Grid Connected PV Based Inverter with Power Factor Correction

R. Sindhura and P.N. Kapil
Department of Electrical Engineering,
Nirma University, Ahmedabad, India
10meep13@nirmauni.ac.in

Department of Electrical Engineering,
Nirma University, Ahmedabad, India
pn.kapil@nirmauni.ac.in

Abstract A worldwide concern for future access to affordable, sustainable energy is driving the development of more efficient solar power generation. In a PV based system inverter is a critical component responsible for control of electrical flow between a PV module, battery, loads and power grid. This paper presents various kinds of grid connected inverter topologies. Based on analog current control PI method, simulation is carried out in PSIM software to validate the performance of the inverter for obtaining power factor close to unity.

Keywords Grid; PV; PI; PSIM; insert

1. INTRODUCTION

Growing concerns about environmental issues and the world energy crisis have attracted a great deal of interests for the development and application of the photo- voltaic (PV) power system that uses the non-polluting and renewable solar energy. The cost of electricity has risen in recent years. The reasons for these price increases include the prices of oil, gas and coal, population growth and manufacturing costs [1]. There are two main reasons for increase in the energy demand are growth in world's population and techno-economic growth in developing countries. As both of these grow, the energy demand grows proportionally. Many societies across the world in which we live have developed a large appetite for electrical energy. PV systems are everlasting clean source of energy which is easy to operate and is highly reliable in nature.

The continuing decrease of the cost of the PV's, the advancement of power electronic and semiconductor technology and favorable incentives in a number of industrial countries in general had a profound impact on the commercial acceptance of grid connected PV systems in the recent years [2].

Grid-connected PV system has become the main form of photovoltaic power generation applications, its advantage is that no intermediate energy storage batteries, saving investment, but also make the system simplified, easy to maintain. In this trend, the Photovoltaic (PV) technology is now available for industrial, commercial and residential consumers and PV plants connected to the utility grid is gaining more and more application.

The main objective of this paper is to show how power factor is to be maintained nearby unity at the load side of an inverter. Among many control techniques PI control method is a common method in a grid connected PV system. Such system will assure a constant switching frequency operation. An analog PI control is used in this paper which uses analog components such as resistors, inductors and operational- amplifiers for its algorithm control [3].

2. EVOLUTION OF INVERTERS

The past technology was based on centralized inverters where number of modules are interfaced with each other [4]. The modules are normally connected in either series, called a string, or parallel in order to reach a high voltage and power level.

However, few limitations such as power losses due to a centralized MPP Tracking (MPPT), power outages and mismatch between modules has lead to lot of issues.

The string inverter is a reduced version of the centralized inverter, where a single string of PV modules is connected to the inverter. Voltage amplification is avoided here because of the high input voltage. In such type of inverters an individual MPPT can be applied for each string since there are no losses generated by the string diodes. However, hot spot risk is still present.

This concept is a well-known, robust, efficient and cheap technology, which provides high reliability and low price per Watt.

The AC-Module is the solution for central and string inverters. It removes the losses due to mismatch between modules and inverter, as well as it supports optimal adjustment between the module and the inverter. Moreover, the hot-spot risk is removed. Hence, a better efficiency may be achieved.

The different inverter technologies are classified as [5]:

2.1 Number of Power Processing Stages

Based on the power processing stages in cascade an inverter can be classified as – Single stage and Two stage inverter.

A single stage inverter involves all kind of MPPT tracking and current control techniques by its own.

In a two stage inverter a DC-DC converter implies MPPT tracking and inverter controls the grid current and other synchronization techniques.

2.2 Type of Power Decoupling between the PV module and the single-phase grid

Power decoupling is normally achieved by means of an electrolytic capacitor which should be kept as small as possible and preferably substituted with film capacitors. The capacitor is either placed in parallel with the PV modules or in the dc link between the inverter stages.

2.3 Whether a Transformer is utilized or not

Some inverters do not use transformers whereas some use line frequency transformer which is placed between grid and inverter in order to reduce injection of dc currents into grid. High frequency transformers are also used and are placed after inverters.

2.4 Type of Grid-Connected Power Stage

These are basically categorized as line commuted current source inverters and self commuted voltage source inverters.

Various kinds of inverters can be used from the above categories according to the type of application. This paper presents a single stage H-bridge inverter which receives a DC supply from MPPT based DC-DC converter and the output is given to the grid through a high frequency transformer. The basic block diagram of the selected topology is shown in fig 1.

3. CONTROLLER

An inverter has to produce pure sine wave single-phase output, which should be according to standard. This type of current controller scheme is basically used for feedback purpose which is being used by a PI controller which is shown in fig. 2.

