INTRODUCTION

This laboratory has been designed to introduce the fundamentals of automatic control technology. The main functions of processes, controllers and controlled systems are shown on a simulated controlled system, as well as the interactions between the transfer elements of a control loop.
Before dealing with the experimental part, the manual offers to the students the synthesis of the basic concepts relevant to the automatic control in order to develop to the best experimentations of this laboratory.
The theoretical topics described in the manual are:

- *General Definitions*
- *Graphical representation of control systems*
- *Subdivision of control systems*
- *Canonical form of systems driven back*
- *Canonical functions and characteristics of control systems*
- *Analysis and design of control systems*
- *Proportional action (P)*
- *Integral action (I)*
- *Derivative action (D)*
- *PID combined action*
- *Preparing the Controller*

The individual components are represented on the panels together with the standard block circuit diagrams. The laboratory has been functionally divided in a number of sections, so that the student can follow a proper educational path, with increasing difficulties from theory to practical applications. The sections have been set up as follows:

Fundamentals of Automatic Control Technology

Processes	*PRO*
Controllers	*PID*
Continuous Automatic Control	*CAC*
Discontinuous Automatic Control	*DAC*

Applications

Control of a DC motor	*MOT*
Temperature control	*TEM*
Light control	*LUM*
Level control	*LEV*
Flow control	*FLO*

AUTOMATIC CONTROL TECHNOLOGY

FUNDAMENTALS OF AUTOMATIC CONTROL TECHNOLOGY

***Processes* - PRO**

In this experimental chapter the student can analyze the typical behaviours of the processes: the transfer characteristics, the behaviour in transitory conditions, the time constants, the 1st and 2nd order processes, the higher order processes, the dead time, etc.

The knowledge of the typical characteristics of the process is extremely important for a correct approach to the design of a control system.

For such reason, before studying the typical behaviours of the controllers, it is necessary to analyze all the possible characteristics that the process to be controlled can practically have.

The processes that are analyzed in this chapter are the following:

- *P type process*
- *I type process*
- *I^2 type process*
- *1st order processes*
- *Processes of order highest than the 1st*

Controllers - PID

In this experimental chapter the student can analyze the characteristics and the typical behaviours of the controllers: linearity, proportionality, dynamic behaviour, gain, conventional values, critical frequency, phase, etc.

After having analyzed the single P, I and D elements, he can study their PI, PD and PID combinations and he can set up both series and parallel configurations.

The knowledge of the typical characteristics of the controllers is extremely important for a correct approach to the design of the control systems.

The controllers that are analyzed in this chapter are the following:

- *P Controller*
- *I Controller*
- *D Controller*
- *PI Controller*
- *PD Controller*
- *PID Controller*

Continuous Automatic Control - CAC

After the experimental chapters where the characteristics and the typical behaviours of processes and controllers have been deeply analyzed, we open here a new chapter where processes and controllers are suitably combined to simulate and to study the most common problems related to the Continuous Automatic Control.

The analysis of the interactions between controllers and processes is complicated by the possible presence of noise; sometimes, the latter can trigger a series of oscillations with consequences, potentially serious, for the process. In this chapter, in addition to the analysis of the interactions between controllers and processes, the student can study the causes of the above mentioned instabilities, in order to find possible solutions.

The topics that are covered in this chapter are the following:

- *P control of a P type process*
- *P control of 1st, 2nd, 3rd and 4th order processes*
- *I control of 2nd order and I type processes*
- *P, PD, PI and PID controls of a high order process: stability and optimization*
- *P, PD, PI and PID controls of a high order process: presetting of the parameters according to Ziegler-Nichols (dynamic method)*

- *P, PD, PI and PID controls of a high order process: presetting of the parameters according to Chien-Hrones-Reswick (static method)*
- *P, PD, PI and PID controls of a high order process: parallel and series configuration*

Discontinuous Automatic Control - DAC

After the experimental chapters where the characteristics and the typical behaviours of processes, controllers and continuous automatic control systems have been deeply analyzed, we open here a new chapter where the Discontinuous Automatic Control systems are simulated and analyzed; in these systems the controller is composed of a an element with discontinuous intervention.

A discontinuous controller is characterized by an output having two or more fixed states and its value is switched among these states according to the input value.

The topics that are covered in this chapter are the following:

- *Two position controllers, three range controllers*
- *Sampling acquisition techniques*
- *The two position controller in a 1st order process*
- *The three range controller in a 2nd order process*
- *The two position controller with delayed feedback in a 2nd order process*
- *The two position controller with elastic feedback in a 2nd order process*
- *The sampling control in a 4th order process*

APPLICATIONS

At the end of the experimental chapters dedicated to the analysis and testing on: Processes, Controllers, Continuous Automatic Control, Discontinuous Automatic Control, we can consider as completed the theoretical-experimental knowledge acquisition which is necessary for the practical application to be performed on real processes.

The Laboratory Experiments that are proposed in this section form a working path purposely structured in order to stimulate students to the application of what has been learned in the previous chapters.

