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# Automatic Battery Testing Platform for Series-Connected Lead Acid Batteries

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**Keywords:** lead acid, LabVIEW, charging/discharging platform.

**Abstract.** In this paper, an automatic testing platform was developed. A complete charging and discharging cycle for the series-connected lead-acid batteries is carried out by the testing platform to record the capacity, charging efficiency, and other relative data of the batteries. A microcontroller unit (MCU) is used to replace the common DAQ card for cost reduction. The voltage and current of the batteries are sampled by the MCU and saved by the software LabVIEW on the personal computer. The charging and discharging procedures are automatically switched by the software LabVIEW according to the state of the batteries. A complete testing data can be provided by the LabVIEW at the end of the testing cycle. New and old battery modules are both tested with the proposed platform and another reliable testing system to evaluate the validity of the proposed system.

## Introduction

In the face of the growing global oil shortages leading to rising oil prices, environmental problems have become increasingly serious. Many countries have gradually given importance to renewable and green energy that cause no pollution. Electric Vehicle (EV) is a new type of carrier that has gradually gained importance in recent years, as there is no need for fossil fuels [1]. An EV draws power by converting energy in the secondary batteries into mechanical energy; its carbon emissions are also lower compared to fuel-based vehicles [2], thus its good chance for replacing fossil fuel-based vehicles. In terms of use, electric vehicles are usually powered by 2-4 lead-acid batteries. After many use cycles, the overall capacity is hampered by the damaged single battery, thus the reduced available capacity of the battery set [3]. Therefore, a battery charging/discharging measurement platform has to be constructed to record changes in information during the battery charging/discharging process, thereby obtaining the available capacity and charging efficiency of the battery set that serve as a reference for replacing a single battery or the battery set.

Early computing capability was not good enough for data process in measuring instruments. However, with the evolution of the times, the capability has enhanced to be able to modulate instrument actions through the computer software program design and transmission interface [4]. With single instrument hardware and computer software and based on different-user written computer programs, a variety of measurement systems featuring different functions with varied degrees of complexity have been composed. Commonly used software programs include LabVIEW (Laboratory Virtual Instrument Engineering Workbench), VEE (Visual Engineering Environment), MATLAB, etc. Among them, LabVIEW has many advents, such as diversity in program writing to reduce development time, process signals received in a variety of ways, and receiving of a variety of communication interfaces that link instruments and the computer [5].

In terms of data acquisition, a variety of DAQ interface cards are used to obtain electronic phenol via the computer. Targeting the measurement data types, the analog signals obtained can be rapidly and accurately digitalized [6]. However, as the acceptable voltage and current ranges are relatively narrower, an extra signal-processing module has to be installed to achieve the ranges detectable by the

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DAQ. Another method is to digitize data through a single chip that has A/D conversion function. DAQ cards available in the market are considerably costly, usually several thousand dollars or higher. The battery experiment in this paper focuses on data recording and computing over a long period of time, without the need for high-speed processing. Hence, this paper used a single chip as the interface for extracting battery data and transmitting it to the PC/LabVIEW terminal for judgment and record.

## Organization of the proposed testing platform

The battery charging/discharging testing platform developed in this paper was adopted to perform one cycle of charging/discharging on a series-connected batteries module. The measured data were used to analyze the status of the batteries. The system framework is as shown in Fig. 1. The power supply was used to charge the battery during the charging period. The electronic load was used as the battery load during discharging. The microcontroller HT66F50 then transmitted the measured battery voltage and current data to the computer through the RS232-USB transmission interface. The LabVIEM on the PC then judged the switching of the charging/discharging loop, as well as displayed and stored the measurement data.

Fig. 2 shows the schematic diagram of the charging/discharging processes. To ensure data accuracy, as soon as the testing procedures begin, the residual charge in the battery set is first discharged, and the residual power would be completely released before the battery enters the charging mode. When the discharge cut-off voltage is reached, the electronic load stops discharging for the next 30-minute rest mode. Then, the battery set is switched to the power supply for charging process. After charging the battery to the cut-off current, the battery set is switched to the electronic load for the rest mode again. After 30 minutes, the electronic load begins to discharge the battery set until the battery set reaches the cut-off voltage. The PC/LabVIEW, on the other hand, continues to record measurement data until the user presses the stop button to terminate the program and complete the cycle.

