K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELECTRONIC CIRCUITS
AC CIRCUITS

Numerical 1: A series RLC circuit contaning a resistance of 25Ω,an inductance of 0.1H and a capacitor of 80μF are connected in series across 100V, 60Hz supply.
Calculate:
a) The total circuit current.
b) V_R, V_L and V_C
c) Power factor.
d) Draw the voltage phasor diagram.

Solution:

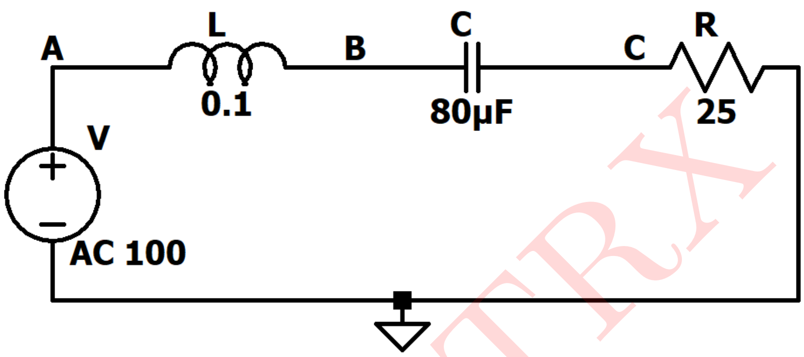


Figure 1: Circuit 1

Given :

V = 100V = 100 ∠ 0°V

R = 25Ω L = 0.1H C = 80μF

f = 60Hz

ω = 2πf = 120π Hz

X_L = Lω = 37.699Ω

$$X_C = \frac{1}{C\omega} = 33.157\Omega$$

$$\begin{aligned} Z &= R + j(X_L - X_C) \\ &= 25 + j\ 4.542\ \Omega \\ &= 25.4092 \angle 10.2971°\Omega \end{aligned}$$

$$\text{a) Total current (I)} = \frac{V}{Z} \qquad \text{(Ohm's Law)}$$

$$\begin{aligned} &= \frac{100\angle 0°}{25.4092\angle 10.2971°} \\ &= 3.9355 \angle{-10.2971}°\text{A} \\ &= 3.9355 \angle 169.7029°\text{A} \end{aligned}$$

I = 3.9355 ∠169.7029°A

b) Finding V_R, V_L and V_C

$$\begin{aligned} V_R &= \mathrm{I} \times \mathrm{R} \\ &= 3.9355 \angle{-10.2971^\circ} \times 25 \\ &= 98.3895 \angle{-10.2971^\circ}\mathrm{V} \end{aligned}$$

$$\begin{aligned} V_L &= \mathrm{I} \times X_L \\ &= 3.9355 \angle{-10.2971^\circ} \times 37.699 \angle 90^\circ \\ &= 148.3644 \angle 79.7029^\circ\mathrm{V} \end{aligned}$$

$$\begin{aligned} V_C &= \mathrm{I} \times X_C \\ &= 3.9355 \angle{-10.2971^\circ} \times 33.157 \angle{-90^\circ} \\ &= 130.489 \angle{-100.2971^\circ}\mathrm{V} \end{aligned}$$

$$\begin{aligned} \boldsymbol{V_R} &= \mathbf{98.3895} \angle \mathbf{-10.2971^\circ V} \\ \boldsymbol{V_L} &= \mathbf{148.3644} \angle \mathbf{79.7029^\circ V} \\ \boldsymbol{V_C} &= \mathbf{130.489} \angle \mathbf{-100.2971^\circ V} \end{aligned}$$

c) Power factor cosϕ

$$\begin{aligned} \phi &= \tan^{-1}\left(\frac{X_L - X_C}{R}\right) \\ &= \tan^{-1}\left(\frac{37.699 - 33.157}{25}\right) \\ &= \tan^{-1}\left(\frac{4.542}{25}\right) \\ &= 10.2971^\circ \end{aligned}$$

$\cos\phi = \cos 10.2971^\circ = 0.9838$

Power factor = 0.9838 (lag)

d) Phasor Diagram

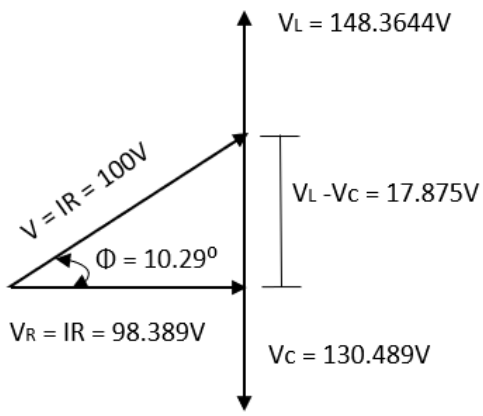
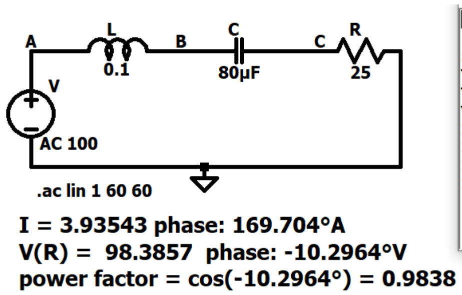


Figure 2: Phasor Diagram

KJSCE ETRX

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

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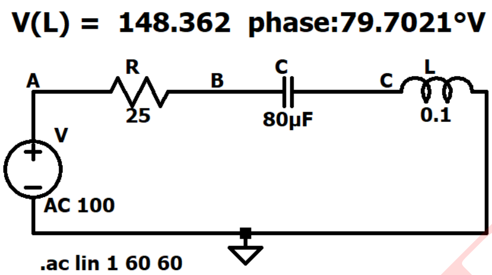
       --- AC Analysis ---

frequency:     60           Hz
V(c):          mag:    98.3857 phase:    -10.2964°       voltage
V(b):          mag:    163.422 phase:    -63.2808°       voltage
V(a):          mag:        100 phase:           0°       voltage
I(C ):         mag:    3.93543 phase:     169.704°       device_current
I(L ):         mag:    3.93543 phase:    -10.2964°       device_current
I(R ):         mag:    3.93543 phase:     169.704°       device_current
I(V ):         mag:    3.93543 phase:     169.704°       device_current
```

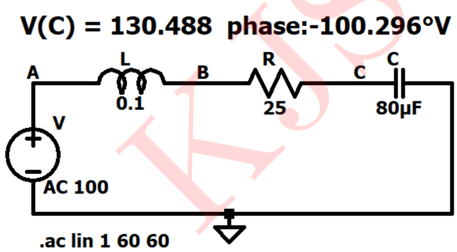
Figure 3: Circuit Schematic and Simulated Results for I, V_R and power factor




```
       --- AC Analysis ---

frequency:     60           Hz
V(b):          mag:    17.8741 phase:      79.691°       voltage
V(a):          mag:        100 phase:          0°        voltage
V(c):          mag:    148.362 phase:     79.7021°       voltage
I(C ):         mag:    3.93543 phase:     169.704°       device_current
I(L ):         mag:    3.93543 phase:    -10.2964°       device_current
I(R ):         mag:    3.93543 phase:     169.704°       device_current
I(V ):         mag:    3.93543 phase:     169.704°       device_current
```

Figure 4: Circuit Schematic and Simulated Results for V_L

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       --- AC Analysis ---

frequency:     60           Hz
V(c):          mag:    130.488 phase:    -100.296°       voltage
V(b):          mag:    163.422 phase:    -63.2808°       voltage
V(a):          mag:        100 phase: 2.03555e-015°      voltage
I(C ):         mag:    3.93543 phase:     169.704°       device_current
I(L ):         mag:    3.93543 phase:    -10.2964°       device_current
I(R ):         mag:    3.93543 phase:     169.704°       device_current
I(V ):         mag:    3.93543 phase:     169.704°       device_current
```

Figure 5: Circuit Schematic and Simulated Results for V_C

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Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
Total Current	3.9355 $\angle 169.7029°$A	3.9354 $\angle 169.704°$A
V_R	98.3895 $\angle -10.2971°$V	98.3857 $\angle -10.2964°$V
V_L	148.3644 $\angle 79.7029°$V	148.362 $\angle 79.7029°$V
V_C	130.489 $\angle -100.2971°$V	130.488 $\angle -100.296°$V
Power factor	0.9838 (lag)	0.9838 (lag)

Table 1: Numerical 1

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Numerical 2: A 50 Hz sinusoidal voltage V = 141 sin ωt is applied to a series R-L circuit. The values of the resistance and the inductance are 4Ω and 0.01H respectively. Calculate:

a) The rms value of the current in the circuit and its phase angle w.r.t to the voltage.

b) The rms value and the phase of the voltages appearing across the resistance and the inductance.

c) Power factor of the circuit.

Solution:

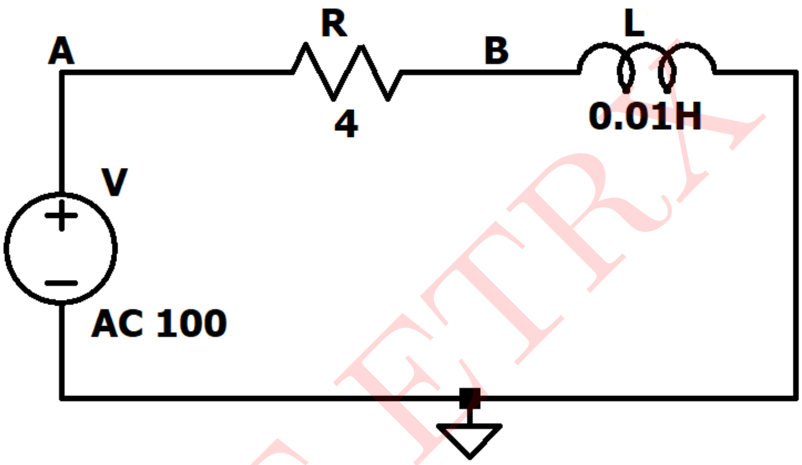

Figure 6: Circuit 2

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Given:

V = 141 sin ωt V

$V_o = \dfrac{141}{\sqrt{2}}$

R = 4Ω

L = 0.1H

f = 50Hz

ω = 2πf = 100π Hz

X_L = Lω = 3.14159Ω

$$\begin{aligned} Z &= R + jX_L \\ &= 4 + j\,3.14159\ \Omega \\ &= 5.0862 \angle 38.146^\circ \Omega \end{aligned}$$

a) Total current $(I_o) = \dfrac{V_o}{Z}$ (Ohm's Law)

$$\begin{aligned} &= \frac{100\angle 0^\circ}{5.0862\angle 38.146^\circ} \\ &= 19.661 \angle{-38.146^\circ} A \\ &= 19.661 \angle 141.854^\circ A \end{aligned}$$

$$I_{RMS} = \sqrt{2} \times I_o$$
$$= \sqrt{2} \times 19.661 \angle 141.854^\circ$$
$$= 27.800 \angle 141.854^\circ \text{A}$$

I_{RMS} **= 27.800 ∠141.854°A**

Phase angle w.r.t Voltage = 141.854°

b) Finding V_R and V_L

$$V_R = \text{I} \times \text{R}$$
$$= 19.661 \angle -38.146^\circ \times 4$$
$$= 78.644 \angle -38.146^\circ \text{V}$$

$$V_L = \text{I} \times X_L$$
$$= 19.661 \angle -38.146^\circ \times 3.14159 \angle 90^\circ$$
$$= 61.766 \angle 51.854^\circ \text{V}$$

V_R **= 78.644 ∠−38.146°V**

V_L **= 61.766 ∠51.854°V**

c) Power factor $\cos\phi$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$
$$= \tan^{-1}\left(\frac{3.14159}{4}\right)$$
$$= 38.146^\circ$$

$\cos\phi = \cos 38.146^\circ = 0.7864$

Power factor = 0.7864 (lag)

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SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

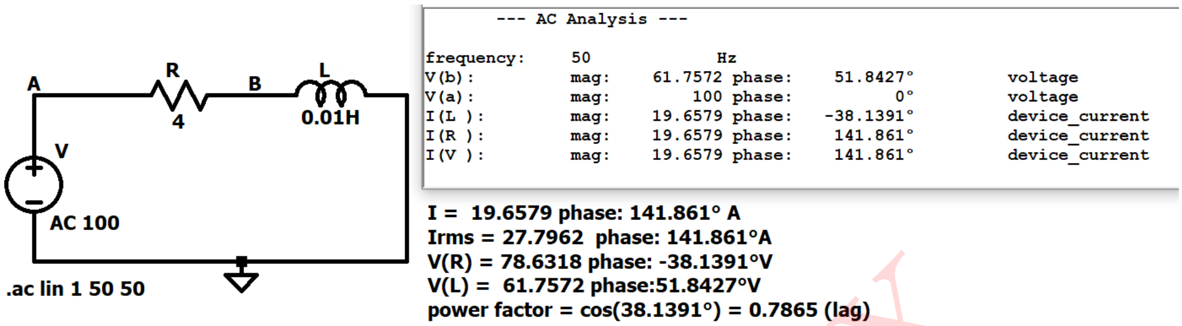

Figure 7: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	$19.661 \angle 141.854°$A	$19.6579 \angle 141.861°$A
I_{RMS}	$27.800 \angle 141.854°$A	$27.7962 \angle 141.861°$A
V_R	$78.644 \angle -38.146°$V	$78.6318 \angle -38.1391°$V
V_L	$61.766 \angle 51.854°$V	$61.7572 \angle 51.8427°$V
Power factor	0.7864 (lag)	0.7865 (lag)

Table 2: Numerical 2

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Numerical 3: A pure resistance of 55 Ω is in series with a pure capacitance of 100 μF. The series combination is connected across 150V, 60 Hz supply. Find
(a) the impedance
(b) current
(c) power factor
(d) phase angle
(e) voltage across resistor
(f) voltage across capacitor.

