PLC - Based Battery Analyser

Romul COPÎNDEAN, Rodica HOLONEC, Eudor FLUERAS

Faculty of Electrical Engineering, Technical University of Cluj-Napoca

***Abstract**: This paper presents a variant of battery analyser, application based on a programmable logic controller (PLC) that uses the current analog output module. The program allows the control of the charging and discharging current, the independent monitoring of the voltage on each battery cell and the calculation of its capacity.*

***Keywords**: Battery capacity measurement, charging current, programmable logic controller*

1. INTRODUCTION

The batteries have lately become the main source of electrical supply for the different types of equipment, like: portable tools, mobile phones, tablets, laptops, watches, portable measure devices, MP3 players, invalid chair, heart stimulators, electric bicycles, cars, solar or wind batteries and the examples could go on.

There is a huge diversity of battery types and of producers that pay special attention to the materials of which these are made of as well as to the way of their exploitation. The batteries are tested for different parameters, like: (current) capacity, resistance, number of charge/discharge cycles, life cycle, the standard or rapid charging time.

2. GENERAL PRESENTATION

In order to check the capacity of a battery, we need to charge it to its full capacity and then to discharge it completely. The capacity is determined by the discharge time and current. An operator would have to measure these two scales and to calculate the capacity. Thus, two problems appear:

- determining the time by checking whether the voltage falls under an imposed limit
- maintaining the current at a constant value

The battery analyser we propose in this paper complies with the two above-mentioned requirements, i.e. it calculates the capacity and displays its results.

2.1. The Wiring Diagram of the Charging Circuit

In fig. 1 a constant current of 4-20mA is injected in the BD237 transistor's base. The charging current is the emitter one and is given by the relation

$$I_e = I_b + I_c = I_b (\beta + 1) \quad (1)$$

$$I_c = \beta I_b$$

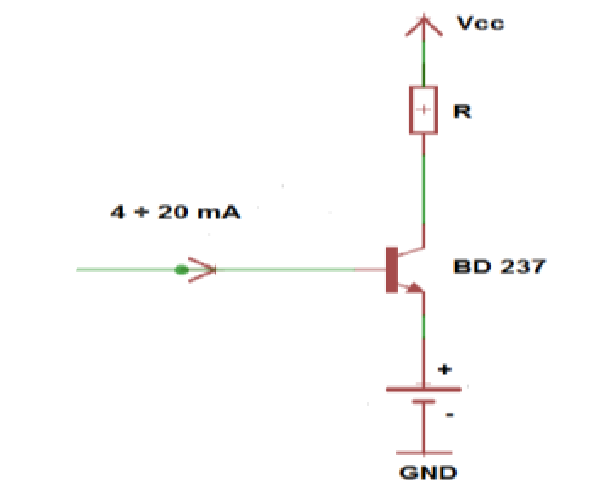

Fig. 1. The wiring diagram of the charging circuit

2.2. The Wiring Diagram of the Discharging Circuit

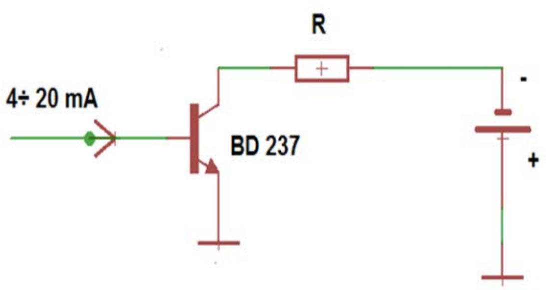

Fig. 2. The wiring diagram of the discharging circuit

In Fig. 2, the discharging current is the collector current and is determined by the ratio (2)

$$Ic = \beta * Ib \quad (2)$$

2.3. The Wiring Diagram of the Charging-Discharging Circuit

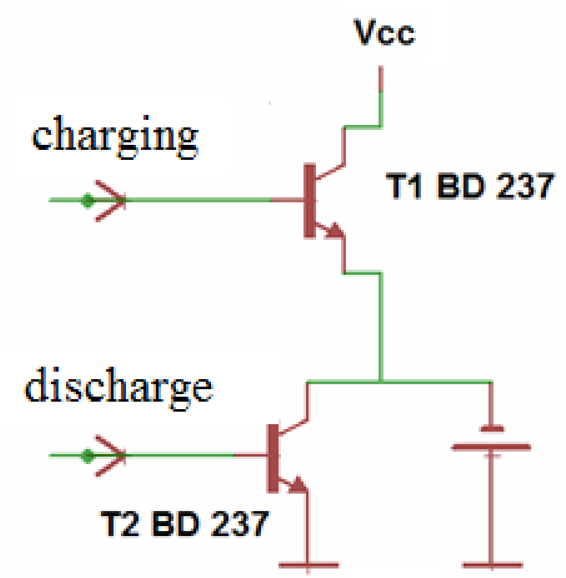

Fig.3. The wiring diagram of the charging-discharging circuit

The Fig. 3 charging-discharging circuit is obtained from the two previous diagrams where the resistors have been eliminated. In this case, the transistors dissipate the whole heat and need more powerful radiators. Both the charging and the discharging current depend on the transistors' current transfer factor, as one can see in ratios no. (1) and (2). Due to this, each used transistor needs a calibration.

