IZMIR UNIVERSITY OF ECONOMICS FACULTY OF ENGINEERING ELECTRICAL AND ELECTRONICS ENGINEERING

FENG 497 PROJECT PROPOSAL

Li-Ion BMS

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OUTLINE

1.Abstract

Li-ion batteries, also called Li-ion batteries, are used by millions of people every day. The battery management system (BMS) is a principal detail for tracking and controlling lithium-ion strength garage systems. Modular Li-BMS could be very clean to put in force in battery packs of numerous kinds and sizes way to its bendy hardware and software program structure.

Lithium-ion batteries are mostly used in electric vehicles. It is one of the best battery types and is widely used with the high energy they can give compared to their weight-size. These batteries have no memory effect, and energy losses are slow when they are not in use. They can be dangerous if used inappropriately. If the necessary precautions are not taken, their life may be shorter than other types of batteries. More advanced lithium-ion battery designs are lithium polymer cell and lithium titanate battery cells.

Our objective in this project is to create a battery management system according to batteries.

In this proposal, topics to be covered, such are, elaborated info regarding our topic (Li-Ion Building Management System) and why precisely we have chosen this study, a quick clarification about our project topic, previous examples and studies during this specific subject, and comparison with our researches.

2.Introduction

A battery management system (BMS) is a system that performs the control and management of battery packs consisting of one or more cells during charge and discharge. The battery pack current, voltage, temperature, etc. by measuring important values, they are structures that interfere with the system when they go beyond the optimal values. A system formed by combining multiple cells is called a battery or battery pack. Battery packs consist of Series or parallel connected cells. In battery packs, serial connections determine the voltage, parallel connections determine the current and capacity to be drawn.

Battery management systems, i.e. BMS, are used to ensure coordination between these serial and parallel-connected systems. BMS (Battery Management System) are electronic systems that control and control rechargeable batteries. It acts as a protector in battery systems, examining the current operating state of the batteries and ensuring that they remain within optimal operating value ranges. There are some drawbacks of centralized BMS. It's more convenient, first. Second, as there is only one BMS, the centralized BMS solution is the most economical. The disadvantages of centralized BMS are, however, obvious. As all the batteries should be directly connected to the BMS, to communicate with all the battery packages, the BMS requires a huge amount of ports. In the BESS, however, there are so many wires, making maintenance hard. A centralized BMS is therefore not a good choice if the BESS includes a lot of battery packages.

The major aim of the BMS is to assure the safety of facility operation, while also tracking and optimizing the use and efficiency of its supervised subsystems to permit more efficient operation. The battery management system monitors the status of charged batteries and provides control of the charging process and battery discharge processes. 1S BMS, 2S BMS 3S BMS, 4S BMS, etc. models are available in the form, expressed in increasing numbers depending on the number of batteries used. During charging, the BMS protection circuit monitors the battery groups and checks that all cells are balanced and charged evenly. It protects discharge by monitoring the voltage and discharges current of the batteries, preventing overdischarge of the batteries if the limit is exceeded.

Li-ion is a type of rechargeable battery. Lithium-ion batteries, used in electronic products from mobile phones to laptops, are accepted and widespread due to the high power they provide according to their weight and size. Li-ion batteries lose between 20 percent and 30 percent of their capacity each year. Their average lifespan is 5 years. These batteries, which need to be protected from direct sunlight and direct heat, are the most common and efficient type of battery/battery currently used. Other types of batteries that can be charged other than Li-ion batteries are Ni-Cd,Ni-Mh,Li-po and accumulators. Lithium ion batteries have more advantages compared to other batteries.

2.1. Problem Statement

The battery management system allows you to balance the voltage values of each cell that makes up the battery pack to maximize the capacity of the batteries and prevent overcharging while charging. If an overvoltage or undervoltage occurs in any cell and the voltage balances deteriorate, it interferes with the system and the system enters the sector. It allows them to balance by taking energy from the most charged cell when necessary, transferring it to the least charged cell. In this way, BMS establishes a continuous control over the system, interfering with the failure of taking the system to the segment for damage that may occur in the event of a failure in the system.

2.2. Why is The Project Worth Doing

Constructing a battery management system for a more effective and affordable standard of life is the key purpose and inspiration that makes this project worth doing. On the other hand, it requires multiple approaches to engineering and is a multidisciplinary project, so we can consider different kinds of materials. We can use numerous programs for design as well. As a result, in order to optimize the battery capacity and prevent the battery pack from being overcharged and each cell voltage balanced, it offers a great opportunity to learn new knowledge in the field of engineering.

Battery Management Systems are the brains in the back of battery packs. They manipulate the output, charging, and discharging and offer notifications at the repute of the battery pack. When you pack so much energy in a small space, you need more prevention to keep people and the device. They additionally offer essential safeguards to guard the batteries against damage. Because one of the most important things it provides is safety under the terms of over/under voltage, over current, or over-temperature, or even more important thermal runaway. In addition, improved performance, a better interface, and other optimized features are definitely worth improving in this project.

3. Objectives of the Work

These three following items are very important:

- Identify faults and weaknesses in the battery bank early so preventative maintenance and replacement can be done in a safe and orderly way.
- Ensure the battery bank is maintained in an optimum environment to maximize performance and life.
- Provide operators with confidence there is sufficient battery capacity to maintain systems for the designated time in the event of a power failure.

With the advances in battery technologies, the amount of energy stored by li-ion batteries per weight and volume increases, and significant developments are occurring in control systems. In addition, with the decrease in the prices of li-ion batteries, it is seen that the use of li-ion batteries has increased in many areas from electric vehicles to user electronics. However, for the high performance use of these batteries, the health and occupancy status must be constantly monitored and controlled. This control is commonly done by using the voltage, current and temperature values of the cells. On the other hand, it should be used as a function input in the swelling and physical wear of the cells in monitoring the safety condition of the battery. Especially in devices such as portable phones and computers, direct contact of the user with the battery creates a security problem. These safety problems are increasing due to the usage habits of the users using different chargers, fast charging and charging.

Li-ion batteries are frequently used in both high power applications and portable low power applications. The most important reason for this is that li-ion batteries have high power density and high efficiency charge / discharge characteristics. Despite all its advantages, its low resistance to physical stresses, makes it necessary to take additional security measures specific to the applications.

In rechargeable lithium-ion batteries, cells consist of three main components primarily responsible for generating and storing energy as in other battery systems. These can be listed as anode, cathode and electrolyte. The anode material serves as the negative electrode and the cathode as the positive electrode. Positive electrodes are generally composed of metal oxides (LiMOx) with tunnel or layered structures. They have stratified structures in negative electrode materials. These structures

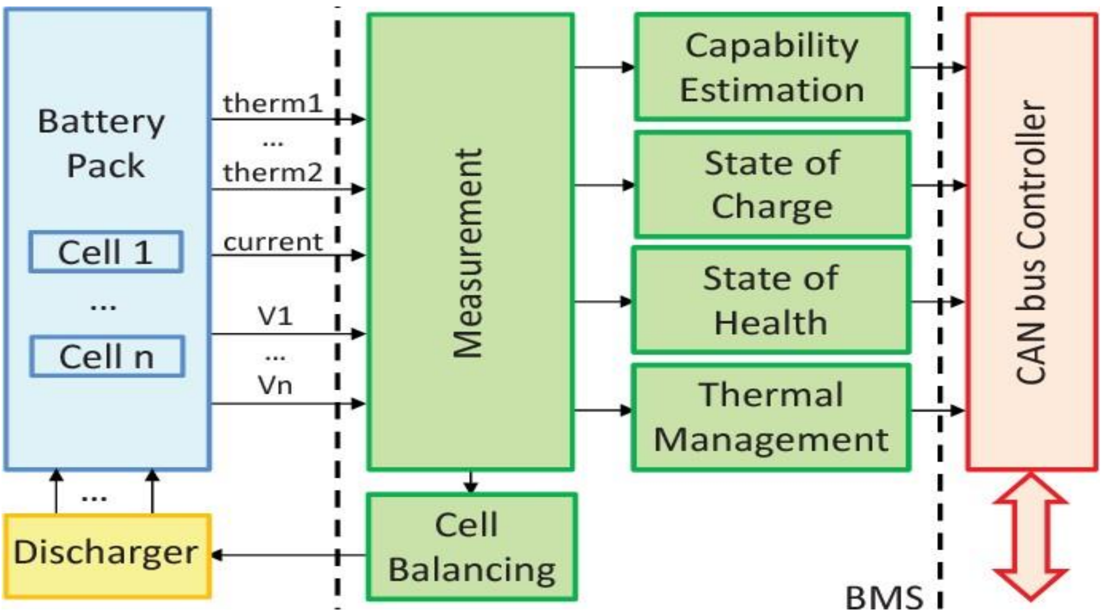
Thanks to this, Li ions can be exchanged mutually between positive and negative electrodes during charging and discharging of the cell / battery. This is defined as the displacement reaction. In this reaction, the active materials are anodes and cathodes and serve as hosts for lithium, while lithium changes its place from one electrode to another as a guest.

4. Scope of The Work

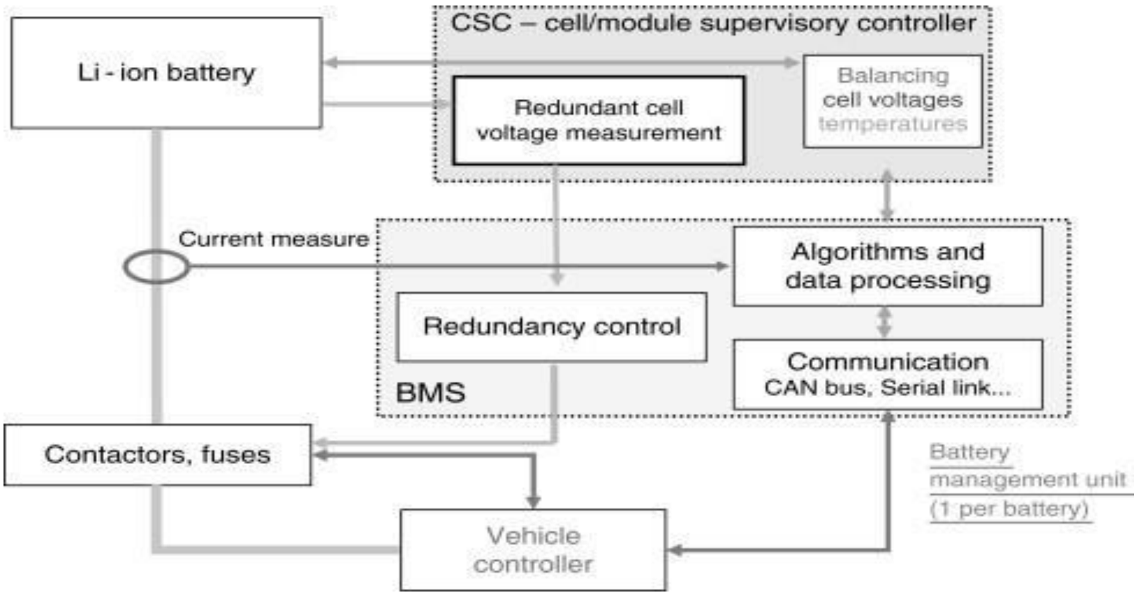
Work Packages			
1A		**Project Process**	**MİRAY**
1B		**BMS Hardware Development**	**İLKSEN**
		Battery cell characterization board development:	
	1 B 1	Charge and discharge circuit	İlksen/Zeynep
	1 B 2	Protection circuits	Zeynep/Miray
	1 B 3	Analog simulation (LTspice, Orcad)	Ege/Zeynep
	1 B 4	Schematic and PCB design (Altium Designer or Kicad)	Miray/Ege
	1 B 5	Board manufacturing	Ege/Miray
1C		**BMS Algoritması Geliştirme**	**MELİH**
		SoC, SoH - Matlab Simulink, m-file	İlksen/Miray /Zeynep
1D		**Mikrodenetleyici programlama**	**EGE**
	1 D 1	STM32 mikrodenetleyici seçimi	Ege/Miray
	1 D 2	Algoritmanın C'de uygulanması	Melih/İlksen
1E		**Yazılım (GUI) Geliştirme**	**MELİH**
		C veya Qt gibi kütüphanlerden arayüz tasarımı	
		Socket programming (UART)	

The main scope of the study is building the battery management system for the Lithium-ion battery. The project aims for a safer and more economical life using lithium-ion-style batteries. As the first step in the project, we aim to develop a battery cell characterization card. At this stage, our goal is to obtain an analog simulation by examining the charge and discharge circuits of the batteries and deciding the required protection circuit.

We will design the necessary schematic using Altium design. In this way, we will be able to complete BMS hardware development. The SOC parameter can be viewed as a thermodynamic quantity enabling one to assess the potential energy of a battery. It is also important to estimate the state of health (SOH) of a battery, which represents a measure of the battery's ability to store and deliver electrical energy, compared with a new battery. We will develop the BMS development algorithm using Matlab Simulink for SOC / SOH monitoring. In our next step, we select the right STM32 kit, create the algorithm in the C programming language and program the microcontroller. We will use graphical user interface development software such as QT libraries to develop the software and the interface of our BMS, and we will use the socket programming technique to manage the communication between the receiver and the sender and finalize the project.



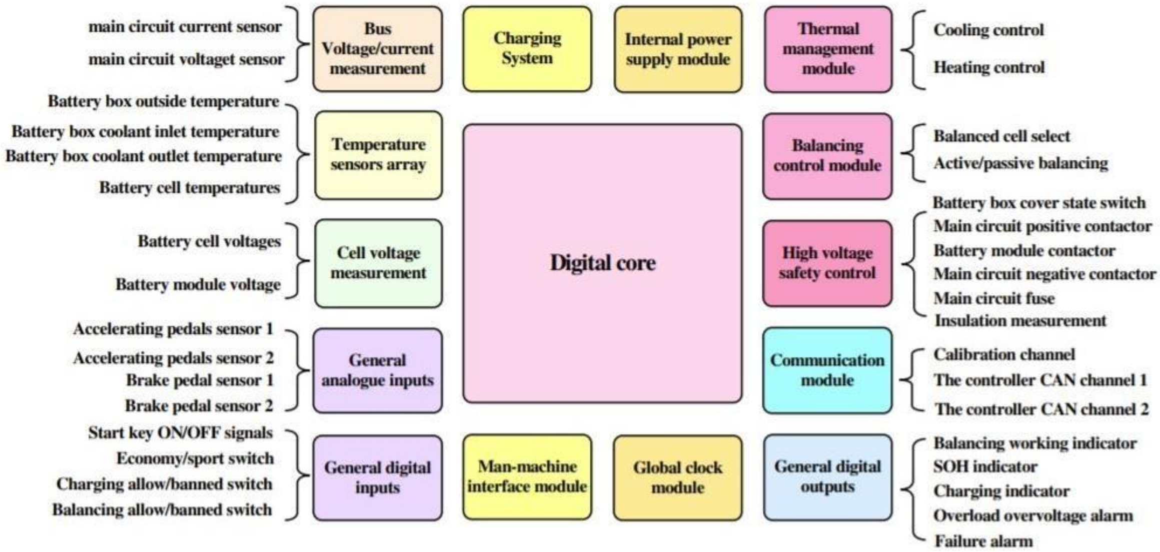
BMS Configuration



BMS Working Principle

5. Literature Survey

Compared to other commonly used batteries, lithium-ion batteries are distinguished by high energy efficiency, high power capacity, long life, and environmental friendliness, and are also extensively used in consumer electronics. However, automotive lithium-ion batteries have high density and large serial-parallel numbers, which, combined with problems such as protection, reliability, uniformity, and cost, place limits on the widespread use of lithium-ion batteries in the automobile. Lithium-ion batteries must operate within a safe and reliable operating area, which is restricted by temperature and voltage windows. [10]



Basic Framework of Software and Hardware in Vehicle

Battery modeling, along with the calculation of the internal states and parameters of the battery, plays a critical role in the discovery of a hologram of the working status of the battery in the applications of electric vehicles, firstly. After these main states are captured, an effective battery charging strategy can be configured to shield the battery from damage, increase energy conversion performance, and extend the battery life. However, most of the main innovations in the BMS are accomplished and tested under clear test conditions. Modeling, predicting, and charging efficiency in real-world systems that may be different from the test conditions, or in the worst-case situation, is impossible to guarantee. Therefore to solve this challenging issue, it is important to explore the shortcomings or to establish a confidence interval of the algorithms and approaches proposed.[12]

Electric traction motor drives in-vehicle applications will see massive growth in their market share over the next few years. A core aspect of the fuel-saving philosophy is the use of large batteries or ultra-powered stacks as energy storage buffers. Lithium-ion batteries are the stateof-the-art equipment for the near future. They deliver a high energy density with low weight and an incredibly high amount of charging and discharge cycles. However, their potentially high life cycle, calendar life, power capacity, and efficient operation can only be accomplished if they are properly handled. In addition to precise control of the voltage, current, and multiple temperature measurement points of each cell, active load balancing is important. The active approach described in this paper has the following advantages compared to the passive balancing procedure:

- Lower power dissipation for dramatically reduced cooling effort and lower temperatures in the system.
- Better battery capacity usage based on balancing, also at the end of the discharge activity.
- Higher overall vehicle fuel efficiency through low power losses

Using Lithium-ion batteries cell balancing methods will be an important factor in bringing energy storage systems to a cost-effective level to automotive standards. [13]

Lithium batteries are used in drones. A Lithium-based battery should be selected for drones because A drone is powered by batteries, which is the major drawback. After all, it is exhausted after 15 minutes of flight, causing a decrease in drone on the ground. The lithium-polymer batteries are used for powering the drones.[14]

