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WIND TURBINE SYSTEM WITH POWER QUALITY IMPROVEMENT OF THREE PHASE SYSTEM USING SERIES ACTIVE AND SHUNT PASSIVE FILTERS USING MATLAB SIMULINK

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Abstract: Parallel active power filter is introduced as the main filter for harmonic currents. The use of Series Active Power Filter for filtering the harmonics of the voltage is also discussed. The passive filters are used also for elimination of harmonic currents and voltages. The use of hybrid filters composed of parallel active power filter with passive filters, or series active power filter with passive filters is applied and studied. Different studied filters and topologies are implemented in MATLAB\Similink. Simulation results are tabulated and discussed. A comparison between the results obtained in this work and other works in literature is carried out and discussed.

Keywords: Series Active Filter, Shunt Passive Filters, Reactive Power, Power Quality Improvement.

I.INTRODUCTION

The increasing use of nonlinear loads which use switching elements has caused many power quality problems. The harmonic emission is increasing noticeably with the development of power electronics devices. The spread of harmonics into power grid causes many problems for the users of these power grids. It affects the normal function of the devices connected to the grid. Harmonic currents can cause the creation of harmonic voltages whose spread can be dangerous for the different users of the electrical power. Control systems, protection circuits, communication systems, and biomedical devices are the most affected devices by harmonic pollution. Different standards and regulations have been adopted by the international electrical committees like IEC and IEEE limiting the harmonic emission of the loads.

Problems of system voltage unbalances and sudden changes in the grid voltages are an important issue in electrical engineering. Many devices are designed to work under limited ranges of voltage and frequency. The sudden changes in the voltage can either affect the function of the devices or even stop their function permanently. For that reason, the use of different types of voltage regulators and protection devices is an important precaution. These regulators can protect the connected devices from voltage variations by keeping the load side of the grid at a fixed voltage level. The main cause of voltage variations in power systems is the turning on and off of the electrical motors. These motors are absorbing high currents in the starting phase of function for a duration of many seconds. The simultaneous starting of many motors in the same time can cause huge variations in the grid voltage.In order to face the harmonic problems, different solutions have been proposed. These solutions differ from applying modifications on the grid or the load, so it emits fewer harmonic to connecting special designed devices to suppress the harmonics and filter them.

The simplest method of harmonic filtering was to use RLC elements under the form of filter banks adjusted to offer a short circuit or low impedance for the frequencies of harmonics to be cancelled. These filters will present high impedance for the main frequency and called passive filters. Passive filters were the first proposed solutions due to their simplicity and ease of installation. They can be considered as good approach in the case of stable static systems where

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many variations are not expected. In the case of dynamic non predictable systems, the passive filters can be less suitable for the reason of their static behavior and that they can't react to the changes in the load. Also they can cause resonance with some frequencies which can cause some stability troubles.

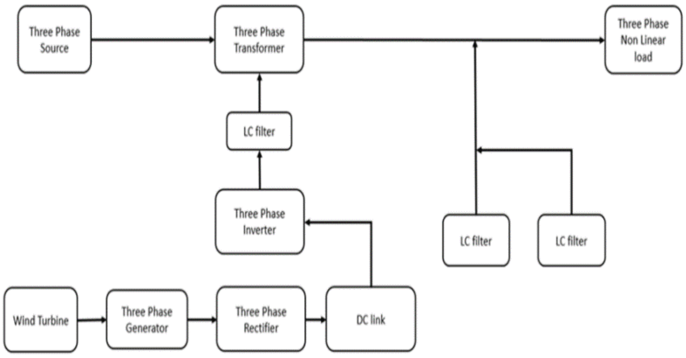

Figure 1: Block diagram of Series Active and Shunt Passive filters three phase system

Active filters were the introduced in the 80th of the last century into the electrical power systems. They are dynamic systems designed carefully to compensate harmonic currents and voltages dynamically. They can react instantly for the load and system changes without the need for any interrupt. Researchers are paying more and more attention for active filters since the day they were introduced. The main advantage of the active filters is their flexibility for the system parameters. They can change effectively their behavior based on the system parameters.

II.OBJECTIVES

Following are the main objectives of this research:
1) To design three phase system with nonlinear load pure line
2) To design the regenerative system of wind turbine generator for dc source
3) To design MPPT for boost converter, MPPT to generate PWM signals
4) To design three phase sinusoidal inverter with source of dc link
5) To design Series Active and Shunt Passive filters for reducing the harmonic of three phase line to improve the power quality

III.PROPOSED SYSTEM CONFIGURATION

The proposed system consists of wind energy generation system with HSAPF for harmonics mitigation due to presence of 3- phase uncontrolled rectifier nonlinear load. Series passive filter mitigates voltage harmonic present in wind AC output. SAPF improve the current quality by injecting equal and opposite current. Control unit of SAPF based on instantaneous unit template generation using PLL for reference current generation and hysteresis band controller for pulse generation fed VSI with DC link capacitor.

