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MODELING AND OPTIMIZATION OF THE PHOTOVOLTAIC SYSTEM IN PARTIALLY SHADED AND DYNAMIC ENVIRONMENTS

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Abstract :- Max power point tracking (MPPT) techniques to monitor PV systems in shaded, partly shaded, and changing irradiance situations are the main topic of this dissertation. In our early research on the subject, we found that parameter extraction and modeling of photovoltaic (PV) cell modules, cells, and arrays were crucial for the analysis and simulation of MPPT systems. Given the limitations of the present approaches for parameter extraction and modeling for PV systems, the scope of this thesis was enlarged to incorporate these topics. The PV model and the justification for the subject of this research are discussed in Chapter 1. Chapter 2 reviews the many methodologies used in the literature to represent PV cell modules, arrays, and MPPT techniques. The effectiveness of each strategy is assessed and contrasted in the table. For the aim of modeling PV modules, we developed a Chebyshev-based functional link neural network (CFLNN) in chapter 3 since approaches presently in use either demonstrate complicated computations or show insufficient accuracy when variables are taken from the PV array. The suggested strategy reduces the complexity of the network-based model while increasing modeling accuracy by removing stacking layers that are concealed from the network architecture. The current predictions made by the two diode models and the Multilayer Perceptron (MLP) modeling techniques are compared to those made by the suggested technique.

1 Introduction

Distributed control is a widely used technique to monitor and manage environmental conditions in industries like robotics, industrial automation, environmental monitoring, and other ones. For controlling the size and interaction of massive, intricate control systems, distributed control has recently gained popularity. Distributed Control Systems (DCS) are composed of a collection of geographically separated hardware components that are interconnected via a network. It is made up of a number of subsystem parts and a communication network for exchanging data. With the development and creation of the network of controllers using wired and/or wireless communication channels, the DCS has shown efficacy in information processing, monitoring, and control. According to Peter Kazanzides and Paul Thienphrapa (2008), they are autonomous control systems that work under the master's direction to achieve a certain goal. Over the last two decades, there has been a substantial increase in interest in controlling and modeling large-scale systems. The connectivity between the different subsystem components is controlled through wired or wireless communication routes. Since the subsystem components' distinct interfaces restrict extensibility and increase the cost of updates, a modular and extensible interfacing standard is plainly necessary for the DCS. Since the DCS depends on several sensors and actuators to function, it is essential to regulate these parts and nodes (Kim and Tran-Dang 2019).

Information processing, monitoring, and control for the DCS's components are significantly influenced by the Software Architecture (SA). It provides a well-organized, abstract description of the general structure of a system. SA provides an abstract description of the DCS's high-level concepts. As a consequence of the improved development of software architecture designs to handle a number of software design issues, several architectural styles have emerged. The communication, deployment, domain, and structural aspects of software architecture each have their own unique styles. A appropriate architectural design eliminates the aforementioned issues and improves partitioning. It may also be altered and put to use once again for other objectives in line with user needs. As a result, the hardware architecture of large-scale DCS is made up of heterogeneous microcontroller systems, heterogeneous communication interfaces and channels, sensors, and actuators that are supervised and managed using the appropriate software architecture style (Veli-Pekka Eloranta et al. 2009, Javier Gamez Garcia et al. 2009).

2 Litreature Survey

According to Gutemberg et al. (2011), a sophisticated robotic system must be able to capture, analyze, and send all detected information via the sensor. This requires the use of robotic architecture. The complexity of robotic systems and the variety of hardware provide obstacles for developing robotic architecture. Distributed hardware and software architecture is created utilizing communication interfaces to address this complexity. Controlling dispersed robots and creating the interfaces for communication that will link them to the control base station are the major goals. The robotic system has the power to make decisions based on data that has been detected. After receiving the information, it processes it using computational models, database mapping, and other methods before acting appropriately. The Universal Robot Bus Architecture (URB), which is defined by Sarnali et al. (2021), enables the robot to execute in real-time for data collecting utilizing RS232 and I2C as uplink and downlink communication, respectively. For autonomous mobile robotic systems, the URB is a modular real-time Field-bus architecture that makes it easier to integrate a variety of sensors, actuators, and computing units. It supports the system's diverse integration of communication protocols and has a two-tiered structure. As a result, numerous hardware and software elements with diverse communication methods and capabilities may be integrated.

A CAN-based distributed system to combine sensors, actuators, and hardware controllers of the DCS employed in a mobile robot platform has been mentioned by Diego P. Losada et al. (2017). These hardware components' integration creates a versatile and reliable platform that may be used with many mobile robot platforms. It focuses on the creation of modular architecture for the integration of sensors and distributed hardware control. The functioning system created utilizing may bus-based architecture may be smoothly attached to and detached from any hardware module.

