Chapter II-3

System Identification Through Frequency Response Techniques

II-3.1 Objectives

In this laboratory, students will learn how to:

- Experimentally sketch the Bode plot of a system.
- Identify the system model from the Bode plot.
- Validate the system model against its time response.

II-3.2 Identifying a First-Order System From Its Frequency Response

Pre-lab

P-II-3.1. The Bode plot of a first-order system is shown in Fig. II-3.1. Use the Bode plot to find the system's DC gain and time constant. Write the system's transfer function. Explain your answer in detail. (20 pts)

P-II-3.2. The step response of a first-order system is shown in Fig. II-3.2. Find the system's DC gain and time constant. Write the system's transfer function. Explain your answer in detail. (20 pts)

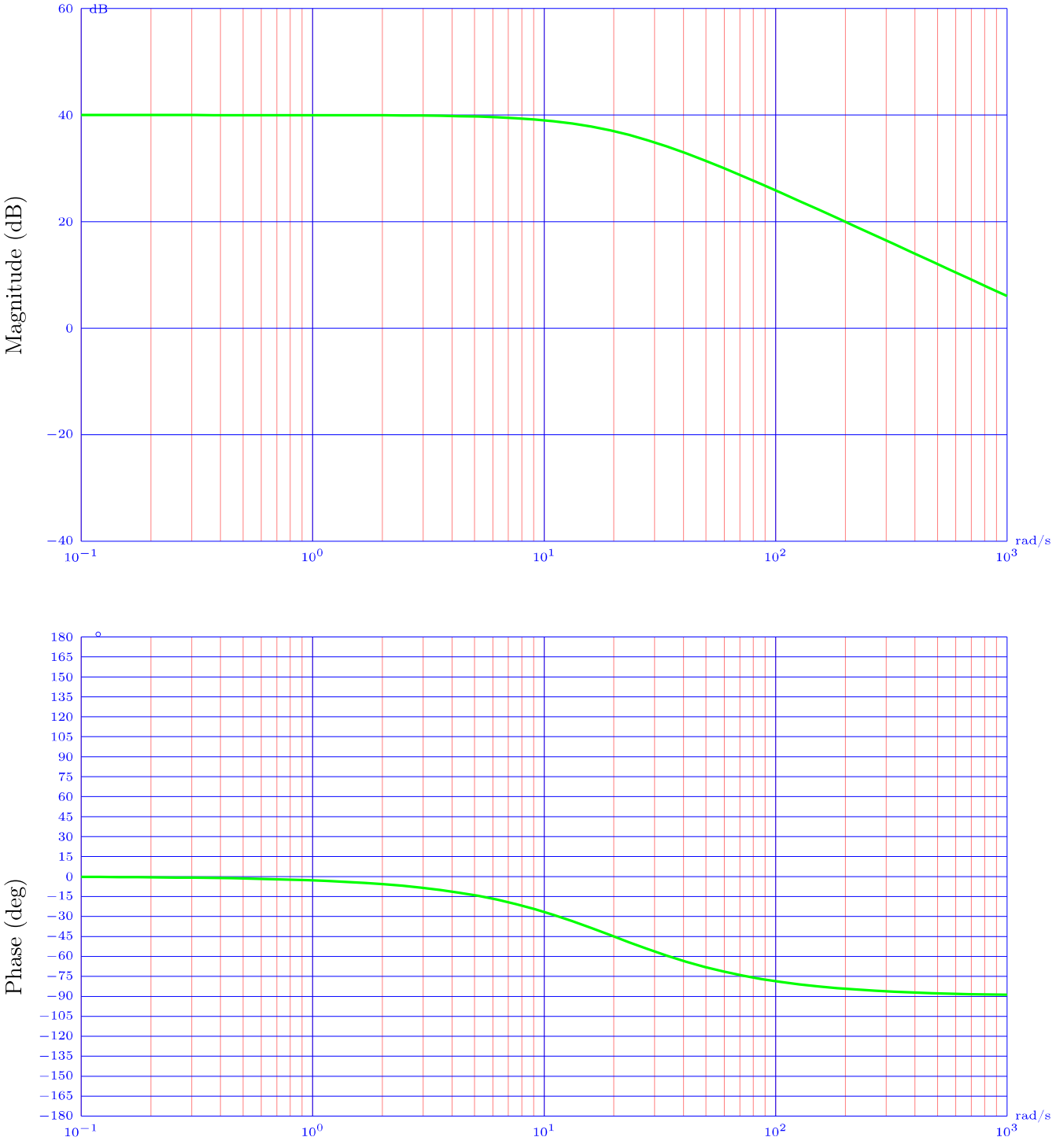

Figure II-3.1: Bode plot of a first-order system

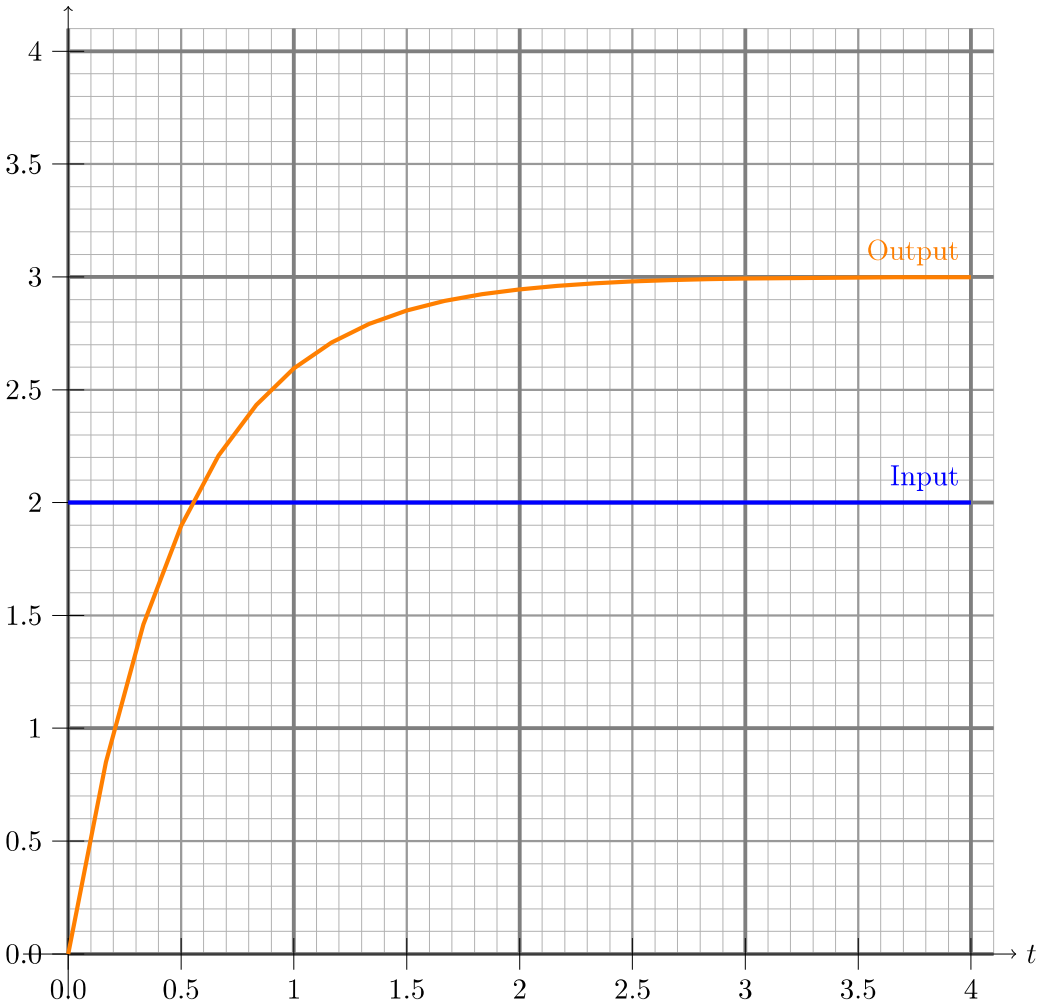

Figure II-3.2: Step response of a first-order system

II-3.3 Lab Procedure

In the laboratory, you will start by experimentally sketch the Bode plot of an LTI system.

L-II-3.1. Connect the K-MCK and the K-ECS boards and launch the K-CSP, as described in Chapter I-1.

L-II-3.2. Upload the appropriate firmware (Hex file) to the K-ECS board.

L-II-3.3. Load this part's configuration file (kcsp file), if any, to the K-CSP.

L-II-3.4. Apply the settings shown in Fig. II-3.3 with the following exceptions:

a) Make sure you pick the right communication port.

Notice the sampling periods.
You may want to adjust the experiment duration so that it is enough to get a few cycles of the input and output signals.

L-II-3.5. Run the necessary experiments to fill out Table II-3.1.
Save your plots and copy the raw data (csv file) on your personal storage media, such as a USB key, for later use. You may want to give them meaningful names so that they do not get mixed up with the files of other experiments.

(10 pts) Demo

D-II-3.1. Make sure you demo to the TA at least one of your runs before leaving the lab.

L-II-3.6. Now, you will record the system's time response so that you can later extract its transfer function and compare it to that obtained from the Bode plot. To do that, choose an adequate input type which allows you to plot the step response of the system. Remember to avoid having the motor running at low speeds at all times (to avoid static nonlinear fiction).

