HARMONIC MITIGATION TECHNIQUES FOR PV GRID CONNECTED INVERTER WITH ADAPTIVE HYSTERESIS BAND CONTROL- A COMPREHENSIVE REVIEW

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Abstract: Mostly type of renewable energy systems works in combination with the present electrical grid. In Photovoltaic (PV) grid connected inverter system, power quality is big matter. This paper presents grid connected photovoltaic (PV) system that not only can inject active power to the grid but also can recompense harmonics and reactive power of nonlinear loads as a shunt active filter. The estimation of inverter is established with effort on high reliability, low cost and mass-production for changing electrical energy from the PV module to the grid. Dissimilar types of inverter topologies are present, associate and calculated against demand, component rating and rate. Inverter connected PV system to clarify electrical performance subjected to different operating situation. This paper defines adaptive hysteresis technique for solar PV system grid connected inverter to mitigate the current related problem. Basically the adaptive hysteresis current control technique changes the hysteresis band width allowing to modulation frequency, supply voltage, dc capacitor voltage and reference current wave. The hysteresis current controller also defines the switching time of the shunt active power filter. Maximum power point tracking (MPPT) algorithm is used in order to obtain maximum power under different sun irradiance from PV; hence, in the blackness the system is used as an active filter and in the sunlight the system operates as both power conditioner and shunt active filter simultaneously. Simulation results using MATLAB/SIMULINK verifies effectiveness of the system in injecting of maximum power captured by the PV system to the grid and compensating of the harmonic currents and reactive power of the nonlinear load.

Keyword: power quality, grid, inverter, photovoltaic, adaptive hysteresis

I. INTRODUCTION

Centralized power generation systems are facing the identical constrains of shortage of fossil fuel and the necessitate to reduce emission. In the Long transmission lines are one of the main issues for electrical power losses. Thus, importance has increased on distributed generation network with integration of renewable energy systems into the grid, which guide to energy efficiency and reduction in emissions. With increase of the renewable energy saturation to the grid, PQ (power quality) of the medium to low voltage power transmission system is becoming major area of interest. The majority of the integration of renewable energy systems to the grid takes place with the aid off power electronics inverter and converter. Now a day, solar energy can be used as an alternative resource due to the worldwide crisis on fossil fuel and increasing concern about worldwide environment problems. PV (Photovoltaic) is basically works to convert solar energy into electricity directly and recently is widely used. With nonlinear characteristics, concerning loads to PV will issue the power generated by PV is not maximum. Another important problem is due to cost of PV arrays. There are many problems when PV connected grid using inverter, one of the main problem is current fluctuation. Applications of PV can be classified into two stages, stand-alone and grid-connected systems. The first one is applications where PV systems are separated from utilities and the second one is applications where PV and grid are integrated . The technical key aspects that will drive improvements in cost, efficiency and reliability of PV inverters, which are means to success, will be addressed in this paper. The paper will point out current related challenges in power quality assurance and overview of to mitigate the different technique. Grid connected photovoltaic power systems are power system energised by photovoltaic panels which are connected to the utility grid. Grid connected power systems comprise of

1. PV panels
2. MPPT
3. Solar inverters
4. Power conditioning units
5. Grid connection equipments

<u>Here two inverter control methods are described.</u>

a) Voltage source inverter control method
b) Power type PWM inverter control method

Thus, even the grid-connected PV generation inverter control system is able to achieve maximum power point tracking (MPPT) and to ensure the high power quality of the photovoltaic cells or not are key issues in the electrical power system.

II. ISSUES OF POWER QUALITY

Around 70 to 80 % of all power quality related issues can be attributed to faulty connection and wiring. There are different problem to grid connected inverter is used like frequency disturbances, electromagnetic interference, transients, harmonics and low power factors. The effects of harmonics on power quality are specially described in. According to the IEEE standard, harmonics in the power system should be limited by two various method, first one is the limit of harmonic current that a user can inject into the utility system at the PCC (point of common coupling) and the other one is the limit of the harmonic voltage that utility can supply to any customer at the PCC. Generally there are two way to reduce the power quality problems- either from the customer side or from the supply side. The first one is called load conditioning, which makes certain that equipment is less sensitive to power distribution, allowing the operation even under significant voltage distribution. Other one is to install line conditioning system that suppress or counteracts the power system disturbances.

