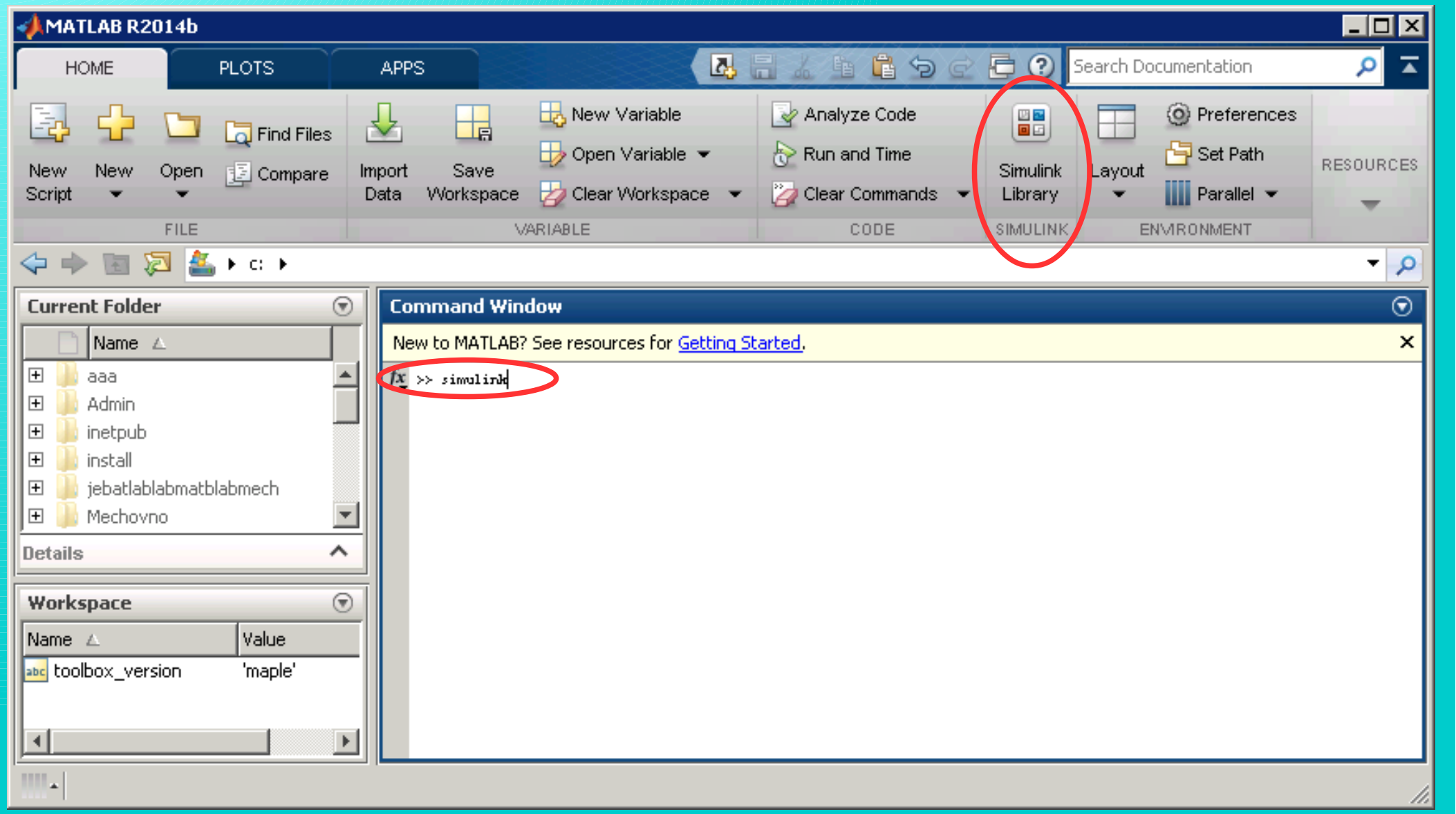
Simulations in Matlab

Simulink, differential equations in Simulink

Simulink

- Simulink is a graphical interface to Matlab
- Its results are time courses of variables depending on one variable, typically time
- Simulink contains built in differential equation solvers, so the discretization of differential equations is not necessary

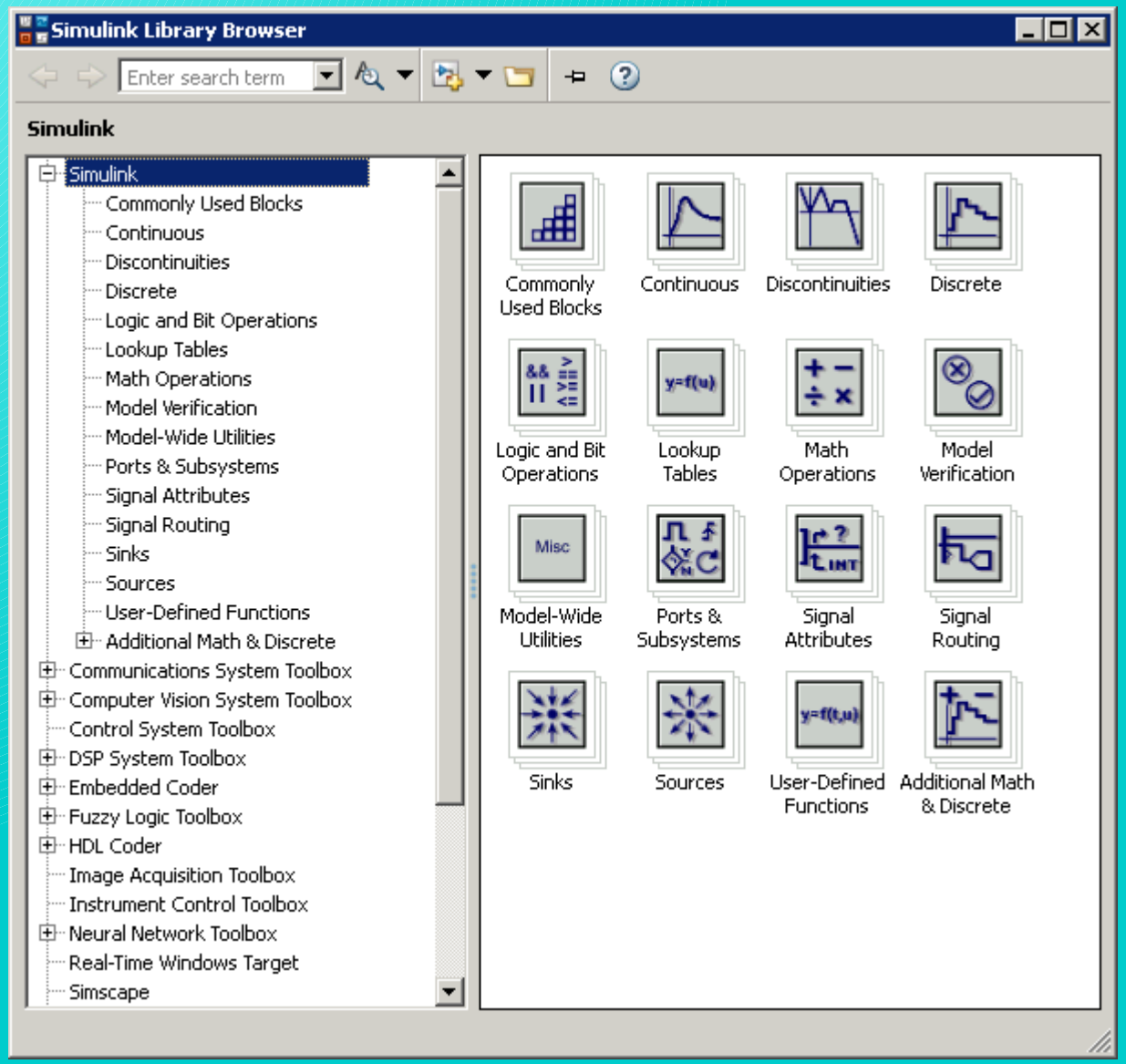
Running Simulink



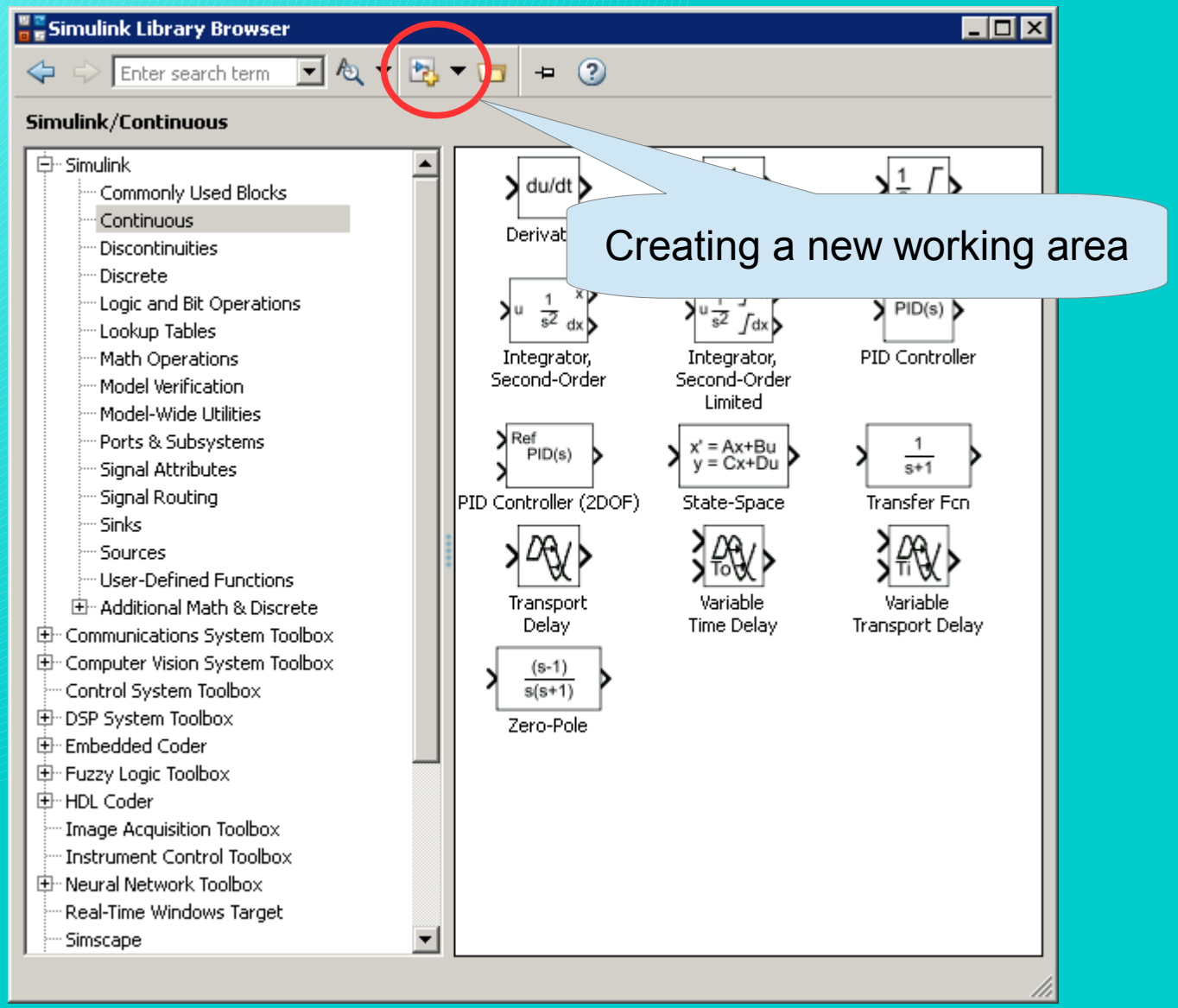
Programming in Simulink

- It is in a graphical form and it is based on placing and connecting blocks
- Blocks represent functions, connections represent variables
- Some blocks have only the output and are designates to generate variable values
- Some blocks have only the input and are designated to process the results – showing, saving, and others

