{I}_2 = 0$$

Malla 2

$$Vo \ - \ j795{,}77\bar{I}_2 = 0$$
$$Vo \ = \ j795{,}77\bar{I}_2$$

Nodo

$$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$$
$$\bar{I}_3 = 0$$
$$\bar{I}_1 = \bar{I}_2$$

Malla 1

$$-5\sqrt{2}\measuredangle 0^0 + 100\bar{I}_1 - j795{,}77\bar{I}_2 = 0$$

$$(100 - 795{,}77)\bar{I}_1 = 5\sqrt{2}\measuredangle 0^0$$

$$\bar{I}_1 = -\frac{5\sqrt{2}\measuredangle 0^0}{802{,}03\measuredangle -82{,}84^0}$$

$$\bar{I}_1 = 8{,}816 \cdot 10^{-3}\measuredangle 82{,}84^0$$

$$\bar{I}_2 = 8{,}816 \cdot 10^{-3}\measuredangle 82{,}84^0$$

Malla 2

$$Vo = j795{,}77(8{,}816 \cdot 10^{-3}\measuredangle 82{,}84^0)$$

$$Vo = (795{,}77\measuredangle 90^0)(8{,}816 \cdot 10^{-3}\measuredangle 82{,}84^0)$$

$$Vo = 7{,}015\measuredangle 172{,}84^0\ V$$

- Para $\boldsymbol{f = 50Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 50$

$\omega = 100\pi$

$C_{eq} = -\frac{1}{\omega \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -\frac{1}{100\pi \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -159{,}15\ \Omega$

Malla 1

$$-5\sqrt{2}\measuredangle 0^0 + 100\bar{I}_1 - j159{,}15\bar{I}_2 = 0$$

Malla 2

$$Vo - j159{,}15\bar{I}_2 = 0$$

$$Vo = j159{,}15\bar{I}_2$$

Nodo

$$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$$

$$\bar{I}_3 = 0$$

$$\bar{I}_1 = \bar{I}_2$$

Malla 1

$$-5\sqrt{2}\measuredangle 0^0 + 100\bar{I}_1 - j159{,}15\bar{I}_2 = 0$$

$$(100 - j159{,}15)\bar{I}_1 = 5\sqrt{2}\measuredangle 0^0$$

$$\bar{I}_1 = -\frac{5\sqrt{2}\measuredangle 0^0}{187{,}96\measuredangle -57{,}86^0}$$

$\bar{I}_1 = 0{,}0376\angle 57{,}86^0$

$\bar{I}_2 = 0{,}0376\angle 57{,}86^0$

Malla 2

$Vo = j159{,}15(0{,}0376\angle 57{,}86^0)$

$Vo = (159{,}15\angle 90^0)(0{,}0376\angle 57{,}86^0)$

$Vo = 5{,}984\angle 147{,}86^0\ V$

- Para $\boldsymbol{f = 100Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 100$

$\omega = 200\pi$

$C_{eq} = -\frac{1}{\omega \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -\frac{1}{200\pi \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -79{,}58\ \Omega$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 - j79{,}58\bar{I}_2 = 0$

Malla 2

$Vo - j79{,}58\bar{I}_2 = 0$

$Vo = j79{,}58\bar{I}_2$

Nodo

$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$

$\bar{I}_3 = 0$

$\bar{I}_1 = \bar{I}_2$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 - j79{,}58\bar{I}_2 = 0$

$(100 - j79{,}58)\bar{I}_1 = 5\sqrt{2}\angle 0^0$

$\bar{I}_1 = -\frac{5\sqrt{2}\angle 0^0}{127{,}8\angle -38{,}51^0}$

$\bar{I}_1 = 0{,}055\angle 38{,}51^0$

$\bar{I}_2 = 0{,}055\angle 38{,}51^0$

Malla 2

$Vo = j79{,}58(0{,}055\angle 38{,}51^0)$

$Vo = (79{,}58\angle 90^0)(0{,}055\angle 38{,}51^0)$

$Vo = 4{,}377\angle 128{,}51^0\ V$

- Para $\boldsymbol{f = 500Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 500$

$\omega = 1000\pi$

$C_{eq} = -\frac{1}{\omega \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -\frac{1}{1000\pi \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -15{,}92\ \Omega$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 - j15{,}92\bar{I}_2 = 0$

