Sinusoidal Steady State Response of RLC circuit

(Series Band pass filter using passive components)

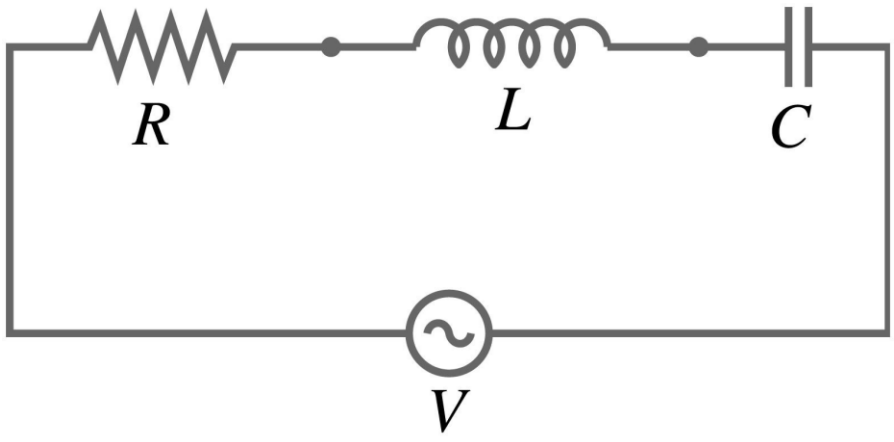
Aim:

To study the sinusoidal steady-state response of the given RLC circuit which can be used in a series bandpass filter.

Software Required:

LTspice software

Theory & Circuit Diagram:



The Series RLC circuit is shown in the above figure. The RLC series circuit can be used as a series bandpass filter by placing a series LC circuit in series with the load resistor. In the series RLC circuit, larger reactance determines the net reactance of the circuit.

If $X_L > X_C$ the circuit behaves like an inductive circuit and the current lags the voltage and if $X_C > X_L$, the circuit behaves like a capacitive circuit and the

current leads the voltage. The magnitude and Phase angle of the current, I in the series RLC circuit is obtained using the following equation,

$$I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + \left(X_L - X_C\right)^2}}$$

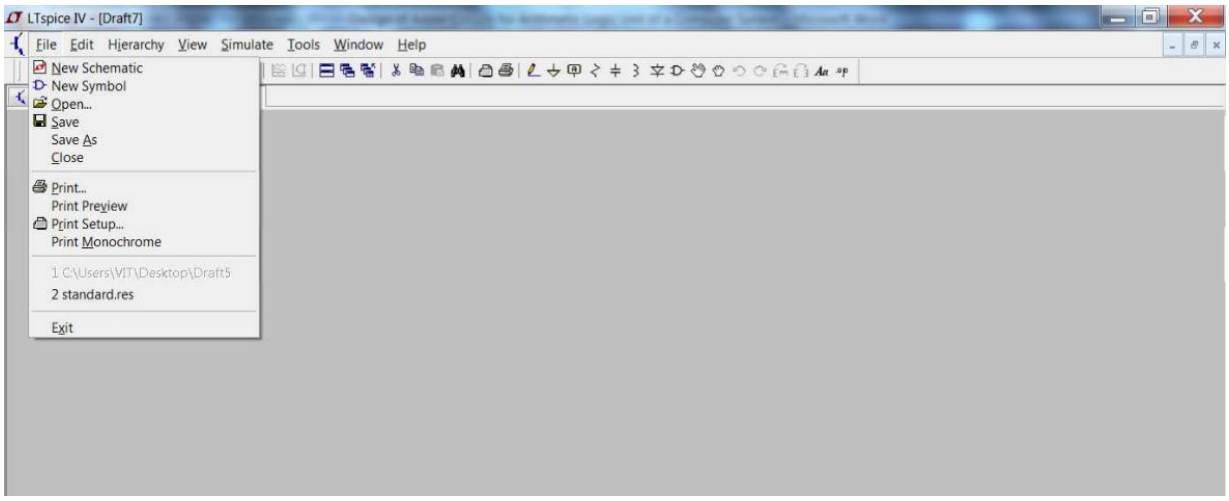
$$\varphi = \frac{\tan^{-1}\left(X_L \square X_C\right)}{R}$$