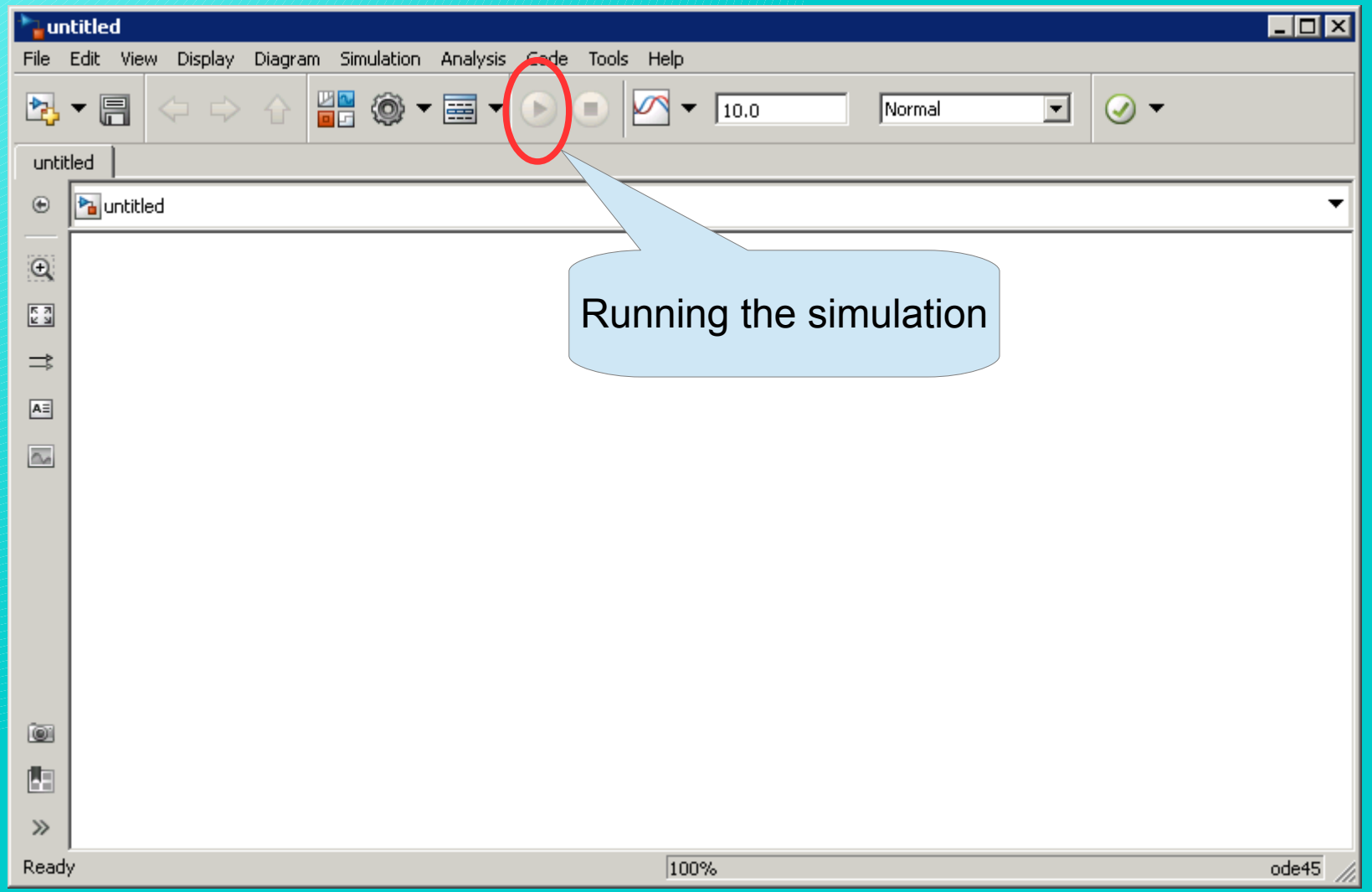
Block library



Block library



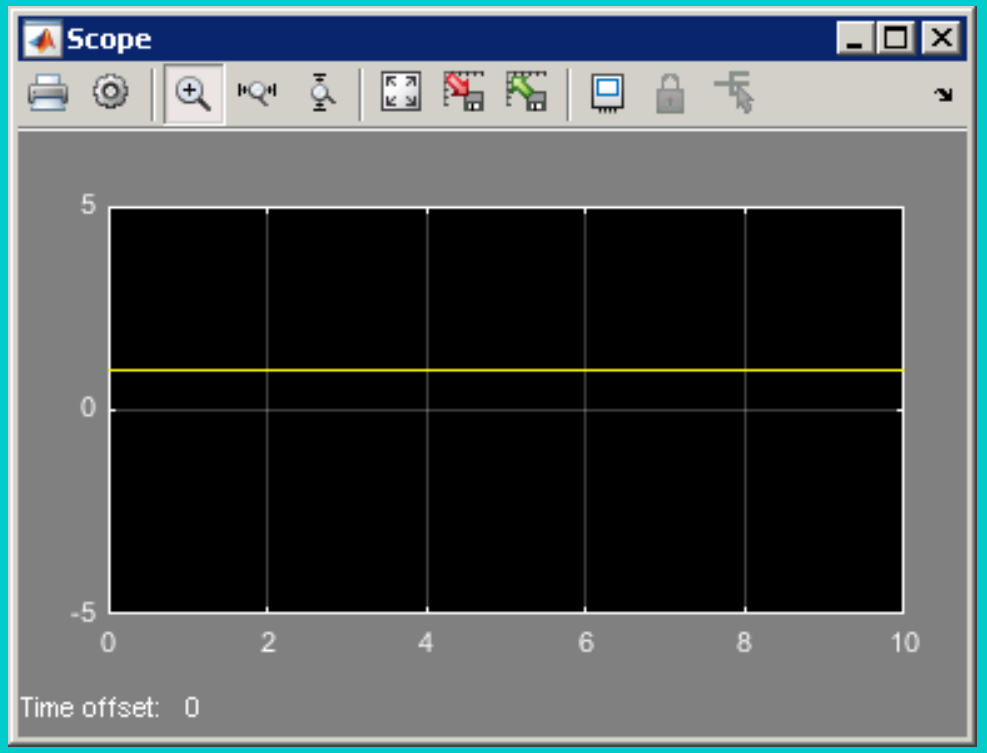
Working area for building a model



Model/scheme in Simulink

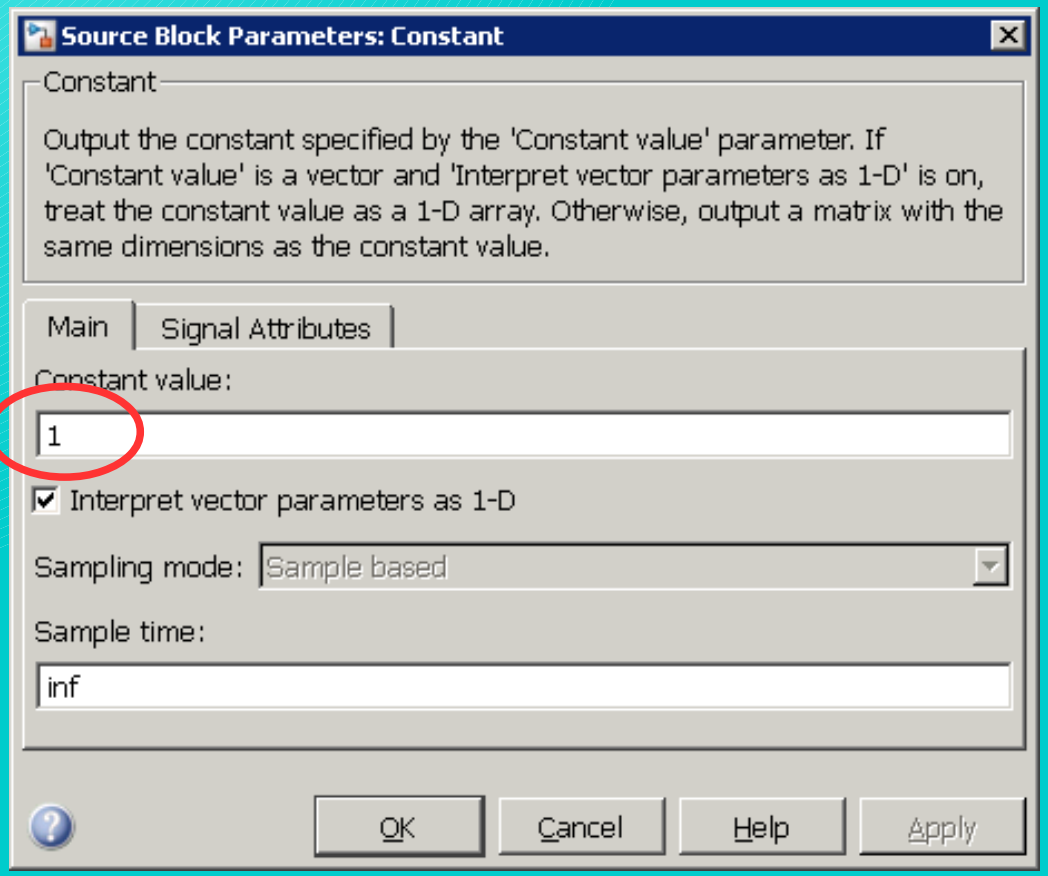
Simple scheme is possible to build with the use of the block Constant (from Simulink/Sources) and the block Scope (from Simulink/Sinks)

After the simulation run and double click on the block Scope, the results are shown.



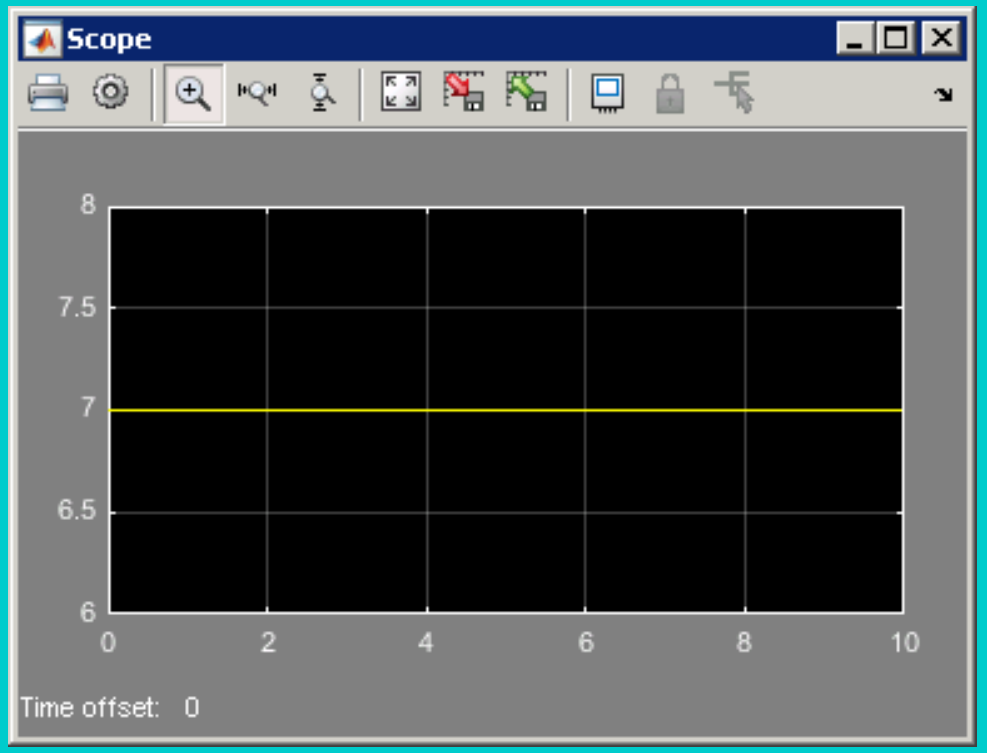
Block parameter settings

The parameters of majority of the blocks are possible to set in the dialog window that appears after double click on the chosen block.



