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

Numerical 1: A series RLC circuit containing a resistance if 15Ω, an inductance of 0.1H and a capacitor of 150μF are connected in series across a 220V, 60Hz supply Calculate:

a) Current drawn by the circuit

b) V_R, V_L and V_C

c) Power factor

d) Draw the voltage phasor diagram

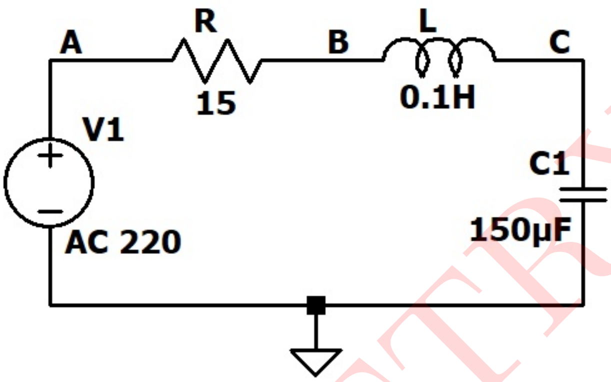

Figure 1: Circuit 1

Solution:
$X_L = 2\pi \text{fL} = 37.6991\Omega$

$V_C = \dfrac{1}{2\pi fC} = 17.6839\Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = 25.0122\Omega$

a) $I = \dfrac{V_S}{Z}$

$I = \dfrac{220}{25.0122} = 8.7957A$

b) $V_R = I \times R = 131.9355V$

$V_L = I \times X_L = 331.589V$

$V_C = I \times X_C = 155.542V$

c) $\cos\phi = \dfrac{R}{Z} = 0.5997$

$\therefore \phi = 53.1515°$

d)Voltage phasor diagram:

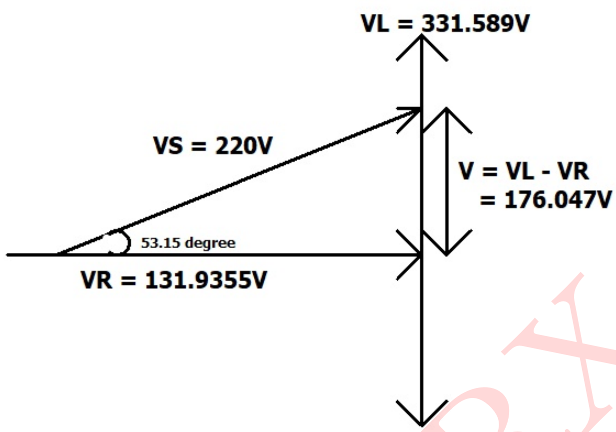

Figure 2: Circuit 1

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

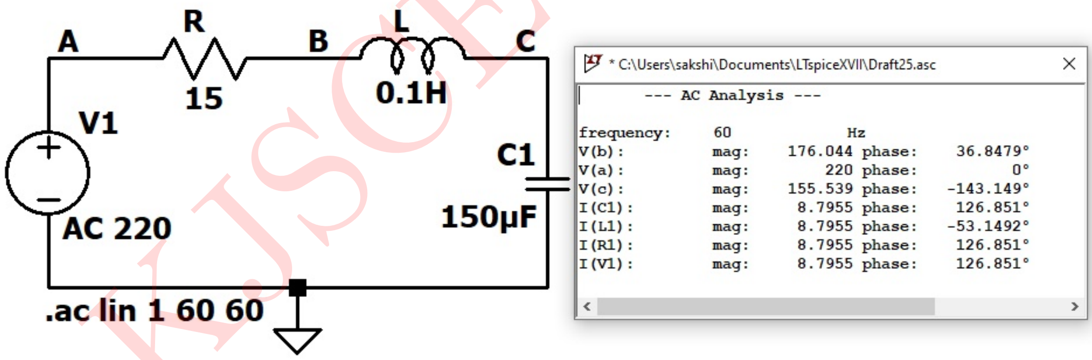

Figure 3: Circuit Schematic and simulated results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	8.7957A	8.7655A
V_R	131.9355V	131.933V
V_L	331.589V	331.583V
V_C	155.542V	155.539V
$power factor$	0.5997	0.5997

Numerical 2: In the given RL circuit R = 3Ω and L = 0.15H
Find:

a) Current through the circuit

b) Power factor

If a 50Hz AC voltage V= $230\angle 60$ is applied across the circuit 2

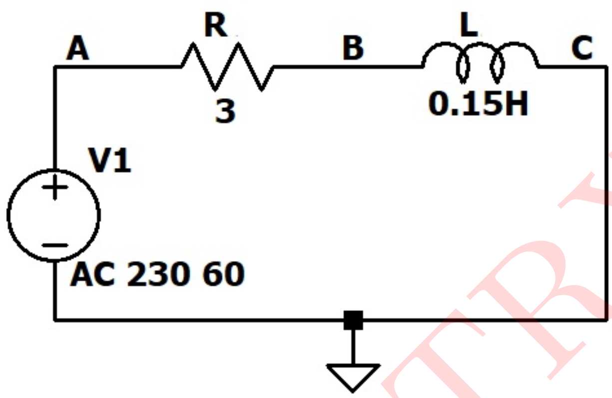

Figure 4: Circuit 2

Solution:
$X_L = 2\pi \text{fL} = 47.12388\Omega$

$Z = 3 + j47.12388 = 47.21927\angle 86.357\Omega$

a) $I = \dfrac{V_S}{Z}$

$I = \dfrac{230\angle 60}{47.21927\angle 86.357} = 4.87089\angle{-26.35}A$

b) power factor $= \cos\phi = \cos(26.35) = 0.8961$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

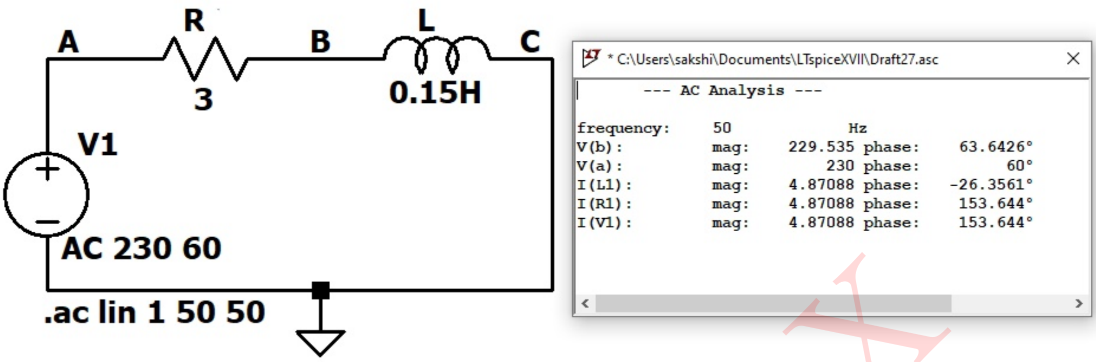

Figure 5: Circuit Schematic and simulated results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	$4.870892\angle{-26.35}A$	$4.870892\angle{-26.35}A$
$power factor$	0.891	0.8961

