UNIVERSIDAD DE COSTA RICA

Control Engineering Research Laboratory
CERLab

MANUAL:

MOO tuning tool for PID controllers

Reference: http://www.cerlab.ucr.ac.cr/

Version 1.0

Contents

1 About us

The Control Egineering Research Lab (CERLab) is in charge of the study and application of Control Engineering Theory within the Electrical Engineering Department at Universidad de Costa Rica. Was founded in may 2012 and is located in the ground floor of the Electrical Engineering Building.

2 Multi-objective optimization tuning tool for PID controllers

This tool allows tuning of two degree-of-freedom PID controllers easily using the *multi-objective control*, from the experimental data directly obtained by plant measurements or with a previously calculated Second Order System Plus Time Delay (SOPTD) model. For this has a software capable to obtain experimental identification of the plant, and in that we can define the desired controller parameters to realize the tuning, its graphical user interface will be show in the next figure.

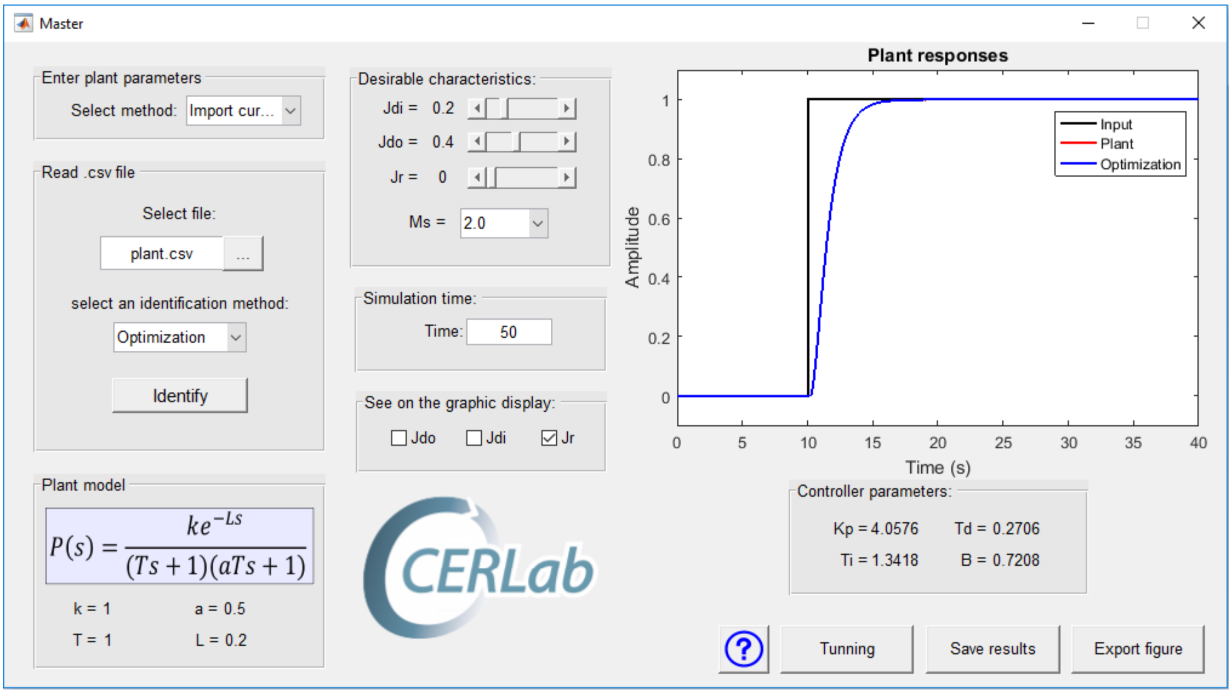


Figure 1: Graphical user interface

3 Plant model

The tool works with a Second Order Plus Time Delay (SOPTD) model, this will be described by the next equation:

$$P(s) = \frac{ke^{-Ls}}{(Ts+1)(aTs+1)} \quad (1)$$

Where:

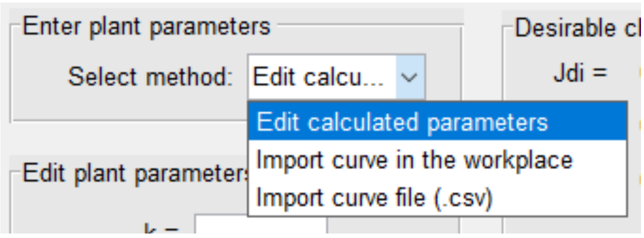
- k: gain for the transfer function of plant.
- L: time delay of plant response.
- T: time constant.
- a: relation between time constants.