Solution:

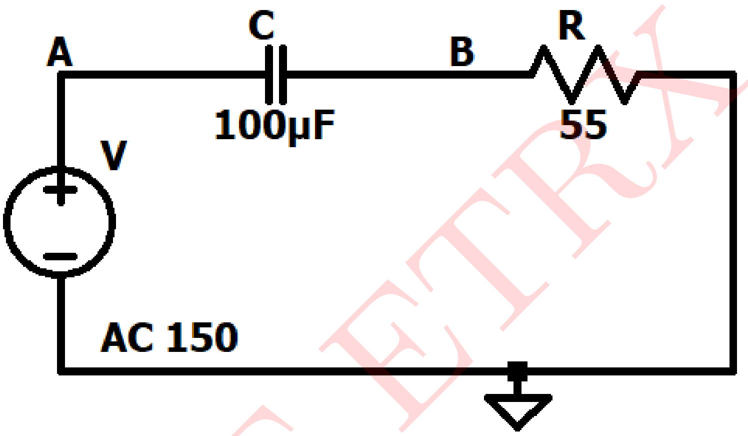

Figure 8: Circuit 2

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Given:

V = 150V

R = 55Ω

C = 100μF

f = 60Hz

ω = 2πf = 120π Hz

$X_C = \dfrac{1}{C\omega} = 26.5258\Omega$

a) Z = R − jX_C

= 55 - j 26.5258 Ω

= 61.0624 $\angle -25.7474°$Ω

= 61.0624 $\angle 154.2526°$Ω

Z = 61.0624 $\angle$154.2526°Ω

b) Total current (I) $= \dfrac{V}{Z}$ (Ohm's Law)

$$= \frac{150\angle 0°}{61.0624\angle 154.2526°}$$

= 2.4565 $\angle 25.7474°$A

= 19.661 $\angle -154.2526°$A

$\mathbf{I = 19.661 \angle{-154.2526}^\circ A}$

c) Power factor cosϕ

$$\phi = \tan^{-1}\left(\frac{X_c}{R}\right)$$
$$= \tan^{-1}\left(\frac{26.5288}{55}\right)$$
$$= 25.7474^\circ$$

$\cos\phi = \cos 25.7474^\circ = 0.9007$

Power factor = 0.9007 (lead)

d) Phase angle ϕ

$$\phi = \tan^{-1}\left(\frac{X_c}{R}\right)$$
$$= \tan^{-1}\left(\frac{26.5288}{55}\right)$$
$$= 25.7474^\circ$$

$\boldsymbol{\phi = 25.7474^\circ}$

e) Finding V_R

$V_R = \text{I} \times \text{R}$
$= 2.4565 \angle 25.7474^\circ \times 55$
$= 135.1075 \angle 25.7474^\circ \text{V}$

$\mathbf{V_L = 135.1075 \angle 25.7474^\circ V}$

e) Finding V_L
$V_C = \text{I} \times X_C$
$= 2.4565 \angle 25.7474^\circ \times 26.5258 \angle{-90}^\circ$
$= 65.1606 \angle{-64.2526}^\circ \text{V}$

$\mathbf{V_L = 65.1606 \angle{-64.2526}^\circ V}$

KJSCE ETRX

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

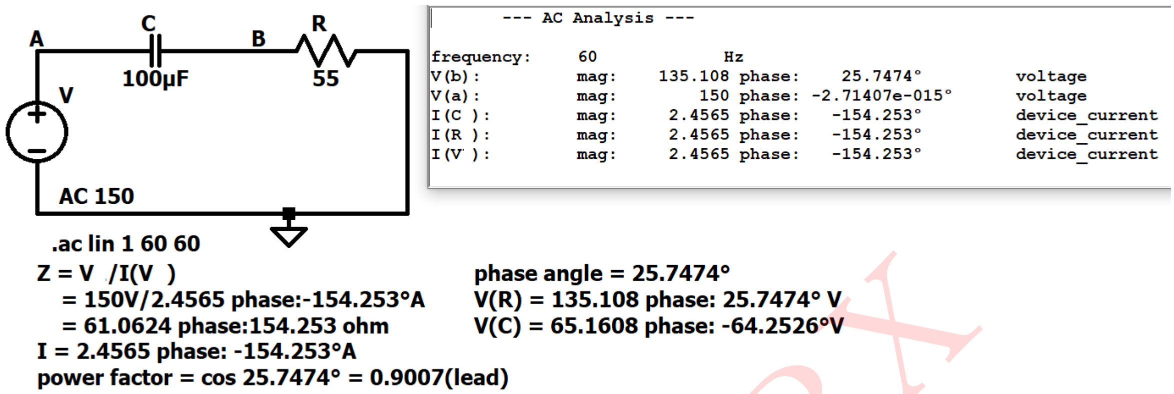

Figure 9: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
Z	$61.0624\ \angle 154.2526°\Omega$	$61.0624\ \angle 154.253°\Omega$
I	$2.4565\ \angle -154.2526°$A	$2.4565\ \angle -154.25^{3}\circ$A
Phase angle	$25.7474°$	$25.7474°$
Power factor	0.9007 (lead)	0.9007 (lead)
V_R	$135.1075\angle 25.7474°$V	$135.108\angle 25.7474°$V
V_C	$65.1606\ \angle -64.2526°$V	$65.1608\ \angle -64.2526°$V

Table 3: Numerical 3

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Numerical 4: A circuit contaning a resistance of 35Ω, an inductance of 54mH and a capacitor of 100μF are connected in parallel across 110V, 50Hz supply.
Calculate:
a) Individual current drawn by each element.
b) Total current drawn from supply.
c) Overall power factor of the circuit.
d) Draw the phasor diagram.

Solution:

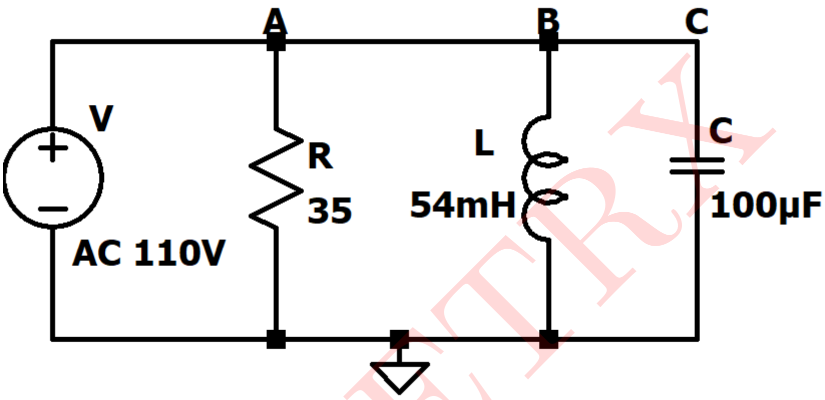

Figure 10: Circuit 4

KJSCE ETRX

Given :

V = 110V = 110 $\angle$ 0°V

R = 35Ω L = 54mH C = 100μF

f = 50Hz

ω = 2πf = 100π Hz

$X_L = \omega$L = 16.9646Ω

$X_C = \dfrac{1}{\omega C} = 31.8309\Omega$

a) Finding I_R, I_L and I_C

$$\begin{aligned} I_R &= \frac{V}{R} \\ &= \frac{110\angle 0^\circ}{35\angle 0^\circ} \\ &= 3.1428 \angle 0^\circ\text{A} \end{aligned}$$

$$\begin{aligned} I_L &= \frac{V}{X_L} \\ &= \frac{110\angle 0^\circ}{16.9646\angle 90^\circ} \\ &= 6.4840 \angle -90^\circ\text{A} \end{aligned}$$

$$I_C = \frac{V}{X_C}$$

$$= \frac{110\angle 0^\circ}{31.8309\angle -90^\circ}$$
$$= 3.4557 \angle 90^\circ \mathrm{A}$$

I_R = **3.1428 ∠ 0°A**
I_L = **6.4840 ∠ −90°A**
I_C = **3.4557 ∠ 90°A**

b) Total current across the circuit (I)

$I = I_R + I_L + I_C$
$= 3.1428 \angle 0^\circ + 6.4840 \angle -90^\circ + 3.4557 \angle 90^\circ$
$= 4.3644 \angle 136.0633^\circ$

Total current across the circuit (I) = 4.3644 ∠ 136.0633°

c) Power factor $\cos\phi$

$\cos\phi = \cos 136.0633^\circ = 0.7201$

Power factor = 0.7201 (lag)

d) Phasor Diagram

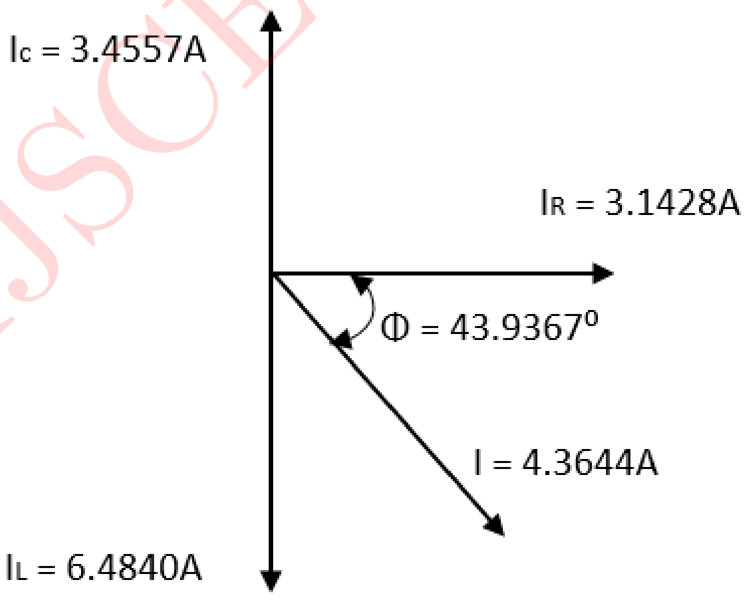

Figure 11: Phasor Diagram

KJSCE ETRX

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

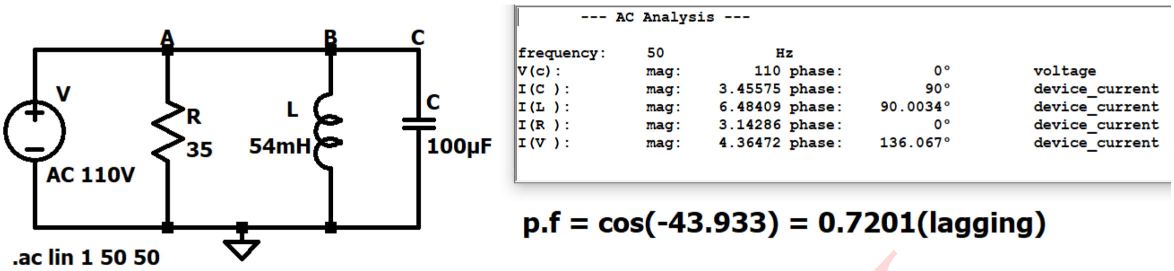

Figure 12: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I_R	$3.1428\ \angle 0°$A	$3.1428\ \angle 0°$A
I_L	$6.4840\ \angle{-90°}$A	$6.4840\ \angle{-90°}$A
I_C	$3.4557\ \angle 90°$A	$3.4557\ \angle 90°$A
Total Current	$4.3644\ \angle 136.0633°$A	$4.3647\ \angle 136.0637°$A
Power factor	0.7201 (lag)	0.7201 (lag)

Table 4: Numerical 4

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Numerical 5: A coil having a resistance of $R_1 = 10\Omega$ and inductance of $L_1 = 0.05$H is arranged in parallel with another coil having a resistance of $R_2 = 3\Omega$ and an inductance of $L_2 = 0.05$H. Calculate the currents I, I_1 and I when a voltage of $V_1 = 100$V at 50 Hz is applied. Also calculate the power factor of the circuit.

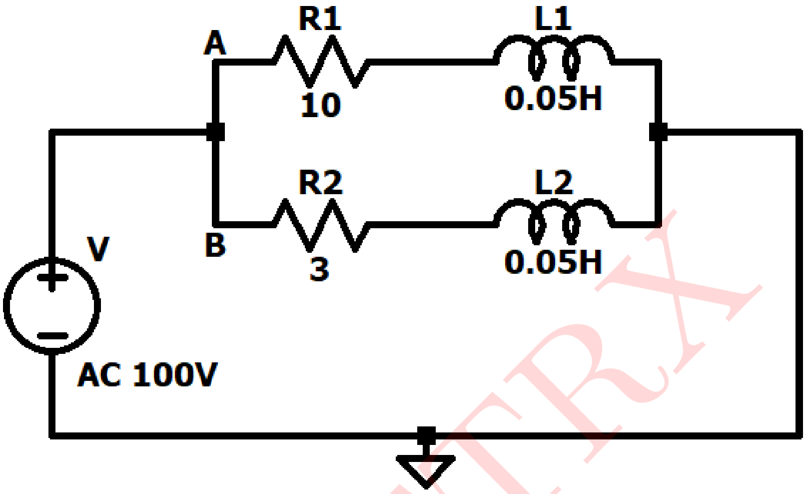

Figure 13: Circuit 5

Given :

V = 100V = 100 $\angle$ 0°V

$R_1 = 10\Omega$ $R_2 = 3\Omega$ $L_1 = 0.05$H $L_1 = 0.05$H

f = 50Hz

$\omega = 2\pi f = 100\pi$ Hz

$X_{L1} = \omega L_1 = 15.7079\Omega$

$X_{L2} = \omega L_2 = 15.7079\Omega$

$$\begin{aligned} Z_1 &= R_1 + \text{j } X_{L1} \\ &= 10 + \text{j } 15.7079\ \Omega \\ &= 18.6209\ \angle 57.518^\circ\ \Omega \end{aligned}$$

$$\begin{aligned} Z_2 &= R_2 + \text{j } X_{L2} \\ &= 3 + \text{j } 15.7079\ \Omega \\ &= 15.9918\ \angle 79.187^\circ\ \Omega \end{aligned}$$

$$\begin{aligned} I_1 &= \frac{V}{Z_1} \\ &= \frac{100\angle 0^\circ}{18.6209\angle 57.518^\circ} \\ &= 5.370\ \angle -57.518^\circ\text{A} \\ &= 2.884 + \text{j}4.529\ \text{A} \end{aligned}$$

