

Lab Report 2.3

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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).

 Independent Voltage Source - V1

Functions

☐ (none)

☒ PULSE(V1 V2 Tdelay Trise Tfall Ton Period Ncycles)

☐ SINE(Voffset Vamp Freq Td Theta Phi Ncycles)

☐ EXP(V1 V2 Td1 Tau1 Td2 Tau2)

☐ SFFM(Voff Vamp Fcar MDI Fsig)

☐ PWL(t1 v1 t2 v2...)

☐ PWL FILE:

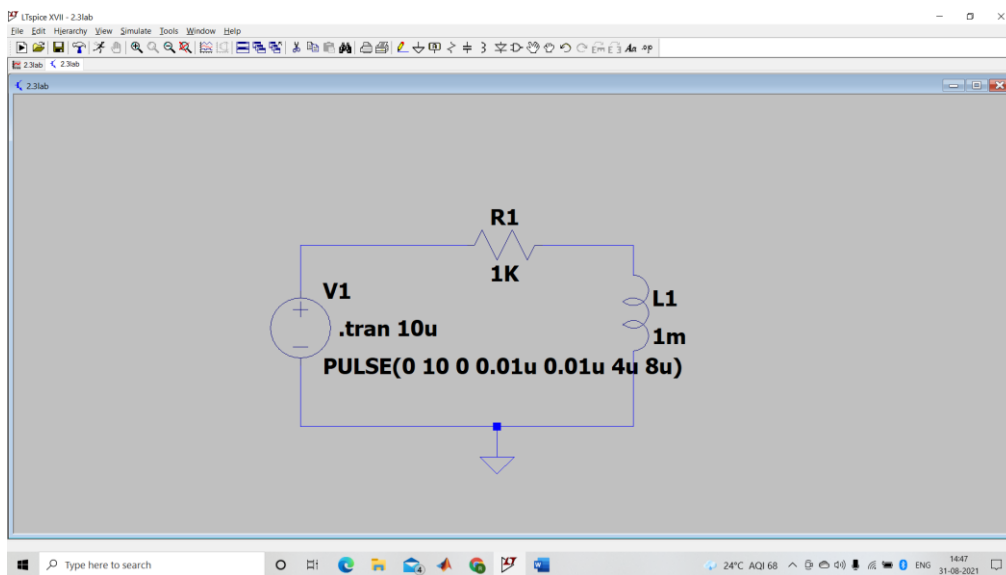
Vinitial[V]:	<input type="text" value="0"/>
Von[V]:	<input type="text" value="10"/>
Tdelay[s]:	<input type="text" value="0"/>
Trise[s]:	<input type="text" value="0.01u"/>
Tfall[s]:	<input type="text" value="0.01u"/>
Ton[s]:	<input type="text" value="4u"/>
Tperiod[s]:	<input type="text" value="8u"/>
Ncycles:	<input type="text"/>

Make this information visible on schematic: ☒

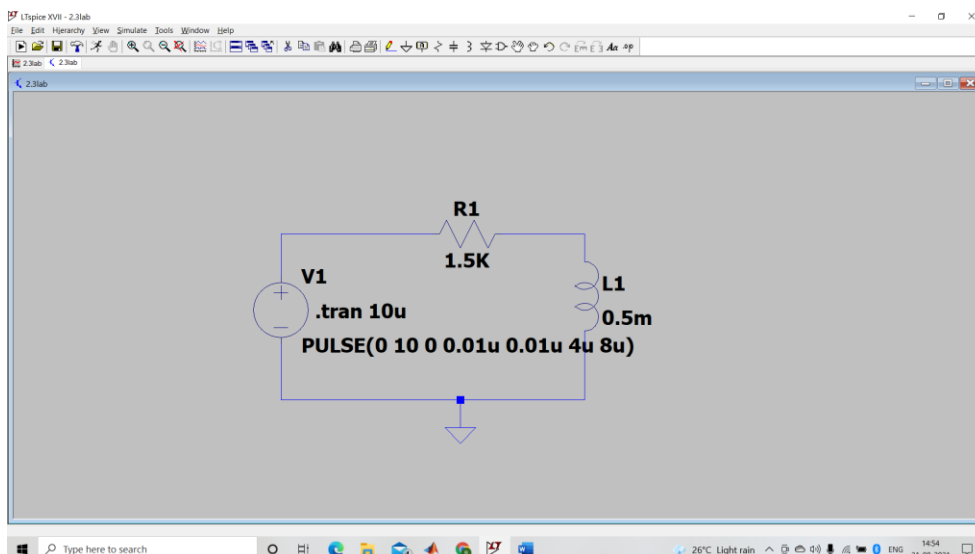
Schematic diagram:

We considered experimenting with the following 4 RL circuit setups:

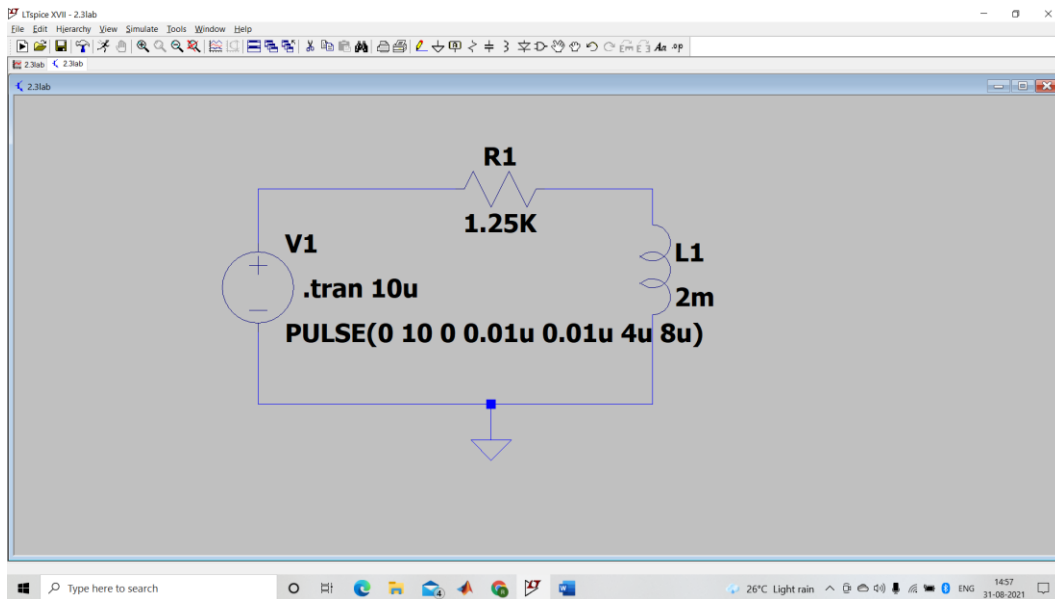
1) $R1 = 1\text{K}\Omega$ and $L1 = 1\text{mH}$



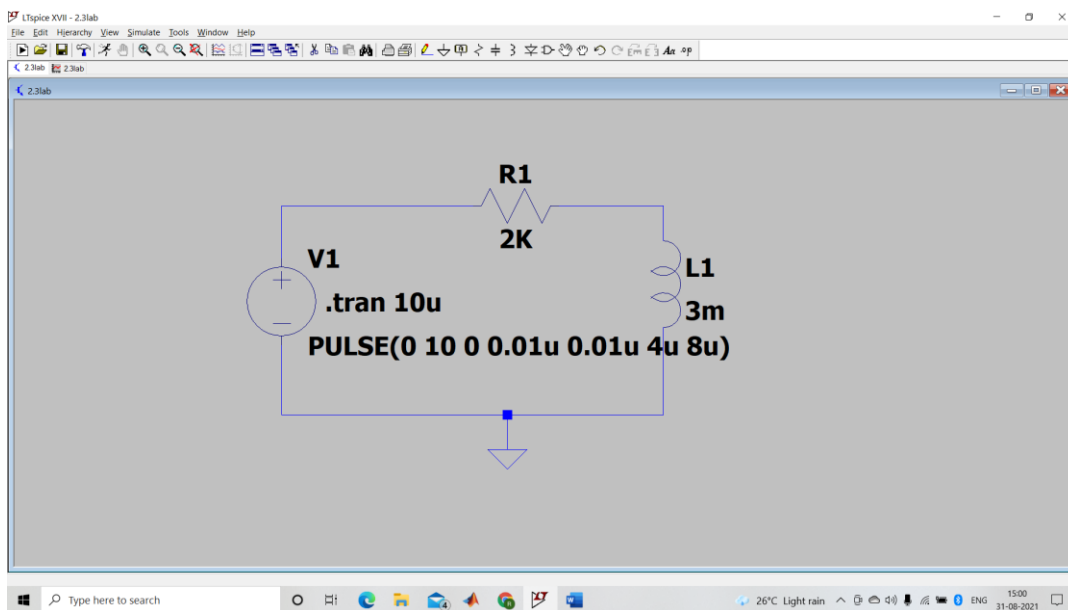
2) $R1 = 1.5\text{K}\Omega$ and $L1 = 0.5\text{mH}$



