EE211 – Assignment 3

Stability analysis and control design

重点是稳定性的确定

Objective

To familiarise students with the determination of stability for dynamical systems, including feedback structures. The assignment focuses on stability determination using:

从闭环传递函数描述确定极点

- The determination of poles from a closed-loop transfer function description
- The determination of eigenvalues from a state-space description

从状态空间描述中确定特征值

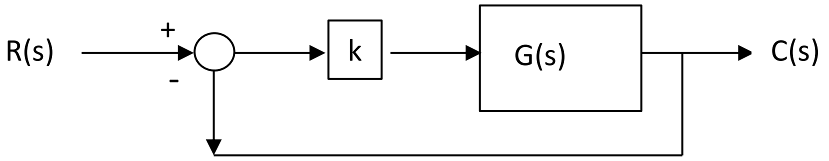

Figure A1: Closed-loop unity feedback system

Group project individuality

The assignment will be carried out in group. Each group will be given a different set of values for A, B1 and B2, such that the following transfer function G(s) is defined:

$$G(s) = A\frac{s-1}{s^2 + B_1 s + B_2}$$

A = 4; B1 = 10; B2 =25

Format of the submission

Reports should be submitted as word or pdf documents. Matlab/Scilab code may be included in the report where useful, but *does not replace* the answer to a question. Plots should be included where relevant (with appropriate scaling, colors, labels and legends for clarity).

Software Requirements and Alternatives

In order to accommodate students that might not have access to a Matlab/Simulink license or even to a computer with sufficient specs, the assignment can be completed using the following three, all equally valid, alternative approaches:

1. A Matlab/Simulink environment.
2. Scilab, freely available for download at https://www.scilab.org/download/6.1.0. This will provide a completely open Matlab-like environment, including a nice alternative to the Simulink simulation tool called XCos. The syntax is similar to Matlab but there are some notable differences particularly for specifying dynamical systems and transfer functions.
3. Pen, paper and calculator. As backup, the students can solve the assignment using known theoretical results for linear dynamical systems.

转化为State-space方程

Procedure

1. For the transfer function provided to you, determine a corresponding state-space representation.
2. Determine the eigenvalues of the state space system.

通过SS计算特征值

通过TF计算特征值 比较极点

3. Determine the poles of the transfer function and show that they are identical to the eigenvalues calculated in 2.
4. Determine the stability (or otherwise) of your system – asymptotically stable, marginally stable or unstable. Comment on the nature of the response (oscillatory or not). 评论稳定性
5. Confirm the stability condition calculated in 4. by: 利用非零初始条件和零输入模拟状态空间系统

确认4计算的稳定条件

   a. Simulating the state-space system, using a non-zero initial condition and a zero input
   b. Simulating the transfer function given to you and using a unit step input. You should be able to conclude that stability is independent of the system input. 使用一个单位阶跃输入

使用状态空间和传递函数块对系统进行仿真

   For Matlab/Scilab users: Simulate the system using the state-space and transfer function blocks in the Simulink (Matlab) or Xcos (Scilab) environments.

   For pen-and-paper: Simulate the system by computing an analytical expression for the output in the time domain using (a) state-transition matrix approach based on diagonalisation of the state-space form, and (b) fraction expansion in the Laplace domain and inverse Laplace transform.

确定图A1中闭环传递函数(CLTF)作为参数k的函数的表达式

6. Determine an expression for the closed-loop transfer function (CLTF) in Fig. A1 as a function of the parameter k. Using simulation, determine a value for k so that the closed loop system is asymptotically stable. 通过仿真，确定k的值，使闭环系统渐近稳定。

   For Matlab/Scilab users: Simulate the closed-loop system in Simulink/Xcos, using either the state-space block or transfer function block.

   For pen-and-paper: Instead of simulating the system, tentatively find a value for the parameter k such that the position of the poles of the CLTF determine an asymptotically-stable system. 使用状态空间和传递函数块对系统进行仿真

7. Starting with the value for k determined in 6., comment on the effect on the transient response of larger and smaller values of k than this value. 使用6中开发的相同仿真模型 但k值不同

评价k值大于或小于此值对瞬态响应的影响

   For Matlab/Scilab users: Use the same simulation model developed in 6 with different values of k as requested.

   For pen-and-paper: Compute analytically the time-domain response of the CLTF to a unit step input for the value of k determined in 6. and for at least one larger value and one smaller value. Compare the transient response behavior of the obtained analytical expressions of the responses. You can also attempt to plot them by evaluating them over a discrete set of values for the time t.

确定图A1中系统的闭环传递函数

8. For the value of k determined from Step 6., determine the closed-loop transfer function (CLTF) for the system in Fig. A1 and, using the 'roots' function in Matlab (or Scilab), calculate the poles of the closed loop system. From the pole values, confirm that the feedback system of Fig.A1 is asymptotically stable. 使用Matlab中的"根"函数

   For pen-and-paper: You can determine the poles analytically, as in 6.

计算闭环系统的极点。从极点值，确认图a1的反馈系统是渐近稳定的。

9. For the value of k determined from Step 6., determine a state-space representation for the closed-loop transfer function (CLTF) for the system in Fig.A1 and calculate the eigenvalues of this system. Hence, confirm the stability assessment determined in Step 8.

   For Matlab/Scilab users: Use You can use the function 'eig' (Matlab) or 'spec' (Scilab) to compute the eigenvalues of the state-space model.

   For pen-and-paper: You can determine the eigenvalues of the state matrix analytically.

确定图a1中系统闭环传递函数(CLTF)的状态空间表示，并计算该系统的特征值