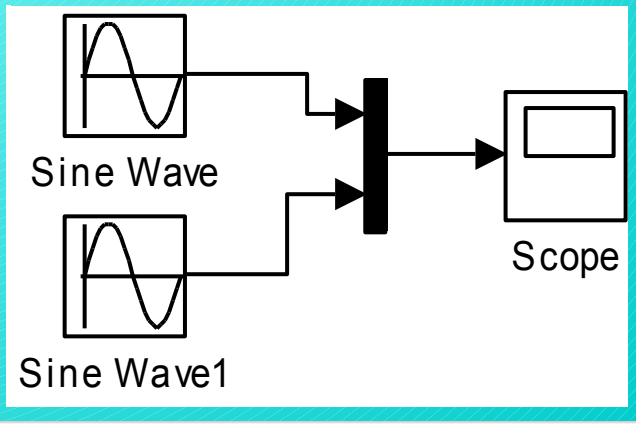
Model/scheme in Simulink

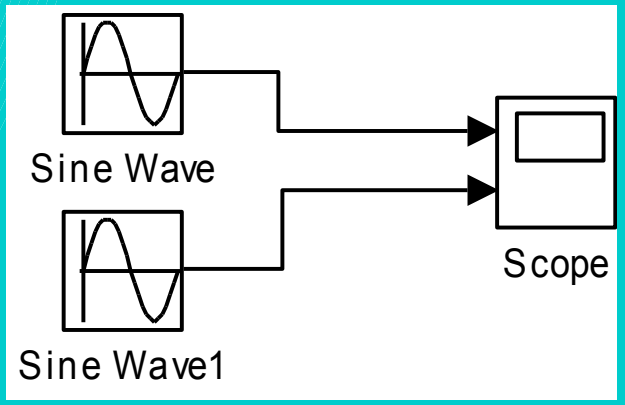
After the change of predefined value in the block Constant, the result is changed (it is necessarz to run the simulation again)

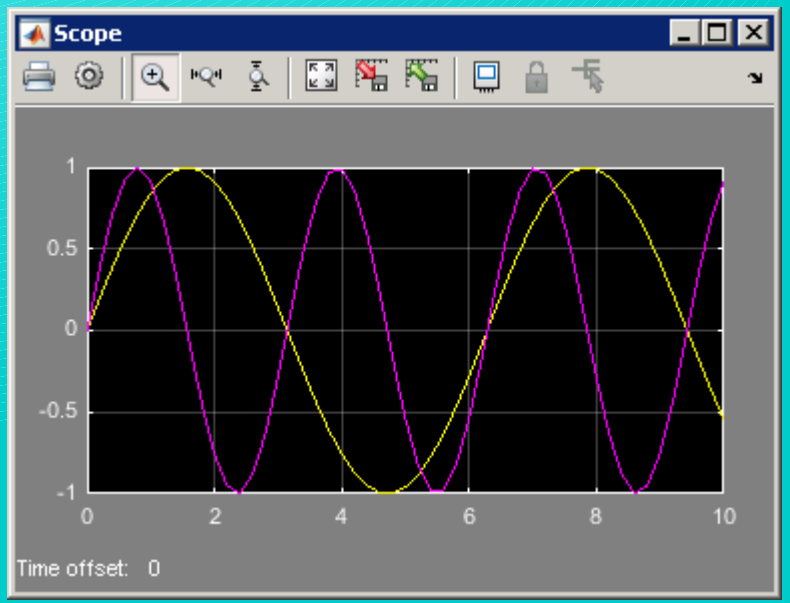


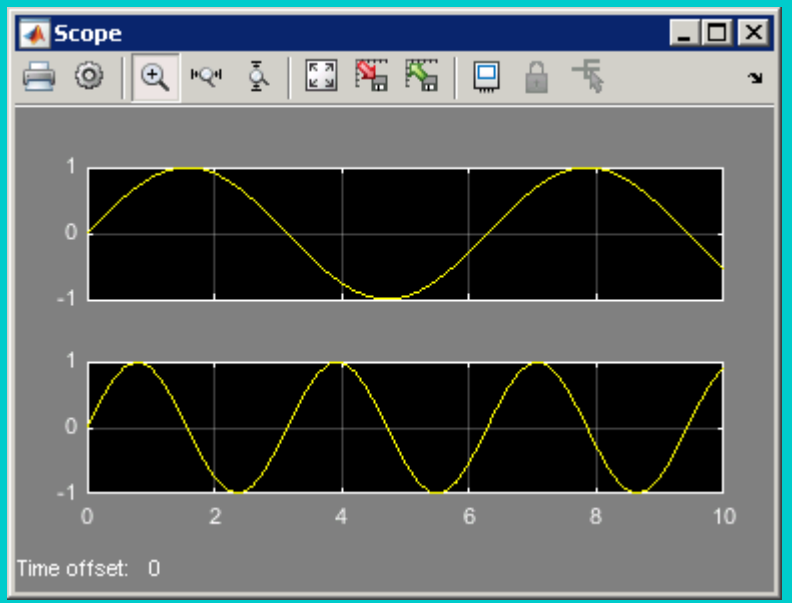
Showing more courses in one block Scope

By the use of a bock Mux (from Simulink/Signal Routing) or by setting of more inputs to the block Scope

