Wireless Battery Management Systems in Electric Vehicle

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***Abstract*— The improvement in Battery Management System (BMS) change the face of electrical powered vehicle. Nowadays most of the electrical vehicle use CAN based communication in BMS unit. Wireless communication is will reduce the complexity, costs, cable requirement for multi-cell pack and increase reliability of BMS in electric vehicle This paper deals with different wireless technology which will use in electric vehicle in future and provides a correct comparison between all the technologies**

***Index Terms*— Electric vehicle, smart grid, stability voltage, superconducting**

I. INTRODUCTION

The evolution of the electric world happens in a very fast manner. In 1800 the spark started inside scientist to think in advanced level for powering the world. In 1830 1st electric motor was invented after that 1859 1st rechargeable battery came in to picture that is the lead-acid battery. By utilizing scientist invented the 1st successful electric car made 1890s. In the 20th century, so many electric vehicle models [1] came, due to large price electric vehicle start to diminish. In 1970s Stanley Whittingham introduce 1st rechargeable li-ion battery to the world [2], [3]. It has so many specialties, due to these specialties all researcher started to dig more function property of Li-ion battery after all Li-ion battery [4] came into the market. With the introduction of new battery again electric vehicle came back along with that the fossil fuel vehicle creates huge pollution because of all this so many countries initiated to provide the fund to EV.

Due to the properties of battery it should be maintained and control properly to get maximum output. Because of the large energy density of Li-ion battery, it should be protected properly otherwise it will create large problem [5]. For all these, a proper system is required that is Battery Management System. In recent years, the efficiency of a battery in terms of how much power it can give output with respect to size and weight has drastically improved [6]. The main reason for growth on battery pack energy storage shows that can ensure maximum performance, safe operation, and optimal lifespan under diverse charge-discharge in different environmental conditions.

II. BATTERY MANAGEMENT SYSTEM

A system that can control and coordinate a rechargeable battery (cell or pack) like operating battery in safe condition, balancing the cells, calculating the required parameter, reporting the data to the user display etc.

According to the power requirement for the electric vehicle, battery cell can be connected in series and parallel [7]. Equivalent circuit of a battery [8] is shown in figure 2.1 and types of cell connection use in electric vehicle shown in figure 2.2.

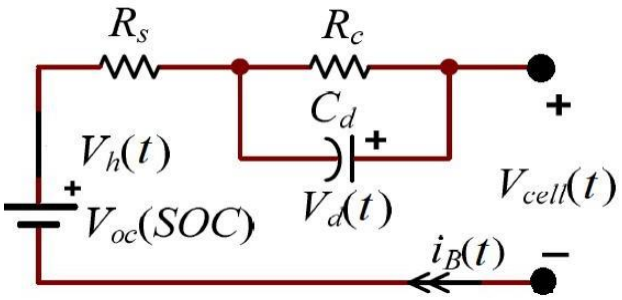


Fig 2.1 equivalent circuit of battery

Battery cell connection change according to the company for example BMW i3 use series connection of battery cell, Nissan leaf use series and parallel connection of battery cell.

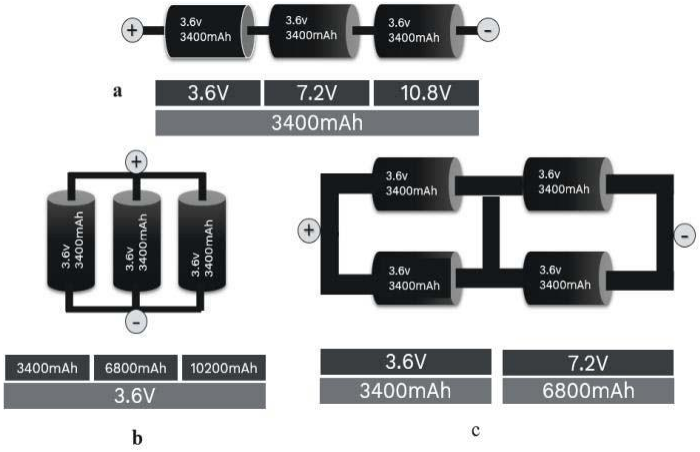


Fig 2.2 a. Series connection b. Parallel connection c. series and parallel connection

From each battery cells we want to measure temperature, voltage and current. This can be done by using suitable battery monitoring module such as BQ76940, BQ76930, and LTC5800 etc. Data from battery monitoring module is send to the BMS unit and from BMS to MCU unit via CAN bus communication. All this communication is through wired manner.

