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

**Numerical 1**: A series RLC circuit containing a resistance of 50Ω, an inductance of 0.2H and a capacitor of 120$\mu$F are connected in series across a 220V, 50 Hz supply. Calculate:

i) The current drawn by the circuit shown in Figure 1
ii) $V_R$, $V_L$ & $V_C$
iii) Power factor
iv) Draw the voltage phasor diagram

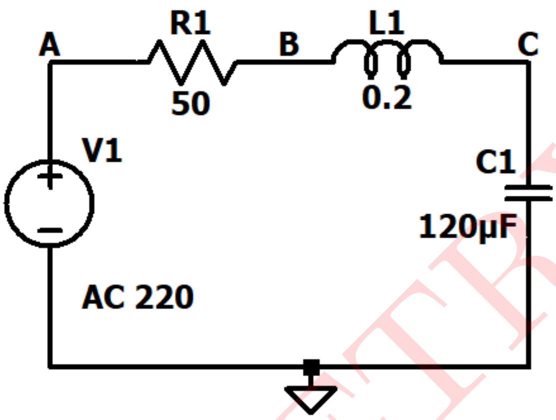



Figure 1: Circuit 1

**Solution:**

Given: $R_1 = 50\Omega,\ L_1 = 0.2H,\ C_1 = 120\mu F = 120 \times 10^{-6}F,\ f = 50Hz,\ V_1 = 220V$

The reactances for the inductor $L_1$ and the capacitor $C_1$ are given by:

$X_L = 2\pi f L_1 = 2\pi \times 50 \times 0.2 = 62.8319\Omega$

$\therefore$ X$_L$ = 62.8319Ω

$$X_C = \frac{1}{2\pi f C_1} = \frac{1}{2\pi \times 50 \times 120 \times 10^{-6}} = 26.5258\Omega$$

$\therefore$ X$_C$ = 33.1572Ω

The Total Impedance(Z) of the circuit is given by:

$$Z = \sqrt{R_1^2 + (X_L - X_C)^2} = \sqrt{50^2 + (62.8319 - 26.5258)^2} = 61.791\Omega$$

$\therefore$ Z = 61.791Ω

To find total current $I$, we use Ohm's Law:

$$I = \frac{V_1}{Z} = \frac{220}{61.791} = 3.5604$$

$\therefore\ I = 3.5604A$

Voltage across each component can be given by:

$V_R = I \times R_1 = 3.5604 \times 50 = 178.02$

$\therefore$ $V_R = 178.02V$

$V_L = I \times X_L = 3.5604 \times 62.8319 = 223.7067$

$\therefore$ $V_L = 223.7067V$

$V_C = I \times X_C = 3.5604 \times 26.5258 = 94.4425V$

$\therefore$ $V_C = 94.4425V$

Power factor can be expressed as:

Power factor $= \cos(\phi) = \frac{R_1}{Z} = \frac{50}{61.791} = 0.809$

$\therefore$ **Power factor = 0.809**

$\therefore \ \phi = \cos^{-1}(0.809) = 35.98°$

$\therefore \ \phi = 35.98°$

Voltage Phasor diagram

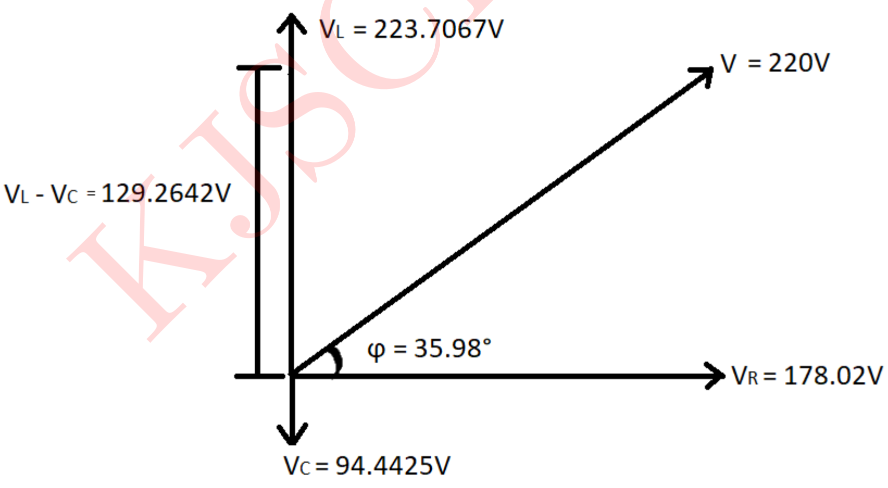



Figure 2: Voltage Phasor diagram

### SIMULATED RESULTS

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

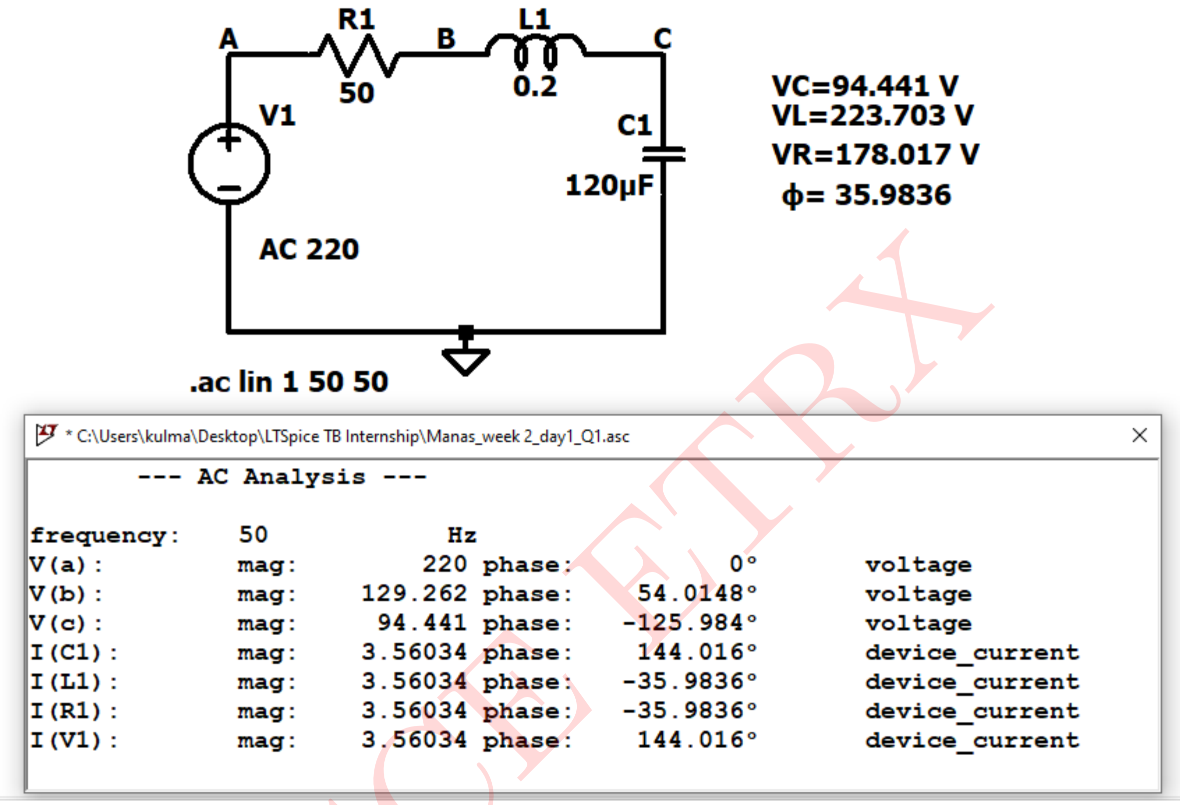



Figure 3: Circuit Schematic and Simulated Results



**Comparison of calculated and simulated values:**

| Parameter | Calculated Value | Simulated Value |
|---|---|---|
| $I$ | 3.5604A | 3.56034A |
| $V_R$ | 178.02V | 178.017V |
| $V_L$ | 223.7067V | 223.703V |
| $V_C$ | 94.4425V | 94.441V |
| $\phi$ | 35.98° | 35.98° |
| Power Factor | 0.809 | 0.8092 |

Table 1: Numerical 1

**Numerical 2**: A voltage V = 100 sin(314)t is applied to a circuit consisting of a 27Ω resistor and an 90$\mu$F capacitor in series. Determine :
(a) an expression for the value of the current flowing at any instant
(b) $V_R$ and $V_C$
(c) Power factor

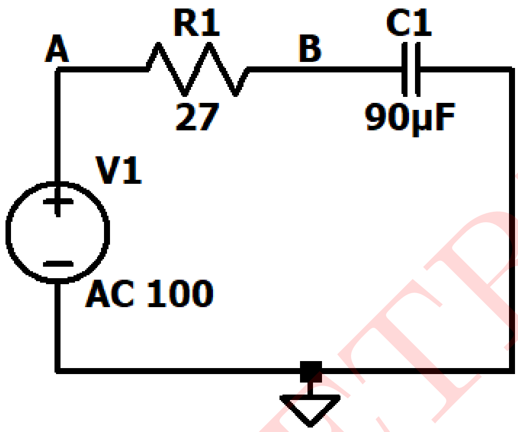



Figure 4: Circuit 2

**Solution:**

Comparing the given equation for voltage V = 100 sin(314)t with the standard equation for a sinusoidal voltage $v = V_m \sin(2\pi f)t$, we get
$V_m = V_1 = 100$V and $f = 50$ Hz

The Capacitive Reactance is given by:
$$X_C = \frac{1}{2\pi f C_1} = \frac{1}{2\pi \times 50 \times 90 \times 10^{-6}}$$
$\therefore$ X$_C$ = 35.3678Ω

Total Impedance of the circuit is given by:
$$Z = \sqrt{R_1^2 + (X_C)^2} = \sqrt{27^2 + (35.3678)^2}$$
$\therefore$ Z = 44.4959Ω

The total current ($I$) can be calculated as:
$$I = \frac{V_m}{Z} = \frac{100}{44.4959} = 2.2474$$
$\therefore$ I = 2.2474A

The expression for the value of current flowing at any instant will be:

**I = 2.2474 sin(314)t**

Voltages across the resistor and capacitor can be given by:

