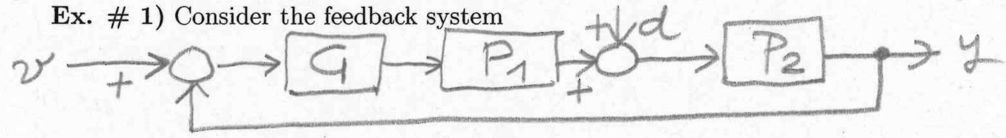
CONTROL SYSTEMS - 20/3/2021

[time 2 hours and 30 minutes; no textbooks; no programmable calculators]

Ex. # 1) Consider the feedback system

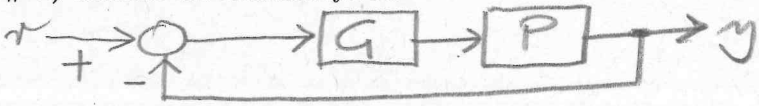


with controlled process $\mathbf{P}_1(s) = \dfrac{1-0.3s}{s+1.5}$ and $\mathbf{P}_2(s) = \dfrac{1}{s}$. Design a controller $\mathbf{G}(s)$ such that

(i) the closed-loop system is asymptotically stable (use Nyquist criterion) with steady state error response $|\mathbf{e}_{ss}(t)| \leqslant 0.05$ to ramp inputs $\mathbf{v}(t) = t$, steady state output response $|\mathbf{y}_{ss}(t)| \leqslant 0.01$ to constant disturbances $\mathbf{d}(t) = 1$ and steady state output response $|\mathbf{y}_{ss}(t)| \leqslant 0.1$ to sinusoidal disturbances $\mathbf{d}(t) = \sin(\omega t)$ for all $\omega \in [0, 0.1]$ rad/sec,

(ii) the open loop system $\mathbf{PG}(s)$ has crossover frequency $\omega_t^* \in [3,6]$ rad/sec and phase margin $m_\phi^* \geqslant 20°$.

Ex. # 2) Consider the feedback system



with $\mathbf{P}(s) = 3\frac{s+\alpha}{(s-1)(s+2)^2}$ and parameter $b \in \mathbb{R}$.

(i) determine the values of $\alpha \in \mathbb{R}$ for which it is possible to design a controller $\mathbf{G}(s) = K$ such that the closed-loop system is asymptotically stable

(ii) set $\alpha = 1$ and design a two-dimensional controller $\mathbf{G}(s)$ such that the closed-loop system is asymptotically stable with closed-loop poles with real part $\leqslant -3$. Draw the root locus of $\mathbf{PG}(s)$ using the Routh table for a study of the crossing points of the imaginary axis.

Ex. # 3) Given $\mathbf{P}(s) = \frac{1}{s+1}$, design a one-dimensional controller $\mathbf{G}(s)$ such that the feedback system $\frac{\mathbf{GP}(s)}{1+\mathbf{GP}(s)}$ is asymptotically stable with 5% settling time (in the step response) $\leqslant 10^{-3}$ sec.