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"Battery Monitoring for State-of-Charge and Power optimization using LabVIEW"

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ABSTRACT:

As the transportation industry strives to electrify their vehicles, the onboard power source remains a weak link. Fuel cells and secondary batteries are often considered major candidates for providing the primary motive power or serving as load-leveling devices. Due to the relative maturity of the secondary batteries, much effort by academia and industry is devoted to making batteries reliable and affordable for the electrification of vehicles. In addition to the development of new batteries with better capacity and power capability, an advanced battery management system is also required to better utilize the capacity of the batteries and to provide diagnostic information for the benefit of the driver. Unfortunately, the internal battery states such as energy remaining are not readily available for direct monitoring. The development of a battery monitoring system that accurately estimates the internal states from available external measurements such as voltage and current is thus important. Therefore, here we present a project dealing with the cause aforesaid. In this we shall implement a method to determine the battery state of charge. Battery state of health and state of Function will also be determined as pre-requisites for the purpose. This project uses system identification techniques to implement a monitoring system for lead-acid batteries in an electric vehicle. Specifically, the information that the proposed methodology provides can help estimate the energy remained in the battery bank (State of-Charge (SOC)) and the power capability of the battery bank (State-of-Function (SOF)).Software requirements will be LabVIEW for the Graphical User Interface.

keyword:
LabVIEW

1. INTRODUCTION

With the development of new batteries with better capacity and power capability, an advanced battery management system is also required to better utilize the capacity of the batteries and to provide diagnostic information for the benefit of the driver. Unfortunately, the internal battery states such as energy remaining are not readily available for direct monitoring. The development of a battery monitoring system that accurately estimates the internal states from available external measurements such as voltage and current is thus important. Most secondary batteries have thin, cylindrical strips for their electrodes. The cylindrical strips are rolled with a separator between the electrode strips and then placed in a cylindrical can. This design tends to achieve a higher electrode surface area that increases the battery power density while lowering the energy capacity due to the increased size of current collector needed to support the electrode . The lead-acid battery technology generally suffers little or no memory effect . Memory effect refers to the restricted capacity that some batteries exhibit when they have been subjected to a particular limited range of capacity use. The lack of memory effect makes this technology a strong candidate for back-up power applications. Lead-acid batteries, however, suffer from a relatively low energy density and irreversible capacity loss during deep discharge.

2. Background Work

As the transportation industry strives to electrify their vehicles, the onboard power source remains a weak link. Fuel cells and secondary batteries are often considered major candidates for providing the primary motive power or serving as load-leveling devices. Due to the relative maturity of the secondary batteries, much effort by academia and industry is devoted to making batteries reliable and affordable for the electrification of vehicles. In addition to the development of new batteries with better capacity and power capability, an advanced battery management system is also required to better utilize the capacity of the batteries and to provide diagnostic information for the benefit of the driver. Unfortunately, the internal battery states such as energy remaining are not readily available for direct monitoring. The development of a battery monitoring system that accurately estimates the internal states from available external measurements such as voltage and current is thus important.

3. The State-of-the-Art Review

On studying this chapter we can say SOF online estimation is based on the information obtained from recent voltage and current measurements. Means if the impedance can be known and the OCV can be treated as constant for the short span of time period then the power capability of the battery can be predicted. The Peukert modification approach attempts to estimate useful energy, thus taking into account SOF, for static

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operating conditions. The emphasis of this work is to establish an adaptive methodology for electric vehicle battery monitoring system. This work proposes to implement the system identification based method on the EV driving cycle, investigate the implementation issues of the estimation system, and present the results of the system in the context of the EV cycle.

4. INTERFACING CARD: NI 6008

The NI USB-6008 provides connection to eight single-ended analog input (AI) channels, two analog output (AO) channels, 12 digital input/output (DIO) channels, and a 32-bit counter with a full-speed USB interface. The firmware on the NI USB-6008 refreshes whenever the device is connected to a computer with NI-DAQmx. NI-DAQmx automatically uploads the compatible firmware version to the device. When you use a DAC to generate a waveform, you may observe glitches in the output signal. These glitches are normal; when a DAC switches from one voltage to another, it produces glitches due to released charges. The largest glitches occur when the most significant bit of the DAC code changes. You can build a lowpass deglitching filter to remove some of these glitches, depending on the frequency and nature of the output signal. For more information about minimizing glitches. refer to the

5. State-of-Charge Estimation Methodology

Now developing the equivalent circuit model based on the chemical processes of lead-acid batteries. The fig. 1 shown below shows the Randles equivalent circuit model. Here two variants of the equivalent circuit, with diffusion and without diffusion, are compared in performance.