In general, the Battery management system includes master controller, module management system and battery monitoring sensors for a large-scale battery system [8]. However, due to the large number of Li-ion cells, the several design deficiencies in current BMSs have impeded the proliferation of large-scale Li-ion battery systems. These deficiencies includes: 1) complicated sensing [9] for large number of cells 2) wire communication between cells/modules and the master controller (example for wired communication are CAN, I2C/SPI). 3) Wired BMS can also cause various issues in physical connection failure due to vibratory environment. 4) The total cost for wired BMS parts such as connectors, protective cases and isolators cost almost portion to battery pack cost. All the problems make BMS unit low reliability and low productivity. Fig 2.3 show block diagram of Wired BMS unit.

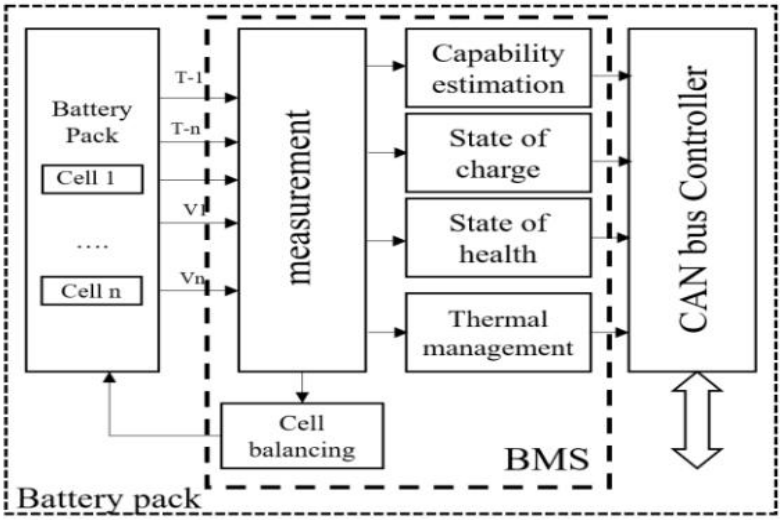


Fig 2.3 Block diagram of Battery Management System

A. Controlled area network (CAN)

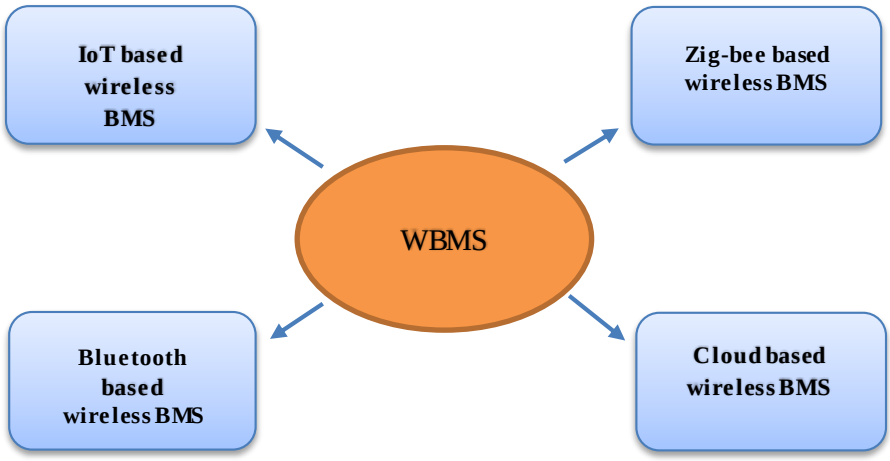
CAN is a serial data communication bus used for German car industry developed by Robert Bosch, the main aim of this protocol is for automotive industry [10]. Today CAN is used in most of all automotive industry with an ISO standard (ISO 11898). It is a twisted pair of wires having high transmission speed with combine error handling and fault confinement facilities. The main advantage of CAN bus is inexpensive, support auto retransmission of lost messages, works in various environments condition etc. Considering disadvantage of CAN bus it is applicable for 64 nodes in electrical loading, maintenance cost and time is high.