A. Series Active Filter and Shunt Passive Filter

The project provides a new control strategy based on the dual formulation of the electric power vectorial theory is proposed. For this, a balanced and resistive load is considered as reference load. The strategy obtains the voltage that the active filter has to generate to attain the objective of achieving ideal behavior for the set hybrid filter-load. When the source voltages are sinusoidal and balanced the power factor is unity, in other words, the load reactive power is compensated and the source current harmonics are eliminated. By this means, it is possible to improve the passive filter compensation characteristics without depending on the system impedance, since the set load-filter would present resistive behavior. It also avoids the danger that the passive filter behaves as a harmonic drain of close loads and likewise the risk of possible series and/or parallel resonances with the rest of the system. In addition, the compensation is also possible with variable loads, not affecting the possible the passive filter detuning.
Although the APF series control based on the instantaneous reactive power theory is not new, in this paper the authors propose a new formulation that has consequences in the control loop design. In fact, the instantaneous reactive power here is defined from a dot product whereas in it is defined as a cross product; this results in a remarkable simplification

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in the implementation of the reference generation method. The final development allows any compensation strategy to be obtained, among them, unit power factor.

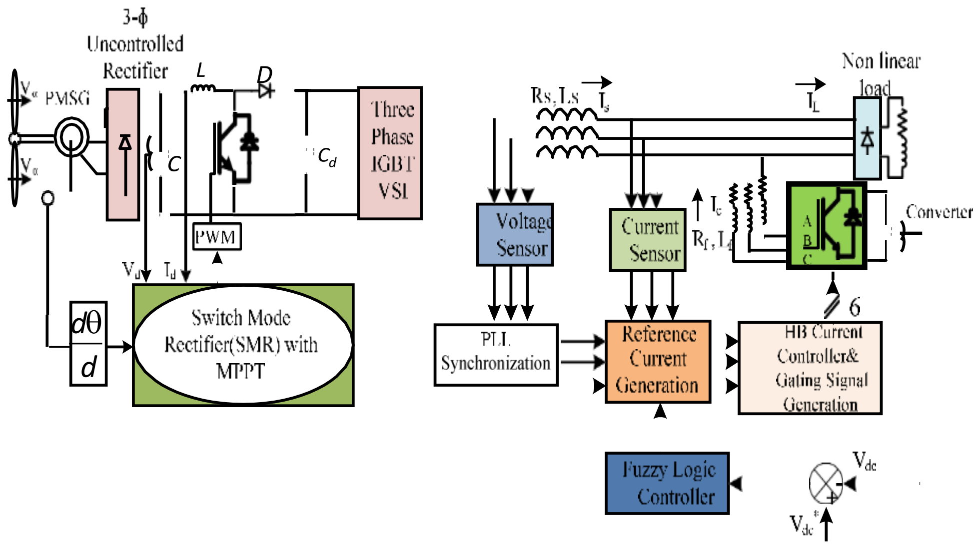

Figure 2: Block diagram proposed architecture

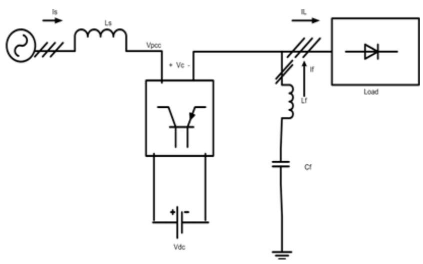

Figure 3: System with compensating equipment

B. Hysteresis Control

Hysteresis current control method is very famous for its fast response and stability. It is the most used until not long time before where the PWM control has become easy and feasible. The main structure of the hysteresis control is shown in figure 3.4. the reference current is enveloped by two limits. Whenever the current generated by the inverter goes out the limits of the envelope, the control changes its output so the the current change its direction or stop. Likewise, the current keep oscillating between the two limits of the envelop around the reference. The frequency of oscillation of current, and by consequence the switching speed of the switches is a function of the width of the band of the limits enveloping the reference. Also, the AC filter play an important rule in controlling the switching function in the case of the hysteresis control. The filter controls the slope of the current such that it can arrive more quickly or faster to the hysteresis limit; the thing which increase or decrease the switching frequency. We can reduce the switching frequency by increasing the band of hysteresis; that will limit the compensation ability and increase the current error but help in keeping the switching frequency within the limits of the IGBT's switching frequency. In our study, the work will concentrate on the PWM control as it is the most used method nowadays. Also its offering a fix switch frequency and good current tracking if using good regulators.

