ISSN: 2366-1313

# PERFORMANCE ANALYSIS OF PHOTOVOLTAIC FED SERIES ACTIVE POWER FILTER FOR POWER QUALITY IMPROVEMENT

[1]Y SAI JYOTIRMAYI, [2]Dr. K VENKATA SUBBAIAH, [3]BHUMIREDDY RAVINDRAREDDY, [4]RATHLAVATH VASUNDHARA, [5]SANGASANI PRATHYUSHA, [6]SONTI PAVAN KUMAR, [7]THOTAKURI SATHISH, [8]SHESHANK

[1]Assistant Professor, Dept. Of EEE, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad,

[2]Professor & Principal, Dept. Of CSE, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad,

[3]Assistant Professor & HOD, Dept. Of MECH, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad,

[4,5,6,7,8]BTech Student, Dept. Of EEE, DRK INSTITUTE OF SCIENCE & TECHNOLOGY, Hyderabad

**Abstract**: This article presents a progressive topology of an active energy harvesting filter coupled with photovoltaic systems to convert the output voltage. The presence of high voltage quality problems has enough functionality to affect consumer electronics and raise various problems within the respective network. Minimizing these voltage problems is critical to achieving the desired satisfactory power output. Therefore, a suitable control algorithm is required for the generation of reference currents that are useful for signal generation. In this article, the method of unit vector template technology is applied for the generation of reference symbols. A hysteresis controller is used for the period of the trigger signal. The required voltage across the DC link during filter operation must be kept constant for high overall efficiency, considering that the PV system is installed and powered through the filter's DC link. The developed device is configured in the Simulink environment and the overall performance of the filter is evaluated by analysing the disturbances associated with different voltages under static conditions.

**Keywords**: power quality, Active filter, Control strategy, grid connected PV system, power quality issues

## I. INTRODUCTION

Age of fossil fuel as source of energy is constantly getting extinct. Demand of fuel and energy is exponentially rising with time. At the same time energy cost is also continuously increasing. To overcome these critical situations, we can use renewable resources at our disposal from which energy can be tapped. Photovoltaic cells convert solar energy to direct electric energy. The advantages of solar energy are:

ISSN: 2366-1313

1. It requires less time to install and start up new unit for generation. 2. It has no rotating parts, hence no noise, no maintenance and long life with less maintenance. 3. Solar energy is abundantly available on earth. 4. Problem of low efficiency and higher initial cost can be overcome by advance technology solar PV panel. 5. This energy source is non-polluting and available continuously free of cost. It is anticipated that Photovoltaic system will be major source of energy fulfilling global energy needs. The application of PV systems in power systems can be divided into two main fields: off-grid or stand-alone applications and on-grid or grid-connected applications. Stand-alone PV systems can be used to provide power for remote loads that do not have any access to power grids while grid-connected applications are used to provide energy for local loads and for the exchange power with utility grids. [1] Photovoltaic system has been increasingly used in medium sized grid with domestic utilities. PV panels are connected in series and parallel to generate usable amount of voltage and current. By series connection voltage level can be built up and by parallel connection current density can be increased. In addition to that Converter configuration should be efficient and cost effective. PV systems can enhance the operation of power systems by improving the voltage profile and by reducing the energy losses of distribution feeders, the maintenance costs, and the loading of transformer tap changers during peak hours [2]. In comparison with other renewable technologies, PV systems still face major difficulties and may pose some adverse effects to the system, such as overloading of the feeders, harmonic pollution, high investment cost, low efficiency, and low reliability, which hinder their widespread use [3]. Moreover, variations in solar irradiation can cause power fluctuation and voltage flicker, resulting in undesirable effects on high penetrated PV systems in the power system. Some control methods, such as Maximum Power Point Tracking (MPPT) can be used to improve efficiency of PV systems. In such controllers, both the produced voltage and the current of the PV array should be controlled. This may complicate the PV system structure with increased possibility of failure while tracking maximum power in unexpected weather conditions. the PV system-based distributed generations (DGs) may energize the local loads after the system has been disconnected from the utility grid during faulty conditions. In these situations, any unintentional islanding may increase the risk of safety problems or

ISSN: 2366-1313

damage to other parts of the system components, which can decrease system reliability. Solar PV system connected at distribution level is termed as distributed generation (DG). The utility is concerned due to the high penetration level of PV system in distribution systems as it may cause to affect stability, voltage regulation and power-quality (PQ) issues. However, the excess use of power electronics-based equipment and non-linear loads at PCC generate harmonic currents, which may affect the quality of power. This creates unbalancing effect on transmission and generation side and also load current harmonics may result in voltage harmonics and can create a serious PQ problem in the power system network. Active power filters (APF) are easily used to compensate the load current harmonics and load unbalance at distribution level. The connection topologies of filtering into the system to overcome the PQ problems are also discussed.

## II. LITERATURE SURVEY

Prakash K et al presents a power quality issues in distributed generation system by environmental changes and also change in load. The solar irradiance or insolation forms a voltage sag and swell system. Author is also mentioning mathematical approach by a technique such as modular probabilistic neutral network (MPNN), support vector machine (SVMs) and least square support vector machine (LS-SVMs) to classify PQ disturbances, S-transform has the advantage of better time Freq. resolution and its capability of detection and localization of disturbance even under noisy condition [4].

John H.R.Enstin,& Peter J.M.H eskes was discuss and analyse phenomenon of harmonic interference of P.V. inverters and to compare the network, interaction of different inverter function and controls. They investigated power quality problems and also try to find out harmonic's pollution regarding series and parallel resonance in distribution network. The simulate the experimental model with laboratory experimental as well as computer modelling of different inverter topologies and summaries it with redesigning with (inverter) outer filters [5].

Minas Patsalides, Demetres Evagorou1, George Makrides was present analysis on effect of solar irradiance on power quality. They studied the low irradiance lead to undesirable variation of power and in supply quality of voltage and current and this variation proves the low solar irradiance has a significant impacts on the power quality of the output of the pv system [6].

ISSN: 2366-1313

M. J. E. Alam,K. M. Muttaqi, and D. Sutanto are provides an overview of some of the known PQ issues related to the introduction of different types of DG systems into a power network. The analysis is based on common types of DG system designs and associated technologies.Common PQ problems arising from DG systems impacting on power network as well as common existing network based PQ issues impacting on DG systems have been identified [7].

Walid A. Omran, M. Kazerani are present a investigation of method for reduction of power fluctuation generated from large grid connected pv system. These fluctuations are happened due to change in irradiation level. This effect are creates fluctuation in power generation. So they focus on investigation method as 1) Use battery storage system,2) use of dump load, 3)curtailment of the generated power by operating the power conditioning unit of the PV system below maximum power point [8].

AchimWoyte, Vu Van Thong is explain the voltage fluctuation happened due to moderate climate characterized. These fluctuations are short time nature. This is mainly happened on low voltage grid/ rural grid. In this study, severity of grid voltage and power flow fluctuation at the point of common coupling as a consequence of fluctuation in solar irradiance. Due to clouds moving over the area. They described specific description of fluctuation has proposed by three parameters – magnitude, duration of transition between clear and cloudy, & speed of the transition, and ratio of magnitude & duration [9].

Dr.SavitaNema, Dr.Prashantbaredar present analysis network behaviour with increasing level of rooftop solar PV penetration into low voltage network. This paper also proposes a three-phase power flow approach and power flow calculation have been performed using the proposed approach to investigate the impact of single-phase variable PV generation. In which PV generation are affected by the solar irradiation and voltage, current rise are rises in system during midday [10].

## III. SYSTEM DEVELOPMENT

For the synchronization of utility grid and grid connected PV system, some condition has to satisfy like voltage level, frequency and phase sequence matching. This synchronization is done by PV inverter which having advance power electronics technology. The power-voltage relationship or current-voltage relationship of the cell can generally be representing

ISSN: 2366-1313

the Electrical characteristics of a PV unit. The changes of solar irradiance on the cell and the cell temperature are directly varies these characteristics. A proper simulation model is needed to convert the changes of temperature and radiation on generated voltage and current of the PV arrays. So that at the different weather conditions, the dynamic performance of PV system can be analyse.

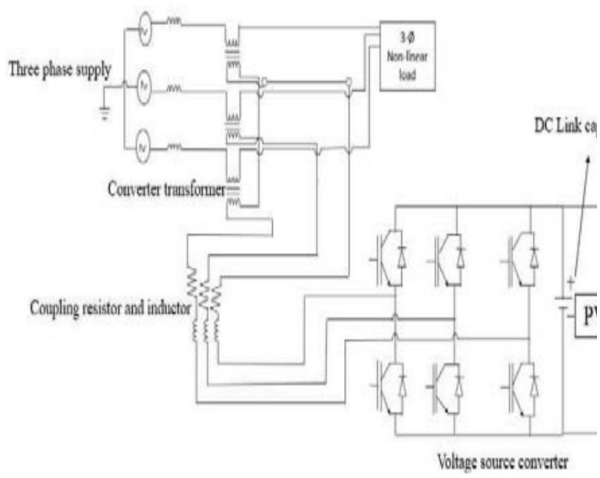


**Fig.1** PV fed series connected filter

Solar cell is basically a photovoltaic cell form of p-n junction. It when exposed to sunlight absorbs some energy greater than band-gap. This creates some hole-electron pairs proportional to incident radiations. These carriers are affected by internal electric fields of p-n junction and forms photo current proportional to solar insolation. PV cells have nonlinear characteristics which vary with radiation intensity and temperature.

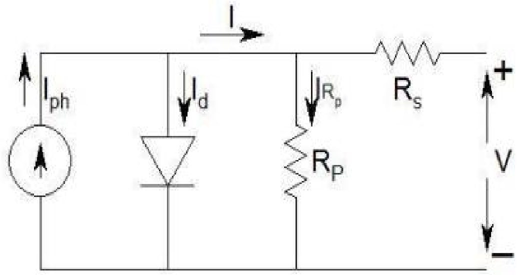


Fig.2 Equivalent circuit Diagram of PV cell

PV cells produces less than 3W at 0.5 to 0.6 Volts, so cells are connected in series to produce enough power. The terminal equation for the current and voltage of the array of PV panels are given as under(fig 2)

$$I = I_P - I_D - I_p = 0$$

$$V = V_D - R_S I$$

$$I_P = \frac{V_{PV} + R_S I}{R_P}$$

$$I_D = I_O(e^{\frac{q(V+R_S I)}{NkT}} - 1)$$

$I_{Ph}$= Light Generated Current
V= Terminal Voltage Of The Cell
$I_d$ = Diode Current
$I_o$ = Saturation Current
$I_P$ = Shunt Current
q = Electron Charge
k = Boltzmann Constant
T =Temperature
$R_D$ = Series Resistance
$R_P$ = Shunt Resistance

**Boost Converter and Inverter:** Boost converter increases voltage level for inverter and control MPPT. Output voltage of boost converter is higher than input

ISSN: 2366-1313

voltage. Input current is same as inductor current and hence it is not discontinuous as buck convertor and hence input filter requirements are relaxed in boost convertor. If solar panels of high rating are implemented then requirement of boost converter can also be relaxed and switching loss in converter can be saved. PV Panels generate DC Voltage and to connect panels to grid DC power has to be converted to AC Power. We require inverter to convert DC to sinusoidal AC before connecting to grid. Output voltage and frequency should be same as that of grid voltage and frequency. Many inverter topologies are available. In proposed scheme PWM (pulse width modulated) Voltage Source Inverter is selected d-q theory with phase. Output of the Inverter is near to Sinusoidal. 6 switches are used and its switching is controlled by discrete PWM signals. Electrical diagram for inverter is shown in Fig. 3.

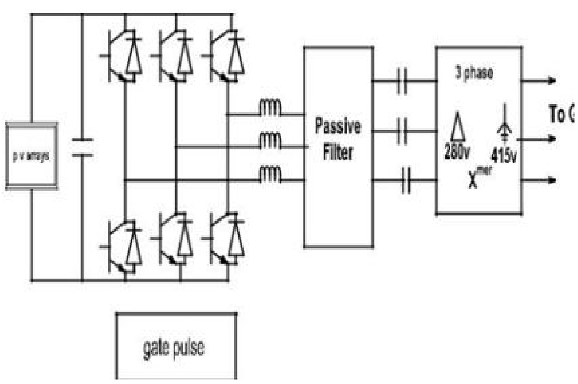


Fig.3 PWM 3 phase inverter with passive filter

## IV. ACTIVE FILTERS

Harmonics, reactive power, fluctuation and/or neutral current in ac networks is being compensated by the Active filter technology. It has been transformed in the last 25 with development of various configurations, power electronics/ switching devices and control strategies. AF's are also used to improve voltage balance, regulate terminal voltage, eliminate voltage harmonics and suppress voltage flicker in three-phase systems. These issues are achieved by combination or individually. But it is depending upon the configuration, control strategy or requirements which have to be select properly. This section presents the development and current status of active filter. Large numbers of publications are presents work regarding the power quality survey, measurements, analysis, cause, and effects of harmonics and reactive power in the electric networks

