Lab Report 2.3

Date: 24th August 2021

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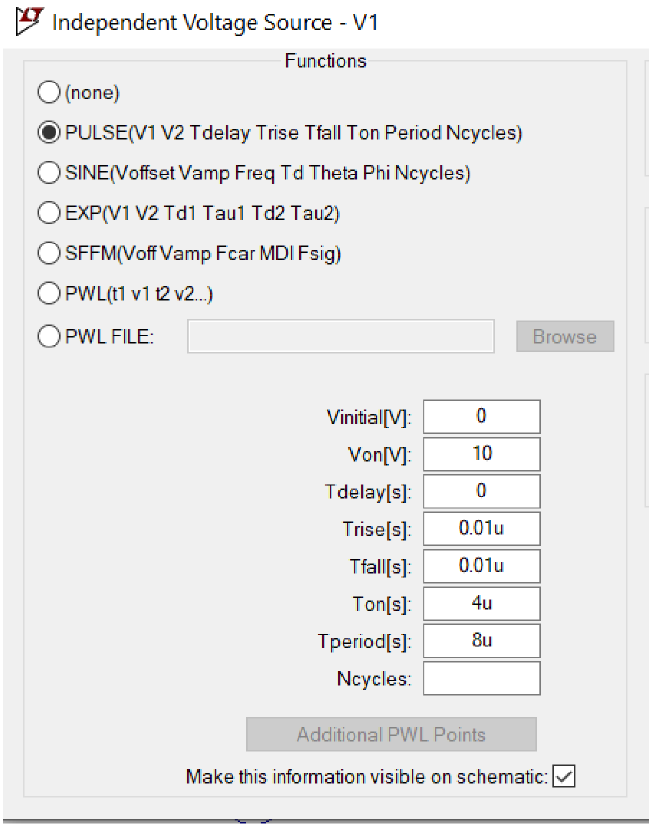
Title of Experiment: Objective 2.3 : Experiment with RL circuit with a DC source. Record the voltage and current across the L with time.

Brief Description:

In this experiment, we had to simulate RL circuits with DC source on LTSpice and then take note of the Voltages and Currents across the inductor with time graphically. The series LR circuit is composed of an inductor (L) and resistor (R) connected in series along with a constant DC voltage source V. Once the circuit is connected to a constant DC voltage source, the current starts flowing through the circuit but takes some time to reach to the maximum value according to Ohm's Law i.e. V/R.

Here are the values/parameters that were for the Independent Voltage Source under the Pulse option. We chose a rise time of 0.01 micro seconds along with a fall time of 0.01 micro seconds as well so as to have a step function to study the transient behaviour (with Vinitial as 0 and Von as 10).

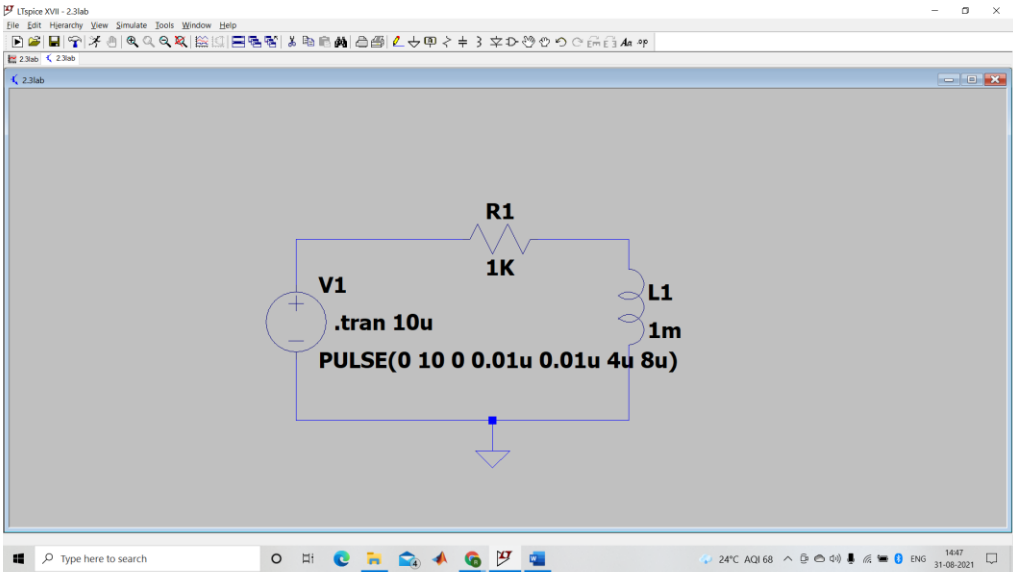


Schematic diagram:

