ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Power Management in Grid under Non-Linear Load Condition by PV Based Active Power Filter

Shaik Raheem
M.Tech-Energy Systems
Dept. of Electrical Engineering,
JBIET-Hyderabad
Telangana, India.

R.Suresh Babu
Associate Professor & HoD
Dept. of Electrical Engineering,
JBIET-Hyderabad
Telangana, India.

Abstract

In this paper, a three-phase three-wire system, including a detailed PV generator, dc/dc boost converter to extract maximum radiation power using maximum power point tracking, and dc/ac voltage source converter to act as an APF, is presented.Grid tied solar power generation is connected to nonlinear loads based on Active Power Filter (APF) by providing predictive control scheme. The dcoutput voltage of PV arrays is connected to a dc/dc boostconverter using a Ripple Co-relation controller to maximize their produced energy. The dc/ac VSC integrated by an APF function should providethe harmonic elimination and reactive power compensationand simultaneously inject the maximum power generatedby PV units. The performance characteristics verified MATLAB/Simulink software.

INTRODUCTION

Distributed generation (DG) based on renewable energy sources are basically small scale power generation units (typically ranges from 20 kW to 20 MW) and they are located at the end user without long distance transmission line. As a result, it reduces the transportation cost of generation and consumption points are close to each other. It is feasible to implement interfaces having ability to operate in grid connected as well as in isolated mode without grid connection which is called micro grids.

Solid-state control of ac power using Thyristors and other semiconductor switches is widely employed to feed controlled electric power to electrical loads, such as adjustable speed drives (ASD's), furnaces, computer power supplies, etc. Such controllers are also used in HV dc systems and renewable electrical power generation. As nonlinear loads, these solid-state converters draw harmonic and reactive power components of current from ac mains. In three-phase systems, they could also cause unbalance and draw excessive neutral currents. The injected harmonics, reactive power burden, unbalance, and excessive neutral currents cause low system efficiency and poor power factor. They also cause disturbance to other consumers and interference in nearby communication networks Extensive surveys have been carried out to quantify the problems associated with electric power networks having nonlinear loads.

PV-APF

Power supply and power quality has been critical issues in power system recently. The grid-connected photovoltaic (PV) generator has nowadays become more popular because of its reliable performance and its ability to generate power from clean energy

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

resources. The dc output voltage of PV arrays is connected to a dc/dc boost converter using a maximum power point tracking (MPPT) controller to maximize their produced energy [5]. Then, that converter is linked to a dc/ac voltage source converter (VSC) to let the PV system push electric power to the ac utility. The local load of the PV system can specifically be a non- linear load, such as computers, compact fluorescent lamps, and many other home appliances, that requires distorted currents. Development of a means to compensate the distribution system harmonics is equally urgent. In this case, PV generators should provide the utility with distorted com- compensation capability, which makes currents injected/absorbed by the utility to be sinusoidal. Therefore, the harmonic compensation function can be realized through flexible control of dc/ac VSC.the power quality of the utility.

PV-APF

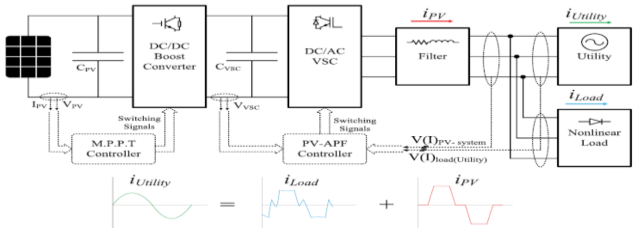


Fig 1:PV-APF system

The detailed PV-APF configuration which shown in fig 1consists of the following

Dynamic Model of PV Array

The PV array involves N strings of modules connected in parallel, and each string consists of M modules connected in series to obtain a suitable power rating. The dynamic model of PV cell is shown in Fig. 2

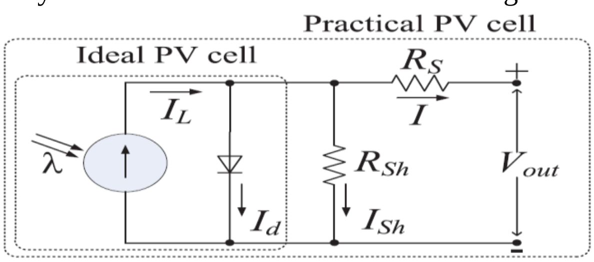


Fig2: Equivalent electrical circuit of the PV cell

The output-terminal current I is equal to the light-generated current IL, less the diode-current Id and the shunt leakage current (or ground-shunt current) ISh. The series resistance RS represents the internal resistance to the current flow.

