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CAN BUS BASED BMS CONTROL CARD DESIGN AND IMPLEMENTATION BY USING STM32f103 SERIES MICROCONTROLLER

ABSTRACT

In this study, battery charge control circuit design which is used for storage in electric vehicles or renewable energy system has been realized. The BMS card is designed for a system of four battery cells. The circuit board is designed based on the CAN-Bus communication system and the STM32f103 series microprocessor is used. Circuit design is made of industrial circuit board specifications. Battery Management System (BMS) card design was realized by taking into consideration the methods to reduce the electromagnetic noise. In this study CAN-Bus communication protocol especially selected. Thanks to this protocol, data from many sensors in the vehicle can be controlled using only 2 wires. Although CAN protocol is used mainly in automotive sector, it is used in many systems including microprocessor due to the reasons such as data transmission rate, low error rate and ease of application. The power circuit, control units and CAN Bus communication layer of the designed card have been tested and ready for use.

Keywords: CAN-BUS Communication, BMS, Control Card, STM Microcontroller, Electric vehicle

1. INTRODUCTION

Todays, the need for energy is increasing day by day. With the digitalization of life and the increase of electronic systems, electrical energy has become one of our indispensable priorities. It is also very important to store and use energy [1]. As is known, batteries are used to store and use energy in DC form. With the digitalization of our daily lives, batteries are the energy storage elements we encounter quite a lot. Batteries have many different applications. In recent years, with the increase of electric vehicles, they are widely used in these areas. In addition to electric vehicles, batteries are used for energy storage in renewable energy production facilities. In this respect, batteries are used in many different applications and the usage of batteries is increasing day by day. However, there are two main factors that limit the use of batteries. The first one is the high cost of the batteries and the second one the service life. The life of the batteries varies depending on their usage, charge and discharge, and temperature [2 and 3]. Therefore, the long-term healthy use of the batteries is very important in terms of the high cost of the batteries. For this purpose, the batteries are used and charged by the control cards in order to avoid any possible negativity. These control systems are generally referred to as Battery Management Systems. The battery or battery cells are properly charged via these systems. BMS control systems can be

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designed in many different ways [4,5 and 6]. There are several points that are important in design. These are the communication protocol, the control method to be used, the microprocessor type and the design of the BMS control circuit board. The communication system is particularly important in these parts. In electric vehicles and battery energy storage systems, the system is generally used by CAN bus based communication [7,8 and 9]. The CAN system is reliable and it is possible to add and remove different units easily. These features are important reasons for choosing CAN communication system [10 and 11]. In this study, an industrial BMS charge control circuit is designed for four battery cells. In this BMS card, the circuit design was carried out by selecting the circuit elements in order to use CAN-Bus communication protocol. The control circuit on the BMS card is created with active and passive balancing method based charge control circuit and sensors for controlling the charge of the batteries. A compact card design was made using the STM32f103C8 as a microcontroller in order to perform the control operations. Data was transferred to the computer interface using the designed BMS circuit.

2. RESEARCH SIGNIFICANCE

The use of electric vehicles is becoming more widespread and the intensity of studies on electric vehicle technology is increasing. An important part of electric vehicles is the battery unit. The characteristics of the batteries such as service life and charging time are among the critical issues that are being developed in electric vehicle technology. Therefore, BMS systems are one of the important and indispensable units of this technology. CAN bus is the communication protocol commonly used in vehicles. The CAN bus-based communication protocol must be used to implement the BMS system in electric vehicles. For this reason, in this study, the system design has been realized so that it can communicate with CAN bus communication protocol. In this respect, the fact that the study is related to the BMS area increases the importance of the study.

3. OVERVIEW OF DESIGNED BMS CIRCUIT CARD FOR BATTERY CHARGING

The designed BMS control card consists of five parts. These are the power circuit, the charge control circuit, the CAN-Bus based communication circuit, the microprocessor circuit and the sensor circuits. These units are arranged to fit on one card in the circuit design. The size of the circuit is reduced to a minimum size and is designed to be as small as possible. The power circuit is where the supply voltage is applied to the BMS card. In this section, a booster circuit of type which increases from 0.9V voltage to 5V voltage is used. The supply voltage of the BMS circuit will be supplied from the adjacent battery cell in the battery pack. Therefore, a boost circuit is used to increase the battery voltage in the adjacent cell to 5V. Thus, the external feeding problem of BMS control cards was desired to be eliminated. The charge control circuit of the BMS system consists of a circuit based on active and passive control method. Depending on the control of the MOSFETs used as the switching element, the control circuit can operate in two different topologies. MOSFET is used as resistance in passive-based control method. In active-based control method, the circuit continues to operate according to the bypass method.

