Process control laboratory practices

Use of MATLAB

Only basic knowledge needed for the Chemical Process Control laboratory practices are discussed here.

Starting MATLAB

After starting MATLAB, a Command Window is shown. Here commands can be entered after the cursor >>, and run by Enter.

Already used commands need not be typed again but can be selected using UP and DOWN arrows.

Left to Command Window the actual folder is shown. A selected file can be opened by doupble clicking.

Left to Command Window and at the bottom a command History is shown.

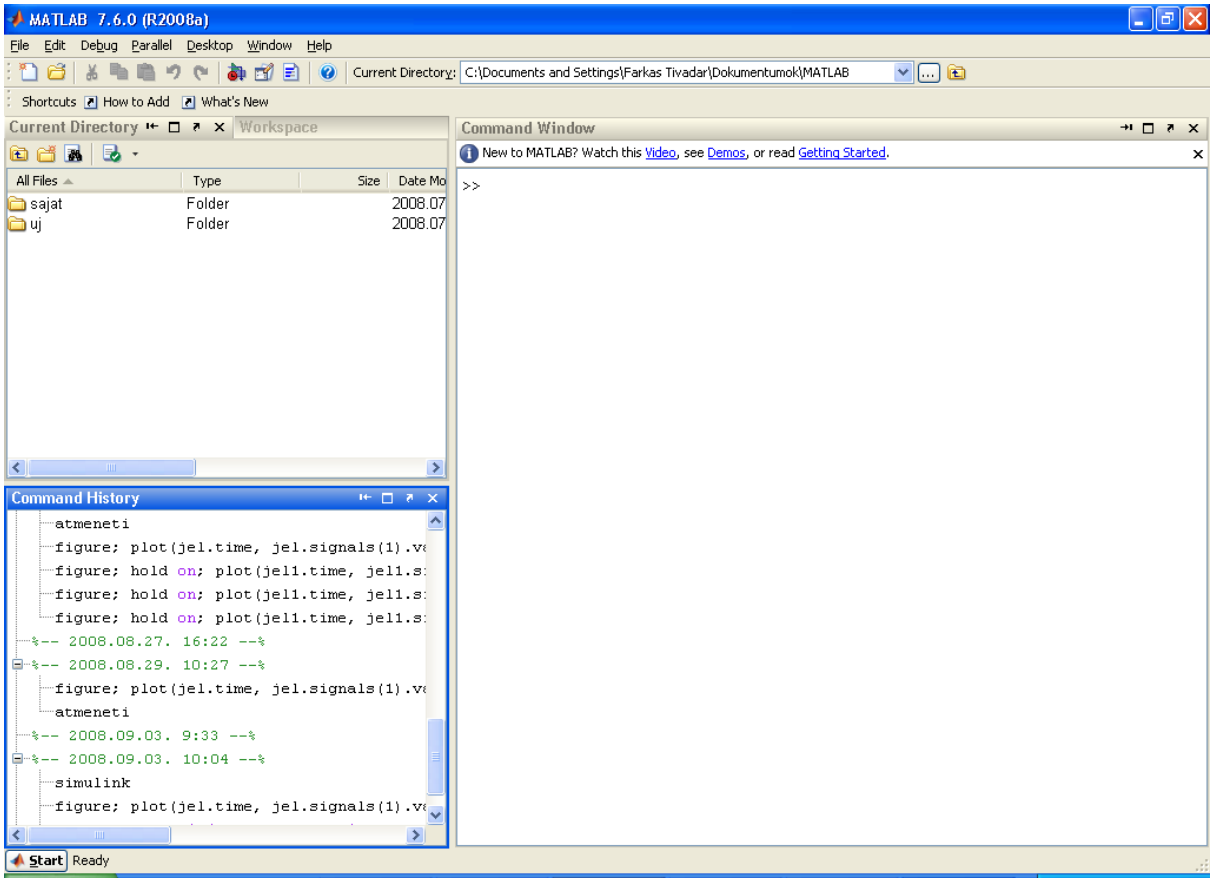


Fig. 1. Starting MATLAB

Simulink

Simulink is a module of MATLAB to model and simulate dynamic systems. This is used in our practices.

Simulink can be started from Command Window using the ’simulink’ command.

Simulink Library Browser

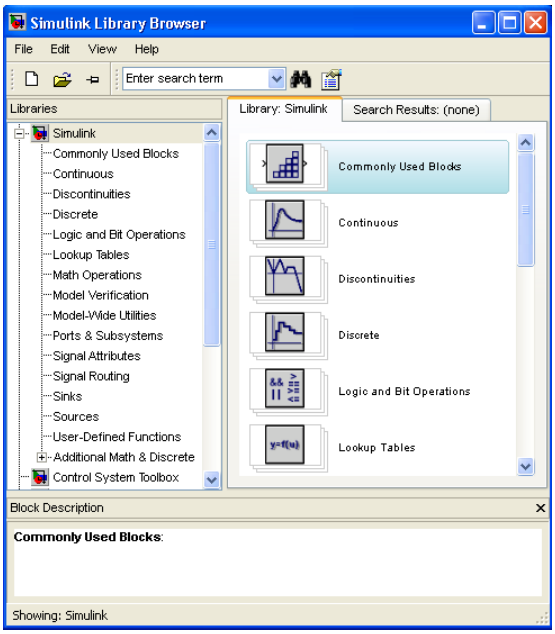
After starting Simulink, the Simulink Library Browser is open showing the units applicable in the models.

New model cen be created by clicking on the icon  in the left upper corner of Simulink Library Browser.

The units from Simulink Library Browser can be copied by mouse to the already created model.

Properties (number of input/output ports and working parameters) of the units can be entered in a pop-up window that opens after double clicking on the unit.

Connection between the units can be created by drawing an arrowed line from an output port to an input port by continuously pressing down the mouse button. The connections can be branched. For this aim the starting point is not an output port but an already existing connection. Then both (or more) tartget points will receive the same signal from the output port.



1.2. ábra Simulink Library Browser

Summing up signals can be done by using the Sum unit.

Simulation

Simulation of a model can be performed by clicking on the icon  over the model. A simulation can be stopped (assuming it is too long) by clicking on the icon  . Length of the simulation can be preset in seconds in a box right to the above two icons.

Results of the simulation can be visualized by using some sink unit and the ’figure’ command.

Configuration Parameters

Step size of the simulation can be given (if needed beause the results are more broken lines than smooth curves) after selecting the menu item Simulation – Configuration Parameters, and then selecting either item ’Variable-step’ or ’Fixed-step’ in the ’Type’ rolling menu. If ’Variable-step’ is selected then the software automatically selects a step size. If ’Fixed-step’ is selected then you can enter a step size in a pop-up box.

Normally a step size 0.1 is acceptable; this is preset in the preliminary prepared models of our laboratory practices.

Bode and Nyquist plots

To produce a Bode plot or a Nyquist plot, at least one In1 unit and one Out1 unit must be present in the model, and you have to select menu intem Tools – Control Design – Linear Analysis. There is a rolling menu in the pop-up window Control and Estimation Tools Manager, and you have to select the type of the diagram and then click on the button ’Linearize Model’ found left to it.

Data of points in the visualized plot can be called up by clicking the point.

If more than one signal are to be visualized then you click on the diagram with the right mouse button and select item I/O Grouping – All in the pop-up menu.

Type of the diagram can be changed in item Plot types in the pop-up menu after clicking on the diagram with the right mouse button.

Bode plot

Default unit of the vertical axis is decibels. This can be modified in the pop-up window shown after selecting item Properties after clicking on the diagram with the right mouse button. Select value ’absolute’ in the first rolling menu and ’log scale’ in the second rolling menu of ’Units’/’Magnitude’

Nyquist plot

Negative frequencies are also shown by default but can be switched off in the item Show of the menu popping up after clicking on the diagram with the right mouse button.

Making plots

Ouput signals can be visualized, after running simulation, using the Scope unit. A more elaborated plot can also be made, but the Scope unit must be there first.

The signal to be plotted must be connected to Scope. A reference name to the signals can and must be given in the properties window of Scope., and the format ’Structure with time’ must be selected before running the simulation.

Then, after running the simulation, the following command in the Command Window makes the figure:

figure; plot(*variable_name*.time, *variable_name*.signals(1).values)

In the place of the dummy ’*variable_name*’ you should type the reference name given in the Scope unit. (In the preliminary prepared models the names are somethig like 'signal' or 'jel'. Name of the signal of the integral criterion is 'ISE' /for interated square error/.)

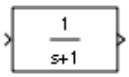
After running the above command, the plot is visualized in a new window. A data tip, showing uo the data of a point, can be set on the figure by first clicking on icon  and a point in the curve. Another data point can also be inserted selecting item Create New Datatip in the pop-up menu after clicking on the diagram with the right mouse button.

Axis scales can be modified in the lower part of the window that opens after selecting item Axes Properties of the menu Edit. Here you can precisely enter the the visualized intervals of the axes.

Units

A few units frequently used in the laboratory practices are listed here together their usual settings.

Simulink / Continuous / Transfer Fcn



Transfer function of PT1, PT2, etc.

Numerator coefficient – Gain

Denominator coefficient – Time constant powers (constant, T_1, T_2^2, etc.)

Simulink / Math Operations / Sum

Calculates sums and differences

List of signs – You can specify if the signals are added (+) to the others or subtracted (–) from the others.

Simulink / Signal Routing / Mux

This unit binds to a bunch the signals to a common Scope unit.

Simulink / Sources / In1

Intput port used for visualizing Bode and Nyquist plots.

Simulink / Sinks / Out1

Output port used for visualizing Bode and Nyquist plots.

Simulink / Sinks / Scope

Plotting signals as time functions

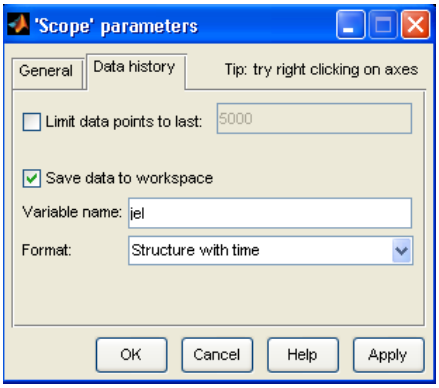
 – Scope parameters

Tick off checkbox 'Limit data points to last'.

Tick on checkbox 'Save data to workspace'.

Write a reference name in the field 'Variable name'.

Write mezőben a 'Structure with time' in the field 'Format' and then you can use the plot command.



1.3. ábra 'Scope' parameters

 – Enlarge the selected box.

 – Enlarge axis X on the selected box.

 – Enlarge axis Y on the selected box.

 – Full diagram with maximum enlargement.

Simulink / Sources / Sine Wave

Sinusoidal disturbance

- Amplitude
- Frequency (rad/sec)

Simulink / Sources / Step

Step disturbance

- Step time
- Final value

Simulink Extras / Additional Linear / PID Controller

PID szabályozó

- Proportional – P gain (A_P).
- Integral – I gain (A_I).
- Derivative – D gain (A_D).