Figure 4, [6] presents a circuit variant that is not dependent on the transistor's current transfer factor.

The current through the battery is offered by the ratio (3):

$$I_c = I_E = (R1/R2) * I_{analog\ out} \tag{3}$$

We can observe that, in this case, the current depends only on the R1 and R2 resistors.

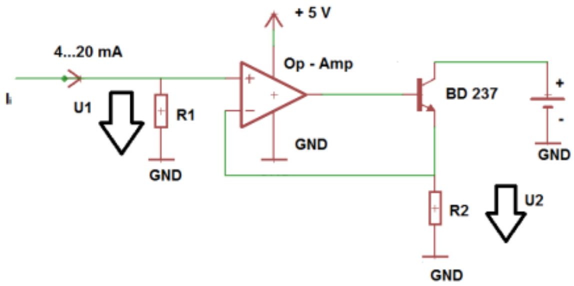

Fig.4. The electric diagram designed with operational amplifier

3. DEVICE'S DESCRIPTION

The wiring diagram of the proposed circuit is presented in fig. 5 and includes the Alpha 2 programmable logic controller, the BD 237 transistors and the AL2-DA analogical output module.

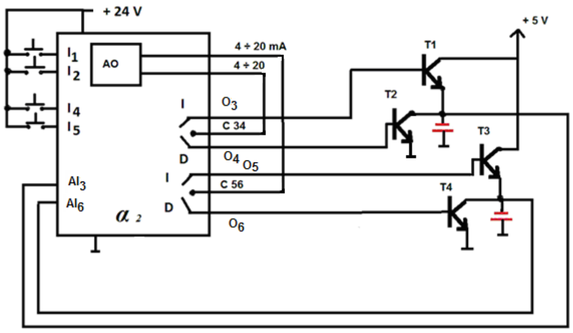

Fig. 5. The wiring diagram of the application

The analogical output module includes two channels that can control the independent charging or discharging of two batteries. The charging is controlled through the inputs I_1 and I_4, and the discharging is controlled through the inputs I_2 and I_5. The voltage of the batteries is monitored through two analogical inputs, AI_3 and AI_6.

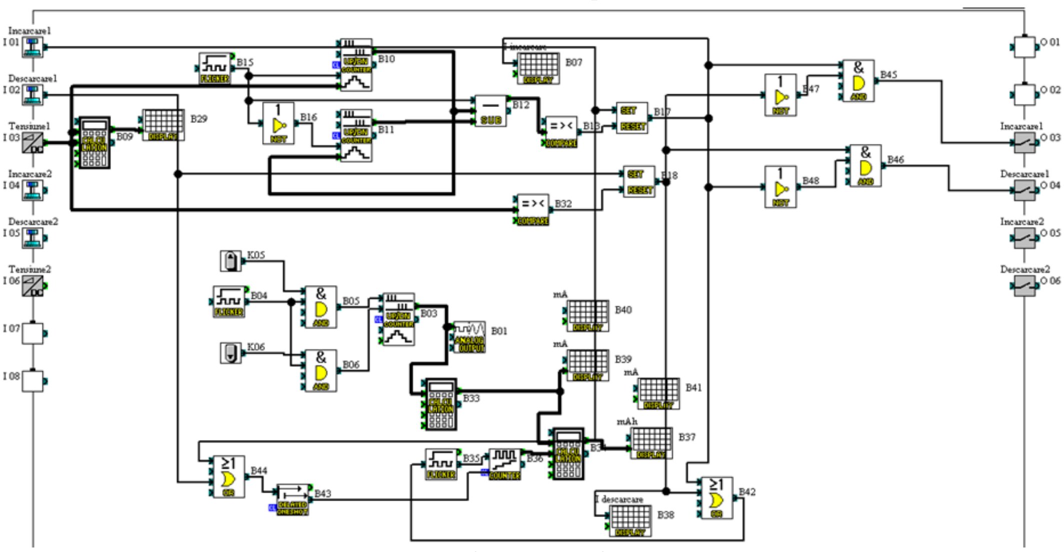

Fig .6. The program for a channel of the battery analyser

4. PROGRAMMING

For the implementation of the application software, the Mitsubishi Electric, Industrial Automation [3] medium of graphic programming with block functions has been used.

