Implementation of MPPT Control Using Fuzzy Logic in Solar-Wind Hybrid Power System

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***Abstract*— The renewable energy sources such as Solar energy and Wind energy are complementary by nature. Utilizing these natural resources to produce power will reduce the power demand on the conventional power generation sector. One of the applications of Solar-Wind hybrid power system (SWHPS) is to reduce the amount of power consumed from the conventional power generation to charge the storage reserves present in the system. The SWHPS comprises of Photovoltaic array, wind turbine, Permanent Magnet Synchronous generator (PMSG), controller and converter. The efficiency of the SWHPS depends on the MPPT controller, which makes the Photovoltaic (PV) and wind power generation system to operate at its maximum power. In PV system Perturb & Observe (P&O) algorithm is used as control logic for the Maximum Power Point Tracking (MPPT) controller and Hill Climb Search (HCS) algorithm is used as MPPT control logic for the Wind power system in order to maximizing the power generated. This paper presents a comparative analysis of MPPT controller built using P&O for PV system and HCS for Wind power system, with MPPT controller implemented using Fuzzy Logic control (FLC) in the both the renewable sources in the hybrid system. The performance of the different implementation of MPPT controllers in the hybrid system are investigated in this paper in MATLAB, Simulink. The SWHPS with the FLC based MPPT has shown to have a better, faster control as compared with the other controllers.**

Keywords—Hybrid power system; MPPT; FLC; Renewable energy; P & O; Wind;

I. INTRODUCTION

Renewable energy sources (RES) such as Solar, Wind, Geothermal, Tidal, Hydro etc. are inexhaustible by nature. The RES have been found promising towards building sustainable and ecofriendly power generation. Due to the limitation of conventional resources of fossil fuels, it has compelled the evolution of hybrid power system. Therefore, new ways to balance the load demand is by integrating RES into the system. Hybrid system enables the incorporation of renewable energy sources and transferals the dependency on fossil fuels, while sustaining the balance between supply and demand. The significant characteristic of hybrid power system includes, system reliability, operational efficiency [1]. The hybrid power system enables to overcome the limitations in wind and photovoltaic resources since their performance characteristics depends upon the unfavorable changes in environmental conditions. It is probable to endorse that hybrid stand-alone electricity generation systems are usually more reliable and less costly than systems that depend on a single source of energy [2]. On other hand one environmental condition can make one type of RES more profitable than other. For example, Photovoltaic (PV) system is ideal for locations having more solar illumination levels and Wind power system is ideal for locations having better wind flow conditions [3].

For RES especially the variable speed wind energy conversion systems, Permanent Magnet Synchronous generator (PMSG) is gaining popularity. PMSG have a loss-free rotor, and the power losses are confined to the stator winding and stator core. A multi-pole PMSG connected to power converter can be used as direct driven PMSG in locations with low wind speed there by eliminating the gearbox which adds weight, losses, cost and maintenance [4]. A gearless construction of wind conversion system represents an efficient and reliable wind power conversion system. In a PV system, a solar cell alone can produce power of 1 to 2 watt [5]. The solar cell is modeled by two diode model [6]. The solar cells are connected in series and parallel to form a PV panel or module. The PV modules are connected in series and parallel to form a PV array in order to generate appropriate amount of power.

Thus a PV system consisting of PV array, Maximum Power Point Tracking (MPPT) boost converters, and Wind power system consisting of wind turbine, PMSG, rectifier and MPPT boost converter is integrated into Solar Wind hybrid power system (SWHPS). The efficiency and reliability of the SWHPS mainly depends upon the control strategy of the MPPT boost converter. The solar and wind power generation cannot operate at Maximum power point (MPP) without proper control logic in the MPPT boost converter. If the MPP is not tracked by the controller the power losses will occur in the system and in spite of wind and solar power availability, the output voltage of the hybrid system will not boost up to the required value [7]. The output voltage of the PV and Wind power generation are quite low as compared with the desired operating level. So, this output voltage is brought to desired operating value of 220V using Boost converter with MPPT controller at each source. The control logic of the MPPT controlled boost converter for the Wind power generation and PV based generation are selected on the basis of ease of implementation and robustness

