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Assessment of LiFePO4 Battery Performance in Stand Alone Photovoltaic Street Light System

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Abstract

This paper is aimed to evaluate the performance of Lithium Iron Phosphate ($LiFePO_4$) batteries as a storage for stand-alone photovoltaic system during charging and discharging. Monitoring has been conducted based on LabVIEW Interface for Arduino (LIFA). The results show that on the discharge condition during 12 hours, the average current was -1.2A - 1.0 A. In charge condition during 8 hours, the current range was 0.10 A - 1.95 A, and the optimal charging process was from 11 am- 2 pm. However, the findings indicated that the battery undergo energy deficit approximately 10% every cycle of operation.

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Keywords: $LiFePO_4$; LIFA; street light; stand alone photovoltaic system

1. Introduction

Street lights are a fundamental part of the street, road, or highway to ensure sufficient visibility at night vision in order to increase the safety and decrease the crash rate. The street lights illuminate more than 13 hours every day and it consumed high electric power [1]. This issue attracted the researcher to use the stand-alone photovoltaic for street light system. It become promising system because it provides enormous benefits such as less emission, no fossil fuel [2], offers low cost [3], and can be applied in an isolated region that could not reach by the power grid. In order to operate this system, battery was needed to store the energy from PV module and supply the energy to the street light.

$LiFePO_4$ is rechargeable battery that has C-$LiFePO_4$ or carbon on the cathode and carbon intercalated with lithium on anode. This battery become a strong candidate for stand-alone photovoltaic street light system because it has excellent features, such as high theoretical capacity 170 mAh g^{-1} [4], high energy density, and total lifespan 6-7 times higher than lead acid battery [5]. This battery runs effectively in the temperature range of 25°C- 45°C and current range of 0.33 C to 2C [6]. As storage, battery performance during charging process is mostly influenced by the PV characteristics. Couple factors can influence PV characteristic, such as variation in solar radiation [7] and temperature [8]. Malfunction of battery may occur during the stand alone PV system operation because large variance of voltage in solar panel can influence the larger variance of battery voltage. In addition, the battery performance will decrease as the time goes and life time becomes shorter when it always operates in unsafe operating area.

In order to overcome the battery from over charge, over discharge, and over heat, comprehensive monitoring the battery is needed. Monitoring of battery for stand-alone system has been done by many researchers with various methods such HOMER software [2], online monitoring [9], and using LabVIEW on PC [10-11].

In this paper, the performance of $LiFePO_4$ battery on stand-alone photovoltaic street light system is presented during charging and discharging operation. The light intensity and temperature data are used for comprehensive analyzing.

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2. Methodology

The experiment has been conducted during May 2016 at Physics Education Program laboratory, Universitas Negeri Sebelas Maret, Surakarta (Indonesia, 7°33'23.9"S 110°51'18.6"E). The data were obtained during charging in the daylight and discharging in the night.

2.1 Stand alone photovoltaic street light system description

The photovoltaic module as an energy source has peak power 50 watt, maximum voltage 17.2 V and maximum current 2.91 A. The slope of the photovoltaic module is 20°. The street light based on LED that has operating voltage 12 Volt power 10 W was used as a load. In this experiment, a Lithium Iron Phosphate ($LiFePO_4$) battery pack Smart UNS manufactured by Chemical Engineering Department Universitas Negeri Sebelas Maret has been selected as an energy storage. It has 21 Ah capacity and nominal voltage 12 V. The battery pack consists of 56 cells which separated into four parts that arranged in series. Every part comprises 14 cells that arranged in parallel.

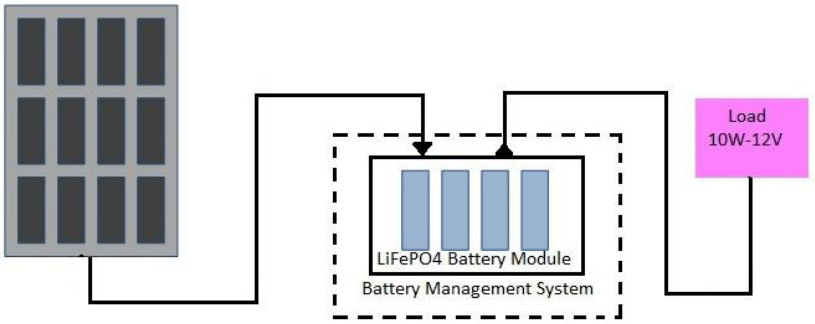

Fig.1 Stand-alone photovoltaic street light system

2.2 Monitoring system

To overcome the data acquisition, battery monitoring system based on LabVIEW Interface for Arduino (LIFA) has been built. It comprises hardware parts and software parts. The hardware parts consist of photovoltaic module, battery, street light, PWM solar charge controller, microcontroller based on ATmega-328 and ATmega-2560, relay, current sensors, voltage sensors, light sensor, temperature and humidity sensor. The software parts consist of LabVIEW and LIFA. LIFA is a toolkit that can be downloaded freely which allows a LabVIEW developer to control and acquire the data from Arduino microcontroller. LIFA helps LabVIEW software easily communicate and move the information from Arduino pins. The results were displayed on the PC.

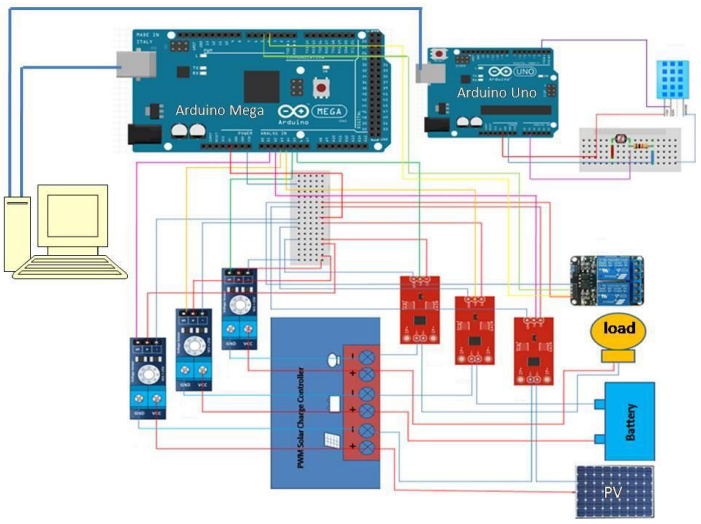

Fig. 2 Instrumentation for monitoring system