

# ELECTRICAL VEHICLE CHARGING WITH INTRELEAVED CONVERTER

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**Abstract:** The rapid growth of electric vehicles (EVs) has increased the demand for efficient and reliable charging systems. Conventional chargers often suffer from high current ripple, poor power quality, and thermal stress. To overcome these challenges, this work proposes an EV charging system using an Interleaved DC–DC Converter. Multiple converter phases operate with phase-shifted control signals to share load current, reducing current ripple, switching losses, and thermal stress. The system includes a front-end AC–DC rectifier with power factor correction followed by the interleaved converter for regulated battery charging. Simulation results show improved efficiency, lower total harmonic distortion (THD), and better dynamic performance compared to conventional converters.

**Keywords:** Electric Vehicle (EV), Interleaved Converter, DC–DC Conversion, Power Factor Correction (PFC), Ripple Reduction, Battery Charging System.

## I. INTRODUCTION

The growing demand for clean and sustainable transportation has accelerated the adoption of electric vehicles (EVs), increasing the need for efficient charging infrastructure. A key component in EV chargers is the **DC–DC converter**, which regulates and boosts voltage for battery charging. Conventional boost converters are simple but often suffer from limited voltage gain, high ripple, and thermal inefficiencies in high-power applications. To overcome these limitations, **Interleaved Boost Converters (IBC)** are widely used. In this topology, multiple converter phases operate with phase-shifted control signals, reducing input current ripple, improving power quality, and distributing thermal stress across components. Interleaving also increases the effective switching frequency, enabling smaller filters, reduced EMI, and improved dynamic response. These advantages make IBCs highly suitable for efficient and reliable EV charging systems.

## II. MAIN BLOCK

- i. DC Input Source
- ii. MOSFET
- iii. Opto-Coupler
- iv. Voltage Sensors
- v. Inductor and Capacitor Calculation
- vi. Arduino UNO (ATmega328P Microcontroller Board)
- vii. Step-Down Transformer (230 V / 12 V, 2 A) • Bridge Rectifier and Filter Circuit
- viii. Diodes (6A4 – Two Units)
- ix. LCD Display (16×2 Alphanumeric Display)
- x. Variable Resistor (Potentiometer)
- xi. Switch
- xii. PCB
- xiii. Connecting Wires and Banana Connectors
- xiv. Wooden Base Board
- xv. Protus

### DC Input Source:

The system is supplied by a 12 V DC input, which can be derived from a solar panel, a DC supply unit, or a battery. This input serves as the primary energy source for the converter, and its low voltage is stepped up by the interleaved converter topology

**MOSFET:**

For selection of MOSFET, the load power, voltage and current ratings are considered. The maximum load voltage is 24V, power is 100W. The MOSFET selected should have voltage rating at least three times the load voltage rating hence MOSFET voltage rating should be greater than 72V. The current rating of selected MOSFET should be greater than two times the rated load current hence MOSFET current should be greater than 9A.

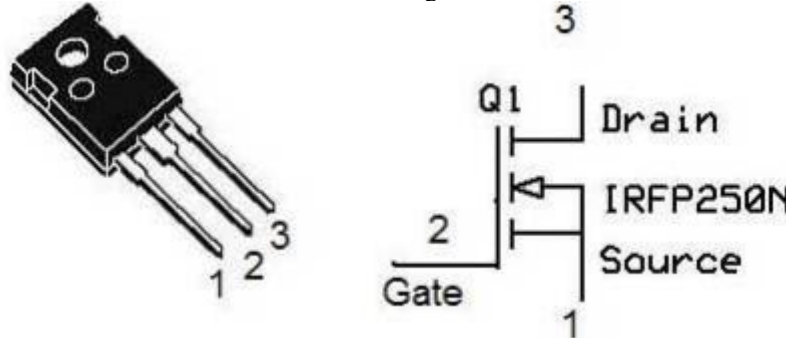


Fig. 1 IRFP250 MOSFET

**Opto-Coupler:**

MOSFET is power electronic switching device operating at high voltage. The microcontroller gives control signal in form of PWM. The desired isolation and coupling between low voltage microcontroller and high voltage MOSFET is provided through PC817 based opto-coupler driver circuit as mentioned in figure.

