Grid-tied Photovoltaic power electronics converters: Overview, analysis, challenges and future trends

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Abstract

Statement of the Problem: Renewable energy is progressively deemed necessary for fulfilling the current and upcoming energy demands. Amongst different renewable energies, solar photovoltaic (PV) is one of the cleanest, unlimited, emission-free, readily, reliable and widely available renewable energy resources. Grid-tied PV systems account for 99% of the whole established capacitance in comparison with 1% of the standalone systems. Grid-tied PV systems are generally categorized into two types, the galvanic isolation and non-isolation/transformerless systems, the latter having some advantages over the former, e.g. small size, weight, low cost and high efficiency. However, leakage current problem is one of the most important challenges in transformerless system which may cause some problems. Power electronics converter topologies play a significant role in restriction of this current. Therefore, a variety of state-of-the-art converter topologies with the ability to overcome this issue are reviewed in this work. Then possible improvements are investigated and proposed for several important aspects such as efficiency, reliability, power quality, cost, weight, velum, and leakage current problem.

Methodology and Theoretical Orientation: A comparative study is done for a wide range of grid-connected PV power electronics converters utilizing computer simulation and calculation as well as reviewing scientific publications.

Findings: This comprehensive research gives a clear picture on the advancement of power electronics converters for the next generation grid-tied PV systems with detailed analytical comparisons. These include the number of power devices and components, voltage stress on semiconductors, current stress on inductors, efficiency, shoot-through issue, leakage current suppuration, optimum design, THD analysis, compactness, and cost-effectiveness.

Conclusion and Significance: The improvement of the whole PV systems will be accelerated with the understanding of functions, limitations, and benefits of grid-connected PV power electronics converters. Therefore, various state-of-the-art topologies introduced in recent years are reviewed and investigated in detail here to give insight into researchers and industries, along with highlighting future trends.

Recent Publications

1. F. Faraji, *et al*. "Single-stage single-phase three-level neutral-point-clamped transformerless grid-connected photovoltaic inverters: topology review," *ELSEVIER, Renewable and Sustainable Energy Review*., vol. 80, pp. 197-214, 2017.
2. F. Faraji, A. Hajirayat, and M. Narimani, "Fault tolerant T-Type Nested Neutral Point Clamped (T-NNPC) converter," *IEEE Southern Power Electronics Conference (SPEC)*, 2017.
3. A. Pourfaraj, M. Monfared, and H. Heydari-doostabad, "Single-phase dual-mode interleaved multilevel inverter for PV applications," *IEEE Trans. Ind. Electron*., vol. 67, no. 4, 2020.
4. S. A. Ahmed, M.S. Manoharan, and Joung-Hu Park, "An efficient singlesourced asymmetrical cascaded multilevel inverter with reduced leakage current suitable for single-stage PV systems," *IEEE Trans. Energy. Conv*., vol. 34, no. 1, 2019.
5. N. Vosoughi, Seyed H. Hosseini, and M. Sabahi, "Single-phase common-grounded transformer-less grid-tied inverter for PV application," *IET Power. Electron*., vol.13, no. 1, 2020.
6. S. Luo, F. Wu, and K. Zhao, "Modified single-carrier multilevel SPWM and online efficiency enhancement for single-phase asymmetrical NPC grid-connected inverter," *IEEE Trans. Ind. Electron*., vol. 16, no. 5, 2020.
7. H. Li *et al*. "An improved H5 topology with low common-mode current for transformerless PV grid-connected inverter," *IEEE Trans. Power. Electron*., vol. 34, no. 2, 2019.
8. V. Sonti, S. Jain, and V. Agarwal, "Analysis of terminal voltage in single-phase extended three-phase transformerless PV inverter topologies," *IEEE Journal of Photovoltaics*., vol. 10, no. 1, 2020.



Biography

Faramarz Faraji received his M.Sc. degree in electrical engineering from Islamic Azad University, Iran in 2016. From 2005 to 2009, he worked as a diesel generator technician in Tehran Railway Company. In 2009 he joined Tehran Regional Electric Company (TREC) as an Electrical Engineer. He is a member of Young Researchers and Elite Club, Islamic Azad University, Tehran, Iran and also an Associated Member in Iranian Association of Electrical and Electronics Engineers (IAEEE). One of his journal papers entitled "*A comprehensive review of flywheel energy storage system technology*," published in ELSEVIER, Renewable and Sustainable Energy Reviews (2017) was placed in the top 1% of the academic field of Engineering based on a highly cited threshold for the field and publication year. In addition, it was a hot paper. He was a Program Committee Member in *International Conference on Sustainable Energy and Environment Sensing (SEES 2018), University of Cambridge, Cambridge city, United Kingdom, 18-19 June, 2018.* He is a reviewer in several prestigious scientific journals and conferences such as IEEE Transactions on Industrial Informatics, International Journal of Circuit Theory and Applications, and IEEE Power Electronics and Industrial Electronics Conferences. His research interests include Renewable Energy Systems, Power Electronics, Multilevel Converters, Transformerless grid-connected photovoltaic inverters, Electrical machines and Drives, and Flywheel Energy Storage System.

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Notes/Comments: