Master study
Systems and Control Engineering
Department of Technology
Telemark University College
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SCEV3006 Advanced Control with Implementation

Exercise 2b

Task 1

Given the system (Maciejowski (1989) p. 46) described by

$$y(s) = \overbrace{\begin{bmatrix} \frac{1}{s^2+3s+2} & -\frac{1}{s^2+3s+2} \\ \frac{s^2+s-4}{s^2+3s+2} & \frac{2s^2-s-8}{s^2+3s+2} \\ \frac{s-2}{s+1} & \frac{2s-4}{s+1} \end{bmatrix}}^{H(s)} u(s) \tag{1}$$

a) Find the pole polynomial $\pi(s)$ and the system poles.

b) Find the system zero polynomial $\rho(s)$ and the system zeroes.

c) Compute the zeroes of the system by using MATLAB.

- define the system by use of the MATLAB function **tf**.
- compute the zeroes by use of the MATLAB function **tzero**.

Task 2

Given the system (Kailath (1980) s. 446) described by

$$y(s) = \begin{bmatrix} \frac{s}{(s+1)^2(s+2)^2} & \frac{s(s+1)^2}{(s+1)^2(s+2)^2} \\ \frac{-s(s+1)^2}{(s+1)^2(s+2)^2} & \frac{-s(s+1)^2}{(s+1)^2(s+2)^2} \end{bmatrix} u(s) \tag{2}$$

a) Find the pole polynomial $\pi(s)$ and the system poles.

b) Find the system zero polynomial $\rho(s)$ and the system zeroes.

c) Compute the zeroes of the system by using MATLAB.

- define the system by use of the MATLAB function **tf**.
- compute the zeroes by use of the MATLAB function **tzero**.

Task 3

Given a system described on state space form with the matrices

$$A = -1 \qquad B = \begin{bmatrix} 1 & 2 \end{bmatrix}$$
$$D = \begin{bmatrix} 1 \\ 2 \end{bmatrix} \quad E = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \tag{3}$$

Find the transmission zeroes of the system by use of the generalized eigenvalue method.

Task 4

Assume given the system $A = -1$, $B = 1$, $D = 1$ and $E = e$. For which values of e has the system a zero ore zeroes? For which values of e is the system a non-minimum-phase system.

Task 5

We will in this exercise take the system in Task 1 into consideration.

a) What is the natural rank (the maximal rank) of the transfer matrix $H(s)$.

b) It can be shown that the transfer matrix to the system in task 1 has a zero $s = z$ where z is a scalar number. Put $s = z$ and evaluate the transfer function $H(s = z)$, i.e., this will result in a matrix $H(s = z)$ with constant numbers.

c) What is the rank of the transfer matrix substituted for $s = z$, i.e., compute $\text{rang}(H(z))$.

d) Find that control u_z which gives $H(z)u_z = 0$. Tips: The control u_z can be computed trough an Singular Value decomposition (SVD) of $H(z)$.

References

Maciejowski, J. M. (1989). *Multivariable Feedback Design*, Addison-Wesly.

Kailath, T. . (1980). *Linear Systems*, Prentice-Hall.