For RLC circuit with R= 10 Ω, L= 1mH, C= 1 μF and V_m = 100 V, f = 50 Hz, X_L = ωL = 2ΠfL = 0.314 Ω, X_C = (1/ωC) = (1/ 2ΠfC) = 3184 Ω, I_m = 0.0314 A, Φ = 89.82°.

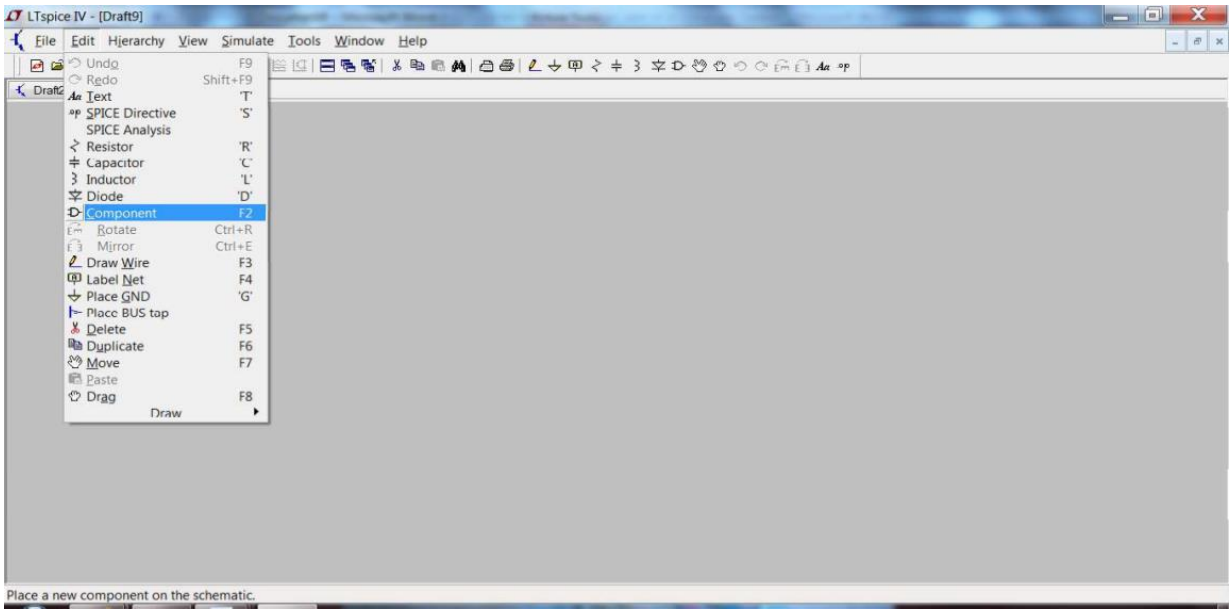
In this example, since $X_C > X_L$, Current leads the voltage.

Procedure:

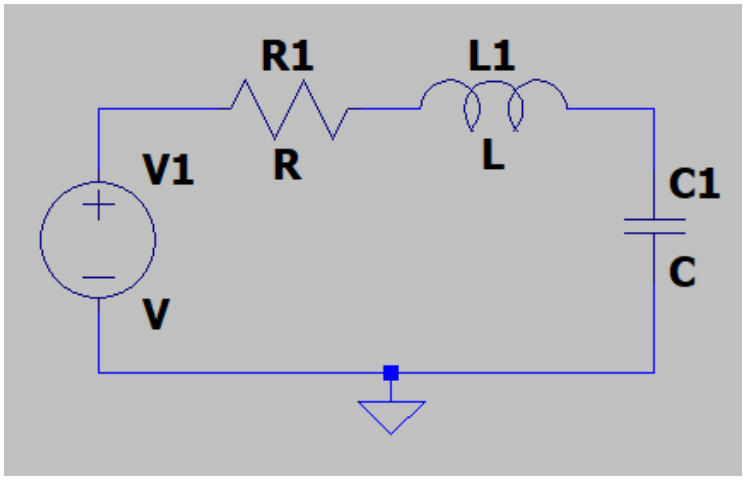
1. Open LTspice. Go to File New Schematic.



