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## REVIEW OF SHUNT ACTIVE POWER FILTERS CONTROL STRATEGIES FOR ELIMINATION OF HARMONICS

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### Abstract

Energy electronic loads are being linked to the allotted energy flora thru strength digital converters and those electricity digital converters and hundreds are the source of harmonics and reactive energy which affects the performance of the strength system network. Switching compensators called lively filters or active strength line conditioners brings an effective alternative to the traditional passive LC filters as they can make amends for numerous harmonic orders, and are unaffected by means of primary changes in community characteristics, keeping off the threat of resonance between the clear out and network impedance and are compact and strong in comparison with traditional passive compensators. The overall performance of the power system relies upon on the excellent of strength on which system are working. The power quality depends on various factors. These factors include voltage & frequency variations, faults and line outages in the system. The reduction in power quality reduces the life and efficiency of the equipment of the system.

### Introduction

The presence of harmonics in energy strains reasons main strength losses within the distribution machine, interference problems in lots of communiqué structures and, once in a while, in operation screw ups of electrical and digital equipment, which might be very touchy as they consist of microelectronic, manipulate systems, which work with very low power ranges. Because of those issues, the challenge of the power exceptional brought to the quit clients is, lots more than ever, an item of higher concern. The lively power filters have come to be a whole lot popular due to remarkable performance to diminish the harmonic and reactive strength issues [1].

Lively electricity filters (APFs) are power digital devices operated in electricity structures for conditioning purposes. In maximum of the cases, APFs are primary designed for contemporary or voltage harmonic reimbursement or isolation. Extra features, including reactive electricity reimbursement or voltage law can be accomplished by using some topologies. The APF compensation concepts were proposed in 1970, and the big development of power electronics technology has allowed engineers to make the APF a sensible reality today [1]-[3].

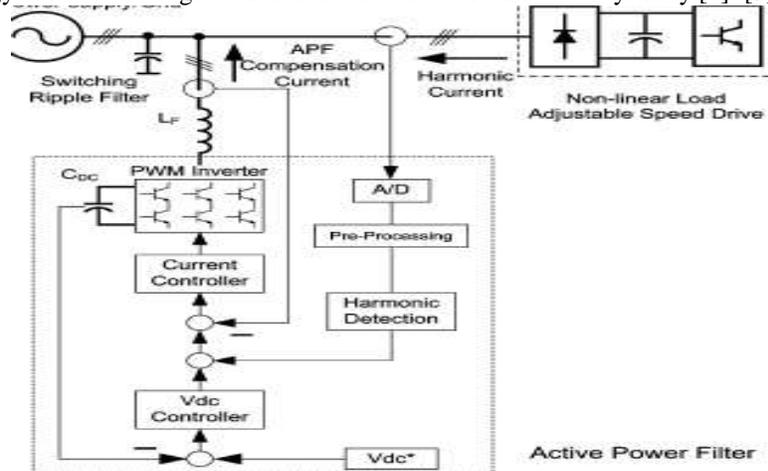


Figure 1: Block diagram of parallel APF topology.

In an Active Power Filter (APF) we install electricity electronics which introduces current components to do away with harmonic distortions incurred via the nonlinear load. Figure 2 shows the basic concept of an active filter. They sense the harmonic additives in the line after which produce and inject an opposing and inverting signal of the detected wave within the system. the 2 primary fields of research in active power filters are the manipulate algorithm for current detection and load current evaluation approach. energetic harmonic filters are mainly used for low-voltage networks because it is hard to match the desired score on power converter [4].

