Synchronization of PV Inverter with Power Grid at Distribution Level with Power Quality Improvement Feature

Miss. Kalyani V. Gattewar[1], Prof. S. S. Raut[2]

[1]*Student, Department of Electrical Engineering, Shri Sai College of Engineering and Technology, Bhadrawati, Maharashtra, India*
[2]*Professor, Department of Electrical Engineering, Shri Sai College of Engineering and Technology, Bhadrawati, Maharashtra, India*

ABSTRACT

At present, Power Quality is one of the key elements, which influences the economy of a nation. Due to rising of population utility supplies excess power to meet the increasing demand of the consumers. To maintain the pollution and the global warming within the particular level alternate sources of energy have used which devolops the pollution less environment. To overcome those issues nonconventional energy come into picture. The whole performance of the electrical utility can be improved by the usage of non-conventional energy resources. There are different forms of Renewable Energy Resource (RES) are available. Among them solar energy is mostly used because it is abundantly available in nature. In addition it has lot of advantages such as no air pollution, no fuel cost, noiseless and low maintenance. Integrating solar power to the grid has adverse effect on the power quality in the grid. This paper presents a novel control strategy for achieving maximum benefits from these grid interfacing inverters when installed in 3-phase 4-wire distribution systems. The inverter is controlled to perform as a multi-function device by incorporating active power filter functionality. The inverter can thus be utilized as: 1) power converter to inject power generated from RES to the grid, and 2) shunt APF to compensate current unbalance, load current harmonics, load reactive power demand and load neutral current. All of these functions may be accomplished either individually or simultaneously. With such a control, the combination of grid-interfacing inverter and the 3-phase 4-wire linear/non-linear unbalanced load at point of common coupling appears as balanced linear load to the grid. This new control concept is demonstrated with extensive MATLAB/Simulink.

Keyword: *Active power filter (APF), distributed generation (DG), distribution system, grid interconnection, power quality (PQ), renewable energy, Fuzzy Logic Control, Buck-Boost Converter.*

1. INTRODUCTION

Requirement of energy for the human is escalating step by step due to globalization and industrialization. In harmony with the above case, since the twentieth century, nations across the world are enchanting process, but the main problem is to solving the prevention of energy getting extinct and to forefending our environment from pollution by amending newer technology in the field of energy. Expanding the fresh and non-conventional energy, for purpose of obtaining them and maintaining them at a constant growth rate is the vital task. In the middle of them, the solar energy is the main spotlight of the energy that can be developed and to be consumed. PV production is renowned as main methodological data and the predicting technology, because of its prevalence upon environmental defense. Inverter topology is the leading topology of PV grid. As the crossing point devices across solar cells and the grid, inverter plays a crucial piece in developing and consuming the new energy schemes, disturbing the financial side and consistency of the photovoltaic (PV) grid generation system openly. To get better PV grid inverter work transmission and consummation excellence is the study to be focused in upcoming era.

Grid Connected solar PV system is a kind of electrical inverter that alters DC current from PV module into alternating current (AC). When the PV system is associated to the grid, it can transmit the extra energy to the grid after satisfying the limited demand. But when the demand is more than the generation, extra energy is obtained from

the grid. Thus PV energy acts as another source of electricity. The PV system, considered in this work, aims to relocate electrical power from PV panel to the grid. Firstly, DC-DC Converter is used to boosts PV voltage to a higher level than the peak of grid voltage. Power converters are used for interfacing the RES to power system. When the power converters are utilized, they introduces the harmonics in the system. Conversely, the increased use of sensitive electronic circuits in the industries and household jointly with privatization and rivalry in electric energy systems, pose the power quality improvement as one of the key problems in electrical industry. Harmonics causes distortion of source voltage, addition loss due to unwanted current flowing in the source. And also it may guide to misoperation of relays, mains and other control units. So it is necessary to reduce the harmonics there a many techniques to reduce the effect of harmonics. One of those methods is to use SAPF which produce harmonic current of equal magnitude and opposite polarity to that of the harmonic current produced in the system such that it cancels the harmonic current in the system. It has a high speed response and flexibility in operation as it contains the power electronic devices.

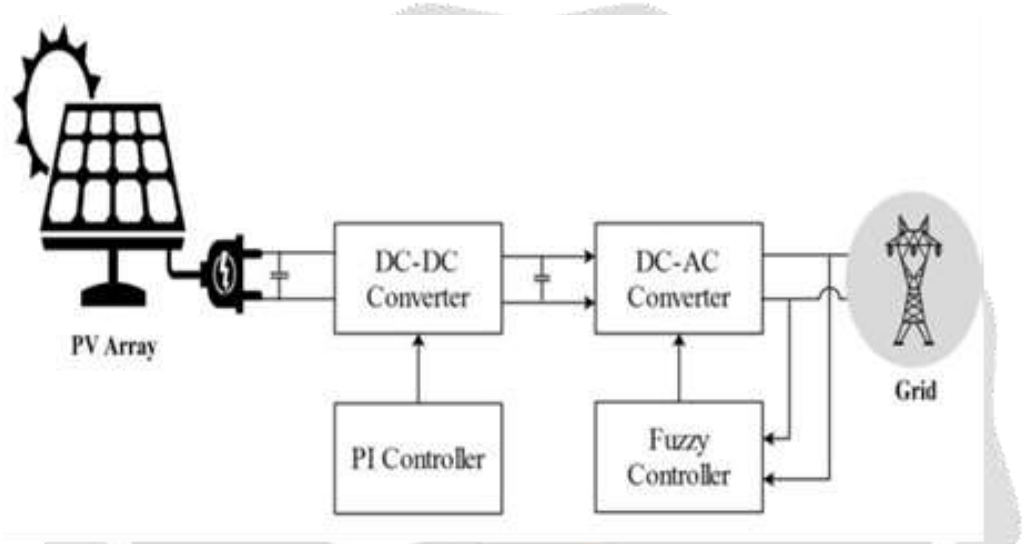

Fig.1: Block diagram of proposed system

Shunt Active Power Filter (SAPF) is proficient of concurrently compensates the harmonics, current distort, and injecting the power produced by non-conventional resources. The SAPF is a voltage source inverter (VSI), is related to the load. Shunt Active Power Filter can keep the current balanced and sinusoidal after remuneration for different load conditions. The DC to AC power conversion is the result of power switching devices. The output waveforms are consequently prepared up of distinct values, producing the output which are more oscillatory rather the filtered ones . The capacity to deliver close sine waveforms around the key recurrence is directed by the regulation technique tyrannical when and how long the power values can become active in nature. General techniques, include the pulse width modulation, fuzzy control based technique is used. The design scheme and configuration of these devices is based on combination of traditional power system components and power electronic elements. In this project, the difficulties and issues involved in the zone of power quality due to the integration of solar power in to grid are to be analyzed. The suitable fuzzy control technique is to be designed and modeled to get better power quality in the grid integrated solar system.

2. METHODOLOGY

A. Solar cell modeling

Solar based cells made of a p-n junction created in thin layer of semiconductors, whose electrical qualities vary practically very little from a diode represented by the condition of Shockley. Therefore the least complex

comparable circuit of a solar based cell is a present source in parallel with a diode as appeared in Fig. 2. So the way toward equation.

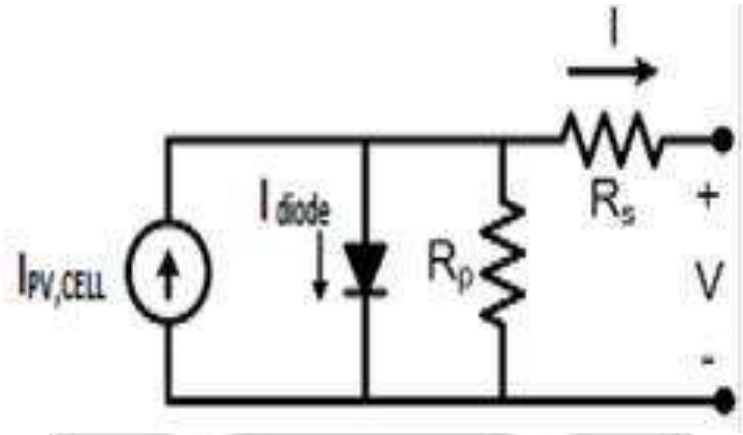

Fig.2: Equivalent Model of Solar Cell

$$I = I_{PV,CELL} - I_{DIODE} \quad (1)$$

$$I = I_{PV,CELL} - I_{O,CELL}\left[\exp\left(\frac{q+v}{\propto+k+T}\right) - 1\right] \quad (2)$$

Where:

$I_{PV,CELL}$ = Current generated by the incident light.

I_{DIODE} = Shockley diode.

$I_{O,CELL}$ = Reverse Saturation current.

q = Electron charge (1.6021×10^{-19}).

k = Boltzmann constant (1.3805×10^{-23}).

T = PN junction diode Temperature.

$\propto$ = Ideally constant (between 1 to 2).

B. MPPT

This area covers the operation of "Maximum Power Point Tracking" using P & O as utilized as a part of solar electric charge controllers. A MPPT or maximum power point tracker is an electronic DC to DC converter that improves the match between the solar based group (PV panels), and the battery bank or utility grid. Fundamentally, they change over a higher voltage DC output from solar panels down to the lower voltage anticipated that would charge batteries. There are numerous calculation for MPPT. I utilized the power under quick differing climatic conditions however it still exceptionally mainstream and basic than some other strategy. With the goal that the state of the output is Square PWM wave. In this paper utilized this on the grounds that on the off chance that we pass this sort of flag in a low pass channel than we get sine wave which matches to the network.

