VASAVI COLLEGE OF ENGINEERING

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DEPARTMENT OF : ECE

NAME OF THE LABORATORY : CSE

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State Space Analysis

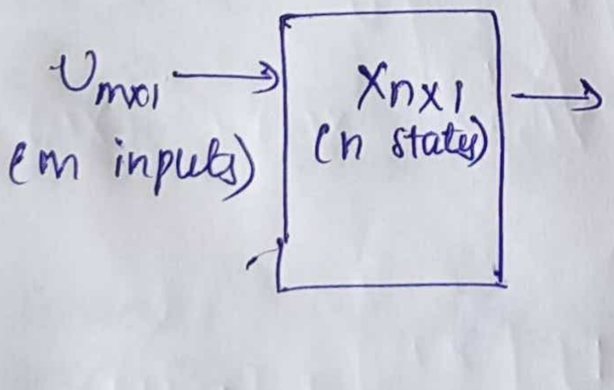
Aim:- To convert state space model to transfer function model and vice versa

Tools Required:- A PC loaded with MATLAB

Theory:-

State space analysis holds significant importance in control systems engineering due to its versatile and comprehensive nature. It provides a unified mathematical framework for representing and analyzing both continuous time and discrete time systems.

By describing the behaviour of complex systems through a set of differential or difference equations, state space models offer a clear and concise representation of system dynamics. Moreover, state space models offer modeling flexibility, allowing engineers to incorporate non linearities, time-varying parameters, and uncertainities more easily than other ~~mode~~ methods.



$$A = \begin{bmatrix} 3 & 1 \\ 0 & -1 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \quad C = [1 \quad 1] \quad D = 0$$

$$TF = C[sI - A]^{-1} B + D$$

$$= [1 \quad 1] \begin{bmatrix} s-3 & -1 \\ 0 & s+1 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= [1 \quad 1] \frac{1}{s^2-2s-3} \begin{bmatrix} s+1 & 1 \\ 0 & s-3 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \frac{1}{s^2-2s-3} [1 \quad 1] \begin{bmatrix} s+1 & 1 \\ 0 & s-3 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \frac{1}{s^2-2s-3} [s+1 \quad s-2] \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \frac{1}{s^2-2s-3} [s+1+s-2]$$

$$= \frac{2s-1}{s^2-2s-3}$$

Program:-

```
clc;
clear;
close all;
A = [3  1; 0  -1];
B = [1; 1];
C = [1  1];
D = 0;
[num, den] = ss2tf (A, B, C, D);
disp ('Numerator coefficients:');
disp (num);
disp ('Denominator coefficients:');
disp(den);
```

~~[x, y, z, a] = tf2ss(num, den)~~

```
clc;
clear;
close all;
num = [1  3  3];
den = [1  2  3  1];
[A, B, C, D] = t2fss (num, den)
```

Result:- Converted state space model to transfer function and vice versa.

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

$$T(s) = \frac{Y(s)}{U(s)} = \frac{X(s)}{U(s)} \times \frac{Y(s)}{X(s)}$$

$$= \left[\frac{1}{s^3+2s^2+3s+1}\right]\left[s^2+3s+3\right]$$

$$\dot{x} = AX + BU$$

$$y = CX + DU$$

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

$$U(s) = s^3X(s) + 2s^2X(s) + 3sX(s) + X(s)$$

Let $x_1 = X(s)$

$x_2 = \dot{x}_1 = sX(s)$

$x_3 = \dot{x}_2 = s^2X(s)$

$\dot{x}_3 = s^3X(s)$

$$U = \dot{x}_3 + 2x_3 + 3x_2 + x_1$$

$$\dot{X} = AX + BU$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -3 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U$$

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

$$Y = CX + DU$$

$$[Y] = [3 \quad 3 \quad 1] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + [0]U.$$