Instrument Calibration – Lab 2:

Date Performed: 03/01/2023

Lab Instructor's name: Mark Vanpoppelen

Honor Statement:
An essential feature of the University of Tennessee, Knoxville, is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the university, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity.

I understand that inappropriate assistance includes:

- Using past lab data
- Using lab data from another section (unless approved by your instructor)
- Using the text from past lab reports
- Using text from another student's lab report

Name: (Printed)
Will Buziak

Signature:

Lab Report #3 – Signal Filters

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ABSTRACT

The Signal Filters lab applied what students have learned in class about different methods of filtering signals of sine waves. Utilizing system dynamics to manipulate oscillatory motion has been a tactic used by engineers for hundreds of years. Filters have a cutoff frequency that, depending on the filter, can remove desired portions of a given frequency. Slight changes in circuitry can produce a different filter, which can be ideal in many situations with limited resources. These methods are all cost effective and relatively simple compared to complex computers and electrical components performing the same operations.

I. Introduction

With only one experiment, the lab sought to walk students through different input frequencies and measure it's output when run through different signal filters. The students walked through high, low and band pass filters with the same testing input frequencies. The students were expected to note the different affects the filters had on the input frequencies. However, the primary deductions were expected to come from data reduction, which was not completed due to an inability to comprehend the expected data parameters for the provided Matlab conditionals. As a result, the author was unable to provide final numerical results or graphs.

A. Theory

Signal filters work by establishing different cutoff frequencies. When portions of a frequency are within the filter's "pass band" the filter allows the signal to come through. When the signal moves out of the filter's pass band, the filter will gradually begin to decrease the response of the signal, effectively vetting the different portions of the signal. After the students test the different filters on the same crop of input parameters, the students should be able to notice different output responses relative to other filters.

B. Procedure

Begin the experiment by turning on the computer, opening the Matlab script and verifying the connections between the signal generator, data acquisition(DAQ) and computer. Connect the high pass filter to the DAQ and turn the signal generator on. Set your parameters on the signal generator and begin iterating through the desired input frequencies and logging the output voltage.

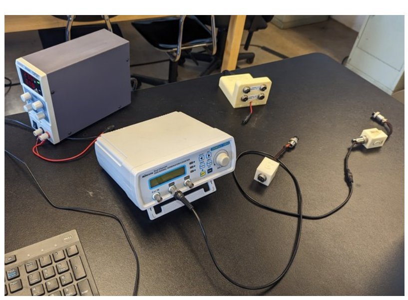


Figure 1
Original lab setup

Figure 2
The high pass filter decreases the output power of lower frequencies, biasing the output to lean towards higher frequencies.

The second portion of the experiment requires the low pass filter in a parallel procedure to the high pass filter.

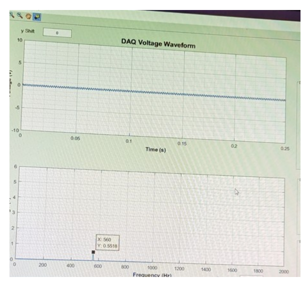


Figure 3
The low pass filter works similarly, but discriminates against higher frequencies producing an output that resembles a lower frequency

Finally, insert the band pass filter and repeat the process. After collecting all of the data, the data collection portion of the experiment has completed, find the high and low cutoff frequencies with the voltage outputs.

C. Data Reduction

In this section of the report, it is apparent that the author struggled to follow the intended relationships that the lab attempted to depict between the data and what is to be expected from the data reduction following the lab.

The following equations relate different test constants and are derived from Ohm's Law. Many of these equations are familiar to statistical environments and do not require much explanation. However, the data collected in the provided Lab Data Sheet does not easily translate to the provided Matlab code for each respective filter. This is an obvious and glaring point of error.

