MAT411 Complex, Special Functions & Numerical Analysis

Fall 2025

Project

- **Problem:**

You are given an electronic circuit that represents the active 2nd order High Pass Filter (HPF). And, you are able to analyze it through the lab equipment experimentally. We are varying the frequency and applying an input voltage and then observing the output voltage. Since the output is varying when the frequency is varying, the gain is therefore varying and it changes with a known relation that is:

$$T(f) = \frac{a_2 f^2}{f^2 + \frac{\omega_0}{Q} f + \omega_0^2}$$

where

- f represents the frequency and T(f) represents the gain,
- a_2 is High Frequency Gain,
- Q is the Quality factor,
- ω_0 is the -3dB frequency at which the gain is $\frac{1}{\sqrt{2}}$ of maximum gain.

We want to determine these values: ω_0, Q, and a_2, and obtain the transfer function of the high pass filter which allows us to determine the gain at a specific given frequency.

The experimental values of [High Pass Filter] are as follows:

Frequency (Hz)	Input Voltage (Vi)	Output Voltage (Vo)	Gain (Vo/Vi)
10	1.64	0.014	0.009
20	1.96	0.074	0.038
30	1.96	0.150	0.077
40	2.00	0.260	0.130
50	2.04	0.408	0.200
60	2.04	0.592	0.290
70	2.04	0.840	0.412
80	2.04	1.100	0.539
90	2.04	1.400	0.686
100	2.04	1.740	0.853
110	2.04	2.160	1.059

120	2.04	2.560	1.255
130	2.04	2.960	1.451
150	2.04	3.680	1.804
160	2.04	4.00	1.961
170	2.04	4.320	2.118
180	2.04	4.480	2.196
190	2.04	4.640	2.275
200	2.04	4.640	2.275
220	2.04	4.720	2.314
230	2.04	4.800	2.353
240	2.04	4.800	2.353
250	2.04	4.800	2.353
260	2.04	4.720	2.314
270	2.04	4.640	2.275
280	2.04	4.640	2.275
300	2.04	4.640	2.275
330	2.04	4.640	2.275
340	2.04	4.560	2.235
350	2.04	4.480	2.196
370	2.04	4.480	2.196
400	2.04	4.480	2.196
420	2.04	4.400	2.157
430	2.04	4.320	2.118
450	2.04	4.320	2.118
470	2.04	4.320	2.118
500	2.04	4.320	2.118
550	2.04	4.320	2.118
600	2.04	4.320	2.118
650	2.04	4.320	2.118
700	2.04	4.240	2.078
750	2.04	4.160	2.039
800	2.04	4.160	2.039
900	2.08	4.160	2.000
1 k	2.08	4.160	2.000
4 k	2.16	4.160	1.926
5 k	2.16	4.120	1.907
6 k	2.16	4.120	1.907
40 k	2.16	4.120	1.907
50 k	2.16	4.120	1.907
80 k	2.16	4.120	1.907
90 k	2.16	4.080	1.889

Q1: Analysis of the Problem and Data Set (20 Pts.)

a) Analyze the provided data set below, and select the proper method (from those studied in this course) that can be used to find a solution to the problem.
b) Describe how this method can be used and state what the expected outcome is.

Q2: Implementation of Selected Method (50 Pts.)

a) Develop a program of the selected method for solving the problem. Write the program using MATLAB.
b) Add comments to explain your program.

Q3: Verification of the Results Obtained (30 Pts.)

a) Verify the results for simple values.
b) Provide the results in a table.
c) Plot the results obtained.
d) Comment on the obtained results.

- **Bonus Task (30 Pts.)**

For the above system, can you use both a numerical and an analytical method to compute the average gain for a signal that occupies a 200 Hz around a carrier frequency of 1 KHz. Validate your analytical result with the numerical one!

To Be Submitted:

- A soft copy of a report with:
  1. Cover page (Name, ID, Course Title, Semester, Date)
  2. Statement of the problem
  3. Analysis of the Data Set and Problem
  4. MATLAB-code of your program
  5. The table and plot
  6. Conclusion (Your analysis of the obtained results)
  7. Bonus Task (If applicable!)