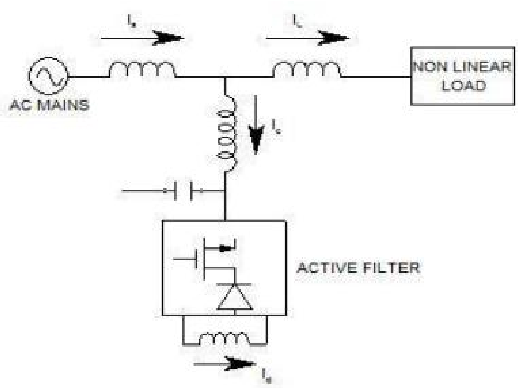


Fig.4 Current-fed-type Active Filter

ISSN: 2366-1313

Active filters are classified on the basis of converter type, tropology, and number of phases. And the converter on the CSI or VSI bridge structure. The topologies are shunt, series, or a combination of both. The third is based on the number of phases, like two-wire (single phase) and three- or four-wire three-phase system.

Active filter has two types of converters. Fig. 4 shows the current-fed (PWM) inverter structure. It behaves as a no sinusoidal current source to meet the harmonic current requirement of the nonlinear load. This converter is to be considered sufficiently reliable but it has higher losses and require higher values of parallel ac power capacitor. For the better performance in higher rating, multilevel mode cannot be used by this converter. Fig. 5 shows the voltage-fed PWM inverter structure. It has a large dc capacitor which supports dc voltage bus. It is lighter, cheaper and multilevel and multistep. Multilevel improve the performance with lower switching frequency. AF's can be classified based on the topology used as series or shunt filters Fig. 5 shows a shunt active filter, it eliminates current harmonics, reactive power compensation and balancing balanced current. A nonlinear load injects current harmonics.so it is mainly used at the load end. It injects equal compensating currents, opposite in phase, to cancel harmonics and/or reactive components of the nonlinear load current at the point of connection. For stabilizing and improving the voltage profile, it can be used as a static var generator in the power system network. Fig. 5 shows a stand-alone active series filter. It is connected before the load in series with the mains, using a matching transformer. It can reduces negative-sequence voltage and regulate the voltage on three-phase systems it can eliminate voltage harmonics, and to balance and regulate the terminal voltage of the load or line.

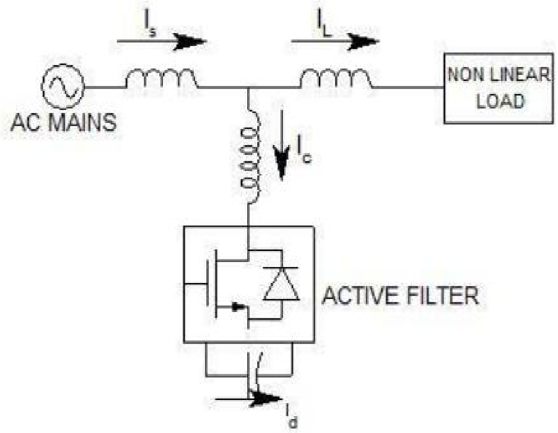


Fig.5 Voltage-fed-type Active Filter.

