Adaptive Power Optimizer for Electric vehicles

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Abstract **-This Paper presents the power optimization techniques in the battery system of the electric motor to continuously run the motor of the electric vehicle without depletion. Also it aims to optimize the power of a battery system adaptively in order to run the electric motor in a hybrid vehicle and to recharge the depleted battery efficiently during the run time of the electric motor. The adaptive battery charging system follows the simple battery charging system for Lithium-Ion batteries. The energy required to run the DC motor in an electric vehicle is provided by this battery system. This can also be applied in other electrical systems which is powered by the rechargeable batteries. Thus this adaptive power optimizing technique will improve the efficiency of charging and helps to improve the run time of the electric vehicles without recharging for a while.**

Keywords— Electric vehicles, Battery optimization, Energy Harvest

I. INTRODUCTION

Research in the field of electrical engineering has been long engaged in the identification of new forms of energy reduction from common and everyday life sources. One of the latest techniques in this exploration phase is the conversion of mechanical energy into electrical energy by the employment of harvesters. This conversion creates micro-productions of electrical energy but it is inadequate for practical applications. In order to generate adequate amount of energy to run an electrical motor in the electric vehicles, the energy from the battery has to be optimized adaptively. The optimized energy is switch over among the depleted batteries in order to conserve the energy effectively. One of the secondary batteries in this system has to be charged initially and another secondary battery can be kept drained. Primary battery can be continuously charged by the secondary batteries and this primary battery continuously run the electric motor. The current development of the transportation system is driven by environmental concerns and the depletion of fossil fuels. Compared to conventional combustion vehicles the use of electric vehicles can provide a sustainable individual mobility since renewable energy sources can be utilized. The comparable simple drive train topology and scalability of components allows the application in various types of vehicles of all sizes. Electric vehicles don't need any gasoline and have no local emissions. As electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) are commercialized, interest has grown in predicting the effect such vehicles will have on electric power system infrastructure, and in mitigating any negative effects.

II. Overview

The Electric motor of the hybrid vehicles use rechargeable batteries which can be charged frequently to run the motor of the vehicle. The need of frequent recharging of batteries become its tremendous drawback. The use of two secondary batteries and a primary battery in the system overcome this drawback by avoiding the frequent charging to run the electric motor.

III. HARDWARE ARCHITECTURE

In our proposed system we make use of the PIC16f877a microcontroller to control to relays and to measure and monitor the status of the secondary batteries. The microcontroller is powered by a secondary battery which is currently in operational state. The high voltage from the microcontroller is suppressed by the voltage divider. The buck converter and boost converter are used to minimize and maximize the voltage in order to run the motor in its ideal state.

IV. SIMPLE BATTERY DEGRADATION MODEL

In order to adaptively optimize battery life and energy cost, estimated equivalent costs of battery degradation are defined here to reduce the battery lifetime. The charge of battery degradation, $\mathbf{C_{bd}}$ is defined as

$$\mathbf{C_{bd} = C_{bat} * \Delta L/L}$$

Here C_{bat} is the charge of the battery pack, ΔL is the life time degradation due to the charge cycle being evaluated per unit time, and L is the total battery lifetime if the charge cycle under evaluation were repeated until the battery's end of life (E_{OL}). By minimizing C_{bd}, we are maximizing battery life. E_{OL} for a vehicle battery is defined as the time when either the battery's energy capacity or its available power drops below a specified minimum. Typically, the E_{OL} energy capacity Q_{EOL} is designed to beabout 80% of the initial capacity Q_0 in order to provide the desired energy storage over the vehicle's design life at minimal charge: $Q_{EOL} = 0.8Q_0$. Battery power is typically oversized relative to the minimum design EOL power for economic reasons: additional power makes more energy accessible at low SOC without requiring addition of expensive active material. To reflect this, EOL power is defined here as PEOL = 0.7P0, where P0 is the initial maximum power.

