The Hashemite University

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Electrical Circuit Lab

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Experiment "6"

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Date : 8/12/2020

Day : Tuesday

“experiment 6”

The Objectives:

- In this experiment, the natural and step response of RL circuit are examined.
- The use of computer controlled equipment is also introduced.

• Introduction and Test Circuits

Inductors and capacitors have the ability to store energy. It is important to determine the voltages and currents that arise in circuits composed by resistors, and either inductors or capacitors, when energy is *released* or *acquired* by the inductor or capacitor as a consequence of an abrupt change in the DC voltage or current in the circuit. The description of the voltages and currents in this type of circuits is done in terms of differential equations of *first order*.

1. Natural Response

The currents and voltages that arise when the energy stored in an inductor or capacitor and suddenly released to the resistors in the circuit are referred to as the *natural response* of the circuit. The behavior of these currents and voltages depends only on the nature of the circuit, and not on external sources of excitation.

• Natural Response of an RL Circuit

In an RL circuit, the natural response is described in terms of the voltage and current at the terminals of the resistor when the external source of power stops delivering energy to the circuit. The expressions for the current and voltage across the resistor are:

$$i(t) = I_{\circ} e^{\frac{-t}{\tau}} \quad , t \geq 0 \qquad (1)$$

$$V(t) = I_{\circ} R e^{\frac{-t}{\tau}} \quad , t \geq 0 \qquad (2)$$

Where *Io* is the initial current through the inductor before the power source goes off and the inductor starts releasing energy to the circuit.

The symbol ***τ*** represents the *time constant* of the circuit:

$$\tau = \frac{L}{R} \qquad (3)$$

An RL circuit is shown in Fig .Down Here, *Vs* provides a square signal with a DC offset voltage such that the bottom part of the wave form is aligned with the zero volts level. *RS* is the internal resistance of the voltage source, hence when the square wave takes the value of zero volts (and can be viewed as a short circuit) the energy of the inductor *L* is released through the combination of *R*1 and *R**S***. In order to observe the natural response of the circuit, the period *T* of the square wave must be long enough to allow the complete charge and discharge of the inductor. UsualSummarizing, the natural response of an RL circuit is calculated by

(1) finding the initial current *Io* through the inductor

(2) finding the time constant τ of the circuit (Eq. 3)

(3) using(Eq. 1) to generate *i*(*t*).

Equipment

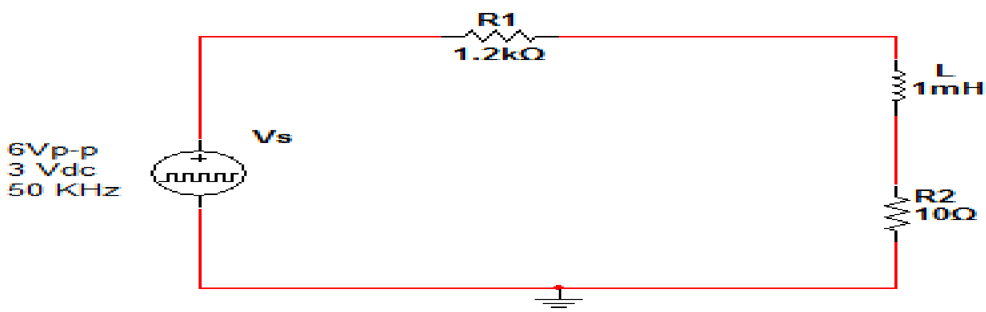
1:- Function Generator (FG)
2:- Cathode Ray Oscilloscope (CRO)
3:- Digital Multimeter (DMM)

Procedure:

There are some calculations we have done about this experiment:

- **Transient RL Circuit**

  a. Construct the following circuit.



  b. Measure the internal resistance of the inductor.

