ME 411 Mechatronics @ UIC

Function generators, Oscilloscope, Capacitors, RC Filters

This lab is to be done in a group of two during lab hours

1 Prelab (not graded)

1.1 Motivation

The goals of the lab are as follow: (1) Introduction to function generator and oscilloscipe. (2) R-C filters.

1.2 Assigned Reading

This part of the Lab needs to be done before you come to the lab. Assigned reading from the textbook is listed below

1. Read about oscilloscope https://en.wikipedia.org/wiki/Oscilloscope and function generator https://en.wikipedia.org/wiki/Function_generator. Please go though this tutorial on using the function generator and oscilloscope on TinkerCAD https://youtu.be/wfvYz1L0Qkk.
2. The Hantek 2D72 manual is here: https://www.circuitspecialists.com/content/476383/HANTEK2D72_Manual.pdf.
3. 4.4 Bandwidth and Frequency Response including example 4.1 Bandwidth of Electrical Network. This is taught in Lecture 5.
4. Bode Plots https://en.wikipedia.org/wiki/Bode_plot. This is also taught in Lecture 5.

1.3 Questions based on reading (not graded)

1. Which of the following are TRUE for Hantek 2D72
   (a) It may be used as a function generator.
   (b) It may be used as an oscilloscope.
   (c) It may be used as digital multimeter.
   (d) It may be used a DC power source.
2. Tick all TRUE statements
   (a) Bandwidth is range of frequencies where the input is not attenuated by more than -3dB.
   (b) Bandwidth is range of frequencies where the input is not attenuated by more than 3dB.
   (c) $dB = 20 \log_{10} \left(\frac{\text{output}}{\text{input}} \right)$
   (d) $dB = 20 \log_{10} \left(\frac{\text{input}}{\text{output}} \right)$

3. A 1MΩ resistor and a 0.1 μ F are connected to form a low pass filter. The cutoff frequency in rad (not Hz) is

   (a) 0.1

   (b) 1

   (c) 10

   (d) 100

4. Identify the DMM, oscilloscope, and function generator probe from the figures below

(a)

(b)

(c)

Answers 1 a,b,c,d. 2 a,c; 3 c. 4. (a), (b), (c) in that order.

2 Labwork (To be done during the lab)

Equipment list

1. Resistor, $R = 1k\Omega$
2. Capacitor, $C = 10\mu F$.
3. Breadboard.
4. Multimeter.
5. Hantek2D72 Oscilloscope/Digital Multimeter/Function Generator or any other Oscilloscope/Function generator
6. DC voltage supply

2.1 Function Generator and Oscilloscope

2.1.1 (20 points) Simulation in TinkerCAD

Watch this video on using the TinkerCAD Function generator and Oscilloscope.
https://youtu.be/wfvYz1L0Qkk. Connect the Function generator to the oscilloscope. Play with the frequency, amplitude, DC offset, and function on the function generator and note the output on the oscilloscope.

1. Generate a square wave of frequency of 10 Hz and amplitude of 10 V. Show the output on the oscilloscope.
2. Now add an offset of 5V. What happens to the output?

Show your work to the teaching assistant.

2.1.2 (20 points) Hardware

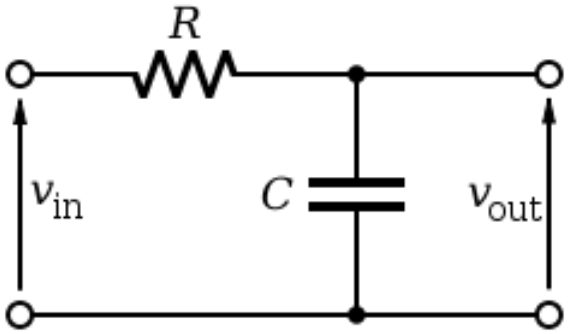
Repeat the above TinkerCAD exercise but using the oscilloscope/function generator in the lab. You could also use 2 Hantek; one as a function generator and one as an oscilloscope. Here is a short video showing how to connect and use a function generator/oscilloscope https://youtu.be/jWDJeiH6veQ. Show your work to the teaching assistant.

2.2 RC Filters

RC circuits are composed of resistors and capacitors. RC circuits can be used to filter a signal by blocking certain frequencies and passing others. We will study the simplest RC circuit consisting of one resistor and one capacitor. RC circuit can be used as a low pass filter (remove high frequency signals) as well as high pass filter (remove low frequency signals).

2.2.1 (30 points) Low-pass Filter

A low-pass filter is an electronic filter that passes low-frequency signals but attenuates (reduces the amplitude of) signals with frequencies higher than the cutoff frequency.



The theoretical cut-off frequency (in hertz) for a low-pass RC filter in terms of R and C is given by f_c given by

$f_c^{\text{theoretical}} =$ _____;

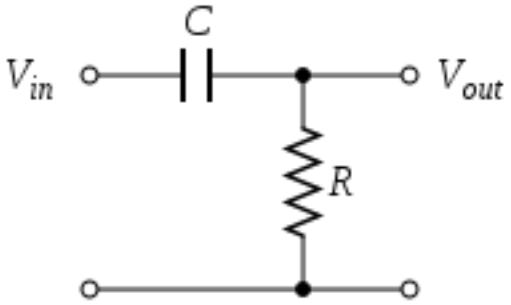
Construct a low-pass filter using TinkerCAD. Use $R = 1k\Omega$ and $C = 10\mu F$. Use the function generator to input various frequency sine waves with suitably chosen input amplitude. Measure the output amplitude. Make a table of frequency versus magnitude (see https://en.wikipedia.org/wiki/Bode_plot if needed).
Find the cut-off frequency from the Bode plot and write it down (numerical value)

$f^{\text{simulation}} =$ _____;

Show the following to the teaching assistant. (1) Your circuit. (2) The Bode plot. (3) The theoretical and simulations-based cut-off frequency.

2.2.2 (30 points) High-pass Filter

A high-pass filter is an electronic filter that passes high-frequency signals but attenuates (reduces the amplitude of) signals with frequencies lower than the cutoff frequency.



The theoretical cut-off frequency for a high-pass RC filter in terms of R and C is given by f_c given by

$f_c^{\text{theoretical}} =$ _____;

Construct a high-pass filter in hardware. Use $R = 1k\Omega$ and $C = 10\mu F$. Follow the same procedure used for low-pass filter and create a Body plot of the magnitude. Now identify the cut-off frequency from the Bode plot.

$f_c^{\text{experiment}} =$ _____;

Show the following to the teaching assistant. (1) Your circuit. (2) The Bode plots. (3) The theoretical and experimental cut-off frequency.