IJARST
International Journal of Advanced Research in
Science and Technology
https://doi.org/10.62226/ijarst20262644
ISSN 2319 – 1783 (Print)
ISSN 2320 – 1126 (Online)

Design and Analysis of Modified PFC Based Sheppard-Taylor Converter for Electric Vehicle Charger Application

R.THANGASANKARAN*, Dr.S.PARTHASARATHY**, V.K.KARTHICK, S.LOGABALAJI***, M.VIGNESH******

**Asst. Professor, Dept of EEE, K.L.N. College of Engineering, Sivagangai, Tamil Nadu, India*

***Professor, Dept of EEE, K.L.N. College of Engineering, Sivagangai, Tamil Nadu, India*

****UG Scholars, Dept of EEE, K.L.N. College of Engineering, Sivagangai, Tamil Nadu, India*

E-Mail: thangasankaranr@gmail.com, sarathy_sps@yhoo.co.in, vkkarthick51@gmail.com, adhibalaji45@gmail.com, sudhavicky73@gmail.com

ARTICLEINFO

Article history:

Received	19 Apr 2026
Accepted	24 Apr 2026
Available online	02 May 2026

Keywords:

Sheppard–Taylor Converter,
PFC, AC–DC Conversion,
EV Charging,
Closed-Loop Control.

Indexed in:

and in major libraries

ABSTRACT

This paper presents the design and analysis of a Sheppard–Taylor converter for efficient AC–DC power conversion in electric vehicle (EV) charging applications. The proposed system integrates power factor correction (PFC) to improve input power quality and reduce harmonic distortion. A high-frequency transformer is employed to achieve electrical isolation and compact design. The converter operates with a closed-loop control strategy to maintain stable output voltage under varying load conditions. Pulse Width Modulation (PWM) is used to control the switching devices, ensuring reduced switching losses and improved efficiency. The system is modeled and simulated using MATLAB/Simulink to evaluate its performance. Simulation results demonstrate improved power factor, regulated DC output, and enhanced overall efficiency, making the proposed converter suitable for modern EV charging and renewable energy applications

1.INTRODUTION:

The increasing demand for efficient power conversion systems has become a critical aspect in modern electrical and electronic applications, especially in electric vehicle (EV) charging and renewable energy systems. Conventional AC–DC converters often suffer from poor power factor, high harmonic distortion, and reduced efficiency, which affect overall system performance. To address these challenges, advanced converter topologies with power factor correction (PFC) techniques are gaining significant attention. [3]

Among various topologies, the Sheppard–Taylor converter offers an effective solution for high-efficiency AC–DC conversion with improved power quality. [6] This converter utilizes a high-frequency transformer to provide electrical isolation and compact design, making it suitable for modern applications. Additionally, the incorporation of PFC helps in reducing input current harmonics and improving the power factor close to unity.[1]

In this paper, a Sheppard–Taylor converter-based AC–DC system is proposed for EV charging applications. The system is designed with a closed-loop control strategy to maintain a stable DC output under varying load conditions. Pulse Width Modulation (PWM) techniques are employed to control the switching operation, thereby reducing switching losses and enhancing efficiency. [8] The proposed system is modelled and analyzed using MATLAB/Simulink to evaluate its performance characteristics.

The main objective of this work is to improve the efficiency, power quality, and reliability of AC–DC conversion systems. The results demonstrate that the proposed convexrter provides better voltage regulation, reduced harmonic distortion, and improved overall system performance, making it a suitable choice for EV charging and related applications.

2. PROJECT OVERVIEW:

This project presents a Sheppard–Taylor converter for efficient AC–DC power conversion in EV charging applications. It enhances power quality by incorporating Power Factor Correction (PFC), reducing harmonic distortion. A high-frequency transformer is used to provide electrical isolation and compact system design. Pulse Width Modulation (PWM) controls the switching devices to achieve high efficiency. A closed-loop control system maintains a stable and regulated DC output voltage. The converter ensures continuous input and output current, improving overall performance. Switching losses are minimized using advanced control techniques. The system is suitable for both EV charging and renewable energy applications. The model is developed and simulated using MATLAB/Simulink for performance evaluation. Results show improved efficiency, better voltage regulation, and enhanced power factor.

