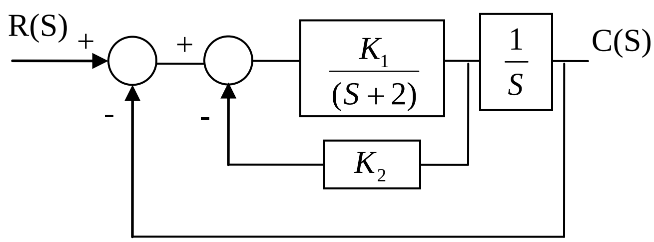
CAIRO UNIVERSITY
ELECTRONICS & COMMUNICATIONS DEP.
CONTROL ENGINEERING

SHEET 3

Transient Response

[1] Referring to the system shown in figure, determine the values of K_1 and K_2 such that the system has a maximum overshoot in unit step response is 25% and the peak time is 2 sec.



[2] The block diagram of a DC motor control system with tachometer feedback is shown in figure 4. Find the values of K and K_t so that the following specifications are satisfied:

- k_v =1
- Dominant characteristic equation roots corresponding to a damping ratio of approximately 0.707

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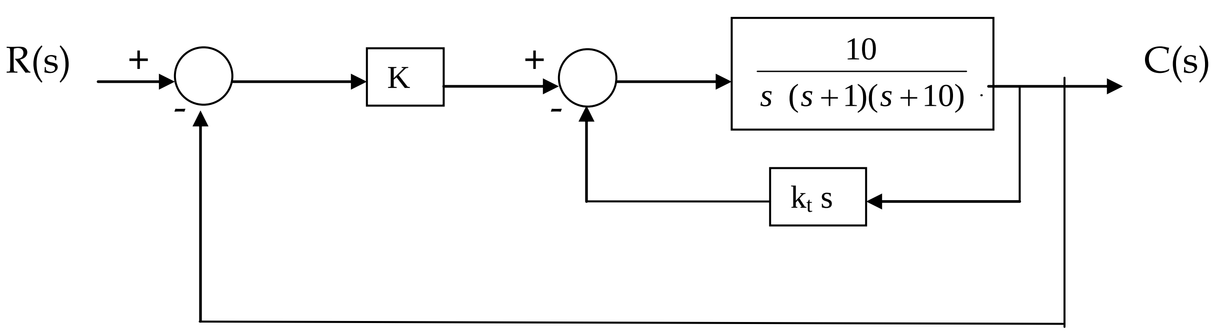
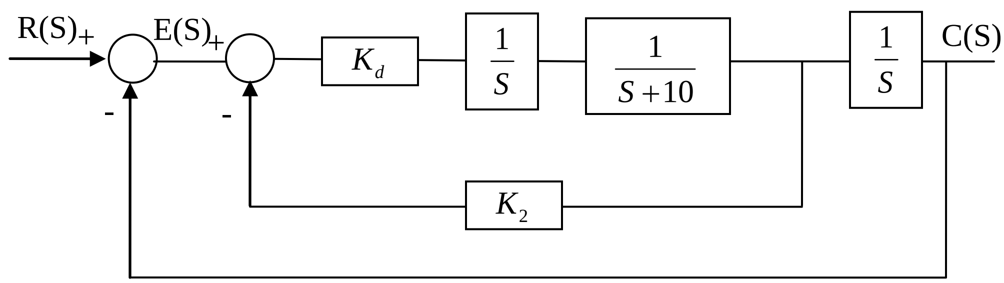


[3] (Quiz 2005) the automatic control of an airplane is one example that requires multiple-variable feedback methods. A simplified model where the rolling motion can be considered independent of other motions is shown in figure. The step response desired has an overshoot less than or equal 10% and a rise time less than or equal 4 second.

a) Select the parameters Kd and K2 that achieve the desired response. (8 points)

b) Find the minimum steady state error that can be obtained by varying the values of Kd and K2, for a unit ramp input. (2 points)



[4](Quiz 2004) The roll control autopilot of a jet fighter is shown in figure 1 .the goal is to select a suitable K so that the response to a unit step command $\Phi_d(t)$ will provide a response $\Phi(t)$ that is a fast response and has an overshoot of less than or equal *9.5%:*

a) Using the concept of dominant poles, find a suitable value of K that will achieve the desired transient response. Predict the transient response of the system (i.e. get t_r t_p and t_s).

b) Find the static error coefficients of the system. Evaluate the value of K that gives minimum steady state error for a unit ramp input.