CAN-Bus communication protocol is used for the communication of the battery cells. ISO1050 IC chip is used for CAN bus communication. The reason for the use of isolated CAN Transceiver is to protect the BMS card in case of a possible short circuit. In the BMS system, a control method was created according to the Master-Slave logic. Therefore, one of the four cells are determined as master controller, while the other three control cards operate as slave. The cells communicate with the CAN bus based to each other's. Data from the cells are transmitted to the computer interface via the serial communication unit. STM32f103C8 was used as a microprocessor module. In the BMS control circuit, the circuit design has been carried out so that the microprocessor module can be easily removed and installed. Thus, a flexible usage possibility has been created. Due to its low cost and high speed, this type of microprocessor module has been selected. There are three main types of sensors on the BMS control board. These are current, voltage and temperature sensors. Sensors are very important for the BMS system since the control process will be performed according to the information from the sensors. ACS712 IC circuit is used as current sensor. In the charging process, the current sensor is very important for controlling the current flow. LM35 is used as a temperature sensor. It is intended to be used in the continuous monitoring of temperature information of the cells. In this way, overheating conditions will be determined in advance and the cells will not be overcharged. Possible explosion and combustion conditions due to overheating of the batteries will be prevented. In this respect, the temperature sensor is essential for the safe operation of the batteries under proper conditions. Designed BMS control card and parts of this card can be seen at Figure 1.

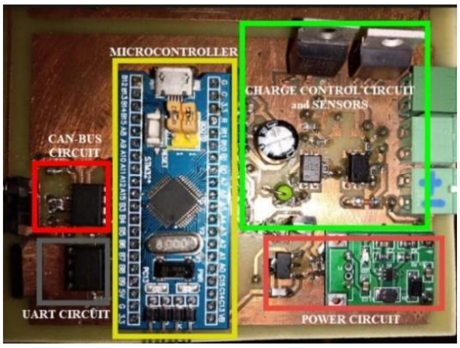

Figure 1. Designed BMS control card

3.1. Pcb Design with Using Smd and Through Hole Technique

Healthy and long-term operation of designed circuits may vary according to the production type. It is also important that the designed circuit for continuous and long-term operation as well as its operation. Through hole and surface mounting techniques were used at this designed for BMS control card. Proteus program of one cell and four cell BMS control card design and 3D view can be seen at respectively Figure 2 and Figure 3. Real-time designed and implemented four cell BMS control card can be seen at Figure 4.