III. WIRELESS BATTERY MANAGEMENT SYSTEM

IV.

In advanced way of BMS, wireless BMS a significant breakthrough that offers the potential for improved reliability, weight and lower cost (reduces wiring complexity, saves galvanic isolations and connectors) for large multicell battery stacks in electric and electric/hybrid vehicles [11][12].

Wireless connectivity makes more flexible placement of battery modules, and makes the installation of additional sensors in locations previously unsuitable for a wiring harness possible. Figure 3.1 shows the mainly used wireless BMS technique.



All the four types are explained briefly below.

A. Cloud-Based Battery Monitoring System.

Utilizing IoT device and cloud component a battery management system for a large scale Li-ion battery is developed. IoT components contains data acquisition and wireless communication components which helps to communicate with cloud components [13]. In this cloud components contains analytic tools, cloud storage and visualization. By using all this a smart small scale, cloud battery management system is developed by Raspberry pi board and google cloud.

In cloud based condition monitoring system which contain a large set of batteries, Wireless Module Management Systems (WMMS)s in addition with IoT devices and Cloud Battery Management Platform (CBMP)

[14] Contain cloud storage, analytics tools, battery calculation and visualization in display. The data acquisition part such as sensor measure data at a sampling time of 1second, the measuring data are battery cell voltage, current and temperature. These data are stored in IoT communication devices which help to send data to cloud data storage in cloud server.

The Module Management System receives State of Health (SOH) and control command from cloud battery management system from cloud BMS. Data transfer can be done by any of device like low power Bluetooth, Wi-Fi, Zigbee with the help of IoT protocols. Graphical user interface (GUI) is also provided for various user interface and web service.

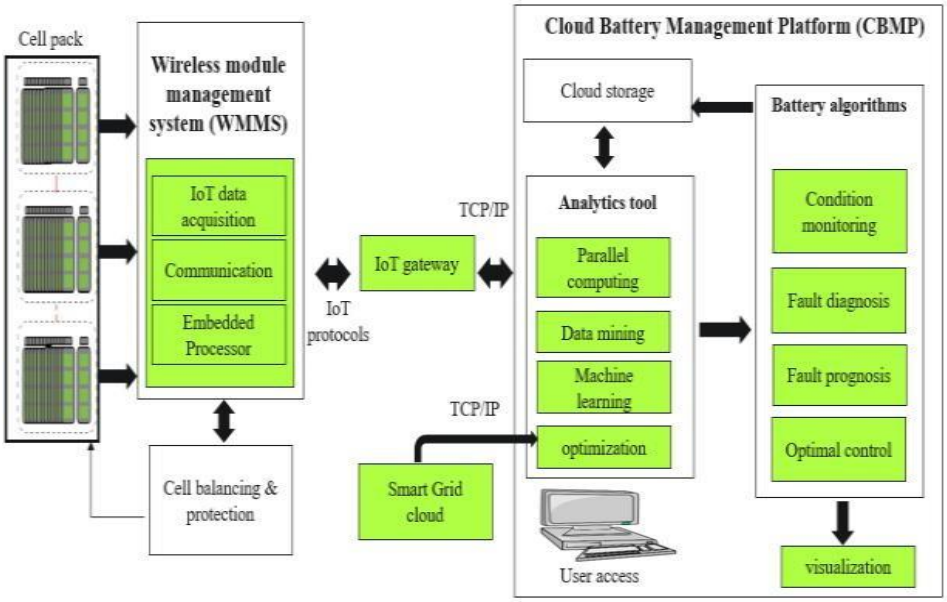


Fig 3.1 Block diagram of Cloud based wireless BMS

The data acquisition and communication have facing mainly three challenges such as,

1- Algorithm for large-scale battery data exchange between devices.

2- Efficiently send battery data by using advanced devices.

3- Selecting cost effective, robust wireless components.

By using extended Kalman filter [15] State of Charge (SOC) is calculated along with that we are using Hybrid Filter-based condition monitoring algorithm.

The result obtained by using cloud based BMS are accurate measurement of SOCs, resistance, and capacity of individual cells with the help of condition monitoring algorithms in the proposed platform. In future by adding cloud based health monitoring, early detecting of battery cell failures and estimating useful life.

