A review of the book "Industrial Control Systems Design" by Michael J Grimble, Wiley, 2001.

The book offers a wide overview of different advanced control design methods with special focus on practical industrial applications. It is structured into three parts: 1. polynomial system descriptions; 2. state-space and frequency response description; and 3. industrial applications. Part 1 and 2 are mostly theoretical, even though small practical numerical examples are disseminated throughout the text. Various discrete-time control strategies are described there, such as H_2 or H_∞ optimal control, but also predictive optimal control or quantitative feedback theory (QFT). Part 1 on polynomial methods, mainly following Vladimír Kučera's school initiated in the late 1970s, is significantly more developed that part 2 on state-space methods, which adequately compensates for the large number of newly published books focusing on pure state-space methods. Part 3 is oriented towards industrial applications, showing clearly that a wide range of different tools is required to cope with various practical requirements. Based on the author's vast experience with industrial projects, comprehensive chapters are dedicated to electrical power generation and transmission, metal rolling processes in hot strip mills, marine control systems for roll stabilization and ship positioning, turbofan engine control and flight control design.

The detailed description of the chapters contents is as follows. Chapter 1 is a general introduction to advanced industrial control. It features an interesting comparison between polynomial techniques and state-space techniques, as well as original, documented overview of fault-tolerant control systems encompassing fault monitoring and diagnosis, redundancy, control reconfiguration and multiple model approaches. Chapter 2, as the first chapter of part 1, is dedicated to the polynomial solution to scalar (SISO) H_2 control, a particular case of which is LQG control. The approach, based on spectral factorization and polynomial Diophantine equations, is quite standard. Multiple degrees-of-freedom H_2 control is described and it is shown that feedforward, feedback and tracking components of the cost function can be tuned independently. Chapter 3 proposes an original extension of chapter 2 to H_2 predictive optimal control. After a short review of historical developments of generalized predictive control (GPC), an LQG optimal predictive control is described based on a nested set of polynomial Diophantine equations. Chapter 4 is an extension to multivariable (MIMO) systems of the polynomial H_2 optimal control law introduced in Chapter 2. The contribution here is twofold. First, with the help of an additional polynomial matrix Diophantine equation, fault detection requirements can be introduced, resulting in a combined fault monitoring H_2 control. Second, an observer-like structure and a separation principle are proposed, which is reminiscent of state-space techniques. In Chapter 5, a polynomial approach to H_∞ optimal control is pursued. The SISO version is first proposed, with feedback tracking and feedforward components, as a counterpart to the H_2 SISO control of chapter 2. Then, a single-input-multiple-output (SIMO) version is introduced, with a specific application to power systems in mind. Finally, the H_∞ equivalent of the LQG predictive control law of chapter 3 is presented. Chapter 6 is the last chapter in part 1 devoted to polynomial techniques. It concerns H_2 and H_∞ filtering and prediction. H_2 estimation is described as a control strategy suitable to stochastic problems, in contrast with H_∞ estimation, rather suitable to robustness problems.

Part 2 of the book, focusing on state-space techniques, opens with chapter 7 on H_2 and H_∞ control and filtering. It is shown that the solution relies on discrete algebraic Riccati equations, Kalman filters and the classical separation principle. Explicit delay elements on input and output channels are considered, and links with Smith predictor techniques are enlightened. Predictive optimal control is the topic of chapter 8, and can be viewed as the state-space counterpart to chapter 3. LQG GPC design with multi-step criterion is shown to overcome undesirable stability and robustness properties of the standard GPC. Through terms are then introduced to approximate fast dynamics between system inputs and outputs. The remainder of the chapter covers predictive optimal control without multi-step criterion, for which future set-point information is incorporated into a usual LQ criterion. Chapter 9 on QFT techniques, as the last chapter of part 2, offers a different perspective to optimal control, allowing direct manipulation of system frequency responses. It is shown how QFT can give insight into previously studied state-space optimal control strategies of part 2. After a comprehensive introduction to SISO QFT design, MIMO design is described and relationships with H_∞ control are unveiled.

The third and last part of the book is a collection of four chapters describing industrial applications of the theory developed in the first two parts. Chapter 10 concerns power generation and transmission. It is shown that the problem of controlling the voltage of a generator can boil down to an H_2 or H_∞ SIMO control problem, as studied in chapter 5. Feedback is required to reduce oscillation between power station and network. The design of control for metal processing is the topic of chapter 11, which offers a well-documented survey on existing techniques for multivariable hot strip mill control. After an extensive description of different control problems that can arise (control of interstand tension, flatness and profile), MIMO state-space H_∞ techniques are applied. Chapter 12 is devoted to marine control systems, and more specifically fin roll stabilization and robust ship positioning systems. Both control problems can be formulated as SISO H_∞ control problems for which the polynomial techniques of chapter 5 offer a neat solution with significant advantages over standard LQG/Kalman method. MIMO state-space H_∞ techniques are then proposed to handle the trade-off between robustness and stochastic requirements. Finally, the closing chapter 13 offers a perspective on aero-engine and flight control design. The first section on gas turbine control describes the application of MIMO state-space H_∞ techniques to control an axial twin spool reheated turbofan engine, whereas the second section focuses on a MIMO state-space H_∞ design for a generic canard-delta aircraft configuration.

Generally speaking, the book covers a wide range of advanced control strategies with a clear preference for polynomial techniques. As its title suggests, the main strength of the book is in a careful description of several industrial applications. Four entire chapters in part 3 are devoted to specific, practical control problems arising in industry. Each chapter opens with a comprehensive expert description of an industrial control problem, with a survey on existing techniques and approaches. Extensive numerical results are then provided illustrating how modern control technologies can successfully be applied. In addition to this, in parts 1 and 2 the theory is systematically illustrated by a remarkable set of small meaningful numerical examples disseminated throughout the text. The examples are meant to bridge the gap between practical industrial concepts and the sometimes too abstract style of control theory textbooks. One may regret however that in part 3 four large chapters on industrial applications cover almost exclusively H_2 and H_∞ techniques, whereas parts 1 and 2 are wider in scope, describing also predictive control, filtering, estimation, and QFT methodologies. Another disappointing feature of the book is that parts 1 and 2 focus systematically on discrete-time formulations and solutions of control problems, whereas part 3 describes only continuous-time applications.

The book is probably not suitable for teaching, as standard techniques are just briefly recalled at the beginning of each section, with no special tutorial care, and then rapidly extended or generalized to cope with less standard, additional requirements. As a result, the reader may sometimes feel overwhelmed by tricky notations and long technical developments.

On the whole, the book can be considered as a reference work meant for experimented control engineers or researchers interested in latest developments and improvements of practical control design methods, benefiting from the impressive experience of the author in industrially-oriented projects.

Didier Henrion, Toulouse, September 2002.