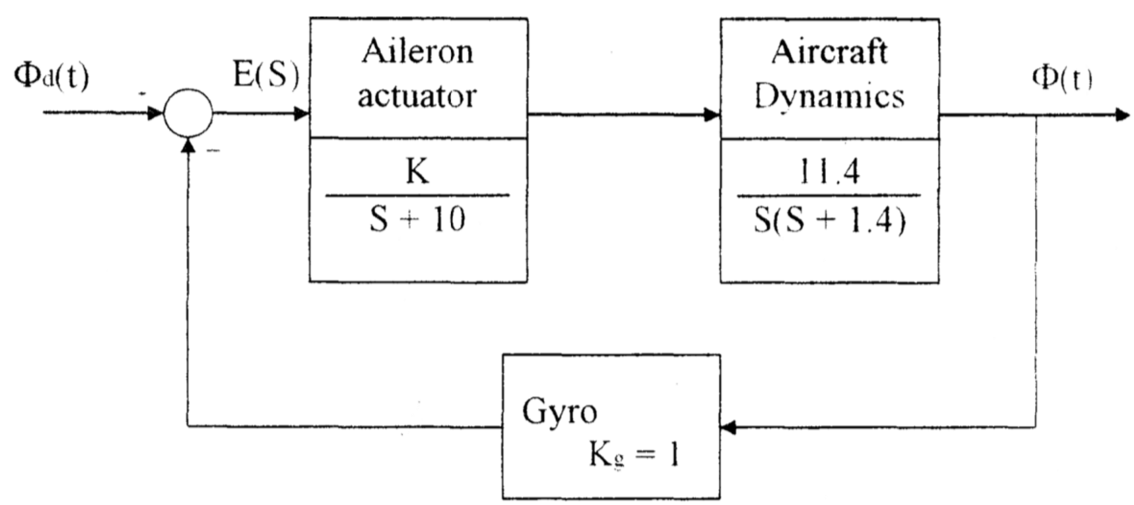
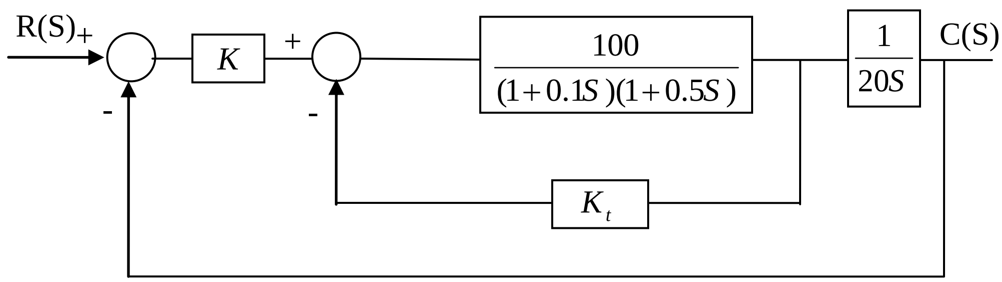


Figure (1) Roll angle control

[5](Final 2204) For the control system shown in the figure, determine the values of K and K_t such that the output has a maximum overshoot 4.3% and the rise time is approximately 2 sec. with the values of K and K_t obtained, find the steady state error when the input is a unit ramp function.



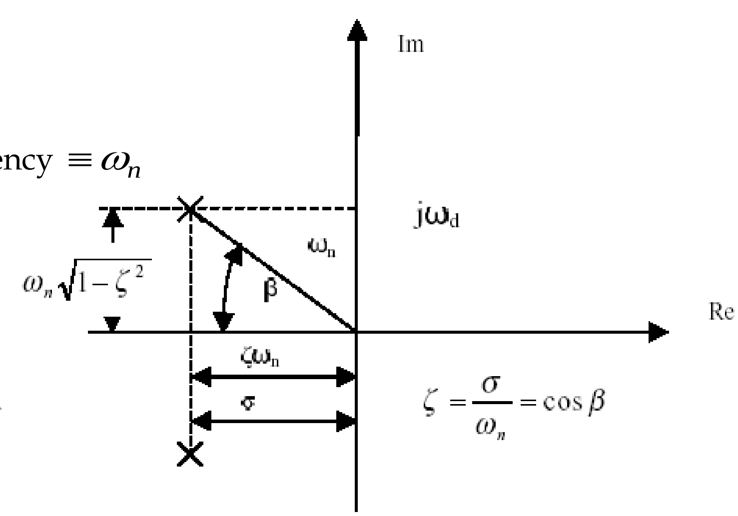
- ***Summary:***

[1] For the second order continuous time system we have:

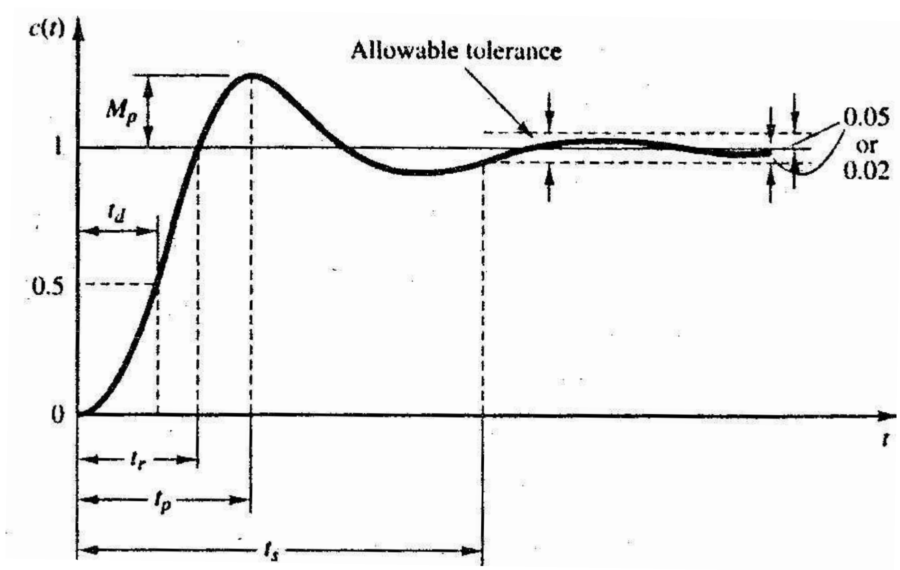
- Open loop T.F = G(S)H(S) = $\dfrac{\omega_n^{\,2}}{S(S+2\zeta\omega_n)}$
- Closed loop T.F = $\dfrac{G(S)}{1+G(S)H(S)} = \dfrac{\omega_n^{\,2}}{(S^2+2\zeta\omega_n S+\omega_n^{\,2})}$
- Damping ratio $\equiv \zeta$ where $0<\zeta<1$

  $\zeta < 0.4 \Rightarrow$ *excessive oscillations will occur*.
  $0.4<\zeta<0.8 \Rightarrow$ *sufficiently damping & sufficiently fast*.
  $\zeta > 0.8 \Rightarrow$ *sluggish system.*

- ζ (in terms of M_p) $= \dfrac{-(\ln M_p)}{\sqrt{(\ln M_p)^2+\pi^2}}$.
- Natural frequency = undamped frequency $\equiv \omega_n$
- Damped frequency $\equiv \omega = \omega_n\sqrt{1-\zeta^2}$
- Time constant $\equiv \tau = \dfrac{1}{\zeta\omega_n}$
- $S_{1,2} = -\zeta\omega_n \pm j\omega = -\zeta\omega_n \pm j\omega_n\sqrt{1-\zeta^2}$



- Rise time $\equiv t_r = \dfrac{\pi - \cos^{-1}\zeta}{\omega} = \dfrac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$
- Peak time $\equiv t_p = \dfrac{\pi}{\omega} = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}}$
- Settling time $\equiv t_s = \dfrac{4}{\zeta\omega_n}$
- Maximum relative overshoot $\equiv M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$



[2] For 3rd order system:

- Characteristic equation is: $(S+\alpha)(S^2+2\zeta\omega_n S+\omega_n{}^2)$.
- The dominant poles are: $(S^2+2\zeta\omega_n S+\omega_n{}^2)$,and the insignificant pole is: $(S+\alpha)$.
- The equation has ***<u>three</u>*** unknown : $\alpha, \zeta, and\ \omega_n$.
- For design:
    1. If we have ***three*** information on the time response, we will directly get the three unknowns: $\alpha, \zeta, and\ \omega_n$.
    2. If we have only ***two*** information on the time response, we need one assumption to get the three unknowns: $\alpha, \zeta, and\ \omega_n$,this assumption is: $\alpha = 5\zeta\omega_n$.