Preamble

Proportional Integral Derivative (*PID*) control is a technique that is well known and widely used in the industrial world. Many authors agree that more than 90% of control loops are of the *PID* type.

It is an old technique that has continued to evolve over more than 70 years: from pneumatic controllers (nozzle-pallet system) through electronic controllers (operational amplifiers) to programmable digital controllers (microprocessors): programmable logic controller (PLC), distributed control systems (DCS).

During this development, many adjustment methods were developed: the first dates back to 1935 (Callender, Hartree and Porter), and especially to 1942 (Ziegler and Nichols), and the very way of approaching adjustment has been structured over the years.

One might therefore think that *PID* tuning is well mastered: it is not the case. It is estimated that only 20% of loops work well (Yu, 2006). In many cases the controllers operate manually, or the derivative action is not used or a manufacturer default setting is used. There are several reasons: there are difficulties due to the equipment (imperfection of sensors and actuators such as valves, for example). But we must also add a too weak dissemination of knowledge in the industrial environment linked in particular to the dispersion of the many articles, books, and publications on the subject, to their spread over decades, and to the gap that still remains between theory and practice.

This book aims to put theory at the service of practice by providing a minimum base of knowledge to use *PID* control in the field, with similar approaches, notations, and criteria for comparison and evaluation of performance obtained, in order to have a better global view of the issue.

In this book, the processes and controllers are described by transfer functions with Laplace notation.

The book is divided into 2 parts and can be addressed to several audiences.

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The first part concerns the main properties of a *PID* controller with its different aspects (continuous, digital) as well as the basic concepts for the use of *PID* control.

The first chapter recalls the characteristics of the *PID* controller. These are the usual notions concerning the continuous *PID*, also called "analogue", with the basic actions: gain, integral derivative. Its different structures (parallel, mixed, series, with actions on deviation or measurement) and also structure conversions are addressed. This is a must-see chapter.

Chapter 2 concerns the digital *PID* resulting from the discretization of the continuous *PID*. It is a sampled controller that uses the z-transformation: the concepts of gain, integral, derivative disappear or at least are no longer available: the adjustment is obtained by calculating the coefficients of the sampled transfer function of the controller that can be written in two ways (*PID* and RST).

You will find the correspondence tables to go from continuous to digital.

This chapter is necessary for the implementation of controllers and the use of the digital adjustment methods (chapter 11). It can be omitted if only the classic setting is considered.

Chapter 3 discusses the implementation of controllers in terms of pseudo-code realization algorithms, close to implementation, with the 2 forms, *PID* and RST. It is typically aimed at IT developers by offering simple algorithms as the bases of the computer development for *PID* controllers. The issues of limitations and integral saturation (anti windup) are also discussed.

Chapter 4 may appear irrelevant as it concerns the process models used in the setting. This is important, however, because in spite of model-free methods, most of the settings methods refer, near or far, to a model for the process. Here, we discuss only simple, often graphic methods to identify the process to be controlled, without using identification software.

This chapter is intended only for the practitioner wishing to identify his process in a simple way. It can be omitted in a first reading.

Chapter 5 outlines the main elements defining a setting, as well as different criteria used to characterize them. It is essential, because it contains concepts, terms and symbols commonly used in the literature and throughout the rest of the book.

Part 2 focuses on adjustment methods for manual tuning. They are categorized as follows:

- Chapter 6: Ziegler–Nichols and Associated Methods
- Chapter 7: Cancellation Methods
- Chapter 8: Optimization Methods
- Chapter 9: Pole Placement Methods
- Chapter 10: Frequency Methods
- Chapter 11: Digital Settings Methods

All these methods are exposed from the principles to the final use in the industrial area. They are always illustrated with numerous examples to show their specificity and performances obtained.

The last chapter deals with the practical reality of the setting with the consideration of constraints: limitations, non-linearities, sampling period, influence of the model and the parameters of identification of the process.

Questions of choice (structures, methods) are also addressed.

This is an important chapter that will allow any automation engineer, specialist or not, to better understand the performances that can be expected from *PID* control.

Finally, the usual ingredients can be found in the appendix to save time in making use of a method: classic curves concerning the systems of the 1st and 2nd orders, conversion of models, conversion from continuous to digital models, and particular points.

This book is above all a practical guide. There are indeed many examples and summary tables allowing immediate use of knowledge, with as less calculations as possible to facilitate the practice of *PID* control.

The book aims to be useful to a wide spectrum of readers interested in *PID* control ranging from practising technicians and engineers in the industrial area to graduate and undergraduate students.