

Nichtlineares ZRM

$$\dot{x}_1 = x_2 \quad \text{Eq. 1.37}$$

$$\dot{x}_2 = \frac{a_2 [(b_2 x_1 x_2 + b_3) x_4 + b_4 x_3 - b_6 x_1 \cos(x_3)] + (m x_1^2 + b_1) (a_3 \sin(x_3) + m x_1 x_4^2) - a_2 l \cos(x_3) u(t)}{a_1 (m x_1^2 + b_1) - a_2 b_5} \quad \text{Eq. 1.38}$$

$$\dot{x}_3 = x_4 \quad \text{Eq. 1.39}$$

$$\begin{aligned} \dot{x}_4 = & \frac{-(b_2 x_1 x_2 + b_3) x_4 - b_4 x_3 + b_6 x_1 \cos(x_3)}{m x_1^2 + b_1} - \frac{b_5 (a_3 \sin(x_3) + m x_1 x_4^2)}{a_1 (m x_1^2 + b_1) - a_2 b_5} \\ & - \frac{a_2 b_5 [(b_2 x_1 x_2 + b_3) x_4 + b_4 x_3 - b_6 x_1 \cos(x_3)]}{(m x_1^2 + b_1) (a_1 (m x_1^2 + b_1) - a_2 b_5)} \\ & + \left(1 + \frac{a_2 b_5}{a_1 (m x_1^2 + b_1) - a_2 b_5} \right) \frac{l \cos(x_3) u(t)}{m x_1^2 + b_1} \quad \text{Eq. 1.40} \end{aligned}$$

Linearisiertes ZRM

$$\underline{A} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ A_{21} & 0 & A_{23} & A_{24} \\ 0 & 0 & 0 & 1 \\ A_{41} & 0 & A_{43} & A_{44} \end{bmatrix} \quad \underline{b} = \begin{bmatrix} 0 \\ B_2 \\ 0 \\ B_4 \end{bmatrix}$$

$$cT=[1 \ 0 \ 0 \ 0]$$

$$d=0$$

$$A_{21} = \frac{-a_2 b_6 (a_1 (m x_{10}^2 + b_1) - a_2 b_5) + 2 m a_1 a_2 x_{10} (b_6 x_{10} + l u_0)}{(a_1 (m x_{10}^2 + b_1) - a_2 b_5)^2} \quad (1.47)$$

$$A_{23} = \frac{a_3 (m x_{10}^2 + b_1) + a_2 b_4}{a_1 (m x_{10}^2 + b_1) - a_2 b_5} \quad (1.48)$$

$$A_{24} = \frac{a_2 b_3}{(a_1 (m x_{10}^2 + b_1) - a_2 b_5)} \quad (1.49)$$

$$A_{41} = \frac{b_6 (-m x_{10}^2 + b_1)}{(m x_{10}^2 + b_1)^2} - \left[1 + a_2 b_5 \frac{2 a_1 m x_{10}^2 + 2 a_1 b_1 - a_2 b_5}{(a_1 (m x_{10}^2 + b_1) - a_2 b_5)^2} \right] \frac{2 m l x_{10} u_0}{(m x_{10}^2 + b_1)^2} - a_2 b_5 b_6 \frac{m x_{10}^2 (3 a_1 m x_{10}^2 + 2 a_1 b_1 - a_2 b_5) + b_1 (-a_1 b_1 + a_2 b_5)}{[(m x_{10}^2 + b_1) (a_1 (m x_{10}^2 + b_1) - a_2 b_5)]^2} \quad (1.50)$$

$$A_{43} = -\frac{b_4}{m x_{10}^2 + b_1} - \frac{a_3 b_5}{a_1 (m x_{10}^2 + b_1) - a_2 b_5} - \frac{a_2 b_4 b_5}{(m x_{10}^2 + b_1) (a_1 (m x_{10}^2 + b_1) - a_2 b_5)} \quad (1.51)$$

$$A_{44} = -b_3 \left(\frac{1}{(m x_{10}^2 + b_1)} + \frac{a_2 b_5}{(m x_{10}^2 + b_1) (a_1 (m x_{10}^2 + b_1) - a_2 b_5)} \right) \quad (1.52)$$

$$B_2 = -\frac{a_2 l}{(a_1 (m x_{10}^2 + b_1) - a_2 b_5)} \quad (1.53)$$

$$B_4 = \left(1 + \frac{a_2 b_5}{(a_1 (m x_{10}^2 + b_1) - a_2 b_5)} \right) \frac{l}{m x_{10}^2 + b_1} \quad (1.54)$$