1. $$V = IR$$

2. $$P = VI = \frac{V^2}{R}$$

3. $$\tau = RC = \frac{1}{2\pi f_c}$$

4. $$M(f) = \frac{A_{out}}{A_{in}}$$

The first three equations relate different parameters with Ohm's law while the last equation was provided by the data sheet. The author's primary issue comes is with the Matlab code.

```
% MABE 345  - Lab 3 (High Pass)
% Summer 2020
  fprintf('  \n')
  fprintf('-----------------')
  fprintf('  \n')
  fprintf(' Band Pass Filter')
  fprintf('  \n')
  fprintf('-----------------')
  fprintf('  \n')
  fprintf('  \n')
  fprintf('Freq: 5Hz, 10Hz, 20Hz, 40Hz, 80Hz, 160Hz, 320Hz, 640Hz, 1280Hz, 2560Hz')
  fprintf('  \n')
  fprintf('       |    |      |     |     |     |      |      |       |       |  ')
  fprintf('  \n')
  fprintf('       v    v      v     v     v     v      v      v       v       v  ')
  fprintf('  \n')
  fprintf('Case:  1    2      3     4     5     6      7      8       9      10')
fprintf('  \n')
fprintf('  \n')
A = input('Enter the frequency case you would like to view: ');
fprintf('  \n')
```

Figure 4

The flow of the Matlab code for each filter is similar. prompting the user for the case number and plots the related data parameters.

The Matlab code is not too complicated and is rather self explanatory, it begins by prompting the user for the case number and will then plot the data from the given case. The student's job is to insert their data into the provided if statement.

```
if      A == 1
    X1 = BP5HzAxes1XData;
    Y1 = BP5HzAxes1YData;
    X2 = BP5HzAxes2XData;
    Y2 = BP5HzAxes2YData;
elseif A == 2
    X1 = BP10HzAxes1XData;
    Y1 = BP10HzAxes1YData;
    X2 = BP10HzAxes2XData;
    Y2 = BP10HzAxes2YData;
elseif A == 3
    X1 = BP20HzAxes1XData;
    Y1 = BP20HzAxes1YData;
    X2 = BP20HzAxes2XData;
    Y2 = BP20HzAxes2YData;
elseif A == 4
    X1 = BP40HzAxes1XData;
    Y1 = BP40HzAxes1YData;
    X2 = BP40HzAxes2XData;
    Y2 = BP40HzAxes2YData;
elseif A == 5
    X1 = BP80HzAxes1XData;
    Y1 = BP80HzAxes1YData;
    X2 = BP80HzAxes2XData;
    Y2 = BP80HzAxes2YData;
elseif A == 6
```

Figure 5

An 'else if' statement is what stores the data collected from the data sheet

It is not apparent to the author what the two separate pairs of axes represent from the data collected in the lab data sheet. It is obvious what the first pair of axes would represent from the required parameters for plotting. The frequency provided and respective voltage measured. However, the second pair is not as obvious. This is a source of a serious error that prevents going forth with data reduction and calculation of the required members in the data sheet.

If the Data is properly inserted and ran in each respective Matlab code, the code will produce graphs that the student is then expected to interpolate and analyze the graphs. These graphs will represent some of your final deductions and your results will be the numerical interpolation of each respective graph for it's cutoff frequency.

When producing a guess of using another pass filter's data as the second pair of axes, the Matlab script will run, but will only produce an empty graph.

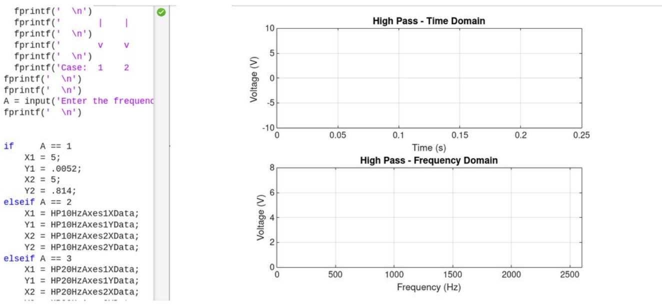


Figure 6

When using another filter's data for the second pair of axes, the graphs produced are empty.

The report asks for a measured time constant and cutoff frequency to use to determine the resistance for the high pass filter, this was another point of confusion that prevents further data reduction

II. Results and Discussion

With an inability to provide final graphs and numerical deductions, the results and discussion will be relatively brief.

