

A REVIEW ON HYBRID ACTIVE POWER FILTER FOR POWER QUALITY IMPROVEMENT

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ABSTRACT- The regularly expanding interest of energy there is a need to extend and overhaul the current power framework. For the unwavering quality and security of the power framework arrange it is fundamental to keep up great quality of energy supply. The most recent innovations utilized as a part of appropriation framework and modern area are depend upon the power hardware based gadgets. Which are the more prominent wellsprings of nonlinear burdens and harmonics in control framework. Poor power quality can bring about voltage droop, swell, era of harmonics, system disappointment because of huge current, voltage, recurrence awkwardness. It is important to familiarity with power quality. This paper exhibit survey about power quality issues, its issues and remedial strategies. Hybrid active power filter (HAPF) comprising of passive filter and active filter in different designs to each different has now turned out to be favored innovation for consonant remuneration in two wire, three wire and four wire AC power systems with nonlinear burdens. This paper introduces a point-by-point study of Hybrid active power filter considering converter topologies, supply framework and passive filter sort. Furthermore, the control procedures are talked about in detail. The principle point of this paper is to give a wide point of view on the status of hybrid active power filter HAPF innovation to analysts and application engineers managing control quality.

Keywords- AC power system, HAPF (Hybrid active power filter), APF (Active power filter), PF (passive filter).

A. INTRODUCTION

Over the previous decade the subject of energy quality has been given an expanded consideration everywhere throughout the world. Control quality is an incorporated some portion of energy designing. Control quality is an arrangement of electrical limits that enables a bit of hardware to work in its expected way without huge loss of execution or life anticipation [1].

Ever a couple of years back the principle worry of buyers of power was the dependability of supply it implies progression of electric supply. But now a day's energy quality too is imperative there are exceptionally touchy burdens that require spotless and continuous power, for example, air activity control, handling plants (texture, sustenance, semiconductor, rayon and so on.), clinics (life bolster, operation theater, persistent information base framework), bank security framework and so on power quality issues like voltage droop, swell, flash, harmonics voltage twisting are different power quality issue make control quality poor they can't be totally dispensed with however limited up as far as possible through different hardware, for example, control figure corrector circuit, truths gadgets, filters etc. In this paper we will audit a few general power quality issue and related remedies [2][3].

Hybrid Active Power filter is one of them and accessible in literature overview. Previously, the passive power filters were regularly used to tackle genuine consonant issues of the network [4,5]. Albeit passive filters were favored as a result of its financial and straightforward structure, new techniques are required because of the detriments of passive filter, for example, prerequisite of a different filter for each consonant current, having constrained sifting attributes, the negative impacts brought about by parallel and series reverberation amongst matrix and filter impedance [6-9].

The dynamic or active power filter, which is produced to cure the weaknesses of the passive filter, comprises of voltage or current source inverter, DC interface stockpiling and yield filter. At the point when active filter is contrasted with passive filter, in spite of the fact that active filter has complex structure and all the more exorbitant, today they can tackle different power quality issues, for example, consonant pay, receptive power pay, voltage irregularity, voltage glimmer [10]. Despite the fact that the dynamic active power filter is a powerful remuneration framework, their cost is expanding genuinely with the extent of expanding force limit [11]. As an answer for this circumstance, the hybrid active power filters have been created by utilizing dynamic and inactive filter together [12,13]. The principle point in the advancement of HAPF is to diminish the cost and rating of active power filter by utilizing passive filter that filters the overwhelming harmonics created by non-direct loads and supplies receptive power prerequisite [14].

B. POWER QUALITY PARAMETERS AND TERMINOLOGYS

Power quality is a measure of different parameters like voltage current and recurrence inside its predefined extend. On the off chance that there has any deviation created different issues like voltage droop, voltage swell, transient, glimmer, harmonics etc. which can be in charge of poor power quality.