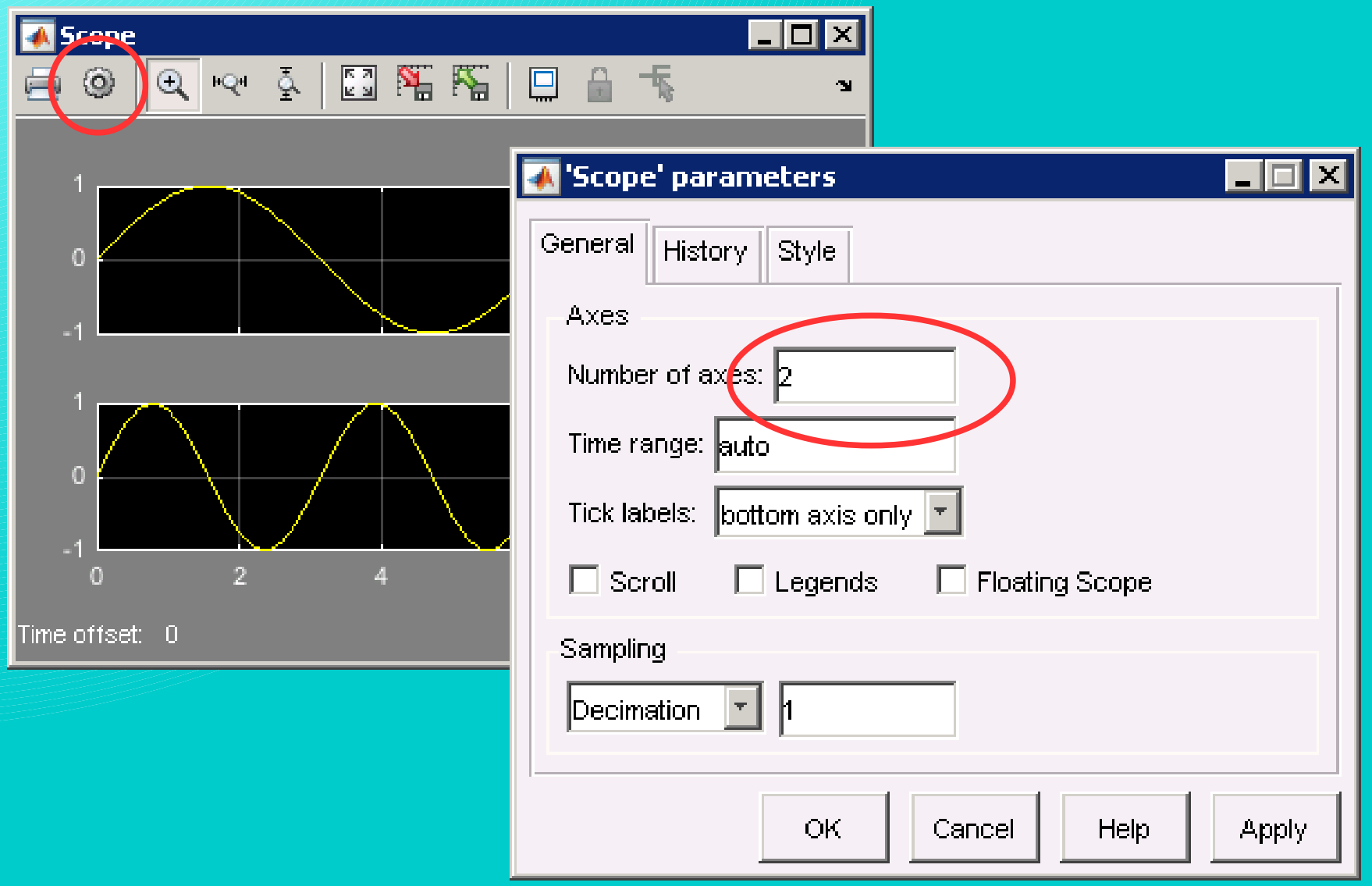




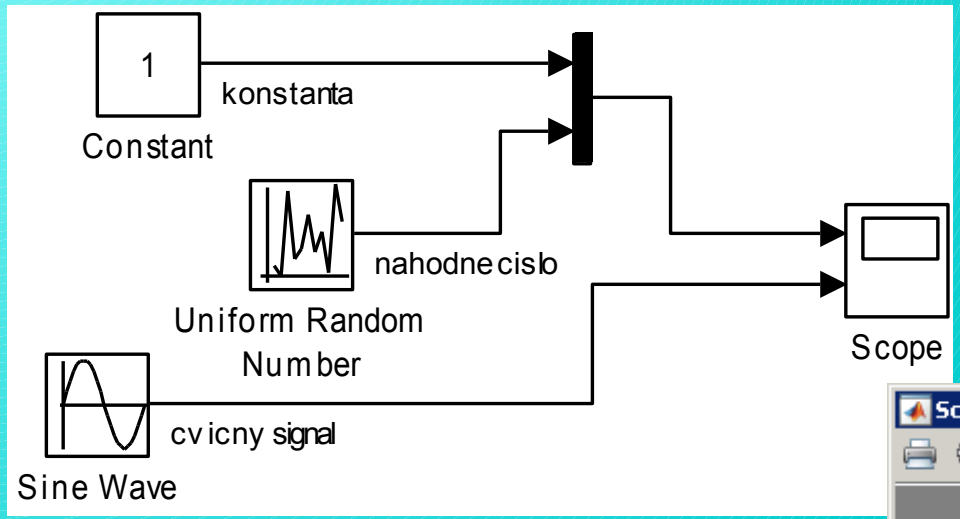


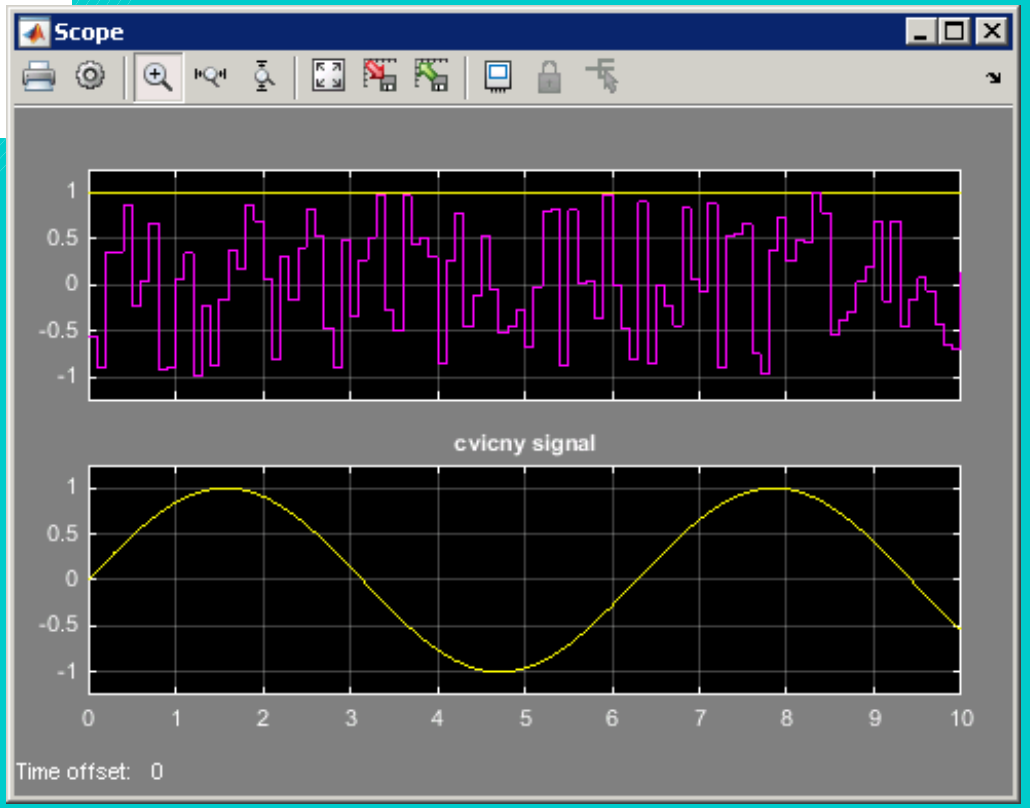


Showing more courses in one block Scope

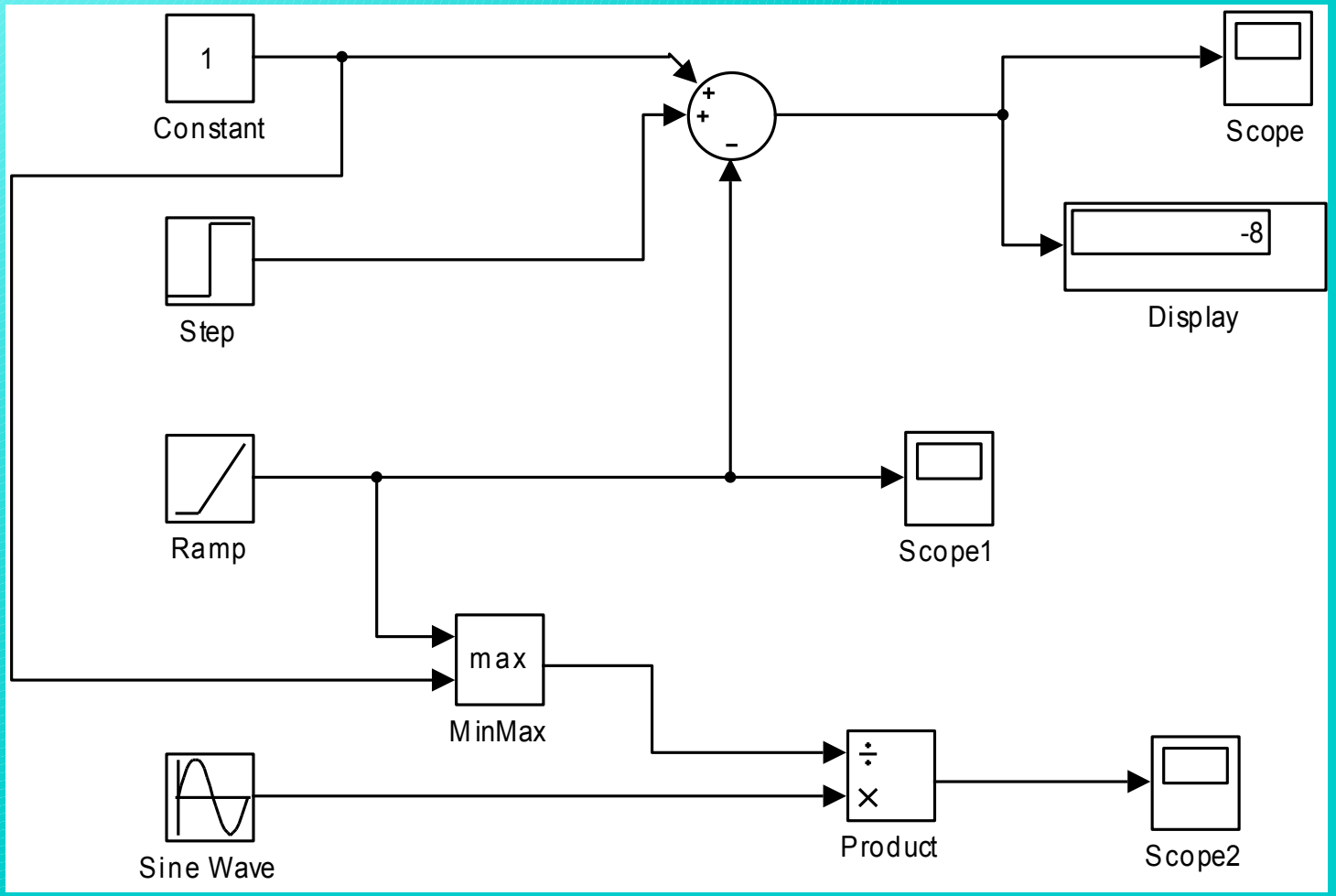


Showing more courses in one block Scope





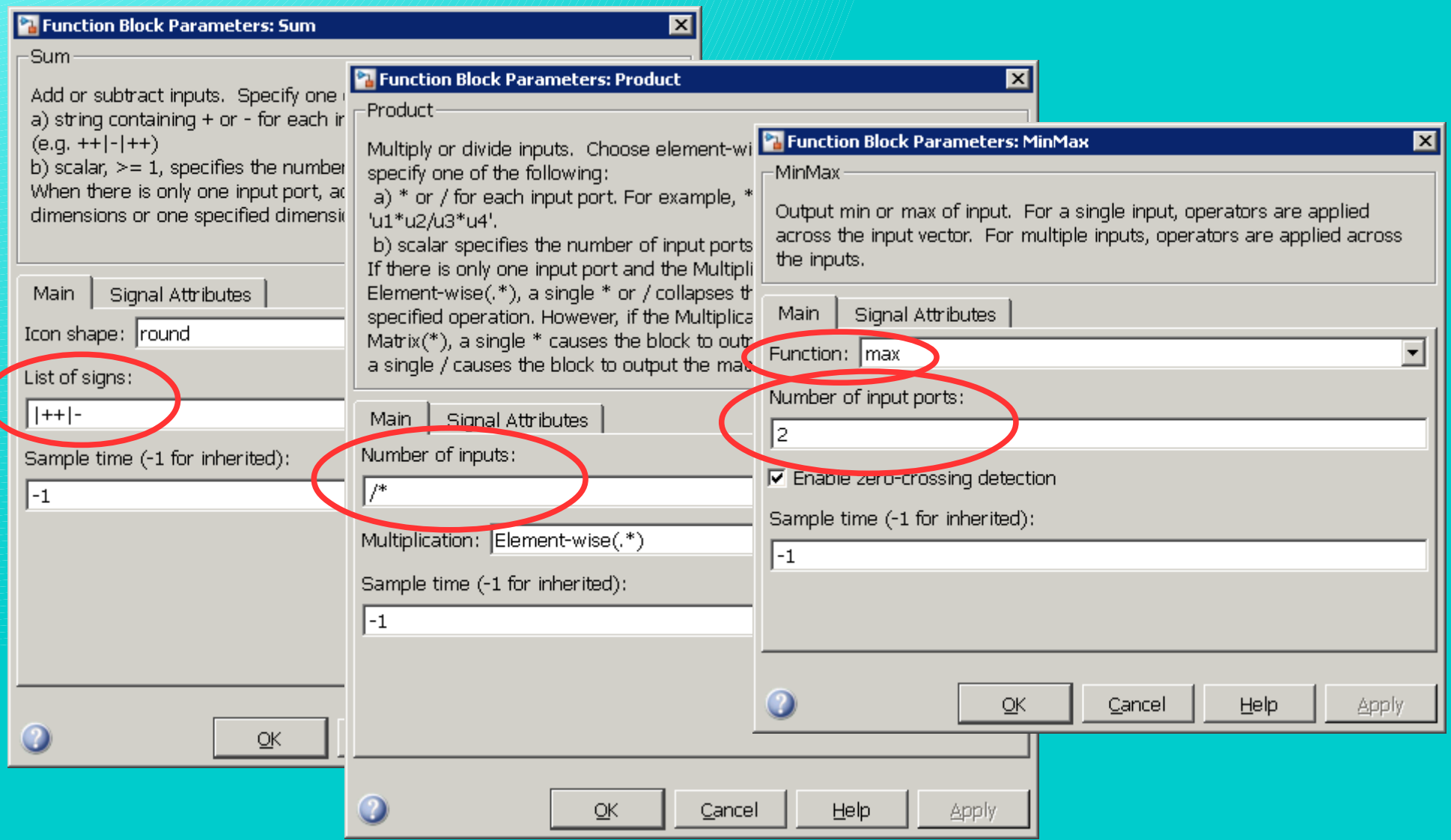
Demonstration scheme



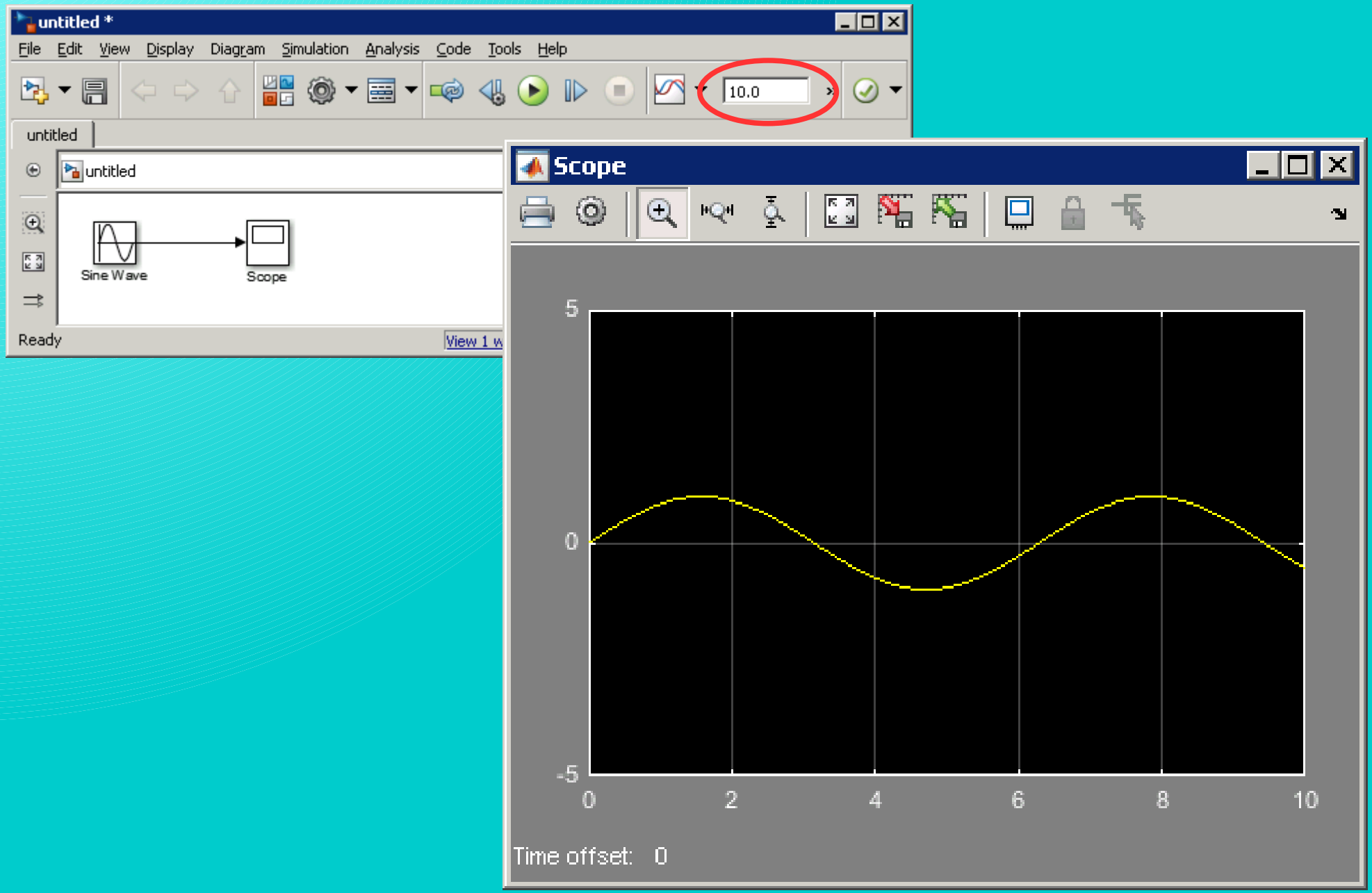
Scheme contains blocks from libraries Simulink/Sources, Simulink/Sinks a Simulink/Math Operations

