FRONTROL

Advanced Process

Control

User's Short Manual

FRONTROL

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Summary

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1. Introduction

Frontrol - System is an advanced control system designed for complex industrial plants. The expected results from the application of Frontrol - System are better product quality, variability reduction, raw material savings, reduction of equipment wear, energy saving, and optimization of production.

The main tool of Frontrol - System is a powerful fuzzy controller that incorporates up to 10 disturbances for each control loop and multiple control variables for each process variable (Fig. 1). The fuzzy inference machine is operated by rules which can be defined automatically by Frontrol - System or created by the user. To have it set automatically, the user must only decide if each disturbance would have a direct or reverse influence on the process variable.
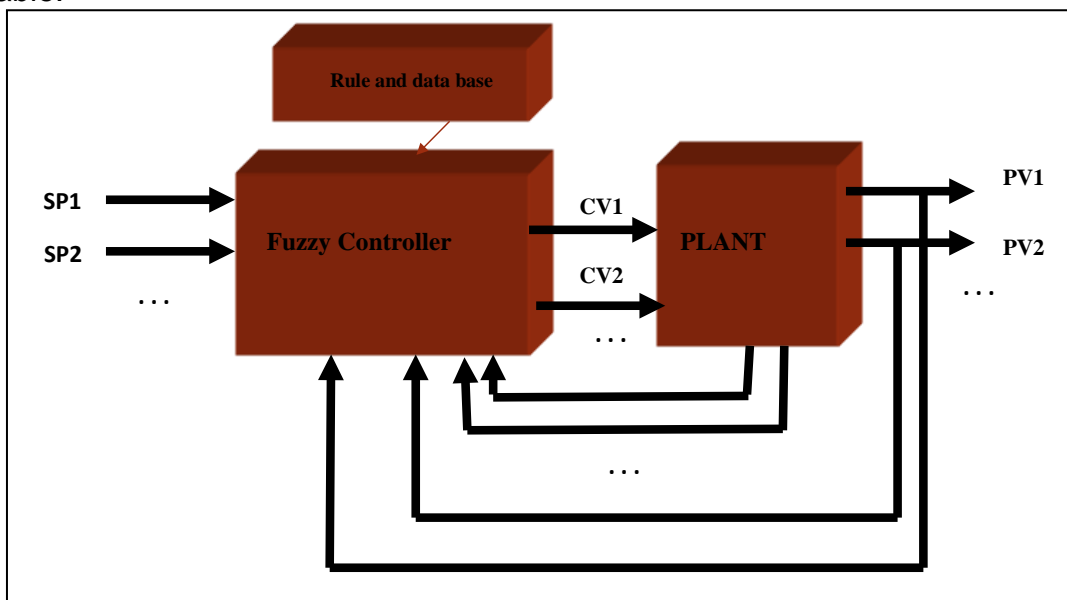

Figure 1 – A Multivariable fuzzy controller.

Frontrol - System can be applied very easily, with a minimal influence on the plant automation systems. The software is implemented in an industrial computer which can be installed in the plant control room. It can also be easily installed in a plant computer server, connected to the control network. It works together with any PLC, or DCS system, using a simple ethernet connection. It needs no keyboard or monitor to run.

Frontrol - System software gets the information it needs from any PLC or DCS through an OPC, or any other driver. The control variable values are also sent to the PLC or DCS (fig. 2) via an Ethernet connection.
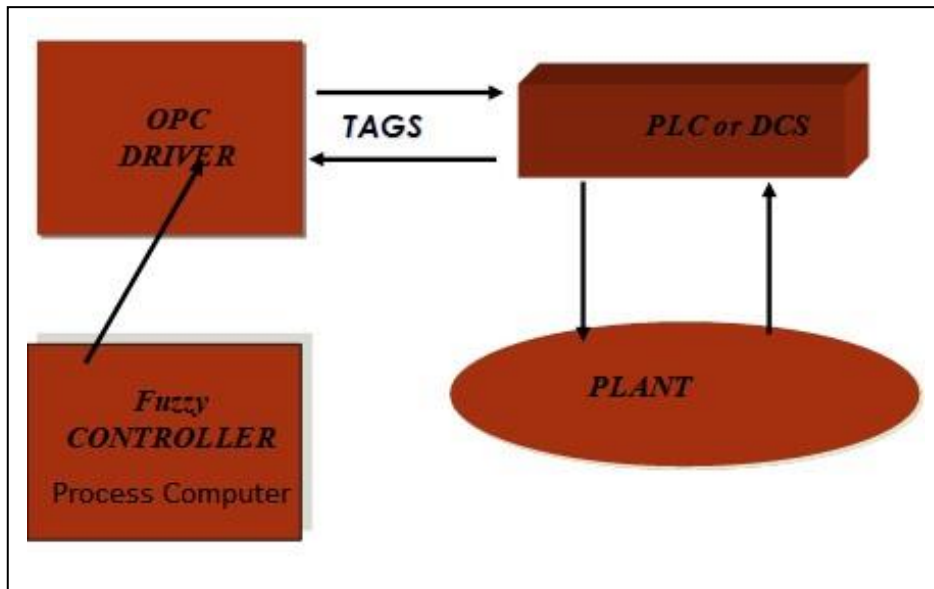
Figure 2 – Communication by OPC driver.

Once Frontrol - System is connected to the control Ethernet network, it must be configured, as described in the following sections.

2. Installation of Frontrol - System

Frontrol - System software and the OPC driver comes already configured in the module. The user must install the module in a rack and connect it to the ethernet control network. A hard, or soft license is also necessary.

3. Definition of the control loops

Defining the control loops is the most important step for the implementation of an advanced control strategy. This is accomplished by a process expert and includes the choice of the disturbances affecting each process variable. It is then necessary to define the operation limits for each variable. The next step would be the introduction of the information for all the tags. All the information is stored in a MySql data base. The tag list is described next.

3.1 Tag table

Each register in the tag table corresponds to a specific tag, with the following information:

- Sequential index

- Tag code
- Tag description
- Instrument range minimum value in PLC units
- Instrument range maximum value in PLC units
- Instrument range minimum value in engineering units
- Instrument range maximum value in engineering units
- Tag unit
- Tag code for the supervisory system -   OPC server code
- Tag type ("R", "W", or "RW")
- Tag minimum operational limit
- Tag maximum operational limit
- Size of the moving window for average evaluation
- Peak factor
- Ramp factor

Each of these parameters are introduced in the system, using the form presented in 4.6.

3.2 Control loops

The control loop list contains all the necessary information for each specific strategy, and is also a table in MySql data base. The information can be introduced directly in the data base forms, or by the form described in 4.9.

3.3 Text file for parameters

General parameters are introduced in the data base in table denominated PARAMETERS. The following data are introduced in this table:

Pwrd: it is a soft key for accessing the system

SampleTime: This is the system sample time in milliseconds.

nRow: In several applications of the program, nRow will be the size of a moving window, for previous input and output values **nStoreMaximum**: This is the maximum number of samples for each file in the historic file

nFileMaximum: This is the maximum number of historic files

Simulation: If this parameter is equal to 1, the current running will be in simulation mode. Otherwise, it will be in normal control processing mode.

Mode: If this parameter is set to 1, then the control loop will be in auto mode and habilitated. Otherwise, it will be manual and unable. **pathTXT**: This is the path for the text files. **pathXLS:** This is the path for the Excel files. **pathLOG**: This is the path for the log or errors and other running occurrences.

StoreHistory: If this parameter is set to 1, then the historic files will be stored. Otherwise, no historic files will be stored.

4. Running Frontrol - System

Before running Frontrol - System, it is necessary to stablish connection with the PLC or DCS that is running the control loops. A button in the supervisory screen, indicating the choice for the Frontrol - System, should also have been installed. In the next section, the first steps for starting the Frontrol - System is presented.

4.1 – First Steps

When Frontrol - System is started, the upper window, shown in figure 3, appears on the screen. If you click the "Task" button, the window in the bottom appears. You have the choices of setting parameters, tags, controller, function, or exit. It is also possible to see the license CDC or OPC data. This is in the bottom right of the screen.
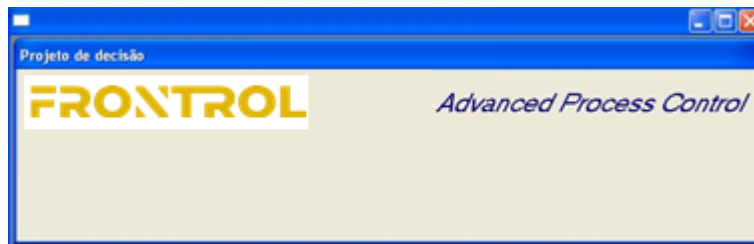

Figure 3 – First start of Frontrol - System.

The main screen shown in figure 4 is used do access the main features of the Frontrol - System.
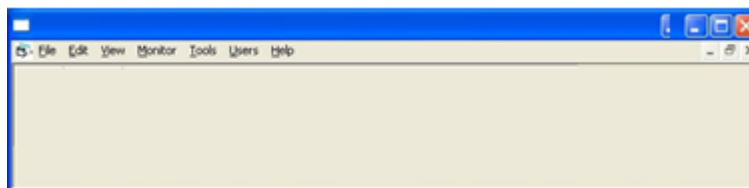

Figure 4 – Main screen of the Frontrol - System.

The options presented in figure 4 follows.

4.2 File Menu

- **New**: is used to create an application
- **Open**: is used to open an application already saved
- **Save**: saves an application
- **Save as**: saves an application using another file name • **Run**: runs an application.
- **Stop**: stops an application.
- **Exit**: closes an application.

4.3 Edit Menu

The Edit option allows the user to modify and save text information in the Frontrol - System text files.
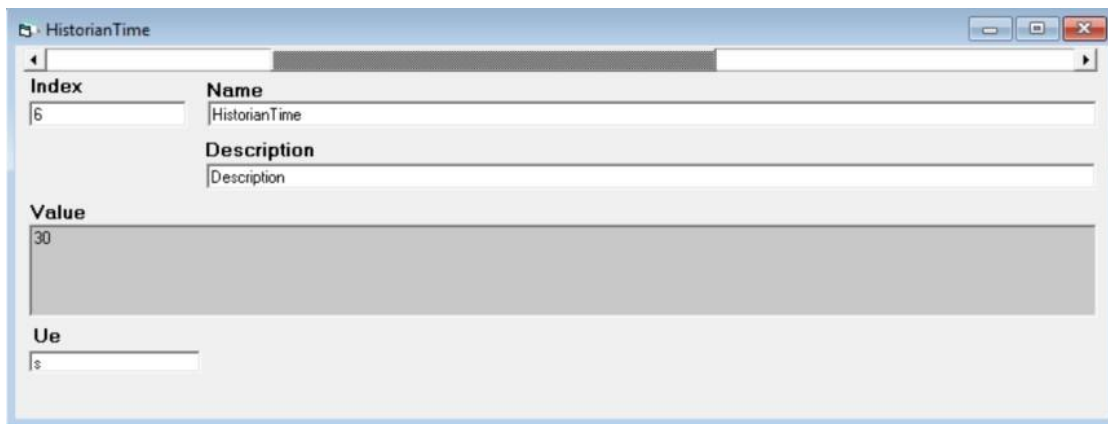
4.4 OPC Information

Frontrol - System uses OPC driver as the main communication tool to connect it to the PLC. Figure 5 shows the screen used to specify the OPC parameters.

Figure 5 – OPC specification

4.5 Updating the parameter file

The main Frontrol - System parameters can be updated directly in the data base or by the screen shown in figure 6.

Fig. 6 – Updating the parameter file.

The next section explains the specification of process variables.

4.6 Specification of tags

Tags are names used to specify the following kinds of variables:

- Transmitter values
- Setpoints
- Control variables
- Auxiliary variables

Figure 7 shows the screen used to specify them.
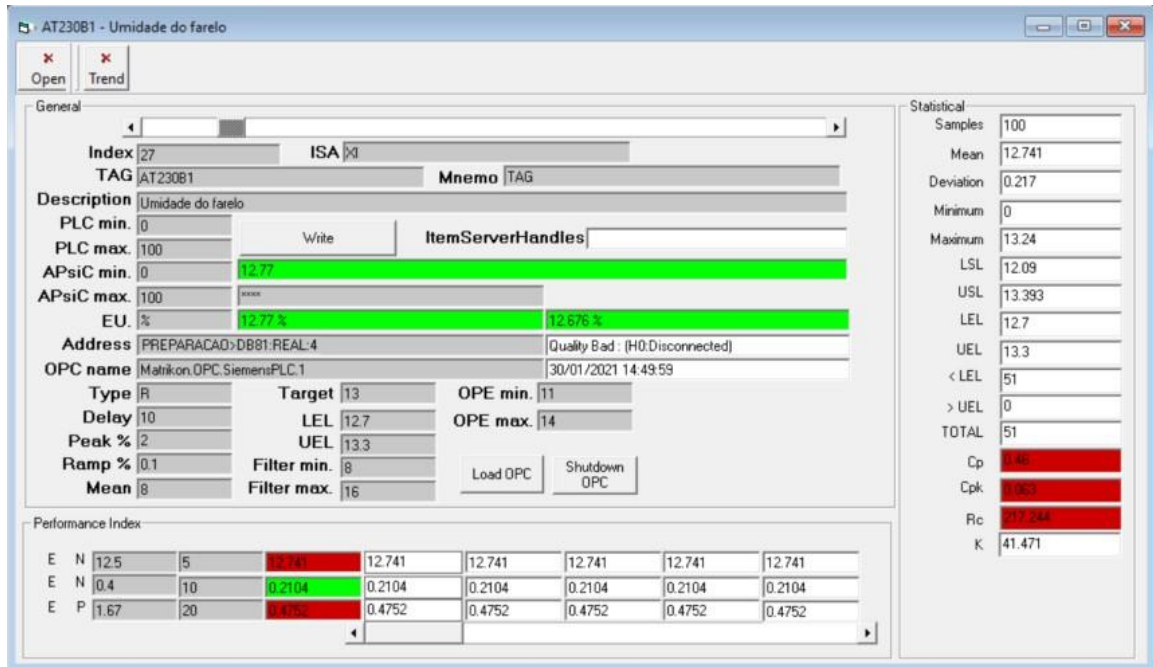
Figure 7 – Tag specification

4.7 Trend Plots

In the screen used to specify loops (fig 10), it is possible to choose the tag to be plotted, clicking on the correspondent checkbox. Figure 8 shows an example of a trend plot.

Figure 8 – Example of trend plots.

4.8 User defined functions

The user can create functions combining tag values. This is done by means of the screen presented in figure 9.
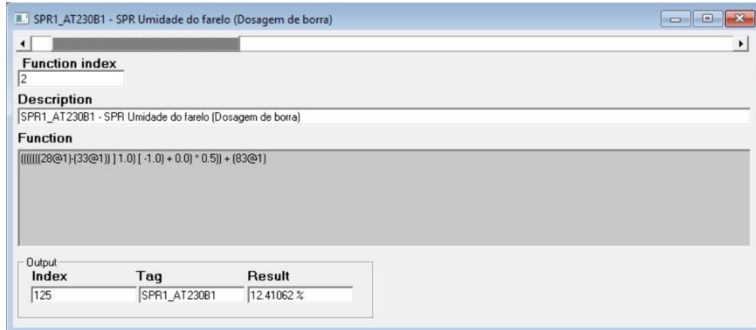
Figure 9 – User defined functions.

