1. Battery Management System (BMS), which manages the electronics of a rechargeable battery, whether a cell or a battery pack, thus becomes a crucial factor in ensuring electric vehicle safety. It safeguards both the user and the battery by ensuring that the cell operates within its safe operating parameters. BMS monitors the State Of Health (SOH) of the battery, collects data, controls environmental factors that affect the cell, and balances them to ensure the same voltage across cells. A battery pack with a BMS connected to an external communication data transfer system or a data bus is referred to as a smart battery pack.

A smart battery pack can manage its own charging, generate error reports, detect and notify the device of any low-charge condition, and predict how long the battery will last or its remaining run-time. It also provides information about the current, voltage, and temperature of the cell and continuously self-corrects any errors to maintain its prediction accuracy.

Battery management systems keep the battery safe, reliable, and increase the senility without entering a damaging state. Different monitoring techniques are used to maintain the state of the battery, voltage, current, and ambient temperature. The BMS communicates with the onboard charger to monitor and control the charging of the battery pack. It also helps maximize the range of the vehicle by optimally using the amount of energy stored in it. It is a crucial component in electric vehicles to ensure that batteries do not get overcharged or over discharged, thus avoiding damage to the battery and harm to occupants.

BMS can be classified into 2:

1. Hardware BMS
2. Software BMS

Hardware BMS is an inevitable component of an EV. The functionality of the BMS is related to the cost of an EV, but a BMS consists of these basic functions.

* Over voltage cutoff
* Under voltage cutoff
* Continues current
* Over current detection
* Over temperature cutoff

 Software BMS consist of all the features like hardware BMS. Data Manipulation is the main feature of it. They can control data, transmit data via CAN, Bluetooth. A smart BMS offers benefits such as online monitoring for battery status regarding voltage, current, impedance, internal temperature, etc. 24/7 monitoring allows for timely response in case of potential battery accidents while reducing human maintenance costs.real-time alarming and online balancing enables the system to analyze uploaded data and auto-judge. A smart BMS can be called a BMS data center due to all the historical data collection, storage, and analysis. At the same time, you can get real-time battery information via a certain system. Additionally, it is straightforward to set up and operate due to the friendly user interface design of the smart BMS.

Types of battery management systems

1.Centralized BMS Architecture

Has one central BMS in the battery pack assembly. All the battery packages are connected to the central BMS directly. The centralized BMS has some advantages. It is more compact, and it tends to be the most economical since there is only one BMS. However, there are disadvantages of a centralized BMS. Since all the batteries are connected to the BMS directly, the BMS needs a lot of ports to connect with all the battery packages. This translates to lots of wires, cabling, connectors, etc. in large battery packs, which complicates both troubleshooting and maintenance.

2.Modular BMS Topology

Similar to a centralized implementation, the BMS is divided into several duplicated modules, each with a dedicated bundle of wires and connections to an adjacent assigned portion of a battery stack. In some cases, these BMS sub modules may reside under a primary BMS module oversight whose function is to monitor the status of the submodules and communicate with peripheral equipment. The downside is overall costs are slightly higher, and there may be duplicated unused functionality depending on the application.

3.Primary/Subordinate BMS

Conceptually similar to the modular topology, however, in this case, the slaves are more restricted to just relaying measurement information, and the master is dedicated to computation and control, as well as external communication. So, while like the modular types, the costs may be lower since the functionality of the slaves tends to be simpler, with likely less overhead and fewer unused features.

4.Distributed BMS Architecture

The electronic hardware and software are encapsulated in modules that interface to the cells via bundles of attached wiring. A distributed BMS incorporates all the electronic hardware on a control board placed directly on the cell or module that is being monitored. This alleviates the bulk of the cabling to a few sensor wires and communication wires between adjacent BMS modules. Consequently, each BMS is more self-contained, and handles computations and communications as required. However, despite this apparent simplicity, this integrated form does make troubleshooting and maintenance potentially problematic, as it resides deep inside a shield module assembly. Costs also tend to be higher as there are more BMSs in the overall battery pack structure.

2.

There are Mainly 6 components for a battery management system.

Battery cell monitor

A battery cell monitor primarily monitors the voltages for battery systems. It is a high-speed system that offers a low overall cost for high voltage measurements.

The easiest way to determine the battery pack’s charge is to monitor individual cell voltage with reference to the set voltage level.

When the voltage of the first cell reaches the voltage limit, the charging automatically trips. It indicates that the battery charging limit has been reached.

If the battery pack has a lesser charge than the average cell, then the least charged cell will reach the limit first, and the rest of the cells will be left partially charged.

Cutoff FETs

FET driver is accountable for connection and isolation between load and charger of the battery pack. The behavior prediction is done through voltage, current measurements, and real-time detection circuitry.

They can be connected to a battery pack’s low or high side.

NMOS FETs activation is needed for enabling high-side connection and requires a charge pump driver. A reference for the solid ground is set using a high-side driver for the rest of the circuitry.

We use a low-side FET driver to reduce costs in integrated solutions since a charge pump is not needed. High voltage devices are not required in such cases.

The ground connection of the battery pack floats using low-side cut-off FETs. This can affect the IC performance, making it more sensitive to insinuated noise measurement.

