5ELEN018W - Tutorial 8 Exercises

1 Bode Plots in Simulink

Consider a dynamic system describing a watertank (Figure 1). Water enters the tank from the top at a rate proportional to the voltage, V, applied to the pump. The water leaves through an opening in the tank base at a rate that is proportional to the square root of the water height, H, in the tank. The presence of the square root in the water flow rate results in a nonlinear plant.

The dynamic system is described by the following differential equation:

$$\frac{d}{dt}Vol = A\frac{dH}{dt} = bV - \alpha\sqrt{H} \tag{1}$$

where H is the height of the water in the tank, Vol is the volume of the water in the tank, b is a constant related to the flow rate into the tank, A relates to the area of the tank and α is a constant related to the flow rate out of the tank.

The following values should be used: $A = 20, \alpha = 2, b = 5, H_{ref} = 10$, where H_{ref} is the desired water level in the tank.

You can download the Simulink model file of the watertank from the following URL:

`https://dracopd.users.ecs.westminster.ac.uk/DOCUM/courses/5elen018w/watertank.slx`

The Simulink model with the PID controller can be opened with the following commands in Matlab (make sure that you execute the commands below when you are in the same directory with the `simulink.slx` file - alternatively open the downloaded file using the Matlab menu Open option):

```
model = 'watertank';
open_system(model)
```

We will see how to Simulink can linearise the model and then use the linearised model to plot the Bode diagram for the chosen input-output system.

2 Creating Transfer Functions in Matlab

The transfer function of a dynamic system can be created in Matlab by using similar code as the one described in the last lecture (Slides 7–8).

Implement in Matlab the following transfer function:

$$\frac{5s + 15}{77s^3 + 4s^2 + 1000s + 10} \tag{2}$$

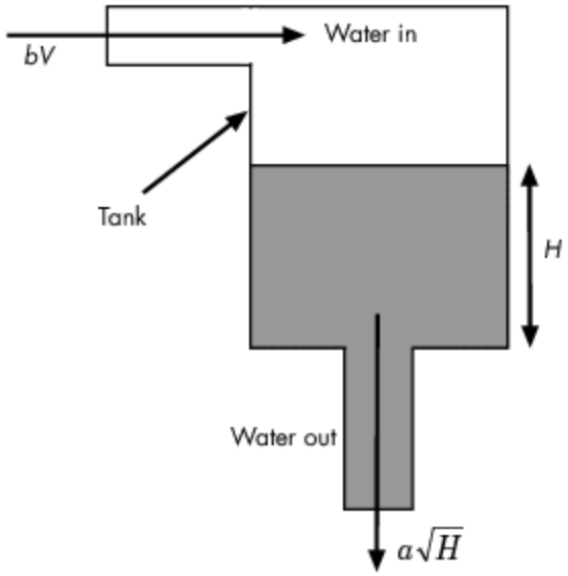

Figure 1: The watertank dynamic system.

3 Drawing Bode Plots in Matlab

1. Implement in Matlab the following transfer function:

$$\frac{0.5s + 5}{0.0002s^4 + 0.0064s^3 + 0.512s^2 + s} \tag{3}$$

2. Draw the Bode plot in Matlab by calling the `bode` function and passing it a single argument corresponding to a variable which is assigned to the transfer function in the previous step.

3. Compare your diagram with the one given in slide 11 of the lecture. Do they match?

4. Is the system stable or unstable? Justify your answer.

4 Implementing a Dynamic System and a Controller in Code (not Simulink)

In the last lecture, we implemented in Java the dynamic system and a PID controller for the car cruise control system.

Consider the robot surgery dynamic system that we studied in the last few weeks. Implement in a programming language of your choice (e.g. Java, Python, etc) the dynamic system and a PID controller with it.