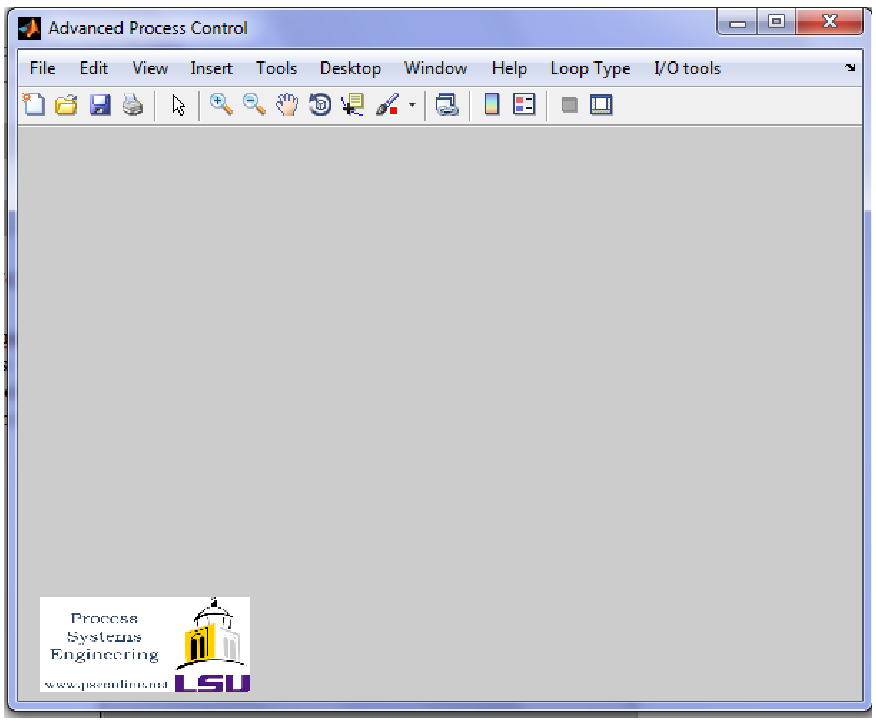
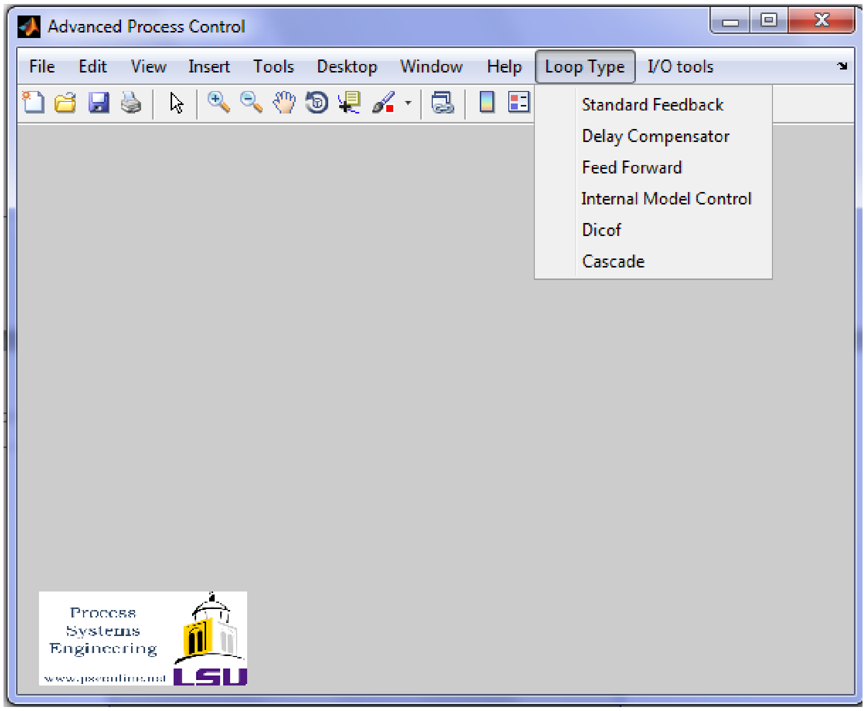
Software for Process Control

ADVANCED PROCESS CONTROL PACKAGE (APCON_TOOL)

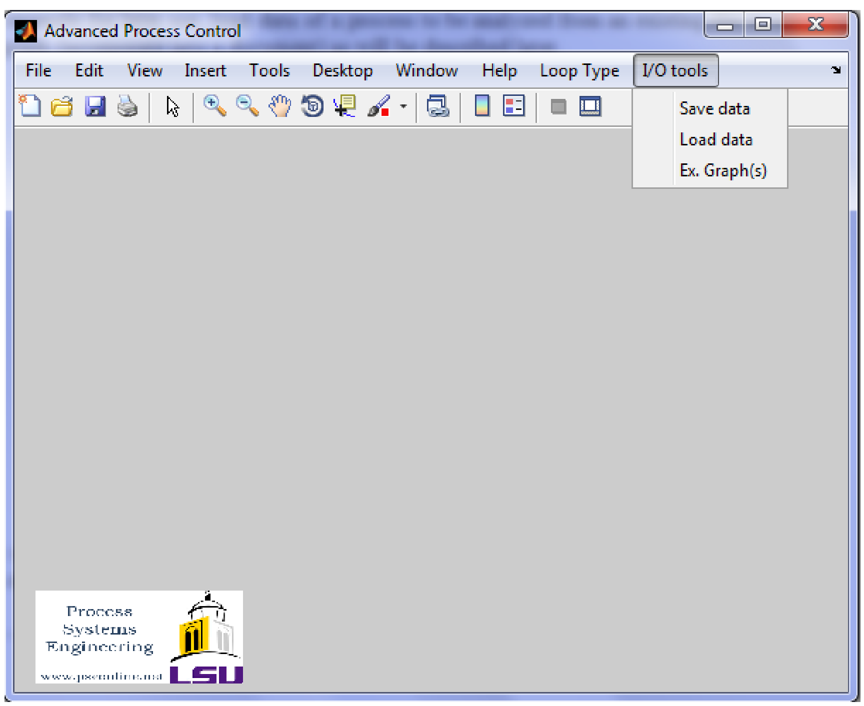
APCON_Tool is an environment facilitating the testing of conventional and advanced control strategies within MATLAB. To enter the APCON_Tool environment, once in MATLAB, simply type *Apcon2* and the following page will appear on the screen



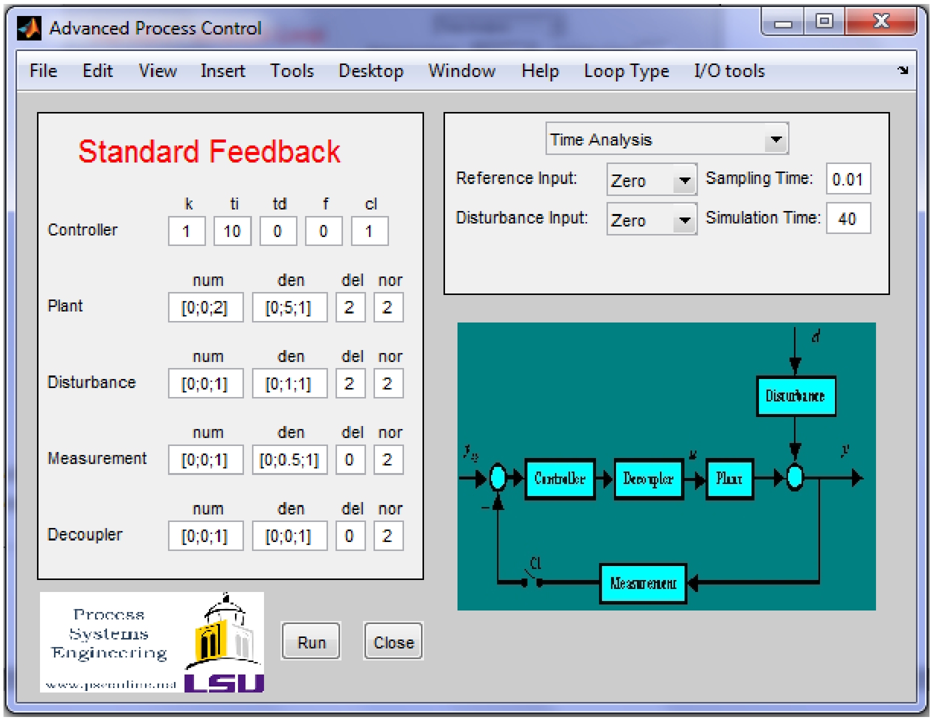
Loop Type is the main menu item on this page. By clicking on *Loop Type*, the following extended menu will appear, which contains different choices of control schemes to be analyzed. The usefulness of *I/O tools* will become clear later.



