Int. J. Adv. Res. Sci. Technol. Volume 15, Issue 4, 2026, pp.1863-1867.

IJARST

International Journal of Advanced Research in Science and Technology

https://doi.org/10.62226/ijarst20262645

ISSN 2319 – 1783 (Print)

ISSN 2320 – 1126 (Online)

Design and Performance Analysis of a Solar-Powered EV Charging System using Landsman Converter

Dr. Parthasarathy*[1], Thangasankaran[2], Pugazhendhi[3], Sanjay[4] and Samuel[5]

**[1]Professor, Dept of EEE, K.L.N. College of Engineering, Sivagangai, Tamil Nadu, India*
[2]Asst. Professor, Dept of EEE, K.L.N. College of Engineering, Sivagangai, Tamil Nadu, India
[3, 4, 5]UG Scholars, Dept of EEE, K.L.N. College of Engineering, Sivagangai, Tamil Nadu, India
sarathy_sps@yahoo.co.in, pugalendhis59@gmail.com

ARTICLEINFO

Article history:

Received	21 Apr 2026
Accepted	24 Apr 2026
Available online	06 May 2026

Keywords:

Landsman Converter, SEPIC Converter, EV Charging, DC-DC Converter, Solar Photovoltaic, Voltage Ripple, PI Controller, Voltage Regulation, Continuous Conduction Mode

Indexed in:

and in major libraries

ABSTRACT

The increasing dependence of electric vehicle (EV) charging systems on conventional grid power results in higher energy costs and grid instability during peak demand periods. To address this, a solar-powered EV charging system using a Landsman DC–DC converter is proposed and its performance is comparatively analyzed against the SEPIC converter under identical operating conditions. The proposed system efficiently converts a variable photovoltaic (PV) input voltage of 17–21 V into a regulated 60 V DC output suitable for EV battery charging. A closed-loop control strategy using a Proportional–Integral (PI) controller ensures stable voltage regulation under varying irradiance conditions. Comparative simulation results carried out in MATLAB/Simulink demonstrate that the Landsman converter achieves significantly lower output voltage ripple (~13 mV), continuous input current, faster settling time (~0.22 s), and higher efficiency compared to the SEPIC converter. These characteristics make the Landsman converter highly suitable for photovoltaic-based EV charging applications. The proposed system provides an efficient, reliable, and sustainable solution for modern EV charging infrastructure using renewable energy sources.

Introduction:

Electric vehicles (EVs) are rapidly gaining importance as a sustainable alternative to conventional fossil-fuel-based transportation due to their potential to reduce carbon emissions and dependence on non-renewable energy sources. With increasing global EV adoption, the demand for efficient, reliable, and eco-friendly charging infrastructure is rising significantly.

Conventional EV charging systems rely heavily on grid power, which leads to increased operational costs, higher carbon footprint, and stress on the electrical grid, particularly during peak demand conditions. Solar photovoltaic (PV) systems provide a clean and renewable alternative for EV charging; however, their output is highly variable due to fluctuations in solar irradiance and temperature. The PV output voltage typically ranges between 17–21 V under varying conditions, which must be efficiently boosted to a stable level suitable for EV battery charging.

To effectively utilize PV energy for EV charging, a high-performance DC–DC converter is essential. The converter must provide high voltage gain, low output ripple, and continuous input current for accurate Maximum Power Point Tracking (MPPT). Among various DC–DC converter topologies studied for such applications, the SEPIC converter has been widely considered due to its flexibility in both step-up and step-down operation. However, its discontinuous input current and relatively higher ripple limit its suitability for PV-based systems.

The Landsman converter emerges as a superior solution due to its continuous input current, high voltage gain, and reduced voltage ripple compared to conventional converters including Boost and SEPIC. These characteristics make it particularly well-suited for solar-powered EV charging systems.

