ABSTRACT

The world is struggling with the pollution caused by harmful gases released by automobiles. Electric Vehicle Technology can be proved as a boon that can be a solution for this problem. But still Electric Vehicles are facing many challenges regarding to Battery Management System, Fire Safety, Charging stations, Charge Monitoring systems,etc. The Battery Management System plays a pivotal role in any electric vehicle which comprise of monitoring, controlling safeguarding the battery pack and thereby certifying the optimal conduction, permanence and safety. With the advancement of IoT (Internet of Things), we can control anything remotely, efficiently and safely. It also sends the alert while it is facing over voltage, temperature and current. It is also beneficial for cloud integration where the data will be sent to the cloud for remote monitoring and it also provides an easy platform for the vehicle owners to access and understand battery relatedinformation. An effective battery management system of an electric vehicle can beachieved with charge monitor and fire protection using IoT consists of Lithium-ion batteries that are commonly used in electric vehicles which can be harmful if not operatedin Safety Operation Area(SOA) as it has greater charge density and much more charge cycles as compared to any battery cell available in the market.

TABLE OF CONTENT

LIST OF FIGURES

+

LIST OF TABLES

TABLE OF ACRONYMS

EV – Electric Vehicle

BMS – Battery Management System

IoT – Internet of Things

BEV - Battery Electric Vehicles

PHEV - Plug-in Hybrid Electric Vehicles

HEV - Hybrid Electric Vehicles

FCEV - Fuel Cell Electric Vehicles

CHAPTER 1
INTRODUCTION

1.1 ELECTRIC VEHICLE

Compared with traditional vehicles, new energy vehicles have the advantages of low pollution, high energy efficiency and low operating cost. The operation benefit of order charging is verified by constructing order charging on the power grid side. The vigorous development of electric vehicles is one of the greatest significances to adjust the optimal designing of industrial structure and promote the sustainable development of industry. In view of the problems existing in the development of electric vehicles at the present stage, the state focuses on the research and development of charging problems of electric vehicles, and carries out researching on the safety and power supply of charging equipment at the present stage so, as to form a safety and effective charging safety system. Through the research of this paper, a set of grid-charging safety warning system is established to promote it. [1] The development of electric vehicles have been guided significance. There are differenttypes of Electric vehicles like Hybrid vehicles, plug-in hybrids, and battery electric vehiclesin the market Battery electric vehicle is a pure electric vehicle, that runs only on electricity.In this paper, BEV (battery electric vehicle) is considered for the analysis and study of the temperature impacts on the range as well as on the characteristics of the battery. The biggestbenefit of battery electric vehicles is that they produce no emissions and are environmentally friendly. The main components of BEV are a traction battery pack, DC-DC converter, inverter, motor, controller, and onboard charger. The battery of a BEV stores electrical energy as direct current (DC). If the battery receives a signal from the controller, it will deliver DC to the inverter, which will then be used to run the motor.[2]

Air pollution is the major problem facing in today's world. Air pollution is caused by many reasons like fuel vehicle, ICE based transportation, bad air produced by industries etc. Air pollution produced by ICE based transportation is by above 45%. So now a days researcher is moving towards non-fueled vehicle transportation. The only solution for this is battery electric vehicles. Transportation industry have high attention on EV. This paper focus on design and analysis of BLDC motor used in EV. The major drawback of EV is cost. The high-capacity vehicles required a high-capacity battery and high cost. Automobiles, particularly those reliant on traditional combustion engines, have long been significant contributors to environmental pollution. The combustion of fossil fuels in these vehicles releases a plethora of harmful pollutants into the atmosphere, including carbon dioxide, nitrogen oxides, sulfur oxides, and particulate matter. These emissions not only degrade air quality but also contribute to climate change and pose serious health risks to human populations. In contrast, electric vehicles (EVs) offer a promising solution to mitigate such pollution. By utilizing electric powertrains, EVs produce zero tailpipe emissions, thereby reducing the release of harmful pollutants into the air. Additionally, as the electricity grid continues to transition towards cleaner energy sources such as renewables, the overall environmental impact of EVs is further diminished. Thus, the adoption of electric vehicles presents a crucial opportunity to combat pollution and foster a more sustainable transportation system. It also helps to provide a clean environment to the society.[3]

Electric vehicles (EVs) offer several advantages over traditional internal combustion engine vehicles, making them an increasingly popular choice for consumers and policymakers alike. Some of the key pros of electric vehicles includes that EVs produce zero tailpipe emissions, significantly reducing air pollution and greenhouse gas emissions compared to gasoline or diesel-powered vehicles. This helps mitigate climate change and improve local air quality, particularly in urban areas where vehicular emissions are a significant contributor to pollution. Electric motors are more efficient than internal combustion engines, converting a higher percentage of energy from the battery into propulsion. This results in lower energy consumption per mile traveled, reducing overall energy consumption and dependence on fossil fuels.[4] EVs have lower fuel and maintenance costs compared to conventional vehicles. Electricity is generally cheaper than gasoline or diesel on a per-mile basis, resulting in lower fuel expenses. Additionally, EVs have fewer moving parts and require less frequent maintenance, leading to reduced maintenance and repair costs over the vehicle's lifetime. Electric motors deliver instant torque, providing smooth and responsive acceleration, often outperforming traditional combustion engine vehicles in terms of acceleration and overall driving experience. EVs also tend to have a lower center of gravity due to the placement of heavy batteries, contributing to better handling and stability. Electric vehicles operate more quietly than internal combustion engine vehicles, leading to reduced noise pollution in urban environments. This can improve the overall quality of life for residents and contribute to a more pleasant driving experience. By reducing dependence on imported oil and transitioning to domestically produced electricity, countries can enhance energy independence and security. This can also lead to economic benefits by stimulating local renewable energy industries and reducing trade deficits associated with oil imports. Overall, electric vehicles offer numerous advantages that make them an attractive and sustainable alternative to traditional vehicles, contributing to a cleaner environment, lower operating costs, and enhanced energy security.

Installing electric vehicle (EV) infrastructure at a national level requires careful planning, investment, and coordination among various stakeholders. Establishing supportive policies and regulations is crucial to promote the adoption of electric vehicles. This may include incentives such as tax credits, rebates, subsidies for EV purchases, and mandates for automakers to produce a certain percentage of electric vehicles. Clear regulations regarding the installation and operation of EV charging infrastructure are also necessary. Apart from that adequate funding and investment are essential to develop and deploy EV infrastructure. This may involve public-private partnerships, government grants, subsidies, and incentives to encourage investment in charging infrastructure by businesses and utility companies. Installing a comprehensive network of EV charging stations is essential to support widespread adoption of electric vehicles. This includes various types of charging stations, such as Level 1, Level 2, and DC fast chargers, strategically located in urban areas, highways, workplaces, parking lots, and residential areas. Ensuring the electric grid has the capacity and stability to support increased demand from electric vehicles is crucial.

Upgrading and modernizing the grid infrastructure, integrating renewable energy sources, and implementing smart grid technologies can help manage electricity demand from EV charging effectively. Establishing interoperability standards for EV charging infrastructure ensures compatibility between different EV models and charging stations. Standardization of connectors, communication protocols, and payment systems simplifies the charging experience for EV owners and promotes market competition. Educating the public about the benefits of electric vehicles, EV charging infrastructure, and the transition to sustainable transportation is essential. Public awareness campaigns, outreach programs, and educational initiatives can help dispel myths, address concerns, and encourage EV adoption. Developing a skilled workforce capable of installing, maintaining, and servicing EV infrastructure is essential. Training programs, certification courses, and apprenticeships can help build a qualified workforce to support the growth of the EV industry. Collecting data on EV adoption, charging patterns, grid impact, and user behavior is important for informed decision-making and planning. Data analytics can help optimize the deployment of EV infrastructure, identify areas of high demand, and improve the efficiency of charging networks.

