MECH 467 - Tutorial 10 - Controller Design

The open-loop block diagram of a ball screw feed drive system is given in Fig. 1. Using a Sampling Frequency of 1000 [Hz], an Amplifier Gain (K_a) of 0.887 [A/V], a Torque Constant (K_t) of 0.72 [Nm/A], an Equivalent Moment of Inertia (J) of 7×10^{-4} [kgm^2], a Viscous Damping Coefficient (B) of 0.006 [Nm/rad/s], and an Encoder Gain (K_e) of 3.18 [mm/rad], solve the following questions.

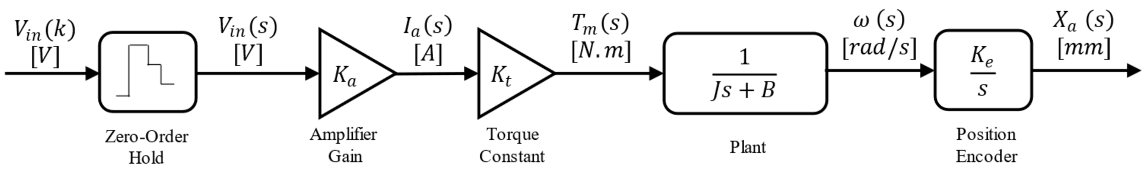

Fig. 1. Open-loop block diagram of ball screw feed drive table

1. Find the open-loop transfer function in the s- and z-domains (i.e. $G_{ol}(s)$ and $G_{ol}(z)$). Plot the Bode diagram of the open-loop system in the z-domain and present the gain and phase margins.

2. Close the system with a unity feedback as shown in Fig. 2. Design the simplest controller possible to achieve a gain cross-over frequency ω_g of 100 rad/s. Plot the old and new open-loop Bode diagram on top of each other.

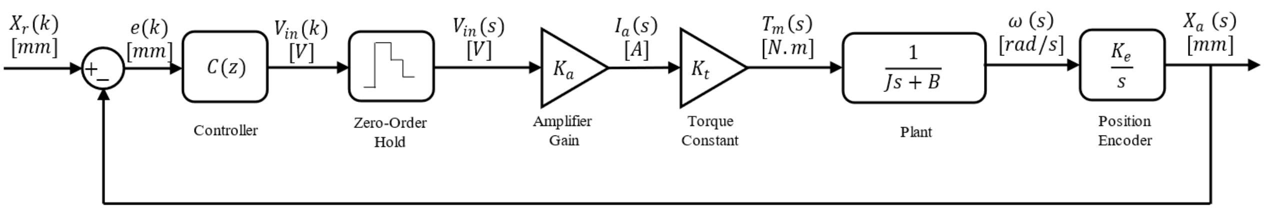

Fig. 2. Closed-loop block diagram of ball screw feed drive table

3. For the closed-loop system shown in Fig. 2, design a controller to achieve a phase margin of 60° at a frequency of ω_c = 300 rad/s. Plot the Bode diagram and show the demanded values are achieved.

4. Design a Pole Placement controller (as shown in Fig. 3) to achieve a damping ratio of ζ_m = 0.8 and a natural frequency of ω_m = 200 rad/s.

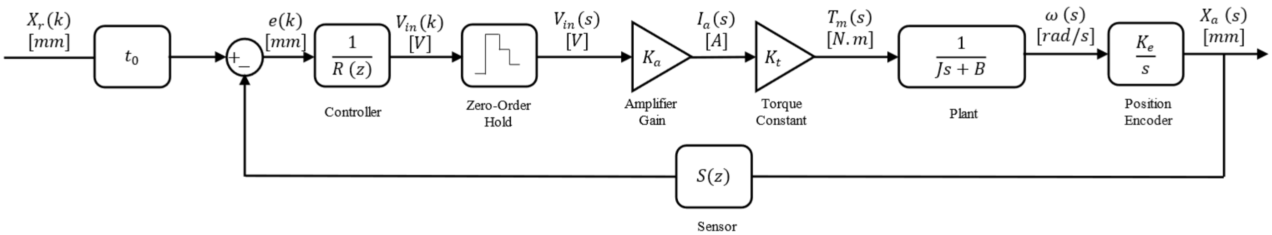

Fig. 3. Pole Placement control of the ball screw feed drive table