sc4026
Exercise Session 6

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Integral Control

Consider the first-order system described by

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s+3},$$

that is, such that $A = -3, B = 1, C = 1$.
Design a system with integral control and two poles at $s = -5$.

$\square$

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Observable Canonical Form from polynomials of Transfer Function

Consider the following transfer function:

$$\frac{Y(s)}{U(s)} = \frac{(s+10)(s^2+s+25)}{s^2(s+3)(s^2+s+36)}.$$

Give a state-space description of the system in its canonical controllable form.

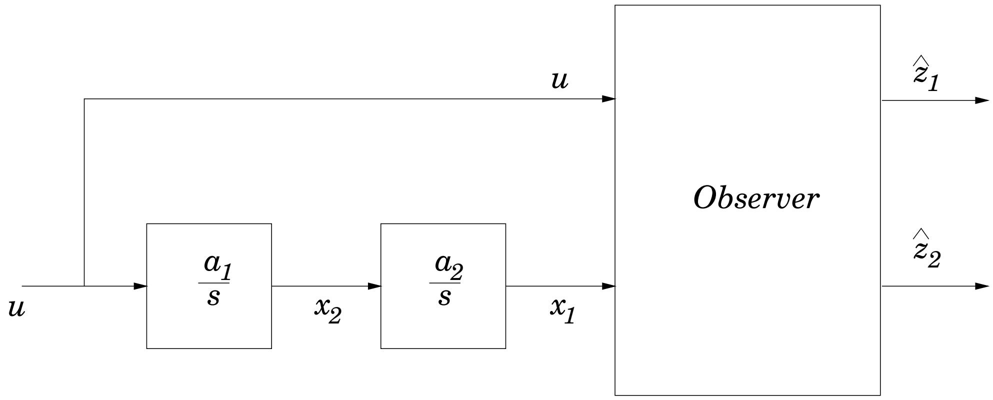
Direct Derivation of Observable Canonical Form from Transfer Function

Given

$$\frac{d^3y}{dt^3} + 2\frac{d^2y}{dt^2} + \frac{dy}{dt} + y = 3\frac{d^3u}{dt^3} + 5\frac{d^2u}{dt^2} + \frac{du}{dt} + 2u,$$

where $y(0) = 1, \dot{y}(0) = 0, \ddot{y}(0) = 0$. Find the observable canonical form.

Observer Design for DC Servo



The Figure above shows a block diagram representation of a simple model of a DC servo system. The variable x_1 is a voltage signal that corresponds to the output, whereas x_2 is the angular velocity.

1. Design an observer, with observer gain matrix $L = [l_1 \; l_2]^T$, for the variables x_1, x_2, and such that the characteristic polynomial associated with the error dynamics is given by:

$$\Delta(s) = s^2 + 2\zeta\omega s + \omega^2.$$

2. The observer is a system with inputs u and x_1, and with outputs $\hat{z}_1$ and $\hat{z}_2$. Thus, there are four possible transfer functions between inputs and outputs these may be included as elements in a 2×2 matrix. Evaluate the following matrix

of transfer functions $M(s)$ between the inputs to the observer u and x_1, and its outputs $\hat{z}_1$ and $\hat{z}_2$

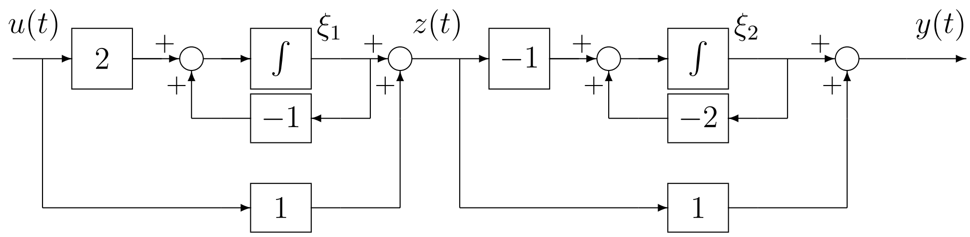
$$M(s) = \begin{bmatrix} \frac{Z_1(s)}{U(s)} & \frac{Z_1(s)}{X_1(s)} \\ \frac{Z_2(s)}{U(s)} & \frac{Z_2(s)}{X_2(s)} \end{bmatrix},$$

as a function of gains l_1 and l_2, as well as of the system parameters a_1, a_2.

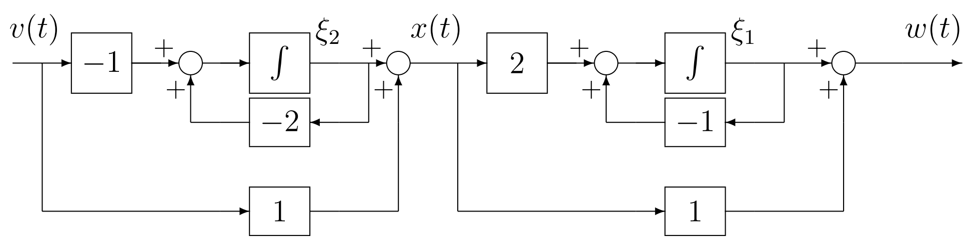
3. Determine $M(s)$ as $l_2 \to \infty$. Discuss the meaning of the result.

Loss of Observability and/or Controllability

Recall a topic developed in Lecture 4. Consider system in series:



Show that it is controllable, though not observable. Show that this corresponds to zero/pole cancellation in the Transfer Functions. Now consider system in series:



Show that it is observable, though not controllable. Show that this corresponds to zero/pole cancellation in the Transfer Functions.