



(1) *Fault process*



(2) *power System fault information*

$t: t_i$

# Fault Diagnosis Systems Fault Diagnosis Systems

**Rolf Isermann**



## **Fault Diagnosis Systems Fault Diagnosis Systems:**

*Fault-Diagnosis Systems* Rolf Isermann, 2005-10-13 With increasing demands for efficiency and product quality plus progress in the integration of automatic control systems in high cost mechatronic and safety critical processes the field of supervision or monitoring fault detection and fault diagnosis plays an important role The book gives an introduction into advanced methods of fault detection and diagnosis FDD After definitions of important terms it considers the reliability availability safety and systems integrity of technical processes Then fault detection methods for single signals without models such as limit and trend checking and with harmonic and stochastic models such as Fourier analysis correlation and wavelets are treated This is followed by fault detection with process models using the relationships between signals such as parameter estimation parity equations observers and principal component analysis The treated fault diagnosis methods include classification methods from Bayes classification to neural networks with decision trees and inference methods from approximate reasoning with fuzzy logic to hybrid fuzzy neuro systems Several practical examples for fault detection and diagnosis of DC motor drives a centrifugal pump automotive suspension and tire demonstrate applications

**Fault-Diagnosis Systems** Rolf Isermann, 2011-11 With increasing demands for efficiency and product quality and progressing integration of automatic control systems in high cost mechatronic and safety critical processes the field of supervision or monitoring fault detection and fault diagnosis plays an important role The book gives an introduction into advanced methods of fault detection and diagnosis FDD After definitions of important terms the reliability availability safety and systems integrity of technical processes is considered Then fault detection methods for single signals without models like limit and trend checking and with harmonic and stochastic models like Fourier analysis correlation and wavelets are treated This is followed by fault detection with process models using the relationships between signals like parameter estimation parity equations observers and principal component analysis The treated fault diagnosis methods include classification methods from Bayes classification to neural networks with decision trees and inference methods from approximate reasoning with fuzzy logic to hybrid fuzzy neuro systems Especially for safety critical processes fault tolerant systems are required Basic redundant structures like n out of m systems cold and hot standby are considered and ways to design fault tolerant sensors actuators and control systems are outlined Several practical examples for fault detection and diagnosis of DC motor drives a centrifugal pump automotive suspension and tire show applications

**Fault-Diagnosis Applications** Rolf Isermann, 2011-04-06 Supervision condition monitoring fault detection fault diagnosis and fault management play an increasing role for technical processes and vehicles in order to improve reliability availability maintenance and lifetime For safety related processes fault tolerant systems with redundancy are required in order to reach comprehensive system integrity This book is a sequel of the book *Fault Diagnosis Systems* published in 2006 where the basic methods were described After a short introduction into fault detection and fault diagnosis methods the book shows how these methods can

be applied for a selection of 20 real technical components and processes as examples such as Electrical drives DC AC Electrical actuators Fluidic actuators hydraulic pneumatic Centrifugal and reciprocating pumps Pipelines leak detection Industrial robots Machine tools main and feed drive drilling milling grinding Heat exchangers Also realized fault tolerant systems for electrical drives actuators and sensors are presented The book describes why and how the various signal model based and process model based methods were applied and which experimental results could be achieved In several cases a combination of different methods was most successful The book is dedicated to graduate students of electrical mechanical chemical engineering and computer science and for engineers

*Data-driven Design of Fault Diagnosis and Fault-tolerant Control Systems* Steven X. Ding, 2014-04-12 Data driven Design of Fault Diagnosis and Fault tolerant Control Systems presents basic statistical process monitoring fault diagnosis and control methods and introduces advanced data driven schemes for the design of fault diagnosis and fault tolerant control systems catering to the needs of dynamic industrial processes With ever increasing demands for reliability availability and safety in technical processes and assets process monitoring and fault tolerance have become important issues surrounding the design of automatic control systems This text shows the reader how thanks to the rapid development of information technology key techniques of data driven and statistical process monitoring and control can now become widely used in industrial practice to address these issues To allow for self contained study and facilitate implementation in real applications important mathematical and control theoretical knowledge and tools are included in this book Major schemes are presented in algorithm form and demonstrated on industrial case systems Data driven Design of Fault Diagnosis and Fault tolerant Control Systems will be of interest to process and control engineers engineering students and researchers with a control engineering background