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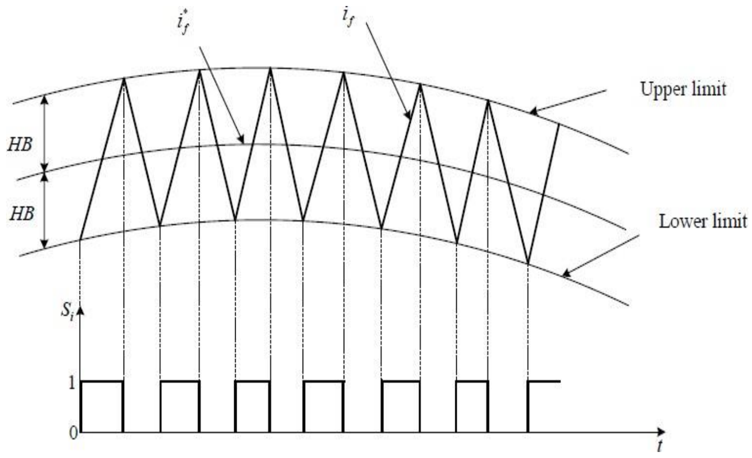

Figure 4: Hysteresis control principle

C. PQ Theory based reference generation

In this section, the control method of series active power filter is introduced and discussed. This method is also based on the so called instantaneous active and reactive power theory. The three phase voltages and currents are transformed into two phase system. The instantaneous active and reactive powers are calculated and passed through a filter to separate the harmonic components from the fundamentals. The equations used in this theory are:

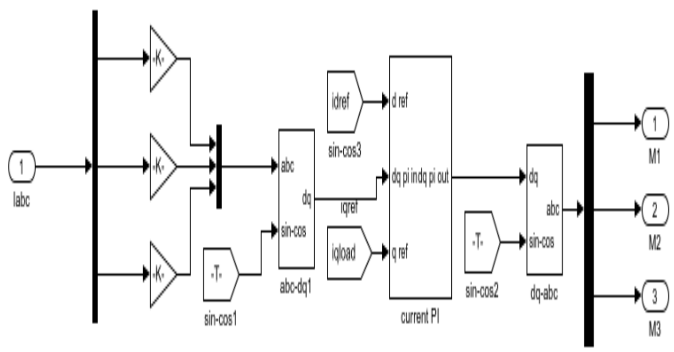

Figure 5: DQ based on PQ method algorithm for voltage reference generation

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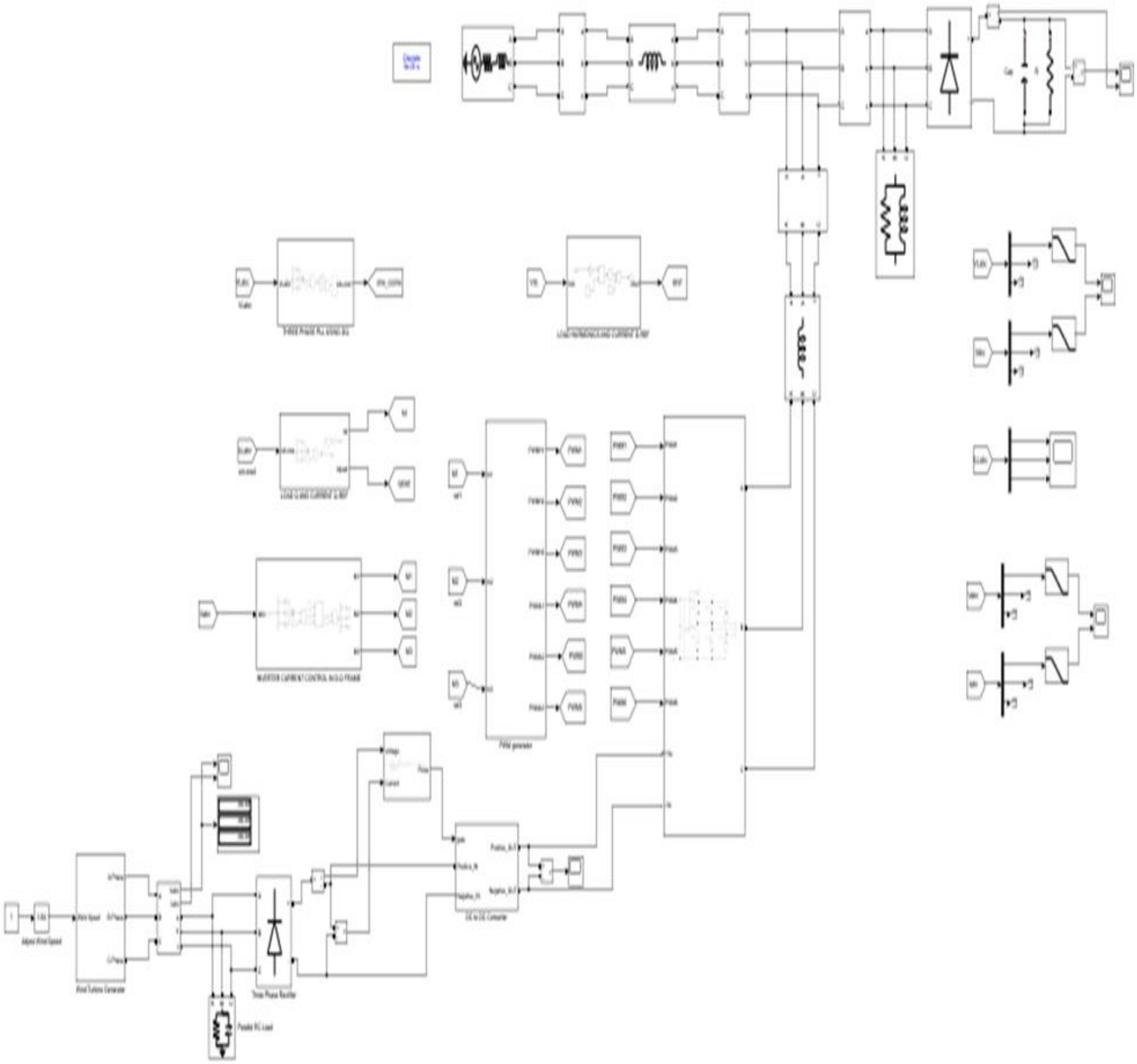

Figure 6: System Diagram

D. Wind Energy

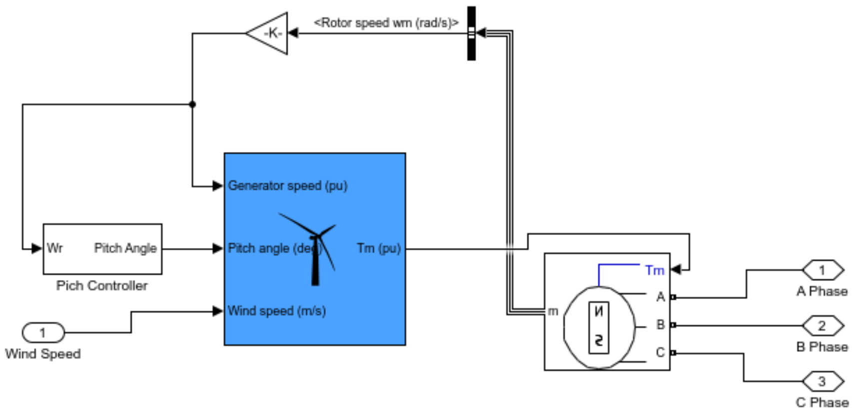

Figure 7: Wind system connected with three phase

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Wind turbine systems can be divided into two main groups based on the shaft orientation. These groups can be further subdivided by looking at rotor blade configuration or the number of blades and the way the turbine system is connected to the grid.

The two main groups of turbines consist of those with horizontal shaft configuration and those with vertical shaft configuration. As the names state, in the case of the horizontal shaft configuration the shaft is in a horizontal position with the blade(s) connected to the one end of the shaft, as shown in Figure 8 (a) The vertical shaft wind turbine has a much longer shaft in a vertical position with the blades connected to the shaft at more than one point, as shown in Figure 8(b).

The vertical shaft configuration turbines are further sub-categorised into groups by looking at the positioning and form of the blades. The most well-known vertical shaft wind turbine is Darrieus's phi-configuration, also known as the eggbeater configuration. Other well-known groups are the Musgrove, Diamond, Savonius, Giromill and Phi types.

