ECE 2260 - Fundamentals of Electrical Circuits: Lab 5

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Purpose

The purpose of this lab is to sumulate and measure the time constant of an RC Circuit

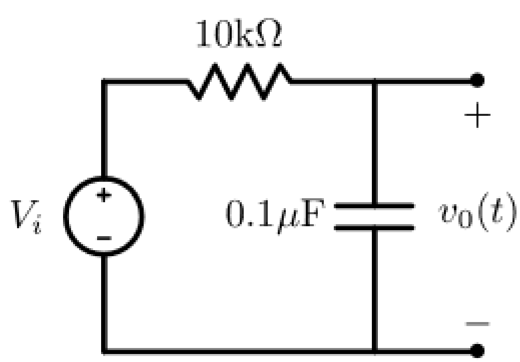
Preliminary

1. In Python, write an analytical solution for $v_o(t)$ (the voltage across the capacitor) assuming V_i is a 0 to 5V step function. Then use Python to graph the function from $t \in [0s, 5\tau]$
2. Using LTspice, create and simulate the RC circuit and use the cursors to identify τ
3. Using the breadboard, build the circuit RC circuit applying 0-5V across using a 100Hz square wave. Measure the time constant using the oscilloscope.

Equipment

- Breadboard
- Multimeter
- Power Supply
- Signal Generator
- Oscilloscope
- Resistor: 10kΩ
- Capacitor: 0.1µF

The Circuit



Python Code

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Date: 02/06/2025

Dependencies

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

Voltage Across the Capacitor

[2]:
```
def capacitorResponse(vf, vo, t, tau):
    return vf+(vo-vf)*np.exp(-t/tau)
```

This function is used to determine the voltage across the capacitor at any given time (t) provided the time constant (τ) and the inital (V_o) and final (V_f) voltage.

Calculating Tau

[3]:
```
def calculateTau(r, c):
    return r*c
```

This function is used to determine the τ of an RC circuit given the resistor and capacitor values.

Finding Tau

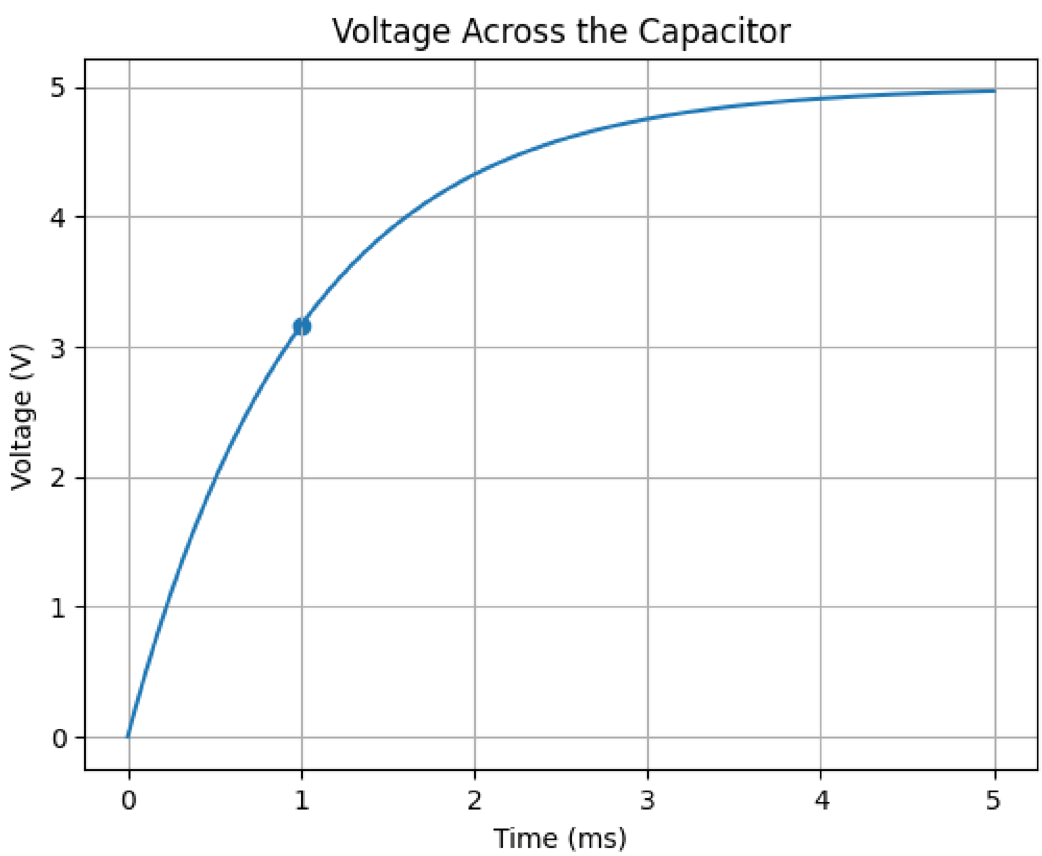
[4]:
```
def positionAtTau(yVal, vf, vo):
    return np.argmax(yVal > capacitorResponse(vf,vo,1,1))
```