- A. Transient: - Transient are brief span and sudden unsettling influences which can bring about by an exceptionally fast change in the unfaltering state of voltage present or both. Transient aggravation is characterized into two classifications oscillatory transient and imprudent transient. [15]
- B. Short time voltage variation: - In any supply voltage, in the event that there has any variety for brief time not more than 1 moment is known as a brief span voltage variety. For the brief span voltage variety deficiencies, stimulation of expansive burdens irregular free association in power wiring is capable. Brief term voltage variety is grouped in to three classifications as voltage list voltage swells and interferences.
- C. Long time voltage variety: - for bigger than 1 minute the voltage deviation encompassing the RMS (root mean square) estimation of energy recurrence is called long voltage variety. Long term voltage varieties are arranged in 3 classes as over voltage, under voltage and managed intrusions. [3]
- D. Waveform contortion: - The voltage and current waveform of sound power supply are perfect sine wave .if there power recurrence wave shape has any relentless state deviation is called wave shape contortion. Wave frame twisting is arranged into taking after classifications .dc balance, harmonics, inter harmonics, scoring, and clamor. [3]
- E. Voltage changes: - The orderly irregular variety of voltage wrap is called voltage variance. The fundamental course of voltage variety is quick change in current extent of load. An exceptionally quick change of supply voltage is called voltage glint, which is a sort of voltage variances.
- F. Variation In power frequency: - For the palatable operation of any power framework, a basic recurrence is predefined .on the off chance that there has any variety in its predetermined ostensible esteem (e.g. 50 to 60 Hz) is called control recurrence variation. A rapid change in the heap, which is associated in the framework, is in charge of energy recurrence variety.

C. Power Quality Problems

- A. Power Factor of Poor Load:- The proportion of the genuine power streaming to the heap to the evident power in the electric circuit is known as the power element of the power framework . It is a vital term of energy framework .The limit of the circuit for doing work in a specific time is called genuine power and result of current and voltage is called obvious control. In power framework in light of different utilization of semiconductor gadgets or nonlinear load the wave state of voltage and current are mutilated which make the evident power will be more noteworthy than the genuine power and get low control consider the circuit. In the event that the power element is low in an electric power framework the measure of current, streaming in the circuit draws more than a heap with a high power figure for a similar measure of helpful power exchanged. At the point when the circuit has high current, the vitality lost in the circuit is higher and required bigger wires and other electric gear. [16]
- B. Harmonics problem: - Harmonic are sinusoidal voltage or current parts having recurrence are whole number products of the supply recurrence. Twisting means the change of the first state of a protest picture harmonics waveform or other type of data and portrayal. Harmonics are likewise a kind of bending which changes the voltage and current waveform of principal power recurrence. Different nonlinear burdens, control semiconductor devices, fluorescent lights flexible speed drives individual PCs and so on are produced harmonics in power framework. This make different destructive impact in framework it can lessening the productivity of framework, plant mal-working of types of gear , maturing of establishment ,overheating and disappointment of machines ,over-burdening of energy component remedy capacitors and power transformers.[17]
- C. Indenting in low voltage: - When the current is driven starting with one stage then onto the next stage some unsettling influence in voltage waveform is called voltage indenting. This is a sort of energy quality unsettling influence. Voltage indent aggravates the voltage waveform and energizes the normal recurrence of the framework more often than not these recurrence range are in radio recurrence run. . Which present the symphonious and non-harmonic recurrence that is substantially higher than those found in higher voltage framework are. Extraction recurrence make high recurrence motions in the voltage of converter circuit. Voltage score harm capacitor banks ,make parallel reverberation ,flag impedance in rationale and correspondence circuit, over stacking in electromagnetic filters.[18]