$V_R = I \times R_1 = 2.2474 \times 27 = 60.6798$

$\therefore$ V$_R = 60.6798V$

$V_C = I \times X_C = 2.2474 \times 35.3678 = 79.4856$

$\therefore$ V$_C = 79.4856V$

$$\text{Power factor} = \cos\phi = \frac{R_1}{Z} = \frac{27}{44.4959} = 0.6068$$

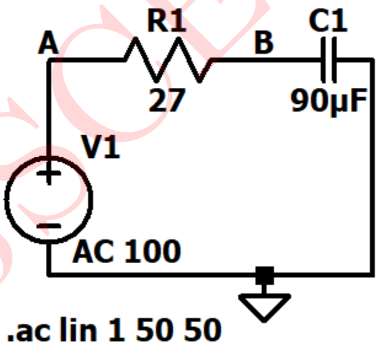
$\therefore$ **Power factor = 0.6068**

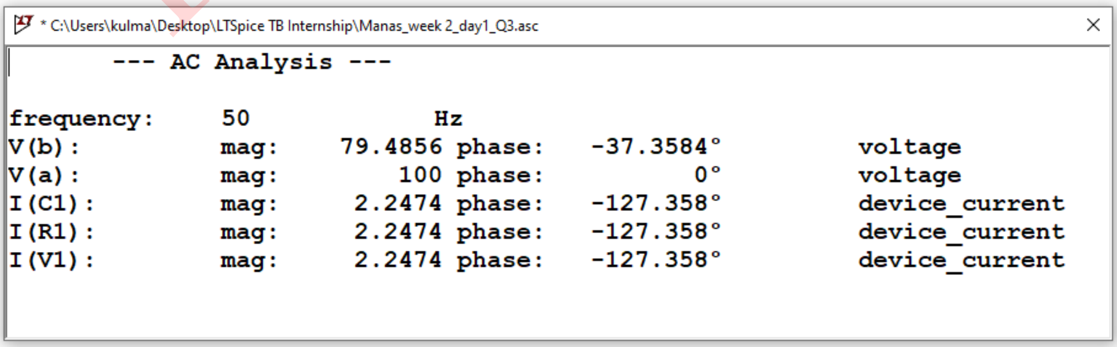
$\phi = \cos^{-1}(0.6068) = 52.6417$

$\therefore \phi = 52.6417°$

### SIMULATED RESULTS

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



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```
        --- AC Analysis ---

frequency:      50              Hz
V(b):           mag:    79.4856 phase:    -37.3584°        voltage
V(a):           mag:        100 phase:          0°         voltage
I(C1):          mag:     2.2474 phase:    -127.358°        device_current
I(R1):          mag:     2.2474 phase:    -127.358°        device_current
I(V1):          mag:     2.2474 phase:    -127.358°        device_current
```

Figure 5: Circuit Schematic and Simulated Results

**Comparison of calculated and simulated values:**

| Quantity | Calculated Value | Simulated Value |
|---|---|---|
| $I$ | 2.2474A | 2.2474A |
| $V_R$ | 135.113V | 135.108V |
| $V_C$ | 79.4856V | 79.4856V |
| $\phi$ | 25.8419° | 25.747° |
| Power Factor | 0.9 | 0.9 |

Table 2: Numerical 2

**Numerical 3**: A circuit consists of resistance of 45Ω, an inductance of 34mH and a capacitor of 50$\mu$F are connected in parallel across a 110V, 50Hz supply.
Calculate:

i) Individual currents drawn by each element of Circuit 3

ii) Total current drawn from the supply

iii) Overall power factor of the circuit

iv) Draw the phasor diagram

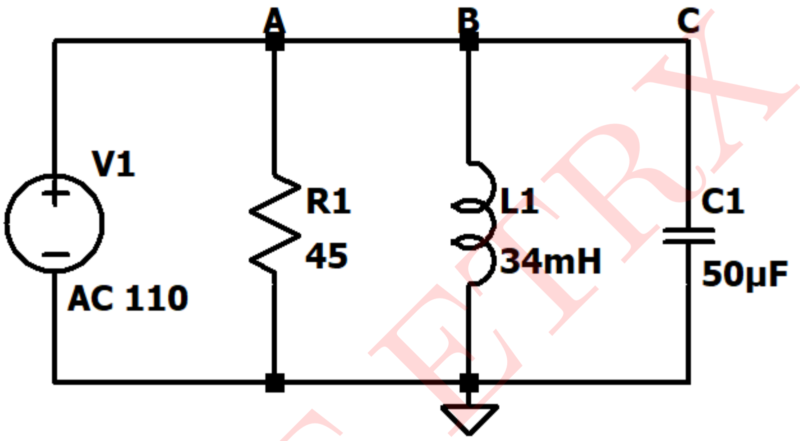



Figure 6: Circuit 3

**Solution:**

Given:

$R_1 = 45\Omega,\ L_1 = 34mH = 34 \times 10^{-3}H,\ C_1 = 50\mu F = 50 \times 10^{-6}F,\ f = 50Hz,\ V_1 = 110V$

The reactances for the inductor $L$ and the capacitor $C$ are given by:

$X_L = 2\pi f L_1 = 2\pi \times 50 \times 34 \times 10^{-3} = 10.6814\Omega$

$\therefore \mathrm{X}_L = 10.6814\Omega$

$$X_C = \frac{1}{2\pi f C_1} = \frac{1}{2\pi \times 50 \times 50 \times 10^{-6}} = 63.662\Omega$$

$\therefore \mathrm{X}_C = 63.662\Omega$

As the circuit is a RLC parallel circuit, the voltage across the entire circuit is same

So, the individual currents drawn by each element can be calculated using Ohm's Law

$$I_R = \frac{V_1}{R_1} = \frac{110}{45} = 2.44A$$

$$I_L = \frac{V_1}{X_L} = \frac{110}{10.6814} = 10.2983A$$

$$I_C = \frac{V_1}{X_C} = \frac{110}{69.512} = 1.7279A$$

The total current in the circuit can be expressed as: $I = \sqrt{I_{R_1}^2 + (I_{L_1} - I_{C_1})^2}$

$\therefore$ I $= \sqrt{45^2 + (10.2983 - 1.7279)^2} = 8.911$

$\therefore$ $\mathbf{I = 8.911A}$

Power factor can be expressed as:

$$\text{Power factor} = \cos(\phi) = \frac{G}{Y} = \frac{Z}{R} = \frac{\frac{V}{I}}{\frac{V}{I_{R_1}}} = \frac{I_{R_1}}{I} = \frac{2.44}{8.911} = 0.2738$$

$\therefore$ **Power factor = 0.2738**

$\therefore$ $\phi = \cos^{-1}(0.2738) = 74.109°$

$\therefore$ $\phi = 74.109°$

Voltage Phasor diagram

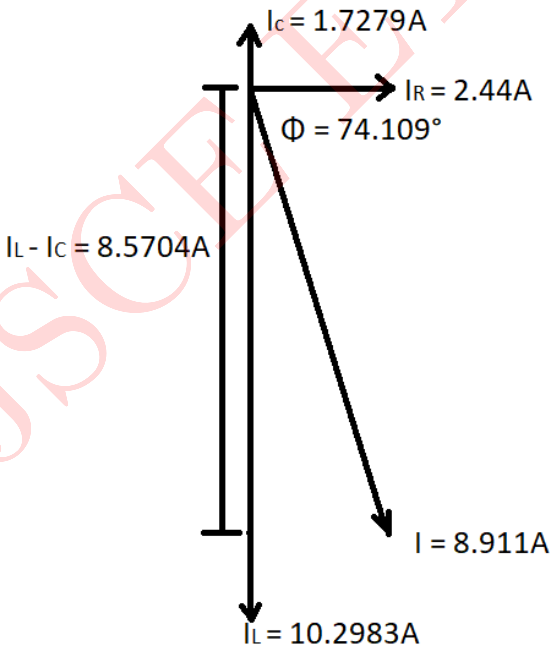



Figure 7: Voltage Phasor diagram

### SIMULATED RESULTS

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

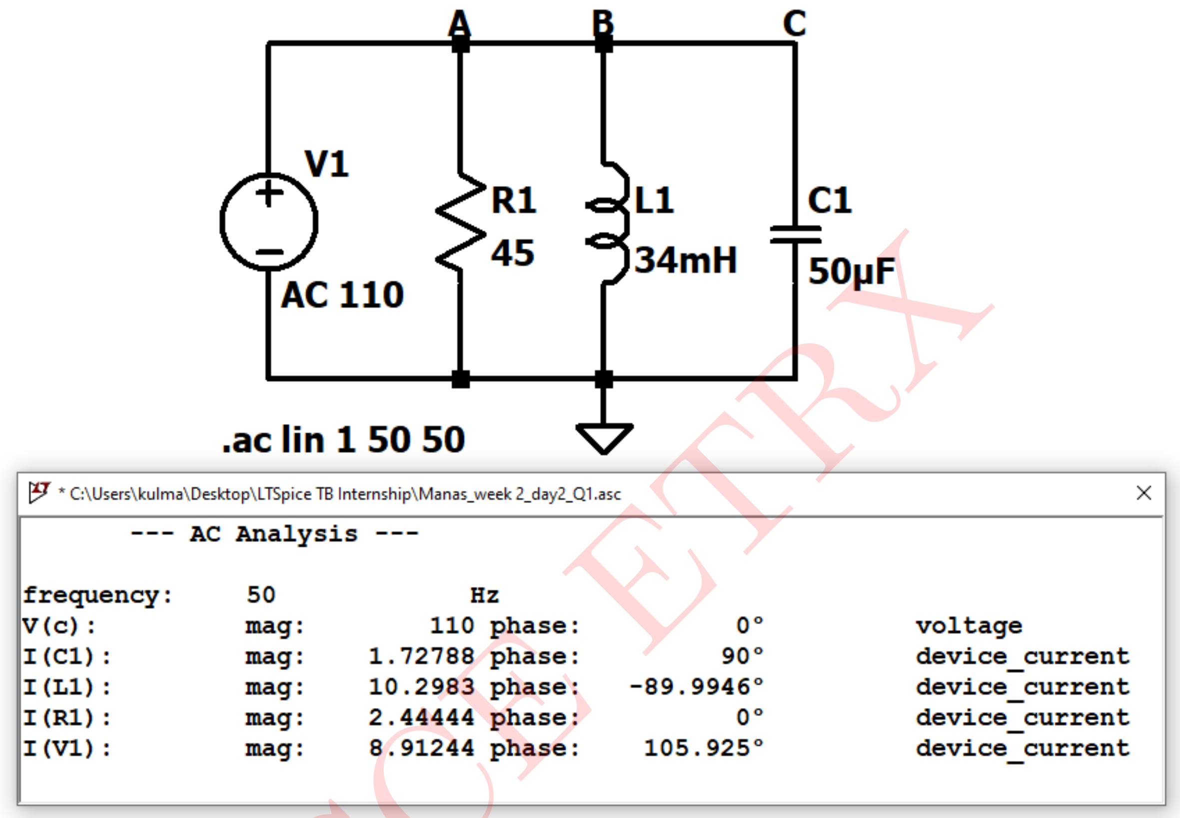



Figure 8: Circuit Schematic and Simulated Results

**Comparison of calculated and simulated values:**

| Parameter | Calculated Value | Simulated Value |
|---|---|---|
| $I$ | 8.911A | 8.9124A |
| $I_R$ | 2.44A | 2.44A |
| $I_L$ | 10.2983A | 10.2983A |
| $I_C$ | 1.7279A | 1.72788A |
| $\phi$ | 74.109° | 74.109° |
| Power Factor | 0.2738 | 0.2738 |

Table 3: Numerical 3

**Numerical 4**: Find I, $I_1$ and $I_2$ and V in the Circuit 4,
If $R_1 = 15\Omega, L_1 = j12\Omega, R_2 = 20\Omega, L_2 = j10\Omega, R_3 = 20\Omega, C_1 = -j8\Omega$

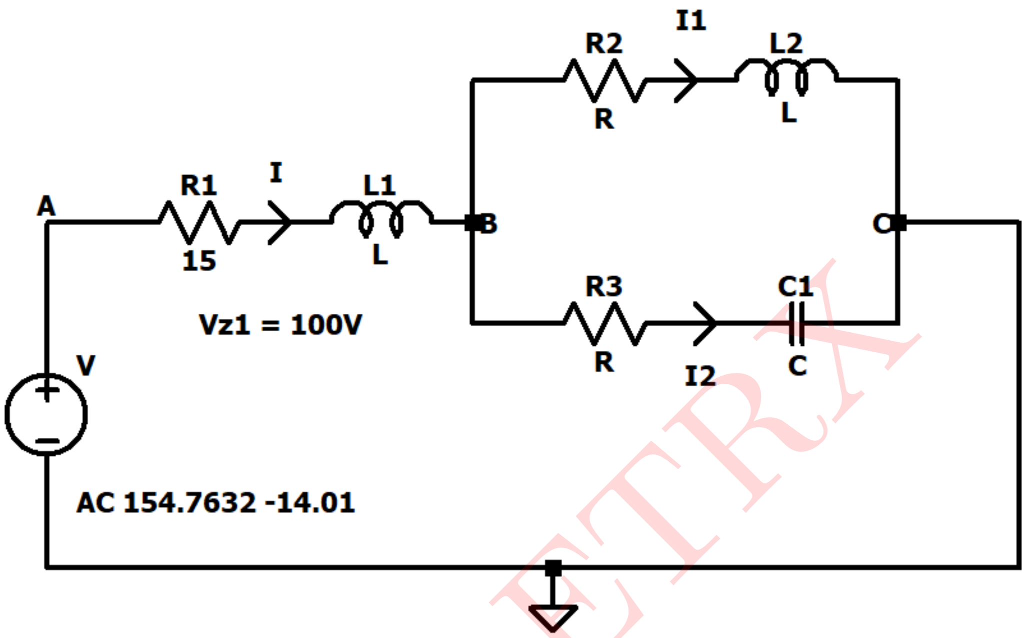



Figure 9: Circuit 4

**Solution:**

From the given data, the equations for $Z_1, Z_2$ and $Z_3$ can be written as:
$Z_1 = 15 + j12, Z_2 = 20 + j10, Z_3 = 20 - j8$

The total impedance($Z$) of the network is given by:

$$Z = Z_1 + \frac{Z_2 \times Z_3}{Z_2 + Z_3}$$

$$\therefore \text{ Z} = (15 + \text{j}12) + \frac{(20 + j10) \times (20 - j8)}{(20 + j10) + 20 - j8)}$$

$$\therefore \text{ Z} = 27.02 + \text{j}12.399$$

$$\therefore \text{ Z} = (29.729\angle 24.65)\Omega$$

The total current ($I$) can be calculated using Ohm's Law as:

$$I = \frac{V_1}{Z_1} = \frac{100}{15 + j12} = 2.2474$$

$$\therefore \text{I} = 4.065 \text{ - j}3.252$$

$$\therefore \text{I} = (5.2057\angle - 38.66)A$$

The value of voltage V can be calculated as:

$V = I \times Z = (5.2057\angle-38.66) \times (29.729\angle 24.65) = 154.76\angle-14.01$

$\therefore$ V $= (154.76\angle-14.01)$

$\therefore$ **V = 154.76V**

To find the branch currents $I_1$ and $I_2$, we use Current Division Rule

$$I_1 = I \times \frac{Z_3}{Z_2 + Z_3}$$

$$\therefore \mathrm{I}_1 = (5.2057\angle-38.66) \times \frac{20 - j8}{(20 + j10) + (20 - j8)}$$

$\therefore$ $\mathrm{I}_1 = 2.799\angle-63.324$

$\therefore$ $\mathrm{I}_1 = 2.799A$

$$I_2 = I \times \frac{Z_2}{Z_2 + Z_3}$$

$$\therefore \mathrm{I}_2 = (5.2057\angle-38.66) \times \frac{20 + j10}{(20 + j10) + (20 - j8)}$$

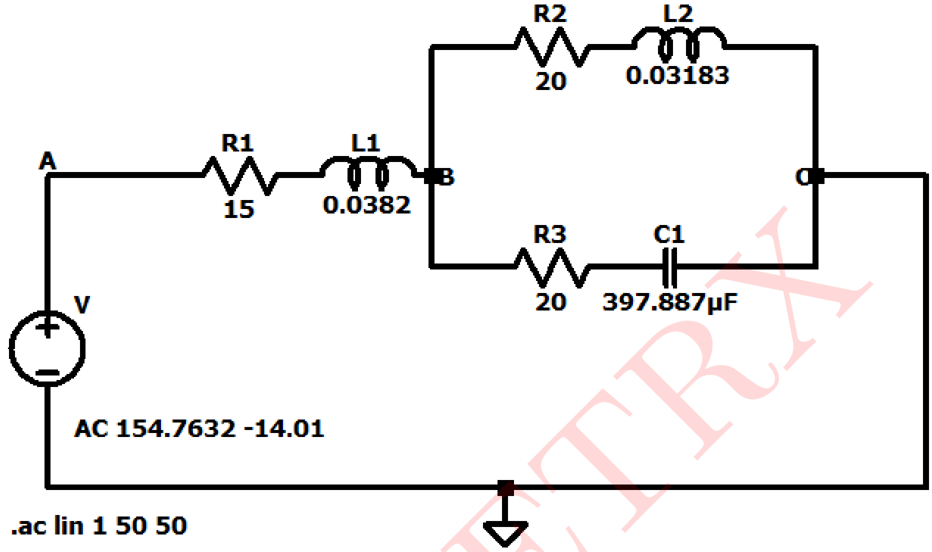
$\therefore$ $\mathrm{I}_2 = 2.9064\angle-14.957$

$\therefore$ $\mathrm{I}_2 = 2.9064A$

The values of the currents I, $I_1$ and $I_2$ and the voltage V are 5.2057A, 2.799A, 2.9064A and 154.76V respectively.

## SIMULATED RESULTS

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

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       --- AC Analysis ---

frequency:      50              Hz
V(n002):        mag:   89.9009 phase:    7.22829°        voltage
V(a):           mag:   154.763 phase:     -14.01°        voltage
V(n001):        mag:   27.9964 phase:    26.6712°        voltage
V(b):           mag:   62.6058 phase:   -36.7599°        voltage
V(n003):        mag:   23.2512 phase:   -104.958°        voltage
I(C1):          mag:    2.9064 phase:    165.042°        device_current
I(L2):          mag:   2.79972 phase:   -63.3231°        device_current
I(L1):          mag:   5.20558 phase:   -38.6598°        device_current
I(R3):          mag:    2.9064 phase:    165.042°        device_current
I(R2):          mag:   2.79972 phase:    116.677°        device_current
I(R1):          mag:   5.20558 phase:     141.34°        device_current
I(V):           mag:   5.20558 phase:     141.34°        device_current
```