By addressing these requirements, countries can create an enabling environment for the widespread adoption of electric vehicles and the development of a robust EV charging infrastructure, contributing to a cleaner and more sustainable transportation system.[5]

1.2 TYPES OF ELECTRIC VEHICLES

Electric vehicles are of mainly four types:-

1. Battery Electric Vehicles (BEVs)
2. Plug-in Hybrid Electric Vehicles (PHEVs)
3. Hybrid Electric Vehicles (HEVs)
4. Fuel Cell Electric Vehicles (FCEVs)

1.2.1 Battery Electric Vehicles (BEVs) :

Battery Electric Vehicles (BEVs) are the epitome of electrification, embodying the future of automotive innovation! Unlike their fossil-fueled counterparts, BEVs eschew traditional combustion engines in favor of pure, unadulterated electric power. Picture this: no more trips to the gas station, no more emissions choking the environment – just smooth, silent, and sustainable transportation. At the heart of every BEV lies a majestic battery pack, a reservoir of energy waiting to be unleashed upon the open road. These batteries, adorned with the latest advancements in lithium-ion technology, serve as the lifeblood of the vehicle, empowering it with the strength to conquer even the most treacherous terrains. And oh, the power they possess! With a single charge, BEVs can travel distances that would make even the most seasoned road warrior gasp in awe. But the marvels of BEVs don't end there! Equipped with electric motors that rival the ferocity of a thousand stampeding stallions, these vehicles accelerate with the grace and swiftness of a cheetah on the hunt. Say goodbye to sluggish starts and hello to instant torque – the kind that pins you to your seat and sends shivers down your spine with every press of the pedal. In conclusion, Battery Electric Vehicles are not just vehicles – they're a revolution, a testament to human ingenuity and our unwavering commitment to a greener, cleaner future. So, embrace the power of BEVs and embark on a journey towards a world where the only thing we leave behind is our tire tracks.[6]

1.2.2 Plug-in Hybrid Electric Vehicles (PHEVs) :

Plug-in Hybrid Electric Vehicles (PHEVs) are the epitome of versatility, seamlessly blending the best of two worlds – the electrifying efficiency of electric power and the convenience of gasoline backup. Imagine a vehicle that offers the freedom to drive on pure electric power for short distances while also providing the peace of mind of extended range capability thanks to its gasoline engine. The magic happens when the PHEV is plugged in to charge. Like a thirsty traveler replenishing its water supply, the vehicle eagerly drinks in electricity, filling its battery with the energy needed for electric-only operation. This charging process can occur at home, at work, or at public charging stations, offering unparalleled convenience and flexibility to PHEV owners. But here's where the brilliance of PHEVs truly shines – their ability to seamlessly transition between electric and hybrid modes. During short trips or daily commutes, PHEVs glide silently along on electric power, emitting zero tailpipe emissions and sipping electricity like fine wine. But when the journey extends beyond the electric range, fear not! The gasoline engine springs to life, effortlessly propelling the vehicle forward while simultaneously recharging the battery for the next electric adventure. In conclusion, Plug-in Hybrid Electric Vehicles represent the pinnacle of automotive engineering, offering the perfect balance between electrification and practicality. With their ability to drive on electric power alone, coupled with the flexibility of gasoline backup, PHEVs are poised to lead the charge towards a cleaner, greener future on the road.[7]

1.2.3 Hybrid electric vehicles (HEVs) :

Hybrid Electric Vehicles (HEVs) are the epitome of automotive ingenuity, seamlessly blending the efficiency of electric power with the reliability of internal combustion engines. Imagine a vehicle that harnesses the best of both worlds, delivering unmatched fuel efficiency without sacrificing performance or convenience. At the heart of every HEV lies a sophisticated powertrain, meticulously engineered to optimize efficiency and minimize environmental impact. Picture this: a powerful electric motor working in harmony with a gasoline engine, each contributing its unique strengths to propel the vehicle forward. Unlike traditional vehicles, where the gasoline engine bears the brunt of the workload, HEVs distribute power between the electric motor and the engine, optimizing efficiency and reducing fuel consumption. But here's where the magic happens the seamless integration of electric and gasoline power. During low-speed driving or idling, the electric motor takes center stage, silently propelling the vehicle forward with whisper-like efficiency. This allows HEVs to operate in electric-only mode, emitting zero tailpipe emissions and conserving fuel in the process. But when the need for additional power arises, such as during acceleration or high-speed driving, the gasoline engine springs into action, seamlessly providing the extra oomph needed to propel the vehicle forward. But the brilliance of HEVs doesn't end there! Through a process called regenerative braking, HEVs are able to capture kinetic energy during deceleration and braking, converting it into electrical energy to recharge the vehicle's battery. This innovative technology not only improves overall efficiency but also extends the driving range of the vehicle, allowing HEV owners to travel farther on a single tank of gas. In conclusion, Hybrid Electric Vehicles represent the pinnacle of automotive engineering, offering unmatched efficiency, performance, and environmental responsibility. With their seamless integration of electric and gasoline power, HEVs are poised to lead the charge towards a cleaner, greener future on the road.[8]

1.2.4 Fuel Cell Electric Vehicles (FCEVs) :

Fuel Cell Electric Vehicles (FCEVs) are the pinnacle of automotive innovation, harnessing the power of hydrogen to propel humanity towards a sustainable and emission-free future. Imagine a vehicle that emits nothing but water vapor from its tailpipe, yet boasts the power and range to rival traditional gasoline-powered cars. That's the marvel of FCEVs. At the heart of every FCEV lies a cutting-edge fuel cell stack, a marvel of engineering that converts hydrogen gas and oxygen from the air into electricity through an electrochemical reaction. This electricity powers an electric motor, which in turn propels the vehicle forward with silent, efficient grace. But the wonders of FCEVs don't stop there. Unlike battery electric vehicles (BEVs) which require lengthy charging times, FCEVs can be refueled in a matter of minutes, offering the convenience and range of traditional gasoline-powered cars without the harmful emissions. And with hydrogen as its fuel source, FCEVs offer a level of energy density that rivals even the most advanced batteries, allowing for longer driving ranges and quicker refueling times. But perhaps the most remarkable aspect of FCEVs is their potential to revolutionize the transportation sector as a whole. With hydrogen as a versatile and abundant resource, FCEVs offer a pathway to decarbonizing not only passenger vehicles but also heavy-duty trucks, buses, and even ships. By leveraging hydrogen as a clean and sustainable fuel source, FCEVs have the power to reshape the way we think about transportation and propel us towards a future of zero-emission mobility. In conclusion, Fuel Cell Electric Vehicles represent the pinnacle of automotive engineering, offering unparalleled efficiency, performance, and environmental sustainability. With their ability to harness the power of hydrogen to generate clean electricity, FCEVs are poised to lead the charge towards a greener, brighter future on the road.[9]

1.3 CURRENT STATUS OF ELECTRIC VEHICLE IN INDIA

The dependency on fossil fuels is increasing as it is dominatingly used for heating, running vehicles, power industry, manufacturing, and for electricity. However, the advent of path-breaking electric vehicles technology in the world has led to low manufacturing and driving costs. The electric vehicle market will continue to grow and be dynamic due to high petroleum prices, new attractive EV modules, advances in battery technology with extending driving range. Thus, helping in reducing consumer concerns and future dependence on exhausting fossil fuels. In this context, we have highlighted the relevance of electric vehicles and their types in this research work. An online survey is conducted to showcase awareness, usage review, and future preferences for electric vehicles in the Indian market.[10]

India is steadily moving up on the path of development. However, this development has some apparent side effects. One of the major concerns of the country at this hour is the ever-increasing emissions from the millions of vehicles that run on the country's roads each day. The major pollutants emitted by ICE vehicles are gases like carbon dioxide, carbon monoxide, photochemical oxidants which are also called air toxins and include substances like benzene (C6H6), 1,3 butadiene (C4H6), lead (Pb), particulate matter (PM), hydrocarbon (HC) compounds like aldehydes, polycyclic aromatic hydrocarbons (PAHs) oxides of Sulphur (SO2) and nitrogen (NOx). India's first electric car was Reva by Mahindra. It was introduced in 2001 but it could sell a few units after its launch. In 2010, Toyota began the Prius hybrid model, followed by the Camry hybrid in 2013. Electric buses and hybrid vehicles have been commenced as a pilot proposal in a few cities like Mumbai, Bangalore and Delhi. India is in need of a transportation revolution. [9] The current trajectory of adding ever more cars running on expensive imported fuel and cluttering up already overcrowded cities suffering from infrastructure bottlenecks and intense air pollution is unfeasible. The transition to electric mobility is a promising global strategy for de-carbonising the transport sector. According to a report of statistics in 2021, India has the fourth-largest automobile industry worldwide. In the year 2022, India became the fourth- largest nation in the world by the automobile industry. India crossed Japan and Germany tobecome the third-largest vehicle market in the world as of 2022 in terms of sales of automotive. India is making rapid progress towards its aim of becoming carbon neutral by 2070. Generally, if the country wants to lower the emissions intensity of its GDP by 45% by 2030, which is a medium-term objective, it must bring the transport industry towards green energy. The status of electric vehicles in India may have evolved since then, with continued government support and increasing public awareness of environmental issues driving further growth in the EV sector. However, the specifics of this progress, such as the number of EVs on the road, the expansion of charging infrastructure, and any new policy developments, would require more recent information beyond current capabilities. For the latest updates on the electric vehicle landscape in India, it is recommend consulting recent news sources or government reports. The electric car has emerged as a feasible option for future green transportation. India is embracing this new wave of change for its renewable future of mobility, much like the rest of the world. Electric vehicles' working depends on the tractionof the battery pack. EVs plug into a charging station that allows them to draw power from the grid, which powers an electric motor and rotates the wheels by storing the electricity inrechargeable batteries. Electric automobiles are lighter to drive because they accelerate more quickly than cars with conventional fuel engines.[11]