KJSCE ETRX

$$I_2 = \frac{V}{Z_2}$$

$$= \frac{100\angle 0°}{15.9918\angle 79.187°}$$

$$= 6.2332 \angle -79.187° \text{A}$$

$$= -1.173 + j6.142 \text{ A}$$

$$\text{I} = I_1 + I_2$$

$$= 2.884 + j4.529 + -1.173 + j6.142$$

$$= -4.057 + j10.671 \text{ A}$$

$$= 11.416 \angle 110.816° \text{A}$$

$\boldsymbol{I_1 = 5.370 \angle -57.518° \text{A}}$
$\boldsymbol{I_2 = 6.2332 \angle -79.187° \text{A}}$
$\mathbf{I = 11.416 \angle 110.816° A}$

c) Power factor cosϕ

$\phi = 110.816 - 180 = -69.184°$

cosϕ = cos $(-69.184)° = 0.3553$

Power factor = 0.3553 (lag)

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

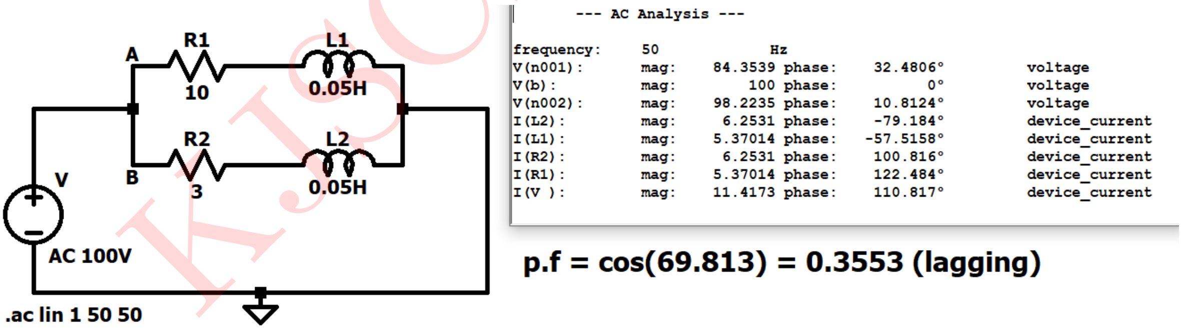

Figure 14: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
Total Current	3.1428 $\angle 0°$A	3.1428 $\angle 0°$A
I_1	6.4840 $\angle -90°$A	6.4840 $\angle -90°$A
I_2	3.4557 $\angle 90°$A	3.4557 $\angle 90°$A
Power factor	0.3553 (lag)	0.3553 (lag)

Table 5: Numerical 5

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Numerical 6: Find I, I_1 and I_2 and voltage drop in each branch, if $R_1 = 12\Omega$, L_1 = j10Ω, $R_2 = 18\Omega$, L_2 = j12Ω, $R_3 = 24\Omega$, $C_1 = -$j7Ω, V=100V, frequency =50Hz.

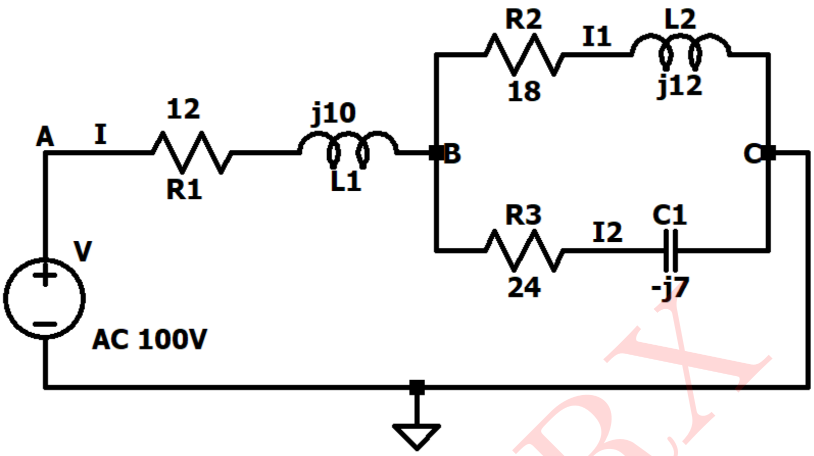


Figure 15: Circuit 6

Given :

V = 100V = 100 ∠ 0°V

f = 50Hz

ω = 2πf = 100π Hz

$Z_1 = R_1$ +j L_1
= 12 + j 10 Ω
= 15.6204 ∠39.805° Ω

$Z_2 = R_2$ +j L_2
= 18 + j 12 Ω
= 21.633 ∠33.690° Ω

$Z_3 = R_3$ +j L_3
= 24 − j 7 Ω
= 25 ∠−16.260° Ω

$$\text{Total Impedence (Z)} = Z_1 + Z_2||Z_3$$
$$= Z_1 + \frac{Z_2 \times Z_3}{Z_2 + Z_3}$$
$$= 12 + j\ 10 + \frac{21.633\angle 33.690^\circ \times 25\angle -16.260^\circ}{18 + j12 + 24 - j7}$$
$$= 24.566 + j\ 12.361\ \Omega$$

Z = 27.5 ∠26.7104° Ω

$$I = \frac{V}{Z}$$
$$= \frac{100\angle 0^\circ}{27.5\angle 26.7104^\circ}$$
$$= 3.636 \angle\ 153.2896^\circ \text{A}$$

KJSCE ETRX

$$
\begin{aligned}
I_1 &= \frac{Z_3}{Z_2 + Z_3} \times \mathrm{I} \\
&= \frac{25\angle -16.260^\circ}{18 + j12 + 24 - j7} \times 3.636 \angle 153.2896^\circ \\
&= 2.1488 \angle 130.2416^\circ \mathrm{A}
\end{aligned}
$$

$$
\begin{aligned}
I_2 &= \frac{Z_2}{Z_2 + Z_3} \times \mathrm{I} \\
&= \frac{21.633\angle 33.690^\circ}{18 + j12 + 24 - j7} \times 3.636 \angle 153.2896^\circ \\
&= 1.8596 \angle 179.889^\circ \mathrm{A}
\end{aligned}
$$

$$
\begin{aligned}
\mathbf{I} &= \mathbf{3.636 \angle 153.2896^\circ A} \\
I_1 &= \mathbf{2.1488 \angle 130.2416^\circ A} \\
I_2 &= \mathbf{1.8596 \angle 179.889^\circ A}
\end{aligned}
$$

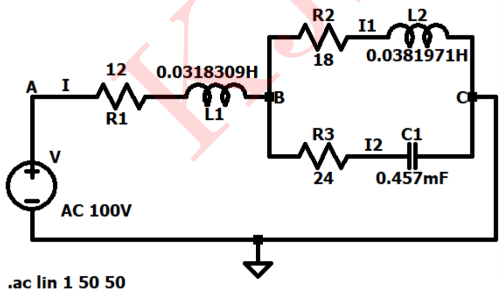
$$
\begin{aligned}
\text{Voltage drop across AB} = V_{AB} &= \mathrm{I} \times \mathrm{Z} - I_1 \times Z_2 \\
&= 100 \angle 0^\circ - 2.1488 \angle 130.2416^\circ \times 21.633 \angle 33.690^\circ \\
&= 145.243 \angle{-5.08}^\circ \mathrm{V}
\end{aligned}
$$

$$
\begin{aligned}
\text{Voltage drop across BC} = V_{BC} &= I_1 \times Z_2 - 0 \\
&= 2.1488 \angle 130.2416^\circ \times 21.633 \angle 33.690^\circ - 0 \\
&= 46.489 \angle{-16.068}^\circ \mathrm{V}
\end{aligned}
$$

$$
\begin{aligned}
V_{AB} &= \mathbf{145.243 \angle{-5.08}^\circ V} \\
V_{BC} &= \mathbf{46.489 \angle{-16.068}^\circ V}
\end{aligned}
$$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:



--- AC Analysis ---

frequency:	50	Hz			
V(n002):	mag:	64.1006	phase:	17.8279°	voltage
V(a):	mag:	100	phase:	0°	voltage
V(n001):	mag:	25.7804	phase:	40.251°	voltage
V(b):	mag:	46.4781	phase:	-16.0557°	voltage
V(n003):	mag:	12.9542	phase:	-89.8721°	voltage
I(C1):	mag:	1.85985	phase:	-179.872°	device_current
I(L2):	mag:	2.14837	phase:	-49.7442°	device_current
I(L1):	mag:	3.6366	phase:	-26.725°	device_current
I(R3):	mag:	1.85985	phase:	-179.872°	device_current
I(R2):	mag:	2.14837	phase:	130.256°	device_current
I(R1):	mag:	3.6366	phase:	153.275°	device_current
I(V):	mag:	3.6366	phase:	153.275°	device_current

Voltage across AB = V(A)-V(B)
= 100 phase 0°-46.4781 phase-16.0557°
= 100+j0 -(-44.665+j12.854)
= 144.665-j12.854
= 145.235 phase: -5.077
Voltage across BC = V(B)
= 46.4781 phase -16.0557°V

Figure 16: Circuit Schematic and Simulated Results

KLISCE ETRX

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	3.636 $\angle 153.2896°$A	3.6366 $\angle 153.275°$A
I_1	2.1488 $\angle$ 130.2416°A	2.1483 $\angle$ 130.256°A
I_2	1.8596 $\angle$ 179.889°A	1.8598 $\angle$ 179.872°A
V_{AB}	145.243 $\angle -5.08°$V	145.235 $\angle -5.077°$V
V_{BC}	46.489 $\angle -16.068°$V	46.4781 $\angle -16.0557°$V

Table 6: Numerical 6

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Numerical 7: A 50 Hz sinusoidal voltage V = 141 sin ωt is applied to a series R-L circuit. The values of the resistance and the inductance are 4 Ω and 0.01 H respectively. Determine the following:

a) Calculate the peak voltage across resistor and inductor and also find the peak value of source current in LTspice
b) Plot input source voltage V_S(t) Vs input source current I_S(t) in LTspice
c) Measure the phase delay/difference between V_S(t) Vs I_S(t) in time and degrees
d) Plot input source voltage V_S(t)) Vs voltage across resistor V_R(t) in LTspice
e) Measure the phase delay/difference between V_S(t) Vs V_R(t) in time and degrees
f) Plot input source voltage V_S(t) Vs voltage across inductor V_L(t) in LTspice
g) Measure the phase delay/difference between V_S(t) Vs V_L(t) in time and degrees
h) Calculate the power factor of the circuit.

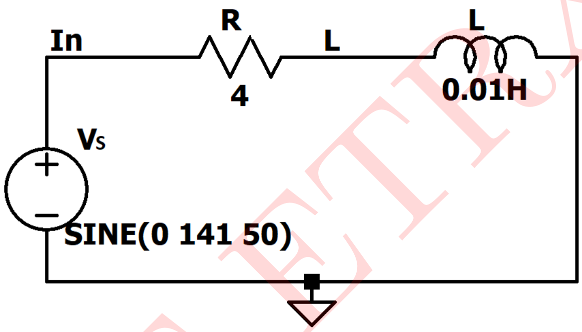

Figure 17: Circuit 7

KJSCE ETEX

Solution:

V_S = V = 141 sin ωtV

$$V_{RMS} = \frac{V_S}{\sqrt{2}} = 100\text{V}$$

f = 50Hz

R = 4Ω
L = 0.01H

$X_L = \omega$L = 3.1415Ω

Z = 4 + j3.1415Ω
= 5.0862 $\angle$ 38.146°Ω

a) Peak value of current (I_S)

$$I_{RMS} = \frac{V_{RMS}}{Z}$$
$$= \frac{100\angle 0^\circ}{5.0862\angle 38.146^\circ}$$
$$= 19.6610 \angle{-38.146^\circ}\text{A}$$

$$I_S = I_{RMS} \times \sqrt{2}$$
$$= 19.6610 \angle{-38.146^\circ} \times \sqrt{2}$$
$$= 27.7992 \angle{-38.146^\circ} \text{ A}$$

I_S **= 27.7992 A**

V_R = I × R
$$= 27.7992 \angle{-38.146°} \times 4$$
$$= 110.292 \angle{-38.146°}\text{V}$$

$$V_L = \text{I} \times X_L$$
$$= 27.7992 \angle{-38.146°} \times 3.1415 \angle 90°$$
$$= 87.333 \angle 51.854°\text{V}$$

$\mathbf{V_R = 110.292 \angle{-38.146°}V}$
$\mathbf{V_L = 87.333 \angle 51.854°V}$

b) Input source voltage V_S(t) Vs input source current I_S(t)

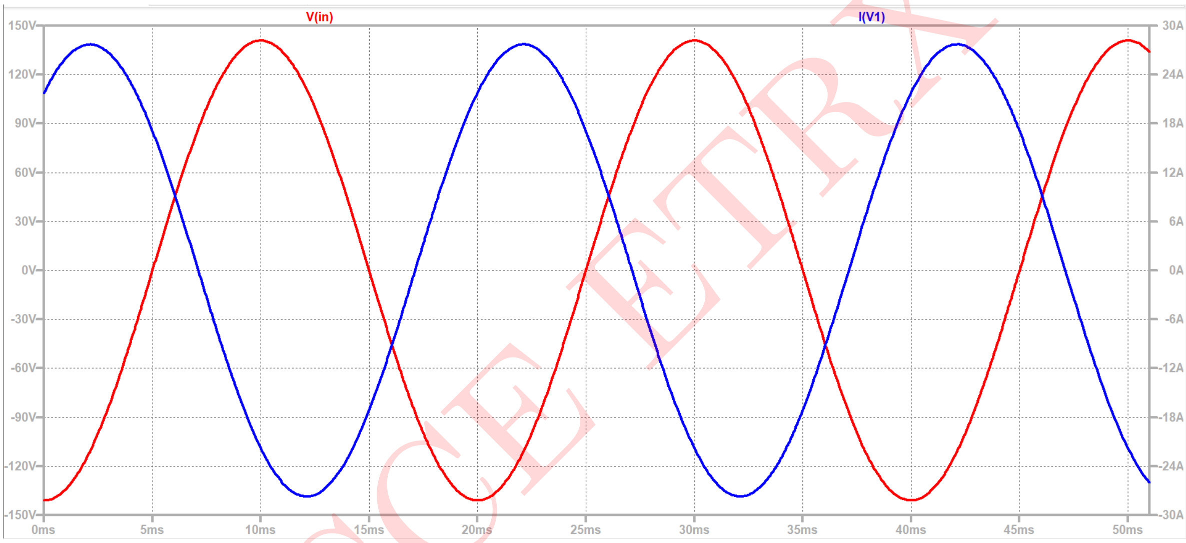

Figure 18: V_S(t) Vs I_S(t)

