Tutorial Sheet 5 – Transient Response Analysis

(Covering section 8 of the notes)

Q1 A transfer function model for a series RL circuit is given as:

$$\frac{I(s)}{V_i(s)} = \frac{1}{sL + R}$$

(i) Obtain an expression for the time constant for this circuit in terms of L and R.

(ii) Determine the value of the time constant given that L = 1H and R = 2Ω.

Q2 The solution of the RC circuit is given as: $y(t) = u\left(1 - e^{\frac{-t}{RC}}\right)$

(i) Derive an expression for the time constant for this circuit in terms of R and C. (*Hint, use the definition of a time constant*)

(ii) Determine the value of the time constant given that C = 2μF and R = 100kΩ.

(iii) Determine how long it takes for the circuit output to reach 98% of its final value.

Q3 Determine the damping ratio and the natural frequency for the systems represented by the following transfer function models. Hence, comment on the typical step response for each system.

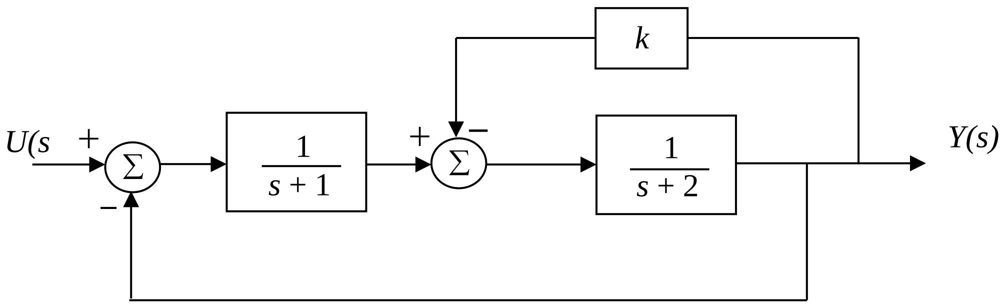
(i) $\dfrac{20}{(s+2)(s+5)}$ (ii) $\dfrac{8}{s^2 + 2s + 5}$

Q4 (i) Determine the conditions for α such that each of the following systems exhibits a critically damped response:

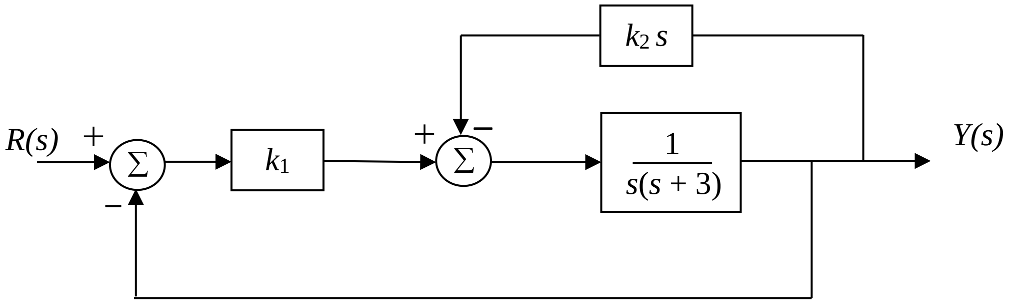
$$\frac{1}{(s+2)(s+\alpha)}$$

(ii) Hence, determine the peak overshoot, settling time and steady-state gain for this system.

Q5 Determine the transfer function of the system given in the figure below and hence determine the value of gain k that results in a closed-loop system which is critically damped.



Q6 Determine the value of controller gains k_1 and k_2 in the control system block diagram in the figure below so that the resulting closed loop system has a damping ratio of 1.6 and a settling time of 0.5 seconds.



Q7 Determine the stability and the nature of the transient response (i.e. oscillatory or non-oscillatory) of the following system: