A PHOTOVOLAIC SUPERCAPACITOR HYBRID ENERGY STORAGE SYSTEM

Mr. Viswanath Prashad Kurmi, Electrical and Electronic Engineering

Dr. C.V. Raman University, Bilaspur

Abstract

Photovoltaic (PV) devices involve a power storage buffer to supply the load with constant electricity when the solar irradiation is insufficient. This application uses Valve Regulated Lead Acid (VRLA) batteries. However, the supply of a big present burst, such as engine start-up, from the battery degrades the battery plates, causing the battery to be destroyed. An alternative way to supply large current bursts is to combine VRLA batteries with supercapacitors to form a hybrid storage system where the battery can supply continuous energy and the supercapacitor can supply the load with instant power. In this paper, MATLAB / Simulink models are used to investigate the function of the supercapacitor in a PV Energy Control Unit (ECU).

Key words: Photovoltaic, VRLA batteries, supercapacitors, MATLAB, Simulink.

Introduction

Standalone photovoltaic devices[1] are most prevalent in distant regions. A hybrid energy storage system for battery supercapacitor is shown in Fig. 1. In this system it is possible to reduce the size of battery in order to maintain greater state of charge (SOC)[2]. The supercapacitor has a higher density of power than the battery, enabling the supercapacitor to provide more power over a short time. On the other hand, when compared to a supercapacitor, the battery has a much higher energy density that allows the battery to store more energy and release it over a long time.

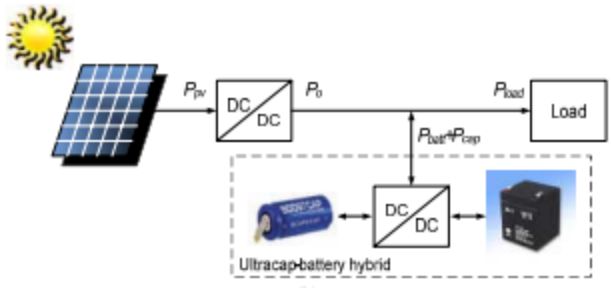

Fig.1

Methodology

1. MATLAB/Simulink models

   The MATLAB/Simulink[3] model is further composed of three models. The first one is photovoltaic model consisting of current, series resistance and a diode. The second one is a battery model to evaluate the impacts of distinct battery charging rates, charging status (SOC) and health status (SOH). The last one is a supercapacitor model made up of capacitance, series and parallel resistance.

2. Battery storage system

   The system includes a photovoltaic battery storage model which contains a converter, load, solar panel, and battery storage. The energy that is produced is further stored in the battery. A battery management system is installed for controlling the energy flow from the panel to the battery and then to the load. Maximum Power Point Tracking (MPPT)[4] is implemented by the DC-DC converter, charges the battery and delivers energy to the load.

3. Hybrid storage system

   The hybrid storage system consists of a photovoltaic hybrid storage model which acquire the advantages of both techniques, high supercapacitor power density as well as high battery power density. The entire photovoltaic system is controlled by the Energy Control Unit (ECU). The ECU is responsible for charging the hybrid battery / supercapacitor and providing the charging power.

4. System load comparison

   The battery management system (BMS) was contrasted under distinct load profiles[5] with the suggested hybrid energy control unit (ECU).

5. Optimization

Photovoltaic systems are sized for worst-case conditions, to ensure that the load requirements can be met throughout the year.

Conclusion

An Energy Control Unit (ECU) has been developed for a photovoltaic supercapacitor hybrid system. Maximum Power Point Tracking (MPPT) allows maximum power to be gained from the photovoltaic panel and the proposed ECU is responsible for calculating State of charge of the battery and supercapacitor. The ECU controls the system based on the power, battery/ supercapacitor SOC and the load required.

References

[1] T. Ma, H. Yang, and L. Lu, "Solar photovoltaic system modeling and performance prediction," *Renewable and Sustainable Energy Reviews*. 2014.

[2] V. Pop, H. J. Bergveld, P. H. L. Notten, and P. P. L. Regtien, "State-of-the-art of battery state-of-charge determination," *Measurement Science and Technology*. 2005.

[3] L. Keviczky, R. Bars, J. Hetthéssy, and C. Bányász, "Introduction to MATLAB," *Advanced Textbooks in Control and Signal Processing*, 2019.

[4] B. Subudhi and R. Pradhan, "A comparative study on maximum power point tracking techniques for photovoltaic power systems," *IEEE Trans. Sustain. Energy*, 2013.

[5] F. M. Andersen, H. V. Larsen, and T. K. Boomsma, "Long-term forecasting of hourly electricity load: Identification of consumption profiles and segmentation of customers," *Energy Convers. Manag.*, 2013.