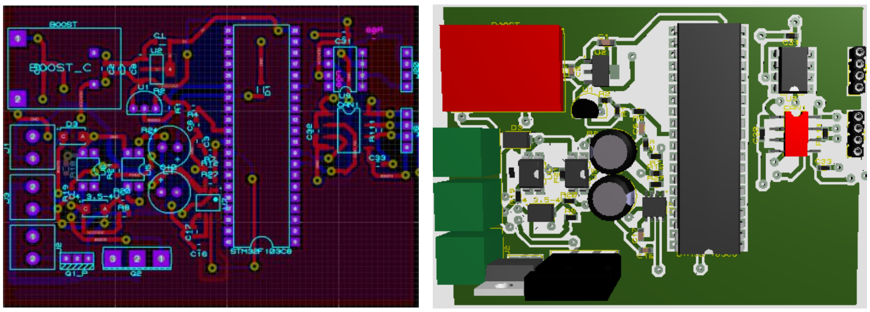

Figure 2. ARES program design of one cell BMS control card and 3D view

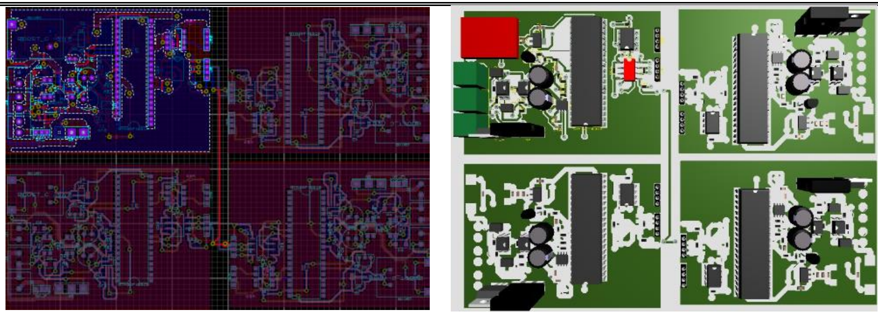

Figure 3. ARES program design of four cell BMS control card and 3D view

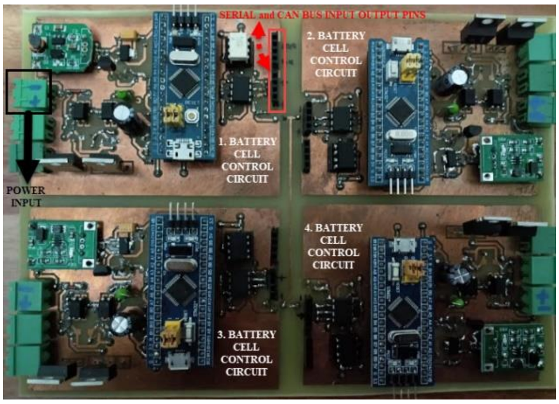

Figure 4. Real time implementation of designed four Cell BMS Control Card

3.2. Can Bus Communication Protocol

The Controller Area Network (CAN) protocol was developed in 1983 by Robert Bosch for use in the automotive industry and was officially used in 1986. This communication protocol aims to reduce the cable network in the vehicles. The CAN communication protocol is message-based. Each message has an ID number. Messages are transmitted through frames and are divided into data and request messages. Request messages do not contain data. In data messages, up to 8 bytes of data are transmitted [12]. In general, a CAN port is shown below. The ports are called nodes and the microcontroller consists of the CAN controller. This CAN controller is included in the chip which is used STM32f103C8 microprocessor, but can be used externally as well. The CAN controller is directly connected to the CAN bus. This CAN bus is a two-wire bus terminated with 120ohm resistors on both sides. General shape of CAN Bus Wiring Diagram can be seen at Figure 5. Microcontroller and communication part of designed BMS control card can be seen at Figure 6.

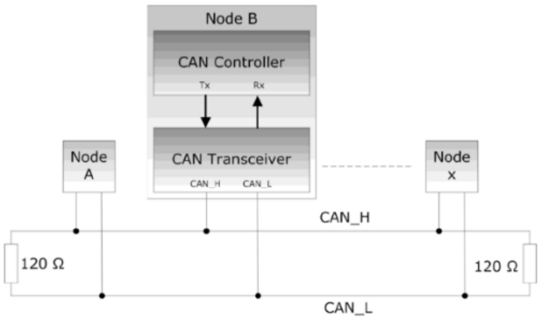

Figure 5. CAN bus wiring diagram

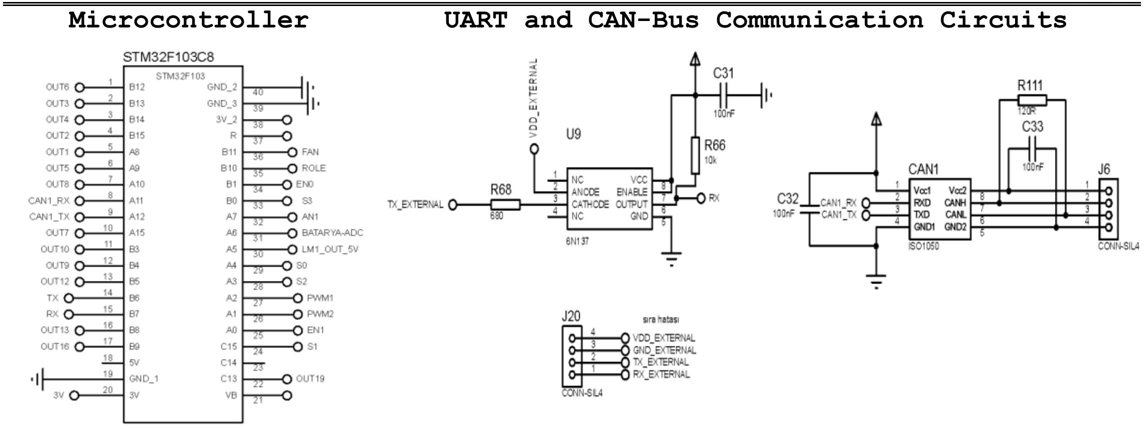

Figure 6. microcontroller and communication part of designed BMS control card

4. WORKING PRINCIPLE OF CAN-BUS BASED DATA ACQUISITION SYSTEM

In the designed system, data were collected from the three cells by the CAN bus to the MASTER processor. The data collected in the MASTER processor is transferred to the computer via serial communication connection. Each slave cell is assigned an ID number. The data to the MASTER processor is read according to these ID numbers. Designed BMS System General Working Schema is given in Figure 7 at the bottom.