Demonstration scheme

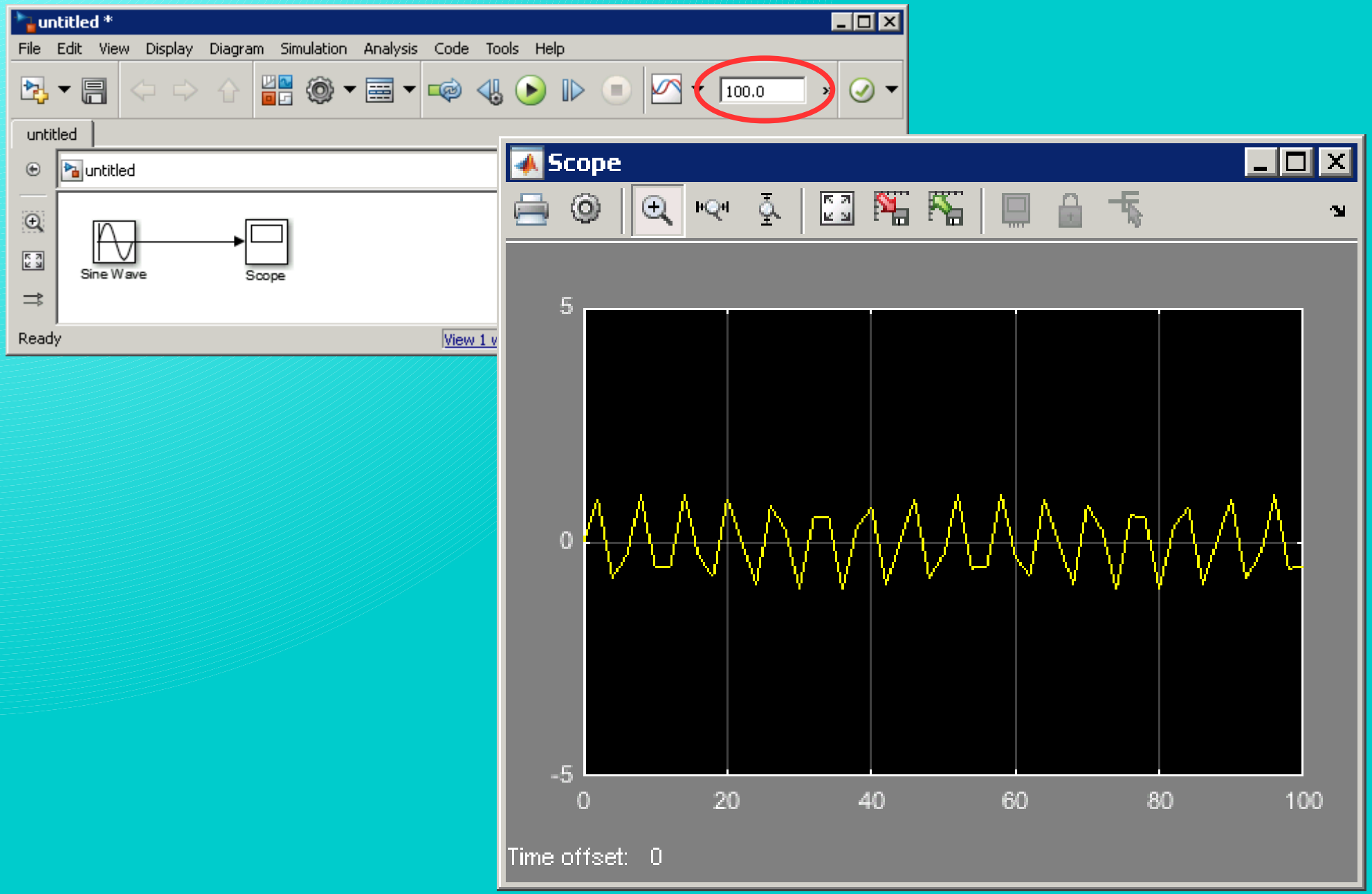
Block parameter settings in the demonstration scheme:



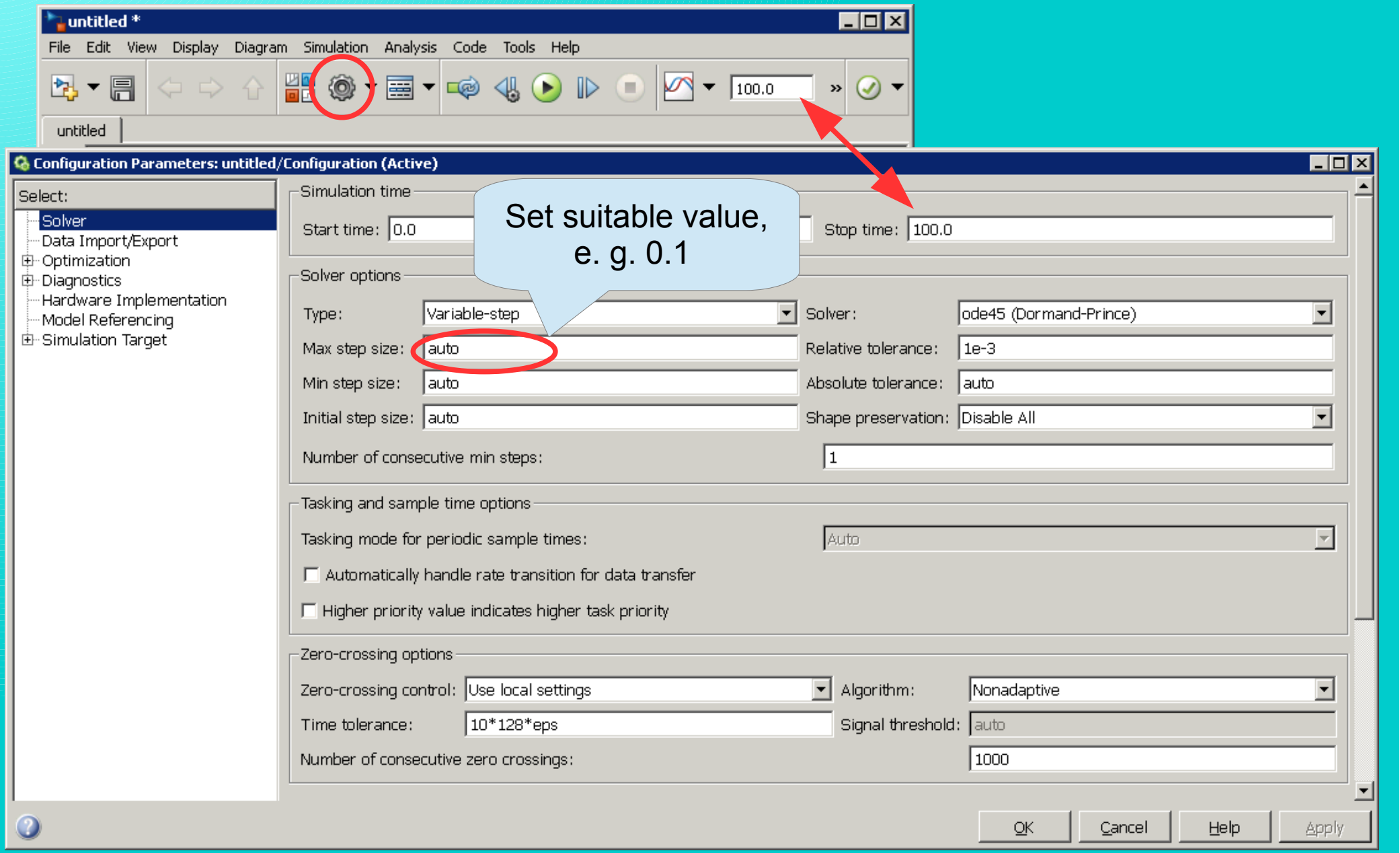
Simulation time and simulation step



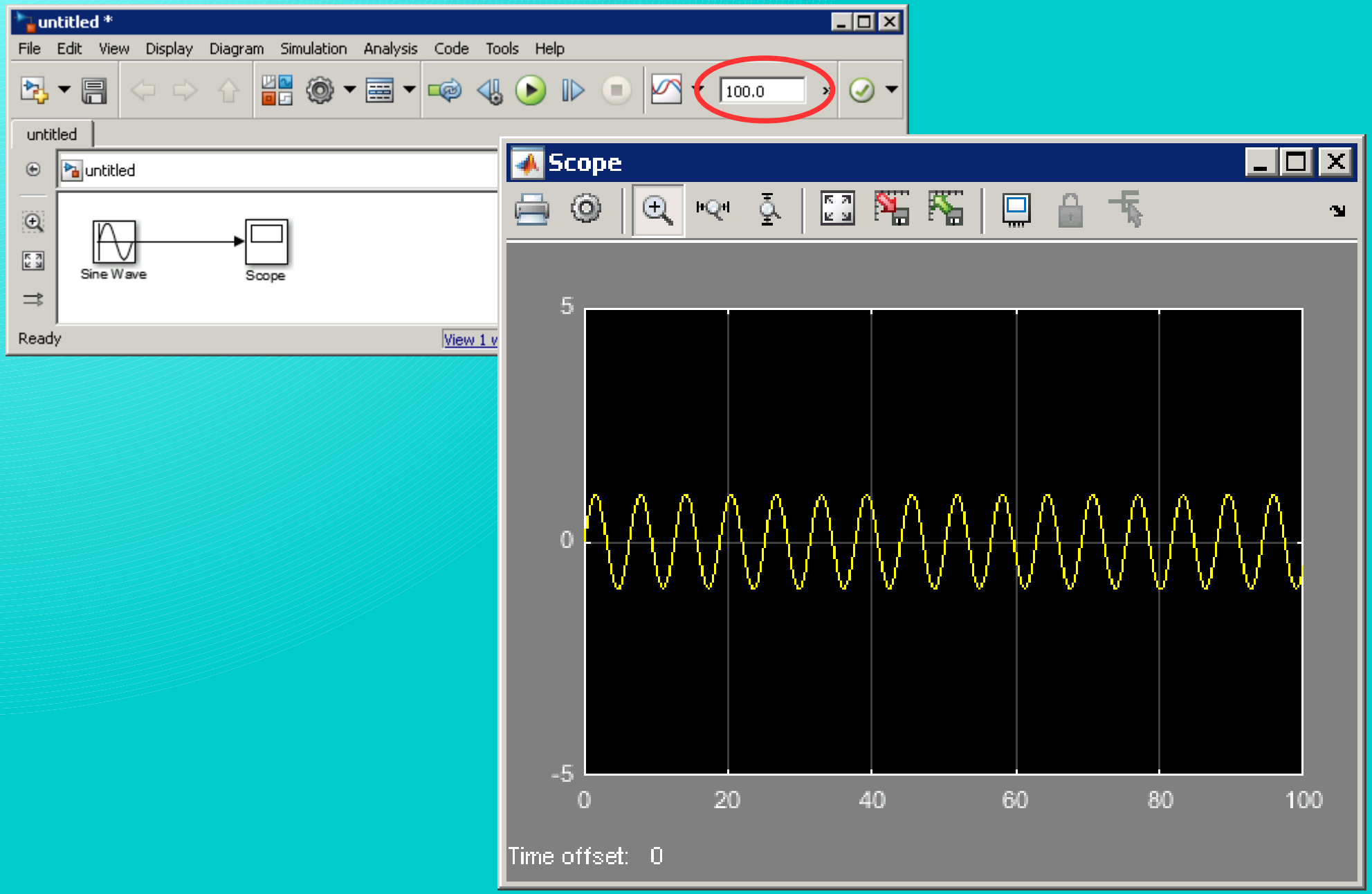
Simulation time and simulation step



Simulation time and simulation step

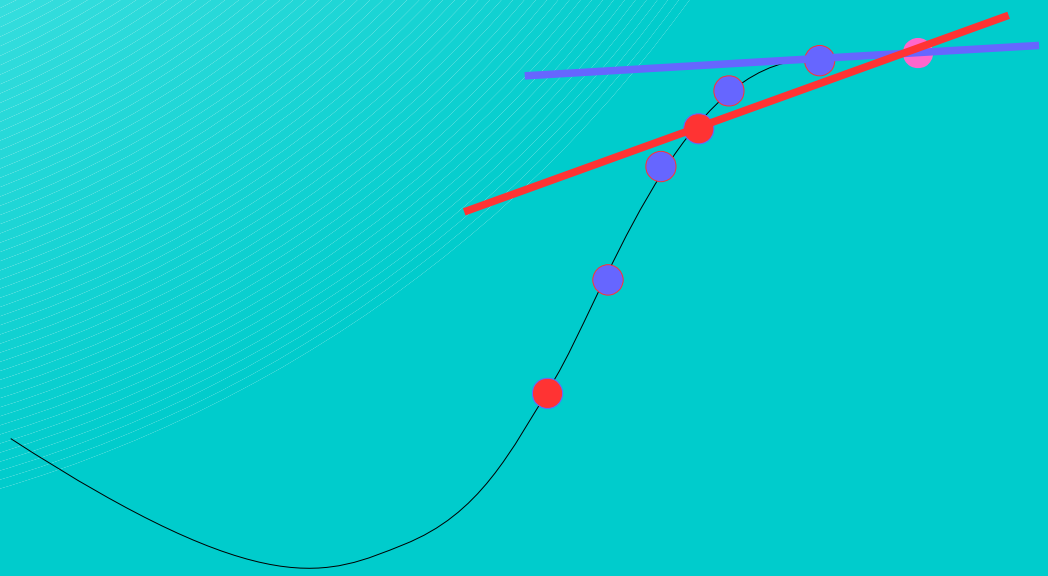


Simulation time an simulation step



Conversion of a differential equation into a Simulink model

There is one rule – avoiding block Derivation if it is possible.



