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COMPREHESIVE ASPECTS VIEWING EFFICIENCY OF MONITORING BATTERY SYSTEM AS PART OF ENERGY STORAGE

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Abstract: The electricity systems evolve and widespread industry understanding of the needs to implement further adaptable storage technologies as power systems are developing. These adaptable solutions are necessary to fulfill the rising demand for a variety of services, including transportation, to reliably integrate intermittent renewable energy sources, and to make it easier and more affordable to transition between supply and storage. A battery management system is a part of energy storage system for preventing the damaging the battery.

Key words: energy storage, efficiency, battery management.

1 INTRODUCTION

As the global electricity systems are shaped by decentralization, digitalization and decarbonization, the worldwide explores the new frontiers with challenges and energy transitions for keeping equilibrium with fast moving developments.

Energy storage systems can be found in industrial as using energy storage systems to relieve congestion instead of constructing extra power lines (it consists of batteries placed at either end of a transmission line to absorb excess renewable production and discharge during peak demand, controlled by a proprietary algorithm), commercial or domestic applications that contain a large number of rechargeable batteries, thus incurring high operating and maintenance costs [1],[2].

Nowadays major decarbonizing efforts are orientated to remove thermal electric power generation and scale up renewable energies, the adoption of energy storage continues to be described as the key changer for electricity systems. Energy storage provides advantages due to flexibility and due to the possibility of closer linking of different energy and economic sectors.

Energy storage is in a deep tie with widespread needs such as relieving congestion or smoothing out the variations in power that occur independently of renewable-energy generation.

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Energy storage can contribute to a better energy transition, often is reduced to battery technologies. In the below diagram (fig.1) is showing the sample of storage technologies.

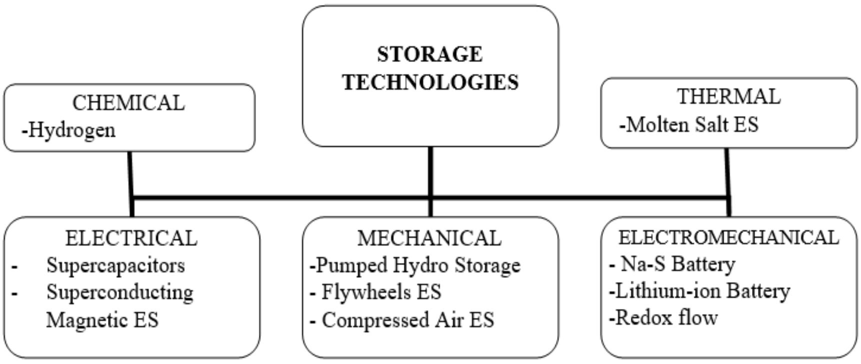


Fig.1. Overview diagram of energy storage

Storage technologies as fuel cells, supercapacitors, were developing and monitoring or controlling systems are recommended. Appear two questions which are taking into account as the place where the energy sector decides to push forward a wide range of technologies or continues to limit energy storage to battery storage and energy policies are enabling regulatory market. The figure below is showing the key between the parties concerned [3].

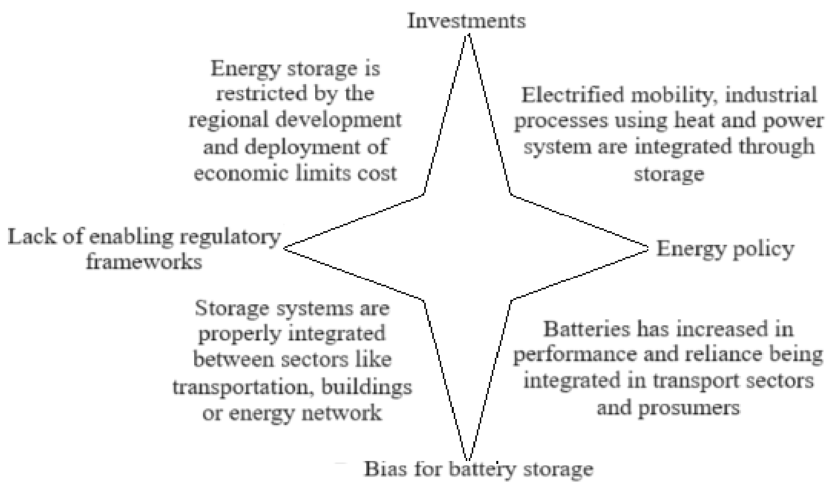


Fig.2. Dependence of the development of innovative technologies and applications

The World Energy Council considers that a wide range of energy storage technologies will be address to the challenges of the energy transition based on battery innovation, in particular lithium-ion. However, lithium-ion batteries may not be fit for a series of requirements of future energy systems, in particular fast charging and long duration storage integration [4].

