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Vehicle to Vehicle Charging with E- Billing System

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ABSTRACT—

The increasing adoption of electric vehicles (EVs) has created a need for flexible and reliable charging solutions, especially when conventional charging stations are unavailable. This paper presents a Vehicle-to-Vehicle (V2V) DC Fast Charging system with E-Billing that enables direct energy transfer from a donor EV to a receiver EV with a low battery level. A bidirectional DC-DC converter is used to control the direction and magnitude of power flow between the vehicles. The Battery Management System (BMS) monitors voltage, current, temperature, and State of Charge (SOC) to ensure safe charging. The proposed system measures the energy transferred between the vehicles and automatically calculates the corresponding charging cost through an e-billing mechanism. This approach combines mobile energy transfer, battery monitoring, controlled power conversion, and digital billing to provide a convenient and flexible solution for EV charging.

Keywords—Electric Vehicle (EV), Vehicle-to-Vehicle (V2V) Charging, DC Fast Charging, Bidirectional DC-DC Converter, Battery Management System (BMS), State of Charge (SOC), Energy Transfer, E-Billing

Introduction

A. Research Background

The increasing use of Electric Vehicles (EVs) has created a growing requirement for convenient, reliable, and flexible charging systems. Conventional EV charging generally depends on fixed charging stations, which may not always be available when an EV has a low battery level. Vehicle-to-Vehicle (V2V) charging provides an alternative approach in which one EV can transfer electrical energy directly to another EV. In the proposed V2V charging system, one vehicle acts as the donor vehicle, which supplies energy, while the other vehicle acts as the receiver vehicle, which receives energy for charging. A bidirectional DC-DC converter is used to control the direction and level of power transfer between the batteries. The BMS is used to monitor battery parameters and support safe charging operation.

Along with energy transfer, the proposed system includes an e-billing mechanism. The amount of energy transferred from the donor vehicle to the receiver vehicle is measured, and the corresponding charging cost can be calculated automatically. Therefore, the system combines V2V energy transfer, battery monitoring, power conversion, energy measurement, and e-billing in a single system. The basic concept and architecture of this system are described in the project work

B. Problem Statement

The availability of fixed charging stations can be a limitation for EV users, particularly during emergency situations or at locations where charging infrastructure is not readily available. An EV with insufficient battery energy may need assistance from another EV. The major problems addressed by the proposed system are: Limited charging availability: Fixed charging stations may not always be accessible. Emergency charging requirement: A low-battery EV may require immediate charging support. Controlled energy transfer: Energy must be transferred safely between two EV batteries. Battery safety: Battery voltage, current, temperature, and SOC need to be monitored. Charging cost calculation: The energy transferred between vehicles should be measured for e-billing.

C. Research Objectives

The main objectives of the proposed system are: To develop a V2V DC fast charging system for direct energy transfer between EVs. To provide controlled power transfer using a bidirectional DC-DC converter. To ensure safe battery operation using a Battery Management System. To monitor important electrical parameters during charging. To measure the energy transferred from the donor EV to the receiver EV. To implement automatic e-billing based on the energy transferred.

D. Organization of the Paper

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electrical parameters during charging. To measure the energy transferred from the donor EV to the receiver EV. To implement automatic e-billing based on the energy transferred.

Methodology

The proposed system is built around two battery systems: a donor battery and a receiver battery. The donor battery supplies energy, while the receiver battery absorbs it. Power flows from the donor side through a controlled DC–DC conversion stage to the receiver side. The converter is bidirectional, so the same hardware can support power flow in either direction if the roles of the two vehicles are reversed. The switching devices in the converter are driven by PWM signals, and the duty ratio sets the output voltage and current level. This gives direct control over how much power moves between the two packs at any moment.

The BMS attached to each battery pack monitors cell voltage, pack current, temperature, and state of charge. It also provides protection against overvoltage, overcurrent, overtemperature, and deep discharge. The BMS communicates its readings to the controller, which uses them to decide whether charging should continue, pause, or stop. If any parameter crosses a safe limit, the controller halts the power transfer.

A current sensor and a voltage measurement circuit are placed on the receiver side to capture the electrical data used for billing. The controller samples these values at fixed intervals. The display shows live voltage, current, power, and accumulated energy so the user can follow the charging process.

