Nonlinear control and aerospace applications - Lab session 2

The plant we consider is a Chua circuit described by the following state equations:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} \alpha(x_2 - x_1 - \rho(x_1)) \\ x_1 - x_2 + x_3 + u \\ -\beta x_2 - R x_3 \end{bmatrix} \tag{1}$$
$$y = x_1$$

where $R = 0.1$, $\alpha = 10.4$, $\beta = 16.5$ and $\rho(x_1) = -1.16x_1 + 0.041x_1^3$.

Exercise 1

1. Design the 'feedback linearization' block in Figure 1, so that the system from v to y is LTI.
2. Design a LTI controller K^1 for the linearized system in Figure 1 (the choice of the design method is up to the student). The task of this controller is to ensure an accurate asymptotic tracking of constant reference signals. The rise time and overshoot of the closed-loop system should be reduced as much as possible.
3. Apply the 'feedback linearization' block and the LTI controller K^1 to the system (1) implemented in Simulink.
4. Test in simulation the closed-loop system, considering constant reference signals of different amplitudes. For each simulation, generate a plot comparing the reference with the resulting output and another plot showing the command input u.
5. Analize and discuss the internal dynamics behavior by plotting the state signals.
6. Repeat Steps 1-5, assuming $R = 0$.

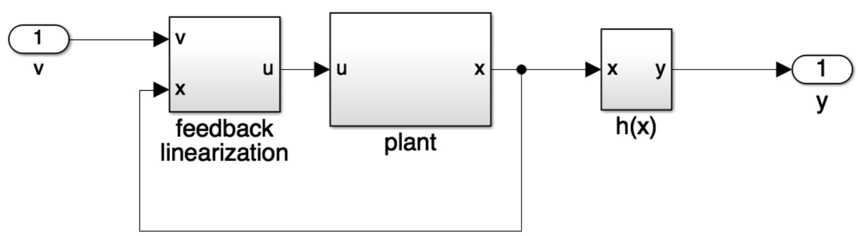

Figure 1: Linearized Chua system.

Exercise 2

1. Linearize the system (1) around the equilibrium point $\bar{u} = 0$, $\bar{x} = (0, 0, 0)$. Linearization is performed computing the matrices
$$A \doteq \left.\frac{\partial f}{\partial x}\right|_{(\bar{x},\bar{u})}, \quad B \doteq \left.\frac{\partial f}{\partial u}\right|_{(\bar{x},\bar{u})}$$
where $\partial f/\partial x$ and $\partial f/\partial u$ are the Jacobians of f with respect to x and u, respectively. A and B are the matrices of the linearized system around the given equilibrium point.
2. On the basis of A and B, design an LTI controller K^2 (use any desired method). The task of this controller should be to ensure an accurate asymptotic tracking of constant reference signals. The rise time and overshoot of the closed-loop system should be reduced as much as possible.
3. Apply the controller K^2 to the system (1) implemented in Simulink.
4. Repeat Steps 4-6 of Exercise 1, using the controller K^2 instead of the controller composed of the 'feedback linearization' block and K^1. Compare the performance provided by the two controllers.