2 THE FEATURES OF BATTERY MANAGEMENT SYSTEM

A battery management system (BMS) has the role to protect the battery for damage, ensuring the safety and life`s prediction in the same time to maintain the battery operation for a high efficiency.

Battery management system (BMS) is technology dedicated to the oversight of a battery pack, which is an assembly of battery cells, electrically organized in a row, column matrix configuration to enable delivery of targeted range of voltage and current for a duration of time against expected load scenarios.

The oversight that a BMS provides usually includes: monitoring the battery, providing battery protection, estimating the battery's operational state, continually optimizing battery performance and reporting operational status to external devices.

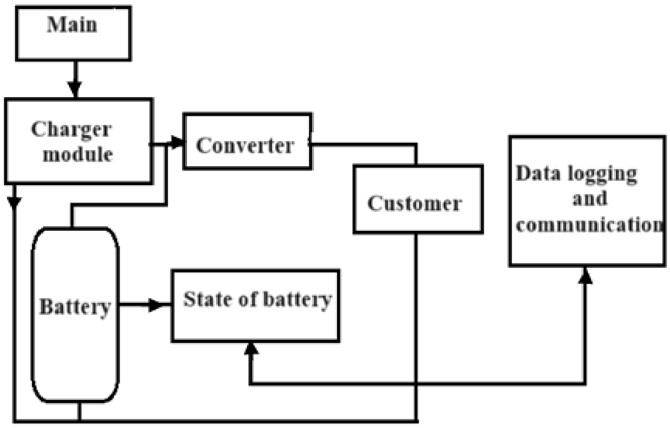


Fig.3. Block diagram of a BMS

The BMS has an important role above energy storage due to three characteristics as: efficiency, safe and dependable [1],[4].

To increase the efficiency of the system is possible through: to select the appropriate charging current for maintain the current density limit at the electrode surfaces; to control and compensate the state of charge range for charging and discharging over the operating range in order to maintain coulombic efficiency; to compensate the cut-off voltage with temperature variations; to keep al cell voltage and state of charge in balance for increasing the operating range; to maintain the optimum temperature range by thermal controlling.

To increase the dependable life time is possible through: maintain the current density for preventing the damage of electrode surfaces; to achieve the balance between capacities in and out at various operating conditions; to increase the overall age of the pack by preventing under charging of good cells and over charging of weak cells; to prevent the deep discharging by limit the discharge at the end of the discharge cut-off voltage; save the battery from abuses of overcharging (that causes heating and out-gassing).

3. THE FUNCTIONS OF BATTERY MANAGEMENT SYSTEM

To provide safety and reliability through: to maintain and control the operations in safety limits; to show the safety alarms beyond the function condition; to prevent the thermal runaway conditions by implement the thermal conditions systems; to indicate the remaining life of battery.

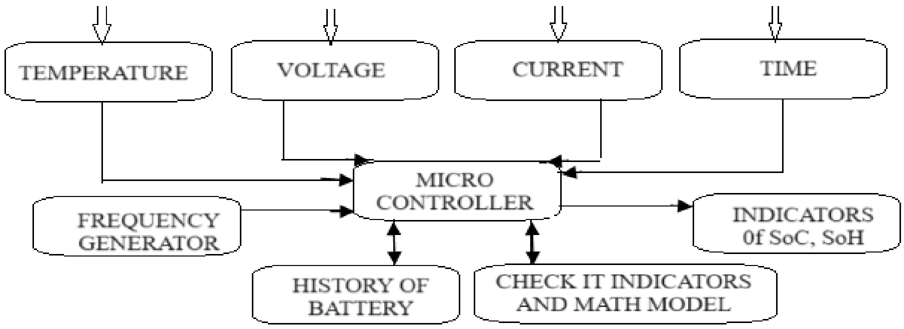


Fig.4. The main functions of a battery management system

Battery management system includes the following functions [5]:

- **monitoring of parameters as temperature** (multiple temperature parameters), **battery current, battery voltage**;

Monitoring the temperature, voltage battery and current battery represent the most basic function of a battery management system in the same time with allowing and foundation of other functions. So, what we want to notice is the fact that the battery state of charge, state of health evaluations is in dependence on accurate of voltage, current and temperature pursuing.

- **battery state estimation** as state of charge (SoC), state of health (SoH), state of function (SoF) and also state of power (SoP), state of life (SoL), state of range (SoR), state of energy (SoE);

The more common features of battery state estimation functions are SoC, SoH, SoF evaluation. The SoC evaluation is an important function of battery management system due to the its role in implementation of the control strategies, efficiency and robustness. The definition of most important factor SoC is expressed below, where the numerator and denominator are in Coulombs (C) or ampere-hour (Ah, 1Ah = 3600C).

$$\text{SoC} = \frac{remaining\ dischargeable}{battery\ capacity} \text{ x } 100\% \qquad (1)$$

The power battery management system has a high tolerance of the temperature monitoring error. Taking into account the SoC evaluation, the effective capacity of the battery varies with the temperature at the same discharge rate.