III. SOLAR CELL

A working of solar cell system converts sunlight into electricity.

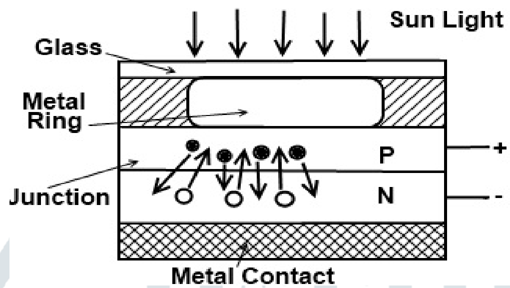

Figure1. Solar Cell

Solar cells may be grouped to call panels or modules. Panels can be grouped to call large solar cell arrays. The word array is usually working to describe a solar cell panel (with numerous cells connected in series and/or parallel) or a group of panels. Mainly of time one are interested in modelling solar cell panels, which are the commercial solar cell devices.

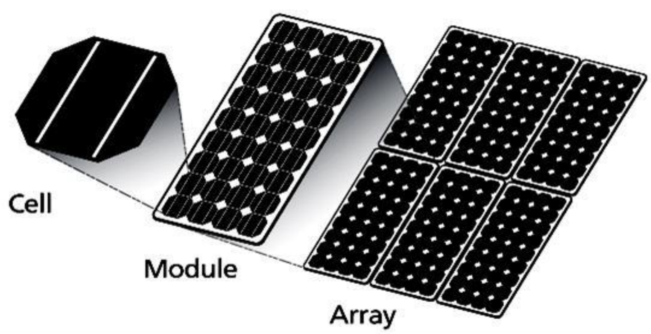

Figure2. Solar cell ladder

The voltage generated by a solar cell is very low, approximately 0.5v. So more than one of solar cells are used to connect both in series and parallel connections to get the desired output. In biased shading case, diodes may be necessary to avoid reverse current in the array. In solar cell, good ventilation behind the solar panels is provided to reduce the possibility of less efficiency at high temperatures. The most of practical purpose, over production of the power by a single PV (photovoltaic) module is not enough to meet the power demands. Inverters use in the PV array can to convert the dc output into ac and another use to apply it for motors, lighting and other loads. The modules are connected in series for more voltage rating and it connected in parallel to meet the current specifications.

IV. GRID CONNECTED PHOTOVOLTAIC GENERATION SYSTEM

Grid-connected PV generation system is mostly composed of the PV array, the inverter device with the function of maximum power tracking and the control system, whose structure shown in Figure3

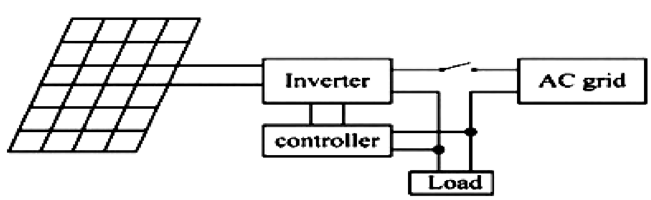

Figure3 Grid connected PV power generation structure

The function of the inverter maximum power point tracking can inverse the electric power into sinusoidal current, and connect to the grid. The control system generally control the maximum power point tracking of photovoltaic, current waveform and power of the output of grid-connected inverter, which makes the output to the grid correspond with the export by PV array.

V. INVERTER CONTROL THEORY

Generally control of Inverter can the switch state of shut and conduct, thus the system may form two different working ways which are parallel operation and separately operation. While the system is working in parallel operation way, the inverter belongs to the current mode. Corresponding circuit of the inverter in parallel operating mode is shown in below figure4.

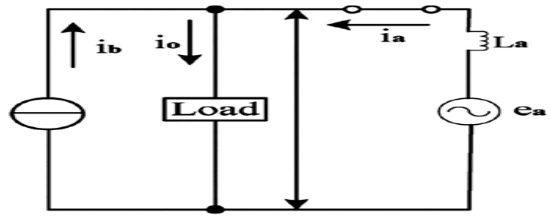

Figure4. Corresponding circuit of the inverter in parallel operating mode

The equation can be easily got from the circuit combing with Kirchoff's Law, as in (1), (2).

e0=ea-La(dia/dt) ….1

ia=i0-ib ….2

where ea = the source voltage, e0 is the AC voltage of the load,

ia = the contact current, i0 is the load current,

ib = the output current of the inverter.

According to equations 1 &2, the relation equation of fundamental component of voltage and current is easily got, as in equation (3).

e01 = ea1 – La[d(i01-ib1)/dt] ….3

The voltage fundamental Eal seen as the baseline vector, thus the fundamental value Eol by the output of inverter and its phase.

VI. CHARACTERISTIC OF PV PANEL

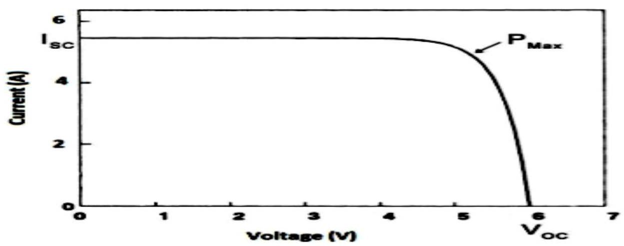

Figure .5 Typical I-V Characteristics of Solar Panel

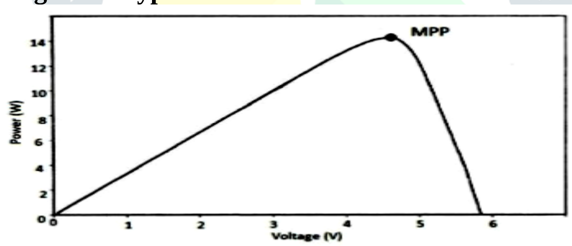

Figure .6 Typical P-V Characteristics of Solar Panel

VII. CLASSIFICATION OF MPPT TECHNIQUES

Varieties of MPPT techniques have been developed implemented and are categorized as offline method, online method and hybrid method. Offline techniques are dependent on solar cell models and are generally require to one or more of the solar panel values, such as short circuit current (Isc), open circuit voltage(Voc), temperature and irradiation.

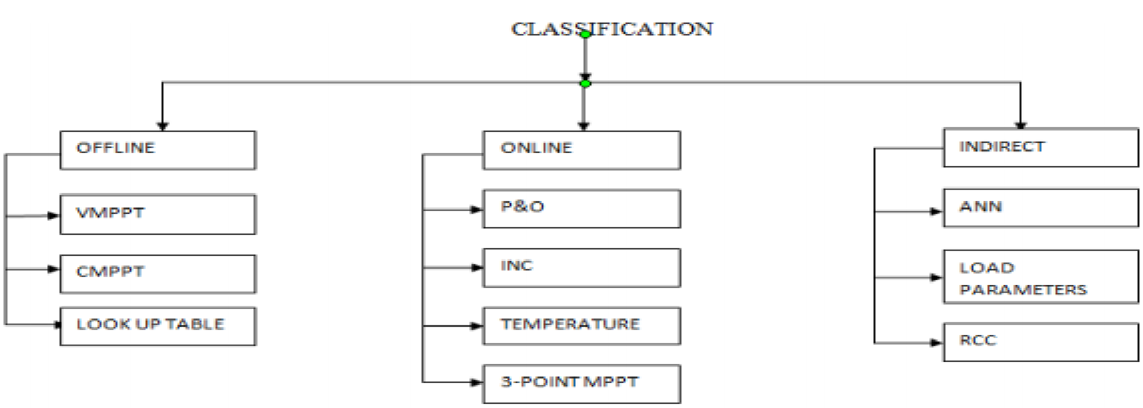

Fig 7: Classification of MPPT techniques

From the fig.7, the offline techniques are cost effective but performance wise less effective than online and other techniques. Online techniques do not specifically rely on modeling of the solar cell behavior. In this technique usually the instantaneous values of the PV output current and voltage are used to generate the control signals, and this control signal is applied to the PV system along with a small methodical and premeditated perturbation in voltage or current or duty cycle and the resulting cycle is determined. Indirect techniques are the combination of offline and online methods, tracking of the MPP are performed in two steps. The first step relies on offline techniques to place the set point close to MPP which involves estimation of MPP. The second step based on the online techniques and attempts to reach the actual value of MPP, which can be regarded as a fine – tuning step.

VIII. PERTURB AND OBSERVE (P&O):

Perturb and Observed (P&O) is the most commonly used method for MPPT, because its simplicity in both measurement and structure. The P&O algorithm is continuously adjusts the electrical operating point by measuring the operating current and voltage of the PV panel to observe the change in power transfer.