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c) Phase delay/difference between V_S(t) Vs I_S(t)

V = 100 $\angle$ 0°V
I = 19.6610 $\angle{-38.146°}$A
$\Delta\phi$ = 180° − 38.146° = 141.854°

$\mathbf{\Delta\phi = 141.854°}$

$$\Delta\text{t} = \frac{\Delta \times T}{360°}$$
$$= \frac{141.854° \times 20}{360°}$$
$$= 7.8807\text{ms}$$

Δt = 7.8807ms

d) Input source voltage V_S(t) Vs voltage across resistor V_R(t)

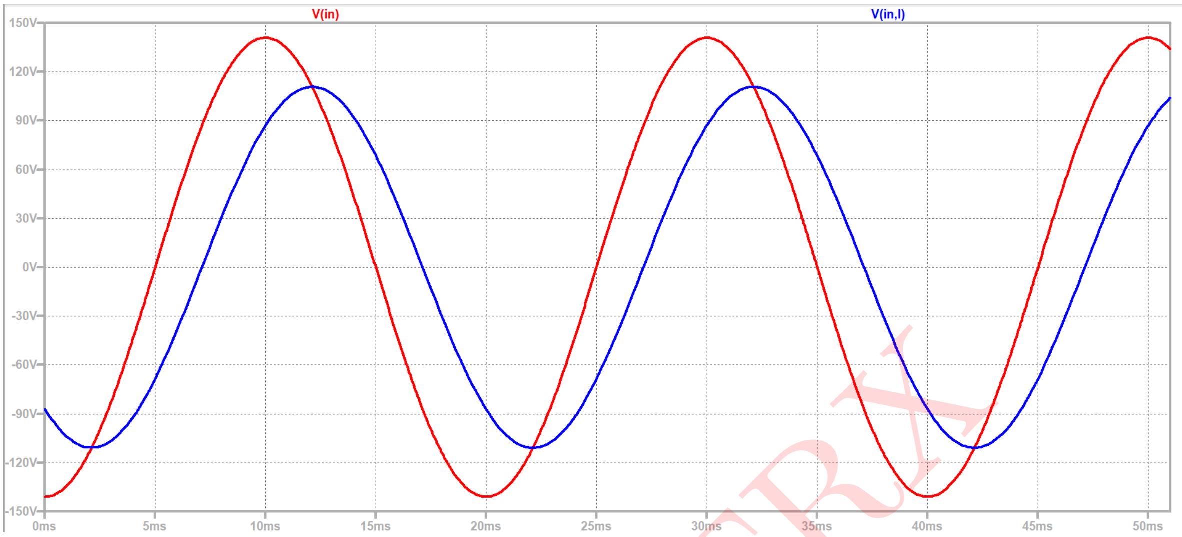

Figure 19: V_S(t) Vs V_R(t)

e) Phase delay/difference between V_S(t) Vs V_R(t)

V $= 100 \angle 0°$V

$V_R = 110.292 \angle{-38.146°}$V

$\Delta\phi$ **= 38.146°**

$$\Delta t = \frac{\Delta \times T}{360°}$$

$$= \frac{38.146° \times 20}{360°}$$

$$= 2.1111\text{ms}$$

Δt = 2.1111ms

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f) Input source voltage V_S(t) Vs voltage across inductor V_L(t)

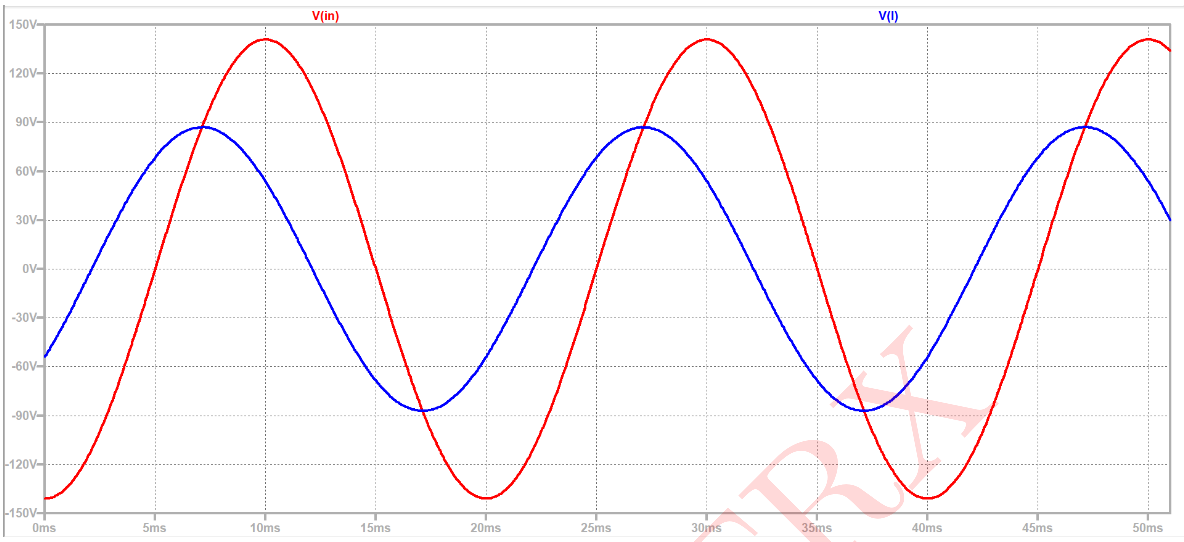

Figure 20: V_S(t) Vs V_L(t)

g) Phase delay/difference between V_S(t) Vs V_L(t)

V = 100 $\angle$ 0°V

V_R = 87.333 $\angle$51.854°V

$\boldsymbol{\Delta\phi}$ **= 51.854°**

$$\Delta t = \frac{\Delta \times T}{360°}$$

$$= \frac{51.854° \times 20}{360°}$$

$$= 2.8252\text{ms}$$

Δt = 2.8252ms

h) Power factor cosϕ

cosϕ = cos 38.146° = 0.7864

Power factor = 0.7864 (lag)

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SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

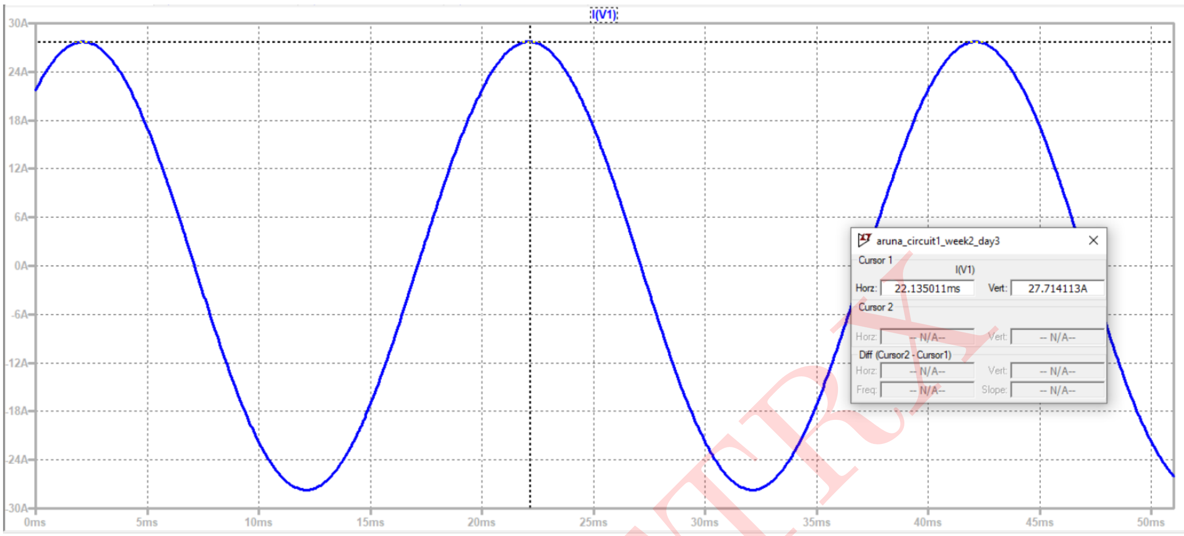

Figure 21: Simulated Results for Source current

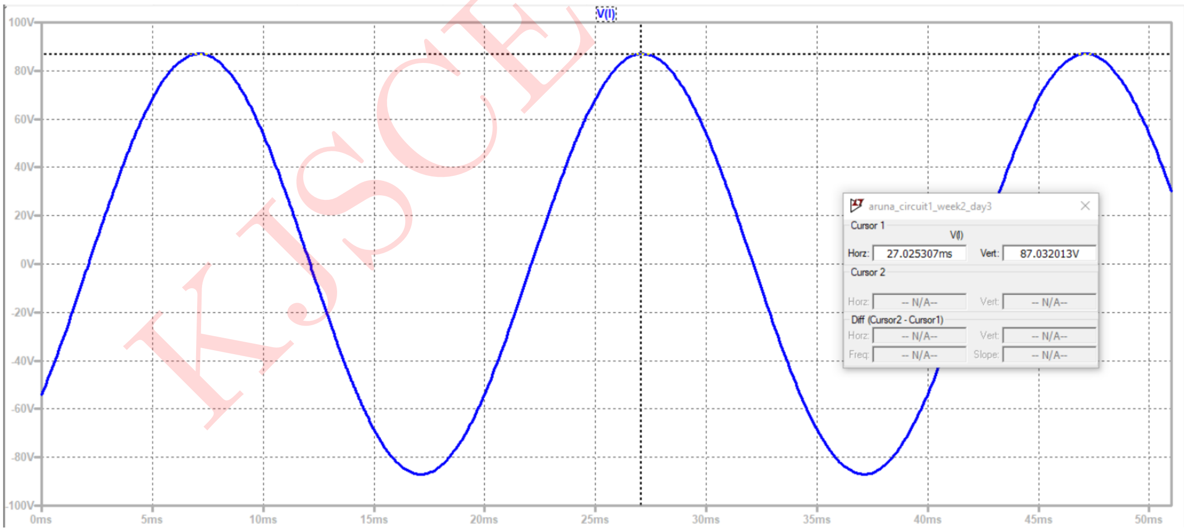

Figure 22: Simulated Results for Voltage across resistor

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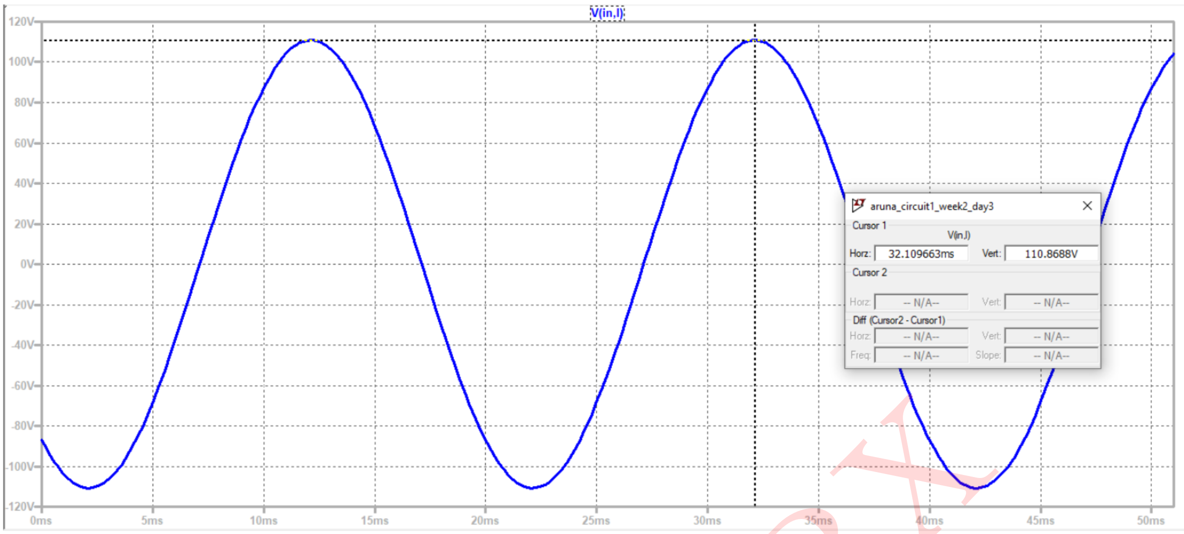

Figure 23: Simulated Results for voltage across inductor

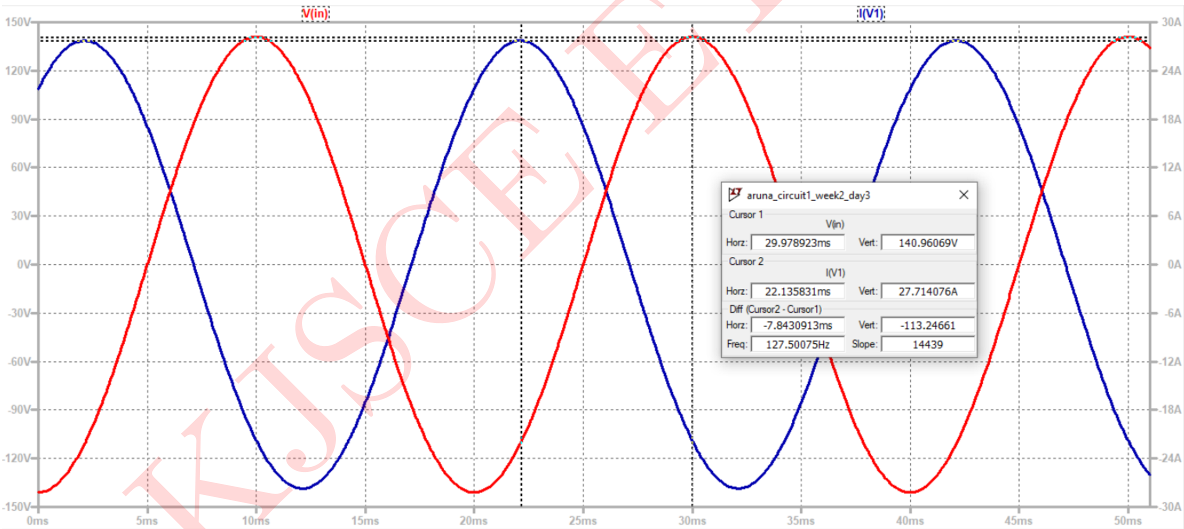

Figure 24: Simulated Results for V_S(t) Vs I_S(t)

