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

# Renewable Power Generation Systems with Active Power Filter Performance Improvement

**B.Balakrishna**
MTech Student
Department of EEE
AnuBose Institute of Technology(ABIT)
Paloncha, Khammam, India

**C.Ch Mohan Rao**
Associate Professor & HoD
Department of EEE
AnuBose Institute of Technology(ABIT)
Paloncha, Khammam, India

***ABSTRACT:***

***An active power filter implemented with a four-leg voltage-source inverter using a predictive control scheme is presented. The use of a four-leg voltage-source inverter allows the compensation of current harmonic components, as well as unbalanced current generated by single-phase nonlinear loads. A detailed yet simple mathematical model of the active power filter, including the effect of the equivalent power system impedance, is derived and used to design the predictive control algorithm. The compensation performance of the proposed active power filter and the associated control scheme under steady state and transient operating conditions is demonstrated through simulations and experimental results.***

***Index Terms—Active power filter, current control, four-leg converters, predictive control.***

## INTRODUCTION:

Renewable generation affects power quality due to its nonlinearity, since solar generation plants and wind power generators must be connected to the grid through high-power static PWM converters. The non uniform nature of power generation directly affects voltage regulation and creates voltage distortion in power systems. This new scenario in power distribution systems will require more sophisticated compensation techniques. Although active power filters implemented with three-phase four-leg voltage-source inverters (4L VSI) have already been presented in the technical literature , the primary contribution of this paper is a predictive control algorithm designed and implemented specifically for this application. Traditionally, active power filters have been controlled using pretuned controllers, such as PI-type or adaptive, for the current as well as for the dc-voltage loops . PI controllers must be designed based on the equivalent linear model, while predictive controllers use the nonlinear model, which is closer to real operating conditions. An accurate model obtained using predictive controllers improves the performance of the active power filter, especially during transient operating conditions, because it can quickly follow the current-reference signal while maintaining a constant dc-voltage So far, implementations of predictive control in power converters have been used mainly in induction motor drives.

In the case of motor drive applications, predictive control represents a very intuitive control scheme that handles multivariable characteristics, simplifies the treatment of dead-time compensations, and permits pulse-width modulator replacement. However, these kinds of applications present disadvantages related to oscillations and instability created from unknown load parameters.

## Existing System:

The configuration of a typical power distribution system with renewable power generation. It consists of various types of power generation units and different types of loads. Renewable sources, such as wind and sunlight, are typically used to generate electricity for residential users and small industries.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. The

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

electrical energy consumption behavior is random and unpredictable, and therefore, it may be single- or three-phase, balanced or unbalanced, and linear or nonlinear. An active power filter is connected in parallel at the point of common coupling to compensate current harmonics, current unbalance, and reactive power. It is composed by an electrolytic capacitor, a four-leg PWM converter, and a first-order output ripple filter, as shown in Fig. 2. This circuit considers the power system equivalent impedance *Zs* , the converter output ripple filter impedance *Zf* , and the load impedance *ZL*. The four-leg PWM converter topology is shown in Fig. 3. This converter topology is similar to the conventional three-phase converter with the fourth leg connected to the neutral bus of the system. The fourth leg increases switching states from 8 (23) to 16 (24), improving control flexibility and output voltage quality and is suitable for current unbalanced compensation.

## Proposed System:

The block diagram of the proposed digital predictive current control scheme is shown in Fig. 4. 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 as time delays and approximations . The main characteristic of predictive control is the use of the system model to predict the future behavior of the variables to be controlled. The controller uses this information to select the optimum switching state that will be applied to the power converter, according to predefined optimization criteria. The predictive control algorithm is easy to implement and to understand, and it can be implemented with three main blocks.

### *Current Reference Generator*

This unit is designed to generate the required current reference that is used to compensate the undesirable load current components. In this case, the system voltages, the load currents, and the dc-voltage converter are measured, while the neutral output current and neutral load current are generated directly from these signals (IV).

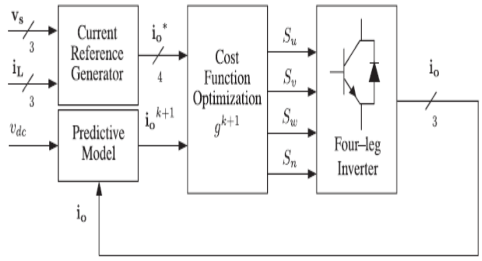



Fig. 4. Proposed predictive digital current control block diagram.

