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A Study on Charging Station for 2-Wheeler Electric Vehicle

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Abstract—The increasing adoption of electric vehicles (EVs), particularly electric two-wheelers, has created a growing need for efficient, accessible and reliable charging infrastructure. This paper presents a study of charging stations for two-wheeler electric vehicles, focusing on charging requirements, battery compatibility, charging methods, charging-unit components, safety measures, user authentication and practical charging-station infrastructure. The study considers the role of Electric Vehicle Supply Equipment (EVSE), AC and DC charging, battery capacity and voltage, power conversion, monitoring and protection. A typical two-wheeler battery range identified in the project is 1.2–3.3 kWh at 48–72 V. The charging unit includes a supply-side cable, residual-current protection, vehicle-side connector, power-conversion stages, sensing and status indication. Important protection functions include overcharge, short-circuit, overcurrent, thermal, surge and reverse-polarity protection. RFID and mobile-app authentication are also considered for controlled access and convenient charging management. A practical survey of existing charging stations, including Ather, Tata and PiEV installations, was used as a case-study component. The paper consolidates the project findings into a research-paper format and identifies the main technical and operational factors required for safe and user-friendly two-wheeler EV charging infrastructure.

***Index Terms*—Electric Vehicle, Two-Wheeler EV, EV Charging Station, EVSE, AC Charging, DC Charging, Battery, Battery Management System, RFID, Mobile Application, Charging Infrastructure.**

1. Introduction

Electric vehicles are increasingly being considered as an alternative to conventional internal-combustion-engine vehicles. An EV is powered by an electric motor supplied by a rechargeable battery and can receive energy from an external source. Electric motorcycles and scooters are especially relevant to urban mobility because of their compact size, maneuverability and suitability for congested roads. The project report identifies battery range, charging infrastructure, performance and cost-effectiveness as important considerations in the design and adoption of two-wheeler EVs.

The transition toward electric two-wheelers is associated with concerns over air pollution, greenhouse-gas emissions and fossil-fuel dependence. However, the usefulness of an EV depends not only on the vehicle and battery but also on the availability of convenient charging facilities. Charging stations form an important part of the EV ecosystem because they provide the electrical interface between the grid and the vehicle battery. A charging station must therefore be designed with suitable electrical ratings, protection, monitoring, compatibility and user-interface features.

This paper focuses on the study of charging stations for two-wheeler electric vehicles. The work examines EVSE characteristics, battery specifications, AC/DC charging, charging-unit components, power-conversion stages, safety requirements, user authentication, charging-station location and practical case studies. The objective is to organize the project findings into a concise technical paper while retaining the terminology and observations of the original study.

2. Literature Survey

The project study reviews the development of electric mobility and charging infrastructure and considers the technical requirements associated with charging different vehicle segments. EVSE is described as the basic unit of charging infrastructure, accessing electrical power from the local supply and using control functions and a wired connection to charge an EV safely. The control system can support authentication, authorization, information recording, network management and data privacy.

Charging requirements vary with vehicle type, battery capacity, charging method and power rating. The project identifies conductive charging as the mainstream charging approach and distinguishes AC charging, where the vehicle's onboard charger converts AC to DC, from DC charging, where conversion is performed externally and DC is supplied directly to the battery. The study also discusses battery compatibility in terms of voltage, current, charging protocol and Battery Management System (BMS).

The literature and project survey further emphasize the importance of safe charging, user-friendly interfaces and appropriate infrastructure. Charging stations need suitable electrical-grid access, parking space and supporting facilities. The study also considers charging connectors and authentication methods such as RFID and smartphone applications. These factors are used as the basis for the system architecture and discussion presented in the following sections.

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3. EV Charging Station Requirements

A. *EV Supply Equipment (EVSE)*

EVSE is the interface that safely supplies electrical power to an electric vehicle. The project describes EVSE as a basic charging-infrastructure unit that accesses local electrical supply and uses control functions to manage charging. For two-wheelers, the charger should be compact, reliable and compatible with the vehicle battery and charging connector. Basic control and management functions are desirable for monitoring and safe operation.

B. *Battery Capacity and Voltage*

The project gives typical battery specifications for different EV segments. For E-2W vehicles, the reported battery capacity is 1.2–3.3 kWh and the battery voltage is 48–72 V. E-3W vehicles are reported at 3.6–8 kWh and 48–60 V, while the car ranges are considerably higher. These values illustrate why charging equipment must be selected according to the target vehicle segment rather than using a single rating for all EVs.

Table 1
Typical battery specifications for different EV segments

Vehicle Segment	Battery Capacity	Battery Voltage
E-2W	1.2–3.3 kWh	48–72 V
E-3W (passenger/goods)	3.6–8 kWh	48–60 V
E-cars (1st generation)	21 kWh	72 V
E-cars (2nd generation)	30–80 kWh	350–500 V

C. *Charging-Station Location and Infrastructure*

The project identifies local regulations, population density and infrastructure development as factors affecting charging-station location. Electrical-grid access, suitable parking spaces, shelters or kiosks, proximity to major roads and possible partnerships with businesses or municipalities also influence site selection. For two-wheeler applications, the station should additionally provide convenient access, adequate space for vehicle parking and safe cable routing.

4. Charging Methods and System Types

A. *AC Charging*

AC charging is commonly used in homes and public charging facilities. In an AC EVSE, the alternating supply is delivered to the vehicle's onboard charger, which performs the AC-to-DC conversion required by the battery. The charging speed is limited by both the charging-point capability and the onboard-charger capability. The project notes that AC charging may be suitable for overnight or longer-duration charging, especially where low-cost and convenient charging is required.

B. *DC Charging*

In DC charging, the conversion stage is located in the charging station and DC power is supplied directly to the vehicle battery. This arrangement can support faster charging, but it requires appropriate power-conversion hardware, control, thermal management and battery compatibility. The charging performance is determined by the charging-station power capability and the vehicle charging-system limits.

C. *Wireless Charging*

The project also describes wireless charging as a technology in which energy is transferred through electromagnetic coupling between a transmitter and a receiver. Stationary, semi-dynamic and dynamic concepts are discussed. The study treats wireless charging as an emerging approach and distinguishes it from conventional wired charging, which remains the principal approach considered for the two-wheeler charging-unit study.

D. *Dynamic and Static Charging*

Two charging-system concepts are identified in the project: dynamic charging and static charging. Dynamic charging allows available charging capacity to be shared between vehicles according to charging demand, while static charging refers to charging when the EV remains stationary. Dynamic allocation can improve utilization where several charging points share a common power capacity.

5. Charging Unit and Power Electronics

A. *Basic Charging Unit*

The two-wheeler charging unit is described as a compact and portable device intended to charge the battery from a standard electrical outlet or a dedicated charging station. The major elements include the charging cable, plug-and-play connection, safety features, compact enclosure and charging-status indicators. The charging assembly broadly consists of a supply-side plug and cable, an RCD unit and a vehicle-side connecting plug. The project specifies a 230 VAC mains input to the charging assembly.

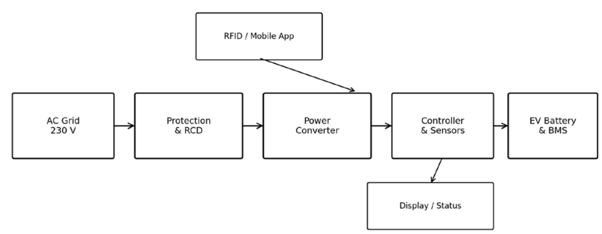

Fig. 1. Conceptual block diagram of a two-wheeler EV charging station based on the project architecture

B. *Power-Conversion Stages*

The project identifies several power-electronic elements used in EV charging units, including a rectifier, half-bridge LLC converter, PWM converter and opto-isolator. The rectifier converts the input AC into a DC link. High-frequency isolated conversion can then be used to obtain a controlled output suitable for the battery. PWM control is used to regulate power delivery, while opto-isolation can provide electrical separation between control and power stages.

C. *Voltage, Current and Temperature Sensing*

Voltage sensors provide the measurement and isolation required for monitoring the electrical conditions of modern charging systems. Current sensors measure current at locations such as the input AC side, DC/DC converter and output side, enabling the controller to verify that the intended charging current is being delivered. Temperature monitoring is important because higher charging power increases heat generation and requires appropriate thermal management.