This paper presents the design and simulation of a solar-powered EV charging system using a Landsman DC–DC converter and provides a detailed comparative performance analysis against the SEPIC converter under identical operating conditions. A PI-controlled closed-loop strategy is implemented in both converters to ensure fair and consistent comparison. The key performance parameters evaluated include output voltage ripple, input current ripple, efficiency, and dynamic response.

Related Work:

Recent research has focused on improving the efficiency and performance of DC–DC converters for photovoltaic and EV charging applications, particularly exploring advanced Landsman converter topologies.

Shirly et al. [1] demonstrated significant improvement in Landsman converter efficiency from 92.69% to 98.13% using Particle Swarm Optimization (PSO) for parameter tuning, highlighting the converter's potential for high-efficiency CCM operation with reduced ripple and improved dynamic response.

Mishra and Singh [2] proposed a bridgeless Landsman converter for EV charging applications that eliminates the conventional diode bridge, achieving near-unity power factor, reduced conduction losses, and improved overall charging efficiency, making it suitable for high-performance EV charging systems.

An interleaved Landsman converter topology [3] distributed current across multiple phases to significantly reduce current ripple and improve thermal management in high-power applications, though at the cost of increased circuit complexity due to additional switching elements.

A modular multiport Landsman converter for hybrid EV charging systems [4] demonstrated improved voltage gain and enhanced energy management by integrating multiple renewable sources including solar, wind, and fuel cells, confirming the converter's scalability for modern charging infrastructure.

Research on Landsman converters integrated with ANFIS-based MPPT for photovoltaic systems [5] achieved a voltage gain as high as 1:16, significantly outperforming conventional Boost and SEPIC converters, with fast and stable maximum power point tracking under varying irradiance conditions.

Further design studies for EV battery charging using Landsman converters [6] validated improved voltage regulation, stable output, and higher efficiency compared to conventional topologies, confirming its suitability for small and medium-scale solar-powered charging applications.

The literature consistently confirms the Landsman converter as a superior candidate over SEPIC and Boost converters for photovoltaic-based EV charging systems in terms of input current continuity, ripple reduction, and efficiency.

Landsman Converter Topology:

The Landsman converter is a non-isolated DC–DC boost topology that consists of an input inductor L_1, an output inductor L_2, an intermediate capacitor C_1, an output capacitor C_2, a MOSFET switch (S), and a freewheeling diode (D). The photovoltaic source is connected at the input, and the EV battery load is connected at the output. The converter operates in two modes based on the switching state of the MOSFET.

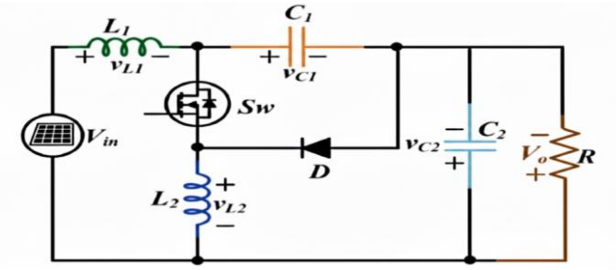

Fig 1 Circuit Diagram of the Landsman Converter

Mode I – Switch ON: When the MOSFET is turned ON, the diode becomes reverse biased. The input inductor L_1 stores energy from the PV source while the intermediate capacitor C_1 discharges through the closed switch. The output capacitor C_2 maintains the load voltage by supplying energy to the load during this interval. This mode represents the energy storage phase.

Mode II – Switch OFF: When the MOSFET is turned OFF, the diode becomes forward biased, providing a current path. The energy stored in inductors L_1 and L_2 is transferred to the output through the forward-biased diode. The intermediate capacitor C_1 recharges from the input source, while the output capacitor C_2 receives and filters energy to maintain a stable output voltage. This is the energy transfer phase.

The voltage conversion ratio of the Landsman converter operating in CCM is given by:

$$\mathbf{M = V_o / V_{in} = D / (1 - D)}$$

where D is the duty cycle of the MOSFET switching signal. At a duty cycle of D = 0.78, the converter boosts the PV input voltage of 17–21 V to a regulated output of 60 V, which is suitable for EV battery charging.

