

System modeling and simulation(ME340)

Chapter 5. state-variable models and simulation methods

5.4 Simulink and linear model

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Brief introduction of simulink

- Simulink provides a graphical user interface that uses various types of elements called blocks to create a simulation of a dynamic system; that is, a system that can be modeled with differential or difference equations whose independent variable is time.
- Its graphical interface enables you to position the blocks, resize them, label them, specify block parameters, and interconnect the blocks to describe complicated systems for simulation.

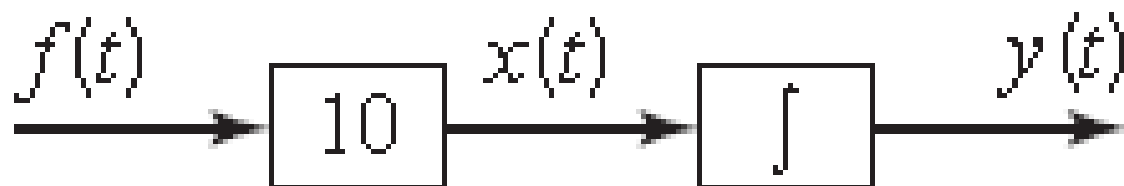
An example

- *Solve the differential equation: $dy/dt = 10 f(t)$.*
- *Maybe, it could be easily solved by hand.*
- *Or, the ode function learned in last lecture could be used to solve it.*
- *Or, a model based on simulink could be constructed*

$$\dot{y} = 10 f(t)$$

$$y(t) = \int 10 f(t) dt$$

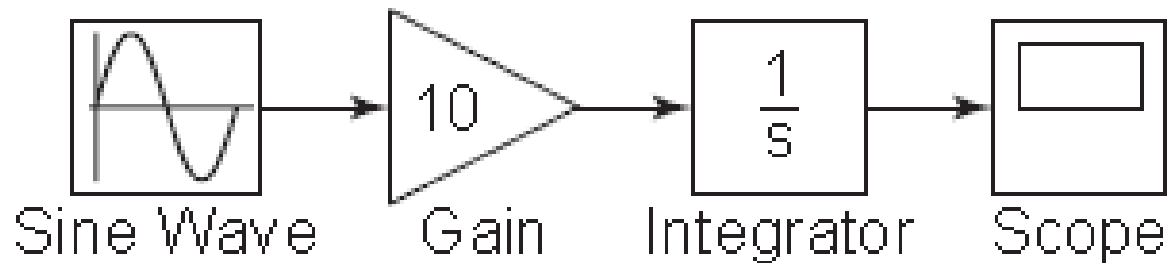
$$x(t) = 10 f(t) \quad \text{and} \quad y(t) = \int x(t) dt$$