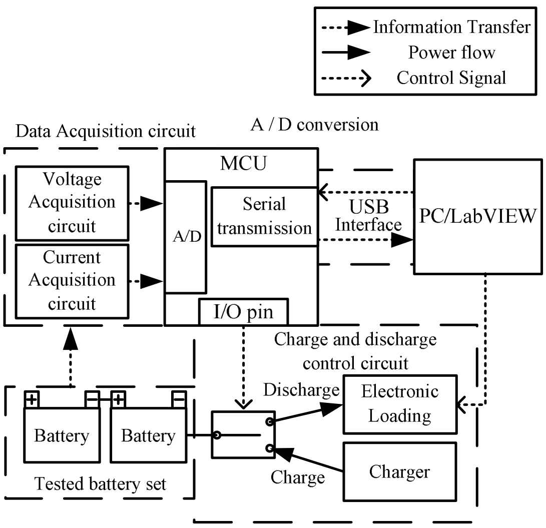


Fig.1. The system framework diagram

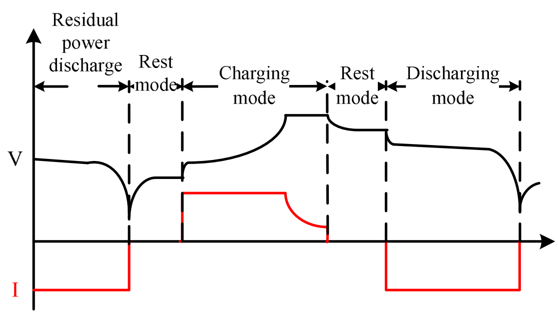


Fig. 2. The charging/discharging testing cycle

## Hardware Circuits and Software Programming

The voltage sensing circuit used in this paper is as shown in Fig. 3. The battery voltage is 9V~15V. In order to obtain the best measurement accuracy, the Zener diode is used to deduct the DC bias in the battery voltage. The organization of charging/discharging platform is as shown in Fig. 5. The relay is controlled by the microcontroller to switch the series-connected batteries to the charger or electronic load. Moreover, the loading power of electronic load is only controlled by the LabVIEW.

The proposed platform used LabVIEW as the man-machine interface. The LabVIEW operating interface is as shown in Fig. 6. The data sent back from the microcontroller is used to judge whether the user's preset charging/discharging cut-off conditions are met. Commands are sent to the microcontroller or electronic load to switch battery set charging/discharging. Different types of battery sets come with different charging/discharging currents and cut-off voltages.