KJSCE ETRX

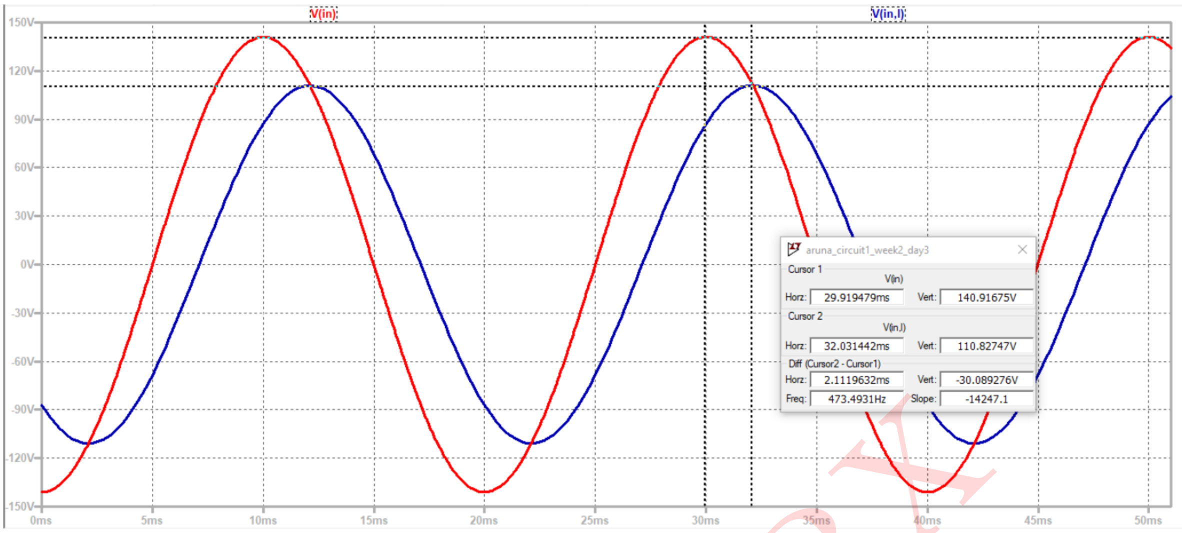

Figure 25: Simulated Results for V_S(t) Vs V_R(t)

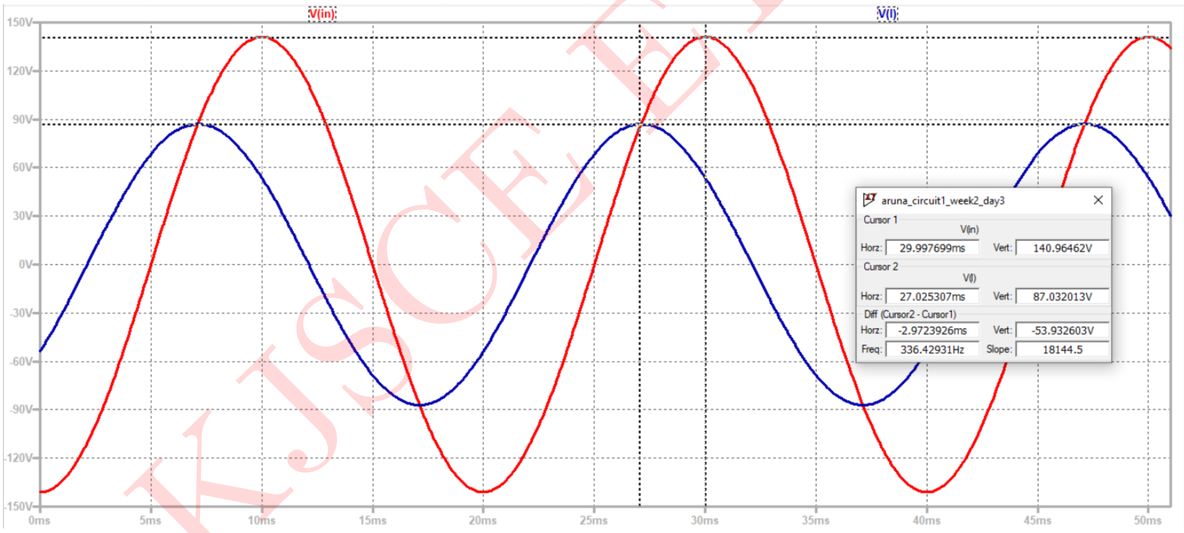

Figure 26: Simulated Results for V_S(t) Vs V_L(t)

KJSCE ETRX

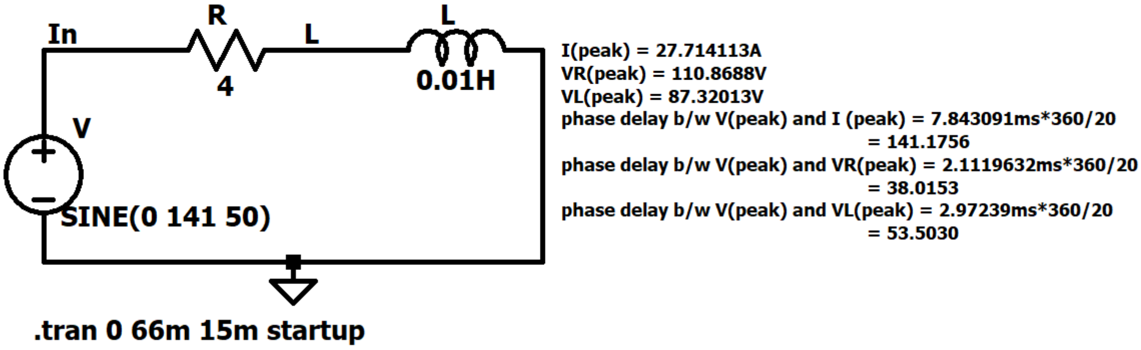

Figure 27: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Simulated Values	Theoretical Values
Peak voltage across resistor	110.8688V	110.292V
Peak voltage across inductor	87.320138V	87.333V
Peak value of source current	27.71411A	27.7992A
Phase delay b/w V_S(t) Vs I_S(t)	7.843ms 141.175°	7.880ms 141.854°
Phase delay b/w V_S(t) Vs V_R(t)	2.111ms 38.0153°	2.111ms 38.146°
Phase delay b/w V_S(t) Vs V_L(t)	2.9723ms 53.503°	2.8252ms 51.854°
Power factor	0.7894 (lag)	0.7864 (lag)

Table 7: Numerical 7

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Numerical 8: A pure resistance of 55Ω is in series with a pure capacitance of 100μF. The series combination is connected across 150V, 60 Hz supply.
Determine the following:
a) Calculate the peak voltage across resistor and inductor and also find the peak value of source current in LTspice
b) Plot input source voltage V_S(t) Vs input source current I_S(t) in LTspice
c) Measure the phase delay/difference between V_S(t) Vs I_S(t) in time and degrees
d) Plot input source voltage V_S(t)) Vs voltage across resistor V_R(t) in LTspice
e) Measure the phase delay/difference between V_S(t) Vs V_R(t) in time and degrees
f) Plot input source voltage V_S(t) Vs voltage across capavitor V_C(t) in LTspice
g) Measure the phase delay/difference between V_S(t) Vs V_C(t) in time and degrees
h) Calculate the power factor of the circuit.

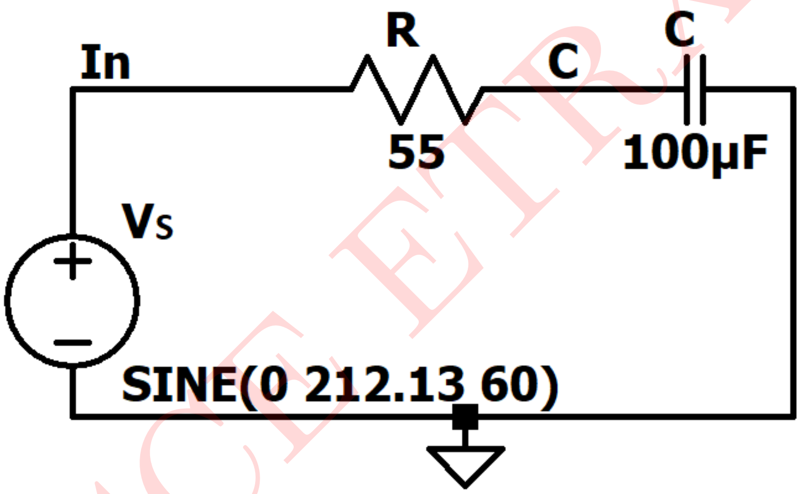

Figure 28: Circuit 8

Solution:
V_S = V = 150V

f = 60Hz

R = 55Ω
C = 100μF

$X_C = \dfrac{1}{\omega C} = 26.5258\Omega$

Z = 55 − j26.5258Ω
= 61.0624 ∠ −25.7474°Ω

a) Peak value of current (I_S)

$$I_{RMS} = \frac{V_{RMS}}{Z}$$
$$= \frac{150\angle 0°}{61.0624\angle -25.7474°}$$
$$= 2.4565\ \angle 25.7474° \text{A}$$

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$$
\begin{aligned}
I_S &= I_{RMS} \times \sqrt{2} \\
&= 2.4565 \angle 25.7474^\circ \times \sqrt{2} \\
&= 3.4740 \angle 25.7474^\circ \text{ A}
\end{aligned}
$$

$\boldsymbol{I_S = 3.4740}$ **A**

$$
\begin{aligned}
V_R &= \text{I} \times \text{R} \\
&= 3.4740 \angle 25.7474^\circ \times 55 \\
&= 191.07 \angle 25.7474^\circ \text{V}
\end{aligned}
$$

$$
\begin{aligned}
V_C &= \text{I} \times X_C \\
&= 3.4740 \angle 25.7474^\circ \times 26.5258 \; -90^\circ \\
&= 92.1506 \angle -64.2526^\circ \text{V}
\end{aligned}
$$

$\boldsymbol{V_R = 191.07 \angle 25.7474^\circ}$**V**
$\boldsymbol{V_C = 92.1506 \angle -64.2526^\circ}$**V**

b) Input source voltage V_S(t) Vs input source current I_S(t)

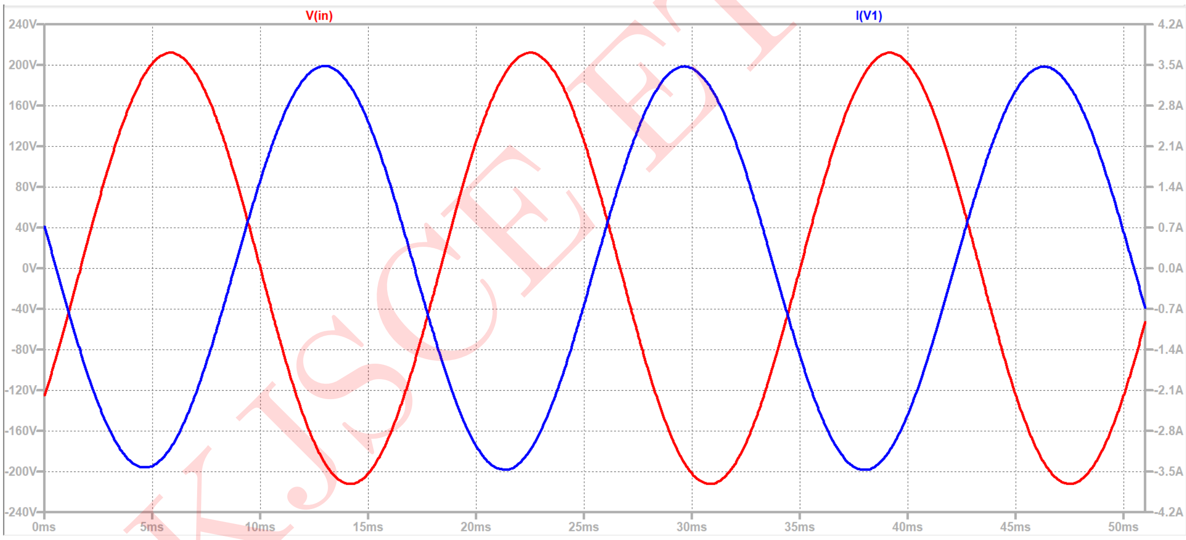

Figure 29: V_S(t) Vs I_S(t)

c) Phase delay/difference between V_S(t) Vs I_S(t)

V = 150 $\angle$ 0°V
I = 2.4565 $\angle$25.7474°A
$\Delta\phi = 180^\circ - 25.7474^\circ = 154.2526^\circ$

$\boldsymbol{\Delta\phi = 154.2526^\circ}$

$$
\begin{aligned}
\Delta\text{t} &= \frac{\Delta \times T}{360^\circ} \\
&= \frac{154.2526^\circ \times 16.69}{360^\circ} \\
&= 7.1427\text{ms}
\end{aligned}
$$

Δt = 7.1427ms

KJSCEETRX

d) Input source voltage V_S(t) Vs input source current V_R(t)

