Lab Report 3.2

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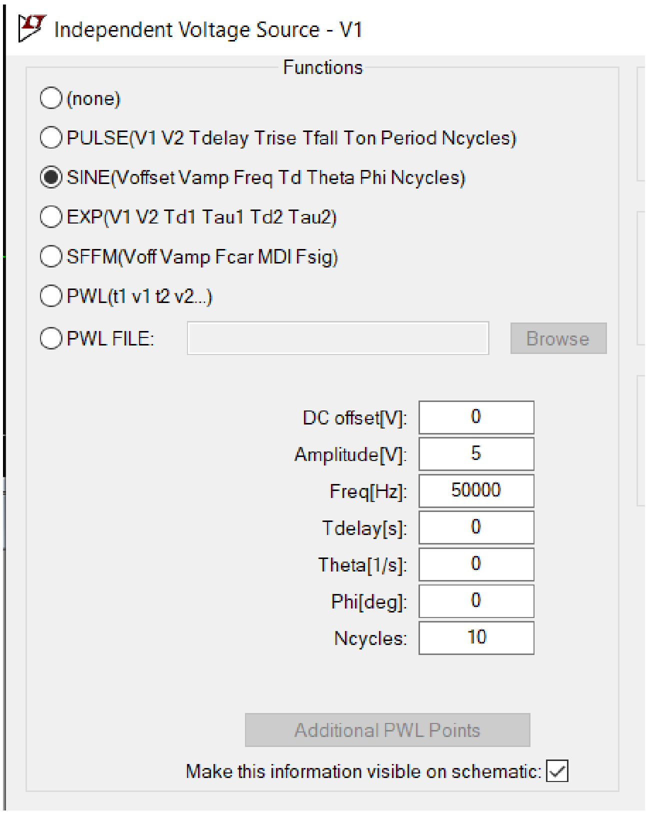
Title of Experiment: Objective 3.1 : Measuring Vout(t) for these combinations for observing underdamp, overdamp and critically damped behaviour after adjusting the appropriate values of RLC

Brief Description:

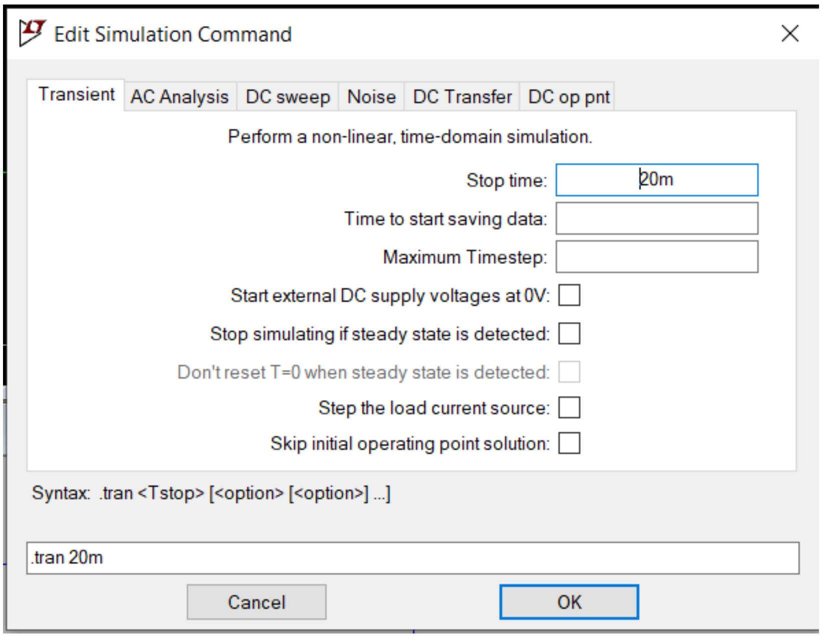
In this experiment, we had to simulate RLC circuits with a sinusoidal input source and AC analysis on LTSpice and then take note of the Voltages across the capacitor with time graphically. This is done for the **overdamped, underdamped and critically damped** cases. The series RLC circuit is composed of an inductor (L) and resistor (R) and capacitor (C) in series and we find the waveforms in each of the three cases for a particular frequency of 50KHz for a fixed time in the transient mode. Instead of analysing each passive element separately, we can combine all three together into a series RLC circuit. The analysis of a **series RLC circuit** is the same as that for the dual series R_L and R_C circuits we looked at previously, except this time we need to take into account the magnitudes of both X_L and X_C to find the overall circuit reactance. Series RLC circuits are classed as second-order circuits because they contain two energy storage elements, an inductance L and a capacitance C

Schematic diagram:

In our circuit, we consider the following settings for the Independent Voltage Source:



We then use Transient for a time of 20m to simulate the circuit.



We considered experimenting with the following 3 RLC circuit setups pertaining to underdamped, critically damped and overdamped respectively. The value of resistance for the critically damped case was calculated and found to be 200 Ω :

Calculations:

To find the value of Resistance in the three cases, we need to solve the following equation:

$$\frac{R}{2*L} = \frac{1}{\sqrt{L}*\sqrt{C}}$$

$$\frac{R}{2*0.01} = 1/\sqrt{10^{-8}}$$

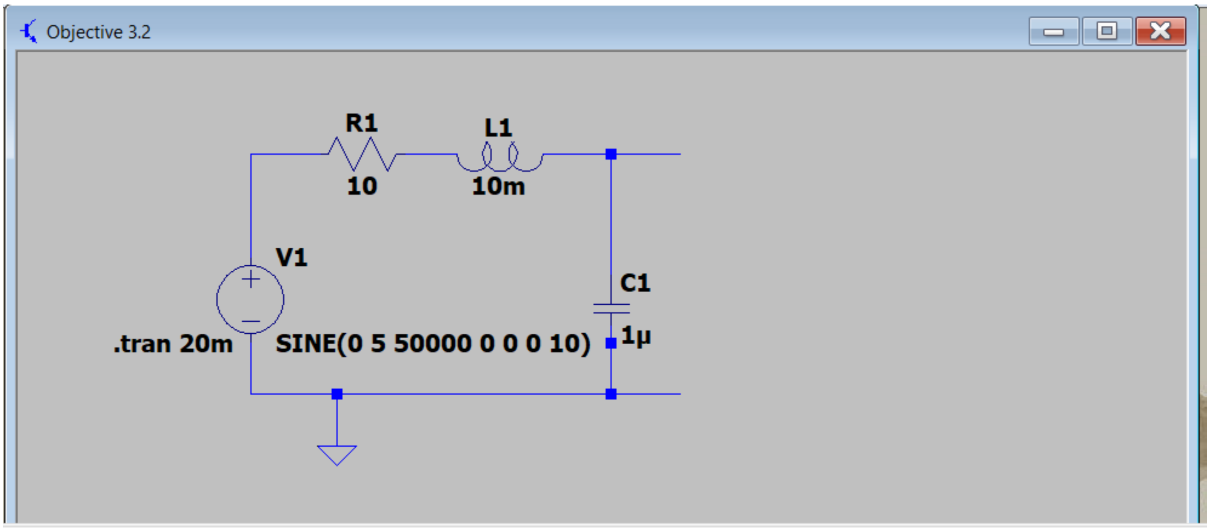
On simplifying, we get R= 2 x 10^2 = 200 Ω

Hence for The Underdamped case, we choose R< 200 Ω = 10 Ω

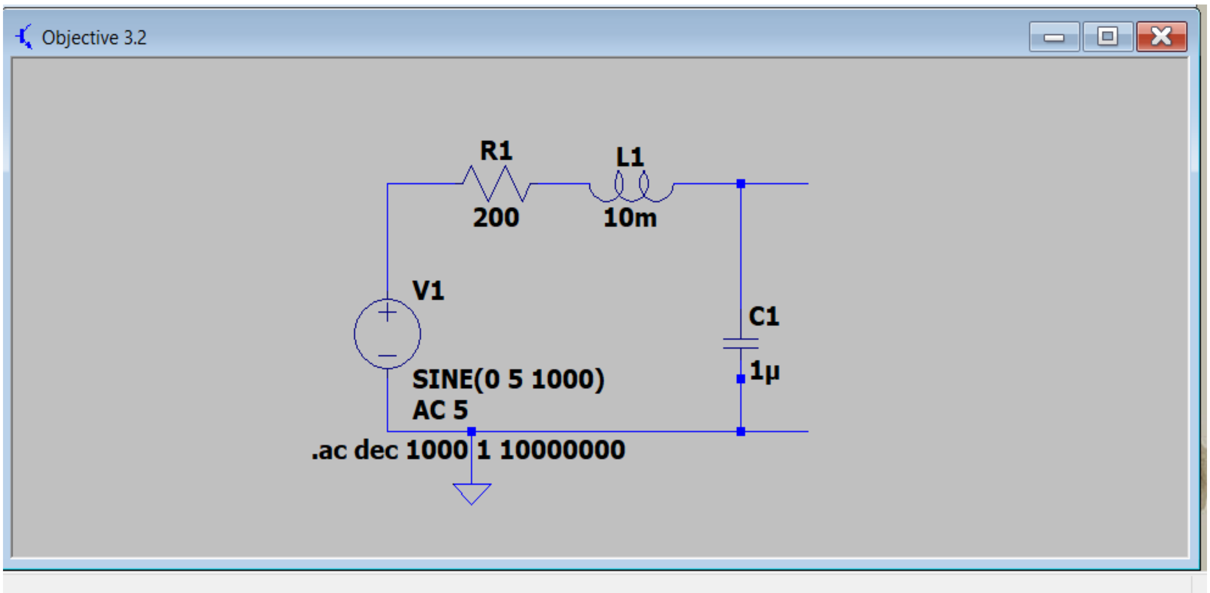
For the Overdamped case, we choose R>200 Ω = 400 Ω

