

# High Efficiency Buck-Boost Converter Devices for EV Powertrains

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**Abstract-** Electric vehicles require a reliable electrical power supply for their propulsion motor, motor controller, sensors, microcontroller, display, communication modules, and other electronic circuits. A nominal 12 V battery does not always maintain a constant voltage during charging, discharging, acceleration, and different load conditions. These voltage variations can affect motor performance and may cause malfunction or resetting of sensitive electronic circuits. This project presents the design and development of an ESP32-based intelligent voltage monitoring and power management system for a 12 V battery-powered electric vehicle. A DC voltage sensor is used to continuously measure the battery voltage, while the ESP32 processes the sensor signal and monitors the battery condition. The electrical system is divided into a propulsion power section and an auxiliary electronics section. A suitable regulated 12 V power stage is provided for loads requiring a controlled 12 V supply, while a DC-DC buck converter generates a stable 5 V supply for the ESP32, sensors, display, and other low-voltage circuits. The proposed system can detect abnormal battery-voltage conditions and provide warning or control actions. This improves the reliability of the electrical and electronic systems of the electric vehicle. The ESP32 also provides the possibility of future IoT-based monitoring, current measurement, temperature monitoring, energy calculation, and intelligent load management.

**Keywords:** Electric Vehicle, ESP32, 12 V Battery, 5 V Supply, DC Voltage Sensor, Voltage Regulation, Power Management, Battery Monitoring.

## I. INTRODUCTION

Electric vehicles have become an important area of engineering development because they use electrical energy for propulsion instead of conventional fossil fuels. A small electric vehicle generally consists of a battery, motor, motor controller, sensors, control electronics, lighting, display, and communication devices.

The battery is the primary energy source. In a small EV prototype, a 12 V battery may be used to supply the propulsion system and auxiliary electrical circuits. However, the voltage of a practical battery varies depending on its state of charge, charging condition, temperature, internal resistance, and load.

For example, a battery described as "12 V" may not remain exactly at 12.0 V during operation. Therefore, sensitive electronics requiring 5 V should not be connected directly to the battery.

The proposed project uses an ESP32 and DC voltage sensor to monitor the battery voltage continuously. The battery supply is then appropriately regulated/distributed to provide the required voltage levels.

## II. PROBLEM STATEMENT

- a) A 12 V battery is not a perfectly constant 12 V source. Its voltage changes according to operating conditions.
- b) The major problems are:
- c) Battery voltage fluctuation.
- d) Voltage drop during high motor load.
- e) Higher voltage during charging.
- f) Possible instability of electronic circuits.
- g) ESP32 reset due to poor power regulation.
- h) Sensor malfunction.
- i) Reduced reliability of vehicle-control circuits.
- j) Difficulty in continuously monitoring battery condition.
- k) Therefore, an intelligent system is required that can:
  - l) Measure battery voltage.
  - m) Monitor voltage continuously.
  - n) Provide a suitable regulated supply to electronic circuits.
  - o) Provide an appropriate power path for the motor/controller.
  - p) Detect abnormal voltage conditions.
  - q) Provide warnings to the user.

### III. AIM & OBJECTIVE-

The main aim of the project is:

To design and develop an ESP32-based intelligent power-management system that monitors a 12 V battery using a DC voltage sensor and provides stable 12 V and 5 V supplies for an electric vehicle's motor/controller and electronic circuits.

#### Objectives

The objectives are:

1. 1 To develop a battery-voltage monitoring system.
2. 2 To interface a DC voltage sensor with ESP32.
3. 3 To continuously measure the 12 V battery voltage.
4. 4 To provide a suitable regulated 12 V supply for required loads.
5. 5 To generate a stable 5 V supply for electronic circuits.
6. 6 To detect low and high battery-voltage conditions.
7. 7 To provide an alert during abnormal voltage conditions.

8. 8 To improve the reliability of EV electronics.
9. 9 To reduce the effect of voltage fluctuations.
10. 10 To provide a platform for future IoT-based EV monitoring.