4.9 Control Loops

Control Loops are the main structure of Frontrol - System. Using the screen in figure 10, the user can define and configure them.
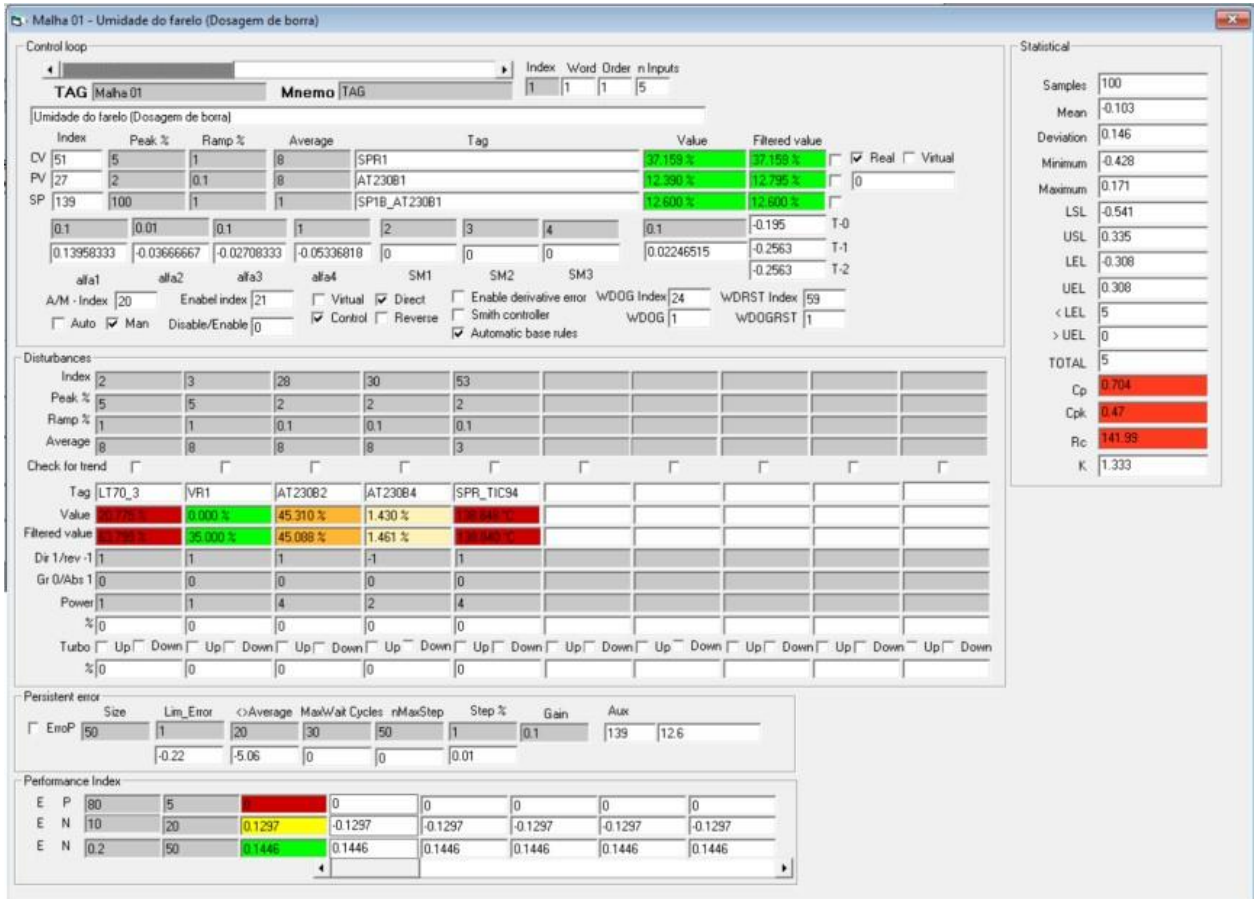
Figure 10 – Configuration of control loops