Different methods for introducing this plant characteristic model are provided:

1. Edit previously calculated parameters.
2. Import data from workspace.
3. Import data from (.csv) file.

3.1 Edit previously calculated parameters

1. In the left top corner of gui, we can visualize the panel *Import plant parameters*, in this the option *Edit calculated parameters* must be selected.



2. After, is open a window in the down part of gui named **Edit plant parameters**, in that we have to introduce the plant parameters in function of equation 1 and push the button **Update** for upload the data in the program, for example see the figure 2.

3. Once the data is loaded, the plant response to a step input will be shown for verification, as the figure 3.

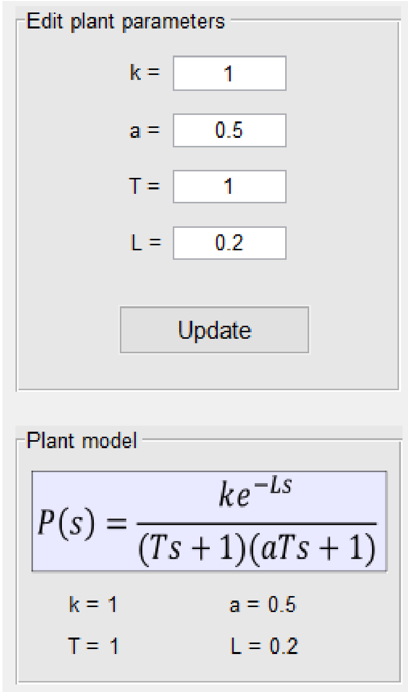


Figure 2: Plant parameters.

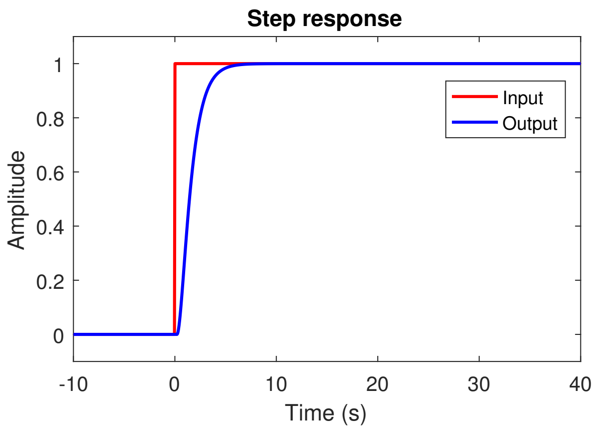


Figure 3: Step response.

3.2 Import data from workspace

This option allows to import the vectors time, input and output plant from workspace Matlab, with these data we can get the characteristic model plant applying two methods of experimental identification: **Alfaro 123** and **Optimization**, for use this method, follow these steps:

1. In the panel named **Import plant parameters**, you must select the **Import curve from workspace** option, then must be edited in the corresponding boxes the name of the curve vector.

2. You should choose the identification method and push the **Identify** button to calcule and load the plant parameters, an example of this process is show in figure 4.

3. An example of the results obtained by this method is shown in the figure 5.

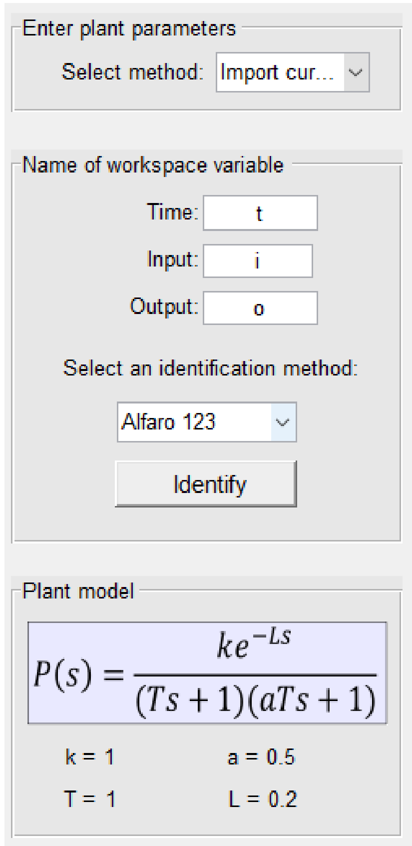


Figure 4: Import from the workspace

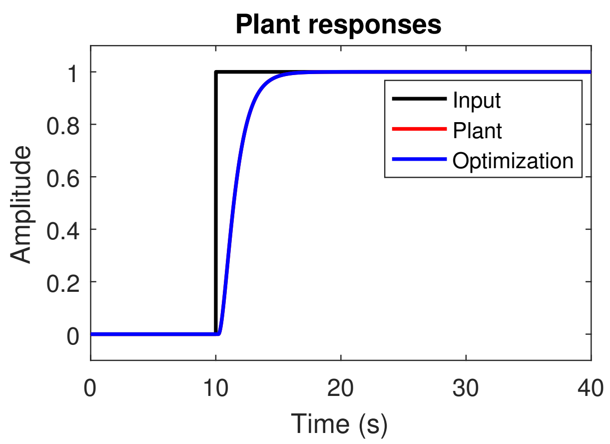


Figure 5: Graphical comparison

3.3 Import data from (CSV) file

1. Select the option **Import curve file (.csv)** in the **Enter plant parameters** panel, this will show a panel called **Read .csv file**.

2. In this window, you must select the file that contain the time values, input and output of the plant, the format of these are:

$$Data = \begin{bmatrix} \mathbf{t}, \mathbf{in}, \mathbf{out} \\ t_1, i_1, o_1 \\ . \\ . \\ . \\ t_n, i_n, o_n \end{bmatrix}$$

   This consists in columns data separated by commas where:

   (a) **t**: time vector.

   (b) **in**: step input.

   (c) **out**: plant response.

3. After the file is loaded, select one of the following experimental identification methods: **Alfaro 123** or **Optimization**.

4. Push the button **Identify** to calculate a Second-Order Plus Time Delay (SOPTD) model plant, and load it to program, example:

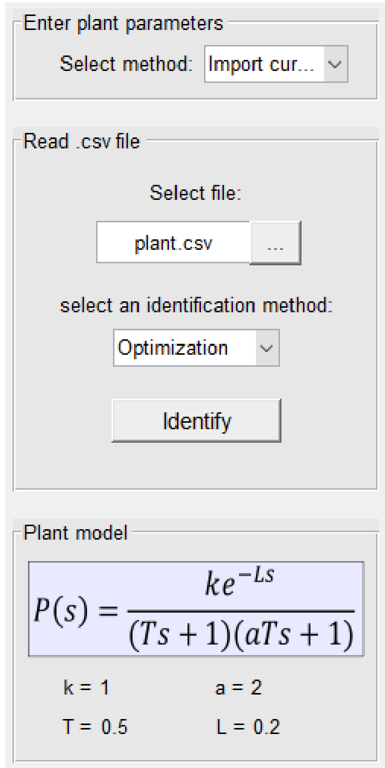


Figure 6: Import from .csv file

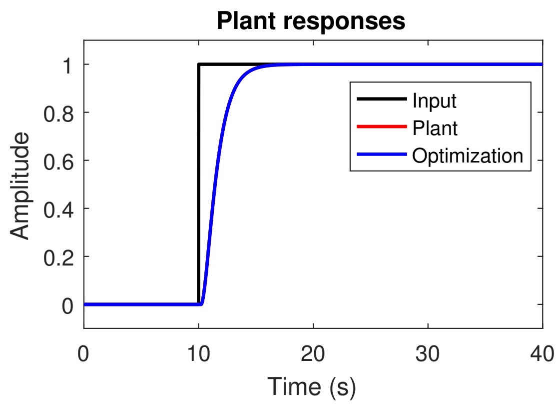


Figure 7: Plant identification

4 Design characteristics of the controller

The desirable characteristics of the controller are chosen in the panel **Desirable characteristics**, in this you can select the sensibility to input changes **Jdi**, output changes **Jdo** and set point signal **Jr**, the range of these values is 0 to 1, where 0 is the optimal value and 1 allows to the program choose the value which creates more suitable. The controller fragility is defined by the variable **Ms** with values of 2.0, 1.8 and 1.6 where 2.0 is the best value and 1.6 the worst value.