L-II-3.7. Run at least 4 experiments with the same input type but different input magnitude.
Save your plots and copy the raw data (csv file) on your personal storage media, such as a USB key, for later use. You may want to give them meaningful names so that they do not get mixed up with the files of other experiments.

(10 pts) Demo

D-II-3.1. Make sure you demo to the TA at least one of your runs before leaving the lab.

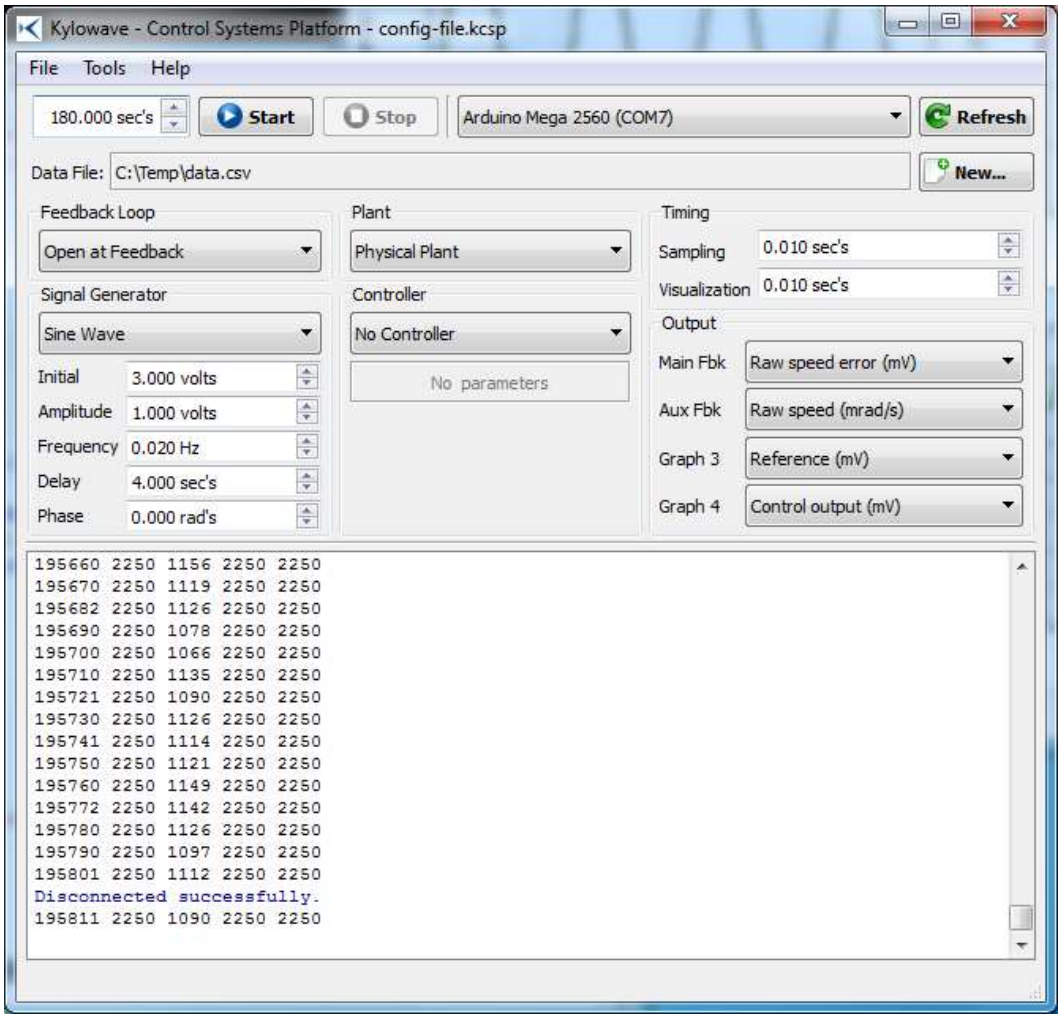

Figure II-3.3: K-CSP settings for the frequency response experiment

Input Frequency (Hz)	Input Magnitude (V)	Input Frequency (rad/s)	Output Magnitude (rad/s)	Magnitude Ratio (rad/(s·V))	Magnitude Ratio (dB)	Output Phase Shift (rad)	Output Phase Shift (°)
0.02	1.0						
0.04	1.0						
0.06	1.0						
0.08	1.0						
0.10	1.0						
0.20	1.0						
0.40	1.0						
0.60	1.0						
0.80	1.0						
1.00	1.0						
2.00	1.0						
4.00	1.0						
6.00	1.0						
8.00	1.0						
10.00	1.0						

Table II-3.1: Frequency response results

II-3.4 Laboratory Report

Include the following in your laboratory report:

Report

R-II-3.1. Include your input and output plots corresponding to each row of Table II-3.1. Label them clearly. (10 pts)

