ABSTRACT

In recent times, the electrical energy demanded by residential, industrial, and commercial segments has grown and consequently contributed to encouraging an increase in energy production based on renewable energy sources (RES). Therefore, the enhancement and development of vitality age plants have turned into a worldwide pattern. Considering the worldwide interest in sustainable development and decreasing ecological effects, the use of RES emerges since they can lessen the effects caused by non-sustainable power sources dependent on petroleum products, for example, coal, oil, or flammable gas. In this context, solar energy and wind energy are featured among the various existing RES used to generate electricity in distributed power generation (DPG) systems. In particular, photovoltaic (PV) cells, which use solar energy to make electricity, have been used a lot in DPG systems.

Generally, one or more power conversion stages are necessary to create a grid-connected PV power system. In a two-stage PV power system, DC/DC conversion is on one power stage and DC/AC conversion is on the other. In this system, MPPT control is performed by the DC/DC converter, while the PV system is connected to the grid by the DC/AC converter. Moreover, sending energy to the service grid and getting the utmost power from the PV array have to be attained in PV systems. For this reason, an incremental conductance algorithm for attaining maximum power point tracking (MPPT) is employed. A DC-DC boost converter and a grid-connected inverter are the two stages of the PV system to be analysed in this work.

Energy Storage Systems (ESS) provide various benefits to RE sources, and a battery energy storage system is linked to the proposed PV power system to maximise PV power utilization. The core contribution of the proposed method is to design a solar PV-based grid connected system with an energy management controller and energy storage to supply continuous power to critical loads under different operating conditions. The developed energy management controller is able to supply critical loads under different operating conditions of the solar PV system. The energy management controller (EMC) manages the power flow from three different sources to the load. Solar panels provide load support when there is sufficient generating capacity. When there is surplus generation in the PV panel, it will be stored in the battery. After the battery has been fully charged, the excess power will be fed to the grid, which improves the usage of generated power. In the event of insufficient power generation from the PV panels, EMC will back up the system with a battery. The grid will support the load when neither photovoltaics nor batteries can meet the load demand. The performance of the energy management controller with an inverter control optimization algorithm was verified with critical loads. In this study, a solar PV-based integrated grid-connected system with a battery energy storage system is used to provide continuous power supply to critical hospital loads. The energy management controller adopted in the system is enhanced with an efficient algorithm to predominantly control the power flow to the load under divergent operation of the renewable power source. The inverter was implemented with a sliding mode controller and an artificial bee colony algorithm. In the developed photovoltaic system, the artificial bee colony algorithm works better than the sliding mode inverter. The laboratory prototype was developed with EMC to power the load under variable operating conditions. To validate the performance of EMC, the system was operated with different loads and conditions. The results obtained show seamless operation of the system.