

Demo Simulation

Brief description of the suggested scheme of simulation and
sample programs with results

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System

A system is described by

$$\dot{x} = Ax + Bu$$

where the system matrices A and B are given by

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}; \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}; \quad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

The control is selected as

$$u = -kx; \quad \text{where} \quad k = \begin{bmatrix} 18 & 6 \end{bmatrix}$$

Problem

Simulate the above system using **MATLAB/ SIMULINK** and plot u and x versus time.

Suggested approach

- ▶ Write a **DATA** file. This is a script file
- ▶ Write a **CONTROL** file. This file is a function file which decides how the **MATLAB FUNCTION** block will work.
- ▶ Make a **SIMULINK** diagram. This enables the simulation of the system. The **MATLAB FUNCTION** block is part of this **SIMULINK** diagram.
- ▶ Let the data file take overall control of the simulation.

Data file program

- ▶ This is a script file with extension .m
- ▶ Give the data like parameter values, initial conditions.
- ▶ All one time calculations are done here.
- ▶ Initiate the simulation from here.
- ▶ At the end of the simulation, the required plotting is done here.

Control file program

- ▶ This is a function file with extension .m.
- ▶ Get the signals, such as states, time etc.
- ▶ Generate the control according to a particular control strategy.
- ▶ Prepare for simulation of the system by generating \dot{x} . The simulink file will integrate \dot{x} to provide x .
- ▶ Output the control signal u and \dot{x} . Output any other signals if required.
- ▶ **IMPORTANT** Make sure that the name of the file and name of the function is the same.
- ▶ Declare all data needed from the workspace in a **GLOBAL STATEMENT** placed just after the function statement.
- ▶ **IMPORTANT** Copy the global statement in the data file.

Simulink diagram

- ▶ This is diagram made by pulling ready made blocks from the **SIMULINK LIBRARY** and connecting them.
- ▶ This diagram is saved with the extension .mdl.
- ▶ **MATLAB FUNCTION** block is part of this diagram which essentially stands for the controller block in a feedback control system.
- ▶ The system is simulated here.
- ▶ The results can be displayed or stored here for displaying later.
- ▶ **IMPORTANT POINT** Enter parameters required using symbols. Define the symbols in the Data file.

Enter data, initiate simulation and plot I

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Approach

Data
Control
Simulink

Code

Data code
Control code
Simulink
diagram

Sample
results

```
%% Shared variables
global k A B
% all data that is shared by the data and
% control files
% is listed under the global command
%% Give the data for the problem
A=[0 1; -2 -3]; B=[0; 1];

% initial conditions
x0=[1;0];
%Feedback matrix calculated according
%some consideration
k=[18 6];
```

Enter data, initiate simulation and plot II

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```
%% Instruct the start of simulation
% simulation time, step size
% method of integration RK4 specified in sim file

stoptime=4; stepsize=.001;
sim('demo_sim')

%% Plot the results
plot(t,u)
xlabel('t'); ylabel('u')
pause
plot(t,x)
xlabel('t'); ylabel('y')
```


Generate control and prepare for plant simulation I

```
function [output] = demo_con(input)

% here input means input to the
% matlab function block
% and output means output from the
% matlab function block
%% Shared variables
global k A B
% all data that is shared by the data and
% control files is listed under
% the global command
%% Rename the input for convenience
x=[input(1);input(2)];
t=input(3);
```

Generate control and prepare for plant simulation II

```
%% Generate the control
u=-k*x;

%% Prepare for simulation of the plant
xdot=A*x+B*u;

% If we now just integrate xdot,
% we will get the states x.
% This is done
% using the simulink file.
%% Define the output
output=[xdot' u];

end
```

Simulate, store or display results

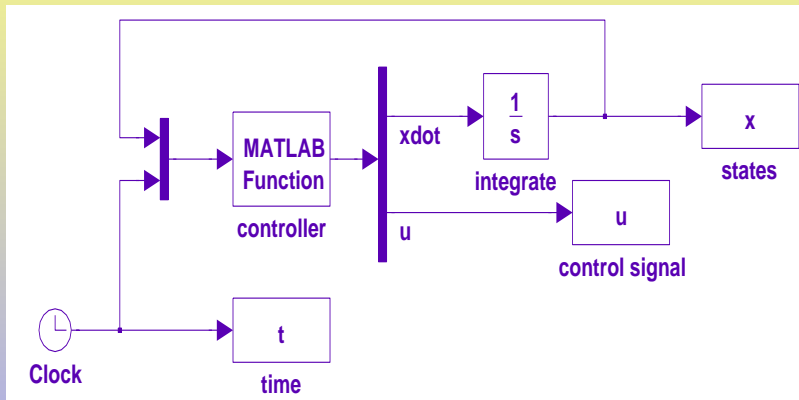


Figure: Simulink Diagram

Plot of u

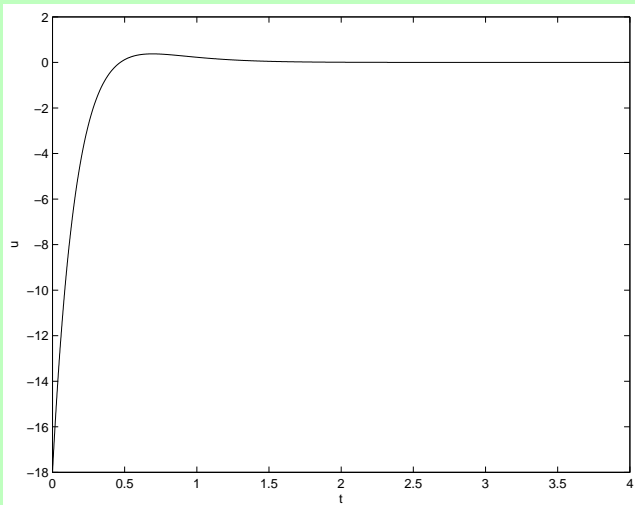


Figure: Control Signal

Plot of x

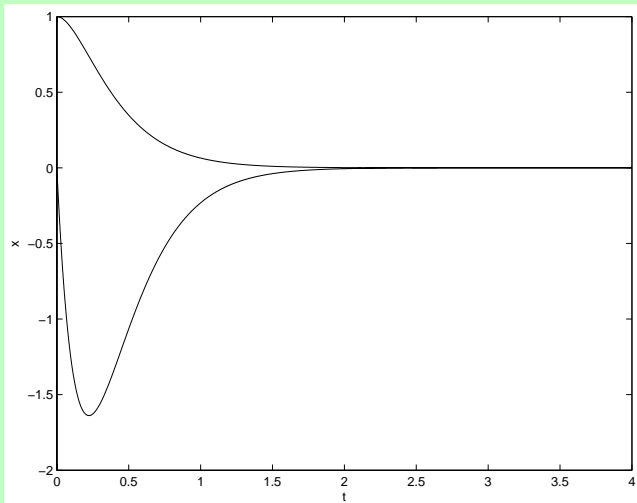


Figure: States x_1 and x_2