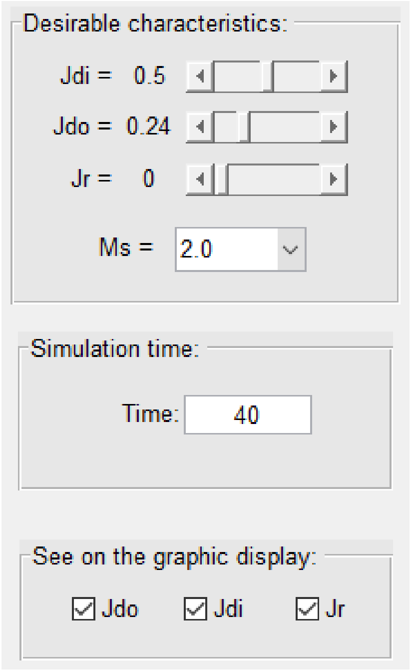


Figure 8: Desirable characteristics

The simulation time is defined in the **Simulation time** panel, option **time**, this is the interval time of signal shown on the graphic display.

In the **See on the graphic display** panel, select the perturbation type applied to the closed loop control that you wish see in the graphic display, the possible perturbations are **Jdo** in the output, **Jdi** in the input and **Jr** in the set point value, example:

In the graphic display are showing the different perturbations applied, this corresponding to design controller features, example:

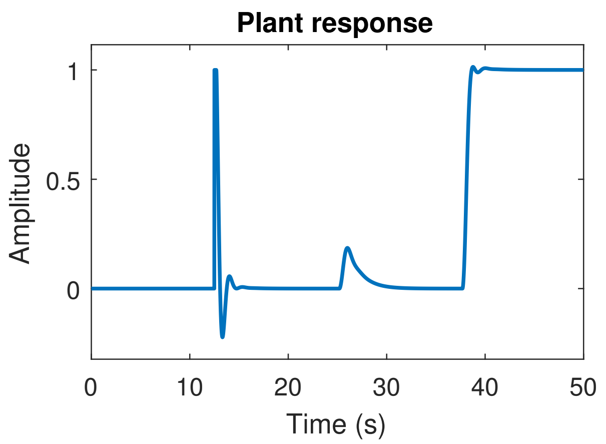
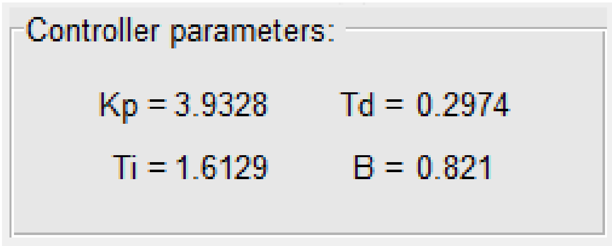


Figure 9: Plant responses

5 Results

5.1 Controller parameters

The parameters obtained from the controller tuning, shown in the bottom right of the interface called **Controller parameters**, these data correspond to a two degree of freedom PID controller where: **Kp** is the controller gain, **Ti** and **Td** are the integral and derivative time respectively and **B** is the weight on the reference signal, example:



5.2 Export data

This program can export each graphic generated and the important characteristics of the controller tuning and parameters of this, for this is available the options **Export figure** and **Save Results** on the bottom left of the interface.

The report file has a **CSV** format, this will contain the important data of the process as the model plant, characteristics of tuning and parameters of the two degrees of freedom (2DoF) Proportional-Integral-Derivative (PID) controller, for example:

```
Characteristic,Value
Plant parameters,Value
K,1
T,1
a,0.5
L,0.2
Desirable characteristics,Value
Jdi,0.5
Jdo,0.24
Jr,0
Ms,2.0
Controller parameters,Value
Kp,3.9328
Ti,1.6129
Td,0.2974
B,0.821
```