Grenze International Journal of Engineering and Technology, January Issue

BMS of EV Charging System with Motor Protection

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***Abstract*— This Paper mainly presents a simplified working model for an Electric Vehicle charging system that is set to demonstrate and compare three levels of EV charging: Level 1 (230V AC), Level 2 (440V AC), and Level 3 (800W DC fast-charging). The principal goal is to demonstrate the charging time differences among the various levels and help the users identify the best option with respect to their needs and time. This paper considers both AC and DC charging, while the transformer supports two currents-1A and 3A. At its core, the system uses a microcontroller along with other necessary electronic components such as resistors, capacitors, diodes, and batteries. The software interface is built in Node.js, which displays the battery level in real-time and estimated charging time, thereby allowing for greater user interactivity and system monitoring. Further, the prototype includes an LCD interfaced with the prototype to display the system faults which include temperature increment and motor overloading to imply the safety and early fault detection. Therefore, the paper gives a very practical and informative visualization of the working of modern-day EV charging stations with an emphasis on effectiveness, versatility, and users safety.**

***Keywords*— EV Charging, EPS, Microcontroller, IOT.**

I. Introduction

With steadily growing environmental concerns and increasing pressure for sustainable mobility, the transition from fossil fuel-driven vehicles to Electric Vehicles (EVs) is picking up pace. And a major issue in promoting the adoption of EVs is charging infrastructure and its efficiencies. However, not all EV users approach the charging process the same way-intermittent quick charges in the middle of the day, and then slow overnight home charging are some considerations.[10] This causes EV charging to be split into three Levels: Level 1 (230V AC): Slow basic charging, best suited to home charging. Level 2 (440V AC): Medium-speed charging for the work location or commercial locations. Level 3 (800W DC): Fast charging for public charging stations or highway stops. [9] This paper has been deemed a prototype that simulates all three charging levels, allowing full clarification about the voltage, current, and time taken for full charging.
The system incorporates 1A and 3A transformers controlled by a microcontroller, along with all the necessary components such as resistors, capacitors, diodes, and batteries. To provide a high level of interactivity, the battery percentage and charging time left are calculated and displayed on the Node.js-based software interface in real time. A display is also provided to indicate faults such as temperature rise, motor overload, etc., thereby enhancing system intelligence and user awareness.[3] The objective of this project is to give practical knowledge about EV charging technologies and analyse which level would best suit different user scenarios. Increasing environmental issues and growing needs for a more sustainable alternative to internal combustion vehicles have paid increasing attention to electric vehicles (EVs).

Grenze ID: 01.GIJET.12.1.503

Consequently, a number of studies and technical developments have been done in the field of EV charging infrastructure.[6] Different studies have suggested the trade-off about charging speed, infrastructure cost, and effect on battery health at these levels.

II. METHODOLOGY

A. Electric Vehicle Block Diagram

In any case, the prototype mainly presents a simplified working model for an Electric Vehicle charging system that is set to demonstrate and compare three levels of EV charging: Level 1 (230V AC), Level 2 (440V AC), and Level 3 (800W DC fast-charging). The principal goal is to demonstrate the charging time differences among the various levels and help the users identify the best option with respect to their needs and time. The prototype considers both AC and DC charging, while the transformer supports two currents-1A and 3A. At its core, the system uses a microcontroller along with other necessary electronic components such as resistors, capacitors, diodes, and batteries. The software interface is built in Node.js, which displays the battery level in real-time and estimated charging time, thereby allowing for greater user interactivity and system monitoring.

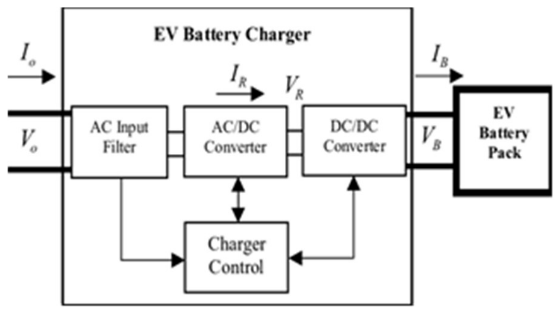

Figure 1. Electric Vehicle Block Diagram

Components:

- ➢ AC Input: This is the port through which the alternating current power is supplied to the charger from thegrid.
- ➢ AC to DC Converter: As a situation of conversion, this stage converts power from AC to DC. It may be required since most EV batteries actually use DC power.
- ➢ DC/DC Converter: This stage changes the DC voltage from AC/DC converter to a voltage level suitable for charging an EV battery pack. The particular voltage and current will also depend on battery Charger.
- ➢ Charger Control: This is the technical management unit for the charger, which monitors and controls the entire charging operation, thereby maximizing safely allowed charging currents and voltages. It may also control the charging algorithms to extend battery life and charging time.
- ➢ EV Battery Pack: This is the final destination of the charging process. The DC/DC converter outputs the appropriate voltage and current with which to charge the battery cells inside the pack.

B. Electric Vehicle (EV) charging system integrated with an IoT-based monitoring and control system

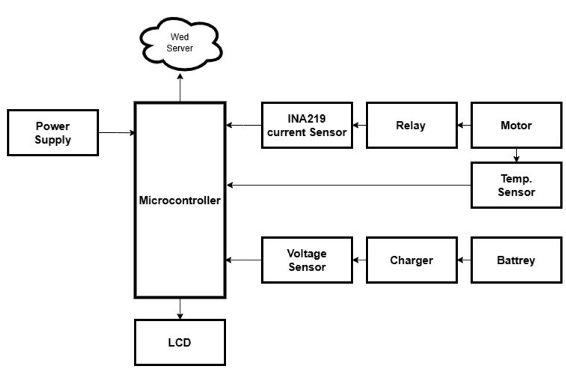

Figure 2. Electric Vehicle Block Diagram with IOT

Block diagram is shown below and the components are explained as follows: -

- Power Supply: Provides the initial power supply to the microcontroller and other system units.
- Microcontroller: It is the central control unit of the system. It interfaces with all sensors and devices. It acquires data concerning current, voltage, and temperature, makes decisions as to how charging should proceed, controls the charging, and finally communicates with the web server.
- INA219 Current Sensor: It is used to measures the current going towards the motor or battery, also it sends current data in real time to the microcontroller
- Relay: It acts as a switch to operate the motor and depending on sensor inputs or remote commands, it is controlled by the microcontroller.
- Motor: Acts as the EV motor. Powered during operation while current and temperature are monitored.
- Temperature Sensor: Checks motor temperature or battery temperature. Prevents overheating by feeding temperature information back to the microcontroller
- Voltage Sensor: Checks battery voltage level. Helps to control a proper charging process.
- 8.Charger: Controlled charging module attached to the battery. Switched on/off by the microcontroller on the basis of voltage and current information.
- Battery: Stores electrical energy. Gets charged through the charger. The charging status is continuously checked.
- LCD: It is used to display the fault that occurs in the real time. It Provides the initial power supply to the microcontroller and other system units
- Webserver: The IoT Module uploads data to a Cloud Web Server. This facilitates monitoring and control during a remote charging process of an EV. Core Functionality is that it gathers data from sensors through a microcontroller and displays information on the LCD. It also controls the charger and motor via relays, while the status information is provided to a web server for remote access purposes. Safe and efficient operations behind EV charging with IoT connectivity.

C. Components used

TABLE I: COMPONENTS

Components	**Rating**	**Quantity**
Transformer - 1	12-24V, 3Amp	1
Transformer - 2	12V, 1Amp	1
SMPS	12V, 1Amp	1
Resistors	100k, 4.7k, 10k, 330Ω	4
Capacitors	100µf, 10µf, 220µf, 2200µf, 4700µf	5
DC Motor	12V	1
Relay	5V	3
INA219 Current Sensor	3.0V to 5.5V, Max 26V, ± 3.2Amp	
ESP32 Microcontroller	3.0V to 3.6V,160–260 mA240MHz 520kb RAM	1
TP4056 Module	5V, 1Amp, 1.2kΩ	3
LCD Display 20x4	3V/5V	1
18650 Lithium Ion Battery	2000mAh, 3.7V,7.4Wh	2
Voltage Sensor	-	1
VFD	-	1

Tables 1 shows components used for the Electric Vehicle (EV) charging system integrated with an IoT-based monitoring and control system.