The energy calculation starts from the measured voltage and current. For roughly constant DC values, power is estimated as $P = V \times I$. Energy is found by accumulating power over the charging interval. When the load varies, the controller integrates the measured power over time rather than using a single average value. This keeps the energy count accurate even when current drifts during charging.

The billing amount is calculated from the total energy delivered and the price per unit of energy. The tariff value and the measurement calibration are set before charging begins, since an uncalibrated sensor or a wrong tariff will produce an incorrect bill. Once charging ends, the controller finalizes the energy total and computes the cost, which is then shown on the display and stored for the e-billing record.

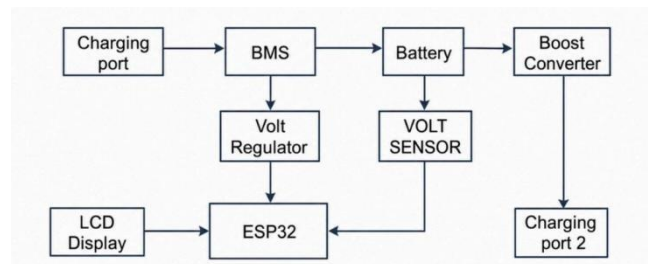


Fig. 1. Block diagram

Design and implementation

The hardware design described in the project material includes a Li-ion battery pack using cells, a battery management system, a DC power jack, an INA219 current sensor, a 5 V relay, a voltage regulator (7805), an ESP32 microcontroller, an OLED display, a piezo buzzer, a BC547 transistor, a push button, and a boost converter. These components form the battery interface, sensing, control, indication, and power-conversion sections of the system. Exact ratings and wiring must follow the component datasheets and the finalized circuit diagram

The battery pack provides the stored energy for the system. It is built from Li-ion cells, and its capacity and voltage depend on how the cells are arranged in series and parallel. The BMS is used to monitor and protect the battery pack within its specified limits. It watches cell voltage, pack current, and temperature, and it disconnects the pack if any value moves outside the safe range. The DC power jacks provide connection points for the circuit and external connections, allowing the donor and receiver sides to be linked and tested

The INA219 is intended to measure bus voltage and current, allowing the controller to estimate power. It communicates with the controller over I2C and returns calibrated digital values, which removes the need for separate analog scaling on the controller side. The ESP32 acts as the control unit. It reads the sensor data, processes the measurements, updates the OLED display, and performs the billing calculation after suitable firmware is developed. The ESP32 also drives the relay, the buzzer, and other indicator circuits through its GPIO pins.

The 7805 voltage regulator provides a regulated 5 V supply where compatible with the circuit design. It steps down a higher DC input to 5 V for the logic and sensing sections, provided the input voltage and current stay within its thermal limits. The relay can be used as a controlled switching element to connect or disconnect a circuit path. Its contact rating and driver circuit must be suitable for the actual load, since the relay coil cannot be driven directly from a GPIO pin in most cases. The BC547 transistor can act as a low-power switching driver for an indicator or buzzer circuit, subject to its current and voltage ratings. The piezo buzzer provides an audible indication, while the push button can provide a user input for starting, stopping, or resetting the charging process.

The boost converter raises DC voltage where required, but it does not by itself provide bidirectional conversion. A standard boost converter allows power to flow in only one direction. If the system needs power to move from the receiver back to the donor, or if the roles of the two vehicles can be swapped, a separate path or a different converter topology is needed.

A key design consideration is that the project description refers to bidirectional DC–DC power transfer, while the component list also includes a boost-converter module. A single boost converter should not be assumed to support bidirectional transfer unless the actual circuit and converter specification confirm this. A bidirectional converter usually needs a synchronous half-bridge or full-bridge arrangement with active switches on both sides, plus gate drivers and a control scheme that selects the direction of flow. The finalized design must clearly identify how the reverse power path is implemented, how current is limited during transfer, and how both batteries are protected against overcurrent, reverse polarity, and short circuits.

