Lab 05: First-Order Circuits

Arturo Salinas-Aguayo
ECE 2001 Electrical Circuits
Dr. David J. Giblin, Section 331.660.701.810-1253
Mechanical Engineering Department

College of Engineering, University of Connecticut
Coded in LaTeX

Contents

1 Abstract

2 Introduction

3 Theory

4 Experimental Procedures

4.1 Circuit One

Initial voltage $V_0 = 0V$, Resistance $R = 10M\Omega$, Capacitance $C = 10\mu F$, Final voltage $V_f = 10V$.

The time constant $\tau = RC = 10M\Omega \times 10\mu F = 100s$.

Transient response:

$$v_C(t) = V_f(1 - e^{-\frac{t}{\tau}})$$

$$v_C(t) = 10V(1 - e^{-\frac{t}{100s}})$$

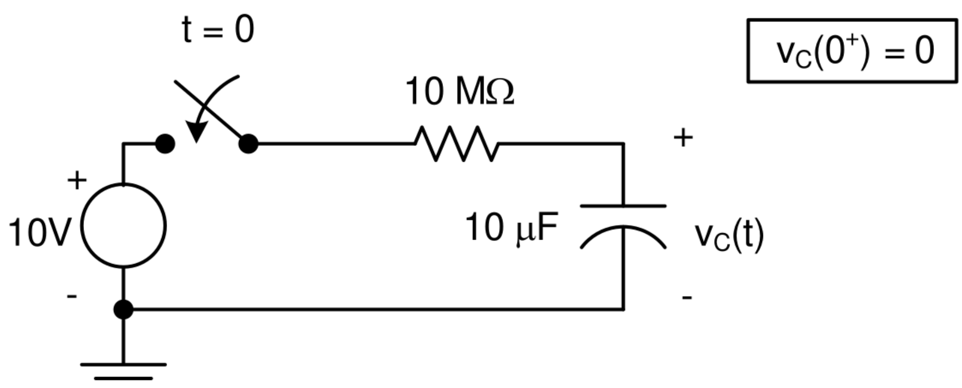

Figure 1: An Virgin Resistive Capacitive Circuit

4.2 Circuit Two

Initial voltage $V_0 = 10V$, Resistance $R = 10M\Omega$, Capacitance $C = 10\mu F$, Final voltage $V_f = 0V$.

The time constant $\tau = RC = 10M\Omega \times 10\mu F = 100s$.

Transient response:

$$v_C(t) = V_0 e^{-\frac{t}{\tau}}$$

$$v_C(t) = 10V e^{-\frac{t}{100s}}$$

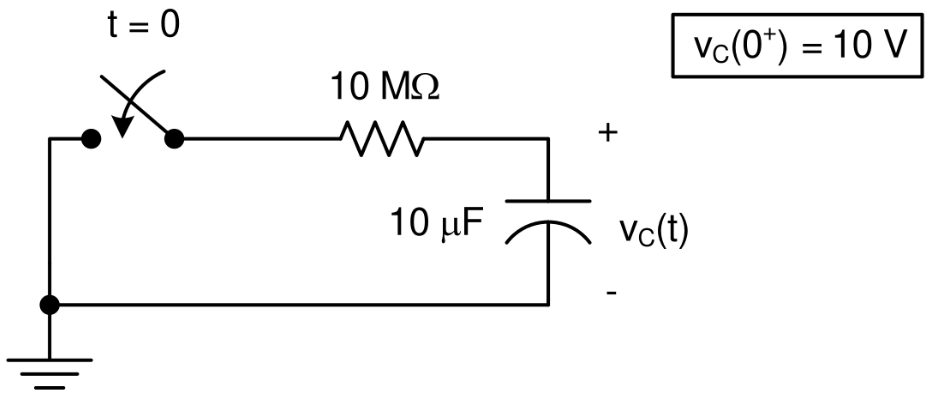

Figure 2: An Excited Resistive Capacitive Circuit

4.3 Circuit Three

Resistance $R = 2.0k\Omega$, Capacitance $C = 10nF$, Time Constant $\tau = 20\mu s$.

Transient response for a square wave input with $5V$ amplitude and $T = 200\mu s$:

$$v_C(t) = 5V(1 - e^{-\frac{t}{20\mu s}}) \quad \text{during charging}$$

$$v_C(t) = 5Ve^{-\frac{t}{20\mu s}} \quad \text{during discharging}$$

$V_c(0^+) = 0V$ The Time Constant, τ is calculated for this circuit.

$$\tau = RC = 10nF * 2.0k\Omega$$
$$\tau = 20\mu s$$

The time constant is then multiplied by a factor of ten to obtain the period for the input sine wave.

