

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:

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

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 should add variables A , a , b in the main Matlab window or as part of the model (the latter is preferable).

The initial condition for the H level should be 1 and this should be set in the integrator.

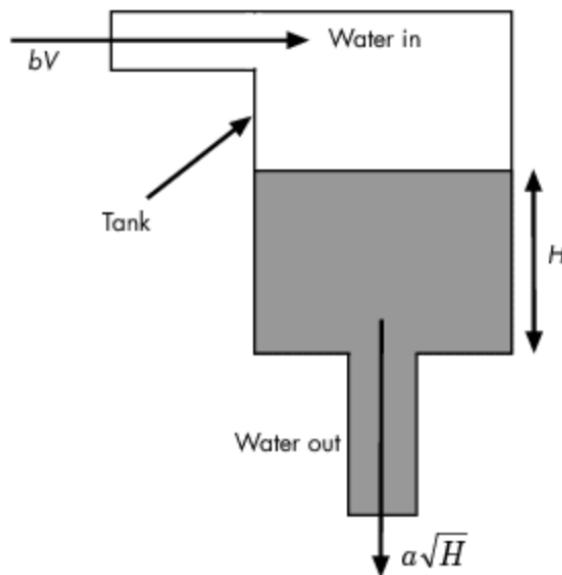


Figure 1: The watertank dynamic system.

1. Build a Simulink model of the system with a PID controller. The PID controller should use the following values for its parameters: $P = 0.208$, $P_I = 0.031$, $P_D = 0$.

- Plot the Bode diagrams and make the appropriate calculations to analyse its stability (see the lecture slides and the lecture recording).

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:

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

3 Drawing Bode Plots in Matlab

- Implement in Matlab the following transfer function:

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

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