Malla 2

$Vo - j15{,}92\bar{I}_2 = 0$

$Vo = j15{,}92\bar{I}_2$

Nodo

$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$

$\bar{I}_3 = 0$

$\bar{I}_1 = \bar{I}_2$

Malla 1

$$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 - j15{,}92\bar{I}_2 = 0$$

$$(100 - j15{,}92)\bar{I}_1 = 5\sqrt{2}\angle 0^0$$

$$\bar{I}_1 = -\frac{5\sqrt{2}\angle 0^0}{101{,}26\angle -9{,}04^0}$$

$$\bar{I}_1 = 0{,}0698\angle 9{,}04^0$$

$$\bar{I}_2 = 0{,}0698\angle 9{,}04^0$$

Malla 2

$Vo = j15{,}92(0{,}0698\angle 9{,}04^0)$

$Vo = (15{,}92\angle 90^0)(0{,}0698\angle 9{,}04^0)$

$Vo = 1{,}111\angle 99{,}04^0\ V$

- Para $\boldsymbol{f = 1000Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 1000$

$\omega = 2000\pi$

$C_{eq} = -\frac{1}{\omega \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -\frac{1}{2000\pi \cdot 20 \cdot 10^{-6}}$

$C_{eq} = -7{,}96\ \Omega$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 - j7{,}96\bar{I}_2 = 0$

Malla 2

$Vo - j7{,}96\bar{I}_2 = 0$

$Vo = j7{,}96\bar{I}_2$

Nodo

$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$

$\bar{I}_3 = 0$

$\bar{I}_1 = \bar{I}_2$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 - j7{,}96\bar{I}_2 = 0$

$(100 - j7{,}96)\bar{I}_1 = 5\sqrt{2}\angle 0^0$

$\bar{I}_1 = -\frac{5\sqrt{2}\angle 0^0}{100{,}32\angle -4{,}55^0}$

$\bar{I}_1 = 0{,}0705\angle 4{,}55^0$

$\bar{I}_2 = 0{,}0705\angle 4{,}55^0$

Malla 2

$Vo = j7{,}96(0{,}0705\angle 4{,}55^0)$

$Vo = (7{,}96\angle 90^0)(0{,}0705\angle 4{,}55^0)$

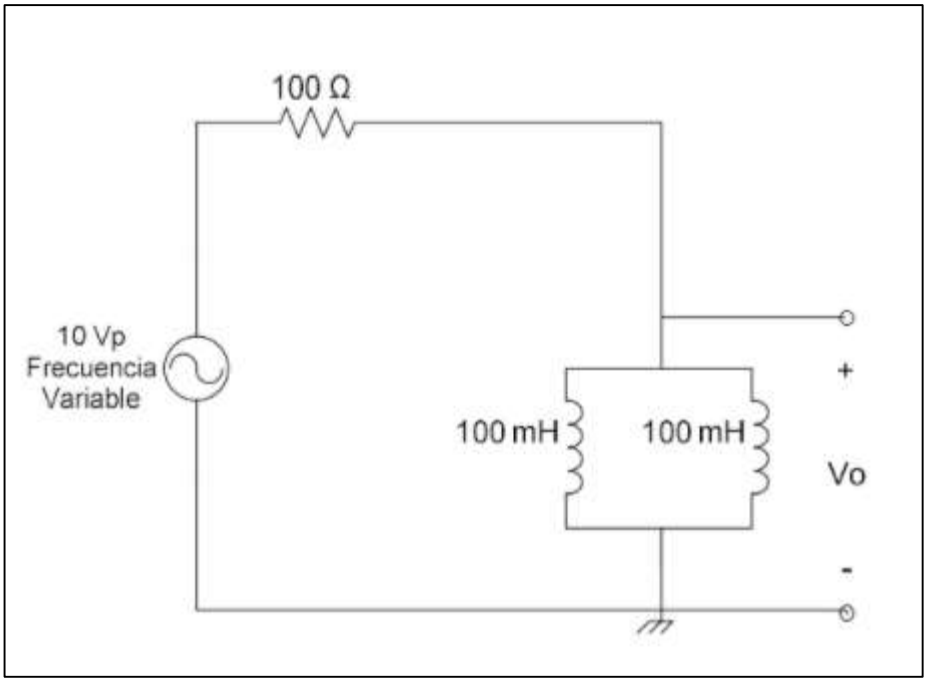
$Vo = 0{,}561\angle 94{,}55^0\ V$

Tabla de cálculos teóricos:

