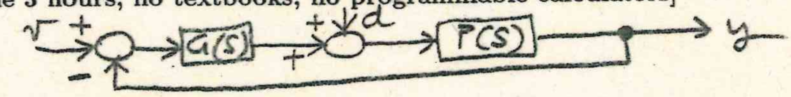
CONTROL SYSTEMS - 5/2/2019 (B)

[time 3 hours; no textbooks; no programmable calculators]

1) Given



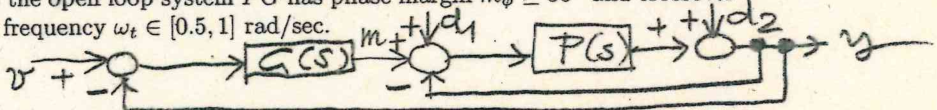
with $P(s) = \frac{2s+1}{s^2}$ design a 1-dimensional controller $G(s)$, if any, such that

(i) the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$ is asymptotically stable (use the Nyquist criterion with reasonable approximations for the Bode plots) and its steady state output response y_{ss} to constant disturbances d is 0,

(ii) $|j\omega G(j\omega)|_{dB} \leq -8\,dB \;\; \forall \omega$

(iii) the open loop system PG has phase margin $m_\phi \geq 30°$ and crossover frequency $\omega_t \in [0.5, 1]$ rad/sec.

2) Given



with $P(s) = \frac{2s+3}{s^3-3s^2-3}$, determine, if any, a 2-dimensional controller $G(s)$ such that the given feedback system has the following properties:

i) it is asymptotically stable with poles having negative real part ≤ -1

ii) the steady state output response to constant disturbances d_1 is 0

ii) the absolute value of the steady state output response to unit ramp disturbances d_2 (i.e. $d_2 = t$) is ≤ 0.1.

3) Given $P(s) = \frac{(s+1)^2}{(s^2+1)s}$ draw the root locus of P and design, if any, a controller $G_1(s) = K$ such that the closed-loop system $W(s) = \frac{PG_1(s)}{1+PG_1(s)}$ is asymptotically stable. With $G_1(s) = \frac{1}{s-1}$ draw the root locus of PG_1 (help: the positive root locus has the singular points $s \approx 0.2 \pm 0.6j$ for $k \approx 0.2$ and $s \approx 0.4$ for $k \approx 0.1$; the negative root locus has the singular point $s \approx -2.4$ for $k \approx -28$). Design, if any, a controller $G_2(s) = K$ such that the closed-loop system $W(s) = \frac{PG_1G_2(s)}{1+PG_1G_2(s)}$ is asymptotically stable.

4) Given the system

$$\dot{x} = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \end{pmatrix} d + \begin{pmatrix} 1 \\ 0 \end{pmatrix} u, \quad y = \begin{pmatrix} 0 & 1 \end{pmatrix} x, \qquad (1)$$

with state $x \in \mathbb{R}^2$, control u, controlled output y, disturbance $d = Dt$, with unknown $D \in \mathbb{R}$, and reference input $v = e^{-t}$, find, if possible, a controller such that the closed loop system is asymptotically stable and its steady state output response y_{ss} is v.