Preliminary report

Basic Information Laboratory

Subject: Basic Information Laboratory

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purpose

This paper is the fifth preliminary report. In this experiment, I will explore the charging and discharging of an RL circuit, including the voltage response across the resistor during this process. Additionally, the basic knowledge of inductors will be included in the theoretical background section.

Theoretical Background

<u>* About inductors</u>

Inductor: A passive component that stores energy in the form of magnetic energy when electric current flows through it. It's also referred to as a coil, choke, or reactor.

-> It functions similarly to a capacitor in storing energy but serves a different role in the circuit.

Impedance of inductor: jwL

-> When the value of w increases, the circuit's total impedance rises. In other words, an inductor does not allow high-frequency signals to pass through the circuit.

-> Vice versa, the impedance of a capacitor is $\frac{1}{jwC}$ so that the capacitor does not allow low-frequency signal to pass through the circuit.

Inductance (L): Property of an inductor that determines how much opposition it offers to changes in current. It's measured in Henries (H). A higher inductance means the inductor will resist changes in current more effectively.

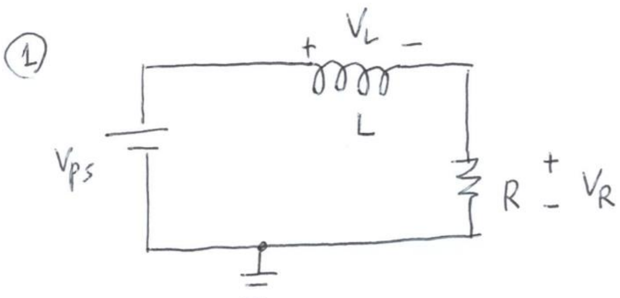
The time constant (τ): The time required to charge the capacitor/inductor to 63.2% of the value through an applied DC voltage. Conversely, the period required to discharge a capacitor/inductor to about 36.8% of its value is also one-time constant of the circuit.

-> The capacitor: RC (R: resistor value, C: capacitance)

-> The inductor: $\frac{L}{R}$ (R: resistor value, L: inductance)

* Both could be derived using the Laplace transform.

<u>Task 1: Expecting the value of V_L & V_R when the DC circuit applied</u>



$$V_{PS} = iR + L\frac{di}{dt}$$

- In DC circuits, the inductor behaves like a short circuit (0 ohms) after initial transients. The current becomes constant over time

- Following Kirchhoff's voltage law, we can find $V_{PS} = iR + L\frac{di}{dt}$. Applying Laplace transform yield, we can find the equation below.

$$V_R = V_{PS}(1 - e^{-\frac{t}{\tau}})$$

$$\tau = \frac{L}{R}$$

* As V_L is a floating voltage, we cannot measure it directly. So, we should find the value with the oscilloscope's subtraction operation as before.

Task 2: Expecting the value of V_L & V_R when the voltage source removed

② No input

$iR + L\frac{di}{dt} = 0$

Here $i(0) \neq 0$!

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$$V_R = V_{PS}e^{-\frac{t}{\tau}}$$

$$\tau = \frac{L}{R}$$

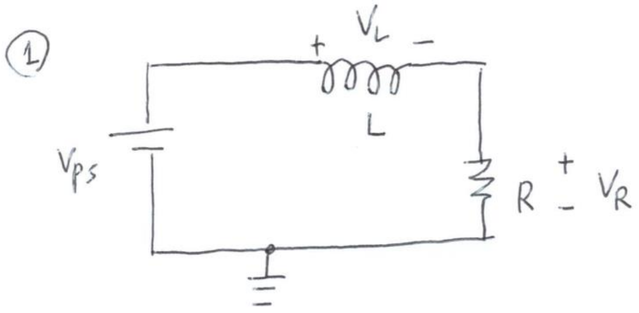
- As V_L is a floating voltage, we cannot measure it directly. So, we should find the value with the oscilloscope's subtraction operation as before.

Task 3: Observing the response of the inductor using a function generator

Now we know how to produce a rectangular signal with a function generator. We will use the signal given by the reference paper.

