Q1. What is a BMS? Types of BMS and differentiate the types of BMS.

ANS:

Thus, an essential component in guaranteeing the security of electric vehicles is a battery management system (BMS), which controls the electronics of a rechargeable battery, whether a cell or a battery pack. By confirming that the cell runs within its safe operating parameters, it protects both the user and the battery. BMS collects information, manages environmental elements that impact the cell and balances them to guarantee that all cells have the same voltage. It also maintains the battery's State Of Health (SOH). A smart battery pack is a battery pack that has a BMS coupled to an external data bus or communication system.

A smart battery pack has the capacity to manage its own charging, provide error reports, and recognize and warn a device when the battery is becoming low. Battery management technologies maintain the battery's safety and dependability while allowing it to age more slowly without being damaged. The battery's condition, the voltage, the current, and the surrounding temperature are all monitored using various approaches. To monitor and manage the battery pack's charging, the BMS interacts with the onboard charger. By employing the energy stored in the vehicle to its fullest potential, it also increases range. Making ensuring batteries in electric cars don't get overcharged or over discharged is essential to preventing damage to the battery and injury to the occupants.

The BMS carries out crucial tasks and functions such:

* Temperature, Current and voltage control and measurement
* SOC and SOH assessment
* Fault detection
* Passive cell balancing
* storage of data

Normally BMS can be classified into two:

1. Hardware BMS
2. Software BMS

A hardware BMS is a necessary part of an EV. A BMS comprises of these fundamental operations, however its functionality and an EV's price are connected.

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

 All the functionalities found in hardware BMS are also included in software BMS. Its primary characteristic is data manipulation. They are data controllers and can Bluetooth and can send data. Benefits of a smart BMS include online monitoring of the battery's voltage, current, impedance, internal temperature, and other parameters. Continuous monitoring lowers the cost of human maintenance while enabling prompt action in the event of possible battery mishaps. The system can automatically appraise and analyse uploaded data thanks to real-time alarms and online balancing. For instance, you may establish a custom alert threshold, and if the uploaded data is anomalous, the system will send a server-based alarm to maintenance. Due to all the historical data collecting, storage, and analysis, a smart BMS might be referred to as a BMS data centre. In addition, a specific mechanism enables you to get real-time battery information. Additionally, it is simple to set up and run because to the smart BMS's user-friendly interface design. The smart BMS is used as a helper in many sectors because of its many advantages.

Types of battery management systems

1.Centralized BMS Architecture

consists of a battery pack assembly with a single central BMS. Direct connections have been made between the central BMS and each battery package. Figure 6 depicts a centralized BMS's construction. There are various benefits to the centralized BMS. Since there is just one BMS, it tends to be more compact and more affordable. But there are drawbacks to a centralized BMS. Since every battery is directly connected to the BMS, the BMS requires a large number of ports to connect with every battery package. Large battery packs consequently have a lot of cables, cabling, connections, etc., which makes maintenance and troubleshooting more difficult.

2.Modular BMS Topology

The BMS is separated into numerous replicated modules, much like a centralized implementation, each with a specific bundle of wires and connects to a neighboring designated area of a battery stack.  These BMS submodules could occasionally be supervised by a main BMS module, whose job it is to keep track of their state and interact with ancillary hardware. Duplicated modularity makes troubleshooting and maintenance simpler, and it makes it simple to expand to bigger battery packs. The drawbacks include somewhat greater total expenses and potential for redundant, underutilised capability, depending on the application.

3.Primary/Subordinate BMS

Although conceptually similar to the modular structure, the slaves in this scenario are more limited to just relaying measurement data, while the master is solely responsible for calculation, control, and external communication. As a result, even while the slaves' functionality tends to be simpler than that of the modular types, there may be less overhead and less unnecessary features.

4.Distributed BMS Architecture

The electrical hardware and software in these topologies are contained in modules that connect to the cells by bundles of connected cabling, which is significantly different from the other topologies. A control board located on the cell or module being monitored houses all the electronic gear in a distributed BMS. As a result, the majority of the wiring is reduced to a few sensor wires and communication cables connecting nearby BMS units. Each BMS becomes more independent as a result and manages calculations and communications as needed. Although it appears straightforward, its integrated form might make maintenance and troubleshooting difficult because it is tucked away inside a shield module assembly. As there are more BMSs in the total battery pack construction, costs also tend to be greater.

Q2. What are the technical parameters to keep in mind while procuring a BMS for assembling a battery pack?

ANS:

Mainly, there are 6 components for a battery management system.

1. Battery cell monitor

2. Cutoff FETs

3. Monitoring of Temperature

4. Cell voltage balance

5. BMS Algorithms

6. Real-Time Clock (RTC)

1. Battery cell monitor

The voltages for battery systems are typically monitored via a battery cell monitor. For high voltage measurements, it is a fast system with a reasonable total cost.

Monitoring each cell voltage in relation to the predetermined voltage level is the simplest technique to assess the battery pack's charge.

The charging automatically stops when the first cell's voltage hits the voltage limit. It serves as a warning when the battery charge cap has been exceeded.

The least charged cell will approach the limit first and the remaining cells will be left partially charged if the battery pack has a lower charge than the average cell.

2. Cutoff FETs

The battery pack's load and charger must be connected and kept separate by the FET driver. Voltage, current, and real-time detecting circuitry readings are used to forecast behaviour.

They may be attached to either the low or high side of a battery pack.

To enable high-side connection, NMOS FETs must be activated, which calls for a charge pump driver. For the remaining circuitry, a high-side driver is used to set a reference for the solid ground.

