Automation of control of parameters of batteries in the process of their tests and operation

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Abstract. The article discusses technical solutions that allow one to comprehensively automate the processes of discharge and charge of accumulator batteries by applying methods of adaptive combination of electronic and resistive loads, control of their resistances and computer processing of the obtained measurement results. All these solutions reduce laboriousness of testing batteries, eliminates the human factor in registration of their results, provides possibility of implementing a continuous objective control of battery parameters, accumulation and subsequent analysis of the information about the characteristics of accumulator batteries to optimize their operation modes. The described device can be useful to those who sell batteries or power supply equipment complete with batteries, as well as to those companies that have distributed or remote objects with batteries and want to monitor the status of batteries with minimal need for qualified personnel.

1. Introduction
The reliability of the tests is influenced by many parameters. Certified and probe-tested test procedures should be correctly selected, measuring instruments and test equipment should be selected to ensure the specified measurement accuracy. Necessary conditions are provided for testing. Also a very urgent task is to eliminate influence of human factor on the process itself.

One of the effective ways to increase degree of objectivity of the tests is their automation through the use of specialized hardware and software measuring systems that provide comprehensive automation not only measurements directly, but also recording their results, saving as protected from unauthorized changes, deletions, etc.

Timely and reliable determination of the technical condition of batteries is made in the course of their diagnosis (testing), which improves the efficiency of battery use and extends their service life [1-7,9-16].

Battery tests, as a rule, take a long period of time due to the applied test method. In a process of testing, it is necessary to periodically record the basic parameters of the battery and monitor their changes over time. Manual fixation in this case does not guarantee the accuracy of measurements.

In addition to testing batteries, a certain amount of interest may be the constant fixation of their parameters during operation, the subsequent analysis of which can provide useful information on optimizing their operation modes.
To solve these problems, it is advisable to use universal, highly customizable automatic devices for discharging and charging batteries.

2. Automation problem statement
At the first stage of development of an automatic device for discharging and charging batteries [8], the market analysis was conducted for existing devices for testing discharging and cycling according to the applicable technical requirements.

The results of the analysis showed the availability of devices with electronic load and minimal automation, both imported and domestic production. All of these devices had flaws and could not provide several modes and conditions for testing. The main purpose of these devices, first of all, are on-site inspections of batteries or testing of battery parameters during their production.

In this regard, it is decided to develop its own device with enhanced functionality that performs all the necessary functions that meet modern requirements. The following tasks were set:
- the device must be modular, i.e. be able to easily scale in power by dynamically connecting additional loads;
- the device must contain an electronic load module;
- it shall be possible to use an active load available at the test site;
- all discharge parameters must be controlled with reference to time: current, voltage on a battery, battery temperature;
- it should be possible to use the device for testing different types of batteries;
- external charger must be used for charging, allowing external control;
- the device should be remotely monitored and the results collected;
- the device should maximize the capabilities of the computer program task and the processing of measurement results;
- decrease in labor intensity of tests due to automatic generation of protocols of a custom form.

As a potential object of testing and control, batteries and monoblocks were selected with a total rated voltage from 6V to 48V.

3. Technical solutions
In the process of developing and prototyping, not always standard technical solutions were used.

1) The ability to use an existing resistive load. In the process of discharging the battery, its voltage drops. The magnitude of the fall in terms of one element is approximately from 2.12V to 1.7V. If the applied resistive load is constant, the discharge current will decrease from 100% to 80%. Thus, one of the ways out of this situation is a combination of loads. As the basic load is a constant resistive load, providing rated discharge current at the beginning of the discharge and 80% of this current at the end of the discharge. As an additional load, an adjustable load is used that is built into the described device and provides at least 20% of the rated discharge current. Thus, in the process of discharge it is possible to maintain the discharge current at the level of 100% of the nominal with high accuracy.

2) As a regulated load, you can use:
- an electronic load;
- a resistive load (in the form of "load store"), switched by relay or switched by electronic keys.

The latter option provides the required accuracy of discharge current stabilization.

The ability to analyze resistance of the existing loads allows one to use any available load (rheostats, heaters, etc.) in the process of discharge of a battery.

3) The battery voltage control, taking into account the operating voltage range from 6V to 48V, is not carried out using voltage dividers, but by using an exact backup voltage, which allows the battery to be monitored in a narrow voltage range depending on their nominal value (for example, 6V battery...
monitoring is conducted in the range from 0 to 10V, and the control of the 48V battery is in the range from 40 to 50V). This ensures the same accuracy for different battery ratings.

4) Control circuits are separated from power circuits. This solution is not original, but necessary. As shown, the estimated method of eliminating the voltage drop in power wires leads to a significant error in the measurements.

5) In terms of methods for setting discharge parameters or cycling, computer processing of results, the form for providing results, remote information transfer and operator interaction with the device, standard widely used formats for presenting information are selected that can be easily processed in external systems. Additionally, a universal program was developed for receiving, processing, storing and visualizing arbitrary streaming data.

The generalized structure of the device and its functional diagram are shown, respectively, in Figures 1 and 2. The authors assumed the constant development and improvement of the device.

![Figure 1. The device structure](image-url)
4. Field of application and perspectives
This development can be useful to those who sell batteries or power supply equipment complete with batteries, as well as to those companies that have distributed or remote objects with batteries and want to monitor the status of batteries with minimal need for qualified personnel.

The battery monitoring devices offered today allow one to control a wide range of parameters, which include the following:

- battery voltage or monoblock battery;
- battery current;
- counting of given and received capacity;
- electrolyte level;
- temperature.

The reason for the lack of demand for such monitoring devices is the same: batteries and accumulator batteries are not used independently, but as part of power plants or power systems. These systems provide necessary control of batteries in the discharge process, as well as control the charge using their own means of measuring voltages and currents in battery circuits. Therefore, there is no need to duplicate such measurements and information.

In the process of development and discussion with potential consumers of the prospects for using the developed device, the idea of a separate application of its “brain”, providing a constant fixation of battery operation modes, appeared. In this case, one of the applications for the device is its integration with a battery.

A potential customer may be interested in special and reliable information about the battery. Customer would probably want to get information about the history of the battery, whether a battery had deep discharges at which its voltage fell below the permissible minimum, whether the battery heated up to relatively high temperatures, how often and how long these critical effects were.

This information is important for an operating organization. It provides an opportunity to evaluate reliability of the battery used. As you know, extreme impacts can greatly reduce reliability. For battery supplier, this information may be ground for refusing a warranty replacement. The manufacturer of batteries, as statistics on real operating conditions accumulate, may adjust the values of recommended charge parameters in the technical documentation or make changes to the battery design.
5. Conclusion
The presence on the market of a wide range of radio-electronic components, functionally complete modules, universal controllers, as well as open software allows you to create effective solutions for automating the testing, maintenance and operation of batteries. The capabilities of modern controllers provide the ability to quickly develop sophisticated equipment and measuring instruments. Considerable practical experience has allowed us to develop modern multi-functional equipment, which is not only successfully used in the test center, but also in demand in the market. The emphasis on the use of primarily software solutions has minimized costs in development of new types of equipment.

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