

ABSTRACT

Battery is an energy storage device that cannot be recycled. It is necessary to handle the battery using Battery Management System to make the performance good and durable. BMS manages several things; one of them is the State of Charge. State of Charge is a variable that cannot be measured directly by a data collection. The appropriate method is required for estimating the battery capacity.

Fuzzy inference systems can be used to estimate the battery capacity. In this research, SOC were performed using the Interval Type 2 Fuzzy Logic System (IT2FLS) and ANFIS as a base to build membership functions and the rule base. The difference area of uncertainty was used to determine the model of type 2 fuzzy system to get the most appropriate model based on the smallest RMSE value. Two methods of type reducer, namely Enhanced Iterative Algorithm with Stop Condition (EIASC) and Enhanced Opposite Direction Search (EODS) were used in this research, which aimed to determine the estimated capacity of the battery appropriately. Two types of datasets were used to determine the performance of the proposed method based on the Mean Square Error (MSE), Root Mean Square Error (RMSE) and Mean Absolute Error (MAPE) to evaluate the State of Charge

The results show that the smallest RMSE value is obtained in IT2FLS method with the value areas of uncertainty, C is 0.04 at static capacity dataset and C value of 0.1 on a pulse variation dataset. Among the three methods, namely, T1FLS, IT2FLS EIASC and IT2FLS EODS, the method that produces the smallest RMSE value is IT2FLS EIASC with the RMSE value of 0.033.

Keywords: Battery, Fuzzy Type 1, Fuzzy Type 2, Type-Reducer, State of Charge.

INTISARI

Baterai merupakan alat penyimpanan energi yang tidak dapat didaur ulang sehingga diperlukan Sistem Manajemen Baterai atau *Battery Management System* (BMS) agar performa baterai lebih baik. Salah satu bagian penanganan BMS adalah kapasitas baterai (*State of Charge*). Kapasitas baterai merupakan variabel yang tidak dapat diukur secara langsung melalui pengambilan data. Metode yang tepat diperlukan untuk melakukan estimasi kapasitas baterai.

Salah satu metode yang digunakan untuk estimasi kapasitas baterai adalah sistem inferensi fuzzy. Pada penelitian ini dilakukan metode estimasi menggunakan *Interval Type 2 Fuzzy Logic System* dengan ANFIS (Adaptive Neuro Fuzzy Inference System) sebagai dasar untuk membangun fungsi keanggotaan dan basis aturan. Perbedaan daerah ketidakpastian digunakan untuk mengetahui model sistem fuzzy tipe 2 yang paling tepat berdasarkan nilai RMSE terkecil. Dua metode *type reducer* yaitu *Enhanced Iterative Algorithm with Stop Condition* (EIASC) dan *Enhanced Opposite Direction Search* (EODS) digunakan pada penelitian ini yang bertujuan untuk mengetahui hasil estimasi kapasitas baterai yang paling tepat. Dua jenis dataset digunakan untuk mengetahui kinerja metode yang diusulkan berdasarkan *Mean Square Error* (MSE), *Root Mean Square Error* (RMSE) dan *Mean Absolute Error* (MAPE) untuk mengevaluasi kapasitas baterai.

Nilai RMSE terkecil diperoleh pada metode IT2FLS dengan nilai daerah ketidakpastian $C = 0,04$ pada dataset beban konstan dan IT2FLS dengan nilai $C = 0,1$ pada dataset beban bervariasi. Berdasarkan pengujian yang dilakukan terhadap tiga metode yaitu T1FLS, IT2FLS EIASC dan IT2FLS EODS, metode yang menghasilkan nilai RMSE terkecil adalah metode IT2FLS EIASC dengan nilai RMSE 0,033.

Kata kunci– Baterai, Fuzzy Tipe 1, Fuzzy Tipe 2, *Type-Reducer*, *State of Charge*.