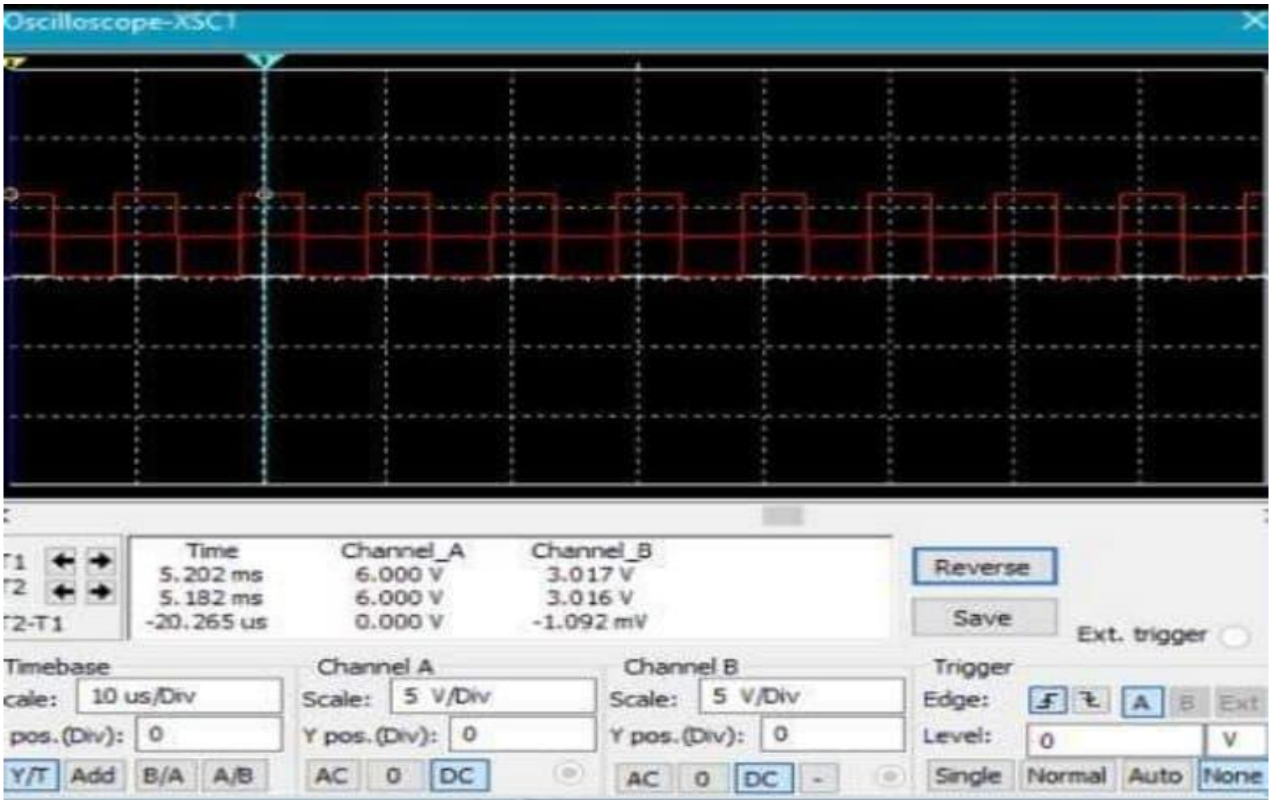
$$\boldsymbol{R_{int} = 12.3\Omega}$$

Element	Unit	Theoretical	Measured
R1	KΩ	1.2	1.19
R2	Ω	10	9.9
R_{int}	Ω		12.3
L	mH	1	
τ	s	8.829×10^{-7}	

c. Calculate the time constant τ.

$$R = \frac{L}{R_{eq}} = \frac{1m}{1.2K+10+12.3} = \frac{1m}{1222.3} = 8.829 \times 10^{-7}\text{S}$$

d. Draw the inductor current & evaluate it at t= $\tau, 3\tau$ *and* 5τ.



