Final Exam.

Closed Book Exam.   (Submit the problem sheet with your answer sheets.)   2003. 12. 17

1.(30) (From the sample exam from the class homepage), For the following closed-loop system,
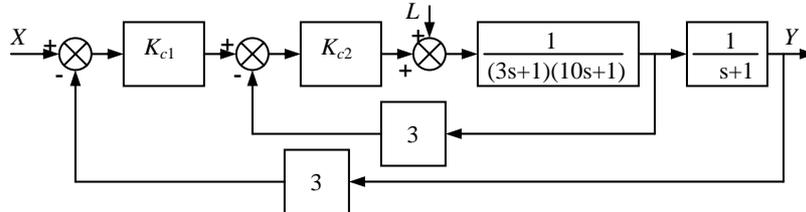
Also, find the value of K_{c2} that gives a 0.707 damping coefficient for the inner loop and find the range of K_{c1} that makes the whole system stable using Routh array with the calculated K_{c2} value.

2.(30) (Seborg *et al.*, Ex. 12.1, p291)
A process has the transfer function $G(s)=K/(10s+1)(5s+1)$ where K has a nominal value of one. PID controller settings are to be calculated using the Direct Synthesis approach with $\tau_c = 5$ min. Suppose that these controller constants are employed and that K changes unexpectedly from 1 to $1+\alpha$.
   a) For what value of α will the closed-loop system be stable?
   b) Suppose that the PID controller constants are calculated using the nominal value of $K=1$ but it is desired that the resulting closed-loop system be stable for $|\alpha| \le 0.2$. What is the smallest value of τ_c that can be used?
   c) What conclusions can be made concerning the effect that the choice of τ_c has on the stability of the closed-loop system to changes in steady-state gain K?

3.(30) For the first order plus time delay system, derive an IMC controller using a first-order Taylor series approximation for the time delay. Also, find the equivalent PID controller setting from the resulting IMC controller.

4.(60) Answer true or false for each statement. *Each problem is worth +5 points when the answer is correct, but it costs –5 points if the answer is wrong.*

   a) The 1/4 decay ratio is too oscillatory for chemical processes. Then the 1/5 decay ratio will be less oscillatory.   (   )
   b) The reset time and the derivative time should increase for same stability margin as the ratio of time delay to dominant time constant increases.   (   )
   c) In IMC design, the order parameter (r) of the IMC filter should be selected so that the order of numerator of G_c^* is same as the order of denominator.   (   )
   d) Using direct synthesis, the resulting controller will be PID for SOPDT model with Taylor series approximation of the delay.   (   )
   e) The relay feedback method requires to specify the size of input change and the desired time constant of closed-loop response.   (   )
   f) The robustness can be defined as the ability of a controller that the control performance and stability can be adjusted automatically.   (   )
   g) In closed-loop frequency response, reasonable resonance peak at relatively low frequency will help to shorten the rise time to set point.   (   )
   h) From a simple Nyquist stability criterion, the diagram should encompass (-1,0) clockwise for stability.   (   )
   i) Small gain and phase margin will result sluggish and oscillatory response.   (   )
   j) In general stability sense, a process is stable as long as the step response in set point will not diverge.   (   )
   k) For stability, the frequency gains of process TF at the critical frequency should be less than one.   (   )
   l) Among IAE, ISE and ITAE for PID tuning, the ISE results most aggressive action.   (   )