Figure 10: Circuit Schematic and Simulated Results

**Comparison of calculated and simulated values:**

| Quantity | Calculated Value | Simulated Value |
|---|---|---|
| $I$ | 5.2057A | 5.20558A |
| $I_1$ | 2.799A | 2.79972A |
| $I_2$ | 2.9064A | 2.9064A |

Table 4: Numerical 4

**Numerical 5**: A series resonance network consisting of a resistor of 27Ω, a capacitor of 2$\mu$F and an inductor of 25mH is connected across a sinusoidal supply voltage which has a constant output of AC 9 volts 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.

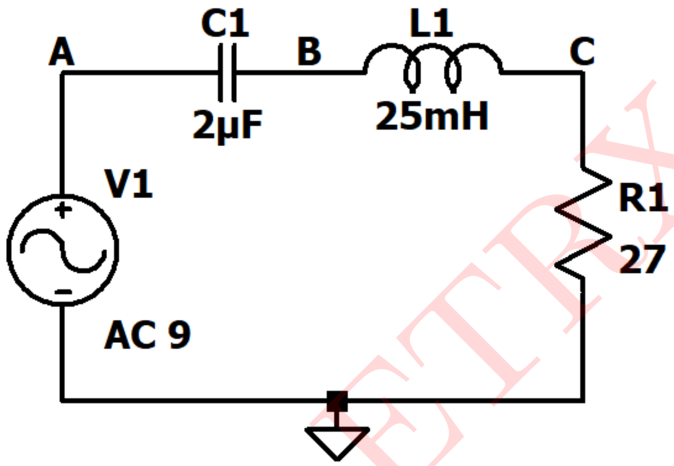


Figure 11: Circuit 5

**Solution:**

Given: $R_1 = 27\Omega, C_1 = 2\mu F, L_1 = 25mH, V_1 = 9V$

Finding Resonant Frequency,

$$f_r = \frac{1}{2\pi\sqrt{L_1C_1}} = \frac{1}{2\pi\sqrt{25 \times 10^{-3} \times 2 \times 10^{-6}}}$$

$f_r = 711.7625Hz$

At resonance, $X_L = X_C$

$\therefore$ Z = R$_1$ = 27Ω

To find maximum current $I_m$, we need the value of current $I$

$$I = \frac{V_1}{Z} = \frac{9}{27}$$

$I = 0.33A$

$I_m = \sqrt{2} \times 0.33$

$I_m = 0.4243A$

$V_L = I_m \times X_L = I_m \times (2\pi fL)$

$\therefore$ V$_L$ $= 0.4243 \times 2 \times \pi \times 711.7625 \times 25 \times 10^{-3}$

$\therefore$ V$_L$ $= 52.7046V$

Since the circuit is at resonance, $V_L = V_C$

$\therefore V_L = V_C = 52.7046V$

$$\text{Quality factor} = Q = \frac{1}{R} \times \sqrt{\frac{L_1}{C_1}} = \frac{1}{27} \times \sqrt{\frac{25 \times 10^{-3}}{2 \times 10^{-6}}} = 4.1409$$

**Q = 4.1409**

$$\text{Bandwidth (B.W)} = \frac{R_1}{2 \times \pi \times L_1} = \frac{27}{2 \times \pi \times 25 \times 10^{-3}} = 171.8873$$