Procedure

Task 1: Expecting the value of V_L & V_R while charging inductor



$$V_{PS} = iR + L\frac{di}{dt}$$

1. Compose the circuit on the left side. (Check the resistor is grounded!!!!!!!!)

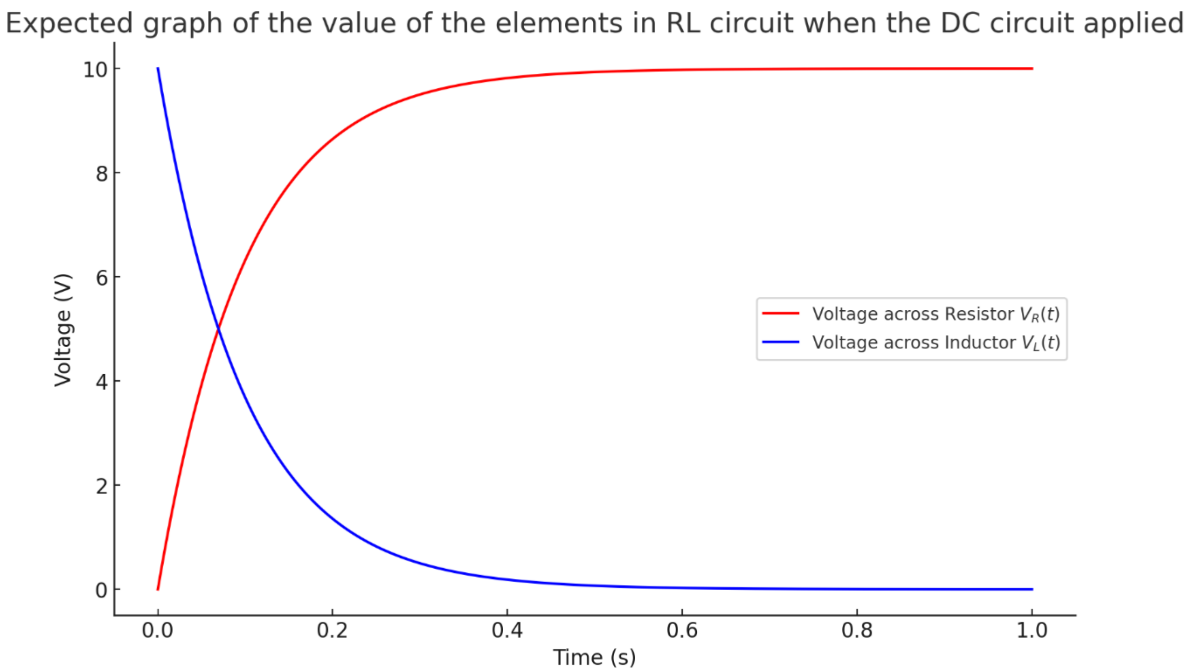
2. Set V_{PS} as 10V

3. Display V_{PS} and V_R in Ch1 and Ch2 respectively. (Make sure V_{PS}=V_R at t=0)

4. Find V_L using the subtraction operation of the oscilloscope.

5. Take a picture of them

- Expected graph (τ is set as 0.1s)



In an RL circuit, the inductor resists sudden changes in current, so it initially takes on almost the entire voltage across the circuit. When the DC power is applied, the inductor opposes the current increase, and most of the voltage appears across the inductor at first.

Over time, as the inductor gradually allows more current to flow (with the magnetic field building up), the voltage across it decreases, approaching zero. Eventually, the resistor takes on the full supply voltage, as the current stabilizes and the inductor's opposition to current changes diminishes.

Task 2: Expecting the value of V_L & V_R when the voltage source removed

(2) No input

$iR + L\frac{di}{dt} = 0$

Here $i(0) \neq 0$!

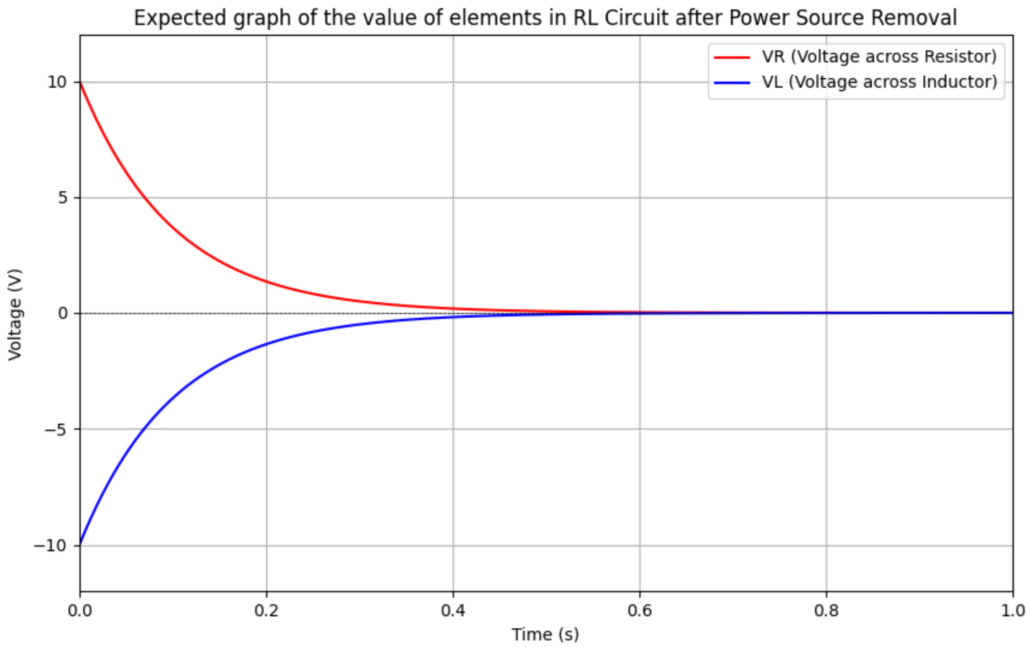
1. Compose the circuit above. (Check the resistor is grounded!!!!!!!!)