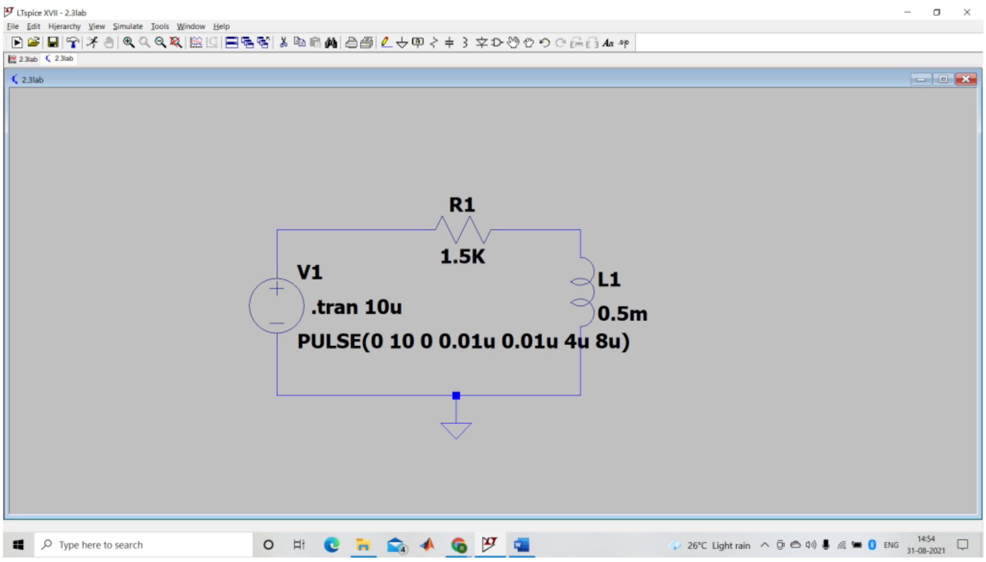
We considered experimenting with the following 4 RL circuit setups:

Charging Cases

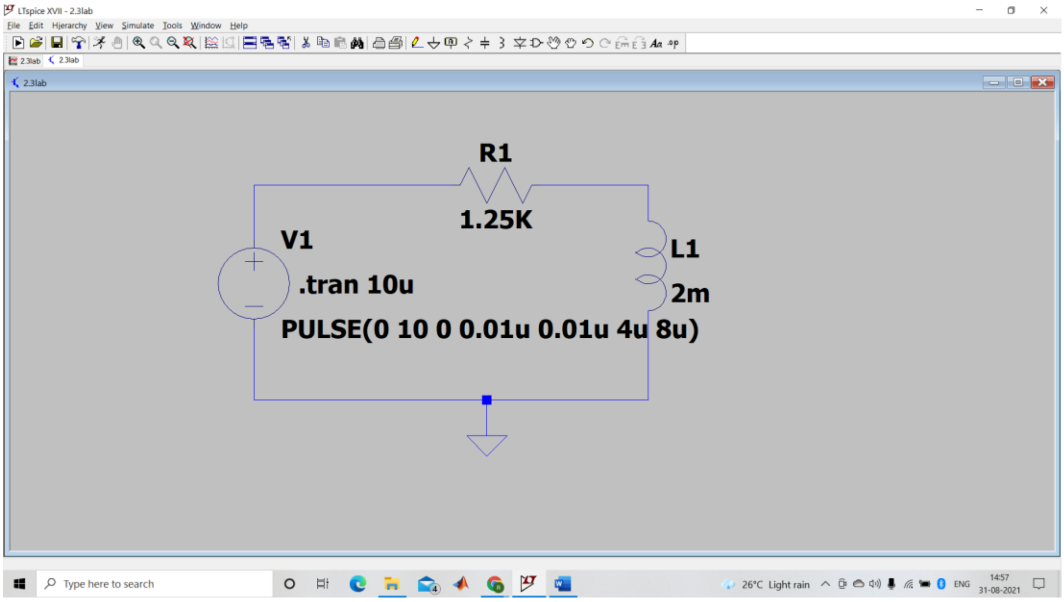
1) R1= 1KΩ and L1= 1mH



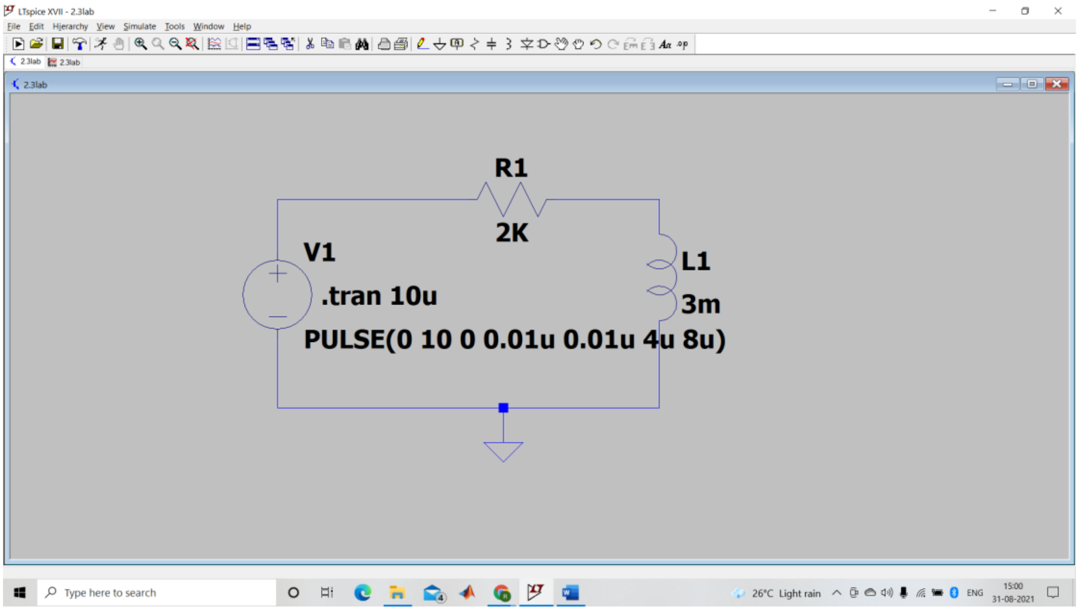
2) R1= 1.5KΩ and L1= 0.5mH



3) R1= 1.25KΩ and L1= 2mH



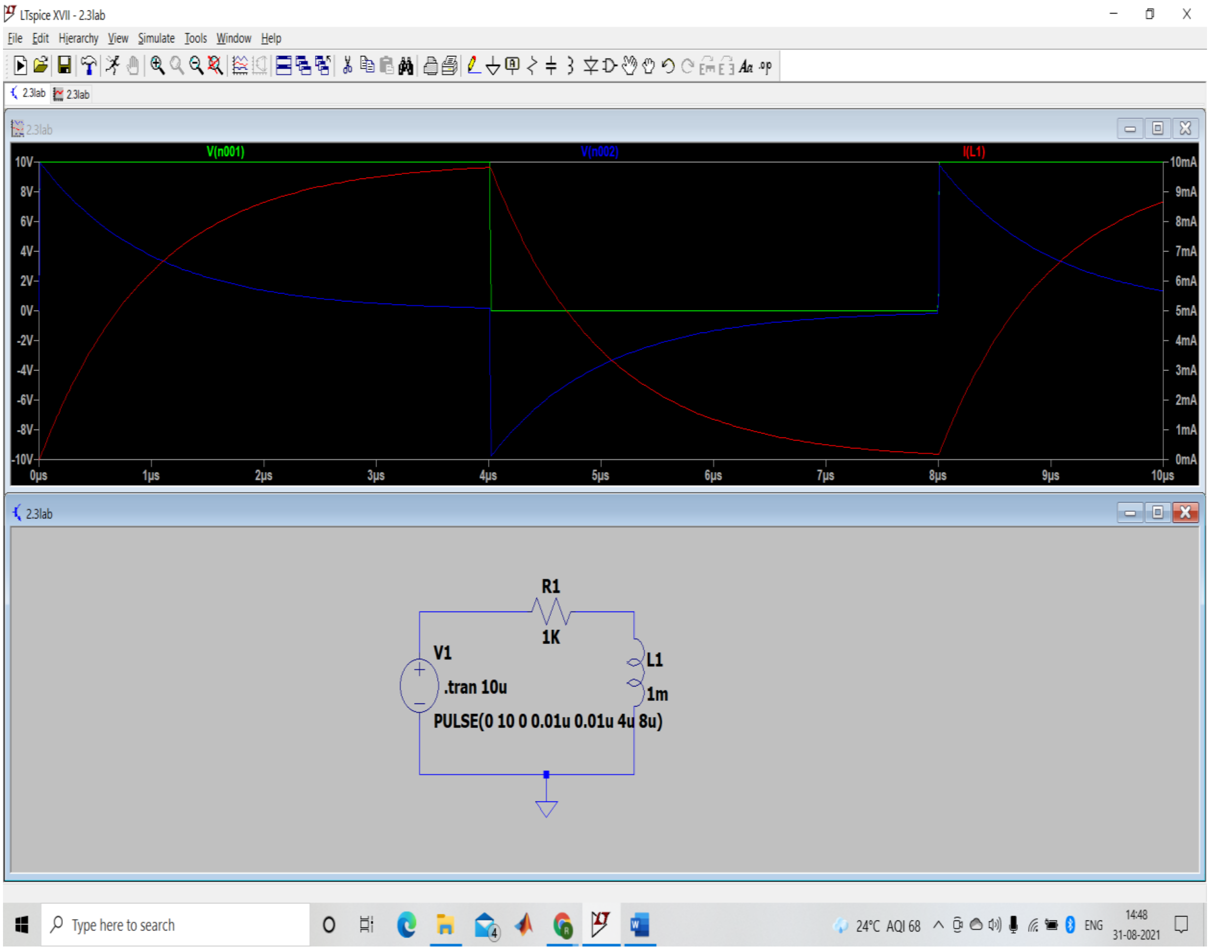
4) R1= 2KΩ and L1= 3mH



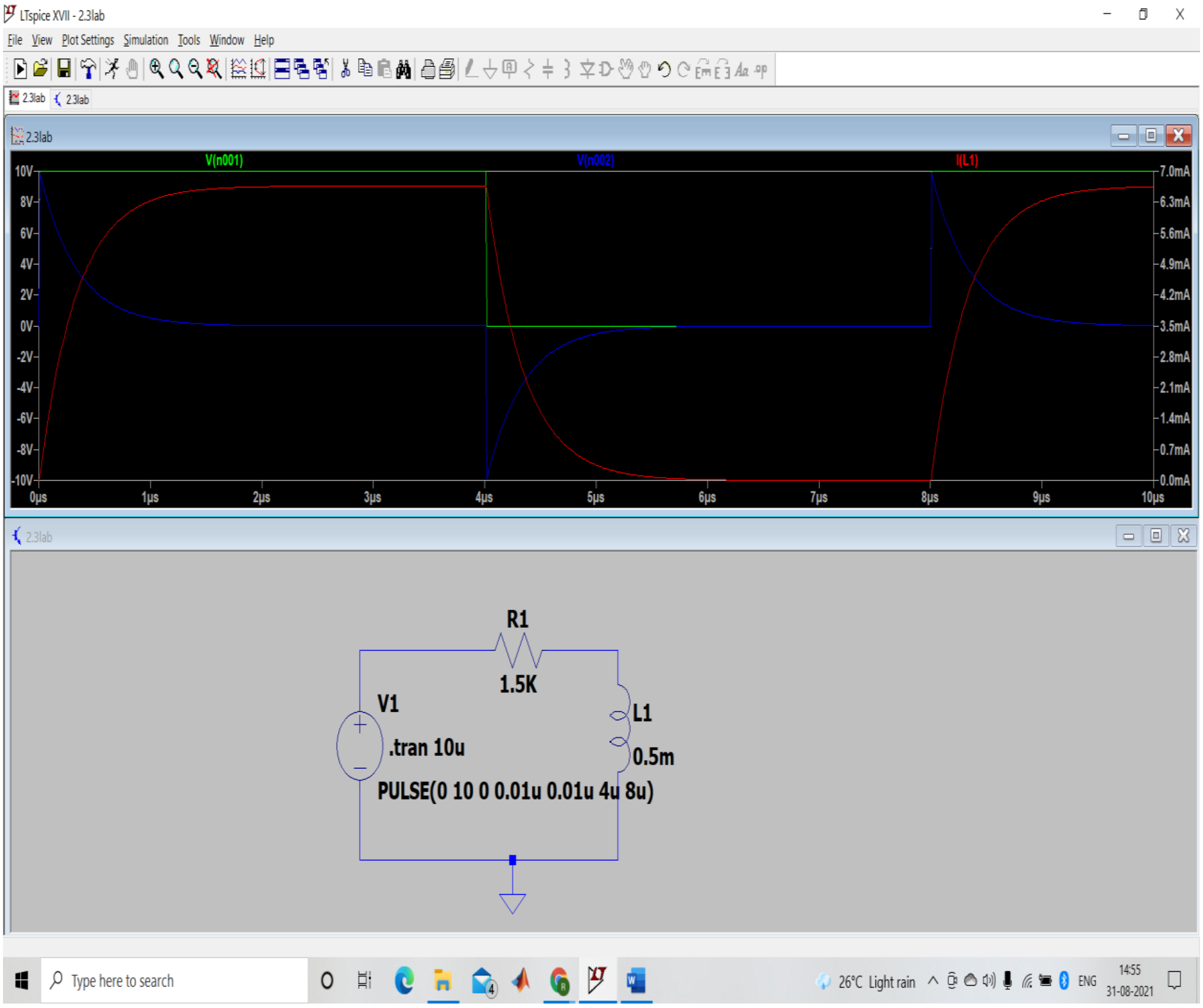
Results:

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

1)



2)


LTspice XVII - 2.3lab
File View Plot Settings Simulation Tools Window Help
2.3lab
V(n001)
V(n002)
I(L1)
10V
8V
6V
4V
2V
0V
-2V
-4V
-6V
-8V
-10V
7.0mA
6.3mA
5.6mA
4.9mA
4.2mA
3.5mA
2.8mA
2.1mA
1.4mA
0.7mA
0.0mA
0µs
1µs
2µs
3µs
4µs
5µs
6µs
7µs
8µs
9µs
10µs
R1
1.5K
V1
L1
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PULSE(0 10 0 0.01u 0.01u 4u 8u)
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26°C Light rain
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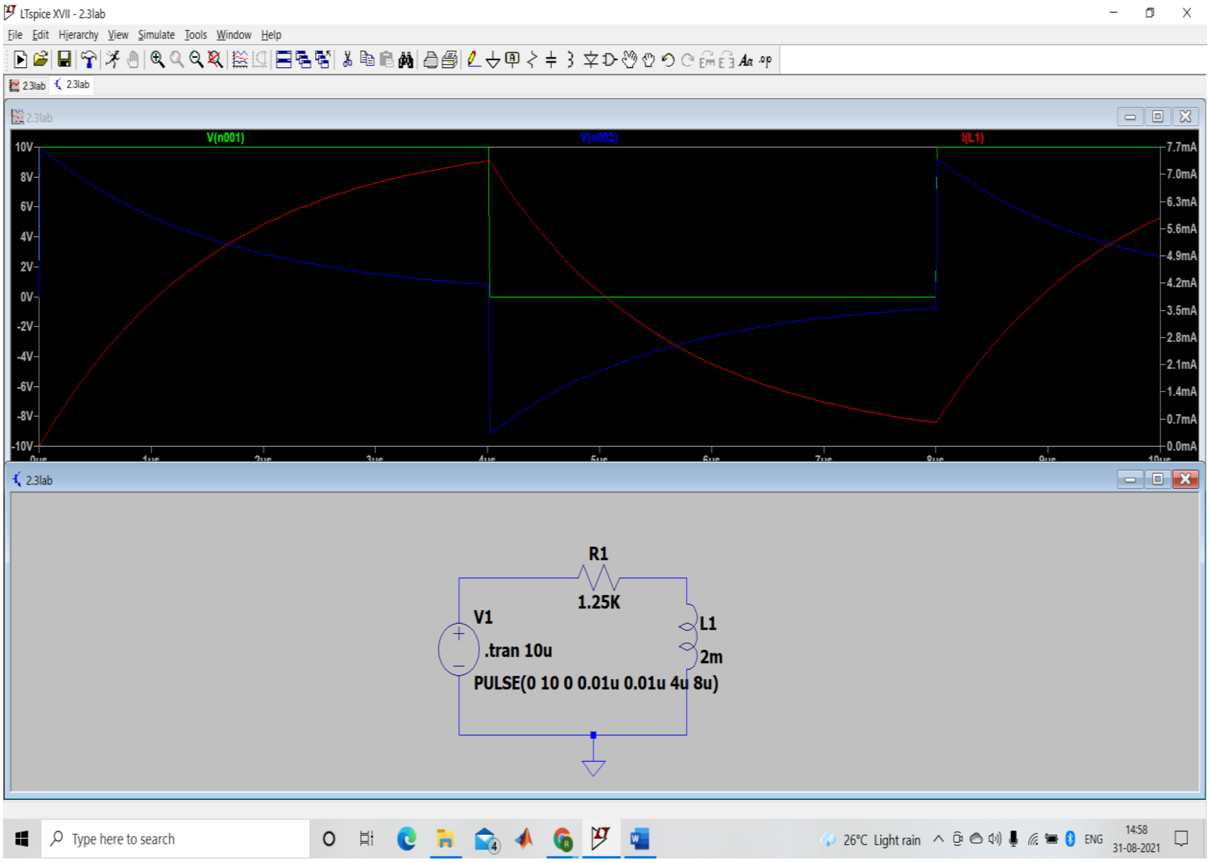
31-08-2021

3)


