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RTA - Assistenz - Übung 2 - 02.10.2015

Normieren + Linearisieren

Gegeben $\ddot{x} = P(t) - kx^2$ Ausgang: $\dot{x}(t)$

Gesucht

Mit $z = [z_1; z_2]^T = [x, \dot{x}]^T$: $\dot{z}_1 = z_2$ $\quad w = z_1$

$\dot{z}_2 = P(t) - k z_1^2$

GGW: $z_2 = 0$ $\quad z_{1e} = \left(\frac{P_e}{k}\right)^{1/2}$ $\quad w_e = z_{1e} = 0$

Normierung mit z_{i0} und (v_0, w_0):

$$z_{10}\dot{x}_1 = z_{20} x_2$$
$$z_{20}\dot{x}_2 = v_0 u - k (z_{10} x_1)^2$$
$$w_0 y = z_{20} \cdot x_2$$

$$\Rightarrow \quad \dot{x}_1 = \frac{z_{20}}{z_{10}} x_2$$
$$\dot{x}_2 = \frac{1}{z_{20}} (v_0 u - k z_{10}^2 x_1^2)$$
$$y = \frac{z_{10}}{w_0} x_2$$

Linearisierung:

$$A = \begin{bmatrix} 0 & \frac{z_{20}}{z_{10}} \\ -\frac{2k z_{10}^2}{z_{20}} \sqrt{\frac{P_e}{k}} \frac{1}{z_{10}} & 0 \end{bmatrix}$$

$$e = \begin{bmatrix} 0 \\ -\frac{v_0}{z_{20}} \end{bmatrix} \qquad c = \begin{bmatrix} 0 & \frac{z_{20}}{w_0} \end{bmatrix} \qquad d = [0]$$

$$\Rightarrow \quad \dot{x}_1 = \frac{z_{20}}{z_{10}} x_2$$
$$\dot{x}_2 = -\frac{2k z_{10}^2}{z_{20}} \sqrt{\frac{P_e}{k}} \frac{1}{z_{10}} x_1 + \frac{v_0}{z_{20}} u$$
$$y = \frac{z_{20}}{w_0} x_2$$

Signalflussbild

Parameterwahl: $\dot{x}_1 = 2x_2 + x_1$ $\quad A = \begin{bmatrix} 1 & 2 \\ -3 & -1 \end{bmatrix}$ $e = \begin{bmatrix} 0 \\ 2 \end{bmatrix}$

$\dot{x}_2 = -3x_1 + 2u + x_2$ $\quad c = [0 \;\; 1]$ $\quad d = [0]$

$y = x_2$