

# AN ENHANCED MPPT TECHNIQUE FOR SMALL-SCALE WIND ENERGY CONVERSION SYSTEMS

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## Abstract

This paper proposes an enhanced Maximum Power Point Technique (MPPT) based on Artificial Neural Network (ANN) for small-scale wind energy conversion systems using Permanent Magnet synchronous Generators (PMSGs). The conventional MPPT technique which used a Perturb and observe (P&O) method is compared with the proposed ANN method. For this, MATLAB/Simulink is used to simulate both the conventional P&O method and the proposed ANN method. The proposed ANN uses the dc-link voltage and duty cycle as the control variables for MPPT. The advantages of the proposed MPPT are low system cost, increase reliability, less mechanical stress of the generator and no need for shaft speed sensing. Moreover the conversion efficiency of the proposed ANN method is increased while comparing with the conventional P&O method.

**Keywords:** Maximum Power Point Technique (MPPT), Perturb and Observe Algorithm (P&O), Artificial Neural Network (ANN), Wind Energy Conversion System (WECS).

## 1. INTRODUCTION

In recent years, the demand for renewable energy has been increased since the prices of conventional fuels are increased. There are different kinds of renewable energy sources available. Wind, solar, biomass renewable resources are clean whereas it reduces green house gases. Among all other sources wind energy get more attention since the easy access and fast implementation of WECS. In case of wind energy source, a wind turbine and a power conversion system are used to produce the electrical energy. For this, a number of Wind Energy Conversion Systems (WECS) are implemented as research projects. Especially in remote areas where grid access is not possible, small-scale WECS are used for residential applications. To design such type of WECS, permanent-magnet synchronous generators are used since the advantages of their compact size, high efficiency, high power density, low maintenance cost and easy control.

To extract the optimum power point in the WECS, a maximum power point tracking (MPPT) algorithm has to be implemented. The accuracy of peak power points tracked by MPPT algorithm is responsible for the amount of power output from a WECS. The maximum power extraction algorithms can be classified into three main control methods, namely Tip Speed Ratio (TSR) control, Perturb and Observe (P&O) control, and Optimum-Relation-Based (ORB) control.

TSR control method is simple. But it needs the accuracy of the wind speed measurement, which is a difficult process for such methods. The TSR control method regulates the rotational speed of the generator in order to maintain the

TSR to an optimum value at which power extracted is maximum. In this method, optimal TSR is maintained using measured wind speed and turbine shaft speed [4] and [6].

In ORB control, the MPP is tracked with the aid of optimum relation between different system variables. Many researchers use the power versus the shaft speed and the power versus the torque as the curve for MPP tracking. The power versus the shaft speed is used [9], [11] and [12]. The power versus the torque is used [7] and [13]. The use of the power versus the rectified dc-link voltage curve for MPP tracking is proposed in [14] and [15]. ORB algorithms have good dynamic response and simple implementation. Though ORB control is mostly used for WECS, it needs the prior knowledge of accurate system parameters that varies from one system to another and also may change due to system aging. This is the main drawback of this method. Therefore such methods requires continuous simulations and lab testing to acquire the prior knowledge of the system parameters.

The P&O control algorithms use the optimum relationship of the system to track the MPP by continuously changing the maximizing variable and observing the power captured. Based on the power measurements variation with the perturbation introduced, the next perturbation size and direction may be determined until the algorithm reaches the MPP. Most of the work done for MPPT using P&O has used the power-speed relation of the wind turbine [1]. But there is a possibility of using other system parameters as control variables for the MPPT, like the dc-link voltage and the duty cycle [5] which in turn will reduce the cost of system and increase reliability by removing the need for shaft speed

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## **An Enhanced Mppt Technique For Small Scale Wind Energy:**

