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NPTEL ONLINE
CERTIFICATION COURSE

STATE SPACE METHOD CONTROLLER DESIGN

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DESIGN VIA STATE-SPACE

Root Locus Technique

- After designing the location of the dominant 2nd order pair of poles, we stop hoping that the higher-order poles do not affect the approximation
- It does not allow for a sufficient no. of unknown parameters to place all the closed-loop poles uniquely
- One gain to adjust or compensator pole and zero to select, does not yield a sufficient no. of parameters to place all the closed-loop poles at desired locations
- To place n - unknown quantities, we need n adjustable parameters

State Space Method

- It solves this problem by introducing into the system other adjustable parameters and their values
- However, it does not allow the specification of closed-loop zero locations; since location of the zero affects the transient response
- It has a wide range of computational support due to in-built support of matrix algebra by many software packages

DESIGN VIA STATE-SPACE

- An n^{th} order feedback system has an n^{th} order closed-loop characteristic equation.

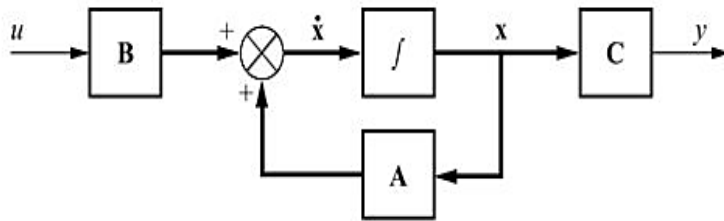
$$s^n + a_{n-1}s^{n-1} + \dots + a_1s + a_0 = 0$$

- The values of n coefficients determine the closed-loop pole location
- Thus if we can introduce n adjustable parameters and relate them to the coefficients, all of the poles of the closed-loop system can be set to any desired location
- If each state variable is fed back to the control, u , through a gain k_i , there would be n gains, k_i ; that could be adjusted to yield the required closed loop pole values

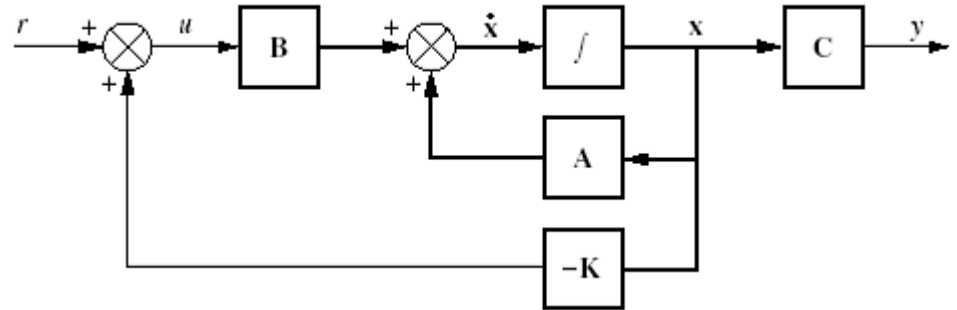
DESIGN VIA STATE-SPACE

$$s^n + a_{n-1}s^{n-1} + \dots + a_1s + a_0 = 0$$

$$s^n + (a_{n-1} + k_n)s^{n-1} + (a_{n-2} + k_{n-1})s^{n-2} + \dots + (a_1 + k_2)s + (a_0 + k_1) = 0$$



State-space representation of a Plant



Plant with state-feedback

Ref: N. S. Nise: Control Systems Engineering, 6th Ed., Wiley, 2013

NUMERICAL EXAMPLE

- Given the plant, $G(s) = \frac{20(s+5)}{s(s+1)(s+4)}$
- Design the phase variable feedback gains to yield **9.5 %** overshoot and a settling time of **0.74** second.

Ref: N. S. Nise: Control Systems Engineering, 6th Ed., Wiley, 2013



REFERENCE BOOKS

- Norman S. Nise, Control Systems Engineering, Wiley, 2013
- Katsuhiko Ogata, Modern Control Engineering, Prentice Hall, 2010.