If one clicks on the *I/O tools* menu, several options will appear. One can either save the data from the example for later use, load data of a process to be analyzed from an existing file or can export a graph (incorporate into a document) as will be described later.

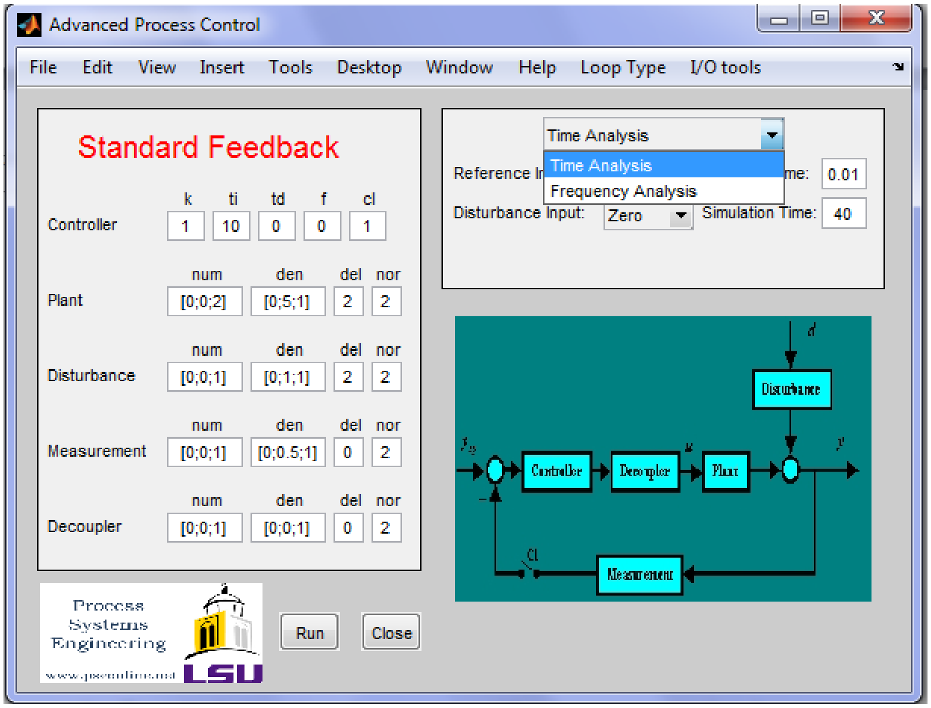


Now, let us assume that the *Standard Feedback Loop* option is selected from the *Loop Type* menu. A new screen will appear as shown below.

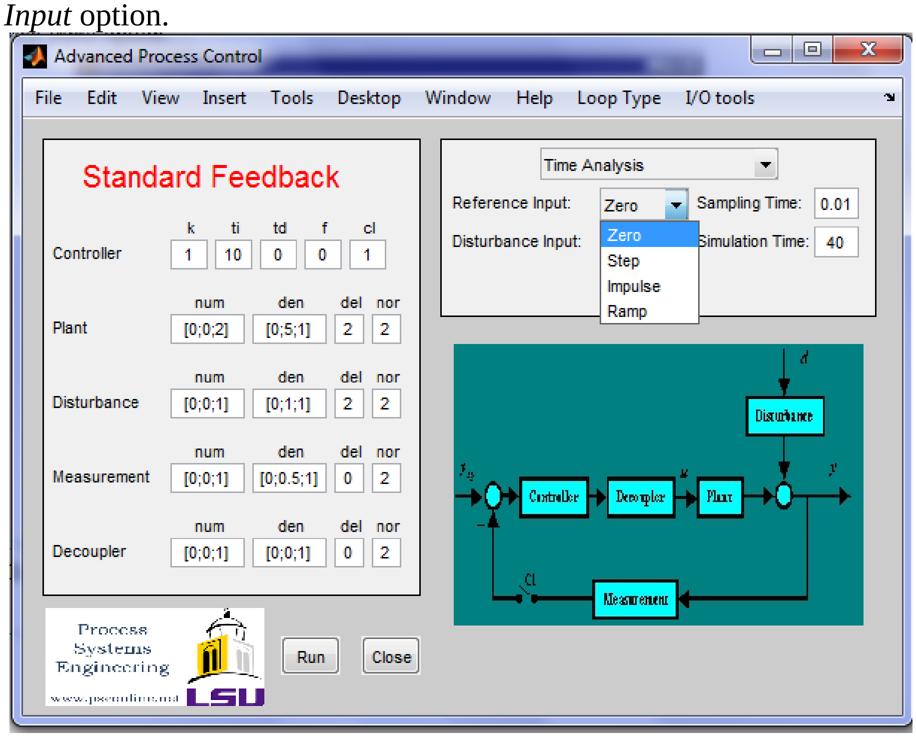


On the left-hand side, one finds all the typical components of a conventional feedback loop (Controller, Plant, Disturbance, and Measurement) in terms of their transfer function representations. The user can freely change all values in each of the components. The values appearing in the screen are the default values. **APCON_Tool** allows working with MIMO systems, so a possible decoupler is also included in the feedback loop. On the right-hand side, at the bottom, one finds the block diagram of the control system to be studied and the locations of the different components involved in the loop. At the top, there is a new menu that allows different tasks to be performed. One can perform a time simulation of the process for both set-point and disturbances changes.

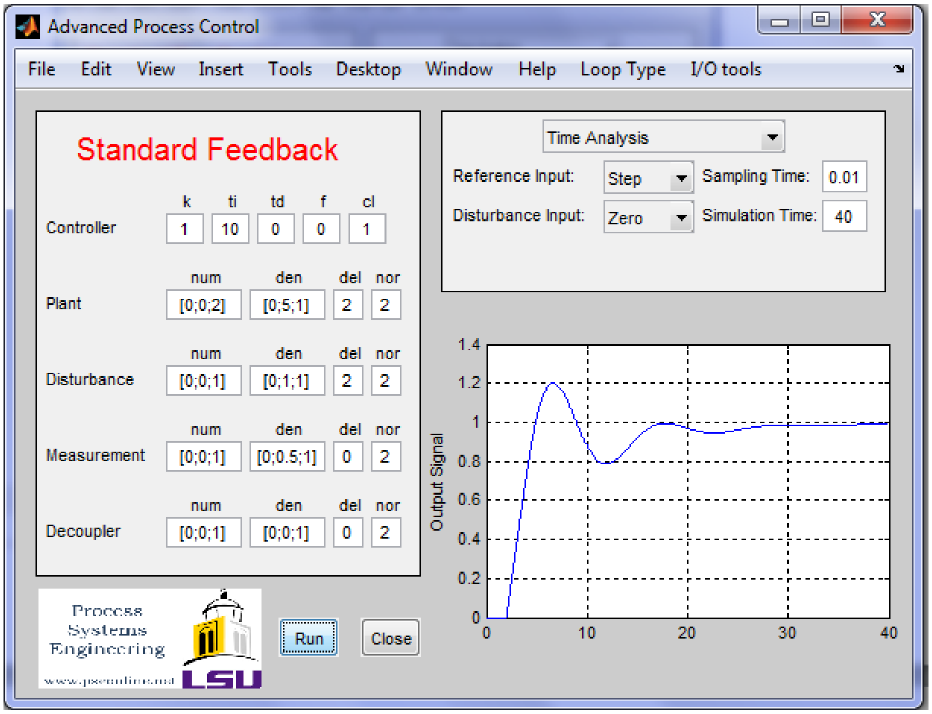
By clicking on the arrow of the *Time Analysis*, a pull-down menu appears allowing the user to choose from a time-domain analysis or a frequency-domain analysis of the closed-loop system as shown below.