### IV. BASIC OPERATING CONCEPT

#### PROPOSED SYSTEM

##### System Overview

The proposed system consists of:

- 12 V battery
- Fuse and protection circuit
- DC voltage sensor
- ESP32
- Regulated 12 V power stage, where required
- 12 V to 5 V DC-DC buck converters
- Motor controller
- DC motor
- Sensors
- Display
- Warning system

### V. BLOCK DIAGRAM

#### Block Diagram -

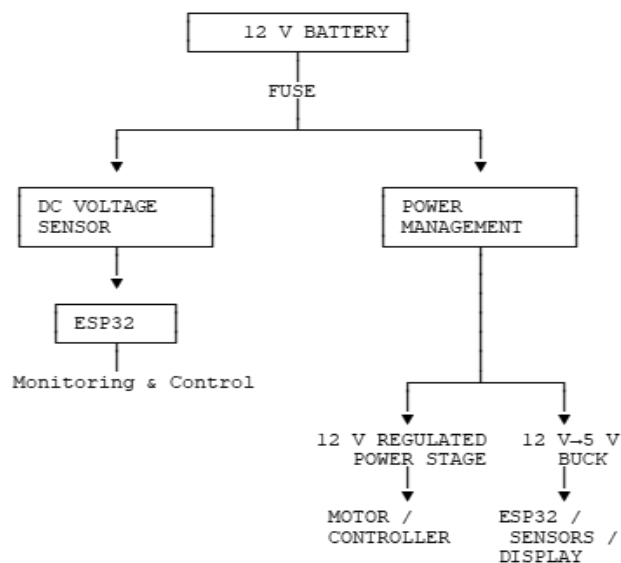
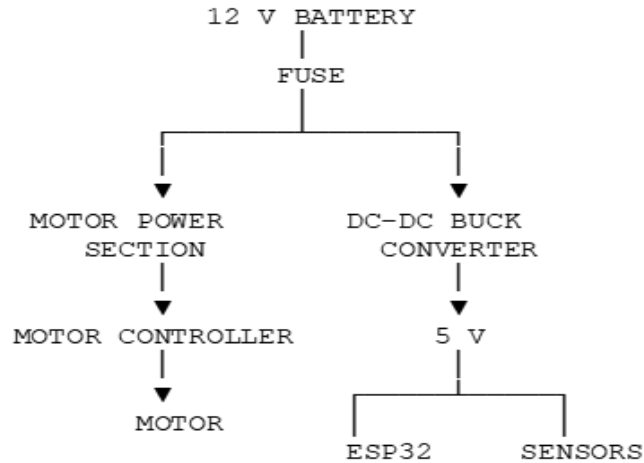


Fig. 2. Proposed system architecture

## VI. CIRCUIT DESIGN

### Power Distribution-



## VII. SYSTEM COMPONENTS AND THEIR FUNCTION

TABLE I. SYSTEM COMPONENTS AND THEIR FUNCTION

| Component        | Function                                    |
|------------------|---------------------------------------------|
| ESP32            | Main control and processing unit            |
| Bug -booster     | To supply constant 12 v to motor            |
| 16×2 LCD         | Displays current and system status          |
| Bug-converter    | To supply constant 5v in electronic circuit |
| Voltage sensor 1 | Battery voltage in wheel motor              |
| Voltage sensor 2 | Battery voltage in circuit                  |
| Power Supply     | 12v 8ah battery                             |
| Connecting Wires | Electrical connections                      |
| Load             | DC geared motor                             |

## VIII. EXPECTED RESULTS

The expected results are:

1. Continuous monitoring of battery voltage.

2. Accurate voltage measurement after calibration.
3. Stable 5 V supply for electronic circuits.
4. Appropriate regulated/protected supply for the motor/controller.

5. Detection of abnormal battery voltage.
6. Warning indication during low battery conditions.
7. Improved reliability of ESP32 and sensor circuits.
8. Reduced effects of battery-voltage fluctuations.
9. Improved monitoring of the EV electrical system.
10. Availability of an IoT-ready platform for future development.

#### IX. ADVANTAGES

The proposed system provides several advantages:

- Continuous voltage monitoring.
- Stable auxiliary 5 V supply.
- Improved reliability of electronics.
- Real-time battery information.
- Low-cost controller.
- Compact system.

