

Computer Exercises for Advanced Control Systems

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1 CE1: Norms of Systems and Model Uncertainty

1.1 Norms of SISO systems

Consider the following second order model:

$$G(s) = \frac{10 - 2s}{s^2 + 0.1s + 16} \quad (1)$$

1.1.1 2-Norm

Compute the two-norm of G using:

1. The residue theorem (pen and paper).
2. The frequency response of G (by approximation of the integral).
3. The impulse response of G (use `impz`).
4. The state-space method (use `are` to solve the Algebraic Riccati Equation and find L).
5. Validate your results with the Matlab command `norm`.

1.1.2 ∞ -Norm

Compute the infinity norm of G using:

1. The frequency response of G .
2. The bounded real lemma (iterative bisection algorithm).
3. Validate your results with the Matlab command `norm`.

1.2 Norms of MIMO systems

Download `G_mimo` that contains the state space model of a MIMO system.

1.2.1 2-Norm

Compute the two-norm using:

1. The frequency response method (by approximation of the integral).
2. The state-space method (use `are` to solve the Algebraic Riccati Equation and find L).
3. Validate your results with the Matlab command `norm`.

1.2.2 ∞ -Norm

Compute the infinity norm using:

1. The frequency response method.
2. The bounded real lemma (iterative bisection algorithm).
3. Validate your results with the Matlab command `norm`.

1.3 Uncertainty modeling

The objective of this part is to convert parametric uncertainty to multiplicative frequency-domain uncertainty. Consider the following model:

$$G(s) = \frac{K}{(\tau_1 s + 1)(\tau_2 s + 1)}$$

where $K = 10 \pm 2$, $\tau_1 = 2 \pm 0.5$ and $\tau_2 = 4 \pm 1$. Compute the weighting filter $W_2(s)$ using Matlab:

- Define the uncertain parameters K, τ_1, τ_2 using `ureal` command.
- Define the uncertain LTI system using the uncertain parameters (you can observe the step response and Bode or Nyquist diagram of the uncertain system using `step`, `bode`, `nyquist` commands).
- Use `usample` to generate two multimodel uncertainty sets: one based on 20 samples and the other one based on 200 samples.
- Use `ucover` command to convert the multimodel uncertainty to multiplicative one. Compare the two weighting filters for 20 and 200 samples.