$$\tau \cdot 10 = T$$
$$20\mu s * 10 = 200\mu s$$

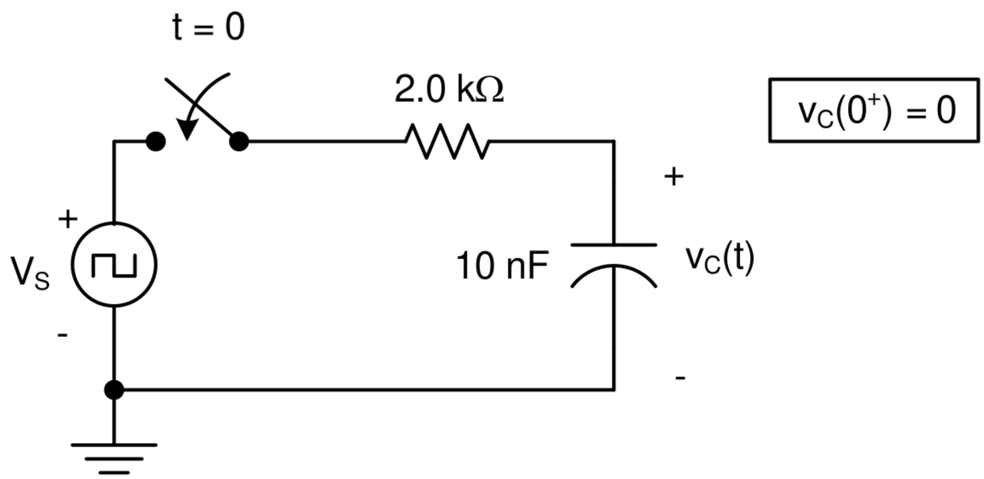

Figure 3: A Square Wave Input RC Circuit

4.4 Circuit Four

Resistance $R = 100k\Omega$, Capacitance $C = 100pF$, Time Constant $\tau = 10\mu s$.

Transient response for a square wave input with $5V$ amplitude and $T = 100\mu s$:

$$v_C(t) = 5V(1 - e^{-\frac{t}{10\mu s}}) \quad \text{during charging}$$

$$v_C(t) = 5Ve^{-\frac{t}{10\mu s}} \quad \text{during discharging}$$

$V_c(0^+) = 0V$ The Time Constant, τ is calculated for this circuit.

$$\tau = RC = 100pF * 100.0k\Omega$$
$$\tau = 10\mu s$$

The time constant is then multiplied by a factor of ten to obtain the period for the input sine wave.

$$\tau \cdot 10 = T$$
$$10\mu s * 10 = 100\mu s$$

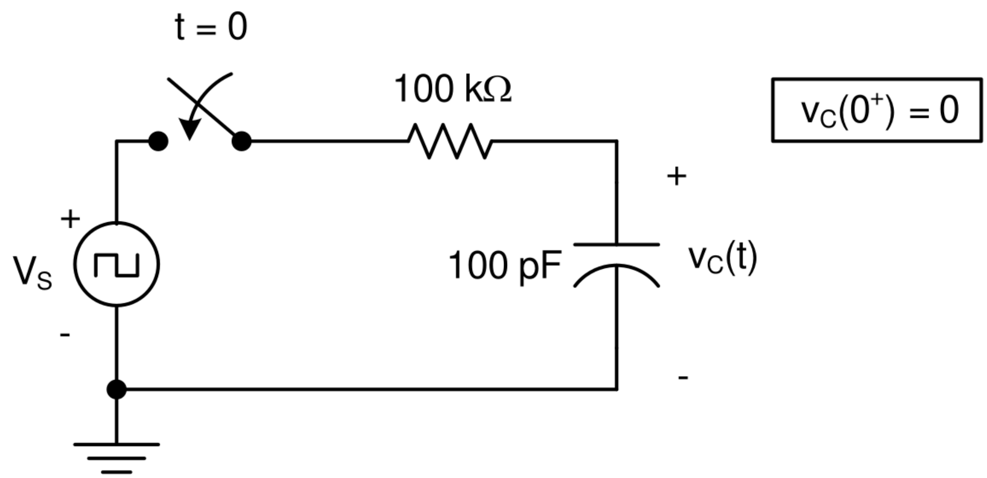

Figure 4: Circuit Three with Adjusted Components

4.5 Circuit Five

Inductance $L = 10mH$, Resistance $R = 100\Omega$, Time Constant $\tau = 100\mu s$.

Transient response for a square wave input with $1V$ amplitude and $T = 1.0ms$:

$$i_L(t) = \frac{V}{R}(1 - e^{-\frac{t}{\tau}}) \quad \text{during the positive half-cycle}$$

$$i_L(t) = \frac{V}{R}e^{-\frac{t}{\tau}} \quad \text{during the negative half-cycle}$$

$I_L(0^+) = 0A$ The Time Constant, τ is calculated for this circuit.

$$\tau = \frac{L}{R} = \frac{10mH}{100\Omega}$$
$$\tau = 100\mu s$$

The time constant is then multiplied by a factor of ten to obtain the period for the input sine wave.