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Chao Zhang

Implementation Of Mppt Control Using Fuzzy Logic In Solar:

Artificial Intelligence in Renewable Energetic Systems Mustapha Hatti,2018-03-12 This book includes the latest research presented at the International Conference on Artificial Intelligence in Renewable Energetic Systems held in Tipaza Algeria on October 22 24 2017 The development of renewable energy at low cost must necessarily involve the intelligent optimization of energy flows and the intelligent balancing of production consumption and energy storage Intelligence is distributed at all levels and allows information to be processed to optimize energy flows according to constraints This thematic is shaping the outlines of future economies of and offers the possibility of transforming society Taking advantage of the growing power of the microprocessor makes the complexity of renewable energy systems accessible especially since the algorithms of artificial intelligence make it possible to take relevant decisions or even reveal unsuspected trends in the management and optimization of renewable energy flows The book enables those working on energy systems and those dealing with models of artificial intelligence to combine their knowledge and their intellectual potential for the benefit of the scientific community and humanity **Evolution in Signal Processing and Telecommunication Networks** Vikrant Bhateja,Anagha Bhattacharya,Sarika Shrivastava,2026-02-14 The book discusses the latest developments and outlines future trends in the fields of microelectronics electromagnetics and telecommunication It contains original research works presented at the International Conference on Microelectronics Electromagnetics and Telecommunication ICMEET 2024 organized by Department of Electronics and Communication Engineering National Institute of Technology Mizoram India during 19 20 December 2024 The book is divided into four volumes and it covers papers written by scientists research scholars and practitioners from leading universities engineering colleges and R D institutes from all over the world and shares the latest breakthroughs in and promising solutions to the most important issues facing today s society **Computational Problems in Science and Engineering II** Nikos E. Mastorakis,Imre J. Rudas,Yuriy S. Shmaliy,2025-02-28 This book provides readers with modern computational techniques for solving variety of problems from electrical mechanical civil and chemical engineering Mathematical methods are presented in a unified manner so they can be applied consistently to problems in applied electromagnetics strength of materials fluid mechanics heat and mass transfer environmental engineering biomedical engineering signal processing automatic control and more **Recent Developments in Control, Automation and Power Engineering** Hemender Pal Singh,Ishak B. Aris,Anwar Shahzad Siddiqui,2025-05-23 This book contains original peer reviewed research papers from the 5th international conference RDCAPE 2023 This book presents the latest developments in the field of electrical engineering and related areas distinctively and engagingly The book discusses issues related to new challenges of renewable energy new control paradigms for efficient automation and decentralized power systems new economics of open auction based electricity generation transmission and distribution markets etc Apart from these many other topics of interest for readers are also covered The papers presented here share the latest findings on various issues as