In this way we want to educationally involve the students in the search for the most suitable solution for that particular type of control of the real process under evaluation.

Control of a DC motor - MOT

- *P, PI and PID controls of the speed of a DC motor using the CHR method*

Temperature control - TEM

- *The two position controller in the temperature process*
- *The two position controller with delayed feedback in the temperature process*
- *The two position controller with elastic feedback in the temperature process*
- *The three range controller in the temperature process*
- *P, PI and PID controls of the temperature process using the CHR method*

Light control - LUM

- *P, PI and PID light controls using the CHR method*

Level control - LEV

- *P, PI and PID level controls*

FLO

Flow control

- *P, PI and PID flow controls*

AUTOMATIC CONTROL TECHNOLOGY

List of modules for experiments:

EXPERIMENTS \ MODULES	DL 2613	DL 2614	DL 2622	DL 2670	DL 2671	DL 2672	DL 2673	DL 2674	DL2675	DL 2676	DL 2677	DL 2678	DL 2679	DL 2680	DL 2681	DL 2682	DL 2625	DL 2684	DL 2685	DL 2686	DL 2687	DL 2688	DL 2689	DL 2690	DL 2691	DL 2692	DL PS-MOD	DL PP-MOD	DL 2109D33	OSCILLOSCOPE	DL 1155ACT	DL 2100-3M
PROCESSES																																
Type P	1								1												1									1	1	1
Type I	1								1												1									1	1	1
Type I^2	1								1												1									1	1	1
1st order	1								1												1									1	1	1
Higher than 1st	1								2												1									1	1	1
2nd order	1									1	1										1									1	1	1
CONTROLLERS																																
Controller P	1			1																	1									1	1	1
Controller I	1				1																1									1	1	1
Controller D	1					1															1									1	1	1
Controller PI	1			1	1			1													1									1	1	1
Controller PD	1			1		1		1				1									1						1			1	1	1
Controller PID	1			1	1	1		1													1									1	1	1
Controller PID with regulation of offset	1			1	1	1		1									1				1									1	1	1
CONTINUOUS AUTOMATIC CONTROL																																
Regulation P, process type P	1	1		1			1		1																					1	1	1
Regulation P, process of 1st order and superior	1	1	1						2																			1		1	1	1
Regulation I , process 2nd order	1	1			1		1		1																			1		1	1	1
Regulation P, PD, PI e PID, process of high order	1	1	1						2																		1	1		1	1	1
Ziegler-Nichols method	1	1	1						2																		1	1		1	1	1
Chien-Hrones-Reswick static method	1	1	1						2																		1	1		1	1	1
Parallel and series configuration	1	1		1	1	1	1	1	2																			1		1	1	1
DISCONTINUOUS AUTOMATIC CONTROL																																
Controllers with 2 positions, controllers with 3 ranges	1	1						1				1	2																	1	1	1
Techniques of acquisition and sampling	1													1							1									1	1	1
Controller with 2 positions, process of 1st order	1	1							1				1															1		1	1	1
Controller with 3 range, process of 2nd order	1	1						1	1			1	2															1		1	1	1
Controller with 2 positions, process of 2nd order, delayed feedback	1	1						1	2				1														1	1		1	1	1
Controller a 2 positions, process of 2nd order, elastic feedback	1	1						1	2				1															1		1	1	1
Controller with sampling, process of 4th order	1	1	1						2					1														1		1	1	1
CONTROL OF A DC MOTOR																																
Regulation P, PI e PID of speed in a DC motor, CHR method	1	1	1	1											1			1										1		1	1	1
Control of a generator	1	1	1	1											1	1		1										1		1	1	1
TEMPERATURE CONTROL																																
Controller with 2 positions	1	1											1					1	1											1	1	1
Controller with 2 positions, delayed feedback	1	1						1	1				1					1	1								1	1		1	1	1
Controller with 2 positions, elastic feedback	1	1						1	1				1					1	1									1		1	1	1
Controller with 3 ranges	1	1						1				1	2					1	1									1		1	1	1
Regulation P, PI e PID of temperature, CHR method	1	1	1															1	1									1		1	1	1
LIGHT CONTROL																																
Regulation P, PI e PID of light, CHR method	1	1	1															1		1								1		1	1	1
LEVEL CONTROL																																
Pump's features	1	1																1				1	1						1		1	1
Measurement system's features	1	1																1				1	1	1					1		1	1
Level process features	1	1																1				1	1	1					1		1	1
Level control with adjuster P	1	1		1			1					1						1				1	1	1					1		1	1
Level control with adjuster PI	1	1		1	1		1	1				1						1				1	1	1					1		1	1
Level control with adjuster PID	1	1	1									1						1				1	1	1			1		1		1	1
Level control with a 2 position controller	1	1																1				1	1	1					1		1	1
FLOW CONTROL																																
Measurement system's features	1	1																1				1	1		1				1	1	1	1
Analysis of flow control features	1	1	1	1														1				1			1	1	1		1		1	1
TOTAL																																
	1	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1