STUDENT NUMBER..

CONTROL SYSTEMS - 5/6/2018

[time 2 hours; no textbooks; no programmable pocket calculator]

1) Given

$$P(s) = \frac{1}{s(s-1)}$$

design a controller $G(s)$ such that the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$

(i) is asymptotically stable (use the Nyquist criterion)

(ii) has zero steady state errors to ramp inputs ($e_1 = 0$)

and the open loop system $PG(s)$ has

(iii) crossover frequency $\omega_t^* = 3$ rad/sec and phase margin $m_\phi^* \geq 30°$.

2) Given

$$P(s) = \frac{s+5}{(s^2+1)(s-1)}$$

a) Draw the root locus using the Routh criterion to determine the exact picture on the imaginary axis
b) Determine, if any, a controller $G(s) = K$ such that the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$ is asymptotically stable.
c) Determine a controller $G(s)$ with dimension 2 (i.e. $G(s) = K\frac{(1+sz_1)(1+sz_2)}{(s+p_1)(s+p_2)}$) such that the feedback system $W(s) = \frac{PG(s)}{1+PG(s)}$ has zero steady state error to constant inputs and it is asymptotically stable with poles having negative real part ≤ -3.

3) Given $P(s) = \frac{K}{s+1}$

(i) for any $K > 0$ calculate the forced output response $y(t)$ with input $u(t) = 1 - e^{t-1}$ if $t \in [0, 1)$, $u(t) = t - 1$ if $t \in [1, 2)$ and $u(t) = 1$ if $t \geq 2$

(ii) has the system a well-defined output steady state response $y_{ss}(t)$? If yes, determine its value

(ii) is it possible to choose K so that the 5%-settling time of the output response $y(t)$ is ≤ 0.01 s?