- D. Voltage irregularity: Voltage awkwardness or unbalance is the proportion of greatest deviation from the normal of 3 stage voltage and current to normal of 3 stage voltage and current. There are numerous locales are in charge of the voltage unbalance, for example, unbalance approaching supply lines, non-equable transformer tap setting ,substantial single stage conveyance transformer on the framework ,blames in control transformer establishing ,open delta associated transformer banks ,unequal impedance in conductors of control supply wiring ,overwhelming responsive single stage load such as welders etc.[8]
- E. Aggravation of supply power: - For a decent control quality of a power framework required totally sin wave of voltage furthermore, current. In any case, interference, bending, list, swell, gleam, over voltage, under voltage and so forth are the unsettling influence in supply control which are in charge of different sorts of control misfortune in the framework. Little term voltage interference make transfer stumbling over warming in the framework, consuming control supply, harm semiconductor segment and numerous issue.

D. Restorative techniques

Power quality issues cannot be totally evacuated in any case, it can be limited up as far as possible. For the restriction of this different techniques are utilized

- A. Control calculates corrector circuit: - Single-stage and three-stage programmed control calculates revision frameworks have certain receptive current restorative control evaluations. At the point when the identified receptive power consumed by the heap is more prominent than the compensator rating, the control element will not be redressed to solidarity, however surely will be enhanced and the obvious power provided by the air conditioner supply will be diminished. Also, the nature of energy supply is enhanced .[16]
- B. Actualities gadgets: - Adaptable Alternating-Current Transmission Systems (FACTS) Is a current innovative advancement in electrical power frameworks. Due to the, each time higher prerequisites of the risk and nature of the power the implantation of gadgets fit for ensuring these necessities will keep expanding. Truths gadgets are enhancing the operation of an electric control framework. The impacts of such gadgets on unfaltering state factor (voltage levels, transmission misfortunes, and creating expenses) are exceptionally amazing force quality advantages. [19]
- C. Filters -Filters are for the most part utilized for control quality change by limiting different issues like poor power consider, voltage distortion, current bending and so forth. There are three sorts of filters being used passive filter, dynamic or active filters and hybrid power filter. Passive filter depend on the R, L and C burdens . Active filter are extremely dependable and for the most part utilized power quality change hardware in control framework. Hybrid framework is mix of both active and passive framework and works adequately for symphonious and other waveform distortion in the framework.

E. CLASSIFICATION OF HYBRID ACTIVE FILTER

The hybrid filter can be classified upon the different parameter.

A. Topology Based

Three fundamental topologies in literature exist for HAPF. These are series active power filter with the shunt passive power filter, second one is shunt active power filter with shunt passive filter and the third one is active power filter in series with the shunt passive filter. Figure-1 shows the outlines of these topologies.

