Improvement of Power Quality in Grid Connected Wind Energy System

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ABSTRACT:

In this paper discussed, Power Quality Improvement for a Grid Connected Wind Turbine Energy System Employing Fuzzy Controllers. The Grid connected wind energy systems are required to comply with strict technical and regulatory frameworks to ensure safe, reliable and efficient operation of overall network. The extensive use of power electronics based equipment and non-linear loads at PCC generate harmonic currents, which may deteriorate the quality of power. The methods of harmonic current compensation play a crucial part in the performance of active power filter. Traditionally, active power filters have been controlled using pre tuned controllers, such as PI-type or adaptive, for the control of current as well as the dc-voltage loops. PI controllers must be designed based on the equivalent linear model. Predictive controllers use the nonlinear model, which is closer to real operating conditions in order to improve the performance and life of the power switches of voltage source inverter (VSI), reduces its switching frequency.

An active power filter implemented with cascaded multilevel inverter using a fuzzy control scheme is presented in this paper. Fuzzy current control algorithm is based on the system model. 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 using MATLAB/SIMULINK. The main aim of the paper is to achieve the maximum benefits with the interfacing inverters when wind turbine energy system is connected to the grid. The proposed methodology improves the quality of power at PCC.

Key Words: Wind Energy Systems, Fuzzy, Power Quality at PCC.

I. Introduction:

Now a day's wide research is going on renewable energy power generation to converge fossil fuels for future generations and to meat present growing power demand due to world industrialization. Among those renewable sources PV and Wind Power generation have considerable role, i.e, wind is one of the best way of power generation among renewable power generations due to its flexibility, less maintenance, cleanness and noise free. The power generation of renewable energy is less compared to non renewable power plants, so the renewable energy inter connected system is known as micro grid. Basically micro grids are operating in two modes, one is grid tied mode of operation and other is Islanded mode of operation. The grid connected mode can facilitates high efficiency, high load demand and wide area of operation due to availability of infinite bus. But in islanded mode BESS system is used for power balance due to its power limitations. The grid integration of wind energy system can perform in two ways one is direct fed another is through transformers. Normally wind is integrated with grid through transformer, here transformer for step up or step down grid and wind ratings. The transformers used are two types one is low frequency and other high frequency or isolated transformers. High frequency transformers can provide isolation between wind and grid. It is heavy wait, large in size and high cost, other considerable one is formation of parasitic capacitance at galvanic isolation, due to this loss are increasing. Recently direct fed or transformer less inverter integration topologies are implemented [1-4].

Grid synchronization algorithms are of great importance in the control of grid-connected power converters, as fast and accurate detection of the grid voltage parameters is crucial in order to implement stable control strategies under generic grid conditions. This paper presents a new grid synchronization method for three-phase three-wire networks, namely three-phase enhanced PLL The enhanced phase-locked loop (EPLL) is a synchronization system that has proven to provide good results in single phase synchronization systems. An EPLL is essentially an adaptive band pass filter, which is able to adjust the cutoff frequency as a function of the input signal. Its structure was later adapted for the three-phase case, in order to detect the positive-sequence vector of three-phase signals, This paper analyses the performance of the proposed synchronization method including different design issues. Moreover, the behavior of the method for synchronizing with highly unbalanced grid is proven by means of simulation demonstrating its excellent performance.

II. PROBLEMS IDENTIFICATION:

When Grid synchronizes with Wind energy different issues are compared with traditional centralized power sources. For example, they are applied to the mains or the loads with voltage of 480 volts or less; and require power converters and different strategies of control and dispatch. All of these energy technologies provide a DC output which requires power electronic interfaces with the distribution power networks and its loads. In most cases the conversion is performed by using a voltage source inverter (VSI) with a possibility of pulse width modulation (PWM) that provides fast regulation for voltage magnitude. Power electronic interfaces introduce new control issues, but at the same time, new possibilities. For example, a system which consists of micro-generators and storage devices could be designed to operate in both an autonomous mode and connected to the power grid. One large class of problems is related to the fact that the power sources such as micro turbines and fuel cell have slow response and their inertia is much less. It must be remembered that the current power systems have storage in generators' inertia, and this may result in a slight reduction in system frequency. As these generators become more compact, the need to link them to lower network voltage is significantly increasing. However, without any medium voltage networks adaptation, this fast expansion can affect the quality of supply as well as the public and equipment safety because distribution networks have not been designed to connect a significant amount of generation. Therefore, a new voltage control system to facilitate the connection of distributed generation resources to distribution networks should be developed. In many cases there are also major technical barriers to operating independently in a standalone AC system, or to connecting small generation systems to the electrical distribution network with lower voltage, and the recent research issues includes: 1. Control strategy to facilitate the connection of distributed generation resources to distribution networks. 2. Efficient battery control. 3. Inverter control based on only local information. 4. Synchronization with the utility mains. 5. Compensation of the reactive power and higher harmonic components. 6. Power Factor Correction. 7. System protection. 8. Load sharing. 9. Reliability of communication. 10. Requirements of the customer. DES offers significant research and engineering challenges in solving these problems. The schematic diagram of grid connected Wind turbine energy system is shown below fig.1.

