Tutorial Sheet 5, EE 302 - S2 Control Systems, 19th March 2024.

Q-1: Use root locus technique & Routh Hurwitz to find range of k to have closed loop stability for open loop transfer fns ($k \in (-\infty, \infty)$)

(a) $\dfrac{1}{(s+1)(s+2)(s+3)}$ (b) $\dfrac{s-1}{(s+1)(s+2)}$ (c) $\dfrac{1}{(s^2+\frac{s}{2})}\dfrac{(s+3)}{(s+1)}\left(\dfrac{s+7}{s+20}\right)$

(d) $\dfrac{(s+1)}{(s+2)(s+3)}$. (e) $\dfrac{(s+2)}{(s^2+s)(s-p)}$, $p \in (-12, -13)$ (all) (d) $1/(s^2+1)(s^2+4)$ For d, f: Breakaway/in point

Q-2: Find range of k that results in closed loop poles left of $s=-1$ line? (vertical line).

(a) $\dfrac{(s+4)}{s(s+2)}$. (b) $\dfrac{1}{s(s+1)(s+2)}$.

(Replace $s = z+1$ or $s = z-1$?? (choose appropriately). (Use Routh Hurwitz)

Q-3:

(a) Use Routh table to find #OLHP roots, $j\mathbb{R}$ roots, #ORHP roots.

(b) If $\exists$ $j\mathbb{R}$ roots, comment about marginal stability. 4 Polynomials.

(i) $s^5 - 7s^4 + 16s^3 - 16s^2 + 15s - 9$

(ii) $s^6 + s^5 + 2s^4 + 2s^3 + 9s^2 + 9s$

(iii) $2s^3 - 24s + 32$; $(s+1)\cdot(2s^3 - 24s + 32)$

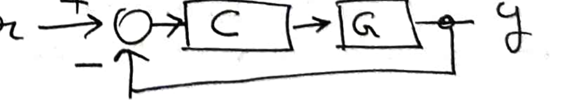
Use both ϵ method & reciprocal method when applicable.

Q-4: Find range of c such that all roots are in OLHP

$$s^2 + (3s + c)s + (2 - c) \qquad (c \in (-\infty, \infty)).$$

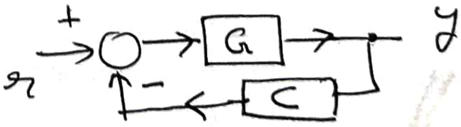
Q-5:

(a) Find closed loop transfer fn from r to y for both configurations



(1)

$C(s) = \dfrac{n_c(s)}{d_c(s)}$, $G(s) = \dfrac{n_p(s)}{d_p(s)}$. and



(2)

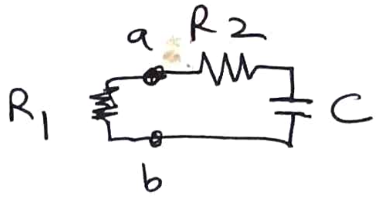
(b) Find closed loop zeros also (from r to y).

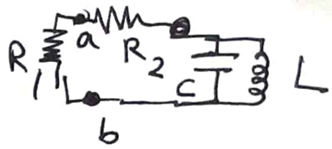
(c) If there is a pole/zero cancellation in G, then would that be the case for r to y also? (Choose $C(s) = k$, $k \in \mathbb{R}$ for this question.)

(d) Same as (c) but "near pole/zero cancellation."

(e) Is it reasonable that in a PI controller (for configuration (1)) the closed loop pole close to origin would have small residue? (for step input)

Q-6 Consider the circuit in which R_1 is to be viewed as connected in feedback and "plant" is the "rest of the circuit"





(a) Replace the rest of the circuit by impedance and write the feedback in feedback configuration with R_1 in forward path & ~~back~~ feedback path for each circuit.

(b) Change the rest of the circuit between load convention & source convention & accordingly use -ve or +ve feedback.

Q-7: Plot/sketch Bode plot for following $G(s)$:

(a) $s+2$ (b) $2\left(1+\frac{s}{2}\right)$ (c) $\frac{s+5}{s-5}$ (d) $\frac{s-5}{s+5}$

(e) $\frac{1}{(s+1)(s+2)(s+3)}$ (f) $\frac{3}{s}$ (g) $\frac{6s}{s+9}$

Q-8 (a) $\frac{s+0.1}{s+0.05}$ (b) $\frac{s+8}{s+20}$ justify lead/lag words for these transfer functions.

Match the pairs

Lead compensator — High pass filter

Lag compensator — All-pass filter

Low pass filter.

Q-9: Prove that

$\sin \omega t \rightarrow \boxed{} \rightarrow y(t) = |G(j\omega)| \sin(\omega t + \angle G(j\omega))$

Q-10: Suppose impedance of a circuit is $Z(s)$. (Load convention).

Relate active power absorbed by the circuit, averaged over one period, for source $i(t) = \sin \omega t$ with $\operatorname{Re} Z(j\omega)$

(Power $(t) = V \cdot I$ in time domain).