LTspice XVII - 2.3lab
File Edit Hierarchy View Simulate Tools Window Help
V(n001)
V(n002)
I(L1)
10V
8V
6V
4V
2V
0V
-2V
-4V
-6V
-8V
-10V
7.7mA
7.0mA
6.3mA
5.6mA
4.9mA
4.2mA
3.5mA
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R1
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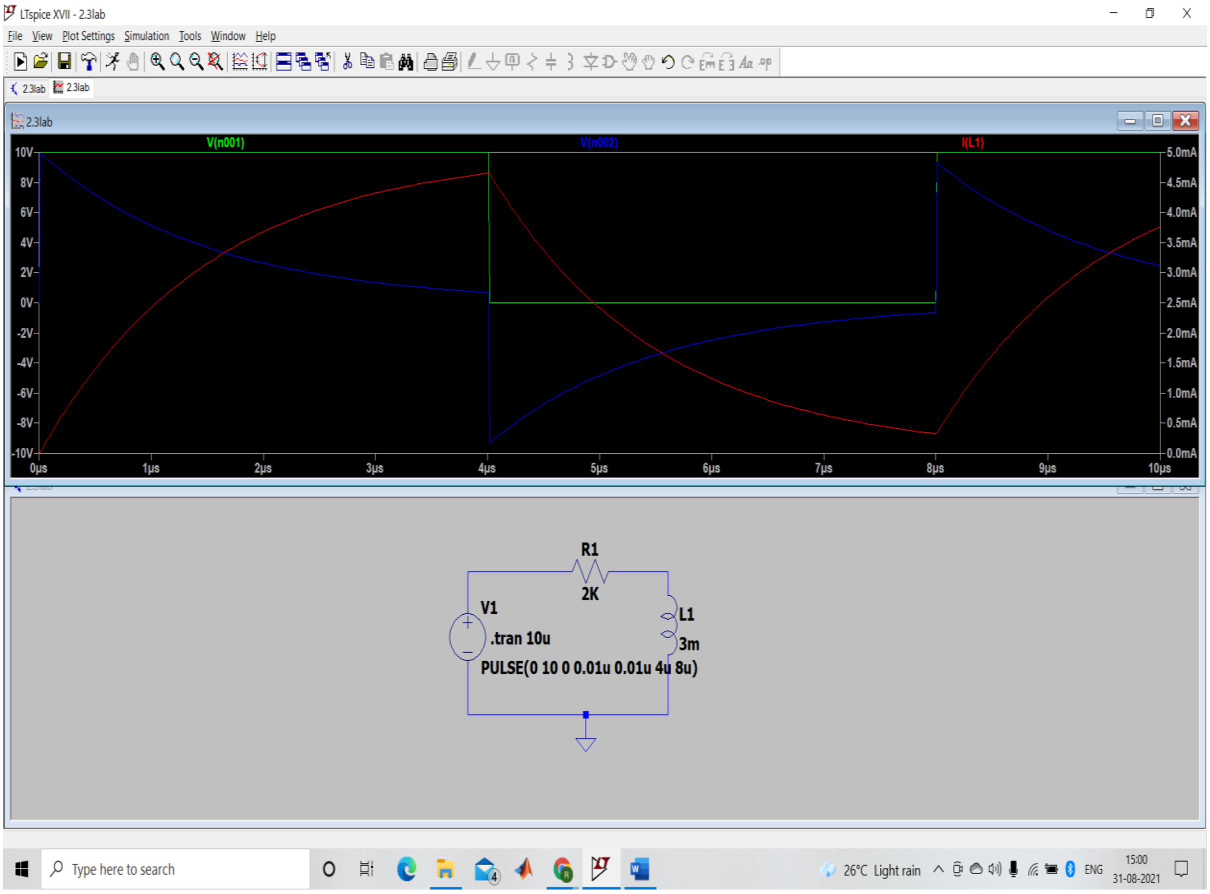
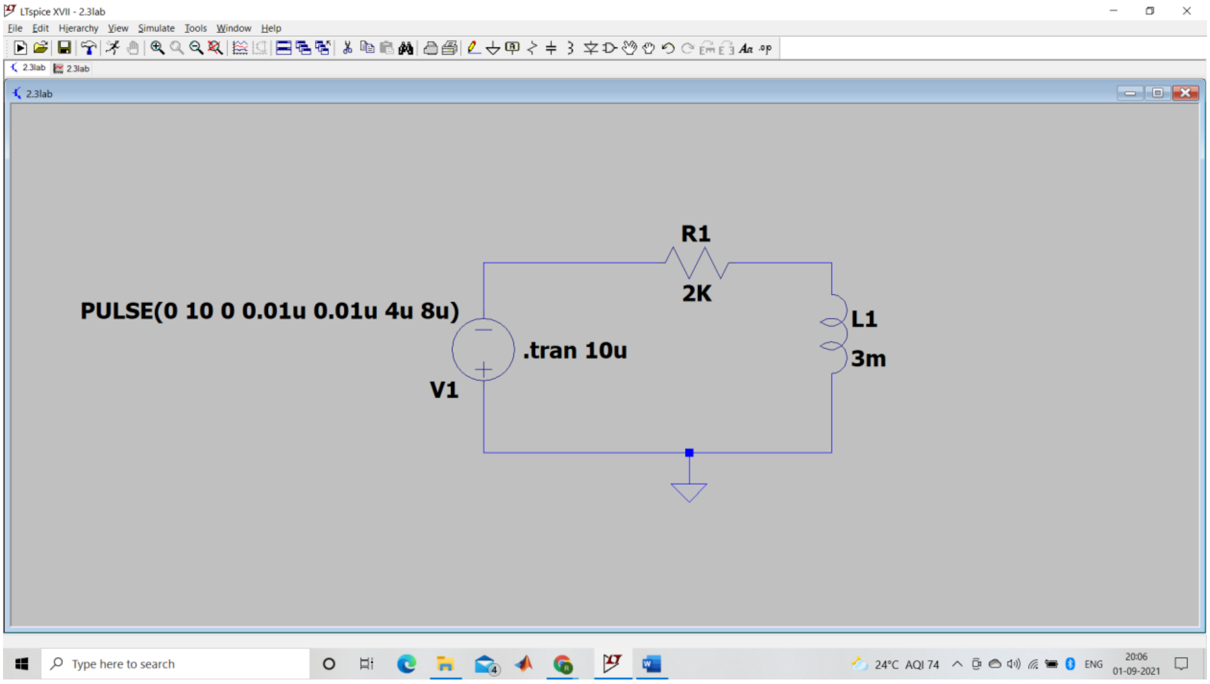
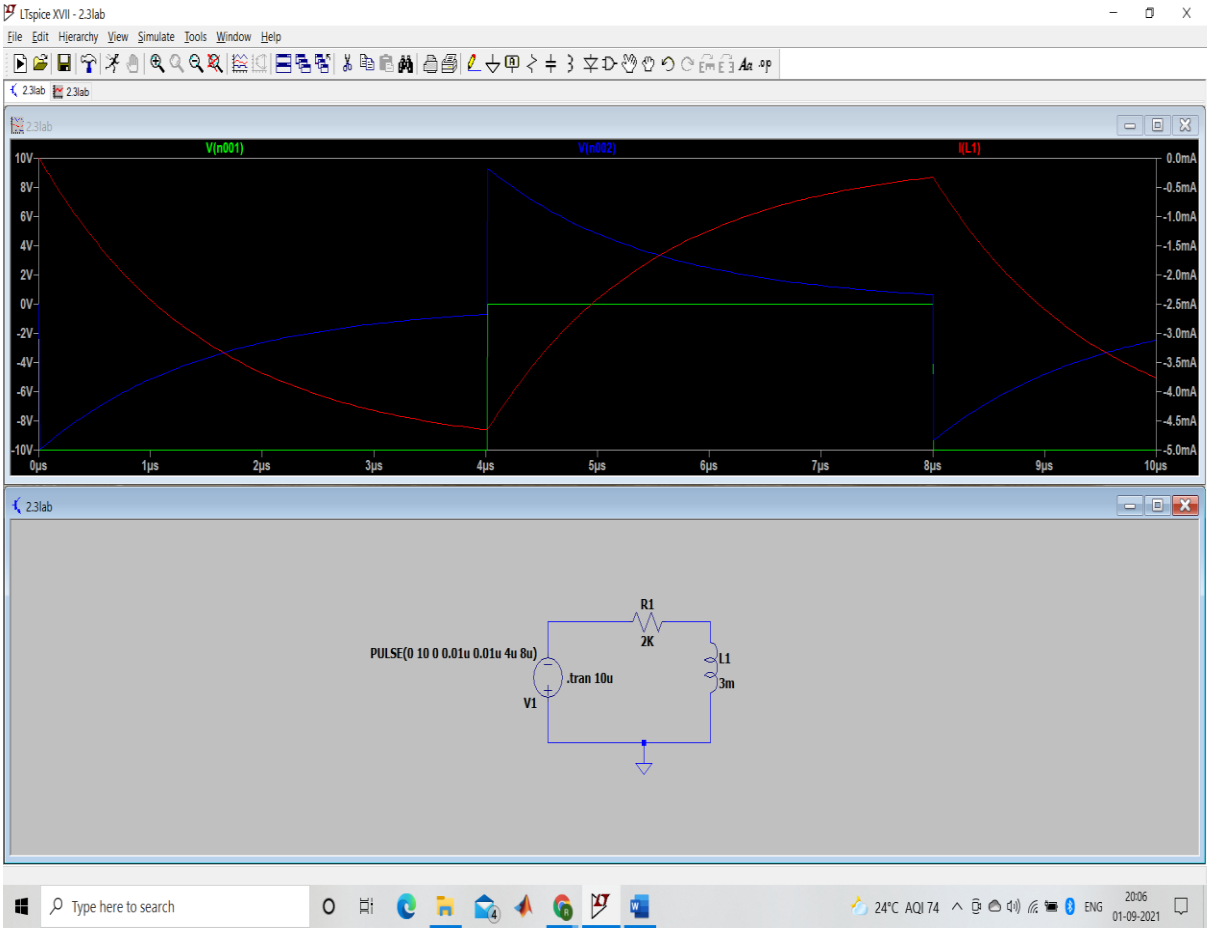
4)