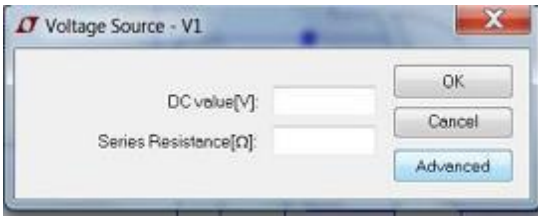
2. On the File Menu, click on Edit Component.

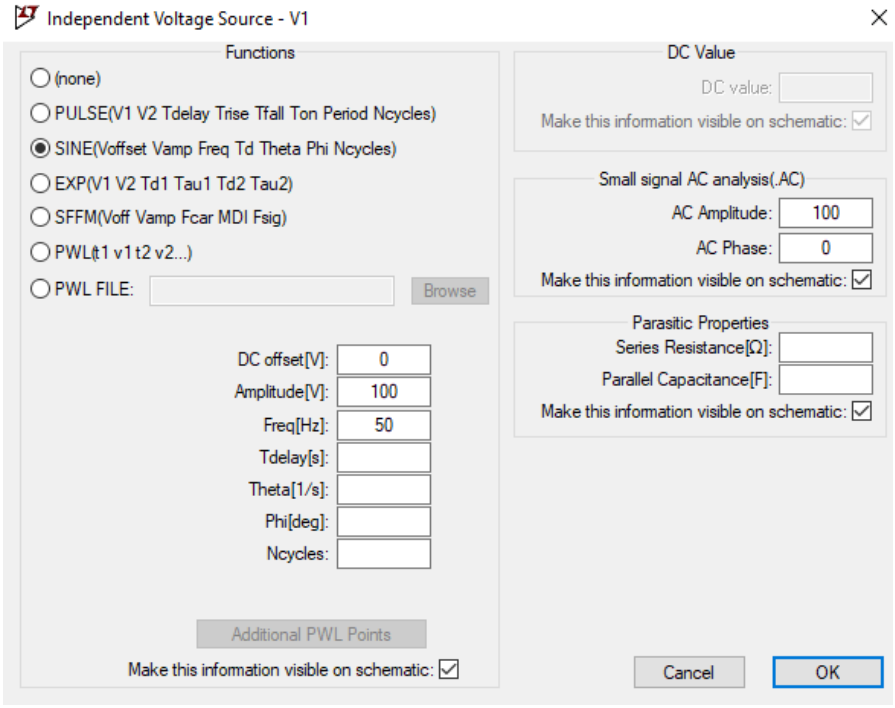


3. Place the voltage sources, resistor, inductor , capacitor and ground on to schematic and make necessary connections as shown in the Figure.