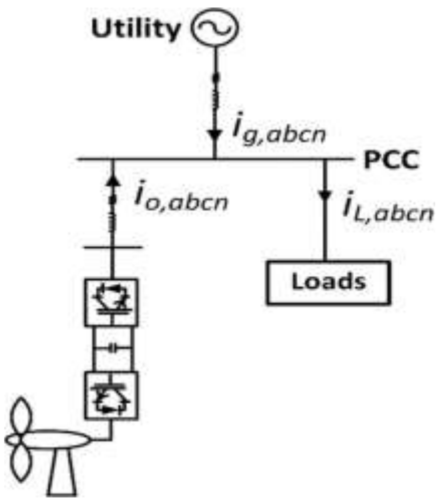


Fig.1. Single Line diagram of Grid connected Wind Turbine energy System

III. Fuzzy Control Strategy:

Several control approaches have been introduced in the literature for wind turbine in standalone and grid connected systems [5], [6]. The machine side controllers are designed to extract maximum power point from wind using hill-climbing control, fuzzy-based, and adaptive controllers [7], most of the time based on field-oriented or vector control approach. The grid side controllers are designed to ensure active and reactive power is delivered to the grid [8], [9]. Controller design for machine side converter and grid side converter is shown in fig.2. and fig.3 respectively.

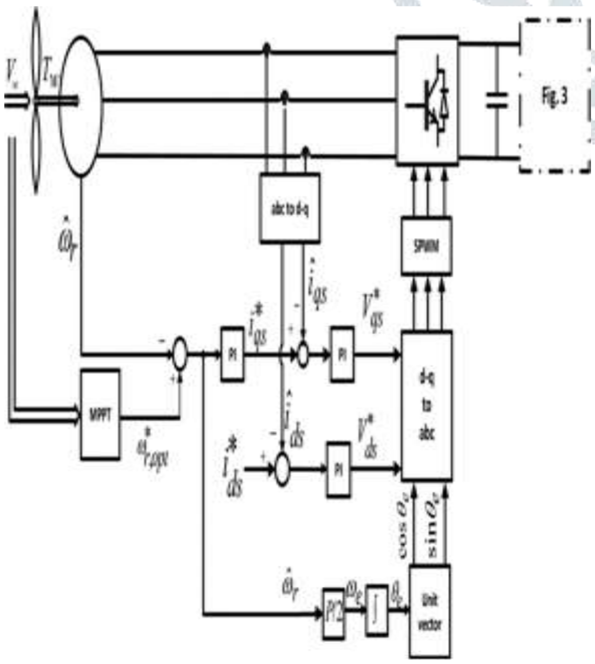


Fig.2. Control scheme of machine side converter.

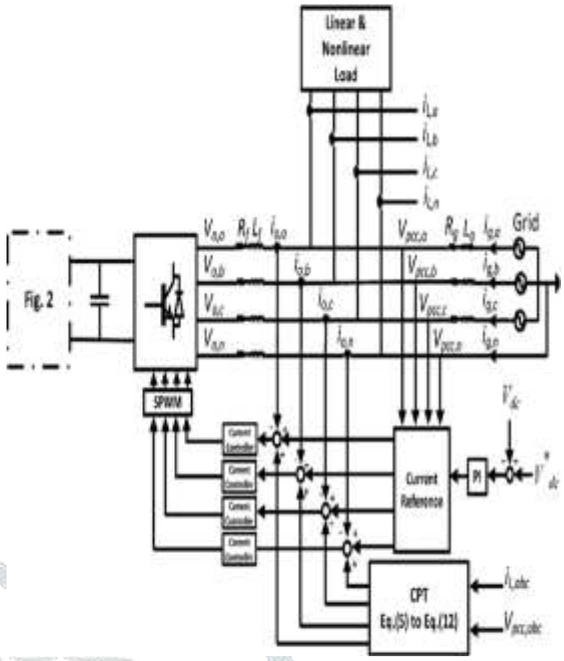


Fig.3. Control scheme of a grid-side converter.

In these machine side converter and grid side converters optimized PI controller values are calculated by using fuzzy controllers.

The Fuzzy control is a methodology to represent and implement a (smart) human's knowledge about how to control a system. A fuzzy controller is shown in Figure.8. The fuzzy controller has several components:

- A rule base that determines on how to perform control
- Fuzzification that transforms the numeric inputs so that the inference mechanisms can understand.
- The inference mechanism uses information about the current inputs and decides the rules that are suitable in the current situation and can form conclusion about system input.
- Defuzzification is opposite of Fuzzification which converts the conclusions reached by inference mechanism into numeric input for the plant.

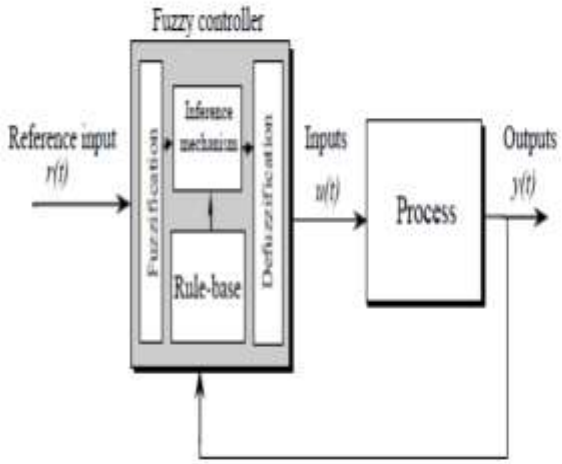


Fig.4. Fuzzy Control System

Fuzzy logic is a form of logic that is the extension of boolean logic, which incorporates partial values of truth. Instead of sentences being "completely true" or "completely false," they are assigned a value that represents their degree of truth. In fuzzy systems, values are indicated by a number (called a truth value) in the range from 0 to 1, where 0.0 represents absolute false and 1.0 represents absolute truth. Fuzzification is the generalization of any theory from discrete to continuous. Fuzzy logic is important to artificial intelligence because they allow computers to answer ‘to a certain degree’ as opposed to in one extreme or the other. In this sense, computers are allowed to think more 'human-like' since almost nothing in our perception is extreme, but is true only to a certain degree.

Table 1: IF-THEN rules for fuzzy inference system

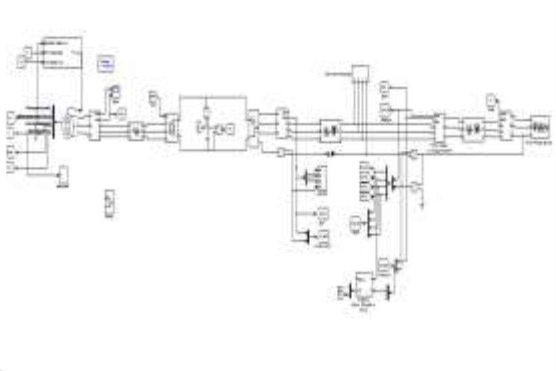
u(t)		e(t)						
		NB	NM	NS	ZO	PS	PM	PB
Δe(t)	NB	NB	NB	NB	NB	NM	NS	ZO
	NM	NB	NB	NB	NM	NS	ZO	PS
	NS	NB	NB	NM	NS	NS	PS	PS
	ZO	NB	NM	NS	ZO	ZO	PM	PM
	PS	NM	NS	ZO	PS	PS	PB	PB
	PM	NS	ZO	PS	PM	PM	PB	PB
	PB	ZO	PS	PM	PB	PB	PB	PB

The fuzzy rule base can be read as follows:

IF e(t) is NB and Δe(t) is NB **THEN** u(t) is NB
IF e(t) is <negative big> and Δe(t) is <negative big>**THEN** u(t) is <negative big>