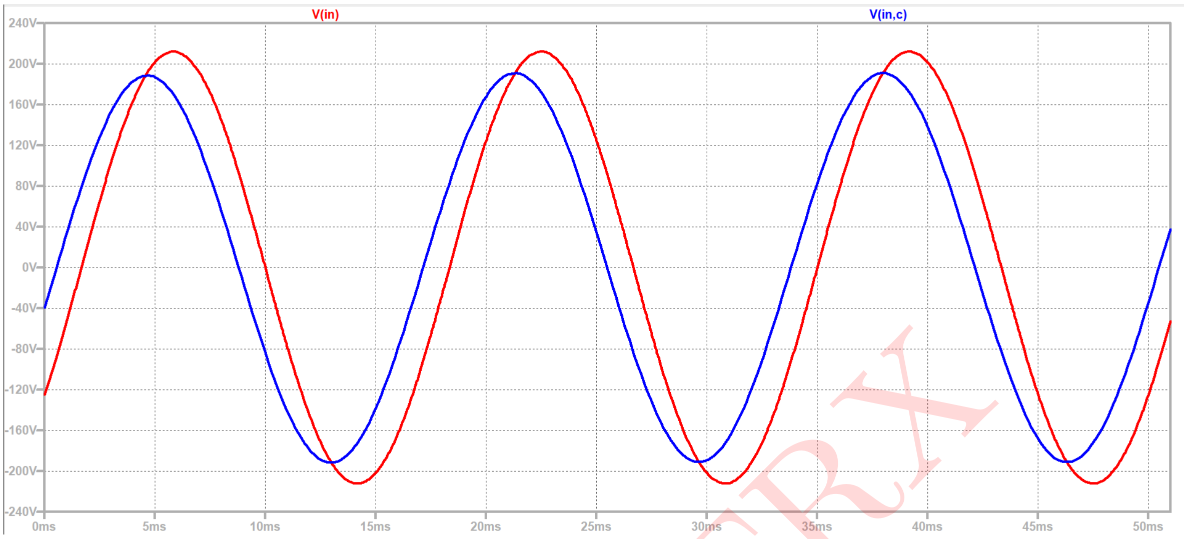

Figure 30: V_S(t) Vs V_R(t)

e) Phase delay/difference between V_S(t) Vs V_R(t)

$$V = 150 \angle 0°V$$
$$V_R = 191.07 \angle 25.7474°V$$
$$\boldsymbol{\Delta\phi = 25.7474°}$$

$$\Delta t = \frac{\Delta \times T}{360°}$$
$$= \frac{25.7474° \times 16.69}{360°}$$
$$= 1.1922ms$$

$$\boldsymbol{\Delta t = 1.1922ms}$$

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f) Input source voltage V_S(t) Vs input source current V_C(t)

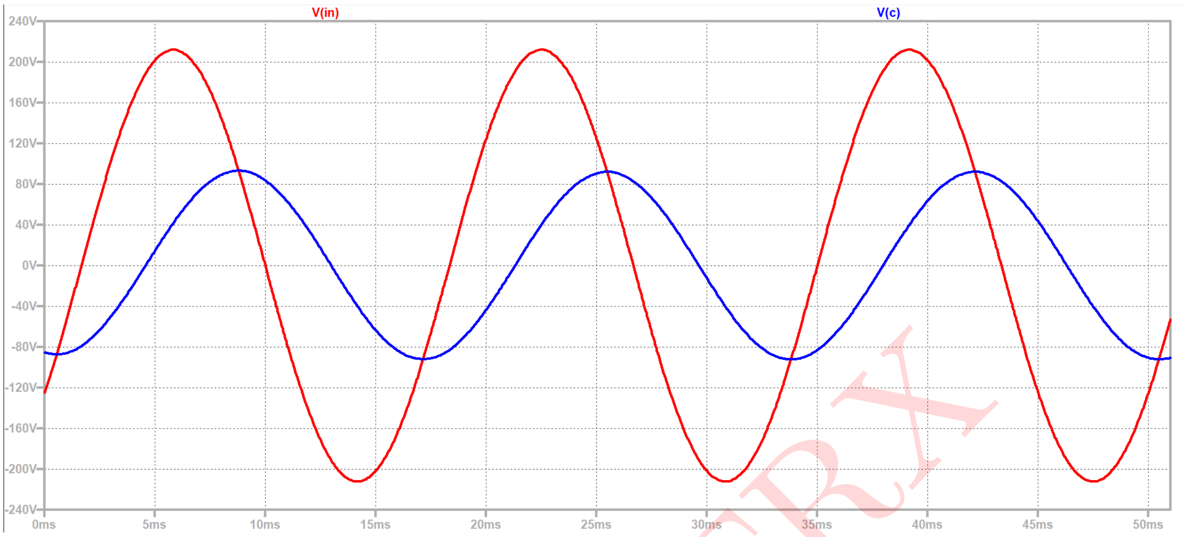

Figure 31: V_S(t) Vs V_C(t)

g) Phase delay/difference between V_S(t) Vs V_C(t)

V $= 150 \angle 0°$V

$V_C = 92.1506 \angle{-64.2526}°$V

$\Delta\phi$ **= 64.2526°**

$$\Delta t = \frac{\Delta \times T}{360°}$$

$$= \frac{64.2526° \times 16.69}{360°}$$

$$= 2.9752\text{ms}$$

Δt = 2.9752ms

h) Power factor $\cos\phi$

$\cos\phi = \cos 25.7474° = 0.9007$

Power factor = 0.9007 (lead)

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SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

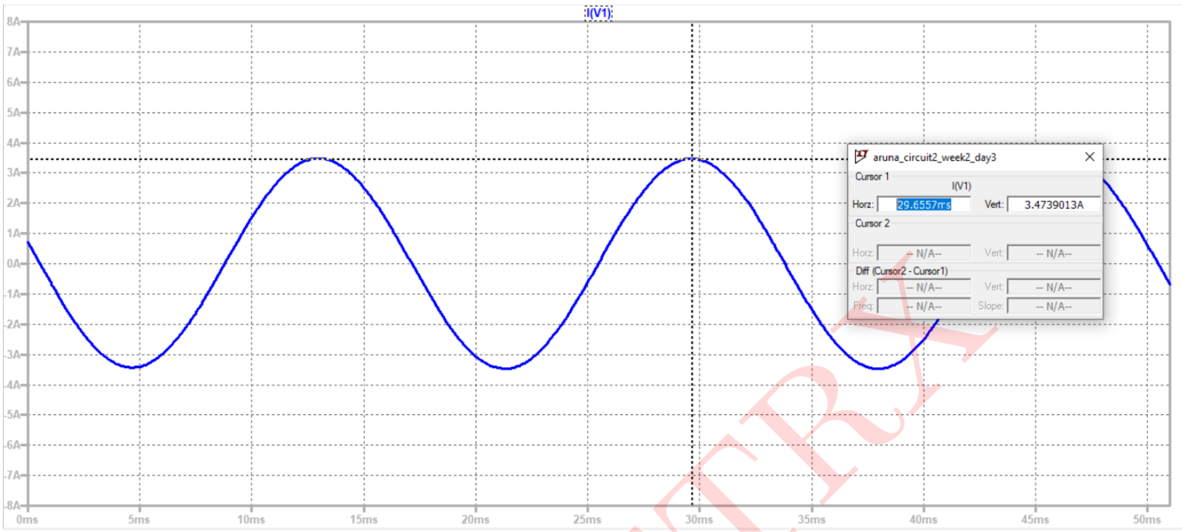

Figure 32: Simulated Results for Source current

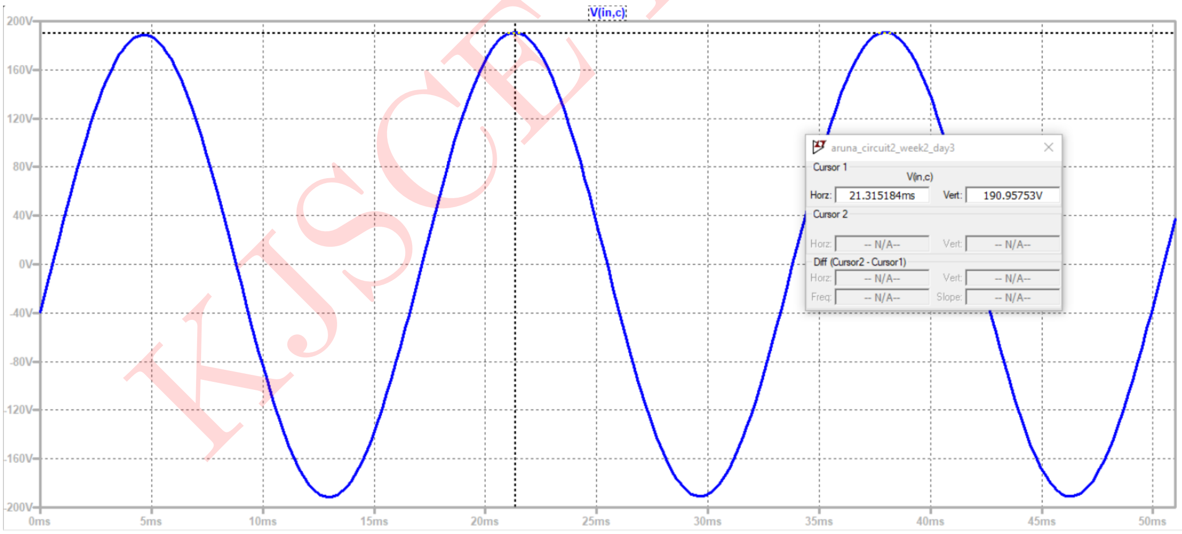

Figure 33: Simulated Results for Voltage across resistor

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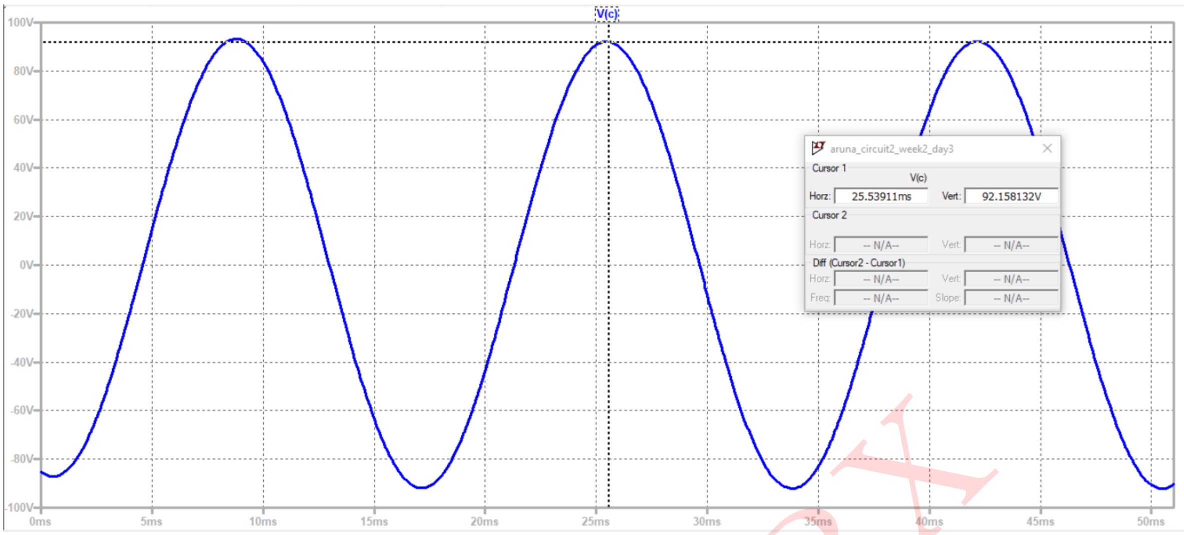

Figure 34: Simulated Results for voltage across capacitor

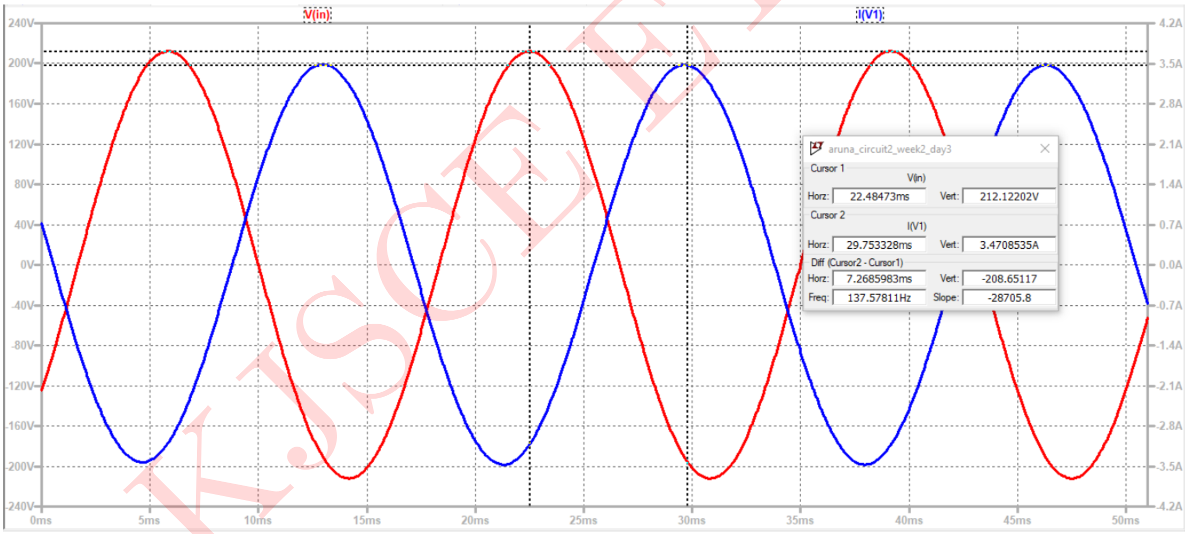

Figure 35: Simulated Results for V_S(t) Vs I_S(t)