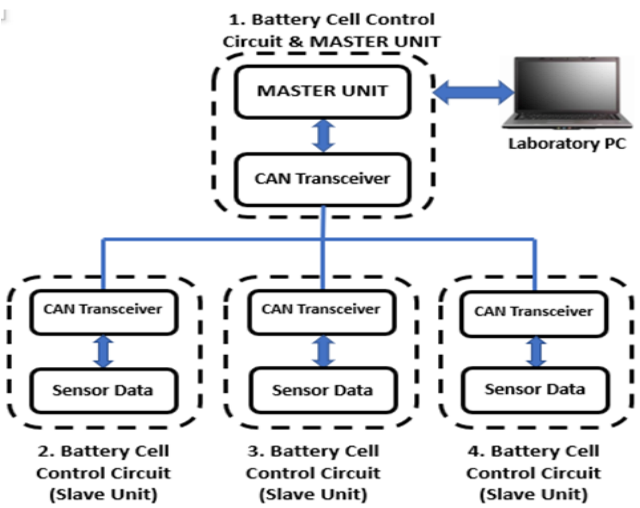

Figure 7. Designed BMS system general working schema

5. EXPERIMENTAL RESULTS AND DISCUSSION

CAN data communication based BMS card was designed and operated properly. Data from three different cells were analyzed and it was determined that the data flow was transferred correctly. MikroC software language was used as software. Values are assigned to the array to test whether the data flow is correct or not. These values are sent to the MASTER processor via CAN bus communication. The MASTER processor, which receives the data according to the ID numbers of the cells, grouped the data. The values sent in the software are considered ASCII code. Therefore, the ASCII code equivalent of these values is shown in the serial port display. It was determined that the data were transmitted to the MASTER controller by examining the ASCII code responses. Data read from the computer is shown in the Figure 8. The following Table I shows the ASCII code equivalents of the data.

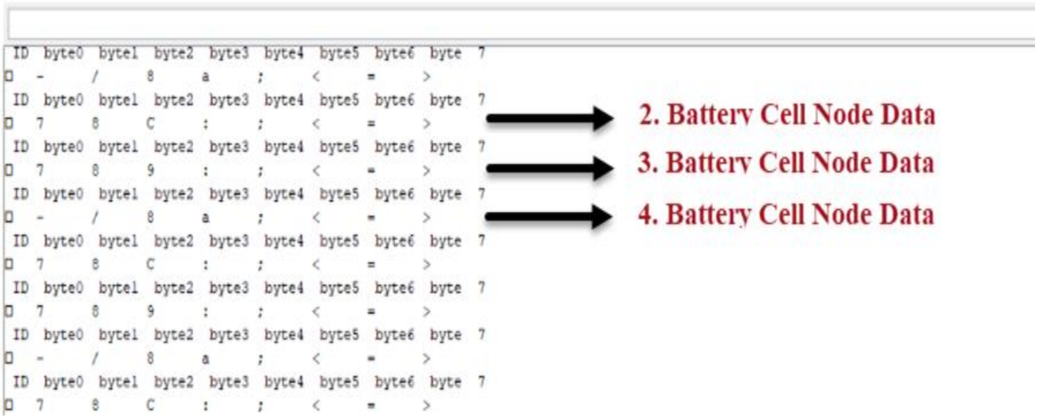

Figure 8. Data collected from different nodes with serial communication to the computer

Table 1. ASCII Code Equivalent of collected data from different nodes with serial communication to the computer

	data1[0]	data1[1]	data1[2]	data1[3]	data1[4]	data1[5]	data1[6]	data1[7]
2. Battery Cell Node	55	56	67	58	59	60	61	62
ASCII Code Equivalent	7	8	C	:	;	<	=	>
3. Battery Cell Node	55	56	57	58	59	60	61	62
ASCII Code Equivalent	7	8	9	:	;	<	=	>
4. Battery Cell Node	45	47	56	97	59	60	61	62
ASCII Code Equivalent	-	/	8	a	;	<	=	>

6. CONCLUSION

In this study, an industrial BMS control card, which can be used for functional and multipurpose, is designed and developed. The components of the control card are described in detail. The communication infrastructure is based on the CAN bus and its software has been created within this scope. The communication unit and the power unit are isolated from each other using an isolated ISO1050 CAN Bus IC. With this design, the charge control of four different battery cells can be performed. In the experimental application, three cells are slave and one cell are set as Master Processor. Data from the slave cells were transferred to the Master cell via the CAN bus. The master cell correctly classified the incoming data according to the ID number. Thus, the collection of data from different points via the CAN bus using the STM32f103C8 microprocessor was accomplished successfully. In the future study, it is aimed to collect and record the data of the BMS system, to communicate with each other and to perform charge control according to the targeted topology. In this respect, the study constitutes the infrastructure of the targeted studies.

NOTICE

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