Tesla uses Lithium ion batteries. The battery pack of the Tesla Roadster electric vehicle is one of the largest and technically most advanced Li-ion battery packs in the world. It is capable of delivering enough power to accelerate the Tesla Roadster from 0 to 60 mph in about 4 seconds. Due to their high energy efficiency, Li-ion batteries have been the technology of choice for smartphones, mobile phones, and many other lightweight applications. Precisely since they have all this energy contained in a limited room, Li-ion batteries can be harmful if they are not adequately maintained. In fact, there have been many cases of thermal leakage of Li-ion batteries in laptop applications leading to the recall of Dell, Apple, IBM, and other manufacturers. However, even with this high energy capacity, the Li-ion batteries in the Tesla Roadster store just about 8 liters of gasoline energy equivalent; a very small volume of energy for a modern car. [15]

Li-ion batteries are relatively low maintenance and do not need scheduled cycling to preserve their battery capacity. They have no memory effect, a dangerous mechanism where repetitive partial discharge/charge cycles will cause the battery to 'remember' a lower power. Lithium-ion is one of the most successful and safe battery chemistries available today. Two billion cells are produced every year.

6. Project Plan and Schedule

	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY				MARCH				APRIL				MAY			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Task																																
General Literature Survey about Battery Manangement System																																
Detailed Literature Survey about BMS																																
Generating Table of Batteries																																
Project Proposal																																
Writing the Report																																
Proof Reading and Submission																																
Making Calculations																																
Comparing Results																																
Report Writing																																
Preparing Presentation																																
Final Presentation																																

7.Risk Analysis

There may be situations where the project employees will not contribute temporarily. (Such as earthquake, epidemic) Material procurement may be delayed. If kits prove to be defective, it may take time to be re-procured. There may be delays and shifts in schedules and plans.

Because of their advantages related to energy density, declining equipment costs, and applications that serve a grid increasingly supplied by intermittent renewable resources, Li-ion batteries are becoming increasingly attractive. The need to recognize and evaluate the risks associated with these facilities increases as the number of ESS facilities increases, particularly in the light of previous negative incidents that have made the headlines. While there is no collection of failure rate data available for Li-ion batteries and their related obstacles, it is possible to quantify ESS risks based on data for the analog devices. Data on process control loops and device failures from other industries are also available to quantify the risk of failure on demand for a battery management system.

In this project, we must minimize the risks in order not to damage the product. So we can use more than one kit and battery to reduce the risk. In other words, we may prevent any problems that may occur by providing extra materials that we will use.

8. REFERENCES

[1]. https://www.lionsmart.com/en/batterymanagementsystem/

[2]. https://www.sciencedirect.com/topics/engineering/building-management-system

[3]. http://technologics.in/bms-project-engineering/

[4]. https://batteryuniversity.com/learn/

[5]. HJ Bergveld, WS Kruijt, PHL Notten - Battery Management Systems, 2002 – Springer

[6]. https://www.power-and-beyond.com/lithium-ion-batteries-explained-a-975937/?cmp=go-taart-trf-PuB_DSA-20200714&gclid=CjwKCAiA-_L9BRBQEiwA-bm5fgVJwmA1FYRnYIEoprC51aUPSvZLqXbBlFjGBt6MwKi5iuTWD63EbBoCvSUQAvD_BwE

[7]. The Design and Implementation of Smart Battery Management System Balance Technology

Xiujuan Zhang, Peide Liu, Darui Wang

Journal of Convergence Information Technology, Volume 6, Number 5. May 2011

[8]. https://www.dnvgl.com/publications/quantitative-risk-analysis-for-battery-energystorage-sites-154811

[9]. Impedance-Based Battery Management System for Safety Monitoring of Lithium-Ion Batteries Bliss G. Carkhuff, Plamen A. Demirev , and Rengaswamy Srinivasan

[10]. A review on the key issues for lithium-ion battery management in electric vehicles https://www.sciencedirect.com/science/article/pii/S0378775312016163

[11]. Kailong LIU, Kang LI, Qiao PENG, Cheng ZHANG

A brief review on key technologies in the battery management system of electric vehicles

[12]. A Cost Optimized Battery Management System with Active Cell Balancing for Lithium Ion Battery Stacks

[13]. P. Cassani, S. Williamson, “Significance of Battery Cell Equalization and Monitoring for Practical Commercialization of Plug-In Hybrid Electric Vehicles,” IEEE APEC Conference December 2008

[14] Drones and Possibilities of Their Using Piotr Kardasz1 *, Jacek Doskocz1 , Mateusz Hejduk2 , Paweł Wiejkut3 and Hubert Zarzyck

[15] The Tesla Roadster Battery System Tesla Motors August 16, 2006 By Gene Berdichevsky, Kurt Kelty, JB Straubel and Erik Toomre