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CHAPTER 2
LITERATURE SURVEY

2.1 LITERATURE SURVEY

This paper is about large scale li-ion battery management system over cloud computing, which basically gives an overview about the cloud computing algorithm for BMS of large li-ion battery, cloud-based health monitoring is discussed. This paper basically describes the monitoring of voltage, current, temperature via battery management system over cloud computing in real time monitoring, it also gives a hardware device overview. [14] This provides an IOT based solution towards venting of li-ion batteries due to overcharging .It suggests to installment of Current- Input- device in the cell structure more over it supports to have Built in positive temperature Coefficient.[12] This Paper Provides information about the Measurement of network impact from electric vehicles during fast and slow charging, 12the network impact provides information that there could be different impacts over fast charging and slow charging due to weak or strong grids or different areas for example Norway has Peak Load situation over some of the coldest winter days. [10] This paper is all about BMS it uses IOT based approach using SOC estimation, it suggests a system Connected with IEEE 802 in Wi-Fi standard, also installs WBMS i.e. wireless battery monitoring system and further concludes over middle ware application server and can run over a distance of 802.11 or packet core network by MQTT Server.[13] This paper works on the problem of SOC estimation for judgement of BMS, It propose an adaptive method of SOC estimation which gives a hybrid model based on conventional coulomb counting and with EKF correction this provides quick and reliable error monitoring and control and shows within 2% of error and 70% decreased complexity compared to EKF method of estimation of SOC.[14]

A Li-ion battery have numerous advantages as compared to other types of batteries available in the market. It is admirable due to high energy density, long life cycle, low self-discharge rate, fast charging, lightweight design, available in compatible designs and sizes and also requires low maintenance. Although it has some issues regarding safety but conclusively after evaluating all the parameters, we find that Li-ion battery is felicitous for the system. It is also beneficial for cloud integration where the data will be sent to the cloud for remote monitoring and it also provides an easy platform for vehicle owners to access and understand battery related information. Thus, BLDC motor will be a better to work in an Electric vehicle Device. It has better power to weight ration which provides better efficiency for vehicles. Opting Internet of Things(IoT) in Wireless Battery Management System(WBMS) of Electric Vehicles enhances the performance of EVs by contributing to improve reliability, safety and user satisfaction. It is best fit for the proposed system as it enabled BMS and allows for real-time monitoring of State of Charge(SoC) and State of Health (SOH) by equipping accurate information about basic parameters current charge level and overall health of the battery. It also sends the alert while it is facing over voltage, temperature and current.

CHAPTER 3
CHALLENGES FACED BY ELECTRIC VEHICLES

3.1 DUE TO OVER VOLTAGE

Overvoltage in Electric Vehicles (EVs) can pose various challenges and potential risks. Here are some of the key issues associated with overvoltage in EVs.

• **Safety Risks:** Overvoltage can lead to safety hazards, including the risk of thermal runaway or fire in the battery pack. Elevated voltage levels may exceed the safe operating limits of battery cells, causing them to overheat or experience other critical failures.

• **Battery Degradation:** Continuous exposure to overvoltage conditions can accelerate the degradation of battery cells. Higher voltage levels may cause increased stress on the cells, leading to a reduction in capacity, efficiency, and overall battery lifespan.

• **System Instability:** Overvoltage can lead to instability in the BMS and other electronic components within the EV. Unexpected voltage spikes can disrupt the proper functioning of the BMS, potentially causing system malfunctions and failures.

• **Costly Repairs:** Mitigating the effects of overvoltage may require costly repairs or replacements of damaged battery components and BMS. Unplanned maintenance and repairs can impact the overall cost of ownership for EV owners.

• **Charging Issues:** Overvoltage during the charging process can damage charging infrastructure and EV charging equipment. Incompatibility with charging stations or voltage irregularities during charging can lead to charging failures and potential safety risks. [15]

3.2 DUE TO HIGH TEMPERATURE

High temperatures in an Electric Vehicle's Battery Management System (BMS) can lead to several challenges and issues. The BMS plays a crucial role in managing and protecting the battery pack. Here are some challenges associated with high temperatures in an EV's BMS:

• **Thermal Run-Away Risk:** In extreme cases, if the BMS fails to manage temperature properly it may lead to thermal runaway, where the heat generated within the battery becomes uncontrollable and can result in catastrophic

• **Charging Difficulty:** Charging the battery at high temperatures can be challenging. Fast charging in particular temperature region generates heat, and if the battery is already at an elevated temperature, it may limit the charging rate to prevent further temperature rise. This can impact the convenience and efficiency of charging.

• **Safety Risk:** Excessive heat can pose safety hazards, especially in lithium-ion batteries commonly used in EVs. High temperatures can increase the risk of thermal runaway, which may lead to a fire or other catastrophic events. Safety features in the BMS are designed to mitigate these risks, but prolonged exposure to high temperatures can still compromise safety.[16]

Fig 1: Fire in Electrical Vehicle due to high temperature of Lithium-ion Battery [43]

3.3 DUE TO HIGH CURRENT

Overcurrent in Electric Vehicles (EVs) can present several challenges and risks, affecting various components within the vehicle's electrical system. Here are some of the key challengesassociated with overcurrent in EVs:

- **Electromagnetic Interference (EMI):** Overcurrent can result in increased value of the electromagnetic interference, affecting the proper functioning of sensitive electronic components in the vehicle. This interference can lead to malfunctions in communication systems, sensors, and other electronic devices.
- **Damage to Power Electronics:** Overcurrent can damage power electronics & some other components such as inverters, converters, and motor controllers. These components areresponsible for managing the flow of electrical energy between the battery and the electric motor. Excessive current can cause overheating and permanent damage to thesecritical components.
- **Charging Infrastructure Compatibility:** Overcurrent issues can increase to an extent of the charging infrastructure. If an EV draws more current than the charging station can safely provide, it may lead to compatibility issues, potential damage to the vehicle, or even damage to the charging station.[17]

3.4 SAFETY MEASURES TO SAVE A ELECTRIC VEHICLE

Ensuring the safety of an electric vehicle (EV) involves several measures, both in terms of preventing accidents and minimizing risks in case of emergencies. Here are some safety measures to consider:

- **Regular Maintenance:** Keep the vehicle well-maintained, including checking the battery, brakes, tires, and other critical components regularly.

- **Battery Safety:** Properly handle and maintain the battery system. Follow manufacturer guidelines for charging, storage, and maintenance. Avoid extreme temperatures and overcharging.
- **Charging Safety:** Use only approved charging equipment and follow safety instructions during charging. Avoid charging in extreme weather conditions or damaged outlets.
- **Emergency Procedures:** Familiarize yourself with emergency procedures specific to your EV, such as how to safely disconnect the battery in case of an accident or fire.
- **Fire Safety:** EVs have unique fire safety considerations due to their high-voltage systems. Firefighters should be trained in handling EV fires, and EV owners should know how to respond to a fire incident safely.[18]

By following these safety measures, we can help ensure the safe operation and longevity of our electric vehicle while minimizing risks to ourself and others on the road.

CHAPTER 4
BATTERY MONITORING TECHNOLOGY

4.1 OVERVIEW OF VARIOUS BATTER MONITORING SYSTEM

Battery monitoring system plays a very crucial role in the safety and performance of any EV battery. Some the Battery Monitoring System classified on the basis of medium of transfer information are described below:

4.1.1 Internet Of Things

The Internet of Things (IoT) is a concept that refers to the network of everyday objects connected to the internet, allowing them to send and receive data. These objects, ranging fromhousehold devices to industrial machinery, are embedded with sensors, software, and other technologies to collect and exchange information. IoT enables seamless communication between devices, creating a smarter and more interconnected world. Common examples include smart thermostats, wearable fitness trackers,and connected home appliances. These devices can be remotely monitored and controlled through the internet, enhancing efficiency and convenience.

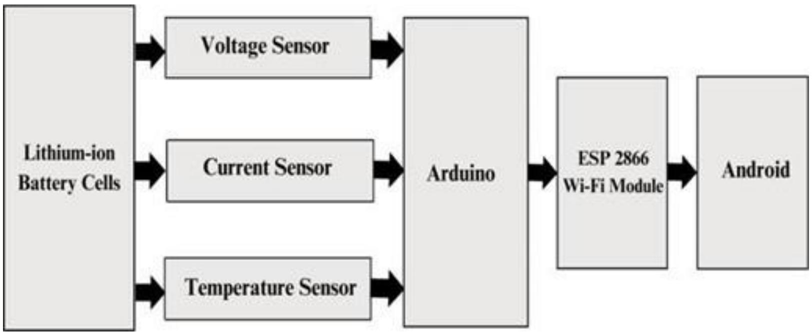

Fig 2 : Block diagram of IoT Based BMS [19]

The data generated by IoT devices can be analyzed to gain valuable insights, optimize processes, and improve decision-making. However, concerns about privacy and security in IoTcontinue to be important considerations. As IoT technology advances, its applications span various industries, such as healthcare, agriculture, transportation, and smart cities, contributingto a more efficient and responsive global ecosystem.

The system used will show the current location, battery status, and time via internet by incorporating GPS system which will be displayed on Google Map application. Opting Internet of Things(IoT) in Wireless Battery Management System(WBMS) of Electric Vehicles enhances the performance of EVs by contributing to improve reliability, safety and user satisfaction. It is best fit for the proposed system as it enabled BMS and allows for realtime monitoring of State of Charge(SoC) and State of Health (SOH) by equipping accurate information about basic parameters as current charge level and overall health of the battery. It also sends the alert while it is facing over voltage, temperature and current.

