

Computer Control of Dynamic Systems

Lecture-8

Current Observer

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Full-Order Current Observer

- The full-order observer is a prediction observer, since the estimate of $x(k)$ is based on the measurement $y(k - 1)$.*

$$q(k+1) = (A-G C) q(k) + G y(k) + B u(k)$$

- The reduced-order observer estimates states at time kT using the measurement at time kT .*

$$q_b(k+1) = (A_{bb} - G A_{ab}) q_b(k) + G Y(k+1) + [A_{ba} - G A_{aa}] Y(k) + [B_b - G B_a] u(k)$$

- We call this type of estimator a current estimator, or current observer.*
- We will now consider a full-order current estimator.*

Full-Order Current Observer

- *The system model is given by*

$$x(k+1) = A x(k) + Bu(k)$$

$$y(k) = C x(k)$$

- *We wish to estimate the state vector $x(k)$ with the vector $q(k)$.*
- *One form of a full-order current observer is given by the two equations*

$$\bar{q}(k+1) = A q(k) + Bu(k)$$

$$q(k+1) = \bar{q}(k+1) + G [Y(k+1) - C\bar{q}(k+1)]$$

- *$\bar{q}(k+1)$ is a first estimate of the state at time $(k+1)T$*

$$\begin{aligned} q(k+1) &= Aq(k) + Bu(k) + G [Y(k+1)] - GC [Aq(k) + Bu(k)] \\ &= (A - GCA) q(k) + GY(k+1) + (B - GCB) u(k) \end{aligned}$$

- The single equation for the estimate is

$$q(k+1) = (A - GCA) q(k) + GY(k+1) + (B - GCB) u(k)$$

- The characteristic equation:

$$|ZI - A + GCA| = 0$$

$$G = \alpha_e (A) \begin{bmatrix} CA \\ CA^2 \\ \cdot \\ \cdot \\ CA^n \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ \cdot \\ 1 \end{bmatrix}$$

- *The controller-estimator transfer function:*

$$D_{ce}(z) = ZK [ZI - A + GCA + BK - GCBK]^{-1} G$$

Example

- Consider the system

$$x(k+1) = \begin{bmatrix} 1 & 0.0952 \\ 0 & 0.905 \end{bmatrix} x(k) + \begin{bmatrix} 0.00484 \\ 0.0952 \end{bmatrix} u(k)$$

$$y(k) = [1 \ 0]x(k)$$

- with control gains

$$K = [4.52 \ 1.12]$$

- The observer characteristic equation as used for the prediction observer is

$$\alpha_e (A) = A^2 - 1.638A + 0.671 I$$

$$= \begin{bmatrix} 0.033 & 0.0254 \\ 0 & 0.00763 \end{bmatrix}$$

$$G = \alpha_e (A) Q_0^{-1} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0.267 \\ 0.0802 \end{bmatrix}$$

$$q(k+1) = (A - GCA) q(k) + G Y(k+1) + (B - GCB) u(k)$$

$$= \begin{bmatrix} 0.742 & 0.0707 \\ -0.0885 & 0.897 \end{bmatrix} q(k) + \begin{bmatrix} 0.258 \\ 0.0885 \end{bmatrix} y(k+1) + \begin{bmatrix} 0.00359 \\ 0.0948 \end{bmatrix} u(k)$$

$$D_{ce}(z) = ZK [ZI - A + GCA + BK - GCBK]^{-1} G$$

$$D_{ce}(z) = \frac{1.27z - 1.12}{z^2 - 1.52z + 0.609}$$

End Of Lecture