Short Communication

A simple electrical circuit for computer-controlled operation of battery charge/discharge units

K.H. Su and **S. C. Yang***

Electrochemistry Laboratory, Energy and Resources Laboratories, Industrial Technology Research Institute, Bldg. 64, 195 Sec. 4, Chung Hsing Rd., Chutung, Hsinchu 31015 (Taiwan)

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Abstract

A simple circuit designed to automate the operation of a commercial battery charge/discharge unit by system-controlling software is reported. By incorporating this circuit, a unit can be computer-controlled to switch between charge and discharge. The control strategy is based on a battery charge threshold voltage, a discharge cut-off voltage, and a charge cut-off temperature.

Introduction

Battery performance testing is tedious and time-consuming. It often needs to operate overnight and to require manual attention. To facilitate testing, there is a demand for units with automatic control. Indeed, the development of some computer-controlled units has been reported [1, 2].

Several international companies supply battery charge/discharge units with automatic mode-switching either by timer or by voltage setting. Although these units can automatically switch between discharge and charge cycle, there are two main drawbacks. These are: (i) manual setting of battery charge and discharge times, battery charge threshold and discharge cut-off voltage; (ii) no facility for setting battery charge cut-off temperature and automatically switching battery charge to other modes based on measured battery temperature. This communication describes equipment designed to overcome these limitations.

Battery charge/discharge system

System design

A computer-controlled charge/discharge system for battery performance testing and analysis has been developed by integrating the following hardware:

*Author to whom correspondence should be addressed.

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a commercial battery charge/discharge unit; *IR* measurement system; IBM PC/AT compatible computer; GPIB interface card; programmable multifunction unit; 16-channel relay multiplexer card; thermocouple compensation card; D/A converter card. A schematic diagram of the system is given in Fig. 1. The system-controlling software is written in Microsoft Quick-Basic. The important battery charge/discharge parameters (including: charge threshold voltage; discharge cut-off voltage; charge cut-off temperature) are set through the software. A display of the parameter menu for performance testing of secondary batteries is given in Fig. 2. The following electrical circuit has been designed to work with the system hardware.

Electrical circuit: working principle

A commercial battery charge/discharge unit usually has four terminals: two for current-flowing and two for voltage-sensing. Both the charge threshold and the discharge cut-off voltages of a battery under test are manually set by the operators. The unit compares the measured battery voltage with both the set discharge cut-off and the charge threshold values. Obviously, battery operation ceases when these limits are exceeded.

The system discussed here uses an HJ2010 Battery Charge/Discharge Unit made by Hokuto Denko Corporation of Japan. The charge threshold voltage range is 0–20 V, and the discharge cut-off voltage range is 0–10 V. Such a unit can be computer-controlled and can automatically set the mode-switching, based on the measured battery voltage and temperature. The required conditions for switching are:

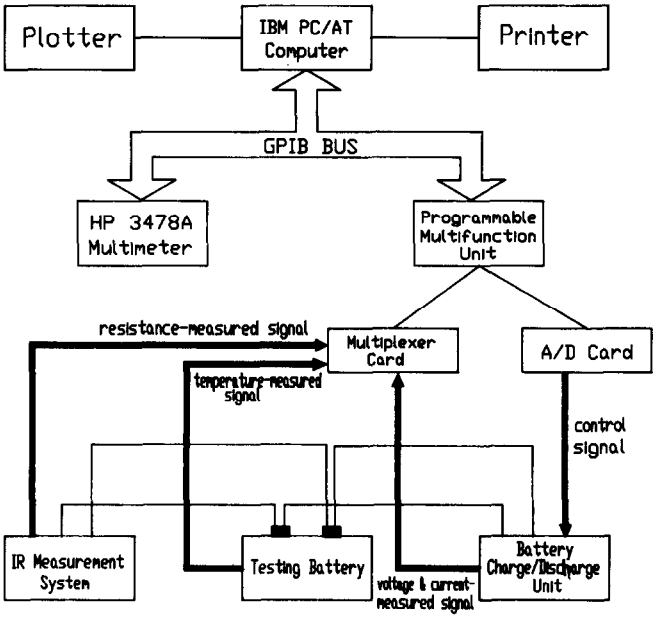

Fig. 1. Schematic diagram of computer-controlled battery charge/discharge system.

