

# Analysis of Power Quality Improvement in Grid Connected Wind Driven Induction Generator at Various Load Conditions

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**ABSTRACT:** As a promising renewable alternative, the wind power is one of the significant sources of generation. Reactive power compensation and harmonic reduction in a low voltage distribution networks for integration of wind power to the grid are the main issues addressed in this paper. This paper proposes a control scheme based on instantaneous Pq theory for compensating the reactive power requirement of a three phase grid connected wind driven induction generator as well as the harmonics produced by the non linear load connected to the PCC using STATCOM. The proposed control scheme is simulated using MATLAB/SIMULINK. The Simulation results are presented in this paper.

**KEYWORDS:** wind power, distribution network, induction generator, STATCOM, reactive power.

## I. INTRODUCTION

The integration of wind power to grid introduces power quality issues, which mainly consist of voltage regulation and reactive power compensation. Induction machines are mostly used as generators in wind power based generations. Induction generators draw reactive power from the grid to which they are connected. Therefore, the integration of wind power to power system networks is one of the main concerns of the power system engineers. The addition of wind power into the electric grid affects the power quality [1]. During the last few years, power electronic technology plays an important role in distributed generation and integration of in d energy generation into the electric grid [2]. A non-linear load on a power system is typically a rectifier (such as used in a power supply), some kind of arc discharge device such as fluorescent lamp, electric welding machine, or arc furnace because current in these systems is interrupted by a switching action, the current contains frequency components that are multiples of the power system frequency. It changes the shape of the current wave form from a sine wave to some other form and also create harmonic currents in addition to the original (fundamental frequency) AC current. The most used unit to reduce the harmonics produced by the non linear load. Compensate for reactive power in the power systems are either synchronous condensers or shunt capacitors, the latter either with mechanical switches or with thyristor switch, as in Static VAR Compensator (SVC). The disadvantage of using shunt Capacitor is that the reactive power supplied is proportional to the square of the voltage. Consequently, the reactive power supplied from the capacitors decreases rapidly when the voltage decreases [3]. To overcome the above disadvantages; STATCOM is best suited for reactive power compensation and harmonic reduction. It is based on a controllable voltage source converter (VSC). By control of the voltage source converter output voltage in relation to the grid voltage, the voltage source converter will appear as a generator or absorber of reactive power [6]. Fig I show the block diagram of grid connected system. In this 3-phase separately excited induction generator feeding non linear load has been presented. A STATCOM is connected at the point of common coupling with this system in order to compensate the reactive power requirements of induction generator as well as load and also to reduce the harmonics produced by the non linear load.

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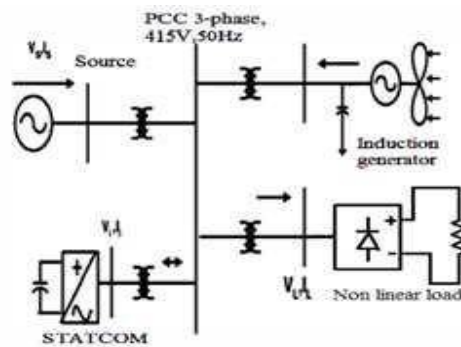


Fig.1 Schematic diagram of grid connected wind energy system.

The proposed STATCOM control scheme for grid connected wind energy generation for power quality improvement has following objective.

This paper is organized as follows. Section II discusses reactive power requirements of induction generator. Section III, IV and V discuss wind driven induction generator with STATCOM, reference current generation and hysteresis current controller for STATCOM respectively.

## II. REACTIVE POWER REQUIREMENTS OF INDUCTION GENERATOR

The induction generators are widely used, due to the advantage of cost effectiveness, robustness, ruggedness, simplicity and requirement of no brush and commutators.

However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected.

A Three phase induction generator feeding a non linear load as well as connected to the grid is simulated using MATLAB/Simulink to study the reactive power requirement of IG and also harmonics produced by the non linear load. Simulation diagram of this system is shown in Fig2.