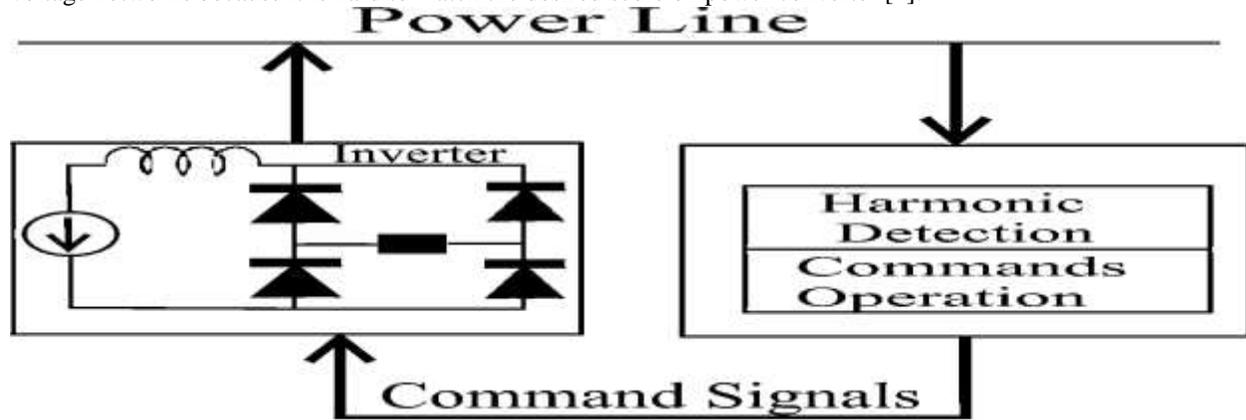


Figure 2. Conceptual demonstration of Active filter

### 1. The Principle Of Shunt Active Power Filter

#### A. Basic Structure

The shunt active out approach is based totally at the principle of injection of harmonic currents into the AC system, of the equal amplitude but contrary in phase to that of the burden harmonic currents.

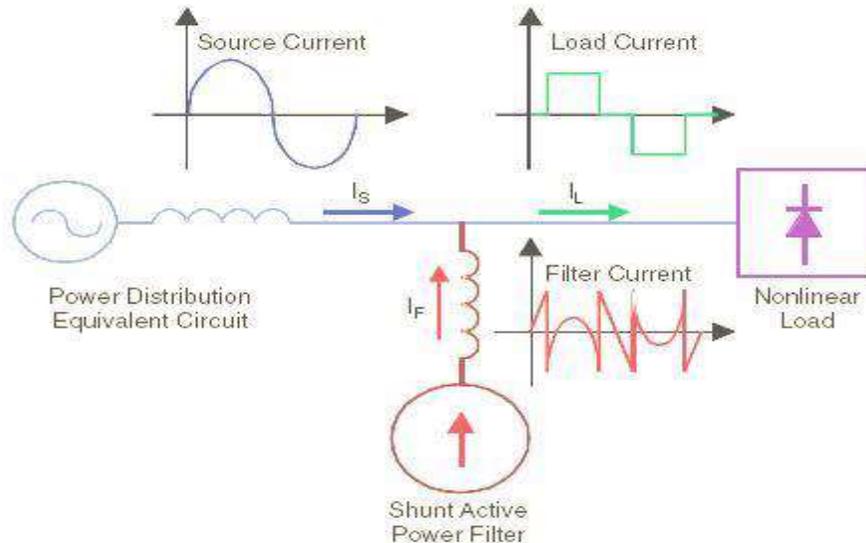


Figure 3. Basic Principle of SAPF System.

Fig. 3 shows the active power filter compensation principle, which is controlled in a closed loop manner to actively form the source modern-day into sinusoid.

#### B. The Calculation of Reference Current

The circuit of reference modern calculation is largely primarily based on three-segment instantaneous reactive power concept [5], which shows a novel method to discover the 3-phase harmonic present day. As shown in Fig 3,  $i_a$ ,  $i_b$  and  $i_c$  are initially detected and then served as the input for the next stage of algorithm, which involves specific calculation of instantaneous active current  $i_{pas}$  as well as reactive current  $i_q$ .

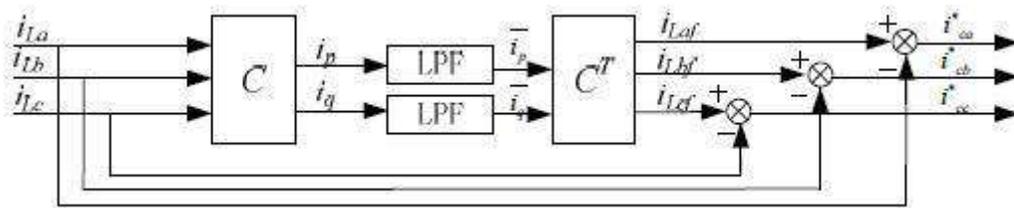


Figure 4. Algorithm of the reference current calculation circuit

**C. Current Tracking Control Circuit**

Current tracking is the first step for the production of targeted compensating current, under the primary characteristic of acquiring the PWM indicators that are responsible for the transfer modes of each device inside the principal circuit. Similarly, the PWM signal is generated by using the assessment between the reference contemporary and the actual compensating contemporary.