The regulator output of MPPT is the duty cycle correction for semiconductor switches. In summary, the controller of the dc/dc boost converter is shown in Fig.3

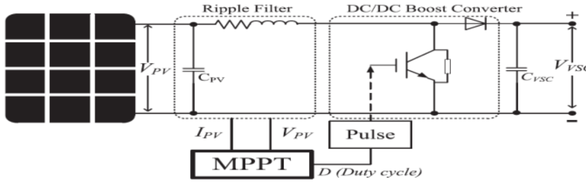


Fig 3: Controller mechanism of the boost converter

SIMULATION VALIDATION

The system in Fig.4 is simulated in MATLAB/SimpowerSystems to test the PV-APF unit, which connects directly to the ac-utility, and to validate its ability to filter out the harmonic of nonlinear loads.

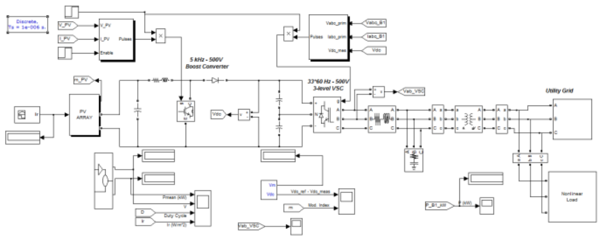


Fig 4: Simulation diagram of PV-Active Power Filter

PV UNIT PERFORMANCE

The PV power output is shown in Fig. 5 without the MPPT control when the dc/dc converter uses constant duty cycle, PV power output could not reach maximum value as MPPT mode does.

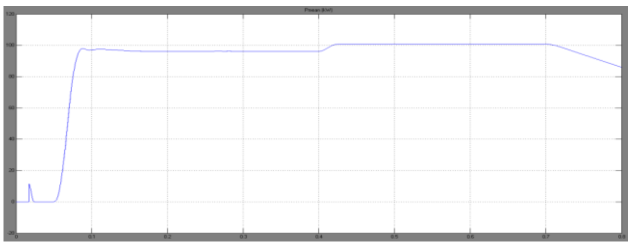
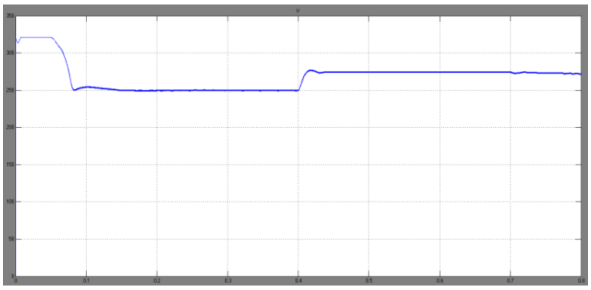


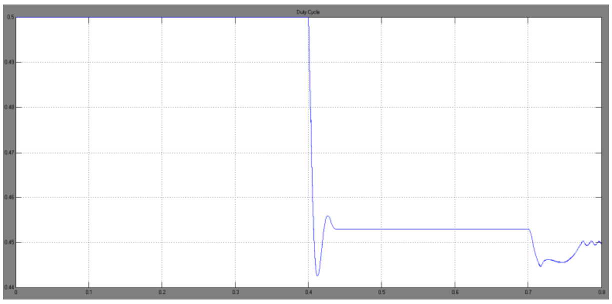
Fig 5: Output power of PV during running time

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

From 0.6 s, the duty cycle running in PV-APF mode slightly increased to adapt to power dynamic response of compensation.



(a).



(b)

Fig 6: Duty cycle and VPV changed by MPPT. (a) Output voltage of PV-unit. (b) Duty cycle of MPPT

ACTIVE POWER FILTER PERFORMANCE

The high load is natural diode rectifiers consuming 450-[A] dc current for three phases and 50-[A] dc current for one phase. Then, the total load power demand is 130 [kW]. This six-ripple dc current brings higher fifth-order and seventh-order harmonics. If a three-phase-controlled rectifier load is used, the THDs increase while the commuted angles increase.