3) $R1 = 1.25K\Omega$ and $L1 = 2mH$



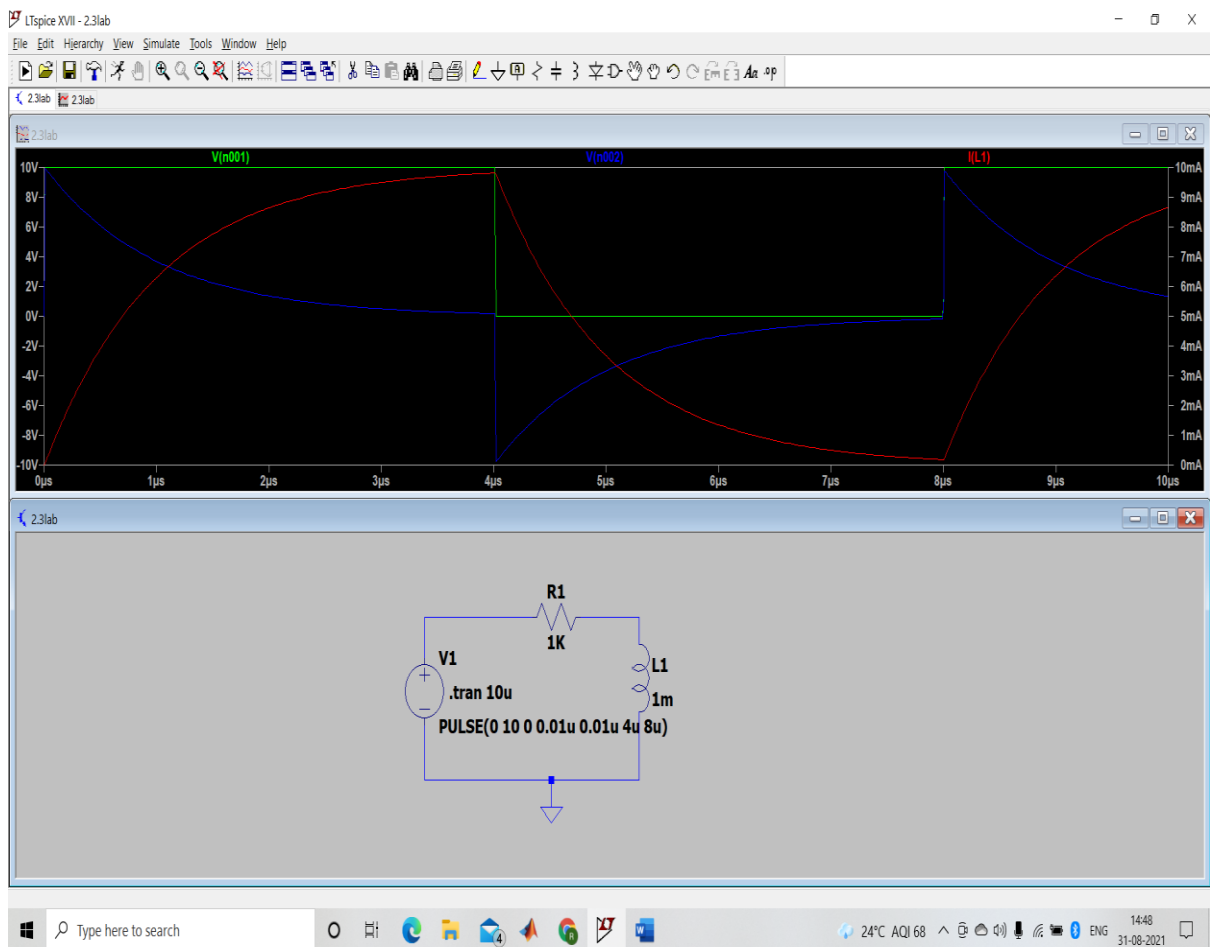
