Fuzzy-Logic Based Control for Battery Management in Micro-Grid

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***Abstract*— In this paper, a Fuzzy-Logic based control framework is proposed for Battery Management in Micro-Grid System. The Micro-Grid system operates synchronously with the main grid and also has the ability to operate independently from the power grid. Distributed renewable energy generators including solar, wind, and batteries supply power to the consumer in the Micro-Grid network. The goal is to control the amount of power given to the storage system in order to minimize a cost function based on payment/profit and distribution loss through reasonable decision making using predefined profiles of system variables such as Load Demand, Electricity Price, and Renewable Generation.**
Simulation results are presented and discussed. The proposed intelligent control system turns out to be capable of achieving effective energy management.

***Index Terms*—Micro-Grid, Control, Power Flow, Fuzzy-Logic, Load Demand.**

I. Introduction

Micro-Grid is can be referred to as a small scale grid that is designed to provide power for small communities. A Micro-Grid is an aggregation of multiple distributed generators (DGs) such as renewable energy sources, conventional generators, and energy storage systems which work together as a power supply network in order to provide both electric power and thermal energy for small communities which may vary from one common building to a smart house or even a set of loads consisting of a mixture of different structures such as buildings, factories, etc. Typically, a Micro-Grid operates in parallel with the main grid. However, there are cases in which a Micro-Grid operates in islanded mode, or in a disconnected state [1]. In this article, in addition to both of the states already mentioned, a third state is assumed for operation of Micro-Grid in which excess power in the Micro-Grid is delivered to the main grid, i.e. the excess power is sold to the grid.

II. System Model

A three bus system is used to model the Micro-Grid network for simulations in this article. One of the busses in the distributed generation system model is assumed to serve the renewable generators which include either solar farm, wind farm, or any other renewable generation units. Another bus is assumed to be working as the grid (utility) bus which will provide the complement part of the power demand that renewable generation system cannot afford to the load. The third bus will be the specific load to which the demanded power is to be provided. This load can be anything from a common building or a smart house, to even a group of plants and factories or a mixture of all of them. Figure 1 shows an overall Micro-Grid schematic including Renewable Electricity Generators and Storage Unit, Utility, and Typical Load.

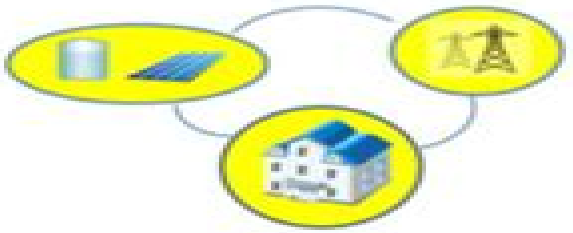

Figure 1 Micro-Grid Schematic

There are two scenarios assumed for simulation in this article, scenario 1 deals with a Micro-Grid which includes the renewable generation unit without any battery storage unit. Therefore there will not be any approaches required for controlling the battery storage system in this scenario. The second scenario deals with the same Micro-Grid system as mentioned in scenario 1 but with the battery storage unit considered to be connected to the same bus as the renewable generators. These two scenarios will be described in more detail in the next section "Problem Statement". The characteristics of busses in each of the two scenarios are as follows:
Scenario 1:

- Bus1 is of type PQ and is used as the renewable generation unit's bus.
- Bus2 is of type Slack (reference) and is used as the Utility (grid) bus.
- Bus3 is of type PV and is used as the Load bus.

Fuzzy Logic Based Control For Battery Management In Micro Grid

Manuel Arias

Fuzzy Logic Based Control For Battery Management In Micro Grid:

