IMPROVED EQUIVALENT CIRCUIT MODEL FOR HIGH CAPACITY LITHIUM FERRO PHOSPHATE BATTERY

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Specially dedicated to my beloved father, mother and friends for their encouragement and support

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ABSTRACT

Electric Vehicle (EV) gets the attention and interest of scientists due to its advantages of zero green house gaseous emissions and higher efficiency. Battery pack is utilised as energy storage element in EV. Strict handling on battery pack is important to ensure battery pack performs in safe and consistent manner under various load demand and driving state. Therefore, an efficient Battery Management System (BMS) which can perform State Of Charge (SOC) estimation, cell equalisation and temperature control, should be put as the primary concern. In this aspect, an accurate battery model is required to give high quality SOC estimation and battery management. Equivalent circuit model is widely used as the battery model since it can be easily connected to external circuit in a simulation platform. However, the existing battery models are generally built for low capacity battery and do not take into account on nonlinear capacity effect. In this thesis, equivalent circuit model for 18 Ah Lithium Ferro Phosphates ($LiFePO_4$) battery is developed. $LiFePO_4$ battery is a good energy storage element for EV since it has good thermal and chemical stabilities. The thesis studies the existing battery modelling technique and investigates the dynamic characteristics of 18 Ah $LiFePO_4$ battery. A new battery modelling approach with consideration of nonlinear capacity effect has also been proposed for high capacity $LiFePO_4$ battery. Moreover, a simplified methodology for battery modelling is proposed to improve existing battery model. Parameter extraction is discussed and the proposed battery model is validated from the experiment data. The comparison between experiment and simulation results shows that the proposed model is capable of predicting dynamic behaviours of the battery with minimum error.

ABSTRAK

Kenderaan elektrik (EV) menarik perhatian dan minat daripada saintis kerana ia tidak menpunyai masalah pelepasan gas rumah hijau dan ia menpunyai kecekapan yang tinggi. Pek bateri diguna sebagai elemen simpanan tenaga dalam EV. Pengendalian bateri pek adalah sangat penting untuk memastikan bateri pek berfungsi secara selamat dan konsisten dalam pelbagai permintaan beban dan keadaan memandu. Maka, sistem pengurusan bateri (BMS) yang cekap dalam penganggaran status caj (SOC), pengimbangan sel dan pengawalan suhu perlu dijadikan sebagai fokus utama. Dalam aspek ini, model bateri yang tepat amat diperlukan dalam penganggaran SOC dan pengurusan bateri. Model litar setara banyak digunakan sebagai model bateri kerana ia mudah disambungkan kepada litar luar dalam platform simulasi. Walau bagaimanapun, model bateri yang wujud biasanya dibina untuk bateri yang berkapasiti rendah atau tidak mengambil kira kesan kapasiti tak linear. Dalam tesis ini, model litar setara yang sesuai bagi 18 Ah bateri Litium Ferro Fosfat ($LiFePO_4$) dibangunkan. Bateri $LiFePO_4$ merupakan alat penyimpanan tenaga yang sesuai untuk EV kerana ia mempunyai ciri-ciri yang stabil dari segi kimia dan terma. Tesis ini mengkaji teknik pemodelan bateri yang sedia ada serta mengkaji ciri-ciri dinamik pada 18 Ah $LiFePO_4$ bateri. Pemodelan model bateri yang baru untuk $LiFePO_4$ berkapasiti tinggi juga dicadangkan. Model baru ini mengambil kira kesan kapasiti tak linear. Selain itu, metodologi pemodelan bateri juga dipermudahkan dan dicadangkan dalam tesis. Langkah-langkah pengenalan parameter telah dibincangkan dan ketepatan model baru yang dicadangkan ini juga disahkan melalui data uji kaji. Perbandingan antara keputusan uji kaji dan simulasi menunjukkan bahawa model yang dicadangkan dapat mewakili ciri-ciri dinamik bateri dengan ralat yang minimum.