4) $R1 = 2K\Omega$ and $L1 = 3mH$



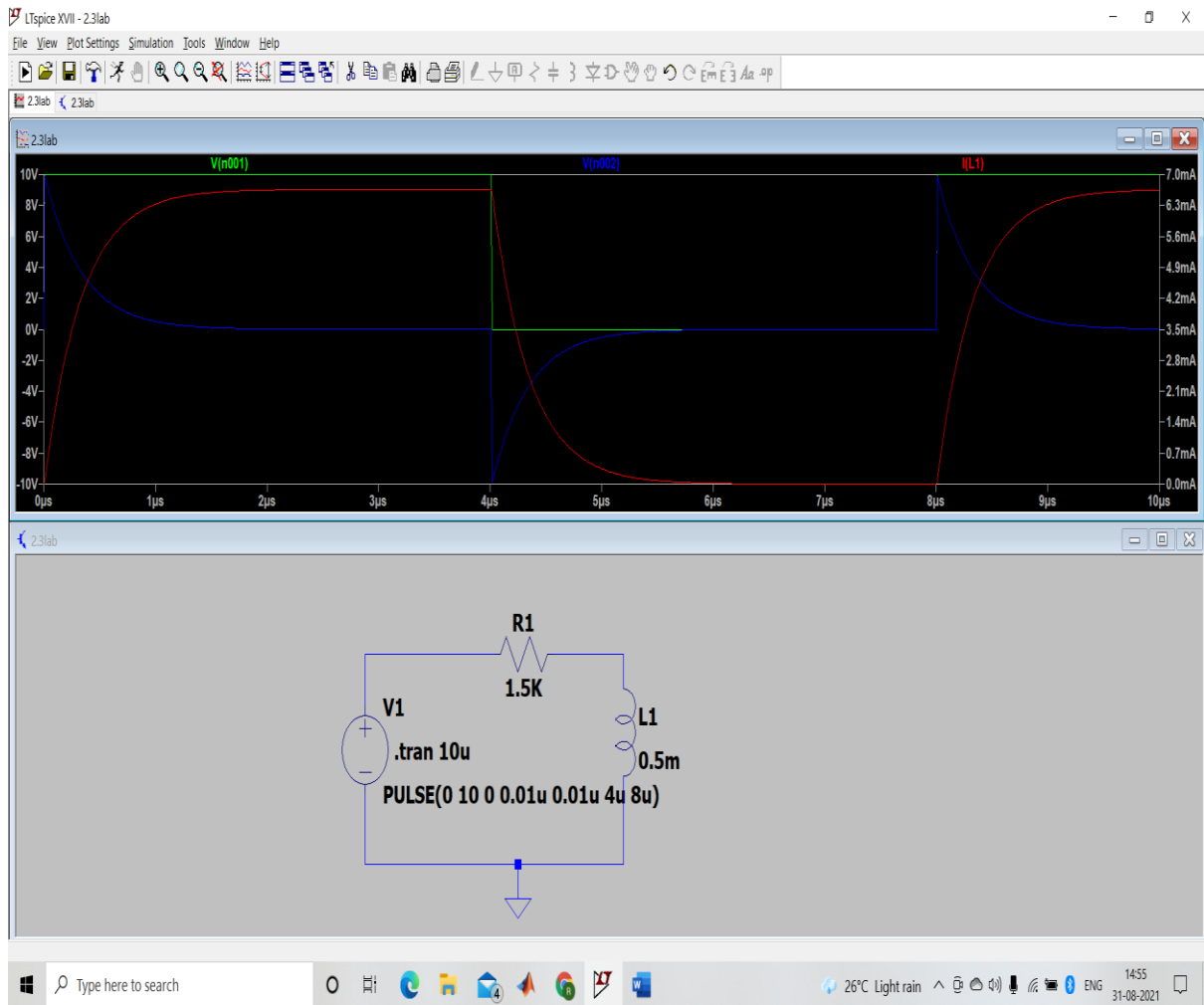
Results:

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

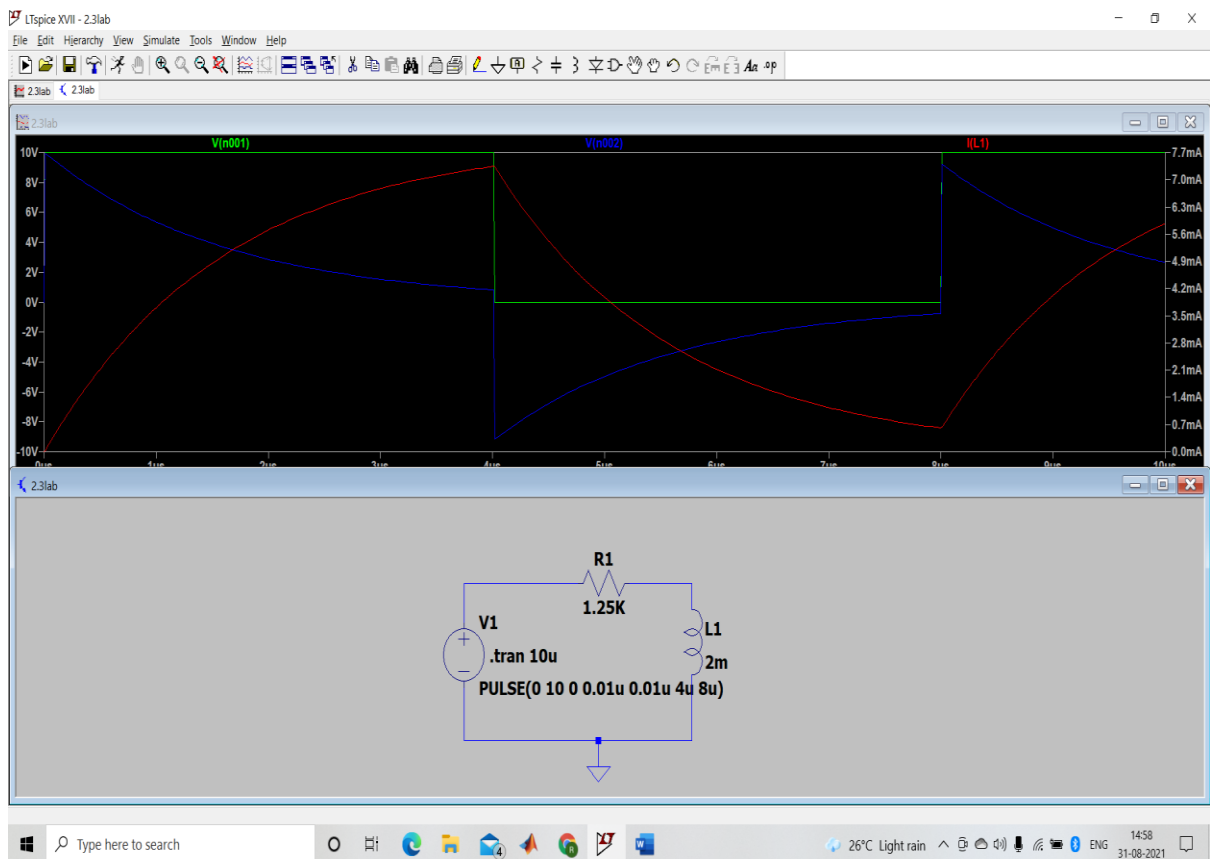
1)