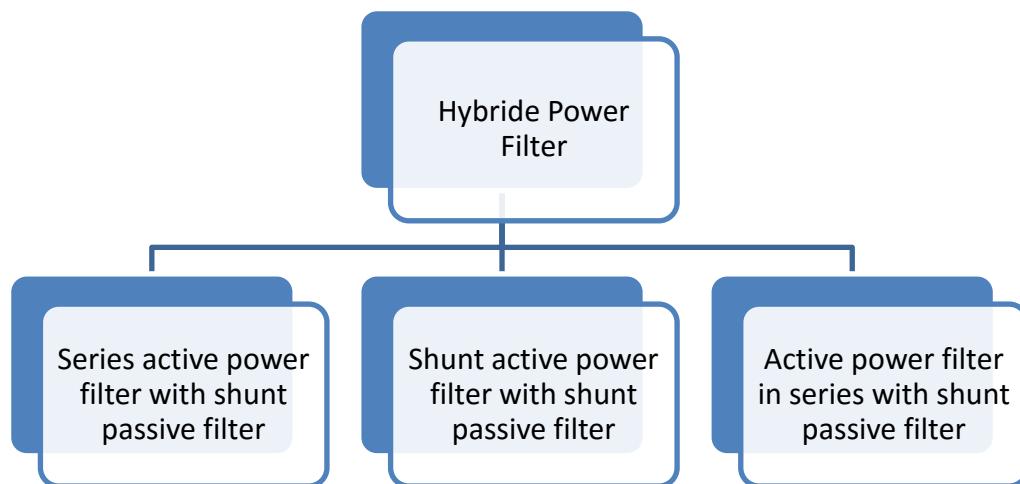


Fig.1- Block diagram for the Classification of hybrid power filter

1) Series Active Power Filter with Shunt Passive Filter

This topology joins the arrangement active power filters and shunt passive filter. Series active power filter demonstrates high impedance with providing symphonious seclusion and empowering the symphonious current to stream on passive filter. This sort of filter is intended to repay receptive power, harmonics and lopsided loads in the medium voltage level of a power circulation framework. In late reviews, multilevel inverter has been utilized to decrease the exchanging misfortunes. This topology isn't favored for commonsense application in light of inconveniences of arrangement active filter. In this manner, there are set number of studies on this filter.[20-22] The schematic diagram of the series active power filter with the shunt passive filter is shown in fig.2.

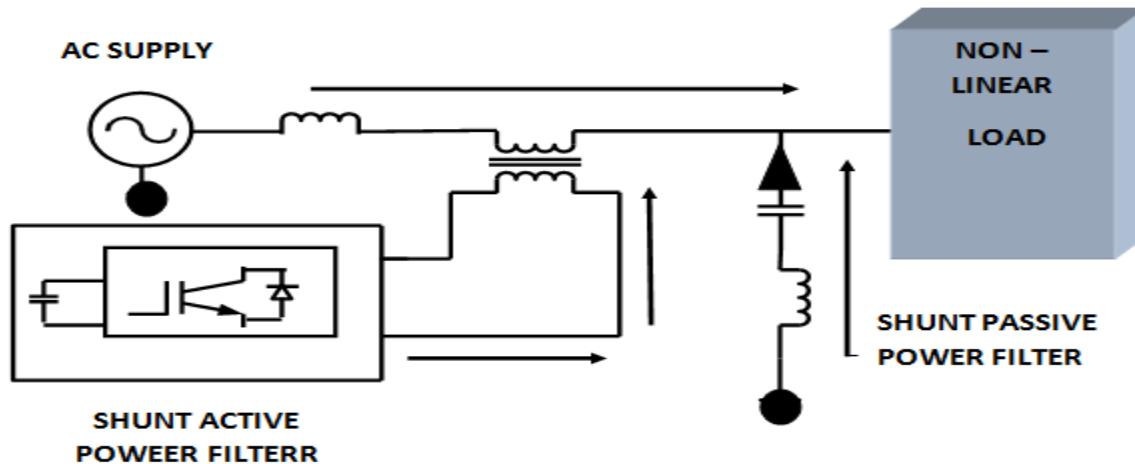


Fig.2 –Schematic diagram of the series active power filter with shunt passive filter.

2) Shunt active power filter with shunt passive filter

This kind of filter is joined with passive and active control filter in parallel setup. The point of utilizing passive filter is to both filter prevailing harmonics of nonlinear stacks in low recurrence and supply responsive power remuneration. In addition, the parallel active power filter not just repays the harmonics that passive filter proved unable filter additionally bolsters receptive power remuneration. With this topology, the evaluated current of APF is lessened. The point of this work is that while passive

part adjusts the major receptive power and low request harmonics, active part remunerates high request harmonics. In this topology, the reverberation issue between passive part and control framework is vanished. Also, the pay limit of active power filter is diminished. The schematic diagram of the shunt active power filter with shunt passive filter is shown in fig.3