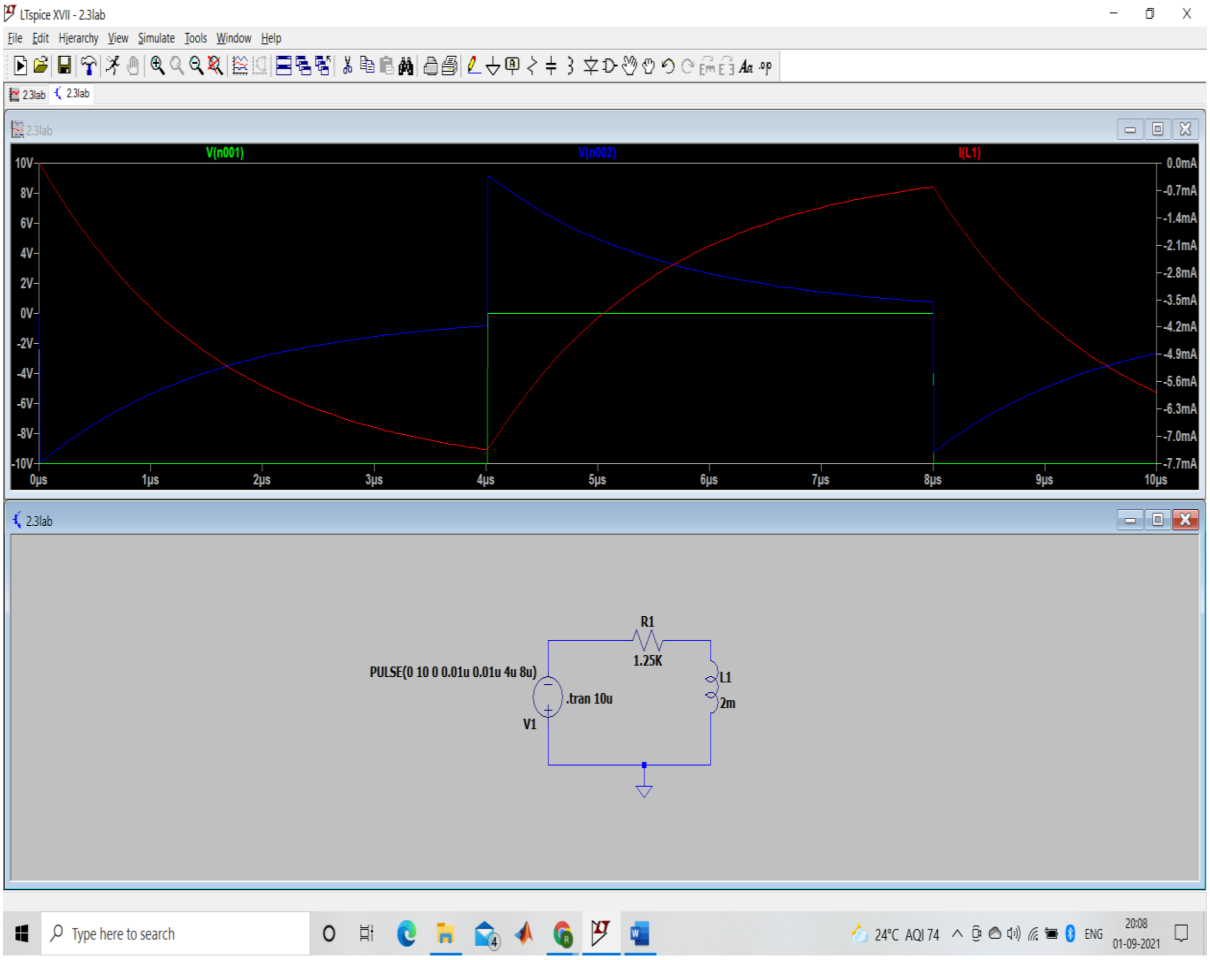


For the discharging case, we were required to reverse the polarity of the voltage source, the circuit and accompanying graph obtained are as follows :

DISCHARGING CASES(S)







As can be seen, the only difference between the charging and discharging graphs is the direction of the curve or slope (slopes have been reversed, preserving magnitude and symmetry and only changing direction). As seen, the for the voltage curves, the discharging graphs so obtained are the mirror images of the charging curves with respect to the x-axis.

The voltage drop across the inductor, V_L will have a value equal to:

$V_L = \ Ve^{(-Rt/L)}$

Then the voltage across the inductor, V_L will have an initial value equal to the battery voltage at time t = 0 or when the switch is first closed and then decays exponentially to zero .

Similarly, the current through the inductor, I_L at any time t can be given by,
$I_L = (V/R)*(1 - e^{-t/\tau})$,

where V is the applied voltage and R is the resistance.

K denotes Kilo or 10^3 while m denotes milli or 10^{-3}

S. No	Resistance (R1)	Inductance(M1)	Time Constant (L1/R1 in mH/ KΩ or in 10^{-6} seconds)
1	1KΩ	1mH	1
2	1.5KΩ	0.5mH	0.75
3	1.25KΩ	2mH	2.5
4	2KΩ	3mH	6

For a charging LR circuit, T = L/R

Time constant = L/R value	Maximum Voltage (in %)	Maximum Current (in %)
0.5 T	39.3	60.7
0.7 T	50.3	49.7
1 T	63.2	36.8
5T	99.3	0.7

Discussion:

The Time Constant, (τ) of the LR series circuit is given as L/R and in which V/R represents the final steady state current value after five time constant values. Once the current reaches this maximum steady state value at 5τ, the inductance of the coil has reduced to zero acting more like a **short circuit** and effectively removing it from the circuit.

The current, i begins to flow through the circuit but does not rise rapidly to its maximum value of Imax as determined by the ratio of V / R (Ohms Law).

This limiting factor is due to the presence of the self induced emf within the inductor as a result of the growth of magnetic flux, owing to Lenz's law. After a while, the voltage source neutralizes the effect of the self induced emf, the current flow becomes constant and the induced current and field are reduced to zero.

The final expression for individual voltage drops around our LR series circuit is given as:

$V(t) = I*R + L (di/dt)$

the voltage drop across the resistor depends upon the current, i, while the voltage drop across the inductor depends upon the rate of change of the current, di/dt.