Li-ion battery power fade P_{fade} is a result of internal resistance growth. $P_{fade}(t)$ defined as $P_{max}(t)/P0$, which is equal to $R_0/R(t)$, where P_{max}, R_0 is the initial internal resistance, and R(t) is the internal resistance at time t. This relationship is derived in Appendix A. Over a daily battery cycle, significant factors that influence power fade and capacity fade are temperature T(t), open circuit voltage $V_{OC}(t)$, and depth of discharge (DOD). The simple battery model proposed here makes two approximations: 1) Each of these effects is independent of the others, and 2) The effects themselves are independent of battery age. Approximation 1 allows the model to be simple enough to be evaluated quickly and allows it to be tuned to fit available data sets that often only consider one of the three factors. The degree of validity of this approximation is a complex question requiring further research. Approximation 2 allows the simple battery model to be time-invariant over battery life. As can be seen by comparing the slope of the curved relative power, P(t) to its average slope, this approximation is very good, but not perfect, over most of the battery lifetime. Finally, we note that VOC maps directly to SOC.

Using these approximations to consider the effects of T(t), SOC(t), and DOD on capacity lifetime and power lifetime, we have that the cost of battery degradation is

$$\mathbf{C_{bd} = max((C_{Q,T} + C_{Q,SOC} + C_{Q,DOD}),(C_{P,T} + C_{P,SOC} + C_{P,DOD}))}$$

where $C_{Q,T}$,$C_{Q,SOC}$, and $C_{Q,DOD}$ are the charges associated with capacity fade and $C_{P,T}$, $C_{P,SOC}$, and $C_{P,DOD}$ are the charges associated with power fade due to temperature, SOC, and DOD, respectively. The battery model presented here models all three capacity-related charges, as well as the cost of power fade due to temperature, $C_{P,T}$. The costs $C_{P,SOC}$ and $C_{P,DOD}$ are assumed to be negligible in comparison to the other charges and hence are not modeled.

Recalling that ΔL/L, the normalized lifetime lost per day, is the measurement used to compute equivalent cost, we calculate the average ΔL/L per day that would result in a power lifetime L_P using

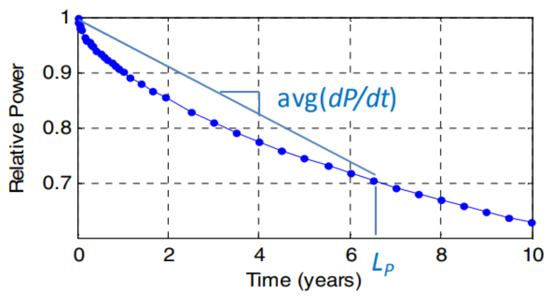

Fig.1. Power vs lifetime LP

The cost of capacity fade due to SOC(t), $C_{Q,SOC}$, was tuned by feeding into NREL's model various 24-hour battery data profiles with a constant, low temperature (6°C). This deemphasizes the effects of temperature degradation. Fig. 5 shows a plot of normalized lifetime lost ΔL/L versus average

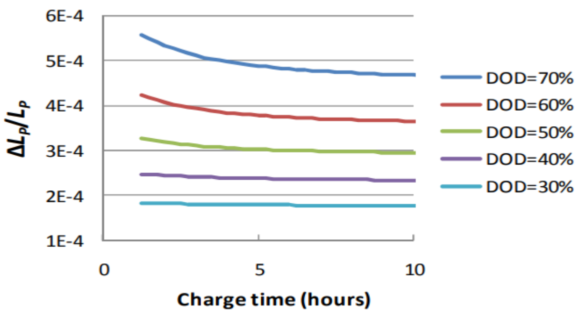

Fig.2.Relation between charge and degradation time of secondary battery

V. Working Principle

This system is based on dynamic battery charging in smart electrical vehicles which is implemented by PIC16f877A microcontroller. It can be implemented by using primary and secondary batteries. Secondary battery comprises of two batteries (6V and 6V), and it is dynamically charged by effective switch over of the pic controller. Primary battery (12V) gets in turn charged by the secondary battery. Initially the secondary battery 1 delivers 12 volts and it is divided by the voltage divider. Then the divided voltage is provided to the microcontroller and it displays the respective attributes of the secondary batteries. The voltage from Secondary batteries has been delivered to the relay circuits 1 and 2. Relays are controlled by the control signals from Pic16F877A microcontroller. The output of relay circuits are given to the boost converter. It increases the voltage from 6V to approximately 60V and then the increased voltage has been driven to the primary battery through the Buck converter which drops the voltage from 60V to approximately 18V. Then the output of the buck converter is provided to the primary battery(12V) and the power delivered from the primary battery is delivered to the DC Motor. Also the power from Primary battery is provided to the relay circuits 3 and 4. When the secondary battery is in need of charging, then the relay 3 has to be turned ON which are programmed prior in accordance with the microcontroller. Thus this cycle continues in the case of Secondary battery 2 in operational state.

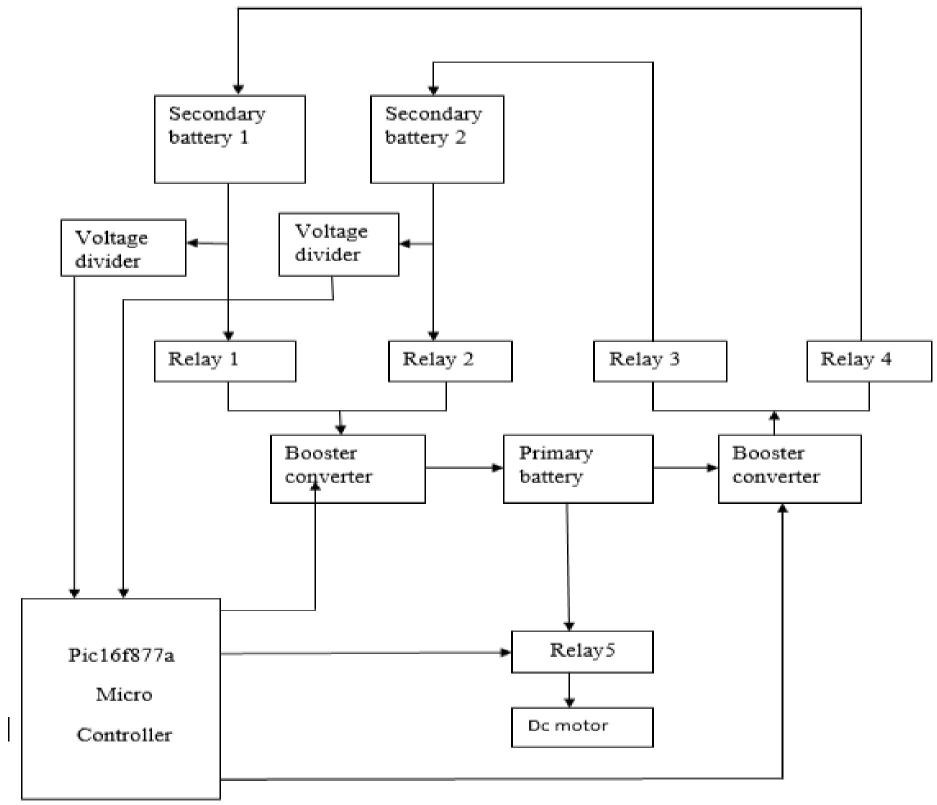

Fig.3 Block Diagram

VI. Implementation

Initially power supply is switched on to initiate the process and to provide supply to the microcontroller. A secondary battery is initially charged to its maximum capacity and another secondary battery is kept drained. The secondary battery's status has been monitored and displayed by the 8bit LCD display which is signaled by the PIC microcontroller. Then the voltage is increased by the booster converter and it has been deducted to the required voltage level for the primary battery by the Buck converter. Then another two relays are used to control the recharging phase of the secondary batteries.

Fig.4 Output of adaptive power optimizer

VII. Result

The optimized output voltages from the secondary batteries are measured and monitored by the microcontroller. The microcontroller uses adaptive comparison method to analyze the battery voltages and regulates the relays to switch the secondary batteries between discharge and charge states.

Fig.5 Output in LCD display

Fig.6 Displays the measured values of battery

Fig.6 illustrates the LCD unit which displays the voltage and current discharge from the secondary batteries. It is measured by the microcontroller for both the secondary batteries during the charging and discharging states.

VIII. Conclusion

Finally this technique helps to increase the efficiency of the battery system and it also helps to improve the power output and running period of the battery system. It also supports other battery systems such as inverters and generators for commercial and residential purposes.

IX.References

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