International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Power Quality Improvement Using Hybrid Filter in Multiphase Conversion

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Abstract: ***The electric power demand is continuously increase with the advancement of technology at their exponential rate. Now a day's quality power is necessary for continuous operation of consumer appliances for these three phase supply is sufficient but due to potential benefit of multiphase (more than three phase) in transmission system. Multiphase electrical drive system is incredibly vital in analysis within the last decade. The quality of power delivered to the end user is affected by various external and internal factors as variations in voltage and frequency, fault occurrence, outages etc. The main affect caused by these problems is the presence of harmonics. This leads to the overheating of the equipment, insulation failure and over speeding of motors etc. to overcome these problems is to filter out these harmonics. This work will be explain about various filtration techniques with their advantageous properties and comparison. In this paper work a conversion of three phase to a multiphase. The connection output gives five phase supply from three phase and can be used in application acquiring five phase supply. The connection scheme is elaborated by using simulation to prove the viability of implementation but these conversion increase the total harmonic distortion (THD) value. In order to reduce these harmonic and to improve the power quality of the power system can be achieved by using a hybrid filter which is a combination of both active and passive filter. The proposed model is simulated with MATLAB /SIMULINK and result are presented in graphs.***

Keywords: Multiphase, Harmonics, Power Quality, filter, Total harmonic distortion

1. Introduction

The power quality (PQ) problems in power utility distribution systems are not new, but only recently their effects have gained public awareness. Advances in semiconductor device technology have fuelled a revolution in power electronics over the past decade, and there are indications that this trend will continue [1]. In recent year's mutltiphase transmission system is mostly the subject of interest in variable speed motor drive applications. Research on multiphase drive is mostly focused on five-phase and six-phase systems with the objective of developing highly reliable and efficient drive system. The research results on multi-phase drives are summarized in [2-3]. It is to be noted that the multi-phase motors are invariably supplied by power electronic converters since variable speed applications are sought. Thus it become the reason of harmonics and directly results poor power quality of the system [4]. The first drawback is that the reactive power (Var) that ends up in poor power issues and therefore the harmonics appears due to presence of power converter devices and nonlinear loads These shorts of significance of heavy industrial loads are normally usually targeted in one plant and served from one network terminal, and thus are often held best by an area compensator connected to an equivalent terminal. Harmonic pollution on a power line is often quantified by a measure referred to as total harmonic distortion or THD. High harmonic distortion can negatively affect a facility's electrical distribution system, and can generate excessive heat in motors, inflicting early failures [5].

2. Main Sources, Causes of Electrical Power Quality Problem

Power quality problem is an occur as a non-standard voltage, current and frequency. The power quality has serious economic implications for customers, utilities and electrical equipment manufacturers. However, in practice, power systems, especially the isolated systems, some of the source of distortion.

Causes of dips, sags and surges:
1. Rural location remote from power source
2. Unbalanced load on a three phase system
3. Switching of heavy loads
4. Long distance from a distribution transformer with interposed loads
5. Unreliable grid systems
6. Equipments not suitable for local supply

Causes of transients and spikes:
1. Lightening
2. Arc welding
3. Switching on heavy or reactive equipments such as motors, transformers, motor drives
4. Electric grade switching

Causes of transients and spikes:
1. Non – Linear Loads
2. Power Electronic Devices
3. IT and Office Equipments
4. Arcing Devices
5. Load Switching
6. Large Motor Starting
7. Larger capacitor bank energies

Major Problems that Arise from Harmonic Distortion Are:
a) Extra losses and heating in rotating machines and capacitors
b) Over voltages due to resonance
c) Interference with ripple control systems used in Demand Side Management (DSM)
d) Telephone interference caused by noise on telephone lines.

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3. Multiphase Conversion

The advantages of N number of phase systems compared to three phase systems have much interest in research .The multiphase systems is used in electric power generation, transmission and utilization. The research on six phase transmission systems was initiated due to rising cost of transmission towers, environmental issues, and various IE rules and laws. Six-phase transmission lines can provide the same power capacity with a lower line voltage and smaller towers as compared to a standard double circuit three-phase line [6]. This paper proposes a special transformer connection scheme to obtain a balanced three-to-five phase supply with sinusoidal waveforms. The expected application areas of the proposed transformer are the electric power transmission system, power electronic converters (ac–dc and ac–ac), and the multiphase electric drive system. The fixed three-phase voltage and fixed frequency available in grid power supply can be transformed to fixed voltage and fixed frequency Five-phase output supply.

Winding Arrangement for Three-Phase to Five-Phase Star Output

In this paper, the input and output supply can be arranged in the following manners:

1) Input star, output star.
2) Input star, output hendegon
3) Input delta, output star.
4) Input delta, output hendegon

Since input is a three-phase system the windings are connected in usual manner. The circuit diagram of the proposed system is shown in figure 1.

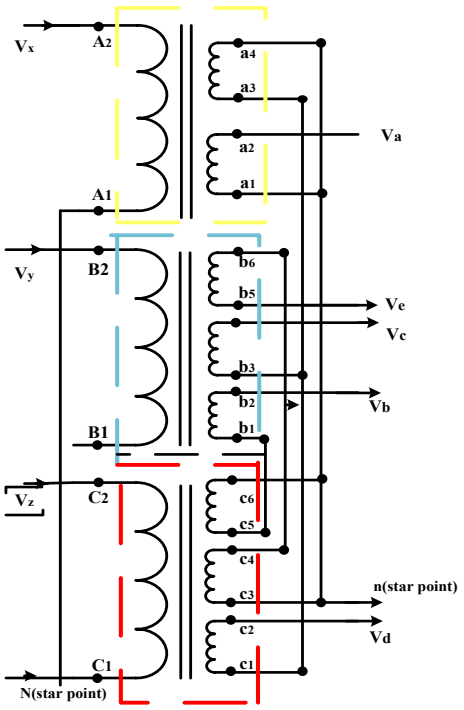


Figure 1: Three to five phase transformation winding arrangement of star-star

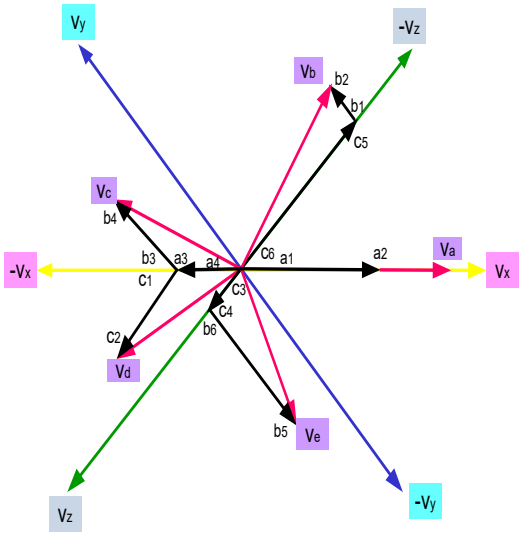


Figure 2: Phasor diagram of five phase transformer connection

Table 1: Design of proposed transformer connection

Primary	Secondary	Turn Ratio (Np/Ns)	SWG
Phase-X	a1a2	1	17
	a4a3	0.47	15
Phase-Y	b1b2	0.68	17
	b4b3	0.858	17
	b5b6	0.24	17
Phase-Z	c1c2	0.68	17
	c4c3	0.858	17
	c5c6	0.24	17

4. Hybrid Filter

The arbitrary use of non-linear loads has given rise to exploration into new compensation equipments. The aim of these equipments is to eliminate the harmonics and reduction of flow of reactive power. For the compensation of non linearity of load Filter is used for reduction of harmonics and power quality improvement. The filter connected to the system should be controlled efficiently and provide desired performance characteristics. Depending on function type, configurations of series or parallel or active and passive filters combination are used. Active power filters can be used in combination with passive filter for enhancing compensation characteristics of the passive filter and to keep away from the possible happening of the generation of series or parallel resonance in the other hand in the absence of passive filters, the active power filter could compensate only voltage regulation and voltage unbalance so The best way is to combine the compensation characteristics of passive and active power filters, which is Hybrid Filter [7].

The hybrid APF used for the power quality improvement a capacitor is used at the input of the filter. This filter is tuned to eliminate higher order harmonics. In certain cases there may be two or more LC branches tuned to eliminate specific order harmonics (especially 5th and 7th). A ripple filter is used in series. The filter parameters are selected such that they do not exceed the burden. The design criteria is [8]-

- XCrf<<XLrf, such that at switching frequency the inverter output voltage drops across Lrf

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- XCrf<< ZS + ZF, to make the voltage divide between Lrf and Crf

Thus, with an efficient control strategy, the APF compensates the voltage unbalances and distortion. The control strategy is designed such that the series APF together with the passive filter act as a balanced resistive load on the overall system.

5. Simulation Model

The overall system model containing the power source, the filter and the nonlinear loads is shown in figure 3 and figure 4.

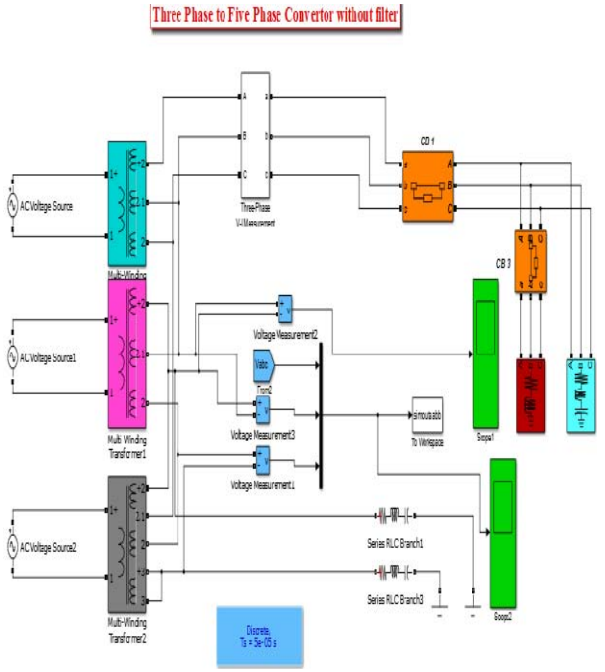


Figure 3: MATLAB based model of Three to Five Phase Conversion without filter

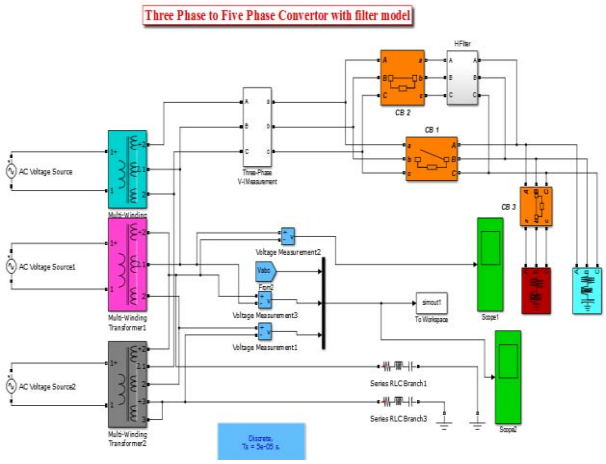


Figure 4: MATLAB based model of Three to Five Phase Conversion with filter

6. Simulation Result

The complete model of multiphase conversion with filter is presented in figure 4 and result is obtained by using MATLAB/Simulink Simpower system Toolbox software. Figure 5 and figure 6 Shows the simulation results obtained in harmonic distortion analysis of the load current, for each phase with nonlinear load.