If one chooses the *Time Analysis* option, then one can either impose a set-point change or a disturbance change on the process. If the *Reference* (*Set-point*) *Input* option is selected, then, a set of alternatives is provided as shown below. Similar alternatives are also available for the *Disturbance Input* option.

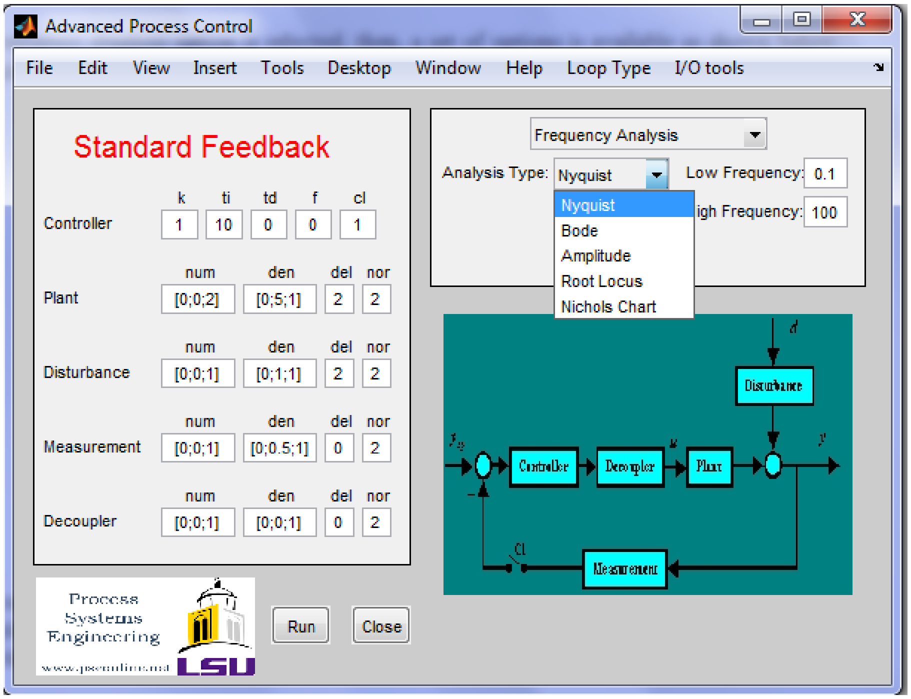


Now, let us assume that the *Standard Feedback Loop* option is selected from the *Loop Type* menu, followed by *Time Analysis* and *Reference Input*. Next, the *Run* button is clicked. After a few seconds, the Figure shown below will appear on the screen showing the changes in the controlled output as a function of time.

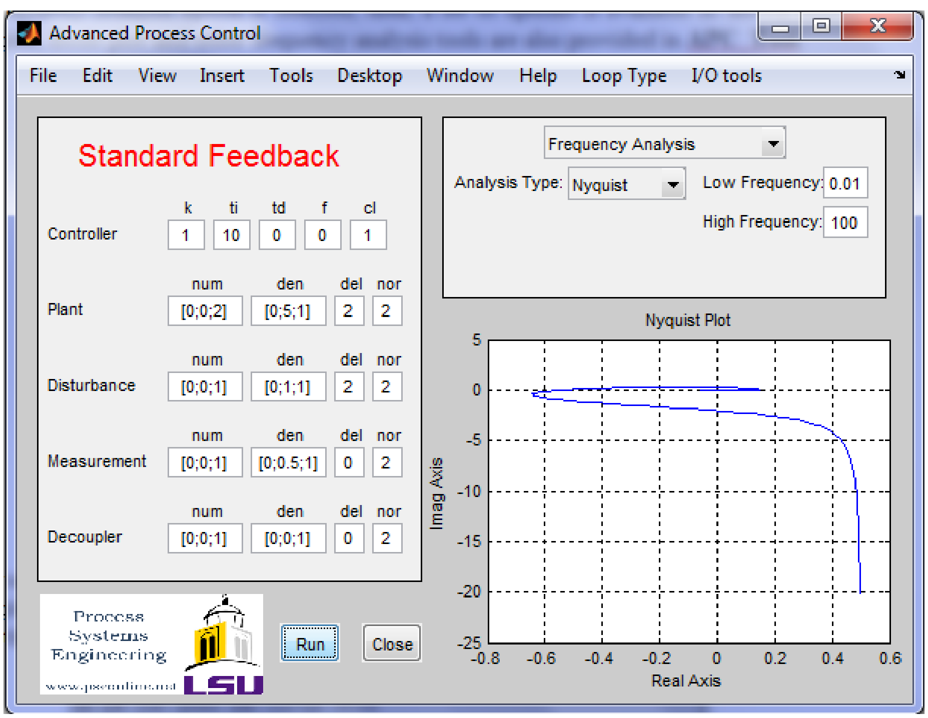


Every time a different option is selected from the menus or a parameter is changed, the program needs to be *Run* again.

If the *Frequency Analysis* option is selected, then, a set of options is available as shown below. Nyquist plot, Bode plot and other frequency analysis tools are also provided in **APCON_Tool**.

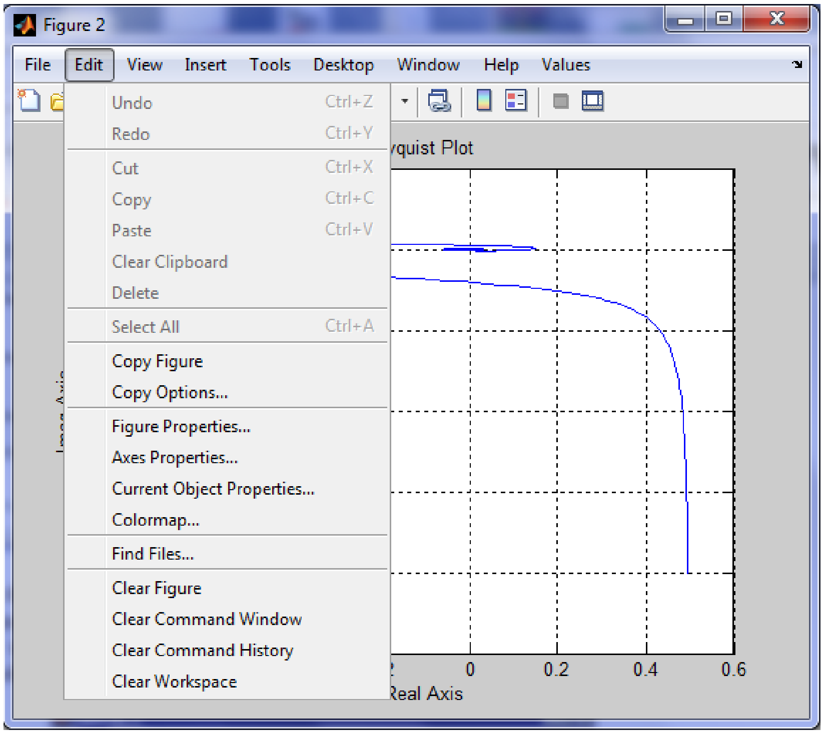


Now, let us assume that the *Frequency Analysis* option is selected from the menu followed by the *Nyquist* plot option. After a few seconds, the Figure shown below will appear on the screen showing the corresponding Nyquist plot for the case under study.



Finally, once the analysis is completed, the graphical information can be extracted to be inserted in other documents or reports by using the I/O tools. After clicking the *Ex. Graph* option in ***I/O***

Tools, a new screen is obtained as shown in the following Figure. One can then have different options to work with the selected plot.

