BME 211 Circuit Analysis Laboratory

Experiment #7

RC–RL Time Constants

Objective

The objective of this experiment is to understand the concept of time constants in simple series R-C and series R-L circuits; observe the charging and discharging of a capacitor and compare the time constant values for different capacitance and resistance values.

Background

RC Time Constants

Consider the first order RC circuit given in Figure 7.1

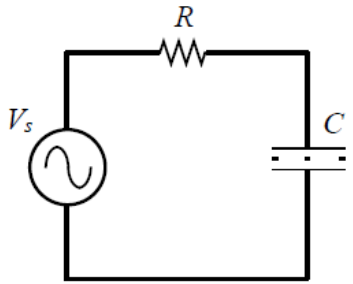

Figure 7.1 Series R-C circuit

The time it takes a capacitor to charge and discharge is directly proportional to the amount of the resistance and capacitance. The time constant which is given in the quation below reflects the time required for a capacitor to charge up to 63.2% of the applied voltage or to discharge down to 36.8%. Chart of time constants required to charge and discharge the capacitor is given in the Figure 7.2.

$$\tau = RC$$

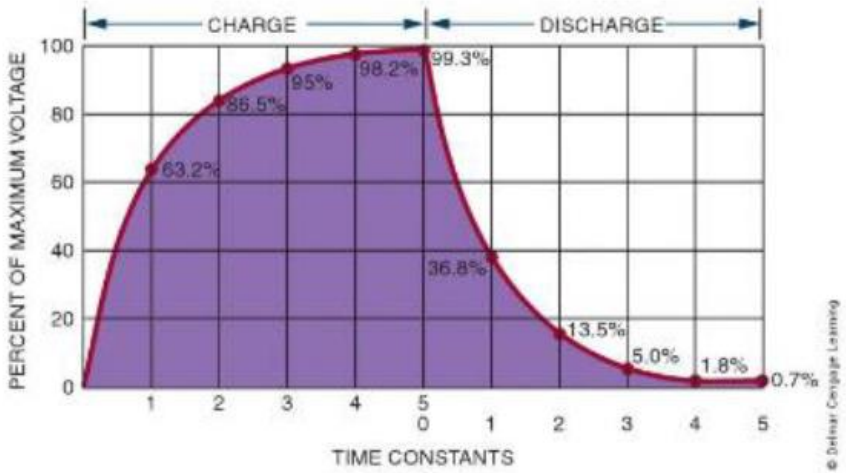

Figure 7.2. Chart of time constants for capacitor

RL Time Constant:

Consider the first order RL circuit given in Figure 7.3.

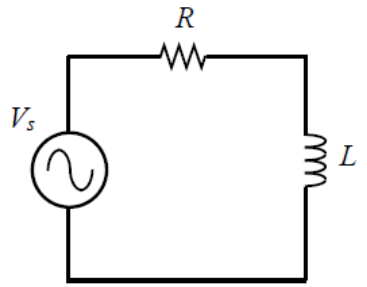

Figure 7.3 Series R-L circuit

A time constant is the time required for current through a conductor to incease to 63.2% or decrease to 36.8% of the maximum current. Chart of time constants required to build up or collapse the magnetic field in an inductor is given in the Figure 7.2 and the expression for the time constant is given as:

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

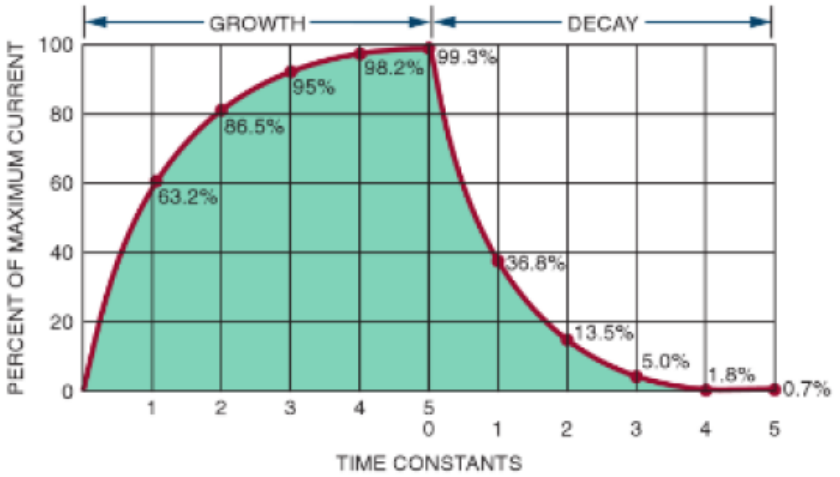

Figure 7.4 Chart of time constants for inductor

Preliminary Work

1. Calculate the time constant for the series R-C circuit in Figure 7.1 for C = 1 µF and R = 470 Ω, 1 kΩ and 2.2 kΩ.
2. Calculate the time constant for the same circuit for R = 1kΩ and C = 0.470 µF, 1 µF and 2.2 µF.

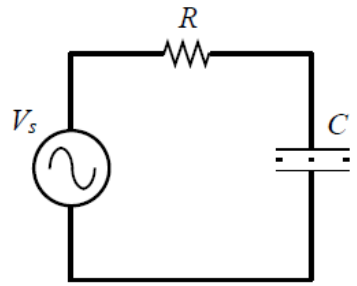

Figure 7.1 Series R-C circuit

Procedure

1. Set up the circuit in Figure 7.1 with the component values given in Preliminary Work Q1. Apply a square wave voltage to the circuit. Adjust the amplitude of the source voltage to $4V_{pp}$ and add 2V offset. Set the frequency to 30Hz. Connect the CH1 of the oscilloscope across the input voltage and CH2 across the capacitor. Make sure that the common terminals of both channels are at the same location in the circuit.

    a. Observe and plot both waveforms simultaneously for R = 470 Ω, 1 kΩ and 2.2 kΩ cases.

    b. Measure the voltage level at t = τ, 2τ, 3τ, 4τ and 5τ and find the percentage of maximum voltage for each case.

    c. Comment on the results based on the time constant values you calculated in the preliminary work. How does the output change with increasing resistance value?

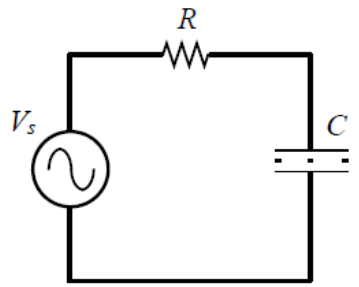

Figure 7.1 Series R-C circuit

2. Set up the circuit in Figure 7.1 with the component values given in Preliminary Work Q2. Apply a square wave voltage to the circuit. Adjust the amplitude of the source voltage to $4V_{pp}$ and add 2V offset. Set the frequency to 30Hz. Connect the CH1 of the oscilloscope across the input voltage and CH2 across the capacitor. Make sure that the common terminals of both channels are at the same location in the circuit.

   a. Observe and plot both waveforms simultaneously for C = 0.470 µF, 1 µF and 2.2 µF.

   b. Measure the voltage level at t = τ, 2τ, 3τ, 4τ and 5τ and find the percentage of maximum voltage for each case.

   c. Comment on the results based on the time constant values you calculated in the preliminary work. How does the output change with increasing capacitance value?

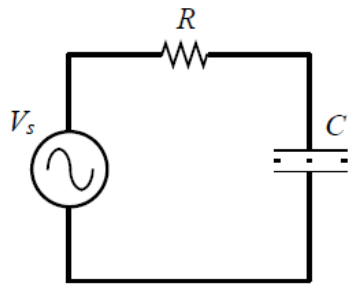

Figure 7.1 Series R-C circuit

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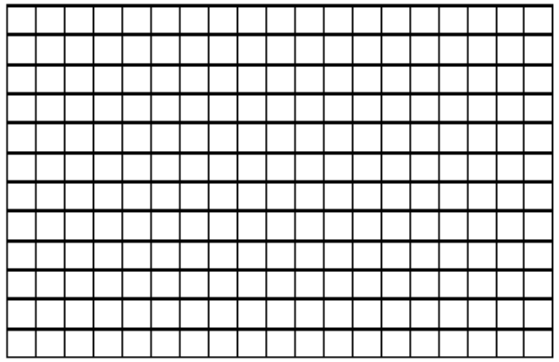
RC - RL TIME CONSTANTS