Schematics of the Cases

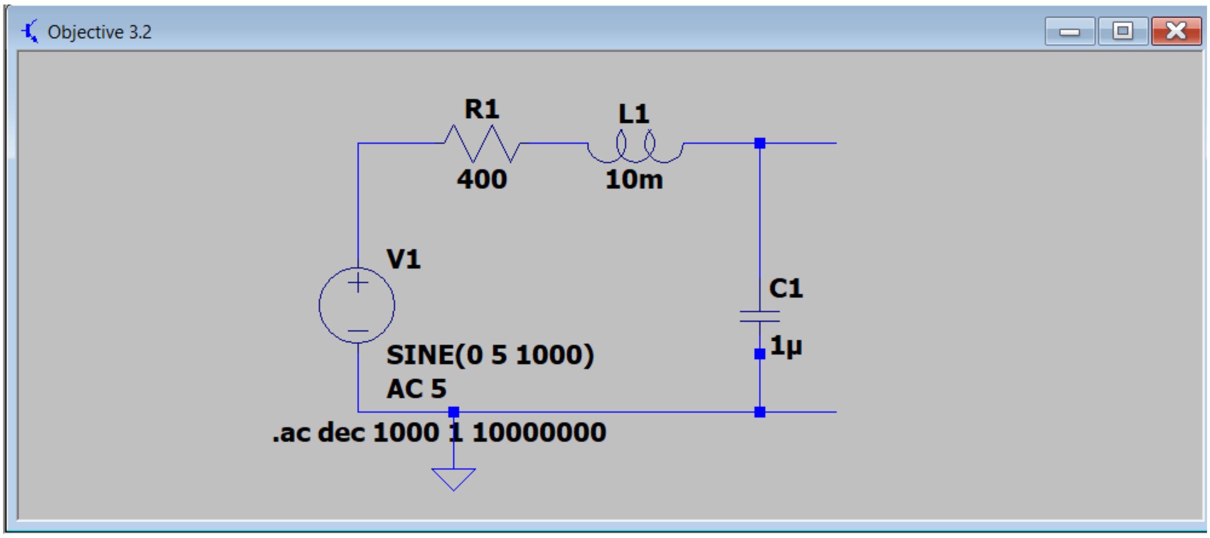
1) **Underdamped case : R=10Ω ; L=10mH ; C=1uF**