Issues of Fault Diagnosis for Dynamic Systems Ron J. Patton, Paul M. Frank, Robert N. Clark, 2000-03-29 Since the time our first book Fault Diagnosis in Dynamic Systems Theory and Applications was published in 1989 by Prentice Hall there has been a surge in interest in research and applications into reliable methods for diagnosing faults in complex systems The first book sold more than 1 200 copies and has become the main text in fault diagnosis for dynamic systems This book will follow on this excellent record by focusing on some of the advances in this subject by introducing new concepts in research and new application topics The work cannot provide an exhaustive discussion of all the recent research in fault diagnosis for dynamic systems but nevertheless serves to sample some of the major issues It has been valuable once again to have the co operation of experts throughout the world working in industry government establishments and academic institutions in writing the individual chapters Sometimes dynamical systems have associated numerical models available in state space or in frequency domain format When model information is available the quantitative model based approach to fault diagnosis can be taken using the mathematical model to generate analytically redundant alternatives to the measured signals When this approach is used it becomes important to try to understand the limitations of the mathematical models i e the extent to which model

parameter variations occur and the effect of changing the systems point of operation      *Data-Driven Design of Fault Diagnosis Systems* Adel Haghani Abandan Sari, 2014-04-22 In many industrial applications early detection and diagnosis of abnormal behavior of the plant is of great importance During the last decades the complexity of process plants has been drastically increased which imposes great challenges in development of model based monitoring approaches and it sometimes becomes unrealistic for modern large scale processes The main objective of Adel Haghani Abandan Sari is to study efficient fault diagnosis techniques for complex industrial systems using process historical data and considering the nonlinear behavior of the process To this end different methods are presented to solve the fault diagnosis problem based on the overall behavior of the process and its dynamics Moreover a novel technique is proposed for fault isolation and determination of the root cause of the faults in the system based on the fault impacts on the process measurements

**Advanced Methods for Fault Diagnosis and Fault-tolerant Control** Steven X. Ding, 2021 After the first two books have been dedicated to model based and data driven fault diagnosis respectively this book addresses topics in both model based and data driven thematic fields with considerable focuses on fault tolerant control issues and application of machine learning methods The major objective of the book is to study basic fault diagnosis and fault tolerant control problems and to build a framework for long term research efforts in the fault diagnosis and fault tolerant control domain In this framework possibly unified solutions and methods can be developed for general classes of systems The book is composed of six parts Besides Part I serving as a common basis for the subsequent studies Parts II VI are dedicated to five different thematic areas including model based fault diagnosis methods for linear time varying systems nonlinear systems and systems with model uncertainties statistical and data driven fault diagnosis methods assessment of fault diagnosis systems as well as fault tolerant control with a strong focus on performance degradation monitoring and recovering These parts are self contained and so structured that they can also be used for self study on the concerned topics The content Basic requirements on fault detection and estimation Basic methods for fault detection and estimation in static and dynamic processes Feedback control observer and residual generation Fault detection and estimation for linear time varying systems Detection and isolation of multiplicative faults in uncertain systems Analysis parameterisation and optimal design of nonlinear observer based fault detection systems Data driven fault detection methods for large scale and distributed systems Alternative test statistics and data driven fault detection methods Application of randomised algorithms to assessment and design of fault diagnosis systems Performance based fault tolerant control Performance degradation monitoring and recovering Data driven fault tolerant control schemes The target groups This book would be valuable for graduate and PhD students as well as for researchers and engineers in the field The author Prof Dr Ing Steven X Ding is a professor and the head of the Institute for Automatic Control and Complex Systems AKS University of Duisburg Essen Germany His research interests are model based and data driven fault diagnosis control and fault tolerant systems as well as their applications in industry with a focus on

automotive systems chemical processes and renewable energy systems      Fault-Diagnosis Systems Qingliang Zhao,Xi Cao,2015      **Fault Detection and Diagnosis in Industrial Systems** L.H. Chiang,E.L. Russell,R.D. Braatz,2012-12-06

