Fault Diagnosis for Electric Power Systems and Electric Vehicles

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First Edition

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Preface

The aim of this monograph on ”Fault diagnosis for electric power systems and electric vehicles” is to analyze methods for fault detection and isolation in electric power systems and in electric traction and propulsion systems. To this end, the following topics are treated:

(a) model-based fault diagnosis with the use of nonlinear estimation methods and statistical fault diagnosis criteria. Modelling of the fault-free condition of nonlinear systems with the use nonlinear Kalman filters and nonlinear observers are extensively presented. At a next stage statistical decision making for fault detection and isolation is analyzed. Statistical approaches to fault diagnosis are introduced as methods that allow for precise and optimized definition of fault thresholds and which permit for distinguishing for incipient parametric changes in the monitored systems and for minimizing the launching of false alarms. In this context, an approach for fault thresholds definition based on the confidence intervals of the χ^2 (chi-square) distribution is presented. Several application examples are given about fault detection and isolation in the electric power transmission and distribution system, interconnected electric power units, conventional AC power units, renewable energy sources, electric power microgrids, and electric machines.

(b) model-free fault diagnosis with the use of nonlinear estimation methods and statistical fault diagnosis criteria. In particular modelling of the fault-free condition of nonlinear systems with the use of nonlinear regressors (e.g. neural networks) and the associated nonlinear least squares techniques are explained. Neural networks with Gauss-Hermite activation functions are introduced as an approach for modelling nonlinear dynamical systems, and particularly electric power generation and electric traction and propulsion systems. Besides, the statistical processing of the residuals of these neural networks, which are the differences between the outputs of the neural models and the outputs of the monitored system is shown to provide clear indications about the existence of faults.

In the present monograph on *Fault diagnosis for electric power systems and electric vehicles*, the following issues are analyzed: Chapter 1 is on Fault diagnosis with model-based and model-free techniques (Model-based fault diagnosis techniques and Model-free fault diagnosis techniques). Chapter 2 is on Control and fault diagnosis for Synchronous Generator-based renewable energy systems (Control of the marine-turbine and synchronous-generator unit and Fault diagnosis of the marine-turbine and synchronous-generator unit). Chapter 3 is on Fault diagnosis for electricity microgrids and gas processing units (Fault diagnosis for electric power DC microgrids and Fault diagnosis for electrically actuated gas compressors). Chapter 4 is on Fault diagnosis for gas and steam-turbine power generation units (Fault diagnosis for the gas-turbine and Synchronous Generator electric power unit and for the steam-turbine and synchronous generator power unit). Finally, Chapter 5 is on Fault diagnosis for wind power units and for the distribution grid (Fault diagnosis for wind power generators and Fault diagnosis for the electric power distribution grid).

Through the detailed and in depth treatment of the aforementioned topics, this monograph is expected to have a meaningful contribution to the members of the research, academic and engineering community. It is anticipated that the monograph will be particularly useful to researchers and university tutors working on fault diagnosis problems of electric power systems and of electric traction and propulsion systems.

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About the authors

Dr. Gerasimos Rigatos obtained his diploma (1995) and his Ph.D. (2000) both from the Department of Electrical and Computer Engineering, of the National Technical University of Athens (NTUA), Greece. In 2001 he was a post-doctoral researcher at IRISA-INRIA, Rennes, France. He is currently a Research Director (Researcher Grade A') at the Industrial Systems Institute, Greece. He is a Senior Member of IEEE, and a Member and CEng of IET. He has led several research cooperation agreements and projects which have given accredited results in the areas of non-linear control, nonlinear filtering and control of distributed parameter systems. His results appear in 8 research monographs and in several journal articles. According to Elsevier Scopus his research comprising 135 journal articles where he is the first or sole author, has received more than 3000 citations with an H-index of 26. Since 2007, he has been awarded visiting professor positions at several academic institutions (University Paris XI, France, Harper-Adams University College, UK, University of Northumbria, UK, University of Salerno, Italy, Ecole Centrale de Nantes, France). He is an editor of the Journal of Advanced Robotic Systems and of the SAE Journal of Electrified Vehicles.

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Dr. Mohamed-Assaad Hamida was born in El Oued, Algeria, in 1985. He received the B.Sc . degree in electrical engineering from the University of Batna, Batna, Algeria, in 2009, the M.Sc. degree in automatic control from Ecole Nationale Superieure d'Ingenieurs de Poitiers (ENSIP), Poitiers, France, in 2010, and the Ph.D degree in automatic control and electrical engineering from Ecole centrale de Nantes, Nantes, France, in 2013. From 2013 to 2017, he was an Associate Professor of Electrical Engineering with the University of Ouargla, Algeria. In 2017, he joined the Ecole Centrale de Nantes and the Laboratory of Digital Sciences of Nantes (LS2N), as an Associate Professor. Dr. Hamida is the local coordinator of the European project E-PiCo on Electric Vehicles Propulsion and Control at Ecole Centrale of Nantes and the head of the real-time systems unit in the same university. His research interests include robust nonlinear control (higher order sliding mode, backstepping, adaptive control, optimal control), theoretical aspects of nonlinear observer design, control and fault diagnosis of electrical systems and renewable energy applications. His current research interests include robust nonlinear control, theoretical aspects of nonlinear observer design, control, and fault diagnosis of electrical systems and renewable energy applications.

Dr. Pierluigi Siano received the M.Sc. degree in electronic engineering and the Ph.D. degree in information and electrical engineering from the University of Salerno, Salerno, Italy, in 2001 and 2006, respectively. He is Full Professor of Electrical Power Systems and Scientific Director of the Smart Grids and Smart Cities Laboratory with the Department of Management and Innovation Systems, University of Salerno. Since 2021 he has been a Distinguished Visiting Professor in the Department of Electrical and Electronic Engineering Science, University of Johannesburg. His research activities are centered on demand response, energy management, the integration of distributed energy resources in smart grids, electricity markets, and planning and management of power systems. In these research fields, he has co-authored more than 700 articles including more than 410 international journals that received in Scopus more than 19200 citations with an H-index equal to 66. Since 2019 he has been awarded as a Highly Cited Researcher in Engineering by Web of Science Group. He has been the Chair of the IES TC on Smart Grids. He is Editor for the Power & Energy Society Section of IEEE Access, IEEE Transactions on Power Systems, IEEE Transactions on Industrial Informatics, IEEE Transactions on Industrial Electronics, and IEEE Systems.