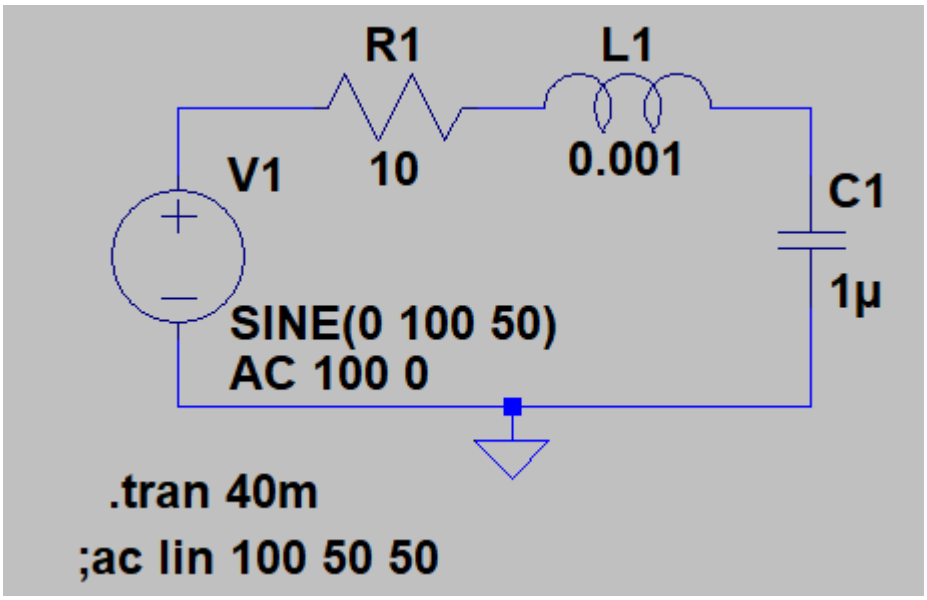


4. As shown in the figures below, Right click on the voltage source V1 and click Advanced option and then Select SINE (Voffset Vamp Freq Td Theta Phi Ncycles) and Set the values as (DC offset = 0, Amplitude =100, Freq = 50).

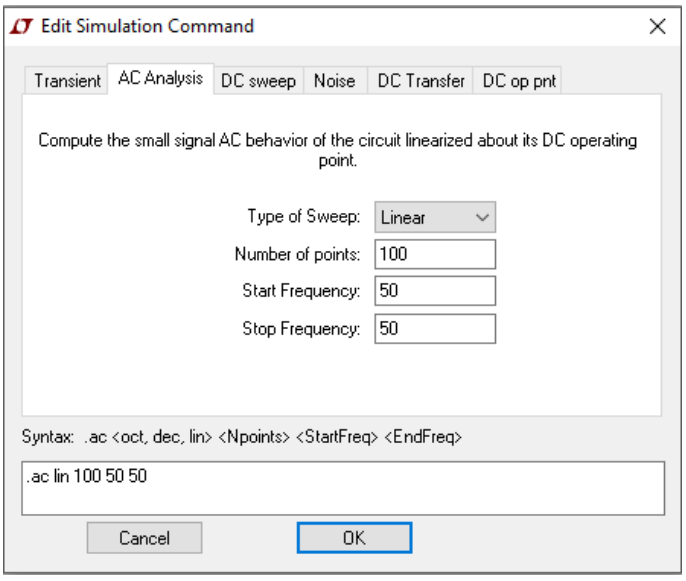




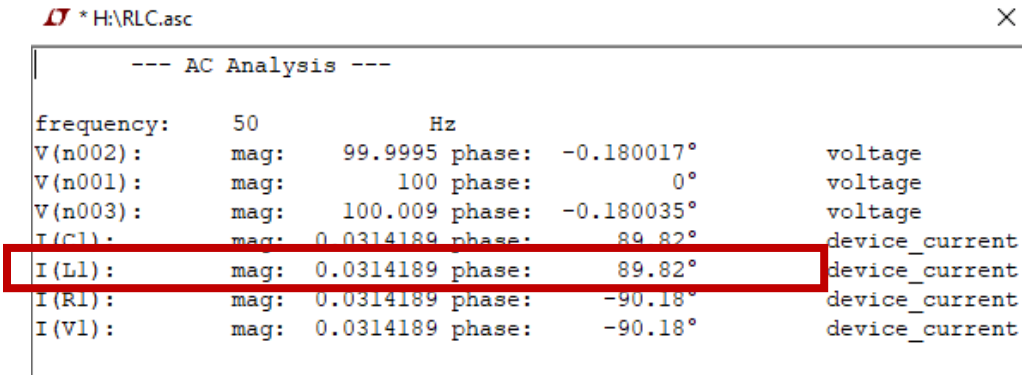
5. As shown in the figure below, Right click on the resistor, inductor and capacitor and set the value as 10 Ω, 0.001 H and 1 µF respectively



