Exercise 4: Equations

In this exercise, you are asked to manipulate experimental data and to prepare a short experimental report. The only thing you do not have to do is perform experimental measurements.

Objective

The objective of the project is to characterize the frequency response of an amplifier; in the specific task represented here, the amplifier's gain is to be characterized as a function of frequency. When the frequency response is characterized, we will know the amplifier's bandwidth, or the range of frequencies over which this amplifier can function without distorting the signal.

Apparatus and Procedure

The apparatus for this project is portrayed schematically in Figure 1. The main elements are a function generator, an oscilloscope and an amplifier. The function generator can produce signals of specified voltage and frequency, the oscilloscope measures signals in units of volts, and the amplifier's response to a range of frequencies is of interest. Signals from the function generator are sent to the input port of the amplifier and to Channel 1 on the oscilloscope. The amplifier's output signal is sent to Channel 2 on the oscilloscope. The oscilloscope measures and records these output signals for later comparison.

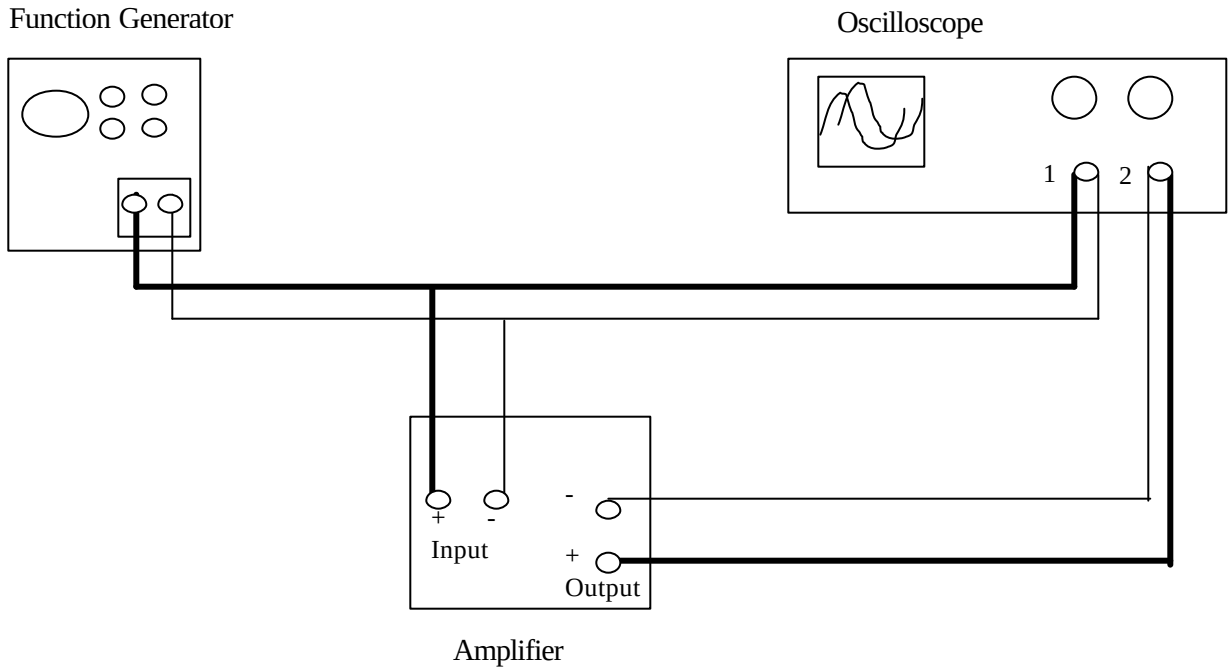

Figure 1. A schematic of the amplifier experiment, showing the connections between the function generator, the amplifier and the oscilloscope.

In this project, the function generator's output voltage is held constant at 1.0 Volts while the output frequency is varied from 10 Hz to 10^6 Hz. Data is collected at 10 frequencies, and that data is displayed in Table 1.

Analysis Methods

In order to plot the relationship of gain to frequency, the amplification factor, the dimensionless value *K*, must be determined; from *K*, the gain, *G*, can be calculated in decibels (dB). The amplification factor *K* is calculated as follows:

$$K = \frac{V_{\text{out}}}{V_{\text{in}}} \tag{1}$$

where V_{out} is the output voltage measured on Channel 2 of the oscilloscope, and V_{in} is the input voltage measured on Channel 1 of the oscilloscope. Once *K* is known, *G* is found as follows:

$$G = 20\left(\log_{10} K\right) \tag{2}$$

Assignment

Given the experimental data collected for the amplifier, shown in Table 1, calculate *K* and *G*, and display them in a complete experimental table; your table must resemble Table 2. Then plot the frequency response, in dB, against the log of the frequency, obtaining the graph shown as Figure 2. Your report should contain your determination of the bandwidth of the amplifier under study.

