Estimation of Maximum Power in Lithium Ion Batteries using IoT

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Abstract: Nowadays, electric vehicles such as cars and bicycles are increasing their popularity due to the rising environmental consciousness. The autonomy required by these means of transport has marked a significant and steady growth in the development of battery technologies. In this sense, it is crucial to estimate and prognosticate critical parameters of battery packs such as the State of Charge (SOC), the State of Maximum Power Available (SoMPA), and the Failure Time. All these indicators are relevant to determine if both the energy stored in the battery of electric vehicles and power specifications are sufficient to successfully complete a required route, avoiding battery preventive disconnection before arrival. In this regard, this paper presents a novel approach to estimate and prognosticate the SOC and SoMPA of Lithium-Ion batteries in the context of electro mobility applications. The proposed method uses the formulation of an optimization problem to find an analytical relationship between the SOC and the SoMPA

Keywords:Particle Filtering, Prognostics, State of Maximum Power Available, Lithium-Ion Battery

I. INTRODUCTION

In recent decades, the scientific community has shown great interest in providing electro mobility solutions that resolve vehicular congestion problems and parking issues, while at the same time, responding to environmental concerns. The use of electric bicycles has been proposed to confront these issues and is becoming a popular solution.The increasing use of lithium-ion batteries in applications such as electric cars and bicycles has led to the development of the Battery Management Systems (BMS) [1]. BMS allow monitoring a number of variables and parameters of the battery: input/output current and voltage, operating temperature, charge and discharge control, among others. Moreover, the BMS must be able to estimate and prognosticate some important parameters of the battery bank such as the State of Charge (SOC), the State of Maximum Power Available (SoMPA) and the Failure Time (FT). These parameters are an important concern for drivers to know if the power and amount of energy stored in the battery is sufficient to complete a particular route. Violating the Safe Operating Area (SOA), which is determined by temperature, voltage, current, power and SOC limits to ensure a safe operation. Finally, the FT is defined as the time in which the battery bank will fail, due to some of its parameters are outside of the SOA. Another example is presented in where an EIS, based on the equivalent circuit model, is used to characterize the battery and to estimate the maximum power available.

II. EXISTING SYSTEM

Electric vehicles are taking over combustion engine vehicles. However, when electric vehicles first came out, there was a lot of confusion regarding their systems and maintenance. Today, the current trend in the automotive market shows that these doubts are lessening. The thermostat, coolant, and radiator system remove heat from the engine. In electric vehicles, thermal management involves the cooling of batteries, power electronic systems, and the motor. The availability of discharge power for starting and acceleration, charge acceptance during regenerative braking, and the health of the battery are at their best at optimal temperatures. As the temperature increases, the battery life, electric vehicle drivability, and fuel economy degrade. Considering the overall thermal effect of the battery on electric vehicles

III. PROPOSED SYSTEM

The proposed prognostic algorithm is based on the PF approach presented in this prognostic algorithm has been modified to estimate the Failure Time Probability Density Function (FT-PDF) by predicting future trajectories for the battery SoMPA and voltage. As the evolution of these variables over time depends on the energy consumption profile, the prognostic algorithm requires a probabilistic characterization of the battery discharge current. This probabilistic characterization is provided by a Markov Chain model, where the discharge current profile is parameterized by a collection of discrete states (e.g., high, nominal, and low consumption) and transition probabilities between them. Several realizations of the Markov Chain, representing equi-probable future scenarios are used to generate conditional PDFs for the state trajectory (i.e., the battery SOC) over time problem

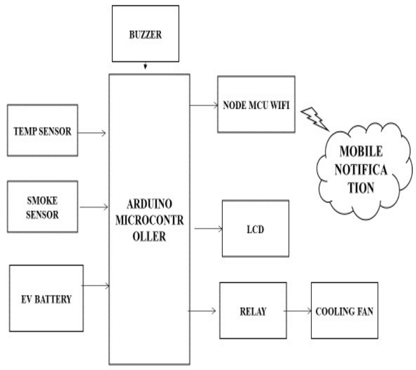


Fig.1. Block Diagram of Proposed System

Then, predicted SOC empirical distributions, as well as the relationship between SOC and SoMPA and the Law of Total Probabilities, are used to approximate the SoMPA PDF as a function of time; allowing computing the definitive outcome of the prognostic module: the FT- PDF. Battery voltage prediction is performed by directly evaluating on future state trajectories. It is worth to remember that the FT is defined as the moment in which the demand of electrical power exceeds the SoMPA, which translates into an unfeasible solution for the associated optimization to events where the minimum voltage in the battery terminals (cut-off voltage, 33V) is violated.

IV. SIMULATION

A. Simulation Diagram of Proposed System

The ampere-hour-based method consists of measuring the input and output current at battery terminals and using this information, to compute the SOC. This method is easy to implement; however, it is susceptible to errors due to imprecise measurements, which forces the utilization of high-cost sensors. The OCV method assumes that there is a relationship between the measurements.Future profiles for the battery discharge current are computed after a characterization of the usage profile for each experimental test. The failure condition is defined as the moment in which the demand of electrical power exceed optimization problem. Particularly during the experimental tests reported in this work, this failure event is related to a situation in which the constraint for the minimum voltage in the terminals of the battery (cut-off voltage, Vc) is violated.

