

EECS 128 Introduction to Control Design Techniques

Problem Set 3

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Problem 1: Heading controllers for ground control of aircraft. A top view of the tricycle landing gear

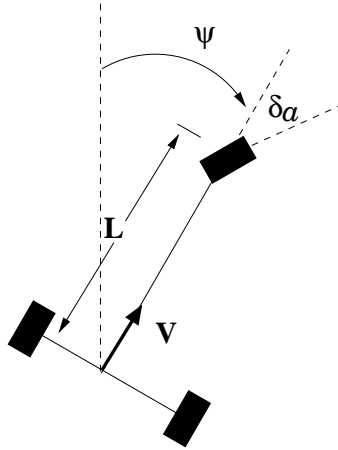


Figure 1: Tricycle landing gear top view.

for a small unmanned aerial vehicle is shown in Figure 1. Consider the case in which the vehicle is moving with constant forward velocity V (achieved by an input motor thrust, not shown here). The only input we would like to consider here is the heading actuator δ_a , which affects the heading ψ . The dynamics between heading actuator and heading, for small angle changes, can be modeled as:

$$\psi(s) = \frac{V}{L} \frac{1}{s(\tau s + 1)} \delta_a(s)$$

(a) Design a controller for this system, so that a given step reference heading $\psi_{ref} = 1$ is achieved with no steady state error.

(b) Design a controller for this system, so that a given step reference heading rate $\omega_{ref} = \dot{\psi}_{ref} = 1$ (corresponding to a changing heading) is achieved with no steady state error.

Problem 2. Root locus design.

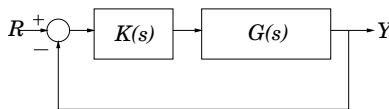


Figure 2: Unity Feedback System with proportional controller $K(s)$, plant $G(s)$

Consider the unity feedback system of Figure 2 with $G(s) = \frac{1}{s(s+1)}$. You would like to have closed loop poles

at $s = -1 \pm j\sqrt{3}$.

(a) Show that this specification *cannot* be achieved by choosing $K(s) = K$, a pure gain.

(b) Design a controller that will meet the specification.

Problem 3. Root locus design.

Consider the unity feedback system of Figure 2 with $G(s) = \frac{4}{s(s+0.5)}$.

(a) Design a controller $K(s)$ to meet the following specifications: steady state error to a unit ramp must be less than 0.02; and, the damping ratio of the dominant closed loop poles must be 0.5; and the undamped natural frequency ω_n of the dominant closed loop poles must be 5 rad/sec.

(b) Now, with this controller in place, write the expressions for the *steady state* output response $y(t)$, to each of the following input signals: (i) $r(t) = \sin t$; (ii) $r(t) = \sin 2t$; (iii) $r(t) = \sin t + \sin 2t$.

Problem 4. You are called in to consult on a control system in a piece of equipment in the field. No one can find the design document of the system, so you take a frequency response of the control system by opening the feedback loop and plotting the gain frequency characteristic. Part of the resulting asymptotic gain frequency characteristic is shown in Figure 3. Assuming the system is minimum phase (no zeros in the right half plane), what is the transfer function $K(s)G(s)$? (Remember to include your best approximation to the constant gain K).

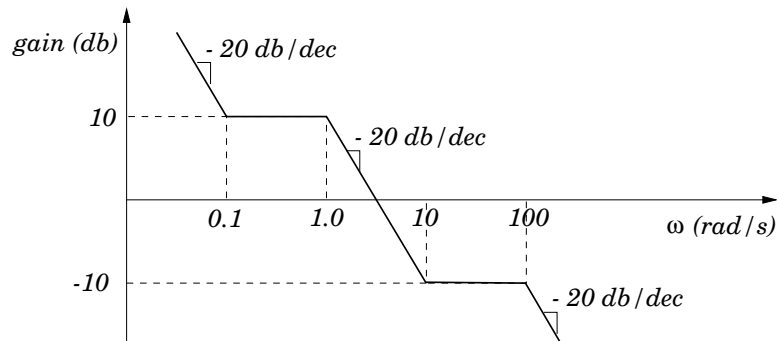


Figure 3: Open Loop TF $K(s)G(s)$