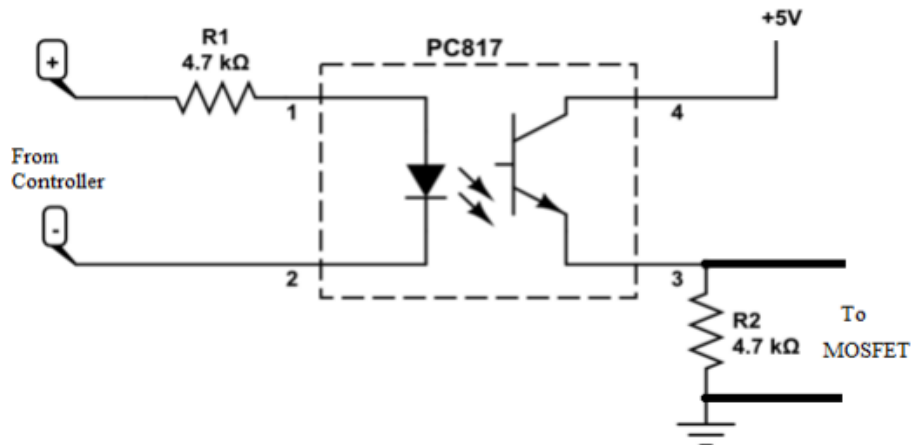


Fig. 2 Driver Circuit for MOSFET

**Voltage Sensors:**

For voltage sensing, a voltage divider arrangement is used as shown in figure. The maximum possible input voltage is considered to be 50V. The PICCOLO board can withstand maximum of 3.3V voltage level for ADC input. Hence voltage divider components should be designed to get output voltage of 3.3V maximum.

**Step-Down Transformer**

A step-down transformer is used to convert the high-voltage 230 V AC mains to a safer 12V AC level suitable for the low-voltage circuits. It has a laminated core construction that minimizes eddy current losses and provides galvanic isolation from the mains supply, ensuring operator safety. The secondary output of the transformer feeds the bridge rectifier, which converts AC to DC for powering the Arduino and driver circuits. The transformer's current capacity (2 A) ensures stable operation without overheating. Proper fuse protection is included at the primary side to prevent overcurrent faults.



Fig. 3 Step-Down Transformer (230 V / 12 V, 2 A)

**Diodes (6A4 – Two Units)**

The 6A4 diodes act as freewheeling (flyback) diodes in each boost converter phase. They are fast-recovery power diodes rated at 6 A and 400 V. Their main function is to provide a path for the inductor current when the MOSFET turns OFF, preventing voltage spikes and ensuring continuous current flow to the load. The diodes conduct alternately depending on which MOSFET is OFF. Their fast recovery time reduces switching losses and improves efficiency at the 1 kHz switching frequency. Placing the diodes close to the inductor and MOSFET helps minimize parasitic inductance and voltage ringing.



Fig. 4 Diodes (6A4 – Two Units)

**Variable Resistor (Potentiometer):**

The variable resistor or potentiometer serves two purposes in the circuit. The first potentiometer (10 k $\Omega$ ) controls the contrast of the LCD, while a second potentiometer can be used to adjust the reference voltage in the sensing circuit, allowing calibration of output voltage readings. Potentiometers are resistive components with a movable contact, enabling continuous adjustment of resistance and hence output voltage levels. They provide manual tuning flexibility during testing and calibration stages, ensuring accuracy of displayed and measured values.



Fig. 5 Variable Resistor (Potentiometer)

**Switch**

The switch acts as a manual control input for starting or stopping the converter. When pressed, it sends a digital HIGH or LOW signal to a dedicated Arduino input pin. The program logic interprets this signal to enable or disable the PWM outputs. Using a push button ensures user-controlled operation, allowing safe activation and deactivation of the converter during testing. Debouncing resistors or software filters are included to eliminate false triggering caused by mechanical vibrations.



Fig. 6 Switch

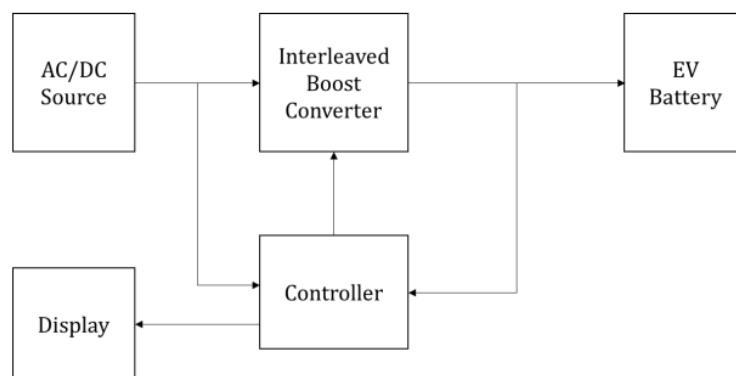
**III. BLOCK DIAGRAM WITH EXPLANATION**

Fig. 6 Block Diagram Of Proposed System

**Interleaved Boost Converter:**

The interleaved boost converter is the core of the system, consisting of two boost converter stages operating in parallel with a 180° phase shift. This interleaving reduces input/output current ripple, improves efficiency and power density, lowers stress on switching devices, and enhances thermal performance. In this project, the converter boosts the input voltage from 12 V DC to 24 V DC for EV battery charging and operates at a 1 kHz switching frequency to ensure smooth energy transfer with reduced ripple.

**Controller:**

The controller (microcontroller or PWM IC) regulates the interleaved boost converter by monitoring input voltage, output voltage/current, and battery charging parameters. It generates PWM signals with a 180° phase shift to drive the MOSFETs. This ensures a stable 24 V output and protects the system from overcurrent and overvoltage conditions.