$$\tau \cdot 10 = T$$
$$100\mu s * 10 = 1.0ms$$

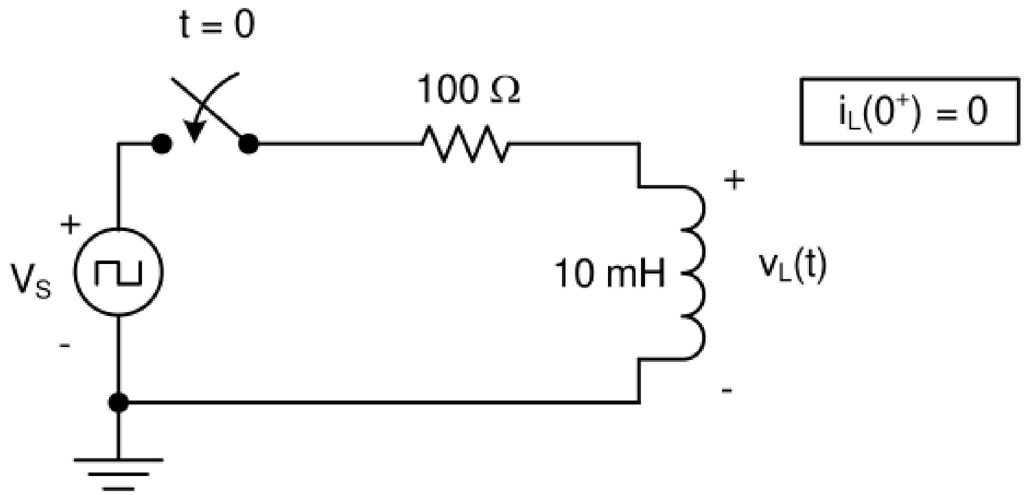

Figure 5: A Resistive-Inductive Circuit with Square Wave

5 Results and Discussion

5.1 Circuit One: Charging Transient

Measure the transient response for the RC circuit (Figure 5-1) as described.

5.1.1 Data Table for Circuit One

Time (s)	Voltage (V)	Notes
0	0	Capacitor initially discharged

5.1.2 Analysis

Question: Are the final voltage and the time constant within the expected variations due to tolerances?

Answer:

5.2 Circuit Two: Discharging Transient

Measure the discharge transient for the RC circuit (Figure 5-2).

5.2.1 Data Table for Circuit Two

Time (s)	Voltage (V)	Notes
0	10	Capacitor fully charged

5.2.2 Analysis

Question: Estimate the time constant from your data. Is this result expected?
Answer:

5.3 Circuit Three: Response to a Square Wave

Measure the transient response using a square wave input (Figure 5-3).

5.3.1 Oscilloscope Image

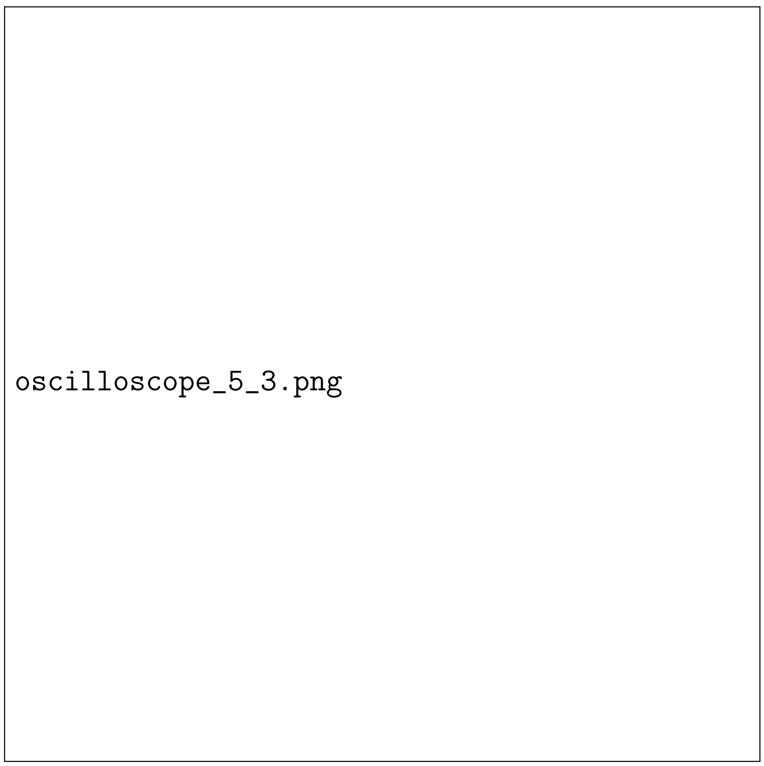

Figure 6: Oscilloscope display for Circuit Three

5.3.2 Analysis

Question: Does the experimental time constant agree with your calculations and PSpice analysis?
Answer:

5.4 Circuit Four: Square Wave Response

Repeat the measurement for Circuit Four with adjusted component values.

5.4.1 Oscilloscope Image

oscilloscope_5_4.png

Figure 7: Oscilloscope display for Circuit Four

5.4.2 Analysis

Question: Does the experimental time constant match the calculated value?
Answer:

5.5 Circuit Five: RL Circuit Response

Measure the transient response for the RL circuit (Figure 5-5) using a square wave.

5.5.1 Oscilloscope Image

oscilloscope_5_5.png

Figure 8: Oscilloscope display for Circuit Five

5.5.2 Analysis

Question: Is the transient response as expected? How does the experimental setup affect the results?

Answer:

6 Conclusion