The inverter current I_{inv} is sensed and fed back to a comparator which compares with reference current I_{ref}. Reference Current (I_{ref}) is obtained by sensing the grid voltage and converting it to reference current. This is to ensure that inverter current and grid voltage are in phase with each other and unity power factor is maintained. The instantaneous current error, e which is being obtained from the comparator is fed to PI controller. The integral term, K_i helps in reducing the instantaneous error between the reference and actual current. The resulting error, U is fed to a comparator and is compared with a triangular carrier signal which in turn produces PWM signals for the inverter switches [3].

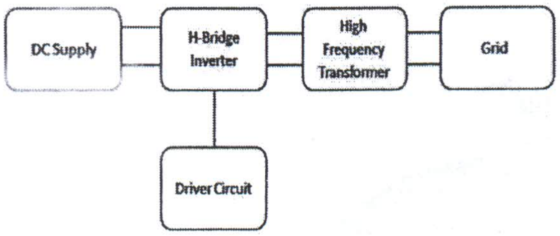

Figure 1. Basic Block Diagram of Selected Topology

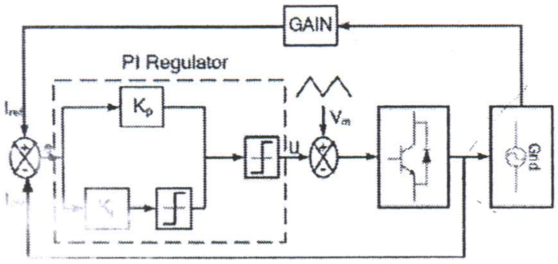

Figure 2. PI Current Controller

4. SIMULATION & RESULTS

The simulation for a grid connected inverter has been carried out using the above PI current control scheme. The simulations have been carried out in PSIM software.

In order to maintain power factor near to unity at the load side, closed loop control using PI controller is being taken into consideration.

The system gives a 100 V fixed DC supply which is being fed to a two-level MOSFET based inverter. A resistor and inductor of values 15 Ω and 2 mH respectively is taken as load. A power factor meter is placed in order to check the power factor at the load side. The switching frequency of the inverter is kept 10 kHz.

Simulations were carried out with the above mentioned parameters to show the effectiveness of this controller.

The simulation model of the closed loop control of two-level grid connected inverter can be shown as given in fig 3.

5. SIMULATION RESULTS

The simulation results are shown in the following figures which shows the respective load current (I_{RL}) and Power factor of the load. Corrective measures are taken to improve power factor at the load side. With the help of PI tuning power factor reaches above 0.8.

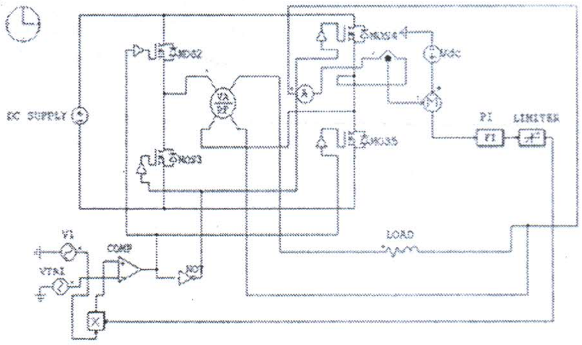

Figure 3. Simulation Model of Inverter

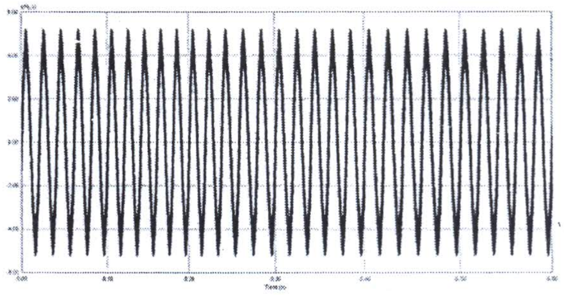

Figure 4. Load Current (I_{RL})

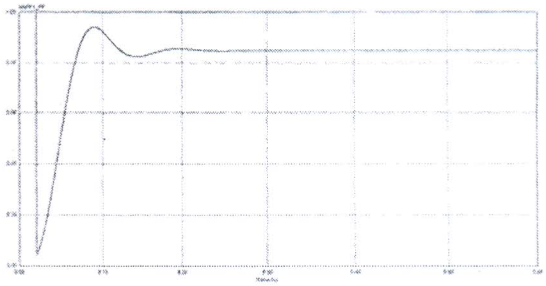

Figure 5. Power Factor at Load Side

6. CONCLUSION

Various kinds of topologies are discussed in this paper. A grid connected H-bridge inverter is selected. The objective of this paper is to improve power factor of the inverter at the load side. Analog based PI current control technique is being implemented for the closed loop system. The simulation has been carried out in PSIM software and appreciable results are obtained.

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