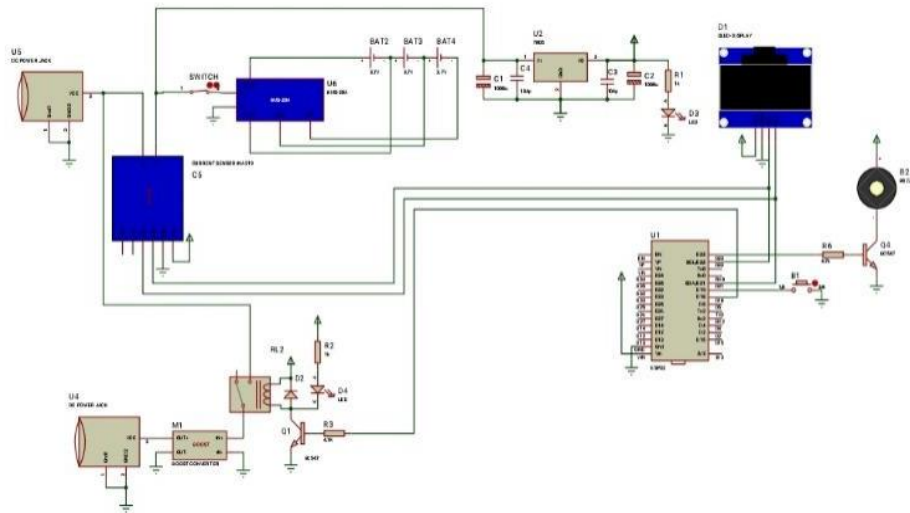


Fig. 2: Design model

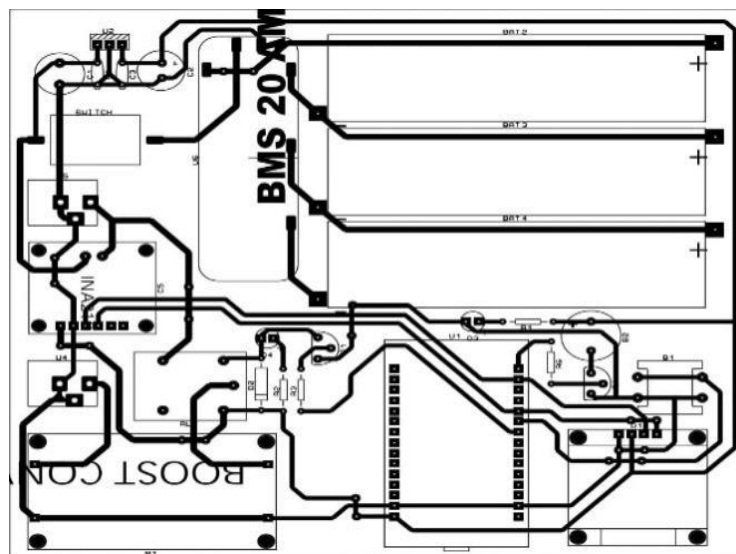


Fig. 3: Multi dc port

Hardware model

The hardware components employed in the Vehicle-to-Vehicle (V2V) charging with e-billing system form an integrated infrastructure for efficient energy transfer and battery management. The system consists of two electric vehicle battery packs, where one vehicle acts as the donor and the other as the receiver. The bidirectional DC-DC converter regulates the voltage during power transfer, enabling energy to flow from the donor battery to the receiver battery. The Battery Management System (BMS) monitors battery conditions and supports safe charging operation, while the microcontroller manages the system functions. The display provides real-time information such as battery percentage, voltage, and current, while the e-billing system is designed to calculate the energy transferred and the corresponding charging cost. These components collectively provide a controlled and efficient approach to mobile electric vehicle charging with digital billing. The PCB model is shown in Fig. 4. The complete hardware model is shown in Fig. 5.

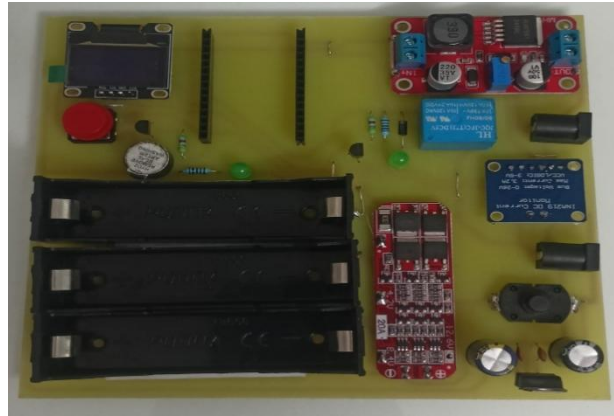


Fig. 4: Circuitry design

According to the project progress material, the main components have been selected and assembled on the prototype PCB. The prototype layout combines the sensing, controller, display, relay, and power-conversion sections. The next steps are to complete the microcontroller program, check each circuit section separately, verify polarity and connections, and conduct low-power tests before attempting battery-to-battery transfer.