- **safety management** is contenting common protections as: over temperature protection, over current protection and over charge or discharge protection;

Over temperature protection is taking into account like a protective measurement for power battery when the temperature exceeds a certain limit value. That means that environment temperature, battery pack temperature and battery cell temperature should be take into account.

Over current protection refers if the working current overtakes the safe value in the process of charging or discharging.

Over charge protection as a disconnection of the charging circuit of the battery should be taken to prevent damage to the battery if is charging after 100% SoC. Over discharge protection refers if the battery is continuously discharged in 0% SoC.

- **energy control management** is based on charging control management, discharging control management and balancing control management,

Energy control management function of BMS provides in real time optimal control for the charging voltage, charging current and charging time, charging efficiency. Also, discharging control management refers to the control of the discharging current based on the battery state during discharging.

By balancing control management, it is possible to reduce the negative effects of cell inconsistency and improve the discharge efficiency of the battery pack.

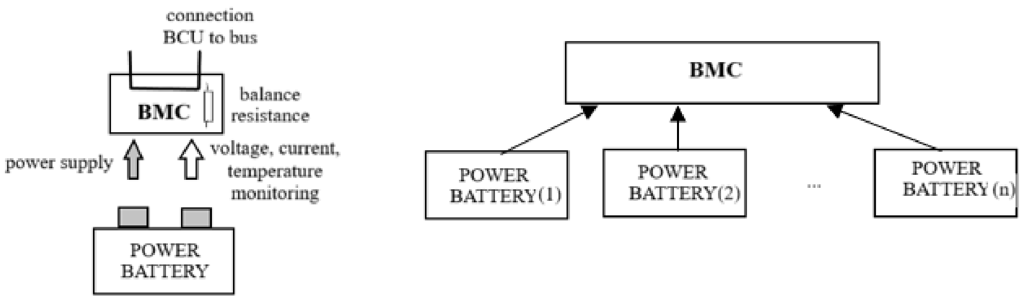
- **information management** is focus on storage battery`s history information, internal and external information interaction and battery information display.

Due to complexity of arrange of cells in the battery pack, a lot of data are generated instantaneous, some of that are provided or are sent to the components other than the battery management system. The historical storage of the battery is similar with a black box of an aircraft, helping in analyzing and identifying data for remove the failure [6].

3. THE STRUCTURE OF A BATTERY MANAGEMENT SYSTEM

The structure of system can be defined taking into account two base structures: a battery monitoring circuit (BMC) and a battery control unit (BCU). Relationship between its and cells are important, too.

There are two characteristic structures as shown in the below figure. The first structure is for each cell corresponds one BMC and the second structure means one BMC corresponding to multiple cells (fig.5). In the first case, the advantage consists in shorter distance between the BMC and the cell but the disadvantage is the higher cost of acquisition.

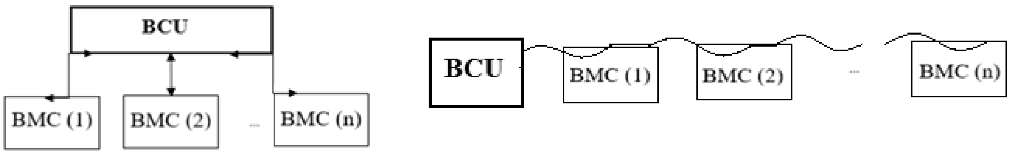


a) **b)**

Fig.5. a) Structure of one BMC monitoring one cell
b) Structure of one BMC monitoring multiple cells

In the second case, compared with the one -to- one structure, the structure is cheaper but there appears a ham of wirings and the acquisition line is longer. Relationship between a BCU and BMC can be achieved in different structures as a star connection or serial type connection (fig.6). The first one has the advantage of suitable access control and lackness of communication impact with another BMC when certain BMC stop working. Besides advantages there are some disadvantages as the difficulty of maintenance of longer line of communication and poor expandability [7],[1].

The second one has the advantage of lower cost of ham of wires, more flexibility connection and strong expandability.



a) **b)**

Fig.6. a) Star connection of BCU and BMS
b) Serial connection of a BCU and BMC

4. CONCLUSIONS

The energy systems are continuously developed, as the storage system becomes essential, especially for automotive and stationary applications. With an efficient control over optimum charge or discharge ranges, the management of battery system can extend the life of energy storage through preventing the risk of damage or failure.

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