The key advantages of the Landsman topology include continuous input current, which is essential for accurate MPPT in PV systems, reduced output voltage ripple due to CCM operation, and high voltage gain achievable with moderate duty cycle values.

SEPIC Converter Topology:

The Single-Ended Primary Inductor Converter (SEPIC) is a DC–DC topology capable of both step-up and step-down voltage conversion. It consists of two inductors (L_1, L_2), two capacitors (C_1, C_2), a MOSFET switch, and a diode. The SEPIC converter offers operational flexibility; however, it suffers from discontinuous input current, which introduces current spikes at the PV source interface and reduces the accuracy of MPPT. Additionally, the SEPIC converter typically exhibits higher voltage and current ripple compared to the Landsman topology under similar operating conditions.

For EV charging applications where continuous input current and low ripple are critical, these limitations reduce the suitability of the SEPIC converter when compared to the Landsman topology.

Comparative Analysis of SEPIC and Landsman Converter:

Both the SEPIC and Landsman converters are designed and simulated under identical operating conditions for a fair performance comparison. The design specifications used for both converters are listed in Table 1.

Parameter	value
Input Voltage (V_{in})	17-21 V(PV Source)
Input Current (I_{in})	8.78 A
Output Voltage (V_o)	60 V
Output Current (I_o)	2.25 A
Switching Frequency (F_{sw})	30KHz
Duty Cycle (D)	0.78
Load Resistance	26.6 Ω
Control Strategy	Closed-loop PI Controller

A qualitative comparison of the two converter topologies across key performance parameters is provided in Table 2.

Table 2. Qualitative Comparison of SEPIC and Landsman Converter

Feature	SEPIC Converter	Landsman Converter
Voltage Gain	Moderate	High
Input Current	Discontinuous	Continuous
Output Voltage Ripple	Moderate–High	Very Low
Input Current Ripple	High	Low
Suitability for PV/MPPT	Moderate	Excellent
CCM Operation	Partial	Full
Switching Stress	Moderate	Lower

The continuous input current of the Landsman converter makes it far more compatible with PV systems, as it ensures smoother energy extraction from the solar panel and enables accurate MPPT. The SEPIC converter's discontinuous input current introduces unnecessary current stress on the PV source.

Input Voltage and Current Waveforms:

The source voltage from the PV system varies between 17–21 V in both converters under the closed-loop PI control. In the Landsman converter, the input current remains continuous and smooth throughout operation, confirming full CCM behavior. This continuous current ensures minimal stress on the PV source and enables efficient energy extraction. In the SEPIC converter, the input current exhibits discontinuities and higher ripple, reducing MPPT accuracy and introducing additional stress on the solar panel interface.

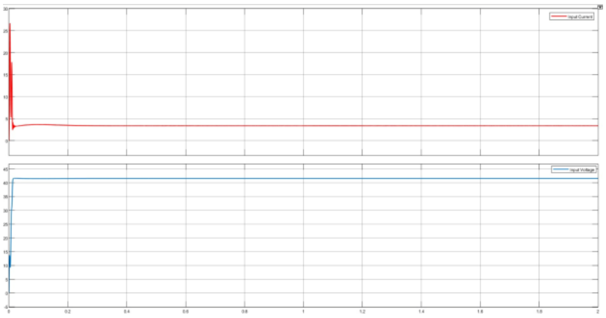

Fig. 2 — Input Voltage and Current Waveform of Landsman

From Fig. 2, it is observed that the input voltage varies between 17–21 V as supplied by the PV source, while the input current remains continuous and smooth throughout operation. This continuous input current confirms full CCM behavior and ensures minimal stress on the PV source, enabling efficient energy extraction and accurate MPPT.