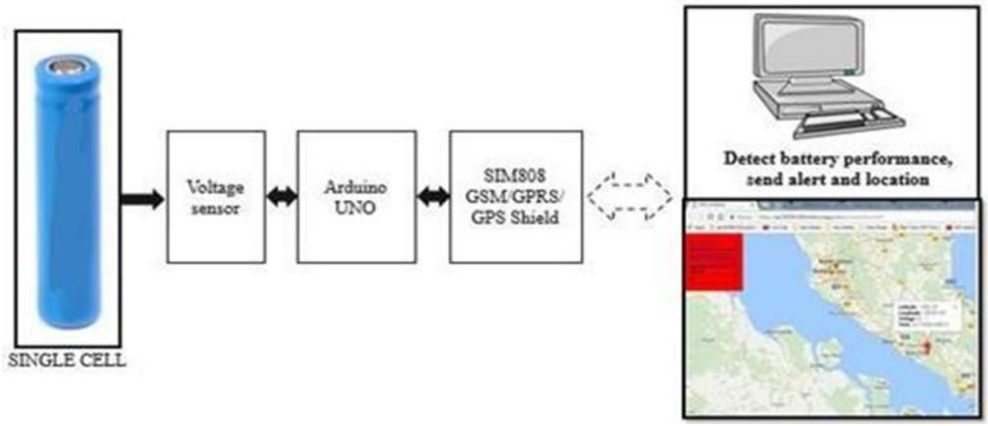

Fig 3 : Block diagram IoT based wireless BMS[20]

In Battery Management Systems (BMS), IoT plays a pivotal role by integrating smart technologies to monitor, control, and optimize the performance of batteries. IoT-enabled BMSutilizes sensors and connectivity to collect real-time data on crucial battery parameters like voltage, temperature, and state of charge

These connected systems allow for remote monitoring, enabling users to assess battery health and performance from anywhere. Through IoT, BMS can send alerts and notifications in caseof anomalies, preventing potential issues and enhancing overall safety. The data gathered by IoT in BMS is not only used for real-time monitoring but also for predictive maintenance. By analyzing usage patterns and performance trends, IoT helps predict when a battery might require maintenance or replacement, optimizing the lifespan of the battery.

Moreover, IoT facilitates the integration of BMS with other smart systems, creating a comprehensive energy management ecosystem. This interconnected approach enhances energyefficiency, reduces downtime, and contributes to sustainable practices in various sectors, including electric vehicles, renewable energy storage, and industrial applications.

4.1.2 Cloud Battery Management Platform

The CBMP has four distinct cloud components: storage, analytics tools, battery algorithms, and visualization. The system is designed for assisting monitoring battery health conditions and optimal battery power management. The cloud storage stores the battery data and the estimated health conditions of the individual battery cells. Analysis tools may include:

- The scalable high-performance parallel computing to handle large numbers of battery and high computational battery health algorithms very fast.
- Data mining and machine learning tools to find abnormal battery cells in the group of batteries .
- Optimization algorithms to make optimal decisions given health conditions and demand of smart grid.

Therefore, the analytics tools that use the sensor data along with historical records that are becoming prevalent can help with diagnoses and prognoses for a number of health conditions and cell failures as well as optimal.

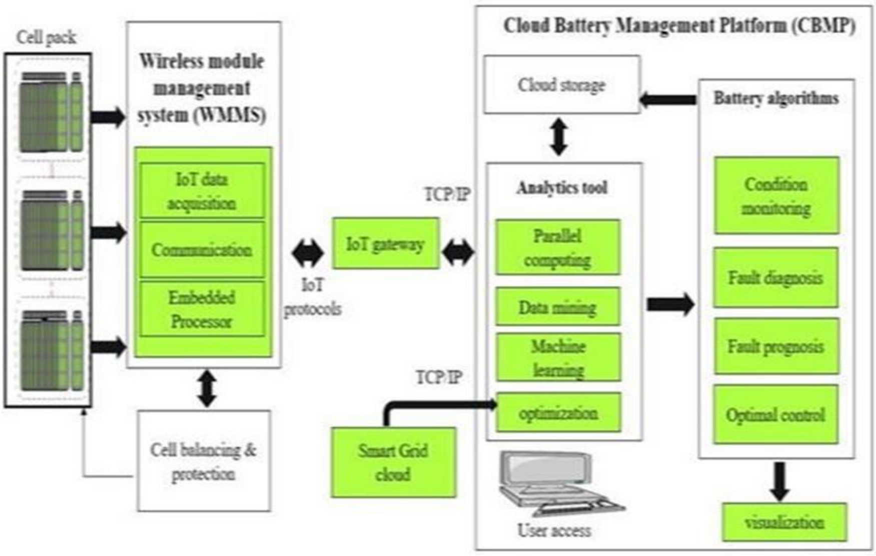

Fig 4 : Block diagram of Cloud based Wireless BMS [20]

4.1.3 Bluetooth Technology

Bluetooth technology plays a crucial role in Battery Management Systems (BMS), offering wireless communication capabilities that enhance monitoring, control, and data exchange. Here’s how Bluetooth is Utilized in BMS:

- **Wireless Data Transmission**: Bluetooth enables wireless communication between the battery management system and external devices such as smartphones, tablets, or dedicated monitoring equipment.
- **Configuration and Control**: Bluetooth allows users to configure and control certain aspects of the BMS without the need for direct physical access. Parameters such as charging profiles, balancing thresholds, and operational modes can be adjusted remotely through Bluetooth interfaces.
- **Mobile Applications**: BMS applications on mobile devices can utilize Bluetooth for seamless connectivity, providing a user-friendly interface for monitoring and managing battery systems. Mobile apps can display real-time data, issue alerts, and offer insights into battery health using Bluetooth as the communication link.
- **Energy-Efficient Communication**: Bluetooth Low Energy (BLE) technology is often employed in BMS to ensure energy-efficient communication, minimizing the impact on the battery's overall power consumption. BLE allows for periodic updates and data transmission without significantly draining the battery.
- **Integration with IoT Ecosystems**: Bluetooth connectivity enables seamless integration with larger IoT ecosystems, allowing BMS data to be part of a broader network for comprehensive energy management.

In summary, Bluetooth technology enhances the functionality of Battery Management

Systems by providing wireless connectivity for data transmission, remote monitoring, configuration, and control. This contributes to improved user convenience, efficient management, and the integration of BMS into larger IoT frameworks.

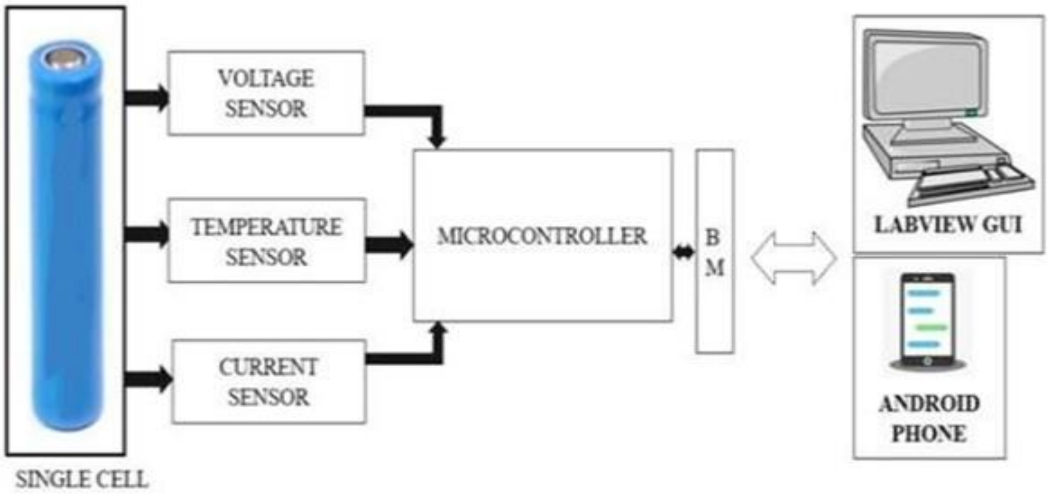

Fig 5 : Block diagram of Bluetooth based wireless BMS[20]

4.2 A BASIC COMPARISON AMONG IOT, CLOUD AND BLUETOOTH BMS

Internet of Things (IoT):

Role: IoT refers to the network of interconnected devices that communicate and share data over the internet. In a BMS, IoT enables real-time monitoring, predictive maintenance, and integration with other smart systems.

Advantages: Allows for remote access, real-time monitoring, predictive maintenance, and seamless integration with diverse devices and platforms.

Considerations: Security and privacy concerns need careful attention, and the scalability of the IoT infrastructure is crucial as the number of connected devices increases.

Bluetooth:

Role: Bluetooth is a wireless communication technology used in BMS for short-range connections between devices. It facilitates remote monitoring, control, and configuration of theBMS.