There are five windows inside the screen:

- Control loop
- Disturbances
- Persistent error
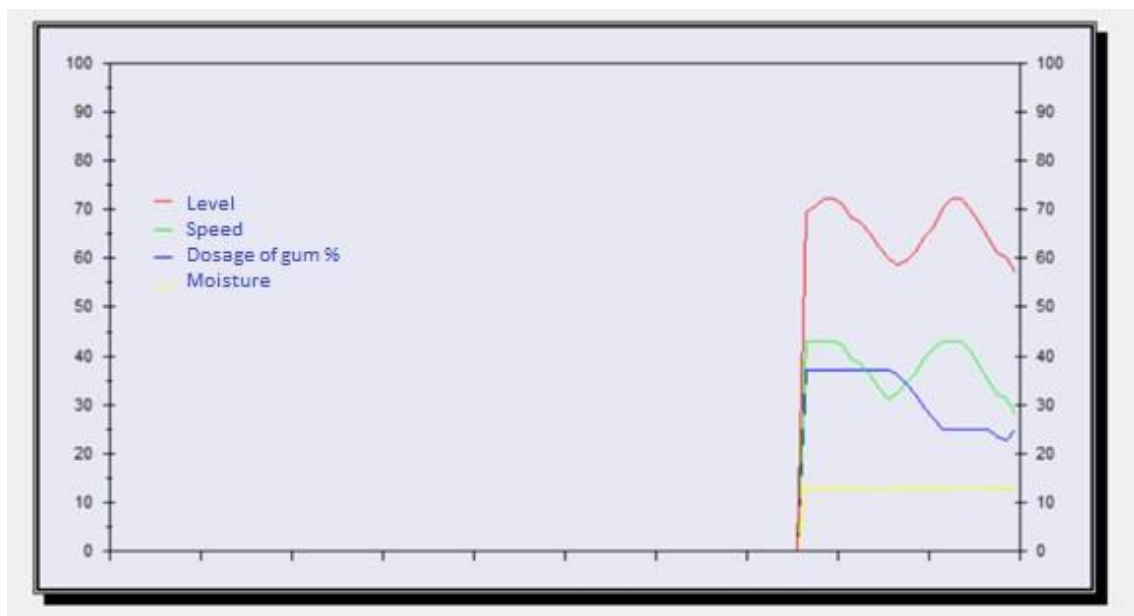- Performance index
- Statistical

A description of each window follows.

Window 1 - Control Loop

Clicking on the right, or on the left arrow, different control loops appear. In this window, there are some information for the control variable (CV), process variable (PV), and setpoint (SP). For each of these variables, the following information is shown:

- Index – it is the index number in the tag file for the CV, PV, or SP.

- Peak % - it represents the threshold for each variable value.

- Ramp % - this value is used in the filtering function for each variable.

- Average – this is the length of the moving average window.
- Tag – represents the tag name.
- Value – it is the variable current value.
- Filtered – it is variable current value after the application of the specified filter.
- Actual – indicates that the data correspond to an actual tag, not a virtual tag.
- Virtual - indicates that the data correspond to a virtual tag.
- A/M index – it is the index in the tag file for the indication if the control loop is in automatic mode.
- Enable index - it is the index in the tag file for the indication if the control loop is enabled.
- WDOG index - it is the index in the tag file for the control loop watch dog.
- WDRST index - it is the index in the tag file for the control loop WDRST.
- WDOG - it can be (1) for enabled, and (0) for not enable.
- WDRST - it can be (1) for enabled, and (0) for not enable

The checkbox at the right side of the filtered value is used to plot the tag values in the trend screen.