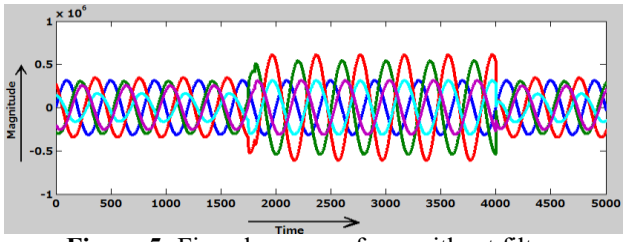


Figure 5: Five phase waveform without filter

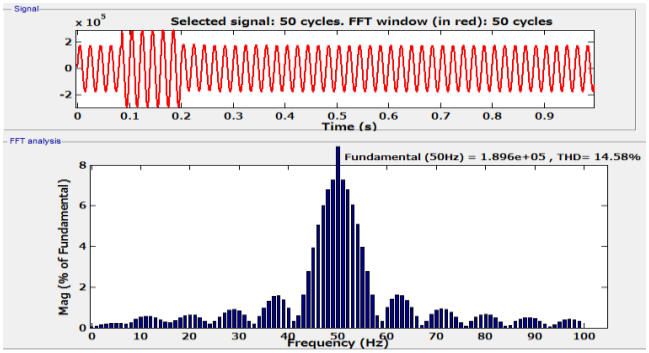


Figure 6: FFT analysis waveform and THD value of Phase A without filter

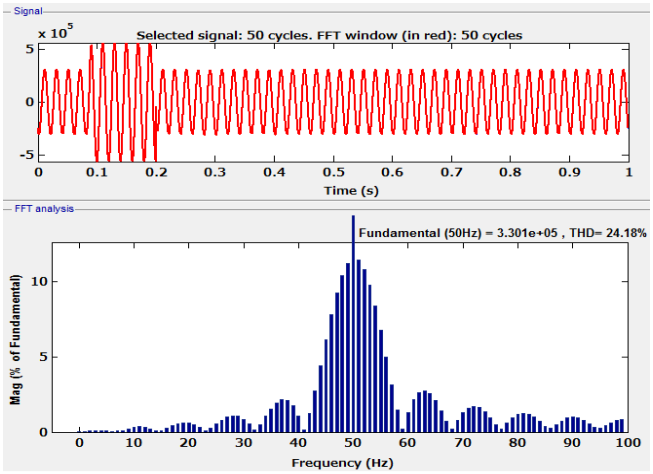


Figure 7: FFT analysis waveform and THD value of Phase B without filter

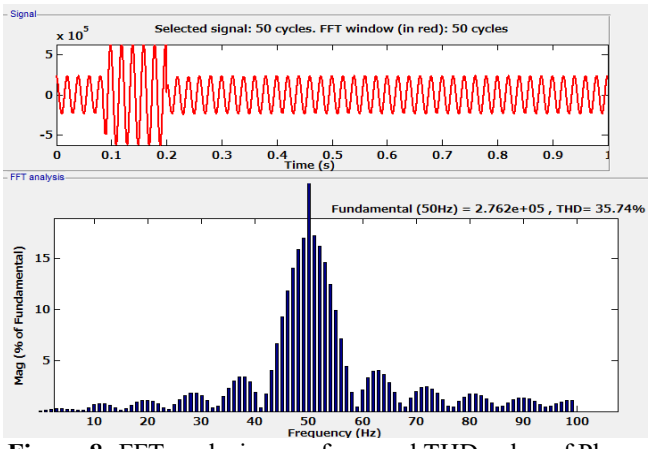


Figure 8: FFT analysis waveform and THD value of Phase C without filter

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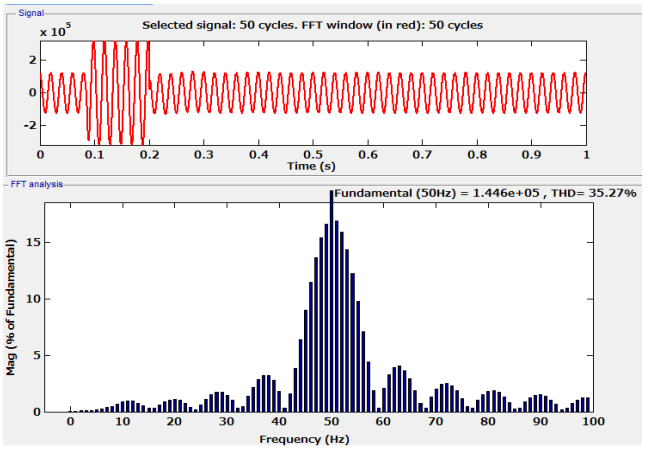