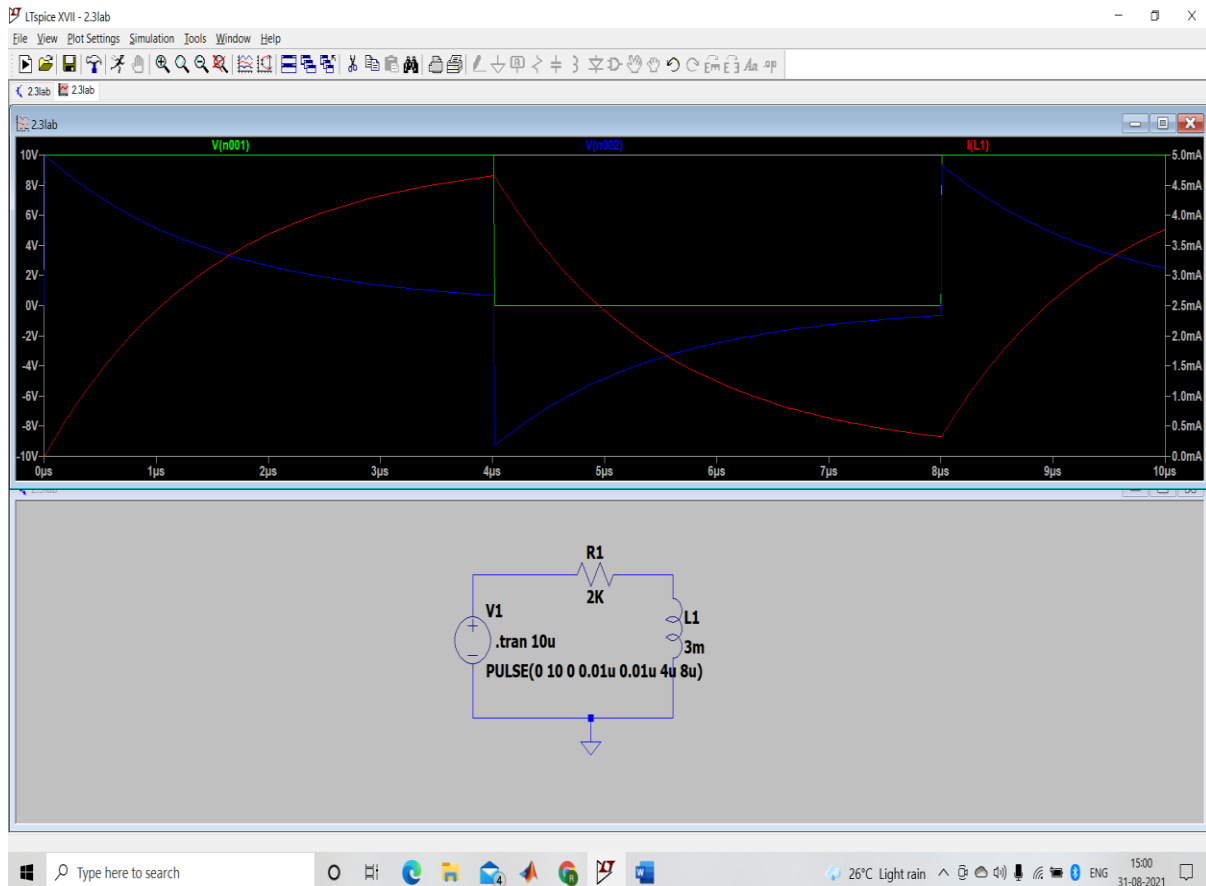
2)



3)



4)



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

$$V_L = V e^{(-Rt/L)}$$

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/ K Ω or in 10^{-6} seconds)
1	1K Ω	1mH	1
2	1.5K Ω	0.5mH	0.75
3	1.25K Ω	2mH	2.5
4	2K Ω	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 I_{max} 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:

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

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 .