Numerical 3: A voltage $V = 120\sin(314)$t is applied to a circuit consisting of a 40Ω resister and a 95μF capacitor in series.
Determine:

a) An expression for the value of current flowing at any instant

b) V_R and V_C

c) Power factor

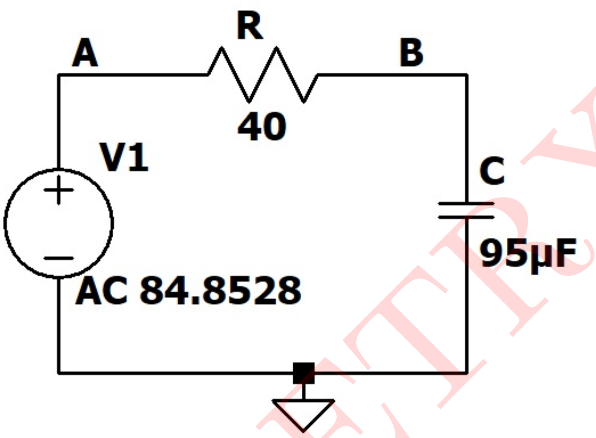

Figure 6: Circuit 3

Solution:
$V = 120\sin(314)t$

$$\therefore V_{rms} = \frac{120}{\sqrt{2}} = 84.8528V$$

$$V_C = \frac{1}{2\pi fC}$$

$$V_C = \frac{1}{0.02982} = 33.5233\Omega$$

$$Z = \sqrt{R^2 + (X_C)^2} = 52.1901\Omega$$

a) $I = \dfrac{V_S}{Z}$

$$I = \frac{84.8528}{52.1901} = 1.6258A$$

b) $V_R = I \times R = 65.0336V$

$V_C = I \times X_C = 54.5035V$

c) $\cos\phi = \dfrac{R}{Z} = 0.766428$

$\therefore \phi = 39.9658°$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

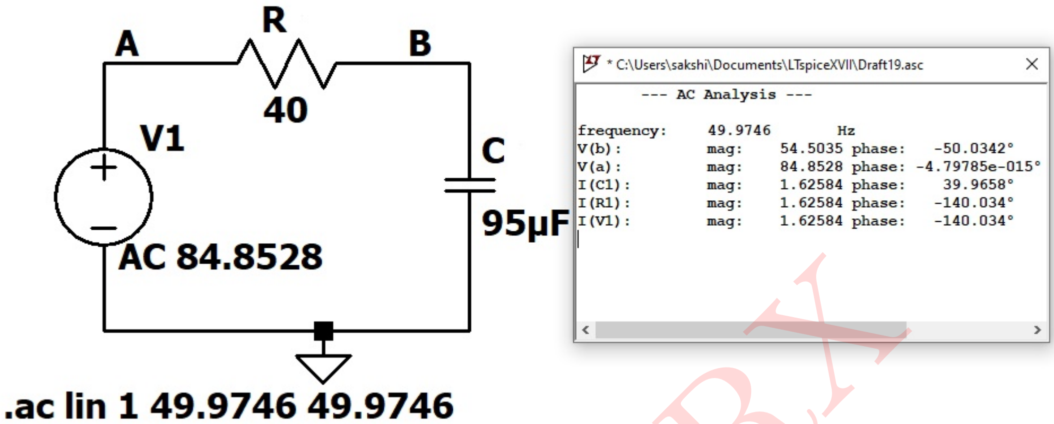

Figure 7: Circuit Schematic and simulated results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	1.6258A	1.6258A
V_R	65.0336V	65.0336V
V_C	54.5035V	54.5035V
$power factor$	0.766428	0.766428

Numerical 4: A circuit consists of resistance of 20Ω, an inductance of 54mH and a Capacitor of 30μF are connected in parallel across a 110V 50Hz supply, calculate:

a) Individual current drawn by each supply

b) Total current drawn from the supply

c) Overall Power factor of the circuit

d) Draw the phasor diagram

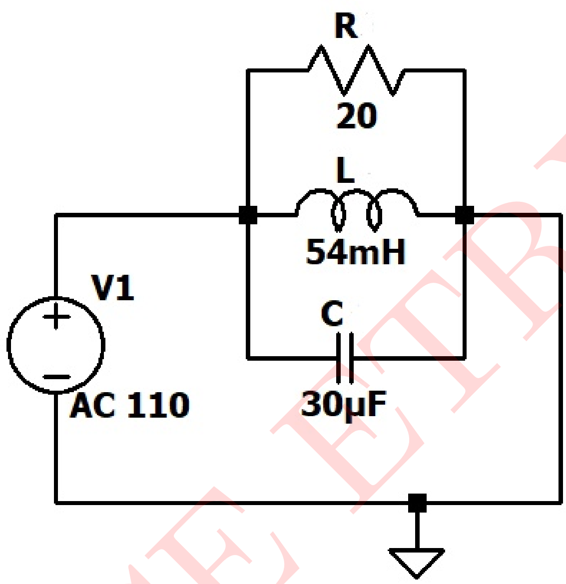

Figure 8: Circuit 4

Solution:

$X_L = 2\pi \text{fL} = 16.9646\Omega$

$V_C = \dfrac{1}{2\pi fC} = 106.1033\Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = 91.35484\angle - 77.3536\Omega$

a) $I = \dfrac{V_S}{Z}$

$I = \dfrac{110}{91.35484\angle - 77.3536} = 1.204096\angle 77.3536A$

b) $I_R = \dfrac{V}{R} = 5.5\angle 0A$ ....(In phase)

$I_L = \dfrac{V}{X_L} = 6.4840\angle 90A$

$I_C = \dfrac{V}{X_C} = 1.03673\angle - 90A$

c) Power factor $= \cos\phi = \dfrac{R}{Z} = 0.218926$ (lagging)

$\therefore \phi = -77.3536°$

d) Phasor diagram:

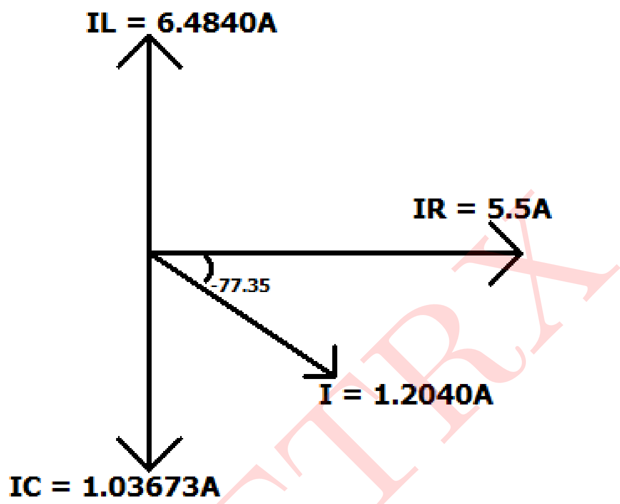

Figure 9: Phasor diagram

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

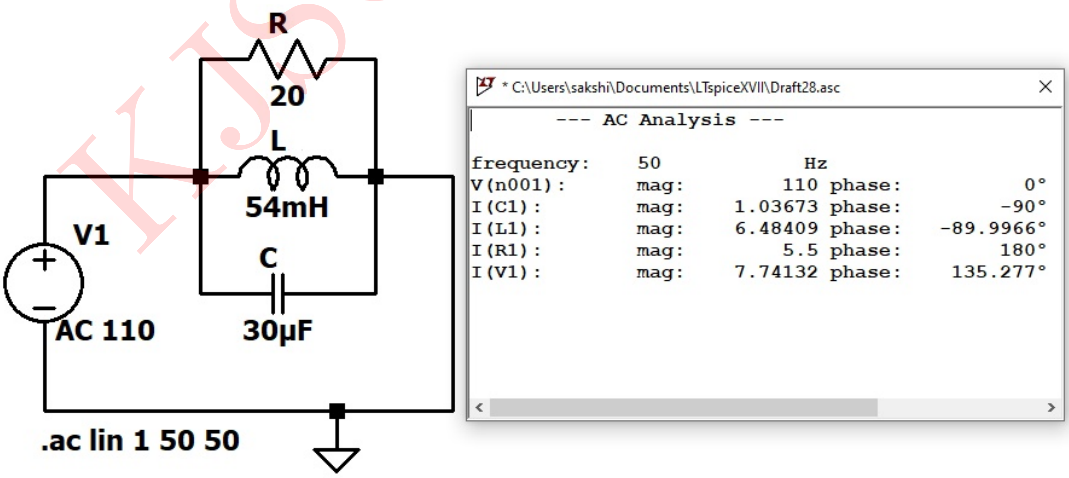

Figure 10: Circuit Schematic and simulated results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	$1.2040\angle -77.35A$	$1.2040\angle -77.35A$
I_R	$5.5\angle 0A$	$5.5\angle 0A$
I_L	$6.4840\angle 90A$	$6.4840\angle 89.99A$
I_C	$1.03673\angle -90A$	$1.03673\angle -90A$

Numerical 5: A coil having a resister of $R_1 = 5\Omega$ and an inductance of $L_1 = 0.02$H is Arranged in parallel with another coil having a resister of $R_2 = 1\Omega$ and an Inductance of $L_2 = 0.08$H, Find:

a) Current through I, I_1 and I_2 when a voltage of $V_1 = 110$V at 60Hz is applied

b) Also the Power factor of the circuit

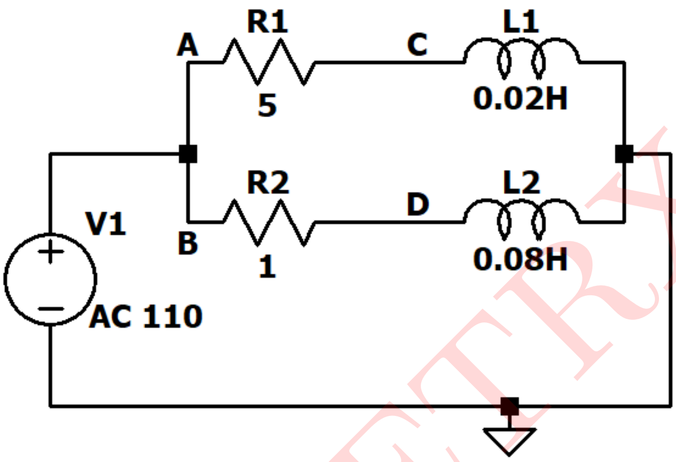

Figure 11: Circuit 5

Solution:

$X_{L_1} = 2\pi f L_1 = 7.5398\Omega$

$X_{L_2} = 2\pi f L_2 = 30.1593\Omega$

$Z_1 = 5 + j7.5398 = 9.04702\angle 56.449\Omega$

$Z_2 = 1 + j30.1593 = 30.17587\angle 88.10\Omega$

a) $I_1 = \dfrac{X_{L_1}}{Z_1}$

$$I_1 = \frac{7.5398}{9.04702\angle 56.449} = 12.1587\angle{-56.449}A$$

$$I_2 = \frac{X_{L_2}}{Z_2}$$

$$I_2 = \frac{30.1593}{30.17587\angle 88.10} = 3.645296\angle{-88.10}A$$

$I = I_1 + I_2 = 15.8039\angle - 63.20$

b) power factor $= \dfrac{I_1}{I} = 0.769343$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

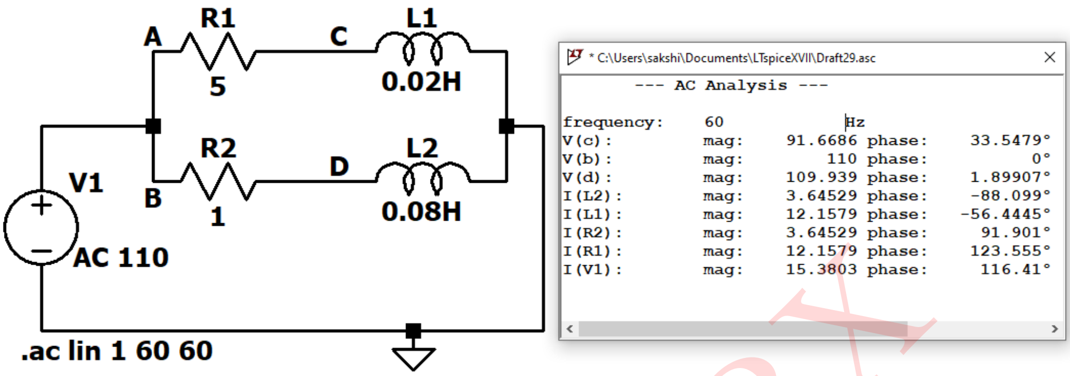

Figure 12: Circuit Schematic and simulated results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	$15.8039\angle{-63.20}A$	$15.3803\angle{-63.20}A$
I_1	$12.1587\angle{-56.449}A$	$12.1579\angle{-56.445}A$
I_2	$3.645296\angle{-88.1}A$	$3.64529\angle{-88.009}A$
$Power factor$	0.76934	0.76934