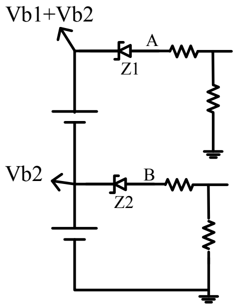


Fig. 3. Voltage sensing circuit

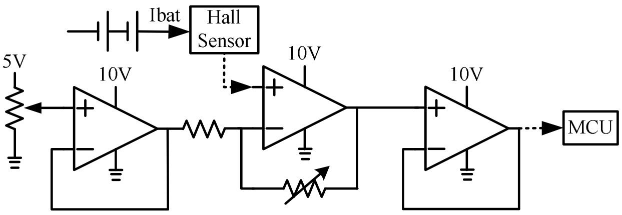


Fig. 4. The current sensing circuit

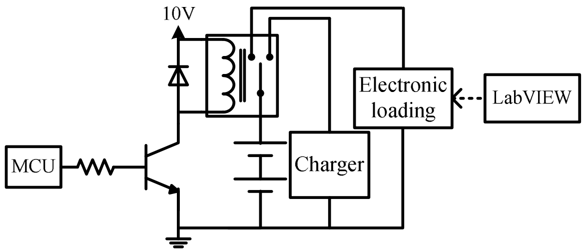


Fig. 5. Charging/discharging platform

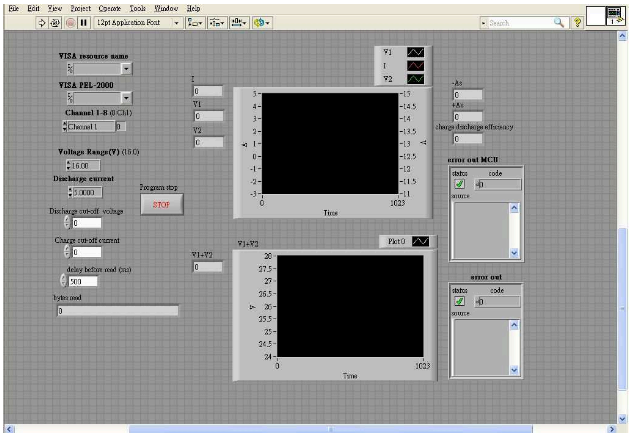

Fig. 6. The LabVIEW operating interface

## Experimental Results

The 7Ah 12V lead acid batteries manufactured byYUASA are used in the experiments. The battery set consists of two series-connected batteries. In the experiments, one new and one old battery sets were used for actual testing. In order to avoid uneven charging/discharging due to initial power and available capacity, leading to battery damage due to a voltage beyond the specified range, before the experiment began, the two batteries were discharged using 0.1C to 11V. After resting for half an hour, the residual power was obtained. Therefore, the two batteries had the same initial power.

In order to verify the performance and validity of the proposed platform, an existing verification platform composed of a power meter WT230 and a PC with WTViewerFree software to record the battery relative data. The proposed testing platform is constructed and shown in Fig. 8.

Table 1 shows the charging/discharging hours and charging efficiency results obtained from the proposed testing platform and the verification platform. Table 2 shows the maximum measurement errors of the verification platform and the proposed testing system in this paper.

## Conclusion

In this paper, one automatic battery charging/discharging testing platform was developed. The system equipment is composed of one microcontroller, one electronic load, and one power supply. Through the integrated control of the microcontroller and LabVIEW, automatic measurement function can be achieved. Based on the measured data, LabVIEW can judge battery charging and discharging. As for data storage, LabVIEW is used to store battery capacity measurement information. Finally, the two different battery sets of lead-acid batteries were used in the experiment through the common constant current and constant voltage charging method. The experiment results have been provided to verified the validity of the proposed testing platform.

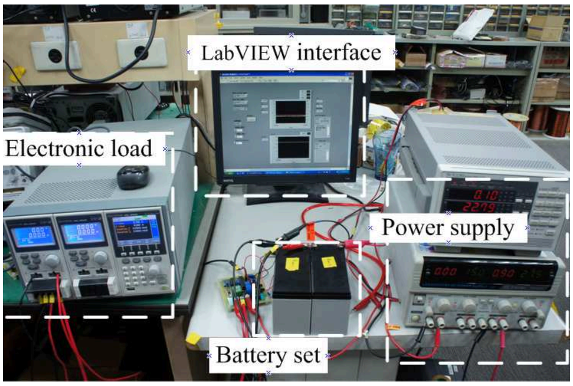

Fig. 8. The entity diagram of the testing system

Table 1. The comparison of charge/discharge hours in the experiment

| | Old battery set | | New battery set | |
|---|---|---|---|---|
| | Proposed | Verification | Proposed | Verification |
| Charging | 4.69Ah | 4.62Ah | 6.65Ah | 6.54Ah |
| Discharging | 4.39Ah | 4.43Ah | 5.96Ah | 6.2Ah |
| efficiency | 93.6% | 95.9% | 89.6% | 94.8% |

Table 2. The maximum errors of measurement data

| | Old battery set | New battery set |
|---|---|---|
| V1+V2 | 0.16V | 0.17V |
| V2 | 0.059V | 0.07V |
| I | 0.045A | 0.11A |
| Charging Ah | 0.07Ah | 0.11Ah |
| Discharging Ah | 0.04Ah | -0.24Ah |
| Charging/discharging efficiency | 2.2% | 5.2% |

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