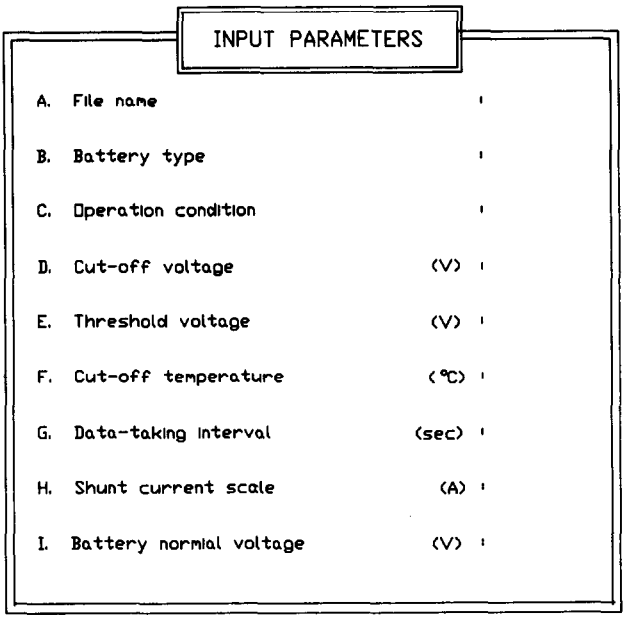

Fig. 2. Parameter menu for performance testing of secondary batteries.

(i) during battery discharge: voltage terminals sense zero volts as $V_{measured}$ and the latter is lower than $V_{cut\text{-}off}$;

(ii) during battery charge: voltage terminals sense 18 V as $V_{measured}$ and the latter is higher than $V_{threshold}$, or $T_{measured}$ is higher than $T_{cut\text{-}off}$. To carry out this action, a simple electrical circuit was designed (Fig. 3). The settings for the charge threshold and the discharge cut-off voltages are usually fixed at a value lower than 18 V and higher than 0 V, respectively.

Electrical circuit

As shown in Fig. 3, the main components of the circuit include two Omron VK2P relays (activated by a 12 V d.c. voltage) and an 18 V voltage source comprising three 6 V alkaline batteries. A schematic diagram of the relay is given in Fig. 4. Normally, the two switches between nodes #1/#4 and #8/#5 are closed, while the two switches between nodes #1/#3 and #8/#6 are open. When a 12 V d.c. voltage is applied to the relays, the aforementioned closed switches will open, while the open switches will close. The operation of the circuit is as follows.

(i) As $V_{measured}$ is lower than $V_{cut\text{-}off}$ set from the software, the A/D card sends a 12 V d.c. signal to relay #1, and zero volts is sensed by the voltage terminals of the unit. Because zero volts is always lower than the set discharge cut-off value, battery discharging is terminated.

(ii) As $V_{measured}$ is higher than $V_{threshold}$ set from the software, the A/D card sends a 12 V d.c. signal to relays #1 and #2, and 18 V is sensed by

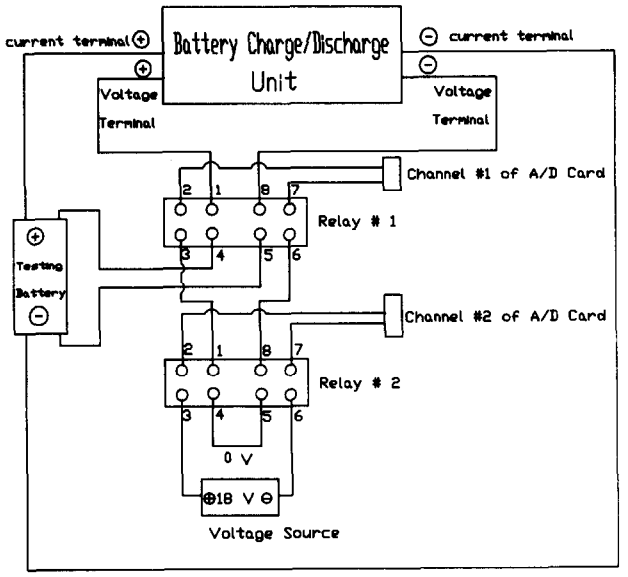

Fig. 3. Schematic diagram of electrical circuit for computer-controlled operation of battery charge/discharge units.

