

RANCANG BANGUN STABILISASI PENGISIAN BATERAI SEPEDA LISTRIK MENGGUNAKAN *BUCK-BOOST CONVERTER*

Amira Rohadatul Aisy

Jurusan Teknik Elektro Universitas Trunojoyo Madura

Email : amiraaaisy004@gmail.com

ABSTRAK

Perkembangan teknologi kendaraan listrik, khususnya sepeda listrik, menuntut sistem pengisian daya yang efisien dan stabil guna menjaga performa dan umur baterai. Penelitian ini bertujuan untuk merancang sistem pengisian baterai sepeda listrik yang stabil menggunakan *Buck-Boost Converter* dengan kendali PID metode *Ziegler-Nichols*. Sistem ini memungkinkan penyesuaian tegangan input dari generator sepeda menjadi sesuai dengan kebutuhan baterai, baik saat perlu ditingkatkan (*boost*) maupun diturunkan (*buck*). Untuk mencapai kestabilan dan efisiensi, pengontrol PID digunakan dalam pengaturan *duty cycle* melalui digital potensiometer. Sistem diuji dengan variasi tegangan input antara 7V hingga 30V, dan hasil menunjukkan bahwa tegangan *output* berhasil distabilkan pada 25,2V dengan deviasi maksimal sebesar $\pm 0,4V$. Arus *output* juga dijaga stabil tidak lebih atau max 2A, saat pengisian baterai lithium-ion 24V/10Ah. Parameter K_u 4.0 dan P_u 0.6 yang diperoleh dari metode *trial and error* dan didapatkan parameter lain yang diperoleh menggunakan metode PID *Ziegler-Nichols* adalah T_i 0.30, T_d 0.80, K_p 2.40, K_i 8.00 dan K_d 0.18, dengan *settling time* sebesar 3 detik dan *overshoot* kurang dari 7.7%. Sistem pengisian ini juga dilengkapi dengan pemantauan tegangan dan arus secara *real-time* menggunakan dua sensor PZEM-017 dan tampilan LCD I2C. Hasil menunjukkan bahwa pengisian berlangsung aman tanpa overcharge, serta suhu baterai tetap terjaga di bawah 40°C dengan rata-rata 27,5°C selama proses pengisian. Penelitian ini berhasil meningkatkan kestabilan pengisian, memperpanjang umur baterai, dan memberikan solusi pengisian mandiri berbasis energi pedal sepeda yang efisien dan ramah lingkungan.

Kata Kunci: Sepeda Listrik, *Buck-Boost Converter*, PID *Ziegler-Nichols*, Baterai *lithium-ion*, Efisiensi Pengisian, Stabilitas Tegangan.

DESIGN AND IMPLEMENTATION OF A STABILIZED CHARGING SYSTEM FOR ELECTRIC BICYCLE BATTERIES USING A BUCK-BOOST CONVERTER

Amira Rohadatul Aisy

Department of Electrical Engineering, Trunojoyo University, Madura

Email : amiraaaisy004@gmail.com

ABSTRACT

The advancement of electric vehicle technology, particularly electric bicycles, demands an efficient and stable charging system to maintain battery performance and longevity. This study aims to design a stable battery charging system for electric bicycles using a Buck-Boost *Converter* controlled by a PID controller based on the Ziegler-Nichols method. The system allows the adjustment of input voltage from a bicycle generator to match the battery's requirements, whether by increasing (boost) or decreasing (buck) the voltage as needed. To achieve voltage stability and efficiency, a PID controller is employed to regulate the duty cycle through a digital potentiometer. The system was tested with input voltage variations ranging from 7V to 30V, and the results showed that the *output* voltage was successfully stabilized at 25.2V, with a maximum deviation of $\pm 0.4V$. The *output* current was also maintained at a stable level, not exceeding 2A, during the charging of a 24V/10Ah lithium-ion battery. Using the trial-and-error method, K_u and P_u values were determined to be 4.0 and 0.6, respectively. Based on the Ziegler-Nichols tuning method, the resulting PID parameters were $T_i = 0.30$, $T_d = 0.80$, $K_p = 2.40$, $K_i = 8.00$, and $K_d = 0.18$, achieving a settling time of 3 seconds and an *overshoot* of less than 7.7%. The charging system is also equipped with *real-time* voltage and current monitoring using two PZEM-017 sensors and an LCD I2C display. The results indicated that the charging process was safe, with no *overcharging* observed, and the battery temperature remained below 40°C, averaging 27.5°C throughout the charging period. This research successfully enhances charging stability, extends battery lifespan, and offers a self-sustaining, pedal-powered charging solution that is both efficient and environmentally friendly.

Keywords: Electric Bicycle, Buck-Boost Converter, PID Ziegler-Nichols, Lithium-Ion Battery, Charging Efficiency, Voltage Stability.