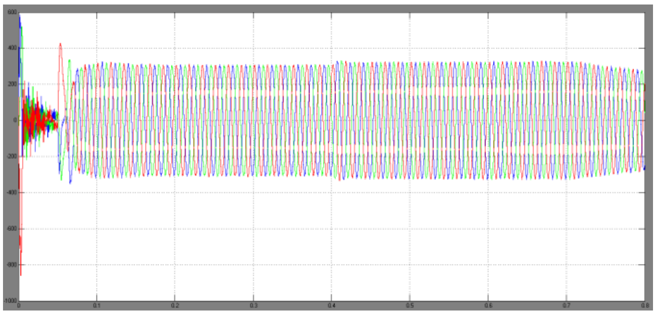


Fig 7: Utility supplied current waveform

During the APF function period [0.5-0.7] s, the current wave-form is enlarged at the bottom of that picture.

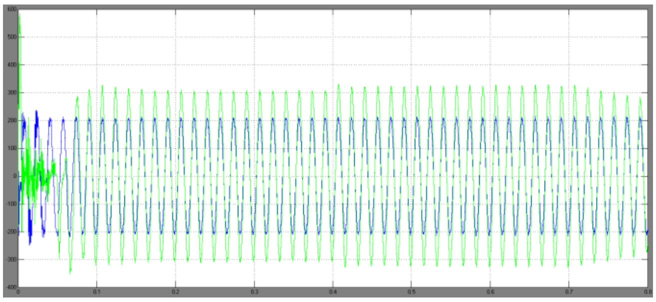


Fig 8: Utility supplied current and PCC voltage waveform

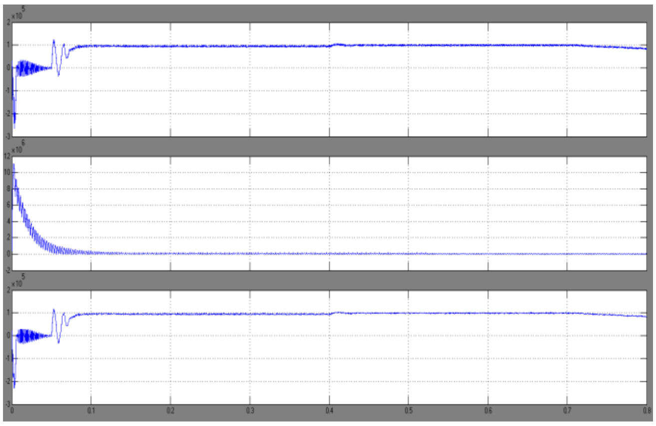


Fig 9: Real power from the (a) utility, (b) PV unit, and (c) load, while the utility supplies power

IMPROVED PV-APF WITH MODEL PREDICTIVE CONTROL TECHNIQUE

This proposed model presents the mathematical model of the 4L-VSI and the principles of operation of the proposed predictive control scheme, including the design procedure. The complete description of the selected current reference generator implemented in the active power filter is also presented. Finally, the proposed active power filter and the effectiveness of the associated control scheme compensation are demonstrated through simulation.

Four-Leg Converter Model

Both types of power generation use ac/ac and dc/ac static PWM converters for voltage conversion and battery banks for long term energy storage. These converters perform maximum power point tracking to extract the maximum energy possible from wind and sun.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

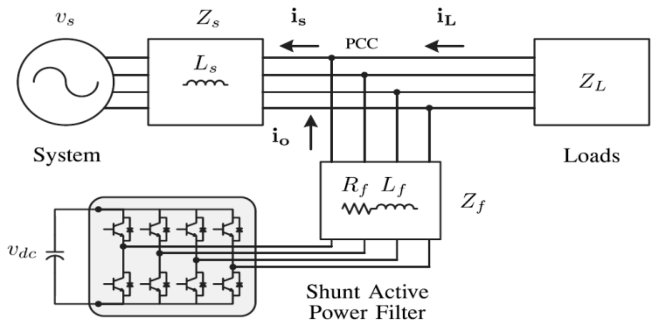


Fig 10: Three-phase equivalent circuit of the proposed shunt active power filter.

