Circuits and Electronic Laboratory

Experiment #5

Purpose of Experiment

This experiment aims to examine the step response of RC circuits and to learn experimental techniques to evaluate some unknown circuit parameters.

General Information

There are three basic passive analog circuit components: the resistor (R), the capacitor (C), and the inductor (L). These may be combined in the RC circuit, the RL circuit, the LC circuit, and the RLC circuit, with the acronyms indicating which components are used. These circuits exhibit a large number of important types of behaviour that are fundamental to much of analog electronics. In particular, they are able to act as passive filters.

To specify the behavior of an electrical circuit as a function of time, the equations related to the circuit must be acquired and solved. Circuit equations include integrals, derivatives and algebraic relations.

Circuits can be grouped as first order and second order circuits. First order circuits consist of a resistor with a capacitor or a inductor but not both. Second order circuits can be made from using both a capacitor and an inductor. For an RC circuit, the voltage across the capacitor (V_C) at any instant in time during the charging period is given as:

$$V_C = V_S \times (1 - e^{-t/RC})$$

the voltage across the capacitor (V_C) as a function of time during the discharge period is defined as:

$$V_C = V_S \times e^{-t/RC}$$

where, V_C is the voltage across the capacitor, V_S is the supply voltage, t is the elapsed time since the removal of the supply voltage, RC is the time constant of the RC circuit. The time required for a capacitor to discharge itself down to one time constant is given as:

$$\tau = R \times C$$

where, R is in Ω and C in Farads.

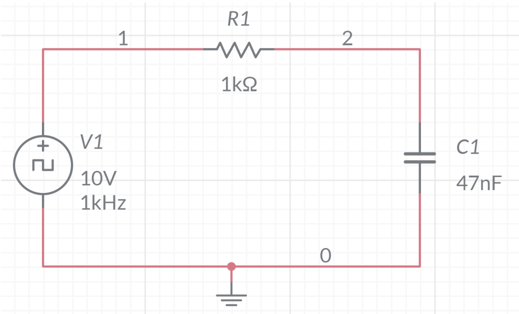
Preparations Before Experiment

The circuit given in Figure (1.a) will be used in the laboratory to observe the properties of RC circuits. The function generator applies square waves whose peak-to-peak voltage is 10 V ($V_p = 5\ V$, i.e. the amplitute of the source voltage is 5 V) and has a 5 V offset voltage. The square wave frequency applied from the function generator is 1 kHz. Figure (1.b) is the source voltage comes from the function generator, Figure (1.c) is the voltage on the capacitor, and Figure (1.d) is the voltage on the resistor.

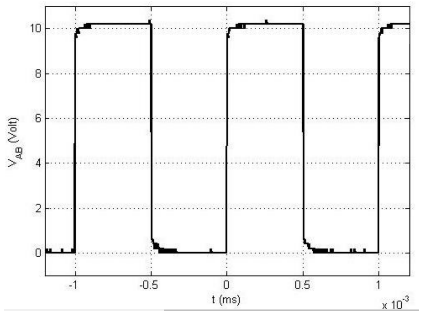
- Simulate the circuit in Figure 1 and obtain the signals given in Figure 1.
- Calculate the time constant of the capacitor and try to understand what does it mean?
- Explain the behavior of the Figure (1.c) and (1.d).
- Change the resistor to $10k$, simulate the circuit, and compare with the previous circuit in terms of time constant and the Figure (1.c) behaviors of the circuits.

The Experiment

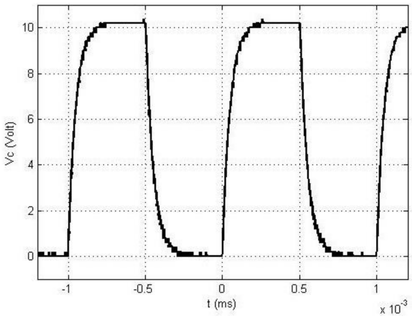
- Construct the circuit depicted in Figure 1 on the board.
- Use signal generator to generate V as -5V to 5V 1kHz square wave.
- Connect first channel of the oscillator to capacitor. (You need to connect the crocodile plug of the oscilloscope to the reference point of your circuit.)
- Calculate the time constant $\tau = ...$
- Use the V_c formula, to calculate a few points, and plot the V_c wave as seen on oscillator to Table 1 (one period of the signal).



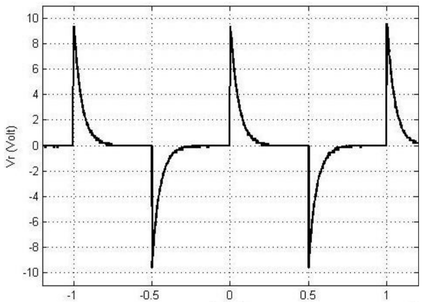
(a) RC Circuit



(b) Source Voltage



(c) The Capacitor Voltage



(d) The Resistor Voltage

Figure 1: The figures of the RC Circuit

Section 2

- Replace 47 nF to 100 nF.
- Use signal generator to generate V as -5V to 5V 1kHz square wave.
- Connect first channel of the oscillator to capacitor. (You need to connect the crocodile plug of the oscilloscope to the reference point of your circuit.)
- Calculate the time constant $\tau =$ ...
- Use the V_c formula, to calculate a few points, and plot the V_c wave as seen on oscillator to Table 2 (one period of the signal).
- Compare the two circuits and explain the differences.

Table 1: V_c Plotted Using Experimental Data

Table 2: V_c Plotted Using Experimental Data