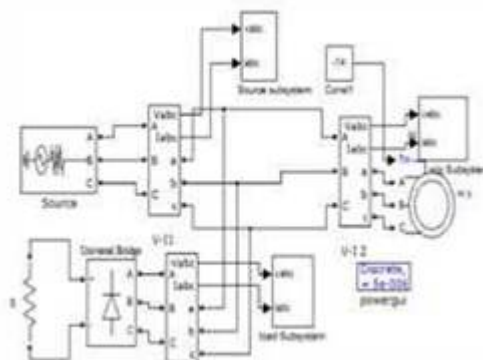


Figure 1

## III. WIND DRIVEN INDUCTION GENERATOR WITH STATCOM

During the operation induction generator draws reactive power from the grid for its magnetization. Non linear load distorts the grid current waveform and also increase the harmonic component. Due to this, grid current is not in phase with the grid voltage and its wave shape is also different from sine wave which is shown in fig 3.

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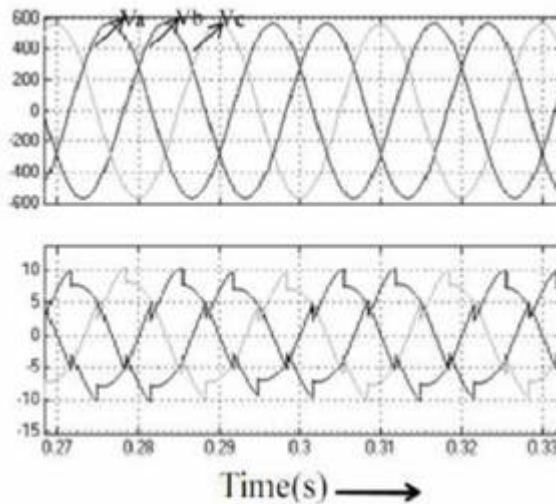


Figure 2

Hence the power factor is not unity. Reactive power requirement of induction generator and load is supplied by the grid. Grid reactive power is the sum of both induction generator and load reactive power is shown in Table I. Grid reactive power, load current and induction generator current is shown in fig 4, 5 and 6 respectively.

## IV. REFERENCE CURRENT GENERATION FOR STATCOM

Reference current for the STATCOM is generated based on instantaneous reactive power theory [7]-[10]. A STATCOM injects the compensation current which is a sum of reactive component current of IG, non-linear load and harmonic component current of non-linear load.

Pq theory gives a generalized definition of instantaneous reactive power, which is valid for sinusoidal or non sinusoidal, balanced or unbalanced, three-phase power systems with or without zero sequence currents and/or voltages.

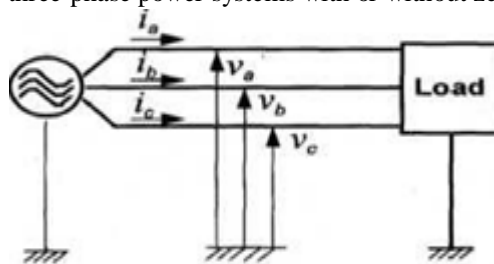


Figure 3

Fig.9 shows the three phase power system, instantaneous Voltages,  $v_a, V_b, v_c$  in volts and instantaneous currents,  $i_a, i_b, i_c$  in amps of a three phase system are expressed as instantaneous space vectors 'v' and 'i' given by(1)

$$v = \begin{pmatrix} V_a \\ V_b \\ V_c \end{pmatrix} \quad i = \begin{pmatrix} i_a \\ i_b \\ i_c \end{pmatrix} \quad (1)$$

'p' is the instantaneous active power of a three-phase circuit in Watts, given by (2)

$$P= v.I \text{ ---- (2).}$$

**V. HYSTERESIS CONTROLLER FOR STATCOM**

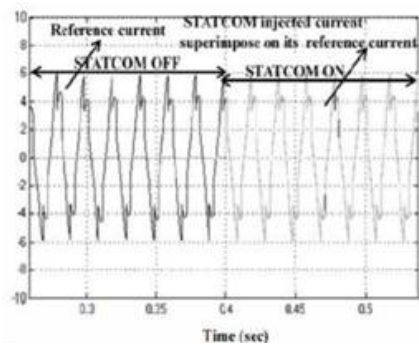
The current control scheme for STATCOM is using a "hysteresis current controller." Using this technique, the controller keeps the STATCOM current between boundaries of hysteresis area and gives correct switching signals for STATCOM operation [11]-[12].