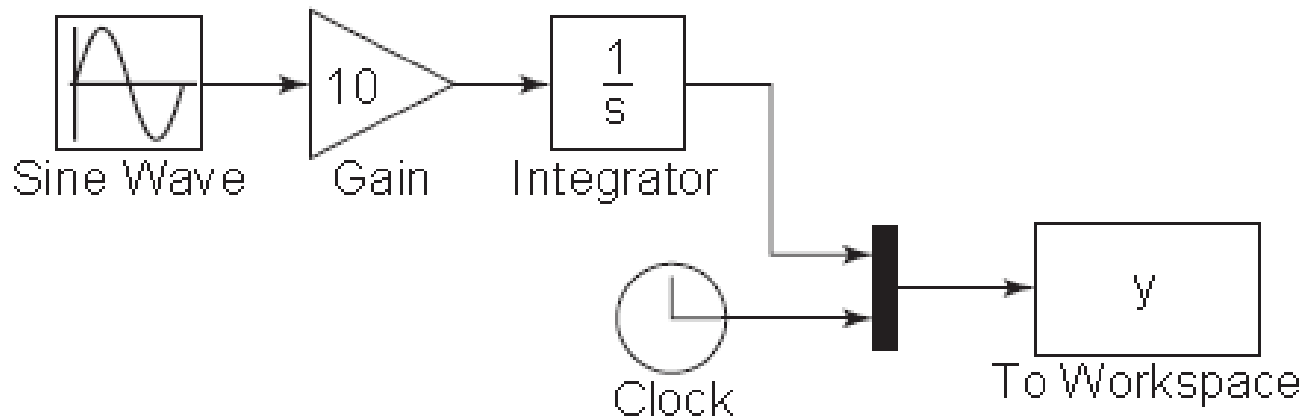
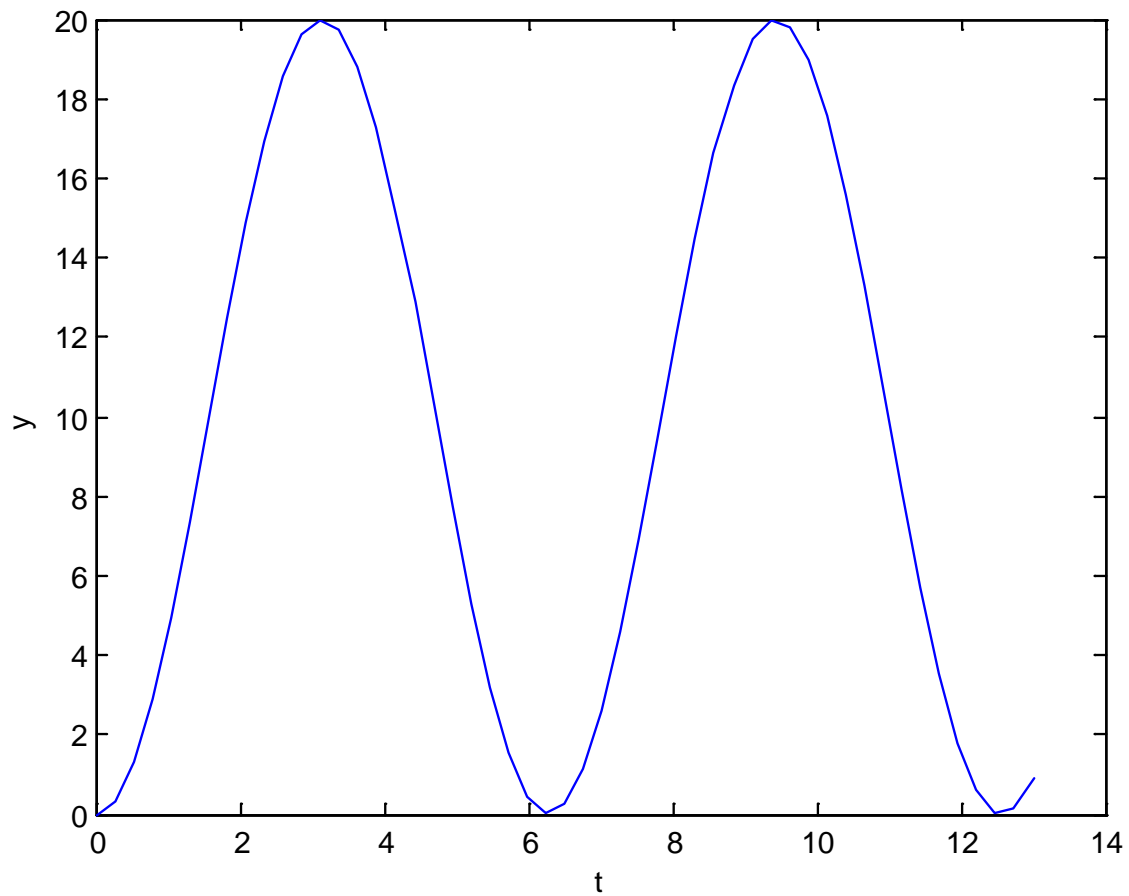


Another example

Let us use Simulink to solve the following problem for $0 \leq t \leq 13$.