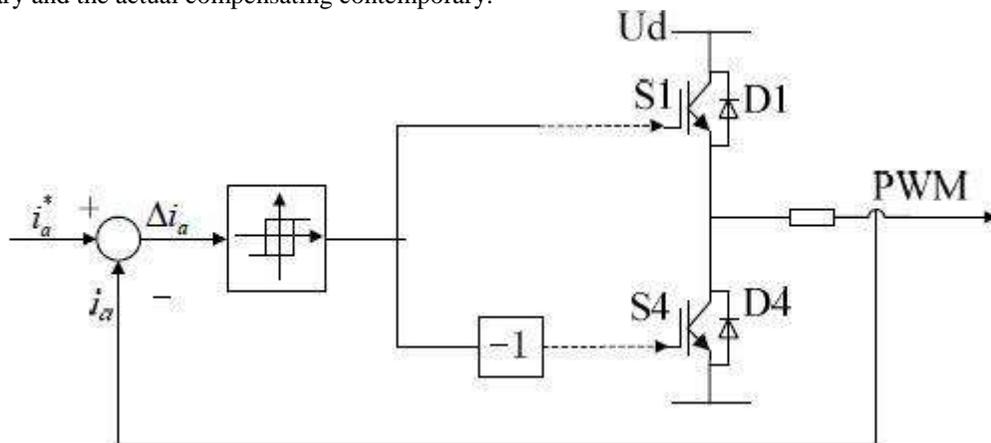


Figure 5. Circuit of current tracking control

The current-tracking-controlled PWM inverters possess various forms, the most common of which is the hysteresis current tracking control shown in Fig 5. represents the reference value and meanwhile the tracking target of the load current. When the hysteresis control is applied, the real output of the current from inverters could maintain a fluctuation value only within  $h$  and  $-h$ , bouncing up and down in zigzag forms, as one of the examples illustrated in Fig.6.

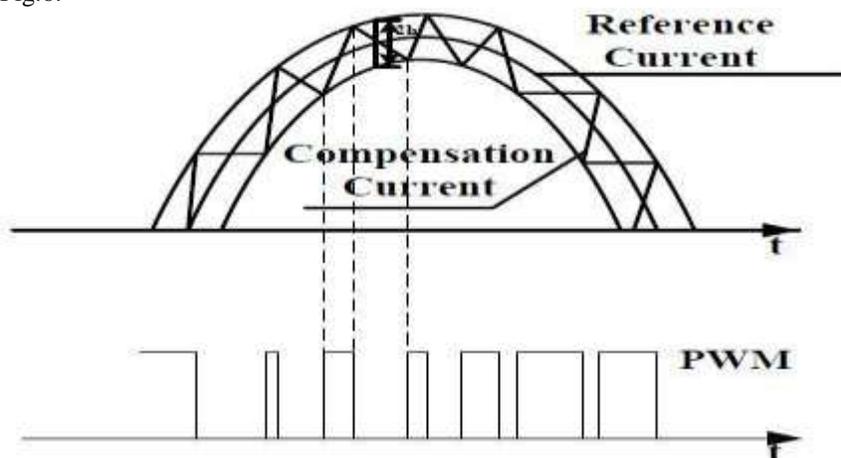


Figure 6. One example of the hysteresis control of the reference and compensating current

## 2. ADALINE

The call Adaline comes from Adaptive Linear Neuron. This network became invented by means of Bernard Widrow and Ted Hoff in 1960. Adaline is a single layer community with multiple inputs and a single output. The output received is surpassed through an activation feature commonly a linear activation function.

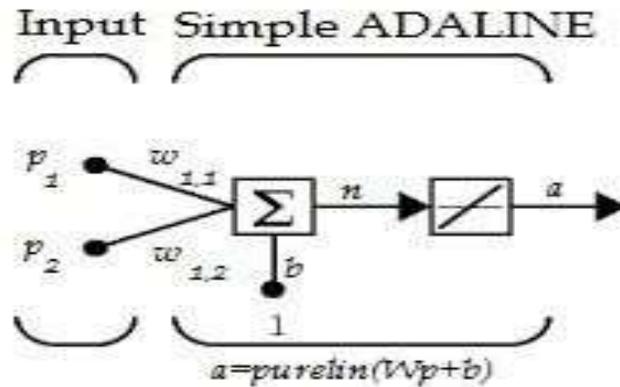


Figure 7: Basic Adaline Neural Network

The weights of the Adaline network are updated using the LMS algorithm. LMS algorithm uses the inputs, output and desired output to adjust the weights of the network. An optimal solution for adjusting the weights of the neural network is given by the LMS algorithm by minimizing the mean of the square of the output that is to be obtained. This is done by computing the error signal for each iteration and adjusting the weights using the error using the delta rule which is also known as Widrow-Hoff learning rule.

