Tutorial 11
ELL-225: Control Engineering

Session: Semester-II (2022-23)

1. For the system shown in Figure 1, do the following:

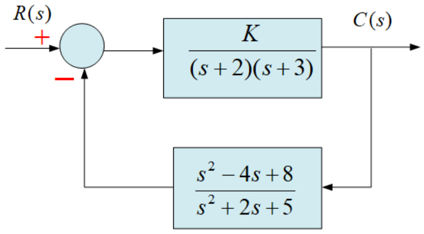

Figure 1: Block Diagram of a Control System

   (a) Sketch the root locus.
   (b) Find the jw-axis crossing point and the gain, K, at the crossing.
   (c) Find the real-axis breakaway to two-decimal place accuracy.
   (d) Find angles of arrival to the complex zeros.
   (e) Find the closed-loop zeros.
   (f) Determine K, using root locus for the closed-loop step response for $\zeta = 0.3577$. At this value of K, obtain the close loop transfer function. Obtain the step response of close loop system and verify the value of ξ using measurement of peak overshoot (use MATLAB).

2. For each system shown in Figure 2, make an accurate plot of the root locus and find the following,
   (a) The breakaway and break-in points.
   (b) The range of K to keep the system stable.
   (c) The value of K that yields a stable system with critically damped second-order system poles.
   (d) The value of K that yields a stable system with a pair of second-order poles that have a damping ratio of 0.707.

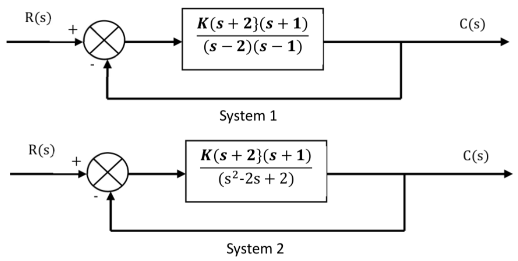

Figure 2: Block Diagram

3. A disk drive is a position control system in which a read/write head is positioned over a magnetic disk. The system responds to a command from a computer to positon itself at a particular track on the disk. A physical representation of the system and the block diagram are shown in the figures below: Consider the following questions

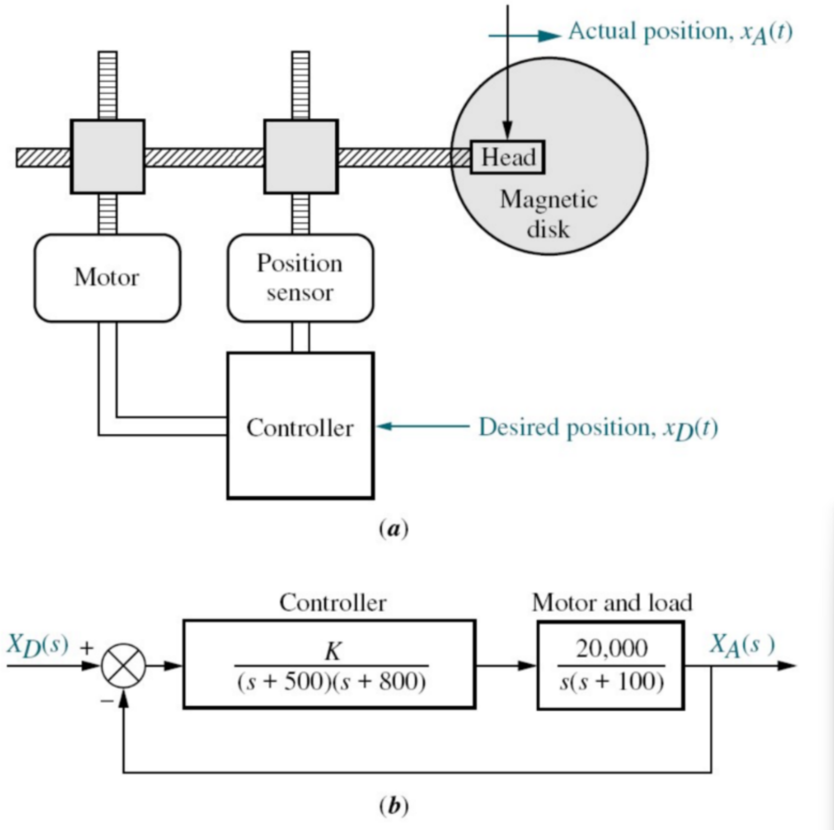

Figure 3: Disk drive (a) physical representation, and (b) block diagram.

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(a) Sketch the root locus.

(b) Are there any points on the real axis where the branches of the root locus form an angle of $\pm 90^o$? If yes, what are those points?

(c) Find the frequency and gain at the imaginary axis crossing.

(d) Find the maximum positive value of K for which the system is stable.

4. Many implantable medical devices such as pacemakers, retinal implants, deep brain stimulators, and spinal cord stimulators are powered by an in-body battery that can be charged through a transcutaneous inductive device. Optimal battery charge can be obtained when the out-of-body charging circuit is in resonance with the implanted charging circuit (Baker, 2007). Under certain conditions, the coupling of both resonant circuits can be modeled as an unity feedback system with open loop T.F. as,

$$G(s) = \frac{Ks^4}{(s^2 + 2w_n s + w_n^2)^2}$$

The gain K is related to the magnetic coupling between the external and in-body circuits. K may vary due to positioning, skin conditions, and other variations. For this problem let $\tau = 0.5$ and $w_n = 1$.

(a) Find the range of K for closed-loop stability.

(b) Draw the corresponding root locus.