A. IoT based wireless BMS

Wireless communication is a type of data communication that is used for delivered and performed wirelessly. There are so many wireless technology used in wireless battery monitoring system such as GSM, Zig Bee, GPRS, Android, Wi-Fi and Bluetooth communication. One of popular and worldwide wireless communication is Global System for Mobile communication (GSM). It's having a frequency band of 900MHz to 1800MHz.

Using GSM and GPS this IoT based wireless BMS unit is developed. Here voltage sensor measure voltage of lithium-ion batteries. By using SIM808 GSM/GPS/GPRS locate the vehicle exactly in the interface computer. The sensed voltage is sent to Arduino Uno microprocessor after processing data is sent to computer via SIM808 shield. Data sensed by the battery monitoring interface in computer will show the updated data also send the low voltage alert and parameters of battery to the user. All data are saved in computer also tracking of vehicle is also done by google map and communication with various user also done by same computer and webpage.

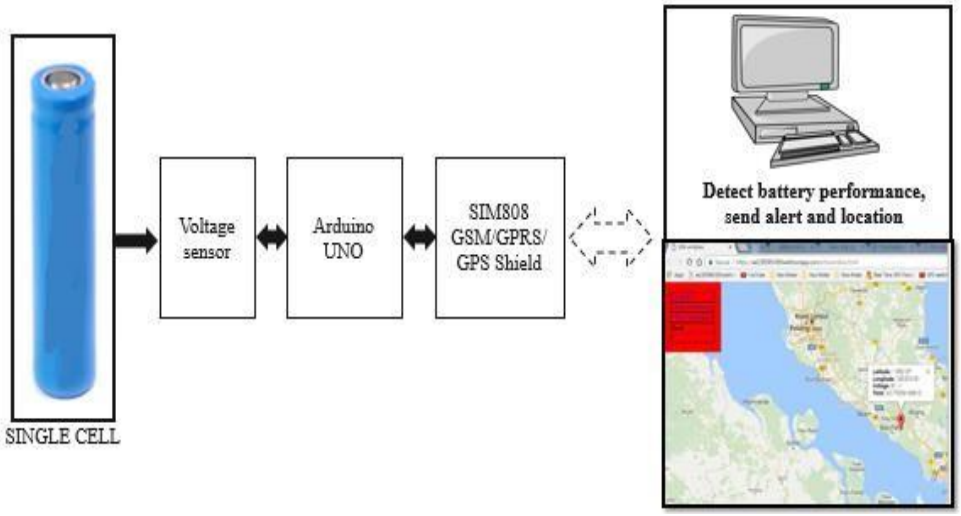


Fig 3.2 Block diagram IoT based wireless BMS

The result obtained by using IoT based wireless BMS [16] is data are accurately measured, send to large distance, stored data in web-based battery monitoring user interface. The system is capable to show information such as location, battery condition and time via internet.

C) Bluetooth Based Wireless BMS

Using low power Bluetooth communication a smart wireless BMS is developed. Bluetooth is a short range wireless technology having 2.4GHz band and consume less power. The controller used for the Wireless BMS is ATMEGA 328 (Arduino UNO) system having 14 digital I/O pins (out of 14, 6 can be used as PWM outputs), 6 analog input pin, USB connection, a power jack, 16MHz ceramic resonator and reset pin. This controller can be powered by using USB cable and adapter (AC-DC converter). The power to the Bluetooth module that is 3.3V to 5V is given from Arduino UNO board. This paper is tested for a single battery cell. The main sensor used for hardware part are Voltage divider module (DRF0051) as voltage sensor. The DRF0051 can sense a voltage up to 25V. Current sensor as (ACS71205B) works on the principle of Hall- Effect. Current sensor having an output sensitivity of 185mV/A and can measure up to +/- 5A [17]. LM 35 is an analog temperature sensor used for sensing ambient temperature required a supply voltage of 5V and having an accuracy of +/- 5°C [18].

LabVIEW and Android smartphone based GUI is devolved to interact with the user. By using App inventor Android application is developed. Figure 3.3 show the layout of Bluetooth based wireless BMS.

