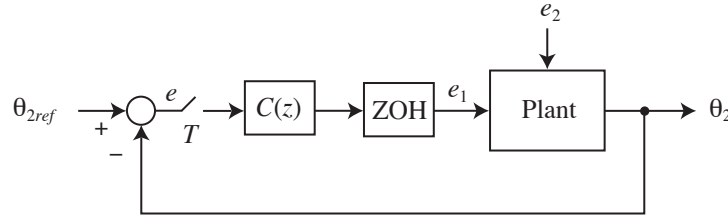


Homework #8

Reading: Sections 10.3 & 10.4

Textbook problems: none

Special problem:



1. Consider the closed-loop system shown above, with the Plant block representing the dynamics of the DC motors apparatus defined by the dcmtrs file. For its controller

$$C(z) = K \frac{(z - z_{z1})(z - z_{z2})}{(z - z_{p1})(z - z_{p2})}$$

use the loopshaping controller/compensator design method to determine values for the controller's parameters  $K$ ,  $z_{z1}$ ,  $z_{z2}$ ,  $z_{p1}$ , and  $z_{p2}$ . Use  $T = 0.02$  sec for the sampling period. The design objectives are:

- (a) Bandwidth for  $\theta_2$  tracking of  $\theta_{2ref}$  to be very close to  $20\pi$  rad/sec.
- (b)  $\theta_2 = 0$ , in the steady state, in response to an  $e_2$  step input, when  $\theta_{2ref} = 0$ .
- (c) Rejection of the effects, on  $\theta_2$ , of low frequency  $e_2$  disturbances to the extent that the amplitude of the steady-state  $\theta_2$  response to  $e_2(t) = \sin(\omega t)$  volts is less than 0.1 volt (peak-to-peak amplitude less than 0.2 volt for all  $\omega \leq 0.1$  rad/sec).
- (d) Phase margin about 60 degrees.

Design your controller to be no more aggressive than is necessary, i.e., so that it meets, but does not significantly exceed, the design objectives.

Include, in your solution:

- The numerical values you determined for  $K$ ,  $z_{z1}$ ,  $z_{z2}$ ,  $z_{p1}$ , and  $z_{p2}$ .
- A clearly written description of your design procedure.
- Simulation plots that show the extent to which your controller satisfies the design objectives.

Objective (c) involves the continuous-time  $\theta_2$  response to a continuous-time  $e_2$  input. You could use Simulink/sampled\_data\_system to test for satisfaction of this objective. Here, however, the designated maximum 0.1 rad/sec frequency for the sinusoidal  $e_2$  input is low enough, compared to the Nyquist frequency, that, for the purpose of testing for satisfaction this objective, you can model the system as if it had a sampler and zero-order hold between its continuous-time  $e_2$  input and the Plant block.