A unique distributed embedded system employing the CAN protocol was described by J.K.R. Sastry et al. (2022). It is based on a network of heterogeneous microcontrollers. It is used in nuclear reactor systems to monitor and regulate reactor temperature. A single master and four slaves make up the CAN-based network that was selected for the application. Finding mechanisms and methods by taking into account different aspects of communication, such as addressing, configuration, transmission, reception, arbitration, synchronization, error detection and control, etc., is necessary because every heterogeneous distributed embedded system requires a different communication system architecture. Data flow control differs depending on the application; in this case, the data packet and its flow are intended to track and regulate the temperatures within a nuclear reactor system. Signals may be driven a distance of 1 KM thanks to communication between the master and slave.

3 Methododlogy

The adoption of sustainable and renewable energy sources has a significant positive impact on power generation. Solar energy has grown in favor as a way of producing electricity since it is a clean, safe, accessible, infinite source of energy. The solar PV system contributes to supplying the rising need for DC power since it provides a DC output. The concept of a distributed generation (DG) DC micro-grid is also supported by this.

Intense research is being done to develop better, more efficient, and environmentally friendly power plants as a result of the development of technology in the sectors of energy and computer techniques and the availability of endless resources. In rural areas, the solar PV system has become an accessible, low-maintenance, and low- to medium-power source. The majority of the energy is transformed into PV-generated systems. They are becoming more powerful as a result of ongoing decreases in PV module prices and increases in efficiency.

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The solar PV module exhibits two crucial characteristics. As mentioned in the chapter before, several research have been done all over the globe to maximize I-V and P-V properties in order to achieve the most performance out of any solar panel. The overall effectiveness of solar output, however, also considers the impact of the solar array system, the applied regulator system (DC/DC or DC/AC converter), the cabling used for connections, and the connected batteries. Therefore, a method for remote DC Micro-Grid with a reliable, self-sufficient DC power supply is necessary for usage in remote places.

The main issue with solar panels since their creation has been their viability. Initially, the panel's efficiency was only around 1%; now, panels with up to 22% efficiency are available. Due to technological developments, markets for solar PV producing have been continually expanding since the creation of the solar panel.

Batteries are deployed in solar PV systems as energy storage because of the limits of cyclic time dependency. When there is no sun radiation, a change in the weather, or partial shadowing, these devices continue to generate power. Thanks to intensive study and advancements in energy storage technology, solar PV systems are being utilized more often and at lower costs. For local DC load types, the concept of a solar PV and battery-powered DC micro-grid is becoming more workable and affordable. The system planner determines the penetration of PV generators for medium and small isolated systems in combination with the array's size, capacity expansion for future usage, demand estimates, and other factors. The next section provides an overview of modeling analysis and approaches.

The boost converter operates in two modes: switch closure, which turns on the MOSFET, and switch opening, which turns the MOSFET off. Both the first and second modes are also known as charging and discharge modes, respectively.

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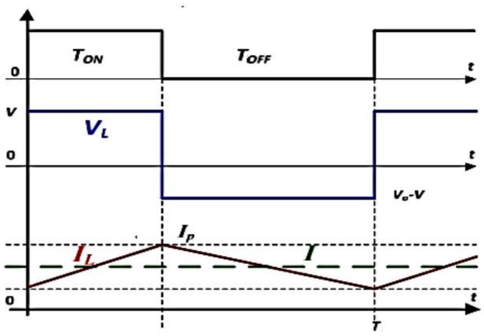

Figure 3.1: Boost converter waveform

The waveform of the boost converter is shown in Figure 3.2; the top waveform depicts the switch state, i.e., turn ON and turn OFF; the middle waveform depicts the voltage across the inductor; and the bottom waveform depicts the current flowing through the inductor.

4 Experiments & Results

A 2-level controller input for the second level of control, which is the proposed AG-MRAC controller, is proposed in this chapter. It aims to ensure fast convergence speed with guaranteed transient performance and overall system stability of the MPPT under rapidly changing environmental conditions. While high adaptation gain avoids negative impacts on the system's stability and resilience, conventional high-static adaptation gain MRAC guarantees transient performance in MPPT.

Additionally, the amount of gain needed in PV systems with rapidly changing environmental conditions depends on the size of the error; as a result, a fixed high gain controller does not fully address the dynamic behavior of non-linear PV systems in these circumstances. With the suggested AG-MRAC architecture, which adjusts the adaption gain based on output tracking error brought on by changes in ambient circumstances, the study is intended to address the aforementioned problems. The suggested AG-MRAC has been mathematically modeled, and stability has been shown using Lyapunov theory.

