**Assignment1**

Problem 1

Given the following plant:

$$G(s) = \frac{(4s-1)(2s-1)}{(5s+1)(2s+1)} \tag{1}$$

Design and compare in simulations for step and ramp references the performance of:

1. a controller obtained using a frequency based method (e.g. loop shaping through lead-lag compensators) and
2. a regulator obtained using the time domain method called Zigler-Nichols.

Problem 2

Define the $H_2$ and $H_\infty$ norms of a transfer matrix G(s) and comment how do you think they can be used for control systems analysis.

Show how a transfer function $G(s) = C(sI-A)^{-1}B + D$ can be represented as a LFT involving a static system and an integrator.

If $G(s) = C(sI-A)^{-1}B$ describe how $H_2$ and $H_\infty$ norms can be calculated in general and demonstrate your method on $G(s) = 3/(s+3)$

**Assignment2**

Problem 1

Assume that $A$ matrix is non-singular. Formulate a condition in terms of $\bar{\sigma}(E)$ for the matrix $A+E$ to remain non-singular.

Do the extreme singular values bound the magnitude of the elements of a matrix $A$?

For a non-singular matrix $A$ how is the minimum singular value related to the largest element in $A^{-1}$?

Problem 2

By $\|M\|_\infty$ we can define either a spatial or a temporal norm. Explain the difference between the two and illustrate your explanation by computing the corresponding $\|\dot{}\|_\infty$ norm for the matrix:

$$M = \begin{bmatrix} 5 & 6 \\ -2 & 4 \end{bmatrix} \tag{2}$$

and continuous time linear time invariant(LTI) system defined in Laplace domain as:

$$M = \frac{3(s-2)}{(s+3)(s+4)} \tag{3}$$

At the same time explain what is the relationship between the RGA-matrix and uncertainty in the individual elements? Use the matrix:

$$M = \begin{bmatrix} 5 & 6 \\ -2 & 4 \end{bmatrix} \tag{4}$$

to illustrate your findings.

**Assignment3**

Problem 1

Determine in a analytical manner the poles and zeros of the following transfer matrix:

$$G(s) = \begin{bmatrix} \frac{(11s^3-18s^2-70s-50)}{s(s+10)(s+1)(s-5)} & \frac{(s+2)}{(s+1)(s-5)} \\ \frac{5(s+2)}{(s+1)(s-5)} & \frac{5(s+2)}{(s+1)(s-5)} \end{bmatrix} \tag{5}$$

Try to determine at a glance how many poles G(s) have?

Problem 2

Consider the output disturbance characterized by

$$G_d(s) = \frac{k_d e^{-\theta_d s}}{(1+\tau_d s)^2} \tag{6}$$

for the following process

$$G(s) = \frac{k e^{-\theta_d s}(1-\tau_\zeta s)}{(1+\tau s)^2} \tag{7}$$

where $k_d$,$k$,$\tau_\zeta$,$\tau_d$,$\theta$,$\theta_d$ are positive numbers. Derive the ideal feed-forward controller for this process. Also give quantitative relationships for $\tau_\zeta$,$\theta$ and $\theta_d$ to achieve perfect feed-forward control.