Expert View

by Sitharthan Ramachandran

Applying AI in Power Electronics for Renewable Energy Systems

The energy crisis is one of the vital problems faced by the world today. Due to the increase in smart industries 4.0 and household components, the electrical usage around the world has substantially increased the demand for energy. Traditionally, nearly 72% of the surplus energy demand has been satisfied by conventional energy resources and 28% by renewable energy resources [1]. Because emission is considered as the preliminary factor for the deteriorating environment, energy sectors have shifted their focus towards renewable energy resources. With the advantage of minimizing carbon pollution, renewable energy is a feasible solution to make the world safer and energy proficient. It has been predicted that 45% of the load demand by 2024 will be satisfied by renewable energy resources and most of the increase will likely come from solar, wind, and hydropower [2].

The integration of renewable energy systems with the existing power grid and energy storage are possible only through a power electronic converter that has always presented many challenges. However, a promising solution for obtaining optimal performance out of the renewable resources are developing an intelligent control strategy that can vary the switching patterns of the power electronic converter depending on the load. Thus, effectively extracting essential power from renewable energy resources to obtain the maximum amount of energy conversion. Advances in artificial intelligence (AI) such as deep neural networks-IoT, and artificial neural network blockchain techniques are rapidly providing this intelligent control solution to enhance the operation of power electronic converters and, thereby, increase the performance of the renewable energy system by tracking the optimal power. For example, in a paper presented in the IEEE Transactions on Circuits and Systems, May 2020 [3], researchers from the University of Electronic Science and Technology of China, Chengdu, discuss an AI neural network-assisted maximum power point tracking control for a solar energy system. Applying the AI control strategy, the researchers demonstrate a solar energy harvesting system with 89.39% efficiency and a minimal tracking error of 0.01–0.5%. The study clearly shows that the integration of AI technique with power electronic devices will increase the extraction of energy from renewable energy resources with maximum efficiency.

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The intelligent control strategy also improves the integration of all micro/macro renewable energy resources to build microgrid and manage distributed energy. The intelligent control strategy enabled power electronic converters will play a vital role in solving the quality and congestion issues in the microgrid. The power control in energy harvesting multiple access systems with an AI algorithm has been developed in reference [4]. In this application, the developed intelligent algorithm controls the power of the integrated renewable energy sources and helps to maintain its optimal performance in battery and renewable resources. The primary concern of the renewable energy source integration is improved safety and reliability. The development of AI and IoT has made it possible to offer improved safety, efficiency, and reliability. The intelligent control strategy with IoT can estimate the energy consumption patterns, identify the energy leakage, and ensure the health of the system. For example, in the AI and IoT coupled system the prognostic analysis will gather the data from renewable energy resources with the sensors to monitor the wear and tear in the

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devices. The system monitors the function of equipment and alerts users when maintenance is required. In [5], fault ranking in a solar standalone system based on AI technology is developed. The developed intelligent technique focusses on the reliability and safety of the integrated photovoltaic system and reduces the risk of fault by taking prior corrective action.

Another concern is energy storage. The energy storage systems have been recognized as viable solutions for implementing the smart grid paradigm, providing features in load levelling, integrating renewable and intermittent sources, voltage and frequency regulation, grid resiliency, improving power quality and reliability, reducing energy import during peak demand periods, and so on. Indeed, energy storage greatly helps to solve issues related to the intermittent renewable energy sources, because of the irregular alternation of production phases with non-producing periods. Integrating the intelligent system with power electronic converter control strategy in a microgrid with energy storage can provide a reliable energy allocation, providing features in load levelling, integrating renewable and intermittent sources, voltage and frequency regulation, grid resiliency, improving power quality and reliability and reducing energy imports during peak demand periods [6]. Therefore, helps the renewable energy resources based microgrid to manage the internal energy needs when integrated with the main grid in terms of power exchange.

In the integration of renewable energy resource with AI, artificial intelligence allows making transformations in traditional control strategies to build up an advanced modern efficient control strategy, thereby creating hassle-free intelligent control techniques for the effective operation of renewable energy systems.

About the Author

Sitharthan Ramachandran received his B.E. degree in Electrical and Electronics Engineering, M.E. degree in Power Systems Engineering, and Ph.D. degree in Electrical Engineering from the Anna University, India, in 2010, 2012, and 2016, respectively. He is an assistant professor in the School of Electrical Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India. He has completed a research funded project as a principal investigator under the ECRA scheme, Science and Engineering Research Board, Department of Science and Technology, Government of India. He has published research articles in refereed journals and received two patents. His research interests include renewable energy systems, artificial intelligence-based control methodology, FACTS devices, soft computing techniques, and piezoelectric materials.

References

[1] M. A. Majid, "Renewable energy for sustainable development in India: Current status, future prospects, challenges, employment, and investment opportunities," *Energy, Sustain. Soc.*, vol. 10, no. 1, pp. 2–36, 2020. doi: 10.1186/s13705-019-0232-1.

[2] "Annual Energy Outlook 2019 with projections to 2050," U.S. Energy Information Administration. Accessed on: July 4, 2020. [Online]. Available: https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf

[3] Y. Wang, P. Luo, X. Zeng, D. Peng, Z. Li, and B. Zhang, "A neural network assistance AMPPT solar energy harvesting system with 89.39% efficiency and 0.01-0.5% tracking errors," *IEEE Trans. Circuits Syst.*, May 2020. doi: 10.1109/TCSI.2020.2990740.

[4] M. Chu, X. Liao, H. Li, and S. Cui, "Power control in energy harvesting multiple access system with reinforcement learning," *IEEE Internet Things J.*, vol. 6, no. 5, pp. 9175–9186, 2019. doi: 10.1109/JIOT.2019.2928837.

[5] S. Perveen, H. Ashfaq, and M. Asjad, "Fault ranking in PV module based on artificial intelligence technique (AIT)," in *Proc. IEEE Int. Conf. Power Electronics, Control and Automation (ICPECA)*, Nov. 2019, pp. 1–6.

[6] B. S. Sami, "Intelligent energy management for off-grid renewable hybrid system using multi-agent approach," *IEEE Access*, vol. 8, pp. 8681–8696, 2020. doi: 10.1109/ACCESS.2019.2963584.

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