The following choices are also available in the same window:

- Auto, or Man – choosing the automatic or manual mode for the control loop.
- Virtual, or Control - choosing if the information of this window corresponds to a control loop or just a virtual meter.
- Direct, or Reverse - choosing if the information of this window corresponds to a direct or reverse action for the control variable (CV).

The user has also the following selections in the same window:

Enable derivative of error – it allows to include the error and the derivative of error in the control strategy.

Smith controller – allows for using the Smith controller technique instead of fuzzy controller.

Automatic rule base generation: it indicates that the Frontrol will create the fuzzy rule base automatically. In this case, the user is also allowed to modify some rules directly in the rule base file.

Window 2 – Disturbances

In this window, the user specifies the tags and the correspondent data for the variables that could have some influence on the control loop. In the window, there are 10 columns, corresponding to each disturbance, and, for each disturbance, the following information must be filled:

Index: it is the tag sequence number corresponding the disturbance

Peak: this value is a multiplier to be applied to the upper range, establishing a threshold for the corresponding disturbance. It is used to avoid transmission sparks.

Ramp: it is a single parameter used to configure a first order filter for the disturbance values.

Average: it is the length of the moving average applied to the disturbance values.

Check for trend: the corresponding check boxes are used to the plot the disturbance values.

Tag: those are the tag names.

Value: current disturbance value.

Filtered value: the current disturbance value after the application of the filter.

Dir (1)/ Rev (-1): this is an information of the disturbance characteristics. If the value is equal to 1, it means that the disturbance has a direct influence on the control variable (CV). In other words, it tells that if the disturbance increases, CV should be increased. On the other hand, if the value is equal to -1, it means that the disturbance has a reverse influence on the control variable (CV). In other words, it tells that, if the disturbance increases, CV will decrease. This is an important information to characterize the fuzzy rule base.

Gr (0) / Abs (1): This is another information about the influence of the disturbance on the control variable (CV). If Gr is equal to zero (0), it means that the derivative of the disturbance function will be considered. On the other hand, if Gr is equal to one (1), it means that de absolute value of to the disturbance function will be considered.

Power: this factor is used to establish different importance for each disturbance. Considering that the power factors are normalized by the program, the user is free to specify any number.

Turbo: for each disturbance, the user can set the checkbox **Up**, or **Down**. When it is checked, the actual disturbance value is used in the fuzzy rule base.

Window 3 - Persistent error

This window is used to introduce the data do treat the case of persistent error. Eventually the control error is not eliminated, even after the action of the fuzzy controller. In this case some parameters must be introduced to detect and treat it. The parameters are:

Checkbox ErroP: if this is checked the treatment of the persistent error is allowed.

Size: stablishes the size of the window to be evaluated in the definition if a persistent error is occurring, or not.

Lim_Error: it is the limit above which the persistent error will be considered as existing.

Average: this is the control error average

MaxWaitCycles: this is the number of cycles to wait until the application of the measures to correct the persistent error.

nMaxStep: maximum number of time steps for the correction of the persistent error. After nMaxStep, the normal procedure is returned, even if the persistent error is still present.

Step%: how much the control variable is increased to try to eliminate the persistent error.

Window 4 - Performance Index

This window presents some important information for software performance and is specific for developers.

Window 5 – Statistics

This window presents a statistical analysis of the specified tag. The following information is shown:

Samples: number of samples.

Mean: it is the average of the samples.

Deviation: it is the standard deviation of the samples.

Minimum: the minimum value to the samples.

Maximum: the maximum value to the samples.

LSL: lower specification limit.

USL: upper specification limit.

LEL: lower estimation limit.

UEL: upper estimation limit.

Cp: Process capability index related to 6 sigma.

Cpk: Process capability index related to 3 sigma.