Frecuencia (Hz)	Vo (V)	Intensidad (mA)
0	-	0
10	7,015	8,816
50	5,984	37,6
100	4,377	55
500	1,111	69,8
1000	0,561	70,5

2. Construya en el protoboard el circuito mostrado en la Figura 2.

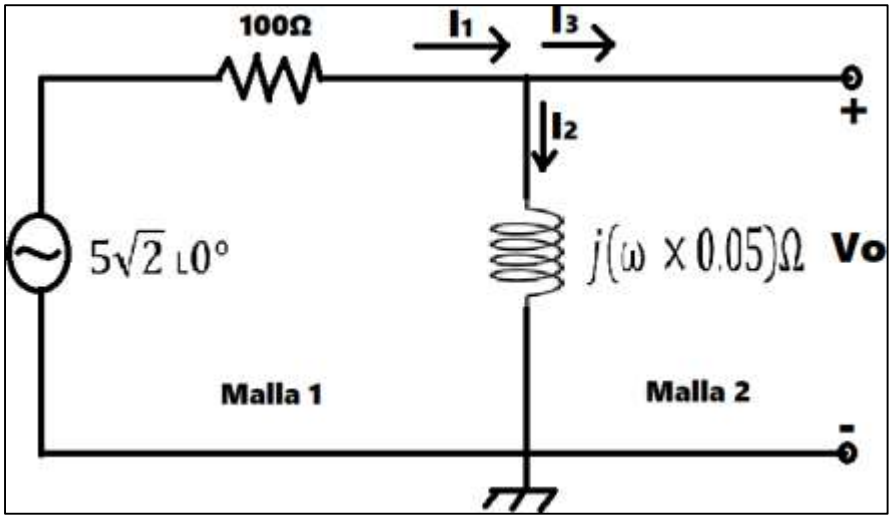
d) Utilice el osciloscopio para observar el voltaje Vo variando la frecuencia entre los valores de 0, 10, 50, 100, 500, 1000 Hz. Anote los valores pico de las ondas observadas.
e) Utilice un multímetro para medir el voltaje Vo variando la frecuencia entre los valores de 0, 10, 50, 100, 500, 1000 Hz. Anote los resultados.
f) Utilice un multímetro para medir la corriente que atraviesa la resistencia variando la frecuencia entre los valores 0, 10, 50, 100, 500, 1000 Hz. Anote los resultados.



Valor del Inductor:

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$
$$\frac{1}{L_{eq}} = \frac{L_1 + L_2}{L_1 L_2}$$
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$$
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$$
$$L_{eq} = \frac{0{,}1 * 0{,}1}{0{,}1 + 0{,}1}$$
$$L_{eq} = 0{,}05\ Hz$$

2- Calculo de Vo y corriente en la figura 2



- Para $\boldsymbol{f = 0Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 0$

$\omega = 0$

$L_{eq} = \omega \cdot 0{,}05$

$L_{eq} = 0 \cdot 0{,}05$

$L_{eq} = 0$

Malla 1

$-5\sqrt{2}\measuredangle 0^0 + 100\bar{I}_1 = 0$

$100\bar{I}_1 = 5\sqrt{2}\measuredangle 0^0$

$\bar{I}_1 = \frac{5\sqrt{2}\measuredangle 0^0}{100}$

$\bar{I}_1 = 0{,}0707\measuredangle 0^0$

Malla 2

$Vo = 0$

- Para $\boldsymbol{f = 10Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 10$

$\omega = 20\pi$

$L_{eq} = \omega \cdot 0{,}05$

$L_{eq} = 20\pi \cdot 0{,}05$

$L_{eq} = \pi\ \Omega$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j\pi\bar{I}_2 = 0$

Malla 2

$Vo + j\pi\bar{I}_2 = 0$

$Vo = -j\pi\bar{I}_2$

Nodo

$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$

$\bar{I}_3 = 0$

$\bar{I}_1 = \bar{I}_2$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j\pi\bar{I}_2 = 0$

