

Chapter 1

Introduction

1.1 Preliminary Remarks

The ability of proportional integral (PI) and proportional integral derivative (PID) controllers to compensate most practical industrial processes has led to their wide acceptance in industrial applications. Koivo and Tanttú (1991), for example, suggest that there are perhaps 5–10% of control loops that cannot be controlled by single input, single output (SISO) PI or PID controllers; in particular, these controllers perform well for processes with benign dynamics and modest performance requirements (Hwang, 1993; Åström and Hägglund, 1995). It has been stated that 98% of control loops in the pulp and paper industries are controlled by SISO PI controllers (Bialkowski, 1996) and that in process control applications, more than 95% of the controllers are of PID type (Åström and Hägglund, 1995). PI or PID controller implementation has been recommended for the control of processes of low to medium order, with small time delays, when parameter setting must be done using tuning rules and when controller synthesis is performed either once or more often (Isermann, 1989).

However, despite decades of development work, surveys indicating the state of the art of control in industrial practice report sobering results. For example, Ender (1993) states that in his testing of thousands of control loops in hundreds of plants, it has been found that more than 30% of installed controllers are operating in manual mode and 65% of loops operating in automatic mode produce less variance in manual than in automatic (i.e. the automatic controllers are poorly tuned). The situation does not appear to have improved more recently, as Van Overschee and De Moor (2000) report that 80% of PID controllers are badly tuned; 30% of PID controllers operate in manual with another 30% of the controlled loops increasing the short term variability of the process to be controlled (typically due to too strong integral action). The authors state that 25%

of all PID controller loops use default factory settings, implying that they have not been tuned at all.

These and other surveys (well summarised by Yu, 1999, pp. 1–2) show that the determination of PI and PID controller tuning parameters is a vexing problem in many applications. The most direct way to set up controller parameters is the use of tuning rules; obviously, the wealth of information on this topic available in the literature has been poorly communicated to the industrial community. One reason is that this information is scattered in a variety of media, including journal papers, conference papers, websites and books for a period of over seventy years.

The purpose of this book is to bring together, in summary form, the tuning rules for PI and PID controllers that have been developed to compensate SISO processes with time delay.

1.2 Structure of the Book

Tuning rules are set out in the book in tabular form. This form allows the rules to be represented compactly. The tables have four or five columns, according to whether the controller considered is of PI or PID form, respectively. The first column in all cases details the author of the rule and other pertinent information. The final column in all cases is labelled ‘Comment’; this facilitates the inclusion of information about the tuning rule that may be useful in its application. The remaining columns detail the formulae for the controller parameters.

Chapter 2 explores the range of PI and PID controller structures proposed in the literature. It is often forgotten that different manufacturers implement different versions of the PID controller algorithm (in particular); therefore, controller tuning rules that work well in one PID architecture may work poorly in another. This chapter also details the process models used to define the controller tuning rules.

Chapters 3 and 4 detail, in tabular form, PI and PID controller tuning rules (and their variations), as applied to a wide variety of self-regulating process models and non-self-regulating process models, respectively. One-hundred-and-sixteen such tables are provided altogether. To allow the reader to access data readily, the author has arranged that each table starts on its own page; each table is preceded by the controller used, together with a block diagram showing the unity feedback closed loop arrangement of the controller and process model.

In Chapter 5, analytical calculations of the gain and phase margins of a large sample of PI and PID controller tuning rules are determined, when the process is modelled in first order lag plus time delay (FOLPD) form, at a range of ratios

of time delay to time constant of the process model. Results are given in graphical form.

An important feature of the book is the unified notation used for the tuning rules; a glossary of the symbols used is provided in Appendix 1. Appendix 2 outlines the range of methods used to determine process model parameters; this information is presented in summary form, as this topic could provide data for a book in itself. However, sufficient information, together with references, is provided for the interested reader.

Finally, a comprehensive reference list is provided. In particular, the author would like to recommend the contributions by McMillan (1994), Åström and Hägglund (1995), (2006), Shinskey (1994), (1996), Tan *et al.* (1999a), Yu (1999), Lelic and Gajic (2000) and Ang *et al.* (2005) to the interested reader, which treat comprehensively the wider perspective of PID controller design and application.