BİLKENT UNIVERSITY
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

EE 311 ELECTRONICS II

Experiment 5

Lab Report

Op-Amp Amplifier Frequency Response and Op-Amp Differentiator

Student Name:

ID Number:

Date:

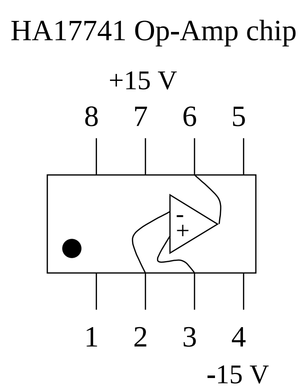
INTRODUCTION

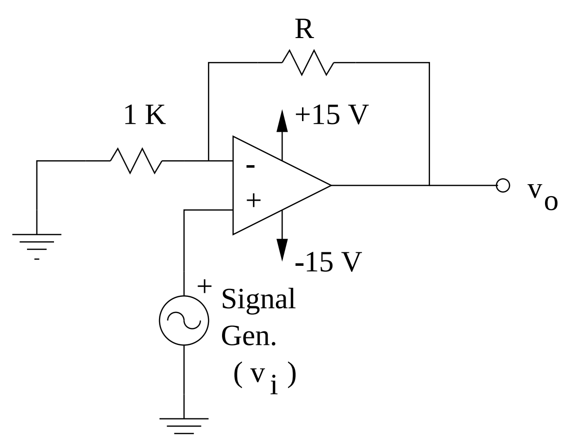
In the first part of this experiment, you will build an op-amp amplifier and investigate the frequency dependence of its gain. You will verify that the gain-bandwidth product of the amplifier circuit is a constant that is equal to the op-amp unity-gain frequency f_T. In the second part of the experiment, you will set up and evaluate a practical differentiator circuit that employs an op-amp.

PRELIMINARY WORK

1. Consider the non-inverting amplifier circuit shown in the figure. The nominal unity-gain frequency of the op-amp (f_T) is 1 MHz. The -3-dB frequency can be found from $f_{3dB} = f_T/A_M$. Determine the midband voltage gain $A_M = v_o/v_{in}$ for $R = 10K$, $22K$, $33K$, $56K$, $82K$, and $100K$. Using these gain values, determine the -3-dB frequency of the amplifier for each value of R. Generate asymptotic Bode plots of the voltage gain (in dB) versus frequency (log scale) between 10 Hz and 2 MHz for all values of R on the same graph.

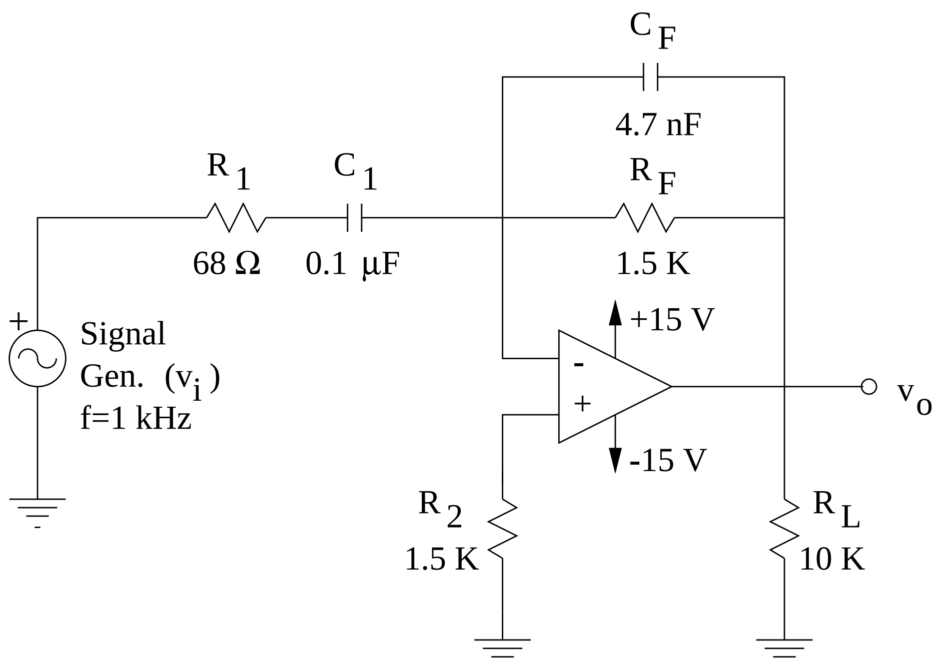
Perform the SPICE simulations of the circuit for each value of R. Use the μA741 as a model for the op-amp. Display the gain (in dB) versus frequency (on a log scale and between 10 Hz - 2 MHz) plots on the same graph. Append the pages containing the input decks and the results of the SPICE simulations to the end of this report.