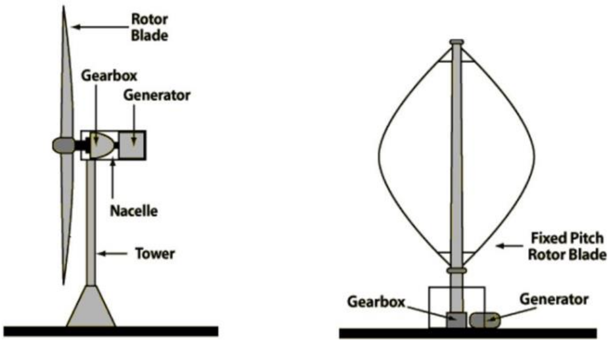

Figure 8: (a) Horizontal shaft configuration (left) (b) vertical shaft configuration (right).

The biggest advantage of the vertical shaft wind turbine is the fact that it is omnidirectional, thus energy could be generated by wind blowing from any side without any adjustments needing to be made to the wind turbine. Such a configuration eliminates the need for yaw gears. Another advantage is that the generator and gearbox can be housed at ground level, leading to a simple and cheaper design, and most of the maintenance of the wind turbine can be done at ground level.

E. Fuzzy Logic

The system variables and a rule table which depend on the variables are described for the control algorithm. The buck converter output voltage is controlled by changing the switching duty cycle. The system error is defined as a difference between the reference voltage and measured output voltage value. For the system; *r(k)* is the reference voltage and *y(k)* is the measured output voltage values then the error voltage is calculated using Equation (1).

$$e(k) = r(k) - y(k) \qquad (1)$$

The change in the error voltage is also calculated as;

$$de(k) = e(k) - e(k-1) \qquad (2)$$

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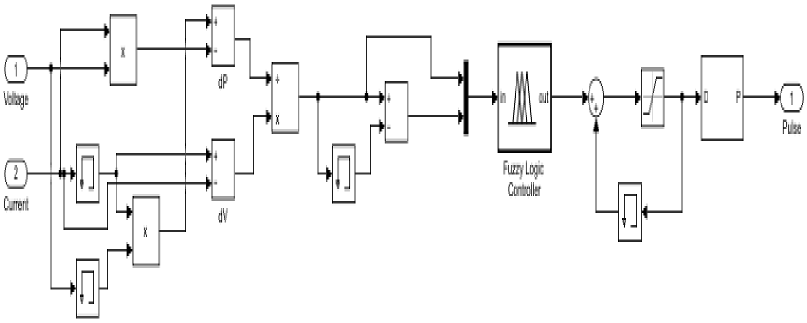

Figure 9: Fuzzy logic control with buck-boost converter system

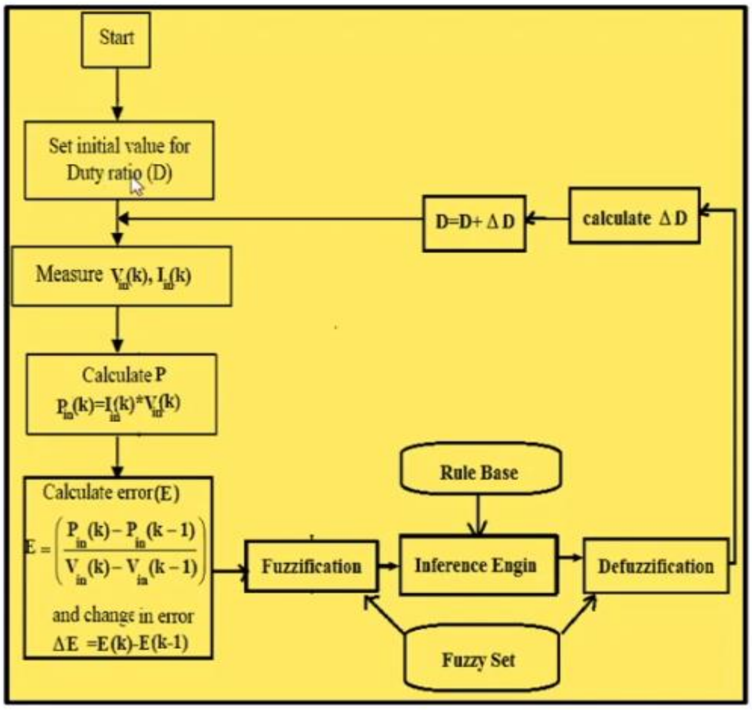

Figure 10: Fuzzy logic flow chart

F. Comparison with Facts Device

The series and shunt compensation are able to increase the maximum transfer capabilities of power network. Concerning to voltage stability, such compensation has the purpose of injecting reactive power to maintain the voltage magnitude in the nodes close to the nominal values, besides, to reduce line currents and therefore the total system losses. At the present time, thanks to the development in the power electronics devices, the voltage magnitude in some node of the system can be adjusted through sophisticated and versatile devices named FACTS. One of them is the static synchronous compensator STATCOM.