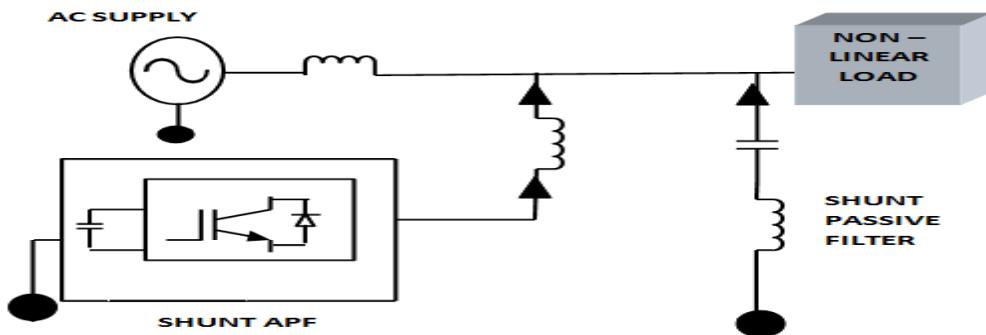


Fig.3 – Shunt active power filter with shunt passive filter.

3) Active power filter in series with shunt passive filter

This kind of filter is the most widely recognized to others. This topology comprises of shunt passive power filter in arrangement with active power filter. Active power filter part supplies to hold on DC interface voltage that requires for harmonics pay. Passive power filter part hangs on the voltage of central segment in matrix. The evaluated voltage of APF can be lessened the proportion of 1/10 contrasted with parallel active power filter. Along these lines, not just the inverter of APF and dc connect limit additionally cost is fundamentally diminished. Also, the exchanging loss of the inverter can diminish with diminishing the evaluated voltage of APF. This topology is analyzed detail to this article. The schematic arrangement of a active power filter with shunt passive filter is shown in fig. 4.

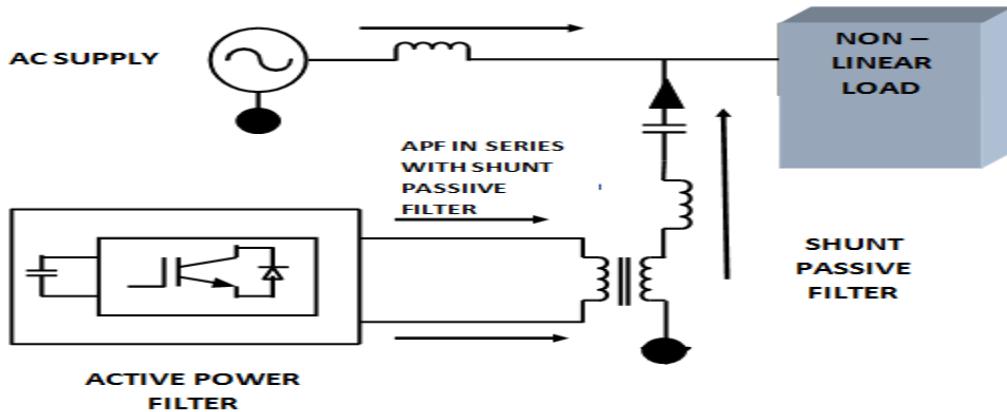


Fig.4 – Schematic arrangement of the active power filter in series with shunt passive filter.

B. Converter Configuration

HAPF topologies comprise of active power filter and passive filter. The active part incorporates inverters. These inverter topologies are as per the following: One of them is three-stage voltage source inverter. VSI, which has a self-supporting dc voltage transport with a huge dc capacitor, has many preferences. This sort of inverter is lighter, less expensive and effortlessly changed over to multilevel to expand the execution for accomplishing low exchanging recurrence. The other converter utilized as in HAPF is present source inverter. This inverter goes about as a non-sinusoidal current source so as to

fulfill the consonant current which the nonlinear stack requires. The yield current is kept consistent independently of the heap on the inverter the yield voltage compelled to change.

The disadvantages of this inverter are that it has higher misfortunes and requires higher estimations of parallel air conditioning influence capacitors. What's more, it is not expandable to multilevel to enhance execution in higher evaluations. In addition, it requires additional control stage to control the current. The dynamic reaction is slower. Last sort is multilevel inverter. The multilevel inverters have turned out to be famous in control industry. In high power and high voltage applications, they have a few disadvantages, for example, exchanging misfortune and limitations of gadget appraisals in operations. Multilevel structure can succeed high power and high voltage inverter without requiring higher evaluations. Likewise, with this structure, the utilization of transformer or synchronized exchanging gadget is not required. In writing, there are three kind of multilevel converters: Diode clipped, flying capacitor, fell.

C. Supply System based configuration

There are three setups in view of supply framework. The first setup is two-wire. Two-wire hybrid active power filter are by and large accessible in low power appraisals. The upside of two-wire mixture active power filter is that they need to manage low power. Moreover, they are capable to be worked at moderately higher frequencies prompting enhanced execution. Another setup is three-wire. Three wire dynamic power filters are reasonable for low power as well as additionally medium and high power applications. In writing, most distributions are on three wire HAPF's with various topologies. Last arrangement is four-wire. Single stage loads which are provided from three stage mains with bringing about unbalance. To conquer these issues, four wire HAPF has been produced.

D. Passive Filter Type based configuration

Hybrid active filter topologies comprise of passive and active filters. The passive filter has an essential part to tune at key recurrence and diminish the power rating of APF. In literature, many sorts of passive filters are applied. Most basic filters is LC filters. The LC filter comprises of an inductor and capacitor in arrangement tune a solitary recurrence. The LC circuit gives a zero impedance way for a particular harmonics current to be sifted. LCL yield filters demonstrate more compelling execution than LC yield filters. A few reviews lean toward this sort of channel. RLC filters comprise of a resistor, an inductor and a capacitor associated in arrangement. It constitutes a consonant isolator. The resistor is utilized for damping .Injection sort of filter is made by including a LC circuit that is tuned to key recurrence of the transformer. In expansion, this topology can be connected for high voltage levels in light of the fact that the current at the basic recurrence does not stream over the active filter. Another sort filter topology is parallel full filter. Another passive filter topology that is tuned at the basic recurrence of the framework is utilized rather than customary passive filter topology. This filter comprises of parallel LC with arrangement. LC is tuned at basic recurrence of the framework. C in parallel LC filter and series L is tuned at wanted harmonics recurrence. This filter exhibits high impedance at basic recurrence segment so it forestalls to stream basic recurrence segment over the active power filter. For the consonant recurrence, this filter shows low impedance so the present harmonics stream over active power filter. The power limit and loss of the inverter are diminished.

F. CONTROL STRATEGIES

The control system is a genuinely basic issue in hybrid active power filter. All control methodologies comprise of four phases which are called as discovery of signs, era of adjusting signals, dc interface voltage control and era of terminating signals.

A. Flag Conditioning

In control system, for the figuring of reference signs to accomplish consonant and reactive power remuneration, quick voltage and current signs should be measured. Instrumentation transformers and Hall-impact sensors are utilized to quantify the voltage and current flags in framework. At that point, these deliberate signs are utilized to produce the reference signals for consonant and responsive power remuneration.

B. Generation of Reference Signals

Reference signs are produced utilizing time space and recurrence space strategies in writing.

1) Frequency Domain Methods

Recurrence space strategies utilize Fourier Transform (FT) to create reference signals. Quick Fourier Transform (FFT) which is a strategy in light of Fourier change, is utilized to gauge harmonics in . Despite the fact that it empowers particular harmonics end and gives to produce reference flags quickly, it has fundamental disadvantages such as necessity no less than one cycle to assess the reference current and control unpredictability contrasted with control strategies in time space which will be clarified more itemized in next subjects.

2) Time Domain Methods

Synchronous Reference Frame (SRF) and Instantaneous Responsive Power Theory (IRPT) are the most well-known and prominent control methods to decide the reference signals in light of time-area. IRPT additionally called as p-q hypothesis changes voltage and current signs from a stationary reference framework in abc directions, to a framework with facilitates. So it decides the harmonics bending by ascertaining prompt power in a three stage system. To create reference signals, Dividing Recurrence Control, Lagrange Interpolator, Optimal Straight Prediction Theory, Generalized Integral PI Controller and Extension PQ Theorem are too control strategies in light of p-q strategy. SRF additionally called, as d-q hypothesis look likes change. Nevertheless, d-q hypothesis figures reference signs of voltage/current in pivoting reference outline not at all like p-q hypothesis. Step channel based method, Indirect Current Control, versatile fluffy separating recurrence control, Recursive Integral consolidated with Fuzzy Controller , Recursive Integral Controller, Neural network, RL, Sliding-Mode Controller, Killjoy Control, Integer Lifting Wavelet Transform, PI-Type Iterative Learning Control Strategy are too control strategies utilized as a part of Hybrid APF.

C. DC Link Control

DC connect control is one of critical subjects which draw consideration in writing. Albeit Hybrid APF goes through lower dc interface voltage and has less commotion contrasted with regular APF, It is vital to keep the voltage size at required level or steady so as to balance out power trade. PI Controller Sliding Mode, Fuzzy, Adaptive DC interface Controller are utilized to control dc interface voltage in Hybrid APF topologies.

D. Generation of Firing Signals

The fourth step is era of terminating signs for exchanging gadgets There are a few procedures to create terminating signals for strong state gadgets in inverter. These procedures play imperative part in viable execution of Hybrid APF. PWM and Hysteresis Controller are the most basic methods, which are utilized to create door signals. Ordinary Sine Triangle PWM, Modified Sine-triangle PWM, Modified PWM, Unipolar PWM are controllers in view of heartbeat width-balance. Space Vector Modulation (SVM) is likewise another control procedure. For example, SVM-based hysteresis current controller and Deadbeat Current Controller based SVM are liked to control the era of terminating signals. Versatile Fuzzy Dividing Frequency Controller and Fuzzy Controller [5] are actualized to get the control signals for the strong state gadgets.

G. CONCLUSION

A broad literature review of HAPF is exhibited to give a reasonable point of view on different parts of HAPF to the analysts and architects working in this field. This paper also gives the overview of different converter topology ,power quality problem and solution of power quality. The audit and characterization of distributed work in this field demonstrates that technology is increases day by day. This paper is also focusing on the power quality problem and their solution. This paper is helpful for the supplier, researchers.