Early and accurate fault detection and diagnosis for modern chemical plants can minimise downtime increase the safety of plant operations and reduce manufacturing costs The process monitoring techniques that have been most effective in practice are based on models constructed almost entirely from process data The goal of the book is to present the theoretical background and practical techniques for data driven process monitoring Process monitoring techniques presented include Data driven methods principal component analysis Fisher discriminant analysis partial least squares and canonical variate analysis Analytical Methods parameter estimation observer based methods and parity relations Knowledge based methods causal analysis expert systems and pattern recognition The text demonstrates the application of all of the data driven process monitoring techniques to the Tennessee Eastman plant simulator demonstrating the strengths and weaknesses of each approach in detail This aids the reader in selecting the right method for his process application Plant simulator and homework problems in which students apply the process monitoring techniques to a non trivial simulated process and can compare their performance with that obtained in the case studies in the text are included A number of additional homework problems encourage the reader to implement and obtain a deeper understanding of the techniques The reader will obtain a background in data driven techniques for fault detection and diagnosis including the ability to implement the techniques and to know how to select the right technique for a particular application      **Fault Diagnosis and Fault Tolerance for Mechatronic Systems: Recent Advances** Fabrizio Caccavale,Luigi Villani,2003-09-05

The field of robotics continues to flourish and develop In common with general scientific investigation new ideas and implementations emerge quite spontaneously and these are discussed used discarded or subsumed at conferences in the reference journals as well as through the Internet After a little more maturity has been acquired by the new concepts then archival publication as a scientific or engineering monograph may occur The goal of the Springer Tracts in Advanced Robotics is to publish new developments and advances in the fields of robotics research rapidly and informally but with a high quality It is hoped that prospective authors will welcome the opportunity to publish a structured presentation of some of the emerging robotics methodologies and technologies The edited volume by Fabrizio Caccavale and Luigi Villani concerns with a wide subject of modern engineering namely mechatronics This new discipline has lately been receiving an increasing deal of attention for its unique connotation to represent a blend of mechanical electronic and information technologies In such a scenario the importance of providing the supervisory control system with fault detection and fault identification capabilities becomes crucial to the effective development of mechatronic systems      **System Fault Diagnostics, Reliability and Related Knowledge-Based Approaches** S.G. Tzafestas,Madan Singh,Günther Schmidt,1987-08-31      *Advanced Solutions in Diagnostics and Fault Tolerant Control* Jan M. Kościelny,Michał Syfert,Anna Szyber,2017-07-28 This book highlights the latest achievements

concerning the theory methods and practice of fault diagnostics fault tolerant systems and cyber safety When considering the diagnostics of industrial processes and systems increasingly important safety issues cannot be ignored In this context diagnostics plays a crucial role as a primary measure of the improvement of the overall system safety integrity level Obtaining the desired diagnostic coverage or providing an appropriate level of inviolability of the integrity of a system is now practically inconceivable without the use of fault detection and isolation methods Given the breadth and depth of its coverage the book will be of interest to researchers faced with the challenge of designing technical and medical diagnosis systems as well as junior researchers and students in the fields of automatic control robotics computer science and artificial intelligence

System Fault Diagnostics, Reliability and Related Knowledge-Based Approaches S.G. Tzafestas, Madan Singh, Günther Schmidt, 2012-12-06 *Fault Diagnosis in Dynamic Systems* Ron Patton, Robert Clark, Paul M. Frank, 1989 Concerned with monitoring techniques to detect predict isolate identify and correct malfunctions and failures of individual components within complex automatic systems used in industry and commerce The approaches examined include parameter estimation Markov modelling for threshold determination **Fault Diagnosis of Nonlinear Systems Using a Hybrid Approach** Ehsan Sobhani-Tehrani, Khashayar Khorasani, 2009-06-06 The increasing complexity of space vehicles such as satellites and the cost reduction measures that have affected satellite operators are increasingly driving the need for more autonomy in satellite diagnostics and control systems Current methods for detecting and correcting anomalies onboard the spacecraft as well as on the ground are primarily manual and labor intensive and therefore tend to be slow Operators inspect telemetry data to determine the current satellite health They use various statistical techniques and models but the analysis and evaluation of the large volume of data still require extensive human intervention and expertise that is prone to error Furthermore for spacecraft and most of these satellites there can be potentially unduly long delays in round trip communications between the ground station and the satellite In this context it is desirable to have onboard fault diagnosis system that is capable of detecting isolating identifying or classifying faults in the system without the involvement and intervention of operators Toward this end the principle goal here is to improve the efficiency accuracy and reliability of the trend analysis and diagnostics techniques through utilization of intelligent based and hybrid based methodologies *Model-Based Fault Diagnosis Techniques* Steven X. Ding, 2012-12-20 Guaranteeing a high system performance over a wide operating range is an important issue surrounding the design of automatic control systems with successively increasing complexity As a key technology in the search for a solution advanced fault detection and identification FDI is receiving considerable attention This book introduces basic model based FDI schemes advanced analysis and design algorithms and mathematical and control theoretic tools This second edition of Model Based Fault Diagnosis Techniques contains new material on fault isolation and identification and alarm management extended and revised treatment of systematic threshold determination for systems with both deterministic unknown inputs and stochastic noises addition of the continuously stirred tank heater as a representative

process industrial benchmark and enhanced discussion of residual evaluation which now deals with stochastic processes Model based Fault Diagnosis Techniques will interest academic researchers working in fault identification and diagnosis and as a text it is suitable for graduate students in a formal university based course or as a self study aid for practising engineers working with automatic control or mechatronic systems from backgrounds as diverse as chemical process and power engineering