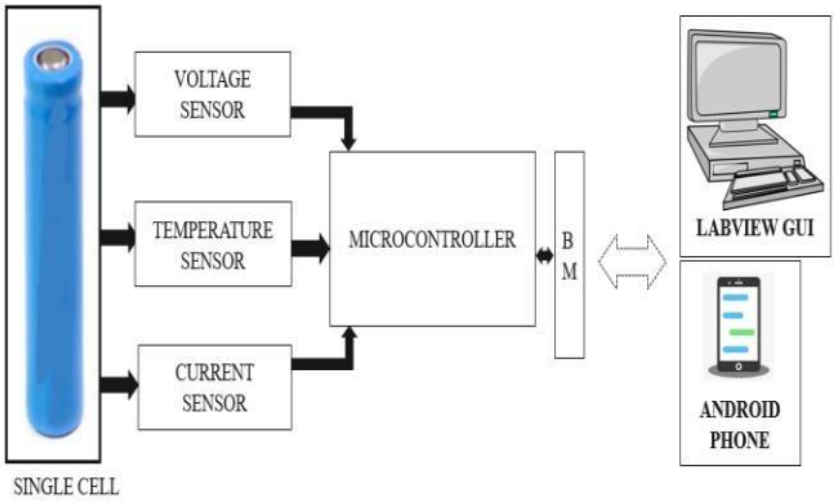


Fig 3.3 Block diagram of Bluetooth based wireless BMS

The sensed data from battery cell is send to the Microcontroller unit then data is sent to the GUI using Bluetooth module. The flowchart for arduino and data sending is shown in fig 3.4

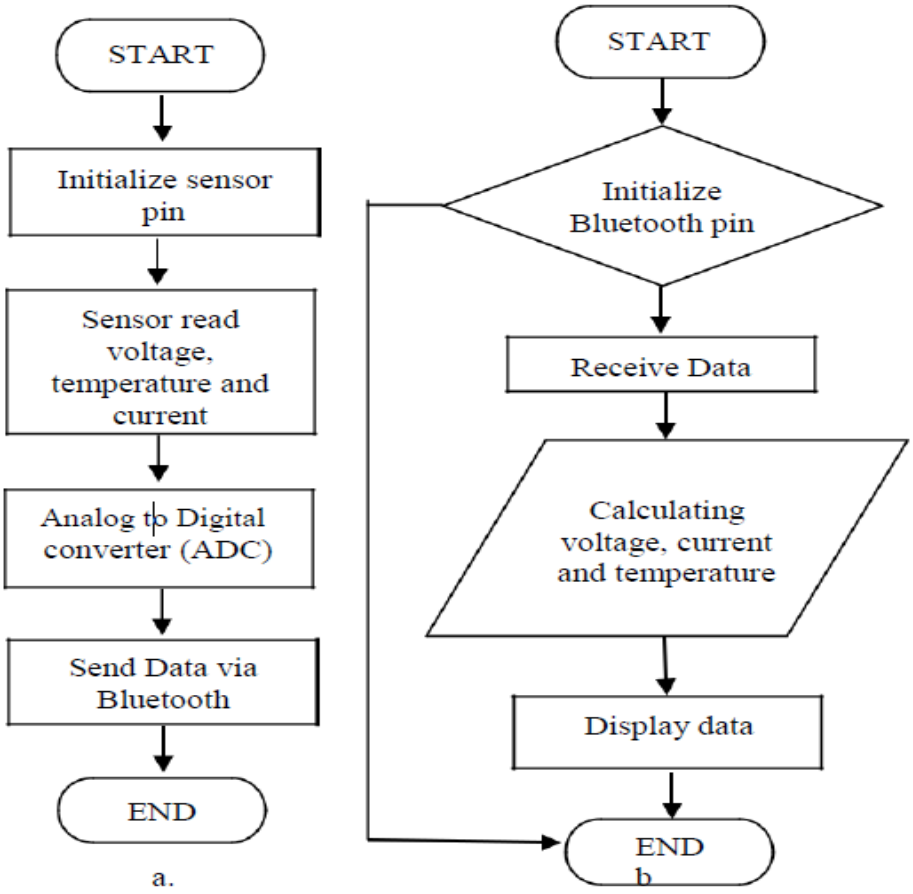


Fig.3.4 a. Flowchart of Arduino b. Flowchart for display unit for Wireless BMS (LabVIEW and Android smartphone).