**Bandwidth = 171.8873Hz**

Graph for Resonance Curve

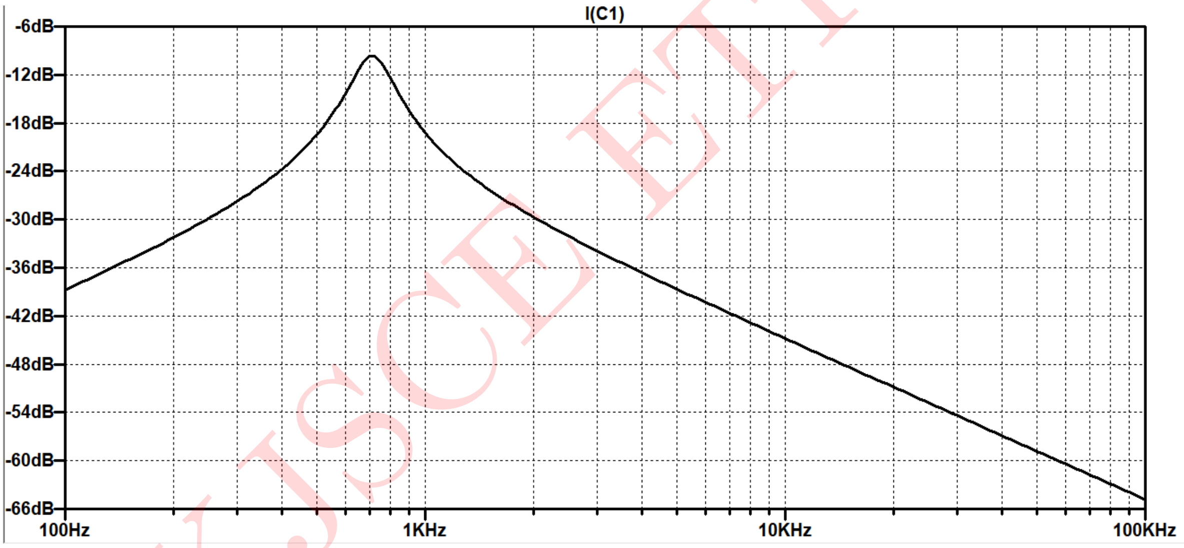


Figure 12: Resonance Curve

Graph for Current through the circuit at resonance

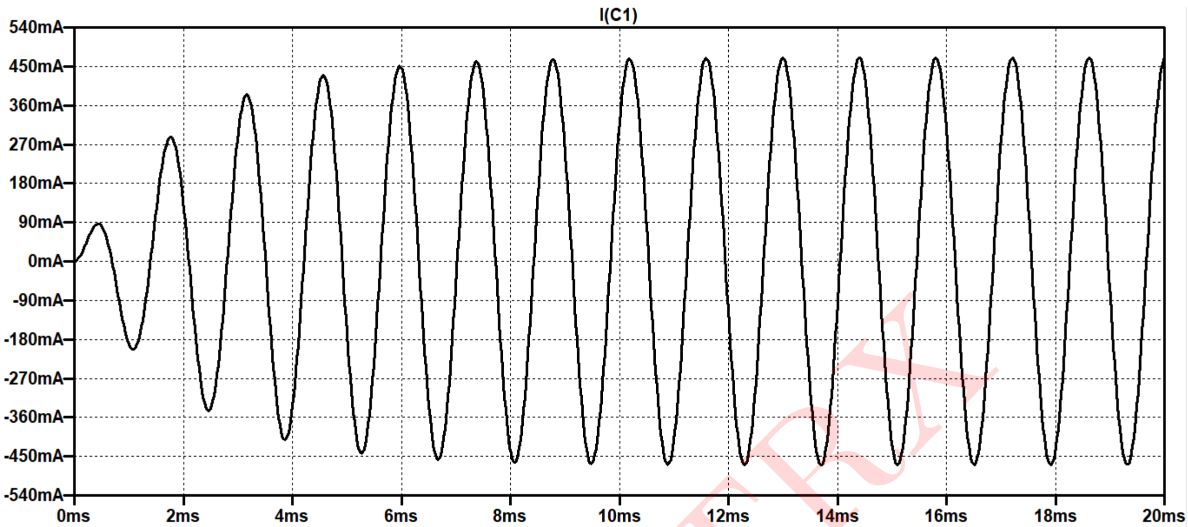


Figure 13: Current at Resonance

Graph for Voltage through Inductor and Resistor at resonance

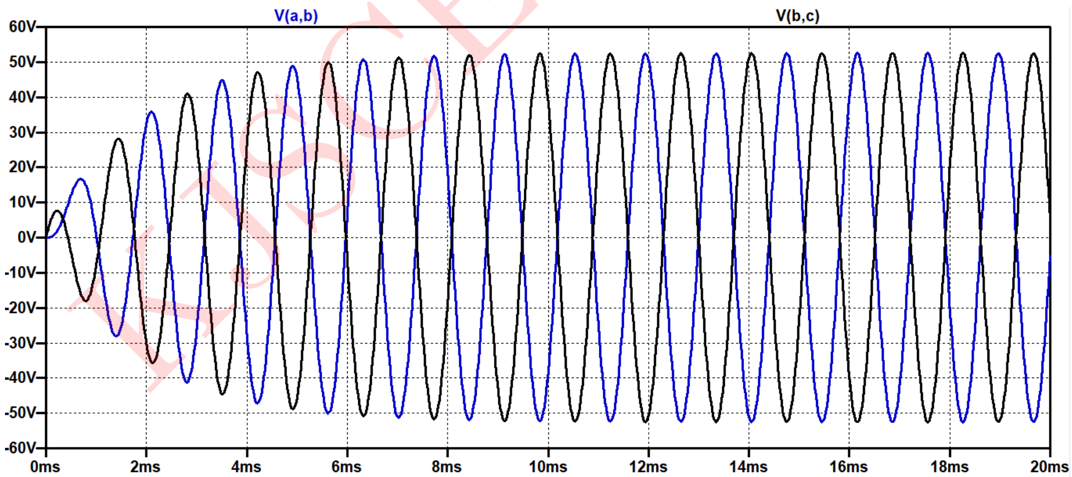


Figure 14: Voltage across Inductor and Resistor at Resonance

## SIMULATED RESULTS

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

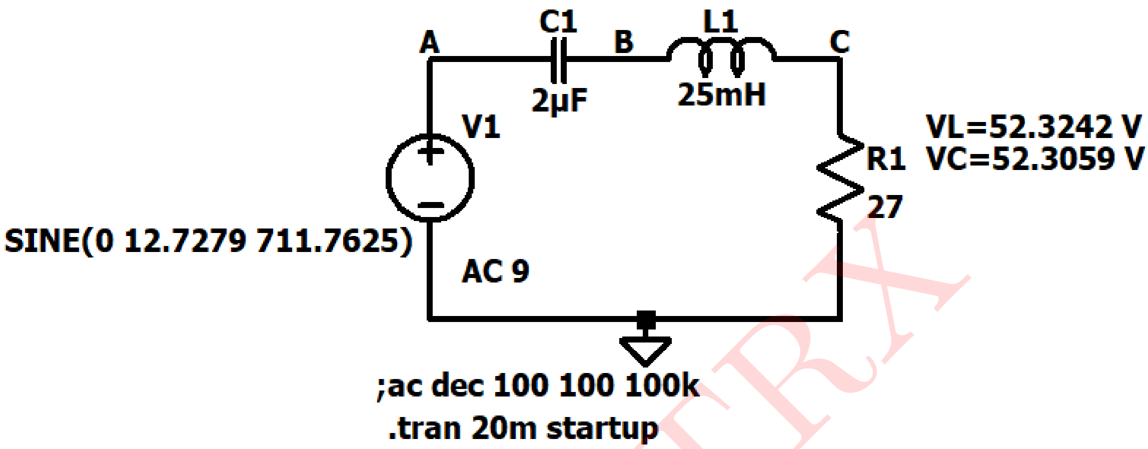


Figure 15: Circuit Schematic

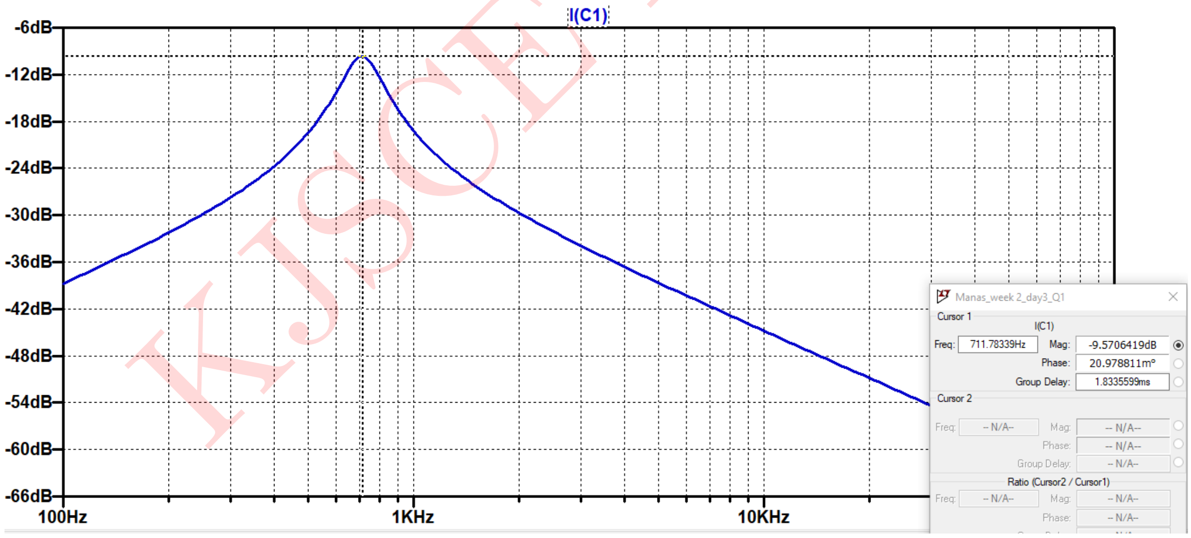


Figure 16: Simulated results for Resonance Curve

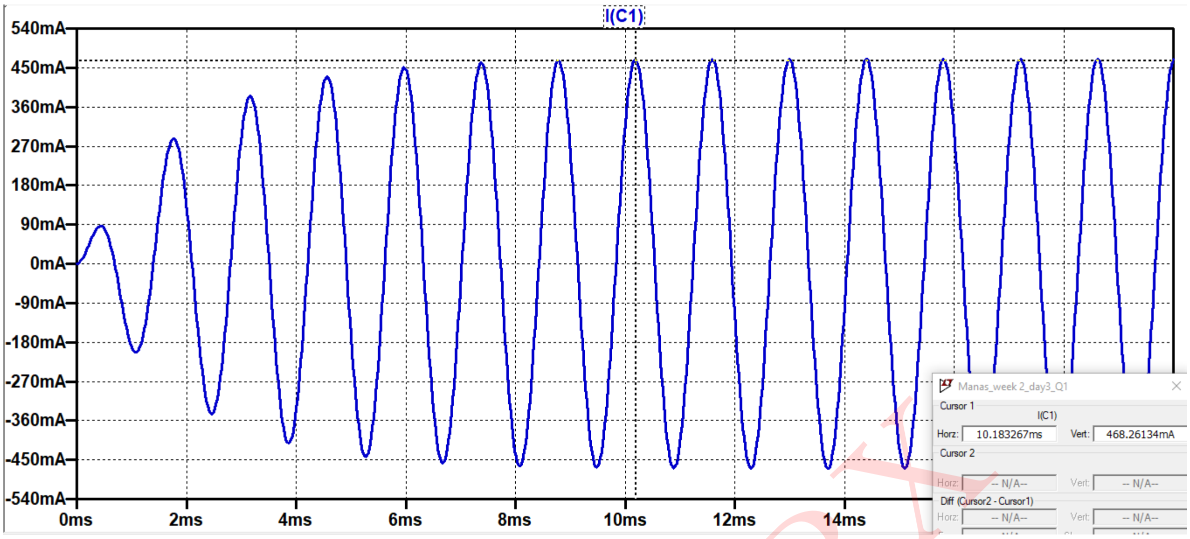


Figure 17: Simulated results for current at Resonance

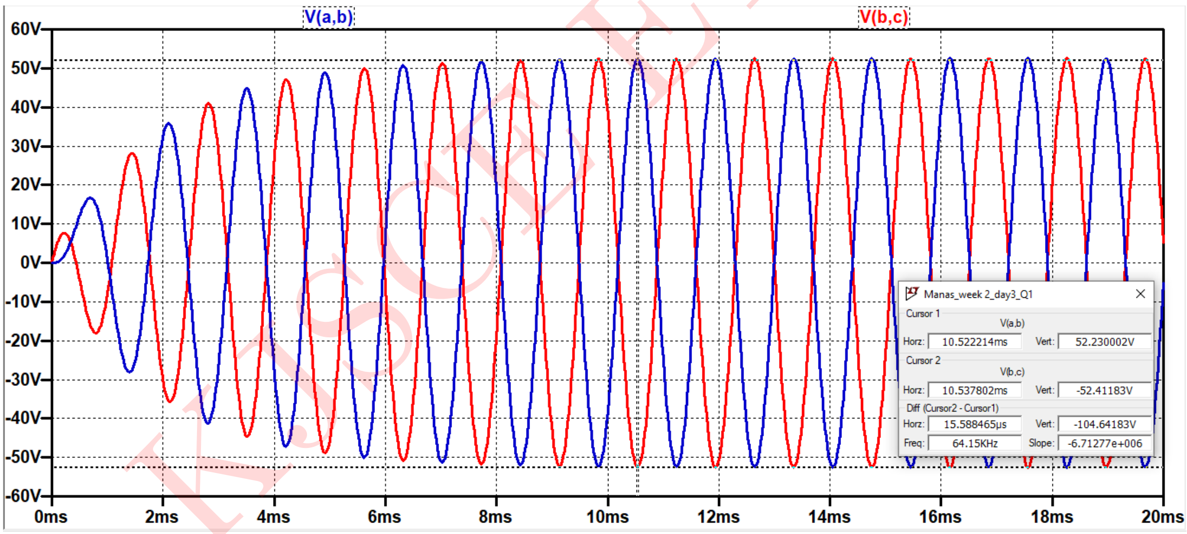


Figure 18: Simulated results for Voltage across Inductor and Resistor at Resonance

**Comparison of Calculated Values and Simulated Values:**

| Quantity | Calculated Value | Simulated Value |
|---|---|---|
| $f_r$ | 711.7625Hz | 711.78339Hz |
| $I_m$ | 0.4243A | 0.4243A |
| $V_L$ | 52.7046V | 52.3242V |
| $V_C$ | 52.7046V | 52.3059V |

Table 5: Numerical 5

**Numerical 6**: A 60Hz sinusoidal voltage V = 141 sin($\omega$t) is applied to a series R-L circuit. The values of the resistance and the inductance are 2$\Omega$ and 0.03H respectively. Determine the following:

a. Calculate the peak voltage across resistor and inductor & 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 & degrees

d. Plot input source voltage $V_S$(t) (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 & 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 & degrees

h. Calculate the power factor of the circuit.

