Minor-II Paper on Control Theory and Applications (MCL212)

Instructions: Attempt all the questions.

Full marks: 35

Time: 1 hour

Problem-1

Assume that the control of angular movement of one of the axes of a robot as given by the block diagram shown below in figure-1. Here the amplifier gain K_A may be chosen appropriately by the user to get desirable motion of the joint.

(a) Determine K_A such that the angle reaches the steady state in the minimum possible time and without any overshoot, if a unit step input is given as the reference i.e. if $\theta_R(t) = u(t)$. (5)

(b) Determine the steady state error of the angle if the reference $\theta_R(t)$ is given as $(5+t)\,u(t)$, i.e. a combination of a step input of strength 5 and a unit ramp input. Assume the value of K_A same as found out in (a). (5)

(c) Also find out the sensitivity, which is a positive real quantity, i.e. $\left|S_{T(s)}^{K_A}\right|$, of the closed loop transfer function T(s) due to a variation in the gain K_A about its nominal value found in (a) for a frequency of 1 radian/second i.e. you may assume $s = 1i$, where i stands for $\sqrt{-1}$. (5)

(d) Use the block diagram to pick states and represent the system in State Space, i.e. write the state and the output equations. For doing this, you may use the symbols used to represent the gains, i.e. 'K_A' for the amplifier gain. Also give an idea about the physical nature of the states chosen by you. (4+1)

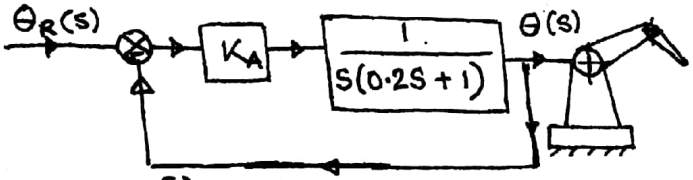

Figure-1

Problem-2

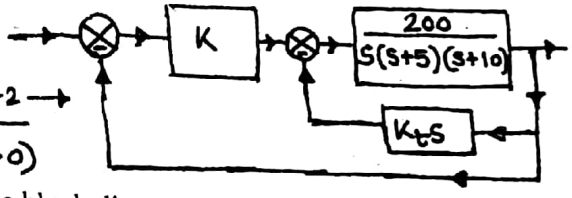

Figure-2 → (K>0, Kt>0)

The position control system of a motor is expressed by the block diagram given in figure-2, where K is an amplifier gain and K_t is the gain of a tachometer feeding back the information of angular speed. For the block diagram shown, find out

(a) The functional relationship between K and K_t for the system to be stable. (4)

(b) Supposing that $K_t = 0.1$ V/radian/second, what value of the gain K will cause the system marginally stable i.e. cause sustained oscillations? What will be the frequency of oscillations in this case? (2+1)

P.T.O.

Problem-3

The block diagram of a SISO system is given in figure-3. Sketch the root locus neatly. Write all the details like, the number of branches, how many branches end at zeros, how many tend to ∞ as $K \to \infty$, the location of the centroid and angles of asymptotes, the location of multiple roots and the breakaway points, the value of K if the loci cross the imaginary axis and for this case the frequency(s) of sustained oscillations. Also mention the angles of arrival and departure if any. (8)

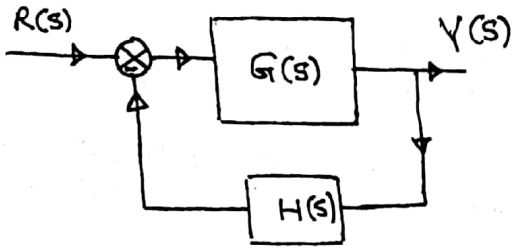

Figure-3.

$$G(s) = \frac{1}{s(s+3)(s+1)^2}$$

$$H(s) = K.$$