

Review on Shunt Active Power Filter for Three Phase Four Wire System

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Abstract— This review provides a survey of shunt active power filter based on inverter in three phase four wire system. These topologies are applied to solve problem due to non linear load in power system network such as a power quality issue, reactive power compensation and harmonic current suppression. In making a review it should be noted that this paper will not attempt to give an all encompassing review of most of the published references. It will rather make an attempt to survey some promising directions and point to the references that can be used as a comprehensive description of those conditions. In order to accomplish its goal this survey will start with a brief overview of the shunt active power filter and how to increase stability of three phase wire system of the survey. Also mention various types of control strategies. Last but not least, the time span covered by this survey should be noticed for the sake of future updates and references.

Index term— Power Quality (PQ), Harmonic current suppression, Shunt active power filter

I. INTRODUCTION

Significant amounts of harmonic currents are being injected into power systems due to the widespread increase of non-linear loads. Harmonic currents flow through the power system impedance, causing voltage distortion at the harmonic currents' frequencies. The distorted voltage waveform causes harmonic currents to be drawn by other loads connected at the point of common coupling (PCC). The existence of current and voltage harmonics in power systems increases losses in the lines, decreases the power factor and can cause timing errors in sensitive electronic equipments. An alternative method to solve or minimize these problems is the use of shunt active power filters (APFs), applied in single-phase and three-phase three-wire and four-wire systems. APFs are used to inject in the line, compensation currents in order to cancel harmonics and/or reactive components of the load currents. For three-phase four-wire systems, depending on the control strategies adopted, the APF can control each phase independently. Thus, it is possible to compensate all the harmonic and reactive current components. In this case, the compensation of the unbalanced load is not taken into account.

Use of non-linear load such as a switching power supplies, inverters, single phase and three phase power supplied, among other, being these used in industrial, commercial and residential applications. This load has contributed for the generation of a great content of harmonic and reactive power, which is responsible to contributing power quality degradation. Power quality (PQ) problem arise when non-linear load are connected to three phase four wire system. Power system transient, power frequency disturbances, grounding and bounding, electro-magnetic interference (EMI), electro-static discharge (ESD), power factor are also issue of power quality.

Passive LC filter are used for current harmonic reduction, for its simplicity and low cost. However, passive filter have several drawbacks such as large size, tuning and risk of resonance problems. So, four legs active power filter system can solve problems of current harmonics, reactive power, load current balancing and excessive neutral current simultaneously, and can be a much better solution than conventional approach.

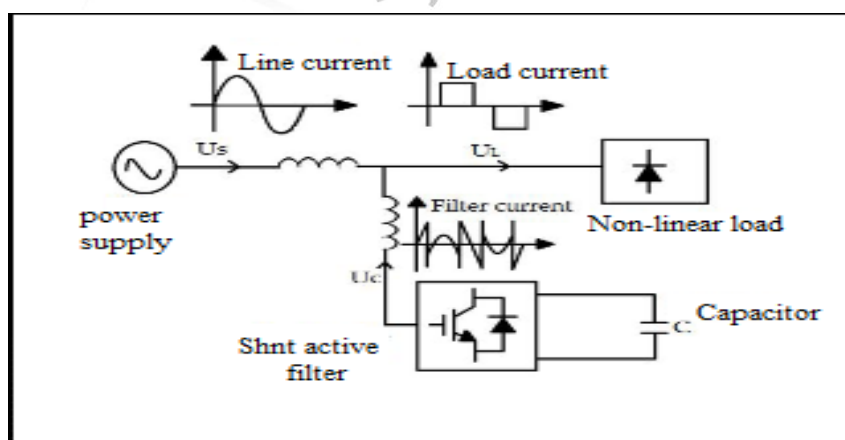


Fig.1.1 Shunt active power filter

Figure-1.1 shows the basic compensation principal of shunt active power filter. It is designed to be connected in parallel with the non-linear load to detect its harmonic and reactive current also to inject the system a compensating current.

II. TYPES OF FILTER

In literature different topologies applied to compensate the harmonics such as filtering like passive, active, and hybrid with shunt, series for two single phase, three-wire three-phase and four-wire three-phase systems.

The traditional method of current harmonics reduction involves LC passive filters such as single tuned, low and high pass filter, which are its simplicity and low cost. However, passive filters have several drawbacks such as large size, tuning and risk of resonance problem. At present, the 4-leg active filters have proven to be very effective to solve problems of current harmonics, reactive power, unbalanced load current and excessive neutral current simultaneously in 3-phase 4-wire system, and can be a much better solution than conventional passive filters. Active filter are classified on converter based, topology based and supply system based. VSI and CSI bridge types filter also used.

1. Passive filter

- (a) Single tuned filter
- (b) First order high pass filter
- (c) Second order high pass filter

2. Active power filter

- (a) Converter-based classification
 - VSI (Voltage Source Inverter) bridge structure
 - CSI (Current Source Inverter) bridge structure
- (b) Topology-based classification
 - Shunt APF
 - Series APF
 - UPQC: Shunt APF + Series APF
 - Hybrid APF: Shunt or series APF + passive filter
- (c) Supply-system-based classification
 - Two-wire APF
 - Three-wire APF
 - Four-wire APF

Table.1.1 Compensation for application

Compensation For specific application	Active power filter topology			
	Shunt APF	Series APF	Hybrid APF	UPCQ
Current Harmonic	Moderate		Fast	Moderate
Reactive power	Fast		Moderate	Moderate
Load Balancing	Low			
Neutral current	Moderate		Low	
Voltage Harmonic		Fast	Moderate	Moderate
Voltage Regulation	Low	Fast	Moderate	Moderate
Voltage Balancing		Fast	Moderate	Moderate
Voltage flicker	Fast	Moderate		Moderate
Voltage Sag	Low	Fast	Moderate	Moderate

III. APF CONTROL STRATEGIES

1. First stage: Signal conditioning

Sensing system information by PT, CT, Isolation amplifiers

- Monitor, measure, record: THD, power factor, Active/reactive power, crest factor.

2. Second Stage: Derivation of compensating signal

- Current level and/or voltage level
- Frequency domain

: Based on Fourier transformation

: Cumbersome computation, large response time

- Time domain

: Based on instantaneous derivation

: P-q theory, synchronous d-q reference frames method, Synchronous detection method, flux-based controller, and Notch filters method.

3. Third stage: Generation of gating signal

- Hysteresis, PWM, SVPWM, sliding mode, fuzzy- logic.

IV. RELATED WORKS

Acordi, Campanhol, Silva, Narcimento described on the shunt active power filter on both topologies, one of the four leg full bridge voltage source inverters and other one is three full bridge voltage source inverters for compensation of reactive power and harmonic current. The synchronous reference frame theory is to generate compensation reference current. PI controller is used to control current. In three phase full bridge topology two strategies adopted on SRF based. In first strategy, the only load harmonic suppression and the load unbalanced current compensation is not in the account. In second strategy, load unbalanced current compensation is not in the account. Simulation results are present in order to evaluate the performance of the APFs approaches.

Patdar describes causes related to poor power quality. In this paper a control scheme based on PI controller has been proposed for generation of reference current to mitigate the harmonics and neutral current for two different topologies. This methodology offer to implement and increases reliability of the system. Three phase four wire active power filter based on three-leg IGBT inverter, adopted with the dc-link composed by two capacitors connected in split. A disadvantage of this topology is the fact that the size of the dc-link capacitors has to be over-dimensioned. The Other topology with four switching-legs was fourth leg provided to return path for neutral conductor. This paper also included significance of D.C. Capacitor. The capacitors are designed to limit the dc voltage ripple to a specified value, typically 1 or 2 %. But in this paper capacitor should be designed for the worst case.

Metin Kesler and Engin Ozdemir take the performance of Shunt Active Power Filter under Unbalanced and Distorted Load Conditions. LC filter have been use to eliminated harmonic but disadvantage of LC filter are bulky, load dependent, inflexible also resonance problem of the system. Due to above problem of LC filter, Active power filter comes in the structure. Shunt active are connected in parallel with non linear load to detect harmonic and reactive power which is produce into compensating current system.

The control method is based on Instantaneous Reactive Power theory (IRP) or P-q theory. This requires only measuring the source currents to reduce the number of Current Sensors (CSs) needed in the conventional control approach. In the conventional p-q theory based control approach for the shunt APF, the compensation current references are generated based on the measurement of load currents. However, the current feedback from the SAPF output is also required and therefore, minimum six CSs are desired in an unbalanced system. To compensates power quality problem and can also interface renewable energy sources with electric grid with 3-phase 4-wire shunt active power filter presented by J.P.Pinto, R. Priziter.

Lonnie Stitt and Jake Chambers described shunt active power filter with a control algorithm of unit vector template method, Power synchronous detection for reference current generation is compared. The active power filter designed in PSIM software and control algorithm done in simulink environment. PSIM and MATLAB software is linked by Sim-coupler. The capacitor voltage maintained constant by using PI controller.

The purpose of the shunt active filter is to provide compensation currents such that the source needs to supply balanced (positive-sequence) fundamental source current at unity power factor even though the load consumes harmonic currents as well as positive, negative, and zero-sequence currents. The instantaneous active and reactive power theory introduced by Akagi has been used very successfully to design and control active power filters. Aredes presents general equations that relate the concept of instantaneous active and reactive power theory and the well-known theory of symmetrical components for the case of three-phase four-wire systems. In the paper novel control approach is the instantaneous power in a three-phase four-wire system is made, design of shunt active filters using the symmetrical component method is described. A major feature of the proposed approach is that symmetrical component transformation is not needed in the control of the active filter. In addition, the power factor of the positive-sequence fundamental component is close to unity and only positive-sequence power is supplied by the source

Vodyakho and Chris C. Mi (2009) are include multilevel inverter based shunt active power filter in three phase three wire and four wire system. That presents a direct current-space-vector control of an active power filter (APF) based on a three-level neutral-point-clamped (NPC) voltage-source inverter. The proposed control can selectively choose harmonic current components by real-time fast Fourier transform to generate the compensation Current. The advantages of three-level VSIs include lower harmonic distortion, lower switching frequency, and lower power loss.

Maria Isabel Milanes Montero, Enrique Romero Cadaval and Fermin Barrero Gonzalez are comparing of various control strategies for shunt active power filters in three-phase four-wire Systems. This paper first presents a review of four control strategies p-q method, d-q method, unity power factor (UPF) method, and perfect harmonic cancellation (PHC) method for the extraction of the reference currents for a shunt active power filter connected to a three-phase four-wire source that supplies a nonlinear load. Then a comparison of the methods is made by simulations under both ideal and distorted mains voltage conditions and various load conditions. Also experimental results are presented.

V. EFFECT OF NON-LINEAR LOAD

1. Effect of non linear with R-C load on source current (I_s)

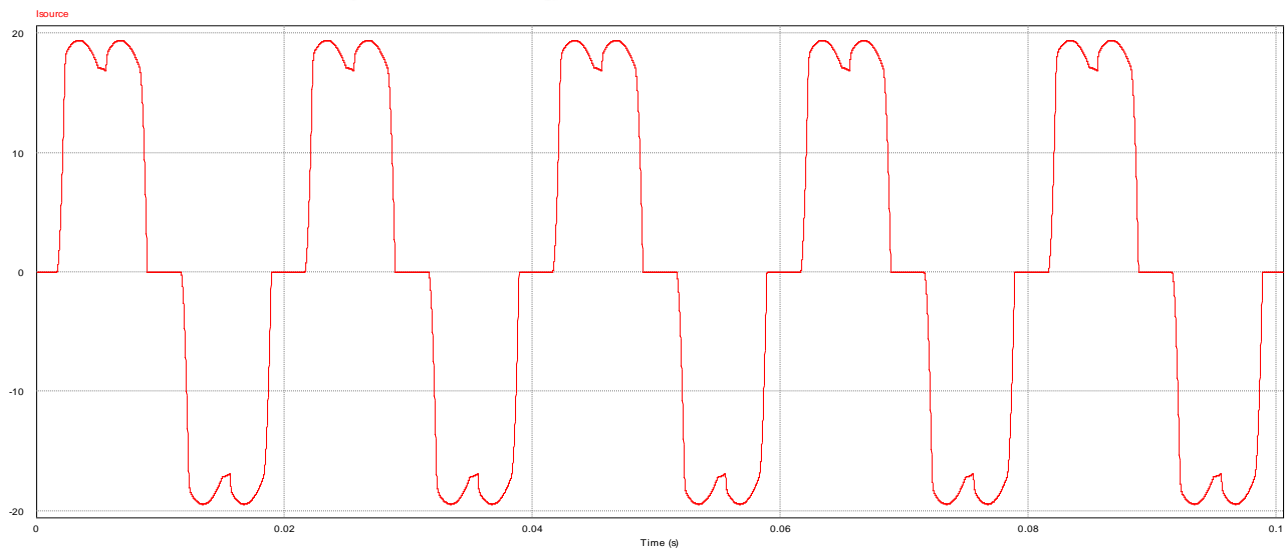
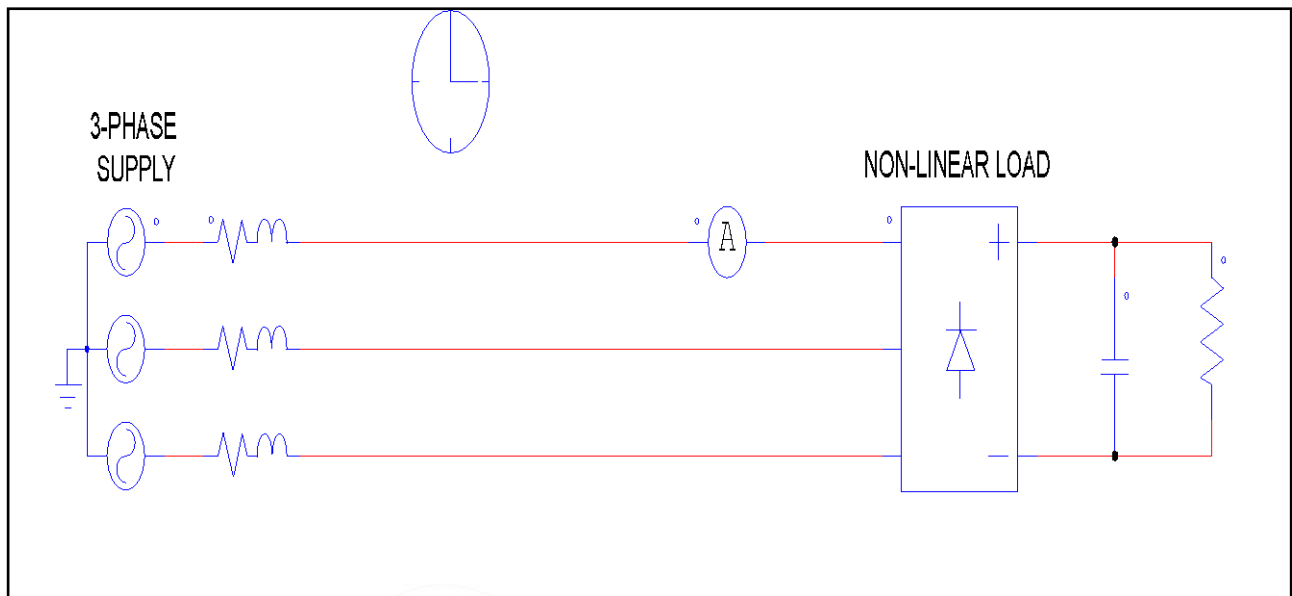


Fig.5.1 simulation and waveform with R-C Load

Above diagram is described 3-phase system with R-C non-linear load. And due to non-linear load present harmonic in supply system is depicted by waveform.

2. Effect of non linear with R-L load on source current (I_s)

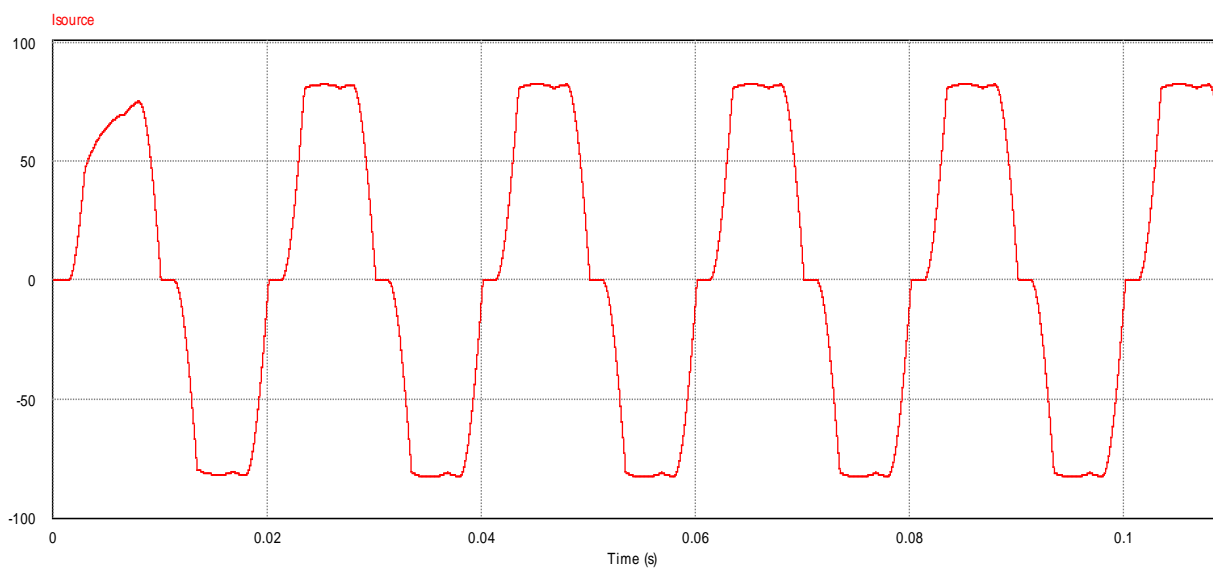
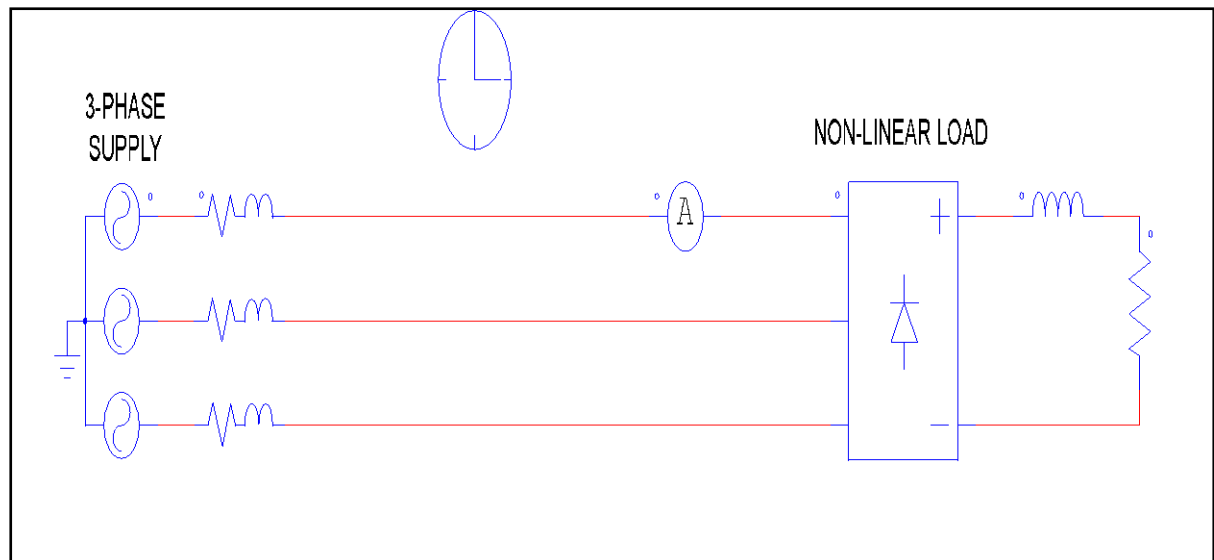


Fig.5.2 simulation and waveform with R-l Load

Similarly, this diagram is described 3-phase system with R-L non-linear load. And due to non-linear load present harmonic in supply system means nonsinusoidal waveform.

VI. CONCLUSION

In this paper describe various types of passive filter and active filter. Also studied various control strategies which are control output of shunt active power filter. How the effect of harmonic on power quality and solution given by shunt active power filter for three phase four wire systems. A method will be simulated any software of electrical.

VII. REFERENCES

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