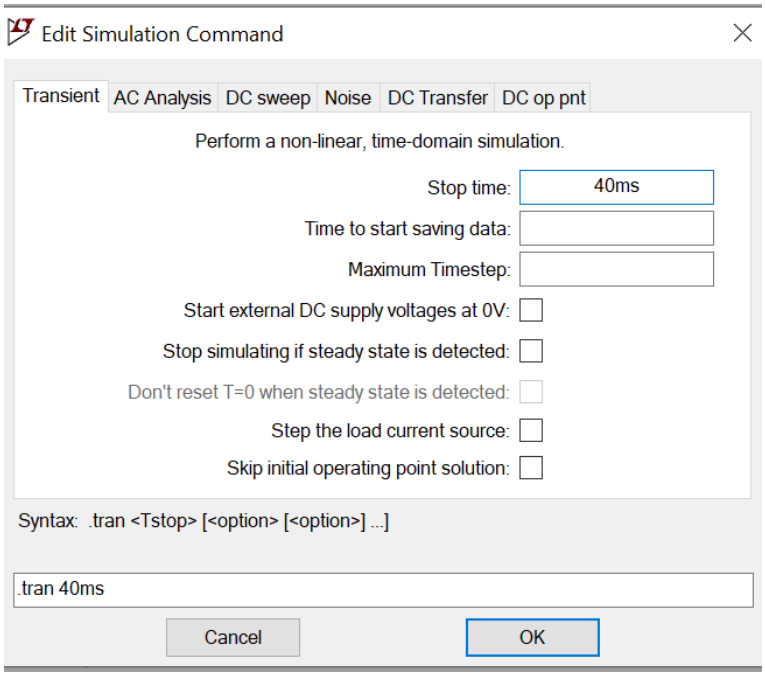
6. Go to Edit → SPICE analysis. Set the type of sweep to Linear, Number of points to 100 and start and stop frequency to 50 each in the AC Analysis command as shown in the figure below and run the simulation. (run symbol on the menu bar).



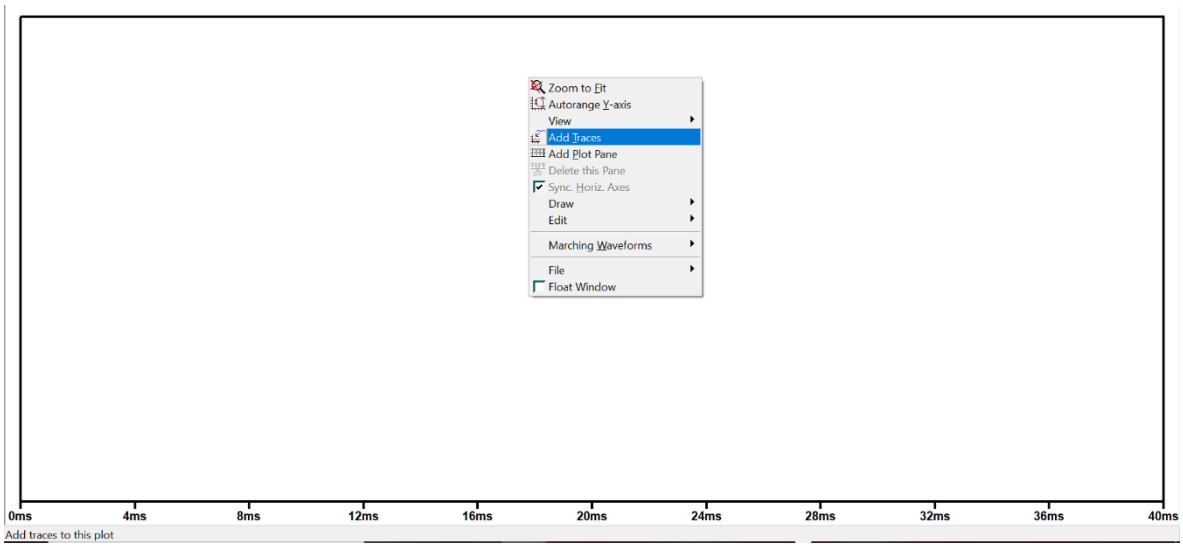
7. Observe the peak value of the current and phase angle from the obtained output window below and note it in the “Theoretical Value” column of the observation table.