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IV.RESULTS AND DISCUSSION

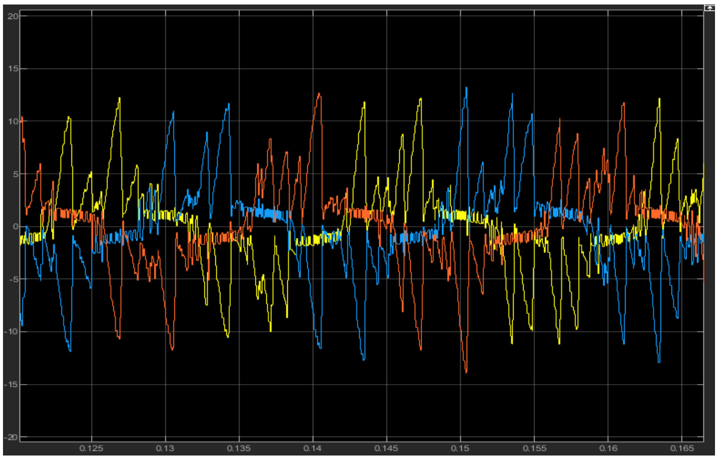

Figure 11: 3 Phase current of non linear load

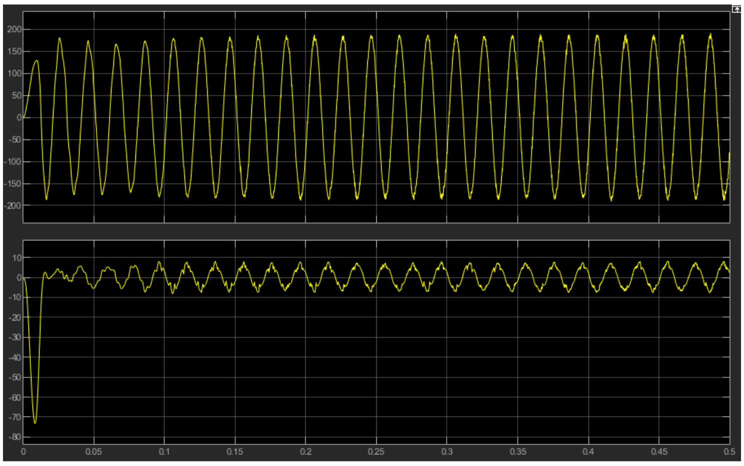

Figure 12: First order LPF of line voltage and inverter current

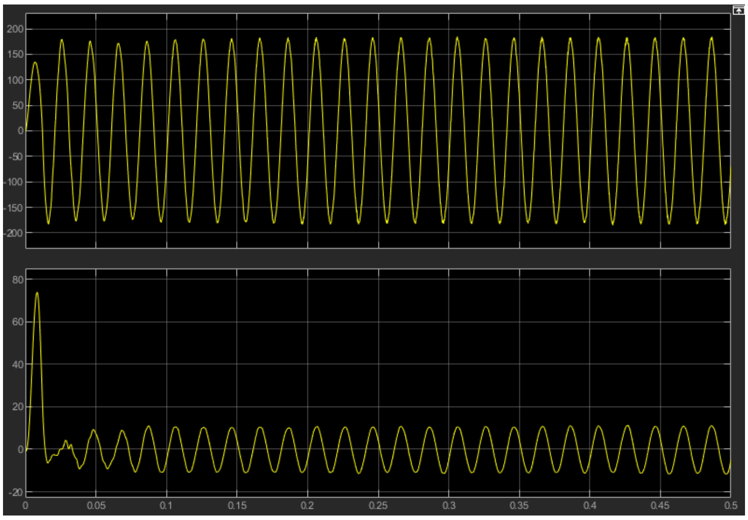

Figure 13: Single phase source voltage and current with LPF

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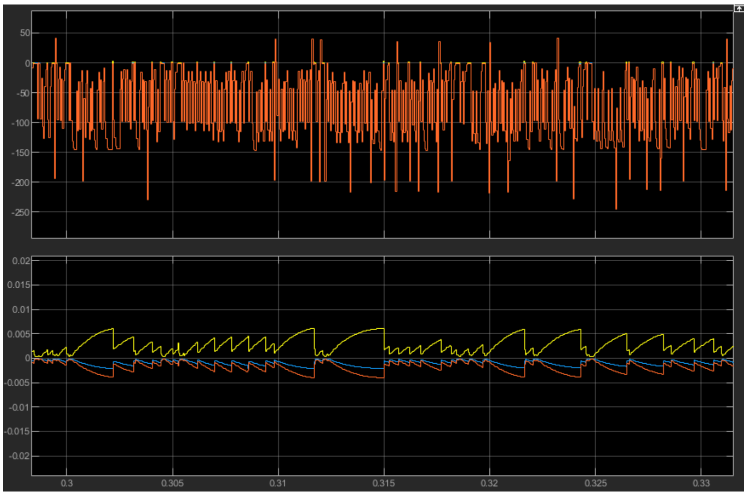