Advantages: Wireless connectivity, energy-efficient protocols like Bluetooth Low Energy(BLE), and ease of use for local device communication.

Considerations: Limited range (typically within a few meters), suitable for short-distance communication, and may not be ideal for long-range or large-scale deployments.

Cloud Computing:

Role: Cloud computing provides the infrastructure for storage, processing, and analysis of datagenerated by the BMS. It enables remote access to information and supports scalability.

Advantages: Offers scalable and flexible storage, remote access to data, computational resources for analytics, and seamless integration with other cloud-based service.

Considerations: Data security, privacy, and potential latency issues can be critical factors. Reliability depends on internet connectivity, and there may be associated costs for cloud services.

Table 1 : Comparison among Various Wireless BMS[20]

Parameters	Cloud	IoT	Bluetooth
Data Storage and Processing	Provides extensive storage and computational resources for large-scale data storage and processing.	Involves distributed data processing, with some processing occurring at the edge (on the device) and some in the cloud.	Limited local processing capabilities; relies on cloud or local systems forextensive data processing.
Connectivity Range	Accessible from anywhere with internet connectivity.	Connectivity depends on the network infrastructure and may range from short distances (e.g.,Wi-Fi, Zigbee) to long distances (e.g.,cellular networks).	Short-range communication suitablefor local device connections.
Real-time Monitoring	Supports real-time monitoring but may introduce some latency.	Enables real-time monitoring, especially with edgecomputing capabilities.	Facilitates real-time monitoring within itslimited range.
Scalability	Easily scalable to accommodate growing data and user demands.	Scalability depends on the network architecture and infrastructure in place.	Suitable for local connections; scalabilitymay be limited in large-scale deployments.
Security	Requires robust security measures; data is stored in centralized servers.	Security protocols need to be implemented, especially in distributed systems.	Has security features butmay have limitations in terms of range and connection security.
Energy Efficiency	Not directly relevantto energy efficiency,as it primarily involves computational resources.	Can be energy-efficient, especially with low-power protocols .	Bluetooth Low Energy(BLE) is specifically designed for energy efficiency, making it suitable for battery-powered devices.

In summary, each technology (IoT, Bluetooth, Cloud) has its strengths and considerations in the context of a Battery Management System. A comprehensive solution may involve the integration of these technologies to leverage their respective advantages and address specific use-case requirement.[20]

CHAPTER 5
BATTERIES USED IN ELECTRIC VEHICLE BMS

5.1 BASIC OVERVIEW OF EV BATTERIES

For electric vehicles, batteries are recognized as the future of electricity storage. Even the firstautomobiles, built in 1842, were battery-powered, that is over two decades before IC engines were developed. But, because of limitations like less range and poor charging rates led to the downfall of electric vehicles in the 20th century. The increase in Climate issues leads to growing concern about environmental factors which compelled us to switch towards renewableenergy sources and focus on the implementation and development of battery energy storage systems. Primary cells are one-time use and non-rechargeable, which are found in TV remote controls and wall clocks etc. They have a high energy density while being significantly less expensive, which makes them more compact, lighter, and cost-effective. The second type of cell is the secondary cell which is a reusable energy storage system. By just switching the current's direction, they can perform reversible reactions in the cells which allow batteries to recharge. There are many varieties of secondary cells found in the market, including nickel cells, lead-acid-based batteries, hydrogen fuel-based cells, lithium-ion cells, and many others. Each of these batteries has advantages and disadvantages. Battery life rises as rechargeable battery temperature drops, whereas performance declines as the temperature rises.[21]

5.1.1 Lithium-Ion Battery

Secondary batteries such as Li-ion batteries that provide power to electronic products have become an integral part of electronic products. Due to the amount of portable electronic products has grown explosively; the demand for secondary batteries has also grown massively. Three chemistries commonly used in today's portable devices are nickel-cadmium, nickel- metal hydride and lithium-ion (Li-ion). Among these, Li-ion batteries are growing at a rapid rate in response to environmental concerns and the need for higher energy density. The conventional Li-ion batteries' charging occurs in two steps, the battery is charged at a constantcurrent until the battery voltage reaches the predefined upper voltage limit followed by a constant voltage charging until the current reaches a predetermined small value. This method is often called Constant Current-Constant Voltage (CC-CV) charging method. The charger researches are mainly focused on shortening charging time, lengthening batteries' lifetime, reducing chargers' weight and volume, and utilizing the novel charging techniques.

Li-ion batteries are commonly used in a large number of EVs due to their high energy per unitmass when compared to other energy storage techniques. They also work well at high temperatures and have low self-discharge, a high power-to-weight ratio, and an outstanding energy economy. Li-ion battery parts may often be recycled. The chemistry of different batteries varies based on their applications. Research is continuously done to improvise the performance and cost of the battery. A battery based on charge and discharge processes betweena lithium metal oxide cathode and a graphite anode is what is meant by the term "lithium-ion,"which can refer to a wide range of chemistries.

Temperature also affects battery life to a greater extent. Low temperatures also lead to a reduction in battery capacity. Moreover, the battery's capacity decreases as the temperature drops. The battery's capacity is quickly diminished as the temperature drops below 5°C. On the other hand, when the temperature rises over 20°C, the battery's discharge capacity gradually changes and essentially reaches its rated capacity. The battery's capacity is always kept at 100%when the temperature is between rated and 45°C. The temperature has a significant impact onthe battery. It is necessary to maintain the optimal temperature for the best performance of thebattery. The battery is the main component of an electric vehicle so it is necessary to manage the temperature of the battery. Battery requires optimal heating as well as optimal cooling temperature to achieve good results. Below figure depicts the link between temperature and battery capacity at various temperatures. A 18650 Lithium-ion battery having 3.7 volt as nominal voltage gives a maximum capacity of 2.6Ah and a standard discharge current value of0.52A, which results in a typical discharge rate of 0.2C and a maximum operating current of 5hours at 0.52A. That implies that the battery is supposed to operate at 2.6A for a whole hour. Due to lower capacity, the battery should run for less than an hour if the discharge rate is 1C or2.6A. According to the datasheet's discharge curves, the battery's capacity decreases by around 85%, or from 2.6Ah to 2.2Ah, at 7.8A or 3C of discharge. Moreover, the battery shouldnot be able to operate at 7.8A for 20 minutes according to Peukert's law. The graphs shown above, however, show that the capacity has only decreased from 2.6Ah to 2.53Ah and thatit will continue to operate at 7.8A for 20 minutes, neither of which should be the case.[22]

5.1.2 Lead- Acid Battery

Lead-acid batteries can be designed to be high power and are inexpensive, safe, recyclable, and reliable. However, low specific energy, poor cold-temperature performance, and short calendarand lifecycle impede their use. Advanced high-power lead-acid batteries are being developed,but these batteries are only used in commercially available electric-drive vehicles for ancillaryloads. They are also used for stop-start functionality in internal combustion engine vehicles toeliminate idling during stops and reduce fuel consumption. For the energy required to run an electric car, the typical car normally has 8-12 kWh lead acid batteries installed, so price is a significant consideration. Their ease of installation makes them that much more attractive as apower source. The disadvantage is their short lifespan of only three years, at which point they can no longer be recharged and must be disposed of. Still, this simple technology is cheap andeasily manufactured. Lead acid batteries use a high amount of reused materials. Flat or disposedbatteries are recycled into new batteries, keeping the carbon footprint low on the lead acid usedin the next batch of batteries and giving about 15 kg CO_2 with the normal l kWh lead acid battery.

The value of raw materials has spiked up the recycling market for recycled lead acid

batterieswhen they are disposed of. Nearly all of the components of a lead acid battery are recyclable –97 percent. The battery case is made of polypropylene; the plates are made of lead, with waterand acid mixed as an electrolyte. The casing and plates can be easily melted down and reformed, since lead's melting point is low. In this way, little energy is required to convert melted lead to the required raw material for reuse.
This ability to keep costs down by reusing materials makes recycling attractive and easily doable. Europe recycles 100 percent lead acid batteries, while the U.S. boasts a 98 percent recycling rate.[23]

5.1.3 Nickel Cadmium Battery

Nickel-cadmium battery is a source for DC voltage. Due to its properties and advantages, it istaking over lead-acid based batteries and gaining popularity in recent times. It is small, compact, easily travelled from one place to another. General uses of this battery are toys, calculators, small DC motors etc. Principle wise it is the same as lead accumulator based batteries. A metal is rolled with cadmium and separator layers and kept in redox so that the chemical reaction produces the DC voltage. Batteries have been popular for a long, and in an effort to increase the efficiency of the battery more and more chemical elements are used. Thismakes the construction compact. Nickel cadmium battery has cadmium (Cd) on negative electrode. On positive electrode it had nickel ox hydroxide NiO (OH)) and the electrolyte usedin nickel cadmium battery is potassium hydroxide (KOH) that is alkaline electrolyte. Typically,Ni-Cd batteries are used when large capacities and high discharge rates are required, making them well-suited for use in RC cars, photography equipment, and home power tools which need a lot of power quickly.[24]

5.1.4 Nickel Metal Hydride Battery

Nickel-metal hydride batteries, used routinely in computer and medical equipment, offer reasonable specific energy and specific power capabilities. Nickel-metal hydride batteries havea much longer life cycle than lead-acid batteries and are safe and abuse tolerant. These batterieshave been widely used in HEVs. The main challenges with nickel-metal hydride batteries are their high cost, high self-discharge rate, heat generation at high temperatures, and the need to control hydrogen loss. NiMH batteries are (re)charged by applying electric current, which reverses the chemical reactions that occur during discharge/use. Devices to supply the appropriate current are called chargers. The electronics in charging systems and control circuitsfor NiMHs are simple and inexpensive, and the battery is considered safe. The NiMH battery also has high self-discharge and can lose up to 20 % of its charge during the first 24 hours and thereafter 10 % per month.[25]

5.2 COMPARISON AMONG VARIOUS EV BATTERIES

Comparing electric vehicle (EV) batteries involves assessing several key factors such as energy density, charging speed, longevity, cost, and environmental impact.

