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An Innovative Technique for Harmonic Mitigation in Power System: A Technological Review

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***Abstract*- Maintaining proper power quality is being an important task in the operation of power system. It is compel by the power quality standards (IEEE-519) to limit the harmonic distortion within the acceptable range. The excessive use of power electronics devices in distribution system has evolved the problem of power quality resulting in harmonics generation & in substantial economic losses. Filters approaches to be the effective & efficient technique for harmonics mitigation. This paper presents the reviews of the adopted method & new technique based on Artificial neural network. Harmonics identification method and compensation control adopted have been discussed.**

Keywords- Active power filter, neural network, Harmonics.

I. INTRODUCTION

With the increasing energy demand, power quality is one of the major constraint in power system transmission & distribution. Power quality is basically the quality of the voltage. A power-quality problem is an occurrence manifested in a nonstandard voltage, current or frequency deviation that results in a failure or a disoperation's of end-use equipment[1].

Due to the advancements in the semiconductor technology & the proliferation of the power electronics devices or non linear loads in power distribution systems, the vulnerability of such equipments to power quality problems has increased. The non linear load including saturated transformers, CFL, arc furnaces, converters for ac drives, SMPS & so on draw non sinusoidal current from the utility & generate harmonics [2]. In many literatures the harmonic is defined as "a component of a periodic wave having a frequency that is an integral multiple of the fundamental power line frequency" [3].

Basically, two approaches for the mitigation of power quality problems are load conditioning & line conditioning . In which line conditioning is found to be better as it becomes difficult to made equipments less sensitive to harmonics. In line conditioning, the system is installed at the point of common coupling that suppress for the effects produced by the non linear loads. To lessen the effects of harmonics, although there is a availability of different technical options but filters have proved to be a viable solution to eliminate harmonics.

Traditionally, passive filters are used to mitigate harmonics. Although with various advantages such as simplicity, easy to implement, create system resonance cheaper, the passive filter suffer from many disadvantages such as tuning problem, fixed compensation characteristics & their bulky size [4]. Active filters avoid the drawbacks of passive filters but its performance depend on the power rating & speed of response. Hybrid filters have been proposed to mitigate the problems of active & passive filters. It provides cost effective & practical harmonic compensation approach for high power non linear loads.[5]

Various harmonics detection techniques were adopted to control the power circuit of the active filter. This paper presents neural network techniques for the detection of the harmonic component. The artificial neural network have been applied in many areas due to its simple structure & high speed learning ability. Neural network provide better results than those of the traditional methods. Section II presents the evolution of Active Power Filter. Section III presents control strategies. Section IV presents the conclusion.

II. EVOLUTION OF ACTIVE POWER FILTER

Active Power filter is a dynamic & flexible solution for harmonic current mitigation due to its compact size, stable operation & no requirement of tuning problem. Active Power filters installation proves indispensable for solving power quality problems in distribution networks, such as compensation of harmonics, reactive power & neutral current in ac networks, regulation of terminal voltage & suppression of the voltage flicker. [5]. Basic difference between the Active

& Passive filters is that the former have the capability to compensate the randomly varying currents. The principle of APF is to produce the specific currents components that cancel the harmonic components produce by the non linear loads.

2.1 CLASSIFICATION OF ACTIVE POWER FILTER

Different Active Filter topologies have been presented. Figure 2.1 shows that APF are divided into three main categories namely Shunt APF, Series APF & Hybrid APF [2]

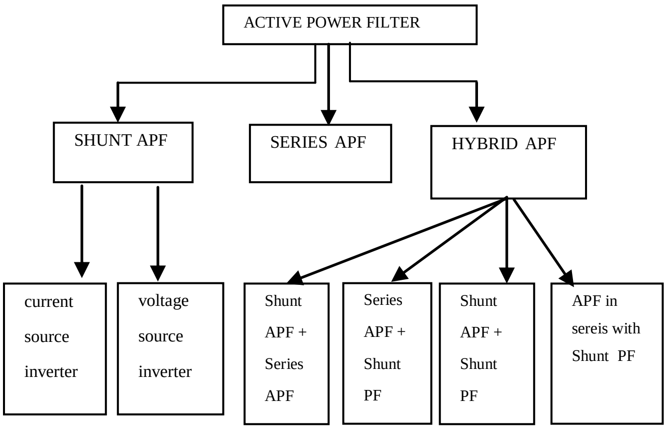

Figure 2.1 Classification of Active Power Filter

Series Active Power Filter acts as a controllable voltage source & Shunt Active Power Filter operates as a controllable current source. Both schemes are implemented with current or voltage source inverter. Currently they are based on PWM voltage source inverters with a dc bus having capacitor reactor element.

An alternative to mitigate the problems of pure active filter & passive filter, Hybrid Filters have been proposed [6]. It gives an efficacious combination of Active & Passive Filters. A Hybrid topology significantly improves the compensation characteristics of passive & active power filters Accuracy of the Hybrid Active Power Filter depends upon the generation of the reference current & the calculation of harmonic current. Various combinations of Hybrid Filter installations are shown in the above figure 2.1.

