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A Review on Modern Innovative Technique for Harmonics Alleviation in Power System

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ABSTRACT
In recent years maintaining power quality is a major concern for the customers. Interference of harmonics is the cause of power quality disturbance such as total harmonics distortion (THD) and individual harmonics distortion (IHD). These harmonics get introduced in power system from non-linear loads, Power electronics equipments and control circuits. The harmonics gets entered and it decay power factors of the system. This paper presents the brief survey on different modern harmonics alleviation techniques.

Keywords - Power quality improvement, Load variation, total harmonic distortion (THD), stability analysis.

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I. INTRODUCTION

The increasing demand of electrical energy, in different type of industries, agriculture and domestic purposes, power quality maintenance is one of the big problems. The power quality of the system basically disturb due to presence of harmonics. These harmonics have large voltage and current magnitude which increases the THD (Total Harmonics Distortion) of the system. Harmonics are undesirable components in the sinusoidal waveform of the AC Power supply. Harmonics occur as integral multiples of the fundamental frequency. That is, the third order harmonic will have a frequency of 3 times the fundamental frequency; 150 Hz which is 3 times the fundamental 50 Hz frequency. Harmonics affect power quality and efficiency [1].

To maintain the power quality in distribution systems, several standards, such as IEEE 519-1992, IEC 61000-3-2, have been developed (IEEE 519-1992; IEC 61000-3-2). The IEC 61000-3-2 imposes limits on harmonic emission from individual equipment (Table 1, 2 and 3), while IEEE 519-1992 tackles the issue at a macro-level by limiting the possible impact of harmonics on the distribution network. Table 10.3 of IEEE 519 lists the harmonic current limits based on the size of the load with respect to the size of the power system to which the load is connected. Power utilities and consumers are expected to respond to these standards so that limiting value of harmonics are not violated, or else face penalties, and accordingly use appropriate custom power devices like power filters[2].

Any deviation from fixed magnitude, phase and frequency of the signal is considered as power quality disturbance (PQD). As per standard different types of PQ disturbance are presented in Figure-1[4]. The high voltage transmission line fault detection and analysis helps to selected and developing for a better to protection purpose and their protection of transmission line [5].Harmonic pollution occurs normally in low voltage and voltage dip in system. Harmonic producing equipments are found in varied locations from offices to manufacturing plants and they are becoming inevitable in daily life. Various harmonic producing equipments are [8]:

(a) Personal computers
(b) Electronic lighting ballasts
(c) Variable and adjustable speed drives
(d) Industrial process controls
(e) Electronic test equipment
(f) Solid state controls
(g) UPS systems
(h) Medical equipment

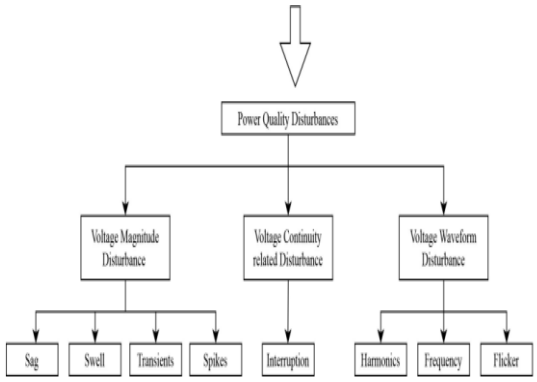

Fig.-1 Categorization tree of power quality disturbances analysis.

II. EFFECT OF HARMONICS

Presence of harmonics increase interference and distortion in power system. Some of the considerable issue build in system are:

1. These harmonics creates noise signal from electromagnetic interference in transmission of communication line.
2. Presence of harmonics current creates heating effect in power system equipments such as generator, motor and transformer. Some time it is also burn the insulation material.
3. Frequency of harmonics differs from the main fundamental signal frequency which cause of undesirable switching operation and improper beaker.
4. Due to harmonics multiple zero crossing form in the generator (distorted current waveform) cause voltage fluctuation and unbalance voltage.