Numerical 6: Find I, I_1 and I_2 and voltage drop in each branch in the following figure 13 if R_1= 8Ω, L_1 = j4Ω, R_2 = 15Ω, L_2 = j8Ω, R_3 = 9Ω, C_1 = −j6Ω, V_1 = 100V, Frequency = 50Hz

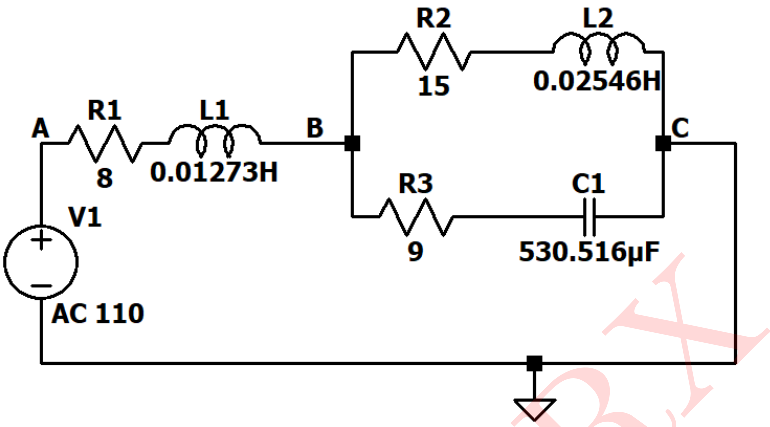

Figure 13: Circuit 6

Solution:

Z_1 = 8+j4 = 8.9443∠26.5650Ω

Z_2 = 15+j8 = 17∠28.0725Ω

$Z_3 = 9 - j6 = 10.8167\angle - 33.69\Omega$

$Z = 15.15 + j2.624 = 15.7307\angle 9.602\Omega$

a) $I = 6.3569\angle - 9.607A$

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

$$I_1 = 6.3569\angle - 9.607 \times \frac{9 - j6}{j8 + 15 + 9 - j6}$$

$I_1 = 2.8551\angle - 48.0563A$

$I_2 = I - I_1 = (6.3569\angle - 9.607) - (2.8551\angle - 48.0563)$

$I_2 = 4.4873\angle 13.7059A$

b) $V_1 = I \times Z_1 = (6.3569\angle - 9.6027) \times (8 + j4)$

$V_1 = 56.8578\angle 16.9623V$

$V_2 = I \times Z_2 = (2.8551\angle - 48.0563) \times (15 + j8)$

$V_2 = 48.5367\angle - 19.9838V$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

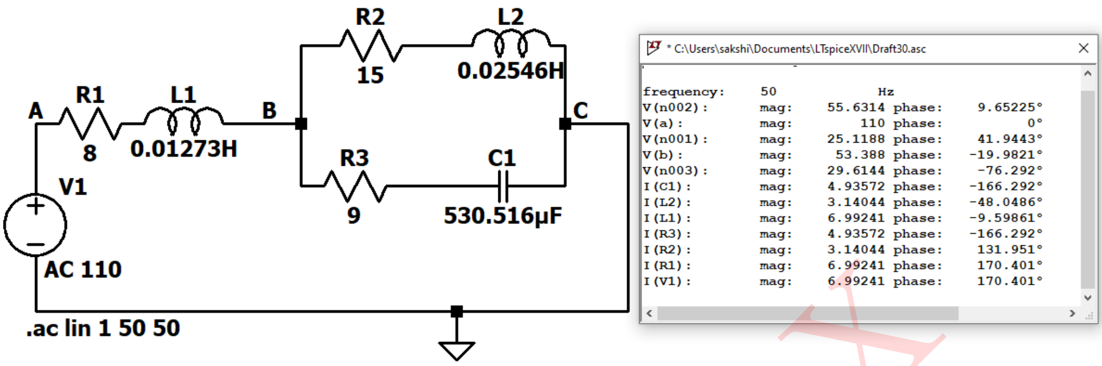

Figure 14: Circuit Schematic and simulated results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	$6.3569\angle-9.607A$	$6.3567\angle-9.5986A$
I_1	$2.8551\angle-48.0563A$	$2.8549\angle-48.0486A$
I_2	$4.4873\angle13.7059A$	$4.48702\angle13.708A$
V_1	$56.8578\angle16.9623V$	$56.8591\angle16.9618V$
V_2	$48.5367\angle-19.9838V$	$48.5346\angle-19.9821V$

Numerical 7: A 50Hz sinusoidal voltage V = 141sin ωt is applied to a series R-L circuit The value of resistance and inductance are 3Ω and 0.012H respectively, Determine:

a) Calculate the peak voltage across resister and inductor and find the peak voltage of Source current in LTspice

b) Plot the input source voltage $V_S(t)$ vs input source current $I_S(t)$ in LTspice

c) Measure the phase difference between $V_S(t)$ vs $I_S(t)$ in time and degree

d) Plot the input source voltage $V_S(t)$ vs voltage across resister $V_R(t)$ in LTspice

e) Measure the phase difference between $V_S(t)$ vs $V_R(t)$ in time and degree

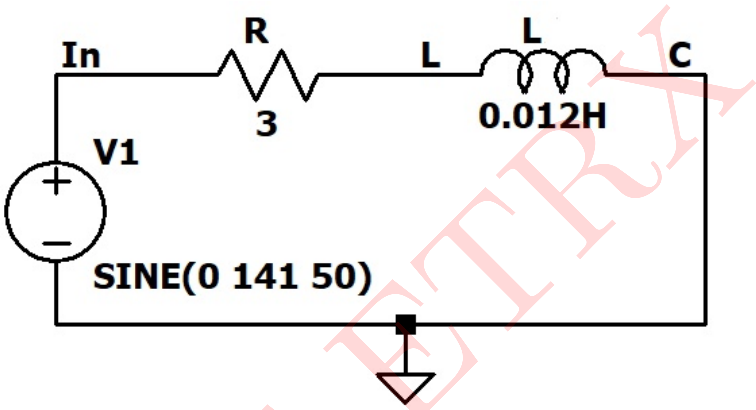

Figure 15: Circuit 7

Solution:

$V_{rms} = \dfrac{V_m}{\sqrt{2}}$

$V_{rms} = \dfrac{141}{\sqrt{2}} = 99.7020V$

X_L = 2πfL

$X_L = 2 \times \pi \times 50 \times 0.012 = 3.76991\Omega$ ...($\pi = 3.14$)