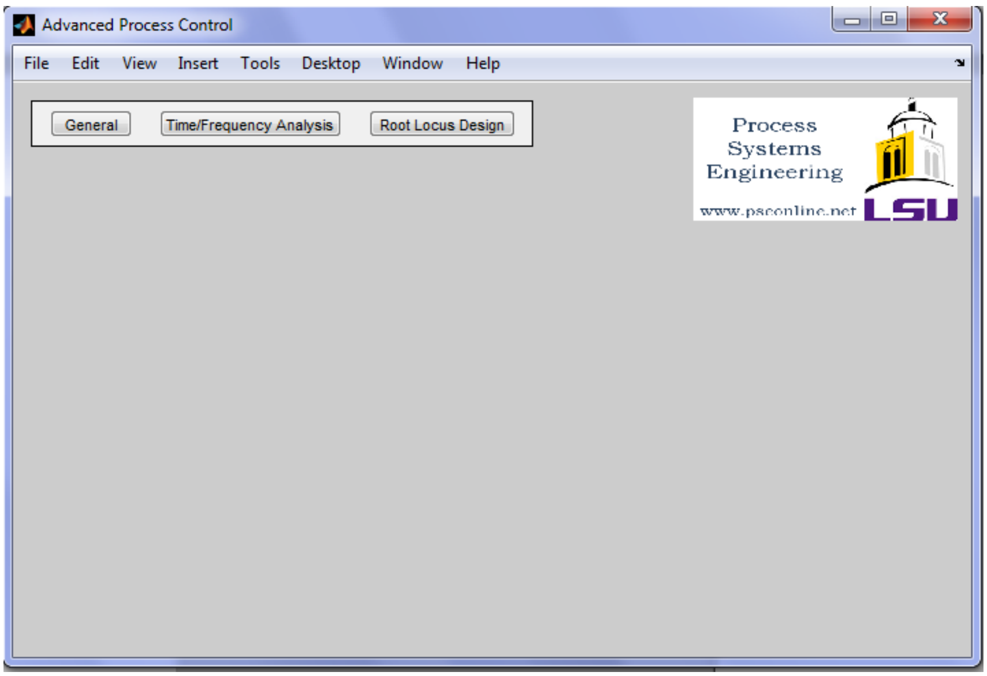


NOTE: If the option to investigate the closed-loop system using the Root-Locus analysis is selected, the delay term needs to be approximated (for example using Pade approximation). That is the model Transfer Function needs to be defined as a rational polynomial in APC_Tool. In this case using higher order Pade approximations will provide results which are closer to the ones obtained using Bode or Nyquist stability criteria.

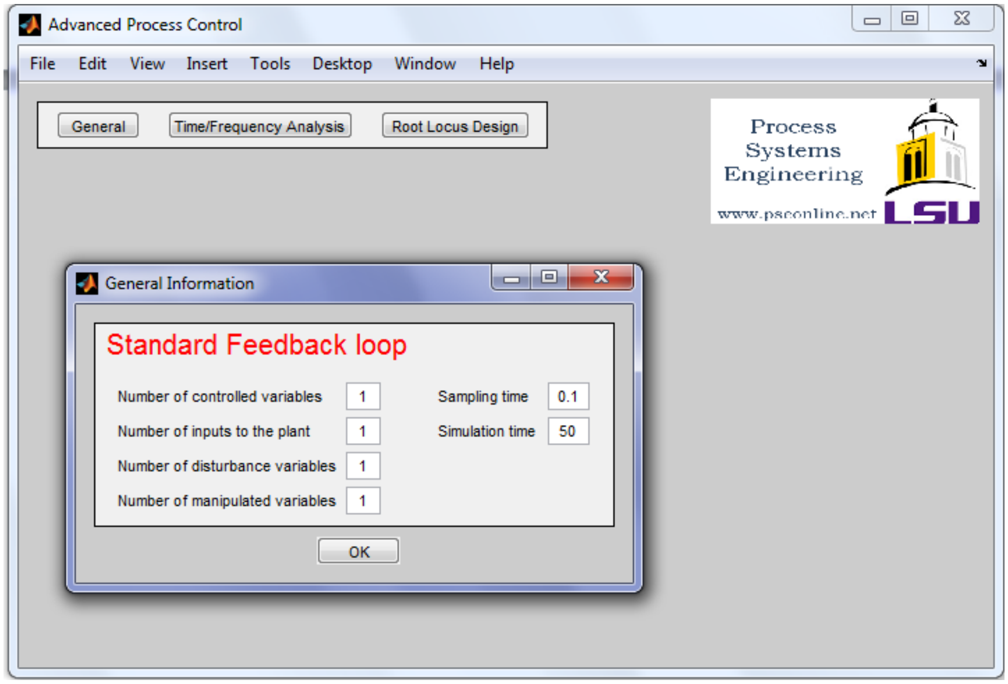
CONTROL DESIGN PACKAGE (SFB_TOOL)

SFB_Tool is an environment facilitating the design/testing of conventional control strategies within MATLAB. It is fully menu-driven, so no knowledge of MATLAB is required. It requires at least MATLAB version 6.5 and the associated toolboxes.

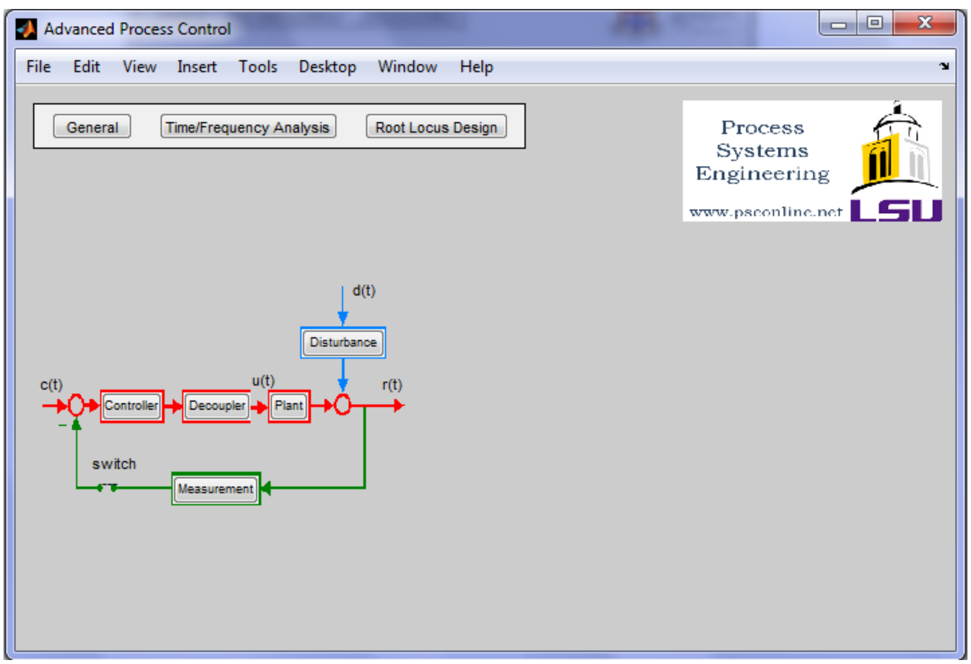
To enter the **SFB_Tool** environment, once in MATLAB, simply type *sfb* and the following page will appear on the screen



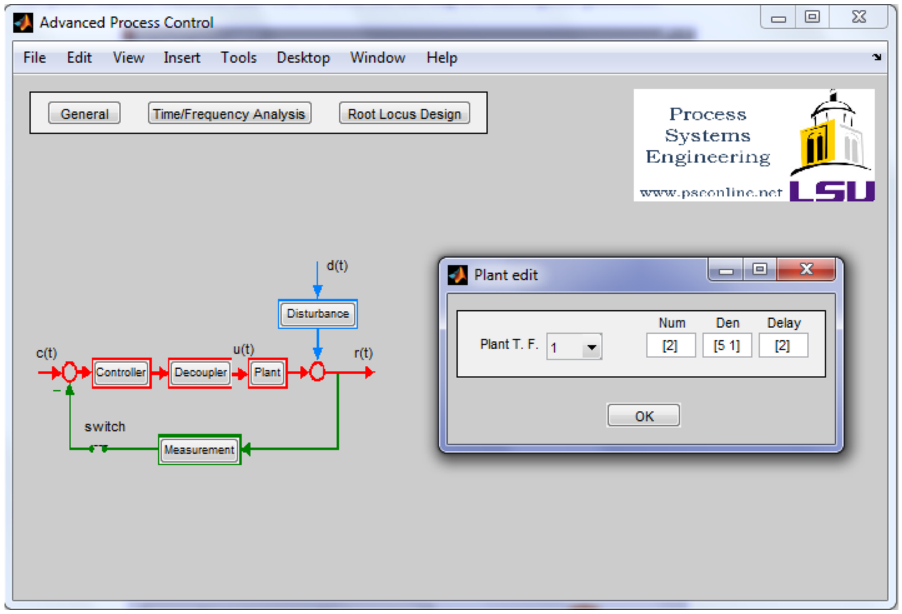
By clicking on *General*, the following extended menu will appear, which contains information to define a case study such as number of inputs, outputs and disturbances. Also one can define here the sampling time and the total simulation time.