Conversion of a differential equation into a Simulink model

The first step is separation of the highest derivation.

$$2\dot{y} + 3y = 0{,}5u$$

$$\dot{y} = \frac{0{,}5u - 3y}{2}$$

Conversion of a differential equation into a Simulink model

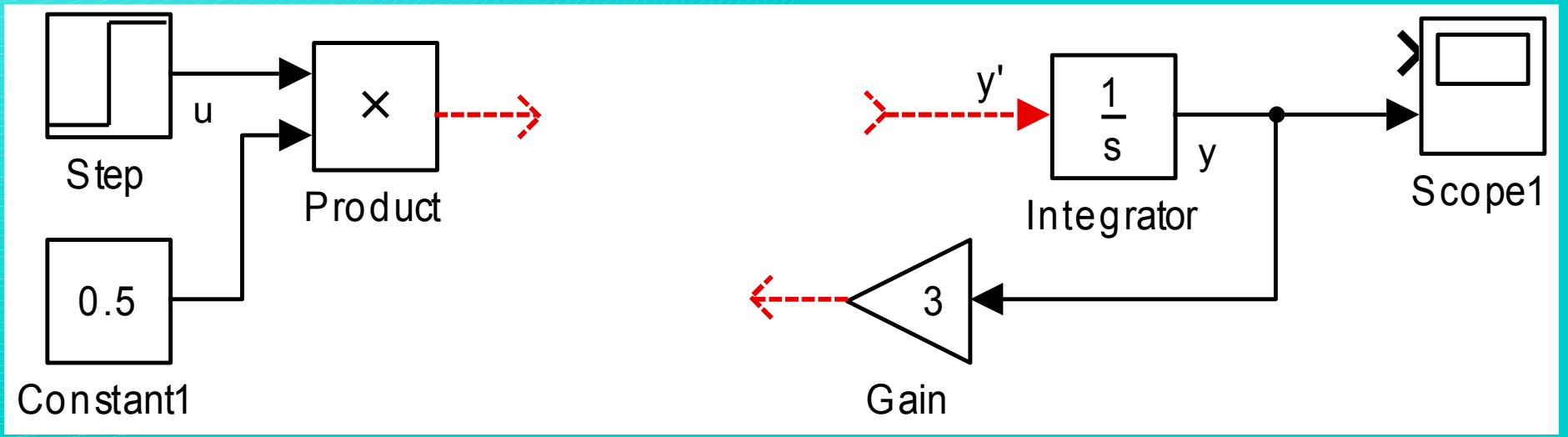
Then it is suitable to put all necessary variables into the scheme.

$$\dot{y} = \frac{0{,}5u - 3y}{2}$$

Conversion of a differential equation into a Simulink model

The next step is to multiply the variables by constants.

$$\dot{y} = \frac{0{,}5\,u - 3\,y}{2}$$

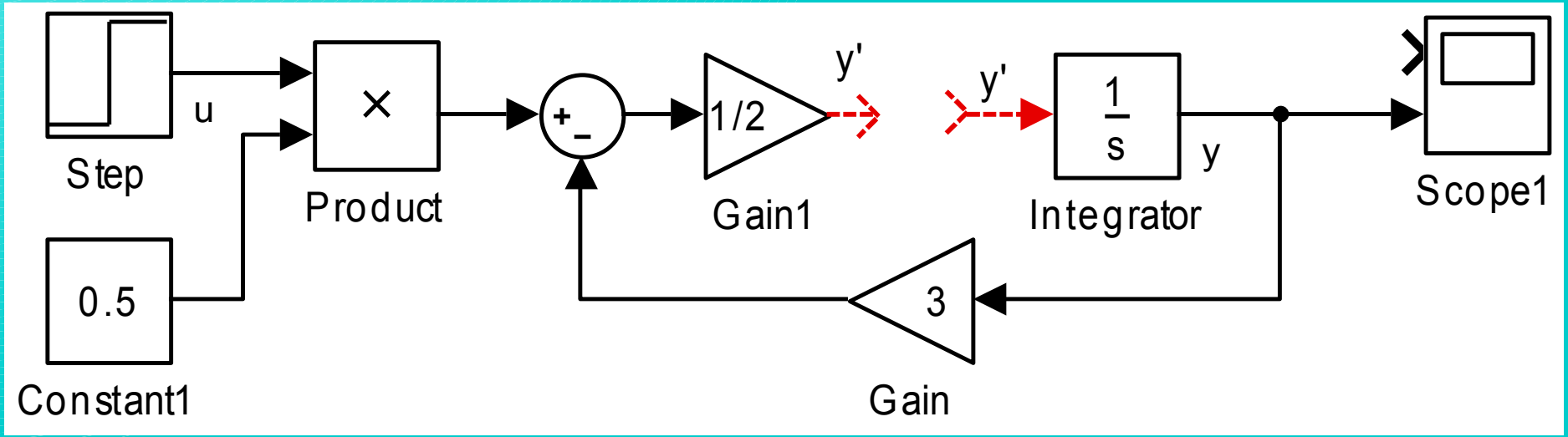


When multiplying by a constant, it is possible to use either the block Gain or the blocks Product and Constant.

Conversion of a differential equation into a Simulink model

Then the conversion of the fraction can be finished.

$$\dot{y} = \frac{0{,}5\,u - 3\,y}{2}$$

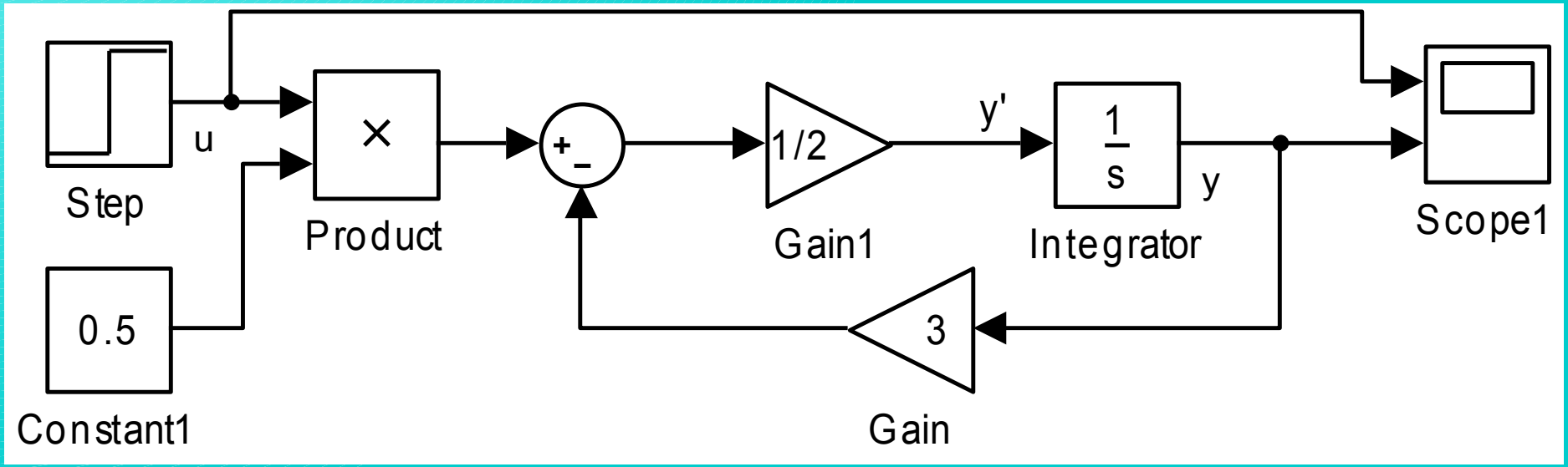


Both, the left side and the right side of the equation are finished now. As the values of both sides must be equal, both sides can be connected.

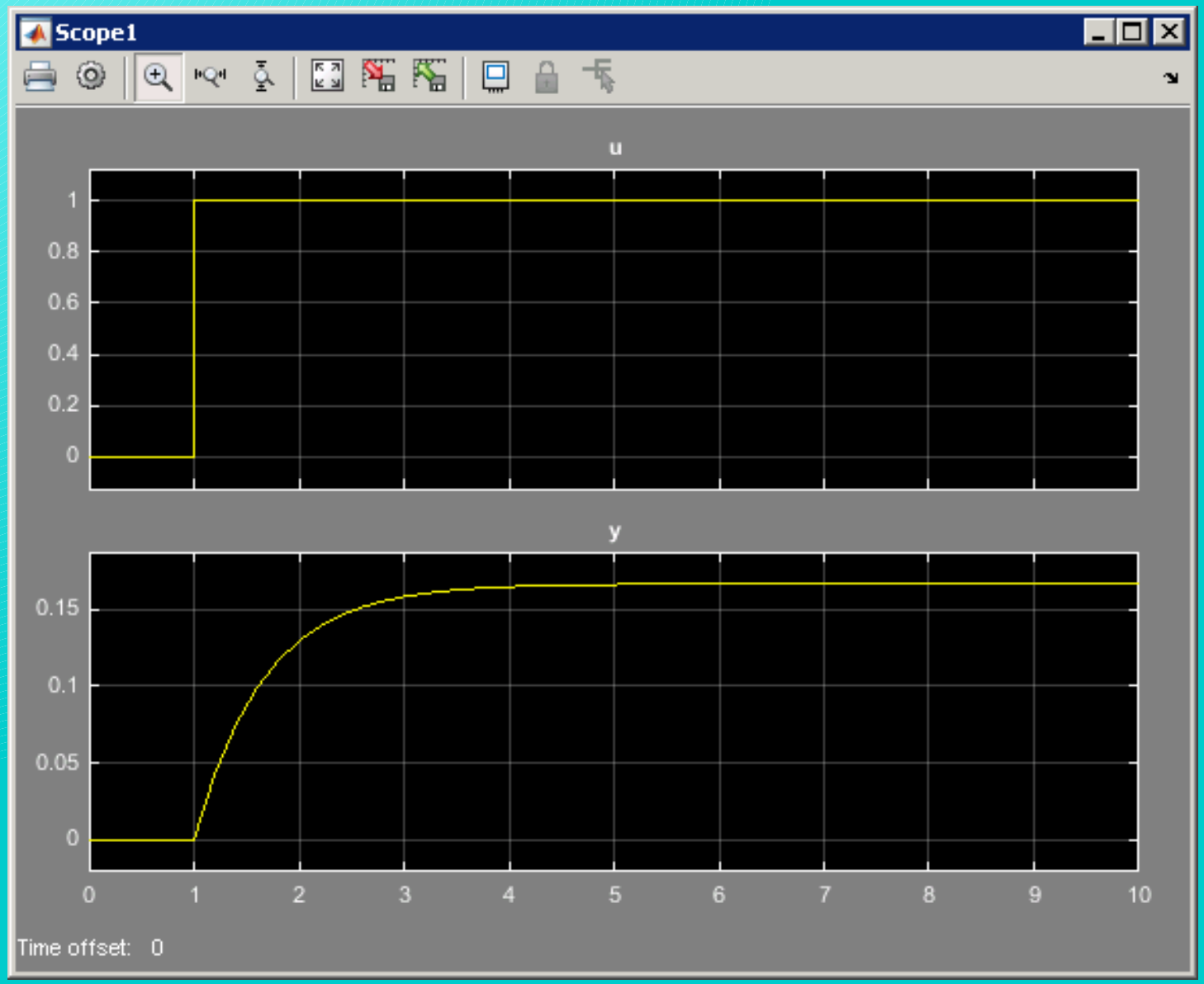
Conversion of a differential equation into a Simulink model

The final Simulink model is get by connecting left and right side of the scheme.Then the simulation can be run.

$$\dot{y} = \frac{0{,}5\,u - 3\,y}{2}$$



Conversion of a differential equation into a Simulink model



Conversion of a differential equation into a Simulink model

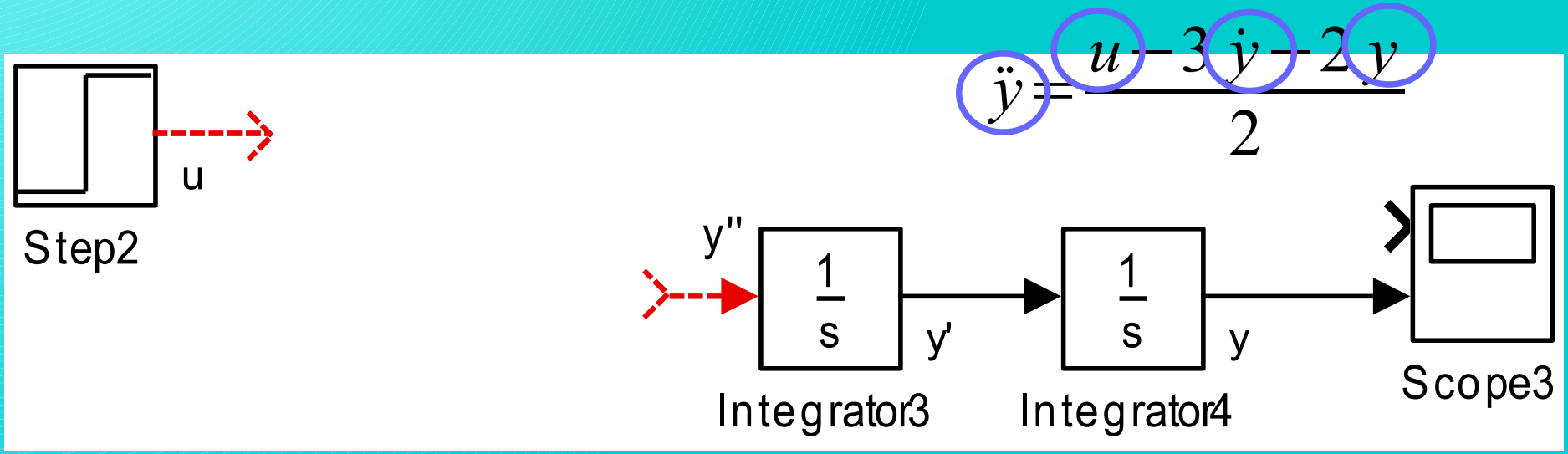
Similar procedure can be used also for differential equations of higher orders.