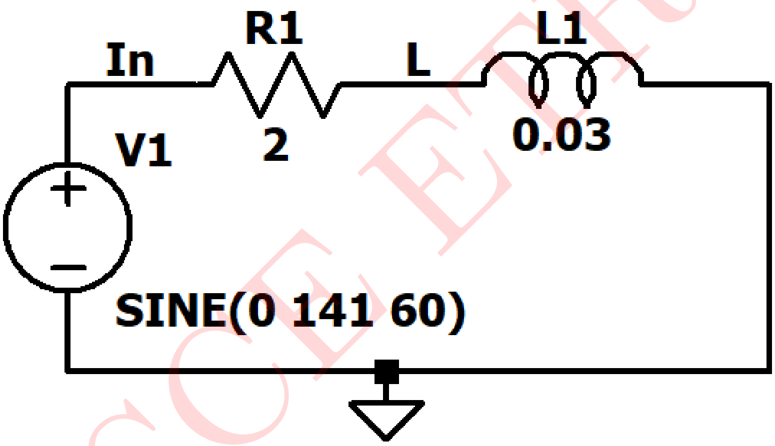


Figure 19: Circuit 6

**Solution:**

Given: $R_1 = 2\Omega,\ L_1 = 0.03H,\ V_1 = 141sin(\omega t),\ f = 60Hz$

Inductive Reactance ($X_L$) is given by:

$X_L = 2\pi f L_1 = 2\pi \times 60 \times 0.03 = 11.3097$

$\therefore$ $X_L = 11.3097\Omega$

Total Impedance (Z) of the network is given by:

$Z = R_1 + jX_L = 2 + j11.3097$

$\therefore Z = (11.4852\angle 79.9715^\circ)\Omega$

Source current $I_S$ can be calculated using Ohm's Law.

$$I_S = \frac{V_1}{Z} = \frac{141}{11.4852\angle(79.9715)}$$

$\therefore$ $I_S = (12.2767\angle - 79.9715^\circ)A$

$V_L = I_S \times X_L = (12.2767\angle-79.9715) \times 11.3097 = (138.8\angle-79.9715)$

$\therefore V_L = (138.8\angle-79.9715°)V$

$V_R = I_S \times R_1 = (12.2767\angle-79.9715) \times 2 = (24.5534\angle-79.9715)$

$\therefore V_R = (24.5534\angle-79.9715°)V$

$$\text{Power factor} = \frac{R_1}{Z} = \frac{4}{11.4852\angle 79.9715} = (0.1741\angle 79.9715)$$