Microgrids and Virtual Power Plants Farhad Shahnia,Josep M. Guerrero,2024-11-01 This book highlights recent research advancements in the area of microgrids and virtual power plants Microgrids and virtual power plants are the future of power generation and delivery systems and there has been significant research interest in this area over the past decade The key emphasis of this book is on the various modelling analysis and management aspects of microgrids and virtual power networks Interesting topics such as their planning operation and technology accommodation are presented in detail The chapters in the book discuss existing and new modelling approaches control and management methods as well as their structures planning monitoring protection and coordination This book introduces and covers these topics in a comprehensive and coherent way for professionals and researchers **Research Anthology on Smart Grid and Microgrid Development** Management Association, Information Resources,2021-09-24 Smart grid and microgrid technology are growing exponentially as they are adopted throughout the world These new technologies have revolutionized the way electricity is produced delivered and consumed and offer a plethora of benefits as well as the potential for further growth It is critical to examine the current stage of smart grid and microgrid development as well as the direction they are headed as they continue to expand in order to ensure that cost effective reliable and efficient systems are put in place The Research Anthology on Smart Grid and Microgrid Development is an all encompassing reference source of the latest innovations and trends within smart grid and microgrid development Detailing benefits challenges and opportunities it is a crucial resource to fully understand the current opportunities that smart grids and microgrids present around the world Covering a wide range of topics such as traditional grids future smart grids electrical distribution systems and microgrid integration it is ideal for engineers policymakers systems developers technologists researchers government officials academicians environmental groups regulators utilities specialists industry professionals and students **Application of Artificial Intelligence in Hybrid Electric Vehicle Energy Management** Jili Tao,Ridong Zhang,Longhua Ma,2024-05-23 Application of Artificial Intelligence in Hybrid Electric Vehicle Energy Management presents the state of the art in hybrid electric vehicle system modelling and management With a focus on learning based energy management strategies the book provides detailed methods mathematical models and strategies designed to optimize the energy management of the energy supply module of a hybrid vehicle The book first addresses the underlying problems in Hybrid Electric Vehicle HEV modeling and then introduces several artificial intelligence based energy management strategies of HEV systems including those based on fuzzy control with driving pattern recognition multi objective optimization fuzzy Q learning and Deep Deterministic Policy Gradient DDPG algorithms To help readers apply these management strategies the book also introduces State of Charge and State of Health prediction methods and real time driving pattern recognition For each application the detailed experimental process program code experimental results and algorithm performance evaluation are provided Application of Artificial Intelligence in Hybrid

Electric Vehicle Energy Management is a valuable reference for anyone involved in the modelling and management of hybrid electric vehicles and will be of interest to graduate students researchers and professionals working on HEVs in the fields of energy electrical and automotive engineering Provides a guide to the modeling and simulation methods of hybrid electric vehicle energy systems including fuel cell systems Describes the fundamental concepts and theory behind CNN MPC fuzzy control multi objective optimization fuzzy Q learning and DDPG Explains how to use energy management methods such as parameter estimation Q learning and pattern recognition including battery State of Health and State of Charge prediction and vehicle operating conditions **Microgrid** Amit Kumar Pandey,Sanjeevikumar Padmanaban,Suman Lata Tripathi,Vivek Patel,Vikas Patel,2024-06-12 The book discusses principles of optimization techniques for microgrid applications specifically for microgrid system stability smart charging and storage units It also highlights the importance of adaptive learning techniques for controlling autonomous microgrids It further presents optimization based computing techniques like fuzzy logic and neural networks to enhance the computational speed Features Discusses heuristic techniques and evolutionary algorithms in microgrids optimization problems Covers operation management distributed control approaches and conventional control methods for microgrids Presents intelligent control for energy management and battery charging systems Highlights a comprehensive treatment of power sharing in DC microgrids Explains control of low voltage microgrids with master slave architecture where distributed energy resources interface with the grid by means of conventional current driven inverters It is primarily written for senior undergraduates graduate students and academic researchers in the fields of electrical engineering electronics and communications engineering computer science and engineering and environmental engineering Microgrids for Commercial Systems Palanisamy Sivaraman,Chenniappan Sharmeela,Sanjeevikumar Padmanaban,2024-03-19 MICROGRIDS for COMMERCIAL SYSTEMS This distinct volume provides detailed information on the concepts and applications of the emerging field of microgrids for commercial applications offering solutions in the design installation and operation of this new cutting edge technology The microgrid is defined as Distributed Energy Resources DER and interconnected loads with clearly defined electrical boundaries that act as a single controllable entity concerning the grid as per IEEE standard 2030 7 2017 It provides an uninterrupted power supply to end user loads with high reliability Commercial systems like IT ITES shopping complexes malls the banking sector hospitals etc need an uninterrupted input power supply with high reliability Microgrids are more suitable for commercial systems to service their clients with no service discontinuity The microgrid enables both connection and disconnection from the grid That is the microgrid can operate both in grid connected and islanded modes of operation The microgrid controller plays an important role in microgrid systems It shall have an energy management system and real time control functions that operate in the following conditions both grid connected and islanded modes of operation automatic transfer from grid connected mode to islanding mode reconnection and re synchronization from islanded mode to grid connected mode optimization of both real and reactive

