# Abstract

The thesis concerns voltage modelling of a lithium-ion cell using electrical equivalent circuit (EEC) and artificial neural network (ANN). The main problem concerning electrical equivalent circuit models is the lack of a clearly defined modelling procedure and a model structure. The multistage process of the EEC model development leads to many possible variants of models. The comparisons of the EEC models presented in the literature do not indicate clearly which model structure has the lowest errors of the modelled cell voltage. Therefore, the modelling aspects influencing the voltage errors of electrical equivalent circuit models are studied in this dissertation. The modelling aspects concern: simplifications in the parameter estimation method, a description of the model's parameters using mathematical functions and a model order choice. The proposed analysis of the modelling procedure revealed that the errors of the estimated voltage by the EEC models are the highest at the high range of depth of discharge (DOD). The performed analysis has shown that the high voltage errors at the high DOD range are caused by simplifications in the estimation procedure and partially by a current dependency of the model resistance, which some scientists also reported. The several quality factors were proposed and calculated in two DOD ranges and zero and non-zero current restrictions. The proposed quality factors allowed observing the dependency of model voltage errors from the EEC model order, the DOD ranges and the load current. It is shown that those differences are difficult to observe using the common quality factor used in the literature - the root mean squared error calculated for entire tests. The second part of the dissertation concerns the artificial neural network model. The advantage of an ANN model, in comparison to an EEC model, is the lack of any simplifying assumptions in model building, which increase the errors of the modelled voltage. Therefore the ANN models can be more accurate than EEC models due to the approximation capability of cell voltage nonlinearities, which are not considered for standard EEC models. The ANN models presented in the literature often use recurrent network structures. The models with recurrent ANN have problems with training in the entire DOD range or require custom network structures and training algorithms. In the dissertation, the solution with a feedforward ANN and a dynamic

preprocessing block is proposed, capable of being trained in the entire DOD range and using standard algorithms. The proposed ANN model is justified and validated on experimental data in the last part of this dissertation.

Keywords – electrical equivalent circuit, artificial neural network, lithium-ion cell, modelling of lithium-ion cells, modelling errors of lithium-ion cells.