

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.

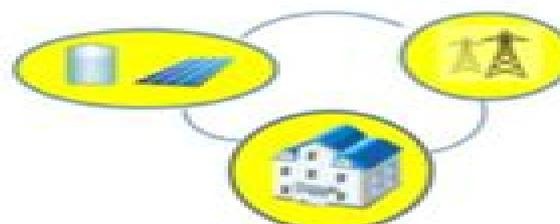


Figure 1. Micro-Grid Schematic

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.

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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

Computing, Internet of Things and Data Analytics

Fausto Pedro García Márquez, Akhtar Jamil, Isaac Segovia Ramirez, Süleyman Eken, Alaa Ali Hameed, 2024-02-22 This book covers selected papers presented at the 2nd International Conference on Computing IoT and Data Analytics ICCIDA in 2022 organized by Universidad de Castilla La Mancha Spain August 11 12 2023 It highlights some of the latest research advances and cutting edge analyses of real world problems related to Computing IoT and Data Analytics and their applications in various domains This includes state of the art models and methods used on benchmark datasets

Advanced Analytics for Reliability and Resilience of Energy System Fausto Pedro Garcia Marquez, René Vinicio Sánchez Loja, Mayorkinos Papaelias, 2026-02-10 Advanced Analytics for Reliability and Resilience of Energy Systems prepares students researchers and industry engineers to design and maintain reliable sustainable energy systems using state of the art AI techniques This book provides a clear foundation in the fundamentals of power systems statistics and reliability including resilience principles and strategies practical applications and real world solutions The AI tools presented range across forecasting the Internet of Things machine learning digital twin technology and big data analysis with a variety of applications to avoid power outages minimise disruption and accurately assess system resilience Including case studies and details methodology for practical techniques Advanced Analytics for Reliability and Resilience of Energy Systems helps energy systems engineers and researchers to provide a stable and consistent power supply in the face of climate change challenges and the energy transition Provides a foundation with the fundamental principles and strategies for reliability and resilience Introduces the readers to a toolbox of AI methodologies with a variety of applications Leverages clear chapter objectives worked problems and detailed case studies to support real world solution building

Design, Analysis and Applications of Renewable

Energy Systems Ahmad Taher Azar, Nashwa Ahmad Kamal, 2021-09-09 Design Analysis and Applications of Renewable Energy Systems covers recent advancements in the study of renewable energy control systems by bringing together diverse scientific breakthroughs on the modeling control and optimization of renewable energy systems as conveyed by leading energy systems engineering researchers The book focuses on present novel solutions for many problems in the field covering modeling control theorems and the optimization techniques that will help solve many scientific issues for researchers Multidisciplinary applications are also discussed along with their fundamentals modeling analysis design realization and

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Hybrid Power Yatish T. Shah,2021-02-18 Hybrid energy systems integrate multiple sources of power generation storage and transport mechanisms and can facilitate increased usage of cleaner renewable and more efficient energy sources Hybrid Power Generation Storage and Grids discusses hybrid energy systems from fundamentals through applications and discusses generation storage and grids Highlights fundamentals and applications of hybrid energy storage Discusses use in hybrid and electric vehicles and home energy needs Discusses issues related to hybrid renewable energy systems connected to the utility grid Describes the usefulness of hybrid microgrids and various forms of off grid energy such as mini grids nanogrids and stand alone systems Covers the use of hybrid renewable energy systems for rural electrification around the world Discusses various forms and applications of hybrid energy systems hybrid energy storage hybrid microgrids and hybrid off grid energy systems Details simulation and optimization of hybrid renewable energy systems This book is aimed at advanced students and researchers in academia government and industry seeking a comprehensive overview of the basics technologies and applications of hybrid energy systems

Energy and Exergy for Sustainable and Clean Environment, Volume 2 V. Edwin Geo,Fethi Aloui,2022-09-19 This multi disciplinary book presents the most recent advances in exergy energy and environmental issues Volume 2 focuses on fundamentals in the field and covers current problems future needs and prospects in the area of energy and environment from researchers worldwide Based on some selected lectures from the Eleventh International Exergy Energy and Environmental Symposium IEEEES 11 and complemented by further invited contributions this comprehensive set of contributions promote the exchange of new ideas and techniques in energy conversion and conservation in order to exchange best practices in energetic efficiency Included are fundamental and historical coverage of the green transportation and sustainable mobility sectors especially regarding the development of sustainable technologies for thermal comforts and green transportation vehicles Furthermore contributions on renewable and sustainable energy sources strategies for energy production and the carbon free society constitute an important part of this book

Energy Management Strategies Based on Fuzzy Logic Control for Grid-tied Domestic Electro-thermal Microgrid Diego Gustavo Arcos Avilés,2016 The environmental and economic benefits related to the reduction of both carbon dioxide emission and transmission losses have made distributed renewable generation systems became a competitive solution for future power systems In this context Microgrids MG are considered as the key building blocks of smart grids and have aroused great attention in the last decade for their potential and the impact they may have in the coming future The MG concept has

captured great attention in the last years since it can be considered one of the most suitable alternatives for integration of distributed generation units in the utility grid. However, this integration involves some challenges to deal with, especially when penetration of Renewable Energy Sources (RES) into the distribution network is increased. Therefore, an effective Energy Management System (EMS) is required to ensure optimal energy utilization within the MG, consequently facilitating both the grid integration and operator control. In this regard, the EMS strategy design depends on the application, MG power architecture, and the power management capability of the MG elements. This dissertation research focuses on the design of different EMS strategies based on Fuzzy Logic Control (FLC) for a residential grid connected electro-thermal MG including renewable power generation (i.e., photovoltaic and wind turbine generators) and storage capability (i.e., battery bank and water storage tank). The main goal of the FLC-based EMS strategies is to minimize the grid power fluctuations while keeping the battery State of Charge (SOC) within secure limits. In order to accomplish this goal, the controller design parameters such as membership functions and rule base of the FLC-based EMS strategies are adjusted to optimize a pre-defined set of quality criteria of the MG behavior. The analysis and design of the FLC-based EMS strategies for electrical and electro-thermal MG power architectures are developed considering two different scenarios: a first scenario where the MG power forecasting is not provided, and a second scenario where the forecast of generation power and load demand are considered. A comparison with the different EMS strategies is presented in simulation level, whereas the features of the enhanced FLC-based EMS strategies are experimentally tested on a real residential microgrid implemented at the Public University of Navarre (UPNA).

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