power generation and consumption by the energy management system grid support ancillary services etc Whenever a microgrid is in islanded mode it will work as an autonomous system without a distribution grid power supply In this mode of operation fault in the transmission or distribution grid will not propagate into the microgrid Whenever a microgrid operates in grid connected mode power flows bi directionally between the distribution grid and microgrid at the point of interconnection Hence microgrids ensure the interrupted power supply to the end user loads with high reliability This book aims to bring together the design installation operation and new research that has been carried out in the field of microgrid applications for commercial power systems **DC Microgrids** Nikita Gupta,Mahajan Sagar Bhaskar,Sanjeevikumar Padmanaban,Dhafer Almakhles,2022-06-21 DC MICROGRIDS Written and edited by a team of well known and respected experts in the field this new volume on DC microgrids presents the state of the art developments and challenges in the field of microgrids for sustainability and scalability for engineers researchers academicians industry professionals consultants and designers The electric grid is on the threshold of a paradigm shift In the past few years the picture of the grid has changed dramatically due to the introduction of renewable energy sources advancements in power electronics digitalization and other factors All these megatrends are pointing toward a new electrical system based on Direct Current DC DC power systems have inherent advantages of no harmonics no reactive power high efficiency over the conventional AC power systems Hence DC power systems have become an emerging and promising alternative in various emerging applications which include distributed energy sources like wind solar and Energy Storage System ESS distribution networks smart buildings remote telecom systems and transport electrification like electric vehicles EVs All these applications are designed at different voltages to meet their specific requirements individually because of the lack of standardization Thus the factors influencing the DC voltages and system operation needed to be surveyed and analyzed which include voltage standards architecture for existing and emerging applications topologies and control strategies of power electronic interfaces fault diagnosis and design of the protection system optimal economical operation and system reliability *Design and Control of Power Converters 2019* Manuel Arias,2021-07-02 In this book 20 papers focused on different fields of power electronics are gathered Approximately half of the papers are focused on different control issues and techniques ranging from the computer aided design of digital compensators to more specific approaches such as fuzzy or sliding control techniques The rest of the papers are focused on the design of novel topologies The fields in which these controls and topologies are applied are varied MMCs photovoltaic systems supercapacitors and traction systems LEDs wireless power transfer etc **Intelligent Systems** Murilo C. Naldi,Reinaldo A. C. Bianchi,2023-10-11 The three volume set LNAI 14195 14196 and 14197 constitutes the refereed proceedings of the 12th Brazilian Conference on Intelligent Systems BRACIS 2023 which took place in Belo Horizonte Brazil in September 2023 The 90 full papers included in the proceedings were carefully reviewed and selected from 242 submissions They have been organized in topical sections as follows Part I Best papers resource allocation and planning rules

and feature extraction AI and education agent systems explainability AI models Part II Transformer applications convolutional neural networks deep learning applications reinforcement learning and GAN classification machine learning analysis Part III Evolutionary algorithms optimization strategies computer vision language and models graph neural networks pattern recognition AI applications *Smart Grids and Microgrids* Prajof Prabhakaran,S. Mohan Krishna,J. L. Febin Daya,Umashankar Subramaniam,P. V. Brijesh,2022-03-22 SMART GRIDS AND MICROGRIDS Written and edited by a team of experts in the field this is the most comprehensive and up to date study of smart grids and microgrids for engineers scientists students and other professionals The power supply is one of the most important issues of our time In every country all over the world from refrigerators to coffee makers to heating and cooling almost everyone in the world needs to have access to power As the global demand rises new methods of delivering power such as smart grids and microgrids have out of necessity or choice been developed and researched In this book modern and advanced concepts of both microgrid and smart grid technology are introduced Beginning from the brief fundamental concepts of microgrids and its various constituents this team of experts discusses different architectures control issues communication challenges measurement stability power quality and mitigation protection and power electronic aspects of the microgrid system Through this book tools and techniques needed to design both microgrids and smart grids are discussed Recent and developing topics like smart meter impact remote data monitoring communication protocols cybersecurity artificial intelligence big data IoT and many others are covered Furthermore this new volume also covers simulation and stability analysis tools pertaining to microgrids and smart grids Throughout the book detailed examples of microgrid and smart grid design and development strategies are provided based on different constraints and requirements Case studies numerical models and design examples are also included Whether for the veteran engineer or student this is a must have volume for any library Audience Engineers scientists industry professionals students and other lay people involved in the business of smart grids and microgrids