2) **Critically damped case : R=200Ω ; L=10mH ; C=1uF**



3) **Overdamped case : R=400Ω ; L=10mH ; C=1uF**

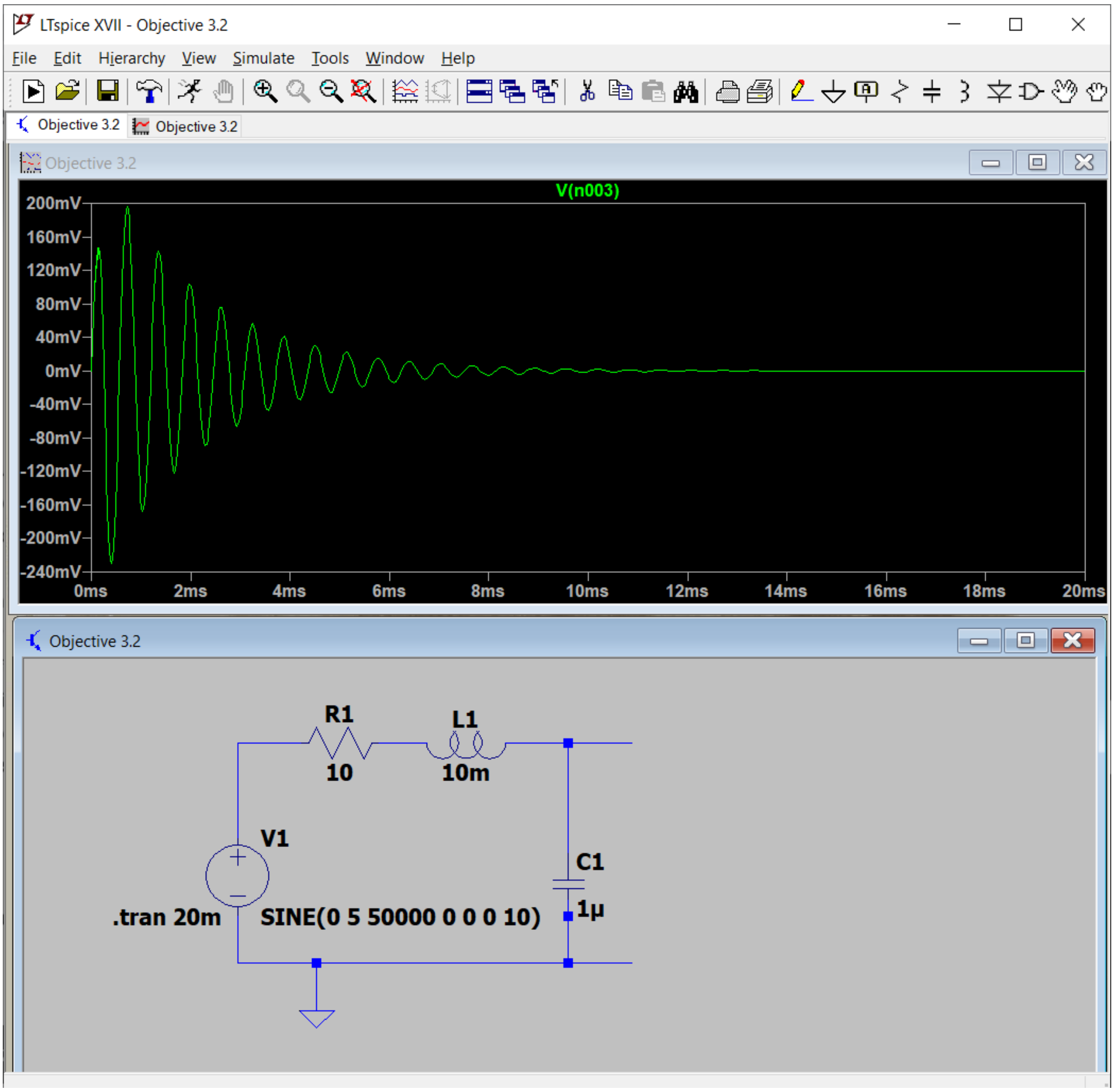


Results:

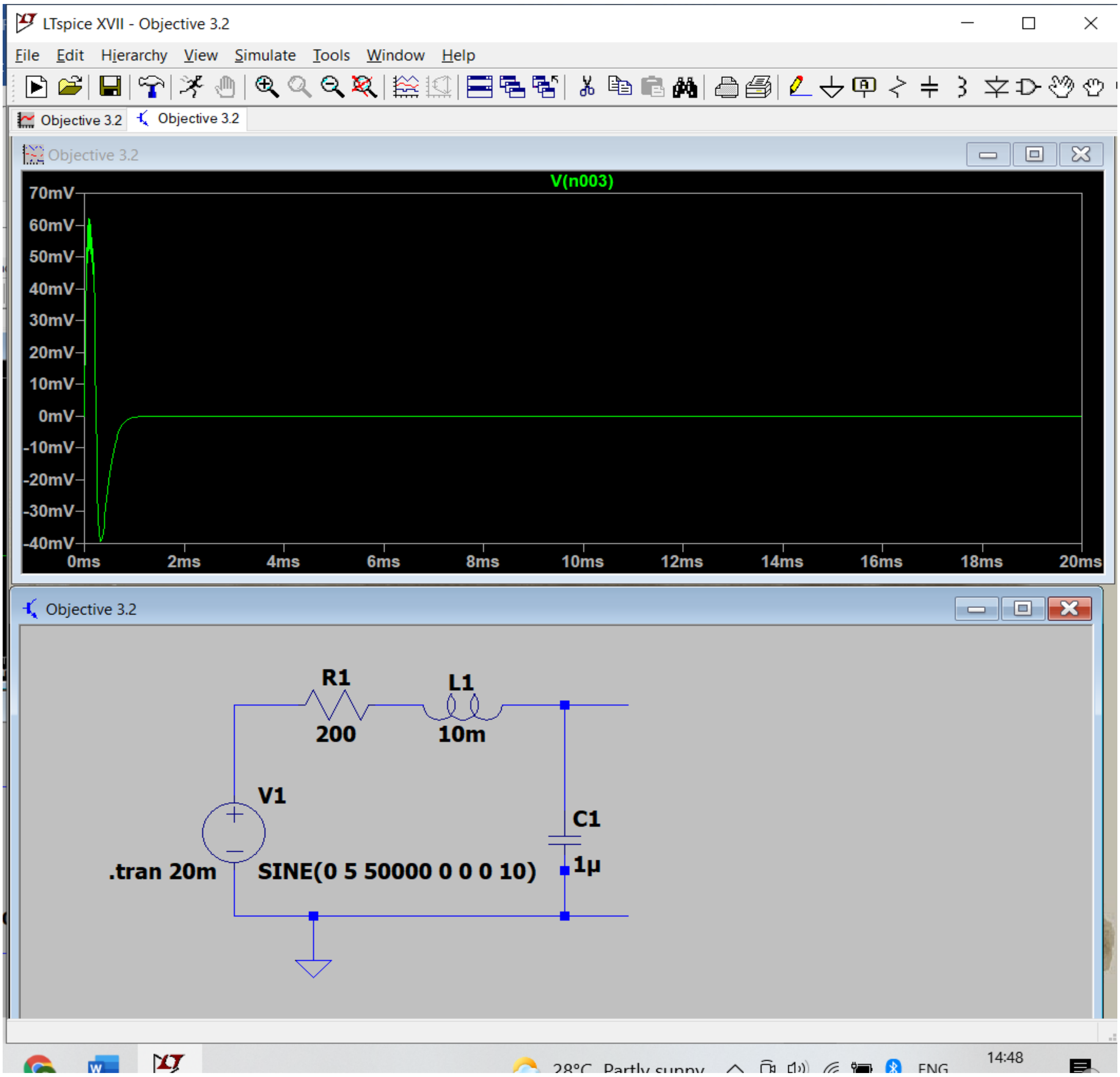
S.No	**Case**	**Resistance (in Ω)**	**Capacitance(in mF)**	**Inductance (in μH)**
1	**Underdamped**	**10**	**10**	**1**
2	**Critically Damped**	**200**	**10**	**1**
3	**Overdamped**	**400**	**10**	**1**

The graphs obtained corresponding to each of the above cases are as follows :