3.1. EXISTING SYSTEM:

The existing AC–DC conversion system commonly used in power applications consists of a bridge rectifier followed by a filter circuit. It converts the AC input supply into DC output, but the output is generally unregulated and contains ripple. [11] In some cases, a basic Power Factor Correction (PFC) stage is added, but it is not sufficient to achieve high performance. The input current waveform is distorted, resulting in low power factor and high harmonic content. These systems usually operate at low frequency, leading to bulky size and increased losses. [16] Due to limited control techniques, the overall efficiency and performance of the system remain low, making it less suitable for modern applications like EV charging.

3.2 LIMITATION OF EXISTING SYSTEM:

The conventional AC–DC converter systems have several limitations that reduce their effectiveness in modern applications. These systems typically exhibit a low power factor due to distorted input current and generate high Total Harmonic Distortion (THD), which degrades power quality. [18] The output voltage is not properly regulated and varies with changes in load conditions. Additionally, they operate at low frequencies, resulting in bulky size and increased weight. Higher switching losses further reduce the overall efficiency of the system. Moreover, the lack of continuous current flow affects stability, making these converters unsuitable for advanced applications such as electric vehicle charging systems. [14]

3.3. PROPOSED METHODOLOGY:

The proposed system is based on the design and implementation of a Sheppard–Taylor converter for efficient AC–DC power conversion in electric vehicle (EV) charging applications. The methodology focuses on improving power quality, reducing harmonic distortion, and achieving a regulated DC output.

Initially, the AC input supply is converted into a controlled DC output using the Sheppard–Taylor converter topology. The converter consists of active switching devices, diodes, inductors, capacitors, and a high-frequency transformer, which provides electrical isolation and compact design. The topology ensures continuous input and output current, thereby reducing ripple and improving efficiency.

To enhance power quality, a Power Factor Correction (PFC) technique is incorporated. This ensures that the input current follows the shape of the input voltage, resulting in a power factor close to unity and reduced total harmonic distortion (THD). The switching of the converter is controlled using Pulse Width Modulation (PWM), which helps in minimizing switching losses and improving overall system performance.

A closed-loop control system is implemented to maintain a stable output voltage. The output voltage is continuously monitored and compared with a reference value. The resulting error signal is processed through a controller, which adjusts the duty cycle of the switches accordingly. This ensures proper regulation of the output voltage under varying load and input conditions.

The entire system is modelled and analyzed using MATLAB/Simulink. Various parameters such as input voltage, switching frequency, and load conditions are considered to evaluate the performance of the converter. The methodology ensures improved efficiency, better voltage regulation, and enhanced power factor, making it suitable for EV charging and renewable energy applications.

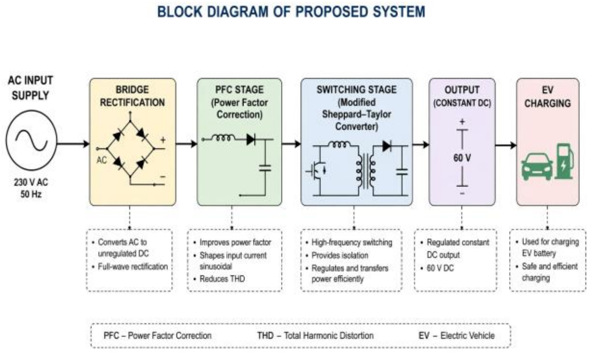
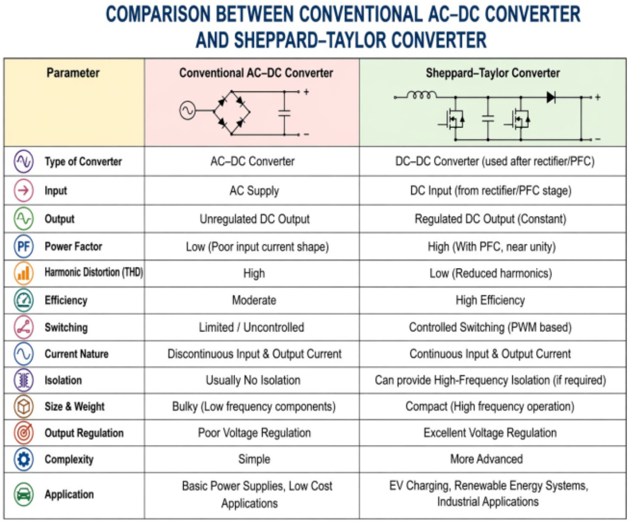


Figure 1: Block diagram of proposed system

- AC Input Supply**:** Provides the input alternating voltage (typically 230V AC).
- Rectifier Stage: Converts AC input into an unregulated DC output.
- Sheppard–Taylor Converter: The main power conversion stage that regulates and transfers power efficiently using inductors, capacitors, switches, and a high-frequency transformer.