Optimizing and Measuring Smart Grid Operation and Control Recioui, Abdelmadjid,Bentarzi, Hamid,2020-11-13 Smart grid SG also called intelligent grid is a modern improvement of the traditional power grid that will revolutionize the way electricity is produced delivered and consumed Studying key concepts such as advanced metering infrastructure distribution management systems and energy management systems will support the design of a cost effective reliable and efficient supply system and will create a real time bidirectional communication means and information exchange between the consumer and the grid operator of electric power Optimizing and Measuring Smart Grid Operation and Control is a critical reference source that presents recent research on the operation control and optimization of smart grids Covering topics that include phase measurement units smart metering and synchrophasor technologies this book examines all aspects of modern smart grid measurement and control It is designed for engineers researchers academicians and students **A Practical Guide for Advanced Methods in Solar Photovoltaic Systems** Adel Mellit,Mohamed Benghanem,2020-05-27 The present

book focuses on recent advances methods and applications in photovoltaic PV systems The book is divided into two parts the first part deals with some theoretical simulation and experiments on solar cells including efficiency improvement new materials and behavior performances While the second part of the book devoted mainly on the application of advanced methods in PV systems including advanced control FPGA implementation output power forecasting based artificial intelligence technique AI high PV penetration reconfigurable PV architectures and fault detection and diagnosis based AI The authors of the book trying to show to readers more details about some theoretical methods and applications in solar cells and PV systems eg advanced algorithms for control optimization power forecasting monitoring and fault diagnosis methods The applications are mainly carried out in different laboratories and location around the world as projects Algeria KSA Turkey Morocco Italy and France The book will be addressed to scientists academics researchers and PhD students working in this topic The book will help readers to understand some applications including control forecasting monitoring fault diagnosis of photovoltaic plants as well as in solar cells such as behavior performances and efficiency improvement It could be also be used as a reference and help industry sectors interested by prototype development **Grid-Connected Renewable Energy Sources** Jesus C. Hernández,2021-08-31 The use of renewable energy sources RESs is a need of global society This editorial and its associated Special Issue Grid Connected Renewable Energy Sources offers a compilation of some of the recent advances in the analysis of current power systems that are composed after the high penetration of distributed generation DG with different RESs The focus is on both new control configurations and on novel methodologies for the optimal placement and sizing of DG The eleven accepted papers certainly provide a good contribution to control deployments and methodologies for the allocation and sizing of DG Intelligent and Fuzzy Systems Cengiz Kahraman,Selcuk Cebi,Basar Oztaysi,Sezi Cevik Onar,Cagrı Tolga,Irem Ucal Sari,Irem Otay,2025-07-25 Artificial Intelligence in Human Centric Resilient Sustainable Industries This book focuses on benefiting artificial intelligent tools in our business and social life under emerging conditions Human centric resilient and sustainable industries are built on ideals like human centricity ecological advantages or social benefits The mission of human centric artificial intelligence is to improve people s lives by offering solutions that boost productivity accessibility to resources security well being and general quality of life The latest intelligent methods and techniques on human centric resilient and sustainable industries are introduced by theory and applications This book covers the chapters of world wide known experts on machine learning medical image processing process intelligence process mining and others The intended readers are intelligent systems researchers lecturers M Sc and Ph D students trying to develop approaches giving human needs values and viewpoints top priority through artificial intelligent systems *Power Converter of Electric Machines, Renewable Energy Systems, and Transportation* Adolfo Dannier,Gianluca Brando,Marino Coppola,2021-09-02 Power converters and electric machines represent essential components in all fields of electrical engineering In fact we are heading towards a future where energy will be more and more electrical electrical vehicles

electrical motors renewables storage systems are now widespread The ongoing energy transition poses new challenges for interfacing and integrating different power systems The constraints of space weight reliability performance and autonomy for the electric system have increased the attention of scientific research in order to find more and more appropriate technological solutions In this context power converters and electric machines assume a key role in enabling higher performance of electrical power conversion Consequently the design and control of power converters and electric machines shall be developed accordingly to the requirements of the specific application thus leading to more specialized solutions with the aim of enhancing the reliability fault tolerance and flexibility of the next generation power systems **Microgrid Technology and Microgrid Cluster Development** Baseem Khan,Salah Kamel,Jose Luis Dominguez-Garcia,2025-06-27 Microgrid Technology and Microgrid Cluster Development is a comprehensive guide to microgrid systems fundamentals optimization control protection and energy management The book explains microgrid architectures that might be combined to create a cluster of microgrids This is a valuable resource for all those looking to gain a complete understanding of current microgrid and cluster technology including students researchers faculty R D professionals engineers and other industry personnel with an interest in grid integration power systems and renewable energy The microgrid is first defined as a standalone entity with potential interconnections with external grids Then the layout line technology and interface technology of potential microgrid cluster topologies are designed with comparison and analysis of the various microgrid and cluster designs in terms of price scalability security dependability stability communications and business models Key aspects are covered in detail including optimization algorithms and the role of machine learning and artificial neural networks control and protection techniques and energy management and storage Offers a thorough overview of microgrid technology and cluster development Presents and analyzes methods for optimization control protection and energy management Addresses key challenges in microgrid operation and grid integration Explores future perspectives **Distributed Energy Storage Systems for Digital Power Systems** Sivaraman Palanisamy,Sharmeela Chenniappan,2024-11-15 Distributed Energy Storage Systems for Digital Power Systems offers detailed information of all aspects of distributed energy resources and storage systems and their integration into modern digital power systems supporting higher power systems operational flexibility towards 100% renewable energy integration Covering fundamentals analysis design and operation and supported by examples and case studies the book also examines many new advances in terms of distributed energy storage systems for DER integration dynamically varying loads of EV charging stations power quality enhancements and ancillary services This is a valuable resource for researchers scientists and graduate students in energy storage renewable energy power systems and engineering as well as engineers R D and other industry personnel working with renewable energy systems energy storage demand response and microgrids Provides an easy tool for understanding distributed energy storage systems for digital power systems Covers fundamentals design analysis application and operation of distributed storage systems Includes

examples and practical case studies to enhance and reinforce learning **Intelligent Systems and Advanced Computing Sciences** Hani Hagras,Younes Bennani,Mohamed Nemiche,2025-07-01 This book constitutes revised selected papers from the thoroughly refereed conference proceedings of the 4th International Conference on Intelligent Systems and Advanced Computing Sciences ISACS 2023 which took place in Taza Morocco in October 26 27 2023 The 30 full papers and 8 short papers presented in these proceedings were carefully reviewed and selected from 131 submissions This conference focusing on all theoretical and practical aspects related to information technology and communications security **Microgrids** Amjad Anvari-Moghaddam,Hamdi Abdi,Behnam Mohammadi-Ivatloo,Nikos Hatziargyriou,2021-03-15 This book provides a comprehensive overview on the latest developments in the control operation and protection of microgrids It provides readers with a solid approach to analyzing and understanding the salient features of modern control and operation management techniques applied to these systems and presents practical methods with examples and case studies from actual and modeled microgrids The book also discusses emerging concepts key drivers and new players in microgrids and local energy markets while addressing various aspects from day ahead scheduling to real time testing of microgrids The book will be a valuable resource for researchers who are focused on control concepts AC DC and AC DC microgrids as well as those working in the related areas of energy engineering operations research and its applications to energy systems Presents modern operation control and protection techniques with applications to real world and emulated microgrids Discusses emerging concepts key drivers and new players in microgrids and local energy markets Addresses various aspects from day ahead scheduling to real time testing of microgrids **Energy Production, Load and Battery Management Framework with Supporting Methods for Smart Microgrids** Francky Catthoor,Ittetsu Taniguchi,Pavlos S. Georgilakis,Dafang Zhao,Dimitrios Soudris,Kostas Siozios,Andreas Kazantzidis,2025-09-02 This open access book provides an overview of the results of a large university collaboration addressing the emerging topic of distributed localized energy grids and also smart grids The authors discuss promising consolidated results from their consortium research activities from the past decade The methods described achieve unprecedented accuracy levels within reasonable run times compatible with on line monitoring and forecasting as needed for smart grids Digital Technologies and Applications Saad Motahhir,Badre Bossoufi,2024-08-31 This book presents volume 4 of selected research papers presented at the fourth International Conference on Digital Technologies and Applications ICDTA 24 Highlighting the latest innovations in digital technologies as artificial intelligence Internet of Things embedded systems chatbot network technology digital transformation and their applications in several areas as Industry 4 0 sustainability energy transition and healthcare the book encourages and inspires researchers industry professionals and policymakers to put these methods into practice

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