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

$$\ddot{y}=\frac{u-3\,\dot{y}-2\,y}{2}$$

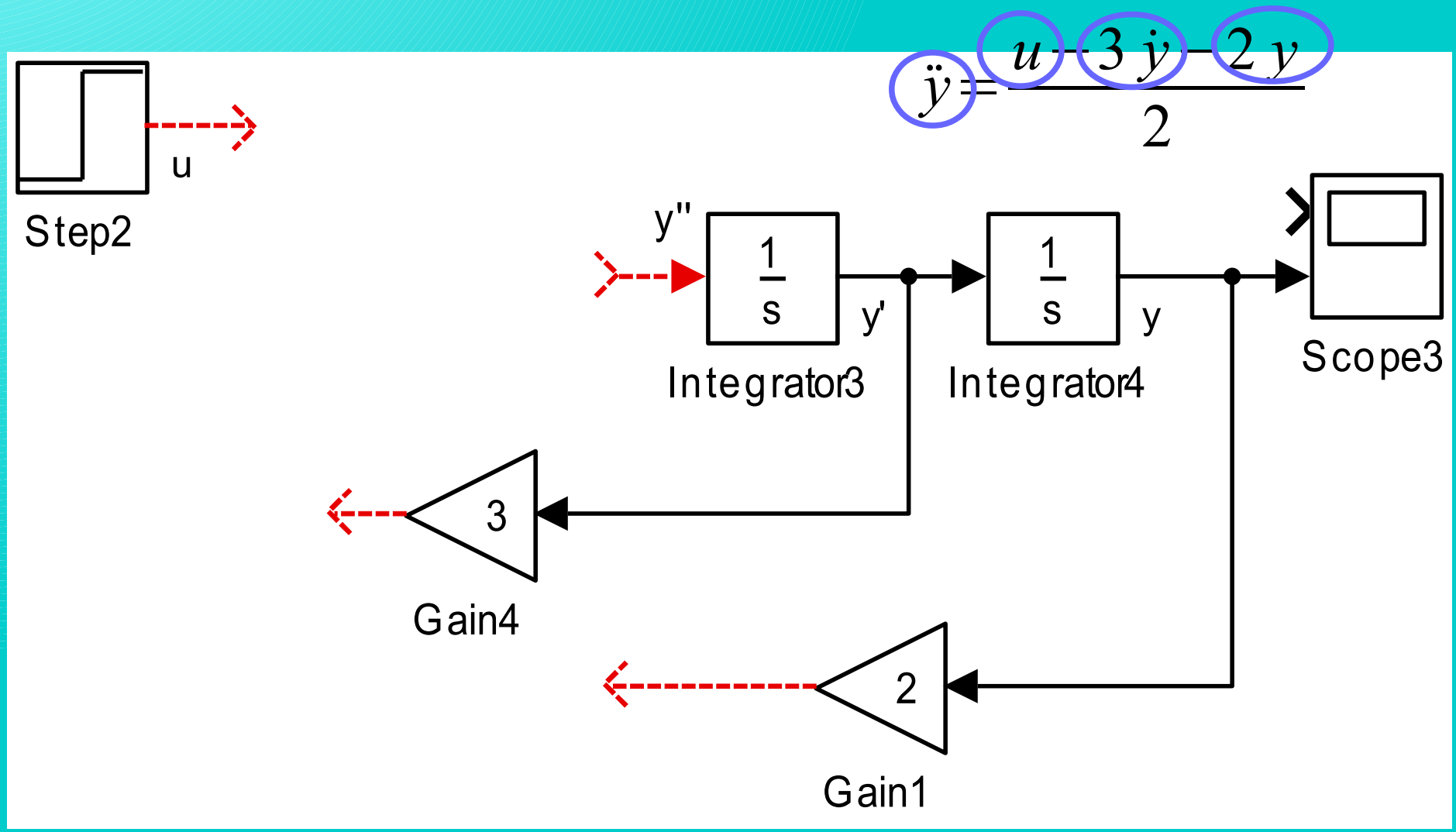
Conversion of a differential equation into a Simulink model

Preparing the variables into the model:



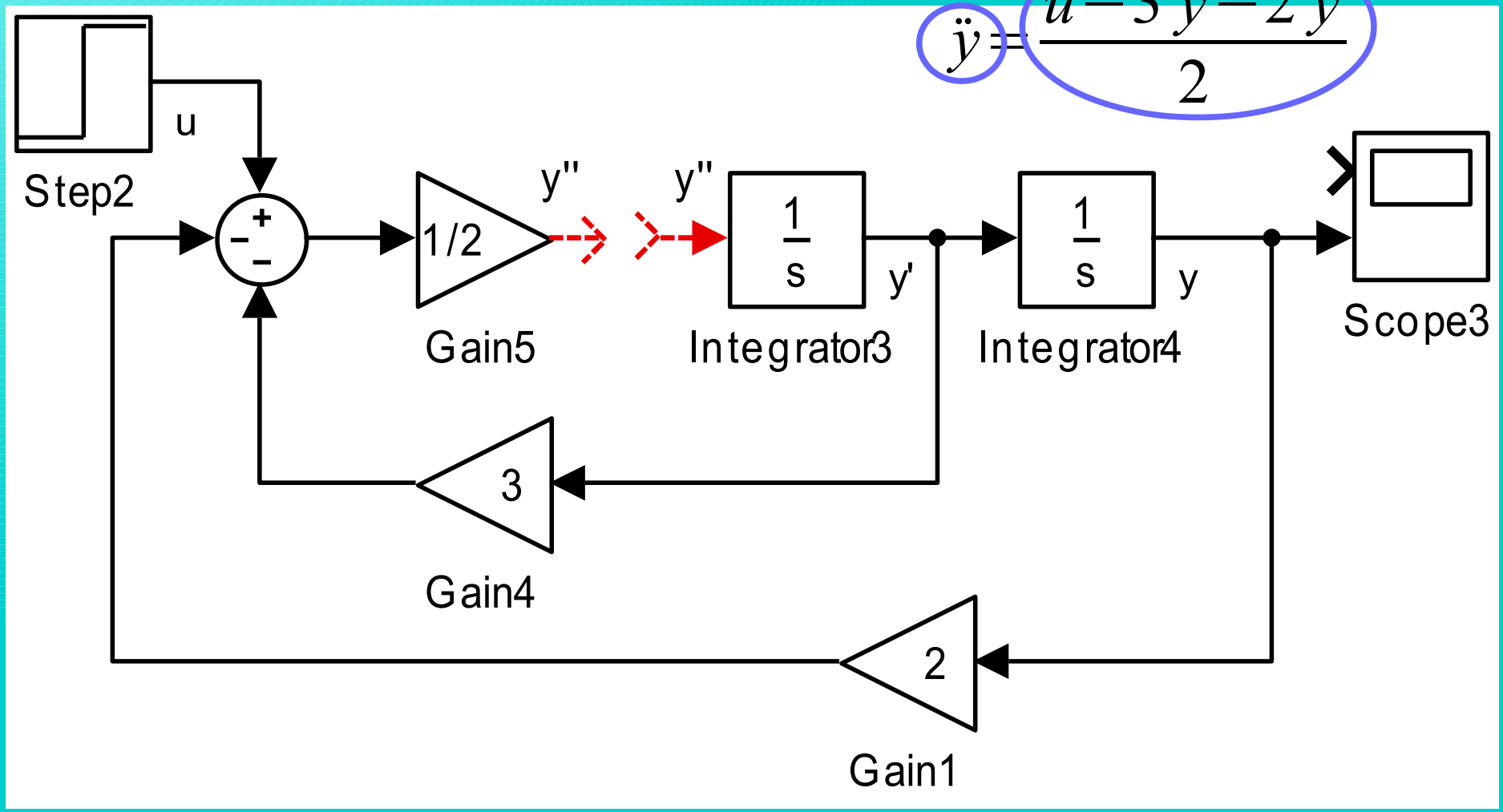
Conversion of a differential equation into a Simulink model

Multiplying variables by constants:



Conversion of a differential equation into a Simulink model

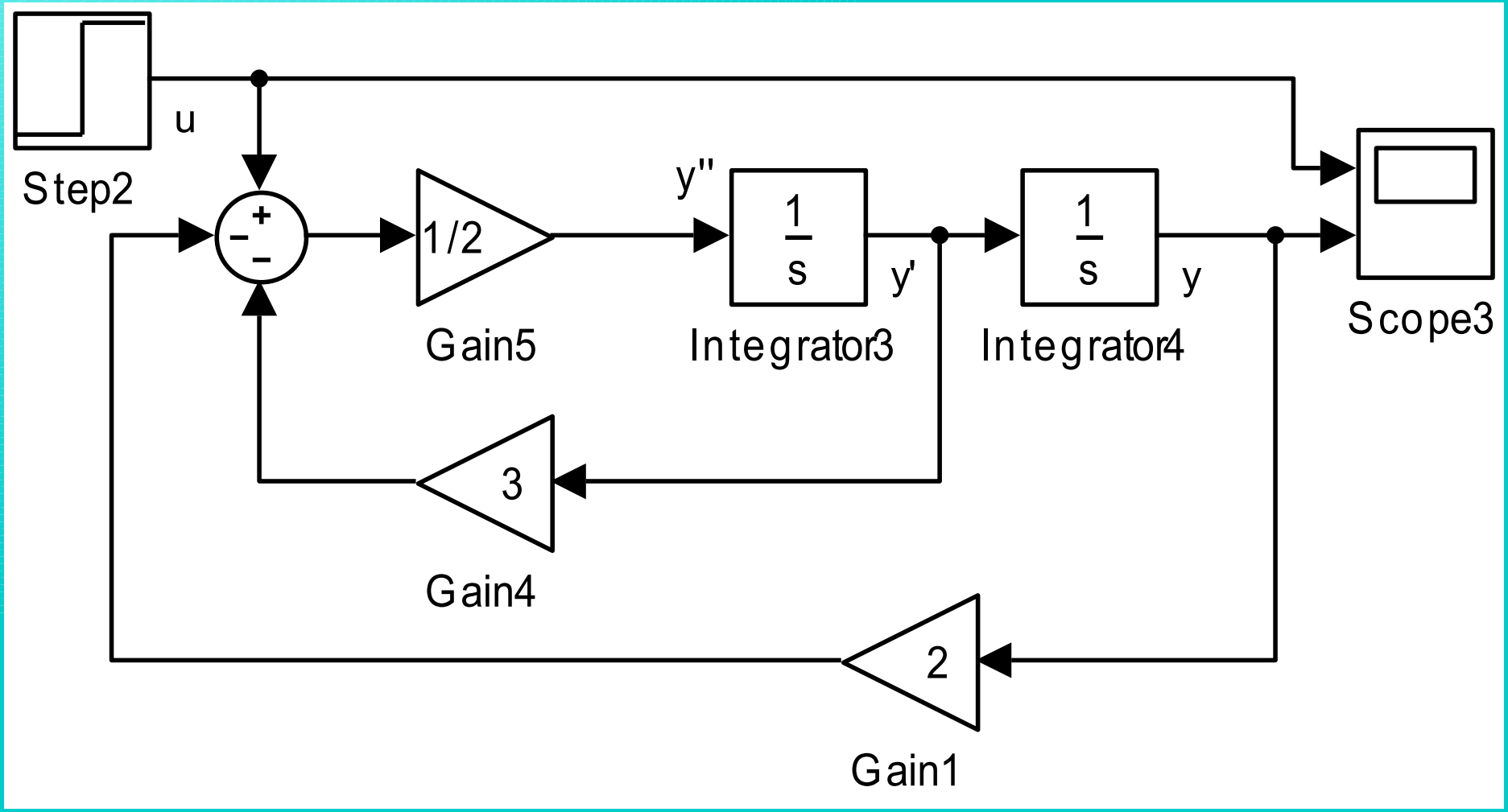
Finishing the fraction:



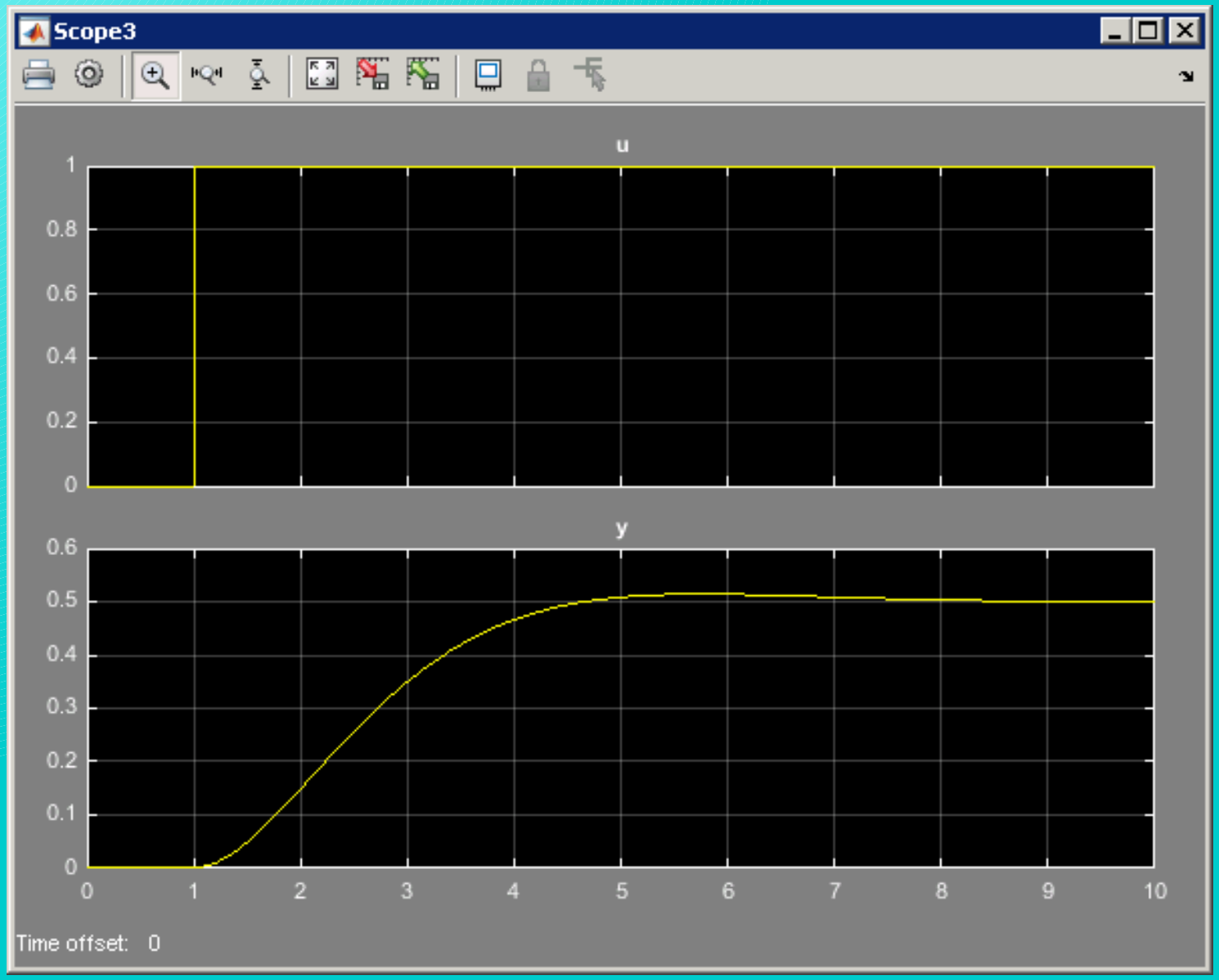
Conversion of a differential equation into a Simulink model

Finishing the model:

$$\ddot{y} = \frac{u - 3\,\dot{y} - 2\,y}{2}$$



Conversion of a differential equation into a Simulink model



Conversion of a differential equation into a Simulink model

Similar procedure can be used also when the differential equation is non-linear

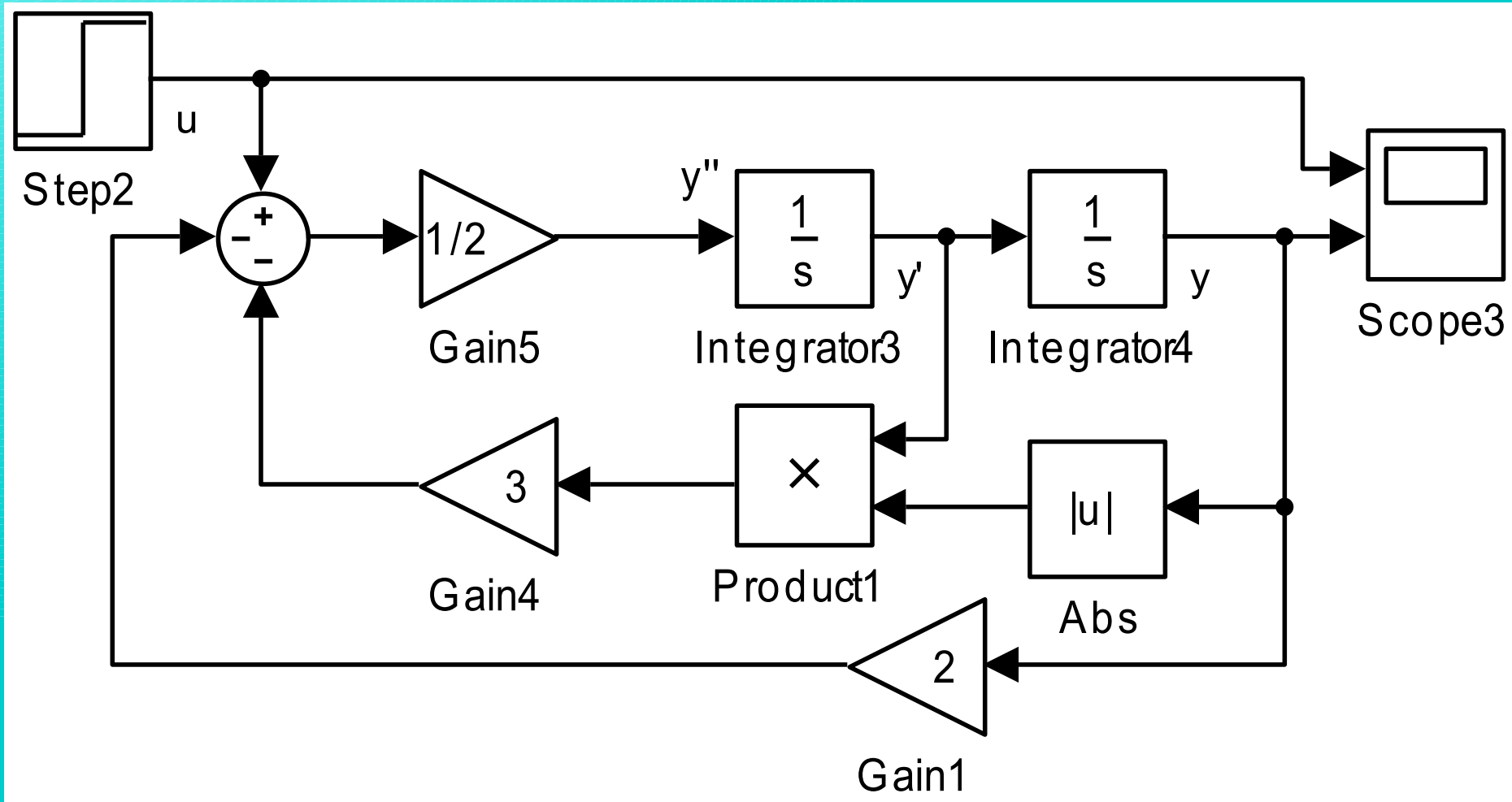
$$2\,\ddot{y}+3\,\dot{y}\,|y|+2\,y=u$$

$$\ddot{y}=\frac{u-3\,\dot{y}\,|y|-2\,y}{2}$$

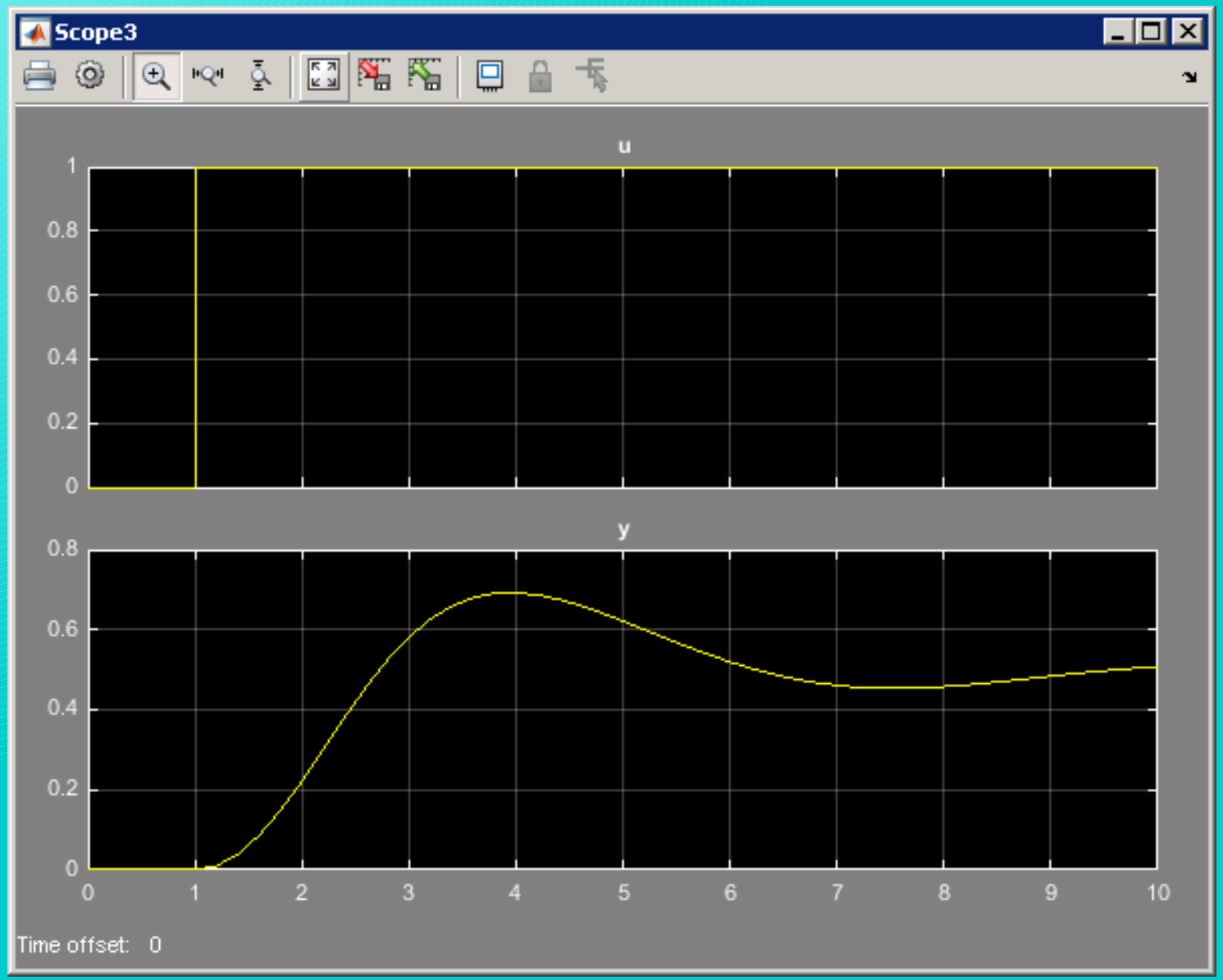
Conversion of a differential equation into a Simulink model

… that leads to a model:

$$\ddot{y} = \frac{u - 3\,\dot{y}\,|y| - 2\,y}{2}$$



Conversion of a differential equation into a Simulink model



Individual task

Create a Simulink model reprenting following differential equation:

$$\dddot{y} + 5{,}5\,\ddot{y} + 3{,}5\,\ddot{y} + 5\,\ddot{y} + \dot{y} + y = u$$