Descriptive Study of Renewable Energy System for Reactive Power Injection and AI Techniques

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ABSTRACT

Solar Photovoltaic (PV) systems have been in use predominantly since the last decade. Inverter fed PV grid topologies are being used prominently to meet power requirements and to insert renewable forms of energy into power grids. At present, coping with growing electricity demands is a major challenge. This paper presents a detailed review of topological advancements in PV-Grid Tied Inverters along with the advantages, disadvantages and main features of each. The different types of inverters used in the literature in this context are presented. Reactive power is one of the ancillary services provided by PV. It is recommended that reactive power from the inverter to grid be injected for reactive power compensation in localized networks. For successful integration with a grid, coordination between the support devices used for reactive power compensation and their optimal reactive power capacity is important for stability in grid power.

I. INTRODUCTION

Grid-tied photovoltaic systems are power-generating systems that are connected with grids. Solar PV energy that is generated must be processed with the help of a grid-connected inverter before putting it to use [1]. This inverter is present between the solar PV arrangement and the utility grid; it could be a single unit or a collection of small inverters attached to the individual PV units. Due to the lowered cost of power electronic devices and advancements in renewable energy technology, there is significant encouragement for the power industry to utilize PV solar energy and to attach it to a medium or low voltage distribution grid. The renewable electrical energy market has experienced an extraordinary increase in scope in recent years. Due to reductions in costs, solar and wind energy are playing an increasingly important role and are proving to be competitive with fossil fuels in many countries [2].

Figure 1 block diagram of hybrid wind solar energy system

It is noted that Solar PV has dominated all other forms of electricity production [3]. Thus, with this increasing trend in use of Solar PVs, it becomes even more important to study the obstacles faced in extracting energy from solar PV systems and then exporting it or
integrating it with the grid [4,5]. The primary factors to be borne in mind while integrating PV solar energy with the grid are:

1. Reducing the cost during power conversion stage
2. Improving the reliability of the converter in use
3. Reducing the harmonics in the output current obtained
4. Reducing the number of switches/components used in grid integration
5. Ensuring continuity in supply by providing back up power for PVs.
6. Controlling the real and reactive power
7. Maintaining a constant direct current (DC) link voltage via a suitable control scheme
8. Detecting the maximum power point of PV panel using Maximum Power Point Tracking (MPPT) techniques.

II. LITERATURE REVIEW

B. Venkatasamy et al. [1] this work mainly focuses on the solar array and grid connected inverter and its performance. The solar irradiation is available only during the day time (i.e., 6 to 8 hours per day). In the absence of solar radiations, the PV system and grid connected inverter will be idle. To increase the utilization of the grid-tie inverter for a day, it can also be operated at reactive power injection mode when the PV power is unavailable. The inverter that can be operated at both active and reactive power injection mode is simulated in this paper. Results and effective analysis are carried out to enhance the operation of grid connected inverter used in the hybrid power station.

Li-Yuan Liu et al. [2] this paper is to propose a reactive power control strategy of the grid-connected inverter for microgrid application. The proposed strategy can actively participate to regulate the voltage, realize the islanding detection, reduce the power quality impact of islanding detection and simplify the controller design. When the distributed energy resource (DR) of the microgrid system generates power to the grid, it may cause the voltage of the point of common couple (PCC) rising. The proposed strategy is to use the grid-connected inverter with the reactive current control to regulate the PCC voltage. Meanwhile, the reactive current disturbance is used to detect the variable frequency in islanding condition. Also, the experimental results are shown to confirm the validity of the design concept of the proposed strategy.

V. Thang Tran et al [3] this paper is to propose a simple structure for reactive power control (RPC) of AC Photovoltaic (AC PV) modules. With the proposed structure, a cost-effective microcontroller can be adopted to achieve an effective reactive power control in order to support the grid voltage within acceptable bounds by absorbing or supplying reactive power. Moreover, the sliding mode control (SMC) is adopted to enhance the current control’s dynamic response and reduce the current harmonic distortion. Comprehensive simulation of an AC PV module connected to grid using PSIM software with different operation modes are used to demonstrate the control strategy. The results from the simulation show that the proposal can provide good reactive power control for the AC PV modules.