The glaring error primarily discussed in the lab is that of the author. After brief discussion with other group members, this was found to be as a common confusion. This results in an inability to completely finish the required members of the data report.

Regardless of the completeness of the data reduction, many deductions can be made by completing the lab and gathering the data. The primary questions that are begged from completing the lab are related to the filters and their physical and electrical differences that ultimately affect the output behavior of your signal. How can this be utilized in the real world and how could this be potentially improved upon to better suit your applications.

The design of each filter is in regards to it's resistance and capacitance, in both physical orientation on the circuit and it's respective sizes related to it's desired strength. When utilizing these methods in your own applications, it is vitally important to consider these components of your design. For instance, in tv remotes and other handheld devices in the modern day it is important to maintain an ergonomic size and shape, requiring a small enough filter to fit inside of the device with all of it's other components. As a design engineer you must consider thermal aspects to your circuitry and that can often relate to physical dimensions and proximity to other materials.

III. Conclusion

The *Signal Filters* lab sought to familiarize students with the methods of controlling output signals. This is an exceptionally useful tool in the modern world of remotes and wireless connectivity utilizing frequencies and waveforms to send data. In cooperation with other system dynamics tools we can mathematically extract information from signals and now, control the behavior of our output frequencies to improve our ability to transmit signals.

An inability to understand the desired functions of the Matlab program and desired high pass parameters produced an inability for final data reductions, but this does not distract from the big questions that should be asked during this lab. Primarily how these methods are used in the real world and the potential design characteristics that are favorable for which situations. There are applications outside of design, but as engineers we often as ourselves how the design can be optimized to better suit our tasks.

References

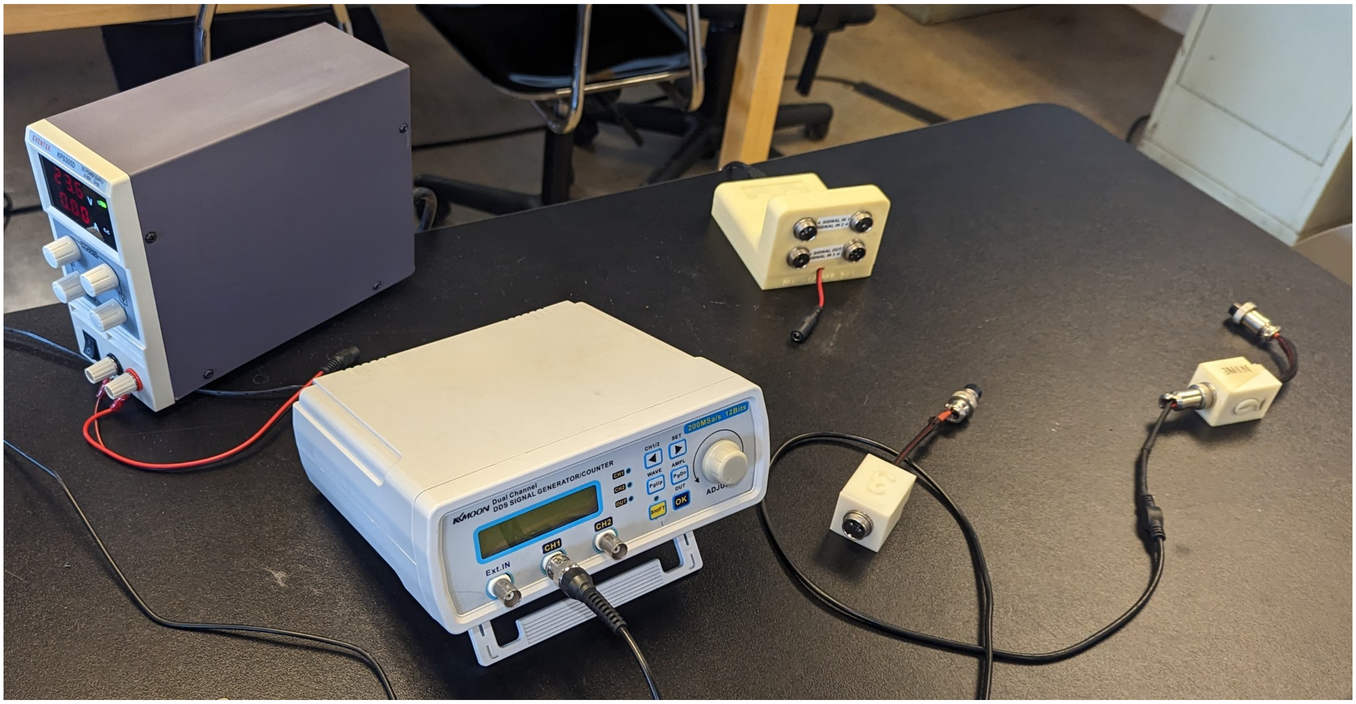
[1] M. Vanpoppelen, "MABE 345 Lab Report Required Sections.docx" U.S., Knoxville, TN, 2023.