Since a charge pump is not required in integrated systems, we employ a low-side FET driver to cut expenses. In such circumstances, high voltage devices are not necessary.

3. Monitoring of Temperature

The batteries have been experiencing an ongoing rise in the delivery of currents at fixed voltages due to the growth in product needs. A catastrophic event like a fire or explosion might be brought on by the ongoing operation procedures.

Temperature data allow us to determine if battery charging or draining is desired.

Temperature sensors are used in small, portable applications to keep an eye on the energy storage system or cell cluster.

The inbuilt ADC voltage-powered thermistor keeps track of the temperature of the circuit. By using the internal voltage reference, the measuring system as a whole is improved and temperature errors are reduced.

4. Cell voltage balance

It is essential to ascertain the battery pack's condition. To make sure that the cells are functioning properly in order to achieve a long battery life, cell voltage monitoring is carried out as a result.

In a lithium-ion battery, the operating voltage varies from 2.5V to 4.2V.

When battery activities are performed outside of the voltage range, the battery life is dramatically impacted. A cell's life span is shortened as a result, perhaps rendering it useless.

While connecting the battery pack in series raises the total voltage, connecting it in parallel increases the overall driving current.

5. BMS Algorithms

To act quickly and wisely in the present depending on the knowledge acquired. A microcontroller for battery management system is required for this task in order to gather, arrange, and evaluate the data from the sensor circuits.

The most well-known use of a battery management system algorithm is the Renesas ISL94203. It is a digital standalone solution that is integrated onto a single chip and has programmable features.

These stand-alone methods may be used to clean the memory and microcontroller for battery management system clock cycles.

6. Real-Time Clock

The real-time clock functions as a "black box" device for time-stamping and memory storing, letting the user know the battery pack's behaviour prior to any warning incident.

Battery authentication prevents the BMS electronics from syncing with a different battery pack.

Through a voltage reference/regulator, the peripheral power circuitry is employed around the battery management system's components.

Q3. What is the purpose of BMS with communication? What are the various protocols of communication used in a BMS?

ANS:

In terms of voltage, current, and temperature, the fundamental objective of BMS is to keep the battery within the safe operating range while it is being charged, discharged, or in some circumstances, when it is open circuit. You often utilise a BMS IC while working with a BMS. You might need to link to an external microcontroller or another external IC, depending on the BMS IC being used to operate your BMS. To send and/or receive information from one another, these ICs must be able to communicate with one another. You might not be able to measure current with your BMS IC, for instance. As a result, you employ an external IC for current measurement. The BMS IC must then receive this current data.

1. UART

The most popular communication protocol used in battery management systems is UART, which stands for Universal Asynchronous Receiver/Transmitter. In serial communication, like UART, bits are transferred sequentially one after the other as opposed to simultaneously in parallel communication, when several bits are sent. A microcontroller and the BMS IC in a BMS frequently communicate using the UART protocol. Additionally, it is employed for interfacing the microcontroller with the GSM, Bluetooth, or WiFi modules. When a BMS's firmware is being developed, it is frequently used for debugging to examine specific portions or lines of code. UART allows code output to be written and shown 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.UARTs do not operate on clock signals but with baud rates. The baud rate is the speed of data transfer expressed in the number of bits per second that the communication occurs in. The baud rates must be set equally on the transmitting and receiving ends in order for communication to work. The baud rates can only vary by about 10% before the timing of the bits goes too far off.Only 2 wires are needed to transmit data between 2 UART devices. For example, if we have 2 devices, device 1 and device 2, each device has 2 connections, Rx and Tx. The Tx of each device connects to the Rx of the other device. This way the transmitting data of one device goes to the receiving end of the other device, thus, establishing communication.

2. 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.

The physical I2C interface consists of the serial clock (SCL) and serial data (SDA) lines. Both SDA and SCL lines must be connected to VCC through a pull-up resistor.Being that the SDA line is bidirectional, it functions to transmit data or receive data.

3. SPI

A master-slave protocol known as SPI, or serial peripheral interface, offers a straightforward and inexpensive interface between a microcontroller and its peripherals. The SPI protocol synchronises the transmitter and receiver, or Master and Slave, using a dedicated clock signal generated by the master device. All other devices, such as peripheral ICs or even additional microcontrollers, are referred to as slave devices since only one device—typically a microcontroller—is designated as the bus's master. Along with other peripheral devices that support SPI communication, the microcontroller may connect with the BMS IC via this protocol. 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.

SPI communication is a full-duplex communication that occurs with very high speeds. By full duplex, it is meant that the transmission and receiving of data can occur simultaneously. This is advantageous over UART or I2C communication, in which there can only be transmission or receiving of data that can occur at a given time but not both simultaneously. The disadvantage of SPI is that 4 wires are required instead of 2 for UART and I2C.

4. CAN

In the automobile sector, the most used communication protocol is called CAN, or Controller Area Network. Because CAN communication eliminates all signal disturbances like electromagnetic sounds, it is commonly utilised in automobile applications. Additionally, it gets rid of a lot of wire harnesses from a system. One of the strongest and most dependable communication protocols is this one. Applications utilising CAN can range from being very simple to being quite complicated. They are utilised in both electric and gasoline-powered cars. A chip that supports CAN communication is used in conjunction with the CAN protocol. 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.

The CAN chip links to the microcontroller, and the CAN chip then connects to the external devices. TXD and RXD pins on the CAN chip enable communication with the microcontroller. The TXD pin is used for data transmission, whereas the RXD pin is used for data reception. Thus, these are the battery management systems' most popular and widely utilised communication protocols.