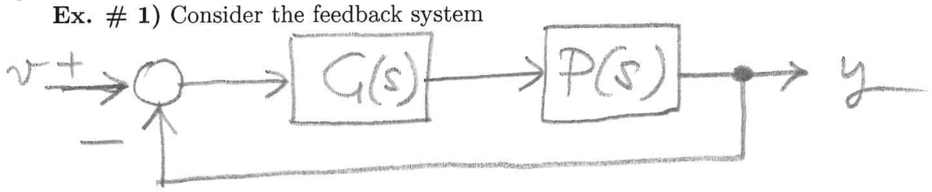
CONTROL SYSTEMS - 6/7/2021

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

Ex. # 1) Consider the feedback system



with $\mathbf{P}(s) = \frac{1}{s(s-1)}$. Design minimal dimensional $\mathbf{G}(s)$ such that

(i) the closed-loop system is asymptotically stable (use Nyquist criterion),

(ii) $|\mathbf{G}(j\omega)| < 20$ dB for all ω,

(iii) the open loop system has maximal crossover frequency ω_t and phase margin $m_\varphi \geqslant 25°$.

Ex. # 2) Consider the feedback system of Ex. # 1 with $\mathbf{P}(s) = \frac{s+2}{s^2+1}$. Design a minimal dimensional and strictly proper controller $\mathbf{G}(s)$ in such a way that

(i) the closed-loop system is asymptotically stable with steady-state error $\mathbf{e}_{ss}(t) \equiv 0$ to inputs $\mathbf{v}(t) = \delta^{(-1)}(t)$ and $\mathbf{v}(t) = \sin(t)$

(ii) the closed-loop poles have the same real part.

Draw the root locus of the open loop system $\mathbf{GP}(s)$ using the Routh table for an accurate study of the intersections with the imaginary axis.

Ex. # 3) Consider the system

$$
\begin{aligned}
\dot{x}_1 &= 3x_1 + 6x_2 - 3x_3 \\
\dot{x}_2 &= -2x_1 - 3x_2 + x_3 + u \\
\dot{x}_3 &= -x_3, \\
y &= x_1.
\end{aligned}
$$

(i) Decompose into observable and unobservable systems

(ii) determine a state feedback $u = Fx + v$ such that the eigenvalues of the closed-loop system are all in -1.

(ii) Is it possible to design a state reconstructor with exponential convergence at least e^{-t}?