**EV Battery:**

The Electric Vehicle Battery is the load of the system. It is charged with a regulated 24 V DC output supplied by the interleaved converter. The converter provides controlled current and voltage suitable for safe and efficient charging of the EV battery. The interleaved design ensures smooth charging, reduced stress on the battery cells, and increased overall lifespan of the battery pack.

**Display Unit:**

The display module shows real-time system information such as input voltage (12 V), output voltage (24 V), and charging status (ON/OFF), allowing easy monitoring of the charging process.

The EV charging system works on the principle of voltage boosting and current interleaving. A 12 V DC input is supplied to an interleaved boost converter with two parallel boost stages operating with a 180° phase shift. Each stage stores

energy in the inductor when the MOSFET is ON and transfers it to the output when OFF. This reduces ripple and improves efficiency.

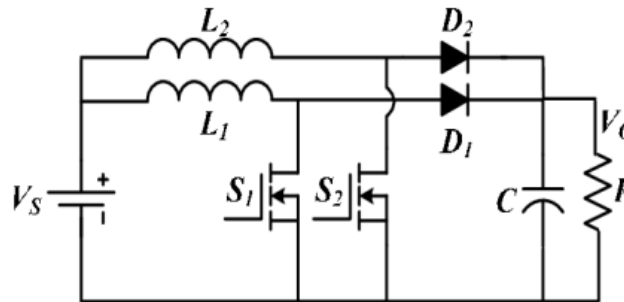


Fig. 7 Circuit Scheme of Interleaved Boost Converter

The controller generates PWM signals to regulate the duty cycle and maintain a stable 24 V output for EV battery charging. It also monitors voltage and current to ensure safe and reliable operation.

The circuit diagram of the Interleaved Boost Converter for EV Charging is shown above. It consists mainly of two boost converter stages connected in parallel and operated with a 180° phase shift between their switching signals. The main components of the circuit include two inductors ( $L_1$  and  $L_2$ ), two power switches ( $S_1$  and  $S_2$ ), two diodes ( $D_1$  and  $D_2$ ), and a single output capacitor ( $C$ ) connected across the load resistance ( $R$ ) representing the EV battery

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#### IV. RESULT AND CONCLUSION

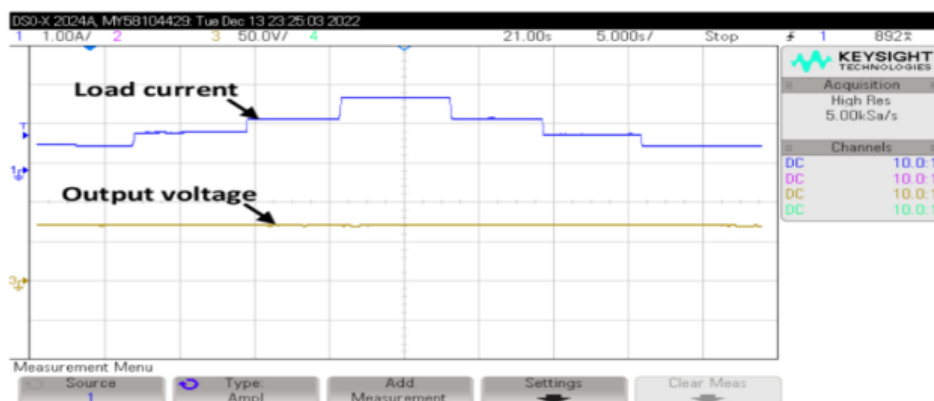


Fig. 7 Output Waveform of Interleaved Boost Converter



Fig. 8 - Output Voltage Waveform of Interleaved Boost Converter

From the experimental testing and visual observations, it is concluded that the designed interleaved converter effectively steps up the input voltage with higher efficiency and lower ripple.

The Arduino-based control system ensured accurate PWM generation, stable output regulation, and real-time monitoring through the LCD.

The practical hardware performance closely matches the theoretical calculations, proving the success and reliability of the project.

The final assembled model is compact, efficient, and suitable for EV charging and renewable energy applications.

### REFERENCES

- [1]. Khan, M. R. Khan, and M. F. Khan, "High efficiency interleaved boost DC–DC converter for electric vehicle charging applications," *Energies*, vol. 16, no. 3810, pp. 1–17, 2023.
- [2]. K. Gupta and A. Sharma, "Analysis of multiphase boost converters for high power EV chargers," *Topic5MO Conference Proceedings*, IEEE, 2023.
- [3]. International Electrotechnical Commission, IEC 61851-1 Electric Vehicle Conductive Charging System – Part 1: General Requirements, IEC, 2021.
- [4]. IRF540N Power MOSFET Datasheet, Infineon Technologies, 2023.
- [5]. D. Lemaitre, F. Costa, and G. Fontes, "Design considerations for interleaved boost converters in EV chargers," in *Proceedings of the PCIM Europe 2024 International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management*, Nuremberg, Germany, 2024, pp. 1–8