III. WORKING MODEL

A. Working

The system accepts both AC and DC inputs, converting AC to DC via a transformer and rectifier for safe batterycharging. A microcontroller-controlled relay selects the appropriate input and regulates charging using real-time data from voltage, current, and temperature sensors. The ESP32 manages all operations, updates an LCD display, and transmits data to a Node.js-based web interface. Faults like motor overload or high temperature trigger automatic shutdown and display alerts, with manual or automatic resets based on the issue. Once charged, the battery powers a motor under the microcontroller's protection to ensure safe operation.

B. RESULT-Fault Detection of Motor

The fault detection mechanism in the system ensures safe and reliable operation by continuously monitoring temperature, current, and voltage. If the temperature exceeds a safe limit, the system automatically shuts down and displays a "High Temperature" warning on the LCD, resuming only after the system cools down. In case of a sudden current or voltage surge indicating a motor overload, the system also shuts down and requires a manual reset to restart. This approach protects the components and enhances the overall safety of the charging process.

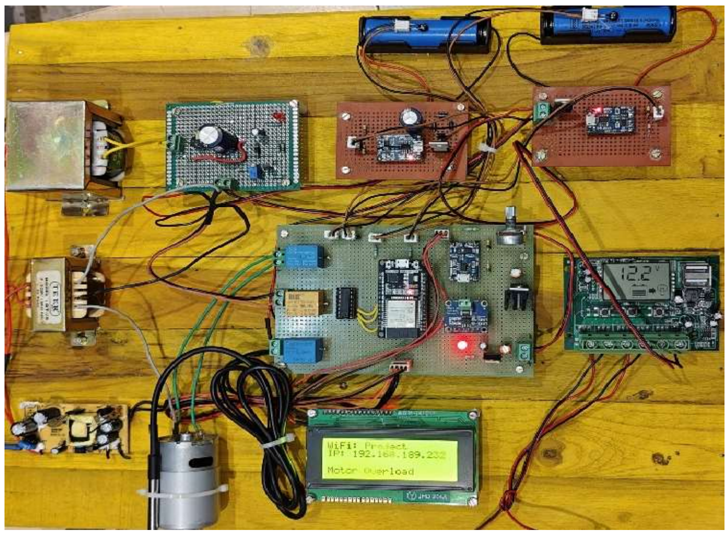

Figure 3. working model of Electric Vehicle with IOT

Figure 3 shows working model of Electric Vehicle with IOT

Fig.4 (a). High Temperature Fault in motor Fig.4 (b). Overload Fault in motor

The LCD panel acts as an interface to display real-time system status and alert messages. Fig. 4.1 shows that when the temperature sensor detects that the system temperature has exceeded a predefined safe limit, it immediately displays the warning "High Temperature" on the LCD, as shown in fig. 4.1(a). This serves as a clear visual indication of the fault to the user. To protect the system from overheating and potential damage, it automatically shuts down all operations. Importantly, even if the reset button is pressed, the system will not restart until the temperature drops back within the safe range. Realtime Paramter Monitoring On The Node.Js. The EV charging system monitoring interface displays real-time parameters like motor temperature, voltage, current, and battery metrics, which Node.js effectively handles by acquiring data from the charging system via serial communication, network protocols, or APIs. Node.js processes this data, potentially storing it in a database, to stream it to the web browser. The browser displays the information through dynamic gauges and charts, such as the "Time vs. Charging" graph, providing a dynamic and easy-to-view representation of the charging process.

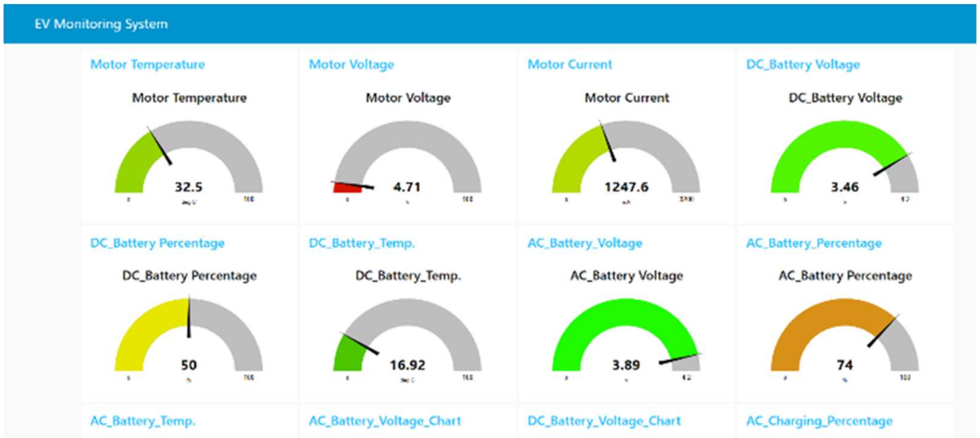

Figure. 5 Real-time monitoring parameters of the system

Figure 4.4 shows software interface of all the real-time parameters that should be considered for monitoring an EV charging system. These value include motor temperature, motor voltage, motor current, DC battery voltage, DC battery percentage, DC battery temperature, AC battery voltage, and AC battery percentage.

Realtime Battery Charging

The graph drawn for DC charging system and AC charging systemm offer a visual analysis of battery charging dynamics, focusing on a comparative view of DC and AC charging methodologies. Specifically, these plots illustrate the progression of battery charge, measured as a percentage, over a recorded time interval. By mapping time along the x-axis and charge percentage on the y-axis, the graphs effectively depict the charging rate and overall efficiency characteristic of each charging method.

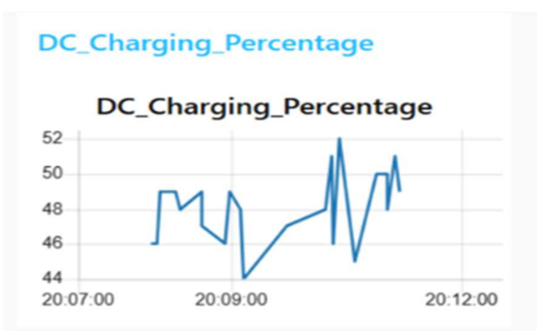

Figure.5 (a) Realtime DC Charging

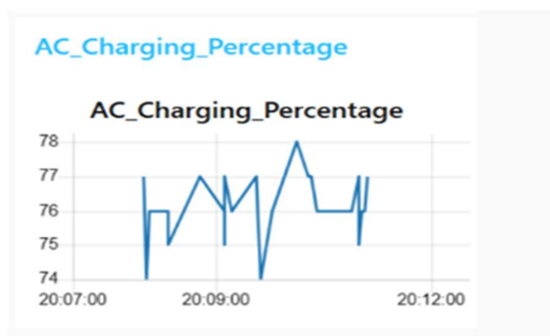

Figure.5 (b) Realtime AC Charging System of EV System of EV

Figure 4.5.a Illustrates and compare the dynamics of DC battery charging. It shows battery charge percentage over time, highlighting the charging rate and efficiency for each method.

Figure 4.5.b Illustrates and compare the dynamics of AC battery charging. It shows progression of the battery charge percentage over time, highlighting the charging rate and efficiency for each method. This comparison helps in understanding how quickly and consistently the battery charges under different conditions, which is crucial for optimizing charging strategies and evaluating charging infrastructure.

IV. Conclusion

This paper gives a system is a smart and efficient EV battery charging solution that not only supports both AC and DC power sources for energy-efficient charging but also actively monitors the entire process in real time. Featuring a Node.js-based web interface, it allows users to remotely access live data such as voltage, current, and temperature through interactive graphs, making it user-friendly and accessible from any device on the same network. The system enhances safety by detecting faults like sudden voltage spikes, temperature rise, or motor overload, automatically shutting down to prevent damage and resuming operation only when conditions are safe. It also tracks long-term performance trends to monitor battery health, ensuring longevity and reliability. Overall, it combines fault tolerance, smart monitoring, and remote accessibility to create a transparent, safe, and health-conscious EV charging experience.

ACKNOWLEDGEMENTS

I thank to all my supporter. This project was carried out in support of Yashwantrao Chavan College of Engineering, Nagpur, India. I also thanks to students for their support.

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