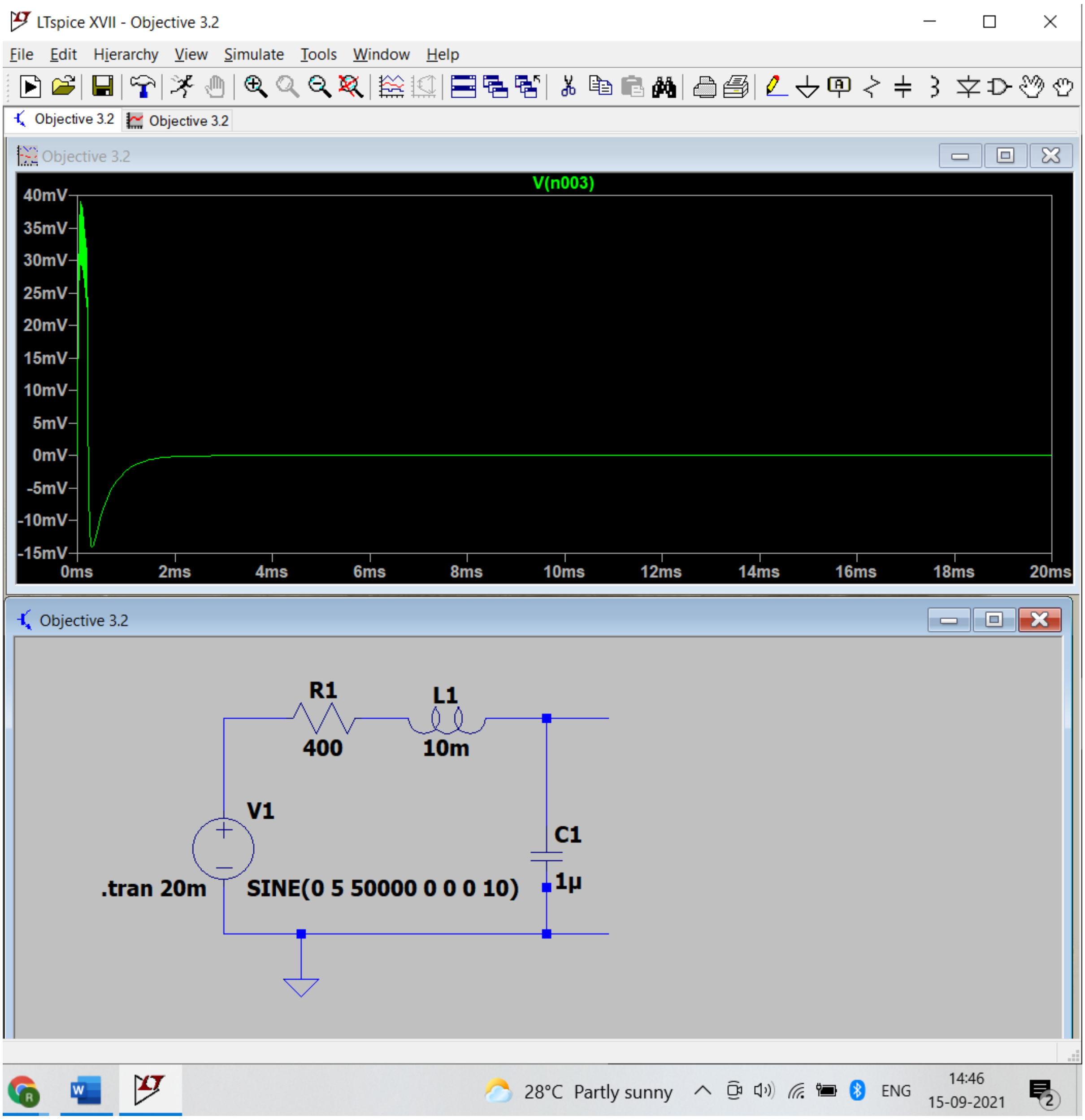
1) Voltage across capacitor for underdamped case



2) Voltage across the capacitor for the critically damped case



3) Voltage across the capacitor for the overdamped case



Discussion:

The following table helps us intuitively understand waveforms and bode plots so obtained.

Element	Resistance	Reactance(X)	Impedance(Z)
Resistor	R	0	Z=R
Inductor	0	ωL	Z = jωL
Capacitor	0	1/ωC	Z=1/(jωC)

In case of pure ohmic resistors, the voltage and current waveforms are in phase with each other. In a pure inductor, the voltage waveform leads the current by 90 degrees and in case of a capacitor, the voltage lags current by 90 degrees. This phase difference depends on the reactive value of the components being used as can be seen from the table above.

If we consider Kirchhoff's Voltage law in our circuit's equation for voltage, namely:

$V_R + V_L + V_C = V(t)$ where V(t) is the input voltage signal, on substituting the values of voltage in terms of the individual device expressions, the differential equation reduces to the following:

$$\frac{d^2}{dt^2}I(t) + \frac{\frac{R}{L}d}{dt}I(t) + \frac{1}{LC}I(t) = 0$$

The above can be further simplified using $\alpha = R/2L$ with the value of $\omega_0 = 1/\text{sqrt}(LC)$ which is the angular frequency. The term R/2L determines how fast the transient response will settle down. So depending on the values of α, we have the critically damped, underdamped and over damped cases as $\alpha = \omega_0$, $\alpha < \omega_0$, and $\alpha > \omega_0$ respectively