FRT010 Computer Exercise: Comparison of Dynamic Systems Using Interactive Software Tools

November 13, 2013

Background

There are many different ways of describing the dynamics of processes and control systems. Examples are step responses, transfer functions, state-space representation, pole-zero diagrams, Bode diagrams, and Nyquist diagrams. An intuitive approach to investigation of the relation between the different representations is to use interactive computer tools. On the homepage

http://aer.ual.es/ilm/

several interactive software modules are available for free download[1]. The module called *Modeling* is appropriate for studying different model representations and its user interface is shown in Figure 1.

The model structure to be investigated is defined by adding poles and zeros in the pole-zero diagram in the program window. The model parameters can later be altered by changing the locations of the poles and/or zeros in the diagram. The time delay can be changed by moving the vertical line. The system can also be defined by specifying the numerical values for the transfer function parameters directly. The scales of the different axes can be changed by clicking on the small triangles located near the axes. It is also possible to zoom in and out in the different plots. Under the menu "File", the convenient option "Reset Data" is available, with which all values and parameters are reset to their original values. The best way to explore the further possibilities of the tool is to experiment with the different options in the menus available in the top of the program window. More information and documentation of the tool are available on the homepage.

Exercises

9.1 Consider the transfer function

$$G(s) = \frac{K}{1 + sT}.$$

Let the nominal model parameters be $K = T = 1$.

---

[1] The software package is developed as a cooperation between the Dept. of Automatic Control, Lund University, and Universidad de Almeria, Spain.

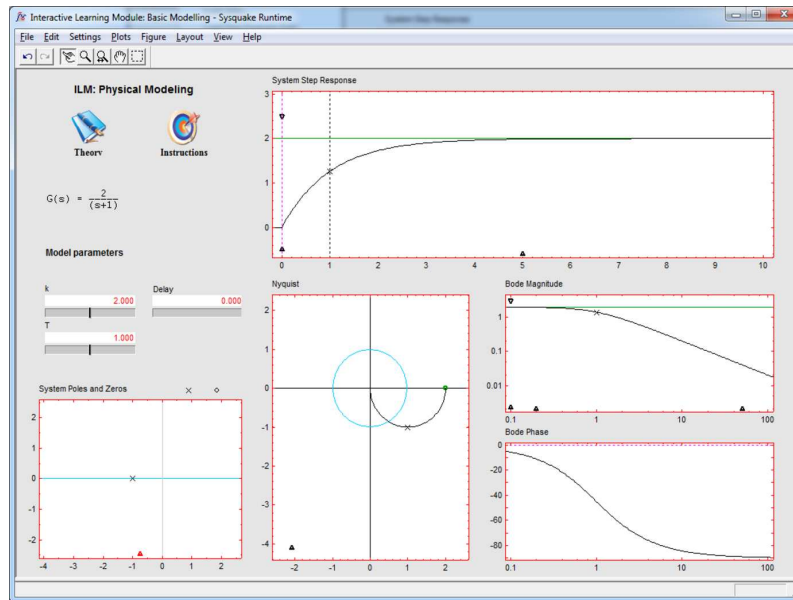Figure 1: Graphical user interface for the model-investigation software tool.

a. Vary the gain K and study how the pole, the step response, and the Nyquist and Bode diagrams are affected. How can the value of the gain K be determined from the step response, the Nyquist diagram, and the Bode diagram, respectively?

b. Let $K = 1$ and vary T instead. How is the different representations of the system affected? Why does not the shape of the Nyquist diagram change?

c. Again let $K = T = 1$ and add a time delay L in the system such that the model structure is
$$G(s) = \frac{K}{1 + sT}e^{-sL}.$$

Vary the time delay L and and study how the different model representations change. Explain the behavior of the step response. Is the obtained Nyquist diagram expected? Why is the Bode magnitude diagram not affected?

9.2 Consider the transfer function
$$G(s) = \frac{K}{(1 + sT_1)(1 + sT_2)}.$$

Let the nominal model parameters be $K = T_1 = T_2 = 1$.

a. First vary the gain K and explore how the poles, the step response, and the Nyquist and Bode diagrams change.

b. Let $K = 1$ and vary T_1 and T_2. Try different cases, and in particular $T_1 \approx T_2$ and $T_1 \gg T_2$. What is a reasonable approximation of $G(s)$ in the latter case?

c. Again let $K = T_1 = T_2 = 1$ and add a zero in the transfer function such that the model structure is

$$G(s) = \frac{K(1 + sT_3)}{(1 + sT_1)(1 + sT_2)}.$$

Vary the parameter T_3 and investigate how the different model representations are affected. What happens when $T_3 < 0$? What are the implications of this system property when designing a controller for the system? Try to explain the phenomenon.

9.3 Consider the transfer function

$$G(s) = \frac{\omega^2}{s^2 + 2\zeta\omega s + \omega^2}.$$

Let the nominal model parameters be $\zeta = 0.7$ and $\omega = 1$.

a. First vary the frequency ω and investigate how the poles, the step response, and the Nyquist and Bode diagrams change.

b. Let $\omega = 1$ and vary ζ. Explore how the model representations change. Try to give a characterization of the system in terms of the model parameters ζ and ω.