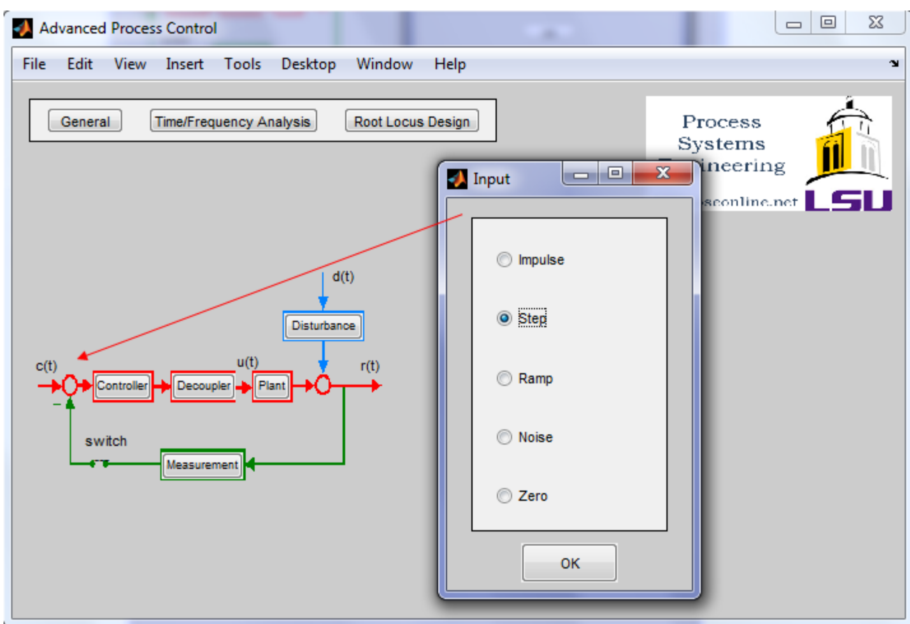
Once the problem is defined, clicking the OK buttom will produce the following page with the feedback control loop with all the components, i.e., the plant, the sensor, the controller, etc.



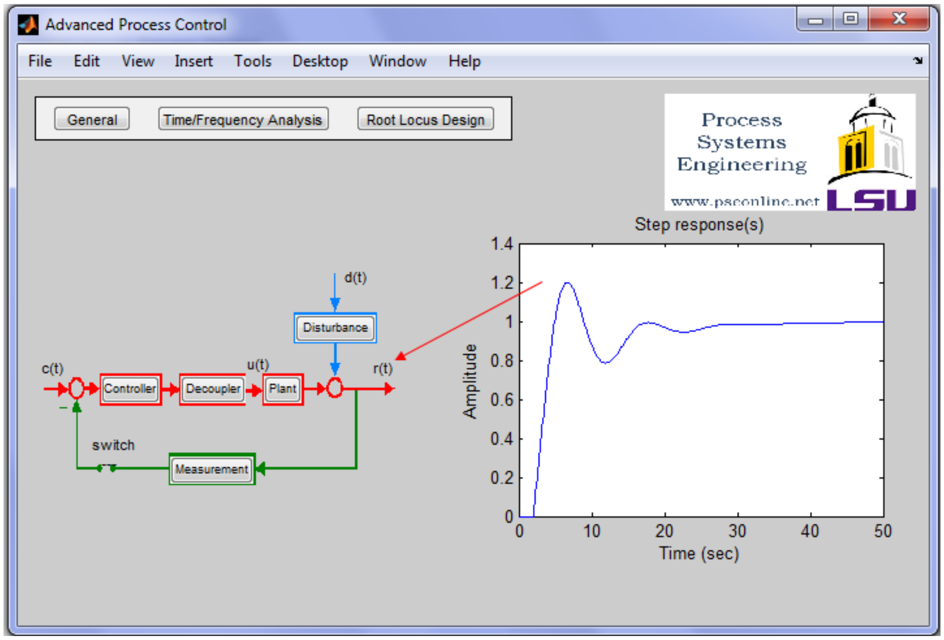
For example, if one clicks on *Plant*, the following menu will appear. Here, the user can define the plant transfer function that will be used for solving the subsequent problems.



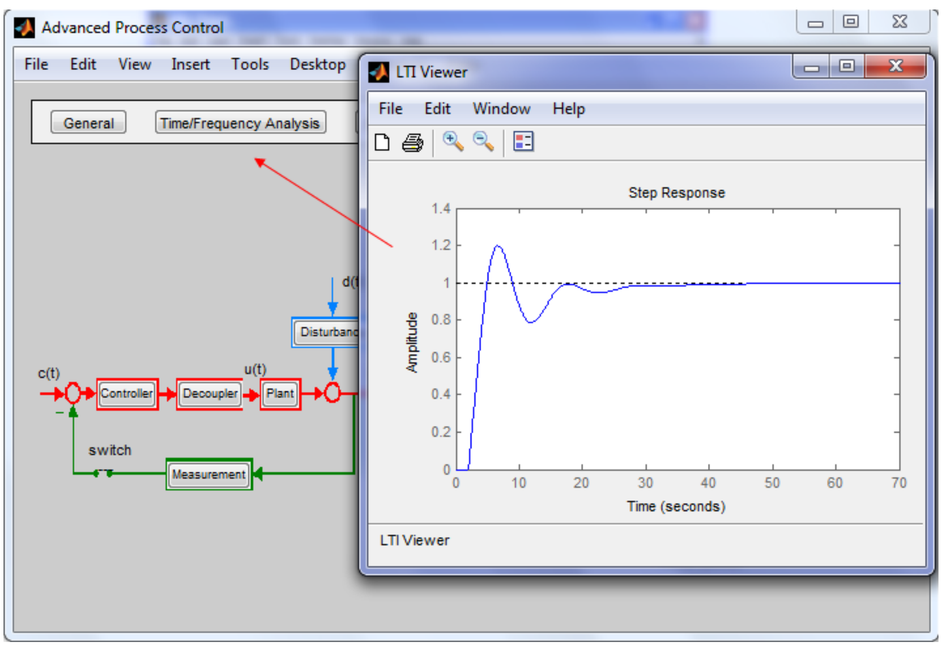
Once, different components of the feedback loop are defined, one can specify the type of perturbation signal to be introduced as shown below..



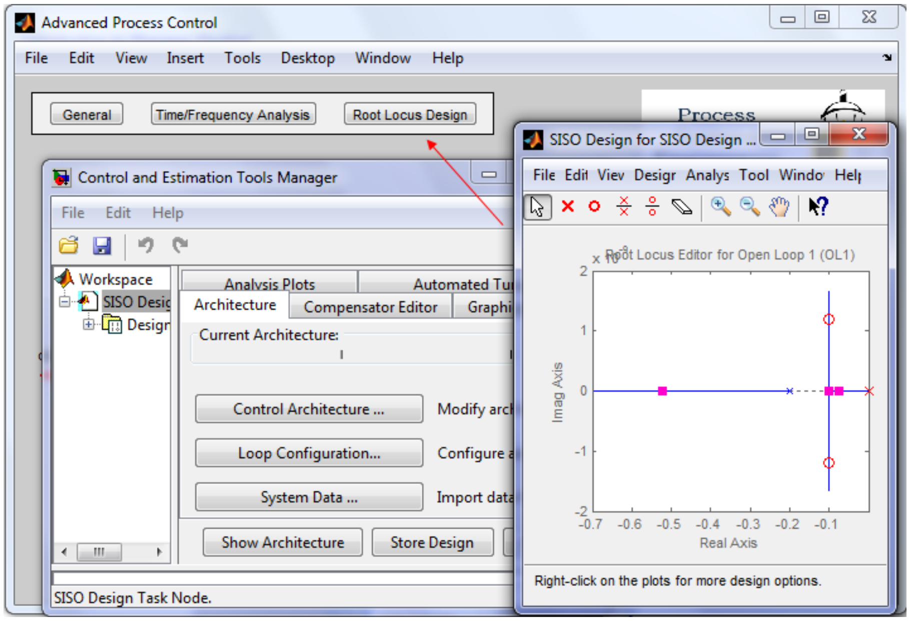
You can see the results by clicking on the the output r(t)