### **IoT-Enabled Energy Efficiency Assessment of Renewable Energy Systems and Micro-grids in Smart Cities**

Mustapha Hatti, 2024-05-27 This book embarks on a transformative exploration of sustainable urban development integrating Internet of Things IoT technologies in energy efficiency assessments of renewable energy systems and microgrids within smart cities This work transcends conventional approaches seamlessly blending theoretical insights with practical applications and prioritizing real time IoT enabled assessments for optimal energy utilization Evolving the understanding of renewable energy systems and microgrids the book distinguishes itself through its hands on application of IoT technologies It not only delves into theoretical aspects but also equips readers with actionable insights guiding the implementation of IoT for informed decision making in the dynamic landscape of smart city environments From IoT sensor deployment strategies to data analytics techniques and practical considerations the book s expansive scope offers a comprehensive roadmap for creating resilient and efficient energy ecosystems Tailored for professionals researchers and policymakers in energy management urban planning and IoT technology this resource speaks to a diverse audience Whether the reader is an engineer aiming to optimize microgrid performance or a policymaker driving urban sustainability the book provides indispensable insights It serves as a compass informing city planners on energy efficient infrastructure guiding researchers in developing impactful IoT applications and assisting policymakers in formulating forward thinking eco friendly regulations In a world embracing smart technologies this book emerges as an essential guide steering stakeholders toward a future where the seamless integration of energy efficiency and IoT defines the landscape of truly smart and sustainable cities

**Wind Power Electric Systems** Djamila Rekioua, 2024-03-27 This book enhances existing knowledge in the field of wind systems It explores topics such as grid integration smart grid applications hybrid renewable energy systems and advancements in control and optimization approaches The book primarily aims to provide a quick and comprehensive understanding of wind systems including models control techniques optimization methods and energy storage systems to students at both undergraduate and postgraduate levels particularly those studying electrical engineering The book is divided into two parts The first part explores various stand alone wind applications such as rural electrification and pumping while the second part focuses on applications in grid connected systems Each system is accompanied by mathematical models and an illustrative example using the MATLAB Simulink package Moreover numerous examples are presented for potential implementation using the DSPICE package The book also introduces different electrical machine control approaches including vector control direct torque control and fuzzy logic controllers for various drive systems Furthermore intelligent techniques are developed to optimize wind operations Aiming to enhance existing knowledge in the field of wind systems this book covers topics such as grid integration smart grid applications hybrid renewable energy systems and advancements in control and optimization approaches This second edition is fully updated New sections on demand side

management and energy storage systems have been included and each section has a summary and comparative table to further enhance clarity. Additionally, this new edition includes discussions on future trends and emerging technologies in wind energy systems, making it a more comprehensive and up-to-date resource.

**Advances in Mechatronics Systems** Ajay Kumar, Parveen Kumar, Aydin Azizi, 2024-12-15. This book consists of eleven chapters that cover all aspects of mechatronics systems from basics to advanced. This book is an edited compilation of original research and applications backed with experimental, numerical, and theoretical data on mechatronics systems, suitably categorized into sections of closely related topics contributed by researchers, academics, scientists, industrialists, and professionals from the field on various aspects of mechatronics. Therefore, it will provide logical, technical, as well as analytical solutions and ideas to complex problems faced by researchers in the field of mechatronics. The academicians and students will get a comprehensive update on the state of the art in this area and ample ideas for further research and innovation in mechatronics.

**Engineering Solutions Toward Sustainable Development** Abdelazim M. Negm, Rawya Y. Rizk, Rehab F. Abdel-Kader, Asmaa Ahmed, 2024-01-16. This book constitutes the referred proceeding of the 1st International Conference on Engineering Solutions Toward Sustainable Development (ESSD2023) organized by the Faculty of Engineering, Port Said University and held in Port Said, Egypt during May 2-3, 2023. The book is devoted to fulfill the need for sustainable development that has never been more urgent. It shows the crucial role of engineering to play in this transition from consumption culture to responsible culture. This book explores the relationship between engineering and sustainability, highlighting the vital role that engineering plays in achieving sustainable development. The book provides a comprehensive guide for engineers, researchers, and experts from different disciplines that are interested in sustainable development. From renewable energy sources to green infrastructure, the book delves into the latest technological advancements, providing insights and practical strategies for designing and implementing sustainable solutions. With practical examples and case studies, readers will gain a deep understanding of how engineering principles and practices can be harnessed to develop sustainable solutions that balance economic, social, and environmental needs and to mitigate the negative impacts of human activity on our planet. The book is very useful for graduate students, researchers, policy planners, decision makers, and stakeholders in the field of renewable energy, clean water development, climate actions, smart cities, and communities, and green infrastructures.