Output Voltage Waveform:

Both converters achieve a regulated output voltage of 60 V at steady state. The Landsman converter reaches the reference voltage with a settling time of approximately 0.22 seconds and minimal overshoot, demonstrating a well-damped and fast dynamic response. The SEPIC converter achieves the same 60 V output but with a longer settling time and relatively higher overshoot under identical PI tuning conditions.

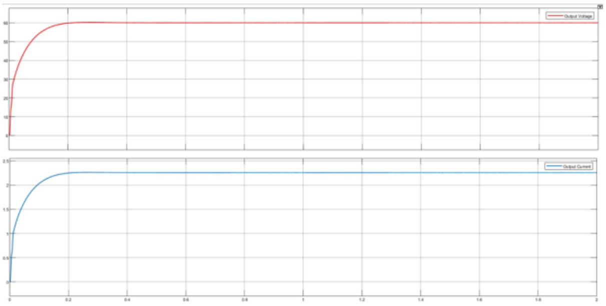

Fig. 3 — Output Voltage Waveform of Landsman Converter

From Fig. 3, the output voltage starts from zero and rises smoothly to the reference value of 60 V with a settling time of approximately 0.22 seconds and minimal overshoot. The stable steady-state output confirms that the PI controller effectively regulates the voltage under varying PV input conditions.

Output Voltage Ripple Comparison:

Output voltage ripple is a critical parameter for EV battery charging, as excessive ripple leads to increased battery heating and reduced battery life. The Landsman converter achieves a very low output voltage ripple of approximately 13 mV owing to its CCM operation, optimized output capacitor design, and 30 kHz switching frequency. The SEPIC converter exhibits a significantly higher output ripple of 20 mV under identical conditions. This difference is clearly visible in the waveforms below.

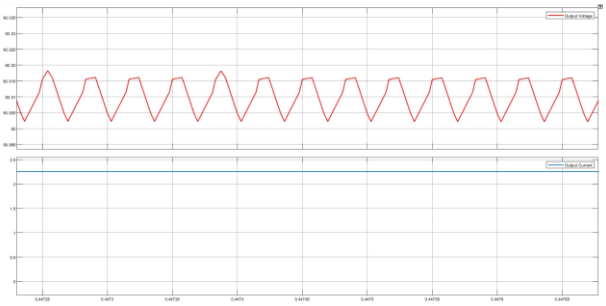

Fig. 4 — Output Voltage Ripple of Landsman Converter

Fig. 4 shows that the Landsman converter achieves a very low output voltage ripple of approximately 13 mV. This low ripple is a result of full CCM operation, optimized output capacitor design, and the 30 kHz switching frequency, ensuring stable and high-quality DC output suitable for EV battery charging.

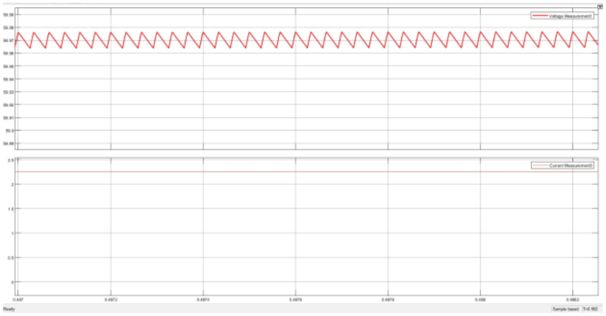

Fig. 5 — Output Voltage Ripple of SEPIC Converter

From Fig. 5, the SEPIC converter produces an output voltage ripple of approximately 20 mV — significantly higher than the 13 mV achieved by the Landsman converter. The higher ripple in the SEPIC converter is due to its partial CCM operation and less effective output filtering, making it comparatively less suitable for sensitive EV battery charging applications.

Input Current Ripple Comparison:

The input current ripple directly affects the quality of power drawn from the PV source and the effectiveness of MPPT. The Landsman converter maintains significantly lower input current ripple compared to the SEPIC converter, as shown in the waveforms below. The CCM operation and inductive filtering at the input stage of the Landsman topology ensure minimal current fluctuations, enabling smooth and efficient power extraction from the solar panel.