KJSCE ETRX

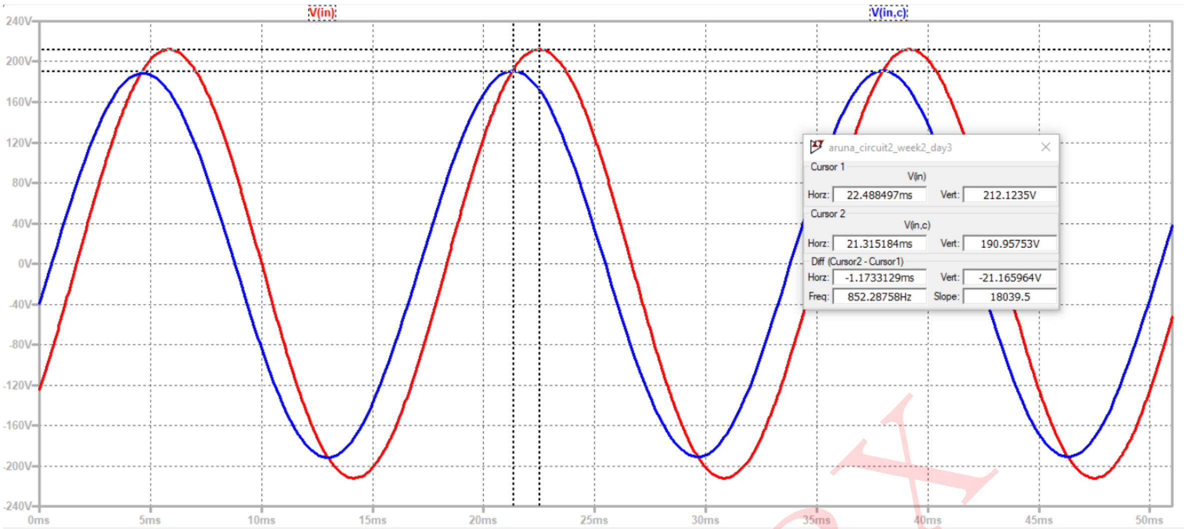

Figure 36: Simulated Results for V_S(t) Vs V_R(t)

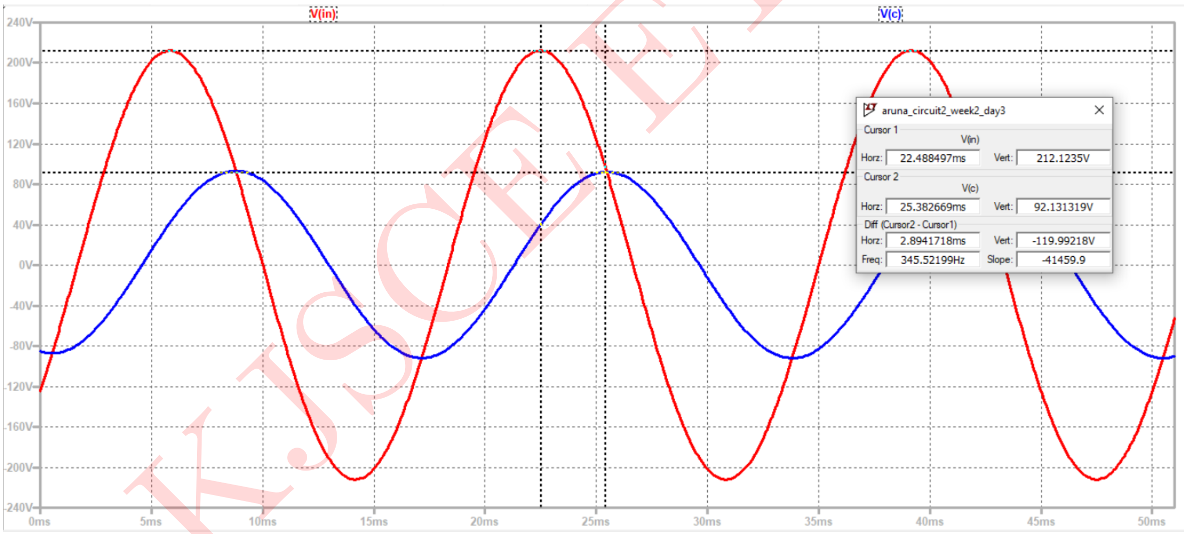

Figure 37: Simulated Results for V_S(t) Vs V_C(t)

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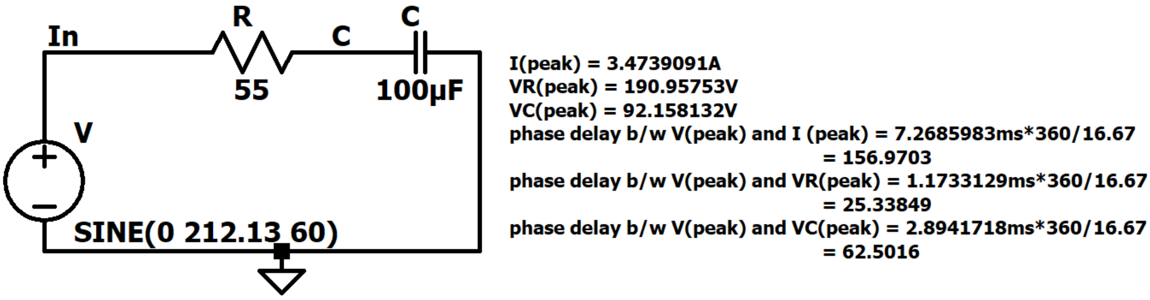

Figure 38: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Simulated Values	Theoretical Values
Peak voltage across resistor	190.9575V	191.07V
Peak voltage across capacitor	92.1581V	92.1506V
Peak value of source current	3.4939A	3.4740A
Phase delay b/w V_S(t) Vs I_S(t)	7.2685ms 156.9703°	7.1427ms 154.2526°
Phase delay b/w V_S(t) Vs V_R(t)	1.1733ms 25.3384°	1.1922ms 25.7474°
Phase delay b/w V_S(t) Vs V_C(t)	2.8941ms 62.5016°	2.9752ms 64.2526°
Power factor	0.9007 (lead)	0.9007 (lead)

Table 8: Numerical 8

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Numerical 9: A series resonance network consisting of a resistor of 25Ω, a capacitor of 2.5μF and an inductor of 22mH is connected across a sinusoidal supply voltage which has a constant output of AC 9V at all frequencies. Calculate, the resonant frequency, the current at resonance, the voltage across the inductor and capacitor at resonance, the quality factor and the bandwidth of the circuit.Plot the resonance curve, the current at resonance, the voltage across the inductor and capacitor at resonance in LTspice.

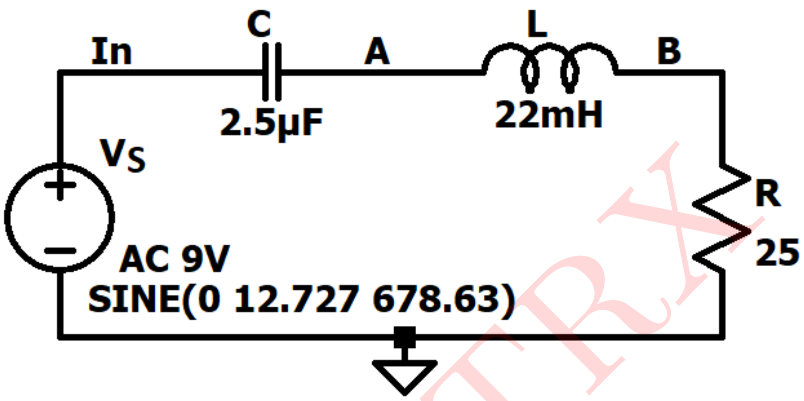

Figure 39: Circuit 9

Solution:
V_S = V = 9V

R = 25Ω
C = 2.5μF
L = 22mH

$$\text{Resonant frequency } (f_o) = \frac{1}{2\pi\sqrt{LC}}$$
$$= \frac{1}{2\pi\sqrt{22\times10^{-3}\times2.5\times10^{-6}}}$$
$$= 678.6389\text{Hz}$$

f_o = **678.6389Hz**

$X_L = \omega \text{L} = 93.8083\Omega$

$X_C = \dfrac{1}{\omega C} = 93.8083\Omega$

a) Peak value of current (I_S)

$$I_{RMS} = \frac{V_{RMS}}{Z}$$
$$= \frac{9\angle 0^\circ}{25\angle 0^\circ}$$
$$= 360\text{mA}$$

KJSCE ETRX

$$
\begin{aligned}
I_S &= I_{RMS} \times \sqrt{2} \\
&= 360 \times \sqrt{2} \\
&= 509.1168\text{mA}
\end{aligned}
$$

$$\boldsymbol{I_S = 509.1168\text{mA}}$$

$$
\begin{aligned}
V_L &= \text{I} \times X_L \\
&= 0.509 \angle 0^\circ \times 93.8083 \angle 90^\circ \\
&= 47.759 \angle 90^\circ\text{V}
\end{aligned}
$$

$$
\begin{aligned}
V_C &= \text{I} \times X_C \\
&= 0.509 \angle 0^\circ \times 93.8083 \angle -90^\circ \\
&= 47.759 \angle -90^\circ\text{V}
\end{aligned}
$$

$$\boldsymbol{V_L = 47.759 \angle 90^\circ\text{V}}$$
$$\boldsymbol{V_C = 47.759 \angle -90^\circ\text{V}}$$

$$\text{Quality factor } (Q_O) = \frac{V_{LO}}{V} = \frac{V_{LO}}{V}$$

$$
\begin{aligned}
Q_O &= \frac{1}{R}\sqrt{\frac{L}{C}} \\
&= \frac{1}{25}\sqrt{\frac{22 \times 10^{-3}}{2.5 \times 10^{-6}}} \\
&= 3.7523
\end{aligned}
$$

Quality factor = 3.7523

$$
\begin{aligned}
\text{Bandwidth (BW)} &= \frac{R}{2\pi L} \\
&= \frac{25}{2\pi \times 22 \times 10^{-3}} \\
&= 180.857\text{Hz}
\end{aligned}
$$

Bandwidth = 180.857Hz

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Graph for Resonance curve

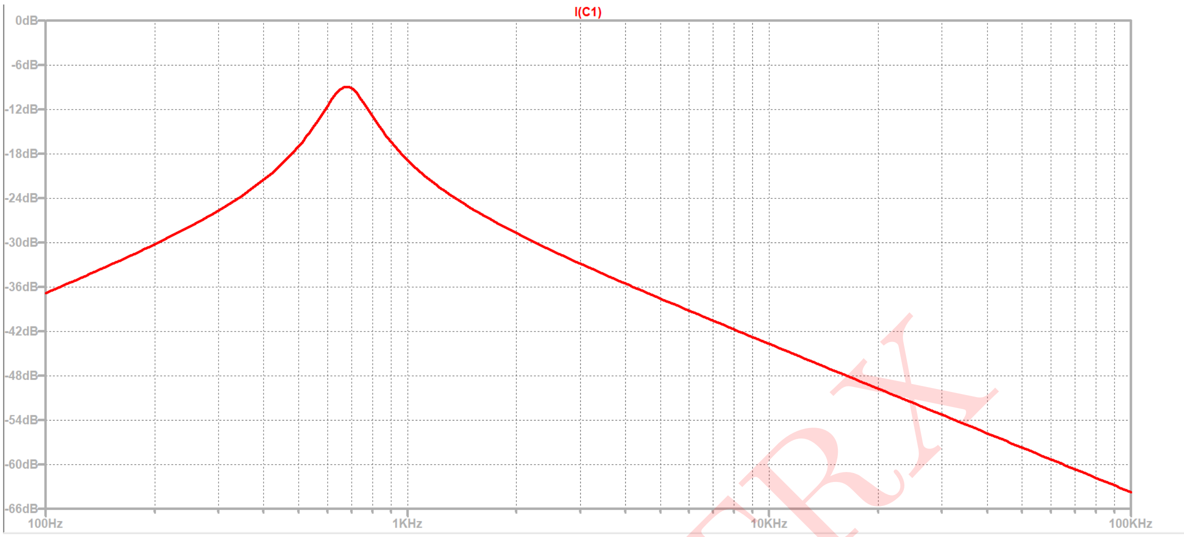

Figure 40: Resonance curve

Graph for current at resonance

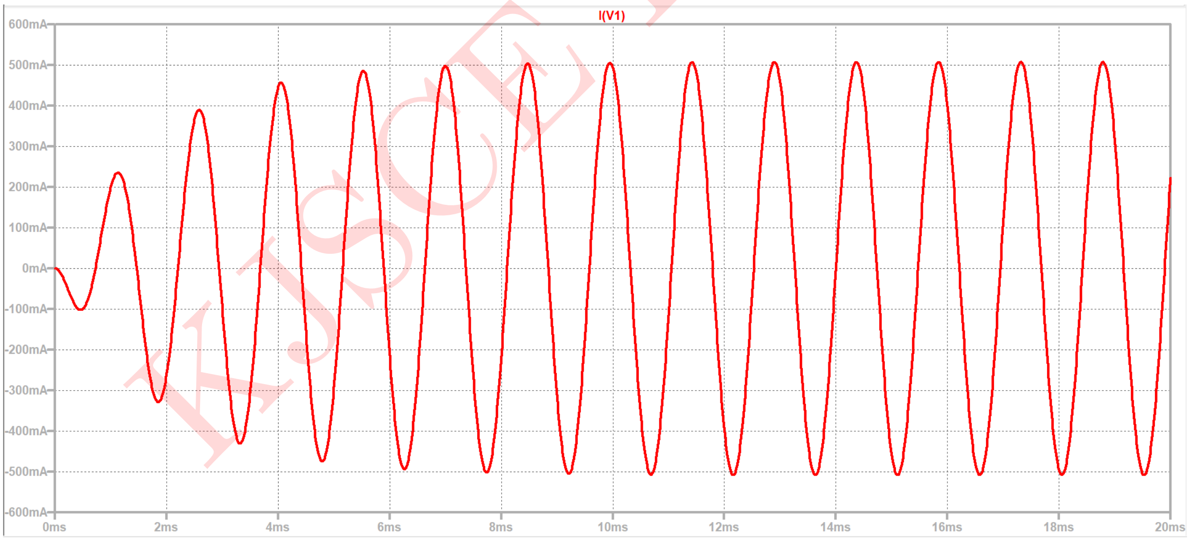

Figure 41: Current at resonance

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Graph for voltage across inductor