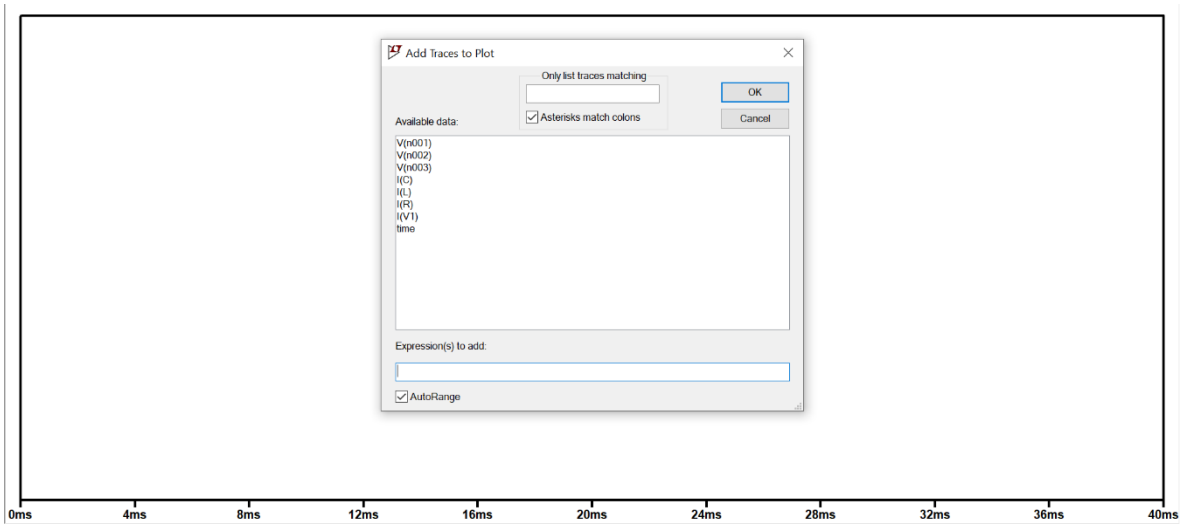


8. **For waveforms:** Go to Edit → SPICE analysis. Set the stop time to 40ms in Transient command as shown in the figure below and run the simulation. (run symbol on the menu bar).

