Control Systems 2 Oct

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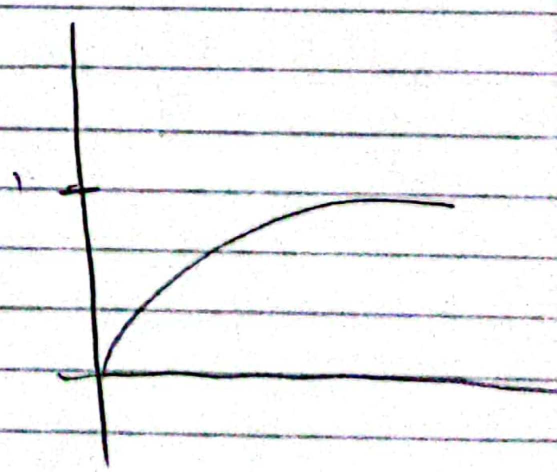
SERIAL: JNB TI, TRANS
        CLR RI
        MOV A, SBUFF
        MOV P0, A
        RETI
TRANS:  CLR TI
        RETI
```

3 main parts of course.

- → System process information.
- → Amplifier example
- → Robot → electromechanical system
- → outputs update according to input.
- → efficiency
  - → noise
  - → stability
  - → oscillation
  - → speed



→ effusion pump

input unit step
unit output

→ washing machine → washing
→ Automobiles → Tesla Car
→ PLC → Logic Controller
→ Adding more data in table
use $y = mx + c$

$y = 2.5x - 3$

→ Mathematically, see the world.
→ In control systems, we see the mathematical form of system.

→ Cyber - Physical World.
↓
Digital World

When we integrate physical world with digital world

→ Solar Panelling → Smart Metering

→ Traditionally → one way

04/10/2024

→ Model → A representation, map based on knowledge
  ↳ Examples

→ Mathematical Model → set of equations ($y = 2x$)

→ Meteoroligist makes weather forecast model for predicting weather.

→ Two types of models
  ↳ stochastic
  ↳ Deterministic
    - black box → Atomic bomb → No idea of internal dynamics
    - Gray box → ~~little knowledge~~ ~~about~~ internal dynamics
    - white box → all info about internal structure

→ Difference b/w step ftion $u(t)$ and unit step ftion

$$\mathcal{L}\{f(t)\} = \int_0^\infty f(t)\, e^{-st}\, dt$$

$$= F(s)$$

Convolution in time domain is multiplication in frequency domain.

$$T.F = \frac{L.T \text{ of } O/P}{L.T \text{ of } i/P}$$

$$R(t) \longrightarrow \boxed{G(t)} \longrightarrow C(t)$$

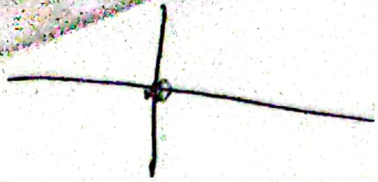
$$C(t) = R(t) * G(t)$$

$$C(s) = R(s) \cdot G(s)$$

$$\frac{C(s)}{R(s)} = G(s)$$

$$\mathcal{L}\left\{\frac{d^2 y(t)}{dt^2}\right\} = s^2 \cdot Y(s)$$

$$\mathcal{L}\left\{\frac{d^2 y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 2y(t)\right\} = \mathcal{L}\{x(t)\}$$



$$s^2 Y(s) + 3s Y(s) + 2 Y(s) = X(s)$$

$$\frac{Y(s)\left[s^2+3s+\cancel{2}\right]}{X(s)\left[\cancel{s^2+3s+2}\right]} = \frac{\cancel{X(s)}}{\cancel{X(s)}} \times \frac{1}{s^2+3s+2}$$

G

$$\frac{Y(s)}{X(s)} = \frac{1}{s^2+3s+2}$$

→ A sys is → stable, unstable or marginally

when poles are on ~~y~~ axis

→ For discrete-time system is stable on basis of unit circle.

→ For STABILITY FIND THE POLE ONLY

9 Oct 2024

$$\mathcal{L}\{h(t)\} = H(s)$$

→ Recap

→ State-Space Model discuss internal dynamics as well not just i/p's and o/p's

→ Contains extra variables (state-space imp variable

SS variables SSModel

→ State Space variables Completely describe the behaviour of a system.

→ x → one SS var

→ $x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ 3 SS vars

→ $\boxed{x(t)}$ → State Space var

→ We have two eqtions
(i) State eqtion
(ii) Output "

$$\dot{x} = A\,x(t) + B\,u(t)$$
$$y(t) = C\,x(t) + \underbrace{D\,u(t)}$$

D is mostly zero.

→ Example 1

$$\dot{x} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 2 & 3 \end{bmatrix} u(t)$$

→ Ex 2

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

$$\dot{x}_1 = x_1 + 2x_2$$
$$\dot{x}_2 = 3x_1 + 4x_2$$

Scanned with CamScanner

$\ddot{y} + 4\dot{y} + 3y = 2u$

order 2 means 2 SS Vars

Soln

$x_1 = y \quad , \quad x_2 = dy/dt = \dot{y}$

$\dot{x}_1 = \dot{y} \quad , \quad \dot{x}_2 = \frac{d^2y}{dt^2} = \ddot{y}$

$\boxed{\dot{x}_1 = \dot{y} = 0x_1 + x_2}$

$\dot{x}_2 = \ddot{y} =$

$\ddot{y} = -4\dot{y} - 3y + 2u$

$\boxed{\dot{x}_2 = -4x_2 - 3x_1 + 2u}$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u(t)$$

$$y = x_1 + 0x_2$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Now we come to transfer function.

→ For transfer function, ~~take~~ convert it to differential equation.

→ Take inverse laplace transform.

$$\frac{C(s)}{R(s)} = \frac{24}{s^3 + 9s^2 + 26s + 24}$$

$$c(s)\left[s^3 + 9s^2 + 26s + 24\right] = 24 \cdot R(s)$$

$$\frac{dx}{dt} = x(s)$$

$$\frac{d^2x}{dt^2} = s^2 x(s)$$

$$\dddot{c} + 9\ddot{c} + 26\dot{c} + 24c = 24x$$

$x_1 = c$ $\qquad \dot{x}_1 = \dot{c}$

$x_2 = \dot{c}$ $\qquad \dot{x}_2 = \ddot{c}$

$x_3 = \ddot{c}$ $\qquad \dot{x}_3 = \dddot{c}$

$\dot{x}_1 = x_2$

$\dot{x}_2 = x_3$

$\dot{x}_3 = -24x_1 - 26x_2 - 9x_3 + 24r$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -24 & -26 & -9 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 24 \end{bmatrix}$$

$c = x_1$

$$c = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$