### *Prediction Model:*

The converter model is used to predict the output converter current. Since the controller operates in discrete time, both the controller and the system model must be represented in a discrete time domain . The discrete time model consists of a recursive matrix equation that represents this prediction system. This means that for a given sampling time *Ts* , knowing the converter switching states and control variables at instant *kT*.

## CURRENT REFERENCE GENERATION

A *dq*-based current reference generator scheme is used to obtain the active power filter current reference signals. This scheme presents a fast and accurate signal tracking capability. This characteristic avoids voltage fluctuations that deteriorate the current reference signal affecting compensation performance . The current reference signals are obtained from the corresponding load currents as shown in Fig. 5. This module calculates the reference signal currents required by the converter to compensate reactive power, current harmonic, and current imbalance. The displacement power factor (sin $\varphi(L)$ ) and the maximum total harmonic distortion of the load (THD(*L*) ) defines the relationships between the apparent power required by the active power filter, with respect to the load 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 harmonic component that can be compensated is equal to one half of the converter switching frequency.

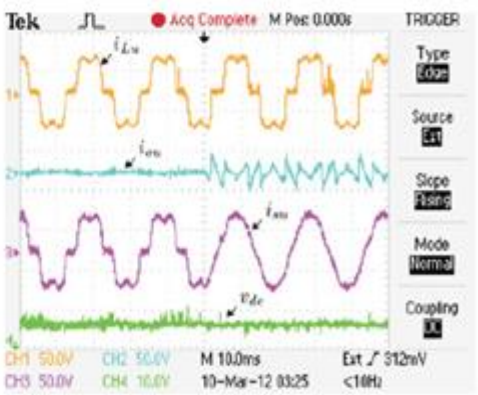
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

## SIMULATED RESULTS

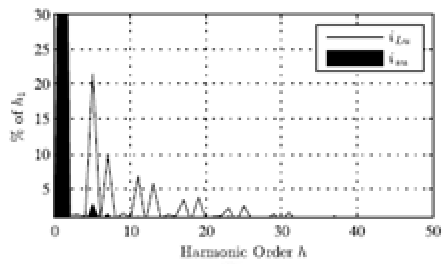
A simulation model for the three-phase four-leg PWM converter with the parameters shown in Table I has been developed using MATLAB Simulink. The objective is to verify the current harmonic compensation effectiveness of the proposed control scheme under different operating conditions. A six-pulse rectifier was used as a nonlinear load. The proposed predictive control algorithm was programmed using an S-function block that allows simulation of a discrete model that can be easily implemented in a real-time interface (RTI) on the dSPACE DS1103 R&D control board. Simulations were performed considering a 20 [$\mu s$] of sample time.

## EXPERIMENTAL RESULTS

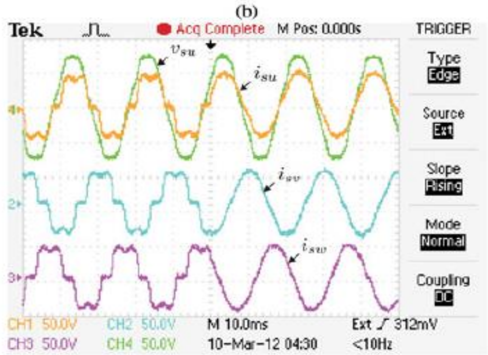
The compensation effectiveness of the active power filter is corroborated in a 2 kVA experimental setup. A six-pulse rectifier was selected as a nonlinear load in order to verify the effectiveness of the current harmonic compensation. A step load change was applied to evaluate the transient response of the dc voltage loop. Finally, an unbalanced load was used to validate the performance of the neutral current compensation.



