

Preface

Electric Power Applications of Fuzzy Systems is intended to offer an introduction to certain applications of fuzzy system theory to selected areas of electric power engineering. The idea is to introduce theoretical background material from a practical point of view and then proceed to explore a number of applications of fuzzy systems.

Fuzzy sets and logic were introduced in the mid-sixties in order to mathematically formalize the treatment of imprecise notions and concepts found in almost every decision-making situation. There has been a phenomenal increase in research activities aimed at implementing fuzzy concepts in many engineering applications. This has been facilitated by the publication of theoretically based books that explain the mathematical foundations of fuzzy sets and logic and, therefore, promote their usage in real-world applications such as in electric power systems.

Most recently, there has been a tremendous surge in research and application articles on applying fuzzy systems in electric power engineering. However, there are currently no books that put together a practical guide to the fundamentals and application aspects. This book is intended to fill this gap in the area of applied computational intelligence.

It is hoped that the book will attract not only the power engineer but also experts in the computational intelligence community, who would benefit from the exposure to the practical aspects of the problems discussed. We have assembled a distinguished panel of experts to write original chapters introducing and summarizing areas of applications. Our panel includes American, Canadian, Chinese, European, and Japanese contributors. All are well respected for their contributions to recent advances in power systems engineering.

The idea of this book is to put together under one cover original contributions by authors who have pioneered in the application of fuzzy system theory to the electric power engineering field. As such, each chapter represents both an introduction to and a state-of-the-art review of each application area.

Following the introduction of Chapter 1, we offer a summary of fundamentals of fuzzy systems in Chapter 2. The remainder of the book is devoted to individual applications. Chapter 3, on fuzzy information approaches to equipment condition monitoring and diagnosis, is written by Tomsovic and Baer. Equipment monitoring and maintenance aim at anticipating failures or accelerated aging in power equipment. Many of the indicators of equipment condition are imprecise and/or unreliable. The chapter emphasizes uncertainty modeling of diagnostic problems. Fuzzy information methods are employed to represent quantitatively the diagnostic capability of a system. Further, several methods are discussed for extracting information from test data and evaluating system performance.

In Chapter 4, El-Sharkawi, Marks II, Streifel, and Kerszenbaum discuss detection and localization of shorted turns in the DC field winding of turbine-generator rotors using novelty detection and fuzzified neural networks. Use of neural networks with fuzzy logic outputs and traveling-wave techniques is shown to be an accurate locator of shorted turns in turbo-generator rotors. The technique is extended to operational rotors by the use of a novelty filter.

Low-frequency oscillations are a common problem in large power systems. A power system stabilizer (PSS) can provide a supplementary control signal to the excitation system and/or the speed governor system of the electric-generating unit to damp these oscillations and to improve its dynamic performance. Chapters 5 and 6 are devoted to this topic.

In Chapter 5, on fuzzy logic controllers as power system stabilizers, Malik and El-Metwally describe the structure and design of a fuzzy logic controller and an algorithm to tune its parameters to achieve the desired performance. Two rule generation methods to automatically generate the fuzzy rule set are proposed.

In Chapter 6, Hiyama presents a study on fuzzy logic control schemes using polar information for stability enhancement. Here, advanced fuzzy logic control rules are introduced based on three-dimensional information of generator acceleration, speed, and phase angle. Stabilizing signals are revised at every sampling instant and fed back to the excitation control loop of the generator. The results have been implemented on a prototype tested on hydro units in the Japanese KEPCO system.

The second contribution of Hiyama is on fuzzy logic switching control of FACTS devices, presented in Chapter 7. Here a fuzzy logic switching control scheme is proposed for devices such as the thyristor-controlled series capacitor modules, static var compensators, and braking resistors.

In Chapter 8 the effects of uncertain load in real time and off-line power network modeling are discussed. Here, Lu and Leou describe different approaches for representing uncertain load in power systems.

Miranda treats power system reliability in Chapter 9, a fuzzy perspective of power system reliability. Here the author concentrates mainly on reliability assessment for mid- to long-term purposes. Three types of models are discussed. In Type I, only a fuzzy description of the system load is available. For Type II fuzzy reliability

assessment, component reliability indices are fuzzy. Extending the concept, we can also deal with a Type III model.

In Chapter 10, Matsumoto discusses an operation support expert system for startup schedule optimization in fossil power plants. The chapter describes expectations of fuzzy theory in fossil power plant operation and two types of expert systems applied to operation support systems for a conventional one through type super-critical pressure fossil power plant and a gas and steam turbine combined-cycle power plant. Fuzzy models of expertise are introduced to modify the plant startup schedule. The most remarkable feature of this approach is that the quantitative optimum schedule is obtained through iterative modification of the schedule from a combination of qualitative knowledge and plant dynamic simulations.

In Chapter 11, Shahidehpour and Ferrero introduce a fuzzy system approach to short-term power purchases considering uncertain prices. Here, the authors present a methodology to evaluate power purchases in an uncertain environment. Power generation, line flows, and prices are considered as triangular fuzzy numbers. The proposed methodology computes the range of control variables that satisfies the set of constraints as well as a certain reduction in the operation cost. The range of control variables is correlated with the desired cost reduction (goal). The lower the desired cost reduction, the narrower the range of control variables that satisfies the set of constraints. The authors point out that the proposed method can be extended to include extra constraints related with operational practices in utilities.

The intended audience includes power system professionals as well as researchers and developers of software/hardware tools of fuzzy systems in particular and the computational intelligence community. It is expected that the reader is a graduate of an engineering/computer science degree program with a modest mathematical background.

*Mohamed E. El-Hawary
DalTech of Dalhousie University*