EE640 Multivariable Control, Tutorial Sheet for 7^{th} Nov 2024.

Q-1: Suggest G_p, G_c such that interconnection is

(a) well-posed

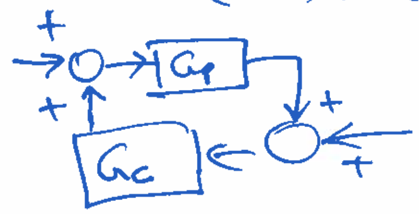
(b) ill-posed with 1^{st} condition (for well-posedness) violated.

(c) ill-posed with only 2^{nd} condition (for well posedness) violated.

(d) ill-posed with only 1^{st} condition violated.

Q-2: check $G_p(s) = \dfrac{(s+1)(s+2)}{(s+1)(s+3)}$ and $G_c = \left(\dfrac{s+2}{s+3}\right)^{-1}$

(Use



(both +ve sign in interconnection))

Q-3: Use $G_p(s) = \dfrac{s+2}{s+3}$ & $G_c(s) = 1$ to check that any state space realization of $G_p(s)$ (take one example) would result in D A E for interconnected system (with $d_1 = d_2 = 0$).

Q-4 Find (regular) state space realization for $\dfrac{s(s+1)}{s+2}$.

($\dot{x} = Ax + Bu$, $y = Cx + Du$)

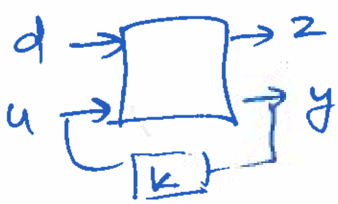
Q-5: ~~Let~~ Take Laplace transform of both sides & find transfer fn from u to y for

$$\frac{d}{dt}\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u$$

$$y = x_1 + x_2 + x_3 + du.$$

(For $E\dot{x} = Ax + Bu$ with E singular, we can realize improper transfer functions also in state space realization: not regular but singular.)

Q-6: Decide all 4 transfer fns in plant



for

– model matching problem

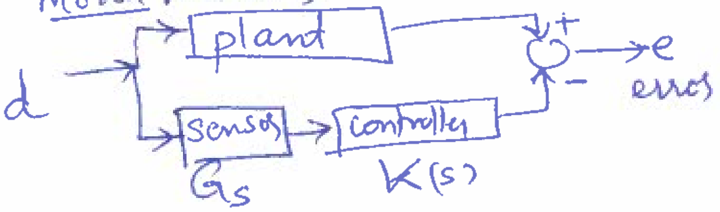
– regulator problem with C in

  – feedback path

  – feedforward path

Q-6: (Contd)

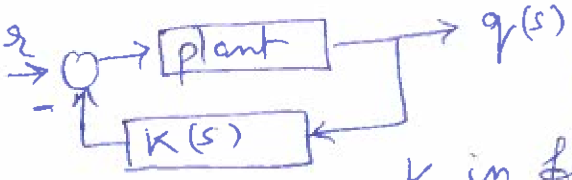
Model matching Assume SISO blocks



Regulator/tracking

we want y to track r

K in feed forward path.



K in feedback path.

Q-7: For each ~~example~~ conditions below provide 2x2 or 3x3 example of A (Provide A, B, C, D for:).

(a) controllable but not stabilizable.
(b) stabilizable but not controllable.
(c) neither observable nor detectable.
(d) improper ~~state~~ transfer function.
(e). Diagonal A and controllable & observable
(f) Diagonal A and controllable & observable and repeated eigenvalues.
g) Diagonal A, repeated eigenvalues & is either controllable or observable
h) No pole/zero cancellation but both controllable & observable.
i) $y = x_1$, uncontrollable, use reduced order observer (A is 2x2) and unstable.

such that $u = C(s)y$ is a stabilizing controller.

(j) $A = \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$, find stabilizing feedback $u = Fx$.

(k) $A = \begin{bmatrix} 3 & 0 \\ 0 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, —ıı —

l) $A = \begin{bmatrix} 3 & 0 \\ 0 & -4 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, —ıı —

For Endsem: not required topics:
- ~~cont~~ controllability indices / observability indices.
- minimum energy control

Syllabus for Endsem: By and large post midsem, but little pre-midsem also