With use of this algorithm, there will always be oscillations approximately the MPP during steady state operation. This problem can be leading to a slightly more unstable system. Another disadvantage of this algorithm is tracking in the wrong direction, caused by quick change in the irradiance or temperature which will confuse the MPPT. Both of these disadvantages cause power loss. A Flowchart of P&O algorithm is illustrated in Figure 8.

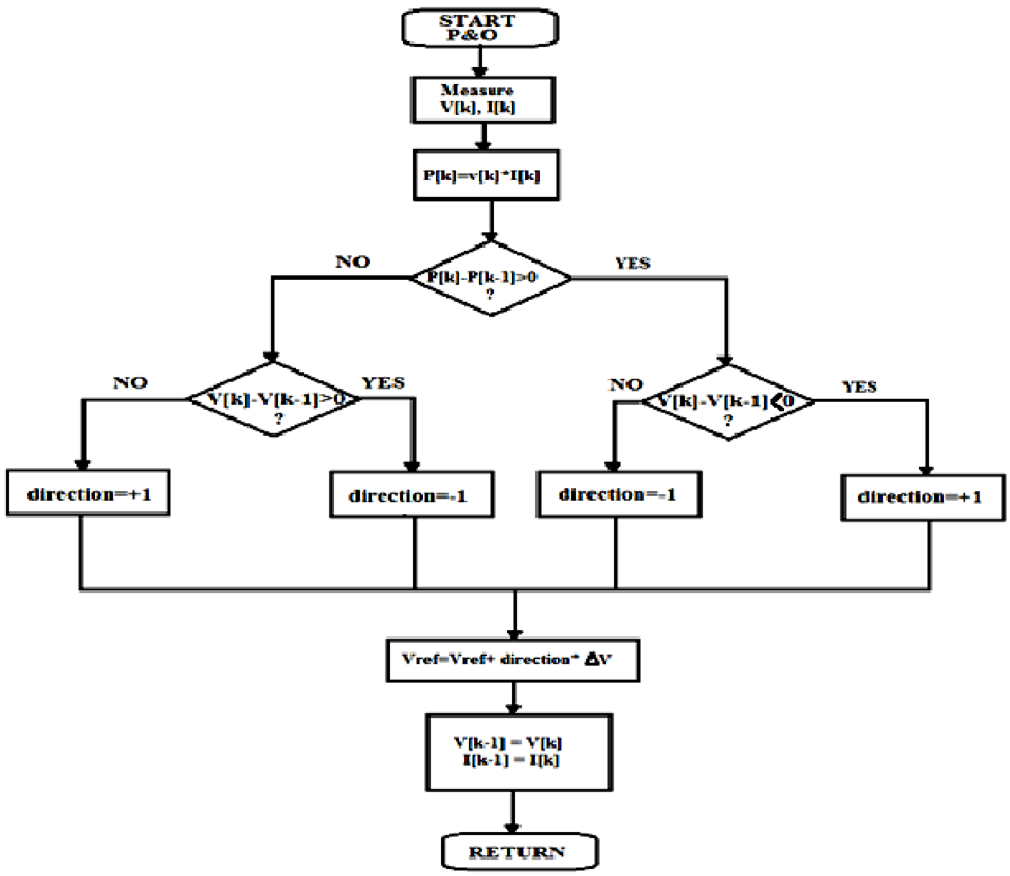

Figure 8. Flowchart of the Perturb and Observe algorithm

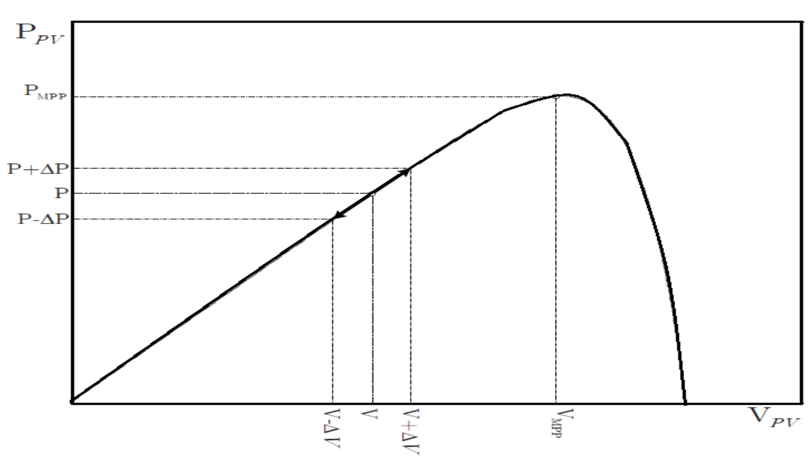

Figure 9. P-V Characteristic of Panel for the P&O Algorithm

The proposed algorithm of MPPT relates the power generated by the PV panel to a function of the converter voltage input Vi and the switching frequency fs. As switching frequency is a control parameter set internally by the microcontroller and the MPP tracking system successfully requires only one external sensor to operate. The generated DC power by a PV source is given equation by:

Ppv=Vpv*Ipv

IX. HYSTERESIS CONTROL

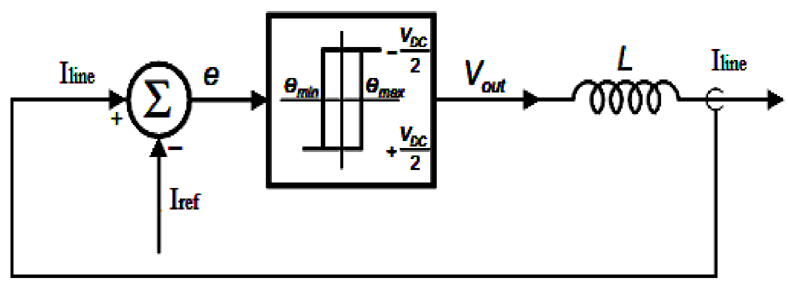

Figure10. Block Diagram of Hysteresis Control

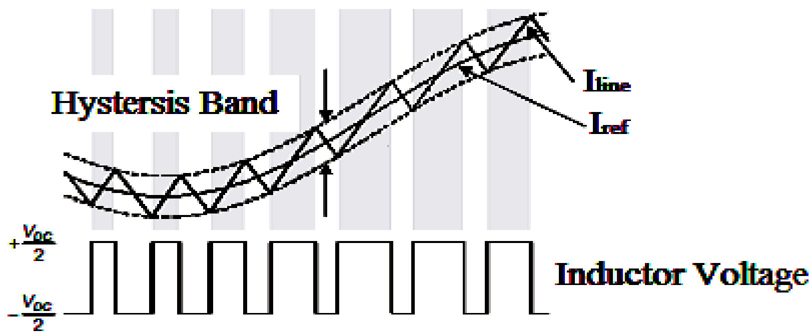

Figure11. Controller operational waveform of Hysteresis control

Basically, Hysteresis current control is a method for controlling a VSI (voltage source inverter) to force the grid injected current follows a reference current. A hysteresis controller block diagram is shown in Figure 8. The reference current and line current are used to control the inverter switches. Upper and lower hysteresis band limitations are correlated to the minimum and maximum error directly (min, max). While the changed the reference current, line current has to stay within these limits. The error signal range directly controls the amount of ripples in the output current from the inverter