- High-Frequency Transformer (HFT): Provides electrical isolation and reduces the size of the system.
- Output Filter: Smooths the DC output by reducing ripple and noise.
- Load (EVBattery): Represents the battery or DC load that receives regulated output.
- Feedback Control System: Monitors output voltage and compares it with a reference value.
- PWM Controller: Generates switching pulses based on the error signal to control the converter.
- PFC Unit: Ensures input current is in phase with voltage, improving power factor.



COMPARISON BETWEEN CONVENTIONAL AC–DC CONVERTER AND SHEPPARD–TAYLOR CONVERTER

Parameter	Conventional AC–DC Converter	Sheppard–Taylor Converter
Type of Converter	AC–DC Converter	DC–DC Converter (used after rectifier/PFC)
Input	AC Supply	DC Input (from rectifier/PFC stage)
Output	Unregulated DC Output	Regulated DC Output (Constant)
Power Factor	Low (Poor input current shape)	High (With PFC, near unity)
Harmonic Distortion (THD)	High	Low (Reduced harmonics)
Efficiency	Moderate	High Efficiency
Switching	Limited / Uncontrolled	Controlled Switching (PWM based)
Current Nature	Discontinuous Input & Output Current	Continuous Input & Output Current
Isolation	Usually No Isolation	Can provide High-Frequency Isolation (if required)
Size & Weight	Bulky (Low frequency components)	Compact (High frequency operation)
Output Regulation	Poor Voltage Regulation	Excellent Voltage Regulation
Complexity	Simple	More Advanced
Application	Basic Power Supplies, Low Cost Applications	EV Charging, Renewable Energy Systems, Industrial Applications

4. METHODOLOGY AND DESIGN:

The proposed system operates by converting a 230V AC input supply into a regulated DC output suitable for EV charging. Initially, the AC supply is fed into a bridge rectifier, where it is converted into an unregulated DC voltage. This DC is then passed through a Power Factor Correction (PFC) stage, which improves the input power factor and reduces harmonic distortion.

The corrected DC is applied to the switching stage, which consists of a modified Sheppard–Taylor converter with two MOSFETs connected in parallel and a capacitor placed between them. The MOSFETs are controlled using Pulse Width Modulation (PWM), which regulates the energy transfer and controls the output voltage. During operation, energy is stored in the inductor when the switches are ON and transferred to the load through the freewheeling diode when the switches are OFF.

The output side includes a filter capacitor and a freewheeling diode to ensure continuous current flow and reduce voltage ripple. A closed-loop control system continuously monitors the output voltage and adjusts the PWM duty cycle to maintain stability. Finally, the system provides a constant DC output of approximately 60V, which is suitable for electric vehicle battery charging applications.

4.1 MODES OF OPERATION:

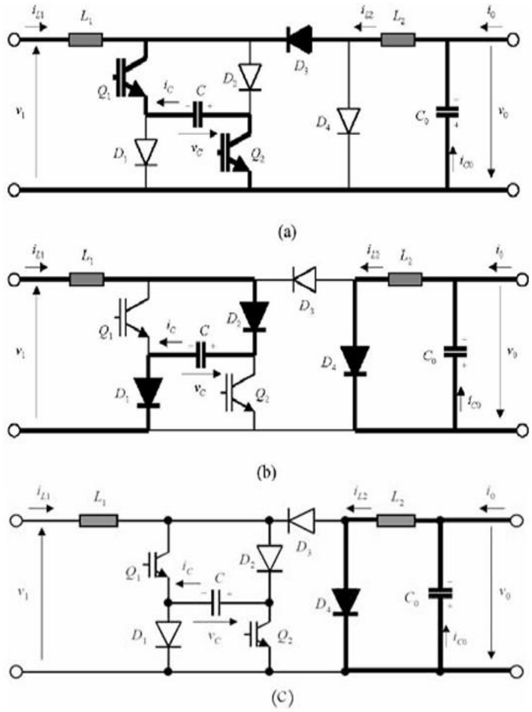


Figure 2: Modes of Operation

Mode 1: Both MOSFETs ON (Energy Storage Mode)

When both switches S1S_1S1 and S2S_2S2 are turned ON, the input DC (from rectifier and PFC stage) is applied across the inductor. The inductor starts storing energy, and current increases gradually. The capacitor placed between the MOSFETs helps in voltage balancing and reduces switching stress. During this mode, the freewheeling diode is reverse-biased, and the load is supplied by the output capacitor.

