



(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

⊕ www.ijirset.com 🖂 ijirset@gmail.com 🖄 +91-9940572462 🕓 +91 63819 07438





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405150|

Implementation of Variable Step Size Incremental Conductance MPPT for Efficient EV Charging Stations

V. Dineshraj¹, Dr. P. M. Balasubramaniam², V. Deepika³, P.Mammuthu⁴

Ph.D. Scholar, Assistant Professor, Department of Electrical and Electronics Engineering, Tagore Institute of

Engineering and Technology, Salem, Tamil Nadu, India¹

Supervisor, Professor, Department of Electronics Communication Engineering, Hindusthan Institute of Technology,

Coimbatore, India²

Assistant Professor, Department of Electrical and Electronics Engineering, Jeppiaar Engineering College,

Chennai, India³

Electrical Engineering, Sri Ganesh Electricals, Chennai, Tamil Nadu, India⁴

ABSTRACT: The increasing integration of renewable energy sources into electric vehicle (EV) charging infrastructure has led to the need for more efficient power management systems. Among the various Maximum Power Point Tracking (MPPT) techniques, the Incremental Conductance (INCC) method has proven to be effective, especially in rapidly changing environmental conditions. However, the conventional INCC algorithm suffers from limitations such as steady-state oscillations and slower tracking during irradiance fluctuations. To overcome these challenges, this work presents the implementation of a Variable Step Size INCC algorithm tailored for EV charging stations powered by photovoltaic (PV) systems. The proposed approach dynamically adjusts the step size based on the proximity to the maximum power point, thereby improving convergence speed and reducing power loss. Simulation results demonstrate a significant improvement in tracking efficiency, response time, and overall energy transfer to the EV battery. This study highlights the potential of adaptive MPPT techniques in enhancing the performance and sustainability of renewable-based EV charging infrastructure.

KEYWORDS: Variable Step Size, Energy Efficiency, Renewable Energy Integration, Adaptive Control Algorithm, Power Management,

I. INTRODUICTION

In this Variable step size Incremental Conductance (INC) algorithms are gaining prominence in enhancing the performance of Photovoltaic (PV)-based Electric Vehicle (EV) charging stations. Unlike conventional fixed-step MPPT techniques, the adaptive nature of these algorithms allows for quicker and more precise identification of the Maximum Power Point (MPP), especially under fluctuating sunlight and temperature conditions.

This adaptability not only minimizes energy loss but also ensures more reliable and consistent energy delivery, thereby increasing the overall system efficiency and responsiveness in real-world scenarios.

By dynamically modifying the step size in response to environmental variations, variable step size techniques can achieve faster convergence to the maximum power point (MPP) and maintain high tracking precision, particularly when solar irradiance or temperature shifts rapidly [2][5][6][7][8][9][10].Such algorithms help reduce fluctuations near the maximum power point (MPP), which leads to decreased current ripple and minimizes energy losses during tracking. In particular, variable step size approaches have demonstrated notably smaller peak-to-peak current variations and improved energy efficiency compared to traditional fixed step size techniques[1][2][5][6].By optimizing the step size, these methods enhance the overall efficiency of the PV system, increasing the output DC power delivered to the EV charging station[7][8][10].

IJIRSET©2025





[www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405150|

II. METHODOLOGY

The diagram illustrates a solar-powered electric vehicle (EV) charging system that integrates a photovoltaic (PV) array, a boost converter, and a Maximum Power Point Tracking (MPPT) controller to ensure efficient power transfer and show in fig.1.

Photovoltaic (PV) System: The process begins with the PV system, which consists of solar panels that convert sunlight into direct current (DC) electricity. The output parameters of the PV system—voltage (V_{pv}) and current (I_{pv}) —are continuously monitored for optimal operation.

MPPT Controller:

The MPPT block is responsible for determining the operating point at which the solar panels generate the maximum possible power. It receives real-time data on the panel's voltage and current, then uses an algorithm— commonly the Incremental Conductance (INC) method with variable step size—to calculate the optimal duty cycle. This duty cycle is crucial for adjusting the power flow efficiently.

Boost Converter:

The boost converter receives both the raw DC power from the PV system and the control signal (duty cycle) from the MPPT controller. Its main function is to increase (or "boost") the voltage level to match the requirements of the EV battery charging system. By dynamically adjusting its output based on the duty cycle, the converter ensures maximum energy extraction and efficient charging.

Electric Vehicle (EV) Charging:

Finally, the regulated power output from the boost converter is delivered to the electric vehicle. This ensures that the EV is charged using solar energy at optimal efficiency, even under changing environmental conditions such as cloud cover or temperature shifts.



Figure .1 Block Diagram For The Proposed System

Variable Step Size Incremental Conductance MPPT:

The Maximum Power Point Tracking (MPPT) technique plays a critical role in optimizing energy extraction from photovoltaic (PV) systems, particularly when environmental conditions such as solar irradiance and temperature vary. Among the MPPT techniques, the Incremental Conductance (INC) method is widely preferred due to its ability to accurately identify the maximum power point (MPP) by analyzing changes in current and voltage.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405150|

Traditional INC algorithms often use a fixed step size to adjust the operating point of the PV system. However, this fixed step size leads to a trade-off: smaller steps result in higher accuracy but slower response, while larger steps offer quick tracking but introduce oscillations and power loss near the MPP. To overcome this limitation, the Variable Step Size Incremental Conductance (VS-INC) approach dynamically adjusts the step size based on real-time system conditions.

The VS-INC algorithm improves tracking performance by analyzing the slope of the power-voltage (P-V) curve. The relationship between the instantaneous conductance (I/V) and the incremental conductance (dI/dV) is used to determine the MPP.