which is called the hysteresis band. The current ramping between the two limits is shown in Figure Hysteresis controllers not only are simple and robustness but also have a good transient response. Due to the relations between the phases, the current error is not limited to the value of the hysteresis band. The switching frequency of hysteresis controller changes by load parameter's variations which is changed the bandwidth and it can cause resonance problems. Furthermore, the losses of switching resist the application of hysteresis control to lower power level. This type of problem can be solved by employing variable limitation as mentioned in. Yet, it needed system parameter's details.

X. CONCLUSION

Pollution and weather change are powerful reasons to reduce our use of coal, oil and natural gas. Conversely, the environment is not the only the reason to substitute the fossil fuel sources with renewable. In fact, if fossil fuels are released no pollution whatsoever, they would still be issue big problems for modern society. Renewable energy is very flexible because of renewable can be used in small systems for distributed generation or in truly substantial installations for centralized generation. As the majority of renewable energy systems are connected to the grid, so using controlled inverter is essential to have a reliable and safe grid interconnection. In this way, this type of the current control inverter is more commonly used, then in this paper the structure of the important current control techniques like hysteresis, predictive and dead beat control were described. Finally, their ability to give a high power quality generation to the grid was explained. In this paper, we concluded that the current related issue hysteresis control is appropriate and easy to implementation.

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