mentioned above It makes the book a useful resource for researchers scientists industry people and students alike Hybrid Renewable Energy Systems Djamila Rekioua,2019-11-27 This book discusses the supervision of hybrid systems and presents models for control optimization and storage It provides a guide for practitioners as well as graduate and postgraduate students and researchers in both renewable energy and modern power systems enabling them to quickly gain an understanding of stand alone and grid connected hybrid renewable systems The book is accompanied by an online MATLAB package which offers examples of each application to help readers understand and evaluate the performance of the various hybrid renewable systems cited With a focus on the different configurations of hybrid renewable energy systems it offers those involved in the field of renewable energy solutions vital insights into the control optimization and supervision strategies for the different renewable energy systems Advances in Energy and Control Systems Afzal Sikander,Marta Zurek-Mortka,Chandan Kumar Chanda,Pranab Kumar Mondal,2024-06-14 This book gathers selected research papers presented at the 5th International Conference on Energy Systems Drives and Automation ESDA 2022 It covers a broad range of topics in the fields of renewable energy power management drive systems for electrical machines and automation This book also comprehensively discusses related tools and techniques and is a valuable resource for researchers professionals and students in electrical and mechanical engineering disciplines **Fuzzy Logic Control of MPPT Controller for PV Systems** Mahmud Ahmed Sasi,2017 This thesis presents a comparison between two methods to optimize the energy extraction in a photovoltaic PV power system The maximum power of a PV module varies due to changing temperature solar radiation and load To maximize efficiency PV systems use a maximum power point tracker MPPT to constantly extract the highest power that can be produced by a solar panel and then deliver it to the load The general structure of an MPPT system contains a DC DC converter an electronic device that converts a source of direct current DC from one voltage level to another and a controller The MPPT finds and maintains operations at the maximum power point using a tracking algorithm during variations in weather conditions Many different algorithms of MPPT have been proposed and discussed in the literature but most of these methods have disadvantages in terms of efficiency accuracy and flexibility Because of the nonlinear behavior of PV module current voltage characteristics and the nonlinearity of DC DC converters due to switching conventional controllers are unable to provide the best response especially when dealing with wide parameter variations and line transients The goal of this work is to design and implement a maximum power point tracker that uses a fuzzy logic control algorithm Fuzzy logic naturally provides a superior controller for this type of nonlinear application This method also benefits from the artificial intelligence approach for overcoming the complexity in modeling nonlinear systems In order to succeed in this work an MPPT system consisting of a PV module a DC DC converter batteries and a fuzzy logic controller is designed and simulated in Simulink Analyses of buck boost and buck boost converter characteristics are carried out to find the most suitable topology for the PV system used An integrated model of the PV module with the identified converter and

batteries is simulated in MATLAB to derive the expert knowledge needed to formulate and tune the fuzzy logic controller The simulation results show that the fuzzy logic controller is able to obtain the desired outcomes and is ready to be applied to the hardware system This entire research work aims to compare two types of controller based MPPT techniques Both MPPTs are based on the same topology of DC DC converter and are applied with the same PV system specifications That is one of the MPPTs was kept at its original specifications and the other one was modified by changing the internal PIC 16F684 controller with an external Arduino Uno controller Based on a MATLAB fuzzy logic design the Arduino code was programmed and uploaded into an Arduino board by using Arduino software IDE The proposed method illustrates that the performance of MPPT is improved in terms of oscillations about the maximum power point speed and sensitivity to parameter variation The results indicate that a significant amount of extra power can be extracted from a photovoltaic module by using a fuzzy logic based maximum power point tracker in comparison with a PIC 16F684 controller based maximum power tracker Moreover this gives improved efficiency for the operation of a PV power system since batteries can be sufficiently charged and used during periods of low solar radiation **Computer, Communication and Electrical Technology** Debatosh Guha,Badal Chakraborty,Himadri Sekhar Dutta,2017-03-16 The First International Conference on Advancement of Computer Communication and Electrical Technology focuses on key technologies and recent progress in computer vision information technology applications VLSI signal processing power electronics drives and application of sensors transducers etc Topics in this conference include Computer Science This conference encompassed relevant topics in computer science such as computer vision intelligent system networking theory and application of information technology Communication EngineeringTo enhance the theory technology of communication engineering ACCET 2016 highlighted the state of the art research work in the field of VLSI optical communication and signal processing of various data formatting Research work in the field of microwave engineering cognitive radio and networks are also included Electrical Technology The state of the art research topic in the field of electrical instrumentation engineering is included in this conference such as power system stability protection non conventional energy resources electrical drives and biomedical engineering Research work in the area of optimization and application in control measurement instrumentation are included as well **Advances in Energy Science and Technology** Xiao Chun Tang,Xiao Hong Chen,Yu Xiang Dong,Xiu Guo Wei,Qing Sheng Yang,2013-02-13 Selected peer reviewed papers from the 2012 International Conference on Sustainable Energy and Environmental Engineering ICSEEE 2012 December 29 30 2012 Guangzhou China Advancements in Automation and Control Technologies Sarojini Selvaperumal,R. Nagarajan,P. Nedumal Pugazhenthi,2014-06-18 Selected peer reviewed papers from the 2014 International Conference on Advancements in Automation and Control ICAAC 2014 April 11 12 2014 Ramanathapuram Tamilnadu India *Solar Engineering* American Society of Mechanical Engineers. Solar Energy Division. Conference,2006 **TENCON 2004** ,2004 **Tamkang Journal of Science and Engineering** ,2004 **The Dhaka**

