

## TP2 system diagnostics

### Synthesis the residue generator by observer

The mathematical model of a system, whether knowledge or representation, involves a set of parameters whose numerical values are generally unknown. Observer estimation techniques make it possible, from a set of measurements carried out on the installation, to determine the vector of the parameters involved.

يتضمن النموذج الرياضي للنظام، سواء المعرفة أو التمثيل، مجموعة من المعلمات التي تكون قيمها العددية غير معروفة بشكل عام. تتيح تقنيات تقدير المراقب، من خلال مجموعة من القياسات التي يتم إجراؤها أثناء التثبيت، تحديد متجه المعلمات المعنية.

**Example 1:** We consider the linear system with invariant time described by the following state representation

$$\begin{aligned}\dot{x} &= Ax + Bu \\ y &= Cx\end{aligned}$$

With :

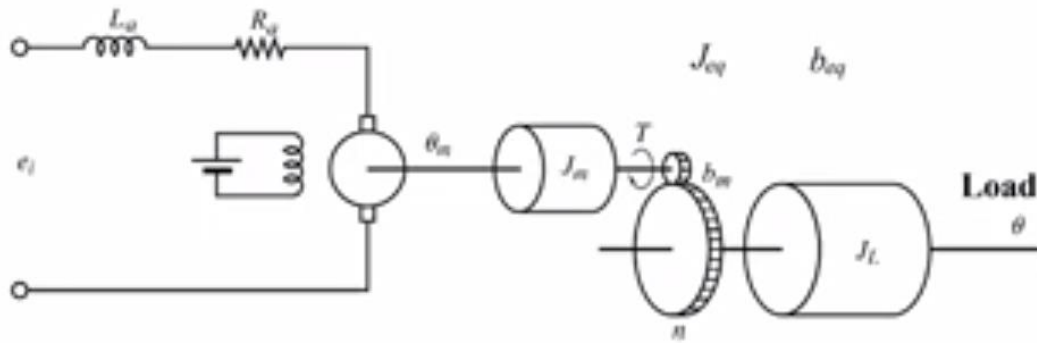
$$A = \begin{bmatrix} 0 & 2 & 0 & 0 & 0 \\ -0.1 & -0.35 & 0.1 & 0.1 & 0.75 \\ 0 & 0 & 0 & 2 & 0 \\ 0.4 & 0.4 & -0.4 & -1.4 & 0 \\ 0 & -0.03 & 0 & 0 & -1 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \quad C = [0.5 \quad 0 \quad 0.5 \quad 0 \quad 0]$$

The system contains non-measurable states  $x_2$  and  $x_4, x_5$  to make us a linear state observer it is necessary that:

1. check the controllability of the system
2. Calculates the controller gain matrix for a pole placement  $[-0.5-0.5i ; -0.5+0.5i ; -3 ; -2.8 ; -2.6]$  with the **place** command
3. The system is observable , check the observability of the system
4. Gives a structure of the observer
5. Calculates the observer gain matrix for 5 times fast pole placement
6. Write a Matlab script to calculate system states using the **ode45** command?

### Example 2 :

Either the system composed of a direct current motor, from an electrical point of view, can be modeled as a system whose input is the control voltage  $e_u(t)$  of the armature (rotor) and the output the position  $\theta(t)$ . The rotor is modeled by a resistance in series with an inductance and a counter electromotive force. The knowledge model of the DC motor is given below:



$$\begin{cases} e_u(t) = L_a \frac{di(t)}{dt} + R_a i(t) + K_w \frac{d\theta(t)}{dt} \\ K_c i(t) = f_e \frac{d\theta(t)}{dt} + J_{eq} \frac{d^2\theta(t)}{dt^2} \\ \omega = \frac{d\theta(t)}{dt} \end{cases}$$

We pose

$$x_1 = \theta(t) , x_2 = \dot{\theta}(t) = \dot{x}_1 , x_3 = i(t) , U = e_u(t)$$

we obtain:

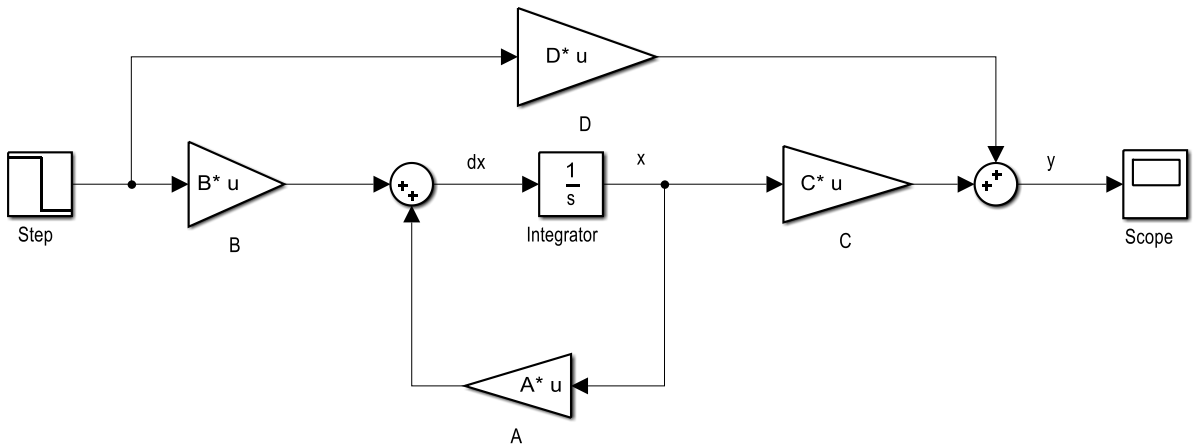
$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -f_e/J_{eq} & K_c/J_{eq} \\ 0 & -K_w/L_a & -R_a/L_a \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1/L_a \end{bmatrix} U$$

$$y = \theta(t) = [1 \quad 0 \quad 0]x$$

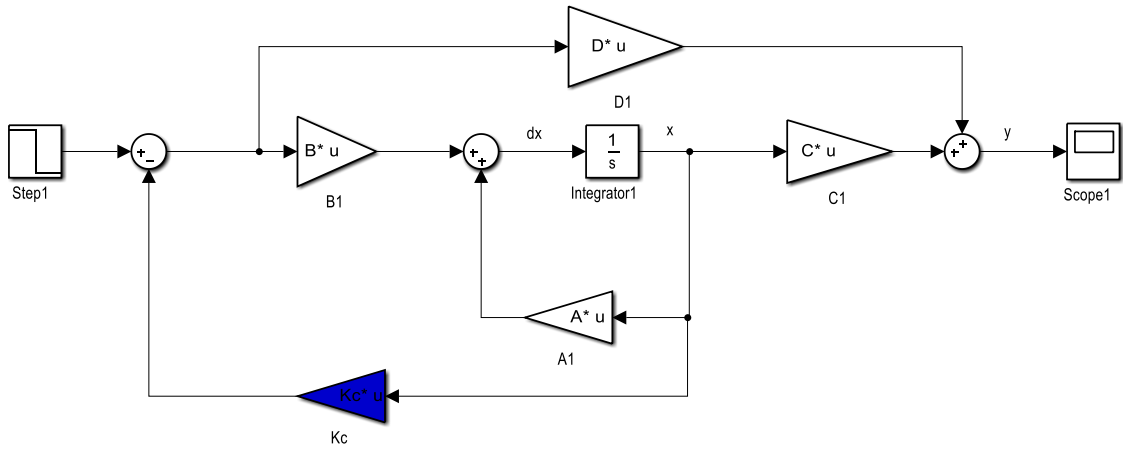
MDC settings:

Ra=0.515Ω; La=0.069 H; J=1.2kgm<sup>2</sup>; kc=0.8, kw= 0.9 , viscous force fe=2.5.

1. check the controllability of the system
2. Calculates the controller gain matrix for a pole placement  $[-3 ; -5-5i ; -5+5i ]$  with the **place** command
3. The system is observable , check the observability of the system
4. Gives a structure of the observer
5. Calculates the observer gain matrix for 5 times fast pole placement
6. Carrying out a matlab simulation allows you to visualize the residuals

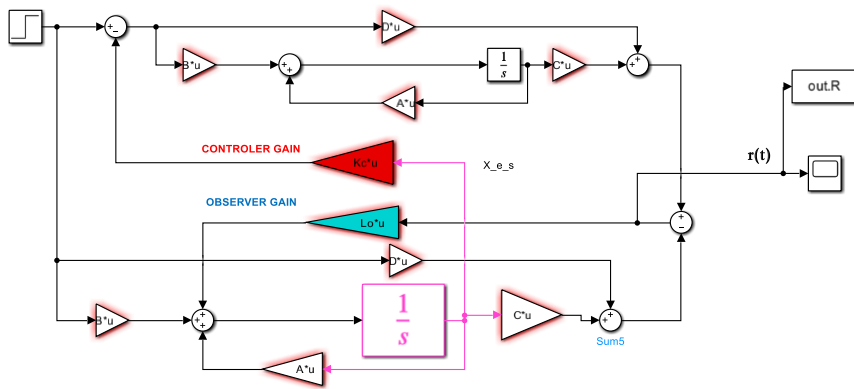


State Space DC Motor



State feedback DC Motor

STATE SPACE CONTROLLER



STATE SPACE OBSERVER