3. Display V_R in oscilloscope.

4. Find V_L using the subtraction operation of the oscilloscope.

5. Take a picture of them

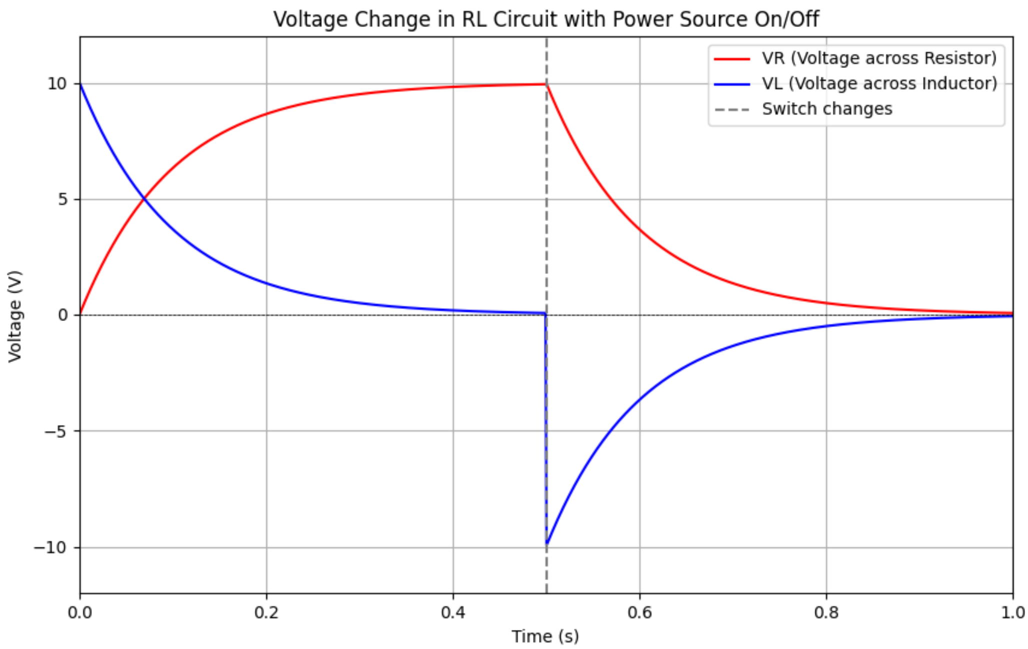
- Expected graph



When a power source is suddenly removed, the inductor tries to maintain the continuity of current flow. Inductors oppose changes in current, and to do this, they generate a voltage in the opposite direction. This is because the inductor wants to keep the sum of voltages in the circuit equal to zero.

Therefore, when the power supply is cut off, the inductor releases its stored energy and creates a voltage that acts in the reverse direction, effectively causing the voltage across the inductor to be negative, equal in magnitude to the initial voltage of the power supply. This behavior is crucial for understanding the voltage changes in an RL circuit after the power source is removed.

+) The connected graph of task 1 and task 2 would be like this



Now, referring to the graph plotted above, the inductor tries to maintain the total voltage in the circuit. When the switch is in the first position, an inductor responds immediately hitting V_{PS}. On the other hand, when the switch changes its position, an inductor becomes negative V_{PS} to maintain zero value. (according to Kirchhoff's Voltage law)

Task 3: Observing the response of the inductor using a function generator

1. Set the function generator to make a rectangular waveform.

2. Set the offset voltage as 2V

-> Push the button next to the 'OFFSET' cursor and set the offset voltage

3. To measure the floating voltage (V_L)use subtraction operator