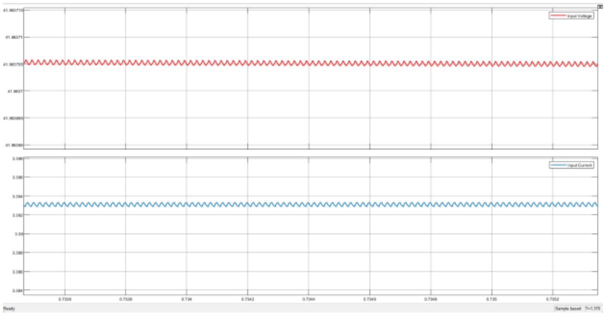

Fig. 6 — Input Current Ripple of Landsman Converter

Fig. 6 confirms that the Landsman converter maintains a very low input current ripple of approximately 2 mA. The inductive filtering at the input stage and CCM operation together ensure smooth and continuous current draw from the PV source, which is essential for accurate and undisturbed MPPT operation.

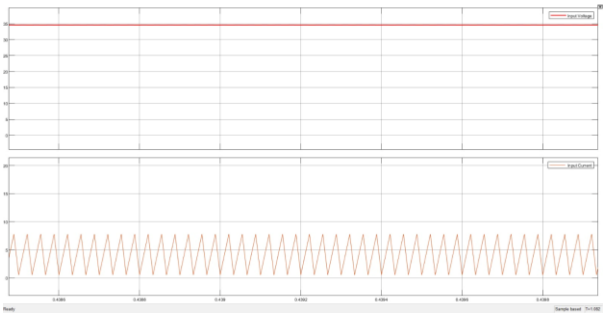

Fig. 7 — Input Current Ripple of SEPIC Converter

From Fig. 7, the SEPIC converter exhibits a significantly higher input current ripple of approximately 6.5 A due to its discontinuous conduction behavior. This high ripple introduces current stress on the PV source and disrupts MPPT accuracy, reducing the overall energy extraction efficiency from the solar panel compared to the Landsman converter.

Performance Summary:

Performance Parameter	SEPIC Converter	Landsman Converter
Output Voltage	60 V	60 V
Output Voltage Ripple	20 mV	13 mV
Input Current Nature	Discontinuous	Continuous
Input Current Ripple	6.5 A	2 mA
Settling Time	0.4 S	0.22 S
Efficiency	88%	90%

The Landsman converter demonstrates superior performance across all parameters, confirming its suitability for solar-powered EV charging applications.

Conclusion:

The design and comparative performance analysis of a solar-powered EV charging system using Landsman and SEPIC DC–DC converters has been successfully presented. Both converters are designed for identical operating conditions — boosting a variable PV input voltage of 17–21 V to a regulated 60 V DC output using a closed-loop PI controller simulated in MATLAB/Simulink.

The simulation results consistently confirm that the Landsman converter outperforms the SEPIC converter across all key performance parameters. The Landsman converter achieves a very low output voltage ripple of ~13 mV, continuous input current, minimal settling time of ~0.22 seconds, and lower input current ripple. These characteristics are critical for PV-based applications, as continuous input current ensures accurate MPPT and reduces stress on the solar panel, while low output ripple ensures safe and efficient EV battery charging.

The SEPIC converter, while offering operational flexibility, suffers from discontinuous input current and higher ripple, which limit its effectiveness in solar-powered EV charging systems. The Landsman converter's superior performance makes it the preferred topology for photovoltaic-based EV charging applications.

The proposed solar-powered Landsman converter-based EV charging system provides an efficient, reliable, and eco-friendly solution for modern EV infrastructure. This work supports the transition towards renewable-energy-based charging systems and contributes to sustainable and clean energy transportation goals.