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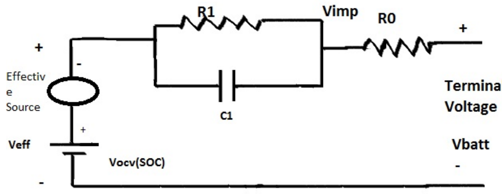


Figure 1: Randles Equivalent Circuit

The following equation estimates the state-of-charge.

$$SOC = \frac{Q_t - Q_r}{Q_t} \times 100$$

here:
Q_t = Total Charge in Battery
Q_r = Remaining Charge in Battery

6. Model-Bases Battery Power Capability Prediction

In this chapter, the use of the developed model for short-term power capability prediction will be discussed. In the discussion on the developed models suitability for short-term power capability, another modeling approach based on frequency spectral separation will be compared with the developed model. The focus will then shift to the performance of the developed model in terms of short-term power capability prediction. The prospect of using the developed model for long-term power Capability prediction is also considered in the chapter.

7. Battery Monitoring System

The system control software is written in LabVIEW. Two main user interfaces exist for programming the desired battery current profile, controller and automation program interface. The controller interface provides an environment to manually set up the battery activities while providing real-time system monitoring information on a visual panel.

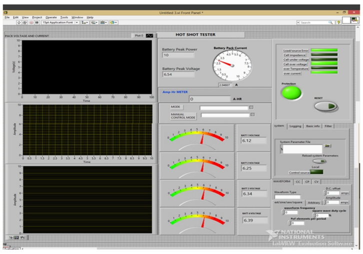
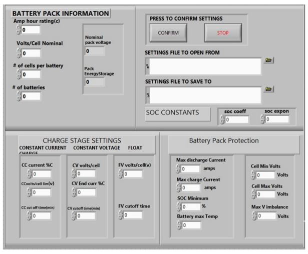


Figure 2: System Controller Interface

in this window we estimate the battery voltage and current and provides diffrent controls for battery monitoring.
The diagram shown below is a snapshot of the controller interface.



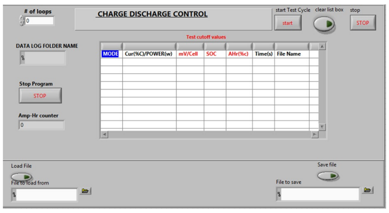
BATTERY PACK INFORMATION
Amp hour rating(c) 0
Volts/Cell Nominal 0
# of cells per battery 0
# of batteries 0
Nominal pack voltage 0
Pack EnergyStorage 0
SETTINGS FILE TO OPEN FROM
SETTINGS FILE TO SAVE TO
SOC CONSTANTS
soc coeff 0
soc expon 0
CHARGE STAGE SETTINGS
CONSTANT CURRENT CHARGE
CC current %C 0
CCvolts/cell lim(v) 0
CC cut off time(min) 0
CONSTANT VOLTAGE
CV volts/cell 0
CV End curr %C 0
CV cutoff time(min) 0
FLOAT
FV volts/cell(v) 0
FV cutoff time 0
Battery Pack Protection
Max discharge Current 0 amps
Max charge Current 0 amps
SOC Minimum 0 %
Battery max Temp 0
Cell Min Volts 0 Volts
Cell Max Volts 0 Volts
Max V imbalance 0 Volts

Figure 3: Battery Paramerter Window

The automation program interface can load a text file written in a certain format and interpret it for commands requested by the user.

Command mode	Description
Standby	The relays are off ,including the supply or load sensor relays to prevent unintended current flow. the cuurent sensor is zeroed to
Constant Current	The battery bank supplies or absorbs a fixed amount of current, as long as the voltage limits and other protection constraints are satisfied.
Constant Voltage	The power supply provides a curret at a fixed voltage , so long as the crrent limits and other pprotection constraints
Constant Power	The load has a CP mode while the supply relise on a proportional power
Current waveform	The waveform generator can produce sine, square,triangle and sawtooth wave. in addition , the user can uplaod a waveform pattern for any

Table 1: T1 Command Modes Available in System Controller Interface



\# of loops 0

Amp-Hr counter 0

MODE	Cur(%C)/POWER(w)	mV/Cell	SOC	AHr(%c)	Time(s)	File Name

File to load from

File to save

Figure 4: Battery Charge Discharge Window

The command modes available for the battery current are listed in Table T1.

To ensure safety, the automated battery testing system actively monitors the battery bank and terminates the operation if any of the pre set conditions are met. Specifically, the following table lists the constraints that the system monitors.

8. Results

A thorough state-of-the-art review of BMS technologies to provide SOC, SOH, and SOF information for the user has been conducted. The primary contributions of this project are summarized as follows:

Following window is the estimation voltage and current curve of lead acid battery.

Voltage 5.97

Current 0.836982

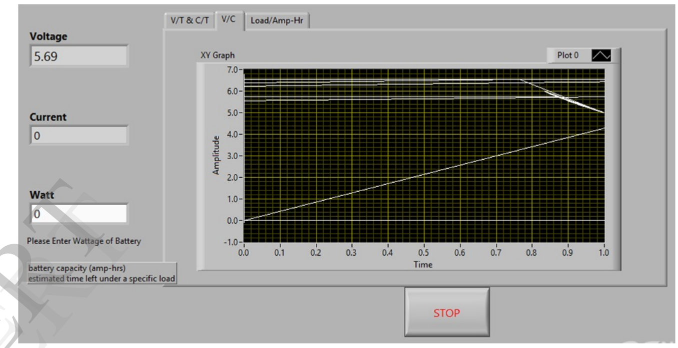
Watt 5

Please Enter Wattage of Battery

battery capacity (amp-hrs)
estimated time left under a specific load

Figure 5: Battery Voltage and Current Curves

Below window is the estimation of remaing power of lead acid battery.