Table 2 : Comparison among different electric vehicle batteries[15]

Parameters	Li-ion	Lead-acid	Ni-Cad	NiMH
Nominal Voltage (V)	3.2 to 3.7	2	1.2	1.2
Life Cycle	600 to 3000	200 to 300	1000	300 to 600
Energy Density (W. H. Kg-1)	100 to 270	30 to 50	50 to 80	60 to 120
Power Density (W.Kg-1)	250 to 680	10	150	250 to 1000
Self-Discharge Rate	3 to 10	5	20	30
Charging Efficiency	80 to 90	50 to 95	70 to 90	65
Discharging Temperature	-20 to 60	-20 to 50	-20 to 65	-20 to 65
Charging Temperature	0 to 45	-20 to 50	0 to 45	0 to 45
Charging Technique	Constant Current-Constant Voltage	Constant Current-Constant Voltage	Constant Current	Constant Current
Charging Performance	Energy cell charges at arate of 0.5c to1c. rise in temperature of around 5ºc(9ºf) at fullcharge	The V-threshold is lowered by 3mv/ ºc at high temperatures. charging at 0.3 or less below freezing.	At 60 ºc, the charging acceptance level drops from 70% to 45%, respectively.0.1 c charging rate between - 17 ºc and 0ºc. 0.3 c charging between 0 ºc and 6 ºc.	At 60 ºc, the charging acceptance level drops from 70% to45%, respectively. 0.1 ccharging rate between - 17 ºc and 0ºc. 0.3 c charging between 0 ºc and 6 ºc.

It also describes about the parameters covered by the battery as voltage, power , life cycle, charging efficiency, etc. It also helps in finding the best battery among all of the batteries available in the market. A comparison among various EV batteries is represented above.

5.3 MOST DURABLE BATTERY AND ITS FEATURES

Based on current technology and market trends, lithium-ion (Li-ion) batteries are the most commonly used and widely regarded as the leading choice for EVs. Within the realm of Li-ion batteries, there are several variations and chemistries, each with its own strengths and weaknesses. Here's a broad overview of why Li-ion batteries are generally considered among the best for EVs:

- **Energy Density:** Li-ion batteries offer high energy density, meaning they can store a large amount of energy relative to their size and weight. This allows for longer driving ranges without significantly increasing the size or weight of the battery pack.
- **Charging Speed:** While charging times can vary depending on the specific battery chemistry and charging infrastructure, Li-ion batteries generally offer reasonable charging speeds, especially with the advent of fast-charging technologies.
- **Longevity:** While Li-ion batteries do degrade over time with use, advancements in battery management systems and manufacturing techniques have significantly improved their lifespan. With proper care and maintenance, Li-ion batteries can last for several years and hundreds of thousands of miles.
- **Cost:** While Li-ion batteries were initially expensive, ongoing research, technological advancements, and economies of scale have led to a significant reduction in their cost. As a result, they are now more affordable and accessible for mainstream EVs.
- **Environmental Impact:** Li-ion batteries have a relatively low environmental impact compared to traditional internal combustion engine vehicles. Additionally, efforts are underway to improve the sustainability of battery production and recycling processes, further reducing their environmental footprint.

While Li-ion batteries currently dominate the EV market, ongoing research and development efforts are focused on improving battery technology even further. This includes advancements in solid-state batteries, which have the potential to offer even higher energy density, faster charging, and improved safety compared to traditional Li-ion batteries. However, solid-state batteries are still in the early stages of development and commercialization, and it may be some time before they become widely available in EVs.

In summary, while Li-ion batteries are currently among the best choices for EVs due to their high energy density, reasonable charging speeds, longevity, cost-effectiveness, and relatively low environmental impact, ongoing advancements in battery technology may lead to even better options in the future.[26]

CHAPTER 6
METHODOLOGY

6.1 METHODOLOGY USED FOR PROTECTION OF BATTERY

We use the methodology consists of Arduino NANO, microcontroller, Li-ion battery, Voltage regulator, Step down Transformer, Voltage sensor, Current sensor, Temperature sensor, Wi-FiModule, Electromagnetic Relays, Buzzer, etc. that connects to an Android app. A Power Supply of 220V is given to 5V Arduino NANO through a Step-down Transformer and Voltage regulator of which both are used to regulate the voltage to get the desired output voltage. All the devices like sensors, buzzer etc. are connected to Arduino NANO for sharing information and follow instructions which will be further used for replica. There are 3 Li-ion cells yieldinga voltage of 3.7 Volts and collectively 12V on full charging. 12V voltage is required to run Brushless Direct Current Motor (BLDC). Voltage Sensor, Current Sensor, DHT11Temperature Sensor are connected near the Li-ion Battery to measure their respective parameters, they are also connected to the Analog pins of Arduino NANO to transfer the information to the Android App through ESP8266 Wi- Fi module. If the Temperature of the battery surrounding exceeds 50°C then temperature sensor will send this information to Arduino NANO which will cut-off the power supply given to the Li- ion Battery for charging and turns on the fan . All the parameters are shown on the 16*2 LCD Display as well as on theAndroid App for monitoring. If any of the parameters exceeds the predefined range then buzzerstarts beeping and the power supply cuts off automatically. Flowchart for proposed methodology is given below:

1. 230V supply is provided to the step-down Transformer which steps down the power up-to 12V.
2. Voltage regulator regulates the voltage up-to 5 Volt. as the Arduino NANO works on 5Vsupply.
3. The Arduino NANO is the connected with devices such as ESP8266 Wi-Fi Module, buzzer, 2x16 LCD Display, temperature sensor, fan, relays R1andR2 (which are connected for the supply of battery voltage), current sensor and the voltage sensor. When the supply is provided to the Arduino NANO, the relays the Switched ON and thebattery gets charged, if any abnormal condition occurs the connected sensors will provide a signal to the Arduino NANO and automatic cut-off will be generated and charging will be switched off.
4. If the connected li-ion battery gets heated similar steps will be followed and signal willbe sends via temperature sensor to the Arduino NANO and another signal is provided tothe fan which is used to cool down the battery system.
5. The reading of the current and voltage is provided by the current sensor and voltage sensor which is first sent to the Arduino NANO and the displayed by the LCD display for monitoring, one signal is also provided to the Wi-fi module which provides the reading over the Android or IOS based smart phone for 24x7 reading

whenever the useris needed.

6. The brushless DC motor is used as a vehicle engine.

A flow diagram is shown below for clear understanding.

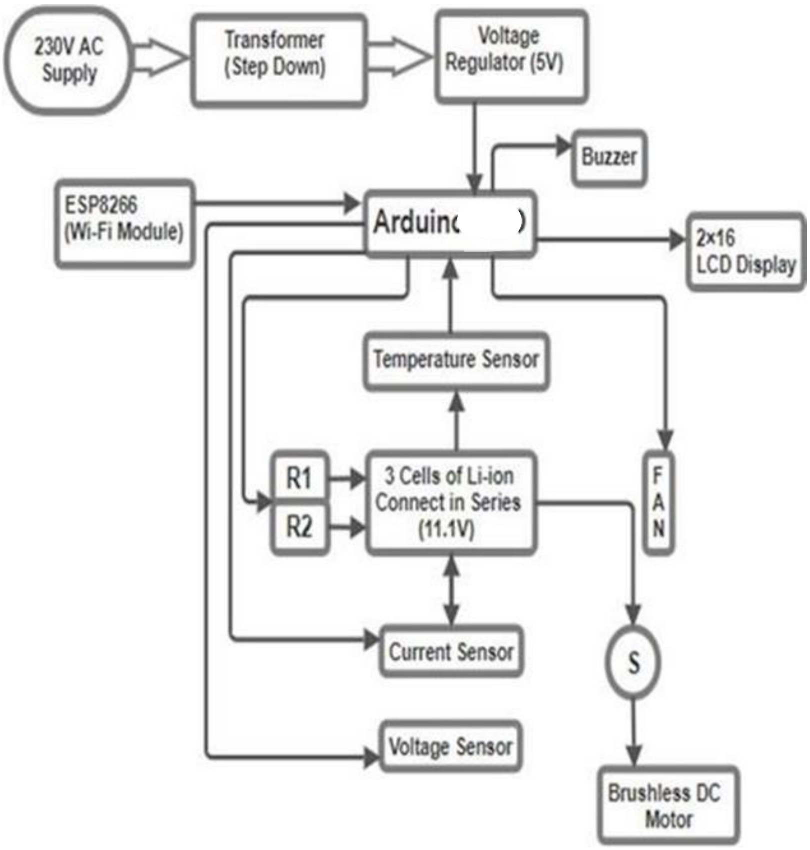

Fig 6 : Flowchart for Proposed Methodology [19]

At its core lies the venerable Arduino NANO, a microcontroller of unparalleled versatility and power, serving as the central hub around which our system revolves. Beneath the watchful gaze of the Arduino NANO, a legion of components stands ready to serve, each playing a vital role in the grand orchestration of our methodology. At the heart of our power management system lies the Li-ion battery, a compact yet potent source of energy that fuels our devices with a reliable and long-lasting supply of power.