This function can be used to find τ in a given array of voltage values across a capacitor provided V_o and V_f.
This function is able to determine the voltage at $t = \tau$ using the capacitor response function. From there the function utilizes the numpy argmax function to determine the first array position that exceeds the determined voltage.

Graphing

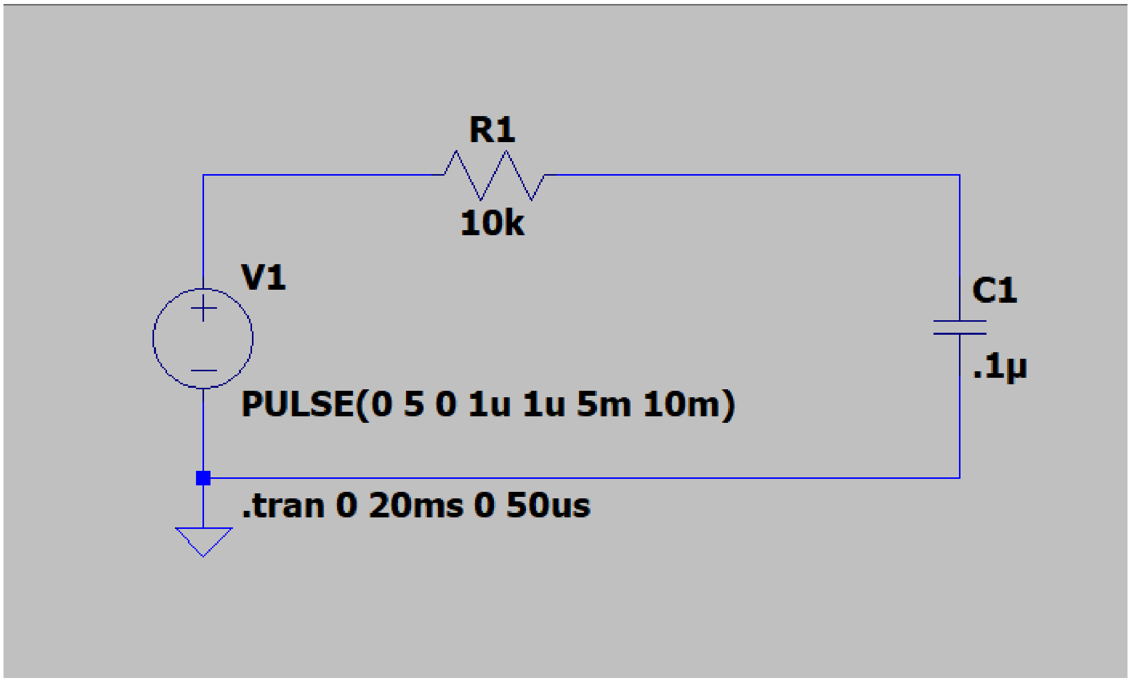
[ ]:
```
def graphResponse():
    r = 10000
    c = .0000001
    tau = calculateTau(r,c)
    vf = 5
    vo = 0
    stepSize = .000001
    xVal = np.array([0])
    yVal = np.array([capacitorResponse(vf, vo, xVal[-1], tau)])
```

```
    while(xVal[-1] < 5*tau):
        xVal = np.append(xVal, [xVal[-1]+stepSize])
        yVal = np.append(yVal, [capacitorResponse(vf, vo, xVal[-1], tau)])

    xVal = xVal*1000

    plt.plot(xVal,yVal)
    plt.scatter(xVal[positionAtTau(yVal, vf, vo)],yVal[positionAtTau(yVal, vf,␣
 ↪vo)])
    plt.xlabel('Time (ms)')
    plt.ylabel('Voltage (V)')
    plt.title('Voltage Across the Capacitor')
    plt.grid()
    plt.show()

if __name__ == '__main__':
    graphResponse()
```