REFERENCES

- [1] C. sankaran, "power quality", CRC PRESS. Washington dc 2001.
- [2]. Arindam ghosh, Gerard ledwich," power quality enhancement using custom power devices", kluwer academic publishers,2002.
- [3]. Rogar c.dugan mark f. mc granaghan surya santosa, H. wayne beaty,"Electrical Power System Quality", second edition, McGraw hill publication.
- [4] P. Salmerón, S.P. Litrán, " A Control Strategy for Hybrid Power Filter to Compensate Four-Wires Three-Phase Systems," Power Electronics, IEEE Transactions on, Volume: 25, Issue: 7 ,Page(s): 1923 – 1931, July 2010.
- [5] P. Cheng, S.Bhattacharya, D. Divan," Experimental Verification of Dominant Harmonic Active Filter for High-Power Applications," Industry Applications, IEEE Transactions on ,Volume: 36 , Issue: 2 ,Page(s): 567 – 577, Mar/Apr 2000.
- [6] C. Lam, W. Choi, M. Wong, Y. Han , "Adaptive DC-Link Voltage-Controlled Hybrid Active Power Filters for Reactive Power Compensation," Power Electronics, IEEE Transactions on , Volume: 27 , Issue: 4 , Page(s): 1758 – 1772, April 2012
- [7] J. Wu, H. Joub, K. Wub, H. Hsiaob," Three-phase four-wire hybrid power filter using a smaller power converter," Electric Power Systems Research ,Volume 87, Pages 13–21,June 2012.
- [8] H.Fujita, H. Akagi, "A Practical Approach to Harmonic Compensation in Power Systems-Series Connection of Passive and Active Filters,"Industry Applications, IEEE Transactions on , Volume: 27 , Issue: 6 ,Page(s): 1020 – 1025, Nov/Dec 1991.
- [9] A.Van Zyl, J.H.R.Enslin, R. Spee, "Converter-Based Solution to Power Quality Problems on Radial Distribution Lines," Industry Applications,IEEE Transactions on , Volume: 32 , Issue: 6 , Page(s): 1323 – 1330,Nov/Dec 1996.
- [10] H. Akagi, E. Watanabe, M. Arede, "Instantaneous Power Theory and Applications to Power Conditioning" , 2007.
- [11] J.-H. Sung, S. Park, K. Nam," New hybrid parallel active filter configuration minimizing active filter size," Electric Power Applications, IEE Proceedings , Volume: 147 , Issue: 2 , Page(s): 93 –98, Mar 2000.
- [12] D.Rivas, L.Moran, J.Dixon, J. Espinoza , "A simple control scheme filter for hybrid active power," Generation, Transmission and Distribution, IEE Proceedings ,Volume: 149 , Issue: 4 , Page(s): 485 – 490, Jul 2002
- [13] Z. Shuai, A. Luo, W. Zhu, R. Fan, K. Zhou , "Study on a Novel Hybrid Active Power Filter Applied to a High-Voltage Grid," Power Delivery,IEEE Transactions on ,Volume: 24 , Issue: 4 , Page(s): 2344 – 2352, Oct.2009
- [14] A. Luo, C. Tang, Z. Kang Shuai, W. Zhao, F. Rong, K. Zhou , "A Novel Three-Phase Hybrid Active Power Filter With a Series Resonance Circuit Tuned at the Fundamental Frequency," Industrial Electronics,IEEE Transactions on ,Volume: 56 , Issue: 7 , Page(s): 2431 – 2440,July 2009
- [15] Abraham Olatoke "INVESTIGATIONS OF POWER QUALITY PROBLEMS IN MODERN BUILDINGS" January 2011.
- [16] Jain Sandesh, Thakur Shivendra Singh and Phulambrikar S.P. "Improve Power Factor and Reduce the Harmonics Distortion of the System" *Research Journal of Engineering Sciences* ISSN 2278 –9472 Vol. 1(5), 31-36, November (2012)
- [17] Mr. Suvas Vora, Mr. Dipak Bhatt " A Comprehensive Review of Harmonics Effects on Electrical Power Quality" INTERNATIONAL JOURNAL OF ENGINEERING DEVELOPMENT AND RESEARCH ISSN: 2321-9939
- [18] Reza Ghandehari, Abbas Shoulaie "Evaluating Voltage Notch Problems Arising from AC/DC Converter Operation", VOL. 24, SEPTEMBER 2009 2111
- [19] M.P. Donsión, J.A. Güemes, J.M. Rodríguez "POWER QUALITY. BENEFITS OF UTILIZING FACTS DEVICES IN ELECTRICAL POWER SYSTEMS"
- [20] A. Varschavsky, J.Dixon, M.Rotella, L.Morán, "Cascaded Nine-Level Inverter for Hybrid-Series Active Power Filter, Using Industrial Controller," Industrial Electronics, IEEE Transactions on, Volume: 57 ,Issue: 8 ,Page(s): 2761–2767,Aug.2010
- [21] S.P.Litran, P.Salmeron, R.S Herrera,"Practical Design of a Control Strategy based in Current and Voltage Detection for Hybrid Power Filters," Power Engineering, Energy and Electrical Drives(POWERENG), 2011 International Conference on ,Page(s):1-6,May2011
- [22] J.Tian, Q.Chen, B. Xie,"Series hybrid active power filter based on controllable harmonic impedance," Power Electronics, IET , Volume: 5 ,Issue: 1 ,Page(s): 142 – 148, January 2012.