2.2 SHUNT ACTIVE POWER FILTER

Shunt Active Power filter is commonly used as an effective method in compensating harmonics components due to non linear loads [7]. The basic function of SAPF is to mitigate harmonics & to improve the reactive power requirements of the load so that the sinusoidal balanced unity power factor currents are only feeds by the ac supply. It compensates the current harmonics as well as voltage harmonics. The current compensation characteristics of SAPF is shown in the figure 2.2

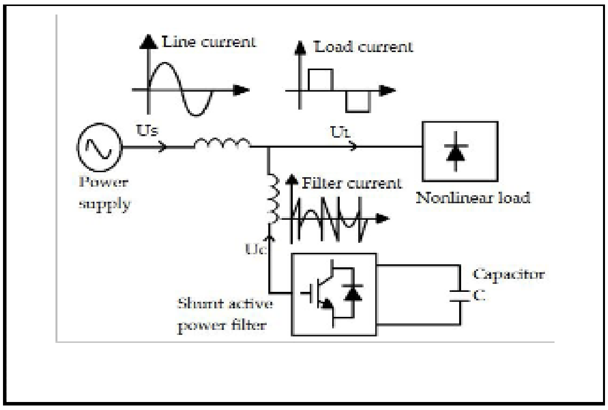

Figure 2.2 Shunt Active Power Filter Compensation characteristics.

Here, SAPF compensates current harmonics by injecting harmonics components generated by the load that is equal & opposite i.e. phase shifted by 180 degree. An IGBT based voltage source is proposed as a current controllable source in SAPF.

III. CONTROL STRATEGIES

The main objective of Shunt Active Power Filter is to improve the power quality by eliminating harmonics using four main components. They are Harmonic detection, Compensating current control, DC voltage control & active power filter.

Various detection techniques were adopted to detect the harmonics components as the instantaneous reactive power theory (PQ) [8], the synchronous reference frame (SRF) [9], the dq axis with fourier (DQF) [10], & the synchronous detection (SD) [11], Fuzzy techniques. Recently, an Artificial Intelligence based Neural Network have been applied to improve the processing time of harmonics current detection.

For the proper response of the active power filter in addition to the harmonics detection & reference current generation, DC voltage control & compensating current control are essential task. [4]**.** APF injects the compensating component to the power system network.

The current controlling techniques are pulse width modulation (PWM), space vector modulation (SVM), & Hysteresis current control. Hysteresis current control technique is basically an instantaneous feedback current control method. It is a method of controlling a voltage source inverter so that the generated output current follows the reference current. The hysteresis band current controller decides the switching pattern of the Hybrid power filter. [12]

A Proportional Integral (PI) controller is employed for DC voltage control. PI controller algorithm involves proportional & integral parameters. Proportional value determines the reaction to the current error & the integral determines the reaction based on the sum of the recent errors [4]. Its transfer function can be represented by

$H(s) = kp +(ki/s)$

where, kp is the propotional constant & ki is the integral constant.

3.1 ARTIFICIAL NEURAL NETWORK CONTROLLER

An Artificial Neural Network is an information processing paradigm that is inspired by the biological nervous system, such as the brain, process information. ANN has been adopted to many applications to perform several tasks such as pattern recognition, fitting function etc. Examples of Neural Network application are aerospace, automotive, banking, defence, electronics, entertainment, financial, industrial, insurance, manufacturing ,medical etc [13].

An Artificial neural network is the interconnection of processing units called as neurons. These neurons are connected to each other by directed communication links, which are associated with weights. It has three layers input, output & hidden layers. The simplest form of Neural Network having one input & one output layer is as shown in the figure 3.1. It is shown that there are three inputs associated with weights. The weighted inputs are the fed to the summation unit. It gives the Net input as,

Net input = Σ XiWi

The Net is the summation of the products of weights & input signal.

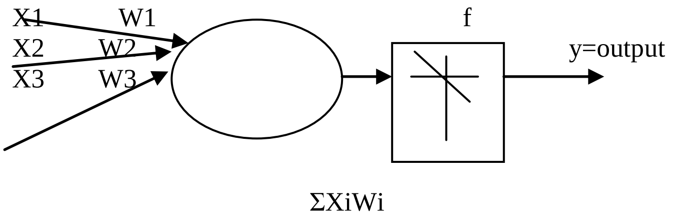

Figure 3.1 Components of an Artificial Neuron

Activation function f is used to calculate the output response of a neuron. The activation function applied can be linear or non linear.

$F(x) = x$ for all x;

The ultimate goal of applying neural network to SAPF is to minimize the uneeded signal. Its objective is to increase the efficiency, accuracy, robustness ability of the system. Various examples of Neural Network architecture which have been designed for solving different problems are Perceptron, ADALINE, Widrow-Hoff, Backpropagation(BP), Radial Basis function(RBF), Hopfield, Hebbian & Grossberg. The most famous architecture of neural network in SAPF are adaline & backpropagation.

IV. CONCLUSION

The paper presented an efficient & effective solution to power quality improvement. The presented techniques satisfactorily mitigate harmonics & maintain the supply current sinusoidal & meet the IEEE 519 standard recommendation. The Harmonic filter includes PI & Hysteresis controller. It revels from the reviews described in the paper that neural network has been applied to SAPF for Harmonic detection. Neural network controller is very popular to all application. In future, artificial intelligence will be applied to ANN controller design for SAPF.

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