CHAPTER 7
MODELLING AND SIMULATION

7.1 HARDWARE MODELLING

The whole model is mounted on hard card board sheet in which the power supply is firstly supplied from the main supply that is 230V, 50Hz to the step- down transformer for getting a lower voltage that is 12V on the secondary. A step-down transformer is a type of transformer that converts the high voltage (HV) and low current from the primary side of the transformer to the low voltage (LV) and high current value on the secondary side of the transformer. The reverse of this is known as a step up transformer. Transformers can step down the voltage going from a higher primary side voltage to a lower secondary side voltage they can also step up the voltage, going from a lower primary side voltage to a higher secondary side voltage.

After that the voltage we get from the secondary of the step-down transformer is transferred to the voltage regulator. Any electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that is 5V and it can be tolerated by the electrical equipment using that voltage. Voltage regulators also are used in electronic equipment in which excessive variations in voltage would be detrimental.

The voltage received from voltage regulator is then transferred to the Arduino NANO as it only works on 5V to make every component connected to it works properly. The Arduino NANO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2010. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9-volt battery or by a DC source of 5V.

The medium of transfer of information is through Wi-Fi module that is ESP-8266 which is powered by the DC voltage provided by the Arduino NANO. ESP8266 Wi-Fi module was introduced and developed by third-party manufacturers like AI thinkers, which is mainly utilized for IoT-based embedded applications development. It is capable of handling various functions of the Wi-Fi network from another application processor. It is a SOC (System On-chip) integrated with a TCP/IP protocol stack, which can provide microcontroller access to any type of Wi-Fi network. This article deals with the pin configuration, specifications, circuit diagram, applications, and alternatives of the ESP8266 Wi-Fi module. An ESP8266 Wi-Fi module is a SOC microchip mainly used for the development of end-point IoT (Internet of things) applications. It is referred to as a standalone wireless transceiver, available at a very low price. It is used to enable the internet connection to various applications of embedded systems.

The alarming component of the project is the buzzer which on abnormal predefined values of the parameters. It is an audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

The display which shows the value of the parameters of the system is LCD Display which is powered by the DC supply provided by the Arduino NANO. The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

Some other sensing elements are also the part of the project which are also powered by the Arduino NANO as Temperature Sensor, Current Sensor and Voltage Sensor. Sensors are devices that can sense or identify and react to certain types of electrical or optical signals. The implementation of a voltage sensor and current sensor techniques have become an excellent choice for the conventional current and voltage measurement methods. A temperature sensor is a device, typically, a thermocouple or resistance temperature detector, that provides temperature measurement in a readable form through an electrical signal. It is predefined in the range of 0 degree Celsius to 50 degree Celsius. A current sensor is a device that detects electric current in a wire and generates a signal proportional to that current. The generated signal could be analog voltage or current or a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control. A voltage sensor measures and monitors voltage levels within an object, detecting either AC or DC voltage. It inputs voltage and outputs various forms such as switches, analog voltage signals, current signals, or audible signals.
The battery cells that are used in this system is Li-ion battery due to its high density and longetivity. A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible intercalation of Li^+ ions into electronically conducting solids to store energy. In comparison with other commercial rechargeable batteries, Li-ion batteries are characterized by higher specific energy, higher energy density, higher energy efficiency, a longer cycle life, and a longer calendar life. Lithium-ion batteries can be a safety hazard if not properly engineered and manufactured because they have flammable electrolytes that, if damaged or incorrectly charged, can lead to explosions and fires. Much progress has been made in the development and manufacturing of safe lithium-ion batteries. Lithium-ion solid-state batteries are being developed to eliminate the flammable electrolyte. Improperly recycled batteries can create toxic waste, especially

from toxic metals, and are at risk of fire. The negative electrode of a conventional lithium-ion cell is graphite made from carbon. The positive electrode is typically a metal oxide or phosphate. Batteries with a lithium iron phosphate positive and graphite negative electrodes have a nominal open-circuit voltage of 3.2 V and a typical charging voltage of 3.6 V. Lithium nickel manganese cobalt (NMC) oxide positives with graphite negatives have a 3.7 V nominal voltage with a 4.2 V maximum while charging. The charging procedure is performed at constant voltage with current-limiting circuitry (i.e., charging with constant current until a voltage of 4.2 V is reached in the cell and continuing with a constant voltage applied until the current drops close to zero). Typically, the charge is terminated at 3% of the initial charge current. In the past, lithium-ion batteries could not be fast-charged and needed at least two hours to fully charge. Current-generation cells can be fully charged in 45 minutes or less. In 2015 researchers demonstrated a small 600 mAh capacity battery charged to 68 percent capacity in two minutes and a 3,000 mAh battery charged to 48 percent capacity in five minutes.

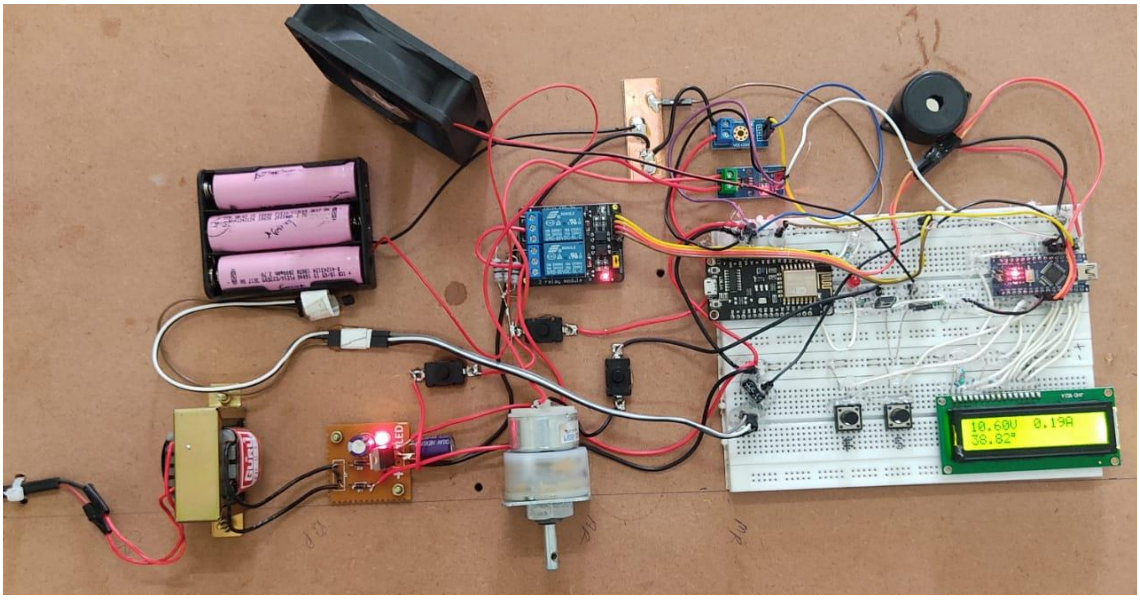

Fig 7 : Image of Hardware model of the project

Battery cells are charge when we switch on the electromagnetic switches which are powered by the Arduino NANO again. The relay is the device that open or closes the contacts to cause the operation of the other electric control. It detects the intolerable or undesirable condition with an assigned area and gives the commands to the circuit breaker to disconnect the affected area. Thus protects the system from damage. It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energises the electromagnetic field which produces the temporary magnetic field. This magnetic field moves the relay armature for opening or closing the connections. The small power relay has only one contacts, and the high-power relay has two contacts for opening the switch. The inner section of the relay is shown in the figure below. It has an iron core which is wound by a control coil. The power supply is given to the coil through the contacts of the load and the control switch. The current flows through the coil produces the magnetic field around it. Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Hence close the circuit, which makes the current flow through the load. If the contact is already closed, then it moves oppositely and hence open the contacts.

7.2 SIMULATION

The simulation model of this project is developed on PROTEUS-8, which is a platform where we designed our model to work virtually and may verify the connections of our desired model.

