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Dedicated to
Our parents, brothers, sisters, teachers, and friends for their love, encouragement, and endless support.
We give all thanks and gratitude to our beloved wife and to our daughters and sons wishing from God to protect them.

بسم الله الرحمن الرحيم
"يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ "
صدق الله العظيم
المجادلة/ 11

Acknowledgment

In the name of Allah, most Gracious, most Merciful

Firstly, all gratitude to Allah who guides and aides us to attain the achievements of this book.

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Abstract

Recently, the permanent growth of the energy demand and the rapid depletion of the conventional power sources have attracted the research interests of the authors toward the renewable energy sources, especially the photovoltaic (PV) energy as alternative sources of energy. The PV energy can be utilized only during the daylight. Therefore, the integration of the PV energy and the energy storage system as the battery supercapacitor can attenuate their individual fluctuations, increase the overall output power, and generate more reliable power with higher quality to the electrical loads in the rural areas. The aim of this book is to study and design the performance analysis of the PV stand-alone systems with energy storage systems as follows:

- This book investigates dynamic modeling, simulation, and control strategy of the PV stand-alone system during variation of the environmental conditions. Moreover, the effectiveness of the implemented maximum power point tracking (MPPT) techniques and the employed control strategy will be evaluated during variations of the solar irradiance and the cell temperature. The simulation results are based on the reliability of the MPPT techniques applied in extracting the maximum power from the PV system during the rapid variation of the environmental conditions. Furthermore, it introduces a review of two MPPT techniques that are implemented in the PV systems, namely, the perturb and observe (P&O) MPPT technique and the incremental conductance (InCond) MPPT technique. The two MPPT techniques were simulated by the MATLAB/Simulink, and the results response of the PV array from voltage, current, and power are compared to the effect of solar irradiation and temperature change.
- Then, the proposed PV stand-alone system is utilized to supply the demanded power of variable loads. The PV array is connected to battery energy storage (BES) through the DC bus in order to supply the demanded power of the variable loads. Moreover, the power flow control strategy is proposed to feed the demanded power of the variable loads. The BES can act as a buffer store to eliminate the mismatch between PV power and load demand. Furthermore, the BES helps to improve the performance of the system through the control used in the

process of charge and discharge to manage the sudden load changes and helps to maintain a stable voltage level on the load and PV terminals.

- Improving the performance of the PV stand-alone system by leveraging the properties of the battery-supercapacitor hybrid energy storage system (BS-HESS), this book proposes an efficient control strategy to enhance the BS-HESS capable of the PV stand-alone system.
- The PV panels are not an ideal source for battery charging; the output is unreliable and heavily dependent on weather conditions. Therefore, an optimum charge/discharge cycle cannot be guaranteed, resulting in a low battery state of charge (SOC%). Low battery SOC leads to sulfation and stratification, both of which shorten battery life. A control strategy is essential for the BS-HESS to optimize the energy utilization and energy sustainability to a maximum extent as it is the algorithm which manages the power flow of the battery supercapacitor.
- Performance analysis of the PV stand-alone system with BS-HESS during the high fluctuation solar irradiation and variable load power for rural household load profile.

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