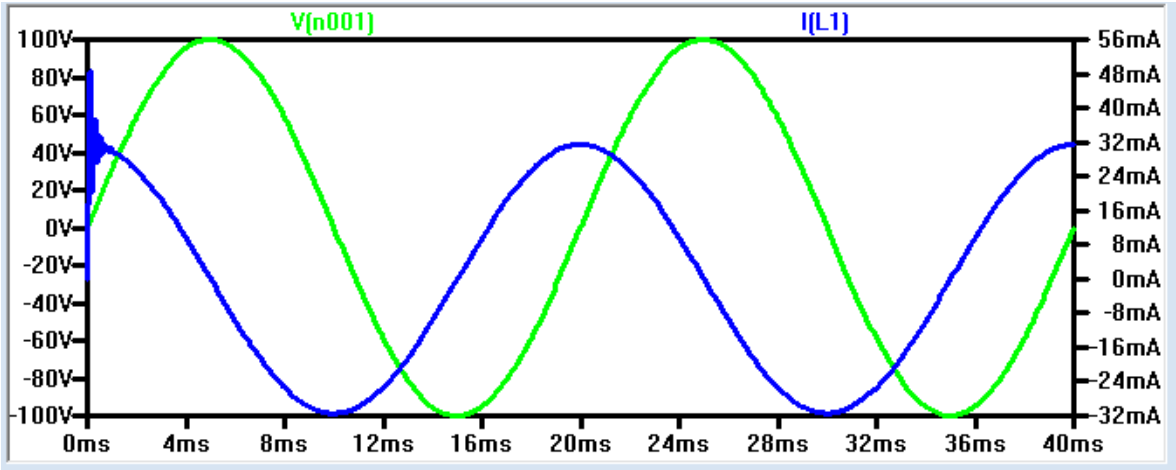


9. To view the results, right click → Add Trace → Select V (<<input node>>) and I (L1).





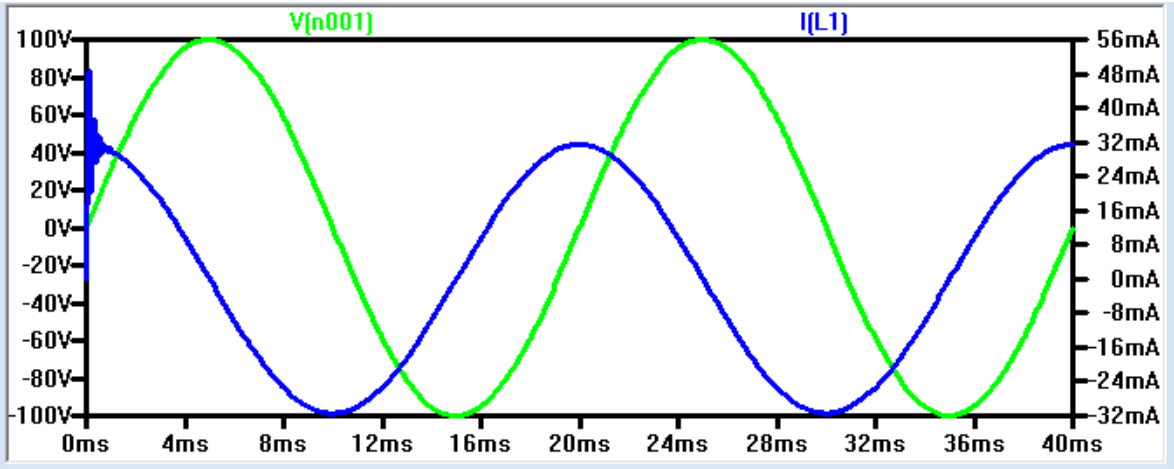
10. Observe the waveforms, change the appropriate colors for proper visibility using color preferences and control panel tool. Sample figure shown below.



Observation table:

S. No.	**Parameter**	**Theoretical Value**	**Observed Value**
1.	I (Peak value)		
2.	Phase angle		

Waveforms:



Result & Inferences:

Thus, a series RLC circuit has been designed and implemented in LTspice software, and the current amplitude and phase angle is observed as 0.0314 A and 89.82° respectively which is matching with Theoretical Values. From the waveforms, it is also observed that the current leads the voltage.

Practical Applications:

The three circuit elements, R, L, and C can be combined in several different topologies by connecting them in series or parallel. RLC circuits have many applications as follows:

- Variable tuned circuit
- Filters - Band-pass filter, Band-stop filter, Low-pass filter or High-pass filter
- Oscillator
- Voltage multiplier
- Pulse discharge circuit

Course Outcome:

CO2. Analyze AC power circuits and networks, its measurement and safety concerns

CO6. Design and conduct experiments to analyze and interpret data
Student Learning Outcomes (SLO): **SLO1**. Having an ability to apply mathematics and science in engineering applications **SLO9**. Having problem-solving ability- solving social issues and engineering problems