**Exergy for A Better Environment and Improved Sustainability 2** Fethi Aloui, Ibrahim Dincer, 2018-08-22. This multi-disciplinary book presents the most recent advances in exergy, energy, and environmental issues. Volume 2 focuses on applications and covers current problems, future needs, and prospects in the area of energy and environment from researchers worldwide. Based on selected lectures from the Seventh International Exergy, Energy, and Environmental Symposium (IEEES7) 2015 and complemented by further invited contributions, this comprehensive set of contributions promotes the exchange of new ideas and techniques in energy conversion and conservation in order to exchange best practices in energetic efficiency. Applications are included that apply

to 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 Exergy for Better Environment and Sustainability Volume 2 will appeal to researchers students and professionals within engineering and the renewable energy fields

**Non-Isolated DC-DC Converters for Renewable Energy Applications**  
Frede Blaabjerg, Mahajan Sagar Bhaskar, Sanjeevikumar Padmanaban, 2021-04-22 Photovoltaic PV energy generation is an excellent example of large scale electric power generation through various parallel arrangements of small voltage generating solar cells or modules However PV generation systems require power electronic converters system to satisfy the need for real time applications or to balance the demand for power from electric Therefore a DC DC power converter is a vital constituent in the intermediate conversion stage of PV power This book presents a comprehensive review of various non isolated DC DC power converters Non isolated DC DC converters for renewable energy system RES application presented in this book 1st edition through a detailed original investigation obtained numerical experimental results and guided the scope to design new families of converters DC DC multistage power converter topologies Multistage X Y converter family Nx IMBC Nx Interleaved Multilevel Boost Converter Cockcroft Walton CW Voltage Multiplier Based Multistage Multilevel Power Converter CW VM MPC converter topologies and Z source and quasi Z source Above solutions are discussed to show how they can achieve the maximum voltage conversion gain ratio by adapting the passive active component within the circuits For assessment we have recommended novel power converters through their functionality and designs tested and verified by numerical software Further the hardware prototype implementation is carried out through a flexible digital processor Both numerical and experimental results always shown as expected close agreement with primary theoretical hypotheses This book offers guidelines and recommendation for future development with the DC DC converters for RES applications based on cost effective and reliable solutions

*Advanced technologies for planning and operation of prosumer energy systems* Bin Zhou, Siqi Bu, Liansong Xiong, Hugo Morais, Junjie Hu, Jingyang Fang, Jian Zhao, Peng Hou, 2023-04-28 [Smart Grid Infrastructure & Networking](#)

Krzysztof Iniewski, 2013 Describing cutting edge technologies for connecting the electrical power infrastructure to modern computerized communications networks this practical comprehensive resource offers essential information on standardization applications protocols automation architecture and management

**Science Abstracts** ,1995 **Government Reports Announcements & Index** ,1993-04 [Index to IEEE Publications](#) Institute of Electrical and Electronics Engineers, 1997 Issues for 1973 cover the entire IEEE technical literature [Dissertation Abstracts International](#) ,1999 **Home Power** ,2008 [The Engineering Index Annual](#) ,1992 Since its creation in 1884 Engineering Index has covered virtually every major engineering innovation from around the world It serves as the historical record of virtually every major engineering innovation of the 20th century Recent content is a vital resource for current

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