Figure 14: Phase output of wind turbine generator

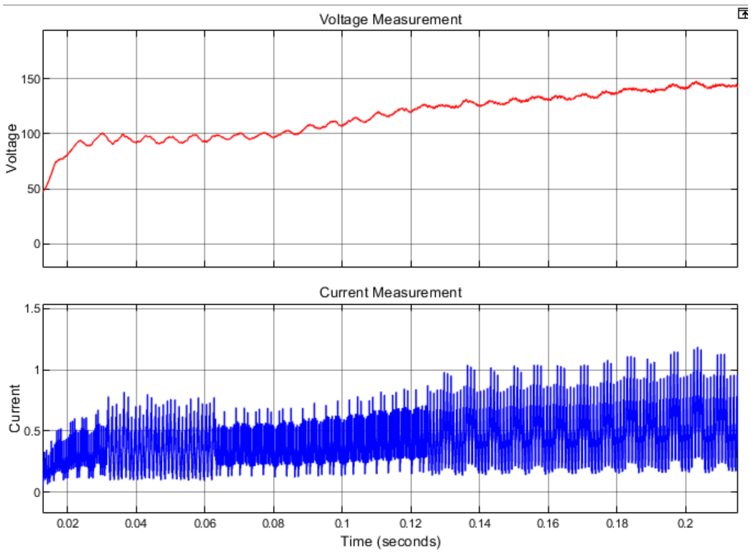

Figure 15: Input of dc to dc converter

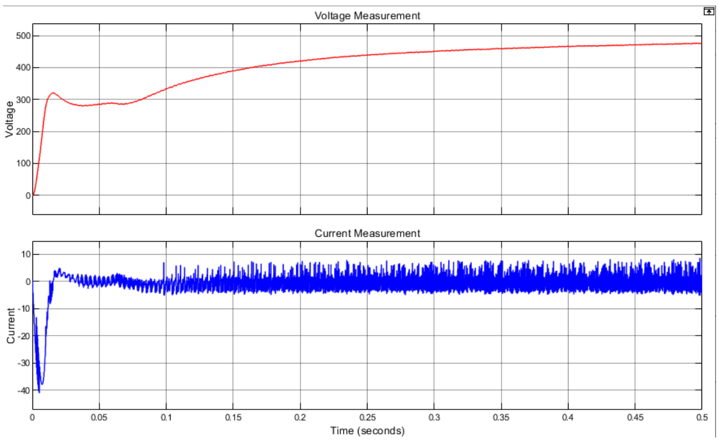

Figure 16: Output of dc to dc converter

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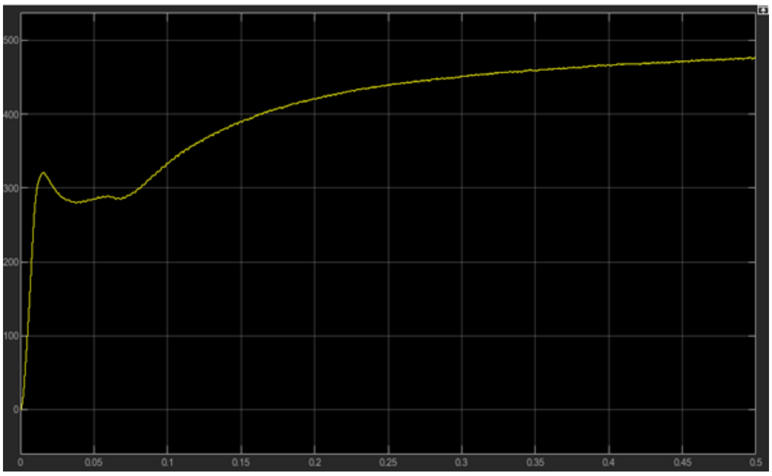