Wireless BMS unit using Bluetooth module [19] send data successfully and display in both lab VIEW and Android smart phone with high accurate way. Voltage, current and Temperature is send while in both charging and discharging process.

D) Zigbee Based Wireless BMS

Zigbee is another type of wireless communication devices havning low power consumption, low cost, high reliability and low data rates [20]. Hardware part contain voltage sensor, current sensor, temperature sensor to measure cell parameter after this data collection, data will send to the slave controller where all this sensor is coonected from here Master controller (A) is connected which calculate SOC, voltage, temperature, and current limt value and sent to suitable control action. Master controller (A) is connected to Master controller (B) via Zigbee coordinator. Master controller (B) is connected with the display unit, alarm and main ON/OFF button. Alarm will indicate the user about critical warning that user can interact. The Master controller used for this project is Arduino UNO. The fig 3.5 shows the point to point topology for a Zigbee based wireless BMS.

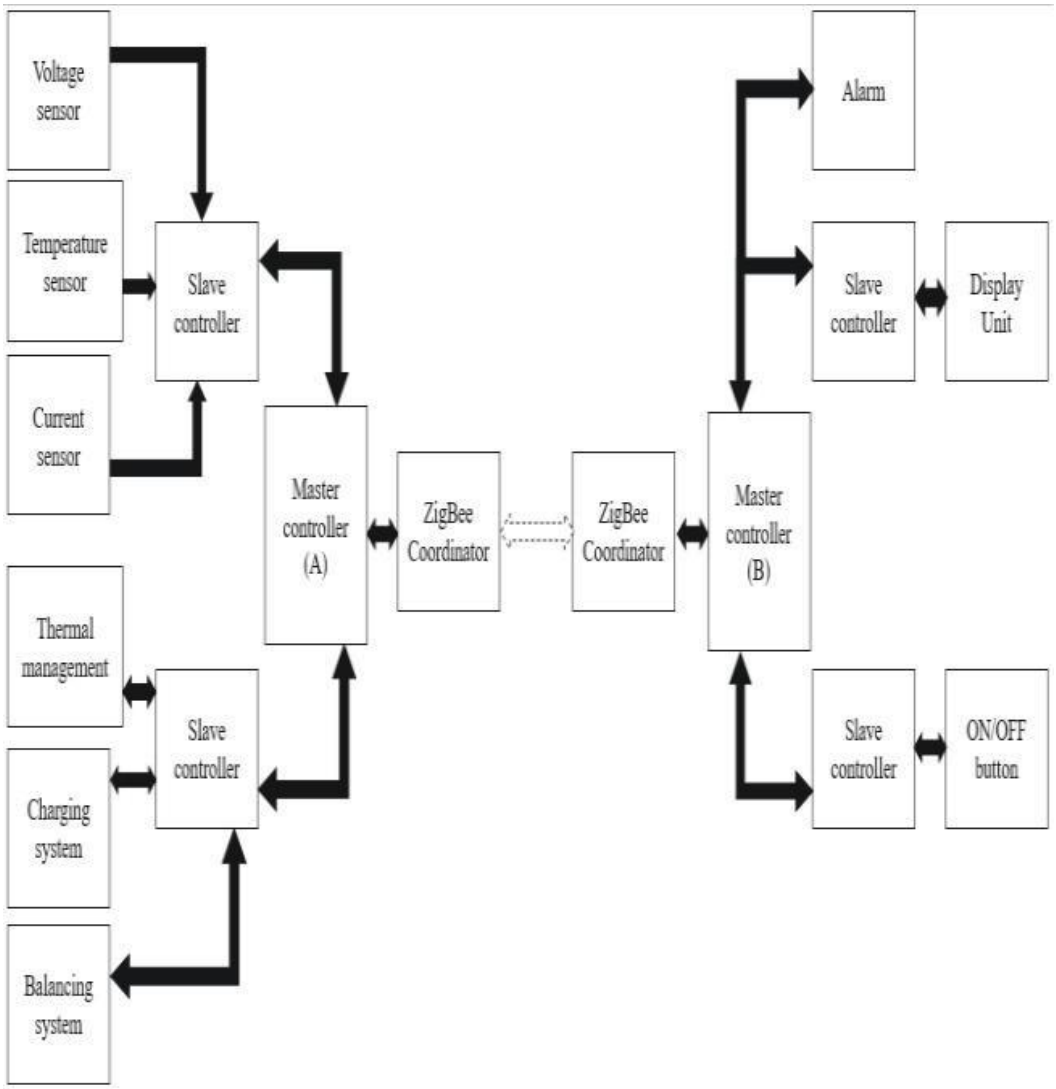


Fig3.5 Point to point topology of Zigbee based wireless BMS unit.

Thermal management, charging system and Balancing and the addition setup provided. By this total setup SOC, SOH and efficient cooling of battery pack is developed. The life span of battery increased by using a proper controller and proper cell balancing.

IV. COMPARISION TABLE ON KEY FINDING

Wireless technologies	Cloud based Wireless BMS	Bluetooth based Wireless BMS	IoT based Wireless BMS	Zigbee based Wireless BMS
Key findings	Platform is implemented and validated by using the small-scale cloud BMS simulator that utilizes Google cloud and three IoT devices. This method validate that SOCs, resistances, and capacities of individual battery cells can be accurately estimated by the multithreads of condition monitoring algorithms in the proposed platform.	