[2] V. Aloi. (2023, February). ME/AE/BME 345 Instrumentation and Measurements class notes. [Online]. Available e-mail: valoi@utk.edu

[3] W. Buziak (2023 March). ME/AE/BME 345 Lab report 3 MATLAB programs [online]. Available e-mail: wbuziak@vols.utk.edu Message: MABE 345 Lab report code(s).

Appendix A: Equipment Information

1. Lab computer (Matlab)
2. Signal Generator
3. DAQ (Signal In)



Appendix B: Hand Calculations

$V = IR$

$\tau = RC$ $\quad f_c = \frac{1}{2\pi\tau}$

$P = VI = \frac{V^2}{R}$

$4 = -4 = R(4E-7)$

$\frac{P_{out}}{P_{in}} = .5 \qquad \frac{V_{out}^2}{V_{in}^2} = .5$

$M(f_c) = \sqrt{.5} = .707$

$y = M(f_c) \qquad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{y - y_1}{x - x_1}$

$x = x_1 + \frac{(x_2 - x_1)}{y_2 - y_1}(y - y_1)$

High Pass	Low Pass	Band pass
.0052	.614	.00574
.00916	.635	.00924
.02772	1.0062	.02752
.05584	.998	.05414
.11192	.971	.09972
.2172	.8884	.15482
.4002	.702	.19616
.6384	.4558	.19262
.8264	.2564	.16272
.9128	.13512	.11036

Appendix C: Complete Data Sheet (data continued on hand written sheet)

Lab No. 3 Data Sheet

Name: Will Buziau

Partners: Brenna Ellis

Partners: Toni Perkins

Partners: ____________

Input Signal: Sine wave, amplitude $A_{in} = 5V$, various f_{in}

Low Pass Filter #	
R (Ω)	1000
C (F)	4E-7
τ (sec)	4E-4
$f_c (Hz)$	338.8

High Pass Filter #	
R (Ω)	
C (F)	4E-7
τ (sec)	
$f_c (Hz)$	

$f_{c,High}$ (Hz)	$f_{c,Low}$ (Hz)

High Pass		
f_{in} (Hz)	A_{out} (V)	$M(f) = A_{out}/A_{in}$
5	.026	
10	.0458	
20	.1386	
40	.2792	
80	.5596	
160	1.086	
320	2.001	
640	3.192	
1280	4.132	
2560	4.564	

Low Pass		
f_{in} (Hz)	A_{out} (V)	$M(f) = A_{out}/A_{in}$
5	4.07	
10	3.175	
20	5.031	
40	4.99	
80	4.855	
160	4.442	
320	3.51	
640	2.299	
1280	1.282	
2560	.6756	

Band Pass		
f_{in} (Hz)	A_{out} (V)	$M(f) = A_{out}/A_{in}$
5	.0287	
10	.0462	
20	.1376	
40	.2707	
80	.4980	
160	.7741	
320	.9506	
640	.9631	
1280	.8136	
2560	.5518	

Lab Instructor's Signature: ____________ ___/___/23