$\therefore$ **Power factor = 0.1741**

$\phi = \cos^{-1}(0.1741)$

$\therefore \phi = 79.9737°$

To calculate Phase difference between the vectors, we use the equation

$$\Delta\theta = \Delta t \times \frac{360°}{T_{Period}}$$

a. For $V_S$ & $V_L$,

$\Delta\theta = 90 - 79.9737 = 10.0285°$

$$\Delta t = \frac{10.0285 \times \frac{1}{60}}{360}$$

$\Delta t = 0.4643ms$

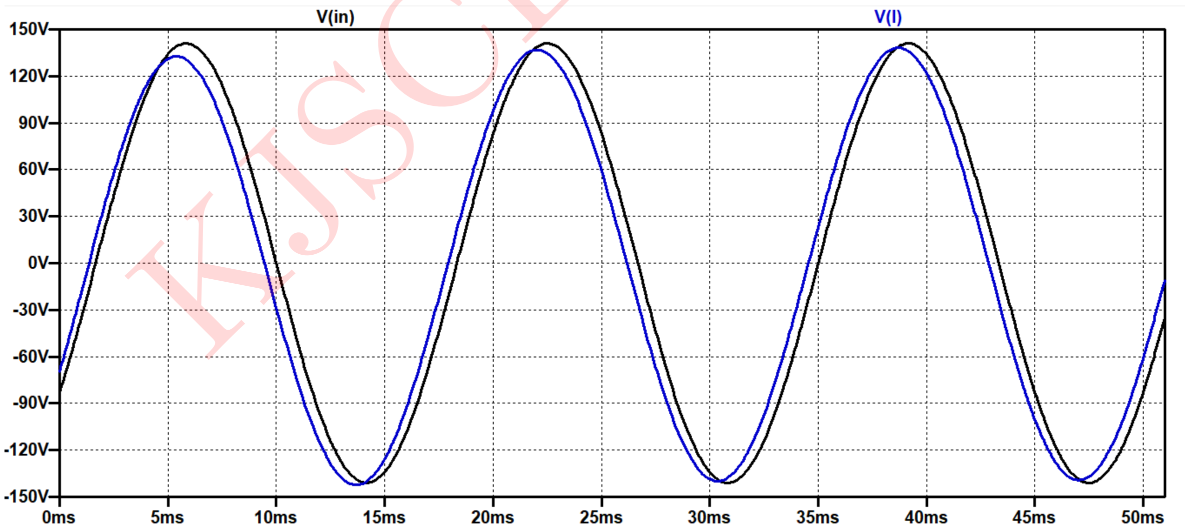


Figure 20: $V_S$ & $V_L$

b. For $V_S$ & $V_R$,

$\Delta\theta = 79.9715°$

$$\Delta t = \frac{79.9715 \times \frac{1}{60}}{360}$$

$\Delta t = 3.7ms$

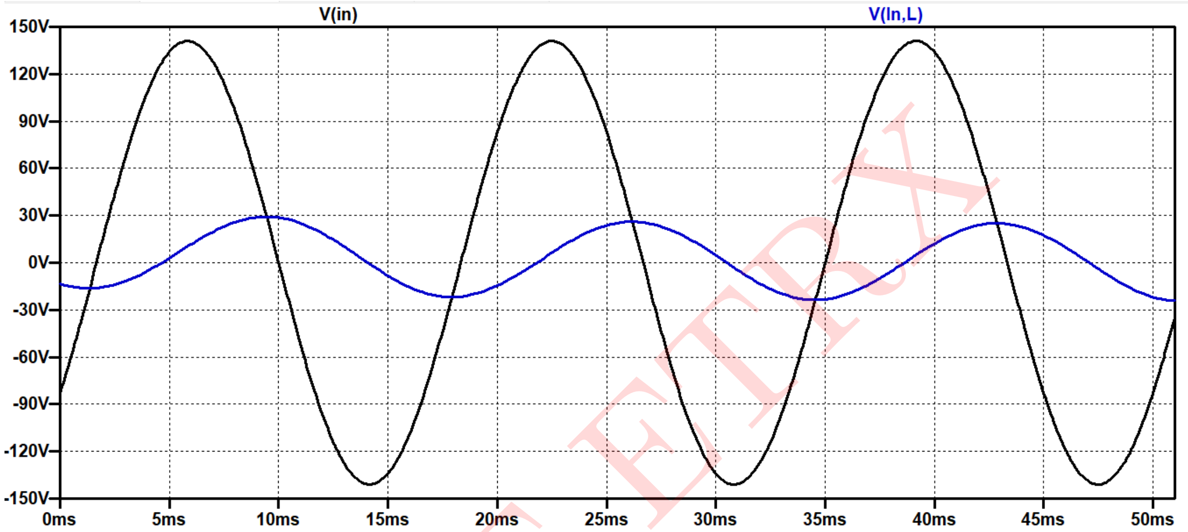


Figure 21: $V_S$ & $V_R$

c. For $V_S$ & $I_S$,

$\Delta\theta = 180 - 79.9715 = 100.0285°$

$$\Delta t = \frac{100.0285 \times \frac{1}{60}}{360}$$

$\Delta t = 4.6309ms$

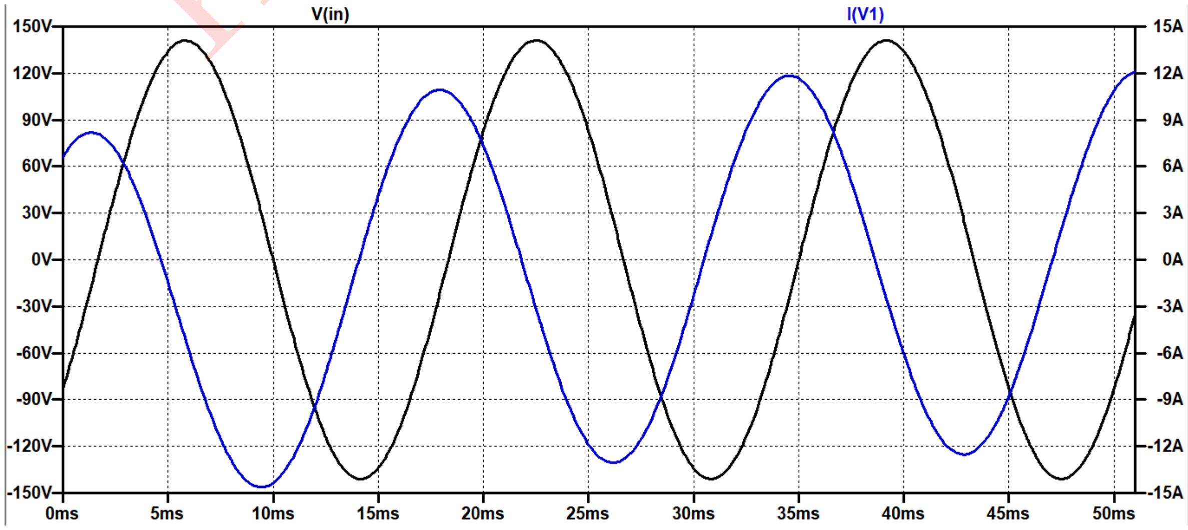


Figure 22: $V_S$ & $I_S$

## SIMULATED RESULTS

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

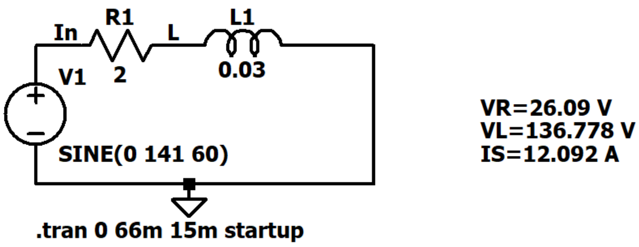


Figure 23: Circuit Schematic

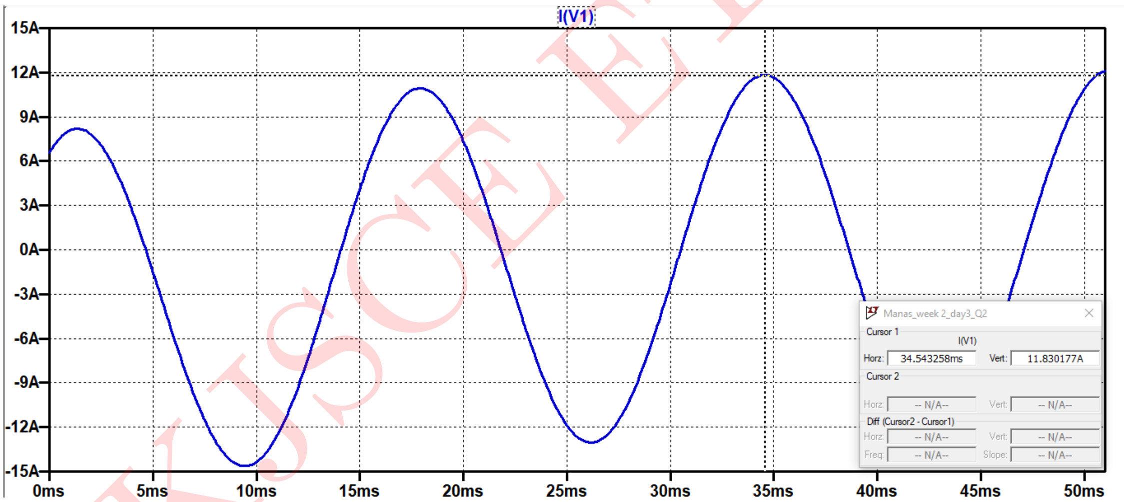


Figure 24: Simulated results for Source Current

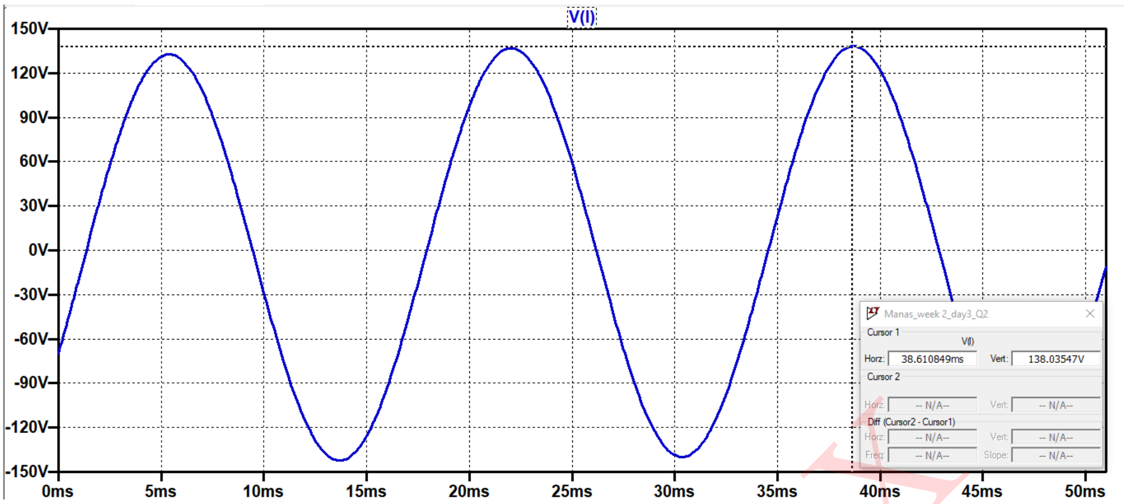


Figure 25: Simulated results for Voltage across Resistor

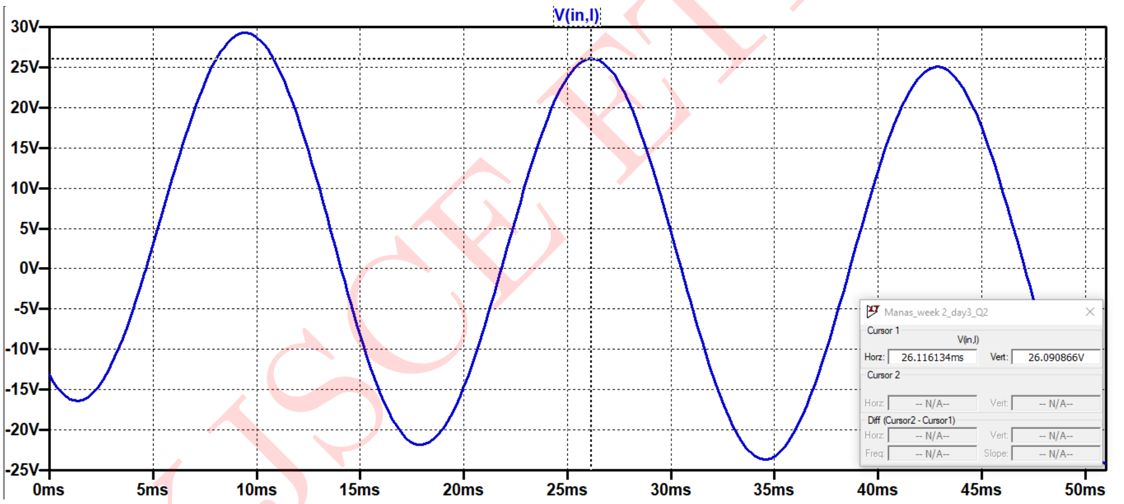


Figure 26: Simulated results for Voltage across Inductor

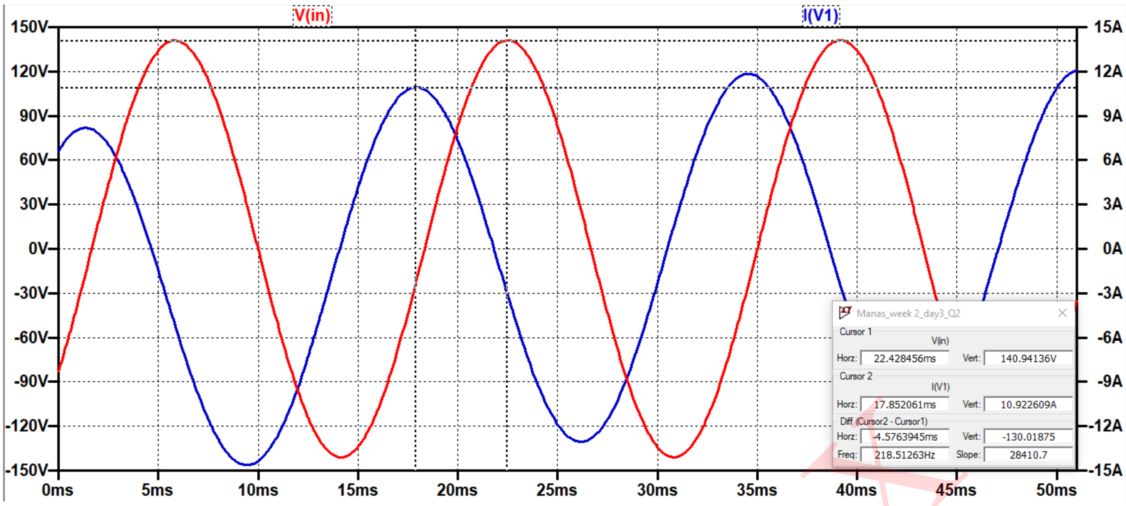


Figure 27: Simulated results for $V_S$ & $I_S$

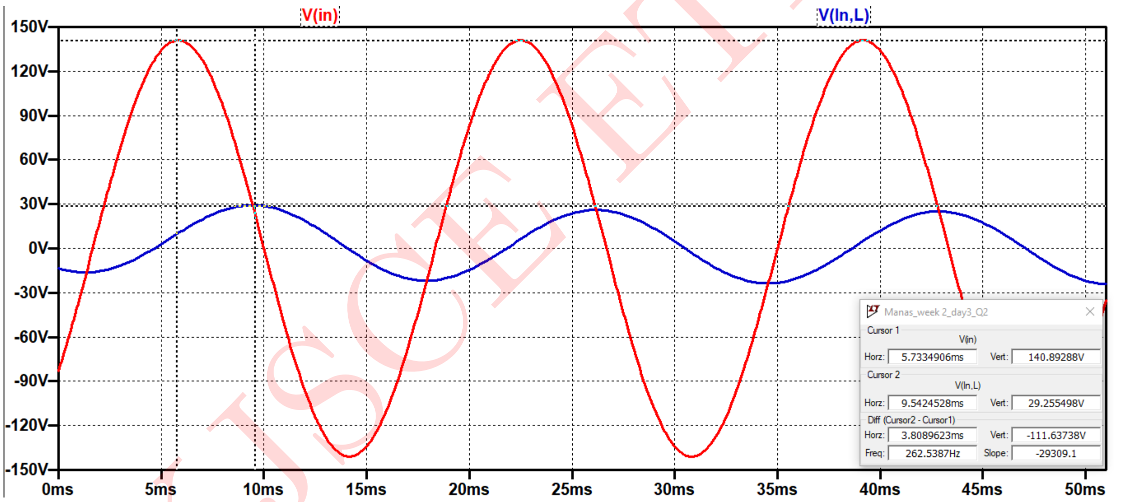


Figure 28: Simulated results for $V_S$ & $V_R$

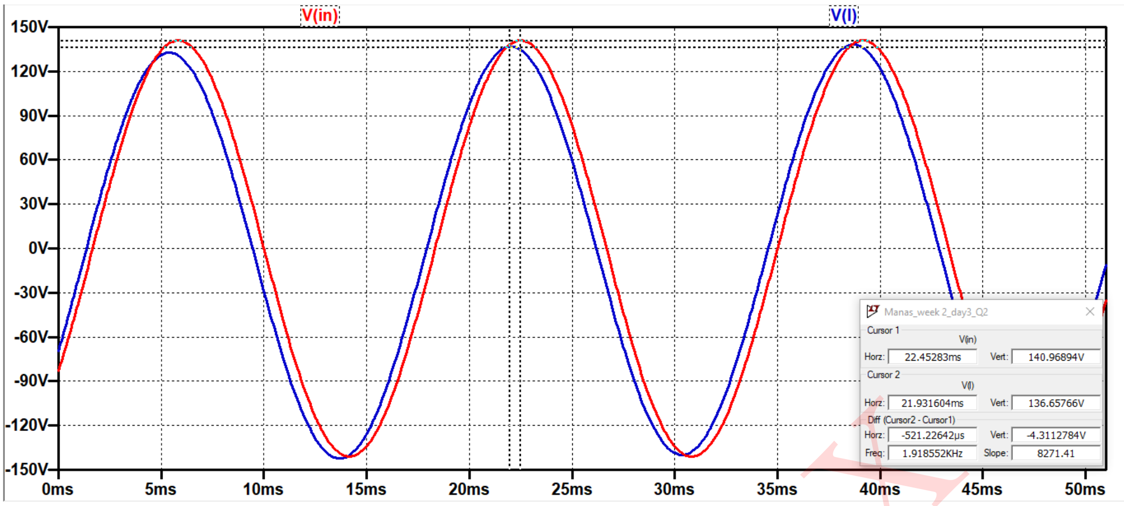


Figure 29: Simulated results for $V_S$ & $V_L$

**Comparison of Calculated Values and Simulated Values:**

| Quantity | Calculated Value | Simulated Value |
|---|---|---|
| $V_R$ | 24.5534V | 26.09V |
| $V_L$ | 138.88V | 136.778V |
| $I_S$ | 12.2767A | 12.092A |
| $\Delta\theta$ & $\Delta t$ for $V_S$ & $V_R$ | 79.9715° & 3.7$ms$ | 79.4102° & 3.6764$ms$ |
| $\Delta\theta$ & $\Delta t$ for $V_S$ & $V_L$ | 10.0285° & 0.4643$ms$ | 10.25° & 0.474$ms$ |
| $\Delta\theta$ & $\Delta t$ for $V_S$ & $I_S$ | 100.0285° & 4.6309$ms$ | 100.615° & 4.658$ms$ |

Table 6: Numerical 6

**Numerical 7**: A pure resistance of 35 ohms is in series with a pure capacitance of 80uF. The series combination is connected across 100V, 60 Hz supply.

Determine the following:

a. Calculate the peak voltage across resistor and capacitor & 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 & 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 & degrees

f. Plot input source voltage $V_S$(t) vs voltage across capacitor $V_C$(t) in LTspice

g. Measure the phase delay/difference between $V_S$(t) vs $V_C$(t) in time & degrees

h. Calculate the power factor of the circuit.

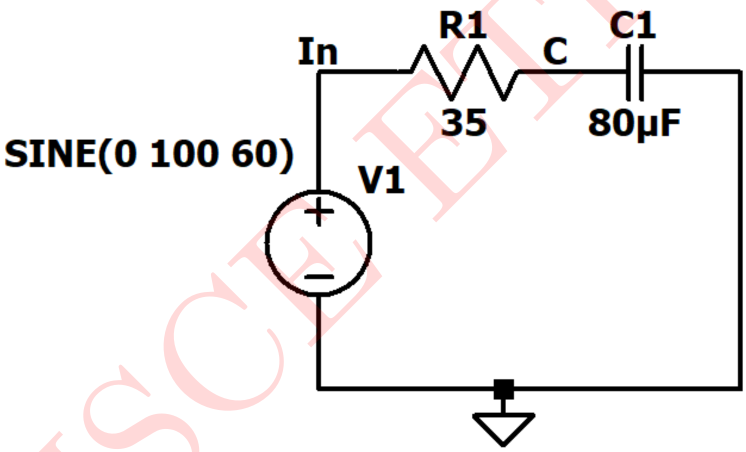


Figure 30: Circuit 7

Capacitive Reactance $X_C$ is given by:

$$X_C = \frac{1}{2\pi f C_1} = \frac{1}{2\pi \times 60 \times 80 \times 10^{-6}} = 33.1573$$

$\therefore$ X$_C$ = 33.1573$\Omega$

The Total Impedance(Z) of the circuit is given by:

$$Z = R_1 + jX_C = 35 + j33.1573 = (59.8856\angle 20.7531)$$

$\therefore$ Z = $(59.8856\angle 20.7531°)\Omega$

Source current $I_S$ can be calculated using Ohm's Law

$$I_S = \frac{V_1}{Z} = \frac{100}{59.8856\angle 20.7531} = (2.0742\angle -43.4513)$$

$I_S = (2.0742\angle -43.4513°)A$

$V_R = I_S \times R_1 = (2.0742\angle - 43.4513) \times 35 = (72.597\angle - 43.4513)$

$\therefore$ V$_R = (72.597\angle - 43.4513°)V$

$V_L = I_S \times X_C = (2.0742\angle - 43.4513) \times 33.1573 = (68.7749\angle - 43.4513)$

$\therefore$ V$_L = (68.7749\angle - 43.4513°)V$

Power factor $= \dfrac{V_R}{V_1} = \dfrac{72.597\angle - 43.4513}{100}$

$\therefore$ **Power factor = 0.72597**

To calculate Phase difference between the vectors, we use the equation

$$\Delta\theta = \Delta t \times \frac{360°}{T_{Period}}$$

a. For $V_S$ & $V_R$,

$\Delta\theta = 43.4513°$

$$\Delta t = \frac{43.4513 \times \dfrac{1}{60}}{360}$$

$\Delta t = 2.0116ms$

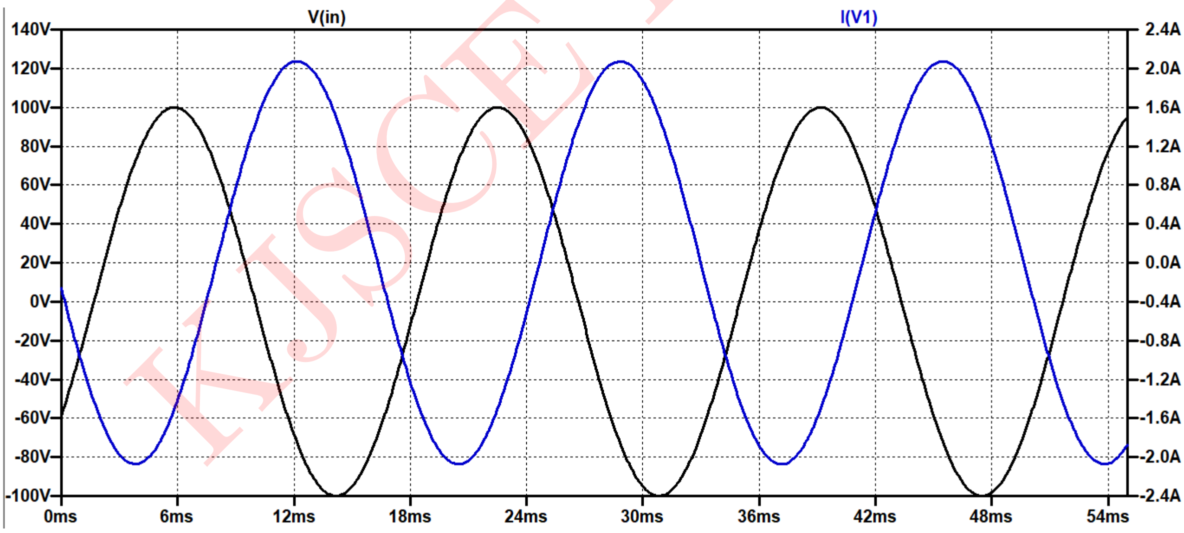


Figure 31: $V_S$ & $V_R$

b. For $V_S$ & $V_C$,

$\Delta\theta = 90 - 43.4513 = 46.5487°$

$$\Delta t = \frac{\Delta\theta \times (T_{Period})}{360°} = \frac{46.5487 \times \frac{1}{60}}{360}$$

