

Course Code: EE411

Course Title: Control Systems 1

Sheet #1

(Revision)

1) Consider the closed loop system:

$$G_o.l.(s) = \frac{wn^2}{s^2 + 2\zeta wn s + wn^2}$$

- **Determine the values for  $wn, \zeta$  so that the system has a 5% overshoot and settling time of 4 sec as a result of a unit step input.**

2) Consider the **unity feedback control system** having an Open-Loop Transfer Function of:

$$G_o.l.(s) = \frac{4}{s(s+2)}$$

- **Determine the rise time, peak time, maximum overshoot and settling time.**

3) Consider the **unity feedback control system** having an Open-Loop Transfer Function off:

$$G_o.l.(s) = \frac{k}{s(s+10)}$$

- **Determine the gain  $K$  so that the damping ratio will be 0.5 . Then determine settling time, peak time, and maximum overshoot as a result of unit step.**

4) For the system shown in Figure 1

- **Determine the values of  $K$  and  $T$  so that the maximum overshoot in a unit step response is 25% and the peak time is 2 sec.**

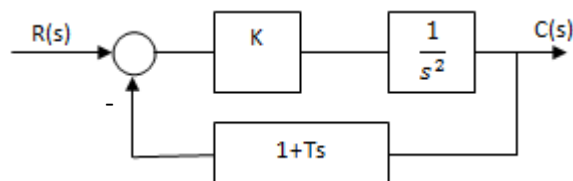


Figure 1

5) Solve the following questions for the system shown in Figure 2:

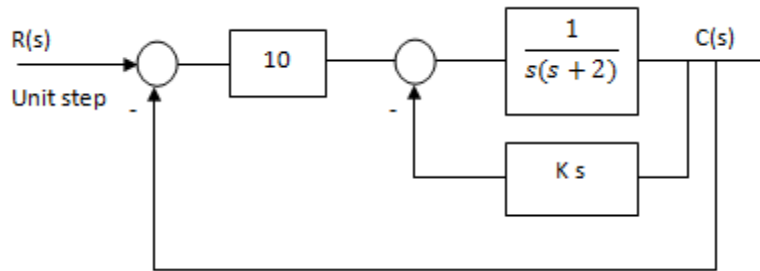


Figure 2

- **In the absence of K, determine the damping ratio, natural frequency.**
- **Apply K, find the value of K which will increase the damping ratio to 0.6**
- **Find the position, velocity and acceleration error constant for case (b).**

6) **Find the error** for the system shown in Figure 3 when the input is:

- **R(t)=10**
- **R(t)=10 t**

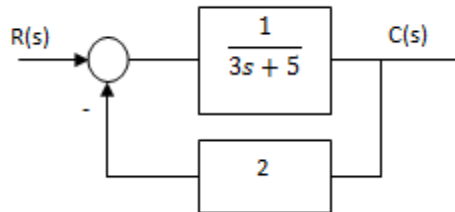


Figure 3

7) The Open-Loop Transfer Function for a unity feedback system is :

$$G_o.l.(s) = \frac{1}{s(s+2)(s+3)}$$

- **Specify the system order and system type.**
- **Determine error constants and steady state error for unit step, unit ramp and unit parabolic input.**

8) For the system shown in Figure 4. **Determine:**

- **System order and system type.**
- **Steady state errors for unit step, ramp and parabolic input.**

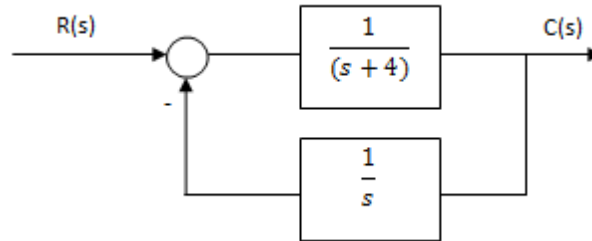


Figure 4

9) Using **Routh-Hurwitz criterion determine** if the following systems, represented by the following characteristic equations are **stable or not**.

$$s^4 + 2s^3 + 8s^2 + 4s + 3 = 0$$

$$s^5 + s^4 + 3s^3 + 9s^2 + 16s + 10 = 0$$

10) **Determine the range of gain K for stability** for the following characteristic equations:

$$s^3 + 3k s^2 + (k + 2)s + 4 = 0$$

$$s^4 + 4s^3 + 13s^2 + 36s + k = 0$$

11) The Open-Loop Transfer function of a unity feedback control system is given by:

$$G o.l.(s) = \frac{k}{(s + 2)(s + 4)(s^2 + 6s + 25)}$$

- **Discuss its stability using Routh-Hurwitz criterion and find the range of k for stability.**
- **Determine the value of K which causes sustained oscillations in the closed-loop system and its oscillation frequency.**