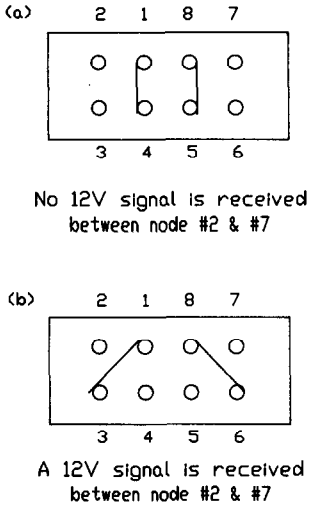

Fig. 4. Schematic diagram of Omron VK2P relay.

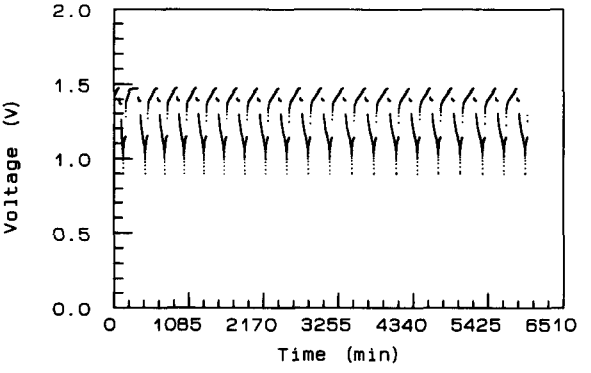

Fig. 5. Charge/discharge cycling curve for a commercial, sealed Ni/Cd battery (AA size).

the voltage terminals of the unit. Because 18 V is always higher than the set charge threshold value, battery charging is terminated.

(iii) As $T_{measured}$ is higher than $T_{cut\text{-}off}$ set from the software, the A/D card sends a 12 V signal to relays #1 and #2. The procedure outlined in (ii) then follows and battery charging ceases.

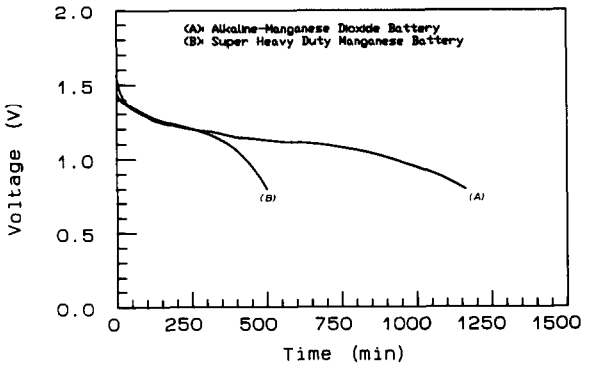

Fig. 6. Discharge curves for (A) alkaline-manganese dioxide and (B) super heavy-duty manganese batteries (AA size). Discharge current: 100 mA.

Test results

The computer-controlled battery charge/discharge system has been successfully employed for testing and analyzing the performance of both primary and secondary commercial batteries. By way of examples, Fig. 5 shows a partial charge/discharge cycling curve for a sealed Ni/Cd battery (AA size), while Fig. 6 presents a comparison of the discharge curves of alkaline-manganese dioxide and super heavy-duty manganese batteries (AA size) under the same operating conditions. These data were originally displayed on the computer monitor of the battery charge/discharge system.

References

1 W. G. Marshall, R. Leek, M. J. Pilkington and N. A. Hampson, *J. Power Sources, 16* (1985) 119–130.
2 K. R. Kannan, A. M. Kannan and A. K. Shukla, *J. Power Sources, 32* (1990) 99–104.