*Knowledge-Driven Board-Level Functional Fault Diagnosis* Fangming Ye,Zhaobo Zhang,Krishnendu Chakrabarty,Xinli Gu,2016-08-19 This book provides a comprehensive set of characterization prediction optimization evaluation and evolution techniques for a diagnosis system for fault isolation in large electronic systems Readers with a background in electronics design or system engineering can use this book as a reference to derive insightful knowledge from data analysis and use this knowledge as guidance for designing reasoning based diagnosis systems Moreover readers with a background in statistics or data analytics can use this book as a practical case study for adapting data mining and machine learning techniques to electronic system design and diagnosis This book identifies the key challenges in reasoning based board level diagnosis system design and presents the solutions and corresponding results that have emerged from leading edge research in this domain It covers topics ranging from highly accurate fault isolation adaptive fault isolation diagnosis system robustness assessment to system performance analysis and evaluation knowledge discovery and knowledge transfer With its emphasis on the above topics the book provides an in depth and broad view of reasoning based fault diagnosis system design Explains and applies optimized techniques from the machine learning domain to solve the fault diagnosis problem in the realm of electronic system design and manufacturing Demonstrates techniques based on industrial data and feedback from an actual manufacturing line Discusses practical problems including diagnosis accuracy diagnosis time cost evaluation of diagnosis system handling of missing syndromes in diagnosis and need for fast diagnosis system development

**Diagnosis and Fault-Tolerant Control** Mogens Blanke,Jochen Schröder,2003 The book presents effective model based analysis and design methods for fault diagnosis and fault tolerant control Architectural and structural models are used to analyse the propagation of the fault through the process to test the fault detectability and to find the redundancies in the process that can be used to ensure fault tolerance Design methods for diagnostic systems and fault tolerant controllers are presented for processes that are described by analytical models by discrete event models or that can be dealt with as quantised systems Four case studies on pilot processes show the applicability of the presented methods The theoretical results are illustrated by two running examples which are used throughout the book The book addresses engineering students engineers in industry and researchers who wish to get a survey over the variety of approaches to process diagnosis and fault tolerant control

Fault Diagnosis Józef Korbicz,2004 This comprehensive work presents the status and likely development of fault diagnosis an emerging discipline of modern control engineering It covers fundamentals of model based fault diagnosis in a wide context providing a good introduction to the theoretical foundation and many basic approaches of



fault detection     Fault Diagnosis and Reconfiguration in Flight Control Systems Chingiz Hajiyeu, Fikret Caliskan, 2003-10-31

The problem of fault diagnosis and reconfigurable control is a new and actually developing field of science and engineering. The subject becomes more interesting since there is an increasing demand for the navigation and control systems of aerospace vehicles, automated actuators etc. to be more safe and reliable. Nowadays the problems of fault detection and isolation and reconfigurable control attract the attention of the scientists in the world. The subject is emphasized in the recent international congresses such as IFAC World Congresses San Francisco 1996, Beijing 1999 and Barcelona 2002 and IMEKO World Congresses Tampere 1997, Osaka 1999, Vienna 2000 and also in the international conferences on fault diagnosis such as SAFEPROCESS Conferences Hull 1997, Budapest 2000. The presented methods in the book are based on linear and nonlinear dynamic mathematical models of the systems. Technical objects and systems stated by these models are very large and include various control systems, actuators, sensors, computer systems, communication systems and mechanical, hydraulic, pneumatic, electrical and electronic devices. The analytical fault diagnosis techniques of these objects have been developed for several decades. Many of those techniques are based on the use of the results of modern control theory. This is natural because it is known that fault diagnosis process in control systems is considered as a part of general control process. In organization of fault diagnosis of control systems the use of the concepts and methods of modern control theory including concepts of state space modeling, controllability, observability, estimation, identification and filtering is very efficient.

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