III. REVIEW OF LITERATURE

1. Passive and active filters

The different techniques used and presented in resent past to mitigate the harmonics from the power system are discussed below. The basic harmonic theory which according to Fourier theorem, periodic non-sinusoidal or complex voltage or current waveforms can be represented by the sum of a series of multiple frequency terms of varying magnitudes and phases [1].Traditionally, passive and active filters are used to mitigate harmonics. The passive and active filtering approaches are extensively used to improve power quality by eliminating voltage or current harmonics with reactive power compensation. Conventionally, passive filters (LC filters) have been used to improve power quality. Though passive compensation is a simple approach, but they have several drawbacks such as size, resonance problem, performance affected by source impendence, separate filters for each harmonics and unsuitability for fast varying loads [2].

Control circuits constitute a minor portion of the total cost of active filters. This is because the new generation of microcontrollers and digital signal processors (DSPs) can operate at extremely high frequencies and at very low cost [7]. The APFs performs the analysis on current consumed at load end and eliminates the load generated harmonics. The following Figure.2 gives the connection of APFs [10].

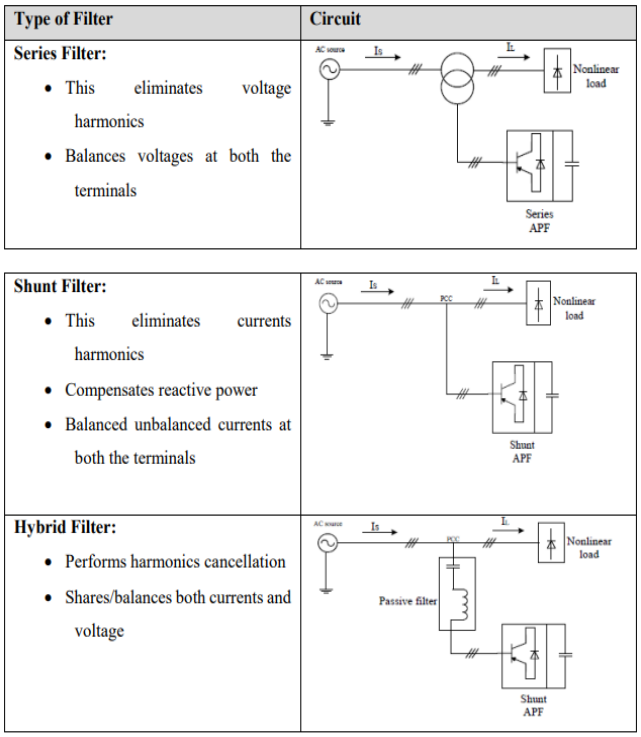

Fig.2 Different connections of power filters

2. Neural Network Controller

However, tuning of such filters is a significant task and complex. Use of artificial intelligence such as neural network, fuzzy logic, genetic theory, etc. in solving such complex problems has gained much attention. Recently, artificial neural network (ANN) in power electronics area due to its self-adapting and rapid calculation characteristics, allows control to handle high non-linearity, uncertainties in a nonlinear system. Neural network gives required output by proper on-line and off-line training based on different learning rules. Fig. 3 shows the basic building block of proposed ADALINE network. The ADALINE is a two layered feed-forward perception, having “n” input units and a single output unit. Its output is a linear combination of the inputs. The process of generating NN block relies on off-line training of the suitable

network with predetermined input and output patterns [2].

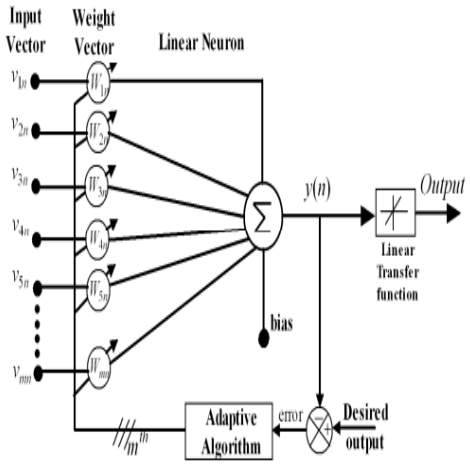

Fig.3 ADALINE based architecture of proposed Neural Network

The basic blocks of this network are input signal delay vector, a purelin transfer function, weight matrix and bias is shown in fig.4[3].

