**Lab 2: RC Circuit**

**Objective:**

Introduction to the time variations of voltages and current in circuits made up of resistors and capacitors (RC).

**Equipment and Components:**

1) Breadboard, Multimeter, Power supply, Signal Generator, Oscilloscope

2) Resistors: 500 Ω and 10 kΩ

3) Capacitors: 0.1 µF

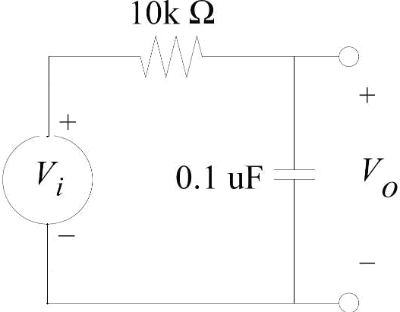


Figure 1: RC Circuit

**Preliminary:**

1. Calculate the time constants for the circuit shown in Figure 1.
2. Use the transient analysis of a circuit simulator to determine the output voltage, Vo, for the following Vi : 0 to 5 V square wave with a frequency of 50 Hz.

*For Multisim:* With R=500 Ω, set Vi to a Pulse Voltage source with initial value = 0 V, pulsed value = 5 V, delay time of 0 sec, rise time = 1 us, fall time = 1 us, pulse width = 1 ms, period = 2 ms. You may also use any Spice for simulation.

1. Repeat the above for R=10 kΩ (adjust the voltage source as rise time = 0.1 us, fall time = 0.1 us, pulse width = 10 ms, period = 20 ms).
2. Calculate the cut-off frequencies for the two circuits (see the note at the end).

**Procedure:**

**Time Domain**

Create the circuit shown in Figure 1. Apply a 0 to 5 volt, 50 Hz square wave and measure the time constant τ (about 1 ms) of Vo with an oscilloscope by two methods:

1. The time it takes the waveform to traverse one time constant.

HINT: This would be at 63% of the maximum value during its charging or 37% of the maximum value during its discharging cycle.

1. Extending the initial slope of the exponential.

HINT: During the charge or discharge cycle, place a straight edge at the point where the voltage/current starts to deviate from linear response. 

**Frequency Domain**

1. With R=500 Ω, use a sinusoidal source of 1 V amplitude and vary the input frequency from 10 Hz to 100 kHz. Record the variation in peak value of Vo at a minimum of 10 different frequencies (i.e. 10 Hz, 50 Hz. 100 Hz, 150 Hz, 200 Hz, 300 Hz, 500 Hz, 1 kHz, 10 kHz, 100 kHz). Plot Vo peak with respect to the input frequency in your lab book. Measure and record the frequency at which the amplitude of the output voltage drops to 0.707 times its amplitude at lower frequency (e.g. 10 Hz).
2. Repeat the above for R=10k Ω. Which one of the two circuits has lower cut-off frequency?

**The following extra measurements may help you to explain the discrepancies between the calculations/simulations and the experiment:**

a) Use a multimeter to measure the value of the resister used.

b) Thevenin resistance of the source must also be accounted for source (Rs = 50 Ω). Account for all three resistors (1 physical, 1 wire, 1 source).

c) Using an LC bridge, measure the capacitance of the capacitor.

**Conclusion:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **C=0.1*μ*F** | | | | |
| **Resistor Value** | **Time Constant τ** | | **Cut-off Frequency *f*** | |
| **Calculated** | **Measured** | **Calculated** | **Measured** |
| **R=500 Ω** |  |  |  |  |
| **Rmeasured =** |
| **R=10 kΩ** |  |  |  |  |
| **Rmeasured =** |

Give plausible reasons for discrepancies between calculations, simulations, and laboratory measurements. Include a discussion about the effect of source and effective resistance on calculated time constants and the accuracy of the LC bridge. Use a table to display each test results and errors from expected values.

***NOTE***: Since the reactive element (capacitor) requires time to respond to variation of voltage it can also act as a filter. For slow variations (low frequency) the circuit can react as expected, reaching a final value. As the variations increase in time (higher frequency variations), the reactive element cannot reach it’s final state before a new transition occurs. The end result is that the “final” values are decreased from the expected value at t = ∞. This circuit is a ***low pass filter*** with a corner or cut-off frequency (half power/3 dB point) such that ***f* =1/(2πτ)** where **τ is the time constant**. Below ***f***,the changes in the source are slow enough that the circuit can respond. Above ***f*** the changes in the source are faster than the ones the capacitor can respond. The capacitor’s reaction to high frequency then attenuates (decreases) the output values.