NE-696: NUCLEAR SYSTEMS DESIGN
Final Examination

May 16, 1996

Open books and Notes

1. Consider a steady-state, subcritical ($k_o < 0$) reactor operating at a constant power level P_o which is maintained by the presence of a source S_o. At $t = 0$, the source strength is varied so as to produce a step decrease in the power to $P_1 < P_o$, i.e.,

$$P(t) = \begin{cases} P_o & t < 0 \\ P_1 & t \geq 0 \end{cases} .$$

   Assume that the reactor can be described by a one delayed-neutron group model. Calculate the source variation $(\ell/\beta)S(t)$ for $t > 0$ needed to produce this step change in the power. Sketch the source transient.

2. Consider a closed-loop system with negative feedback for which the open-loop transfer function is

$$G(s)H(s) = \frac{K(s+1)}{s(s+2)(s+3)(s+4)} \qquad (0.1)$$

   (a) Write the characteristic for the closed-loop system as a polynomial in s.
   (b) Construct the Routh array for this system.
   (c) For what values of K is the system stable?

3. Consider a closed-loop system with positive feedback for which the open-loop transfer function is

$$G(s)H(s) = \frac{K(s+6)(s+8)}{s(s+2)^2(s+3)(s+5)} \qquad (0.2)$$

   Sketch the root-locus diagram for the roots of the characteristic equation for both positive and negative K.

4. Consider a closed-loop system with negative feedback for which the open-loop transfer function is

$$G(s)H(s) = \frac{K(s+10)}{s^2(s+100)}, \quad K > 0. \qquad (0.3)$$

   (a) Sketch the Bode plots for this open-loop transfer function.
   (b) Sketch the Nyquist diagram for the closed-loop system. Is the system stable?
   (c) Is the closed-loop system stable for $K < 0$?