$(100 + j\pi)\bar{I}_1 = 5\sqrt{2}\angle 0^0$

$\bar{I}_1 = \dfrac{5\sqrt{2}\angle 0^0}{100{,}049\angle 1,8^0}$

$\bar{I}_1 = 0{,}076 \cdot 10^{-3}\angle -1,8^0$

$\bar{I}_2 = 0{,}076 \cdot 10^{-3}\angle -1,8^0$

Malla 2

$Vo = -j\pi(0{,}076 \cdot 10^{-3}\angle -1,8^0)$

$Vo = (\pi\angle -90^0)(0{,}076 \cdot 10^{-3}\angle -1,8^0)$

$Vo = 0{,}222\angle -91,8^0\ V$

- Para $\boldsymbol{f = 50Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 50$

$\omega = 100\pi$

$L_{eq} = \omega \cdot 0{,}05$

$L_{eq} = 20\pi \cdot 0{,}05$

$L_{eq} = 5\pi\ \Omega$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j5\pi\bar{I}_2 = 0$

Malla 2

$Vo + j5\pi\bar{I}_2 = 0$

$Vo = -j5\pi\bar{I}_2$

Nodo

$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$

$\bar{I}_3 = 0$

$\bar{I}_1 = \bar{I}_2$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j5\pi\bar{I}_2 = 0$

$(100 + j5\pi)\bar{I}_1 = 5\sqrt{2}\angle 0^0$

$\bar{I}_1 = \dfrac{5\sqrt{2}\angle 0^0}{101{,}23\angle 8{,}93^0}$

$\bar{I}_1 = 0{,}0698\angle -8{,}93^0$

$\bar{I}_2 = 0{,}0698\angle -8{,}93^0$

Malla 2

$Vo = -j5\pi(0{,}0698\angle -8{,}93^0)$

$Vo = (5\pi\angle -90^0)(0{,}0698\angle -8{,}93^0)$

$Vo = 1{,}096\angle -98{,}93^0\ V$

- Para $\boldsymbol{f = 100Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 100$

$\omega = 200\pi$

$L_{eq} = \omega \cdot 0{,}05$

$L_{eq} = 200\pi \cdot 0{,}05$

$L_{eq} = 10\pi\ \Omega$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j10\pi\bar{I}_2 = 0$

Malla 2

$Vo + j10\pi\bar{I}_2 = 0$

$Vo = -j10\pi\bar{I}_2$

Nodo

$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$

$\bar{I}_3 = 0$

$\bar{I}_1 = \bar{I}_2$

Malla 1

$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j10\pi\bar{I}_2 = 0$

$(100 + j10\pi)\bar{I}_1 = 5\sqrt{2}\angle 0^0$

$\bar{I}_1 = \dfrac{5\sqrt{2}\angle 0^0}{104{,}82\angle 17{,}44^0}$

$\bar{I}_1 = 0{,}0675\angle -17{,}44^0$

$\bar{I}_2 = 0{,}0675\angle -17{,}44^0$

Malla 2

$Vo = -j10\pi(0{,}0675\angle -17{,}44^0)$

$Vo = (10\pi\angle -90^0)(0{,}0675\angle -17{,}44^0)$

$Vo = 2{,}12\angle -107{,}44^0\ V$

- Para $\boldsymbol{f = 500Hz}$

$\omega = 2\pi \cdot f$

$\omega = 2\pi \cdot 500$

$\omega = 1000\pi$

$L_{eq} = \omega \cdot 0{,}05$

$L_{eq} = 1000\pi \cdot 0{,}05$

$L_{eq} = 50\pi\ \Omega$

Malla 1

$$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j50\pi\bar{I}_2 = 0$$

Malla 2

$$Vo + j50\pi\bar{I}_2 = 0$$
$$Vo = -j50\pi\bar{I}_2$$

Nodo

$$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$$
$$\bar{I}_3 = 0$$
$$\bar{I}_1 = \bar{I}_2$$

Malla 1

$$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j50\pi\bar{I}_2 = 0$$
$$(100 + j50\pi)\bar{I}_1 = 5\sqrt{2}\angle 0^0$$
$$\bar{I}_1 = \frac{5\sqrt{2}\angle 0^0}{186{,}21\angle 57{,}52^0}$$

$$\bar{I}_1 = 0{,}03797\angle -57{,}52^0$$
$$\bar{I}_2 = 0{,}03797\angle -57{,}52^0$$