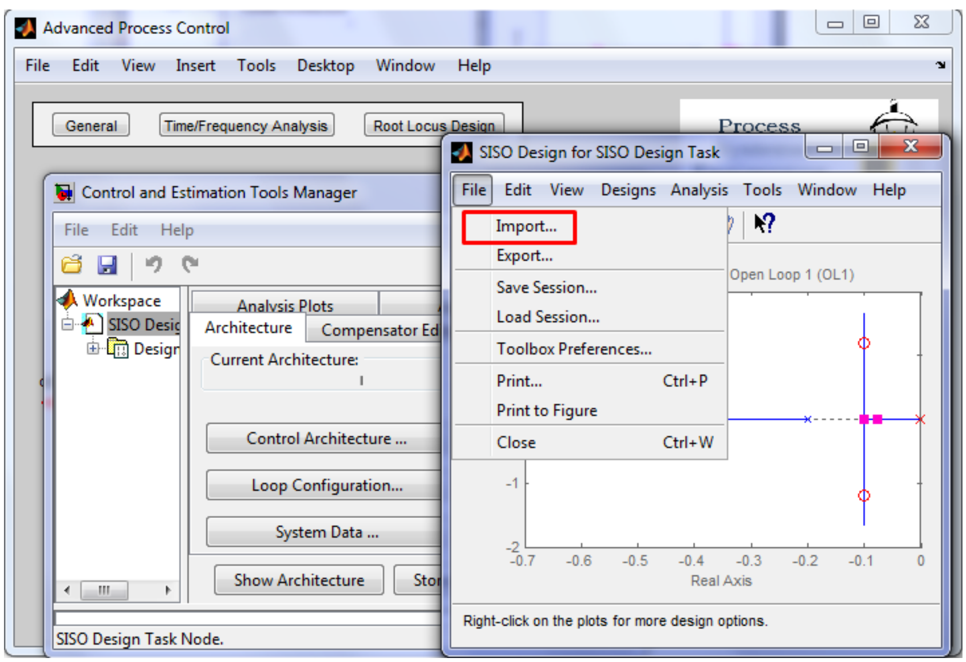
You can perform a time frequency analysis by clicking in the corresponding menue and then by right clicking on the mouse you can can see the system responses in a number of plot tiypes as well as different systems

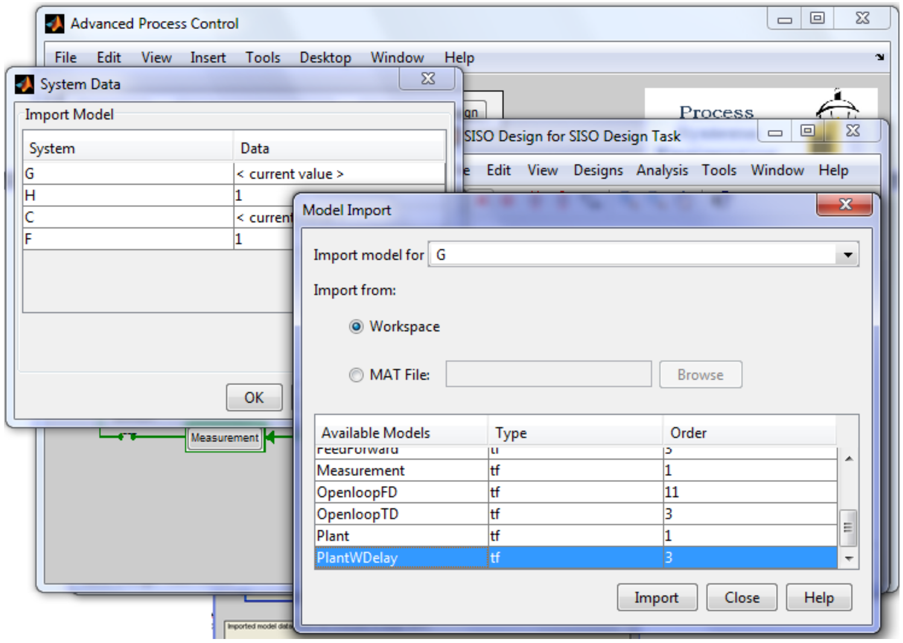


Root-Locus design can also be performed on the existing system by clicking on the corresponding menue.



In this case you need to import the corresponding system using the file menue in the SISO design tool.




Advanced Process Control
File Edit View Insert Tools Desktop Window Help
System Data
Import Model
System Data
G < current value >
H 1
C
F 1
OK
SISO Design for SISO Design Task
Edit View Designs Analysis Tools Window Help
Model Import
Import model for G
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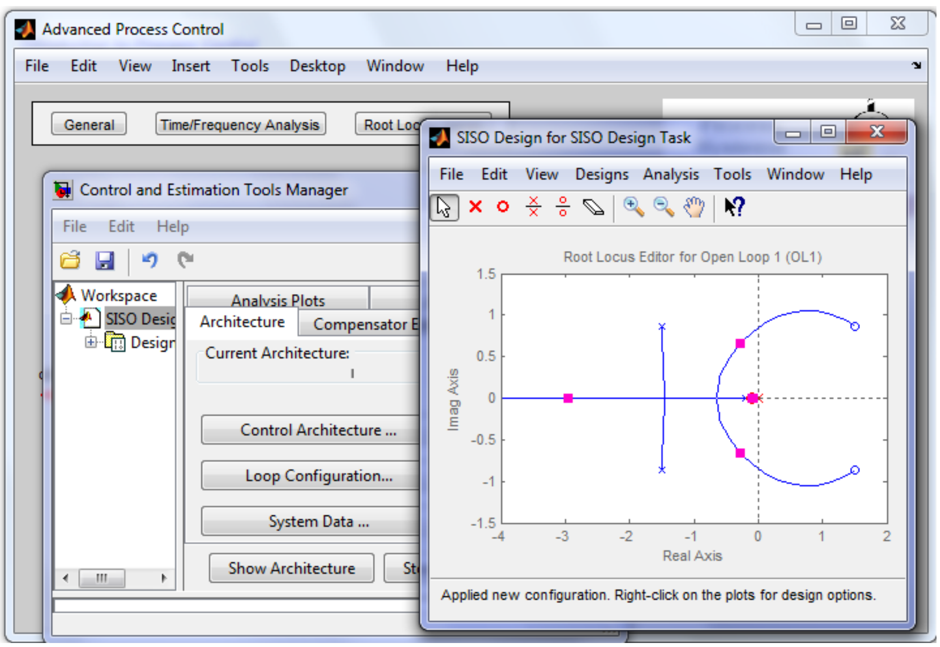
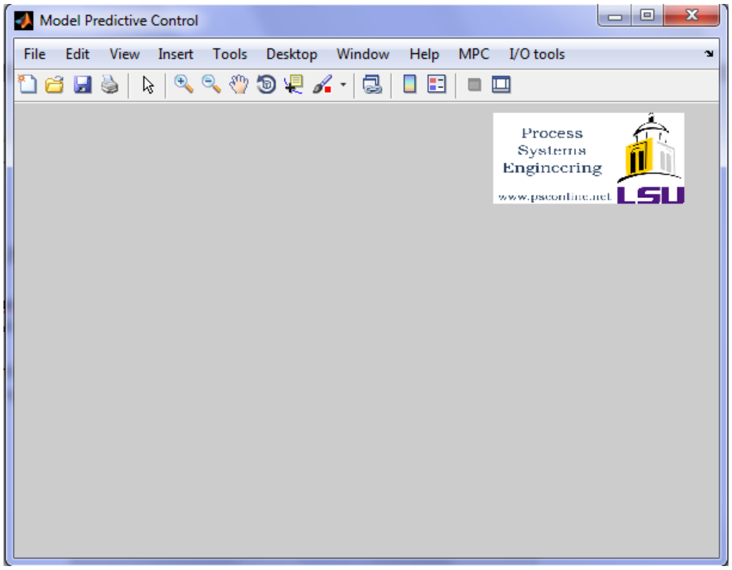
Workspace
MAT File:
Browse
Available Models Type Order
Measurement tf 1
OpenloopFD tf 11
OpenloopTD tf 3
Plant tf 1
PlantWDelay tf 3
Import Close Help


Advanced Process Control
File Edit View Insert Tools Desktop Window Help
General
Time/Frequency Analysis
Control and Estimation Tools Manager
File Edit Help
Workspace
Analysis Plots
Architecture
Current Architecture:
Control Architecture ...
Loop Configuration...
System Data ...
Show Architecture
SISO Design for SISO Design Task
File Edit View Designs Analysis Tools Window Help
Root Locus Editor for Open Loop 1 (OL1)
Imag Axis
Real Axis
Applied new configuration. Right-click on the plots for design options.

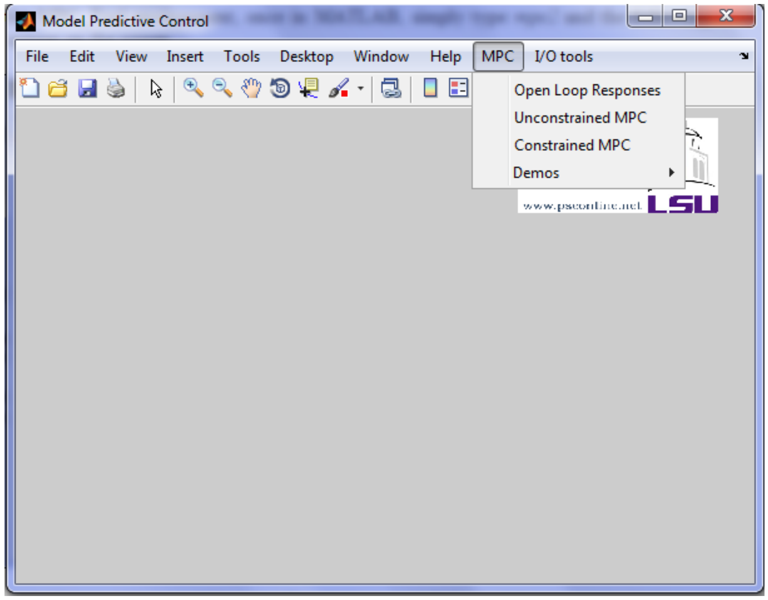
MODEL PREDICTIVE CONTROL PACKAGE (MPC2_TOOL)

MPC2_Tool is an environment utilized in the testing of Model Predictive Control strategies within MATLAB, and has similar set-up requirements as SFB_Tool and APCON_Tool.

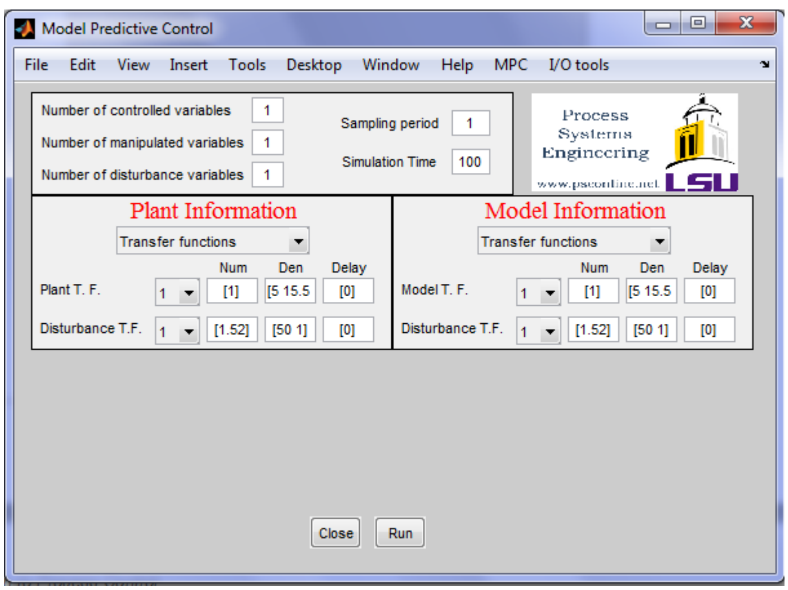
To enter the MPC2_Tool environment, once in MATLAB, simply type *MPC2* and the following page will appear on the screen



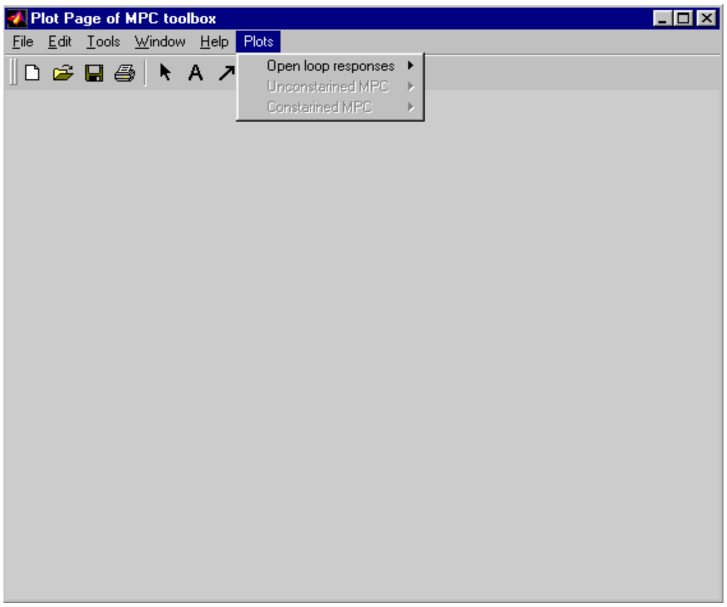
MPC2 is the main menu item on this page. By clicking on *MPC*, the following extended menu will appear, which contains different choices of control schemes to be analyzed. The options in the *I/O tools* will be discussed later.



Always when a new session is started with the **MPC2_Tool**, one has to click on the *Open Loop Response* option that will automatically open a new screen with the definitions of the default process. ***It is also necessary, at the beginning of a session, to click on each of the arrows to open the different modules (plant definition, disturbance transfer function, model transfer function, etc).*** Once each module is open, one can proceed either with the analysis of this case or can download the information of another process from an existing file using *I/O tools*.

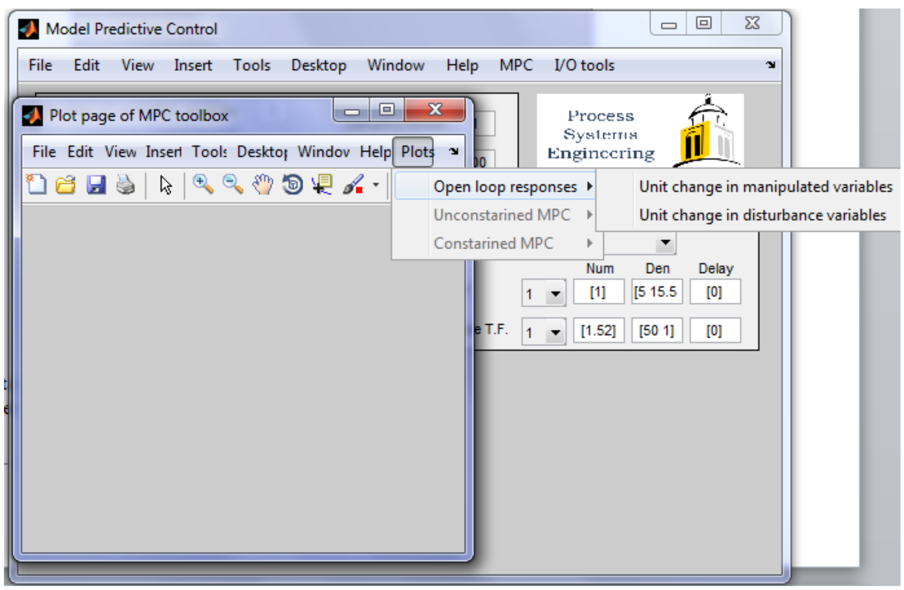


Next, *Run* button is clicked, and a new screen appears. By clicking on the *Plots* menu, the options displayed in the Figure below will appear. Here, one can observe the open-loop responses of the process, the closed-loop responses under MPC with no constraints as well as MPC with constraints.

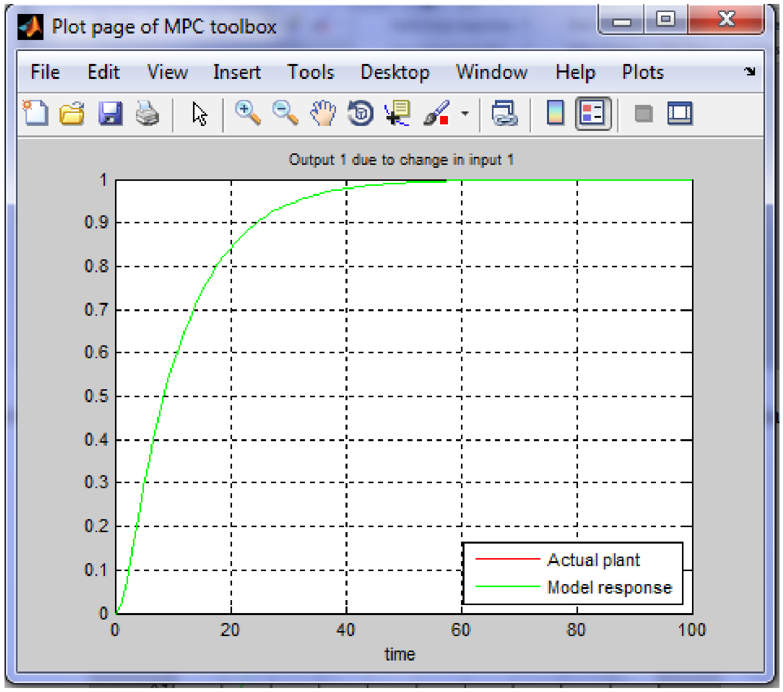


At his stage, however, one only has access to the first option since the unconstrained and constrained MPC has not been executed yet.

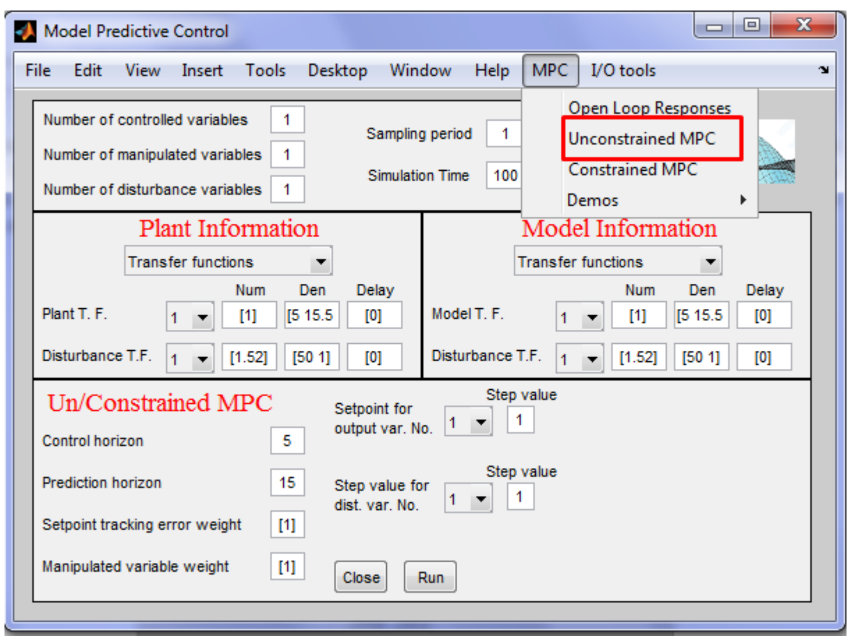
By clicking on the *Open Loop Response* arrow, one can then have the option to see the open-loop responses for the process for both changes in manipulated and disturbance variables.



The following figure shows the open-loop output variable response to a unit step-change.



Returning to the original **MPC2_Tool** screen, if one chooses the *Unconstrained MPC* option in the *MPC* menu, the following Figure appears with the complete definition of an MPC problem with no constraints. The user can change all numbers freely. In a similar fashion as before, one can see the plots by running the program and choosing to see the unconstrained MPC results.



To see the closed-loop results in terms of the controlled variable, one selects, from the *Plot* menu, *Unconstrained MPC* and then *Controlled variable set-point tracking* and the following

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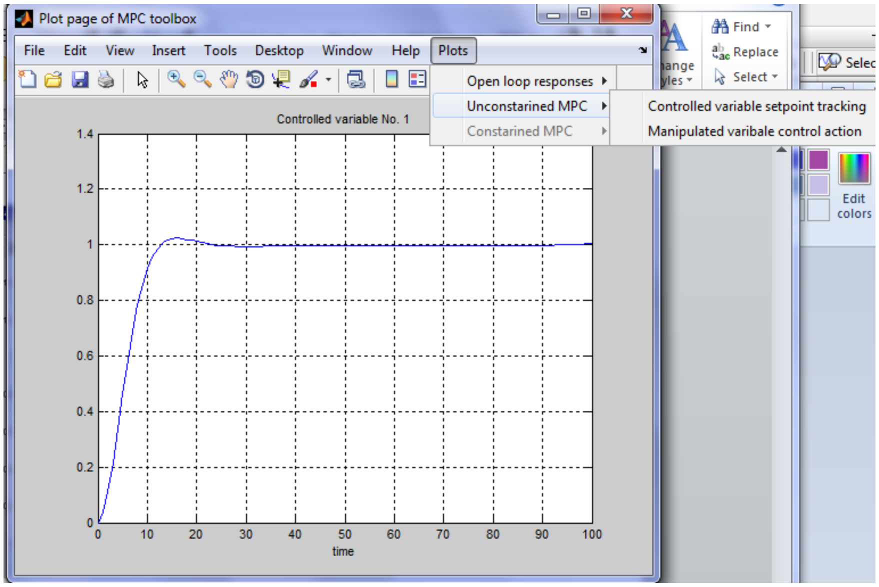
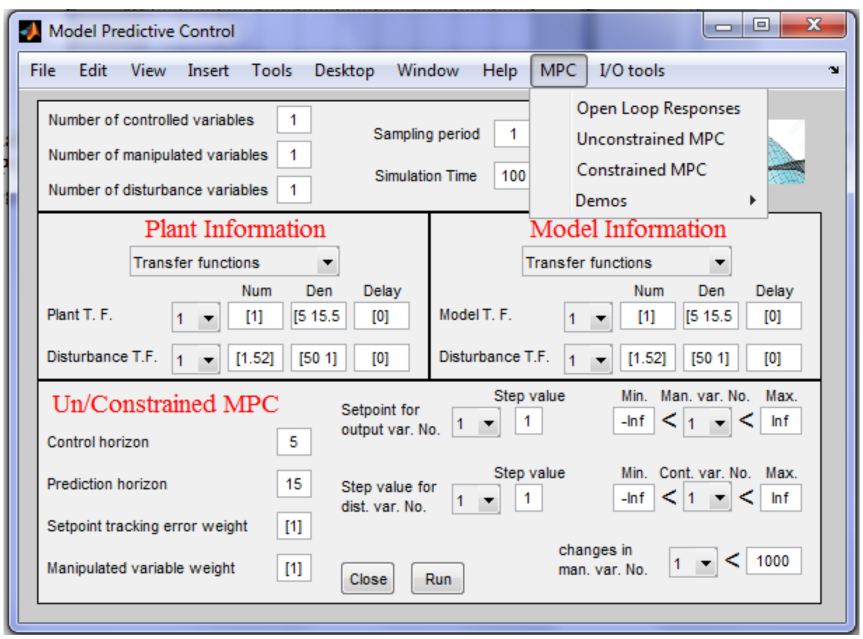
Figure is obtained.



Finally, by choosing the *Constrained* option in the *MPC* menu, the complete screen for the **MPC2_Tool** package will appear. Once can access to the closed-loop responses by running the program and using the *Plot* menu.



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