Renewable and Sustainable Energy Reviews 45 (2015) 69–86

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Single phase transformerless inverter topologies for grid-tied photovoltaic system: A review

Monirul Islam [a,*], Saad Mekhilef [a,*], Mahamudul Hasan [b]

[a] *Power Electronics and Renewable Energy Research Laboratory (PEARL), Department of Electrical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia*
[b] *Department of Mechanical Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia*

ARTICLE INFO

Article history:
Received 10 October 2013
Received in revised form
12 December 2014
Accepted 4 January 2015
Available online 31 January 2015

Keywords:
Common mode voltage
Grid connected
Leakage current
Renewable energy
Photovoltaic
Transformerless inverter

ABSTRACT

Grid-tied inverters are the key components of distributed generation system because of their function as an effective interface between renewable energy sources and utility. Recently, there has been an increasing interest in the use of transformerless inverter for low-voltage single-phase grid-tied photovoltaic (PV) system due to higher efficiency, lower cost, smaller size and weight when compared to the ones with transformer. However, the leakage current issues of transformerless inverter, which depends on the topology structure and modulation scheme, have to be addressed very carefully. This review focuses on the transformerless topologies, which are classified into three basic groups based on the decoupling method and leakage current characteristics. Different topologies under the three classes are presented, compared and evaluated based on leakage current, component ratings, advantages, and disadvantages. An examination of demand for the inverter, the utility grid, and the PV module are presented. A performance comparison in MATLAB/Simulink environment is done among different topologies. Also an analysis has been presented to select a better topology. Finally, based on the analysis and simulation results, a comparison table has been presented. Furthermore, some important experimental parameters have been summarized.

Contents

* Corresponding authors.
E-mail addresses: monir04eee@yahoo.com (M. Islam), saad@um.edu.my (S. Mekhilef).

http://dx.doi.org/10.1016/j.rser.2015.01.009
1364-0321/

1. Introduction

The conventional generation systems such as coal fired, gas and nuclear power as well as hydroelectric dams are centralized and often require electricity to be transmitted over long distances. The security and stability of the conventional electrical power system are under threat due to a number of blackouts caused by chain failure [1] and electric grid ruptures caused by extreme weather [2]. In contrast, distributed energy resources such as solar power, wind power, biomass, and biogas are decentralized, modular and more flexible. As well, these energy sources have the advantage that the power is produced in close proximity to where it is consumed [3,4]. This way the losses due to transmission lines can be reduced. In addition, the constant consumption of fossil fuels is leading to energy crisis and increasing environmental pollution problems. Therefore, the distributed energy resources, particularly PV and wind power basis [5], have achieved great response in current years to meet the world energy demand and become the important alternatives of traditional power sources [3,4,6].

Among a variety of renewable energy sources, PV is predicted to have the biggest generation, up to 60% of the total energy by the end of this century [7,8], because the energy which is converted into electrical energy is the light from the sun, which is free, available almost everywhere and will still be present for millions of years long after all non-renewable energy sources have been depleted [7,9]. Though the PV module is still expensive, due to the large-scale manufacturing it is becoming increasingly cheaper in the last few years. In addition, the PV module has no moving parts, which have made it a very robust, long lifetime and low maintenance device. Based on the newest report of International Energy Agency (IEA) on installed PV power, the milestone of 100 GW PV system all over the world was achieved at the end of 2012, and increased to 140 GW at the end of 2013 which is shown in Fig. 1 [10].

Fig. 2 shows the share of grid-tied and off-grid PV installation. It can be seen that the off-grid market can hardly be compared with the grid-tied market. The evaluation of the share of grid-tied PV market per region from 2000 to 2013 is shown in Fig. 3. Though Asia started to dominate the market in the early 2000, after 2004 a great development can be seen in Europe. While Europe and Asia presented a major part of grid-tied PV installation globally in 2013, the Middle East & Africa started to grow in 2012 and 2013. However, for grid-tied PV system, the power electronic technology plays an important role in the integration of PV energy sources

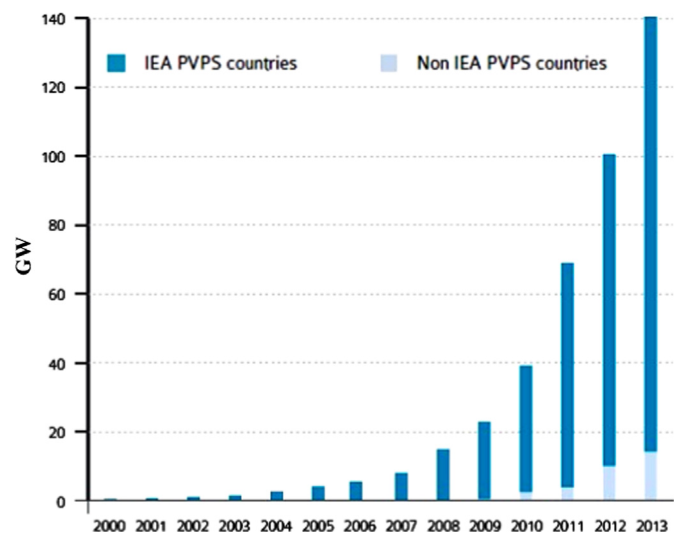

Fig. 1. Evaluation of PV installation [10].

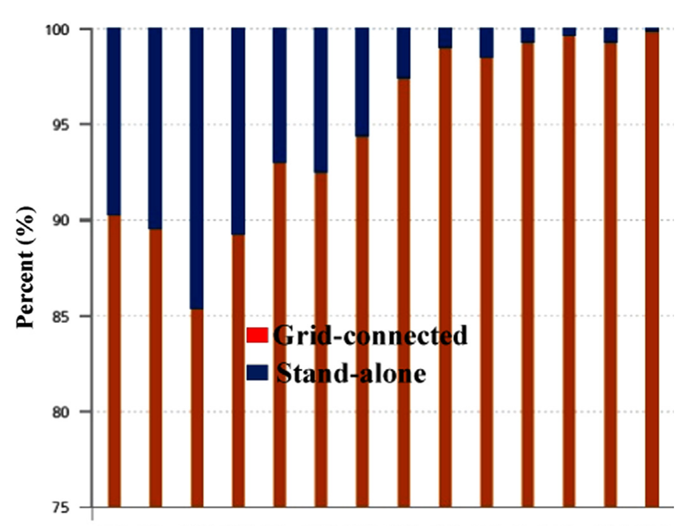

Fig. 2. Share of grid-connected and standalone PV installation [10].