D. *Real-Time Control*

The project emphasizes real-time control for efficient charging, reduced power loss and improved interaction between the charging station and the user. A controller can monitor charging parameters, operate protection functions, update the display and support communication. The study also discusses the use of an i.MX 6 single-board computer as a platform capable of supporting display interfaces, Ethernet connectivity and remote monitoring functions.

E. *Thermal Management*

Thermal management becomes increasingly important as charging power is increased to reduce charging time. The project notes that higher charging power can cause a substantial rise in temperature and therefore controlled heat dissipation is required. Heat sinks and appropriate thermal design are examples of measures used to maintain reliable operation of electronic hardware.

6. Safety and User Interface

A. *Safety Considerations*

Safety is a central requirement for an EV charging station. The project identifies six important protection functions: overcharge protection, short-circuit protection, overcurrent protection, thermal protection, surge protection and reverse-polarity protection. These measures protect both the vehicle battery and the charging equipment and reduce the likelihood of electrical and thermal hazards.

B. *User Interface*

A charging station should provide clear labels, simple instructions and recognizable symbols. Visual feedback can include LED indicators, progress information, battery level and estimated charging time. Start/stop controls should be accessible and responsive. The project also considers mobile-app integration for scheduling, notifications and charging-history access. Compatibility with different EV models and connector standards is another usability consideration.

C. *Charging Safety Practice*

The project recommends following manufacturer charging guidelines, using certified equipment and avoiding unsuitable extension arrangements. For domestic charging, the installation should be appropriately isolated and protected, with suitable earthing and short-circuit protection. Allowing a battery to cool before charging is also identified as a safety practice in the project.

Table 2
Principal safety functions identified in the study

Protection	Purpose
Overcharge	Stops charging beyond the safe battery capacity.
Short circuit	Interrupts excessive current caused by a short circuit.
Overcurrent	Limits current to prevent overheating and component damage.
Thermal	Stops or limits charging when temperature exceeds safe limits.
Surge	Protects against sudden voltage spikes and transients.
Reverse polarity	Prevents damage from an incorrect electrical connection.

7. User Authentication and Charging Management

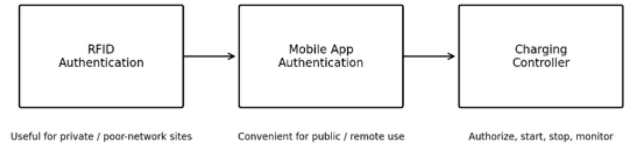

Fig. 2. RFID and mobile-app authentication concept for controlled charging access

A. *RFID Authentication*

RFID authentication can be useful for private charging stations, subscription-based facilities or locations where mobile connectivity is poor. The user presents an authorized card to start or stop the charging session. The project notes that RFID provides a physical access mechanism, although issuing and managing cards may require additional administrative effort.

B. *Mobile Application*

A smartphone application can provide a more flexible interface for public charging. The project describes functions such as locating a charger, checking availability, starting or stopping a charging session, selecting payment options, receiving billing information and maintaining usage history. Mobile applications can therefore combine authentication, monitoring and payment functions in one interface.

Table 3
Comparison of RFID and mobile-app authentication

Feature	RFID	Mobile App
User authentication	Yes	Yes
Useful for private access	High	High
Remote session control	No	Yes
Charger availability	No	Yes
Payment support	Limited/configured	Yes
Usage history	Limited	Yes
Dependence on mobile network	Low	Higher

8. Proposed Operating Sequence

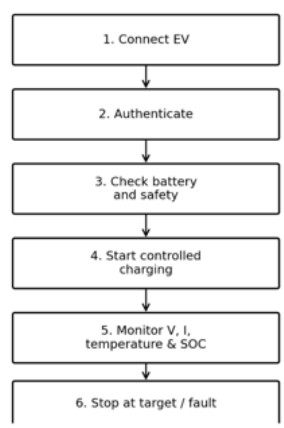

Fig. 3. Charging-session operating sequence

Table 4
Consolidated findings from the project study

Parameter/Factor	Observation from the project study
Two-wheeler battery range	1.2–3.3 kWh; 48–72 V
Primary charging approach studied	Conductive charging
AC charging	Uses vehicle onboard charger for AC-to-DC conversion
DC charging	External conversion; DC supplied directly to battery
Core protection functions	Overcharge, short circuit, overcurrent, thermal, surge, reverse polarity
User authentication	RFID and mobile application
Field survey	Ather, Tata and PiEV charging stations
Display information	Battery level, charging status, estimated completion time

The charging sequence derived from the project can be summarized as follows. First, the user connects the EV to the charging unit. The user is then authenticated, if access control is enabled. The charging system checks the battery and safety conditions before enabling the power stage. During charging, voltage, current and temperature are monitored. The controller regulates the charging process and updates the user interface. Charging is stopped when the required condition is reached or when a fault is detected. The sequence provides a simple framework for integrating electrical protection, battery management and user interaction.