IV. Simulation Results:

The MATLAB Simlink diagram of grid connected Wind turbine energy system is shown in below figure .5



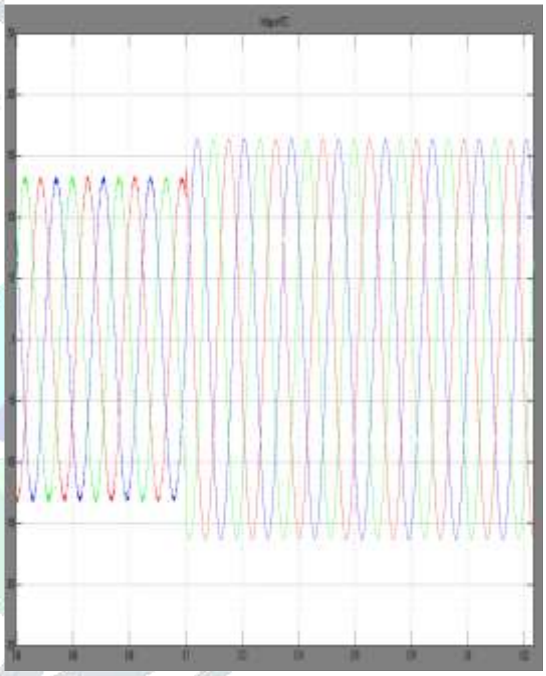


Fig.6. Voltage measurement at PCC

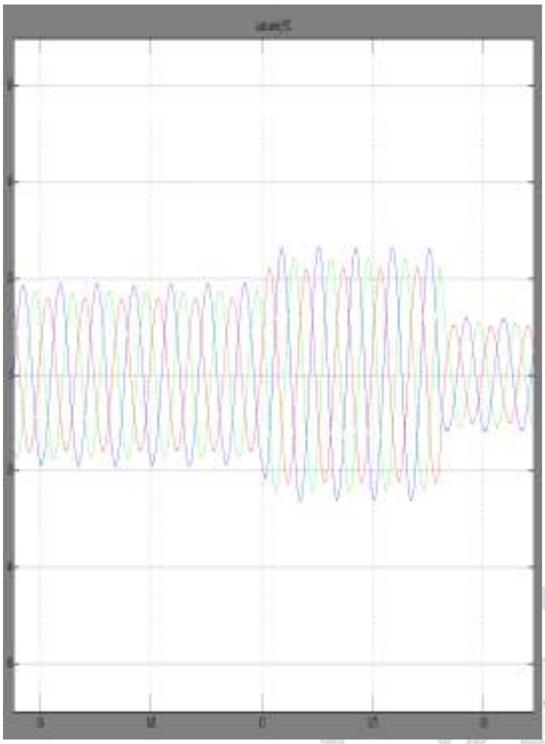


Fig. 7. Load current

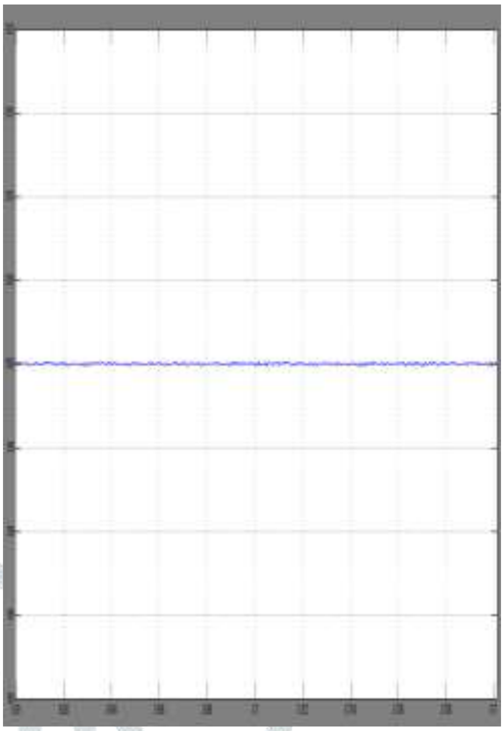


Fig.10. DC voltage

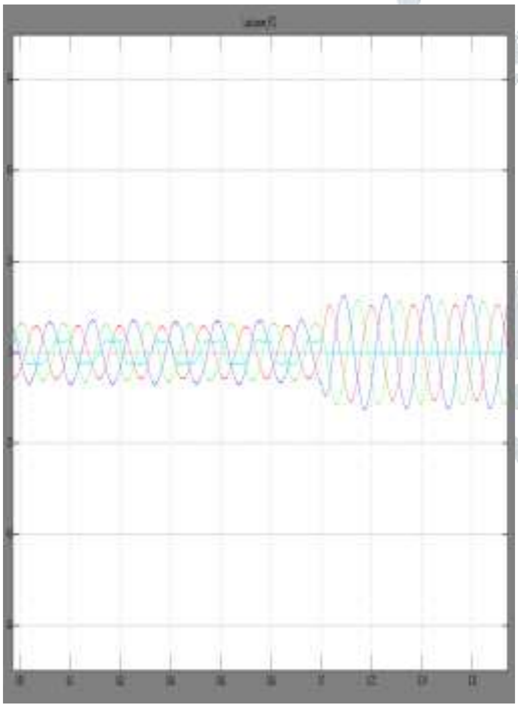


Fig.8. PCC current

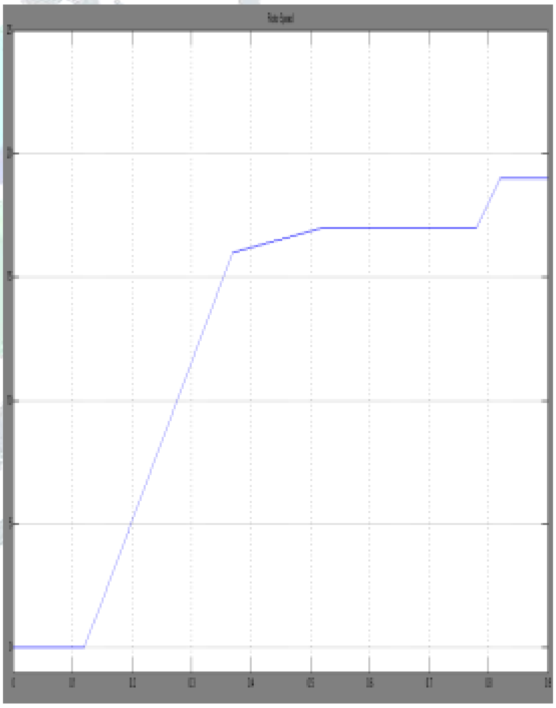


Fig.11. Rotor speed

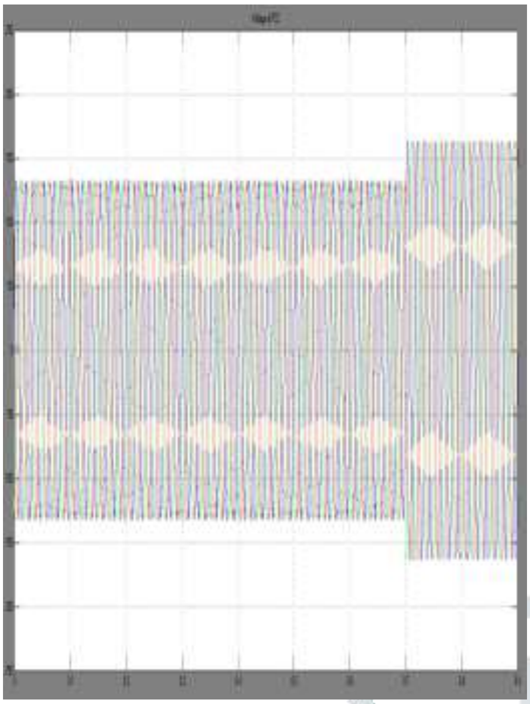