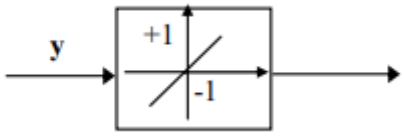

Fig. 4 Input/Output relationship of purlin transfer function

The ultimate goal of applying neural network to SAPF is to minimize the unneeded 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, Back-propagation(BP), Radial Basis function(RBF), Hopfield, Hebbian & Grossberg. The most famous architecture of neural network in SAPF are adaline & back-propagation [12].

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3. Fuzzy control system

Fuzzy logic is multi valued logic, that gives approximations and its truth value ranges in between 0 and 1. In the fuzzy logic, the main benefit is its explicit knowledge representation in making simple IF-THEN rule [4].

The fuzzy model for the harmonic distortion diagnostic was implemented in MATLAB using the fuzzy logic toolbox. This toolbox allows for the creation of input membership functions, fuzzy control rules, and output membership functions [8]. The controller-based on Fuzzy Logic generates the desired harmonic reference currents and are regulated with HPF. The outcomes of this give significant results in harmonics mitigation [10]. In fuzzy controller the control action is determined by sets of linguistic rules. The advantage is it does not require mathematical model and works with imprecise inputs [15]. The process of converting numerical variable to linguistic variable is done in fuzzification. Here seven triangular shaped membership functions are used and their linguistic variables are Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero Error (Z), Positive Small (PS), Positive Medium (PM) and Positive Big (PB).

Each membership function is defined using three vertices {a,b,c} which represents the values corresponding to the left minimum, peak and right minimum of a triangle representing the membership function. This is shown in Fig. 5.

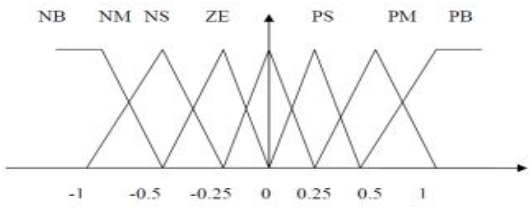

Fig 5: Membership function of fuzzifier input variables e, Δe and defuzzifier output variable μa (x)

Table 1 Fuzzy Rule Base

e / Δe	NS	NM	NB	Z	PS	PM	PB
NB	PB	PM	PS	PS	PS	PS	Z
NM	PM	PS	PS	PS	PS	Z	NS
NS	PS	PS	PS	PS	Z	NS	NS
Z	PS	PS	PS	Z	NS	NS	NS
PS	PS	PS	Z	NS	NS	NS	NS
PM	PS	Z	NS	NS	NS	NS	NM
PB	Z	NS	NS	NS	NS	NM	NB

The rule base store the linguistic control rule base need by rule evaluator. Large errors in transient state need coarse control and in small errors need fine control in steady state. Based on these elements, 49 rules of the rule table used in the paper are shown in Table-I [16].by the help of fuzzy logic system classification accuracy of the applied approach is increased.

III. Conclusion

In this paper different techniques are studies as per critical review active and passive filters are lacks in some point such as size of system, presence of resonance and not efficient for the sudden load change. Artificial neural network based control algorithm help to improve the system performance under non-liner load and disturb supply source conditions. Artificial neural network (ANN) finds the solution of complex problem and real-time case studies. ANN improves the mitigating capability of harmonics and increases system efficiency. As compare to ANN and traditional active and passive filters method Fuzzy logic controller (FLC) work for mitigation of total harmonics in the source current. It is observed that the total harmonic distortion (THD) for both balance and unbalance load condition found better result in FLC as compare to active and passive filter.FLC increased the effectiveness of filter with different combination circuit.

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