This circuit considers the power system equivalent impedance Z_s, the converter output ripple filter impedance Z_f, and the load impedance Z_L. The four-leg PWM converter topology

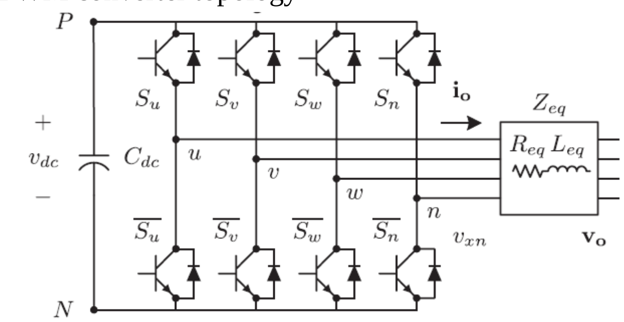


Fig 11: Two-level four-leg PWM-VSI topology

Model Predictive Current Control

The block diagram of the proposed digital predictive current control scheme is shown in Fig. 13. This control scheme is basically an optimization algorithm and, therefore, it has to be implemented in a microprocessor. Consequently, the analysis has to be developed using discrete mathematics in order to consider additional restrictions such

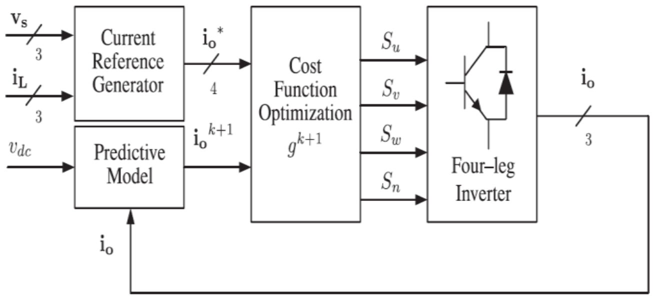


Fig 12: Proposed Predictive Digital Current Control Block Diagram

Current Reference Generation

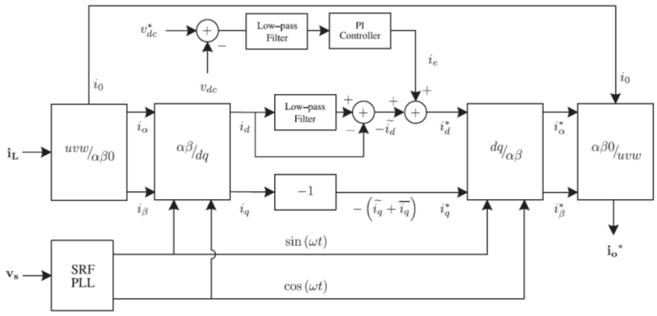


Fig 13: dq-based current reference generator block diagram.

Where the value of $THD_{(L)}$ includes the maximum compensable harmonic current, defined as double the sampling frequency fs. The frequency of the maximum current

Improved PV-APF with model predictive control technique

A simulation model for the three-phase four-leg PWM converter with the parameters shown in Table I has been developed using MATLAB-Simulink. The objective is to verify the current harmonic compensation effectiveness of the proposed control scheme under different operating conditions.

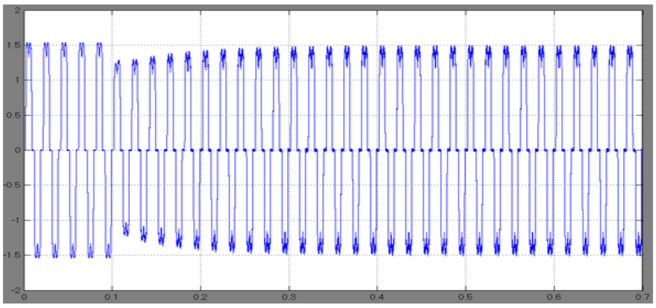


Fig 14: Load Current

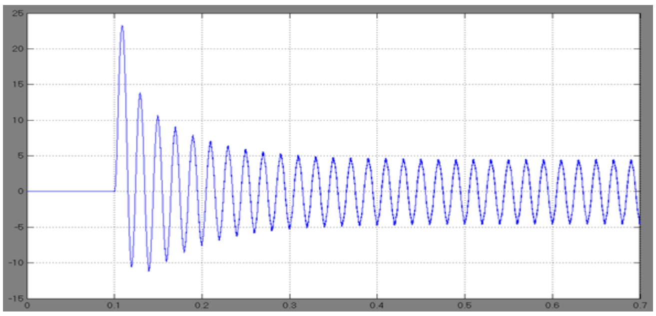


Fig 15: Active power filter output current.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