Data of battery monitoring are displayed on Personal Computer (PC) with LABVIEW program and android smartphone. The monitoring system was able to show real-time data of voltage, current and temperature and display data on android smartphone and PC simultaneously.	The system is capable to show information such as location, battery condition and time via internet by incorporating GPS system to detect the coordinate and display it on the Google Maps application	The enhancement of the battery lifespan would be more by using the wireless battery management system. Balance the battery cells in shorter time with keeping the cells variation about 2.5 to 5%.

Table 4.1. Shows the key findings of different technologies.

Going in to electric vehicle Battery management system all BMS unit is placed inside the battery pack unit. The future model for a Wireless BMS unit is shown in figure 4.1

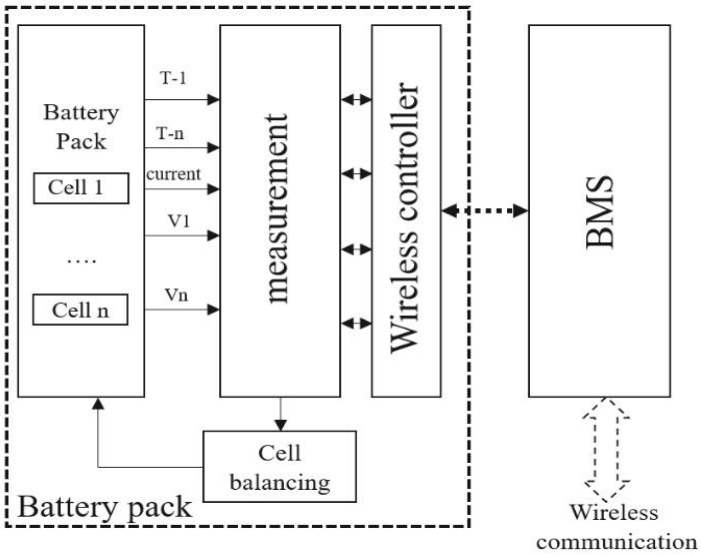


Fig 4.1 Block diagram of wireless BMS

In this model BMS unit is separated from Battery pack. The parameters such as Voltage, current and temperature are measured by suitable module and send this data to the BMS unit via wireless communication from there BMS unit will evaluate SoC, SoH, faults and provide a proper control signal to the monitoring module & ECU.

V. CONCLUSION

This paper explain various types of Wireless Battery Management System implemented so far along with its working and key finding of each system. We get to know that Bluetooth and Zigbee are two wireless communication having low power consumption. Bluetooth become more popular in automotive industry while compare with other wireless technologies. Cloud and IoT based technology make wireless communication in broad way by adding with google internet platform. Wireless technologies are updating day-by- day so it will be the future of Battery Management System in electric vehicles. Usage of CAN communication will reduce in future if an effective Wireless BMS unit came in to automotive industry.

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