University of Victoria

ELEC 250

Linear Circuits I

Lab 3 - Transient Analysis

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1 Object

This lab will study the transient response of an RC and an RL circuit.

2 Results

An Agilent 33220A signal generator was used to create the momentary single pulse excitation, while an Agilent DSOX-2012A oscilloscope was used to analyze transient responses of the RC and RL circuits.

2.1 RC Circuit

The circuit was constructed as shown in Figure 1 and excited using a 5 V_{pp} single pulse source for a duration of 5ms.

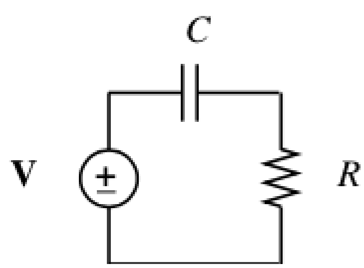


Figure 1: RC circuit driven by a source. $R = 4.7$ kΩ and $C = 100$ nF.

Measured values of the change in voltage across the capacitor and resistor in this circuit were recorded on the oscilloscope and are displayed in Figure 3. In order to measure v_R, it was necessary to switch the order of R and C.

The expected value of the time constant τ is given by

$$\tau = RC \tag{1}$$

Using (1), the expected value of τ is 480μs. By measuring the time it took for v_C to decay to 37.25% of its original value in Figure 3.c, τ was determined to be 480μs.

2.2 RL Circuit

The circuit was constructed as shown in Figure 2 and excited using a 5 V_{pp} single pulse source for a duration of 23.53μs.

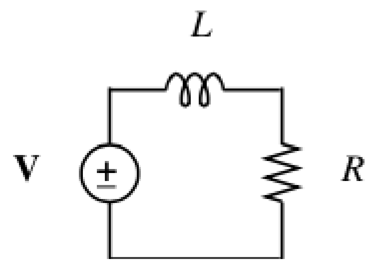


Figure 2: RL circuit driven by a source. $R = 680\ \Omega$ and $L = 1.00$ mH.

Measured values of the change in voltage across the inductor and resistor in this circuit were recorded on the oscilloscope and are displayed in Figure 4. In order to measure v_R, it was necessary to switch the order of R and L.

The expected value of the time constant τ is given by

$$\tau = \frac{L}{R} \tag{2}$$

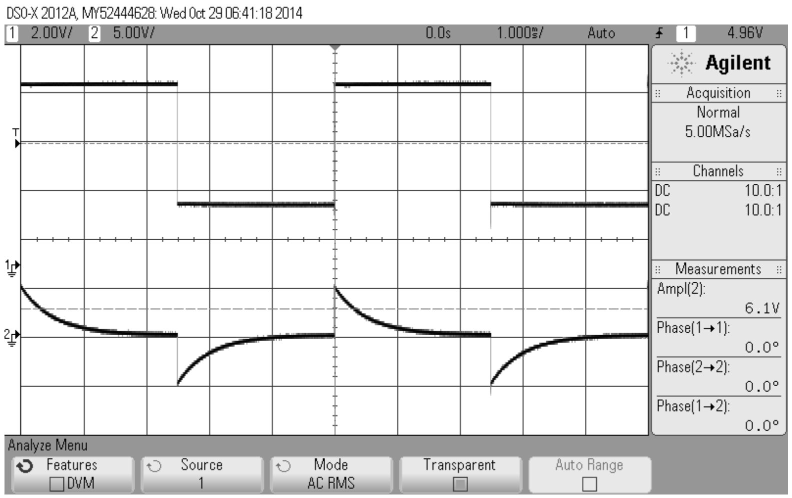
Using (2), the expected value of τ is 1.4μs. By measuring the time it took for v_R to rise to 67.75% of its final value in Figure 4.c, τ was determined to be 1.4μs. The time for v_L to decay to 37.25% of its original value in Figure 4.d yielded a τ of 1.34μs.

3 Discussion and Conclusion

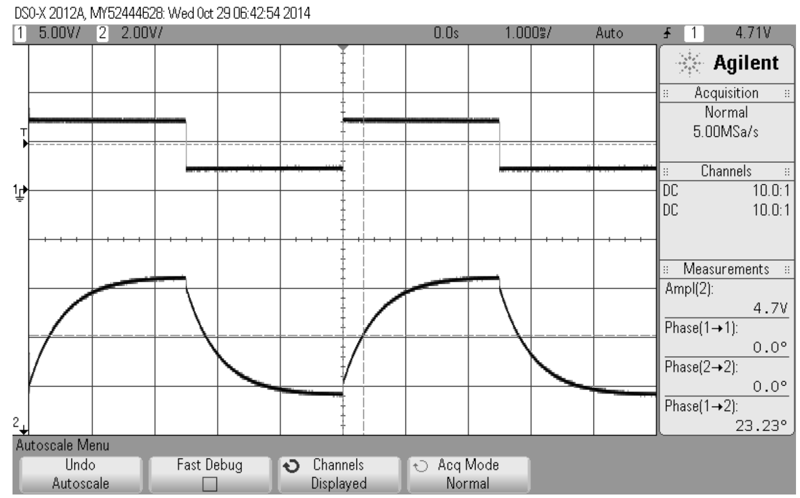
The RC and RL circuits performed as expected with respect to their natural responses. One time constant τ is equivalent to the time an RC or RL circuit takes to reach 37.25% of its original voltage.

The time constant τ was measured to be 480μs and 1.34μs, which can be verified in Figure 3.c and 4.d, for the RC and RL circuits respectively. Similarly, τ was estimated to be 480μs and 1.40μs using equations (1) and (2) for the RC and RL circuits respectively.

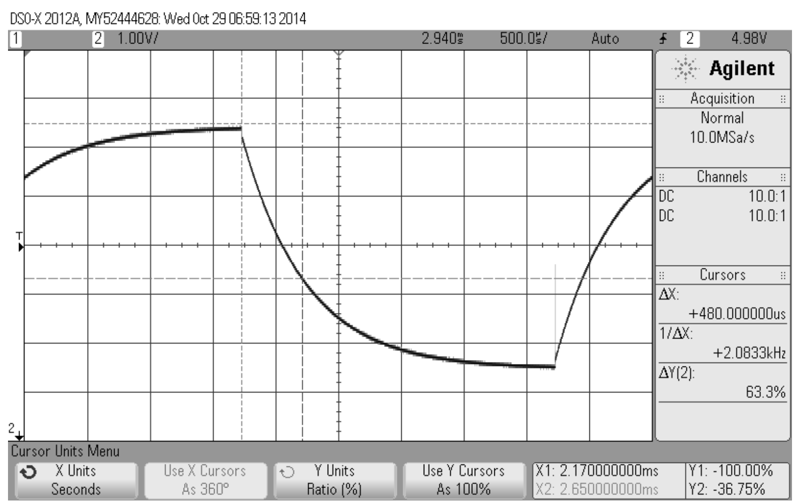
While the RC circuit performed exactly as expected, the RL yielded a slight inaccuracy of 4.29%. The physical inductor doesn't perform ideally, which can be observed in Figures 4(a through d). At the beginning and end of each cycle, for a brief moment, a spike in voltage can be observed where the inductor creates the counter-electromotive force necessary to oppose current. The spike is responsible for the inaccuracy measured in the RL circuit.



(a) v_s and v_R

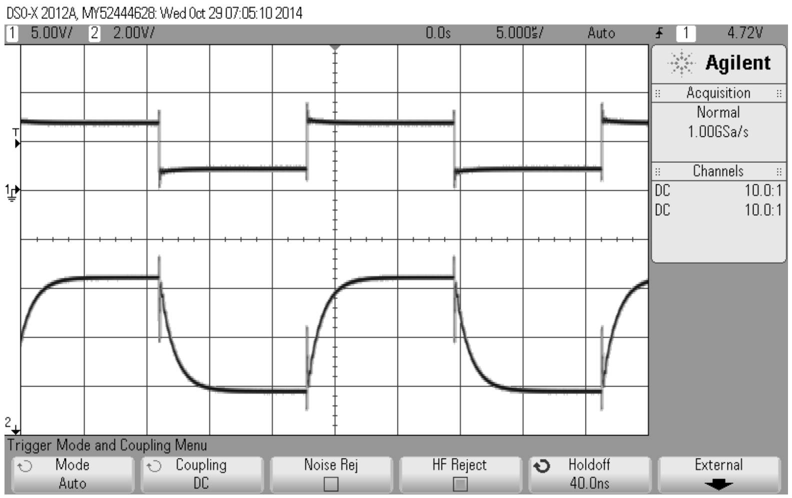


(b) v_s and v_C

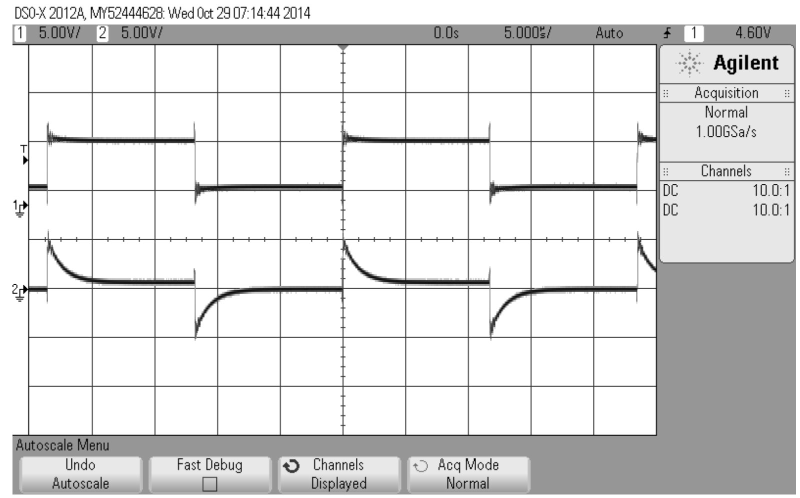


(c) Decay of v_C used to find τ

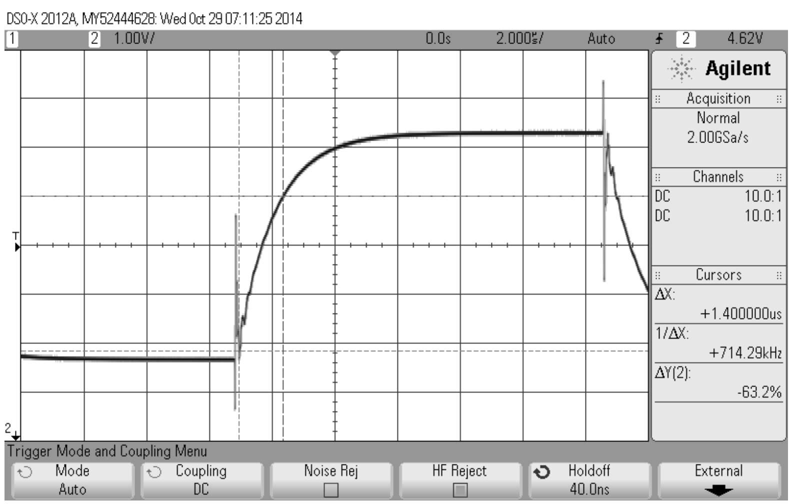
Figure 3: Transient response of the RC circuit



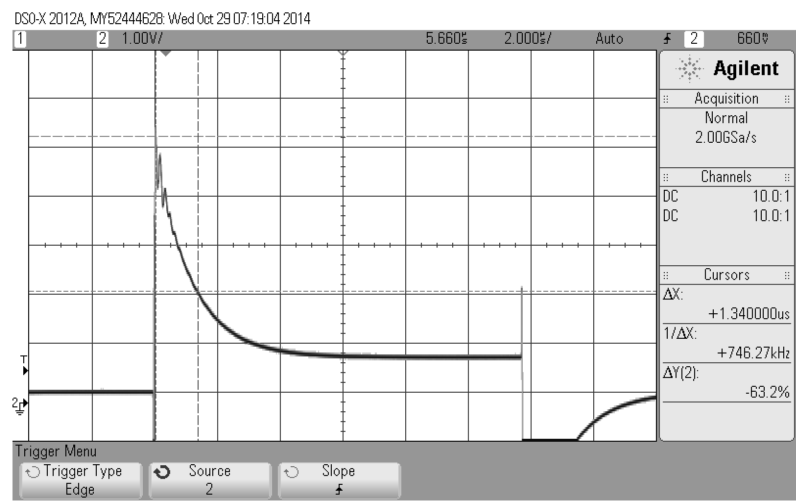
(a) v_s and v_R



(b) v_s and v_L



(c) Rise of v_R used to find τ



(d) Decay of v_L used to find τ

Figure 4: Transient response of the RL circuit