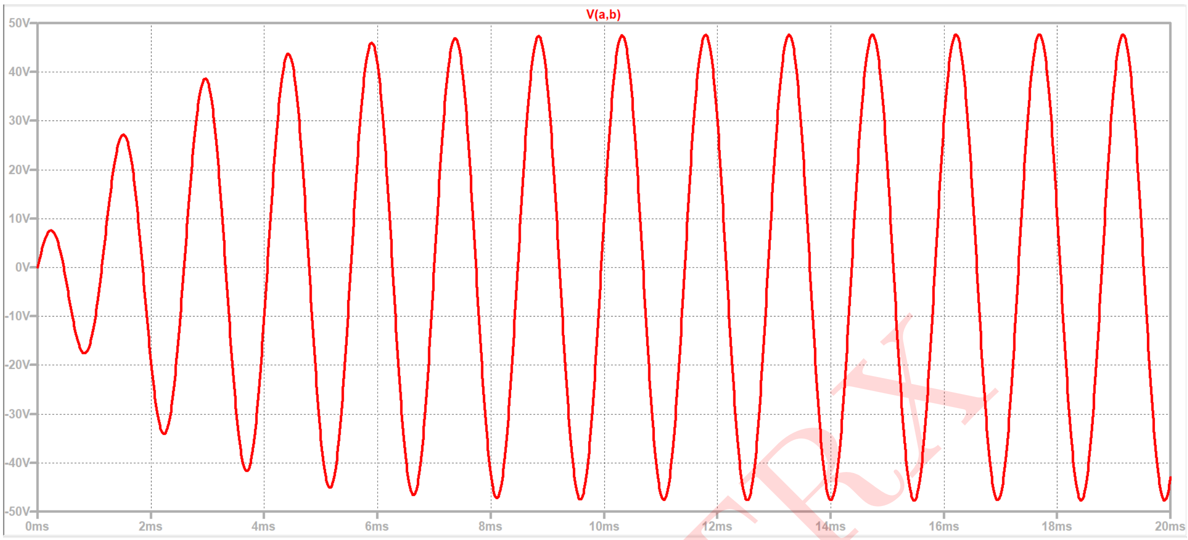

Figure 42: Voltage across inductor

Graph for voltage across capacitor

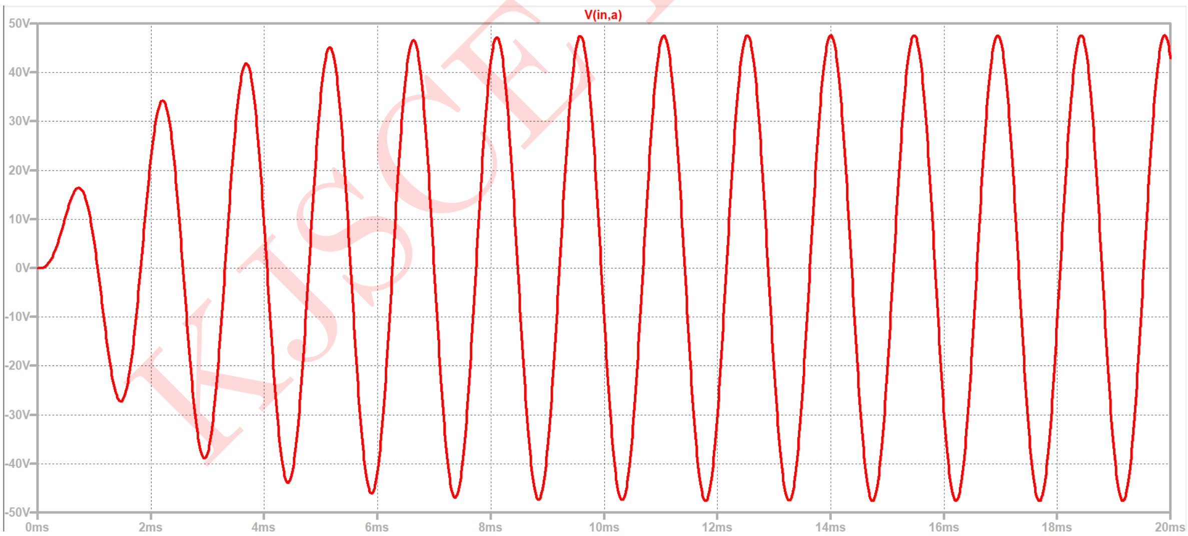

Figure 43: Voltage across capacitor

KJSCE ETRX

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

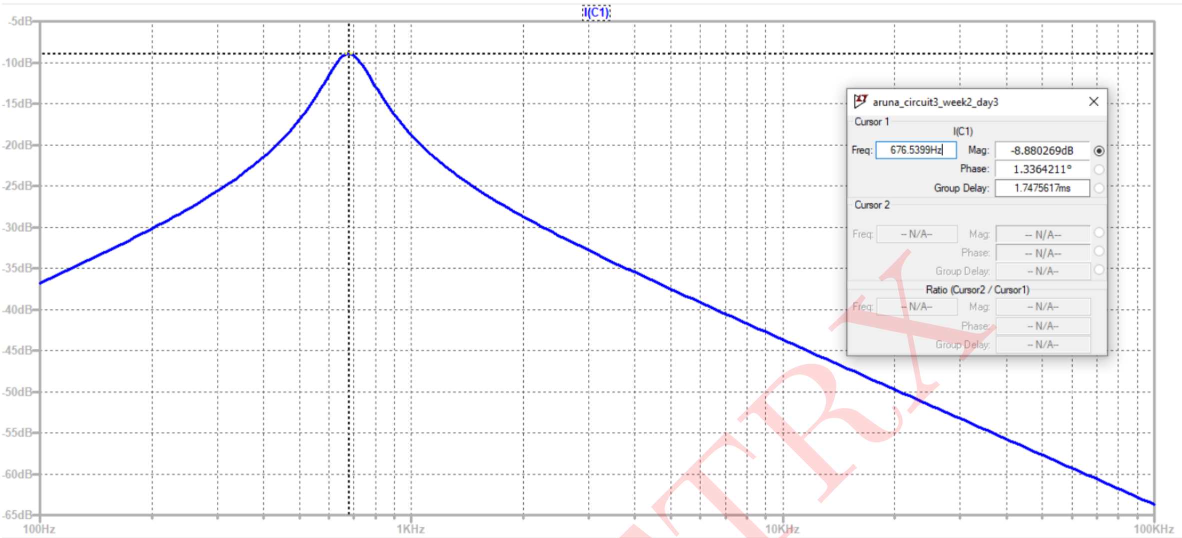

Figure 44: Simulated Results for resonance curve

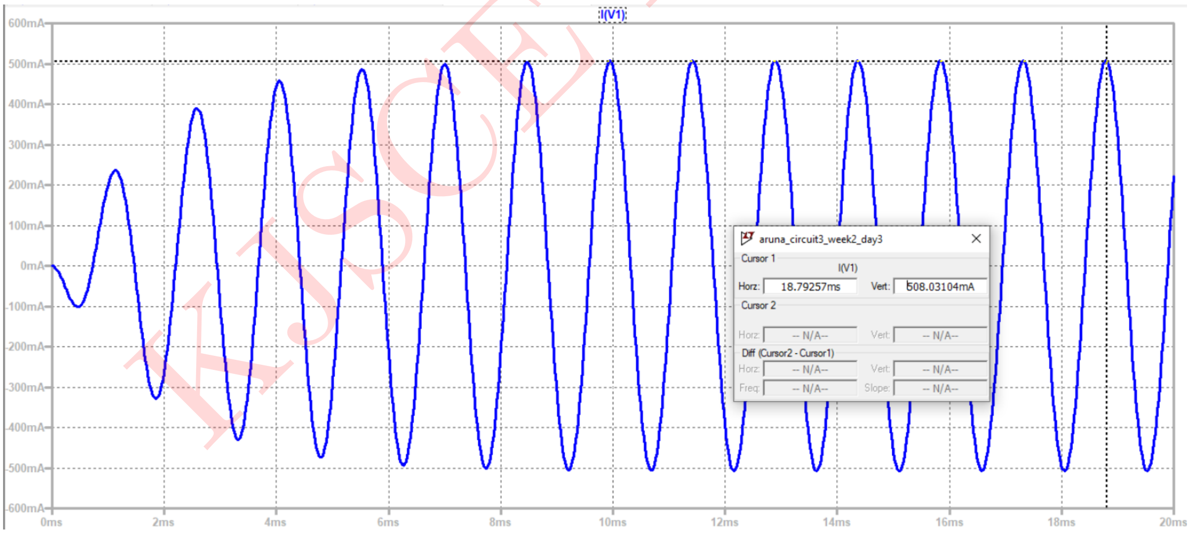

Figure 45: Simulated Results for current at resonance

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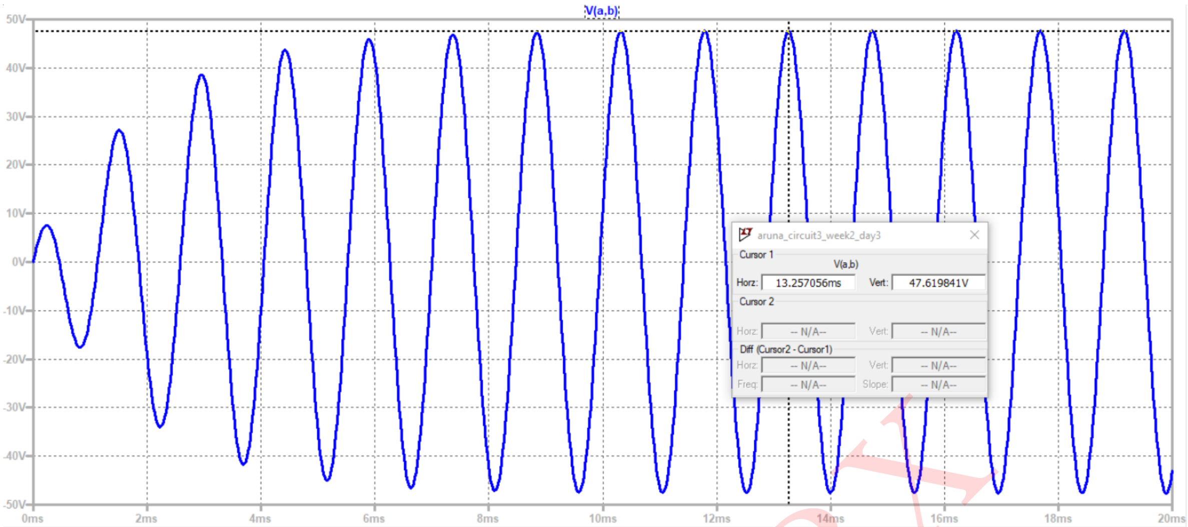

Figure 46: Simulated Results for voltage across inductor

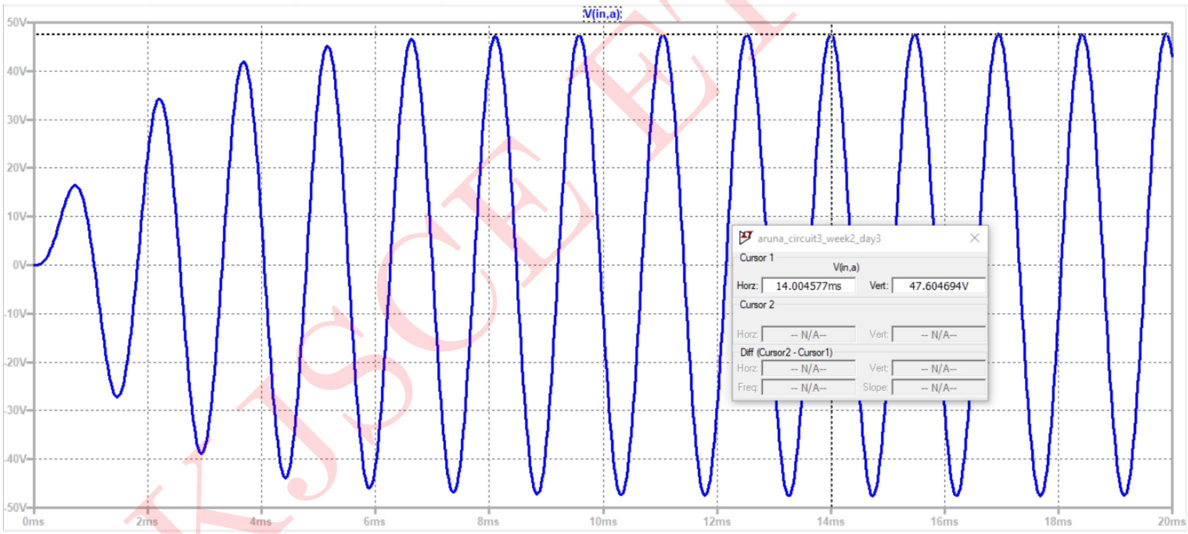

Figure 47: Simulated Results for voltage across inductor

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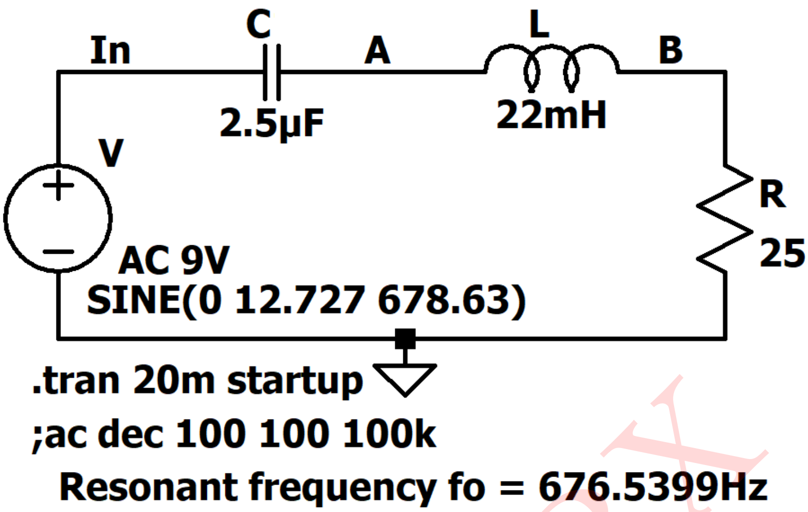

Figure 48: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Simulated Values	Theoretical Values
Resonant frequency	676.5399Hz	678.6389Hz
Current at resonance	509.0310A	509.1168A
Voltage across inductor	47.6198V	47.759V
Voltage across capacitor	47.6046V	47.759V

Table 9: Numerical 9

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