2. Consider the practical differentiator circuit shown in the figure. R_F and C_1 are the usual differentiator resistance and capacitance in a simple differentiator. R_1 and C_F are included to avoid instability and high-frequency noise problems that a simple differentiator circuit usually shows. The value of the product R_1C_1 is chosen to be approximately equal to the value of R_FC_F.

Perform an ac analysis of the circuit using SPICE. Use the μA741 as a model for the op-amp. Plot the voltage gain in dB versus frequency on a log scale between 10 Hz - 10 MHz. Determine the frequency up to which the circuit acts as a differentiator. Append the pages containing the input decks and the results of the SPICE simulations to the end of this report.



EXPERIMENT:

1. Construct the non-inverting amplifier circuit given in part 1 of the preliminary work.

For $R = 10$ K and $R = 100$ K, do the following:

(a) Set the output of the signal generator to be a sine-wave with a peak-to-peak amplitude of 100 mV and a frequency of 1 KHz. At this frequency, determine the midband gain of the circuit.

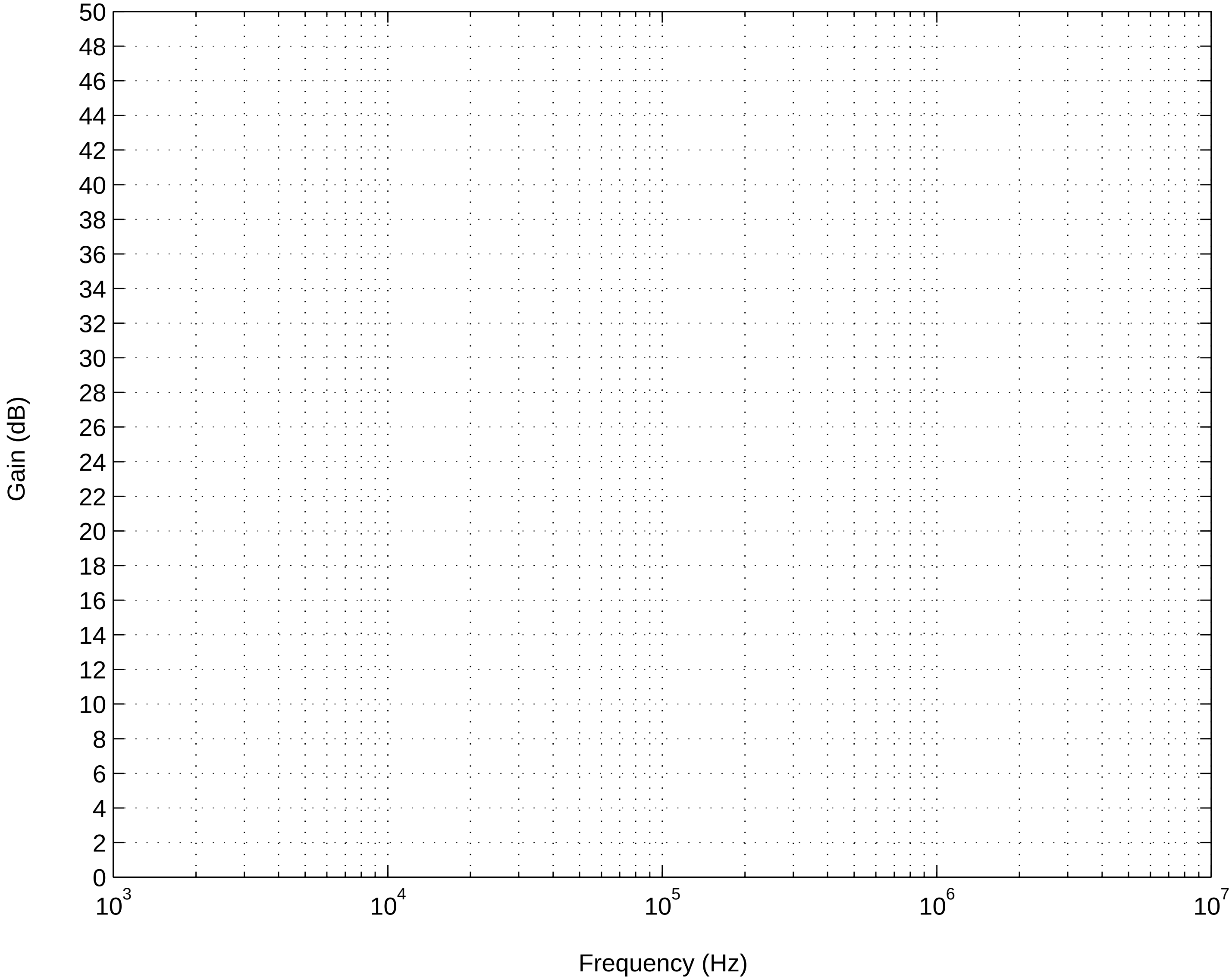
(b) Determine the -3 dB frequency (corner frequency) of the amplifier by adjusting the frequency of the signal generator, and noting at which frequency the gain value is $1/\sqrt{2}$ times the midband gain.

