Physics 3053   Intro to Electronics Lab

Background

In this lab you will learn how to assemble and test basic electronic circuits using resistors and capacitors. These circuits will be built using an electronic breadboard, which is a standard technique used in prototyping electronic circuits.

Electronic Breadboards

An electronic breadboard is used to quickly put together electronic circuits without the need to use solder. This enables rapid prototyping of circuits. For more information look at: http://en.wikipedia.org/wiki/Breadboard
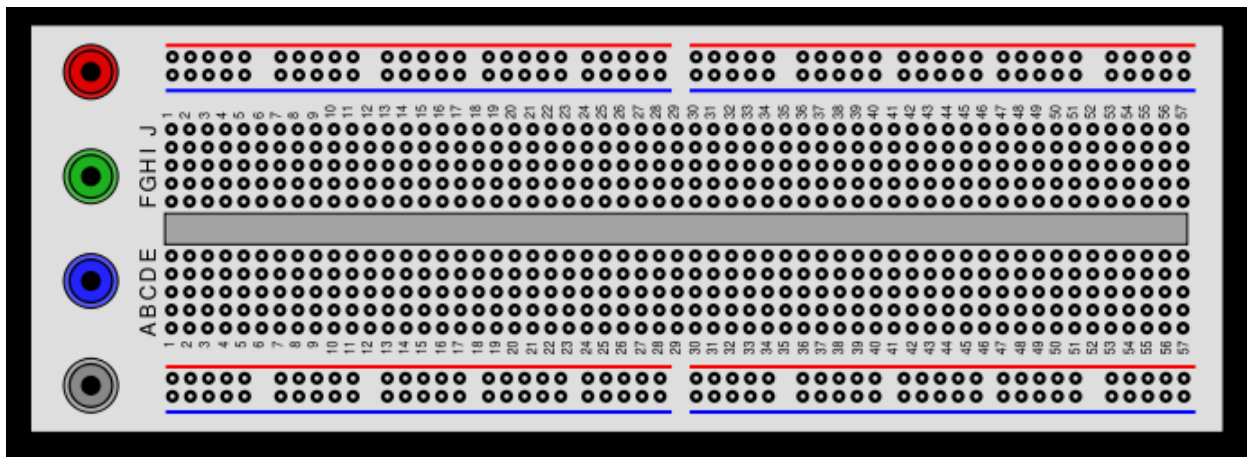

Figure 1 – schematic of breadboard

The breadboard is internally wired according to the diagramme in Figure 2. The two top and two bottom rows are referred to as bus strips. They are used to provide power and ground to the circuits. The columns (labelled A-J in Figure 1) are used to connect electronic devices.
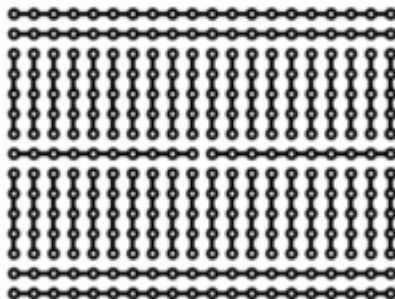

Figure 2 – electrical schematic of breadboard

The electronic breadboard is design to be used with simple devices (resistors, capacitors, inductors) as well as dual in-line packaged devices (as shown in Figure 3) using pins spaced by 0.1" (2.54mm) .

Figure 3 DIP (dual in-line package)

Complex Impedance

For a sinusoidal signal, the impedance of a capacitor or inductor can be simplified for easier analysis of circuits. The current through a capacitor is described by:

$i = C\dfrac{dV}{dt}$. Now assume: $V = Ae^{j\omega t}$. Then: $i = C\dfrac{d}{dt}\left(Ae^{j\omega t}\right) = j\omega ACe^{j\omega t} = j\omega CV$

The impedance of the capacitor is therefore: $Z_C = \dfrac{V}{i} = \dfrac{1}{j\omega C}$.