The intended control sequence is: (1) initialize the controller and display; (2) read battery and sensor values; (3) check that voltage, current, and battery conditions are within the permitted limits; (4) enable the transfer path only when the required safety conditions are met; (5) repeatedly measure voltage and current and accumulate energy; (6) calculate the estimated cost using the configured tariff; (7) display the charging values and billing amount; and (8) stop transfer if a protection limit is reached or the user ends the session. This sequence describes the intended logic and is not a claim that the firmware is already operating.

Each step in this sequence depends on the one before it. Initialization sets the display and sensor communication before any reading is taken. The safety check must pass before the relay closes, since connecting two packs of different voltage or state of charge without a check can cause a large inrush current. Once the transfer path is enabled, the controller samples voltage and current at fixed intervals and adds each sample to a running energy total. This running total feeds the billing calculation, which uses the tariff value entered before the session began. The session ends either when the user presses the button or when the BMS reports a value outside the safe range, and in both cases the relay opens to break the transfer path.

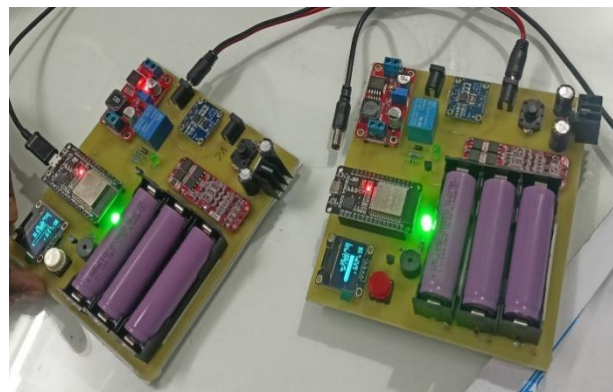


Fig. 5: Hardware prototype

Result and discussion

After programming, the prototype should be tested in stages. First, verify the regulated supply rails and controller operation without connecting the battery packs. This confirms that the 5 V and other supply lines are stable and that the microcontroller boots, initializes the display, and communicates with the sensors before any power path is energized. Next, calibrate the voltage and current measurements against suitable reference instruments. The INA219 readings are compared with a multimeter or bench meter, and a correction factor is applied if the values differ. This step is important because the billing calculation depends on accurate voltage and current data

Then test relay operation and display updates using a current-limited, low-voltage source. This allows the switching logic and screen refresh to be checked without exposing the batteries to fault conditions. The relay should close only when the safety conditions are met and open when a limit is crossed or the user ends the session. Finally, perform controlled transfer tests using appropriately protected batteries and record input/output voltage, current, transferred energy, temperature, and calculated cost. Each test run should be repeated at different load levels so that the energy count can be checked across a range of conditions. Results should be compared with reference measurements to evaluate measurement and billing accuracy. Any gap between the recorded

energy and the reference value points to a calibration error, a sampling error, or a timing issue in the accumulation routine, and each of these can be traced and corrected before the next run.

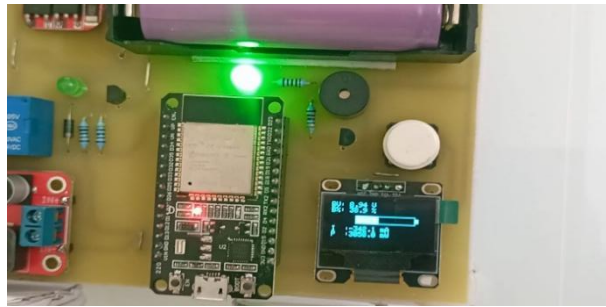


Fig. 6: Initial Charging Condition of the Receiver Vehicle (Below 50%)

The figure shows the initial charging condition of the receiver vehicle, where the battery state of charge (SOC) is below 50%. This means the receiver vehicle needs more energy to raise its charge level. The V2V charging system transfers electrical energy from the donor vehicle to the receiver vehicle to meet this requirement