An experimental and simulation models have been developed to test the validity of the proposed control mechanism, and analysis has been conducted with similar efforts in the past to evaluate the effectiveness of the proposed control system. The previous research [2] was the source of inspiration for this study in which we propose a modified 2 level MPPT control system (Fig. 3.1) that includes adjustable adaptation gains MRAC (AG-MRAC). With MRAC is a fast convergence process that is possible with an extremely high gain for adaption.

The chapter discusses how to achieve this gain and a modified two-level MPPT control scheme that is illustrated in Fig.3.2. The AG-MRAC proposed for control regulates adaptation gain in a way that is efficient and rapidly reduces the error in tracking to zero, since it alters the gain of adaptation as a proportional to the system's track error. Furthermore, it proves that excessive absenteeism levels are prevalent.

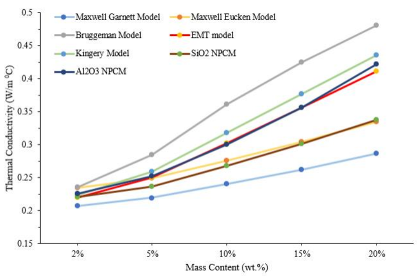

Figure 4.2 Comparison of the thermal conductivity between SNPCM and ANPCM using experimental and theoretical methods

To compare and analyse the theoretical as well as actual thermal conductivity of the Al2O3 and SiO2 NPCM conductivity results from five different models have been calculated. While the thermal conductivity could be calculated using a mathematical modeling model of the formulation, straightforward aggregate of nanoparticles results in an important difference between estimated thermal conductivity as well as the actual conductivity. The outcomes from applying five different models to the calculated results for thermal conductivity of NPCM can be observed in figure 4.1. The SNPCM as well as ANPCM experiment results are displayed in order to be the most compatible with Maxwell Eucken and EMT theoretical models. The NPCM differed from the theoretical and experimental value in the range of 5.98, 7.63, 5.45, 1.31, and 1.49 percent, respectively for 2 10, 15 and 20wt percent SiO2. The Al2O3 the NPCM's deviation from its theoretical as well as measured value was 3.19, 0.8, 0.66, 0.28, and 3.31 percentage, respectively, with mass fractions of 2 5 10, 15, and 20wt percent.

5 Conclusion

The proposed work's complex method has been described in this article. The RCC stage in the very first step of the two-level MPPT control system proposed in Fig. 3.2 will handle the converter's slower dynamic response to changes in the solar ecoupled analyses.

When using a two-level MPPT control technique, the time constant for the first level control has to be lower than the speed of changes to the environment. Likewise, the time constant of the second level control should be less than the one at the top. It is possible to divide those studies that are conducted for the initial and second levels is made possible due to the significant difference in the time constants. This helps simplify the overall MPPT control plan. The AG-MRAC model will be responsible for maintaining the duty cycle of the RCC when faced with rapidly shifting environmental conditions. The most significant contribution to this research is the creation of a proposed AG-MRAC which controls the fast-changing dynamics of the converter in order to combat variations in solar energy and is widely discussed in research literature.

6 References

1. Abdalla, A.N.; Nazir, M.S.; Tao, H.; Cao, S.; Ji, R.; Jiang, M.; Yao, L. Integration of energy storage system and renewable energy sources based on artificial intelligence: An overview. J. Energy Storage 2021, 40, 102811. [CrossRef]

2. Olabi, A.; Abdelkareem, M.A. Renewable energy and climate change. Renew. Sustain. Energy Rev. 2022, 158, 112111. [CrossRef]

3. Gawre, S.K. Advanced Fault Diagnosis and Condition Monitoring Schemes for Solar PV Systems, in Planning of Hybrid Renewable Energy Systems. In Electric Vehicles and Microgrid; Springer: Berlin, Germany, 2022; pp. 27–59. [CrossRef]

4. Firth, S.; Lomas, K.; Rees, S. A simple model of PV system performance and its use in fault detection. Sol. Energy 2010, 84, 624–635.[CrossRef]

5. Garoudja, E.; Harrou, F.; Sun, Y.; Kara, K.; Chouder, A.; Silvestre, S. Statistical fault detection in photovoltaic systems. Solar Energy 2017, 150, 485–499. [CrossRef]

6. Brooks, B.; White, S. Photovoltaic Systems and the National Electric Code; Routledge: London, UK, 2018. [CrossRef]

7. Albers, M.J.; Ball, G. Comparative evaluation of DC fault-mitigation techniques in large PV systems. IEEE J. Photovoltaics 2015, 5,1169–1174. [CrossRef]

8. Ram, J.P.; Manghani, H.; Pillai, D.S.; Babu, T.S.; Miyatake, M.; Rajasekar, N. Analysis on solar PV emulators: A review. Renew.Sustain. Energy Rev. 2018, 81, 149–160. [CrossRef]