Malla 2

$$Vo = -j50\pi(0{,}03797\angle -57{,}52^0)$$
$$Vo = (50\pi\angle -90^0)(0{,}03797\angle -57{,}52^0)$$
$$Vo = 5{,}96\angle -147{,}52^0\ V$$

- Para $\boldsymbol{f = 1000Hz}$

$$\omega = 2\pi \cdot f$$
$$\omega = 2\pi \cdot 1000$$
$$\omega = 2000\pi$$
$$L_{eq} = \omega \cdot 0{,}05$$
$$L_{eq} = 2000\pi \cdot 0{,}05$$
$$L_{eq} = 100\pi\ \Omega$$

Malla 1

$$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j100\pi\bar{I}_2 = 0$$

Malla 2

$$Vo + j100\pi\bar{I}_2 = 0$$
$$Vo = -j100\pi\bar{I}_2$$

Nodo

$$\bar{I}_1 - \bar{I}_2 - \bar{I}_3 = 0$$
$$\bar{I}_3 = 0$$
$$\bar{I}_1 = \bar{I}_2$$

Malla 1

$$-5\sqrt{2}\angle 0^0 + 100\bar{I}_1 + j100\pi\bar{I}_2 = 0$$
$$(100 + j100\pi)\bar{I}_1 = 5\sqrt{2}\angle 0^0$$
$$\bar{I}_1 = \frac{5\sqrt{2}\angle 0^0}{329{,}69\angle 72{,}34^0}$$
$$\bar{I}_1 = 0{,}0214\angle -72{,}34^0$$
$$\bar{I}_2 = 0{,}0214\angle -72{,}34^0$$

Malla 2

$$Vo = -j7{,}96(0{,}0214\angle -72{,}34^0)$$
$$Vo = (7{,}96\angle -90^0)(0{,}0214\angle -72{,}34^0)$$
$$Vo = 6{,}72\angle -162{,}34^0\ V$$

Tabla de cálculos teóricos:

Frecuencia (Hz)	Vo (V)	Intensidad (mA)
0	0	0
10	0,222	70,6
50	1,096	69,8
100	2,12	67,5
500	5,96	37,97
1000	6,72	21,4

Calculo para hallar el valor del capacitor que se utilizará en la simulación:

$$C_{eq} = C_1 + C_2$$
$$C_{eq} = 10\mu F + 10\mu F$$
$$C_{eq} = 20\mu F \ = \ 20 \ * \ 10^{-6} F$$

3. Análisis de resultados

1. Para cada uno de los circuitos anteriores, elabore una tabla con los resultados de las diferentes mediciones de voltaje realizadas con el osciloscopio y multímetro. Compare y comente los resultados obtenidos tomando en cuenta las distintas frecuencias utilizadas.

Circuito Uno:

Frecuencia (Hz)	Vo con osciloscopio (V)	Vo con multímetro (V)	Intensidad (mA)
0	0	0	0
10	9,81	7,04	8,88
50	8,40	6	37,7
100	6,10	4,38	55,4
500	1,54	1,10	69,7
1000	0,775	0,55	70,4

Cálculo de la Reactancia y tabla:

Frecuencia (Hz)	Reactancia $x = \frac{v_0}{I}$
0	0
10	0,7928
50	0,1592
100	0,0791
500	0,0158
1000	0,00781

La ecuación de la Reactancia es:

$$x = \frac{v_0}{I}$$

$$x = \frac{v_0 \ con \ multímetro}{Intensidad}$$

Circuito 2:

Calculo para hallar el valor del Inductor que se utilizará en la simulación:

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$
$$\frac{1}{L_{eq}} = \frac{L_1 + L_2}{L_1 L_2}$$
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$$
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$$
$$L_{eq} = \frac{0{,}1 * 0{,}1}{0{,}1 + 0{,}1}$$
$$L_{eq} = 0{,}05\ Hz$$

Frecuencia (Hz)	Vo con osciloscopio (V)	Vo con multímetro (V)	Intensidad (mA)
0	0	0	0
10	0,312	0,22	70,2
50	1,56	1,1	69,8
100	3,03	2,14	67,3
500	8,43	5,97	37,6
1000	9,48	6,73	21,2

Cálculo de la Reactancia y tabla:

Frecuencia (Hz)	Reactancia $x = \frac{v_0}{I}$
0	0
10	0,0031
50	0,0158
100	0,0318
500	0,159
1000	0,31745

Calculo del error:

Circuito 1:

Vo:

$$\%error1 = \frac{v_E - v_T}{v_T} * 100 = \frac{0 - 0}{0} * 100 = 0\%$$
$$\%error2 = \frac{v_E - v_T}{v_T} * 100 = \frac{7{,}04 - 7{,}015}{7{,}015} * 100 = 0{,}36\%$$
$$\%error3 = \frac{v_E - v_T}{v_T} * 100 = \frac{6 - 5{,}984}{5{,}984} * 100 = 0{,}267\%$$

$$\%error4 = \frac{v_E - v_T}{v_T} * 100 = \frac{4{,}38 - 4{,}377}{4{,}377} * 100 = 0{,}07\%$$
$$\%error5 = \frac{v_E - v_T}{v_T} * 100 = \frac{1{,}1 - 1{,}111}{1{,}111} * 100 = -0{,}99\%$$
$$\%error6 = \frac{v_E - v_T}{v_T} * 100 = \frac{0{,}55 - 0{,}561}{0{,}561} * 100 = -1{,}96\%$$

Intensidad:

$$\%error1 = \frac{v_E - v_T}{v_T} * 100 = \frac{0 - 0}{0} * 100 = 0\%$$
$$\%error2 = \frac{v_E - v_T}{v_T} * 100 = \frac{8{,}88 - 8{,}816}{8{,}816} * 100 = 0{,}73\%$$
$$\%error3 = \frac{v_E - v_T}{v_T} * 100 = \frac{37{,}7 - 37{,}6}{37{,}6} * 100 = 0{,}266\%$$
$$\%error4 = \frac{v_E - v_T}{v_T} * 100 = \frac{55{,}4 - 55}{55} * 100 = 0{,}73\%$$
$$\%error5 = \frac{v_E - v_T}{v_T} * 100 = \frac{69{,}7 - 69{,}8}{69{,}8} * 100 = -0{,}14\%$$
$$\%error6 = \frac{v_E - v_T}{v_T} * 100 = \frac{70{,}4 - 70{,}5}{70{,}5} * 100 = -0{,}142\%$$

Circuito 2:

Vo:

$$\%error1 = \frac{v_E - v_T}{v_T} * 100 = \frac{0 - 0}{0} * 100 = 0\%$$
$$\%error2 = \frac{v_E - v_T}{v_T} * 100 = \frac{0{,}22 - 0{,}222}{0{,}222} * 100 = -0{,}9\%$$
$$\%error3 = \frac{v_E - v_T}{v_T} * 100 = \frac{1{,}1 - 1{,}096}{1{,}096} * 100 = 0{,}365\%$$
$$\%error4 = \frac{v_E - v_T}{v_T} * 100 = \frac{2{,}14 - 2{,}12}{2{,}12} * 100 = 0{,}94\%$$
$$\%error5 = \frac{v_E - v_T}{v_T} * 100 = \frac{5{,}97 - 5{,}96}{5{,}96} * 100 = 0{,}17\%$$
$$\%error6 = \frac{v_E - v_T}{v_T} * 100 = \frac{6{,}73 - 6{,}72}{6{,}72} * 100 = 0{,}15\%$$

Intensidad:

$$\%error1 = \frac{v_E - v_T}{v_T} * 100 = \frac{0 - 0}{0} * 100 = 0\%$$
$$\%error2 = \frac{v_E - v_T}{v_T} * 100 = \frac{70{,}2 - 70{,}6}{70{,}6} * 100 = -0{,}57\%$$

$$\%error3 = \frac{v_E - v_T}{v_T} * 100 = \frac{69{,}8 - 69{,}8}{69{,}8} * 100 = 0\%$$

$$\%error4 = \frac{v_E - v_T}{v_T} * 100 = \frac{67{,}3 - 67{,}5}{67{,}5} * 100 = -0{,}296\%$$

$$\%error5 = \frac{v_E - v_T}{v_T} * 100 = \frac{37{,}6 - 37{,}97}{37{,}97} * 100 = -0{,}97\%$$

$$\%error6 = \frac{v_E - v_T}{v_T} * 100 = \frac{21{,}2 - 21{,}4}{21{,}4} * 100 = -0{,}935\%$$