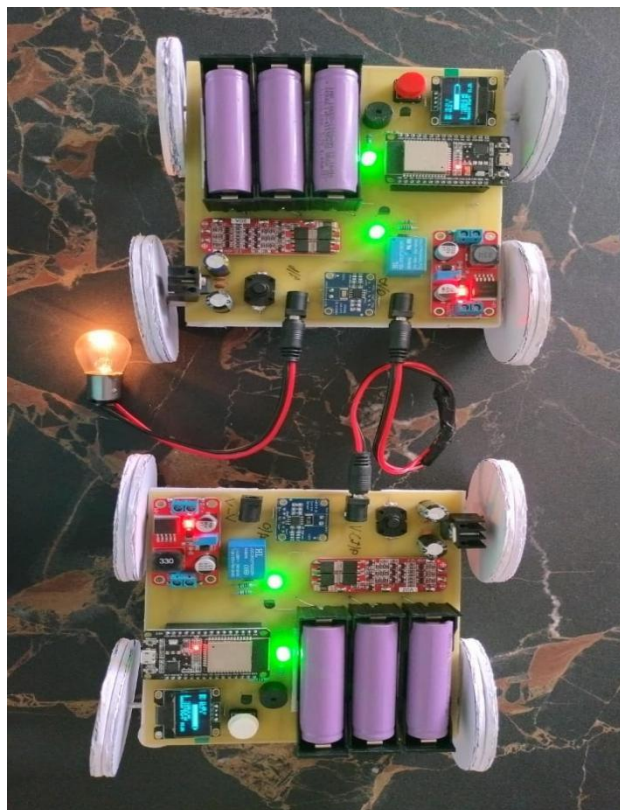


Fig. 7. Power Transfer from Donor Vehicle to Receiver Vehicle

The figure shows the charging process in which electrical energy is transferred from the donor vehicle to the receiver vehicle through the V2V charging system. During this process, the power conversion circuit regulates the energy

transfer, while the battery management system helps monitor battery conditions. The e-billing system is intended to record the energy transferred and calculate the corresponding charging cost.

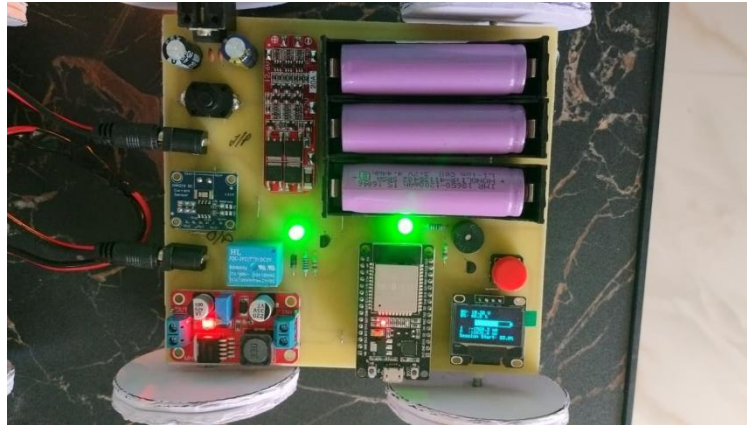


Fig. 8: Receiver Vehicle Charging Condition Above 50%

The figure illustrates the receiver vehicle's charging condition after energy transfer from the donor vehicle. The battery state of charge increases above 50%, indicating an improvement in the receiver vehicle's available battery energy. This rise in SOC shows that the transfer path remained stable during the session and that the receiver pack accepted charge within its safe limits. The BMS confirms that cell voltage, pack current, and temperature stayed within the permitted range throughout the process. The controller stops the transfer once the target SOC is reached or the user ends the session. The e-billing system records the total energy delivered and calculates the corresponding charging cost from the tariff value entered before charging began. This demonstrates the intended operation of the V2V charging system, in which energy from one electric vehicle can be used to charge another vehicle, with e-billing providing a basis for tracking the energy transferred and its associated cost.

Conclusion

This paper presents the proposed design of a Vehicle-to-Vehicle DC charging system with e-billing. The concept combines battery monitoring, controlled power transfer, voltage and current measurement, controller-based processing, and display of energy and cost. It is intended to provide a flexible option for emergency EV charging and to make energy exchange more transparent. The prototype PCB has been assembled, while programming and experimental validation are still required. Future work includes completing the firmware, confirming the bidirectional power-conversion arrangement, calibrating the sensors, implementing safety interlocks, validating the energy and cost calculations, and measuring charging performance under controlled conditions. Further improvements may include data logging, wireless monitoring, and user identification, provided these features can be implemented without compromising electrical safety.

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