електроенергії // Автомобільний транспорт. - Х.: ХНАДУ. 2019. Вип. 45. – С. 70-78.

15. Patlins, A., Hnatov, A., Arhun, S., & Dzyubenko, O. (2019). Design and research of constructive features of paving slabs for power generation by pedestrians. Transportation Research Procedia, 40, 434-441.

16. Patļins, A., Hnatov, A., Arhun, S., Bogdan, D., Dziubenko, O. Development of an Energy Generating Platform for Converting Kinetic Energy into Electrical Energy Using the Kinematic Synthesis of a Three-Stage Multiplier. In: TRANSPORT MEANS 2019. Sustainability: Research and Solutions. PROCEEDINGS OF THE 23rd INTERNATIONALSCIENTIFIC CONFERENCE PART I., Lithuania, Palanga, 2-4 October, 2019. Kaunas: Kaunas University of Technology, 2019, pp.403-408.

17. Hnatov, A., Arhun, S., Tarasov, K., Hnatova, H., Mygal, V., Patļins, A. Researching the model of electric propulsion system for bus using Matlab Simulink //2019 IEEE 60th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON). – IEEE, 2019. – С. 1-6.

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BATTERY MANAGEMENT SYSTEM

Conditionally, in an electric vehicle, there are 3 main constituent elements (systems): an energy source, a propulsion system and an auxiliary system.

The battery management system is one of the important elements of an energy source. This system is able not only to provide data exchange with the charger, but also to regulate the operation of the batteries in such a way as to maximize their performance in various conditions, as well as inform the user about the degree of their legal capacity.

Batteries of electric vehicles consist of a plurality of series-connected accumulators, which cannot be identical in mass production. Capacity, internal resistance, self-discharge rate and degradation of the same type of battery are always slightly different.

This effect is most characteristic when the battery is divided into several modules of batteries connected in series and placed in different compartments of the electric vehicle (in the engine compartment, in the luggage compartment, in the passenger compartment or under the bottom and suchlike).

With prolonged use of the battery, the problem of its imbalance arises. The negative impact of the battery imbalance described in the following situation [1].

During the movement of an electric vehicle, the voltage on one of the battery cells dropped to a predetermined lower level, below which irreversible battery degradation can occur, that is, this cell or module is discharged. In this case, the safety system of the electric vehicle will open the battery discharge circuit and the electric vehicle will not be able to continue driving. But after all, individual cells were still not completely discharged. And this indicates an inefficient use of the

battery. In the future, when operating such a battery, we will not receive full capacity, that is, our electric car will be able to travel a shorter distance. Moreover, due to the uneven distribution of charge, the battery will quickly become unusable.

BMS makes possible to avoid the negative destructive processes in the battery. The control system ensures that all cells receive equal voltage at the end of charging. As the charging process comes to an end, the BMS makes balancing by shunting the charged cells. It can also transfer the energy of elements with a higher voltage to elements with a lower voltage. Shunt - a device that allows electric current (or magnetic flow) to flow bypassing any part of the circuit, usually a low-resistance resistor, coil or conductor.

With passive balancing, the cells that completely replenish the charge receive less current or are excluded from the charging process until all the battery cells have an equal voltage level. The battery management system (BMS) maximizes the battery life balancing and also providing temperature control and a number of other functions [2-3].

The main objectives of the application of BMS [1]:

1. Protection of battery cells and the whole battery from damage;
2. increased battery life;
3. maintaining the battery in the state in which completing all the tasks assigned to it becomes possible.

BMS Features

To achieve these goals, BMS must perform the following functions:

1. The first function of the BMS is to monitor the state of the battery cells, namely:

a. Voltage: total voltage, voltage of individual cells, minimum and maximum cell voltage;

b. Temperature: average temperature, electrolyte temperature, outlet temperature, temperature of individual battery cells, BMS boards. The BMS electronic board is equipped with both internal temperature sensors and external ones, which are used to control the temperature of specific battery cells;

c. Charge and depth of discharge;

d. Charge / discharge currents;

e. Serviceability.

The control system can store in memory such indicators as the number of charge/discharge cycles, the maximum and minimum voltage of the cells, the maximum and minimum value of the charge and discharge current. These data make it possible to determine the state of the battery operability.

Incorrect charge is one of the most common causes of battery failure, therefore, charge control is one of the main functions of the BMS microcontroller.