Leonardo B. Garcia Campanhol et al. [4]This study deals with the analysis and implementation of compensation algorithms applied to a shunt active power filter, which uses three single-phase full-bridge converters sharing the same dc-bus voltage. The shunt filter is applied to three-phase four-wire systems, performing harmonic current suppression, reactive power compensation and power factor improvement. In addition, load unbalances compensation is also carried out. Two different control strategies are presented. In the first strategy, which is called independent current control, the currents of the three-phase power source are independently compensated performing harmonic suppression and load reactive power compensation, that is, the three-phase four-wire system is treated as three independent single-phase systems.

III. ARTIFICIAL NEURAL NETWORK

Artificial neural networks (ANN) or connectionist systems are computing systems vaguely inspired by the biological neural networks that constitute animal brains. Such systems "learn" to perform tasks by considering examples, generally without being programmed with task-specific rules. An ANN is based on a collection of connected units or nodes called artificial neurons, which loosely model the neurons in a biological brain. Each
connection, like the synapses in a biological brain, can transmit a signal to other neurons. An artificial neuron that receives a signal then processes it and can signal neurons connected to it [6].

In ANN implementations, the "signal" at a connection is a real number, and the output of each neuron is computed by some non-linear function of the sum of its inputs. The connections are called edges. Neurons and edges typically have a weight that adjusts as learning proceeds. The weight increases or decreases the strength of the signal at a connection. Neurons may have a threshold such that a signal is sent only if the aggregate signal crosses that threshold. Typically, neurons are aggregated into layers. Different layers may perform different transformations on their inputs. Signals travel from the first layer (the input layer), to the last layer (the output layer), possibly after traversing the layers multiple times.

There are several other AI based techniques that were studied for optimization. Various techniques has been discussed in [7,8].

IV. STRUCTURE AND CONTROL OF GRID CONNECTED PV SYSTEM

Single-stage PV systems do not require DC/DC converter and MPPT control is accomplished through inverter. Low cost, economic characteristics and high efficiency are some of the advantages of these systems because of their less converter comprised structure. In this study, single-stage structure is applied. The general structure of the grid connected PV system is shown. Generated electrical energy is transferred to grid through PV modules using single phase CCVSI. MPPT controller is applied to extract the maximum power of module during the day light and RPC is applied to exchange reactive power with the grid in both day and night modes. Using RPC, the reference current with low THD and appropriate speed is injected to grid [9].

Solar and wind energy resources are alternative to each other which will have the actual potential to satisfy the load dilemma to some degree. However, such solutions any time researched independently are not entirely trustworthy because of their effect of unstable nature. In this context, autonomous photovoltaic and wind hybrid energy systems have been found to be more economically viable alternative to fulfill the energy demands of numerous isolated consumers worldwide [10,11].

The inverters and their outputs can be controlled for further enhancement. The distortion level (THD), power output and voltage at the grid level has to be kept in mind while designing of control for the inverter. Also implementation of any new power electronic device like compensators, filter etc can subject the system to distortion or unbalance. This change has to be overcome while designing of any control system. As the trend supports the utilization of the renewable and clean sources of energy the system can be further integrated with another sources like fuel cell technology or geothermal stations etc.
V. CONCLUSION

In this work, a hybrid system with solar power generation is taken for analysis. The need of reactive power generation in the PV inverter has been discussed. The control strategy for the generation of reactive power in the grid-tie inverter has been addressed. The Simulink model of the grid-connected PV system is developed using MATLAB. The PV inverter operated in active and reactive power generation mode has been simulated. The various active and reactive power measurements were taken for analysis. The reactive power compensation should be made in a solar power plant itself, which will improve the effective utilization of the system.

References