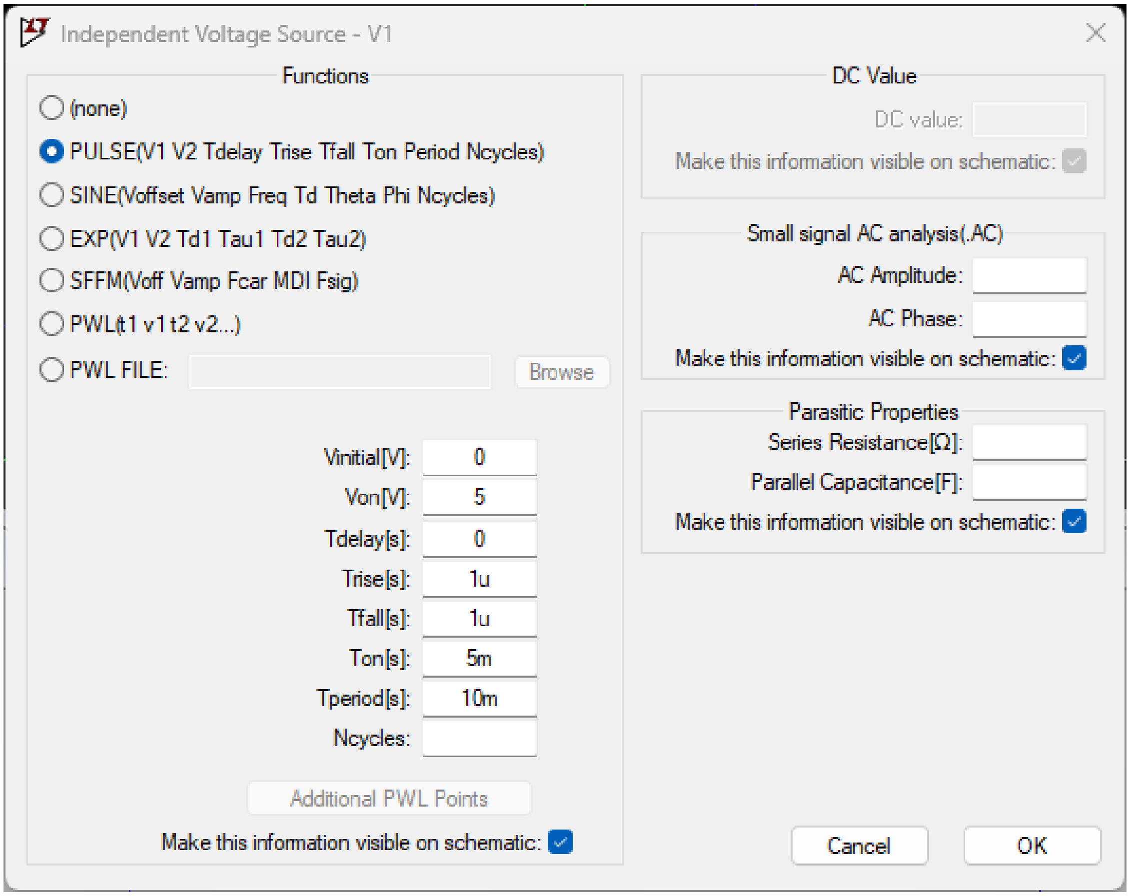


LTspice Simulation

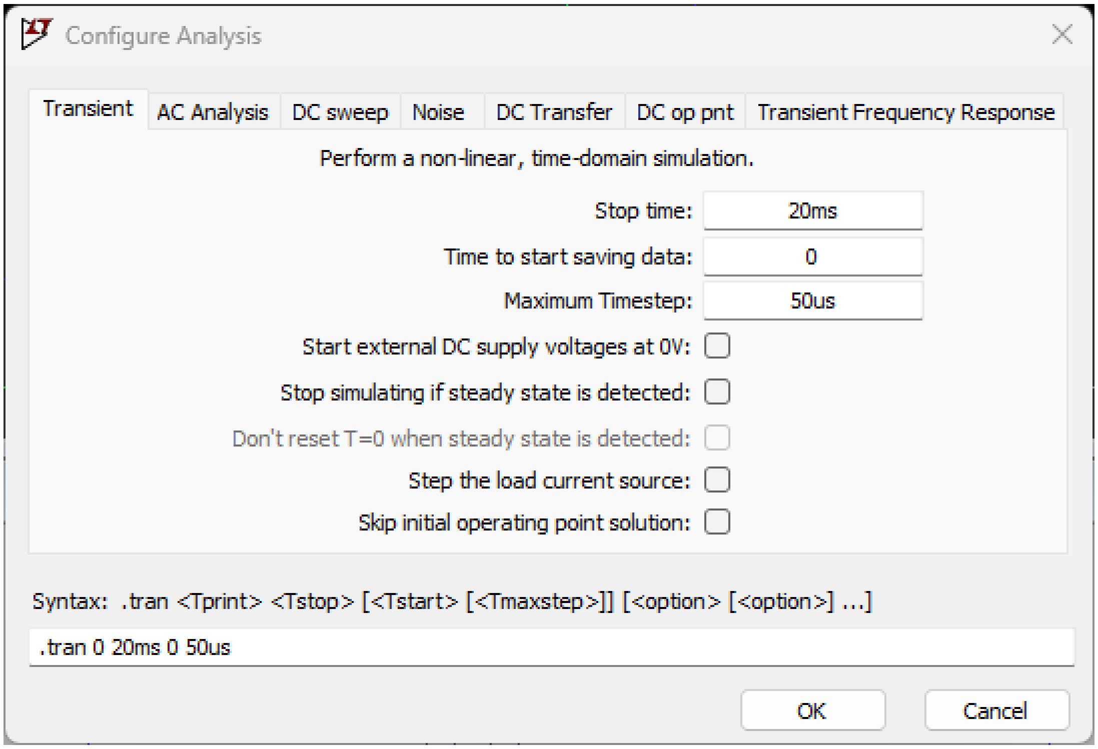
Circuit Diagram



Settings

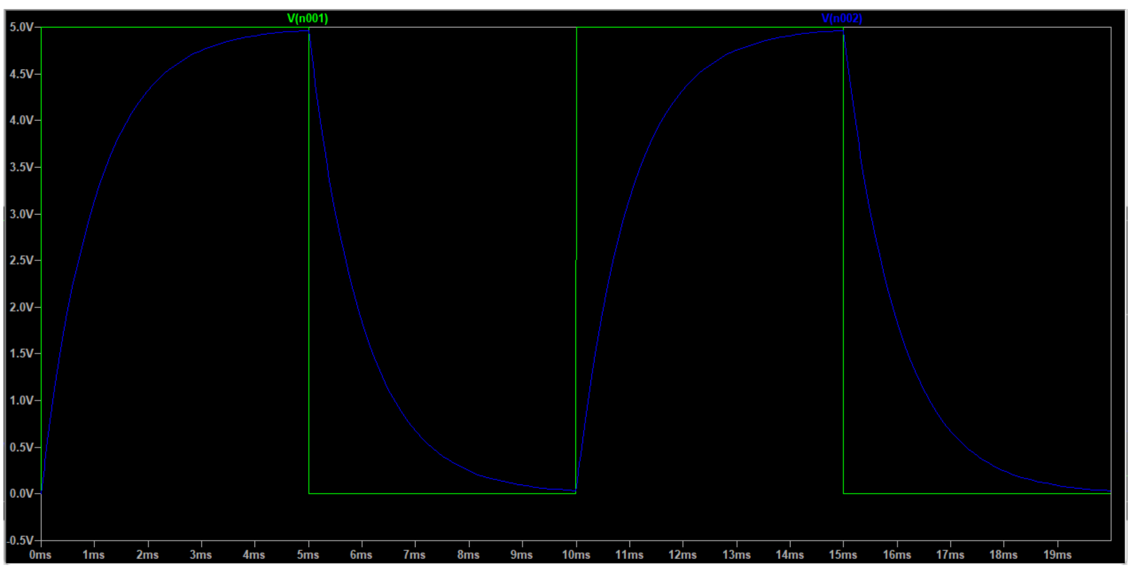


This sets the voltage source to a square wave from 0 to $5V$ with a period of $10ms$, an on time of $5ms$, and a rise/fall time of $1\mu s$



This sets the oscilloscoope output to show two periods with a maximum step size of $50\mu s$

Oscilloscope Trace



Building the Circuit