12) For the system shown in Figure 5, **show that the closed loop system is unstable for all values of K.**

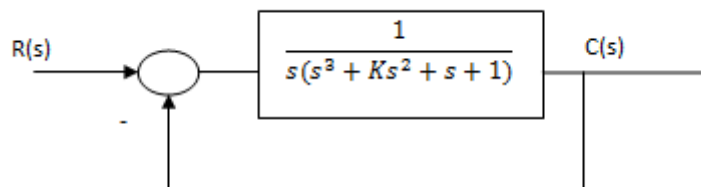


Figure 5

- 13) The system shown in Figure 6 oscillates with frequency ( $\omega$ ), if it has poles at  $s = \pm j\omega$ , which also satisfies the auxiliary equation. **Determine values of  $k, a$  so that the system oscillates at  $\omega = 2 \text{ rad/sec}$ .**

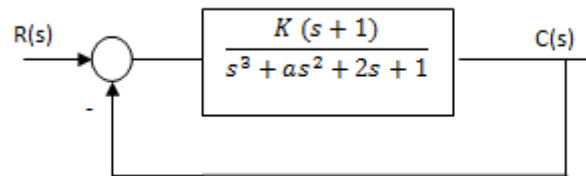


Figure 6

- 14) **Find  $C(s)/R(s)$**  for the block diagram shown in Figure 7:

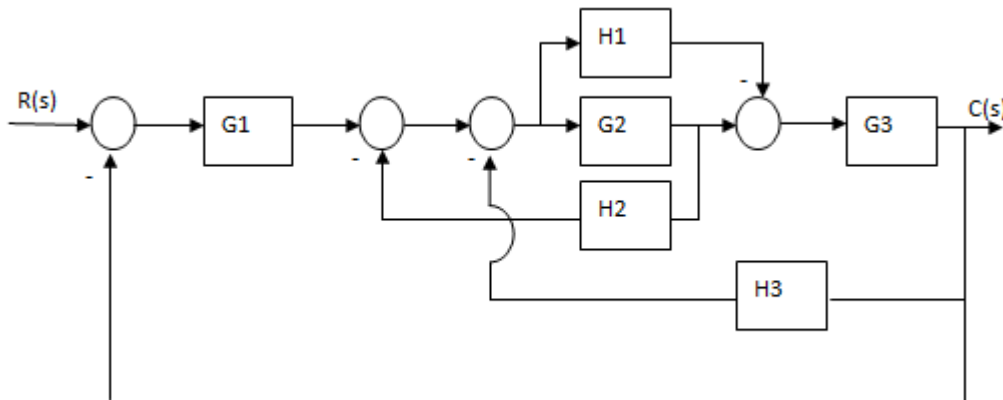


Figure 7

- 15) Find the **mathematical model** for the circuit is shown in Figure 8.

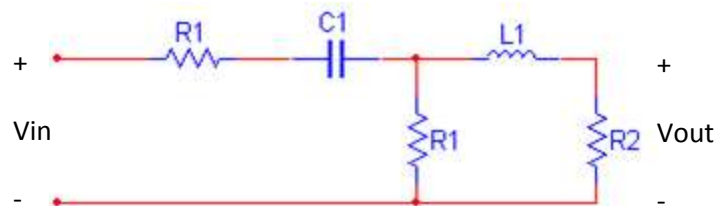


Figure 8

16) A speed control system is shown in Figure 9. A tacho generator is used to give a feedback speed  $K_t W$  where  $K_t$  (volts/rad/sec) is constant. The amplifier gain is  $K_A$  (amp/volt). The generator gain is  $K_g$  (volt/amp field). The motor constant  $K_m$  (N.m./amp). The inductance is neglected. **Draw a block diagram of this system. Indicate the Transfer function of each block.**