$\Delta t = 2.155ms$

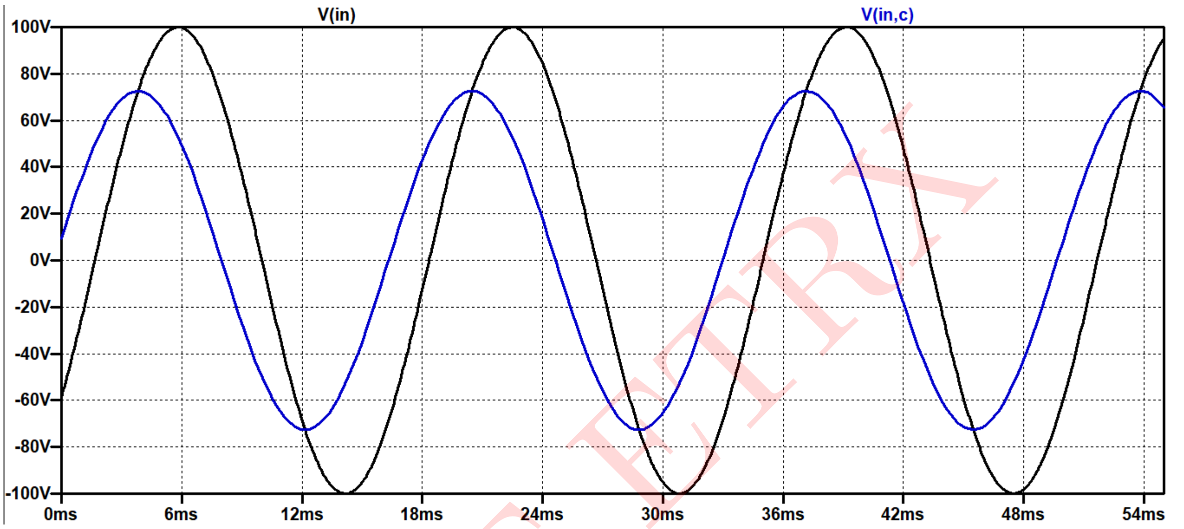


Figure 32: $V_S$ & $V_C$

c. For $V_S$ & $I_S$,

$\Delta\theta = 180 - 43.4513 = 136.5487°$

$$\Delta t = \frac{136.5487 \times \frac{1}{60}}{360}$$

$\Delta t = 6.3217ms$

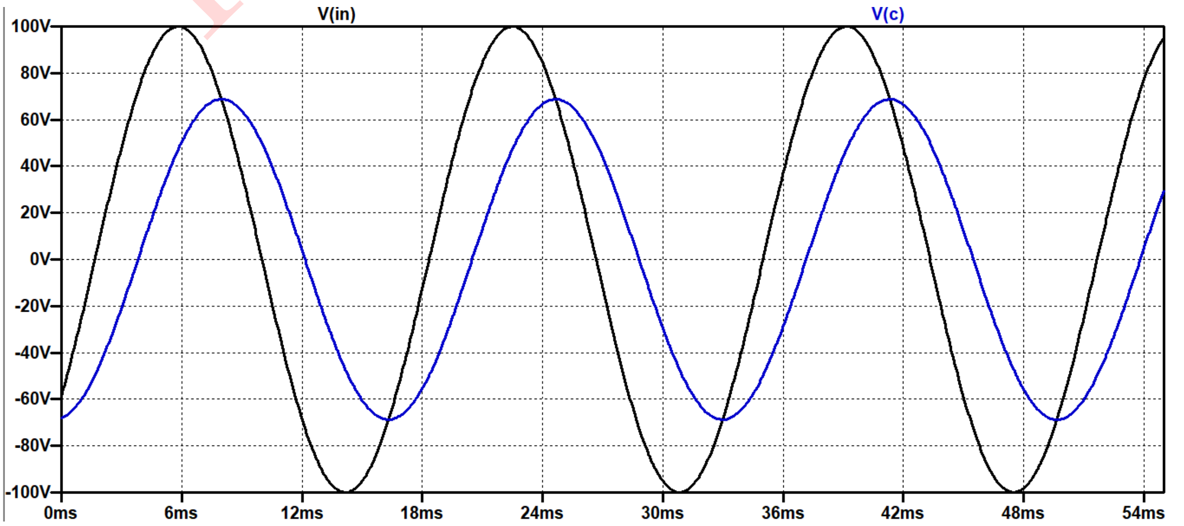


Figure 33: $V_S$ & $I_S$

## SIMULATED RESULTS

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

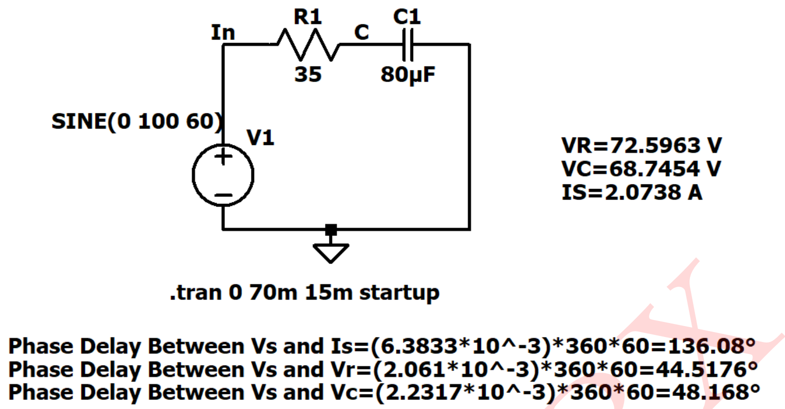


Figure 34: Circuit Schematic

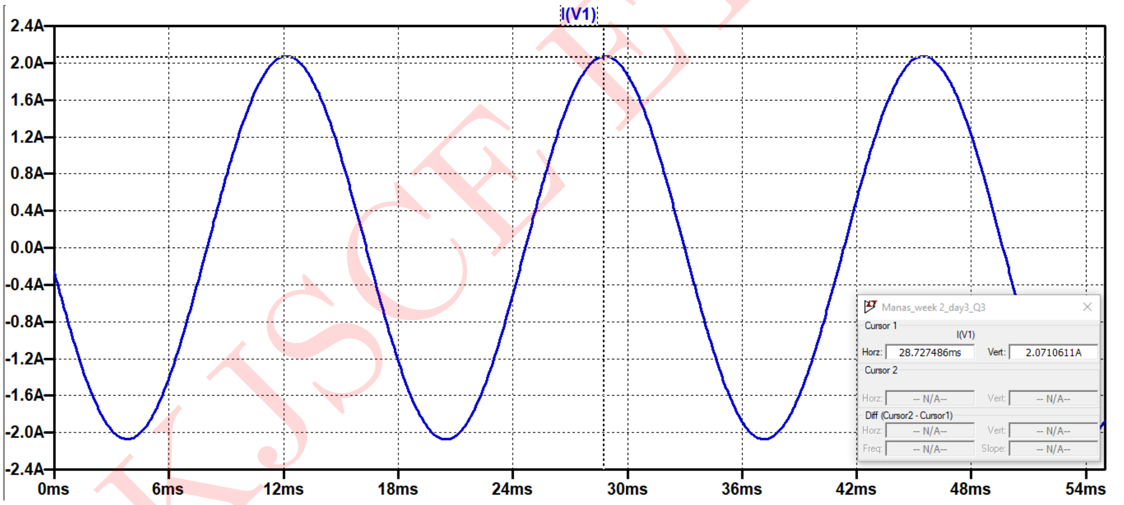


Figure 35: Simulated results for Source Current

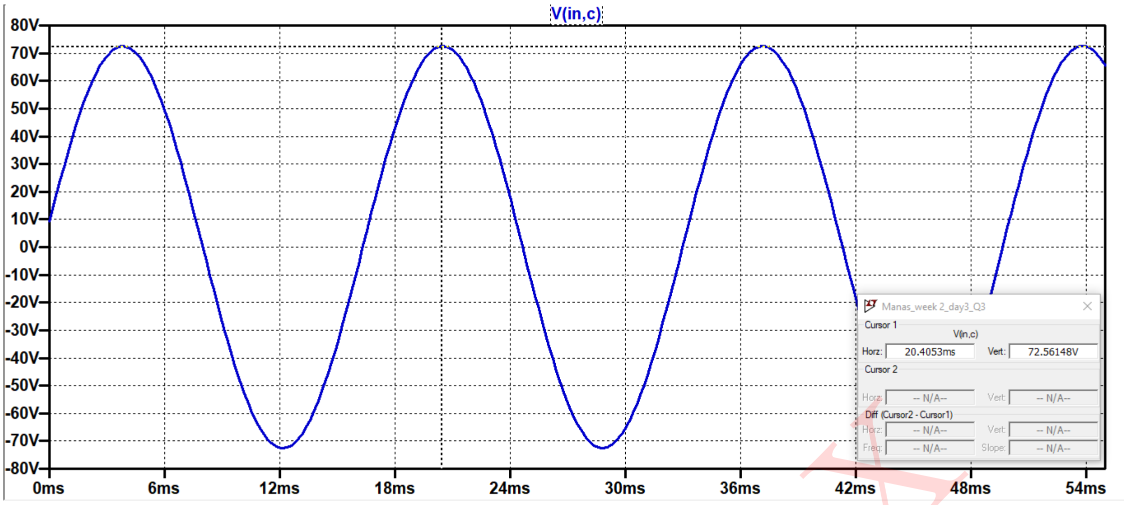


Figure 36: Simulated results for Voltage across Resistor

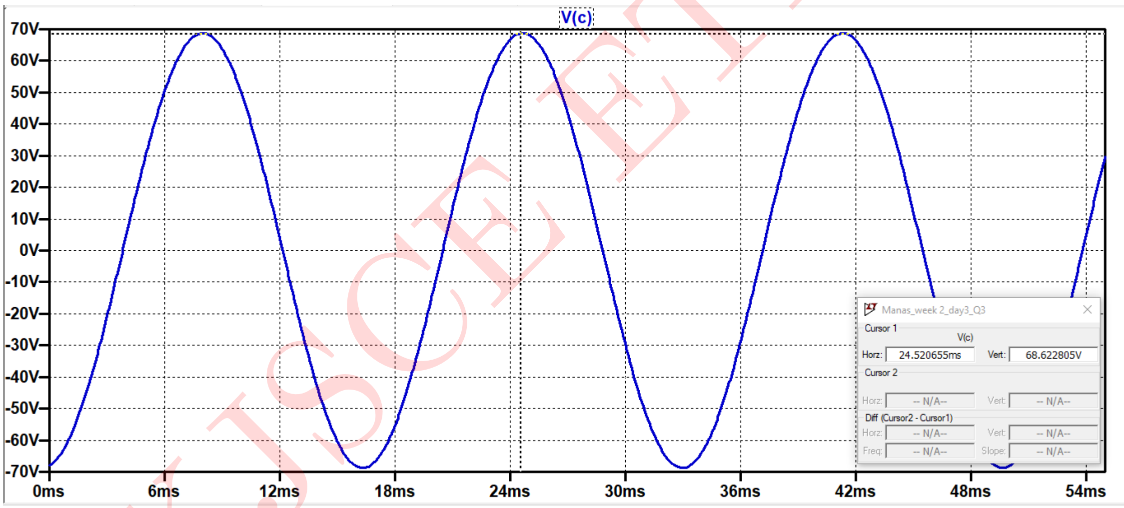


Figure 37: Simulated results for Voltage across Capacitor

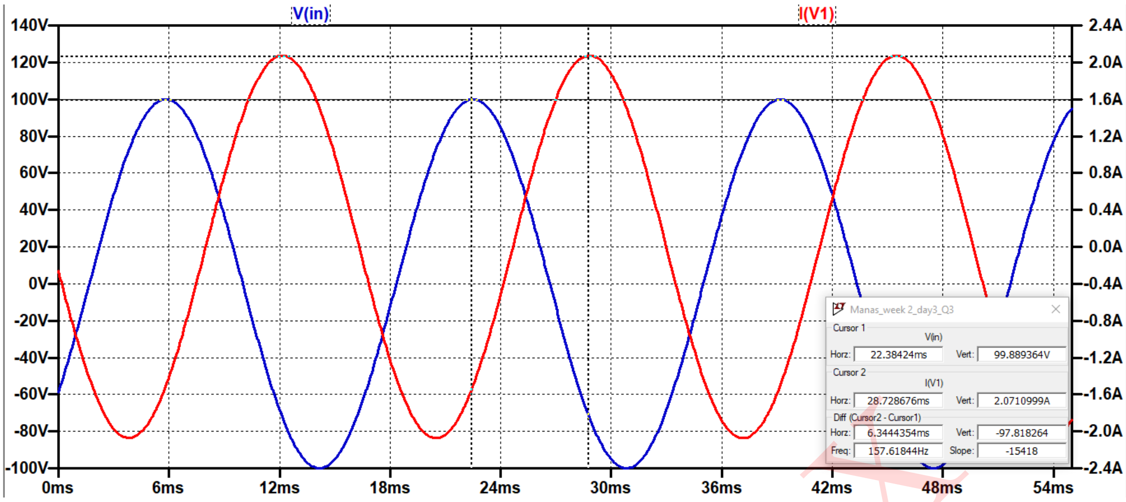


Figure 38: Simulated results for $V_S$ & $I_S$

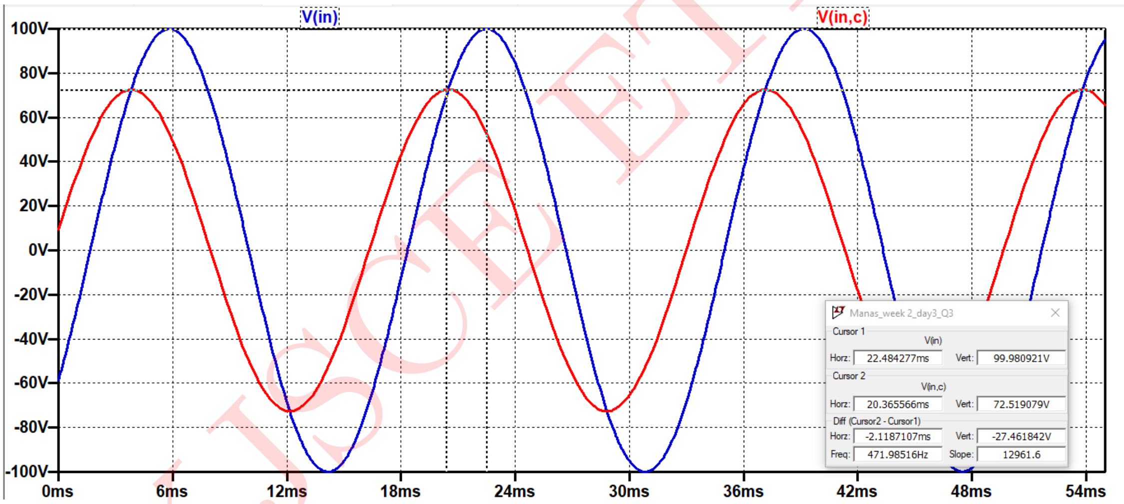


Figure 39: Simulated results for $V_S$ & $V_R$

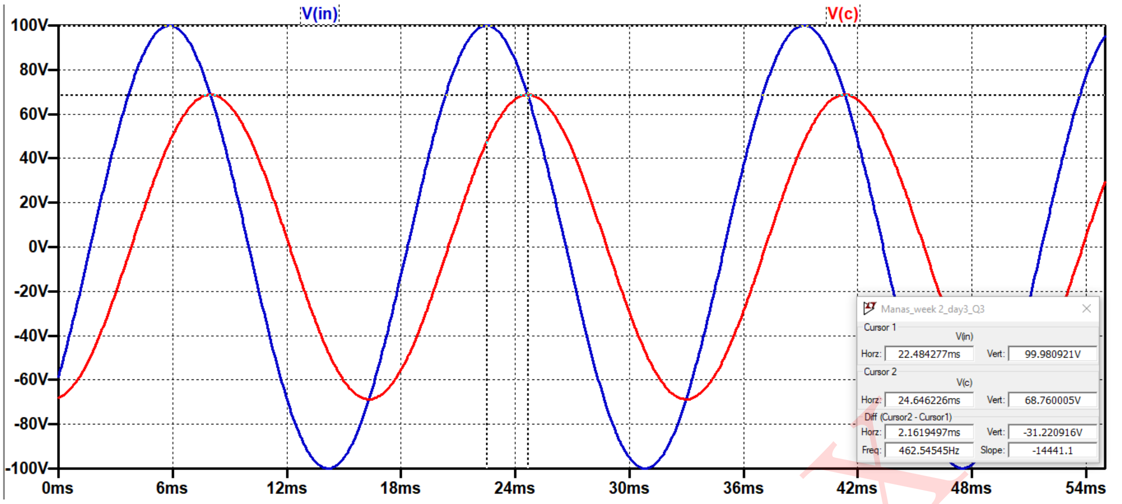


Figure 40: Simulated results for $V_S$ & $V_C$

**Comparison of Calculated Values and Simulated Values:**

| Quantity | Calculated Value | Simulated Value |
|---|---|---|
| $V_R$ | 72.597V | 72.5963V |
| $V_C$ | 68.749V | 68.7454V |
| $I_S$ | 2.0738A | 2.072A |
| $\Delta\theta$ & $\Delta t$ for $V_S$ & $I_S$ | 136.5487° & 6.3217$ms$ | 136.08° & 6.3833$ms$ |
| $\Delta\theta$ & $\Delta t$ for $V_S$ & $V_R$ | 43.4513° & 2.0116$ms$ | 44.5176° & 2.061$ms$ |
| $\Delta\theta$ & $\Delta t$ for $V_S$ & $V_L$ | 46.5417° & 2.155$ms$ | 48.168° & 2.2317$ms$ |

Table 7: Numerical 7