भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

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Department of Electrical Engineering

EE1220 – Basic Control Theory

Assignment 03 – (Stability Analysis)

Submission Deadline: None

Key Learning from the Assignment:

- Routh-Hurwitz criterion

Instructions: RN = last two digits of your roll number.

1. For unity feedback (negative) system, forward path transfer function G(s) is given below. Determine if the closed loop system will be stable (K = RN, when not specified). Also determine how many poles will be in right half plane, in the left half plane and on the imaginary axis. Further state the range of K for the system to be stable.

   a. $G(s)=\dfrac{K(s+8)}{s(s+2)(s+4)(s+6)}$

   b. $G(s)=\dfrac{K}{(s+3)(s^2+4s+5)}$

   c. $G(s)=\dfrac{K(s+8)}{(s+1)^3(s+4)}$

   d. $G(s)=\dfrac{K(s^2+3s-4)}{s^4+4s^3+5s^2+8s+6}$

   e. $G(s)=\dfrac{K(s^3+2s^2+7s+21)}{s^5-2s^4+3s^3-6s^2+2s-4};K=1$

   f. $G(s)=\dfrac{128K}{s(s^7+3s^6+10s^5+24s^4+48s^3+96s^2+128s+192)};K=1$

2. A controlled system is represented by the following dynamic equations:

$$\dot{x}_1(t)=-x_1(t)+5x_2(t)$$
$$\dot{x}_2(t)=-RNx_1(t)+u(t)$$
$$y(t)=x_1(t)$$

   A feedback control law is designed such that:

$$u(t)=-k_1x_1(t)-k_2x_2(t)+r(t)$$

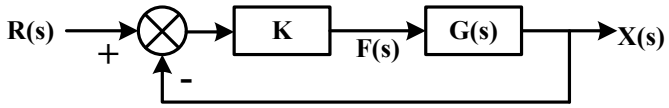
   Sketch the region of (k_1, k_2) for the closed loop system to be stable.

3. For a unity feedback (negative) system, forward path transfer function $G(s)=\dfrac{K(s+\alpha)(s+2)}{s(s^2-1)}$.

   Find the region in the α vs. K plane for the system to be stable.

4. The r/w head assembly arm of a computer hard disk drive (HDD) can be modeled as a rigid rotating body with inertia J. Its dynamics can be described by $F(t) = J\, d^2x(t)/dt^2$, where $F(t)$ is the applied force and $x(t)$ is the displacement of the r/w head. Show that if the HDD is

controlled by a purely proportional controller, the arm will oscillate and cannot be positioned with any precision over a HDD track. Find the oscillation frequency.



5. For a unity feedback system, $G(s)=\dfrac{K(s+\alpha)}{s(s+3)(s+6)}$. Find values of K and α such that (-1 + j100) is one of the poles of the closed loop system.