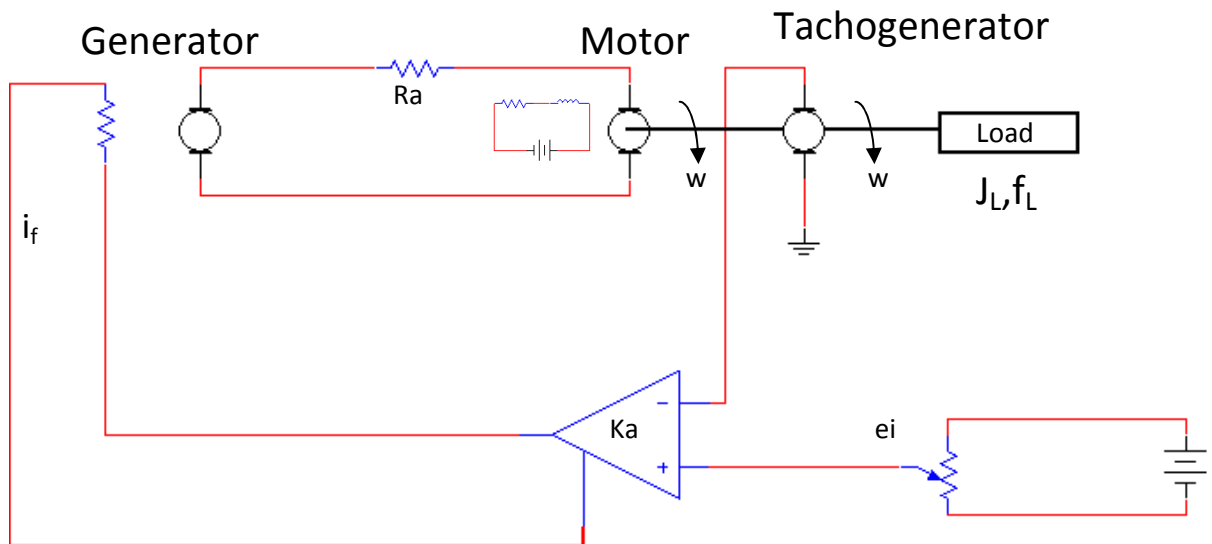


Figure 9

17) Figure 10 represents a simple position control system. It has the following parameters:

- Two potentiometers of constant  $\frac{24}{\pi}$  volt/rad
- Amplifier of gain 10 volt/volt
- A gear train of ratio 1:10
- Armature controlled d.c. motor having the following constants:
  - $R_a=0.2\Omega$
  - $L_a=0$  H
  - $J_m=2.5 \times 10^{-3}$  Nm/rad/sec<sup>2</sup>
  - $B_m=0.02$  Nm/rad/sec
  - $K_a=0.05$  volt/rad/sec

- a) **Draw a detailed block diagram** for the above system.
- b) **Find the closed-loop transfer function.**
- c) **Find the damping ratio and the undamped natural frequency.**
- d) **For a unit step input find the maximum overshoot and the settling time of the output.**

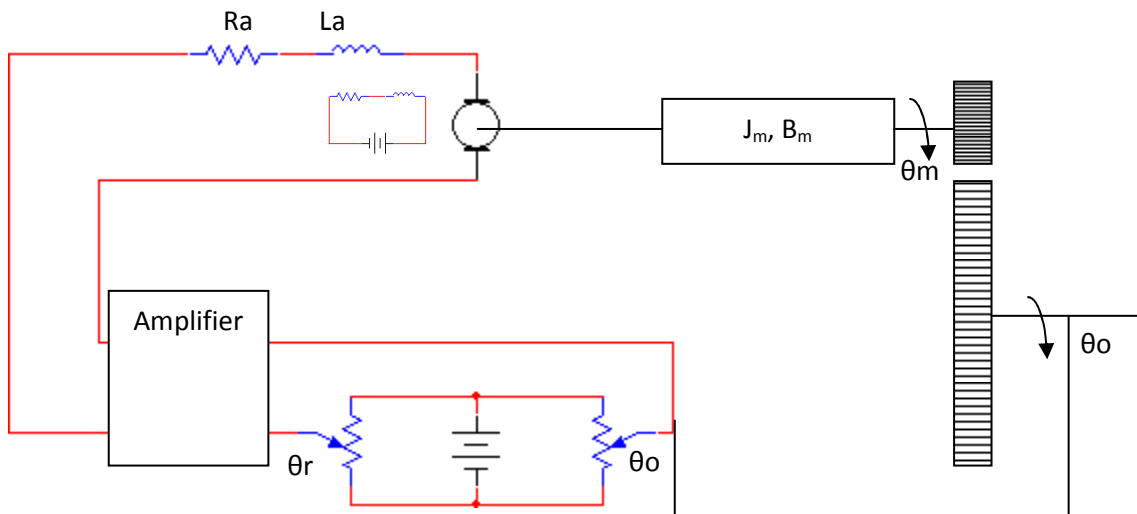


Figure 10