$$iL(t) = \frac{V_S}{R_1 + R_2}\left[1 - e^{\frac{-t}{\tau}}\right]$$

$$iL(t) = \frac{V_S}{R_1 + R_2}\left[e^{\frac{-t}{\tau}}\right]$$

At t= τ

$$il(t) = \frac{6}{1.2k + 10}[1 - e^{-1}] = 3.13mA$$

$$il(t) = \frac{6}{1.2k + 10}[e^{-1}] = 1.82mA$$

At t=3 τ

$$il(t) = \frac{6}{1.2k + 10}[1 - e^{-3}] = 4.711mA$$

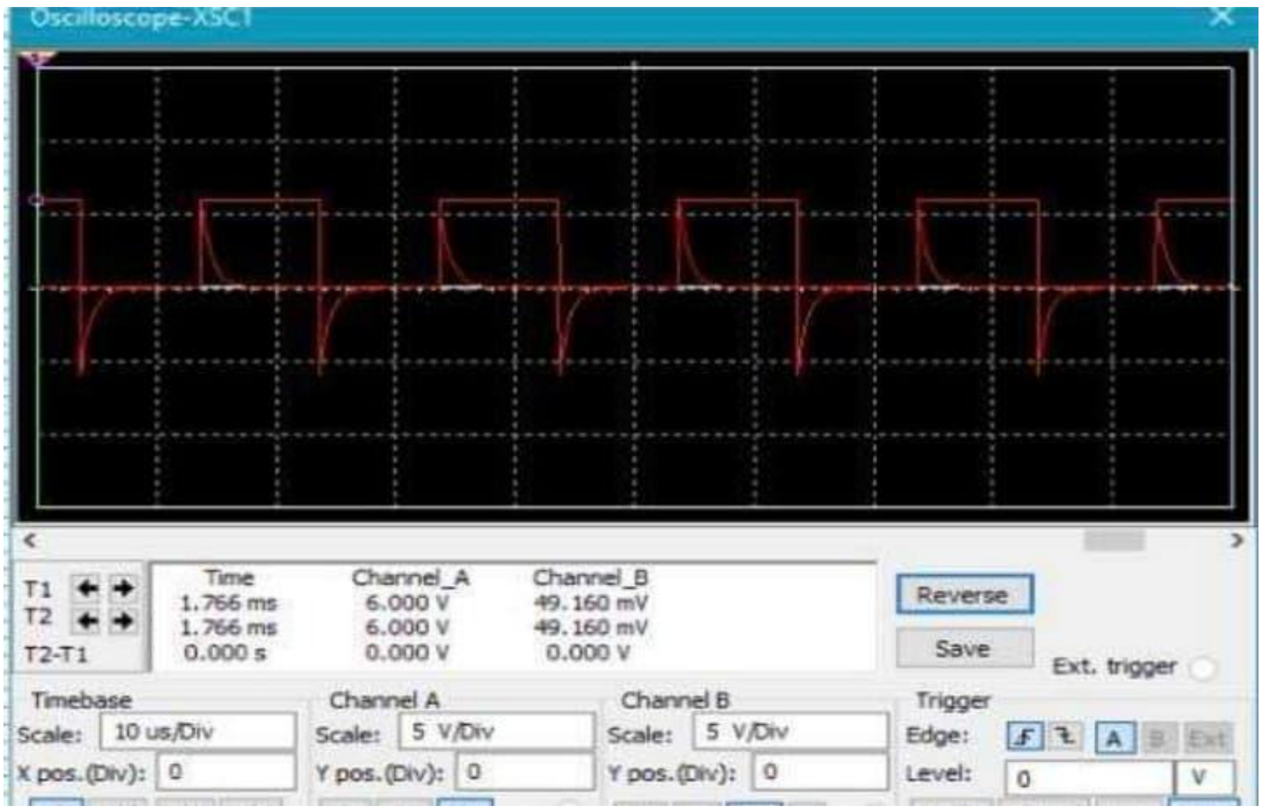
$$il(t) = \frac{6}{1.2k+10}[e^{-3}] = 0.2468mA$$

At t=5 τ

$$il(t) = \frac{6}{1.2k + 10}[1 - e^{-5}] = 4.925mA$$

$$il(t) = \frac{6}{1.2k + 10}[e^{-5}] = 0.03411mA$$

e. **Draw the voltage source and inductor voltage in the same graph.**



Conclusion:

1- we learn how to use **Function Generator (FG**) to choose the wave form for Ac source .

2- we learn how evaluate the inductor current and how deal with the inductor in circuit

3- the inductor current is increasing whenever the time is increases