R-II-3.2. Finish filling in Table II-3.1 and include it in your report. (20 pts)

R-II-3.3. Use the graph on page 62 to draw the system's Bode plot. (10 pts)

R-II-3.4. From the Bode plot, find the DC gain and time constant, and write the system's transfer function. Explain your reasoning in detail. (20 pts)

R-II-3.5. Include your step response plots. Label them clearly. (10 pts)

R-II-3.6. Now use the step response plots to find the DC gain and time constant. You would better calculate them from each plot and average them out. Write the system's transfer function. Explain your reasoning in detail. (20 pts)

R-II-3.7. Compare the transfer functions you derived from the frquency and time responses. How close are they? Try to explain the source of differences, if any. (10 pts)

Attention

When answering pre-lab or lab report questions, ALWAYS indicate the number of the question you are answering.

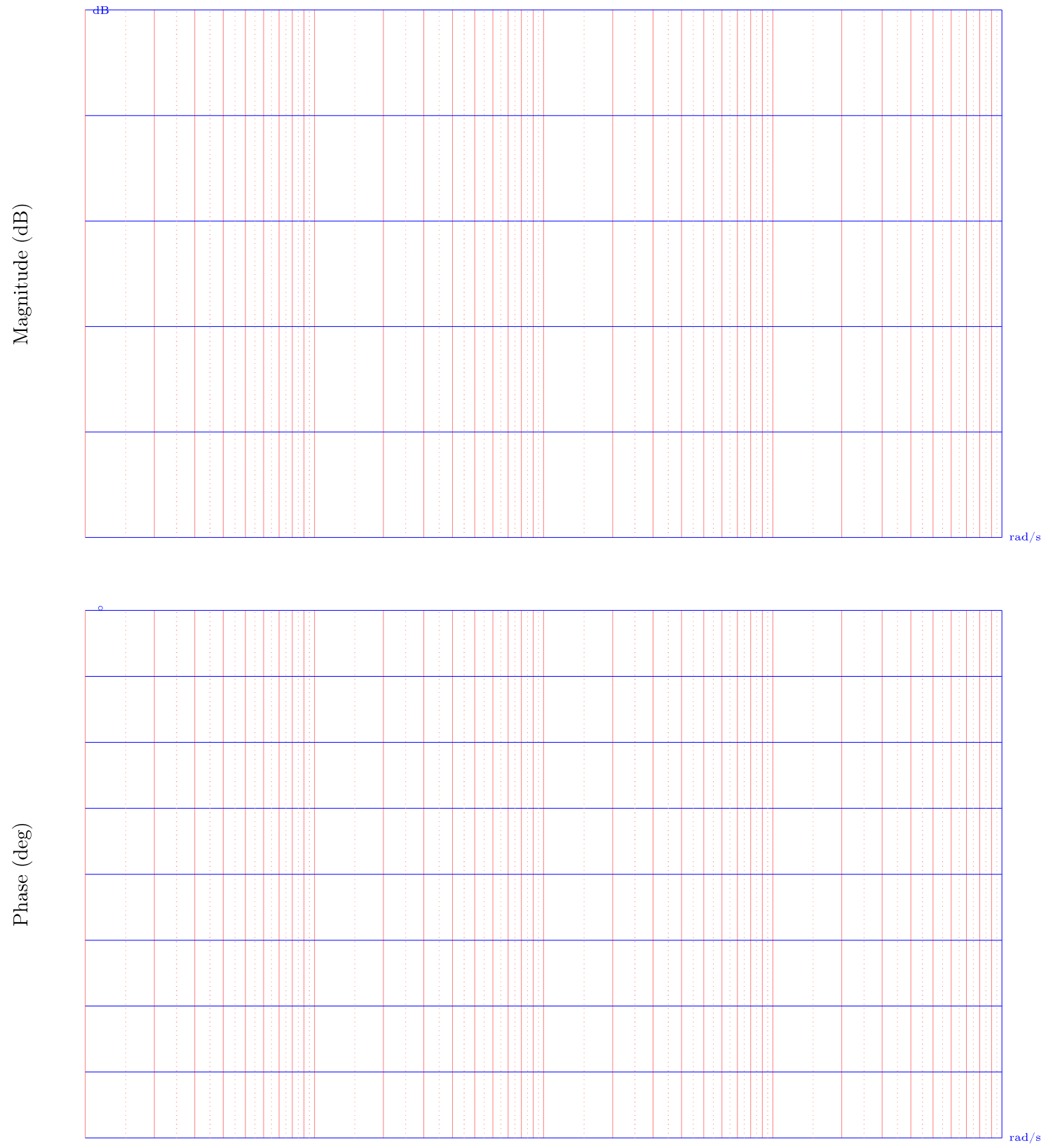

Figure II-3.4: A template for sketching Bode plots