Mode 2: Both MOSFETs OFF (Energy Transfer Mode)

When both switches are turned OFF, the energy stored in the inductor is released to the output side. The freewheeling diode becomes forward-biased and conducts, allowing current to flow to the load. This ensures continuous current and maintains the output voltage. The output capacitor smooths the voltage and reduces ripple, providing a constant DC output.

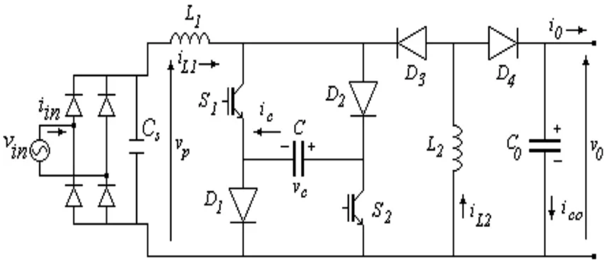


Figure 3: SHEPPARD TAYLOR CONVERTOR CIRCUIT DIAGRAM

Mode 3: One MOSFET ON, One OFF (Transition Mode)

In this mode, one switch (either S1S_1S1 or S2S_2S2) is ON while the other is OFF. This mode helps in controlling the rate of energy transfer and maintaining smooth current flow. The capacitor between the MOSFETs stabilizes voltage during switching transitions. This improves efficiency and reduces switching losses.

Table 1: List of Parameters used

Parameter with Symbol	Value
Input Inductors (L_{i1}, L_{i2})	1.32 mH
Source Inductor (L_s)	2.64 µH
Output Inductors (L_{o1}, L_{o2})	47.8 µH
Output Capacitor (C_o)	2.7 mF
Capacitors (C_1, C_2)	10 µF
Switching Frequency (f_{sw})	50 kHz
Filter Capacitor (C_f)	270 µF
Load Resistance (R_L)	3.6 Ω

5. SIMULATION ANALYSIS:

The proposed modified Sheppard–Taylor converter is modeled and analyzed using MATLAB/Simulink to evaluate its performance for EV charging applications. The simulation setup includes an AC input source (230V), bridge rectifier, Power Factor Correction (PFC) stage, switching circuit with two MOSFETs, capacitor between switches, freewheeling diode, and output filter.

The AC input is first converted into DC and then processed through the PFC stage, where the input current waveform is shaped to follow the input voltage. This results in an improved power factor close to unity and reduced harmonic distortion. The DC output from the PFC stage is then applied to the modified Sheppard–Taylor converter.

The switching stage is controlled using Pulse Width Modulation (PWM), where the duty cycle is adjusted to regulate the output voltage. The simulation results show that the MOSFET switching operation ensures efficient energy transfer, while the capacitor between the switches reduces voltage stress and switching losses.

At the output, the freewheeling diode and filter capacitor ensure continuous current flow and reduced voltage ripple. The system successfully produces a stable DC output of approximately 60V, suitable for EV battery charging. The output voltage waveform is smooth and well-regulated under varying load conditions.

Overall, the simulation results confirm that the proposed system achieves improved efficiency, reduced harmonics, better voltage regulation, and high power factor, making it effective for modern power conversion applications.

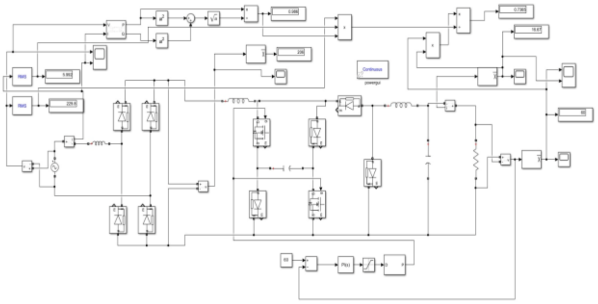


Figure 4: Closed Loop Simulation in MATLAB

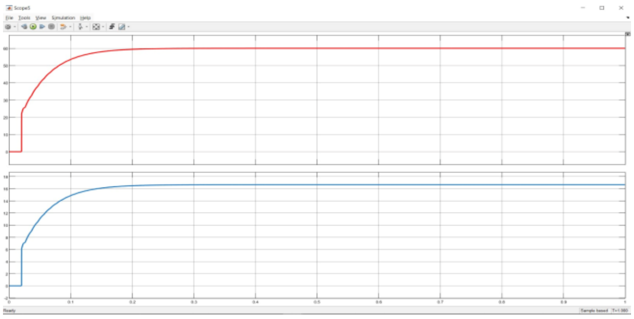


Figure 5: Output Voltage and Current Waveform

The fig 5 shows how the converter output increases and becomes stable. At the beginning, the output is zero because the system is just starting. Then the voltage rises quickly due to switching and capacitor charging. After that, it increases slowly and smoothly until it reaches a constant value. The output voltage and current settled at time t=0.2S around 60V and 16–17A. There are no oscillations or fluctuations, which means the system is stable. This smooth rise indicates good closed-loop control and proper working of the converter.