Your tables, equations and graphs are to be inserted into the body of your report, as they are inserted into the body of this assignment sheet. You are to do this insertion electronically; scissors, tape and photocopying are not acceptable methods for inserting figures into project reports.

Table 1. Experimental data from study of the frequency response of an amplifier.

Frequency (Hz)	*V*in (Volts)	*V*out (Volts)
10.0	1.0	5.0
100.0	1.0	9.8
1000.0	1.0	10.1
10000.0	1.0	10.0
50000.0	1.0	10.1
80000.0	1.0	10.6
90000.0	1.0	10.7
100000.0	1.0	10.1
200000.0	1.0	6.0
1000000.0	1.0	3.0

Table 2. The completed data characterizing the frequency response of the amplifier.

Frequency (Hz)	*V*in (Volts)	*V*out (Volts)	*K*	*G* (db)
10.0	1.0	5.0	5.0	14.0
100.0	1.0	9.8	9.8	19.8
1000.0	1.0	10.1	10.1	20.1
10000.0	1.0	10.0	10.0	20.0
50000.0	1.0	10.1	10.1	20.1
80000.0	1.0	10.6	10.6	20.5
90000.0	1.0	10.7	10.7	20.6
100000.0	1.0	10.1	10.1	20.1
200000.0	1.0	6.0	6.0	15.6
1000000.0	1.0	3.0	3.0	9.5

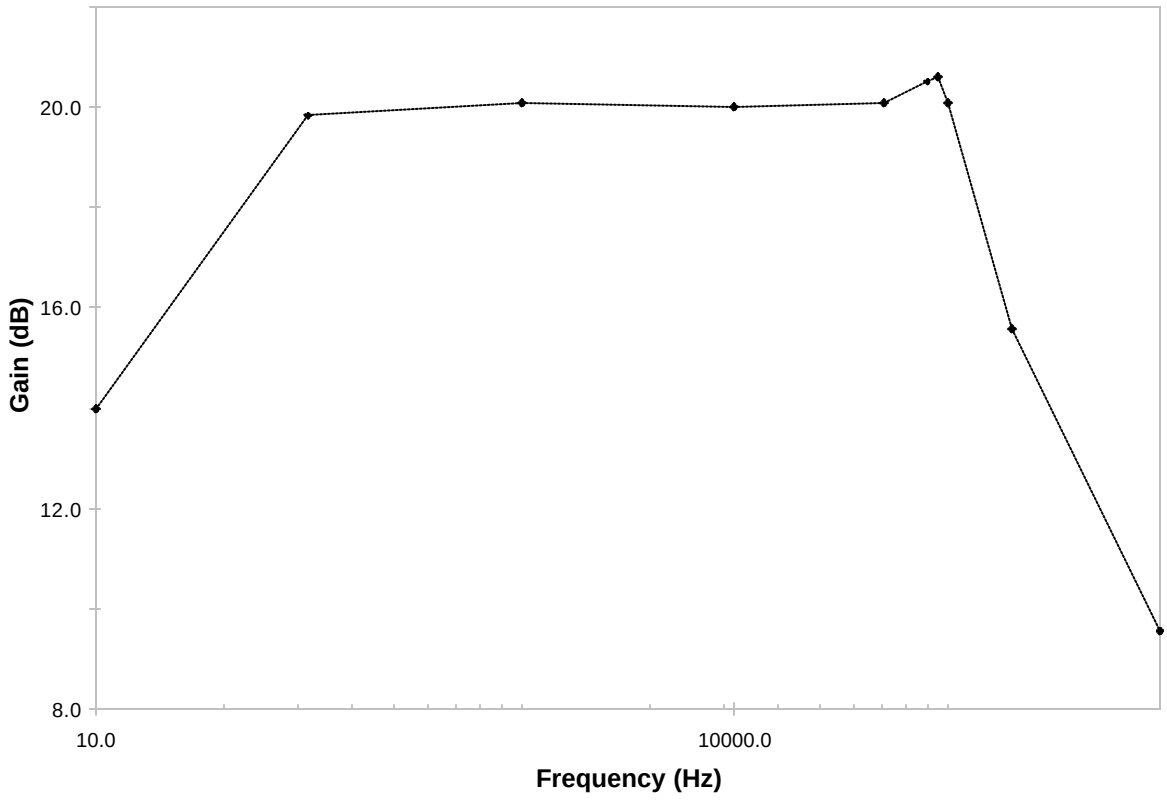

Figure 2. The frequency response of the amplifier is shown on a log linear plot.