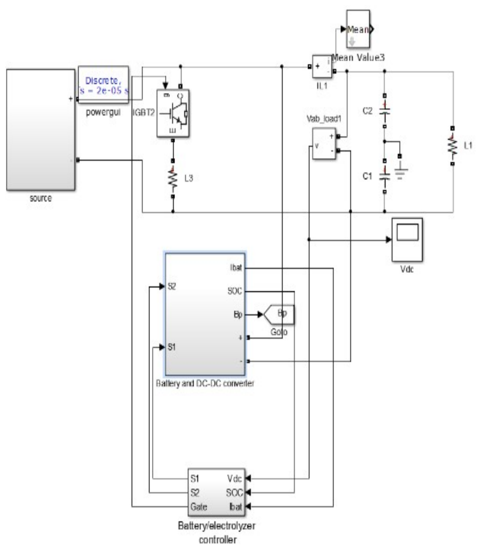
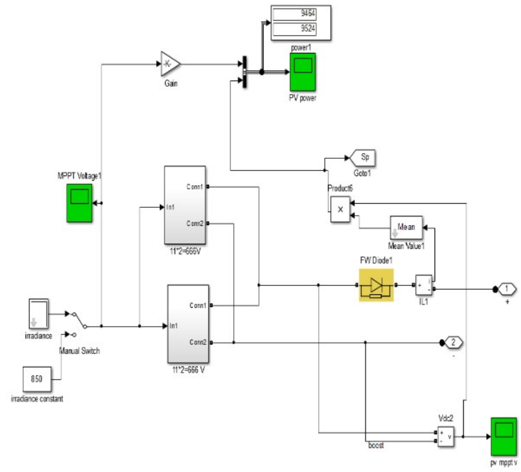


Fig.2.Simulation Diagram of Proposed System

The latter means that if the predicted voltage at the battery pack reaches Vc, at that time is considered that the fault occurs. It is worth remembering that the Vc, is given by the battery manufacturer, and for the batteries used in this work, it is equal to 33V.The ampere-hour-based method consists of measuring the input and output current at battery terminals and using this information, to compute the SOC. This method is easy to implement;

however, it is susceptible to errors due to imprecise measurements, which forces the utilization of high-cost sensors.The cut-off value of 33 V. Indeed, if the FT-PDF is computed solely based on information about the predicted voltage, then it cannot be used to provide a reasonable expectation



Since the Markov chain Characterization of the future operating profile is not able to anticipate a sudden change in the power consumption that takes place at t = 5866[s]. Interestingly enough, the proposed method (based on the analysis of the battery SoMPA) is still able to provide an adequate representation of the conditions that define a possible fault in the system: as soon as the measured power intersects the predicted SoMPA 95% confidence interval the failure event takes place, thus validating the proposed approach as a method to define the maximum power requirements that the system may handle without interruptions in the system operational continuity. Battery is inferior to the maximum power available. Fig. 4 shows estimates for the magnitude of the battery internal impedance, SOC, and SoMPA in the Data Set #2.It noteworthy that this data set corresponds to a situation where the bicycle is driven through a route with elevation. Similarly to the results obtained for Data Set #1, estimates of the internal impedance range between 0.2[Ω] to 0.3[Ω] while the battery SOC varies between Internal Impedance, SOC, and SOMPA estimates - Data Set #3. 0.9 and 0.6, meaning that at the beginning of the test. It should be noted that in this experiment, the BMS of the battery bank activates the under-voltage protection when the SOC is approximately 0.6. The latter is caused by the fact that the power required by the bicycle to follow the route is very high, forcing a significant voltage drop and activating the low-voltage protection of the system. This situation implies that the power required from the battery during this test route reached the estimated SoMPA, as shown in the last graph of Fig. 5.

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. This section focuses on the results obtained with the proposed SoMPA estimator. Notice that for all validation sets, the initial SoC is arbitrarily initialized at 50% of the true value to analyse the impact of erroneous initial conditions

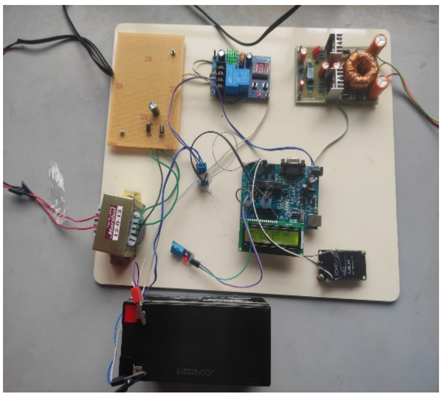


Fig.4. Hardware Kit

The results for each validation set are as follows. shows (i) the expectation of the SoMPA and the confidence interval (of 95%) of the SoMPA estimate at each time instant, and (ii) the PDF of SoMPA of the estimator at some arbitrary time instants for validation sets #1, #2 and #3, respectively [3]. The proposed SoMPA estimator computes the expected value as well as the confidence interval for a given confidence level. The proposed framework allows us to compute the conditional SoMPA PDF estimate at any arbitrary time instant. Fig. 6 and e depicts the performance of the PF-based PDF estimate at moments in which the filter has converged (uncertainty associated with the estimate is mainly due to measurement X or Y is 500 volts. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts. The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 v0lts, as result of the small voltage drop across the diode. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000 volts. Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

V.CONCLUSION

To generate different usage profiles. In all the experimental tests, the FT for the electric bicycle (defined as the moment in which the voltage in battery terminals falls below a given threshold) is approximated With a prediction error smaller than12%, offering a precision comparable with prognosis results previously reported in literature It is noteworthy that the proposed prognostic scheme is suitable to be used in electro mobility applications such as electric cars, electric bikes, electric trucks, among others. Last but not least, it is a fact that many aspects related to battery modelling could still be improved. In this regard, as future work, the effects of the temperature, SOH, SOC, current rate to characterize the This project introduces a novel methodology, based on PF algorithms, to estimate and prognosticate the SOC, the SoMPA, and the FT for lithium-ion batteries in the context of electro mobility applications (specifically, an electric bicycle). The proposed method uses the formulation of an optimization problem to find an analytical relationship between the SOC and the SoMPA; whereas the battery pack is modelled in terms of both the polarization resistance and the SOC.

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