 Monitoring of Temperature

With the increase in product requirements, the batteries have been on a constant surge in delivering currents at fixed voltages. The continuous operation processes may cause a catastrophic event such as fire or explosion.

We can identify whether battery charging or discharging is desirable using temperature measurements.

Temperature sensors monitor the energy storage system or cell grouping for compact portable applications.

The circuit temperature is monitored by the internal ADC voltage-powered thermistor. Employing the internal voltage reference helps reduce the temperature inaccuracies and improves the overall measurement system.

Cell voltage balance

It is crucial to determine the health of the battery pack. That is why cell voltage monitoring is done to ensure that the cells are in a proper running condition for attaining a long battery life.

The operating voltage ranges from 2.5V to 4.2V in a lithium-ion battery.

The battery life is significantly affected while performing battery operations beyond the voltage range. This reduces the life of a cell, which may even make it unfit for use.

Connecting the battery pack in parallel increases the overall drive current, whereas series connection adds the overall voltage.

 BMS Algorithms

To make quick and effective decisions in real-time based on the information received. For this purpose, a microcontroller for battery management system is needed to collect, organize and assess the information from the sensing circuitry.

 Real-Time Clock

Allowing the user to know the battery pack’s behavior before any alarming event, the real-time clock acts as a black box system for time-stamping and memory storage.

3.

The main goal of BMS is to keep the battery within the safety operation region in terms of voltage, current, and temperature during the charge, the discharge, and in certain cases at open circuit. BMS Communication is used for communication between devices .for, example , CAN 2.0 BMS send communication from the battery to vehicle control unit(VCU). It can continuosly transmit data to the battery’s thermal profile and monitor its temperature continously.It Uses collected data points (Temperature, Voltage,Current) to estimate SOC, SOH etc of the battery pack.Data can be either be stored or can be transmitted by CAN to VCU or sent to cloud.

 UART

UART, which stands for Universal Asynchronous Receiver/Transmitter, is the most widely used communication protocol used in battery management systems.UART is a form of serial communication, which means bits are sent one after another sequentially instead of multiple bits sent at once which is what occurs with parallel communication.The UART communication is widely used for communication between a microcontroller and the BMS IC in a BMS. It is also used for communication between the microcontroller and the GSM, bluetooth, or WIFI modules. It is also used extensively for debugging purposes when developing the firmware of a BMS to check particular sections or lines of code; using UART, the output of code can be printed and displayed on a screen.In UART communication, two UARTs communicate directly with each other.UARTs transmit data asynchronously, which means there is no clock signal to synchronize the output of bits from the transmitting UART to the sampling of bits by the receiving UART.

 I2C

I2C, Inter-Integrated Circuits communication, is a protocol used for IC to IC communication.I2C is intended primarily for short-distance communication between 2 ICs (Integrated Circuits) on the same printed circuit board (PCB).I2C allows Multi Master - Multi Slave topology.The I2C is a standard bidirectional interface that uses a controller known as the master to communicate with slave devices. Examples of slave devices include things such as an RTC clock, an EEPROM, flash memory, or SD card memory. The device that generates the clock is the master device, while all other devices are slave devices.Each device on the I2C bus has a specific device address to differentiate between other devices that are on the same I2C bus.A device can have one or multiple registers where data is stored, written, or read.

SPI

SPI, Serial Peripheral Interface, is a master-slave type protocol that provides a simple and low cost interface between a microcontroller and its peripherals.The SPI protocol uses a dedicated clock signal that is created by the master device to synchronize the transmitter and receiver or Master and Slave.One device is considered the Master of the bus (usually a microcontroller) and all the other devices (peripheral ICs or even other microcontrollers) are considered as slave devices.The microcontroller can communicate with the BMS IC via SPI communication, along with other peripheral devices that can communicate with SPI communication. These applications omc;ide memory devices such as SD cards, MMC, EEPROM, or Flash, sensors such as temperature or pressure sensors, control devices such as ADC, DAC, digital POTs, and audio codec, and other devices such as touch screen devices, LCD devices, RTC, or video game controllers.SPI communication uses 4 lines for each device. There is an input data line (receiving data), and output data line (transmitting data), a clock line, and a chip select line to identify which slave device the master is trying to communicate with. If there are multiple SPI slave devices connected to the master, then the chip select line functions to select the specific slave device either to transmit data to it or receive data from it.Specifically, the pins of a SPI bus are MOSI (Master Out, Slave In), MISO (Master In, Slave Out), SCLK (Serial clock), and CS or SS (Chip Select or Slave Select). The MOSI is how the master device transmit data to the slave and the MISO is how the master device reads information from a slave device.

 CAN

CAN, Controller Area Network, is the most widely used communication protocol in the automotive industry. CAN communication are used frequently in automotive applications because it removes all signal noises such as electromagnetic noises. It also removes a host of wire harnesses from a system. It is one of the most robust and reliable communication protocols.CAN applications can be used in simple to extremely complex applications.They are used in both gasoline and electric vehicles.The CAN protocol is used with a chip that allows for CAN communication. Texas Instruments is one manufacturer which makes CAN chips that allow for CAN communication between devices. One example of this is the TCAN1042-Q1 Automotive Fault Protected CAN Transceiver with CAN FD.