Figure 17: Input of 3 phase inverter

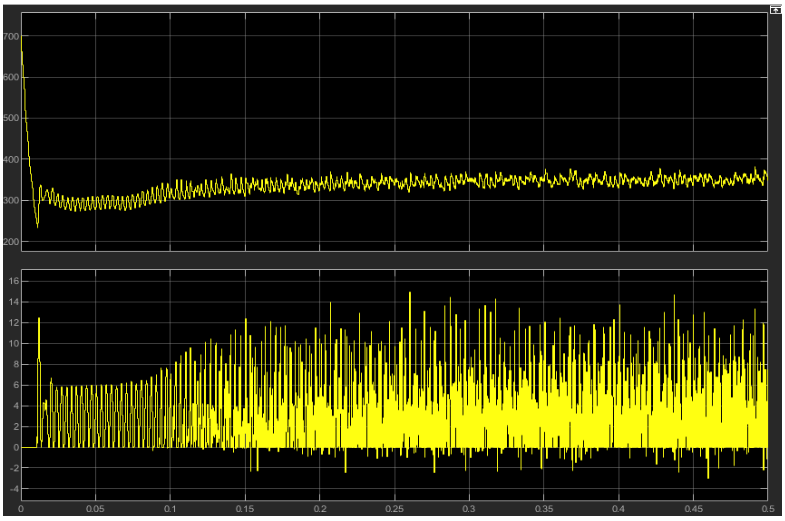

Figure 18: Non linear load output

Power quality studies are aimed at maintaining the power systems' current and voltage as pure sinusoidal with a 1 p.u magnitude at a 1 p.u frequency and the phase shift between the adjacent phases in a three-phase power system. Harmonic distortion is one of the power quality problems that are associated with nonlinear loads which draw non-sinusoidal currents and cause power quality deterioration. In this paper, the design aspects of a three-phase three-wire shunt active power filter, based on the instantaneous reactive power theory and hysteresis-PI control algorithm, have been simulated using the MATLAB/Simulink platform. The effectiveness of the filter in minimizing the current harmonics has been evaluated under balanced and unbalanced nonlinear load conditions. A comparative analysis with other algorithms has been performed to measure the proposed system performance compared with the other techniques in question.

V.CONCLUSION

A control calculation for a hybrid power filter comprised by a series active filter and a passive filter associated in parallel with the load is proposed. The control procedure depends on the dual vectorial theory of electric power. The new control approach accomplishes the following targets.

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- The compensation characteristics of the hybrid compensator do not depend on the system impedance.
- The set hybrid filter and load presents a resistive behavior. This fact eliminates the risk of overload due to the current harmonics of nonlinear loads close to the compensated system.
- This compensator can be applied to loads with random power variation as it is not affected by changes in the tuning frequency of the passive filter. Furthermore, the reactive power variation is compensated by the active filter.
- Series and/or parallel resonances with the rest of the system are avoided because compensation equipment and load presents resistive behavior.

Therefore, with the proposed control algorithm, the active filter improves the harmonic compensation features of the passive filter and the power factor of the load.

VI.REFERENCES

[1] P. Salmerón and S. P. Litrán, "Improvement of the electric power quality using series active and shunt passive filters," IEEE Trans. Power Del., vol.25, no. 2, Apr. 2010.

[2] B. Singh, K. Al-Haddad, and A. Chandra, "A review of active filters for power quality improvement," IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 960–971, Oct. 1999.

[3] J. W. Dixon, G. Venegas, and L. A. Moran, "A series active power filter based on a sinusoidal current-controlled voltage-source inverter," IEEE Trans. Ind. Electron., vol. 44, no. 5, pp. 612–620, Oct. 1997.

[4] R.S.Herrera and P. Salmerón, "Instantaneous reactive power theory: A comparative evaluation of different formulations," IEEE Trans. Power Del., vol. 22, no. 1, pp. 595–604, Jan. 2007

[5] Darwin Rivas, Luis Morán, Juan W. Dixon and José R. Espinoza, "Improving passive filter compensation performance with active techniques," IEEE Trans. Ind. Electronics,vol. 50, no. 1, Feb 2003.

[6] J. C. Das, "Passive filters-potentialities and limitations," IEEE Trans.Ind. Appli., vol. 40, no. 1, pp. 232–241, Jan. 2004.

[7] F. Z. Peng and D. J. Adams, "Harmonics sources and filtering approaches," in Proc. Industry Applications Conf., Oct. 1999, vol. 1, pp. 448–455.

[8] H. Akagi, "Active harmonic filters," Proc. IEEE, vol. 93, no. 12, pp. 2128–2141, Dec. 2005.

[9] J. A. Pomilio and S. M. Deckmann, "Characterization and compensation of harmonics and reactive power of residential and commercial loads," IEEE Trans. Power Del., vol. 22, no. 2, pp. 1049–1055, Apr. 2007.