The analogical output module represented by the block function B01 receives the piece of information from the bidirectional counter B03. The content of the counter can be modified with the K05, K06 keys with the help of two logical gates, B05 and B06, and of B04 flicker block.

The analogical output current is applied to the T1 transistor that charges, and, respectively to the T2 transistor that discharges.

The current supplied at the output of the AL2 – DA analogical block is of 0-20 mA (for a resolution of 12 Bit). This current is amplified with β=100 and can be adjusted between 0 and 2000 mA.

The current's result is displayed on B39 through the computational function B23 that correlates the numeric value of the convertor's input with the output one in mA.

The charging/discharging capacity is displayed in mA on the B37 display. For this, a B35-B36 minute counter and a computation function have been used to multiply the value of the current by the charging time.

During charging, the charger detects the moment the battery voltage starts to decrease according to fig. 7, i.e. the moment when ΔV/Δt becomes negative.

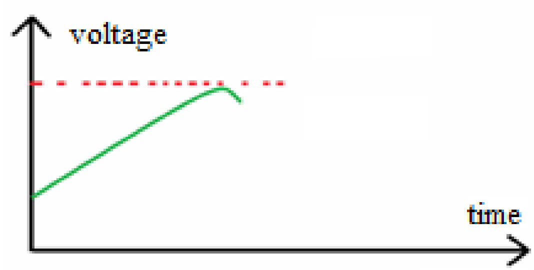

Fig .7. The charging diagram for Ni-Cd, Ni-Mh batteries

In order to implement this function we used two B10 and B11 counters which memorize the voltage at two different moments within an interval of 1 – 5 minutes. The B12 function makes the difference, and if this is negative, the charging process stops, the "Reset" (B17) function is applied, situation detected by the OUT3 output.

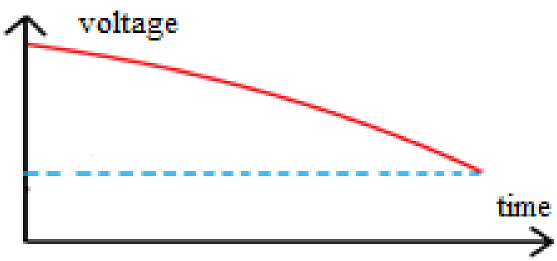

Fig .8. The discharging diagram

For the discharge, the voltage on the batteries is read, and if this decreases below 0,9 V, the B32 comparator resets the B18 block function that stops the process of discharge through B04 output. In order not to simultaneously activate both the charge and discharge, we introduced the B45 and B48 functions that achieve the OUT3 and OUT4 interlocking.

5. RESULTS

We used Ni-Mh 2500 mAh batteries to test the application.

Different charges at different current values were made followed by a 500 mA current discharge. The following results were obtained:

- for a 200mA current full charge we obtained at the discharge a capacity of 2430 mAh.

- for a 1000mA current full charge we obtained at the discharge a capacity of 1623 mAh.

Consequent to the performed tests, we noticed that in the case of high current charges, the charging times are shorter but the battery capacity decreases.

REFERENCES

1. ALPHA2 Simple Application Controller, Hardware Manual, Manual number:JY992D97301, Manual revision:F, Mitsubishi Electric, Industrial Automation, Date:08. 2005
2. ALPHA2 Simple Application Controller, Programming Manual, Manual number:JY992D97101, Manual revision:C, Mitsubishi Electric, Industrial Automation, Date:08. 2005
3. SW0D5-ALVLS-EUL, V02.60, ALPHA Programming Software, Date:03/2008, Mitsubishi Electric, Industrial Automation, Distributor: Sirius Trading & Services SRL
4. Valer Pop, Henk Jan Bergveld, Dmitry Danilov, Paul P. L. Regtien, Peter H. L. Notten, Battery Management Systems : Accurate State-of-Charge Indication for Battery-Powered Applications, Springer Science + Business Media B.V, Philips Research Book Series, ISBN: 978-1-4020-6944-4, Dordrecht, 2008.
5. Isidor Buchmann, Batteries in a Portable World, Cadex Electronics, May 01 2001, ISBN: 0968211828
6. Gheorghe Todoran, Romul Copindean, Masurari electronice : amplificatoare si convertoare de masurare, Cluj-Napoca : Mediamira, 2003 ISBN: 973-9357-61-X

Romul COPÎNDEAN,
Rodica HOLONEC,
Eudor FLUERAS

Electrical Engineering and Measurements Department
Faculty of Electrical Engineering
Technical University of Cluj-Napoca
Str. Memorandumului nr. 28, 400114 Cluj-Napoca