The delta rule for updating the  $i$ th weight for each iteration is given by

$$\Delta W_i(t+1) = \eta \{d(t) - \sum_{i=1}^n W_i(t) X_i(t)\} X_i(t) \quad (3.12)$$

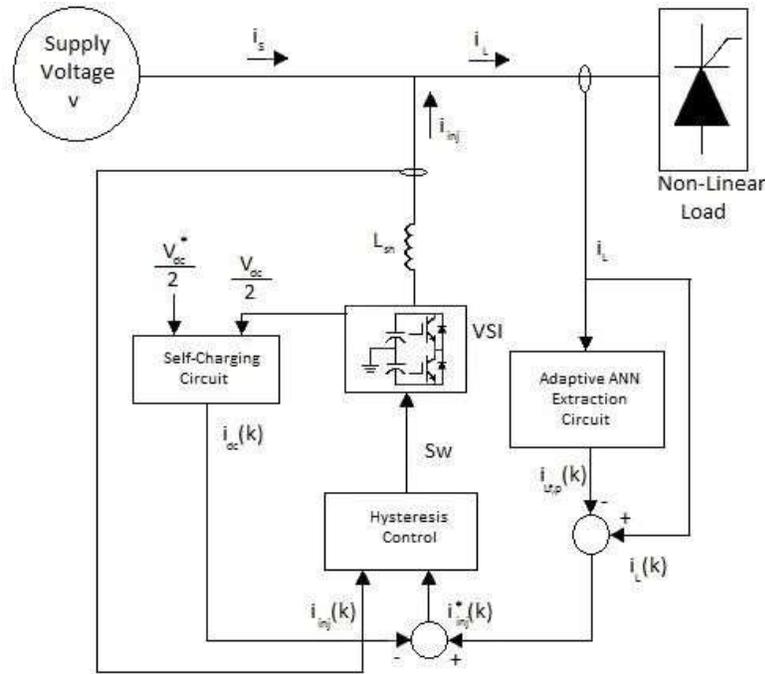
Where  $0 < i < n$

$\eta$  represents the learning rate, it is a small number ranging in between 0 and 1

### A. Adaline Based Decomposer

on this technique neural community is used for the decomposition of the load present day. the load current is decomposed into essential superb and negative series factor, reactive component and harmonic additives with none segment shift. The Adaline-based totally neural community is used to estimate the reference currents via monitoring of unit vectors by way of adjusting of the weights. practically the scheme may be applied by way of the usage of the virtual sign processors.

An AC device with power conditioner as shunt APF is used. The mixed masses consists of the variable frequency type ac vehicles that's balanced harmonic producing load and linear unbalanced resistive-inductive kind load. The Adaline primarily based neural network that's based on complex LMS set of rules for the decomposition of the load currents to reap the fundamental and harmonic current additives.



**Figure 8: System Block Diagram of Single-Phase Adaptive Shunt Active Filter.**

**4. Proposed of harmonic compensation:**

Objectives of harmonic compensation are as follows;

1. Eliminate real power oscillations
2. Power factor improvement
3. Eliminate current harmonics
4. Provide harmonic damping

These objectives can be done by configure the Active Power Filter.

**I. PI controller:**

PI control is becoming one of the most studied, well known and established control techniques in most of the applications, in which the constant or slowly varying reference should be tracked. However, the application is to control alternating signals of PI regulators is not straight forward.

Application of PI controllers in desk bound body offers upward push to a giant regular nation error, due to the fact they best assure ideal tracking at 0 Hz. a good way to achieve unit closed loop benefit for alternating indicators, those ought's to be first of all converted into dc values. this could be achieved with the aid of the park remodel.

A conventional PI controller is defined by the transfer function.

$$G_{PI}(s) = K_P + K_I/s$$

Where  $K_P$  and  $K_I$  are the proportional and integral gains, respectively.

**II. PR controller:**

In case of three-phase systems, synchronous frame PI control with voltage feed forward can be used, but it usually requires multiple frame transformations, and can be difficult to implement using a low-cost fixed-point digital signal processor (DSP). Overcoming the computational burden and still achieving virtually similar frequency response characteristics as a synchronous frame PI controller, [20-21], develops the Proportional Resonant (PR) controller for reference tracking in the stationary frame. Interestingly, the same control structure can also be used for the precise control of a single-phase converter. primarily based on similar control idea, PR filters can also be used for generating harmonic command reference exactly in an lively electricity filter, especially for single phase systems, the d-q transformation theory isn't relevant. Another advantage associated with PR controllers and filters in the possibility of implementing selective harmonic compensation without requiring excessive computational resources.

The basic functionality of PR controller is to introduce infinite gain at a particular frequency for eliminating steady state error at that particular frequency.

**5. Conclusion**

The proposed inverter switching signals are generated the usage of triangular-sampling modern-day controller; it gives a dynamic overall performance underneath transient and steady nation situations. On the idea of the simulation, to discover harmonic wave and reactive load present day efficiently, compensate the burden contemporary efficiently by way of reshaping the source contemporary to that much like sine wave and reducing the THD cost to below 5%. The compensation performance of the simulation result provides a practical approach to the basis of APF & applied to Induction Drive to check the performance characteristics.

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