$Z = R + jX_L = 3 + j3.76991 = 4.8179\angle 51.4881$

$I = \dfrac{V}{Z}$

$I = \dfrac{99.7020\angle 0}{4.8179\angle 51.488} = 20.6940\angle - 51.488A$

$V_R = I \times R = 3 \times 20.6941\angle - 51.488$

$V_R = 62.083\angle - 51.488V$

$V_L = I \times L$

$V_L = (20.6941\angle - 51.488) \times (3.76991\angle 90)$

$V_L = 78.01489\angle 38.512V$

Peak value of current $= I_{rms} \times \sqrt{2} = 29.26587A$

$V_R(peak) = V_R(rms) \times \sqrt{2}$

$V_R(peak) = 87.79862V$

$V_L(peak) = V_L(rms) \times \sqrt{2}$

$V_L(peak) = 110.3297V$

c) Power factor $= \cos\phi = \cos(51.488) = 0.622678$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

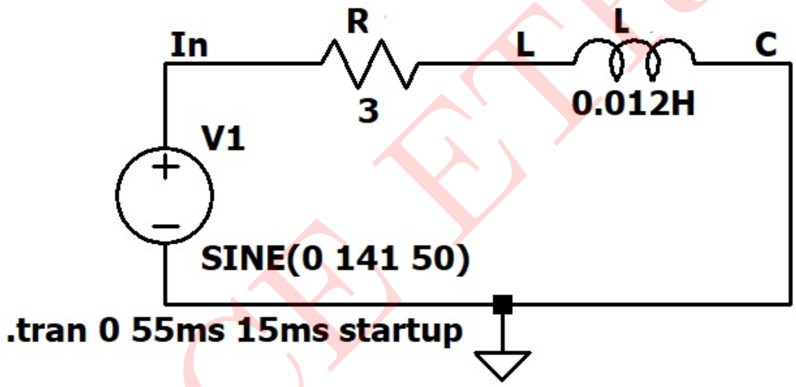

Figure 16: Circuit Schematic

The $V_S(t)$ vs $I_S(t)$ curve is shown in figure 17:

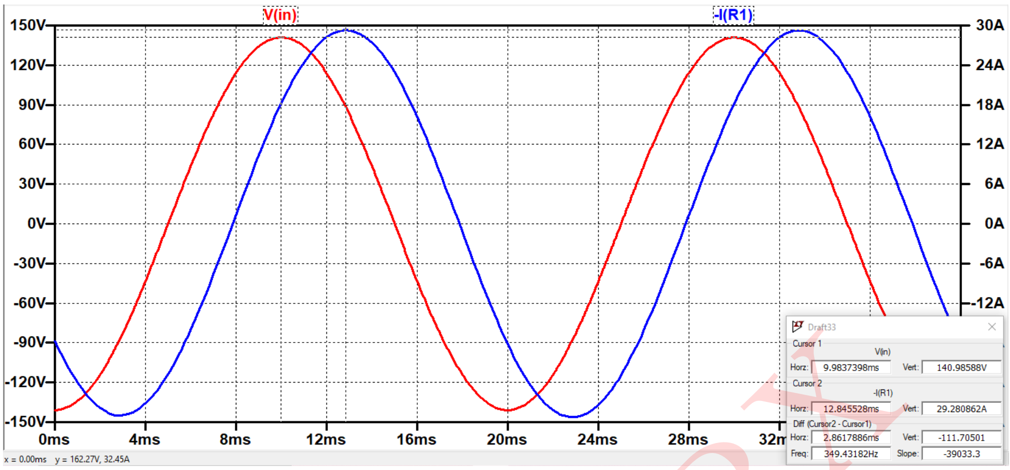

Figure 17: Plot of input source voltage vs input source current

The input vs output source voltage is shown in figure 18:

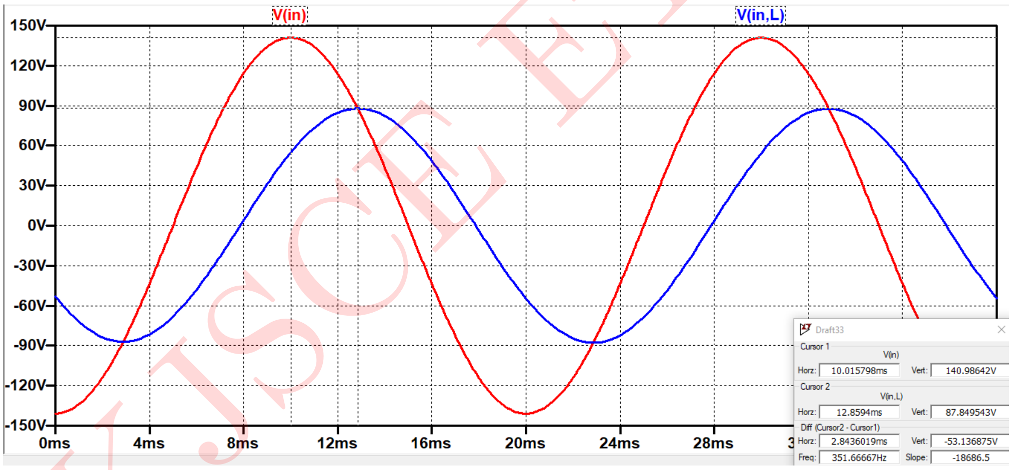

Figure 18: Plot of input source voltage vs voltage across resistere

Input source voltage vs voltage across Inductor is shown in figure 19:

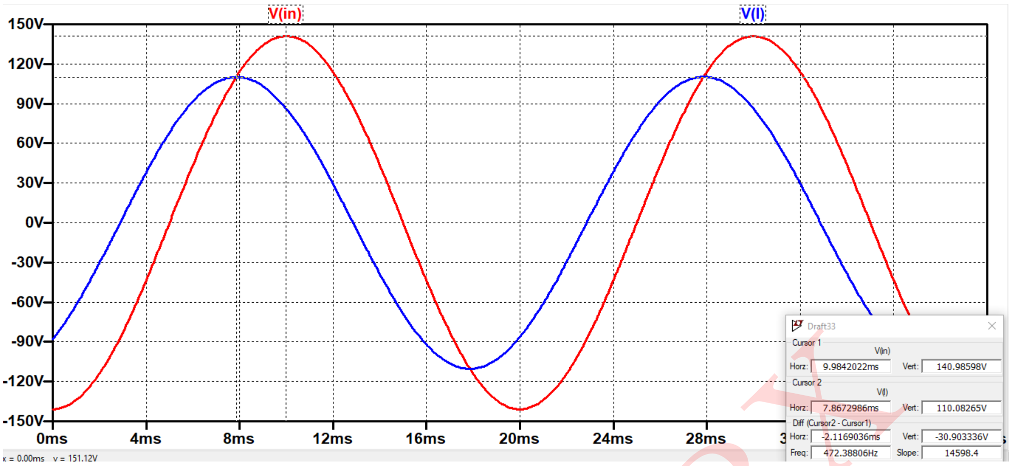

Figure 19: Plot of input source voltage vs voltage across Inductor

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I_{peak}	$29.26587A$	$29.281052A$
$V_R(peak)$	$87.7862V$	$87.84V$
$V_L(peak)$	$110.3297V$	$110.08134V$
$\phi(V_S, I_S)$	$51.488°$	$51.5121948°$
$\phi(V_S, V_R)$	$51.488°$	$51.1848342°$
$\phi(V_S, V_L)$	$38.512°$	$38.1042648°$