University Journal of Science ,2006 **Index to IEEE Publications** Institute of Electrical and Electronics Engineers,1998 Issues for 1973 cover the entire IEEE technical literature **Maximum Power Point Tracking Using Fuzzy Logic Control** Mohamed Ezzat Salem,2011-06-29 Scientific Study from the year 2004 in the subject Electrotechnology language English abstract This paper proposes an intelligent control method for the maximum power point tracking MPPT of a photovoltaic system under variable temperature and insolation conditions This method uses a fuzzy logic controller applied to a DC DC converter device The different steps of the design of this controller are presented together with its simulation The PV system that I chose to simulate to apply my techniques on it is stand alone PV water pumping system Results of this simulation are compared to those obtained by the system without MPPT They show that the system with MPPT using fuzzy logic controller increase the efficiency of energy production from PV **Government Reports Announcements & Index** ,1994-12 **Design and Implementation of a Multivariable Controller Using Fuzzy Logic** Reginald Eugene Waddell,2002 **Enhanced MPPT Controllers for Smart Grid Applications** Mohamed Khallaf,2019 Over the past years the energy demand has been steadily growing and so methods of how to cope with this staggering increase are being researched and utilized One method of injecting more energy to the grid is renewable energy which has become in recent years an integral part of any country s power generation plan Thus it is a necessity to enhance renewable energy resources and maximize their grid utilization so that these resources can step up and reduce the over dependency of global energy production on depleting energy resources This thesis focuses on solar power and effective means to enhance its efficiency through the use of different controllers In this regard substantial research efforts have been done However due to the current market and technological development more options are made available that are able to boast the efficiency and utilization of renewables in the power mix In this thesis an enhanced maximum power point tracking MPPT controller has been designed as part of a Photovoltaic PV system to generate maximum power to satisfy load demand The PV system is designed and simulated using MATLAB consisting of a solar panel array MPPT controller boost converter and a resistive load The solar panel chosen for the array is Sun Power SPR 440NE WHT D and the array is designed to produce 150 kW of power The MPPT controller is designed using three different algorithms and the results are compared to identify each controller s fortes and drawbacks The three designed controllers used are based on Perturb and Observe P the first is when the panel array is subjected to constant amount of solar irradiance along with a constant atmospheric temperature and the second scenario has varying solar irradiance and atmospheric temperature The performance of these controllers is analyzed and compared in terms of the output power efficiency system dynamic response and finally the oscillations behavior After analyzing the results it is shown that Fuzzy Logic Controller design performed better compared to the other controllers as it had in most cases the highest mean power efficiency and fastest response Abstract **Solar Photovoltaic Power Plants** Radu-Emil Precup,Tariq Kamal,Syed Zulqadar Hassan,2019-02-07 This book discusses control and optimization techniques in

the broadest sense covering new theoretical results and the applications of newly developed methods for PV systems Going beyond classical control techniques it promotes the use of more efficient control and optimization strategies based on linearized models and purely continuous or discrete models These new strategies not only enhance the performance of the PV systems but also decrease the cost per kilowatt hour generated

Reviewing **Implementation Of Mppt Control Using Fuzzy Logic In Solar**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is really astonishing. Within the pages of "**Implementation Of Mppt Control Using Fuzzy Logic In Solar**," an enthralling opus penned by a highly acclaimed wordsmith, readers attempt an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve to the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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