III. RESULTS AND DISCUSSIONS

The implementation of the Variable Step Size Incremental Conductance (VS-INC) MPPT algorithm in a PV-based electric vehicle (EV) charging station was simulated and analyzed under varying environmental conditions. The results demonstrated clear improvements in both tracking efficiency and system responsiveness when compared to the conventional fixed step size INC algorithm.

During the simulations, the VS-INC method accurately identified the maximum power point (MPP) across different levels of solar irradiance and temperature. Unlike the fixed step size approach, which exhibited noticeable oscillations around the MPP, the variable step size version maintained stability and minimized fluctuations. The algorithm quickly adjusted the duty cycle of the boost converter to keep the PV panel operating near its optimal point, even under rapidly changing input conditions.

The average efficiency of power conversion increased by approximately 2–4% with the VS-INC method. This is primarily due to the reduced current ripple and quicker convergence to the MPP, which minimizes power losses during the tracking process. As a result, more usable power was delivered to the EV battery, improving the charging rate and overall station performance.

When subjected to sudden changes in irradiance, such as passing clouds, the VS-INC algorithm adapted more quickly than its fixed step counterpart. The step size automatically increased when the operating point moved far from the MPP, allowing the system to track the new MPP rapidly.

Once the MPP was approached, the step size decreased, which helped maintain system stability without overshooting. The improved performance of the VS-INC MPPT strategy is especially valuable for standalone EV charging stations powered by solar energy. It ensures maximum power harvesting during daylight hours, reduces dependency on auxiliary grid support, and contributes to better energy management in renewable-based charging infrastructure and show in the figures.





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405150|







Figure .3 Solar Panel Voltage Graph





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405150|



Figure .4 Solar Panel Power Graph



Figure .5 EV Charging Voltage Output Graph



Figure.6 EV Charging Current Output Graph





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405150|

IV. CONCLUSION

This work presents an effective approach for enhancing the performance of photovoltaic-powered electric vehicle (EV) charging systems through the implementation of a Variable Step Size Incremental Conductance (VS-INC) MPPT algorithm. By dynamically adjusting the step size in response to changes in solar irradiance and temperature, the system

consistently tracks the maximum power point with improved speed and accuracy compared to conventional fixed step size methods. The proposed method significantly reduces power loss, minimizes oscillations around the operating point, and ensures stable charging even under rapidly changing environmental conditions. Simulation results validate that the VS-INC technique improves tracking efficiency, reduces current ripple, and optimizes energy delivery to the EV batteries. Overall, the VS-INC MPPT strategy proves to be a promising solution for sustainable and efficient energy management in solar-based EV charging stations.

REFERENCES

[1] Gupta, A., Pachauri, R., Maity, T., Chauhan, Y., Mahela, O., Khan, B., & Gupta, P. (2021). Effect of Various Incremental Conductance MPPT Methods on the Charging of Battery Load Feed by Solar Panel. IEEE Access, 9, 90977-90988. https://doi.org/10.1109/ACCESS.2021.3091502.

[2]Chuang, M., Liu, Y., & Ye, S. (2020). A Novel Variable Step Size Incremental Conductance Method with an Adaptive Scaling Factor. Applied Sciences. https://doi.org/10.3390/app10155214.

[3]Mazumdar, D., Biswas, P., Sain, C., & Ustun, T. (2024). GAO Optimized Sliding Mode Based Reconfigurable Step Size Pb&O MPPT Controller With Grid Integrated EV Charging Station. <u>IEEE Access</u>, 12, 10608-10620. https://doi.org/10.1109/ACCESS.2023.3344275.

[4]Yan, Z., Fei, L., Yin, J., & Duan, S. (2008). Study on realizing MPPT by improved Incremental Conductance method with variable step-size. 2008 3rd IEEE Conference on Industrial Electronics and Applications, 547-550. https://doi.org/10.1109/ICIEA.2008.4582575.

[5]Loukriz, A., Haddadi, M., & Messalti, S. (2016). Simulation and experimental design of a new advanced variable step size Incremental Conductance MPPT algorithm for PV systems. ISA transactions, 62, 30-8 . https://doi.org/10.1016/j.isatra.2015.08.006.

[6]Ali, M., Mahmoud, K., Lehtonen, M., & Darwish, M. (2021). An Efficient Fuzzy-Logic Based Variable-Step Incremental Conductance MPPT Method for Grid-Connected PV Systems. IEEE Access, 9, 26420-26430. https://doi.org/10.1109/ACCESS.2021.3058052.

[7]Chendi, L., Yuanrui, C., Dongbao, Z., Junfeng, L., & Jun, Z. (2016). A High-Performance Adaptive Incremental Conductance MPPT Algorithm for Photovoltaic Systems. Energies, 9, 288. https://doi.org/10.3390/EN9040288.

[8]Liu, F., Duan, S., Liu, F., Liu, B., & Kang, Y. (2008). A Variable Step Size INC MPPT Method for PV Systems. IEEE Transactions on Industrial Electronics, 55, 2622-2628. https://doi.org/10.1109/TIE.2008.920550.

[9]Mei, Q., Shan, M., Liu, L., & Guerrero, J. (2011). A Novel Improved Variable Step-Size Incremental-Resistance MPPT Method for PV Systems. IEEE Transactions on Industrial Electronics, 58, 2427-2434. https://doi.org/10.1109/TIE.2010.2064275.

[10]Singh, P., Shukla, N., & Gaur, P. (2020). Modified variable step incremental-conductance MPPT technique for photovoltaic system. International Journal of Information Technology, 13, 2483 - 2490. https://doi.org/10.1007/s41870-020-00450-8.









INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY





www.ijirset.com