Fig.12. Voltage measurement at PCC

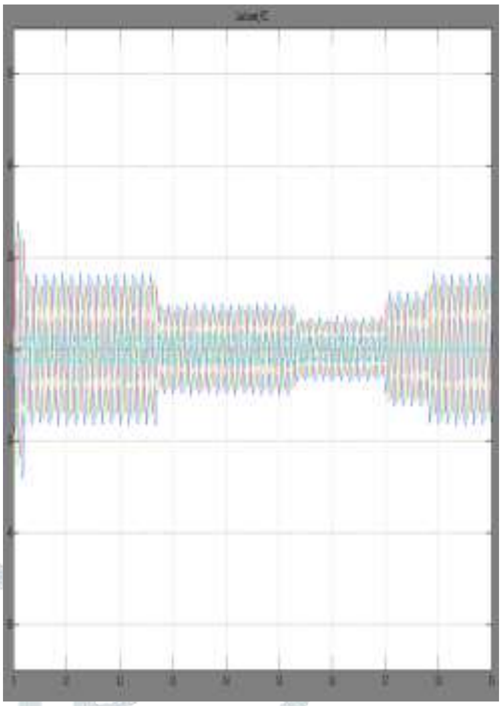


Fig.14. PCC Current

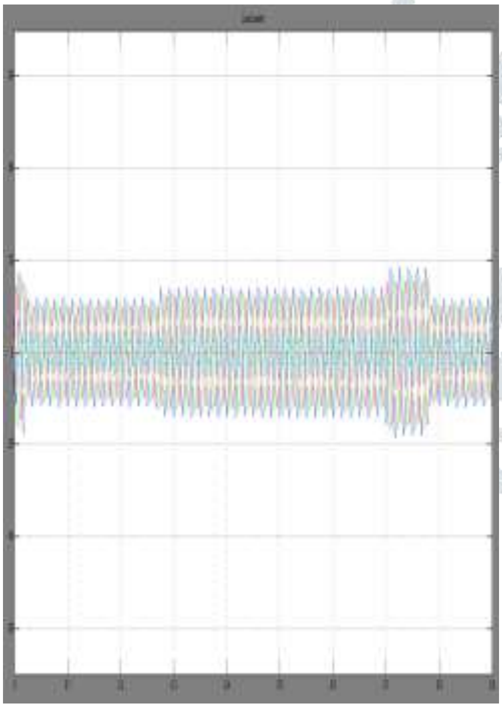


Fig.13. Load current

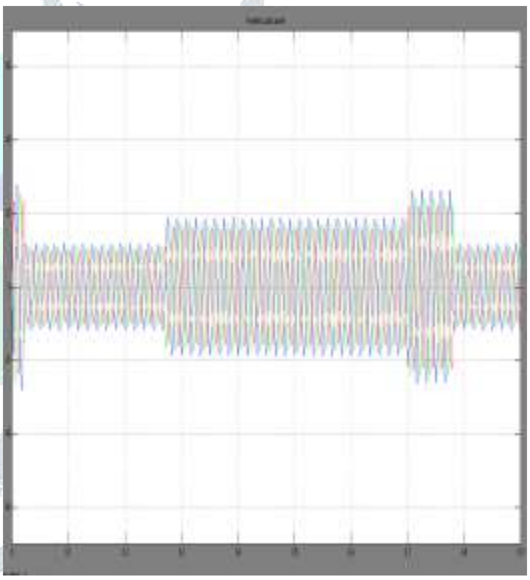


Fig.13. Inverter Current

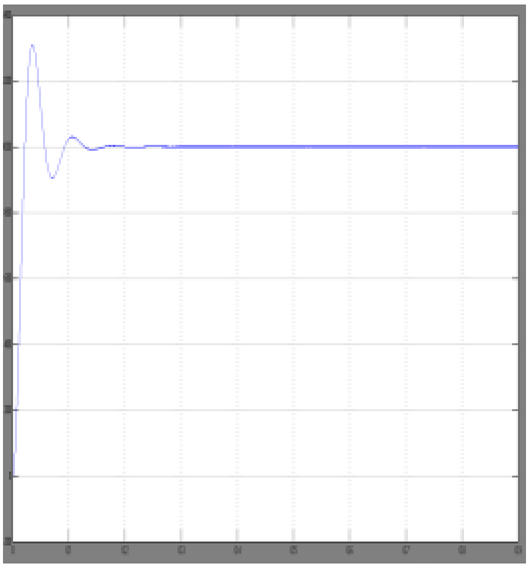


Fig.14. DC voltage

V. Conclusion:

The proposed Fuzzy control scheme based grid connected wind energy system has more advantages like simplicity, implementation and modeling. The use of a fuzzy control algorithm for the converter current loop proved to be an effective solution for improving current quality of the distribution system (Grid side and Machine side). The system tracking capability and transient response is improved. Proposed fuzzy current controller scheme is a stable and robust solution. The proposed algorithm mitigates the system harmonic currents and reactive power compensation simulated results have been shows the compensation effectiveness of the proposed active power filter.

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