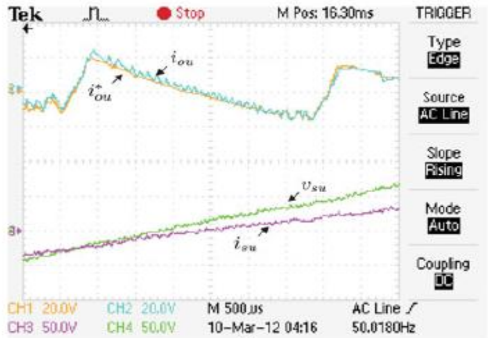
(a)



(b)



(c)



(d)

Fig. 9. Experimental transient response after APF connection. (a) Load Current *iLu* , active power filter current *iou* , dc-voltage converter *vdc* , and system current *isu* . Associated frequency spectrum. (c) Voltage and system waveforms, *vsu* and *isu* , *isv* , *isw* . (d) Current reference signals *i ou* , and active power filter current *iou* (tracking characteristic

## CONCLUSION

Improved dynamic current harmonics and a reactive power compensation scheme for power distribution systems with generation from renewable sources has been proposed to improve the current quality of the distribution system. Advantages of the proposed scheme are related to its simplicity, modeling, and implementation. The use of a predictive control algorithm for the converter current loop proved to be an effective solution for active power filter applications, improving current tracking capability, and transient response. Simulated and experimental results have proved that the proposed predictive control algorithm is a good alternative to classical linear control methods. The predictive current control algorithm is a stable and robust solution. Simulated and experimental results have shown the compensation effectiveness of the proposed active power filter.

## REFERENCES

[1] J. Rocabert, A. Luna, F. Blaabjerg, and P. Rodriguez, "Control of power converters in AC microgrids," *IEEE Trans. Power Electron.*, vol. 27, no. 11, pp. 4734–4749, Nov. 2012.

[2] M. Aredes, J. Hafner, and K. Heumann, "Three-phase four-wire shunt active filter control strategies," *IEEE Trans. Power Electron.*, vol. 12, no. 2, pp. 311–318, Mar. 1997.

[3] S. Naidu and D. Fernandes, "Dynamic voltage restorer based on a fourleg voltage source converter," *Gener. Transm. Distrib., IET*, vol. 3, no. 5, pp. 437–447, May 2009.

[4] N. Prabhakar and M. Mishra, "Dynamic hysteresis current control to minimize switching for three-phase four-leg VSI topology to compensate nonlinear load," *IEEE Trans. Power Electron.*, vol. 25, no. 8, pp. 1935–1942, Aug. 2010.

[5] V. Khadkikar, A. Chandra, and B. Singh, "Digital signal processor implementation and performance evaluation of split capacitor, four-leg and three h-bridge-based three-phase four-wire shunt active filters," *Power Electron., IET*, vol. 4, no. 4, pp. 463–470, Apr. 2011.

[6] F. Wang, J. Duarte, and M. Hendrix, "Grid-interfacing converter systems with enhanced voltage quality for microgrid application;concept and implementation," *IEEE Trans. Power Electron.*, vol. 26, no. 12, pp. 3501–
3513, Dec. 2011.

[7] X.Wei, "Study on digital pi control of current loop in active power filter," in *Proc. 2010 Int. Conf. Electr. Control Eng.*, Jun. 2010, pp. 4287–4290.

[8] R. de Araujo Ribeiro, C. de Azevedo, and R. de Sousa, "A robust adaptive control strategy of active power filters for power-factor correction, harmonic compensation, and balancing of nonlinear loads," *IEEE Trans. Power Electron.*, vol. 27, no. 2, pp. 718–730, Feb. 2012.

[9] J. Rodriguez, J. Pontt, C. Silva, P. Correa, P. Lezana, P. Cortes, and U. Ammann, "Predictive current control of a voltage source inverter," *IEEE Trans. Ind. Electron.*, vol. 54, no. 1, Feb. 2007.

[10] P. Cortes, G. Ortiz, J. Yuz, J. Rodriguez, S. Vazquez, and L. Franquelo, "Model predictive control of an inverter with output *LC* filter for UPS applications," *IEEE Trans. Ind. Electron.*, vol. 56, no. 6, pp. 1875–1883, Jun. 2009.

## Author's Biographies

**Mr.Bathula Balakrishna,** PG Scholar and Completed B.E degree in Electrical & Electronics Engineering in 2011 from ANDHRA UNIVERSITY,vishakapatnam. He is presently pursuing M.Tech in "Power Electronics" in Anubose Institute of Technology,paloncha ,India.

**Mr.Chettumala Ch Mohan Rao** was born in 1980. He graduated from kakatiya University, warangal in the year 2002. He received M.Tech degree from Jawaharlal Nehre Technological University, Hyderabad in the year 2012. He is presently working as Associate. Professor in the Department of Electrical and Electronics Engineering at **Anubose Institute Of Technology, Paloncha, India.** His research area includes DTC and Drives.