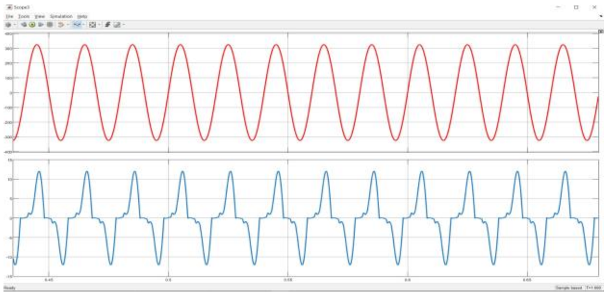


Figure 6: Source Voltage and Source Current Waveform

The fig 6 shows the input voltage of 325v and input current of around 6A

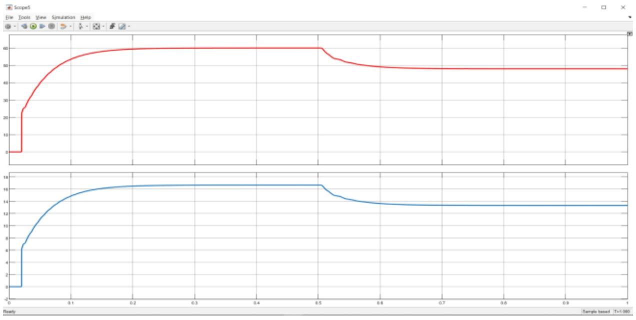


Figure 7: Sudden Output Voltage Variation (Dynamic Analysis)

The fig 7 shows the static analysis of the closed loop simulation of output waveform. when the sudden change in output set voltage from 60v-48v at time t=0.5S. after 0.5S output voltage becomes constant at 48v.

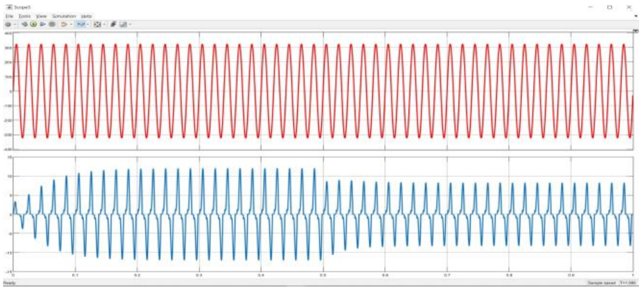


Figure 8 : Corresponding Source current Variations (Dynamic Analysis)

The fig 8 shows the corresponding input voltage and current of satic analysis . sudden change in output voltage ,the input current was reduced to compensate the power balance

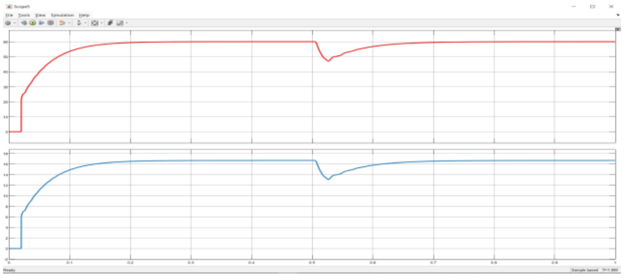


Figure 9: Sudden Supply Voltage Variation which is observed in Output Voltage (Dynamic Analysis)

The fig9 shows the dynamic analysis of the closed loop simulation of output waveform. Suddenly the source voltage was dropped, but the output voltage was settled at their actual set voltage of 60v with in 0.16 seconds.

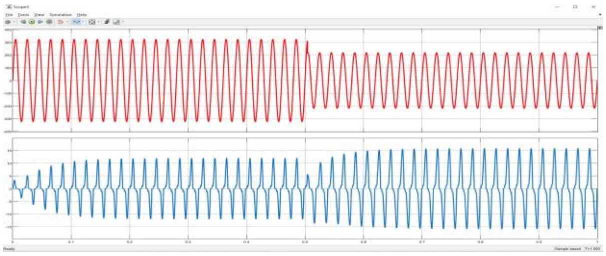


Figure 10: Corresponding Source Variations (Dynamic Analysis)

The fig10 shows the corresponding input voltage and current of dynamic analysis, the change in input voltage causes the increase of input current.

6. INFERENCES

The simulation results show that the proposed system operates effectively for AC–DC power conversion. The 230V AC input is successfully converted into a stable DC output suitable for EV charging applications. The output voltage is maintained at approximately 60V with minimal ripple, indicating good voltage regulation. The inclusion of the Power Factor Correction (PFC) stage improves the power factor close to unity. The input current waveform closely follows the input voltage, which reduces harmonic distortion. The MOSFET switching controlled by PWM ensures efficient energy transfer and reduced losses. The inductor current remains continuous throughout the operation, confirming stable performance. The freewheeling diode helps maintain continuous current flow to the load. The overall system demonstrates improved efficiency and reliability. Hence, the proposed converter performs better than conventional AC–DC converters.

7. CONCLUSION:

The proposed system successfully demonstrates efficient AC–DC power conversion using a modified Sheppard–Taylor converter for EV charging applications. The 230V AC input is effectively converted into a stable DC output of approximately 60V with minimal ripple. The inclusion of the Power Factor Correction (PFC) stage improves the input power factor (nearly around 0.9990) and reduces harmonic distortion. The use of PWM-controlled MOSFET switching ensures efficient operation with reduced losses. The system maintains continuous current flow and stable voltage under varying conditions. Overall, the proposed converter achieves better efficiency, improved power quality, and reliable performance compared to conventional AC–DC converters, making it suitable for modern EV charging applications.

8. REFERENCES:

1. B. Singh, B. N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, and D. P. Kothari, “A Review of Single-Phase Improved Power Quality AC–DC Converters,” ***IEEE Transactions on Industrial Electronics***, vol. 50, no. 5, pp. 962–981, Oct. 2003.
2. B. Singh, A. Chandra, K. Al-Haddad, and A. Pandey, “A Review of Three-Phase Improved Power Quality AC–DC Converters,” ***IEEE Transactions on Industrial Electronics***, vol. 51, no. 3, pp. 641–660, June 2004.
3. B. Singh, S. Singh, A. Chandra, and K. Al-Haddad, “Comprehensive Study of Single-Phase AC–DC Power Factor Corrected Converters with High-Frequency Isolation,” ***IEEE Transactions on Industrial Informatics***, vol. 7, no. 4, pp. 540–556, Nov. 2011.
4. B. Singh and G. D. Chaturvedi, “Modeling, Simulation and Development of Isolated Cuk AC–DC Converter in DCM and CCM Operation,” ***IETE Journal of Research***, vol. 54, no. 6, pp. 414–420, 2008.
5. B.Singh and S. Gairola, “Zigzag Autotransformer Based Full-Wave AC–DC Converters,” ***Asian Power Electronics Journal***, 2008.
6. B. Singh and G. D. Chaturvedi, “Modeling, Simulation and Development of Isolated Cuk AC–DC Converter in DCM and CCM Operation,” ***IETE Journal of Research***, vol. 54, no. 6, pp. 414–420, 2008.
7. B. Singh, G. Bhuvaneswari, and R. Kalpana, “Power Quality Improvement in Switched Mode Power Supplies Using Auto connected Transformer Based AC–DC Converters,” ***IETE Journal of Research***, vol. 56, no. 5, pp. 270–285, 2010.
8. B. Singh, G. Bhuvaneswari, and V. Garg, “A Novel Polygon Based 18-Pulse AC–DC Converter for Induction Motor Drives,” ***IEEE Transactions on Power Electronics***, vol. 22, no. 2, pp. 488–497, 2007.
9. 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.
10. 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.

11. 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.
12. 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.
13. 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.
14. 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.
15. 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.
16. 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.
17. 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).
18. Thangasankaran, R., Ms S. Shanthini, and S. Parthasarathy. Design And Analysis of AC-DC Interleaved Negative Output Cuk Converter for Power Quality Enhancement.
19. 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."
20. Thangasankaran, R., S. Parthasarathy, K. Karthick Raja, P. Guru Bathrinath, and S. Jeeva. "Design of a High Efficiency AC-DC Converter with Interleaved Zeta Topology for Electric Vehicle off Board Chargers."