

HOSTED BY



Contents lists available at ScienceDirect

Engineering Science and Technology, an International Journal

journal homepage: www.elsevier.com/locate/jestech

Full Length Article

A new topology with the repetitive controller of a reduced switch seven-level cascaded inverter for a solar PV-battery based microgrid

Buddhadeva Sahoo, Sangram Keshari Routray*, Pravat Kumar Rout

SOA University, India

ARTICLE INFO

Article history:

Received 17 January 2018

Revised 22 May 2018

Accepted 5 June 2018

Available online xxxxx

Keywords:

Battery cell

Photovoltaic cell

MPPT technique

Reduced switch cascaded inverter (RSCI)

LCL filters

Repetitive control (RC)

Incremental conductance (IC)

ABSTRACT

In this manuscript, a repetitive control approach for the reduced switch seven-level cascaded inverter (RSCI) is proposed for active and reactive power control with enhanced power quality standard for a solar PV-battery based microgrid. The proposed repetitive control approach is applied for the RSCI and the performance is tested on a grid-connected microgrid integrated with photovoltaic (PV) and battery energy sources. To capture maximum power, a control strategy based on incremental conductance method (I&C) is adapted for optimal maximum power point tracking (MPPT) operation. The battery energy storage system in both charging and discharging mode of operation is controlled by repetitive controlled based RSCI as a support to PV for better power management. To show the feasibility and robustness in operation of the proposed approach, a variable irradiance input to the PV unit is considered. To justify the practical applicability of the proposed approach and to satisfy IEEE-1547 power quality constraints, a LCL filter is selected to minimize the harmonic distortion in the grid side current levels. The improved performance of the proposed technique is justified by presenting comparative simulation results with respect to three-level neutral point clamped inverter (NPC) with proportional integral (PI) controller. By using MATLAB software, the validity of the proposed approach is studied by simulation under constant and varying irradiance condition.

© 2018 Karabuk University. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

In the energy generation sector, due to the pollution and energy crisis in the world, distributed generation has been merged as a solution with advanced semiconductor based power electronic devices and smart grid technology [1–3]. Even though the distribution generation (DG) system plays an important role in the power system, it has also come with the challenges to look forward and find out an optimal solution for control and protection [4–6]. PV system gives more attractive features for which it is widely accepted and widely implemented in various power sectors of different countries. Specific to a distribution system, PV is chosen in renewable energy sectors because it permits small power generators for installation purpose and gives low or medium voltage levels [7,14].

In real-time applications of PV-battery based microgrid, single-stage and two-stage inverters are used by voltage source based advanced power electronic devices for power conversion system.

In two-stage conversion system, one converter is used to change pulsating DC to constant DC and the other converter is used to change constant DC to AC for better power quality and efficiency [15]. To execute the single stage conversion system, a multilevel inverter is preferable to implement instead of conventional voltage source inverter (VSI), as it gives more voltage levels with minimize voltage error and harmonics [16]. In renewable energy sectors to enhance the power generation capability and reliability of power management under varying environmental depended input, the MPPT control is needed to implement. There are many methods are suitable for uniform and varying irradiance condition [17,18]. The incremental conductance method is widely used for inverter control to generate maximum power to the grid or to the load. The attractive feature behind its preference is improved results in most condition and easy to implement in a digital controller.

Various multi-level inverter (MLI) topologies are suggested by the various researcher based on three-level Neutral point clamped inverter (NPC), Flying capacitor inverter (FCI) and Cascaded inverter (CI) [20,26]. However, the major limitation to be focused on a better solution of these types of inverters is the requirement of a large number of power electronic switches, capacitors, and diodes. Furthermore, with the increase in the voltage levels, the number of

* Corresponding author.

E-mail address: routraysk@gmail.com (S.K. Routray).

Peer review under responsibility of Karabuk University.

components is also increased. It is necessary to focus on the configuration and the control aspects of the integrated converter during the design stage to find solutions for simple design, cost effectiveness, better power control and power quality issues.

The PI controllers are widely used in real-time applications due to its simple design structure and cost-effectiveness. However, these controller performances depend on their gain parameters. Due to use of constant gain parameters, these controllers fail to show their optimum performance with a change in the system and input variations under different operating conditions. To enhance the controller performance and to overcome the associated limitations of PI controllers various suggestions are proposed by various authors such as fuzzy tuned PI controller, adaptive PI controller, self tuned PI controller and evolutionary optimized PI controller etc. [27–29]. Other possibility is to use different control strategy for the controller. In addition to power control, it is also necessary for the inverter control to eliminate the THD. In this aspect the repetitive control (RC) can track or eliminate periodic signals in an effective way, particularly in case of closed loop system application. RC based controller is effective to track or eliminate any periodic signals including any order harmonics due to its superior error cancelation characteristics [30–36]. RC controller application has been extensively investigated for multi-level inverter in this study. The LCL filter is used to further reduce harmonic distortion at the inverter side (AC) voltage and current, and also to act as a protection for its capability to suppress any sudden change in voltage due to harmonics [37,38].