Voltage 5.69

Current 0

Watt 0

Please Enter Wattage of Battery

battery capacity (amp-hrs)
estimated time left under a specific load

Figure 6: Estimated Remaining Power

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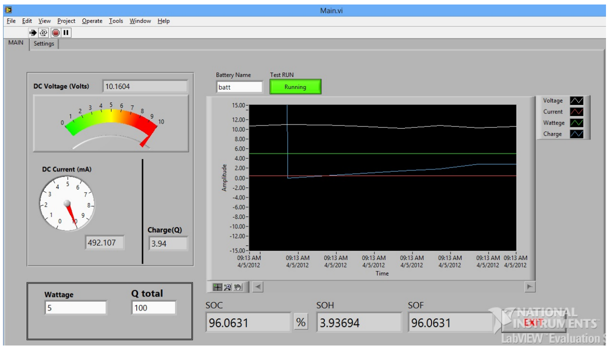
The simulation results are presented . The voltage tracking performances are first compared in Fig. 7 and Fig. 8.

Therefore, further determining the remaining SOC, SOH and SOF for a battery.



DC Voltage (Volts) 10.1604

DC Current (mA) 492.107

Charge(Q) 3.94

Battery Name batt

Test RUN Running

Wattage 5

Q total 100

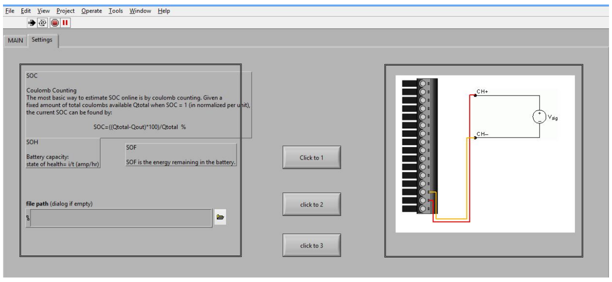
SOC 96.0631 %

SOH 3.93694

SOF 96.0631

Figure 7: SOC, SOH and SOF tester

Connection profile and formula SOC, SOH and SOF for a battery.



SOC

Coulomb Counting
The most basic way to estimate SOC online is by coulomb counting. Given a fixed amount of total coulombs available Qtotal when SOC = 1 (in normalized per unit), the current SOC can be found by:

SOC=((Qtotal-Qout)*100)/Qtotal %

SOH

Battery capacity:
state of health= i/t (amp/hr)

SOF

SOF is the energy remaining in the battery.

file path (dialog if empty)

Figure 8: Connection With NI 6008

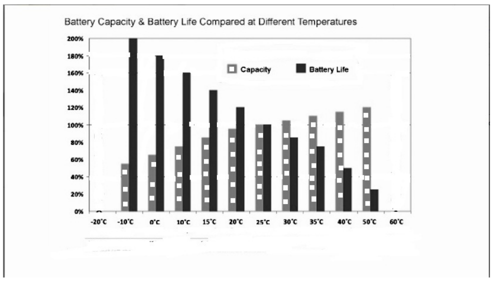


Figure 9: Performance of battery with temperature

In the above window interfacing with NI 6008 and basic terms equations which determine the SOC,SOH and SOF is shown.

9. Conclusions

State-of-charge, state-of-health and state-of-function is estimated. Also the approximate time for which the battery can work under a load would be determined. This idea has a great deal of potency and can be used to determine the batteries with higher potential beforehand. This can be further enhanced to provide online battery monitoring in industrial applications. It can be extended to be used in industries where simultaneous discharging of batteries is done before charging again.

9. Future Aspects :

Many other possible improvements to the proposed method were considered.In which first one consider temperature effect.By varying temperature battery performance also change.

The lead acid battery is an electrochemical device. Heat accelerates chemical activity; cold slows it down. Normal battery operating temperature is considered to be 77F (25C). Higher-than-normal temperature has the following effects on a lead acid battery: Increases performance, Increases internal discharge or local action losses, Lowers cell voltage for a given charge current , Raises charging current for a given charge voltage Shortens life, Increases water usage, Increases maintenance requirements.

Lower than normal temperatures have the opposite effects. In general, at recommended float voltage, a battery in a cool location will last longer and require less maintenance than one in a warm location.

If the operating temperature is something other than 77F (25C), it is desirable to modify the float voltage as follows: For temperatures other than 77F (25C), correct float voltage by 2.8 mV/F (5.0 mV/C). Add 2.8 mV (0.0028 Volt) per F (5.0 mV/C) below 77F (25C).

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