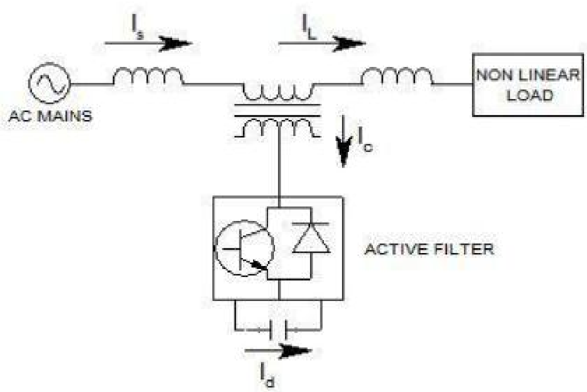


Fig.6 Series-type Active Filter

ISSN: 2366-1313

ASD's are major applications of power electronics converter, and many three phase three wire nonlinear loads are incorporating active filters in their front-end design. Different types of configurations had appeared on three wire shunt/series active filter by a large number of publications. In three-wire active filters, all the configurations are developed with three wires on the ac side and two wires on the dc side. The current-fed type (Fig. 4) or voltage- fed type with single-stage (Fig. 5) or multistep/multilevel configurations are developed in shunt active filter. Active shunt AFs are also designed with three single-phase AF's with isolation transformers for proper voltage matching, independent phase control, and reliable compensation with unbalanced systems.

## V. CONCLUSION

An extensive review on possible effects of grid-connected PV systems on power quality in distribution systems under varying solar irradiances has been presented to provide a clear perspective various aspects of the active power produced by PV system causes voltage rise, voltage flicker, and power factor reduction, which may create severe problems on the system components. The substantial increase in the use of power electronics devices results in harmonic pollution above the tolerable limits. Utilities are finding it difficult to maintain the power quality at the consumer end. Active filter technology is well developed and many manufacturers are manufactures active filters with large capacities. A large number of AF configurations are available to compensate harmonic current, reactive power, neutral current, unbalance current, and harmonics. Here with the issues, shunt active filter is one the best configuration which can be used to compensate these issues. So, Shunt active filter can be preferred for used in grid connected PV system.

## REFERENCES

1. Pinto JP, Pregitzer R, Monteiro LFC, Afonso JL., 3- Phase 4-wire shunt active filter with renewable energy interface. Proc. of IEEE Conference, Renewable Energy & Power Quality, Seville, Spain (2007).
2. Joorabian, M., Jassas, N., and Barati, H., Active power filter simulation for nonlinear Load Harmonics Effects Reduction. Proc. of the 6th International Conference on Industrial Electronics and Applications (ICIEA):1376- 1380 (2011).
3. Premalatha K, Vasantharathna S and Dhivyaah T., Selfexcitation system for control of wind turbine driven

ISSN: 2366-1313

induction generator using direct torque control, Journal of Vibration and Control: 1–20 (2014).

4. Hongbo Li, Kai Zhang, and Hui Zhao., Active DC-link power filter for single phase PWM rectifiers. Proc. of the 8th IEEE International Conference on Power Electronics and ECCE Asia (ICPE & ECCE), Wuhan, China: 2920 – 2926 (2011)
5. Abdullah Abusorrah , Mohammed M. Al-Hindawi , Yusuf Al-Turki , Kuntal Mandal Damian Giaouris, Soumitro Banerjee, Spyros Voutetakis, Simira Papadopoulou., Stability of a boost converter fed from photovoltaic source, Solar Energy 98 : 458-471 (2013)
6. Karuppanan P, Kamala Kanta Mahapatra., PI and fuzzy logic controllers for shunt active power filter — A report. ISA Transactions 51:163–169 (2012).
7. Nimal, R.J.G.R., Hussain, J.H., Effect of deep cryogenic treatment on EN24 steel, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-113- 116, 2017
8. Parameswari, D., Khanaa, V., Deploying lamport clocks and linked lists, International Journal of Pharmacy and Technology, V-8, I-3, PP-17039-17044, 2016
9. Parameswari, D., Khanaa, V., Case for massive multiplayer online roleplaying games, International Journal of Pharmacy and Technology, V-8, I-3, PP-17404-17409, 2016
10. Parameswari, D., Khanaa, V., Deconstructing model checking with hueddot, International Journal of Pharmacy and Technology, V-8, I-3, PP-17370-17375, 2016
11. Parameswari, D., Khanaa, V., The effect of self-learning epistemologies on theory, International Journal of Pharmacy and Technology, V-8, I-3, PP-17314-17320, 2016.
12. Pavithra, J., Thooyamani, K.P., A cram on consumer behaviour on Mahindra two wheelers in Chennai, International Journal of Pure and Applied Mathematics, V-116, I-18 Special Issue, PP-55-57, 2017.
13. Pavithra, J., Thooyamani, K.P., Dkhar, K., A study on the air freight customer satisfaction, International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-179-184, 2017.