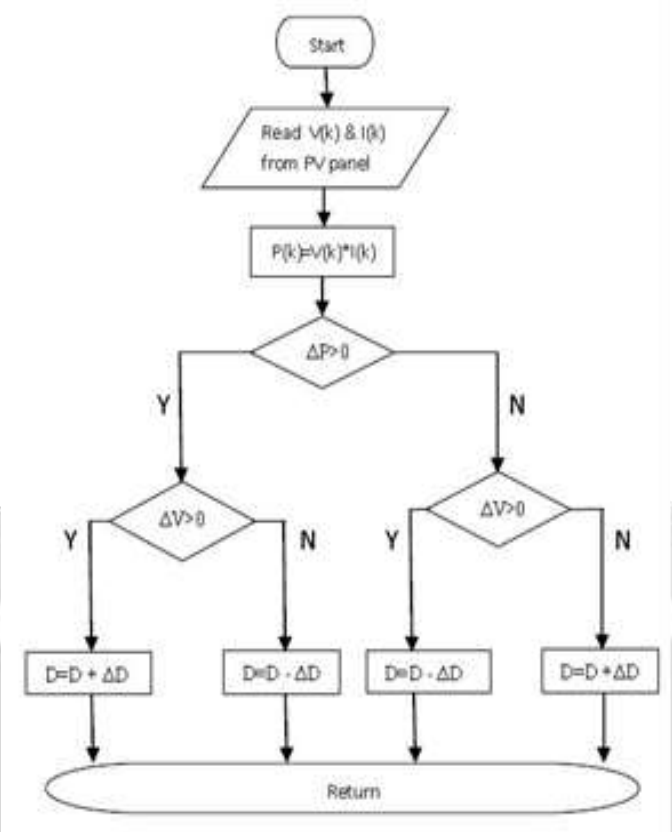

Fig.3: Flow Chart of MPPT

C. BUCK-BOOST CONVERTER

The buck-boost converter system with the controller, the actual output voltage *V0* is compared to the reference voltage *Vref* to produce an error signal that is used to determine the switching signal duty cycle. The switching signal is applied on the MOSFET used to reduce and enlarge output voltage on the circuit. The proposed buck-boost converter is designed for a battery power system that inconstant input voltage to constant output voltage for different currents. For 50Watt power, 20 kHz switching frequency, and 10% regulation the system is designed. The buck converter system is analyzed for switch on time and off time which is called duty cycle ratio *D*.

D. FUZZY LOGIC

The system variables and a rule table which depend on the variables are described for the control algorithm. The buck converter output voltage is controlled by changing the switching duty cycle. The system error is defined as a difference between the reference voltage and measured output voltage value. For the system; *r(k)* is the reference voltage and *y(k)* is the measured output voltage values then the error voltage is calculated using Equation (1).

$$e(k) = r(k) - y(k) \quad (1)$$

The change in the error voltage is also calculated as;

$$de(k) = e(k) - e(k-1) \quad (2)$$

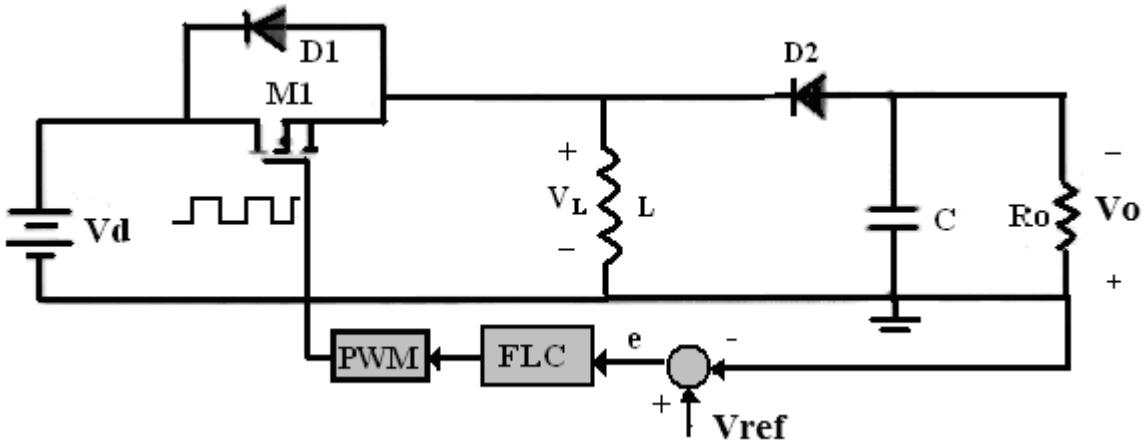

Fig.4: Fuzzy logic control with buck-boost converter system

4. CONCLUSIONS

In this paper the issues and difficulties involved due to the Grid integration of Solar PV System was completely analyzed. The harmonics present in this proposed system was efficiently eliminated using SAPF. Comparison with other conventional techniques shows that FUZZY controlled SAPF limit the total percent of THD. Voltage effectively to an attainable level. This prototype affords reliability in feeding the load. This prototype also supplies the active power indispensable during the unreliable grid operation all the way through the solar energy linked at the DC side of the SAPF. The obtained results prove that the proposed model animatedly performs the THD of source voltages at inverter and Grid is reduced.

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