(c) Determine the slope of the high frequency asymptote. To do this, set the signal generator frequency to twice the corner frequency found in the previous part. Record the gain value at this point. Then, set the signal generator frequency to be four times the corner frequency found in part (b). Record the gain value at this point. Determine the slope from your measurements.

(d) Mark all your measurements on the gain (in dB) versus frequency graph provided on the next page.

Considering the two curves (for $R = 10$ K and $R = 100$ K) on the gain versus frequency graph, and verify that the two curves merge asymptotically and cut the frequency axis (where the gain is 0 dB) at a common point, f_T. Determine the approximate value of f_T from the graph.

For $R = 100$ K, increase the frequency of the signal generator up to a value where the gain becomes 0 dB. Record the frequency f_T at this point. This is a more accurate f_T measurement for the op-amp.


50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Gain (dB)
10^3
10^4
10^5
10^6
10^7
Frequency (Hz)

2. Construct the practical differentiator circuit given in part 2 of the preliminary work.

(a) Set the output of the signal generator to be a sine-wave with a peak-to-peak amplitude of 2 V and a frequency of 1 KHz. Plot v_o and v_{in} versus time on the same graph. Does the circuit perform differentiation? Record the gain of the circuit and compare that with the SPICE result.

(b) Set the output of the signal generator to be a square-wave with a peak-to-peak amplitude of 2 V and a frequency of 1 KHz. Plot v_o and v_{in} versus time on the same graph.

(c) Set the output of the signal generator to be a triangular-wave with a peak-to-peak amplitude of 2 V and a frequency of 1 KHz. Plot the v_o and v_{in} versus time on the same graph.

(d) Set the output of the signal generator to be a sine-wave with a peak-to-peak amplitude of 200 mV and a frequency of 400 KHz. Plot the v_o and v_{in} versus time on the same graph. Does the circuit perform differentiation? Record the gain of the circuit and compare that with the SPICE result.