Numerical 8: A pure resistance of 33Ω is in series with a pure capacitor of 90μF The series combination is connected across 110V,60Hz supply, Determine:

a) Calculate Peak voltage across resister and capacitor and also find the peak value of Source current in LTspice

b) Plot $V_S(t)$ vs $I_S(t)$ in LTspice

c) Measure the phase difference between $V_S(t)$ vs $I_S(t)$ in time and phase

d) Plot $V_S(t)$ vs $V_R(t)$ in LTspice

e) Measure phase difference between $V_S(t)$ vs $V_R(t)$

f) Plot $V_S(t)$ vs $V_C(t)$ in LTspice

g) Measure the phase difference between $V_S(t)$ vs $V_C(t)$

h) Calculate the power factor of the circuit

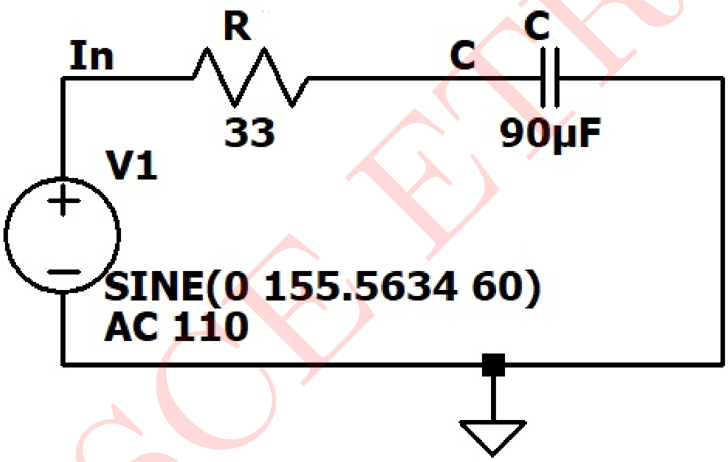

Figure 20: Circuit 8

Solution:
$V_{rms} = 110V$

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2 \times \pi \times 60 \times 90\mu F} = 29.4733\Omega \ ...(\pi = 3.14)$$

$$Z = R + jX_C = 33 + j29.4733 = 44.2456\angle 41.7690$$

$$I = \frac{V}{Z}$$

$$I = \frac{110\angle 0}{44.2456\angle 41.7690} = 2.48612\angle -41.7690A$$

$$V_R = I \times R = 33 \times 2.48612\angle -41.7690$$

$$V_R = 82.04196\angle -41.77690V$$

$$V_C = I \times C$$

$V_C = (2.48612\angle -41.7690) \times (29.4733\angle -90)$

$V_C = 73.27416\angle -131.769V$

Peak value of current $= I_{rms} \times \sqrt{2} = 3.515905A$

$V_R(peak) = V_R(rms) \times \sqrt{2}$

$V_R(peak) = 116.02485V$

$V_C(peak) = V_C(rms) \times \sqrt{2}$

$V_C(peak) = 103.6253V$

c) Power factor $= \cos\phi = \cos(41.7690) = 0.745865$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

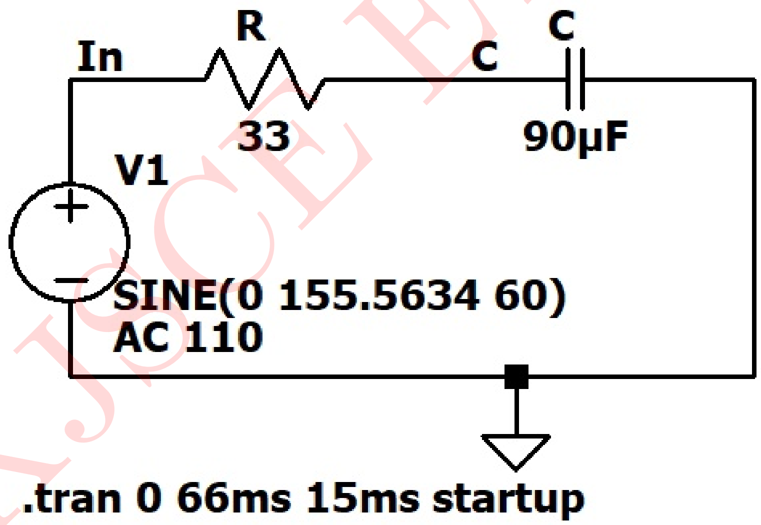

Figure 21: Circuit Schematic

Graph of $V_S(t)$ vs $I_S(t)$ graph is shown below in 22:

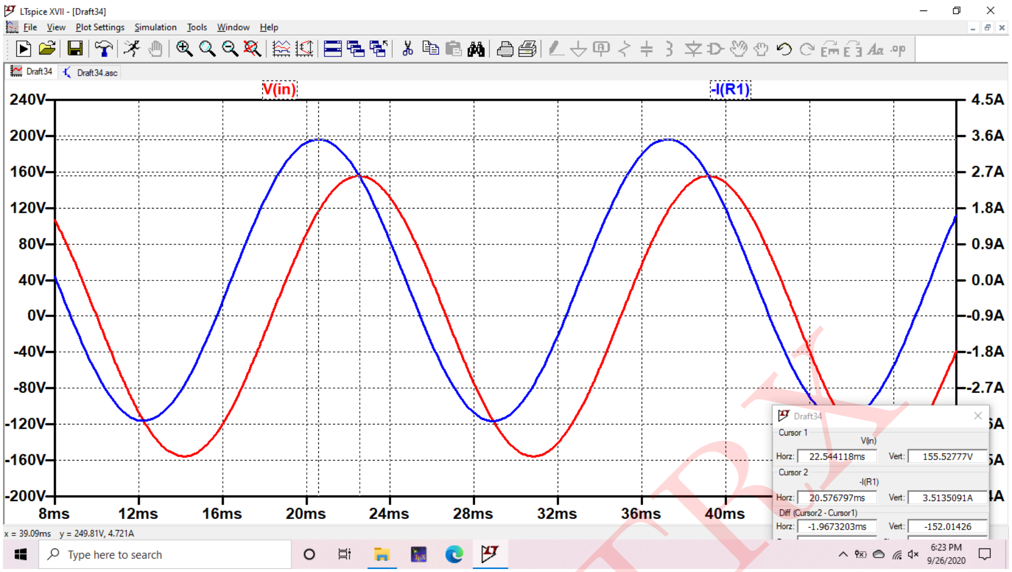

Figure 22: Plot of input source voltage vs input source current

Graph of $V_S(t)$ vs $V_R(t)$ is shown below in figure 23:

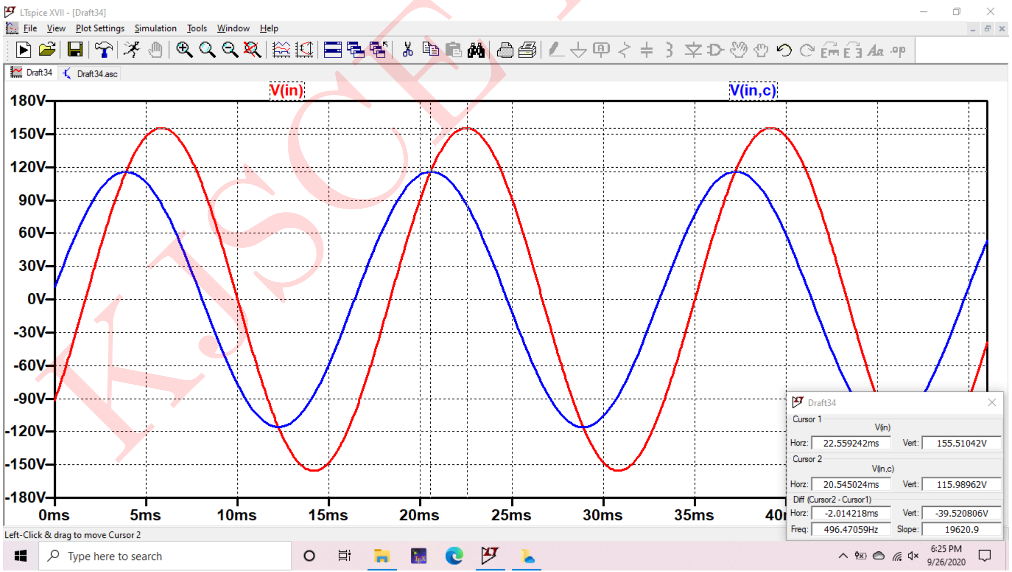

Figure 23: Plot of input source voltage vs voltage across resistere

graph of $V_S(t)$ vs $V_C(t)$ is shown below in figure 24:

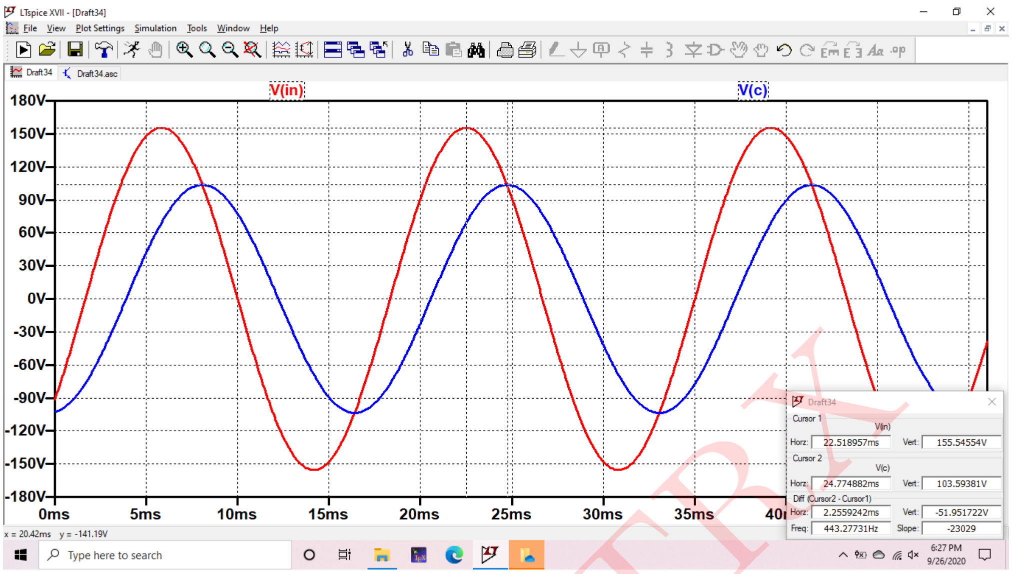

Figure 24: Plot of input source voltage vs voltage across capacitor

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I_{peak}	$3.515905A$	$3.515905A$
$V_R(peak)$	$116.02485V$	$115.98962V$
$V_C(peak)$	$103.6253V$	$103.59381V$
$\phi(V_S, I_S)$	$41.769°$	$42.662°$
$\phi(V_S, V_R)$	$41.769°$	$42.456°$
$\phi(V_S, V_C)$	$48.213°$	$48.7182°$

Numerical 9: A series resonance network consisting of a resistor of 20Ω, a capacitor of 5μF and an inductor of 30mH 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

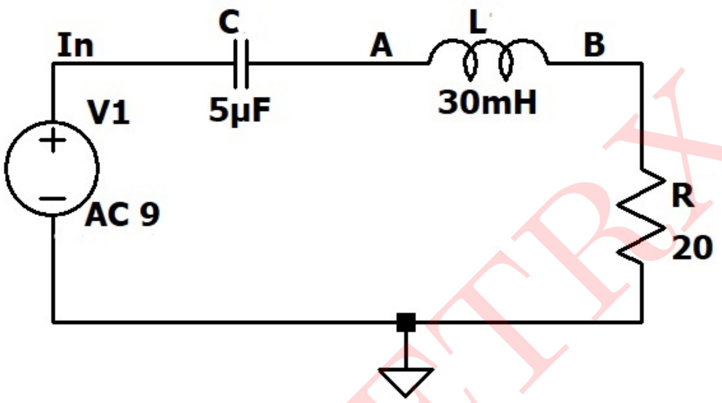

Figure 25: Circuit 9

Solution:

a) Resonant frequency $f_o = \dfrac{1}{2\pi\sqrt{LC}}$

$$f_o = \frac{1}{2 \times \pi \times \sqrt{30mH \times 5\mu F}} = 410.936Hz$$

b) Circuit current at resonance $I_m = \dfrac{V}{R}$

$$I_m = \frac{9}{20} = 636.396mA$$

c) Inductive Reactance, $X_L = 2\pi f L = 77.45\Omega$

$V_L/V_C = I \times X_L = 49.288V$

d) Quality factor (Q) $= \dfrac{X_L}{R} = 3.8725$

e) Band width $= \dfrac{f_o}{Q}$

Band width $= \dfrac{410.936}{3.8725} = 106.116$

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

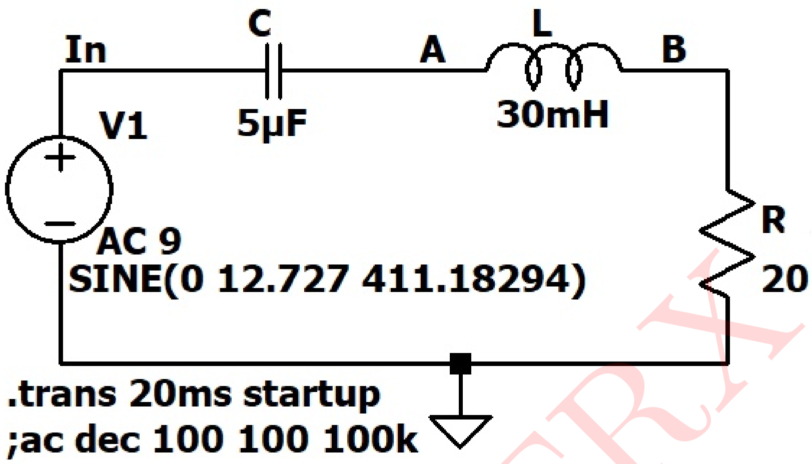

Figure 26: Circuit Schematic

Graph of resonance Curve is shown below in figure 27:

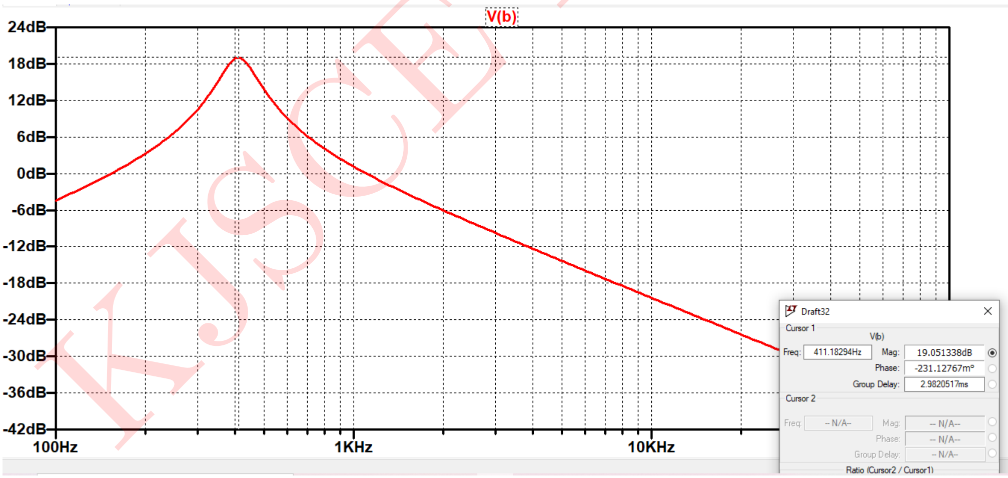

Figure 27: Plot of resonence curve

Graph for current at resonance is shown in figure 28:

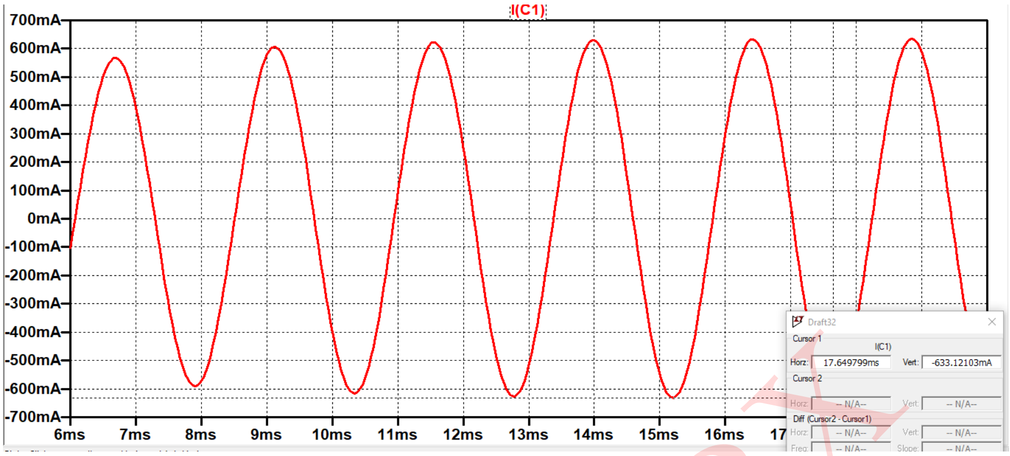

Figure 28: Plot of current at resonance

Graph for Voltage across inductor and capacitor at resonance is shown in figure 29:

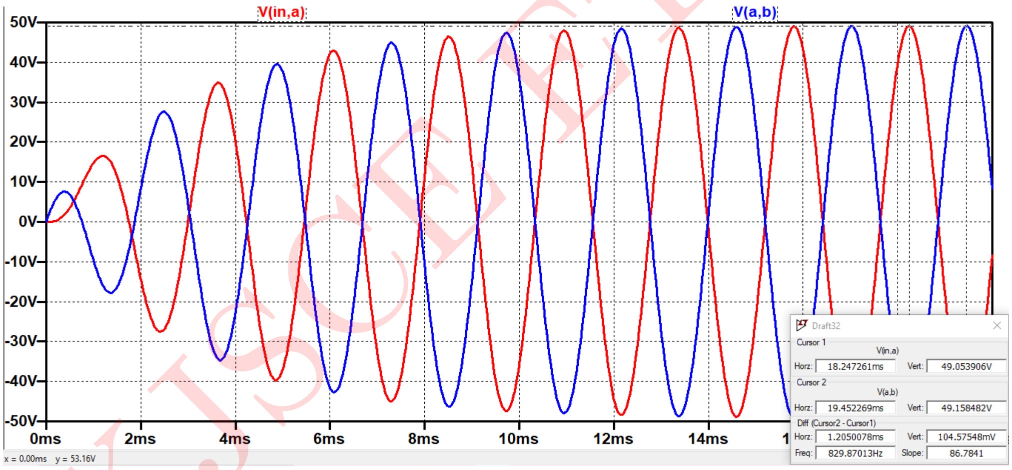

Figure 29: Plot of voltage cross inductor and capacitor at resonence

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
f_o	$410.936Hz$	$411.1829Hz$
I_m	$636.396mA$	$634.0582mA$
V_L/V_C	$49.288V$	$49.158482V$

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