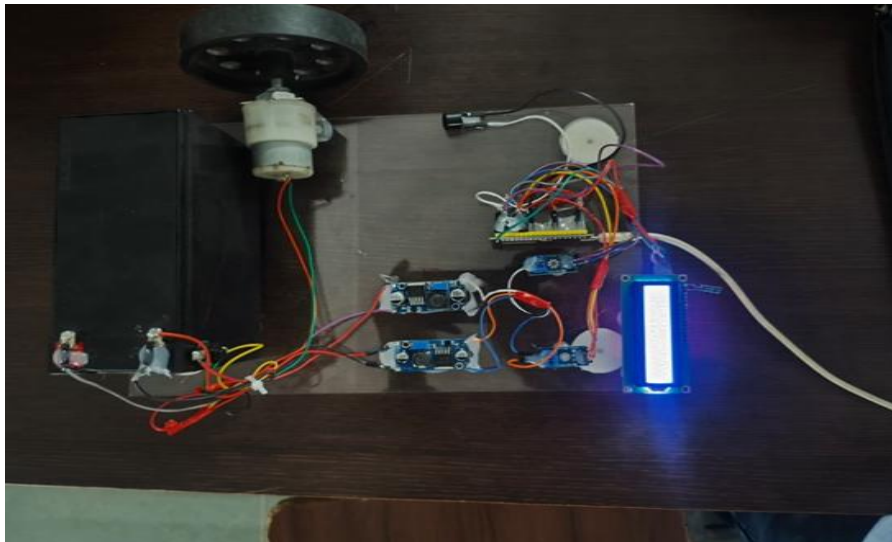
- ESP32 Wi-Fi and Bluetooth capability.
- Easy integration with sensors.
- Possibility of automatic protection.

Suitable for educational and prototype EV applications

#### X. APPLICATIONS

The proposed concept can be applied or developed for:

- Small electric vehicles
- Electric scooters
- Electric carts
- Electric wheelchairs
- Battery-powered robots
- AGVs
- Solar electric vehicles
- Agricultural electric vehicles
- Educational EV prototypes
- Industrial battery-powered machines



#### XI. FUTURE SCOPE

IoT-Based Monitoring

ESP32 Wi-Fi can be used to transmit:

- Battery voltage
- Motor current
- Power consumption
- Battery temperature
- Vehicle status

to a mobile or web dashboard.

Current Sensor

A current sensor can be added to measure motor current.

The instantaneous electrical power can then be calculated:

$$P = V \times I$$

Battery State-of-Charge

Voltage and current measurements can be combined with a battery model or coulomb-counting method for improved state-of-charge estimation.

## XII. CONCLUSION

This thesis presents the design and development of an ESP32-based intelligent voltage monitoring and power-management system for a 12 V battery-powered electric vehicle. The proposed system uses a DC voltage sensor to continuously measure the battery voltage and an ESP32 to process the measurement and monitor the electrical condition of the vehicle.

The power system is divided into appropriate propulsion and auxiliary sections. A suitable regulated 12 V stage can be used where a tightly controlled 12 V supply is required, while a DC-DC buck converter provides a stable 5 V supply to the ESP32, sensors, display, and other electronic circuits.

The system provides a practical method for monitoring battery voltage, detecting abnormal conditions, and improving the reliability of vehicle electronics. The addition of current sensing, temperature measurement, IoT communication, and intelligent load management can further improve the system.

The proposed project therefore provides a foundation for developing a more reliable and intelligent low-voltage electrical architecture for small electric vehicles.

## REFERENCES

- [1] Espressif Systems, *ESP32 Series Datasheet*. [Espressif Systems](#)
- [2] Espressif Systems, *ESP32 Technical Reference Manual*. [Espressif Systems](#)
- [3] Arduino, *Arduino IDE Documentation*. [Arduino](#)
- [4] *Battery manufacturer datasheets and application manuals*.
- [5] *DC-DC converter manufacturer datasheets*.
- [6] *Motor-controller manufacturer specifications*.
- [7] *General literature on electric vehicle power-management systems*.
- [8] *General literature on rechargeable battery charging and monitoring*.
- [9] *Technical documentation for DC voltage-sensor modules*.
- [10] *Technical literature on embedded systems and electric vehicle auxiliary power systems*.