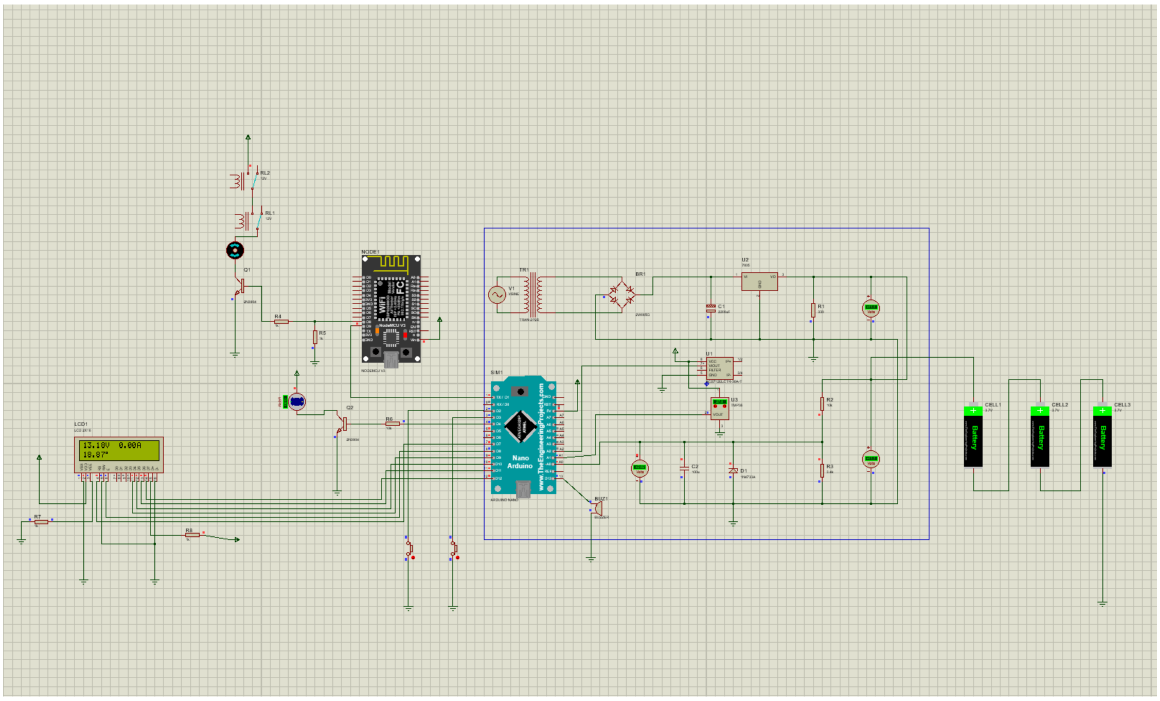

Fig 8 : Simulation of the model

This is the screenshot of the simulation window of the simulation of the project. This programs contains various tools and modes to run a project a virtually we firstly read about all the specifications and the basic study required to use the platform and then started our virtual model by adding required elements, some elements were added via online website by adding the .idx file to library of the proteus professional to the platform and moving further by joining them correctly, the supply of 220V is provided by using a sine element and further connected to a transformer which is as similar as our methodology the transformer is joined by a bridge rectifier to complete the circuit with voltage regulator added a voltmeter is applied parallelly to showcase the exact voltage at that line. Further, more sensors such a current sensor, voltage sensor, temperature sensor are connected with their pins as directed which is then connected to ARDUINO NANO and ESP8266 Wi-Fi Module, the library of these elements are extracted and complied via ARDUINO IDE to converts .idx to .hex file.

Hence, the virtual model is simulated and the verifies our assumed model. It may show an error if not coded correctly. Each and every pin of the module needs to be connected and the values should calibrated such that there should be minimum chances of error.

CHAPTER 8
RESULT ANALYSIS

As we have two basic motives in our proposed methodology i.e. To make the platform IoT Based instead of Bluetooth Technology and secondly to monitor charge and protect the battery from being catching fire.

Hence these two motives are successfully implemented over our project, basically we have interchanged the devices and gave a new improved model in Battery Management system, it took around 8-months for the completion of project and around a week for the analysis of the results.

As the simulation is successfully verified. We proceeded towards our real model i.e. project model it showed us various values and notes which are important to this project.

We had successfully improvised our model by adding a esp-8266 Wi-Fi Module and the values were shown in both LCD as well as Android App, here we used Blynk IoT app for showing our various values.

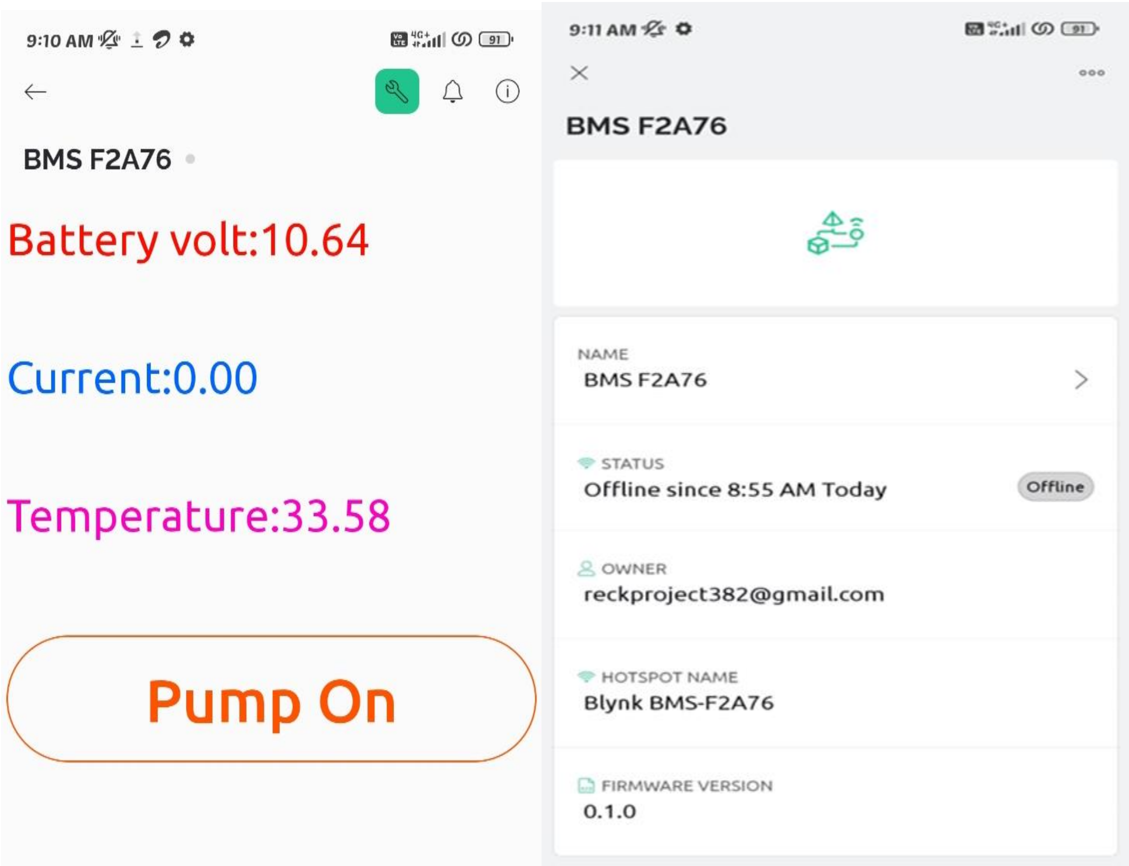

Fig 9: Reading of the battery's parameter

As we have tested our model three to four times, it took around 1.4 Hours to charge our model completely the maximum values reached in our battery was 11.8V and current around 0.32A with having a surrounding temperature of 42.01^{0} C.

As any other normal batteries, it also fluctuates some sort of value’s (firstly the voltage will decrease by a value of 0.1-02V) and then reaches the higher values, which is due to electrolytes present in the battery.

CHAPTER 9
CONCLUSION

Battery Management System of an Electric Vehicle by considering several parameters which are important for monitoring and taken into consideration to avoid explosion of Li-Ion Battery Cells. Several papers are reviewed to understand the behaviour of Li-Ion battery, Technology used for gathering information through IoT, etc. Moreover, this project has investigated about IoT technology that can be used for monitoring purpose of battery's voltage , temperature and current. The information/data we receive through different sensors is used for monitoring purpose and protecting our battery from being destroyed. An efficient and smart working model through which we can protect our battery and also do fire prevention. By monitoring the parameters like temperature , voltage and current we can also prevent and save our device from short circuit etc. In short , it makes this system highly efficient , safe and user friendly. It also includes enhancing the precision and dependability of battery monitoring systems to deliver more accurate and timely data regarding the charge, health, and function of the battery pack.

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Basically, our review paper was based on a basic concept and after reading several paper's mostly from IEEE we had concluded our basic model and an enhancement was done i.e. Wi-Fi Based Module.

Our review paper consisted basic introduction of batteries and overall review over the previous models and accordingly the literature survey. Our proposed methodology explains how we want to enhance the model and make it more-easier to use. Finalizing it by a final conclusion and at ending by the references. We used overall 34 references including our base paper.