$$\frac{dy}{dt} = 10 \sin t \quad y(0) = 0$$



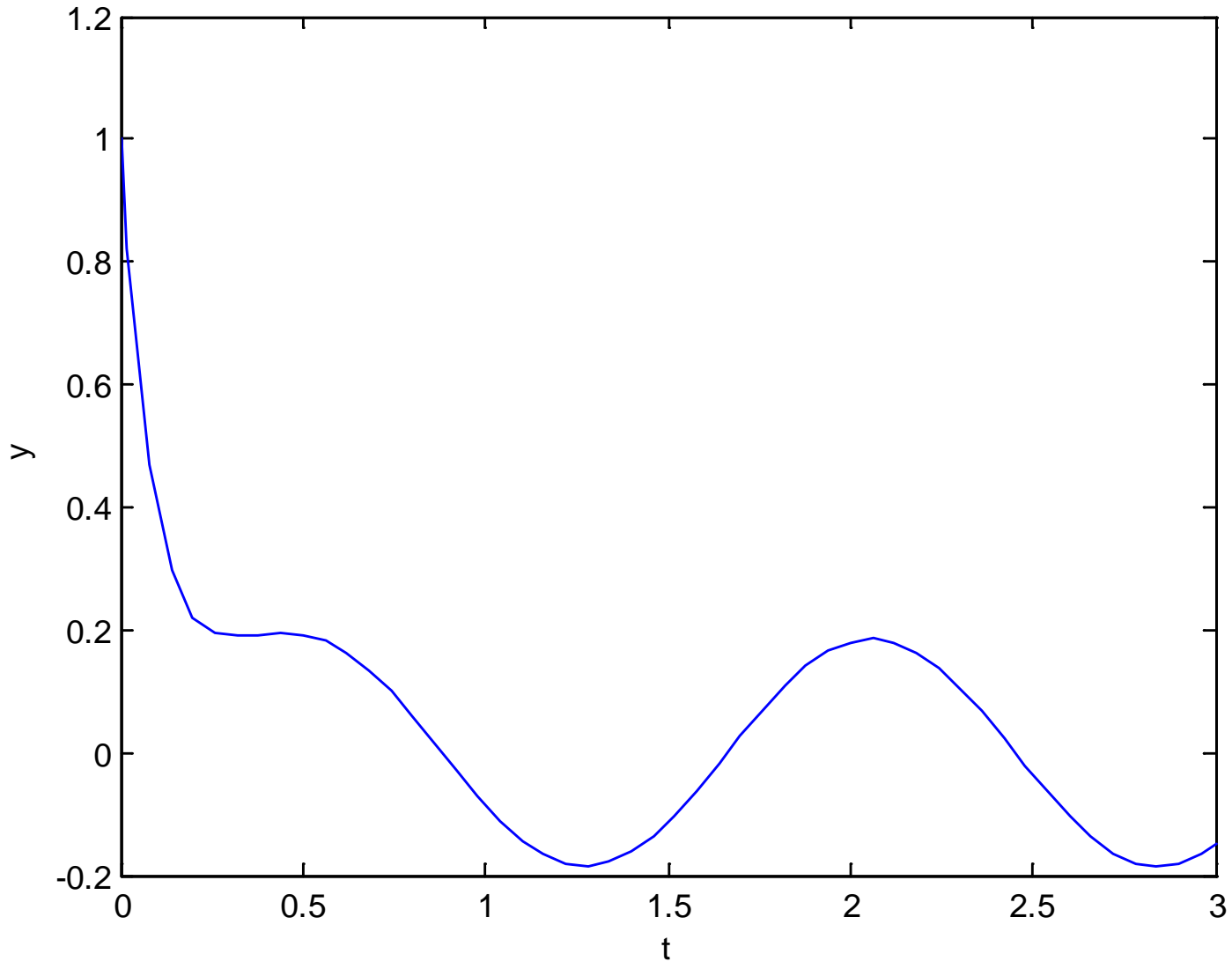


Exercise

- Construct a Simulink model to solve

$$dy/dt = -10y + f(t) \quad y(0) = 1$$

where $f(t) = 2 \sin 4t$, for $0 \leq t \leq 3$. and plot the results in a matlab plot function.



Simulating state-variable models

- State variable models, unlike transfer function models, can have more than one input and more than one output. It is complicated to build the simulink model for the MIMO system.
- Simulink has the State-Space block that represents the linear state variable model

$$\dot{\mathbf{x}} = \mathbf{Ax} + \mathbf{Bu}, \mathbf{y} = \mathbf{Cx} + \mathbf{Du}$$

The vector \mathbf{u} represents the inputs, and the vector \mathbf{y} represents the outputs. Thus when connecting inputs to the State-Space block, care must be taken to connect them in the proper order.

Example

$$\dot{\mathbf{z}} = \mathbf{A}\mathbf{z} + \mathbf{B}f(t)$$

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & -\frac{12}{5} & \frac{4}{5} & \frac{8}{5} \\ 0 & 0 & 0 & 1 \\ \frac{4}{3} & \frac{8}{3} & -\frac{4}{3} & -\frac{8}{3} \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ \frac{1}{3} \end{bmatrix}$$

$$\mathbf{C} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \quad \mathbf{D} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