2. The second function is called intelligent computing. It is responsible for assessing:

a. the maximum allowable charge current;

b. the maximum permissible discharge current;

c. the amount of energy supplied as a result of charging, or lost during discharge;

d. the cell internal resistance;

e. the total number of work cycles.

3. The third function is connective. That is, BMS shares the data listed in the previous paragraph. BMS can transmit data through both wired and wireless communication.

4. The fourth function is protective. BMS protects the battery from:

a. over current;

b. overvoltage (during charging);

c. voltage drops below the permissible level (during discharge);

d. overheating;

e. hypothermia;

f. current leakage.

Battery Management System (BMS) disconnects the battery from the load or the charger when at least one of the operating parameters exceeds the permissible range.

5. The fifth function of the BMS is balancing. This is what we have already talked about. Balancing is a method of evenly distributing the charge between all cells of the battery, due to which the battery life is maximized [2, 3].

In order to protect the BMS board from the negative effects of moisture and dust, it is coated with a special epoxy sealant. Not always batteries have only one control and balancing system. Sometimes, instead of a single BMS board, several regulatory electronic boards connected to each other are used at once, each of which controls a certain number of cells and supplies the output data to a single controller.

This system is vital for an electric car since the functionality of BMS allows not only to improve the operating mode of batteries, but also to maximize their service life [4].

The architecture of the battery management system for each manufacturer is different. BMS can be designed using a variety of function blocks and design methods [5].

Conclusions. The Battery Management System (BMS) is an electronic system that:

- controls the charge / discharge process of the battery;
- responsible for the safety of the battery;
- monitors battery status;
- assesses secondary health data;
- conducts individual control of voltage and resistance of each battery element;
- distributes currents between the components of the battery during the charging process;
- guarantees safe connection / disconnection of the load;
- when recovering energy, BMS also regulates the process of recharging the battery.

The battery management system is a very important part of the electric car, and it performs much more functions than just managing the battery. BMS is the brain of the battery pack.

Reference
1. Hongbin R., Yuzhuang Z., Sizhong C., Taipeng W. Design and implementation of a battery management system with active charge balance based on the SOC and SOH online estimation. *Energy*. (1 January 2019), 2019, vol. 166, pp. 908-917.
2. Wei L., Jie L., Wenji S., Ziping F. Study on passive balancing characteristics of serially connected lithium-ion battery string. *2017 13th IEEE International Conference on Electronic Measurement & Instruments (ICEMI)*. Yangzhou, 2017, pp. 489-495.
3. Y. Barsukov Battery Cell Balancing: What to Balance and How. *Texas Instruments.* 2009. pp. 21-28.
4. Garche J., Jossen A. Battery management systems (BMS) for increasing battery life time. *TELESCON 2000. Third International Telecommunications Energy Special Conference*. Dresden, 2000, pp. 81-88.
5. Bergveld H. J. Battery management systems design by modelling. *Royal Philips Electronics N.V.,* 2001, pp. 1-306.

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СИСТЕМА АВТОМАТИЗОВАНОГО УПРАВЛІННЯ ЗЧЕПЛЕННЯМ ДЛЯ АВТОБУСІВ ТА ВАНТАЖНИХ АВТОМОБІЛІВ

Значна частина часу руху автомобіля в міських умовах припадає на несталі режими, перемикання передач і рушання з місця. Часта дія на орган керування зчепленням негативно позначається на фізичному стані водія та призводить до помилок у керуванні. Розробники автомобільної техніки багато уваги приділяють питанню зниження зусилля на педалі зчеплення та автоматизації перемикання передач, особливо це важливо для автобусів і вантажних автомобілів де максимальне зусилля на педалі зчеплення коливається в діапазоні 150…250 Н. Ця задача може бути вирішена переходом від гідропневматичного приводу щеплення до електропневматичного з електронним управлінням.

Для визначення найбільш оптимального варіанту конструкції електропневматичного виконавчого механізму керування зчепленням було проведено ряд попередніх експериментальних досліджень відомих конструкцій САУЗ, розглянутих у [1]. З цією метою була створена лабораторна установка, конструкція якої, принцип дії і результати дослідження показано в [2].

Однією із найпоширеніших є конструкція САУЗ, робота якої заснована на керуванні двома електропневматичними клапанами. Це клапани впуску та випуску стиснутого повітря. Структурна схема дослідного зразка представлена на рисунку 1.