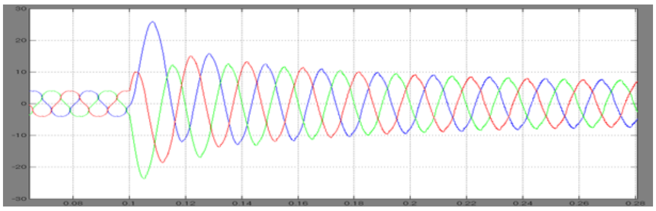


Fig 16: System currents

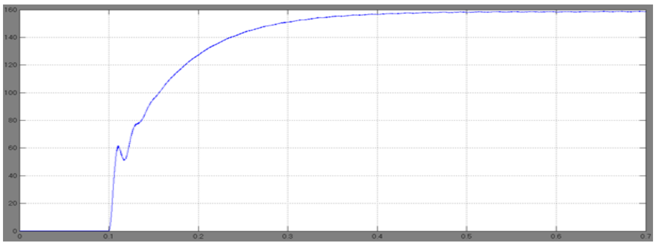


Fig 17:DC voltage converter

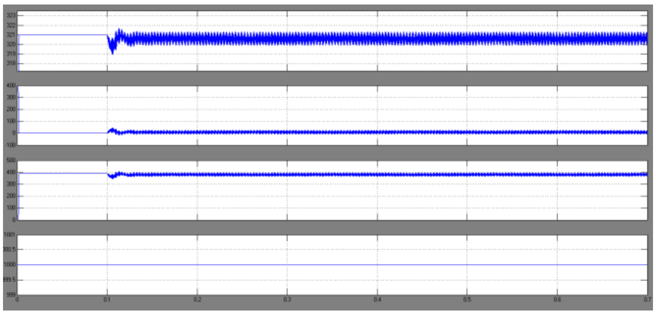


Fig18: PV-Array Characteristics (Voltage, Current, Diode Current, Irradiance)

CONCLUSION

The positive influence of MPPT on maximizing PV power output is also validated. While a PV unit is deactivated, the APF function can still operate.The new controller based on instantaneous power balance has been explained accordingly. It is, therefore, technically feasible for these power electronics-interfaced DG units to actively regulate the power quality of the distribution system as an ancillary service, which will certainly make those DG units more competitive. .The switching among three controllers to dc/ac VSC brings different current waveforms. Preferably, the PV-APF controller compensates the utility currents successfully. As a result, the conventional dq-current controller should not be applied when PV is connected to a local nonlinear load regarding power-quality viewpoint.

REFERENCES

[1] L. Hassaine, E. Olias, J. Quintero, and M. Haddadi, ``Digital power factor control and reactive power regulation for grid-connected photovoltaic inverter," Renewable Energy, vol. 34, no. 1, pp. 315321, 2009

[2] N. Hamrouni, M. Jraidi, and A. Cherif, ``New control strategy for 2-stage grid-connected photovoltaic power system," Renewable Energy, vol. 33, no. 10, pp. 22122221, 2008.

[3] M. G. Villalva, J. R. Gazoli, and E. R. Filho, ``Comprehensive approach to modeling and simulation of photovoltaic arrays," IEEE Trans. Power Electron., vol. 24, no. 5, pp. 11981208, May 2009

[4] N. R. Watson, T. L. Scott, and S. Hirsch, ``Implications for distribution networks of high penetration of compact uorescent lamps," IEEE Trans. Power Del., vol. 24, no. 3, pp. 15211528, Jul. 2009.

[5] I. Houssamo, F. Locment, and M. Sechilariu, ``Experimental analysis of impact of MPPT methods on energy efciency for photovoltaic power systems," Int. J. Elect. Power Energy Syst., vol. 46, pp. 98107, Mar. 2013.

[6] M. A. G. de Brito, L. P. Sampaio, G. Luigi, G. A. e Melo, and C. A. Canesin, ``Comparative analysis of MPPT techniques for PV applications," in Proc. Int. Conf. Clean Elect. Power (ICCEP), Jun. 2011, pp. 99104.

[7] M. El-Habrouk, M. K. Darwish, and P. Mehta, ``Active power filters: A review," Proc. IEE Elect. Power Appl., vol. 147, no. 5, pp. 403413, Sep. 2000.

[8] H. Akagi, Y. Kanagawa, and A. Nabae, ``Generalized theory of the instantaneous reactive power in three-phase circuits," in Proc. Int. Conf. Power Electron., Tokyo, Japan, 1983, pp. 13751386.