9. Tina, G.M.; Cosentino, F.; Ventura, C. Monitoring and diagnostics of photovoltaic power plants. In Renewable Energy in the Service f Mankind Volume II; Springer: Berlin, Germany, 2016; pp. 505–516. [CrossRef]

10. Tsanakas, J.A.; Ha, L.D.; Al Shakarchi, F. Advanced inspection of photovoltaic installations by aerial triangulation and terrestrial georeferencing of thermal/visual imagery. Renew. Energy 2017, 102, 224–233. [CrossRef]

11. Tsanakas, J.A.; Ha, L.; Buerhop, C. Faults and infrared thermographic diagnosis in operating c-Si photovoltaic modules: A review of research and future challenges. Renew. Sustain. Energy Rev. 2016, 62, 695–709. [CrossRef]

12. Davarifar, M.; Rabhi, A.; El-Hajjaji, A.; Dahmane, M. Real-time model base fault diagnosis of PV panels using statistical signal processing. In Proceedings of the 2013 International Conference on Renewable Energy Research and Applications (ICRERA),Madrid, Spain, 20–23 October 2013.

13. Dhanalakshmi, B.; Rajasekar, N. Dominance square based array reconfiguration scheme for power loss reduction in solar PhotoVoltaic (PV) systems. Energy Convers. Manag. 2018, 156, 84–102. [CrossRef]

14. Pillai, D.S.; Rajasekar, N. A comprehensive review on protection challenges and fault diagnosis in PV systems. Renew. Sustain. Energy Rev. 2018, 91, 18–40. [CrossRef]

15. Chouder, A.; Silvestre, S. Automatic supervision and fault detection of PV systems based on power losses analysis. Energy Convers. Manag. 2010, 51, 1929–1937. [CrossRef]

16. Rahman, M.; Khan, I.; Alameh, K. Potential measurement techniques for photovoltaic module failure diagnosis: A review. Renew. Sustain. Energy Rev. 2021, 151, 111532. [CrossRef]

17. Alam, M.K.; Khan, F.; Johnson, J.; Flicker, J. A comprehensive review of catastrophic faults in PV arrays: Types, detection, and mitigation techniques. IEEE J. Photovoltaics 2015, 5, 982–997. [CrossRef]

ISSN: 2057-5688

18. Jadidi, S.; Badihi, H.; Zhang, Y. Fault Diagnosis in Micrograids with Integration of Solar Photovoltaic Systems: A Review. IFAC-Pap. Online 2020, 53, 12091–12096. [CrossRef]

19. Abubakar, A.; Almeida, C.F.M.; Gemignani, M. Review of Artificial Intelligence-Based Failure Detection and Diagnosis Methods for Solar Photovoltaic Systems. Machines 2021, 9, 328. [CrossRef]

20. Triki-Lahiani, A.; Abdelghani, A.B.-B.; Slama-Belkhodja, I. Fault detection and monitoring systems for photovoltaic installations: A review. Renew. Sustain. Energy Rev. 2018, 82, 2680–2692. [CrossRef]

21. Stefenon, S.F.; Branco, N.W.; Nied, A.; Bertol, D.W.; Finardi, E.C.; Sartori, A.; Meyer, L.H.; Grebogi, R.B. Analysis of training techniques of ANN for classification of insulators in electrical power systems. IET Gener. Transm. Distrib. 2020, 14, 1591–1597. [CrossRef]

22. Karthikeyan, M.; Sharmilee, K.; Balasubramaniam, P.; Prakash, N.; Babu, M.R.; Subramaniyaswamy, V.; Sudhakar, S. Design and implementation of ANN-based SAPF approach for current harmonics mitigation in industrial power systems. Microprocess. Microsystems 2020, 77, 103194. [CrossRef]

23. Gil-González, W.; Montoya, O.D.; Grisales-Noreña, L.F.; Cruz-Peragón, F.; Alcalá, G. Economic dispatch of renewable generators and Bess in DC microgrids using second-order cone optimization. Energies 2020, 13, 1703. [CrossRef]

24. Khalid, M. Wind power economic dispatch—Impact of radial basis functional networks and battery energy storage. IEEE Access 2019, 7, 36819–36832. [CrossRef]

25. Liu, H.; Shen, X.; Guo, Q.; Sun, H. A data-driven approach towards fast economic dispatch in electricity–gas coupled systems based on artificial neural network. Appl. Energy 2021, 286, 116480. [CrossRef]

26. Saeed, I.K. Artificial Neural Network Based on Optimal Operation of Economic Load Dispatch in Power System. ZANCO J.PURE Appl. Sci. 2019, 31, 94–102. [CrossRef]