References:

1. D. Shirly A.R., J. Shamni, M. Sudhilaya, J. Poorani, and Y. Priyadharshini, "Improving Efficiency and Power Loss Minimization in Landsman DC–DC Converter using Particle Swarm Optimization Technique (PSO)," *Proc. IEEE 2nd Int. Conf. on Emerging Technology (INCET)*, 2021.
2. K. Mishra and B. Singh, "Bridgeless Landsman Converter for EV Charging Applications," *IEEE Conference/Journal Publication*, 2024.
3. Jothimani, Gnanavadivel, Yogalakshmi Palanichamy, Senthil Kumar Natarajan, and Thangasankaran Rameshkumar. "Single-phase front-end modified interleaved Luo power factor correction converter for on-board electric vehicle charger." International Journal of Circuit Theory and Applications 49, no. 9 (2021): 2655-2669.
4. Gnanavadivel, J., R. Thangasankaran, N. Senthil Kumar, K. S. Krishnaveni, and Mepco Schlenk. "Performance analysis of PI controller and PR controller based three-phase AC-DC boost converter with space vector PWM." International Journal of Pure and Applied Mathematics 118, no. 24 (2018): 1-16.
5. Lakshmi, M. Bharani, R. Thangasankaran, J. Gnanavadivel, and ST Jaya Christa. "Performance evaluation of fuzzy controlled single phase PWM rectifier." In 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), pp. 1974-1979. IEEE, 2018.
6. Shanthi, R., S. Kalyani, and R. Thangasankaran. "Performance analysis of speed control of PMSM drive with sinusoidal PWM and space vector pwm fed voltage source inverters." In 2017 International Conference on Innovations in Green Energy and Healthcare Technologies (IGEHT), pp. 1-10. IEEE, 2017.
7. Thanzasankaran, R., ST Jaya Christa, J. Gnanavadivel, and NiSenthil Kumar. "Design and analysis of negative output Luo converter for power quality enhancement." In 2018 International Conference on Current Trends towards Converging Technologies (ICCTCT), pp. 1-6. IEEE, 2018.
8. Alagesan, J. Siva, R. Thangasankaran, and B. Karthikeyan. "Study of harmonic content elimination with three phase pwm rectifier and phase-controlled rectifier." International Journal of Scientific Research in Science and Technology (IJSRST) 4, no. 2 (2018): 1075-1081.
9. Thangasankaran, R., Tapaswini Patnaik, A. Bhuvanesh, M. Geetha, and T. Reena Raj. "Investigation on Application of Novel Converters for Hybrid Renewable Energy Systems." In 2024 2nd International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT), pp. 259-265. IEEE, 2024.
10. Thangasankaran, R., and S. Parthasarathy. "Proteus/Simulink Analysis of Rectifier based E-Vehicle Charger Circuit." In E3S Web of Conferences, vol. 387, p. 01011. EDP Sciences, 2023.
11. Thangasankaran, R., S. Parthasarathy, P. G. Harish Prabu, R. Praveen Thiyagarajan, and R. Arun Kumar. "MATLAB/Simulink analysis of a ripple-free high-efficiency buck-boost type converter for EV charging and controlling applications." International Research Journal of Engineering and Technology 9, no. 06 (2022).
12. THANGASANKARAN, R. "DESIGN AND ANALYSIS OF AC TO DC SEPIC CONVERTER FOR LOW POWER APPLICATIONS." INTERNATIONAL JOURNAL 13, no. 3 (2025): 1276-1283.
13. Thangasankaran, R., Ms S. Shanthini, and S. Parthasarathy. Design And Analysis of AC-DC Interleaved Negative Output Cuk Converter for Power Quality Enhancement.
14. Siddharthan, Mr ST, P. G. Scholar, Mepco Schlenk, Mr R. Thangasankaran, J. Gnanavadivel, and ST Jaya Christa. "Design and Analysis of DC–DC Cuk Converter with Interleaved Topology."