

Nonlinear System Theory

Homework 9

Due date: 5/30/2023

1. Consider the system

$$\begin{aligned}\dot{x}_1 &= -x_1 + x_2 - x_3 \\ \dot{x}_2 &= -x_1 x_3 - x_2 + u \\ \dot{x}_3 &= -x_1 + u \\ y &= x_3\end{aligned}$$

- (a) Find the relative degree of the system.
- (b) Transform this nonlinear system into the normal form and specify the region over which the transformation is valid.
- (c) Is the system minimum phase?

2. Consider the 3rd-order system

$$\begin{aligned}\dot{x}_1 &= x_2 + \tan x_3 - 2u \\ \dot{x}_2 &= x_2^2 + x_3 \\ \dot{x}_3 &= -\sin x_3 - x_2 - x_1^3 + u \\ y &= x_2\end{aligned}$$

- (a) Find the relative degree and the normal form of the system.
- (b) Write down the zero dynamics of the system and check whether the system is minimum phase or not.
- (c) Design an input-output feedback linearization controller such that the transfer function from an external command r to the output y is $\frac{100}{s^2+15s+100}$.