Figure 9: FFT analysis waveform and THD value of Phase D without filter

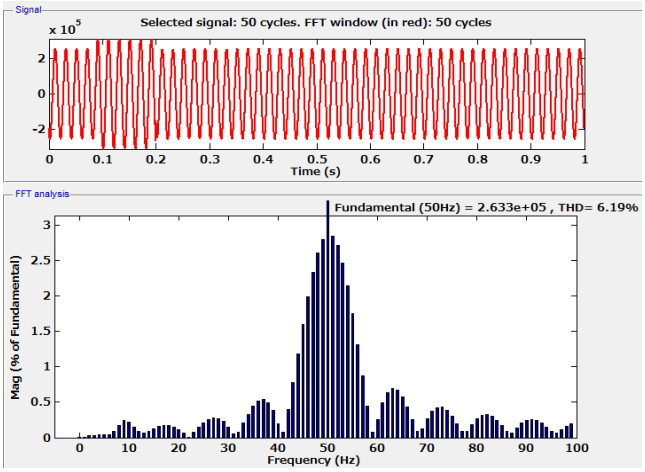


Figure 10: FFT analysis waveform and THD value of Phase E without filter

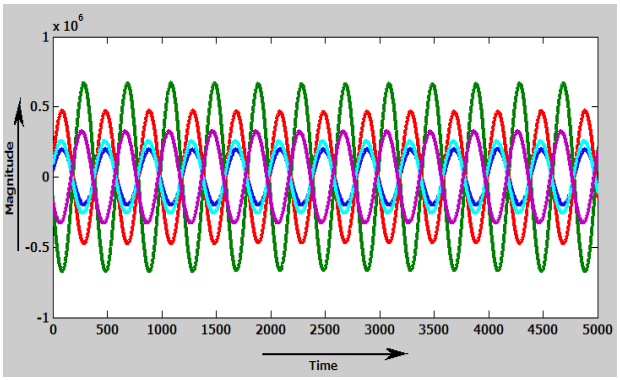


Figure 11: Five phase waveform with filter

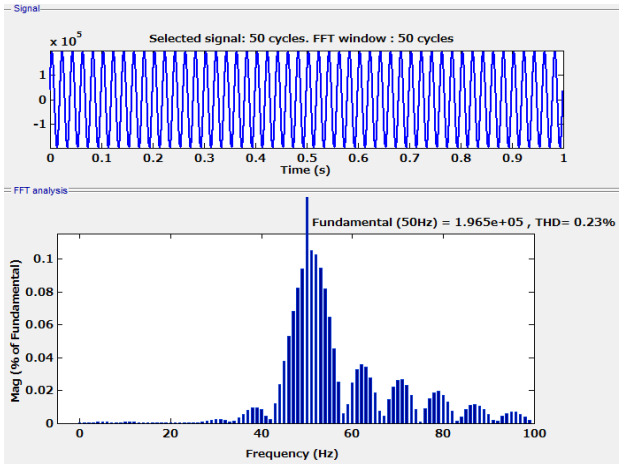


Figure 12: FFT analysis waveform and THD value of Phase A with filter

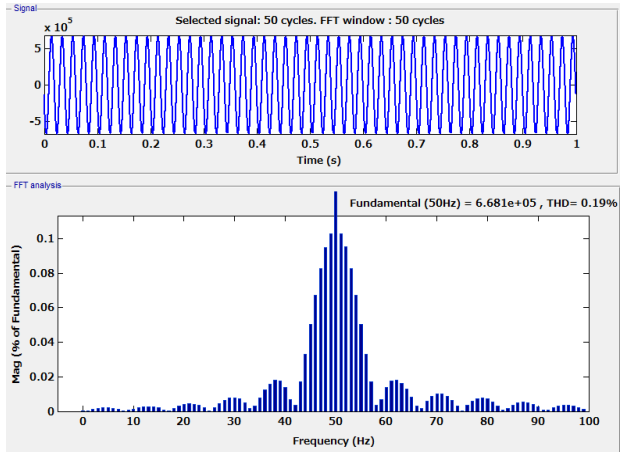


Figure 13: FFT analysis waveform and THD value of Phase B with filter

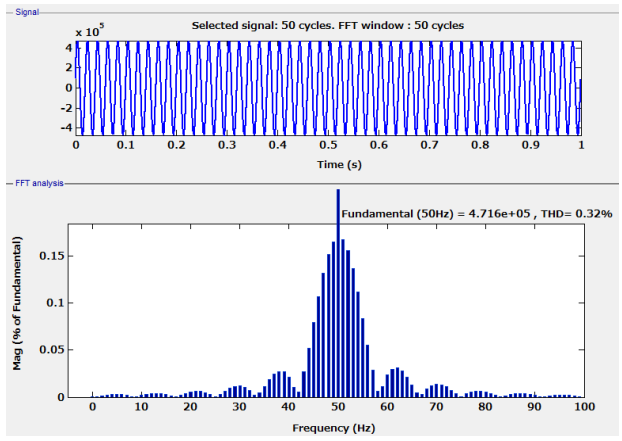


Figure 14: FFT analysis waveform and THD value of Phase C with filter

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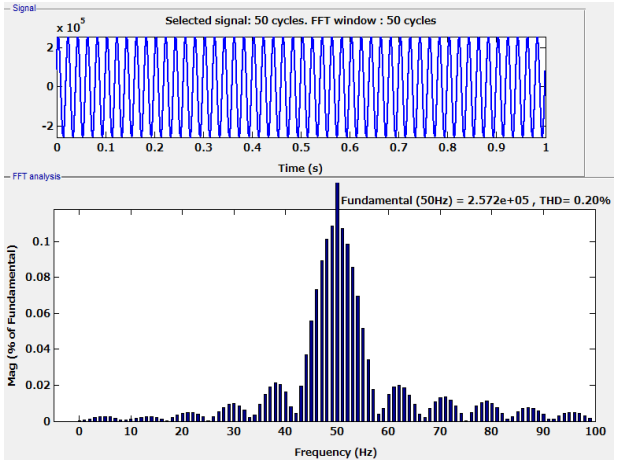


Figure 15: FFT analysis waveform and THD value of Phase D with filter

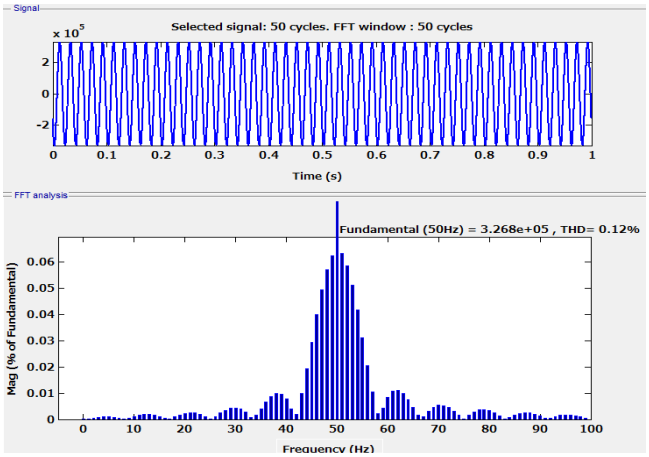


Figure 16: FFT analysis waveform and THD value of Phase E with filter

A comparative result of the three phase to five phase conversion THD value with the use of hybrid filter and without hybrid filter during unbalanced load conditions is presented in below Table 2. From these results it is clear that the proposed control strategy works better at almost all operating conditions and thus helps in improving the quality of electric power delivered to the end user.

Table 2: Comparison of THD value with and without using Hybrid filter

Phase	THD% Without Hybrid Filter	THD% With Hybrid Filter	% increased
A	14.58%	0.23%	98.42%
B	24.18%	0.19%	99.21%
C	35.74%	0.32%	99.10%
D	35.27%	0.20%	99.43%
E	6.19%	0.12%	98.06%

7. Conclusion

This paper presents the three to five phase conversion model by exploitation star-star connection and by exploitation FFT analysis we have a tendency to found huge amount of harmonic distortion and due to these calculated THD become very high thus for the reduction of these harmonics we are using filter from the study of assorted present harmonic reduction technique hybrid power filter found the most effective for each linear and non-linear load due to their advantageous quality of active and passive filter. This hybrid filter is tested and verified using MATLAB program. Modeling of filter is conceded out by two phase stationary reference frame $(\alpha - \beta)$ by using clarke's transformation. Therefore, it is concluded that the hybrid filter consisting of series Active Power filter and a shunt passive filter are feasible economic solution for improving the power quality in electric power system.

8. Future Scope

The works done in this work are often more comprehensive such new enhancement are found. The possible choices are-

- To simulate the projected control strategy with grid faults and study the behavior of APF in power quality improvement
- To implement the control strategy by means of Artificial Intelligence (AI) techniques
- To implement this model by exploitations PWM techniques.

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