It is a feedback current control method where the actual current tracks the reference current within a hysteresis band. The current controller generates the firing pulses to the VSI by comparing the reference and actual current.

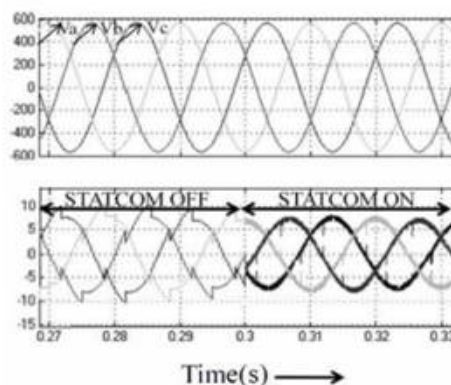
The hysteresis current control scheme for generating the switching signals to the STATCOM is shown in Fig.10. If the current exceeds the upper limit of the hysteresis band, upper switch of the inverter arm is turned off and the lower switch is turned on. As a result, the current start to decay. If the current crosses the lower limit of the hysteresis band, the lower switch of the inverter arm is turned off and the upper switch is turned on.

**VI. SIMULATION RESULTS**

The performance of the system is analyzed with and without ON the STATCOM at time t=0.3s. The simulation parameters considered are given in Table 1. Initially the STACOM current is zero after 0.3seconds the STATCOM starts tracking the reference current within the hysteresis band which is shown in Fig.



Figure

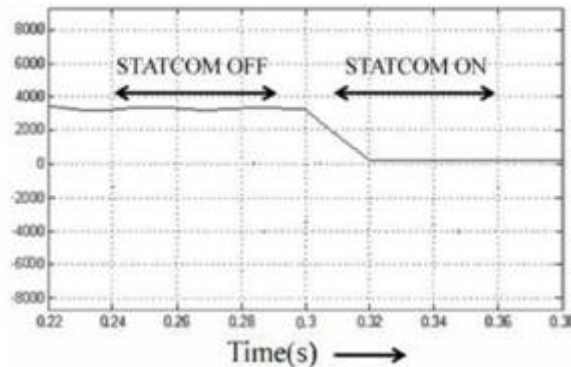


Figure

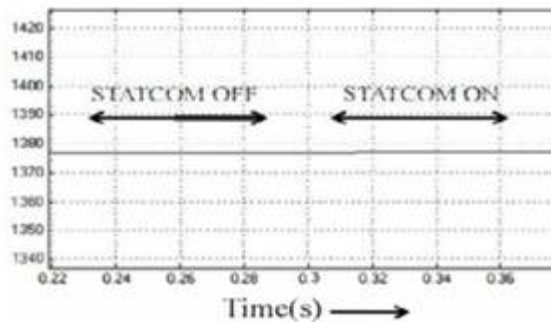
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Figure



## VII. CONCLUSIONS

This paper presents the STATCOM-based control Scheme for reactive power compensation and harmonic reduction in grid connected wind generating system feeding non linear load. The control system for the STATCOM is simulated using MATLAB/SIMULINK. The Simulation results shows the grid voltage and current are in-phase, making the power factor unity, which implies that the reactive power demand of Induction generator and load is no longer, fed by the grid rather it is supplied by the STATCOM. Also the shape of the grid current is almost sinusoidal and the %THD has been improved from 11.08 % to 5.78 % after compensation. The proposed control scheme has improved the power quality requirement of a low voltage grid connected wind driven IG system feeding a non-linear load.

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