One of the major concerns of PV-battery based microgrid systems is their unpredictable, non-linear and fluctuating nature. Due to extensive use of power electronic devices, power quality issues degrade the operational performance of the system. The urgent requirements of high power consuming industrial sectors need a medium to high voltage distribution system with better power management, voltage and frequency control. Grid connected renewable energy systems accompanied by battery energy storage, appropriate filter, and proper inverter control to overcome all these above mentioned issues. This paper is concerned with the designed and study of a grid connected three phase solar PV system integrated with battery storage, LCL filter, and reduced switch seven-level cascaded inverter (RSCI). The feasibility of the proposed system is obtained under fixed and varying irradiance condition. The

proposed control approach based on repetitive control and incremental conductance (IC) has the capability of regulating MPPT, harmonic elimination, better power control, and battery charging and discharging conditions. The proposed approach is verified and results indicate a better power flow control with enhanced power quality, increased efficiency, and reliability. The major contributions of this paper inline to its objectives are as follows:

- To design a repetitive controller for power control regulation.
- To design a RSCI for energy storage based PV microgrid.
- To integrate MPPT technique with different irradiance condition to extract maximum available energy.
- To ensure the harmonic levels within the IEEE-1547 standard for better power quality improvement.

The rest part of the manuscript is coordinated as follows. Section 2 presents the modeling of the photovoltaic system and reduced switch seven-level cascaded inverter (RSCI). The design of LCL filter is also presented in this section. Control of MPPT, vector selections, d-q current and battery conditions along with repetitive control are described in Section 3. In Section 4 simulation results under various operating conditions are demonstrated and analyzed to justify the applicability of the proposed approach in the real-time application. Section 5 concludes the manuscript mentioning the output analysis and findings of this work.

2. Modeling

The test system comprised of PV-battery based microgrid with grid support RSCI inverter control is considered for verifying the

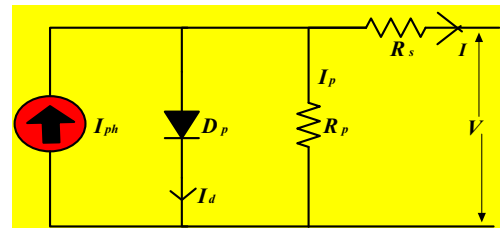


Fig. 2. Equivalent circuit of single diode PV cell.

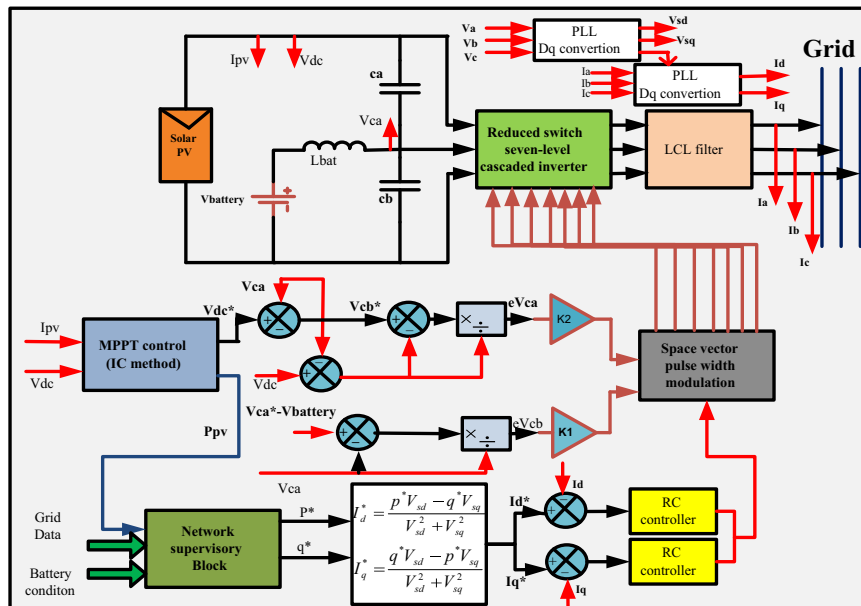


Fig. 1. Block diagram of the control system to integrate PV and battery storage.

Download English Version:

<https://daneshyari.com/en/article/6893558>

Download Persian Version:

<https://daneshyari.com/article/6893558>

[Daneshyari.com](https://daneshyari.com)