Objective

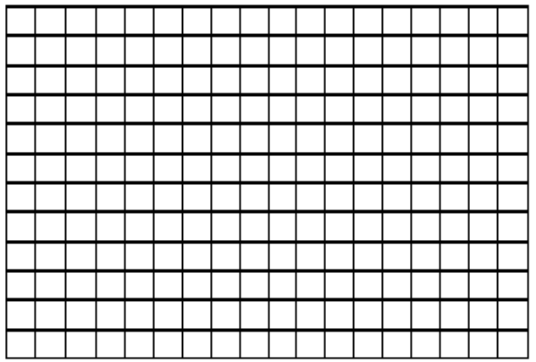
Results

1. a) Input and output signals

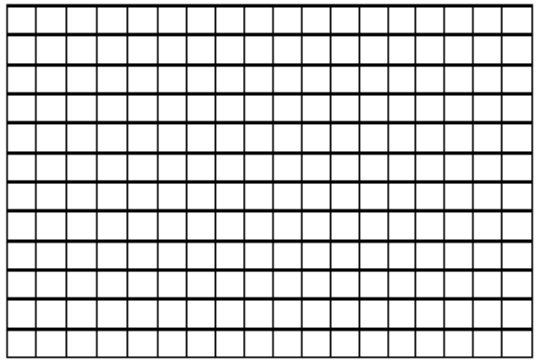
470 Ω



1 kΩ



2.2 kΩ



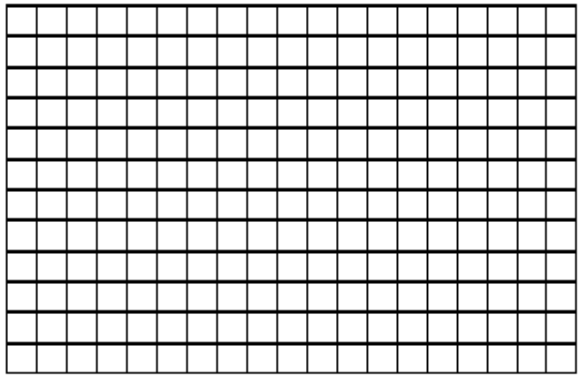
b) Voltage measurements (470 Ω)

T	T	2 T	3 T	4 T	5 T
V_{max}					
%					

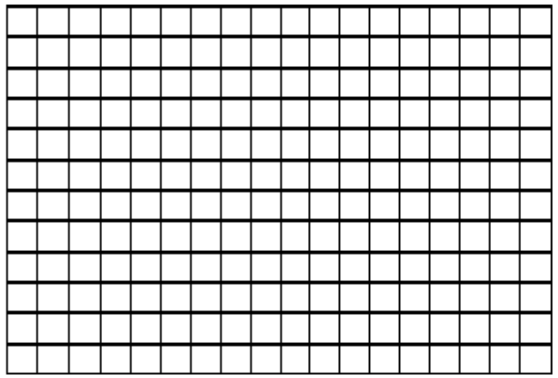
c) Comments

2. a) Input and output signals

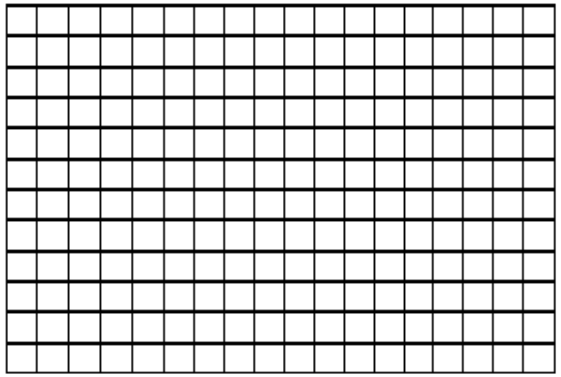
0.470 uF



1 uF



2.2 uF



b) Voltage measurements (0.470 uF)

T	T	2 T	3 T	4 T	5 T
V_{max}					
%					

c) Comments