9. Case Studies and Field Survey

A practical survey was carried out as part of the project to obtain information about existing charging units and charging-station infrastructure. The study reports visits to Ather, Tata and PiEV charging stations. These observations were used to understand the practical deployment of charging infrastructure, user interaction and the physical arrangement of charging equipment.

A. Ather Charging Station

The project records a survey visit to an Ather Grid charging station at Pastry Chef–Vepagunta, Pendurthi. The station was considered as one of the field examples for understanding charging infrastructure and practical deployment.

B. Tata Charging Station

A Tata charging station at Kancharapalem was included in the field survey. The project uses this installation as another practical example for comparing charging-station arrangements and accessibility.

C. PiEV Charging Station

A PiEV charging station at NAD Junction was also included in the survey. Together, the three case-study locations provide practical reference points for the study of charging equipment and charging infrastructure.

10. Results and Discussion

A. Charging Time and Battery Capacity

The project identifies charging time for different battery capacities as an important result parameter. Charging time is influenced by battery capacity, initial state of charge, charging power and the limits imposed by the battery and charging system. The study also recognizes that charging power cannot be considered independently of the vehicle's onboard charging capability and battery requirements.

B. Charging-Status Display

The charging-station display is intended to provide the user with the current battery level, charging status and estimated time to full charge. The project highlights the use of an i.MX 6 single-board computer as a possible display-control platform because it supports interfaces such as HDMI, LVDS and MIPI DSI and provides network connectivity for monitoring and management.

C. Practical Findings

The study indicates that an effective two-wheeler charging station should combine electrical safety, suitable power conversion, battery compatibility, monitoring and user convenience. The field survey further indicates the importance of accessible locations and clear charging interfaces. RFID can be appropriate where controlled physical access is required, whereas mobile applications can provide broader public-facing functions such as availability information, payment and remote session control.

11. Advantages and Limitations

A. Advantages

The studied charging-station concept provides convenient charging for electric two-wheelers, supports safe controlled power delivery, permits monitoring of charging parameters and can incorporate user authentication. Compact charging units are suitable for home, workplace and public applications. Smart interfaces can improve the user experience and provide information about charging status and availability.

B. Limitations

The project is primarily a study and field-survey-based investigation. The available project material does not provide a complete experimentally validated efficiency dataset, a full charger prototype specification or a controlled comparison of charging times for multiple battery packs under identical laboratory conditions. Therefore, the paper presents the reported technical characteristics and field observations without introducing unreported numerical performance claims.

12. Future Enhancements

Future development can focus on integrating smarter charging control, improved thermal management, real-time monitoring and wider interoperability. A charging station can be enhanced with communication connectivity, remote diagnostics, automated billing and data logging. Multi-point charging can use coordinated power allocation to improve utilization of available electrical capacity. Renewable-energy integration, particularly solar-assisted charging, can also be considered where site conditions permit. Further experimental work should measure charging efficiency, energy loss, thermal rise, charging time and battery-state-of-charge response under controlled conditions.

13. Conclusion

This paper presented a consolidated study of charging stations for two-wheeler electric vehicles based on the project investigation. The study covered EVSE characteristics, battery capacity and voltage, AC and DC charging, charging-unit construction, power-electronic stages, sensing, real-time control, thermal management, safety protection, user authentication and practical charging-station infrastructure. For the two-wheeler segment, the project identifies a typical battery range of 1.2–3.3 kWh and 48–72 V. The study also identifies Ather, Tata and PiEV charging stations as practical field-survey examples. Overall, safe electrical design, battery compatibility, monitoring, appropriate site infrastructure and convenient user interaction are essential for reliable two-wheeler EV charging. The findings provide a structured basis for further prototype development and experimental evaluation of smart charging infrastructure.

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