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.

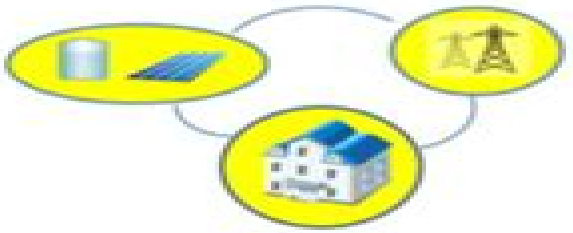

Figure 1 Micro-Grid Schematic

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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Chao Zhang

Fuzzy Logic Based Control For Battery Management In Micro Grid:

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gaps between different interdisciplinary applications ranging from mathematical concepts modeling and analysis up to the realization and experimental work Presents some of the latest innovative approaches to renewable energy systems from the point of view of dynamic modeling system analysis optimization control and circuit design Focuses on advances related to optimization techniques for renewable energy and forecasting using machine learning methods Includes new circuits and systems helping researchers solve many nonlinear problems **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 IEEES 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 Science Abstracts ,1995 *Journal of Scientific and Industrial Research* ,2015 *NASA SP.* ,1962 **Large Space Structures & Systems in the Space Station Era** ,1992 *Large Space Structures and Systems in the Space Station Era: A Bibliography with Indexes (supplement 04)* ,1992 Synerjy ,1996 **International Aerospace Abstracts** ,1999 Electrical & Electronics Abstracts ,1997 **Alternative Energy Systems** M. Godoy Simões,Felix A. Farret,2008 Durable and cost effective induction power generators have undergone numerous improvements that make them an increasingly attractive option for renewable energy applications particularly for wind and hydropower generation systems From fundamental concepts to the latest technologies Alternative Energy Systems Design and Analysis with Induction Generators Second Edition provides detailed and accurate coverage of all aspects related to the design operation and overall analysis of such systems Placing a greater emphasis on providing clear precise and succinct explanations this second edition features new revised and updated content as well as figures tables equations and examples Each chapter introduces a multi step chapter length problem relating the material to a real application The solution appears at the end of the chapter along with additional practice problems and references New Material in This Edition Updated definitions for generated power and efficiency Technological advances such as new applications using doubly fed induction generators New methodologies such as the magnetization curve representation for induction generators Additional focus on renewable energy applications such as sea wind and hydropower systemsAlternative Energy Systems provides the

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Enjoying the Tune of Phrase: An Mental Symphony within **Fuzzy Logic Based Control For Battery Management In Micro Grid**

In a world used by monitors and the ceaseless chatter of fast interaction, the melodic beauty and psychological symphony developed by the published word frequently diminish in to the backdrop, eclipsed by the relentless noise and interruptions that permeate our lives. However, located within the pages of **Fuzzy Logic Based Control For Battery Management In Micro Grid** a marvelous literary treasure overflowing with natural emotions, lies an immersive symphony waiting to be embraced. Constructed by a masterful musician of language, this captivating masterpiece conducts visitors on a psychological trip, well unraveling the concealed melodies and profound impact resonating within each cautiously constructed phrase. Within the depths of the moving assessment, we shall discover the book is central harmonies, analyze its enthralling publishing fashion, and submit ourselves to the profound resonance that echoes in the depths of readers souls.

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