Similarly, an inductor can be described by: $V = L\dfrac{di}{dt}$

If the current varies sinusoidally: $i = Be^{j\omega t}$ then: $V = L\dfrac{d}{dt}\left(Be^{j\omega t}\right) = j\omega LBe^{j\omega t} = j\omega Li$

The impedance of the inductor is therefore: $Z_L = \dfrac{V}{i} = j\omega L$.

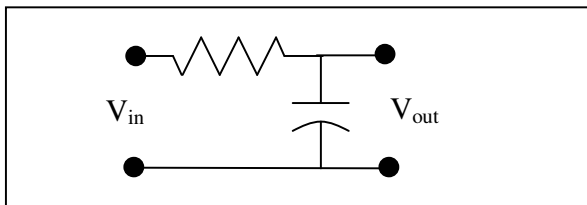**Frequency Response of RC Circuit**

Figure 4 RC Circuit

A simple RC circuit can is down in Figure 4. Using the complex impedance approach the output voltage can be calculated as a function of the frequency and the input voltage.

The total impedance of the circuit is: $Z_{tot} = R + Z_C = R + \dfrac{1}{j\omega C}$

The current that flows through the circuit is: $i = \dfrac{V_{in}}{Z_{tot}} = \dfrac{V_{in}}{R + \dfrac{1}{j\omega C}}$

Therefore the output voltage is: $V_{out} = iZ_C = \dfrac{V_{in}\dfrac{1}{j\omega C}}{R + \dfrac{1}{j\omega C}} = \dfrac{V_{in}}{1 + j\omega RC} = \dfrac{V_{in}}{1 + j2\pi fRC}$.

The voltage frequency response of the circuit is: $\left|\dfrac{V_{out}}{V_{in}}\right| = \dfrac{1}{\sqrt{1+\left(2\pi fRC\right)^2}}$
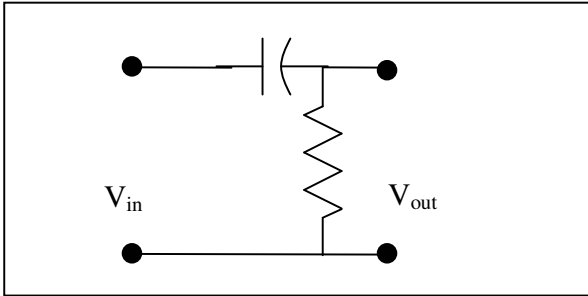

Figure 5 RC Circuit

Procedure:

Part A – Theory
1. Use the complex impedance approach to calculate the frequency response of the RC circuit shown in Figure 5.
2. Compare the frequency response characteristics of the RC circuit from Figure 4 and that of Figure 5. Describe these circuits using the terms: low pass filter, high pass filter or band pass filter.

Part B – Breadboard
1. Make sure that the prototyping board or breadboard is switched off.
2. Build the RC circuit shown in Figure 4, using one of the unmarked capacitors and your choice of resistor.
3. The breadboard has a function generator that is built in. Using a wire, connect the output of the function generator to one of the two top rows of the breadboard (as shown in Figures 1 and 2)
4. Connect the ground to one of the bottom rows or bus strips.
5. Using a resistor connect one end to the bus strip that is connected to the function generator, and the other end to your choice of the breadboard columns (labelled A-J in Figure 1)
6. Connect the capacitor between the breadboard column selected in (5) and also to the bus strip used for the ground connection.
7. Connect the ground wire of the oscilloscope to the bus strip used for the ground signal.
8. Connect the signal wire of the oscilloscope to the breadboard column selected in (5). This is the output voltage.

Part C – Experiment
1. Turn on the breadboard, and measure the frequency response as a function of frequency.
2. Measure the value of the capacitor based on the equation for frequency response, and your data. Graph both the experimental and theoretical curves to support your choice of value for the capacitor.
3. What is the estimated error of your measurement? What value of resistance did you use?
4. Consider your choice of resistor, and redo the experiment using a resistor that will minimize your experimental error. What do you believe is the correct resistance in order to minimize the error?
5. Graph the new results and provide your new value for capacitance including the experimental error.

WARNING:

The lab write up requires many items which have not explicitly been asked for.
Error analysis, graphs, data, discussion, conclusion etc.